# JWST Science

Jeff Valenti

Four JWST science themes

End of the dark ages: First light and reionization

Assembly of galaxies

Birth of stars and protoplanetary systems

Planetary systems and the origin of life
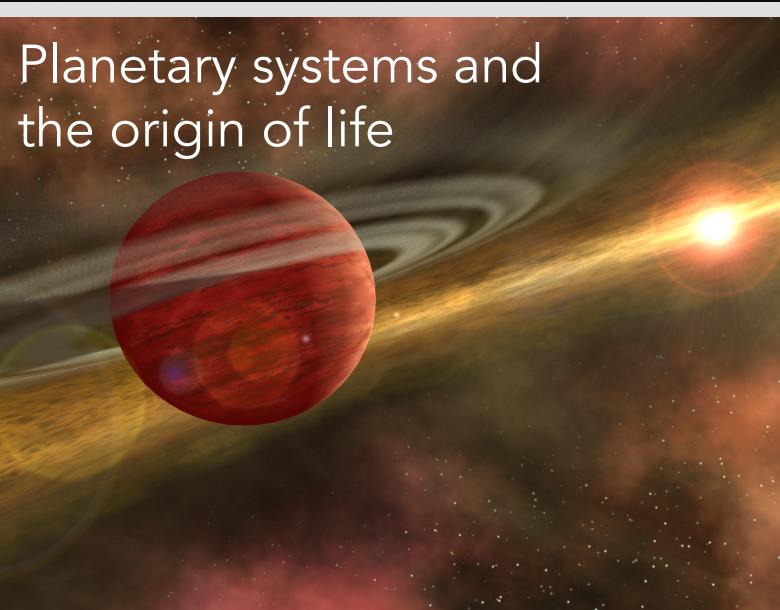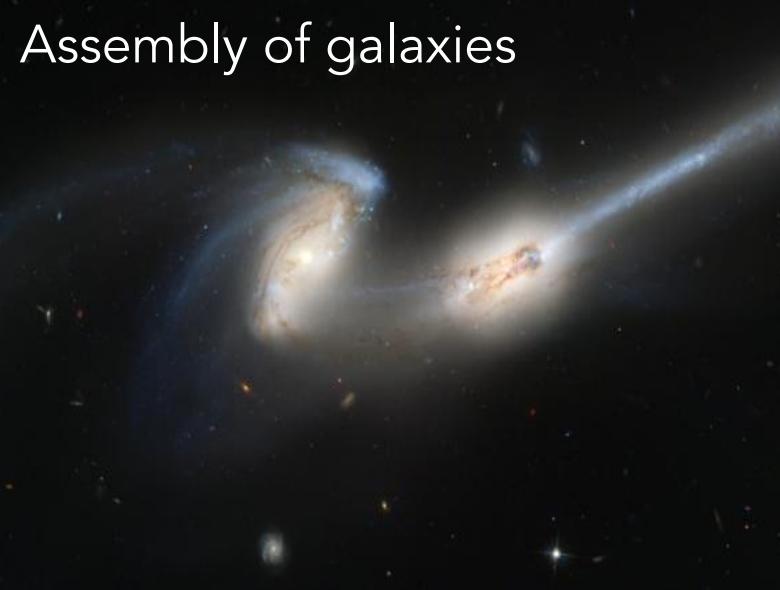
Four science instruments

