THESEUS, a small ESA payload for multiwavelength transients

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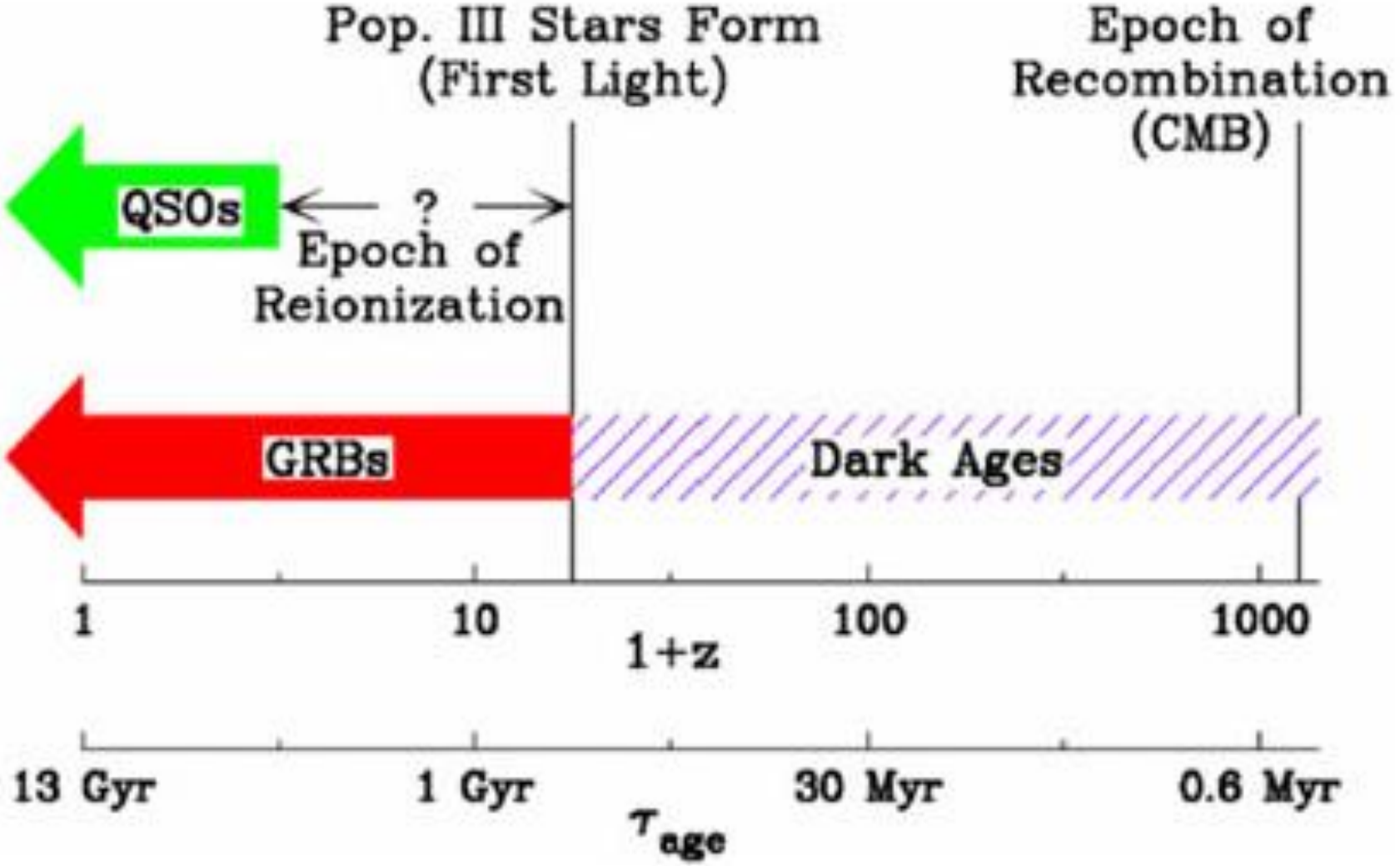
On behalf of a European consortium
Interested partners: China, USA, Brazil

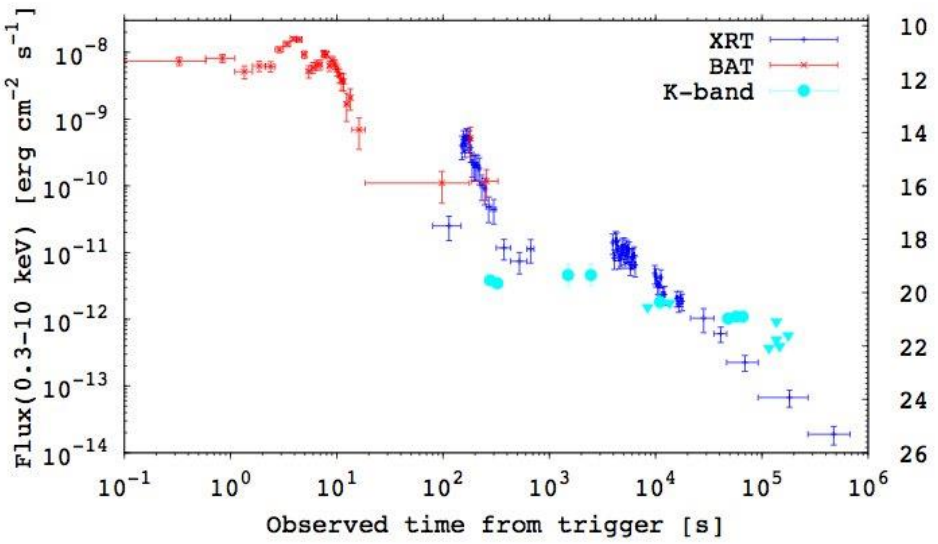
GRBs in Cosmological Context



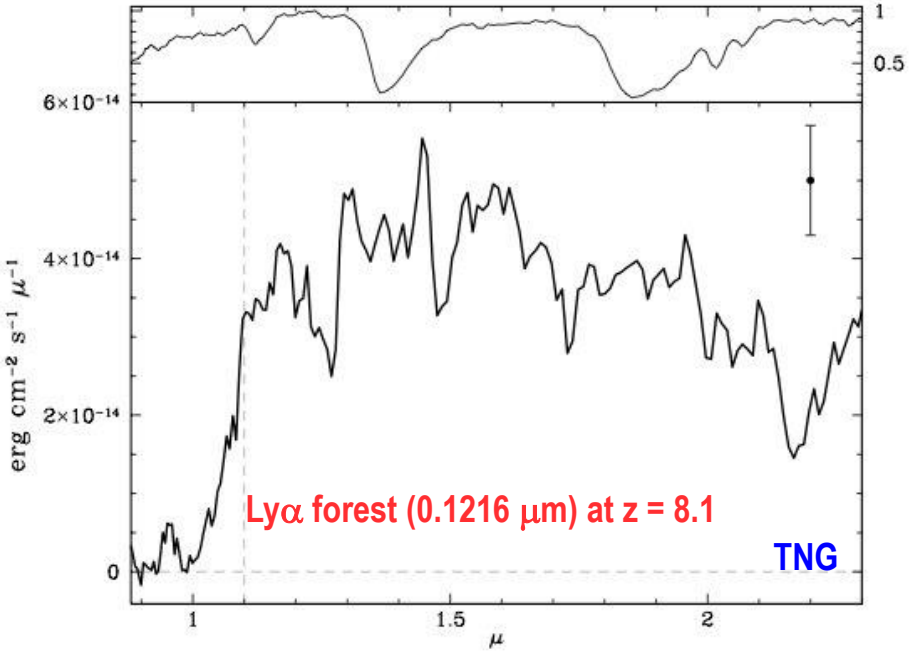
Lamb and Reichart (2000)

