EXPANDING THE FRONTIERS OF SPACE ASTRONOMY

Status of candidate enhancements for Cycle 1 (focus on overheads and efficiencies)

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Overview of presentation

- Status of *candidate* launch-delay enhancements
  - Organized by category

Code	Category
OE	Observing efficiency
DQ	Data quality
UT	User tools
SC	New science capability
SE	S&OC enhancement

  - More detail provided for work completed or in progress ⓘ
  - Most enhancements are listed in launch delay letter, but some new ones
- Bug fixes
- Priorities for JWST work by Instrument Division over next 6 months

Science enhancements – Observing efficiency (OE)

JIRA Ticket	ID	OSS	Build*	Description
n/a	OE1	No	**IC 14.45**	~~Precompile scripts~~ → Compile scripts more quickly (ISIM)
JWSTOSS-6882	OE2a	**Yes**	**OSS 8.1**	Reuse exposure setup (NIRCam)
JWSTOSS-6917	OE2b	**Yes**	OSS 8.2	Reuse exposure setup (MIRI)
JWSTOSS-6881	OE2c	**Yes**		Reuse exposure setup (NIRSpec)
JPPS-261	OE3a	No	PPS 14.9	Enable more coordinated parallel combinations
JSOCINT-159	OE3b	No	PPS 14.10	Enable more pure parallel combinations
JSOCINT-164	OE4	No	PPS 14.9	Maximize FOV of WFSS observations (NIRISS)
JSOCINT-208	OE5	No	**PPS 14.8**	Package IFU mosaic in one visit
JSOCINT-143	OE6	**Yes**		Enable NIRCam SW+LW coronagraphy
JSOCINT-201	OE7	**Yes**		Enable NIRSpec IFU + MOS prism
JSOCINT-308	(OE)	No	PPS 14.9	Move guide star ID attitude closer to science attitude

*Build: Bold means enhancement already implemented, blank means not yet allocated to a build

A brief history of OSS script compile time

- Script compile times grew substantially after OSS 5
  - Added dithers, parallels, target acquisition, and other capabilities
  - Many more #include statements in each MAIN script
  - Compilation took an order of magnitude longer than predicted by APT
- ISIM FSW team investigated precompiling lower-level scripts
  - Measured compile times using prototype software on an unloaded system
  - Dramatic reduction in compile times for all MAIN scripts
- ISIM FSW team tuned compiler settings
  - Substantial reduction in compile times without precompiling lower-level scripts
  - Compile times are now shorter than predicted by APT

Quicker script compilation (OE1)

Instrument	Activity	APT 27.1	Before Change	After Change
FGS	Guide star acquisition	(282)	103	9
MIRI	Per exposure specification	25	157	16
	TA		135	17
NIRCam	Per exposure specification	40	373	19
	TA	30	262	19
	End of visit	30	135	4
NIRISS	Per exposure specification	30	150	13
	TA	30	147	16
NIRSpec	Per exposure specification	65	229	21
	TA (MSA)	30	237	25
	TA (bright object)	30	269	23
	End of visit	30	29	7

Faster detector setup for dithered/repeat exposures (OE2)

Template	PRIME				PARALLEL				Overhead
	nactivity	ntotexp	nrepeat	overhead	nactivity	ntotexp	nrepeat	overhead	Reduction
NIRCam Imaging	846	3463	2617	73040	1212	3668	2456	68547	0.93%
NIRCam Wide Field Slitless Spectroscopy	300	1092	792	22105					0.14%
NIRCam Coronagraphic Imaging	300	460	160	4466					0.03%
NIRCam Grism Time Series	25	25	0	0					0.00%
NIRCam Time Series	1	1	0	0					0.00%
TOTAL – NIRCam				**99611**				**68547**	**1.10%**
MIRI Imaging	544	1920	1376	19952	272	1664	1392	20184	0.26%
MIRI Medium Resolution Spectroscopy	937	2950	2013	29189					0.19%
MIRI Coronagraphic Imaging	84	379	295	4278					0.03%
MIRI Low Resolution Spectroscopy	44	70	26	377					0.00%
TOTAL – MIRI				**53795**				**20184**	**0.49%**
NIRSpec MultiObject Spectroscopy	903	2681	1778	21016					0.14%
NIRSpec IFU Spectroscopy	665	2071	1406	16619					0.11%
NIRSpec Fixed Slit Spectroscopy	63	147	84	993					0.01%
NIRSpec Bright Object Time Series	19	19	0	0					0.00%
TOTAL – NIRSpec				**38628**					**0.25%**

Enable more coordinated parallel combinations (OE3a)

Prime Template	Parallel Template
MIRI Imaging	NIRCam Imaging
	NIRISS WFSS
NIRCam Imaging	NIRISS WFSS
	MIRI Imaging
	NIRISS Imaging
(NIRCam WFSS)	**(MIRI Imaging)**
	(NIRISS Imaging)
NIRISS WFSS	MIRI Imaging
	NIRCam Imaging
NIRSpec MOS	NIRCam Imaging
	(MIRI Imaging)

Parenthetical items in **bold** are candidates for implementation in PPS 14.9, which will be released before the GO call for proposals

Enable more pure parallel combinations (OE3b)

