



**STScI** | SPACE TELESCOPE  
SCIENCE INSTITUTE

EXPANDING THE FRONTIERS OF SPACE ASTRONOMY

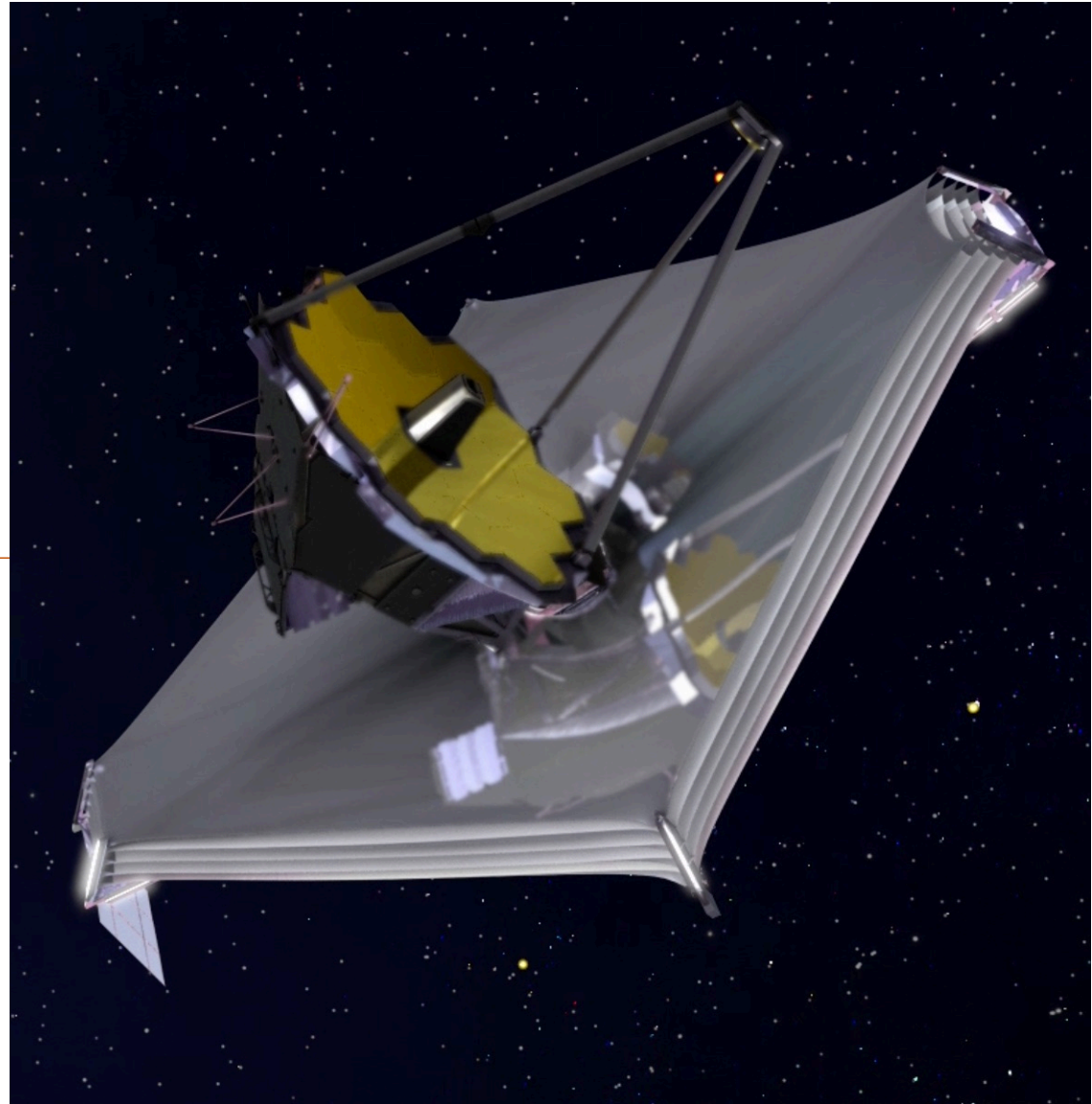
# **JWST Cycle 1 Capabilities**

