STScI | SPACE TELESCOPE SCIENCE INSTITUTE

EXPANDING THE FRONTIERS OF SPACE ASTRONOMY

Moving Targets Level 2

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JWST Master Class

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Where to get help

Where to go for help

JWST Documentation on Moving Targets (JDox)

Can be found at JWST Moving Target Observations

Context Sensitive Help in the APT

Hovering the cursor over the parameters in the form editor will display a question mark.
When clicked on it will bring up the relevant section of JDox.

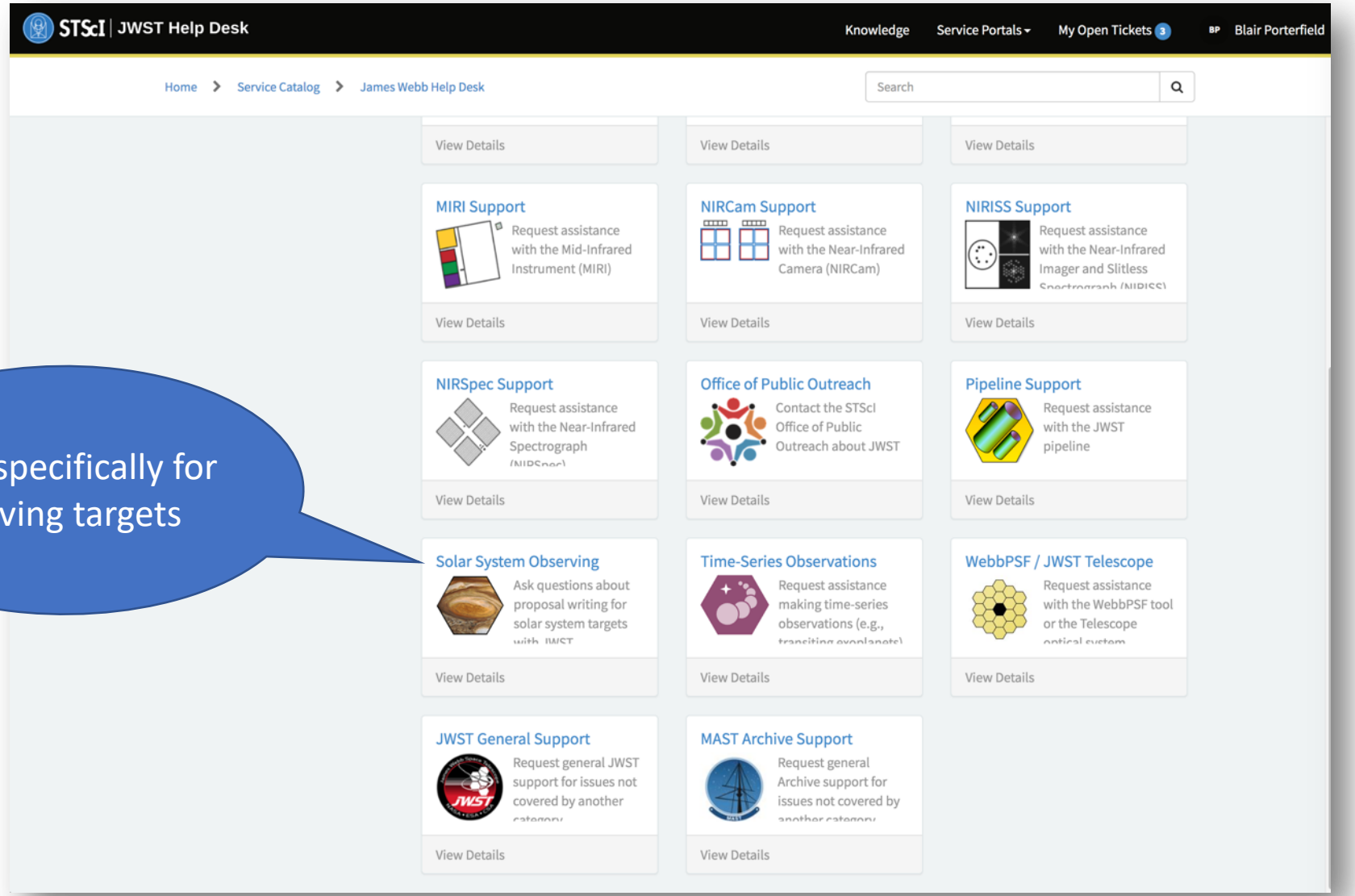
Context Sensitive Help in the ETC

Blue question mark icons are present throughout the web application.
When clicked they will bring up the relevant section of JDox.

JWST Help Desk

Can be found at https://stsci.service-now.com/jwst
Requires a MyST account to submit questions (as does submitting a proposal)
Can search the knowledge database without an account

Where to go for help



Card specifically for moving targets

Moving Target Visibility Tool (MTVT)

MTVT: Background

The MTVT is a command line tool used to determine the time periods when a target of interest is in the JWST field of regard (FOR). It is a wrapper to the General Target Visibility Tool (GTVT).

The MTVT was originally developed by Mike Kelley. Mees Fix is responsible for ongoing development and maintenance of the tool.

MTVT: Installation

- The MTVT comes as part of a package with the General Target Visibility Tool (GTVT)

Installation and usage

One can download a .zip file or clone the repository for GTVT from the following GitHub link:

https://github.com/spacetelescope/jwst_gtvt

and install the tool inside the resulting "jwst_gtvt-master" directory (you should see a file called "setup.py" in this directory) with the command

```
python setup.py install
```

Alternatively, if you are familiar with "pip", you can install the tool directly with

```
pip install git+https://github.com/spacetelescope/jwst_gtvt.git
```

- Python package dependency: *astroquery*

```
conda install astroquery
```

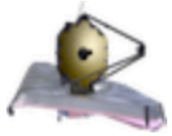
Alternatively, if you are familiar with "pip", you can install the package with the following command:

```
pip install astroquery
```

MTVT: Documentation

Home / Other Tools / Target Visibility Tools / JWST General Target Visibility Tool Help

JWST General Target Visibility Tool Help

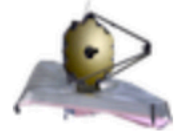


The JWST General Target Visibility Tool (GTVT) is a command-line Python tool that provides quick-look assessments of target visibilities and position angles for all JWST instruments.

General Target Visibility Tool Help

Home / Other Tools / Target Visibility Tools / JWST Moving Target Visibility Tool Help

JWST Moving Target Visibility Tool Help



The JWST Moving Target Visibility Tool (MTVT) is a command-line Python tool that provides quick-look assessments of moving target visibilities and position angles for all JWST instruments.

Moving Target Visibility Tool Help

MTVT: Usage

```
jwst_mtvt [-h] [--smallbody] [--v3pa V3PA] [--save_plot SAVE_PLOT]
          [--save_table SAVE_TABLE] [--instrument INSTRUMENT]
          [--name NAME] [--start_date START_DATE] [--end_date END_DATE]
          desg [desg ...]
```

Only required argument: Target name or number

[redacted]

MTVT: Demonstration

- Visibility of a planet
- Visibility of a satellite
- Visibility of an asteroid/NEA/Trojan/Centaur/KBO
- Visibility of a comet
- Visibility of an interstellar object

Moving Target Visibility Tool (MTVT): On-line Resources

JDox:

- **JWST Field of Regard**: JWST Observatory Coordinate System and Field of Regard
- **JWST Orbit**: JWST Orbit
- **GTVT**: General Target Visibility Tool Help
- **MTVT**: Moving Target Visibility Tool Help

Other links:

- **JPL/Horizons**: https://ssd.jpl.nasa.gov/horizons.cgi
- **Astroconda**: https://astroconda.readthedocs.io/en/latest/
- **Astroquery**: https://astroquery.readthedocs.io/en/latest/

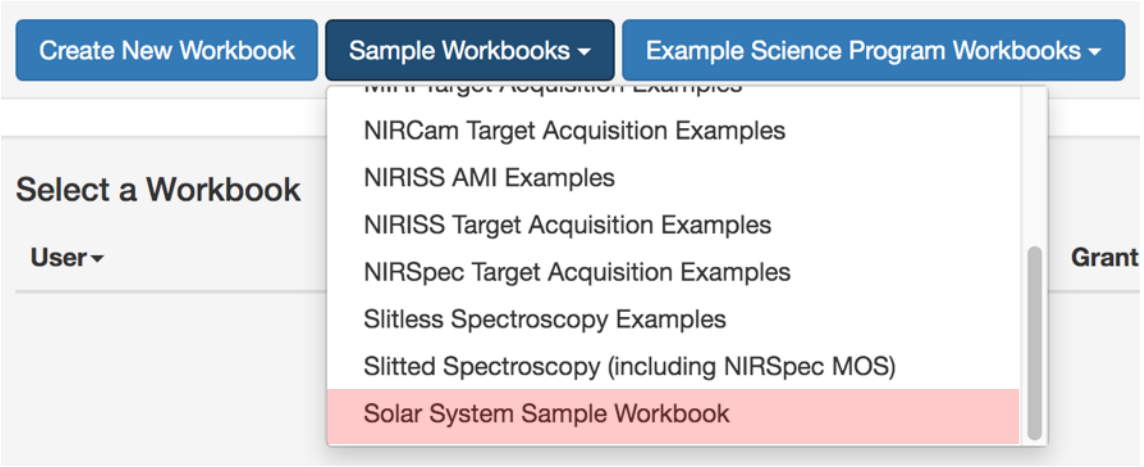
Exposure Time Calculator (ETC)

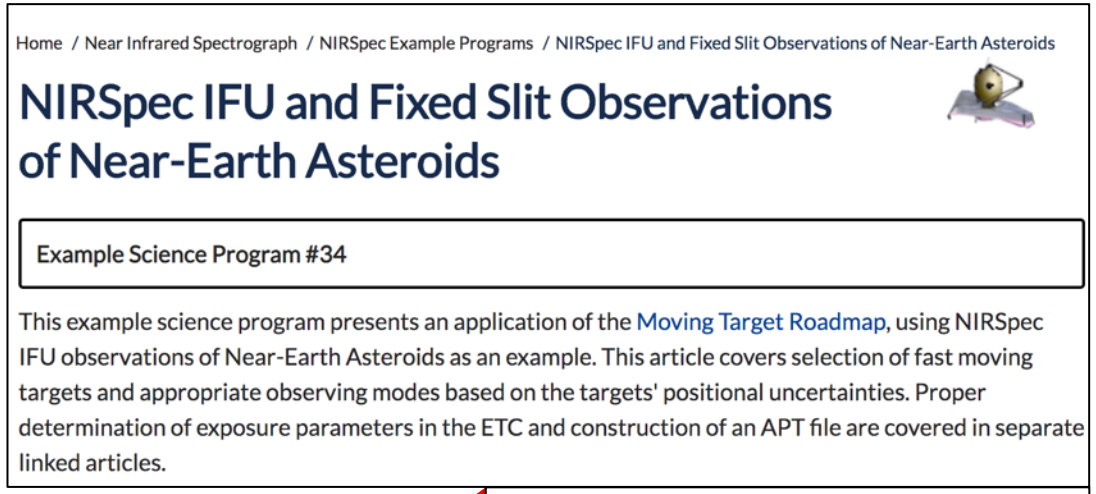
ETC: Moving Targets in the ETC

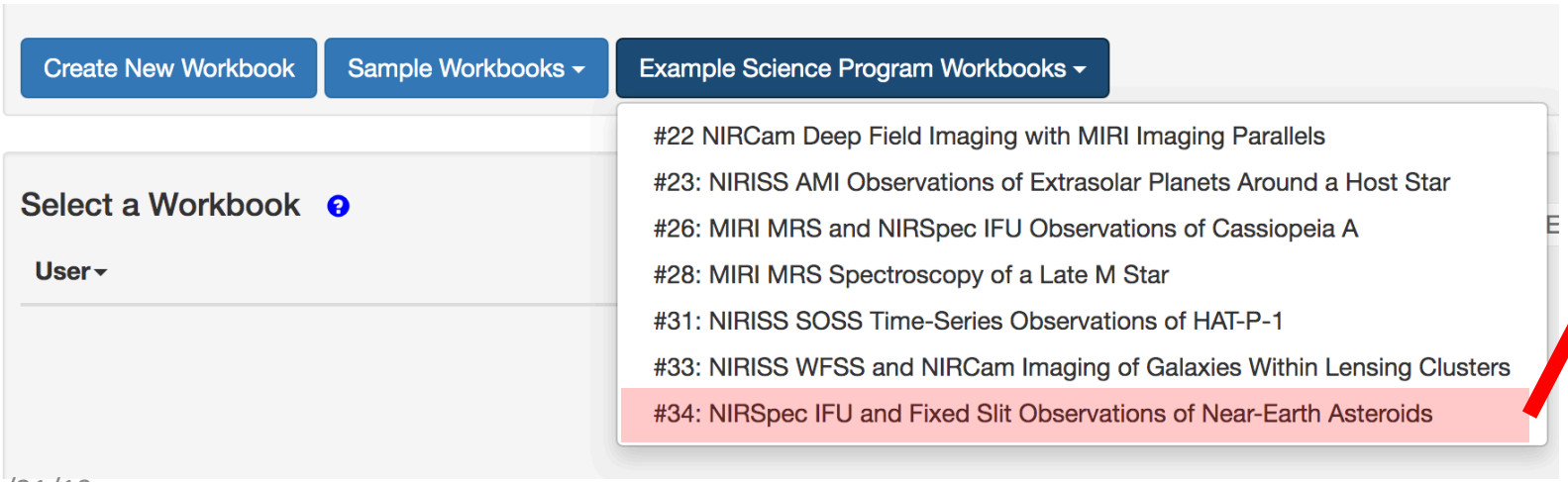
There are currently no unique features for moving targets in the JWST ETC.

