Future Observations of Gamma-ray Bursts and their Afterglows with ASTRO-H

ASTRO-H White Paper: arXiv:1412.1179

Makoto S. Tashiro (Saitama Univ.),
on behalf of ASTRO-H WPTF#20 & HXI/SGD shield team
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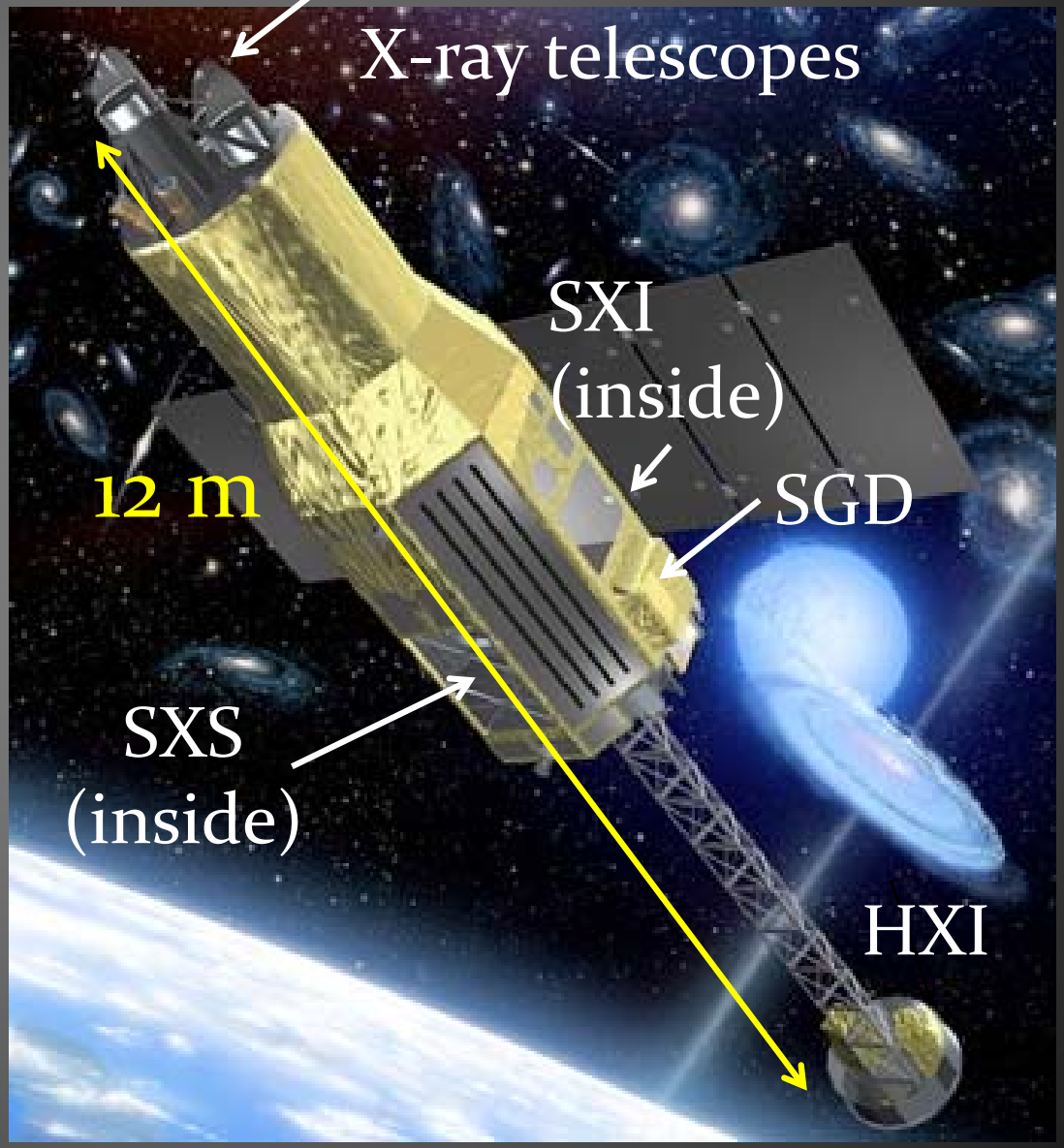
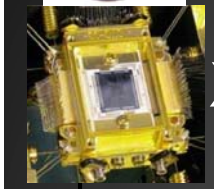
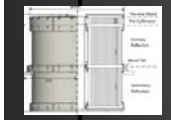
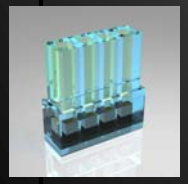
ASTRO-H

will be launched in FY2015



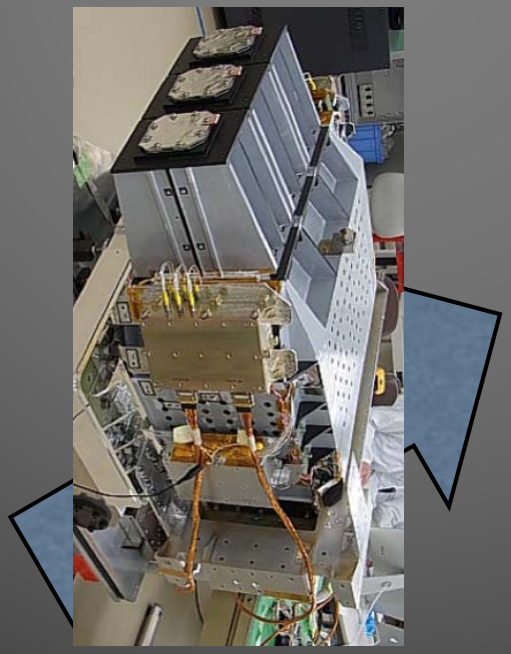
ASTRO-H Performance

  Soft X-ray Spectrometer (SXT-S+XCS) X-ray μ-calorimeter array **0.3-12 keV**	Angular resolution 1.7 arcmin (HPD) Effective area 210 cm^2@6 keV Energy resolution 4-7 eV FWHM FOV 3 arcmin @ 6 keV
  Soft X-ray Imaging System (SXT-I+SXI) X-ray BL CCD **0.5-12 keV**	Angular resolution <1.7 arcmin (HPD) Effective area 360 cm^2@6 keV Energy resolution 150 eV FOV 34 x 34 $arcmin^2$
 Hard X-ray Imaging System (HXT+HXI) multi-layered hard X-ray mirror DS-Si-D+ CdTe **5-80 keV (F.L 12 m)** 	Angular resolution 1.7 arcmin (HPD) Effective Area 300 cm^2 @30 keV Energy resolution 2 keV FOV 9 arcmin @ 30 keV
Soft Gamma-ray Detector (SGD) Si-Pad+ CdTe-Pad **10-600 keV** 	Compton Camera Effective area 100 cm^2@100 keV Energy resolution 2 keV 1mCrab @ 200 keV polarimetry

