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JAMES WEBB SPACE TELESCOPE MISSION

SCIENCE AND OPERATIONS CENTER

Science Operations Design Reference Mission

Revision C

Released: 27 September 2012

Operated by the Association of Universities for Research in Astronomy, Inc., for the National Aeronautics and Space Administration under Contract NAS5-03127

CM Foreword

This document is an STScI JWST Configuration Management-controlled document. Changes to this document require prior approval of the STScI JWST CCB. Proposed changes should be submitted to the JWST Office of Configuration Management.

Signature Page

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STScI JWST Document Change Record		
Title: Science Operations Design Reference Mission		
STScI JWST CI No: JWST-STScI-000045		**Revision: C**
Change No./Date	Description of Change	Change Authorization/Release:
JWST-STScI-CR-000025	Initial Release to SOCCER	12/21/2004 CCB (out-of-board)
JWST-STScI-CR-000140	Revision A	02/15/2005 CCB (out-of-board)
JWST-STScI-CR-000478	Revision B	10/25/2005 CCB (out-of-board)
JWST-STScI-002849	Revision C	09/27/2012 CCB (out-of-board)

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1 Summary

The Science Operations Design Reference Mission (SODRM 2012) provides a set of realistic JWST science programs that cover at least 1 year of observations. The SODRM 2012 programs represent the current best estimate of the type, mix, and distribution of observations that JWST will carry out during the 1st year of operations. The SODRM 2012 is the product of over 50 scientists across the JWST community and, as a result, reflects the current view of planned JWST observations. The goal of the SODRM 2012 is to provide a basis for quantitative investigations of JWST operations, specifically to explore ways to improve the efficiency and reliability of JWST operations. There are no mission design or performance requirements dependent on the specific content of the SODRM 2012. The SODRM 2012 programs do not represent allocations or reservations of observing time, the real JWST cycle 1 programs will be comprised of Guaranteed Time observations and programs competitively chosen by the the JWST Telescope Allocation Committee (TAC)

2 Introduction

The Science Operations Design Reference Mission (SODRM) defines an observing program of at least one year of representative science observations for the James Webb Space Telescope (JWST), as realistically as is currently feasible, as an aide to planning, analysis, systems engineering, and the design of the ground system. The SODRM conforms to the high-level science requirements of the JWST Science Requirements Document (SRD; Mather 2009) with a discrete set of observing programs that could be scheduled and executed by the telescope. The SODRM also includes calibration observations and observatory maintenance operations for the first year of science operations. The SODRM does not include commissioning programs that happen prior to the start of regular observations. The SODRM is not intended to impose any requirements beyond those already in the SRD.

JWST's actual science program will consist predominantly of Guest Observer programs selected by competitive peer review and a smaller portion of Guaranteed Time Observations. The SODRM cannot predict the exact observations that will result from that process. Instead the SODRM aims for a representative mixture of scientific programs that cover the four JWST science themes and exercise all supported science instrument modes. The goal is to achieve a realistic model of the variety of scientific programs, the distribution of instrument usage and instrument mode usage (e.g. imaging vs. spectroscopy), as well as the distribution of integration times, sample sizes, and distributions of targets on the sky. The SODRM is designed to reflect both the expected mean and variance of actual JWST science operations.

The SODRM implements the science themes of the JWST Science Requirements Document. While the themes will remain current throughout mission development and flight, the specific research projects that they motivate must evolve to keep pace with new scientific discoveries.

For example, the field of extrasolar planets is growing rapidly, with large observational programs on the Hubble and Spitzer Space Telescopes. As a result, the "Planetary Systems and the Origins of Life" science theme is now anticipated to occupy a larger fraction of JWST's observing time than originally envisioned. To ensure that the SODRM's implementation of the SRD science themes remains scientifically current, the SODRM includes ideas from the JWST White Papers (2004-2010, http://www.stsci.edu/jwst/doc-archive/white-papers/),the review by Gardner et al. 2006), and the "Frontier Science Opportunities with JWST" conference held in June 2011 (http://www.stsci.edu/institute/conference/jwst2011).

A key purpose of the SODRM is to inform systems engineering analysis of mission operations and to aid in the development of major ground system components. For example, the SODRM will be used to test algorithms for calculating scheduling efficiency and for momentum management. Such mock scheduling exercises will generate a distribution of slew times and distances, which will prove useful in analysis of observatory thermal issues and scheduling efficiencies. Section 4 describes other potential analyses that could draw on this update of the SODRM.

3 Development of the SODRM

The first version of the SODRM was developed by the SODRM Working Group[2] and published in 2005 (SODRM 2005, Petro et al. 2005). The development of JWST has evolved significantly since 2005. Notable changes since then include the introduction of Observing Templates (Stockman 2005; Fullerton et al. 2008; Gordon et al. 2008) and Engineering Templates (Beck et al. 2008) to simplify the input of observer requests and operations, the definition of instrument specific dither patterns (Tumlinson et al. 2010), a more complete specification of target acquisitions (e.g. Gordon & Meixner 2008), and the modification of the TFI instrument into the NIRISS instrument. In addition, the scientific priorities of the astronomical community interested in using JWST have evolved and this has led to some changes in the types of programs anticipated (e.g., increased emphasis on exoplanet observations). The planning system and operational scripts now implement more sophisticated capabilities (e.g. dithering, coronagraphy, targets of opportunity, etc.) that enable more varied and realistic programs. Finally, the significant increase in the number of JWST science staff and increasing interest of the science community in JWST has broadened the science expertise directly available for the SODRM effort. As a result, one of the main chartered tasks of the JWST Efficiency Working Group[3] (EffWG) is to update the SODRM and, in the future, continue to improve the fidelity of the SODRM as the JWST operations system develops.

The SODRM is different than the “Monograph 5” DRM (Mather et al. 2000) which has remained static and has been used as the requirements case study. The “Monograph 5” DRM was developed early in the JWST design and centers on the type of science program, such as deep fields/first light science that involve longer average integrations than the SODRM. The SODRM is a more realistic and broader representation of the actual science programs that are predicted to be carried out with JWST.

The SODRM programs encompass the science themes described in the JWST SRD (Mather 2009) and the mapping of the updated SODRM programs to the SRD is discussed in Section 3.2.

3.1 Methodology

The main goal of this SODRM revision (hereafter SODRM 2012) is to bring it up to date with the current JWST instrument capabilities and to account for the advancing frontier in each of the science themes. To accomplish this, the programs in SODRM 2005 were reviewed by the EffWG and divided into six broad categories: Solar System (IDs 92000-92999), Galactic (93000-93999), Nearby Galaxies (94000-94999), Distant Galaxies & Cosmology (95000-95999), Instrument Calibration (96000-96999), and Observatory Calibration (97000-97999). Each category was given a large range of possible ID numbers to provide for easy future revision of the SODRM. All the SODRM IDs are above 90000 to avoid any future confusion with actual JWST observing programs. After all the programs were submitted, it was found that a large fraction of the Galactic category programs were to investigate extra-solar planets. Given the strong interest in directly probe extra-solar planets was added.

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[2] L. Petro, V. Balzano, W. Kinzel, R. Lucas, M. Meixner, M. Regan, A. Roman, P. Royle, A. Sivaramakrishnan, D. Soderblom, M. Stiavelli, J. Valenti, R. Whitman (STScI); J.P. Gardner, and L. Purves (GSFC).

[3] K. Gordon, H. Ferguson, B. Blair, J. Lotz, V. Balzano, W. Kinzel, & J. Tumlinson (STScI), G. Sonneborn and J. Rigby (GSFC).

As with SODRM 2005, each program in SODRM 2012 consists of a text summary description of he scientific goals of the program and a separate specification providing the technical details of the observations. To provide this information, each program in SODRM 2012 was assigned a STScI lead who was charged with ensuring that the two files were created and submitted. The leads were encouraged to work with other interested JWST community members (both internal and external to STScI). A template for the text document was provided (see section 5.1). After a review of the existing capabilities of the Astronomer's Proposal Tool (APT), the EffWG found that NIRCam, NIRSpec, and MIRI observations could be defined using APT, while NIRISS observations required a custom spreadsheet. The use of APT for three of the instruments did require a small number of custom, carefully formatted comments to be added to the APT file to allow the base level of functionality to be captured. The use of a spreadsheet for NIRISS was required as APT did not yet include NIRISS Templates.

A Google site was created to support the SODRM 2012 effort. This site included an overview of the SODRM 2012 effort, instructions on how to construct the two required files, a place for the files to be submitted, and locations for feedback on the process. Access to the Google site was given to anyone in the greater JWST community interested in participating in this effort. The SODRM 2012 effort was advertised to the JWST SWG early in the process and various members of the JWST community participated by contributing to programs and, in a few cases, becoming the lead of a program.

Finally, the goal of the SODRM is to provide programs that add up to at least 1 year of operations. The target size of the SODRM was set to 1.5 years to ensure this goal was met and that there was a sufficient pool of programs to provide scheduling flexibility to ensure a full schedule for an entire year.

The 56 scientists who worked directly on the SODRM 2012 provide the broad range of science expertise needed to cover the full range of expected JWST science. The names of those contributing to this SODRM update effort are listed in Section 8.

3.1.1 Science Categories

In addition to the SODRM 2005 programs, additional program ideas for the non-calibration categories were added to better cover the expected science use of JWST. Ideas for these programs were taken from WIT team observing scenarios (e.g., Soderblom et al. 2012), presentations given at the "Frontier Science Opportunities with the James Webb Space Telescope" meeting in June 2011, knowledge of the expected GTO observations, experiences from participation in the Hubble and Spitzer TAC processes, and general knowledge of each science area. The general science categories were allocated a nominal total of 84.6% of the total SODRM program, with the other 15.6% of time allocated to the calibration and observatory maintenance (Gordon, K., et al. 2011). The SODRM science time was nominally split between the science categories with 10% for Solar System, 35% for Galactic, 20% for Nearby Galaxies, and 35% for Distant Galaxies. This translates to 8.5%, 29.6%, 16.9%, and 29.6% of the SODRM 2012 time. Each notional program idea and existing SODRM 2005 programs were given a nominal time allocation to provide a start at ensuring program balance across the SODRM. It should be emphasized that these starting allocations were just guidelines. The science development of each program idea drove the final requested time for each program and instruments used. The science programs for SODRM 2012 are listed in Appendix A.

3.1.2 Calibration Categories

The science instrument calibration programs were provided by the WIT Cycle 1 Calibration WG[4] and the observatory calibration programs by the STScI Telescopes Group. The SODRM 2012 calibration programs were created by instrument and represent the regular calibration programs. These programs follow an extensive set of commissioning activities which will provide a baseline calibration of each instrument. The science programs for SODRM 2012 are listed in Appendix A and the text summaries for each program are given in Appendix B.

3.2 Science Program Heritage

The SODRM 2012 represents a realistic implementation of the science themes laid out in the SRD. To document this flowdown, the last column of Table A-1 gives the SRD science theme that motivates each SODRM program. The science of the SRD is captured by twenty-six programs, with assigned ID numbers and titles, given in Table A-3. These SRD programs are defined by their appropriate descriptive sections of the SRD. Furthermore, to aid in drawing the correspondence of these SRD scientific investigations to the SODRM programs, the SRD programs are characterized in terms of the primary observational requirements: science instrument, target brightness, instrumental spectral resolution (R), wavelength, and target number surface density. Most of the SODRM 2012 programs have direct connections to the SRD. There are a small number that do not directly tie to the SRD. For these programs (6 total), there are either strong cases for them in JWST white papers (4 programs) or they are included as they represent important areas of science that will strongly benefit from JWST observations (2 programs).

3.3 Future Plans

It is expected that the SODRM will be updated several times before the launch of JWST. Currently the operational system is incomplete (e.g. missing support of NIRISS Observing Templates and NIRSpec MSA configurations; incomplete coronagraphic imaging templates, the lack of Visit creation from specified Observations and constraint analysis in APT). In addition, the operations concepts for the SIs and observatory are still evolving. As the fidelity of the operational system improves, an updated SODRM will be required to ensure that it continues to be a useful tool for ongoing development. In the near term, two major SODRM 2012 updates are planned. First, when the NIRISS templates are available in APT, the NIRISS programs specified in the spreadsheet format will be input using APT. Second, the current version of APT did not support the creation of Visits from Observations nor detailed scheduling constraint analysis, in particular, the guide star availability. Future analysis using APT or the Visit Scheduling System will reveal observations that are very difficult if not impossible to schedule as proposed. For example, because the permitted orientations of the JWST field of view onto the sky are a function of ecliptic latitude, there will be some specified targets that simply cannot be observed at the particular specified orientation and/or time relative to another observation. In addition, when processed, some observations will not have usable guide stars. The unschedulable observations will be modified to make them schedulable.

There are areas where the fidelity of the operations plans are lacking (e.g., robust definition of the NIRISS Observing Templates, NIRSpec MSA configurations, coronagraphic target

[4] J. Muzerolle, H. Ferguson, K. Gordon and A. Koekemoer

acquisition, and orientation constraints). As the fidelity of the operations improves, an updated SODRM will be needed to ensure that it continues to be a useful tool for ongoing development.

4 Applications

The SODRM 2005 has supported a number of important development and policy issues to date. Having a set of expected science observations that address the core science of JWST has been important as a development tool to ensure that support systems are in place to implement the desired observing schemes and strategies. This includes front-end user support tools such as the exposure time calculators and Astronomers Proposal Tool as well as the downstream scheduling system and data management system development. This section discusses some possible applications of the new SODRM.

4.1 Scheduling and Efficiency Studies

The ~1.5 years of realistic observations contained in the SODRM 2012 combined with the operational scheduling software that includes automated visit scheduling, automated momentum management and automated wavefront-sensing target selection will allow JWST scheduling exercises that will provide significant insight into the challenges associated with planning and scheduling a diverse ensemble of observations and observatory- level activities. This is a major driver from the perspective of the EffWG—to identify the major sources of overhead, those overheads that can be reduced, and to ultimately improve the overall efficiency of the observatory.

4.1.1 Data volume studies

Generation of SODRM schedules will allow modeling of the SSR management to provide a demonstration of concept for different operational conditions (e.g., high data volume observations or, missed data downlink contacts).

4.1.2 Mechanism Utilization Studies

The fidelity of SODRM 2012 for studying mechanism usage is much better than SODRM 2005. However, it is important to note that strategies for JWST observing are still evolving. A major issue is whether to cycle though filters at each dither position or cycle though dithers for each filter setting. The strategy may end up being different for different instruments and will be informed by overhead and mechanism utilization studies using the SODRM 2012.

4.1.3 Impact of Timing and Orientation Constraints

One outcome of interest is understanding the impacts of timing and orientation constraints. Examples include such things as a) fixed timing events, such as exoplanet transits, which must be scheduled at absolute times, b) fixed orientation requests (for instance, as part of coronagraphy observations or for other needs), or c) solar system (moving target) observations, which by their very nature must be scheduled according to their ephemerides and guide star availability. The SODRM will allow a determination for the volume of tightly constrained visits and will allow numerous test schedules to be developed to assess the difficulty of creating efficient Observation Plans.

Another aspect of scheduling and efficiency involves the interaction with the user and the TAC process that will be used to select proposals for the observatory. A user needs to know how much total (exposure and overhead) time to ask for, and a TAC panel needs to know the total time of a given program, but before the observation in question have actually been scheduled. It is expected that a broad range of overheads can be estimated with sufficient accuracy so that this goal can be accomplished, but some of the overhead values are dependent upon how well the operational system can maximize the science efficiency. SODRM scheduling exercises will allow us to estimate these overhead values and their variance and inform science policy decisions.

4.1.4 Day-in-the-Life Ground Testing

A representative set of SODRM visits will be used for a variety of simulator and hardware/software ground tests. To support our "test-it-as-you-fly-it" operations concept, the SODRM visits can be used as input to operational ground test requirements.

4.1.5 Additional Momentum Management Studies

Orbit determination requirements and propellant usage requirements may restrict RWA momentum dumping to once every 22 days (Kinzel 2004). The SODRM visit pool will allow a determination of whether this scheduling constraint can be mitigated without seriously impacting the telescope efficiency by using proactive scheduling algorithms and restrictions on the characteristics of the observing pool.

4.1.6 Visit Maximum Duration Limit Study

Visit durations may be limited to a maximum of one day, in order to always allow modification of the executing timeline within 24 hours, as required by the Mission Requirements (MR–293). The SODRM visit pool will be comprised of visits with typical durations of less than one day, but its range of values will allow numerous test schedules to be developed to assess the difficulty of creating efficient Observation Plans using visits from different visit duration distributions. The study will indicate if a maximum duration limit of less than a day is preferable.

4.2 Calibration Programs

The cycle 1 calibration program will need to be analyzed in conjunction with the calibration needs of the science programs. This will help make sure that the cycle 1 program is sufficient to meet the calibration needs of the science in the SODRM. In addition, the use of science data for instrument calibration and support will also be studied.

4.3 Parallel Observing

Parallel calibrations are needed to meet the mission science efficiency requirement (Henry and Casertano 2002). The SODRM 2012 implements all suitable calibration programs as parallel observations. The SODRM will be analyzed to determine how well the parallel calibrations can be matched with the available science visits and to determine the number of parallel calibration requests that can be done per year. This information will be used to modify, if needed, the parallel calibration programs and to determine the fraction, if any, of the programs that cannot be obtained as parallels. If necessary, mitigation strategies can be explored to decrease the loss of observatory efficiency.

The idea of science parallels holds with it the possibility of significantly enhanced science return and observatory efficiency from the overall mission, as has actually been done on HST. Parallel science observations are not baselined for JWST, so the SODRM 2012 does not include them beyond a simple note in the program text descriptions indicating if parallel observations would be scientifically useful for that program. As such, the SODRM could be used to estimate the possible parallel science observation opportunities and if implemented, the impact of parallel science observations on efficiency, data volume, and hardware resources.

4.4 Astronomers Proposal Tool Feedback

The vast majority of the inputs for the updated SODRM were entered using version 19.4 of the Astronomers Proposal Tool (APT). The SODRM development exercised all of the currently available observing templates. In addition, the large number of users entering realistic observations identified a significant number of usability issues, shortcomings of the templates, and missing special requirements. In addition, the users produced many suggestions for improvement, such as, the need for improved tools to help users derive the information needed in the Observing Templates. We will be systematically analyzing this feedback and using it to prioritize APT development of this important tool. Likewise, the need for improved tools to help users derive the information needed in the Observing Templates has also been noted.

5 SODRM Program Data Products

There are two data products associated with each SODRM program: a text description of the program and a detailed specification of the exposures needed to carry out the program.

5.1 Text Description

The text description of each program gives a high-level overview of the science and observations in each program. A template file was provide for users to follow. For each program, this includes:

1. a title
2. the assigned ID number
3. the science goal for the program
4. the nominal time allocation (where appropriate)
5. an estimate of the total time required
6. the targets
7. the Observing Templates needed
8. a brief description of the observations
9. any timing or orientation constraints
10. a comment on the usefulness of parallel observations for this program
11. any additional relevant comments
12. author(s) and date

Appendix B provides these summary files for all the SODRM 2012 programs.

5.2 Detailed Exposure Specifications

The detailed exposure descriptions were given in APT files for all NIRCam, NIRSpec, and MIRI observations. For NIRISS observations, this information was given in a custom spreadsheet format designed to capture the same type of information. The difference between NIRISS and the rest of the instruments was simply driven by the fact that the NIRISS Observing Templates have yet to be implemented in APT. For the other instruments, their Observing Templates were not always fully implemented in APT and specifically formatted text in the comments field of these APT files was used to provide the needed functionality.

6 Statistical Summary

The balance of the SODRM by science area, instrument, and observing template is shown in this section. The total times for each program were calculated uniformly for all programs using custom python scripts that parse the APT/spreadsheet files and apply the direct overheads as given in Gordon et al. (2011). The total times are preliminary and will change as the operations concept evolves. For example, these calculations assume all observations carry a full new target slew overhead (e.g., no cluster targets) and each IFU mosaic tile is placed into a single visit. In addition, changes to the Visit splitting rules or mechanism usage will change the overall observing efficiency.

The distribution of SODRM programs by category, instrument, or template are not allocations or reservations of observing time. The SODRM is simply the current estimate of how observing time may be allocated for the 1st year of JWST science operations.

The summary of the SODRM programs by science/calibration category is given in Table 6-1 and shown graphically in Figure 6-1. In each category, the table gives the number of programs, the total time in days, and the percentage of the total time. There are 112 SODRM programs comprised of 70 science programs and 42 calibration programs. The total time for the SODRM 2012 is 649 days = 1.78 years.

Table 6-1 Summary of SODRM Programs by Category

Category	# of Programs	Total Time [days]	Percentage of Total Time
Solar System	8	51.3	7.9%
Exoplanets	14	104.4	16.1%
Galactic	19	132.3	20.4%
Nearby Galaxies	13	111.3	17.2%
Distant Galaxy & Cosmology	16	204.5	31.5%
Instrument Calibration	40	31.9	4.9%
Observation Calibration	2	13.0	2.0%
Total	112	648.7	100.0%

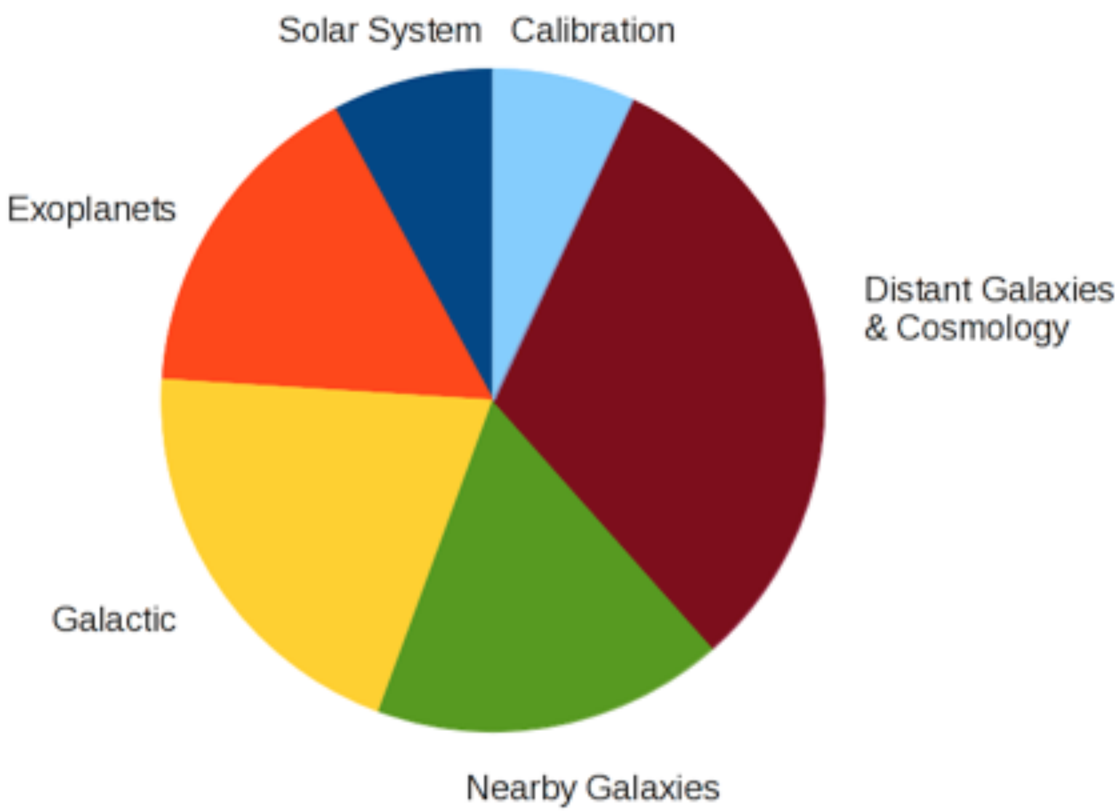

Figure 6-1 The distribution of the SODRM programs is shown graphically by science/calibration categories.

This illustrates that all of the expected science and calibration areas are well represented in the SODRM 2012.

The summary of SODRM programs by instrument is given in Table 6-2. For reference, in SODRM 2005 the time split by instrument was 40% NIRCam, 28% NIRSpec, 28% MIRI, and 4% FGS-TFI (Petro et al. 2005).

Table 6-2 Summary of SODRM Programs by Instrument

Category	Total Time [days]	Percentage of Total Time
NIRCam	225.3	34.7%
NIRSpec	194.4	30.0%
NIRISS	51.9	8.0%
MIRI	177.1	27.3%
Total	648.7	100.0%

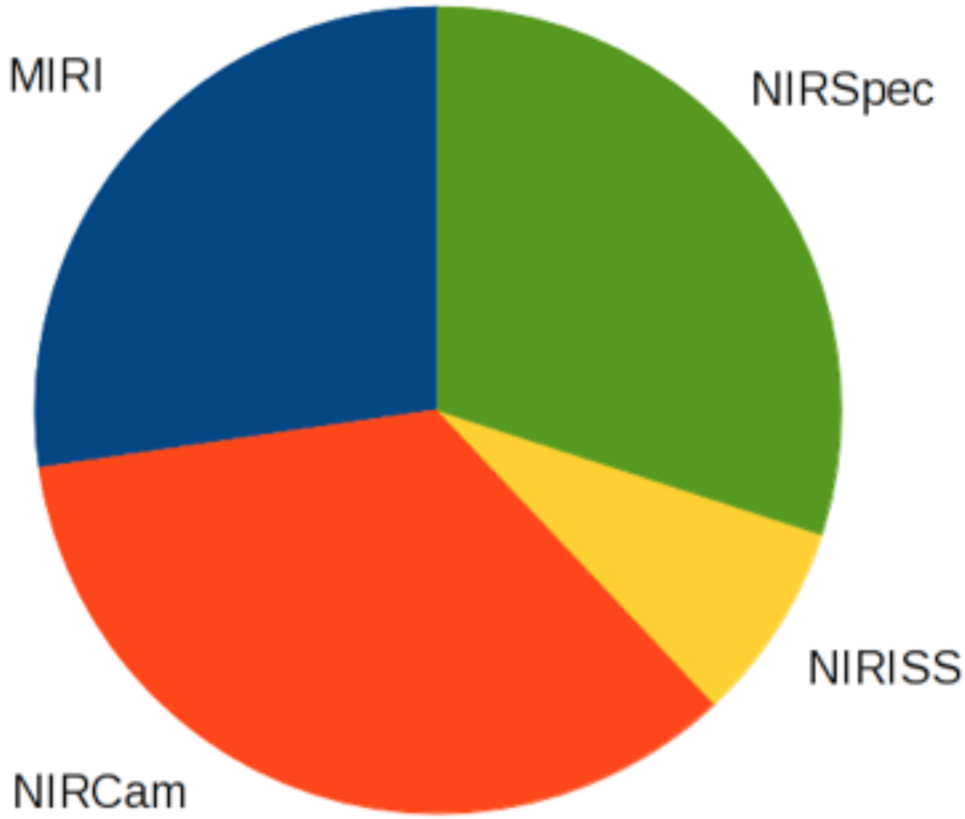

Figure 6-2 The distribution of the SODRM programs is shown graphically by instrument. This illustrates that all of the JWST instruments are well represented in SODRM 2012.

The summary of SODRM programs by Observing Template is given in Table 6-3. The time spent on Engineering templates is not included. The split between observation type is shown in the last three rows of this table.

Table 6-3 Summary of SODRM Programs by Observing Template

Category	Total Time [days]	Percentage of Total Time
NIRCam Imaging	200.1	30.8%
NIRCam Coronagraphy	25.2	3.9%
NIRSpec Multi-Object Spectroscopy	102.2	15.8%
NIRSpec Integral Field Slit Spectroscopy	43.5	6.7%
NIRSpec Fixed Slit Spectroscopy	48.7	7.5%
NIRIS Slitless Wide Field Spectroscopy	10.2	1.6%
NIRISS Slitless Single Object Spectroscopy	17.3	2.7%
NIRISS Aperture Mask Interferometry	22.7	3.5%

Category	Total Time [days]	Percentage of Total Time
NIRISS Imaging	1.7	0.3%
MIRI Imaging	94.6	14.6%
MIRI Coronagraphy	28.7	4.4%
MIRI Low Resolution Spectroscopy	18.8	2.9%
MIRI Medium Resolution Spectroscopy	35.0	5.4%
Total	648.7	100.0%
Subtotal by Observation Type		
Total Imaging	296.4	45.7%
Total Coronagraphy	76.6	11.8%
Total Spectroscopy	275.7	42.5%
Total	648.7	100.0%

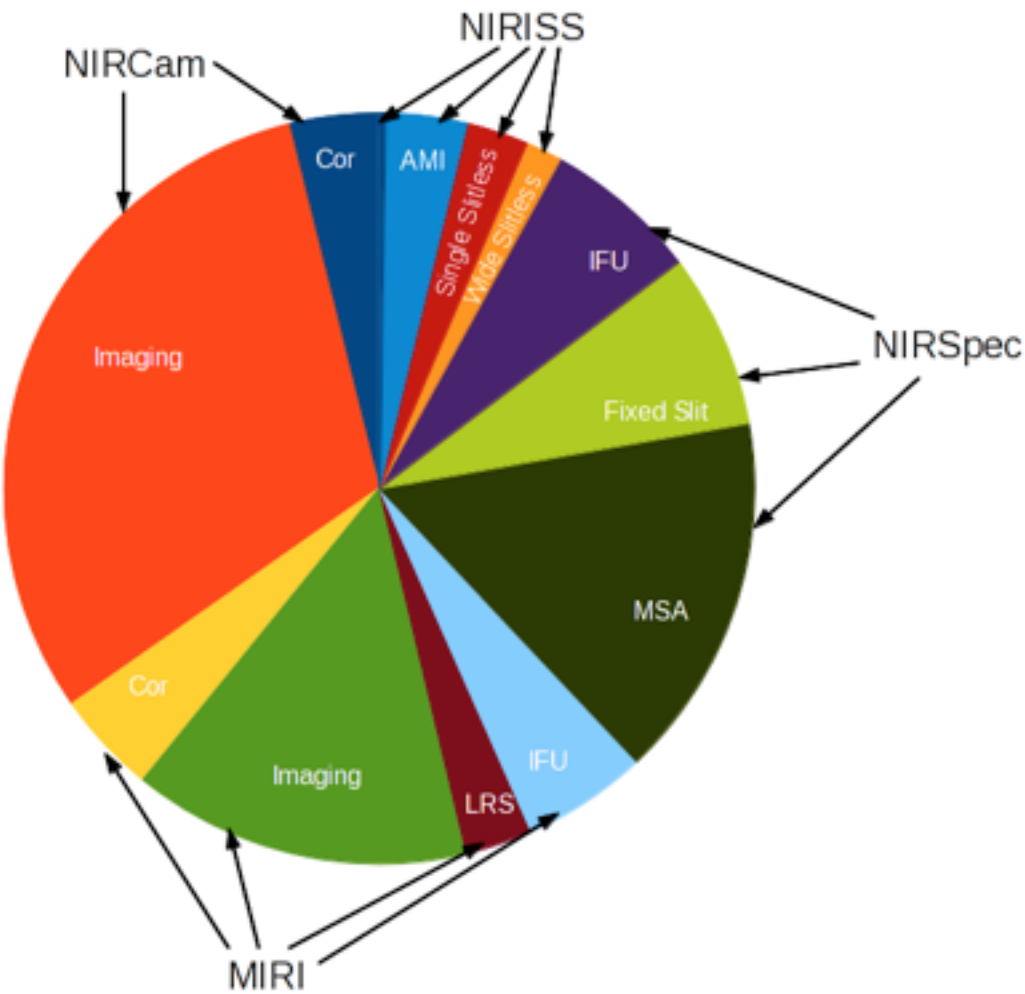

Figure 6-3 The distribution of the SODRM programs is shown graphically by observing template. This illustrates that all of the currently planned observing templates are well represented in SODRM 2012.

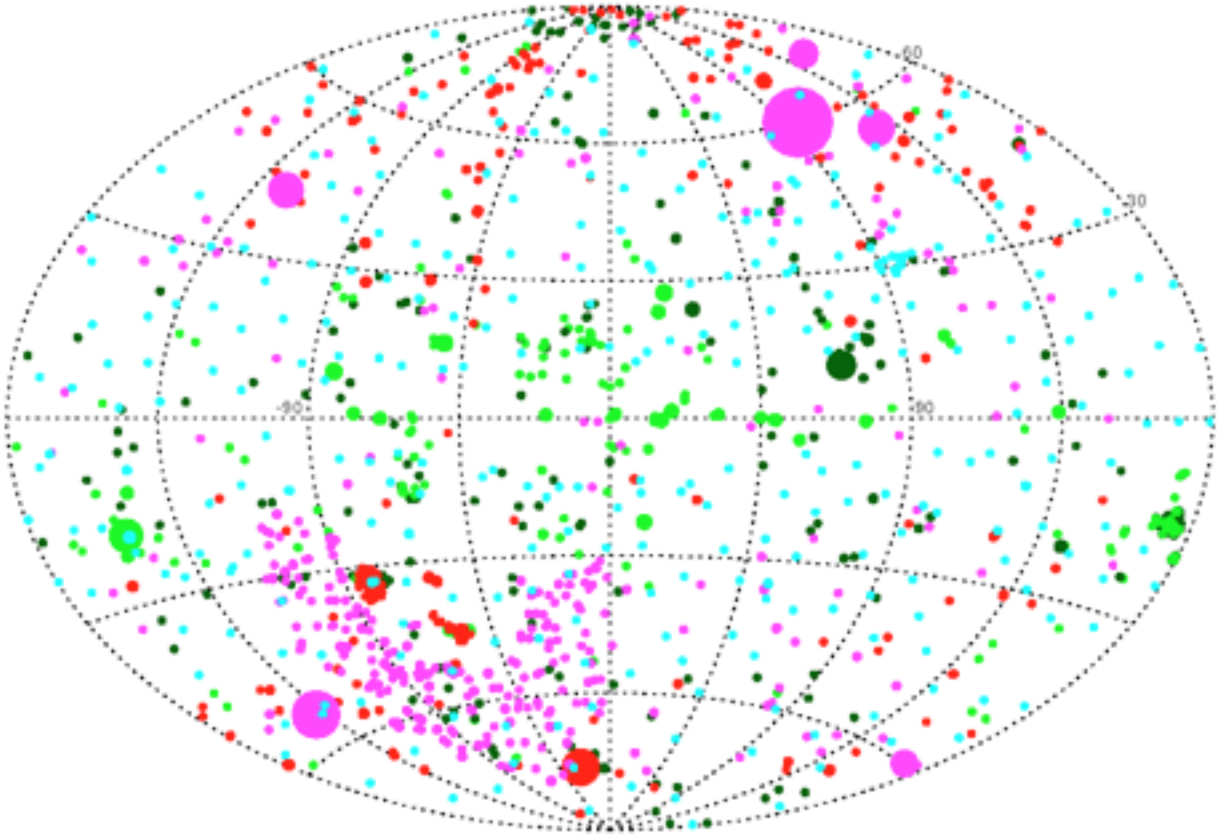

Figure 6-4 The distribution of non-moving sources from all the SODRM porgams is shown in galatic coordinates.

The size of the symbol is proportional to the total exposure time per observing template on that target. The symbols are coded by science/calibration area with dark green for Exoplanets, light green for Galactic, red for Nearby Galaxies, purple for Distant Galaxies & Cosmology, and light blue for Instrument/Observatory Calibration. Solar System targets are moving targets and not shown. The large purple circles show the locations of the JWST deep field programs.

The distribution of sources around the sky is plotted in Figure 6-4 where the size of the symbol is linearly proportional to the total exposure time per Observing Template (integrated over filters, gratings, etc.).

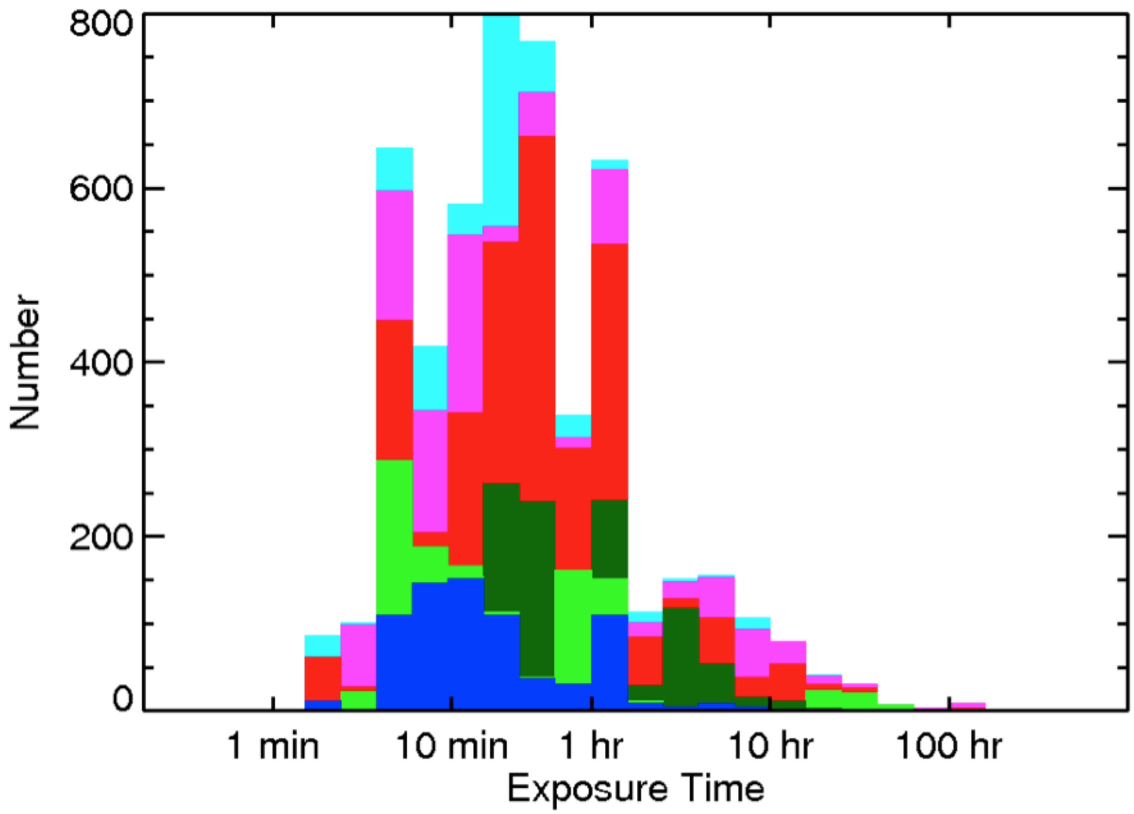

Figure 6-5 The distribution of total exposure time per target per instrumental template as shown as a cumulative histogram.

The symbols are coded by science/calibration area with blue for Solar System, dark green for Exoplanets, light green for Galactic, red for Nearby Galaxies, purple for Distant Galaxies & Cosmology, and light blue for Instrument/Observatory Calibration.

The distribution of total exposure time per target per observing template is shown in Figure 6-5.
The median time spent per target per observing template is 0.38 hours.
The mean time spent per target per observing template is 1.84 hours.

7 Summary

The SODRM 2012 provides a set of realistic JWST science programs that cover at least 1 year of observations. The SODRM 2012 programs represent the current best estimate of the type, mix, and distribution of observations that JWST will carry out during the 1st year of operations. The SODRM 2012 is the product of over 50 scientists across the JWST community and, as a result, reflects the current view of planned JWST observations. The goal of the SODRM 2012 is to provide a basis for quantitative investigations of JWST operations, specifically to explore ways to improve the efficiency and reliability of JWST operations. The SODRM 2012 programs do not represent allocations or reservations of observing time, the real JWST cycle 1 programs will be comprised of Guaranteed Time observations and programs competitively chosen by the JWST Telescope Allocation Committee (TAC).

8 Acknowledgements

This SODRM would not have been possible without the effort of a large group of people. We thank all those that contributed.

Special thanks to the science program leads (J. Anderson, T. Beck, W. Blair, T. Brown, C. Chen, J. Debbes, H. Ferguson, S. Friedman, K. Gordon, P. Goudfrooij, D. Hines, J. Kalirai, T. Keyes, A. Koekemoer, D. Lafrenière, D. Lennon, C. Lisse, J. Lotz, R. Maiolino, M. Meixner, J. Muzerolle, K. Pontoppidan, M. Regan, A. Rest, J. Rigby, M. Robberto, K. Sahu, J. Stansberry, R. Soummer, J. Tumlinson, & J. Valenti) and calibration program leads (H. Ferguson, K. Gordon, A. Koekemoer, J. Muzerolle, & M. Perrin).

Thanks to all the others that have contributed to the creating the SODRM programs but were not leads (R. Abraham, S. Arribas, T. Boker, M. Boyer, A. Bunker, N. Chanover, S. Charlot, C. Engelbracht, C. Evans, P. Ferruit, M. Franx, T. Greene, H. Hammel, B. Hansen, P. Jakobsen, W. Kinzel, D. Karakla, K. Noll, H. Richer, H.-W. Rix, J. Seale, D. Soderblom, K. Uckert, C. Willott, M. Wolff).

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Appendix A. SODRM Programs

All the SODRM programs are listed in Table A-1 (Science) and Table A-2 (Instrument and Observatory Calibration). The columns list the current SODRM program number, the estimated total time (exposure and direct overheads), the title, the instruments used, the program lead, the previous SODRM number (if applicable), and the SRD science "program." The SRD science "programs" are listed in Table A-3 and described in Appendix B. These total times do not agree with the times initially apportioned to each category because these allocations were not enforced, in favor of allowing for individual programs to expand and contract as required by the science.

The times listed are the combination of the total time spent exposing as well as the direct overheads (Gordon et al. 2011).

To see the traceability from each SODRM science program back to the science requirements document, one should use the far-right column of Table A-1, which lists the corresponding science program from the SRD, as summarized and organized in Table A-3.

Table A - 1 SODRM Science Programs

Number	Time (hr)	Title	NIRCam	NIRSpec	NIRISS	MIRI	Lead	Prev. #	SRD
Solar System									
92010	38.2	Martian Atmosphere		X		X	Hines		6b[5]
92020	179.6	Periodic Comets				X	Hines Stansberry	107	6d
92030	54.4	Bright Comets, Targets of Opportunity (ToO)	X	X		X	Hines Lesse	108	6d
92040	138.1	Icy Dwarf Planets		X		X	Hines Stansberry	106	6e
92050	96.8	Solar System Ice Giants: Uranus & Neptune	X	X		X	Hines		[6]
92060	245.1	Giant Planet Satellites		X		X	Hines	109	[7]
92070	329.2	Kuiper Belt Objects	X	X		X	Hines	301	6e
92080	150.4	Main-Belt Asteroids		X		X	Hines Stansberry		[8]

[5] This science topic is extensively discussed in the Lunine et al. (2010) white paper on planetary observations with JWST

[6] This topic does not appear in the SRD. It does appear in the Lunine et al. (2010) white paper.

[7] One of the 15 moons in this program (Titan) is discussed in the SRD and the in the Lunine et al. (2010) white paper. The other moon are not.

[8] This topic does not appear in the SRD. It does appear in the Lunine et al. (2010) white paper.

Number	Time (hr)	Title	NIRCam	NIRSpec	NIRISS	MIRI	Lead	Prev. #	SRD
Exoplanets									
93030	519.0	Direct Observations of Planetary systems: MIRI				X	Soummer	501, 502	6a,b
93031	144.5	Direct Observations of Planetary systems: NIRCam	X				Soummer		6a,b
93032	99.8	Direct Observations of Planetary systems: NIRISS			X		Soummer		6a,b
93035	69.0	Direct Imaging of Planetary Systems around White Dwarfs	X			X	Debbes		6a,b
93040	21.7	High S/N NIRCam Observations of an Earth Analogue Around a Nearby Sun-like Star	X				Sahu		6a,b
93041	492.1	Transit, Eclipse, and Orbital Phase Spectroscopy of Exoplanets with NIRSpec		X			Valenti		6a,b
93042	129.3	Determining the Frequency of Hot Earths	X				Sahu		6a,b
93044	170.6	Imaging and Spectroscopy of Transiting Exoplanets-MIRI				X	Sahu		6a,b
93050	278.2	Search for giant planets in the Taurus star-forming regions			X		Lafrenière, Ferguson		6a,b
93051	49.5	Long wavelength follow-up of planets found by ground-based extreme adaptive optics planet finders			X		Lafrenière, Ferguson		6a,b
93052	116.5	Search for giant planets around young low-mass stars			X		Lafrenière, Ferguson		6a,b
93053	118.7	Transit spectroscopy of a habitable Earth-like planet around an M dwarf			X		Lafrenière, Ferguson		6a,b
93054	149.6	Transit spectroscopy of exoplanets with NIRISS			X		Lafrenière, Ferguson		6a,b
93055	140.5	Phase curves of hot Jupiters with NIRISS			X		Lafrenière, Ferguson		6a,b
Galactic									
93020	115.3	Scattered Light Mapping of Debris Disks	X				Chen	503	6c
93021	60.8	Thermal Emission Mapping of Debris Disks				X	Chen		6c
93022	44.1	Thermal Emission Spectroscopy of Debris Disks				X	Chen		6c

Number	Time (hr)	Title	NIRCam	NIRSpec	NIRISS	MIRI	Lead	Prev. #	SRD
93060	350.4	Imaging of Galactic Massive Star Forming Regions and Young Clusters	X			X	Muzerolle		5c
93061	277.9	MOS Spectroscopy of Galactic Massive Star Forming Regions and Young Clusters		X			Muzerolle		5c
93070	280.4	Imaging and Coronagraphy of Protoplanetary Disks	X			X	Muzerolle	11	6a,b, c
93080	278.0	JWST Survey of the Orion Nebula	X			X	Robberto	504	6c
93090	433.7	The Initial Mass Function at sub-stellar masses	X				Robberto	603	5e
93100	64.3	Revealing Outflows, Disks and Accretion Processes in High Mass Protostellar Objects (HMPOs)		X		X	Beck	303	5c,f
93110	144.4	IFU Survey of Resolved Young Stellar Objects		X		X	Muzerolle		5c,f
93115	135.9	High resolution imaging-spectroscopy of gas in protoplanetary disks		X		X	Pontoppidan		5f
93120	124.0	Ice Mapping in Molecular Clouds		X		X	Friedman	601	5g
93130	95.2	IFU mapping of PDRs/HI filaments		X		X	Keyes		5d,5g
93140	43.9	Energy Feedback into Star Forming Clouds		X			Beck	602	5d,5g
93150	27.3	Galactic Center monitoring	X	X			Anderson		
93180	280.3	The JWST Globular Cluster Survey	X				Kalirai		5e
93190	48.0	HST legacy Astrometry	X				Anderson		5e
93200	280.3	White Dwarf Cooling Ages of Globular Clusters	X				Kalirai		5e
93210	61.4	Dense Field Spectroscopy of Omega Cen		X			Tumlinson		4b
Nearby Galaxies									
94010	494.2	Imaging of resolved stellar populations	X			X	Gordon		5g
94020	101.2	Bottom of the Main Sequence in Nearby Local Group Galaxies	X				Brown	410	5e
94030	513.8	Star Formation in the Large Magellanic Cloud / Small Magellanic Cloud	X	X		X	Meixner	501, 502	5c,f
94050	153.7	The Structure of Cold Gas in Star Forming Regions	X				Blair		5d
94060	488.9	NIR Imaging and Spectroscopy of Compact Sources in Nearby Galaxies	X	X			Goudfrooij		4b

Number	Time (hr)	Title	NIRCam	NIRSpec	NIRISS	MIRI	Lead	Prev. #	SRD
94070	89.3	Monitoring of recent SNe for dust formation				X	Blair		5g
94090	176.1	The ISM in the Center of Nearby Galaxies		X			Regan	605	4b,4d
94100	70.3	IFU/Imaging of HII/SF regions	X	X		X	Gordon		5g
94110	70.6	Coronagraphy of nearby AGN	X			X	Hines		4e
94120	52.5	Cepheids in galaxies that have hosted Type 1a SNe	X				Rigby		[9]
94130	134.4	Near- and Mid-IR Imaging of Galaxies at a Resolution of 10-30 pc	X			X	Goudfrooij		4a,c
94140	140.1	Galactic halo streams and stellar populations	X				Brown		4b
94150	186.1	Quantitative spectroscopy of extragalactic red supergiants		X		X	Lennon		5g
Distant Galaxies & Cosmology									
95010	420.4	JWST Ultra-wide NIRCam and MIRI Mosaic of the Extended Groth Strip	X			X	Lotz		3a,b,h
95020	487.3	JWST NIRCam and MIRI Mosaic of the Chandra Deep Field South	X				Lotz	404	3a,b,h
95030	442.4	JWST Ultra Deep Field Imaging Survey	X			X	Koekemoer	401	3a,b,h
95040	824.6	JWST Wide-Area Spectroscopic Followup		X			Ferguson	606	3b,c,e,f
95050	242.4	Grism spectra of deep fields	X		X		Ferguson		3b,d
95060	447.2	JWST Ultra-Deep Spectroscopy		X			Ferguson	402	3b,c,e,f,g
95070	143.8	MIRI LRS spectra of distant galaxies				X	Ferguson		3b,f,g
95080	332.7	Confirmation, photo-z's and Physical Properties of SZ-selected Galaxy Clusters	X				Rest		
95090	129.5	MIRI MRS spectra of distant galaxies				X	Ferguson	304	4b, 4c
95100	67.2	MIRI Observations of High-Redshift Active Galactic Nuclei				X	Koekemoer	305	4e

9 This science topic is not discussed in the SRD, but is discussed at length in the white paper, "JWST Studies of Dark Energy", Gardner et al. (2010).

Number	Time (hr)	Title	NIRCam	NIRSpec	NIRISS	MIRI	Lead	Prev. #	SRD
95110	103.4	Lyman Alpha Forest Search for Reionization		X			Tumlinson	405	3c,d
95120	661.5	Weak and Strong Lensing of SZ-selected Galaxy Clusters	X				Rest		
95140	43.0	High Redshift SNe/GRB Followup - A NIRSpec TOO		X			Tumlinson		3a
95150	65.1	NIRCam imaging of z~6 QSO Host Galaxies	X				Lotz		4e
95170	244.3	The Physics of Galaxy Assembly: Spatially resolved spectroscopy of high-z galaxies		X			Maiolino		3g,4c
95180	254.5	Constraining cosmological parameters with a restframe NIR SN Ia Hubble Diagram		X		X	Rest		3a

Table A - 2 SODRM Calibration Programs

Number	Time (hr)	Title	Instruments	Lead	Previous SODRM #
NIRCam Calibration					
96000	372.0	Dark Current & Readnoise	NIRCam	Koekemoer	422
96010	50.5	Flat Field Monitor	NIRCam	Koekemoer	421
96020	86.7	Photometric Zeropoint Monitoring	NIRCam	Koekemoer	423
96030	3.5	Total-Count and Count-Rate Linearity Characterization	NIRCam	Koekemoer	
96040	41.7	Persistence Characterization	NIRCam	Koekemoer	
96050	6.8	PSF Characterization	NIRCam	Koekemoer	425
96060	3.2	Astrometry and Distortion Monitor	NIRCam	Koekemoer	424
96070	24.2	LW Grism Characterization	NIRCam	Koekemoer	
96080	7.1	Coronagraphic Mode	NIRCam	Koekemoer	
NIRSpec Calibration					
96200	90.5	Dark Monitor	NIRSpec	Muzerolle	650
96201	125.4	Wavelength Calibration Monitor	NIRSpec	Muzerolle	660
96202	4.2	Flat Lamp Monitor	NIRSpec	Muzerolle	

Number	Time (hr)	Title	Instruments	Lead	Previous SODRM #
96203	21.1	MSA L-Flat Verification	NIRSpec	Muzerolle	
96204	12.6	IFU Spectral Flat Monitor	NIRSpec	Muzerolle	
96205	12.3	Absolute Flux Calibration Monitor	NIRSpec	Muzerolle	661
96206	24.9	Absolute Flux Calibration Extension	NIRSpec	Muzerolle	
96207	20.7	Relative Throughput	NIRSpec	Muzerolle	
96208	12.1	MSA Shutter Throughput Verification	NIRSpec	Muzerolle	661
96209	6.7	MSA Shutter Contrast Monitor	NIRSpec	Muzerolle	
96210	20.3	Astrometric Calibration Monitor	NIRSpec	Muzerolle	652, 653
NIRISS Calibration					
96400	83.7	Darks	NIRISS	Ferguson	444
96410	27.5	Linearity	NIRISS	Ferguson	
96420	11.3	Linearity & Persistence Monitoring	NIRISS	Ferguson	
96430	8.4	WFSS Wavecal	NIRISS	Ferguson	
96440	2.0	SOSS Wavecal	NIRISS	Ferguson	
96450	23.5	WFSS Spectrophotometric Calibration	NIRISS	Ferguson	
96460	5.2	SOSS Spectrophotometric Calibration	NIRISS	Ferguson	
96470	2.0	Astrometry & Distortion Monitor	NIRISS	Ferguson	
96480	8.6	LFLAT and WFSS Spectral Traces	NIRISS	Ferguson	
MIRI Calibration					
96610	572.4	Dark Monitoring	MIRI	Gordon	323
96620	185.8	Internal Flat Monitor	MIRI	Gordon	321, 322
96630	33.2	External Flat Monitor (Imaging/Coronagraphy)	MIRI	Gordon	321, 329
96640	2.6	External Flat Monitor (LRS)	MIRI	Gordon	321
96650	9.7	External Flat Monitor (MRS)	MIRI	Gordon	322
96660	34.8	Absolute Flux Calibration (Imaging)	MIRI	Gordon	325
96670	34.8	Absolute Flux Calibration (Coronagraphy)	MIRI	Gordon	328
96680	31.3	Absolute Flux Calibration (LRS)	MIRI	Gordon	327, 331
96690	21.0	Absolute Flux Calibration (MRS)	MIRI	Gordon	324, 326

Number	Time (hr)	Title	Instruments	Lead	Previous SODRM #
Observatory Calibration					
97010	267.5	Routine Wavefront Sensing	NIRCam	Perrin	750
97011	45.1	Multifield Wavefront Sensing	NIRCam	Perrin	750

The SRD science themes are analyzed and represented in Table A-3 by twenty–six "programs," with assigned ID numbers and titles. For more details, see section 3.2.

