



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.

The background of the slide is a deep blue and purple starry sky. A large, diffuse nebula with wispy, ethereal structures is visible, primarily on the left and bottom-left sides. The sky is filled with numerous stars of varying brightness and colors, including many bright blue stars. A thin, horizontal orange line is positioned below the title text.

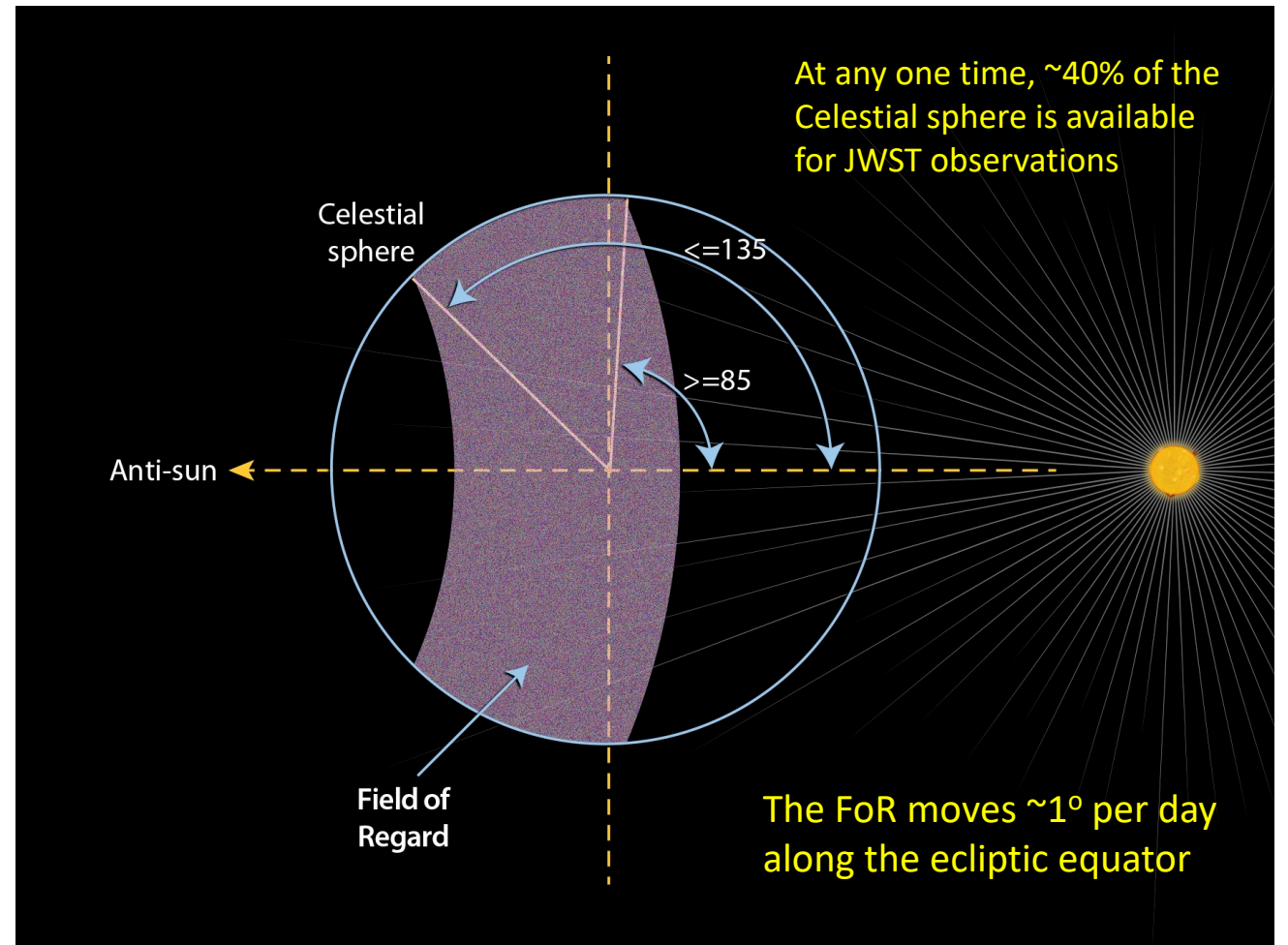
Target Visibility Overview



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.

