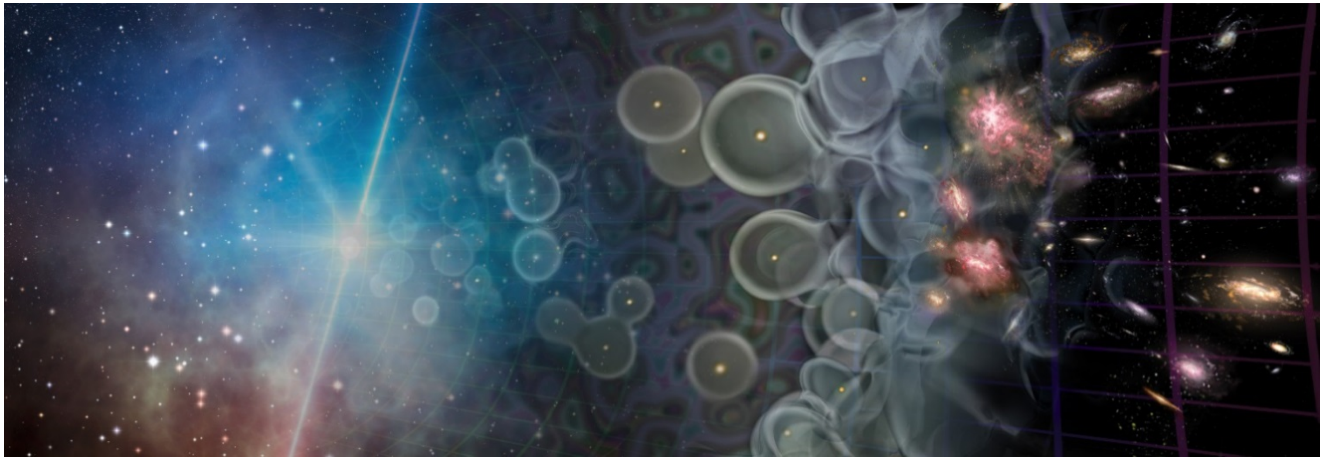


Observing strategy of the THESEUS Mission

Filippo Frontera,

UNIFE and INAF-IASF Bologna

On behalf of the

THESEUS Collaboration

Main observing-strategy requirements

- Discover at low X-ray energies (0.3-5 keV) as many as possible new transient events, mainly GRBs.
- Localize the detected new transients with 0.5-1 arcmin accuracy;
- Identify the nature of the detected transients;
- Promptly follow-up the secure GRBs in the NIR band and determine their position with arcsec accuracy, and perform NIR spectroscopy or photometry;
- Promptly communicate GRB triggers to the ground to enable ground/space observatories to follow-up the new transients;
- Get the needed pointing stability for at least 1 ks to detect the longest transients, while the detected events are observed in the NIR band.

