theseus

TRANSIENT HIGH ENERGY SKY AND EARLY UNIVERSE SURVEYOR

Lorenzo Amati

(INAF – OAS Bologna)

on behalf of the THESEUS international collaboration

ISTITUTO NAZIONALE DI ASTROFISICA INAF

theseus
transient high energy sky and early universe surveyor

http://www.isdc.unige.ch/theseus/

Amati et al. 2017 (Adv.Sp.Res., arXiv:1710.04638)
Stratta et al. 2017 (Adv.Sp.Res., arXiv:1712.08153)

HEPRO VII

HIGH ENERGY PHENOMENA IN RELATIVISTIC OUTFLOWS VII

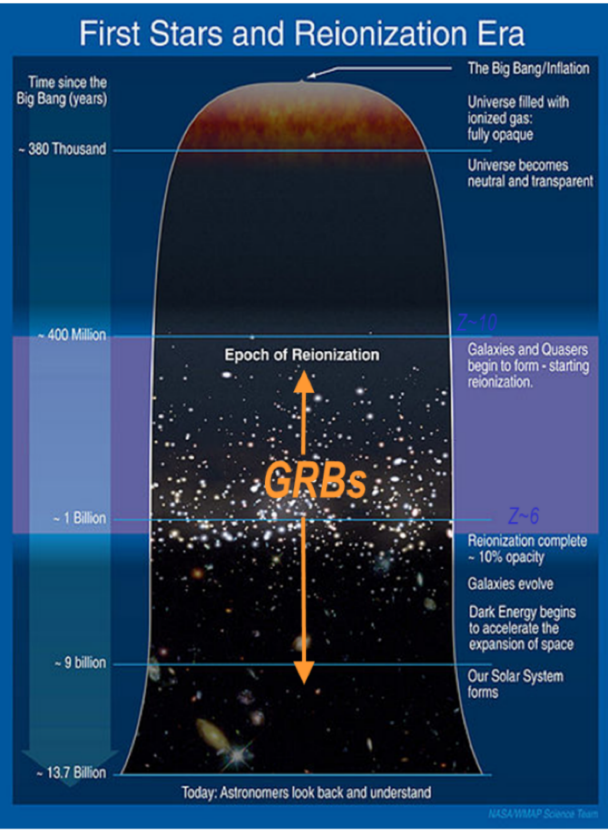
BARCELONA, 9-12 JULY 2019

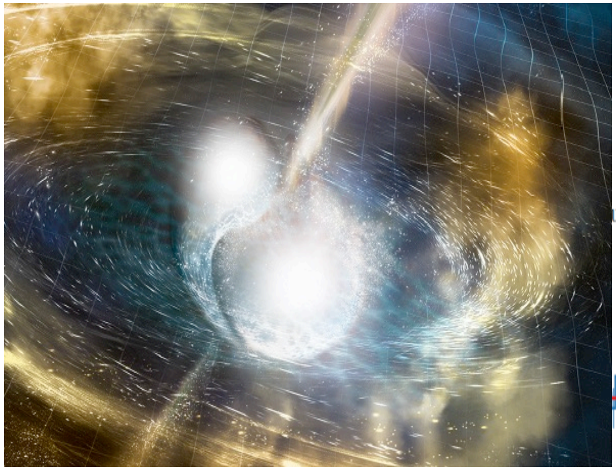
www.isdc.unige.ch/theseus/workshop2017-programme.html

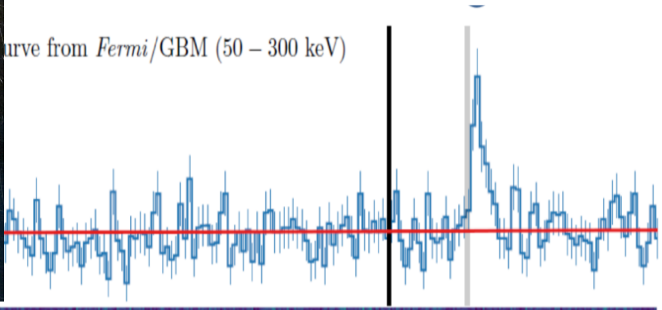
Proceedings preprints on the arXiv in early February

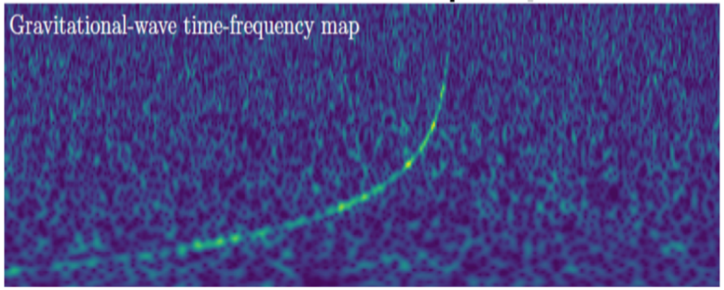
(Mem.SAIt, Vol. 89 – N.1 - 2018)

Probing the Early Universe with GRBs
Multi-messenger and time domain Astrophysics
The transient high energy sky
Synergy with next generation large facilities (E-ELT, SKA, CTA, ATHENA, GW and neutrino detectors)









THESEUS
Transient High Energy Sky and Early Universe Surveyor

Lead Proposer (ESA/M5): Lorenzo Amati (INAF – OAS Bologna, Italy)

Coordinators (ESA/M5): Lorenzo Amati, Paul O'Brien (Univ. Leicester, UK), Diego Gotz (CEA-Paris, France), C. Tenzer (Univ. Tuebingen, D), E. Bozzo (Univ. Genève, CH)

Payload consortium: Italy, UK, France, Germany, Switzerland, Spain, Poland, Czech Republic, Ireland, Hungary, Slovenia , ESA

Interested international partners: USA, China, Brazil

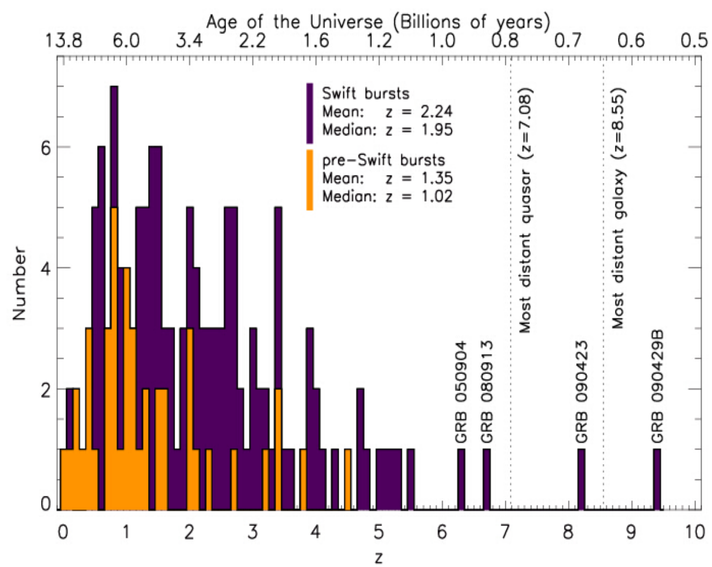
May 2018: THESEUS selected by ESA for M5 Phase 0/A study

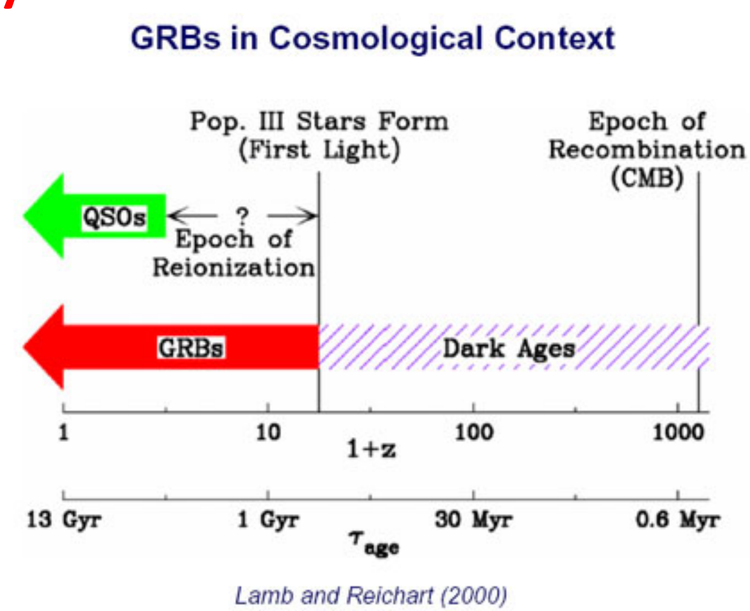
Activity	Date
Phase 0 kick-off	June 2018
Phase 0 completed (EnVision, SPICA and THESEUS)	End 2018
ITT for Phase A industrial studies	February 2019
Phase A industrial kick-off	June 2019
Mission Selection Review (technical and programmatic review for the three mission candidates)	Comleted by May 2021
SPC selection of M5 mission	June 2021
Phase B1 kick-off for the selected M5 mission	December 2021
Mission Adoption Review (for the selected M5 mission)	March 2024
SPC adoption of M5 mission	June 2024
Phase B2/C/D kick-off	Q1 2025
Launch	2032

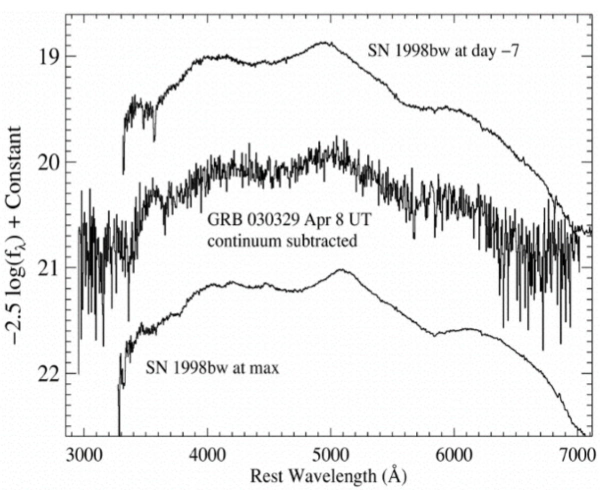
- ❑ **Smooth CDF study, successful MDR -> Phase A**
- ❑ Efficient and positive interaction between ESA and consortium

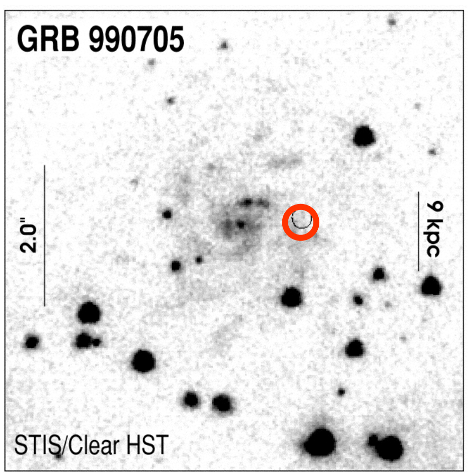
Shedding light on the early Universe with GRBs

Because of their huge luminosities, mostly emitted in the X and gamma-rays, their redshift distribution extending at least to z ~9 and their association with explosive death of massive stars and star forming regions, GRBs are unique and powerful tools for investigating the early Universe: **SFR evolution, physics of re-ionization, galaxies metallicity evolution and luminosity function, first generation (pop III) stars**





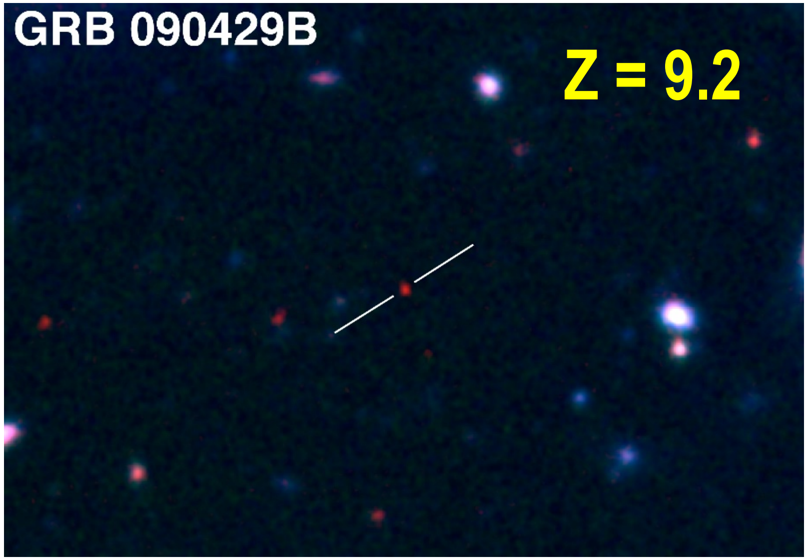


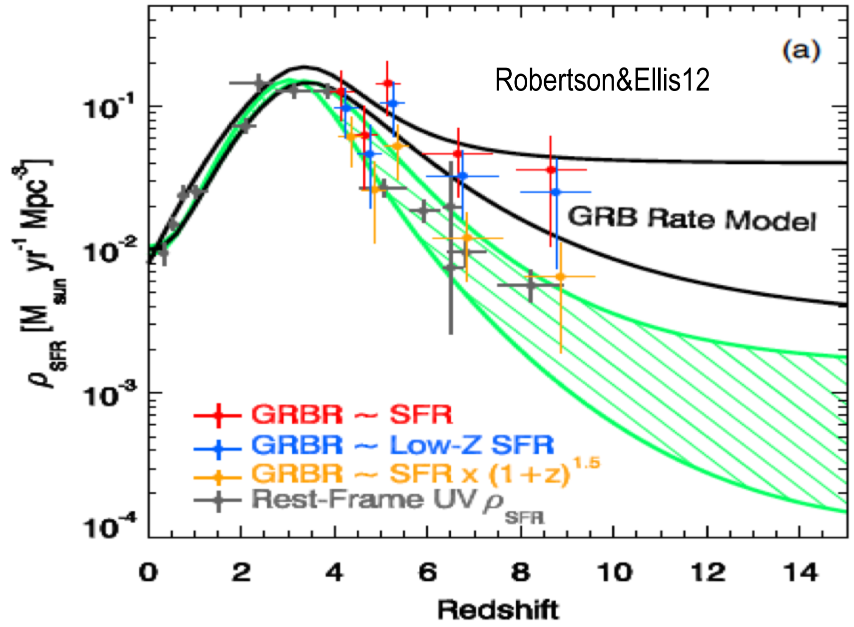


A statistical sample of high–z GRBs can provide fundamental information:

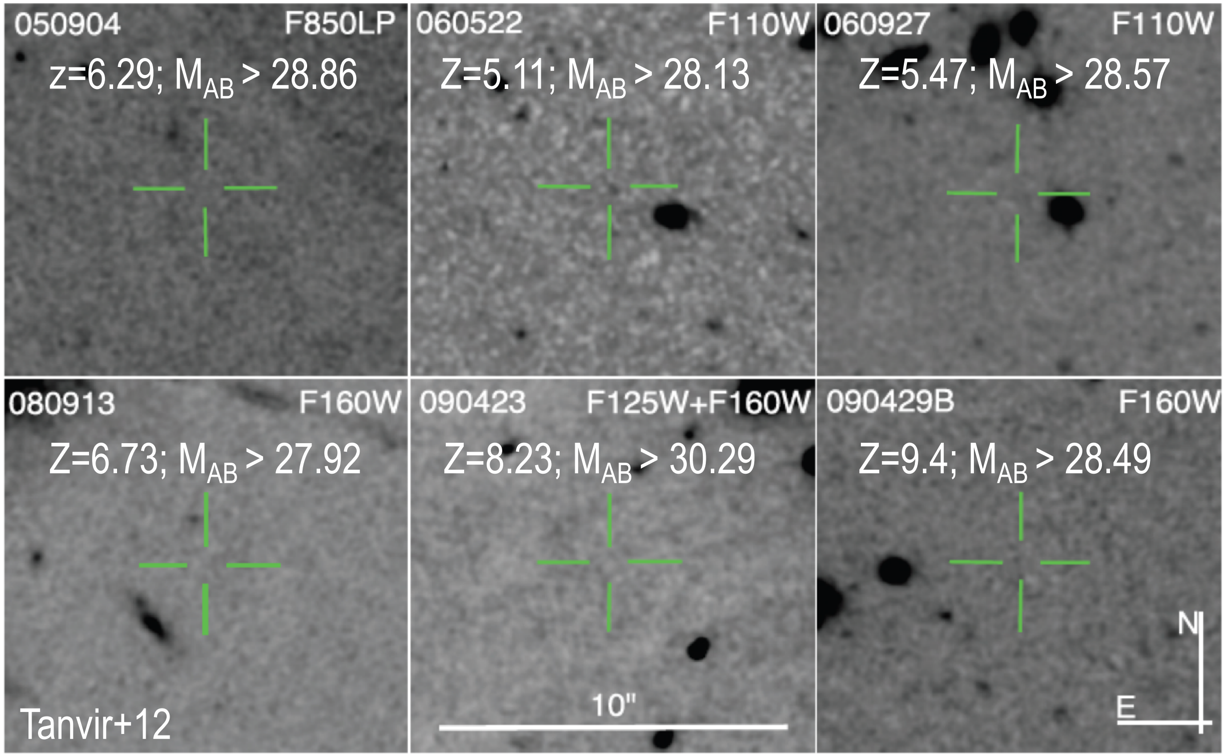
- measure independently the **cosmic star–formation rate**, even beyond the limits of current and future galaxy surveys

- directly (or indirectly) detect the **first population of stars (pop III)**





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

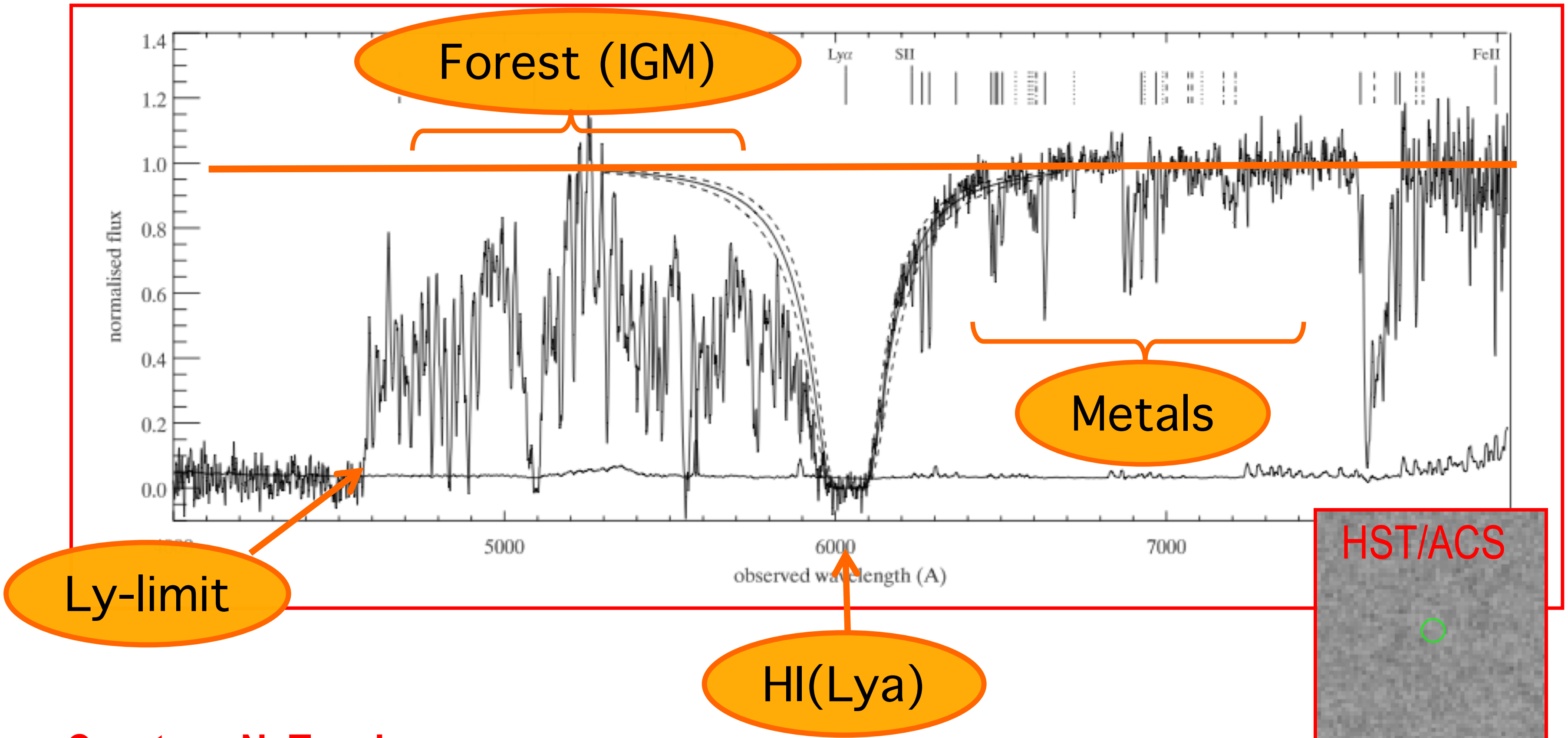


Robertson&Ellis12

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**

Abundances, HI, dust, dynamics etc. even for very faint hosts. E.g. GRB 050730: faint host (R>28.5), but z=3.97, [Fe/H]=-2 and low dust, from afterglow spectrum (Chen et al. 2005; Starling et al. 2005).



Courtesy N. Tanvir

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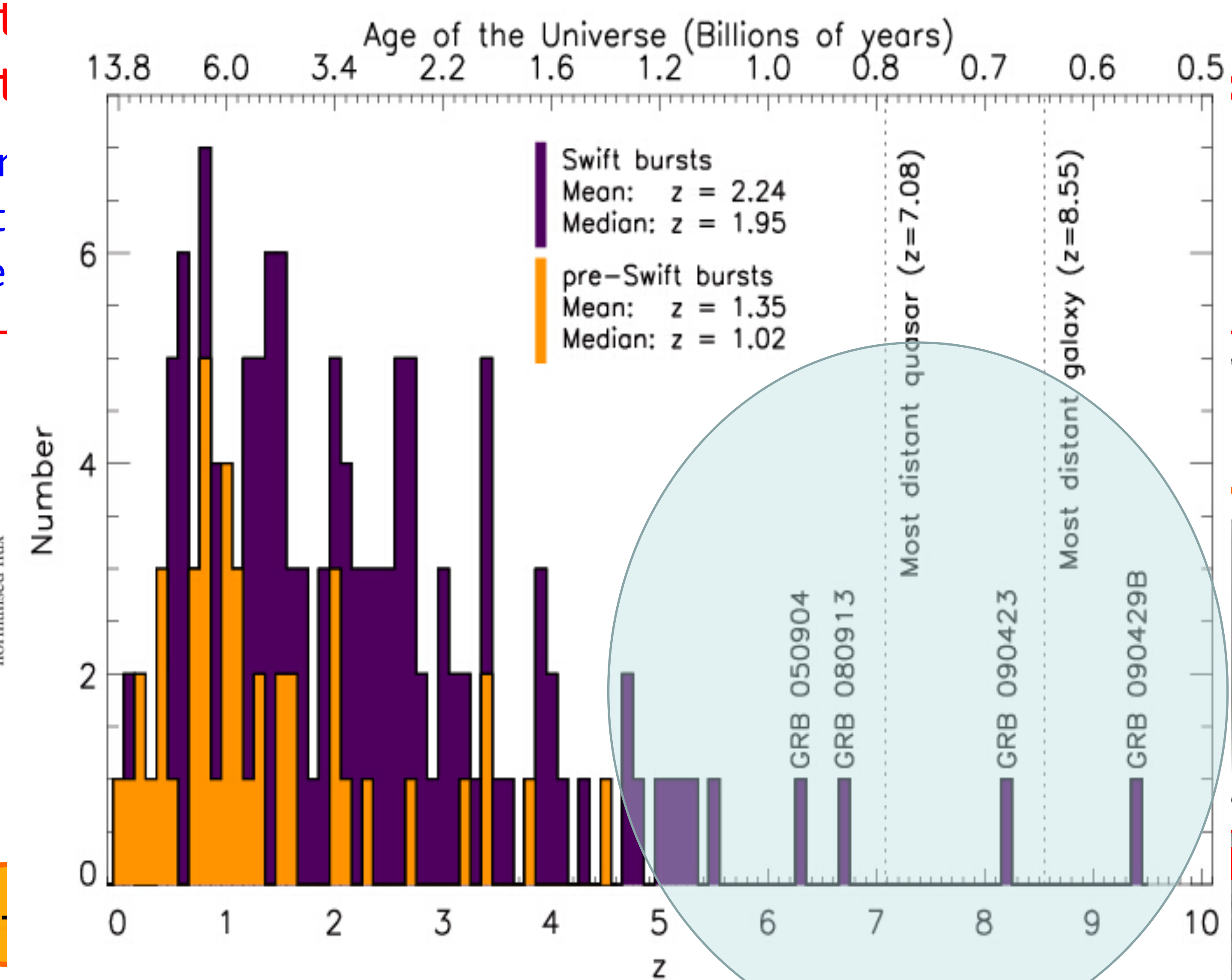
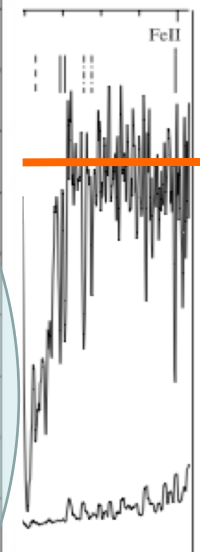
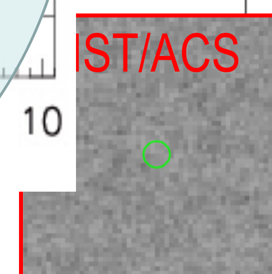






normalised flux

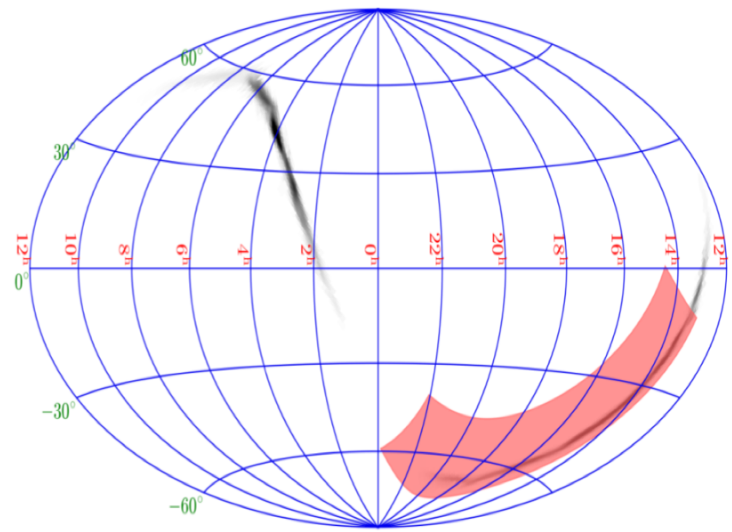
Ly-

HI(Lya)

Courtesy N. Tanvir

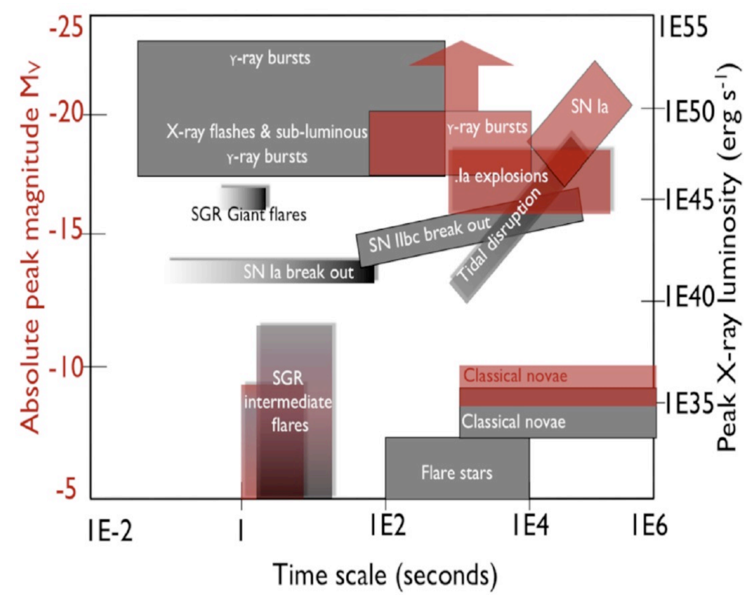
Exploring the multi-messenger transient sky

- **Locate and identify the electromagnetic counterparts to sources of gravitational radiation and neutrinos, which may be routinely detected in the late '20s / early '30s by next generation facilities like aLIGO/aVirgo, eLISA, ET, or Km3NET;**

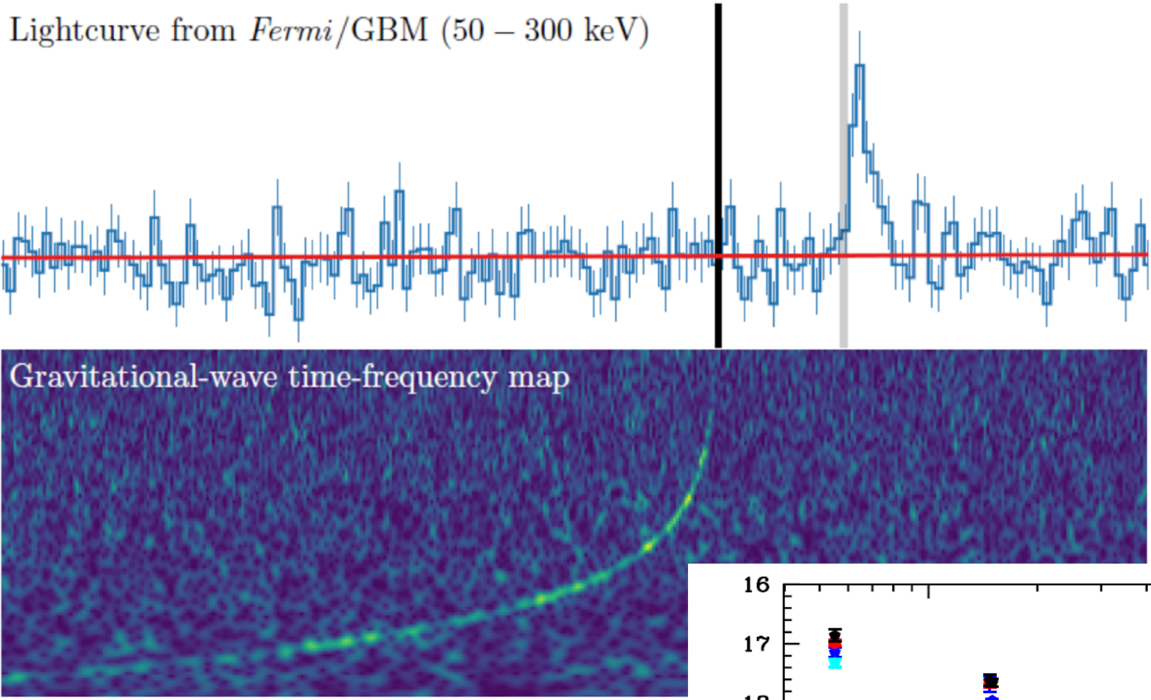


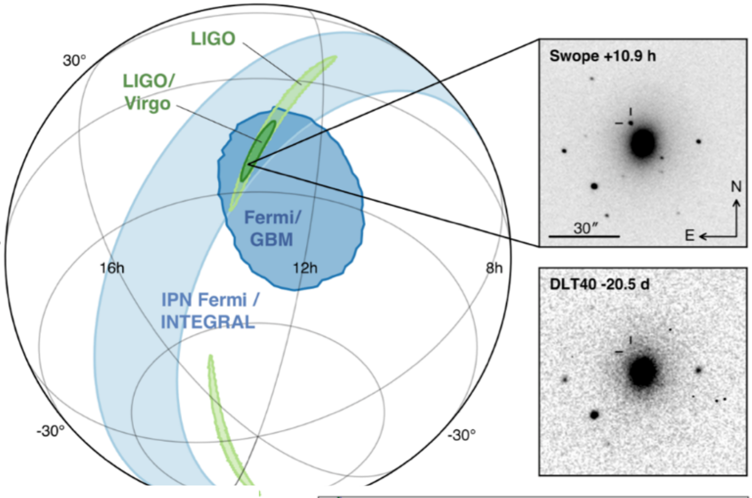
- Provide real-time triggers and accurate (~1 arcmin within a few seconds; ~1'' within a few minutes) **high-energy transients for follow-up with next-generation optical-NIR (E-ELT, JWST if still operating), radio (SKA), X-rays (ATHENA), TeV (CTA) telescopes; synergy with LSST**

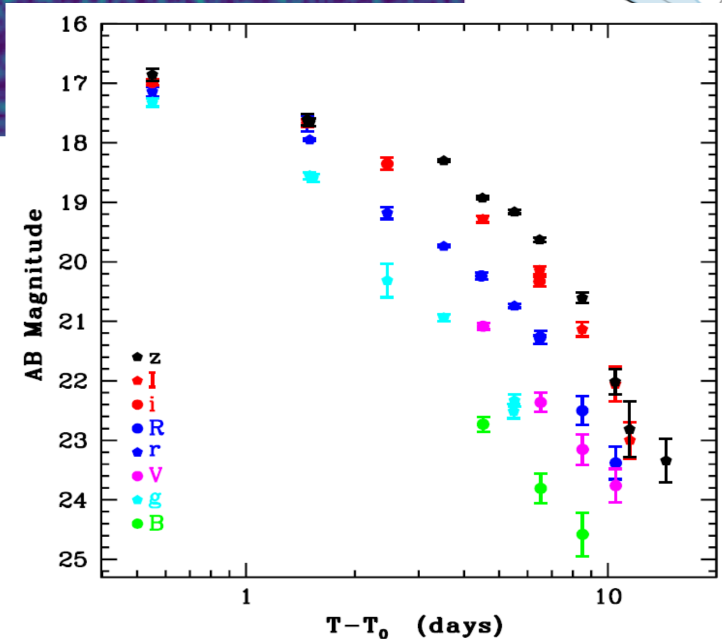
- Provide a fundamental step forward in the comprehension of the physics of various classes of transients and **fill the present gap in the discovery space of new classes of transients events**