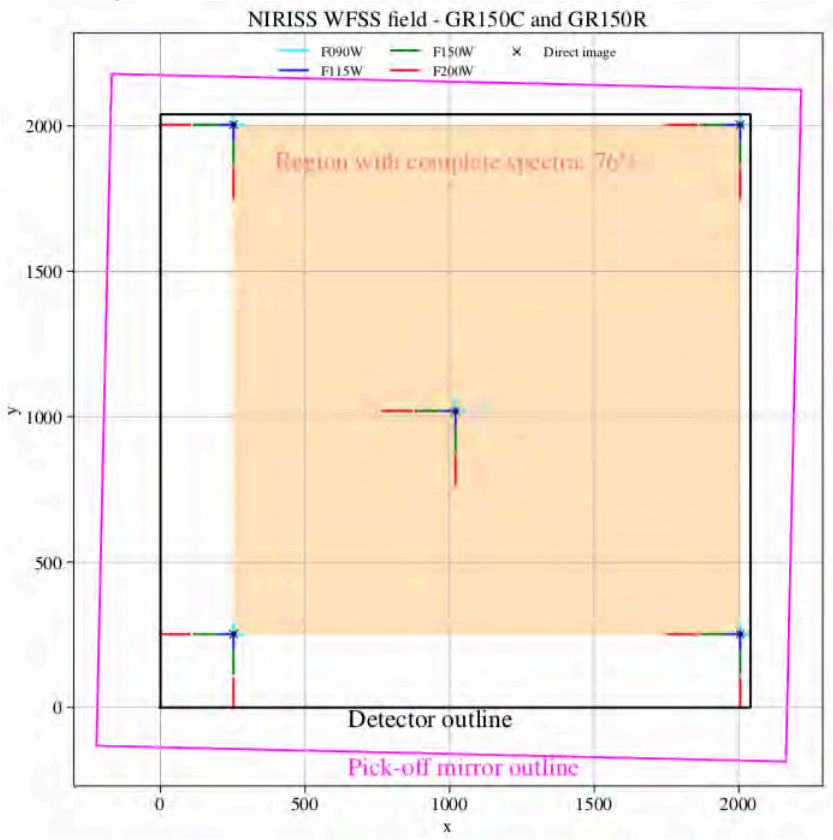
Added **NIRISS WFSS** as a pure parallel option

Allowed parallel templates:

- NIRCam Imaging
- MIRI Imaging
- NIRISS Imaging
- **NIRISS WFSS**
- **(NIRCam WFSS)**

Prime Template	Parallel Template
MIRI Imaging	NIRCam Imaging
	NIRISS WFSS
	(NIRCam WFSS – Priority 1)
NIRCam Imaging	MIRI Imaging
	NIRISS Imaging
	NIRISS WFSS
NIRISS WFSS	MIRI Imaging
	NIRCam Imaging
NIRSpec MOS	NIRCam Imaging
	(MIRI Imaging – Priority 2)
NIRSpec IFU	**(NIRCam Imaging – Priority 3)**
	(MIRI Imaging – Priority 4)

NIRISS WFSS currently gets complete spectra for 76% of FOV



Location of NIRISS WFSS spectra at 5 direct image positions for the operations concept currently implemented. Direct image locations are marked with a black cross. Grism spectra are shown with colored lines for different filters. The black square outline shows the 2040x2040 active pixels on the detector. The outline of the oversized pick-off mirror is shown in magenta. **Only sources within the orange region have all of their spectra on the detector.** This region comprises 76% of the total direct image area.

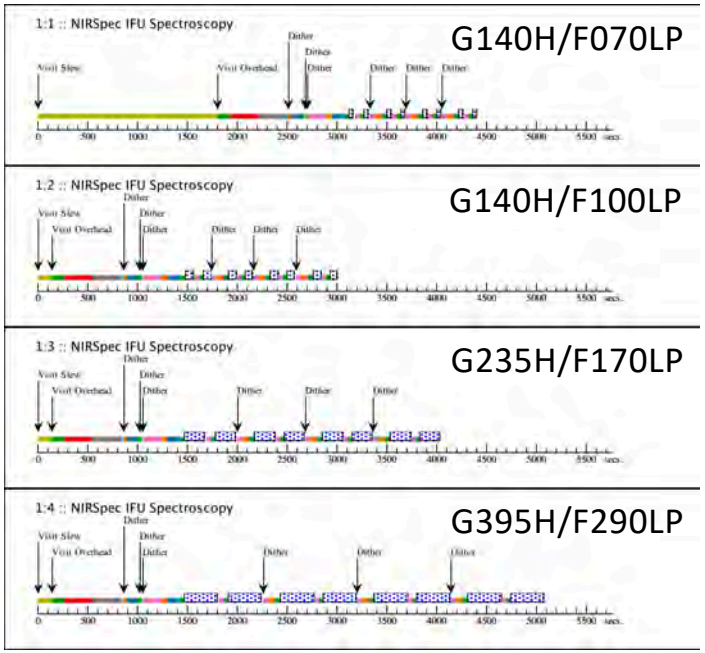
Maximize FOV of NIRISS WFSS observations (OE4)

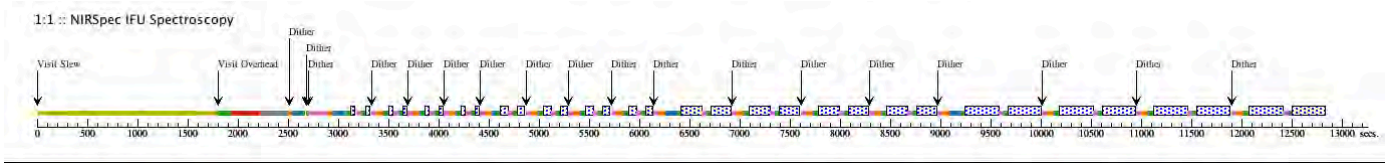
- Chris Willot, Gabe Brammer, Paul Goudfrooij, and Swara Ravindranath show that without any telescope offsets between NIRISS direct images and grism exposures, only 76% of the sources in the direct image will have complete spectra from 0.88 to 2.23 microns.
- They analyzed two revised observing sequences, where filter-dependent telescope offsets provide better overlap of imaging and spectral regions.
  - Both options improved overlap from 76% to 89%, **increasing efficiency by 17%**.
  - Option 2 is preferred because direct images are obtained at some of the exact same positions as grism exposures, enabling higher accuracy astrometric and wavelength solutions.