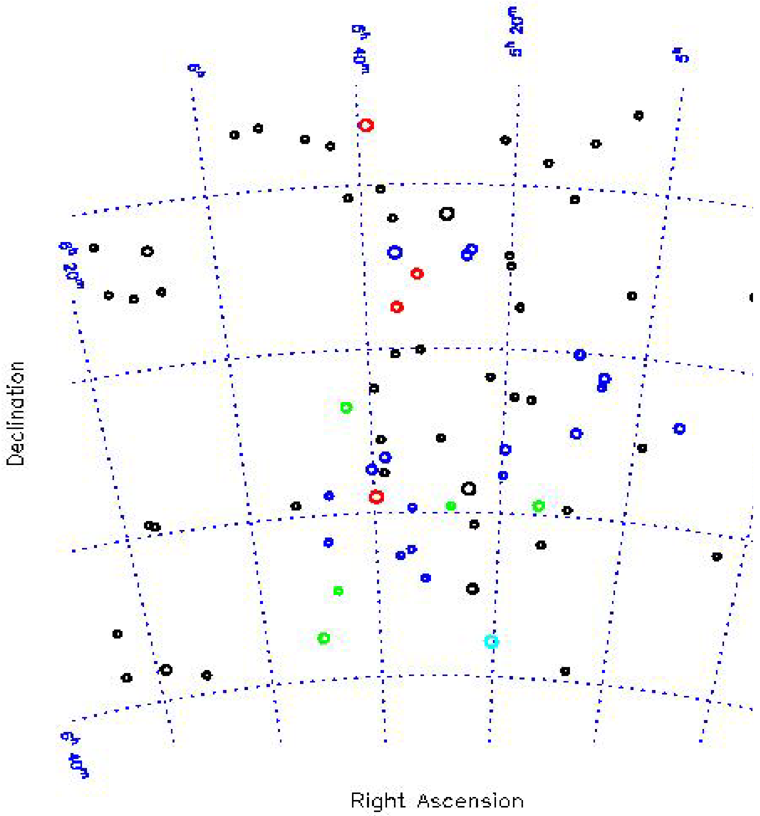
How to achieve these goals

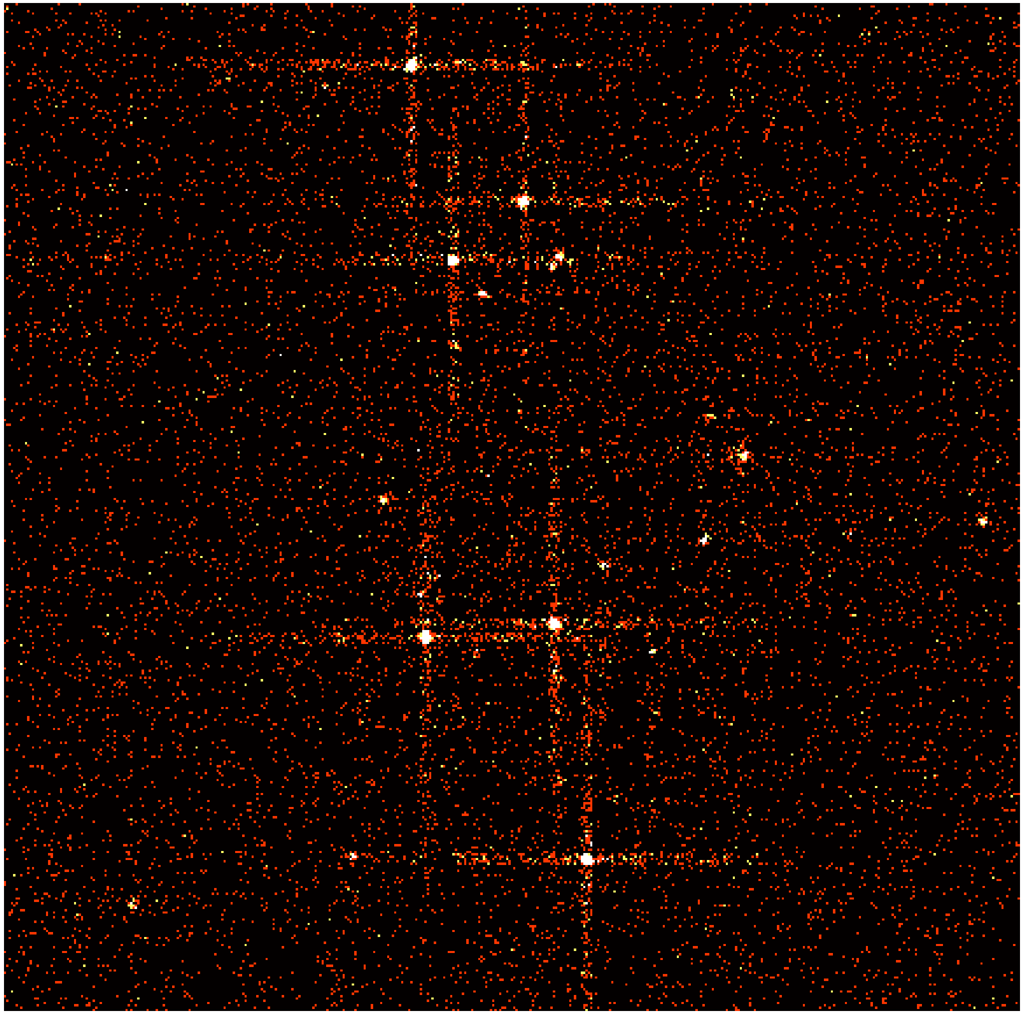
- A Soft X-ray imager (SXI) based on 4 Lobster-Eye telescopes with 0.3-6 keV energy band, 0.5-1 arcmin location accuracy, and FOV of about 1 sr.
- An X-/Gamma-Ray Imaging Spectrometer (XGIS), based on 3 coded-mask telescopes with 2 keV-20 MeV band, similar sensitivity of the SXI in the common energy band (2-6 keV), 5 arcmin positioning accuracy up 50 keV, XGIS FOV covering the SXI FOV.
- An Infrared Telescope (IRT) of 70 cm aperture, Cassegrain type, 0.7-1.8 μm band, 10’x10’ FOV, Sensitivity H=20.6 AB mag (300 s).
- IRT observation condition of the GRB located with SXI: when satellite stabilization within 1 arcsec.
- 5 min integration time for Low Resolution Spectra with IRT (sensitivity limit H=18.5 (AB))

