



JWST Overheads

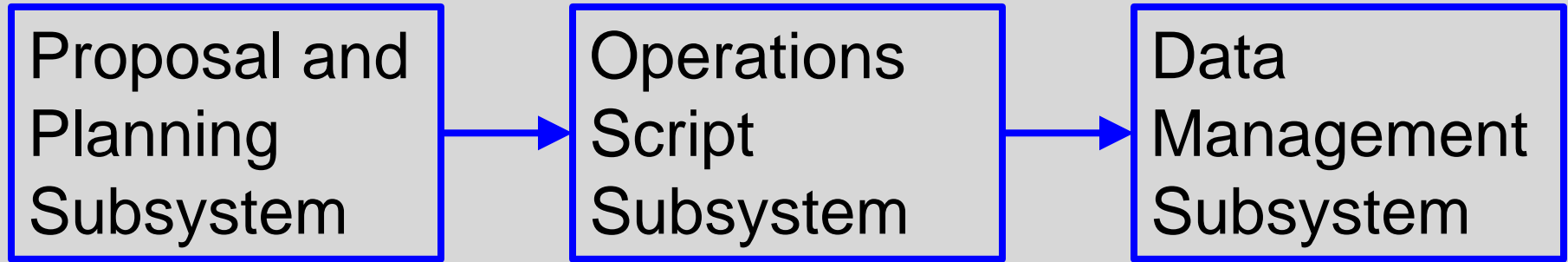
Jeff Valenti

S&OC Mission Scientist

Topics

- JWST observations
- APT timing model
- Observing efficiency

Flow of a program through the system

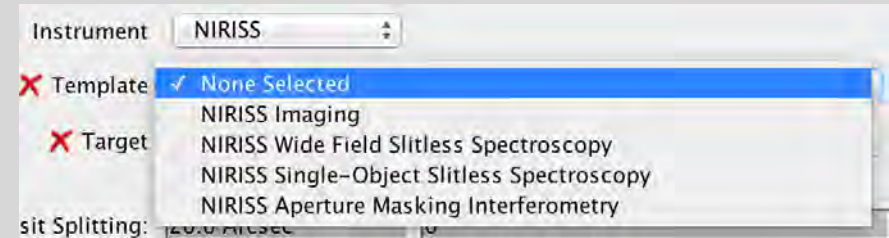
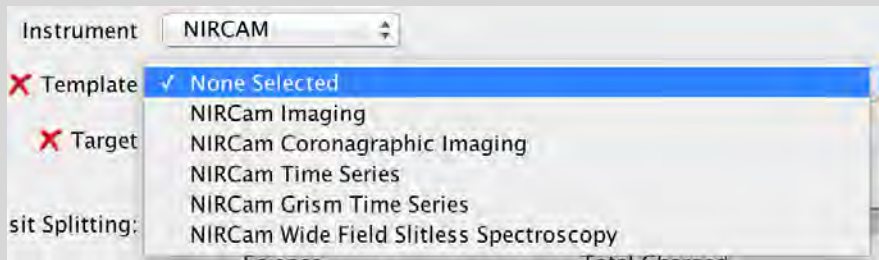
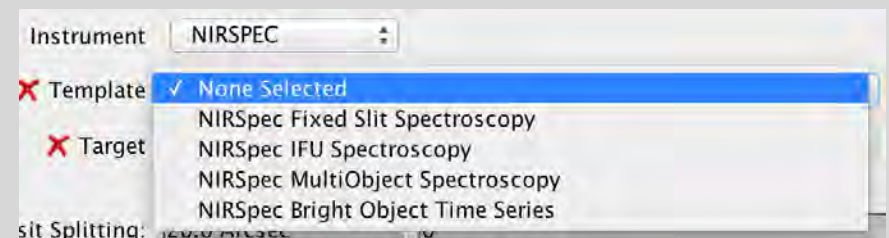
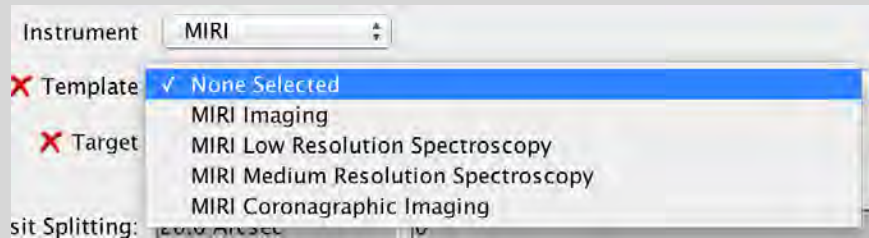