Package IFU mosaic in one visit (OE5)

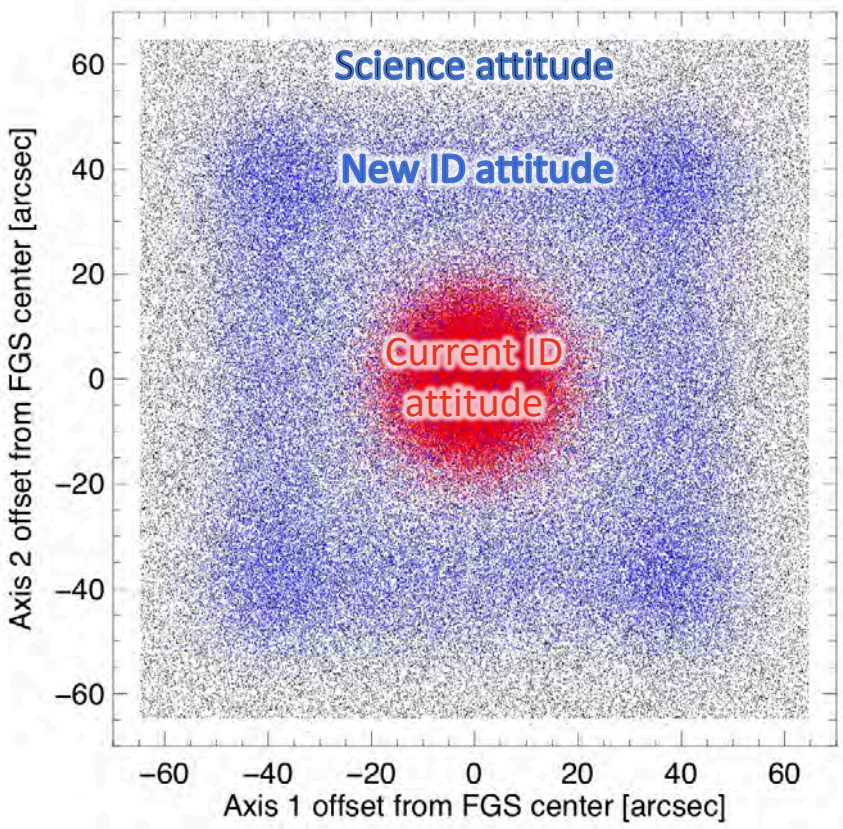
PPS 14.7 – Each visit contains one disperser and all tiles.

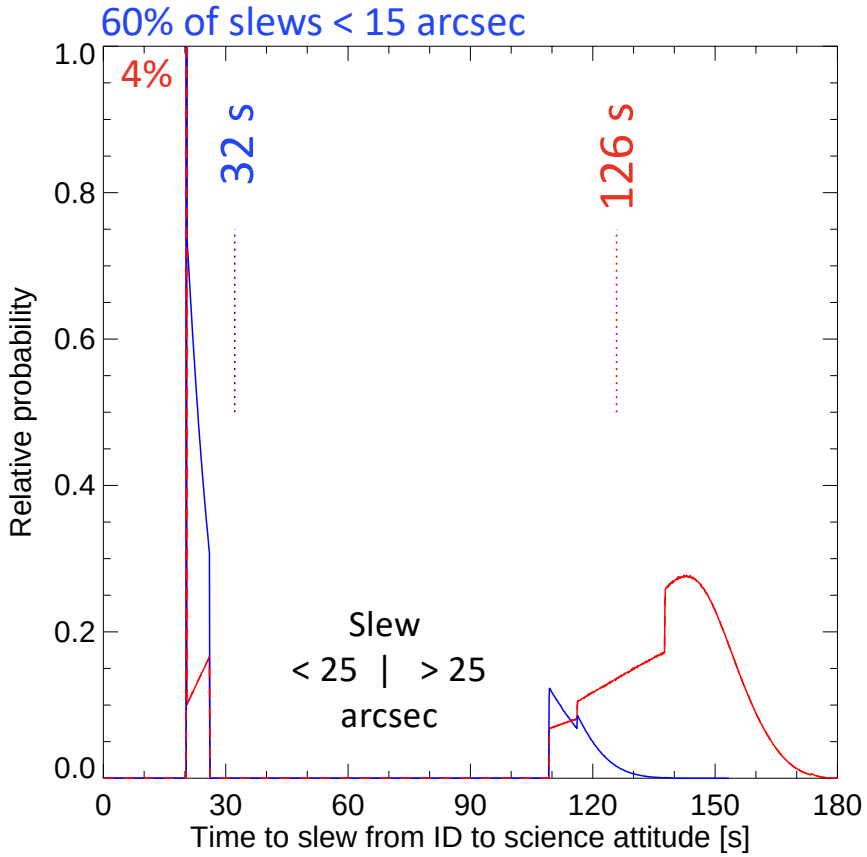
PPS 14.8 – One visit contains all dispersers and all tiles.