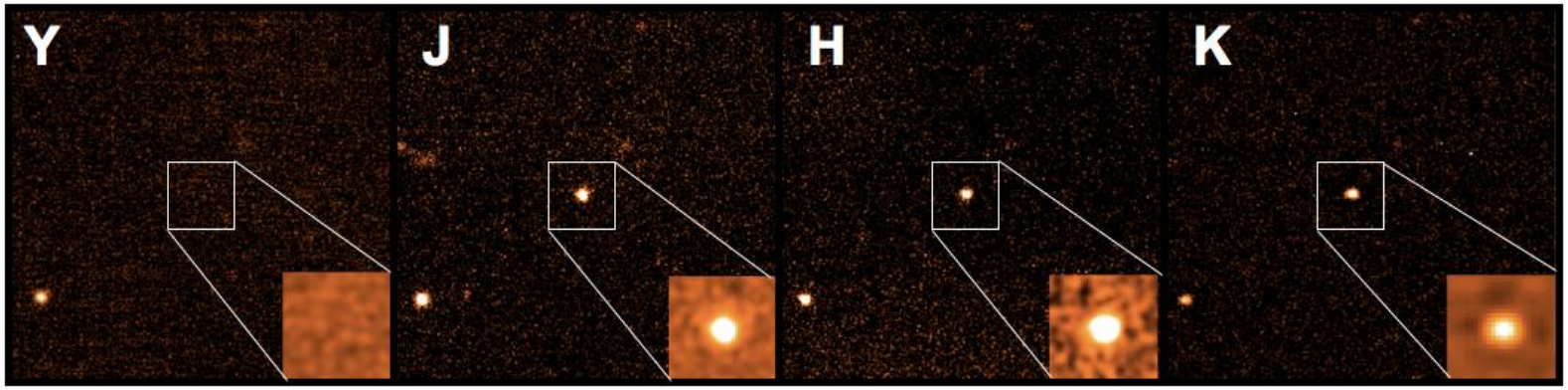
THESEUS motivation: Use gamma-ray bursts for investigating the early Universe

GRB090423 (z = 8.1)