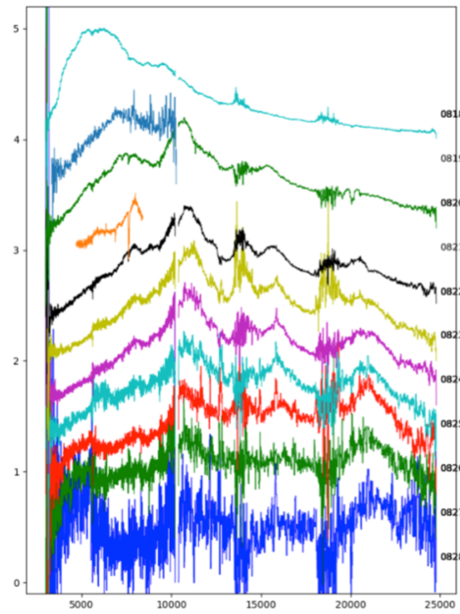


LIGO, Virgo, and partners make first detection of gravitational waves and light from colliding neutron stars



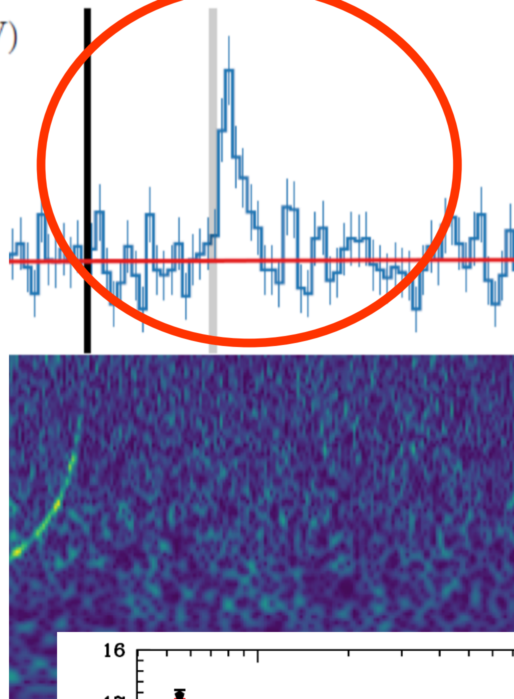






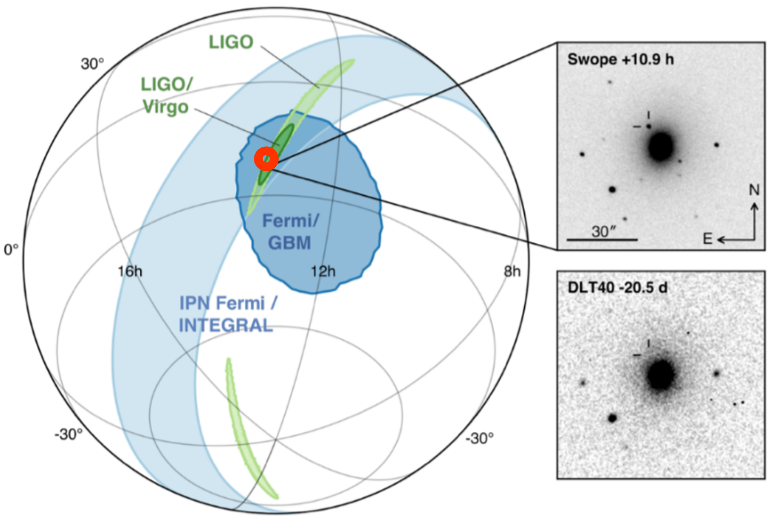
LIGO, Virgo, and partners make first detection of gravitational waves and light from colliding neutron stars

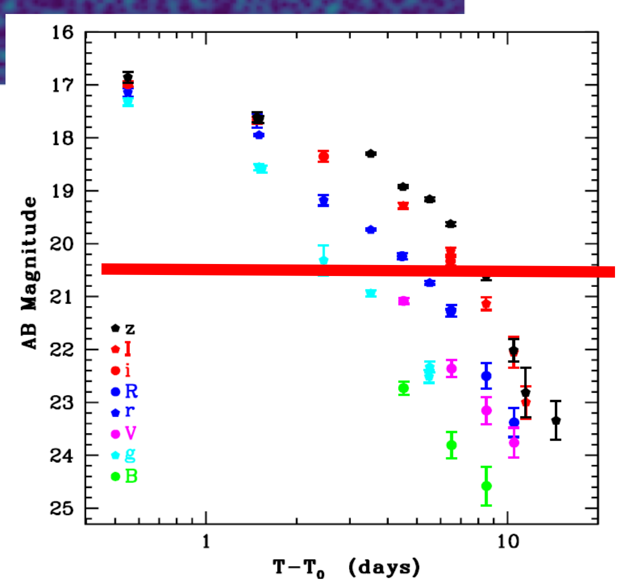
Lightcurve from *Fermi*/GBM (50 – 300 keV)

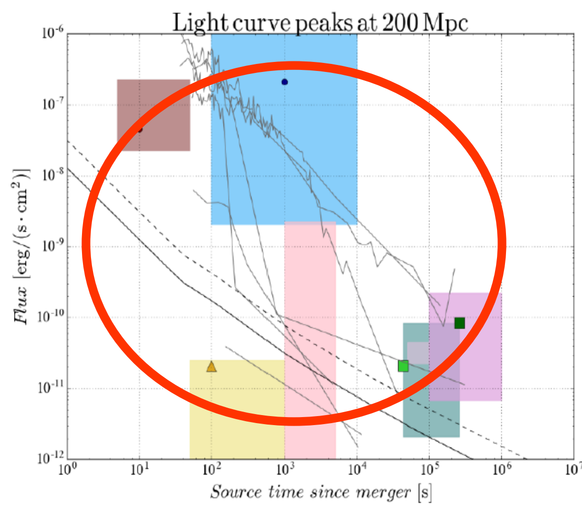


THESEUS:

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

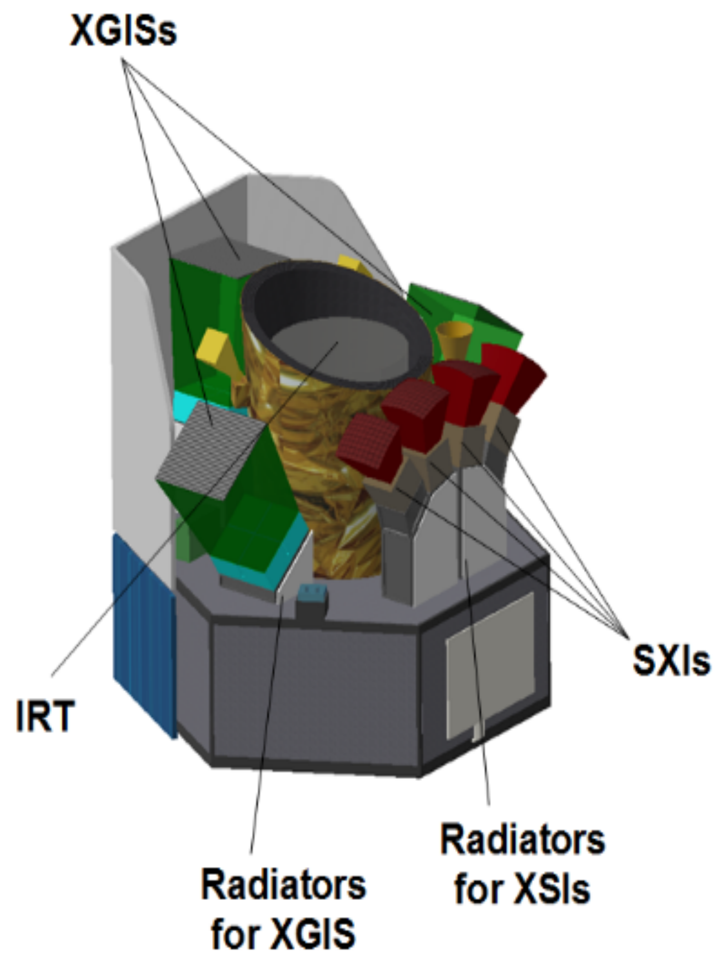






THESEUS mission concept

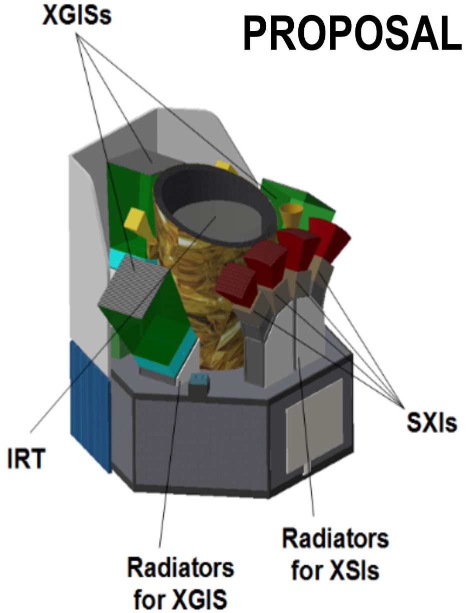
- **Soft X-ray Imager (SXI):** a set of four sensitive lobster-eye telescopes observing in **0.3 - 5 keV band, total FOV of ~1sr with source location accuracy 0.5-1';**
- **X-Gamma rays Imaging Spectrometer (XGIS,)**: 3 coded-mask X-gamma ray cameras using bars of Silicon diodes coupled with CsI crystal 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)**



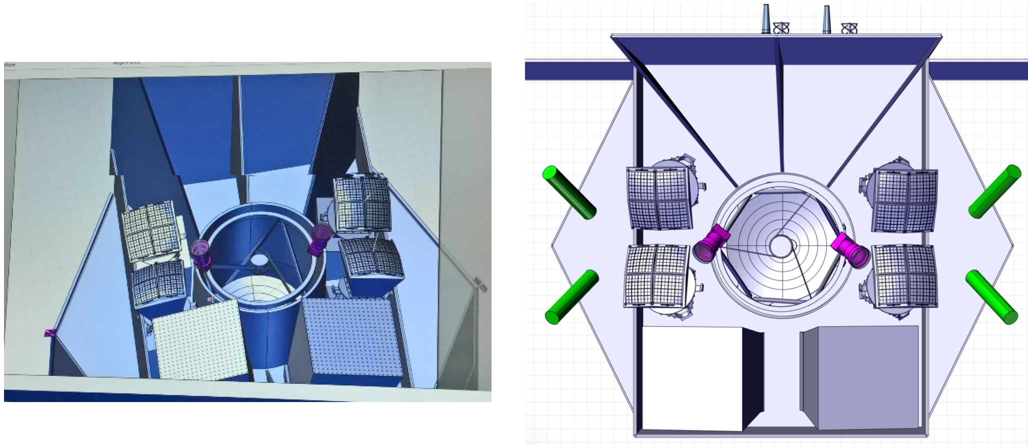
LEO (< 5°, ~600 km)
Rapid slewing bus
Prompt downlink

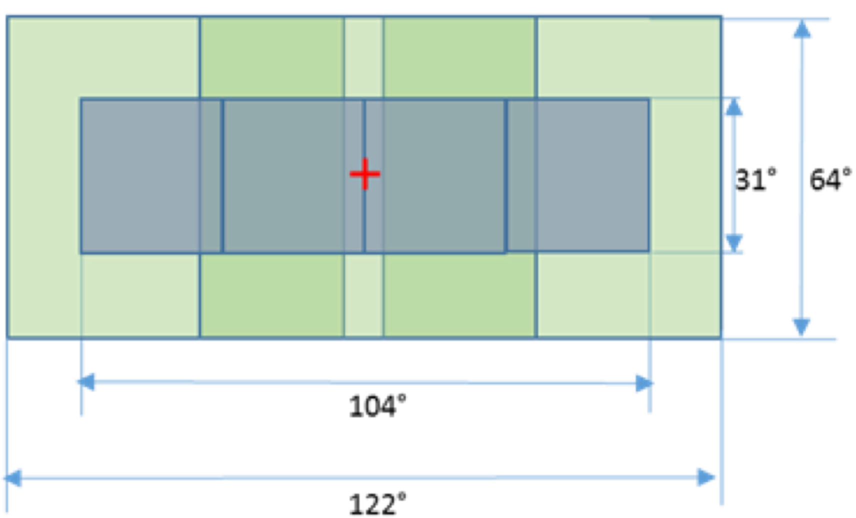
THESEUS mission concept: ESA study

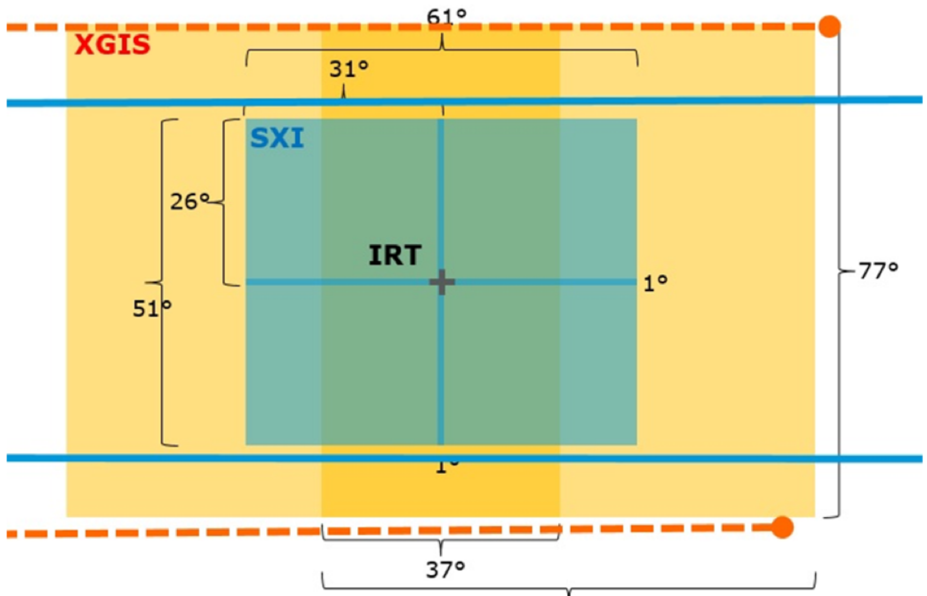
PROPOSAL



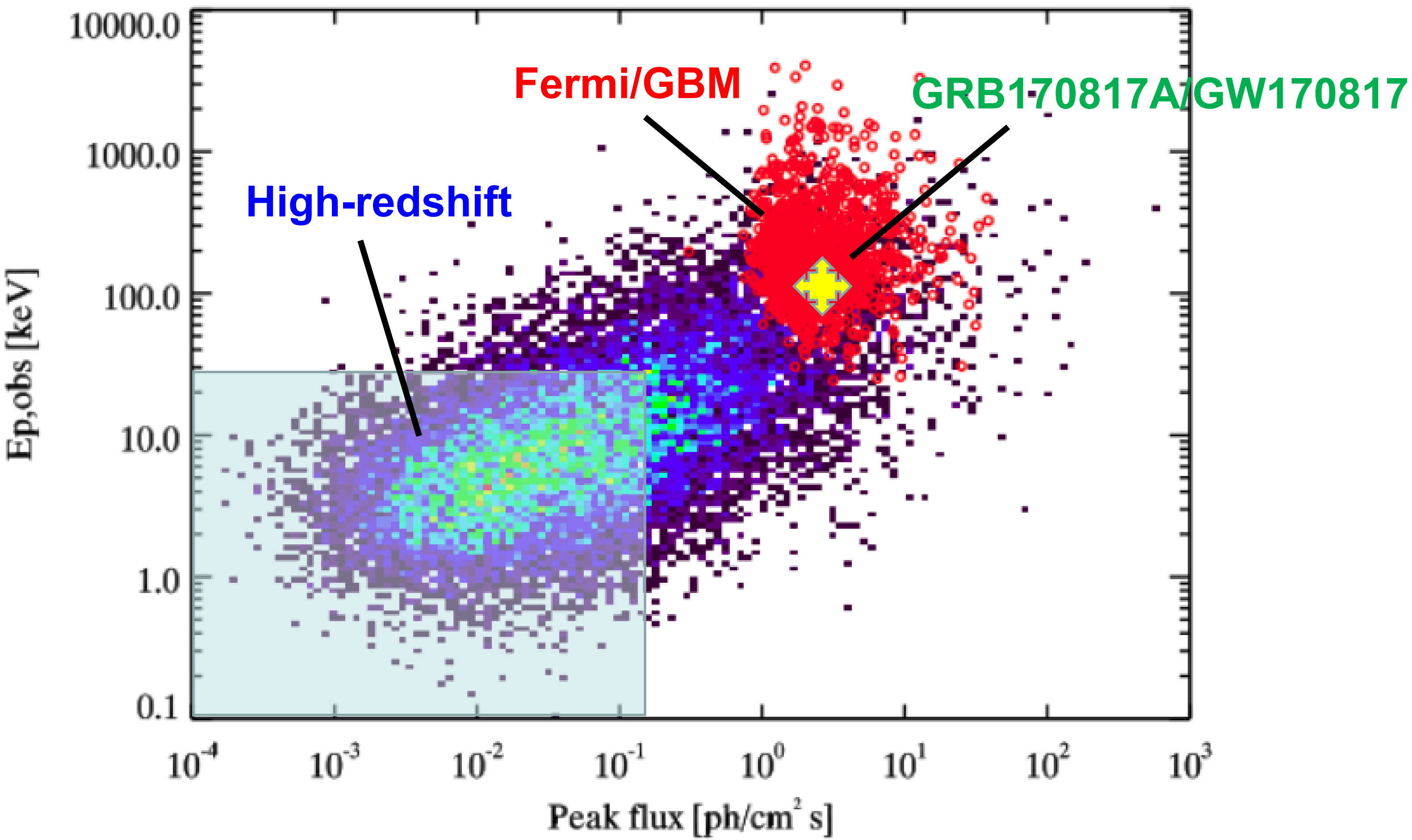
CDF STUDY



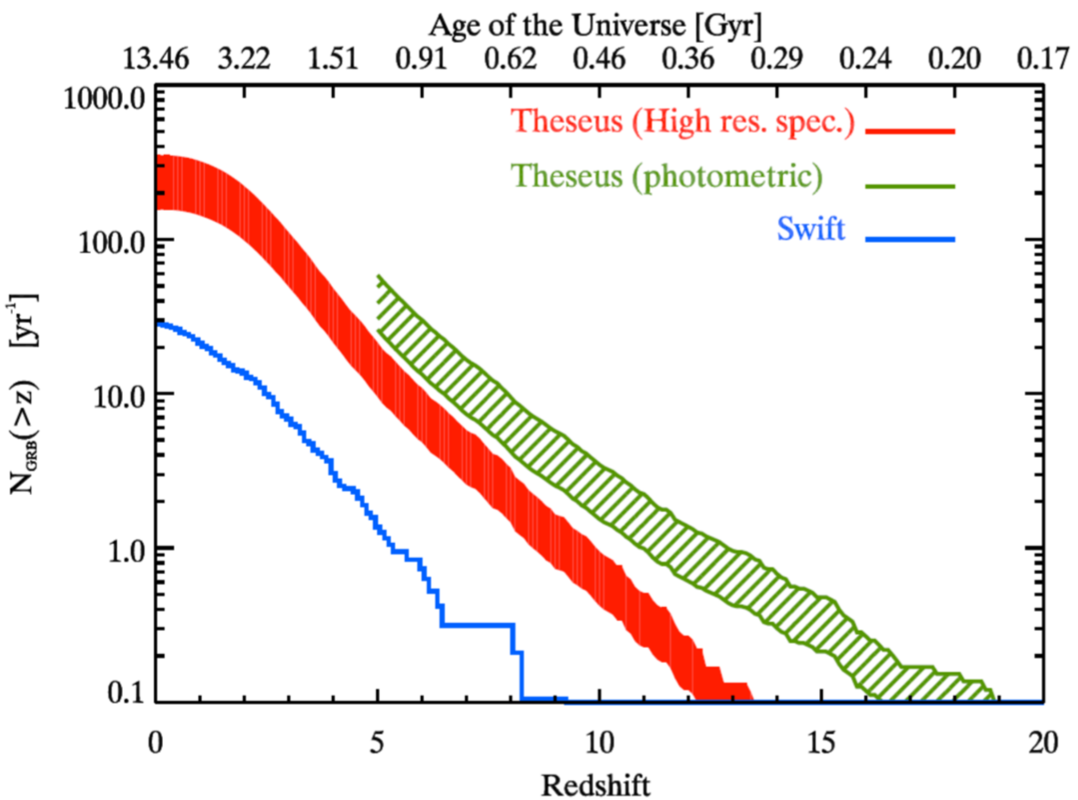




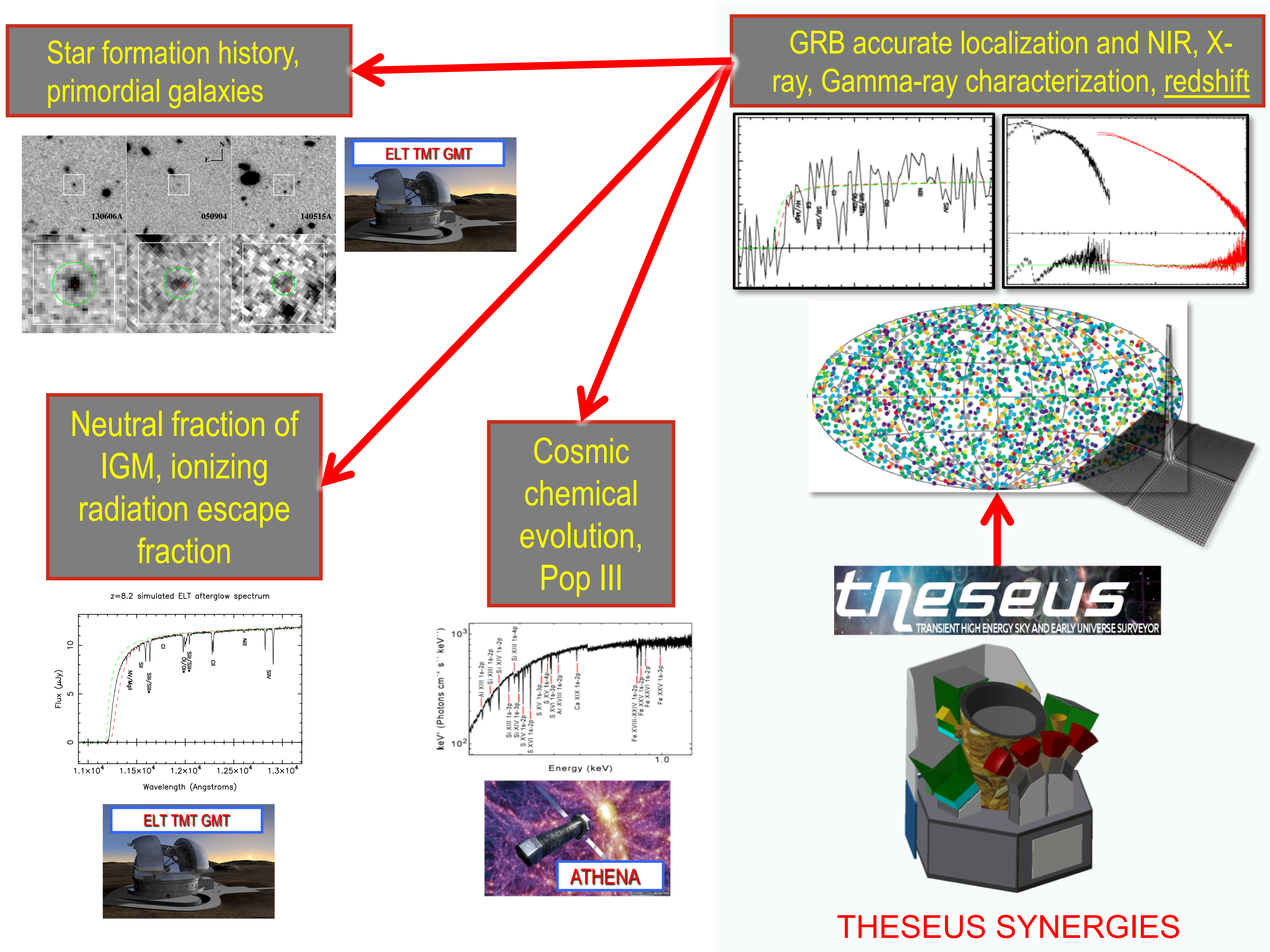
❑ **THESEUS will have the ideal combination of instrumentation and mission profile for detecting all types of GRBs (long, short/hard, weak/soft, high-redshift), localizing them from a few arcmin down to arsec and measure the redshift for a large fraction of them**



❑ Shedding light on the early Universe with GRBs



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


Star formation history, primordial galaxies
GRB accurate localization and NIR, X-ray, Gamma-ray characterization, redshift
130606A
050904
140515A
ELT TMT GMT
Neutral fraction of IGM, ionizing radiation escape fraction
Cosmic chemical evolution, Pop III
z=8.2 simulated ELT afterglow spectrum
Flux (μJy)
Wavelength (Angstroms)
Energy (keV)
ELT TMT GMT
ATHENA
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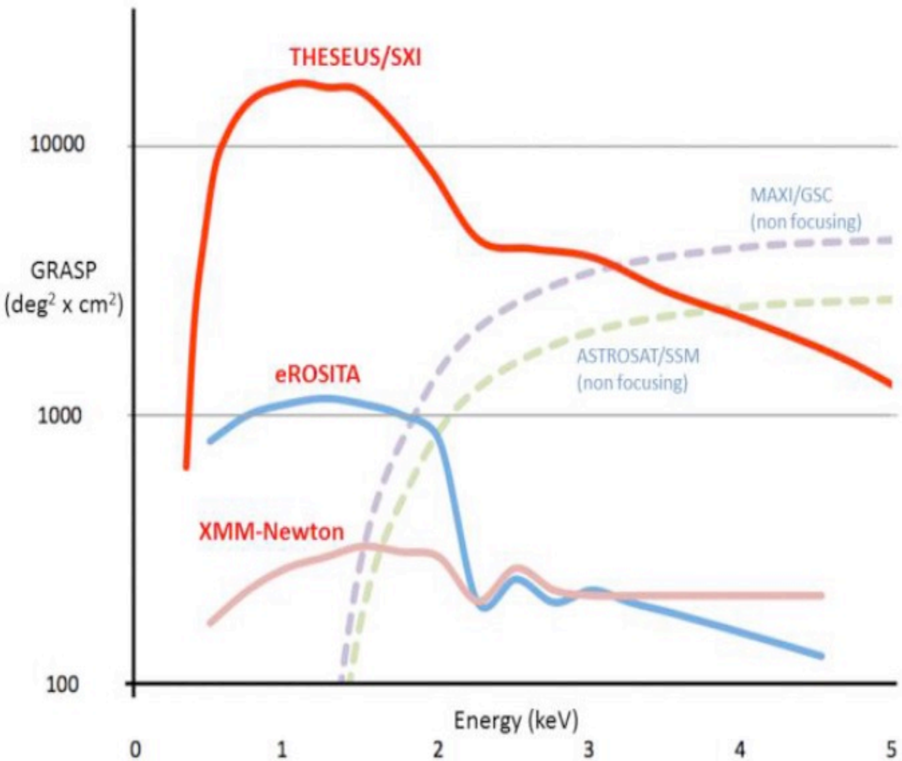
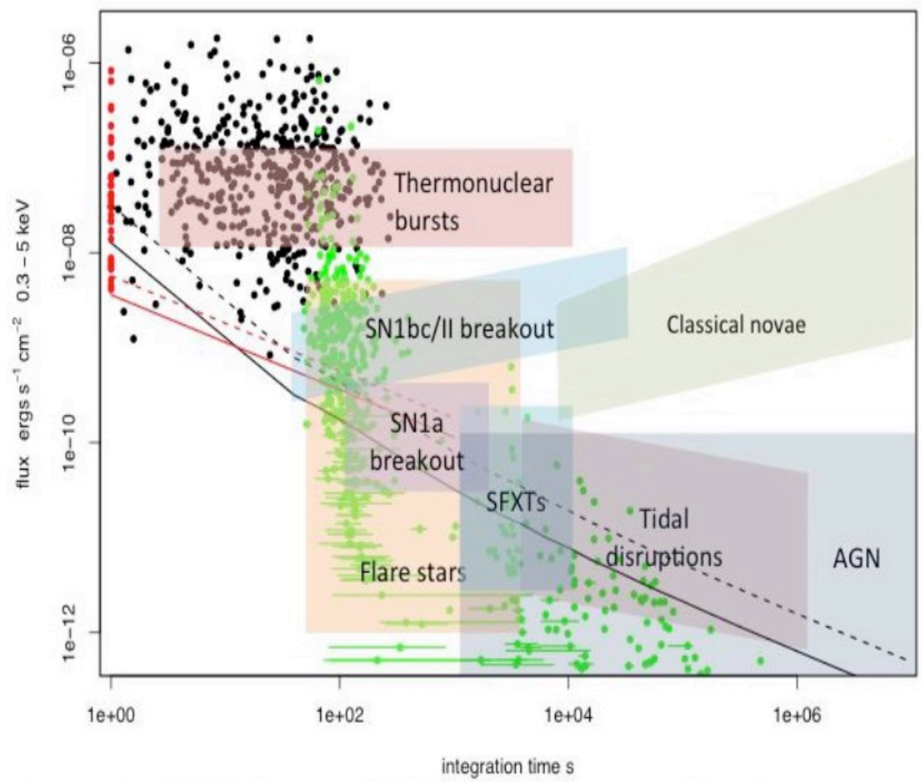
THESEUS SYNERGIES

❑ THESEUS will also detect and localize down to 0.5-1 arcmin the soft X-ray short/long GRB afterglows, of NS-NS mergers and of many classes of galactic and extra-galactic transients

❑ For several of these sources, THESEUS/IRT may provide detection and study of associated NIR emission, location within 1 arcsec and redshift





❑ GW/multi-messenger and time-domain astrophysics

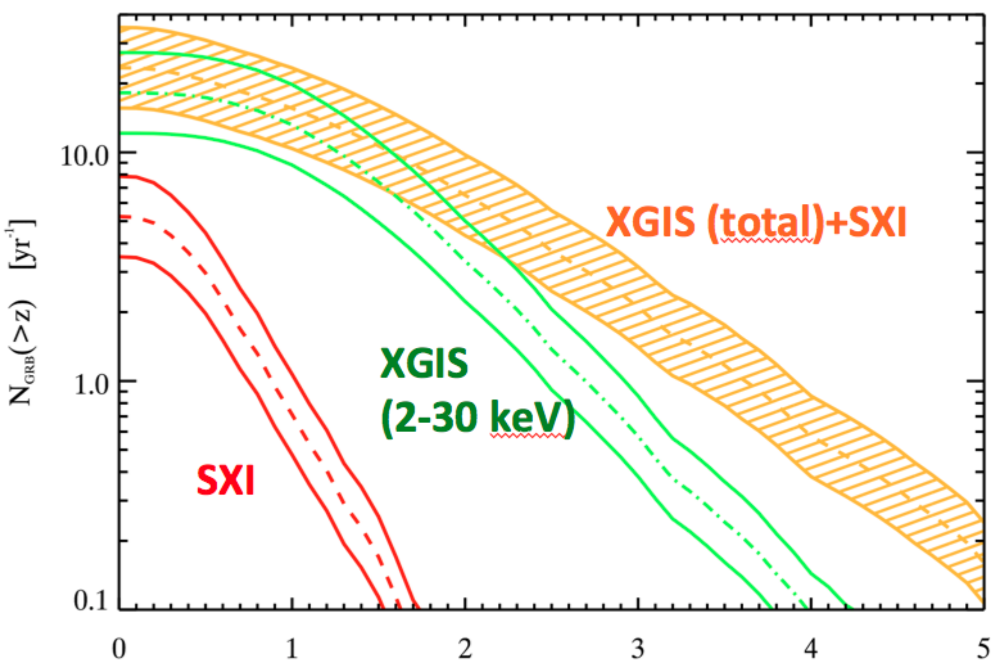
GW transient sources that will be monitored by THESEUS include:

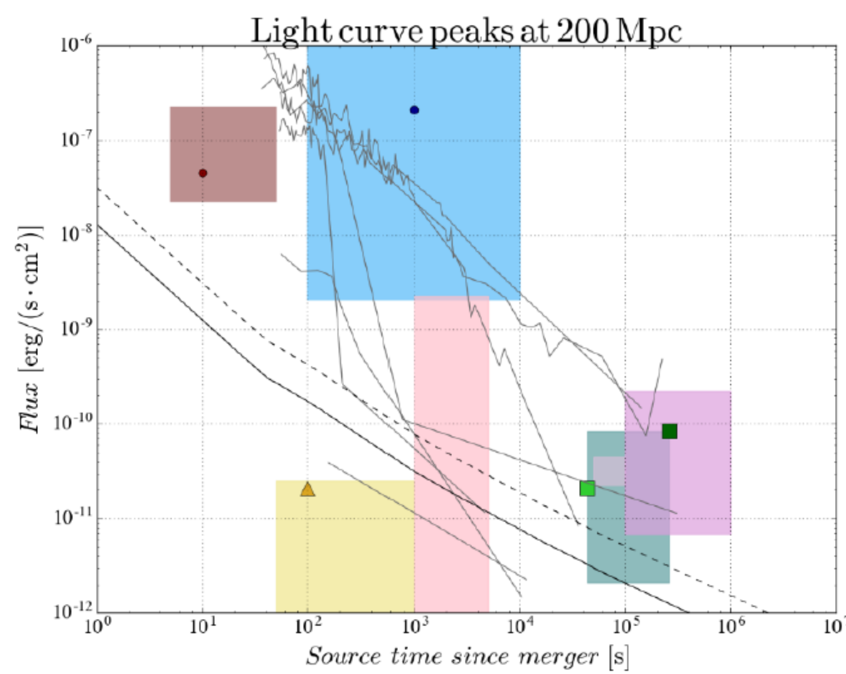
- ❑ **NS-NS / NS-BH mergers:**
  - ❑ **collimated** EM emission from short GRBs and their afterglows (rate up to 20/yr for 3G GW detectors as Einstein Telescope)
  - ❑ Optical/NIR and soft X-ray **isotropic** emissions from **macronovae, off-axis afterglows** and, for NS-NS, from newly born ms magnetar spindown (rate of GW detectable NS-NS or NS-BH systems, i.e. dozens-hundreds/yr)
- ❑ Core collapse of massive stars: Long GRBs, LLGRBs, ccSNe (much more uncertain predictions in GW energy output, possible rate of ~1/yr)
- ❑ Flares from isolated NSs: Soft Gamma Repeaters (although GW energy content is ~0.01%-1% of EM counterpart)

