STScI | SPACE TELESCOPE SCIENCE INSTITUTE

EXPANDING THE FRONTIERS OF SPACE ASTRONOMY

Ancillary Tools

Bill Blair

JWST Master Class Plenary

November 2019

What do we mean by “ancillary tools”?

- The JWST ETC and APT are the primary tools every proposer needs to create a JWST proposal.
- However, many proposers may find it useful to perform some preliminary work to scope out their proposed science ideas.
- This is where ancillary tools come in!

What do we mean by “ancillary tools”?

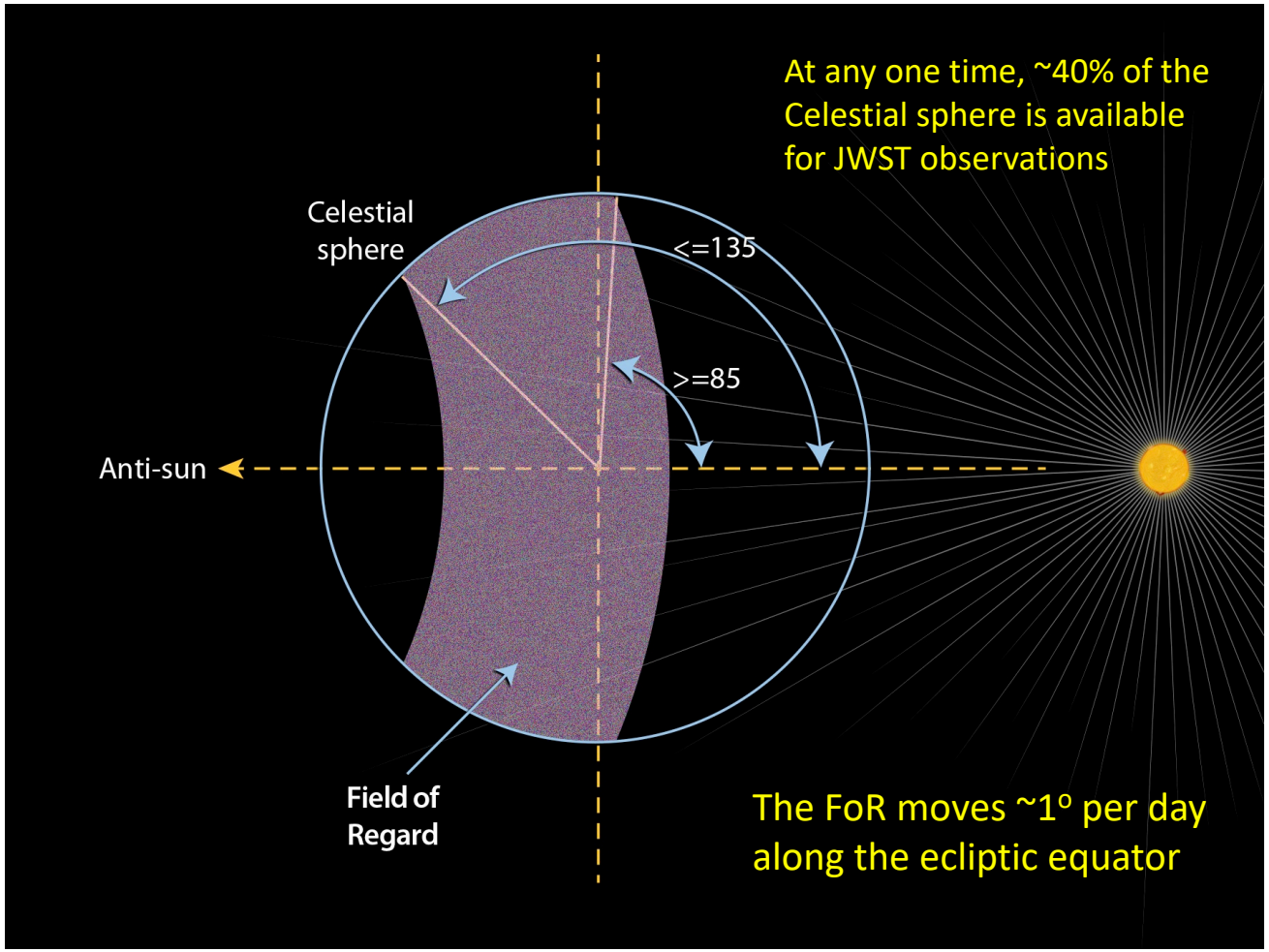
- STScI provides a number of stand-alone tools that allow users to
  - check target visibilities and available position angles,
  - investigate sensitivity to the IR background, and
  - get a sense for the feasibility (exposure times, likely S/N) of observing their favorite targets.
- Also, while not a “tool” *per se*, the process of duplication checking is something that most users will want to look at early in the process to avoid surprises at the time of submission.
- This talk will provide an overview of these ancillary tools and processes.

Target Visibility Overview

Target Visibility Tools: Why are they needed?

- JWST can observe the entire sky; just not all at the same time!
- If your proposed targets have no timing or position angle constraints, you probably don't have to concern yourself with the target visibility tools.
- However, if timing or position angle is important for your observations, the TVTs can save a lot of headaches by showing you what is possible up front in the planning process.

