ORIGIN: Metal Creation and Evolution from Cosmic Dawn

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on behalf of the ORIGIN consortium

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SRON
Netherlands Institute for Space Research

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Cosmic Vision: grand themes

ESA CV: 4. How did the Universe originate and what is it made of?

4.2 The Universe taking shape: Find the very first gravitationally bound structures assembled in the Universe (precursors to today's galaxies and clusters of galaxies) and trace their evolution to today.

The very first clusters of galaxies back to their formation epoch are keys to study their relation to AGN activity and the chemical enrichment of the Inter Galactic Medium.

4.3 The evolving violent Universe: Life cycles of matter in the Universe along its cosmic history. Understand the processes at work in SN and Hypernovae xplosions connected to Gamma Ray Bursts

ASTRO2010 priority:

Cosmic Dawn: When and how the first galaxies and the earliest stars started to shine

The key science

- When were the first metals created?
- How does the cosmic metal content evolve?
- Where do most of the metals reside in the Universe?
- What is the role of metals in Structure formation and evolution?

Creation and evolution of metals

Formation first stars

Pop III

Formation BH

Evolution galaxies of clusters

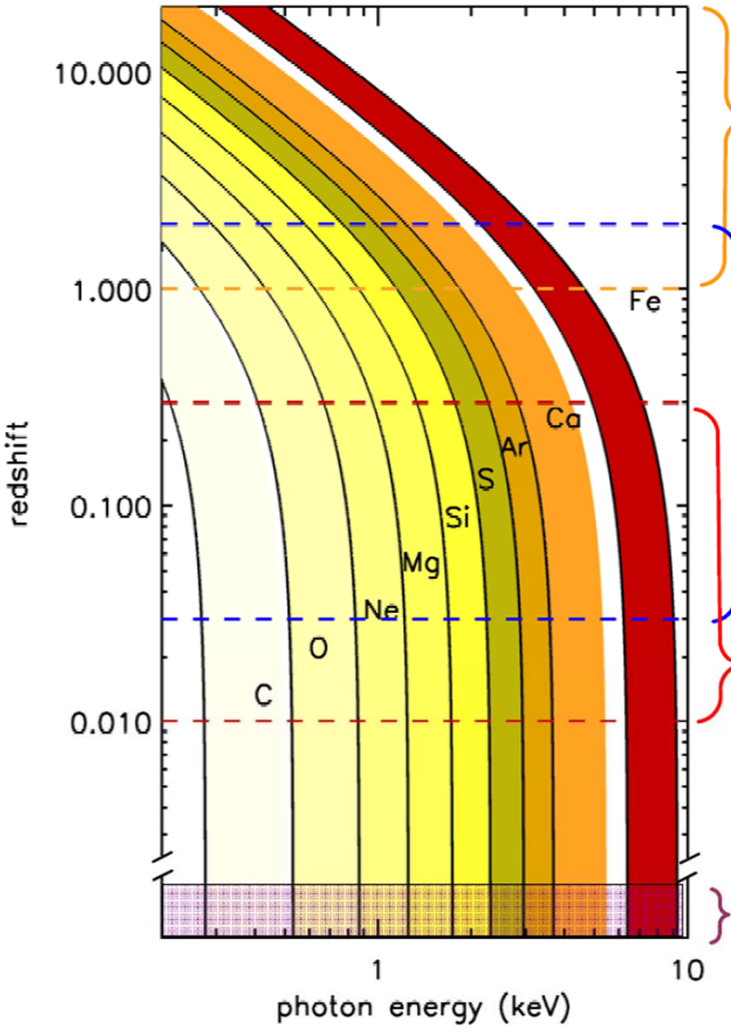
Mixing of metals: Dynamics and feedback

Origin of chemical composition of clusters of galaxies

Metal enrichment of the WHIM

Morphology of the WHIM

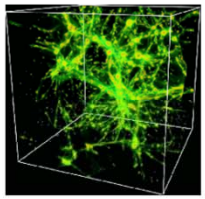
Localization of hot gas in the ISM



Local host galaxies GRB (1 – 20)

Large scale structures Clusters (0.03 – 2)

