Observing with JWST: Operations, Proposing, & What it all Means for NIRSpec

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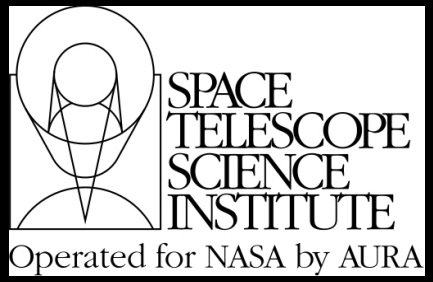
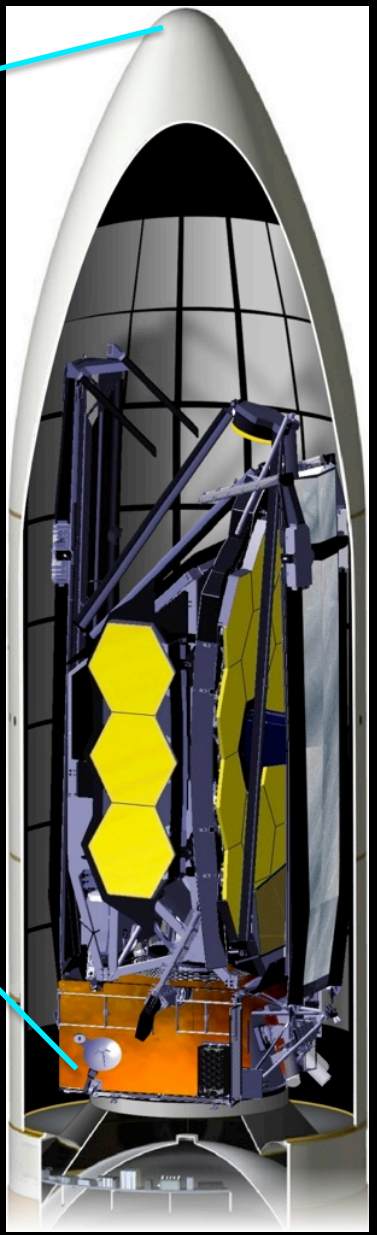