- Proposal tool (APT)
- Program constraints
- Planning
- Scheduling
- Visit files
- Observation plan

- Obs plan executive
- Onboard scripts

- Data processing
- Calibration pipeline
- Archive
- Data analysis tools

Science templates in APT



Template, observation, and visit

■ Template

- Constrained observing strategy
- Defines interface between subsystems
- Reduces complexity, but still quite complicated

■ Observation

- An instance of a template
- Expresses a high-level observing task
- Can expand into multiple visits

■ Visit

- Smallest scheduling unit
- Usually begins with a guide star acquisition

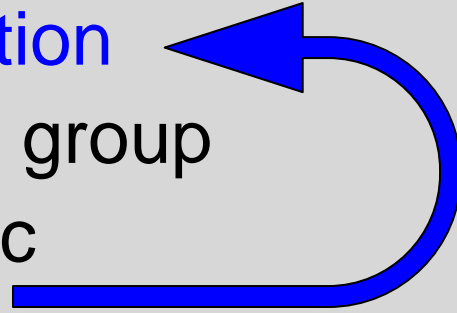
Standard nesting hierarchy for observation

- Targets in a target group
 - Tiles in a mosaic
 - ◆ Instrument configuration
 - ▶ Dither points
 - ★ Exposures
 - Integrations
 - Groups (downlinked to the ground)
 - ✧ Frames (combined into groups)

Modified nesting hierarchy for observation

■ Instrument configuration

- Targets in a target group
 - ◆ Tiles in a mosaic
 - ▶ Dither points
 - ★ Exposures
 - Integrations
 - Groups
 - ✧ Frames



■ Applies only to these three templates:

- MIRI MRS , NIRSpec IFU , NIRSpec fixed slit

Topics

- JWST observations
- APT timing model
- Observing efficiency

Resource usage philosophy

- APT estimates resource usage in terms of mission-elapsed time required to carry out a program:
 - Science time, when any pixel is collecting photons that contribute to groups downloaded to the ground.
 - Direct overheads associated with a visit, including the slew to a target, any wait for an observer-specified time window, and time during a visit before, between, and after integrations.
 - Indirect overheads for observatory maintenance, such as instrument calibration, wavefront sensing and control, and momentum management.

APT timing model – top level

■ Charged duration

- Slew time
 - ◆ Initial slew in a scheduling set (1800 s)
 - ◆ Smart accounting slew (assumes no other programs)
- Scheduling duration
 - ◆ Science duration
 - ◆ Instrument overhead (expanded in next two charts)
- Direct scheduling overhead
 - ◆ Tight timing window (currently 1 hour)
 - ◆ Rapid target of opportunity
- Observatory overhead (16%)

Instrument overheads – part 1

■ Initial overhead

- Guide star acquisition (282)
- Target acquisition (1200 w/ NIRSpec MSA, 600 otherwise)

■ Small angle maneuvers

- Move (0 for $<0.06''$, 23 for $<20''$, 105 for $20''$, ...)
- Settle (5 FSM, 10 dither, 30 slew)
- Guide star reacquisition (5 for $<0.06''$, 17.5 for $<3''$, 97.5 otherwise)

$<20''$ soon

■ Exposure overhead

- Exposure setup (allocate buffers, configure data flow)
- Frame synchronization ($t_{\text{frame}} * 0.5$)
- Reset (0 for MIRI, $t_{\text{frame}} * n_{\text{int}}$ for NIR)
- Exposure cleanup (deallocate buffers)

Instrument overheads – part 2

- Mechanisms
 - NIRCcam has 8 wheels
- Onboard script compilation
- Configure MSA (20 for arm only, 90 for shutters)
- Switch to or from NIRSpec IRS2 mode.
- Visit setup (compile constraint scripts)
- Visit cleanup
 - Exposure setup (allocate buffers, configure data flow)
 - Frame synchronization ($t_{\text{frame}} * 0.5$)
 - Reset (0 for MIRI, $t_{\text{frame}} * n_{\text{int}}$ for NIR)
 - Exposure cleanup (deallocate buffers)

