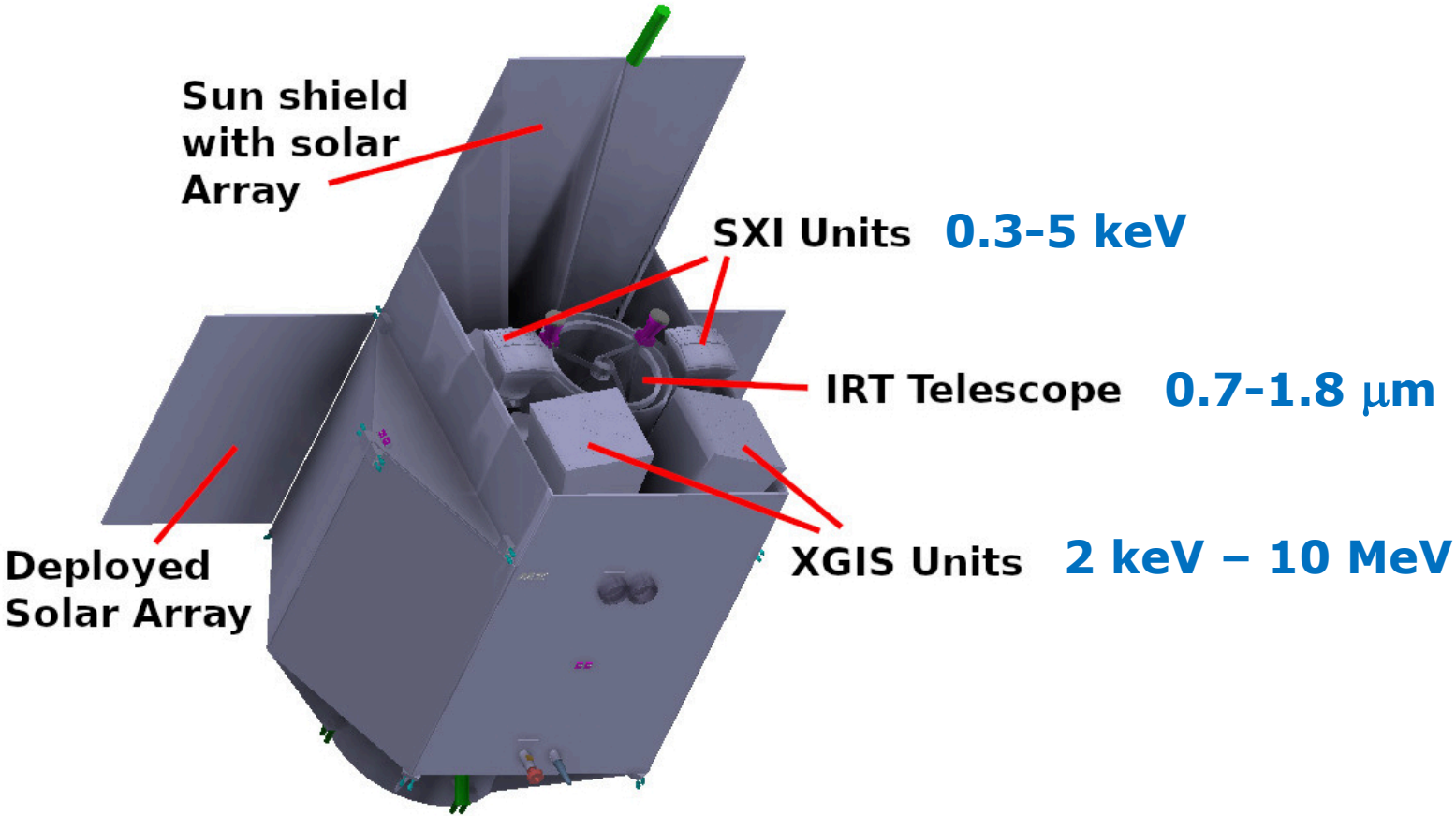
THESEUS capabilities for time variability studies

