Gamma-Ray Bursts at the extreme

The experimental challenge to detect high-redshift (z>12) sources

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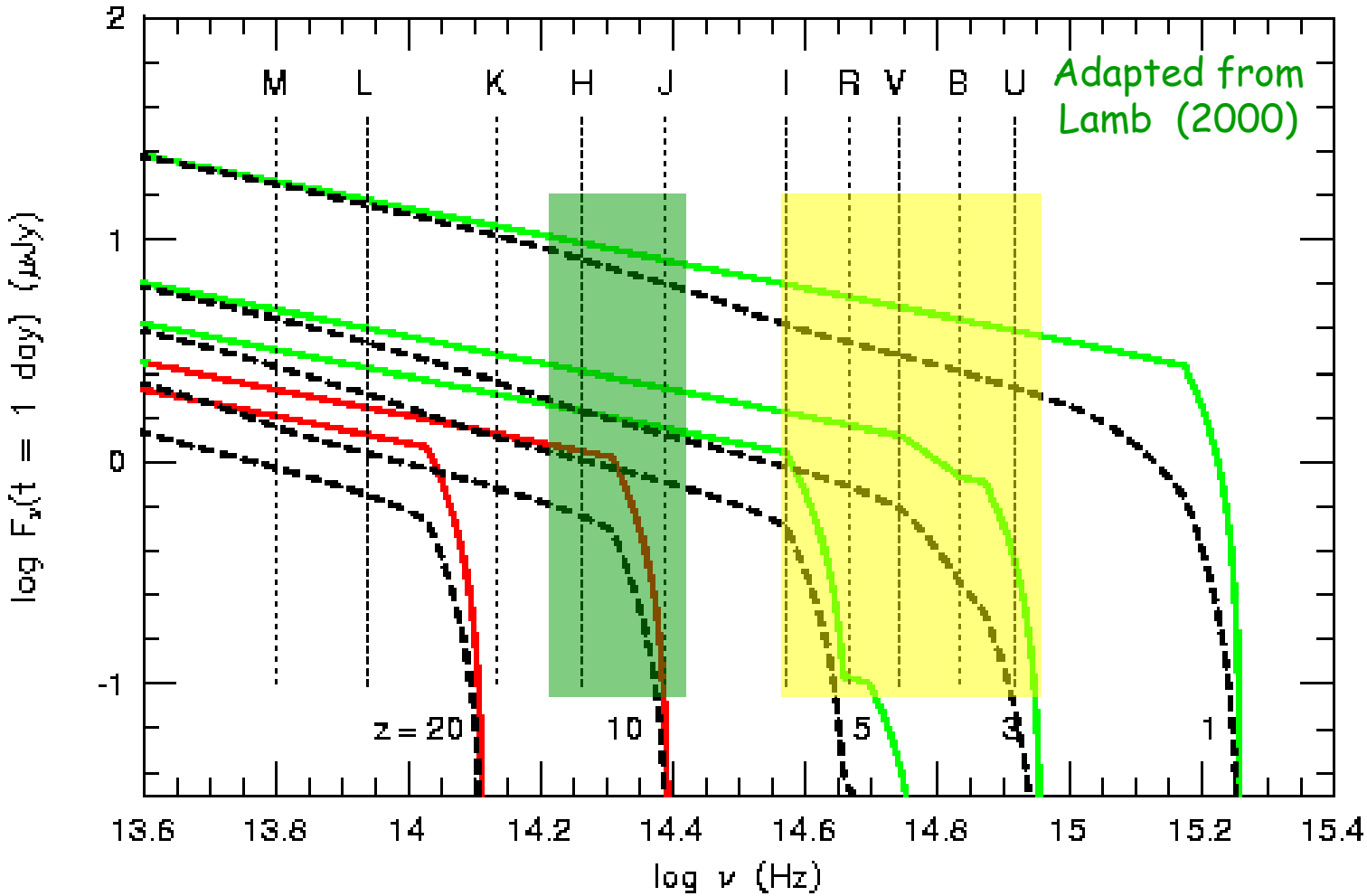
How to find high-redshift GRBs?

Due to characteristic spectrum of GRB Afterglow:

- ☆ Photometry in optical: up to z~6
- ☆ Photometry in NIR: up to z~12-14 (GROND)



