

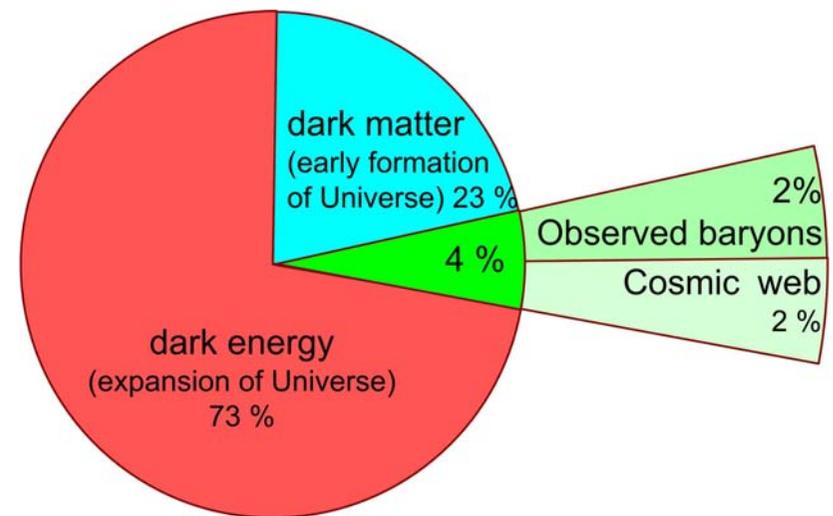
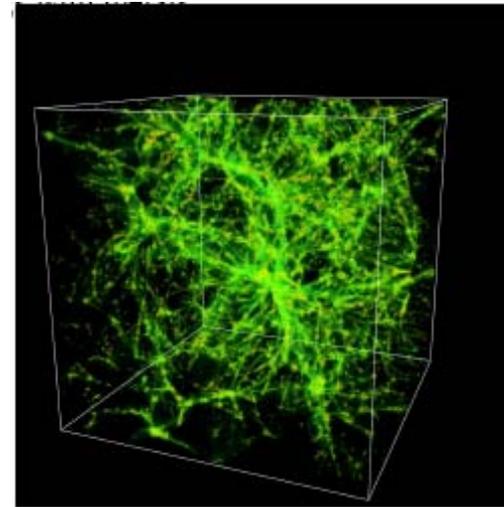
IXO and the WHIM

