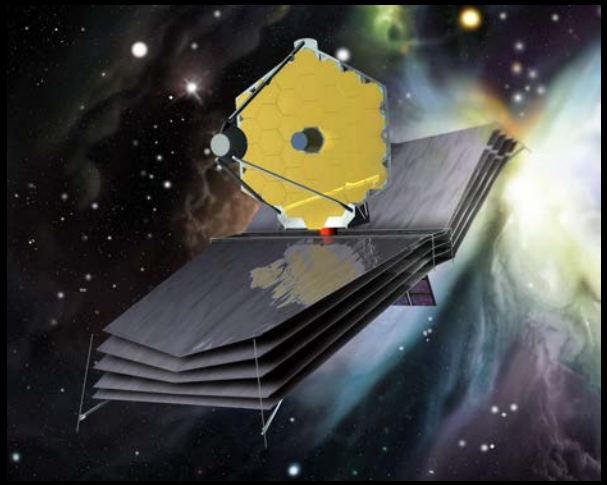
Long-term Variability Monitoring Strategies for HST and JWST

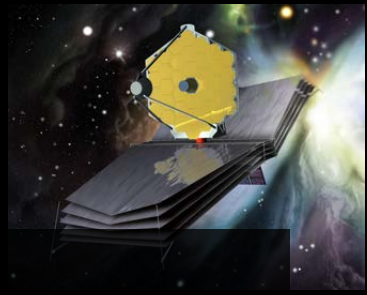
Report to JSTUC
March 19, 2024



50 years

Seeking community input on key science areas that exploit long time-baseline observations.

Long-Term Variability Monitoring Strategies for HST and JWST



Working Group membership

Co-chairs: Dana Casetti (Southern Connecticut State University) and Saurabh Jha (Rutgers University)

Members: Gary Bernstein (UPenn), Matt Hayes (Stockholm), Lidia Oskinova (Potsdam), Andrew Pace (Carnegie Mellon), Robert Quimby (San Diego State), Megan Reiter (Rice), Armin Rest (STScI), Adam Riess (JHU/STScI), David Sand (Arizona), Dan Weisz (Berkeley)

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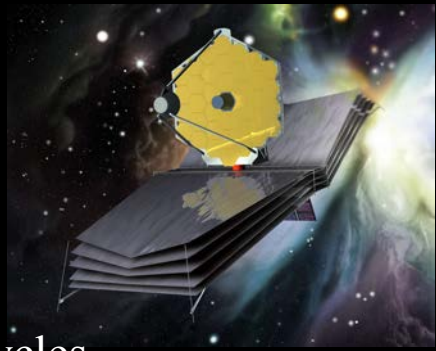
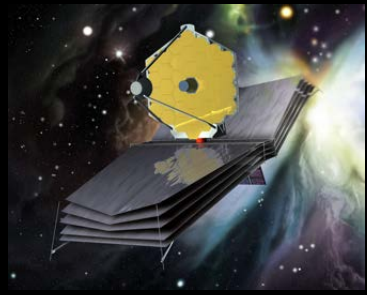


"Variability" includes photometry, spectroscopy, or astrometric motion;
"Long-Term" refers to observations incompatible with standard proposal cycles

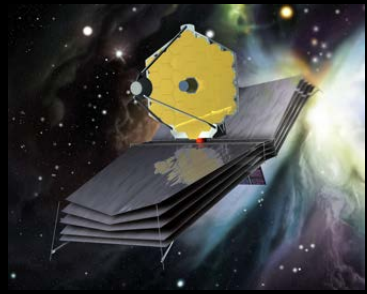
Charter: collect community input, identify key science themes, and make recommendations for HST/JWST LTVM programs and a JWST DDT program for high-redshift transients

Timeline



- June 15, 2023: call for community input released
- August 17, 2023: virtual town hall
- September 8, 2023: due date for community input via survey form or short contributions
- December 2023: presentation to STUC/JSTUC meeting PDF
- January 2024: sent preliminary recommendations to STScI Director
- March 2024: working group will present final report
- Working group is *advisory* to STScI Director,
  who will make final decisions on implementation, etc.

Working Group Recommendations: LTVM



Based on the input we received, it is clear
there is strong community interest in this science.

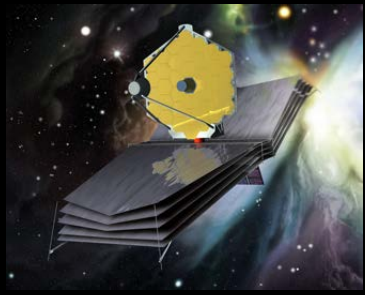
1. Our primary recommendation is that long-term science should be enabled and prioritized for HST and JWST.