ETC: Useful Features for Moving Targets

Example Science Program and Sample Workbook



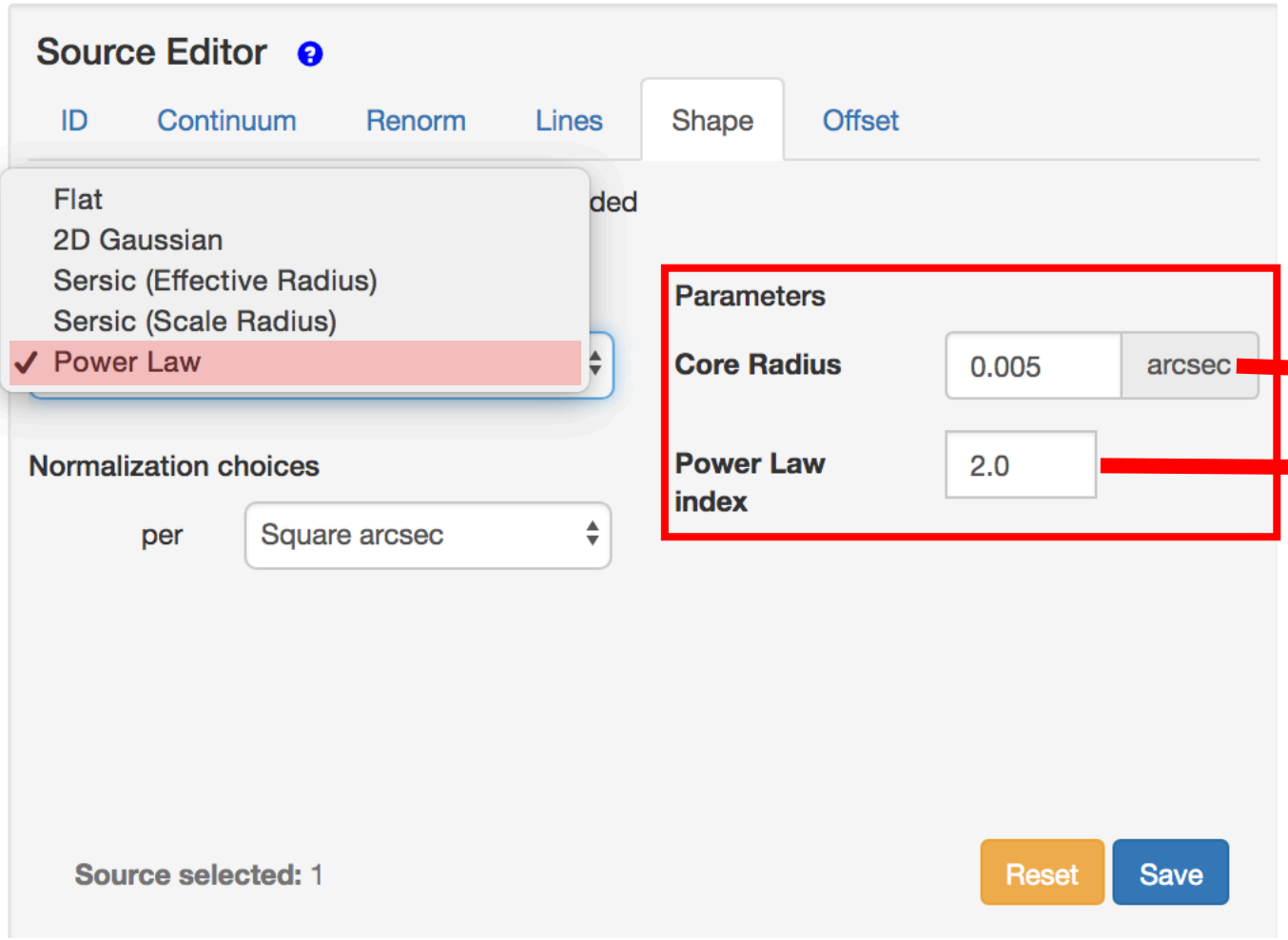


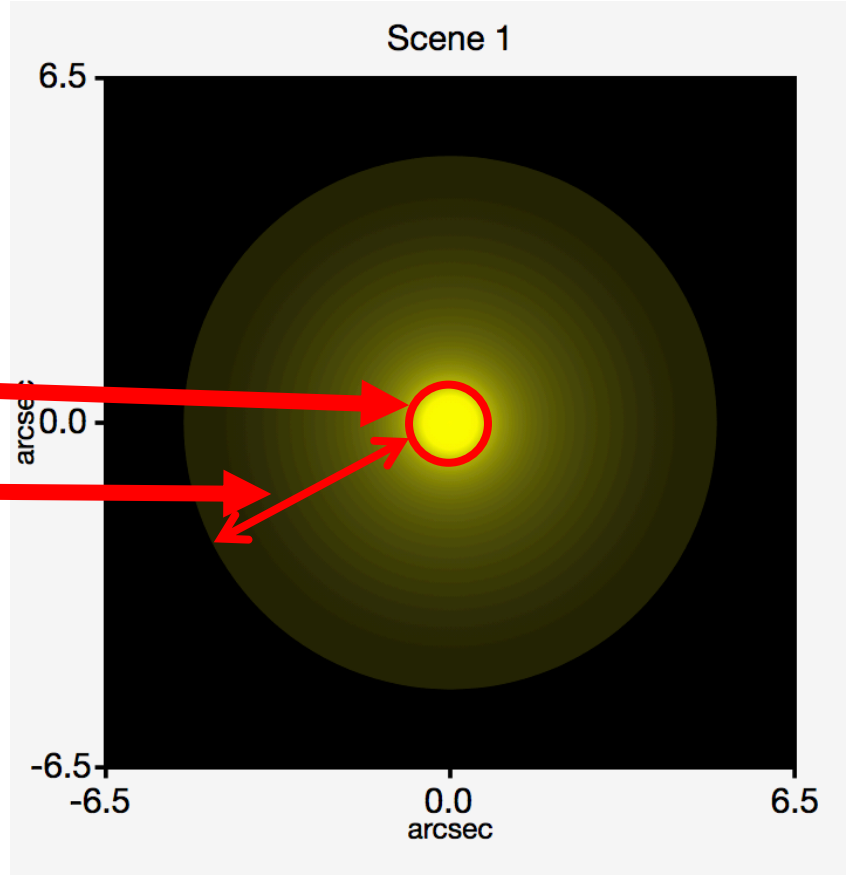


https://jwst-docs.stsci.edu/near-infrared-spectrograph/nirspec-example-programs/nirspec-ifu-and-fixed-slit-observations-of-near-earth-asteroids

ETC: Useful Features for Moving Targets

Power-law flux distribution

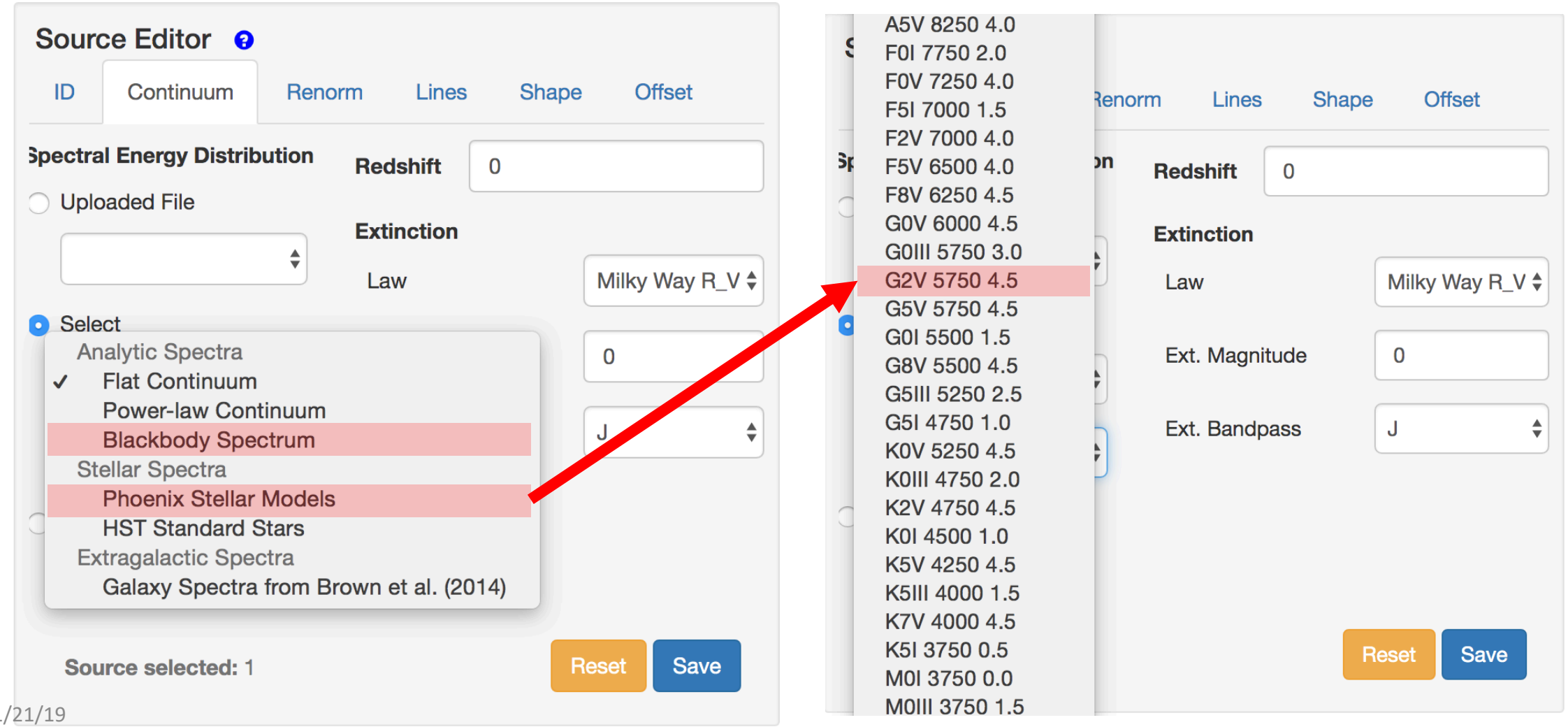




(Spherical shape only)

ETC: Useful Features for Moving Targets

Template spectra: G2V Phoenix stellar model & Blackbody



ETC: Demonstration

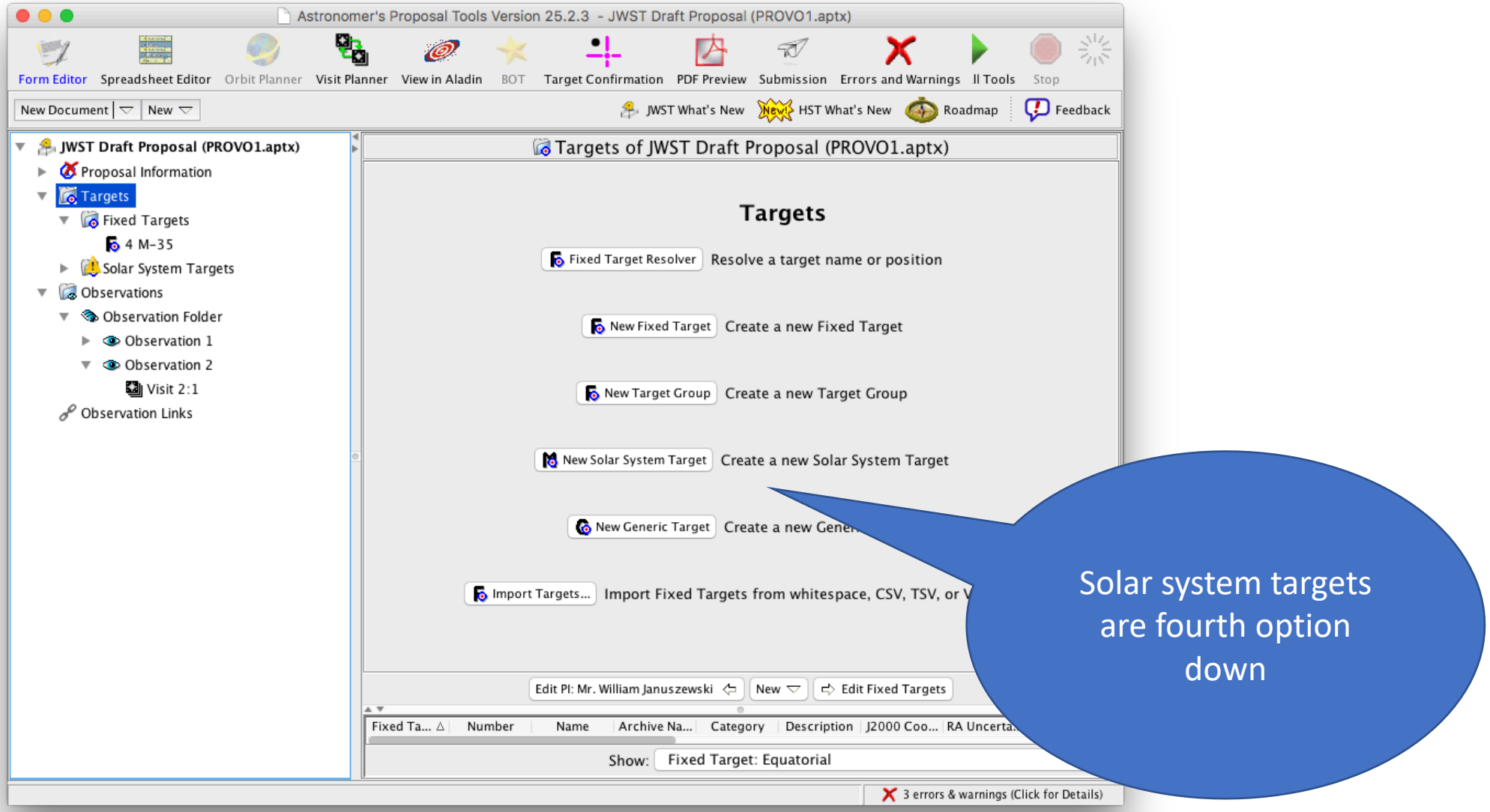
- Understand the workaround for modeling the flux from a giant planet
- Model scattered light from a giant planet for observations of a satellite
- Model a comet

ETC Moving Targets: On-line Resources

- JWST ETC web application: https://jwst.etc.stsci.edu/
- JWST ETC documentation: Exposure TIme Calculator Overview
- Pandeia engine documentation: JWST ETC Pandeia Engine Tutorial
- Moving targets in the ETC: JWST Moving Targets in ETC

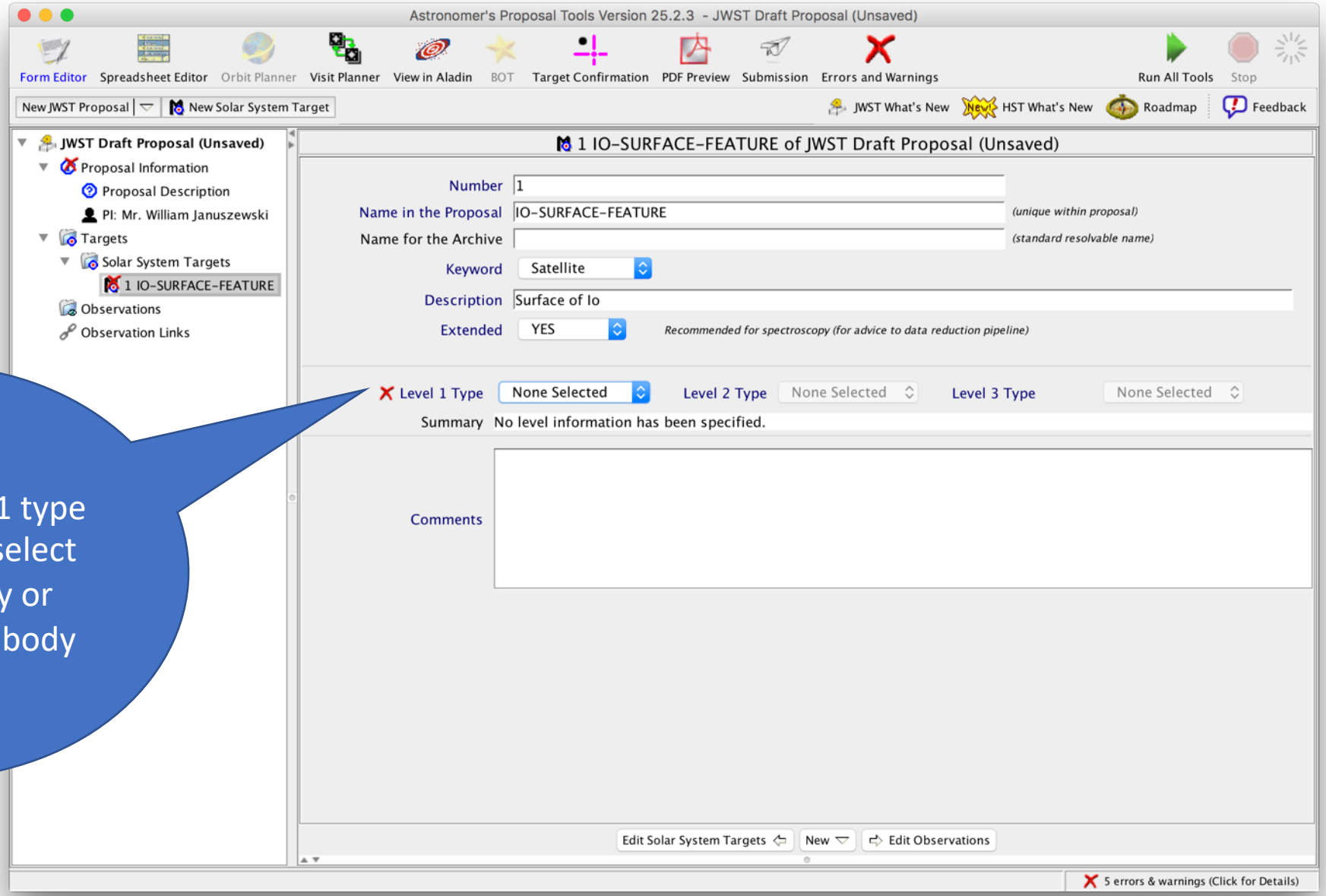
Specifying Moving Targets

New Moving Target



Solar system targets are fourth option down

Moving Target Template



Selecting Level 1 type allows user to select standard body or define a minor body

Moving Target Levels

Level 1 refers to a target in orbit about the Sun.

- Planets, Asteroids, and Comets.