❑ GW/multi-messenger and time-domain astrophysics

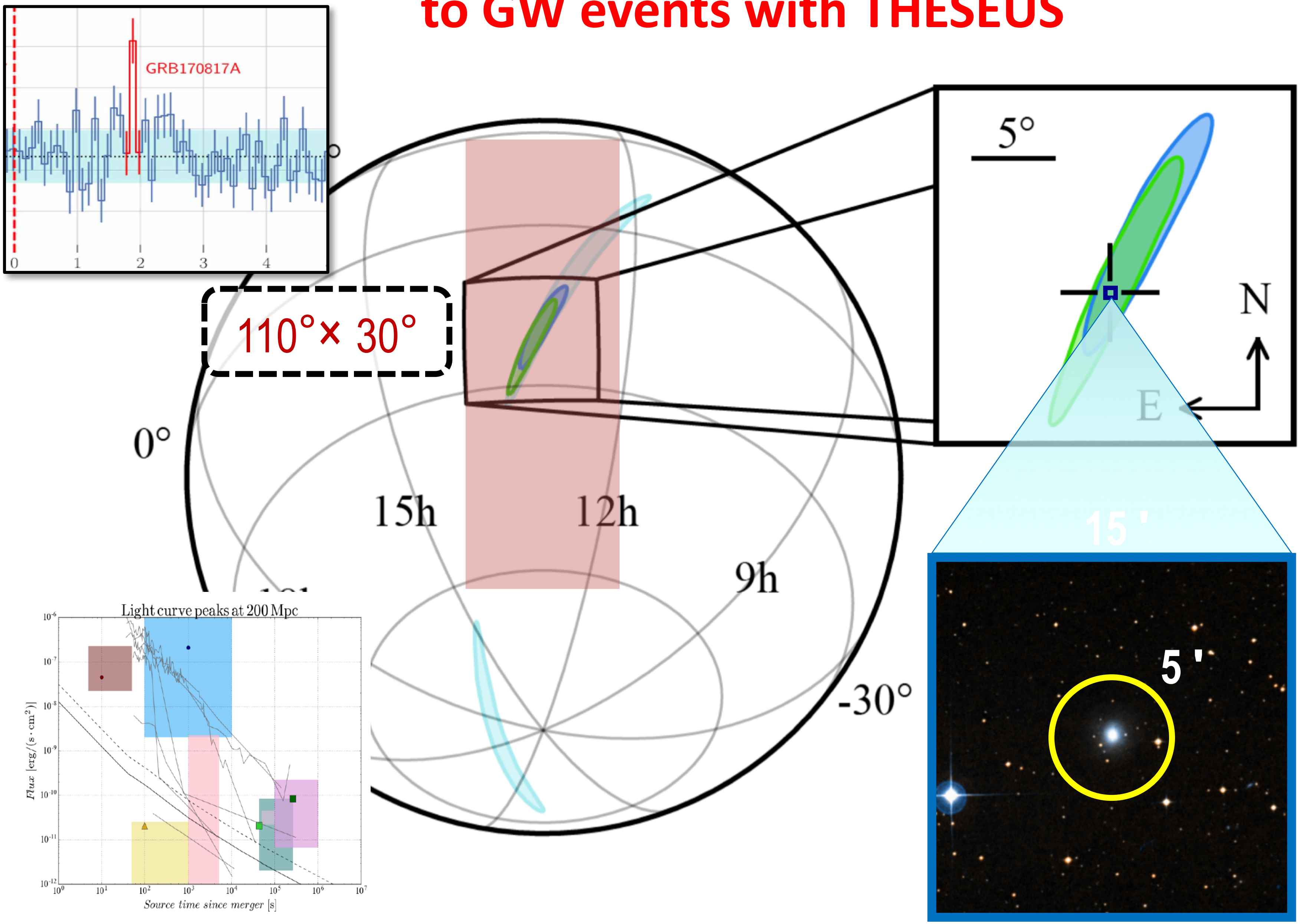
GW transient sources that will be monitored by THESEUS include **NS-NS / NS-BH mergers**:

- ❑ **collimated** on-axis and off-axis prompt gamma-ray emission from short GRBs
- ❑ Optical/NIR and soft X-ray **isotropic** emissions from kilonovae, off-axis afterglows and, for NS-NS, from newly born ms magnetar spindown

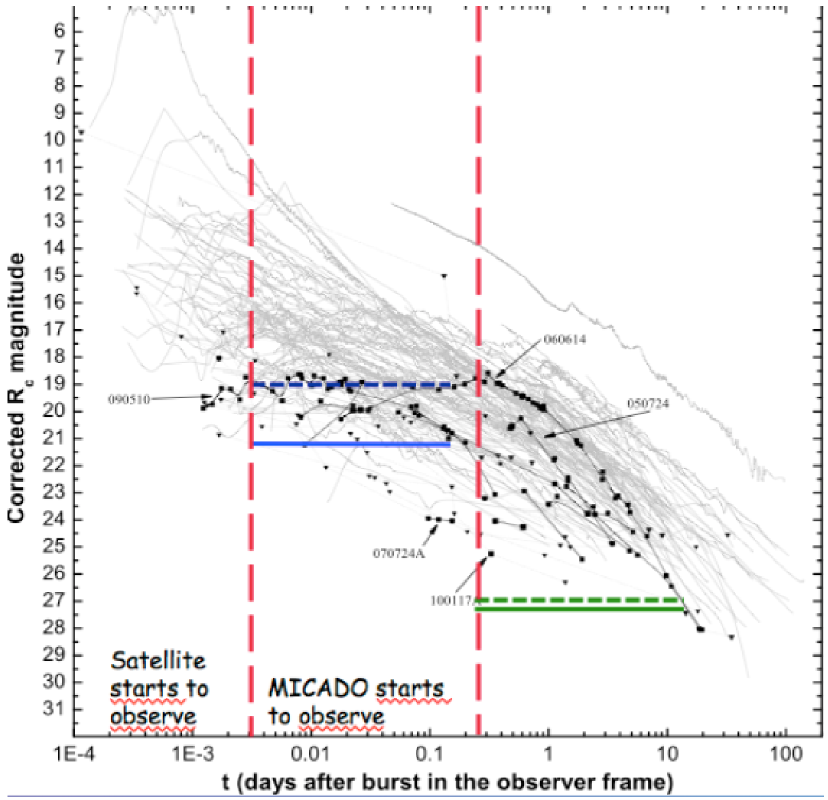


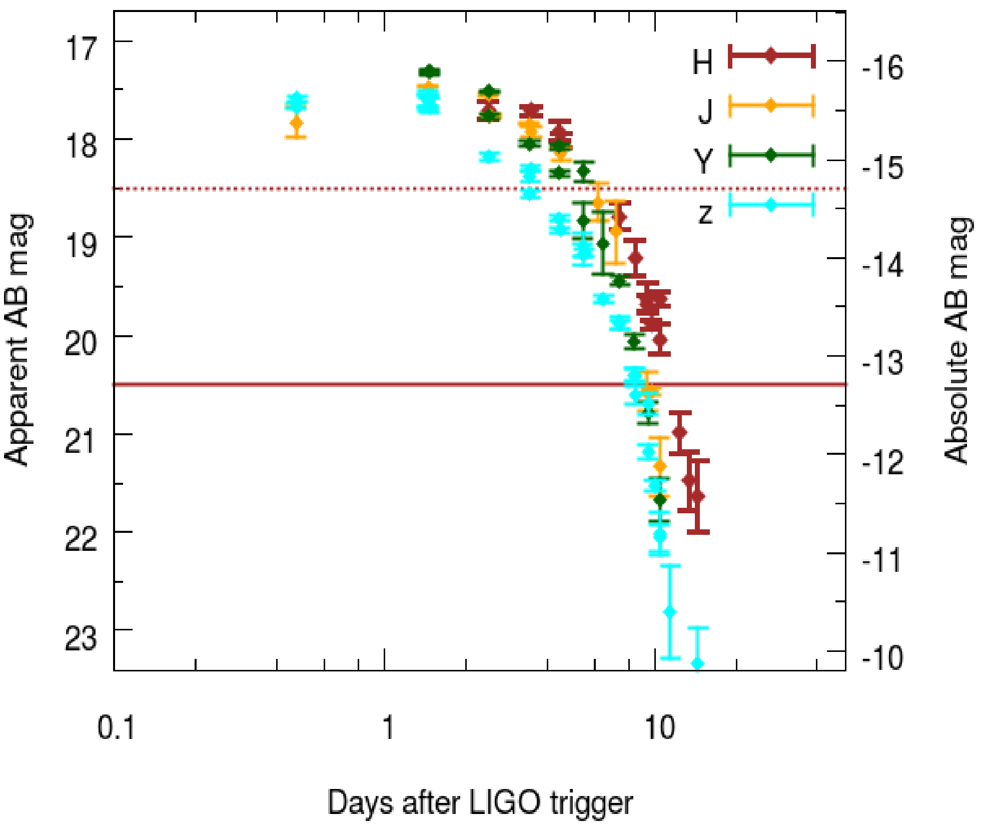


❑ Promptly and accurately localizing e.m. counterparts to GW events with THESEUS



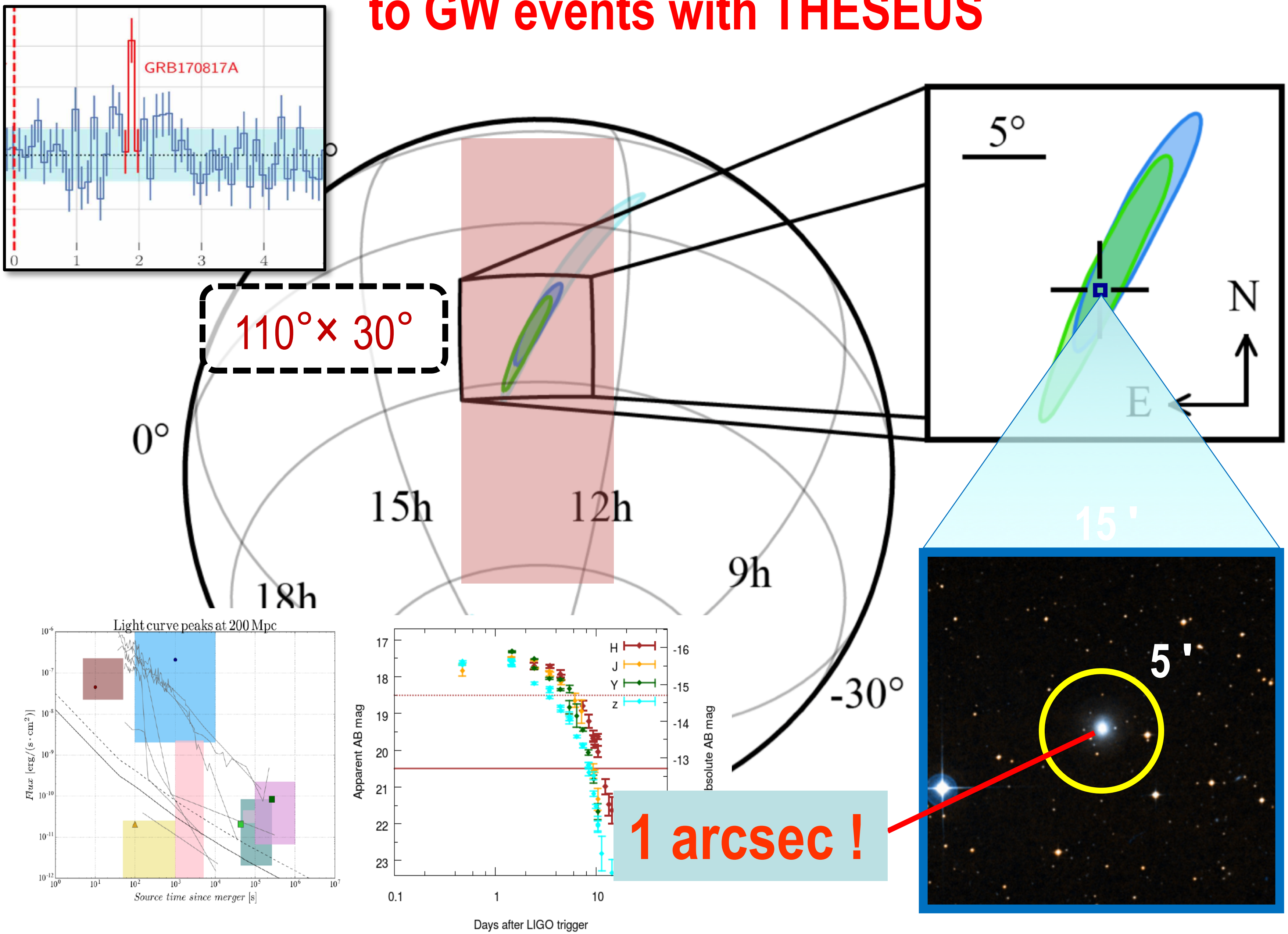
❑ Detection, study and arcsecond localization of afterglow and kilonova emission from shortGRB/GW events with THESEUS/IRT



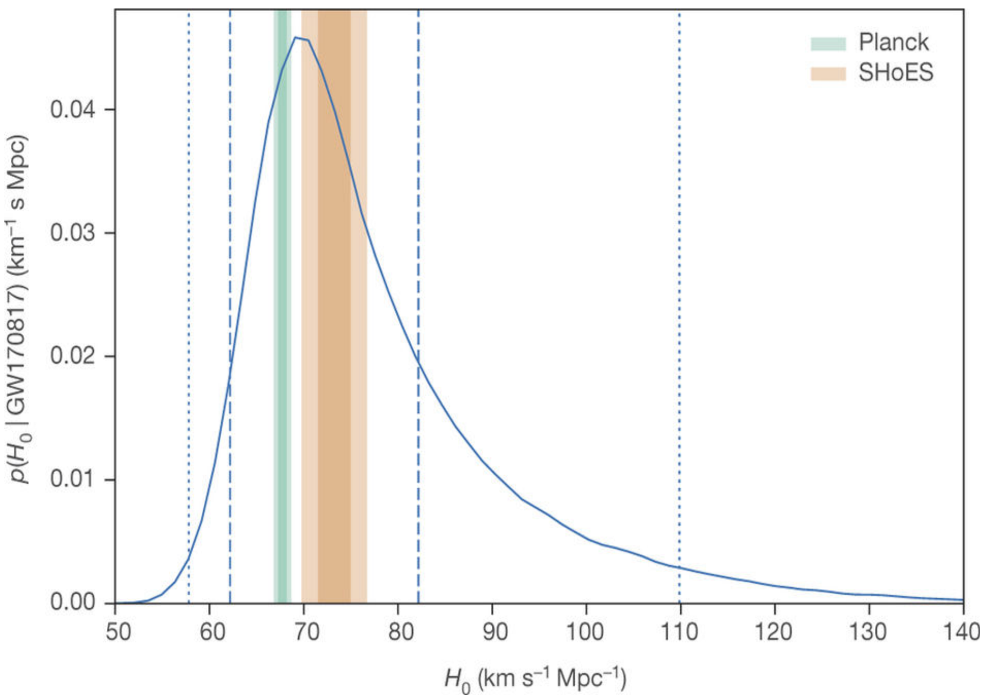


Precise localization is mandatory to activate large ground-based telescopes as VLT or ELT from which detailed spectral analysis will reveal the intrinsic nature of these newly discovered phenomena

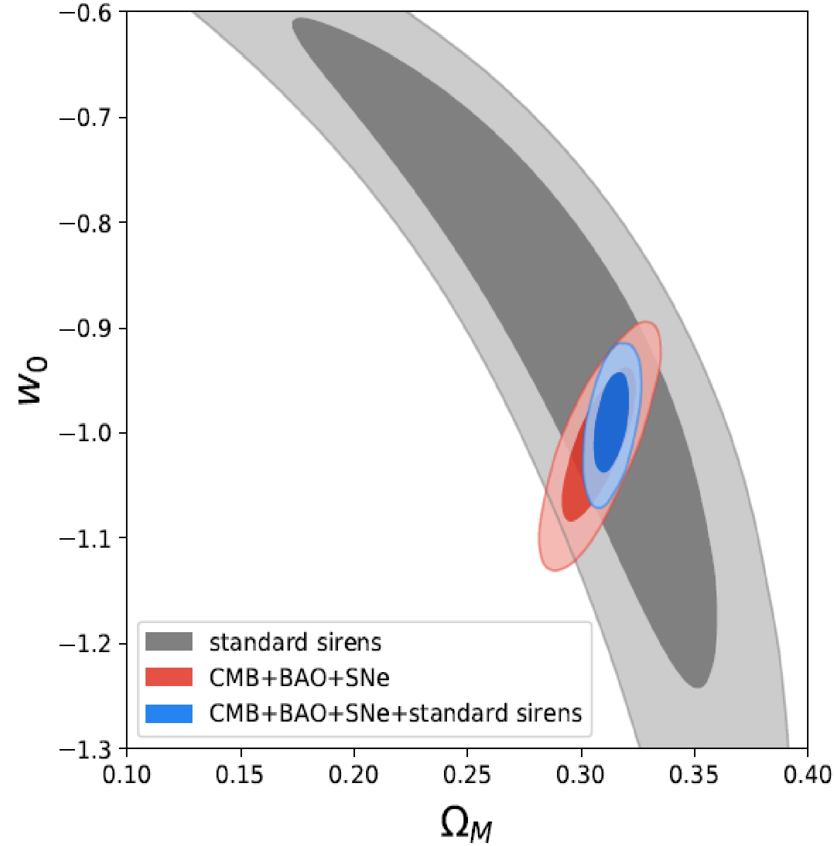
❑ Promptly and accurately localizing e.m. counterparts to GW events with THESEUS



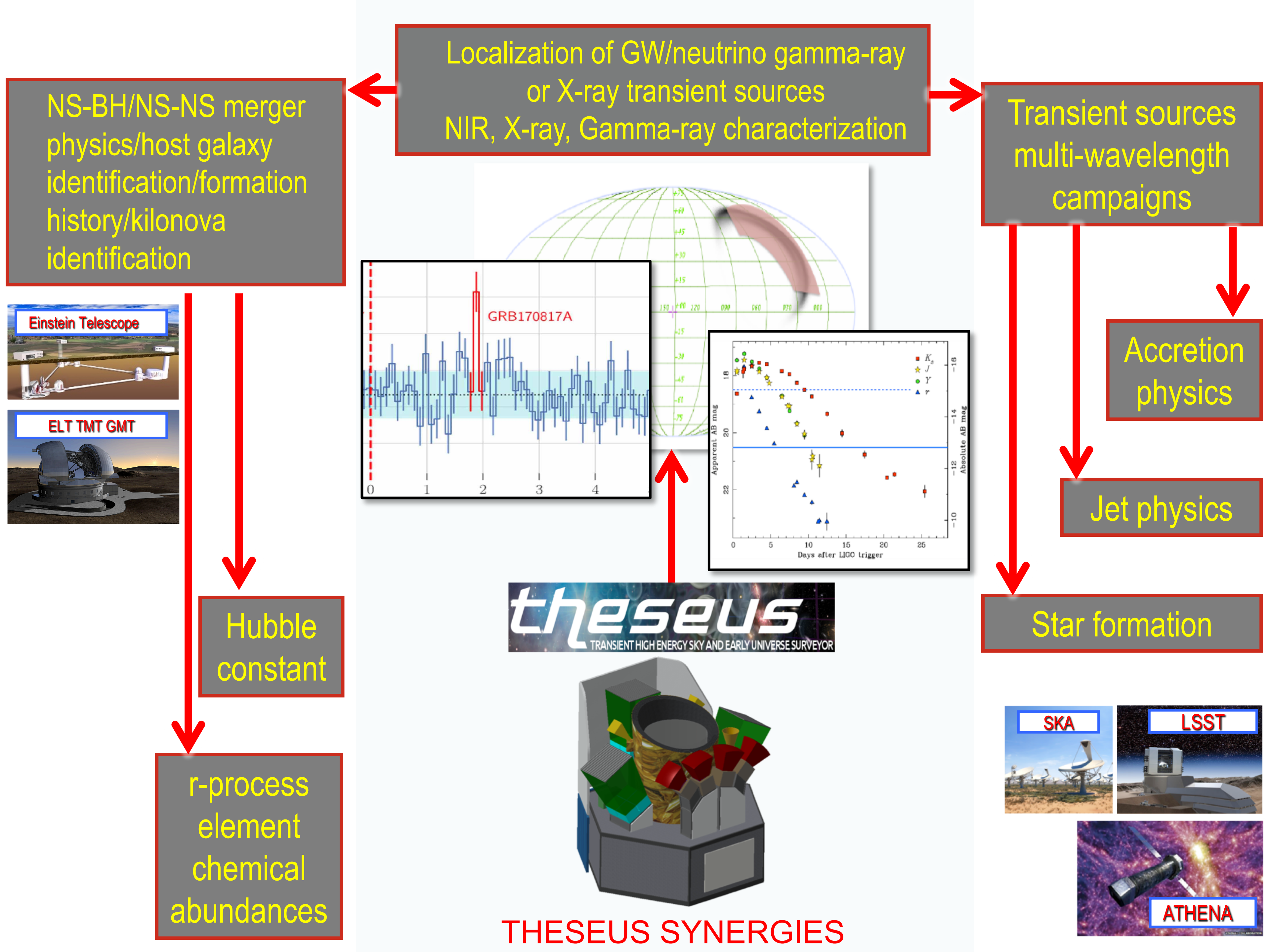
- **THESEUS measurements + sinergy with large e.m. facilities -> substantial improvment of redshift estimate for e.m. counterparts of GW sources -> cosmology**



Estimating H0 with GW170817A (LVC 2017)



Investigating dark energy with a statistical sample of GW + e.m. (Sathyaprakash et al. 2019)


Localization of GW/neutrino gamma-ray
or X-ray transient sources
NIR, X-ray, Gamma-ray characterization
NS-BH/NS-NS merger physics/host galaxy identification/formation history/kilonova identification
Transient sources multi-wavelength campaigns
Einstein Telescope
ELT TMT GMT
Hubble constant
r-process element chemical abundances
GRB170817A
Apparent AB mag
Absolute AB mag
Days after LIGO trigger
Accretion physics
Jet physics
Star formation
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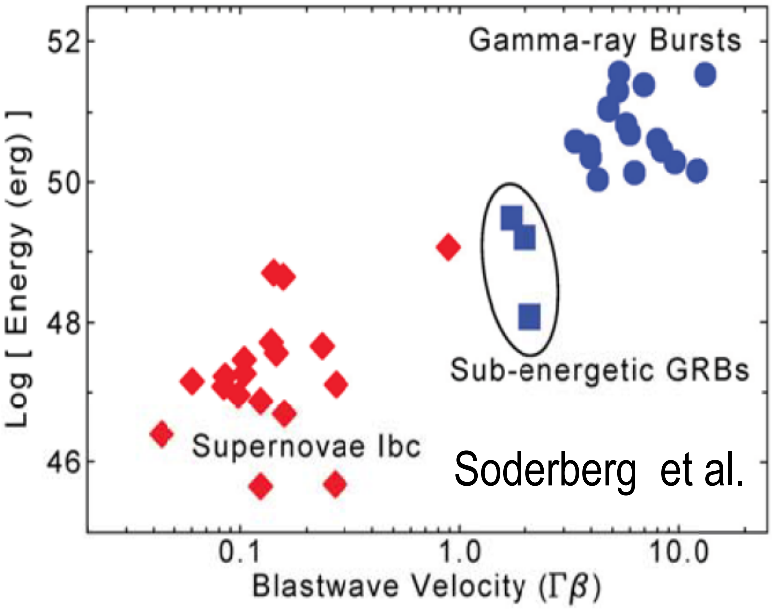
TRANSIENT HIGH ENERGY SKY AND EARLY UNIVERSE SURVEYOR
SKA
LSST
ATHENA
THESEUS SYNERGIES

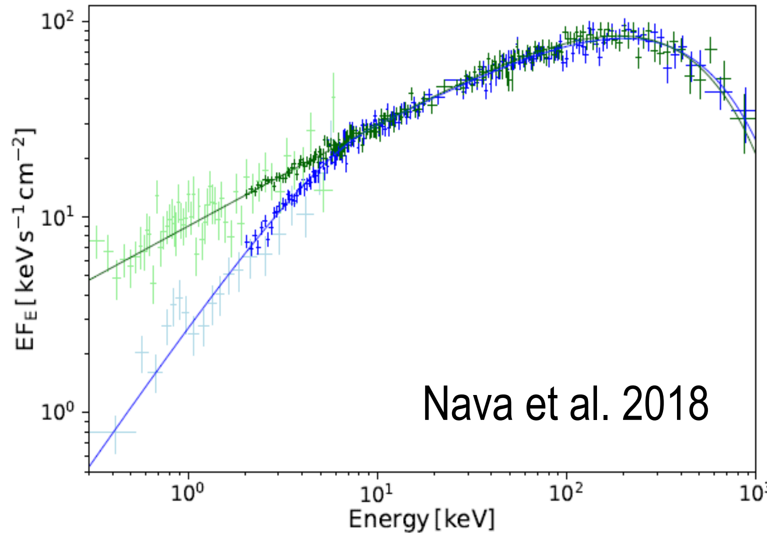
❑ Time-domain astronomy and GRB physics

- survey capabilities of transient phenomena similar to the Large Synoptic Survey Telescope (LSST) in the optical: a remarkable scientific sinergy can be anticipated.

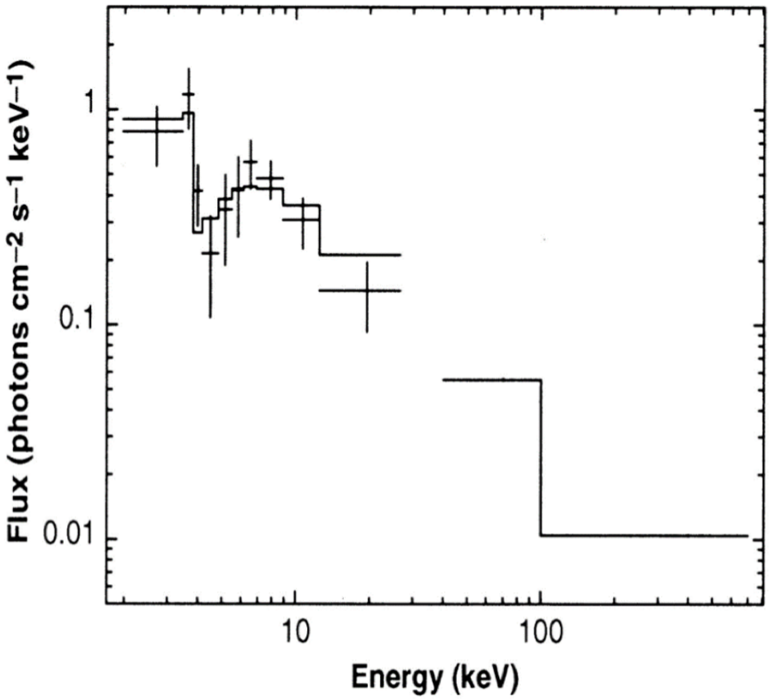
- substantially increased detection rate and characterization of sub-energetic GRBs and X-Ray Flashes;

- unprecedented insights in the physics and progenitors of GRBs and their connection with peculiar core-collapse Sne;

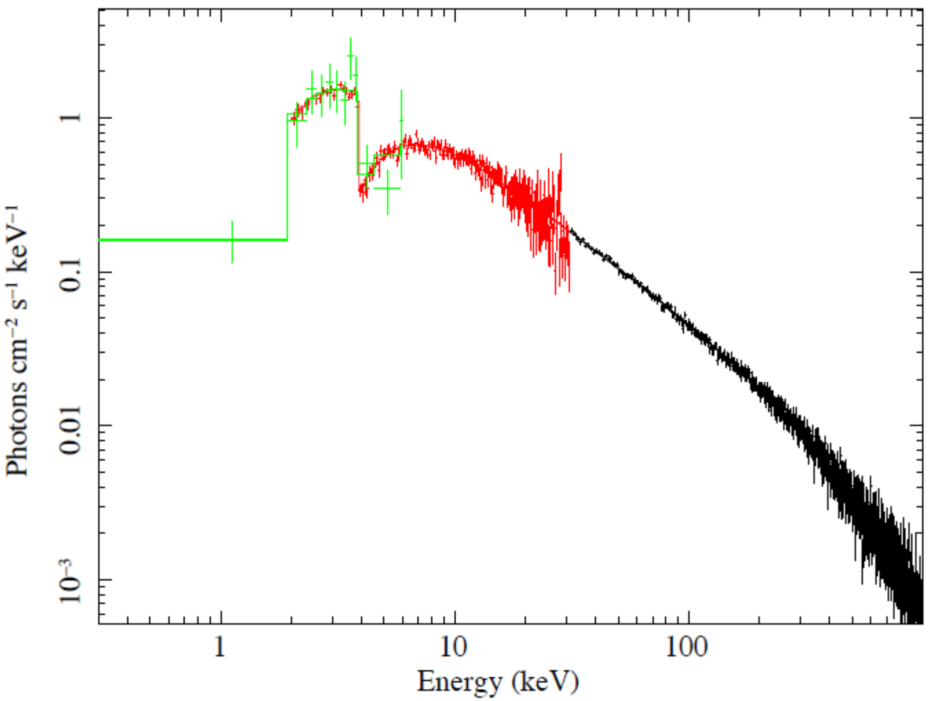




❑ Absorption features: the case of GRB990705 (edge at 3.8 keV -> redshifted neutral iron k-edge -> z = 0.85 -> confirmed by host galaxy spectroscopy: redshift estimate through X-ray spectroscopy (need energy resolution < ~1 keV in X-rays)

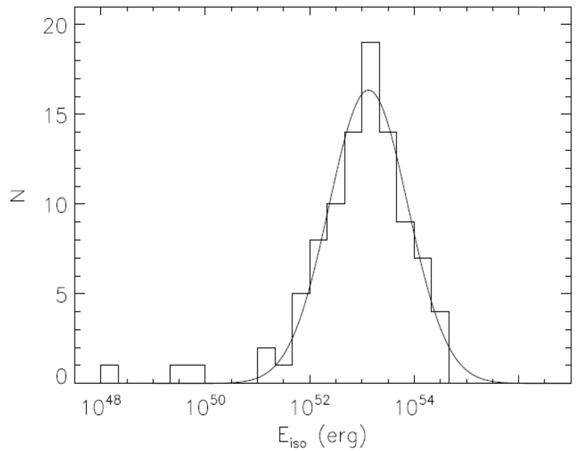


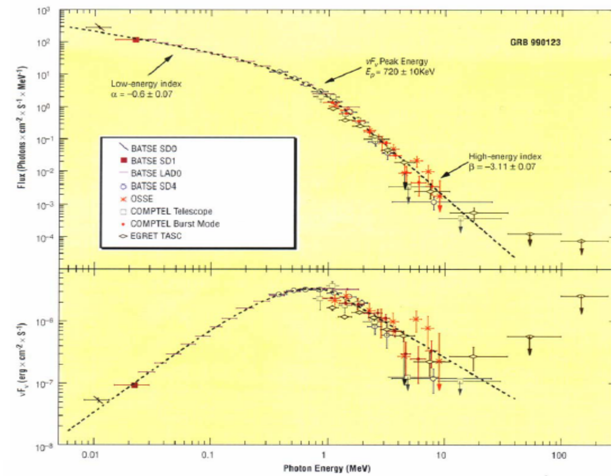
BeppoSAX WFC + GRBM
(Amati et al. 2000)

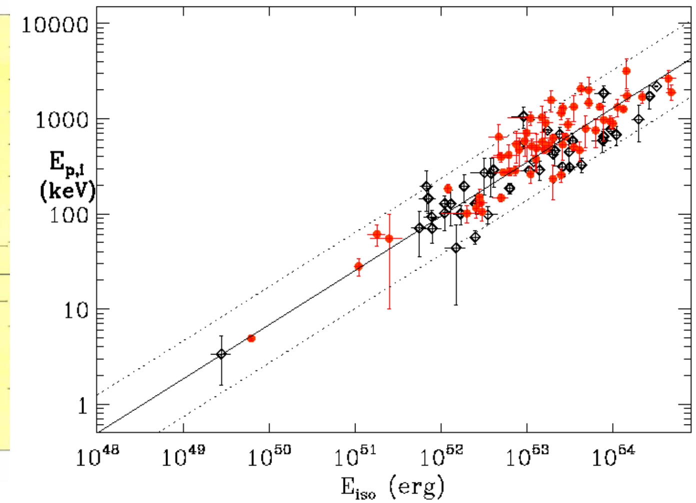


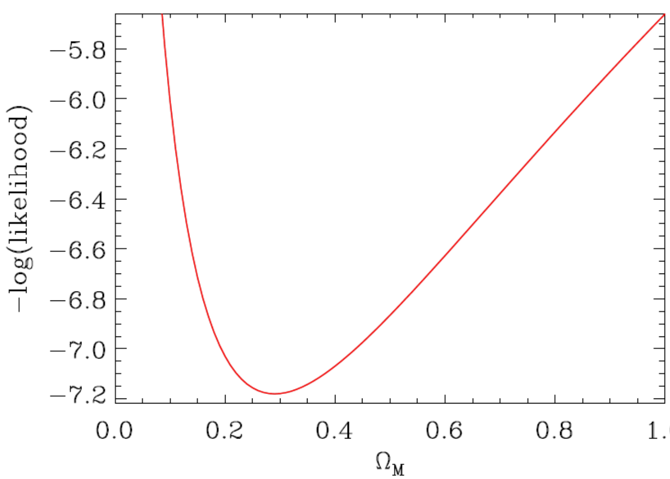
THESEUS SXI + XGIS
(Nava et al. 2018)

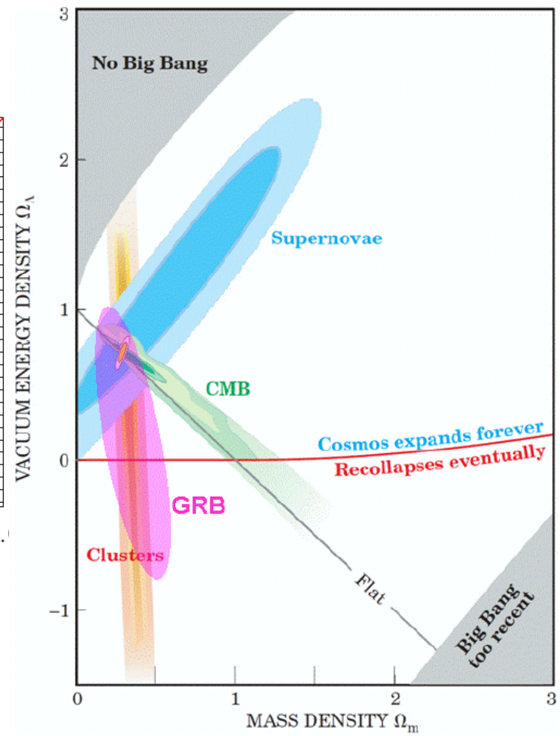
❑ measuring cosmological parameters with GRBs