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2017 Sep 14

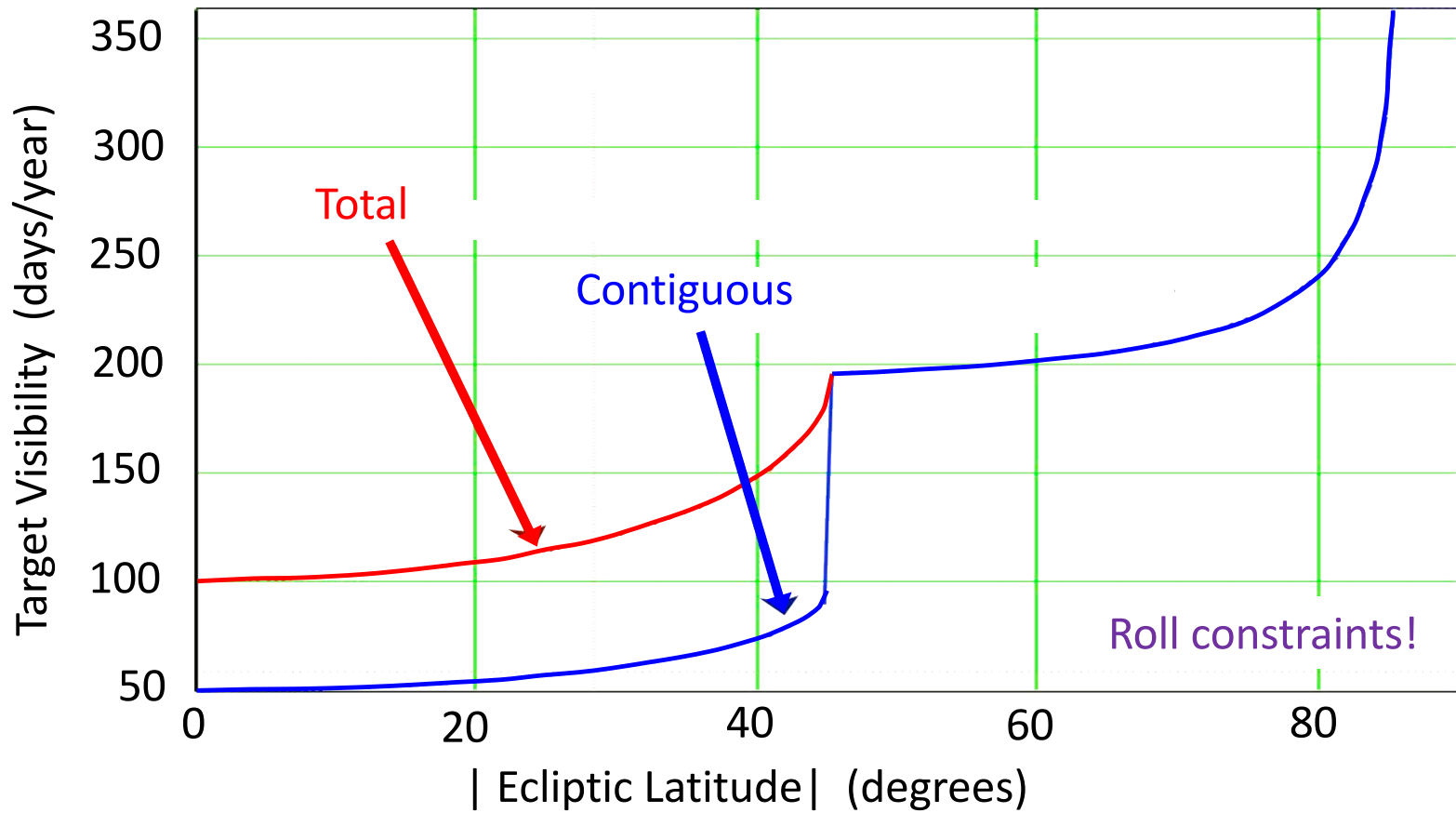
# Observatory

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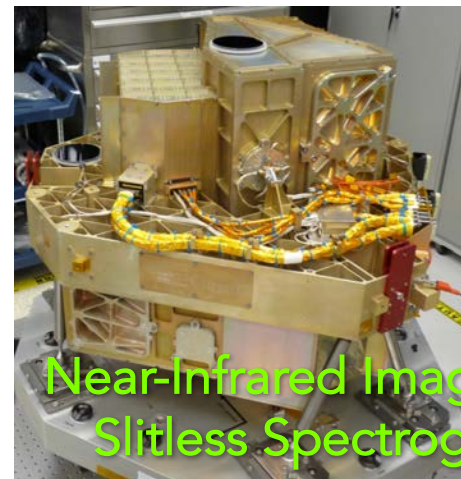