Jelle Kaastra

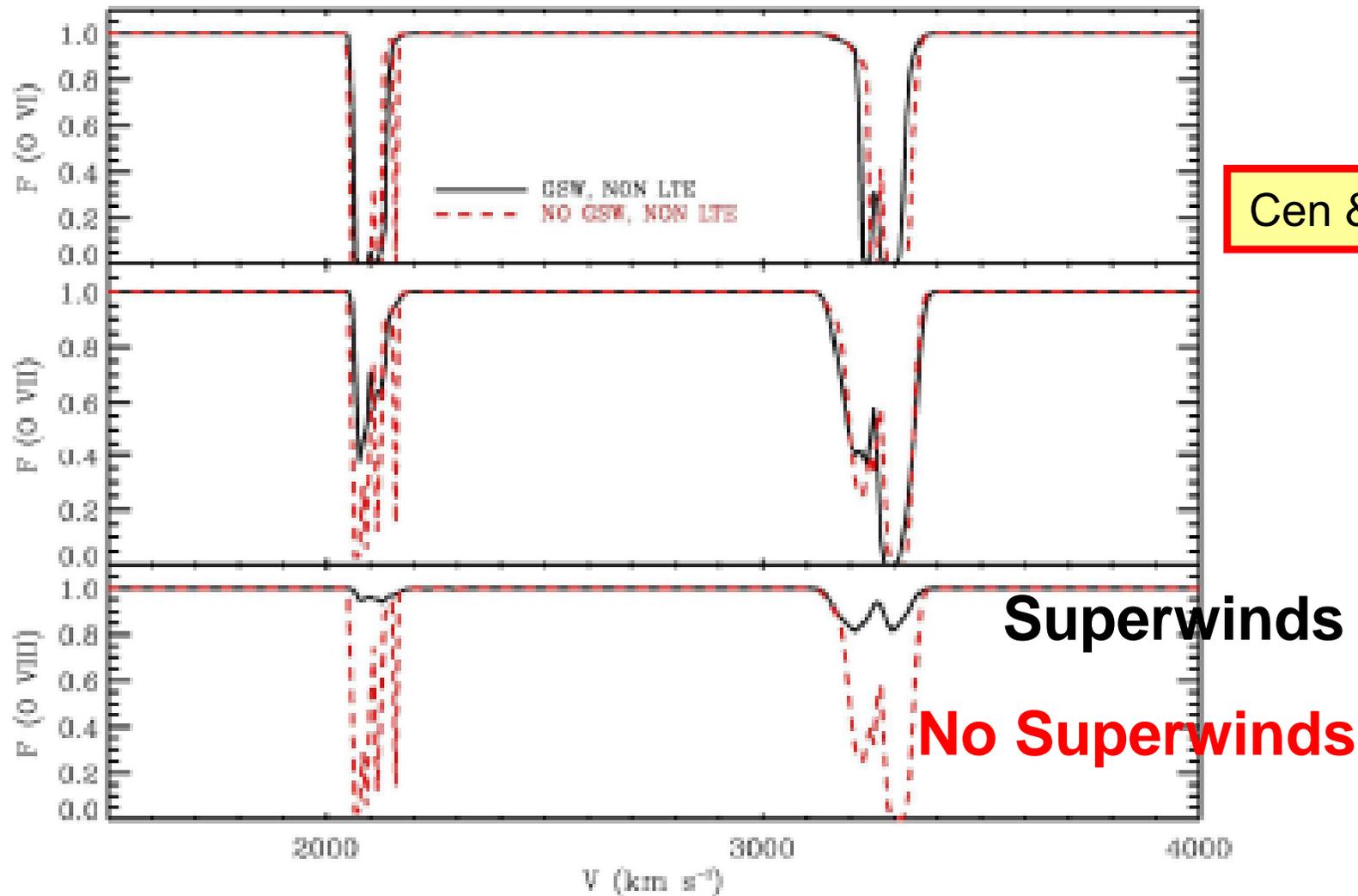
SRON

Finding the missing baryons

- Goal: find the missing baryons (~50 %); should be most in Warm-Hot (10^5 - 10^7 K) phase