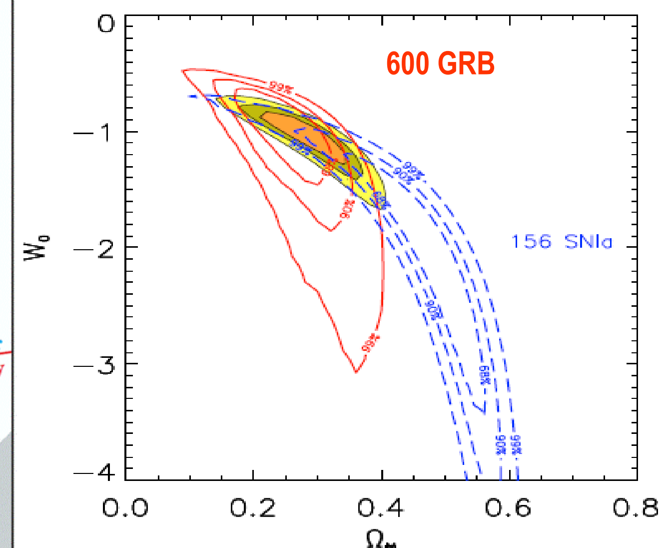






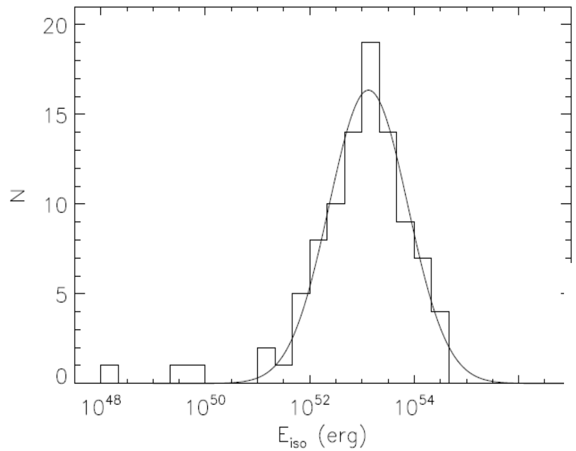


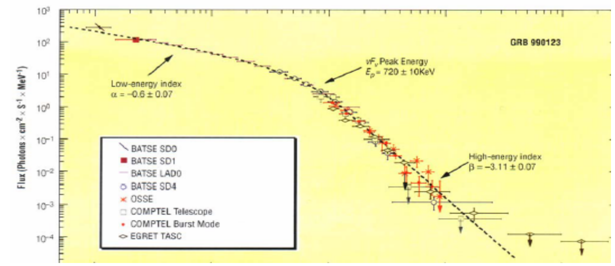


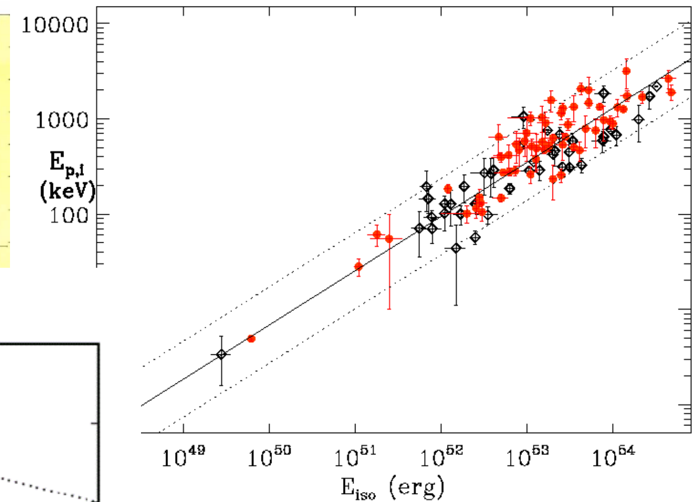


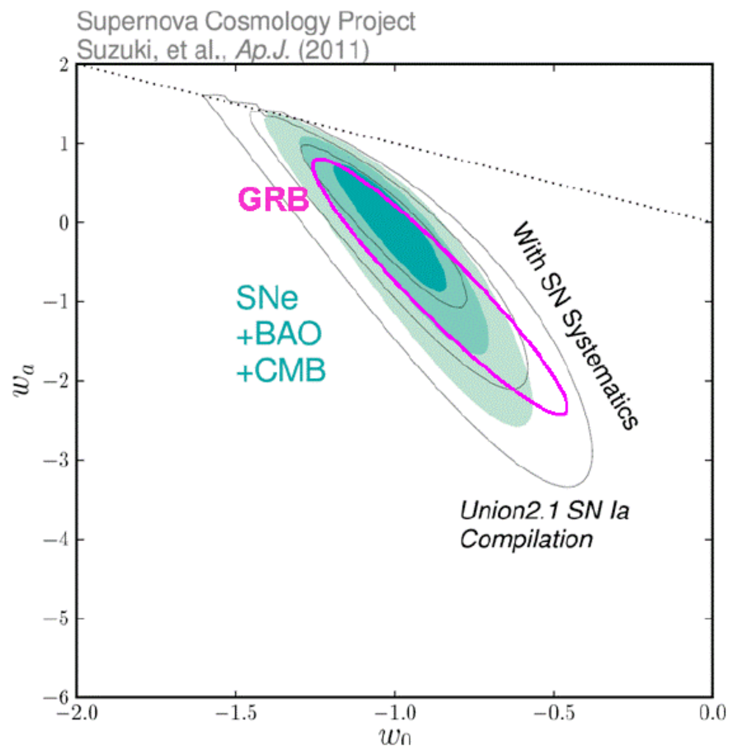
$$w(z) = w_0 + \frac{w_a z}{1+z}$$

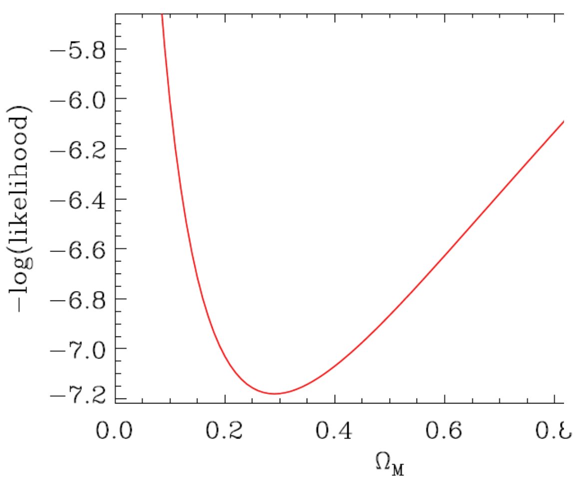
❑ measuring cosmological parameters with GRBs

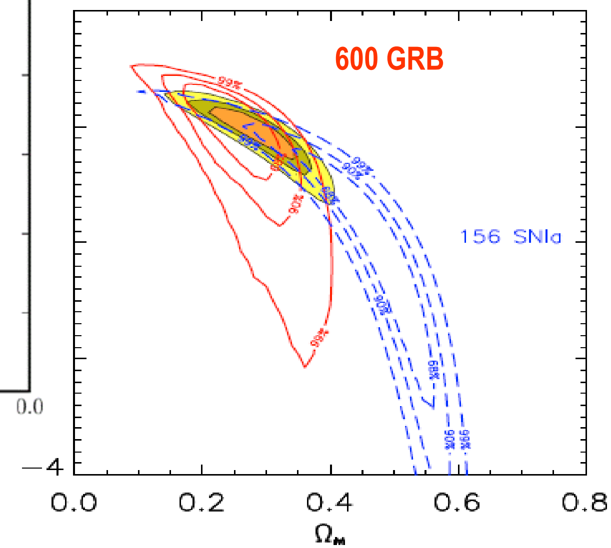


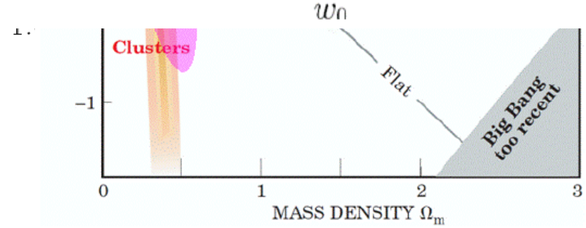












$$w(z) = w_0 + \frac{w_a z}{1+z}$$

THESEUS
TRANSIENT HIGH ENERGY SKY AND EARLY UNIVERSE SURVEYOR

- ***THESEUS*** **Core Science is based on two pillars:**
  - probe the **physical properties of the early Universe**, by discovering and exploiting the population of high redshift GRBs.
  - provide an **unprecedented deep monitoring** of the soft X-ray transient Universe, providing a fundamental contribution to multi-messenger and time domain astrophysics in the early 2030s (synergy with aLIGO/aVirgo, eLISA, ET, Km3NET and EM facilities e.g., LSST, E-ELT, SKA, CTA, ATHENA).

- ***THESEUS*** **Observatory Science includes:**
  - study of thousands of faint to bright X-ray sources by exploiting the **unique simultaneous availability of broad band X-ray and NIR observations**
  - provide a **flexible follow-up observatory** for fast transient events with multi-wavelength ToO capabilities and **guest-observer programmes**.

In summary

- THESEUS, submitted to ESA/M5 by a large European collaboration with strong interest by international partners (e.g., US) will fully exploit GRBs as powerful and unique tools to investigate the early Universe and will provide us with unprecedented clues to GRB physics and sub-classes.

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

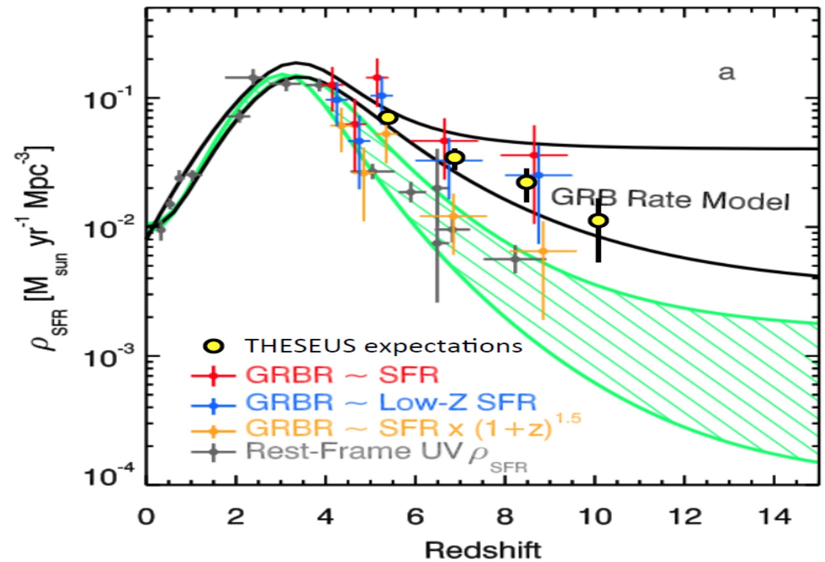
- THESEUS is a unique occasion for fully exploiting the European and Italian leadership in time-domain and multi-messenger astrophysics and in key-enabling technologies

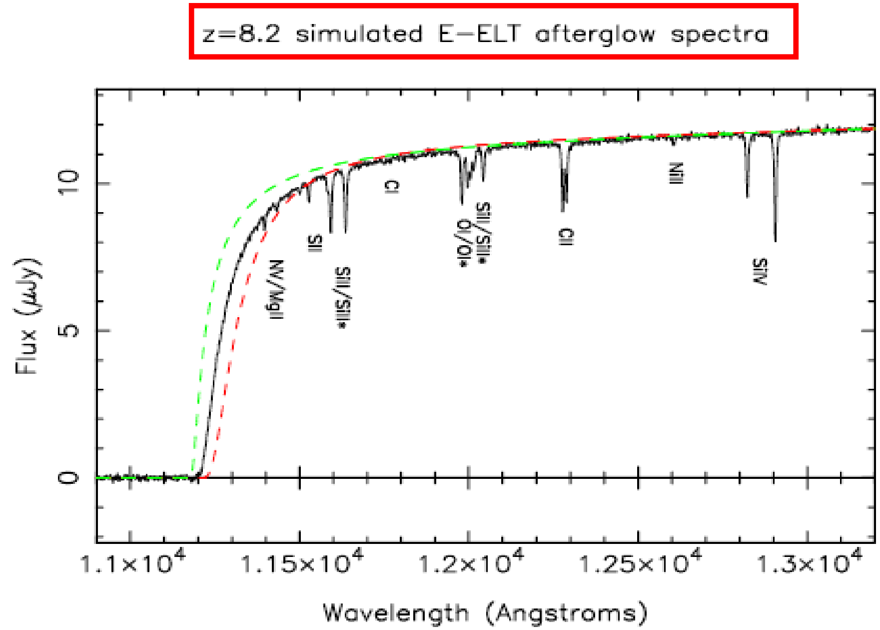
- THESEUS observations will impact on several fields of astrophysics, cosmology and fundamental physics and will enhance importantly the scientific return of next generation multi messenger (aLIGO/aVirgo, LISA, ET, or Km3NET;) and e.m. facilities (e.g., LSST, E-ELT, SKA, CTA, ATHENA)

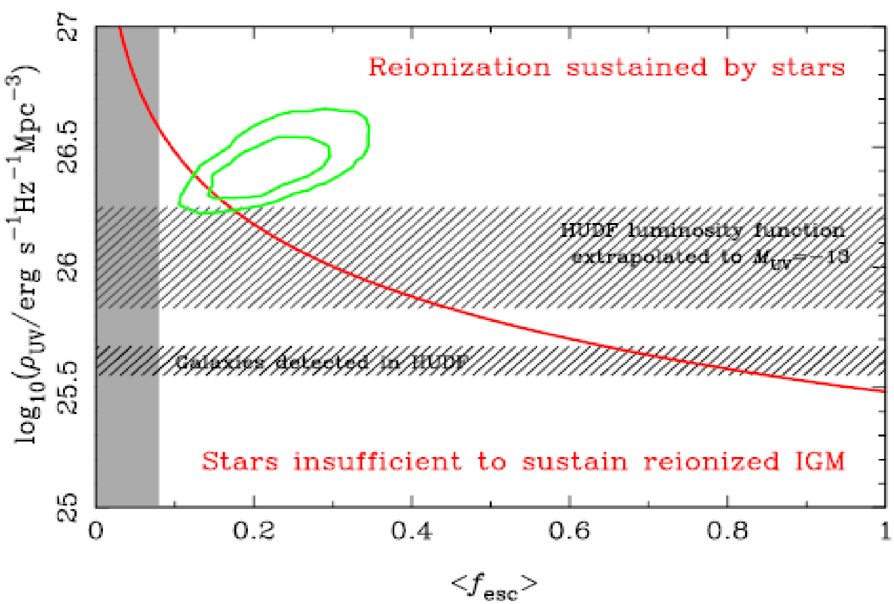
- Call for participating THESEUS scientific WGs will be issued very soon; THESEUS science session at EWASS 19 in Lyon; Theseus Consortium meeting in Bologna on July 3-5; THESEUS International Conference in Malaga on 12-15 May 2020

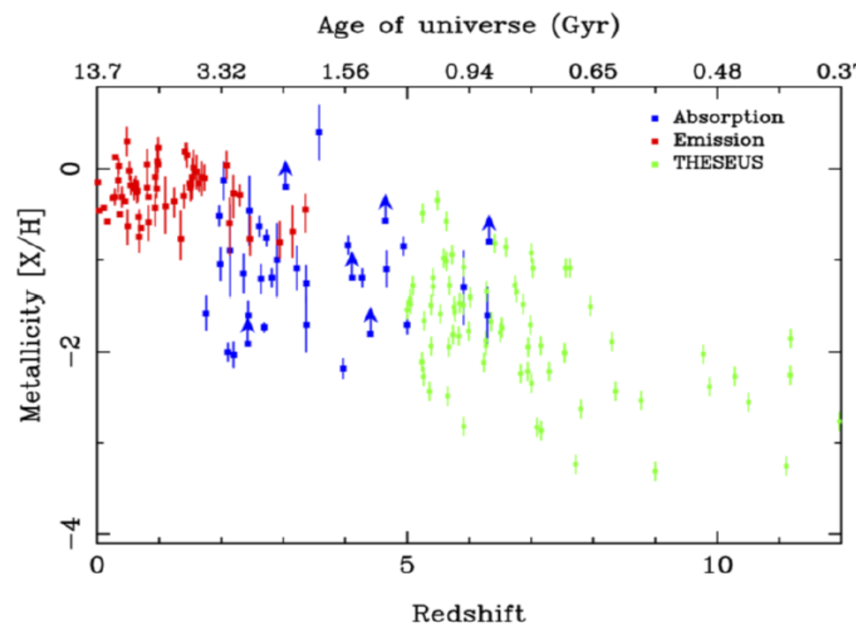
Back-up slides

❑ Shedding light on the early Universe with GRBs



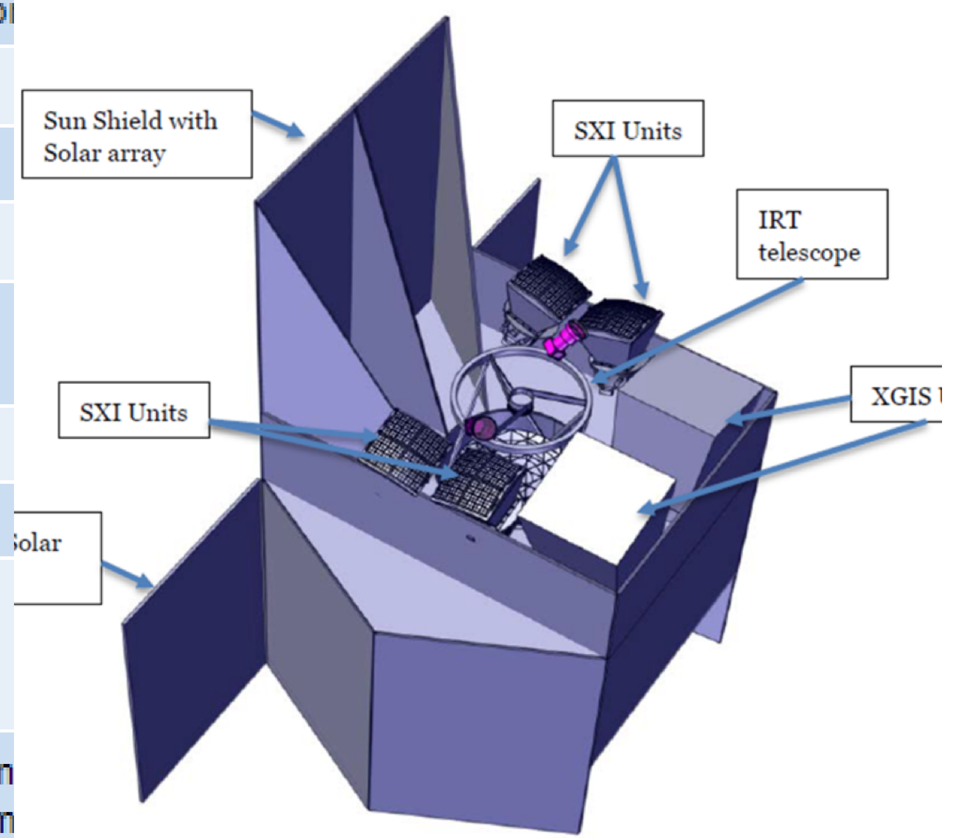






Mission profile and budgets

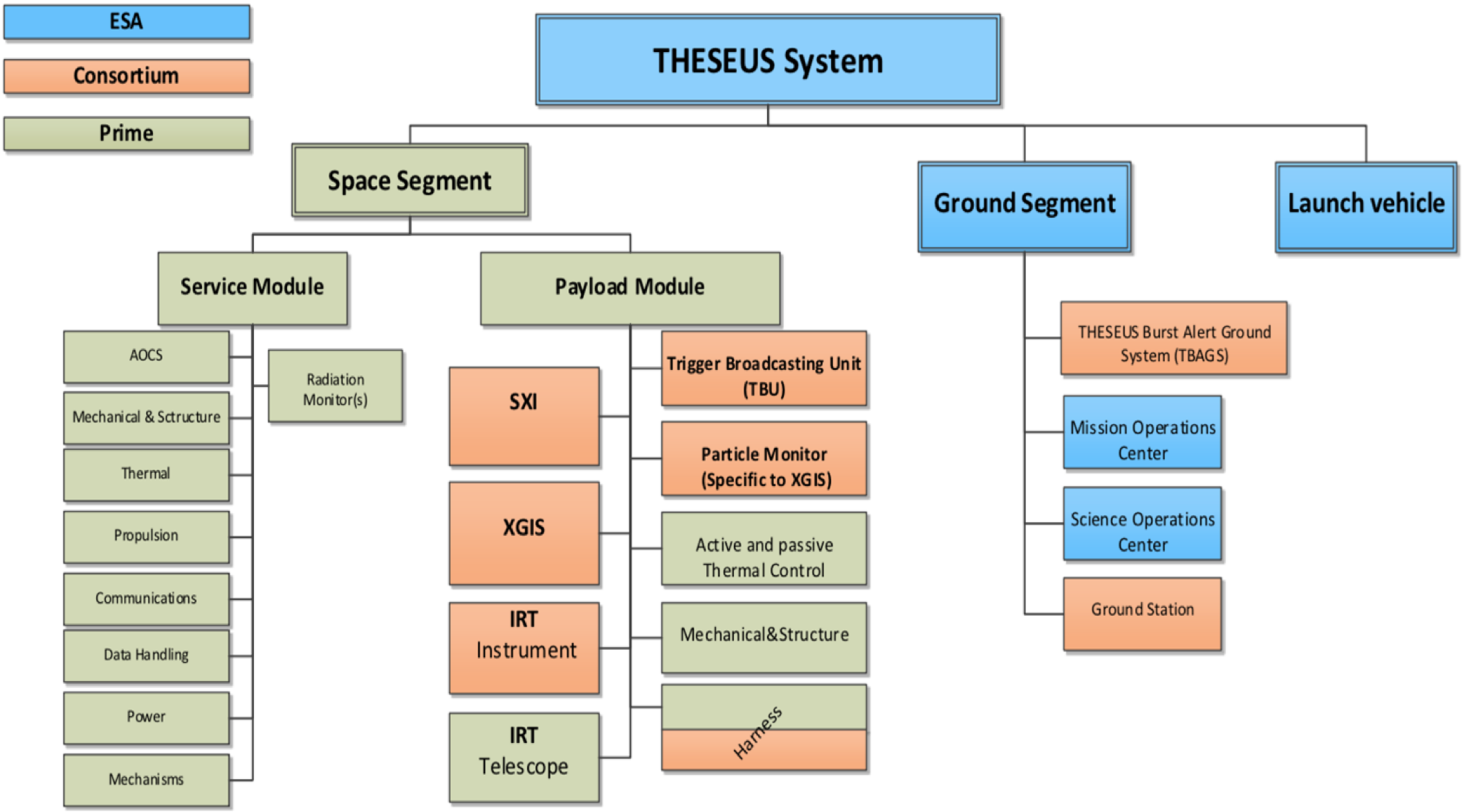
Launch vehicle	VEGA-C (backup Ariane62)
Launch date	2032 (night launch)
Lifetime	Nominal 3 years (consumables fo
Orbit	Circular LEO
Altitude	600 km
Inclination	5.4°
Ground stations	Malindi (backup Kourou) VHF SVOM network
Delta-V	225.8 m/s
Re-entry	Controlled re-entry (4 burns)
Mass	Dry mass w/ margin 1504 kg Wet mass 1702 kg Total (wet + adapter) 1697 kg
Dimensions	Launch conf.: 4.23 m x 3.02 m Deployed conf.: 4.23 m x 4.40 m
Payload	1x InfraRed Telescope (IRT) 2x X-Gamma-rays Imaging Spect 4x Soft X-ray Imager (SXI) 2x Radiation monitors



THESEUS payload consortium: contributions

- **Italy -** L.P. / project office, XGIS, Malindi ground station, Trigger Broadcasting Unit
- **UK -** SXI (coord., optics, cal., s/w)
- **France -** IRT (coord.,camera, cal., s/w), Theseus Burst Alert Ground Segment
- **Germany (with Poland and Denmark)** - I-DHUs and Power Supply Units (PSUs)
- **Switzerland**: SDC (s/w, data processing, pipelines, quick-look) + IRT filter wheel
- **Spain:** XGIS coded mask, +… (IRT detectors / optics? SXI focal plane structure / optics….?)
- **ESA P/L contribution:** IRT telescope (including cooler), SXI detectors
- **Other contributions: Spain** (XGIS coded mask, SXI focal plane assembly, IRT), **Belgium** (SXI integration and tests), **Czech Rep.** (mechanical structures and thermal control of SXI)
- **Possible minor contributions: Ireland** (XGIS detectors, IRT on-board s/w)**, Hungary** (spacecraft interface simulator, I-DHU, IRT calib.), **Slovenia** (X-band)
- **Possible international non-enabling contributions: USA:** (XGIS sim. + tests, TDRSS), **Brazil:** Alcantara ground station, **China** (SXI, XGIS)

THESEUS responsibilities product tree



THESEUS consortium: contact persons

THESEUS contact persons

Coordination team

Name and Surname	Country	Institute
Lorenzo Amati (Mission PI, lead Scientist)	Italy	INAF-OAS Bologna
Paul O'Brien	United Kingdom	Leicester University
Diego Goetz	France	CEA/Saclay
Andrea Santangelo	Germany	IAAT
Enrico Bozzo (Project configuration control)	Switzerland	University of Geneva

Payload and science data center

Element	Name and Surname	Institute	Country
SXI	Paul O'Brien and Ian Hutchinson	University of Leicester	United Kingdom
XGIS	Lorenzo Amati and Claudio Labanti	INAF-OAS Bologna	Italy
IRT	Diego Goetz and Stephane Basa	CEA, Saclay	France
I-DHU	Andrea Santangelo and Chris Tenzer	IAAT, Tuebingen	Germany
SDC	Stephane Paltani and Enrico Bozzo	University of Geneva	Switzerland

Guido Parissenti (System ewngineering coordination)	Italy	GPAP

+ science key persons in the TSST and instruments leads and key persons in the SEWG

THESEUS teams: ESA

L. Colangeli (ESA, Head of Science Coordination Office), P. Falkner (ESA, Head of Mission Studies Office

ESA study team

Name and Surname	Role	Institute	Country
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Jonan Larranaga	System engineer	ESA/ESTEC	Netherlands
Thibaut Prod'homme	Payload manager	ESA/ESTEC	Netherlands
Tim Oosterbroek	Payload system engineer	ESA/ESAC	Spain
Matteo Guainazzi	Study scientist	ESA/ESTEC	Netherlands
Isabel Escudero Sanz	Optics expert	ESA/ESTEC	Netherlands
Guillaume Belanger	Operations expert	ESA/ESAC	Spain

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Author	Country	Institute
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Götz Diego	France	CEA - Saclay / Irfu / SAp
Hanlon Lorraine	Ireland	UCD
O'Brien Paul	United Kingdom	University of Leicester
Paltani Stephane	Switzerland	University of Geneva
Santangelo Andrea	Germany	IAAT, University of Tuebingen
Stratta Giulia	Italy	INAF - OAS Bologna
Tanvir Nial	United Kingdom	University of Leicester

THESEUS consortium science: 6 WGs, > 200 contributing scientists

http://www.isdc.unige.ch/theseus/

1. Exploring the Early Universe with GRBs		
Surname and Name	**Country**	**Institute**
Tanvir Nial	United Kingdom	University of Leicester

2. Gravitational waves and multi-messanger Astrophysics		
Surname and Name	**Country**	**Institute**
Stratta Giulia	Italy	Urbino University

3. Exploring the time domain Universe		
Surname and Name	**Country**	**Institute**
Osborne Julian	United Kingdom	University of Leicester

4. Sinergy with other electromagnetic facilities (including LSST)		
Surname and Name	**Country**	**Institute**
Rosati Piero	Italy	University of Ferrara

5. Scientific requirements		
Surname and Name	**Country**	**Institute**
Ghirlanda Giancarlo	Italy	INAF-OA Brera

6. The IRT as a flexible Guest Observer IR observatory		
Surname and Name	**Country**	**Institute**
Blain Andrew	United Kingdom	University of Leicester

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ADVANCES IN SPACE RESEARCH (a COSPAR publication)
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The THESEUS space mission concept: science case, design and expected performances

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THESEUS: A key space mission concept for Multi-Messenger Astrophysics

G. Stratta [a,b,l,*], R. Ciolfi [c,d], L. Amati [b], E. Bozzo [e], G. Ghirlanda [f], E. Maiorano [b], L. Nicastro [b], A. Rossi [b], S. Vinciguerra [g], F. Frontera [h,b], D. Götz [i], C. Guidorzi [h], P. O'Brien [j], J.P. Osborne [j], N. Tanvir [k], M. Branchesi [m,l], E. Brocato [x], M.G. Dainotti [n,b,aw], M. De Pasquale [o], A. Grado [p], J. Greiner [q], F. Longo [r,s], U. Maio [t,u], D. Mereghetti [v], R. Mignani [v,w], S. Piranomonte [x], L. Rezzolla [y,z], R. Salvaterra [v], R. Starling [j], R. Willingale [j], M. Böer [aa], A. Bulgarelli [b], J. Caruana [ab], S. Colafrancesco [ac], M. Colpi [ad], S. Covino [f], P. D'Avanzo [f], V. D'Elia [ae,x], A. Drago [h], F. Fuschino [b], B. Gendre [ag,ah,af], R. Hudec [ai,aj], P. Jonker [ak,al], C. Labanti [b], D. Malesani [am], C.G. Mundell [an], E. Palazzi [b], B. Patricelli [ao], M. Razzano [ao], R. Campana [b], P. Rosati [h], T. Rodic [ap], D. Szécsi [aq,ar], A. Stamerra [ao], M. van Putten [as], S. Vergani [at,f], B. Zhang [au], M. Bernardini [av]

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Symposium S4 24-25 June 2019

Cosmology and multi-messenger astrophysics with Gamma-Ray Bursts

News: December 3rd: potential invited speakers are being contacted, list will be announced soon.

Aims and scope

Gamma-Ray Bursts (GRBs) are the most extreme and powerful emissions of electromagnetic radiation in the Universe. Since their discovery in the late '60s, they constitute one of the most fascinating and mysterious phenomena for modern science, with strong implications for several fields of astrophysics and fundamental physics. This special session will focus on the key-role of GRBs for cosmology and multi-messenger astrophysics. Indeed, the huge luminosity, the redshift distribution extending at least up to z~10 and the association with the explosive death of very massive stars make long GRBs (i.e., those lasting up to a few minutes) potentially extremely powerful cosmological probes (geometry and expansion rate of space-time, "dark energy", early Universe). At the same time, short GRBs (lasting no more than ~1-2s) are the most prominent electromagnetic signature of gravitational-wave sources like NS-NS and NS-BH merging events, and both long/short GRBs are expected to be associated with neutrino emission.