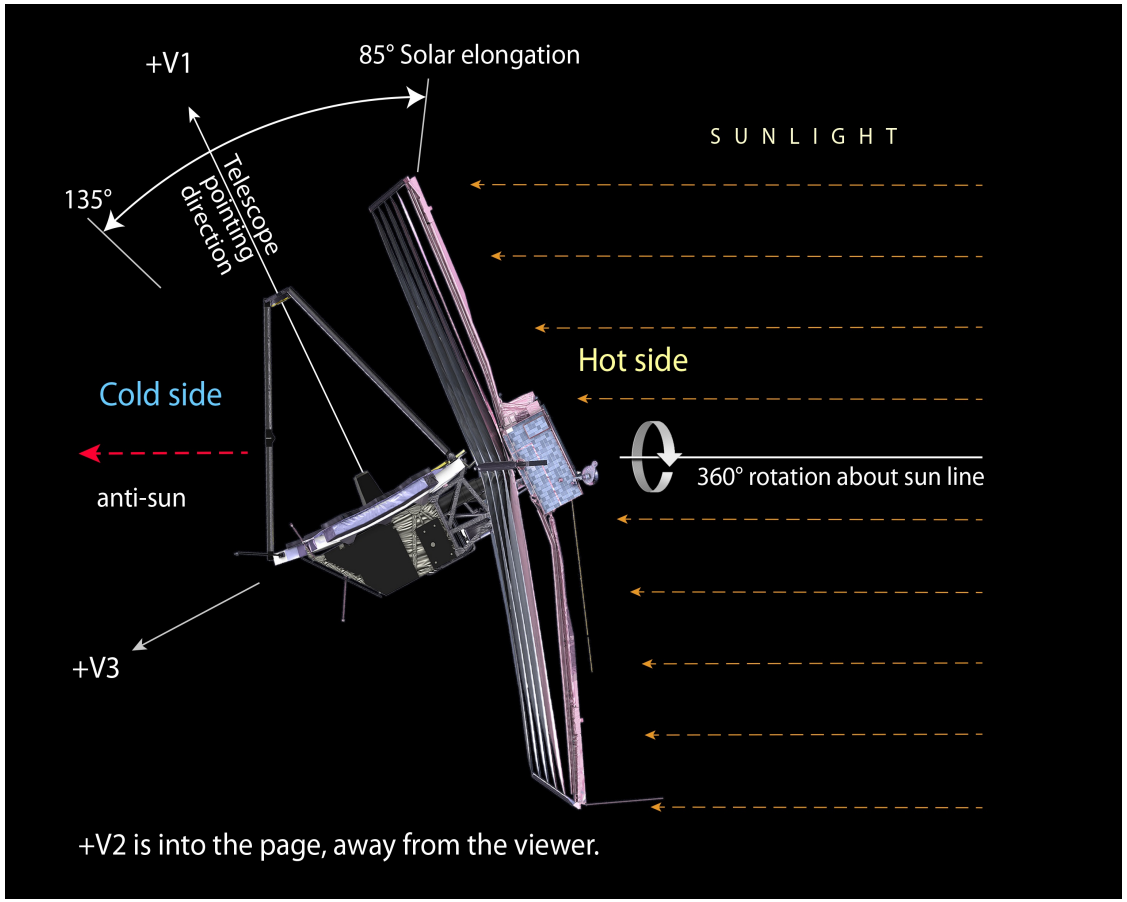
The JWST Field of Regard

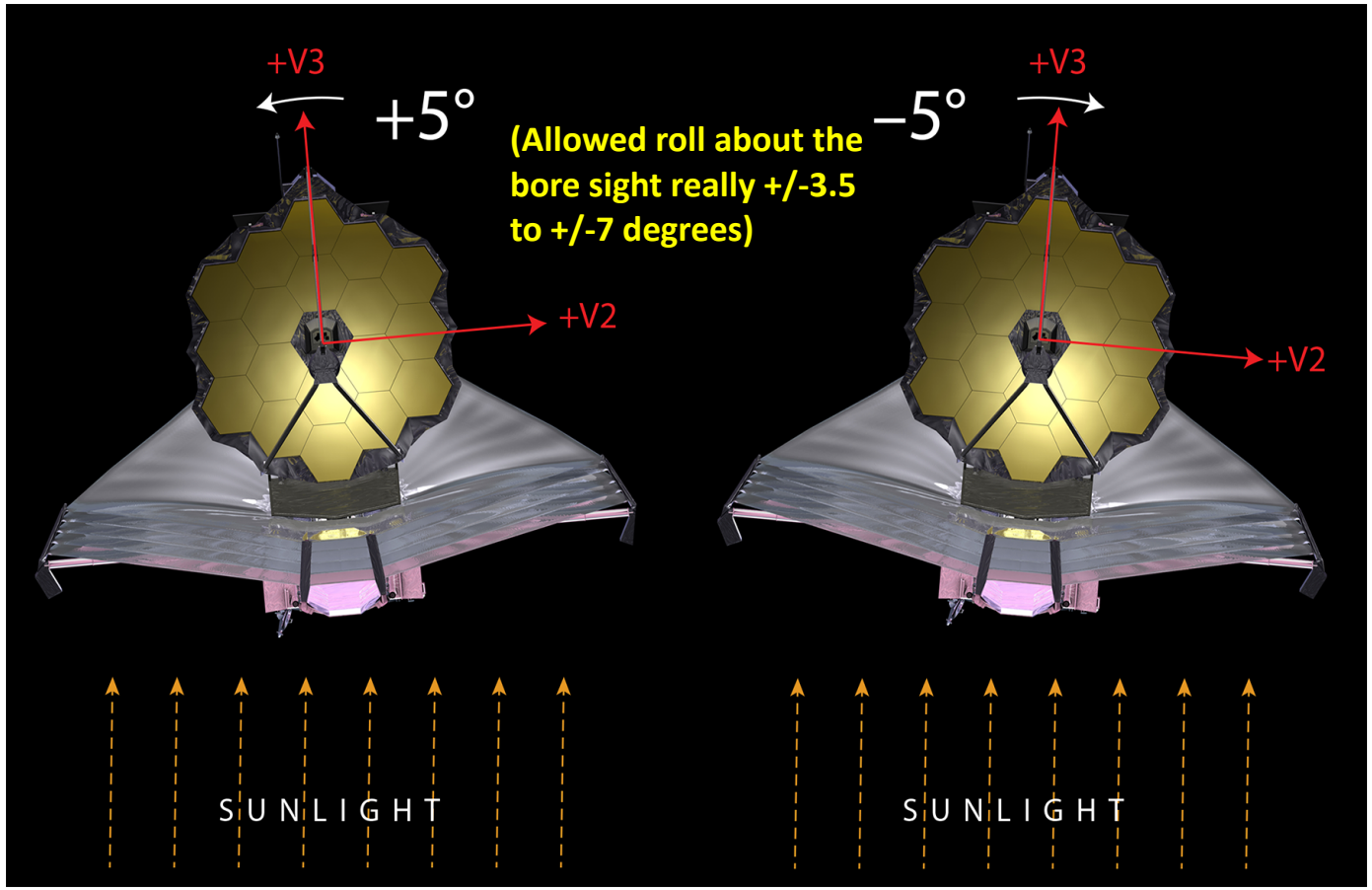


JDox: JWST Observatory Coordinate System and Field of Regard

Target Visibility Tools: Why are they needed?

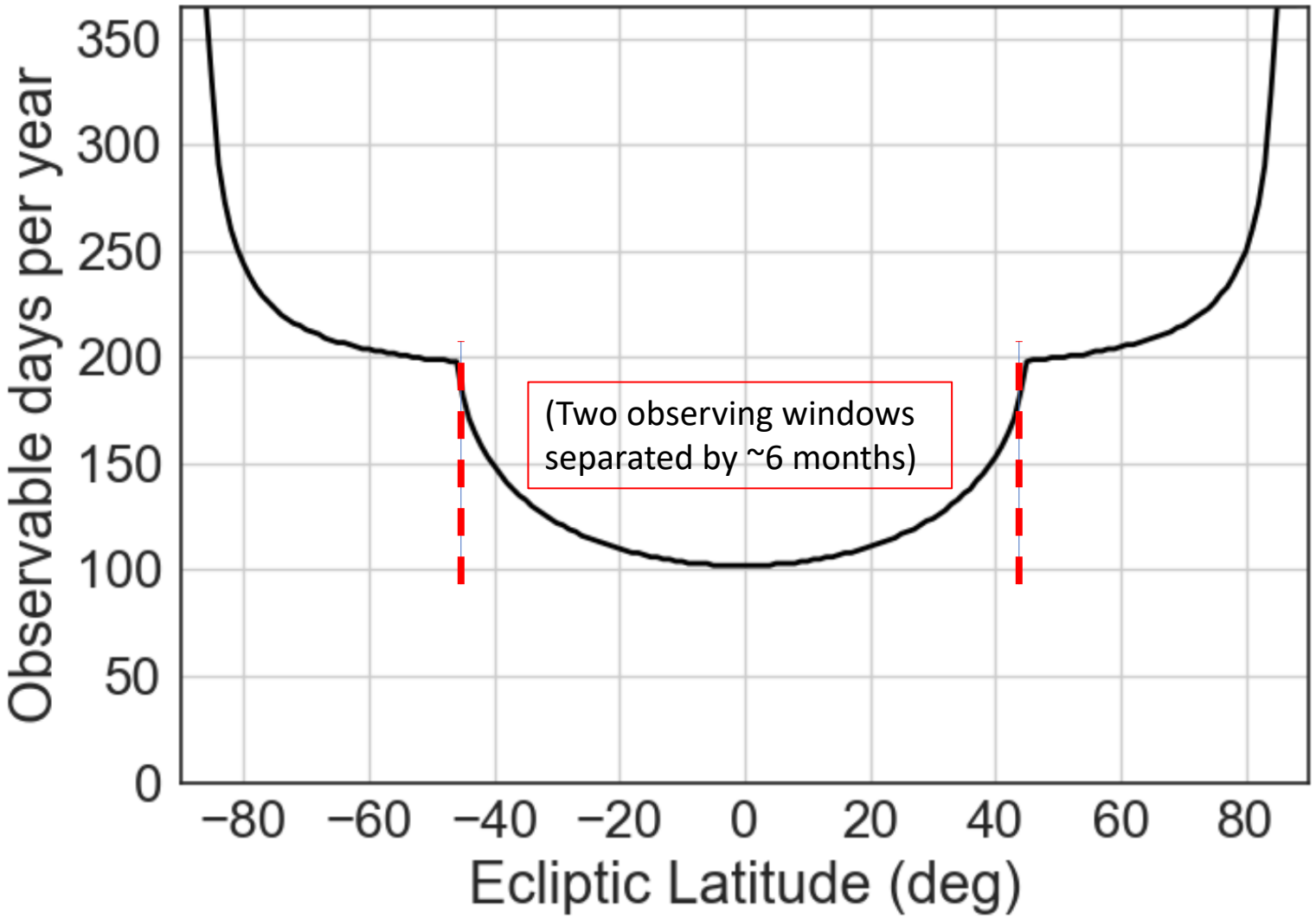
- JWST can rotate 360° about the sun line, but can only roll about the bore sight by ~5°.
- These constraints impact the angles of the JWST field of view on the sky as well as visibility.