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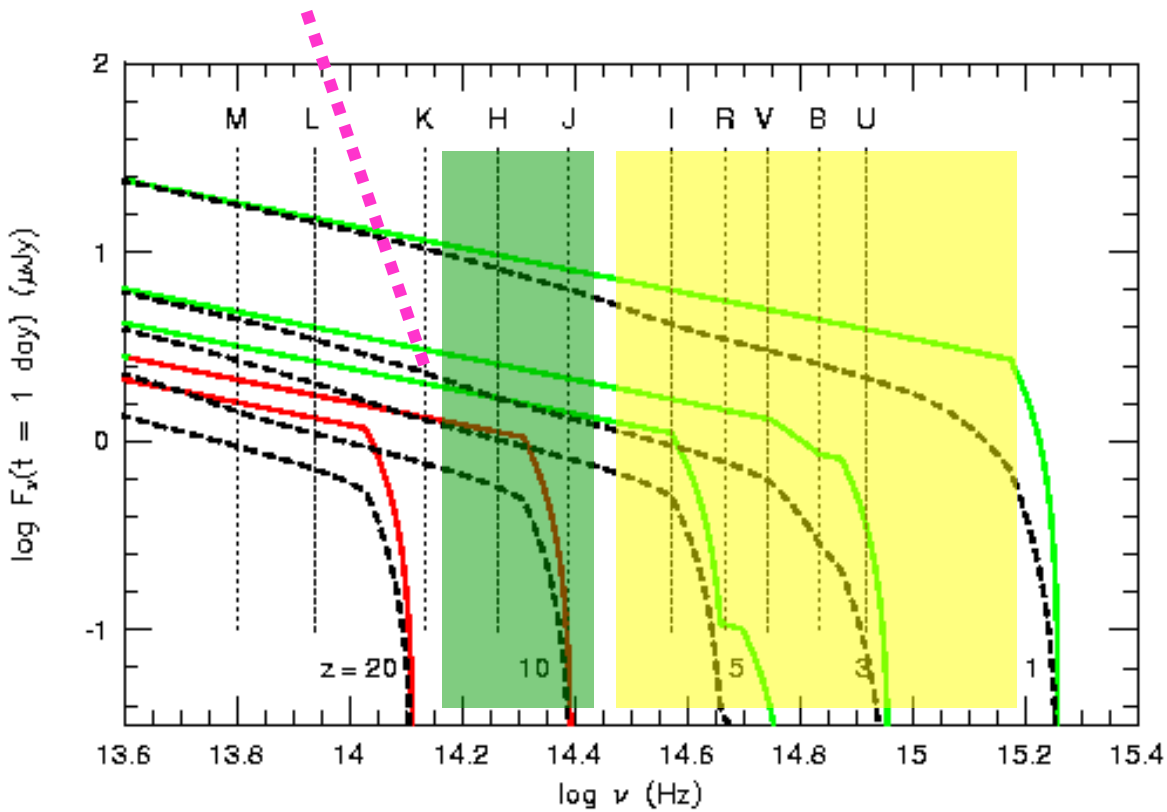
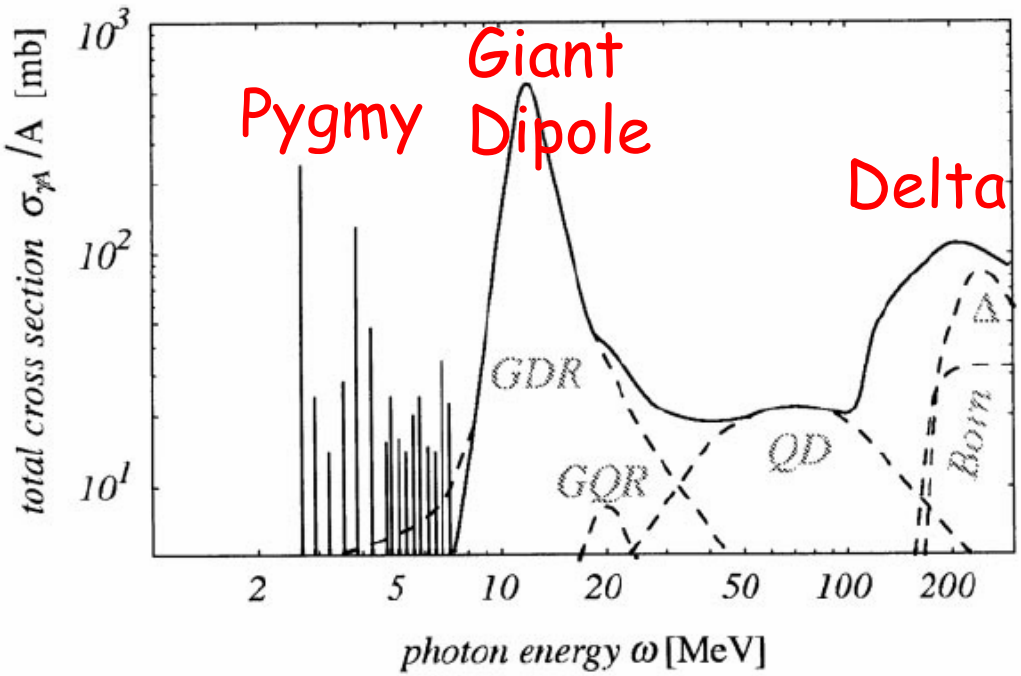
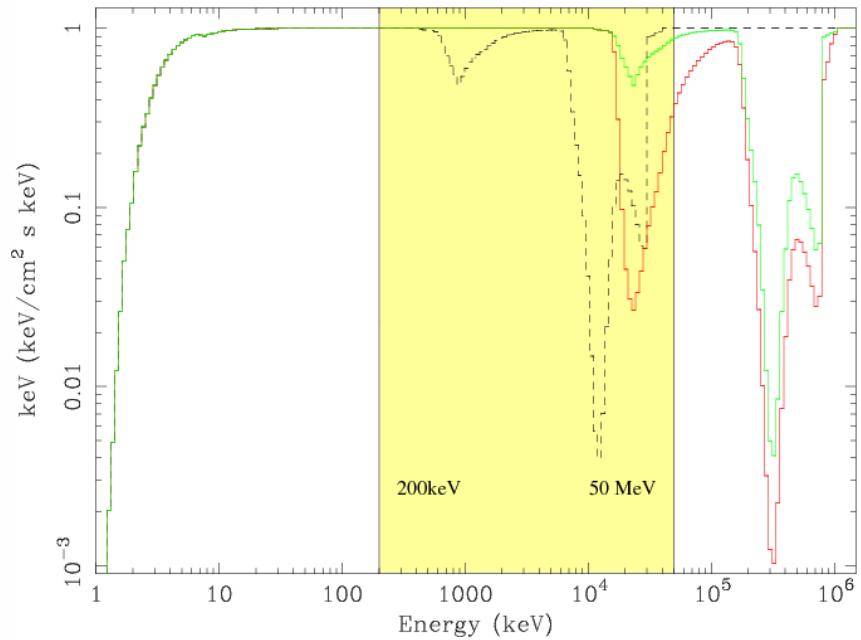
Due to characteristic spectrum of GRB Afterglow:

- ☆ Photometry in optical: up to z~6
- ☆ Photometry in NIR: up to z~12-14 (GROND)
- ☆ **Beyond z~14: not feasible from ground:**
  L-band sensitivity about 7 mag fainter than K-band
  ➔ in gamma-rays?!
  Needs a spectral feature above 10 keV!



Interactions of Photons and Atomic Nuclei



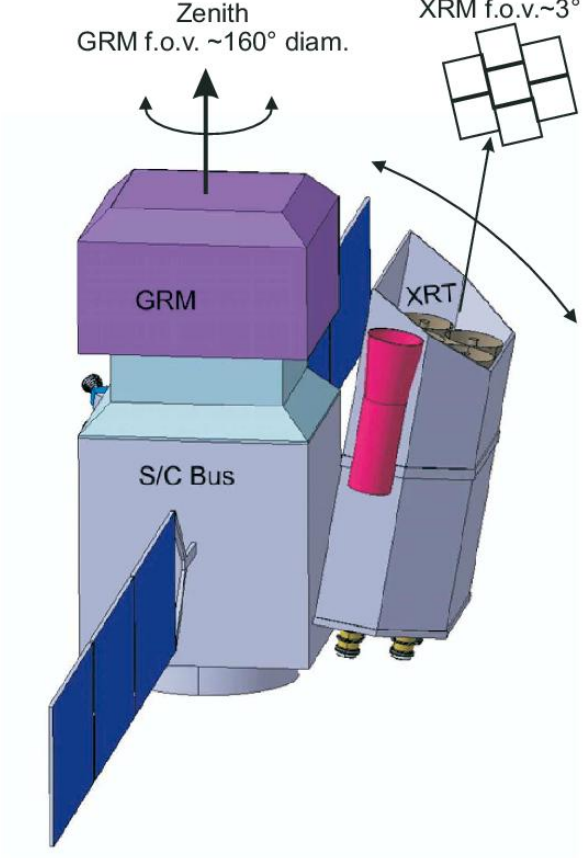


We See Effects of (with increasing energy):

- ☞ Excitation of Single Nucleons in Nucleus Potential ("Nuclear Lines")
  - $h\nu = E_{nucl}$
- ☞ Collective Excitations of Nucleon Groups ("Pygmi/Giant Resonances")
  - giant resonances: protons versus neutrons
  - quasi-deuteron resonances: a pair of proton and neutron
  - each of these occur in all multipole orders
- ☞ Excitations of Single Nucleons ("Delta Resonance")

Absorption independent of

- ionization state
- isotope ratio
- GDR/DR ratio: metallicity



Proposed for ESA's Cosmic Vision 2007
Ranked 4th; only 1-3 selected for study

LEO, 0 degree, 500 km, zenith pointing
Gamma-ray Monitor: 160° FOV
X-ray telescope: 3° FOV
GRB alerts for follow-up

Instruments/capabilities

Gamma-ray Monitor

Energy range	200 keV–50 MeV
Localisation	1° (radius)
Polarisation	1% (@top 10% GRB)

X-ray Monitor

Energy range	0.1-10 keV
Localisation	30" (radius)