How to localize new transients with SXI

- **Apply a reconstruction algorithm to the data** to get an event list with position in CCD pixels and pulse height for different integration times (2, 20, 200, 2000 s);
- Convert pixel positions into a local coordinate frame;
- Subtract background pattern from the histograms;
- Scan the histograms for significant peaks and extract candidate positions;
- Calculate an accurate position in the local frame;
- Transform the position into global sky coordinates;
- Check positions against on board-catalogues of known sources;
- Communicate unidentified transients to the OBDH.

SXI Location capability



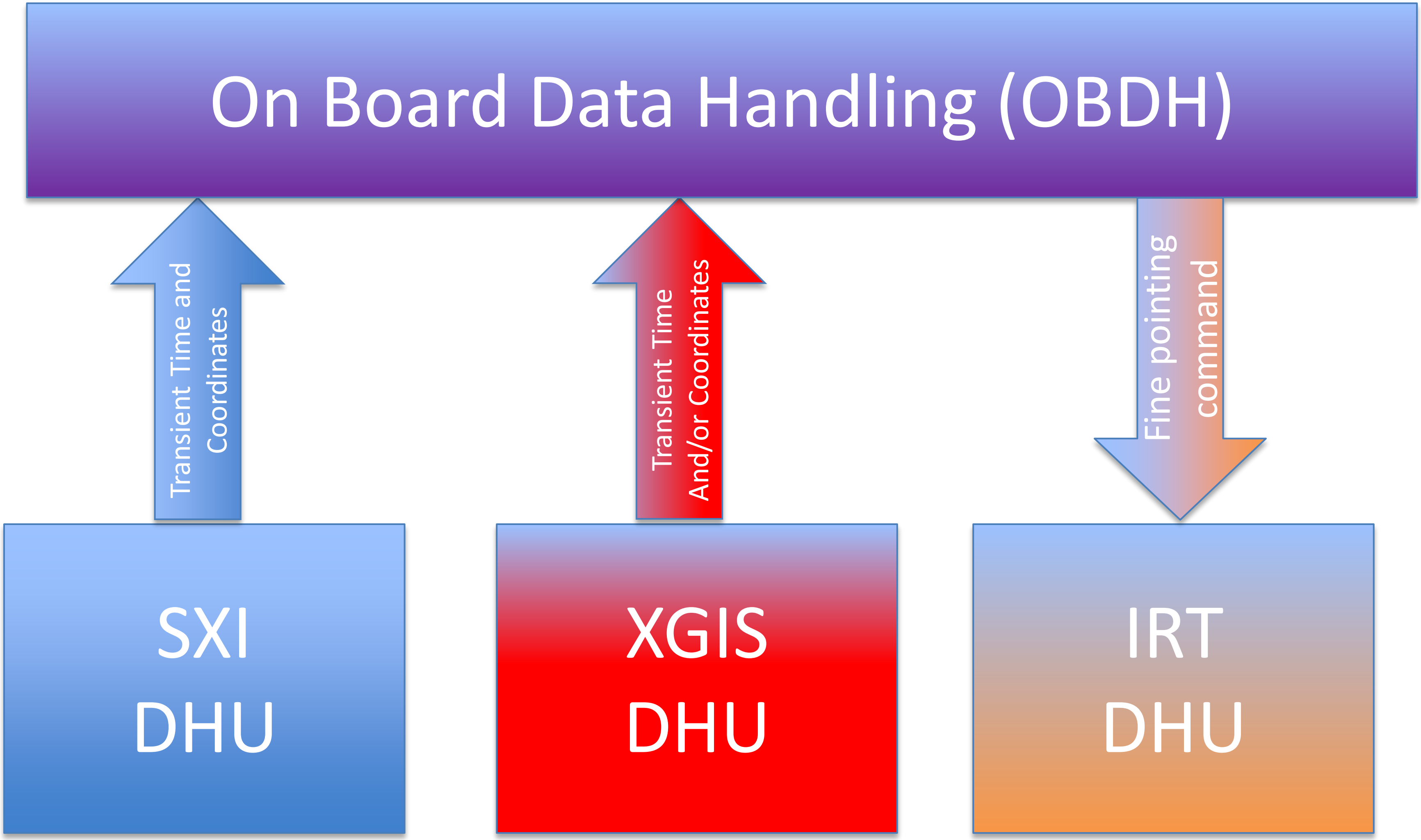


Simulation of LMC Region

How to identify the nature of events detected by SXI

- **XGIS Trigger based on images**
  - For each XGIS unit, the 2-30 keV images continuously compared with reference images (e.g., average of 30 previous images);
  - Trigger condition is satisfied if a spot in the images emerges at a significance level of $n\sigma$ (likely n=5).
- **XGIS Trigger based on data rate**
  - Continuous monitoring of the data rate in the 2-30 keV and 30-200 keV for each of the 4 modules that make each of the 3 XGIS units.
  - Trigger condition is satisfied when, in one or both energy ranges, at least 3 detection modules see a simultaneous excess at a significance level of 5σ on at least one of different time scales (e.g., 10 ms, 100 ms, 1 s, 10 s) .
- **Time of XGIS data excess and/or event direction to the OBDH.**

