XARM/XRISM ability for the distant Warm hot plasma

Search for chemical evolution with:

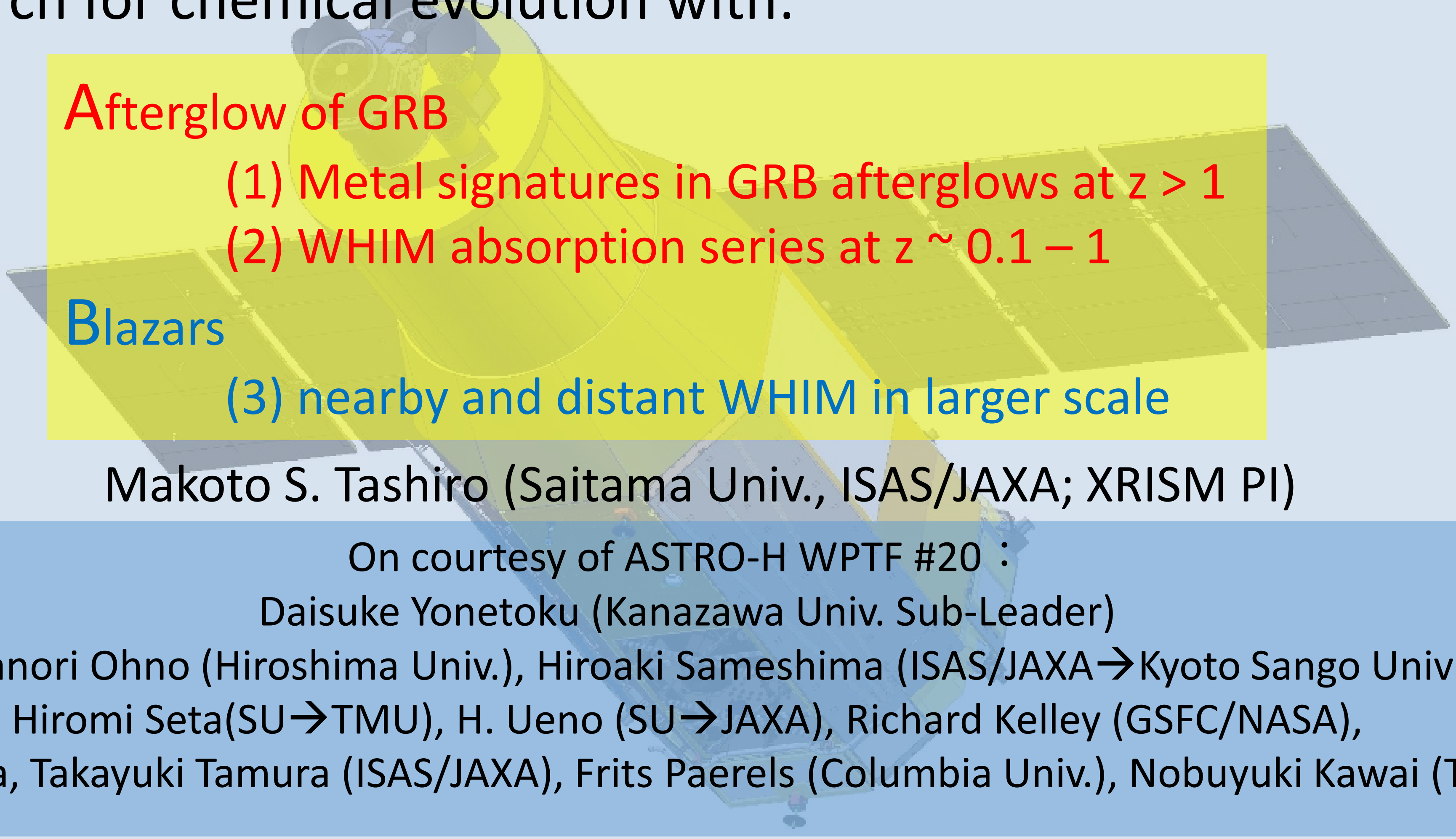
Afterglow of GRB

(1) Metal signatures in GRB afterglows at $z > 1$

(2) WHIM absorption series at $z \sim 0.1 - 1$

Blazars

(3) nearby and distant WHIM in larger scale



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On courtesy of ASTRO-H WPTF #20：

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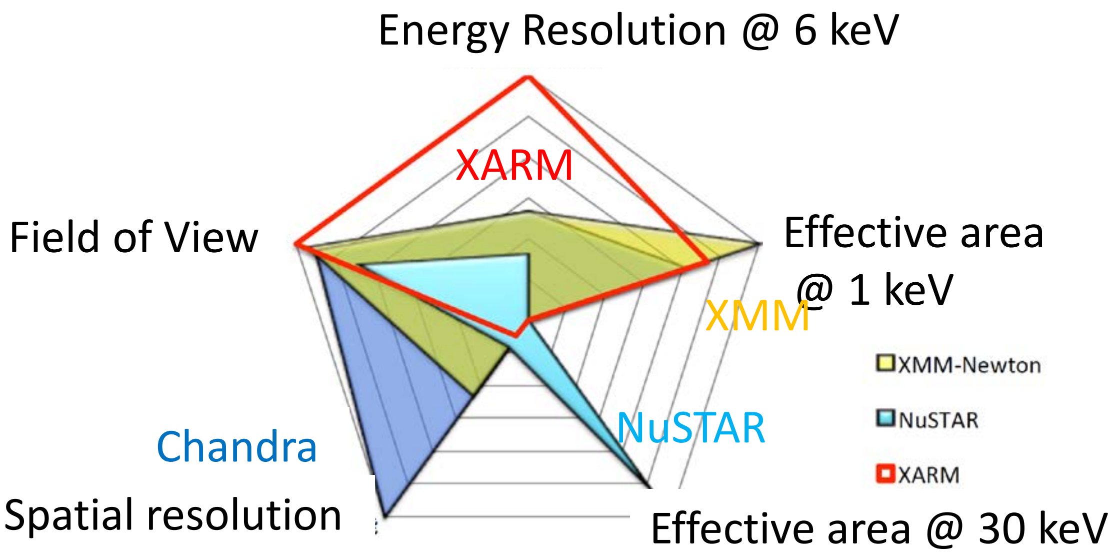
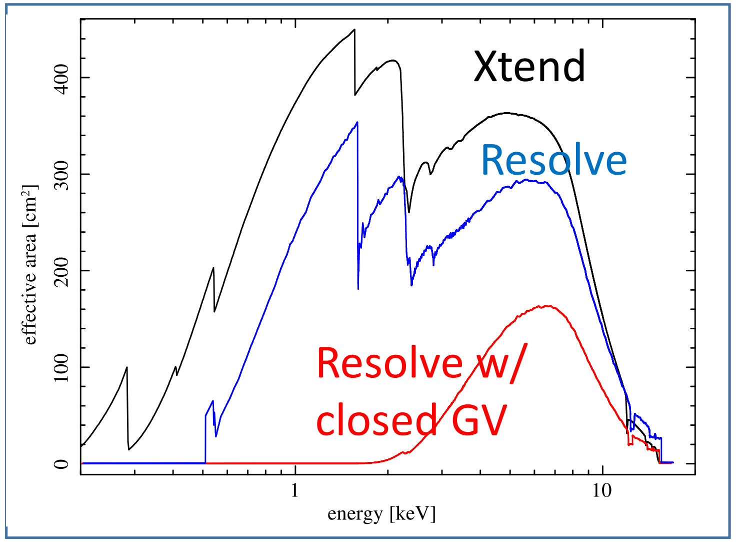
XRISM instruments