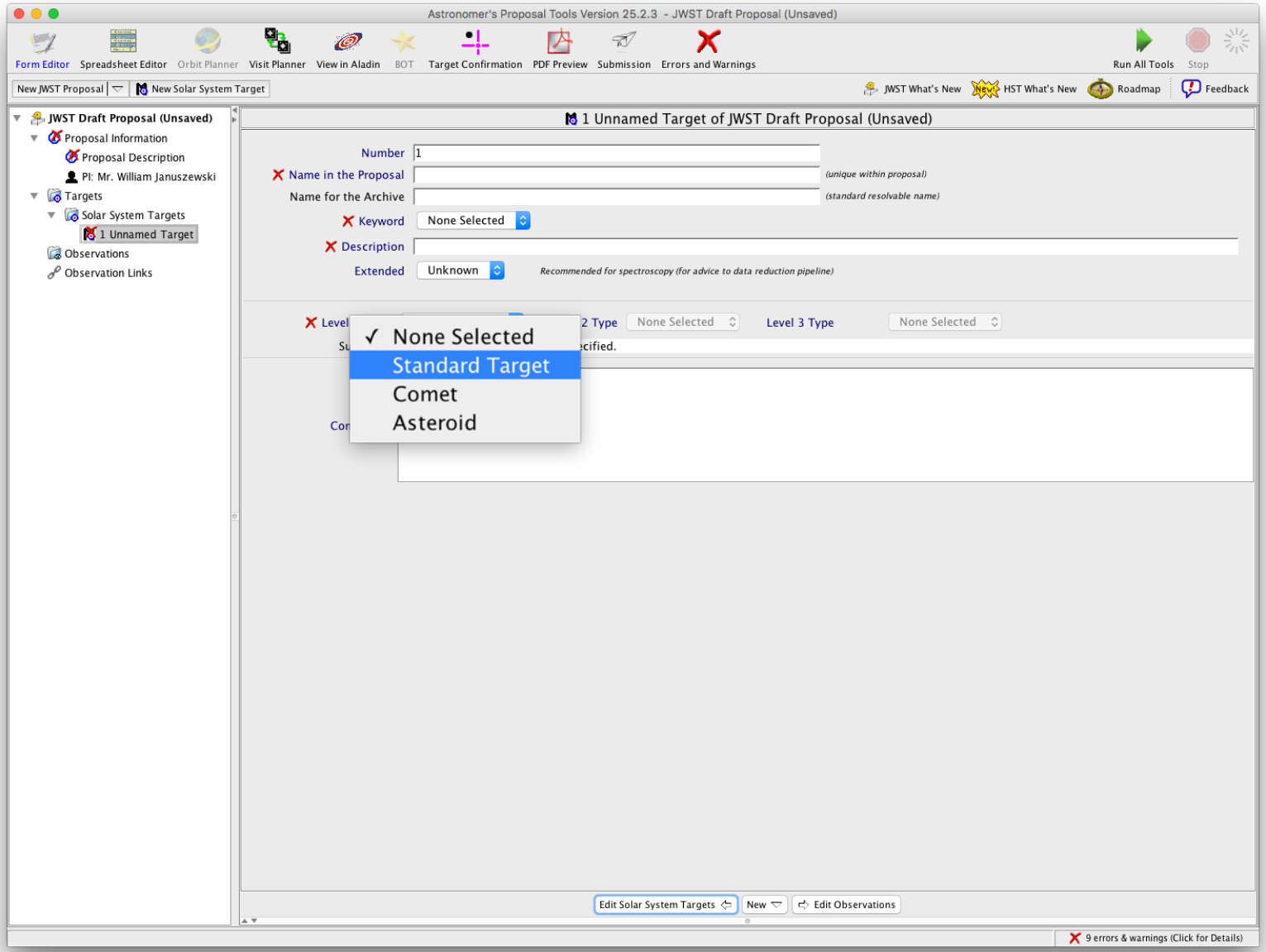
Level 2 refers to a target whose motion is normally described with respect to a Level 1 object.

- Planetary Satellites, Surface features on Planets, offsets from Asteroid or Comet.

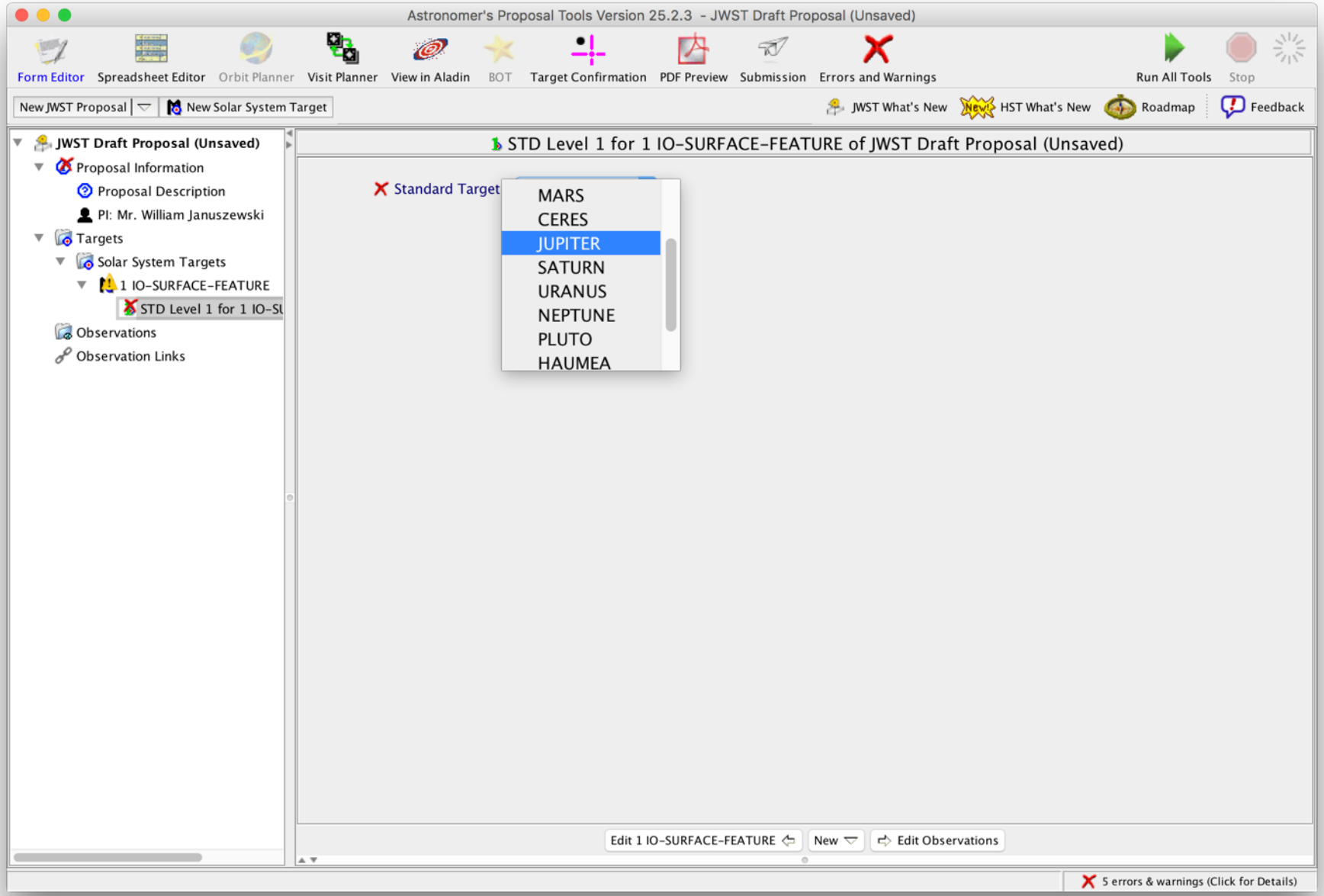
Level 3 refers to a target whose motion is normally described with respect to a Level 2 object.

- Surface feature on planetary satellites, Pointing offset from planetary satellite.

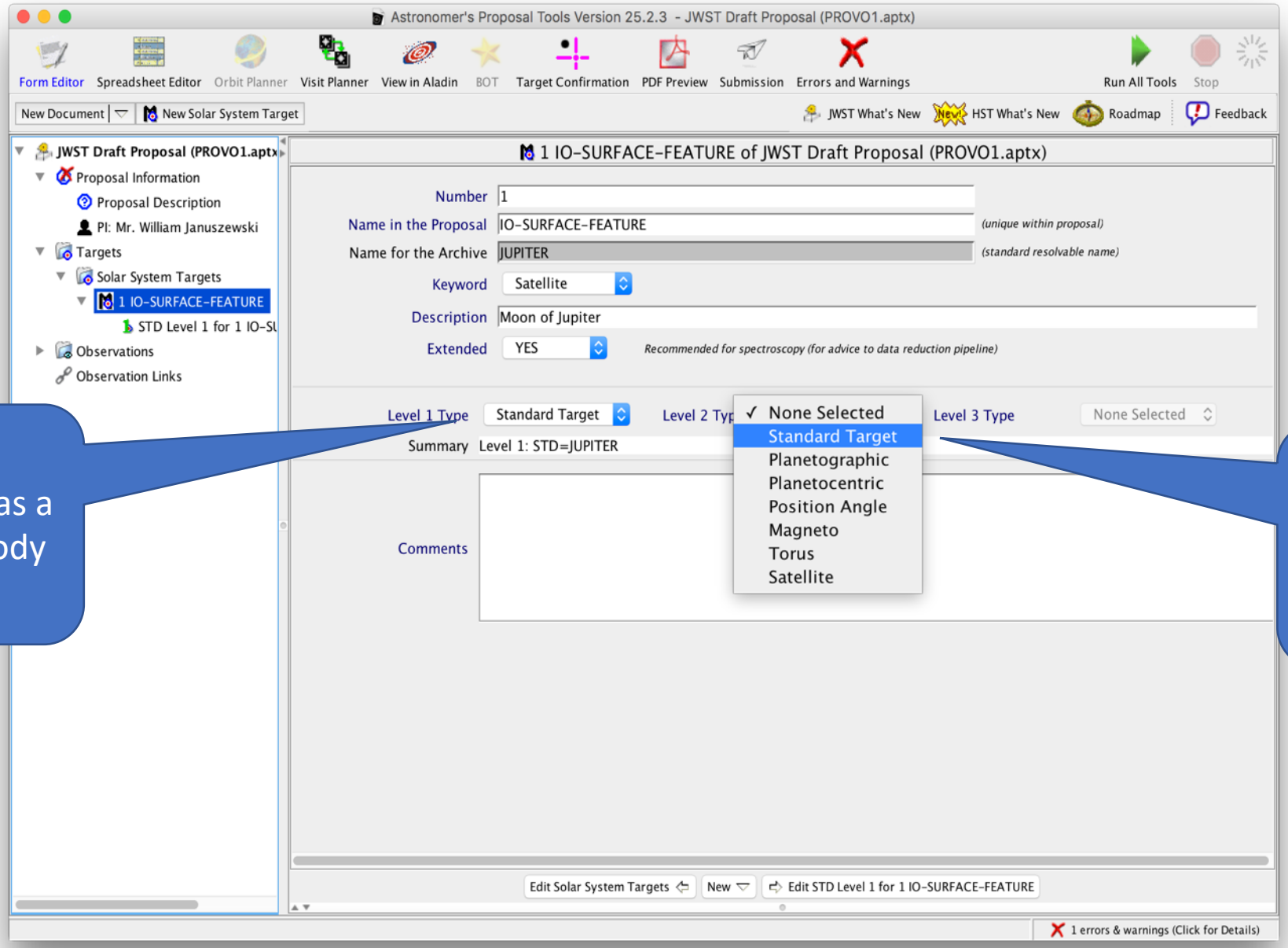
Moving Target Template: Io



Moving Target Template: Io



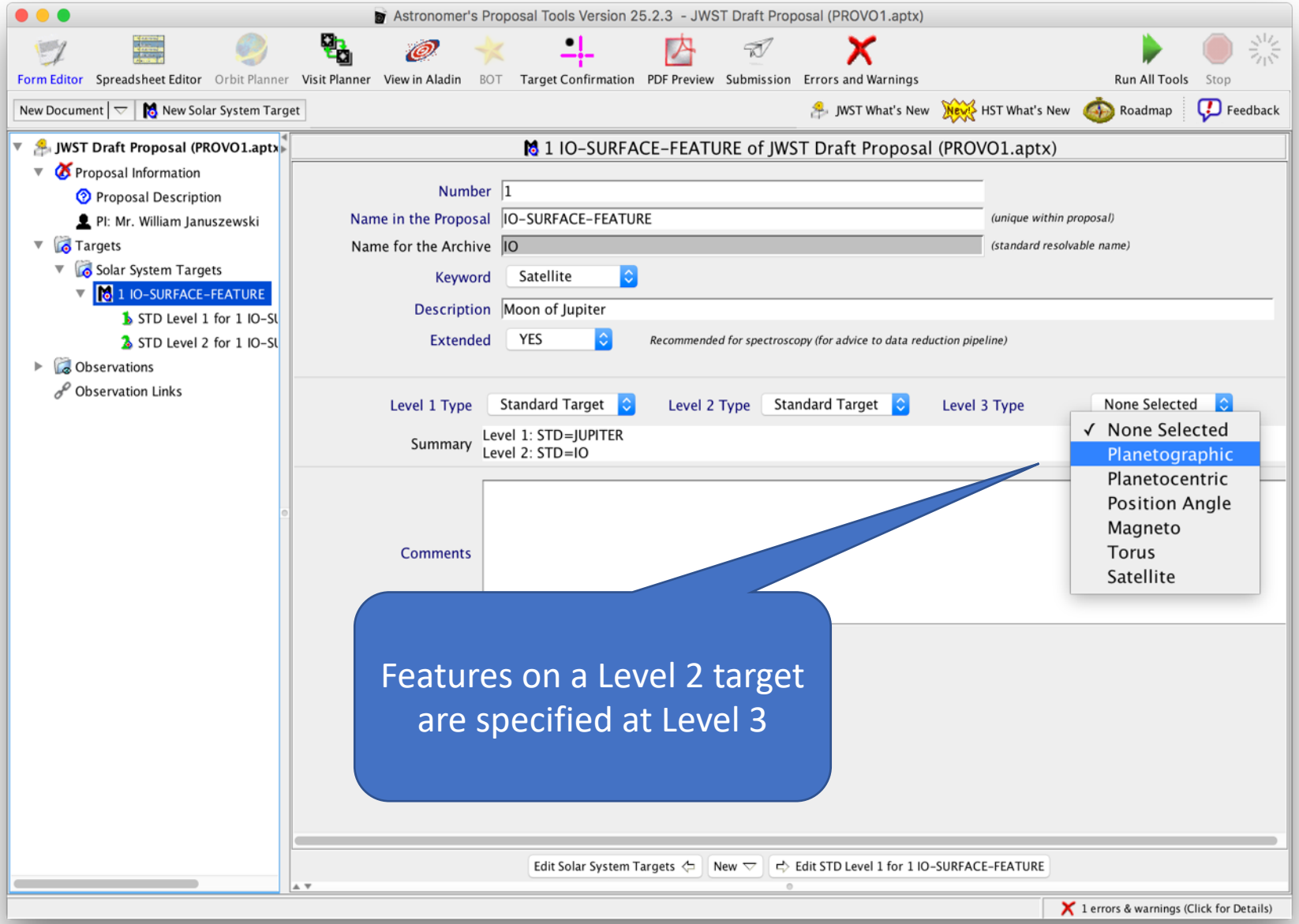
Moving Target Templates: Io



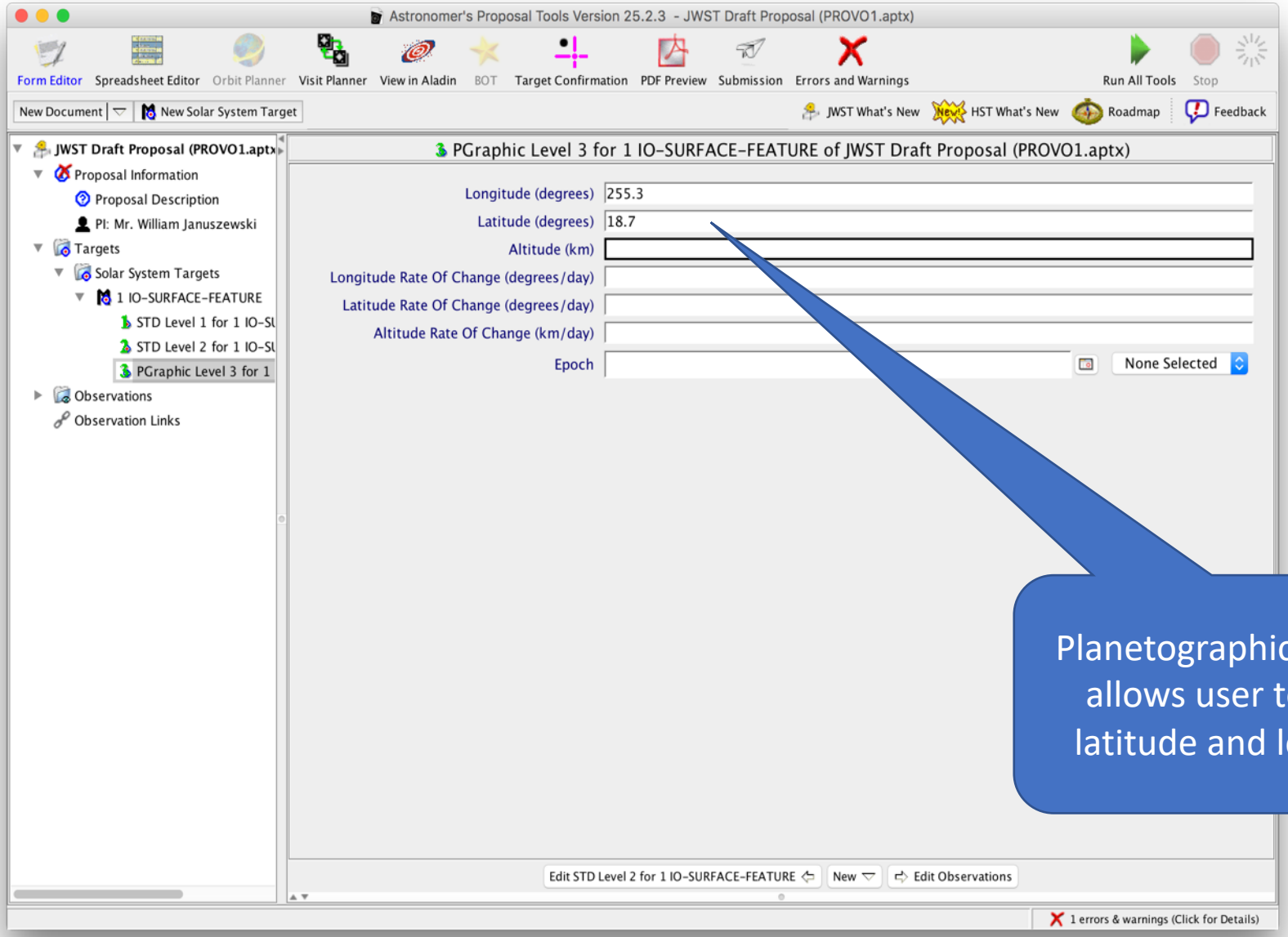
Jupiter is specified as a Level 1 standard body

