Update on MAJIS
Jupiter observations planning

D.Grassi, T. Fouchet, A. Mura, E. d'Aversa
davide.grassi@inaf.it

MAJIS meeting
October 2019

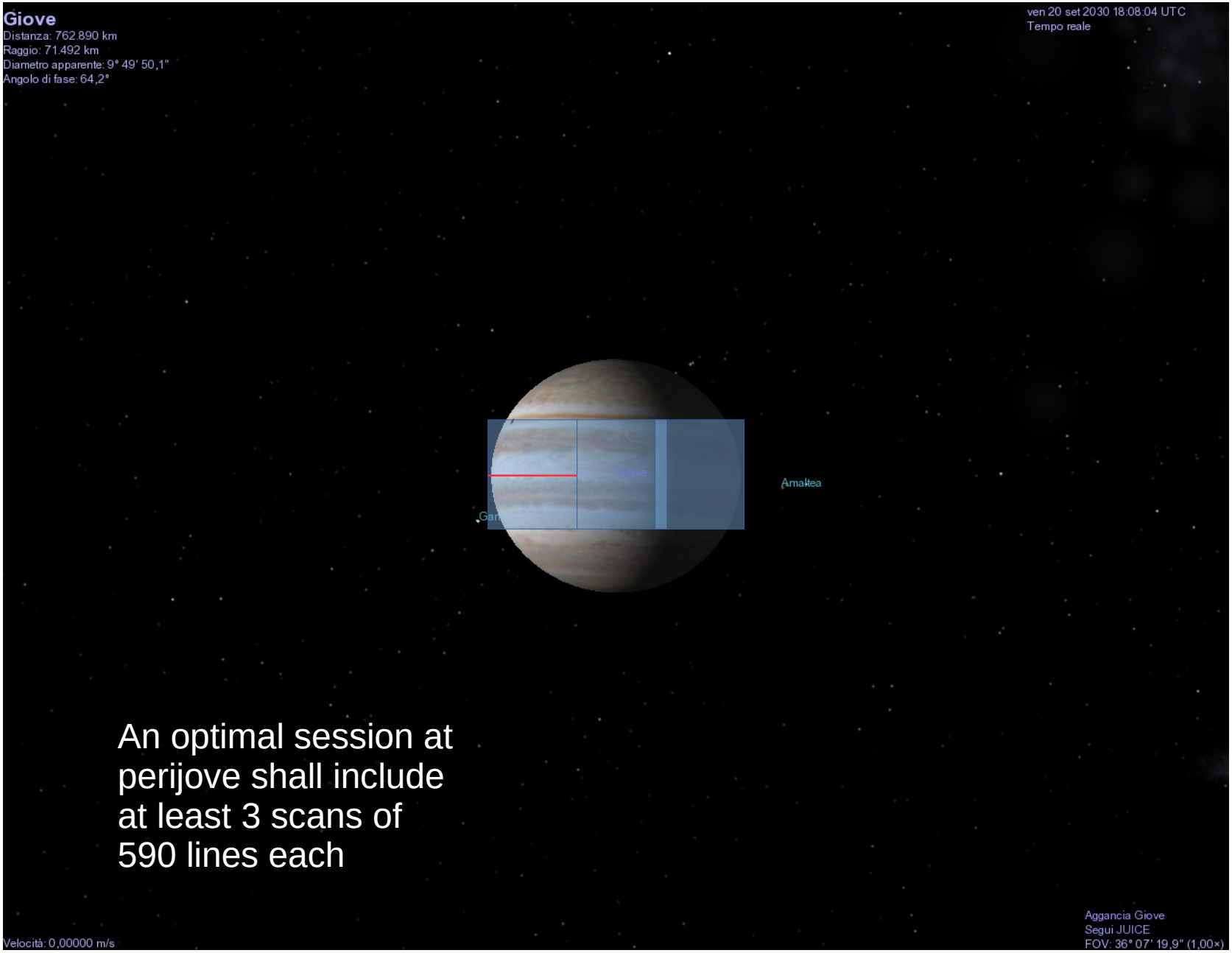
Overview

- Planning principles
- Resulting data production profile
- Instrument flexibility
- On the PJ2 activities
- On auroral observations

Planning principles

- Well defined and consistent since several years
  - To provide coverage of Jupiter with a temporal rate as uniform as possible, *with periods complimentary to those provided by JIRAM-Juno*, at least in equatorial regions [30S;30N] Larger latitudinal coverage possible, if datavolume available
  - To provide coverage of planet limbs at passages at phase angles values of 0° (morning/limb comparison) and ±90° (solar/antisolar comparison)
- They result in a set of planning rules that allows one to develop an algorithm to distribute observations along the Jupiter tour (useful, since we are still working on Crema 3.0)
- Conflicts are managed mostly by time shift of observations within ‘acceptable’ limits (in time or in phase angle)

MAJIS_JUP_DISK_SCAN



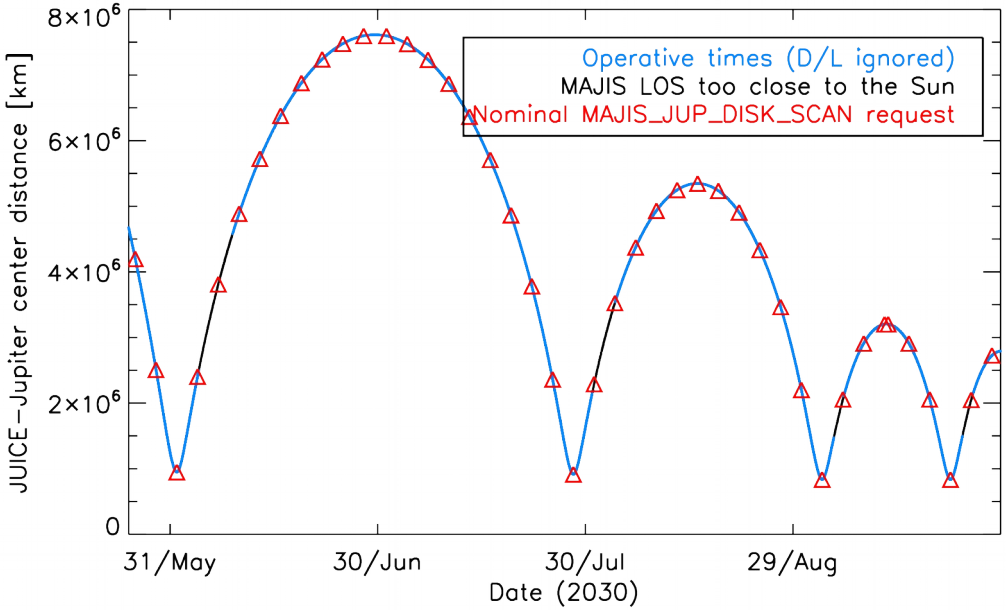
MAJIS_JUP_DISK_SCAN

- Are by far the most common and most data-volume-demanding observing type

Proposed planning criteria:

- Uniformly distributed in time. We must cope with multiples of Earth days to avoid continuous conflicts with downlink.
- Each set of scans aims to cover the entire equatorial region (-30°:+30°)

  The polar regions will be observed preferentially during the 'high-latitude' phase 4
- Level-0 planning was performed considering a `MAJIS_JUP_DISK_SCAN` every three Earth days. More frequent activity would produce too much data.



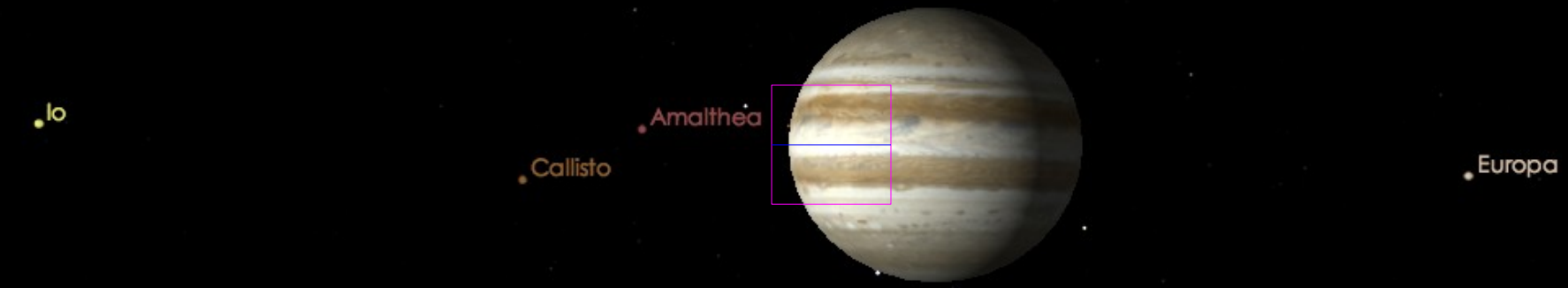
Ideal scan distribution

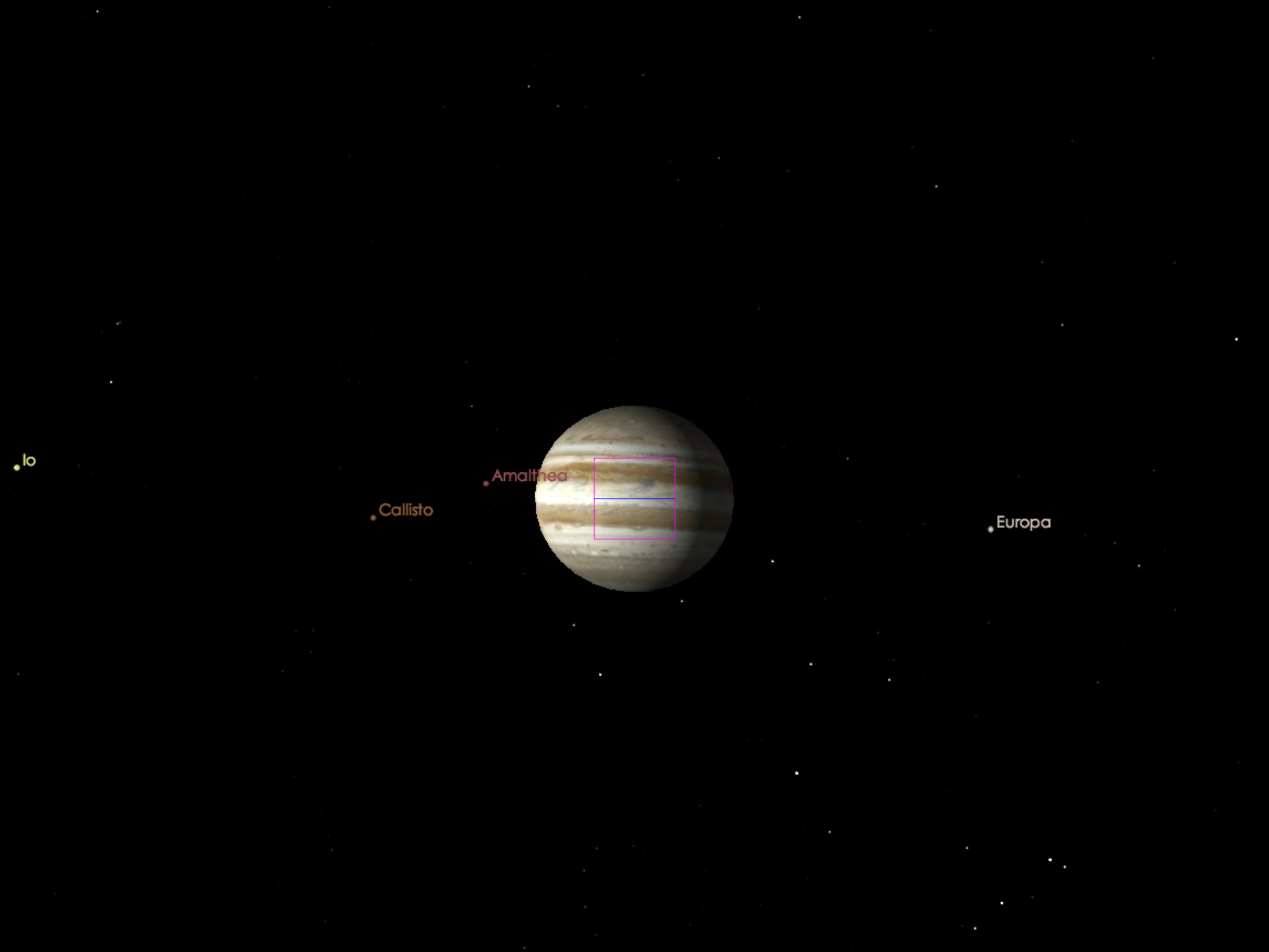
Caveats:

- Downlink sessions
- Moon flybys
- High phase angle (but not eclipse)
- MAG “rolls”

  Algorithm already tackles the first three types of issues. Criteria for MAG placements still to be clarified

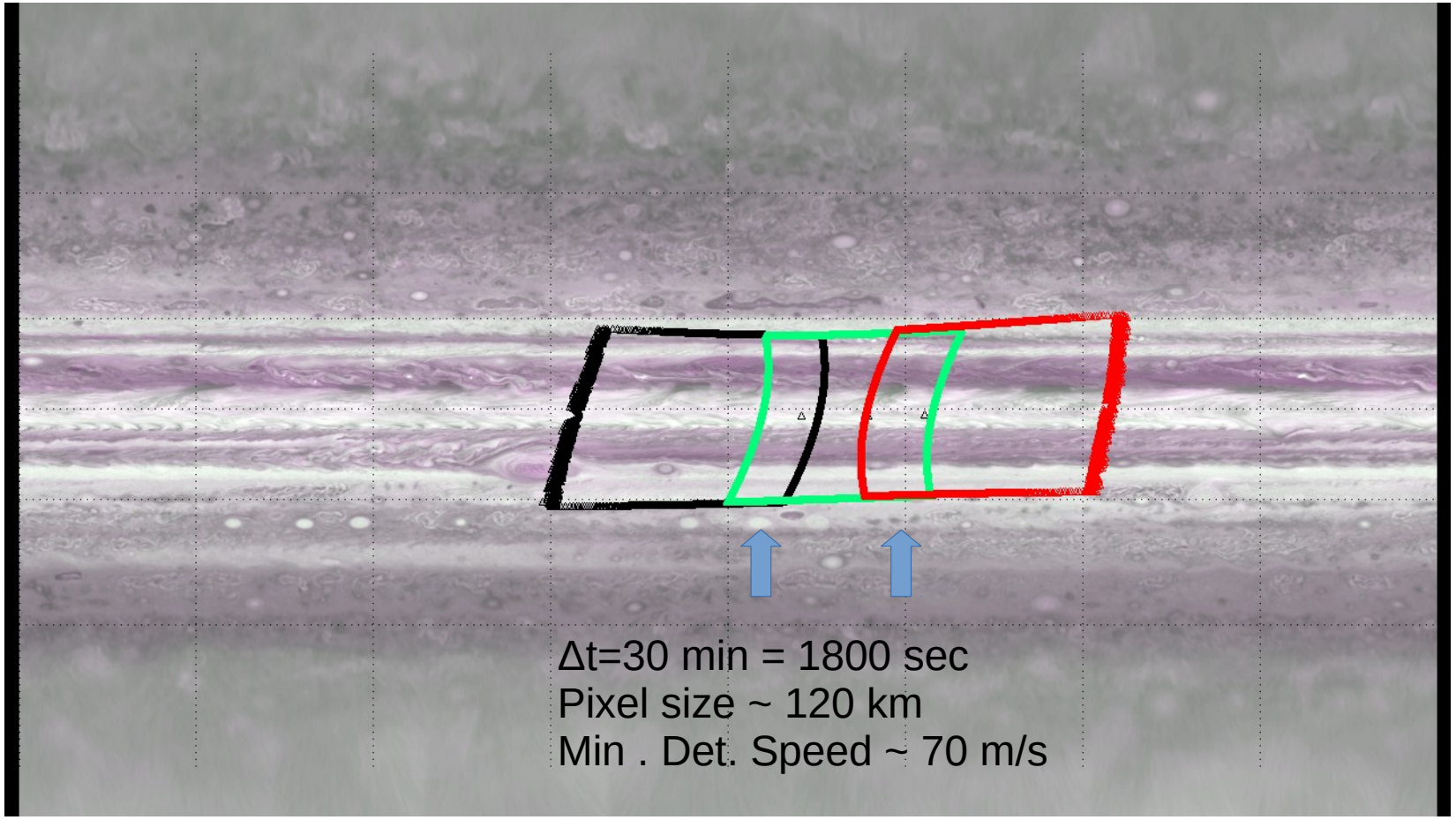
Example from PJ2
Not actually feasible due to MAG rolls




Io
Amalthea
Callisto
Europa


Io
Callisto
Amalthea
Europa

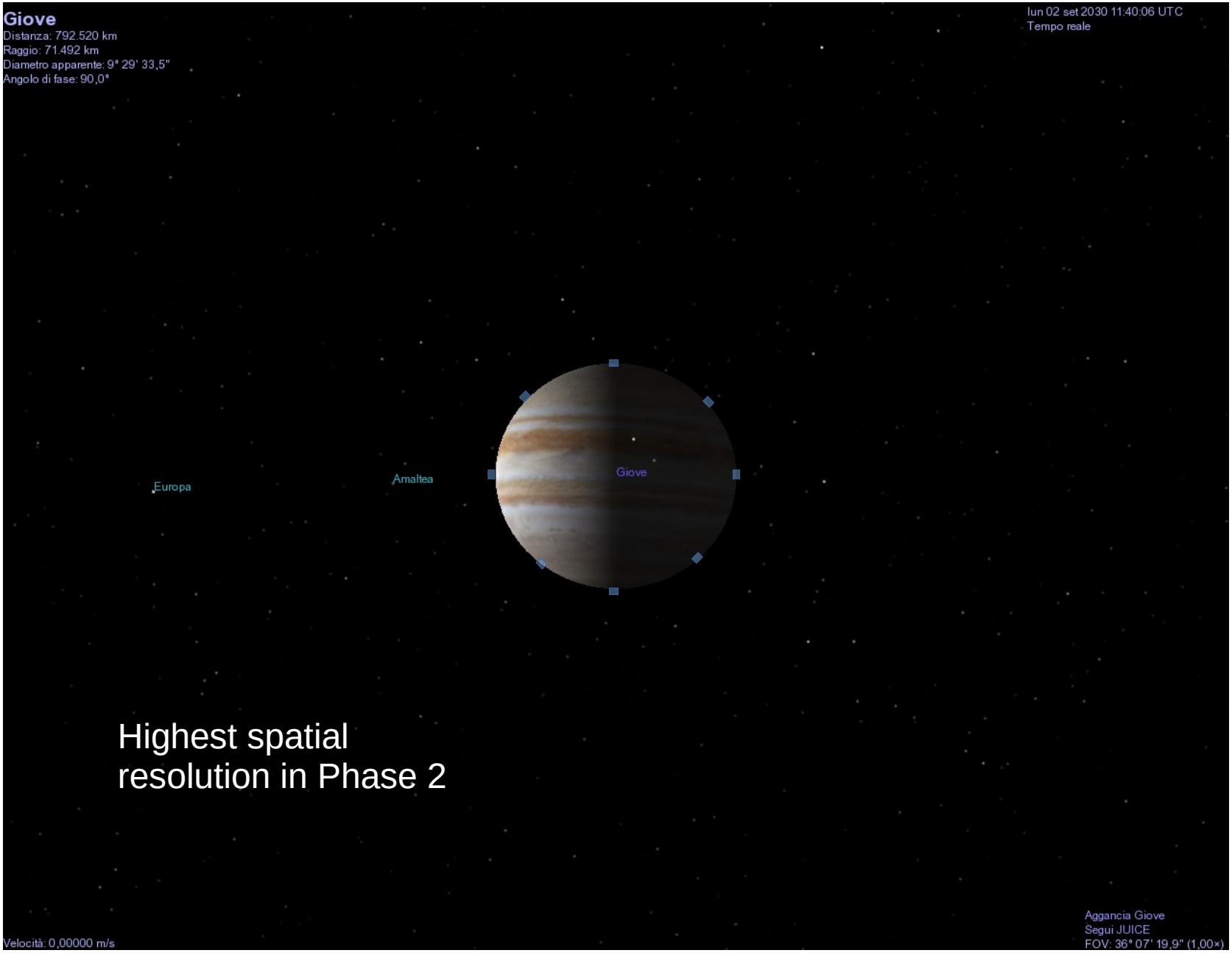
MAJIS nominal coverage



Moving the pointing estward between individual scans

Moving westward increase longitudinal coverage but decrease overlap

MAJIS_JUP_LIMB_SCAN



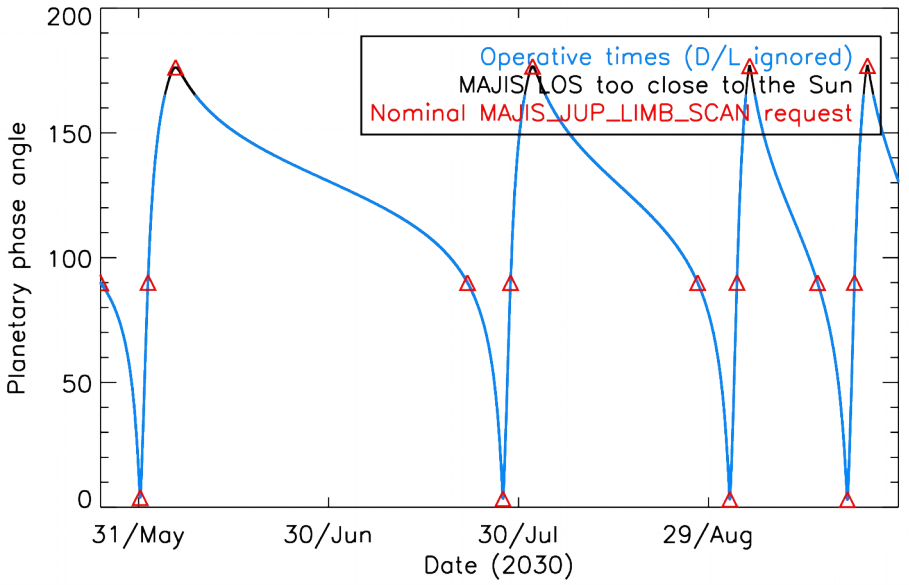
MAJIS_JUP_LIMB_SCAN

- MAJIS IFOV is not adequate for an accurate limb profile at JUICE-Jupiter distance. We can attempt a profile super-sampling and subsequent deconvolution. Noteworthy, this requires
  - Accurate characterization of pixel sensitivity in the spatial domain
  - Capability to re-point MAJIS own mirror with an accuracy better than 12 micro-rad ***do we have any update on this?***
- A spatial editing to transmit only the tangent (central) part of the slit is adequate in most cases
- Extremely demanding for the s/c: slit must be placed tangent to the limb and solar panel are far from most power-effective conditions. Proposed scheme of 8 sampling points requires at least 5 s/c repointings!