Table A - 3 JWST SRD Science Programs

ID	SRD Sections	Title	Instrument	Limiting magnitude	Target density
3a	3.3.1.1, 3.3.1.3	Identify high-*z* galaxies and SNe	NIRCam	AB = 31	1 arcmin^{-2}
3b	3.3.1.2	Study first-light sources	NIRSpec	AB = 28, R = 100	1 arcmin^{-2}
			MIRI	AB = 28	1 arcmin^{-2}
3c	3.3.2.1	Ly-a forst diagnostics	NIRSpec	2 x 10^{-19} ergs cm^{-2} s^{-1}	pointed
3d	3.3.2.2	Transition of Ly-a sources	NIRISS	2 x 10^{-19} ergs cm^{-2} s^{-1}	1 arcmin^{-2}
3e	3.3.2.3	Ly-a/Balmer ratio	NIRSpec	2 x 10^{-19} ergs cm^{-2} s^{-1}, R = 1,000	1 arcmin^{-2}
3f	3.3.2.4	Measure ionizing continuum	NIRSpec	2 x 10^{-19} ergs cm^{-2} s^{-1}, R = 1,000	1 arcmin^{-2}
3g	3.3.2.5	Ionization source nature	NIRSpec		
			MIRI		
3h	3.3.2.6	LF of dwarf galaxies	NIRCam		
4a	4.3.1	Faint galaxy morphology	NIRCam	AB = 30.3	high
4b	4.3.2	Galaxy metallicities & IGM pollution	NIRSpec	5 x 10^{-19} ergs cm^{-2} s^{-1}	high
4c	4.3.3	Galaxy scaling relations	MIRI	AB = 23 (9 μm)	low
4d	4.3.4-5	Obscured galaxies	MIRI	1.4 x 10^{-19} W m^{-2}	very low
4e	4.3.6	AGN & black holes	NIRCam, MIRI, NIRSpec	AB = 23 (9 μm)	1/field
5a	5.1	Clouds, cores, collapse	NIRCam	9 nJy @ μm	1/field
			MIRI-im	1 mJy/arcsec^2 @ 7 μm	
5b	5.2	Early evolution of protostars	MIRI-im	0.1 μJy @ 6 μm; 1 μJy @ 15 μm	1/field
			MIRI-spec	7 x 10^{-22} W m^{-2} @ 15 μm	
5c	5.3	Formation of massive stars	NIRCam	2 μJy @ 3.8 μm; 10 μJy @ 4.8μm	1/field
5d	5.3	Impact of massive stars	NIRCam	55 nJy @ 3.5 μm; 2.3 μJy/arcsec^2 @ 4.8μm	10/arcmin
			NIRSpec	34 μJy @ 20 μm	
			MIRI-im		

ID	SRD Sections	Title	Instrument	Limiting magnitude	Target density
5e	5.4	Bottom of IMF	NIRCam	2.9 μJy @ 2.2 μm	100/arcmin
			NIRSpec	290 μJy @ 2.2 μm	
5f	5.5	Birth of protoplanetary systems	MIRI	10^{-20} W/m^2/arcsec^2 @ 1.87 μm	10/arcmin
			NIRCam		
5g	5.6	Lifecycles of Gas and Dust	MIRI-spec	2.6 x 10^{-20} W/m^2/arcsec^2 @ 17 μm	1/field
6a	6.1.3.1, 6.1.2.1	Extra-solar planets	NIRCam	AB = 30	few
6b[10]	6.1, 6.2	In-depth study of planets	NIRISS	AB = 27, R = 100	few
			NIRSpec	AB = 23, R = 3,000	
			MIRI	AB = 23	
6c	6.1.3.2	Circumstellar disks	MIRI	AB = 24	few
6d	6.2.2.1	Comets	NIRSpec	AB = 23, R = 3,000	10/yr
			MIRI	AB = 23	
6e	6.2.2.2	Kuiper Belt Objects	NIRCam	AB = 30	1/arcmin^2
			NIRSpec	AB = 23, R = 3,000	
			MIRI	AB = 23	
6f	6.3.1.2	Satellites	NIRSpec	AB = 23, R = 3,000	few
			MIRI	AB = 23	

[10] Giant planets are discussed in the SRD; more details and smaller planets are discussed in JWST white papers (Seager et al. 2004; Clampin et al. 2007; Sonneborn et al. 2009; Clampin et al. 2009)

Appendix B. Program Text Description

As part of the SODRM 2012 inputs, we requested that each program leader produce a short text file describing both the scientific goals of the program and summarizing the observational characteristics and strategies to be used. This file was intended to supplement the APT or spreadsheet submissions that specified the technical aspects of each program. This Appendix concatenates the text file inputs for SODRM 2012, organized by the same major categories used for the SODRM itself.

The total times listed in the program text descriptions are those estimated by the leads for each program. They are not the same as those listed in Table A-1 and Table A-2 that were calculated uniformly using custom python code (see section 6).

Solar System Programs

TITLE: Martian Atmosphere

ID: 92010

GOAL:

While Mars continues to be the subject of reconnaissance missions (both orbital and landing), there remains a deficiency in the knowledge of the detailed diurnal cycles of various gasses and aerosols in the atmosphere. Current and planned probes are not capable of sampling multiple local times "i.e., local diurnal variation" on sub-seasonal time-scales for most of the Martian surface area; they are not Mars-synchronous, and are high inclination orbits. Furthermore, there are no planned Thermal-IR instruments for Mars. Perhaps we'll get methane (3µm)…

While HST affords a look at the entire disk, the current instrumentation is insufficient to probe the thermal infrared. In addition, the orbital constraints on HST forbid prolonged, continuous. Monitoring of the atmospheric changes over Martian day.

JWST solves these problems with it's suite of instrument, and its L2 orbit, which enables the observatory to monitor the Martian atmosphere on timescales from a few minutes, to weeks with any cadence that is required by the observer. Here we use the NIRSpec and MIRI IFUs to obtain synoptic monitoring of gases, aerosols and dust in the Martian atmosphere over the entire disk.

We monitor the over 2 consecutive Martian days (24.6 earth hours), 4 times during the Martian year. The four yearly epochs will coincide with important seasonal transitions where the atmosphere is undergoing significant heat load changes. It is necessary to monitor Mars for two full days in order to get full coverage of the Martian surface with both instruments, and a minimum interruption due to instrument change overheads.

IMPORTANT – Mars varies in angular diameter from ~3.5 – 25.1". Herein, I assume we will observe at closest approach, so develop the mosaic for 10".

NOMINAL ALLOCATION (hours):

None specified

ACTUAL TIME (hours):

228.7 hours (but see below)

TARGET(S):

Mars

OBSERVING TEMPLATE:

MIRI IFU Spectrocopy

NIRSpec IFU Spectroscopy

OBSERVATION DETAILS:

NIRSpec will be used to measure the strengths of ice features, which constrain particle size (aerosol components). CO and H_2O will be measured.

MIRI IFU observations can constrain:

1) The dust particles size distribution via the ratio of 9.7µm/21µm silicate feature strength.
2) Can also constrain the CO_2, since the 15µm feature is optically thick… Measure cloud

depths?

For both instruments, it will be necessary to form a mosaic to cover the entire face of Mars. The Mosaics are designed with ½ array overlap.

We select a 5x5 mosaic (with half-array offsets) to achieve full disk coverage for the shortest wavelengths of MIRI and for the NIRSpec IFU. In addition, we apply a 4-point (2x2) raster at each mosaic tile.

MIRI IFU – 105.5 hrs

For each epoch, 6 of the following observations will be executed for one Martian day.

Therefore the total time per epoch is 26.4 hours. Four epochs implies 105.5 hours for MIRI IFU

NIRSpec IFU – 123.2 hrs

For each epoch, 3 of the following observations will be executed for one Martian day.

Therefore the total time per epoch is 30.8 hours. Four epochs implies 123.2 hours for NIRSpec IFU.

The total program thus requires 228.7 hours. It's possible that the actual program could drop up to two of the epochs, thus cutting the program to 114.3 hrs.

CONSTRAINTS:

Epochal observations need to be uninterrupted. Ideally, the NIRSpec and MIRI observations should be interleaved. Regardless, the NIRSpec and MIRI should be executed back-to-back.

One possible problem with observing the planet for two full Martian days is the need to switch guide stars in order to track the planet.

PARALLEL Observations possible (yes/no/pure parallel)?

COMMENTS:

The NIRSpec ETC doesn't provide a way to compute the SNR for extended emission. That's an obvious, and no doubt planned-for, upgrade. As a result, the SNR for these objects was estimated by computing the surface brightness expected from the coma (assuming an optical depth of 10^{-4}), converting that into an equivalent point-source flux, and adding the coma and nucleus contributions. The accuracy of this estimate is probably OK, but it would be far preferable to have the capability within the ETC.

The NIRSpec ETC doesn't directly report the SNR that will be achieved on spectroscopic lines. Here we estimated that by computing the SNR just outside a line (longer and shorter wavelengths), and comparing that to the SNR in the core of the line. Again, far preferable if the ETC directly reported the SNR for any/all lines the user specifies in the input.

AUTHOR/DATE: Dean C. Hines (hines@stsci.edu) 9 January 2012a

Michael Wolff (Space Science Institute)

TITLE: Periodic Comets

ID: 92020

GOAL:

1) Composition and Activity of Comets

The composition and dynamics of dust and gas in the comae of 6 active comets will be studied using NIRSpec and MIRI. The NIRSpec data will be acquired through the 0.2 x 3.3" slit. Because those spectra will be dominated by reflected sunlight, spectra of an appropriate Solar-type spectroscopic standard star will also be needed. These Solar calibration spectra will have an SNR significantly higher than those we expect to acquire on the comets, so that the comparison spectrum will not degrade the SNR of the cometary spectra. The MIRI data will be strongly dominated by thermal emission, so no Solar comparison spectrum will be needed for the LRS data. MIRI will also be used to make 10 μm maps of the coma and dust-trail structure. Each comet will be observed twice to sample activity at different phases in its orbit.

NIRSpec medium resolution spectra (G235M, G395M) will be used to characterize broad emission lines from H2O, CO2 and organic molecules in the gas phase. These spectra will also be highly sensitive to the presence of water ice and silicates in the dust grains of the coma. Spectra will be taken of the region surrounding the comet nucleus to characterize the gas and dust composition before interactions with UV and chemical evolution have taken place, and also at a position offset from the nucleus to characterize the photo/chemical processes in the coma. The 0.2 x 3.3" slit will be used. These data will be dominated by reflected sunlight,

NIRSpec high resolution spectra (G235H) will be used to measure abundances of higher-order organic molecules, and to measure the D-H ratio of the water in the coma. As with the medium resolution data, spectra will be acquired both on the nucleus and at an offset position. The 0.2 x 3.3" slit will be used.

MIRI LRS data from 5–14 μm will be used to characterize the composition of the dusty component of the coma, and will be sensitive to the emission features of silicates, PAHs and other large organic molecules. The LRS data also provides sensitive constraints on the temperature of the dust, and its grain-size distribution. The LRS data will only be taken on the near-nucleus region of the coma.

MIRI 10 μm maps, covering roughly 8' x 20', will be made of the coma and near-nucleus dust trail. The maps will reveal jet structures in the coma, providing constraints on the rotation state of the nucleus, and the dust production rate and velocity of ejection.

2) Physical properties and possible activity of distant comet nuclei

MIRI LRS spectra and 15 μm imaging of 18 periodic comet nuclei will be acquired while those objects are near their perihelia. Activity should be absent (all will be at distances > 6AU when observed). The data will be interpreted using thermal models, which will be fit to the LRS thermal spectra and the anchoring the 15 μm photometric point. The data will also provide very sensitive constraints on whether activity is truly absent. The 15 μm PSF will be examined for any evidence of extended emission, and the spectra will be sensitive to the presence of very small amounts of fine-grained dust, should there be any coma. Each comet will be observed twice to sample activity at different phases in its orbit.

NOMINAL ALLOCATION (hours):

None specified

ACTUAL TIME (hours): 96.0 hrs

TARGET(S):

Active-Comet Sample:

31P/Schwassmann-Wachmann_2
68P/Klemola
101P/Chernykh
200P/Larsen
231P/LINEAR-NEAT
232P/Hill

Distant-Nuclei Sample:

8P/Tuttle
27P/Crommelin
55P/Tempel-Tuttle
63P/Wild_1
93P/Lovas_1
97P/Metcalf-Brewin
99P/Kowal_1
126P/IRAS
134P/Kowal-Vavrova
140P/Bowell-Skiff
142P/Ge-Wang
151P/Helin
179P/Jedicke
192P/Shoemaker-Levy_1
195P/Hill
241P/LINEAR
242P/Spahr
248P/Gibbs

Solar Analog

HD 129357 – G2V

OBSERVING TEMPLATE:

MIRI LRS Spectrocopy

MIRI Imaging

OBSERVATION DETAILS:

1) Composition and Activity of Comets

MIRI LRS – 10.2 hrs

Each epoch of LRS observations will have the following characteristic.

Two epochs will require 1.7 hrs. To observe all six comets will require 10.2 hrs

MIRI 10 µm Imaging – 5.4 hrs

We use a 5 point dither pattern with the shortest exposure per pointing. For each epoch this yields.

Two epochs will require 0.9 hrs. To observe all six comets will require 5.4 hrs.

NIRSpec Fixed-Slit – 19.2 hrs

We use a two-position dither and 5 exposures at each dither. For each epoch, this yields:

Two epochs will require 3.2 hrs. To observe all six comets will require 19.2 hrs.

2) Physical properties and possible activity of distant comet nuclei

MIRI LRS – 45.0 hrs

Each epoch of LRS observations will have the following characteristic.

Two epochs will require 2.5 hrs. To observe all six comets will require 45.0 hrs.

MIRI 15 µm Imaging – 16.2 hrs

We use a 5 point dither pattern with the shortest exposure per pointing. For each epoch this yields.

Two epochs will require 0.9 hrs. To observe all six comets will require 16.2 hrs.

CONSTRAINTS:

PARALLEL Observations possible (yes/no/pure parallel)?

In general parallels are not useful since these are moving targets.

COMMENTS:

The NIRSpec ETC doesn't provide a way to compute the SNR for extended emission. That's an obvious, and no doubt planned-for, upgrade. As a result, the SNR for these objects was estimated by computing the surface brightness expected from the coma (assuming an optical depth of 10^{-4}), converting that into an equivalent point-source flux, and adding the coma and nucleus contributions. The accuracy of this estimate is probably OK, but it would be far preferable to have the capability within the ETC.

The NIRSpec ETC doesn't directly report the SNR that will be achieved on spectroscopic lines. Here we estimated that by computing the SNR just outside a line (longer and shorter wavelengths), and comparing that to the SNR in the core of the line. Again, far preferable if the ETC directly reported the SNR for any/all lines the user specifies in the input.

AUTHOR/DATE: Dean C. Hines (hines@stsci.edu) 23 December 2011

John Stansberry (Arizona)

Wayne M. Kinzel (STScI)

TITLE: Bright Comets, Targets of Opportunity (ToO)

ID: 92030

GOAL:

Comets are the building blocks of the solar system and contain pristine samples of the early solar system debris cloud. Spectroscopic observations will allow determination of the comets' composition.

Sample and sky coverage:

Assumed one comet, 134P/Kowal-Vavrova at three epochs between 2012.5 and 2013.5 when the comet is in the JWST field of regard. Each epoch will have a MIRI and NIRSPEC visit. The comets parameters were taken from the JPL DASTCOM database (JPL 2004a).

We will observe comets that are newly discovered as well as those in the main asteroid belt that flare unexpectedly. Multiple epochs are useful, but it is more important to monitor over a few day period to trace rotational changes.

NOMINAL ALLOCATION (hours): 105.8

ACTUAL TIME (hours): 96

TARGET(S):

Comets

OBSERVING TEMPLATE:

MIRI MRS-IFU

NIRSpec IFU

NIRCam Imaging

OBSERVATION DETAILS:

Each comet should be observed three times. The total time for this program could be reduced if we reduced the sightings to two, and could drop NIRCam.

Basis for exposure time estimates (S/N & brightness):

A S/N of about 10 is assumed. The JPL Horizons program (JPL 2004b) was used to produce ephemerides of the comets over the time range 2012.5 - 2013.5 and to determine when the comet was within the field of regard for JWST. It also produced an estimate of the nucleus visual magnitude, which was used to estimate the IR magnitudes. Conversions from (I, J, K) to AB magnitudes were from the ABmag calculator on the JWST web site.

NIRCam Imaging – 24.4 hrs

Time per single observations. This is repeated three times per comet, for five comets.

NIRSpec IFU Spectroscopy – 62.5 hrs

2x2 mosaic and 3-position dither at each location. Time per single observations. This is repeated three times per comet, for five comets.

MIRI IFU Spectroscopy – 18.9 hrs

CONSTRAINTS:

Moving targets

At least three sightings should be done per comet: one when comet is far away from Sun, and another when the comet has developed a large coma and tail.

PARALLEL Observations possible (yes/no/pure parallel)?

These are moving targets, so parallels are not appropriate.

COMMENTS:

There needs to be a better way in APT to link observations rather than by "number." As the program is changed and edited, it becomes VERY cumbersome to link observations if even ONE number changes.

AUTHOR/DATE: Dean C. Hines (hines@stsci.edu) 12 December 2011

John Stansberry (Arizona)

Carey Lisse (JHU)

TITLE: Icy Dwarf Planets

ID: 92040

GOAL:

Beyond Neptune there are 4 dwarf planets (Pluto, Eris, Makemake and Sedna) with significant inventories of volatile ices on their surfaces. These ices give rise to organic molecules via UV photolysis and radiolysis by galactic cosmic rays. Haumea is also a dwarf planet, but is not currently known to possess any volatile ices. The physical state of the ices and the composition of the organics on these objects are of significant interest because these bodies are large enough to have retained nearly the entire inventory of material from which they accreted, because the volatile ices are mobile, moving in response to seasonal variations in insolation, and the ices also support the vapor-pressure atmospheres around these bodies. An important goal for JWST will be to make detailed studies of the composition of each object to determine what molecules are present on their surfaces (and in their atmospheres), measure isotopic compositions on each, and map the distribution of the constituents vs. longitude. JWST may also allow for the first detection of the low-temperature phase of solid N2 on one or more of these objects, for the first time, and determine whether N2 is present at all on Eris (where there is only indirect evidence for it).

The thermal state of the surfaces for each of these objects is also of interest, so MIRI 25um photometry will be done to measure the thermal lightcurves for the brighter objects (for comparison with Spitzer and Herschel lightcurve data, and to measure secular changes related to seasonal cycles), and to measure the mid-IR thermal emission for the first time for the fainter objects.

Summary of observation requirements for dwarf planets:

We will use multiple observations in several cases to probe multiple longitudes.

Estimated requirements below. Actual times are those allowed in APT.

NIRSpec:

SNR calculated at 1.5, 2.5, 4.3 um for G140, G235, G395, respectively
and is per resolution element.

			G140H		G235H		G395M		Total	
Object	m_J	Visits	ExpTime	SNR	ExpTime	SNR	ExpTime	SNR	Exptime	NOTE
Pluto	14.0	4	1200	300	3600	300	3600	150	5.3	G395H
Eris	18.2	4	3600	100	14400	90	14400	75	36.0	
Make	16.9	2	7200	200	7200	120	7200	100	12.0	
Sedna	20.7	1	14400	60	14400	35	28800	15	16.0	ALL medium res.
Haumea	17.0	1	7200	200	7200	130	7200	100	8.0	

Total: 77.3 hrs

Will want to sample specific longitudes on each object, but it isn't critical the data all be taken within ~1 rotation period. For simplicity, apply a timing constraint to each visit for each target.

MIRI:

Jy	#	25.5 um			
Object	F24	Visits	ExpTime	SNR	Note
Pluto	5.0e-3	12	100	300	Rotational lightcurve
Make	1.1e-4	12	600	170	Rotational lightcurve
Sedna	7.7e-6	5	7200	4	Follow-on/sky subtraction
Haumea	2.2e-4	12	1800	60	Rotational lightcurve
	Total:	28.3 hrs			

Flux densities derived from 45K BB, and normalized to 24um flux density.

For simplicity, use follow-on constraints that space the observations about 12 hours apart. Actual constraints will depend on the object, but won't be vastly different than 12 hours. The first visit for each target should also include a timing constraint.

Specifics for each object:

Pluto (6.4 day period), but doesn't have to be contiguous.

Because Pluto has such a long period, it makes sense to interleave the instruments over a two day period.

Eris we want four longitudes 1.08 days rotation.

Make (don't know period) 2 visits over 24 hrs

Sedna 10.3 hrs rotation period, one visit NIRSpec, so maybe 4 visits MIRI.

Haumea 4.7 hrs (rotation too fast for multiple longitudes… one visit.

NOMINAL ALLOCATION (hours): None specified

ACTUAL TIME (hours): 134

TARGETS:

24um flux in mJy

Vmag and F24 are for epoch c. June 2019

Jmag a wag from Vmag

NIRSpec integration times assume G2V normalized to Jmag

Object	**Vmag**	**Jmag**	**Rhelio**	**Delta**	**F24um**
Pluto	14.4	14.0	33.9	34.6	5.0
Eris	18.8	18.2	96.0	95.1	1.0e-4
Makemake	16.9	16.9	52.6	52.7	0.11
Sedna	21.0	20.7	84.6	85.0	7.7e-3
Haumea	17.2	17.0	50.3	49.5	0.22

OBSERVING TEMPLATE:

MIRI Imaging

NIRSpec fixed-slit spectroscopy

OBSERVATION DETAILS:

ACTUAL integration times are from APT.

NIRSpec – 90.7 Hrs (with overheads)

Object	m_J	# Visits	G140H ExpTime	G140H SNR	G235H ExpTime	G235H SNR	G395M ExpTime	G395M SNR	NOTE
Pluto	14.0	4	1310	300	3668	300	3668	150	G395H
Eris	18.2	4	3668	100	14462	90	14462	75	
Make	16.9	2	7336	200	7336	120	7336	100	
Sedna	20.7	1	14672	60	14672	35	29344	15	ALL medium res.
Haumea	17.0	1	7336	200	7336	130	7336	100	

MIRI – 43.3 hrs

Object	Jy F24	# Visits	25.5 um ExpTime (sec)	SNR	Note
Pluto	5.0e-3	12	137.5	300	Rotational lightcurve
Make	1.1e-4	12	666	170	Rotational lightcurve
Sedna	7.7e-6	5	7315	4	Follow-on/sky subtraction
Haumea	2.2e-4	12	2033	60	Rotational lightcurve

CONSTRAINTS:

PARALLEL Observations possible (yes/no/pure parallel)?

In general parallels are not useful since these are moving targets.

COMMENTS:

APT should also have the capability to access the orbital elements for a moving target on the JPL Horizons ephemeris server, rather than having the user input them. The orbital elements for many objects of interest (e.g. newly discovered objects; comets) change as new astrometry is submitted by observers, so the JWST ground system should access the Horizons database just prior to production of an observation plan in order to guarantee that the orbital elements are the best available for the epoch when the data will be collected.

AUTHOR/DATE: Dean C. Hines (hines@stsci.edu) 12 January, 2012

John Stansberry (University of Arizona)

TITLE: Solar System Ice Giants: Uranus & Neptune

ID: 92050

GOAL:

The ice giant planets of our solar system, Uranus and Neptune, are prime candidates for infrared imaging and spectroscopic observations with the James Webb Space Telescope (JWST). Their atmospheres, which are rich in hydrocarbons and seasonally varying clouds and storms, can be probed by JWST to explore their chemistry and thermal balance with unprecedented precision. Current ground-based observatories are unable to probe the atmospheres of ice giants (Uranus and Neptune) to large vertical depth or with sufficient accuracy because of terrestrial atmospheric absorption and high thermal background. Spatially resolved measurements of methane and ethane emission features in the upper atmospheres of Uranus and Neptune will help constrain the abundances of these compounds and the photochemistry involved in their formation. The abundances and variability of chemical species, including the confirmation of radicals thought to be involved in the hydrocarbon photolysis process, may be observed with JWST to more accurately characterize the atmospheric processes and formation of these planets.

NIRCam imaging, NIRSpec IFU spectroscopy, and MIRI IFU spectroscopy imaging will be obtained for both planets. Neptune is too bright for MIRI Imaging. These observations will be obtained with a cadence that will enable us to probe these atmospheres 4 times during their rotation periods (17.24 hours for Uranus and 16.11 hours for Neptune). The observation suite will be repeated at least 2 times per earth year to probe long-term variations.

NOMINAL ALLOCATION (hours): 168

ACTUAL TIME (hours): 178.7

TARGET(S):

Uranus, Neptune

OBSERVING TEMPLATE:

MIRI MRS-IFU

NIRSpec IFU

MIRI Imaging

NIRCam Imaging

OBSERVATION DETAILS:

All observations are taken 4 times to sample the latitudinal variations on the planet.

General Description of Exposure Time Calculations

We used the JWST exposure time calculator (ETC) to estimate exposure times of Uranus and Neptune in each observing mode based on flux values derived from existing IR spectra of both planets. We compared the exposure time estimates for wide and narrow-band imaging with the planetary rotation rates (17.24 hours for Uranus and 16.11 hours for Neptune) to determine the number of imaging filters and spectral resolution elements that may be sampled before significant planetary rotation occurs. Tables 1 and 2 provide a list of proposed exposure times with corresponding SNRs for Uranus and Neptune, respectively. Based on the observing plans provided in Tabke s 1 and 2, Uranus will rotate by 18.4° and Neptune will rotate by 6.4° if all observations are made in succession, assuming no overheads. Overhead estimates are not currently available, but if we assume ~50% efficiency for Uranus and ~10% efficiency for Neptune... Filters were selected for exposure time calculations based on filter bandwidth and spectral feature overlap.

Table 1 Example Uranus Exposure Time Calculations

Instrument	*Filter*	*l (mm)*	*Feature (mm)*	*Exp. Time (s)*	*SNR*	*Total Time (s)*
MIRI	MRS 1.c	6.49 – 7.76	CH_4: 7.5	245	20	1225
MIRI	MRS 3.a	11.47 – 13.67	C_2H_6: 12.3	135	20	675
MIRI	MRS 3.b	13.25 – 15.8	C_2H_2: 14.0	27.105	35	135.525
MIRI	F0770W	6.6 – 8.8	CH_4: 7.50	27.105	35	135.525
NIRSpec	R=2700	0.6 – 5.0	–	100	28	1000

Table 2 Example Neptune Exposure Time Calculations

Instrument	*Filter*	*l (mm)*	*Feature (mm)*	*Exp. Time (s)*	*SNR*	*Total Time (s)*
MIRI	MRS 1.c	6.49 – 7.76	CH_4: 7.15	27.105	215	81.315
MIRI	MRS 2.a	7.45 – 8.90	CH_4: 7.95	27.105	530	81.315
MIRI	MRS 3.a	11.47 – 13.67	C_2H_6: 12.25	27.105	480	81.315
NIRCam	F480M	4.6 – 5.0	CO: 4.7	10.6	430	53
NIRCam	F335M	3.18 – 3.52	H_3^+: 3.4	10.6	290	53
NIRCam	F356W	3.12 – 4.0	CH_4: 3.5, 3.8	10.6	590	53
NIRSpec	R=2700	0.6 – 5.0	–	50	48	625

MIRI Imaging for Uranus — 25.6 hrs

MIRI imaging will be obtained in all 7 filters using SUB256 with a 5 position cycling dither for Uranus, and 4 filters for using SUB64 with a small Gaussian dither for Neptune (Neptune is 100x brighter than Uranus in most bands).

Per Dirunal Sampling

Total for 4 dirunal samplings and 2 epochs

NIRCam Imaging of Uranus — 38.1 hrs

NIRCam imaging will be obtained in 3 filters for isolating methane absorption features to constrain the atmospheric vertical aerosol distribution. A small INTRASCA dither pattern 4 sub-pixel dithers will be used for each observation.

Per Dirunal Sampling

Total for 4 dirunal samplings and 2 epochs

MIRI IFU Uranus — 15.4 hrs

The MIRI IFUs range in size from ~3.0″ × 3.9″ at the shortest wavelengths, to ~6.7″ × 7.7″ at the longest, and will provide simultaneous spatial and spectral (R ≈ 2000 - 3700) data on selected regions of the planetary disk. Due to the wavelength dependence of the IFU fields of view (FOVs) and the similarity of the size of the FOVs and the angular diameter of the ice giants, a four-position dither pattern will ensure adequate spatial and spectral sampling across the planet. A sky chop will be executed.

Per diurnal sampling

Total for 4 dirunal samplings (with one sky chop) and 2 epochs

NIRSpec IFU Uranus — 28.3 hrs

The NIRSpec can perform observations of ice giants using fixed slits. Alternatively, NIRSpec is equipped with a 3” x 3” integral field unit (IFU) that is well matched for Neptune observations, and Uranus. A sky chop will be executed.

Per diurnal sampling

Total for 4 dirunal samplings (plus sky chop) and 2 epochs

NIRCam Imaging for Neptune — 38.1 hrs

Per Dirunal Sampling

Total for 4 dirunal samplings and 2 epochs

MIRI IFU Neptune — 10.7 hrs

Per Dirunal Sampling

Total for 4 dirunal samplings (plus sky chop) and 2 epochs

NIRSpec IFU Neptune — 24.5 hrs

Per diurnal sampling

Total for 4 dirunal samplings (plus sky chop) and 2 epochs

CONSTRAINTS: Moving targets

Diurnal observations per mode must be nested within a short period (≤ 2 days) and phased to yield 4 samplings of the longitudinal structure during a rotation of the planet. The option to try to match phase in other ways is not possible because of the event-driven scheduling.

Epochs should be spaced by ~ 6 earth months.

PARALLEL Observations possible (yes/no/pure parallel)?

These are moving targets, so parallels are not appropriate.

COMMENTS:

There needs to be a better way in APT to link observations rather than by “number.” As the program is changed and edited, it becomes VERY cumbersome to link observations if even ONE number changes.

AUTHOR/DATE: Dean C. Hines (hines@stsci.edu) 12 December 2011

Kyle Uckert (NMSU)

Nancy Chanover (NMSU)

Heidi B. Hammel (AURA)

TITLE: Giant Planet Satellites
ID: 92060

GOAL:

The diversity (size/composition) of the satellites provides natural field laboratory for studies of materials critical for planet formation. Spectra will be used to study the diverse surface composition. Sample and sky coverage: For each planet, one to five satellites will be observed for Saturn, Uranus, and Neptune.

It is desirable to obtain spectra at different phases in the satellite rotation period. We assume 4 samplings, which gives 2x sampling per "face."

We emphasize that the diversity is extreme. Three of the faint moons of Uranus could probably be dropped.

NOMINAL ALLOCATION (hours): 168

ACTUAL TIME (hours): 251.9

218 if we drop the three faint moons of Uranus.

TARGET(S):

		Wavelength [microns]			
Satellite	Epoch	1.4	2.35	3.95	10
S2_Enceladus	Feb 1, 2012	12.1	12.4	13.4	10.8
S3_Tethys	Feb 1, 2012	11.2	11.4	12.9	9.6
S4_Dione	Feb 1, 2012	11.5	11.6	13.1	9.8
S5_Rhea	Feb 1, 2012	10.3	10.6	12.2	9.0
S6_Titan	Feb 1, 2012	10.0	10.4	12.1	7.3
S8_Iapetus	Feb 1, 2012	11.6	11.6	13.1	11.3
U1_Ariel	Jul 1, 2012	14.7	14.8	16.3	13.8
U2_Umbriel	Jul 1, 2012	15.3	15.4	16.9	14.5
U3_Titania	Jul 1, 2012	14.2	14.4	15.9	13.4
U4_Oberon	Jul 1, 2012	14.5	14.6	16.1	13.7
U5_Miranda	Jul 1, 2012	16.8	16.9	18.4	15.5
U_Puck	Jul 1, 2012	21.6	21.2	22.7	19.6
U_Porta	Jul 1, 2012	21.3	21.3	22.8	20.4
U_Rosalind	Jul 1, 2012	22.8	22.8	24.3	21.7
N1_Triton	Jun 2, 2012	13.6	13.8	15.3	12.9
N_Proteus	Jun 2, 2012	22.7	22.1	23.6	21.2

OBSERVING TEMPLATE:

MIRI LRS Spectroscopy

NIRSpec Fixed-Slit

OBSERVATION DETAILS:

Basis for exposure time estimates (S/N & brightness):

TBD, depends upon the satellites selected. S/N about 10. A S/N of about 100 is needed. For most satellites, the magnitudes were derived from parameters in Allen (2000). For Miranda, Porta, Puck, and Rosalind, the parameters came from Trilling (2000). For many satellites, the K-L and V-N colors were missing. In those cases we assumed K-L = -1.5 and V-N = 6, approximating other outer satellites. Conversions from (I, J, K) to AB magnitudes were from the ABmag calculator on the JWST web site.

MIRI LRS – 26.3 hrs

NIRSpec Fixed Slit Spectra – 36.7 hrs

CONSTRAINTS:

Moving targets

PARALLEL Observations possible (yes/no/pure parallel)?

These are moving targets, so parallels are not appropriate.

COMMENTS:

There needs to be a better way in APT to link observations rather than by "number." As the program is changed and edited, it becomes VERY cumbersome to link observations if even ONE number changes.

AUTHOR/DATE: Dean C. Hines (hines@stsci.edu) 21 December 2011

Wayne M. Kinzel (STScI)

TITLE: Kuiper Belt Objects

ID: 92070

GOAL:

Objectves:

- Determine diameters and albedos for a large sample of transneptunian objects
- Search for evidence of collisionally–induced changes in albedo.
- Make near–simultaneous measurements to mitigate rotational
- Observe a large enough sample to search for differences in different classes of objects.

Technique:

- Measure both reflected light and thermal emission from TNOs with NIRCam and MIRI.
- Multiple thermal wavelengths allow for better modeling of non–isotropic emission (beaming parameter), unknown pole position, and unknown therma lineria lightcurve uncertainty.
- A "typical" TNO has Teq ≈ 42K (R ≈ 40AU, p ≈ 0.15, T = TO (1-p)1/4 (RO/2R)1/2
- Crossover from reflected to thermal emission is at λ ≈ 10μm

Most lightcurve periods fall in the range from 3-12 hours

- Amplitudes vary from <0.05 mag to >1 mag.
- Most objects have measurable lightcurve (>0.03 mag) ~15% are > 0.15mag (H>5.5).
- The fraction is expected to increase at smaller sizes.
- Need near simultaneous observations.

Secondary science objective: search for water ice absorption.

- 1.5 μm filter samples water ice feature.
- 3.5 μm filter samples adsorbed H2O feature.

Observe 100 objects

NOMINALALLOCATION (hours): 168

ACTUAL TIME (hours): 276.7 hrs

Note that this program can be "fit" within the 168 hors if only 60 TNOs are observed instead of 100.

TARGET(S):

100 KBOs will be supplied by K. Noll. These are not yet available.

OBSERVING TEMPLATE:

NIRCam imaging

MIRI imaging

NIRSpec slit spectroscopy

OBSERVATION DETAILS:

λ (μm)	F_{min} (μJy)	itime (s) (S/N=10)
1.15	.5	*20*
1.50	.3	*40*
2.77	.2	60
3.56	.1	200
21	35	1000
25.5	100	1350

Nominal 100 km target (30 times fainter than Huya, Fig 1). S/N calculated with relevant instrumental and astronomical backgrounds.

Dithers

NIRCam - 4 position box dither
- avoid detector artifacts
- cosmic ray rejection
- cumulative S/N -> 20 in LWC, significantly higher in SWC

MIRI - 4 position dither at half itime
- avoid detector artifacts
- minimize contamination by background sources
- S/N ~ 7 in individual integrations
- time limited due to lightcurve concerns

NIRCam Imaging – 112.5 hrs

MIRI Imaging – 61.2 hrs

NIRSpec Fixed-Slit Spectroscopy – 100 hrs

CONSTRAINTS:

PARALLEL Observations possible (yes/no/pure parallel)?

In general parallels are not useful since these are moving targets.

COMMENTS:

The ability to load targets from a flat text file seems to have vanished from APT. This make entering hundreds of targets ridiculously cumbersome. In addition, moving targets with know ephemeri should be accessed through the JPL database and auto load the orbital parameters, automatically.

The APT file thus contains an example of each observations, but does not contain the entire 115 object source list nor their detailed observations.

AUTHOR/DATE: Dean C. Hines (hines@stsci.edu) 21 December 2011
Keith Noll (GSFC)

TITLE: Main-Belt Asteroids

ID: 92080

GOAL:

Asteroids represent some of the oldest bodies in the solar system.

3) Organics, hydrates and water in small, outer Main-Belt Asteroids
NIRSpec medium-resolution spectra in the 0.9 – 5 micron region will be used to search for organics, hydrated minerals and water ice for a sample of ~100 small (D < 20km) asteroids in the outer main-belt (3.5 – 4 AU). Features from these materials will occur in the 1.5 – 5 micron region; spectra in the 0.9 – 1.5 micron region will constrain the silicate composition of each body so that a more accurate and complete picture can be drawn of the composition of each body, and of compositional diversity amongst objects in that region. Current dynamical models for the evolution of the solar system indicate that a fraction of the objects in this region may have originated much further from the Sun, so those objects may be revealed as a distinct compositional class by these data.

4) Thermo-physical properties of S- and C-type Main-Belt Asteroids
MIRI LRS spectra of 15 main-belt asteroids will provide sensitive determination of the temperature distribution on their surfaces, as well as compositional information through the silicate emission features broadly clustered around 10 microns wavelength. The objects were selected to have similar sizes (as determined by IRAS), and are in two groups: A) high-albedo objects near 2.5 AU (S-type), and B) low-albedo objects near 3.5 AU (C-type). Each target will be observed twice in order to better constrain the thermal inertia of surface materials. For objects with large (>0.25 mag) rotational lightcurves the two observations will be timed to coincide with lightcurve minimum and maximum. For objects with smaller lightcurve amplitudes (0.1 – 0.2 mag), one observation will be timed to view the dawn-side, and a second roughly 6 months later will view the dusk-side, emission.

NOMINAL ALLOCATION (hours): None specified

ACTUAL TIME (hours): 150.5

TARGET(S):

<u>*MIRI LRS Targtes*</u>

1146_Biarmia

1197_Rhodesia

123_Brunhild

1411_Brauna

1421_Esperanto

1471_Tornio

1605_Milankovitch

288_Glauke

3118_Claytonsmith

340_Eduarda

4169_Celsius

550_Senta

653_Berenike
73_Klytia
766_Moguntia

NIRSpec Sample

1089_Tama
1152_Pawona
1155_Aenna
1170_Siva
1226_Golia
1252_Celestia
1318_Nerina
1378_Leonce
1414_Jerome
1425_Tuorla
1458_Mineura
1501_Baade
1503_Kuopio
1504_Lappeenranta
1537_Transylvania
1545_Thernoe
1549_Mikko
1552_Bessel
1742_Schaifers
1743_Schmidt
1808_Bellerophon
1904_Massevitch
1909_Alekhin
2002_Euler
2038_Bistro
2057_Rosemary
2084_Okayama
2153_Akiyama
2169_Taiwan
2179_Platzeck
2185_Guangdong
2191_Uppsala
2201_Oljato

2215_Sichuan
2304_Slavia
2313_Aruna
2321_Luznice
2465_Wilson
2474_Ruby
2512_Tavastia
2531_Cambridge
2695_Christabel
2715_Mielikki
2724_Orlov
2729_Urumqi
2753_Duncan
2904_Millman
2950_Rousseau
2987_Sarabhai
299_Thora
3013_Dobrovoleva
3017_Petrovic
3052_Herzen
3082_Dzhalil
3115_Baily
3389_Sinzot
3406_Omsk
343_Ostara
3591_Vladimirskij
3684_Berry
3724_Annenskij
3872_Akirafujii
3961_Arthurcox
3983_Sakiko
3999_Aristarchus
4006_Sandler
4009_Drobyshevskij
4049_Noragal'
4061_Martelli
4107_Rufino

4124_Herriot

4141_Nintanlena

4159_Freeman

4194_Sweitzer

4222_Nancita

4250_Perun

4343_Tetsuya

4470_Sergeev-Censkij

4500_Pascal

4505_Okamura

4790_Petrpravec

4812_Hakuhou

4889_Praetorius

496_Gryphia

502_Sigune

5105_Westerhout

5236_Yoko

531_Zerlina

5576_Albanese

594_Mireille

5959_Shaklan

6129_Demokritos

630_Euphemia

7083_Kant

770_Bali

896_Sphinx

955_Alstede

OBSERVING TEMPLATE:

MIRI LRS Spectrocopy

NIRSpec slit spectroscopy

OBSERVATION DETAILS:

We will use MIRI LRS to obtain spectra that will constrain the temperature of the asteroid.

MIRI LRS Spectroscopy — 37.5 hrs

Per Target. This is repeated twice for each object.

NIRSpec Fixed-Slit Spectroscopy – 113.0 hrs

NIRSpec Modes

Fixed slit, 0.4x3.8" probably OK (typically ~0.3 - 10 mJy sources)?

Filter Grating Purpose

F070LP G140M 0.9 - 1.3 um silicate features

F170LP G235M H, K band hydration features

F290LP G396M L, M band hydration, H2O ice features, other volatiles

All the spectra for a target should be acquired back-to-back. Sort of like the old chain constraint for Spitzer.

CONSTRAINTS:

PARALLEL Observations possible (yes/no/pure parallel)?

In general parallels are not useful since these are moving targets.

COMMENTS:

The ability to load targets from a flat text file seems to have vanished from APT. This make entering hundreds of targets ridiculously cumbersome. In addition, moving targets with know ephemeri should be accessed through the JPL database and auto load the orbital parameters, automatically.

The APT file thus contains an example of each observation, but does not contain the entire 115 object source list nor their detailed observations.

AUTHOR/DATE: Dean C. Hines (hines@stsci.edu) 12 December 2011

John Stansberry (Arizona)

Exoplanet Programs

TITLE: Direct observations of planetary systems--MIRI

ID: 93030

GOAL: This program performs direct imaging of planets using the coronagraph on MIRI. The program is designed assuming that it focuses entirely on following up known planets that will be discovered using one or more large upcoming ground based surveys (Gemini Planet Imager, VLT/SPHERE, Subaru, Palomar, etc.).

By choice this program does not include a "search" for new planets in this first version. The decision to build this program entirely as follow-ups of known planets is motivated by putting more stress on the scheduling system. Because we assume the planets to be known, we request tight constraints on the absolute orientation for each target, as well as an immediate 10-degree roll, and an immediate PSF reference star observation. As a result, because of limitations on allowed rolls as a function of ecliptic latitude, it is expected that a number of these observations may not be schedulable. The goal is to better understand the physical limitations for coronagraphic observations and develop mitigation strategies if necessary, and to define a set of rules to prevent the observer from requesting un-schedulable observations.

We assume that we know where the planets are located and that we want to avoid certain features of the coronagraph, e.g. the axes of the FQPM mask. This will be particularly important for observing multiple-planet systems such as the HR8799 four-planet system where the orientation of the FQPM mask or the wedge has to be carefully chosen to avoid the planets is possible. If/When multiple-planet systems are detected with GPI/SPHERE, they will be highly desirable targets for coronagraphy. For planets at small inner-working angles (also highly desirable targets) an absolute orientation of the telescope is necessary as well.

Each target star is also associated with a reference star to be observed immediately after the target. The reference stars have been picked loosely to provide a very good match both in magnitude and spectral type. This means that the requested slews can be very large in some cases and large (degrees) in most cases, and it is possible that these observations may not be schedulable. In many cases it should be possible to relax these constraints. For example, with MIRI it is very likely that spectral type matching will not be very important criterion, so that we should be able to use reference stars much closer to the targets in most cases. Again, a range of separations is assumed here to help understand what realistic limitations are for reference star separations.

The program includes 20 stars to be observed by MIRI in three filters. Theses stars are representative of the possible targets that will be observed by JWST. They include a few well-known targets such as HR8799, Beta Pic, etc., and a few stars selected randomly in several nearby young moving groups (TWA, Beta Pic, Tuc/Hor, Cha Near, AB-Dor etc.).

The 20 targets are split in two groups to test two possible observing scenarios:

- The first group of 10 targets is assumed to have planets at "large-separations", which means that a 10 deg roll right away will be sufficient to move the planet off itself on the detector. (Note: this assumes the initial observation is offset from nominal roll by 5 degrees and then rolled to 5 degrees on the other side of nominal roll for the second observation.) We assume one hour total exposure time per target per filter.

- The second group of 10 targets is assumed to have planets at "small-separations", which means that a 10 deg roll is not sufficient to move the planet off itself on the detector, but it is sufficient to provide a "roll-dither" of the PSF at the pixel level. This second group will be observed with a 10 deg roll (for the roll-dither effect) and then again at a later date to provide a larger roll offset. In this case, both sets of observations have an absolute orientation that is specified. We assume one hour total exposure time per target per filter.

NOMINAL ALLOCATION (hours):

350 hours

ACTUAL TIME (hours):

363 hours from calculations, see Excel spreadsheet provided

MIRI type 1 (single set of observations): 10 stars at 14.1 hours = 141 hours

MIRI Type 2 (with second set at later date): 10 stars at 22.2 hours = 222 hours

TARGET(S):

i) Well known targets

HR8799

Fomalhaut

beta Pic

GQ Lup

2MASSWJ1207334-393254

1RXS J160929.1-210524

UScoCTIO108

CT Cha

ii) TWA moving group

HD 298936

2MASS J12153072-3948426

iii) Beta Pic moving group

HR 9

HIP 92024

HIP 88399

iv) Tuc/Hor moving group

HIP 107947

HD 13183

HD 13246

CD-60 416

v) AB Dor moving group

HIP 6276

HIP 26373

vi) Cha Near moving group

RXJ1239.3-7502

OBSERVING TEMPLATE:

MIRI coronagraphy

OBSERVATION DETAILS:

MIRI coronagraphy (First 10 stars, single observations)

- Target observations in each FQPM coronagraph (with absolute orient)
- Immediate Roll 10 degrees and repeat target observations in each FQPM coronagraph
- Immediate Slew to reference star and observation in each FQPM coronagraph

MIRI coronagraphy (Last 10 stars, repeated observations for larger roll)

i) Target observations in each FQPM coronagraph (with absolute orient)
ii) Immediate Roll 10 degrees and repeat target observations in each FQPM coronagraph
iii) Immediate slew to reference star and observation in each FQPM coronagraph
iv) Target observations in each FQPM coronagraph with 30-40 degree roll (at later date)
v) Immediate Roll 10 degrees and repeat target observations in each FQPM coronagraph
vi) Immediate slew to reference star and observation in each FQPM coronagraph

CONSTRAINTS:

Specific position angles and some relative timing links

PARALLEL Observations possible (yes/no/pure parallel)?

n/a

COMMENTS:

There are remaining things with the APT files that I cannot do by hand and did not manage to script:

When duplicating the observations folder the special requirements are not duplicated. Each observations folder should be the same as the first one: each observations for a given target should be grouped with zero day, the first target observation has an absolute aperture orient, with following observations at same orient, except for the roll itself, and the first observation of the reference PSF, which has no absolute orient constraint. All other observations are at same orientation as the previous observation. See the first observation folder for reference.

Absolute orientation was set to a range of 10 degrees and unique. However, for MIRI this is to avoid the four axes of the FQPM and therefore the absolute orientations can be set modulo 90 degrees.

PI field is missing because the accent on my first name breaks APT and since I am already in the APT system I cannot remove the accent.

AUTHOR/DATE: Rémi Soummer (December 18, 2011)

Updated by Bill Blair (January 2012)

TITLE: Direct observations of planetary systems -- NIRCam

ID: 93031

GOAL: This program performs direct imaging of planets using the coronagraph on NIRCam.. The program is designed assuming that it focuses entirely on following up known planets that will be discovered using one or more large upcoming ground based surveys (Gemini Planet Imager, VLT/SPHERE, Subaru, Palomar, etc.).

By choice this program does not include a "search" for new planets in this first version. The decision to build this program entirely as follow-ups of known planets is motivated by putting more stress on the scheduling system. Because we assume the planets to be known, we request tight constraints on the absolute orientation for each target, as well as an immediate 10-degree roll, and an immediate PSF reference star observation. As a result, because of limitations on allowed rolls as a function of ecliptic latitude, it is expected that a number of these observations will not be schedulable. The goal is to better understand the physical limitations for coronagraphic observations and develop mitigation strategies if necessary, and to define a set of rules to prevent the observer from requesting un-schedulable observations.

We assume that we know where the planets are located and that we want to avoid certain features of the coronagraph, e.g. the NIRCam coronagraphic wedge. This will be particularly important for observing multiple-planet systems such as the HR8799 four-planet system where the orientation of the wedge has to be carefully chosen to avoid the planets is possible. If/When multiple-planet systems are detected with GPI/SPHERE, they will be highly desirable targets for coronagraphy. For planets at small inner-working angles (also highly desirable targets) an absolute orientation of the telescope is necessary as well.

Each target star is also associated with a reference star to be observed immediately after the target. The reference stars have been picked loosely to provide a very good match both in magnitude and spectral type. This means that the requested slews can be very large in some cases and large (degrees) in most cases, and it is possible that these observations may not be schedulable. In many cases it should be possible to relax these constraints. For example, with MIRI it is very likely that spectral type matching will not be very important criterion, so that we should be able to use reference stars much closer to the targets in most cases. Again, a range of separations is assumed here to help understand what realistic limitations are for reference star separations.

The program includes 20 stars to be observed by NIRCam in three filters. Theses stars are the same targets as in program 3030 (MIRI) and are representative of the possible targets that will be observed by JWST. They include a few well-known targets such as HR8799, Beta Pic, etc. and a few stars selected randomly in several nearby young moving groups (TWA, Beta Pic, Tuc/Hor, Cha Near, AB-Dor etc.).

The 20 targets are split in two groups to test two possible observing scenarios:

- The first group of 10 targets is assumed to have planets at "large-separations", which means that a 10 deg roll right away will be sufficient to move the planet off itself on the detector. (Note: this assumes the initial observation is offset from nominal roll by 5 degrees and then rolled to 5 degrees on the other side of nominal roll for the second observation.) We assume one hour total exposure time per target per filter.
- The second group of 10 targets is assumed to have planets at "small-separations", which

means that a 10 deg roll is not sufficient to move the planet off itself on the detector, but it is sufficient to provide a "roll-dither" of the PSF at the pixel level. This second group will be observed with a 10 deg roll (for the roll-dither effect) and then again at a later date to provide a larger roll offset. In this case, both sets of observations have an absolute orientation that is specified. We assume one hour total exposure time per target per filter.

NOMINAL ALLOCATION (hours):

170 hours

ACTUAL TIME (hours):

171 hours from calculations, see Excel spreadsheet provided

NIRCam type 1 (single set of observations): 10 stars at 7.7 hours=77 hours

NIRCam Type 2 (with second set at later date): 10 stars at 9.7 hours= 94 hours

TARGET(S):

i) Well known targets

HR8799

Fomalhaut

beta Pic

GQ Lup

2MASSWJ1207334-393254

1RXS J160929.1-210524

UScoCTIO108

CT Cha

ii) TWA moving group

HD 298936

2MASS J12153072-3948426

iii) Beta Pic moving group

HR 9

HIP 92024

HIP 88399

iv) Tuc/Hor moving group

HIP 107947

HD 13183

HD 13246

CD-60 416

v) AB Dor moving group

HIP 6276

HIP 26373

vi) Cha Near moving group

RXJ1239.3-7502

OBSERVING TEMPLATE:

NIRCam coronagraphy

OBSERVATION DETAILS:

NIRCam coronagraphy (First 10 stars, single observations)

i) Target observations with wedge in three filters (with absolute orient)
ii) Immediate Roll 10 degrees and repeat target observations with wedge in three filters
iii) Immediate slew to reference star and observations with wedge in three filters
1.

NIRCam coronagraphy (Last 10 stars, repeated observations for larger roll)

i) Target observations with wedge in three filters (with absolute orient)
ii) Immediate Roll 10 degrees and repeat target observations with wedge in three filters
iii) Immediate slew to reference star and observations with wedge in three filters
iv) Target observations with wedge in three filters with 30-40 degree roll (at later date)
v) Immediate Roll 10 degrees and repeat target observations with wedge in three filters
vi) Immediate slew to reference star and observations with wedge in three filters

CONSTRAINTS:

Specific position angles and some relative timing links

PARALLEL Observations possible (yes/no/pure parallel)?

n/a

COMMENTS:

There are remaining things with the APT files that I cannot do by hand and did not manage to script:

When duplicating the observations folder the special requirements are not duplicated. Each observations folder should be the same as the first one: each observations for a given target should be grouped with zero day, the first target observation has an absolute aperture orient, with following observations at same orient, except for the roll itself, and the first observation of the reference PSF, which has no absolute orient constraint. All other observations are at same orientation as the previous observation. See the first observation folder for reference.

Absolute orientation was set to a range of 10 degrees and unique.. For NIRCam this is to avoid the wedge and the angle can be specified modulo 180 degrees.

PI field is missing because the accent on my first name breaks APT and since I am already in the APT system I cannot remove the accent.

AUTHOR/DATE: Rémi Soummer (December 18, 2011)

Updated by Bill Blair (January 2012)

TITLE: Direct observations of planetary systems -- NIRISS

ID: 93032

GOAL: This program performs direct imaging of planets using the NRM on NIRISS.

By choice this program does not include a “search” for new planets in this first version. The decision to build this program entirely as follow-ups of known planets is motivated by putting more stress on the scheduling system. Because we assume the planets to be known, we request tight constraints on the absolute orientation for each target, as well as an immediate 10-degree roll, and an immediate PSF reference star observation. As a result, because of limitations on allowed rolls as a function of ecliptic latitude, it is expected that a number of these observations will not be schedulable. The goal is to better understand the physical limitations for coronagraphic observations and develop mitigation strategies if necessary, and to define a set of rules to prevent the observer from requesting un-schedulable observations.

Each target star is also associated with a reference star to be observed immediately after the target. The reference stars have been picked loosely to provide a very good match both in magnitude and spectral type. This means that the requested slews can be very large in some cases and large (degrees) in most cases, and it is possible that these observations may not be schedulable. In many cases it should be possible to relax these constraints. For example, with MIRI it is very likely that spectral type matching will not be very important criterion, so that we should be able to use reference stars much closer to the targets in most cases. Again, a range of separations is assumed here to help understand what realistic limitations are for reference star separations.

For NRM observations, we used 9 targets that were provided by the NRM team. These are very well known targets of interest for the NRM observations.

NOMINAL ALLOCATION (hours):

80 hours

ACTUAL TIME (hours):

79 hours from calculations, see Excel spreadsheet provided.

NRM Type 1 (single set of observations): 5 stars at 7.9 hours=40 hours

NRM Type 2 (with second set at later date) 4 stars at 9.4 hours= 39 hours

TARGET(S):

NRM targets in star forming regions

DM Tau

GM Aur

LkCa 15 (=V1079 Tau)

UX TauA (=HD285846)

LkHa 330 (=IRAS 03426+3214)

Em* SR 21 (=2MASS J16271027-2419127)

TW Hya

HD 135344B (=CD-36 10010B)

T Cha

OBSERVING TEMPLATE:

NIRISS NRM

OBSERVATION DETAILS:

NIRISS NRM (First 5 targets)

i) Target observations with 9-point dither in each three filters (with absolute orient)
ii) Reference observations with 9-point dither in each three filters
2.

NIRISS NRM (Last 4 targets)

i) Target observations with 9-point dither in each three filters (with absolute orient)
ii) Reference observations with 9-point dither in each three filters
iii) Target observations with 9-point dither in each three filters with Roll 30-40 deg (at later date)
iv) Reference observations with 9-point dither in each three filters

CONSTRAINTS:

Specific position angles and some relative timing links

PARALLEL Observations possible (yes/no/pure parallel)?

n/a

COMMENTS:

AUTHOR/DATE:

Rémi Soummer (December 18, 2011)

Updated by Bill Blair (January 2012)

Updated by Harry Ferguson (June 6, 2012 to add in the alternate target names and remove the comments.)

TITLE: Direct Imaging of Planetary Systems around White Dwarfs

ID: 93035

GOAL:

Planetary systems do not necessarily die when their stars do. White dwarfs (WDs), the end state for 1-8 $M_{\odot}$ stellar evolution, can show evidence for the presence of planetary systems in orbit around them in the form of infrared excesses due to dust disks and pollution of their atmospheres from the surface accretion of dust grains. The dust disks observed around WDs are most likely caused by the tidal disruption of asteroids a few tens of WD radii away. The asteroids are perturbed by presumed unseen gas giant planets at distances of 5-10 AU. The disks are relatively bright in the infrared and can be characterized in detail at resolutions >10 times better than previously done with Spitzer using the MIRI MRS. The spectra will be used to compare mineral chemistry in the disk with what is accreted onto the WD photospheres in order to determine detailed atomic abundances of dust that participated in terrestrial and giant planet formation. Because of their low luminosity, WDs are excellent targets for direct imaging surveys for giant planets—in the F480M filter of NIRCAM, the contrast of a 5~Gyr 2 M_{Jup} planet is $2x10^{-4}$, $1x10^{-4}$, and $4x10^{-5}$ relative to WDs with T_{eff}=5000, 10000, and 25000 K, the range of T_{eff} for WDs within 10 pc of the Sun (Burrows, Sudarsky & Lunine 2003; Bergeron et al., 1996; Holberg et al., 2008).

NOMINAL ALLOCATION (hours): 50

ACTUAL TIME (hours): 49

TARGET(S):

(Disks) G29-38, GD 362, GD 56, GD 40, WD 1150-153, WD 2115-560, GD 16, GALEX J1931+0117, GD 133, WD 1015+161 (Direct Imaging) G29-38, WD 0046+051, WD 1142-645, WD 0413-077, WD 0426+588, WD 0752-676, WD 1748+708, WD 0552-041, WD 0553+053, WD 2251-070, WD 1334+039, WD 0839-327, WD 0435-088, WD 1132-325, WD 0738-172, WD 0038-226, WD 0310-688, WD 0245+541, WD 0912+536

OBSERVING TEMPLATES:

NIRCAM Coronagraphic Imaging

MIRI MRS

OBSERVATION DETAILS:

The observing strategy will be as follows: A sample of the brightest 10 WD dust disks (roughly half of currently known disks) will be observed with the MIRI MRS to fully characterize the 5-20 **μ**m spectrum in order to determine dust grain composition, abundances, and disk structure. A 1hr observation per disk (1000 s for G29-38) will ensure S/N>10 for all MRS wavelengths <20 **μ**m assuming a G29-38 analog spectrum scaled to the flux for our dimmest target at 8 **μ**m. We will observe a volume limited sample of WDs (+G29-38, the closest WD dust disk) within 10 pc at 1hr integration/target in the F480M filter and the MASKLWB coronagraphic wedge with PSF Rolls. JWST is sensitive to a 5 Gyr, 2 M_{Jup} companion at a S/N > 10 at this distance, provided that the object is not dimmer than 3 times the PSF brightness/pixel. It is assumed that the full sample of WDs can be used as a basis set of PSFs for a variant of the LOCI reduction procedure in conjunction with a coronagraphic mask to ensure sensitivity goals without positional or roll dithers. If roll or position dithers are needed this may increase the required direct observing time. Some targets may not need the use of a coronagraphic mask if detailed contrast calculations show that the desired sensitivity can be obtained with direct PSF subtraction.