Near-Infrared Camera

Near-Infrared Spectrograph

Mid-Infrared Instrument

Near-Infrared Imager and Slitless Spectrograph

3
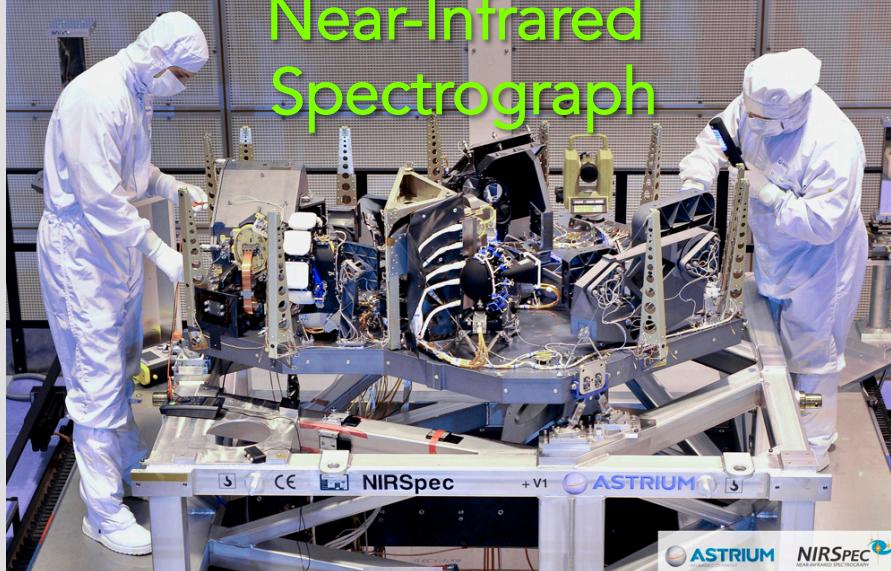
JWST imaging modes

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'
Coronography	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'

JWST spectroscopic modes

Mode	Instrument	Wavelength (micron)	Resolution (R=$\lambda / \Delta \lambda$)	Field of View
Single 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 0.6-2.5	150 700	2.2x2.2' single object
	NIRCam	2.4-5.0	1700	2.2x2.2'
Integral Field Unit Spectroscopy	NIRSpec	0.6-5.0	100,1000, 2700	3.0x3.0"
	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"

JWST field of view
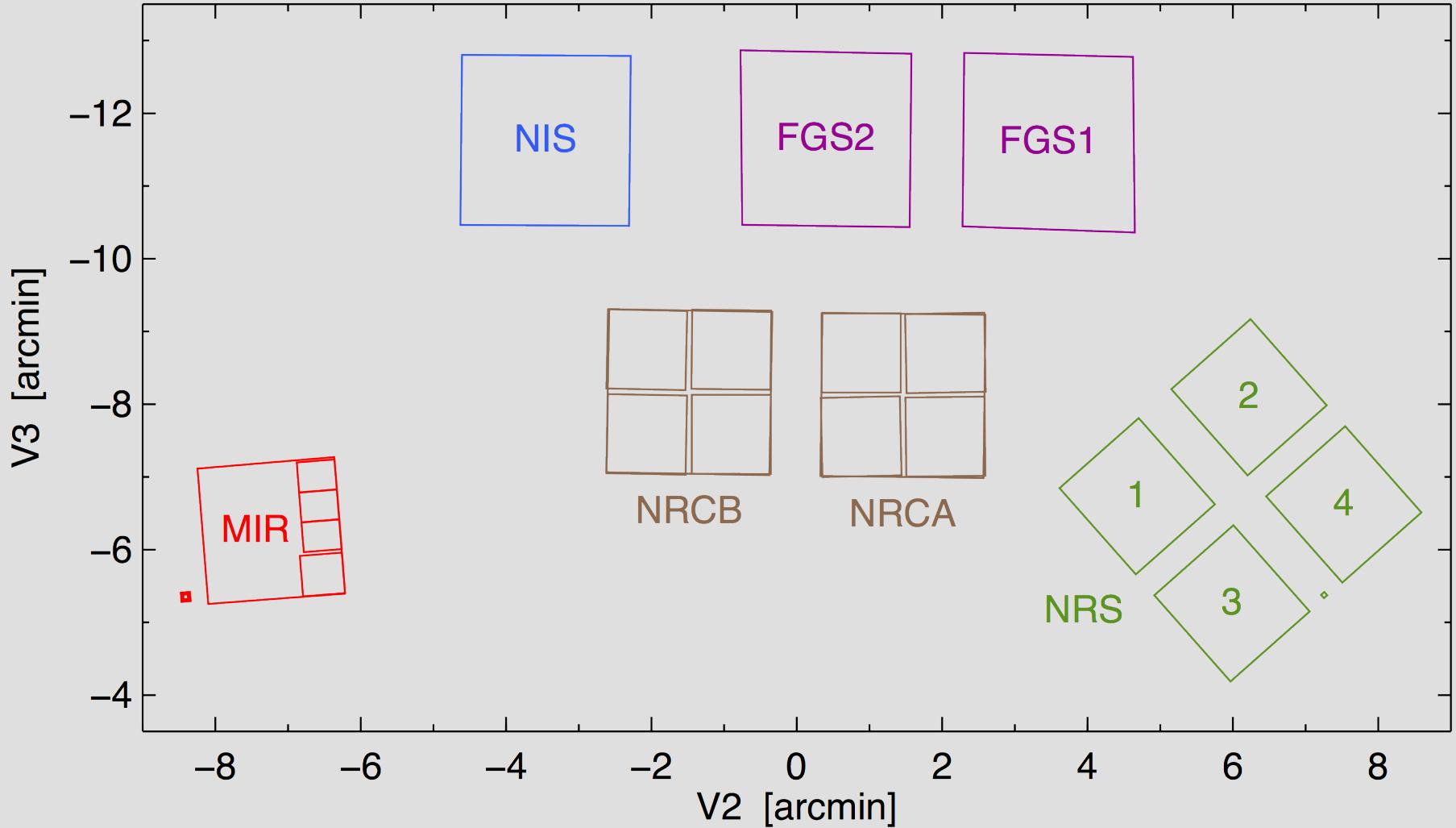
Flow of a program through the system