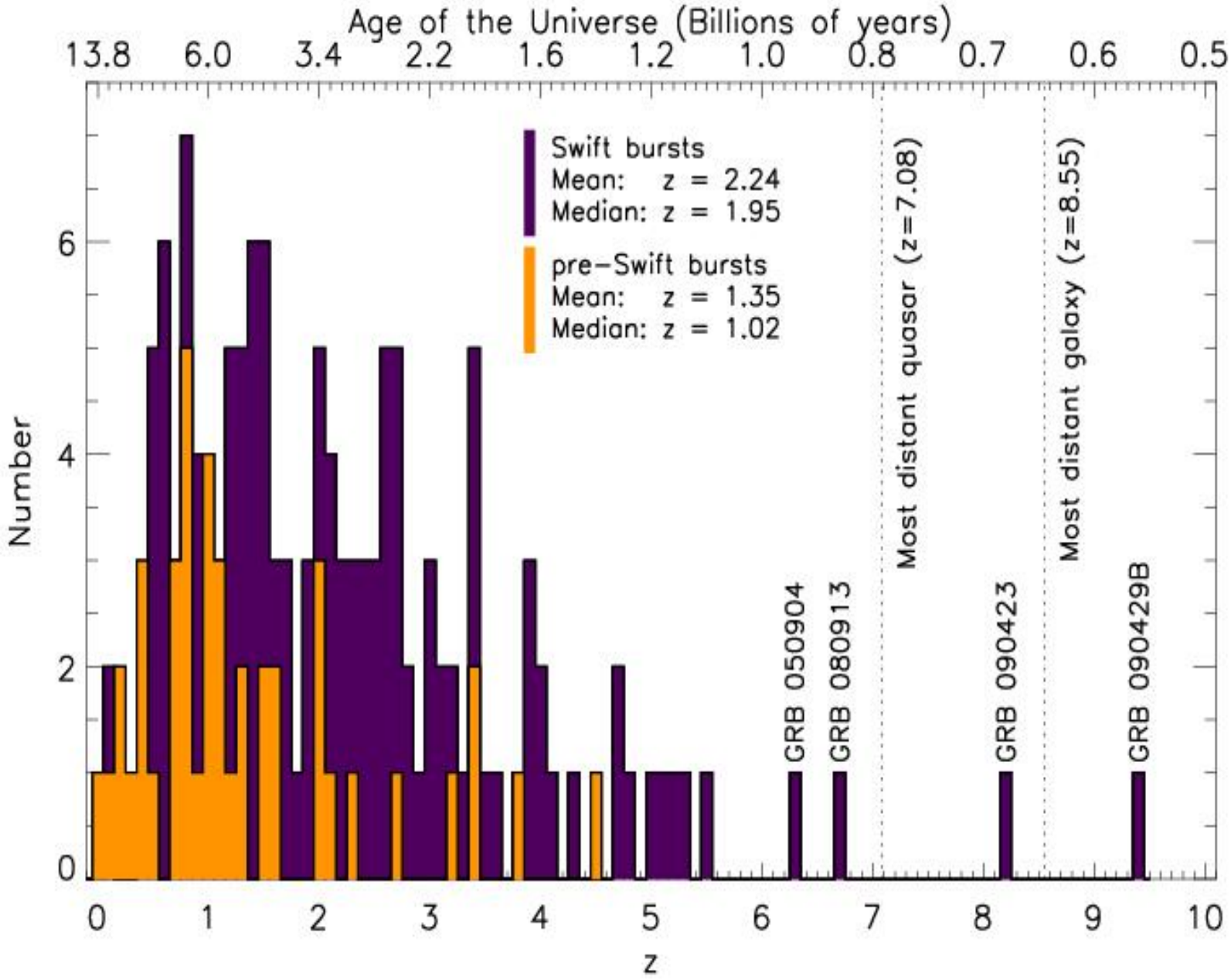
UKIRT





Salvaterra et al. 2009; Tanvir et al. 2009

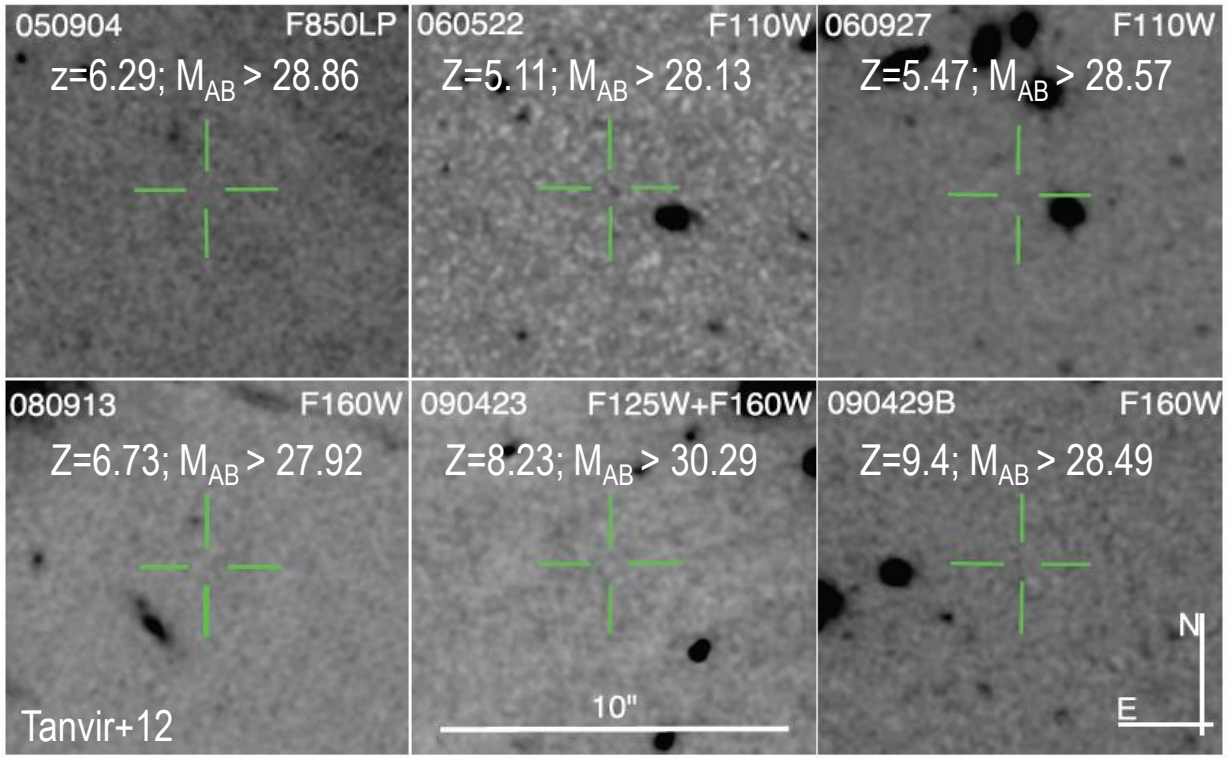
Early Universe with GRBs



A statistical sample of high–z GRBs can provide fundamental information:

- measure independently the **cosmic star–formation rate**, even beyond the limits of current and future galaxy surveys
- directly (or indirectly) detect the **first population of stars (pop III)**
- the number density and properties of **low-mass galaxies**

The number density and properties of **low-mass galaxies**

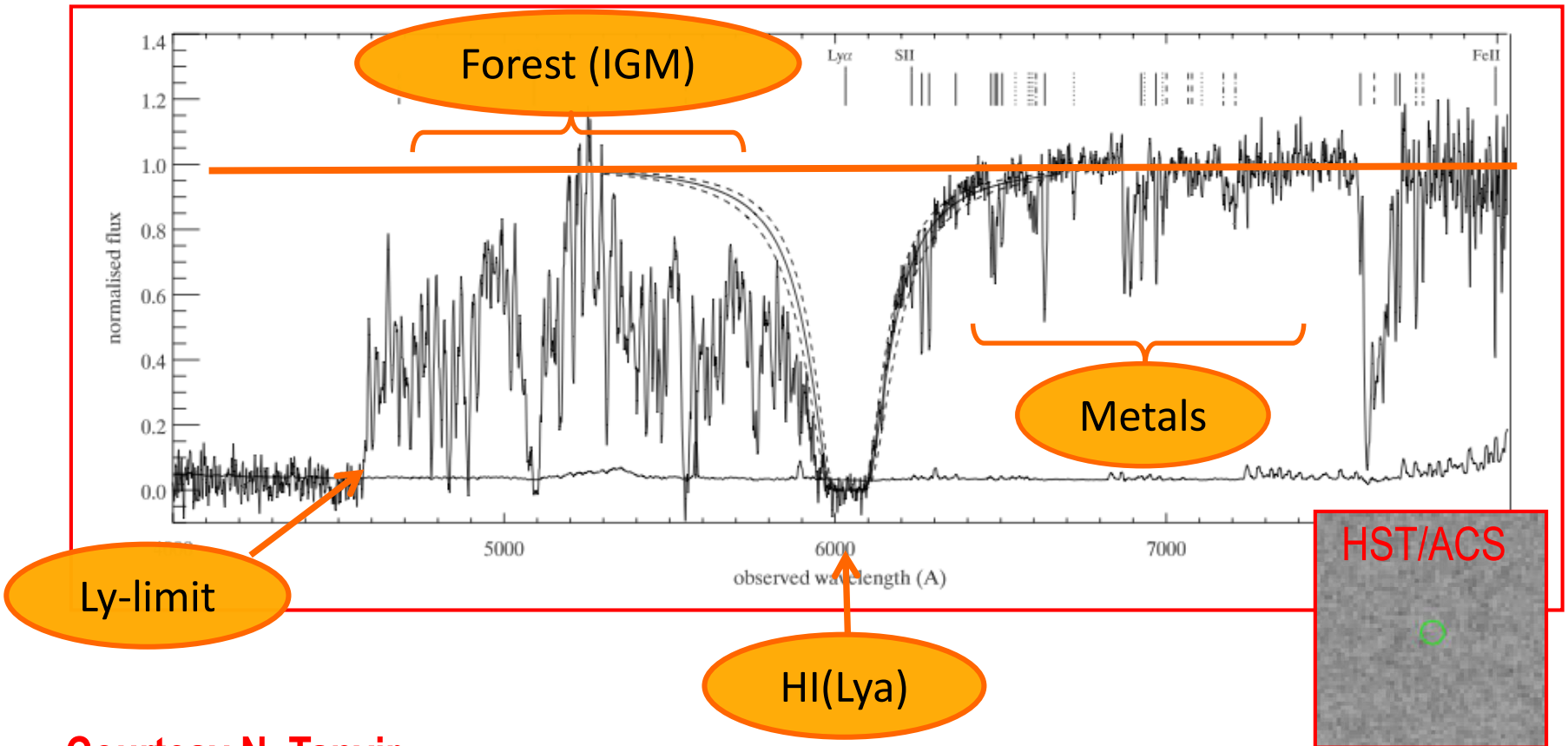


Robertson&Ellis12

Even JWST and ELTs surveys will be not able to probe the faint end of the galaxy Luminosity Function at high redshifts (z>6-8)

- the neutral hydrogen fraction
- the escape fraction of UV photons from high-z galaxies
- the early metallicity of the ISM and IGM and its evolution