THESEUS: straightforward synergies with ET

- Detection, accurate location (from few arcmin to few arcsec) and possibly redshift measurement (also through other e.m. facilities) and m-w characterization of the e.m. counterpart (short GRB, soft X-ray emission, kilonova) of several tens of GW signals from NS-NS and NS-BH (e.g, NS-NS, KN and GRB physics; use of GW signals as standard sirens for cosmology (H0, dark energy,…)

- Investigating SFR cosmic history up to early Universe and getting clues to pop III stars with two complementary methods **(**THESEUS through high-z long GRBs, ET through population and properties of BHs upt to very high z)

- GW signals form CC-Sne (THESEUS is likely to unveal the bulk of the population of “local”, soft and sub-energetic GRBs produced by peculiar CC-Sne) and SGRs

Launch vehicle	VEGA-C (backup Ariane62)
Launch date	2032 (night launch)
Lifetime	Nominal 3 years (consumables for 2 more years)
Orbit	Circular LEO
Altitude	600 km
Inclination	5.4°
Ground stations	Malindi (backup Kourou) VHF SVOM network
Delta-V	225.8 m/s
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Mass	Dry mass w/ margin 1504 kg Wet mass 1702 kg Total (wet + adapter) 1697 kg
Dimensions	Launch conf.: 4.23 m x 3.02 m x 2.35 m Deployed conf.: 4.23 m x 4.40 m x 2.35 m
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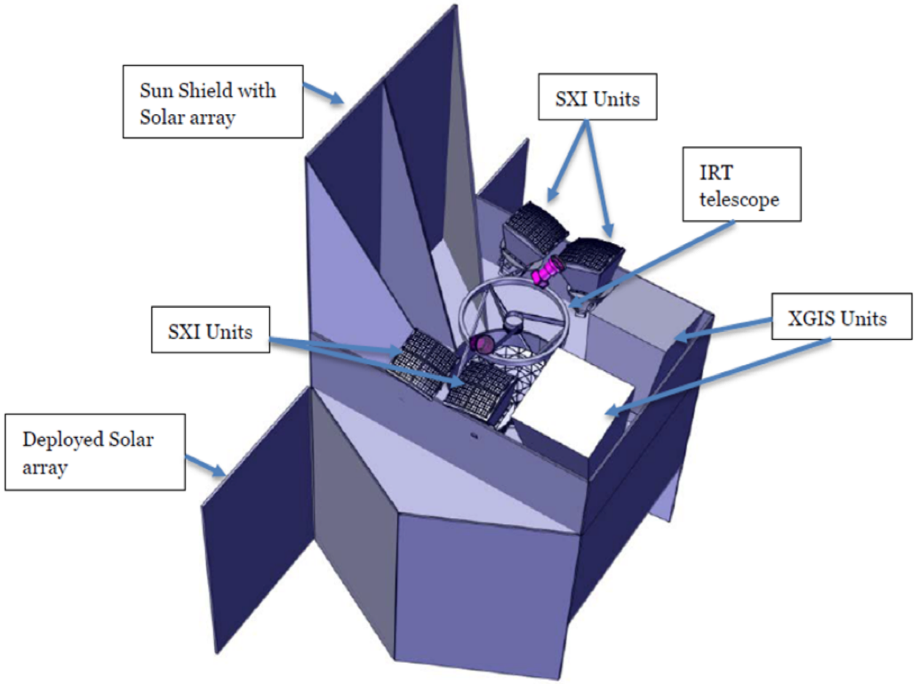
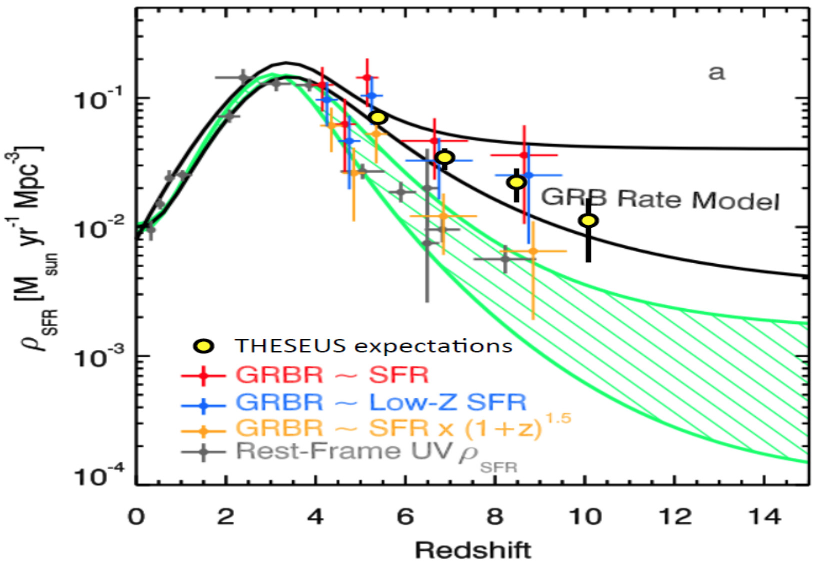
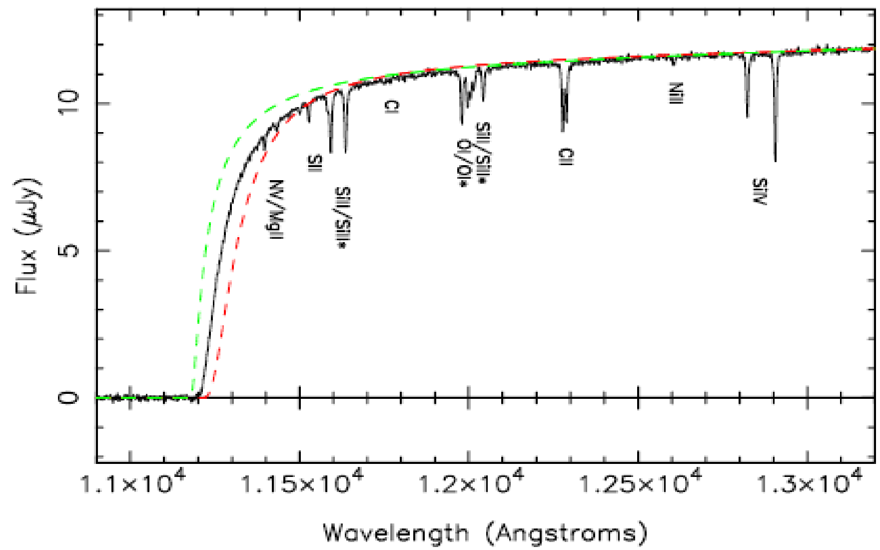
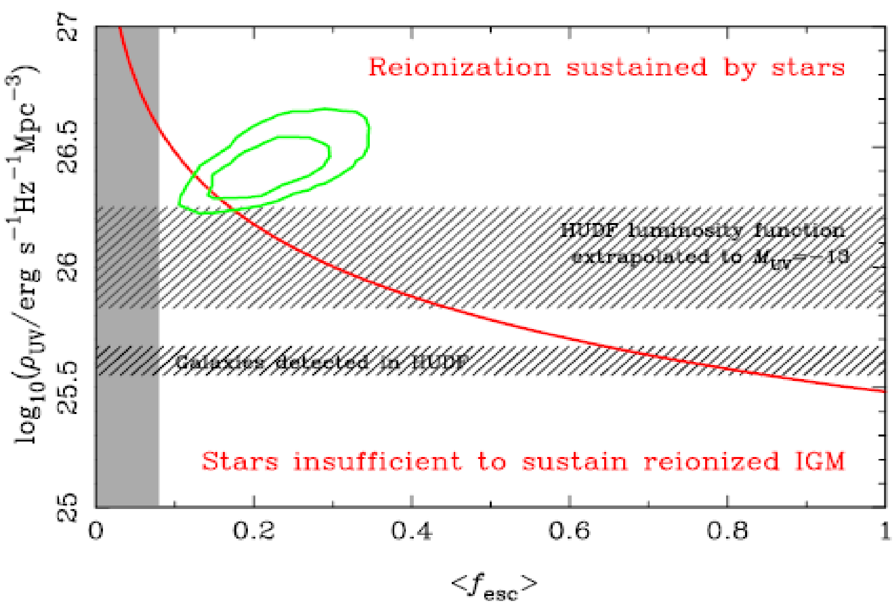


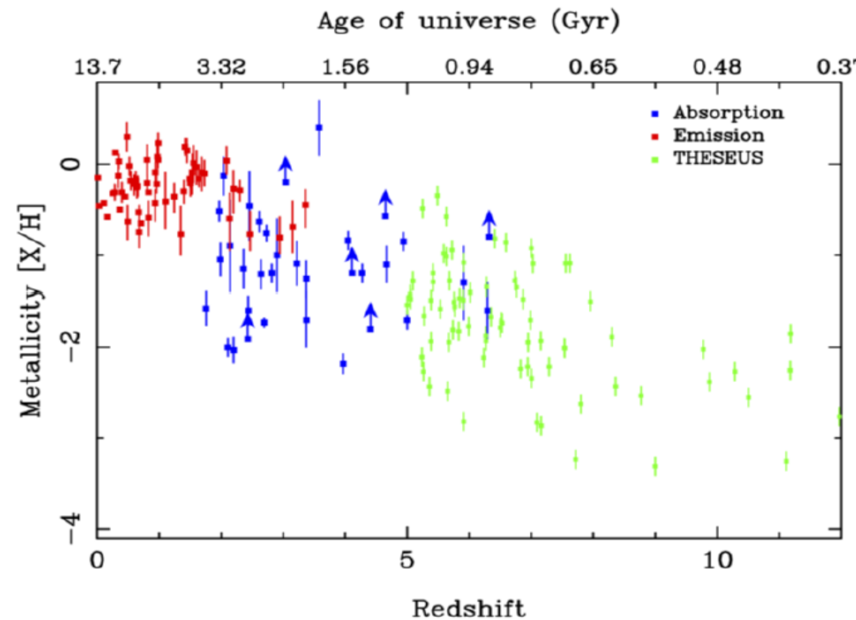
❑ Shedding light on the early Universe with GRBs



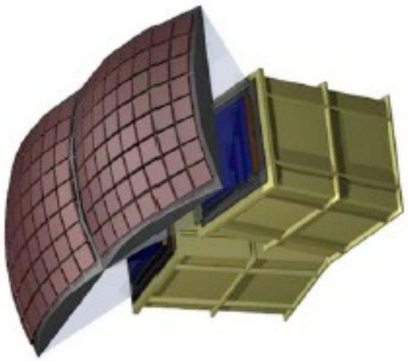
z=8.2 simulated E-ELT afterglow spectra

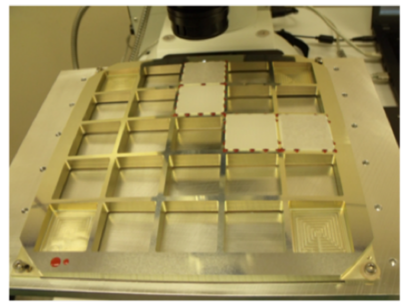


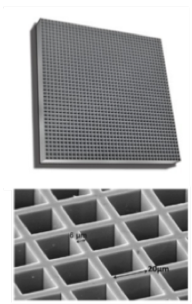


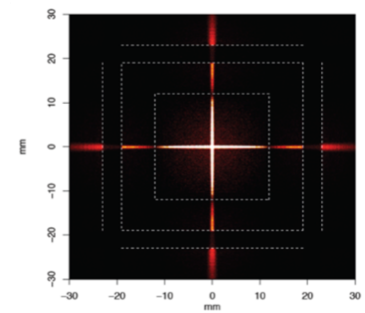


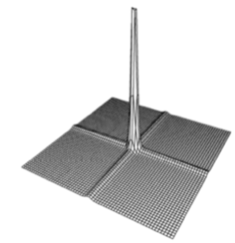
The Soft X-ray Imager (SXI) – led by UK











4 DUs, each has a 31 x 26 degree FoV

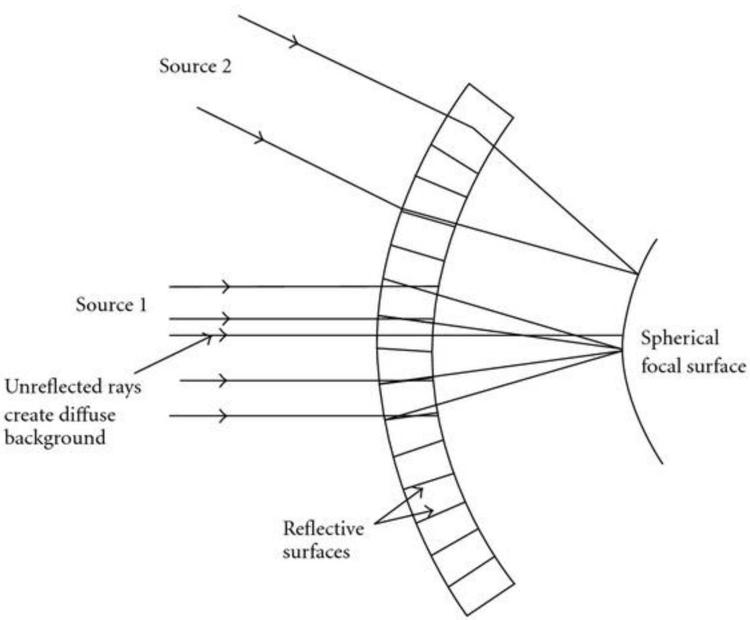
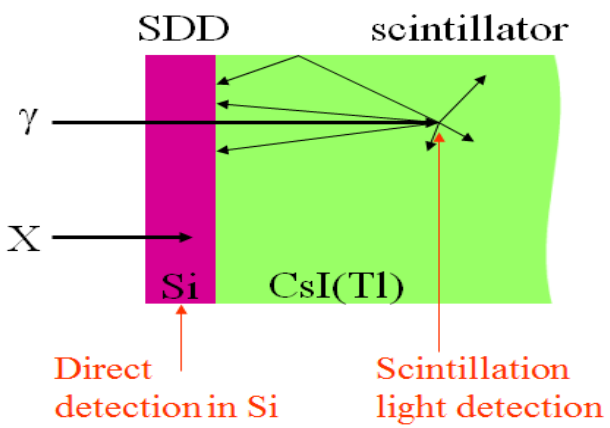
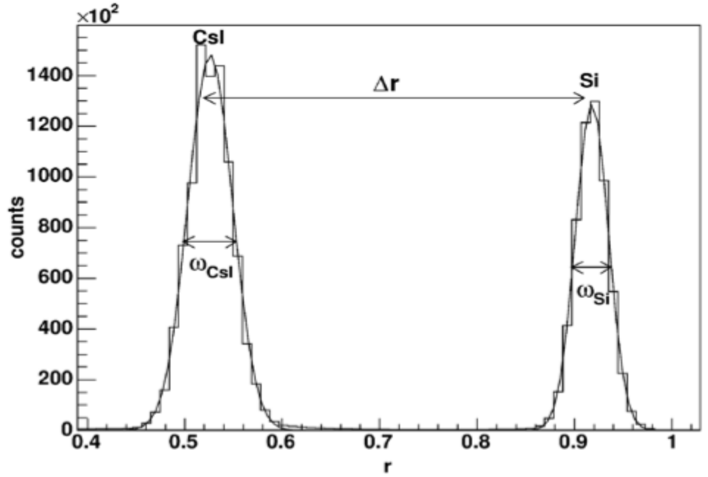


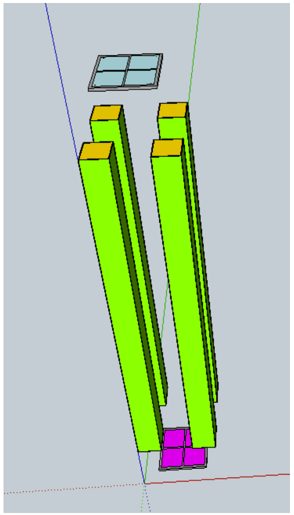
Table 4 : : SXI detector unit main physical characteristics

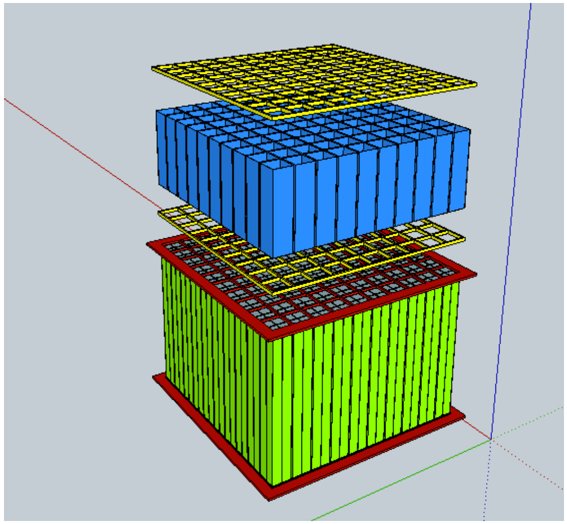
Energy band (keV)	0.3-5
Telescope type:	Lobster eye
Optics aperture (mm2)	320x320
Optics configuration	8x8 square pore MCPs
MCP size (mm2)	40x40
Focal length (mm)	300
Focal plane shape	spherical
Focal plane detectors	CCD array
Size of each CCD (mm2)	81.2x67.7
Pixel size (µm)	18
Pixel Number	4510 x 3758 per CCD
Number of CCDs	4
Field of View (square deg)	~1sr
Angular accuracy (best, worst) (arcsec)	(<10, 105)
Power [W]	27,8
Mass [kg]	40

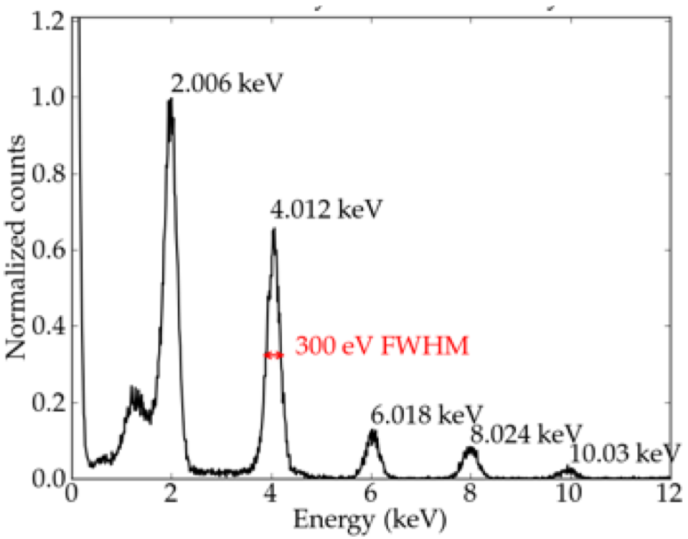
The X-Gamma-ray imaging spectrometer











The X-Gamma-ray imaging spectrometer

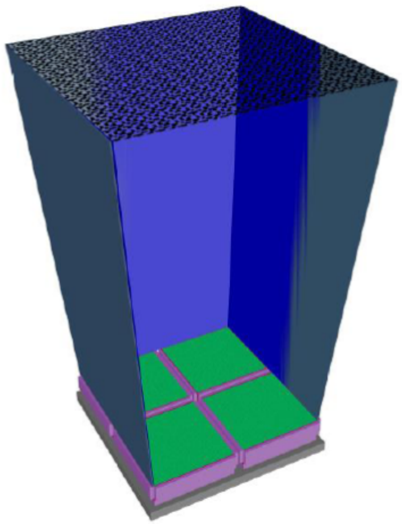


Figure 17: Sketch of the XGIS Unit.

Table 5: XGIS detector unit main physical characteristics

Energy band	*2 keV – 20 MeV*
# detection plane modules	*4*
# of detector pixel / module	*32x32*
pixel size (= mask element size)	*5x5 mm*
Low-energy detector (2-30 keV)	*Silicon Drift Detector 450 μm thick*
High energy detector (> 30 keV)	*CsI(Tl) (3 cm thick)*
Discrimination Si/CsI(Tl) detection	*Pulse shape analysis*
Dimension [cm]	*50x50x85*
Power [W]	*30,0*
Mass [kg]	*37.3*

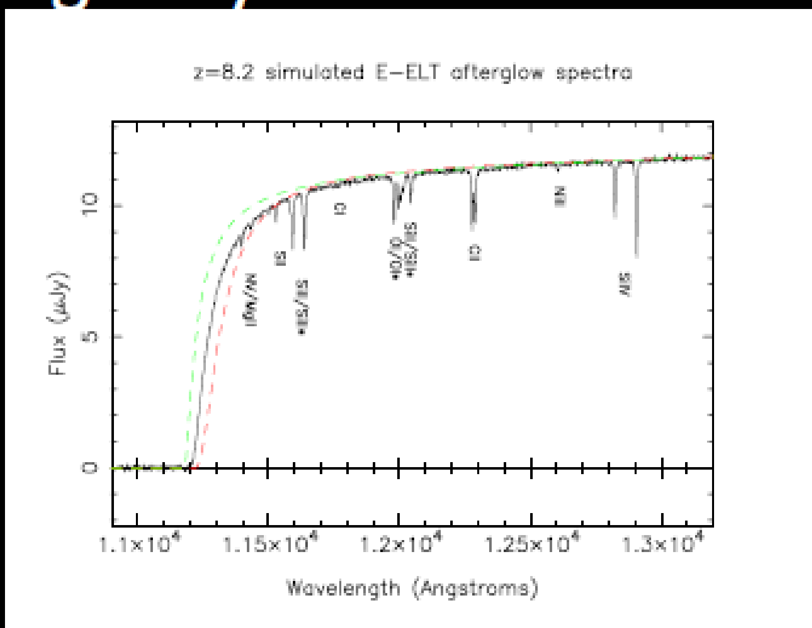
Table 6: XGIS unit characteristics vs energy range

	2-30 keV	30-150 keV	>150 keV
Fully coded FOV	9 x 9 deg^2		
Half sens. FOV	50 x 50 deg^2	50 x 50 deg^2 (FWHM)	
Total FOV	64 x 64 deg^2	85 x 85 deg^2 (FWZR)	2π sr
Ang. res	25 arcmin		
Source location accuracy	~5 arcmin (for >6 σ source)		
Energy res	200 eV FWHM @ 6 keV	18 % FWHM @ 60 keV	6 % FWHM @ 500 keV
Timing res.	1 μsec	1 μsec	1 μsec
On axis useful area	512 <cm^2	1024 cm^2	1024 cm^2

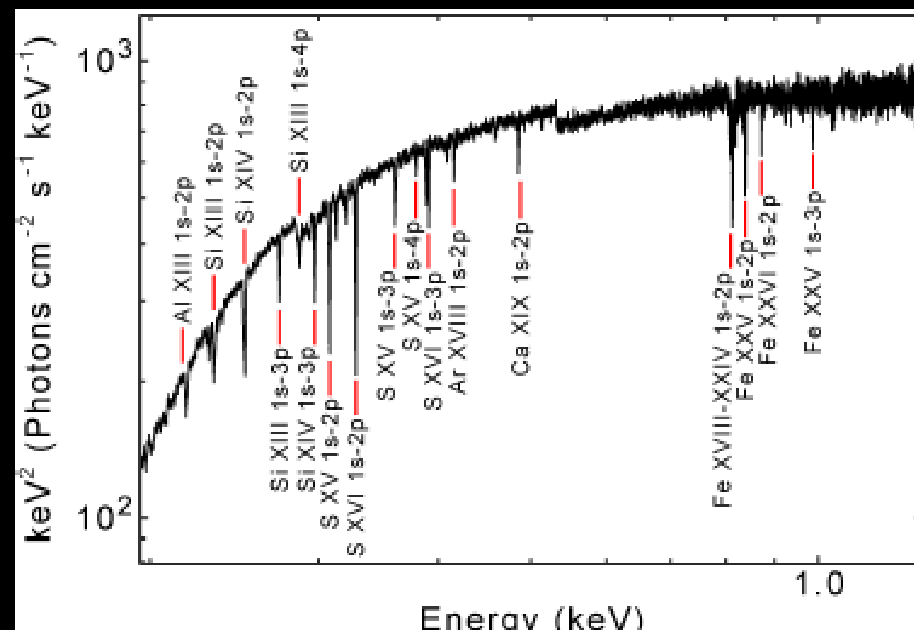
Follow-up of high-z GRB with large facilities

- Optical/IR abs. spectroscopy of the host galaxy

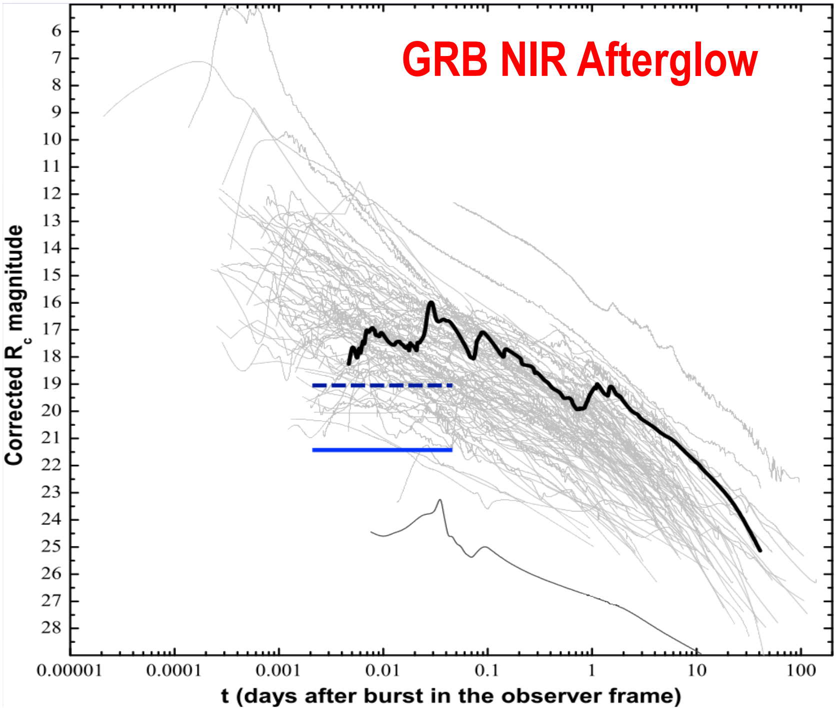
X-ray spectroscopy of the progenitor environme

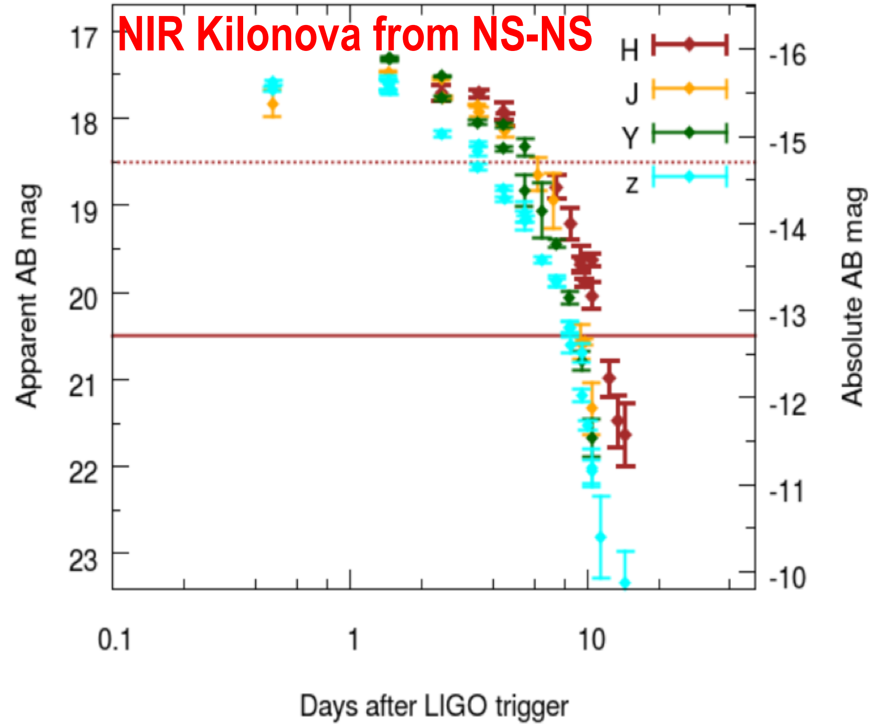


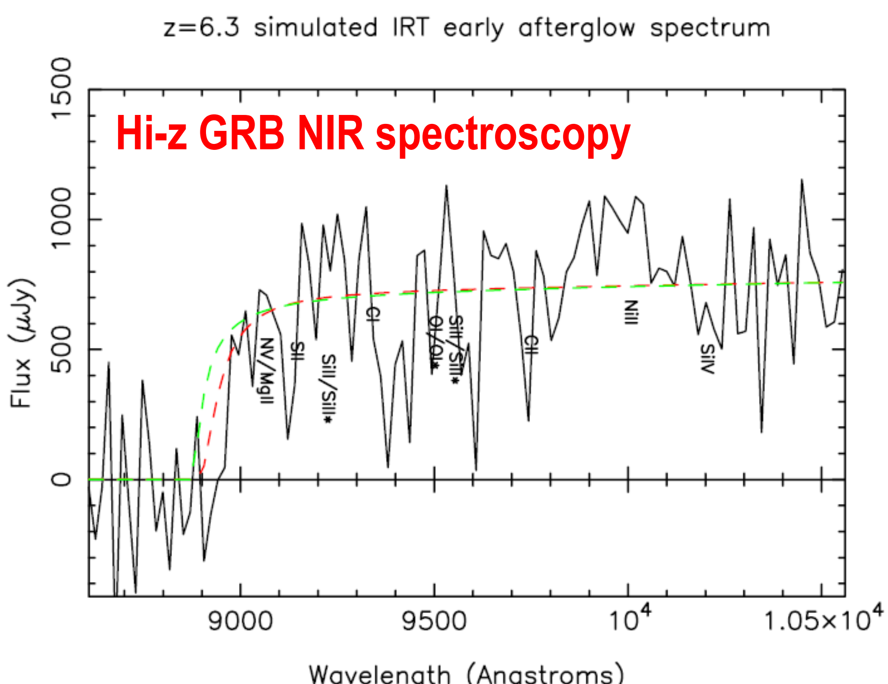
30+ m class ELTs

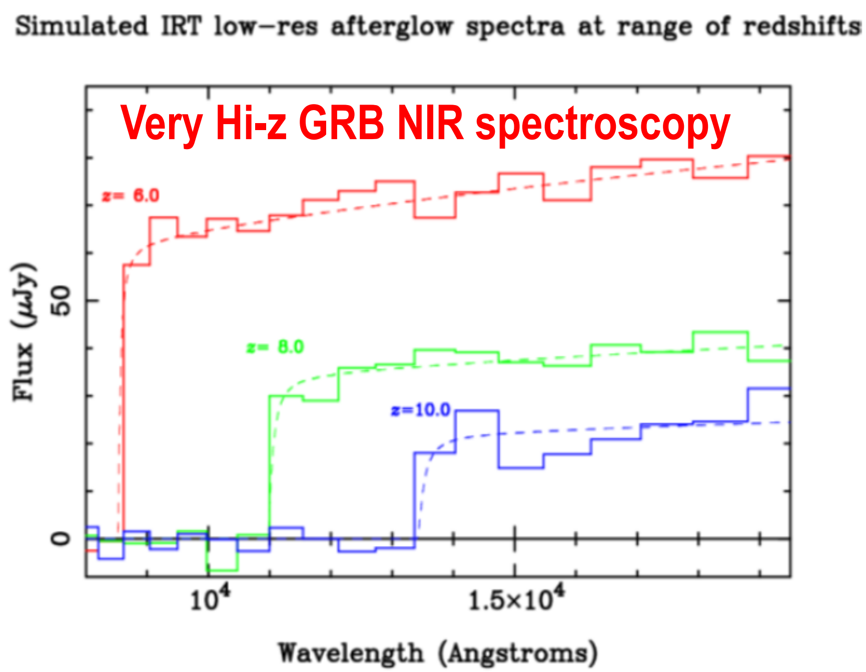


ESA L2 X-ray Observatory


GRB NIR Afterglow
Corrected R_c magnitude
t (days after burst in the observer frame)
0.00001
0.0001
0.001
0.01
0.1
1
10
100


NIR Kilonova from NS-NS
H
J
Y
z
Apparent AB mag
Absolute AB mag
Days after LIGO trigger
0.1
1
10

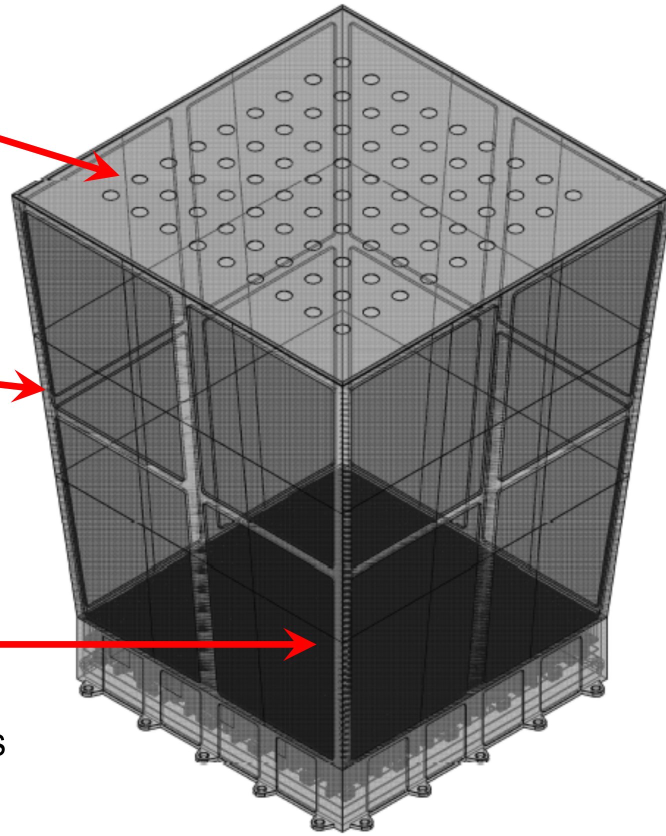

z=6.3 simulated IRT early afterglow spectrum
Hi-z GRB NIR spectroscopy
Flux (μJy)
Wavelength (Angstroms)
NV/MgII
SII
SiII/SiII*
CI
OI/OI*
SiII/SiII*
CII
NiII
SiIV
9000
9500
10^4
1.05×10^4


Simulated IRT low-res afterglow spectra at range of redshifts
Very Hi-z GRB NIR spectroscopy
z= 6.0
z= 8.0
z=10.0
Flux (μJy)
Wavelength (Angstroms)
10^4
1.5×10^4

XGIS detection unit (camera)

Coded mask

Field delimiter



Detection plane
Made of 10x10
(or 9x9 TBD) modules

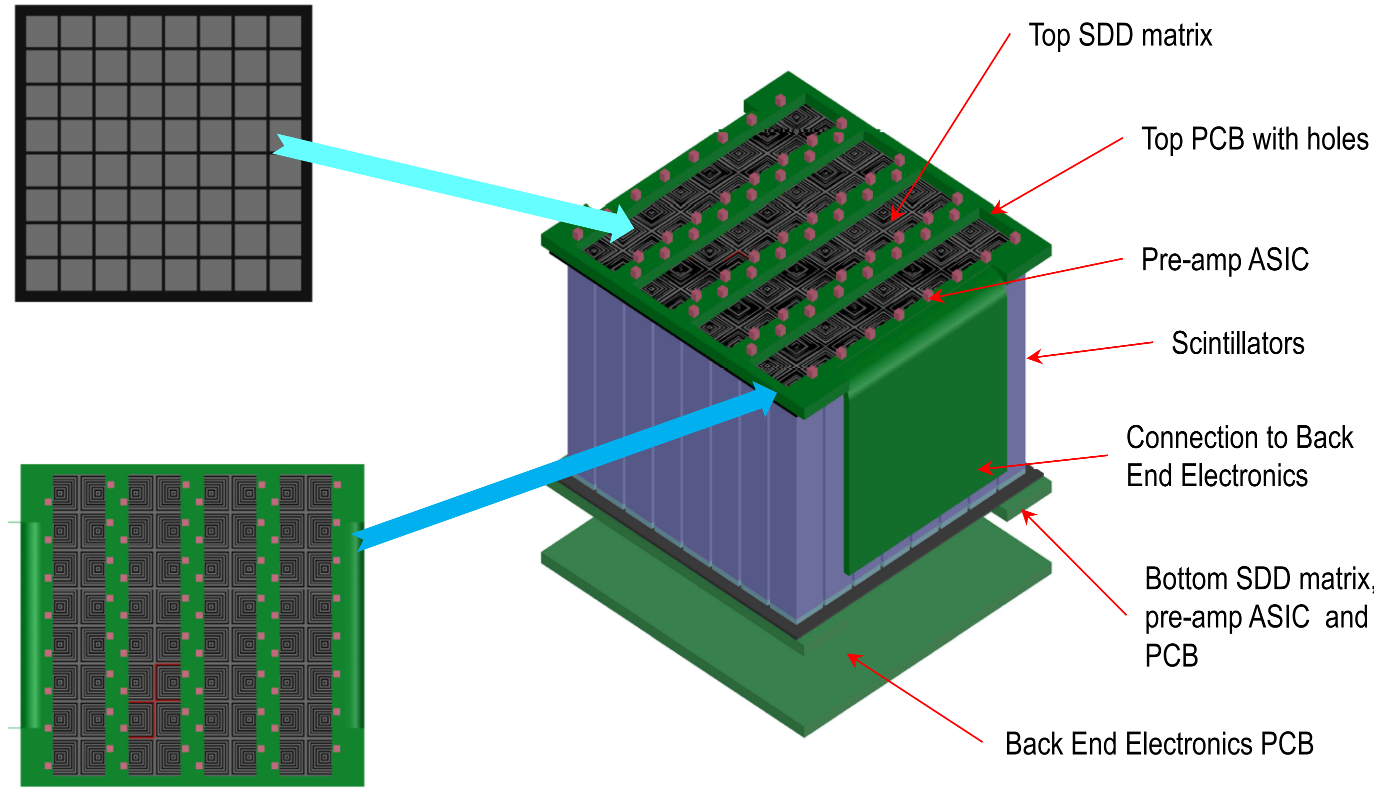
+

- **DHU (Data Handling Unit)**
- **Instr. Specific SW**
- **Harness**
- **Particle monitor**
- **…..**

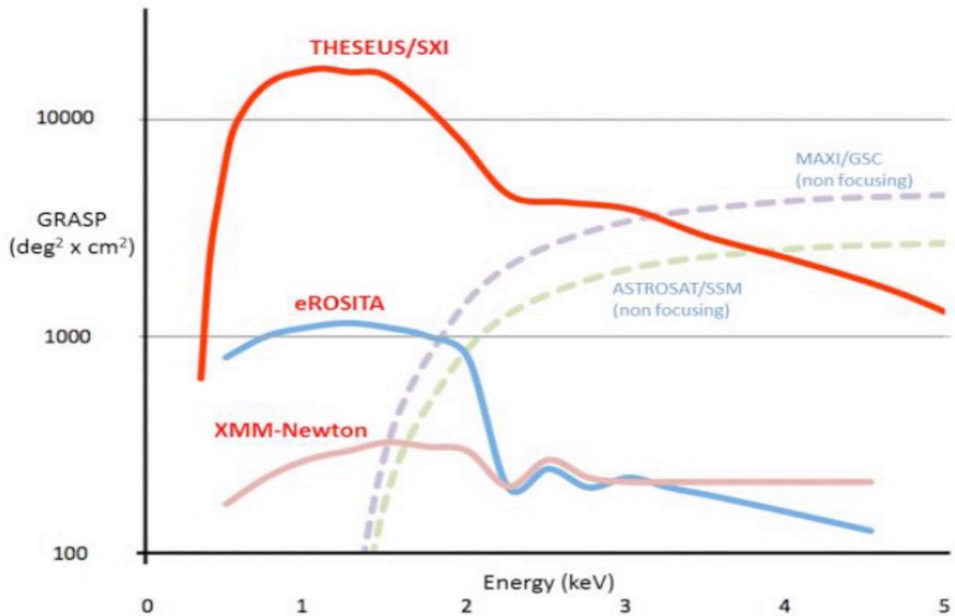
XGIS detection plane module

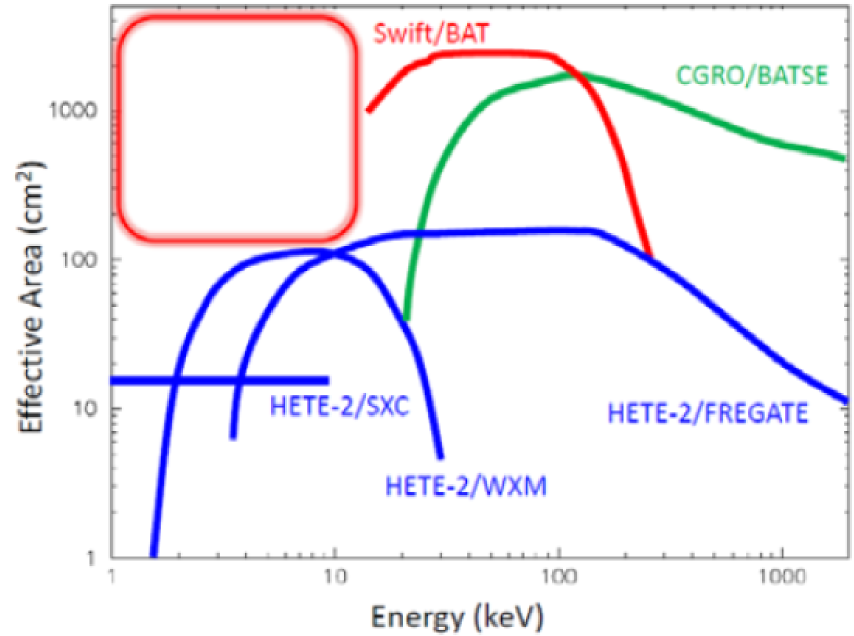
Self standing **Detection module** made of **8x8** individual detectors, electronics, I/F

8x8 Pixel SDD



Top PCB with open windows for low energy X-ray radiation and pre-amp Front ASICs in the opposite side of the SDD





	Energy Band	FOV	Energy resolution	Peak eff. area	Source location	Operation
CGRO/BATSE	20–2000 keV	open	10 keV (100 keV)	~1700 cm^2	>1.7 deg	ended
Swift	15–150 keV	1.4 sr	7 keV (60 keV)	~2000 cm^2	1–4 arcmin	active
Fermi/GBM	8 keV – 40 MeV	open	10 keV (100 keV)	126 cm^2	>3 deg	active
Konus–WIND	20 keV – 15 MeV	open	10 keV at 100 keV	120 cm^2	–	active
BeppoSAX/WFC	2–28 keV	0.25 sr	1.2 keV (6 keV)	140cm^2	1 arcmin	ended
HETE-2/WXM	2–25 keV	0.8 sr	1.7 keV (6 keV)	350cm^2	1–3 arcmin	ended
THESEUS	0.3–20000 keV	1 - 1.4 sr	300 eV (6 keV)	1500 cm^2	0.5–1 arcmin	2032
SVOM	4 keV – 5 MeV	1.5 sr	2 keV (60 keV)	1000 cm^2	2–10 arcmin	2022

+ Infrared telescope and fast slewing !!!