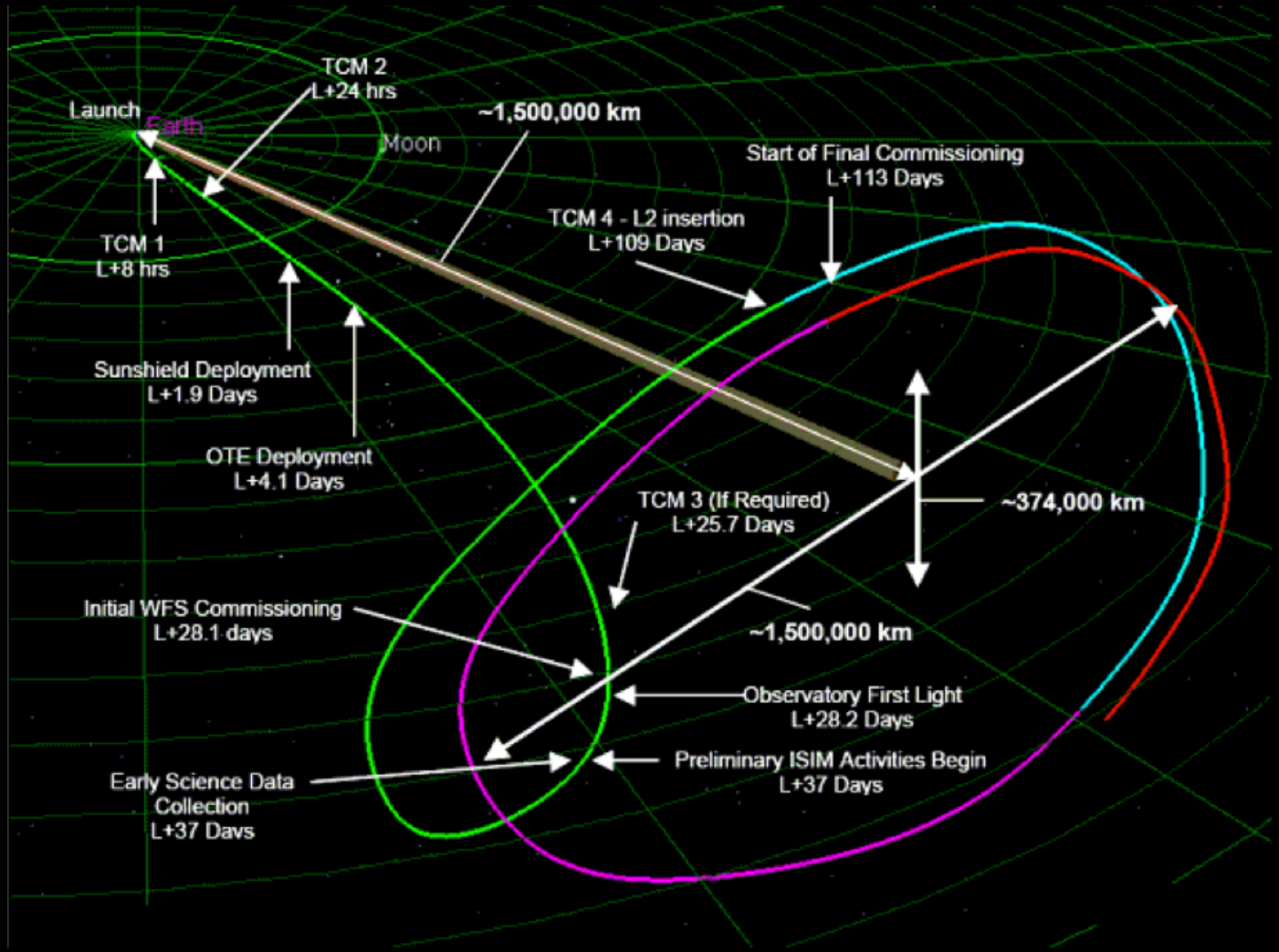
The JWST Partnership

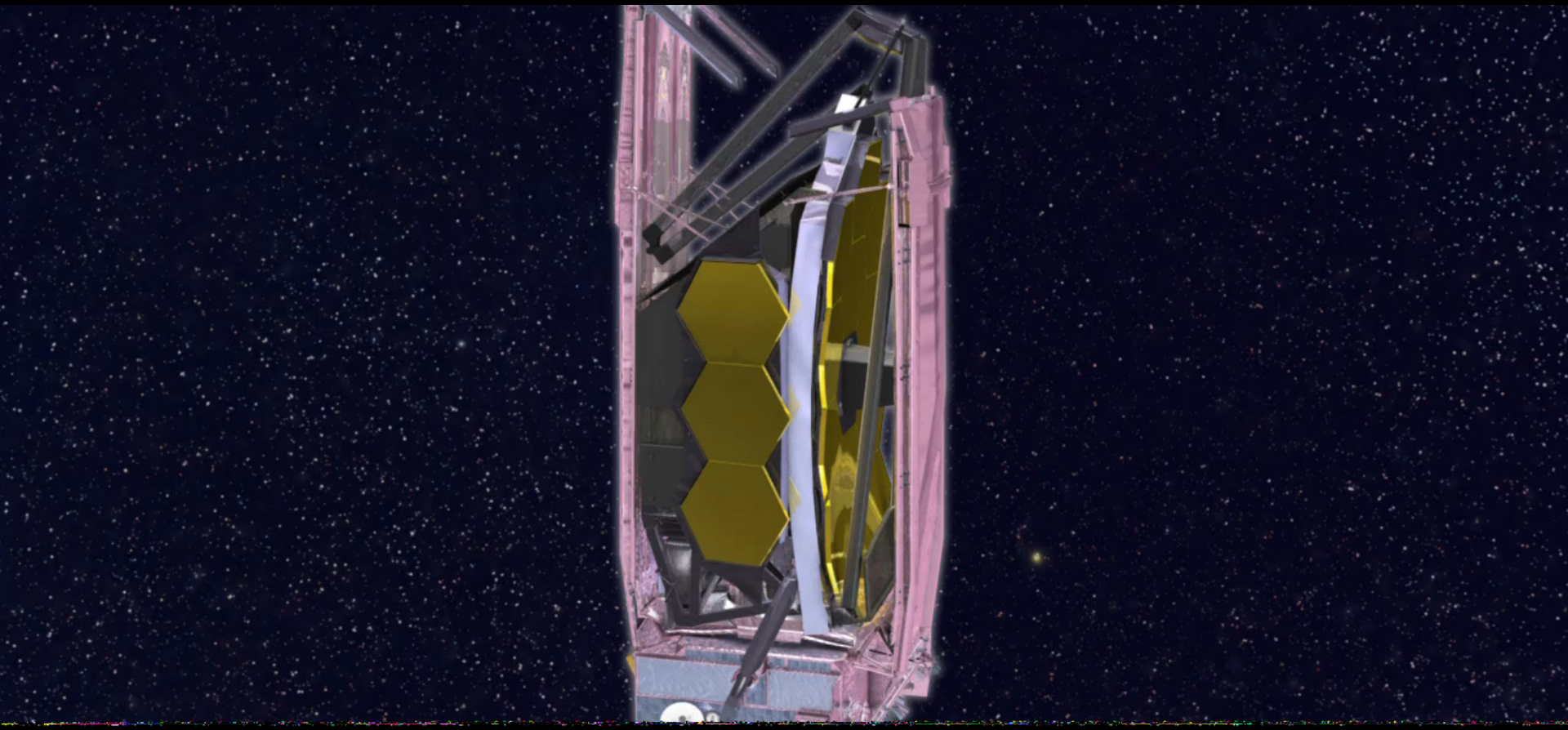
- JWST is an international partnership between NASA, ESA and CSA:
- National Aeronautics & Space Administration –
  - Managing, Integrating & Testing JWST at Goddard SFC NASA Facility, Greenbelt, MD
  - Building Spacecraft, sun-shield, telescope (Northrup-Grumann, Ball Aerospace, major industrial partners)
  - Building 1.5 of the 4 science instruments: NIRCam (including WFS&C), ½ of MIRI
  - Operates JWST at the Science & Operations Center at STScI (Baltimore, MD)
- Canadian Space Agency
  - Building the Fine Guidance Sensor (FGS) / NIRISS Instrument
  - Leading the effort on JWST Guiding Capabilities
- European Space Agency
  - Launching JWST to its L2 orbit on an Ariane 5 rocket
  - Building 1.5 of the 4 science instruments: NIRSpec, ½ of MIRI