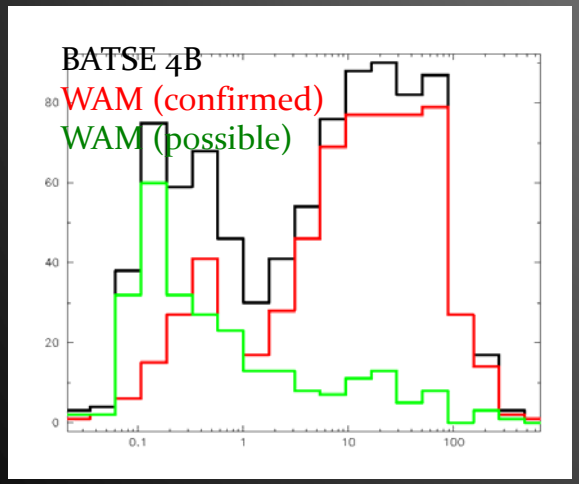
Prompt emission with SGD-Shield

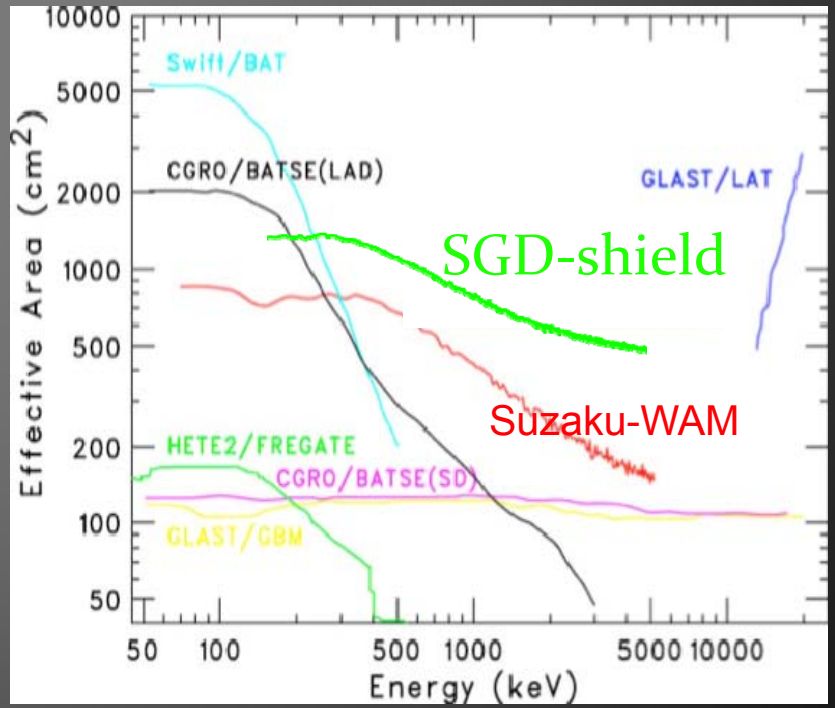
- ✓Effective area ~800 cm² at 1 MeV (2 x of WAM)
- ✓Energy range: 150(TBR)-5000 keV
- ✓ High speed spectroscopy:
  32 enegy ch in every 16 ms (covers 5.376 s /GRB)
- ➔enhance the hard-X-ray spectroscopy science