Diagram of charged duration for a visit

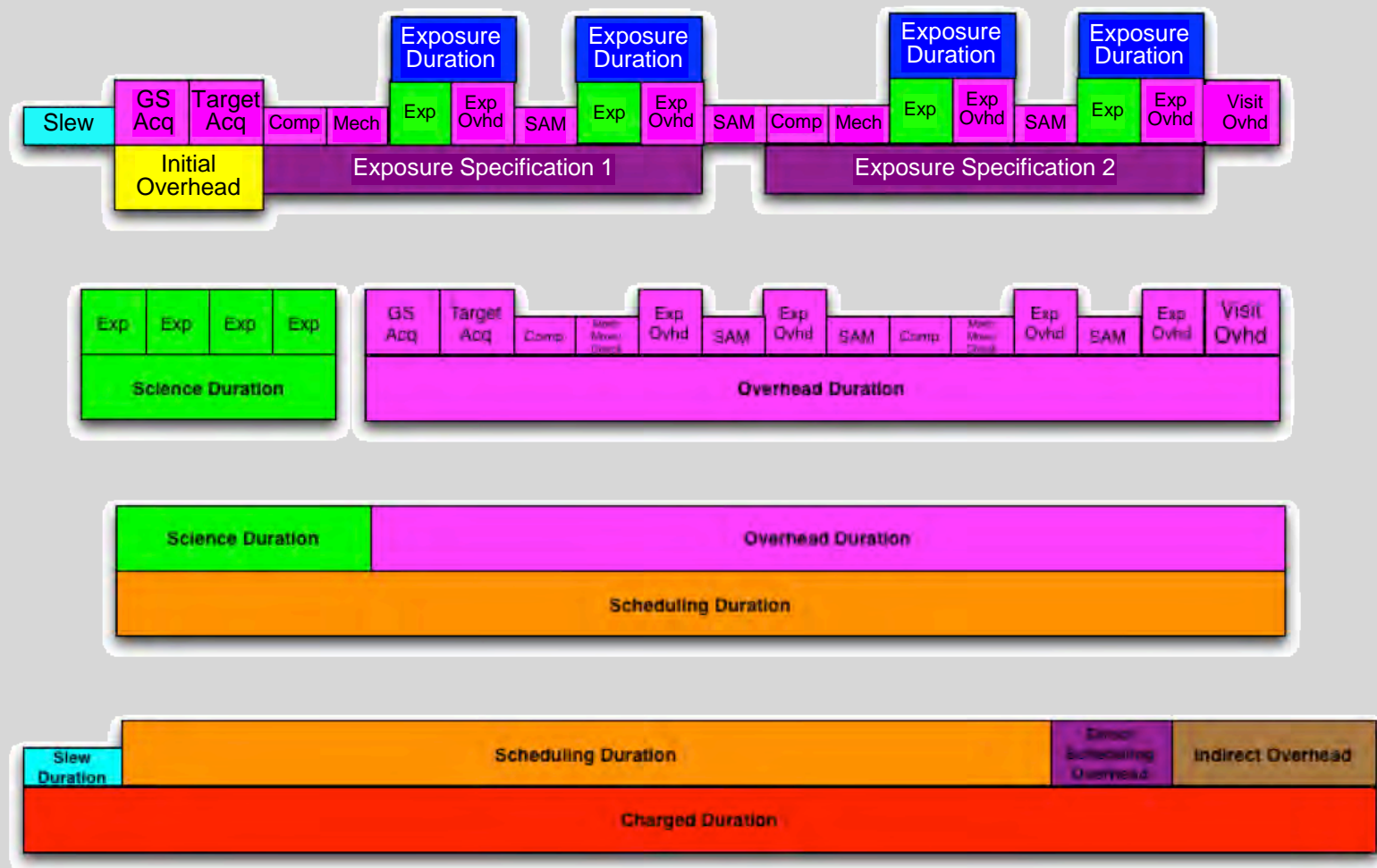


Figure created by Rob Douglas

Diagram of overheads for an exposure

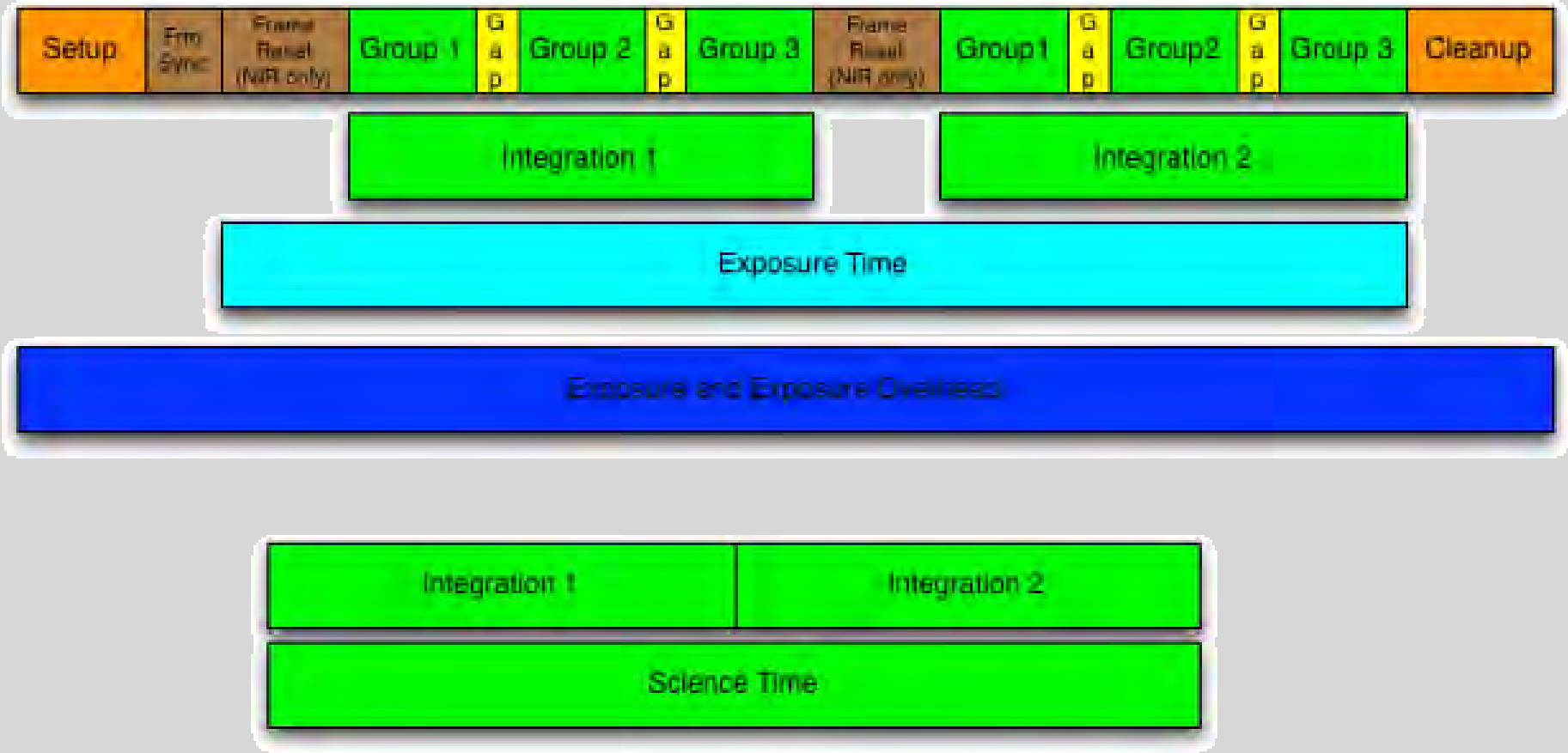


Figure created by Rob Douglas

Getting detailed overheads from APT

In APT: File → Export... → times file → OK

Science Total Time
Duration Charged
 39168 55533

Exposure Specifications:

Exp	SUBARRAY	READOUT	FrameRead	Groups	NFrame	GrpGap	...
1	FULL	DEEP8	10.737	12	8	12	...