## Days per year a target is visible





## Four science instruments



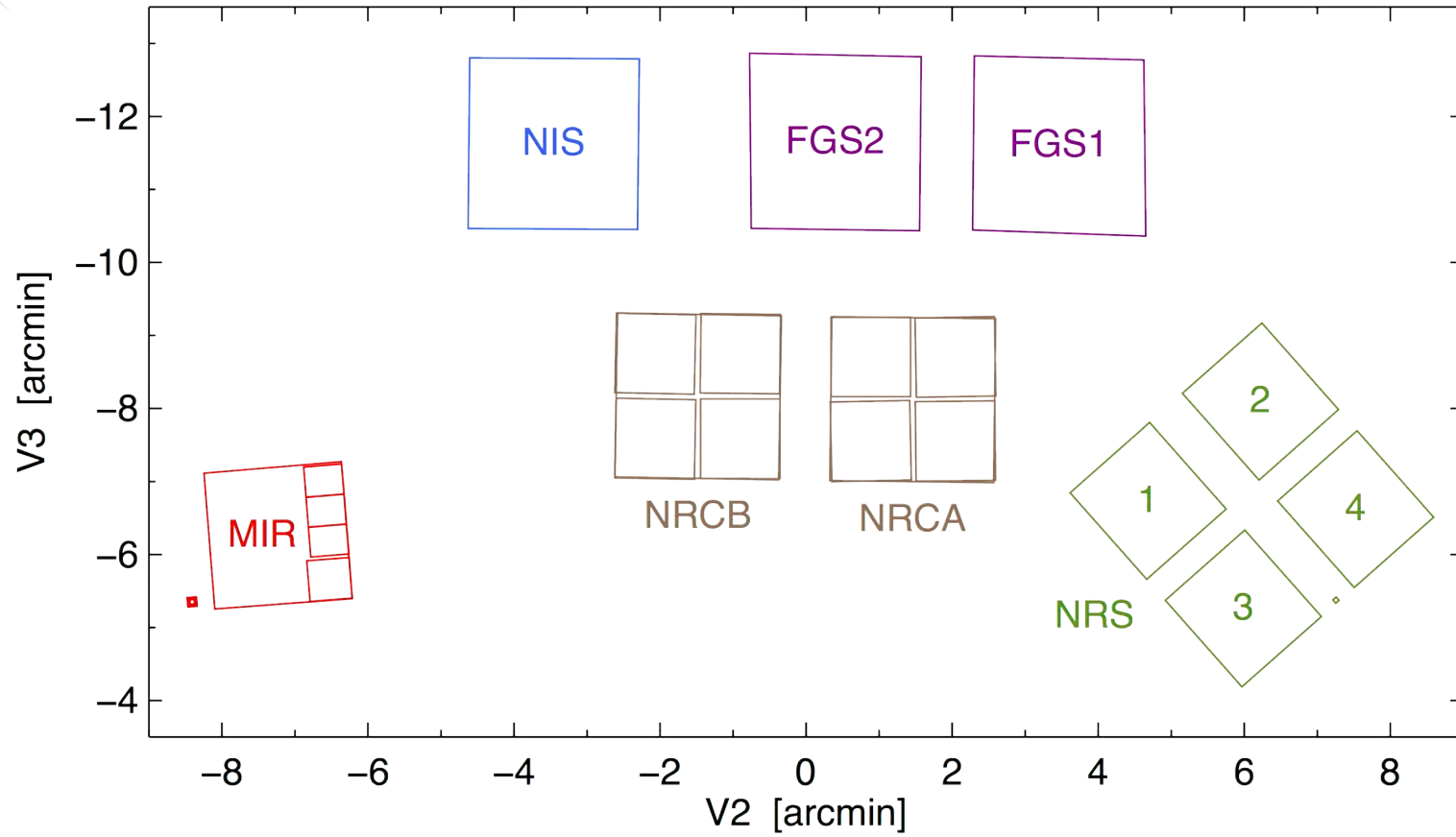


## Imaging modes

Mode	Instrument	Wavelength (micron)	Pixel Scale (arcsec)	Field of View
Imaging	NIRCam	0.6-2.3	0.032	2.2x4.4'
		2.4-5.0	0.065	2.2x4.4'
	NIRISS	0.9-5.0	0.065	2.2x2.2'
	MIRI	5.0-28	0.11	1.2x1.9'
Coronagraphy	NIRCam	0.6-2.3	0.032	20x20"
		2.4-5.0	0.065	20x20"
	MIRI	10.65	0.11	4Q: 24x24"
		11.4	0.11	4Q: 24x24"
		15.5	0.11	4Q: 24x24"
		23	0.11	Lyot: 30x30"
Aperture Mask Interferometry	NIRISS	3.8-4.8	0.065	2.2x2.2'



