

The transient Universe with Athena

From the solar system to the early Universe

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Transient Universe in Athena

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Transient Universe in Athena

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- **399 Transient Universe in discovery science**

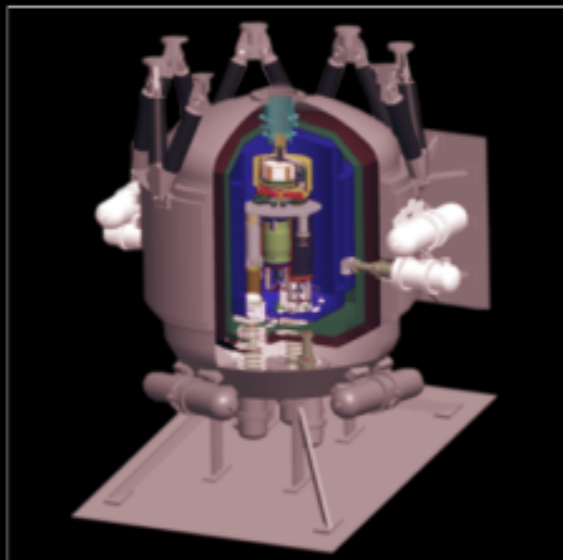
ATHENA

The Athena Observatory

Willingale et al, 2013
arXiv1308.6785

L2 orbit Ariane V

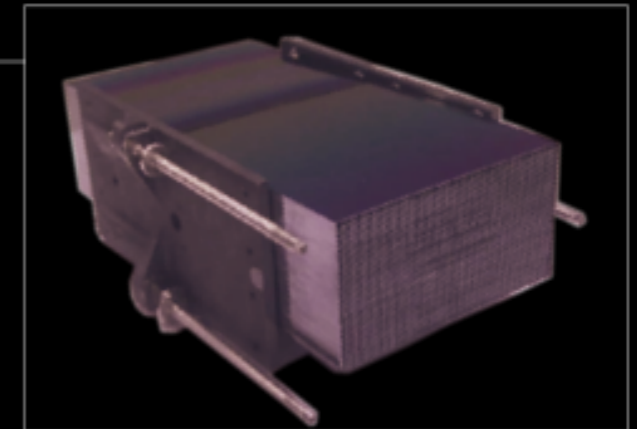
<5100 kg
power 2500 w
5 year mission
FoR=50%
TOO in 4hrs



X-ray Integral Field Unit:

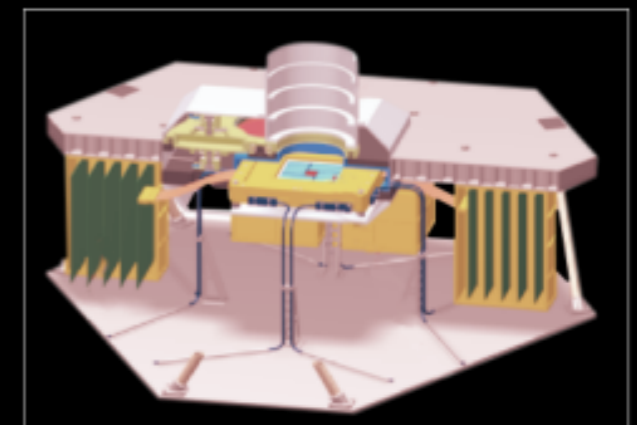
ΔE : 2.5 eV
Field of View: 5 arcmin
Operating temp: 50 mk

Barret et al., 2013 arXiv:1308.6784



Silicon Pore Optics:

1.4-2 m² at 1 keV
5 arcsec HEW
Focal length: 12m
Sensitivity: 3×10^{-17} erg cm⁻² s⁻¹