Move guide star ID attitude closer to science attitude (OE)





Faster slew during guide star acquisition (OE)

- 1080 GTO + 188 ERS visits = 1286 visits → 1286 guide star acquisitions
- Save 94 seconds per guide star acquisition (on average)
- Save 1286 * 94 s = 120884 s

- GTO + ERS programs will take 15250783 s (with observatory overheads)

- **Recover 0.8%** (120884/15250783) **of mission lifetime for science**
- Observatory overheads include additional guide star acquisitions

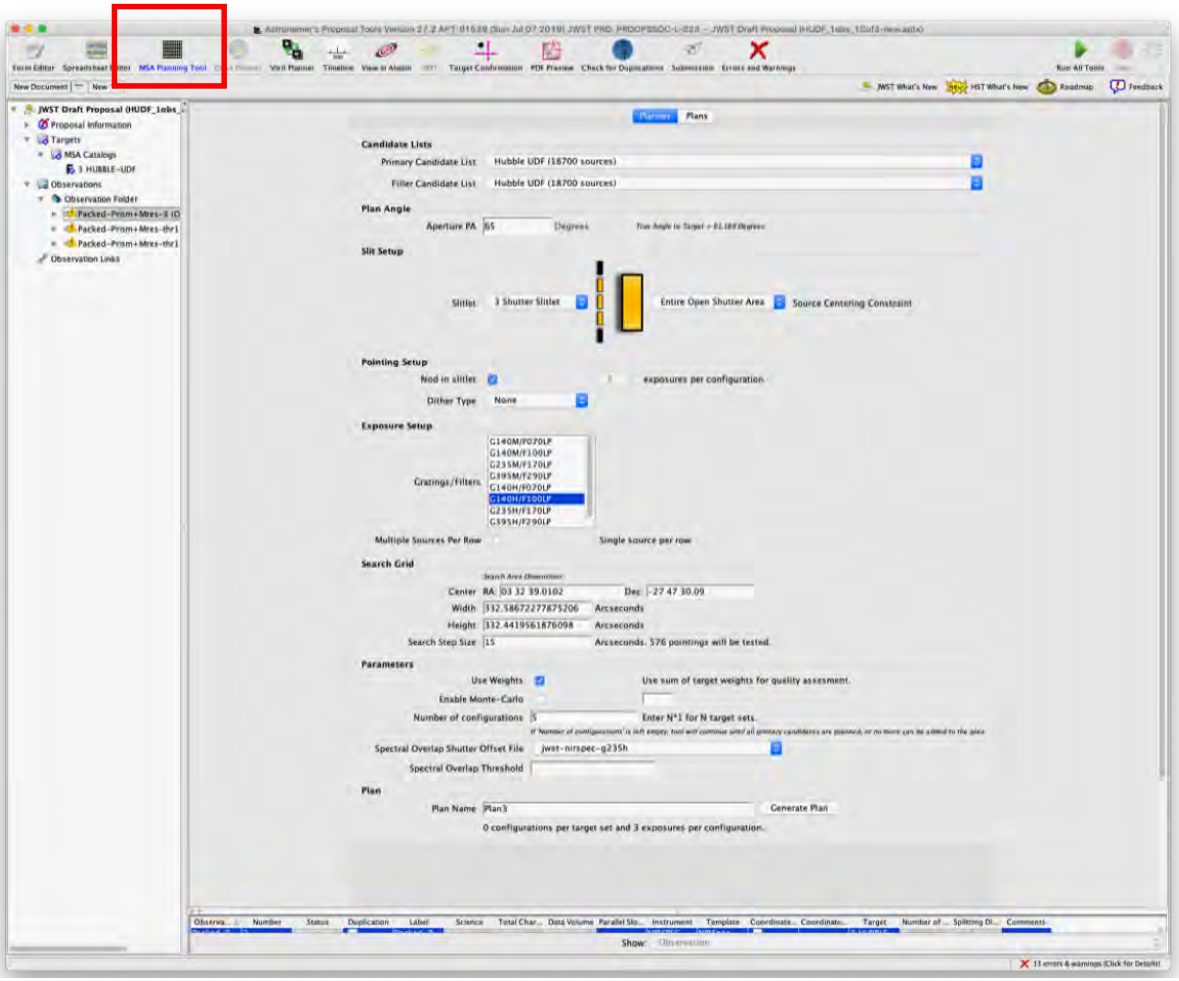
Science enhancements – Data quality (DQ)

JIRA Ticket	ID	OSS	Build	Description
JP-290	DQ1	No		Put image products in Gaia astrometric frame (in progress for HST)
JSOCINT-282	DQ2	Yes		Enable moving target "shadow" observations (modify FSW)
JSOCINT-192	DQ3	Yes		Enable TA in IRS2 detector mode
Tracking page	DQ4	No		Improve data calibration algorithms
JSOCINT-123	DQ5	Yes	OSS 8.2	Enable SOSS+F277W calibration
JSOCINT-75	DQ6	Yes	OSS 8.2	Enable TA confirmation image for MIRI LRS
	DQ7	Yes		Enable read-reset-read detector mode (modify ASIC registers)
	DQ8	Yes		Enable read-reset detector mode (modify ASIC firmware)
	DQ9	Yes		Improve ASIC tuning procedures
JSOCINT-11	(DQ)	Yes		TA for MIRI Imaging (GTO: 10 eclipses of TRAPPIST-1b)
JSOCINT-58	(DQ)	Yes	OSS 8.2	Allow coronagraphy subarrays in NIRCam Dark template
JSOCINT-158	(DQ)	No		Make TA optional for MIRI coronagraphy (AGN science)
JSOCINT-224	(DQ)	Yes		Enable more resets between MIRI integrations (brighter targets)