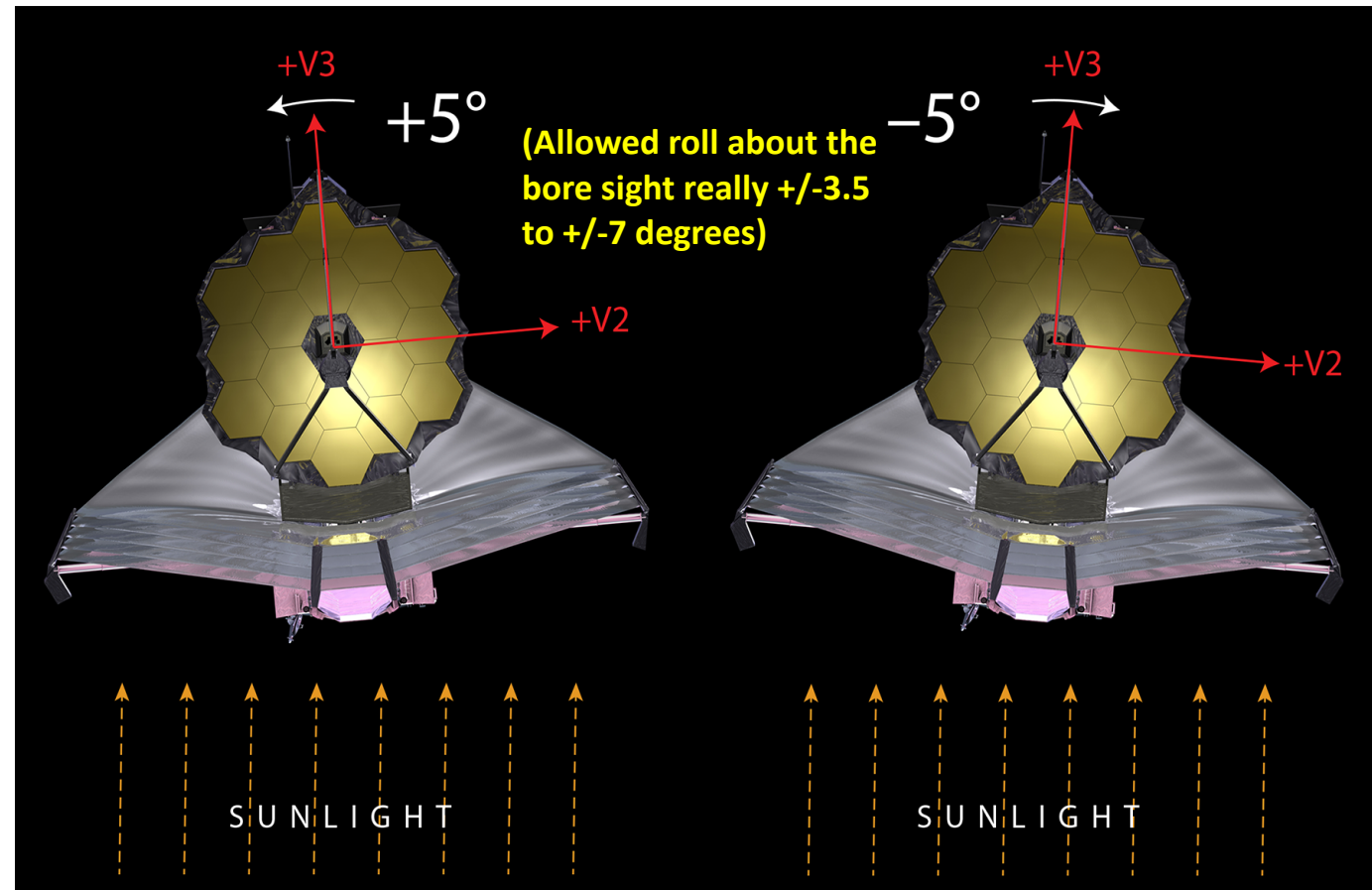
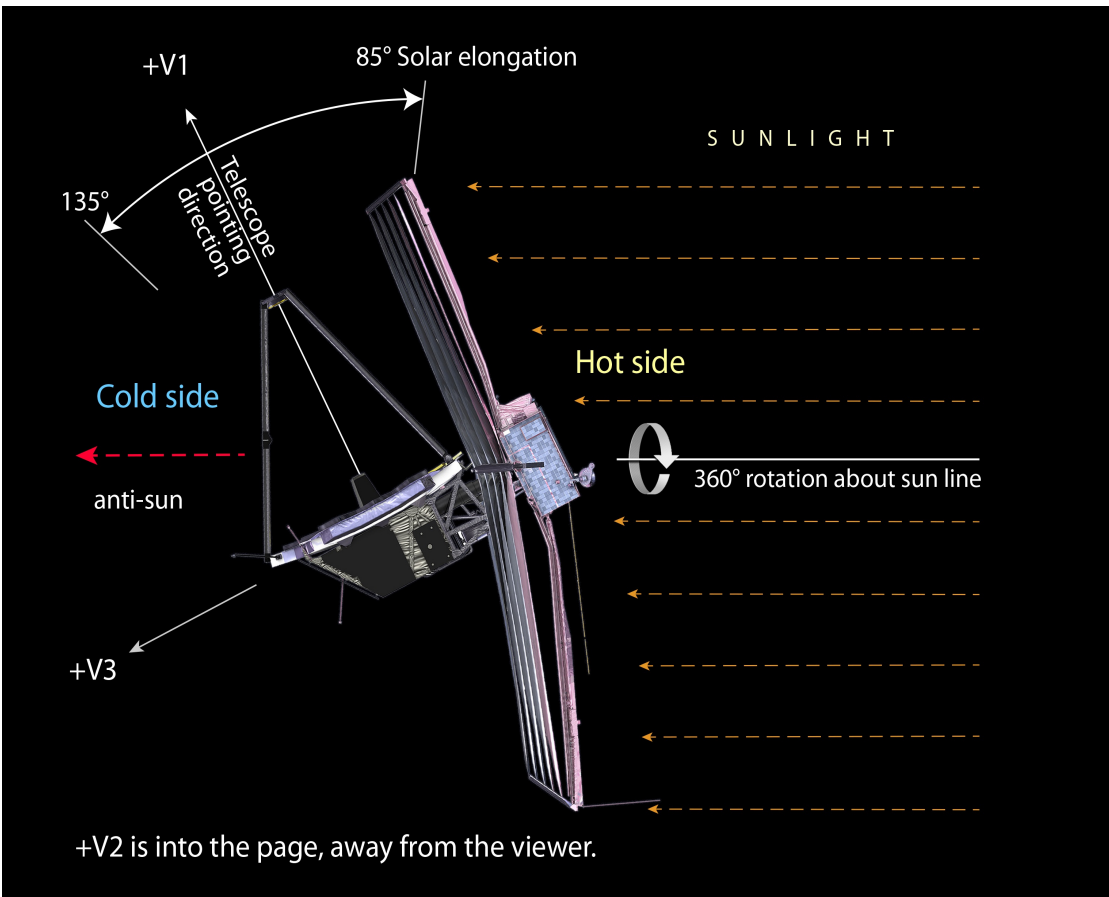
The JWST Field of Regard

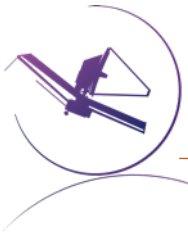




Target Visibility Tools: Why are they needed?