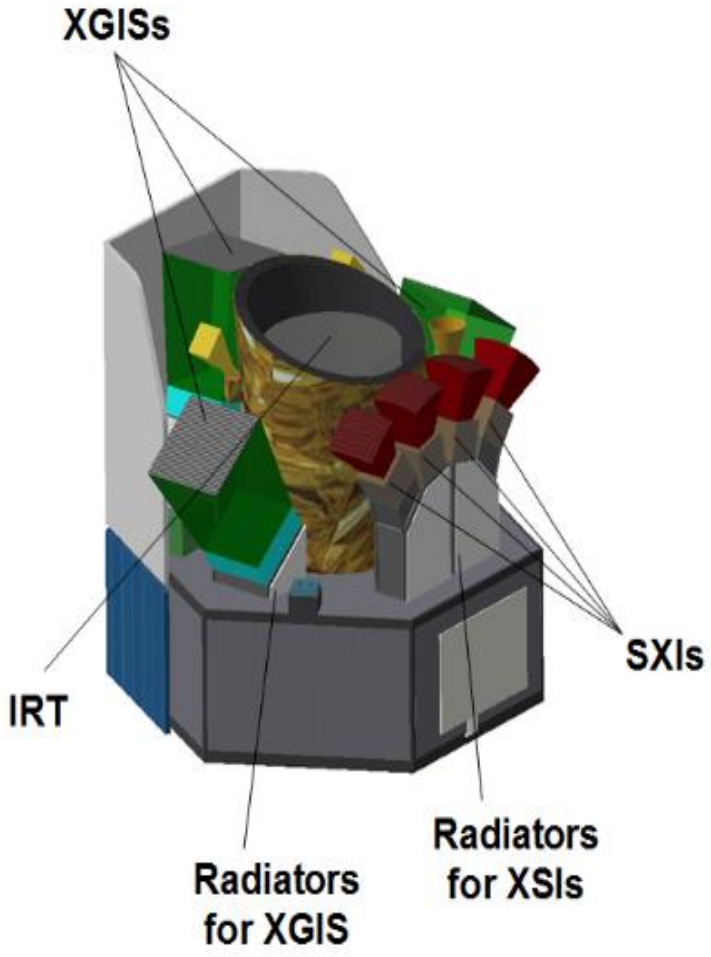
GRB 050730 (z=3.97)



Courtesy N. Tanvir

THESEUS mission concept

- **Soft X-ray Imager (SXI):** a set of four sensitive lobster-eye telescopes observing in **0.3 - 5 keV band, total FOV of ~1sr with source location accuracy 0.5-1';**
- **X-Gamma rays Imaging Spectrometer (XGIS,)**: 3 coded-mask X-gamma ray cameras using bars of Silicon diodes coupled with CsI crystal scintillators observing in **2 keV – 10 MeV band, a FOV of ~2-4 sr, overlapping the SXI, with ~5' GRB location accuracy** in 2-30 (150) keV
- **InfraRed Telescope (IRT)**: a 0.7m class IR telescope observing in the **0.7 – 1.8 µm band, providing a 10'x10' FOV, with both imaging and moderate resolution spectroscopy capabilities (-> redshift)**



LEO (< 5°, ~600 km)
Rapid slewing bus
Prompt downlink

TIMELINE

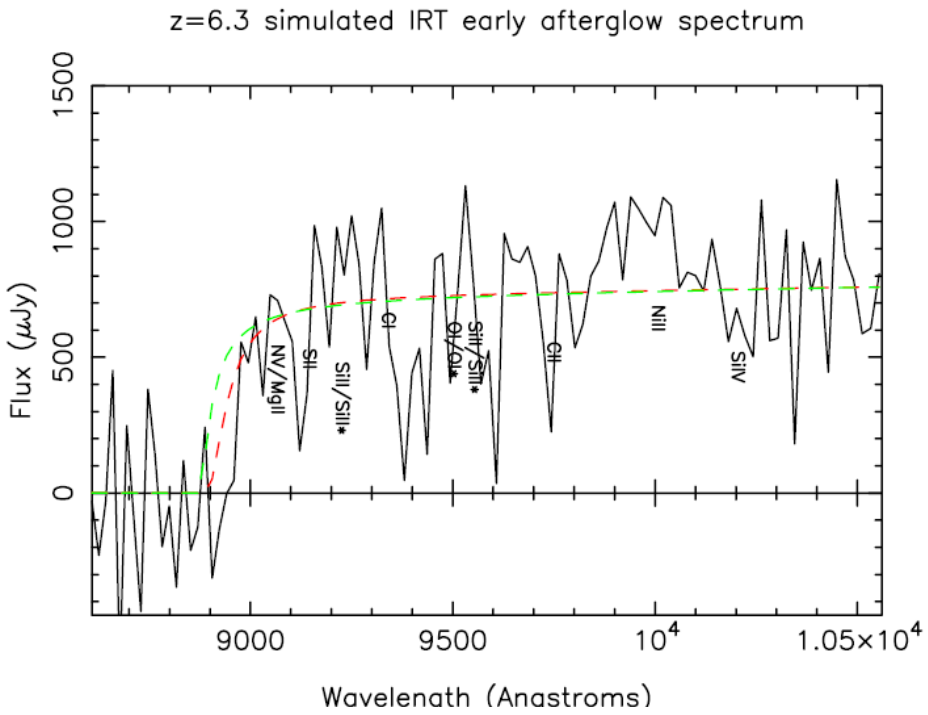
THESEUS is currently under Phase A study by the European Space Agency (ESA) as a candidate M5 mission in view of a launch opportunity in 2032 (https://www.isdc.unige.ch/theseus).

Competition for ESA M5 class missions will close in June 2021

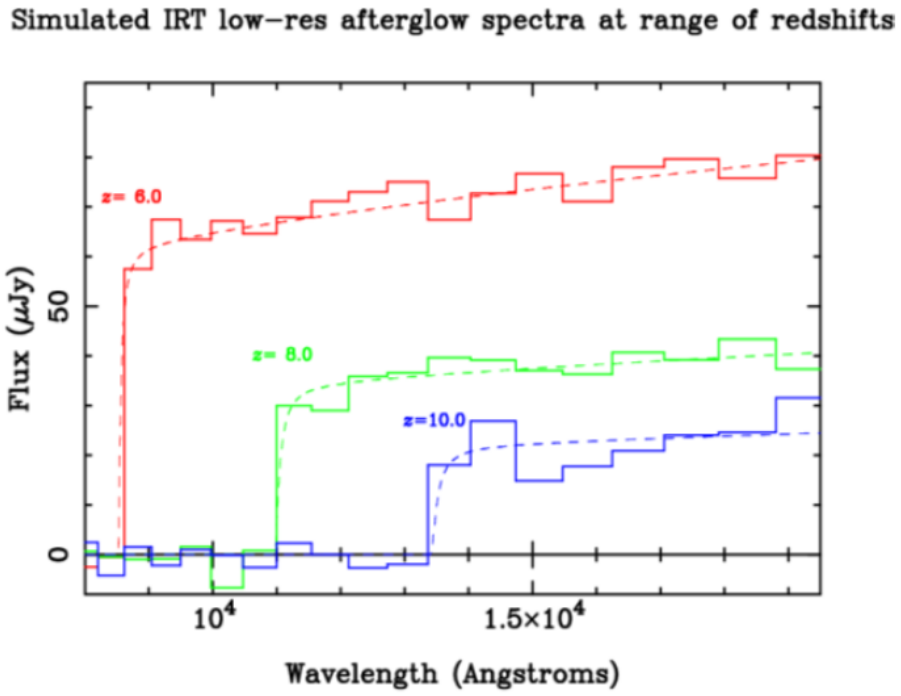
Amati et al. 2017 (arXiv:1710.04638)
Stratta et al. 2017 (arXiv:1712.08153)