THESEUS CONFERENCE 2021, VIRTUAL
23-26 March 2021

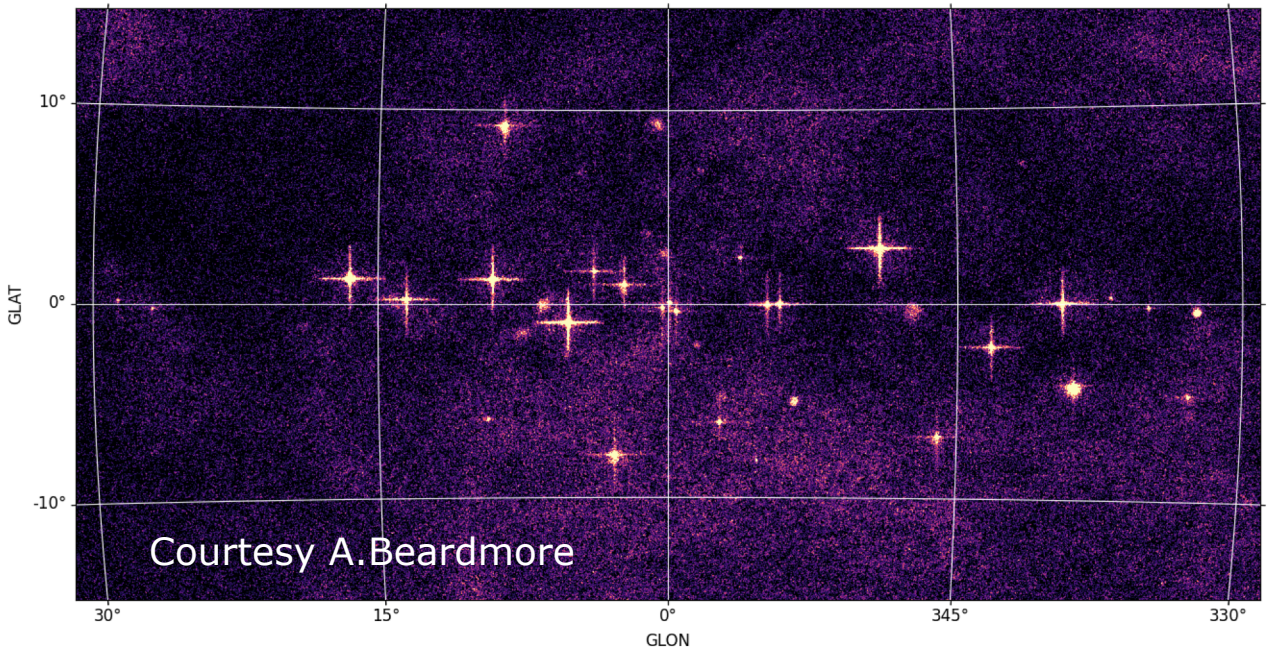
Sandro Mereghetti - INAF, IASF-Milano

on behalf of the Science Working Group
on Time-domain Astronomy

THESEUS Satellite



SXI: High and uniform sensitivity over wide FoV



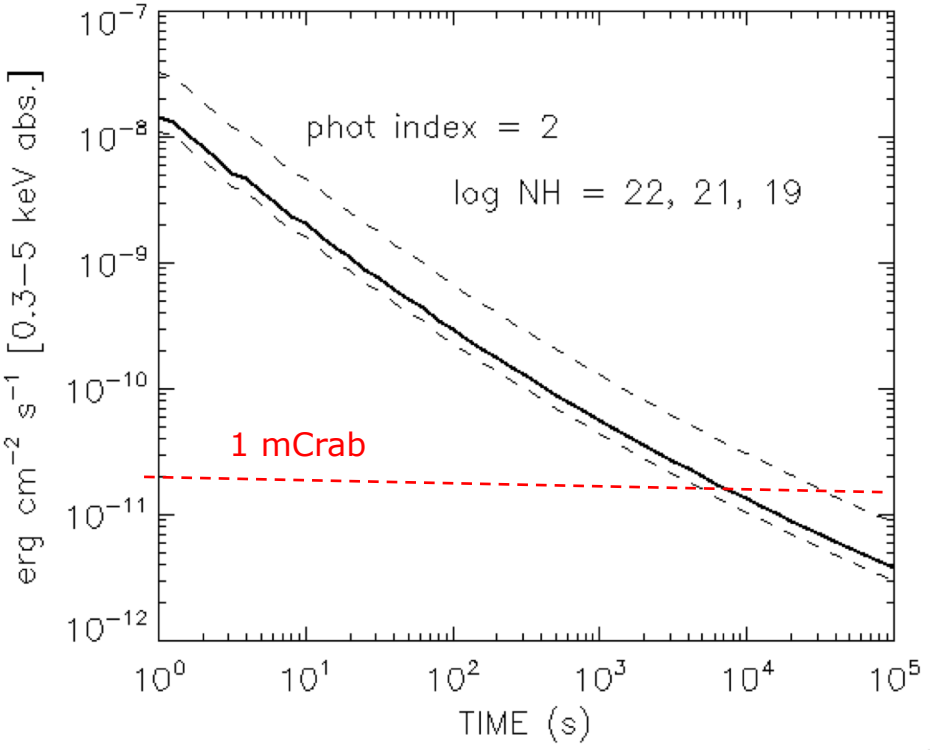
Simulation of Galactic Center region

2.4 ks exposure

60 x 30 deg^2

0.3-5 keV

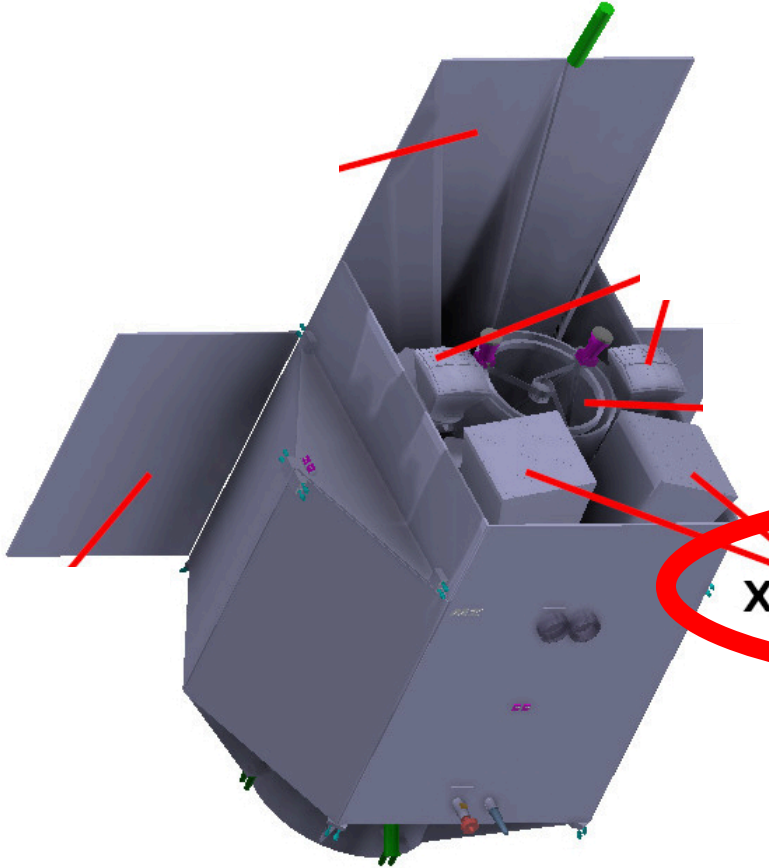
SXI: High and uniform sensitivity over wide FoV