Source detections in 1 yr

Type	#
GRBs	660
Blazars	820
Other AGN	250
Pulsars/AXP	60
Unidentified	170

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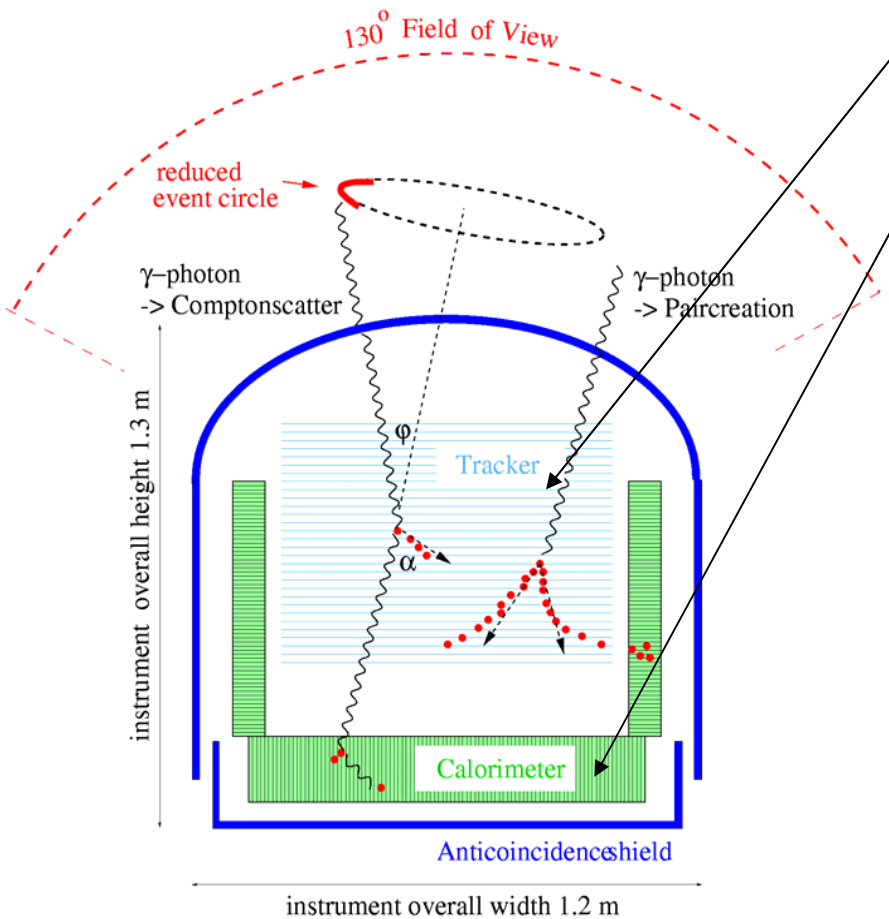
The Telescope Concept

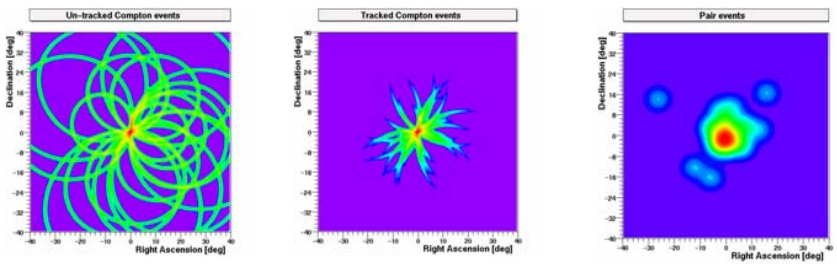


Tracker: double sided Si strip detectors

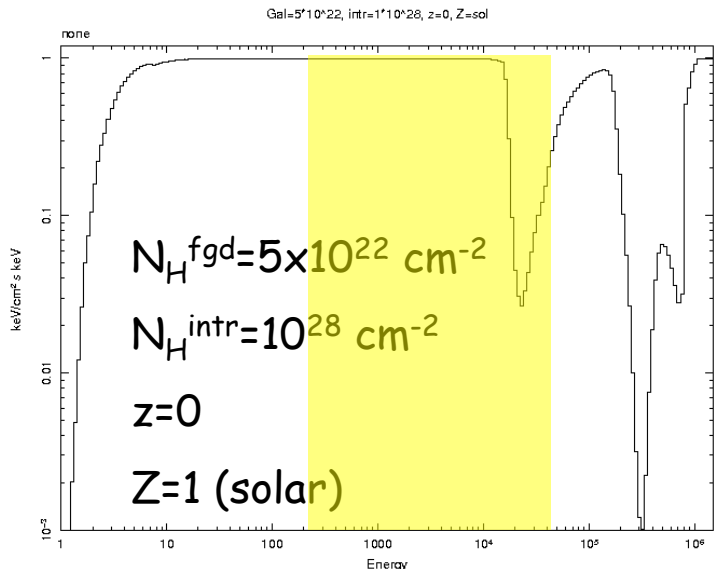
Calorimeter: 3D resolving $LaBr_3$ / Si drift diode