MAJIS_JUP_LIMB_SCAN

Proposed planning criteria:

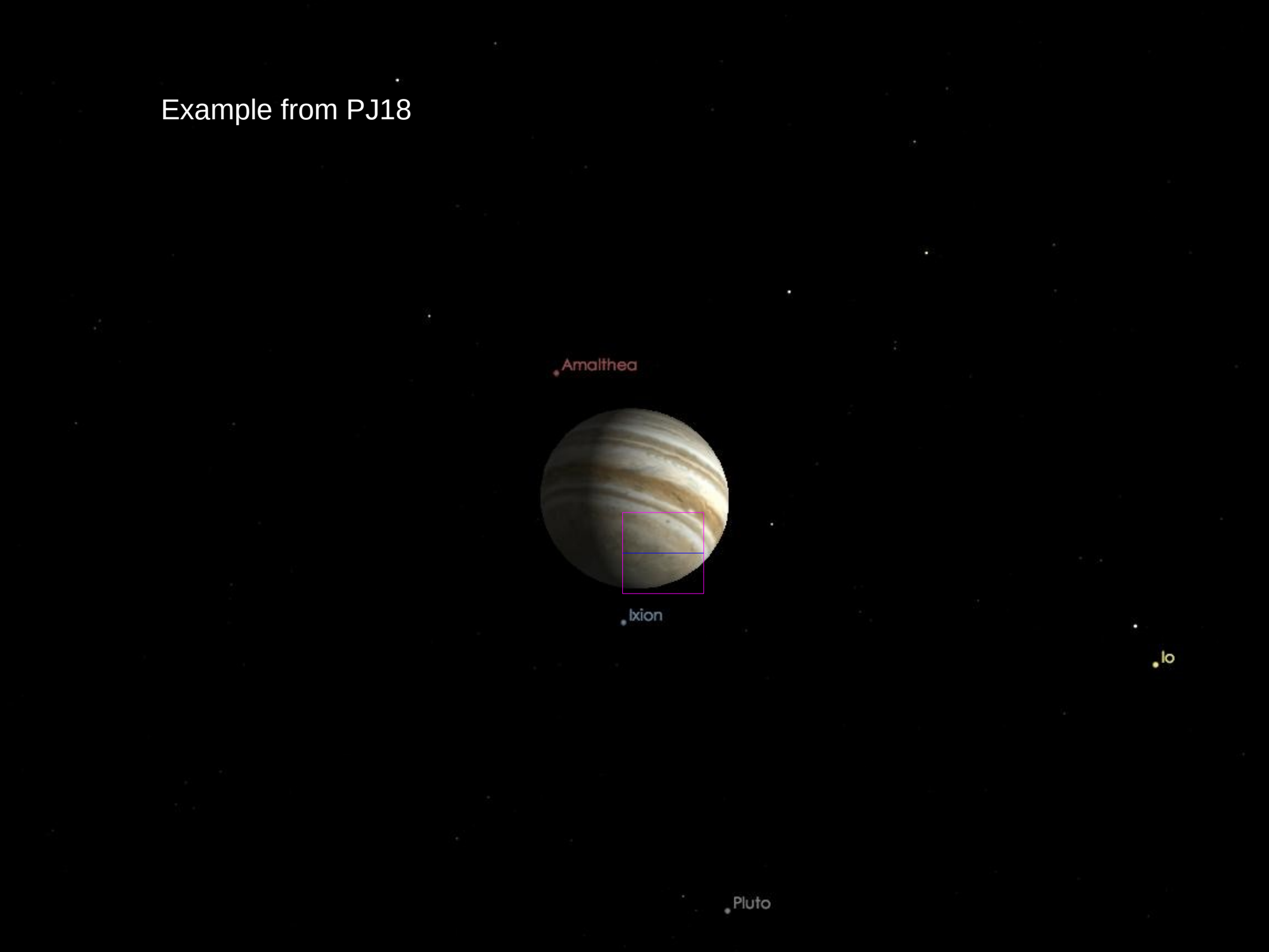
- Are required preferentially around 90°phase angle (for best views over sub-solar and anti-solar regions) and 0° (for best view of terminators and comparison)
- Are performed only at distances from Jupiter below the tentative limit of 2 10^6 km
- We plan observations up to 3000 km above the nominal 1 bar surface and with a supersampling x10
- Detailed analysis demonstrated that a substantial amount of `MAJIS_JUP_LIMB_SCAN` is conflict with downlink or moon fylbys because of their length (high exposure times, high number of lines)

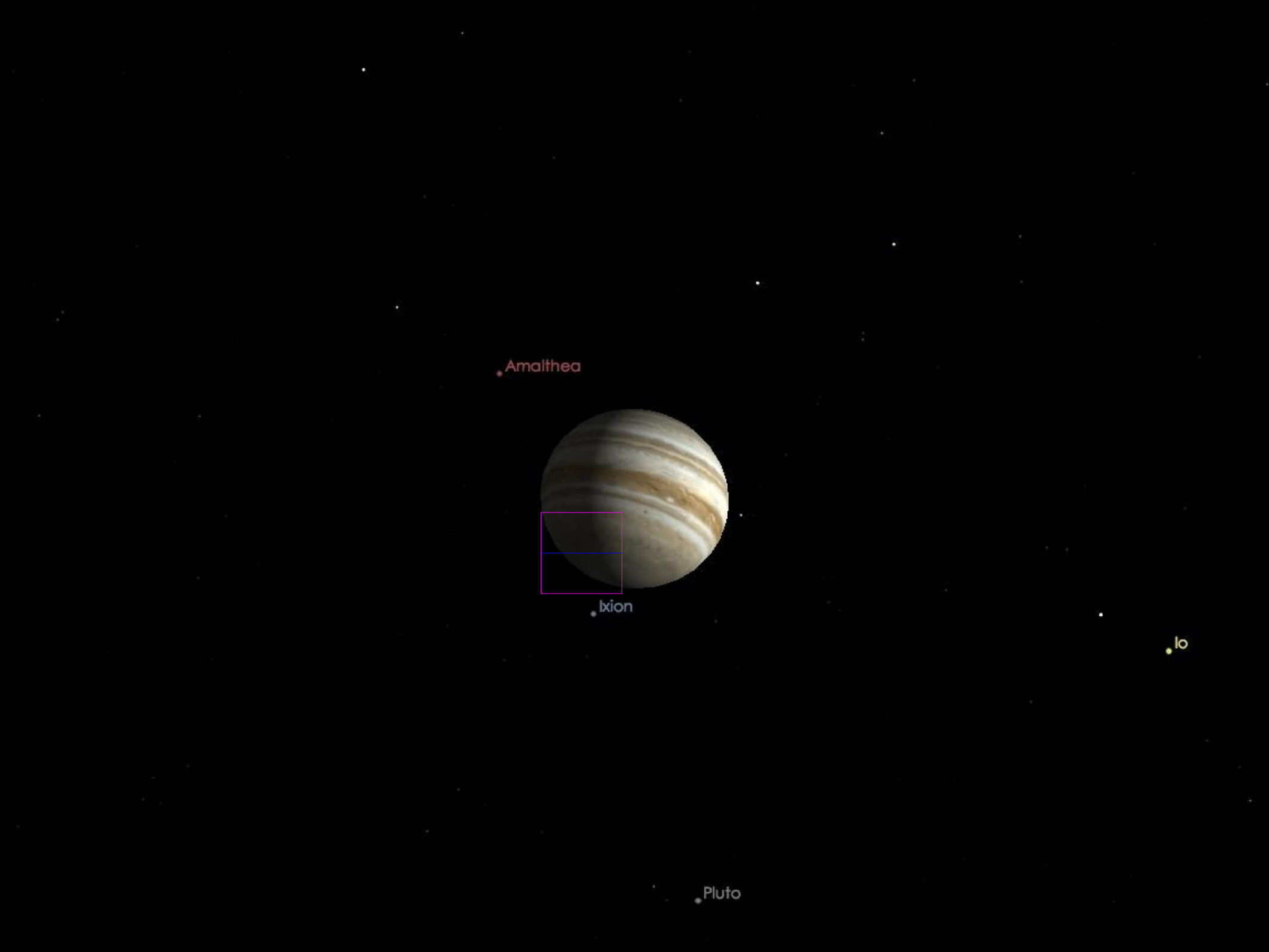


Phase – 4 ‘high latitude’

- “Place further MAJIS_JUP_DISK_SCAN sessions at every passage at minimum/maximum sub-spacecraft latitude when this value exceeds ±5 degrees”
- Visibility of polar regions remains however rather critical, longer session to exploit planet rotations wold be extremely beneficial