SGD



Suzaku-WAM
Observed over
1000 confirmed GRBs

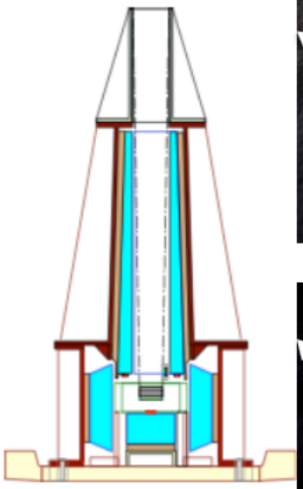


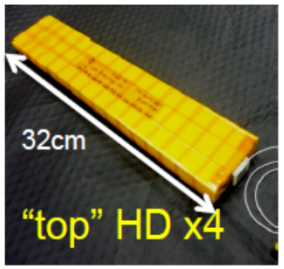


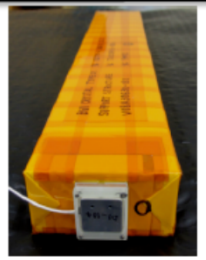
twice of Suzaku-WAM's

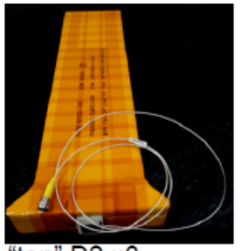
BGO active shields © M. Ohno

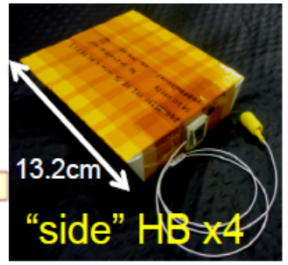
BGO Active Shields for HXI/SGD

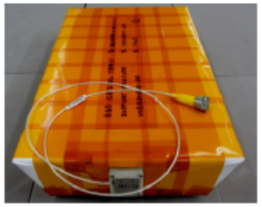


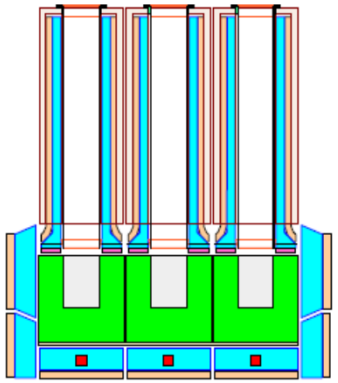


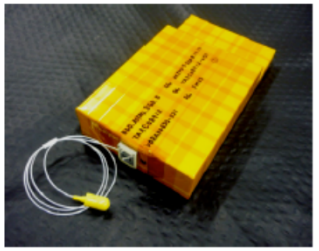

"top" D1 x6

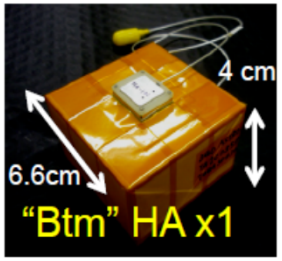

"top" D2 x6



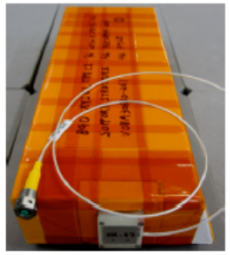

"side" C1 x2



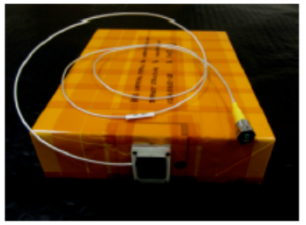

"side" B x6



HXI: 9BGOs
w/ 3types

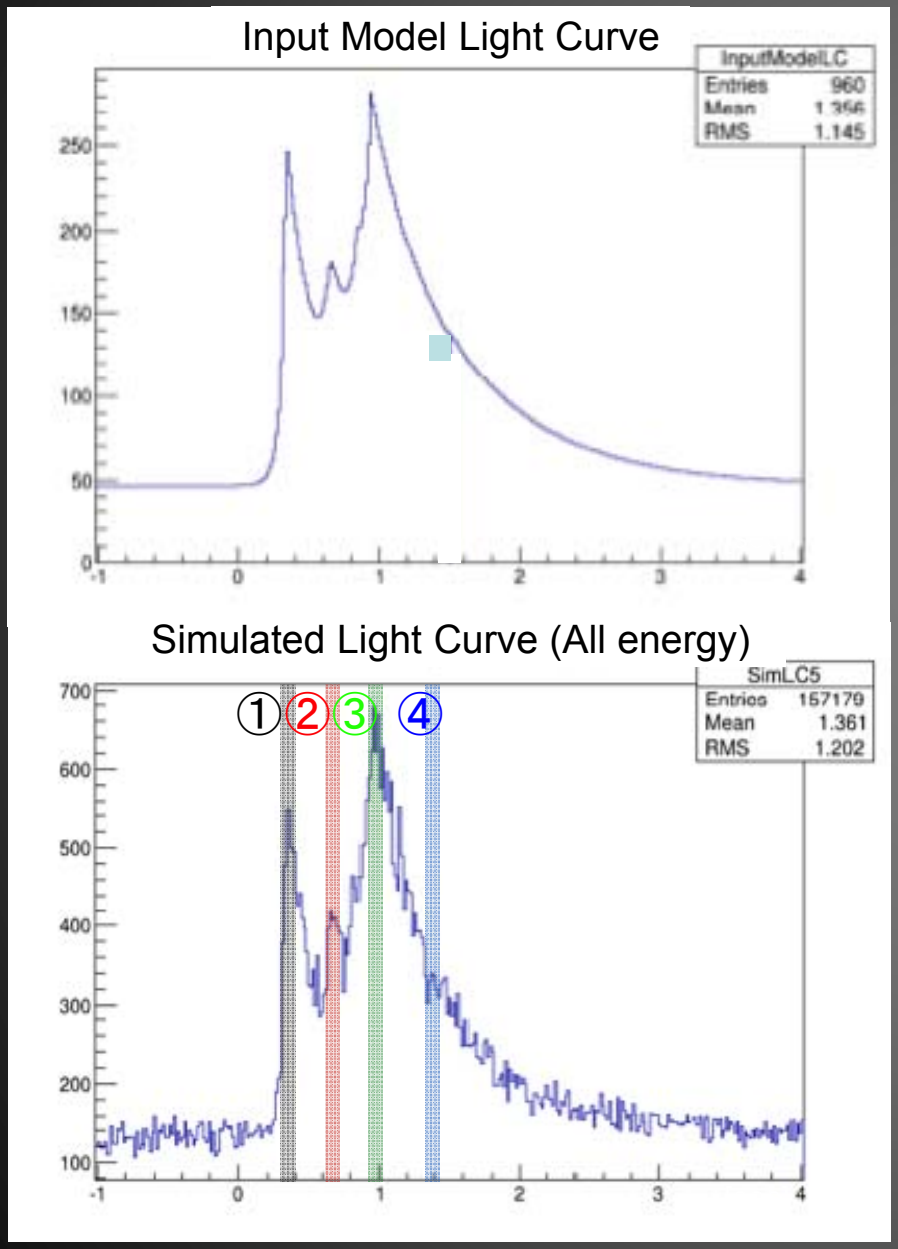

"side" C2 x2

SGD: 25 BGOs
w/ 6 types

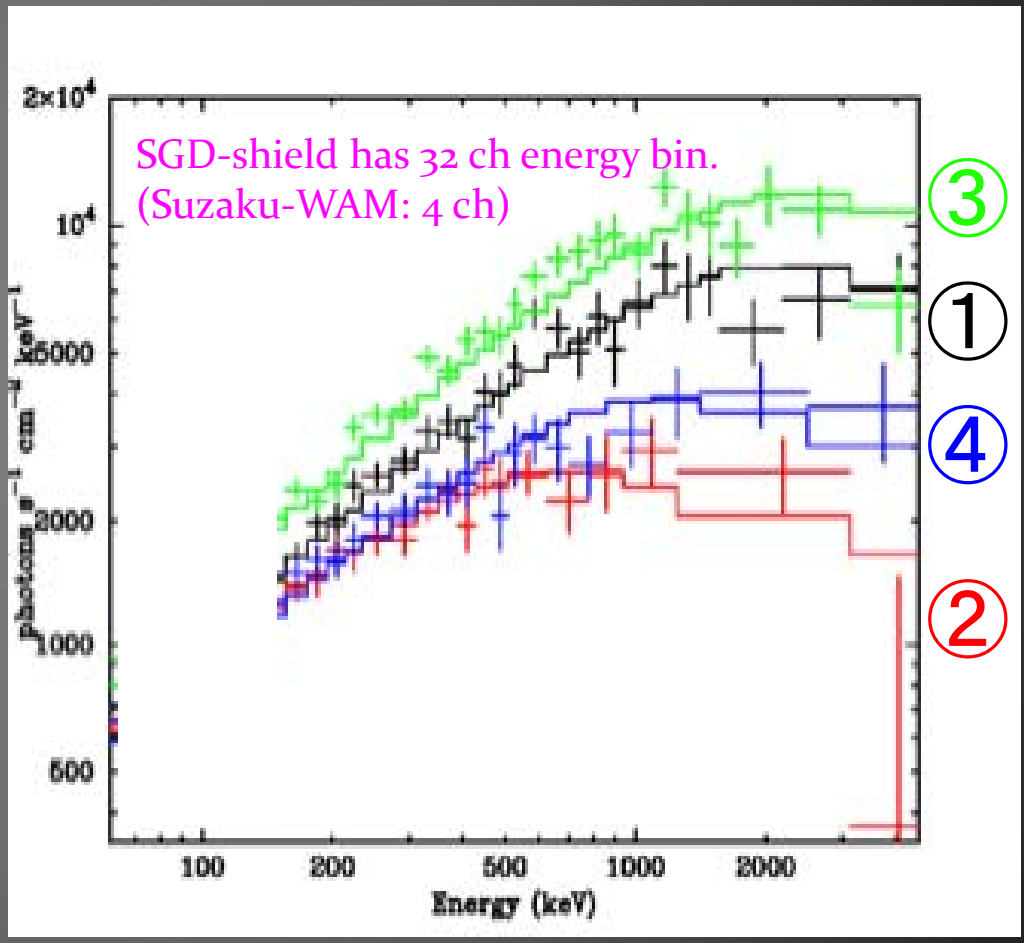

"Btm" Ax3

There are various complicated shape of BGO crystals
Readout each crystal independently by avalanche photo-diode

Short GRB simulation with SGD-shield



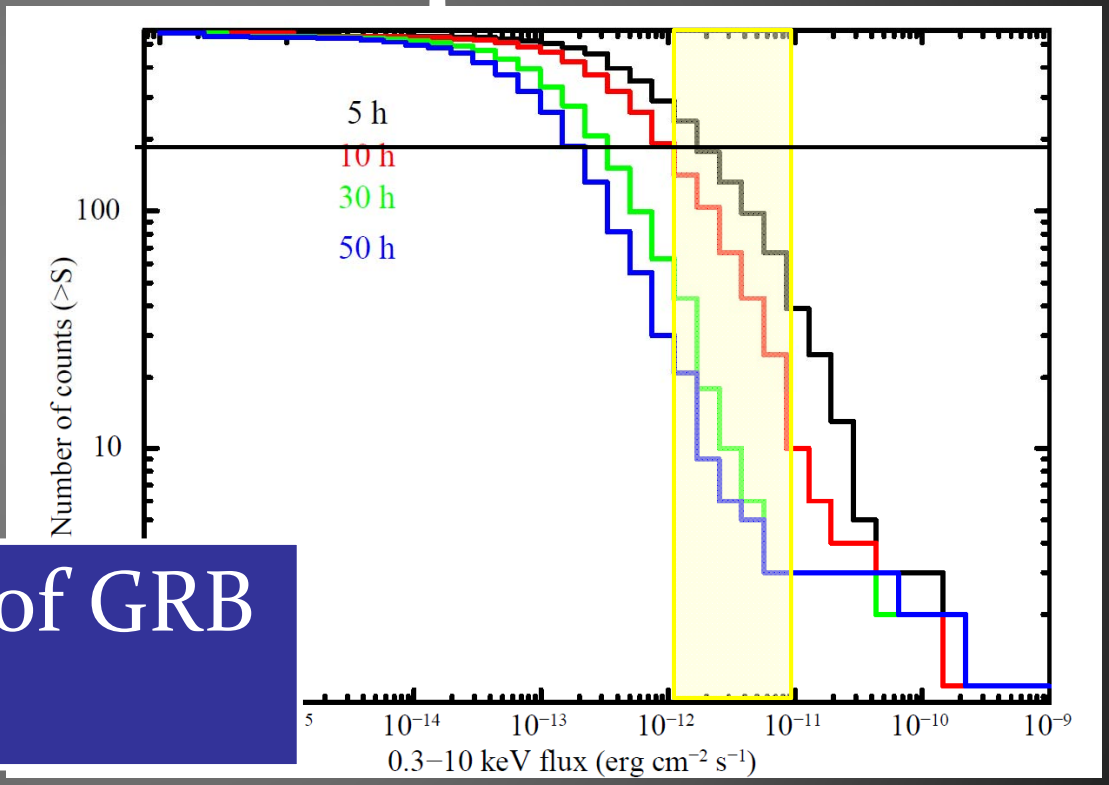
Assumed spectra: Band function alpha = -0.8 and beta = -2.3. including evolution of the E_{peak} = 200 → 1500 keV



Time-resolved spectra with ~0.1 s time resolution

Afterglow observation with telescopes

luminosity functions of GRB afterglow
based on 572 samples of 6-year Swift/XRT data.
Evans et al. (2009, MNRAS, 397, 1177)