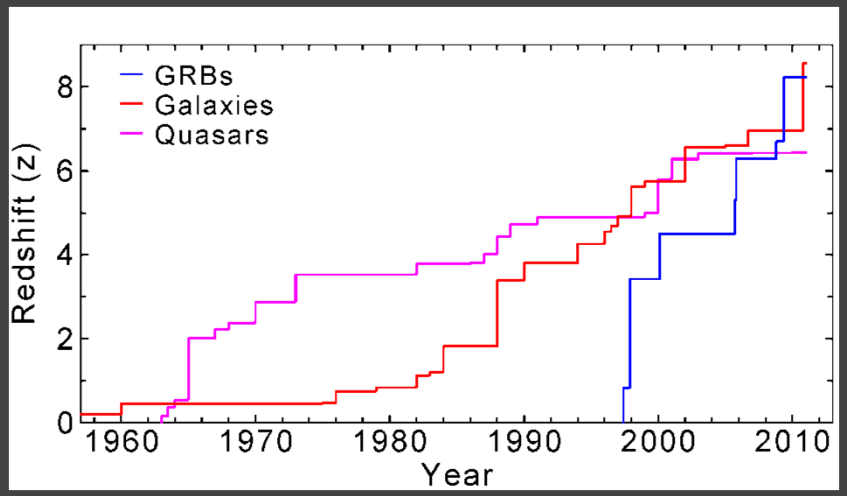
WHIM filaments (0.01 – 0.3)



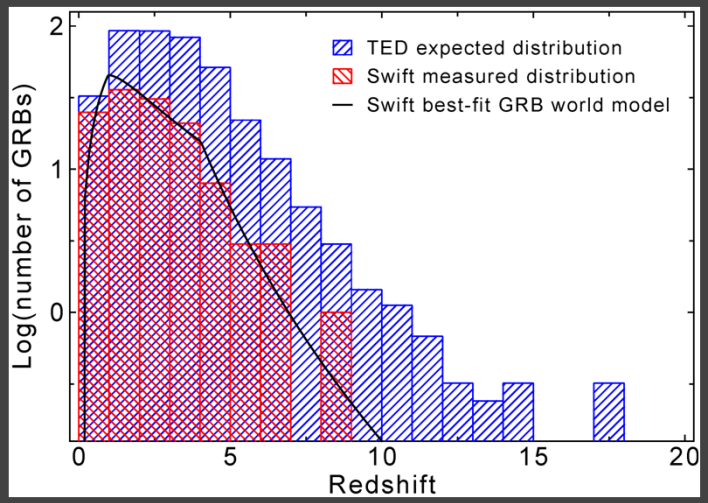
Our Galaxy (z=0)

The high redshift Universe

- PopIII stars around 100 solar masses likely exploded as superenergetic GRB (upto 10^{57} erg) forming the first BH
- Fast evolution of subsequent population quickly enriched the environment
- ORIGIN will observe about 65 GRB at z>7 in 5 yr (and several hundreds at lower z) with precise measurements of z, ionization stages and metal abundances