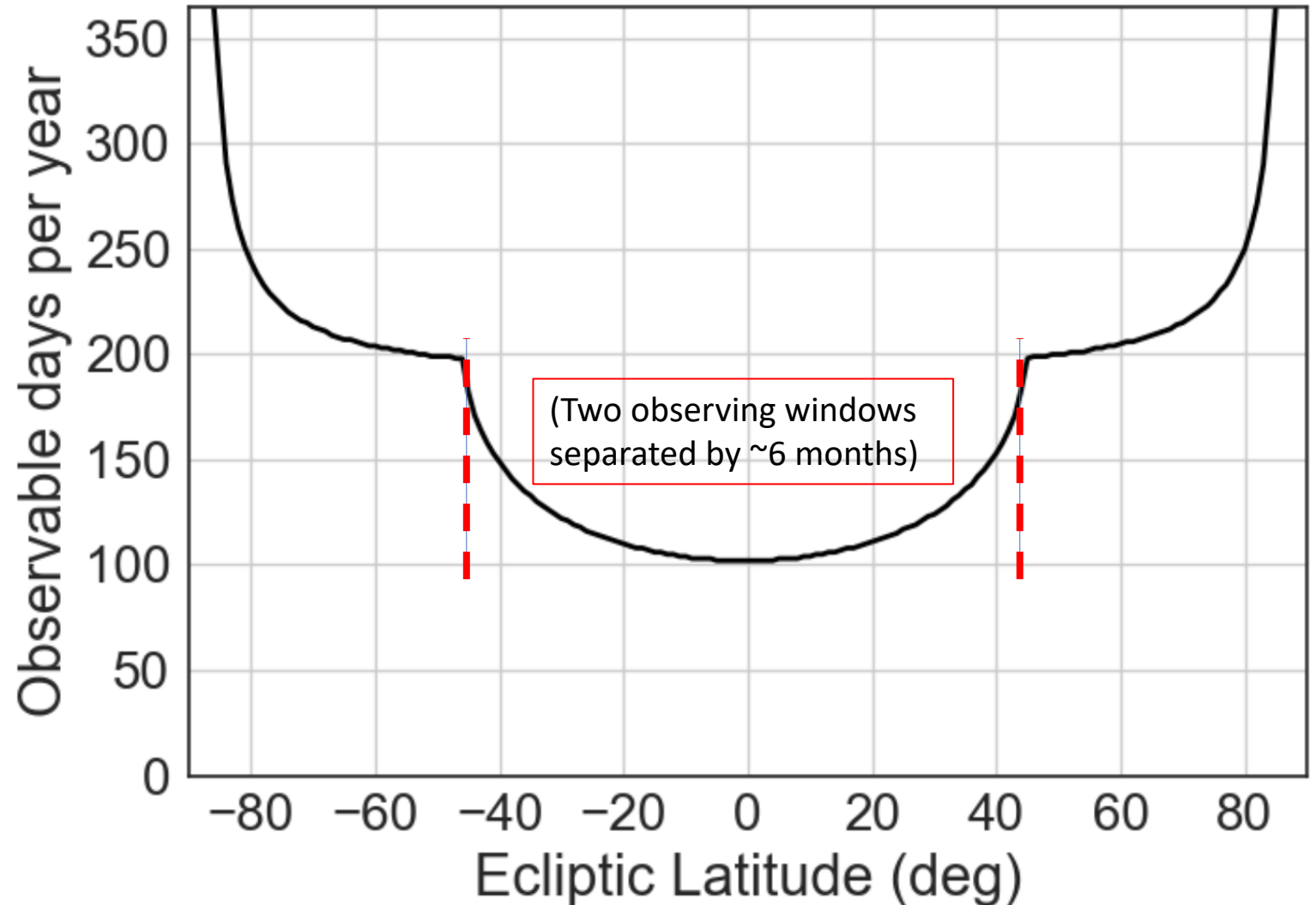
- JWST can rotate 360° about the sun line, but can only roll about the bore sight by ~5°.
- These constraints impact the angles of the JWST field of view on the sky as well as visibility.





Total Visibility vs. Ecliptic Latitude

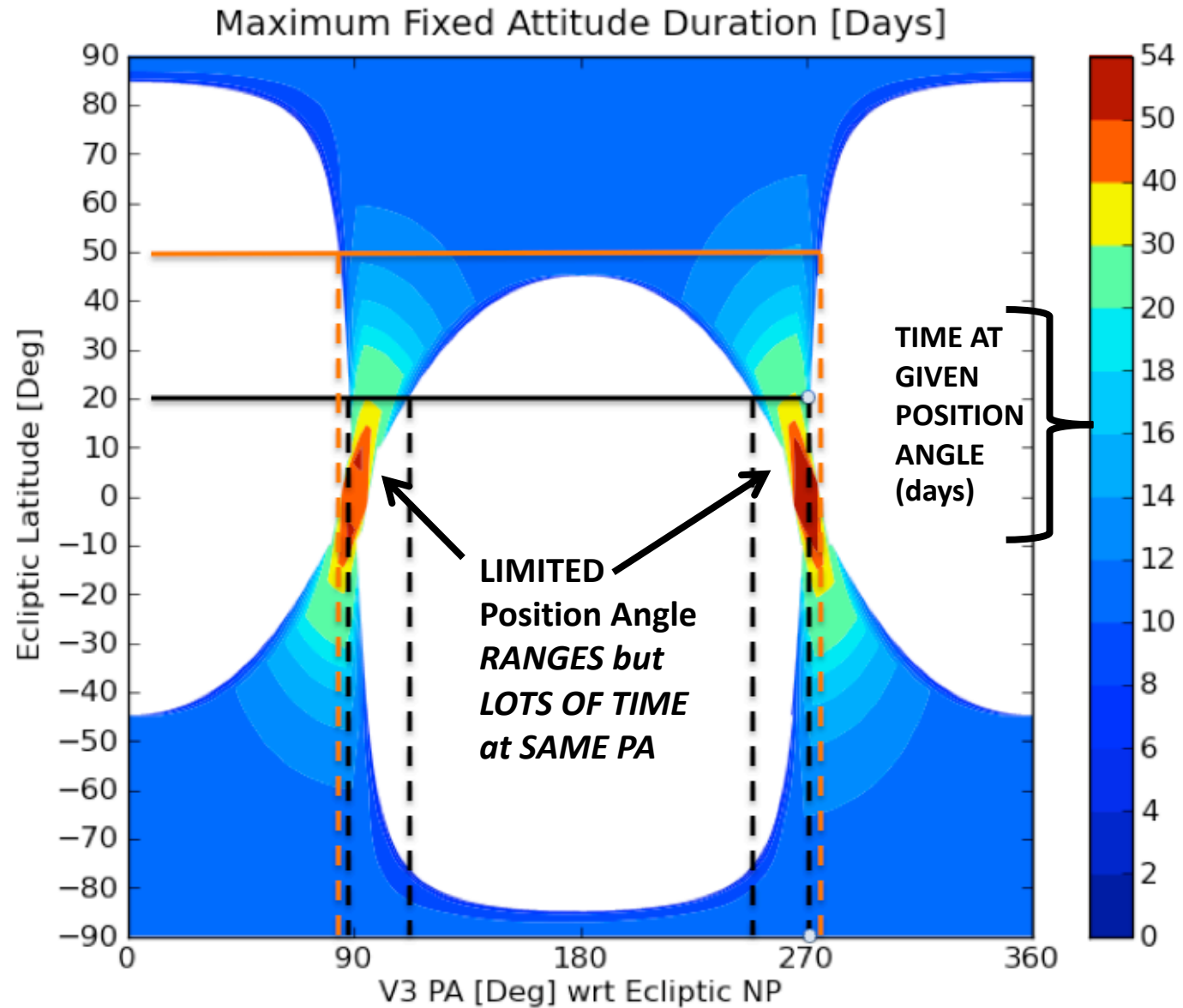
- Targets below $|45^\circ|$ in ecliptic latitude have less total visibility and it is split into two periods ~ 6 months apart.
- Above $|45^\circ|$, targets have one longer period of visibility that increases with higher ecliptic latitudes.
- There are small Continuous Viewing Zones (CVZs) near each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