CONSTRAINTS:

N/A.

PARALLEL Observations possible (yes/no/pure parallel)?

no

COMMENTS:

This program could be expanded to encompass all WDs out to 20pc, the nominal distance limit to JWST's sensitivity to 2 M_{Jup} objects with ages of <3 Gyr, which would increase the coronagraphic imaging time by a factor of 60. Recent studies show that the maximum fraction of WDs that show dust disks is on the order of 1-5% and if the WD sample is complete by JWST launch out to 100pc, a total of 25-200 more disks may be available for spectroscopic characterization with MIRI in low and medium resolution modes, assuming a space density for WDs of 4.7 pc^{-3}.

AUTHORS/DATE: John H. Debes/12/14/2011

TITLE: High S/N NIRCam Observations of an Earth Analogue Around a Nearby Sun-like Star

ID: 93040

GOAL:

The discovery of an earth-like planet around a sun-like star will certainly be deemed as a major milestone in the study of extrasolar planets. Many large efforts, including space missions like Kepler, are currently under way to achieve this goal. The discovery will be most interesting if the host star happens to be bright enough so that the molecular signatures from the atmosphere of such a planet can be detected by JWST.

Since bright host stars will be particularly interesting, let us estimate the brightness of the brightest of such objects. The probability of transit for an earth at 1 AU around a G-type star can be expressed as $R_{\odot}/a \sim 7 \times 10^{10}/1.5 \times 10^{13} \sim 0.5\%$. Assuming every star has an earth-like planet, the optimal sample size needed to observe the first earthlike planet around a sun-like star is thus ~200. Taking the brightness distribution of known stars, the expected brightness of the first sun-like host of an earth-like planet is V ~ 6. As described in detail by Sahu et al. (Technical Report, JWST-STScI-001999), special configurations can be used to avoid saturation in such bright-target observations.

The JWST observations of this earth analogue include continuous monitoring of the star before, during, and after the transit. We note that the expected transit duration is ~12 hours for a planet with an orbital period of 1 year around a Sun-like star. Since this is a differential observation, the baseline observations outside the transit should preferably have higher S/N than the observations during the transit. One way to achieve this would be to spend equal amount of time during and outside the transit, and use on-chip comparisons. Thus the observations last 36 continuous hours (12 hours during transit and 24 hours outside). Time resolution of ~10 minutes would be desirable to sample the ingress/egress of the transit, and to detect/study occasional passage of the planet over star spots. The observations involve imaging with NIRCam: to get high S/N required for accurate radius determination and determination of inclination angle. Since the timing of the transit is generally known to high accuracy, full time resolution is needed only during ingress and egress. During the main part of the event, sparser time sampling would be adequate.

NOMINAL ALLOCATION (hours): 36

ACTUAL TIME (hours): 36

TARGET:

Kepler 22-b (We use Kepler 22-b as the target, which is an earth-analogue around a fainter star, but we have changed its magnitude to V=6 in anticipation of future discoveries.)

OBSERVING TEMPLATES:

NIRCam Imaging

OBSERVATION DETAILS:

Observations are carried out for a continuous period of 36 hours: 12 hours before, 12 hours during, and 12 hours after the transit. In the SW, we need to use a weak lens to avoid saturation (which is still to be implemented in the template). In the LW, we need to use the grism for the same reason (grism also needs to be implemented in the template). We use RAPID readout pattern with N_GROUP=2 and N_INT=460, resulting in 9752 sec of integration time per exposure. We request 8 of these exposures, which adds up to approximately 36 total hours when overheads are included.

CONSTRAINTS:

N/A.

PARALLEL Observations possible (yes/no/pure parallel)?

No

COMMENTS:

It is worth noting that observations with the different instruments are likely to use different transits because of (i) the overheads involved in switching between different instruments, (ii) the high time resolution needed for the ingress/egress portion of event, and (iii) the need to achieve stability in the photometry, spectroscopy, wavelength calibration, etc.

AUTHORS/DATE: Kailash Sahu(ksahu@stsci.edu)

TITLE: Transit, Eclipse, and Orbital Phase Spectroscopy of Exoplanets with NIRSpec

ID: 93041

GOAL:

Characterize diverse exoplanet properties via differential spectroscopy in and out of transit and eclipse and as a function of orbital phase. Differential spectroscopy constrains stellar mean density, orbital inclination, orbital eccentricity, planetary radius, planetary atmosphere composition, temperature structure, and surface heat redistribution.

NOMINAL ALLOCATION (hours):

600 hours for all exoplanet observations (program 3040)

No sub-allocation for this program yet.

ACTUAL TIME (hours):

As ubmitted, 537 hours, which is probably more like 2 years worth of observations.

This was trimmed (some from each of the three observation groups) to approximate a 1.5 year program, for consistency with other submissions. Each observation group type stresses the scheduling system in a different way.

TARGET(S):

The 23 currently known transiting exoplanet hosts with K band [Vega] magnitude between 5.5 and 9. The list (sorted by decreasing K-band brightness) is HD 189733 b, HD 97658 b, GJ 436 b, HD 209458 b, HD 17156 b, HD 149026 b, HAT-P-11 b, HD 80606 b, WASP-33 b, HAT-P-2 b, WASP-38 b, WASP-8 b, ~~WASP-18 b~~, ~~WASP-7 b~~, HAT-P-17 b, WASP-14 b, GJ 1214 b, WASP-29 b, ~~XO-3 b~~, WASP-34 b, HAT-P-14 b, ~~HAT-P-8 b~~, and ~~HAT-P-13 b~~. The number of targets in this brightness range will likely double between now and the launch of JWST.

Note: strike-throughs above show targets cut to reduce program size. Additionally, 6 eclipse visits were trimmed from the series on GJ 1214 b. (W. Blair, 3/7/2012)

OBSERVING TEMPLATE:

NIRSpec Fixed Slit Spectroscopy

OBSERVATION DETAILS:

Each observation begins with a NIRSpec target acquisition into the S1600A1 aperture [*not yet implemented*], which is 1.6 x 1.6 arcsec square. For a well-centered star, this large aperture is relatively insensitive to target drift (due to ISIM thermal changes and/or rotation about the FGS guide star) because the wings of the PSF have dropped roughly symmetrically to relatively low levels at the edge of the aperture.

The standard MSA acquisition will not work because exoplanet hosts are too bright for full-frame NIRCam imaging, so the position of the exoplanet host relative to reference stars cannot be measured precisely enough. A dispersed light acquisition and peakup [*not yet implemented, see JWST-STScI-1751 by Tracy Beck*] is needed to acquire exoplanet hosts. In the associated spreadsheet, we assume that this alternate target acquisition will take 15 minutes.

Nominally, a new target acquisition is required after 10,000 seconds to compensate for target drift and to allow the observatory an opportunity to repoint the antenna. Repeating target acquisition may affect precise calibration more than target drift, so here we assume only one target acquisition per observation.

After target acquisition, 1-5 exposures will be obtained with minimum interruption between. Each observation will consist of hundreds to thousands of integrations. Each integration will have 2-38 groups, tuned to approach but not exceed saturation of the detector A/D converter. By rule individual exposures will not exceed 10000 seconds, *but longer exposures would be useful*. Exposure times are adjusted below this maximum to avoid exposure breaks near ingress or egress.

Transiting planets have well-defined ephemerides. Most known exoplanets have orbital periods of one to several days, implying tens of scheduling windows per year. Visits do not have an orientation constraint.

Given the flexibility of event-driven observations, the observatory may be ready to execute an exoplanet visit before the nominal start time. As soon as the preceding visit completes, the observatory should slew from the old attitude to the exoplanet-observing attitude. Slewing immediately allows slew-related mechanical and thermal transients to decay as much as possible before the high-precision exoplanet observation begins. The observer will be charged (at least statistically) for the time spent by the observatory waiting for the exoplanet transit or eclipse window to occur. The associated spreadsheet assumes an overhead of 15 minutes per observation, waiting for the observation to begin.

Transit observations will generally be obtained at short wavelengths where the star is bright, except where going to longer wavelengths is necessary to avoid saturation (e.g., HD 189733). Eclipse observations will be obtained at long wavelengths, where the planet is brighter and the star is fainter. Exposures will be obtained with high-resolution gratings to resolve spectral features, allow binning in wavelength to mitigate detector artifacts, and to increase slightly the bright limit. Thus, the nominal grating and filter combinations will be G140H/F100LP for transits and G395/F290LP for eclipses.

Exposures will be obtained with a 2048 x 32 pixel subarray. Spectra will curve on the detectors, but 32 pixels should be enough to record spectra from a point source well centered in the aperture. APT 19.4 assumes a frame time of 1.31 seconds for the DEFAULT subarray. The exposures in this program are based on a frame time of 0.968691 seconds, which is currently the best estimate for a 2048 x 32 subarray.

Because exoplanet hosts are bright, integrations will saturate after only a few frames. The NRSRAPID detector pattern (one frame per group, i.e. NFRAMES=1) will be used to record as many groups as possible without saturating. [Note: the A/D converter saturates at 64k ADU before charge fills the pixel wells.] Because the data rate for a subarray is 25% the data rate for a full-frame, NRSRAPID can be used indefinitely without exceeding the NIRSpec data volume allocation.

CONSTRAINTS:

Every visit has a PERIOD, ZERO-PHASE, and PHASE special requirement. Periods are one to several days, so there will typically be many scheduling opportunities per year. ObsGroup1 has a transit observation and an eclipse observation for 23 different exoplanets spread over the entire sky, each with a different ephemeris. ObsGroup2 has 32 eclipse observations of the same exoplanet to build S/N, requiring many large slews to and from this target. ObsGroup3 has 3 phase curve observations that span one transit and one eclipse, requiring visits that are 16-24 hours in duration.

PARALLEL Observations possible (yes/no/pure parallel)?

No dithering is possible during exoplanet observations, so while parallel exposures would be quite deep, it would be difficult to correct for detector artifacts. Since exoplanet hosts are typically near the galactic plane, bright stars in the field could give rise to persistence in parallel instruments that are not shuttered.

COMMENTS:

AUTHOR/DATE: Jeff Valenti (valenti@stsci.edu)/2011-Dec-17; revised 2012-Mar-7 by W. Blair.

TITLE: Determining the Frequency of Hot Earths

ID: 93042

GOAL:

This project is to determine the frequency of hot earths in a given population. We note that the expected transit depth caused by a hot earth (R ~ 3 R_{Earth}) is ~ 0.1%, the expected transit duration is ~ 3 hours, and the expected orbital period is 1 to 5 days. We also note that for the minimum pixel-by-pixel reset+read time of (10.6+10.6=) 21.2sec, using F150W filter, saturation will be just avoided for stars with V ~17 for a G-type star. This is close to the turn-off magnitude for NGC 6791, making this an ideal target.

A reasonable way to achieve this goal therefore, is to monitor a nearby, rich, high-metallicity cluster, such as NGC 6791 ([Fe/H] ~ +0.4). The expected observations will be similar to the SWEEPS program towards the Galactic bulge (Sahu et al. 2006) or the 47-Tuc monitoring program (Gilliland et al. 2001), where a rich stellar field was monitored continuously for about a week. Hot-earths can be detected with 10-sigma detection in such an observational scenario. Monitoring of 2000 to 5000 stars can potentially lead to the detection of ~20 hot earths (where we assume that 10% of the earth-size planets are "hot earths", and 10% of them transit), perhaps further boosted by the higher metallicity of the cluster. Being able to reach to a few Earth radii as the limit for planet size, and determining the frequency of such planets would certainly be worthwhile experiment that is likely to be carried out with JWST.

Since the expected transit duration is ~ 1 to 3 hr, the observations need to be continuous so that no transits will be missed. The observations should be preferably carried out in 2 filters, which serve as a guard against astrophysical false positives (such as star spots and binaries), as demonstrated by the SWEEPS data.

We note that ICDH [ISIM (Integrated Science Instrument Module) Command and Data Handling] hardware is capable of co-adding up to 16 frames (in powers of 2) of a maximum of 5 SCAs. Since we need to monitor a large number of stars, 5 detectors need to be used simultaneously for the monitoring program.

NOMINAL ALLOCATION (hours): 105

ACTUAL TIME (hours): 105

TARGET:

NGC 6791

OBSERVING TEMPLATES:

NIRCam Imaging

OBSERVATION DETAILS:

Observations are carried out for a continuous period of 105 hours. We use RAPID readout pattern with N_GROUP=2 and N_INT=460, resulting in 9752 sec of integration time per exposure. 38 such exposures can be taken in 105 hours.

CONSTRAINTS:

N/A.

PARALLEL Observations possible (yes/no/pure parallel)?

Possible to do parallel observations with NIRISS which will increase the efficiency of the detection of hot Earths.

COMMENTS:

Additional Capabilities Needed (for 3040 and 3042):

1. In order to keep the data volume within limits, it must be possible to operate single detectors (hereafter referred to as Single Chip Arrays, or SCAs) in the short wavelength (SW) and long wavelength (LW) channels, both in subarray and full-frame modes.
2. An on-board averaging capability from 2 to 16 frames in powers of 2 is necessary.
3. Grism needs to be implemented in APT.
4. Weak lenses need to be supported for exoplanet transit studies.
5. Program 3042 (monitoring of a cluster) can be best done with sub-pixel dithering in different integrations. That is, the targets must stay within 0.5 pixels in all integrations, but must be dithered by a sub-pixel. This facility will be useful to achieve high S/N in difference image analysis.

AUTHORS/DATE: Kailash Sahu (ksahu@stsci.edu) 1/3/12

TITLE: Imaging and Spectroscopy of Transiting Exoplanets - MIRI

ID: 93044

GOAL:

The primary goal of this program is to characterize a few interesting exoplanets, with an emphasis on giant, Neptune-sized, and mini-Neptune planets. Planets as small as Earth with M star hosts may also be good targets if they have H-dominated (large scale height) atmospheres. Mid-IR imaging and spectroscopy in and out of transit and eclipse, and as a function of orbital phase, will be used to determine (i) the average temperatures and profiles, (ii) surface temperatures , (iii) atmospheric compositions, and (iv) heat transfer of the exoplanets.

NOMINAL ALLOCATION (hours): 40

ACTUAL TIME (hours): 125 (See Table)

TARGET(S):

We use the currently known list of transiting exoplanets for our targets (203 transiting planets). These do not include and Earth-sized planets observable with JWST, but we hope and expect that such planets will be discovered in the coming years. We have chosen targets that span a variety of masses, surface gravities, stellar insolations, and are likely to show spectral features that would be useful in diagnosing their atmospheric compositions, temperature profiles, and thermal emissions/heat transfer in a single transit or eclipse observation.

The details of the targets are given in table 1. The first 9 in the list are slitless LRS observations, and the last one is a photometric observation. The Table also lists the transit and eclipse durations, which are in the 1 - 3 hour range.

Planet	Star SpT	V* (mag)	V-N (mag)	mJy Fnu (10um)	t_trans (m)	t_ecl(m)	t* (#events)	# trans	# eclipse	total (hr)
HD 189733b	K1.5	7.7	1.96	215	110	110	2	1	1	12.2
HD 209458b	G0V	7.7	1.42	131	144	144	2	1	1	15.6
HD8606b	G5	8.9	1.60	51	728	101	2	0	1	5.6
TrES-3	G (T=5720K)	12.4	1.54	2	78	78	2	0	1	4.5
WASP-12b	G0V	11.7	1.42	3	162	162	2	0	1	8.7
WASP-17b	F6	11.6	1.23	3	262	262	2	1	1	27.4
WASP-18b	F9	9.3	1.39	29	135	135	2	1	1	14.7
GJ 436b	M2.5V	10.7	4.68	166	60	60	2	1	1	7.2
GJ1214b LRS	M4.5V	14.7	6.10	15	50	50	6	0	4	10.7
GJ1214b MIRIM	M4.5V	14.7	6.10	15	50	50	8	0	8	18.1
TOTAL										**125**

OBSERVING TEMPLATES:

MIRI Imaging, MIRI-LRS

OBSERVATION DETAILS:

The observations are mainly designed for spectroscopic monitoring around transits and eclipses with the LRS in slitless mode, and for some photometric monitoring to detect the thermal emission from exoplanets in habitable zones. Each transit and eclipse observation will begin 1 event period before the transit or eclipse event and will conclude 1 period after the event. All host stars are very bright, so the SLITLESSPRISM subarray will be used. Some targets may still be too bright to be observed with this subarray.

Transiting planets have well-defined ephemerides. Most known exoplanets have orbital periods of one to several days, implying tens of scheduling windows per year.

CONSTRAINTS:

Every visit has a PERIOD, ZERO-PHASE, and PHASE special requirement. Periods are one to several days, so there will typically be many scheduling opportunities per year.

PARALLEL Observations possible (yes/no/pure parallel)?
The whole program could in principle be done with a parallel program deep imaging program.
COMMENTS:
AUTHOR/DATE: Kailash Sahu + Tom Greene

TITLE: Search for giant planets in the Taurus star-forming regions

ID: 93050

GOAL:

The identification and characterization of planets in star-forming regions can uniquely address several important questions. Looking for such newborn planets is the only way to uncover a pristine planet population, unaffected by dynamical evolution that is expected to occur over the first tens of Myr. This primordial population is a direct tracer of the planet formation mechanism. Also, by comparing results in star-forming regions with results from studies of older stars, this further allows studying the dynamical evolution process itself. The study of planets at these young ages also allows probing the timescale for planet formation, expected to be 1-10 Myr for giant planets. Also, the ability to study planets at a well-established age in a regime where evolution models are poorly constrained is useful to calibrate the evolution models and understand the early evolution of giant planets.

The goal of this proposal is to find young gas giant planets at 10-50 AU around stars of various masses in the Taurus star-forming region (1-2 Myr, ~150 pc). The proposed NRM observations will typically be >50% complete for planets of >1 Mjup at >10 AU. Because of the optical faintness of the target stars, these observations will not be possible from the ground using extreme adaptive optics systems.

NOMINAL ALLOCATION (hours):

From spreadsheet.

ACTUAL TIME (hours):

180 hours (150 hours for the first observation of the 100 targets, plus 30 hours for the follow-up of ~5 planets in two additional filters).

TARGET(S):

100 stars (~0.2-1.5 Msun) in Taurus. Typical M band magnitudes between 7 and 11. The coordinates of all targets are close to RA=4h40, DEC=+25.

OBSERVING TEMPLATE:

NIRISS NRM

OBSERVATION DETAILS:

The initial observations for this project would be made in only one of the three red medium band filters of NIRISS, likely F430M. A typical observing sequence would be the following.

1. select NRM element

2. select desired filter

3. perform a Target Acq

4. repeat 9-25 times

4.1. take several exposures

4.2. dither

The observations will use either the 256x256 or 512x512 subarrays with the TFIRAPID or TFI readout patterns, depending on the target magnitude. Each target will be observed at 9 (up to 25) dither positions, and at each position several exposures will be acquired successively, always keeping the brightest PSF pixel close to but below 70000 electrons. Each observing sequence will amount to 90 minutes total (clock time).

Any planet detection made will require follow-up observations in the other two filters for characterization. The observing approach will be identical to above.

CONSTRAINTS:

NRM observations require the observations of calibrator stars, ideally of similar spectral type and brightness, and to be acquired close in time. For this program, these calibrators will be other targets from the program, so it would be good when possible to plan observation of two or three targets successively in a group.

PARALLEL Observations possible (yes/no/pure parallel)?

Yes.

COMMENTS:

For the spreadsheet, 100 targets were selected from Luhman et al. 2010, ApJS, 186, 111 with RA between 67<RA<72 degrees and 23<Dec<27 degrees. Coordinates and K band mags were grabbed from SIMBAD, and acquisition fluxes were computed from the K band magnitudes assuming 0 color correction. Target acquisition is put in with F430M for all the targets and just a single ramp. SUB128 is used if the target was brighter than K=9 and SUB256 if the target is fainter. The number of reads and iterations is set to give a total exposure time of 3600s for each source and have no more than 30 reads, where the number of reads was taken to be INT(10-0.4(M-K)) with M=8 for SUB256 and M=6.6 for SUB128. This is just a rough guess to provide some variety in the readout subarrays and NINTS so that any data volume studies have some semi-realistic variety. Every source is viewed at 25 dither positions.

Three additional fake reference stars were added, and linked so that a given reference is used for 10 successive targets. There should be no telescope rephrasing between target and reference. Coordinates and K band mags were grabbed from SIMBAD, and acquisition fluxes were computed from the K band magnitudes assuming 0 color correction.

This program is a clear candidate for “cluster targets,” since the stars are all relatively close together.

AUTHOR/DATE:

David Lafrenière, March 21, 2012. STScI contact Harry Ferguson.

TITLE: Long wavelength follow-up of planets found by ground-based extreme adaptive optics planet finders

ID: 93051

GOAL:

New instruments specialized for direct exoplanet imaging will begin operation in the next year or so. Probably the two most important such instruments are the Gemini Planet Imager (GPI) and the Spectro-Polarimetric High-contrast Exoplanet REsearch instrument (SPHERE, for the VLT). These instruments will probe angular separations of 0.1”-1” at very high contrast (10^{-7}:1) and detect and characterize giant exoplanets at wavelengths of 1.0-2.5 µm. Both GPI and SPHERE will be mostly used for large campaigns, to occur over the 2013-2018 periods, and will be over when JWST begins its operation. Monte Carlo simulations indicate that these two main surveys should uncover about 100 new planets with masses of 1-10 MJup and semi-major axes of 5-40 UA.

These new planets will have been well characterized over 1-2.5 µm, the operating wavelength range of both instruments, but not at longer wavelengths. However, the 2.5-5.0 µm region contains a significant fraction of the planets flux and is quite important for atmospheric characterization and accurate luminosity measurements. At L’, ground-based NRM observations can reach contrast of 7-8 mag and a limiting magnitude of about 14, insufficient to detect most planets. The long wavelength characterization of the GPI (and SPHERE) planets will thus likely be impossible to accomplish from the ground. Many of the GPI (and SPHERE) planets will be inside the IWA of the JWST coronagraph, and thus will be observable with JWST only with the NIRISS NRM. This proposal is to do precisely that: acquire photometric measurements at 3.8-4.8 microns for giant planets previously discovered from the ground but uncharacterized at long wavelengths.

NOMINAL ALLOCATION (hours):

ACTUAL TIME (hours):

75 hours (15 targets, each target observed for 2 hours in three filters, plus observations of 5 calibrators).

TARGET(S):

15 planets detected by GPI or SPHERE that fall inside the IWA of the NIRCam coronagraph and have expected contrasts within the reach of NIRISS NRM at ~4 microns. The target magnitudes at L and M will be between 5 and 8.5. The targets will be spread across the whole range of right ascension and will be at declinations below +20.

OBSERVING TEMPLATE:

NIRISS NRM

OBSERVATION DETAILS:

A typical observing sequence would be the following.

1. select NRM element
2. select desired filter
3. perform a Target Acq
4. repeat 9-25 times

4.1. take several exposures

4.2. dither

5. switch filter

6. go back to 3.

The observations will use either the 128x128 or 256x256 subarray with the TFIRAPID readout patterns. Each target will be observed at 9 dither positions, and at each position several exposures will be acquired successively, always keeping the brightest PSF pixel close to but below 70000 electrons. Each observing sequence in a given filter will typically amount to 2 hours total (clock time).

The observations will be repeated in three filters (F380M, F430M and F480M) for each target.

In addition to the targets, 5 calibrator stars will be observed using identical sequences.

CONSTRAINTS:

NRM observations require the observations of calibrator stars, ideally of similar spectral type and brightness, and to be acquired close in time. For this program, we plan on having 5 such calibrators for the 15 targets, so the same calibrator will be used for about 3 targets. Thus it would be good to plan observations in groups of four (three targets plus one calibrator).

This strategy may or may not be practical given the limited field-of-regard of JWST.

PARALLEL Observations possible (yes/no/pure parallel)?

Yes.

COMMENTS:

For the spreadsheet, random stars with $7<V<9.5$ and $6.5<K<10$ were selected with dec < +20. Each filter was given 1800s of exposure time. Target acquisition is put in with F430M for all the targets and just a single ramp. The number of reads was taken to be $\mathrm{INT}(10^{-0.4(M-K)})$ with M=6.6 for SUB128. Given the limiting magnitudes for GPI and SPHERE, small subarrays are probably going to keep the readout times short enough. The spreadsheet has strawman timing links between targets and reference stars that probably will not work in practice given the JWST field of regard.

AUTHOR/DATE:

David Lafrenière, March 21, 2012. STScI contact Harry Ferguson.

TITLE: Search for giant planets around young low-mass stars

ID: 93052

GOAL:

In the next few years ground-based imaging surveys for exoplanets will mainly probe solar or higher mass stars, as they are brighter and thus amenable to extreme adaptive optics observations. These surveys will fully bridge the gap in semi-major axis with indirect techniques and provide a complete picture of the giant planet population around solar and higher mass stars. The giant planet populations at large separations (few to tens of AUs) around low mass stars will remain unconstrained however, as they are too faint for extreme adaptive optics observations. Fortunately, it will be possible to observe these stars with the NIRISS NRM and search for planets in the relevant regime of mass and semi-major axis. This will allow us to determine how often and where do gas giants form around low-mass stars compared to more massive ones, which in turn will greatly help us understand the planetary formation process. NIRISS NRM will be able to detect planets of 1-3 MJup at separations of 3-20 AU around young (10-100 Myr) nearby (10-75 pc), low-mass stars (0.1-0.5 Msun). Thus NIRISS NRM offers a good, and possibly the only, means of probing the same orbital separation for low-mass stars as specialized ground-based instruments (GPI/SPHERE) will probe for more massive stars. In addition, these observations might have the sensitivity to detect molten rocky planets afterglow, following a collision by a large planetesimals.

NOMINAL ALLOCATION (hours):

From spreadsheet.

ACTUAL TIME (hours):

75 hours (50 targets, each target observed for 90 minutes in one filter).

TARGET(S):

50 young M stars (10-100 Myr, 0.1-0.5 Msun) spread across the sky. Typical M band magnitudes between 7 and 11.

OBSERVING TEMPLATE:

NIRISS NRM

OBSERVATION DETAILS:

The initial observations for this project would be made in only one of the three red medium band filters of NIRISS, likely F480M. A typical observing sequence would be the following.

1. select NRM element

2. select desired filter

3. perform a Target Acq

4. repeat 9-25 times

4.1. take several exposures

4.2. dither

The observations will use either the 256x256 or 512x512 subarrays with the TFIRAPID or TFI readout patterns, depending on the target magnitude. Each target will be observed at 9 (up to 25) dither positions, and at each position several exposures will be acquired successively, always keeping the brightest PSF pixel close to but below 70000 electrons. Each observing sequence will amount to 90 minutes total (clock time).

CONSTRAINTS:

NRM observations require the observations of calibrator stars, ideally of similar spectral type and brightness, and to be acquired close in time. For this program, these calibrators will be other targets from the program, so it would be good when possible to plan observation of two or three targets successively in a group.

PARALLEL Observations possible (yes/no/pure parallel)?

Yes.

COMMENTS: For the spreadsheet, SIMBAD was used to select M stars with high proper motions and/or parallaxes, and with 7.5<K<11. These were then grouped by RA & Dec, and a guess was made as to which might be able to be observed at the same time. There were 6 in the that didn't have other nearby targets in the list, so 6 reference stars were made up with positions within about 2.5 degrees of each of those targets. Target acquisition is put in with F480M for all the targets and just a single ramp. SUB128 is used if the target was brighter than K=9 and SUB256 if the target is fainter. The number of reads and iterations is set to give a total exposure time of 4320s (90 minutes on target at 80% efficiency) for each source and have no more than 30 reads, where the number of reads was taken to be INT(10-0.4(M-K)) with M=8 for SUB256 and M=6.6 for SUB128. This is just a rough guess to provide some variety in the readout subarrays and NINTS so that any data volume studies have some semi-realistic variety. Every source is viewed at 25 dither positions.

AUTHOR/DATE:

David Lafrenière, March 21, 2012. STScI contact Harry Ferguson.

TITLE: Transit spectroscopy of a habitable Earth-like planet around an M dwarf

ID: 93053

GOAL:

Over the next few years, based on large campaigns such as SPIROU (near-infrared radial velocity survey), it is highly likely that a few transiting, habitable Earth-like planets will be found. The atmospheric composition of those planets can be probed with NIRISS transit spectroscopy (0.6-2.5 μm simultaneous coverage), and molecules such as H_2O and CO_2 could potentially be detected. This proposal is to observe the most favorable of these transiting habitable Earth-like planet to characterize its atmosphere. The goal is to reach a 1σ accuracy of 10 ppm per resolution element at a resolving power of 150, sufficient to detect H_2O with confidence.

NOMINAL ALLOCATION (hours):

From spreadsheet.

ACTUAL TIME (hours):

138 hours (2 target observed 12 times each for 5.75 h per visit)

Given the parameters of the star and planet (see below), a S/N of 13500 is reached per resolution element at R=700 for each visit, equivalent to a S/N of 29000 at R=150. To reach the goal of 10^5 at R=150, 12 visits are needed.

TARGET(S):

2 M dwarfs harboring a transiting Earth-like planet. Such targets are still unknown but for this exercise we assume the targets to be 0.25 Msun stars (~M4-M5), for which the habitable zone is at separation ~0.1 AU (orbital period 23 days); we assume that the planet lies precisely at this separation. At 10 pc, the targets would have V=12 and J=9. Assuming that they are to be found with SPIROU, they would have a northern declination.

Given this stellar mass and planet semi-major axis, assuming a circular orbit, the transit duration would be 2.54 h for the flat part (T23), and 2.69 h for the full transit (T14). The transit depth would be 0.0008.

OBSERVING TEMPLATE:

NIRISS G700XD

OBSERVATION DETAILS:

The observations will begin with a target acquisition to position the star precisely at a predefined location (specific to G700XD observations) on the array. Then the G700XD element will be inserted into the beam. We assumed 15 minutes are needed to complete this.

A long, uninterrupted sequence of several exposures will then be acquired spanning 5.5 hours and approximately centered on the mid-transit time. To keep the maximum pixel signal below 50000 e-, the individual exposure time will be 31.8 s (26.5 s effective integration time), using the 256x2048 subarray (t_{frame}=5.3 s) with TFIRAPID readout and N_{group}=6. Accounting for overheads, each exposure will require 40 s. For the 5.5 h sequence, a total of 495 exposures will be required. No dithers will be performed.

This observing mode requires the observation of calibrators, likely bright white dwarfs with a well-modeled spectrum, to monitor the flat field and wavelength solution. These observations need not be done every time a target is observed, but only once a month or so as a baseline calibration for the observatory. We did not account for the time needed for this calibration here.

CONSTRAINTS:

The observations must be scheduled such that the middle of the sequence occurs within about 1 hour of the mid-transit time. Over a 1.5 year period, there will be 23 transit events per target; 12 of those need to be observed.

PARALLEL Observations possible (yes/no/pure parallel)?

Yes, but not dithers possible.

COMMENTS: For the spreadsheet, two M stars were selected with K~9. One was given a 20 day period, the other a 30 day period. Plausibly small intervals for the phase of the transit were selected.

AUTHOR/DATE:

David Lafrenière, April 5, 2012. STScI contact Harry Ferguson.

TITLE: Transit spectroscopy of exoplanets with NIRISS

ID: 93054

GOAL:

Characterize the atmosphere (composition and structure) of several exoplanets using NIRISS transit spectroscopy, which provides a 0.6-2.5 μm simultaneous coverage with a resolving power of 700. For these observations, the goal is to reach a S/N or 10000 per resolution element for differential in/out of transit spectroscopy.

NOMINAL ALLOCATION (hours):

From spreadsheet.

ACTUAL TIME (hours):

125 hours (15 targets, each observed for 2X the transit duration, four are observed twice, one is observed 4 times)

TARGET(S):

15 transiting exoplanet systems: the five brightest systems with a hot Jupiter (0.1-2 M_{Jup}), the five brightest with a hot Neptune (10-30 M_{Earth}), and the five brightest with a hot super-Earth (2-10 M_{Earth}). Targets brighter than J=7 are not considered as they would saturate the array. With the current sample of known exoplanets the targets would be for hot Jupiters: HD 149026 b, WASP-7 b, HAT-P-8 b, HAT-P-1 b, and HAT-P-30 b; hot Neptunes: Kepler-21 b, HAT-P-11 b, Kepler-10 c, HAT-P-26 b, and Kepler-19 b; super-Earths: Kepler-10 b, CoRoT-7 b, GJ 1214 b, Kepler-20 b, and Kepler-11 e.

The desired S/N can be reached for all but 5 targets in a single visit. For Kepler-19 b, CoRoT-7 b, GJ 1214 b, and Kepler-20 b, two visits will be needed, while for Kepler-11 e 4 visits will be needed.

OBSERVING TEMPLATE:

NIRISS G700XD

OBSERVATION DETAILS:

The observations will begin with a target acquisition to position the star precisely at a predefined location (specific to G700XD observations) on the array. Then the G700XD element will be inserted into the beam.

A long, uninterrupted sequence of several exposures will then be acquired spanning twice the transit duration (to get sufficient off-transit baseline coverage) and approximately centered on the mid-transit time. Individual sequences will typically last for 3-6 hours. The maximum pixel signal will be kept below 50000 e- by adjusting the individual exposure times. The 256x2048 subarray (t_{frame}=5.3 s) will be used with, typically, a TFIRAPID readout mode.

This observing mode requires the observation of calibrators, likely bright white dwarfs with a well-modeled spectrum, to monitor the flat field and wavelength solution. These observations need not be done every time a target is observed, but only once a month or so as a baseline calibration for the observatory. We did not account for the time needed for this calibration here.

CONSTRAINTS:

The observations must be scheduled such that the middle of the sequence occurs within about 1 hour of the mid-transit time. The orbital periods of the target planets are a few days at most, so there are plenty of opportunities for observations.

PARALLEL Observations possible (yes/no/pure parallel)?

Yes, but dithers are not possible.

COMMENTS: For the spreadsheet, the desired time for each source was set to 30ks * 10^(0.15*(K-9.1)), where K is the K magnitude either taken from 2MASS or a guess from a V mag. For some sources, the total integration can't be reached in a single transit, so the observations are spread over multiple transits, taking the time per transit to be twice the transit duration. Visits of more than 10ks duration were broken up into equal chunks of integration time. The number of reads was taken to be 10^(-0.4*(7-K)) for G700sub and 10^(-0.4*(5.5-K)) for G700sub4, with a minimum of 1 read before going to the smaller subarray. The resulting number of transits, visits per transit, and the readout pattern are listed in the table below. For the phasing, of the observations, a random fraction of the period was added to JD 2458547.5, and the phase start and end were set to encompass twice the transit duration.

Name	Period (days)	Transit Duration (min)	Texp	# transits	Texp per transit	Pattern	Nread	Nint	Nvisit
HD149026-b	2.876	190	13650	1	13650	G700sub4	3	1690	2
GJ1214-b	1.58	52	26861	5	6240	G700sub	5	236	1
COROT7-b	0.854	75.1	38337	5	9012	G700sub	13	131	1
WASP-7-b	4.955	220	23557	1	23557	G700sub	4	371	3
HAT-P-8-b	3.076	250	28485	1	28485	G700sub	6	299	3
HAT-P-1-b	4.465	150	27047	2	18000	G700sub	5	340	2
HAT-P-30-b	2.811	130	30523	2	15600	G700sub	7	211	2
Kepler-21-b	2.786	206	14276	1	14276	G700sub4	4	1326	2
HAT-P-11-b	4.888	135	14575	1	14575	G700sub4	4	1353	2
Kepler-10-c	42.295	412	34445	1	34445	G700sub	10	163	4
HAT-P-26-b	4.235	147	35410	3	17640	G700sub	11	152	2
Kepler-19-b	9.287	202	57826	3	24240	G700sub	30	51	3
Kepler-20-b	3.696	180	55863	3	21600	G700sub	30	46	3
Kepler-11-e	31.996	260	146934	5	31200	G700sub	30	50	4

AUTHOR/DATE:

David Lafrenière, April 5, 2012. STScI contact Harry Ferguson.

TITLE: Phase curves of hot Jupiters with NIRISS

ID: 93055

GOAL:

Characterize the emission spectrum of hot Jupiters as a function of orbital phase with NIRISS spectroscopy (0.6-2.5 µm simultaneous coverage with a resolving power of 700). This will inform us about the planet temperatures, atmosphere structure, heat redistribution, and composition. For these observations, the goal is to reach a S/N or 30000 per resolution element for each visit.

NOMINAL ALLOCATION (hours):

From spreadsheet.

ACTUAL TIME (hours):

95 hours (5 targets, each observed 6 different orbital phases)

TARGET(S):

5 brighest stars (with J>7) with a transiting hot jupiters: HD 149026, HD 17156, WASP 33, HAT-P-2, and WASP-18.

The desired S/N can be reached in 1.1, 1.1, 1.7, 2.1 and 3.6 hours for the above targets, respectively.

OBSERVING TEMPLATE:

NIRISS G700XD

OBSERVATION DETAILS:

The observations will begin with a target acquisition to position the star precisely at a predefined location (specific to G700XD observations) on the array. Then the G700XD element will be inserted into the beam.

A long, uninterrupted sequence of several exposures will then be acquired; the corresponding times are given above. The maximum pixel signal will be kept below 50000 e- by adjusting the individual exposure times. The 256x2048 subarray (t_{frame}=5.3 s) will be used with a TFIRAPID readout mode.

Each target will be observed at 6 different orbital phases, one of which will coincide with the primary transit and one with the secondary eclipse. For the observation covering the primary transit and secondary eclipse, the sequence duration will be modified to last for twice the transit/eclipse duration, such that differential spectroscopy can be done.

This observing mode requires the observation of calibrators, likely bright white dwarfs with a well-modeled spectrum, to monitor the flat field and wavelength solution. These observations need not be done every time a target is observed, but only once a month or so as a baseline calibration for the observatory. We did not account for the time needed for this calibration here.

CONSTRAINTS:

The observations must be scheduled such that the middle of the sequence occurs within about 1 hour of the mid-transit time.

PARALLEL Observations possible (yes/no/pure parallel)?

Yes, but not dithers possible.

COMMENTS: For the spreadsheet, the desired time for each source was set to 2x the transit duration for both eclipse and transit. For the other phases, it was set to 1.1, 1.1, 1.7, 2.1 and 3.6 hours, respectively, for the different targets. Visits of more than 10ks duration were broken up into equal chunks of integration time. The number of reads was taken to be 10^(-0.4*(7-K)) for G700sub and 10^(-0.4*(5.5-K)) for G700sub4, with a minimum of 1 read before going to the smaller subarray. The resulting exposure times and readout patterns are listed in the table below. For the phasing, of the observations, a random fraction of the period was added to JD 2458547.5, and the phase start and end were set to encompass 1.2 times the exposure time (to account for overhead), centered on the desired phase.

Name	Period	Duration (min)	Texp transit	Texp non-transit	Pattern	Nread
HD149026-b	2.876	190	22800	3960	G700sub4	3
HD17156b	21.216	188.6	22633	3960	G700sub4	3
WASP33-b	1.22	163	19560	6120	G700sub	2
HAT-P-2-b	5.633	254.9	30588	7560	G700sub	2
WASP-18-b	0.941	128.6	15432	12960	G700sub	3

AUTHOR/DATE:
David Lafrenière, April 5, 2012. STScI contact Harry Ferguson.

Galactic Programs

TITLE: Scattered Light Mapping of Debris Disks

ID: 93020

GOAL:

Spatially resolved, scattered light maps of debris disks can be used to constrain dust properties (composition, size, distance from central star) and therefore to infer the dynamics of dust grains and place constraints on the presence of low mass planets at large distances in exo-planetary systems. The JWST/NIRCam medium band filter set is expected to provide (for the first time) high resolution, high contrast imaging in the 3 mm water ice feature and at wavelengths > 4 mm. It will provide long-wavelength constraints on the scattered light SEDs of debris disks to determine the composition of dust grains and in particular allow mapping of water ice grains in debris disks as a function of position to determine the location of the snow line. Since the NIRCam coronagraph performance is expected to be approximately commensurate with that obtained by HST/ACS on-flight, initial NIRCam coronagraph observations of debris disks will focus on detailed characterization of disks that have already been detected and resolved in scattered light.

This program will obtain spatially resolved scattered light maps for a subset of 14 well studied, spatially resolved debris disks using NIRCam Coronagraphy in four filters: F210M, F300M, F335M, and F430M. The F210M and F335M filters will provide measurements of the disk surface brightness at wavelengths adjacent to the 3.0 mm water ice band (F300M) to determine whether an absorption feature is present. The measured surface brightness in the F430M filter can be compared with surfaced brightnesses measured using HST ACS, NICMOS, and STIS to measure the reflected light color and further constrain the composition of the dust. Since the central star is expected to be very bright compared to the faint disk surface brightness, all observations will be obtained in coronagraphic mode, using the sombrero-squared circular occulters.

NOMINAL ALLOCATION (hours): 120

ACTUAL TIME (hours): 140

Used Remi Soummer's Coronagraphy spreadsheet to estimate overheads. We assume one 30 min slew to each target and one 30 min slew to its corresponding reference star (because the majority of the reference stars are within 10° of their targets, we expect the true slew time to be ~15 min.) Target acquisition is required for NIRCam Coronagraphy.

Time (direct only) for NIRCam Coronagraphic targets is 36,200 sec per target (24,100 sec for the target and 12,100 for the reference star). Assuming 14 NIRCam Coronagraphic targets implies a total direct time of 506,000 sec for this program.

TARGET(S):

Well-characterized, spatially resolved debris disks in scattered light: HD 141569, HR 4796, HD 32297, Fomalhaut, beta Pic, HD 15745, HD 15115, HD 181327, HD 139664, HD 10647, HD 107146, HD 61005, HD 92945, and AU Mic.

OBSERVING TEMPLATES:

NIRCam Coronagraphy

OBSERVATION DETAILS:

Simulations of NIRCam coronagraphic performance suggest that bright disks, with fractional infrared luminosities, $L_{IR}/L_* > 1.6\times10^{-4}$, can be detected and spatially resolved in 5000 sec of exposure time (Krist et al. 2011). All of the targets proposed here are bright and the majority have fractional infrared luminosities larger than this fiducial target; therefore, we have assumed 5000 sec integration times for each of the proposed targets in each proposed filter.

Each NIRCam Coronagraphy target will be observed with the Mask210R/F210M, MASK335R/F300M, MASK335R/F335M, and MASK430R/F430M mask/filter combinations to map dust grain color as a function of position in the disk. Each target is observed at two telescope rolls. Including both rolls, each point in the FOV will possess a total observation time ~5000 sec per filter.

Since the JWST mirrors will be phased every two weeks, we have included observations of reference stars immediately before or after each of our NIRCam observations. Since the PSF is expected is change substantially at near-infrared wavelengths, observations of reference stars are critical for good PSF subtraction. Reference stars were selected to possess similar spectral types and V-band magnitudes as the target star and to be located within 10° of the target. The reference stars selected here are preliminary and do not necessarily possess optimum V-K color matches that are necessary for short wavelength NIRCam coronagraphy.

CONSTRAINTS:

Reference star observations must be executed back-to-back with target observations. Comment "SAME OBSERVATION" has been added on each Observation folder to indicate this. In addition, MIRI Coronagraphy observations possess orientation constraints on the target to ensure that the edges of the 4QPM or the bar in the Lyot Coronagraph do not overlap with disk structures. The two roll angle observations of targets in MIRI Coronagraphic mode must be offset by >8° to minimize the occulted region in both rolls.

PARALLEL Observations possible (yes/no/pure parallel)?

N/A

COMMENTS:

This is a program that is similar to a debris disk imaging program that was discussed by the NIRCam Science Team (discussion lead by J. Krist) that focuses on constraining grain composition from a similar filter suite.

There are currently 15-20 debris disks that have been resolved in either scattered light (HST); although, many more debris disks may be resolved using future facilities (e.g. Gemini/GPI and VLT/SPHERE). Once new objects have been identified with future facilities, this program may be expanded by a factor of 2.

AUTHORS/DATE: Christine Chen (cchen@stsci.edu)/16 Dec 2011

Dean Hines

James Muzerolle

Updated: 1/27/12

TITLE: Thermal Emission Mapping of Debris Disks

ID: 93021

GOAL:

Spatially resolved, thermal emission maps of debris disks can be used to constrain dust properties (composition, size, distance from central star) and therefore to infer the dynamics of dust grains and place constraints on the presence of low mass planets at large distances in exo-planetary systems. The excellent sensitivity and angular resolution of JWST/MIRI is expected to enable thermal emission mapping of nearly all debris disks around A-type stars within ~100 pc (Smith & Wyatt 2010); however, the overheads associated with observing are expected to be sufficiently high that the initial MIRI imaging observations of debris disks will focus on detailed characterization of already spatially-resolved disks. To date, approximately 15-20 debris disks have been spatially resolved in scattered light using HST and ~50 debris disks have been spatially resolved in thermal emission using space-based (Spitzer and Herschel) and ground-based (Gemini and VLT) facilities.

This program will obtain spatially resolved thermal emission maps for a subset of 20 well studied, spatially resolved debris disks using MIRI Imaging and Coronagraphy in two filters. Two is the minimum number of filters required to map disk color as a function of position. Debris disks around stars with F_n(24 mm) > 0.8 Jy are expected to saturate rapidly the MIRIM detector in direct imaging mode and will therefore be observed using the MIRI Four Quadrant Phase Mask and Lyot Coronagraphs. Debris disks around stars with F_n(24 mm) < 0.8 Jy are expected to be sufficiently faint that they can be observed in direct imaging mode, requiring less observatory time for target acquisition and fewer scheduling constraints.

NOMINAL ALLOCATION (hours): 60

ACTUAL TIME (hours): 64

Used (1) George Rieke's MIRI sensitivity spreadsheet to estimate exposure time, and (2) Karl Gordon's MIRI Imaging and Remi Soummer's Coronagraphy spreadsheets to estimate overheads. We assume one 30 min slew to each target and one 30 min slew to its corresponding reference star (because the majority of the reference stars are within 10 degrees of their targets, we expect the true slew time to be ~15 min.) No target acquisitions are needed for the MIRI Imaging observations; however, target acquisitions are required for MIRI Coronagraphic Imaging. Time (direct only) for MIRI Imaging targets is 8400 sec (4200 sec for the target and reference star each) and for MIRI Coronagraphic Imaging targets is 16200 sec (10700 sec for the target and 5500 sec for the reference star). Assuming 12 MIRI Imaging targets and 8 MIRI Coronagraphic Imaging targets implies a total direct time of 230,000 sec for this program.

TARGET(S):

Well-characterized, spatially resolved debris disks in scattered light: HD 141569, HR 4796, HD 32297, Fomalhaut, beta Pic, HD 15745, HD 15115, HD 181327, HD 139664, HD 10647, HD 107146, HD 61005, HD 53143, HD 92945, and AU Mic.

Subset of currently known, spatially resolved debris disks in thermal emission: epsilon Eri, Vega, gamma Oph, beta Leo, and beta UMa.

OBSERVING TEMPLATES:

MIRI Coronagraphy

MIRI Imaging

OBSERVATION DETAILS:

Since all of our targets have observed using Spitzer (IRS and MIPS), the 15 and 25.5 μm brightness of their central stars and the 15 and 25.5 μm unresolved disk fluxes have been measured. The approximate surface brightness of the disk can be estimated, SB = F_{ex}(25.5 mm)/(π D^2), where D is the measured angular size of the disk from either scattered light or thermal emission imaging. We estimate typical 25.5 mm surface brightnesses ~0.01 – 20 mJy/arcsec^2 for disks that are already spatially resolved at mid- to far-infrared wavelengths. We design the MIRI Imaging observations to obtain a SNR ~95 and ~25 for a disk with average surface brightness ~0.01 mJy/arcsec^2 at 15.0 and 25.5 mm, respectively. We design the MIRI Coronagraphic observations to obtain a SNR ~9 and ~33 for a disk with average surface brightness ~0.01 mJy/arcsec^2 at 15.5 and 24.0 mm, respectively.

Imaging: Each MIRI Imaging target will be observed with F1500W and F2550W filters using the FULL array to map dust grain color as a function of position in the disk. Each Imaging observation is dithered to mitigate for bad pixels using a subset of 5 points from the Cycling/Medium pattern. Including dithering, each point in the FOV will possess a total observation time 555 sec.

Coronagraphy: Each MIRI Coronagraphy target will be observed with the F1550C Four Quadrant Phase Mask and the F2300C Lyot Coronagraph to map dust grain color as a function of position in the disk. Each target is observed at two telescope rolls. Including both rolls, each point in the FOV will possess a total observation time 728.8 sec and 1033.6 sec at 15 μm and 25.5 μm, respectively.

Since the JWST mirrors will be phased every two weeks, we have included observations of reference stars immediately before or after each of our MIRI observations; however, the MIRI observations requested here are at such long wavelengths that they may be insensitive to mirror phase changes. Reference stars were selected to possess similar spectral types and V-band magnitudes as the target star and to be located within 10° of the target (if possible).

CONSTRAINTS:

Reference star observations must be executed back-to-back with target observations. Comment "SAME OBSERVATION" has been added on each Observation folder to indicate this. In addition, MIRI Coronagraphy observations possess orientation constraints on the target to ensure that the edges of the 4QPM or the bar in the Lyot Coronagraph do not overlap with disk structures. The two roll angle observations of targets in MIRI Coronagraphic mode must be offset by >8° to minimize the occulted region in both rolls.

PARALLEL Observations possible (yes/no/pure parallel)?

N/A.

COMMENTS:

This is a program that is similar to a debris disk imaging program that was discussed by the MIRI Science Team (discussion lead by K. Su and G. Rieke) that focuses on resolving disk structures indicative of the presence of planets and/or tracing out the snowline in debris disks.

There are currently 50+ debris disks that have been resolved in either scattered light (HST) or thermal emission (Gemini, Herschel, Spitzer, VLT) imaging and many more debris disks are expected to be resolved using future facilities (e.g. Gemini/GPI and VLT/SPHERE); therefore, this program could easily be expanded by a factor of a few.

AUTHORS/DATE: Christine Chen (cchen@stsci.edu)/16 Dec 2011

Dean Hines

James Muzerolle

Updated: 1/27/12

TITLE: Thermal Emission Spectroscopy of Debris Disks

ID: 93022

GOAL:

Mid-infrared spectroscopy of debris disks can be used to constrain dust properties (composition, size, crystallinity) and therefore to infer the nature of parent bodies and the evolutionary status of debris disks. For example, detailed analysis of the Spitzer IRS spectrum of HD 172555, an A7V member of the ~12 Myr β Pictoris Moving Group, has revealed the presence of glassy silicas found in impact and magmatic systems and possible SiO gas, indicating the presence of a recent giant, collision (Lisse et al. 2009). By contrast, detailed analysis of the spectrum of η Crv, a ~1.4 Gyr old F2V main sequence star, has revealed the presence of water and carbon-rich dust that may have been delivered to the inner Solar System by a primitive Kuiper Belt Object (Lisse et al. 2011). The excellent sensitivity and angular resolution of JWST/MIRI is expected to enable spectroscopic mapping of debris disks to search for gradients in grain properties that may be expected if debris disks possess multiple parent bodies belt or if dust grains are dynamically sorted by size (for example). The excellent spectral resolution of JWST/MIRI will enable sensitive searches for molecular and atomic gas that may either by the remnant of primordial gas or second-generation gas produced from the dust.

This program will obtain MIRI MRS (R~3000) spectra of (1) 10 debris disk systems with Spitzer IRS identified 10 μm silicate emission features to carry out detailed spectroscopic analysis of the dust, search for variability and SiO gas emission that may further indicate that giant collisions have occurred in these systems and (2) 4 spatially resolved debris disk systems to measure directly the SEDs of individual belts in multiple belt systems and to search for gradients in grain properties as a function of position. The spectra will be obtained using ALL three MRS grating settings to provide complete spectral coverage over the MIRI MRS wavelength range (5.0 – 30 μm).

NOMINAL ALLOCATION (hours): 20

ACTUAL TIME (hours): 35.2

Used (1) George Rieke's MIRI sensitivity spreadsheet to estimate exposure time, and (2) Karl Gordon's MIRI MRS spreadsheet to estimate overheads. We assume one 30 min slew to each target and one 30 min slew to its corresponding reference star (because the majority of the reference stars are within 10 of their targets, we expect the true slew time to be ~15 min). Target acquisition is required for MIRI MRS observations.

Time (direct only) for MIRI MRS targets is 9200 sec (4600 sec for the target and reference star each) with no mapping or dithering of any of the observations. Assuming 14 MIRI MRS targets implies a total direct time of 128,800 sec for this program.

TARGET(S):

Silicate Feature Targets: BD+20 307, HD 23514, zeta Lep, HD 69830, eta Tel, EF Cha, eta Crv, HD 113766, HD 145263, and HD 172555

Multiple Dust Belt Targets: beta Pic, Fomalhaut, epsilon Eri, and Vega

OBSERVING TEMPLATES:

MIRI MRS-IFU

OBSERVATION DETAILS:

Since all of our targets have been observed using Spitzer (IRS and MIPS), the brightnesses of their central stars and the unresolved brightnesses of the disks have been measured. The approximate surface brightness of the disk can be estimated, SB = F_{ex}(24 mm)/(π D^2), where D is the measured angular size of the disk from either scattered light or thermal emission imaging. We estimate typical 24 mm surface brightnesses ~1 – 20 mJy/arcsec^2 for disks that possess 10 μm spectral features or are very bright and extended. We design the MIRI MRS observations to obtain a SNR ~12 for a disk with average surface brightness ~1 mJy/arcsec^2 at 22.5 mm.

Each MIRI MRS target will be observed with ALL of the grating settings. For each grating setting, each point in the MRS FOV will possess a total observation time 555 sec.

At the current time, the observations include only one MRS field-of-view (FOV) per target; however, spatially resolved targets will need to be mapped by stitching multiple MRS FOVs together. In addition, for each FOV, the target should be dithered over a four-point pattern to improve spatial sampling in the sub-slice direction and to improve sub-pixel sampling in the dispersion direction for Channel 1.

Since the JWST mirrors will be phased every two weeks, we have included observations of reference stars immediately before or after each of our MIRI observations especially since accurate subtraction of the PSF at the shortest wavelengths may be necessary to reveal the spectrum of warm dust and gas. Reference stars were selected to possess similar spectral types and V-band magnitudes as the target star and to be located within 10° of the target (if possible).

CONSTRAINTS:

Reference star observations must be executed back-to-back with target observations. Comment "SAME OBSERVATION" has been added on each Observation folder to indicate this.

PARALLEL Observations possible (yes/no/pure parallel)?

N/A.

COMMENTS:

This is a program that is similar to a debris disk spectroscopy program that was discussed by the MIRI Science Team (discussion lead by K. Su and G. Rieke) that focuses on young debris disks that may be experiencing giant collisions during the end stages of terrestrial planet formation and on mapping silicate emission features in bright, extended disks.

To date, approximately 15-20 debris disks have been spatially resolved in scattered light using HST and ~50 debris disks have been spatially resolved in thermal emission using space-based (Spitzer and Herschel) and ground-based (Gemini and VLT) facilities. Many of these systems are large compared to the MRS Channel 1 and/or show evidence for multiple dust belt populations; therefore, this program could be expanded by a factor of 2-3.

AUTHORS/DATE: Christine Chen (cchen@stsci.edu)/16 Dec 2011

Dean Hines (STScI)

James Muzerolle (STScI)

Updated 1/27/12

TITLE: Imaging of Galactic Massive Star Forming Regions and Young Clusters

ID: 93060

GOAL:

This program will survey young massive clusters and star forming regions in the Milky Way, with the goal of determining YSO classifications and characterizing circumstellar disk emission for the full stellar mass range (and, in many cases, into the brown dwarf regime). A total of 11 regions have been selected, with distances ranging from ~ 2 to 7 kpc. The sample includes a range of cluster sizes, from thousands to tens of thousands of stars, and apparent ages ranging from <1 to ~5 Myr. The NIRCam images will be used primarily for characterization of very young and low mass stellar objects, as well as target identification for follow-up NIRSpec MSA observations (using the F187N filter in order to measure positions for the brightest possible stars). We selected 6 MIRI broad band filters in order to sample both dust continuum emission and 10 and 18 micron silicate features for the most detailed possible spectral energy distributions of protostars and Class II disked stars.