JWST, to be Launched in an ESA Ariane 5 Rocket in 2018

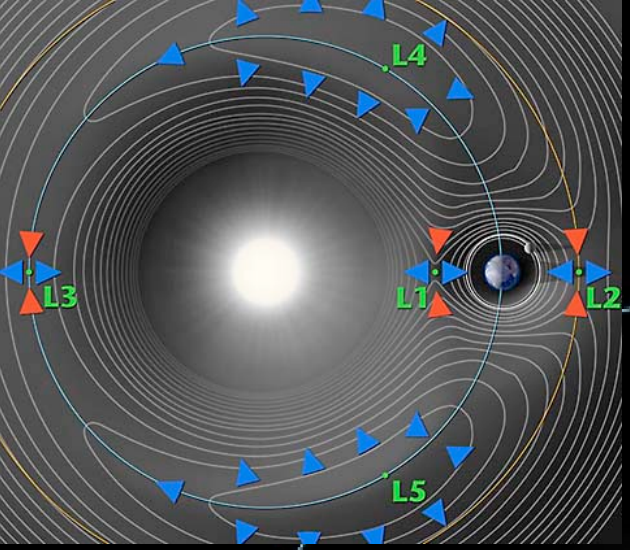


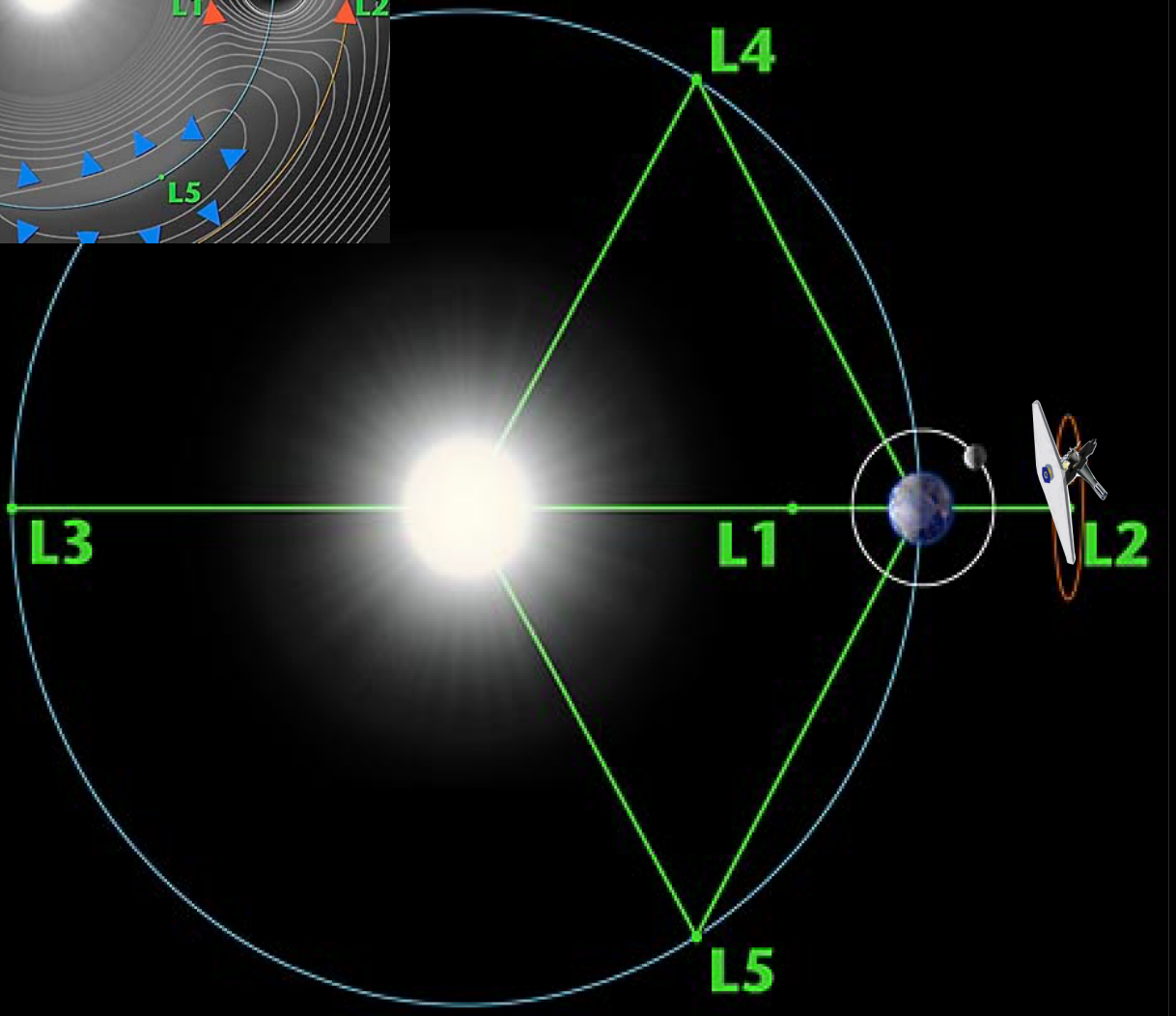
Observing with JWST





JWST Operations

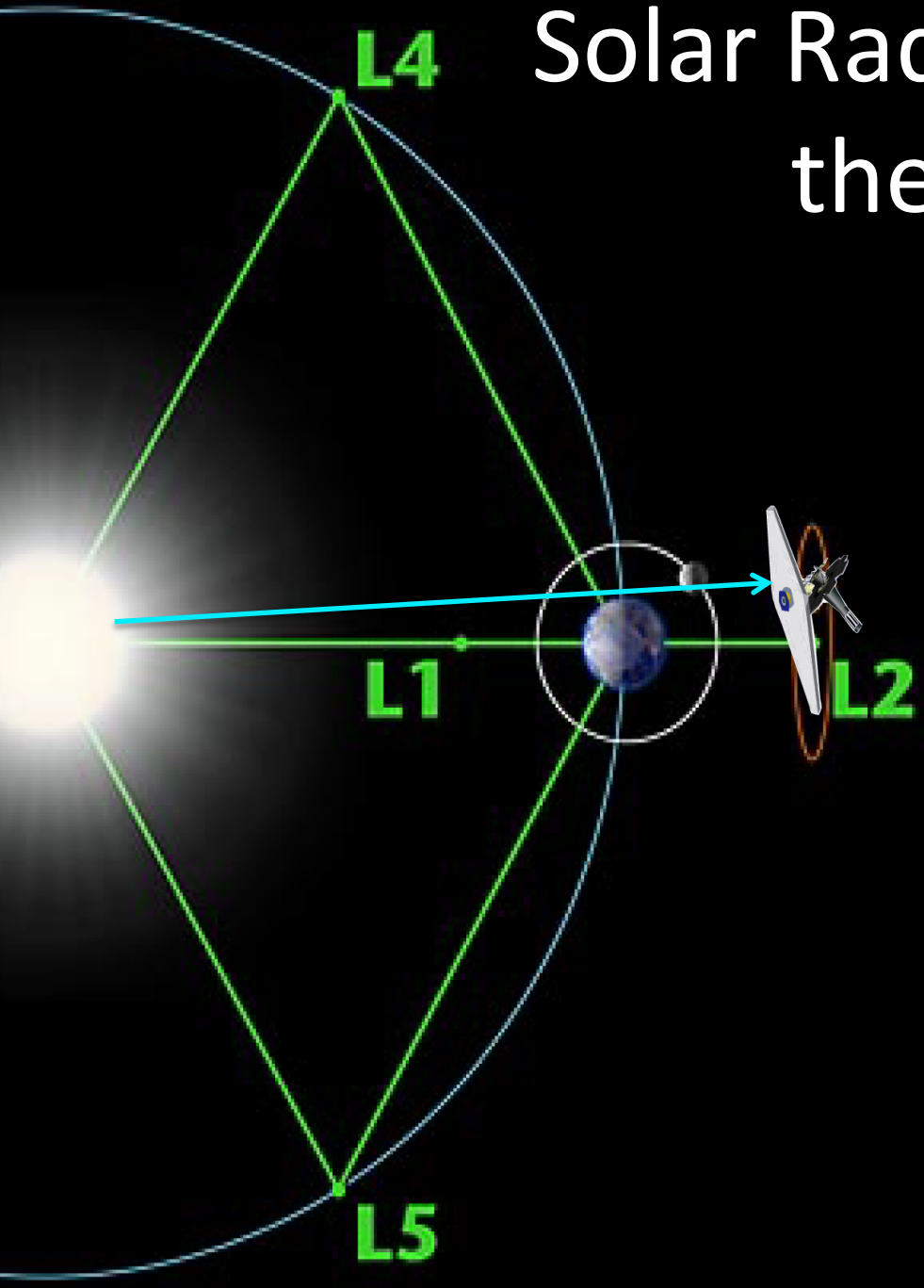




JWST in a Lissajous Orbit at L2

"Station Keeping" is required, approximately every ~3 weeks

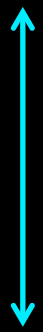
Solar Radiation Pressure on the Sun Shield…



Solar Radiation Pressure Vector not aligned with Observatory center of Gravity? Torque is applied to the observatory!