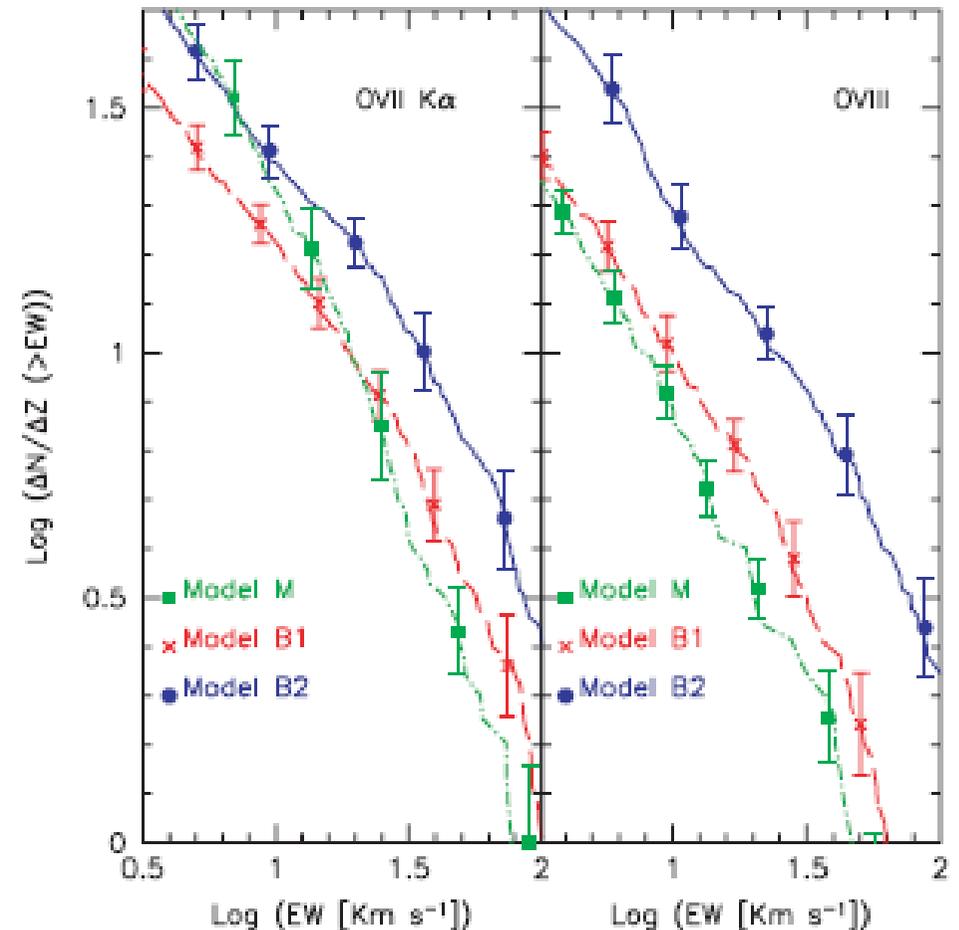


Role of galactic superwinds



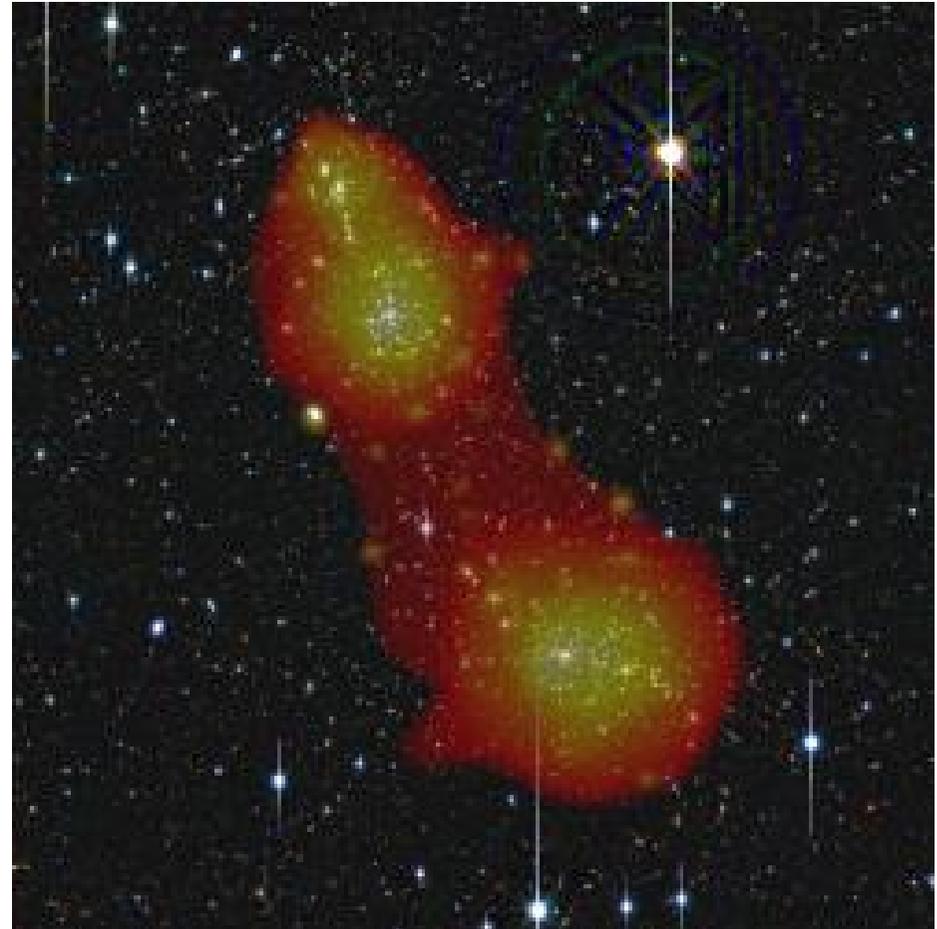
Chemical evolution & mixing

- Predicted WHIM properties depend strongly upon metallicity distribution:
 - $Z \sim n^{1/3}$
 - $Z \sim n^{1/2}$
 - Z stochastic