GRB z distribution with ORIGIN



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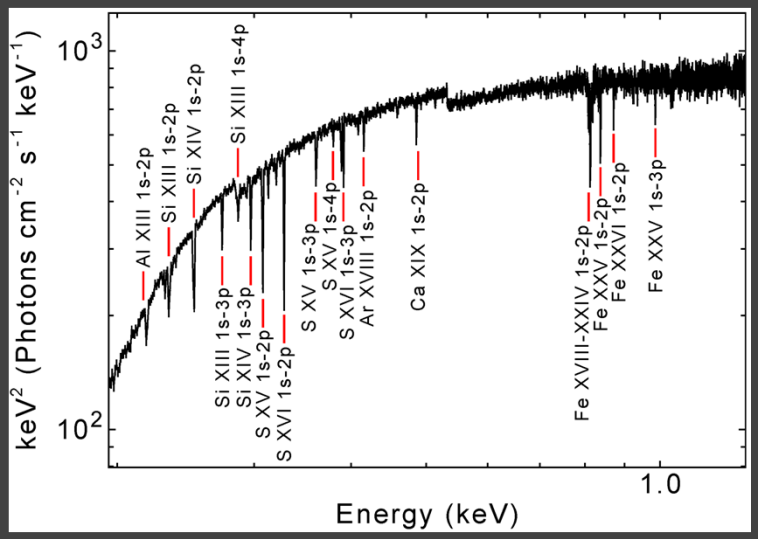
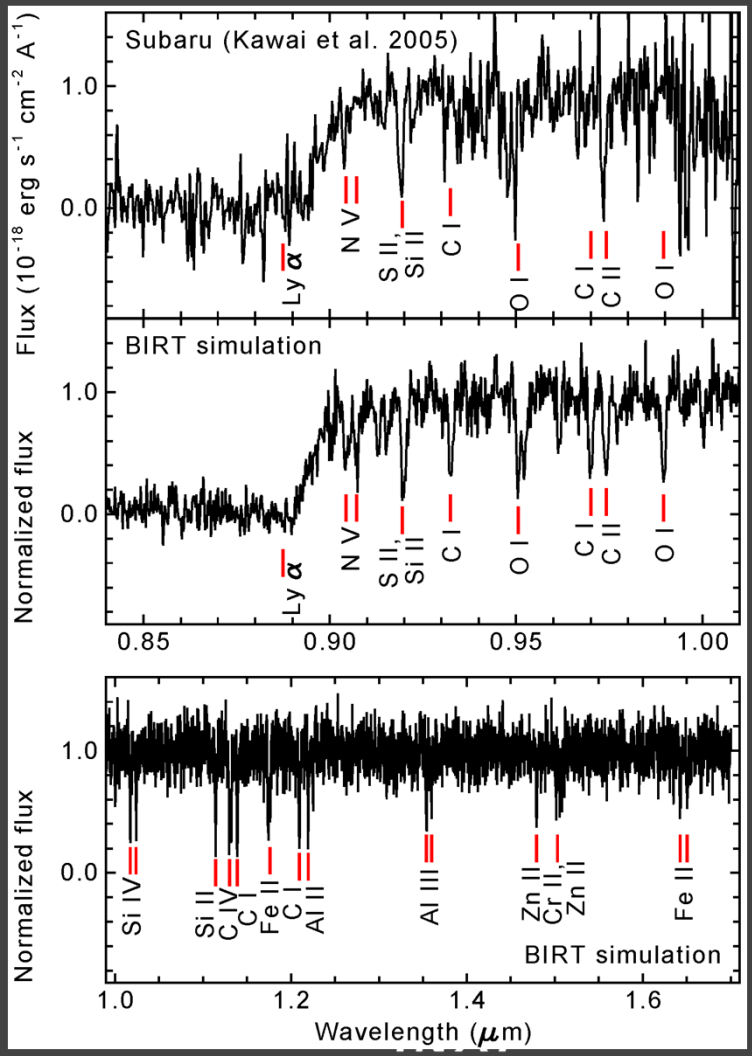
Metallicities in the high redshift Universe

- 65 GRB @ z>7: formation of earliest star populations
- 500 GRBs: evolutionary trends as function of z, sequence Pop III to present stars
- Combined with other facilities: galaxy evolution

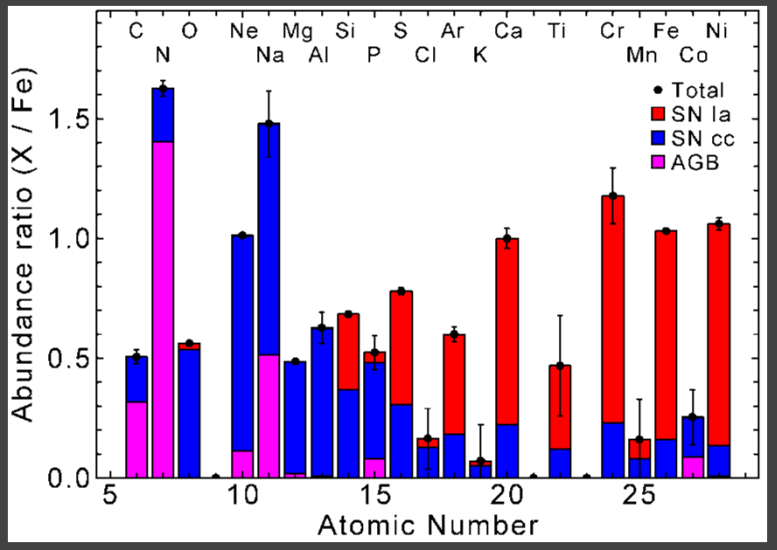
z=7
Sx = 4 10^{-6} erg/cm²
50 – 50.000 s