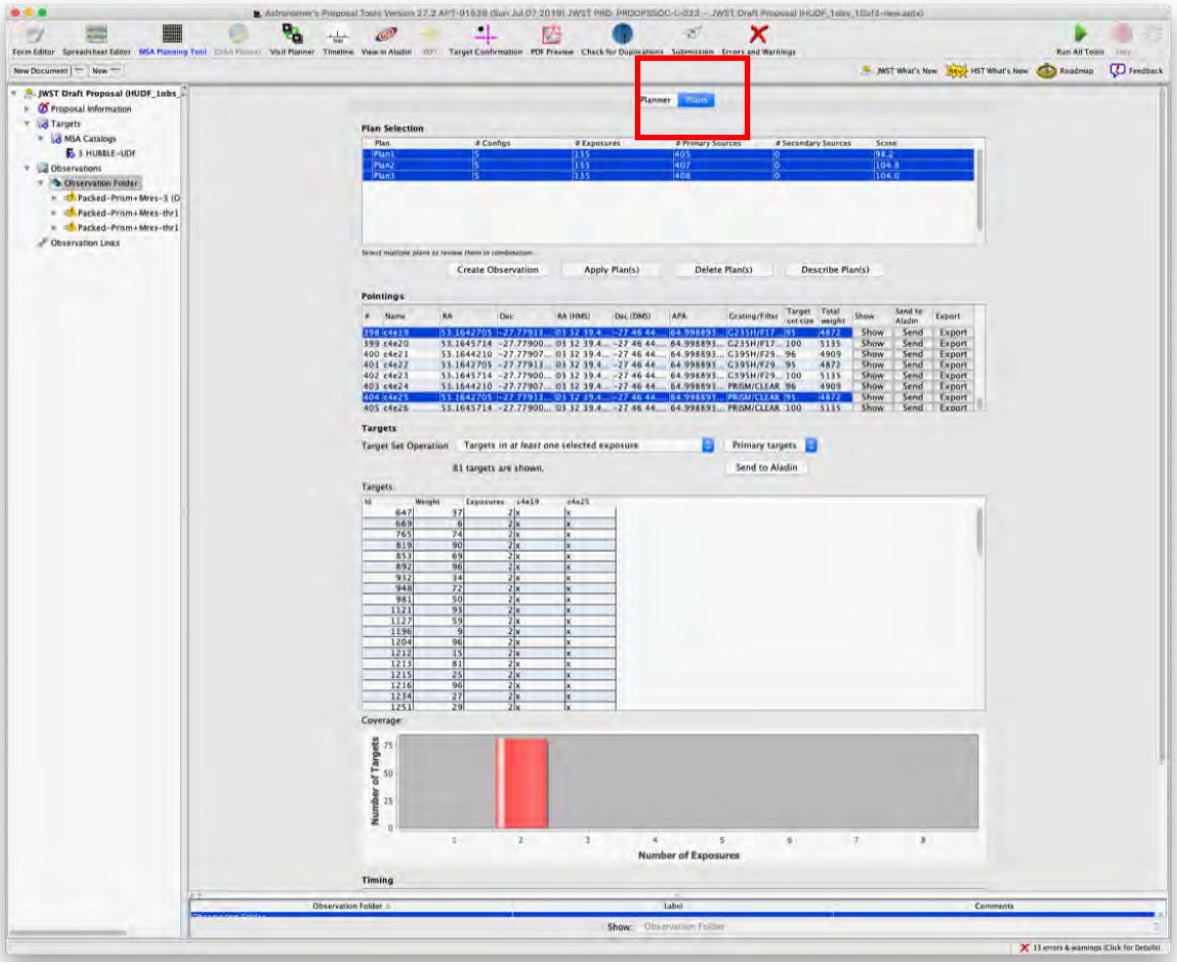
Science enhancements – User tools (UT)

JIRA Ticket	ID	OSS	Build	Description
Multiple	UT1	No	**PPS 14.7, JDox**	Address GO Cycle 1 feedback (see talk by Klaus Pontoppidan)
APT-72607	UT2	No	**PPS 14.8**	Implement a visit timeline in APT
JSOCINT-6	UT3	No	PPS 14.9	Reimplement MSA planning tool (huge effort)
JSOCINT-189	(UT)	No	ETC 1.5	ETC support for NIRSpec confirmation/verification images