Proposal and Planning Subsystem	→	Onboard Script Subsystem	→	Data Management Subsystem

- Proposal tool
- Program constraints
- Planning
- Scheduling
- Observation plan

- Observation plan executive

- Data processing
- Science software
- Archive
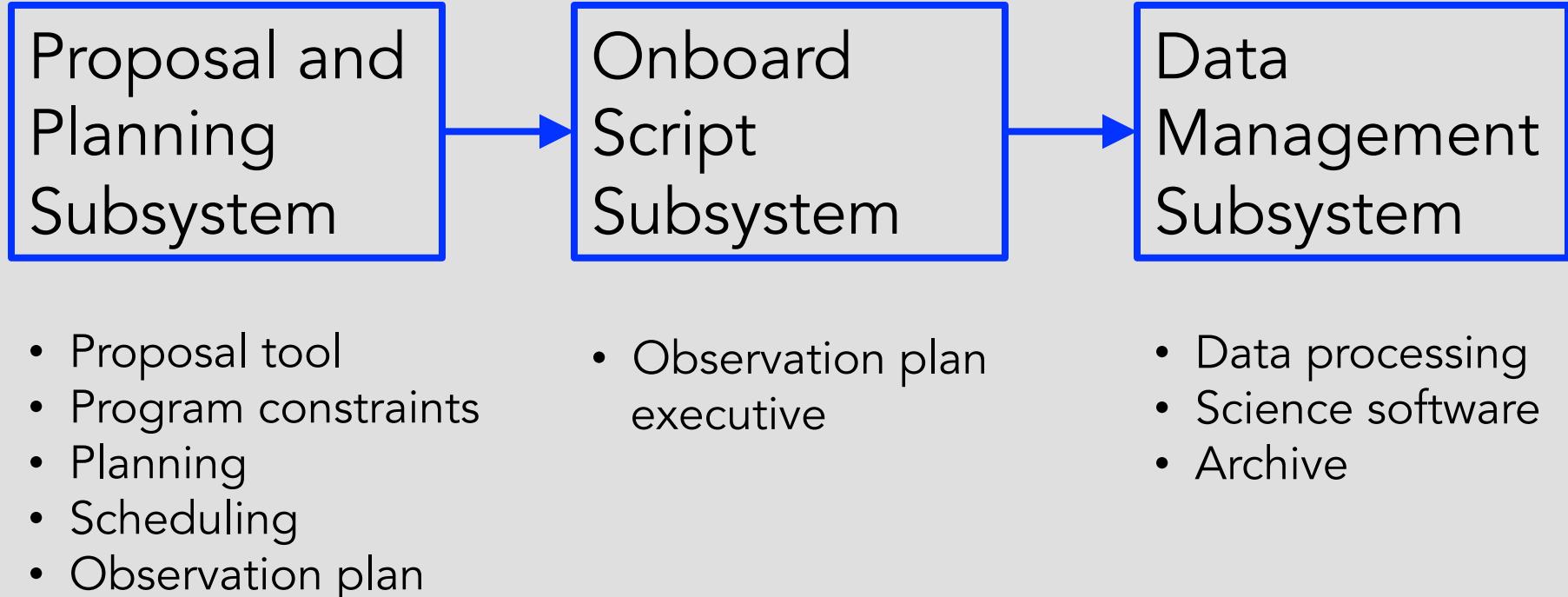
Templates and observations