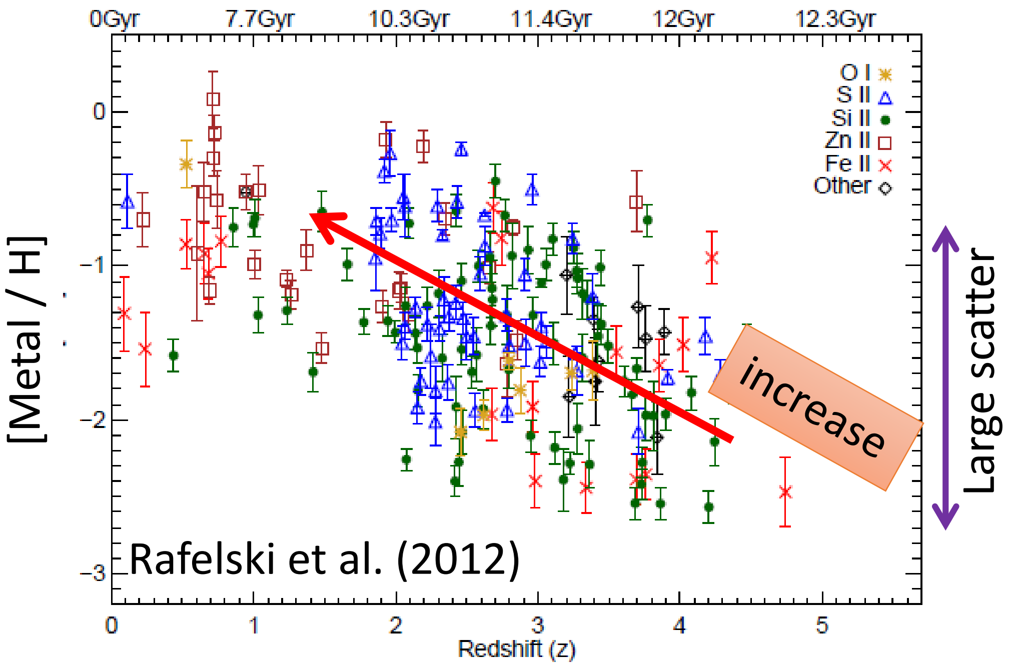
Instrument	FOV/pix	ΔE (FWHM @6 keV)	Energy band
Resolve (XMA + X-ray microcalorimeter)	2.9’ □ / 6 x 6 pix	7 eV (goal 5 eV)	0.3 – 12 keV
Xtend (XMA + X-ray CCD)	38’ □/ 1280 x 1280 pix	< 250 eV at EOL (< 200 eV at BOL)	0.4 – 13 keV

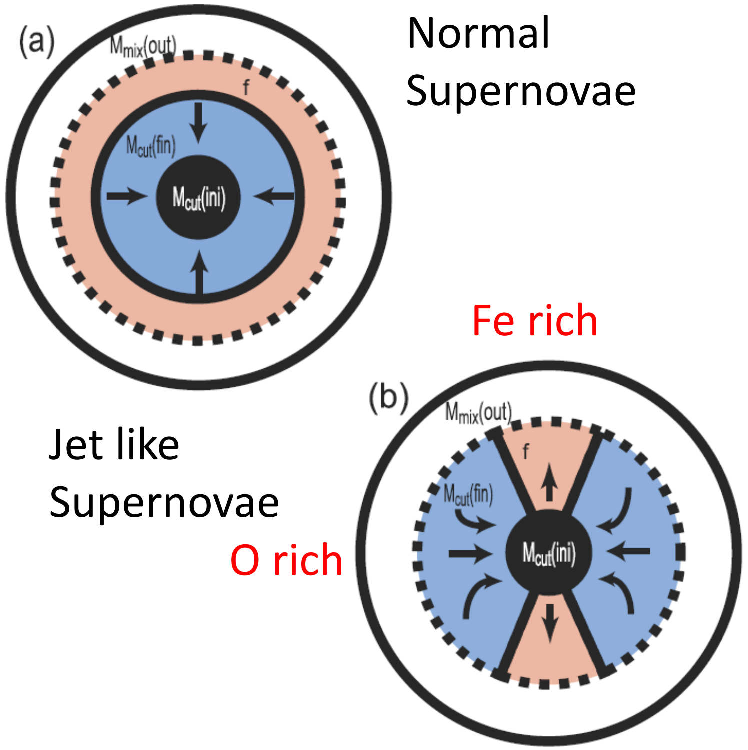




Chemical evolution of the universe (Optical)

Metallicity in Damped Lyman-α galaxies.





- A clear trend of metal enrichment.
- Large scatter may be interpreted as inhomogeneous metal distribution by asymmetric supernova explosions. (Tominaga et al. 2007)
- Fe rich elements in the axis-direction, O rich elements in perpendicular direction.

➔ "axis-sensitive" SN selection by GRB and "CSM free" by Blazars

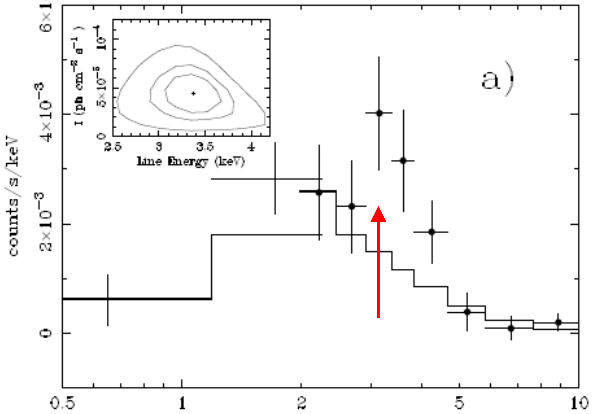
Chemical evolution ⟺

- Direct measurement of metal abundance
- investigation of circumstellar environment

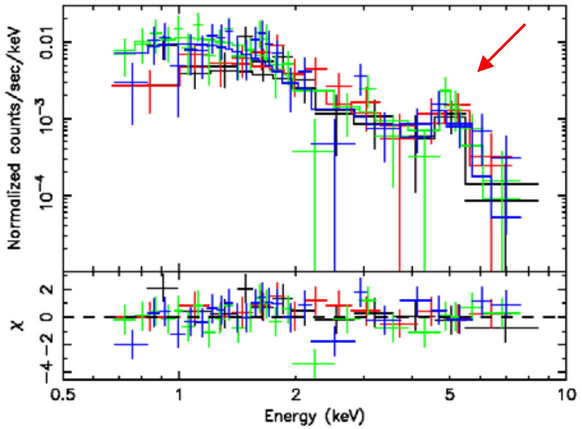
X-ray observation

reported signatures of elements in GRB afterglows

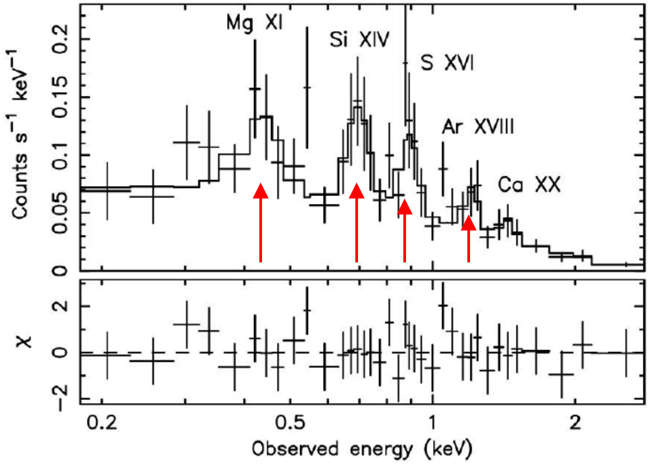
GRB970508 (Piro et al.)