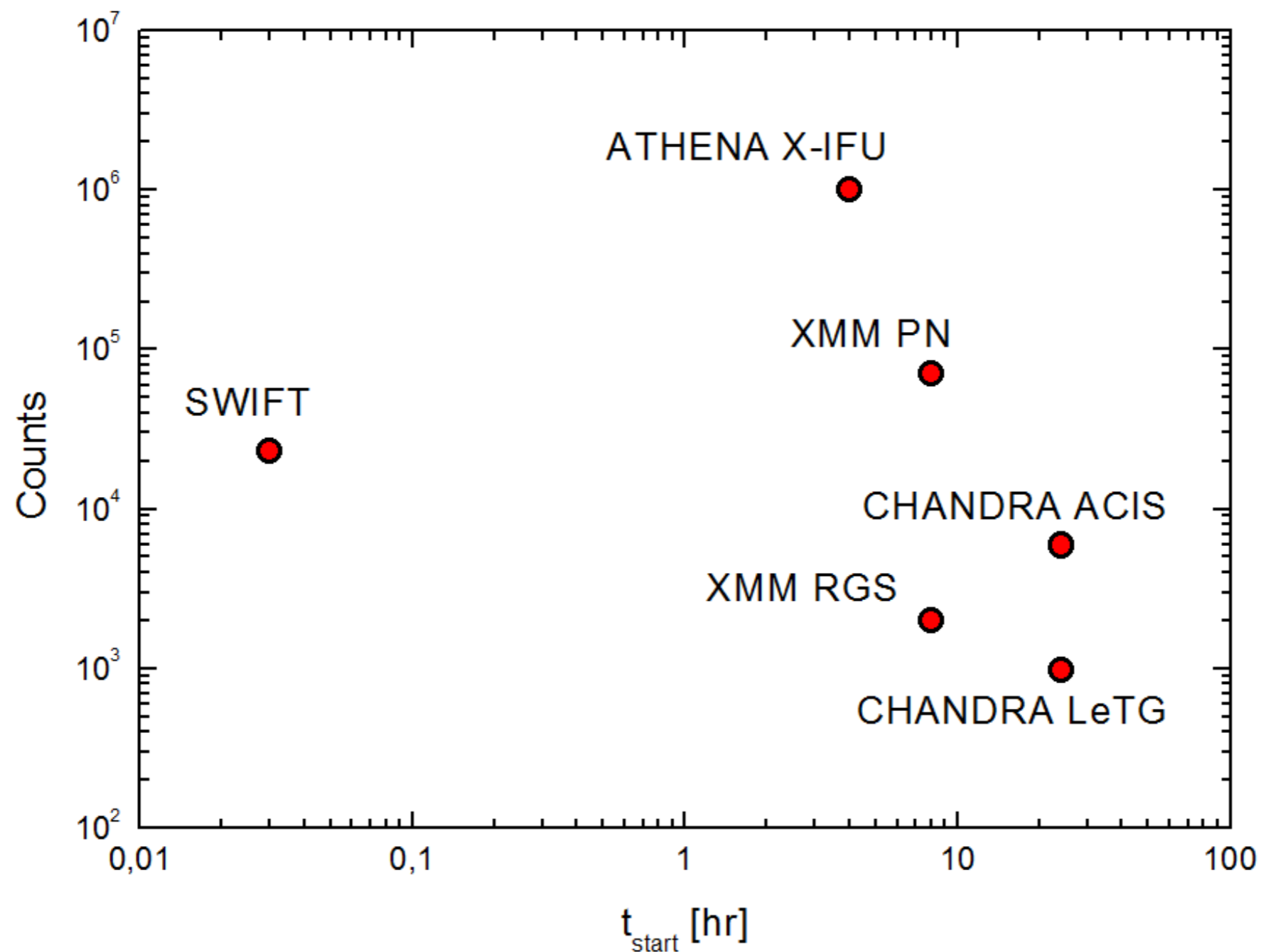


Wide Field Imager:

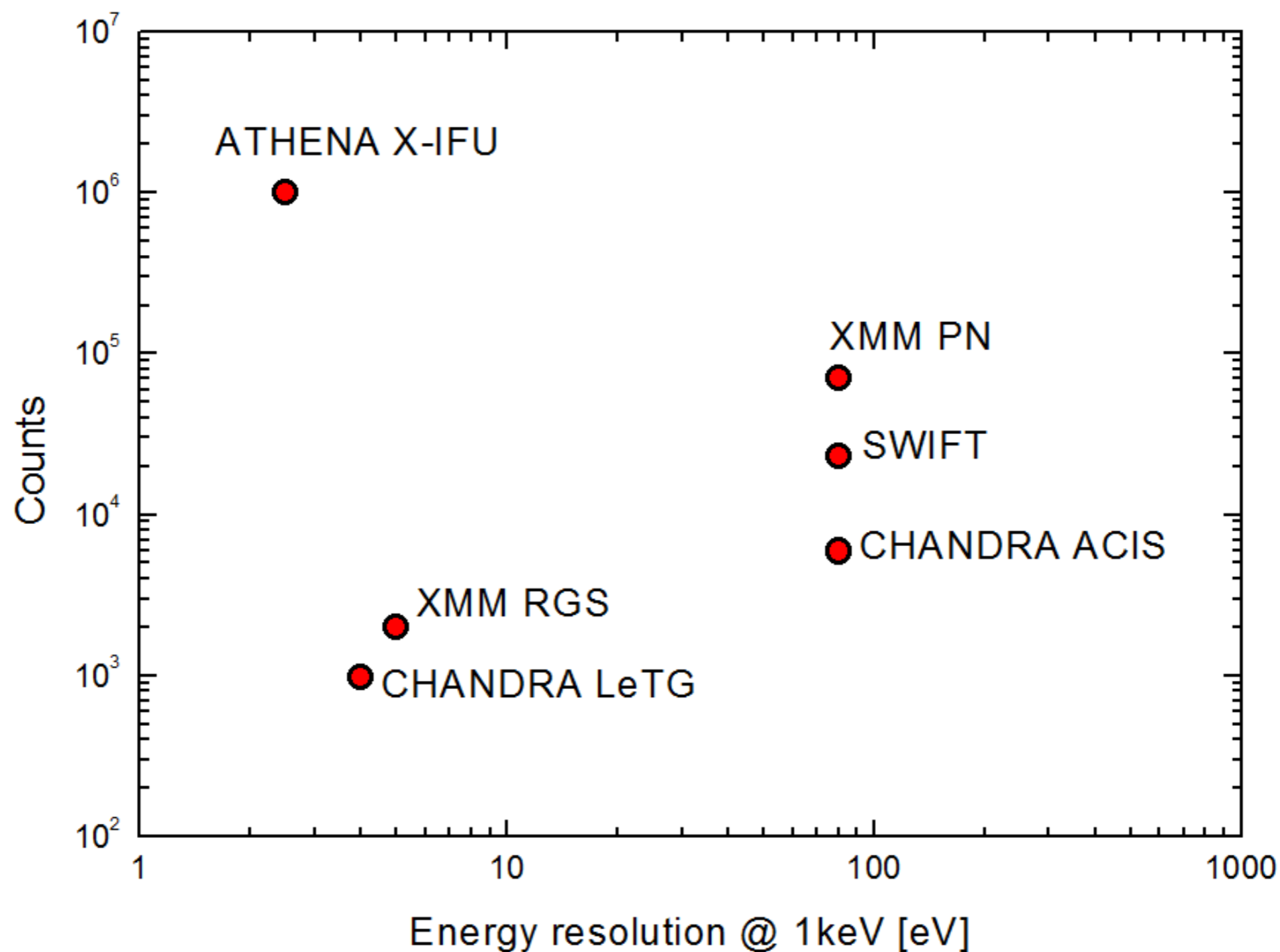
ΔE : 125 eV
Field of View: 40 arcmin
High countrate capability