Simulated THESEUS/IRT spectra

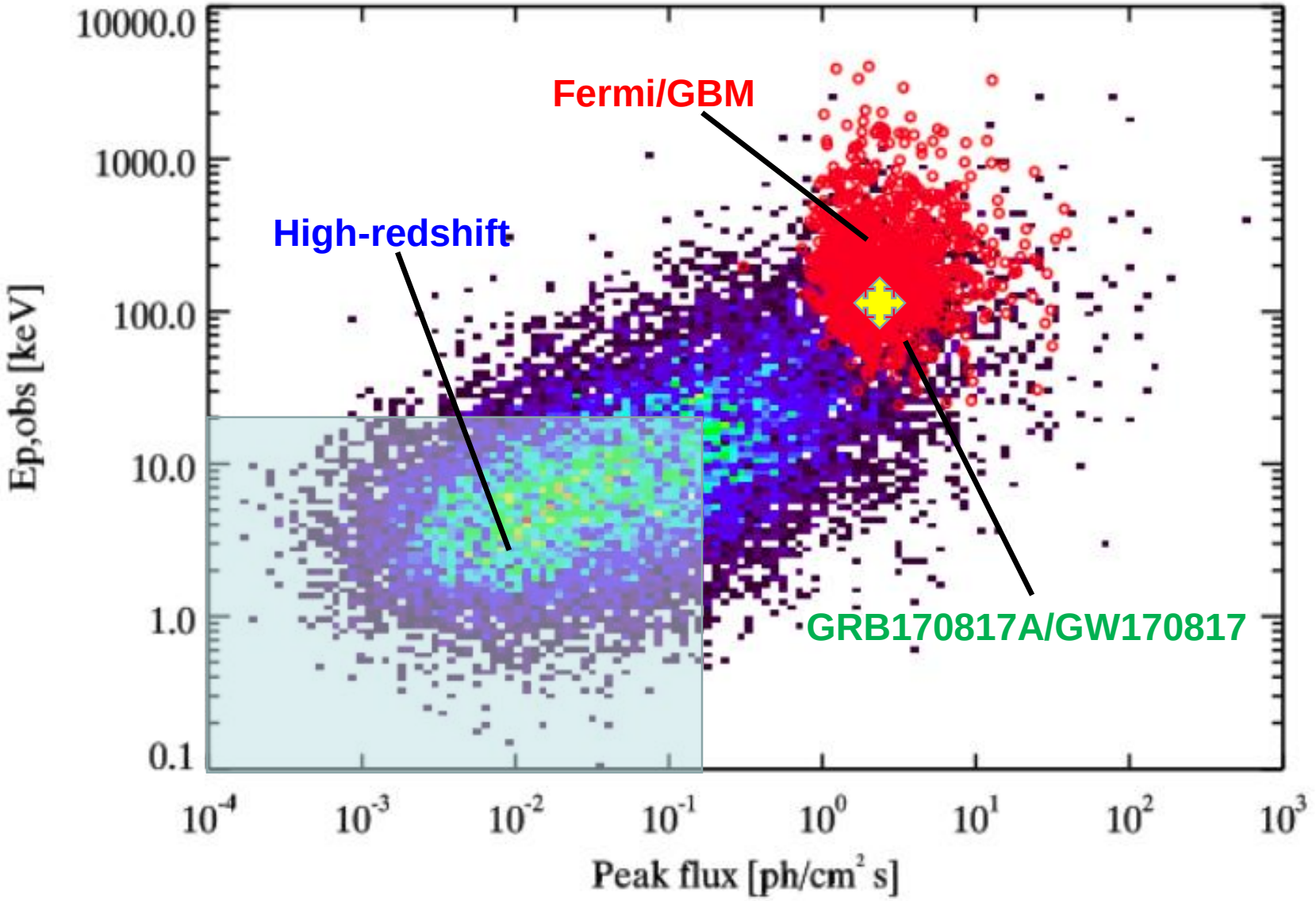
Hi-z GRB NIR spectroscopy



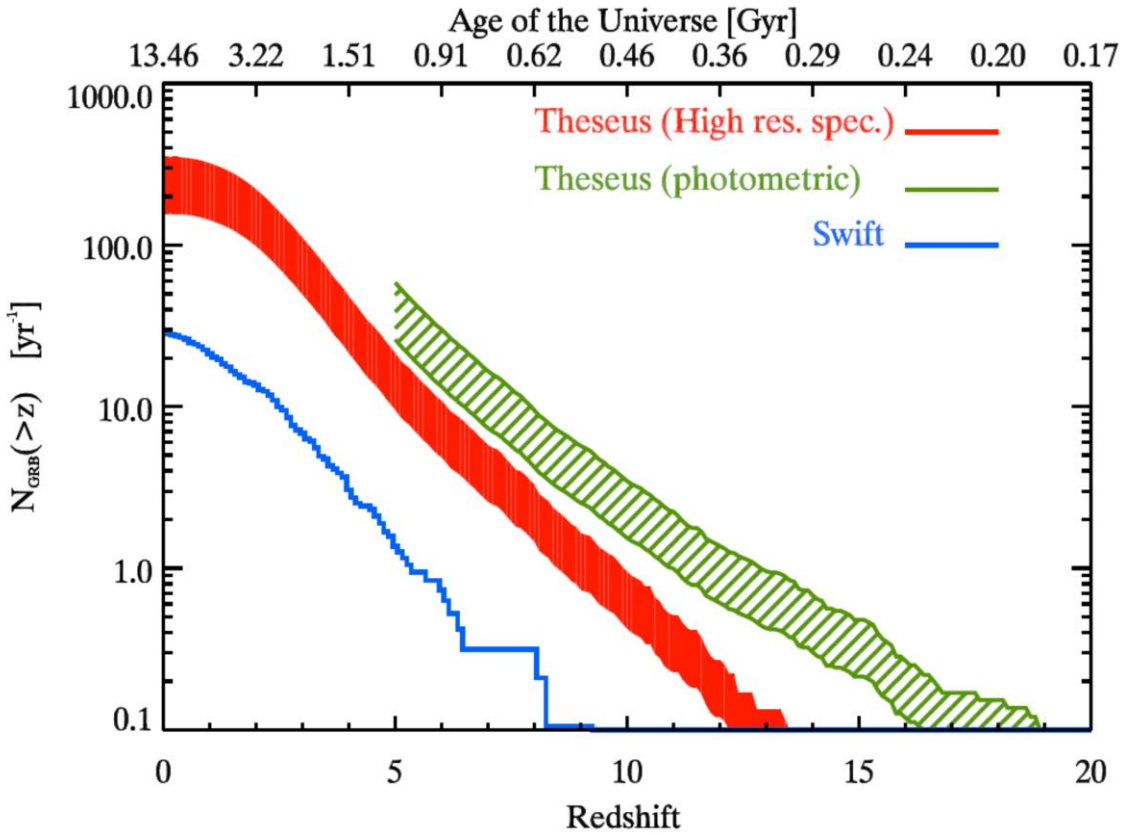
Very Hi-z GRB NIR spectroscopy



Peak energy vs peak flux of GRBs

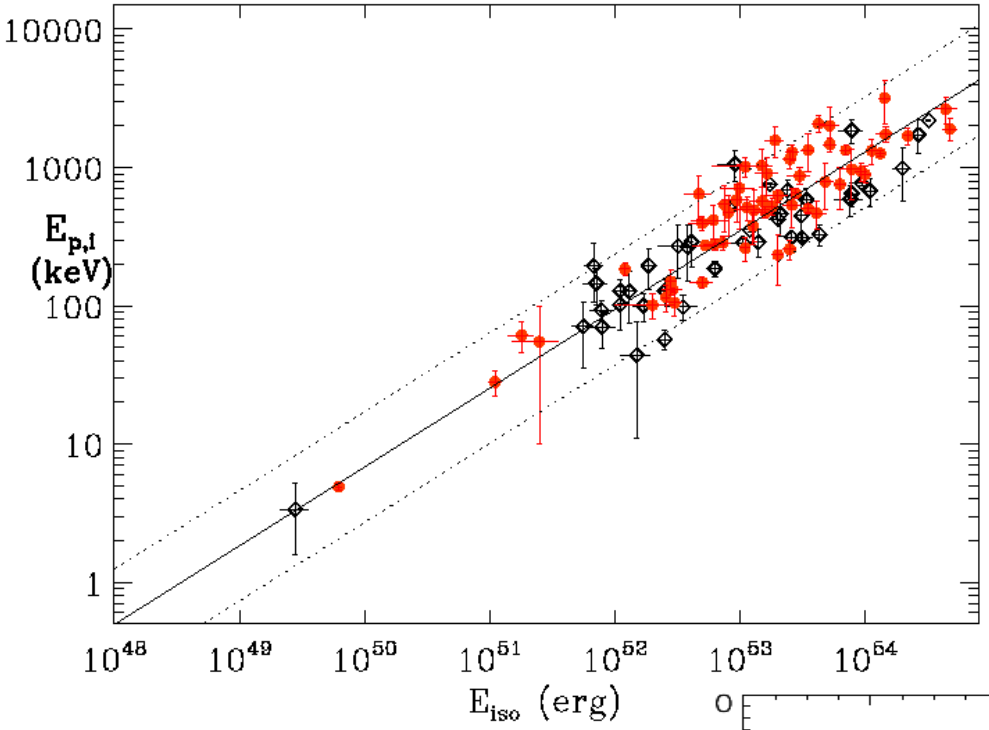