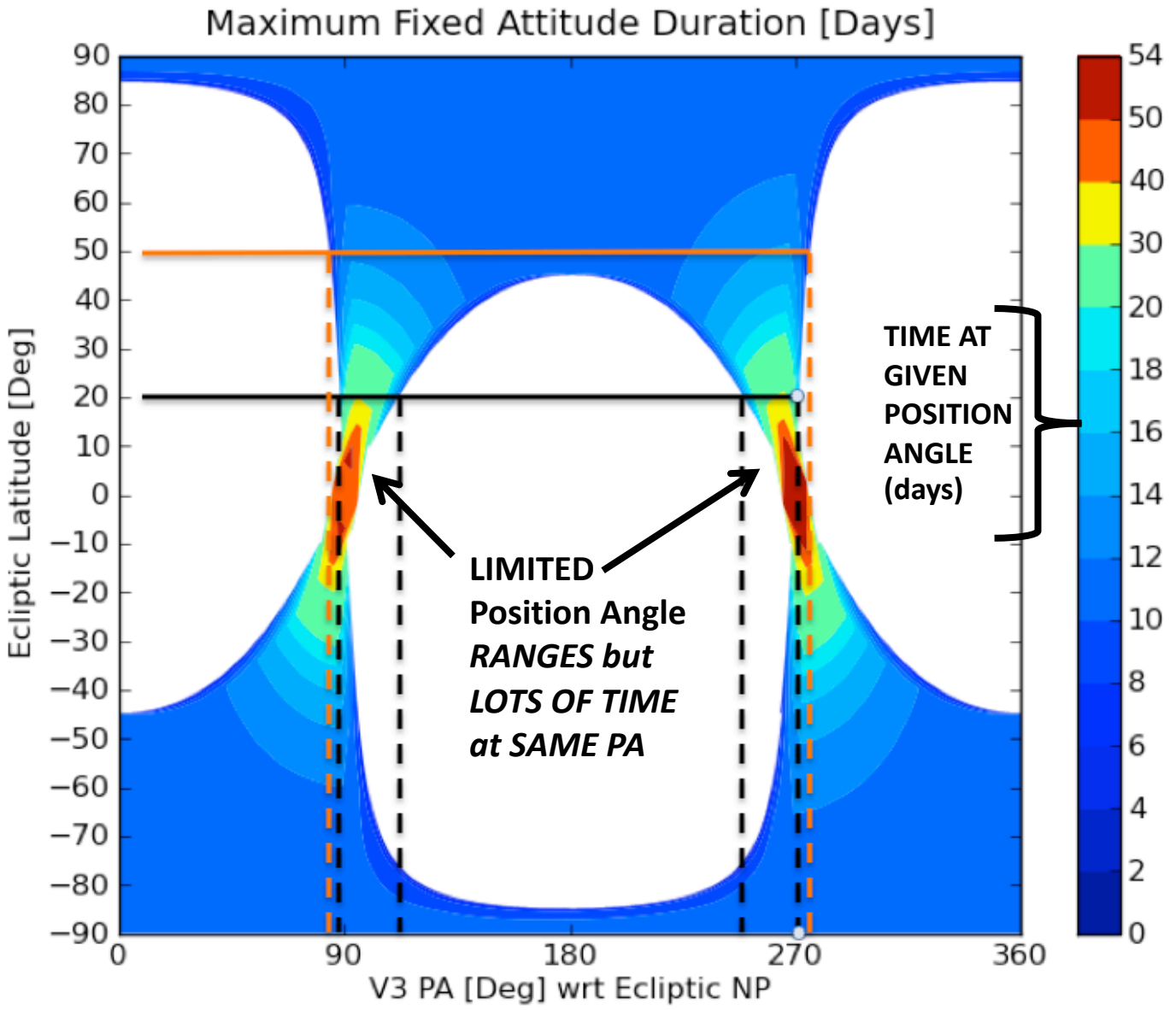
Total Visibility vs. Ecliptic Latitude

- Targets below |45°| in ecliptic latitude have less total visibility and it is split into two periods ~6 months apart.
- Above |45°|, targets have one longer period of visibility that increases with higher ecliptic latitudes.
- There are small Continuous Viewing Zones (CVZs) near each ecliptic pole.



Position Angle Restrictions

- "V3PA" is an observatory reference angle on the sky (similar to but not exactly like astronomical position angle).
- Below |45°| ecliptic latitude, *the range* of available position angles becomes increasingly restricted.
- However, the length of time the observatory can stay at *the same* position angle increases!
- Note that over much of the sky, the observatory can only maintain *the same position angle* for about 10 days.



Target Visibility Tools

- General Target Visibility Tool (GTVT)
  - Simple command line tool producing text and plot output.
  - Shows visibility and position angle as a function of time for all science instruments.
  - Output can be saved to files.
- Moving Target Visibility Tool (MTVT)
  - A variant on GTVT that links to JPL/Horizons for moving target support.
- Coronagraphic Visibility Tool (CVT)
  - A GUI visibility tool with added functionality for coronagraphy applications.
  - Focused on MIRI and NIRCam coronagraphic modes
- Tools provide *ecliptic coordinates* of each target for reference.