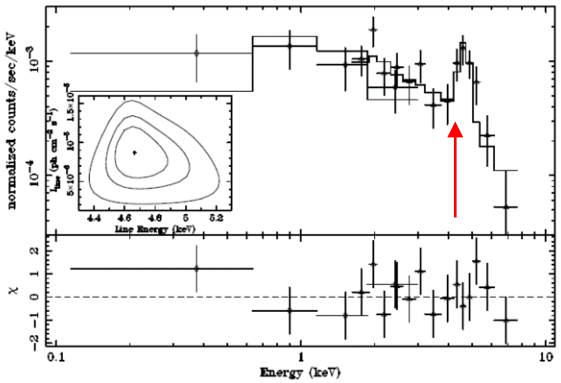
GRB970828 (Yoshida et al.)



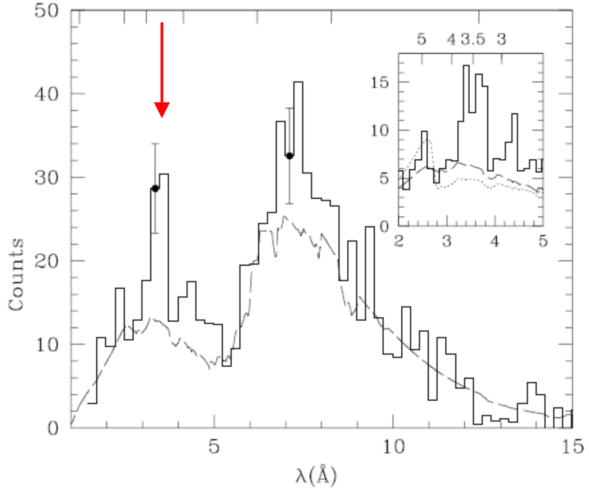
GRB011211 (Reeves et al.)



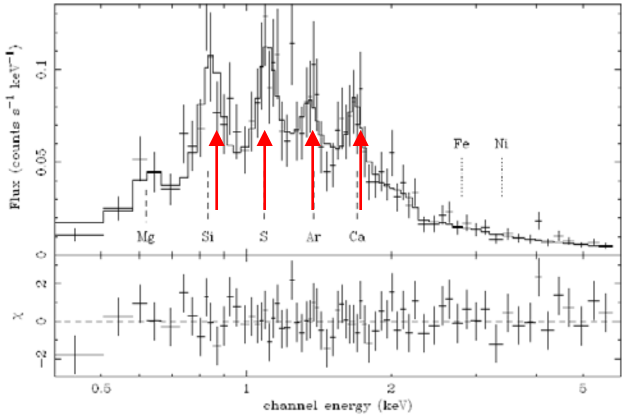
GRB000214 (Antonelli et al.)



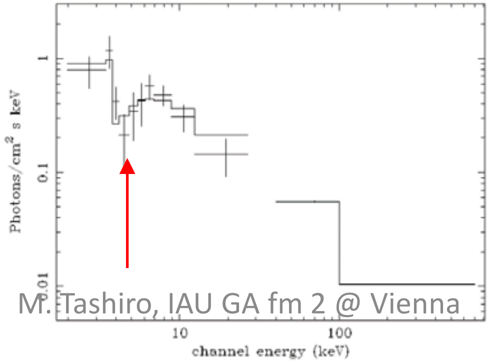
GRB991216 (Piro et al.)



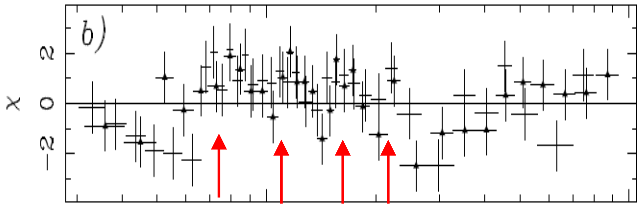
GRB030227 (Watson et al.)



GRB990705 (Amati et al.)



GRB001025A (Watson et al.)



Simulation of X-ray afterglow spectra

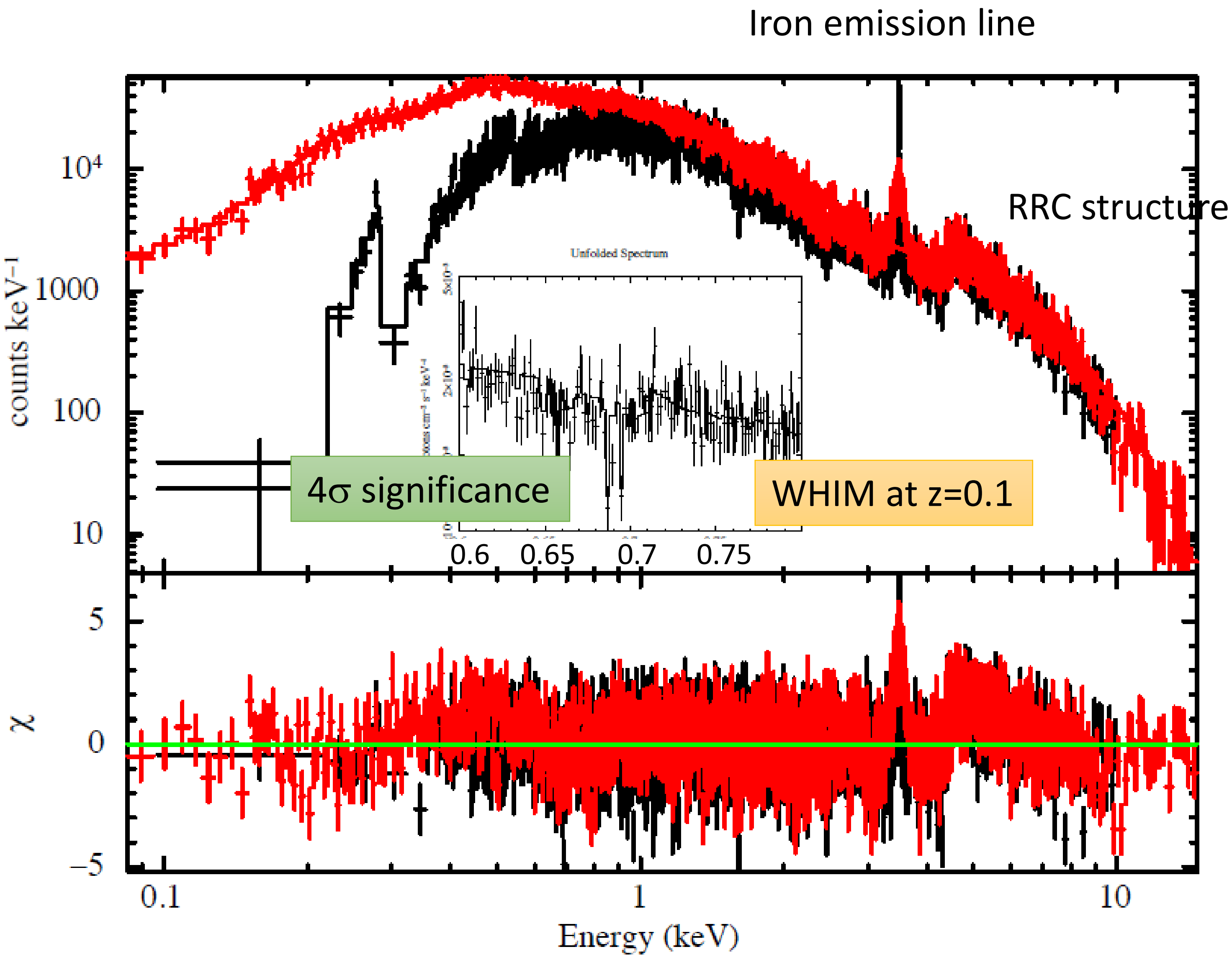
Including WHIM structure at z = 0.1 estimated by XSTAR