Position Angle Restrictions

- “V3PA” is an observatory reference angle on the sky (similar to but not exactly like astronomical position angle).
- Below $|45^\circ|$ 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

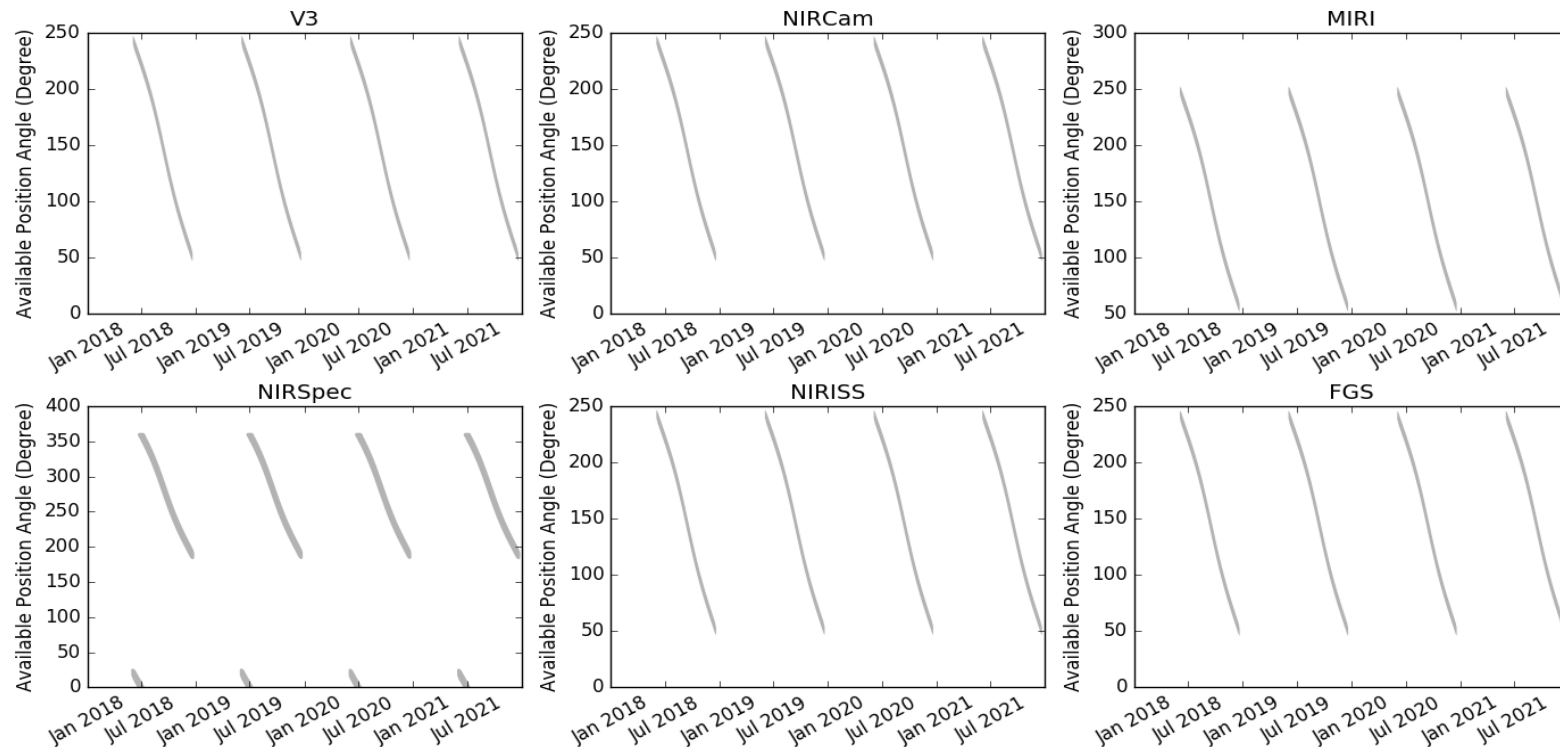
```
jwst_gtvv 325.678 43.586 --name "SS Cyg"
```

(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_gtvv 325.678 43.586 --name "SS Cyg" --save_plot SSCyg_all.png
```

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

SS Cyg (RA = 325.678, DEC = 43.586)



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

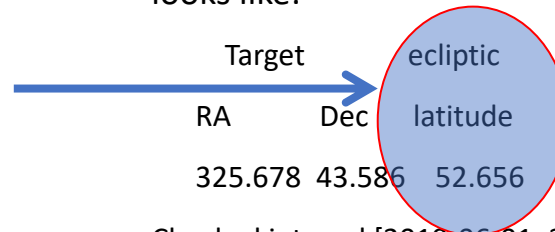


GTVT command line examples -- output

```
jwst_gtv 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



Summary of overall visibility windows

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

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

Date	V3PA		NIRCam		NIRSpec		NIRISS		MIRI		FGS	
	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.												