JDox:

General Target Visibility Tool Help

Moving Target Visibility Tool Help

Coronagraphic Visibility Tool Help

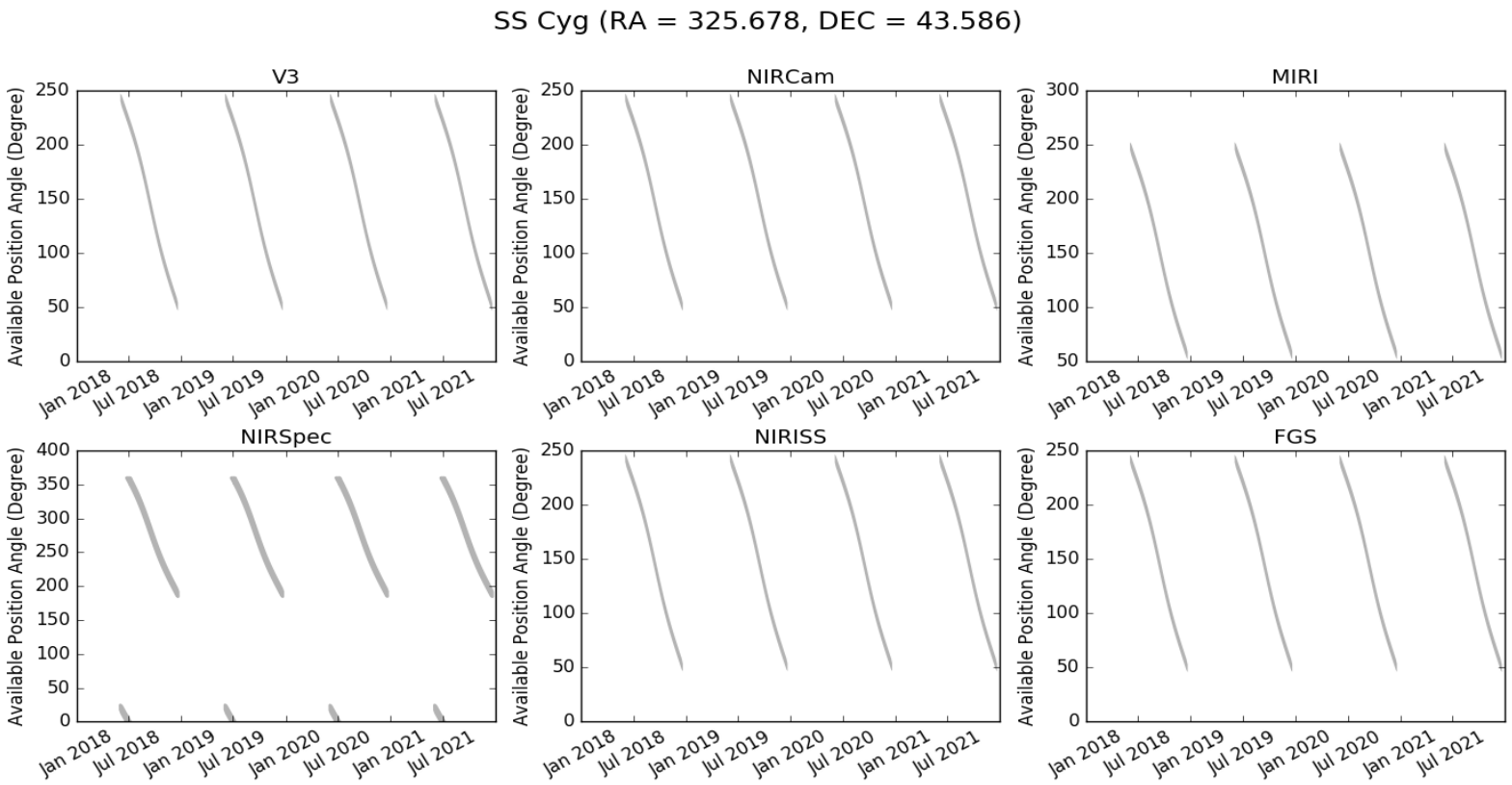
GTVT command line examples -- plots

jwst_gtvt 325.678 43.586 --name "SS Cyg"

(Runs and produces a plot on the screen for all six instruments that can be interacted with. No save file produced. Close plot window to exit program.)

jwst_gtvt 325.678 43.586 --name "SS Cyg" --save_plot SSCyg_all.png

(Just saves plot file, does not provide interactive plot.)



Plot on screen is interactive; you can pan and zoom as needed to see details.

GTVT command line examples -- output

jwst_gtvt 325.678 43.586 --name "SS Cyg" --save_plot SSCyg_all.jpg --save_table SSCyg1.dat

(Saves both outputs to the files specified; no interactive.) Here is what the top of the Table looks like:

Ecliptic latitude reported in output file

Target		ecliptic
RA	Dec	latitude
325.678	43.586	52.656

Checked interval [2019-06-01, 2021-12-31]

Summary of overall visibility windows

Window [days]			Normal V3 PA [deg]			
Start	End	Duration	Start	End	RA	Dec
2019-06-02	2019-12-21	201.93	244.06365	50.05444	325.67800	43.58600
2020-06-02	2020-12-20	201.00	243.55157	50.26286	325.67800	43.58600
2021-06-02	2021-12-21	202.00	243.75011	49.65785	325.67800	43.58600

Long listing showing nominal range of angles available each day for each instrument mode.

	V3PA		NIRCam		NIRSpec		NIRISS		MIRI		FGS	
Date	min	max	min	max	min	max	min	max	min	max	min	max
2019-06-03	240.63	247.46	240.60	247.44	18.11	24.95	240.06	246.89	245.64	252.48	239.38	246.21
2019-06-04	239.50	247.06	239.47	247.03	16.99	24.54	238.93	246.49	244.51	252.07	238.25	245.80
2019-06-05	238.37	246.65	238.34	246.63	15.86	24.14	237.80	246.08	243.39	251.67	237.12	245.40

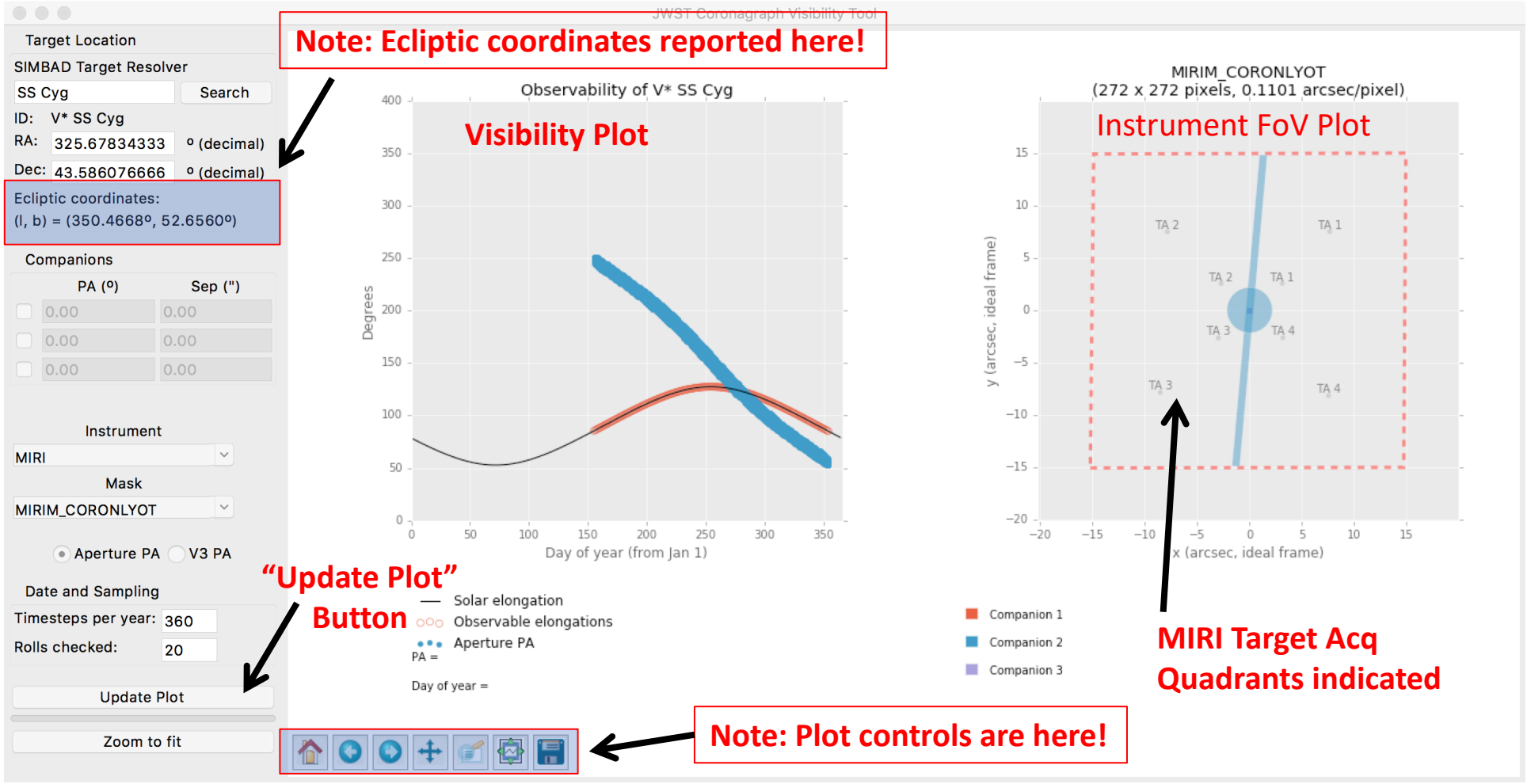
…etc.