Io is specified as a Level 2 body

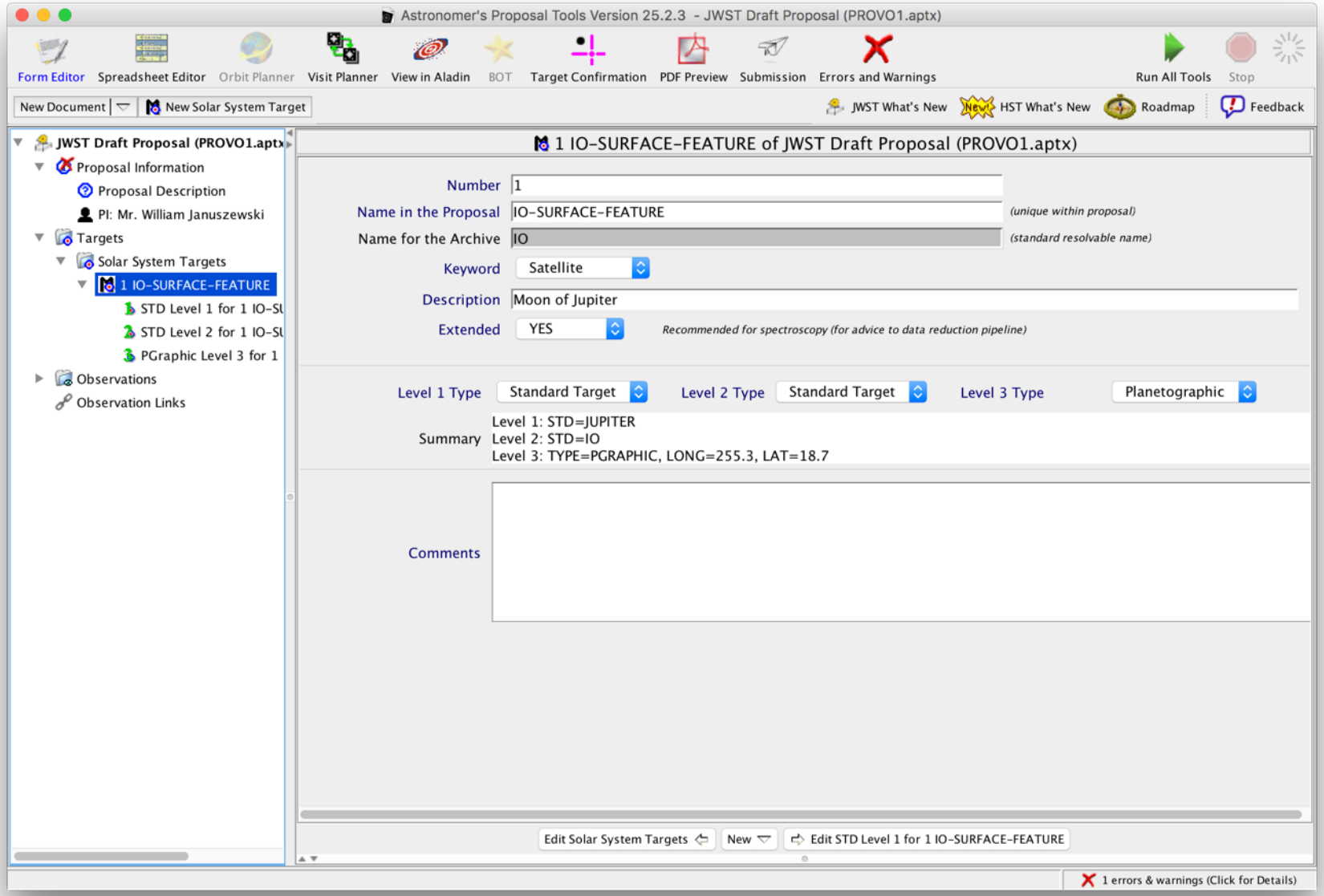
Moving Target Templates: Io



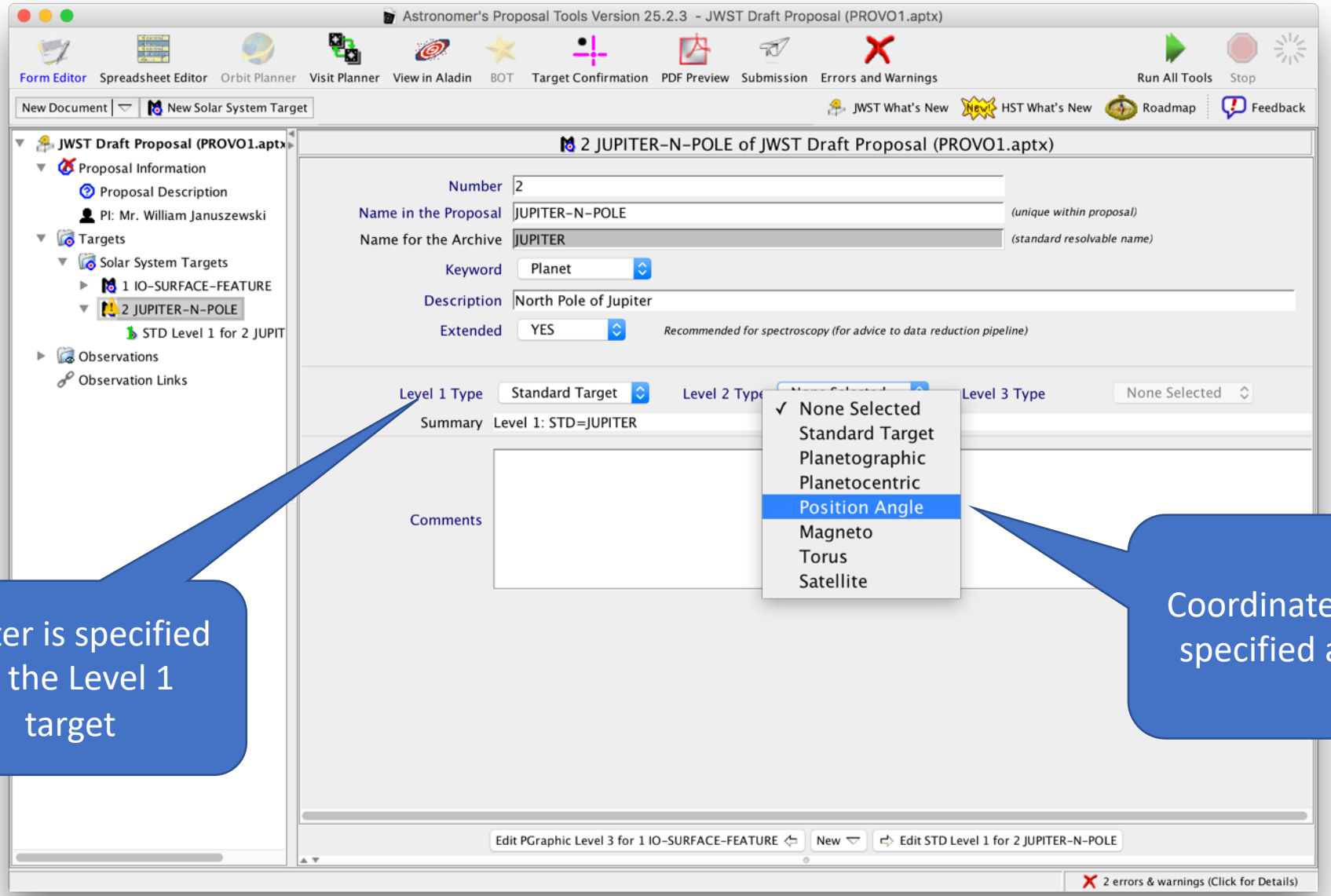
Planetographic Template –Level 3



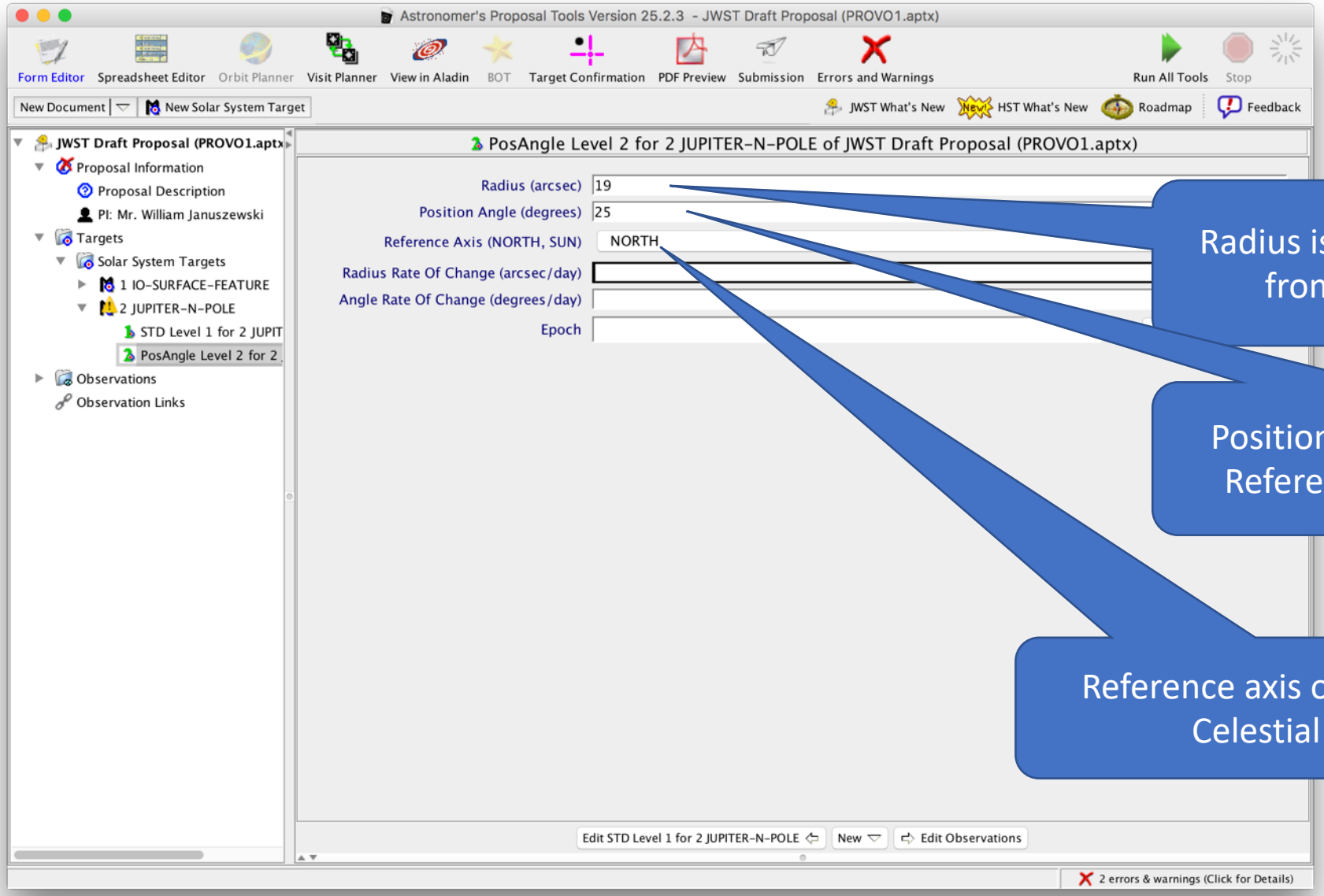
Defined Target for Io Surface Feature



Moving Target Template: Jupiter N Pole



Position Angle Template

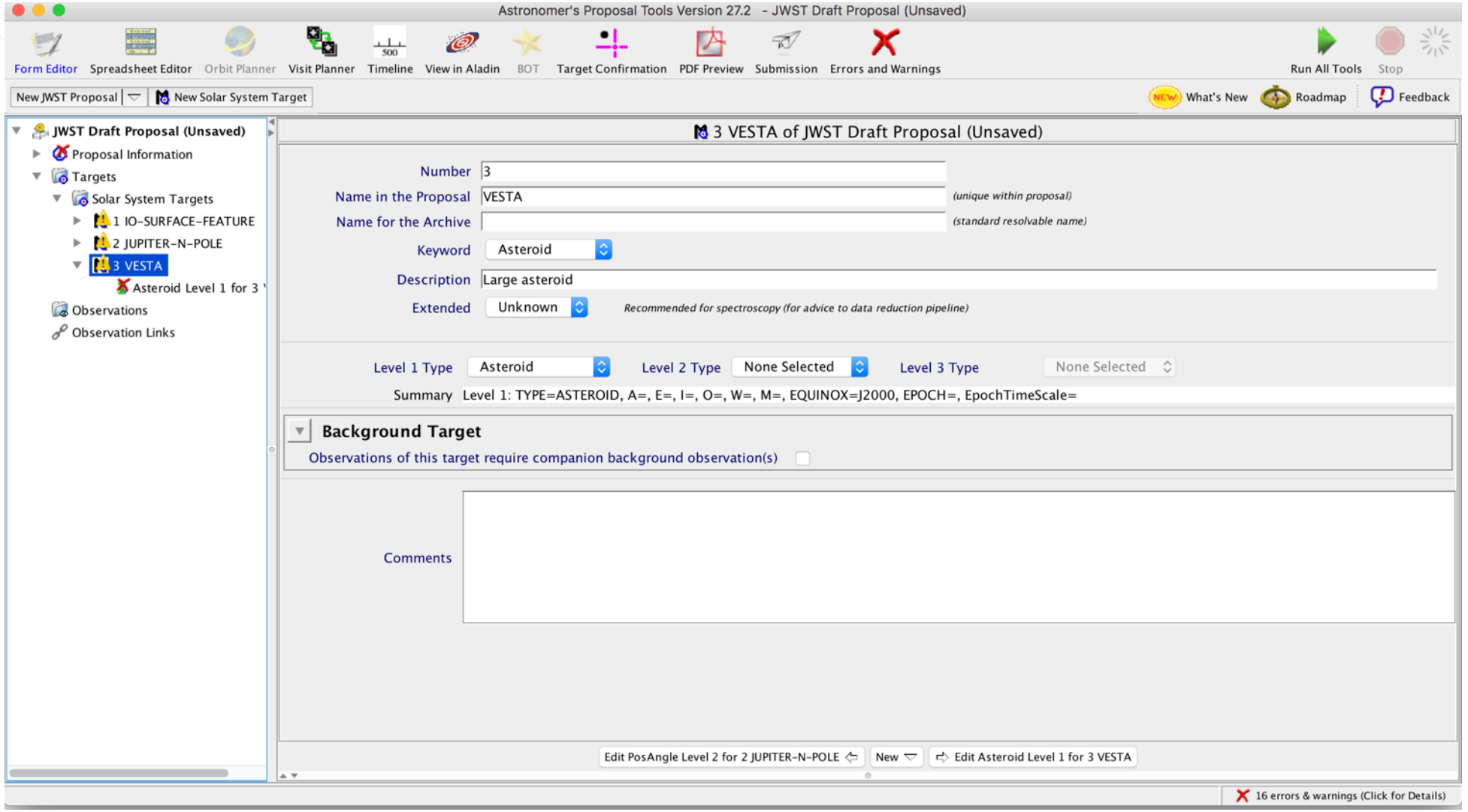


Radius is measured in arcsec from center of body

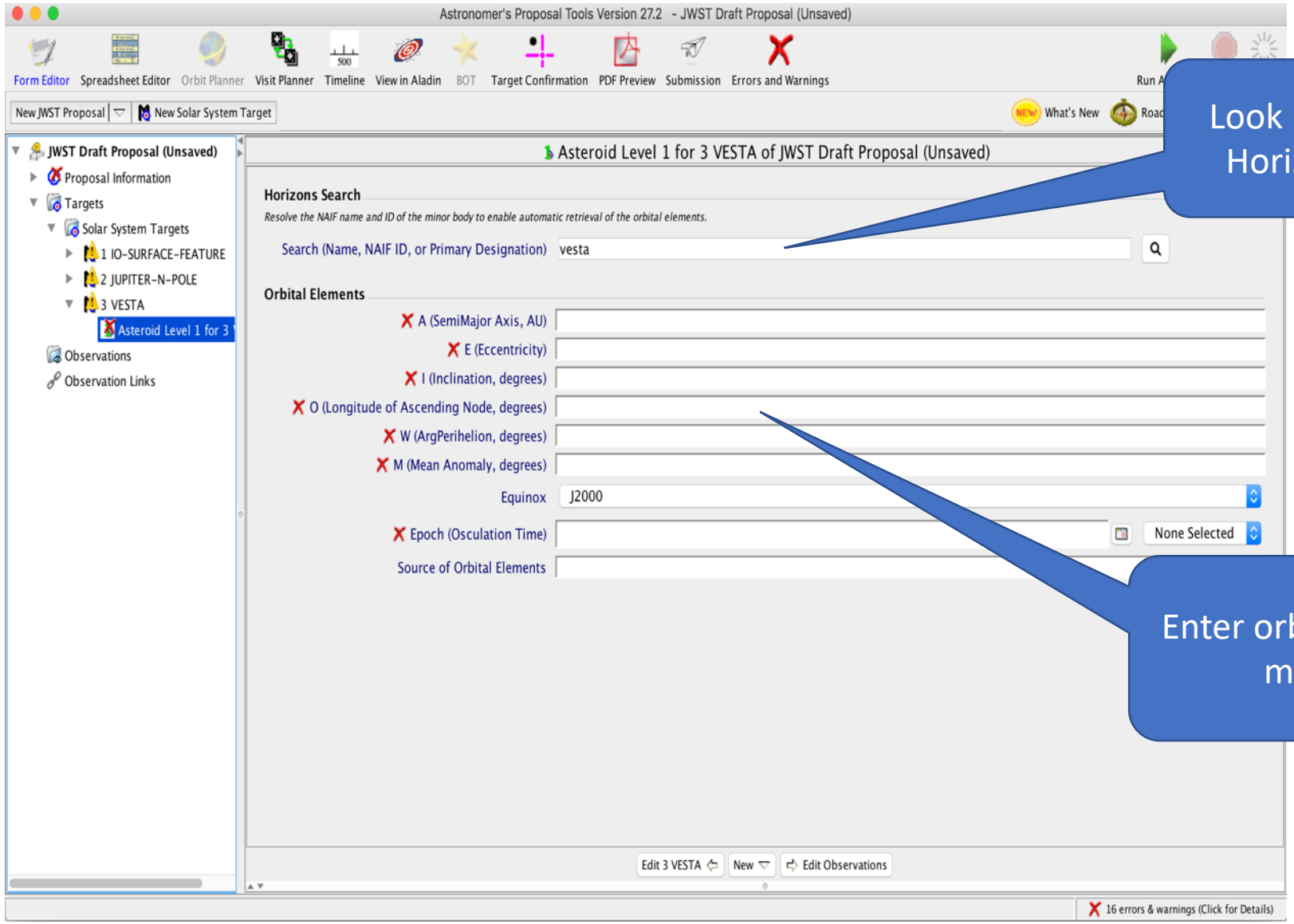
Position Angle is relative to Reference axis in degrees

