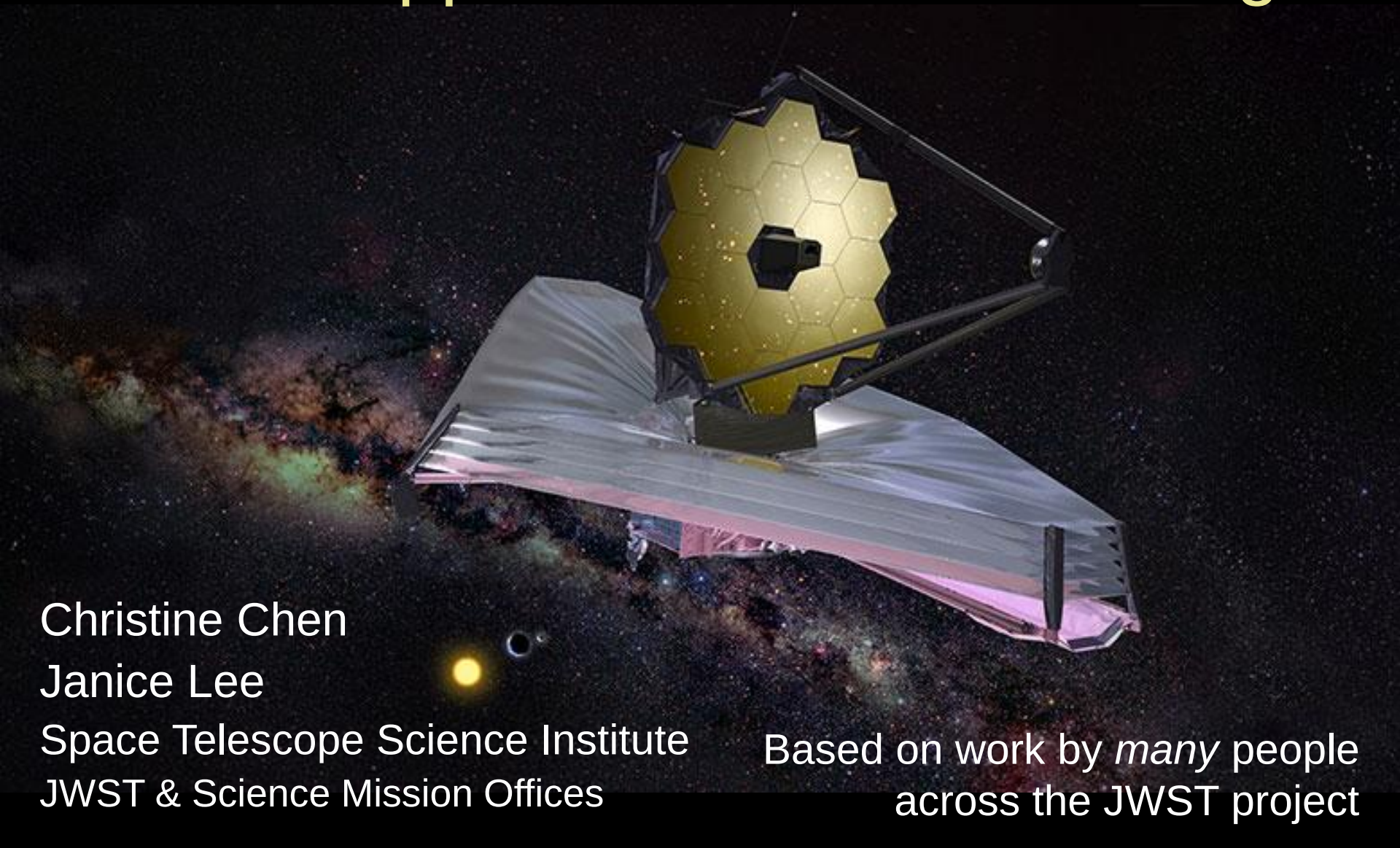
Getting Ready for JWST: Science Opportunities and Challenges

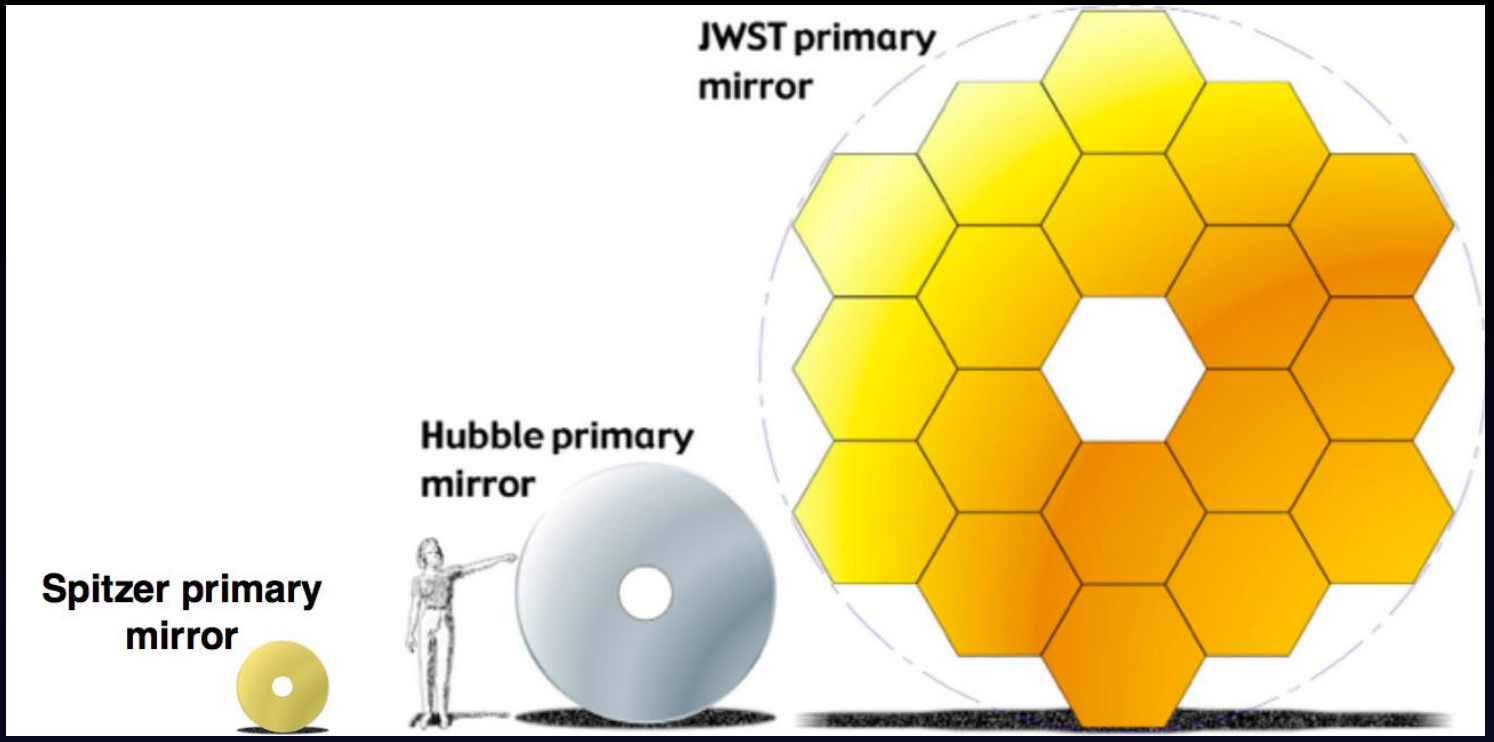


Christine Chen
Janice Lee
Space Telescope Science Institute
JWST & Science Mission Offices

Based on work by *many* people across the JWST project

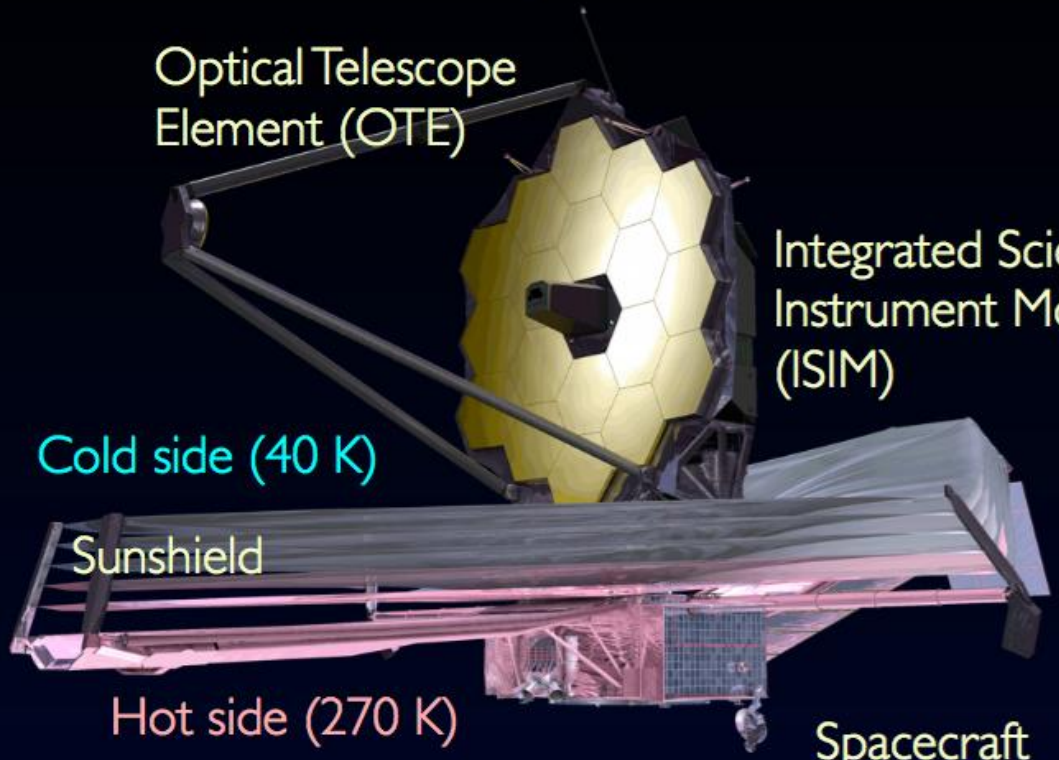
Outline

- JWST:
  - *Observatory Design*
  - *Project Status*
- Science Opportunities:
  - *Observatory Timeline*
  - *Early Release Science (ERS) Program*
- Observer Support:
  - *User Tools*
  - *Additional Educational Opportunities*



	Hubble	Spitzer	JWST
Primary diameter	2.4	0.85	6.6
Collecting Area (m^2)	4.24	0.5	26.3
Observatory Mass (kg)	11,000	860	6,300
Observatory Volume, when stowed (m^3)	190	13	155
Orbit Location	LEO	Earth-trailing solar	Sun-Earth L2

JWST Observatory Design

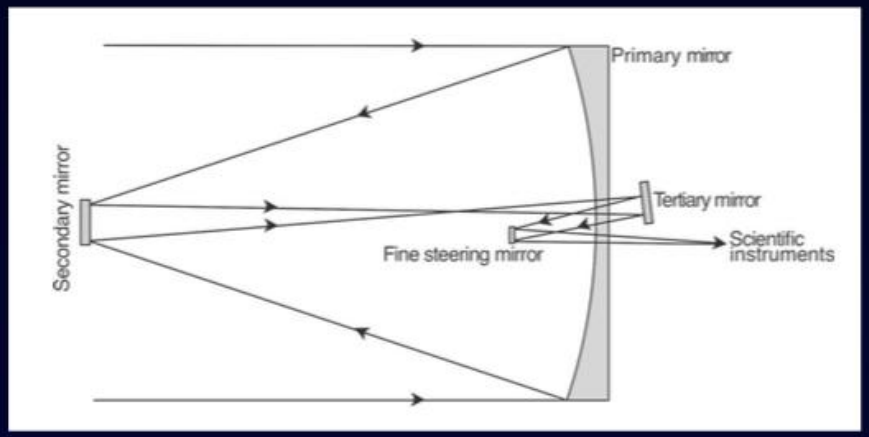


- Passively cooled, open telescope
- Beryllium optics, gold coated

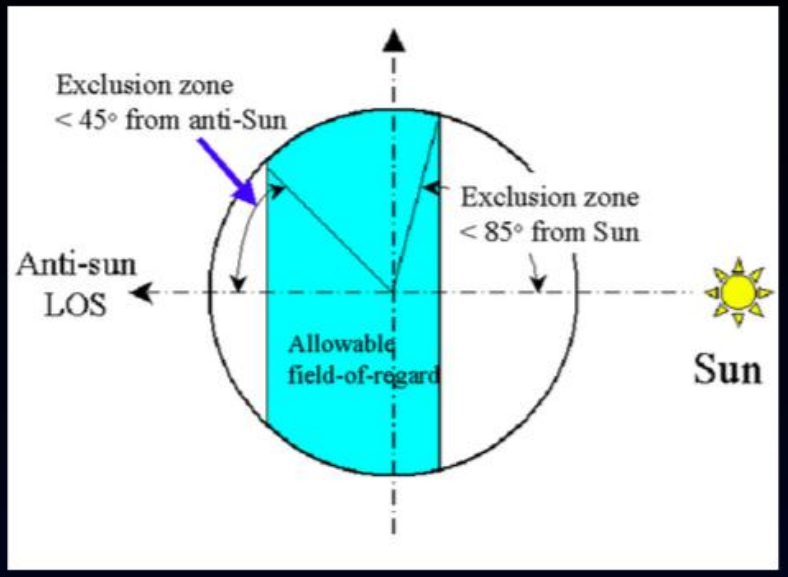
  Lightweight and stiff, very low CTE
- Three Mirror Anastigmat

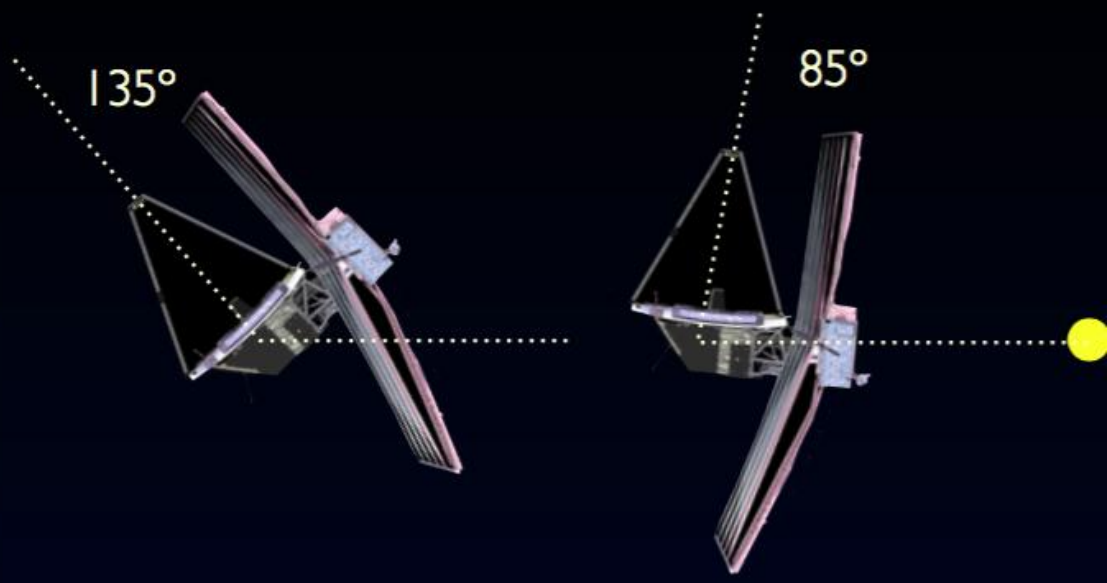
  Relatively wide field diffraction limited performance.
- Fine steering mirror driven by FGS at 15 Hz

  7 mas rms pointing control
- Baffles for stray light at intermediate image and focal planes.



Field of Regard and Orientation are constrained



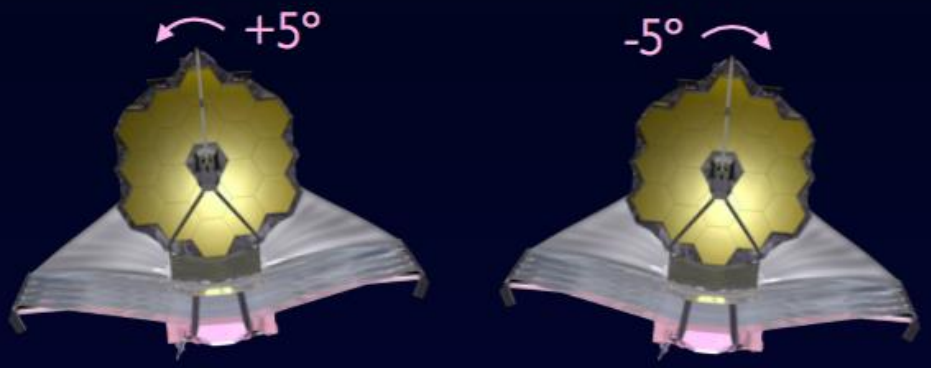


49.8% of the sky at a time

Pitch: 85°-135° from the sun

Continuous Viewing Zone

above ±85° at ecliptic poles

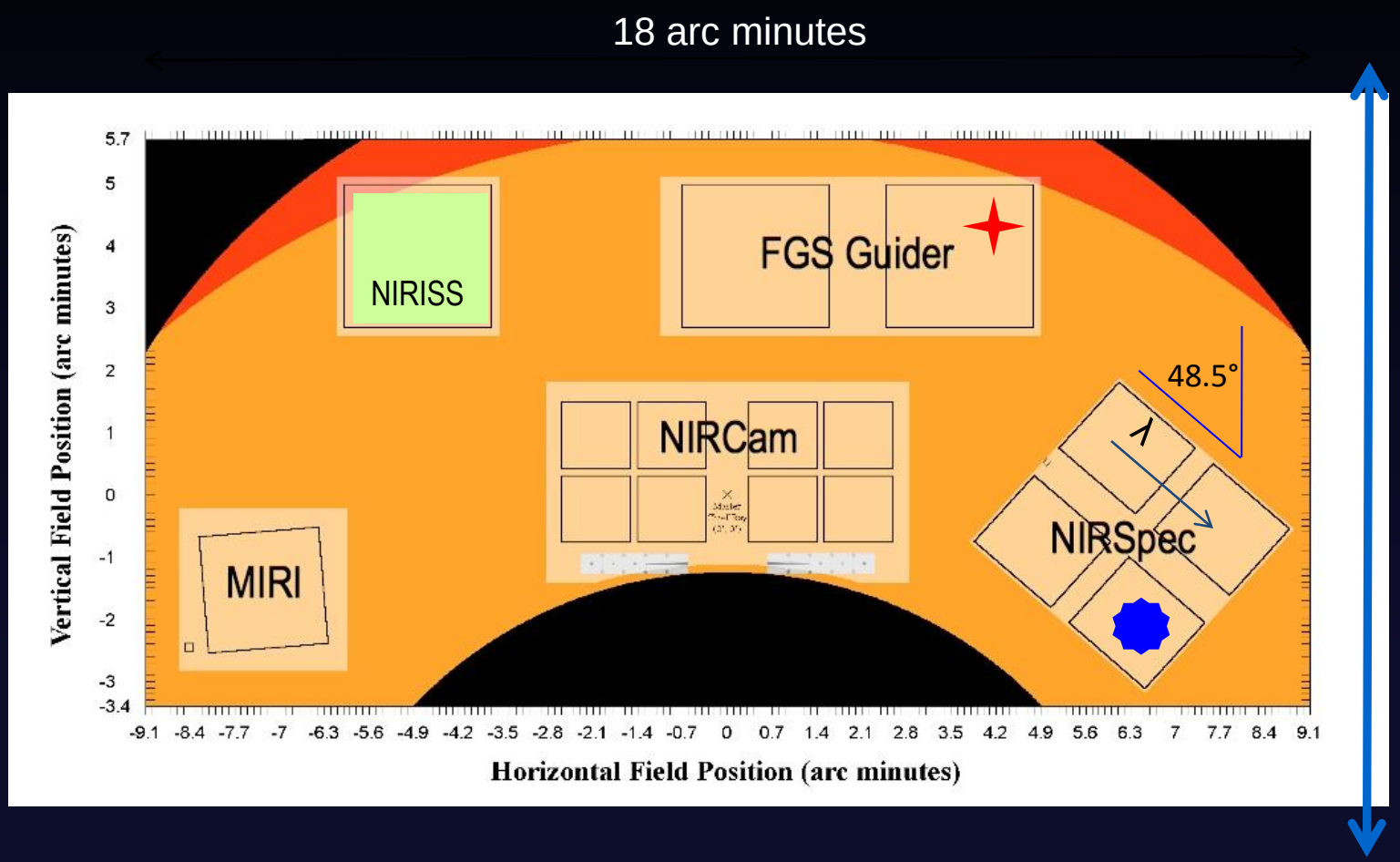


Roll: Only ±5° at any one time

non-instantaneous roll depends on ecliptic latitude.