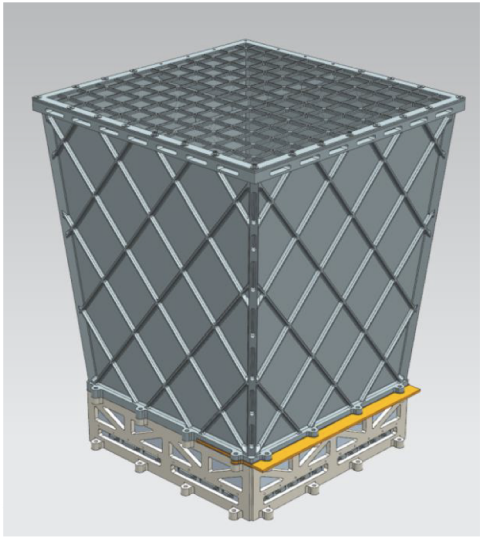


~ mCrab sensitivity in 10 ks in the soft energy range

Exact value depends on source spectrum and absorption

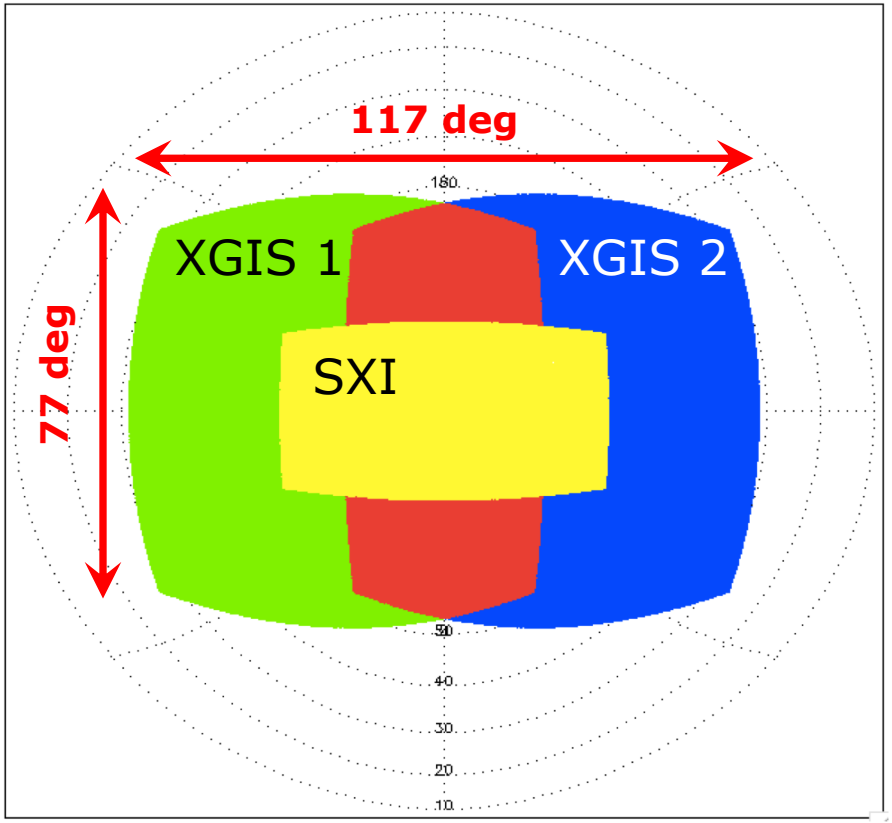
THESEUS Satellite: XGIS





XGIS Units **2 keV – 10 MeV**

XGIS: increases the FoV and energy coverage



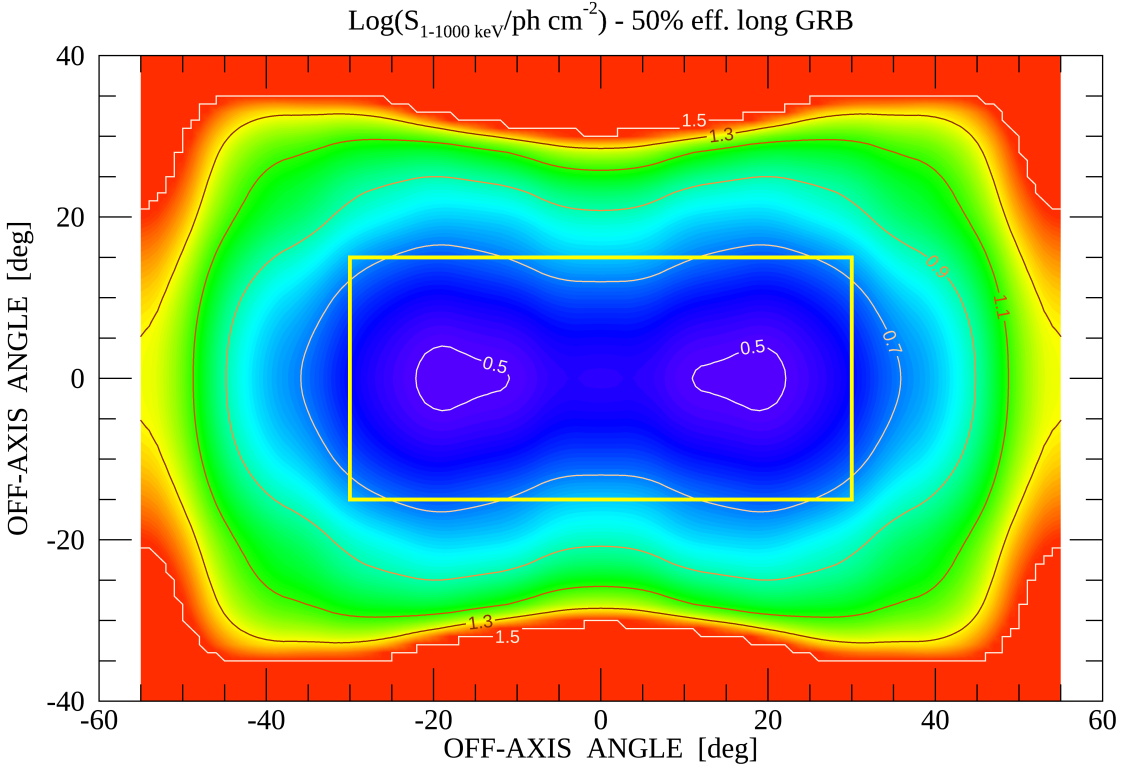
2 – 150 keV
with imaging on 2 sr FoV

150 keV - 10 MeV
without imaging on ~4 sr FoV

XGIS sensitivity depends on source direction

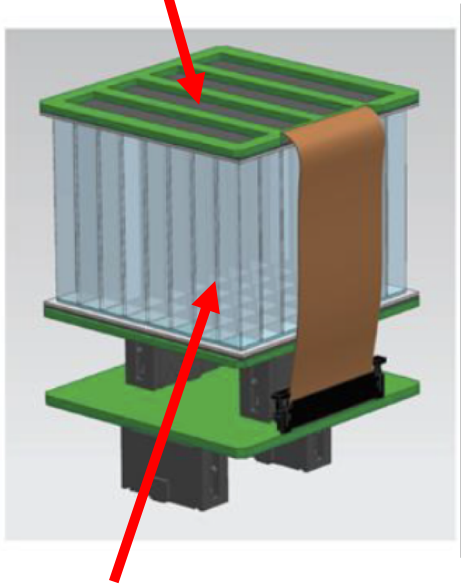