NOMINAL ALLOCATION (hours): 300

ACTUAL TIME (hours): 345

TARGET(S):

NGC 3603, RCW 49, M 16, M 17, Westerlund 1, NGC 3576, W43, W51A/B

OBSERVING TEMPLATE:

NIRCam imaging

MIRI imaging

OBSERVATION DETAILS:

Each region will be observed with the NIRCam and MIRI imagers, with mosaics covering the relevant areas (typically ~ 5' – 10'; see attached figure for an example). Short exposures will be used for all NIRCam filters in order to mitigate against saturation, but which ensure detection of stellar photospheres at all wavelengths for objects below the substellar limit in all target regions. Exposure times for MIRI imaging were estimated with the goal of reaching the stellar photosphere of a 1 Myr-old 0.1 Msun star at 5 kpc with S/N > 10 at 5-10 microns.

NIRCam setup:

short/long filters: F090W/F277W, F115W/F356W, F150W/F444W, F187N/F480M

both modules, full array, 3TIGHT primary dither with 3 subpixel positions

mosaics with 2-4 rows, 1 column, 10% overlap

RAPID readout, 3 groups, 1 integration for each filter

MIRI setup:

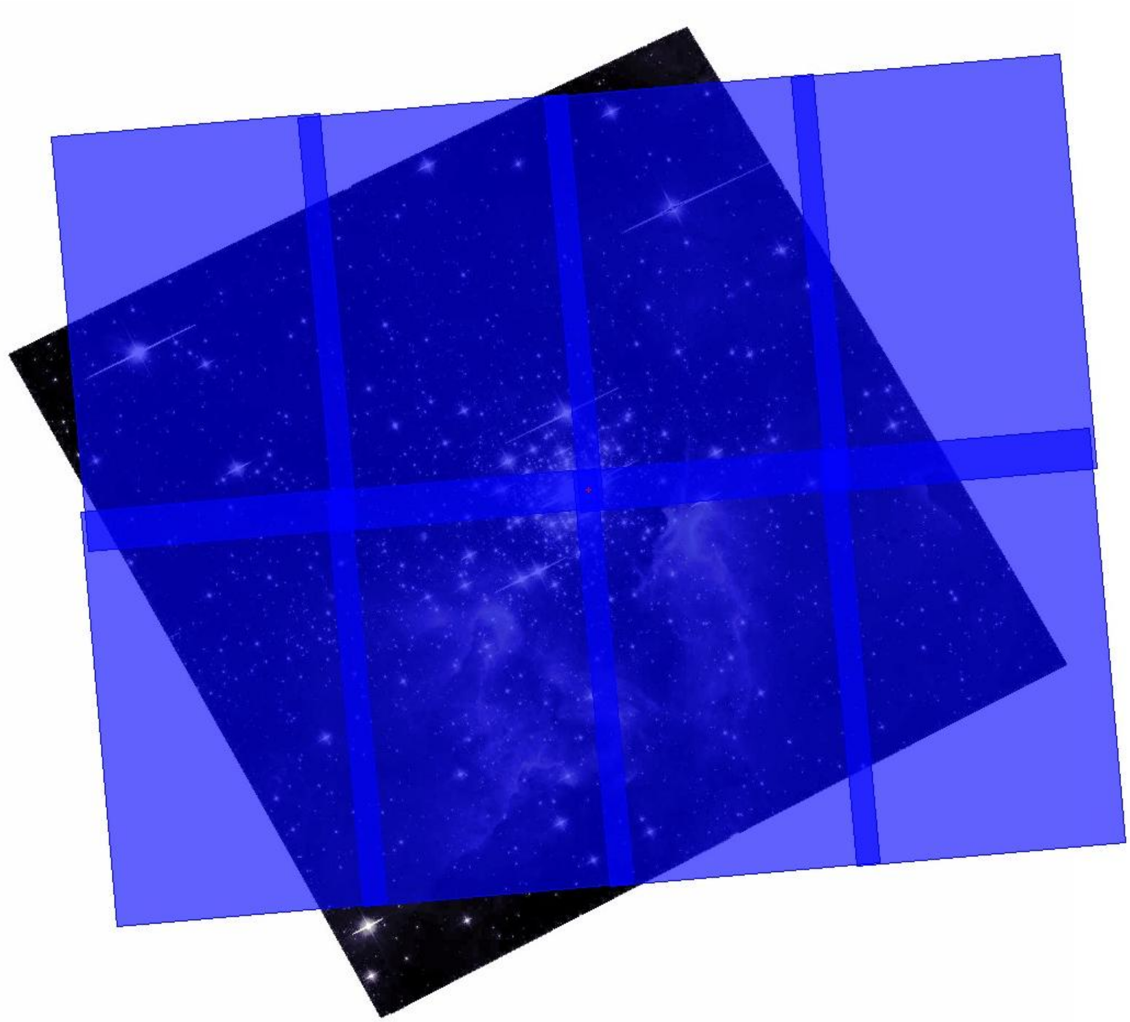
filters: F560W (FAST readout, 2 groups/int.), F770W (FAST readout, 4 groups/int.), F1000W (SLOW readout, 6 groups/int.), F1500W (SLOW readout, 6 groups/int., F1800W (SLOW readout, 6 groups/int.), F2550W (FAST readout, 6 groups/int.)

full array, cycling 5pt dither pattern

10 integrations per exposure for F2550W, 1 int./exp. for all other filters

mosaics sized for each target region, 10% row/column overlap

Two observations per target, one for each instrument. The observations are collected into separate observation folders. The total time estimate was calculated assuming that the 30 min. target slew would be charged to each of the two observations of each target. However, a single slew with observations by both instruments in sequence, would be more efficient, saving approximately 5.5 hours.



HST/WFC3 image of NGC 3603, with proposed MIRI mosaic FOV.

CONSTRAINTS: none

PARALLEL Observations possible (yes/no/pure parallel)? no

COMMENTS: The target sample is a representative selection, mostly chosen to span parameter space and require relatively small mosaics to cover.

AUTHOR/DATE: James Muzerolle (muzerol@stsci.edu)/ 14 Dec 2011

TITLE: MOS Spectroscopy of Galactic Massive Star Forming Regions and Young Clusters

ID: 93061

GOAL:

This program will follow up the photometric survey of young massive clusters and star forming regions in the Milky Way done in program 3060 by obtaining near-infrared spectra of a representative sample of stars from each region. The primary goals will be to determine spectral types and characterize stellar mass accretion and circumstellar disk emission for the full stellar mass range (and, in most cases, well into the brown dwarf regime). Spectroscopic targets will be selected from the same 11 regions observed in 3060, with distances ranging from 2 to 7 kpc, cluster sizes ranging from a few to ten thousand stars, and apparent ages ranging from <1 to ~5 Myr. The total number of targets for each region will be commensurate with the cluster size and selected in order to provide a statistical sampling of the mass function.

NOMINAL ALLOCATION (hours): N/A

ACTUAL TIME (hours): 325

TARGET(S):

NGC 3603, RCW 49, M 16, M 17, Westerlund 1, NGC 3576, W43, W51A/B

OBSERVING TEMPLATE:

NIRSpec MSASPEC

OBSERVATION DETAILS:

These observations are ideally suited to the NIRSpec MSA. Accurate coordinates for individual stellar targets, as well as reference stars for target acquisition, would be measured from the appropriate NIRCam images observed in program 3060. The dynamic range in brightness for these regions is extremely large (depending on the level of dust extinction, some 8 magnitudes or more separate the intermediate-mass stars from the brown dwarfs), so the samples must be broken up into separate brightness bins in order to avoid significant saturation. For this exercise, I assumed that putative candidate sets for each region would be split into two magnitude bins, “bright” and “faint”. Roughly 100/500 stars in the bright/faint bin should be feasible with 3/10 MSA target sets, respectively, which would provide a minimum statistical sampling in the most populous clusters of the sample. Each target set requires two MSA configurations because a wavelength gap-filling dither is required. The total time estimate assumes a total of 26 configurations for each region (6 bright and 20 faint); in reality, some regions would require more and some fewer depending on the stellar density and overall spatial extent, but this should provide a reasonable average estimate.

NIRSpec setup:

> gratings/filters: G140M/F100LP, G235M/F170LP
>
> 3-shutter slitlet pattern for each target, with appropriate dithers to nod the targets between each shutter (i.e., “NNOD=2”)
>
> the wavelength gap must be recovered (“WAVEGAP=yes”)
>
> bright target exposures: NRSRAPID readout, NGROUP=3, NINT=1
>
> faint target exposures: NRS readout, NGROUP=14, NINT=1

CONSTRAINTS: none

PARALLEL Observations possible (yes/no/pure parallel)? no

COMMENTS: The target sample is identical to program 3060, as this is meant to represent a follow-up program. The duration estimate includes only one 30 min. target slew per region, which is an underestimate since not all observations must or should be done contiguously.

AUTHOR/DATE: James Muzerolle (muzerol@stsci.edu)/ 9 Jan 2012

Time updated 3/2/12 per instructions from James (Blair)

TITLE: Imaging and Coronagraphy of Protoplanetary Disks

ID: 93070

GOAL:

Spatially resolved imaging of protoplanetary disks at a wide range of wavelengths will provide unprecedented constraints on dust grain growth and radial structure. The target sample is split into edge-on disks, which can be observed with direct imaging, and brighter less-inclined objects that must be observed with coronagraphy.

NOMINAL ALLOCATION (hours):

300

ACTUAL TIME (hours):

290

TARGET(S):

edge-on disks:

HV Tau C, HK Tau B, DG Tau B, V1213 Tau. 2MASS J04331650_2253204, 2MASS J15491551-2600501, Gomez' Hamburger, Orion 114-426, LkHa 263 C, 2MASS J16281370-2431391 (“Flying Saucer”)

coronagraphic disks:

GG Tau, FN Tau, GM Aur, HL Tau, V1079 Tau, UY Aur, AA Tau, CI Tau, CY Tau, DM Tau, DO Tau, TW Hya, HD 31293, HD 36910, HD 100546, CD 36-10010B, HD 142527, HD 150193, HD 169142, HD 97048, HD 319139, HD 31648, IM Lup, MP Mus, V1032 Cen, 2MASS J04324303+2552311, 2MASS J16270233-2437272

V1121 Oph, BP Psc

OBSERVING TEMPLATE:

NIRCam imaging

MIRI imaging

NIRCam coronagraphy

MIRI coronagraphy

OBSERVATION DETAILS:

The times in this program are still quite schematic, particularly for the coronagraphic specifications. The time estimate was calculated using a single prototype source for each part; in reality the sample will span a wide range of fluxes. However, the overheads largely dominate.

NIRCam imaging:

Short/long filters: F070W/F277W, F115W/F356W, F150W/F444W, F200W/F480M

128x128 subarray

duration per target = 0.35 hr

MIRI imaging:

Filters: F560W, F1000W, F1500W, F2550W

FAST readout, 38 groups/int.

5pt Gaussian dither pattern with subpixel sampling duration per target = 1 hr

NIRCam coronagraphy:

210R, 335R, 430R masks

RAPID readout, 10 groups/int., 1/4/12 int./exp.

Reference star observations

duration per target = 1.2 hrs

MIRI coronagraphy:

4-quadrant phase masks with F1065C, F1140C, F1550C filters

reference star observations

included 2 dither movements and TAs for placement of targets in two directions

duration per target = 6.8 hrs

CONSTRAINTS:

none

PARALLEL Observations possible (yes/no/pure parallel)?

no

COMMENTS:

Note that the "SAME OBSERVATION" comment has been added on the coronagraphy observations to keep the target and reference star observations together. The imaging portion of this program would also benefit by a capability for multi-instrument (sequential) observations of the same target. There is a reason to at least keep the imaging observations close in time to avoid impacts from stellar variability, but back-to-back observing is not a requirement.

AUTHOR/DATE: James Muzerolle (muzerol@stsci.edu)/ 16 Dec 2011

Updated: Feb. 3, 2012

TITLE: JWST survey of the Orion Nebula

ID: 93080

GOAL:

We will use NIRCAM and MIRI to survey the Orion Nebula Cluster, the richest young stellar cluster in the solar vicinity (414pc), over an area comparable to the HST Treasury Program at optical wavelengths. We will obtain a complete, unbiased sample of thousand of circumstellar disks in a variety of environments and evolutionary status, e.g. photoevaporated by external UV radiation (proplyds), by their central stars, or in a relatively quiescent status more germane to planet formation. The IR SEDs, reconstructed from 1 to 26 micron, will allow us to constrain the disk structure (flaring angle, gaps, dust settling,…) from a few stellar radii to beyond the habitable zone. We will use color-color diagrams to disentangle the population of young stars from reddened background sources and then reconstruct a reliable, unbiased IMF of the cluster, analyzing its variation vs. the distance from the center. We will discover an unknown but presumably significant number of infrared companions and free floating "Jupiters" down to 1 MJup. We will also trace embedded jets and HH objects from the youngest protostars, dusty "cometary tails" of photoevaporated mass loss, high density Class 0 cores, etc.

NOMINAL ALLOCATION (hours):

100

ACTUAL TIME (hours):

NIRCAM: 126.2 hr (NIRCAM) + 64.6 (MIRI)

TARGET(S): M42 (Orion Nebula)

OBSERVING TEMPLATE: NIRCam Imaging

OBSERVATION DETAILS:

NIRCAM;

SWC: 2 Filters (F115W, F200W) each 212s (Bright2/10) exposure

LWC: 2 Filters (F356W, F480M)

Pattern: 3 Point Tight + 2 pt tailor

Mosaic : 12 rows x 10 columns = 100 Tiles (visits)

Total obs. time: 212s x 2filter x 2smalldither x 3large dither x 120 visits = 84.8hr

Total time : [2,544s/visit (exposure) + 1,278s/visit (direct) + 722s/visit (indirect)] x100 visits = 166.5hr

Effiiency: 84.8/166.5= 0.51 (Next Target slews excluded, depending on scheduled with/without breaks)

MIRI:

4 filters: F770W, F1280W, F180W, F2550W

Readout Pattern: FAST, 10 groups, 4 integrations: 111s/filter

Pattern: For this wide field survey I require only 1 small dither move for bad pixel removal. Apparently this is not implemented in the current set of dither pattern, which have a minimum of 4 dither pointing.

Mosaic: 12 rows x 15columns=180 tiles (visits)

Obs Time: 111s x 4 filter x2 dither x180 visits = 44.4 hours

Total Time: [888s/visit (exposure) + 741s/visit(direct) + 308s/visit(indirect)] x 180 visits= 64.6hr

Effiiency: 44.4/64.6= 0.69 (Next Target slews excluded, depending on scheduled with/without breaks)

CONSTRAINTS:

none

PARALLEL Observations possible (yes/no/pure parallel)?

MIRI parallels would reduce the total observing time.

COMMENTS: For the MIRI wide field survey I require only 1 small dither move for bad pixel removal. Apparently this is not implemented in the current set of dither pattern, which have a minimum of 4 dither pointing.

AUTHOR/DATE: M. Robberto, Nov.30, 2011; updated Feb. 10, 2012

(Spreadsheets removed for SODRM Appendix use.)

TITLE: The Initial Mass Function at Sub-Stellar Masses

ID: 93090

GOAL:

Our proposed NIRCam survey will discover and characterize the substellar population (down to ~13MJup, the D-burning limit) in a variety of astrophysical environments. Understanding the initial mass funcion (IMF) of brown dwarfs is critical to clarify the role of D-burning vs. gravothermal contraction and accretion. These are the main mechanisms controlling the energy output of protostar and regulate the relative invariance of final stellar masses. We will use color magnitude and 2-color diagrams in F115W, F140M and F162M filters to determine Av , Teff and memberships across the whole BD domain. By probing 15 cornerstone regions of different age, environmental conditions and metallicity we will analyze how the IMF, and the characteristic stellar mass, may vary with the galaxy type and across the history of the universe.

NOMINAL ALLOCATION (hours):

300

ACTUAL TIME (hours):

324 hr

TARGET(S): LH95, NGC3603, 30Dor core, Westerlund 1, W3, Arches, W51, W2, NGC602, NGC346, Omega Cen, 47Tuc, S106, N80, MonR2

OBSERVING TEMPLATE:

OBSERVATION DETAILS:

NIRCAM;

SWC: 3 Filters (F115W, F140M, F182M) each 1144s (DEEP8/6) exposure

LWC: 2 Filters (F277W-1144s and , F356W-2x1144s)

Pattern: 3 Point Tight + 3 pt tailor (same as example 5.1 in Overhead document); Table A-3 fully applies here.

1144s x 3filter x 3smalldither x 3large dither x 2 tiles = 61,776s exposure = 17.16hr

Total time

15 targets x (17.16hr/target + 1.5hr/target (direct) + 3.0hr (indirect) = 324hr

CONSTRAINTS:

none

PARALLEL Observations possible (yes/no/pure parallel)?

Yes, MIRI

COMMENTS: exposure times could be tuned to the distance of the target.

AUTHOR/DATE: M. Robberto, Nov.30, 2011

TITLE: Revealing Outflows, Disks and Accretion Processes in High Mass Protostellar Objects (HMPOs)

ID: 93100

GOAL:

In this project, we will use MIRI + MRS and the NIRSpec IFU to map the environments of approximately three high mass protostellar objects (HMPOs) to reveal the spatially resolved structure and physics associated with the mass accretion and outflow processes. The goal is not only to get good S/N on continuum flux associated with the high mass protostars, but also understand gas and solid-state absorption features in the spectra that trace environmental chemistry and map spatially extended emission line species that reveal the disk and outflow properties. Additionally, observations of main sequence O/B stars show that they rarely (never) form in isolation. We will study the clustering properties of HMPO environments at this extremely young evolutionary state.

NOMINAL ALLOCATION (hours): 100

ACTUAL TIME (hours): 96.5

Using spreadsheets to calculate the time. Assuming one slew to each target and then mapping dithers with the MIRI and NIRSpec IFUs to generate a spectral datacube (as large as ~18"x18") at all 3 grating settings with MIRI, 2 grating settings with NIRSpec.

Total time for MIRI for 7x7 IFU mosaic on Target G11.94-0.62: 28.2hrs/target (57% efficiency, 23.8hrs direct time – NOTE – there is still a large amount of confusion/uncertainty on MIRI MRS sensitivity, (probably largely on my part?). It seems that the "MIRI cheat-sheet" and the other team spreadsheet tools give very different sensitivities. I've used the estimates based on the MIRI cheat sheet which show the saturation for a point source to be 2.5, 1.5 2.5 and 3 Jy for the four channels, respectively. The other spreadsheet calculations seem to be as much as a factor of 10 different).

Total time for NIRSpec for 7x7 IFU mosaic on Target G11.94-0.62: 17.5hrs/target (59% efficiency, 14.8hrs direct time).

Other targets have smaller IFU mosaic x / y dimensions and/or shorter pointing exposure times.

Total time for 3 targets = 96.5 hrs. Total program efficiency is estimated to be 54%.

TARGET(S):

Potential regions of embedded high mass galactic star formation: G11.94-0.62 (See Figure 1), G29.96-0.02, G45.07+0.13

OBSERVING TEMPLATES:

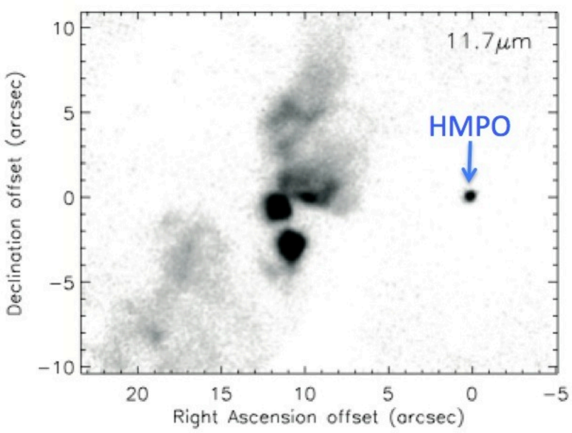
MIRI MRS-IFU

NIRSpec IFU

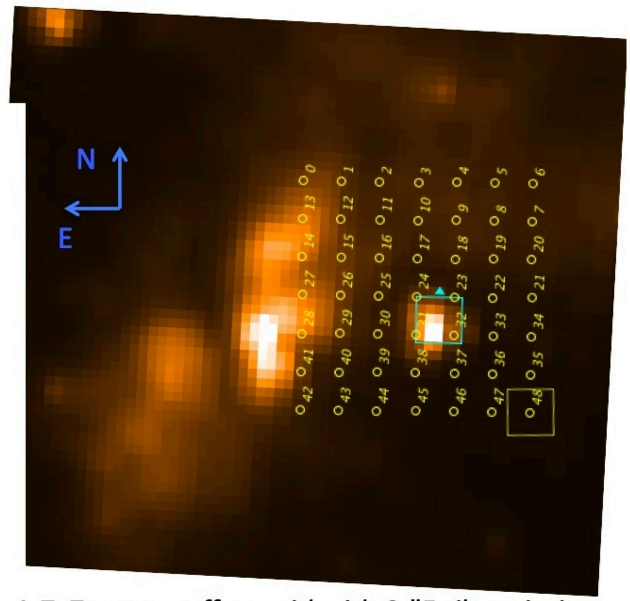
OBSERVATION DETAILS:

Spectroscopy: Each HMPO and the 10-20" region around it will be mapped with the MIRI MRS IFU mode (all three grating settings, whenever possible) and the NIRSpec IFU (Bands II and III) using the intra-visit IFU mosaics. The spatial mapping region depends on the geometry of the system, and because some areas have extremely high flux – especially at the long wavelength MIRI range at 20ìm and greater – some MIRI MRS IFU "tile positions" may need to have different readout parameters than other tiles in the IFU mosaic (some may need “turned off”). Each MIRI tile position will execute the 4-point intra-tile dither pattern. NIRSpec IFU observations will also execute a comparable intra-tile dither.

Example Observation of G11.94-0.62



Gemini T-ReCS 11.7μm image of the HMPO and surrounding nebulosity associated with G11.94-0.62. The 11.7μm flux of the HMPO is 94mJy (from DeBuizer et al. 2005)



A 7x7 square offset grid with 2.”5 tile pointing offsets, over-plotted on a Spitzer IRAC 4.5μm broadband image of the HMPO and environment of G11.94-0.62. The 4.7μm flux of the HMPO is 37mJy.

This is an IFU mapping program, so to decrease mechanism movements and optimize overheads, it is likely most efficient to execute a full dither pattern at each grating setting prior to moving the grating (20s dither overheads/offset vs. ~60s). Some regions in the HMPO environments are extremely bright at 20ìm and long-ward (>10Jy). When possible, the bright nebular regions will be avoided in the IFU mapping. But the HMPOs can also be extremely bright in the longest wavelength MIRI channels and the long wave grating settings will saturate in some regions of an IFU mosaic. It would be optimal to execute all dither positions that will not saturate the detector with all gratings first, and then return to the dither positions that will likely saturate towards the end of the target visit. The saturation will be worst in the long wavelength channel with MIRI, so perhaps the longest grating setting should be executed last for each target, to limit persistence effects.

Slew overheads could be minimized if MIRI observations and NIRSpec observations are consecutive.

The embedded high mass stars all have luminous IR nebula nearby or associated with them (surface brightness of 5 Jy/arcsec or higher). Hence, detailed MIRI imaging of these regions will likely prove unfeasible. This makes the IFU mapping the main means to reveal the detailed environments of the HMPOs.

CONSTRAINTS:

Some IFU mosaic tile positions may need different readout patterns and/or exposure times. Ordering of dithered exposure positions may be needed to mitigate persistence effects in this program and subsequent observations.

PARALLEL Observations possible (yes/no/pure parallel)?

Because of the IFU mapping nature of this observation, it needs to be executed as prime science. It might be possible/desirable to execute some MIRI MRS program background exposures while NIRSpec IFU is integrating on the targets (perhaps also to flush persistence from the MRS detectors, post-observing if MIRI is executed first). Taking pure parallel NIRCam imaging might be useful for galactic stellar populations work.

APT CONSTRAINT COMMENTS:

MIRI Observations:

IFU "mosaic" tool right now shows MIRI Imaging field. Not so useful for trying to define/understand IFU mosaic field.

To avoid very bright nebulosity, one IFU mosaic needs to be offset from the centroid of the high mass protostellar object (HMPO) that will be the target for acquisition. Dithered IFU mosaic observations need to execute using an initial offset from the TA object.

Some IFU mosaic tile positions may need different readout patterns and/or exposure times. Ordering of dithered exposure positions may be needed to mitigate persistence effects in this program and subsequent observations.

Brightest target in region will be too bright for MIRI imaging TA, may cause persistence.

NIRSpec Observations:

NOTE - NIRSpec IFU observations assume that "coarse accuracy" Target Acquisition is implemented! So that IFU target acq can be executed with catalog coordinates and NIRCam pre-imaging is NOT NEEDED!

The desired 7x7 mosaic was increased to 14x7 to mock up a 4pt / tile dither patten instead of the supported 2pt/tile pattern.

IFU Dither parameters should not use the word "slitlet". There are no slits in the IFU.

IFU dither parameters are not complete, want to do a 4 pt dither offset pattern per IFU pointing tile and this is not presently possible. (As a place holder for 4 exposures per tile, chosen 5 slice offset and subpix spatial).

As a note - NIRSpec IFU dither positions were defined based on incorrect information we were given on the IFU instrument optics.

Not sure what field is shown in the Aladdin window for the IFU mosaic tool...? But it's not NIRSpec IFU...

NIRSpec TA will center IFU field on a blank region of sky, nearby to one (or two) HMPO targets, at a position that will serve as the centroid of the dithered mosaic of IFU tiles.

NIRSpec observations at the brightness peaks in one target need multiple integrations with shortest possible individual integration times (10.6s) to avoid saturation in the Band III grating setting. For NIRSpec Band III grating settings some IFU mosaic tile positions may need different readout patterns and/or exposure times. Ordering of dithered exposure positions may be needed to mitigate persistence effects in this program and subsequent observations.

COMMENTS:

AUTHORS/DATE: Tracy Beck (tbeck@stsci.edu)/5 Dec 2011

TITLE: IFU Survey of Resolved Young Stellar Objects

ID: 93110

GOAL:

Spatially-resolved observations of young stellar objects (YSOs) are critically important for understanding star formation and early stellar evolution. Constraints on the spatial distribution of line and dust continuum emission reveal key details of mass loss in jets, the interaction between jets and infalling envelopes, and the chemical and kinematic structure of disks and envelopes. The NIRSpec and MIRI IFUs will enable spatially resolved observations of many nearby YSOs. This program outlines one possible study comprising a sample of known extended YSOs, including Class I protostars and proplyds in order to span a range of evolutionary states and birth environments. The proposed observations will measure mass outflow and accretion rates, the chemical and density structure of protostellar envelopes and proplyd photoionization fronts, and the luminosities, spectral types, and multiplicity of the central stars. Spectral diagnostics of interest include the shock emission features from jets (such as H_2 and [FeII]), silicate and water ice features seen in absorption against background stars, dust continuum and silicate feature emission from disks, atomic gas emission from mass accretion, and photospheric absorption lines. Binary companions may be detected, along with the disk seen in the mm range. Key observational concerns are the background selection, saturation avoidance by bright spoiler stars in the field, and from the background nebular emission at long wavelengths. Samples consist of many resolved close-by protostars and their jets with a wide magnitude range (K~11-18 at 2 kpc), and circumstellar disks around protostars (proplyds).

NOMINAL ALLOCATION (hours):

100

ACTUAL TIME (hours):

212

TARGET(S):

Protostars: a representative sample of 4 fields with 1 or 2 moderately extended protostars in each field, including L1527 IRS, L1634, L1157.

Proplyds: 9 known objects close to the Trapezium in the Orion Nebula Cluster

OBSERVING TEMPLATES:

MIRI IFU

NIRSpec IFU

OBSERVATION DETAILS:

The protostars will be observed with the MIRI and NIRSpec IFUs using mosaics to cover at least a 10”x10” region. For both instruments, all 3 grating settings are used whenever possible without saturating on the central source. This will produce full spectra at each point from 0.6-28.3 microns.

CONSTRAINTS:

May want specific Position Angles for some sources?

PARALLEL Observations possible (yes/no/pure parallel)?

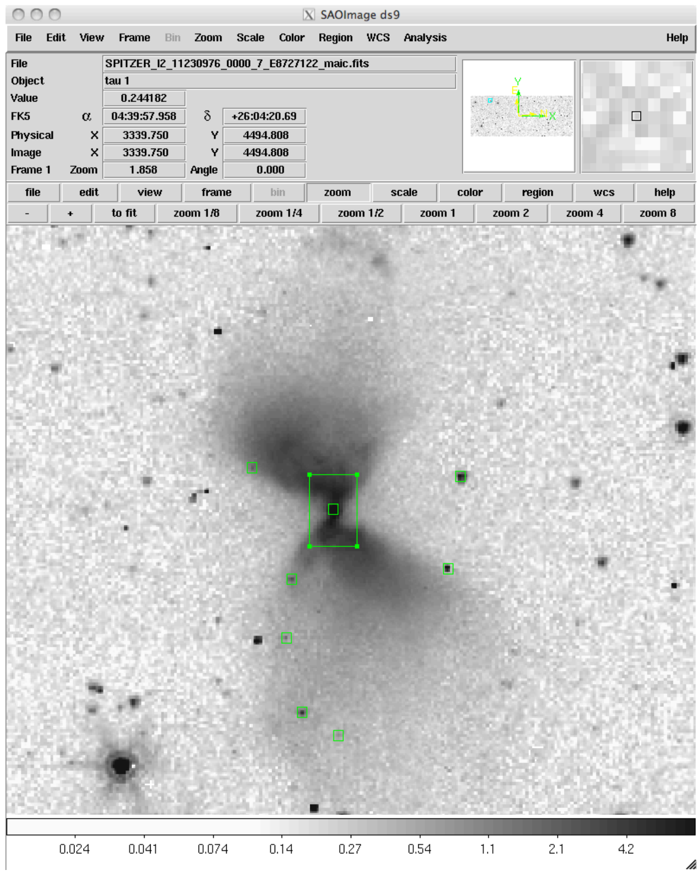
May possibly get background measurements from the alternate instrument during parallels for this program.

COMMENTS:

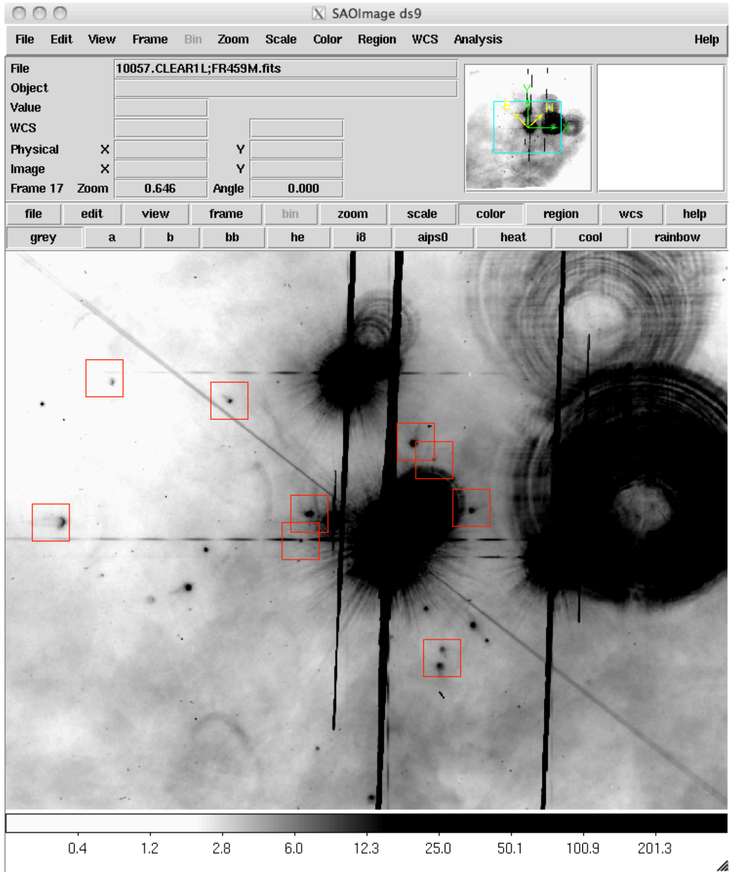
Many of these observations could be taken with the same GS slew as cluster targets. We have grouped them together in the program under a single observation folder to indicate which we think could be done this way.

The pointing accuracy needed for the IFU mosaics would likely not not require a TA.

This program could be expanded to more targets. Many more protostars with resolvable jets and outflow cavities exist in the literature.



L1527 with overlays showing the MRS mosaic and individual pointings on several background stars.



Orion Proplyds near the Trapezium. Shown are positions for MRS and NIRSpec IFU observations.

AUTHOR/DATE: James Muzerolle (muzerol@stsci.edu)
Diane Karakla (dkarakla@stsci.edu)
12/16/2011, updated 2/13/2012

TITLE: High resolution imaging-spectroscopy of gas in protoplanetary disks

ID: 93115

GOAL: This program aims at obtaining high fidelity, high S/N (>200) NIRSpec+MIRI IFU spectroscopy of gas in a significant sample of protoplanetary disks. The key objectives are to 1) obtain high quality spectra of the central point source (and any companions) and 2) search for extended line emission on 0.2-1.0 arcsecond scales. The targeted lines/bands include: CO2 (4.3, 15 micron), CO (4.7 micron), H2O (5.5-28 micron), OH (10-28 micron), CH4 (7.5 micron), NH3 (8 micron), SiO (8 micron), C2H2 (13.6 micron), HCN (13.9 micron), and various forbidden atomic lines, including [NeII] (12.81 micron.

NOMINAL ALLOCATION (hours):

100 hours

ACTUAL TIME (hours):

176 hours

TARGET(S):

59 bright (0.05-0.5 Jy) and nearby (Perseus, Taurus, Oph, Lupus) protoplanetary disks spanning a range of evolutionary stages from the classical T Tauri stage up to the transitional stage. All are known to harbor large reservoirs of molecular gas, from ground-based IR CO surveys (e.g., Salyk et al. 2011). About half have detected water and OH gas with Spitzer (Pontoppidan et al. 2010).

OBSERVING TEMPLATE:

NIRSpec IFU spectroscopy

MIRI MRS

OBSERVATION DETAILS:

The program requires that the IFU image reconstruction and the CR corrections are optimized with a sufficient number of dithers. IFU dithers are not fully defined yet, so the time estimate assumes 5 point NIRSpec dithers and 5 point MIRI dithers. The integration times are adjusted to, on average yield S/N ratios >200 on the point source, while also maintaining high sensitivity to faint extended line emission from larger spatial scales in the disk, and in order to detect any contaminating jet emission. The program will also include a search for many weak lines on top of the bright disk continuum (including the rare isotopologues of water $H_2{}^{18}O$ and $H_2{}^{17}O$). This drives the observing strategy towards obtaining the highest possible S/N, ideally as high as S/N~500-1000. Most targets are bright, and will reach full detector wells at about 3-4 frames at about S/N~200 per full well. NIRSpec will obtain 5 ints x 5 dithers=25 full well ramps and MIRI 8 ints x 5 dithers = 32 full ramps, for a theoretical S/N of 1000. Of course, actual detector performance and other considerations with likely limit this estimate, but a S/N~500 should be a realistic goal (based on Spitzer experience).

The spectral setups will cover a contiguous span of 3-28 micron using one NIRSpec setup and all of the available MIRI MRS setups:

NIRSpec setups: F290/G395H

MIRI setup: MRS - bands I, II and III

Using the NIRSpec and MIRI overhead spreadsheets, a total time per target of 4080s for NIRSpec and 6100s for MIRI. It is assumed that a separate target slew is required for each instrument.

CONSTRAINTS:

There are no additional scheduling constraints.

PARALLEL Observations possible (yes/no/pure parallel)?

This program does not have obvious potential for parallel observations.

COMMENTS:

Given the many bright targets and short exposure times, this is a very inefficient program. The total time required might be significantly decreased by scheduling the NIRSpec and MIRI observations concurrently for each target, thus eliminating one target slew. Also, the targets are highly clustered with median shortest angular separations of 10s of arcminutes to 1 degree, potentially mitigating long telescope slews.

AUTHOR/DATE: Klaus Pontoppidan, 12/13/11

Revised 02/13/12

TITLE: Ice Mapping in Molecular Clouds

ID: 93120

GOAL:

Ices are commonly found in the cold molecular clouds that are collapsing in the process of star formation. They form a large reservoir of various metals and may contain, for example, up to 80% of the available carbon and oxygen in these systems. Ices play a central role in the chemistry and evolution of protostellar disks. The chemical processing often occurs on the mantles of dust grains and understanding these processes is required to explain the observed chemical evolution. Observations of ices in the lines of sight toward protostar regions has been an important goal of the Spitzer c2d Legacy program, as well as other investigations. Oberg et al (2011) give an excellent summary of the state of knowledge about ice evolution. Many species of ice have been investigated with Spitzer/IRS and supplemented with ISO and ground based observations (Pontoppidan 2006) in the spectral range 3–20 microns. Among these are H_2O (3.1, 6.0, 11.2 micron), CO (4.7 micron), CO_2 (4.3, 15.2 micron), CH_3OH (3.5, 9.7 micron), NH_3 (8.0 micron), CH_4 (7.7 micron), and XCN (4.6 micron). The Spitzer data, all at l > 5 microns, has a spectral resolving power of only R=100 (only the 15.2 micron CO2 band could be observed with R=600) and the analysis of these data requires complex decomposition techniques. We propose a small survey of ices in 12 molecular clouds using background stars to obtain absorption line spectra using the MIRI MRS and the NIRSpec MSA. This will allow us to produce preliminary maps of the fractional ice abundances as a function cloud density, temperature and the distance from embedded protostars. The improved resolving power and sensitivity will allow a much better analysis of the ice abundances relative to H_2O and constrain models of chemical evolution in these environments.

NOMINAL ALLOCATION (hours): 100

ACTUAL TIME (hours): 130.4 hours

See the spreadsheets for calculations of the total time.

TARGET(S):

LDN-328

BHR78

L438

B59

L1772

B72

DC300.2-03.5

DC300.7-01.0

L429C

Mu 8

L100

DC346.6+07.8

OBSERVING TEMPLATE:

MIRI MRS and NIRSpec MSA

OBSERVATION DETAILS:

5 background stars will be observed with the MIRI MRS toward each cloud. Although most of the targets in each cluster are more than 20 arcsec apart, some are not. However, there is no way in the current APT to make a mosaic with, for example, 2 targets that are well separated. So we assumed completed new observations for each target. When APT implements improved mosaic capability, and especially when cluster targets are implemented, the required time for this program will be substantially reduced, by 2.5-3 hours for each of the 12 target molecular clouds.

For each background star we observe with all 3 MIRI MRS grating configurations. The scientific goals require a resolving power of only 500-1000 so we intend to bin the data by a factor of about 5. The exposure times were set to obtain S/N=50 per resel in the binned data for a 1 mJy background star. A 4-point dither is requested. This is followed by NIRSpec MSA observations using the medium and long wavelength gratings only; we are not requesting coverage from 1–1.7 microns. The MSA is large enough to cover all 5 targets simultaneously although we do request a 2-point dither (nslitlet=2) on each side of the wavegap. For the NIRSpec observations the total time is strongly driven by the overheads. It takes almost no additional time to obtain S/N=100 rather than S/N=50, so the exposure times were specified on this basis. Up to 50 additional background stars will be observed with the NIRSpec exposures, covering bands of H_2O, CO and CO_2, in addition to the 5 MIRI targets.

CONSTRAINTS:

None.

PARALLEL Observations possible (yes/no/pure parallel)?

Obtaining NIRSpec MSA spectra during the long MIRI MRS observations would yield a nice dataset on additional sightlines in the clusters.

COMMENTS:

This program is a great example of one for which cluster targets would represent a huge improvement. Currently, a target slew is specified for each star in the cloud. This requires 6 such slews (1 for each of the 5 MIRI observations and 1 for the NIRSpec observation). This requires 3 hours for the out of a total of 8.2 hours for each cloud. Reducing this to 1 target slew would save 2.5 hours, or about 30% of the total time.

These observations will likely be followed by more intensive mapping of the best individual clouds. In these cases, cluster targets will be absolutely essential. Without this mechanism, the overheads will be so excessive that it will severely limit this kind of science investigation.

AUTHOR/DATE: Scott Friedman, Klaus Pontoppidan 16 December 2011; updated 13 February 2012

TITLE: IFU Mapping of PDRs / HI Filaments

ID: 93130

GOAL:

Emission from aromatic hydrocarbons and low states of molecular hydrogen dominates the JWST-accessible IR spectra of dense photodissociation regions (PDRs). These species are important diagnostics of the physical properties of gas and dust in intense UV radiation fields. Detailed physical conditions, the distribution of various tracers of PDR structure, comparison of resolved emission feature widths, gas density and temperature distribution, clumpiness of the clouds, the excitation wavelength of different aromatic features and the nature of their carrier, measurement of the penetration depth of the exciting photons, and elemental and molecular abundances can be studied with high resolution observations in the different wavelength regions provided by MIRI and NIRSpec IFU spectra and associated confirmation imagery.

The three PDRs included here, NGC 7023, NGC 2023, and IC 63, were mapped with Spitzer (cf., Fleming et al, 2010, ApJ, 725, 159), but with the JWST observations described here it is possible to obtain much higher spectral and spatial resolution observations for more detailed study of important portions of specific interesting filaments in these bright regions as well as in other fainter targets.

NOMINAL ALLOCATION (hours): 100

ACTUAL TIME (hours): 98.1

Used updated MIRI and NIRSpec IFU spreadsheets to calculate the time. As described in the Observation Details section below, we observe four different filaments in each of the three objects. Within each filament we obtain dithered IFU mosaics at each of four separate pointings, therefore there are a total of sixteen separate target pointings in each object at which 1x*n* (*n*=4 for NIRSpec and *n* =3 for MIRI)mosaic patterns are obtained with each tile of each mosaic dithered in a 2x2 pattern. No target acquisitions are needed for the IFU observations as we are mapping 3"x10" regions at each pointing – were TA to be required, an ~10 additional hours would be needed for this program. Although many of these targets are close together on the sky, since a "cluster target capability (observe more than one pointing on a single target slew/GS acq) is NOT implemented, our program is currently structured with each individual pointing as a single observation. Therefore, sixteen separate pointings are made with each instrument in each of the three objects.

Times given below are time exposing plus direct overheads, no indirect overheads.

Time for an individual filament (4 target slews, four separate pointings at which dithered mosaics are obtained): Total NIRSpec = ~15600 sec (~4.34 hours); Total MIRI = ~10900 sec (~3.03 hours);.

Program Totals (12 filaments): total NIRSpec = 52.1 hours; total MIRI = 46.0 hours

Program Sum = 98.1 hours.

(for illustrative purposes, we note that by using a conservative calculation of the slew overheads with a modest "cluster target" capability (that is, we assume one slew for each pair of pointings and a minimal slew to the second nearby pointing in the filament), we obtain durations of: NIRSpec=38.4 hours, MIRI=34 hours, Program Sum=72.4 hours (a savings of more than 25%).

TARGET(S):

PDRs in NGC 7023, IC 63, and NGC 2023.

OBSERVING TEMPLATES:

MIRI MRS-IFU

NIRSpec IFU

OBSERVATION DETAILS:

Spectroscopy: Each PDR will be observed with the MIRI and NIRSpec IFUs to cover a 3”x10” region (requires 1x3 MIRI and 1x4 NIRSpec mini-map/mosaic with four-point dithering for excellent spatial sampling and NIRSpec spectrum gap coverage). For MIRI, all 3 grating settings will be taken. For NIRSpec, two grating settings are needed to cover the 3.3 micron aromatic feature as well as obtain good diagnostic atomic/molecular emission lines (G395H/F290LP & G235H/F170P). This produces full spectra at each point from 1.7-28.3 μ.

Imaging: Confirmation imaging with MIRI and possibly NIRSpec to facilitate alignment of the IFU maps would be beneficial, but it is not clear at this point how to specify this.

We will observe four filaments in each of three targets (NGC 7023, NGC 2023, and IC 63). Each filament will be observed at four separate locations (pointings labeled A through D) along the filament. The observations of the four pointings in each filament are grouped within an observation folder in APT on the presumption that (in the future) all four observations can be accomplished with only a single target slew (as in a “cluster target” scenario. However, as noted above our official time estimates assume only one target slew per observation as the current APT implementation provides, and for illustrative purposes, we also provided conservative estimates of the reduced durations to be expected on the assumption that two slews would be required for each filament.

At each pointing separate 10x3 arcsec "mini-maps" of size 1x3 for MIRI IFU and 1x4 for NIRSpec IFU will be obtained. Each mini-map sequence will consist of four dithered exposures at each tile of the map using G235H and G395H for NIRSpec and all MIRI spectral elements.

Our observing strategy yields for the mosaic at each pointing 16 separate NIRSpec exposures for each of the two NIRSpec gratings used and 12 separate exposures for each of the three MIRI gratings or a total of 128 NIRSpec exposures and 144 MIRI exposures per filament.

We note that for NIRSpec the IFU dither parameters in APT are not complete. We want to do a four-point dither offset pattern per IFU pointing tile with the pattern offsets in x and y chosen in arcsec; the present specification does not accomplish this as it produces only two exposures. Accordingly we have DOUBLED the number of integrations for each grating to produce the total exposure time and detector reset overheads that approximate our desired durations which would be produced by obtaining four dithered exposures at each tile.

Similarly, for MIRI, the IFU dither parameters are not yet implemented at all. We want to do a four-point dither offset pattern per IFU pointing tile with the pattern offsets in x and y chosen in arcsec or some optimal fraction of slice size. The present implementation in APT does not produce any dithering, i.e., only one exposure is produced from the specification.

As a result, we have increased the number of integrations in our optimal single-point exposure specification by a factor of 4 (increased from 1 to 4) to produce the total exposure time and detector reset overheads that approximate our desired durations which would be produced by four dithered exposures at each tile.

CONSTRAINTS:

N/A.

PARALLEL Observations possible (yes/no/pure parallel)?

Parallel NIRCam/MIRI imaging to the MIRI/NIRSpec IFU observations could be useful.

COMMENTS:

This program is loosely based upon a 2010 presentation by Gordon to the MIRI Science Team at Ringberg Castle.

This program could easily be expanded to more filaments of the included targets as well as a variety of other targets such as moderately extended planetary nebulae, regions in the galactic center, Orion, and the nuclei of starburst galaxies to name a few.

AUTHORS/DATE: Tony Keyes (keyes@stsci.edu) / 2 February 2012 (ver 3)

Tract Beck (tbeck@stsci.edu)

Karl Gordon (kgordon@stsci.edu)

TITLE: Energy Feedback into Star Forming Clouds

ID: 93140

GOAL: In regions of low mass star formation, outflows in the form of jets and winds from young stars provide the most important mechanism for feedback of energy into the star forming clouds. Winds and jets from young stars are believed to power the cloud turbulence, help to regulate the star forming efficiency (SFE) and even disrupt and help to disperse parent cloud material and the extended envelopes of young stars. Yet, the dynamics of this process remain unclear. Snapshot imaging and spectroscopy can reveal the morphology and dynamics of a young star outflow, and comparison with shock excitation models place constraints on shock velocities and pre-shock densities. This allows for estimation of the effects of outflow feedback into the star forming clouds. Yet, more accurate information can also be derived from observations that reveal the full 3-D kinematic structure in the outflow through proper motion monitoring. Multi-cycle observations of young star jets from the *Hubble Space Telescope* have revealed that the temporal evolution of outflows is important to understand the full dynamical impact of turbulent energy feedback into the parent clouds. At the distance of Orion (~400pc), knots in young star jets have proper motions of up to ~0.”1 per year. In this program, we describe observations with NIRSpec MSA and IFU that will measure and study the full 3-D velocity and density profiles in Herbig-Haro (HH) jets from young stars, to quantify the turbulence and its effect on star formation. MSA observations will be executed on two outflows which have broad spatial extents (>2”), and two highly collimated jets will be observed with the IFU where the 3” field of view is well matched to the 1.5-2” jet widths. Observations will be acquired in the R~3000 (high resolution) setting in NIRSpec Band I, II and III for full coverage of the 1-5mm spectral region. Target emission lines of interest include numerous shock-excited H2 lines in this spectral region, and forbidden atomic emission species such as [Fe II]. Observations of four jets will be acquired and repeated one to two times (two to three observations in total) over the course of 2 observing cycles with JWST.

NOMINAL ALLOCATION (hours): 100

ACTUAL TIME (hours): 107.3

The Time for the MSA Observations is:

HH 211 – 4pt dither at each of two MSA configs @ 3 grating settings for ~3 target sets, + setups and overhead = 14.6hrs total (39% efficiency, 12.3hrs of direct time). Repeat 1 time at an annual cadence for a total of 2 observations. To identify HH jet knots for spectroscopy slit positioning, pre-imaging will be acquired with NIRCam (w/ the H_2 filter) prior to each of the two observation epochs, and will take about 0.8hrs. *NIRCam=1.6hrs, NIRSpec MSA =29.2hrs, Total = 30.8hrs.*

HH 110 – 3pt dither at two MSA configs @ 3 grating settings for ~3 target sets, + setups and overhead = 10.3hrs total (39% efficiency, 8.6hrs of direct time). Repeat 1 time at an annual cadence for a total of 2 observations. To identify HH jet knots for spectroscopy slit positioning, pre-imaging will be acquired with NIRCam (w/ the H_2 filter) prior to each of the two observation epochs, and will take about 0.8hrs, *NIRCam=1.6hrs, NIRSpec MSA = 20.6hrs, Total = 22.2hrs*.

Total time for the IFU Observations of a target is:

HH 111 – 4pt dither at 1x10 IFU mosaic @ 3 grating settings, + setups and overhead = 8.7hrs total (37% efficiency, 7.3 hrs direct time). Repeat 2 times at approximately annual cadence for 3 total observations. *Total = 26.1hrs.*

HH 34 – 4pt dither at 1x11 IFU mosaic @ 3 grating settings, + setups and overhead = 9.4hrs total (37% efficiency, 8.0 hrs direct time).). Repeat 2 times at approximately annual cadence for 3 total observations. *Total = 28.2hrs.*

TARGET(S):

Potential targets for NIRSpec MSA / IFU observations of young star outflows to probe energy feedback into star forming clouds: HH 211, HH 111, HH110, HH 34

OBSERVING TEMPLATES:

NIRSpec MSA

NIRSpec IFU

OBSERVATION DETAILS:

MSA Observations of HH 211 and HH 110: NIRSpec observations in the Band I, II and III grating settings will be obtained for full spectral coverage at R~3000 from 1-5mm. MSA configurations will be created for optimal placement of knots, & dithered through 4 positions for each MSA configuration (ie., targets are dithered behind a fixed MSA config to build up spatial sampling of the HH knots). The detector gap will be dithered to recover missing wavelengths (ndither= 3-4 positions at two MSA configurations). Overheads are derived assuming gratings are iterated before MSA configurations are changed. Estimate is that 3 different target sets (6 MSA configurations) are needed to get full coverage of HH jet knots. Individual exposure times are on the order of 100s (3 integrations so not to saturate on brightest lines). Observations will be repeated to derive 3-D kinematic structure in the outflow. Observations will be repeated to derive 3-D kinematic structure in the outflow.

IFU Observations of HH 34 and HH 111: NIRSpec observations in the Band I, II and III grating settings will be obtained for full spectral coverage at R~3000 from 1-5mm. The IFU field will be dithered along the jet axis in a 1x~10 field mosaic. Individual exposure times are on the order of 100s per exposure (using 3 integrations to not to saturate on brightest lines), with a 4pt dither pattern at each IFU mosaic position. For sensitivity comparison to verify requested exposure times, Subaru 8m Telescope IR spectral observations of HH 34 were reported by Takami et al. (2006) at 1200s and 1400s in the H and K infrared bands, respectively. Scaling for PSF size differences and IR sky backgrounds from the ground, we estimate that our requested NIRSpec exposures will be more sensitive. Observations will be repeated two times to derive 3-D kinematic structure in the outflow (total number of observations = 3 per target).

CONSTRAINTS:

MSA observations of HH 211 and HH 110 will require pre-imaging with NIRCam, and so full spectroscopy definition of these observations with the MSA will only come after pre-imaging is observed.

IFU Observations of HH 111 and HH 34 do not require pre-imaging, and assume that "coarse accuracy TA" using catalog positions for reference star positions is available. Once IFU observations are started at a given telescope orient, the repeat observations should be executed at a similar orientation for proper reference of proper motions.

PARALLEL Observations possible (yes/no/pure parallel)?

This program needs to be executed as prime science because of the specific dither pattern requested (matched to HH target geometries). Parallel observations w/ NIRCam or MIRI could be possible, but might not be so useful on "blank" sky in these star forming regions.

APT CONSTRAINT COMMENTS:

MSA Observations:

Jet knots in HH energy sources are extended, "blobby" and not point sources. Some knots can extend to >2" widths or lengths. These objects will be spatially resolved, and so defining these as "targets" for MSA observations will be tricky. "Catalog positions" are going to be very difficult to define using an automated tool or routine. Also, because each outflow can have dozens and dozens of knots associated with it, making the user define knot positions and extents by hand one-by-one is also very time consuming (read: annoying). It might be best if users can define spatially extended target regions of interest within their pre-images, i.e, based on source fluxes above a threshold value in the image, or something similar. As a note - This is not a unique problem for HH objects, other astronomical sources – such as H II regions in nearby galaxies, for example – will be spatially resolved and users will want to define the full extent as a "target".

For the MSA observations on target HH 110, a catalog of potential knot positions was created and loaded into the MSA planning tool to generate a test observation. As it presently stands, the MSA planning tool centers catalog coordinates in the 4 quadrant MSA field, and tries to optimize with the central position – instead of identifying the center of the target positions and placing the that center at an optimal location to get as many targets observed through the shutters as possible. For example see the figure:

Figure 1: APT MSA Tool Aladdin view of the HH 110 region from an HST ACS F658 filter image. Yellow circles represent HH knots of emission in the target catalog that was created for this object. As can be seen in this optimization run, the targets are placed behind the MSA mounting structure not within the (blue) MSA quadrant fields of view. Because of the way the MSA tool currently does the centroiding to place sources in all four quadrants, only two jet knot targets are observed in this configuration (in the lower right quadrant).

The NIRSpec team is currently working with APT developers to define what rules should be used to identify the central pointing for MSA observations.

NOTE: This program seeks to offset the astronomical field behind a fixed MSA shutter configuration pattern to build up spectra over multiple spatial locations. This is essentially stepping the (fixed) MSA configuration of slitlets across a small field. At present, this capability is not captured anywhere in the APT dither parameter definitions.

NOTE: Collimated jet targets (& in fact, any linear distribution of targets with a cross-dispersion spatial extent of less than ~1 arc minute) should be preferentially placed on LEFT MSA quadrants, to optimize spectral coverage of emission lines in the resulting data.

IFU Observations:

Execute an IFU mosaic along the axis of the collimated HH 111 and HH34 jets, the mosaic should be aligned along the jets. The 3" IFU field is well matched to the ~1."5-2" width extent of the jets. A 4pt dither will be executed at each IFU mosaic position in each grating. Multiple integrations are used so as not to saturate on the brightest emission lines in the jet. For sensitivity to very faint lines, total on-source exposure time is 95.4X4=381.6 for each position for each grating.

IFU observations would optimally be acquired with a 4 pt dither pattern in a square offset, which is presently not possible in the hard-coded dither patterns.

Mosaics of the IFU fields can be done with a linear 1x10 mosaic at a specific orient that corresponds to the jet (See Figure 2 for HH 111), or at a flexible orient with a mosaic skew that can take into account jet alignment (See Figure 3 for HH 34).

Figure 2 – An aligned, fixed orient 1x10 IFU mosaic used to map the collimated jet in the HH 111 outflow. The 3" square IFU field is presented in yellow and over-plotted on a WFPC2 F673N image of the [S II] atomic emission, with mosaic tile overlaps of 10% (0.3").