0-360 range at poles; only 0 &180 at equator.

JWST Focal Plane



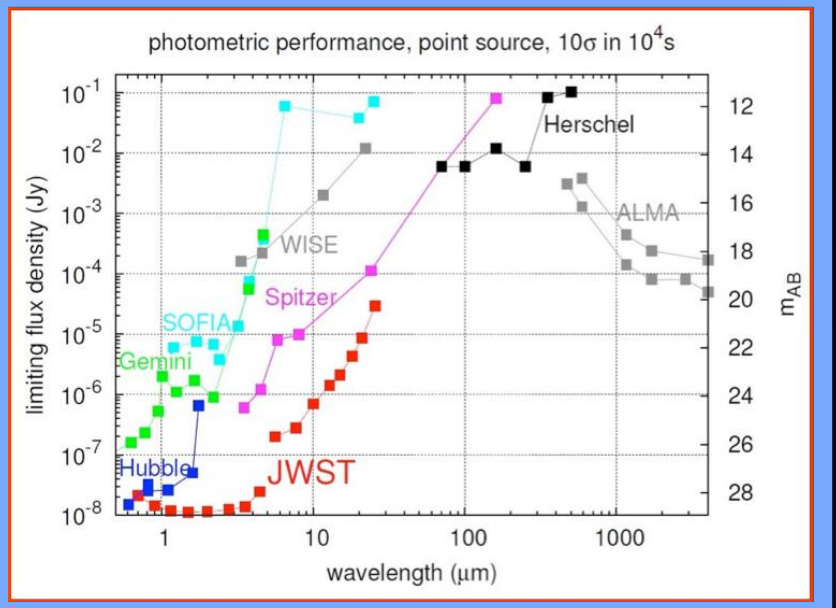
JWST will have exquisite sensitivity

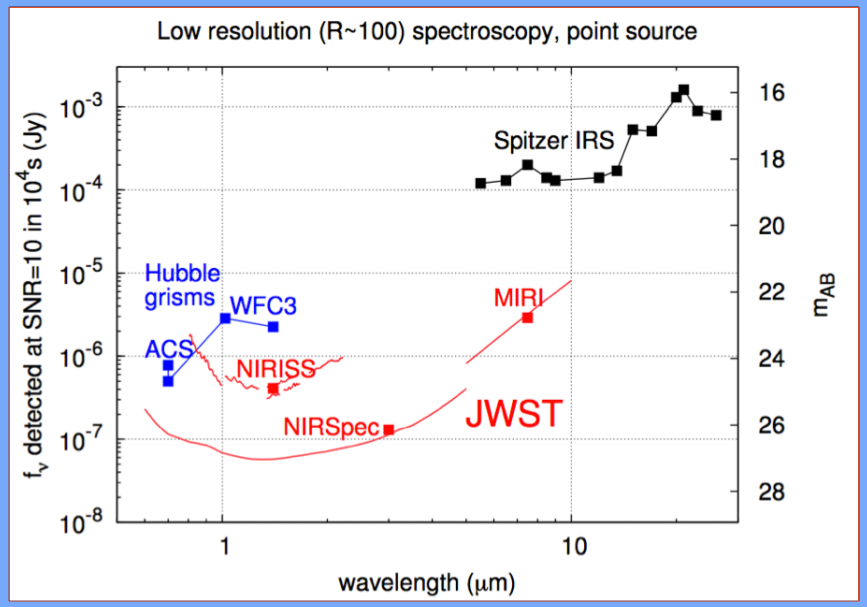
100× Gemini at 2 μm

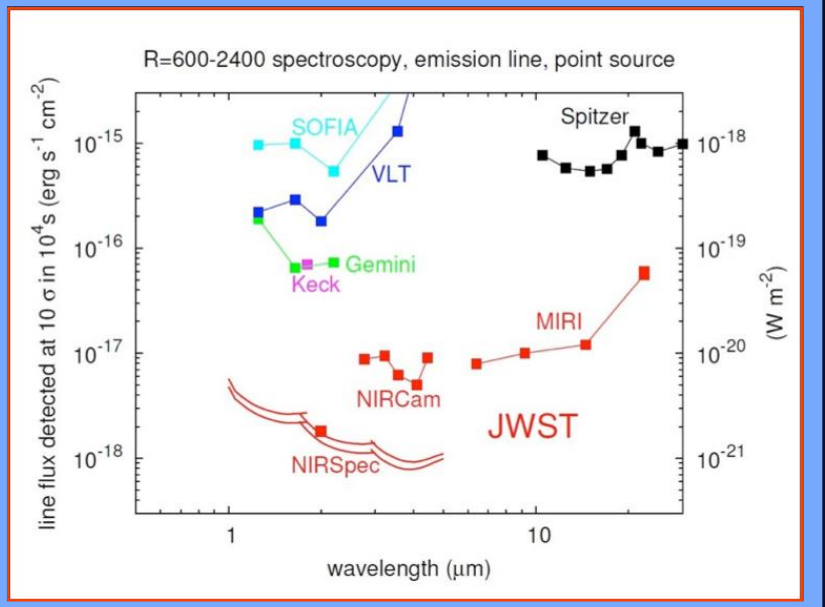
Low infrared background in space

50× Spitzer at 8 μm

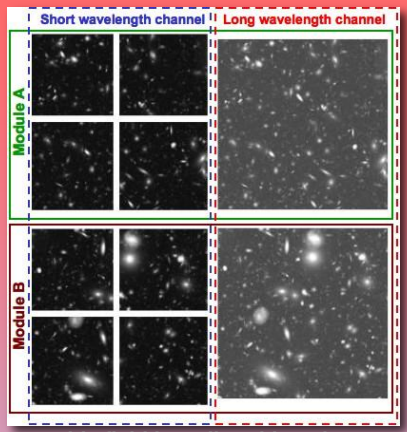
Large aperture cryogenic telescope





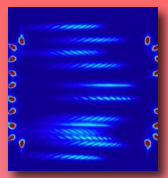


JWST Science Instruments



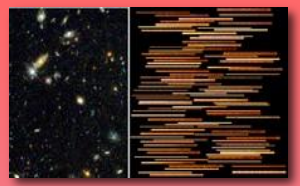
Deep, wide field broadband-imaging

Wavefront Sensing & Control (WFSC)

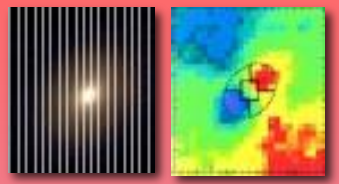


Coronagraphic Imaging

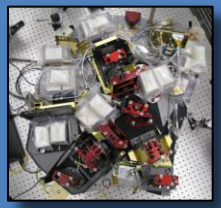
Multi-Object, IR spectroscopy



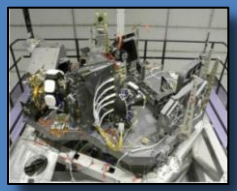
IFU spectroscopy



NIRCam

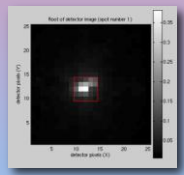


NIRSpec



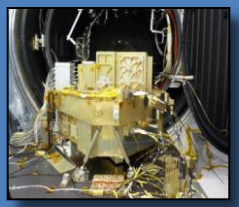
Long Slit spectroscopy

Fine Guidance Sensor



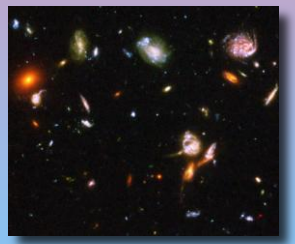
Moving Target Support

FGS/NIRISS

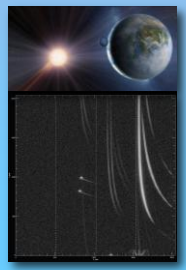


MIRI

Mid-IR, wide-field Imaging

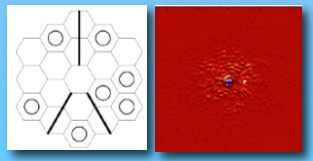


Slitless Spectroscopy



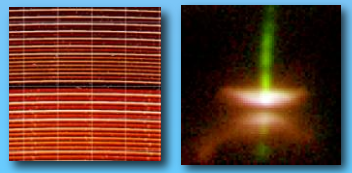
Near-IR imaging

High Contrast Closure Phase Imaging

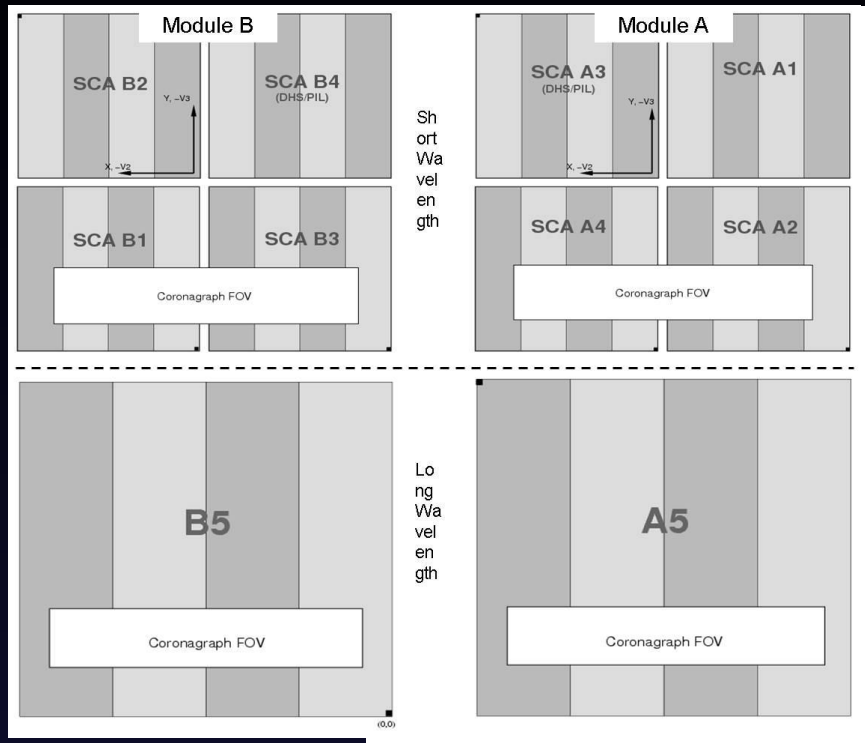


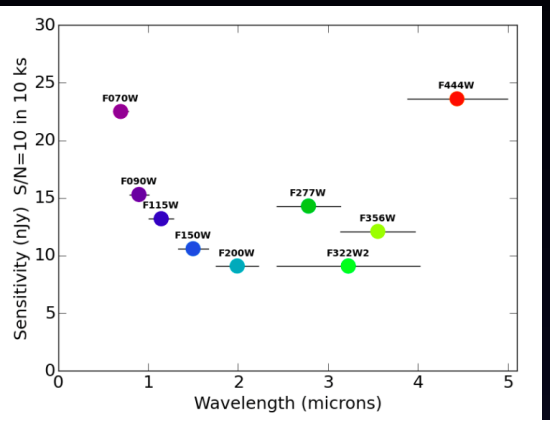
Mid-IR Coronagraphic Imaging

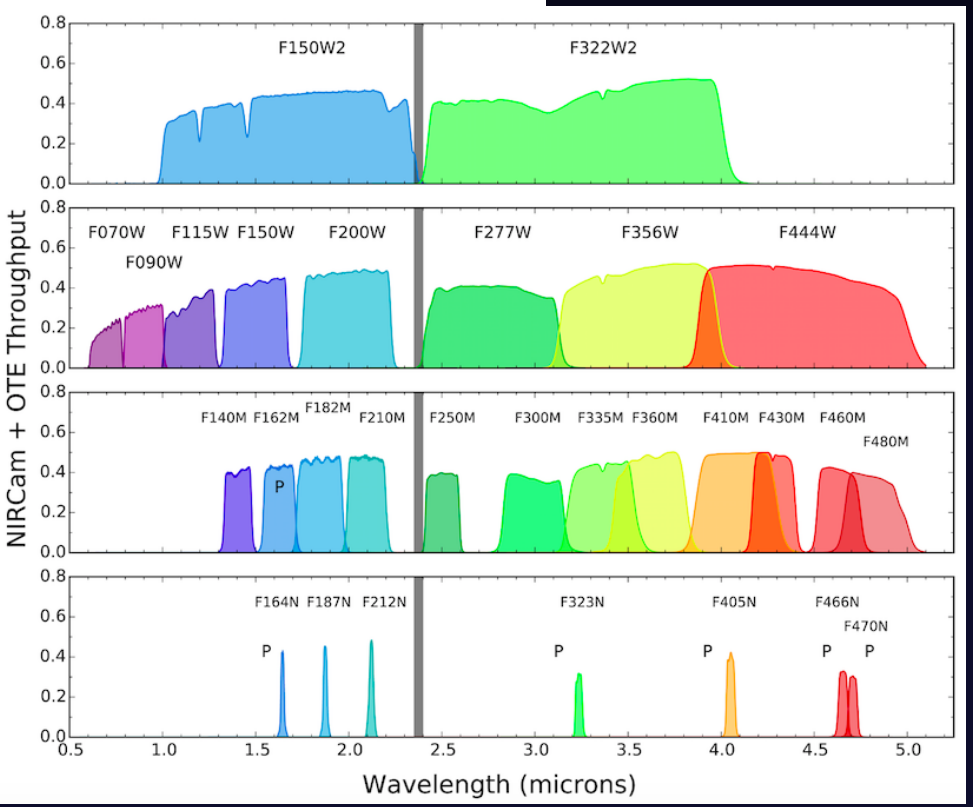
IFU spectroscopy

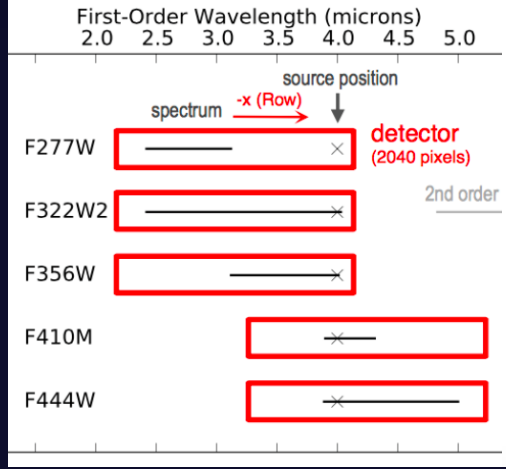


The Near-Infrared Camera (NIRCam)





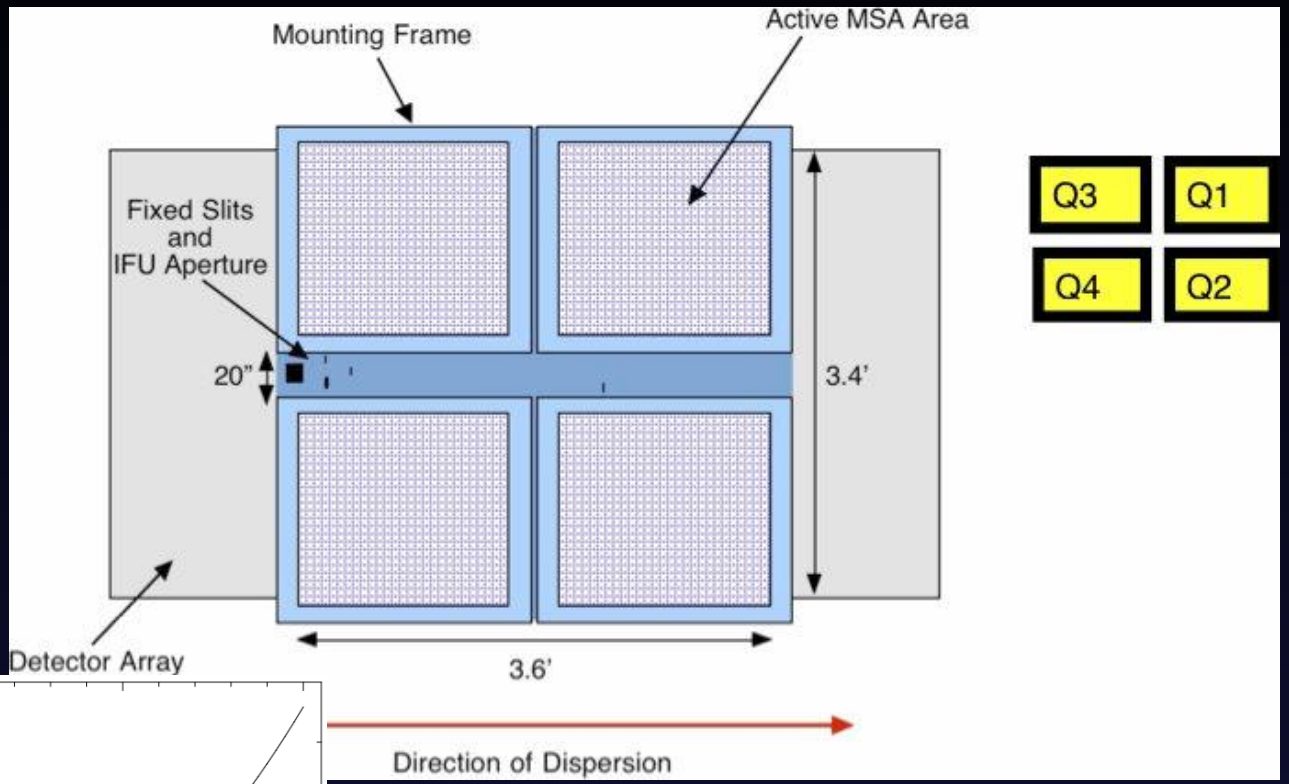


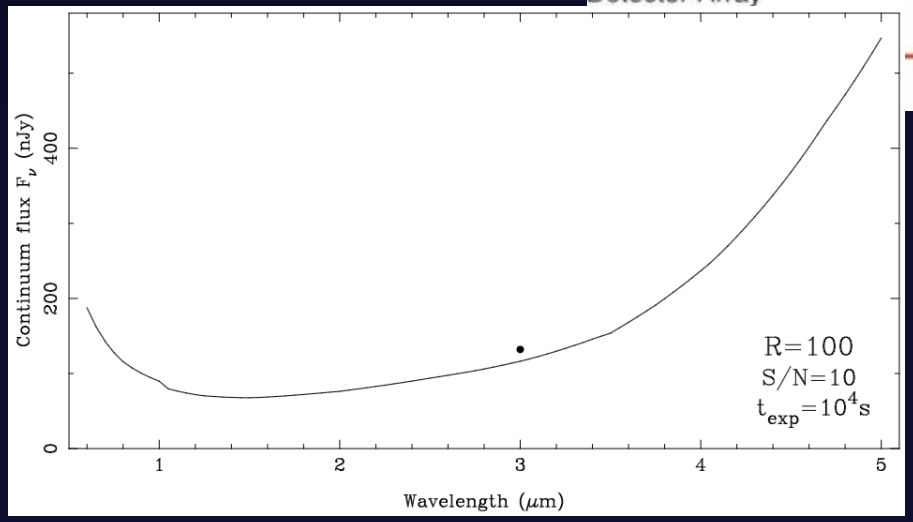


Pocket Guide
http://www.stsci.edu/jwst/instruments/nircam/docarchive/NIRCam-pocket-guide.pdf

The Near-Infrared Spectrograph (NIRSpec)

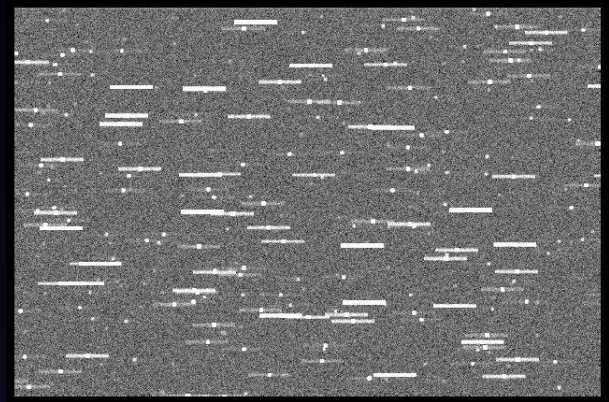
Pocket Guide
http://www.stsci.edu/jwst/instruments/nirspec/docarchive/NIRSpec-pocket-guide.pdf