Visit Durations:

Visit	Pointing Dist	Science Duration	Instrument Overhead	(GS (SAMs)	(Acq)	(Targ Acq)	(Exp Ovhd)	...
1	0.00	9792	1519	(486)	(282)	(0)	(276)	...
2	283.81	9792	1519	(486)	(282)	(0)	(276)	
3	291.34	9792	1519	(486)	(282)	(0)	(276)	
4	283.81	9792	1519	(486)	(282)	(0)	(276)	

Smart accounting

- Does APT know execution order?
 - ✓ Pointings in a visit – YES
 - ✗ Order of visits in all programs – NO
- Smart accounting mock schedules visits in program
 - Respects all scheduling constraints
 - Ignores potential impact of all other programs
 - Visits that schedule back-to-back form a "scheduling set"
 - ◆ Split a scheduling set that spans more than 1 degree
 - ◆ Split a scheduling set longer than 2 day
 - One "initial slew" overhead for each scheduling set
 - ◆ Initial slew overhead is currently 30 minutes

Smart accounting example – form editor

JWST Draft Proposal (twosi.a)

- Proposal Information
- Targets
- Observations
 - Observation Folder
 - NIRSpec Slit (Obs 1)**
 - MIRI MRS (Obs 2)
 - Observation Links

NIRSpec Slit (Obs 1) of JWST Draft Proposal (twosi.a.ptx)

Template: NIRSpec Fixed Slit Spectroscopy

Target: 1 V-BP-TAU

Splitting Distance: 70.0 Arcsec Number of Visits: 1

Visit Splitting: 70.0 Arcsec 1

Science: Total Charged: 3637

Duration (secs): 185 3637

Data volume: 262 MB

NIRSpec Fixed Slit Spectroscopy Mosaic Properties Special Requirements Comments

Target Acquisition Parameters

NirSpec Target Acquisitions using the MSA are designed for each visit.

Science Parameters

Slit: S200A1

Subarray: SUBS200A1

Primary Dither Positions: 5 Sub-Pixel Pattern: NONE

Dither Parameters: 5 NONE

#	Grating/Filter	Readout Pattern	No. of Groups	No. of Integrati...	Autocal	Photon Collect...	Total Photon C...
1	G140H/F100LP	NRSRAPID	3	1	NONE	4.672	23.36
2	G235H/F170LP	NRSRAPID	5	1	NONE	7.786	38.93
3	G395H/F290LP	NRSRAPID	15	1	NONE	23.359	116.7950000...

Edit Observation Folder New Edit Visit 1:1

Observation	Number	Label	Science	Total Charged	Parallel/Instrument	Template	Co... Co...	Target	Number of ...	Splitting Di...
NIRSpec Slit (Obs 1)	1	... NIRSpec Slit	185	3637	NIRSPEC	NIRSpec Fixed Slit...		1 V-BP-TAU	1	70.0 Arcsec
MIRI MRS (Obs 2)	2	... MIRI MRS	252	3692	MIRI	MIRI Medium Res...		1 V-BP-TAU	1	70.0 Arcsec

Show: Observation

Smart accounting example – visit planner

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

New Document | New Observation Folder | JWST What's New | **NEW!** HST What's New | Roadmap | Feedback

JWST Draft Proposal (twosi.a

- ▶ Proposal Information
- ▶ Targets
- ▶ **Observations**
 - ▶ Observation Folder
 - ▶ NIRSpec Slit (Obs 1)
 - ▶ MIRI MRS (Obs 2)
 - ▶ Observation Links

Zoom

Current Range (UT): ~ 17 Months

19.060:00:00:00 | 01-Apr-19 00:00:00 | 24-Jun-19 00:00:00 | 16-Sep-19 00:00:00 | 09-Dec-19 00:00:00 | 02-Mar-20 00:00:00 | 25-May-20 00:00:00

- ▶ ✓ NIRSpec Slit (Obs 1)
- ▶ ✓ MIRI MRS (Obs 2)

Update Display | Reports | Print

All selected visits are schedulable.