The current proposal process does not adequately enable this science for observations that need longer than a three cycle time baseline

- double (or multiple) jeopardy having to get proposals approved by different panels
- science return of “first epoch” observations is limited compared to other proposals promising immediate results

2. We recommend consideration of whether the three cycle limit for multicycle observations in a single proposal should be extended. The limit should be determined with a scientific rationale.
hereafter “long-term” = longer than what can be done in one proposal

Working Group Recommendations: LTVM



Two main categories of long-term programs: regular monitoring observations over a long time baseline and widely separated observation epochs (e.g., proper motion measurements). We aim to accommodate both.

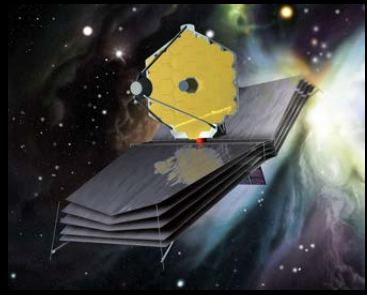
3. We recommend identifying Long-Term Programs through an APT checkbox.
Checking this box should require information to be supplied in “Special Requirements”, including details of the future observations.

4. We recommend that Long-Term Programs be assigned to a separate panel in the proposal review.
This panel will require expertise in a wide range of science, but can be attuned to the specific issues of Long-Term Programs. The panel should be instructed how to judge the proposed science and technical aspects of the overall program, rather than just the near-term observations.

5. We recommend consideration of a pool of observing time for Long-Term Programs.
This pool can be used for subsequent epochs in approved programs.

6. We recommend establishing a mechanism to review progress for Long-Term Programs and suggest changes if necessary.
This would allow monitoring programs to proceed without repeatedly requiring panel review, but also allow for programs to be stopped or modified if circumstances change.

Working Group Recommendations: LTVM

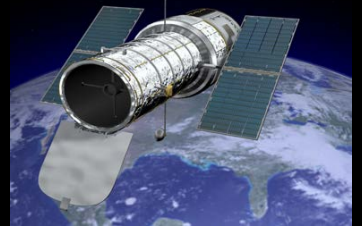


Issues for further consideration: coordination of Long-Term Programs with other observatories, accounting for the time allocated to future epochs, proprietary periods for Long-Term Programs, funding allocations for Long-Term Programs, follow-up of discoveries from monitoring programs, and changing proposers, multiple teams, or duplicated targets in Long-Term programs.

Separately from GO Long-Term Programs that can go through the regular proposal process, we note that we are at the beginning of an expected long life for JWST and this provides an important opportunity for a concerted effort (larger than can be expected for individual proposals) to acquire early data for long-term studies:

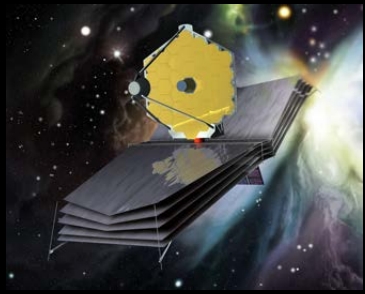
7. To establish JWST legacy observations with the longest time baseline, we recommend a community process to identify highest-priority fields that should be observed with JWST as soon as feasible.

As an example, we anticipate observations could be for first-epoch astrometry of selected fields (e.g., nearby galaxies), with significant ancillary science, which could be followed up with JWST, or future facilities (e.g,. Habitable Worlds Observatory), on timescales of decades. We recommend either Director's Discretionary Time or a call for Treasury proposals to obtain these data.



Contemporaneous HST observations may allow tying JWST astrometry to past HST astrometry. The astrometric calibration of JWST should be monitored and prioritized throughout its operation. These data should have legacy value for future observatories beyond HST and JWST.

JWST DDT program for high-redshift transients



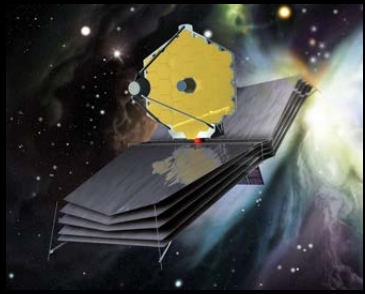
- A key mission success science goal for JWST is to observe the first generation of stars and galaxies: discovering a Pop III supernova would achieve this and is something only JWST can do
  - but there are major uncertainties in the properties and rates of Pop III SN