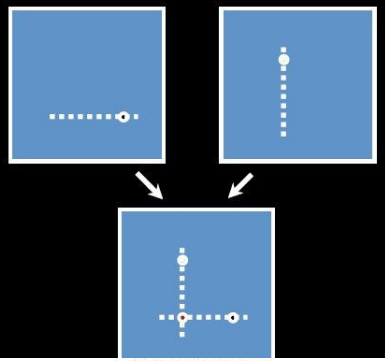


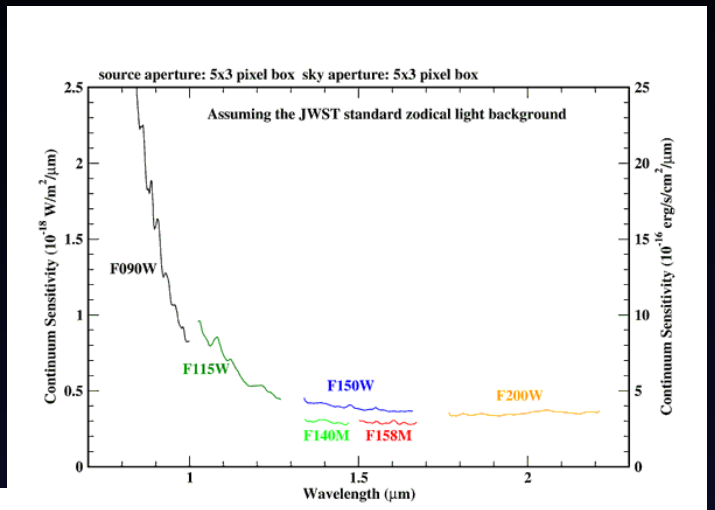


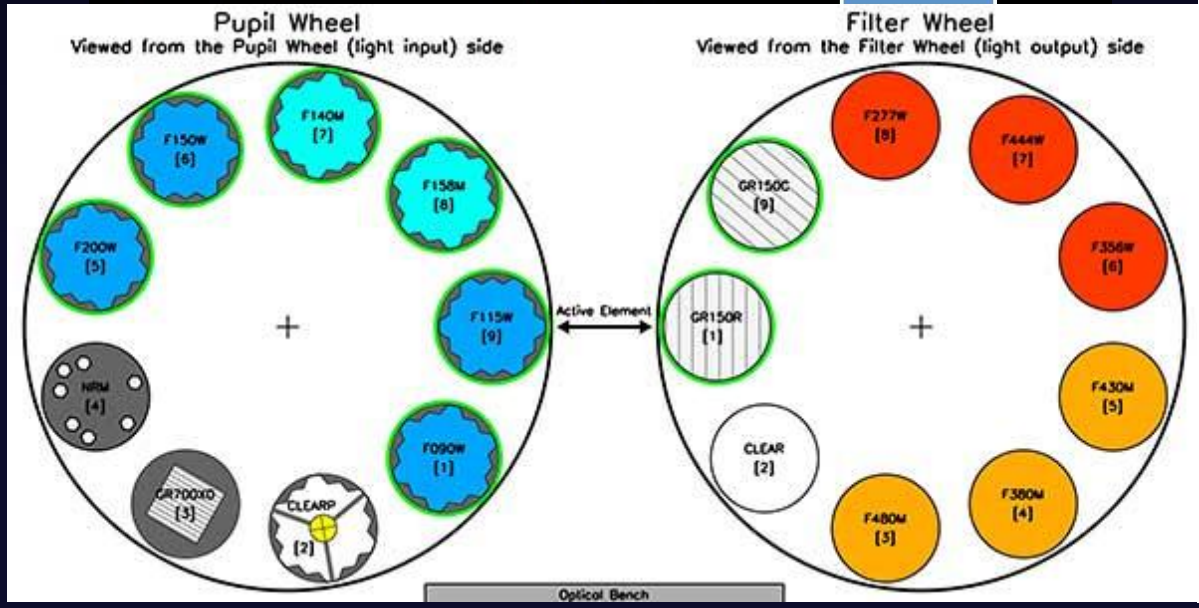
	Aperture Mask	Spectral Resolution
MSA	Any configuration of 0.2"×0.46" microshutters	100 (single prism), 1000 (three gratings), 2700 (three gratings)
Fixed Slit	0.1"×1.9", 0.2"×3.3", 0.4"×3.8"	100, 1000, 2700
Integral Field	3.0"×3.0" IFU	100, 1000, 2700

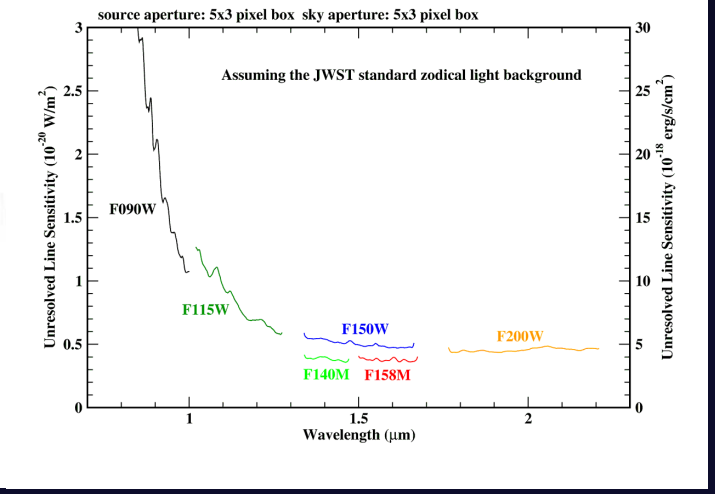
The Near-Infrared Imager and Slitless Spectrograph (NIRISS)





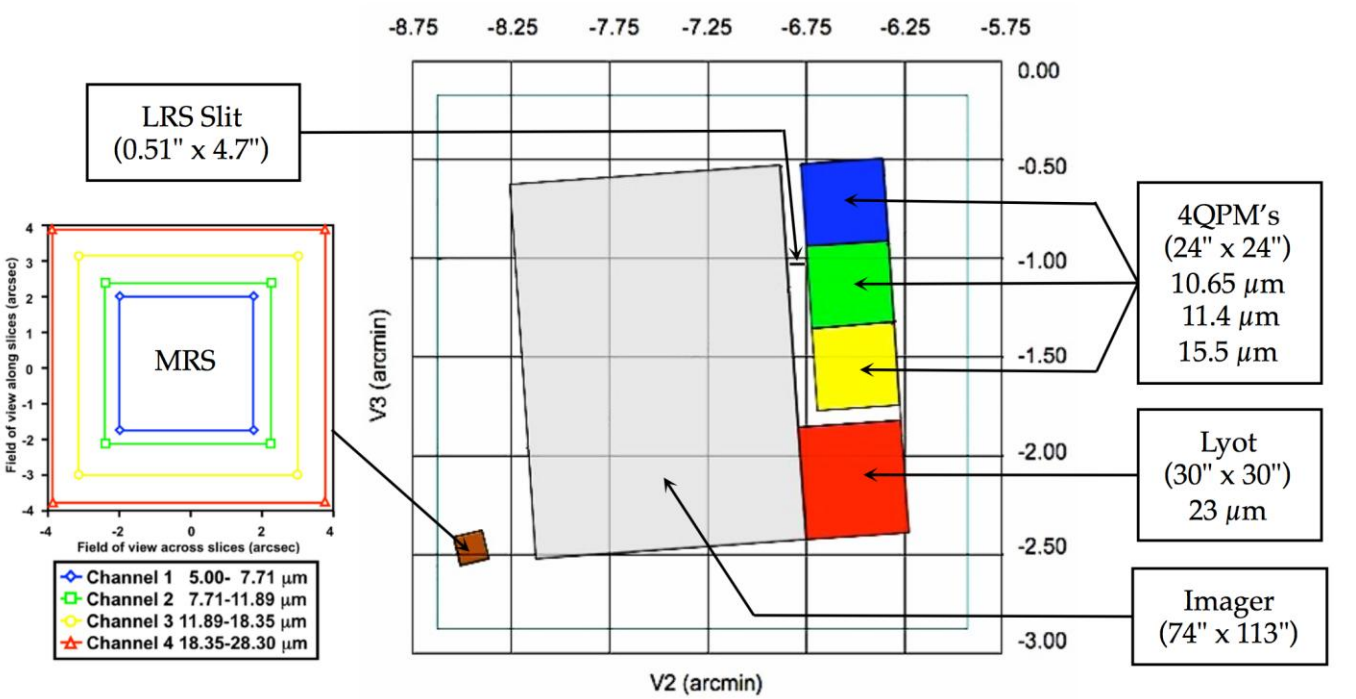




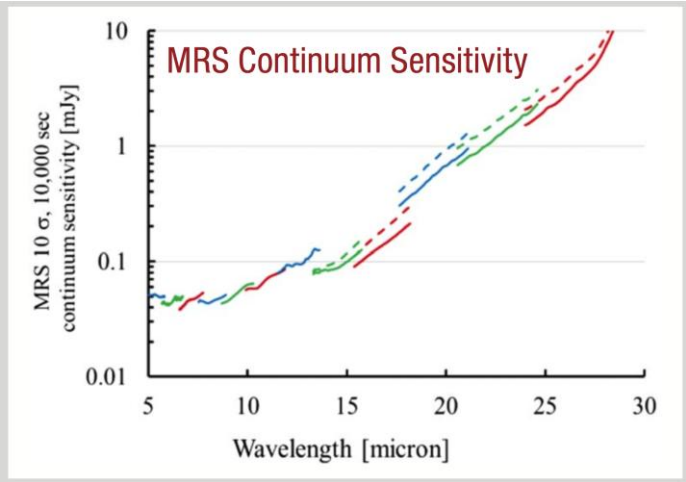


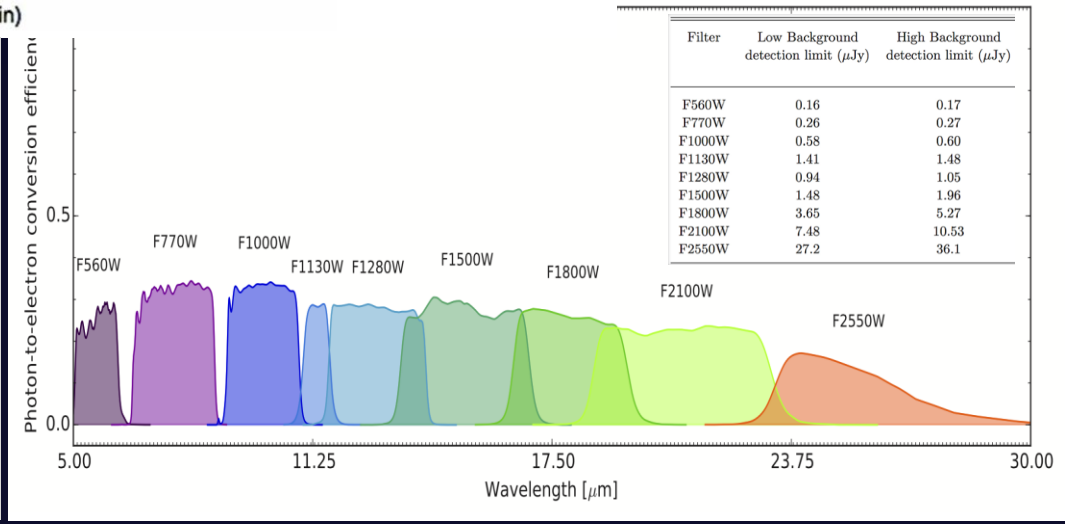
Pocket Guide http://www.stsci.edu/jwst/instruments/niriss/docarchive/NIRISS-pocket-guide.pdf

The Mid-Infrared Instrument (MIRI)



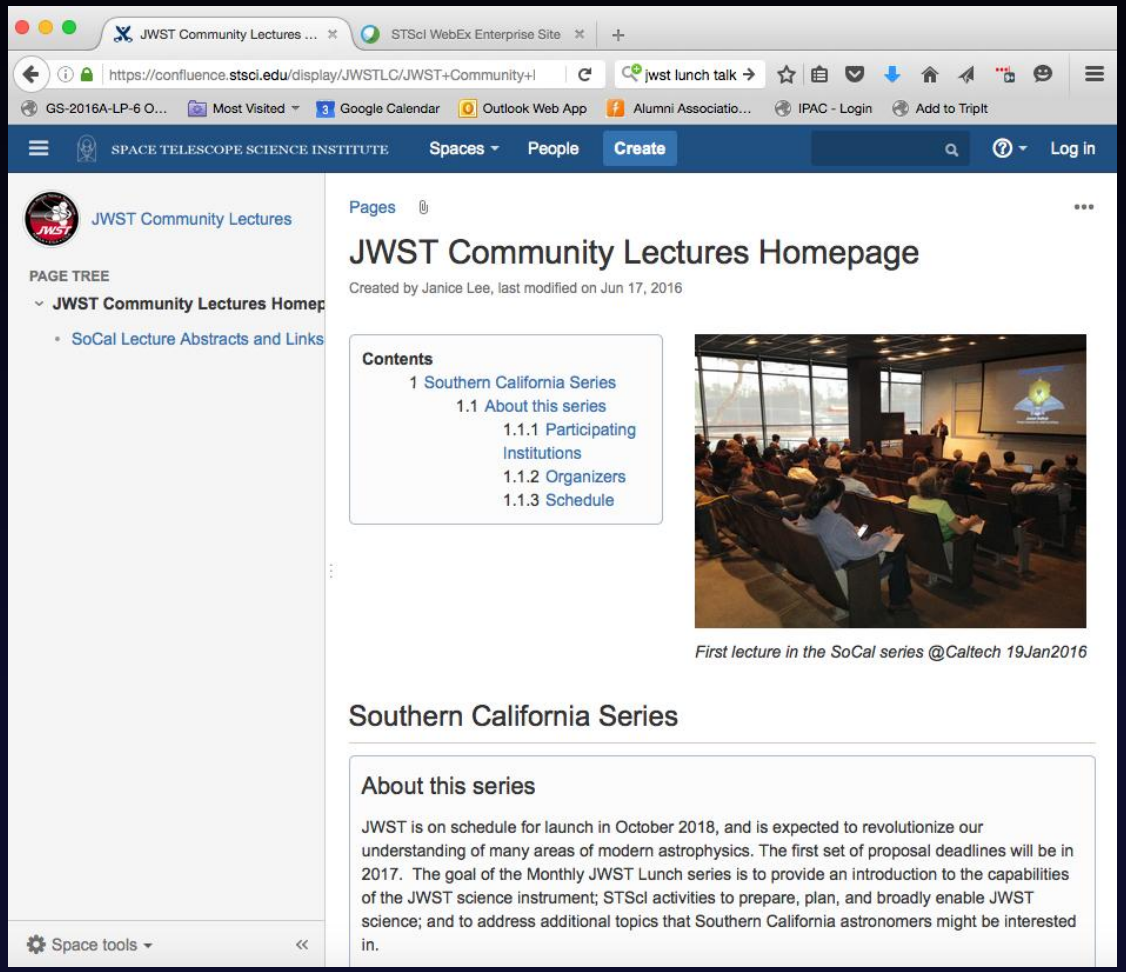
Pocket Guide
http://www.stsci.edu/jwst/instruments/miri/docarchive/miri-pocket-guide.pdf
Encyclopedia
http://ircamera.as.arizona.edu/MIRI/encyclopedia.htm





Filter	Low Background detection limit (μJy)	High Background detection limit (μJy)
F560W	0.16	0.17
F770W	0.26	0.27
F1000W	0.58	0.60
F1130W	1.41	1.48
F1280W	0.94	1.05
F1500W	1.48	1.96
F1800W	3.65	5.27
F2100W	7.48	10.53
F2550W	27.2	36.1

JWST SoCal Lunch Talk Series

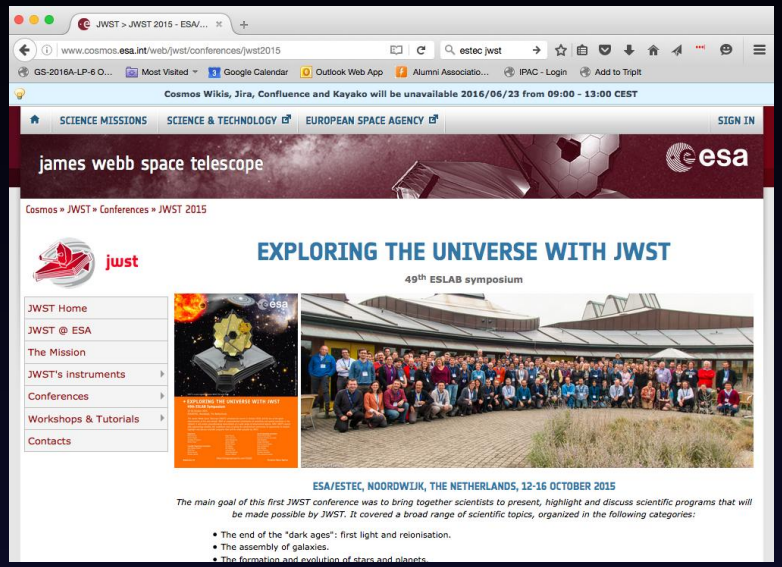


Talk abstracts, slides, and recordings archived on-line

- Jason Kalirai (STScI), *Preparing for JWST, an Overview*
- Marcia Rieke (U Arizona), *NIRCam, Your Next Near-Infrared Camera*
- Pierre Ferruit (ESA), *NIRSpec*
- Rene Doyon (U de Montreal), *NIRISS*
- Susan Kassin (STScI), *Data Analysis Tools*
- George Rieke (U Arizona), *The Mid-infrared Instrument for JWST*

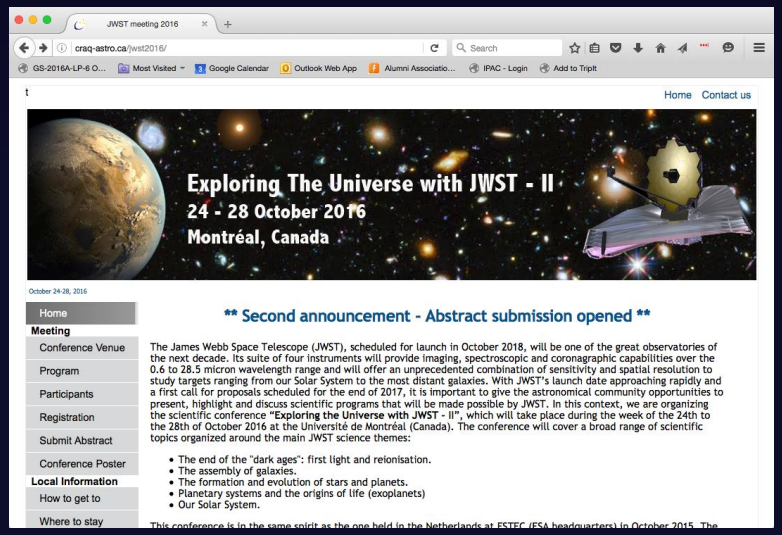
Website https://confluence.stsci.edu/display/JWSTLC/JWST+Community+Lectures+Homepage

Major International Science Conferences



October 2015 at ESTEC: "Exploring the Universe with JWST" http://www.cosmos.esa.int/web/jwst/conferences/jwst2015

Website includes archived talks with presentations from GTOs on planned GTO programs



October 2016 in Montreal: "Exploring the Universe with JWST II" http://craq-astro.ca/jwst2016/

JAMES WEBB SPACE TELESCOPE

An Early Release Science Program

Janice C. Lee
STScI Science Mission Office
Molecules and dust as fuel for star formation
KITP, 24 June 2016

Motivation

to maximize the science return of JWST within its required-5yr, expected-10yr lifetime.

Janice C. Lee
STScI Science Mission Office
Molecules and dust as fuel for star formation
KITP, 24 June 2016

Principle

to realize JWST's science potential, the community must rapidly understand and use its capabilities.