# Field of view



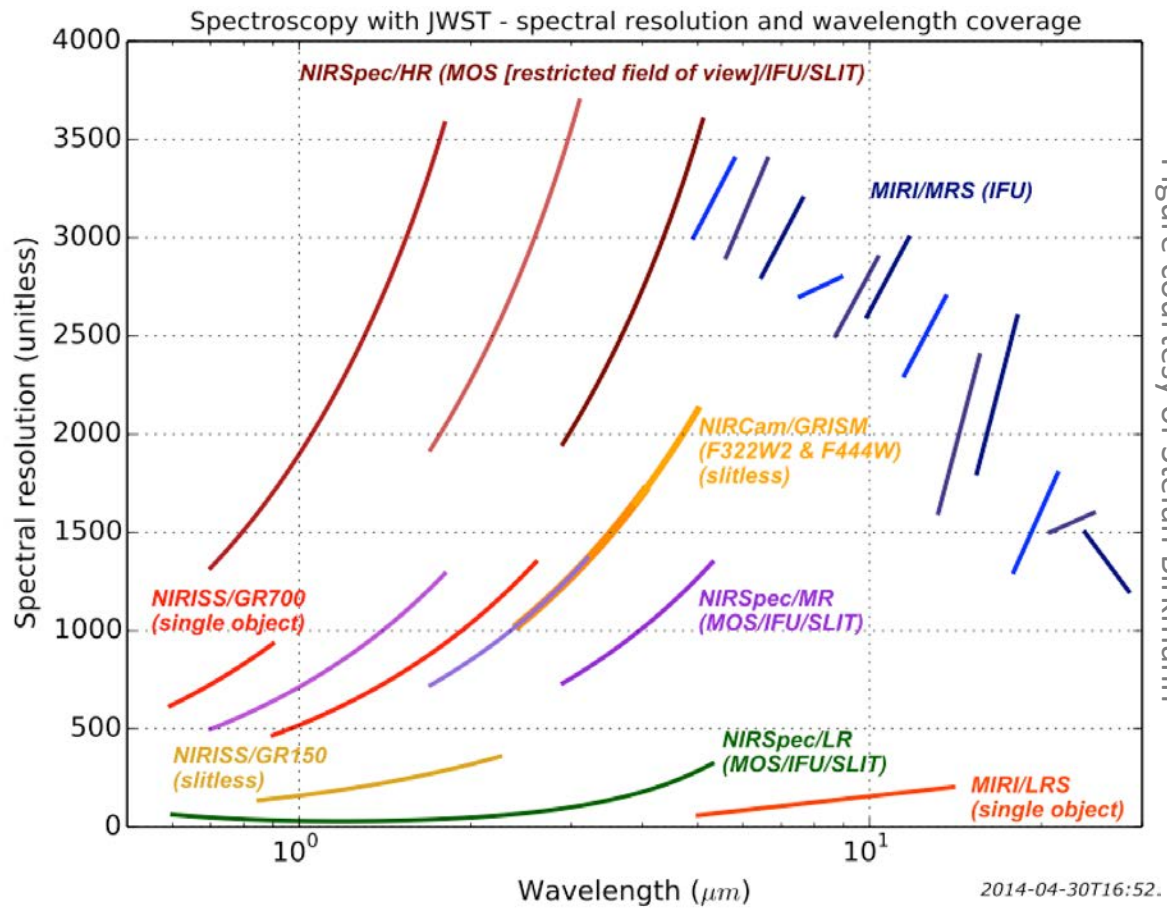


## Spectroscopy modes

Mode	Instrument	Wavelength (micron)	Resolution ( $R=\lambda/\Delta\lambda$ )	Field of View
Slit Spectroscopy	NIRSpec	0.6-5.0	100, 1000, 2700	0.4x3.8" 0.2x3.3" 1.6x1.6"
	MIRI	5.0-12.0	100	0.6x5.5" slit
Multi-Object Spectroscopy	NIRSpec	0.6-5.0	100, 1000, 2700	3.4x3.4' 0.2x0.5" shutters
Slitless Spectroscopy	NIRISS	1.0-2.5	150	2.2x2.2'
		0.6-2.5	700	single object
Integral Field Unit Spectroscopy	NIRCam	2.4-5.0	1700	2.2x2.2'
		NIRSpec	0.6-5.0	100,1000, 2700
	MIRI	5.0-7.7	3500	3.0x3.9"
		7.7-11.9	2800	3.5x4.4"
11.9-18.3	2700	5.2x6.2"		
18.3-28.8	2200	6.7x7.7"		