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

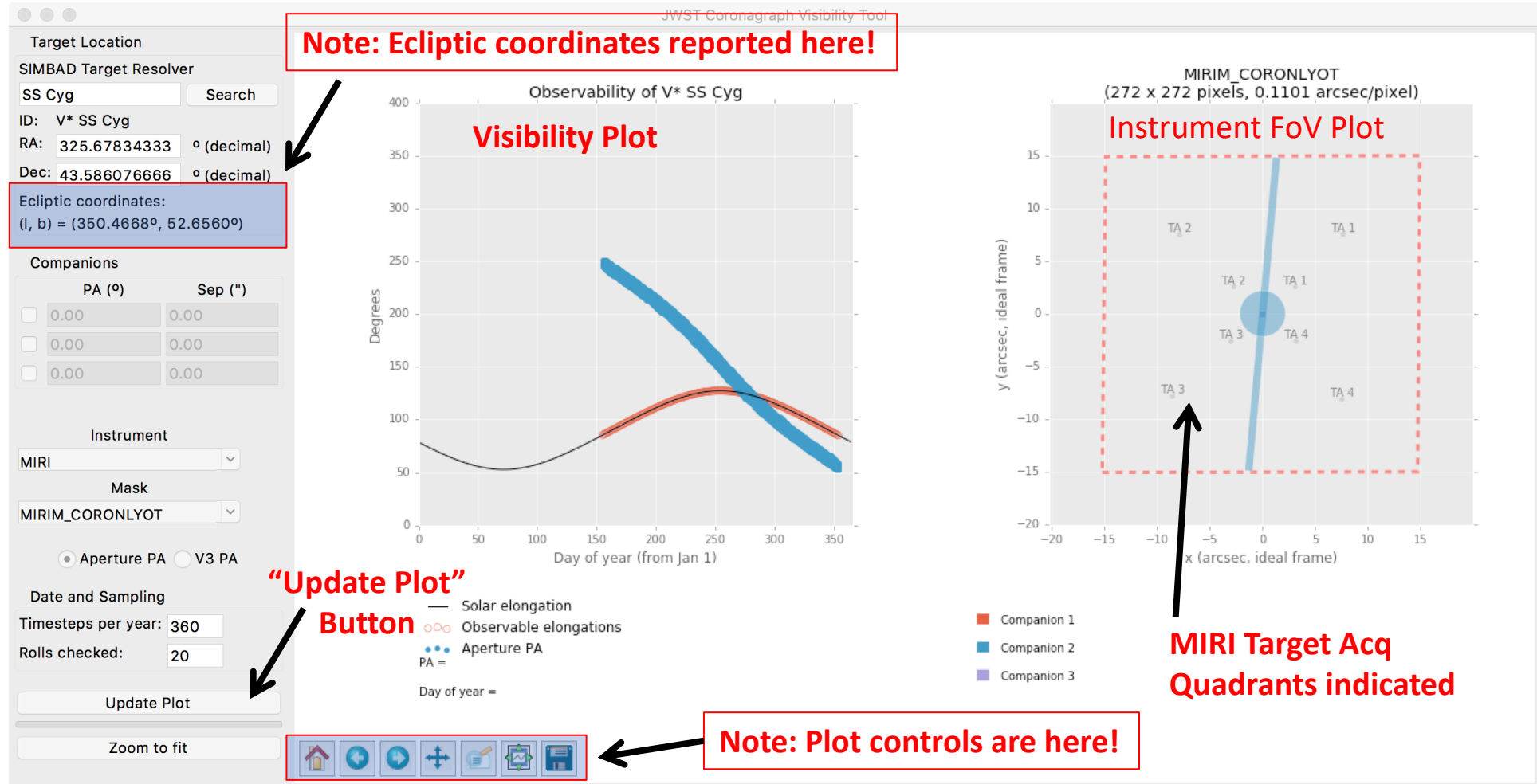


CVT is a GUI-based tool with GUI/matplotlib interface

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.



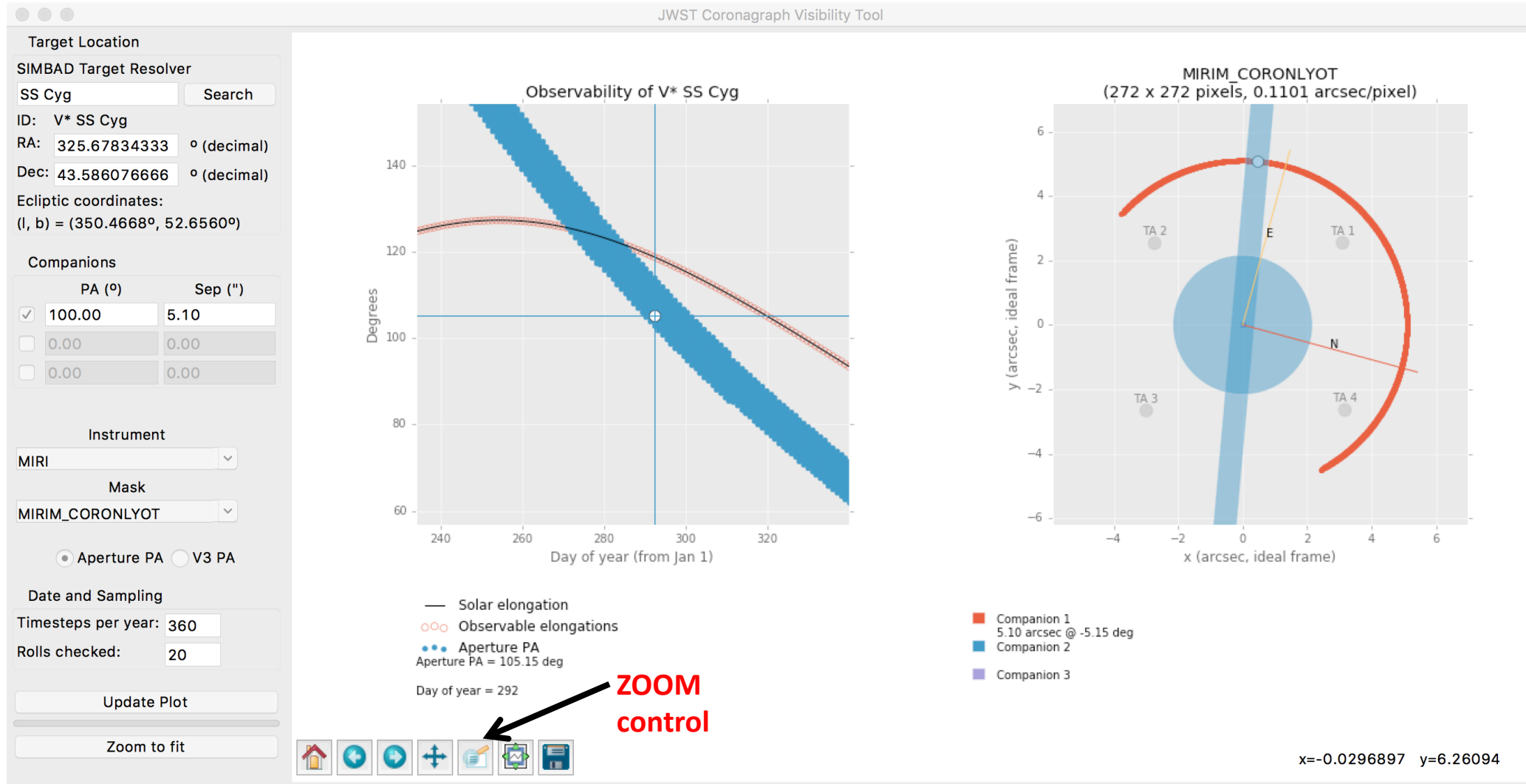


CVT example with a companion

Here both panels have been enlarged to show the details.