Janice C. Lee
STScI Science Mission Office
Molecules and dust as fuel for star formation
KITP, 24 June 2016

Strategy

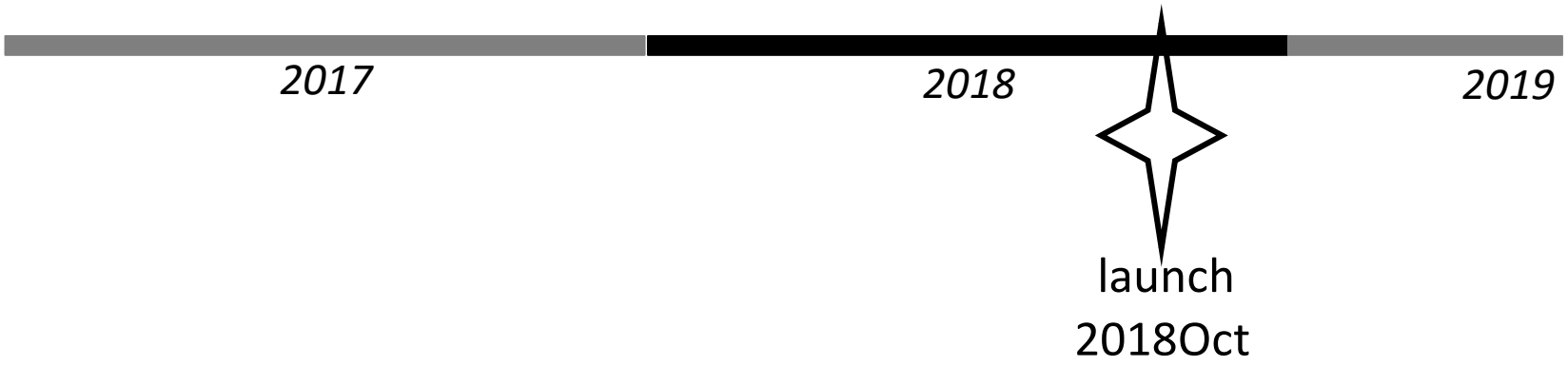
provide open access to a broad suite of JW science observations as early as possible in Cy1 to seed initial discovery and inform Cy2 proposals.

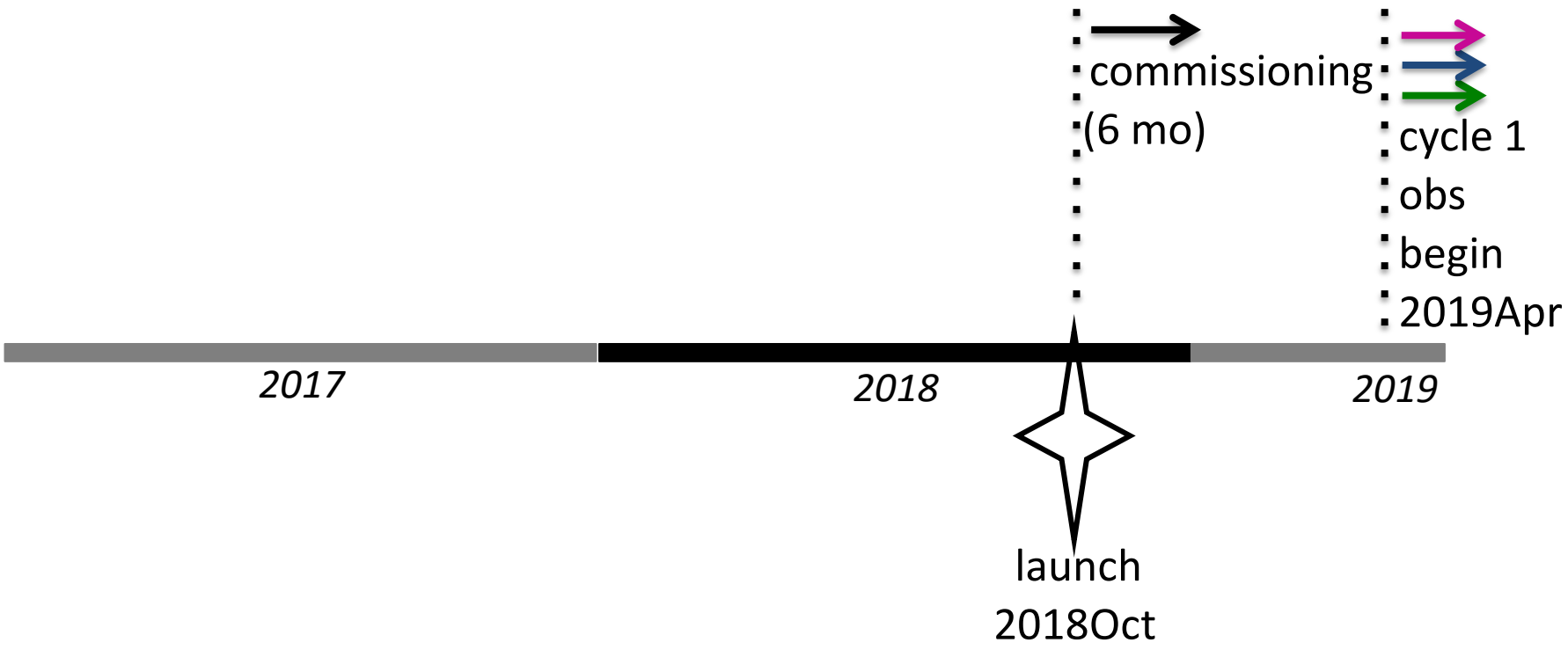
Janice C. Lee
STScI Science Mission Office
Molecules and dust as fuel for star formation
KITP, 24 June 2016

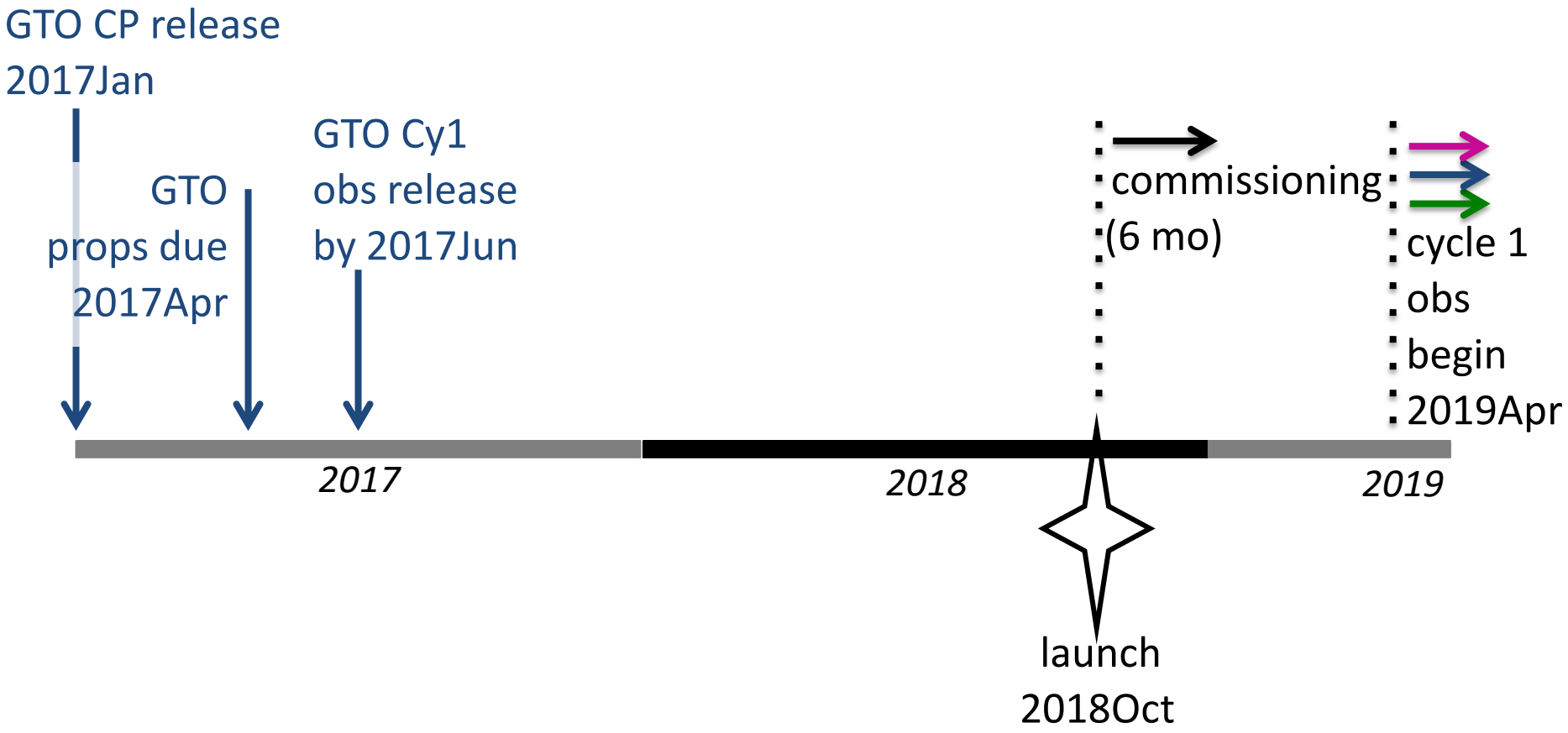
Outline

- Overall JWST science timeline: what's happening when?
- Motivation for a JWST Early Release Science Program
- Current JWST ERS concept

Janice C. Lee
STScI Science Mission Office
Molecules and dust as fuel for star formation
KITP, 24 June 2016


2017
2018
2019
launch
2018Oct


commissioning
(6 mo)
cycle 1
obs
begin
2019Apr
2017
2018
2019
launch
2018Oct


GTO CP release
2017Jan
GTO
props due
2017Apr
GTO Cy1
obs release
by 2017Jun
commissioning
(6 mo)
cycle 1
obs
begin
2019Apr
2017
2018
2019
launch
2018Oct

Classes of Observations

Commissioning [6 mo: 2018 Oct-2019 Apr]

- full schedule of deployment & check-out activities

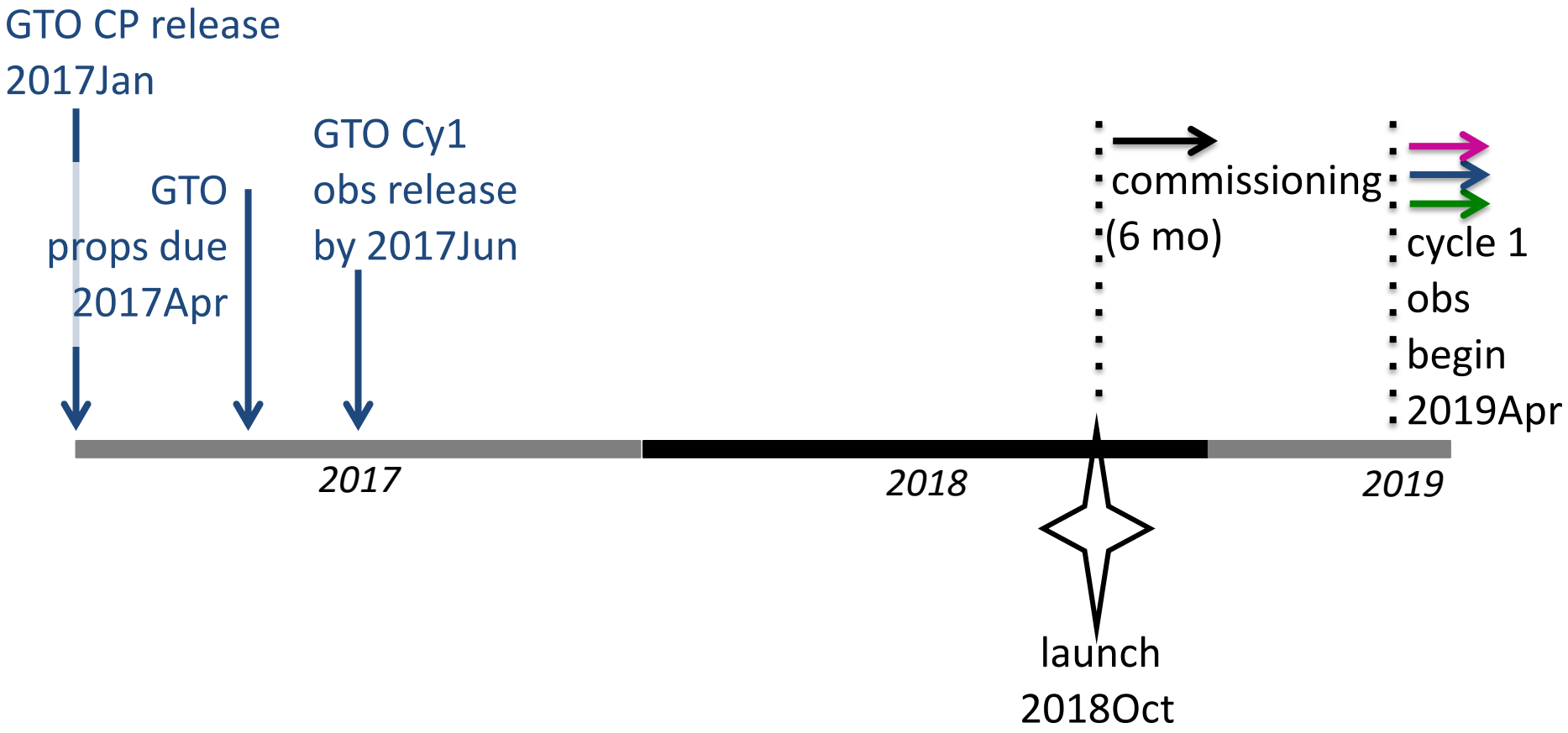
- limited set of science calibration obs possible

- science obs begin after commissioning

Guaranteed Time Observation Program [2019 Apr -]

- 3,960 hr total allocation in first 30 mo. after commissioning

- ~10% of time available in nominal 5 yr lifetime


GTO CP release
2017Jan
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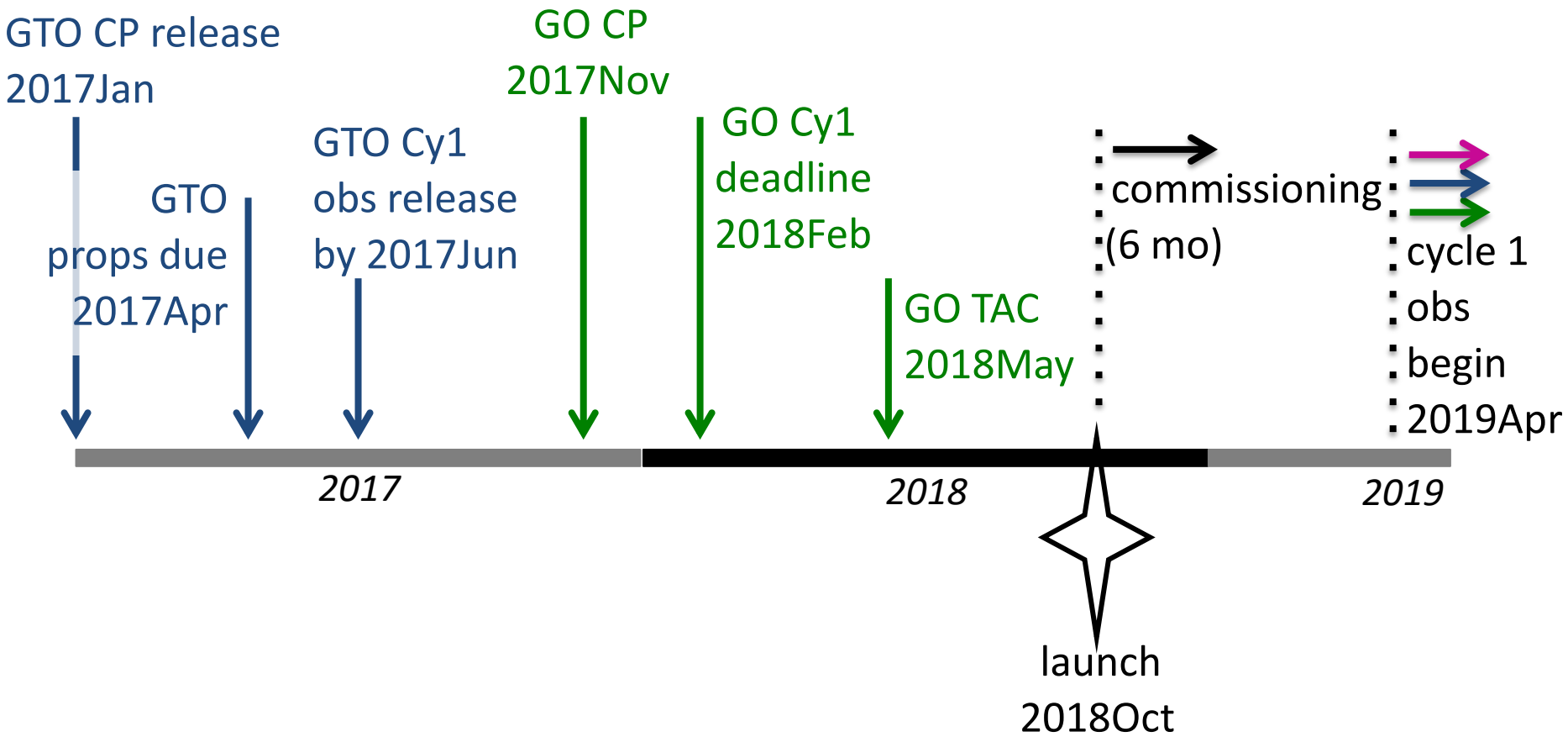
GTO CP release
2017Jan
GTO
props due
2017Apr
GTO Cy1
obs release
by 2017Jun
GO CP
2017Nov
GO Cy1
deadline
2018Feb
GO TAC
2018May
commissioning
(6 mo)
cycle 1
obs
begin
2019Apr
2017
2018
2019
launch
2018Oct

Classes of Observations

Commissioning [6 mo: 2018 Oct-2019 Apr]

- *full schedule of deployment & check-out activities*
- *limited set of science calibration obs possible*
- *science obs highly unlikely*

Guaranteed Time Observation Program [2019 Apr -]

- *3,960 hr total allocation in first 30 mo. after commissioning*
- *~10% of time available in nominal 5 yr lifetime*

Guest Observer Program [2019 Apr -]

- *use GO programs from HST, Spitzer, Chandra, etc. as models*
- *flexible to accommodate programs with range of sizes*
- *support archival research*
- *details TBD, consultations with JSTAC*

JSTAC: JWST Advisory Committee

Roberto Abraham (Toronto)
Neta Bahcall (Princeton)
Stefi Baum (Rochester)
Roger Brissenden (Chandra/SAO)
Hashima Hasan (NASA, ex-officio)
Tim Heckman (Johns Hopkins)
Garth Illingworth (Santa Cruz, Chair)
Malcolm Longair (Cavendish)
John Mather (NASA, ex-officio)
Mark McCaughrean (ESA, ex-officio)
Chris McKee (Berkeley)
Brad Peterson (Ohio State)
Alain Ouellet (CSA, ex-officio)
Joseph Rothenberg (JHR Consulting)
Sara Seager (MIT)
Eric Smith (NASA, ex-officio)
Lisa Storrie-Lombardi (Spitzer/Caltech)
Monica Tosi (Bologna)

Garth Illingworth (UCSC)
JSTAC Chair

Committee of community representatives charged with advising the STScI Director on optimum strategies for maximizing the science productivity of JWST.