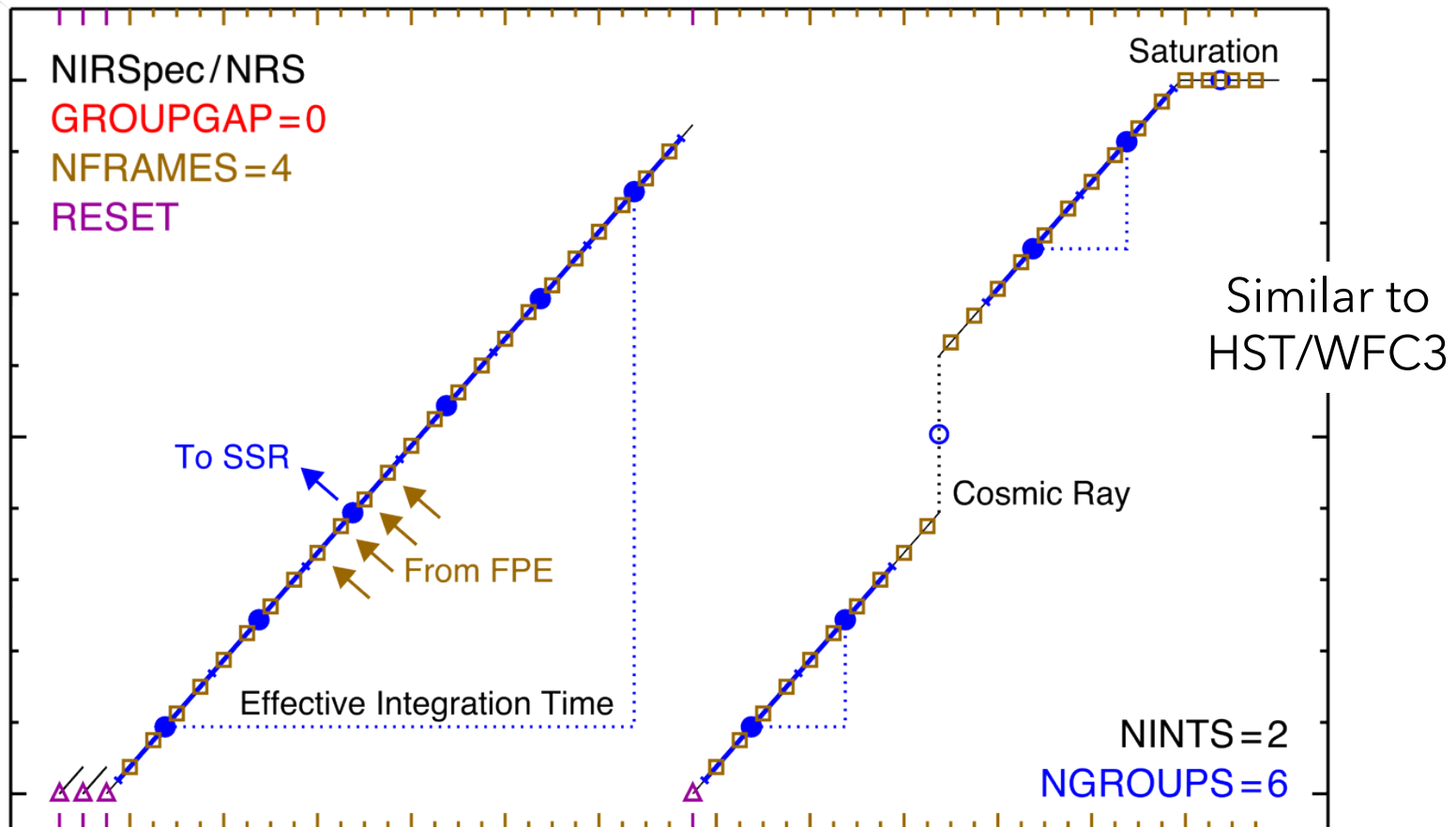


# Many spectroscopy choices





## Detectors sample up-the-ramp, ISIM coadds



# Science & Operations Center

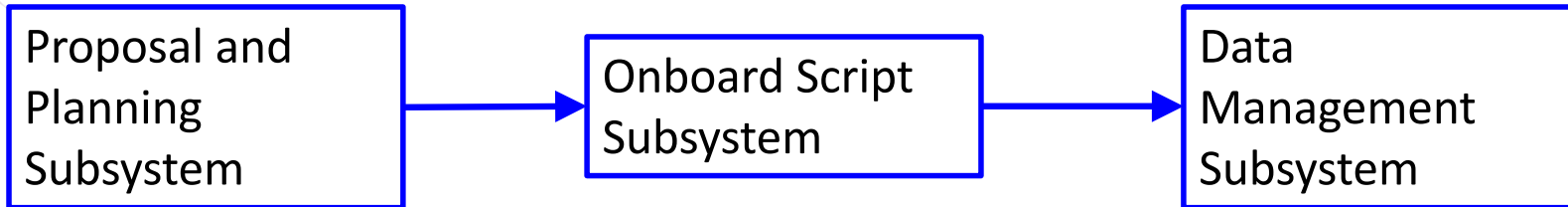
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## Flow of a program through software systems

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- Proposal tools
- Program constraints
- PPS database
- Long range plan
- Short term schedule
- Observation plan

- Observation plan
- Visit files
- Activities
- ISIM and spacecraft
- Solid state recorder

- Science data (re)processing
- Ingest
- Calibration
- Archive
- Distribution
- Data analysis tools



## Templates, observations, and visits

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- Template
  - Constrained observing strategy
  - Defines interface between subsystems
  - Reduces complexity, but still quite complicated
- Observation
  - Expresses a high-level observing task
  - An instance of a template
  - Can expand into multiple visits
- Visit
  - Smallest scheduling unit
  - Begins with a guide star acquisition
  - Cumulative pointing offset less than 30-80 arcsec



## Users begin by selecting a template

Instrument  MIRI

Template

Target

- ✓ MIRI
- NIRCAM
- NIRSPEC
- NIRISS

Instrument  MIRI

Template

Target

- ✓ None Selected
- MIRI Imaging
- MIRI Low Resolution Spectroscopy
- MIRI Medium Resolution Spectroscopy
- MIRI Coronagraphic Imaging

Site Splitting: 20.0 Arcsec

Instrument  NIRSPEC

Template

Target

- ✓ None Selected
- NIRSpec Fixed Slit Spectroscopy
- NIRSpec IFU Spectroscopy
- NIRSpec MultiObject Spectroscopy
- NIRSpec Bright Object Time Series

Site Splitting: 20.0 Arcsec

Instrument  NIRCAM

Template

Target

- ✓ None Selected
- NIRCam Imaging
- NIRCam Coronagraphic Imaging