The Italian contribution to THESEUS

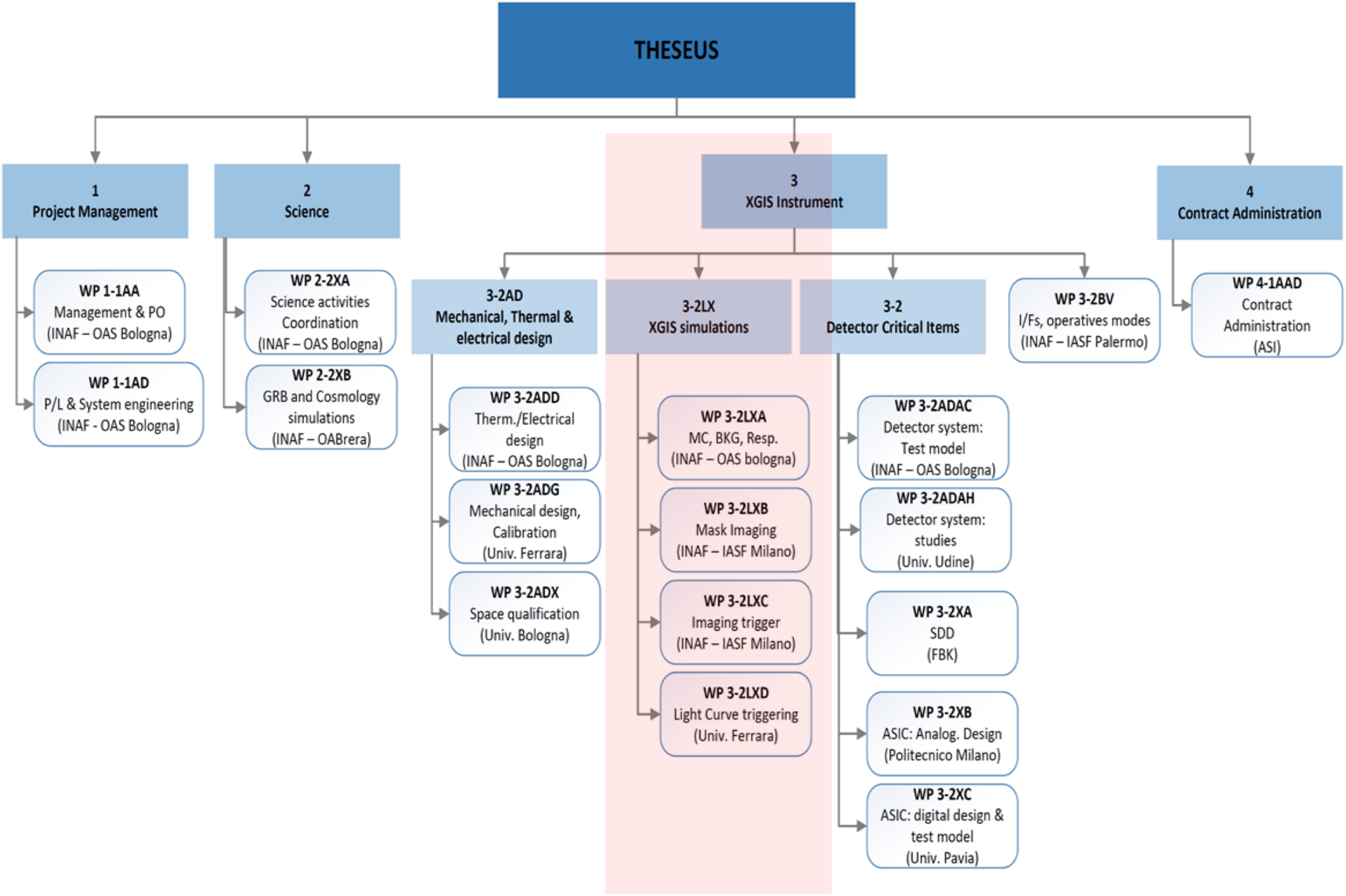
- **Theseus consortium coordination: INAF** (Lead Proposer, project office)
- **Science: INAF** (Lead Scientist; OAS, IASF-MI, Oss. Brera, IAPS, IASF-PA, Oss. Napoli, Oss. Roma, …), **Universities** (e.g., Univ. Ferrara, Pol. Milano, SNS Pisa, Univ. Federico II Napoli, Univ. Urbino, …)
- **XGIS** (including radiation monitor): **INAF** (PI; OAS, IASF-MI, IAPS, IASF-PA, …), **Universities** (Politecnico Milano, Univ. Pavia, Univ. Ferrara, Univ. Udine, **FBK** Trento
- **TBU** (Trigger Broadcasting Unit)**: INAF**
- **Malindi ground station: ASI (**in-kind contribution)
- **Industries:** involvement already in Phase A (contrib. XGIS and TBU studies)

ASI funding for Phase A study: ~500 KEuro (2019-2020)

Co-funding from INAF + Universities: ~660 KEuro

Likely further ESA funding for XGIS module prototyping: ~450 KEuro

Italian contribution: break-down



THESEUS: straightforward synergies with SKA and CTA

- **SKA:** early Universe cosmology (pop III stars, cosmic re-ionization, first galaxies), GRBs and transients physics, multi-messenger astrophysics

- **CTA:** GRB and transient physics, test of fundamental physics, multi-messenger astrophysics

- **THESEUS synergies Working Group:** investigating Theseus-CTA and Theseus-SKA synergies

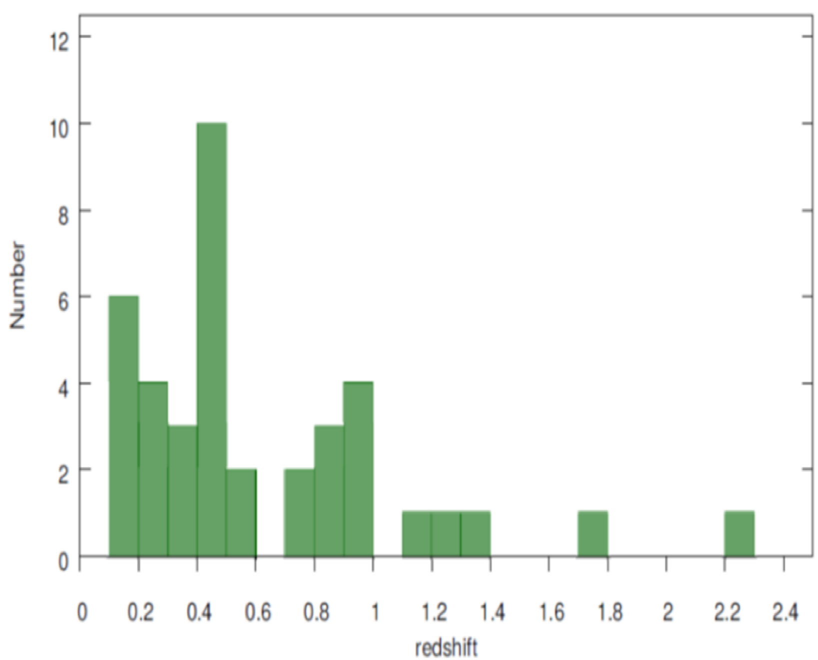
- *ESA L2/L3 review:* “The SSC strongly endorses the need to continue pursuing in the future the discovery of GRBs”

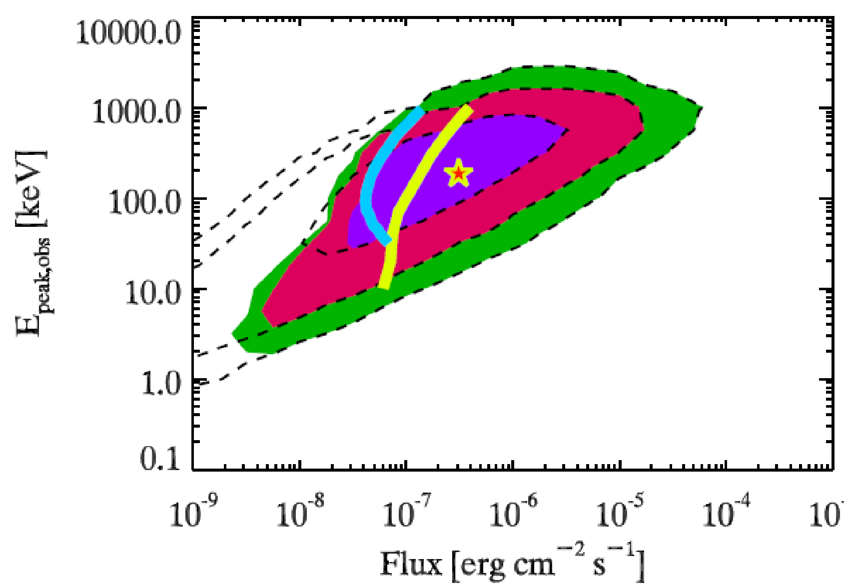
- THESEUS will be a really unique and superbly capable facility, one that will do amazing science on its own, but also will add huge value to the currently planned new photon and multi-messenger astrophysics infrastructures in the 2020s to > 2030s.

Table 2: Number of NS-NS (BNS) mergers expected to be detected in the next years by second- (2020+) and third- (2030+) generation GW detectors and the expected detection number of electromagnetic counterparts as short GRBs (collimated) and X-ray isotropic emitting counterparts (see §3.1 and 3.2) with THESEUS SXI and XGIS (see text for more details). BNS rate is a realistic estimate from Abadie et al. 2010 and Sathyaprakash et al. 2012 and the BNS range indicates the sky- and orbital inclination-averaged distance up to which GW detectors can detect a BNS with $SNR = 8$.

GW observations			THESEUS XGIS/SXI joint GW+EM observations		
Epoch	GW detector	BNS range	BNS rate (yr^{-1})	XGIS/sGRB rate (yr^{-1})	SXI/X-ray isotropic counterpart rate (yr^{-1})
2020+	Second-generation (advanced LIGO, Advanced Virgo, India-LIGO, KAGRA)	∼200 Mpc	∼40*	∼5-15	∼1-3 (simultaneous) ∼6-12 (+follow-up)
2030+	Second + Third-generation (e.g. ET, Cosmic Explorer)	∼15-20 Gpc	>10000	∼15-35	$\gtrsim$100

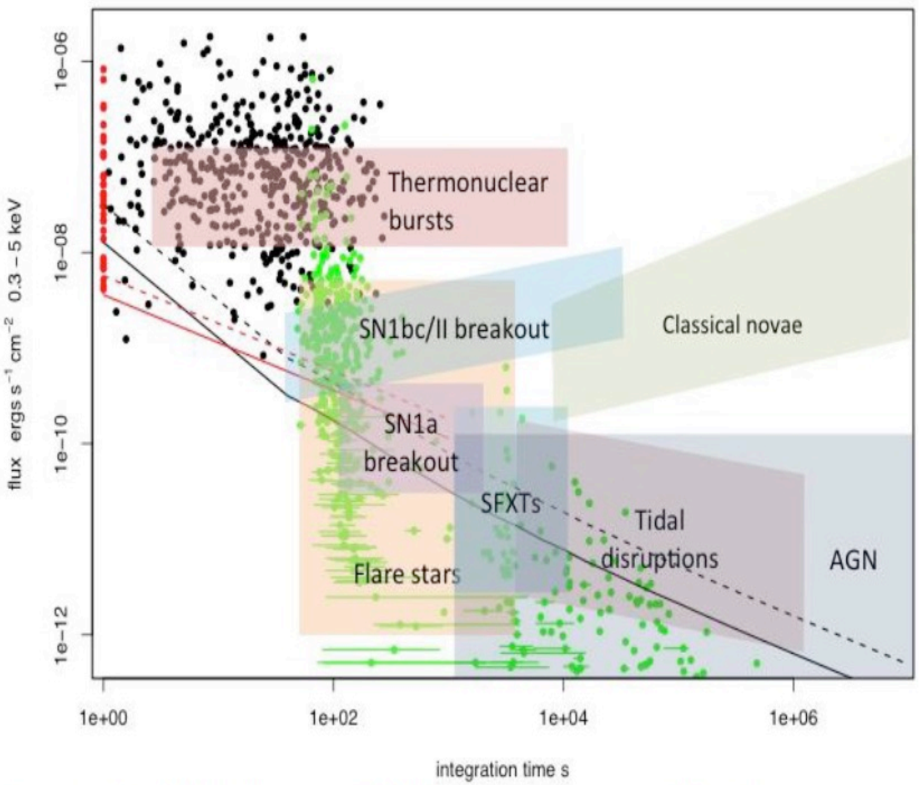
* from Abadie et al. 2010a

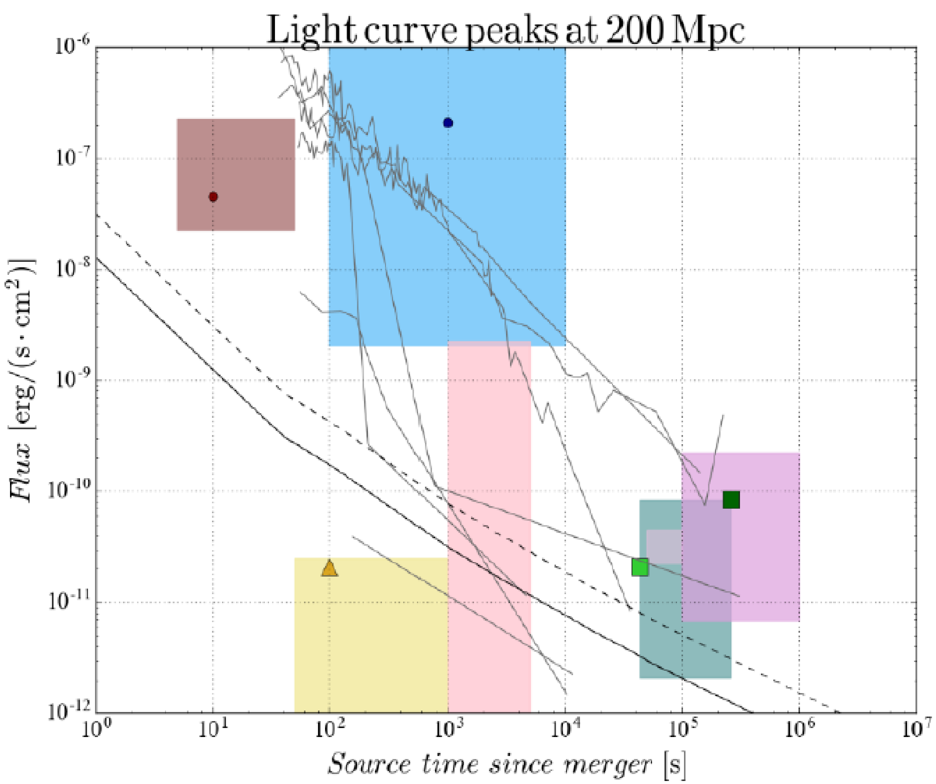




❑ THESEUS will also detect and localize down to 0.5-1 arcmin the soft X-ray short/long GRB afterglows, of NS-NS (BH) mergers and of many classes of galactic and extra-galactic transients

❑ For several of these sources, THESEUS/IRT will provide detection and study of associated NIR emission, location within 1 arcsec and redshift

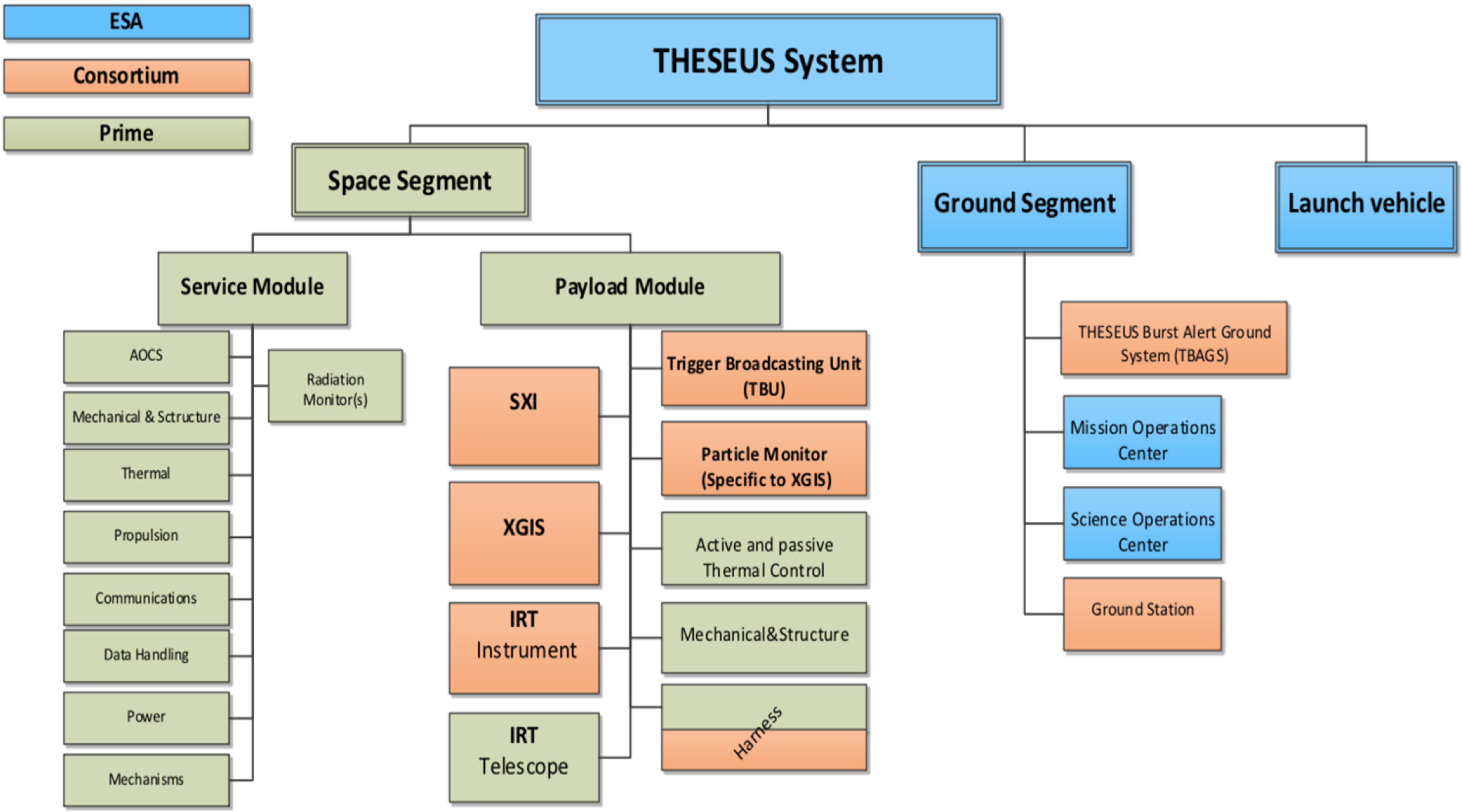




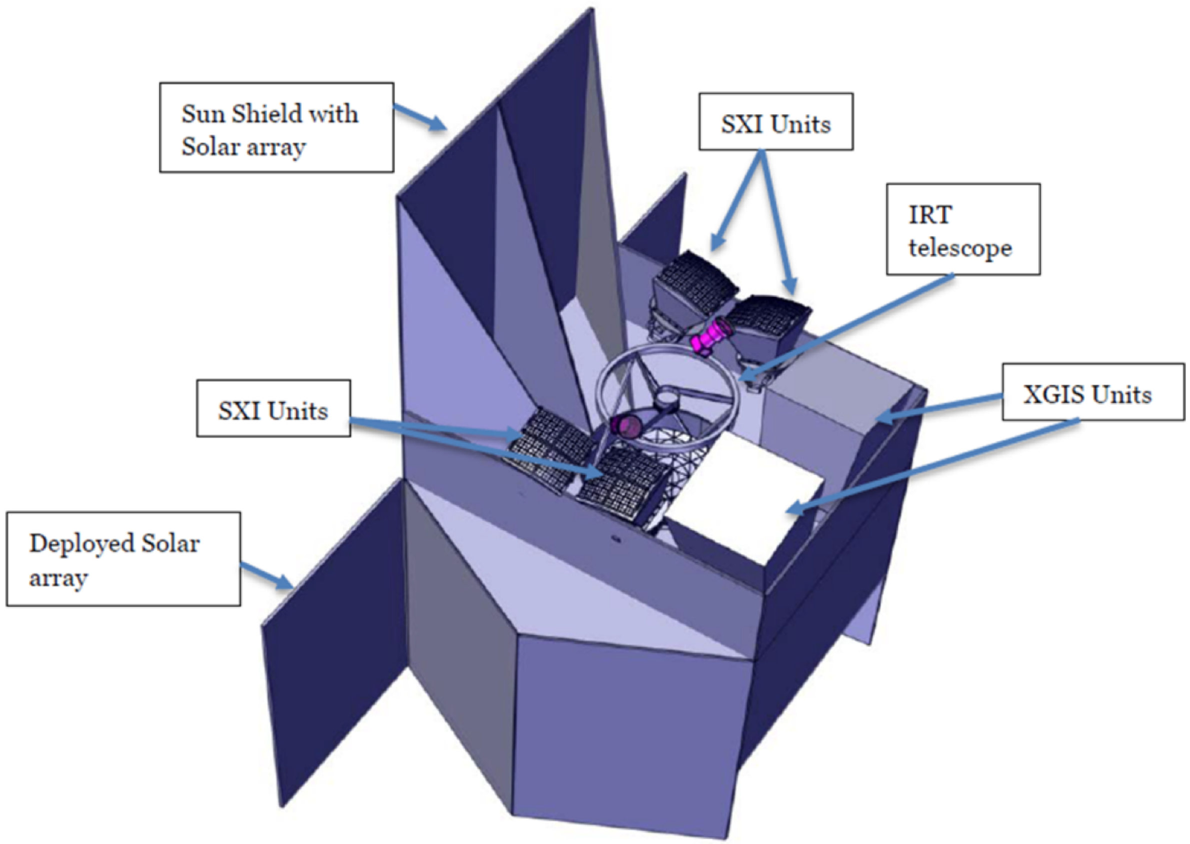
THESEUS payload consortium: contributions

- **Italy -** L.P. / project office, XGIS, Malindi ground station, Trigger Broadcasting Unit
- **UK -** SXI (coord., optics, cal., s/w)
- **France -** IRT (coord.,camera, cal., s/w), Theseus Burst Alert Ground Segment
- **Germany (with Poland and Denmark)** - I-DHUs and Power Supply Units (PSUs)
- **Switzerland**: SDC (s/w, data processing, pipelines, quick-look) + IRT filter wheel
- **Spain:** XGIS coded mask, +… (IRT detectors / optics? SXI focal plane structure / optics….?)
- **ESA P/L contribution:** IRT telescope (including cooler), SXI detectors
- **Other contributions: Spain** (XGIS coded mask, IRT), **Belgium** (SXI integration and tests), **Czech Rep.** (mechanical structures and thermal control of SXI)
- **Possible minor contributions: Ireland** (XGIS detectors, IRT on-board s/w)**, Hungary** (spacecraft interface simulator, I-DHU, IRT calib.), **Slovenia** (X-band)
- **Possible international non-enabling contributions: USA:** (XGIS sim. + tests, TDRSS), **Brazil:** Alcantara ground station, **China** (SXI, XGIS)

THESEUS responsibilities product tree

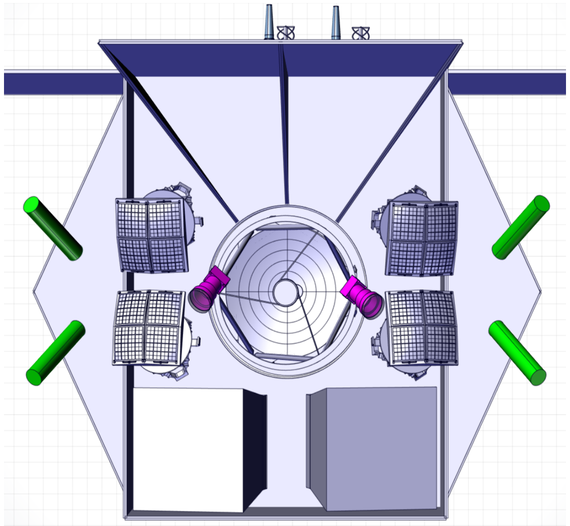


THESEUS mission concept: ESA study



Further instruments design changes

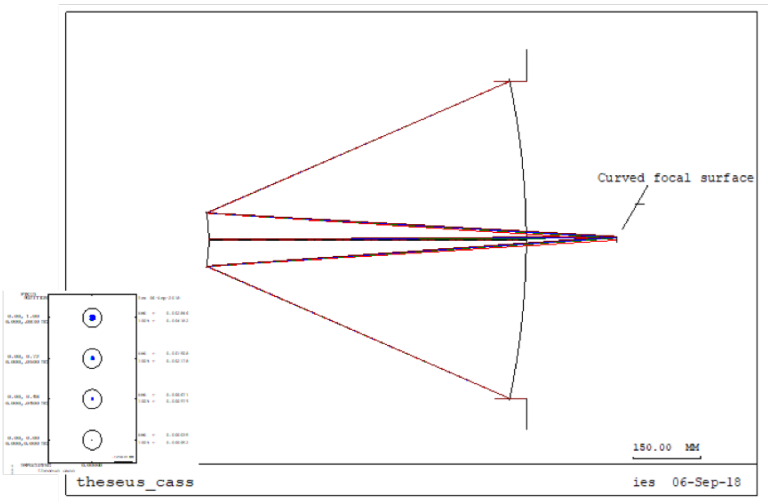
- Slight down-sizing of IRT and XGIS required -> verify impact (see next talks)
- Change of IRT optics design -> advantages and disadvantages
- Impact of spacecraft pointing performances on IRT imaging and spectroscopy sensitivity
- SXI detectors: from CCD to CMOS ? -> impact (energy band, efficiency, …)



Option 1: Ritchey-Chretien. On axis.

Interface at focus. EFL 5400mm.

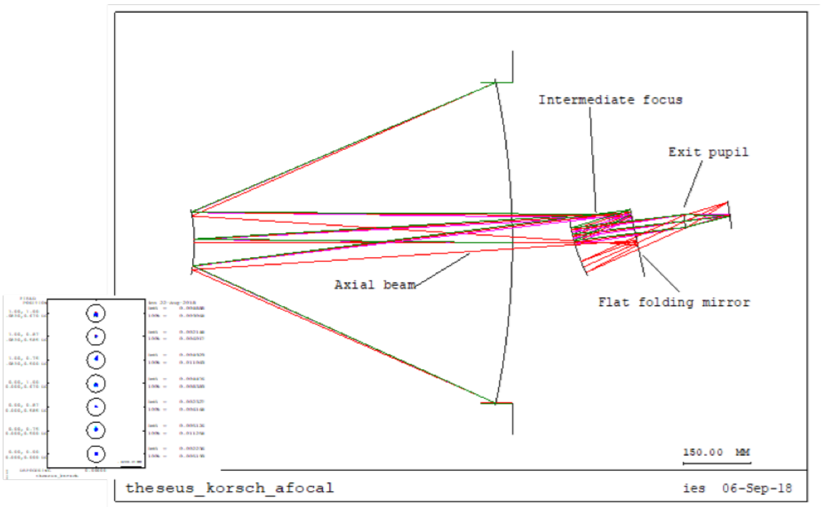
Diffraction limited (in curved focal surface).



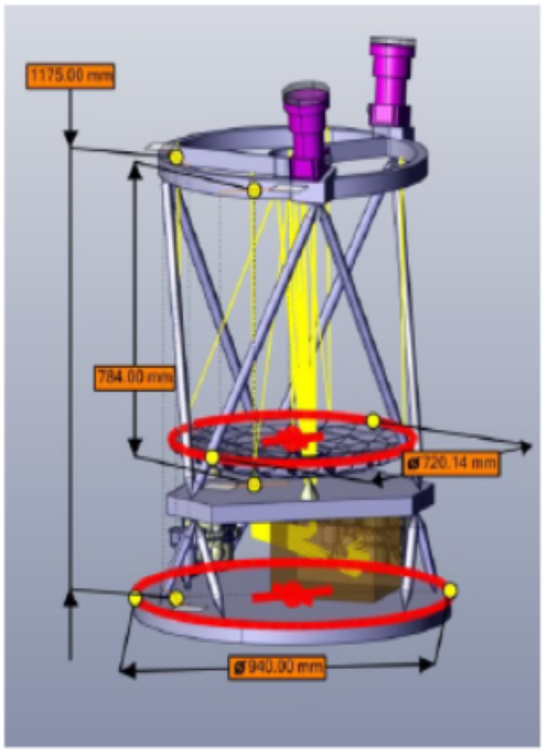
Option 2: Korsch. FoV off axis.

Interface at exit pupil. Afocal.

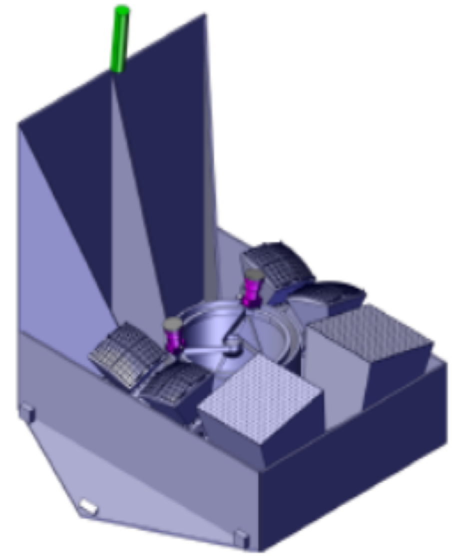
Diffraction limited.