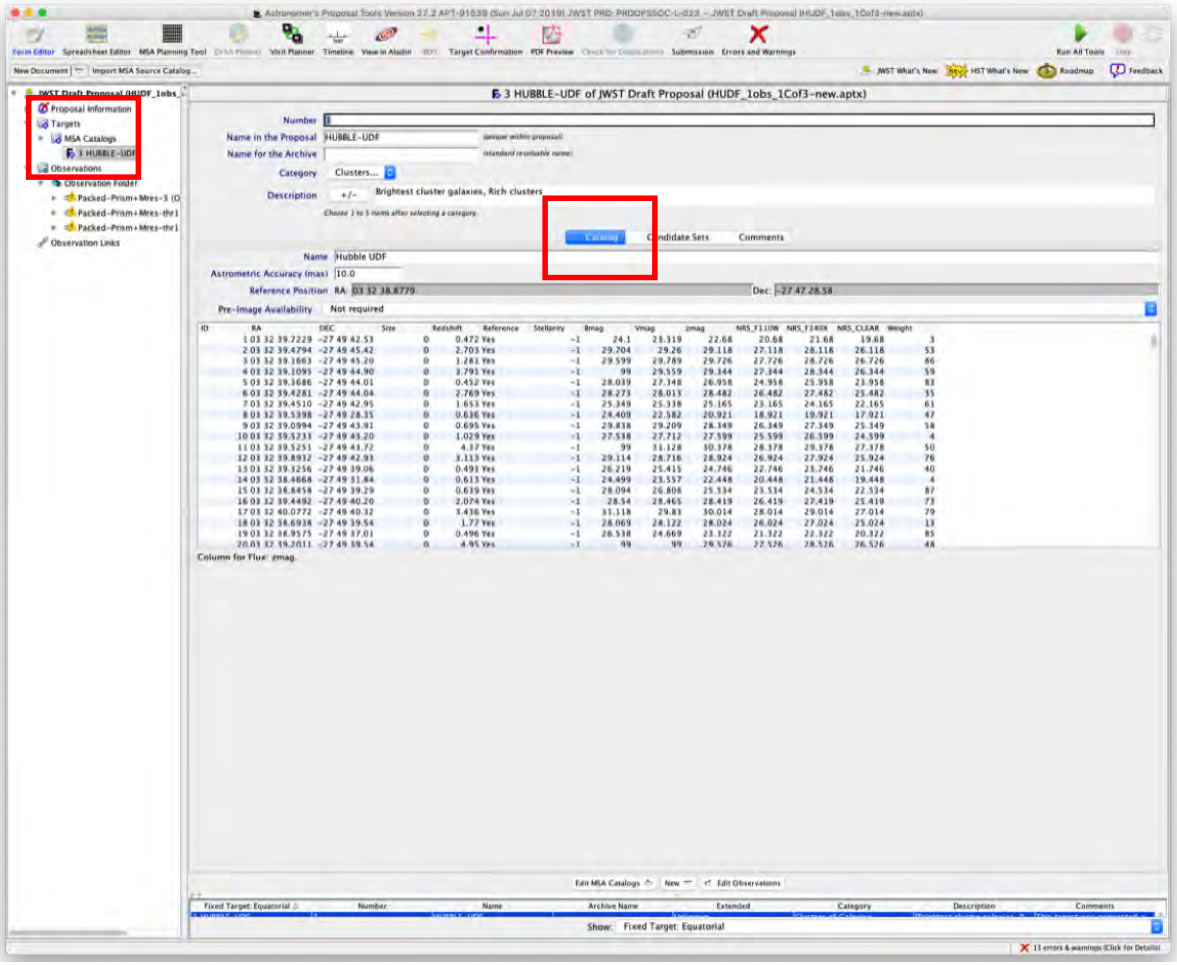
Reimplement MSA planning tool (UT3) – Proper APT tool now



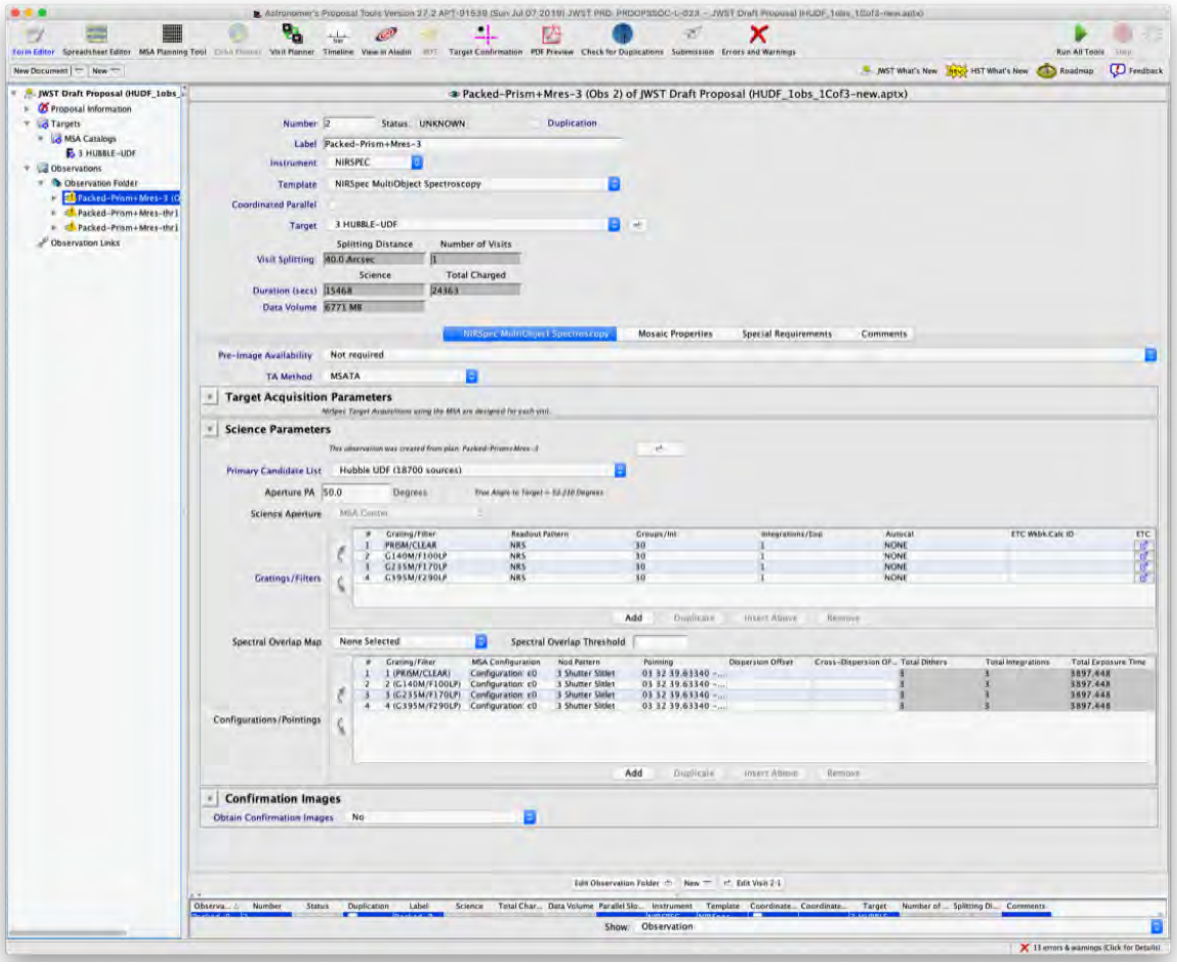
Reimplement MSA planning tool (UT3) – New plans tab