- NIRCam Time Series
- NIRCam Grism Time Series

Site Splitting: 20.0 Arcsec

Instrument  NIRISS

Template

Target

- ✓ None Selected
- NIRISS Imaging
- NIRISS Wide Field Slitless Spectroscopy
- NIRISS Single-Object Slitless Spectroscopy
- NIRISS Aperture Masking Interferometry

Site Splitting: 20.0 Arcsec



## End-to-end support for several target types

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- Fixed target
- Moving target (solar system)
- Faint companion (coronagraphy, AMI)
- Variable source (time series)
- Extended source (IFU)
- Target group (IFU, slit)
- Multi-object spectroscopy (slitless, MSA)
- Extended field (mosaic, parallels)



## Coordinated parallel support

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1. NIRCam Imaging + MIRI Imaging
2. NIRCam Imaging + NIRISS Wide Field Slitless Spectroscopy
3. MIRI Imaging + NIRISS Wide Field Slitless Spectroscopy
4. NIRCam Imaging + NIRISS Imaging
5. NIRSspec MOS + NIRCam Imaging
6. NIRSspec MOS + NIRCam Imaging (Cycle 2)
7. NIRSspec IFU + NIRCam Imaging (Cycle 2)
8. NIRSspec IFU + MIRI Imaging (Cycle 2)



## Ambitious suite of data products at launch

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- Single exposure
  - Calibrated image
  - Extracted spectra
- Multiple exposures (associations)
  - Images – combine dithers and mosaic tiles
  - Coronagraphic images – combine rolls and subtract PSF
  - Aperture mask interferometry – combine rolls and subtract reference star
  - Individual spectra – combine 2D images and extract
  - IFU – combine slices and dithers into 3D cube
  - Time series – special handling to maintain precision
- Online cache updated when calibration files/software change
- Users can run the pipeline at home with custom parameters