Reference axis of North is for Celestial north

Minor Body Template



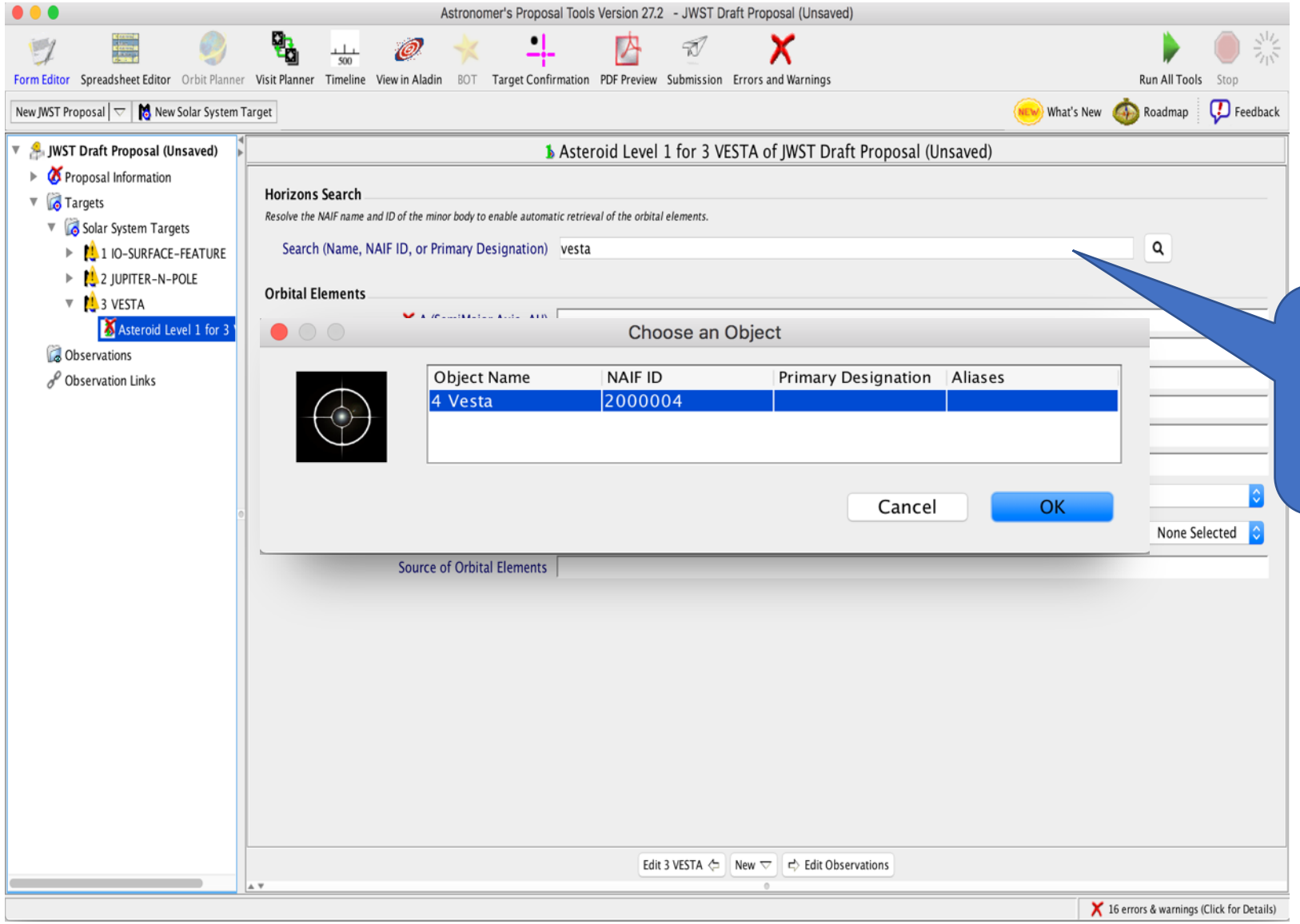
Minor Body Template



Look up target in the Horizons Database

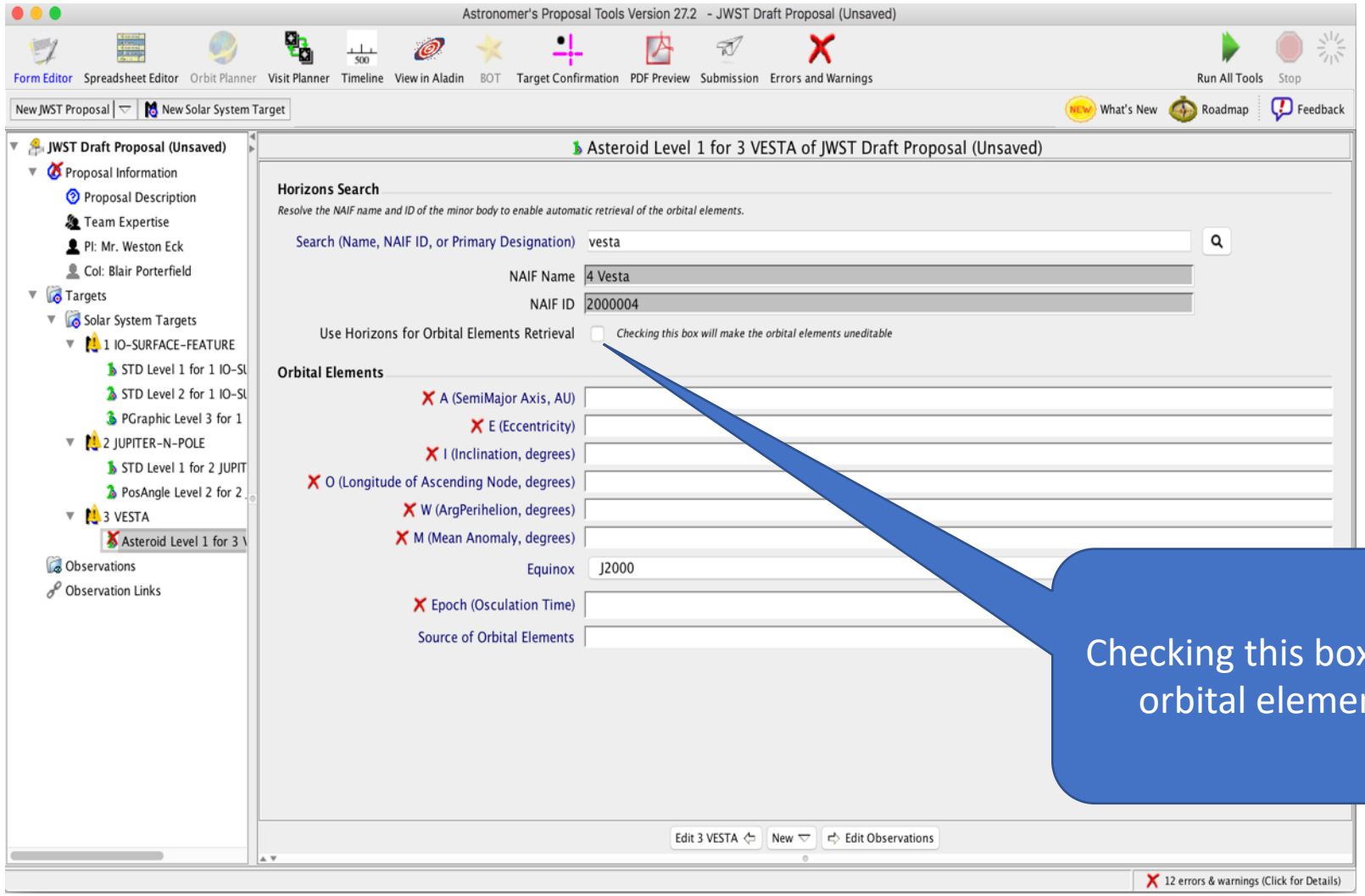
Enter orbital elements manually

Horizons Interface

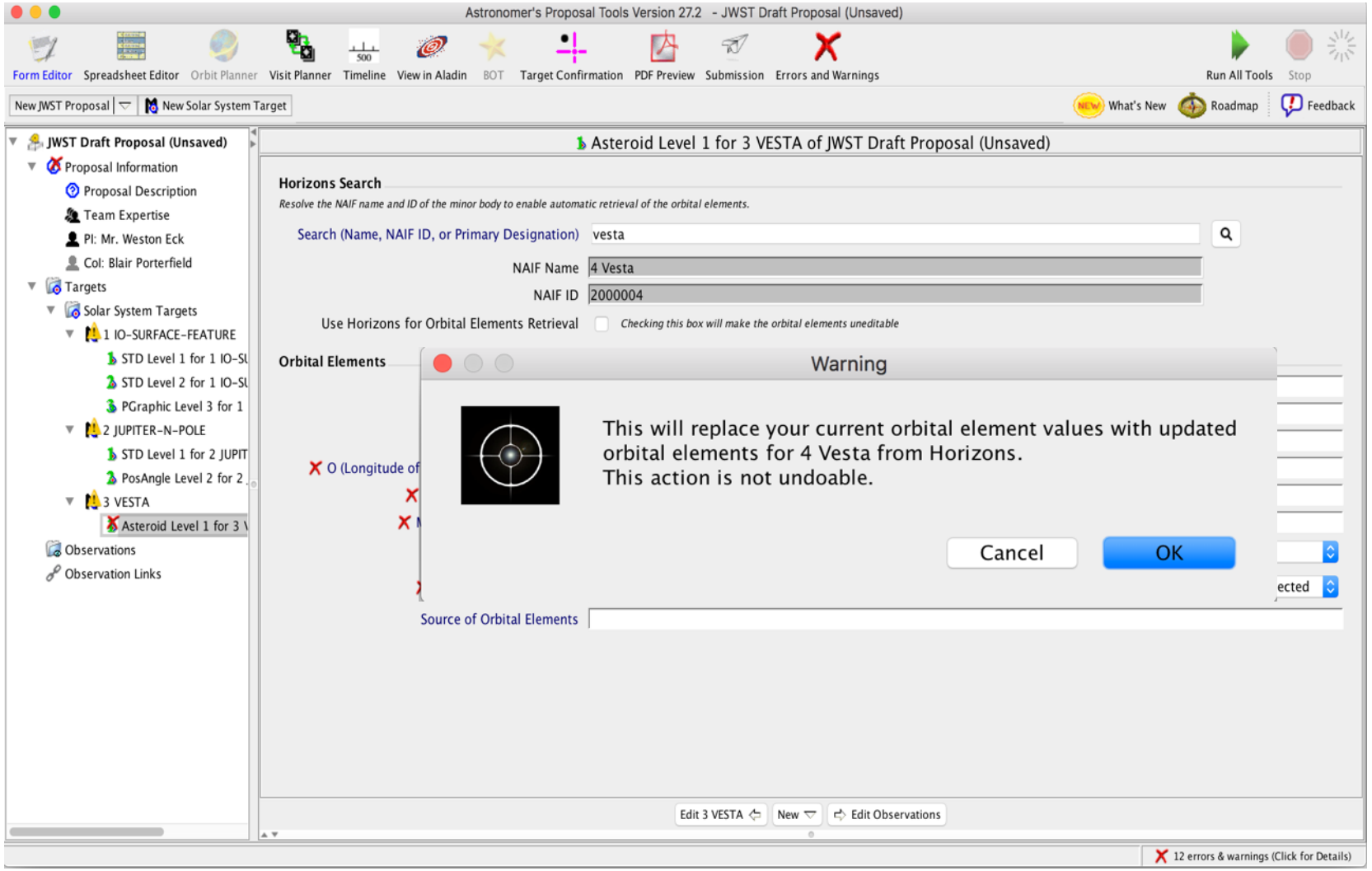


To retrieve elements from Horizons enter the name of the body

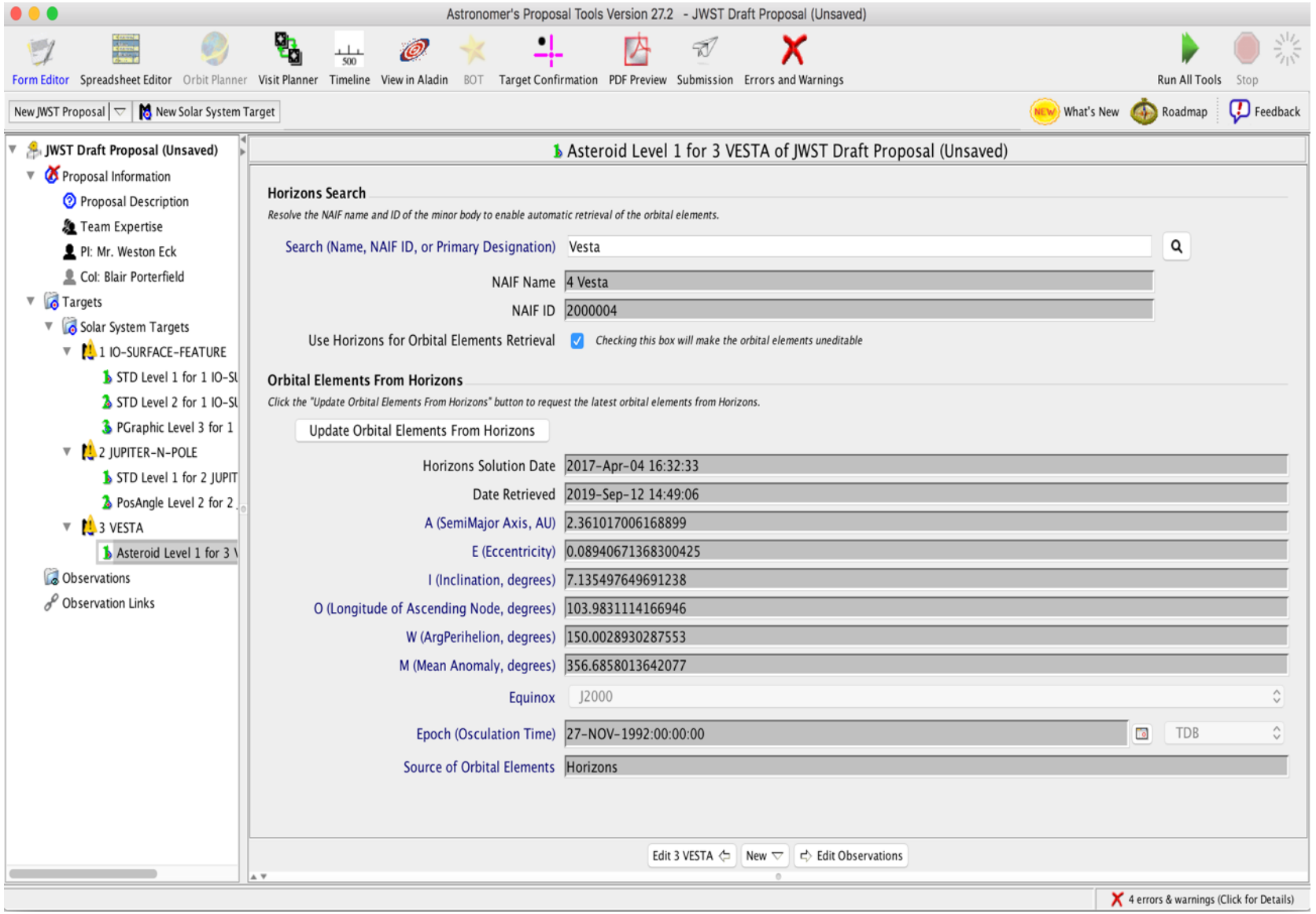
Horizons Interface



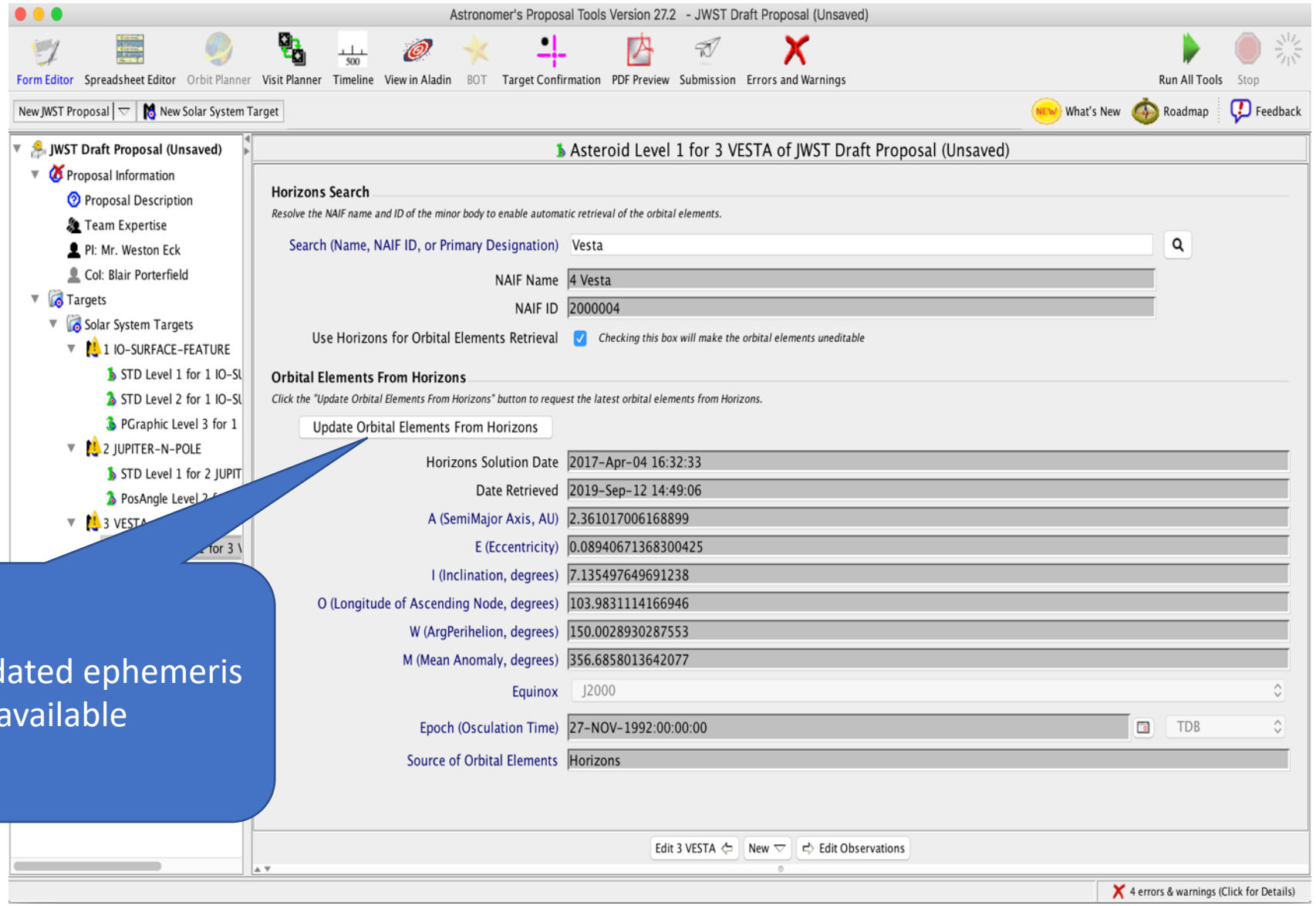
Horizons Interface



Minor Body Template

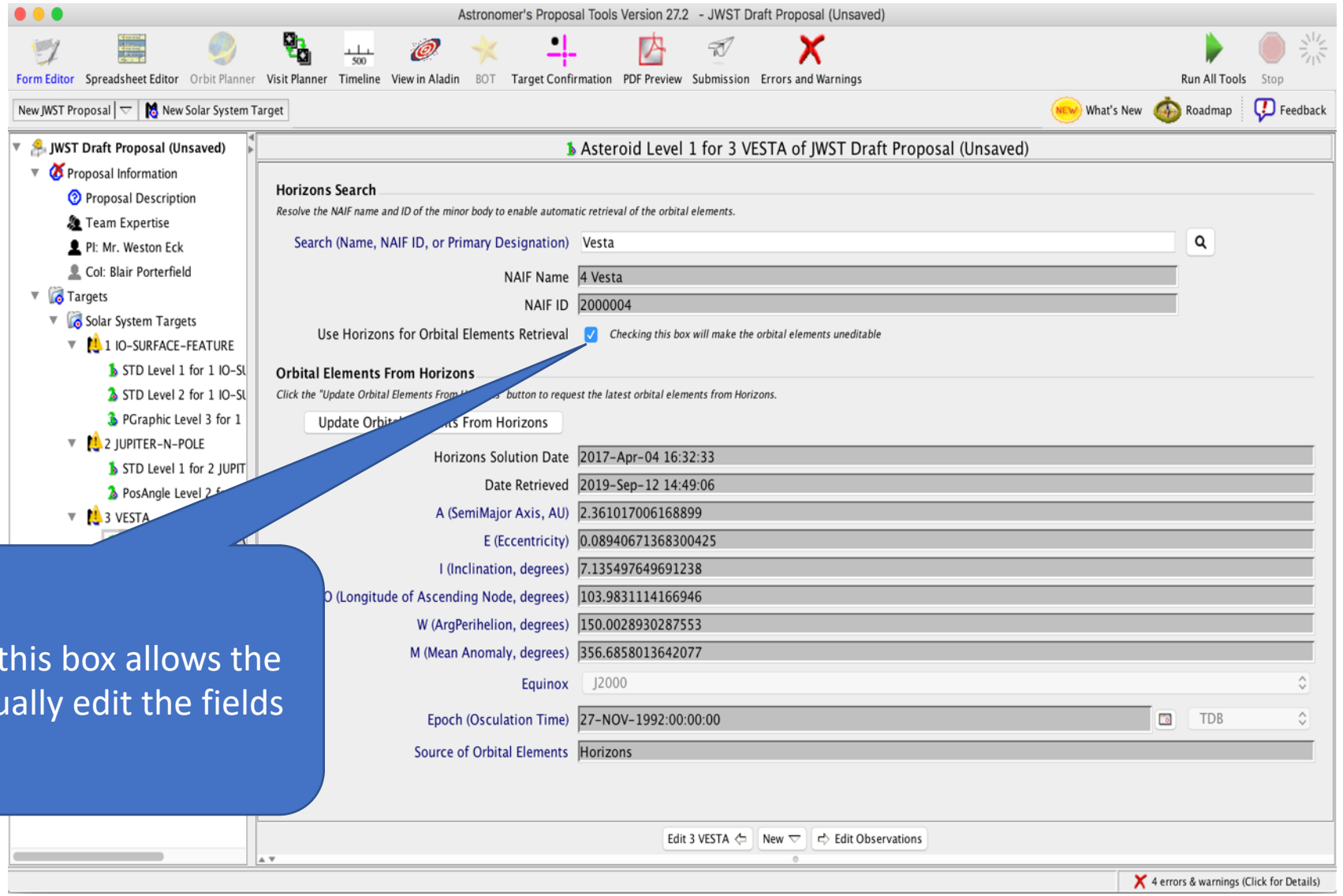


Minor Body Template



Retrieves an updated ephemeris if one is available

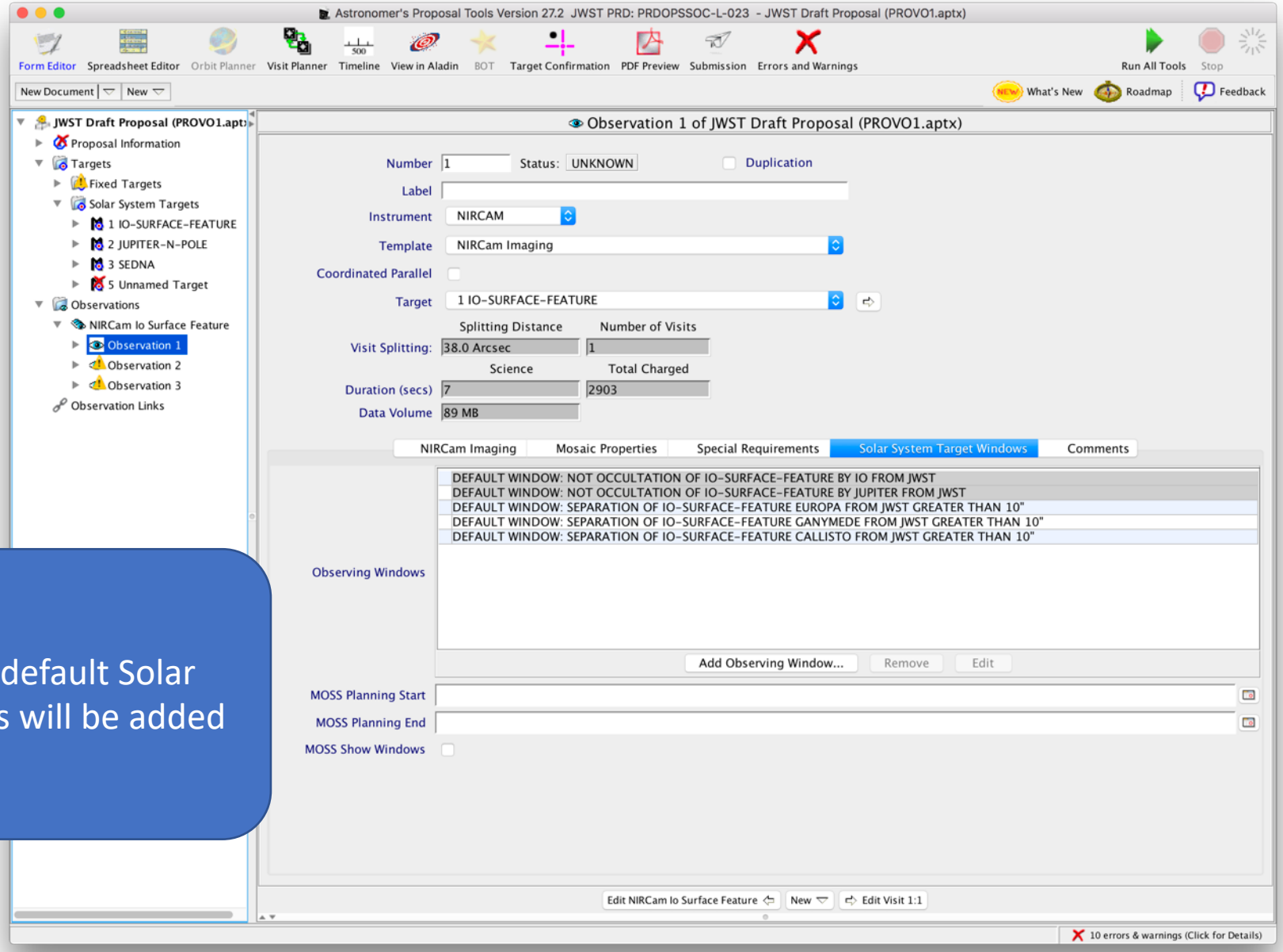
Minor Body Interface



Unchecking this box allows the user to manually edit the fields

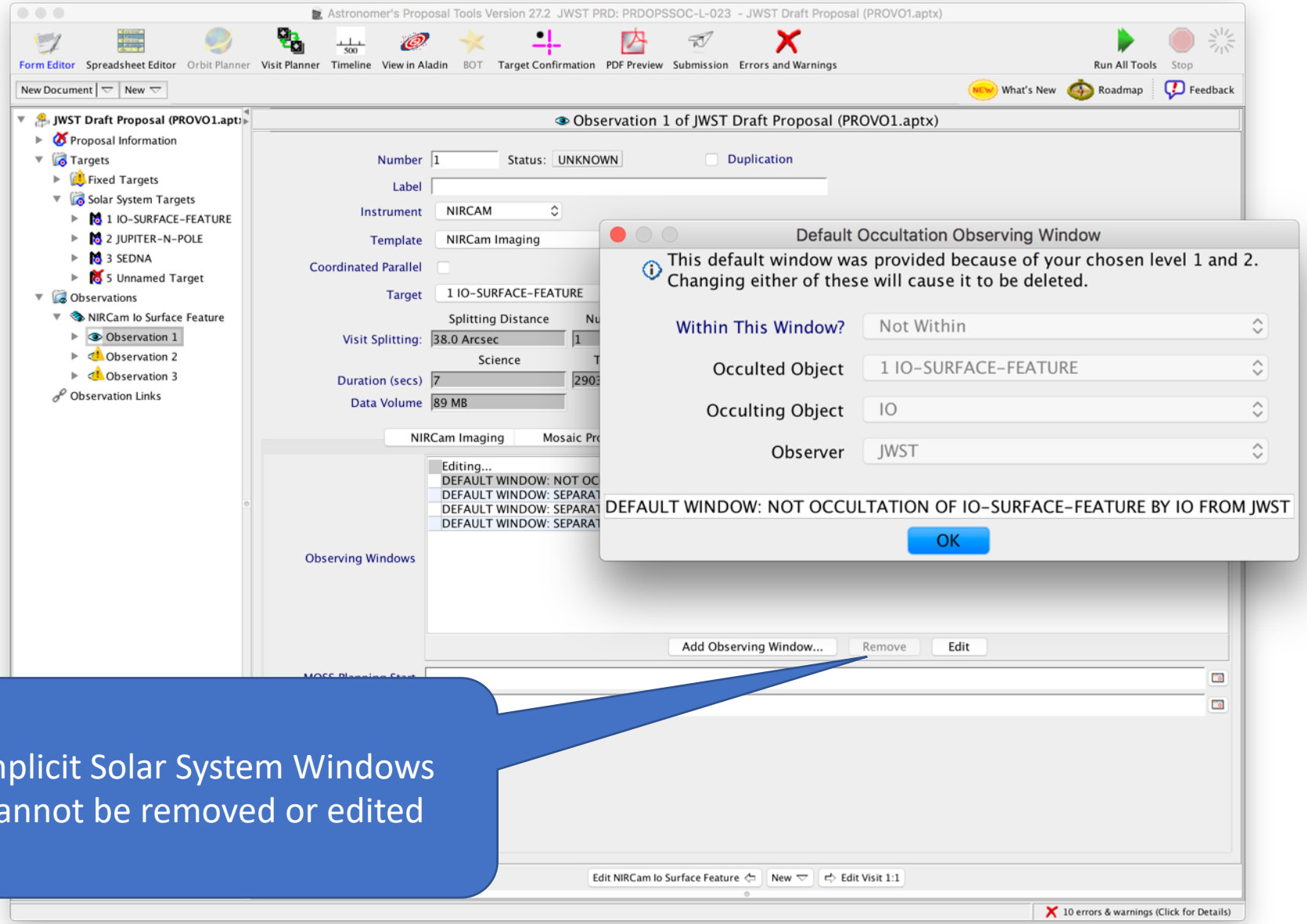
Solar System Target Windows

Solar System Target Windows



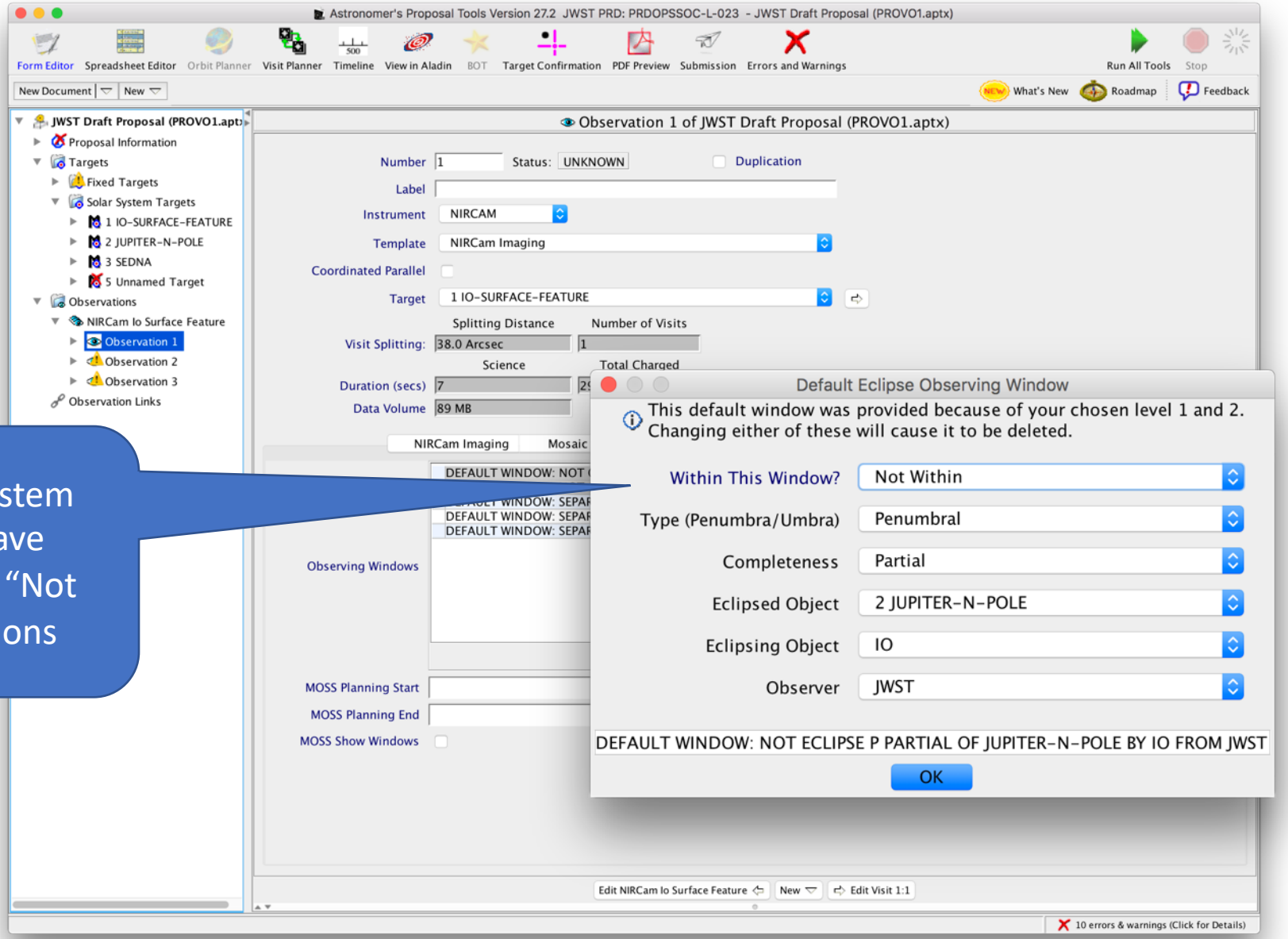
In some cases default Solar System Windows will be added

Solar System Target Windows



Implicit Solar System Windows cannot be removed or edited

Solar System Target Windows



Most solar system windows have "Within" and "Not Within" options