Rau et al. 2013 arXiv1307.1709

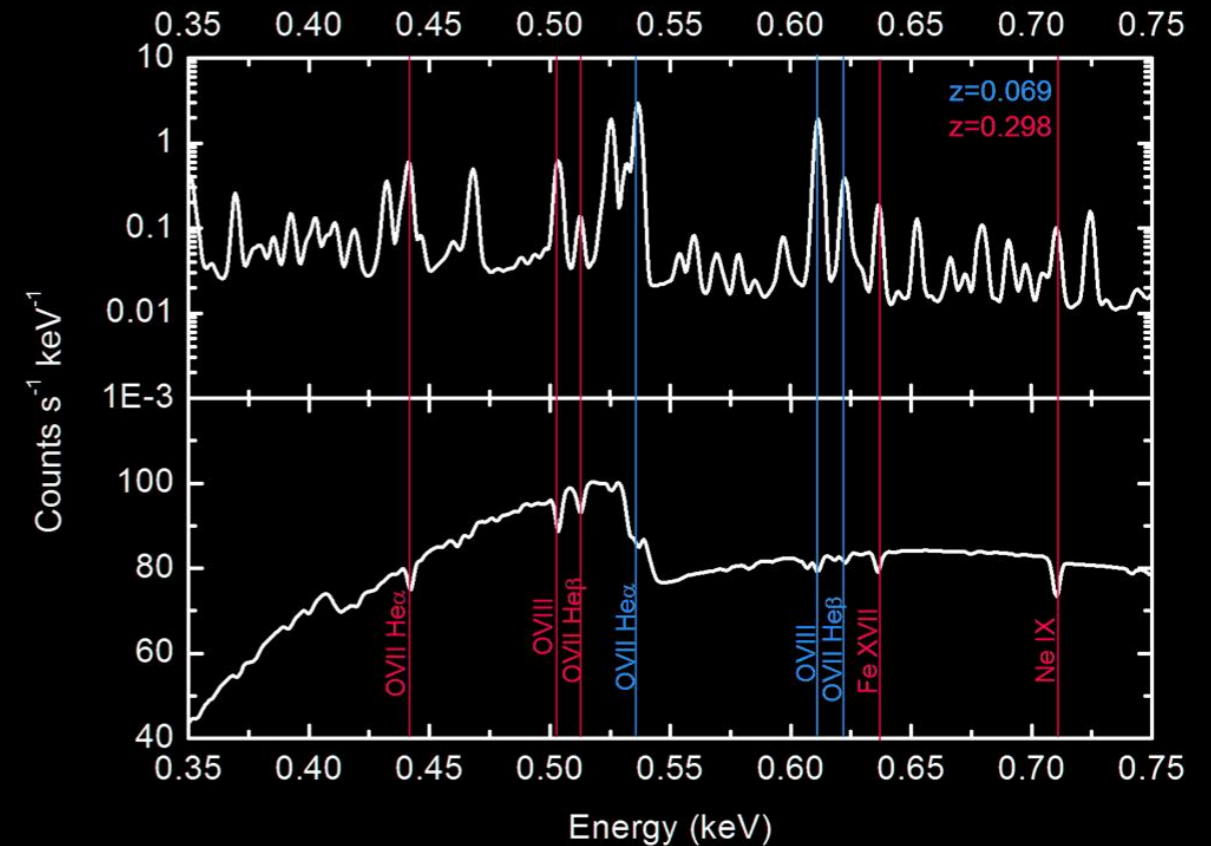
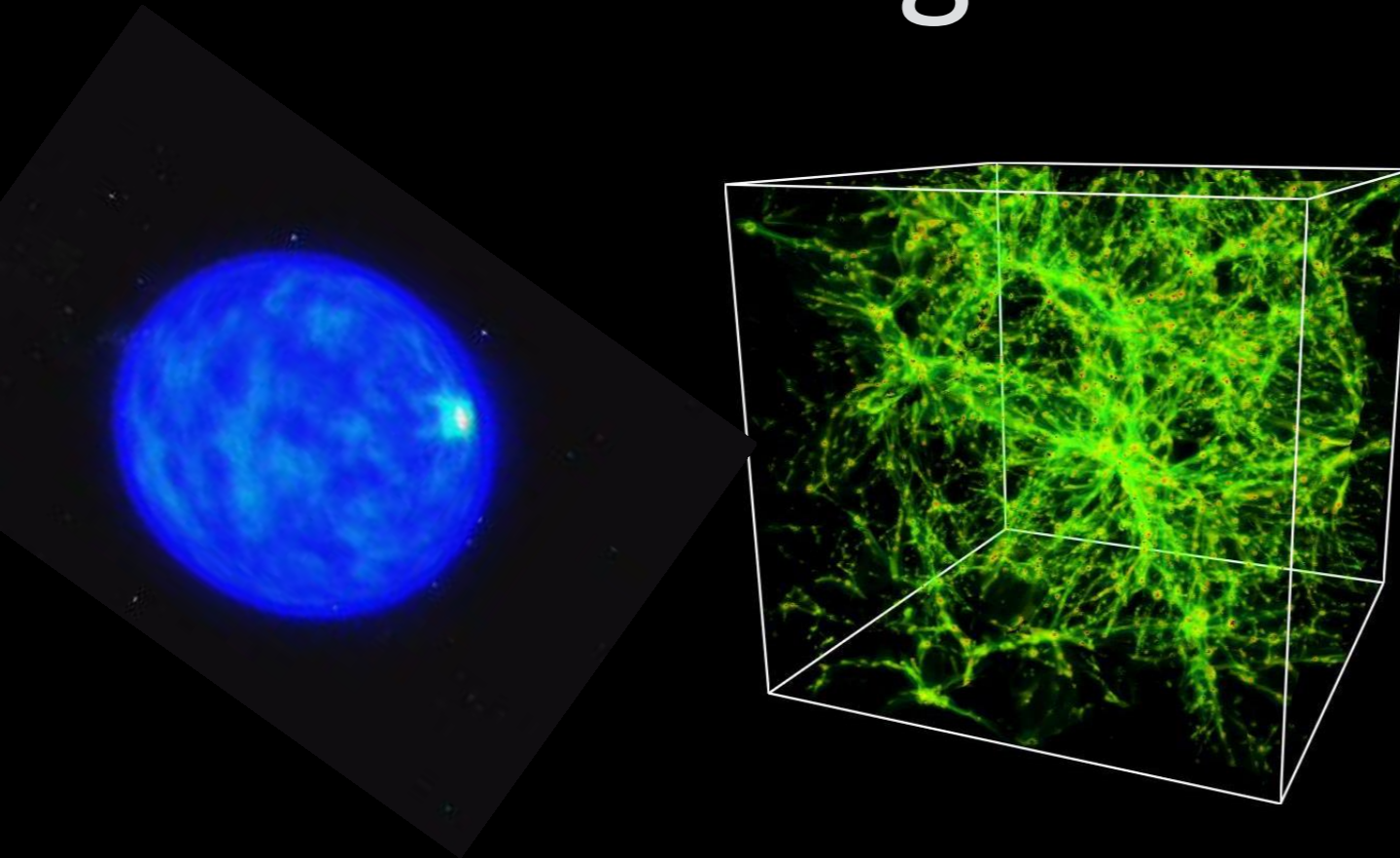
Athena TOO capability on GRBs