Figure 3 – A skewed 1x11 IFU mosaic of the HH 34 jet that could be optimized for a range of telescope orients. The 3" square IFU field is presented in yellow and over-plotted on a WFPC2 F673N image of the [S II] atomic emission, with mosaic tile overlaps of 10% (0.3").

NOTE: For direct comparison of multi-epoch observations, it would be optimal if repeated observations were executed with a similar orientation and mosaic / skew set up.

NOTE: For IFU observations, spatial reference for the proper motion derivation will be verified using the jet exciting source position and field reference stars using acquisition images observed through the MSA (in "coarse accuracy" TA). This TA capability is not currently available in the APT template or the observing scripts (not yet implemented).

COMMENTS:

AUTHORS/DATE: Tracy Beck (tbeck@stsci.edu), Diane Karakla (dkarakla@stsci.edu) /9 Jan 2012

TITLE: Galactic Center Monitoring

ID: 93150

GOAL:

This program will study the kinematics and chemistry of stellar populations near the Galactic center. NIRCam imaging at two epochs will provide proper motions for a very large number of stars. NIRSpec MSA spectroscopy will yield radial velocities with 10 km/s precision and chemical abundances for 1000 bright ($9 < K < 13$) giants with prominent spectral features in the 1.7-3.0 µm spectral region. The ultimate goal is to understand how the central cluster formed and whether it is a transient phenomenon indicative of a recent cluster-merger event or whether it is more of a steady-state phenomenon that regularly ingests small clusters to maintain a mix of old and young stars. If young stars all share certain phase-space parameters, this will lend credence to the first interpretation.

NOMINAL ALLOCATION (hours): 100

ACTUAL TIME (hours): 24 hours of imaging + 4.6 hours of spectroscopy (assuming a more capable NIRSpec MSA Spectroscopy template). With the NIRSpec MSA Spectroscopy template in APT 19.4, the spectroscopy would take 10.5 hours and double the number of MSA, grating wheel, and filter wheel moves.

Imaging (one epoch): Slew to the target will be 1800s. We will mosaic the field with 8 NIRCam tiles, in a 2×4 tiling. We will use the 6-point full-field dither pattern with two sub-pixel dithers at each primary location; this will require two GS acquisitions per tile. In addition to the 2 GS-acq slews per tile, there will be 10 small dithers without dropping GS lock. The mosaic will be done twice, once with narrow-band filters and once with medium-band filters. The overhead (excluding exposure time) for each mosaic will then be: 8 tiles × [2×240s GS acq + 10×257s dither slew + 5s config] = 8 hours. With two mosaics, this will total to 16 hours. The exposure time will be (8 tiles) × (12 exposures/tile) × (200s) = 19200s for the narrow-band filters and 4800s for the medium-band filters for a total of 19200s + 9600s = 8 hours observation time.

In net, then the imaging portion of the first epoch should require the initial slew, overheads, and on-sky imaging totaling: 24.5 hours = 0.5 + 16 + 8 hours. So, the overall observing efficiency will be about 30%. In addition to providing a first-epoch for the proper motions, this imaging will provide a catalog with precise astrometry for the NIRSpec MSA spectroscopy.

The NIRSpec observation will take 4.6 hours of spacecraft time, including the initial slew. The total time consists of 1.0 hour for gathering science photons and 3.6 hours of overhead. Thus, the fraction of time spent gathering science photons is 26% for the NIRSpec part of this program. Because of the multiplexing capability of the MSA, one target spectrum is obtained for every 17 seconds of spacecraft time. Details of the exposure times, visit structure, and overheads are in an associated spreadsheet (sodrm_3150_anderson_v2.xlsx).

TARGET(S):

Imaging of a 10′×10′ region centered on the Galactic center.

Spectroscopy of 1000 bright giants in 5 separate fields contained in this larger imaging region.

OBSERVING TEMPLATES:

NIRCam Imaging

NIRSpec MSA Spectroscopy

OBSERVATION DETAILS (NIRCam):

The observations will be done in three phases. The first two phases will be done during the first year of operations, and the last phase will be done three to four years later, to maximize the baseline for the proper motions.

The NIRCam imaging will cover the inner 10′×10′ of the central cluster, taken with a 2×4 mosaic tile. At each tile in the mosaic, we will take a 6-point full-field dither with 2 secondary dithers at each primary location for a total of 12-pointings per tile. We will construct the mosaic in the SWC and LWC simultaneously using a narrow-band pair of filters (F187N+F405N) and a medium-band pair of filters (F182M+F410M). The narrow-band images will be 100s total and the medium-band images will be 200s total.

OBSERVATION DETAILS (NIRSpec):

The NIRSpec spectroscopy will cover 5 fields of view contained in the 10′×10′ imaging region. Each field of view contains 1-3 target sets for a total of 10 target sets. Each target set contains about 100 targets for a total of 1000 targets. The MSA must be configured during NIRSpec target acquisition to block light from bright targets and minimize persistence in the detector.

The MSA will be configured with slitlets that are 1 shutter wide along the dispersion axis and 2 shutters tall along the spatial axis to measure background while minimizing contamination in this crowed region. Sources will be placed first in the bottom shutter of each slitlet and then nodded to the top shutter. The MSA will then be reconfigured to shift every slitlet by one shutter along the dispersion axis. Sources will be placed first in the top shutter and then the bottom shutter of the new slitlet. In total, each source will be observed in four times in two slitlets.

NIRSpec exposure times will be short (0.5-11 minutes) because the stars are very bright ($9 < K < 13$). The NRSRAPID readout pattern (NFRAME=1) is used when the NRS readout pattern (NFRAME=4) would yield fewer than 6 groups. Targets in FIELD-C3 are so bright that only 3 groups are possible before saturation, so we obtain 3 integrations to facilitate cosmic ray identification and correction.

An MSA confirmation image will be obtained for the 6 fainter target sets that do not saturate in two groups. The MSACONF image will be used to improve radial velocity accuracy. The remaining 4 target sets are too bright for a confirmation image.

About 1 hour of spacecraft time will be spent on each field. Dithers within each field will be less than 1 arcsec, even when switching between target sets. Thus, only 1 NIRSpec target acquisition is needed for each field of view. Ideally, each field of view should be one visit with one FGS guide star acquisition and one NIRSpec target acquisition. All the NIRSpec observations should form a single observation with one large slew and four medium angle offsets.

The NIRSpec MSA Spectroscopy template in APT 19.4 does not allow multiple MSA configurations in a visit or multiple fields of view in an observation. The only way to express this program is with 10 separate observations, each with a slew, an FGS guide star acquisition, and a NIRSpec target acquisition. Requiring 10 observations instead of 1 triples the overhead from 3.6 hours to 9.5 hours. More importantly, using 10 observations instead of 1 doubles the number of filter wheel moves, grating wheel moves, and MSA reconfigurations. All of these mechanisms have limited lifetimes.

CONSTRAINTS:

The NIRSpec MSA observations must be at least 2 months (TBC) after the NIRCam imaging to allow time for the observer to select targets and specify MSA configurations.

PARALLEL Observations possible (yes/no/pure parallel)?

It might be interesting to take some MIRI observations in parallel with the NIRCam observations, if that is possible. It will give us some kind of probe into the mid-IR populations in the vicinity of the galactic center. The NIRCam mosaic will be large enough that if MIRI is observed in parallel in all observations, then we will get some MIRI-NIRCam overlap.

The NIRSpec observations will observe at 4 dither locations, so pure parallel imaging might be useful.

COMMENTS:

This is a program combines two observing scenarios, one authored by Jeff Valenti and one authored by Jay Anderson.

AUTHORS/DATE: Jay Anderson (jayander@stsci.edu), December 13, 2011

Jeff Valenti (valenti@stsci.edu), December 16, 2011

TITLE: The JWST Globular Cluster Survey

ID: 93180

GOAL:

NIRCam imaging of a large population of Milky Way globular clusters will be used to establish the infrared color magnitude diagram and calibrate its dependency on metallicity. Infrared imaging offers the opportunity to measure the complete stellar populations of each cluster, from the brightest giants to the coolest dwarfs, and will reveal features in the color magnitude diagram that can be modeled to derive fundamental parameters for each system (e.g., accurate ages and distances). The stellar mass function will be measured down to the hydrogen-burning limit and its dependency on dynamics can be studied by exploring population trends.

The F090W and F277W filters can be observed simultaneously for this study, and a single JWST field of view will yield enough stars. The location of the field can be set to directly overlap the existing HST ACS survey of clusters to provide panchromatic wavelength coverage. The exposure depth will need to reach 0.5 mag below the bottom of the main-sequence with a S/N ~ 10. For a 12 Gyr population, a 0.08 Msun metal-poor star has J = 11 according to the Dartmouth Stellar Evolution models. According to the JWST ETC, for clusters at ~10 kpc, the exposure times will be 1 hour in F090W and 0.5 hours in F277W (based on an M5V star). At ~20 kpc (the furthest clusters in the survey), the exposure times will be 5 hours in F090W and 3 hours in F277W. The table below summarizes these approximate constraints for clusters with d < 5 kpc, d < 10 kpc, d < 15 kpc, and d < 20 kpc.

NOMINAL ALLOCATION (hours): 248 hours

ACTUAL TIME (hours):

10 clusters x 0.5 hours + 24 clusters x 1.0 hours + 15 clusters x 3.0 hours + 10 clusters x 5.0 hours = 124 hours

TARGET(S):

Cluster	$[Fe/H]$	$E(B-V)$	d (kpc)	Exp Time (hours)
NGC 6101	-1.82	0.05	15.2	5.0
NGC 6934	-1.54	0.10	15.7	5.0
NGC 5466	-2.22	0.00	15.8	5.0
NGC 5053	-2.29	0.04	16.3	5.0
NGC 1261	-1.35	0.01	16.4	5.0
NGC 6981 (M72)	-1.40	0.05	17.0	5.0
NGC 5024 (M53)	-1.99	0.02	17.8	5.0
IC 4499	-1.60	0.23	18.9	5.0
NGC 4147	-1.83	0.02	19.2	5.0
NGC 6426	-2.30	0.36	20.7	5.0

Cluster	$[Fe/H]$	$E(B-V)$	d (kpc)	Exp Time (hours)
NGC 6121 (M4)	−1.20	0.36	2.2	0.5
NGC 6397	−1.95	0.18	2.3	0.5
NGC 6656 (M22)	−1.64	0.34	3.2	0.5
NGC 6366	−0.82	0.71	3.6	0.5
NGC 6791	+0.40	0.14	4.0	0.5
NGC 6752	−1.56	0.04	4.0	0.5
NGC 6838 (M71)	−0.73	0.25	4.0	0.5
NGC 6254 (M10)	−1.52	0.28	4.4	0.5
NGC 104 (47 Tuc)	−0.76	0.04	4.5	0.5
NGC 6218 (M12)	−1.48	0.19	4.9	0.5
NGC 3201	−1.58	0.23	5.0	1.0
NGC 6809 (M55)	−1.81	0.08	5.3	1.0
NGC 6352	−0.70	0.21	5.7	1.0
NGC 6304	−0.59	0.53	6.0	1.0
NGC 6171 (M107)	−1.04	0.33	6.4	1.0
NGC 4833	−1.80	0.32	6.5	1.0
NGC 6535	−1.80	0.34	6.8	1.0
NGC 6541	−1.83	0.14	7.0	1.0
NGC 6717 (Pal 9)	−1.29	0.22	7.1	1.0
NGC 5904 (M5)	−1.27	0.03	7.5	1.0
NGC 5927	−0.37	0.45	7.6	1.0
NGC 6205 (M13)	−1.54	0.02	7.6	1.0
NGC 6362	−0.95	0.09	7.6	1.0
NGC 6624	−0.44	0.28	7.9	1.0
NGC 6528	−0.04	0.54	7.9	1.0
NGC 7099 (M30)	−2.12	0.03	8.0	1.0
NGC 6341 (M92)	−2.28	0.02	8.2	1.0
NGC 362	−1.16	0.05	8.5	1.0
NGC 6144	−1.75	0.36	8.5	1.0
NGC 6723	−1.12	0.05	8.7	1.0
NGC 288	−1.24	0.03	8.9	1.0
NGC 6681 (M70)	−1.51	0.07	9.0	1.0
NGC 6637 (M69)	−0.70	0.16	9.1	1.0
NGC 2808	−1.15	0.22	9.6	1.0
NGC 6093 (M80)	−1.75	0.18	10.0	3.0
NGC 6388	−0.60	0.37	10.0	3.0
NGC 6652	−0.96	0.09	10.1	3.0
NGC 6779 (M56)	−1.94	0.20	10.1	3.0
NGC 4590 (M68)	−2.06	0.05	10.2	3.0
NGC 7078 (M15)	−2.26	0.10	10.3	3.0
NGC 5272 (M3)	−1.57	0.01	10.4	3.0
NGC 5986	−1.58	0.28	10.4	3.0
NGC 2298	−1.85	0.14	10.7	3.0
NGC 5286	−1.67	0.24	11.0	3.0
NGC 6496	−0.64	0.15	11.5	3.0
NGC 7089 (M2)	−1.62	0.06	11.5	3.0
NGC 6441	−0.53	0.47	11.7	3.0
NGC 1851	−1.22	0.02	12.1	3.0
NGC 6584	−1.49	0.10	13.4	3.0

OBSERVING TEMPLATE: NIRCam Imaging

OBSERVATION DETAILS:

Use the APT mosaic tool to produce multiple, dithered observations in each field, with Modulu=ALL and Subarray=FULL. The dithers should be designed to mitigate hot pixels and cosmic rays, and also to improve the sampling of the PSF in each channel. At least four exposures are required for each field. It is not necessary to fill the chip gap. Shorter exposures will likely not be needed given the ramp fitting. For APT exposure time estimates, we have binned the clusters into four groups depending on their distances (summarized in the table above). For the 0.5 hour exposures (10 clusters), we will use the SHALLOW 4 sequence with 5 groups (254 s). Two primary dithers with four subpixel dithers are set in the INTRAMODULE pattern. For the 1.0 hour exposures (24 clusters), we will use the MEDIUM 2 sequence with 5 groups (445 s) and the same dither pattern configuration. For the 3.0 hour exposures (15 clusters), we use the DEEP 8 sequence with 7 groups (1357 s) and the same dither pattern configuration. For the deepest observations requiring 5 hours of integration (10 clusters with d > 15 kpc), we use the DEEP 8 sequence with 6 groups (1145 s) and use 4 primary dithers with 4 subpixel steps. In all cases, the S/N reached in F277W will exceed what is needed given the common setup on the dual channel observations.

The actual exposure time is 124 hours and the efficiency is estimated to be 50% given the number of targets.

CONSTRAINTS:

The fields should overlap the previous ACS imaging from the HST Treasury Survey as much as possible. Given the field of view, this should not impose strict constraints on the roll angle.

PARALLEL Observations possible (yes/no/pure parallel)?

NIRISS parallel imaging would provide additional field coverage in the periphery of each cluster. This imaging would be useful to explore stellar population gradients and to constrain dynamical models of clusters (e.g., mass segregation).

COMMENTS:

AUTHOR/DATE: Jason Kalirai (jkalirai@stsci.edu) / 5 Jan 2012

TITLE: HST Legacy Astrometry

ID: 93190

GOAL:

When globular clusters formed, gas clouds condensed into objects with a variety of masses. Objects with more than about 0.08 $M_{\odot}$ of mass were able to ignite hydrogen as they collapsed, and these low-mass stars continue to shine with about a thousandth of the sun's luminosity. Objects less massive than this were not able to ignite hydrogen and thus could not generate their own heat; these brown dwarfs were doomed to die a slow, cold death. Although these brown dwarfs start off with about the luminosity of their slightly more massive stellar brothers, after about 10 Gyrs, these 0.07 $M_{\odot}$ brown dwarfs have about five millionths of the sun's luminosity and a temperature of about 1000 K. Since globular clusters are about 12.5 Gyrs old, there should be a sharp contrast between the stars that could ignite hydrogen and those that are just fading away.

When we use HST to look for faint main-sequence stars in globular clusters, we do not see a sharp end to the main sequence, which would be indicative of the hydrogen-burning limit (HBL). Rather, we see a gradual tapering of the luminosity function, indicating that the stars are getting fainter and their photons redder than HST can observe. By going to the IR, we will be able to see the stars that have faded redward of HST's sensitivity. Our goal in this program is to use NIRCam to image the deep fields in M4, NGC 6397, 47 Tuc, and Omega Centauri that have already been observed by HST so that we can complement HST's visible images with IR images. A sub-HBL star with about 0.07 $M_{\odot}$ will receive about 1000 photons in a 1000s F150W NIRCam exposure, and will receive even more flux more through the redder filters. We should be able to detect brown dwarfs down to about 0.05 $M_{\odot}$ in the reddest filters, assuming the background from the halos of the brightest giants is not pathological. This will give us new information about the cooling properties of low-mass objects, and the formation details of the clusters themselves.

The overall plan will be to take this set of observations early in JWST's lifetime, then to repeat the observations near the end of JWST's lifetime, so that we can get PM-membership information for the faint stars.

NOMINAL ALLOCATION (hours): 50

ACTUAL TIME (hours): 57

We will spend ~5 hours on each of M4 and NGC6397 and ~20 hours on each of 47 Tuc and Omega Cen, as the last two clusters are about a factor of 2 farther away. There exist deep fields in each of these clusters that HST has already observed, so we will focus on these fields so that we can get visible and IR colors for as many stars as possible.

Our standard deep exposures will be 975 seconds, taken with ten groups of the MEDIUM2 readout mode. We will take 8 exposures for the two closest clusters and 32 exposures for the two far ones. We will use the INTRA-MODULE pattern, covering the SCA gaps with 4 primary dithers and taking either 2 or 8 secondary dithers at each primary-dither location. We will perform the observations with SW+LW filter combination F150W+F356W, then with the combination of F200W+F444W, to get a total of 4 filters for each star. Each visit can be done with a single guide star.

For the two closest clusters, we have 1800s (target slew) + 240s GS acq + 2 filters ×(120s filter move + 8×[257s dither slew + 5s detector config + 975s exposure)] = 22,068s = 6.1 hours. For the far clusters, we will have the same slew and setup time, but four times as many exposures, for a total of 22.6 hours. In total, then this program will have two clusters with 6.1 hours each, and two with 22.6 hours each, for a total of 57.4 hours.

TARGET(S):

M4 (NGC 6121):	16:23:54.7	−26:32:25.8
NGC6397:	17:41:02.7	−53:44:20.8
47 Tuc (NGC 104):	00:22:37.2	−72:04:14.0
Omega Centauri (NGC 5139):	13:25:35.5	−47:40:06.7

OBSERVING TEMPLATES:

NIRCam Imaging

OBSERVATION DETAILS:

Imaging: We will center one of the NIRCam modules on a field that HST has previously observed deeply. This will be a field at an intermediate radius where there are plenty of stars, but the crowding is not bad. We will dither only to cover the SCA gaps. The other module will take a similar set of data on a field that does not have previous observations.

CONSTRAINTS:

N/A.

PARALLEL Observations possible (yes/no/pure parallel)?

It might be worthwhile to take some MIRI observations, if we can observe at an orientation where MIRI will be imaging a field at a larger cluster radius, so that crowding will not be an issue for MIRI. We may even want to make sure there are no particularly bright stars in MIRI's field of view.

It might be interesting to take spectra with NIRSpec of the parallel fields. The star fields in the vicinity of these deep fields should be relatively well mapped from the ground such that we can get good positions to know which MSA slits to open.

COMMENTS:

This program is a follow-on program to several HST prorams that Harvey Richer has been PI of. Some of the observations may overlap with Jason Kalirai's WD JWST program but it is likely that our focus on faint red things may make for an optimal observing strategy for WDs.

AUTHORS/DATE: Jay Anderson, December 8, 2011

TITLE: White Dwarf Cooling Ages of Globular Clusters

ID: 93200

GOAL:

NIRCam imaging of the nearest 11 globular clusters will be used to uncover the remnant population of white dwarfs in each system. The white dwarf cooling sequences will be measured using two-filter photometry down to the truncation point. The luminosity and color function of these white dwarfs provides an excellent, and main-sequence turnoff independent, age diagnostic for each cluster. The cooling sequences from this study will also motivate new tests to white dwarf models in the near IR, where collisionally induced absorption of H2 (seen in the visible) is expected to be important. HST has successfully performed these studies in the three nearest globular clusters at optical wavelengths. Only JWST can extend the study to additional clusters.

Although young white dwarfs are hot, the stars near the bottom of the cooling sequence in old stellar populations have Teff = 4000 K. These stars are quite red, and can be imaged efficiently with JWST/NIRCam's bluer filters. The F090W filter has much better overall throughput than the bluer F070W filter, and the F150W filter is strongly preferred over the F115W (short wavelength baseline with F090W) and F200W (too red for white dwarfs) filters. The location of each field will be carefully chosen to ensure that a statistically significant number of white dwarfs are in the field of view, while now compromising photometric accuracy because of crowding. The dual channel of NIRCam can be used to obtain simultaneous imaging with F277W during both the F090W and F150W observations. These redder data will provide valuable characterization of the stellar main sequence in each cluster, and also be sensitive to accretion disks or planets around the brighter white dwarfs (e.g., through spectral energy modeling).

Based on previous HST experience and white dwarf models from B. Hansen, the truncation point of the white dwarf cooling sequence in a 12 Gyr population occurs at M_F814W = 15.2. The exposure time for each cluster is set to achieve a S/N = 10 measurement of this limit in both F090W and F150W. The F277W depth is not constrained. The limiting magnitude is set after factoring in both the distance to each cluster and the extinction along the line of sight, as summarized in the Table below. The last two columns give the exposure time in hours for each cluster, based on the JWST ETC. The three clusters previously observed on HST, M4, NGC 6397, and 47 Tuc are also included here. At <10% of the cost of the program, it would be beneficial to observe them in the same filters and set up as the new clusters to rule out systematic, wavelength-dependent errors in the models.

NOMINAL ALLOCATION (hours): 330 hours

ACTUAL TIME (hours):

264 hours, efficiency is estimated to be 80%

TARGET(S):

Cluster	(m-M)o	A_F814W	Target WD F814W	F090W Exp Time (h)	F150W Exp Time (h)
NGC 6121 (M4)	11.7	0.54	27.4	1.0	1.5
NGC 6397	11.8	0.27	27.4	1.0	1.5
NGC 104 (47 Tuc)	13.2	0.06	28.5	6.9	10.6

NGC 6656 (M22)	12.5	0.53	28.2	4.0	6.1
NGC 6752	13.0	0.06	28.3	4.9	7.4
NGC 6838 (M71)	13.0	0.37	28.6	8.3	12.6
NGC 6254 (M10)	13.2	0.41	28.8	12.5	18.3
NGC 6218 (M12)	13.5	0.28	29.0	17.2	26.4
NGC 3201	13.5	0.34	29.0	17.2	26.4
NGC 5139 (Om Cen)	13.6	0.18	29.0	17.2	26.4
NGC 6809 (M55)	13.6	0.12	28.9	14.4	21.9

OBSERVING TEMPLATE: NIRCam Imaging

OBSERVATION DETAILS:

Use the APT mosaic tool to produce multiple, dithered observations in each field, with Module=ALL and Subarray=FULL. The dithers should be designed to mitigate hot pixels and cosmic rays, and also to improve the sampling of the PSF in each channel. At least four exposures are required for each field. It is not necessary to fill the chip gap. Shorter exposures will likely not be needed given the ramp fitting. APT exposure times are reached using a primary dither pattern with subpixel dithers in the INTRAMODULE pattern. F277W is used in the dual channel on both the F090W and F150W exposures.

The actual exposure time is 264 hours and the efficiency is estimated to be 80% given the simplicity of the program. The total exposure time are dominated by deep shots of several clusters.

CONSTRAINTS:

PARALLEL Observations possible (yes/no/pure parallel)?

NIRISS parallel imaging would provide additional field coverage in the periphery of each cluster. The imaging would characterize both white dwarfs and main-sequence stars providing added leverage to study stellar and dynamical evolution processes.

COMMENTS:

AUTHOR/DATE: Jason Kalirai (jkalirai@stsci.edu) / 5 Jan 2012

Brad Hansen (hansen@astro.ucla.edu)

Harvey Richer (richer@astro.ubc.ca)

Jay Anderson (jayander@stsci.edu)

TITLE: NIRSpec Dense Field Spectroscopy of Omega Cen

ID: 93210

GOAL: Obtain radial velocities and chemical abundances for CNO from R=3000 spectra of > 5000 stars in Omega Cen. This globular cluster observation will also flex the capabilities of NIRSpec for operating in a very dense field of sources, with 1 source for every 5-10 shutters on the MSA.

NOMINAL ALLOCATION (hours): 50

ACTUAL TIME (hours):

This program will use 43 separate MSA configurations to observe 5896 stars in the center of Omega Cen (Field #2 in the observing scenario report). We will obtain ~10 min exposures with all three gratings at each configuration. To preserve the placement of targets within operable shutters, this program is executed with no dithering. With observatory and instrument overheads, we estimate that this program will require approximately 31 hours.

TARGET(S): Targets are drawn from Jay Anderson's ACS catalog of stars in the center of Omega Cen. They are main sequence and giant branch stars ranging from J ~ 12 - 20.

OBSERVING TEMPLATE: NIRSpec MSA spectroscopy

OBSERVATION DETAILS:

Obtain R = 3000 NIRSpec spectra in all available bands (G140H, G235H, G395H). Use 43 MSA configurations to obtain spectra of 5896 stars in Field #2 from the observing scenario report.

No contemporaneous pre-imaging is necessary because there is high-quality astrometry available from HST/ACS.

CONSTRAINTS: No constraints aside from roll angle, which is determined by MSA planning.

PARALLEL Observations possible (yes/no/pure parallel)? Could do deep NIRCam, MIRI or NIRISS imaging observations together with this spectroscopy. The spacing between the SI FOVs mean that no two instruments can observe the center of the cluster at the same time.

COMMENTS: The linked WIT observing scenario for this program is #205.

AUTHOR/DATE: Jason Tumlinson, November 21, 2011

Nearby Galaxies Programs

TITLE: Imaging of resolved stellar populations

ID: 94010

GOAL:

Investigate the stellar populations in well resolved galaxies. The main goal is to probe the evolved stellar population (AGBs) and the very young YSOs. For the AGBs, these observations provide a measure of their dust mass loss. For the YSOs, this provides a meausre of the circumstellar dust mass. In general, near-infrared photometry probes the stellar atmosphere and the mid-infrared photometry probes the circumstellar environment. This program builds on the successful Spitzer SAGE programs in the Magellanic Clouds by extending this type of work to more distant galaxies as well as better sampling the mid-infrared SEDs (e.g., the 10 micron silicate feature).

NOMINAL ALLOCATION (hours): 400

ACTUAL TIME (hours): 426

Using the spreadsheets to calculate the time. Assuming one slew to each target and then minimal slews between the different instrument observations.

Time (direct only) for nucleus: 12.9 hrs (MIRI) and 2.3 hrs (NIRCam), total = 15.2 hours.

Assuming the same set of observations for all 28 regions gives 425.6 hours.

TARGET(S):

4 positions in M31 to sample up to 10 kpc (nucleus to 10 kpc star forming ring).

3 position each in the LMC, SMC, and NGC 6822 to sample a range of metallicities and environments.

2 positions in M33, M51, M81, & M82 to sample center and disk.

1 position in NGC 925, NGC 1097, NGC 3351, NGC 4125, NGC 4594, NGC 5866 & NGC 6946.

This sample of galaxies will probe a range of stellar populations in different galaxy types.

OBSERVING TEMPLATES:

MIRI Imaging

NIRCam Imaging

OBSERVATION DETAILS:

Imaging: Each region will be observed with 2 NIRCam filters and 5 MIRI filters to provide good photometric SEDs to measure the stellar and circumstellar properties of the stars.

Mosaics for MIRI (4x4) and NIRCam (4x1) are done to provide a large enough region to sample the evolved stellar population as well as different star forming environments.

CONSTRAINTS:

N/A.

PARALLEL Observations possible (yes/no/pure parallel)?

Ideal for parallel observations. Larger regions can be mosaiced with NIRCam/MIRI by taking observations separated by 6 months in parallel. Data volume could be managed by only saving data from one side of NIRCam. Idea is to do something similar to what has been done for the PHAT M31 MCT.

COMMENTS:

AUTHORS/DATE: Karl Gordon (kgordon@stsci.edu)/3 Jan 2012Martha Boyer

TITLE: Bottom of the Main Sequence in Nearby Local Group Galaxies

ID: 94020

GOAL:

NIRCam images in the F090W and F277W filters (obtained simultaneously in the short and long wavelength channels, respectively) will be used to survey the low-mass stellar content of nine Local Group galaxies closer than 100 kpc. Each of these galaxies will be mapped along two strips that are approximately orthogonal, as done in the incarnation of this program that appeared in the 2005 SODRM (Program #410). At each position in the map, a half hour of exposure time will provide stellar photometry on the lower main sequence. The faint limit will vary from galaxy to galaxy, but will roughly reach 5.5 bolometric magnitudes below the old main-sequence turn-off. The resulting color-magnitude diagrams will be used to study luminosity and mass functions for the low-mass main-sequence stars as a function of position in the galaxy, along the two axes mapped.

For reference, assume an isochrone of a 10 Gyr population with a metallicity of Z=0.008 ([Fe/H]=-0.4) from the Padova isochrone library, which shows that a 0.25 M_{Sun} star has an effective temperature of 3750K (M0V) and the following absolute magnitudes (relative to Vega): M_V=10.9, M_I=9.0, M_J=8.0, M_H=7.1 mag. This point is 5.5 bolometric magnitudes below the turnoff.

NOMINAL ALLOCATION (hours): 400 hours

ACTUAL TIME (hours):

276 tiles x 869 sec/tile x 1/3600 hr/sec @ 50% efficiency = 133 hours.

TARGET(S):

Name	R.A. (J2000)	Dec (J2000)	Dist (kpc)	Dims (’)	F090W M0V SNR	F277W M0V SNR	Mosaic Tiles
LMC	05:23:48	-68:09:23	49	650x550	7	11	100
SMC	00:52:45	-72:37:43	58	280x160	5	8	100
Sag DEG	18:55:04	-29:26:08	24	190x490	25	39	100
Sculptor	00:59:59	-32:45:51	78	45x40	3	4	38
Sex A	10:11:06	-04:43:00	90	6x5	2	3	8
Sex B	10:00:00	+05:20:00	90	6x4	3	3	8
Carina	06:41:41	-49:07:59	87	24x15	2	3	16
Ursa Minor	15:08:48	+67:11:38	69	41x26	4	5	24
Draco	17:20:00	+57:55:04	76	51x31	3	4	30

OBSERVING TEMPLATE: NIRCam Imaging

OBSERVATION DETAILS:

Use the APT mosaic tool to create a strip that has only 1 row, with the number of columns chosen to span the width of the galaxy, employing 0% column overlap. This will create a strip with a width equal to a single 2.16' module. Each spot along the strip will have two 869 sec exposures, because one module will always be landing on a spot imaged by the other module in the neighboring exposure, except for the endpoints of the strip. The two exposures can be used to mitigate detector artifacts but will not provide PSF resampling. Assume MEDIUM2 with NGROUPS=9, which gives an exposure time of 869 sec per exposure, F090W on the short wavelength channel, F277W on the long wavelength channel, MODULE=ALL, and SUBARRAY=FULL.

Each galaxy should have two strips; one strip should have an orientation rolled ~90 or ~270 degrees relative to the other strip. The length of each strip should be approximately the shorter of the two axes of the galaxy, such that the crossed strips can rotate freely on the sky and offer more scheduling opportunities (i.e., the strips will not extend to the very edges of the galaxy on the long axis of the galaxy). For the 3 galaxies with the greatest extent on the sky (LMC, SMC, Sag DEG), it is not practical to extend the strips across the entire width of the galaxy, so set the maximum strip length to 50 mosaic tiles (106' at full depth, with roughly 2.5' on each end of the strip that have half the depth). If one was willing to forego contiguous strips in the three extended galaxies, one could alternatively use sparsely-sampled strips, but these would incur more regions with half the depth.

Assume an efficiency of 50%, near the low end of the range seen in other shallow imaging programs. We are obtaining a series of short (869 sec) exposures, where each exposure is at least 2 arcmin from any other exposure in the program.

CONSTRAINTS:

To efficiently obtain two exposures for each piece of sky, the mosaic tiles on a given axis will always be offset in a direction parallel to the line connecting the centers of the two modules. That means that one of the axes must be scheduled with an orientation ~90 or ~270 degrees relative to the other axis.

PARALLEL Observations possible (yes/no/pure parallel)?

MIRI parallel imaging would provide interesting diagnostics on cool populations.

COMMENTS:

Based upon program 410 in the 2005 SODRM. Note that APT v19.4 does not allow more than 50 tiles in a mosaic axis.

AUTHOR/DATE: Tom Brown (tbrown@stsci.edu) / 6 Dec 2011 (Version 1)
Version 2: Updated with additional references to Program 410 (T. Brown, 1 Feb 2012)

Version 3: Updated to reflect actual number of tiles instead of the larger number originally planned to cover the full extent of each galaxy (T. Brown, 1 Marc 2012)

Original SODRM program author: Jeff Valenti (valenti.stsci.edu) / 19 Jan 2005

TITLE: Star Formation in the Large Magellanic Cloud / Small Magellanic Cloud

ID: 94030

GOAL:

The overwhelming majority of observational studies of star formation have been conducted on Milky Way star formation regions. However, star formation in the Universe is dominated by star formation at low metallicity, i.e. sub solar. The metallicity of the interstellar medium (ISM) during the peak star formation rate in the Universe, which occurs at a redshift of z ~ 1.5, is comparable to that of the Large Magellanic Cloud (LMC) and Small Magellanic Cloud (SMC). In the Spitzer-SAGE programs, thousands of new candidates young stellar objects were discovered a marked increase over the 1 YSO known prior in the SMC and 20 YSOs known in the LMC. This program will both followup candidate YSOs from Spitzer using MIRI MRS and NIRSpec IFU spectroscopy. We will also conduct sensitive imaging projects with NIRCam and MIRI to detect and characterize YSOs with lower mass and dust content than reachable by Spitzer. The targeted flux limit should reach individual 2 solar mass T-Tauri type star at the distance of the Magellanic Clouds.

NOMINAL ALLOCATION (hours): 500

ACTUAL TIME (hours): 583.4

TARGET(S):

For MIRI & NIRSpec spectroscopy: 100 YSOs in the LMC, some in clusters and some isolated; 50 YSOs in the SMC, some in clusters and some isolated; see the APT file for the source list

For MIRI & NIRCam imaging: 4 fields in the LMC and 2 fields in the SMC

OBSERVING TEMPLATE:

MIRI MRS spectroscopy, full wavelength coverage

NIRSpec IFU spectroscopy, full wavelength coverage

MIRI imaging

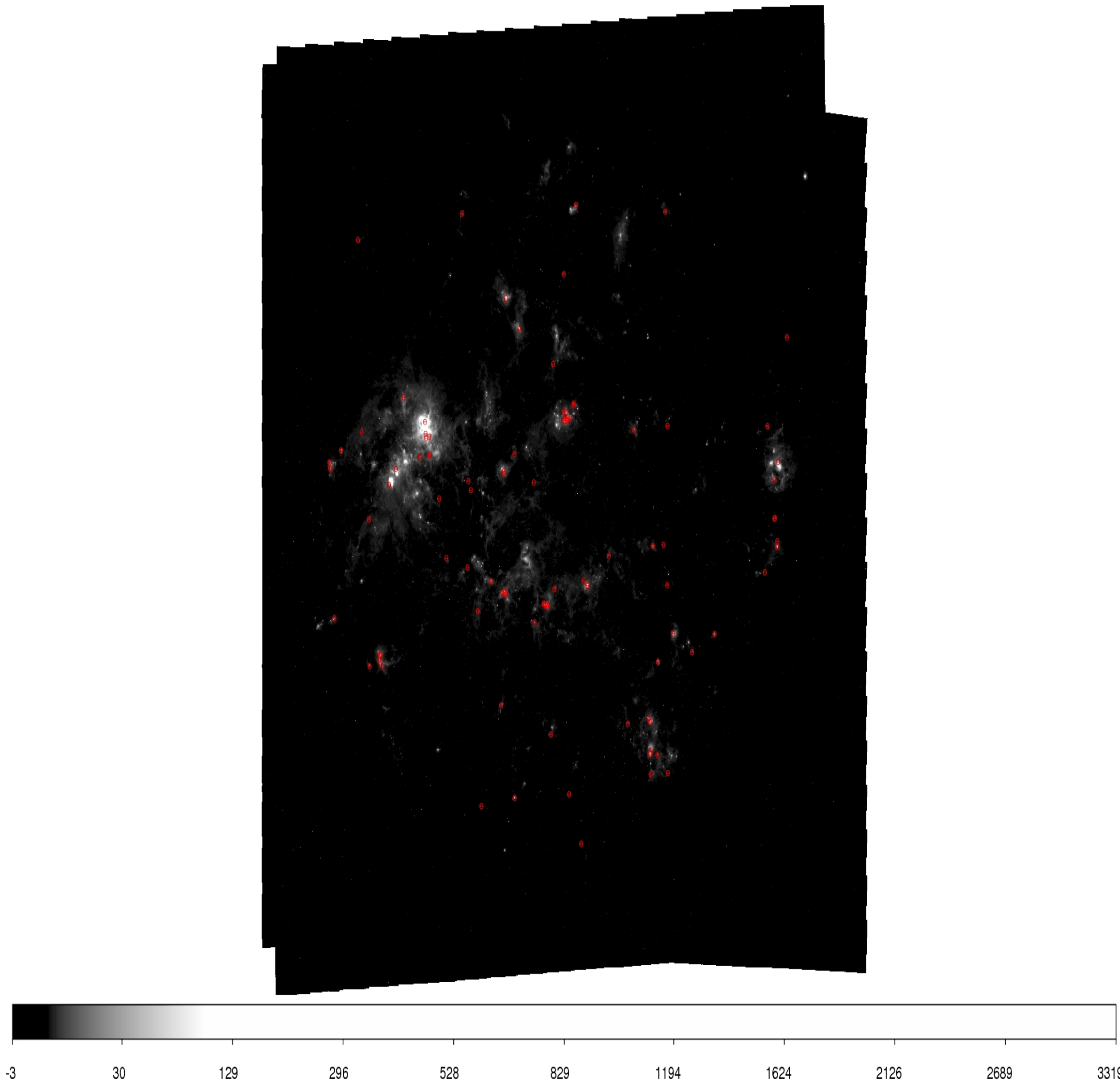
NIRCam imaging

OBSERVATION DETAILS:

This set of observations is a follow-up on a large sample of individual YSOs in the Magellanic Clouds and on several of the large star formation regions in which they are organized.

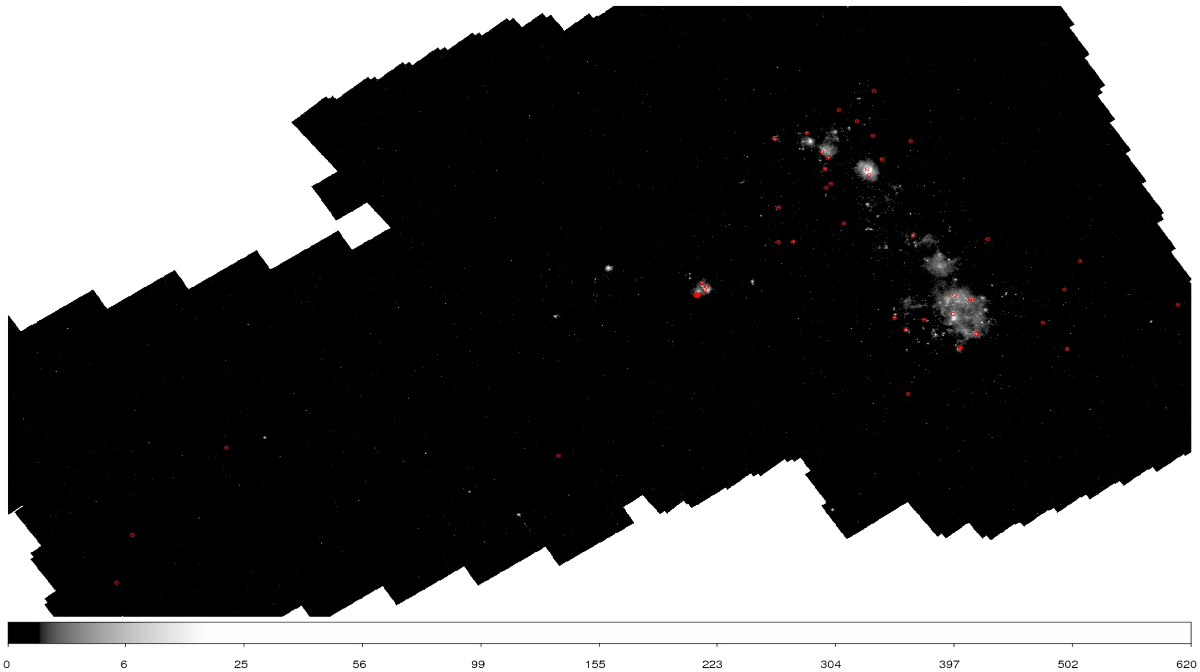
MIRI & NIRSpec Spectroscopy:

We have selected 150 YSOs as targets for spectroscopic observation with JWST – 100 in the LMC and 50 in the SMC. Objects were chosen to be randomly distributed in both galaxies and sample a range in 8.0 m flux. The random selection is a proxy for source total luminosity, as a realistic proxy for a scientifically driven need to sample different types of YSOs and different environments. All chosen targets have an 8.0 m flux greater than 2 mJy.



The Large Magellanic Cloud in Spitzer/MIPS 24 micron band in grey scale with the location of the targeted YSOs, marked by red dots. Some are clustered and others are isolated.

To cover the full range of spectral wavelengths afforded by JWST, we will use both MIRI Medium Resolution Spectroscopy and NIRSpec IFU Spectroscopy. In the mid-IR, the selected YSOs have typical continuum fluxes of >2 mJy. In 10 minutes of on source integration, MIRI can attain a continuum SNR for the dimmest sources of ~50, and >1000 for the brightest. Emission lines, often seen in the mid-IR spectra of YSOs to be an order of magnitude above the continuum will be detected to a SNR of at least several hundred. Each source requires three integrations (one for each wavelength region – short, medium, and long), so each target requires 30 minutes of on source integration. With 150 targets at 30 minutes of integration each, MIRI's spectroscopy will require 75 hours of on-source integration. Overheads for each source include slewing to the source (1800 seconds), guide star acquisition (240 seconds), target acquisition (600 seconds), dither slews for the 4 dithers anticipated (30 seconds each, 12 dither slews total, 360 seconds total), three grating/dichroic changes (60 s each, 180 s total), and detector overheads (5 s configure + 42 seconds deadtime = 47 sec per dither slew, 564 s total). The total overheads time is 3744 seconds, 62.4 minutes or 1.04 hours per source.



The Small Magellanic Cloud and its wing, and tail in Spitzer/MIPS 24 micron band in grey scale with the location of the targeted YSOs, marked by red dots. Some are clustered and others are isolated.

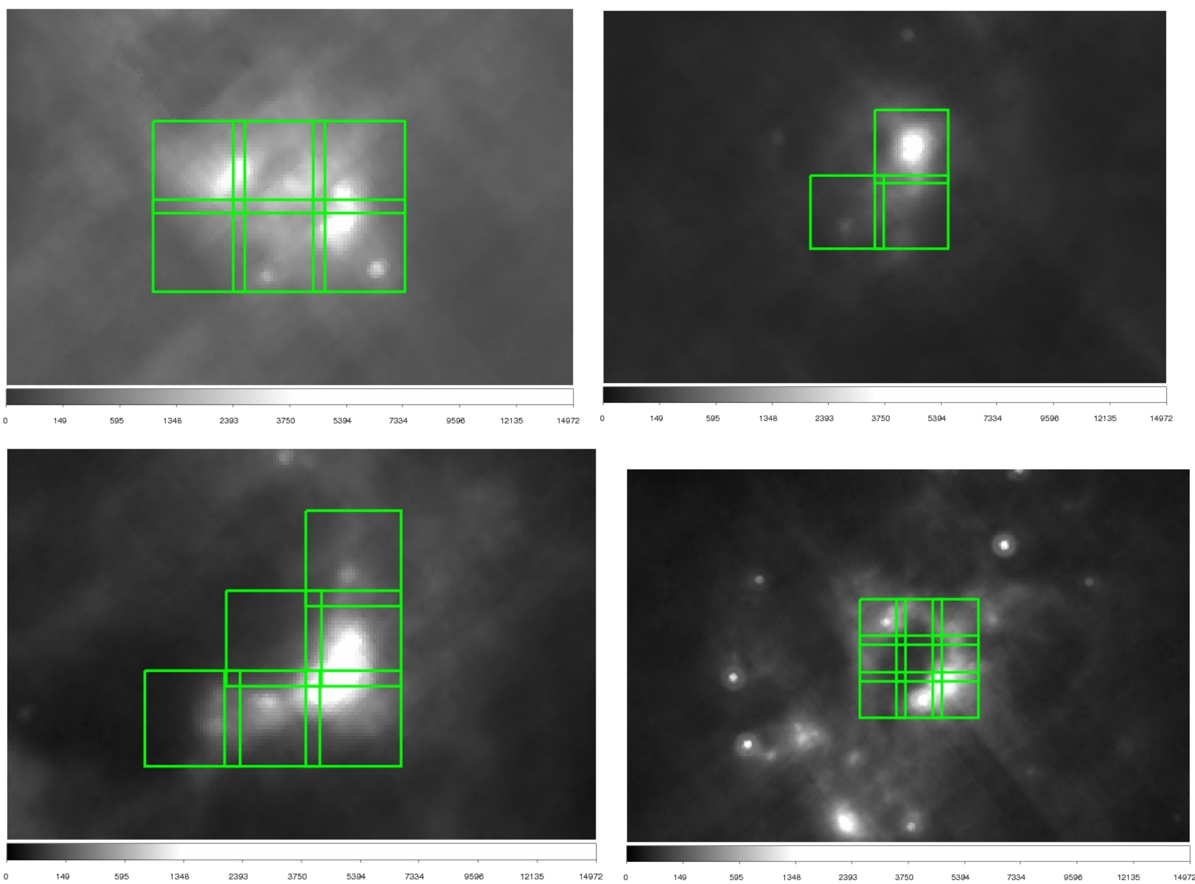
We use all high resolution gratings (G140H, G235H, and G395H) to cover the complete NIRSpec wavelength range. This wavelength range is particularly important for detecting ices via absorption and gas-state molecules in emission. Even the dimmest sources can attain a high continuum SNR (>50) in 5 minutes of integration. For the three filters this will require 50 minutes of integration per source. For 150 sources, this amounts to 37.5 hours of on source integration time. By taking the spectrum using NIRSpec immediately following the same source's MIRI Spectral observation, we can significantly reduce the overheads by avoiding a full slew to the source. In this case the overheads include guide star acquisition (240 seconds), target acquisition (600 seconds), dither slews for the 4 dithers anticipated (30 seconds each, 12 dither slews total, 360 seconds total), three grating/filter changes (150 s each, 450 s total), and detector overheads (20 s configure + 15.9 seconds deadtime = 25.9 sec per dither slew, 430.8 s total). The total overheads time is 2080.8 seconds, 34.68 minutes or 0.578 hours per source.

In summary, the total on source integration time per target is 80 minutes (30 for MIRI and 50 for NIRSpec) or 1.3 hrs and the total overhead for the target is 1.62 hours, adding the indirect overheads at 15.9% of total time or 0.464 hours. Thus the total burden on the observatory is 1.3 hrs on source integration, and 2.084 hrs overhead for a total of 3.384 hrs. The total spectroscopy program time is 150 x 3.384 hours or 508 hours. This spectroscopy program is 38.4% efficient.

NOTE: For the overhead calculations, we have assumed that the NIRSpec observation is not charged the slew overhead for moving from MIRI spectroscopy to NIRSpec spectroscopy because we anticipate these observations will be linked; the distances will not be large and a full slew tax would be unreasonable. If this assumption is invalid, then overheads on this program will need to be increased by 150 x 1800 seconds. We could enable further efficiencies if we allowed a cluster mode to target several of the YSOs in active star formation regions. We did not assume such an efficiency in this overhead calculation.

MIRI & NIRCam Imaging:

We have selected six (four in the LMC and two in the SMC) star formation regions for imaging with both MIRI and NIRCam. The observations will require mosaicking multiple pointings to completely cover the regions. In the LMC, we have selected N44, N105, N113, and N159, while in the SMC we have selected NGC 602 and N66. Each of these regions requires 3-9 pointings each (see the figures below).

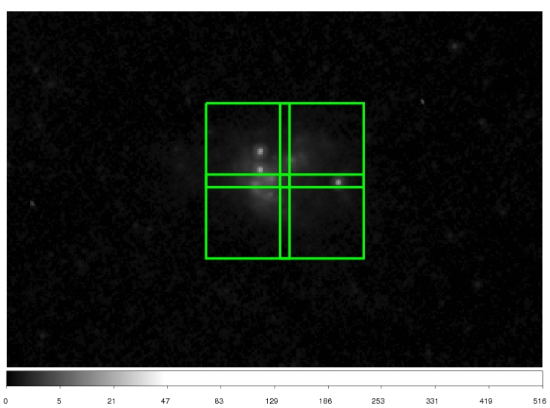


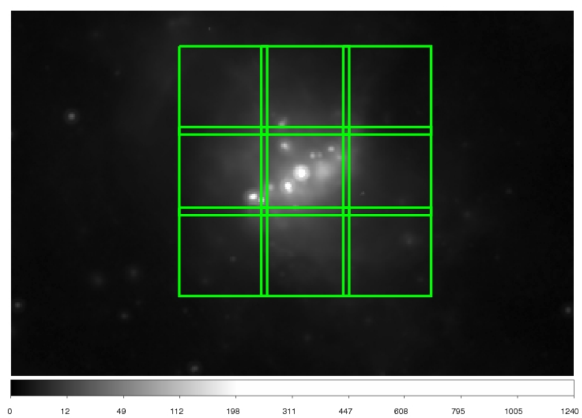
LMC star formation regions with the tiling shown for the MIRI and NIRCam mapping strategy. Clockwise: N159 (top, left), N105 (top right), N44 (bottom right), and N113 (bottom left).

We have estimated the observing time required to detect a 2 solar mass T-Tauri type star at the distance of the Magellanic Clouds, and therefore should be sensitive to objects above this mass threshold. Depending on the exact nature of the source (presence of circumstellar envelope, etc.), we may be sensitive to even lower mass objects. With the MIRI imager, we will observe with two different filters in the mid-IR, F560W and F2100W. To reach the desired YSO mass detection threshold (~10 sigma detection) will require 10 minutes of integration at 5.6 m and 60 minutes of integration at 21 m, or 70 minutes per pointing. There are a total of 37 pointings to cover the regions, giving a total on source integration time of 43.16 hours. Overheads for each source include slewing to the source (1800 seconds), tile slew (100 seconds per mosaic pointing), guide star acquisition (240 seconds), dither slews for the 4 dithers anticipated (30 seconds each, 120 seconds per mosaic tile), filter changes (60 s each), and detector overheads (5 s configure + 42 seconds dead time = 47 sec per dither slew). The total overheads varies for each source and we refer to the spreadsheets for the details.

The summary from the MIRI spreadsheets are as follows: For N105, on source integration time is 12600 seconds, overheads including the 15.9% indirect is 5553 seconds. For N159, on source integration time is 25200 seconds, overheads including the 15.9% indirect is 8880 seconds. For N113, on source integration time is 25200 seconds, overheads including the 15.9% indirect is 8880 seconds. For N44, on source integration time is 37800 seconds, overheads including the 15.9% indirect is 12208 seconds. For NGC602, on source integration time is 16800 seconds, overheads including the 15.9% indirect is 6662 seconds. For NGC346/N66, on source integration time is 37800 seconds, overheads including the 15.9% indirect is 12208 seconds.

Bottom line for MIRI imaging: 43.2 hours on source, 15.1 hours overhead; 58.3 hours total time.





SMC star formation regions with the tiling shown for the MIRI and NIRCam mapping strategy. NGC602 (left), and NGC 346 (a.k.a. N66; right).

We will also image each region in the near IR with NIRCam. A 10-sigma detection of a 2 solar mass YSO detection can be attained in ~5 minutes of integration time with the F070W, F277W, F150W, and F356W filters. A pair of short and long filters can be used simultaneously so that For each pointing, only two integrations are needed. Each integration is 5 minutes, so each pointing requires 10 minutes of integration; all 37 pointings can be completed in a total of 6.16 hours. As we did with the spectroscopy program, we assume we can reduce overheads by using MIRI Imaging and NearCam Imaging sequentially for each source, thus eliminating a slew to the target. Overheads for each source include tile slew (100 seconds per mosaic pointing), guide star acquisition (240 seconds), dither slews for the 4 dithers anticipated (30 seconds each, 120 seconds per mosaic tile), filter changes (60 s each), and detector overheads (5 s configure + 42 seconds dead time = 47 sec per dither slew). The total overheads varies for each source and we refer to the spreadsheets for the details.

The summary from the NIRCam spreadsheets are as follows: For N105, on source integration time is 3600 seconds, overheads including the 15.9% indirect is 1969 seconds. For N159, on source integration time is 7200 seconds, overheads including the 15.9% indirect is 2841 seconds. For N113, on source integration time is 7200 seconds, overheads including the 15.9% indirect is 2841 seconds. For N44, on source integration time is 10800 seconds, overheads including the 15.9% indirect is 3714 seconds. For NGC602, on source integration time is 4800 seconds, overheads including the 15.9% indirect is 2260 seconds. For NGC346/N66, on source integration time is 10800 seconds, overheads including the 15.9% indirect is 3714 seconds.

Bottom line for NIRCam imaging: 12.3 hours on source, 4.8 hours overhead; 17.1 hours total time.

Bottom line for MIRI imaging: 43.2 hours on source, 15.1 hours overhead; 58.3 hours total time.

In summary, the total on source integration time for MIRI and NIRCam imaging is 55.5 hours and overhead is 19.9 hours for a total imaging program time burden of 75.4 hours. This imaging program is 73.6% efficient.

NOTE: For the overhead calculations, we have assumed that the NIRCam observation is not charged the slew overhead for moving from MIRI imaging to NIRCam imaging focal planes because we anticipate these observations will be linked; the distances will not be large and a full slew tax would be unreasonable. If this assumption is invalid, then overheads on this program will need to be increased by 6 x 1800 seconds.

In total this program of imaging and spectroscopy has 75.4 + 508 = 583.4 hours of total time.

CONSTRAINTS:

None

PARALLEL Observations possible (yes/no/pure parallel)?

Yes, one can imagine taking some spectra while imaging is prime and taking some imaging frames with MIRI or NIRCam while taking spectra.

COMMENTS: See the embedded comments on assumptions on linked; i.e. no slew taxed observations.

AUTHOR/DATE: Margaret Meixner & Jonathan Seale /27 January 2012

TITLE: The Structure of Cold Gas in Star Forming Regions

ID: 94050

GOAL:

The purpose of this program is to image the gas in a range of star forming regions using NIRCam imaging with a range of narrow filters. Medium filters are used to characterize the stellar populations and allow continuum subtraction to achieve pure emission line images.

NOMINAL ALLOCATION (hours): 100 hours=360 ks

ACTUAL TIME (hours):

As specified, the program contains about 185 ksec of observing time. An experiment with the first observation in the program indicates an efficiency of about 40%, so this would correspond to about 462 ksec or 128 hours.

TARGET(S): I have selected some Magellanic Cloud H II regions, and other star forming regions in Local group galaxies (M31, M33) as well as mosaics of nearby galaxies M51, M83, M101, NGC 4449 and NGC 4214.

OBSERVING TEMPLATE: NIRCam Imaging

OBSERVATION DETAILS:

There are 13 targets listed. Some require only a single field, while others assume mosaics of various sizes to cover the region of interest. Including all of the mosaic tiles, there are 88 executions of the basic sequence that follows:

Short Filter Long Filter Requested ExpTime Readout Pattern No. of Groups No. of Integrations Actual Exp Time

1 F162M+F150W2 F410M RAPID 5 1 53.0

2 F182M F430M RAPID 5 1 53.0

3 F210M F480M RAPID 5 1 53.0

4 F164N+F150W F405N+F410M RAPID 15 1 159.0

5 F187N F466N+F460M RAPID 15 1 159.0

6 F212N F470N+F444W RAPID 15 1 159.0

3-point Intramodule primary dithers are assumed to cover gaps, but no sub-pixel dithers are required. Note: Both modules are used with paired filters, and FULL arrays.