A single companion has been added.

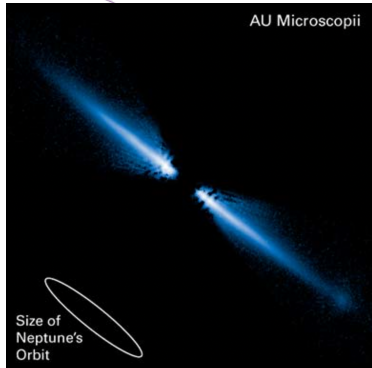
Clicking on either plot highlights the point in the other plot.





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!)



JWST Coronagraph Visibility Tool

Target Location
SIMBAD Target Resolver
SS Cyg Search
ID: V* SS Cyg
RA: 325.67834333 ° (decimal)
Dec: 43.586076666 ° (decimal)
Ecliptic coordinates:
(l, b) = (350.4668°, 52.6560°)

Companions

	PA (°)	Sep (")
<input checked="" type="checkbox"/>	100.00	5.10
<input checked="" type="checkbox"/>	100.00	-4.50
<input type="checkbox"/>	0.00	0.00

Instrument: MIRI
Mask: MIRIM_CORONLYOT
 Aperture PA V3 PA

Date and Sampling
Timesteps per year: 360
Rolls checked: 20
Update Plot
Zoom to fit

Observability of V* SS Cyg

Y-axis: Degrees (0 to 400)
X-axis: Day of year (from Jan 1) (0 to 350)

Legend:
— Solar elongation
○ Observable elongations
● Aperture PA
Aperture PA = 206.80 deg
Day of year = 201

MIRIM_CORONLYOT (272 x 272 pixels, 0.1101 arcsec/pixel)

Y-axis: Y (arcsec, ideal frame) (-20 to 15)
X-axis: x (arcsec, ideal frame) (-20 to 15)

Legend:
■ Companion 1
5.10 arcsec @ -106.80 deg
■ Companion 2
-4.50 arcsec @ 73.20 deg
■ Companion 3

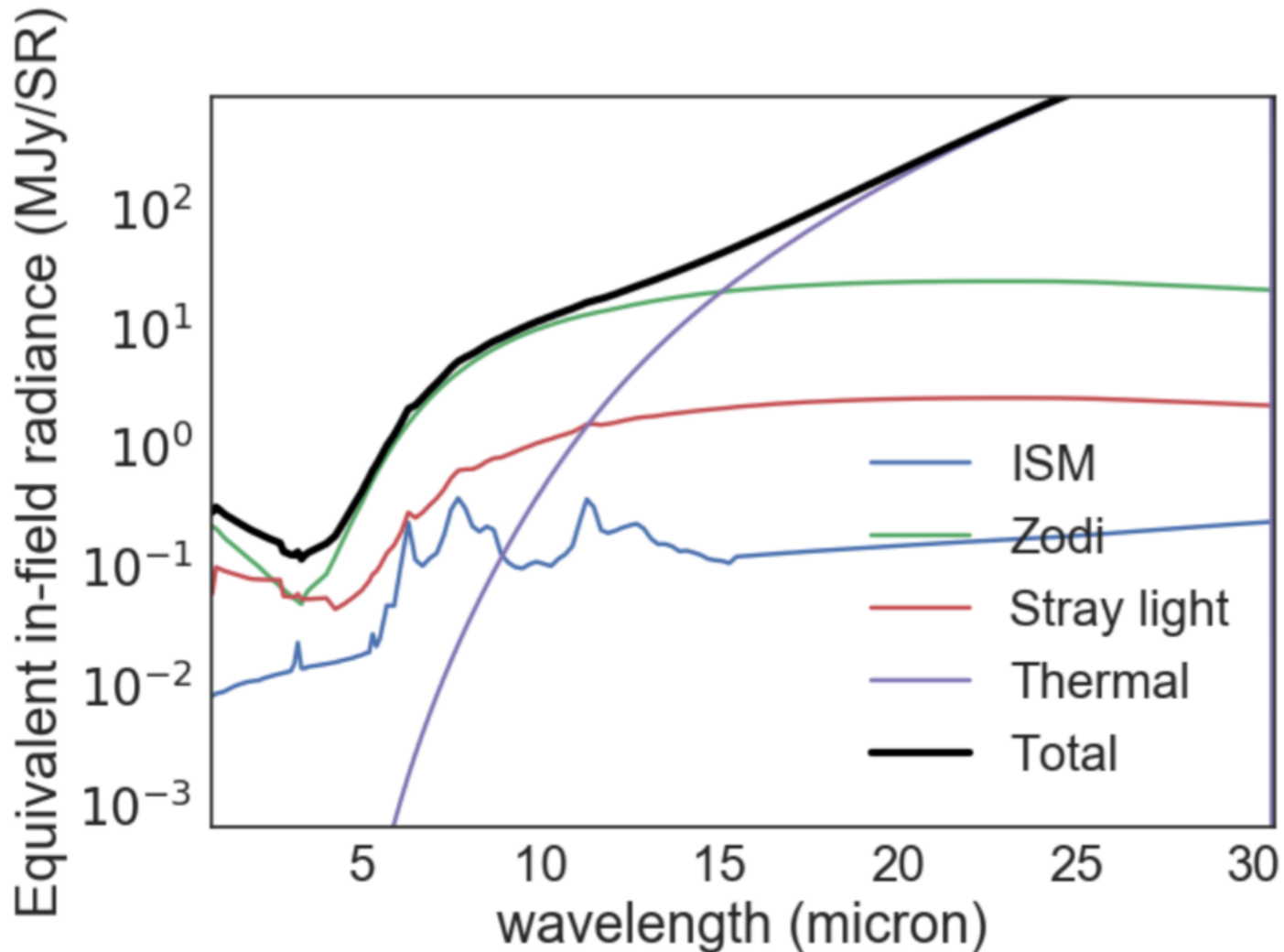
Disk orientation shown by arrows on day 201



Impact of Infrared Background and Variability



Variable background can impact visibility periods



Zodiacal light is the most variable component of the background and dominates below about $10 \mu\text{m}$. It is also time variable.