Athena TOO capability on GRBs



WHIM: GRB transients as probes of the large scale structures

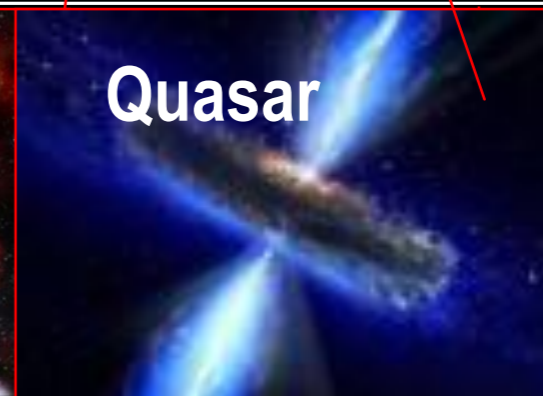
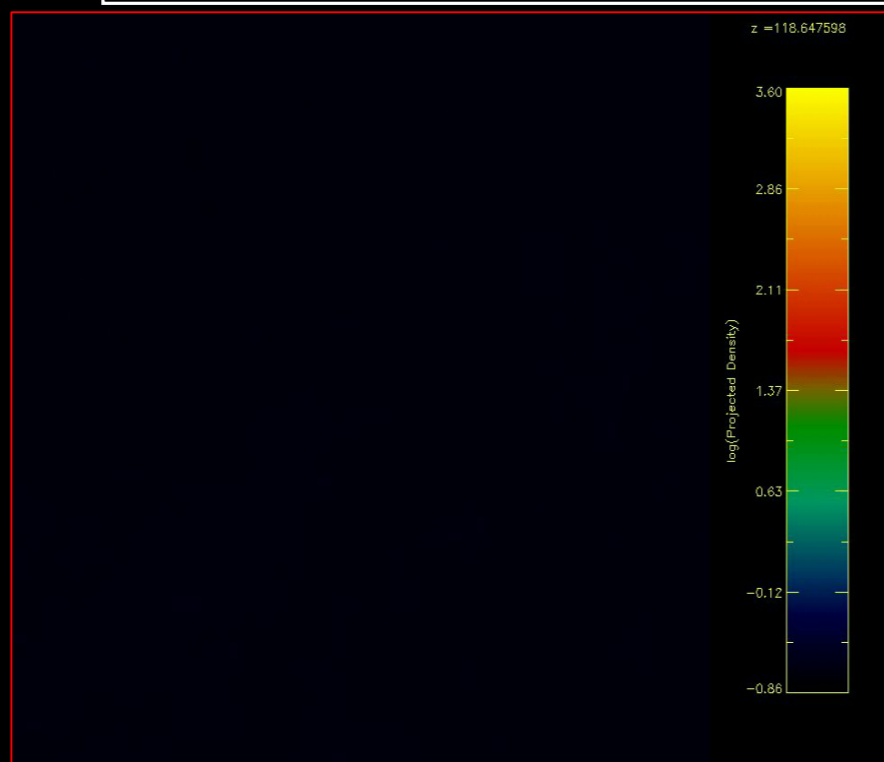
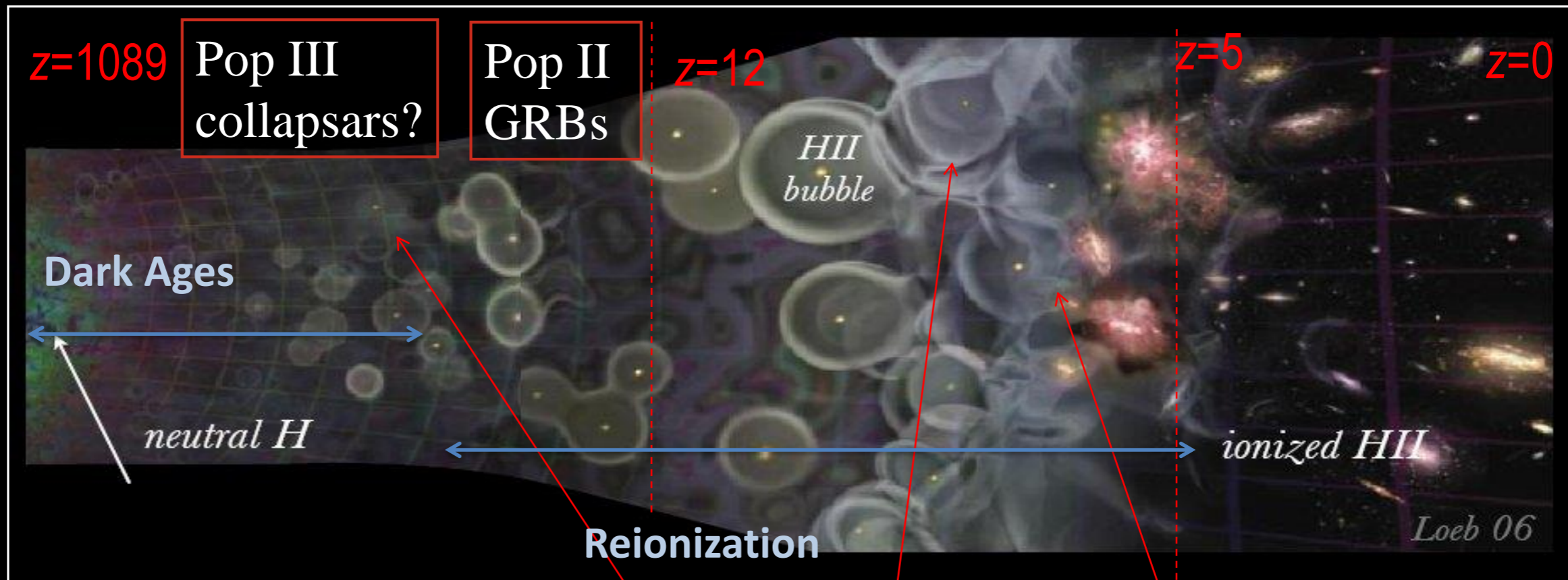


R-SCIOBJ-141 Missing Baryons

Detect 200 WHIM filaments in absorption, 100 towards BL Lacs and 100 towards 50 bright GRB afterglows to sample the WHIM up to $z=1$. Determine metal abundances from emission lines in targeted regions

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The first stars, the first BH, the first metals