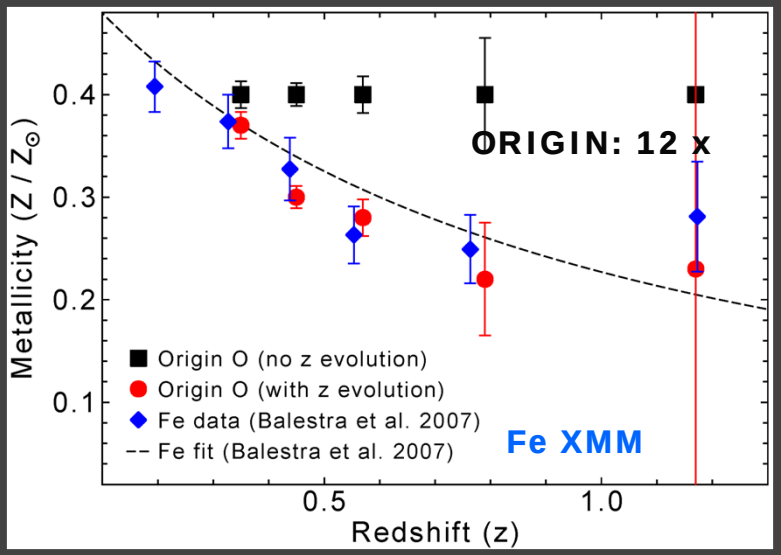


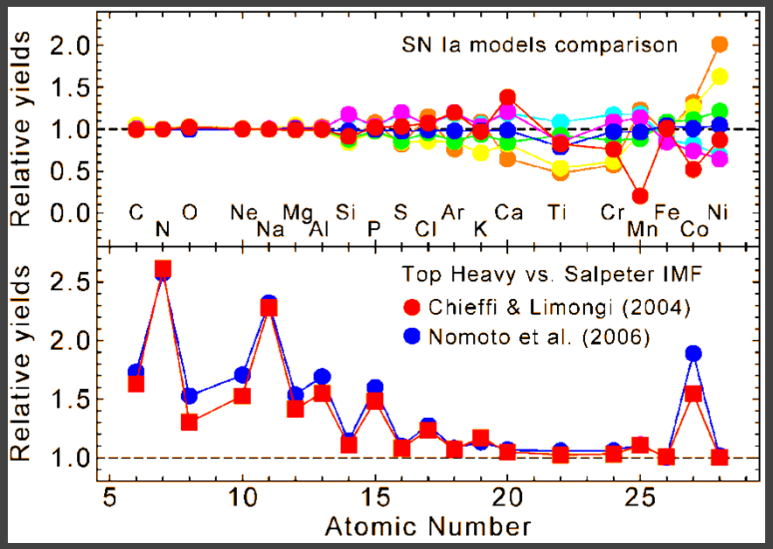


Metals at large scales

- Abundance ratios in clusters show different contributions (AGB start, SN 1a, SNcc)
- Abundance ratios constrain IMF
- Feed back mechanisms and evolution







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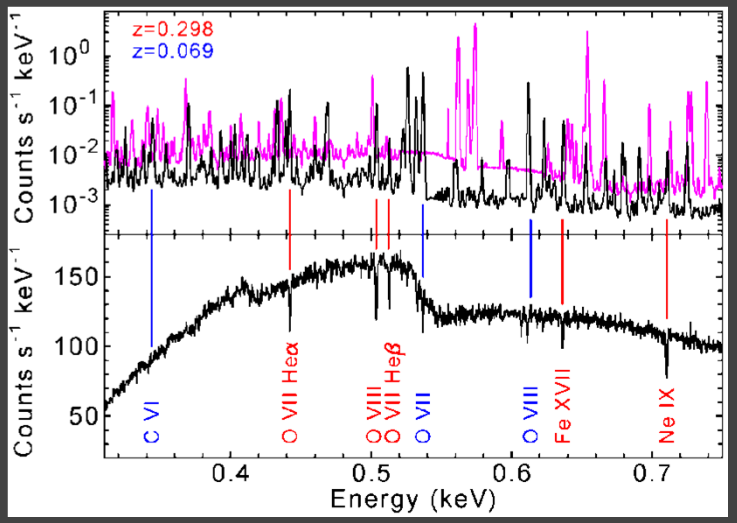
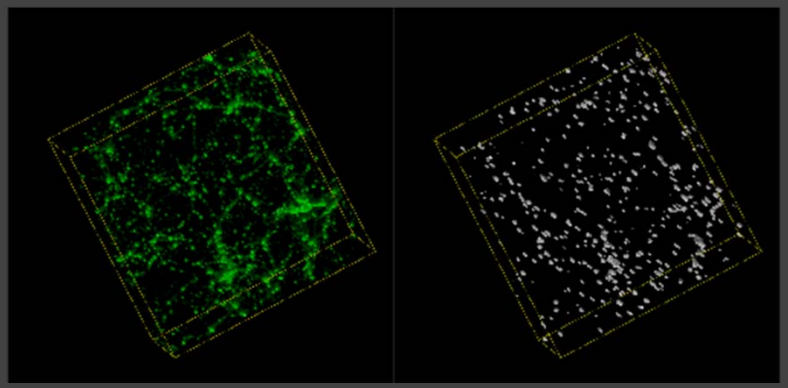
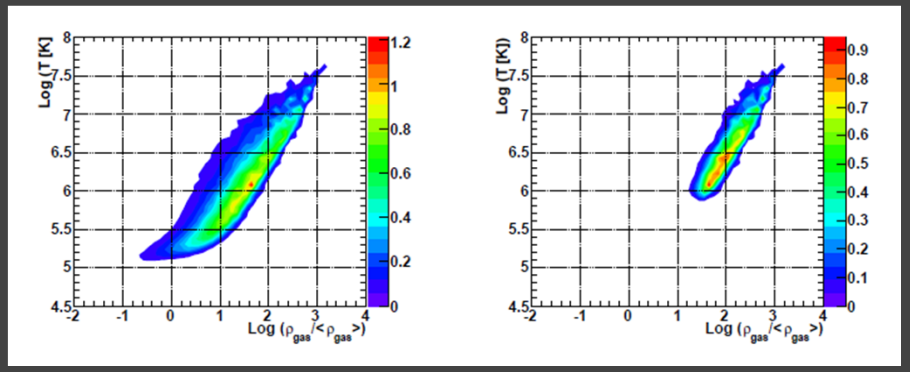
Cosmic Web: observations