Reaction Wheel Assembly (RWA) stores torque accumulated by radiation pressure, “dumps” momentum by firing balancing thrusters = “Momentum Management” (*on average* ~2days***)

Observing with JWST:
Wavefront Sensing and Control



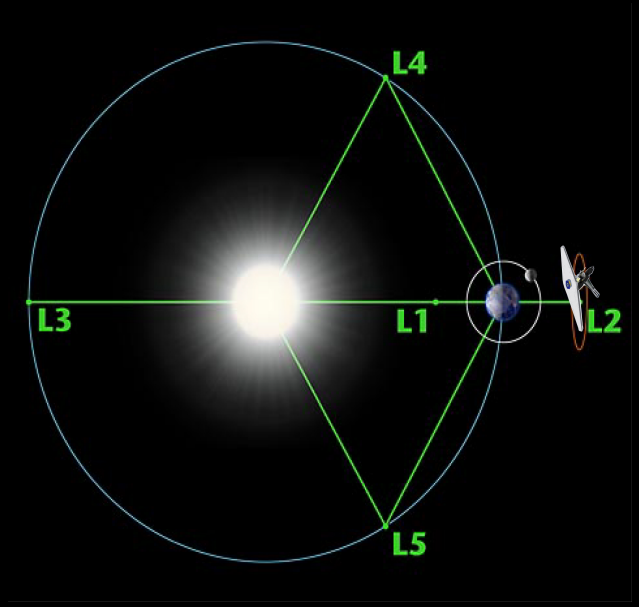
18 Mirror Segmented Primary

Need to monitor and control wave-front shape to ensure optimal image quality…

Monitoring, every ~2 days…

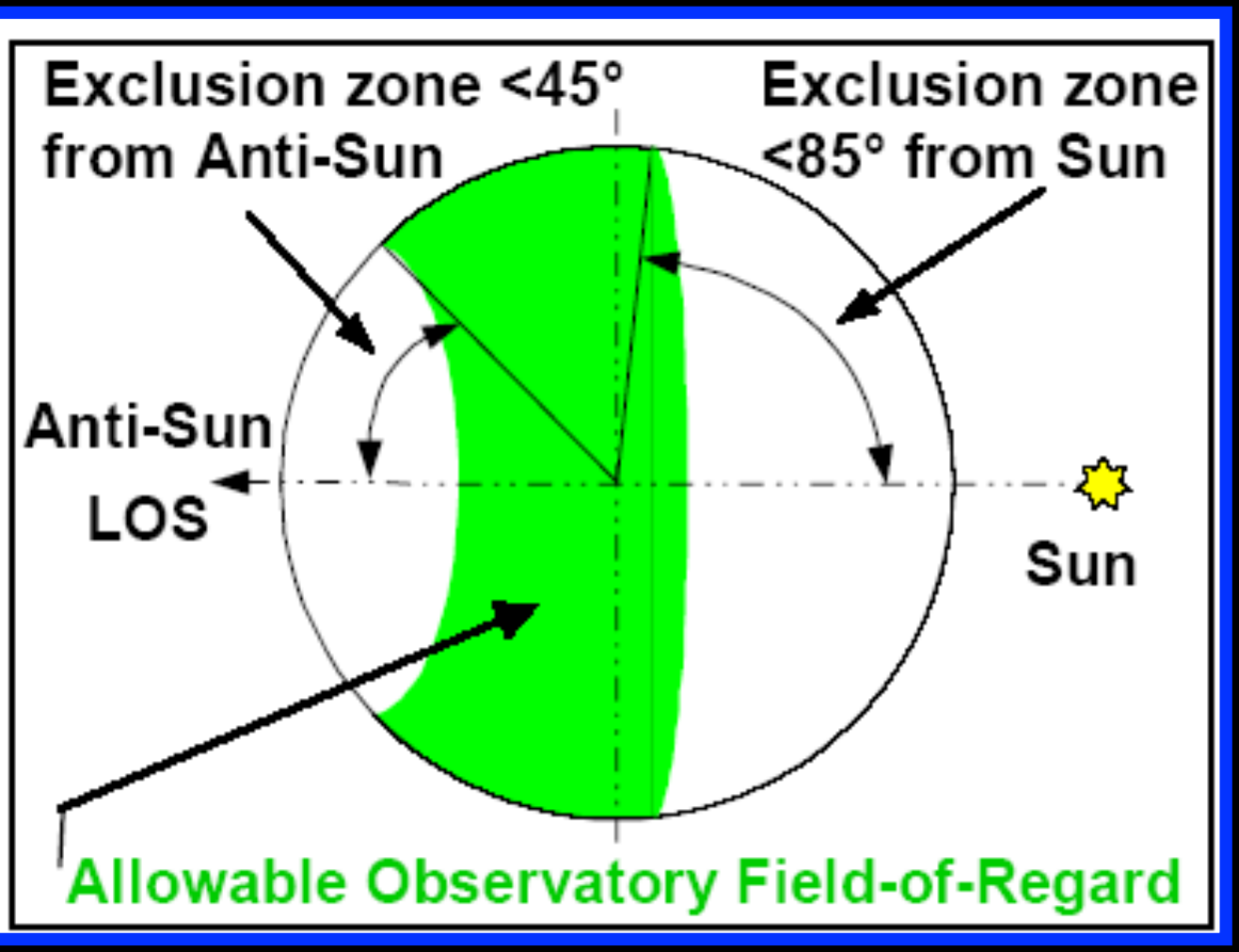
Control, every ~ 2 weeks

Observing with JWST – Indirect Overheads



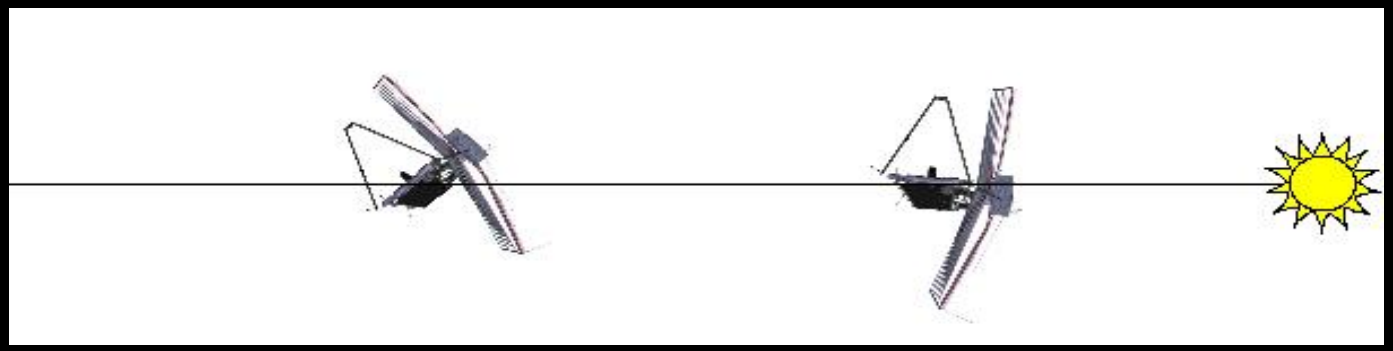
- "Indirect Overheads" – Activities that take time and are required for proper observatory function and performance:
- Station Keeping (~3 Weeks)
- Momentum Management (~2 days)**
- Wavefront Sensing (~2 days)
- Wavefront Control (~2 weeks)
- + Other indirect overheads, real-time procedures, Flight Software (FSW) updates, instrument calibration, etc…

These activities subtract from available observing time =
Total Indirect Overheads amount to ~15% of Observatory Time