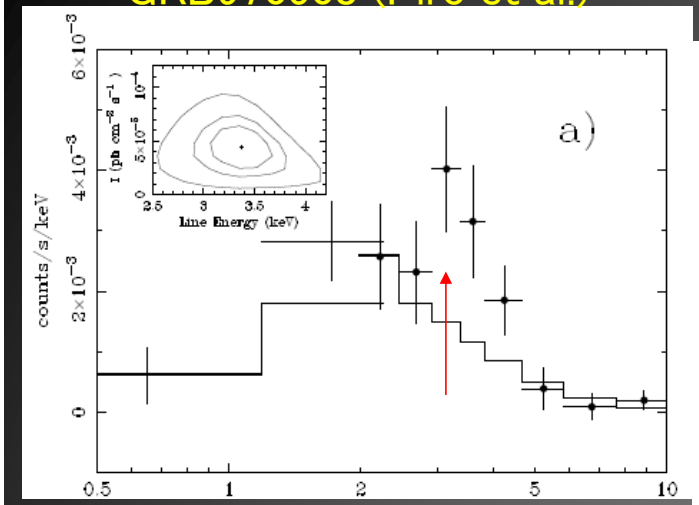


A follow-up observation of GRB will be in the PV phase

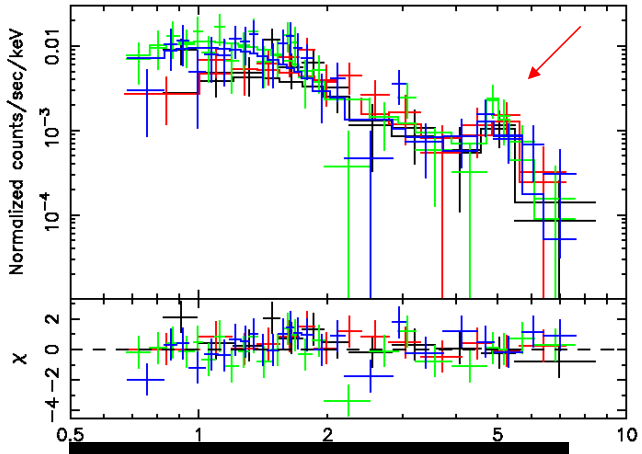
Flux	To + 10 hr.	To + 30 hr.	To + 50 hr.
> 10^{-11} erg s^{-1} cm^{-2}	1.7 GRB/yr.	0.5 GRB/yr.	0.2 GRB/yr.
> 10^{-12} erg s^{-1} cm^{-2}	20 GRB/yr.	10 GRB/yr.	3 GRB/yr.

Atomic features in X-ray afterglow spectra

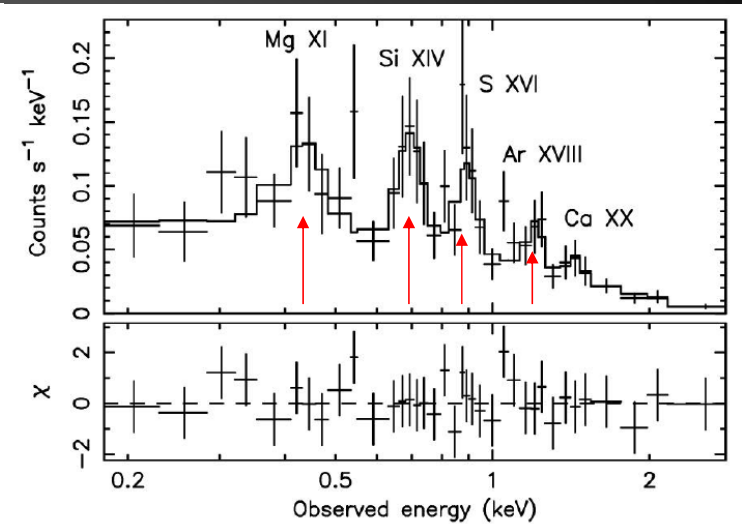
GRB970508 (Piro et al.)



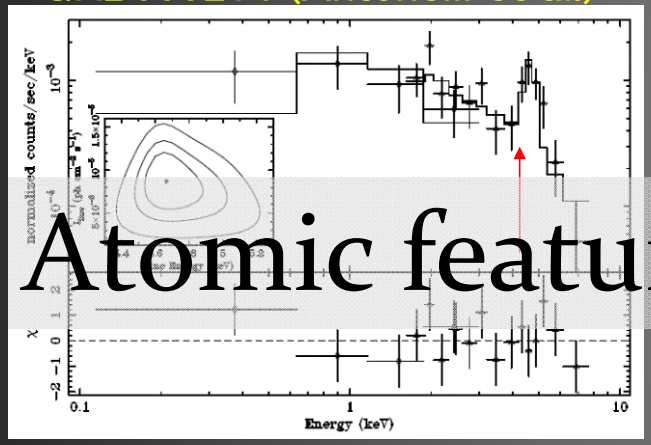
GRB970828 (Yoshida et al.)



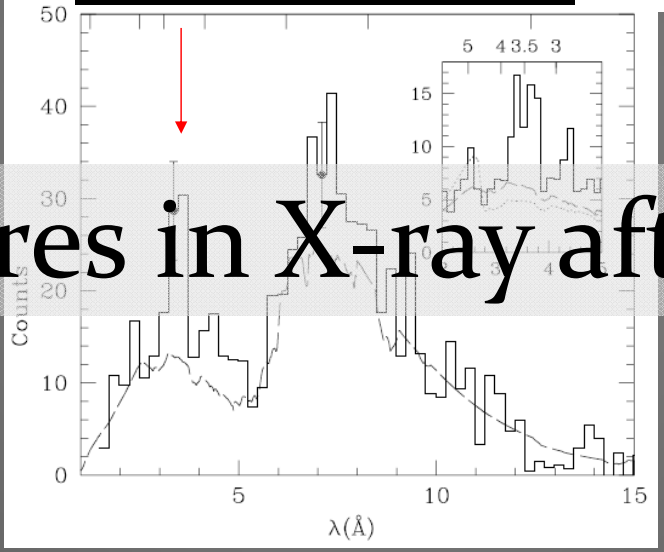
GRB011211 (Reeves et al.)



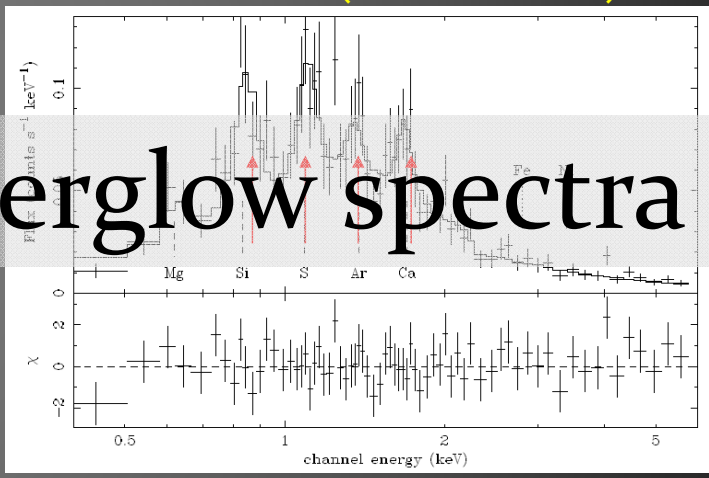
GRB000214 (Antonelli et al.)



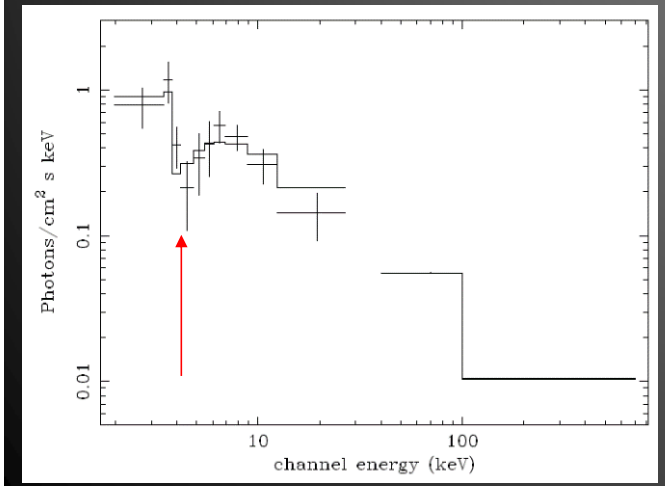
GRB991216 (Piro et al.)