Convened in 2009. Meets twice annually. Next meeting Dec 2016.

https://jwst.stsci.edu/science-planning/jwst-advisory-committee-jstac

JSTAC: JWST Advisory Committee

Roberto Abraham (Toronto)
Neta Bahcall (Princeton)
Tomasso Treu (UCLA)
Roger Brissenden (Chandra/SAO)
Hashima Hasan (NASA, ex-officio)
Tim Heckman (Johns Hopkins)
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Kelsey Johnson (U. Virginia)
Alain Ouellet (CSA, ex-officio)
Natalie Batalha (NASA Ames)
Heather Knutson (Caltech)
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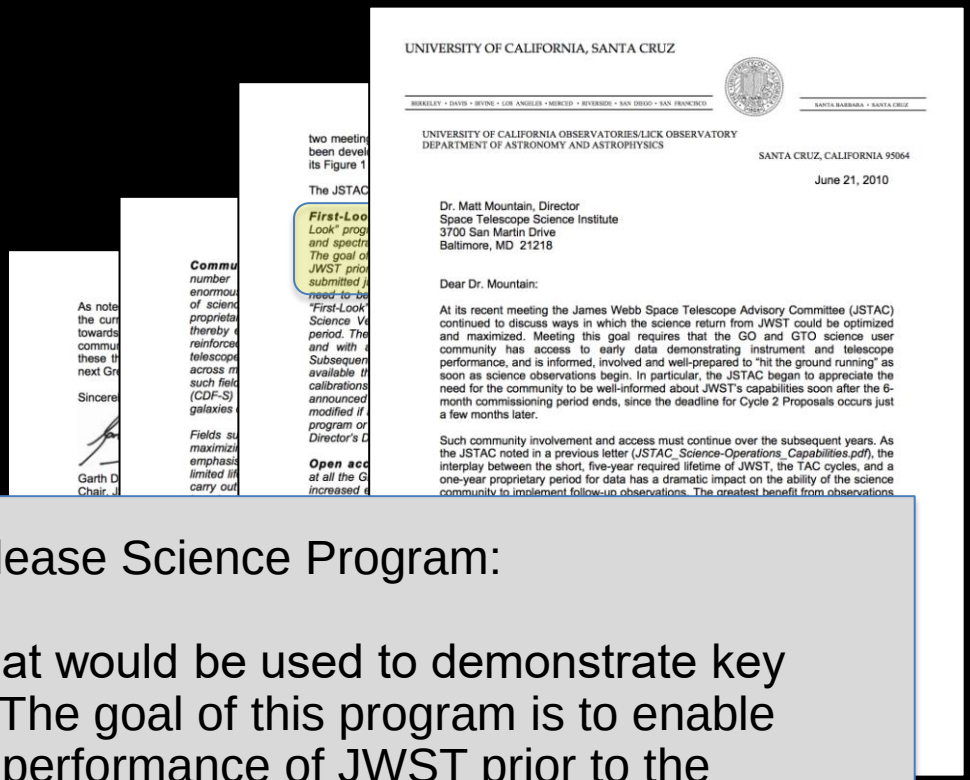
Science Timeline Realities

- addressed by JSTAC 06-2010



UNIVERSITY OF CALIFORNIA, SANTA CRUZ

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UNIVERSITY OF CALIFORNIA OBSERVATORIES/LICK OBSERVATORY
DEPARTMENT OF ASTRONOMY AND ASTROPHYSICS

SANTA CRUZ, CALIFORNIA 95064

June 21, 2010

Dr. Matt Mountain, Director
Space Telescope Science Institute
3700 San Martin Drive
Baltimore, MD 21218

Dear Dr. Mountain:

At its recent meeting the James Webb Space Telescope Advisory Committee (JSTAC) continued to discuss ways in which the science return from JWST could be optimized and maximized. Meeting this goal requires that the GO and GTO science user community has access to early data demonstrating instrument and telescope performance, and is informed, involved and well-prepared to "hit the ground running" as soon as science observations begin. In particular, the JSTAC began to appreciate the need for the community to be well-informed about JWST's capabilities soon after the 6-month commissioning period ends, since the deadline for Cycle 2 Proposals occurs just a few months later.

Such community involvement and access must continue over the subsequent years. As the JSTAC noted in a previous letter (*JSTAC_Science-Operations_Capabilities.pdf*), the interplay between the short, five-year required lifetime of JWST, the TAC cycles, and a one-year proprietary period for data has a dramatic impact on the ability of the science community to implement follow-up observations. The greatest benefit from observations

The JSTAC recommends an Early Release Science Program:

> "..to obtain images and spectra that would be used to demonstrate key modes of the JWST instruments. The goal of this program is to enable the community to understand the performance of JWST prior to the submission of the first post-launch Cycle 2 proposals that will be submitted just months after the end of commissioning."

> "The JSTAC recommends that… data be released both in raw form and with any initial calibrations as soon as possible; the key aspect is speed."

Science Timeline Realities

04-2019 Cy1 science obs begin

04-2020 Cy2 science obs begin

Science Timeline Realities

04-2019	Cy1 science obs begin
07-2019	GTO Cy2 deadline
09-2019	GO Cy2 CP released
12 (early)-2019	GO Cy2 deadline
04-2020	Cy2 science obs begin

Availability of non-proprietary data is quite limited at time of Cy2 proposal preparation.

Science Timeline Realities

- addressed by JSTAC 06-2010

ERS concept discussions

- *JSTAC 2014 Dec*
- *AAS 2015 Jan*
- *SWG 2015 Apr*
- *JSTAC 2015 May, 2015 Dec, 2016 Jun*

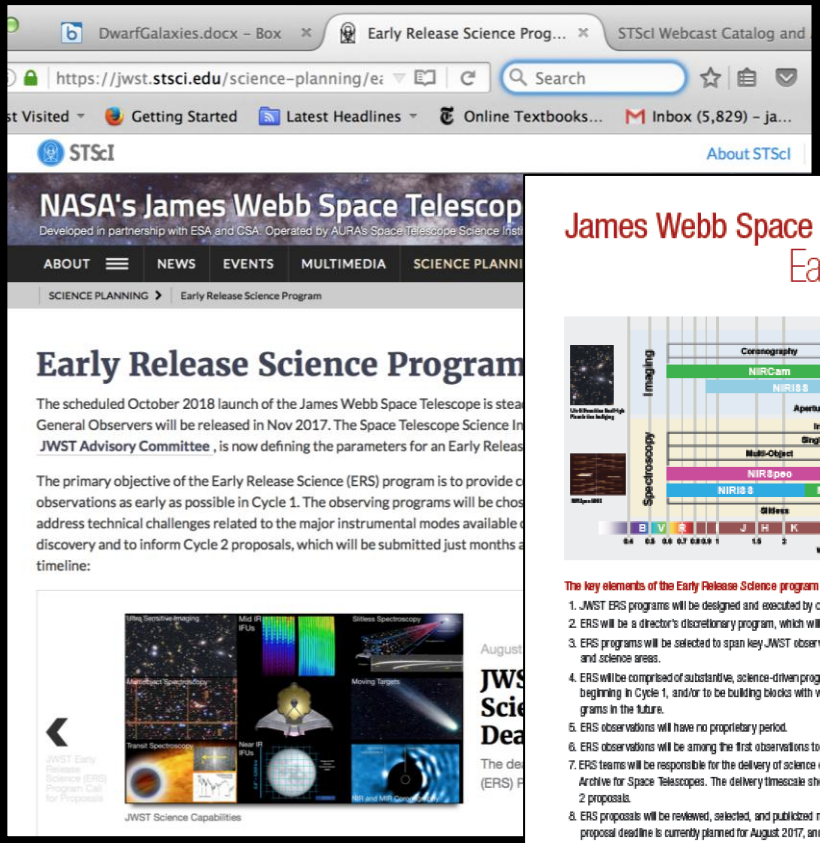
The JSTAC recommends an Early Release Science Program:

> "..to obtain images and spectra that would be used to demonstrate key modes of the JWST instruments. The goal of this program is to enable the community to understand the performance of JWST prior to the submission of the first post-launch Cycle 2 proposals that will be submitted just months after the end of commissioning."

> "The JSTAC recommends that… data be released both in raw form and with any initial calibrations as soon as possible; the key aspect is speed."

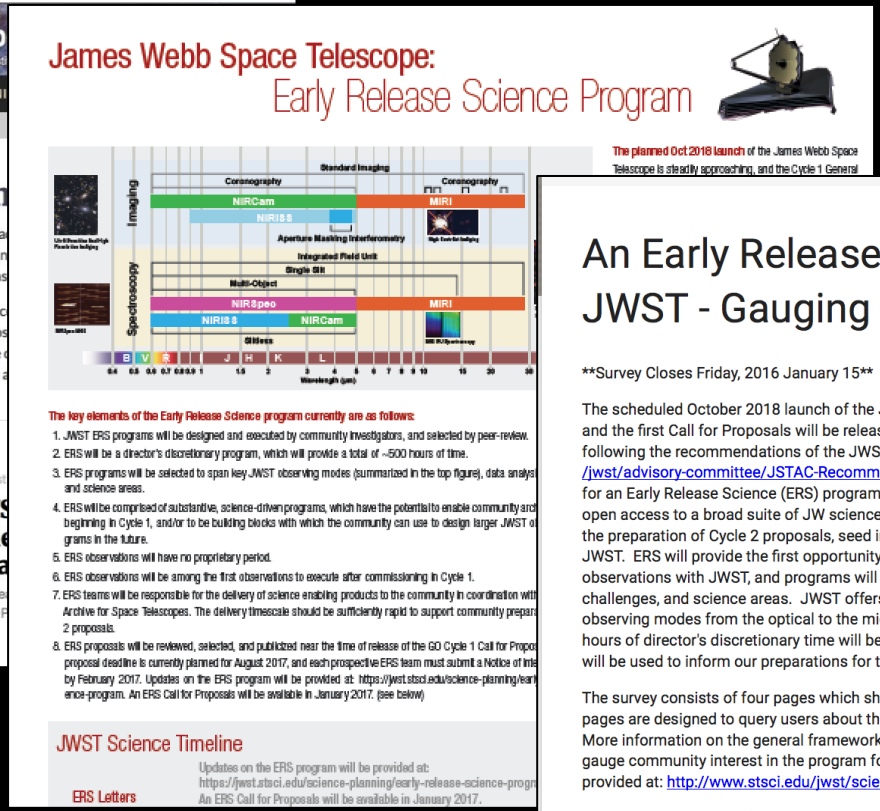
How has the ERS-DD program framework been communicated?

STScI JWST Website

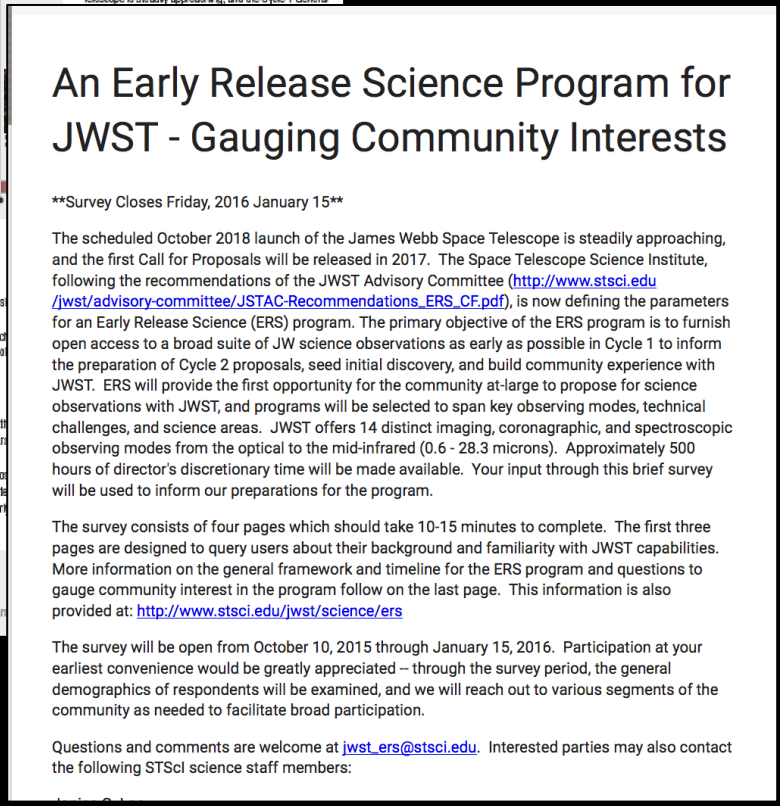


jwst.stsci.edu/science-planning/early-release-science-program

Meeting Fliers



On-line Survey



JAMES WEBB SPACE TELESCOPE

Survey to Gauge Community Interests

Goals

Inform development of ERS program, selection criteria, proposal review.

- Estimate number of ERS proposals, size distribution
- Estimate usage of JWST observing modes
- collect feedback on ERS program boundary conditions
- collect feedback on resources needed for ERS teams to produce science-enabling products for community.

Concomitant goals

- Announce ERS program
- Gauge familiarity with JW capabilities
- Provide basic education (overview) on JW capabilities

JAMES WEBB SPACE TELESCOPE

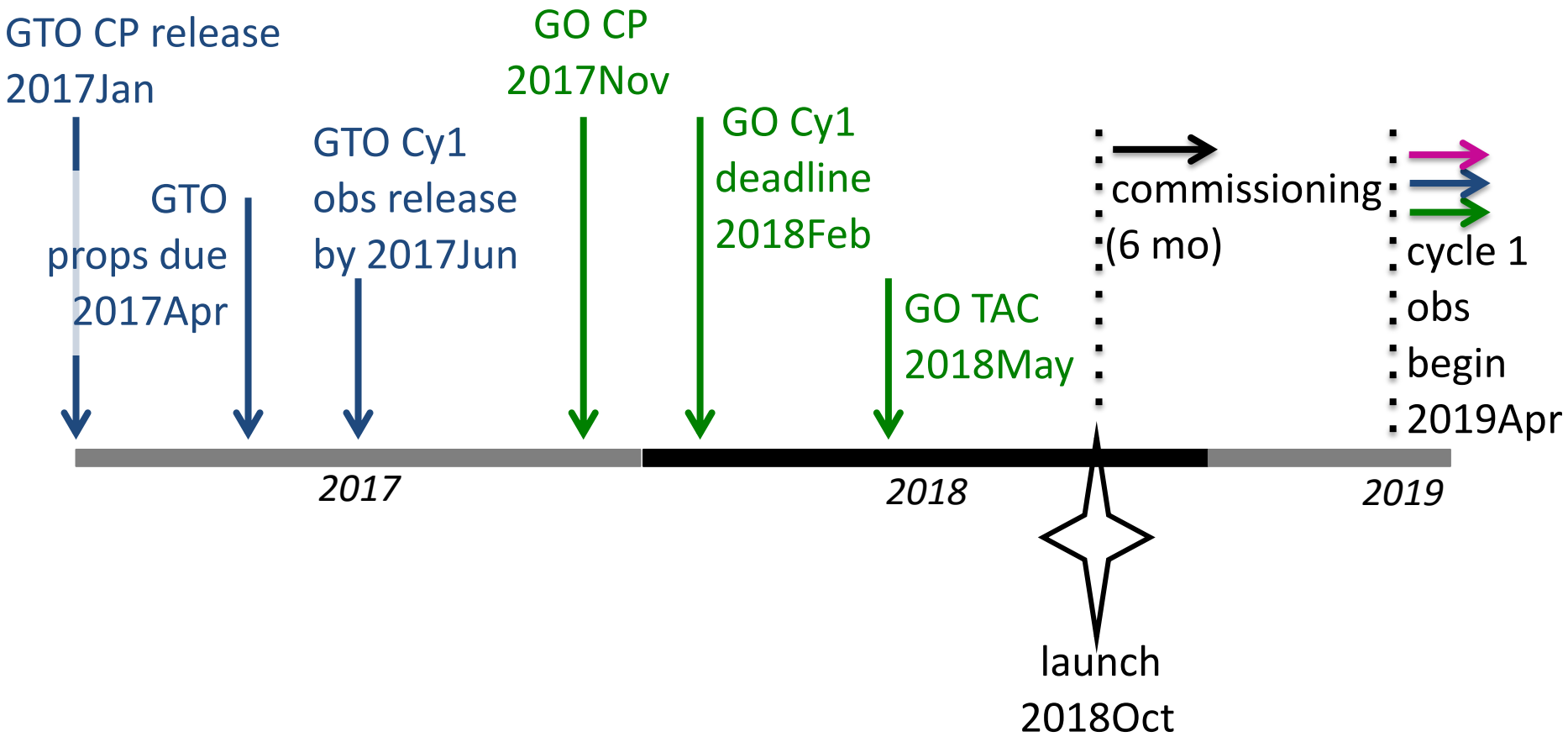
Survey to Gauge Community Interests

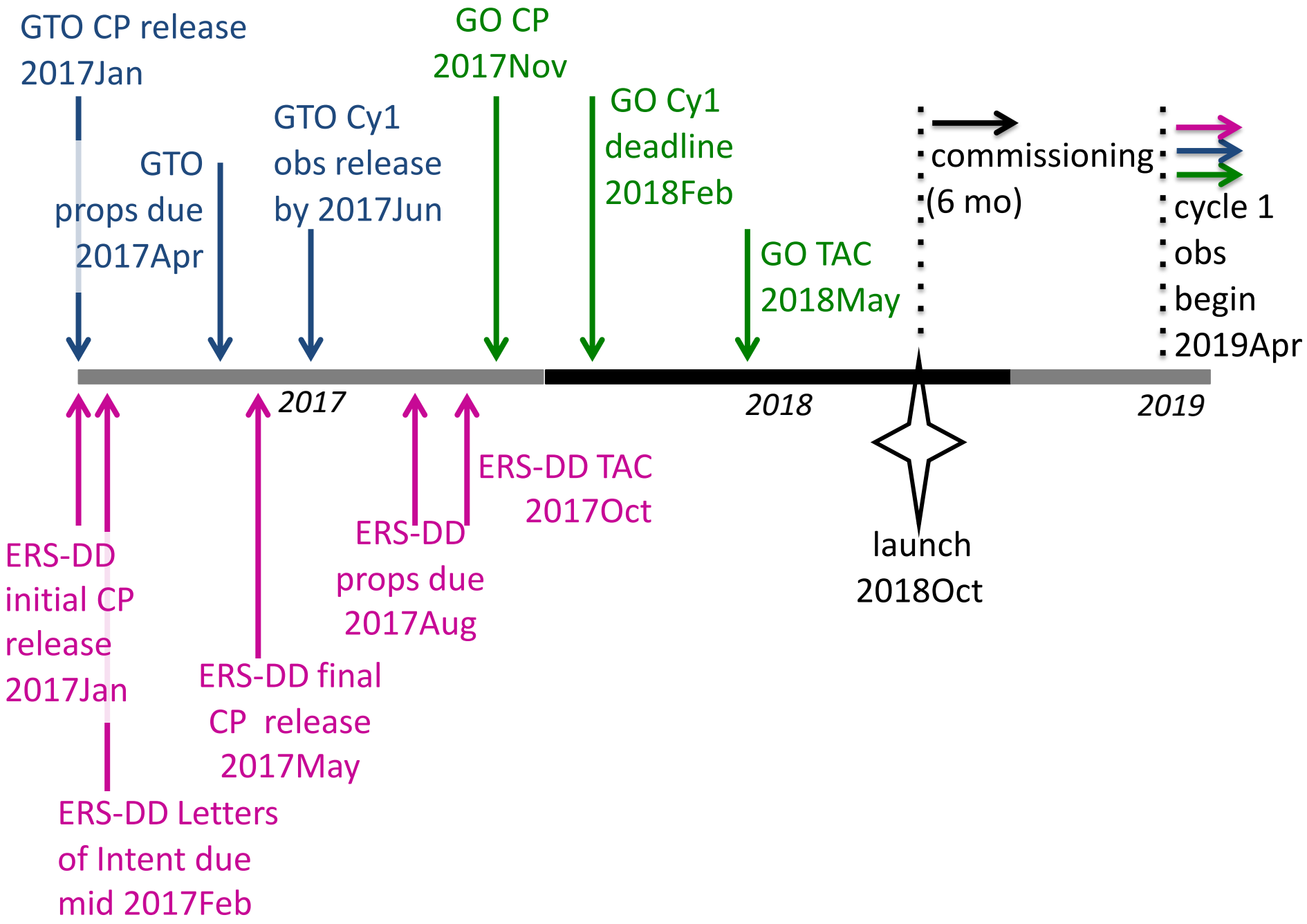
Status

- Survey development and testing (Sept-Oct 2015)
- Survey open Oct 2015 – Jan 2016 (after AAS).
- 589 respondents completed entire survey; strong expressions of support and interest from respondents
- Summary of analysis to be provided to community in STScI newsletter article.

ERS program framework iterated with Director and JSTAC

1. Designed, executed by teams with broad representation of community investigators; selected by peer-review.
2. Director's discretionary program, total ~500 hours.
3. Data have no proprietary period.
4. Spans key JWST observing modes and science areas. Coherent programs in multiple modes encouraged. (14 distinct JWST imaging, coronagraphic, spectroscopic observing modes.) *10-15 medium sized (30-70 hr) programs.*
5. Substantive, science-driven programs of broad community interest (enable archival research in Cy1, prep for Cy2, and/or be building blocks for community to design more challenging JWST future program).
6. Among first obs to execute after commissioning in Cy1. *Must be schedulable early Cy1; CVZ targets preferred.*
7. ERS teams responsible for delivery of science enabling products to community in coordination with MAST. Delivery timescale to support community preparation of Cycle 2 proposals.
8. Reviewed, selected, publicized prior to release of GO Cy1 Call for Proposals. NOI deadline 2017Feb. Proposal deadline 2017Aug.