($F=3x10^{-12}$ $erg/cm^2/s$,

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

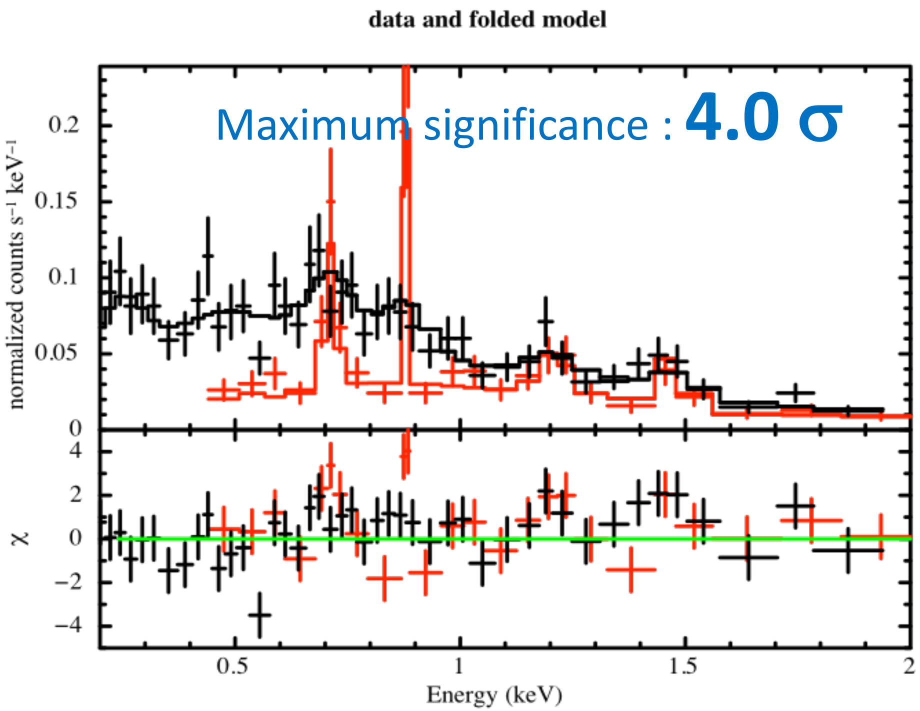
~0.15mCrab

100 ksec exposure



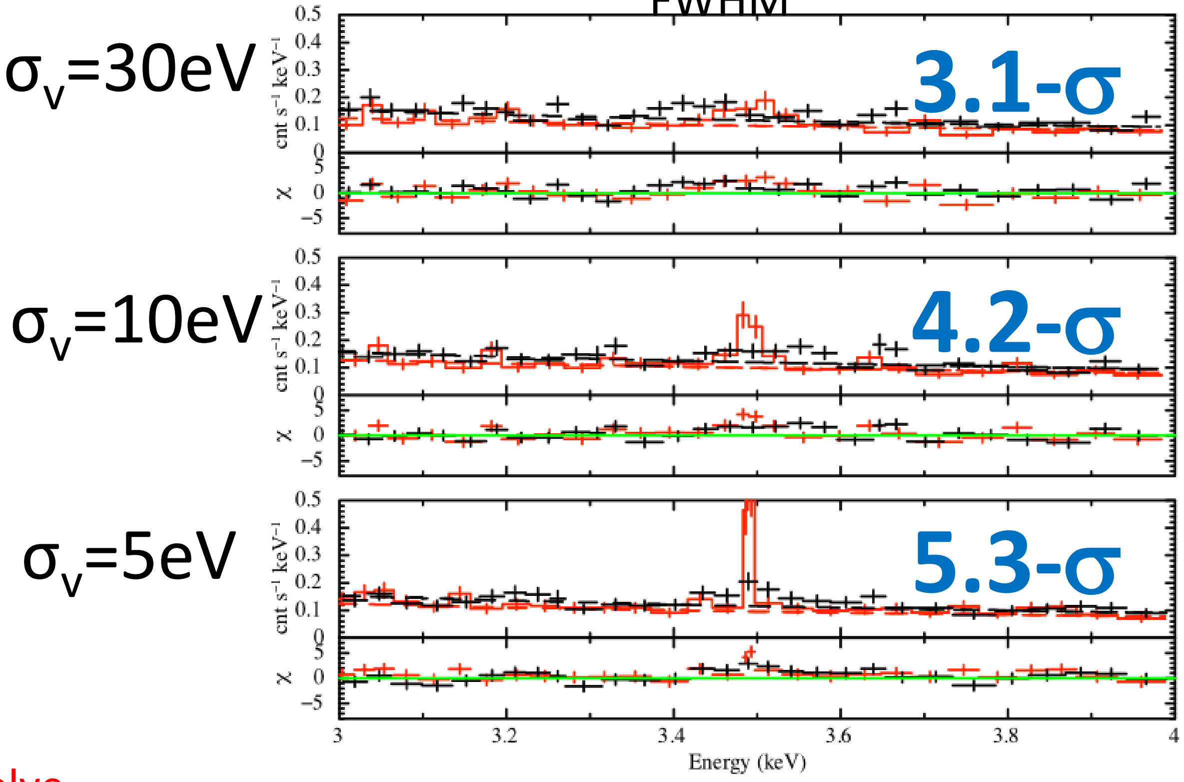
How powerful is XRISM/Resolve?