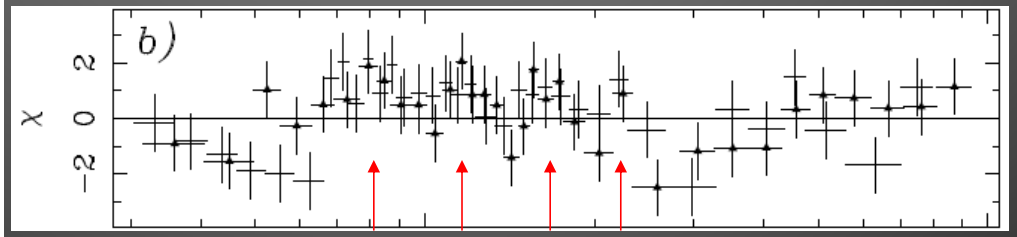
GRB030227 (Watson et al.)

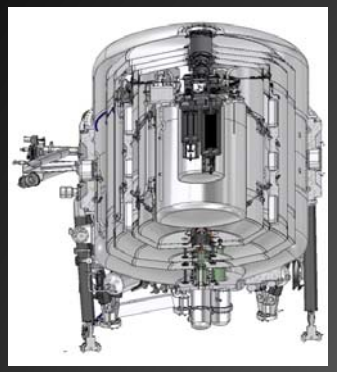


GRB990705 (Amati et al.)



GRB001025A (Watson et al.)



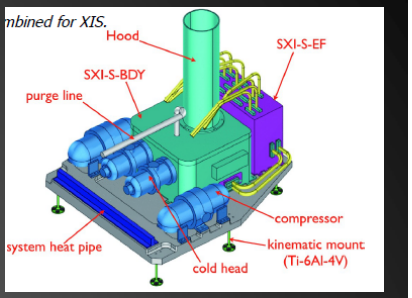


Afterglows with SXS+SXI

Including WHIM structure at z = 0.1 by XSTAR

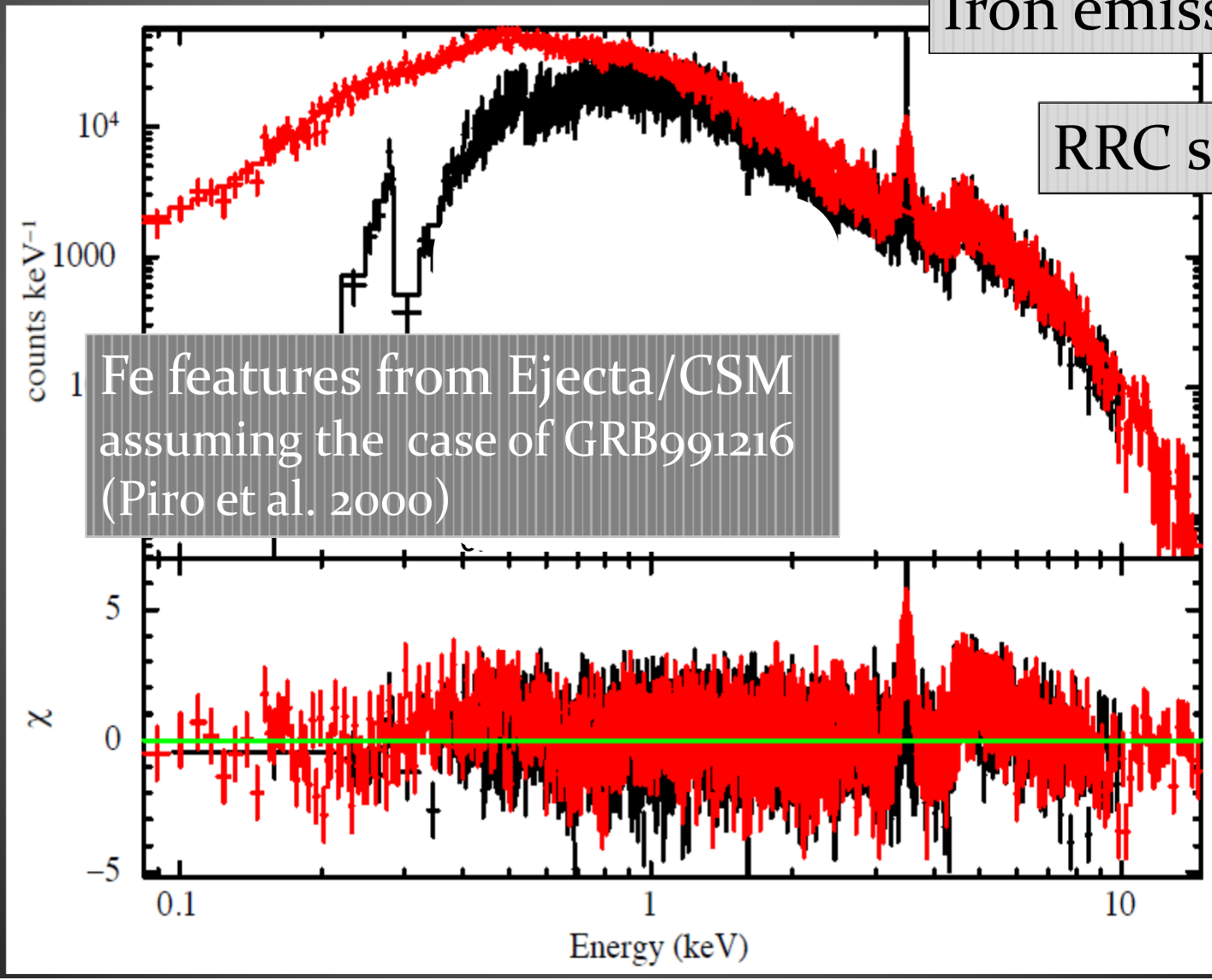
(100 ks exp. $F=3\times10^{-12}$ erg/cm^2/s,

$T=10^5$ K, $Z = 0.2\ Z_{SUN}$, $N_H = 10^{22}$ cm^{-2})



Iron emission line

RRC structure



Fe features from Ejecta/CSM assuming the case of GRB991216 (Piro et al. 2000)