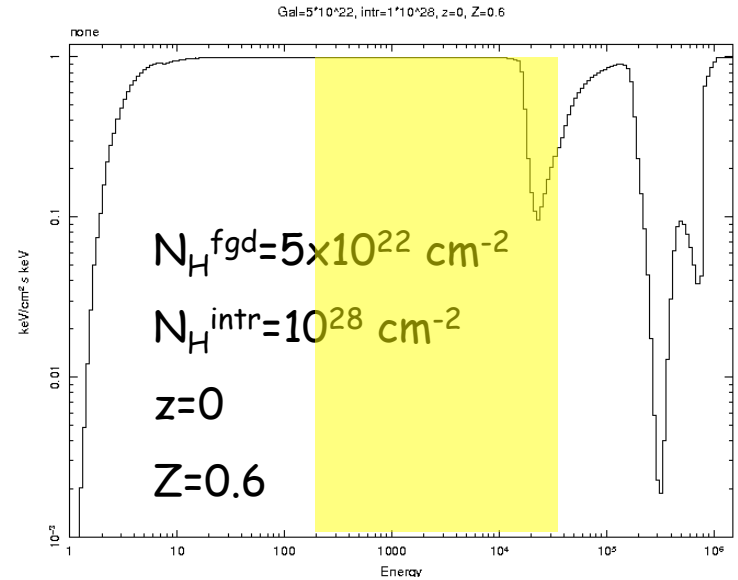
Images

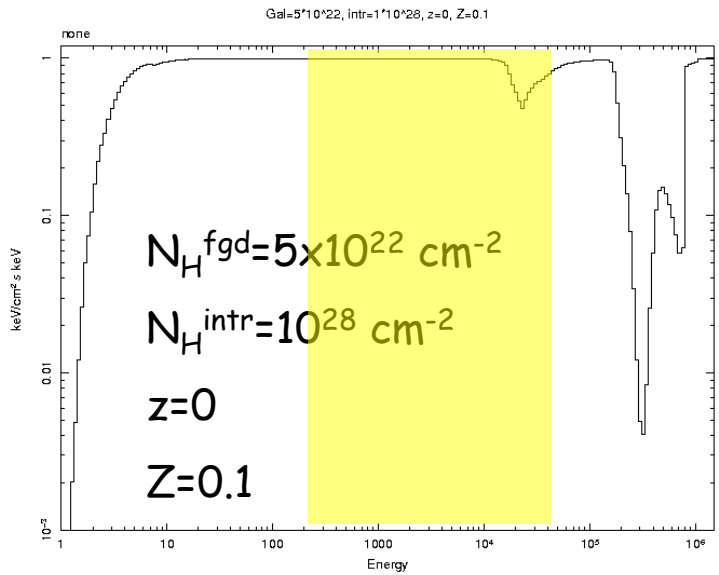
Classical Compton | Tracked Compton | Pairs