- Unique observational capabilities: imaging and GRBs as backlight
- Combine emission and absorption



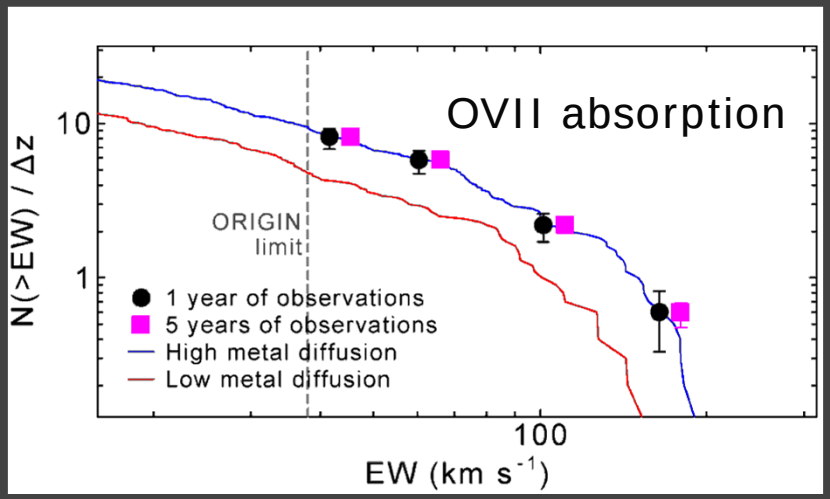


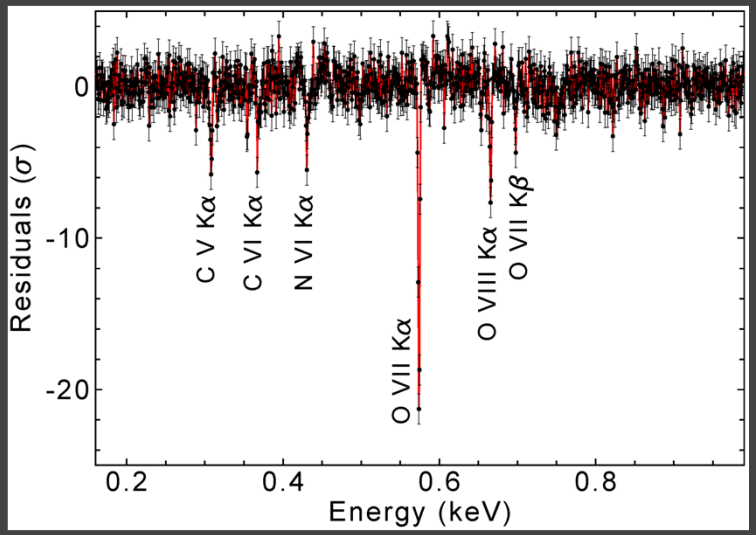


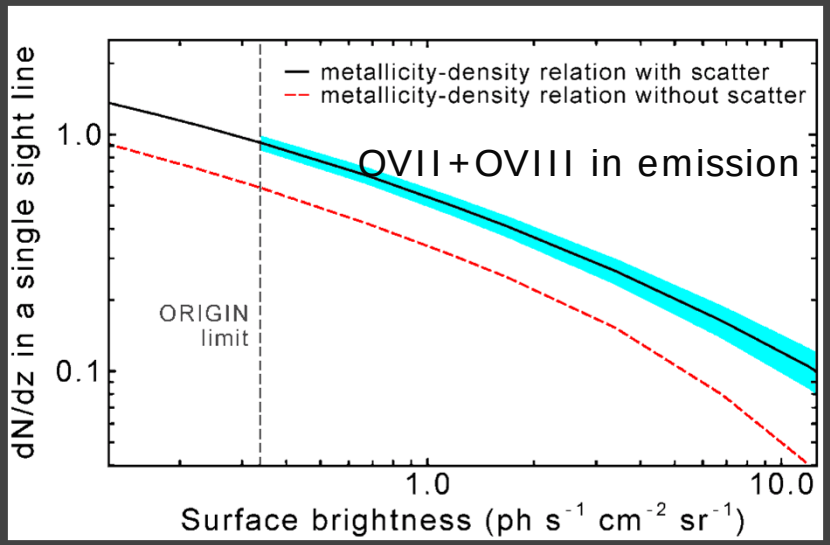
5σ O VII + O VIII

Cosmic Web: science

- Distinguish between metal circulation scenarios