SXI

SXS

X-RAY OBSERVATORY ASTRO-H

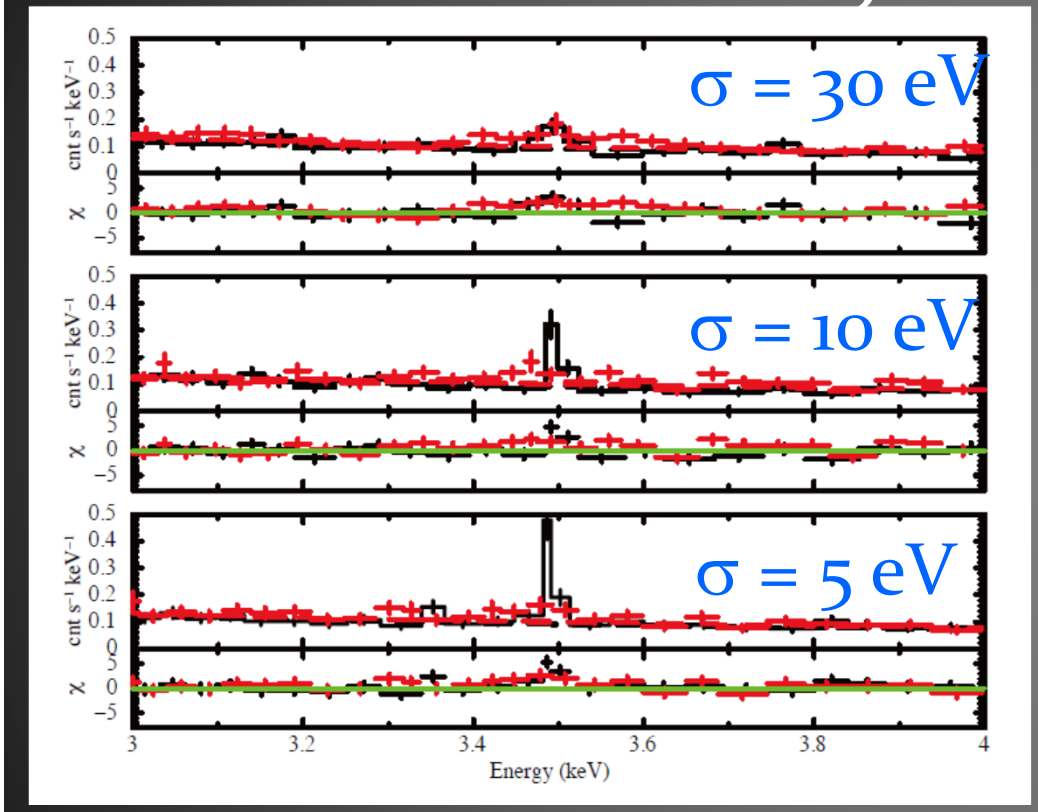
Simulation of X-ray afterglow spectra

10 ksec exposure

Search the emission lines in X-ray afterglow spectra.

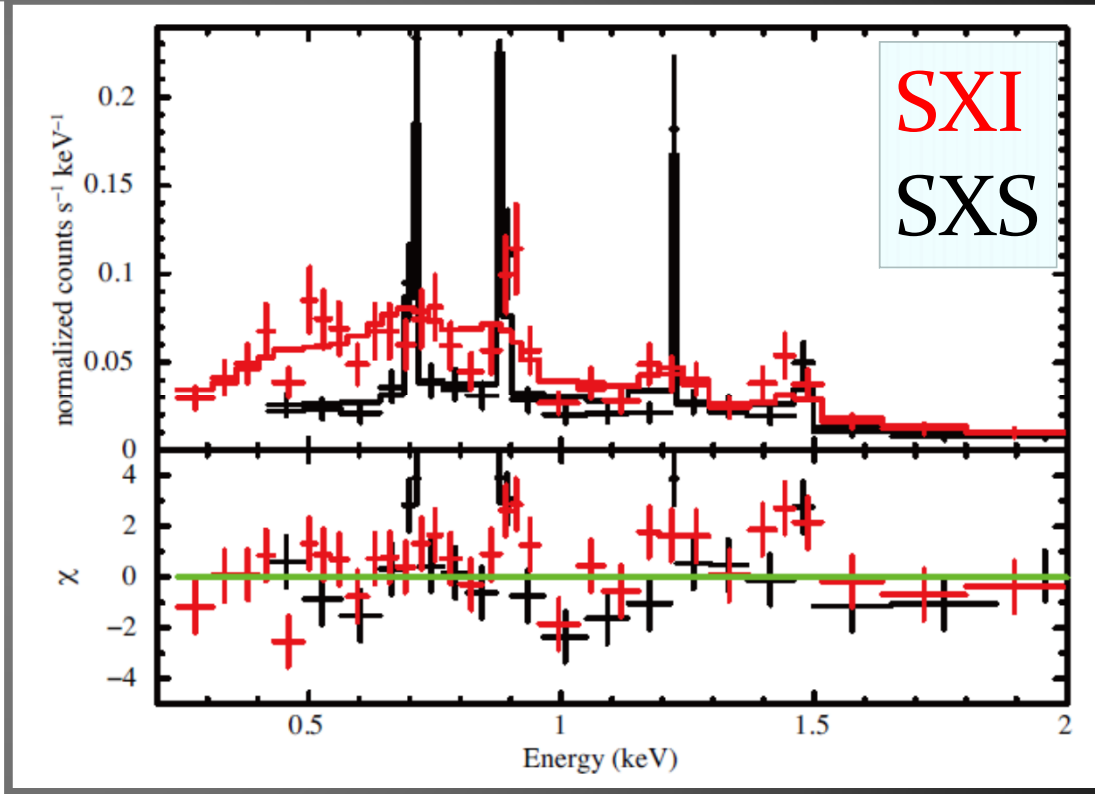
Weak iron emission line

EW = 50 eV



Soft X-ray emission lines

as reported from GRB 011211 by XMM (Reeves et a



Doppler velocity and time variation of emission lines show a geometrical structures of GRB explosions.

We can trace the circumstellar chemical environment of GRB progenitors.

Absorption features in high-z GRB Afterglows

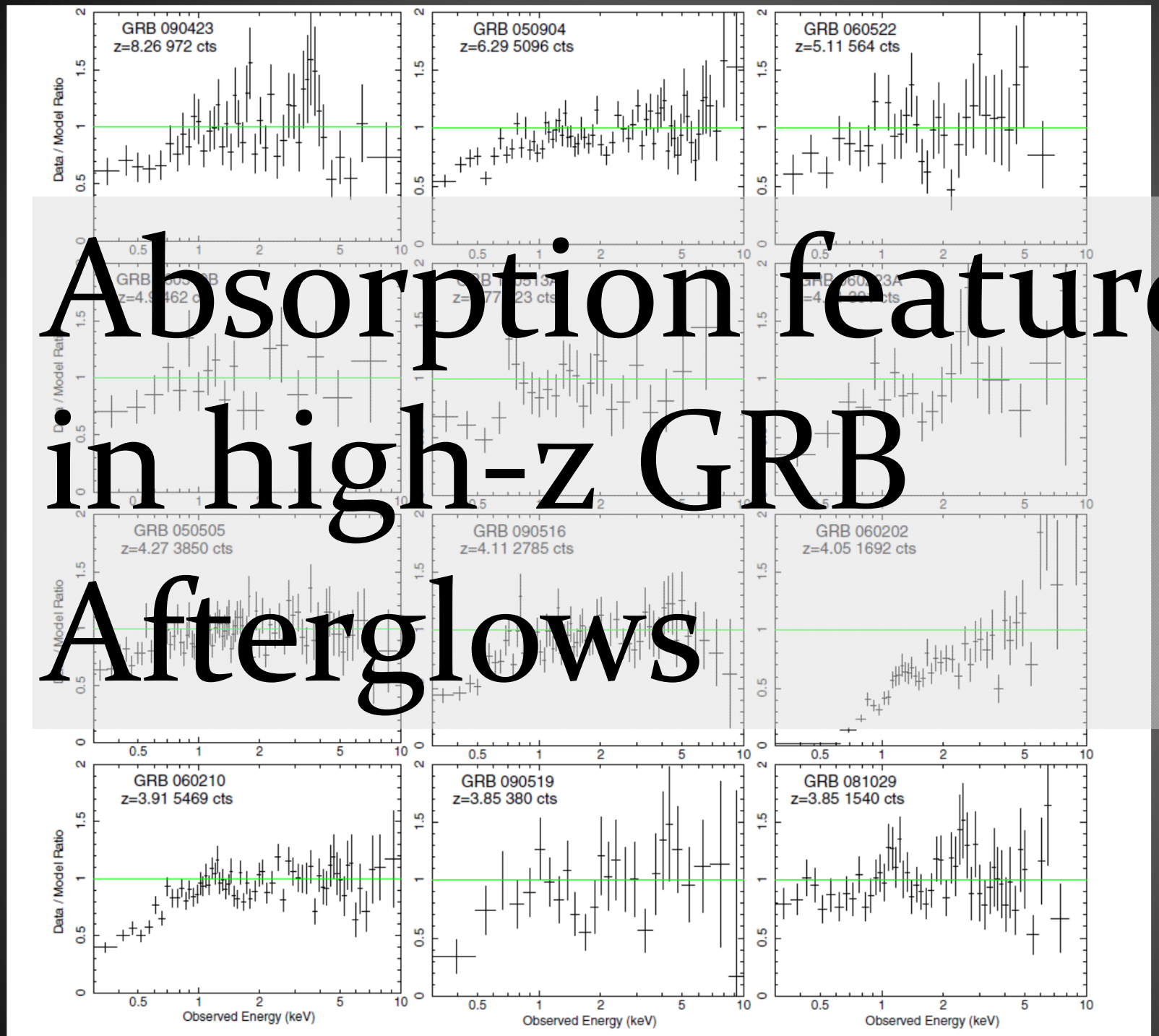
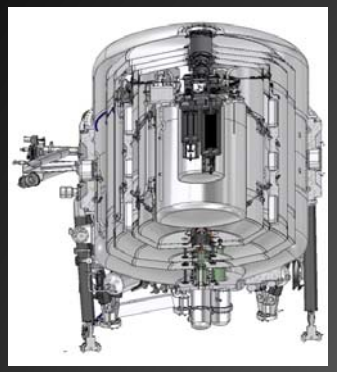