Example from PJ18

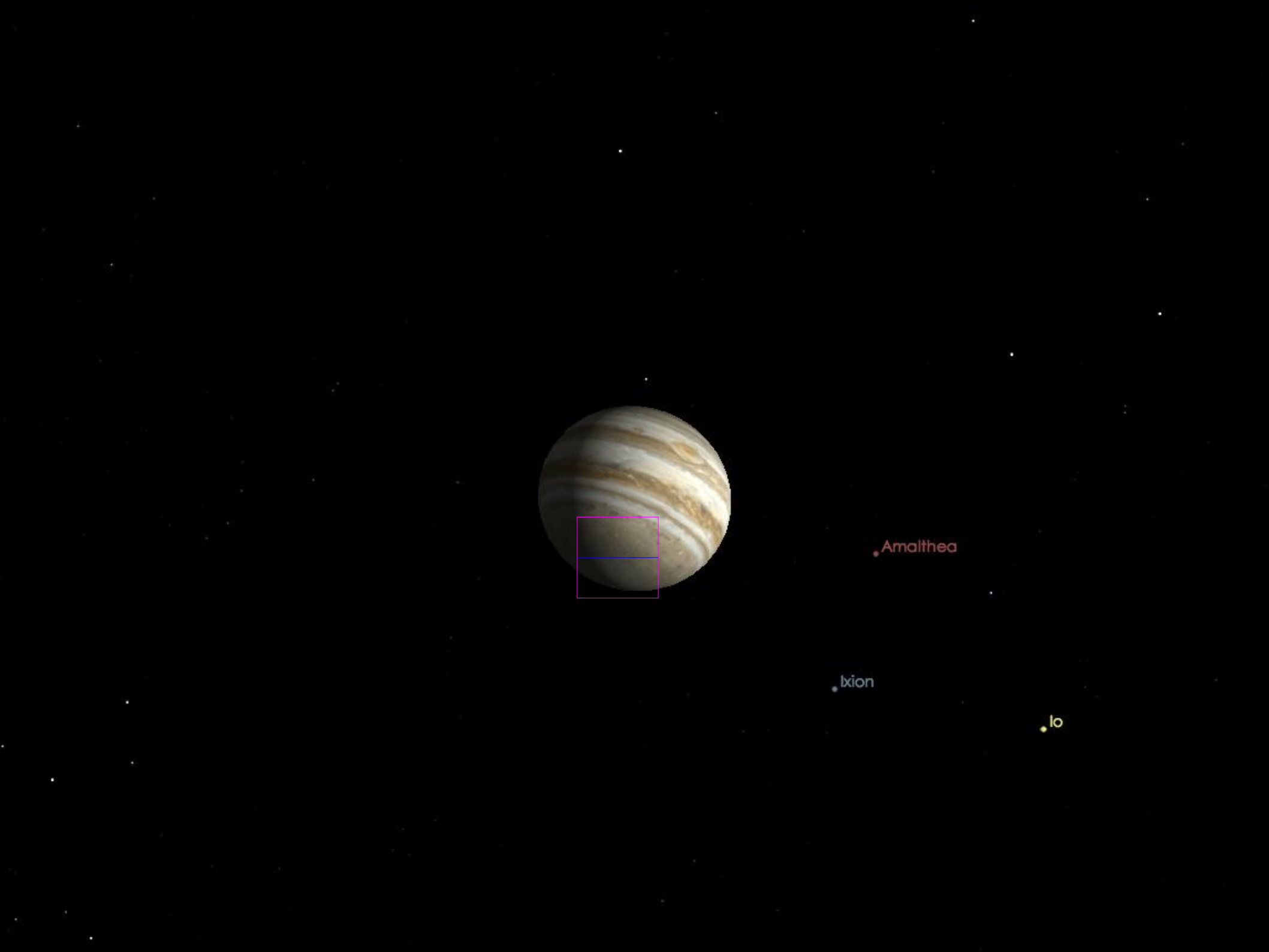


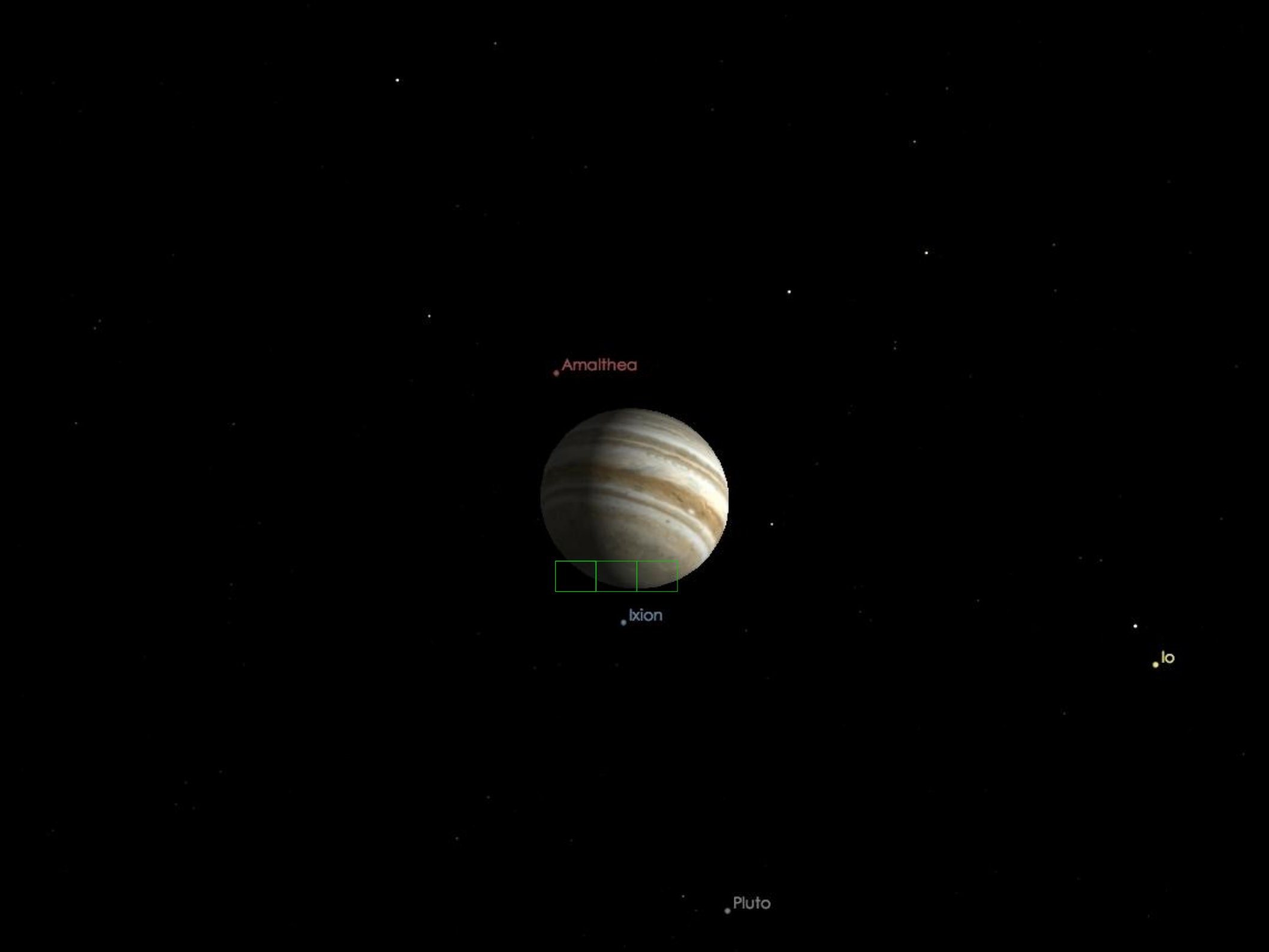

Amalthea
Ixion
Io
Pluto

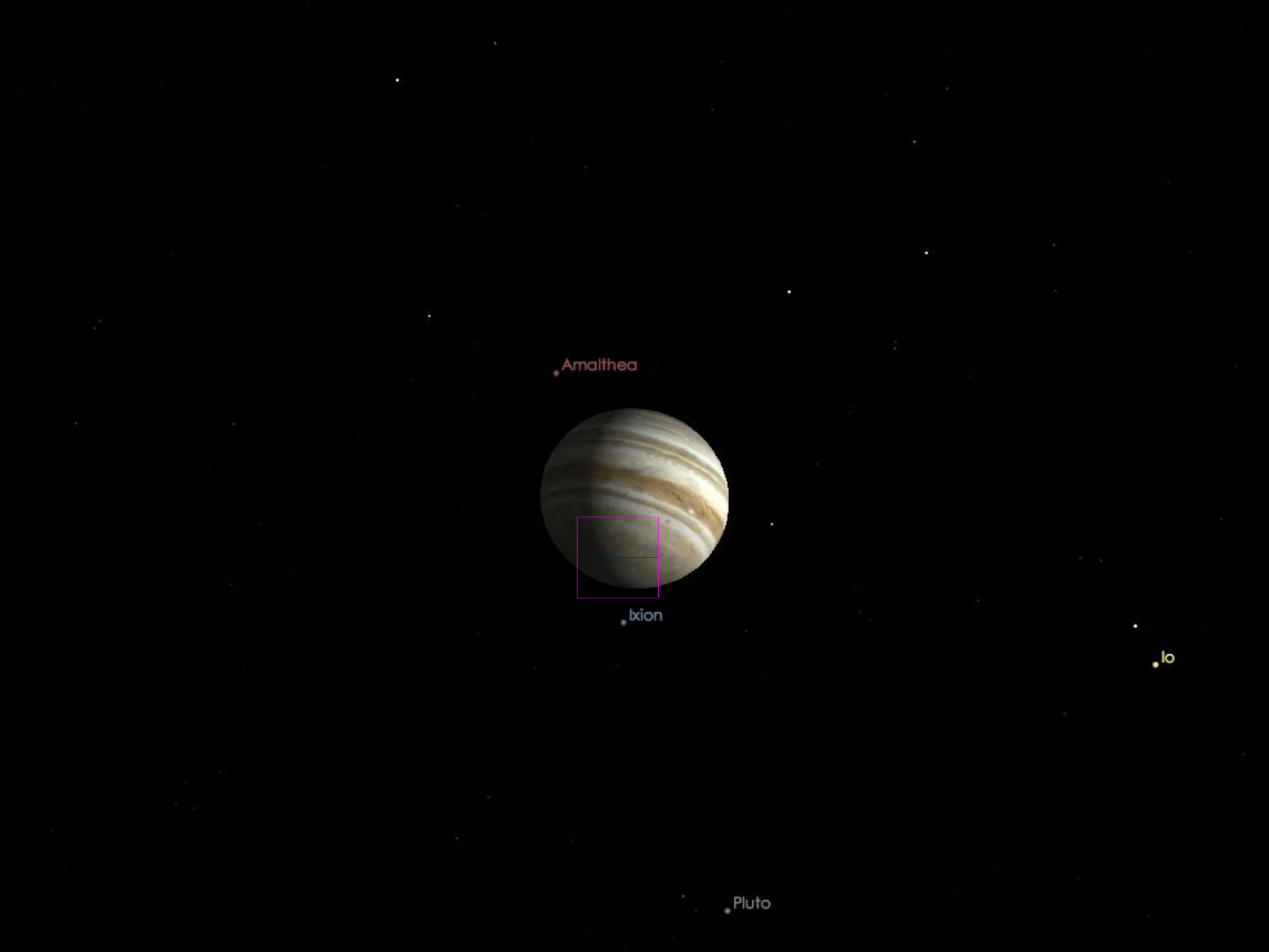
IR ‘patch’ includes the entire 9-cyclones pattern seen by JIRAM