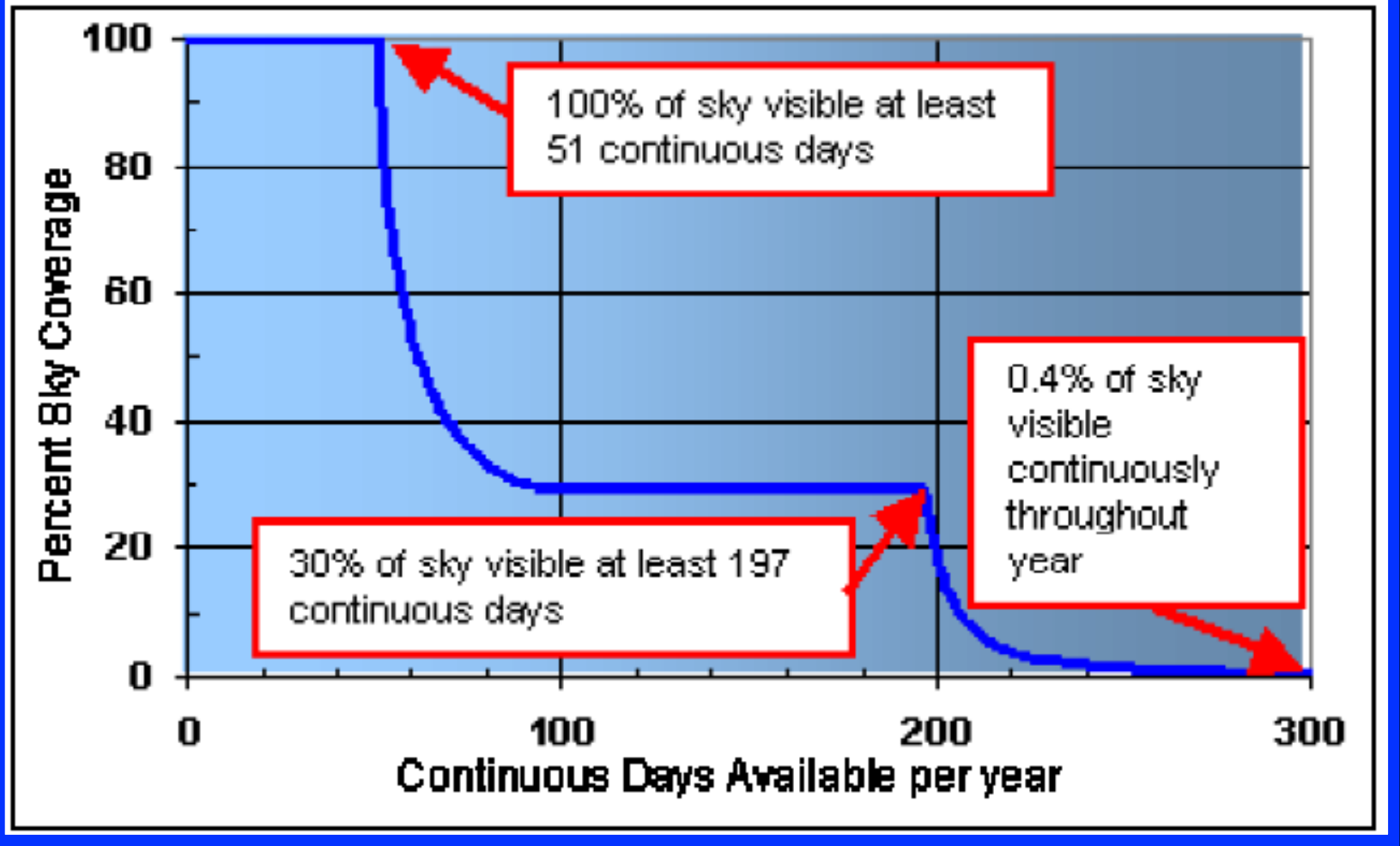


Observing with JWST – Spacecraft Pointing

JWST's Field Of Regard is 45 degrees wide, it can't point anti-sunward!

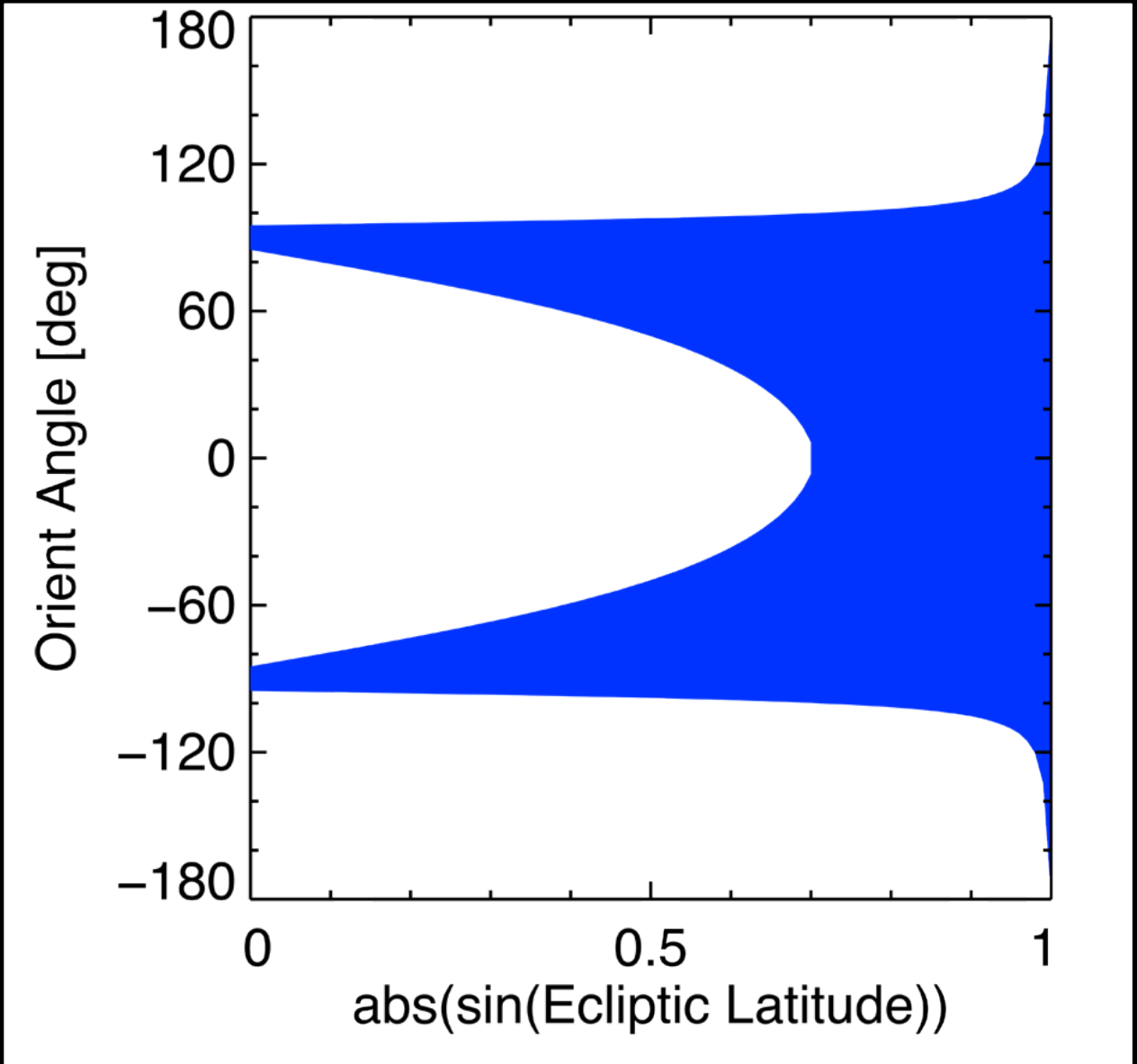


Observing with JWST – Sky Viewing Coverage



JWST has 100% coverage of the sky for at least 51 days, but only a very small region (the CVZ) is viewable all the time