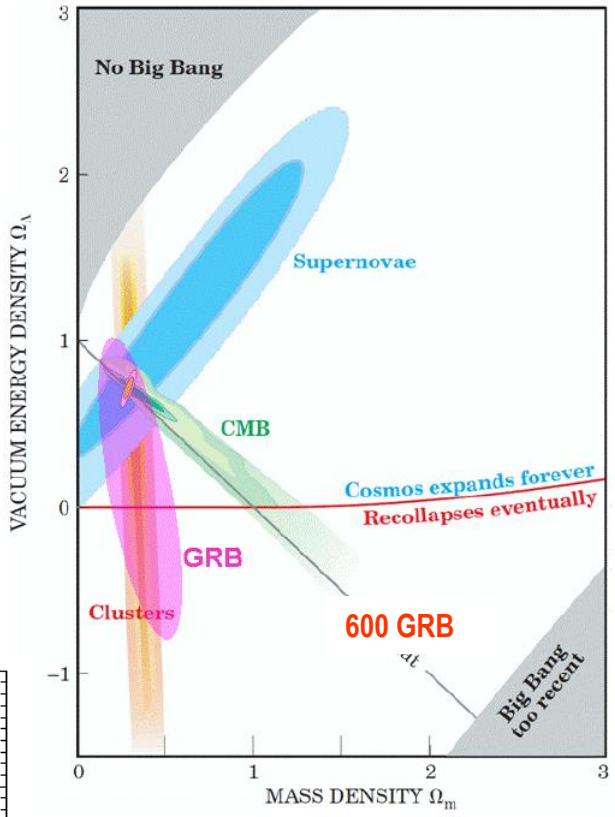
Comparison between THESEUS and Swift

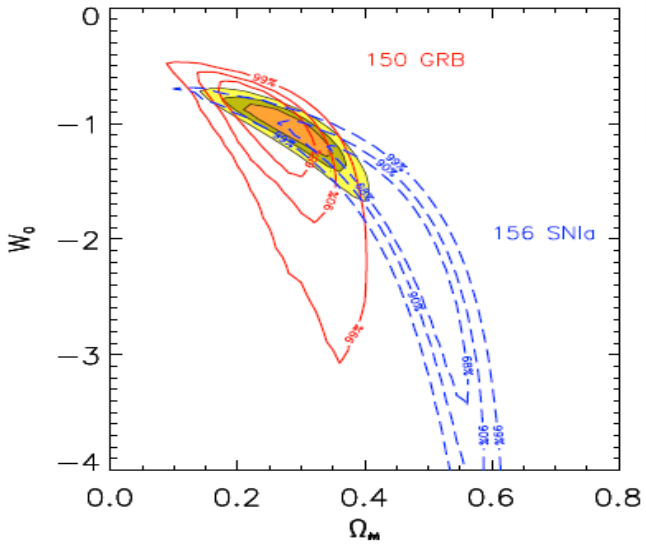


THESEUS GRB#/yr	All	z > 5	z > 8	z > 10
Detections	387 - 870	25 – 60	4 – 10	2 - 4
Photometric z		25 – 60	4 – 10	2 - 4
Spectroscopic z	156 - 350	10 - 20	1 - 3	0.5 - 1