Result 1: light element detection



Result 2: iron-line broadening

ΔE_{FWHM} = 7 eV

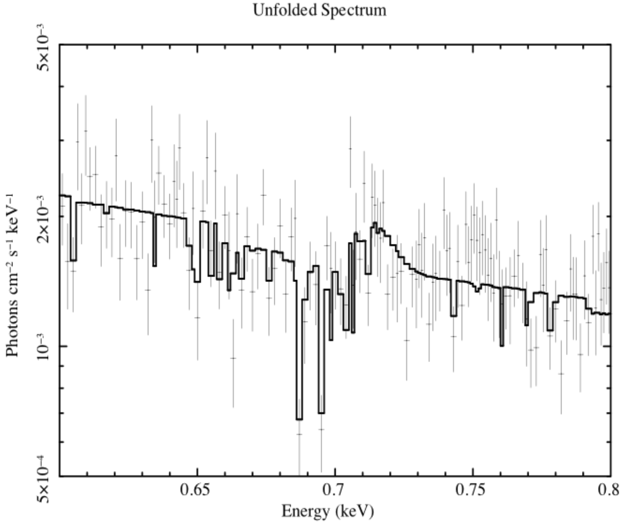


Red: Resolve
Black: Xtend

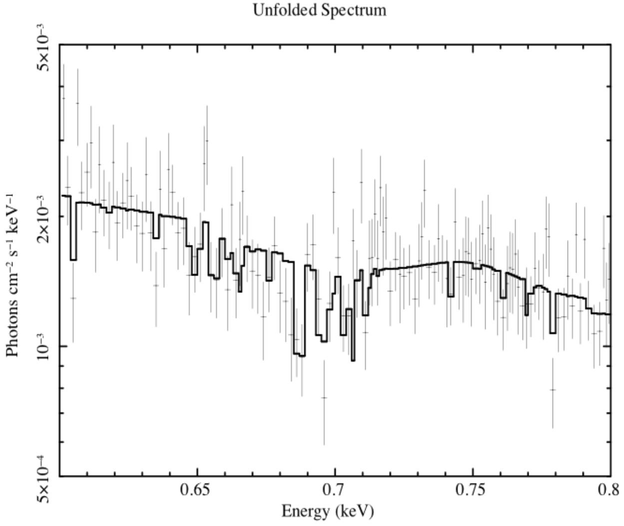
How powerful is XRISM/Resolve?

Result 3: WHIM absorption

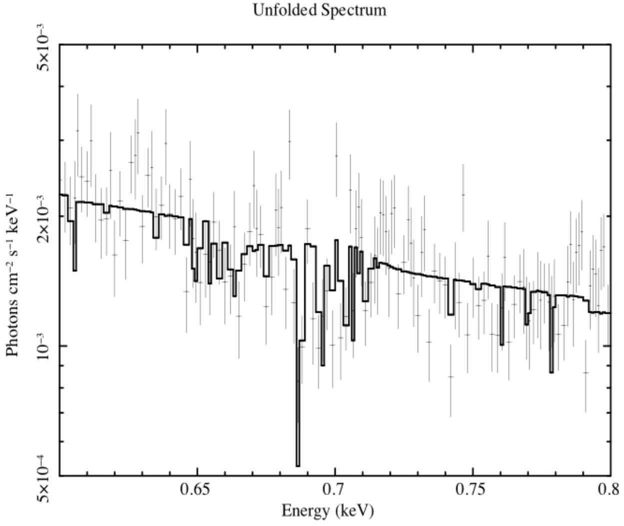
ΔE = 5 eV



ΔE = 7 eV



ΔE = 10 eV



Maximum significance : 3.9σ

Maximum significance : 3.7σ

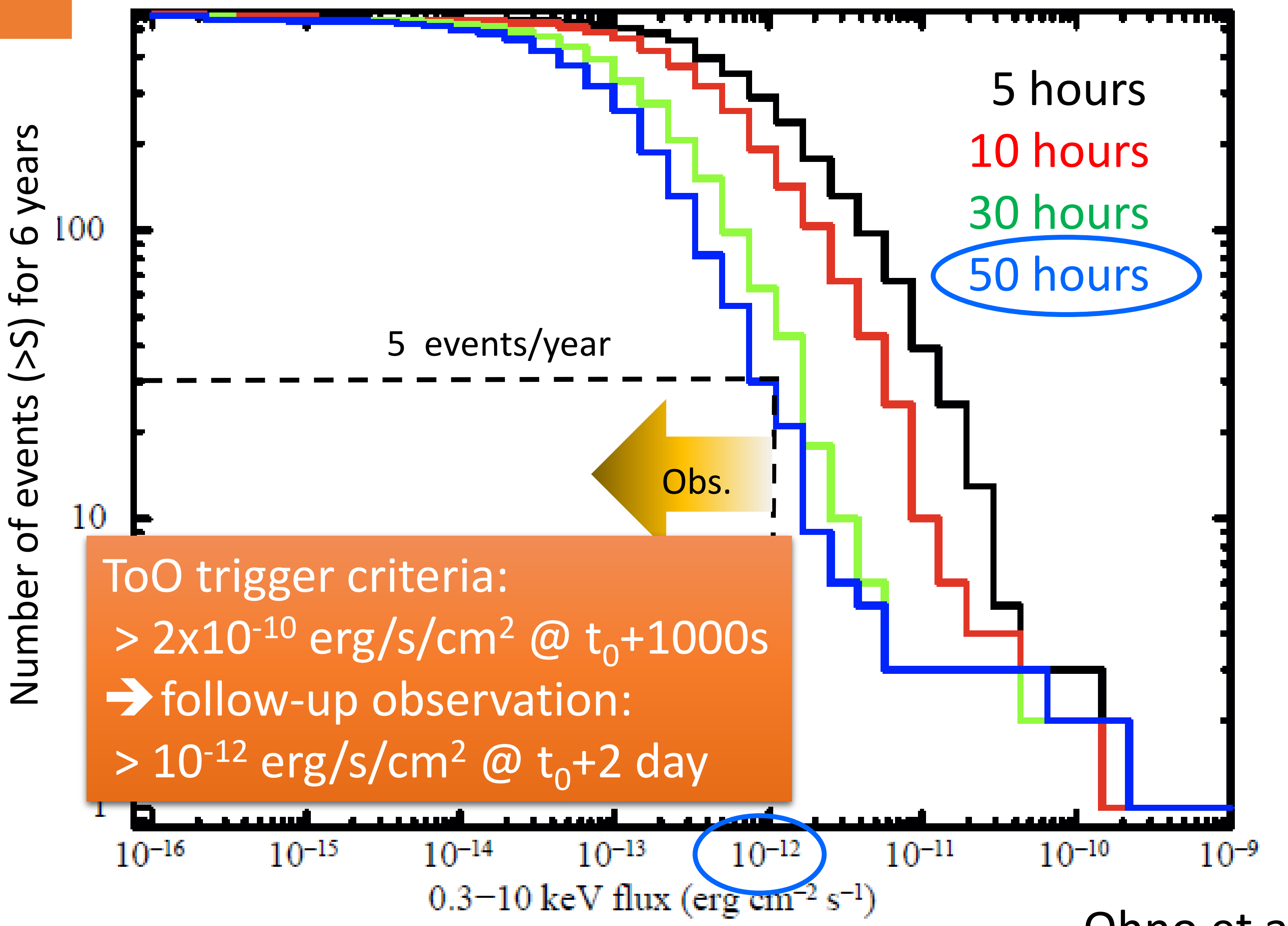
Maximum significance : 3.3σ

Even though there is no significant changes in the simulated spectrum, the calculated detection significance slightly decreased as the XRISM/Resolve energy resolution become worse.