Combining the two XGIS units

→ nearly uniform sensitivity over a FoV equivalent to that of SXI

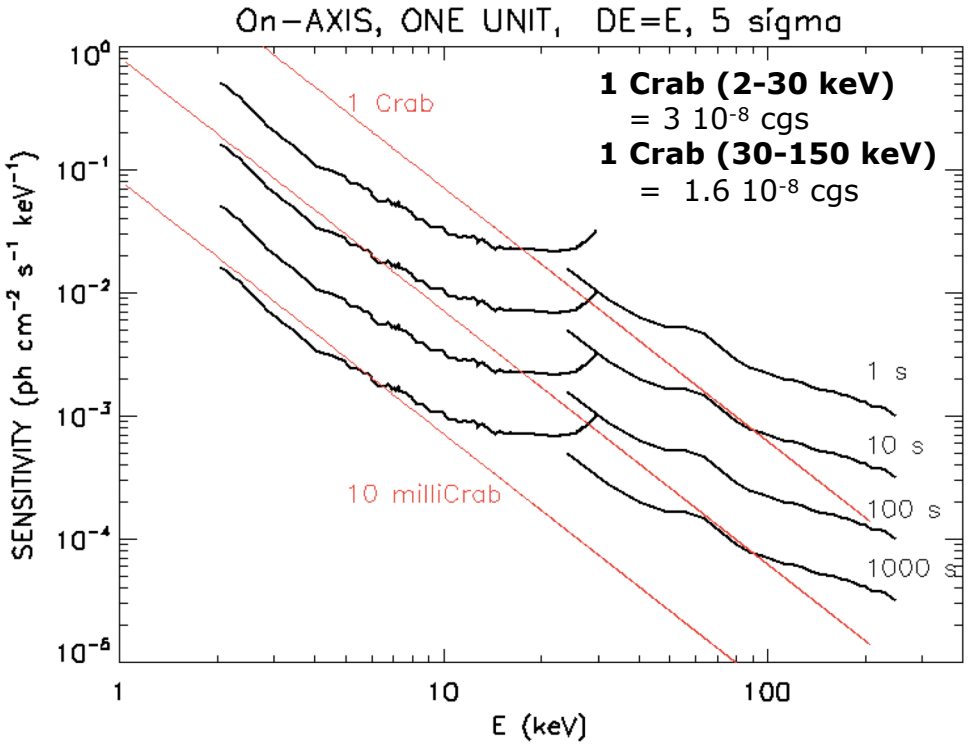


XGIS sensitivity

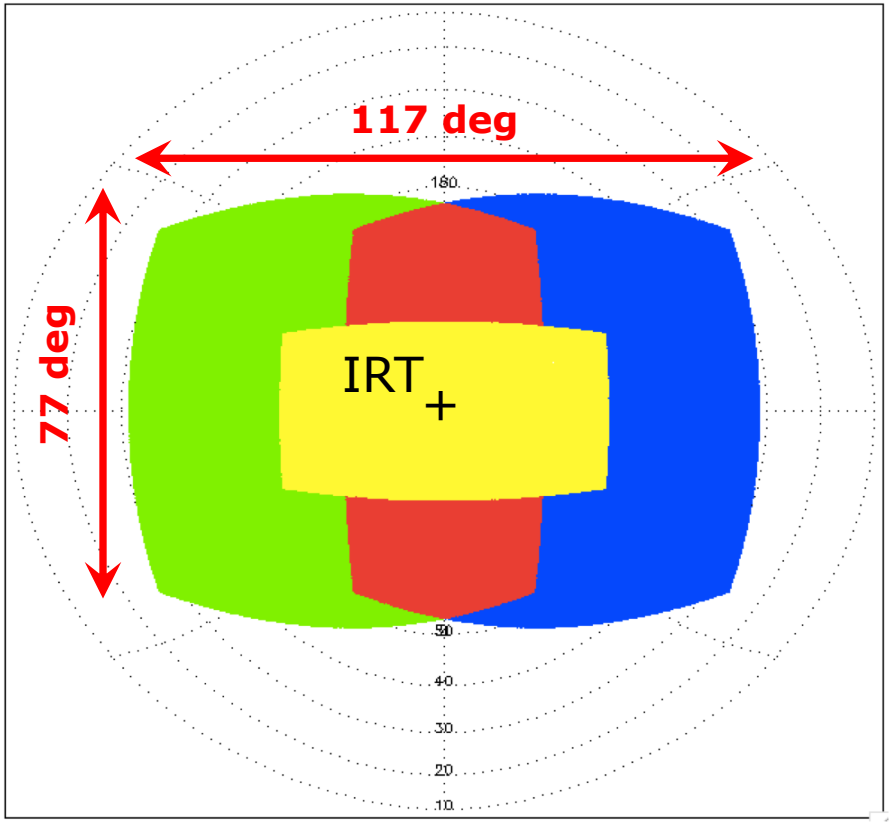
SDD 2-30 keV



CsI 30 keV – 10 MeV



Pointing direction of the Infrared Telescope



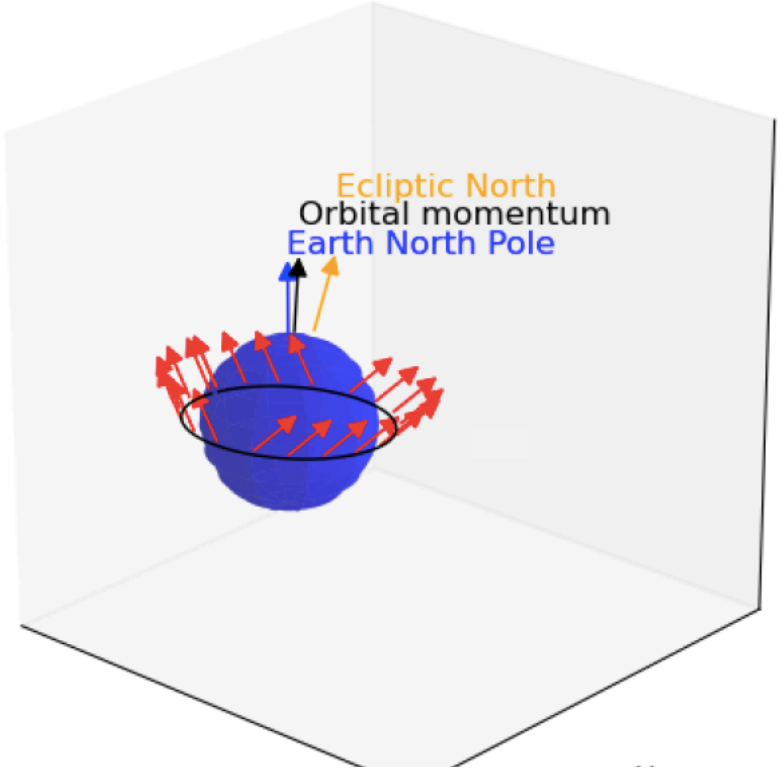
IRT points at the center of SXI FoV

15x15 arcmin^2

Small (~few deg) shift wrt nominal *survey pointings* to have always interesting targets in IRT FoV