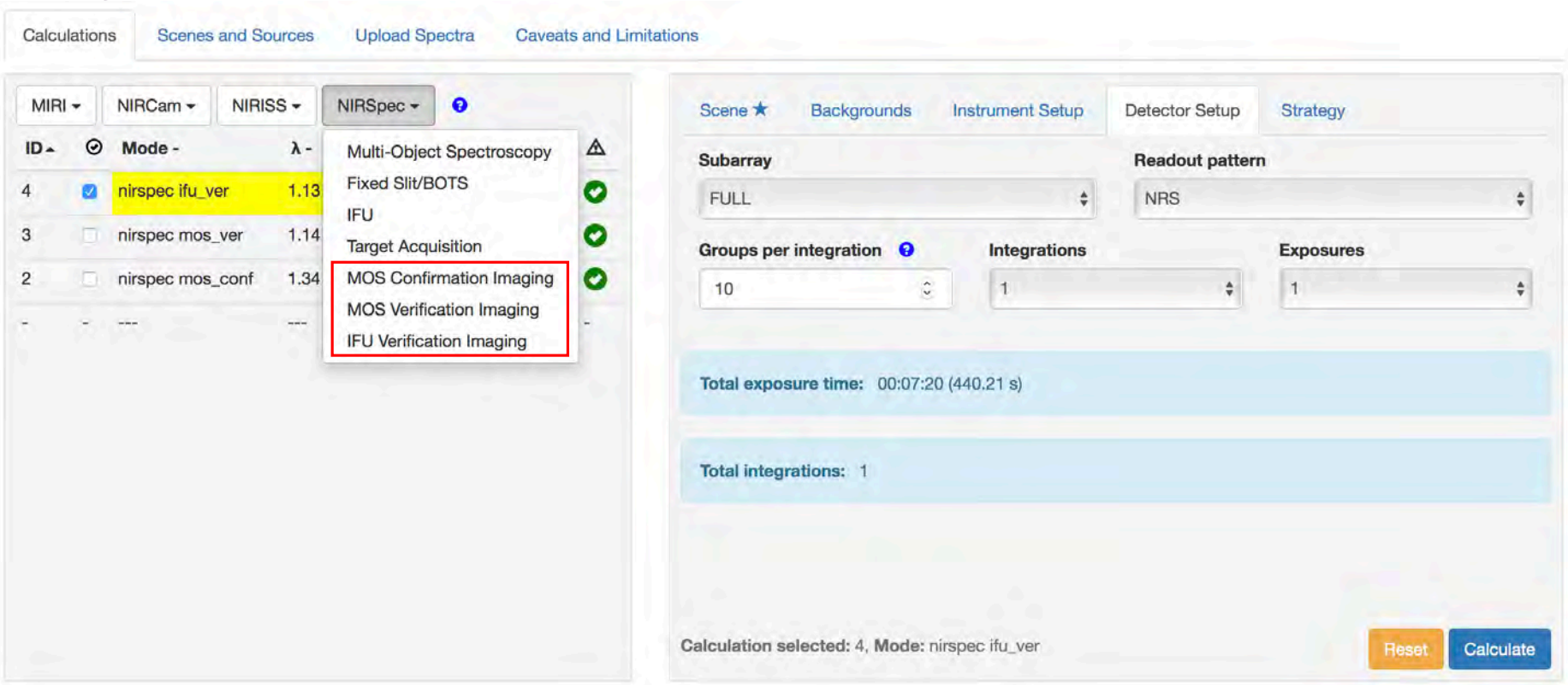
Reimplement MSA planning tool (UT3) – Catalogs are now targets



Reimplement MSA planning tool (UT3) – Manually editor is simpler



Add ETC support for NIRSpec confirmation/verification images (UT)

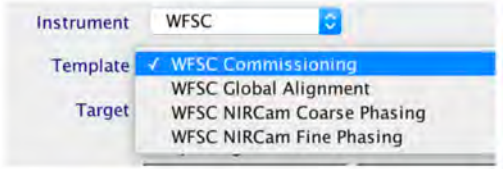


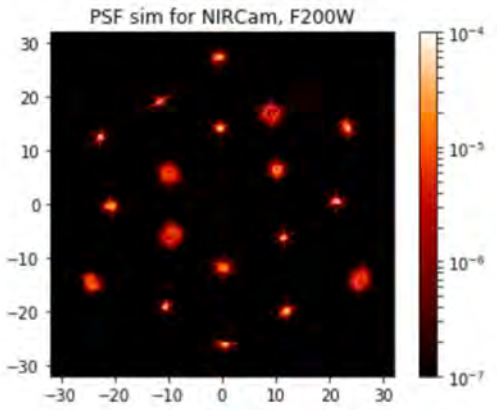
Science enhancements – New science capability (SC)