- Template
  - Constrained observing strategy
  - Defines interface between subsystems
  - Reduces complexity, but still quite complicated
- Observation
  - Expresses a high-level observing task
  - Can expand into multiple visits
  - An instance of a template

APT File Edit Tools Form Editor Help

Wed Dec 30 3:39 PM

46%

Form Editor | Spreadsheet Editor | Orbit Planner | Visit Planner | View in Aladin | BOT | Target Confirmation | PDF Preview | Submission | Errors and Warnings | Run All Tools | Stop

New JWST Proposal | New

JWST What's New | HST What's New | Roadmap | Feedback

- JWST Draft Proposal (wfss_examp
  - Proposal Information
    - Proposal Description
    - Unnamed PI
  - Targets
    - Fixed Targets
      - 1 FIELD1
  - Observations
    - Observation Folder
      - WFSS, F150W (Obs 1)
        - Visit 1:1
        - Visit 1:2
        - Visit 1:3
        - Visit 1:4
        - Visit 1:5
        - Visit 1:6
        - Visit 1:7
        - Visit 1:8
        - Visit 1:9
      - WFSS, F200W (Obs 2)
        - Visit 2:1
        - Visit 2:2
        - Visit 2:3
        - Visit 2:4
        - Visit 2:5
        - Visit 2:6
        - Visit 2:7
        - Visit 2:8
        - Visit 2:9
    - Observation Links

WFSS, F150W (Obs 1) of JWST Draft Proposal (wfss_example.aptx)

Number: 1

Label: WFSS, F150W

Instrument: NIRISS

Template:

| NIRISS Imaging |
| ✓ NIRISS Wide Field Slitless Spectroscopy |
| NIRISS Single–Object Slitless Spectroscopy |
| NIRISS Aperture Masking Interferometry |

Target:

	Splitting Distance	Number of Visits
Visit Splitting:	30.0 Arcsec	9

	Science	Total Charged
Duration (secs)	31932	47121

Data volume: 7,550 MB

NIRISS Wide Field Slitless Spectroscopy | Mosaic Properties | Special Requirements | Comments

Science Observation

WFSS Dither Name: WFSS4PT

Filter: F150W   Grism: BOTH

	Readout Pattern	No. of Groups	No. of Integrations	Photon Collect Duration	Total Photon Collect Duration
Exposure Time	NIS	10	1	429.47	3435.76

Direct Image

	DI Readout Pattern	DI No. of Groups	DI No. of Integrations	DI Photon Collect Duration	DI Total Photon Collect Duration
DI Exposure Time	NISRAPID	10	1	107.368	107.368

Edit Observation Folder | New | Edit Visit 1:1

Observa... △	Number	Label	Science	Total Char...	Instrument	Template	Target	Number of ...	Splitting Di...	Comments
WFSS, F15...	1	WFSS, F15...	31932	47121	NIRISS	NIRISS Wid...	1 FIELD1	9	30.0 Arcsec	
WFSS, F20...	2	WFSS, F20...	31932	47121	NIRISS	NIRISS Wid...	1 FIELD1	9	30.0 Arcsec	