GTO CP release
2017Jan
GTO
props due
2017Apr
GTO Cy1
obs release
by 2017Jun
GO CP
2017Nov
GO Cy1
deadline
2018Feb
GO TAC
2018May
commissioning
(6 mo)
cycle 1
obs
begin
2019Apr
2017
2018
2019
launch
2018Oct


GTO CP release
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cycle 1
obs
begin
2019Apr
2017
2018
2019
ERS-DD TAC
2017Oct
ERS-DD
props due
2017Aug
launch
2018Oct
ERS-DD
initial CP
release
2017Jan
ERS-DD final
CP release
2017May
ERS-DD Letters
of Intent due
mid 2017Feb

ERS proposal requirements (distinguishing elements from GO Cy1)

1. *Justification for ERS time*
   How will your program help the community learn to do science with JWST and prepare for Cy2? What science-enabling products are proposed for development and release? How will your program demonstrate baseline JW science capabilities.

2. *Scientific Justification*
   Why are the observations scientifically compelling.

3. *Team Diversity*
   Demonstration of how the proposing team represents and has input from diversity of experts with braod demographics within sub-discipline.

4. *Description of the Observations*
   Establish feasibility for early execution, and flexibility in target selection to accommodate any change to start date for Cy1 science obs.

5. *Project Management Plan & Budget*
   Describe data processing and analysis plan, roles, responsibilities, work schedule, budget.

ERS proposal requirements (distinguishing elements from GO Cy1)

6. *Mandatory Notice of Intent to Propose (due 2017Feb)*
   Enables STScI to identify community members well-suited for review (appropriate expertise, w/o conflict).

   "Material in a NoI is deemed confidential. The purpose for requiring the submission of NoIs is not to be restrictive, but rather to enable STScI to prepare for the proposal review."

   The NoI must include:

   - *project title,*
   - *brief (~few paragraphs) description of the proposed science project, including JWST instruments and modes to be used, to the best of the proposing team's knowledge at the time of NoI submission,*
   - *name(s) and affiliation(s) of the PI (or co-PIs),*
   - *name(s) and affiliation(s) for as many of the Co-Is as are known at the time of NOI submission.*
   - *a brief description of how proposing team broadly represents relevant experts and demographics of sub-discipline.*

JAMES WEBB SPACE TELESCOPE

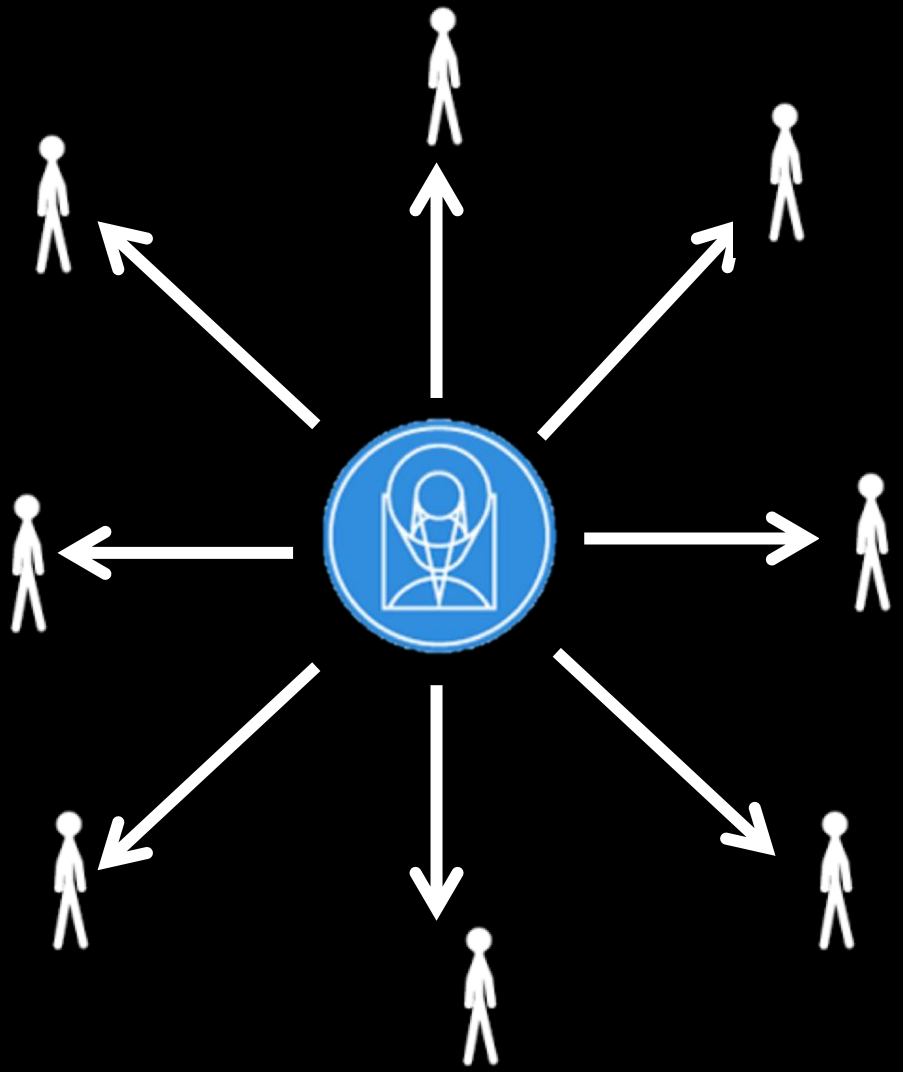
An Early Release Science Program

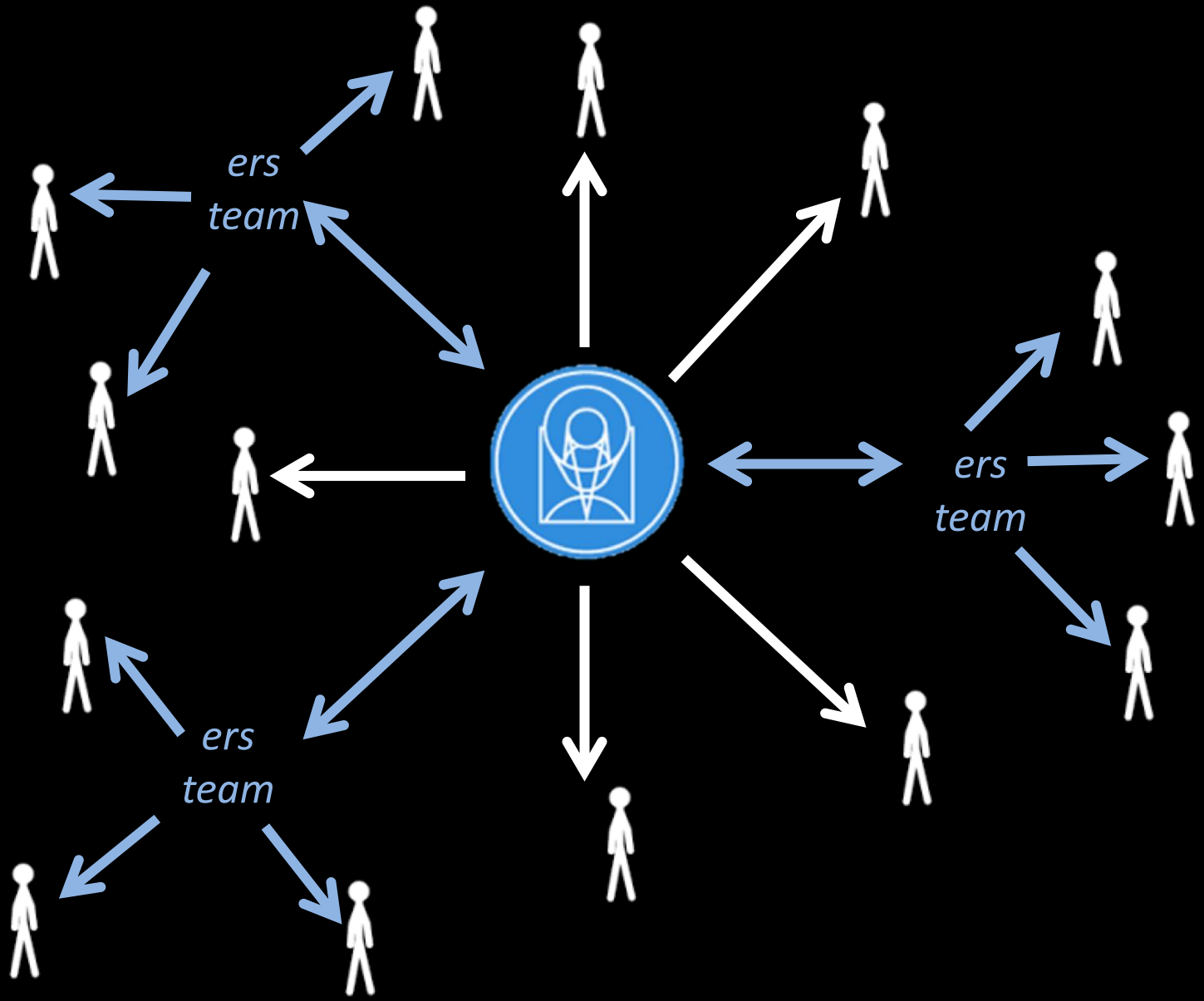
Products

- Building blocks for Cy1+ GO programs
  - APT files available at Cy1 CP release
  - Data & science-ready products available as early as possible in Cy1
  - Enables Cy1 archival programs
- Provides kernels for cohesive science-based training sets
  - Observation & proposal planning
  - Data reduction and analysis cookbooks
- Increased community familiarity about JW capabilities for Cy1 GO proposal review

In addition to immediate release of data, ERS activities provide focal point for organization of GO user support, and dissemination of information on JWST performance and results.

Accelerate dissemination of JWST know-how with 5-yr required, 10-yr anticpated lifetime.

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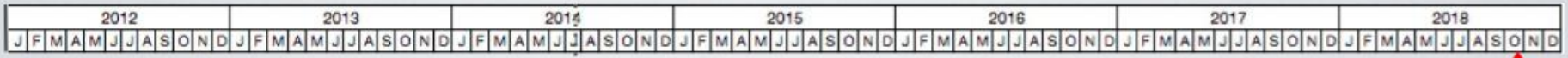
JWST Schedule



OTE = Optical Telescope Element
OTIS = Optical Telescope + ISIM

k months of project funded critical path (mission pacing) schedule reserve

Spacecraft

Spacecraft panels to I&T

Spacecraft Component Development

Spacecraft Fabrication and Assembly

Spacecraft I & T

Observ I&T

4

Spacecraft Structure to I&T

Sunshield Des. & Development

Flight Sunshield Fabrication, Assembly and Test

I & T

Science Instruments

Cryo 1

Cryo 2

Cryo 3

ISIM Integration

ISIM Cryo Testing & Detector Changeout

OTIS

3

Telescope

Segment Gear Motor replacement

OTE

6

Optical Telescope Element Fabrication and Testing

Northrop-Grumman

Goddard Space Flight Center

Ball Aerospace

ATK

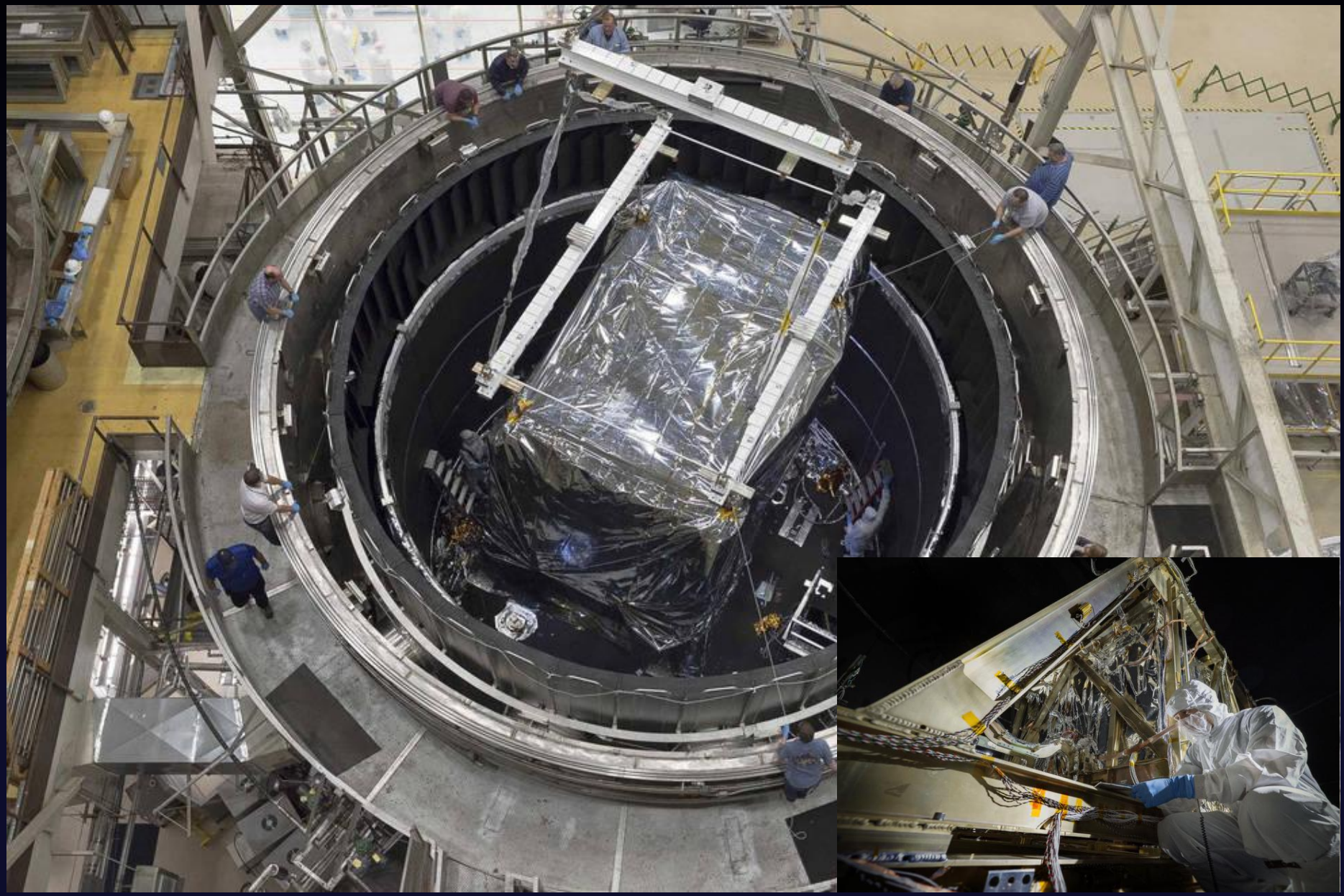
Johnson Space Center

Guiana Space Center

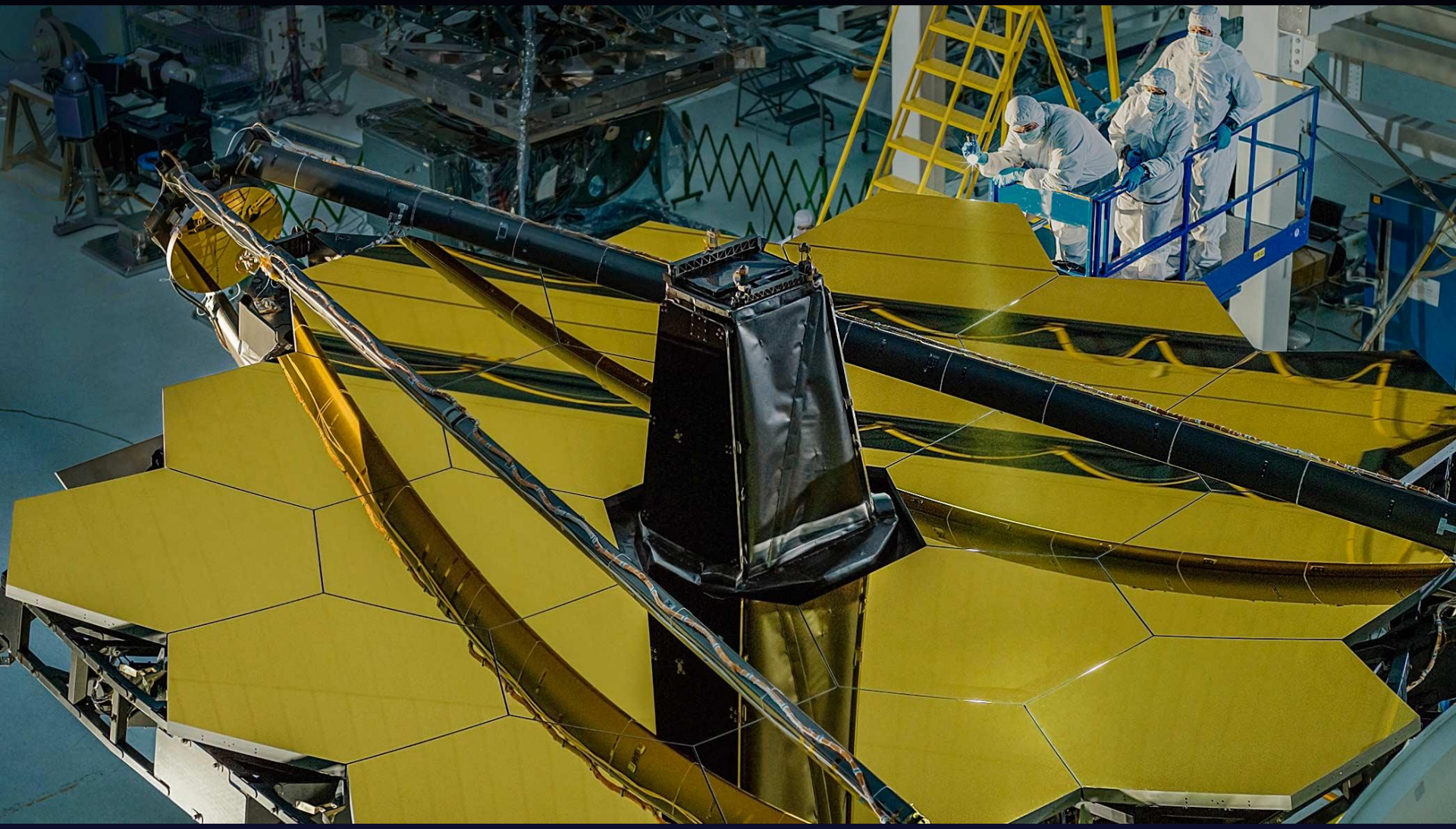
Faded areas are completed

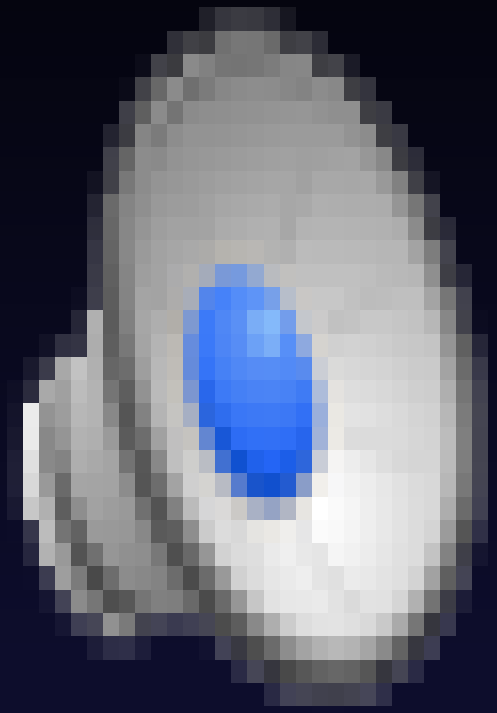
slide adapted from Eric Smith, JWST town Hall, Jan '14

ISIM CryoVac 3 Testing Completed (January 2016)