Special Requirements

Solar System Special Requirements are a powerful tool for defining what conditions are occurring for optimal science return

Just don’t get carried away.

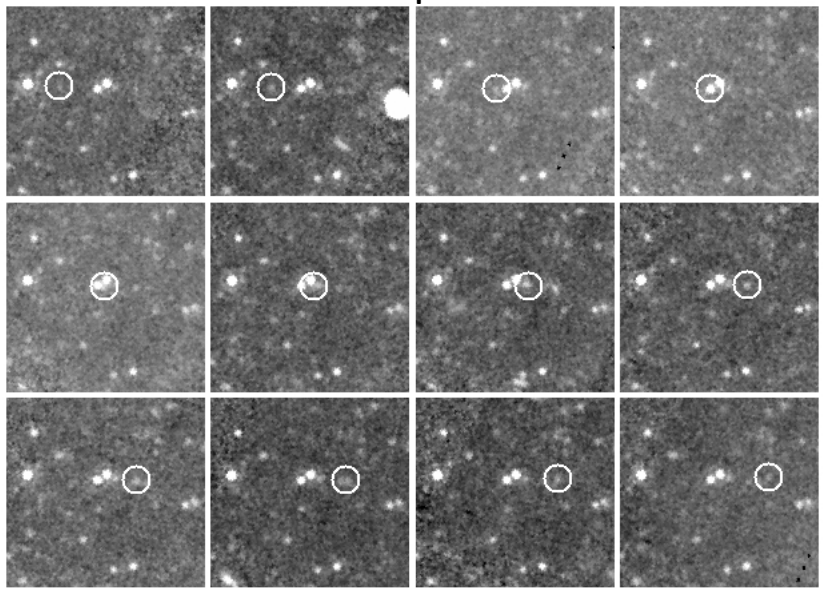
Use the windows you need to meet your science goals but keep in mind that each requirement restricts scheduling windows.

Special Requirements Example: Moving Follow-on

This strategy combines 2 or more observations of a target, taken close together in time, to remove most of the background objects from the data.

- This results in improved SNR for observations of targets that are comparable to the brightness of typical background objects (or fainter!).
- Many measurements made with *Spitzer* and *Herschel* would not have been possible had they not implemented moving follow-on constraints.

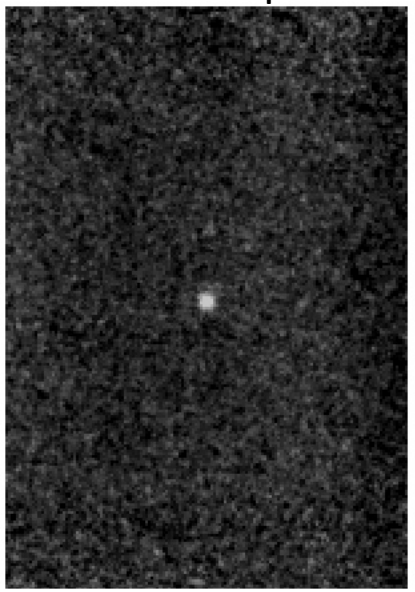
24 µm



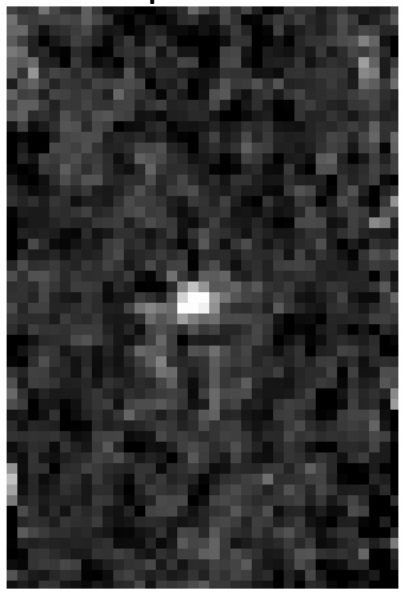
26308 (1998 SM165) - *Spitzer*

1) Co-add in sky coordinates
2) Subtract Sky from individual images
3) Coadd result in co-moving frame

24 µm



70 µm



Special Requirements Example: Moving Follow-on