Although, it still keep >3 sigma detection level, if we need more significant detection, we need deeper observation or brighter GRB event.
(if with x2 exposure or brighter event, we can achieve > 4 sigma significance level)

Possible follow-up plan?

Luminosity Function of X-ray Afterglow



ToO trigger criteria:

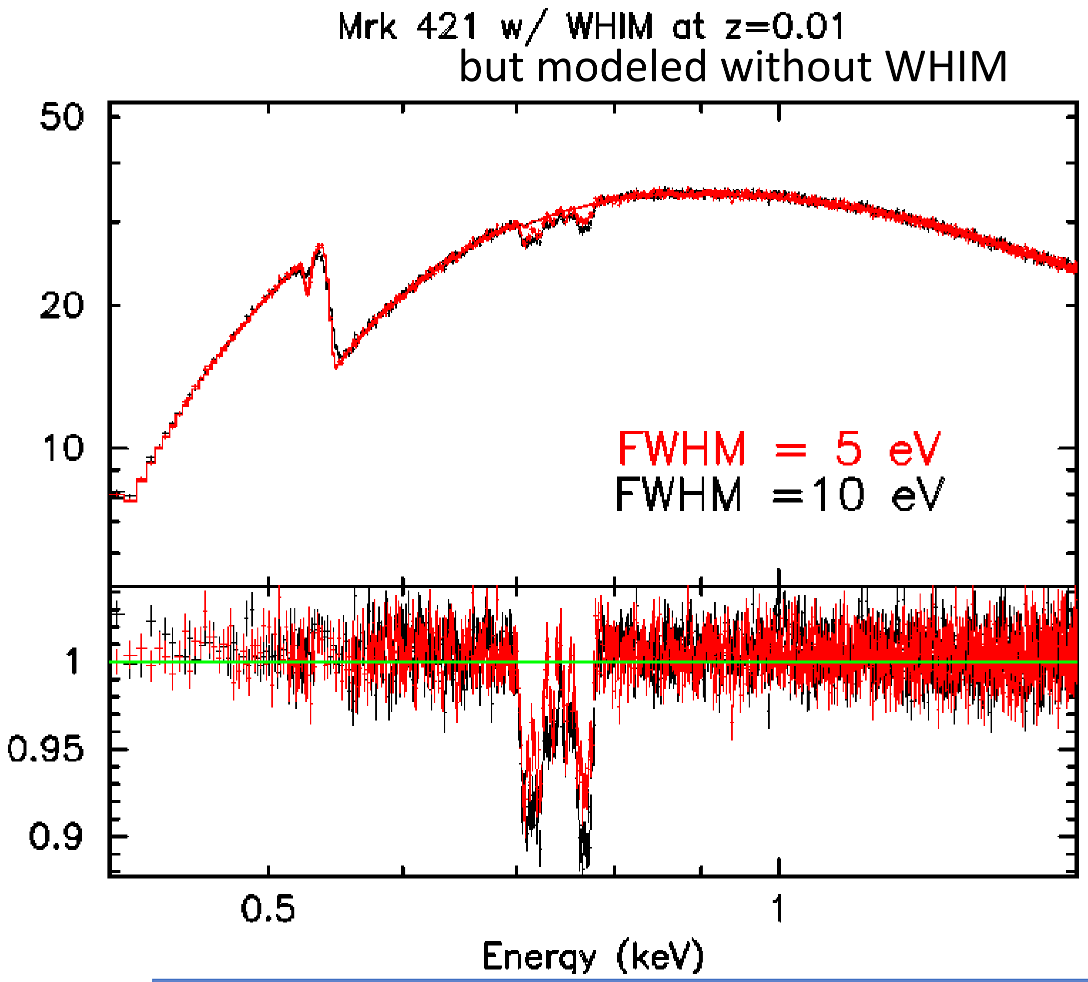
> 2×10^{-10} erg/s/cm^2 @ t_0+1000s

➔ follow-up observation:

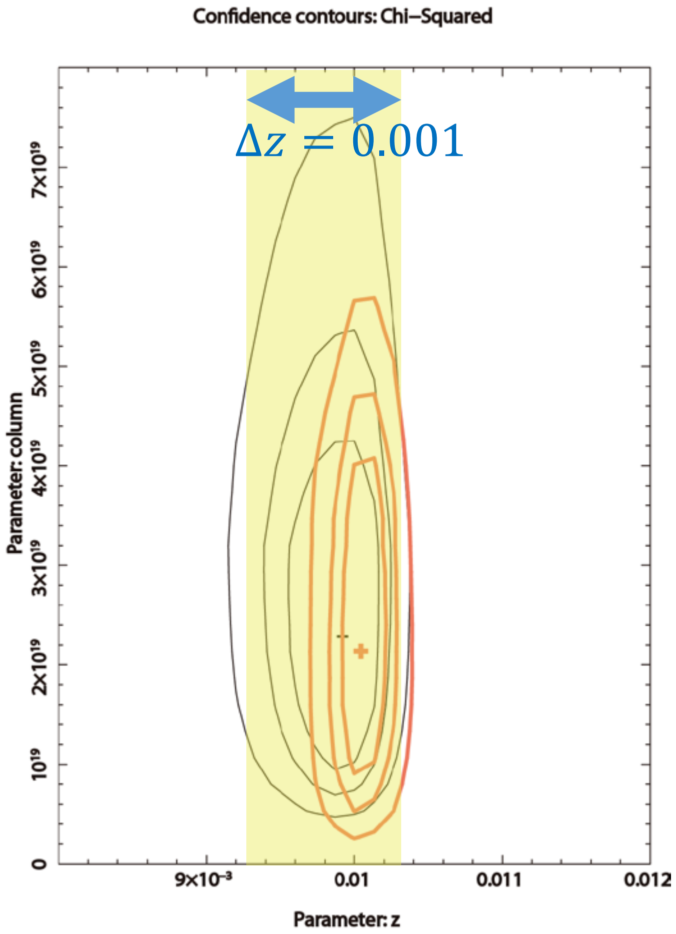
> 10^{-12} erg/s/cm^2 @ t_0+2 day

Ohno et al.