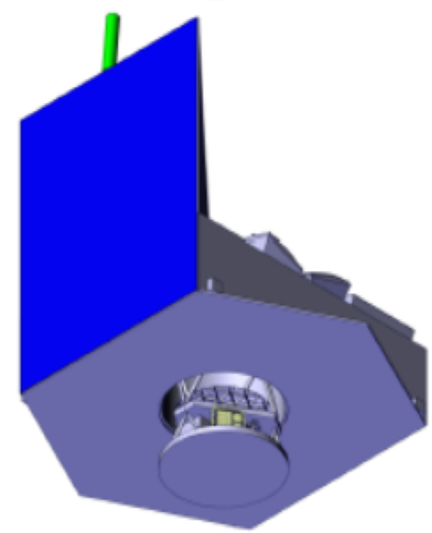


THESEUS CDF payload module concept



- **Korsch FoV off-axis** telescope
- Telescope mass compatible with Zerodur/CFRP or SiC
- **M2 focus mechanism**
- **Spider** supporting structures for M2 assembly
- **2x** XGIS units
- **Squared** combined FoV for SXI
- **Active** thermal control with **LHP (Propylene)**
- **Coarse** star Trackers





THESEUS consortium science: 6 WGs, > 200 contributing scientists

http://www.isdc.unige.ch/theseus/

1. Exploring the Early Universe with GRBs		
Surname and Name	**Country**	**Institute**
Tanvir Nial	United Kingdom	University of Leicester

2. Gravitational waves and multi-messanger Astrophysics		
Surname and Name	**Country**	**Institute**
Stratta Giulia	Italy	Urbino University

3. Exploring the time domain Universe		
Surname and Name	**Country**	**Institute**
Osborne Julian	United Kingdom	University of Leicester

4. Sinergy with other electromagnetic facilities (including LSST)		
Surname and Name	**Country**	**Institute**
Rosati Piero	Italy	University of Ferrara

5. Scientific requirements		
Surname and Name	**Country**	**Institute**
Ghirlanda Giancarlo	Italy	INAF-OA Brera

6. The IRT as a flexible Guest Observer IR observatory		
Surname and Name	**Country**	**Institute**
Blain Andrew	United Kingdom	University of Leicester

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Synergies of THESEUS with the SKA: a brief report

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Abstract. We present a short report on the main synergies between Theseus and SKA in the study of high-redshift transients and we summarize a few more aspects where Theseus and SKA can contribute to explore fundamental physics in the universe.

Key words. Cosmology: early Universe Galaxies: high-redshift, Transients

1. Introduction

The Transient High Energy Sky and Early Universe Surveyor (THESEUS) is a space mission concept whose core science goals of THESEUS comprise the exploration of the cosmic dawn and re-ionization era through the prompt detection and characterization of transients up to high redshifts.

The Square Kilometer Array (SKA) has similar key science programs working in the very-low (70-350 MHz) to mid- (0.4-10 GHz) radio frequency range (for a comprehensive illustration of the SKA science topics and

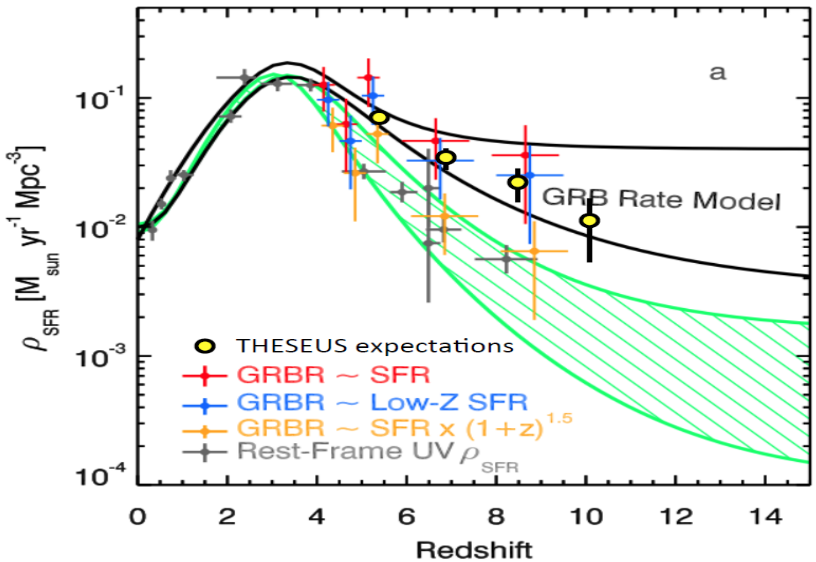
1.1. Blob-ology

This is mainly the case of the GRB (radio afterglows) population study.

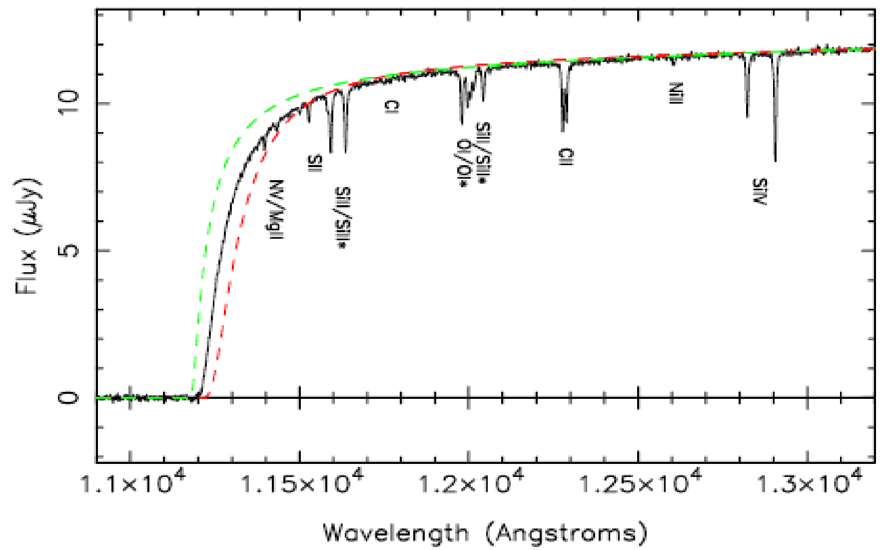
The first moral we can get from this study is that the sensitivity of the SKA will allow to observe almost the complete population of GRBs, provided that a X/g-ray instrument (more sensitive than Swift) will be operational in the SKA era (e.g., Theseus) and provided a GRB localisation to a few arcsec resolution Burlon et al. (2015).

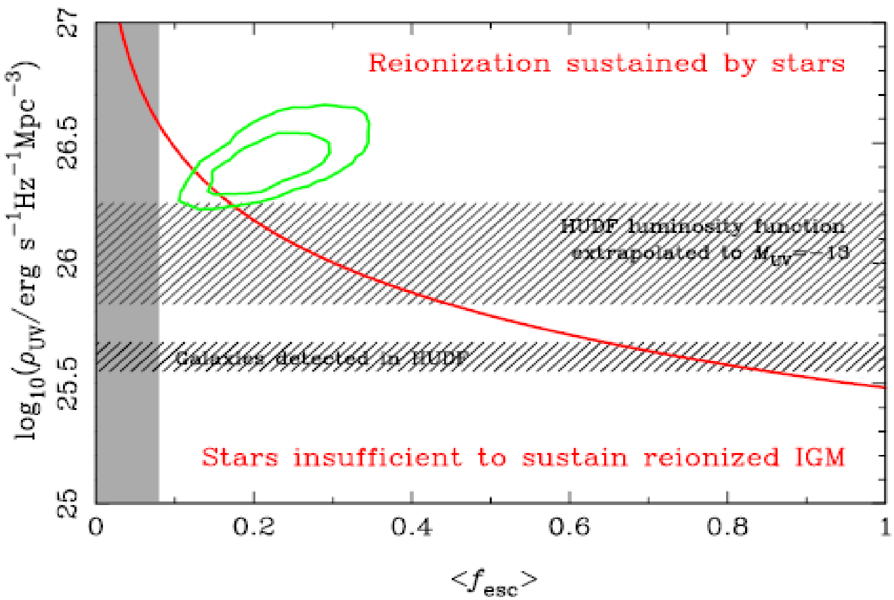
The second moral we can get is that once you have a relatively large sample of sparks

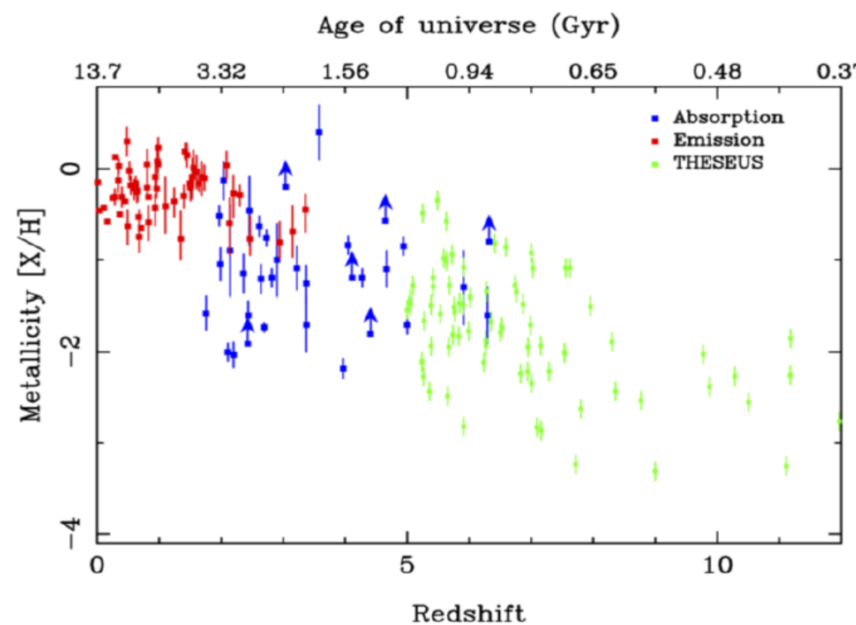
❑ Shedding light on the early Universe with GRBs



z=8.2 simulated E-ELT afterglow spectra



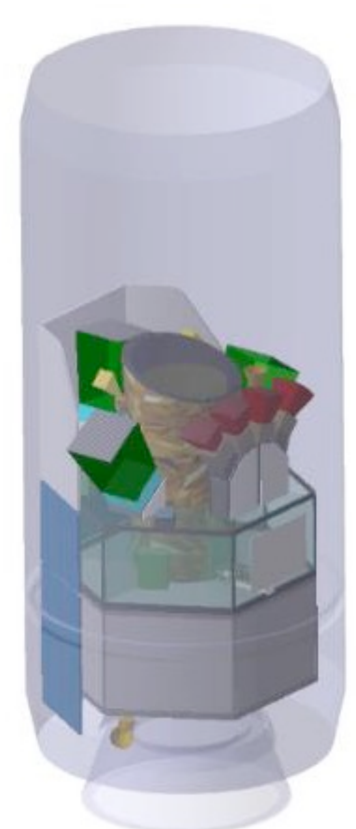




Mission profile and budgets

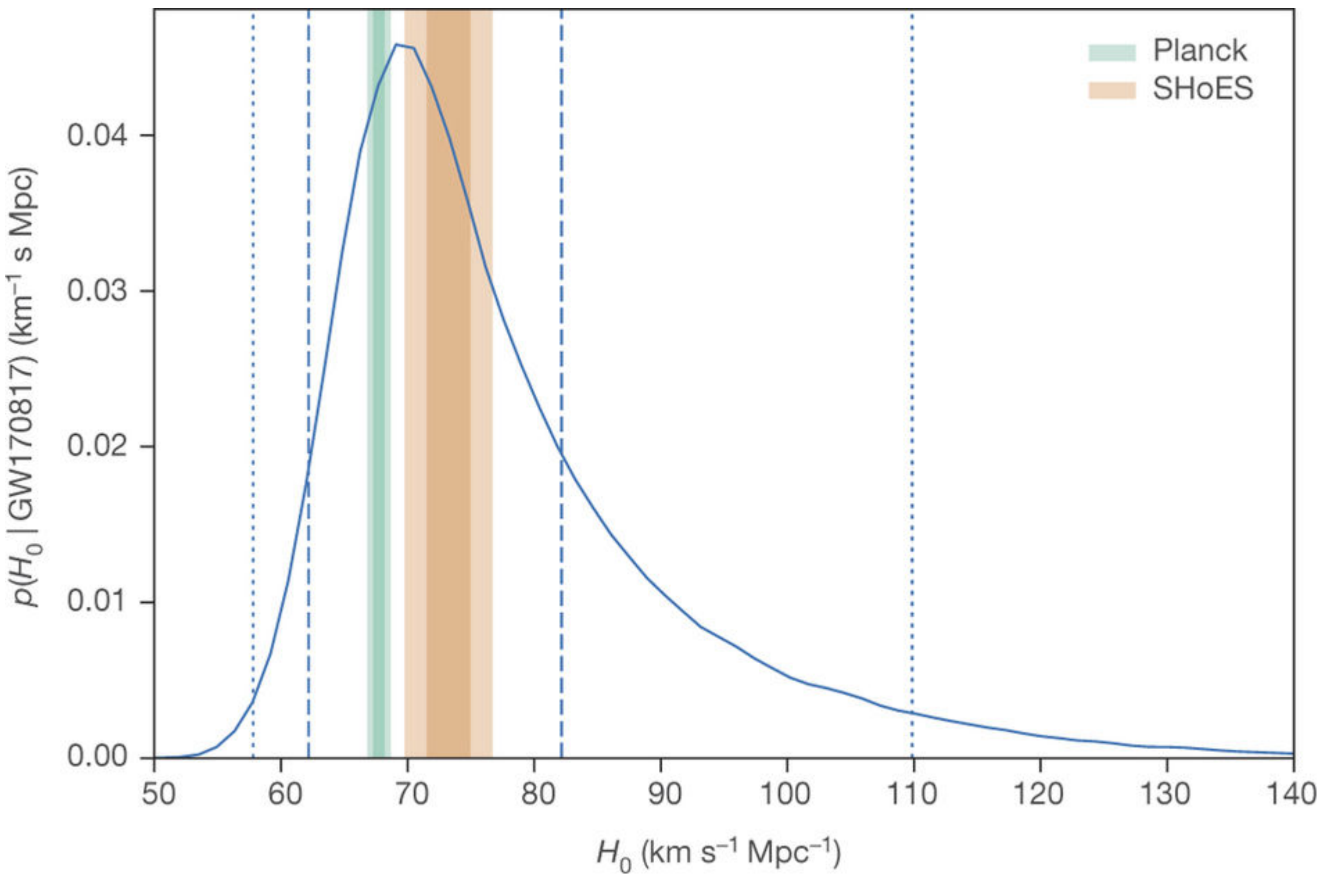
FUNCTIONAL SUBSYSTEMS	Basic Mass (kg)	Margin (%)	Margin (kg)	Current Mass (Kg)
SERVICE MODULE				
AOCS (gyro, RW, SAS, ST)	115,1	10%	11,5	126,6
PDHU + X BAND	31,4	10%	3,1	34,5
DATA HANDLING	24,4	5%	1,2	25,6
EPS (PCU, Battery, SA)	85,1	10%	8,5	93,6
SYSTEM STRUCTURE	129,1	10%	12,9	142,0
PROPULSION	17,0	15%	2,5	19,5
THERMAL CONTROL (heaters+blankets)	14,2	10%	1,4	15,6
HARNESS	46,0	20%	9,2	55,2
Total Service Module Mass	462,3	11%	50,5	512,8
PAYLOAD MODULE				
SXI	100,0	20%	20,0	120,0
XGIS	93,0	20%	18,6	111,6
IRT	94,2	20%	18,8	116,0
i-DHU + i-DU + NGRM + TBU + harness (TBC)	23,1	20%	4,6	27,7
Total P/L Module Mass	310,3		62,1	375,3

Total Service Module Mass (kg)	512,8
Total Payload Module Mass (kg)	375,3
System level margin (20%)	177,6
Dry Mass at launch (kg)	**1065,6**
Propellant	100,0
Launcher adapter	31,7
Total mass at launch (kg)	**1197,3**



- Launch with VEGA-C into LEO (< 5°, ~600 km)
- **Spacecraft slewing capabilities (30° < 5 min)**
- **Prompt downlink options : WHF network (options: IRIDIUM network, ORBCOMM, NASA/TDRSS, ESA/EDRS)**

- THESEUS measurements + sinergy with large e.m. facilities -> substantial improvment of redshift estimate for e.m. counterparts of GW sources -> **cosmology**



Estimating H0 with GW170817A

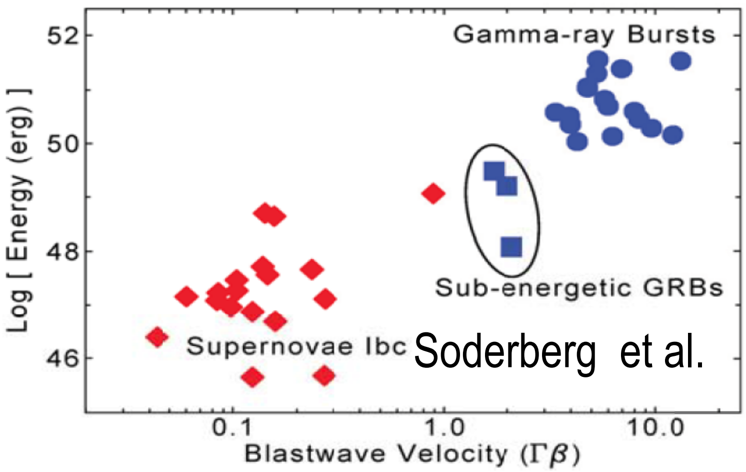
❑ Time-domain astronomy and GRB physics

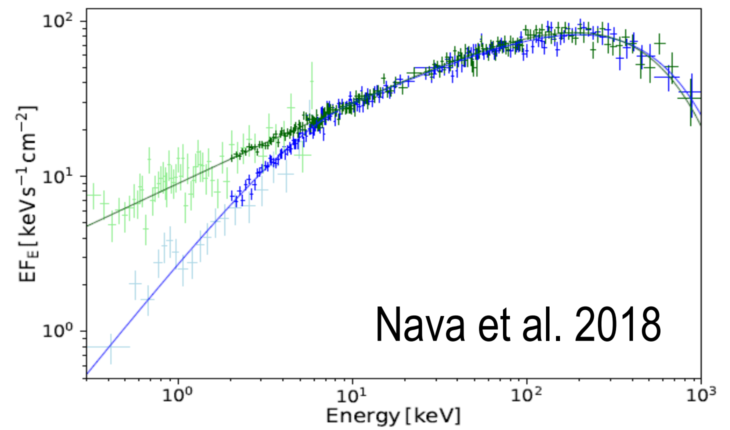
- survey capabilities of transient phenomena similar to the Large Synoptic Survey Telescope (LSST) in the optical: a remarkable scientific sinergy can be anticipated.

- substantially increased detection rate and characterization of sub-energetic GRBs and X-Ray Flashes;

- unprecedented insights in the physics and progenitors of GRBs and their connection with peculiar core-collapse Sne;

Transient type	SXI rate
Magnetars	40 day^{-1}
SN shock breakout	4 yr^{-1}
TDE	50 yr^{-1}
AGN+Blazars	350 yr^{-1}
Thermonuclear bursts	35 day^{-1}
Novae	250 yr^{-1}
Dwarf novae	30 day^{-1}
SFXTs	1000 yr^{-1}
Stellar flares	400 yr^{-1}
Stellar super flares	200 yr^{-1}

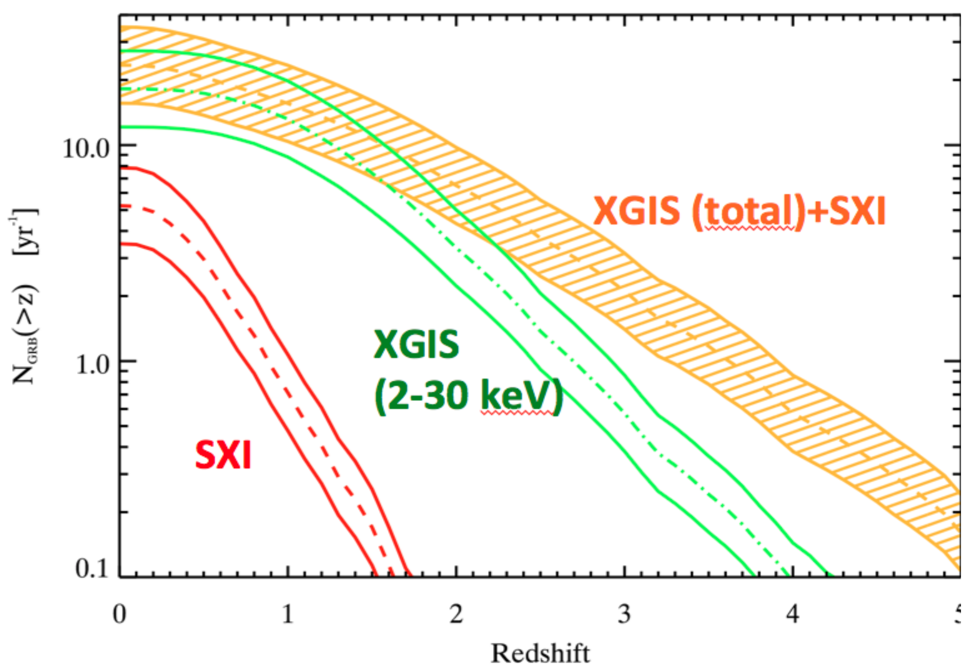


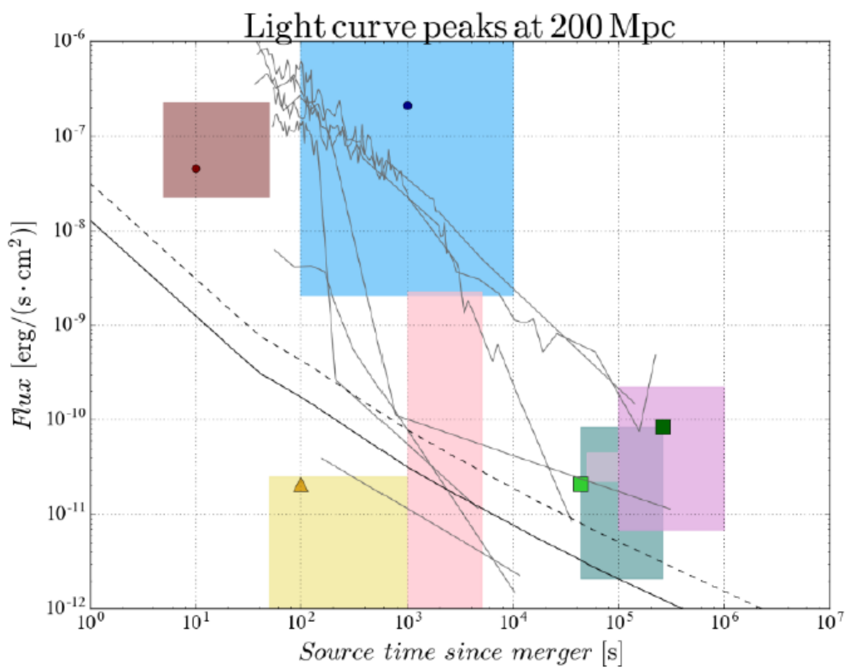


❑ GW/multi-messenger time-domain astrophysics

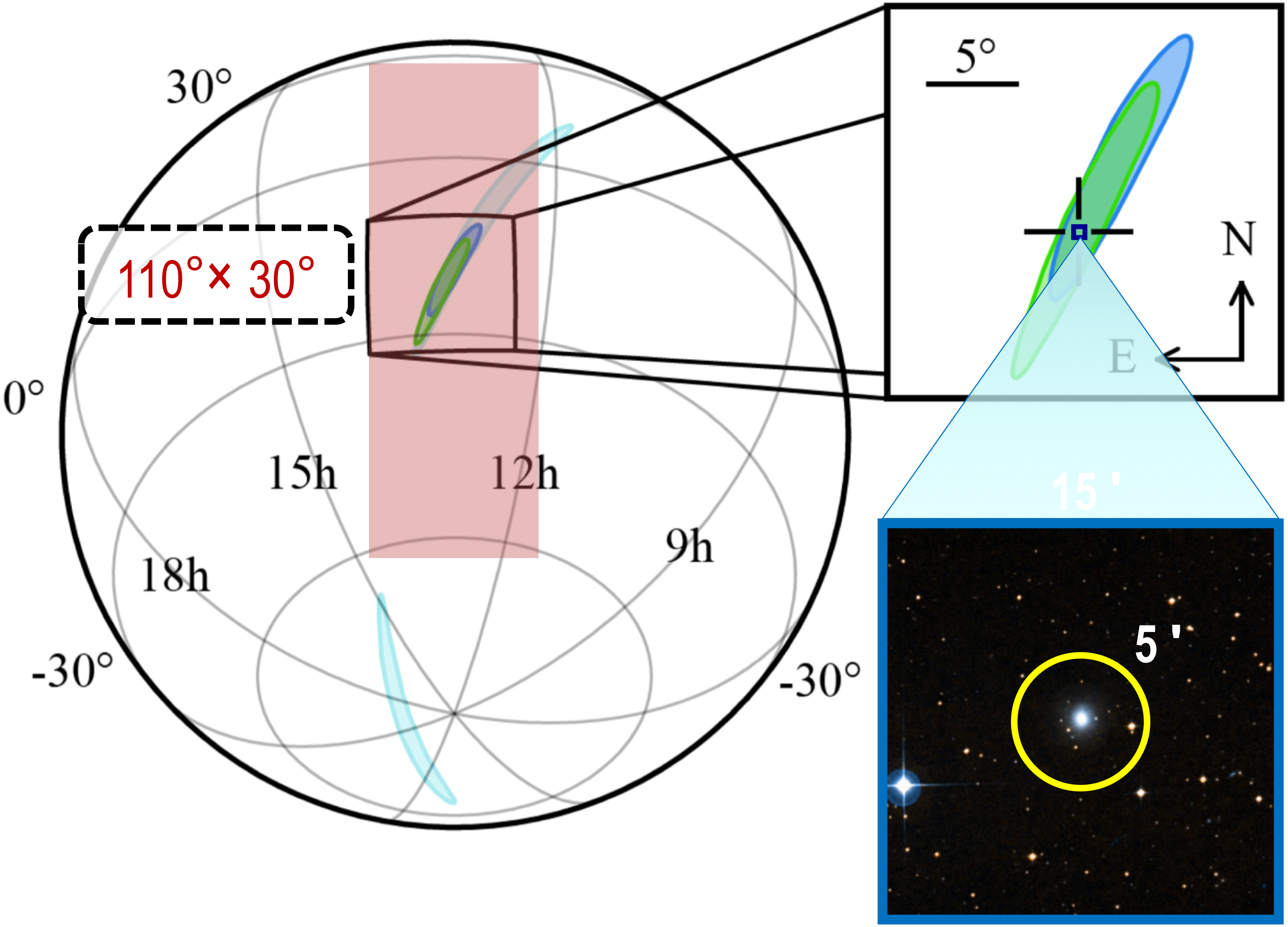
GW transient sources that will be monitored by THESEUS include **NS-NS / NS-BH mergers**:

- ❑ **collimated** on-axis and off-axis prompt gamma-ray emission from short GRBs
- ❑ Optical/NIR and soft X-ray **isotropic** emissions from kilonovae, off-axis afterglows and, for NS-NS, from newly born ms magnetar spindown

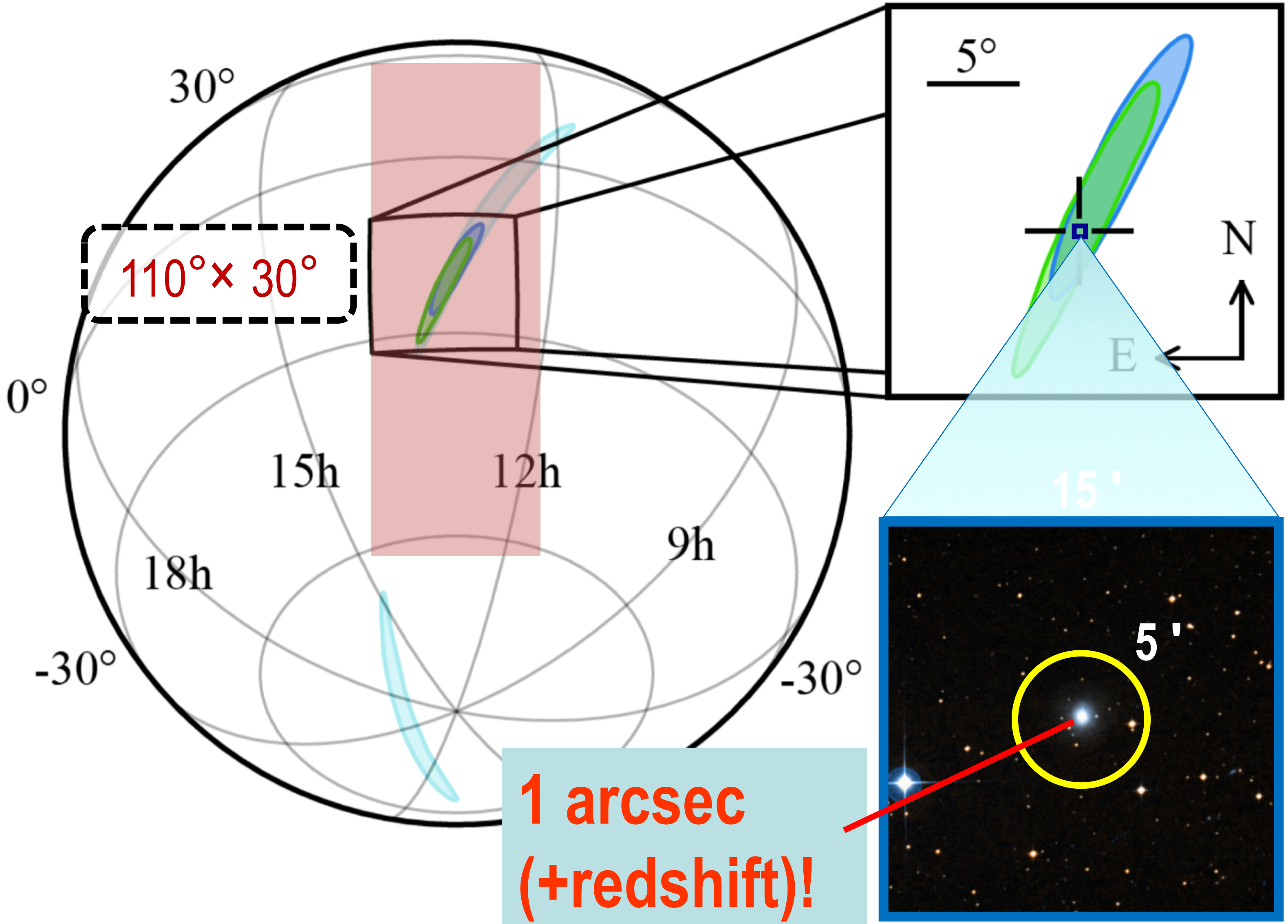




❑ **Promptly and accurately localizing e.m. counterparts to GW events with THESEUS**



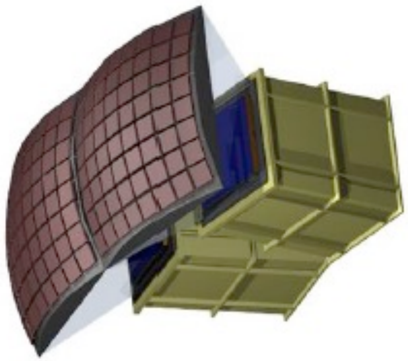
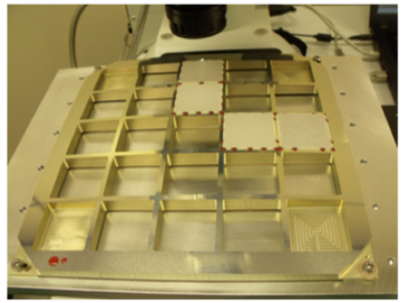
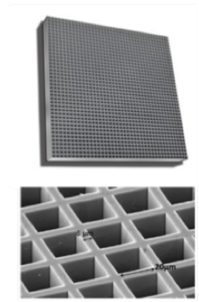
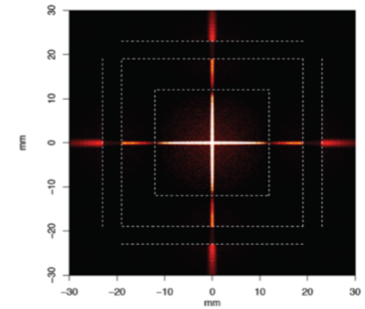
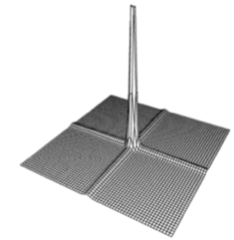
❑ Promptly and accurately localizing e.m. counterparts to GW events with THESEUS



THESEUS payload consortium (M5)

- **ITALY -** L.P. / project office, XGIS, Malindi antenna
- **UK -** SXI (optics + detectors + calibration) + S/W (SXI pipeline and remote contribution to SDC)
- **France -** IRT (coordination and IR camera, including cooler) , **ESA -** IRT optics + SXI CCDs
- **Germany, Poland** - Data Processing Units (DPU) for both SXI and XGS, Power Supply Units (PSU)
- **Switzerland**: SDC (data archiving, AOs, + pipelines) + IRT focal plane assembly
- **Other contributions: Spain** (XGIS collimators), **Belgium** (SXI integration and tests), **Czech Rep.** (mechanical structures and thermal control of SXI), **Ireland** (IRT focal plane)**, Hungary** (spacecraft interface simulator, PDHU, IRT calib.), **Slovenia** (X-band transponder, mobile ground station)
- **International optional contributions: USA:** (TDRSS, contrib. to XGS and IRT detectors), **Brazil:** Alcantara antenna, **China** (SXI, XGS), **Japan** ?
- **Industrial partners:** CGS (OHB group), GPAP

The Soft X-ray Imager (SXI)