CVT is a GUI-based tool with GUI/matplotlib interface

Simple example: entered "SS Cyg" and did a search; coords added automatically.

Selected MIRI and Lyot coronagraph and hit "Update Plot."

- The fat blue line shows the visibility windows and MIRI aperture PA values over 1 year. The vertical thickness of the line shows the *roll range* available at any given time. (Zoom in)
- The red line just highlights the period of visibility.
- The Instrument view changes for different coronagraph selections.

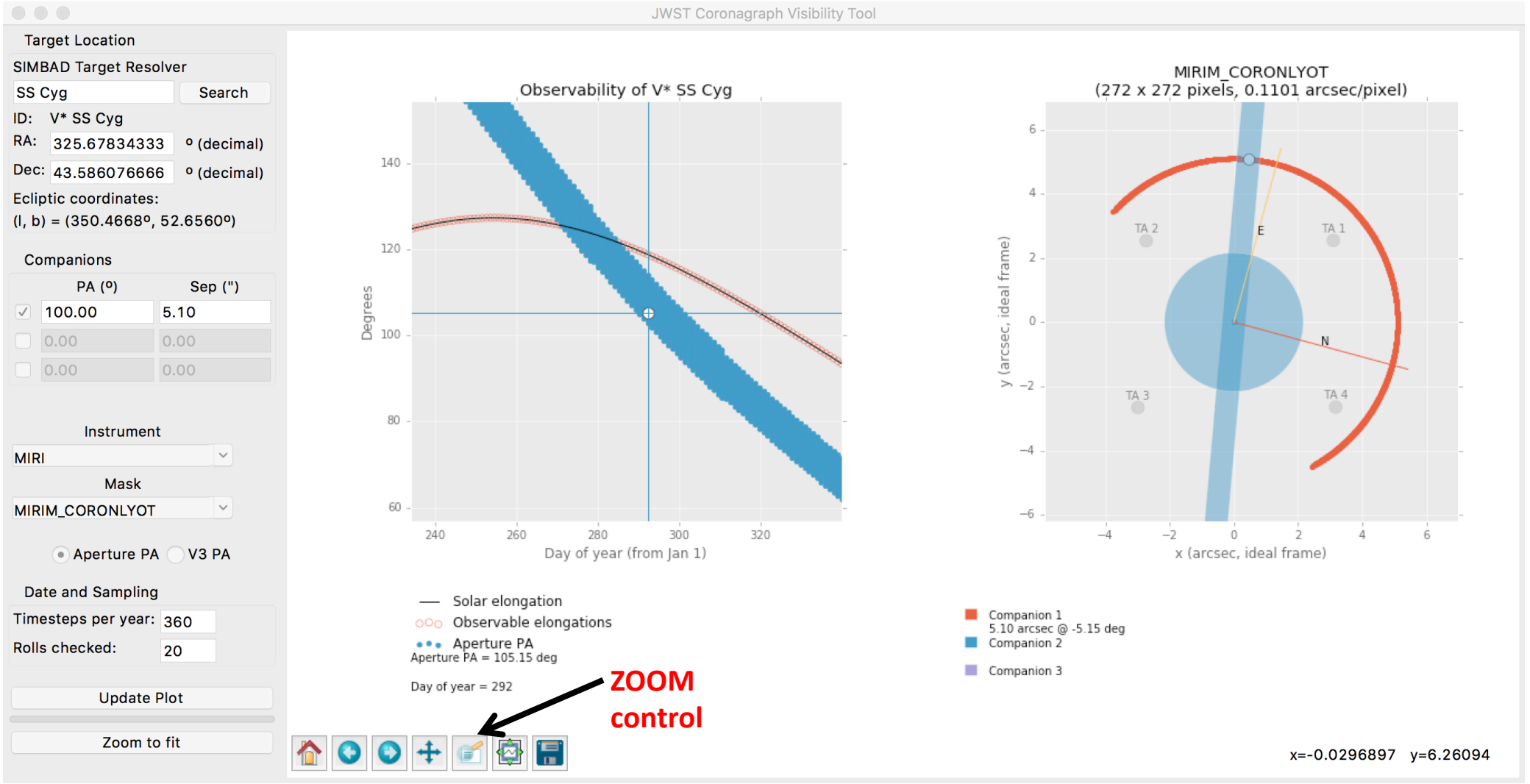


CVT example with a companion

Here both panels have been enlarged to show the details.

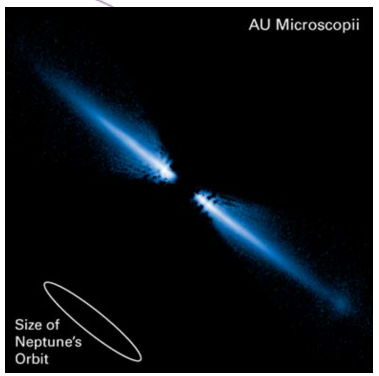
A single companion has been added.

Clicking on either plot highlights the point in the other plot.