→ talk by A. Blain on Observatory Science

THESEUS Pointing Strategy

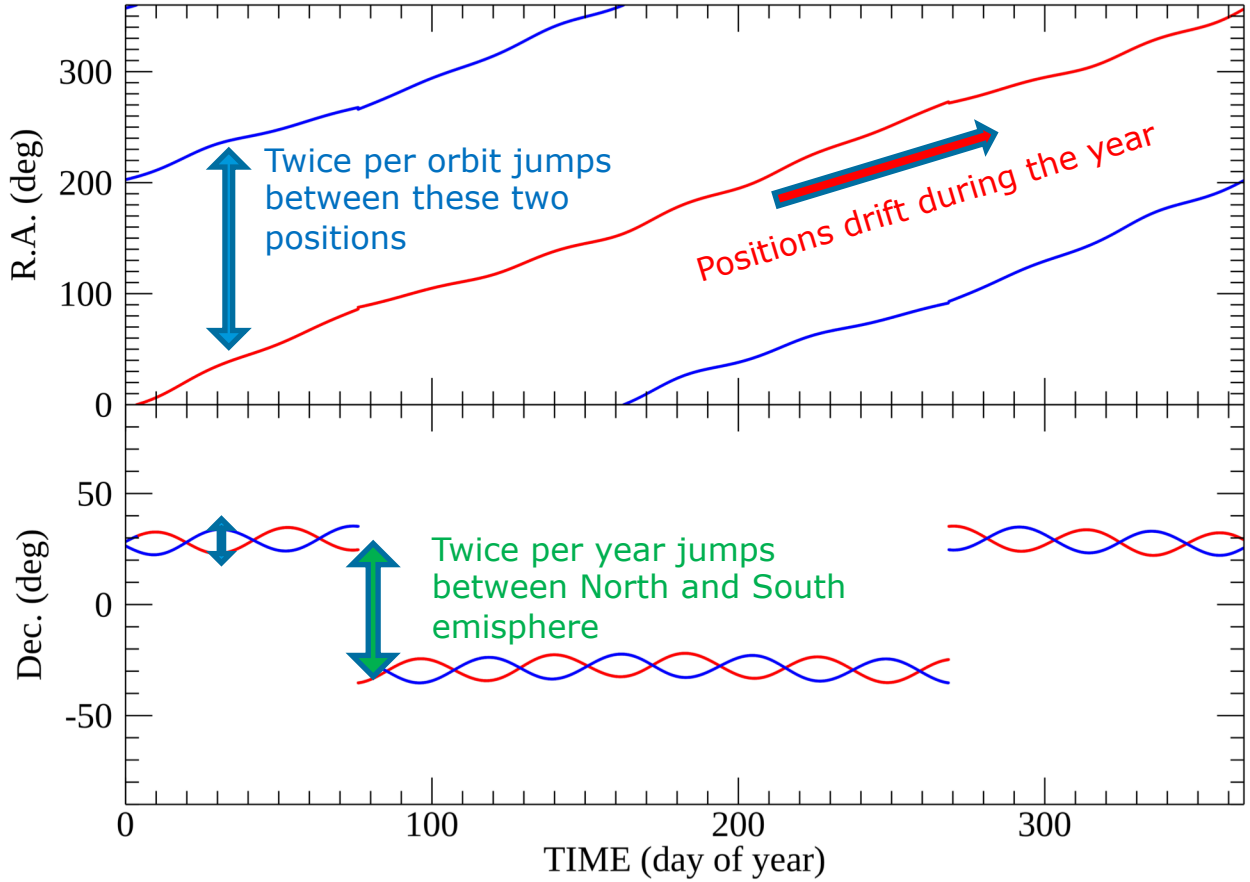


Two ***Survey Pointing*** directions for each orbit

- Minimize Earth in the FoV
- Optimize follow-up from large telescopes on ground

Interrupted ~once per day to follow-up the discovered GRBs

Survey Pointing directions in one year

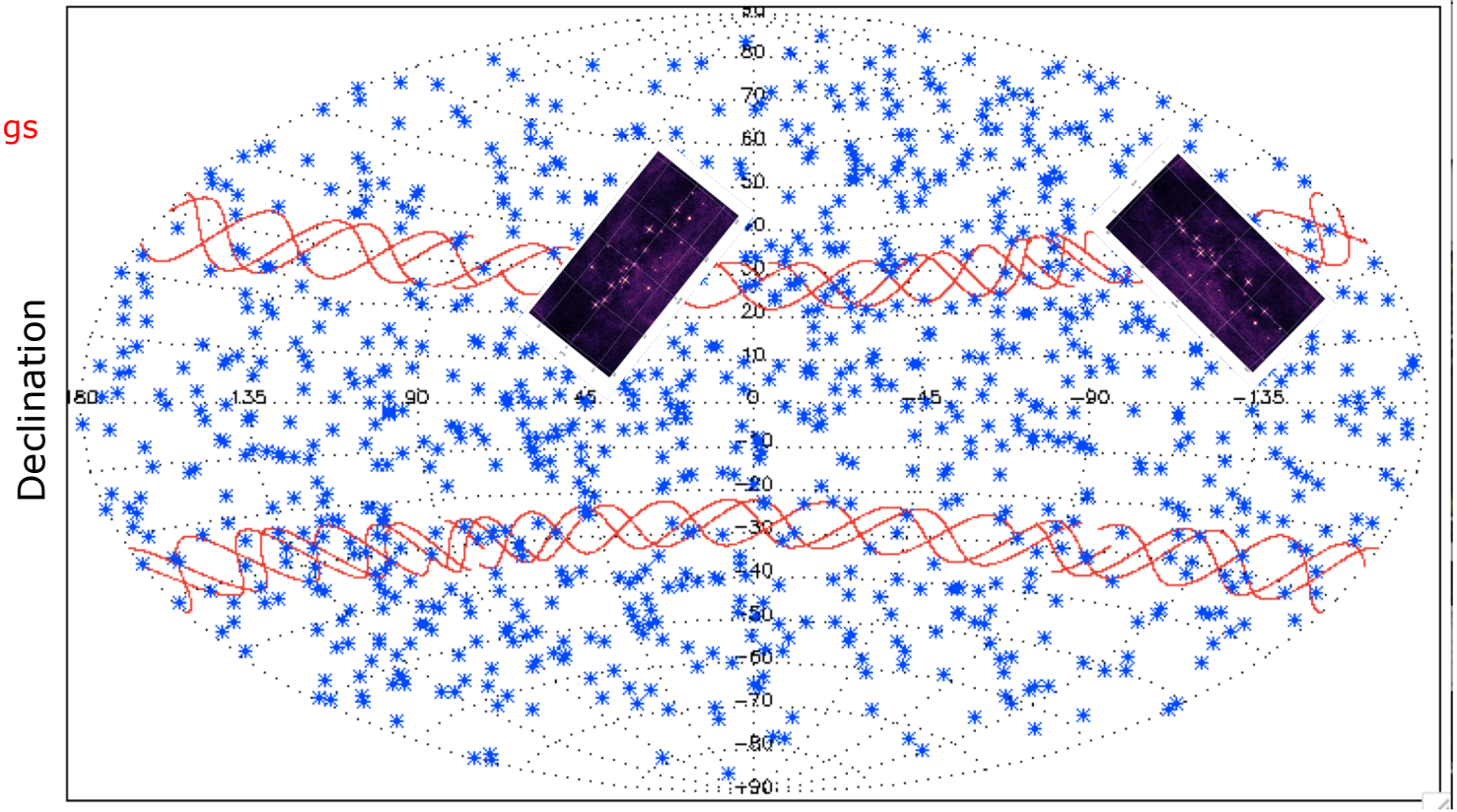


THESEUS Pointing Strategy

In ~3.5 years:

~31000 Survey pointings (~2.3 ks each)

~1000 GRB pointings (~1–20 ks)