Alternative approach


Amalthea
JANUS mosaic
Ixion
Io


Amalthea
Ixion
Io

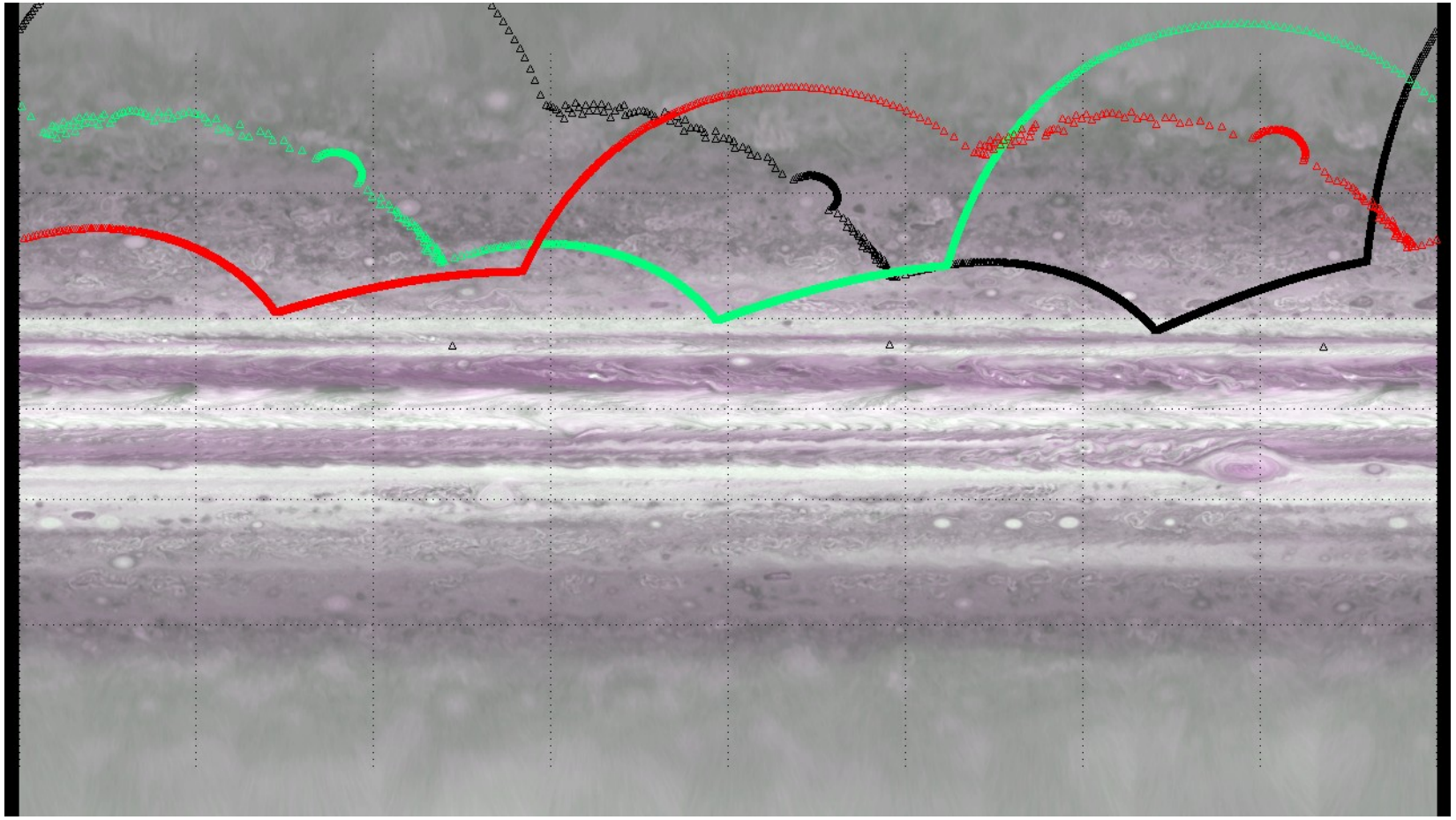

Amalthea
Ixion
Io
Pluto


Amalthea
Ixion
Io
Pluto


Pluto
Ixion
Amalthea
Io

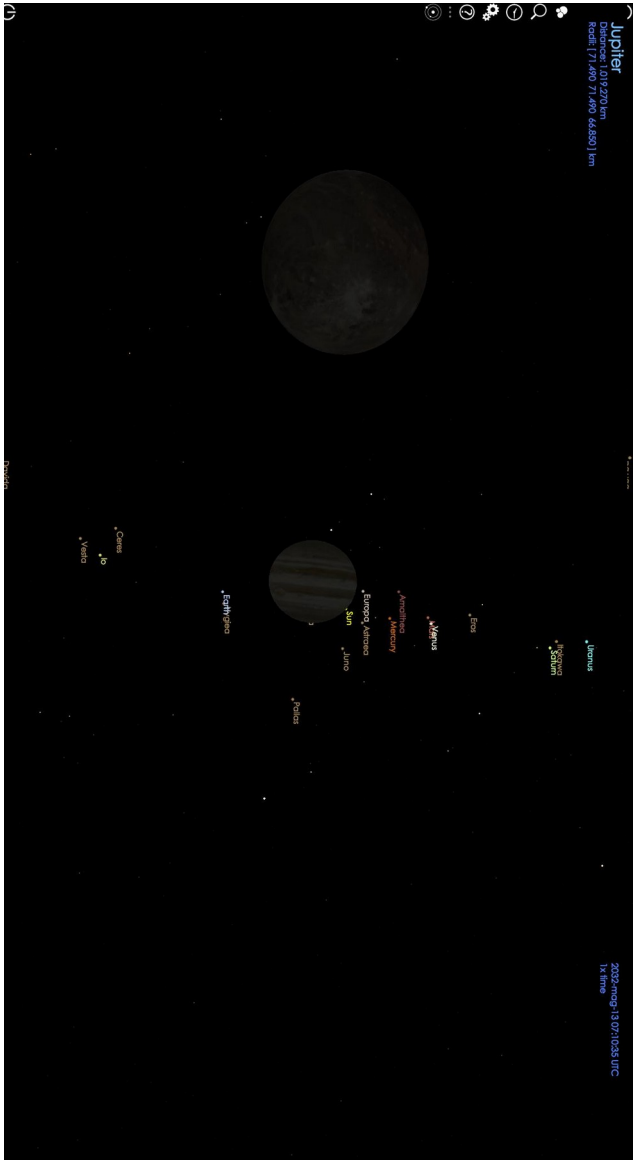

Pluto
Ixion
Amalthea
Io

MAJIS optimized coverage



Other opportunities

Eclipses

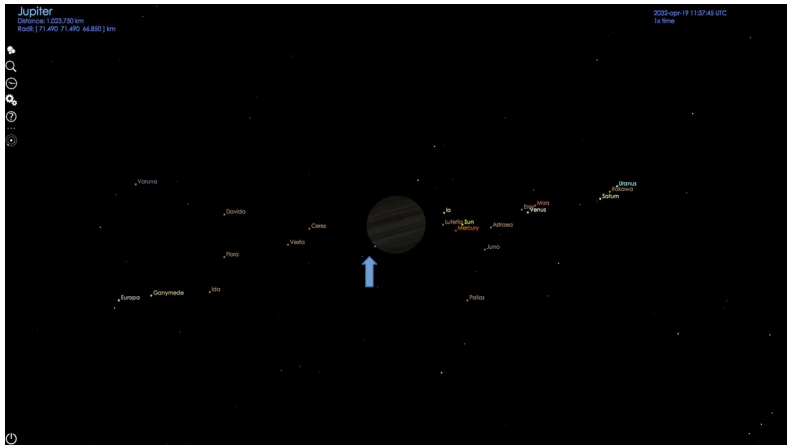


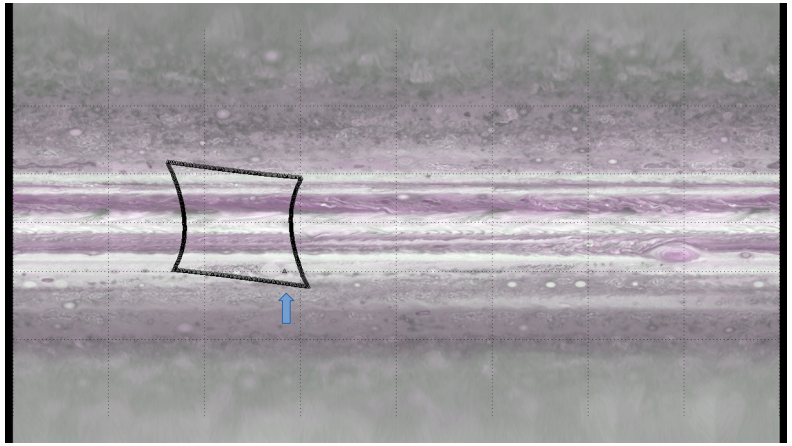
- Phase 5 hosts an eclipse season of 24 events lasting more than 100 min.
- Obvious operative difficulties
  - Power
  - Pointing of optical instruments away from the sun
- Great scientific value
  - Aerosol phase functions at very high scattering angles (on the limb)
  - Global mapping of airglows, aurorae, thunderstorms
  - Rings and satellite science as well

Example from PJ40


Davida
Ceres
Vesta
Earth
Hygiea
Sun
Mercury
Asteroid
Amalthea
Eros
Mars
Venus
Juno
Pallas
Io
Uranus
Rokawa
Saturn

3GM radio occultations



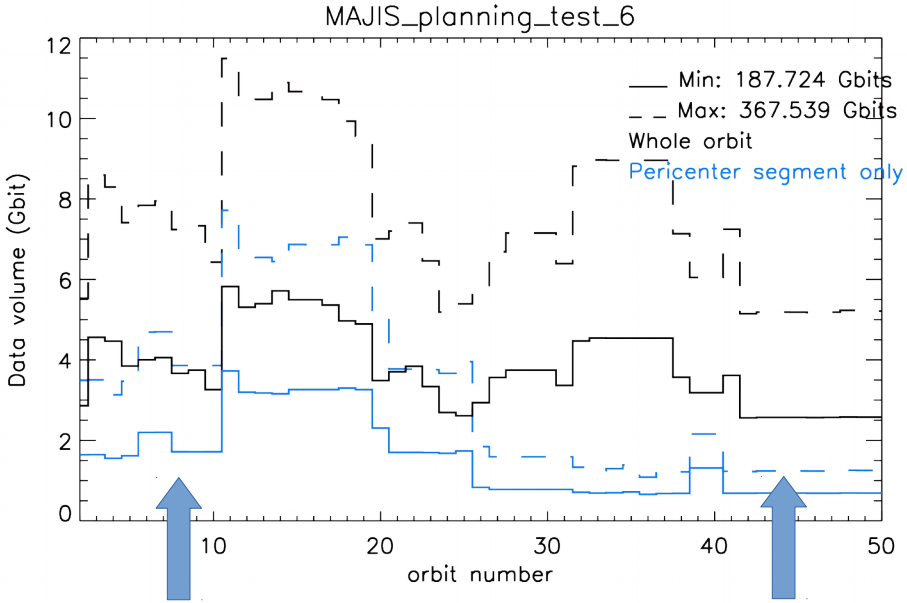


Orbit 39:
The ingress region can be observed by MAJIS after 3.1 h from the event (and 15 m from egress) at a resolution of 140 km/px

- In the CreMA 3.0 scenario, Jupiter tour phases host 26 radio occultation opportunities.
- Obviously, main difficulty in joint observation consists in vicinity of Sun to optical axis of MAJIS and Janus (min 15° for MAJIS).
- Given the relative speeds (planet rotation and s/c orbital motion), the two instruments can observe the same region either:
  - After the ingress or
  - Before the egress

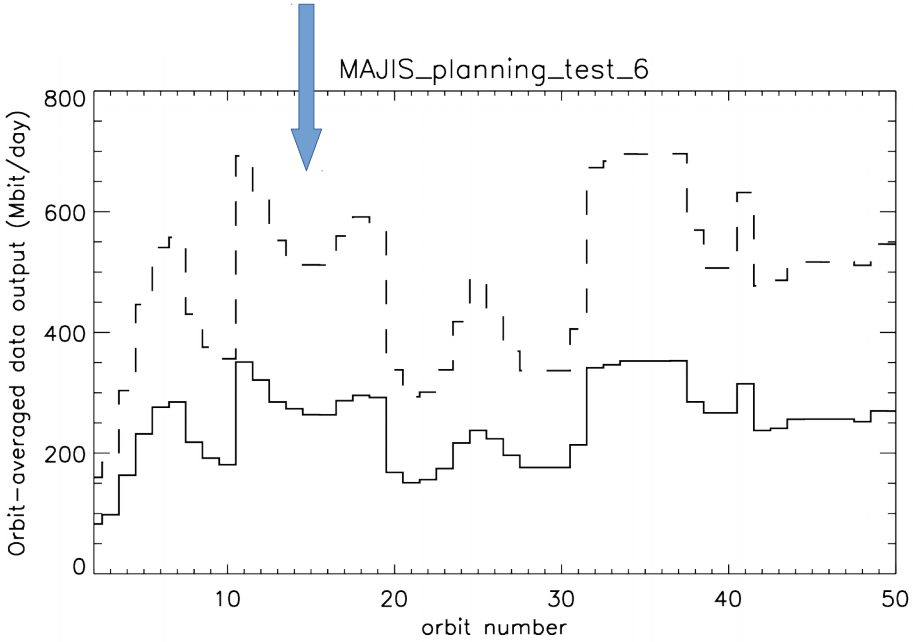
  however, always on the nightside
- In the CreMA 3.0 scenario there are 7 ingress events where sampled region can be observed within 4 hours (always after the corresponding ingress). The events cover uniformly the latitude range [-35;-25]