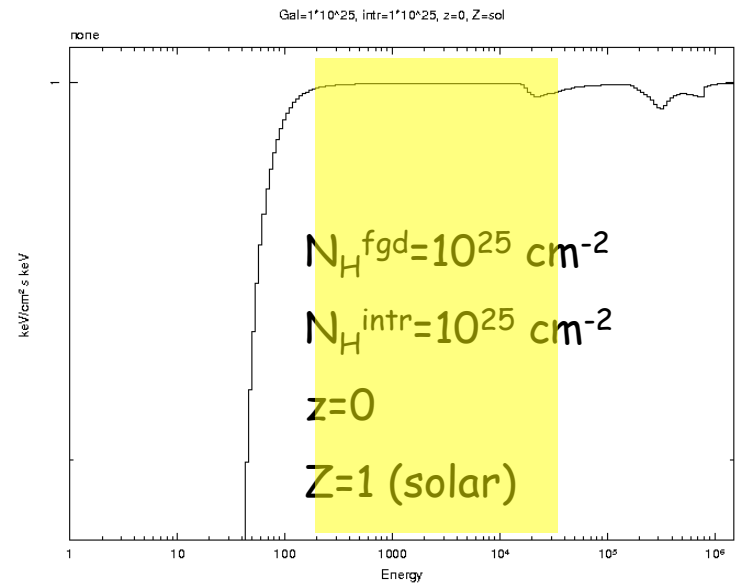


Resonance absorption: the effect









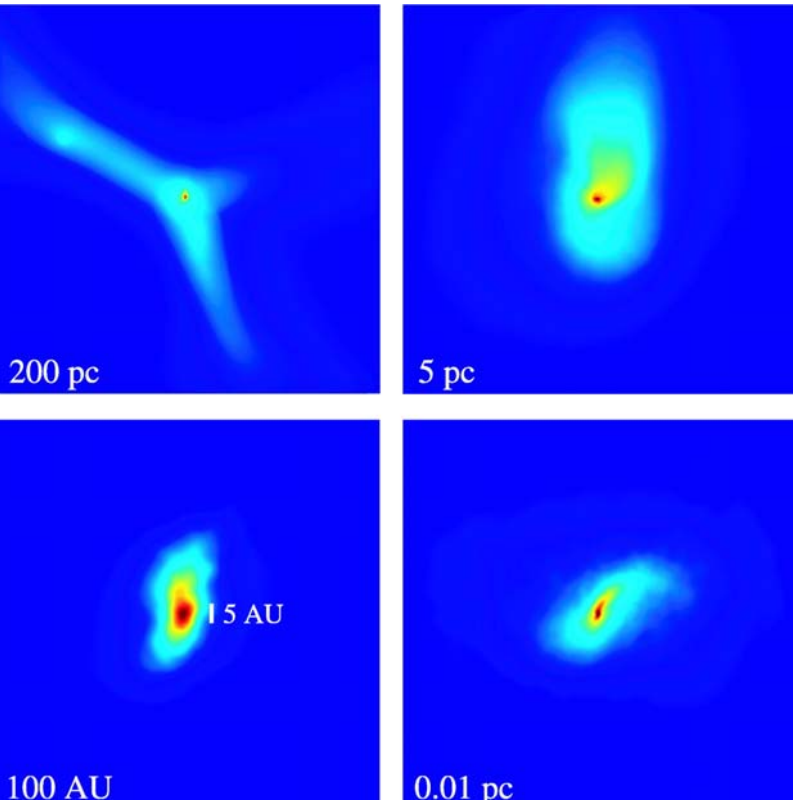
Matter near first star/GRB

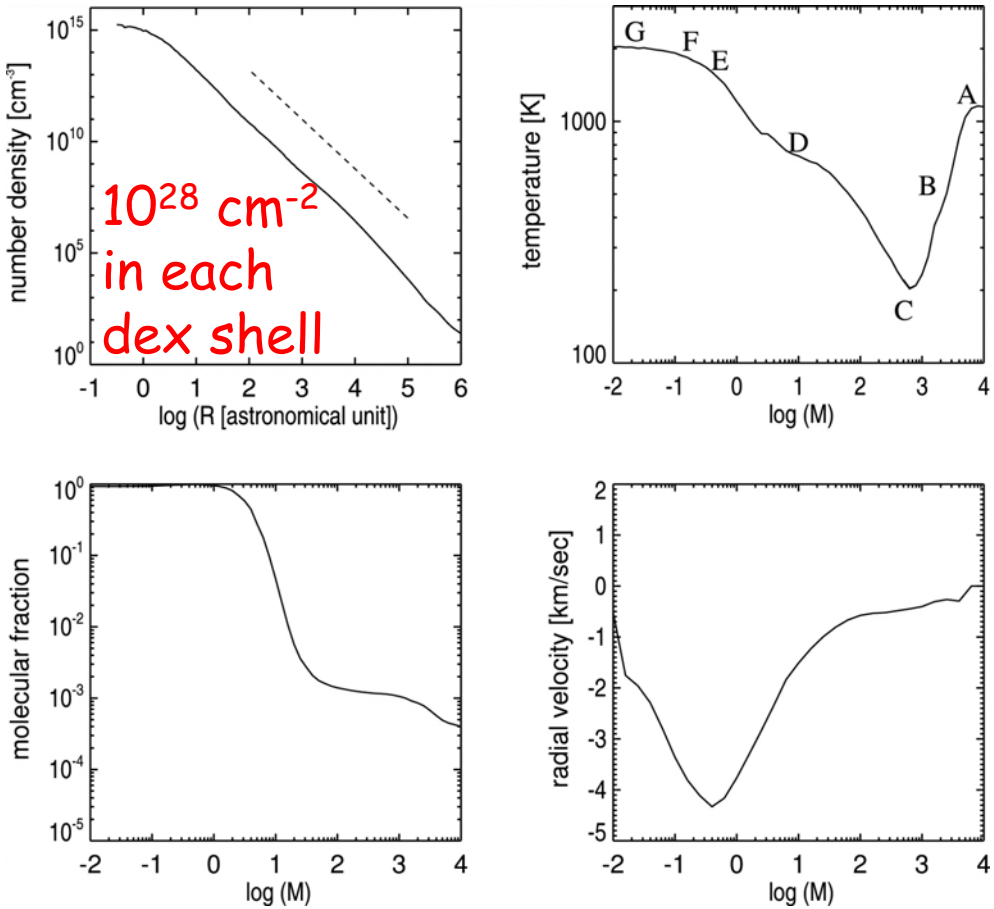
- Gas clouds stable against fragmentation (no star clusters)
- Substantial fraction is ionized
- Mass or mass ranges for first stars still difficult to predict
- Radiation pressure is generally not important (no dust)