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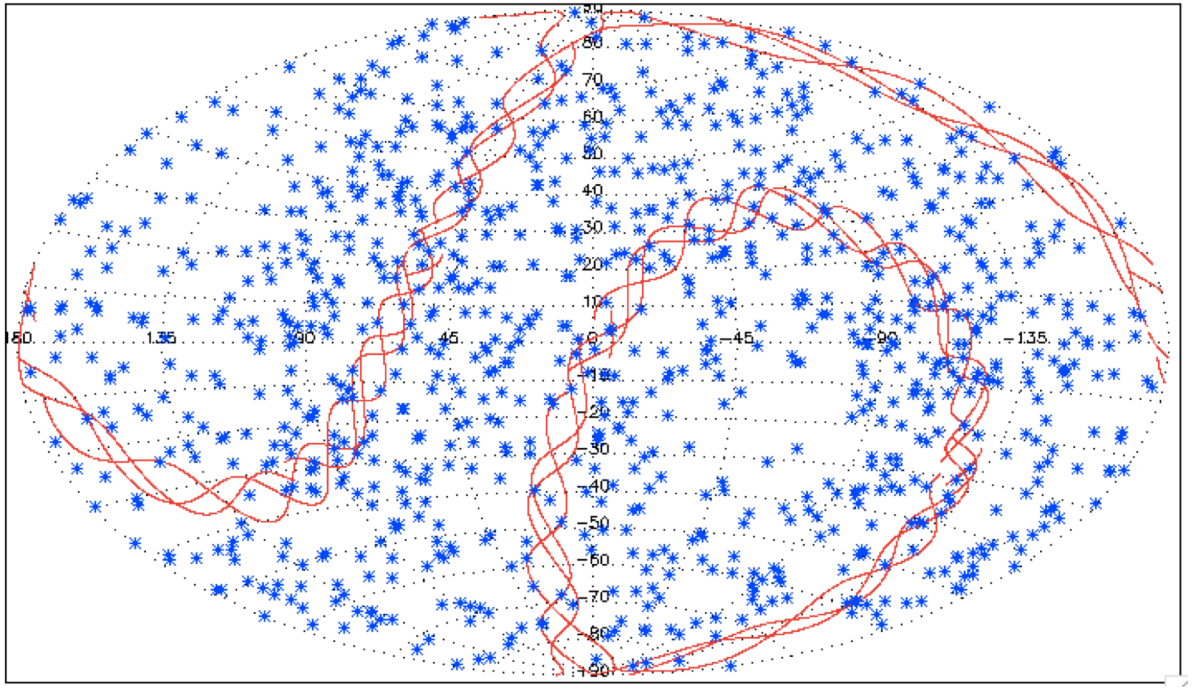
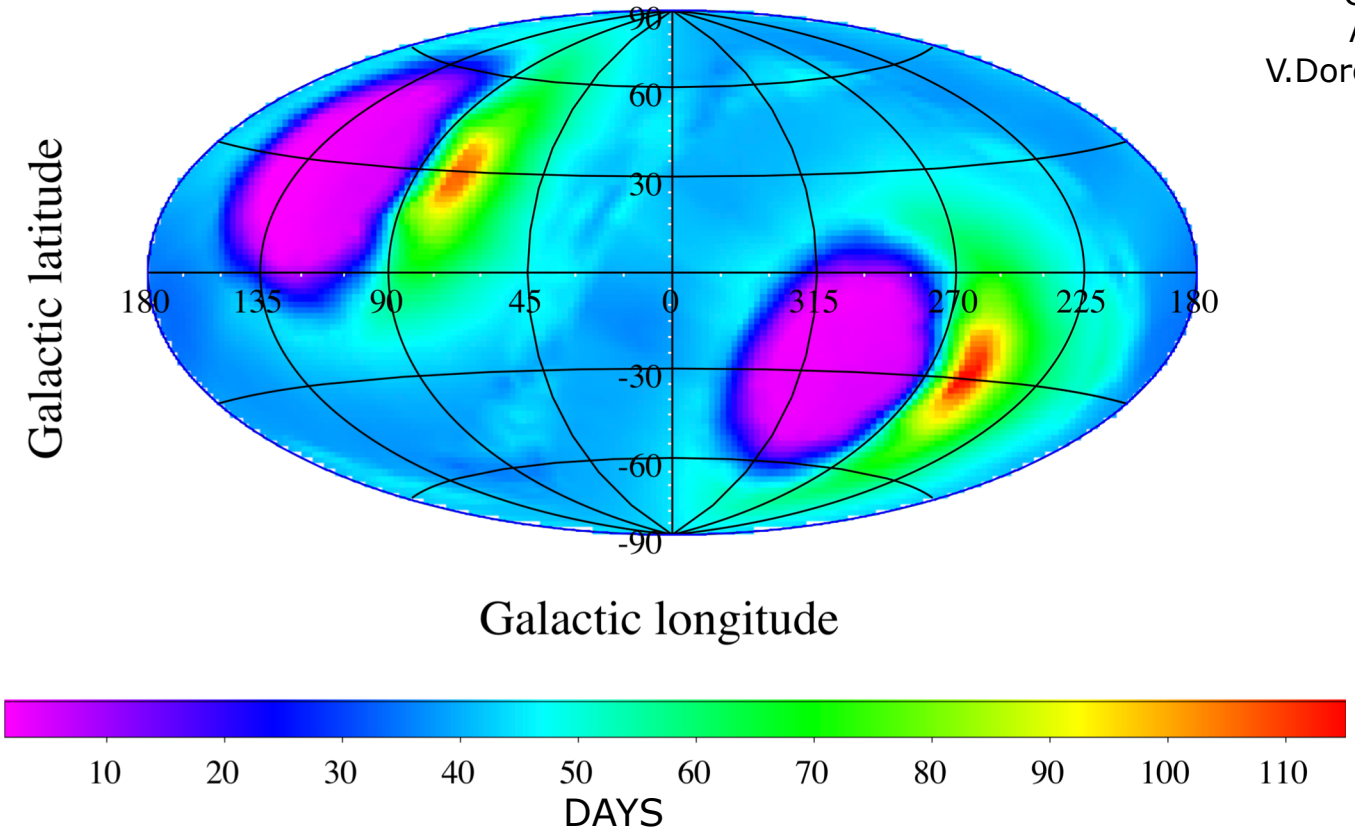
Galactic Coordinates



SXI exposure map

Courtesy
A.Rocchi
V.Doroshenko



XGIS exposure map

Courtesy
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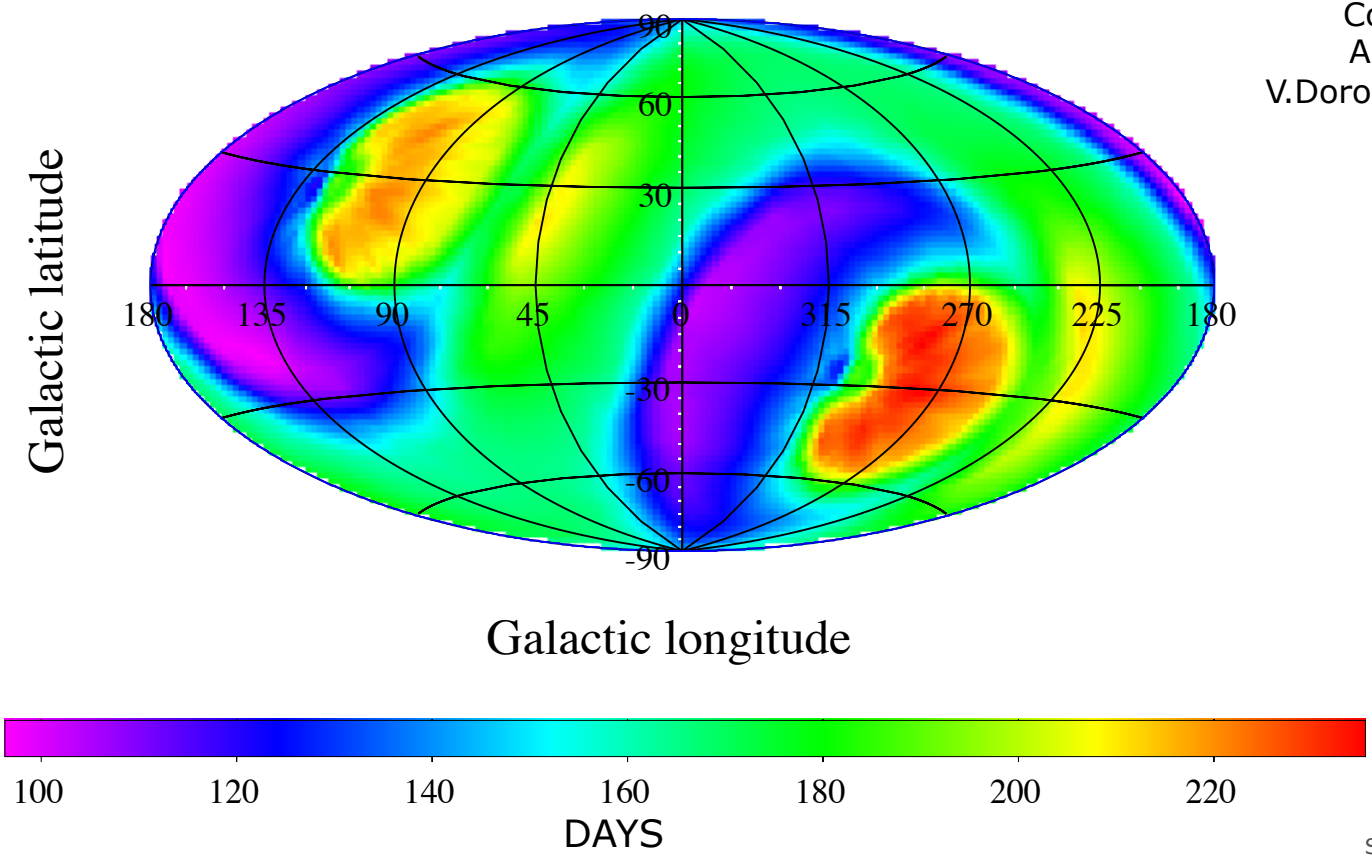
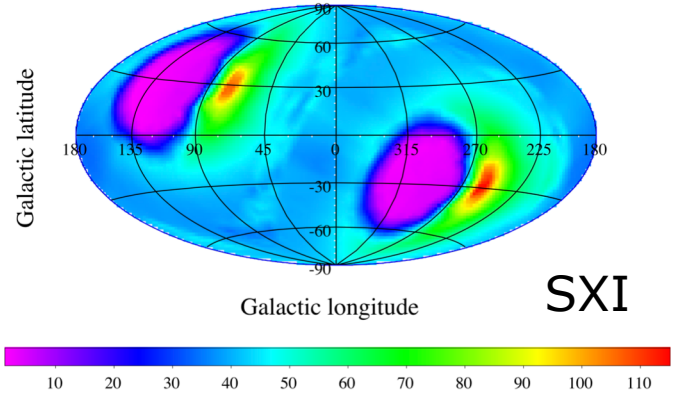
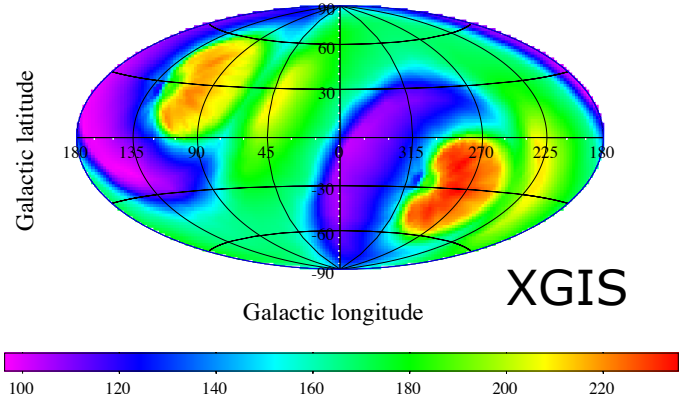