Data production profile



Data collection hampered by moons flyby

More data for high latitude observations



Orbit eccentricity becomes smaller and off-pericenters scans become more bulky

Instrument flexibility

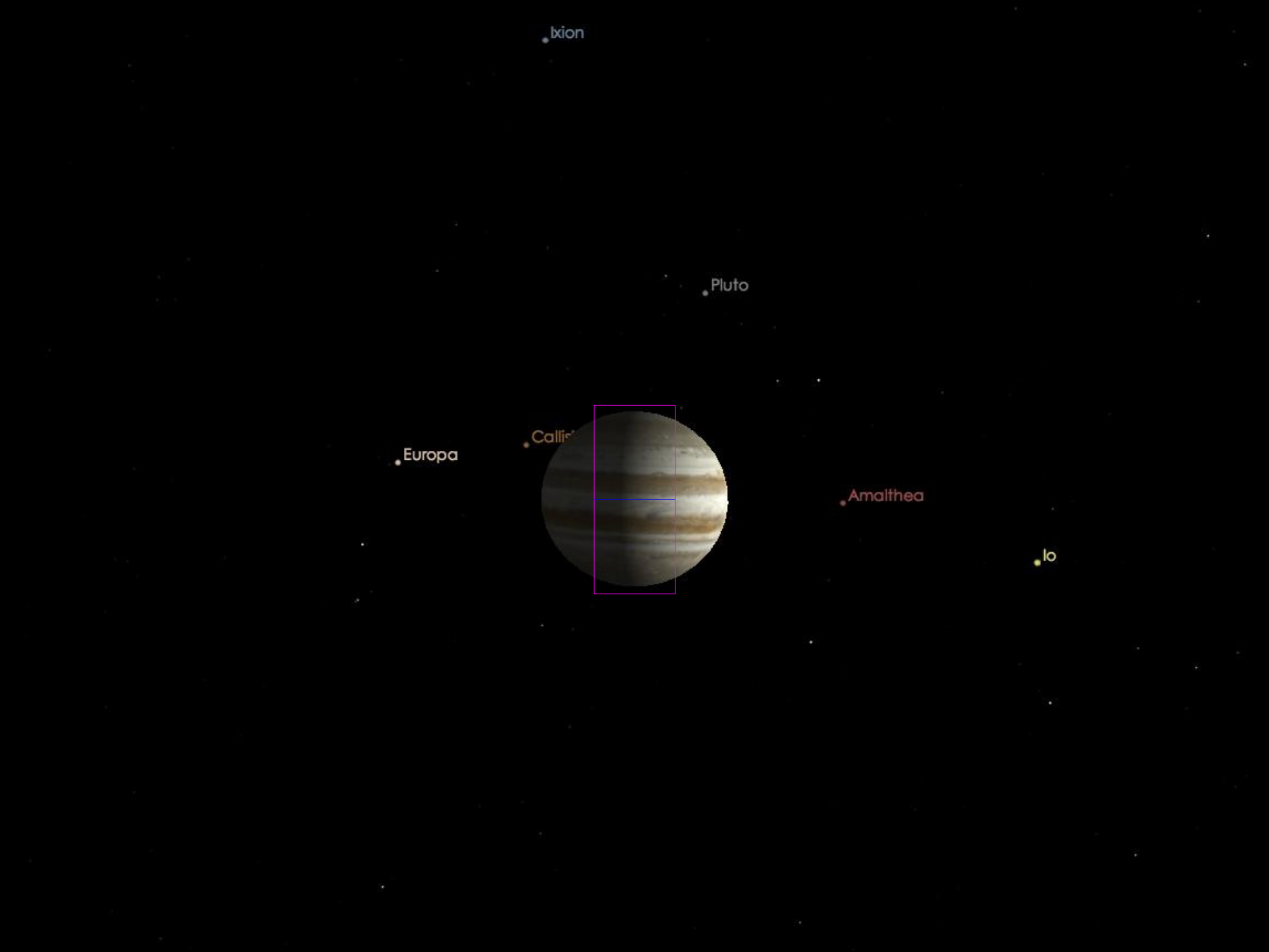
- Difference between minimum and maximum estimates arises from different assumption on spectral editing. Max. values refers to full spectra and best quality.
- Much more options are available to tune data volume *retaining the planning concepts*
  - increase the time sampling step from 3 to 4 (or 5) Earth days (this reduce the activation events)
  - reduce the maximum cubes number at pericenter from four to three
  - merge together set of disk scans at pericenter and maximum subspacecraft latitude occurring very close in time
  - remove most of the disk scans requests during eclipses
  - reduce the latitudinal coverage
- Several combinations of these can be envisaged to reduce the datavolume by 30, 50 and 70 Gbit, as required in the post-SWT exercise.

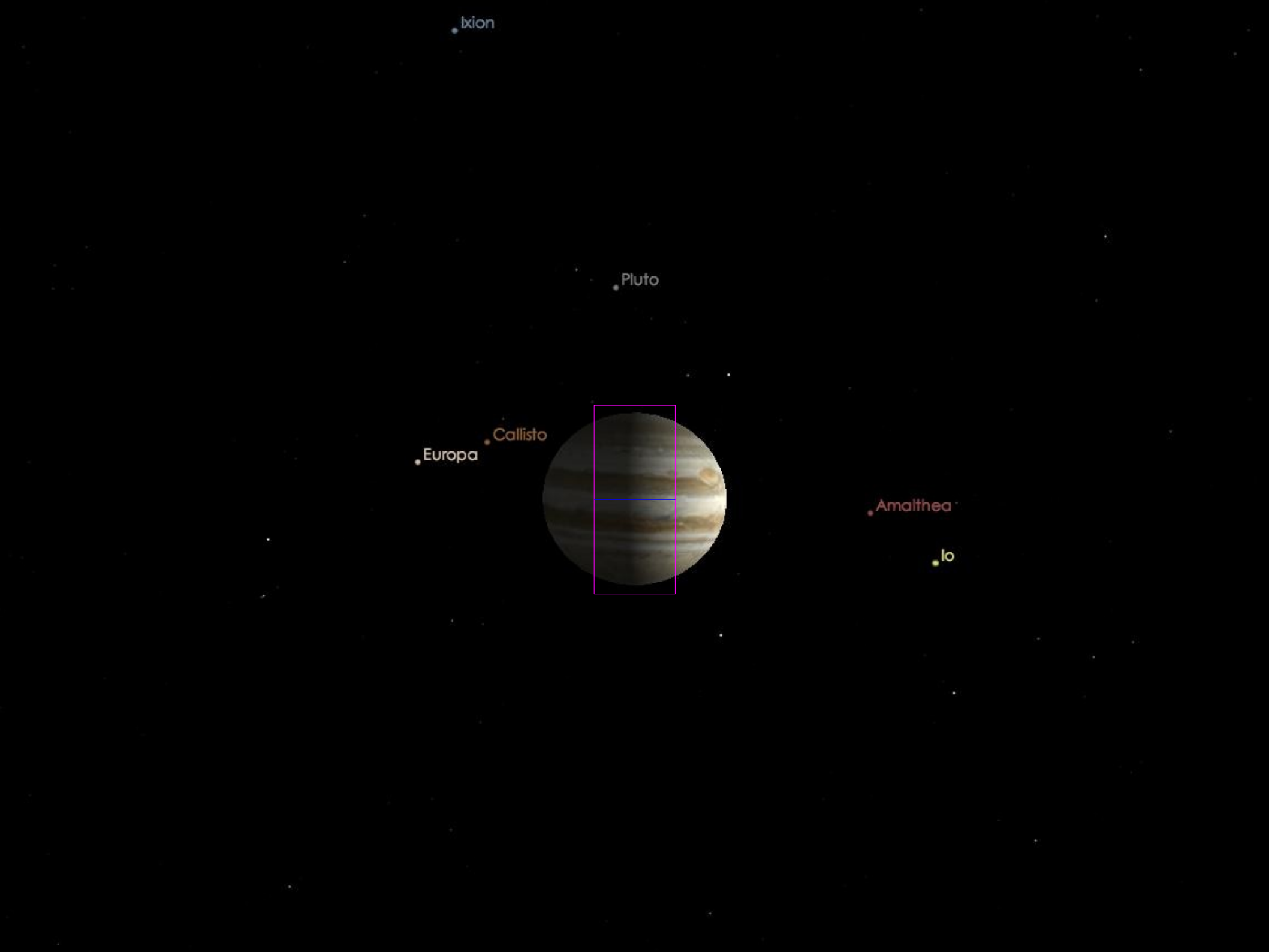
Auroral observations

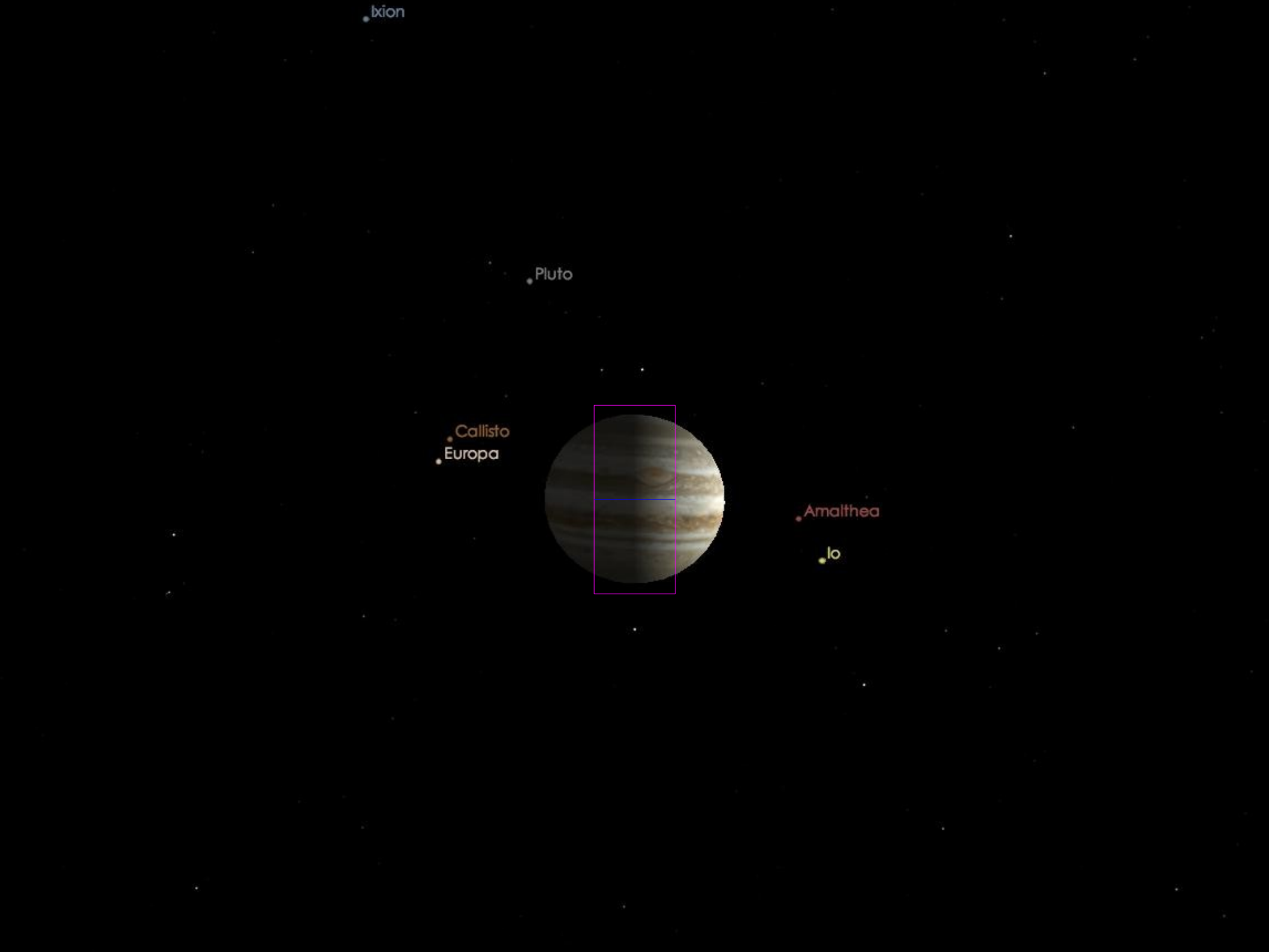
- With expertise from A. Mura we defined a special spectral mask for auroral observations (325 spectel out of 1016) including H_3^+, H, He, CH_4 non-LTE and polar haze continuum
- A ride-alone campaing would consist in four cubes per pericenter passage, *on the northern polar oval while in best visibility*, poleward of 50N, for about 0.25 Gbit per pericenter (upon previous figures)