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Efficiency

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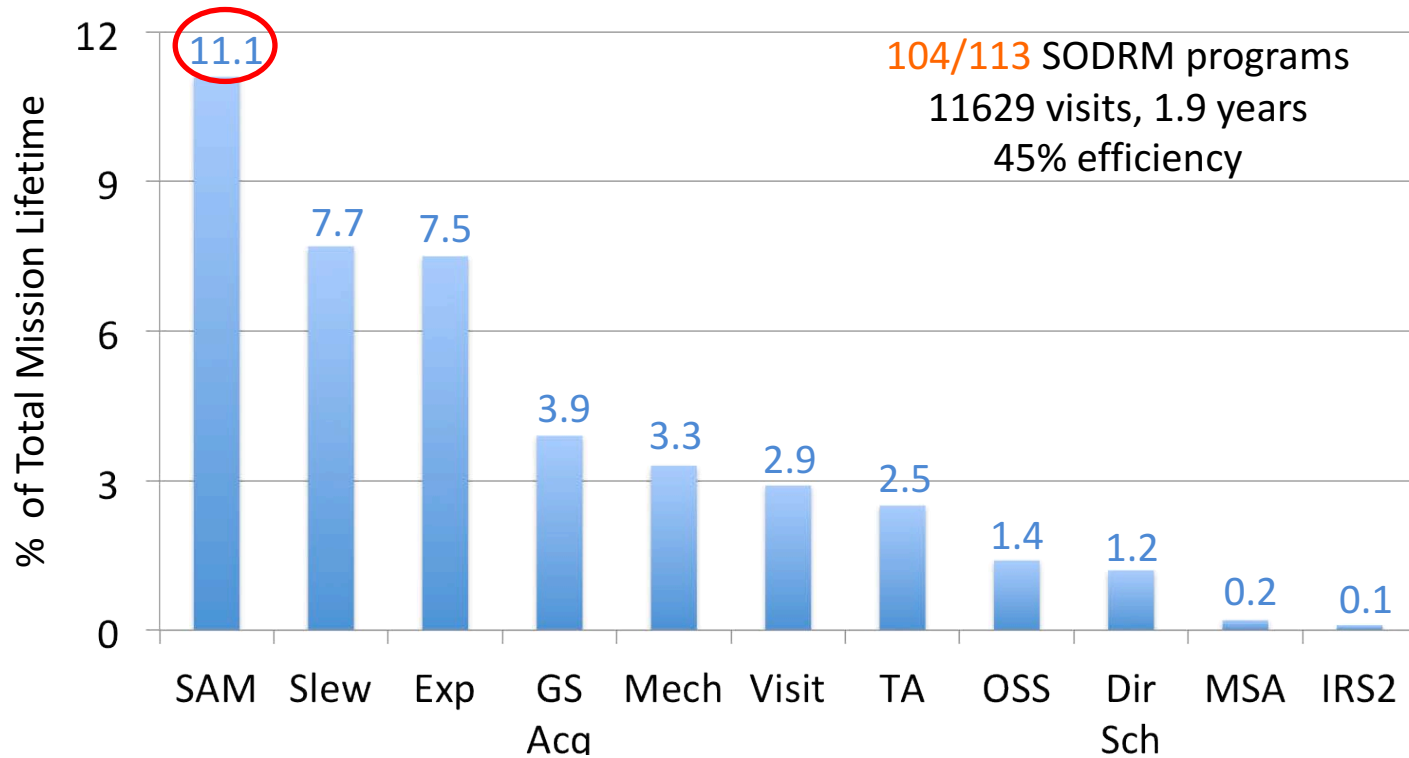
## Efficiency work done before GTO observation descriptions (Mar 2017)

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- Multi-object spectroscopy
- Event-driven operations
- Multiple integrations
- Parallel calibrations
- Parallel science
- Target groups
- ...