WHIM with nearby bright Blazars
A case study of WHIM: example of Mrk 421 (based on Nicastro+05)



confidence contours w/ WHIM



A 25 mCrab Blazar will resolve WHIM filament in the accuracy of $\Delta z=0.001$

distant blazars

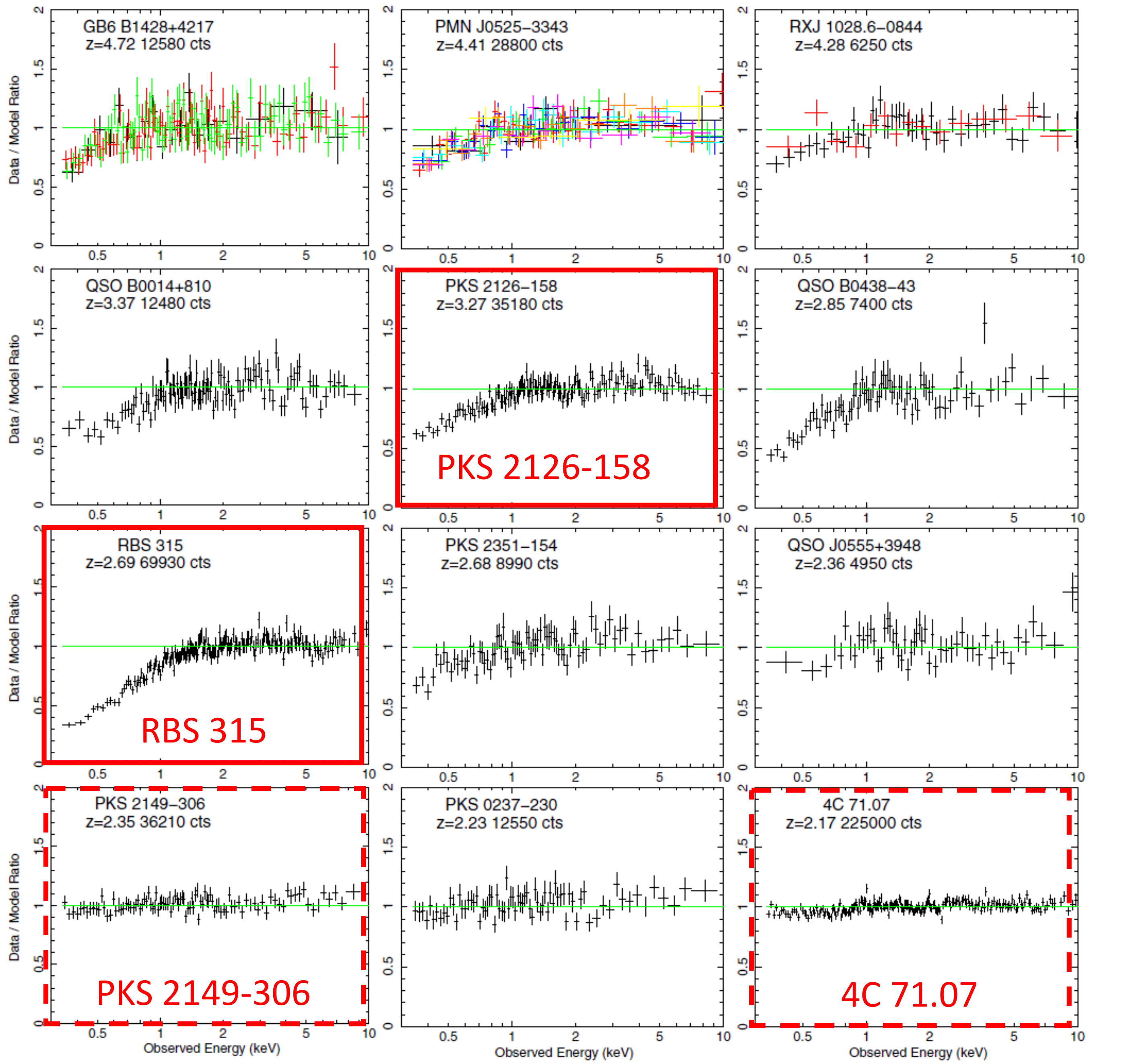


Figure 5. Data to model ratio plots for the QSO sample of Table 1. Data are binned to conveniently represent the extragalactic transmission functions. Note the overall similar absorption effect, but the lack of absorption for $z < 2.5$. Multiple spectra for a given source represent separate *XMM-Newton* observations.

Target	z	N_H^{Gal}	N_h^{ext}	Flux
RBS 315	2.690	9.26	2.90	1.08
PKS 2126-158	3.366	4.82	1.80	1.10
4C 71.07	2.172	2.85	0.09	1.40
PKS 2149-306	2.345	1.61	0.08	1.00
N_H^{Gal} : 10^{20} cm^{-2}, N_H^{ext} : 10^{22} cm^{-2}, Flux : 10^{-11} erg/cm^2/s				

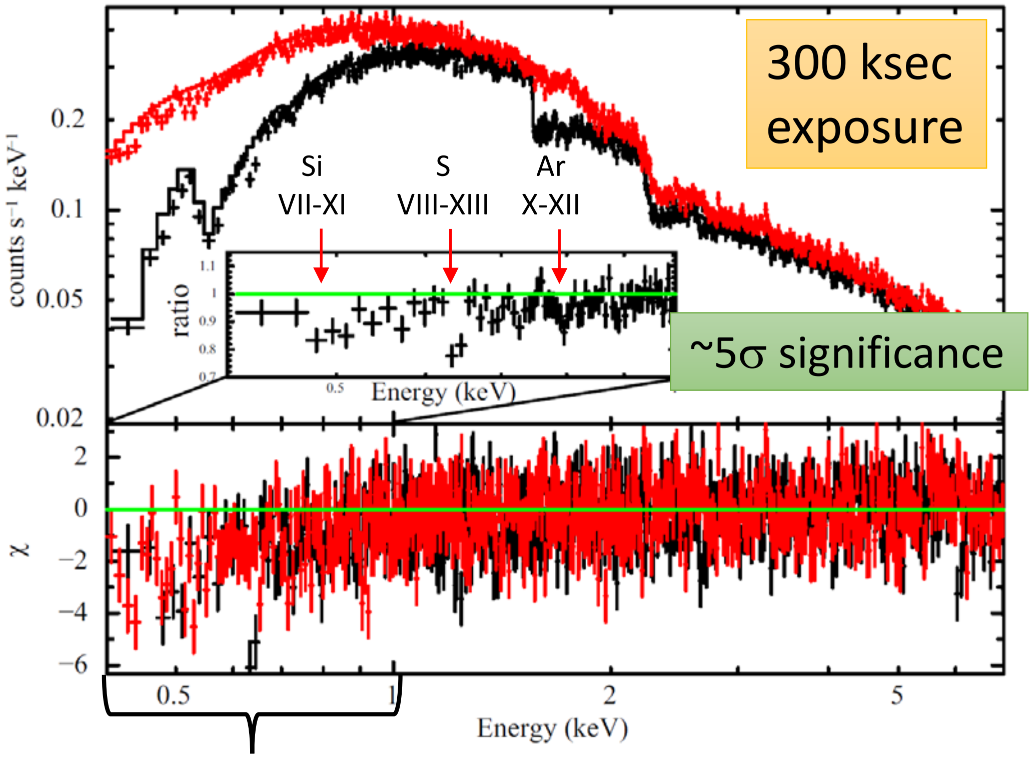
Bright High-z blazars
(Behar+ 2011 w/ XMM)

A case study of WHIM: example of RBS 315 (based on Behar+11)