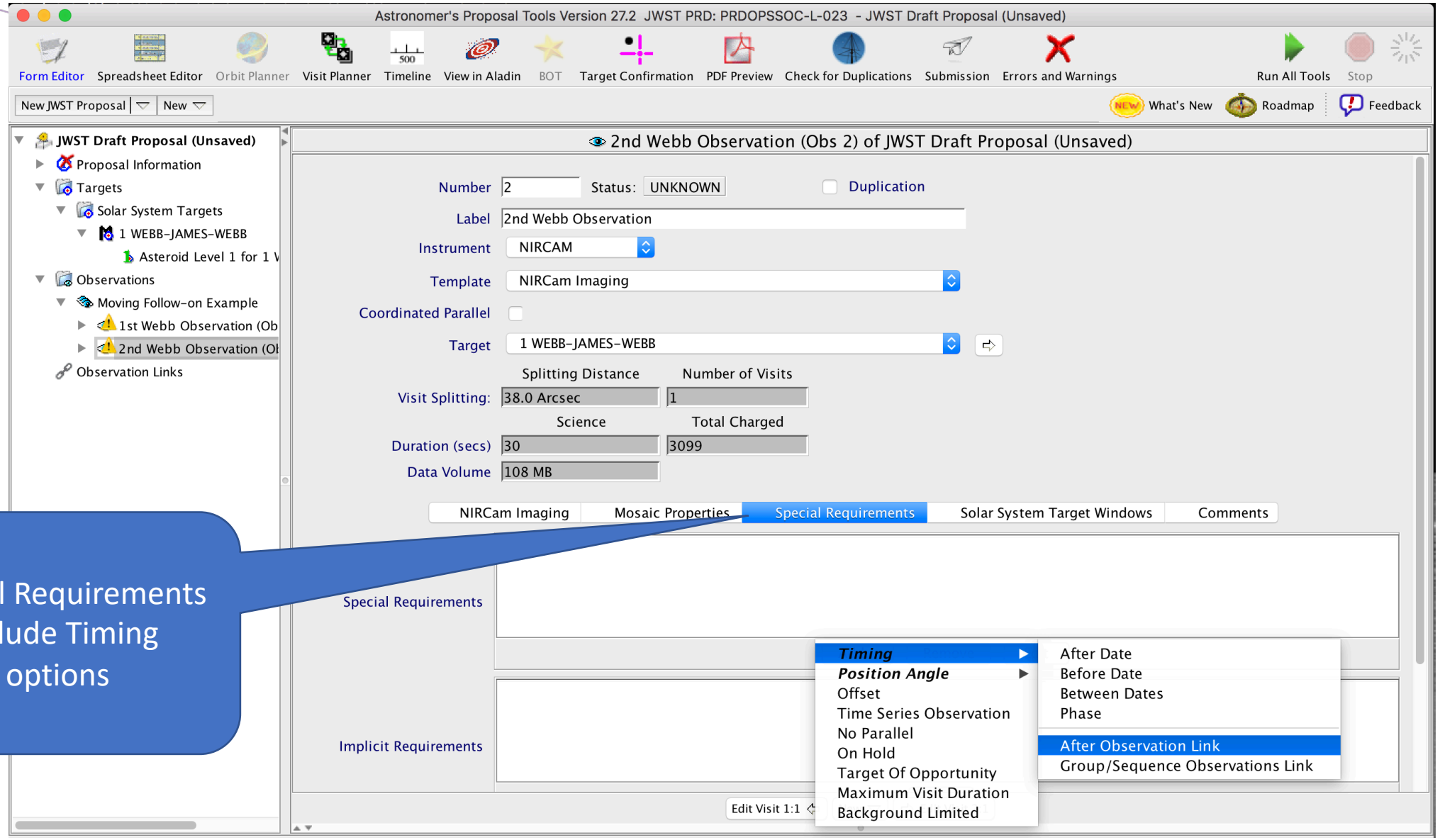
For moving follow-on to work requires:

1. Target moves a significant distance relative to the PSF size (well-separated target observations).
2. Target moves significantly less than ½ of the FOV of the individual observations.

APT Implementation:

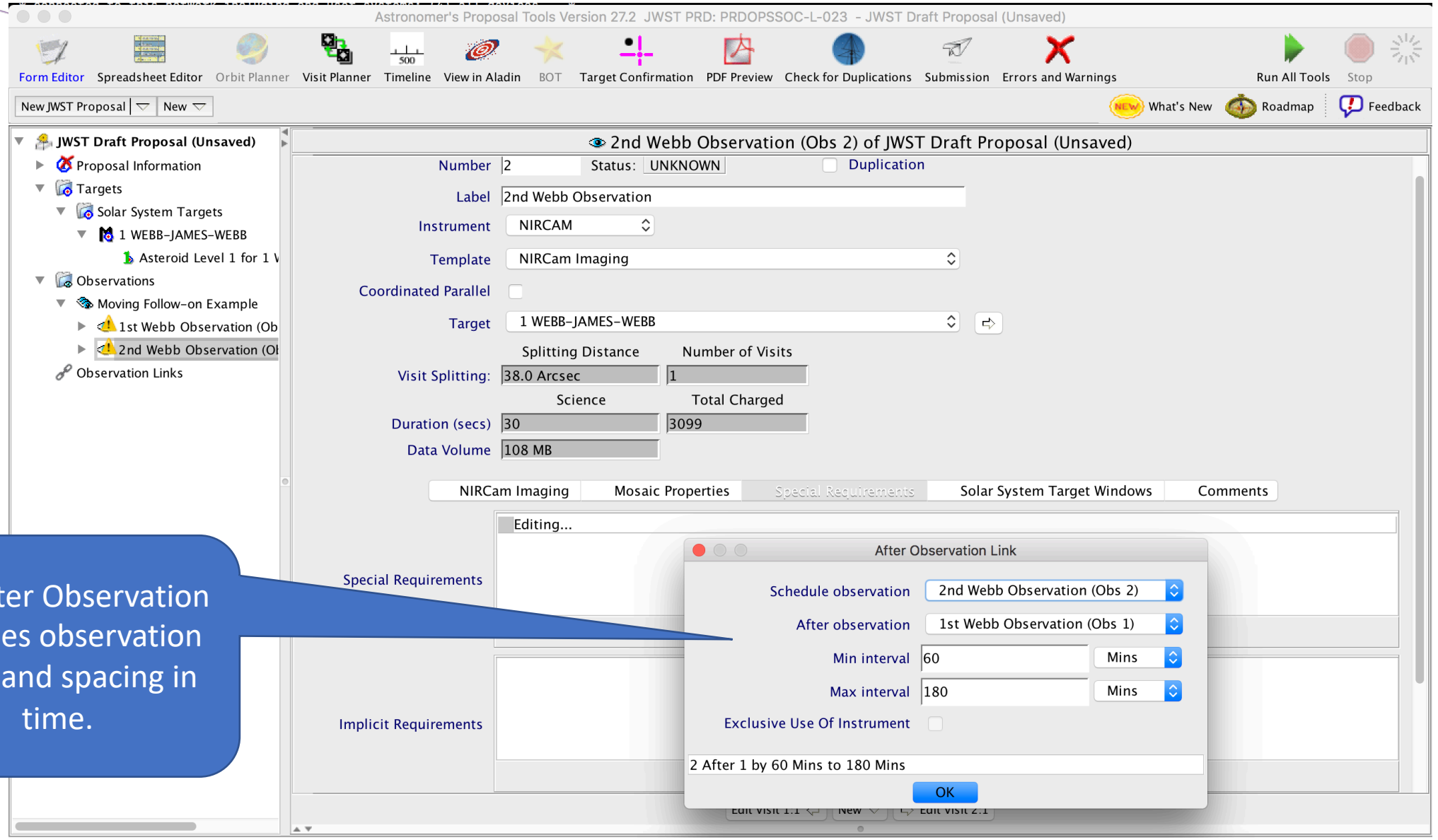
1. Create 2 observations of the target.
2. Create a Special Requirement on the 2nd observation: *Timing -> After Observation* link.
   - Based on the apparent rate of motion (d”/dt) of the target, set the Min and Max Interval:
     1. Min: d”/dt * Min > N * FWHM (where N > 3)
     2. Max: d”/dt * Max < FOV_size * Frac (where Frac < 0.3)
3. If the apparent rate of motion varies significantly during the observing window, create a *Solar System Target -> Angular Rate Observing Window* on one observation.
   1. You will have to choose to constrain the angular rate to be > or < your preferred rate.
   2. Choose a limiting rate that satisfies the After Observation conditions above while providing maximum scheduling flexibility.
4. ***Check your results in Visit Planner!!***