Figure 3. Data to model ratio plots for the 12 highest-z GRBs with confirmed absorption. Data are binned to represent conveniently the extragalactic transmission functions. Note the overall similar absorption amplitude irrespective of z.

Behar et al. (2011)

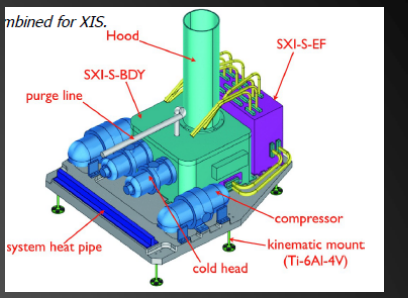


Afterglows with SXS+SXI

Including WHIM structure at z = 0.1 by XSTAR

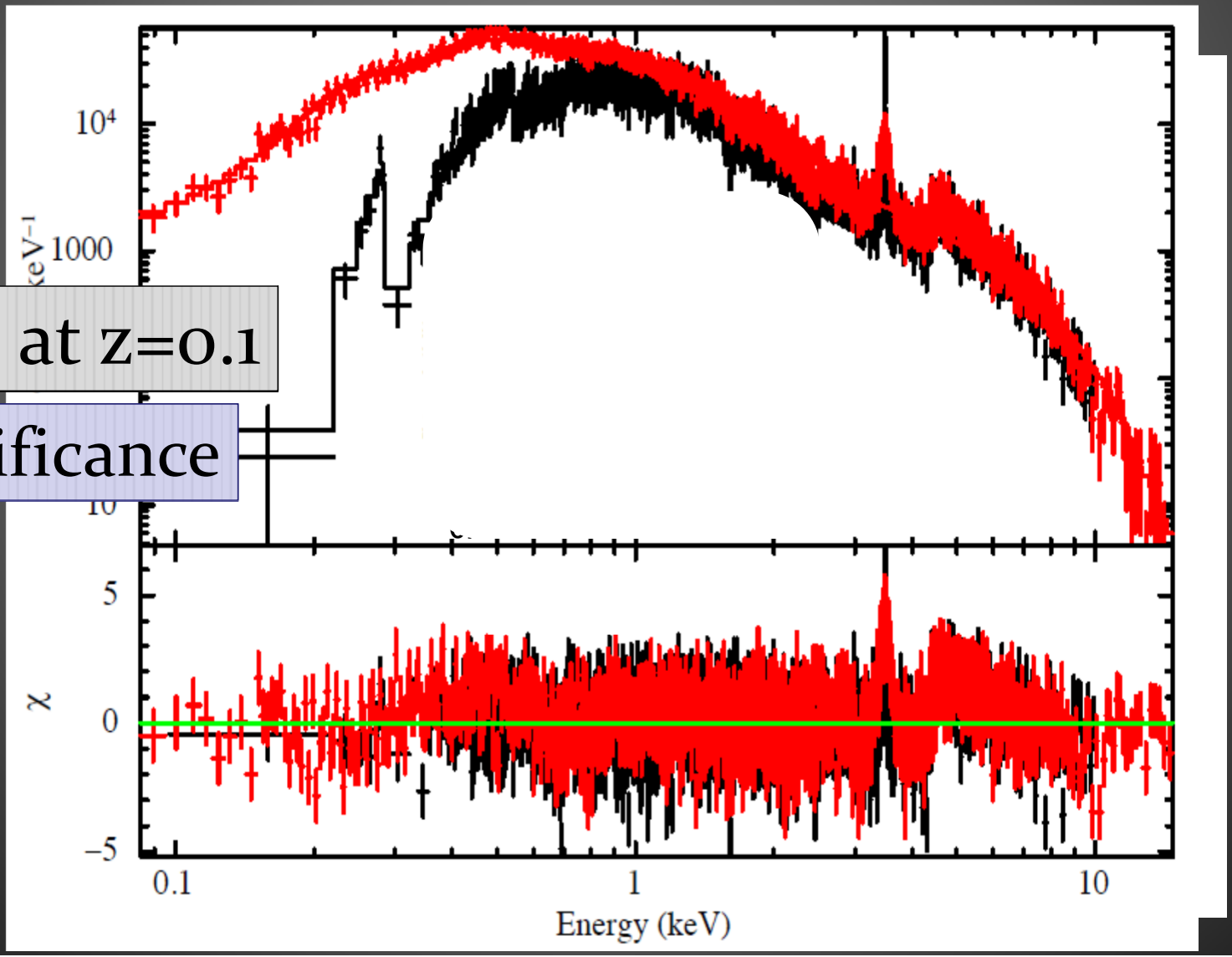
(100 ks exp. $F=3\times10^{-12}$ erg/cm^2/s,

$T=10^5$ K, $Z = 0.2\ Z_{SUN}$, $N_H = 10^{22}$ cm^{-2})