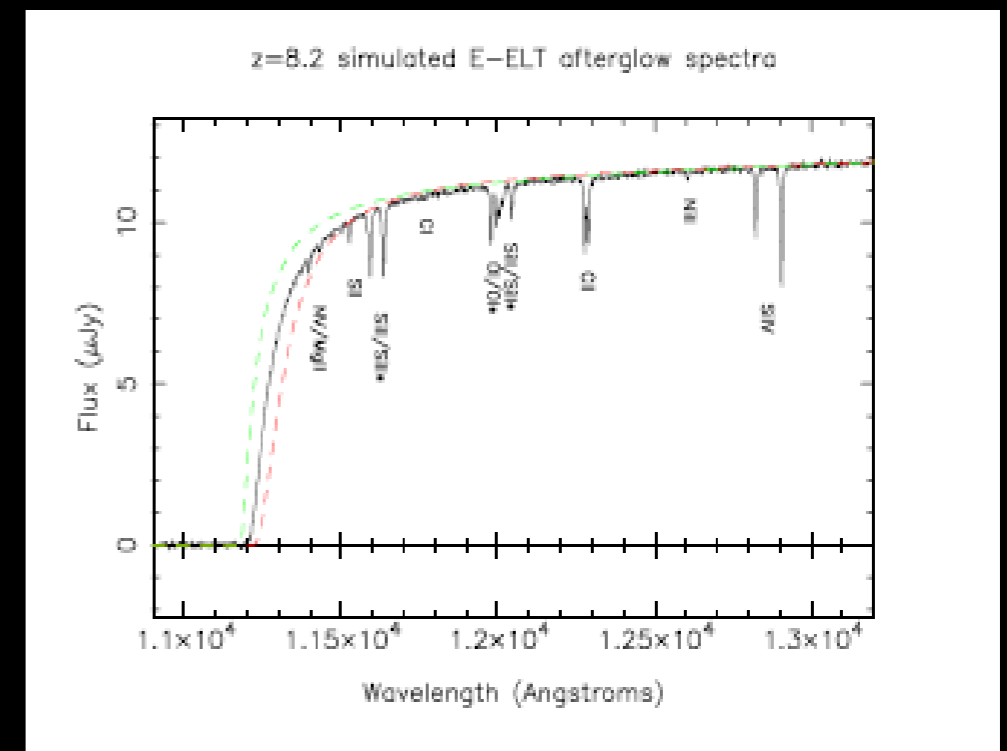
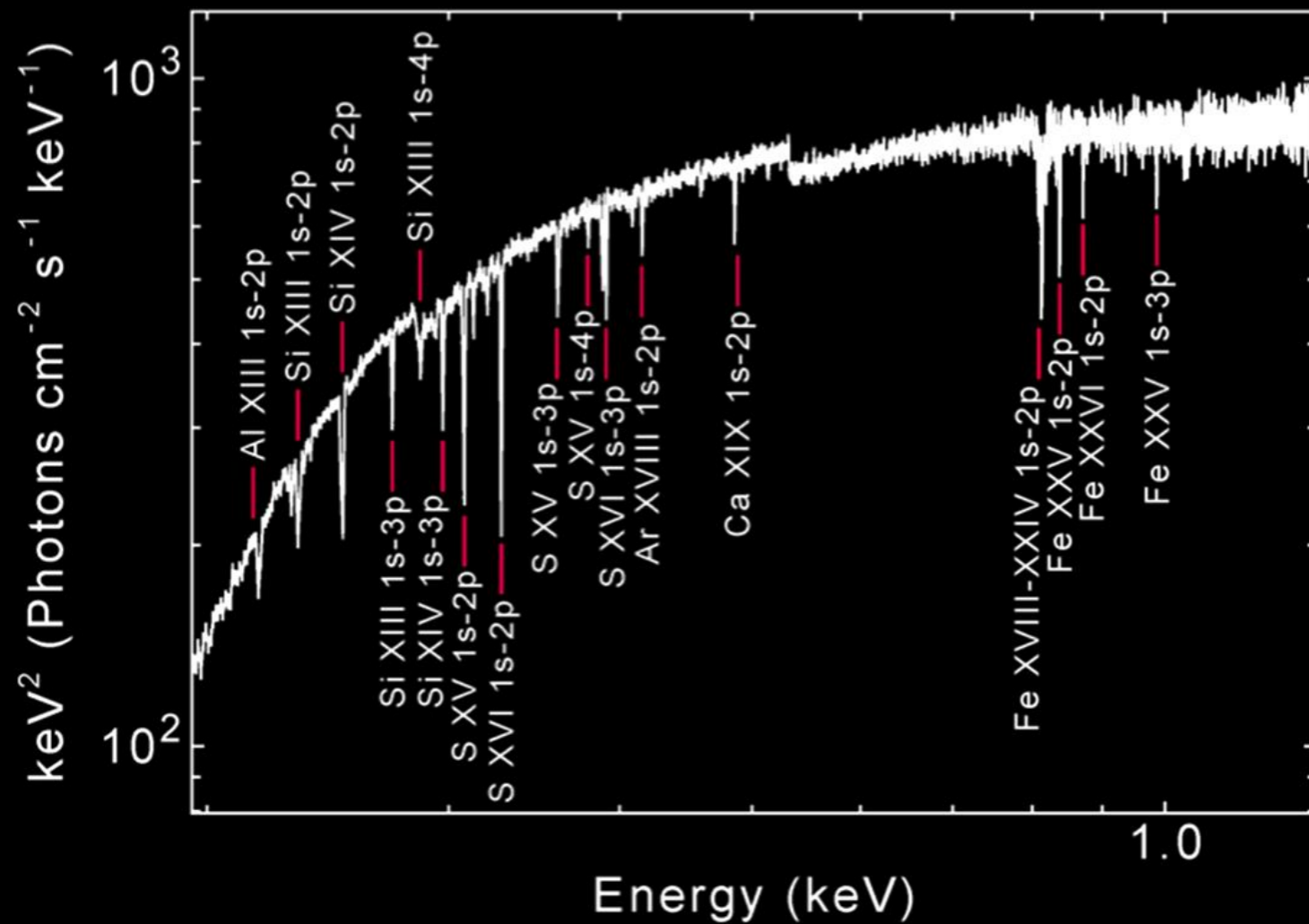


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High-Z GRBs: The first stars and black holes

When did the first generation of stars explode to form the first seed black holes and disseminate the first metals in the Universe?