Branchini et al. 2009

Connection with clusters & groups

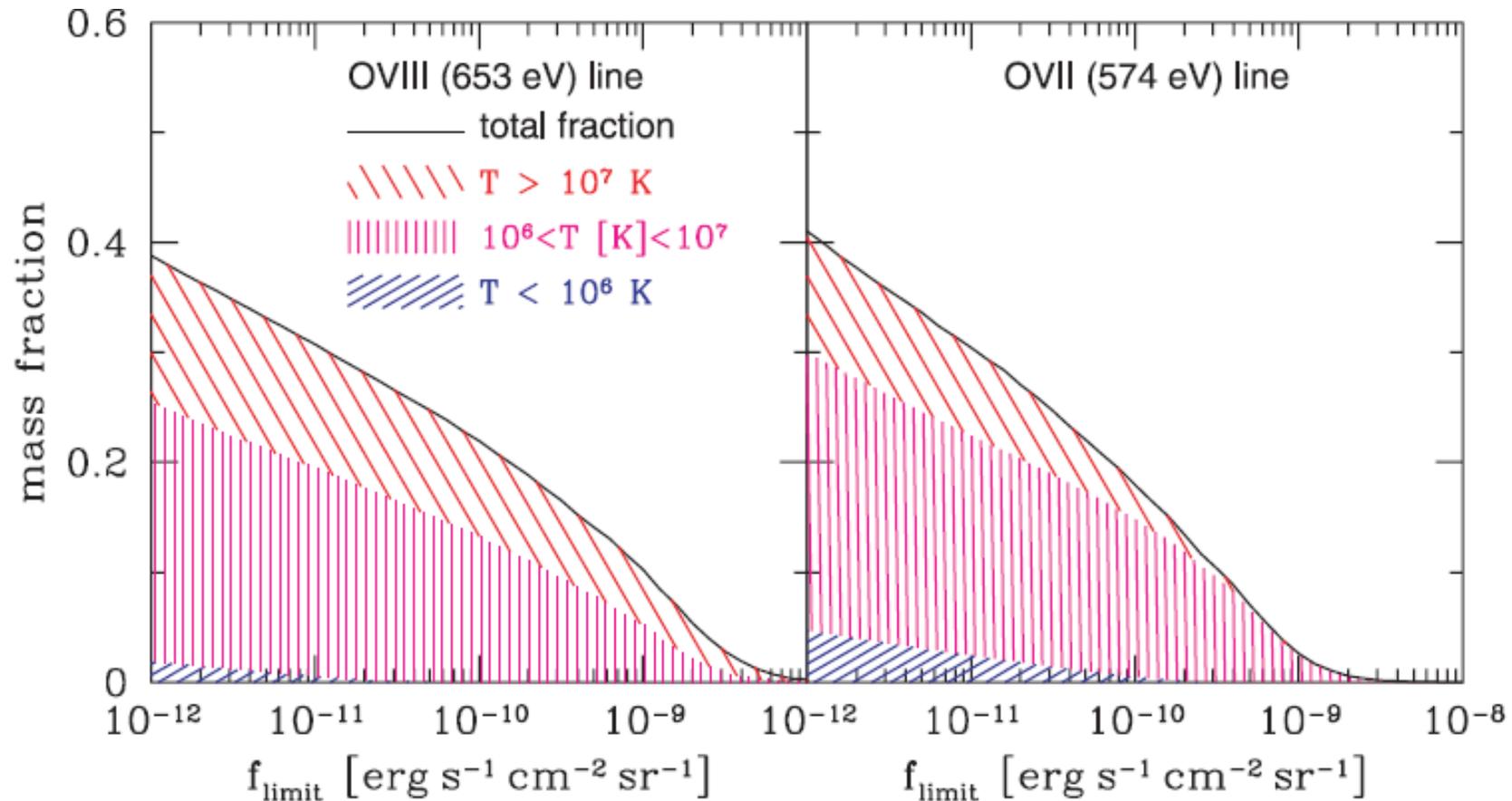


A 222 / A 223

Werner et al. 2008

IXO meeting, Otaru 3 July 2009

Importance of O lines for the WHIM



Yoshikawa et al. 2004

Observing the WHIM in absorption: background sources

GRBs

- Fluence @ 0.5 keV:

$10^5 \text{ ph m}^{-2}\text{\AA}^{-1}$:

365 GRBs/yr

$10^6 \text{ ph m}^{-2}\text{\AA}^{-1}$:

34 GRBs/yr

(Branchini et al. 2009)

AGN @ $z > 0.3$

- Fluence @ 0.5 keV:

$10^5 \text{ ph m}^{-2}\text{\AA}^{-1}$

(10^5 s , $F = 1 \text{ ph m}^{-2} \text{ s}^{-1}\text{\AA}^{-1}$)