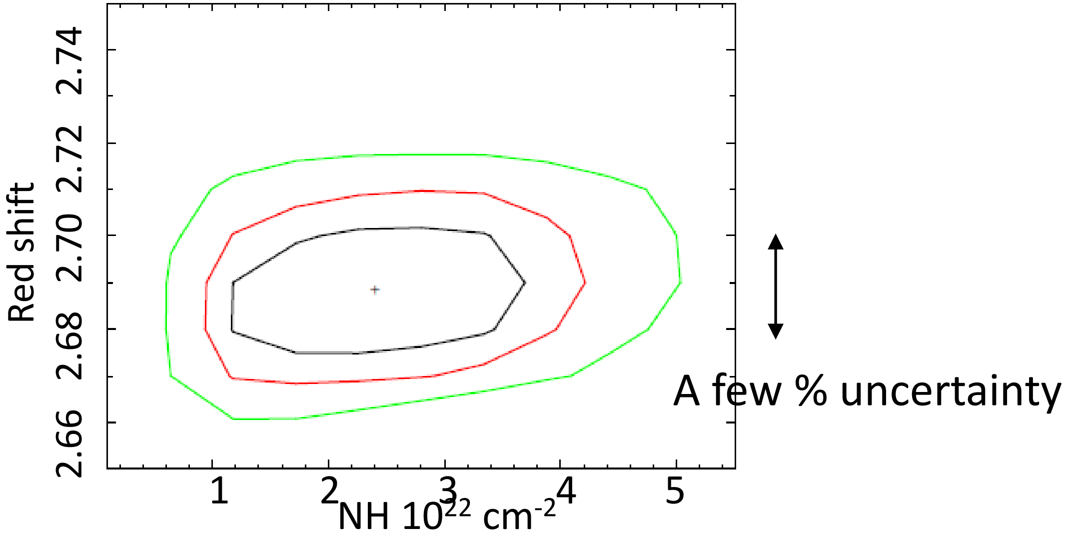
RBS 315 spectral simulation ($F = 10^{-11}$ erg/cm^2/s)

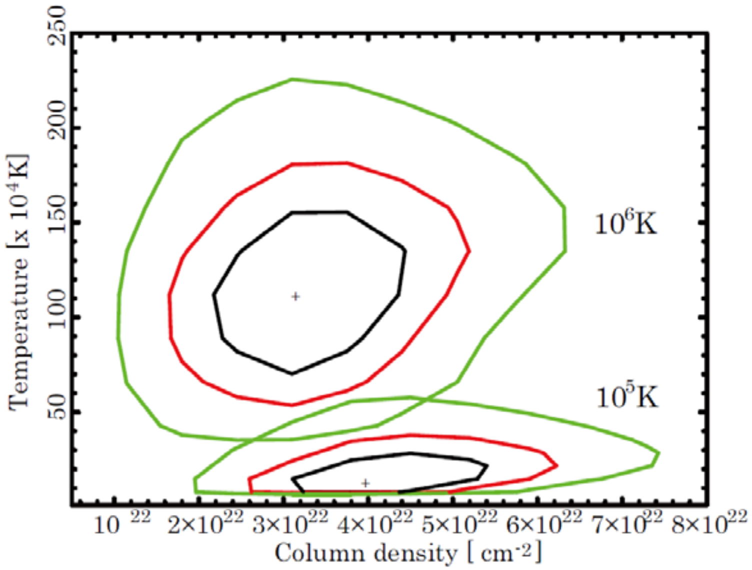
assume WHIM characteristics of

$T = 10^6$ K, $Z = 0.2\ Z_{sun}$, $N_H = 2.9 \times 10^{22}$ cm^{-2} at $z = 2.69$ with XSTAR



Residuals w/o WHIM components





We can detect the existence of WHIM absorber, and determine its redshift, column density, and temperature.

Summary of capability study for WHIM ad high-z chemical evolution

see ASTRO-H WP#20
arXiv:1412.1179

GRB X-ray Afterglows (ToO observation)

ToO trigger: F > 2 x 10^{-10} erg/cm^2/s (~1mCrab) at t_0+1000s

- resolve distant CSM & search for inter-galactic absorption

Near bright Blazars (ToO if Fx > 0.5 x10^{-9} erg/cm^2/s: 25 mCrab)

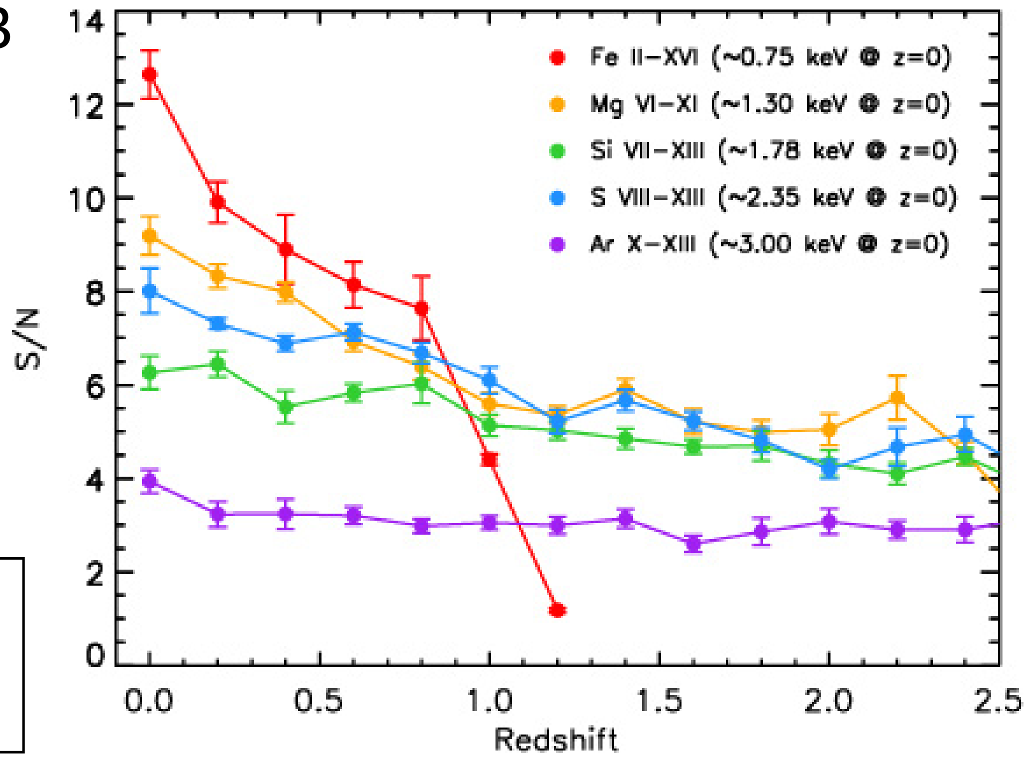
Candidates: Mrk 421, Mrk 501, 3C454.3, 3C273

- detailed study of (low-z) WHIM candidates

Distant bright Blazars (Fx > 10^{-11} cgs)

Candidates: RBS 315, PKS 2126-158, 4C71.07, PKS 2149-306

- search for (high-z) WHIM



Assuming various redshift of WHIM with the same characteristics, we evaluated expected level of significance. We can expect significant detection with XRIMS if they are.