- Determine physical parameters
- Galactic outflows in our own Galaxy



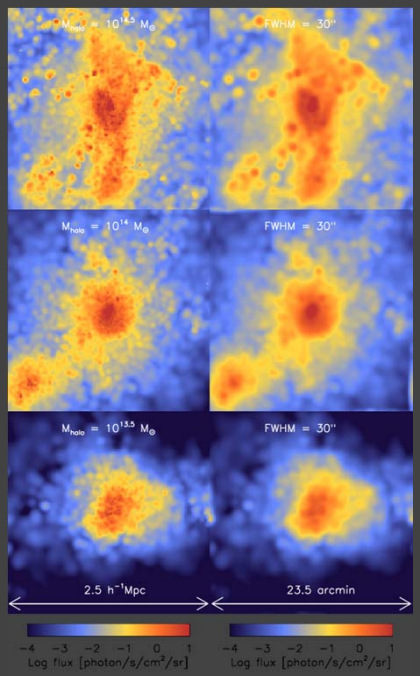


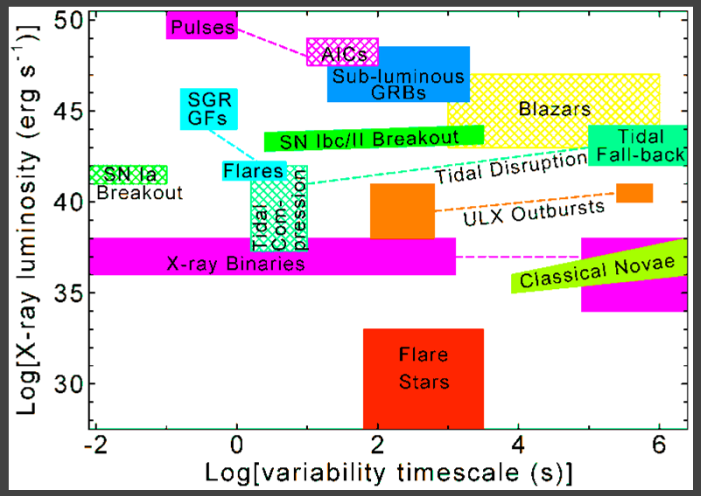


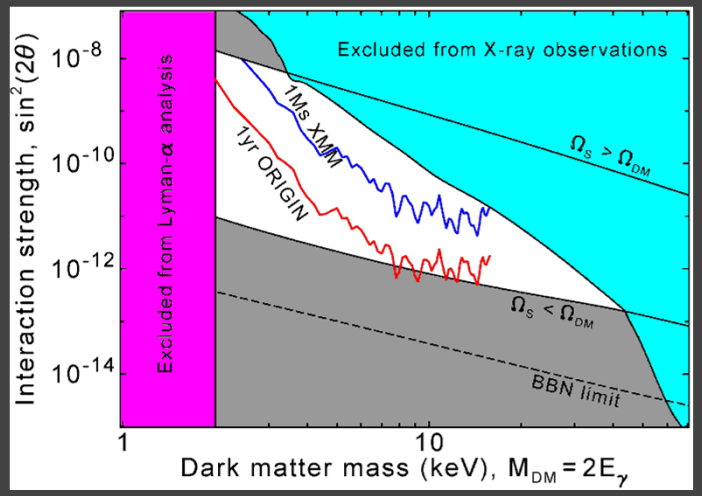
Observatory science

- Unique 'all' sky monitoring for transient events
- Galaxy formation
- Sterile neutrino's (extension of the standard model)