CONSTRAINTS:

No constraints are assumed, although one could imagine it might be desirable to constrain the position angles of some of the mosaics.

PARALLEL Observations possible (yes/no/pure parallel)?

A parallel program of similar observations could be crafted, but this specific proposal does not seem like a good parallel opportunity because it targets specific objects.

COMMENTS:

AUTHOR/DATE: Bill Blair, December 9, 2011

TITLE: NIR Imaging and Spectroscopy of Compact Sources in Nearby Galaxies

ID: 94060

GOAL: Extragalactic globular cluster (GC) systems provide an excellent tool to trace the star formation and chemical enrichment histories of their host galaxies. Optical imaging programs using HST have established that several nearby early-type galaxies are known to host rich GC systems. In several such galaxies, the imaging yielded hitherto unknown and unexpected evidence for the presence of significant subpopulations of intermediate-age GCs with ages of 1-5 Gyr, i.e., formation redshifts $0.1 < z < 1$. However, optical colors are strongly degenerate in age and metallicity. Spectroscopy of such GCs are needed *(i)* to confirm or deny the intermediate ages and *(ii)* to provide information on the chemical composition of such GCs. Unfortunately, these subpopulations are mainly found in the inner regions of galaxies, and the strong and sometimes complex galaxy background in these regions has so far prevented one from obtaining sufficient S/N in spectra, even when using ground-based 10-m class telescopes. With NIRSPEC on JWST, we can finally obtain adequate spectra of these targets down to relevant levels of the GC mass function, using multi-object spectroscopy. This program will obtain such observations in nearby galaxies in which evidence for the presence of intermediate-age GCs has been found. In addition to spectroscopy of NIR features that are sensitive to age and metallicity, imaging with a variety of filters will be taken to compare optical/NIR colors with the relative line strengths of spectral features in the NIR.

NOMINAL ALLOCATION (hours): 200

ACTUAL TIME (hours): 175

Using custom ETC to account for background diffuse light from the target galaxy. Aim for S/N = 30 per resel at M_V = -8.5 mag (using appropriate SED) for spectroscopy. Use median distance of all known galaxies with candidate intermediate-age GCs.

Using the spreadsheets to calculate the time. Assuming one slew to each target and two MSA configs/pointings per target galaxy. No target acqs needed for the NIRCam observations.

Time (direct only) per target galaxy: 10.5 hrs (NIRSpec MSA) + 2.0 hrs (NIRCam Imaging), total = 12.5 hours.

Assuming the same set of observations for the assumed 14 nearby target galaxies at similar distances yields 175 hours.

TARGET(S):

Candidate young or intermediate-age globular clusters in the inner regions of nearby galaxies.

OBSERVING TEMPLATES:

NIRSpec MSA

NIRCam Imaging

OBSERVATION DETAILS:

Spectroscopy: In each galaxy, multi-object spectroscopy will be used to produce spectra of several GCs per pointing. For NIRSpec, two gratings are needed (G140M/F070LP and G235M/F170LP) to cover the temperature (and hence age)-sensitive lines Paγ and Paδ as well as metallicity-diagnostic lines (Na, Fe, CO, N). We assume that 2 pointings (and target ACQs) will be used per galaxy target.

Imaging: Each galaxy will be observed with 4 NIRCam filters (i.e., 2 pairs: F090W/F277W and F200W/F356W) to provide good photometric coverage over the entire wavelength range of the spectral observations. Use 8 dithers per filter pair (INTRAMODULE dithers, 4 primary, 2 subpixel).

CONSTRAINTS:

N/A.

PARALLEL Observations possible (yes/no/pure parallel)?

Taking parallel imaging with NIRCam or NIRISS while NIRSpec or NIRCam is prime would be great for stellar populations work.

COMMENTS:

This program could be expanded to include MIRI imaging and/or more targets.

AUTHORS/DATE: Paul Goudfrooij (goudfroo@stsci.edu); 14 Dec 2011

TITLE: Monitoring of Recent SNe for Dust Formation

ID: 94070

GOAL:

Monitor a number of nearby SNe of various types to look for evidence of dust formation. For the purpose of this SODRM program, assume 5 SNe of two different core-collapse types (SN II-P and II-n) should be monitored for dust formation over a range of timescales relevant to the SODRM. Assume Texp + 20 days, 40 days, 80 days, and 120 days, and 160 days.

NOMINAL ALLOCATION (hours):

100 hours = 360 ks

ACTUAL TIME (hours):

Roughly 24 hours of actual observing time are specified. Assuming a roughly 50% efficiency, this program as specified probably amounts to about 50 hours rather than the allocated 100 hours.

TARGET(S): I have selected five recent SNe as representative of actual targets that might be observed. I have fictitiously named the SN as if they were objects discovered in 2018 and 2019.

OBSERVING TEMPLATE: MIRI Imaging, MIRI LRS

OBSERVATION DETAILS:

MIRI LRS observations cover the 5-14 um range at R=100. Then MIRI imaging with a number of medium band filters is used to look for the 18 um silicate feature (plus sample continuum on either side) and to observe the longer wavelength continuum to provide a longer lever arm on the dust temperature.

For LRS, I assume “PT SOURCE” for dither type (e.g. two dither steps) and readout pattern SLOW, for no other reason than it eats up more time and makes the integrations longer. No great care has gone into selecting the exposure times.

For the imaging, I assume 3-pt dithers and sub-pixel, nominally to produce the best image quality for photometry.

CONSTRAINTS:

The observations are ToO, in the sense that it is assumed five different SNe will be targeted at some point in the SODRM (1.5 year) period, with the first observation at 20 days post-explosion. Then a sequence of observations are requested for monitoring the targets for possible changes indicating the formation of dust in and around the SNe. For purposes of the SODRM, I assume the desire to monitor at post-explosion times of 20, 40, 80, 120, and 160 days for each SN.

I have thus added timing links (with a +/-5 day for scheduling flexibility), and I have used a “group within 2 hours” requirement to force the LRS and Imaging observations to be done at the same time.

PARALLEL Observations possible (yes/no/pure parallel)?

This would not be a good parallel program opportunity.

COMMENTS: For the SODRM exercise, we should decide on how to specify when to start the clock for each of the SNe (e.g. when does each SN pop off) in order to allow a staggered start to the monitoring sequence for each SN. At the moment, I have just suggested start times from the assumed beginning of the SODRM cycle in the comments of the APT file.

A couple of additional comments on implementing a program such as this:

- Since the target brightness will vary over time, this may complicate the target acquisition procedure.
- If any SNe to be observed are in spatially large galaxies, this might also affect the ability to find appropriate guide stars.

In reality, the timeframe for observations of dust formation are probably quite a bit longer than the time frame assumed here. Hence, this program is provided more as a way to enter some modest ToO and monitoring-type observations into the SODRM than anything else.

AUTHOR/DATE: Bill Blair, December 15, 2011; updated 2/2/12

TITLE: The ISM in the Center of Nearby Galaxies

ID: 94090

GOAL:

The goal of this proposal is to investigate the centers of 75 nearby well studied galaxies (the SINGS sample) to study the ISM from 1 to 5 microns. This wavelength range gives us access to a wide variety of spectral features at sensitivities that are unprecedented. The project has two goals. The first is to learn about the ISM in these galaxies using the unique capabilities of the IFU on the JWST NIRSpec instrument. The spatial resolution and sensitivity will allow us to study star formation and topics such as black hole fueling without being affected by the dust extinction that can be significant in the optical bands. The second goal is to calibrate potentially new diagnostics against the well calibrated galaxy characteristics of the sample galaxies. The SINGS sample is an excellent sample for this given the large variety of observations of these galaxies at all wavelengths. This calibration will be extremely useful for other JWST NIRSpec observations.

NOMINAL ALLOCATION (hours): 50

ACTUAL TIME (hours): 286

Using the spreadsheets to calculate the time. Assuming one slew to each target and then four small dithers per target. ***No target acquistions are needed for the IFU observations*** as guide star catalog uncertainty is small enough. If TA is needed the total time goes up to 298 hours.

The efficiency without TA works out to be 62%. Compared to 60% with TA.

TARGET(S): The 75 SINGS galaxies

OBSERVING TEMPLATES: NIRSpec IFU

OBSERVATION DETAILS:

Spectroscopy: Each HII region will be observed with the MIRI and NIRSpec IFUs to cover at least a 5"x5" region (requires multiple mini-map/mosaic positions). For MIRI, all 3 grating settings will be taken. For NIRSpec, two grating settings are needed to cover the 3.3 micron aromatic feature as well as obtain good diagnostic atomic/molecular emission lines (G395H/F290LP & G235H/F170P). This will produce full spectra at each point from 1.7-28.3 microns.

Imaging: Each HII region will be observed with 4 NIRCam filters and 6 MIRI filters to provide good photometric coverage over the entire wavelength range of the spectral observations.

CONSTRAINTS: N/A.

PARALLEL Observations possible (yes/no/pure parallel)?

Parallels with either of the cameras and/or NIRISS would in principle be useful.

COMMENTS: None.

AUTHORS/DATE: Michael Regan (mregan@stsci.edu)/21 Jan 2012; updated 15 Feb 2012 (Blair)

TITLE: IFU/Imaging of Extragalactic HII/SF regions

ID: 94100

GOAL:

The mid-infrared aromatic (PAH) features have been seen to be nearly ubiquitous in dusty astrophysical objects and have the potential to provide a strong diagnostic of the dust and environmental properties of star formation regions in nearby and distant galaxies. The aromatic features have been seen to vary strongly as a function of environment from Spitzer observations. These Spitzer observations have shown that the strength of the aromatic features is roughly constant up to some threshold in ionization (as probed be the [NeIII]/[NeII] line ratio) and then drops quickly with increasing ionization. While the strength of the aromatic features changes by over a factor of 10, the ratio of different features does not vary by more than a factor of two. This result has been seen in M101 HII regions (Gordon et al. 2008, ApJ, 682, 336) and a large sample of nearby starburst galaxies (Engelbracht et al. 2008, ApJ, 678, 804). This lack of significant variation in the aromatic feature ratios is unexpected given that the most probably carrier of these features is polycyclic aromatic hydrocarbon molecules (PAHs). If the carriers are PAH molecules, the feature ratios are predicted to vary strongly due to ionization and size selective destruction mechanisms. Unfortunately, the wavelength resolution and sensitivity of the Spitzer/IRS instrument was not high enough to probe for feature ratio variations larger than about a factor of two or to measure the aromatic features for faint HII regions in nearby galaxies. With JWST, we can obtain much higher spectral and spatial resolution observations for both bright and faint targets. This program will obtain such observations in M101 and other nearby galaxies. In addition to the spectroscopy, imaging with a variety of filters will be taken to calibrate a broad band based measurements of the aromatic features.

NOMINAL ALLOCATION (hours): 50

ACTUAL TIME (hours): 43.3

Using the spreadsheets to calculate the time. Assuming one slew to each target and then minimal slews between the different instrument observations. No target acquistions are needed for the IFU observations as we are mapping a 5”x5” region.

Time (direct only) for nucleus: 3200 s (MIRI-IFU), 2700 s (NIRSpec IFU), 3100 s (MIRI Imaging), 3000 s (NIRCam Imaging), total = 1,2000 s = 3.3 hours. (This is the “fastest” possible for the brightest target).

Assuming the same set of observations for all 13 targets in M101 gives 43.3 hours.

TARGET(S):

M101 HII regions from Gordon et al. (2008).

OBSERVING TEMPLATES:

MIRI MRS-IFU

NIRSpec IFU

MIRI Imaging

NIRCam Imaging

OBSERVATION DETAILS:

Spectroscopy: Each HII region will be observed with the MIRI and NIRSpec IFUs to cover at least a 5"x5" region (requires multiple mini-map/mosaic positions). For MIRI, all 3 grating settings will be taken. For NIRSpec, two grating settings are needed to cover the 3.3 micron aromatic feature as well as obtain good diagnostic atomic/molecular emission lines (G395H/F290LP & G235H/F170P). This will produce full spectra at each point from 1.7-28.3 microns.

Imaging: Each HII region will be observed with 4 NIRCam filters and 6 MIRI filters to provide good photometric coverage over the entire wavelength range of the spectral observations.

CONSTRAINTS:

N/A.

PARALLEL Observations possible (yes/no/pure parallel)?

Taking parallel NIRCam/MIRI Imaging while the other was prime would be good for stellar populations work. Parallel NIRCam/MIRI imaging while the MIRI/NIRSpec IFU observations would be great for the same reasons. A +/-180 degree flip still provides useful information.

COMMENTS:

This is a program that is similar to one that was discussed by the MIRI Science Team (discussion lead by Gordon) and by the NIRCam Science Team (lead by Engelbracht).

This program could be expanded to more targets. Galaxies that would be of interest would be M31, M33, NGC 6946, & M81 (to just name 4).

AUTHORS/DATE: Karl Gordon (kgordon@stsci.edu)/3 Jan 2012; updates 15 Feb 2012 (Blair)
Charles Engelbracht (UofAz)

TITLE: Coronagraphy of Nearby AGN

ID: 94110

GOAL:

The goals are to answer fundamental questions about AGN:

How are AGNs and host galaxies related/connected?

a. There is a strong correlation between AGN mass/luminosity and host galaxy bulge luminosity/mass
b. Some type of feedback mechanism must be at work.

To this end we define the objectives of this program:

1) Determine relative contribution from the AGN and host galaxy
2) Determine the nature of structures in object
3) Outflows generated by the AGN
4) Outflows generated by star formation

This program uses the coronagraphic capabilities of NIRCam and MIRI to generate high contrast images of the vicinity of the active nucleus. Coronagraphy is needed even for those objects that are Type 2, because the dust extinction drops dramatically in the near- to mid-IR.

We will use the Sinc masks in NIRCam with the F210M, F335M, F430M filters, and the 4QPM and Lyot masks in MIRI.

NOMINAL ALLOCATION (hours): 50.0

ACTUAL TIME (hours): 56.8

TARGET(S):

The sample consists of 6 of the nearest AGNs: three of Type 1 and three of Type 2.

Mrk 231, NGC 1068, NGC 1275, NGC 4151, NGC 7469, Circinus

Plus six reference stars of similar brightness and rough color.

OBSERVING TEMPLATES: NIRCam Coronagraphic Imaging**,** MIRI Coronagraphic Imaging

OBSERVATION DETAILS:

NIRCam — 11.7 hrs

Mask 210R, F210M.

Mask 335R, F335M

Mask 430R, F430M

Per target

	time (sec)	%
Time Exposing (Sci. photons)	140.4	3.374844157
Direct Overhead	3358.5	80.72944516
Indirect Overhead (15.9%)	661.2921	15.89571068
Total Time	4160.1921	1
Total Direct Time	3498.9	84.10428932
Efficiency		3.374844157

MIRI — 45.1 hrs

Per Target

F1065C

F1400C

F1550C

F2300C

	time (sec)	%
Time Exposing (Sci. photons)	182.4	1.134795713
Direct Overhead	13336	82.96949361
Indirect Overhead (15.9%)	2554.9776	15.89571068
Total Time	16073.3776	1
Total Direct Time	13518.4	84.10428932

Total direct time = 57.8 hrs

CONSTRAINTS:

All NIRCam coronagraphy for a specific target and its associated reference star must be obtained within one day.

All MIRI coronagraphy for a specific target and its associated reference star must be obtained within one day.

PARALLEL Observations possible (yes/no/pure parallel)?

In general parallels are not useful on the galaxies in question since they are typically small (≤ few arcmin). However, parallel imaging as a general rule (e.g. for nearby regions) could work here.

COMMENTS:

AUTHOR/DATE: Dean C. Hines (hines@stsci.edu) 12 December 2011; updated 15 February 2012 (Blair)

TITLE: Cepheids in galaxies that have hosted Type 1a SNe

ID: 94120

GOAL:

Determining the Hubble Constant H_0 was one of the original key projects for the Hubble Space Telescope. The current era of precision cosmology demands a measurement of H_0 precise to ~1%, because that, in concert with other cosmological measurements, can break degeneracies and constrain cosmological parameters including the equation of state of dark energy, the energy density of cold dark matter, and the mass of neutrinos (Hu 2005; Freedman & Madore 2010).

Two groups are currently building a path for a 1% measurement of H_0 with JWST. One group is using HST and concentrating on the near-IR (PI Riess), and the other is using Spitzer and concentrating on 3.5 micron (PI Freedman). Both groups agree that Cepheid parallaxes from GAIA will improve the precision of the Cepheid distance scale. In addition, both groups envision a strategy in which JWST observes Cepheids in galaxies that have hosted Type Ia supernovae or have a Tully Fisher distance, to tie the Cepheid distance scale to either the Type Ia SNe or the TF distance scales, respectively.

Supernovae are rare; Hubble is only capable of observing Cepheids in less than 20 Ia SNe host galaxies, which will result in a 1.4% precision on $H_{0.}$ (Riess, talk at 2011 JWST Frontiers Workshop). JWST will be able to reach more like ~45 SNe that are currently known, plus an additional ~30 that will be discovered between now and 2020. This will give an ultimate total of ~75 galaxies with both a Ia and a Cepheid distance, producing a 0.7% precision on H_0 (Riess, ibid).

This SODRM program is envisioned as the first phase in that larger effort. The goal of this first phase is to get Cepheid magnitudes at 1.15 and 3.6 um for the 20 nearest galaxies that have hosted modern (good photometry) Type Ia SNe. All already have Cepheid periods measured by Hubble, so only one JWST epoch is required. These observations will return SNR>25 (15) down to Cepheid periods of 20d (30d) in typical integrations of 0.5hr (1.5hr) at 1.15um (3.6um). This program would be tie together the Cepheid distance scales from HST, JWST, and Spitzer, as well as the JWST distance scales for Type Ia SNe and Cepheids.

As such, we have put together a plausible logical first H_0 proposal for JWST. It would not solve the whole JWST H_0 enchilada, but it is a plausible program for the first 1-2 years of JWST science.

A plausible second phase for the future, not part of this proposal, would be to observe Cepheids in the 25 additional Type Ia hosts that are accessible to JWST but not WFC3/HST, as well as host galaxies of new Type Ia SNe that explode between now and the end of the JWST mission. Phase 2 would require regularly-spaced, multi-epoch observations, since the Cepheids must be discovered and their periods measured.

NOMINAL ALLOCATION (hours):

From spreadsheet.

ACTUAL TIME (hours):

30 hr total integration. Program size of 45.8 hr, found by modifying sodrm_4100_gordon_nircam_imaging_totaltime.xls spreadsheet.

TARGET(S): 20 nearby host galaxies of Type Ia SNe. The targets themselves have not been vetted, and are probably wrong in detail, but the RA/DEC range should be approximately right.

OBSERVING TEMPLATE: NIRCam imaging

OBSERVATION DETAILS:

How far JWST can see Cepheids at 3.6um: JWST is more sensitive at 3.6um than 1.1um, but Cepheids are fainter. Here's the math: From the LMC PL relation from Scowcroft 11, we would have about a dozen LMC Cepheids (ignoring the extremely long-P ones) at a mag cutoff of m(3.6)=11.0, which corresponds to P≥30d. The distance modulus to the LMC is 18.5. So, we want to reach an absolute magnitude of M=-7.5. The ETC says that, for a G0I star, we can get SNR=30 in 30 min at m(Vega,3.6um)=23.7. If we relax to SNR=15 and t=1.5hr, we can get to m(Vega,3.6um)=25.1. These correspond, respectively, to distance moduli of **u=31.2 and 32.6** (or distances of 17 and 33 Mpc). So, at 3.6um, JWST can see Cepheids about as far away as HST+WFC3 can. Taking WFC3 numbers from Adam's Frontier's talk, this is Cepheids in ~20 Type Ia SNe hosts.

How far JWST can see Cepheids at 1.15um. 1.15 um turns out to be the best band for observing faint Cepheids with JWST, as the best combination of star brightness and telescope sensitivity. Let's work through that math. In J-band, m(vega)=11.5 is a good cut from Persson et al. 2005; that's P≥16d and M=-7. For a G0I star, the ETC says can get SNR=30 in 30 min down to m(Vega, J)=25.4. If we relax to SNR=15 and t=1.5hr, we can get to m(Vega, J)=26.8. These correspond to distance moduli of **u=32.4 and u=33.8**; the latter is the u quoted by Adam Riess quoted in his JWST Frontiers workshop talk. (These are distances of 30 and 57 Mpc, respectively.)

So, for this program, we're targeting 20 objects with NIRCAM, duplexing 90 min integrations at 1.15um and 90 min integrations at 3.6um. So that's 40 hr of observations without overheads. The dither pattern can be quite simple, enough for good photometry. No mosaicking is required. We will need to avoid saturation on the brighter Cepheids; I haven't checked this yet**.

Target selection: Were this a real proposal, there would be a careful selection of targets, to make sure that these targets all have HST—measured Cepheids, and that the Type Ia SN in each galaxy was well-measured with modern photometry, and was a well-behaved supernova I have not done any of this. I merely retrieved from NED the closest 20 galaxies that have hosted Type Ia SNe. So in detail the target list is unreliable. But the RA,DEC distribution should be roughly right, which is what matters here. A real proposal would also carefully choose roll angles to cover the most known Cepheids possible per galaxy, and might mosaic on the largest galaxies. I have not done so.

CONSTRAINTS:

Timing: Cepheids in a galaxy may be observed long after the SN has faded, so the SN imposes no timing constraints. In the 20 closest galaxies, the Cepheids will have known periods from HST, and thus require fewer photometric epochs per galaxy. Let's say one epoch.

In the logical follow-up to this proposal ("Phase 2"), the Cepheids will not have been discovered or have known periods, so JWST must observe many (a dozen?) epochs in the span of something like 40d. So that phase will require timing constraints. But that's not in this proposal.

The position angle doesn't matter. Nor are there TOO needs.

PARALLEL Observations possible (yes/no/pure parallel)?

Pure parallel is possible, I suppose, although it's hard to see a strong science case.

COMMENTS:

AUTHOR/DATE: Jane Rigby, 1/25/2012. Send comments to Jane.R.Rigby@NASA.gov

TITLE: Near- and Mid-IR Imaging of Galaxies at a Resolution of 10-30 pc

ID: 94130

GOAL: Obtain Near-IR and Mid-IR imaging of early-type galaxies at a 2-pix resolution of 10-30 pc in the near-IR (1-2.5 mm), similar to optical HST imaging of nearby galaxies out to slightly beyond the Virgo cluster. For the near-IR observations, reach a depth that allows one to perform accurate multi-component galaxy model fitting, measure surface brightness fluctuations and radial stellar population gradients, characterize dynamical and population properties of globular cluster systems and ultra-compact dwarf galaxies, measure the effect of galaxy environment upon morphological components, and scaling relations among galaxies in different environments. For the mid-IR observations, reach a depth that allows one to detect the presence of a significant intermediate-age (TP-AGB) component or warm ISM in otherwise "old, quiescent" galaxies.

NOMINAL ALLOCATION (hours): 200

ACTUAL TIME (hours): 175

NIRCam observations: Using custom ETC to account for background diffuse light from the target galaxy. Aim for S/N = 20 at M_I = -7.5 mag (slightly beyond the turnover magnitude of globular cluster systems), using K0III stellar SED. Use a distance of 80 Mpc, similar to the median distance of the sample.

Using the spreadsheets to calculate the time. Assuming one slew to each target.

MIRI observations: Aim for S/N = 5 at M_I = -10 mag using K0III stellar SED. Use mean distance of 30 Mpc for the MIRI observations. Use only "inter-observation slew" for the MIRI imaging. No target ACQs needed.

Time (direct only) per target galaxy: 1.7 hrs (NIRCam Imaging) and 2.4 hrs (MIRI imaging).

Assuming NIRCam observations of 30 nearby-ish target galaxies and MIRI observations of the 10 nearest galaxies in the sample yields a total of ~75 hours.

TARGET(S):

Inner regions of galaxies at distances out to m-M ~ 35 mag.

OBSERVING TEMPLATES:

NIRCam Imaging, MIRI Imaging

OBSERVATION DETAILS:

NIRCam Imaging: Each galaxy will be observed with 4 NIRCam filters (i.e., 2 pairs: F090W/F277W and F200W/F356W) to provide wavelength coverage that yields adequate metallicity and mass determination. Use 8 dithers per filter pair (INTRAMODULE dithers, 4 primary, 2 subpixel).

MIRI imaging: Observe nearby galaxies with two filters (F770W, F1280W) to enable detection of intermediate-age component or warm ISM.

As to the targets: For this exercise, we randomly selected 10 early-type galaxies (T <= 0) at high Galactic latitude (|b| > 45 degrees) with 4000 < v [km/s] < 4500 (for NIRCam and MIRI observations) and 20 more galaxies with 4500 < v [km/s] < 7500 (for only NIRCam observations). We used the SQL query in HyperLEDA to define the sample.

CONSTRAINTS:

N/A.

PARALLEL Observations possible (yes/no/pure parallel)?

Yes, taking parallel imaging with MIRI or NIRCam while NIRCam or MIRI is prime, respectively, would be great for stellar populations-related science.

COMMENTS:

This program could be expanded to include more targets.

AUTHORS/DATE: Paul Goudfrooij (goudfroo@stsci.edu); 16 Dec 2011

TITLE: Galactic Halo Streams and Stellar Populations

ID: 94140

GOAL:

The detailed star formation history in spiral galaxy halos has only been characterized in the Local Group. The analysis requires photometry reaching stars on the old main sequence, below the main sequence turnoff (M_V of 4 to 4.5 mag). These low-mass stars (~0.8 M_{Sun}) are only accessible to Hubble within approximately 1 Mpc, and well beyond the reach of ground-based observatories. The increased sensitivity of Webb will allow us to probe such populations beyond the confines of the Local Group. Color-magnitude diagrams constructed from the F090W and F200W filters on NIRCam provide an accurate probe of the age and metallicity distribution in a population (i.e., the star formation history), rivaling the most commonly-used probes on Hubble (e.g., ACS F606W & F814W), given the long wavelength baseline between the NIRCam filters. The well-known age-metallicity degeneracy can be broken if the color-magnitude diagram includes the main sequence, subgiant branch, and red giant branch.

The spiral galaxy NGC 55 is a good example of a spiral galaxy well beyond the reach of Hubble but perfectly suitable to Webb. It is inclined nearly edge-on, lies at a distance of 1.9 Mpc, and has a low foreground reddening of E(B-V)=0.013 mag. The bare minimum depth needed to obtain an accurate star formation history is a color-magnitude diagram reaching 0.5 mag below the turnoff at a signal-to-noise ratio of 5. Assuming an old (12 Gyr) population of somewhat low metallicity ([Fe/H]=-1.1) in the halo, this point on the NGC 55 main sequence will have an effective temperature of 6200 K and an apparent magnitude of V= 31 Vega magnitudes.

NOMINAL ALLOCATION (hours): 200

ACTUAL TIME (hours): 173

(at 80% efficiency)

TARGET(S): Minor axis field in NGC55

OBSERVING TEMPLATE: NIRCam Imaging

OBSERVATION DETAILS:

To obtain a signal-to-noise ratio of 5 in each filter, the NIRCam ETC claims we need 200 ksec in F090W and 290 ksec in F200W for an F8V star at V=31 mag. This corresponds to 136 hours of exposure time, or 170 hours of actual time with overheads, assuming an efficiency of 80% (given the similarity to other deep NIRCam imaging programs in the draft overheads report). While exposing in the F090W and F200W filters in the short-wavelength detectors, we will employ the F277W in the long-wavelength detectors. The time in F277W will provide a lower signal-to-noise ratio (3.7) at a point 0.5 mag below the turnoff, but will provide additional metallicity and temperature leverage. The exposures can be obtained with a simple PSF-resampling dither pattern, and there is no need to tile a mosaic larger than the NIRCam field of view, nor fill in the various gaps between the detectors and modules. However, all of the images should be obtained at the same orientation to maximize area covered at the full depth.

In the APT, using NIRCam DEEP2, 6 groups gives an exposure time of 1081 sec, and 8 groups gives an exposure time of 1505 sec. We want each integration to be at a distinct dither position, to improve PSF sampling and beat down detector artifacts and flat field errors. 192 integrations will give 208 ksec in F090W (6 groups, 1081 sec per integration, DEEP2) and 289 ksec in

F200W (8 groups, 1505 sec per integration, DEEP2). Although we do not need the gaps between detectors filled, we can specify the 192 integrations as 4 primary dithers (INTRAMODULE) and 48 subpixel dithers, to beat down the systematic errors as much as possible. To maximize the areal coverage, we should also set MODULE=ALL (full NIRCam field of view) and SUBARRY=FULL.

CONSTRAINTS: Same orientation for all exposures

PARALLEL Observations possible (yes/no/pure parallel)?

Yes. The other instruments will have access to other parts of the NGC 55 environment, so one can imagine a variety of possible parallel observations (e.g., deep NIRISS imaging in similar filters, deep spectroscopy of composite disk populations).

COMMENTS:

NGC 55 is a representative target in this program. There are other galaxies beyond the Local Group where similar science could be pursued using a program analogous to the one described here.

This program should be in the "Nearby Galaxies" set not the "Galactic" set. The program number (3170) is drawn from the "Galactic" set because this was originally designated as a program to explore the Galactic halo.

This has been fixed and the program number changed to 4140.

AUTHOR/DATE: Tom Brown (tbrown@stsci.edu) 5 Dec 2011

TITLE: Quantitative spectroscopy of extragalactic red supergiants

ID: 94150

GOAL:

A promising new method to probe chemical abundances in external galaxies is with red supergiants (RSGs). With their peak flux at ~1µm and with luminosities in excess of $10^4 L_{\odot}$, they are extremely bright in the near-IR (M_J = −7 to −11). Davies, Kudritzki & Figer (2010) developed a new technique to use RSGs as chemical 'beacons' to map the star-forming history of their host galaxies, via analysis of absorption-line spectroscopy in the J-band. Optical spectroscopy of blue supergiants has been used to estimate metallicities (via oxygen) in some external galaxies (e.g. Bresolin et al. 2002; Urbaneja et al. 2005; Evans et al. 2007; Kudritzki et al. 2008). However, the RSG technique will provide direct estimates of iron abundances, as well as for α-elements such as Si and Mg, allowing the ratio α/Fe to be studied, an important diagnostic of the star-formation history of the host system.

The new technique has been studied in the context of ELTs and JWST by Evans et al. (2011). It requires good signal-to-noise (S/N>50) at only moderate spectral resolving power (*R* ~3000), in a part of the J-band where the diagnostic lines are well separated. With JWST-NIRSpec we will be able to map stellar abundances and approximate radial velocities across entire galaxies at distances well beyond the Local Group, providing a 3D picture of their star-formation histories and leading to new constraints on the mass-metallicity relation.

NOMINAL ALLOCATION (hours): 200

ACTUAL TIME (hours):

Approximately 5 hrs x 3 + 15 hrs x 3 + 35 hrs x 3 = 165 hrs

TARGET(S):

RSGs in two of the closest 'Grand Design' spirals: M83 (at 4.5 Mpc) and M51 (8.5 Mpc), and the face-on spiral NGC 3621 (6.7 Mpc).

OBSERVING TEMPLATE:

NIRSpec MSA

OBSERVATION DETAILS:

Each galaxy requires multiple NIRSpec pointings to map the radial gradients along the primary axes. Only J-band spectroscopy is required. Using the NIRSpec MSA ETC, adopting: G140H grating/F100 LP filter (R~2700), M0I spectral template, λ(S/N)=1.25µm, modest E(B-V) ~0.15mag, for $M_J \geq -8$ at S/N>50, requires total exposures of: M83 (J=20.3): 5hrs/pointing; NGC 3621 (J=21.1): 15 hrs/pointing; M51 (J=21.65): 35 hrs/pointing. Three pointings in each galaxy leads to a total of 165hrs.

CONSTRAINTS:

Will require repeat observations with the MSA at the same position angle on the target galaxy.

PARALLEL Observations possible (yes/no/pure parallel)?

Taking parallel NIRCam/MIRI Imaging would be useful for studies of stellar populations (in many instances complementing WFPC2/ACS/WFC3 optical observations).

COMMENTS:

The galaxies here were selected as prime examples for this type of program; there are numerous other examples out to a distance beyond 10 Mpc.

AUTHORS/DATE: Daniel Lennon (lennon@stsci.edu)/Jan 2012 Chris Evans (UKATC)

Distant Galaxies Programs

TITLE: JWST Ultra-Wide NIRCam and MIRI Mosaic of the Extended Groth Strip

ID: 95010

GOAL: Wide field NIRCam (F200W/F356W) and MIRI (F1500W) for statistical extra-galactic studies; rest-frame optical and IR structures and high-spatial resolution spectral energy distributions for $1 < z < 8$ galaxies to study galaxy assembly, star-formation histories, AGN host galaxy properties, and faint/low mass galaxy populations during the first half of the universe's lifetime. This program will reach point source depths of ~29 ABmag in K, ~26.5 ABmag in F356W, and 24 ABmag in F1500W. The large area and sample obtained by ultra-wide field (~0.5 deg x 0.5 deg) allows for studies of rare objects and for understanding the effects of cosmic variance.

NOMINAL ALLOCATION (hours): 500

ACTUAL TIME (hours): 487.5 hours

TARGET(S): Extended Groth Strip (~0.5 deg x 0.5 deg FOV)

OBSERVING TEMPLATE: NIRCam imaging, MIRI imaging

OBSERVATION DETAILS:

NIRCam 10 x 9 Mod A+B mosaic, MIRI 15 x 14 mosaic

NIRCAM:

Modules A + B

Full array

SWC : F200W LWC: F356W

Dither pattern: FULL, 3 primary dithers, no secondary dithers

Exposures: DEEP8, 5 groups, 932.8 s exp per dither position = 2798.4 per pointing x 90 pointings (10 x 9 mosaic) = 70.0 hours NIRCam science integration time.

MIRI:

FULL array

Filter: F1500W

Dither pattern: Cycling, 5 point,s, MEDIUM pattern size, no secondary dithers

Exposures: SLOW, 37 groups, 1002.885 s exp per dither position = 5014.4 per pointing

x 210 pointings (15x14 mosaic) = 292.5 hrs MIRI science integration time

==> total science integration time = 362.5 hrs

Overheads:

Slews: at least two will be required because the program is longer than 10 days (240 hours)

-- 1-2 hours slew time

Per NIRCam pointing:

240 s (GS acq) + 60s (filter change/setup) + 5 s + (15.9s x3) + 444.9 s (calibration overhead) + 554 s (statistical overhead for 3-pt full dither pattern/GS changes) = 1351.6 s

== ~ 34 hours of overhead

Per MIRI pointing:

240s (GS acq) + 120s (filter change/setup) + 5s + (42s x 5) + 797.2s (calibration overhead) + (5 x 30s) (dither slews) = 1522.2 s = (x 210 MIRI pointings) --> 89 hours of overhead

total program time: 362.5 (science) + 34 (NIRCam overhead) + 89 (MIRI overhead) + 1 (slew) = 487.5 hours

CONSTRAINTS:

Given NIRCam's rectangular shape, 'same as' orient constraints for all NIRCam mosaic pointings. No such constraints given for MIRI mosaic pointings, although gaps between mosaic tiles are undesirable.

PARALLEL Observations possible (yes/no/pure parallel)?

Yes -- parallel NIRSpec observations for wide-field spectroscopy; NIRSS parallel imaging would make the program 1/3 more efficient.

COMMENTS: Assumed statistical likelihood that guide star change(s) were needed within a NIRCam single pointing/dither pattern. Assumed filter change/reset required for each pointing. Assumed "cluster" target mode . therefore only 2 slew charges.

AUTHOR/DATE: Jennifer Lotz, 12/12/2011; revised 12/22/2011

TITLE: JWST NIRCam and MIRI Mosaic of the Chandra Deep Field South

ID: 95020

GOAL: To obtain deep and 'wide' NIRCam multi-band, multi-epoch mosaic of well-studied extra-galactic field; to detect z~8-10 galaxies, measure high redshift galaxy properties (luminosities, star-formation rates, structures), and detect high redshift transients. Deep MIRI imaging in F2100W will measure spatially-resolved mid-IR luminosities and SFR ~five times deeper than current Spitzer 24 micron imaging, with 5-sigma limiting SFRs ~ 1, 5 Msun/yr at z~1, 2 respectively.

NOMINAL ALLOCATION (hours): 400

ACTUAL TIME (hours): 490 hours

TARGET(S): Chandra Deep Field South, ~ 10" x 16" FOV

OBSERVING TEMPLATE: NIRCam imaging; MIRI imaging

OBSERVATION DETAILS:

NIRCam:

Number of pointings/targets/epochs: 12 pointings for 1 cluster target for 10 epochs

Cluster Target: Yes

Modules A + B

Full array

SWC:	F090W 30 ks	per pointing (total)	LWC:	F444W 30 ks (total)
	F115W 15 ks			F227W 15 ks
	F150W 15 ks			F356W 15 ks

Dither pattern: FULL, 3 primary dithers, no secondary dithers

Exposures:

F090W/F444W, DEEP8, 6 groups, 1144.8s exp per dither position for 3434.4 s per pointing

F115W/F277W, DEEP8, 3 groups, 508.8s exp per dither position for 1526.4s per pointing

F150W/F356W, DEEP8, 3 groups, 508.8s exp per dither position for 1526.4s per pointing

x 12 pointings x 10 epochs = 217 hours NIRCam science integration time.

MIRI:

Number of pointings/epochs: 56 pointings for 1 cluster target for 1 epoch

Cluster Target: Yes

MIRI imaging, FULL array, FILTER= F2100W

Dither pattern: CYCLING, 10 pts, MEDIUM

Readout pattern: SLOW, 37 groups, 1 integration, 1002.885 exp. time per dither

for total exposure per pointing ~ 10,029 s

x 56 = 156 hours MIRI science integration time

Overheads:

Slews: assuming cluster target mode, 1800s per epoch x 11 epoch = 5.5 hours

Per NIRCam Pointing:

(assumes filter changes within each dither step, to minimize guide star overhead.)

240 s (GS) + 3 x [60s (filter change/setup) + 5 s + 15.9s] + 1031.46 s (calibration overhead) + 554 s (statistical overhead for 3-pt full dither pattern/GS changes) = 2068.2 s per pointing

== ~69 hours of NIRCam overhead

Per MIRI pointing:

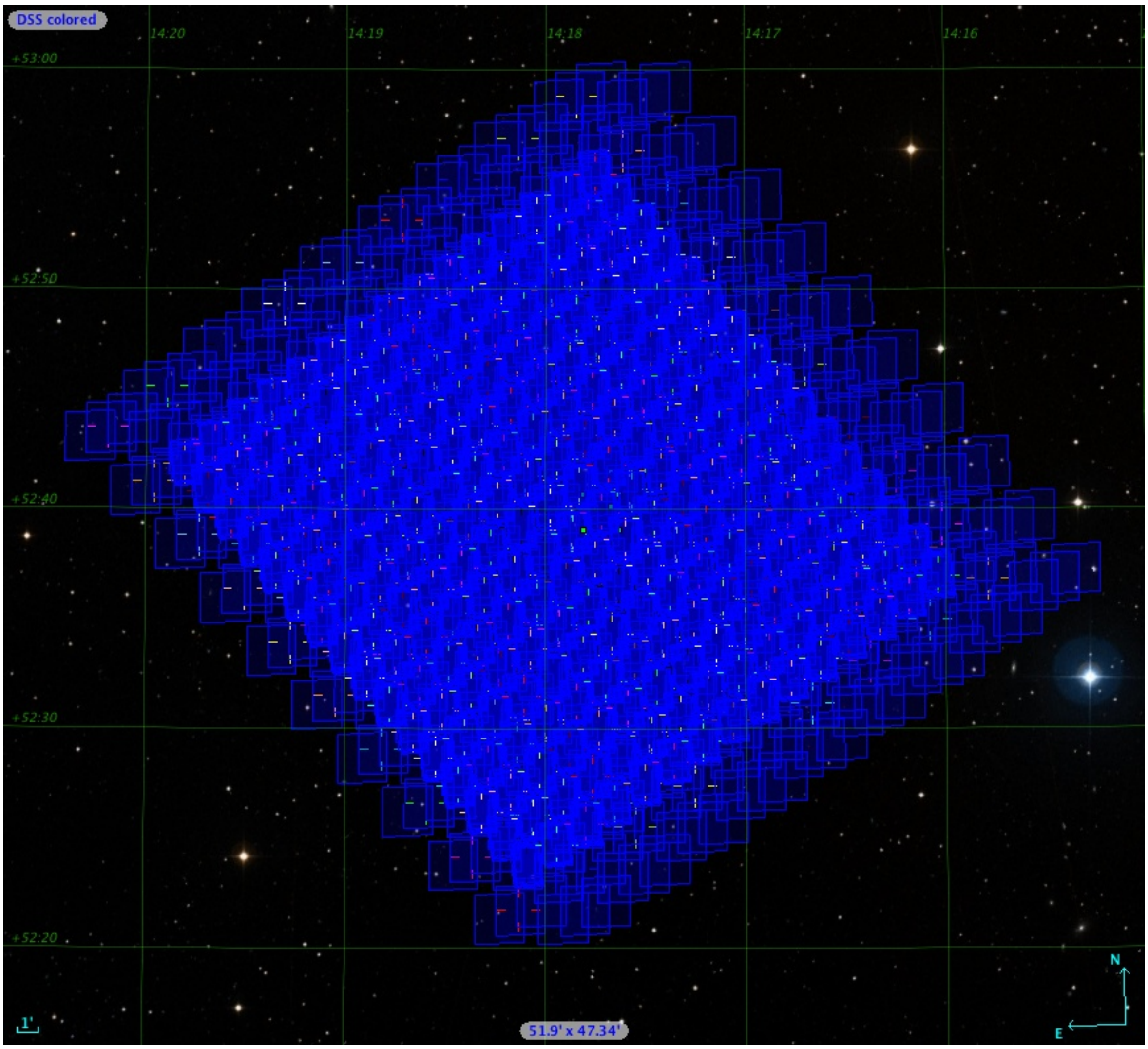
240s (GS acq) + 120s (filter change/setup) + 5s + (10 x 42s) (detector deadtime per slow readout) + 1594.5s (calibration overhead) + (10 x 30s) (dither slews) = 2679.5 s per pointing

= (x 56 MIRI pointings) --> 41.7 hours of MIRI overhead

total science integration time = 373. hours

total overhead = 116.2 hours

total program time: 489.2 hours, efficiency = 76.2%



Overlapping NIRCam 10 x 9 pointing mosaic and MIRI 15 x 14 mosaic (center) planned by APT. MIRI exposures are much more expensive, hence only cover the high-coverage regions of the NIRCam mosaic.

CONSTRAINTS:

Orient constraints within each epoch to maintain a uniform mosaic. Given the rectangular nature of NIRCam FOV, unique mosaic patterns for each orient/epoch would be preferred to give best overlap of different epochs (not done in APT). Required all observations at given epoch performed within 15 days.

Timing constraints with 30-50 day cadence between epochs for optimal high-z SNe search.

No constraints on MIRI observations.

PARALLEL Observations possible (yes/no/pure parallel)?

Yes -- parallel NIRSpec observations for wide-field spectroscopy; NIRSS parallel imaging would make the program 1/3 more efficient.

COMMENTS: Assumed statistical likelihood that guide star change(s) were needed within a single NIRCam pointing/dither pattern. Assumed filter change/reset required for each pointing. Assumed "cluster" target , with 1 slew charge per epoch.

AUTHOR/DATE: Jennifer Lotz, 12/16/2011; revised to include MIRI 1/13/2012

TITLE: JWST Ultra Deep Field Imaging Survey

ID: 95030

GOAL:

The primary purpose of this program is to search for first light objects, allowing the identification of the sources of reionization and the study the evolution of the star formation rate of the Universe from first light to reionization. This program aims to reach depths in the range AB~31-31.5 in the F090W, F110W, F150W, F200W, F227W,F356W, and F444W NIRCam filters, along with MIRI F560W and F777W, with a goal of probing the z ~ 10 – 15 universe to measure the physical properties of the highest redshift galaxies and star-forming regions.

Sample and sky coverage will be a single field, proposed to be the Hubble UDF. Because of 90 degrees orient changes one of the two cameras will be on the same field for the entire program, the second camera will observe 2 displaced fields. The program remains feasible even without a constraint on the orient changes different angle would change the fraction of area covered as a function of depth. The MIRI field is unconstrained as the field of view of MIRI is fully contained within one NIRCam camera.

NOMINAL ALLOCATION (hours): 600

ACTUAL TIME (hours): 600

NIRCam, short wave arm: 100 hours each in F090W, F115W, F150W, F200W

NIRCAM, long wave arm: 100 hours each in F277W, F356W, and 200 hours in F444W (simultaneous to SW).

MIRI, 200 hrs of imaging total, 100h each with F560W and F777W, FULL array

TARGET(S):

HST UDF (03 32 -27 40)

OBSERVING TEMPLATES:

NIRCam Imaging

MIRI Imaging

OBSERVATION DETAILS:

The NIRCam observations are divided into a total of 20 observations, each one at a different pointing center from the Intra-SCA medium dither pattern sequence. Each of these observations will consist of a 4-point secondary dither pattern, and at each of these 4 points there will be 4 exposures, in the 4 SW filters (along with 3 LW filters in a 1:1:2 ratio). The total integration time per filter at each dither pointing is 3264.8 sec (and 4 integrations, one for each SW and LW filter in parallel, are obtained at each of the 4 secondary dither pointings),.

The MIRI observations are also obtained at 20 different pointing centers, with each observation utilizing a 16-point Spiral Reuleaux pattern as a secondary dither pattern. At each of these 16 points, 2 exposures will be obtained, one each for F560W and F777W, in SLOW mode, 34 groups, FULL array. The total integration time per filter at each dither pointing is 921.57 sec (and 2 filters are obtained at each of the 16 secondary dither pointings).

Overhead calculations:

NIRCam observation:

1800s	Target slew
240s	Guide star acq
4x192s	4-point dither slews
16x60s	Filter changes
16x(5+15.9)s	Detector config + deadtime
16x3264.8s	Total science integration time
56339s	Subtotal of all the required time
8958s	Indirect overheads (calibration+observatory: 15.9%)
65297s	Total time per observation

Per MIRI observation:

1800s	Target slew
240s	Guide star acq
389s	16-point Reuleaux pattern slews
32x120s	Filter changes
32x(5+42)s	Detector config + deadtime
32x921.6s	Total science integration time
37263s	Subtotal of all the required time
5925s	Indirect overheads (calibration+observatory: 15.9%)
43188s	Total time per observation

Total times and efficiency (NIRCam + MIRI observations):

454 hours	Total Science integration time
149 hours	Overhead
603 hours	Total Program time

75.33% efficiency

CONSTRAINTS:

For the NIRCam observations, the field needs to be revisited at least 4 times with 90 degree orientations. Each of these epochs will consist of 5 observations. Supernovae will be searched at each epoch. For the 4 epochs option each set of visits at the same orient lasts 100 hrs.

There is no constraint on the MIRI observations.

PARALLEL Observations possible (yes/no/pure parallel)?

Taking parallel NIRCam/MIRI Imaging while the other was prime would be highly advantageous for constructing multiple parallel deep fields.

COMMENTS:

This program is an updated version of 401 (Stiavelli et al.) that was presented in the initial SODRM (JWST-STScI-CI-0045).

AUTHORS/DATE: Anton Koekemoer (koekemoer@stsci.edu)/2 Dec 2011

TITLE: JWST Wide-Area Spectroscopic Followup

ID: 95040

GOAL:

This goal of this program is to measure redshifts continuum SEDs and emission-line strengths for galaxies in JWST wider-area surveys. This will help to constrain the evolution of galaxies, the masses of their dark-matter halos (via clustering), the evolution of AGN, and the buildup of dust and metals, all of which are core goals of JWST. As a fiducial goal, we will adopt S/N = 10 in the continuum for AB=26.0 for a flat-spectrum source for low-resolution prism spectra, and a flux limit of $5x10^{-18}$ erg cm^{-2} s^{-1} for emission-lines near the center of the prism bandpass. The continuum limit corresponds to an unobscured star-formation rate of 86 at z=6.

Features of interest at redshifts include the rest-UV & optical continuum and various diagnostic lines, Lya l1216, He II l1640, [O III] l5007, Ha, Hb, [Ne V] l1575,3426, [Ne IV] l1602,2423, OIII] l1663, and [OII] l2471,3727, NV 1240, Si II 1309, CII 1335, CIV 1550, CIII] 1909, and a variety of others (e.g. Humphrey et al. 2008, MNRAS, 383, 11; Inoue 2011, MNRAS, 415, 2920).

According to the prototype ETC for the prism, for a source with AB=26 at (2,3.5) mm one could get S/N = (19,10) per resel in 3 hours. According to the prism sensitivity tables on the web, the 10s limiting emission-line flux limits in 3 hours at 2,3.6 mm are 22,9.0 x 10^{-19} erg cm^{-2} s^{-1}.

NOMINAL ALLOCATION (hours): 400

ACTUAL TIME (hours):

Will adjust NTSET & NSLITLET to stay within the 400 hour allocation.

TARGET(S): CANDELS fields

Field	RA	Dec	Tiling pattern
GOODS-S	03:32:30	-27:48:20	11x7
GOODS-N	12:36:55	+62:14:15	7x11
EGS	14:17:00	+52:30:00	6x17
UDS	02:17:49	-05:12:02	4x13
COSMOS	10:00:28	+02:12:21	4x13

The details of the tiling patterns depend on the orientation.

OBSERVING TEMPLATE: NIRSPec MulitObject Spectroscopy

OBSERVATION DETAILS:

For this strawman program, we observe only with the prism at R=100, since the goal is to sample a large volume. The density of galaxies at AB=26 is about 100 per square arcminute. If we take the 171 slits in the spatial direction and assume we have one galaxy every 5 slits, on average, along the spatial direction, and that we are able to fit three sources per row on average without overlapping the spectra in the dispersion direction, then we can achieve 103 galaxies per square arcminute.

We assume we have NIRCam images to identify candidates, and will do the target acquisition using brighter sources in the F110W target-acquisition filter.

The fields will be observed in overlapping tiles, such that most of the sources are observed in three different tiles. If we adopt a fiducial 1 hour per tile, then most sources get 3 hours of observations, and sources near the border of the mosaic mostly get 2 hours, with just the corners getting 1 hour. Tiles that overlap by 50-60% accomplish this. Because each source ends up with 2-3 very different slitlets, we simply add a single nod on top of that. So each tile gets exposed twice for about 1800s each time, with a nod in between the exposures.

Mode	Total hours	NTSET	NSLITLET	NNOD	WAVEGAP
Prism	3	1	1	2	NO

CONSTRAINTS:

The fields can be mosaiced at any orientation, but some orientations are a bit more efficient than others. Having picked an orientation, it is best to do the entire field at that orientation.

PARALLEL Observations possible (yes/no/pure parallel)?

While some of the science goals could be accomplished with a NIRspec pure parallel program, obtaining a target list and assigning slits would be challenging.

COMMENTS:

AUTHOR/DATE: H. Ferguson +??

TITLE: Grism Spectra of Deep Fields

ID: 95050

GOAL:

The primary goal of this program is to search for galaxies at redshifts z>7 with strong emission lines of Lyman-a or HeII 1640. The main benefit of slitless spectroscopy for this program is that it enables a truly blind search for such galaxies. Early star-forming galaxies, before forming significant amounts of dust, may have extremely large Lyman- a equivalent widths (albeit scattered by the IGM), and hence may be difficult to detect in the continuum. Very metal-poor galaxies expected to be very strong in He II 1640 A. Some Lya predictions are provided by Stark et al. 2007, ApJ, 668, 627.

To get a rough idea of exposure times, Lya redshift ranges and number of sources per sq. arcmin for h,W, W_m, W_l = 0.7,1,0.73,0.27 are given for a fiducial number density of 10^{-3} Mpc^{-3}. Fluxes corresponding to a Lya luminsity of 10^{42} erg s^{-1} are provided, and compared to the emission-line sensitivity limits for 10ks, 10s (read from the plot on the NIRISS web page, and taken from Greene et al. 2007 SPIE for NIRCAM).

Mode	z	N $arcmin^{-2}$ for $n=10^{-3}Mpc^{-3}$	Flux limit (10^{-18} erg s^{-1} cm^2)	Flux corresponding to 10^{42} erg s^{-1}
NIRISS F115W	7.2-9.6	5.1	7-15	1.2
F140M	9.9-11.2	2.3	5	0.64
F158M	11.3-13	2.6	5	0.47
F150W	9.9-12.8	4.7	7	0.54
F200W	13.4-17.3	4.7	6	0.27
NIRCAM F250M	18.9-20.2	1.3	5	0.16
F300M	22.4-24.9	1.8	5	0.11
F335M	25.2-27.9	1.8	5	0.08
F360M	27.1-30.1	1.8	5	0.07
F410M	31-34.4	1.7	5	0.05

Exposure times for these fiducial numbers range from very long to hopeless. For example, reaching 10s at 10^{42} erg s^{-1} in F140M would take about 170 hours. The trade between observing with F150W to cover the full range z=10-13 versus splitting the range with F140M and F158M looks like a bit of a wash. However, if one suspects that the lower part of the redshift range is where the detectable sources will be, then concentrating on F140M probably wins.

NOMINAL ALLOCATION (hours): 200

ACTUAL TIME (hours):

From calculations.

TARGET(S):

OBSERVING TEMPLATE: NIRISS WFSS, NIRCam Grism (template does not yet exist in APT).

OBSERVATION DETAILS:

We put most of the time into NIRISS F140M because it is likely to yield the most sources. We do a shallow survey at other wavelengths in case there are sources much brighter than expected from the models.

NIRISS F140M – 100 hours

NIRISS F158M – 30 hours

NIRISS F200W – 40 hours

NIRCAM F250M – 30 hours

The F200W and F250M observations will primarily help with interloper rejection, finding the H associated with [OIII] emitters in the shorter filters.

We split the time 50/50 between the two grisms (counter-dispersed in NIRISS, cross-dispersed in NIRCam). We also rotate 10 degrees to break degeneracies in extracting sources. We dither in a small pattern because we do not care about filling gaps between detectors.

CONSTRAINTS:

The exact orientation is probably not terribly important. Being able to obtain 2 frames with about 10 degrees difference in orientation helps with deblending the spectra.

PARALLEL Observations possible (yes/no/pure parallel)?

The whole program could in principle be done as a parallel program deep imaging programs. In fact, it is extremely interesting as a parallel program because the depth*area constraints needed for interesting constraints on the Lya luminosity function verge on prohibitive for a prime program.

COMMENTS:

AUTHOR/DATE: H. Ferguson +??

TITLE: JWST Ultra-Deep Spectroscopy

ID: 95060

GOAL:

The primary goal of this program is to confirm candidates for very high-redshift galaxies and look for spectral signatures of young, extremely-metal-poor stellar populations. We assume the candidates have been selected from NIRCam and/or NIRISS programs and have a range of brightness, but that there are a small number that will want the full exposure time. Features of interest include the rest-UV & optical continuum and various diagnostic lines, Lya l1216, He II l1640, [O III] l5007, Ha, Hb, [Ne V] l1575,3426, [Ne IV] l1602,2423, OIII] l1663, and [OII] l2471,3727, NV 1240, Si II 1309, CII 1335, CIV 1550, CIII] 1909, and a variety of others (e.g. Humprhey et al. 2008, MNRAS, 383, 11; Inoue 2011, MNRAS, 415, 2920). A variety of papers have made flux predictions, which at high-redshifts tend to be challenging even for the deepest NIRSpec exposures (e.g. Johnson 2011; astroph1105.5701). Half-light radii are expected to be 0.05-0.1 arcsec for z>6 (Wyithe & Loeb 2011, MNRAS, 413, L38).

Consider sources at z=10,15,20 with flat-spectrum AB magnitude 29. (This corresponds to unobscured star-formation rates of ~18,44,84 solar masses per year). According to the prototype ETC for the prism, for a source with AB=29 at (1.3,2,2.6) mm one could get S/N = (10,8,7) per resel in 100 hours. Scaling the the sensitivity tables on the web by $t^{-0.5}$, 10s limiting emission-line fluxes in 100 hours at 1.3,2,2.6 mm are 4.1,2.4,1.9 x 10^{-19} erg cm^{-2} s^{-1}.

NOMINAL ALLOCATION (hours): 400

ACTUAL TIME (hours):

Will adjust NTSET & NSLITLET to stay within the 400 hour allocation.