Sample Heading

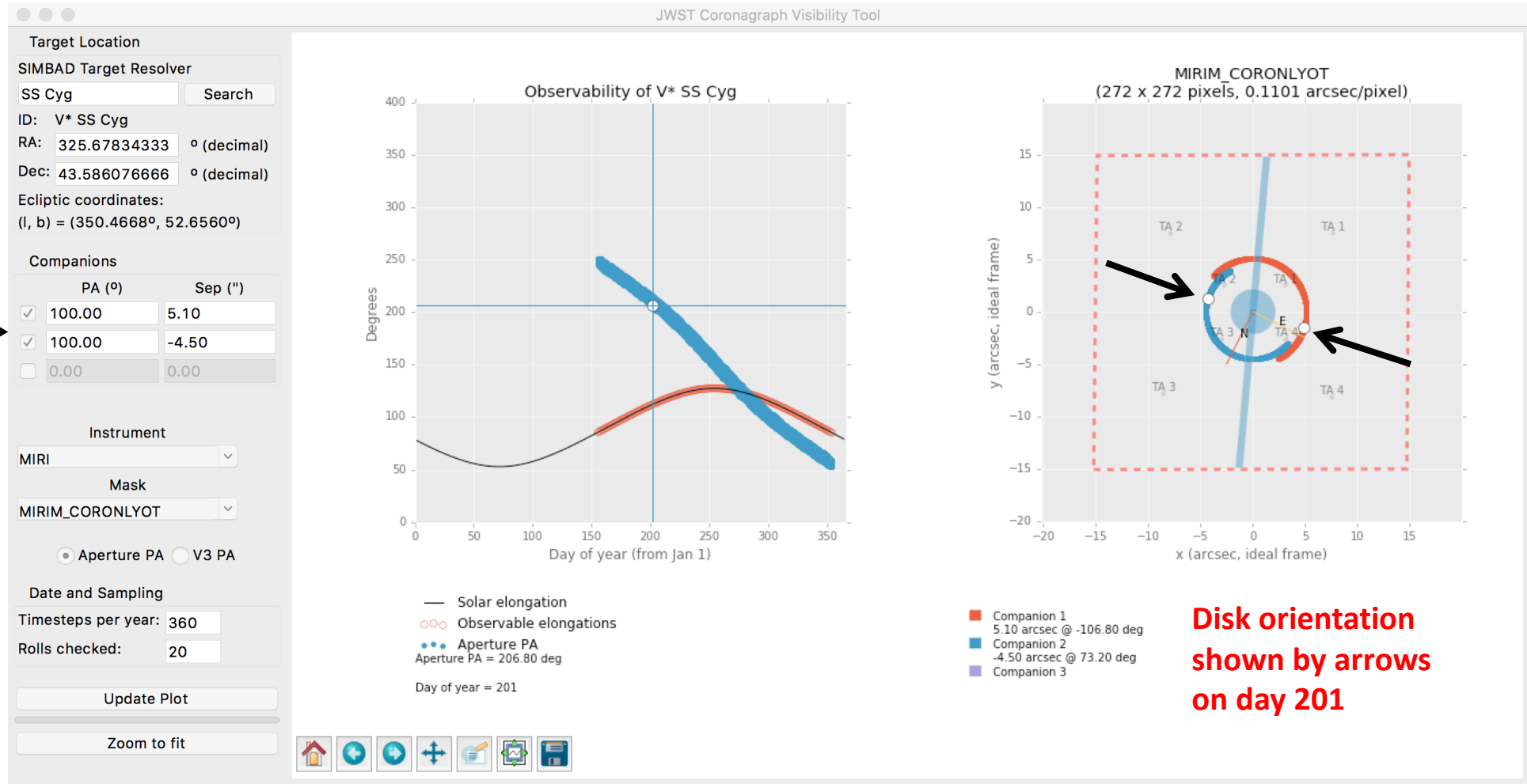
HINT: To show a disk orientation, place a “companion” on either side at the PA of the disk. Use a different distance for the two companions so the tracks in the right panel will not overlap.



Note: two companions, Same PA, opposite sides

User can note angles and/or times that are appropriate (or not) and use in APT Special Requirements as needed.

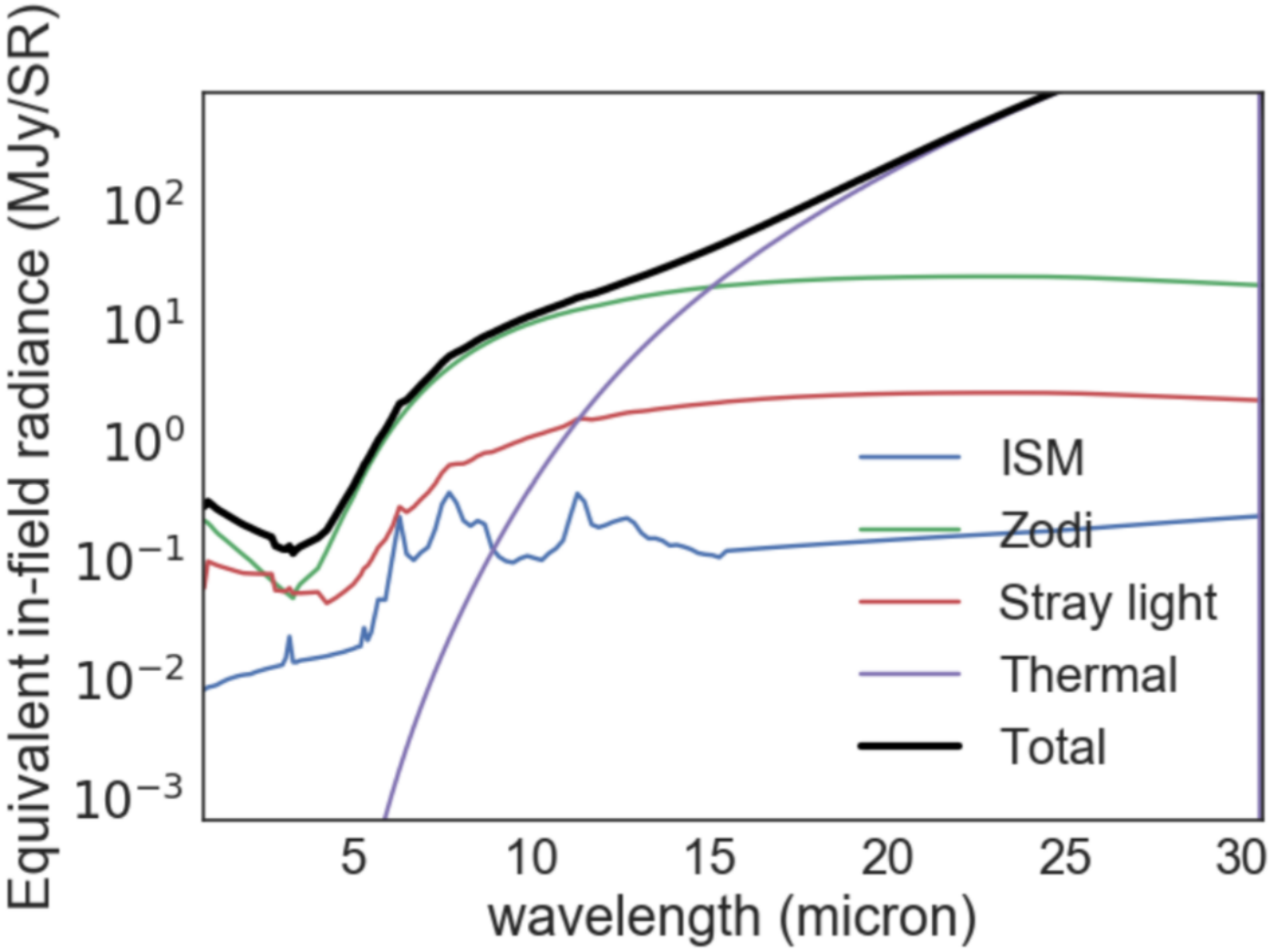
(Very hard to diagnose this sort of thing within APT itself!)



Disk orientation shown by arrows on day 201

Impact of Infrared Background and Variability

Variable background can impact visibility periods



(Figures courtesy of Jane Rigby, NASA/GSFC)

Zodiacal light is the most variable component of the background and dominates below about 10 μm. It is also time variable.

For background-limited observations, scheduling at low backgrounds is an additional constraint that can reduce observing windows.