O VIII Lya
M_{halo} $10^{14.5, 14, 13.5}$







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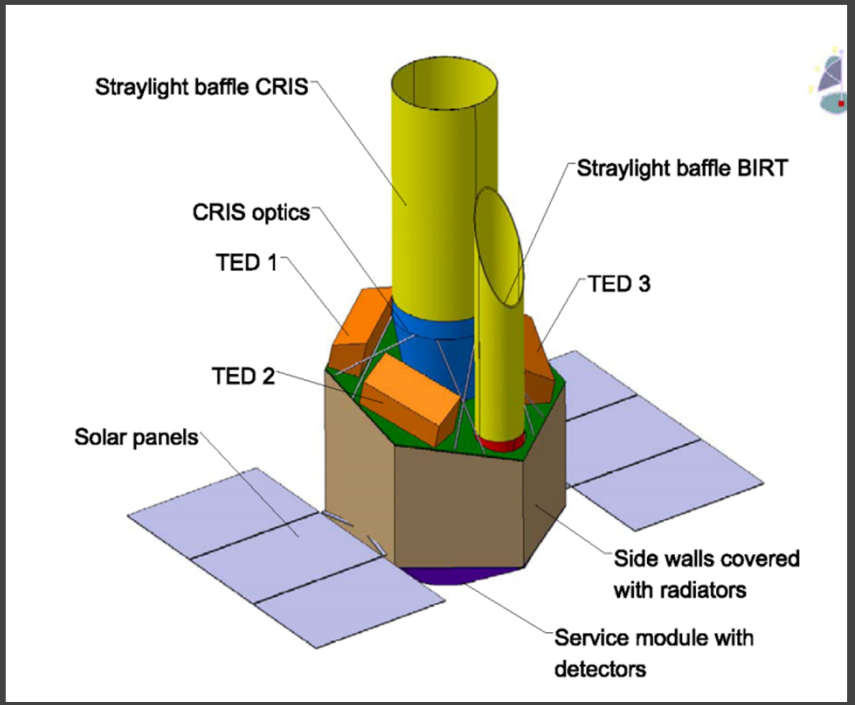
Key characteristics

CRIS: Cryogenic Imaging Spectrometer

> 1000 cm^2, 2.5 eV, 0.25 deg^2, 30 arcsec

TED: Transient Event Detector
125 GRB/year with appropriate fluence > 10^{-6} $erg/cm^2/s$ in 15-150 keV

BIRT: Burst InfraRed Telescope
Mirror: 70 cm, R=20, multiband photometry and R=1000