Yoshida etal 2006, ApJ 652, 6

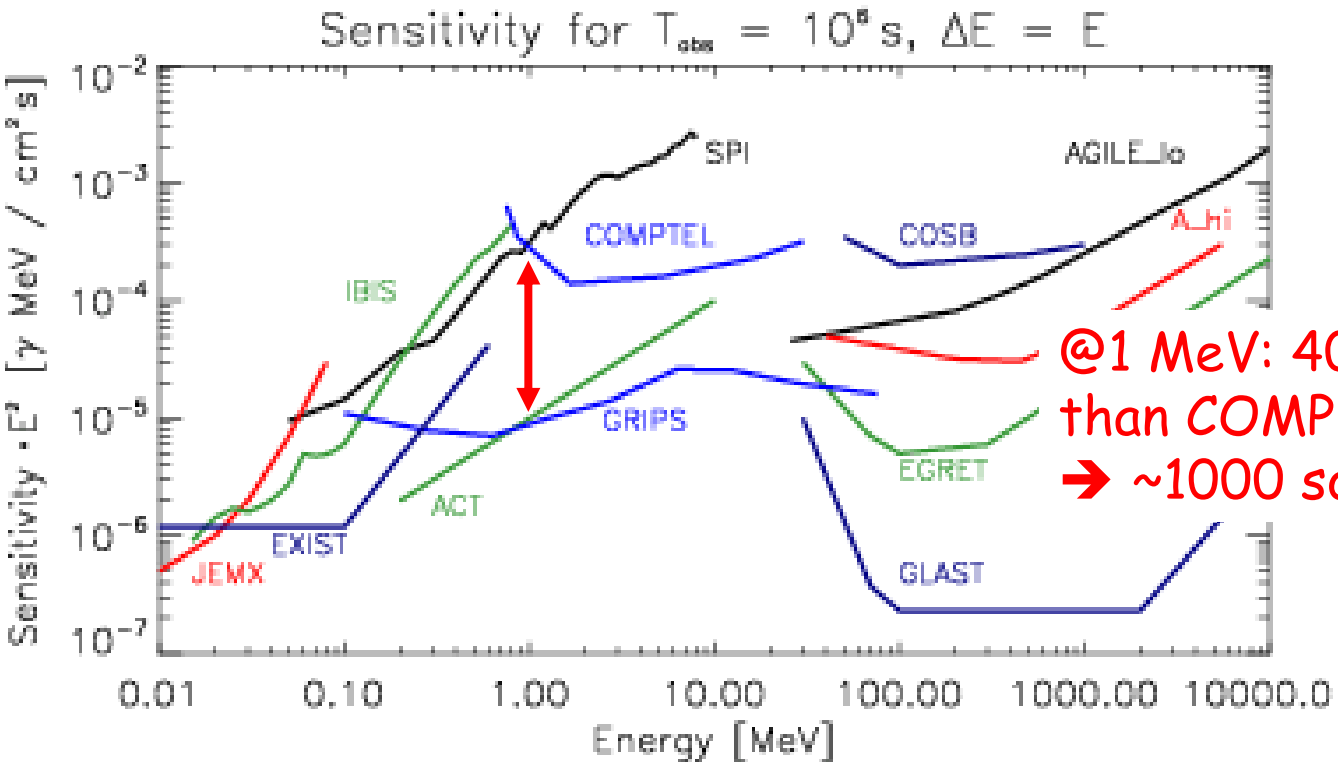
Radial profiles at z=19.

Projected density distribution at z=19





GRIPS sensitivity in context



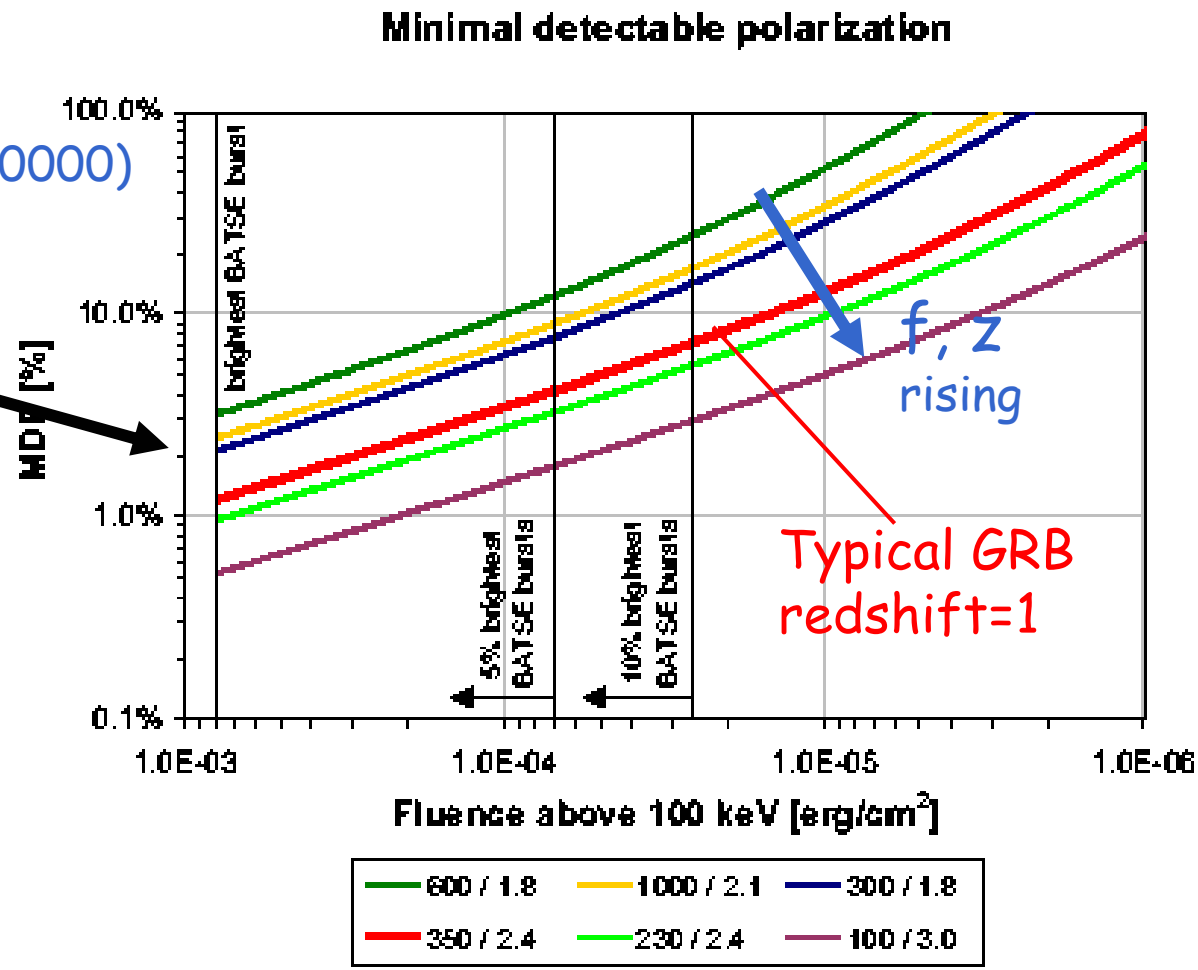
@1 MeV: 40x more sensitive than COMPTEL/INTEGRAL
➔ ~1000 sources in 1 yr survey

- more sensitive than EXIST above 200 keV
- similar sensitivity to Laue lens (GRI): ~20% diffraction efficiency is just compensated by focusing. Also much wider energy coverage and not the ambiguity of line energy / sky position as the lens.