The JWST Backgrounds Tool (for background limited observations)

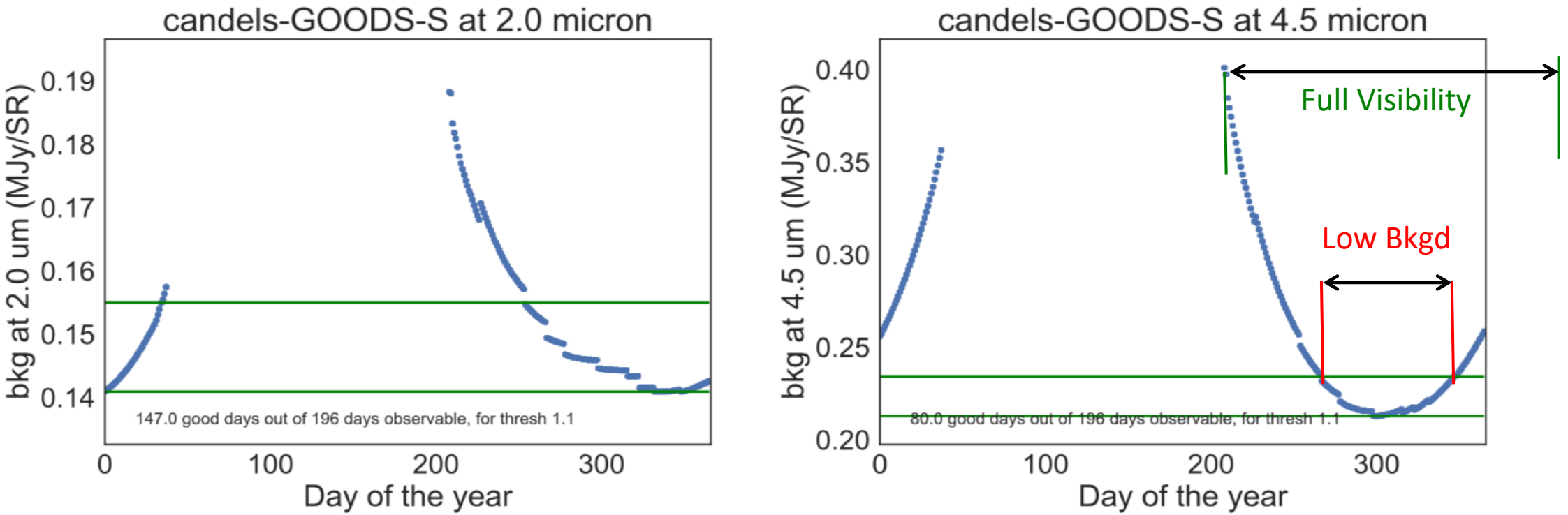


Figure 3: The total background versus calendar date, also known as "bathtub curves", for the GOODS-S field, at 2 micron and 4.5 micron.

APT has a special requirement that can limit scheduling to low background periods.

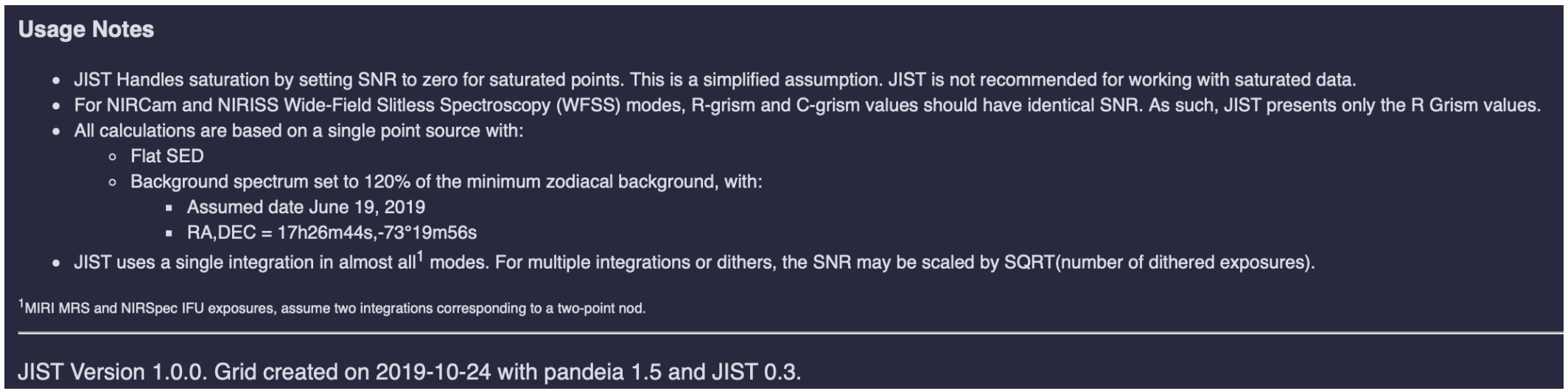
JDox: JWST Background Model, How JWST Backgrounds Vary, The Backgrounds Tool

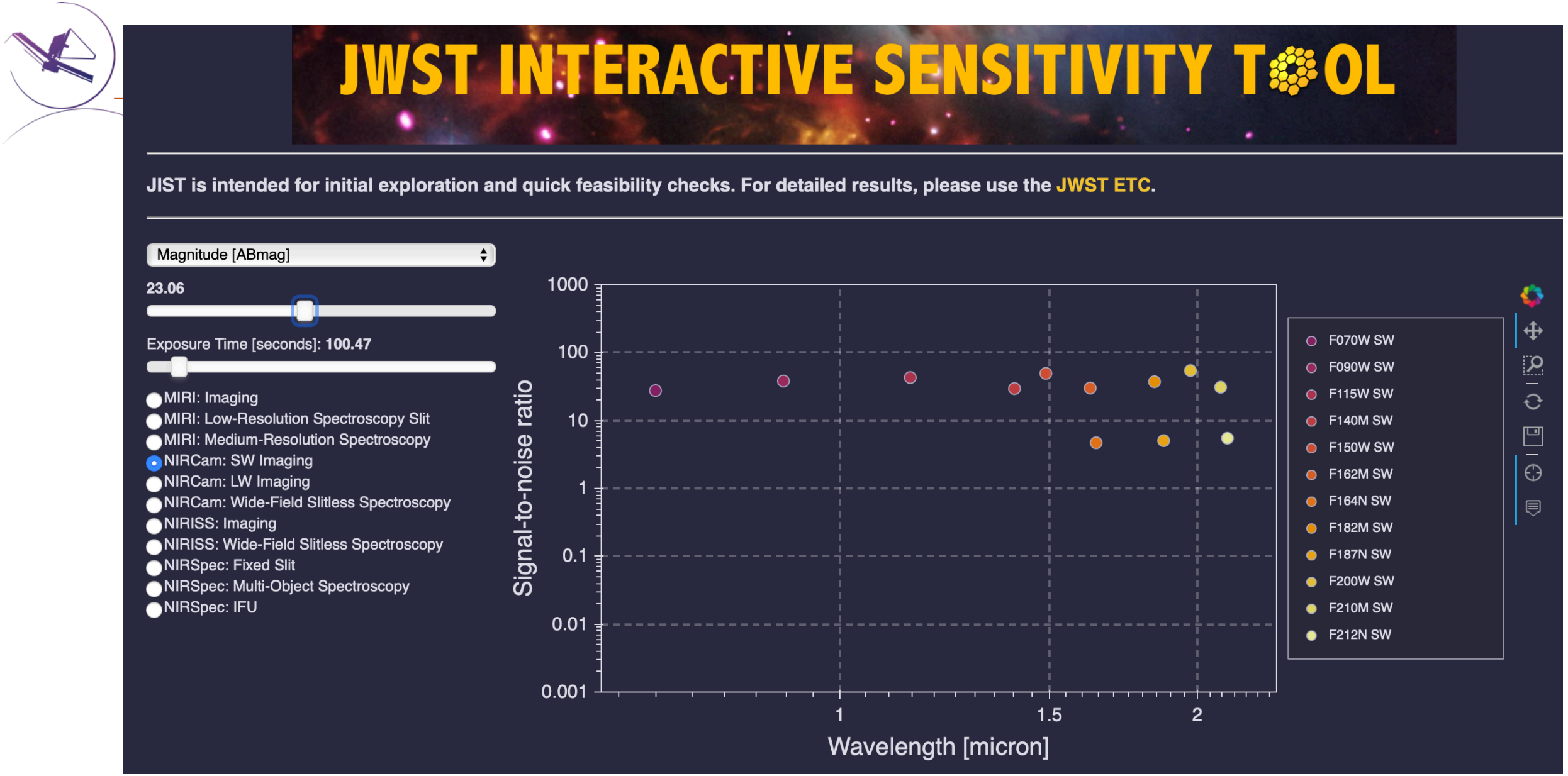
Quick Look at Observation Feasibility

JWST Interactive Sensitivity Tool (JIST)