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

(Figures courtesy of Jane Rigby, NASA/GSFC)



The JWST Backgrounds Tool (for background limited observations)

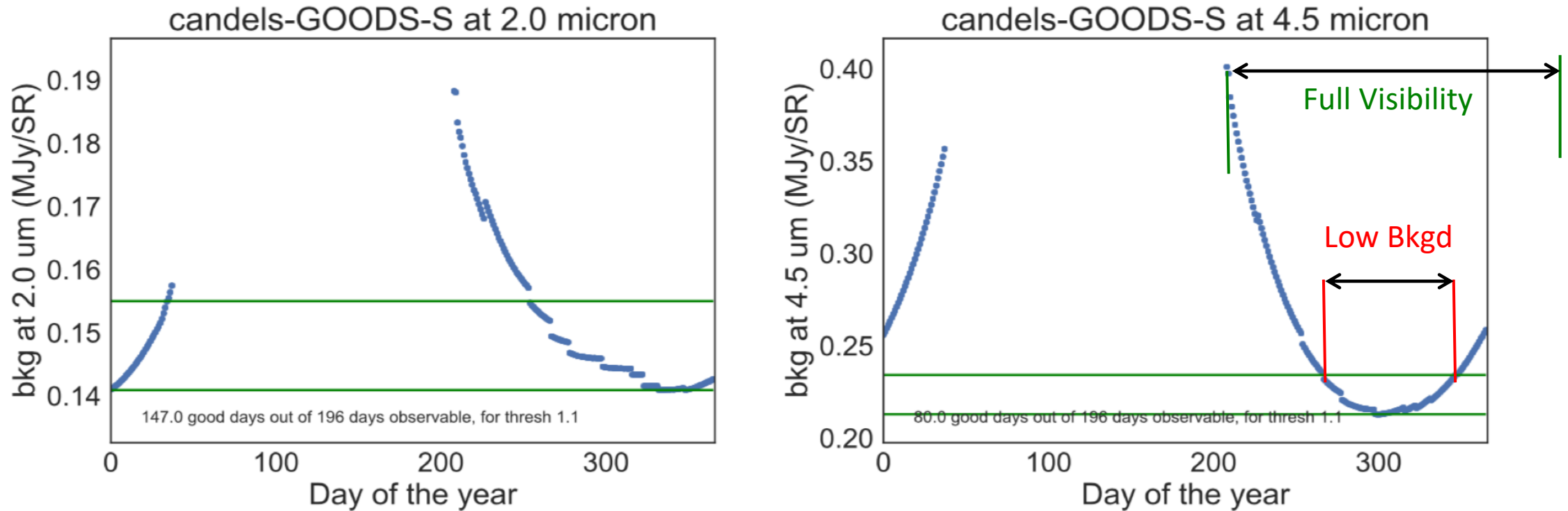


Figure 3: The total background versus calendar date, also known as “bathtub curves”, for the GOODS-S field, at 2 micron and 4.5 micron.

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

JDox: [JWST Background Model](#), [How JWST Backgrounds Vary](#), [The Backgrounds Tool](#)

The background of the slide is a deep blue and purple starry sky. A large, diffuse nebula with wispy, cloud-like structures is visible, primarily on the left and bottom-left sides. The sky is filled with numerous stars of varying brightness and colors, including many bright blue stars. A thin, horizontal orange line is positioned below the title text.

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](#)

Usage Notes

- JIST Handles saturation by setting SNR to zero for saturated points. This is a simplified assumption. JIST is not recommended for working with saturated data.
- For NIRCам and NIRISS Wide-Field Slitless Spectroscopy (WFSS) modes, R-grism and C-grism values should have identical SNR. As such, JIST presents only the R Grism values.
- All calculations are based on a single point source with:
 - Flat SED
 - Background spectrum set to 120% of the minimum zodiacal background, with:
 - Assumed date June 19, 2019
 - RA,DEC = 17h26m44s,-73°19m56s
- JIST uses a single integration in almost all¹ modes. For multiple integrations or dithers, the SNR may be scaled by SQRT(number of dithered exposures).

¹MIRI MRS and NIRSpec IFU exposures, assume two integrations corresponding to a two-point nod.



JWST INTERACTIVE SENSITIVITY TOOL

JIST is intended for initial exploration and quick feasibility checks. For detailed results, please use the [JWST ETC](#).

Magnitude [ABmag]