TARGET(S): HST Ultra-Deep Field

OBSERVING TEMPLATE: NIRSPec MulitObject Spectroscopy

OBSERVATION DETAILS:

For this strawman program, we observe both with the prism at R=100 and with the G140M, G235M, and G395M gratings at R=1000 (all grating settings). The R=100 setting will be most useful for measuring the continuum and spectral breaks. The R=1000 setting will be more sensitive for emission lines. The most important lines are probably Lya, He II, and [O III]. Because [OIII] is beyond the NIRSpec wavelength range for *z*>9, and HeII is in the G235M range for *z*<17, we invest less time in G395M.

We assume we have NIRCam images to identify candidates, and will do the target acquisition using brighter sources in the F110W target-acquisition filter. Assume that we have ~20 targets scattered around the field that desire maximum depth, and a wedding-cake of brighter sources that can be placed on slits for shorter amounts of time. We would probably optimize the pointing centers to put the best high-z candidates in the sweet-spot of the apertures.

For faint objects, sky subtraction will be the limiting factor. The strategy here combines "nodding" along a slitlet with larger moves to help remove detector systematics. The faintest targets would

Mode	Total hours	NTSET	NSLITLET	NNOD	WAVEGAP
Prism	100	10	5	2	NO
G140M	125	8	3	2	YES
G235M	125	8	3	2	YES
G395M	50	4	2	2	YES

CONSTRAINTS:

Probably one will want to constrain the orientation to optimize the coverage with NIRCAM, but this would allow 4 possible orientations with windows of at least 10 degrees around each. Having started in one observing mode (e.g. prism), one will probably want to complete the observations with the same orientation. However, the limited amount of time available at one orientation may force the observations to be broken up.

PARALLEL Observations possible (yes/no/pure parallel)?

Parallel imaging with the other instruments would be possible.

An obvious thing to consider would be to designate two deep fields such that one could do imaging on one in parallel with spectroscopy on the other; then come back in 6 months and swap the imaging and spectroscopy.

COMMENTS:

AUTHOR/DATE: H. Ferguson +??

TITLE: MIRI LRS spectra of distant galaxies

ID: 95070

GOAL:

This program serves as a catch-all for MIRI low-resolution spectroscopy of high-redshift galaxies (z>2). There are a wide variety of science goals, including (1) constraining star-formation rates, dust, extinction and metallicity during the epoch of reionization at z>7 using strong features such as Ha, [OIII], and the 4000 Angstrom break. (2) Measuring the chemical evolution of galaxies and the incidence of AGN over a broad range of redshift using a wide variety of spectral diagnostics such as Paschen and Brackett lines, H_2 and CO features, [SIII], [OIII], [FeII], Ne VI, and the Calcium triplet. (3) Measuring the evolution of hot dust through PAH features such as those at 6.2, 7.7 and 8.6, and 11.3 microns.

We assume that all of the sources in this program have been previously identified by other surveys and have high-resolution shorter-wavelength images. Sources for this program include:

- "Main-sequence" star-forming galaxies at z ~ 13, 8, 4, 2 (lensed and unlensed)
- Sub-mm galaxies at z~4,2 (lensed and unlensed)
- Passive galaxies (& candidate passive galaxies) at z~5, 2

NOMINAL ALLOCATION (hours): 100

ACTUAL TIME (hours):

This will run over the 100 hour allocation.

TARGET(S):

Target type	# examples	Typical Exptime (ks)	Features of interest	Comments, reference
z~13 Main-seq	2	50,10	[OIII], Ha, 4000A break	e.g. Source J1 in Laporte et al. 2011
z~8 Main-seq	2	25	Ha	Yan et al. 2001, Oesch et al. 2012
z~4 Main-seq	5	10	Rest-K continuum	Lee et al. 2004, Ouchi et al. 2004
z~2 Main-seq	5	5	Brb,g, CO 2.3mm, H_2 1-0, PAH 3.3 mm	Reddy et al. 2005
z~4 sub-mm	5	10	Rest-K continuum	Daddi et al. 2009, Knudsen et al. 2006
z~2 sub-mm	5	5	Brb,g, CO 2.3mm, H_2 1-0, PAH 3.3 mm	Lapi et al. 2011, Ashby et al. 2006, Pope et al. 2006
z~5 passive	5	5	Ca triplet, Pa series	Wiklind et al. 2008
z~2 passive	5	10	Brb,g, CO 2.3mm, H_2 1-0, PAH 3.3 mm	Reddy et al. 2006

OBSERVING TEMPLATE: MIRI Low Resolution Spectroscopy

OBSERVATION DETAILS:

For some of these sources it is likely that target acquisition from a brighter reference target will be preferred, to save time. MIRI (or NIRCam) pre-imaging would be required to select the reference sources. We have put in some MIRI images to serve as placeholders for this, although it is quite likely that most such sources would be identified from separate imaging programs

CONSTRAINTS:

None.

PARALLEL Observations possible (yes/no/pure parallel)?

These are pointed observations, so can't really be done in parallel with other observations.

They are long pointings, often in favorite parts of the sky, so parallel observations with other instruments would be desirable.

COMMENTS:

AUTHOR/DATE: H. Ferguson +??

TITLE: Confirmation, photo-z's and Physical Properties of SZ-selected Galaxy Clusters

ID: 95080

GOAL:

Galaxy clusters are a powerful probe of the structure growth in the Universe. Currently, several projects use the SZ-effect to detect the most massive galaxy clusters candidates in a blind, redshift-independent search. With these NIRcam observations, we confirm 500 SPT cluster candidates in a 2005 deg^2 field, determine their photo-z, and use their physical properties to constrain galaxy evolution and structure growth.

NOMINAL ALLOCATION (hours): 200

ACTUAL TIME (hours): 570, 1.14h per target

TARGET(S): 500 SPT cluster candidates.

OBSERVING TEMPLATE: SODRM.5080.sptclusters.aptx

OBSERVATION DETAILS:

8x53 second exposures in each F356W and F444W with LWC, SWC is bonus. RAPID readout, 5 groups, 1 integration is 53 seconds. Small dithers fill out the intrasca chip gaps, 4 large dithers optimize deep in the core (300 sec effective exposure time) and shallower outside (see observing scenario). The area covered is a circle with a diameter of 5', deeper at the core (diameter of ~1.5').

CONSTRAINTS:

The 1.14h per target is dominated by slew time (~45%), and re-aquisition of guide stars (30%), leading to an efficiency of ~25%. Since the density of targets is 1 cluster per 5 square degree, typical slews are only a couple of degrees, and the slew time is probably much less if planned wisely. The dithers should be on the order of 1.5', so with a good plan of the dithering the aquisition of guide stars can also be minimized.

PARALLEL Observations possible (yes/no/pure parallel)? no

COMMENTS:

AUTHOR/DATE: Armin Rest, 12/12/2011

TITLE: MIRI MRS spectra of distant galaxies

ID: 95090

GOAL:

This program serves as a catch-all for MIRI MRS spectroscopy of high-redshift galaxies (z>2). Compared to the LRS program, the observations provide detailed line strengths and line widths, spatial mapping, and kinematics. Science goals include constraining star-formation rates, dust evolution, kinematics, ISM energetics (inflows and outflows), and the chemical evolution of galaxies over a broad range of redshifts. Features of interest include redshifted Ha, the Paschen and Brackett lines, H_2 and CO features, [SIII], [OIII], [FeII], Ne VI, [Ar II] and the Calcium triplet. Evolution of hot dust will be constrained using PAH features such as those at 6.2, 7.7 and 8.6, and 11.3 microns.

We assume that all of the sources in this program have been previously identified by other surveys and have high-resolution shorter-wavelength images. Sources for this program include:

- "Main-sequence" star-forming galaxies at z ~ 13, 4, 2 (lensed and unlensed)
- Sub-mm galaxies at z~4,2 (lensed and unlensed)
- Passive galaxies (& candidate passive galaxies) at z~5, 2

NOMINAL ALLOCATION (hours): 100

ACTUAL TIME (hours):

This will run over the 100 hour allocation.

TARGET(S):

Target type	# examples	Typical Exptime (ks)	Features of interest	Comments, reference
z~13 main seq	1	25	Ha	Probably would need a lensed source
z~8 Main-seq	2	10	Ha	Yan et al. 2001, Oesch et al. 2012
z~4 Main-seq	5	10	Rest-K continuum, Pa, Br series, CO 2.3mm, H_2 1-0, PAH 3.3 mm	Lee et al. 2004, Ouchi et al. 2004
z~2 Main-seq	5	10	Br series, CO 2.3mm, H_2 1-0, PAH 3.3 mm	Reddy et al. 2005
z~4 sub-mm	4	10	Rest-K continuum, Pa, Br series, CO 2.3mm, H_2 1-0, PAH 3.3 mm	Daddi et al. 2009, Knudsen et al. 2006
z~2 sub-mm	5	10	Br series, CO 2.3mm, H_2 1-0, PAH 3.3 mm	Lapi et al. 2011, Ashby et al. 2006, Pope et al. 2006
z~5 passive	2	20	Ca triplet, Pa series	Wiklind et al. 2008
z~2 passive	2	15	Br series, CO 2.3mm, H_2 1-0, PAH 3.3 mm	Reddy et al. 2006

OBSERVING TEMPLATE: MIRI Medium Resolution Spectroscopy, MIRI Imaging

OBSERVATION DETAILS:

Exposure times are *very* rough guesses, probably tending to be on the optimistic side. A galaxy with an unobscured star-formation rate of 100 solar masses per year at z=8 will have Ha = 1.5×10^{-20} W m^{-2}, which is within range in 10ks, but the known sources at *z*=8 have lower inferred star-formation rates from their rest UV. Similar calculations suggest long exposure times for z=4 UV main-sequence sources in Paschen a. On the other hand, detecting the 3.3 micron PAH feature in bright sub-mm galaxies should be pretty easy.

For a few of these sources it is likely that target acquisition from a brighter reference target will be preferred, to save time. MIRI (or NIRCam) pre-imaging would be required to select the reference sources. These sources are all small enough to fit into the MRS field of view. Given the long exposure times, one presumably use a small dither pattern to improve spatial sampling.

Different channels will be of interest for different redshift ranges.

It is difficult at this stage to know whether investigators will tend to choose one grating setting (e.g. to go after a specific line) versus all of the settings to get several lines or the continuum. Many of these sources will probably be undetectable in continuum in the MRS. Some will probably have redshifts prior to the observations (e.g. from ALMA), but others won't. For this SODRM program, we have selected one grating setting on a few sources, and all three settings for most of them.

MRS dithering does not appear to be implemented yet in APT. We have put in separate exposures for each dither position, and put the dither position in the comments. It is likely that a short MIRI image will be taken at each dither position to aid in registration. This also doesn't appear to be implemented in APT. We have put in one example by hand, but left of these registration images out.

CONSTRAINTS:

None.

PARALLEL Observations possible (yes/no/pure parallel)?

These are pointed observations, so can't really be done in parallel with other observations.

They are long pointings, often in favorite parts of the sky, so parallel observations with other instruments would be desirable.

Parallel imaging with the MIRI imager (if it were possible) would of course save having to take a separate reference image for each dither position.

COMMENTS:

AUTHOR/DATE: H. Ferguson +??

TITLE: MIRI Observations of High-Redshift Active Galactic Nuclei

ID: 95100

GOAL:

This program aims to probe the relationship between AGN fuelling and galaxy mergers, by observing a sample of extremely IR-luminous galaxies at the peak of cosmic star formation and AGN activity (z~2-3). In models of galaxy / black hole co-evolution (eg Hopkins et al. 2005, 2007), mergers between galaxies can lead to substantial fuelling of heavily obscured central AGN, and in fact up to 90% of AGNs at this redshift range may be heavily obscured (e.g., Gilli et al. 2009). We must understand this population to learn the role they play in the evolution of galaxies and the integrated light of the Universe. Explorations of these source types must be concentrated in the MIRI wavelength bands because of the strong extinction. Although it has taken 30 years to gain a reasonable understanding of the mid-infrared properties of local Ultraluminous Infrared Galaxies and Type 2 AGNs, the power of JWST lets us extend many key observations all the way back to the quasar heyday at z ~ 2 – 2.5.

The hard UV / Xray fluxes from the obscured AGN can be traced by means of the high excitation mid-infrared fine structure lines from their ionizing radiation. A key line is [NeVI] at 7.65μm rest wavelength; it is the shortest wavelength bright high excitation line, and its rest wavelength lies in a region of exceptional transparency of the interstellar medium, A(7.6μm) < 0.02 A_V. Thus, sources where the rest optical line emission is totally inaccessible can be studied with this line using MIRI up to z ~ 2.5, determining key parameters such as the true AGN hard UV energetics. Studies can be extended to even higher redshifts using the “coronal” high excitation lines. There are a number of strong lines of this type at 2 to 4μm rest wavelengths (e.g., Greenhouse et al. 1993, Moorwood et al. 1997), such as the lines of [MgVIII] and [SiIX] in Figure 3. The sensitivity of the MIRI, combined with the absence of terrestrial atmospheric absorptions, can access these lines even for AGNs of modest luminosity.

NOMINAL ALLOCATION (hours): 129

The typical line fluxes for such sources, are 0.05 to 2 mJy or 19.68 to 15.68 AB magnitudes at 16 microns (from previous Spitzer observations, Charmandaris et al. 2004). A S/N of >10 is desirable to enable line strengths and ratios to be accurately determined, thus requiring 5 hours of exposure time per source

TARGET(S):

Sample and sky coverage will consist of z ~ 2-3 galaxies selected on the basis of previous photometry work by Spitzer, WFC3/IR, Herschel, ALMA, or ground based means. Sky coverage may be random on the sky. Total number of sources or pointings, 18.

OBSERVING TEMPLATES:

MIRI IFU

OBSERVATION DETAILS:

At z = 2.5, the [NeVI] line is shifted to 27 microns, therefore MIRI needs to have good spectral response up to at least this wavelengh. In order to examine all of the spectral lines simultaneously, we will need full wavelength coverage from 5-28.5 microns that the MIRI IFU provides. The observations are obtained over 18 visits, 1 visit per object (total time 5 h per visit), with the following setup

Slew to target so that is place in the sweetspot area

Image target with MIRI Imager (5.6 micron)

Offset to MIRI IFU

Expose with SHORT grating using SLOWMode (9-point dither pattern, 623s/dither)

Expose with MEDIUM grating using SLOWMode (9-point dither pattern, 623s/dither)

Expose with LONG grating using SLOWMode (9-point dither pattern, 623s/dither)

Note that all four IFU FOVs: IFU1A, 1B, 2A and 2B, are obtained simultaneously

Overhead calculations for each observation:

1800s	Target slew
240s	Guide star acq
120s	MIRI imager filter move
4x(5+42s)	Detector config + deadtime
4x271.05s	Imaging science integration time
600s	Target acq
3x60s	Grating moves
3x9x(5+42)s	Detector config + deadtime
3x9x623s	Total science integration time
22302.2s	Subtotal of all the required time
3546s	Indirect overheads (calibration+observatory: 15.9%)
25848.2s	Total time per observation

Total times and efficiency (for the full program total of 18 observations):

89 hours	Total Science integration time
40 hours	Overhead
129 hours	Total Program time

69.27% efficiency

CONSTRAINTS:

None.

PARALLEL Observations possible (yes/no/pure parallel)?

Parallel observations with NIRCam would be highly valuable in exploring their environments.

COMMENTS:

This program is an updated version of program 305 (Meixner) that was presented in the initial SODRM (JWST-STScI-000045).

AUTHORS/DATE: Anton Koekemoer (koekemoer@stsci.edu)/2 Dec 2011

TITLE: Lyman Alpha Forest S1earch for Reionization

ID: 95110

GOAL: To measure the Gunn-Peterson trough and history of reionization in the IGM from one high-S/N R = 1000 spectrum of the redshift Lyα transition toward a high-z QSO. An additional spectrum will be obtained at R = 100 to detect the possible presence of the "Lyman beta island", or transmission of flux in the Lyβ region of the same spectrum, which would indicate a partially reionized IGM.

NOMINAL ALLOCATION (hours): 200

ACTUAL TIME (hours): NIRSpec will obtain S/N = 50 per resel at 1.2 micron for source of AB = 23 in 60,000 sec (NIRSPEC.sp.249887). Since we desire two such S/N = 50 exposures (one on each side of the wavelength gap), these two exposures with overheads will require approximately two days. For the R = 100 observation, assuming the source has AB = 27, we get S/N = 12 in 300,000 sec (NIRSPEC.sp.249906). Accounting for overheads, this set of visits should require four days. Thus the total program requires 6 days total (144 hours).

TARGET(S): A suitably chosen high-redshift QSO (z > 6). Will likely have AB=23 in the continuum longward of redshifted Lyα. We assume AB = 27 for the absorption trough where we will search for transmission at Lyβ.

OBSERVING TEMPLATE: NIRSpec fixed-slit spectroscopy (S200A1)

OBSERVATION DETAILS: Will use G140M (R = 1000) and the prism (R = 100). We need the short wavelength data only. We want to map the IGM along the full sightline, so dithering over the wavelength gap is required. We will use spatial and spectral dithering to optimize S/N.

CONSTRAINTS: none

PARALLEL Observations possible (yes/no/pure parallel)?

COMMENTS: This program had ID number 405 in the 2005 SODRM.

AUTHOR/DATE: Jason Tumlinson, November 22, 2011

TITLE: Weak and Strong Lensing of SZ-selected Galaxy Clusters

ID: 95120

GOAL: Galaxy clusters are a powerful probe of the structure growth in the Universe. Currently, several projects use the SZ-effect to detect the most massive galaxy clusters candidates in a blind, redshift-independent search. Weak and strong lensing is one of the most important mass proxies for galaxy clusters, since it is a direct measure of the gravitational potential. With these NIRcam observations, the mass for 40 clusters is determined, which can then be used to calibrate other mass proxies obtained from X-rays, optical, and CMB measurements.

NOMINAL ALLOCATION (hours): 300

ACTUAL TIME (hours): 300

7.5 hours per target, 66% efficiency

TARGET(S): 40 clusters

OBSERVING TEMPLATE: NIRCam Imaging

OBSERVATION DETAILS:

For 400 seconds exposure time, assuming galaxy template M82 at redshift 1.5, the resulting S/N=5 for F444W AB mag=27 and S/N=8.5 for F227W AB mag=27. With a 3-point dither pattern, 200 second exposure per dither, the effective exposure is 2/3*(3*200 sec)=400 sec. The size of a single 3-point dither pattern is 5'x2'. A 2x5 mosaic gives then a 10'x10' mosaic size. The 3 wide LWC filters (F277W, F356W, F444W) and 3 out of the 5 SWC filters (F070W, F115W, F200W) should suffice for photo-z's

Bright2, 10 groups, 1 integration gives exposure time of 212 seconds

CONSTRAINTS:

PARALLEL Observations possible (yes/no/pure parallel)? No

COMMENTS:

AUTHOR/DATE: Armin Rest, 12/12/2011

TITLE: High Redshift SNe/GRB Followup - A NIRSpec TOO

ID: 95140

GOAL: Obtain high-S/N spectroscopy of z > 4 supernovae and GRB afterglows, from which the explosion energy and other properties can be inferred. These observations also enable measurements of foreground gas, both in the ISM of the host galaxy and the IGM all along the sightline. Observations for many GRBs can measure the mass-metallicity relation at high z.

NOMINAL ALLOCATION (hours): 200

ACTUAL TIME (hours):

NIRSpec ETC shows that NIRSpec will reach S/N ~ 20 in 800 sec on a source with 10 μJy at 1.2 micron. This was the brightness of GRB090423 at ~ 20 hours past trigger. Fainter and/or more distant GRBs can be studied down to ~ 1 μJy at S/N = 10 per resel in 2 hr exposures. This program treats the longer observations on the fainter sources as nominal. With observatory and instrument overheads, we guess that this observation will require approximately 8-10 hours. We are planning for approximately 6 such high-z GRBs over the first 1.5 years of mission science. This is accomplished by replicating the single observation 6 times in the APT file. The total time is thus 60 hours.

TARGET(S): TBD, pending trigger from Swift, another space-based mission, or ground-based facilities such as LLST and PanSTARRS.

OBSERVING TEMPLATE: NIRSpec fixed-slit spectroscopy

OBSERVATION DETAILS: Obtain R = 1000 NIRSpec spectra in all available bands (G140M, G235M, G395M). Requires peak-up target acquisition to place the target in the S1600A1 aperture (note that this is not available in APT19.4, so S200A1 is used instead).

CONSTRAINTS: This is a target-of-opportunity observation, requiring a rapid response. Having JWST on target within 24 hours of the trigger is desirable.

PARALLEL Observations possible (yes/no/pure parallel)? N/A

COMMENTS: Since TA reference stars will not be known in advance for these TOO fields, they can be triggered only when astrometry is adequate to place the target within reach of the peakup TA method for S1600A1. Since neither S1600A1 or peakup TA are available in APT19.4, they are omitted now and should be added to this program when available.

The linked WIT observing scenario for this program is #230.

AUTHOR/DATE: Jason Tumlinson, November 15, 2011

TITLE: NIRCam Imaging of z~6 QSO Host Galaxies

ID: 95150

GOAL: NIRCam imaging of 25 z~6 QSO host galaxies and their immediate environments will be obtained to determine the nature and triggering mechanisms for the first quasars. We will obtain deep rest-frame 5000A and 2800A imaging with the F356W LWC and F200W SWC at 2 orientations to measure the underlying structure of the z~6 QSO hosts in module A.

Small dither steps and multiple orientations are required for PSF subtraction of the bright QSO point source. Module B observations will be used to probe the surrounding environment of the z~6 QSOs.

NOMINAL ALLOCATION (hours): 50

ACTUAL TIME (hours): 59.5 hours

TARGET(S): 25 z~6 QSOs from Fan et al. 2006, Wilcott et al. 2007, 2009, and 2010

OBSERVING TEMPLATE: NIRCam imaging

OBSERVATION DETAILS:

25 targets, each observed at two orients ~45 degree apart.

Modules A + B, with target centered on Mod A.

Full array

SWC : F200W

LWC: F356W

Dither pattern: INTRASCA, LWC, 5 points, medium dither size, 1 subpixel steps (?)

Exposures: SHALLOW4 readout mode, 7 groups, 1 integrations, 360.4s exp per dither step; 1802s total exposure time per orientation

CONSTRAINTS:

Second visit has orient offset 20-70 degrees from first visit for PSF subtraction.

PARALLEL Observations possible (yes/no/pure parallel)?

No

COMMENTS:

Will have high slew overhead and low efficiency because of the large number of widely spaced targets and need for orient change.

AUTHOR/DATE: Jennifer Lotz, 11/23/2011

TITLE: The Physics of Galaxy Assembly: Spatially resolved spectroscopy of high-z galaxies

ID: 95170

GOAL:

Observations up to redshift z = 2 show that there are two modes of star formation: a "quiescent mode" with low star formation efficiency in galactic disks and a "burst mode" characterized by much shorter timescales, often associated with mergers. Recent results have shown that the former is the dominant mode of star formation at these redshifts (e.g. Rodighiero et al. 2011, ApJ 739, L4). Black hole accretion, around the same cosmic epochs, is also found to be mostly associated with secularly evolving systems (e.g. Mainieri et al. 2011, A&A 535, 80). At higher redshifts the universe is denser and consequently interactions, responsible for boosting star formation efficiency, are expected to be more frequent. However, the halo gas cold inflow rate is also expected to be higher, which is also expected to generate higher star formation rates. Understanding the galaxy evolutionary mechanisms at z>2.5 has been hampered by the fact that Ha (powerful tracer of star formation and of galaxy dynamics) is redshifted out of the atmospheric transmission K-band, making ground-based integral field spectroscopic studies limited to other nebular lines, which are more ambigous diagnostics, weaker, and more subject to dust extinction (Maiolino et al. 2008, A&A 488, 463, Gnerucci et al. 2010, A&A 528, 88). Moreover, the high background in ground-based observations, combined with the rapidly dimming surface brightness at high redshift, makes ground-based spatially resolved spectroscopy even more challenging. This is particularly true for spatially resolved continuum spectroscopic observations (crucial to constrain the distribution of stellar population), which are nearly impossible from ground, even at lower redshifts (z~1-2).

We propose to obtain NIRSpec IFU observations of about 40 star forming galaxies in the redshift range spanning from z~2 to z~6, both with and without an AGN nucleus, by also including lensed systems, with the goal of constraining the physical processes responsible for galaxy evolution in the early Universe. We will use the Ha line to study the distribution of star formation within high-z galaxies to distinguish between clumpy versus diffuse star formation. By tracing the spatially-resolved ionized gas kinematics we will determine the dynamical status of these galaxies. In particular, we will identify disks characterized by a regular rotation pattern, we will measure the disk turbulence, and we will identify merging objects or those with disturbed dynamics. By measuring the gas kinematics we will also be able to identify galactic outflows, which may trace negative feedback onto the host galaxy. By combining Ha maps, probing recent star formation, and maps of the stellar continuum features, probing older populations, we will study the spatially-resolved star formation histories of galaxies. Emission line ratios will be used to derive spatially-resolved metallicities and gradients. These will provide important constraints on the integrated history of star formation and on the role of gas inflows and outflows. In galaxies hosting AGNs the broad component of Ha will allow us to infer the Black Hole mass, the narrow Ha kinematics will allow us to infer the galaxy dynamical mass, while the continuum resolved spectrum will provide the host galaxy stellar mass. This information will allow us to investigate the evolution of the M_{BH}-M_{dyn} and M_{BH}-M_{star} relation out to z~6, which will provide tight constraints on the galaxy-BH coevolutionary models.

NOMINAL ALLOCATION (hours):

300

ACTUAL TIME (hours):

282

TARGET(S):

Ten star forming galaxies at z~2; five star forming galaxies at z~3; five star forming galaxies at z~6; five lensed galaxies at 2<z<6; ten AGNs at 1<z<3; five AGNs at 4<z<6.

OBSERVING TEMPLATE:

NIRSpec IFU

OBSERVATION DETAILS:

Depending on redshift, each target will be observed with one or two of the high resolution R=2700 gratings (to map the main nebular optical lines) and all of them will be observed with the R=100 prism (for the continuum mapping). Integration times are 2 to 6 hours for each high resolution grating setup, depending on the source brightness, and about 1-2 hours for each prism observation. Each source fits well within the IFU FoV, therefore there is no need for mosaic.

Dither parameters per grating are 3 slitlet positions, with spatial sub-pixel offsets.

CONSTRAINTS:

None

PARALLEL Observations possible (yes/no/pure parallel)?

Possible, but not relevant for the project.

COMMENTS:

AUTHOR/DATE: R. Maiolino, K. Gordon, S. Arribas, H.-W. Rix, T. Boker, P. Ferruit, C. Willott, P. Jakobsen, A. Bunker, S. Charlot, M. Franx

TITLE: Constraining cosmological parameters with a restframe NIR SN Ia Hubble diagram

ID: 95160

GOAL: Although the existence of dark energy is now well established, little is known about it and understanding its nature is one of the biggest outstanding problems of modern astrophysics. Type Ia supernovae (SNe Ia) are well suited to probe the expansion history during precisely the cosmic epoch (0<z<1) in which the Universal expansion makes a transition from deceleration to acceleration. However, for SNe Ia, we are already approaching the limit where the statistical error is of the same order as the systematic error, with host galaxy extinction one of the two most significant systematic sources. With a Hubble diagram in the restframe NIR, this systematic is nearly eliminated since the extinction in these red bands is an order of magnitudes lower than in the visual. Hubble diagram with 50 SNe Ia per year, totaling 250 SNe Ia over 5 years.

NOMINAL ALLOCATION (hours): 200

ACTUAL TIME (hours): 243 hours

0.69 hours per target, 12% efficiency

TARGET(S): 50 SN Ia

OBSERVING TEMPLATE: NIRCam Imaging

OBSERVATION DETAILS:

I use the ETC to calculate the S/N of the SN Ia at peak for different redshifts. As input spectrum, I use the Hsiao SN Ia template at peak:

http://supernova.lbl.gov/~hsiao/uber/hsiao_template.tar.gz

z=1, H=23 Vega at peak

#filter	S/N(H)	exptime (s)
F115W	23.5842	100
F150W	16.4425	100
F200W	14.3047	100
F277W	12.3956	100
F356W	13.0389	150
F444W	10.3607	200

z=0.5, H=22 Vega at peak

#filter	S/N(H)	exptime (s)
F115W	40.0799	100
F150W	40.1238	100
F200W	32.5786	100
F277W	32.2797	100
F356W	15.6408	100

z=0.2, H=21 Vega at peak

#filter S/N(H) exptime

F115W 44.3754 50

F150W 38.4119 50

F200W 28.6820 50

We always observe the SWC/LWC filter pairs: F115W+F277W, F150W+F356W,F200W+F444W, RAPID readout. At peak we need at minimum S/N=10. Thus we choose exposure times for 3 difference redshift ranges:

z<=0.2: exposure times = 50 seconds for all filters

0.2 < z <= 0.6: exposure times = 100 seconds for all filters

0.6 < z : exposure times:

F277W=100 sec

F356W=150 sec

F444W=200 sec

In order to cover the light curve, we observe 7 epochs. Their spacing depends on the redshift. For redshift z0=0.5, we choose a spacing of dt0=4 days, with a +-1 day wiggle room. For all other redshifts, we calculate the spacing dt=dt0 * (z+1.0)/(z0+1.0) . At later phases, the spacing between the epochs can be longer, therefore we space the last three epochs by 2.5*dt.

CONSTRAINTS: TOO observations.

PARALLEL Observations possible (yes/no/pure parallel)?

COMMENTS:

Efficiency is completely dominated by slew time. Time-domain surveys at the time JWST is launched will produce many more SNe that can be observed with JWST, which most likely will allow to cut down the slew time by smartly selecting events in close spatial proximity.

AUTHOR/DATE: Armin Rest, 01/05/2012

Instrument Calibration Programs

TITLE: NIRCam Dark Current and Read-Noise Monitor

ID: 96000

GOAL:

This program monitors the dark current and read noise by taking dark observations through all read-out patterns and observing modes. The exposures are obtained by setting the short- and long-wavelength pupil wheels to the "flat-field pinhole/ dark" position, with the lamp off, and using each of the 9 readout patterns: RAPID, BRIGHT1, BRIGHT2, SHALLOW2, SHALLOW4, MEDIUM2, MEDIUM8, DEEP2, and DEEP8. Given the expected low dark current signal (nominally 0.01 e/sec/pixel), a total exposure time of 10^4 seconds should yield a dark current signal-to-noise per pixel ~10 (*TBC pending FM ground test results*). To mitigate negative effects of an uncertain cosmic ray hit rate, individual integrations should be limited to ~3000 seconds. The arrays will be read out in NRSRAPID mode in order to best identify discrete cosmic ray events. The deliverables from this program will consist of dark reference files, read-noise measurements, and bad pixel maps for the calibration pipelines.

NOMINAL ALLOCATION (hours): N/A

ACTUAL TIME (hours): 648 hours for 1.5 years (36 hours/month), all obtained in parallel since these are all internal darks.

TARGET(S):

Internal Dark

OBSERVING TEMPLATES:

NIRCam Dark

OBSERVATION DETAILS:

Each month, the observations will consist of a total of 4 sets:

1. the 1st and 2nd set will be for Module A and Module B respectively, cycling through 5 readout patterns (RAPID, BRIGHT1, BRIGHT2, SHALLOW2, SHALLOW4) with NFRAME=1, NSKIP=0, NGROUPS=50, and NINTS=25 for both sets
2. the 3rd and 4th set will be for both modules, cycling through 4 readout patterns (MEDIUM2, MEDIUM8, DEEP2, and DEEP8), with NFRAME=2,NSKIP=8 for the 3rd set and NFRAME=8, NSKIP=2 for the 4th set.; both will use NGROUPS=40 and NINTS=25

The total time required for these observations is 36 hours each month, which would all be done in parallel and spread throughout each month, continuously for the 1.5-year nominal cycle.

CONSTRAINTS:

N/A.

PARALLEL Observations possible (yes/no/pure parallel)?

Yes, these are observations taken in parallel since they are all internal darks.

COMMENTS:

The individual integrations do not have to be contiguous, but should be spread out over each 1-month period in order to track possible instrument changes (*TBC*).

AUTHORS/DATE: Anton Koekemoer (koekemoer@stsci.edu)/17 Feb 2012

TITLE: NIRCam Flat Field Monitor
ID: 96010

GOAL:

This program monitors the flat fields through all the filters on NIRCam's filter wheel (note that spectral elements on the pupil wheel are not monitored since the lap itself is on the pupil wheel; ground-test flats will be used for those filters.) The SWC and LWC have 11 and 12 filters on the filter-wheel respectively, fall of which need calibration. For each filter, 10 exposures will be obtained, repeated for 5 integrations, with the lamp intensity set to approach full-well depth in 10 frames. Separate flats need to be obtained for each of the filters, and for both modules, since the LWC and SWC cannot take lamp flats simultaneously.

NOMINAL ALLOCATION (hours): N/A

ACTUAL TIME (hours): A total of 38 hours, from monthly cycling through all the flats, over the nominal 1.5 year period.

TARGET(S):

Internal Flat

OBSERVING TEMPLATES:

NIRCam Internal Flat

OBSERVATION DETAILS:

The 10 frames for each integration for each filter, repeated for 5 integrations, require between 106s and 318s per filter, depending on the filter. To this must be added the overheads of 60s per filter move and 5 s for configuring the detector, as well as 15.9s of detector dead time, for each integration. The total integration time for the 11 SW filters on each of modules A and B is 1802s, thus a total of 3691.8s for all the SW filters on both modules. The total integration time for the 12 LW filters on each of modules A and B is 1961s, thus a total of 3902.6s for all the SW filters on both modules. Since these will all be cycled through each month, this leads to a total of 25 hours for the entire 1-year Cycle 1 calibration period.

Each individual SCA frame is 8 MB (2048 x 2048 two-byte pixels). Each SWC observation will save 4 SCAs and each LWC will save 1 SCA. So, the total volume of data required is: (4 x 11 SWC filters + 1 x 12 LWC filters) x 10 frames x 5 integrations x 2 modules x 8 MB/frame = 44.8 GB. The observations can be taken at different times (during slews, etc), and could therefore be broken down into smaller pieces if needed. Some of the broad-band filters may saturate before 10 frames *(pending results from FM testing)*, so they would require fewer reads, and the data requirements would be reduced accordingly.

CONSTRAINTS:

N/A.

PARALLEL Observations possible (yes/no/pure parallel)?

No; other instruments cannot observe while lamps are on in NIRCam. However, they can be taken during slews, momentum dumps, etc.

COMMENTS:

These observations use lamps and should therefore not be run for more than 1 hour at a time, to avoid impacting the thermal budget. The different channels should also be cycled through (SWA, SWB, LWA, LWB) to minimize heat build up in any one part of NIRCam. These observations cannot be made in parallel, since they use lamps. However, they can be taken during slews, momentum dumps, etc.

AUTHORS/DATE: Anton Koekemoer (koekemoer@stsci.edu)/17 Feb 2012

TITLE: NIRCam Photometric Zeropoint Monitoring

ID: 96020

GOAL:

This program monitors the photometric zero-point calibration through all the NIRCam filters, using three calibration target stars that are observed three times each. These will likely be the same targets that other instruments use, so there will be some consolidation of slews. There will be some targets in the CVZ, so that we can observe them periodically over the commissioning period. We will observe each standard star through each of NIRCam's filters. There are 12 filters in the short-wave channel (5 wide-, 4 medium-, and 3 narrow-band) and 15 in the long-wave channel (3 wide-, 8 medium-, and 4 narrow-band). Since the SW and LW observations can be obtained in parallel, this means a total of 15 sets of filter changes (including 12 for the SW, in parallel with the first 12 of the LW). The stars will generally be too bright to observe in full-array mode so will be observed in subarray mode, using 10 integrations at each of 5 dither positions. The integrations will be long enough to bring the star near full-well. Since the different modules will have slightly different filters and other optical elements, the observations should be done separately on each module. Although we are observing the standard stars three times, we can probably use a subset of the filters on subsequent visits.

NOMINAL ALLOCATION (hours): N/A

ACTUAL TIME (hours): A total of 15.8 hours, cycling three times over the set of standard stars during the 1.5 year period.

TARGET(S):

Flux standard stars

OBSERVING TEMPLATES:

NIRCam Imaging

OBSERVATION DETAILS:

For each of the observations, the on-sky time will be a small fraction of the execution time. Each observation will require 15 filter changes, and within the observations for each filter we will take 5 dithers. The overheads for each filter change will require 60s and each (very small) dither will require 30s, so that the observations for each filter will take about 60s + 5 x 30s = 210s. For the full set of 15 filters (on the LW, done in parallel with the 12 on the SW), this would require 3150s. This does not include any overhead that may be required to initialize the subarrays before and after observations. To observe all 3 stars with both modules would therefore require 5.2 hours. Repeating this 3 times during the calibration cycle therefore requires 15.8 hours.

This program should require relatively low data volume storage, as we will be using the subarrays with relatively short exposures. Obtaining 10 integrations with 10 frames saved per integration, at each of 5 dither positions with a 96 x 96-pixel subarray, for 15 filters with two SCAs at a time (long and short), will require 10 x 10 x 5 x 96 x 96 x 15 x 2 x 2 bytes = 264 MB for each target. If each of the three targets is observed during three visits for both modules, the total data storage required will be 3 x 3 x 2 x 300 MB = 4.7 GB. Each star will be observed separately, and the data downloaded separately.

CONSTRAINTS:

N/A.

PARALLEL Observations possible (yes/no/pure parallel)?

Not possible; all these targets need to be observed as prime targets.

COMMENTS:

This program observes three calibration stars, each of which we would plan to observe three different times during the cycle, to track any potential changes in the photometric zeropoints. At least one of the targets is likely to be a solar analog and another to be a white dwarf. It is likely that other instruments will observe the same stars, so some consolidation in terms of visit scheduling should be possible. The calibration target list is still being constructed, but there will likely be a few targets in the CVZ, and some will be brighter than others so that we will have to tailor the exposure times and subarray patterns to the particular star/filter combination.

AUTHORS/DATE: Anton Koekemoer (koekemoer@stsci.edu)/17 Feb 2012

TITLE: NIRCam Total-Count and Count-Rate Linearity Characterization

ID: 96030

GOAL:

This program measures the total-count and count-rate (flux-dependent) linearity response of the NIRCam detectors, and also provides comparison with results from ground testing. The observations will use the flat-field lamps, which can only be operated one channel at a time, therefore each set of observations is repeated four times (for SWC-A, SWC-B, LWC-A and LWC-B). The filter wheel is set to a broad filter (F200W in the SWC and F444W in the LWC) and the pupil wheel to “flatfield/ dark”. Four lamp settings will be used: (1) a low setting, with a 100-frame integration in RAPID mode designed to just saturate the detector at the end; (2) doubling the lamp intensity, with a 500s exposure, again designed to just barely saturate at the end of the integration; (3) doubling the lamp intensity again with a 200s exposure; (4) doubling the intensity a final time, with a 100s exposure. At each lamp setting, the observations will be repeated 3 times before moving to the next highest setting. These observations will characterize how the detector linearity varies with total counts and also count-rate.

NOMINAL ALLOCATION (hours): N/A

ACTUAL TIME (hours): A total of 6 hours, run once during the nominal period.

TARGET(S):

Internal Flat

OBSERVING TEMPLATES:

NIRCam Internal Flat

OBSERVATION DETAILS:

The total time of one set of observations will be: 1000 s + 500 s + 200 s + 100 s = 1800 s, repeated 3 times at each lamp setting for a total of 5,400 s. Given that these will need to be obtained separately for each of the 4 channels, the total time required will therefore be 6 hours.

Each SCA frame is 8 Mb (2048 x 2048 two-byte pixels), and there will be four SCAs per read-out for the SWC, and 1 for the LWC for each set. Each SWC will require 32 Mb per frame, and each LWC 8 Mb per frame. The total number of frames is just the total number of seconds divided by 10, so this will require 180 frames for each channel. The total storage needed then is: 8 Mb x 180 x (4 + 1) x 3 repeats x 2 modules = 42 Gb total.

CONSTRAINTS:

N/A.

PARALLEL Observations possible (yes/no/pure parallel)?

No; other instruments cannot observe while lamps are on in NIRCam. However, they can be taken during slews, momentum dumps, or while other instruments are taking lamp-flat observations.

COMMENTS:

These observations use lamps and should therefore not be run for more than 1 hour at a time, to avoid impacting the thermal budget. The different channels should also be cycled through (SWA, SWB, LWA, LWB) to minimize heat build up in any one part of NIRCam. These observations cannot be made in parallel, since they use lamps. However, they can be taken during slews, momentum dumps, or while other instruments are taking lamp-flat observations.

AUTHORS/DATE: Anton Koekemoer (koekemoer@stsci.edu)/17 Feb 2012

TITLE: NIRCam Persistence Characterization

ID: 96040

GOAL:

This program characterizes the NIRCam persistence. Observations are obtained with the lamps at different brightness settings to induce various amounts of saturation, followed by a series of darks to examine the persistence. There are a total of 3 sets of integrations, with each integration consisting of 10 reads. The first set of integrations is aimed to just barely saturate the detector by the end of the integration; the second set will saturate it by a factor of 10, and the 3rd set by a factor of 100. The array will then be reset and read out as a series of dark frames with the lamp off and the pupil wheel in a dark position, to follow the persistence. The observations will be repeated 5 times at each lamp setting. The observations need to be done separately for each channel in each module, since only one lamp can be turned on at a time, and the persistence characteristics of each individual pixel need to be mapped.

NOMINAL ALLOCATION (hours): N/A

ACTUAL TIME (hours): A total of 10 hours, obtained once during the nominal 1.5 year period.

TARGET(S):

Internal Flat

OBSERVING TEMPLATES:

NIRCam Internal Flat

OBSERVATION DETAILS:

The up-the-ramp reads for each of the lamp settings should take 100s, while the subsequent dark frames should extend for 500s. We will repeat this five times for each of three lamp settings for each channel in each module. So, the total time will be about 600s x 5 repeats x 3 settings x 4 channels = 36,000s, or about 10 hours. This can be broken up and done in pieces. The 500s suggested above for dark readout is a conservative estimate, and may need to change after results from FM tests have been obtained.

Each observation will provide a total of 60 frames (including the flats and the darks). For one SWC channel, a frame is 40 MB, giving a total of 2.4 GB for each observation, while the LWC will require 600 MB for each observation. There will be two such observations for each module, repeated 5 times for each of 3 lamp settings. The total amount of data will be (2.4 + 0.6 GB) x 2 modules x 5 times x 3 = 90 GB. This can be obtained in 2.4 GB or 610 MB campaigns between slews. If we find from ground tests that less than 500s is sufficient for the dark component of the survey, then the data volume will be reduced accordingly.

CONSTRAINTS:

N/A.

PARALLEL Observations possible (yes/no/pure parallel)?

No; other instruments cannot observe while lamps are on in NIRCam. However, they can be taken during slews, momentum dumps, or while other instruments are taking lamp-flat observations.

COMMENTS:

These observations use lamps and should therefore not be run for more than 1 hour at a time, to avoid impacting the thermal budget. The different channels should also be cycled through (SWA, SWB, LWA, LWB) to minimize heat build up in any one part of NIRCam. These observations cannot be made in parallel, since they use lamps. or while other instruments are taking lamp-flat observations. Care should also be taken not to obtain the high-saturation exposures before the low-saturation ones, and also not to schedule NIRCam-prime observations immediately after one of these visits.

AUTHORS/DATE: Anton Koekemoer (koekemoer@stsci.edu)/17 Feb 2012

TITLE: NIRCam PSF Characterization

ID: 96050

GOAL:

This program aims to characterize the PSF in all the NIRCam filters. Observations of the JWST calibration field through each filter will allow the PSF quality to be assessed for all locations on the detectors. This PSF can be compared with optical models to verify that there are no unexpected sources of wavefront error or throughput anomalies, as well as providing an accurate empirical set of PSFs. The images will be as short as possible for each filter, since there are a sufficient number of bright stars across the calibration field, with the exposure times designed to achieve similar S/N for each filter.

NOMINAL ALLOCATION (hours): N/A

ACTUAL TIME (hours): A total of 4.2 hours for the observations, as well as additional time required to slew to the CVZ target area.

TARGET(S):

JWST CVZ calbration field.

OBSERVING TEMPLATES:

NIRCam Imaging

OBSERVATION DETAILS:

The exposure time for the medium-band filters will be about 2 times longer than the wide-band filters, and the narrow-band filters will be 5 times longer. The wide filters will use 5 integrations with the RAPID readout mode (50s). The medium-band filters will use the SHALLOW4 readout mode with 3 GROUPS (156s). The narrow-band filters will be read out with the MEDIUM8 readout mode with 5 GROUPS (530s). There are 5 wide-band filters on the SWC and 3 on the LWC; there are 4 medium-band filters on the SWC and 8 on the LWC; and there are 3 narrow-band filters on the SWC and 4 on the LWC. Since the SWC and LWC observations can be obtained in parallel, observing all the wide, medium, and narrow-band filters will require a total exposure time of 3 x 50s + 8 x 156s + 4 x 530s = 3518s. In addition, the observations for each filter will be obtained in a 4-point sub-pixel dither pattern.

The overheads between each exposure will be 60s for filter changes, in addition to 30s needed for each of the 4 small dither offsets. Thus, the total time required will be 15x60 + 4x(3518+30) = 15,092s, or 4.2 hours. The slew time to the calibration field in the CVZ may be an additional overhead relative to the nominal 1800s slew time. However, some time could be saved by observing this field in conjunction with the other instruments.

Each SCA frame is approximately 8.4 MB (2048 x 2048 two-byte pixels), and there will be ten SCAs per read-out. Thus, each frame saved will be 84 MB. Each wide-band filter exposure will contain 6 frames (the first plus the 5 read frames), each medium-band exposure will save 4 frames (the first frame plus the 3 groups), and each narrow-band-filter exposure will save 5 frames (again, the first frame plus the 4 groups). Therefore, the total number of frames stored will be 4 x (5 x 6 + 8 x 4 + 5 x 5) = 348, and the activity will require 29 GB total storage.

CONSTRAINTS:

N/A.

PARALLEL Observations possible (yes/no/pure parallel)? No

COMMENTS:

AUTHORS/DATE: Anton Koekemoer (koekemoer@stsci.edu)/17 Feb 2012

TITLE: NIRCam Astrometry and Distortion Monitor

ID: 96060

GOAL:

This calibration program monitors the plate scale, orientation, and geometric distortion for each SCA in each NIRCam module at a range of wavelengths. This will involve observing a standard astrometric field at a set of dithered offsets (~5) through a representative set of filters (~4). The LMC calibration field (R.A = 05:21:57 and Dec = -69:29:51) in JWST's CVZ has been carefully chosen and mapped with HST's ACS to facilitate such a calibration.

NOMINAL ALLOCATION (hours): N/A

ACTUAL TIME (hours): To be run once, at any time during the cycle, for a total of 70 minutes (plus slew time required to reach the CVZ calibration field).

TARGET(S):

JWST CVZ calbration field.

OBSERVING TEMPLATES:

NIRCam Imaging

OBSERVATION DETAILS:

The required observations should be short, with 10 frames of integration in RAPID readout mode. This will provide about 2500 point sources per SCA with S/N better than 30 and positions better than 2 mas. The filters F070W, F110W, F150W, and F200W will be used for the short-wave channel and F277W, F356W, F444W, and F480M for the long-wave channel, since these cover the full wavelength ranges of each channel. While a single observation of the reference field should in principle be sufficient to solve for the geometric parameters, the multiple dithers will allow for important cross-checks. The dithers will be taken with offsets to ensure that all parts of the NIRCam field are covered at least twice within the high-precision region of the calibration field. Each exposure will take about 90s total and the filter changes and dithers will add about 120s overhead. The total time will thus be 210s x 4 filters x5 dithers = 70 minutes.

Each SCA frame is approximately 8.4 MB (2048 x 2048 two-byte pixels), and there will be ten SCAs per read-out (8 for the SWC and 2 for the LWC). Thus, each frame saved will be 84 MB. Each exposure will save all 10 frames (the first frame, plus 9 up-the-ramp reads), amounting to 840 MB total. There will be one exposure for each of the five dithers for each of the four wide-band filters, so the total data collected for the activity will be 5 x 4 x 840 MB = 16.8 GB.

CONSTRAINTS:

N/A.

PARALLEL Observations possible (yes/no/pure parallel)? No

COMMENTS:

AUTHORS/DATE: Anton Koekemoer (koekemoer@stsci.edu)/17 Feb 2012

TITLE: NIRCam LW Grism Calibration

ID: 96070

GOAL:

This program is aimed at calibrating and characterizing the wavelength solution, line spread function (LSF), flux calibration and L-flat correction for the NIRCam grism. This is located in the pupil wheel, so would be crossed with the filter wheel. There are three types of observations: (1) the wavelength solution will be determined by observing a planetary nebula in M31 (eg M31-363, used also in the WFC3/IR grism calibration) which provides a rich set of spectral lines, and is also sufficiently compact to enable the LSF to be measured; (2) the flux calibration will be carried out by observing one of the NIRCam standard stars in LW broad-band filters (F277W, F356W, F444W) and with the same filters crossed with the grism, in order to provide a direct cross-calibration; (3) the L-flat correction will be obtained by observing the JWST calibration field, which will provide a large number of stars across the field in order to map spatial variations in the grism throughput. Each of these sets of observations will be obtained in a 3x3 grid pattern across the LW SCA, to sample the spatial variation of these characteristics.

NOMINAL ALLOCATION (hours): N/A

ACTUAL TIME (hours): For the 3 different targets, the time is as follows: M31: 4.8h; standard star: 1.2h; L-flat target: 3 hours. Thus the total time required is 9 hours, but these 3 targets can be observed separately during the cycle.

TARGET(S):

M31 PN (M31-363); Flux calibration standard; JWST CVZ calibration field.

OBSERVING TEMPLATES:

NIRCam Imaging

OBSERVATION DETAILS:

The grism location is in the pupil wheel, therefore crossed with spectral elements in the LW filter wheel. All observations are obtained by crossing with the 3 broad-band LW filters F277W, F356W, F444W, which cover the entire grism spectral range, as well as observing the fields with just the filters alone in order to provide accurate zeropoints for the wavelength calibration.

The expected exposure time for the M31 PN observations is expected to be relatively short, ~10s integration with the filters alone, and ~50s integration with the grism crossed with the filters *(TBC once the grism properties are known from FM testing)*. At each of 9 dither positions, a secondary 4-point dither would be employed to provide sub-pixel dithering, with a total of 6 exposures obtained at each dither position (3 with just the filters, and 3 with the filters crossed with the grism). The total integration time for the M31 observations would thus be 9 x 4 x 3 x (10 + 50) s = 6,480s or 1.8 hours for each of modules A and B; including overhead for filter changes, this yields a total time of 4.8 hours for both modules.

The flux calibration would be obtained in a similar way, but does not require the 4-point sub-pixel dither. The expected integration time should also be of the order of 10 seconds without the grism and 50s with the grism *(TBC once the grism properties are known from FM testing)*, therefore its total required time is 9 x 3 x (10 + 50) s = 1,620s for each of modules A and B; including overhead for filter changes, this yields a total time of 1.2 hours for both modules.

The L-flat correction also does not require the 4-point sub-pixel dither but would likely require longer integrations since the targets are fainter; the expected integration times here are of the order of 30 seconds without the grism and 150s with the grism *(TBC once the grism properties are known from FM testing)*, therefore its total required time is 9 x 3 x (30 + 150) s = 4,860s for each of modules A and B; including overhead for filter changes, this yields a total time of 3 hours for both modules.

Each LW SCA frame requires 8 MB (2048 x 2048 two-byte pixels), multiplied by 2 for modules A and B. The M31 observations will yield a total of 3 x 2 x 2 images (96Mb) at each dither position, thus 3.5 Gb for the full set of 4-point dithers at each of the 3x3 grid locations. The standard star and L-flat observations, not being dithered, will produce 4 times less data volume each, therefore the total data volume for this program is expected to be 5.2 Gb.

CONSTRAINTS:

N/A.

PARALLEL Observations possible (yes/no/pure parallel)? No

COMMENTS:

AUTHORS/DATE:

Anton Koekemoer (koekemoer@stsci.edu)/17 Feb 2012

TITLE: NIRCam Coronagraphic Calibration

ID: 96080

GOAL:

This program calibrates the coronographic mode of NIRCam, including distortion / astrometry, target acquisition, photometry and PSF characterization. The distortion / target acquisition will be measured by observing the JWST calibration field, and observing stars behind the ND squares as well as in the vicinity of the coronagraphic spots to quantify the distortion behind the coronagraphic pupil. The photometric calibration will be monitored using the mask/filter combinations that span the coronagraphic imaging wavelength range, in particular the MASK210R/F210M, MASK210R/F212N, MASK335R/F300M, MASK335R/F335M, MASK430R/F410M, MASK430R/F430M, MASKSWB/F210M, and MASKLWB/430M mask/filter combinations, which will also provide information on the PSFs.

NOMINAL ALLOCATION (hours): N/A

ACTUAL TIME (hours): The program consists of two parts, namely the distortion/astrometry component (3.3 hours) and photometry/PSF (2.7 hours), for a total of 6 hours, carried out once during the calibration cycle.

TARGET(S):

JWST calibration field, photometric standard stars

OBSERVING TEMPLATES:

NIRCam Coronagraphic Imaging

OBSERVATION DETAILS:

The coronagraphic mask contains 12 ND squares arranged in 2 rows of 6, centered on a row of 5 masks (3 radially symmetric ones, and 2 wedge-shaped ones). The full distortion solution will have been obtained during commissioning, therefore this program simply aims to monitor changes, using a total of 10 ND-to-mask offsets (5 from each direction). In each case, after an initial target acq of a bright star on the ND square (requiring 300s of overhead), a blind offset is performed to place the star behind the associated occulter. A 9-point dither is then performed to map the true location of the star, requiring 100s at each dither position (10 frames). The total expected time is therefore 10 x (300s + 9 x 100s) = 12000s, or 3.3 hours, and the total data volume (with 10 frames at each dither position) is 10 x (10 x 9 x 8 Mb) = 7.2 Gb.

The photometric calibration and monitoring will be carried out by observing one of the JWST standard stars through a total of 8 mask/filter combinations that span the observable wavelength range. For each of these, the standard star will be first acquired, then offset to the relevant mask, and subsequently observed in a 9-point dither pattern, with 10 frames at each dither location (100s total time). The total time expected for this part of the program is therefore 8 x (300s + 9 x 100s) = 9600s, or 2.7 hours, and the total data volume (using just subarrays this time, with 10 times less pixels) is 8 x (10 x 9 x 0.8 Mb) = 0.6 Gb.

CONSTRAINTS:

N/A.

PARALLEL Observations possible (yes/no/pure parallel)? No

COMMENTS:

AUTHORS/DATE:

Anton Koekemoer (koekemoer@stsci.edu)/17 Feb 2012

TITLE: NIRSpec dark monitor

ID: 96200

GOAL:

These observations will provide a set of dark frames for measuring the detector dark current and read noise. The observation will be repeated twice monthly to monitor for any changes. Given the expected low dark current signal, a total exposure time of 10^4 seconds should yield a dark current signal-to-noise per pixel ~10 (*TBC pending FM ground test results*).

NOMINAL ALLOCATION (hours): N/A

ACTUAL TIME (hours): 100

TARGET(S):

N/A

OBSERVING TEMPLATE: NIRSpec dark

OBSERVATION DETAILS:

Individual observations will consist of 3 integrations of 70 groups each in NRS readout mode (to mitigate negative effects of an uncertain cosmic ray hit rate, individual integrations should be limited to ~3000 seconds). Multiple observations will be spread throughout the period with a cadence of roughly two per month.

CONSTRAINTS:

"After by" constraints are used to provide the proper cadence for each repeated set of darks.

PARALLEL Observations possible (yes/no/pure parallel)?

Yes (preferable).

COMMENTS:

AUTHOR/DATE:

James Muzerolle (muzerol@stsci.edu) / 22 Nov 2011

TITLE: NIRSpec wavelength calibration monitor

ID: 96201

GOAL:

One or more emission line sources will be observed with both the MSA and the IFU in order to check the stability of the wavelength calibration of the instrument. An appropriate target will be selected, preferably the same one observed during the commissioning activity for wavelength calibration.