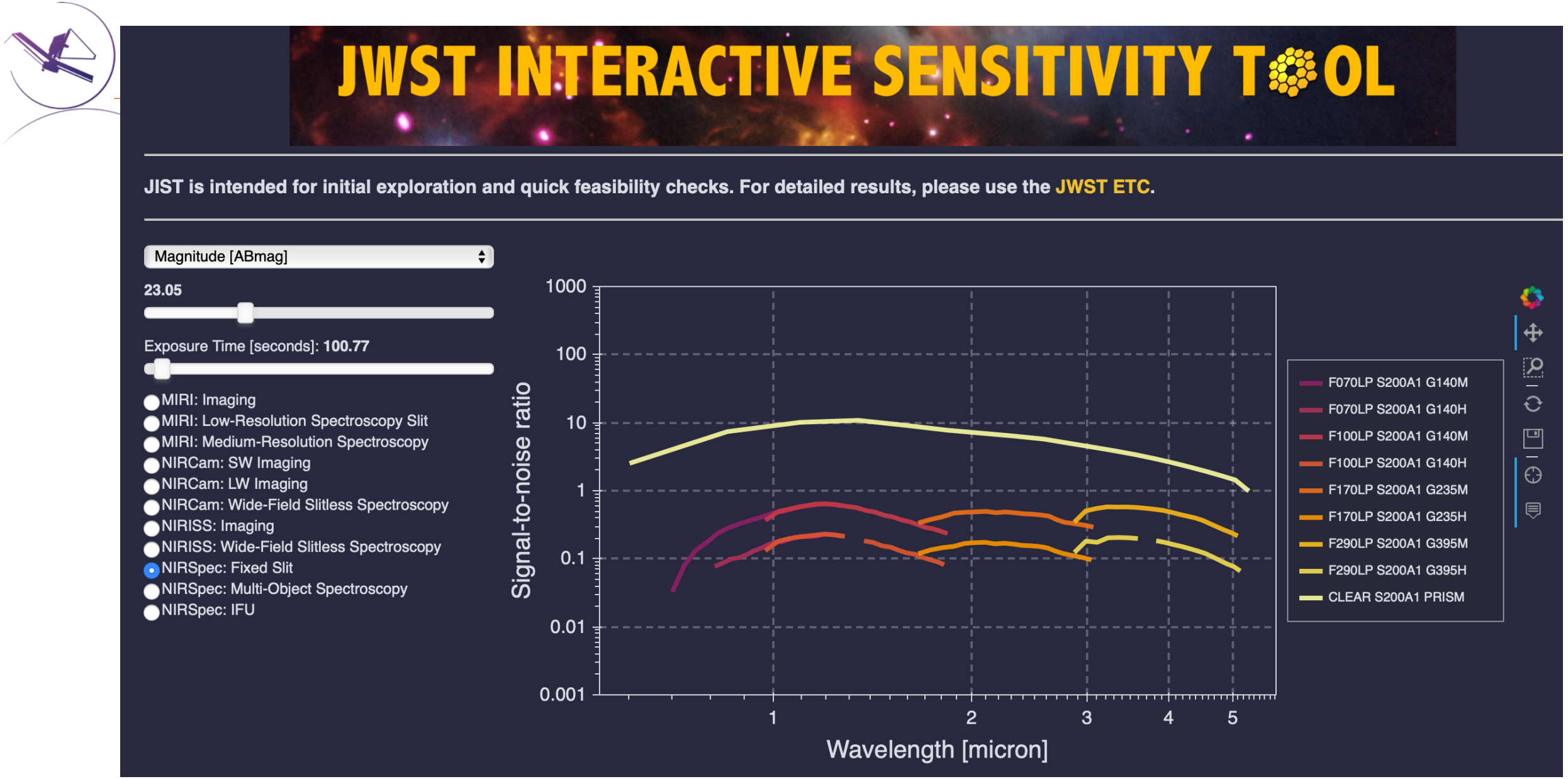
- JIST is a quick-look tool that allows exploration of observation feasibility for all JWST basic observing modes.
- JIST allows you to explore signal-to-noise values in real time by adjusting source flux or telescope exposure time.
- JIST uses a number of simplifying assumptions and does not supplant the use of the ETC for providing detailed exposure specification information.
- JIST runs directly in your browser window!

Online Tool: jist.stsci.edu
JDox: [JWST Interactive Sensitivity Tool]





Imaging/filters example



Spectroscopy example

Checking for Duplications

What Constitutes a "Duplication"?

- There is a JWST policy that defines the details of what is considered a duplication.
  - (A revised article for Cycle 1 support is in preparation, but the generalities are known.)
- "Targets" are not protected. Observations of targets are protected.
- To first order, a proposed observation is a duplication if the following are true:
  - (a) same source or field;
    (b) same or similar instrument;
    (c) same mode or template;
    (d) similar (within a defined factor) exposure time or signal-to-noise ratio; and
    (e) for spectral modes, similar spectral resolution and/or significantly overlapping spectral coverage.
- There are some subtleties (e.g. regions being covered by MSA footprint) that will need to be identified only as "potential duplications." These will be adjudicated on a case-by-case basis if the proposal is accepted.

Checking for Duplicating Observations

- Duplicate observations should be avoided unless scientifically justified.
  - E.g. time variable phenomena may be justified.
- Duplications versus previously observed or accepted observations need to be assessed.
  - For Cycle 1, there are only “previously accepted” programs, e.g., GTO and ERS.
- Most users will want to check for duplications before going to the work of assessing ETC feasibility and APT schedulability!
- For Cycle 1, this process involves either one or two steps, depending on your target and situation.

Duplication Checking Basics

- Information about accepted GTO and ERS targets and observations will be available within the MAST portal:
  - *MAST Data Discovery Portal*
- As a first step, in MAST enter a target name and/or coordinate and a search radius.
  - If your target is not planned for observation, there can be no duplication and you are done!

JDox: JWST Duplication Checking (overview) and
Identifying Potential Duplicate Observations (procedure)

Duplication Checking Basics

- If your target ***is*** slated for observation, note the instrumentation and exposure information and determine if there is a potential duplication with your intended observations.
  - Unfortunately, not all observation details are available within MAST.
  - Hence, step 2 is to note the program ID and download the APT file of the GTO or ERS program and inspect the planned observation details to determine if a duplication exists.
  - JWST observer website has listing of all GTO/ERS programs.

Accepted Observing Program Information

Questions and Comments