Show: Observation

2 errors & warnings (Click for Details)

Form Editor   Spreadsheet Editor   Orbit Planner   Visit Planner   View in Aladin   BOT   Target Confirmation   PDF Preview   Submission   Errors and Warnings   Run All Tools   Stop

New JWST Proposal   New

JWST What's New   HST What's New   Roadmap   Feedback

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        - Visit 1:5
        - Visit 1:6
        - Visit 1:7
        - Visit 1:8
        - Visit 1:9
      - WFSS, F200W (Obs 2)
        - Visit 2:1
        - Visit 2:2
        - Visit 2:3
        - Visit 2:4
        - Visit 2:5
        - Visit 2:6
        - Visit 2:7
        - Visit 2:8
        - Visit 2:9
  - Observation Links

WFSS, F150W (Obs 1) of JWST Draft Proposal (wfss_example.aptx)

Number   1

Label   WFSS, F150W

Instrument   NIRISS

Template   NIRISS Wide Field Slitless Spectroscopy

Target   1 FIELD1

	Splitting Distance	Number of Visits
Visit Splitting:	30.0 Arcsec	9

	Science	Total Charged
Duration (secs)	31932	47121

Data volume: 7,550 MB

NIRISS Wide Field Slitless Spectroscopy   Mosaic Properties   Special Requirements   Comments

Rows	3	Columns	3
Row Overlap %	10.0	Column Overlap %	10.0
Row shift	0.0	Column shift	0.0

View in Aladin

Edit Observation Folder   New   Edit Visit 1:1

Observa... △	Number	Label	Science	Total Char...	Instrument	Template	Target	Number of ...	Splitting Di...	Comments
WFSS, F15...	1	WFSS, F15...	31932	47121	NIRISS	NIRISS Wid...	1 FIELD1	9	30.0 Arcsec	
WFSS, F20...	2	WFSS, F20...	31932	47121	NIRISS	NIRISS Wid...	1 FIELD1	9	30.0 Arcsec	

Show: Observation

2 errors & warnings (Click for Details)

Science templates in APT
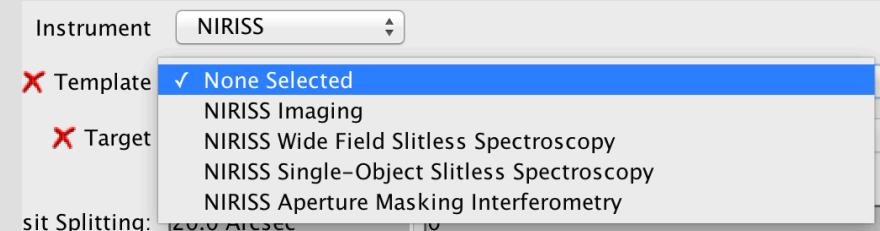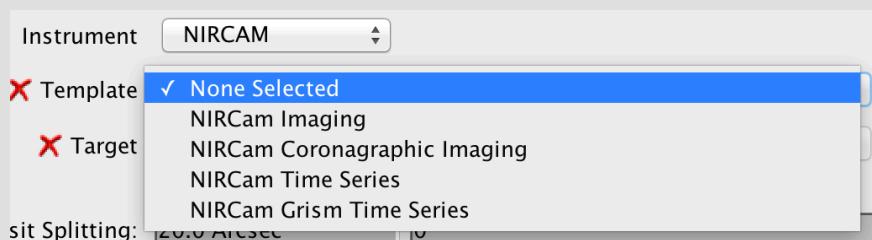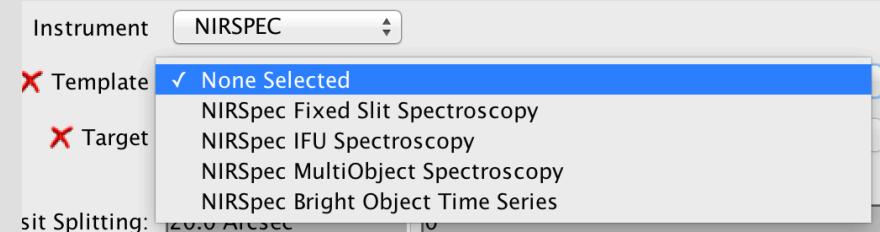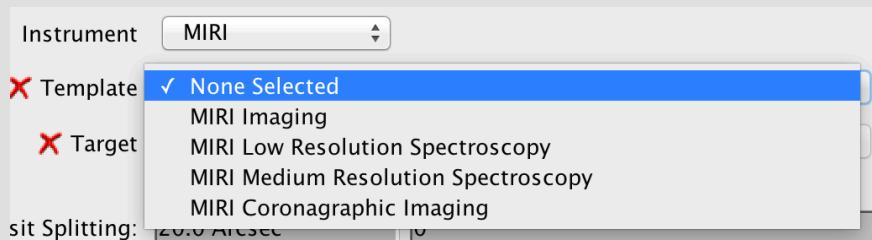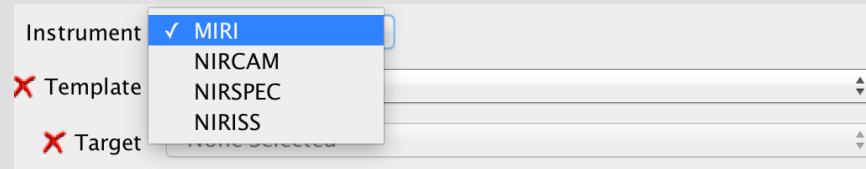
Draft science timeline