On Board Logic for Internal Triggers



How to promptly down-link trigger results

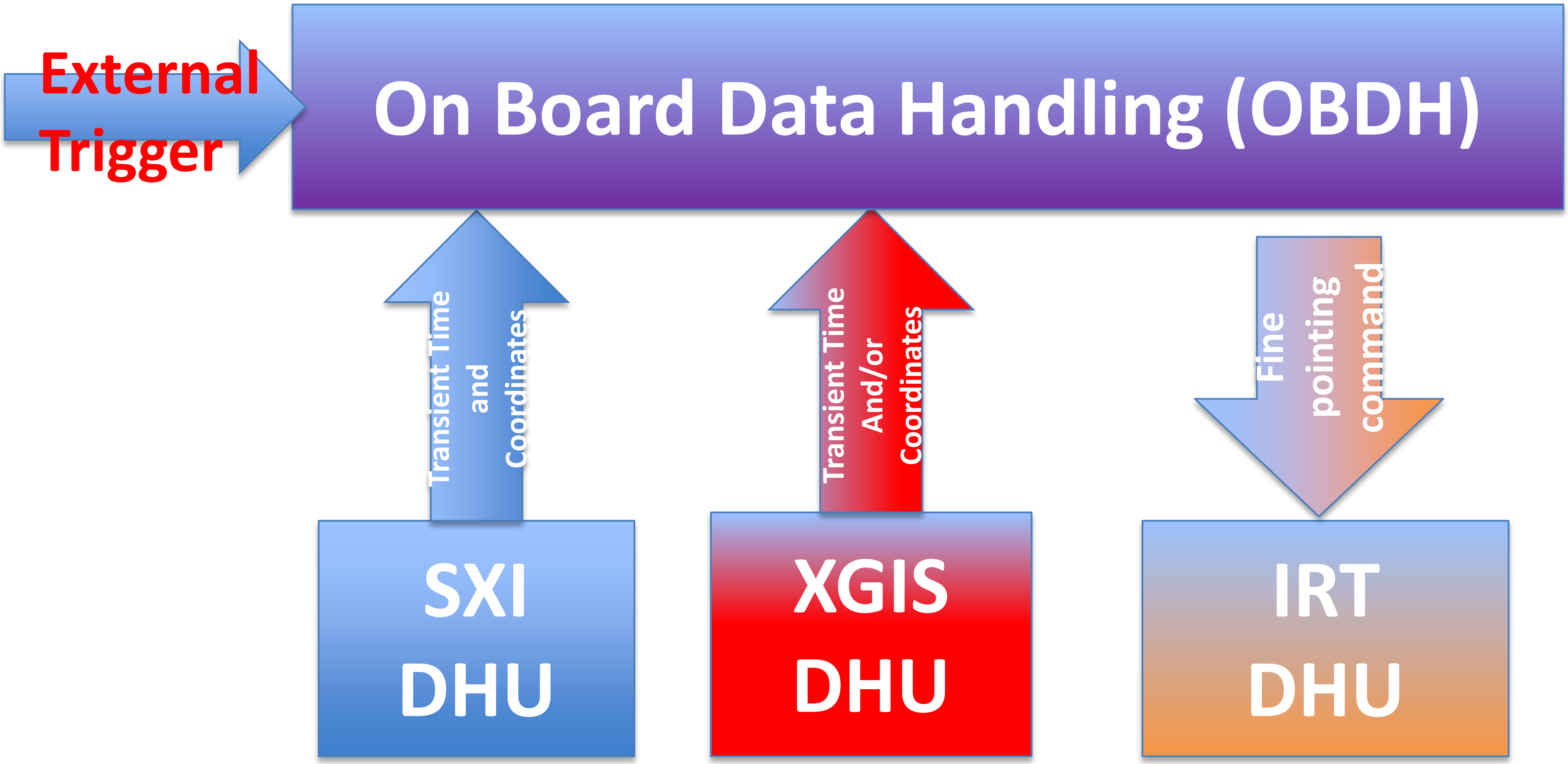
Different possibilities to be investigated during the Phase A study:

- ***Exploitation of the VHF network adopted for SVOM: 10 min (BASELINE)***
- ***Exploitation of the Iridium satellite constellation (in advanced development, Iridium NEXT): 1 min***
- ***European TDRSS (under development): <1 min***
- ***American TDRSS: <1 min (in the case of an international participation by NASA)***

Predicted GRB detection rate and their properties

- 300-700 GRB/yr, 5-10 times more than Swift at the highest z.
- Photometric redshifts for the GRBs with highest z, spectroscopic redshift for the majority.
- Those GRB triggers detected on board without spectroscopy are the best candidates for getting with ground telescopes the best spectra of high z GRBs.
- THESEUS is expected to provide more spectroscopic redshifts on board in one year than those provided by *Swift* in a decade.