NOMINAL ALLOCATION (hours): N/A

ACTUAL TIME (hours): 58

TARGET(S):

NGC 6543

OBSERVING TEMPLATE: NIRSpec MSASPEC, IFUSPEC

OBSERVATION DETAILS:

Data will be taken with all filter and grating combinations (F070LP with G140M/H, F100LP with G140M/H, F170LP with G235M/H, F290LP with G395M/H, and CLEAR with PRISM). The MSA will be configured with an open shutter slit pattern commensurate with the angular extent of the target (probably a 3-shutter slitlet in the case of an unresolved source). The slit pattern will be repeated at 4 different positions across the MSA, for a total of 108 exposures . A similar set of exposures will be taken with the IFU, with the target observed at 4 positions (including a 3-slice width offset in the spatial direction, and a subpixel offset in the spectral direction). NRSRAPID readout will be used with exposure times of roughly 100 seconds (depending on the actual brightness of the source emission and its spatial extent). Observations will be repeated about every 60 days in order to monitor stability.

CONSTRAINTS:

'Group within' and 'after by' constraints are used for each set of IFU and MSA observations in order to provide the proper repeat cadence.

PARALLEL Observations possible (yes/no/pure parallel)?

No

COMMENTS:

For the purposes of this program, we assume an unresolved source, even though the target specified is actually a resolved planetary nebula. The MSA shutter slitlet length and IFU dither pattern should be tuned according to the extent of the target in the case of an extended source. Which target type might be best is still *TBD*; a stellar absorption line source may also suffice.

AUTHOR/DATE: James Muzerolle (muzerol@stsci.edu) / 5 Jan 2012

TITLE: NIRSpec flat field lamp monitor

ID: 96202

GOAL:

This program will check the long-term stability of the internal flat lamps by obtaining exposures with all CAA continuum lamps once per month.

NOMINAL ALLOCATION (hours): N/A

ACTUAL TIME (hours): 3

TARGET(S):

N/A

OBSERVING TEMPLATE: NIRSpec Internal Lamp

OBSERVATION DETAILS:

Short exposures (NRSRAPID with Ngroup=3) will be taken through the fixed slits (MSA=ALL_CLOSED) with each CAA continuum lamp and corresponding medium resolution grating position (FLAT1/FLAT4 with G140M, FLAT2 with G235M, FLAT3 with G395M, and FLAT5 with PRISM). The full set of exposures will be repeated every month in order to track changes in the flux.

CONSTRAINTS:

All observations in each folder (the complete set of internal lamps) are placed in a group within constraint to ensure that they be observed contiguously. After by constraints are used to provide the proper cadence for each repeated set of observations.

PARALLEL Observations possible (yes/no/pure parallel)?

No

COMMENTS:

This program may be redundant if flat field autocals are adopted.

AUTHOR/DATE:

James Muzerolle (muzerol@stsci.edu) / 5 Jan 2012

TITLE: NIRSpec MSA L-flat verification

ID: 96203

GOAL:

The MSA low-frequency spectral flat field must be determined for each shutter. Since it is not practical to obtain data for every case, a model will be constructed by extrapolating between an instrument model and flat spectra observed through a small subset of shutters. This program will build on the initial L-flat data cube obtained during FM testing and commissioning by measuring flats at additional MSA longslit positions.

NOMINAL ALLOCATION (hours): N/A

ACTUAL TIME (hours): 21

TARGET(S):

N/A

OBSERVING TEMPLATE: NIRSpec Internal Lamp

OBSERVATION DETAILS:

Data will be taken with the appropriate CAA continuum lamp and grating positions (FLAT1/FLAT4 with G140M/H, FLAT2 with G235M/H, FLAT3 with G395M/H, and FLAT5 with PRISM). The MSA will be configured to a long slit pattern of open shutters. Based on preliminary FM test data, sufficient S/N should be achieved with exposure times of ~100 seconds (NRSRAPID with Ngroup=9). As many longslit positions should be observed as is feasible; here I assume a total of 50, with no scheduling constraints.

CONSTRAINTS:

All observations for each slit are placed in a group within timing constraint to ensure that they be observed contiguously.

PARALLEL Observations possible (yes/no/pure parallel)?

yes

COMMENTS:

A single longslit observation should fit within a typical slew, thus would be perfectly suitable as a parallel. In the APT file, the observations for each flat lamp/grating setting were grouped with a timing constraint to ensure all settings for a single slit would be observed contiguously; in the future, they should be specifiable within a single visit.

AUTHOR/DATE:

James Muzerolle (muzerol@stsci.edu) / 31 Jan 2012

TITLE: NIRSpec IFU spectral flat monitor

ID: 96204

GOAL:

This program will check the long-term stability of the IFU spectral flat field and location using internal flat lamps, with a monthly cadence. The full IFU spectral cube will be extracted, and the flux as a function of wavelength will be compared to earlier observations. The location of the spectra on the FPA will also be measured and compared with earlier determinations to check for any movement over time.

NOMINAL ALLOCATION (hours): N/A

ACTUAL TIME (hours): 11

TARGET(S):

N/A

OBSERVING TEMPLATE: NIRSpec Internal Lamp

OBSERVATION DETAILS:

Data will be taken with the appropriate CAA continuum lamp and grating position (FLAT1/FLAT4 with G140M/H, FLAT2 with G235M/H, FLAT3 with G395M/H, and FLAT5 with PRISM). Based on preliminary FM test data, sufficient S/N (~50) should be achieved with exposure times of ~100 seconds for the medium gratings and 200 seconds for the rest (NRSRAPID with Ngroup=9,19).

CONSTRAINTS:

A group within timing constraint is applied to all the observations to ensure that they be observed contiguously.

PARALLEL Observations possible (yes/no/pure parallel)?

yes

COMMENTS:

A single observation at all lamp/grating settings should fit within a typical slew, thus would be perfectly suitable as a parallel. In the APT file, the observations for each flat lamp/grating setting were grouped with a timing constraint to ensure all settings for a single slit would be observed contiguously; in the future, they should be specifiable within a single visit.

AUTHOR/DATE: James Muzerolle (muzerol@stsci.edu) / 1 Feb 2012

TITLE: NIRSpec absolute flux calibration monitor

ID: 96205

GOAL:

Observations of a spectrophotometric standard will be taken through the square aperture in order to monitor the stability of the absolute flux calibration. Data will be taken with all dispersers. The observation will be repeated roughly every 3 months.

NOMINAL ALLOCATION (hours): N/A

ACTUAL TIME (hours): 9

TARGET(S):

P177D

OBSERVING TEMPLATE: NIRSpec Fixed Slit Spectroscopy

OBSERVATION DETAILS:

Data will be taken with all filter and grating combinations (F070LP with G140M/H, F100LP with G140M/H, F170LP with G235M/H, F290LP with G395M/H, and CLEAR with PRISM). The star will be observed through the square aperture slit using a 3-point dither pattern. Exposure times were selected to achieve S/N > 50 per resolution element. The bright G-type standard P177D (K~11.9) was adopted from the nominal JWST list of standards, yielding the following parameters (all using NRSRAPID readout, with one integration per exposure): 3 groups/int (prism, G140M, G235M); 10 groups/int (G395M, G140H); 16 groups/int (G235H); 39 groups/int (G395H). The observation will be repeated about every 90 days in order to monitor stability.

CONSTRAINTS:

N/A

PARALLEL Observations possible (yes/no/pure parallel)?

No

COMMENTS:

AUTHOR/DATE: James Muzerolle (muzerol@stsci.edu) / 1 Feb 2012

TITLE: NIRSpec absolute flux calibration extension

ID: 96206

GOAL:

Observations of multiple spectrophotometric standards will be taken to extend the initial absolute flux calibration done during commissioning and cycle 1. Standard stars with different brightnesses and spectral types will be observed in order to further constrain the flux calibration and also test for flux nonlinearity.

NOMINAL ALLOCATION (hours): N/A

ACTUAL TIME (hours): 12

TARGET(S):

2MASS-J18052927+6427520

GD 71

BD+52-913 (G191B2B)

2MASS-J17325264+7104431

2MASS-J17403468+6527148

2MASS-J18022716+6043356

TYC-4413-304-1 (P041C)

GSC-02581-02323 (P330E)

OBSERVING TEMPLATE: NIRSpec Fixed Slit Spectroscopy

OBSERVATION DETAILS:

Data will be taken with all filter and grating combinations (F070LP with G140M/H, F100LP with G140M/H, F170LP with G235M/H, F290LP with G395M/H, and CLEAR with PRISM). Each star will be observed through the square aperture slit using a 3-point dither pattern. Exposure times were selected to achieve S/N > 50 per resolution element. The target sample includes all stars in the current JWST primary calibrator list except the target observed in program 6205 and three other stars that would either saturate or are too faint to observe in a reasonable amount of time (a total sample of 8 stars).

CONSTRAINTS:

N/A

PARALLEL Observations possible (yes/no/pure parallel)?

No

COMMENTS:

AUTHOR/DATE: James Muzerolle (muzerol@stsci.edu) / 1 Feb 2012

TITLE: NIRSpec relative throughput

ID: 96207

GOAL:

A star will be observed with all fixed slits, the IFU, and multiple positions over the MSA in order to measure the relative throughput of these apertures with respect to the square aperture.

NOMINAL ALLOCATION (hours): N/A

ACTUAL TIME (hours): 16

TARGET(S):

BD +52-913

OBSERVING TEMPLATE: NIRSpec Fixed Slit Spectroscopy, IFU, MSASPEC

OBSERVATION DETAILS:

Data will be taken with the prism and R~1000 gratings only. A 3-point dither pattern will be used for the fixed slit and MSA observations, and 4-point for the IFU (including spatial and spectral sub-pixel offsets). For the MSA, a 3-shutter slitlet will be opened at eight different positions across the field of view, preferably near the center and near a corner of each quadrant. Exposure times were selected to achieve S/N > 50 per resolution element.

CONSTRAINTS:

All the observations are placed in a group within 1 week constraint to minimize offsets from any time-dependent throughput variations.

PARALLEL Observations possible (yes/no/pure parallel)?

No

COMMENTS:

The observations do not have to be executed contiguously. The total duration was calculated assuming one large slew for each of the 14 observations, which is likely an overestimate since many of them could and should be scheduled within single visits.

AUTHOR/DATE: James Muzerolle (muzerol@stsci.edu) / 1 Feb 2012

TITLE: NIRSpec MSA shutter throughput verification

ID: 96208

GOAL:

One or more stars will be mapped across open MSA slitlets in order to characterize microshutter slit losses as a function of wavelength and offset from the shutter center.

NOMINAL ALLOCATION (hours): N/A

ACTUAL TIME (hours): 9

TARGET(S):

LMC astrometric field

OBSERVING TEMPLATE: NIRSpec MSASPEC

OBSERVATION DETAILS:

The target stars should be bright and reasonably isolated, and preferably known to be non-variable (for the time estimate, a stellar magnitude K=14 was assumed). I adopted the standard 3-shutter slitlet pattern that is expected to be the most common use case. The mapping pattern consists of 5 x 13 positions, with nominal spacing of 0.05" in the dispersion direction and 0.12" in the spatial direction, spanning the entire 3-shutter slitlet. Exposure times are set for S/N~60 when the target is perfectly centered in a shutter (which should correspond to a minimum S/N~15-20 when the target is at the shutter edges). Observations will be taken with all medium-resolution gratings and the prism.

CONSTRAINTS:

N/A

PARALLEL Observations possible (yes/no/pure parallel)?

No

COMMENTS:

I created the mapping pattern in APT using a mosaic with 99.9% overlap. This does not actually give the correct spacing between pointings; in the future, there should be a way to specify offsets in arcseconds.

AUTHOR/DATE:

James Muzerolle (muzerol@stsci.edu) / 2 Feb 2012

TITLE: NIRSpec MSA shutter contrast monitor

ID: 96209

GOAL:

This program will provide periodic measurements of the MSA shutter contrast using internal lamp imaging. Contrast values for each microshutter will be determined by taking the ratio of ALL_OPEN and ALL_CLOSED exposures. Newly failed shutters will also be identified by comparing with the current failed shutter map. The observation will be repeated once per month.

NOMINAL ALLOCATION (hours): N/A

ACTUAL TIME (hours): 6

TARGET(S):

N/A

OBSERVING TEMPLATE: NIRSpec MSASPEC

OBSERVATION DETAILS:

Two exposures will be taken with the internal lamp "TEST" turned on, first with the MSA configured to ALL CLOSED, and then ALL OPEN. Exposure times will be selected to enable measurement of contrast values as high as 10^4, while avoiding saturation in the ALL OPEN case (nominally 950 and 60 seconds, respectively; *TBC*).

CONSTRAINTS:

N/A

PARALLEL Observations possible (yes/no/pure parallel)?

yes

COMMENTS:

Appropriate as an intra-slew parallel. The cadence is notional, and should be taken as a likely upper limit for a typical 1.5-year slice of the mission.

AUTHOR/DATE:

James Muzerolle (muzerol@stsci.edu) / 7 Feb 2012

TITLE: NIRSpec astrometric calibration monitor

ID: 96210

GOAL:

This activity will monitor the plate scale, orientation, geometric distortion across both NIRSpec SCAs, as well as monitor the IFU slice mapping. The observations will be repeated every 3 months.

NOMINAL ALLOCATION (hours): N/A

ACTUAL TIME (hours): 8.5

TARGET(S): N/A

OBSERVING TEMPLATE: NIRSpec IMAGING, IFUSPEC

OBSERVATION DETAILS:

Imaging:

The LMC astrometric calibration field will be imaged with the MSA set to all open, GRATING=MIRROR, FILTER=F140W (**note that there is no template for this currently in APT – I "faked" the observation by using the MOS template with a random grating position**). A 4-point dither pattern with half-shutter offsets (0.1" x 0.22") in the dispersion and spatial directions will be used to minimize systematic centroiding errors caused by vignetting from the MSA bars, as well as improve PSF sampling at short wavelengths. Short exposures will be necessary to minimize saturation, with multiple integrations to improve the S/N of fainter sources (NRSRAPID readout with 3 groups/integration, and 4 integrations per dither position). The narrow target acquisition filter F140W will be used in order to further minimize saturation.

IFU:

An appropriate region of the LMC calibration field will be observed with the IFU using the prism. A 2x2 dither pattern, including a single-slice offset with spectral and spatial sub-pixel offsets, will be used for improved spatial and spectral resolution. To estimate the exposure time I assumed a target brightness K~16 and desired S/N>100; NRSRAPID readout with 12 groups/integration, and 1 integration per dither position should be sufficient.

CONSTRAINTS: N/A

PARALLEL Observations possible (yes/no/pure parallel)? no

COMMENTS:

The cadence is notional, and should be taken as a likely upper limit for a typical 1.5-year slice of the mission. An imaging template is sorely needed, as this type of calibration observation will be fairly frequent during the mission.

AUTHOR/DATE: James Muzerolle (muzerol@stsci.edu) / 16 Feb 2012

TITLE: NIRISS Dark Current and Read-Noise Monitor

ID: 96400

GOAL:

The purpose of this activity is to take dark observations through all read-out patterns and observing modes in order to characterize the read-noise and the dark current. For this activity, one would ideally like to block out all light. The instrument has no way to do this,

but it may be possible to achieve reasonably good light rejection by crossing F140M with F480M.

We will need to determine the dark current for each of the readout patterns, currently envisioned to be NIS and NISRAPID, for both full frame and subarrays. The dark current itself is generally expected to be unimportant as a source of noise. However, dark frames are likely to be the best way to determine the bias-level corrections. Exposure times need to be long enough to cover the range expected for most science exposures.

NOMINAL ALLOCATION (hours):

ACTUAL TIME (hours): 2 hours per week.

TARGET(S):

N/A

OBSERVING TEMPLATE: NIRISS Dark

OBSERVATION DETAILS: We will need to determine the dark current for each of the readout patterns, currently envisioned to be NIS and NISRAPID, for both full frame and subarrays. The dark current itself is generally expected to be unimportant as a source of noise. However, dark frames are likely to be the best way to determine the bias-level corrections. Exposure times need to be long enough to cover the range expected for most science exposures.

For the purposes of the SODRM, we have

CONSTRAINTS:

On set of darks per week for each readout pattern.

PARALLEL Observations possible (yes/no/pure parallel)?

Yes.

COMMENTS:

AUTHOR/DATE:

Harry Ferguson (ferguson@stsci.edu) / 12 February 2012

TITLE: NIRISS Flat Monitor

ID: 96410

GOAL:

This program is designed to acquire the data required to produce a flat field image for each of the broad-band and medium-band ("W" and "M") filters through observations of relatively bright reflection nebulae (the outskirts of Orion, for example). These "sky flats" represent the only full-frame, end-to-end, pixel-to-pixel flat field information for NIRISS in these filters. The total exposure time in each filter is designed to achieve S/N ~ 200 per pixel for observations. Possible strategies for optimizing this might include trailing the observations along one axis, and/or defocusing the telescope, since the major problem with reconstructing the flat from observations is the rapid variation of intensity level in the vicinity of point sources.

For the purposes of the SODRM, we assume dithered observations with no defocussing, and that the flat would be constructed using self-calibration techniques (Fixsen et al. 2000).

NOMINAL ALLOCATION (hours):

ACTUAL TIME (hours): 6 (not counting overheads)

TARGET(S):

Two positions in Orion selected by visual inspection of Massimo Robberto's K-band image. No real attempt to check whether the surface brightness is appropriate.

OBSERVING TEMPLATE: NIRISS Imaging

OBSERVATION DETAILS: For the first iteration, assume 30 minutes of *heavily dithered* exposures per filter on a bright, relatively diffuse source per filter. For 7 wide filters and 5 medium band filters, this sums to 6 hours of observing time, not counting overheads. Repeat for one filter as a check. Guessing that this ends up being about 12 dither positions per filter, which may be a bit on the low side for selfcal. Probably the way to execute the program would be to a short and a long wavelength filter very early in the cycle. Derive the flats and use the lessons learned from that to adjust the rest of the observations. It is unclear if all filters are needed, since one may be able to interpolate in wavelength. Repeat a couple of broadband filters about 6 months after the first set to check for trends.

CONSTRAINTS:

PARALLEL Observations possible (yes/no/pure parallel)? No

COMMENTS:

AUTHOR/DATE:

Harry Ferguson (ferguson@stsci.edu) / 12 February 2012

TITLE: NIRISS Linearity Correction and Persistence Measurement

ID: 96420

GOAL:

The linearity behavior of each NIRISS pixel will be measured during the ground tests. The purpose of this activity is to verify that the linearity behavior has not changed. Darks taken between exposures are used to calibrate persistence and make a trap-density map for the detector.

NOMINAL ALLOCATION (hours):

ACTUAL TIME (hours): 6.5

TARGET(S):

Orion nebula, two positions (eyeballed from a K-band image, but have not checked whether flux levels are appropriate).

05:35:09.977 -05:27:01.15

05:35:06.394 -05:28:39.90

OBSERVING TEMPLATE: NIRISS Imaging

OBSERVATION DETAILS: This activity will use observations of a diffuse nebula (e.g. the outskirts of Orion). Because there could be nonlinearity effects related to persistence, as well as the effects related the pixel capacitance, it would be prudent to do the linearity calibration on fields with different mean fluxes. For example choose a field where the mean sky levels saturate the pixels in 5 minutes, and another where this takes 10 minutes. Repeat each exposure at 5 different dither positions to mitigate the effects of stars and cosmic rays. Take 30 minute darks between each exposure to calibrate persistence.

CONSTRAINTS: This program will leave persistence, so there should be gap before subsequent science observations.

PARALLEL Observations possible (yes/no/pure parallel)? No

COMMENTS:

AUTHOR/DATE: Harry Ferguson (ferguson@stsci.edu) / 12 February 2012

TITLE: NIRISS Wavelength Calibration for Wide-Field Slitless Spectroscopy

ID: 96430

GOAL:

This program is designed to determine the wavelength calibration of the two wide-field grisms as a function of position in the field of view for each of the allowed blocking filters.

NOMINAL ALLOCATION (hours):

ACTUAL TIME (hours): 3

TARGET(S):

M31-363

OBSERVING TEMPLATE: NIRISS Imaging

OBSERVATION DETAILS: Following the approach established by HST/WFC3, an unresolved planetary nebula in M31 (e.g., M31-363) is used to provide a rich emission-line spectrum to characterize the dispersion and line-spread functions of the G150R and G150L grisms.

This implementation consists of repetitions of the following sequence at multiple positions in the field of view:

1. Image the field with F115W+G150R
2. Image the field with F115W+G150L
3. Image the field with F150W+G150L
4. Image the field with F150W+G150R
5. Image the field with F200W+G150R
6. Image the field with F200W+G150L
7. Image the field with F200W+OPEN

For each configuration, a 4-point dither is executed to improve the sampling and mitigate cosmetic blemishes on the detector. The image of the field is obtained last to minimize the effects of persistence. The exposure time / dither is assumed to be short, ~40 s.

Steps 1-7 are repeated (with dithers) in a 3x3 grid across the FOV to determine the wavelength calibration as a function of position.

CONSTRAINTS:

PARALLEL Observations possible (yes/no/pure parallel)? No

COMMENTS: This program might be implemented more efficiently using subarrays.

AUTHOR/DATE: Harry Ferguson (ferguson@stsci.edu) / 12 February 2012

TITLE: NIRISS Wavelength Calibration for Single-Object Slitless Spectroscopy

ID: 96440

GOAL:

This program is designed to determine the wavelength calibration of the cross-dispersed grism.

NOMINAL ALLOCATION (hours):

ACTUAL TIME (hours): 1

TARGET(S):

M31-363

OBSERVING TEMPLATE: NIRISS Imaging

OBSERVATION DETAILS: Following the approach established by HST/WFC3, an unresolved planetary nebula in M31 (e.g., M31-363) is used to provide a rich emission-line spectrum to characterize the dispersion and line-spread functions of the G700XD grism.

The spectroscopic observation is preceded by a target acquisition, which ensures that the wavelength calibrator illuminates the same pixels as "science" targets. The calibrator needs to be quite point- like for the target acquisition procedure to work. The integration time assumed for the target acquisition may need to be increased. It is assumed that a single integration of ~1500 s duration will provide a sufficient number of emission lines in each order. The target is not dithered.

CONSTRAINTS: Should be done early in cycle-1 or during commissioning, since it is a pre-requisite for science from this mode. It should be repeated about 6 months later to verify stability.

PARALLEL Observations possible (yes/no/pure parallel)? No

COMMENTS:

AUTHOR/DATE: Harry Ferguson (ferguson@stsci.edu) / 12 February 2012

TITLE: NIRISS Spectrophotometric Calibration for Wide-Field Slitless Spectroscopy

ID: 96450

GOAL:

This program is designed to determine the spectrophotometric calibration of the G150 grisms combined with each of the filters.

NOMINAL ALLOCATION (hours):

ACTUAL TIME (hours): 4.4

TARGET(S): Selected from JWST-STScI-002540 "JWST Absolute Flux Calibration II":

Hot Stars

Name	RA	DEC	SpType	V	K	New
LDS749B	21 32 16.01	+00 15 14.3	DBQ4	14.73	15.217	N
WD1057+719	11 00 34.31	+71 38 03.3	DA1.2	14.8		Y
WD1657+343	16 58 51.10	+34 18 54.3	DA1	16.1		Y

A Stars

Name	RA	DEC	SpType	V	K	New
1743045	17 43 04.48	+66 55 01.6	A5V	13.5	12.772	Y

G Stars

Name	RA	DEC	SpType	V	K	New
C26202	03 32 32.88	-27 51 48.0	G0-5	16.64		Y
SF1615+001A	16 18 14.23	+00 00 08.4	G0-5	16.75		Y
SNAP-2	16 19 46.13	+55 34 17.7	G0-5	16.2		Y

OBSERVING TEMPLATE: NIRISS WFSS

OBSERVATION DETAILS: This program uses bright, well-characterized standard stars to provide spectrophotometric calibration of the G150L and G150R grisms in combination with each of their blocking filters. The calibration is repeated at 9 positions in the field of view.

This implementation consists of repetitions of the following sequence at multiple positions in the field of view:

1. Image the field with F200W+G150R
2. Image the field with F200W+G150L
3. Image the field with F150W+G150L
4. Image the field with F150W+G150R
5. Image the field with F115W+G150R
6. Image the field with F115W+G150L
7. Image the field with F140M+G150L

8. Image the field with F140M+G150R
9. Image the field with F158M+G150R
10. Image the field with F158M+G150L
11. Image the field with F200W+OPEN

For each configuration, a 4-point dither is executed to improve the sampling and mitigate cosmetic blemishes on the detector. The image of the field is obtained last to minimize the effects of persistence. The exposure time / dither is assumed to be short, ~40 s.

Steps 1-1 are repeated (with dithers) on one of the standard stars in a 3x3 grid across the FOV to evaluate the spectrophotometric calibration as a function of position. For the other stars, just do the central position.

CONSTRAINTS: Should be done early in cycle-1 or during commissioning, since it is a pre-requisite for science from this mode. It should be repeated about 6 months later to verify stability.

PARALLEL Observations possible (yes/no/pure parallel)? No

COMMENTS: This could be made more efficient by defining subarrays for the grid locations.

AUTHOR/DATE: Harry Ferguson (ferguson@stsci.edu) / 12 February 2012

TITLE: NIRISS Spectrophotometric Calibration for Single-Object Slitless Spectroscopy

ID: 96460

GOAL:

This program is designed to determine the spectrophotometric calibration of the NIRISS cross-dispersed grism.

NOMINAL ALLOCATION (hours):

ACTUAL TIME (hours): 1

TARGET(S): Selected from JWST-STScI-002540 "JWST Absolute Flux Calibration II":

Hot Stars

Name	RA	DEC	SpType	V	K	New
HD 60753	07 33 27.32	-50 35 03.3	B3IV	6.68	6.83	Y
G191B2B	05 05 30.62	+52 49 54.0	DA0	11.781	12.764	N

A Stars

Name	RA	DEC	SpType	V	K	New
HD 37725	05 41 54.37	+29 17 50.9	A3V	8.35	7.90	Y
HD 116405	13 22 45.12	+44 42 53.9	A0V	8.34	8.48	Y

G Stars

Name	RA	DEC	SpType	V	K	New
HD 38949	05 48 20.06	-24 27 49.9	G1V	8.0	6.44	Y
P330E	16 31 33.85	+30 08 47.1	G0V	13.01	11.379	N

OBSERVING TEMPLATE: NIRISS SOSS

OBSERVATION DETAILS: This program uses bright, well-characterized standard stars to provide spectrophotometric calibration of the G700XD grism.

The spectroscopic observation is preceded by a target acquisition, which ensures that the spectrophotometric standard illuminates the same pixels as "science" targets. It is assumed that the standard will not saturate the detector during the short integrations required to determine its centroid.

It is assumed that a single integration of ~1000 s duration will provide a spectrum of sufficient quality. The target is not dithered.

Ideally, a small suite of spectrophotometric standards will be observed, to enable long-term trending (through repeated observations of the same standard) and to constrain any large systematic errors associated with the absolute calibration of individual standards, while also "beating down" the statistical uncertainties. For the SODRM, we observe 3 separate standards and repeat one of them.

CONSTRAINTS: Should be done early in cycle-1 or during commissioning, since it is a pre-requisite for science from this mode. It should be repeated about 6 months later to verify stability.

PARALLEL Observations possible (yes/no/pure parallel)? No

COMMENTS:

AUTHOR/DATE: Harry Ferguson (ferguson@stsci.edu) / 12 February 2012

TITLE: NIRISS Astrometry and Distortion Monitor

ID: 96470

GOAL: The purpose of this activity is to determine the plate scale, orientation, and geometric distortion required to transform raw NIRISS images to a distortion-free astronomical frame of reference.

NOMINAL ALLOCATION (hours):

ACTUAL TIME (hours): 1

TARGET(S):

LMC Astrometric reference field

OBSERVING TEMPLATE: NIRISS Imaging

OBSERVATION DETAILS: This will involve observing a standard astrometric field at a set of dithered offsets (~5) through a representative set of filters (~4). The LMC calibration field (R.A = 05:21:57 and Dec = -69:29:51) in JWST's CVZ has been carefully chosen and mapped with HST's ACS to facilitate such a calibration.

The observing sequence is as follows:

1. Images will be obtained through one short-wavelength filter and one long-wavelength filter to check for wavelength- dependent distortion. These are arbitrarily selected to be F200W and F444W, respectively. If a significant dependence on wavelength is found, this program will have to be expanded to determine the separate distortion coefficients for the other filters.
2. A short exposure time is assumed to go sufficiently deep. Integration times per dither of 225 s (F200W) and 118 s (F444W) are assumed.

The observations will be dithered to provide accurate determinations of the locations of the PSFs of the sources. A more elaborate dither pattern is assumed for observations through short-wavelength filters since the PSF is more severely undersampled at these wavelengths. Dither steps will need to be large enough to avoid biasing the astrometry due to persistence, but small enough to accurately subsample the PSF. This could be tricky. It might make sense to insert darks between exposures to mitigate persistence, but this would be costly.

CONSTRAINTS: Should be done early in cycle-1 or during commissioning, since it is a pre-requisite for WFSS spectroscopy. It should be repeated about 6 months later to verify stability.

PARALLEL Observations possible (yes/no/pure parallel)? Possibly, if the field is big enough.

COMMENTS:

AUTHOR/DATE: Harry Ferguson (ferguson@stsci.edu) / 12 February 2012

TITLE: NIRISS L-flat verification and WFSS spectral traces

ID: 96480

GOAL: This is a companion to 6410. That program aims to derive a PFLAT, which characterizes the pixel-to-pixel sensitivity variations on small spatial scales, but might not correctly calibrate sensitivity variations on the scale of the whole field (e.g. due to vignetting), and might be affected by scattered light (as was the case for WFC3). An important cross-check is to verify that the photometry and spectrophotometry of stars is independent of position in the field. This program is aimed at carrying out that verification both for the imaging mode and for WFSS spectrophotometry.

The goal is to use multiple observations of the JWST LMC astrometric field to extract information about the large-scale illumination patterns seen by the NIRISS detector. This is done in broad-band imaging mode and in wide-field sliteless spectroscopy mode. For the latter, the data also provide spectral traces as a function of position on the detector.

NOMINAL ALLOCATION (hours):

ACTUAL TIME (hours): 3.5

TARGET(S):

LMC Astrometric reference field

OBSERVING TEMPLATE: NIRISS Imaging, WFSS

OBSERVATION DETAILS: Obtain images with one short-wavelength filter and one long-wavelength filter to check the wavelength-dependence of the illumination flat. These filters are arbitrarily selected to be F200W and F444W, respectively. Other filters can be investigated subsequently if a significant dependence on wavelength is found. The field is systematically repositioned 9 times in a pattern that is TBD but ensures a significant degree of overlap. At each position, a set of 3 dithered exposures are taken to subsample the PSF. For WFSS, obtain spectra with F115W, and F200W repositioning and dithering as for the imaging exposures. Obtain single exposures in F150W, F140M and F158M, to measure the traces and check for consistency.

CONSTRAINTS: Should be done early in the cycle and repeated annually to monitor changes.

PARALLEL Observations possible (yes/no/pure parallel)? Maybe. Since only relative photometry is needed and the LMC is big, it is possible that one could calibrate multiple instruments in parallel. Although different exposure times & dithering requirements might make this a bit complex.

COMMENTS:

AUTHOR/DATE: Harry Ferguson (ferguson@stsci.edu) / 12 February 2012

TITLE: MIRI Read Noise and Dark Current Monitoring

ID: 96610

GOAL:

These observations will provide a set of dark frames for monitoring the dark current and read noise for all three detectors. These observations will also be used to create the dark calibration reference files. Observations will be needed in FAST and SLOW readout patterns for all three detectors for the full array. For the imager detector, dark observations with all the subarrays in FAST readout pattern only (e.g., MASKLYOT, MASK1065, MASK1140, MASK1550, BRIGHTSKY, SUB256, SUB128, SUB64, and SLITLESSPRISM). Given the expected low dark current signal (nominally 0.03 e/sec/pixel), a total exposure time of 30,000 seconds would yield a dark current signal-to-noise per pixel ~30 (TBC pending FM ground test results). To mitigate negative effects of an uncertain cosmic ray hit rate, individual integrations should be limited to ~1000 seconds. The total exposure time should be the goal for the combination of a number of the monitoring observations. The full-array data will be used to monitor the cosmic ray hit rate and energy flux distribution. These data will also be used to monitor hot and high-noise pixels for updating the bad pixel mask.

The readnoise and dark current for full frame and all subarrays, and for fastmode and slowmode, will be measured using established techniques. Cosmic ray hit rates will be measured, as well as statistics on the amount of charge deposited. Bad pixel maps will also be produced. Repeat measurements will provide a means of monitoring any changes in these characteristics over time. All of the data will be combined to construct the read noise and dark reference files for the calibration pipeline (assuming no temporal variations).

NOMINAL ALLOCATION (hours): N/A

ACTUAL TIME (hours): 312 hours for 1.5 years (all in parallel as these are darks)

TARGET(S):

Internal Dark

OBSERVING TEMPLATES:

MIRI Dark

OBSERVATION DETAILS:

Nominal exposures for full-array observations (all three detectors exposed in parallel) would be:

10 x 111 s (40 frames) FAST

10 x 1110 s (40 frames) SLOW

Nominal exposures for sub-array observations (only the imager detector) would be:

10 x 47.3 s (40 frames) BRIGHTSKY

10 x 18.1 s (40 frames) SUB256

10 x 4.0 s (40 frames) SUB128

10 x 2.6 s (40 frames) SUB64

10 x 12.8 s (40 frames) MASKLYOT

10 x 9.3 s (40 frames) MASK1065

10 x 9.3 s (40 frames) MASK1140

10 x 9.3 s (40 frames) MASK1550

10 x 6.6s (40 frames) SUBPRISM

Full-array FAST observations will take ~1,200 s per week.

Full-array SLOW observations will take ~12,000 s per week.

Subarray FAST observations will take:

BRIGHTSKY: ~500 s per week

SUB256: ~200 s per week

SUB128: ~50 s per week

SUB64: ~30 s per week

MASKLYOT: ~150 s per week

MASK1065: ~100 s per week

MASK1140: ~100 s per week

MASK1550: ~100 s per week

SUBPRISM: ~100 s per week

Total: 4 hours per week (208 hours per year).

Repeated every week.

CONSTRAINTS:

N/A.

PARALLEL Observations possible (yes/no/pure parallel)?

Yes, these are observations taken in parallel as they are darks.

COMMENTS:

The individual integrations do not have to be contiguous, but should be scheduled within a 24 hour period (*TBC*).

AUTHORS/DATE:

Karl Gordon (kgordon@stsci.edu)/10 Feb 2012

TITLE: MIRI Internal Flat Monitor

ID: 96620

GOAL:

Internal flats (pixel flats) will be obtained using the prime lamp filament in both the imager calibration source and the MRS calibration source. Imager flats will be taken through each filter (including the coronagraphic filters), LRS flats with the slit and with the SLITLESSPRIM subarray, and MRS flats will be taken at all three grating positions.

NOMINAL ALLOCATION (hours): N/A

ACTUAL TIME (hours): 92 hours per 1.5 years

TARGET(S):

External flat location (faint background)

OBSERVING TEMPLATES:

MIRI Imaging

MIRI Coronography

MIRI LRS

MIRI MRS

OBSERVATION DETAILS:

Three flats will be obtained for each configuration, all in fastmode. Imager integration times will be 6 seconds for each normal imager filter and F2300C, 12 seconds for F1140C, 18 seconds for F1550C, and 24 seconds for F1065C. The LRS integrations will be 60 seconds. All MRS integration times will be 60 seconds. (Exposure times to be confirmed based on FM ground test data.) Exposures will be obtained at lamp currents settings of medium and high.

The current plan is to take these internal flats without closing the CCC. This requires the telescope to slew to a dark region of the sky (in the CVZ ideally), take background observations with a 5 position dither pattern (5pt_Gaussian_LG, for Imaging; 5pt_Gaussian_SM for coronography, standard 2 pt dither pattern for LRS, and the 4pt MRS pattern), followed by the same set of observations with the internal flat on. To avoid cycling the internal flat lamp, all the background observations for all the filters/ gratings will be taken followed by the internal flat lamp observations.

The imaging internal flats take ~10,000 sec (including the slew to the dark position on the sky).

The coronagraphy internal flats take ~2,300 sec (no new observation slew needed).

The LRS internal flats take ~3,200 sec (no new observation slew needed).

The MRS-IFU internal flats take ~2,800 sec (no new observation slew needed).

The number of filters for the imaging may be reduced if there are no variations in the internal flats with wavelength. Only a subset of the filters/gratings may be monitored monthly, with the full suite only being done once or twice a year.

The slope images will be fit with a low order polynomial to remove the large scale variations (likely caused by the illumination pattern of the lamp). The resulting multiple images per filters will be coadded to improve the S/N. The coadded images will be compared between filters/grating settings to probe the wavelength dependence of the pixel flat. Indications from ground-testing is that there will be no such variations and then the pixel flats from different filters will be coadded to produce super pixel flats for all filters and for all grating settings.

Total: 5.1 hours per month (61 hours per year).

CONSTRAINTS:

N/A.

PARALLEL Observations possible (yes/no/pure parallel)?

No.

COMMENTS:

The observations for all there modes should be done back-to-back to avoid extra observation slews.

AUTHORS/DATE:

Karl Gordon (kgordon@stsci.edu)/10 Feb 2012

TITLE: MIRI External Flat Monitor - Imaging/Coronagraphy

ID: 96630

GOAL:

External flat fields (illumination flats) will be taken to provide the large spatial scale flat fielding for MIRI. Due to the strong telescope emission at MIRI wavelengths, the change in the relative fluxes of point sources when moved around the FOV will be used (the "thousand-points-of-light" technique). The LMC astrometric field will be used for this measurement. In addition to the external flat field, the geometric scale factors and distortion will also be monitored.

NOMINAL ALLOCATION (hours): N/A

ACTUAL TIME (hours): 13.6 hours per 1.5 year.

TARGET(S):

external flat location (faint background)

OBSERVING TEMPLATES:

MIRI Imaging

MIRI Coronography

OBSERVATION DETAILS:

A selection of imaging filters that span the imaging wavelength range and all the coronagrahic filters will be used. It may be possible that there is no wavelength dependence to the Pflats and, if this is the case, the number of filters will be reduced. A 4-point dither pattern will be used. Minimum required exposure times are 12, 30, 900, and 10,000 seconds for F560W, F1280W, F1800W, and F2550W in the imager. For the last two of the filters, the exposure time will be split among the 4 dither positions. For the first two filters, the exposure times are short so 3 integrations of 12 and 30 seconds will be used at each dither position to assure the highest quality data. For the coronagraph, exposure times are around 100 sec (TBR), except for F2300C which is around 1000 sec (TBR) where each exposure will be split into 10 integrations.

The imaging external flats take ~25,000 sec (including the slew to the astrometric field).

The cononagraphic external flats take ~7,600 sec (no observation slew needed).

Total: 9.1 hours per 6 months (18.2 hour per year)

CONSTRAINTS: N/A.

PARALLEL Observations possible (yes/no/pure parallel)? No.

COMMENTS:

AUTHORS/DATE: Karl Gordon (kgordon@stsci.edu)/10 Feb 2012

TITLE: MIRI External Flat Monitor - LRS

ID: 96640

GOAL:

External flat fields (illumination flats) will be taken to provide the large spatial scale flat fielding for MIRI. Due to the strong telescope emission at MIRI wavelengths, the change in the relative fluxes of point sources when moved around the FOV will be used (the "thousand-points-of-light" technique). In addition to the external flat field, the geometric scale factors and distortion will also be monitored.

The flux for the star will be measured and how they vary between dither positions will provide the large spatial scale flat field (Lflat). The SLITLESSPRISM Lflat (no dithering allowed) will be determined directly from the absolute flux calibration observations.

NOMINAL ALLOCATION (hours): N/A

ACTUAL TIME (hours): 3 hours per 1.5 year.

TARGET(S):

Flux standard star.

OBSERVING TEMPLATES:

MIRI LRS

OBSERVATION DETAILS:

For the LRS observations, the integration time will be selected to provide one very bright star that will take a minimum exposure time. This star will be one of the absolute flux calibration stars. Selecting one that gives 100,000 counts/pixel in 10 fastmode frames at 5 microns will give approximately 3700 counts/pixel at 15 microns, due to the Rayleigh-Jeans spectral distribution of the star and the slit losses at the longer wavelengths. This is sufficient in a single exposure to get a 50 S/N at all relevant wavelengths.

The star will be dithered at 10 positions along the LRS slit.

The LRS external flats take ~3,500 sec (including a new observation slew).

Total: 1 hour per 6 months (2 hours per year).

CONSTRAINTS:

N/A.

PARALLEL Observations possible (yes/no/pure parallel)?

No.

COMMENTS:

The observations for all there modes should be done back-to-back to avoid extra observation slews.

AUTHORS/DATE:

Karl Gordon (kgordon@stsci.edu)/10 Feb 2012

TITLE: MIRI External Flat Monitor - MRS

ID: 96650

GOAL:

External flat fields (illumination flats) will be taken to provide the large spatial scale flat fielding for MIRI. Due to the strong telescope emission at MIRI wavelengths, the change in the relative fluxes of point sources when moved around the FOV will be used (the "thousand-points-of-light" technique). In addition to the external flat field, the geometric scale factors and distortion will also be monitored.

The flux for the star will be measured and how they vary between dither positions will provide the large spatial scale flat field (Lflat).

NOMINAL ALLOCATION (hours): N/A

ACTUAL TIME (hours): 18.3 hours per 1.5 year.

TARGET(S): Flux standard star.

OBSERVING TEMPLATES: MIRI MRS

OBSERVATION DETAILS:

For the MRS observations the integration time will be selected to provide one very bright star that will take a minimum exposure time. This star may be in the LMC astrometric field or may be one of the absolute flux calibration stars. For planning purposes, the star will be assumed to be bright enough to obtain a S/N of 50 in less than 30 sec and not located in the astrometric field. This may require different stars to be used for different grating settings or, if not possible, then a longer exposure time to obtain good S/N observations at the longer wavelengths. The star will be dithered in a 10x10 grid around the MRS field-of-view of the largest (longest wavelength) IFU. This will be repeated for each of the 3 possible grating settings.

The derived Lflat will be compared to that derived in the ground-testing. The lflat derived during the ground-testing (i.e. FM test) should be used if it agrees with the on-orbit lflat as it is a higher S/N measurement. The MRS external flats take ~22,000 sec (including a new observation slew). Total: 6.1 hours per 6 months (12.2 hours per year).

CONSTRAINTS: N/A.

PARALLEL Observations possible (yes/no/pure parallel)? No.

COMMENTS:

AUTHORS/DATE: Karl Gordon (kgordon@stsci.edu)/10 Feb 2012

TITLE: MIRI Absolute Flux Calibration - Imaging

ID: 96660

GOAL:

Observe one of the JWST photometric standards through each of the 9 imaging filters . This will be done done once a month to build up the necessary 12 different standard stars (4 each in the hot stars, A-type stars, and G-type stars categories) to ensure that the contribution of the flux calibration uncertainty is below the value in the allocated error budget. The target S/N is 200 to allow for nominal 0.5% measurements to be obtained. The exposures times have been estimated to be 200 sec on average using the plots presented by Gordon & Bohlin (2011, JWST-STScI-002450). Given the different sensitivity ranges between the shortest and longest wavelength filters, it is estimated that 2 different stars will be needed to cover all the filters each time this measurement is executed. The large 5 Gaussian point dither pattern will be used for each filter (TBR).

Repeat every month.

The fluxes of each star will be measured and compared to the predicted fluxes. The average of the ratios of these two numbers for all the stars provides the absolute flux calibration.

NOMINAL ALLOCATION (hours): N/A

ACTUAL TIME (hours): 56 hours per 1.5 year.

TARGET(S):

Flux standard star.

OBSERVING TEMPLATES:

MIRI Imaging

OBSERVATION DETAILS:

Each execution of this measurement will take ~11,000 sec (including two observation slews).

Total: 3.1 hours per month (37.2 hours per year).

CONSTRAINTS:

N/A.

PARALLEL Observations possible (yes/no/pure parallel)?

No.

COMMENTS:

AUTHORS/DATE: Karl Gordon (kgordon@stsci.edu)/10 Feb 2012

TITLE: MIRI Absolute Flux Calibration – Coronagraphy

ID: 96670

GOAL:

Observe one of the JWST photometric standards through each of the 4 coronagraphic filters. This will be done done once a month to build up the necessary 12 different standard stars (4 each in the hot stars, A-type stars, and G-type stars categories) to ensure that the contribution of the flux calibration uncertainty is below the value in the allocated error budget. The target S/N is 200 to allow for nominal 0.5% measurements to be obtained. The exposures times have been estimated to be 200 sec on average using the plots presented by Gordon & Bohlin (2011, JWST-STScI-002450). Only 1 star per execution is needed given the relative similarity of the sensitivities for all 4 coronagraphs. The star will be placed in each quadrant of each coronagraph, requiring an engineering template as no dithering is allowed in the MIRI coronagraphy observing template.

Repeat every month

The fluxes of each star will be measured and compared to the predicted fluxes. The average of the ratios of these two numbers for all the stars provides the absolute flux calibration.

NOMINAL ALLOCATION (hours): N/A

ACTUAL TIME (hours): 15 hours per 1.5 year.

TARGET(S):

Flux standard star.

OBSERVING TEMPLATES:

MIRI Coronagraphy

OBSERVATION DETAILS:

Each execution of this measurement will take ~9,000 sec (including two observation slews).

Total: 2.5 hours per month (30 hours per year).

CONSTRAINTS:

N/A.

PARALLEL Observations possible (yes/no/pure parallel)?

No.

COMMENTS:

AUTHORS/DATE: Karl Gordon (kgordon@stsci.edu)/10 Feb 2012

TITLE: MIRI Absolute Flux Calibration – LRS

ID: 96680

GOAL:

Observe one of the JWST photometric standards through LRS slit and at the SLITLESSPRISM subarray location. This will be done done once a month to build up the necessary 12 different standard stars (4 each in the hot stars, A-type stars, and G-type stars categories) to ensure that the contribution of the flux calibration uncertainty is below the value in the allocated error budget. The target S/N is 50 per resolution element to allow for nominal 0.5% measurements to be obtained. The exposures times have been estimated to be 500 sec on average using the plots presented by Gordon & Bohlin (2011, JWST-STScI-002450). The star will be placed in each the two standard dither positions in the LRS slit and only in one position for the SLISTLESSPRISM subrarry.

Repeat every month

The fluxes of each star will be measured as a function of wavelength and compared to the predicted fluxes. The average of the ratios of these two numbers for all the stars provides the absolute flux calibration as a function of wavelength.

NOMINAL ALLOCATION (hours): N/A

ACTUAL TIME (hours): 27 hours per 1.5 year.

TARGET(S):

Flux standard star.

OBSERVING TEMPLATES:

MIRI LRS

OBSERVATION DETAILS:

Each execution of this measurement will take ~5,200 sec (including one observation slew).

Total: 1.5 hours per month (18 hours per year).

CONSTRAINTS:

N/A.

PARALLEL Observations possible (yes/no/pure parallel)?

No.

COMMENTS:

AUTHORS/DATE: Karl Gordon (kgordon@stsci.edu)/10 Feb 2012

TITLE: MIRI Absolute Flux Calibration – MRS

ID: 96690

GOAL:

Observe one of the JWST photometric standards with the MRS IFU. This will be done done once a month to build up the necessary 12 different standard stars (4 each in the hot stars, A-type stars, and G-type stars categories) to ensure that the contribution of the flux calibration uncertainty is below the value in the allocated error budget. The target S/N is 50 per resolution element to allow for nominal 0.5% measurements to be obtained. The exposures times have been estimated to be 500 sec on average using the plots presented by Gordon & Bohlin (2011, JWST-STScI-002450). The star will be placed in each of the 4 standard dither positions. All 3 grating positions will be observed.

Repeat every month

The fluxes of each star will be measured as a function of wavelength and compared to the predicted fluxes. The average of the ratios of these two numbers for all the stars provides the absolute flux calibration as a function of wavelength.

NOMINAL ALLOCATION (hours): N/A

ACTUAL TIME (hours): 27 hours per 1.5 year.

TARGET(S):

Flux standard star.

OBSERVING TEMPLATES:

MIRI LRS

OBSERVATION DETAILS:

Each execution of this measurement will take ~5,200 sec (including two observation slews).

Total: 1.5 hours per month (18 hours per year).

CONSTRAINTS:

N/A.

PARALLEL Observations possible (yes/no/pure parallel)?

No.

COMMENTS:

AUTHORS/DATE: Karl Gordon (kgordon@stsci.edu)/10 Feb 2012

Observatory Calibration Programs

TITLE: Wavefront Sensing and Control Routine Maintenance

ID: 97010

GOAL: Maintain JWST's wavefront quality by sensing every two days and correcting as needed.

NOMINAL ALLOCATION (hours): 2.26% of mission = 198 hrs/year

Previous estimates are 1.49% of total mission time for WFS, with an additional 0.77% of total mission time for WF Control. (~50 min for WFS every 2 days, 3 hrs for WFSC every 2 weeks)

ACTUAL TIME (hours): 2.45% of mission = 214 hrs/year

Essentially identical to the nominal allocation.

Based on spreadsheet calculations using JWST Overheads report (from scratch, not relying on previous time estimates), I now estimate 45 min for WFS, 2.9 hours for WFSC. This is increased slightly by also including the more in-depth multifield monitor program 7011 but that's a negligible increase since it only happens twice per year.

Those times assume a target slew of only 900s, justified by the fact that we provide a grid of WFS stars every 10 degrees over the whole sky so (except for some regions of the galactic plane) we never have to slew more than 10 degrees. Since this program is itself an observatory overhead, we do not include any additional statistical overheads here. That is, the 45 minutes and 2.9 hours represent the current best guess at the execution time for the actual observations only.

(note the above 2.45% total includes the 0.25% split out into program 7011 as well)

TARGET(S):

~400 isolated 9th magnitude stars, spaced as evenly as possible over the sky subject to crowding limitations in the galactic plane. Taken from Anderson 2009, STScI-TR-001558, Target Stars for Routine WFS.

OBSERVING TEMPLATE:

NIRCam Imaging.

APT does not yet support the custom template that will be used for WFS&C visits. This is thus an attempt to mock up a reasonable facsimile using the available imaging template. This does not get the details of the observation exactly write (uses wrong filter positions and dither pattern), but does have the right number and duration of exposures and the correct number of mechanism moves.

OBSERVATION DETAILS:

This proposal implements the routine wavefront sensing (WFS) necessary to periodically control JWST's primary mirror to maintain good optical performance. Using NIRCam, every two days we observe a target star using the weak lenses to obtain phase diversity.

In reality, a WFS observing sequence will make use of the weak lenses in the NIRCam short wave channels, along with the F212N filter. Since APT does not support these, we mock up a set of observations switching between the F212N and F187N filters (so the number of wheel mechanism motions will be approximately correct.). Likewise, APT will use a custom 5-pixel dither step, which for current purposes is adequately approximated as a 2 position subpixel dither.

Exposure parameters (SHALLOW2, NGROUPS=6) taken from WFSCOWG PIF 27. The last exposure in RAPID should actually use the SUBW1A 512x512 subarray, but the imaging template does not allow different subarrays for the various filters.

CONSTRAINTS:

TIMING: One observation should be selected for execution roughly every two days (48 +- 12 hours). See comments below.

PARALLEL Observations possible (yes/no/pure parallel)?

No.

COMMENTS:

This program is a unique case in many regards.

One unique aspect of this program is the selection of target stars. We provide a list of several hundred acceptable targets distributed over the sky, and whenever a WFS visit is needed the scheduling system should choose the closest acceptable target to wherever the OTE happens to be pointing then. See Henry & van der Marel, JWST-STScI-0001816. The use of a given target for one WFS visit does not preclude its being used again for subsequent visits at another time. Following the discussion in Henry & van der Marel, we simply provide 10 duplicate visits for each science target. Thus this program has ~4000 visits, but we expect only 180 will actually be executed over the course of a year.

As noted above, the every-two-day nominal cadence has considerable flexibility. Planners should be free to move an individual WFS visit ahead or back by up to 12 hours (i.e. gaps of 36-60 hours between visits are acceptable) so long as the overall average cadence remains roughly once every two days.

Every few weeks we will have to correct the mirror positions. Those visits take longer as noted above: 3 hours versus 45 min for sensing alone. To mock this up approximately for the SODRM, we suggest planners could, once every two weeks, schedule 4 WFS visits from this proposal back-to-back on the same target. If higher fidelity is desired, the Telescopes group would be happy to create another set of longer visits that mock up the WFSC process with a bit higher fidelity.

Every six months we will supplement Routine WFS with the longer Multifield Monitor WFS visits, described in a separate proposal. On occasions when a Multifield Monitor WFS visit is scheduled, that serves in place of a Routine WFS visit for that instance of the two day cadence. See program 7011.

For the sake of simplicity in the SODRM, let’s assume that Multifield Monitor WFS visits will never also be a correction visit.

AUTHOR/DATE: Marshall Perrin, Jay Anderson, Rémi Soummer, Roeland van der Marel

2011-12-01

TITLE: Wavefront Sensing and Control Multi Field Monitor

ID: 97011 This is a related program to 7010; read the docs on 7010 first.

GOAL: Maintain JWST's wavefront quality over a wide field by sensing at many field points

NOMINAL ALLOCATION (hours):

None, but implicitly included in the 2.26% allocated to wavefront sensing and control.

ACTUAL TIME (hours): 23 hrs/yr = 0.25% of total telescope time

Based on spreadsheet calculations using JWST Overheads report (from scratch, not relying on previous time estimates), I estimate 11.5 hours to perform wavefront sensing at 10 field points (rather than the typical 1) and using 5 defocus settings (rather than the typical 2) plus in-focus imaging.

We currently are contemplating doing this process twice per year, hence a total of 23 hours/year or 0.25% of the total telescope time in a year.

TARGET(S):

Same as 7010: ~400 isolated 9th magnitude stars, spaced as evenly as possible over the sky subject to crowding limitations in the galactic plane. Taken from Anderson 2009, STScI-TR-001558, Target Stars for Routine WFS.

OBSERVING TEMPLATE:

Same as 7010: NIRCam Imaging.

APT does not yet support the custom template that will be used for WFS&C visits. This is thus an attempt to mock up a reasonable facsimile using the available imaging template. This does not get the details of the observation exactly write (uses wrong filter positions and dither pattern), but does have the right number and duration of exposures and the correct number of mechanism moves.

OBSERVATION DETAILS:

Routine wavefront sensing for JWST occurs every two days, but only at a single field point nominally in NIRCam A. With only one field point, there are certain degeneracies in mirror position that cannot be sensed well. Multi field wavefront sensing is necessary to break these degeneracies and allow accurate determination of the position of the PM+SM Cassegrain telescope as a whole. While there is a detailed plan for multifield sensing during commissioning, planning for multifield maintenance is less advanced. For the sake of the SODRM we will notionally adopt a schedule of multi-field sensing every 6 months.

The targets and observing sequence are identical to what is used for WFSC Routine Maintenance, with the exception that the target is observed at all 5 WFSC field points in each NIRCam module for a total of 10 positions. Furthermore, we expand the sensing observations to use the full suite of weak lenses (+-4, +-8, +12) instead of just the +-8 used during routine monitoring.

For multi field monitor, in reality we will observe the target at 5 different positions that will be defined as SIAF apertures, repeated for both modules. For SODRM purposes, we mock this up as a 2-column mosaic with 5 primary dither positions for each mosaic tile. As in Routine Monitor, exposures are taken in pairs dithered by a few pixels.

CONSTRAINTS:

TIMING: One multifield monitor observing sequence should be scheduled roughly every six months.

PARALLEL Observations possible (yes/no/pure parallel)?

No.

COMMENTS:

See the WFSC Routine Maintenance program for discussion of target stars. We provide here ~400 available observation requests, one for each WFSC target star. Schedulers may draw from that list whichever target is most convenient when this program needs to execute, as discussed in Henry & van der Marel, JWST-STScI-0001816. For a nominal 6 month cadence, thus we expect only 3 of these observations to execute during the SODRM's 1.5 year period.

For the sake of simplicity in the SODRM, let's assume that a Multifield Monitor WFS visit will never also be a correction visit.

On occasions when a Multi Field Monitor visit is scheduled, that serves in place of a Routine WFS visit for that instance of the two day cadence.

AUTHOR/DATE: Marshall Perrin, Jay Anderson, Rémi Soummer, Roeland van der Marel

2011-12-01