measuring cosmological parameters with GRBs

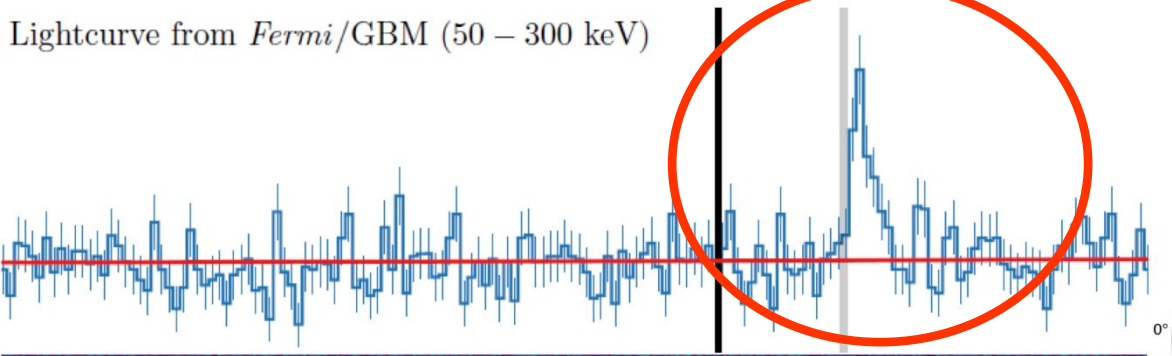


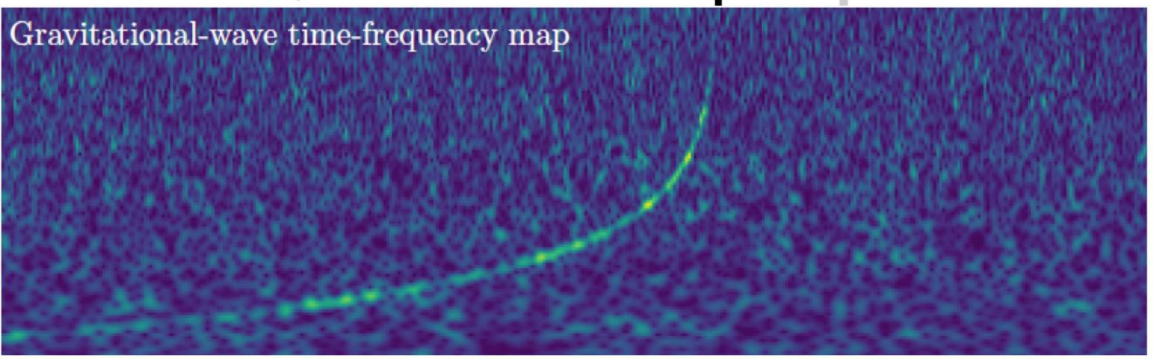


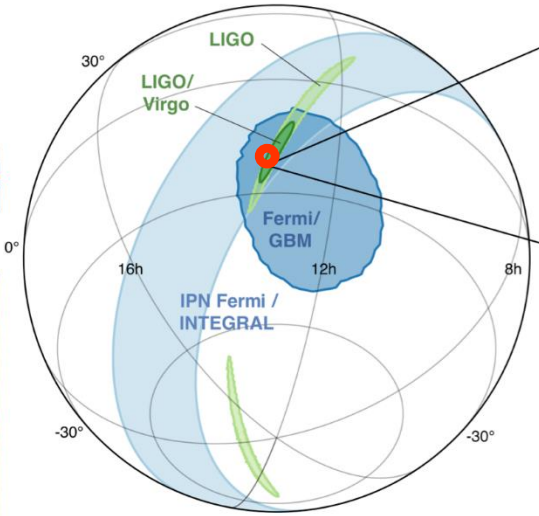


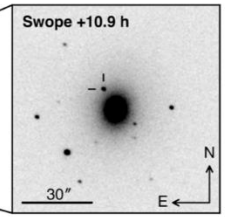
$$w(z) = w_0 + \frac{w_a z}{1+z}$$

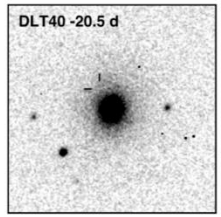
LIGO, Virgo, and partners make first detection of gravitational waves and light from colliding neutron stars