WHIM at z=0.1

4σ significance



SXI

SXS

Fine spectroscopy of Afterglows

Search for the missing baryons --- WHIM

WHIM elements detectability

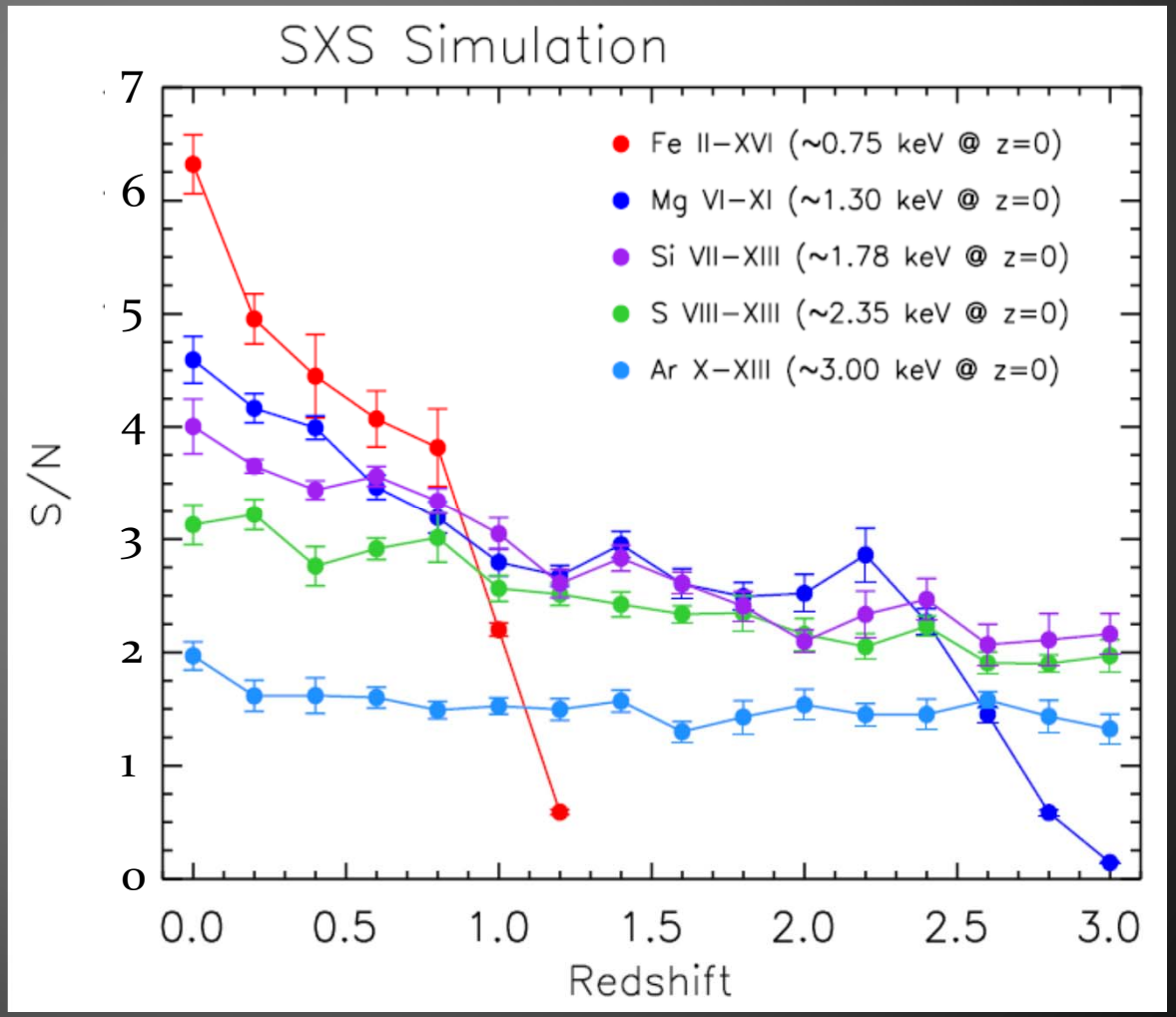
$F_{2\text{-}10keV}$= 2 x 10^{-12} cgs (100 ks)

WHIM of

N_H= 10^{22} cm^{-2}

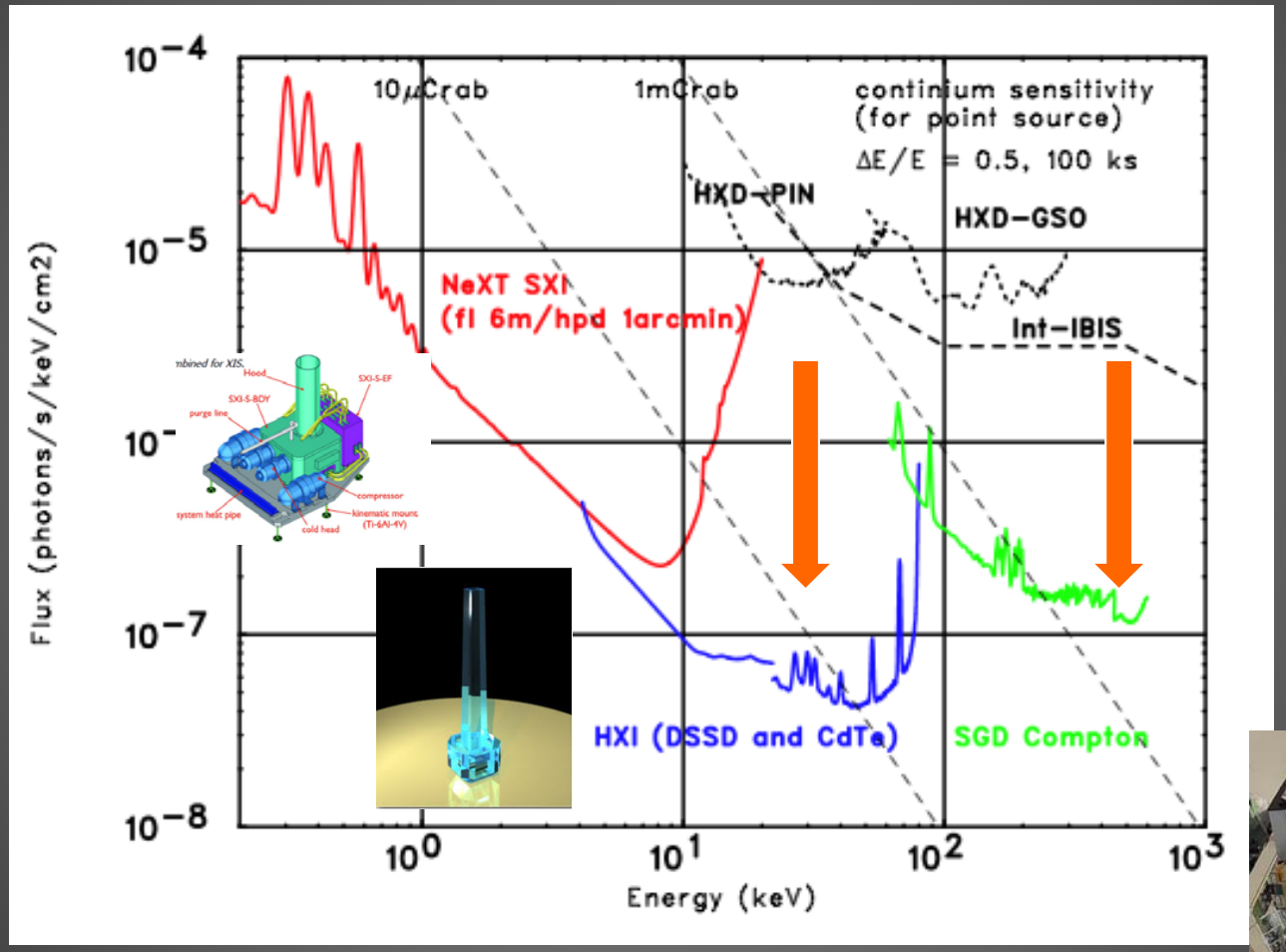
T_{WHIM} = 10^5 K

Z_{WHIM} = 0.2 Z_{solar}



Hard X-ray/Gamma-ray Sensitivity

Expected sensitivity of SXI, HXI and SGD



Schedule

2010 2011 2012 2013 2014 2015 2016

Phase A

Phase B

Phase C

Fabrication

TTM/MTM MIC/ EIC

Integration Test

Finalize

Initial Operation

Operation

Launch

SDR

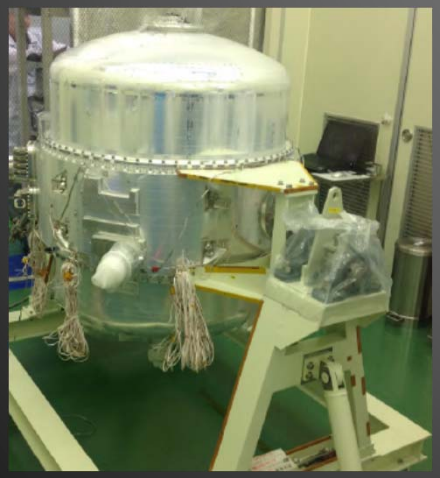
PDR

CDR

Summary
Suazku to ASTRO-H

Suzaku

1. Prompt emissions with WAM
   - Confirmed BATSE like spectral parameter distribution w/ ~1200 GRB
   - Temporal studies using large sample
2. Afterglows with XIS+HXD
   - Spectral study of 4 GRBs afterglows



ASTRO-H SXS-XCS (flight model) 2014-09-6

ASTRO-H

1. Prompt with SGD-Shield
   Doubled area than that of Suzaku/HXD-WAM
   High time resolution spectroscopy
2. Follow-up with narrow fovs
   - ✓ Elemental features in spectra
     - ✓ Ejecta/CSM search with the High resolution spectroscopy with SXS (ΔE ~ 7eV @ 6keV)
     - ✓ WHIM at distant universe
   - ✓ wide band high sensitivity observation up to 80 (600) keV by SXT-SXI + HXT-HXI (+SGD)