- Aim to design a program that is capable of detecting Pop III SN if they are common enough, that also should detect many kinds of high-redshift ($z > 2$) transients

  - Hubble diagram with tens of SN Ia from $z > 2$ out to $z \sim 5$ (+ further if they exist)

  - have a goal of finding some very high redshift transients
    - $z > 6$ CCSN (rates track changes in IMF; spectra can track changing metallicity)
    - variable AGN at $z > 7$ to determine SMBH seeding mechanism
    - rarer transients: SLSN out to $z \sim 10$; TDE at $z > 5$

Working Group Recommendations: JWST DDT



8. Our highest priority recommendation is cadenced NIRCam imaging of fields in the JWST CVZ.

The CVZ allows for search and follow-up observations at any time. Fields near the NEP can leverage existing programs (e.g., PEARLS Time Domain Field), but SEP could also be considered. These fields will become new benchmark deep fields for multiwavelength study.

Reach 28th mag 5σ depth per epoch in three or four filters (F150W, F200W, F277W, F444W).
Cover a total area of approximately ~0.1 deg^2.
Image full area twice a year, with dynamically chosen subset (with most interesting transients) imaged four times a year. Coadd images to get highest-redshift, slowly-evolving transients.

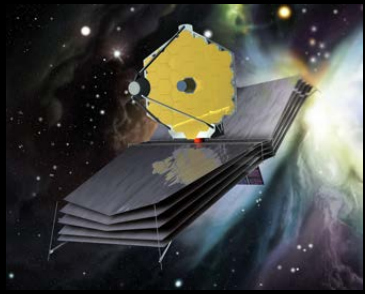
Recommend at least three years of observations, with subset of area observed for five years, and a total investment of **260 hours** for these fields.

9. We also recommend re-observation of the COSMOS-Web extragalactic deep field.

Leverages unmatched pre-existing wide-field NIRCam imaging as templates.

Recommend two epochs over one year (at start of the observing windows) to identify long-timescale transients. Make use of extant multiwavelength data and host redshifts to identify most exciting transients. Recommend **100 hours** to observe ~0.1 deg^2 with best existing coverage.

Working Group Recommendations: JWST DDT



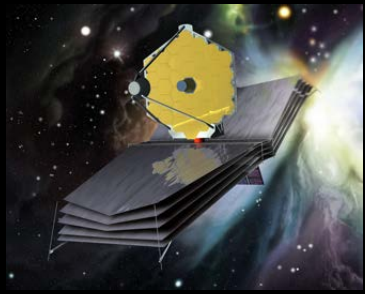
10. We recommend ~twice-yearly NIRCam imaging for three+ years of one or more cluster lenses most favorable for very high redshift transients.
Recommend **40 hours** for these observations.

11. At high priority we recommend approximately 100 hours be reserved for follow-up of exciting high-redshift transients.
Targets do not necessarily have to be from this program; any high-redshift transients could qualify. Follow-up could include higher cadence imaging, different imaging filters, or spectroscopy.

Requests to use this pool should be open to all. Recommend a standing committee (including STScI staff and community representatives) to help review requests with an open, transparent process.

This should not preclude normal DDT or GO proposals for high-redshift transients. Indeed, we encourage the design of the survey to enable additional proposals for related and ancillary science. We suggest that GO programs that leverage the public survey data with observations that would be useful for further transient discovery or characterization in these fields waive any proprietary period.

Working Group Recommendations: JWST DDT



12. We recommend parallel observations for all of the survey data.
For the CVZ prime NIRCam imaging, we recommend parallel NIRISS imaging to increase sky area for transient discovery.

For the COSMOS prime NIRCam imaging, we recommend parallel NIRSpec spectroscopy of interesting (e.g., high-redshift) targets found in the extant imaging.

Lensing cluster prime NIRCam imaging could be complemented with either parallel NIRISS imaging or NIRSpec spectroscopy.

We recommend STScI explore the possibility of using more than two JWST instruments simultaneously. The more sky area that can be imaged, the better. Even the FGS might provide useful science data.

13. HST observations could also be valuable.
We especially recommend HST UV and optical imaging of the JWST CVZ survey fields as well as HST follow-up of discovered objects to discriminate lower-redshift transients.

14. We recommend establishing an implementation team at STScI for the survey.
The observing plan should be broadly announced and the community should be encouraged to share discoveries and follow-up plans. STScI should also allocate resources (people, computation, etc.) to create infrastructure to interface with the survey, including data searching, storage, and delivery of high-level science products (images, coadds, subtractions, transient alerts, catalogs, etc.) to the community in a structured and easy-access way.