Visit Δ	Status	Reference ...	Science	Instrument..	Slew	Observato...	Direct Sche...	Total Char...
Visit 1:1			185	2700	250	502	0	3637
Visit 2:1			252	1130	1800	510	0	3692

Show: Visit

A few tips for reducing overheads

- Design observations that can schedule back to back.
 - Less slew time (as reported by smart accounting)
- Minimize visit splitting
 - Use tighter dither patterns
 - Increase mosaic tile overlap
 - Use target groups
- Use multiple integrations rather than repeat exposures at the same dither point.
- **Don't sacrifice science for the sake of efficiency!**

Timing model liens

- Detailed timing model for target acquisition
- Overhead for sequential tasks during parallels
 - Script compilation for parallel instrument
 - Mechanisms for parallel instrument
- Moving Targets
 - Missing guide star acquisition overhead
 - Missing smart accounting savings
- Include slew time for rolls in smart accounting
 - Affects coronagraphy
- Other updates possible...

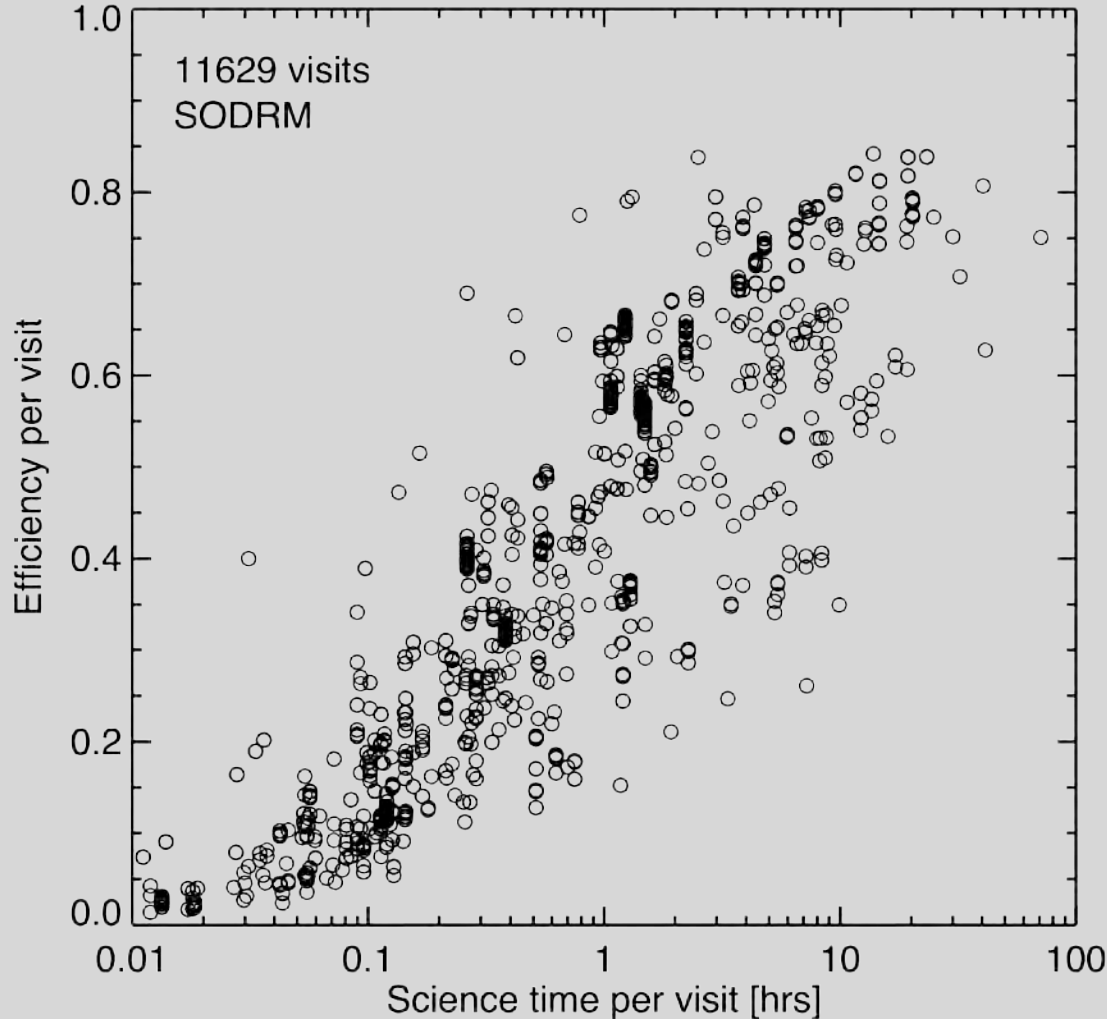
Topics

- JWST observations
- APT timing model
- Observing efficiency

SODRM overview

- Science Operations Design Reference Mission
 - ~100 representative science and calibration programs
 - ~12,000 visits
 - ~2 years to execute
- Purpose
 - Study mechanism usage
 - Study scheduling algorithms
 - ◆ Study momentum management
 - ◆ Study solid state recorder usage
 - Study overheads
- Will be superseded by actual Cycle 1 programs

Deep exposures are more efficient...

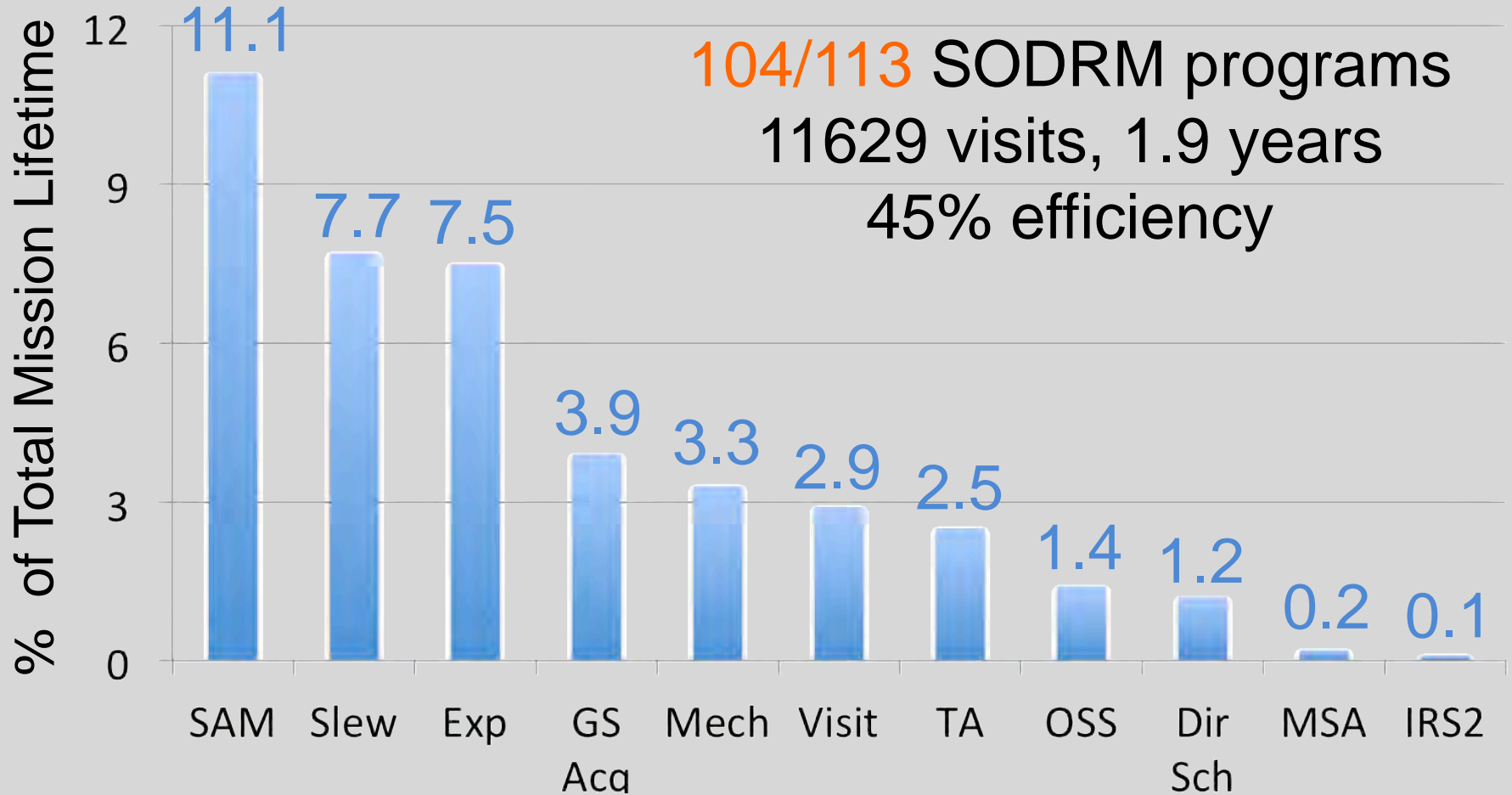


But time allocation committee assesses science per unit time.