JIRA Ticket	ID	OSS	Build	Description
	SC1	**Yes**		Enable target locate for saturated stars
JSOCINT-264	SC2	**Yes**	OSS 8.2?	Enable DHS use in NIRCam Grism Time Series
JSOCINT-113	(SC)	**Yes**	OSS 8.2?	Add filter options to NIRCam TA (brighter targets)
JSOCINT-104	(SC)	**Yes**	**OSS 8.1**	Allow FASTGOUPAVG=8/16/32/64 in MIRI TA (relatively easy)
JSOCINT-189	(SC)	No	PPS 14.9	Allow multiple exposures in NIRSpec BOTS

Science enhancements – S&OC enhancement (SE)

JIRA Ticket	ID	OSS	Build	Description
Tracking page	SE1	No	**Ongoing**	Generate simulated data
	SE2	No	**WebbPSF 0.8.1**	Enhance model of wavefront error (commissioning scenarios)





Fix bugs in implemented capabilities and address liens

JIRA Ticket	ID	OSS	Build	Description
JSOCINT-146	(bug)	Yes	**OSS 8.1**	Improve robustness of NIRSpec TA (NRSRAPIDD6 pattern)
JWSTOSS-6537	(bug)	Yes	**OSS 8.1**	Use bad pixel mask during MIRI TA
JWSTOSS-6810	(bug)	Yes	**OSS 8.1**	Allow dithering for MIRI external flats
Dozens more relevant to commissioning, S&OC architecture, requirements verification, etc.				

Improve robustness of NIRSpec target acquisition

- Cosmic ray mitigation during NIRSpec target acquisition
  - Find centroid in image cutout: Min(Group2–Group1, Group3–Group2)
- NIRSpec target acquisition uses two detector readout patterns
  - NRSRAPID – each group consists of one frame
  - NRS – each group is the average of four frames
- Problem occurs when cosmic ray occurs in in the middle of a group
  - G1: [0, 0, 0, 0] → 0 ; G2: [0, 0, 10k, 10k] → 5k ; G3: [10k, 10k, 10k, 10k] → 10k
  - Min(G2-G1, G3-G2) = 5k due to cosmic ray, not the target
  - Predicted to impact 23% of NRS centroids in a full-frame MSA target acquisition
- Solution is to ignore (drop) most frames in a group: NRSRAPIDD6
  - G1: [0, x, x, x, x, x] → 0 ; G2: [0, x, x, x, x, x] → 0 ; G3: [10k] → 10k
  - Min(G2-G1, G3-G2) = 0 mitigating the cosmic ray

Priorities for JWST work by Instrument Division over next 6 months

- Now through Cycle 1 General Observer Call for Proposals on 2020 Jan 23
- Instruments Division staff (astronomers, scientists, analysts)

Priority	Task
1	Prepare curriculum for and support Master Class (see presentation by Bonnie Meinke)
2	Support rehearsals in the Mission Operations Center using the Observatory Test Bed simulator
3	Support update of the APT timing model ⓘ
4	Evaluate DMS 7.3 calibration pipeline and report any bugs
5	Support data analysis tools development (product owners, developers, validation)
6	Improve robustness of INS developed user tools (e.g., visibility tool)
7	Support NIRSpec MSA Planning Tool rewrite/release
8	Make any remaining changes to science instrument aperture file needed for launch
9	Begin submitting APT files for Cycle 1 calibration programs

More priorities for JWST work by Instrument Division

Priority	Task
10	Provide science inputs for science enhancements listed in the launch delay letter
11	Provide science inputs for important pipeline enhancements
12	Generate simulated data for pipeline/tools testing (also: release MIRAGE simulator)
13	Support Exposure Time Calculator (ETC) development
14	Update JDox and videos for Cycle 1 Call for Proposals (beyond Master Class, timing model, etc.)
15	Support MIRI detector tests at JPL
16	Promptly answer Help Desk questions (volume should be low)
17	Develop pipeline validation tests and report issues (particularly for associations)
18	Maintain calibration pipeline reference files. Updates needed by DMS are higher priority
19	Continue developing commissioning analysis plans, code, and simulated data
20	Develop initial set of monitors for science performance trending tool (JWQL)

APT timing model

- Overheads currently in APT are based on ground tests with OSS 5
- JWST software (S&OC, OSS, flight software) has evolved since then
- Observatory Test Bed (OTB) runs latest OSS and flight software
  - Has some flight-like hardware (e.g., ISIM computer)
  - Simulates instruments (including detector electronics) in software
- S&OC is using OTB telemetry to update APT timing model
  - Development branch available for internal testing by end of September
  - Public release in mid-December (PPS 14.9) before GO Call for Proposals
  - Release minor updates in March (PPS 14.10) before proposal deadline

Changes will be to overhead duration

Charged duration =

- Slew duration +
- **Scheduling duration** +
- Direct scheduling overhead +
- Indirect overhead

Scheduling duration =

- Science duration +
- **Overhead duration**

Overhead duration =

- Initial overheads +
- Visit start overheads +
- Between overheads +
- SAM times +
- Mechanism move times +
- Exposure overheads +
- SI specific overheads +
- Visit cleanup

Examples of changes to overhead duration

- Reduce OSS compile times
- Reduce detector setup overheads for some exposures
- Add time to drop guiding before a small angle maneuver
- Add time (~24 s) to manage logical structures in a visit file
- Update time required to handle a failed guide star acquisition
- Update time to slew between FGS ID and science attitude
- Update time to process an end of visit (mode dependent)
- Model target acquisitions in more detail (mode dependent)
- Model NIRCam subarray configuration in more detail
- Model new observing strategies (e.g., dither during NIRISS WFSS)

Will visit overheads increase or decrease?

- We don't know yet
  - Many low-level changes to the timing model
  - Need the APT implementation to assess the global impact
- Impact will be mode dependent
- Plan to run GTO/ERS programs and analyze any large changes