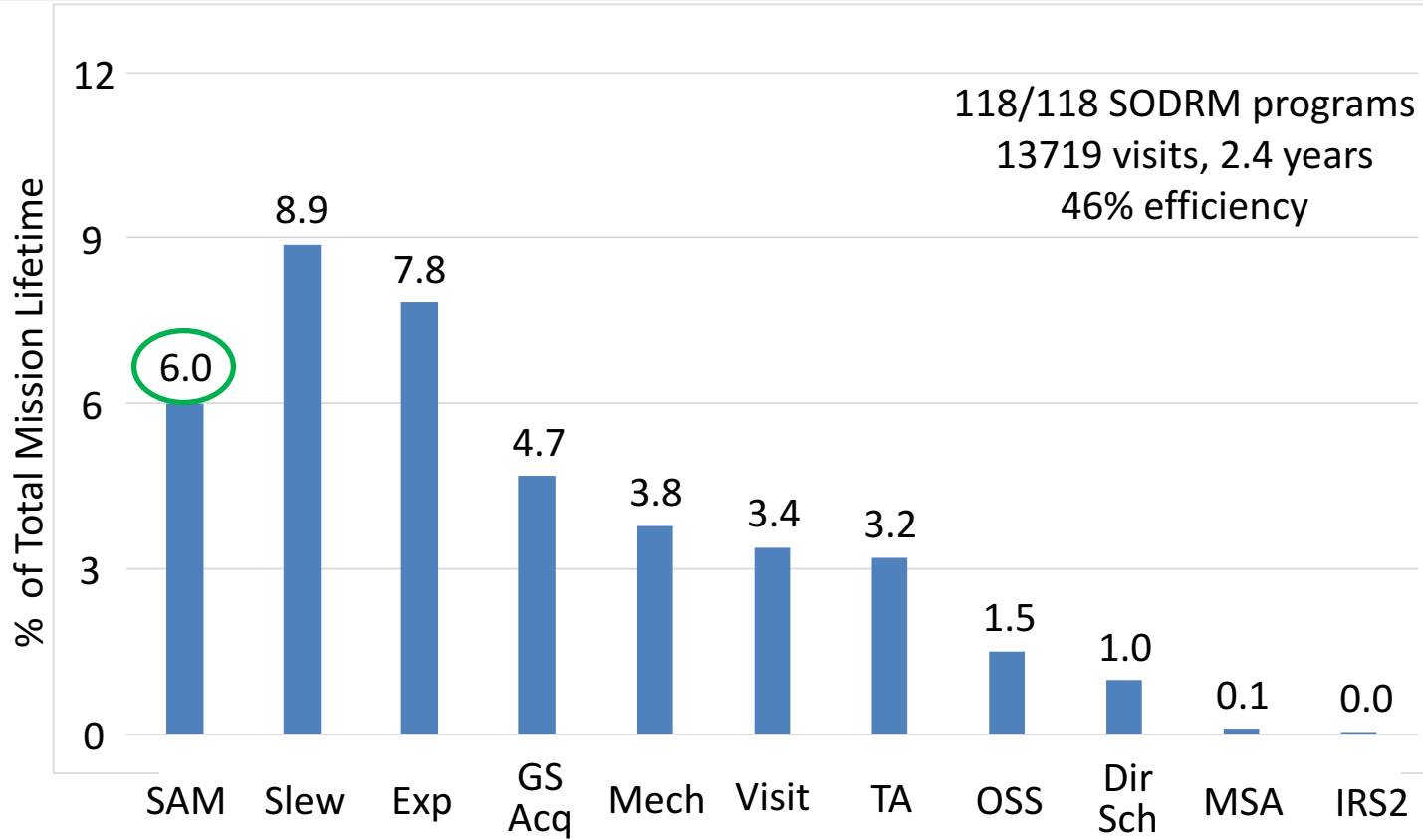
## SODRM overheads as of Mar 2017



Science Operations Design Reference Mission is a suite of plausible observing programs



## SODRM overheads as of June 20 (preliminary analysis)





## Efficiency work that will be done by GO Call for Proposals (Nov 2017)

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- Increase threshold for FGS ACQ after a SAM from 3" to 20"
- Reduce FGS ACQ time from 97.5 to 65 s
- Don't move NIRCcam wheels to home position at end of visit
- Allow more integrations for NIRCcam imaging with subarray
- Package MOS nod sets as a single activity
- Implement wide aperture target acquisition
- Remove reset time between MIRI successive integrations
- Include overhead for rolls in smart accounting
- Do more setup in parallel (difficult to implement)
- Refactor scripts to reduce activity compilation time (recertify)



## Efficiency work after APT 25.0.4

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- Reorder dither points and mosaic tiles to reduce visit breaks
- Reverse filter order when a set is used multiple times
- Slew more quickly (requires on orbit performance data)
- Configure detectors once for multiple exposures (infrastructure)
- Combine IFU exposures with different gratings in the same visit
- Modify timing pattern for time series observations in the NIR

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## Summary

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- The JWST observatory is quite complicated and capable
- JWST software systems are complex and will continue to evolve
- Efficiency will continue to improve





## Long exposures are more efficient than short exposures