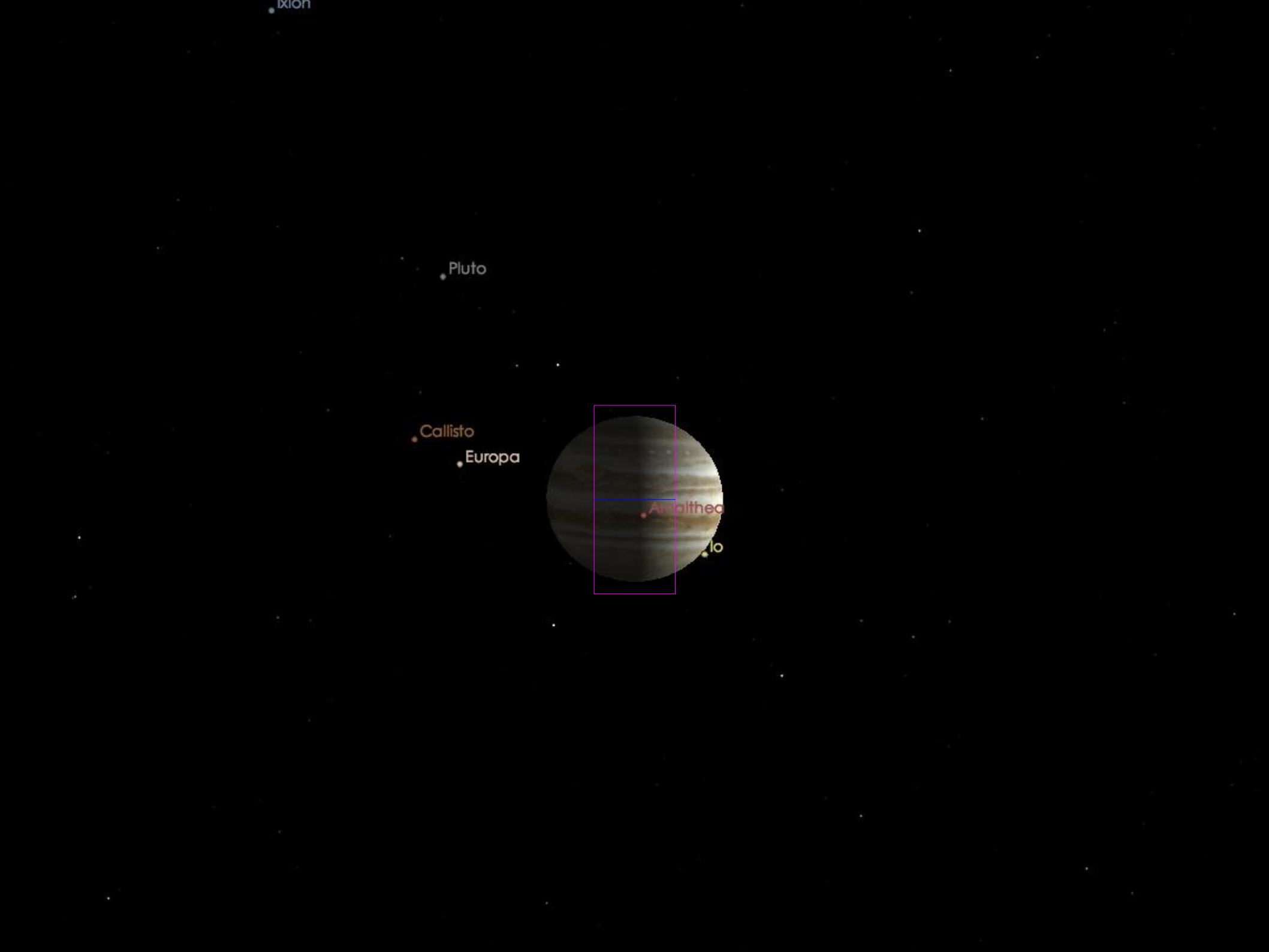
Observations in PJ2

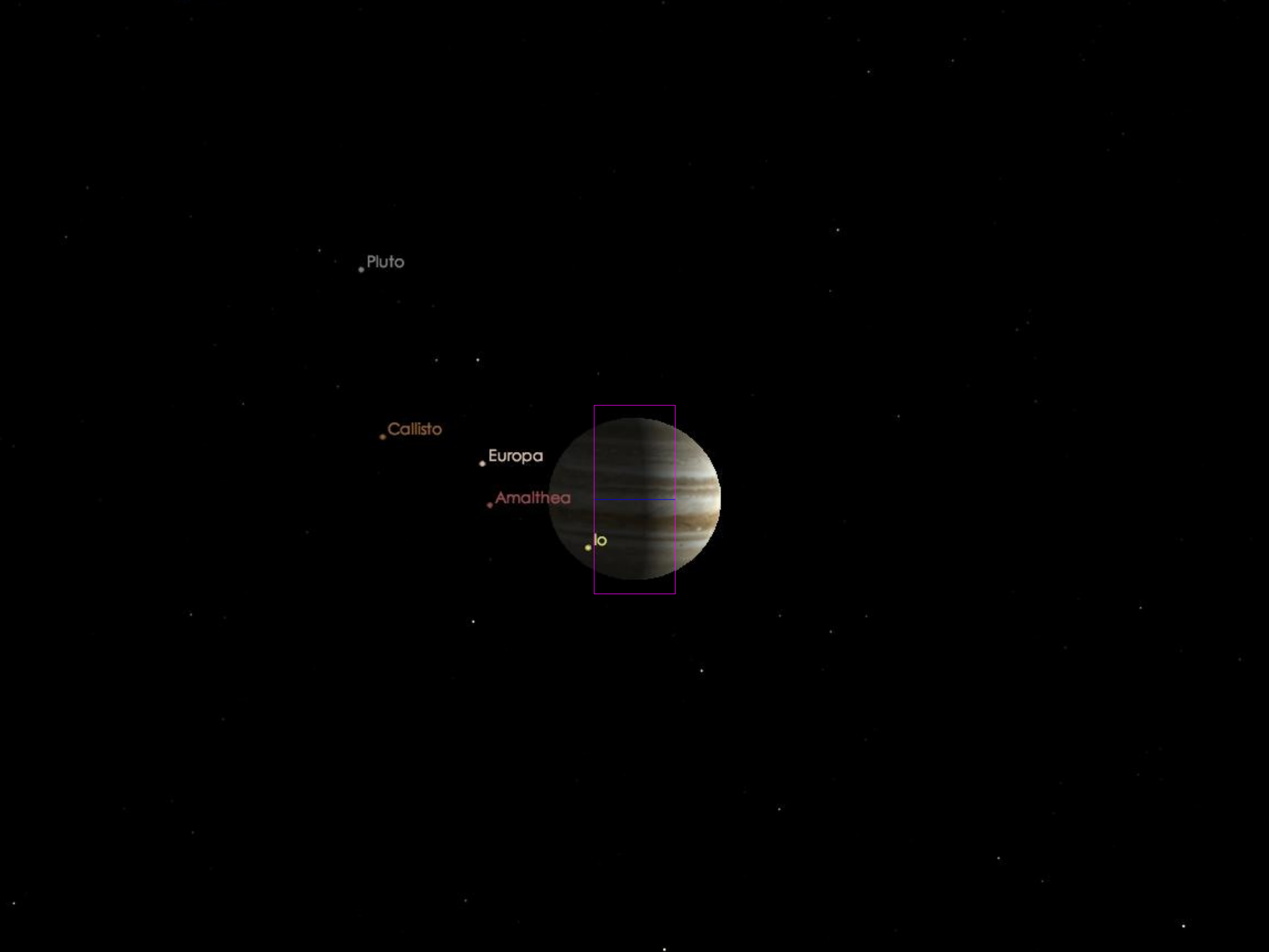
- In the case PJ2 actually offers high data possibilities, MAJIS would perform, for about 23 Gbit extra
  - Coverage of the atmosphere on daily basis for 10 days, at full spectral resolution
  - Full mosaic of the entire planet at full spectral resolution (old ‘full disk mosaic’)
- Full mosaic requires about ten hours of operations, and its timing depends critically on visibility of ground stations in the final trajectory.
- Full mosaic is actually not feasible due to MAG rolls