Shallow observations with JWST can be transformative.

Don't focus too much on efficiency at the proposal stage.

SODRM overheads in APT 25.0.4



SODRM overheads by template type

total	sci	slew	dir	gs	ta	oss	mech	msa	sam	exp	irs2	vis	obs	effic	si	template
5286	1850	762	0	464	0	99	378	0	286	315	0	397	729	0.35	nrc	Imaging
4209	1215	195	80	102	0	41	82	0	1466	437	0	18	569	0.29	mir	Imaging
2181	1240	131	0	45	96	17	18	0	194	126	0	8	300	0.57	mir	MRS
1414	549	139	0	44	160	57	42	14	93	91	1	26	195	0.39	nrs	IFU
1035	819	17	4	5	21	3	5	1	6	4	0	1	142	0.79	nrs	FS
879	539	40	81	6	13	1	2	0	0	82	0	2	110	0.61	nrs	BOTS
641	399	25	46	3	8	0	0	0	0	73	0	0	82	0.62	nis	SOSS
512	252	19	0	13	56	13	31	9	0	12	5	27	70	0.49	nrs	MOS
331	211	9	0	7	0	6	9	0	20	18	0	1	45	0.64	nis	WFSS
277	120	30	0	15	33	2	4	0	7	5	0	17	38	0.43	nrc	Coron
262	80	36	0	24	51	2	4	0	18	3	0	4	36	0.31	mir	Coron
231	122	7	1	1	2	0	0	0	1	62	0	1	31	0.53	nrc	TSO
226	81	36	17	13	29	1	2	0	10	2	0	2	28	0.36	mir	LRS
223	91	7	0	1	3	1	1	0	18	67	0	0	30	0.41	nis	AMI
13	4	3	0	1	0	0	0	0	0	0	0	1	0.31	nis	Imaging	
8	1	3	0	0	0	0	0	0	0	0	0	1	0.12	nrs	Imaging	

Results for APT 25.0.4 – some changes expected

Legend for the previous slide

total	Total charged time (sum of science time and all overheads)
sci	Science time (exposure time contributing to downloaded signal)
slew	Slew time at start of a visit (1800 seconds or smart accounting value)
dir	Direct scheduling overhead (tight timing window, target of opportunity)
gs	Guide star acquisition overhead (start of visit)
ta	Target acquisition overhead (still a placeholder value)
oss	Operations script subsystem overhead (compiling activity description scripts)
mech	Instrument mechanism overhead (wheels, lamps, not the MSA)
sam	Small angle maneuver overhead (slew, settle, guide star reacquisition)
exp	Exposure overhead (exposure time not contributing to downloaded signal)
vis	End of visit overhead (script compilation, wheels to home, stop guiding)
obs	Observatory overhead (activities not directly associated with science visits)

Efficiency enhancement work

- Faster guide star reacquisition after a dither
- Remove wait when MIRI readout mode changes
- Allow more integrations for NIRCcam subarray image
- Eliminate mechanism moves after a NIRCcam visit
- Implement new target acquisition type for NIRSpec
- Reorder dither pointings
- Reorder mosaic tiles
- Reorder instrument configurations

- *Balance efficiency work against other priorities.*

Key points

– JWST observations

- An observation is an instance of an APT template
- APT breaks an observation into one or more visits
- Nesting hierarchy is implicit for a given template

– APT timing model

- There are several types of overheads
- Design observations that can schedule back to back
- Avoid visit splitting, but don't compromise the science

– Observing efficiency

- TAC will assess science per unit time
- SODRM indicates most important overheads
- Efficiency enhancements will be implemented over time