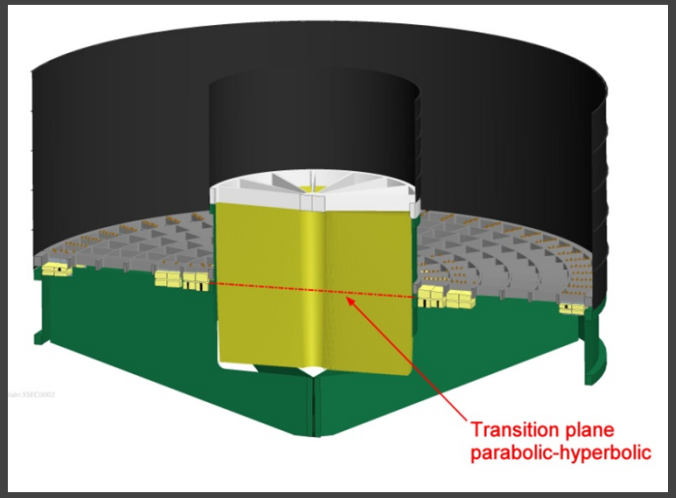


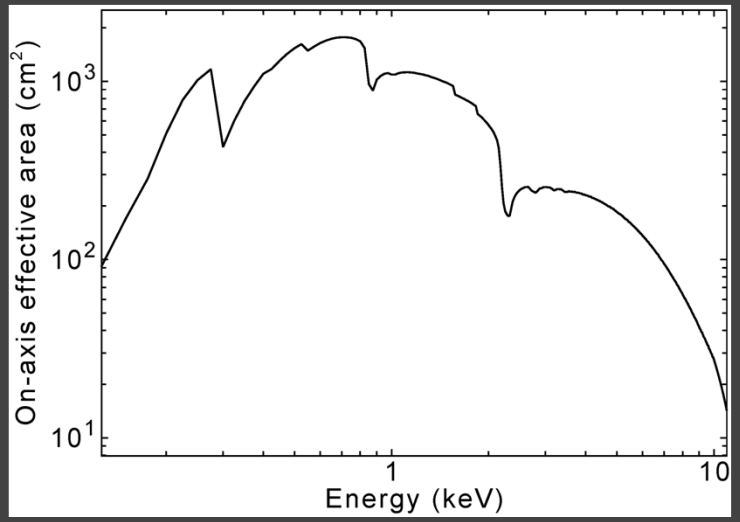
fast reaction
< 60 sec

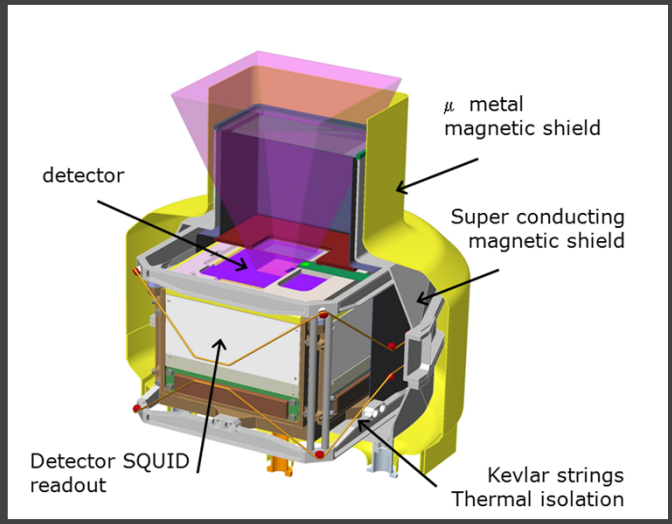
Cryogenic Imaging Spectrometer

- IXO detector, somewhat simplified
- IXO cooler (simple version of ASTRO-H)
- Hybrid optics: IXO + classical

- Optimized low energy response

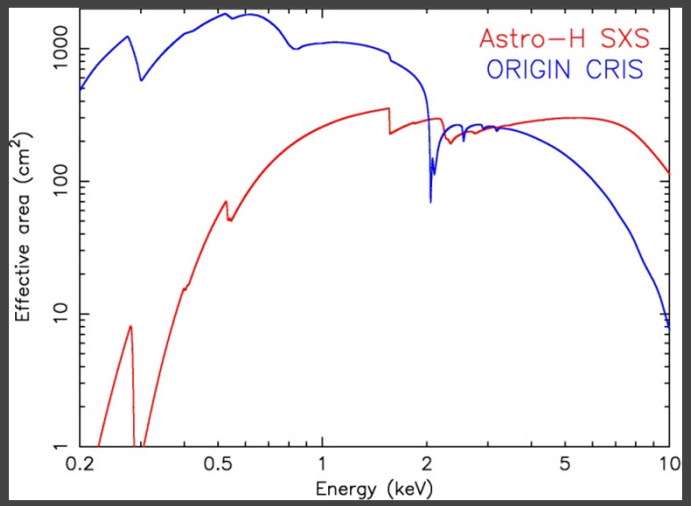


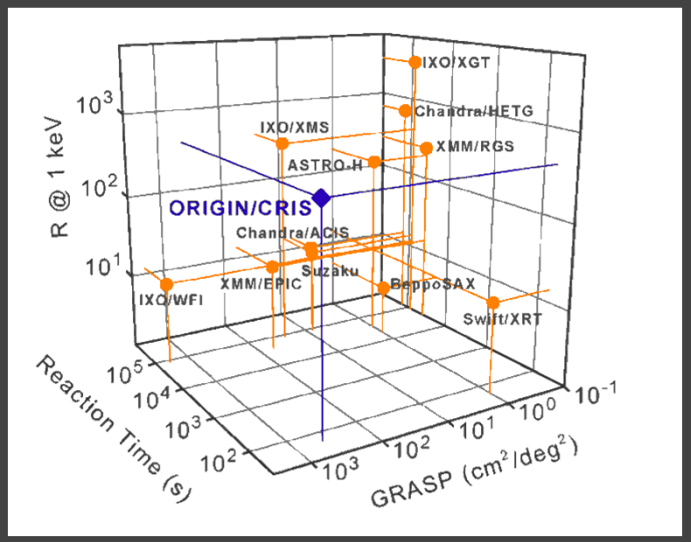




ORIGIN: a unique facility

- Unique combination of FoV, resolution, effective area
- Fast reaction time
- Complementary to all other missions (IXO, ASTRO-H, eROSITA, LOFT, ….)





Too ambitious for M3?

Some science not doable with *New IXO*

But for other science *New IXO* will be superior