03/2017	ERS call for proposals
07/2017	ERS proposal deadline
09/2017	ERS time allocation
11/2017	Cycle 1 call for proposals
02/2018	Cycle 1 proposal deadline
05/2018	Cycle 1 time allocation
10/2018	Launch and commissioning
05/2019	Begin science operations
09/2019	Cycle 2 call for proposals
12/2019	Cycle 2 proposal deadline

} Early Release Science

Only 7 months

Time is of the essence for the mission

- Unprecedented sensitivity, huge discovery space
- 5 year design lifetime (nothing precludes 10 years)
  - Shorten time for each "intellectual cycle"
  - Quick public access to useful data is the key
- Discussing shorter exclusive-access period
  - Guaranteed time observers, 12 months
  - General observers, 6 months (still discussing)
  - Early release science program, 0 months

Make it easier to get and assess data

- Download files directly via URL
- Update files as needed via background reprocessing
  - Impractical to keep all superseded files
  - Notification when new version is available
  - Version information is recorded in the header
- Association summaries (not yet designed)
  - Exposure list, pointings, optical configurations, …
- Engineering database, e.g. exoplanet light curves

Pipeline will produce high-level products!

- After all input observations are complete
- Mosaics, catalogs, combined spectra, IFU data cubes
  - NIRCam catalogs needed for NIRSpec MSA use
- Roll combined, PSF subtracted coronagraphic images
- Archive users can rerun and customize pipeline
- Data analysis tools in and affiliated with astropy
  - Development with domain experts in "sprints"
  - Visualization, model fitting, PSF tools, geometry
  - Mode-specific tools, source extraction, and more

Users can rerun and build on pipeline

- User creates an association table file in JSON format

```
"products": [{"name": "output_drz.fits",
"members": [
{"expname": "jw00017001001_01101_00001_NRCA1_cal.fits"},
{"expname": "jw00017001001_01101_00001_NRCA2_cal.fits"},
{"expname": "jw00017001001_01101_00001_NRCA3_cal.fits"},
{"expname": "jw00017001001_01101_00001_NRCA4_cal.fits"}]}]
```

- User passes association table file to pipeline

```
% strun calimage3.cfg sample_asn.json
```

- User can skip, modify, and add pipeline steps