Gamma Ray Burst at $z=7$

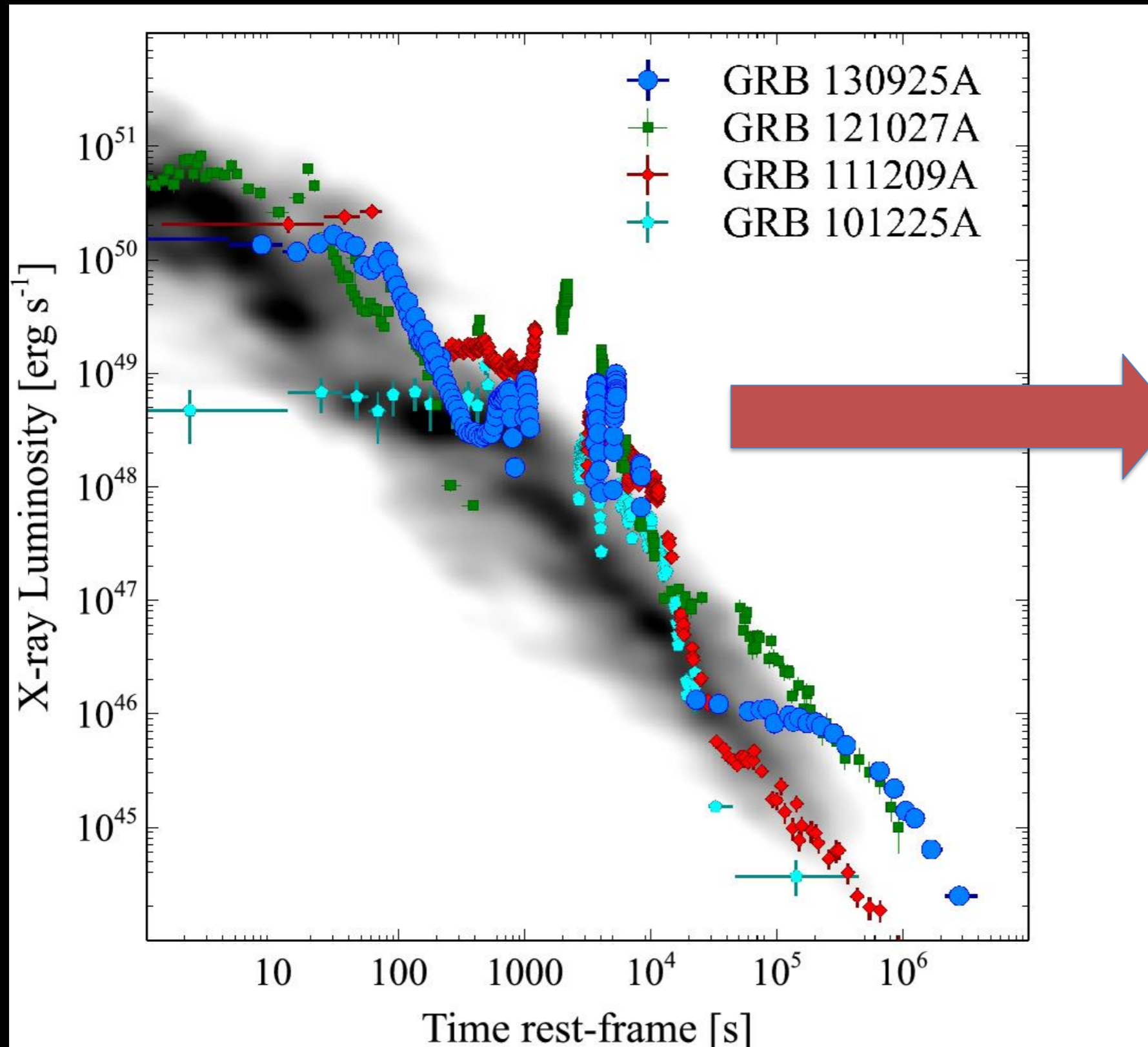


30+ m class ELTs

Jonker, O'Brien et al., 2013 arXiv1306.2336

How do black holes grow and shape the Universe?

Ultralong GRB: a popIII analogue?