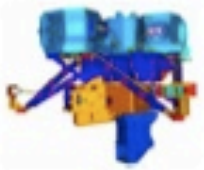
Observing with JWST – Spacecraft Pointing



- & As a result, MANY pointings with JWST will have restricted Orient availability

- The Two extremes:
- At the ecliptic poles (0.4% of the sky), ALL orients are available, but a specific orient is schedulable for only ~10 days.
- In the ecliptic plane, only specific orient ranges are possible, those are available for ~50 day windows.

JWST Instruments and Observing Modes

Instrument	Science Goal	Key Capability
NIRCam Univ. Az 	*Wide field, deep imaging* ⇒ 0.6 μm - 2.3 μm (SW) ⇒ 2.4 μm - 5.0 μm (LW)	Two 2.2' x 2.2' SW Two 2.2' x 2.2' LW
NIRSpec ESA 	*Multi-object spectroscopy* ⇒ 0.6 μm - 5.0 μm	9.7 Sq arcmin Ω 100 selectable targets R=100, 1000
MIRI ESA/JPL 	*Mid-infrared imaging* ⇒ 5 μm - 27 μm *Mid-infrared spectroscopy* ⇒ 4.9 μm - 28.8 μm	1.9' x1.4' 3.7"x3.7" - 7.1"x7.7" R=3000 - 2250
FGS / NIRISS CSA 	*Fine Guidance Sensor* ⇒ 0.8 μm - 5 μm *NIR Imager & Slitless Spectro* ⇒ 1.6 μm - 4.9 μm	Two 2.3' x 2.3' 2.2' x 2.2' R=100

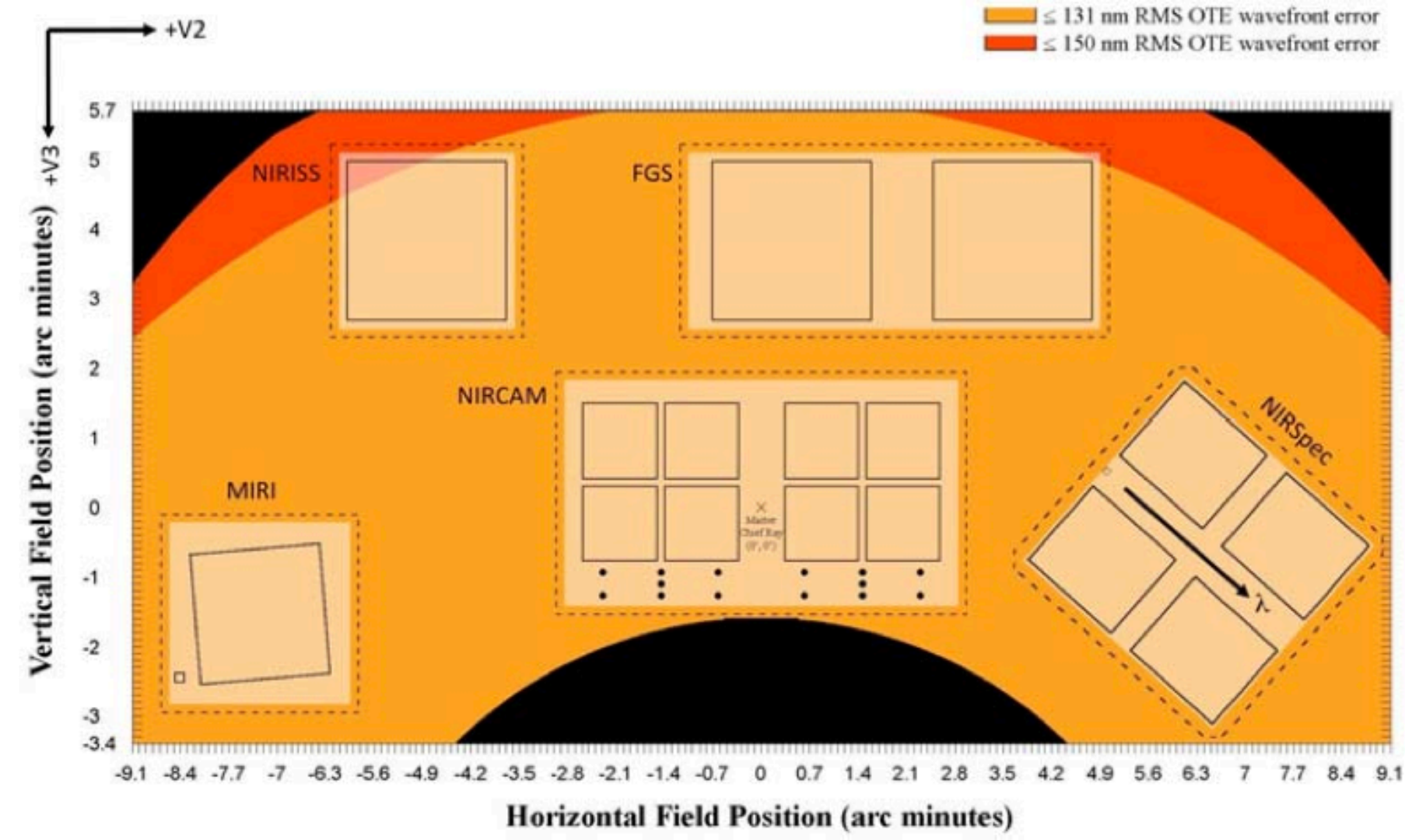
Imaging
Grism
Coronography

IFU
MOS
Fixed Slit

Imaging
Coronography
Low Res
Spectra
Med Res
Spectra

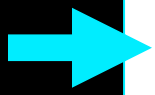
Imaging
Coronography
NRM

Observing with JWST – JWST Instruments in the Focal Plane



Observing with JWST… the HST Foundation

- The Space Telescope Science Institute Serves as the Science & Operations Center for JWST
  - STScI operates the *Hubble Space Telescope*, much expertise on *Hubble* is being translated to JWST
  - The model for the proposal and observation definition process and scheduling comes from the "Phase I" / "Phase II" process of Hubble



The NIRSpec instrument has prime capabilities that have not been handled by *Hubble*… especially IFU, and MOS spectroscopy with the MSAs

Observing with JWST

- Organization of JWST Observing
  - "Visit" = A set of data acquired with a given instrument mode, which uses a specific guide star.
    - Visits acquire "exposures" - .fits files, & may be science observations, target acquisition activities, or calibration exposures.
    - Visit durations are limited to ~24 hrs (duration is likely constrained by momentum management activities)
  - Visits may be grouped together for efficient scheduling and observing – Rules for this are still being worked out...