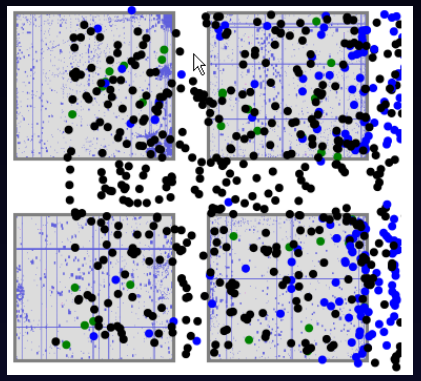
Installed 18 primary mirror segments, secondary mirror and Aft Optics System, including Fixed Tertiary mirror and Fine Steering Mirror (February – April 2016)

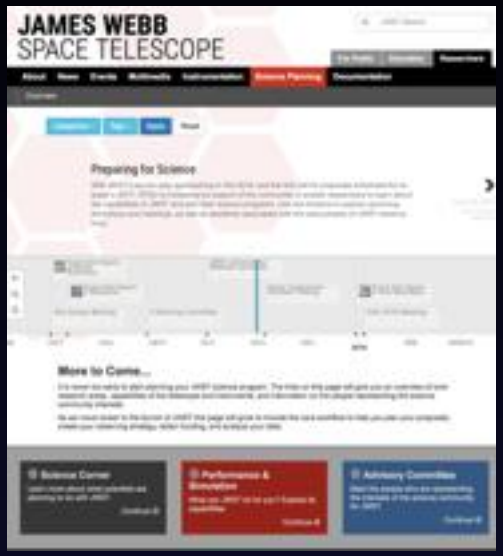




Installed Science Instrument package into Optical Telescope Element (May 2016)

JWST User Tools





- User Documentation (Handbooks, etc.)
- Space Telescope Imaging Product Simulator (STIPS)
- WebbPSF
- Exposure Time Calculator (ETC)
- Astronomer's Proposal Tool (APT)
- Calibration Pipeline
- Data Analysis Tools
- Archives

New Website and Documentation

A New Paradigm for JWST User Documentation (coming 2016)

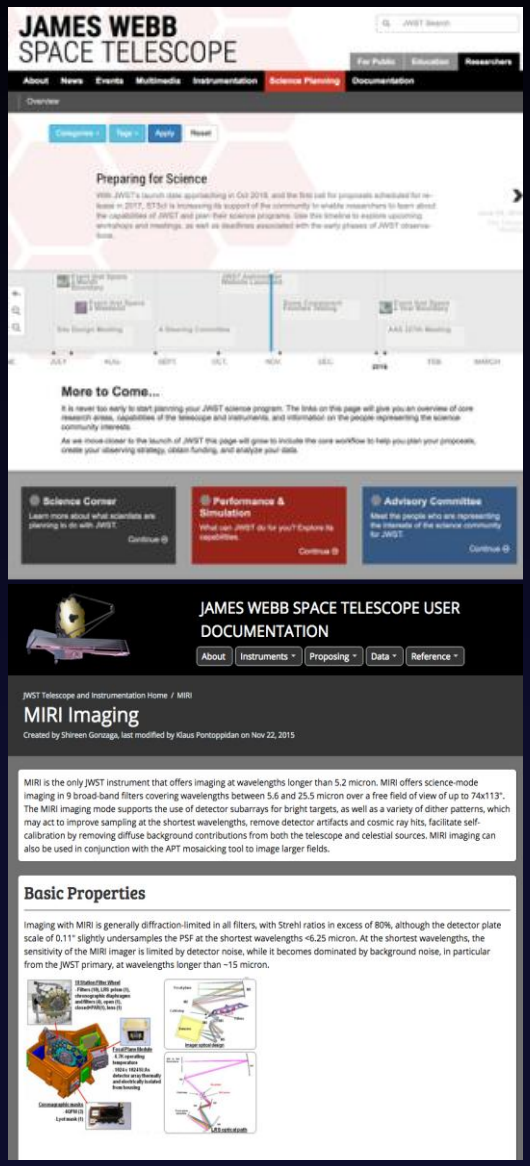
New JWST website will contain higher level mission information and JWST science content

New documentation system: “Every page is page one” (Mark Baker)
- Short articles
- Self-contained, one-level information
- Hyperlinked network rather than monolithic handbook

Think Wikipedia (but it’s not a wiki)

Multiple conceptual spaces: Background articles, planning cookbooks, science policy, engineering specs

Incremental releases (as articles are written and reviewed), beginning with instruments, APT, ETC articles



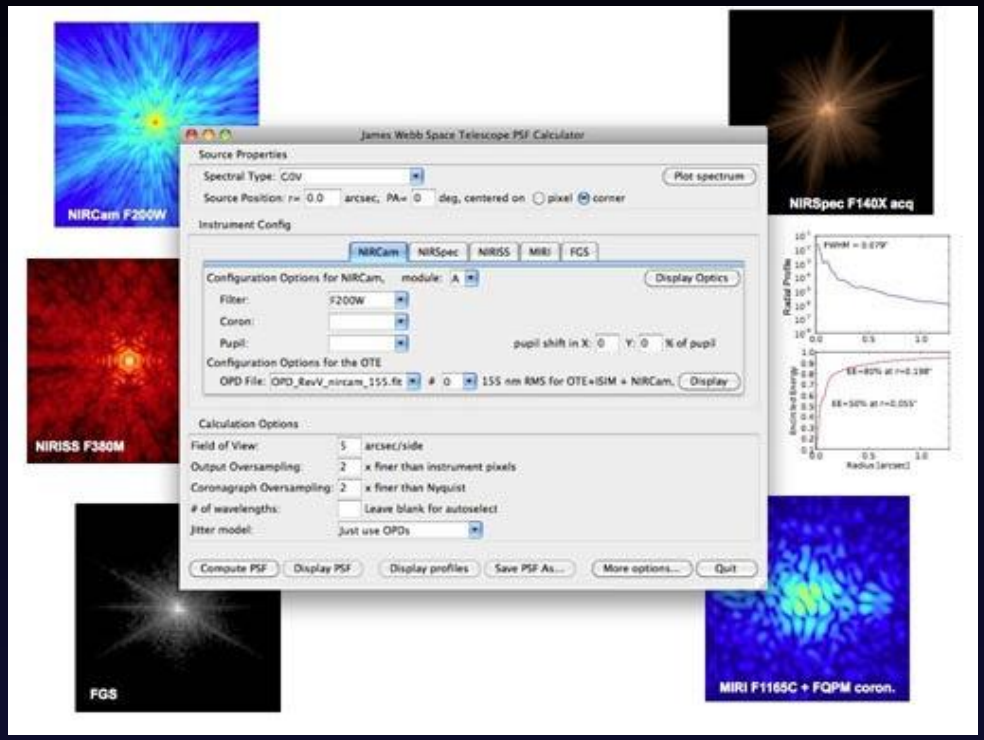
Space Telescope Image Project Simulator (STIPS)

- Simulators needed to model full fields of view, complex observing sequences, dithers, and simulated data products
- STIPS
  - Web tool
  - Initial release includes JWST imaging modes
  - Different astrophysical models: stellar populations, galaxy populations
  - Full FOV, WebbPSFs
- Initial Release in 2016

Website https://jwst.stsci.edu/science-planning/performance--simulation-tools-1/image-and-spectroscopy-simulator

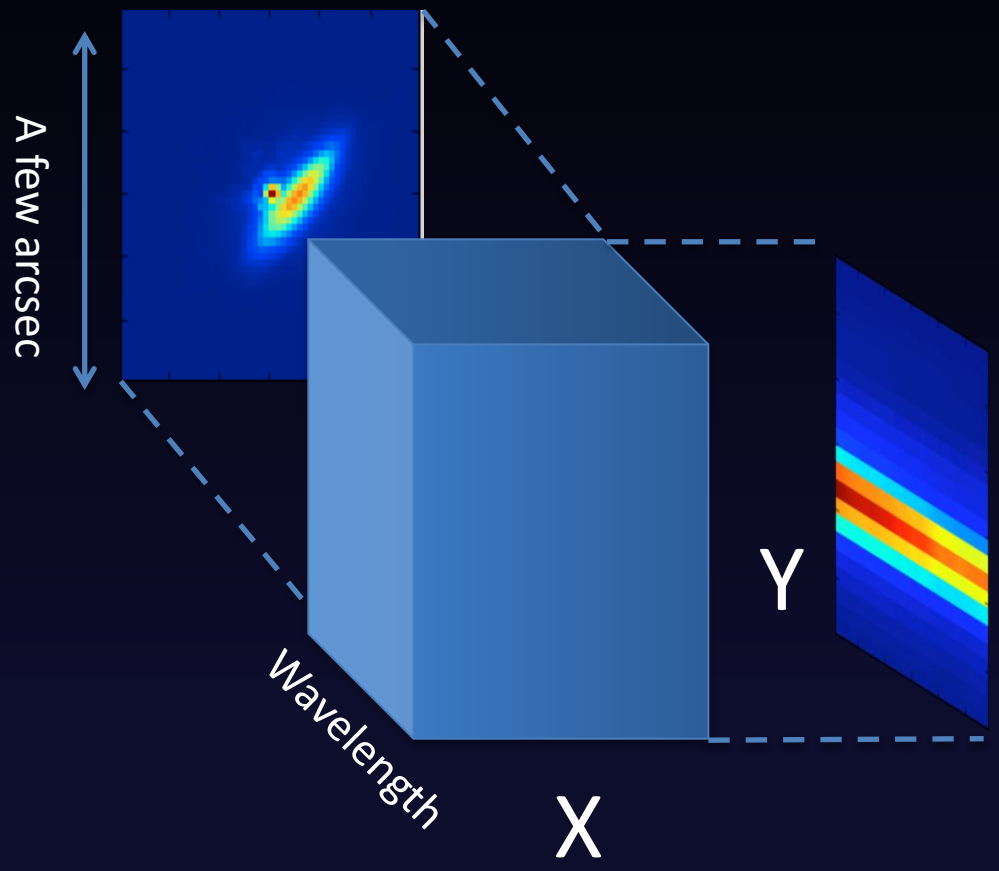
WebbPSF

- PSF simulation tool
- Includes a library of Optical Path Difference (OPD) files, consistent with the optical error budget, including wavefront errors in the OTE
- Assumes Fraunhofer (far-field) propagation
- Supports Direct Imaging, Coronagraphy, and Non-Redundant Mask modes
- Includes normalized filter throughputs, detector pixel scales, and orientations for all instruments
- Arbitrary sampling of output PSFs



Website https://jwst.stsci.edu/science-planning/performance--simulation-tools-1/psf-simulation-tool-webbpsf

JWST Exposure Time Calculator (Pandeia)



- Reference Files
  - *Throughput, PSFs, noise parameters*
- Engine
  - *General Python Library*
- Server
  - *Stores your calculations*
- User Interface
  - *Web application accessed through your browser*

Release Schedule

ETC engine development release: Spring 2016

ETC WebApp release: January 2017

Available Workbooks

#	Name	Load	Description	Options
1024	Imaging workbook	[Load]	Imaging observations of a 1 microJy flat spectrum source.	[Copy][Remove] [Sharing]
1025	High-resolution spectroscopy workbook	[Load]	High-resolution spectroscopy observations of a 1 mJy flat spectrum source.	[Copy][Remove] [Sharing]
1026	Medium-resolution spectroscopy workbook	[Load]	Medium-resolution spectroscopy observations of a 1 mJy flat spectrum source.	[Copy][Remove] [Sharing]
1027	Multiple extended source workbook	[Load]	Multiple extended sources observed in imaging and spectroscopy.	[Copy][Remove] [Sharing]
1028	Sample NIRSpec MSA Calculations	[Load]	Sample of NIRSpec MSA calculations showing the effects of shutter location, source location within the shutter, and the impact of multiple sources within a scene.	[Copy][Remove] [Sharing]
1029	Example Source Flux Distributions	[Load]	Example imaging calculations for each of the supported source geometries: point, flat, 2D gaussian, and sersic	[Copy][Remove] [Sharing]
1030	Sample Coronagraphy Calculations	[Load]	Coronagraphy calculations using three faint sources, one central star, and one reference source	[Copy][Remove] [Sharing]
1031	Sample NIRISS WFSS Calculations	[Load]	Sample NIRISS WFSS Calculations	[Copy][Remove] [Sharing]
1032	Sample backgrounds	[Load]	Same calculation for five different background options	[Copy][Remove] [Sharing]
1033	IFU starter sample workbook	[Load]	Modified, to be edited	[Copy][Remove] [Sharing]

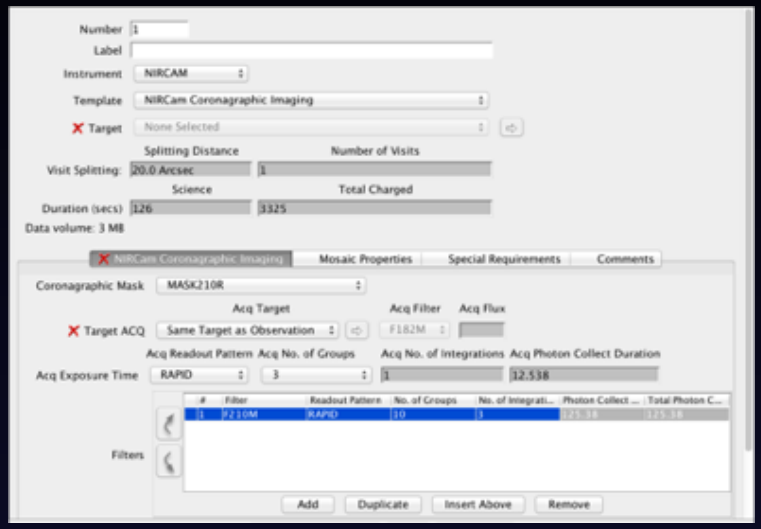
Create New Workbook | Get a Copy of the Sample Workbooks

User Access Permissions for ???

User	Read	Write	Grant	Revoke

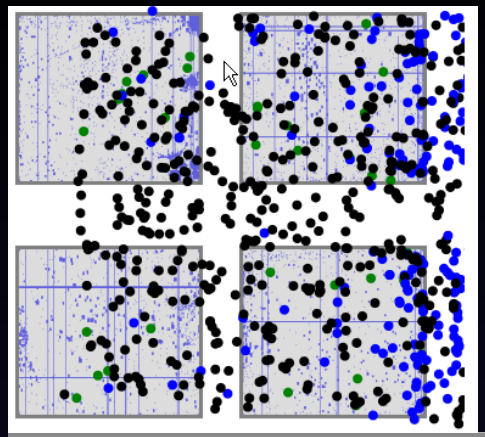
Astronomer's Proposal Tool (APT)

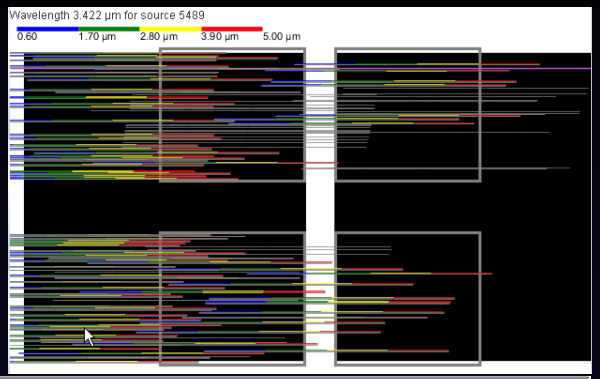
- Tool used to define observing programs and submit observing proposals
- Developmental releases already available in current HST APT release, http://www.stsci.edu/hst/proposing/apt

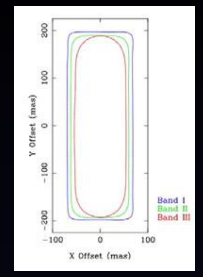


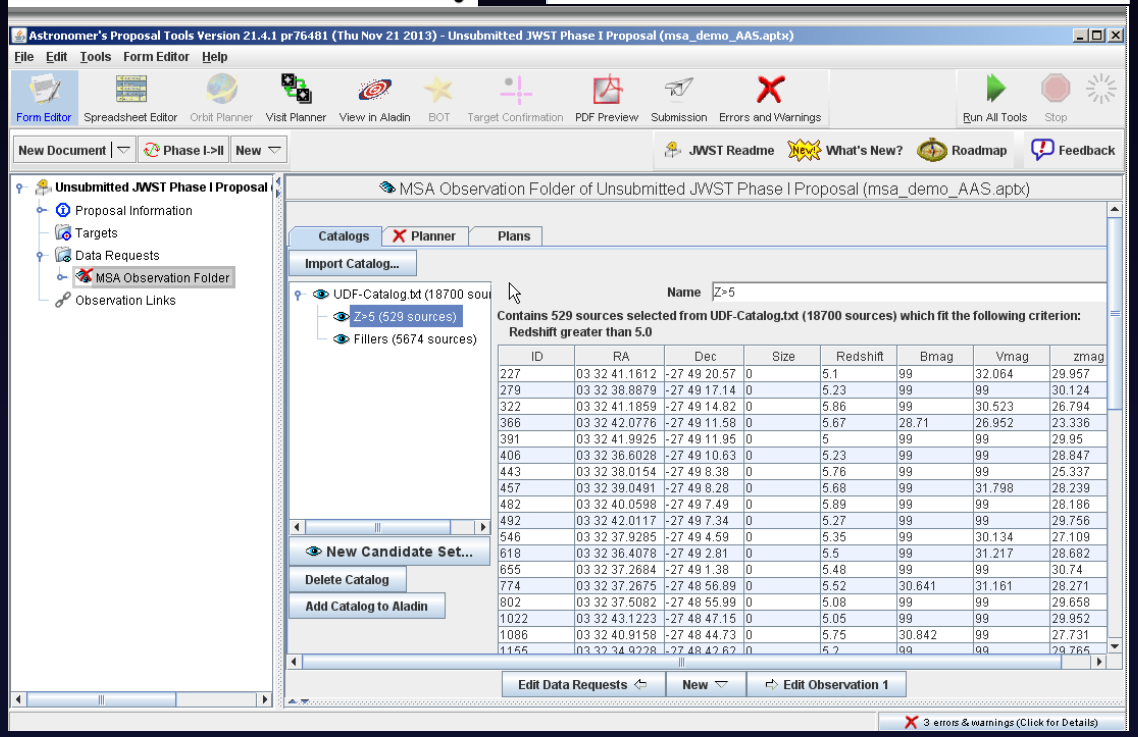
- Uses template concept developed for other observatories
- One template per Instrument mode (e.g. MIRI Imaging, NIRSpec IFU)
- Automatically splits observations into visits (sequences using a single guide star) and exposures

MSA Planning Tool





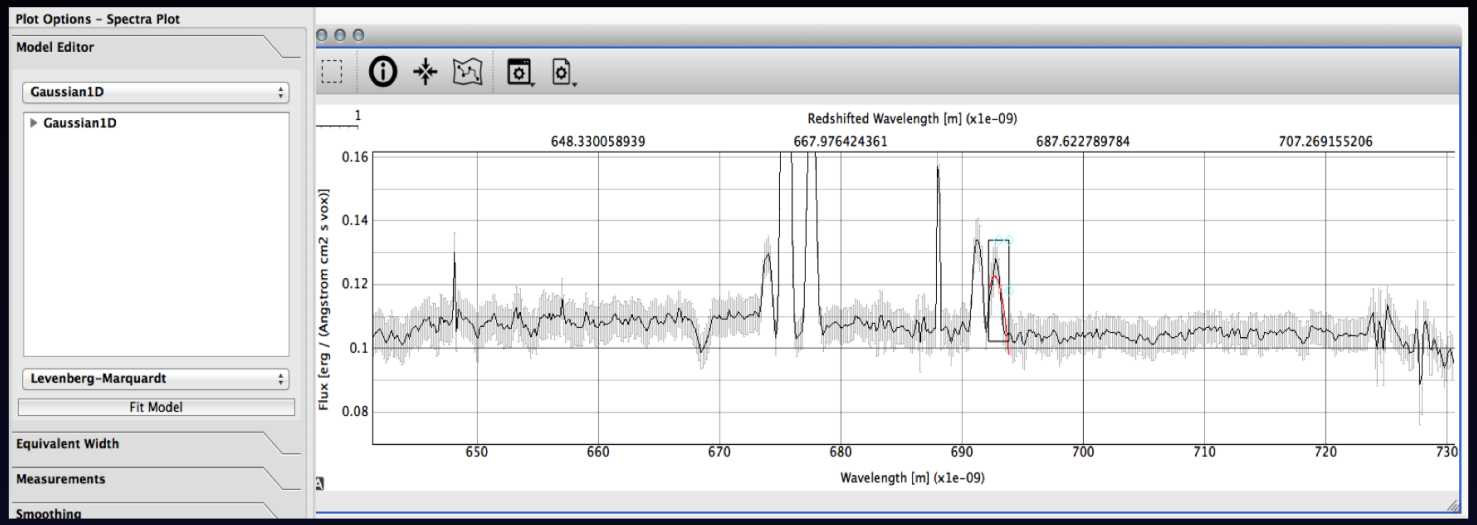




- Within APT
- Input source catalog, primary and filler candidate lists, slitlet set-up, dither set-up, exposure set-up, number of configurations
- Calculates configurations based on slit throughput
- Displays configurations, lists sources, shows layout of spectra on the detector