Special Requirements Example: Moving Follow-on



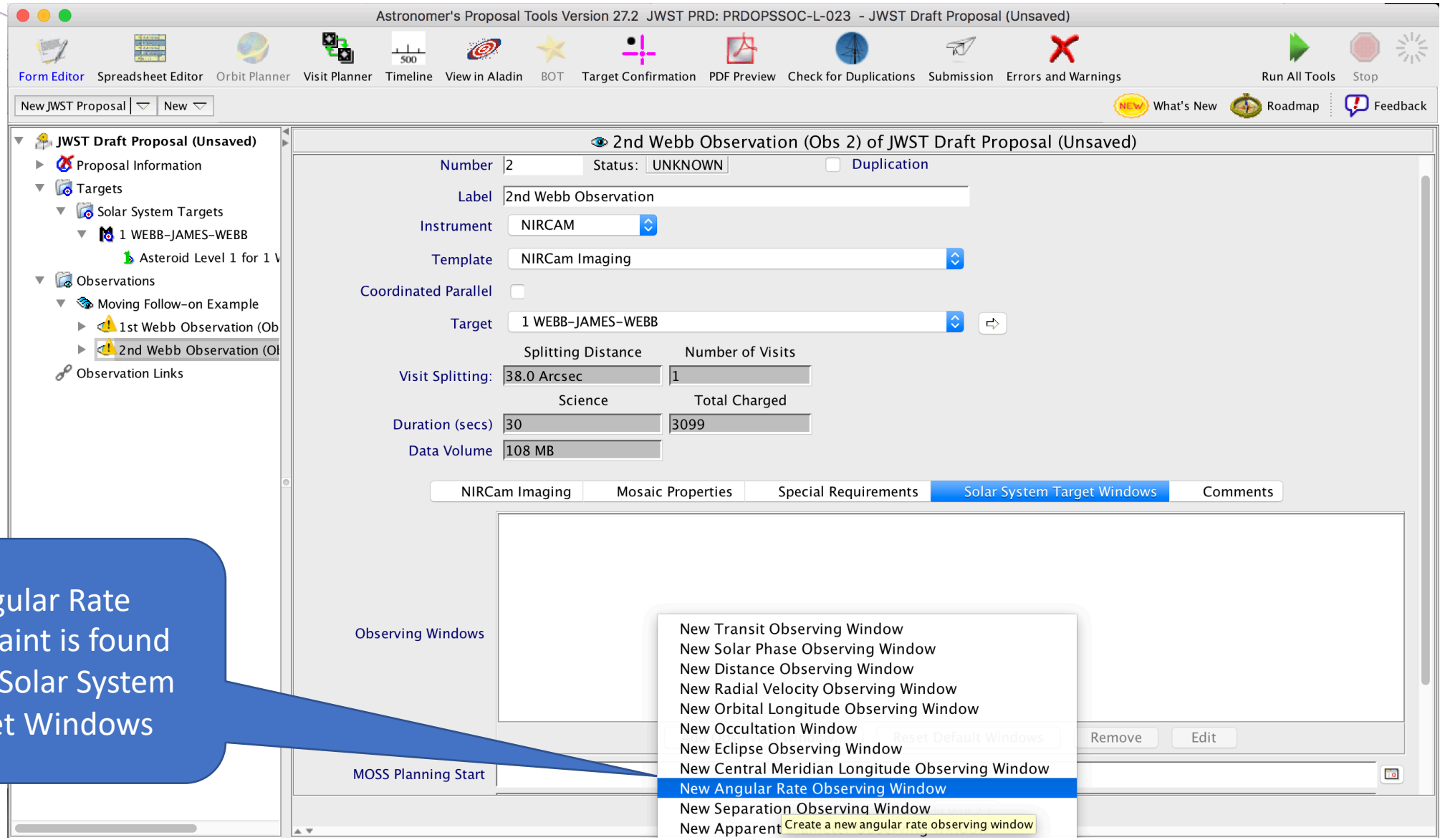
Special Requirements include Timing options

Special Requirements Example: Moving Follow-on



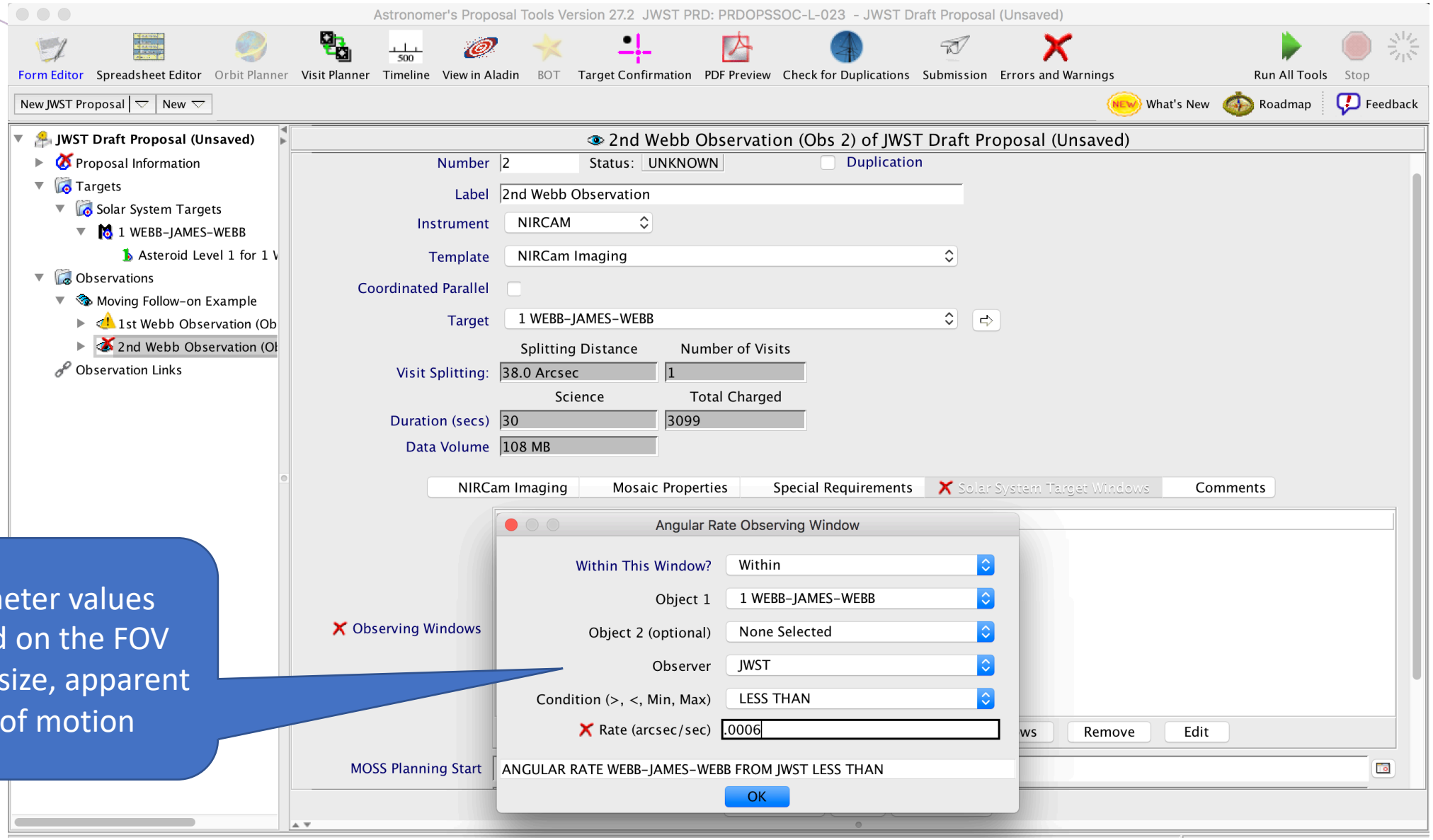
The After Observation specifies observation order and spacing in time.

Special Requirements Example: Moving Follow-on



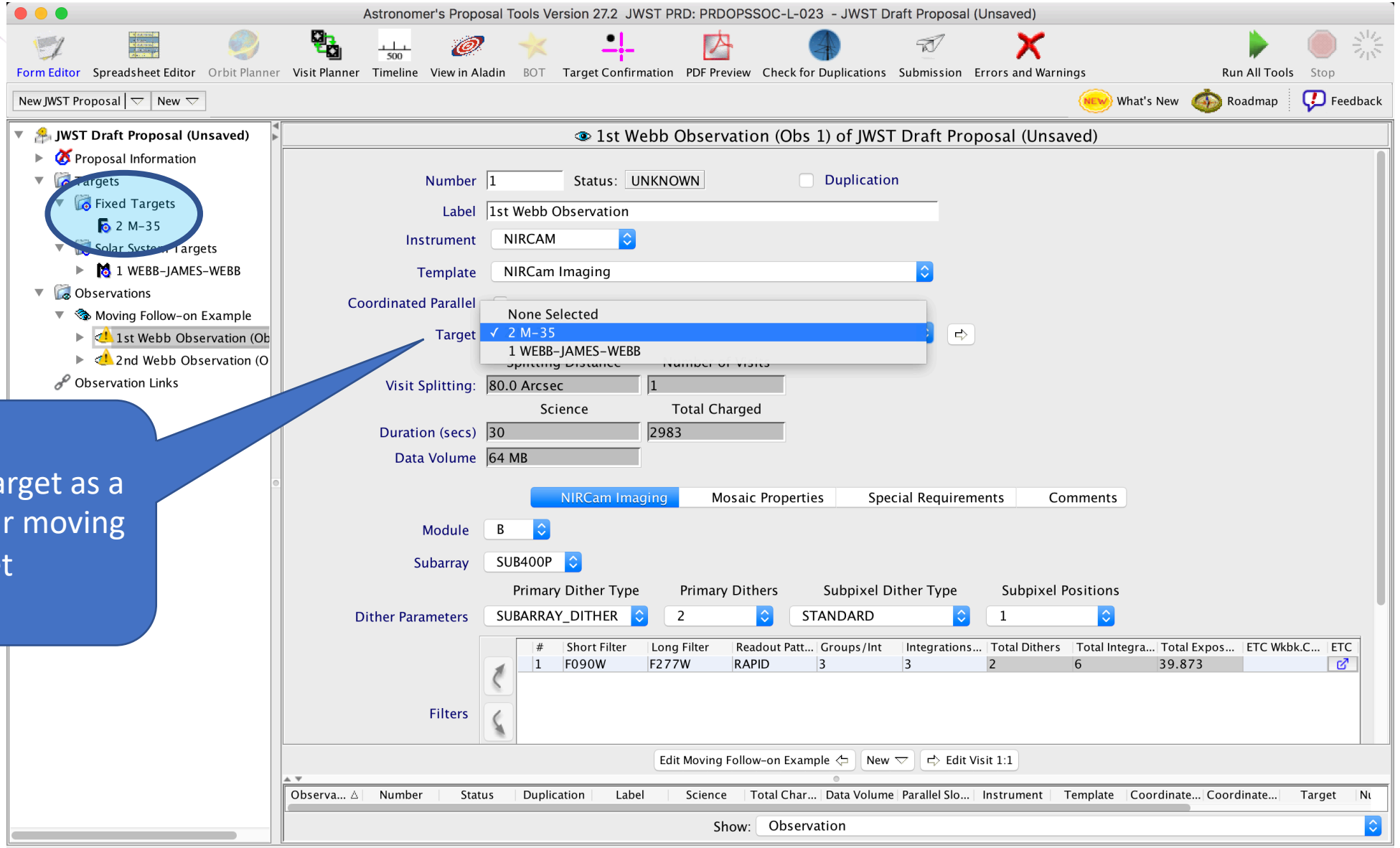
Angular Rate constraint is found under Solar System Target Windows

Special Requirements Example: Moving Follow-on



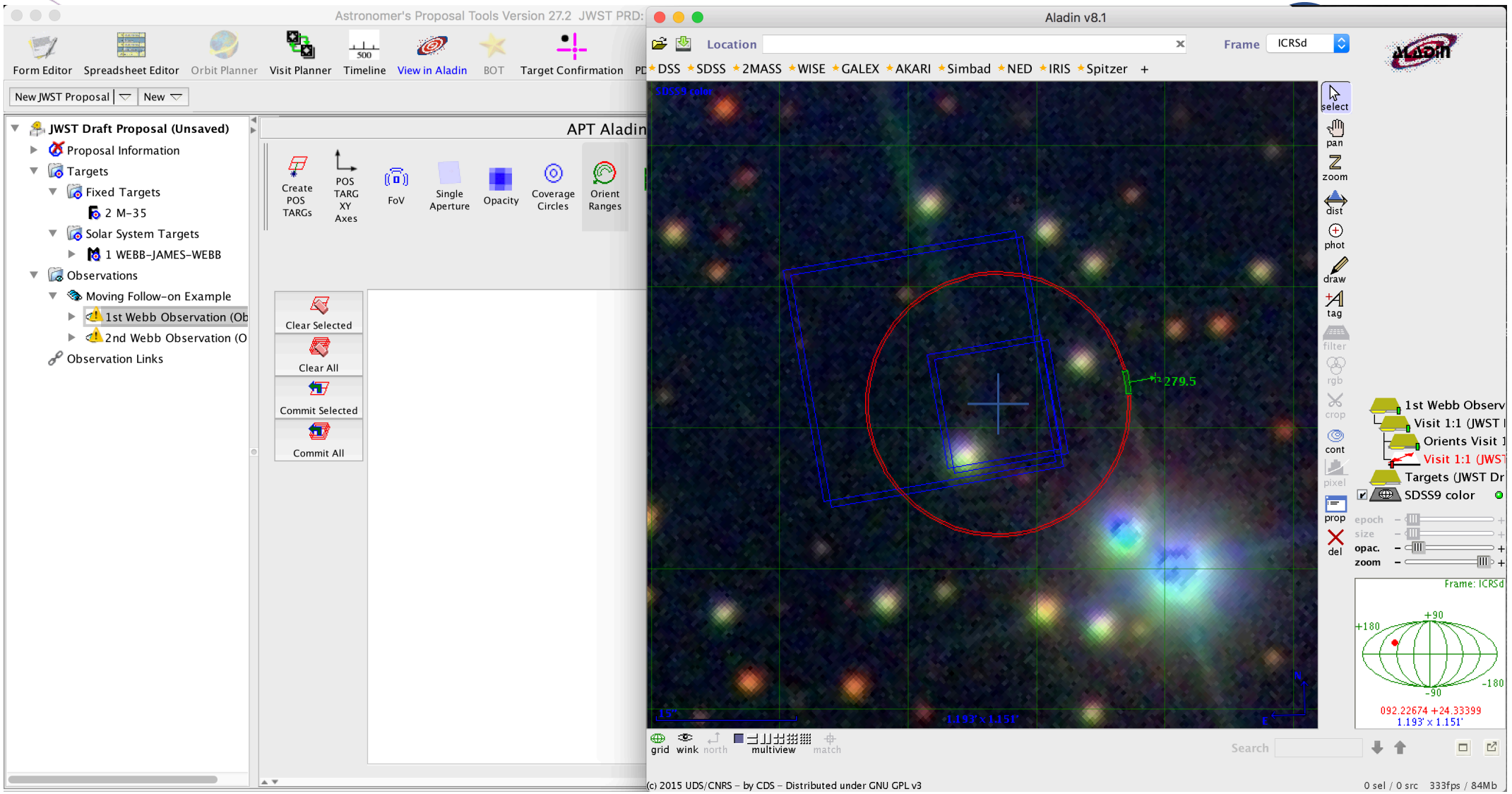
Parameter values depend on the FOV and PSF size, apparent rate of motion

Visualization: Moving Target Proxy



Use a fixed target as a proxy for your moving target

Moving Target Visualization: Proxy Fixed Target



APT Moving Targets: On-line JDox Resources

- Moving targets in APT: Moving Targets in APT
- APT Solar System Target Windows: Solar System Special Requirements
- Visualizing Moving Target Observations: Tutorial on Visualizing Dithers of a Solar System Observation in APT
- APT Special Requirements: APT Special Requirements
- ETC to APT interface: ETC to APT Interface Support Information
- APT Visit Planner: APR Visit Planner
- General APT documentation: Astronomers Proposal Tool Overview