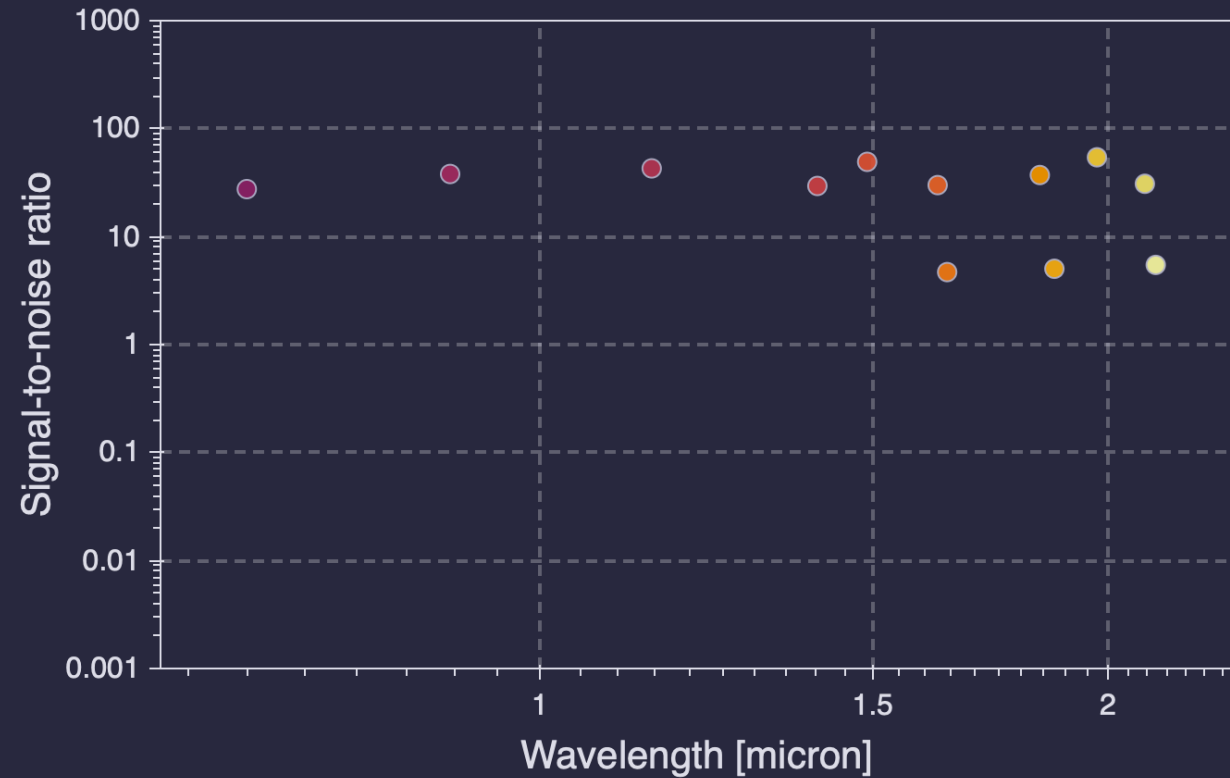
23.06



Exposure Time [seconds]: 100.47



- MIRI: Imaging
- MIRI: Low-Resolution Spectroscopy Slit
- MIRI: Medium-Resolution Spectroscopy
- NIRCam: SW Imaging
- NIRCam: LW Imaging
- NIRCam: Wide-Field Slitless Spectroscopy
- NIRISS: Imaging
- NIRISS: Wide-Field Slitless Spectroscopy
- NIRSpec: Fixed Slit
- NIRSpec: Multi-Object Spectroscopy
- NIRSpec: IFU



- F070W SW
- F090W SW
- F115W SW
- F140M SW
- F150W SW
- F162M SW
- F164N SW
- F182M SW
- F187N SW
- F200W SW
- F210M SW
- F212N SW



Imaging/filters example



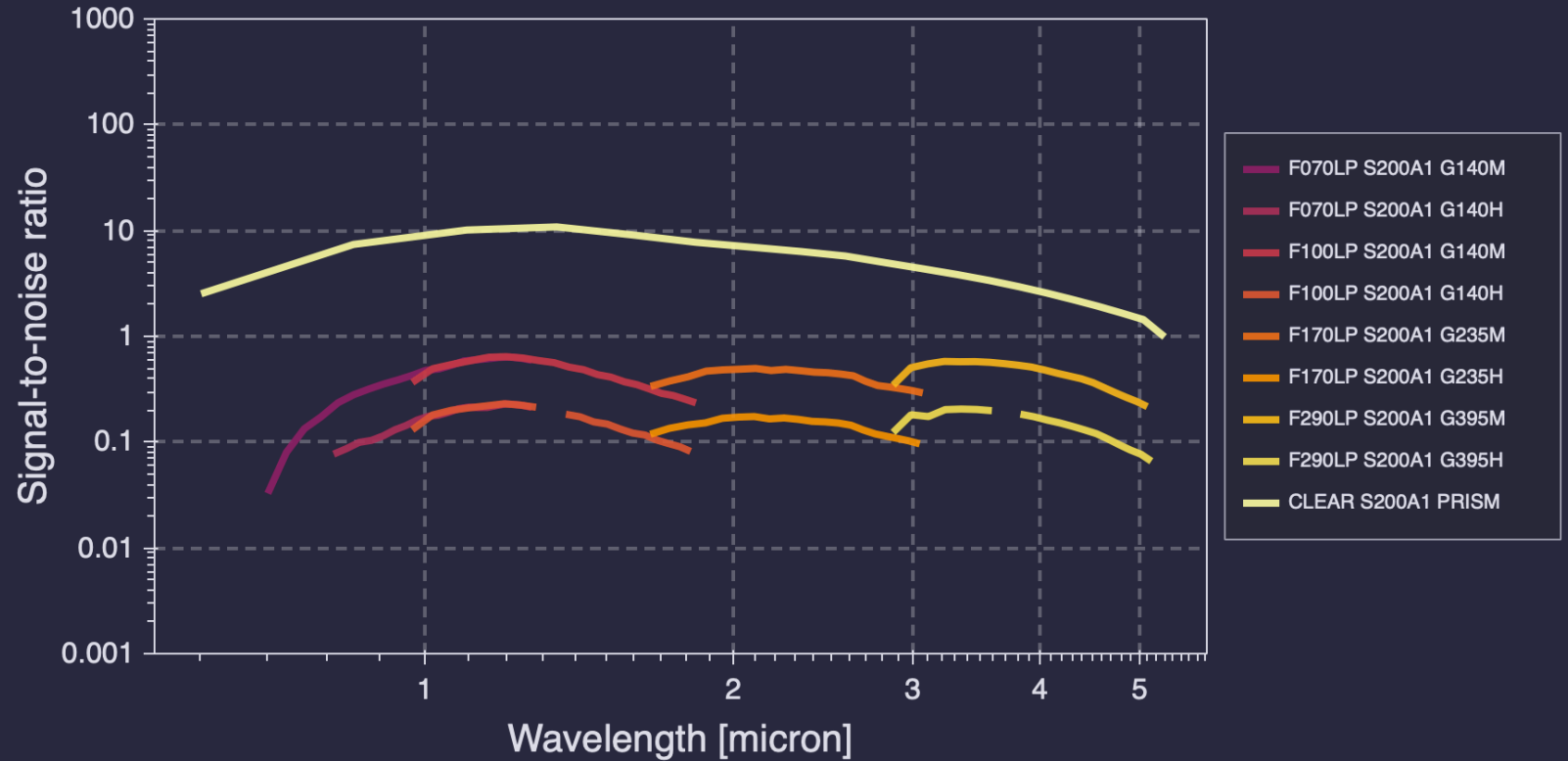
JWST INTERACTIVE SENSITIVITY TOOL

JIST is intended for initial exploration and quick feasibility checks. For detailed results, please use the [JWST ETC](#).

Magnitude [ABmag]

Exposure Time [seconds]: 100.77

- MIRI: Imaging
- MIRI: Low-Resolution Spectroscopy Slit
- MIRI: Medium-Resolution Spectroscopy
- NIRCcam: SW Imaging
- NIRCcam: LW Imaging
- NIRCcam: Wide-Field Slitless Spectroscopy
- NIRISS: Imaging
- NIRISS: Wide-Field Slitless Spectroscopy
- NIRSpec: Fixed Slit
- NIRSpec: Multi-Object Spectroscopy
- NIRSpec: IFU



Spectroscopy example

The background of the slide is a deep blue and purple starry night sky. A large, diffuse nebula with wispy, ethereal structures is visible on the left side, extending towards the center. The sky is filled with numerous stars of varying brightness and colors, including many bright blue stars. A thin, horizontal orange line is positioned below the title text.

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