On Board Logic for External Triggers from Ground



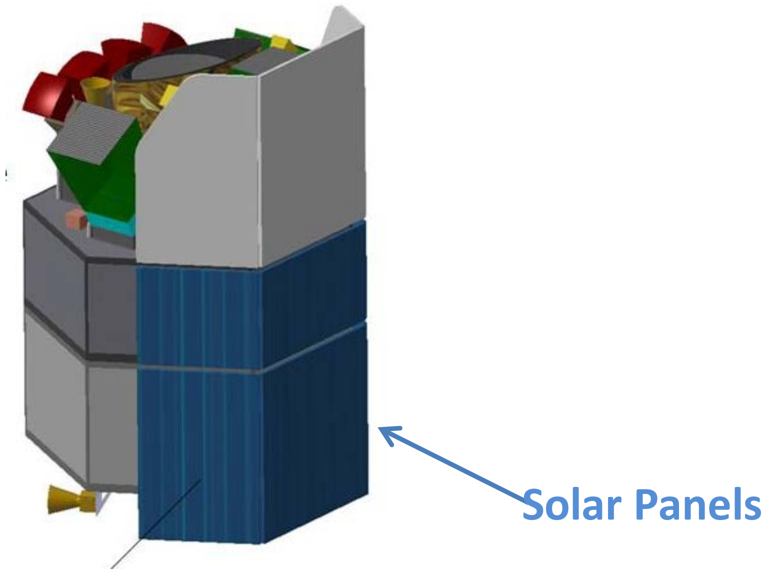
How to up-link the external triggers/TOO requests

Different possibilities to be investigated during the phase A study:

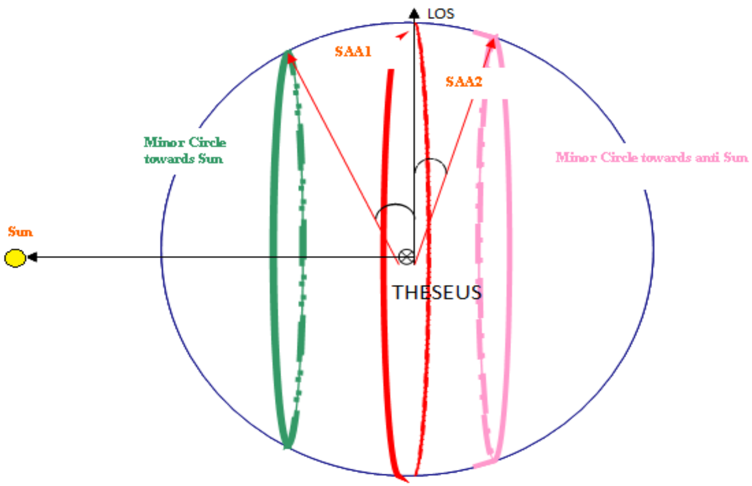
- ***THESEUS ground station (Malindi): 90 min***
- ***VHF equatorial network adopted for SVOM: 10 min***
- ***Iridium satellite network (advanced development): 1 min***
- ***European TDRSS (under development): <1 min***
- ***American TDRSS: <1 min (in the case of an international participation by NASA)***