Cadence of Survey Pointings observations

- Coverage depends on source sky coordinates

XGIS provides greater coverage due to larger FoV





Cadence of Survey Pointings observations

- Coverage depends on source sky coordinates

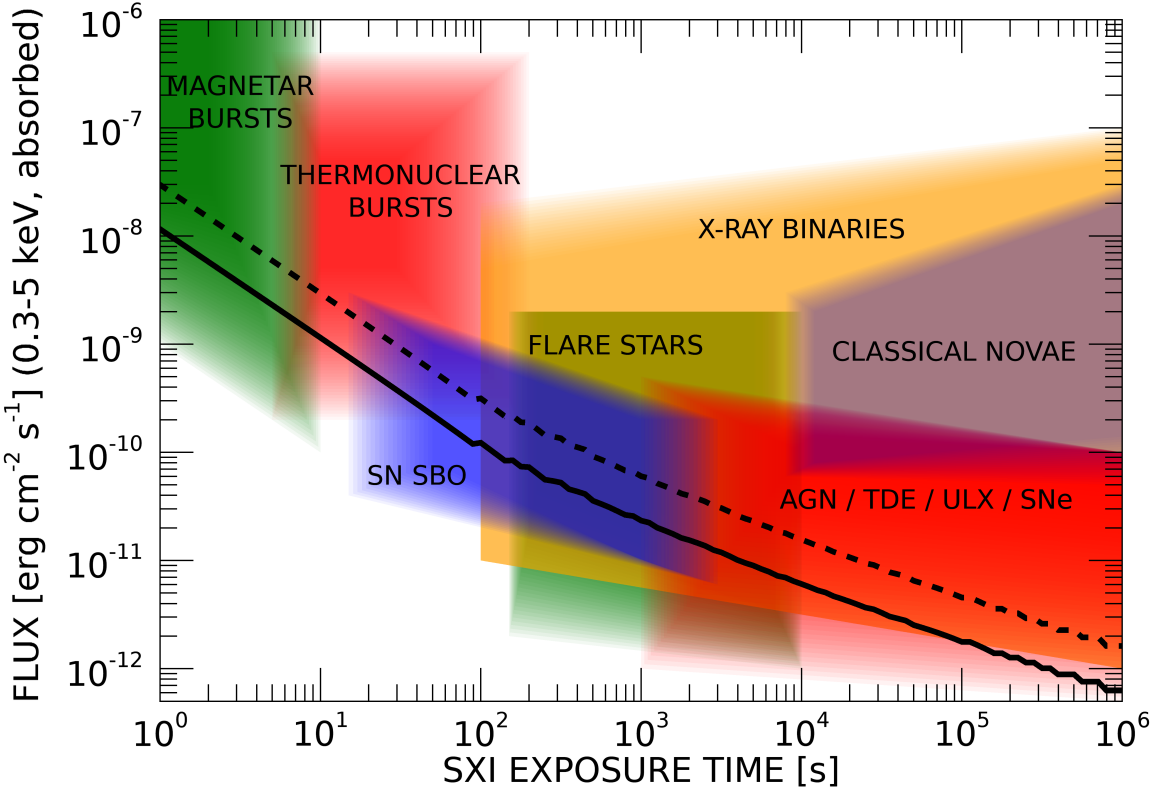
  XGIS provides greater coverage due to larger FoV

- Seasonal visibility periods from few days to few months

  with 15 pointings of 2.3 ks each every day at ~1.5 hr intervals

  F_{MIN} ~3 10^{-11} erg/cm^2/s in each pointing (0.3-5 keV)
  F_{MIN} ~5 10^{-12} erg/cm^2/s in one day

Efficient monitoring of many classes of sources



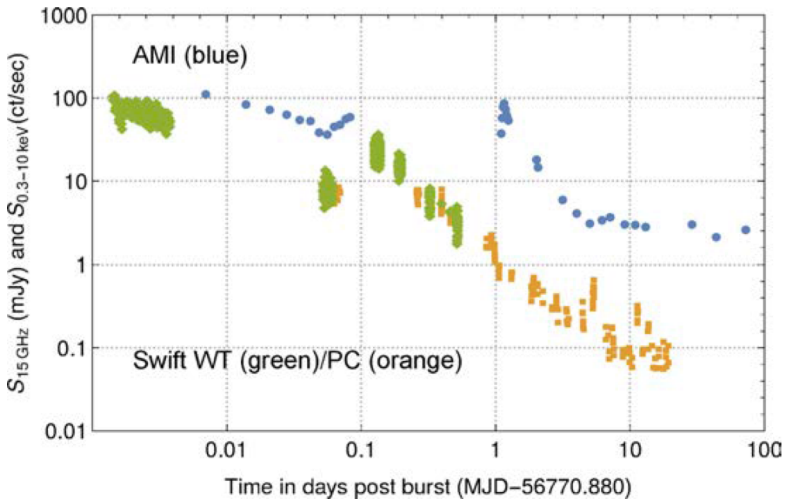
Stellar flares

High rate expected in SXI

On-board catalog of nearby active stars to prevent undesired slews,

EXCEPT in case of **Super-Flares**:

- rare events with much larger energy (x10^4) and longer duration (~days)
- can have hard X-ray emission detectable with XGIS
- unique opportunity for correlated NIR / soft X / hard X observations
- synergies with ground based multi-λ



Compact objects in X-ray binaries

- physics of accretion/ejection in WD, NS, BH exploiting wide energy coverage

- Periodic and non-periodic variability on all timescales
(bursts / outbursts of transients / changes of state / …)

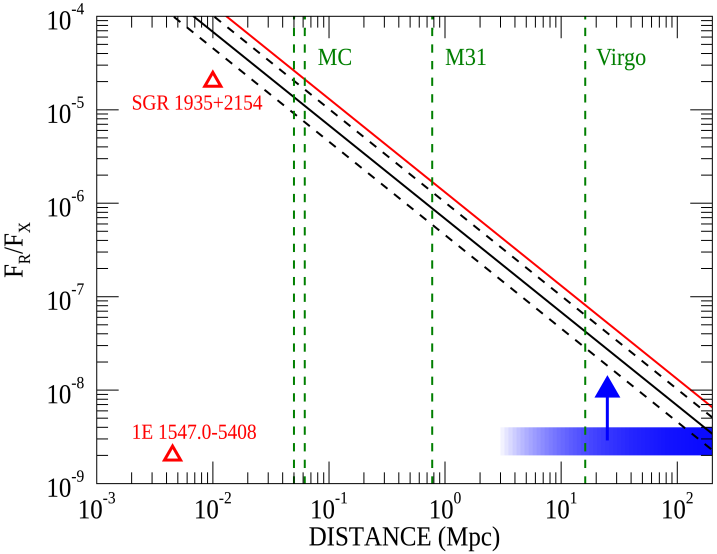
- Long term monitoring with high cadence will provide information on duty cycles, orbital/super-orbital modulations (e.g. SFXTs), triggers for transients

- Accreting ms-PSRs (and transitional MSP) → **talk by D.De Martino**

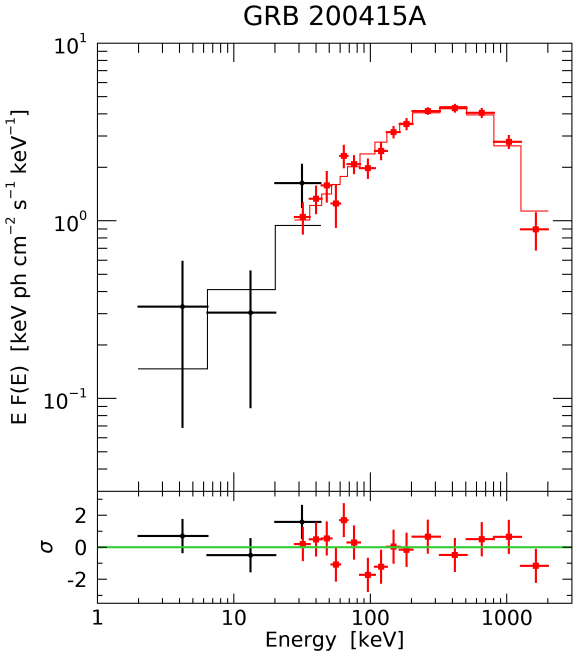
- HMXB variability → **talk by V.Doroshenko**

Magnetars / Fast Radio Bursts

Monitoring of few tens of Galactic magnetars + newly discovered ones
Counterparts of Fast Radio Bursts
Giant Flares in nearby (tens Mpc) galaxies



SXI and XGIS detectabiliy of FRB as a function of ratio of Radio to X-ray fluence



Simulated XGIS spectrum of GRB200415A a likely Giant Flare from a magnetar in NGC 253

→ Talks by N.Rea, M.Doyle, O.Roberts

Extragalactic sources

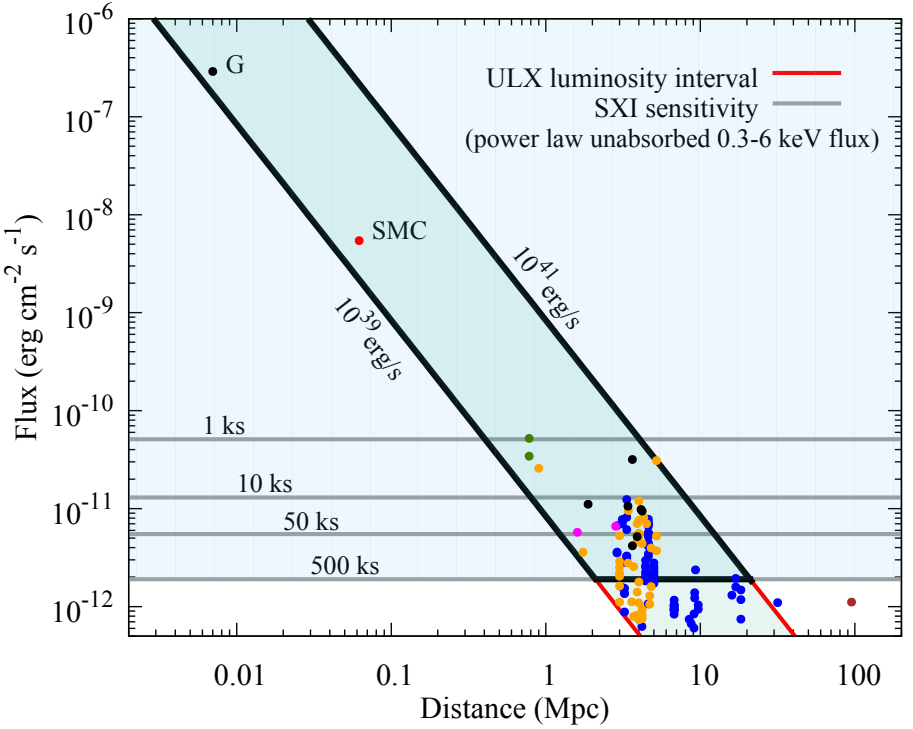
- ULXs

- Tidal Disruption Events
  → **talk by N.Webb**

- SNe and shock breakouts
  → **talk by L.Izzo**

- AGNs changing look AGNs – Quasi Periodic Eruptions – Blazars
  → **talks by C.Ricci, A. Markowitz, M.Caballero-Garcia**

THESEUS detectability of ULXs
(courtesy M.H.Erkut)



CONCLUSIONS

- **High sensitivity** + **Large FoV** + **Broad energy range** of XSI & XGIS offer great opportunities for additional science *without interfering with THESEUS's main objectives*

- Frequent cadence of observations and large sky coverage

  → statistical characterization of spectral/variability properties of large samples of Galactic and extra-Galactic sources

  → discovery of new transients and synergies with other facilities

- Added value thanks to the availability of IRT for simultaneous observations