The Time Necessary to Slew JWST to a new science target can be significant. JWST moves 90 degrees across the sky in 1 hour, so we need to optimize the scheduling!

JWST Operations – Observing Overheads

- Slew Time…
  - As mentioned, JWST Slew time can be significant - 90 degrees in 1 hour
  - The concept of an "Observation" was adopted as a means to group visits that *could be* executed together, to minimize slew overheads.
  - Actual slew tax for Observations & grouped visits is TBD, and will likely be based on a *statistical average* model for slew distances…

Direct Overheads – Are charged to your science program because they are mostly program-specific. Slew time is a *direct overhead*.

JWST Operations – Observing Overheads

- Slew to your JWST Field of Science Interest… then…
  - Acquire your guide star…
  - Execute target acquisition (For NIRSpec, this can be a lengthy process for MSA observations)
  - Set up the science instrument for your requested configuration…
  - THEN… acquire science exposures…
    - Dither…
    - Acquire more science exposures… etc…

These are all *Direct Overheads* – They are charged to your science program because they are program-specific

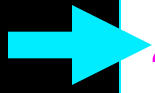
JWST Operations – Observing Overheads

- Programmatic direct overheads include:
  - slew time [statistical average]
  - guide star acquisition
  - target acquisition (if needed)
  - time for SI science set-up, mechanism movements
  - total time exposing
  - time for dithers
  - time to tile a mosaic, observe targets in a given area (multi-visit)
  - other taxes that may be levied (i.e., timing constraints, etc…)

Direct Overheads –serve to decrease overall observing efficiency. Programs with short exposures and a lot of dithers can be extremely inefficient (4%?!). Long exposures are better!

JWST Operations – The Observing Process

- As for HST, JWST Science will operate based on Observing *Cycles:*
  - The "Call For Proposals" is released to the astronomical Community
  - Prospective General Observers (GOs) write their science proposal, and fill out examples of their observations in the "Phase I" process using the Astronomers Proposal Tool (APT)
  - The Time Allocation Committee (TAC) meets – programs are assigned time (or not!...)
  - The "Phase II" process refines instructions for science programs to create an executable file in APT…



The First Call For Proposal for JWST Observing Time will go out ~18 months prior to the Launch date (~sometime in late 2016)

JWST Observing Process

Proposer

GO Proposals Cycle Boundary

DD Proposals Accepted Anytime

Phase I

Guide Star Availability Check

PI uses ETC To Determine Amount of Time Needed

PI uses APT To Prepare Science Proposal

Peer Review Of Science Proposals

STScI Director Review & Approval

Preparing Science Proposal for Science Review

PI Gets Time on the Observatory ***YEAH!***

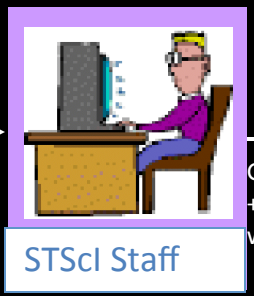
GO Programs

Grant Process Begins (MONEY!!! $$)

Guide Stars

Proposal Constraint Generator

Phase II



STScI Staff

GO Programs, + Calib & Eng work

PI uses ETC To Prepare Observations For Flight

APT used to Develop Sci/Cal/Eng Program

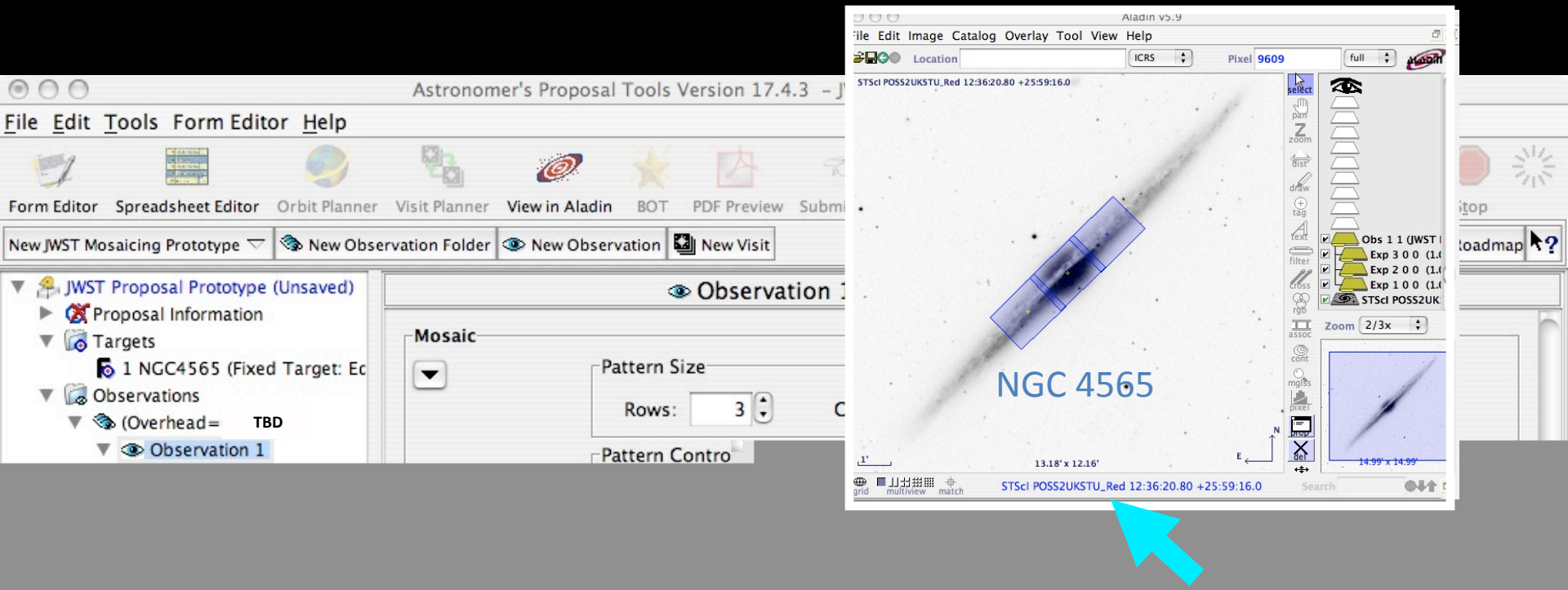
Long Range Planning

Short Term Scheduling

JWST Observing Process

- "Phase I" - Proposing & Observing Definition in TEMPLATES in the *APT*
  - Proposers for JWST time will use the TEMPLATES = interfaces to JWST instrument capabilities that don't require users to define details of every single exposure
  - Goal is to have Phase I program definition *as complete as possible at the proposal submission time!*
  - Guide star *availability* must be verified in Phase I check before proposal submission (*JWST* guide field is much smaller than HST)