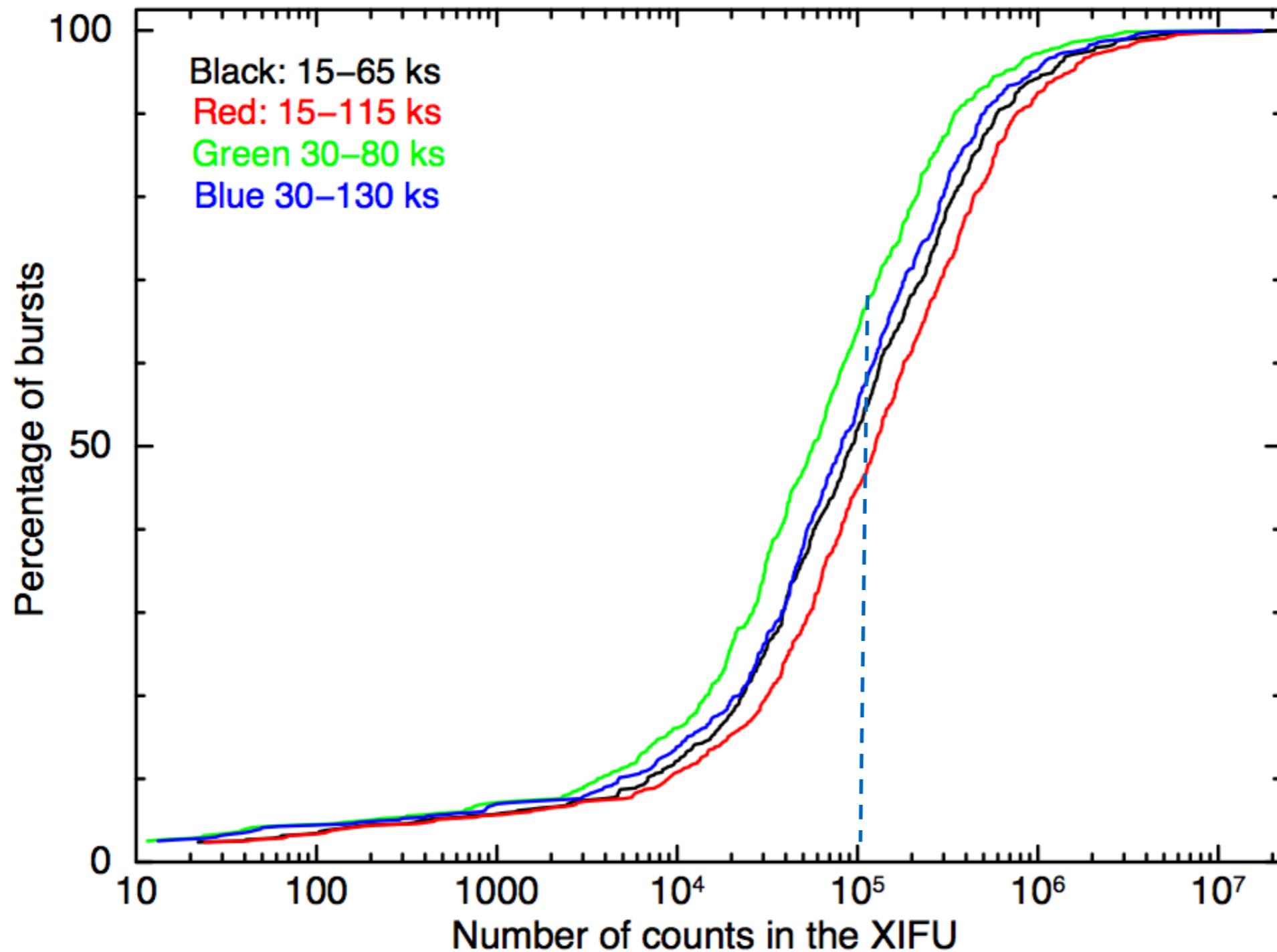


Flux@z=10

$10^{-12-11} \text{ erg/cm}^2/\text{s}$

Piro+ 2014

GRB fluence vs TOO start time



P O'Brien, P Evans

Discovery science on Transient Universe

- The next decade will be characterized by facilities discovering transient events with Athena playing a prominent role in disclosing their nature via follow-up
- **The WFI, with its large FoV, is particularly suited to Object ID. The XIFU, when precise positions are available, can in turn provide high res spectra:**
 - LIGO/VIRGO sources (NS-NS mergers, BH mergers=X-ray afterglows)
 - LISA (X-ray disk accretion from SMBH merger)
 - transient optical phenomena discovered by LSST, PTF, etc (kilonovae, various types of Sne,...),
 - FRB by radio facilities
 - ν 's EM counterparts
 - ?
- Wide/all sky X-ray&Gamma ray monitors in the future: SVOM, Einstein Probe, (~2022), plus Theseus, TAP, eXTP (2026-2030),..
- This exciting discovery science brings in a wide community across the board
- It requires an adequate FoR and TOO capability as provided by the Athena
- The expected numbers of some of these populations is \sim ten per year

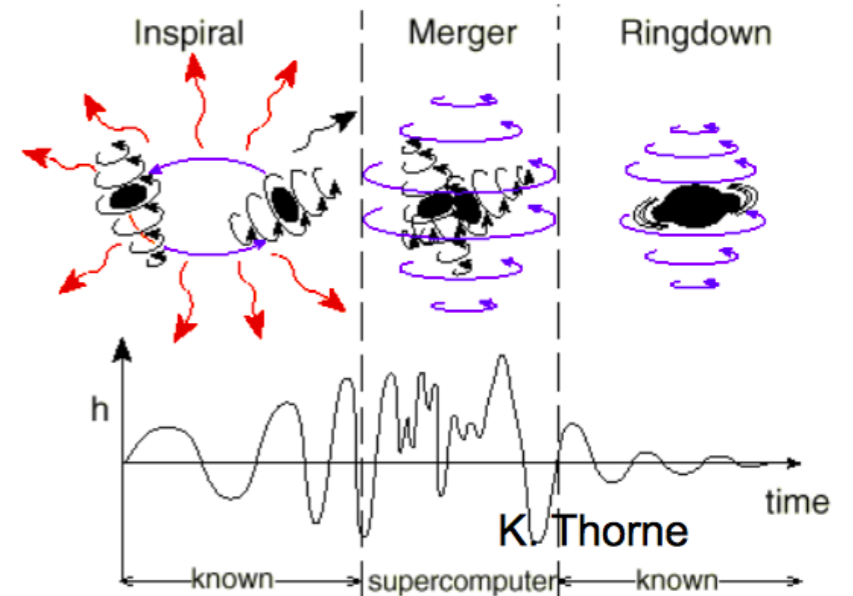
The GW-EM connection for NS-

1) Electromagnetic window:

- Jet :
- Prompt GRB
- GRB Afterglow from radio to X
- Isotropic features:
- Off-axis (orphan) afterglow: X-to-radio
- Cocoon (X to opt)
- Kilonova (O-IR)

NS mergers

2) Gravitational waves by GRBs:

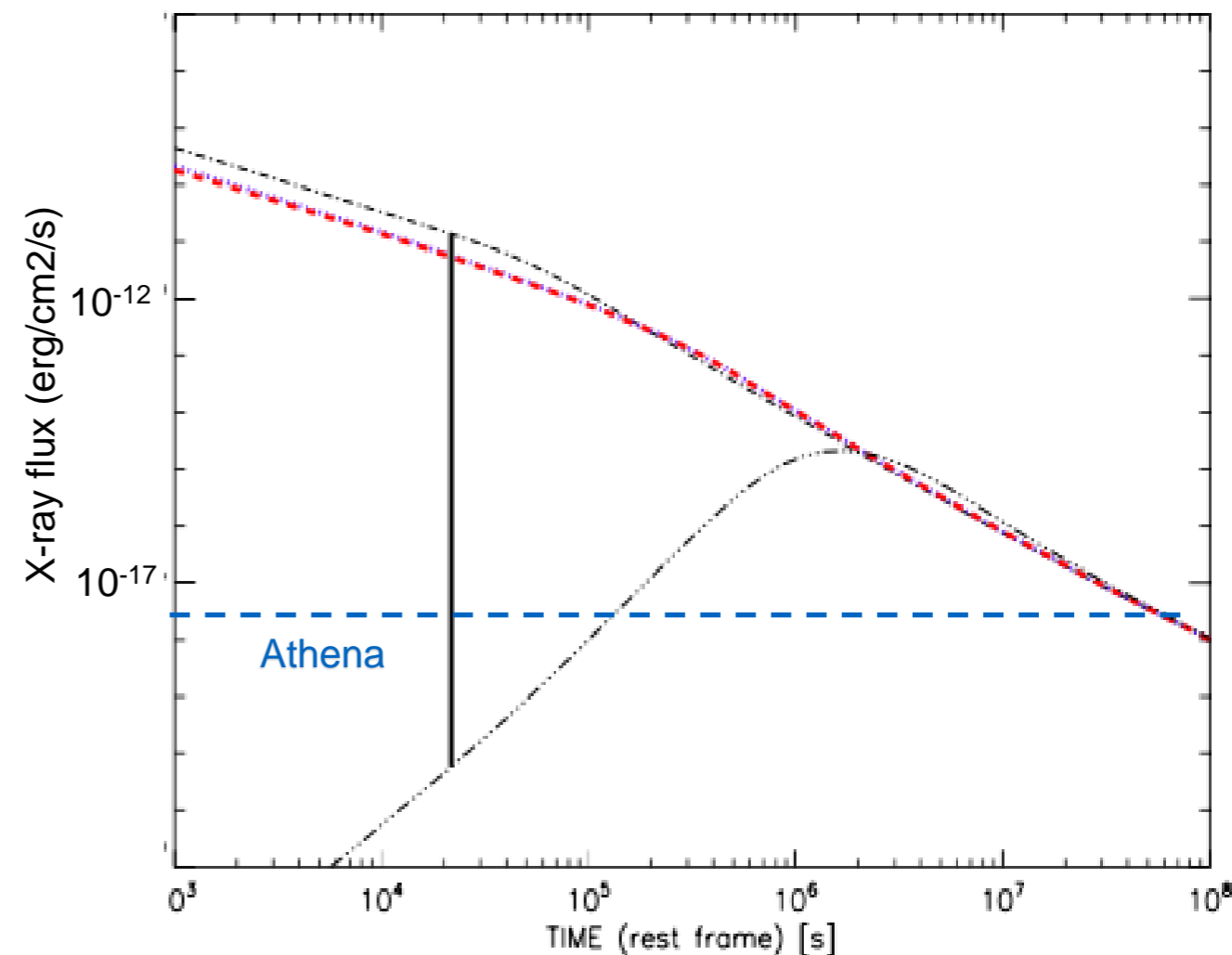
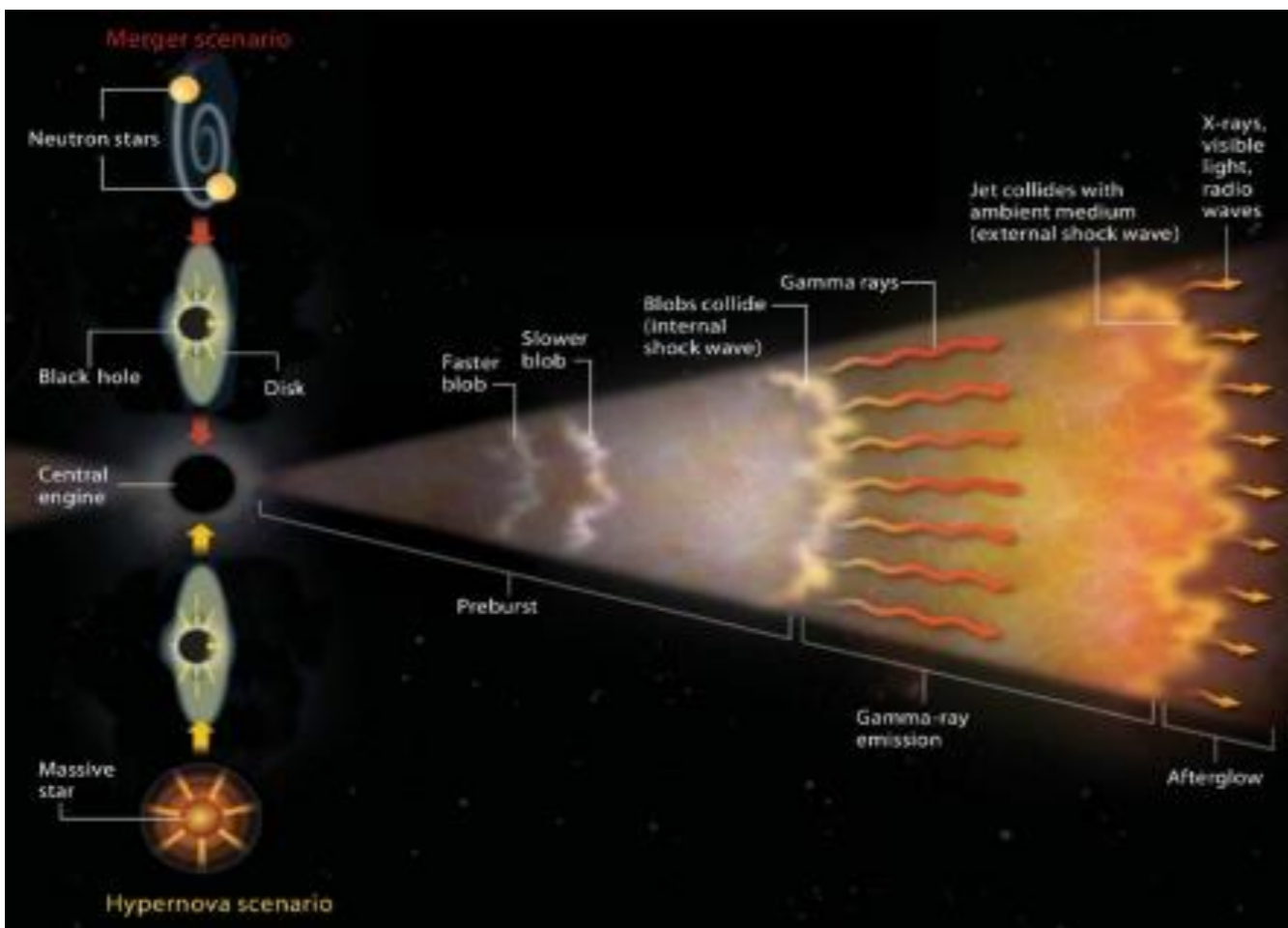


On and off-axis afterglow: X-rays

A “typical” short GRB at 200 Mpc (ALIGO)

$\theta_v \sim 30$ deg

- Beaming angle $\sim 1/\Gamma$



D'Alessio, LP & Rossi 2006

- for $\theta_v > \sim 50$ deg (70 % of the total) \Rightarrow only Athena

Theseus role

- ✓ Provide triggers/positions of X-ray transient candidates for deep X-ray follow up observations by Athena
- ✓ XIFU FOV is 5' => localization at ~ arcmin level: Theseus OK
- ✓ For the WHIM only the brightest (top 10%) => FOV > 1/3 sky sr: only a fraction from Theseus
- ✓ For high z GRB about 10 candidate needed per with photo-z for pre-selection: Theseus OK

Athena science in context



Athena is a crucial part of the suite of large observatories needed to reach the science objectives of astronomy in the coming decades

Conclusions

- Transient Universe Science of Athena involves core, observatory discovery science
- It is the key topic of the next decade, involving a much broader community than our own
- Huge discovery space