4 DUs, each has a 31 x 26 degree FoV

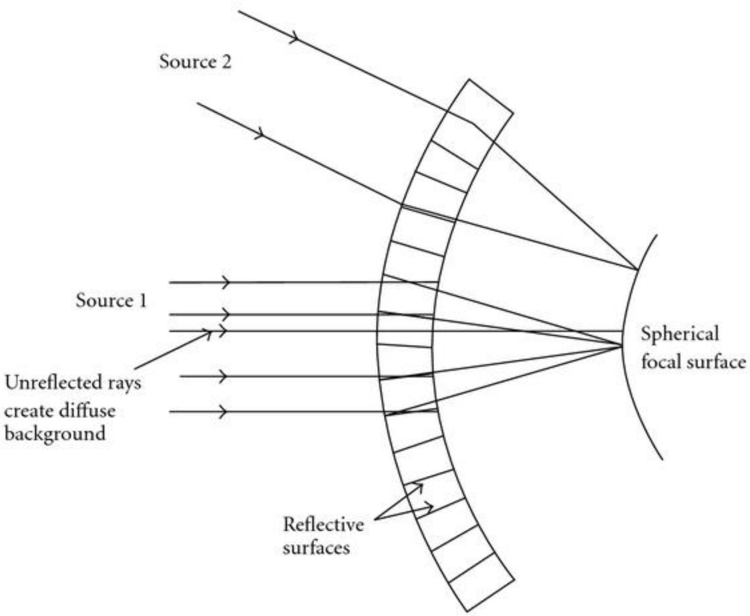
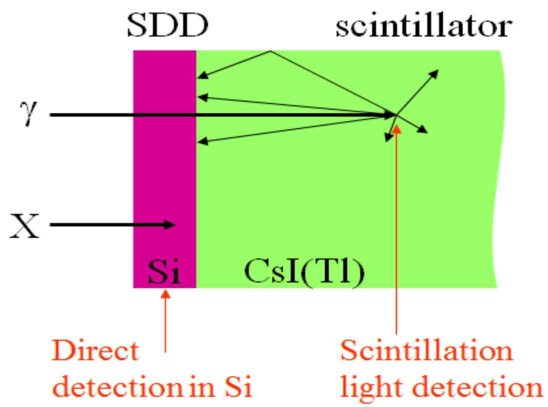
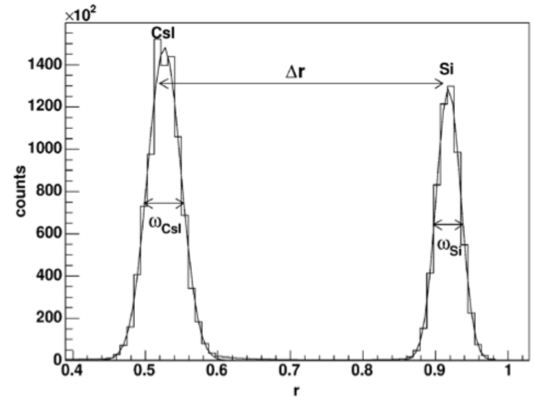


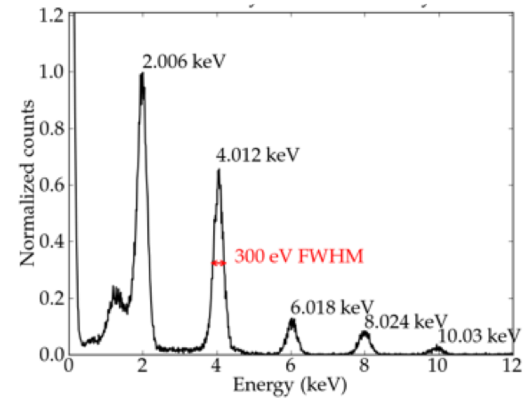
Table 4 : : SXI detector unit main physical characteristics

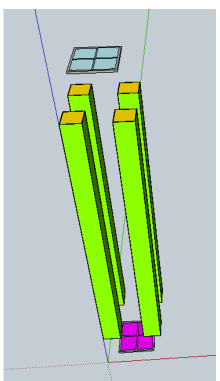
Energy band (keV)	0.3-5
Telescope type:	Lobster eye
Optics aperture (mm2)	320x320
Optics configuration	8x8 square pore MCPs
MCP size (mm2)	40x40
Focal length (mm)	300
Focal plane shape	spherical
Focal plane detectors	CCD array
Size of each CCD (mm2)	81.2x67.7
Pixel size (µm)	18
Pixel Number	4510 x 3758 per CCD
Number of CCDs	4
Field of View (square deg)	~1sr
Angular accuracy (best, worst) (arcsec)	(<10, 105)
Power [W]	27,8
Mass [kg]	40

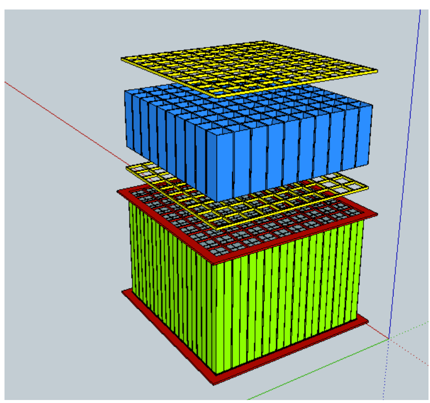
The X-Gamma-rays spectrometer (XGS)

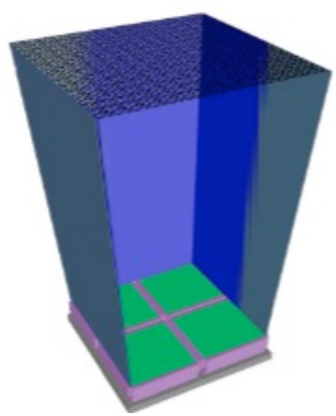












Energy band	*2 keV – 20 MeV*
# detection plane modules	*4*
# of detector pixel / module	*32x32*
pixel size (= mask element size)	*5x5 mm*
Low-energy detector (2-30 keV)	*Silicon Drift Detector 450 μm thick*
High energy detector (> 30 keV)	*CsI(Tl) (3 cm thick)*
Discrimination Si/CsI(Tl) detection	*Pulse shape analysis*
Dimension [cm]	*50x50x85*
Power [W]	*30,0*
Mass [kg]	*37.3*

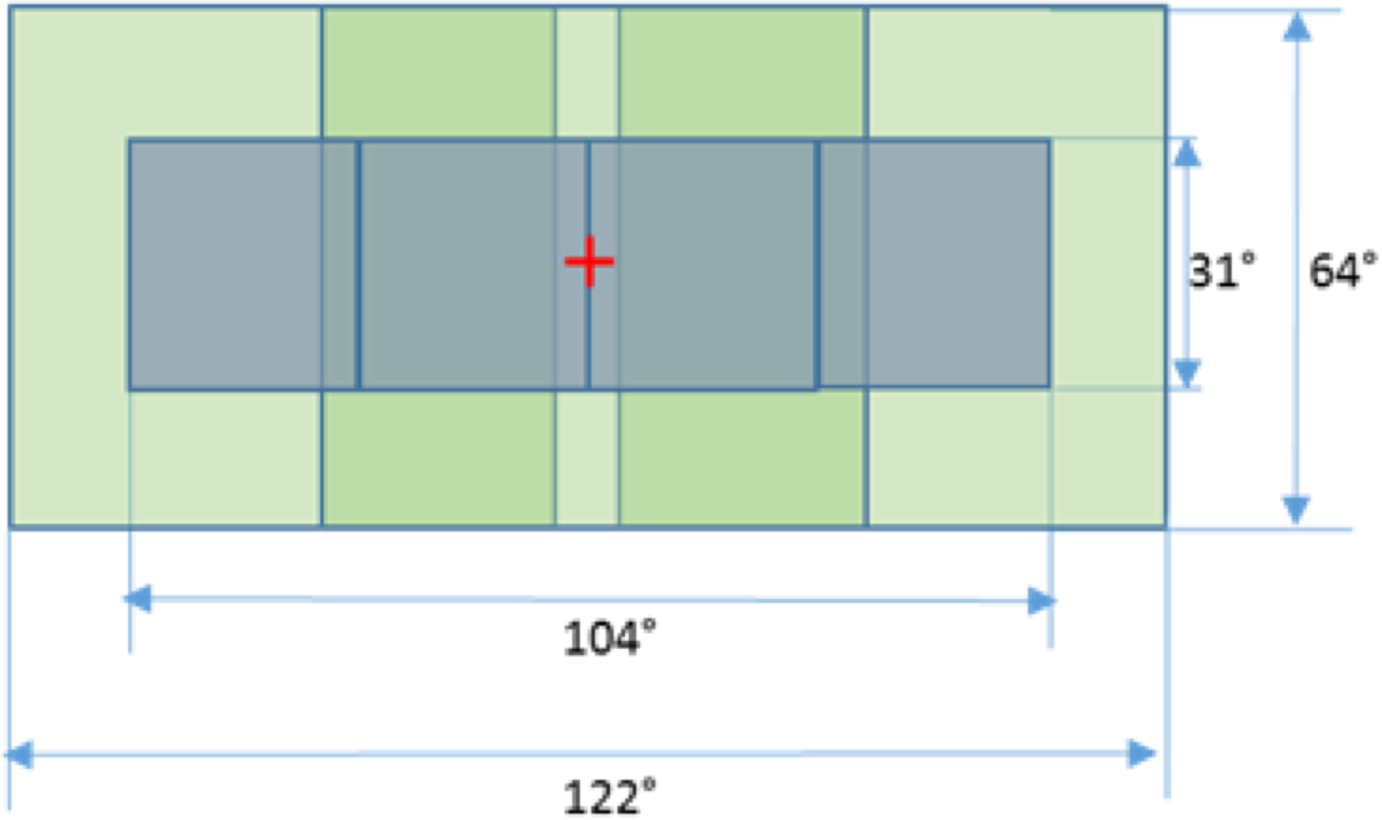
	2-30 keV	30-150 keV	>150 keV
Fully coded FOV	9 x 9 deg²		
Half sens. FOV	50 x 50 deg²	50 x 50 deg² (FWHM)	
Total FOV	64 x 64 deg²	85 x 85 deg² (FWZR)	2π sr
Ang. res	25 arcmin		
Source location accuracy	~5 arcmin (for >6 σ source)		
Energy res	200 eV FWHM @ 6 keV	18 % FWHM @ 60 keV	6 % FWHM @ 500 keV
Timing res.	1 μsec	1 μsec	1 μsec

Field of view

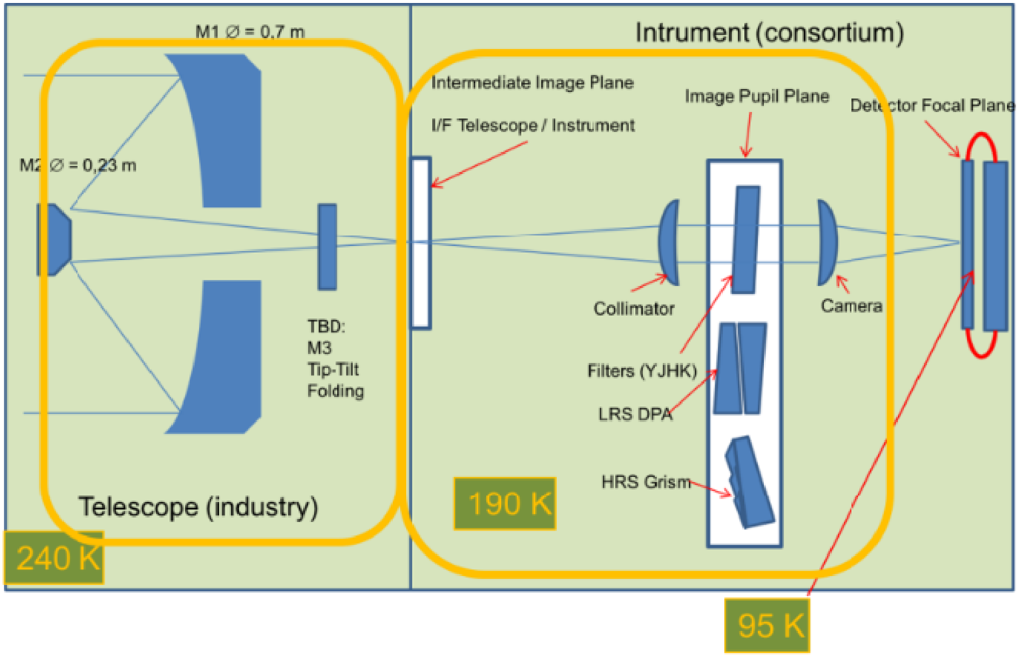
XGIS

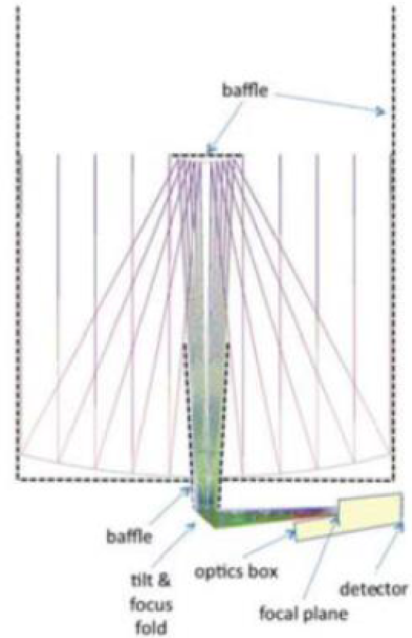
SXI

IRT

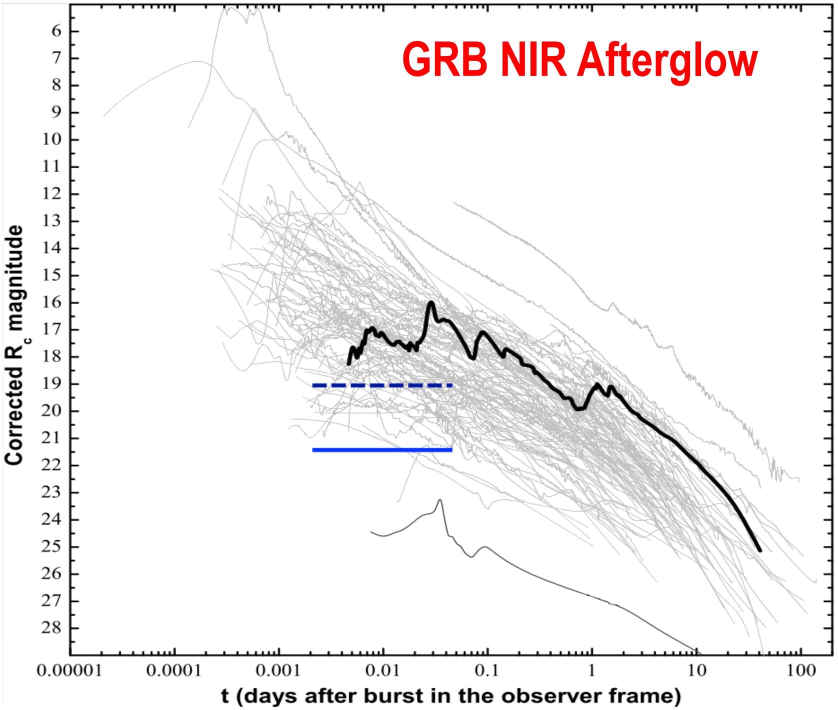


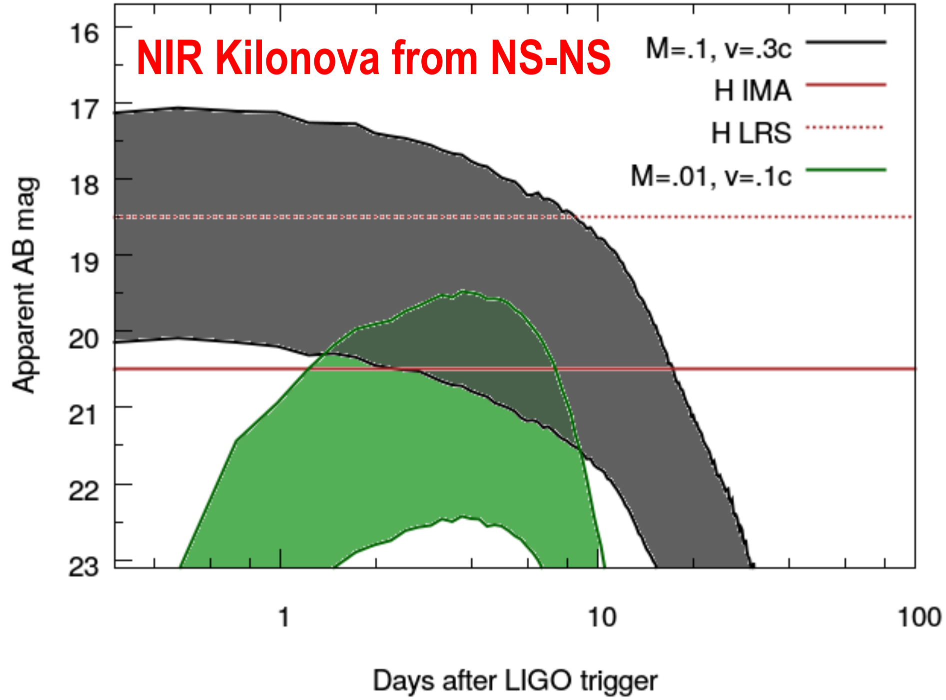
The InfraRed Telescope (IRT)

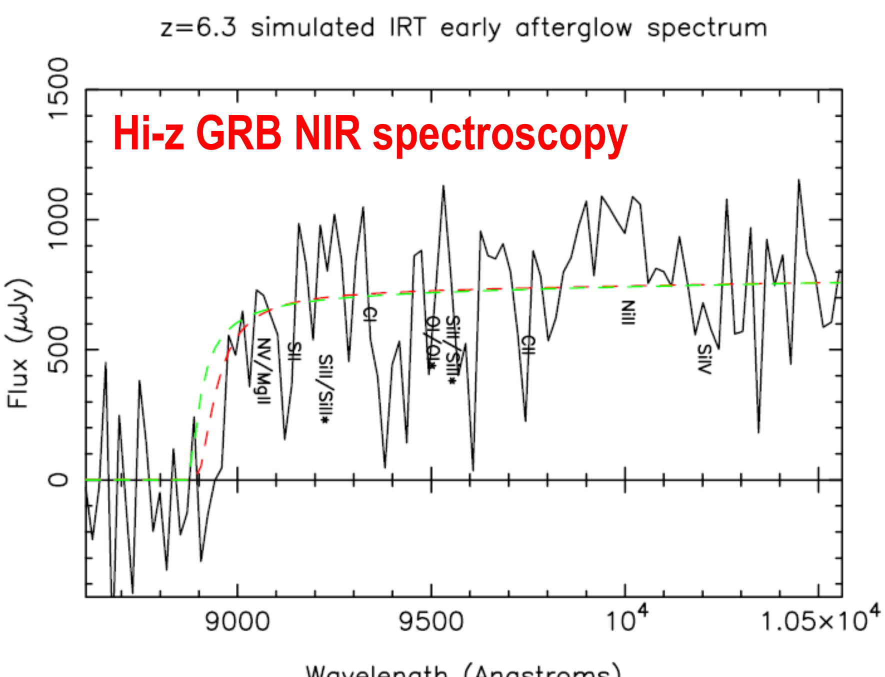


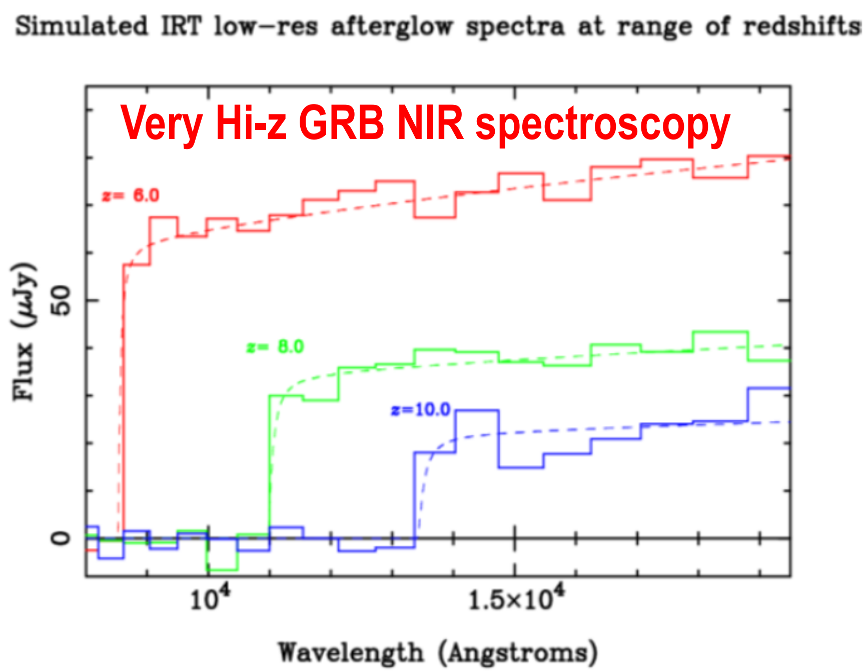


Telescope type:	Cassegrain		
Primary & Secondary size:	700 mm & 230 mm		
Material:	SiC (for both optics and optical tube assembly)		
Detector type:	Teledyne Hawaii-2RG 2048 x 2048 pixels (18 µm each)		
Imaging plate scale	0".3/pixel		
Field of view:	10' x 10'	10' x 10'	5' x 5'
Resolution (λ/Δλ):	2-3 (imaging)	20 (low-res)	500 (high-res), goal 1000
Sensitivity (AB mag):	H = 20.6 (300s)	H = 18.5 (300s)	H = 17.5 (1800s)
Filters:	ZYJH	Prism	VPH grating
Wavelength range (µm):	0.7-1.8 (imaging)	0.7-1.8 (low-res)	0.7-1.8 (high-res, TBC)
Total envelope size (mm):	800 Ø x 1800		
Power (W):	115 (50 W for thermal control)		
Mass (kg):	112.6		


GRB NIR Afterglow
Corrected R_c magnitude
t (days after burst in the observer frame)
0.00001
0.0001
0.001
0.01
0.1
1
10
100

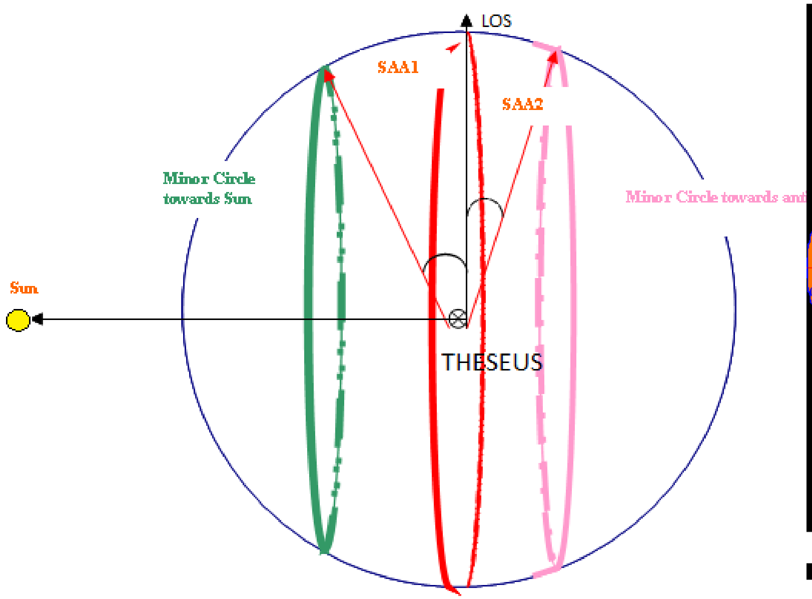

NIR Kilonova from NS-NS
M=.1, v=.3c
H IMA
H LRS
M=.01, v=.1c
Apparent AB mag
Days after LIGO trigger

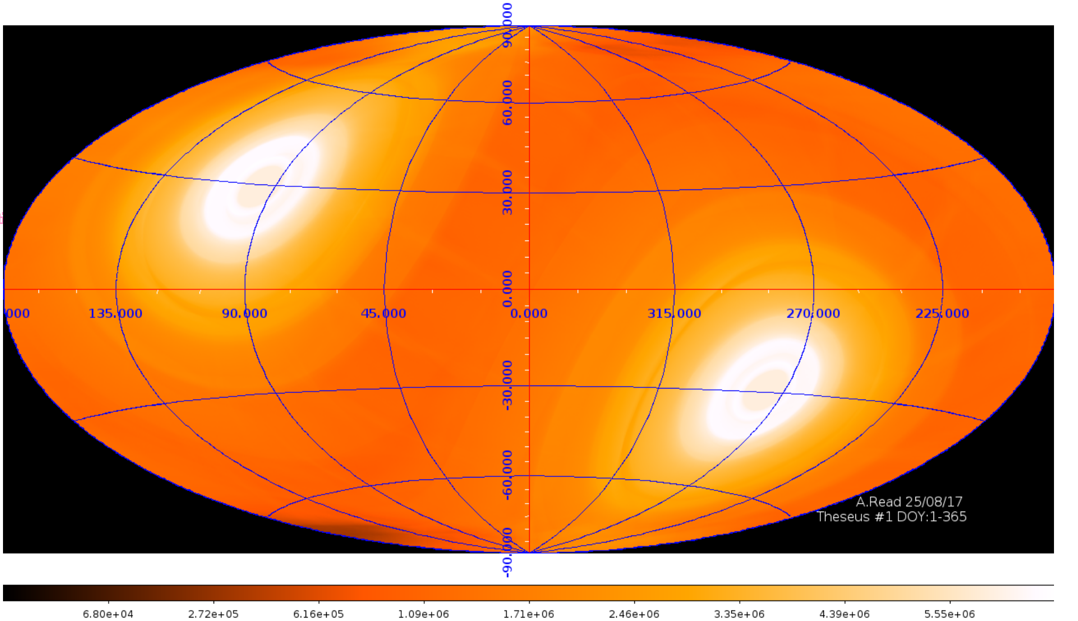

z=6.3 simulated IRT early afterglow spectrum
Hi-z GRB NIR spectroscopy
Flux (μJy)
Wavelength (Angstroms)
NV/MgII
SII
SiII/SiII*
CI
OI/OI*
SiII/SiII*
CII
NiII
SiIV


Simulated IRT low-res afterglow spectra at range of redshifts
Very Hi-z GRB NIR spectroscopy
z= 6.0
z= 8.0
z=10.0
Flux (μJy)
Wavelength (Angstroms)

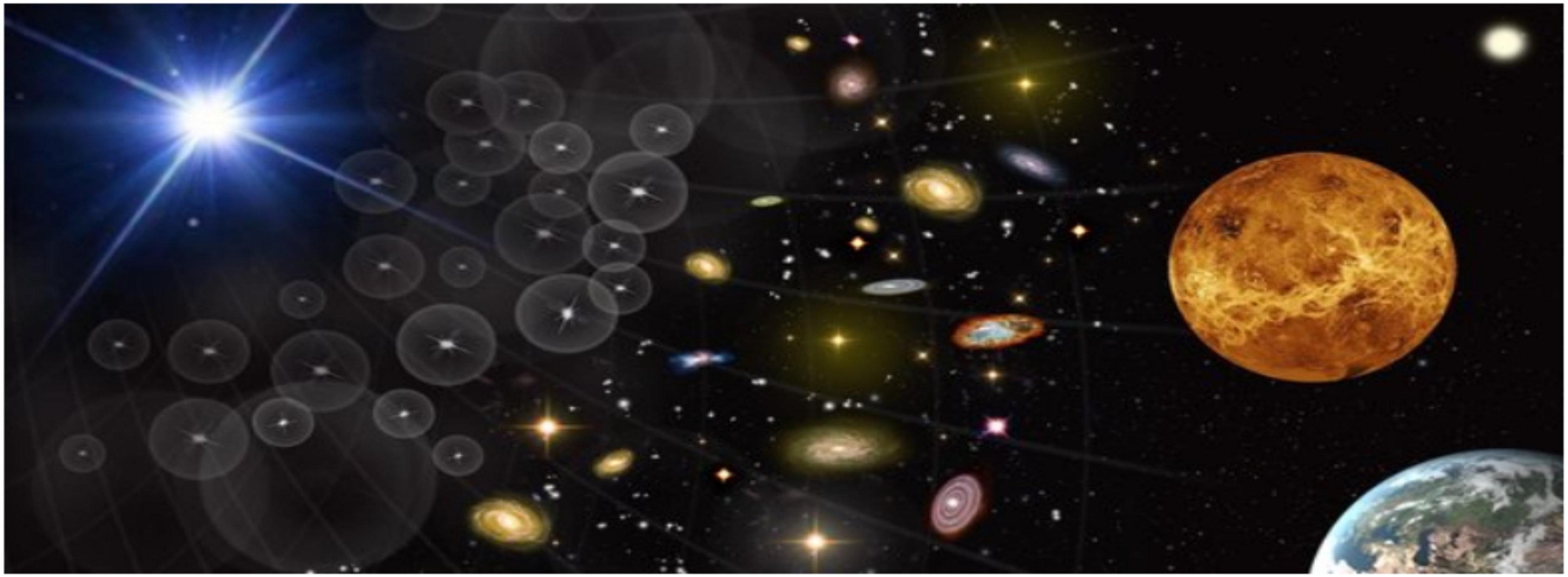
THESEUS mission profile

- Low-Earth Orbit (LEO), (< 5°, ~600 km)
- Rapid slewing bus (>10°/min)
- Prompt downlink (< 10-20s)
- Sky fraction that can be observed: 64%





May 2018: THESEUS selected by ESA for Phase 0/A study (with SPICA and ENVISION)



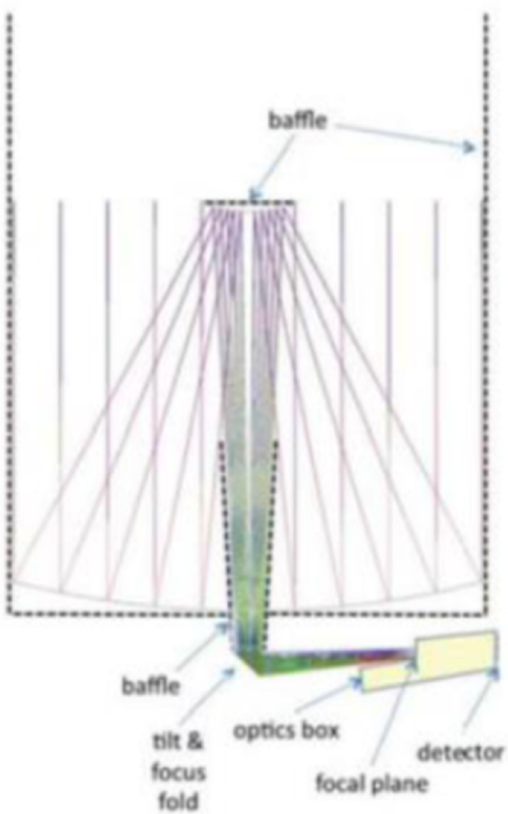
M5 mission themes

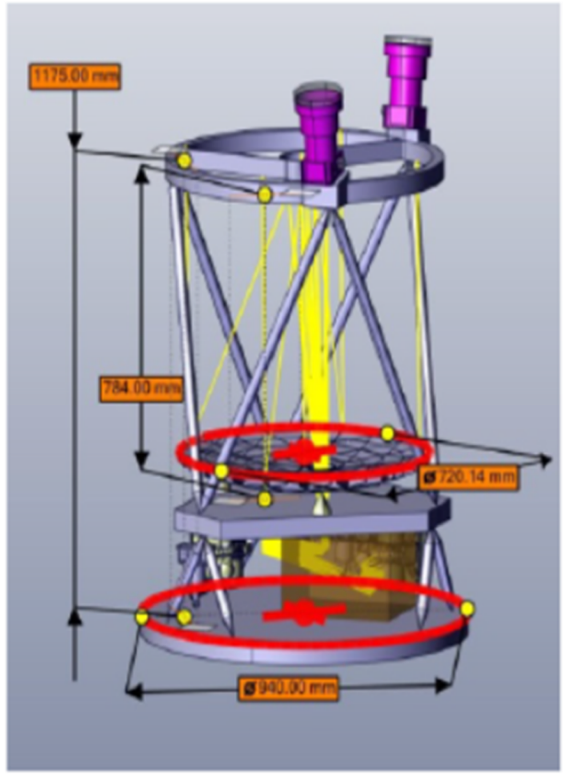
ESA SELECTS THREE NEW MISSION CONCEPTS FOR STUDY

7 May 2018 A high-energy survey of the early Universe, an infrared observatory to study the formation of stars, planets and galaxies, and a Venus orbiter are to be considered for ESA's fifth medium class mission in its Cosmic Vision science programme, with a planned launch date in 2032.

The three candidates, the Transient High Energy Sky and Early Universe Surveyor (Theseus), the SPace Infrared telescope for Cosmology and Astrophysics (Spica), and the EnVision mission to Venus were

IRT – Telescope ESA Study





- **Korsch FoV off-axis** telescope
- Telescope mass compatible with Zerodur/CFRP or SiC
- **M2 focus mechanism**
- **Spider** supporting structures for M2 assembly
- **2x** XGIS units
- **Squared** combined FoV for SXI
- **Active** thermal control with **LHP (Propylene)**
- **Coarse** star Trackers

A **Korsch telescope** is corrected for spherical aberration, coma, astigmatism, and field curvature and can have a wide field of view while ensuring that there is little stray light in the focal plane.

THESEUS website

THESEUS Mission

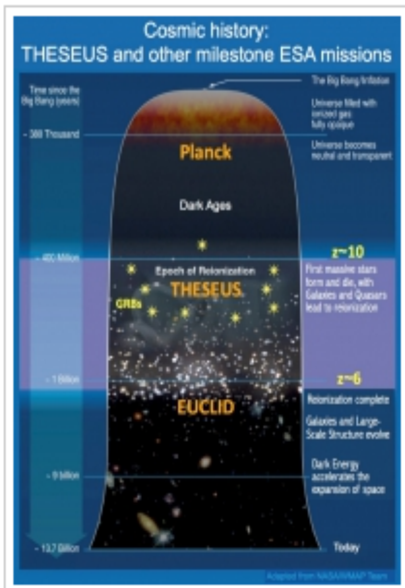
- Mission Overview
- Mission Payload and Profile
- Science with THESEUS
- Scientific Requirements
- THESEUS White Paper 2017
- Multi-Messenger
- Astrophysics with THESEUS
- 2017 Workshop Proceedings

Teams

- Contact Persons
- Project Office
- Science Study Team
- Core Team
- Payload Team
- Contributing Scientists

The THESEUS mission

THESEUS is a mission concept proposed in response to the ESA call for medium-size mission (M5) within the Cosmic Vision Programme and **selected by ESA on 2018 May 7 to enter an assessment phase study**.



THESEUS in context.

The mission is designed to vastly increase the discovery space of the high energy transient phenomena over the entirety of cosmic history. Its primary scientific goals will address the Early Universe ESA Cosmic Vision themes "How did the Universe originate and what is made of?" (4.1, 4.2 and 4.3) and will also impact on "The gravitational wave Universe" (3.2) and "The hot and energetic Universe" themes. This is achieved via a unique payload providing an unprecedented combination of: 1) wide and deep sky monitoring in a broad energy band (0.3keV - 20 MeV); 2) focusing capabilities in the soft X-ray band providing large grasp and high angular resolution; and 3) on board near-IR capabilities for immediate transient identification and redshift determination.

http://www.isdc.unige.ch/theseus/