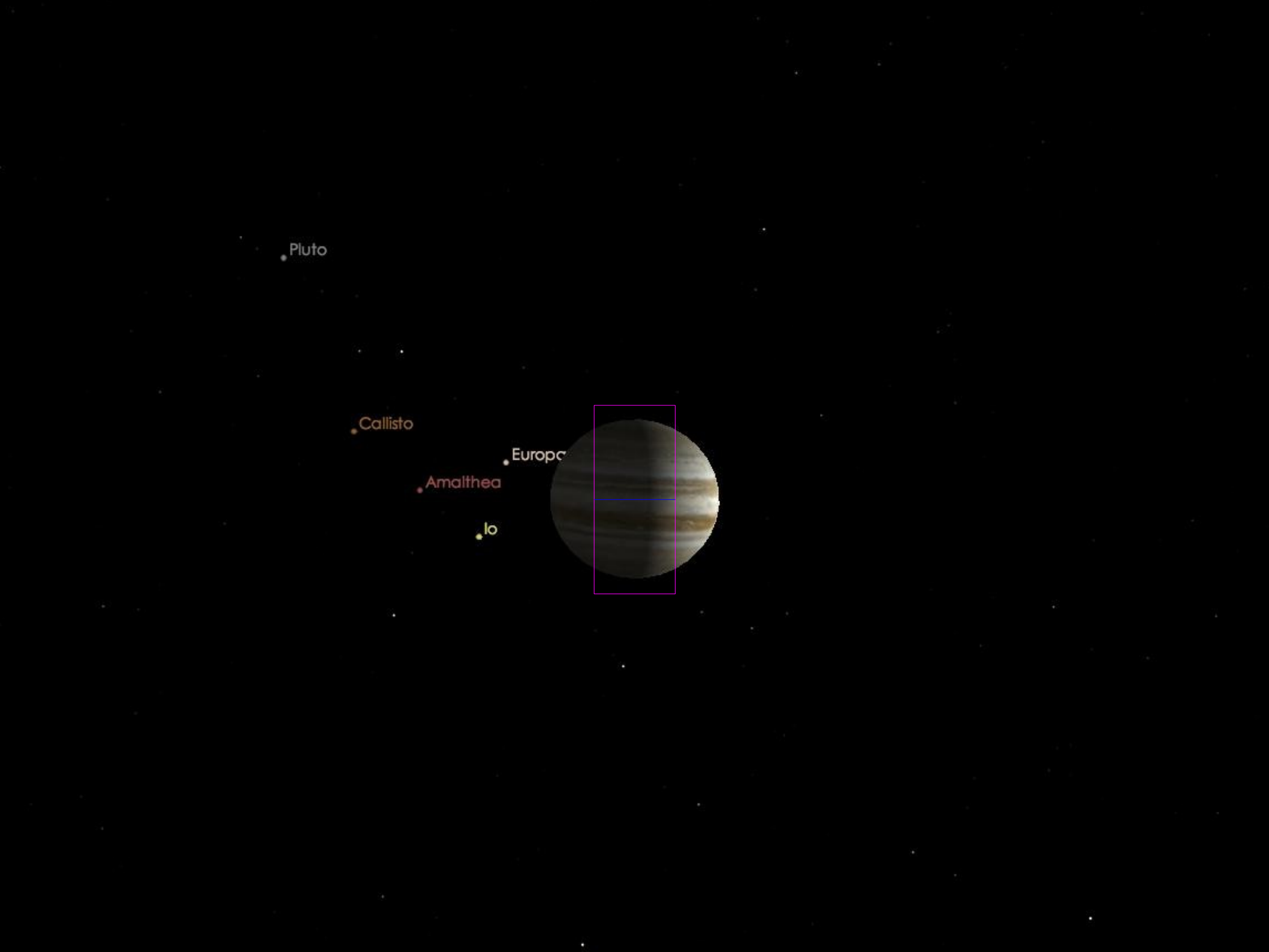

Ixion
Pluto
Europa
Amalthea
Io

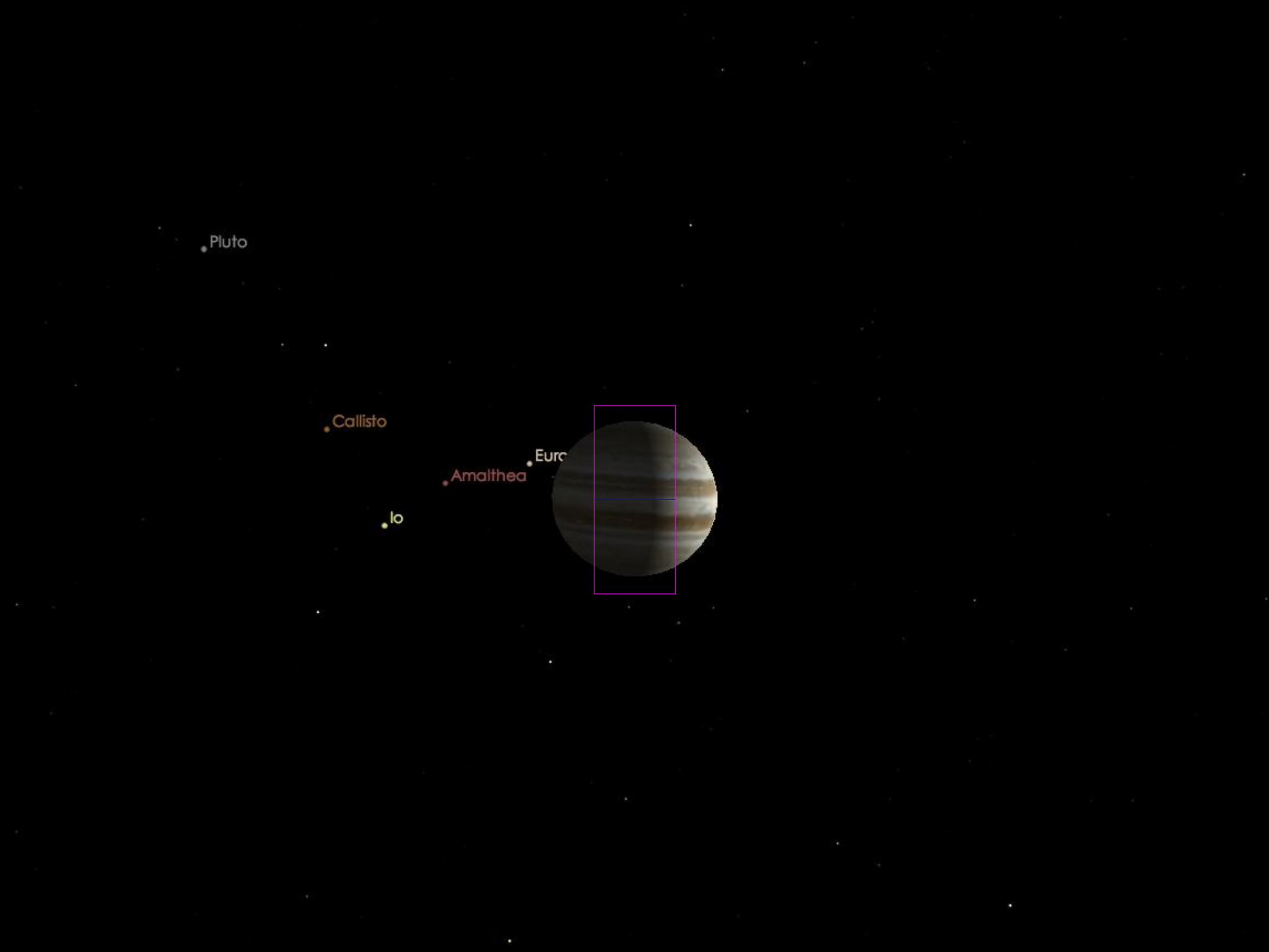

Ixion
Pluto
Callisto
Europa
Amalthea
Io


Ixion
Pluto
Callisto
Europa
Amalthea
Io

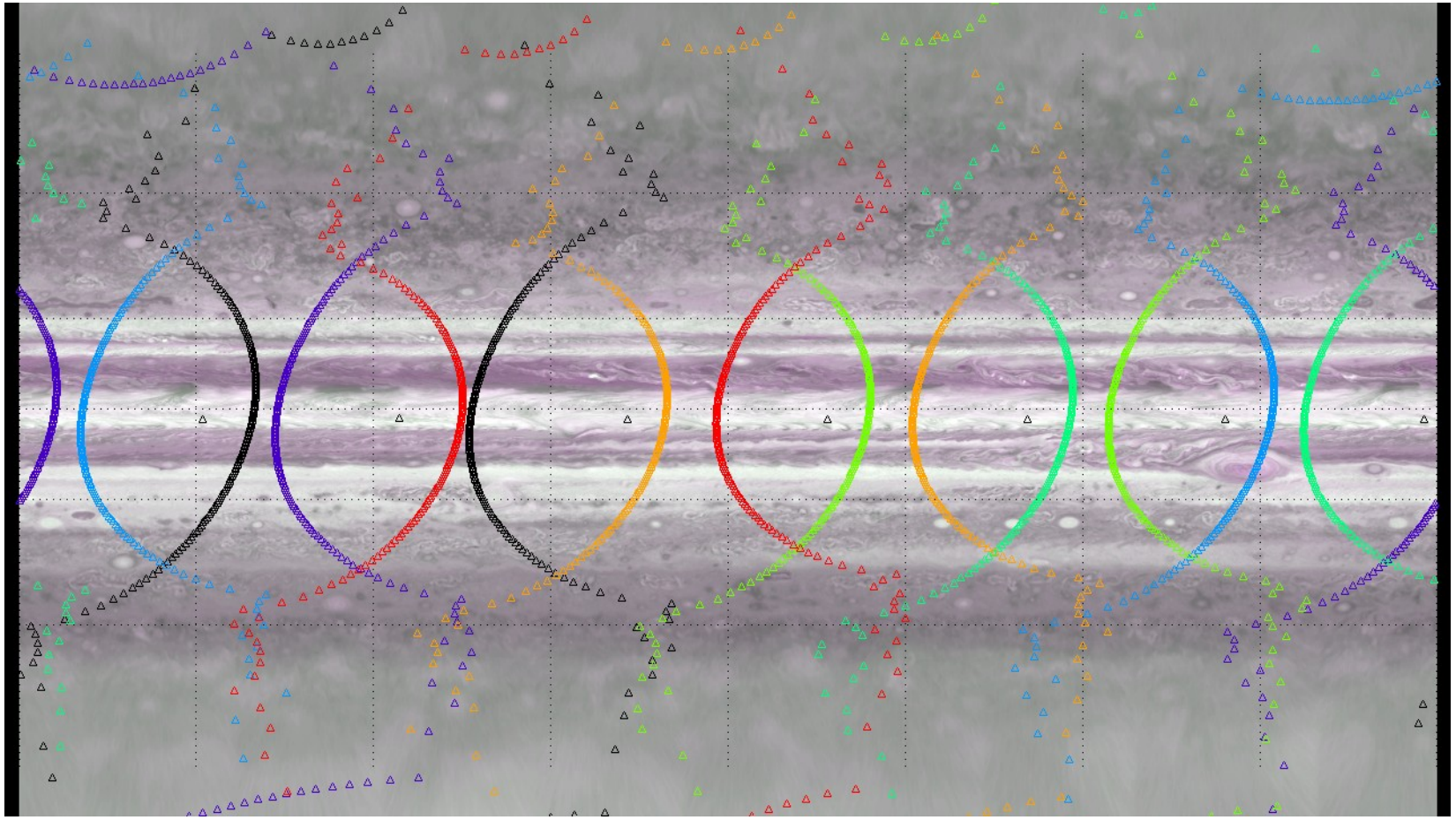

Ixion
Pluto
Callisto
Europa
Amalthea
Io


Pluto
Callisto
Europa
Amalthea
Io


Pluto
Callisto
Europa
Amalthea
Io


Pluto
Callisto
Amalthea
Io

PJ2 full mosaic



Observations in the Ganymede phases

- Tentative proposal
  - A single MAJIS_JUP_DISK_SCAN per month (0.5-1 Gbit per month)
  - 3GM Joint science (a single MAJIS_JUP_DISK_SCAN after ingress), 4 events distributed over all Ganymede phases (about 0.36 Gbit per event)

Conclusions

- Detailed analysis demonstrated the feasibility of MAJIS Jupiter observations with data volume figures compatibles to those actually expected
- Data share definition now in the hands of PI
- High flexibility of MAJIS reaffirmed once again

Please put forward other concepts, requests, ideas before the end of 2019! We need feedback from those interested in Jupiter atmosphere!

Open issues

- Assess the data downlink profile over the Jupiter tour phases (SSMM filling)
- We expect from ESOC/industry/project confirmation on the possibility
  - To operate while in eclipse
  - To operate in non-optimal power conditions during limb scans
- We expect from ESOC/industry/project assessment on settling time after repointing
- Synergic planning with other instruments (some concepts already under scrutiny with Janus and 3GM, by ASI solicitation)
- Synergic planning with UVS on auroral observations
- Detailed planning of stellar occultations (data volume negligible)

Spectral mask definition

- Current DV minimal estimates assume a reduction factor of 0.5 by spectral editing
- In my view (DG), DV is far from being consolidated, but exercise is required to define realistically the spectral editing that allows us to get this 0.5 value.
- Guideline for daytime spectra
  - Ensure 4. -5.6 µm range is always transmitted at full spectral resolution
  - Degrade resolution toward visible beyond 3 µm
  - Transmit only one side of methane bands in the NIR-VIS range

Quantitative assessment on the basis of information content is required, volunteers needed