JWST Phase I Templates, MIRI Imaging Example



Defines Aperture
Orient on the sky, not spacecraft orient

More on the Planning interface for NIRSpec in MSA Planning Tool Presentation on Thursday

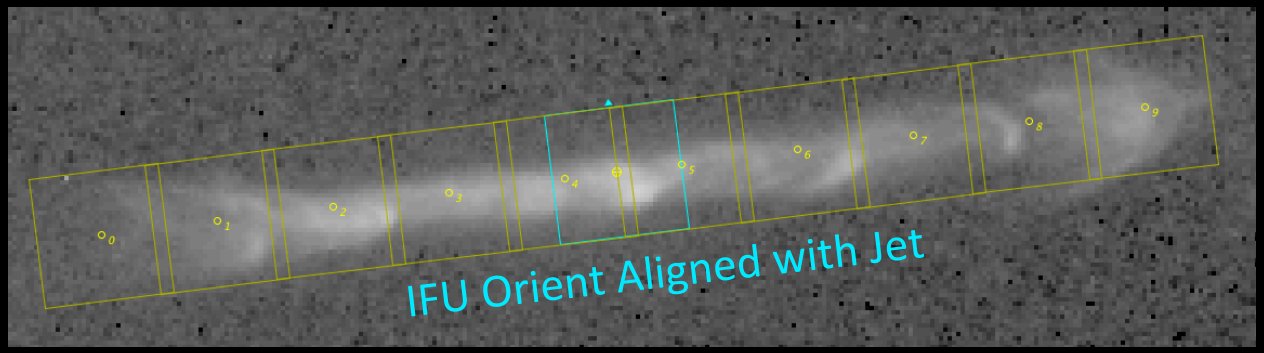
JWST Observing Process

- "Phase II" - Finalizing Observations for Execution
  - While our goal is to have as many proposals submitted as complete as possible, it is not feasible *to require* that all programs are executable at Phase I.
  - The Phase II uses the same syntax, same upload as the Phase I submission.
  - STScI Staff will interact with GOs to ensure that their Phase II observations are in good executable shape at the Phase II deadline.
  - (NIRSpec MSA Mode is a "problem child!"…. More on this in a minute…)

JWST Observing Process – Scheduling Cycles

- Planning And Scheduling -
  - After the Proposal Deadline and the TAC meets and accepts programs, the JWST Observing Cycle has been defined.
  - STScI will create a draft "Long Range Plan" (LRP), which provides a rough outline of the planning for the Cycle**.
  - Programs will be assigned potential Observing windows (visit windows), & within these windows spacecraft orient (ranges) and timing constraints will be set. Visit windows will be finalized after final Phase II deadline.
  - The Short Term Schedule (2-3 week durations) is built after the Phase II deadline, using the LRP as a guideline.
  - A hope is that many science programs will be unconstrained in orient, & they can slip into the long and short range plans as scheduling will allow…

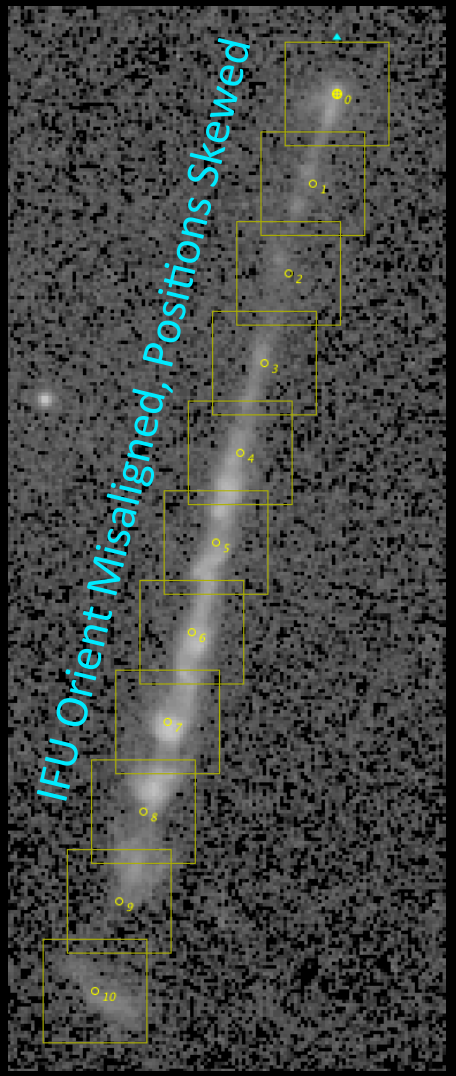
JWST Observing Process – Flexible Orient NIRSpec Observations?



IFU Observations of Outflows from Young Stars…

(HST Hα images, with 3”x3” IFU Pointings Overplotted)

(Targets near ecliptic, orient will be restricted!)



JWST Observing Process – Why NIRSpec is a "Problem Child"

- In many Cases, NIRSpec MSA Observations will "break" the previously described Phase I/II Format… WHY?...

NIRSpec MSA Science requires ***Pre-Imaging*** of the science field to define where the targets of interest are…

- If pre-images of a field are not available at very precise coordinate accuracy (5mas catalog coordinate accuracy is necessary for TA), then pre-images must be acquired.
- If pre-imaging is needed, this will be taken with NIRCam, & the images must be taken before NIRSpec MSA science can be planned.
- Phase I proposal deadline → NIRCam Phase II Deadline for Imaging → NIRSpec MOS Spectroscopy Phase (II take 2?) Deadline! There's an extra step in the process!

JWST Observing Process – Why NIRSpec is a "Problem Child"

- In many Cases, NIRSpec MSA Observations will "break" the previously described Phase I/II Format… WHY?...

Nearly All NIRSpec MSA Observations will Require a ***FIXED Orient…***

  - Orient for NIRSpec MSA defined at Phase I (when pre-imaging is available) or FIXED after the Phase II MSA definition Process
  - Can't alter the orient after MSA plan completion for new scheduling windows, or targets will rotate out of their planned MSA shutters!
  - Scheduling of these programs could be tricky, the fixed orient means a more rigid execution window.
  - Very long duration observations may need multiple orients used to complete science (especially out of the ecliptic, 10 day limit on orients in CVZ).

Observing with JWST…
(and NIRSpec!)

- Summarized JWST Observatory Characteristics and Operations
- Outlined JWST Observing Overheads, Indirect and Direct
- Outlined JWST Proposal Process, APT and the Phase I, Phase II System
- Highlighted Some Key Features for NIRSpec Operations

Any Questions?