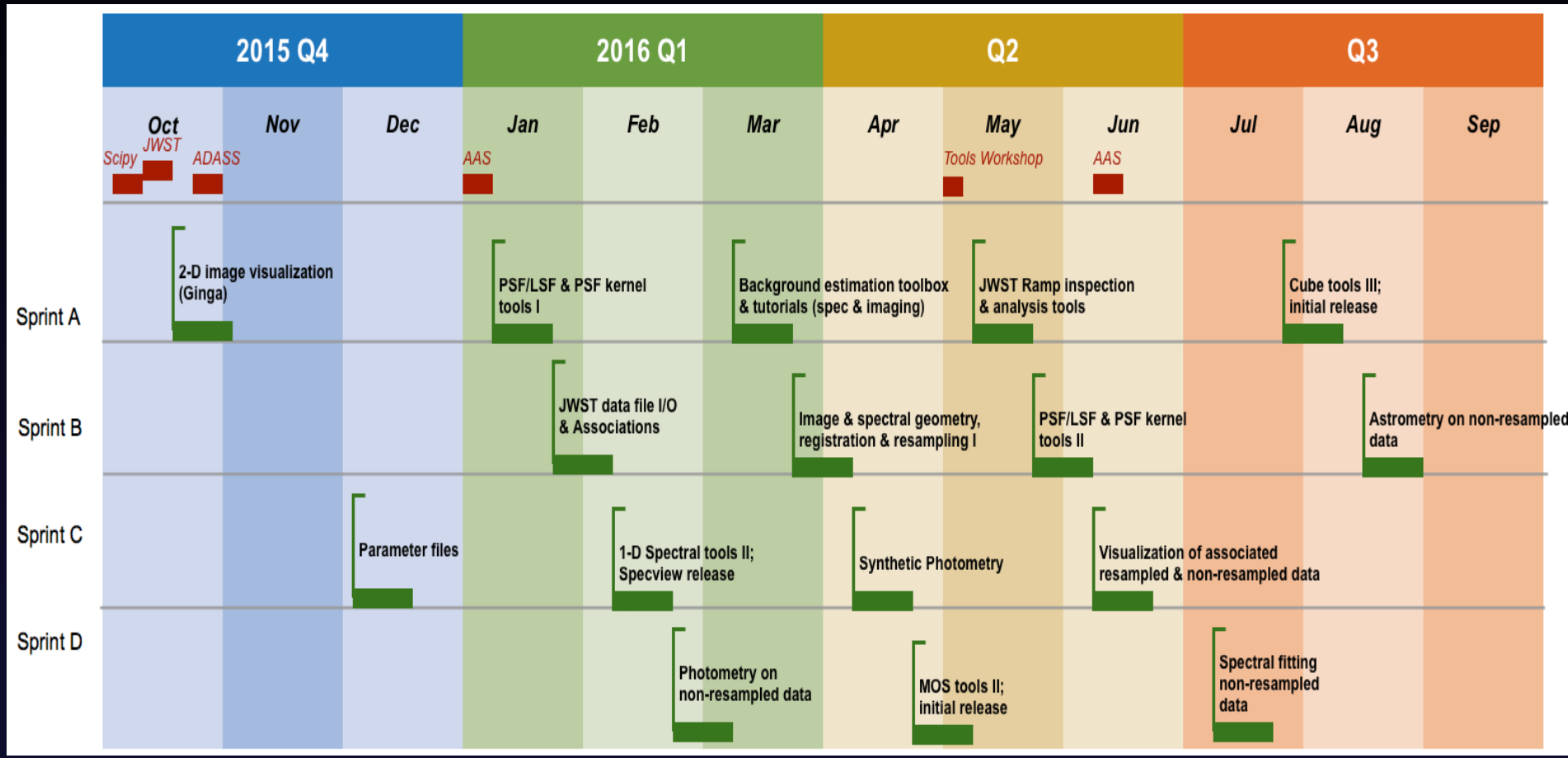
Documentation http://www.stsci.edu/jwst/instruments/nirspec/msa-planning-tool

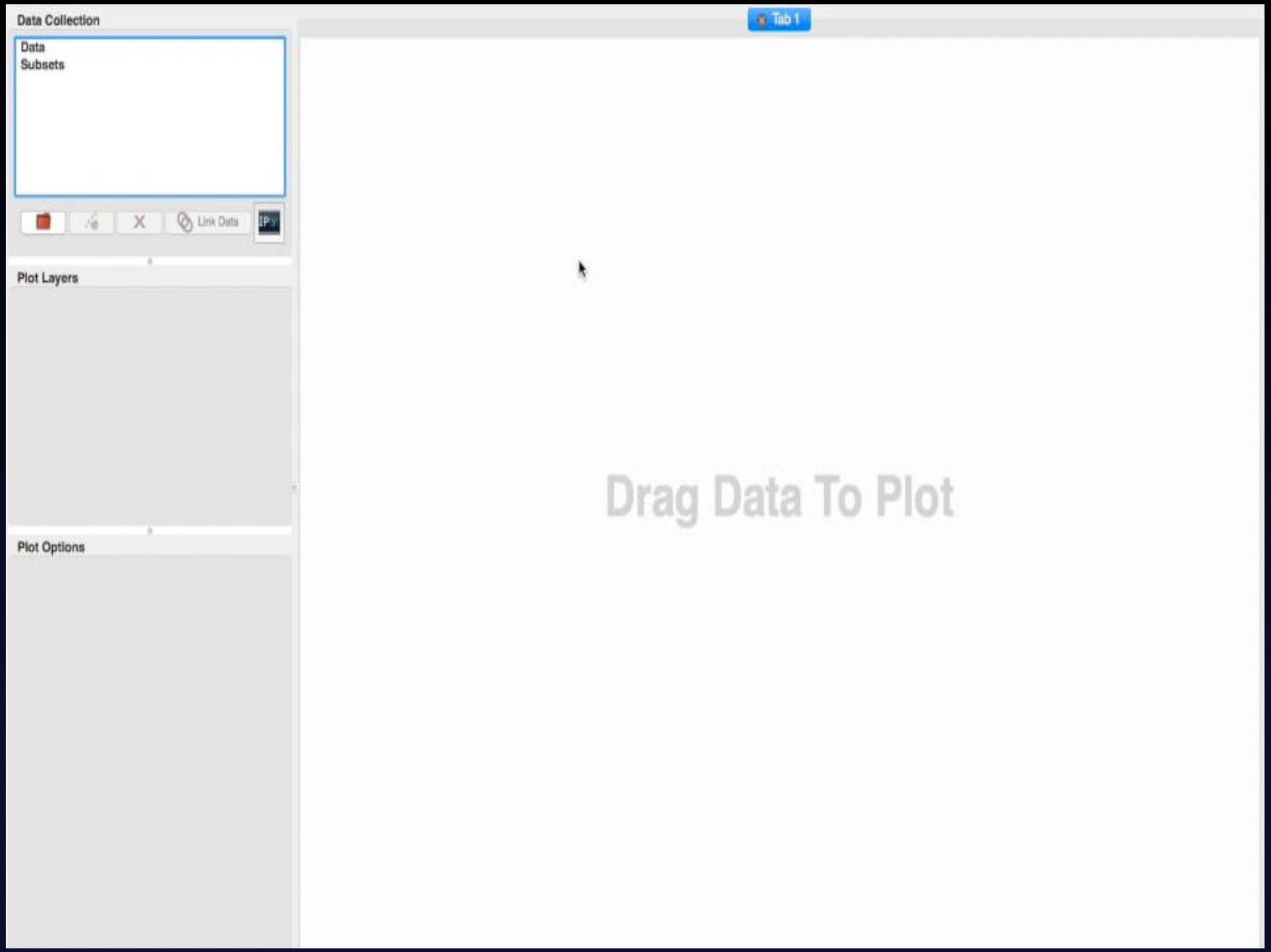
Data Analysis and Visualization Tools



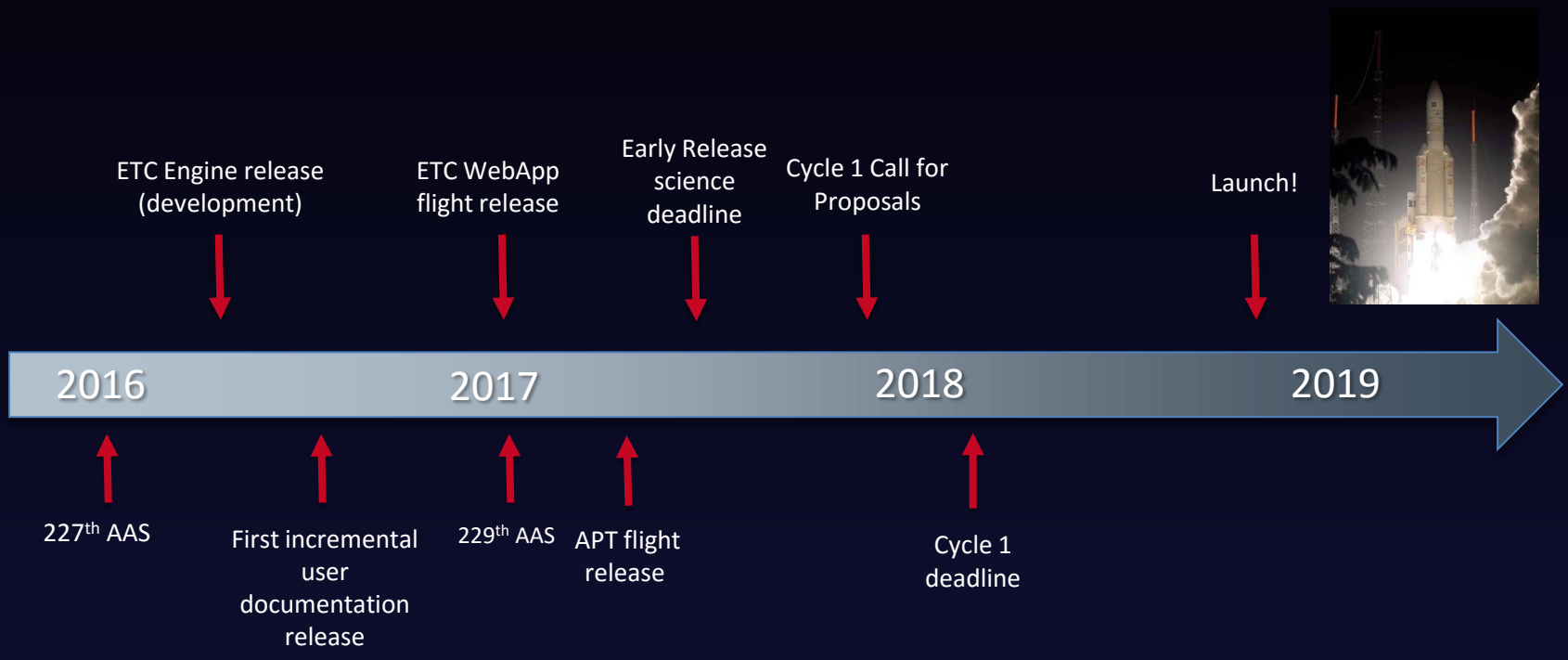
- JWST users need to inspect, manipulate, and model their data
- JWST data analysis will be in Python/Astropy
- Basic capabilities familiar with users of IRAF, STSDAS, and IDL will be available (many already are)
- Visualization will be in Ginga & Glue
- Tools understand JWST data structures, including uncertainties, data associations, and data quality flags
- Extensible visualization tools are being developed for interactive workflows
- Up-to-date development code and discussion available via: bit.do/jwst

Data Analysis Tools Development Plan

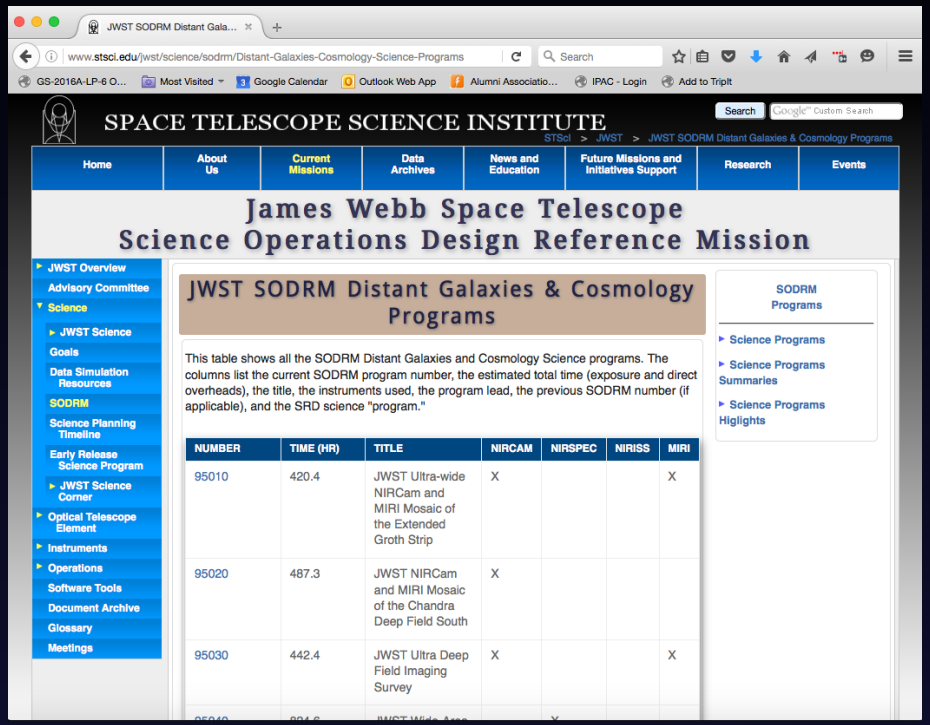



Data Collection
Data
Subsets
Link Data
Plot Layers
Plot Options
Tab 1
Drag Data To Plot

User Tools Timeline Summary



Science Operations Design Reference Mission (SODRM)



- Contains 112 representative science and calibration programs covering a wide range of science topics and observing modes
- Text description: Title, ID number, Science Goal, Estimated Observatory Time, Targets, Observing Templates, Description of Observations, Timing /Orientation Constraints
- Detailed Exposure Specifications
  - APT files for all NIRCam, NIRSpec, and MIRI observations
  - Spreadsheets for NIRISS observations

Website
http://www.stsci.edu/jwst/science/sodrm
Documentation
http://www.stsci.edu/jwst/science/sodram/SODRM-Revision-C.pdf

Other JWST Science Meetings and Preparatory Workshops

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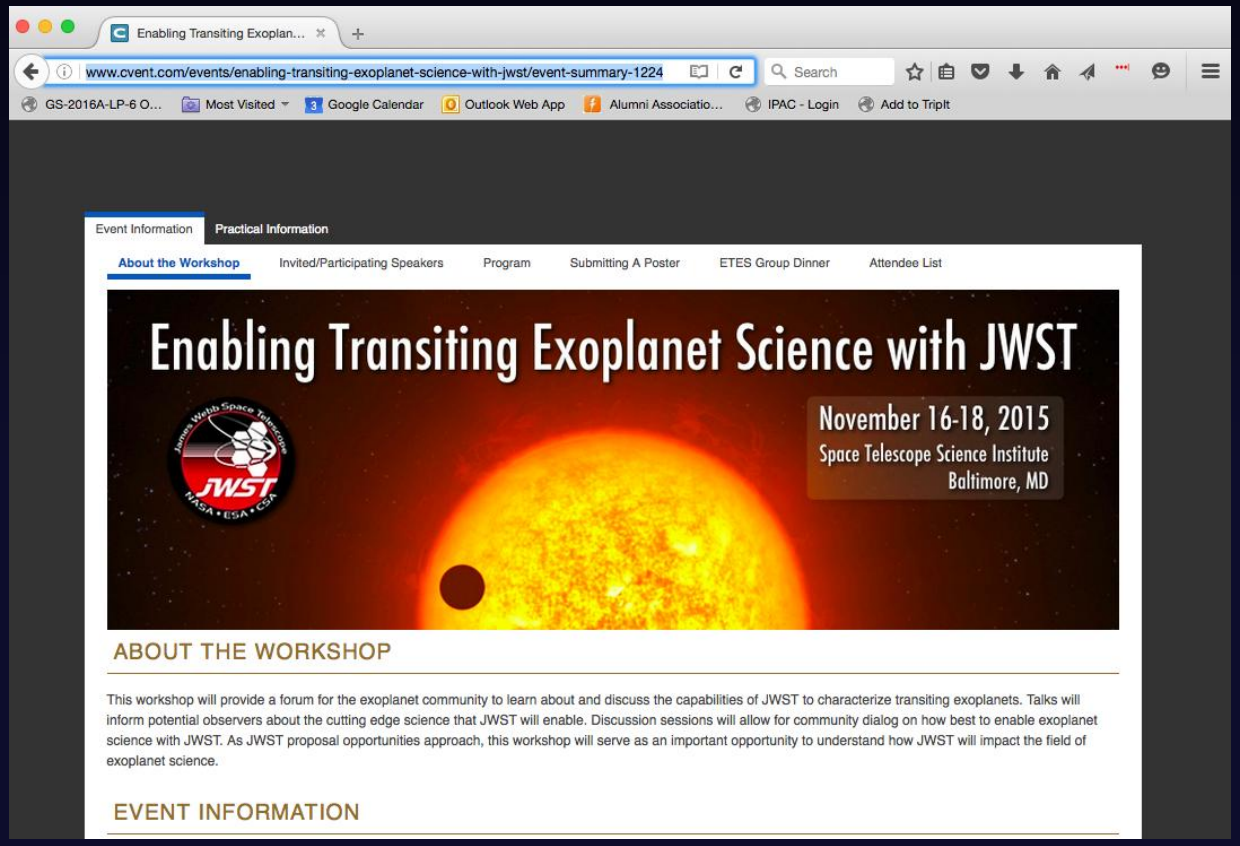
  - 2-3 day workshops on major JWST science themes will be organized at STScI throughout 2016-2018, will include hands-on introduction to software and systems



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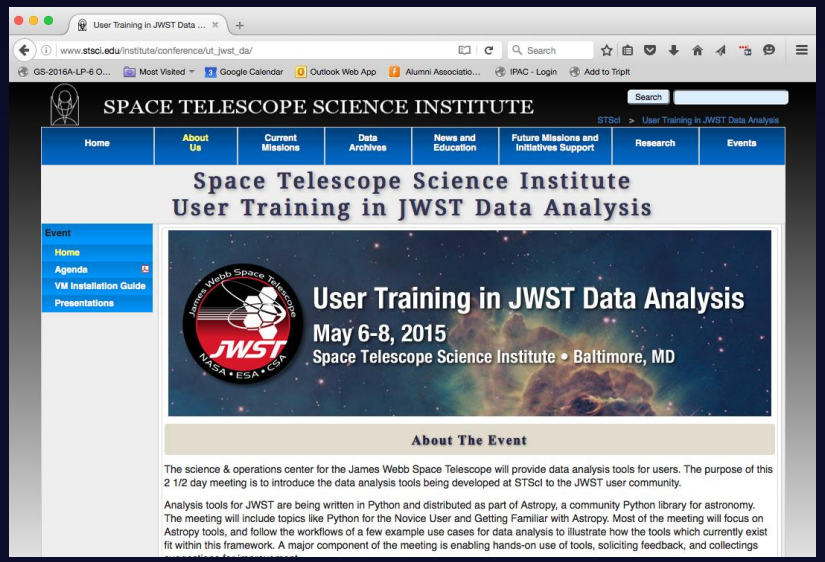

Website includes archived talks
http://www.stsci.edu/institute/conference/ut_jwst_da

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- JWST “Colloquium Series”
  - Contact us if you would like a holistic presentation about JWST and user preparation at your institution
- JWST “Community Days” (Coming Soon)
  - Open call to US institutions to host hands-on JWST 1-2 day workshops (w/ optional science meeting), includes ERS program planning, JWST modes and flight capabilities, observing techniques, etc.