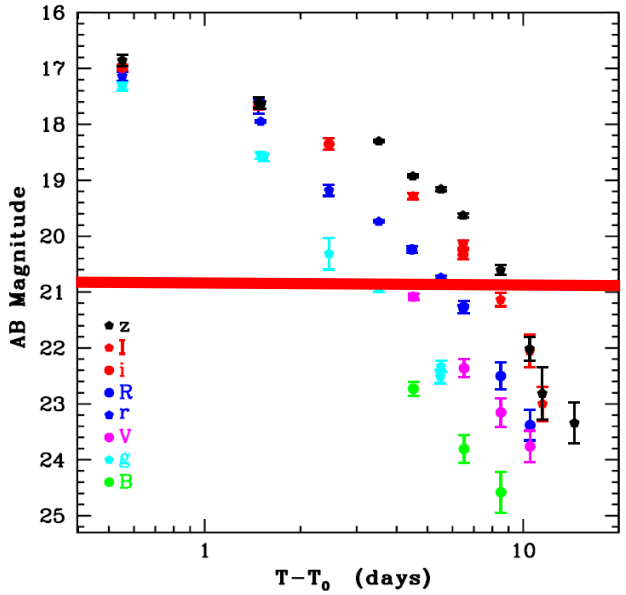








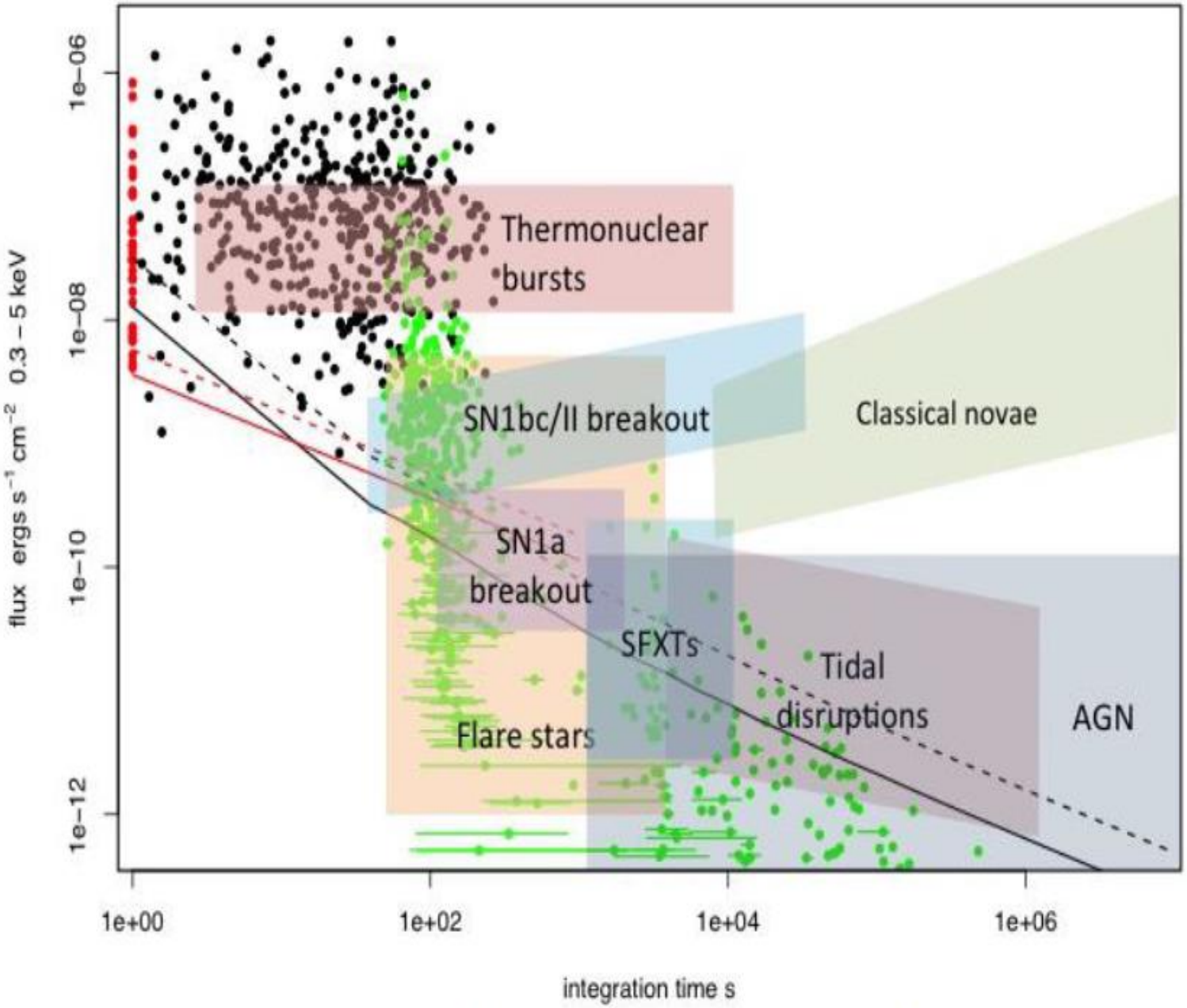




THESEUS:

- ✓ **short GRB detection over large FOV with arcmin localization**
- ✓ **Kilonova detection, arcsec localization and characterization**
- ✓ **Possible detection of weaker isotropic X-ray emission**

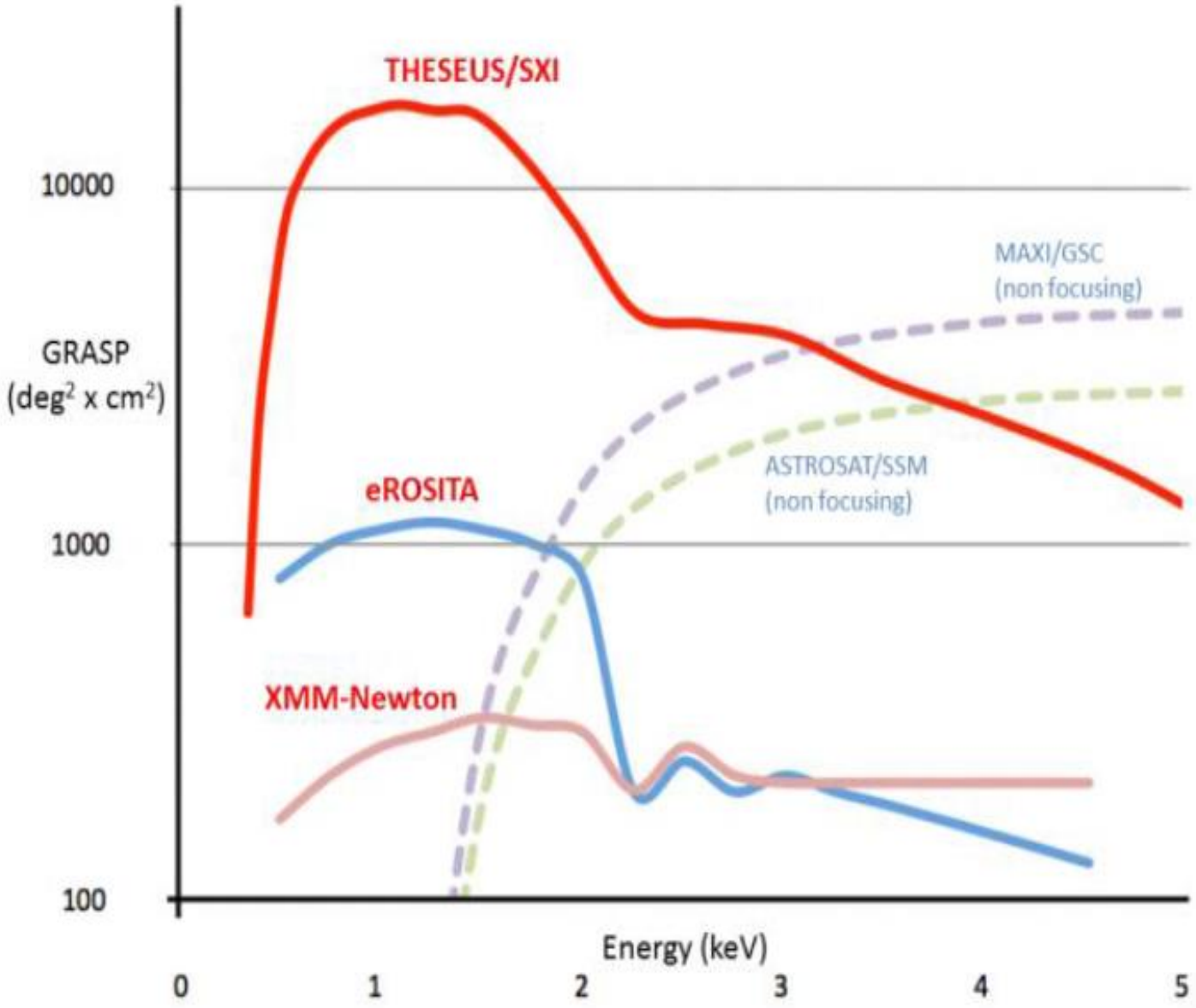
galactic and extra-galactic transients



Comparison with other GRB missions

- **Swift:** great, but narrow band for prompt (15-150 keV), follow-up only in X-rays: needs follow-up from ground telescopes for redshift determination (-> inefficiency)
- **Fermi/GBM:** large FOV and energy band, but small detectors, energy band > 10 keV, small efficiency above 300 keV (up to several MeVs only for bright events); localization only tens of square degrees
- **SVOM (2022-):** prompt emission down to 5 keV and up to MeVs, prompt follow-up with small X-ray and OUV telescopes, dedicated on-ground telescopes
- **HXMT:** limited to > 500 keV but with unprecedented area (optimal for short GRBs and joint analysis)

Comparison with other high energy missions



Summary

THESEUS (launch foreseen in 2032), currently under ESA/M5 Phase A, will exploit GRBs as powerful and unique tools to investigate the early Universe

THESEUS will also play a fundamental role for GW/multi-messenger and time domain astrophysics by providing a flexible follow-up observatory for fast transient events with multi-wavelength ToO capabilities and guest-observer programmes

Synergies are foreseen with the large observatories existing or coming online during the next decade: LSST, Athena, SKA, E-ELT, TMT, CTA, JWST, aLIGO/aVirgo, IceCube, Antares, Km3Net, eLISA, Einstein Telescope….

THESEUS CONFERENCE 2020: MALAGA (SPAIN), 12-15 May 2020
https://www.isdc.unige.ch/theseus/theseus-conference-2020.html