Which are the THESEUS attitude constraints

- **Satellite in the Sun light:**

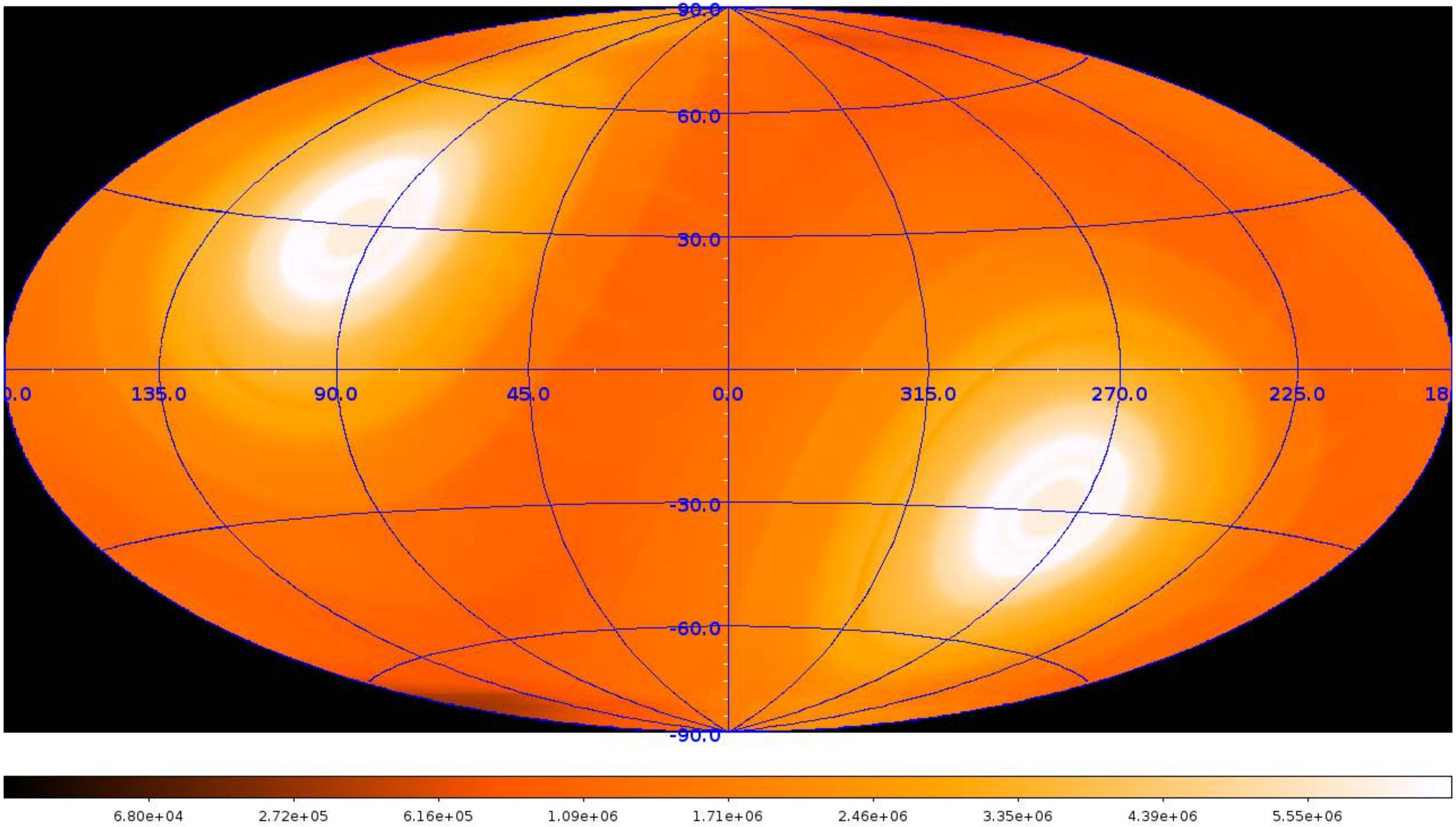


Sun Attitude Angle (SAA) = 40°



- **Satellite in the Earth shadow**: other possible attitudes, including the AntiSun direction, will be investigated in the Phase A study.

Sky exposure map (1 yr) for the Sun light attitude constraints



Conclusions

- The main science goals of the mission (the most demanding) can be achieved using the described strategy.
- Other technical constraints era crucial to enable the discussed observing strategy: temperature stability, attitude stability and accuracy, OBDH logic reliability, reliability of the re-pointing automatic system for a fast IRT observation.
- They will be discussed by the next speakers.