Perfect to measure Polarisation

Polarisation sensitivity best at 200-500 keV:
f=flux(200-500)/flux(200-50000)

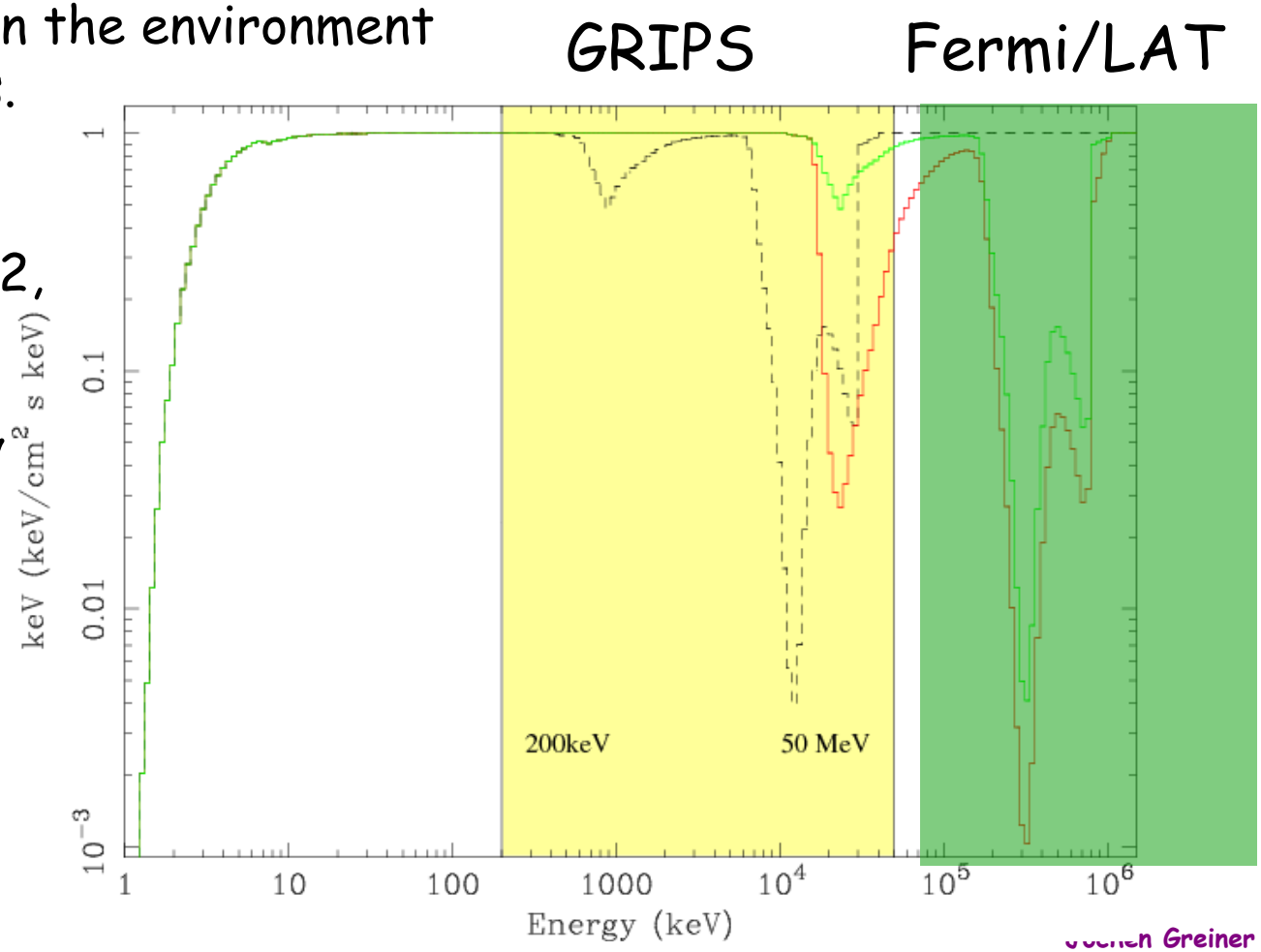
- in Gamma-Ray Bursts
- in SGRs, AXP flares
- Pulsars
- other bright sources



Fermi: expectation for nuclear resonance

Fermi-LAT is the obvious experiment to establish the existence of large column densities in the environment of cosmic sources.

BUT:

LAT only covers z < 1-2, using just DR

GBM sensitivity not sufficient >5 MeV