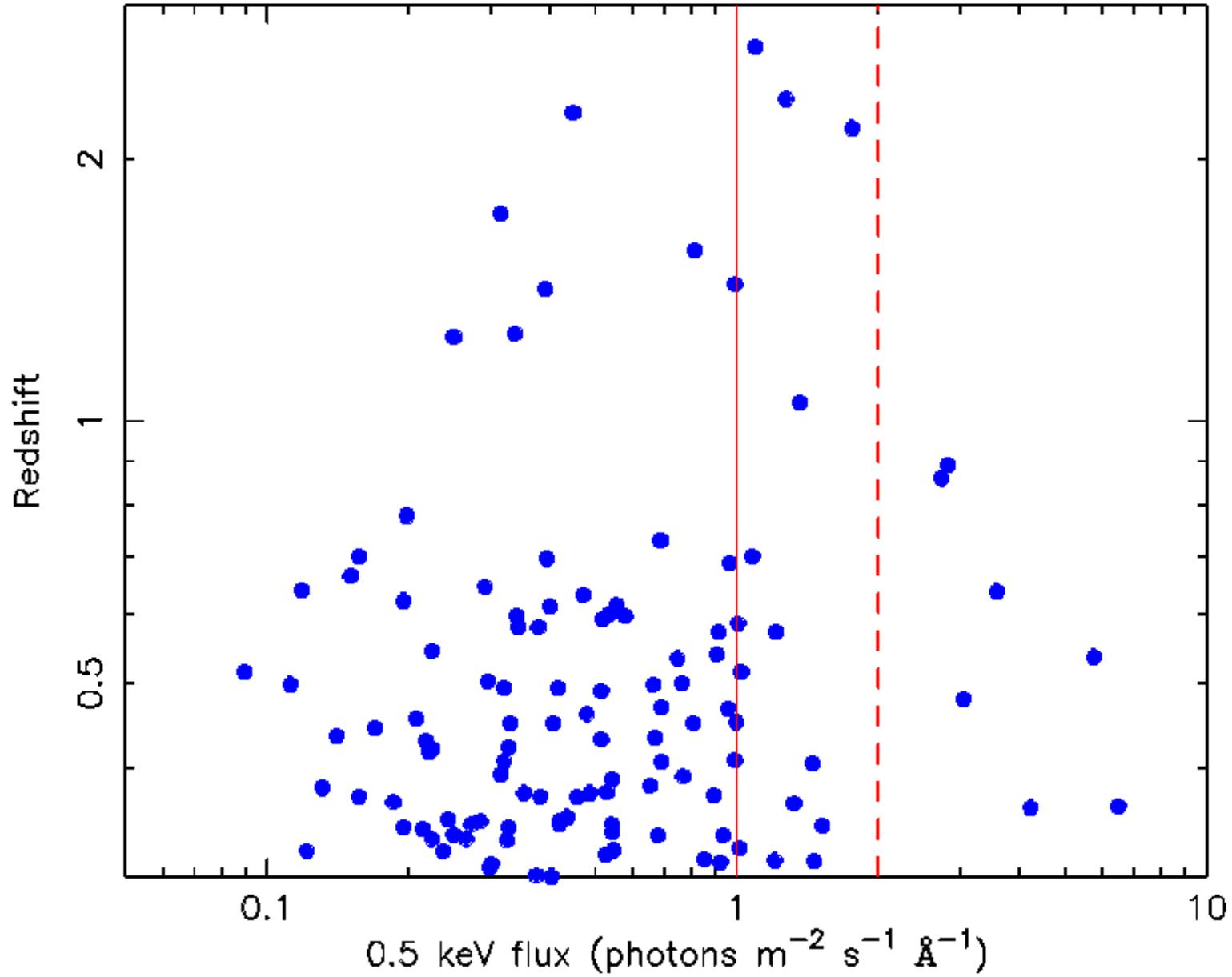
$10^6 \text{ ph m}^{-2}\text{\AA}^{-1}$

($5 \times 10^5 \text{ s}$, $F = 2 \text{ ph m}^{-2} \text{ s}^{-1}\text{\AA}^{-1}$)

A few dozen available

(Conciatore et al. 2008)

Voges et al. 2000, AGN with $z > 0.3$



IXO meeting, Otaru 3 July 2009

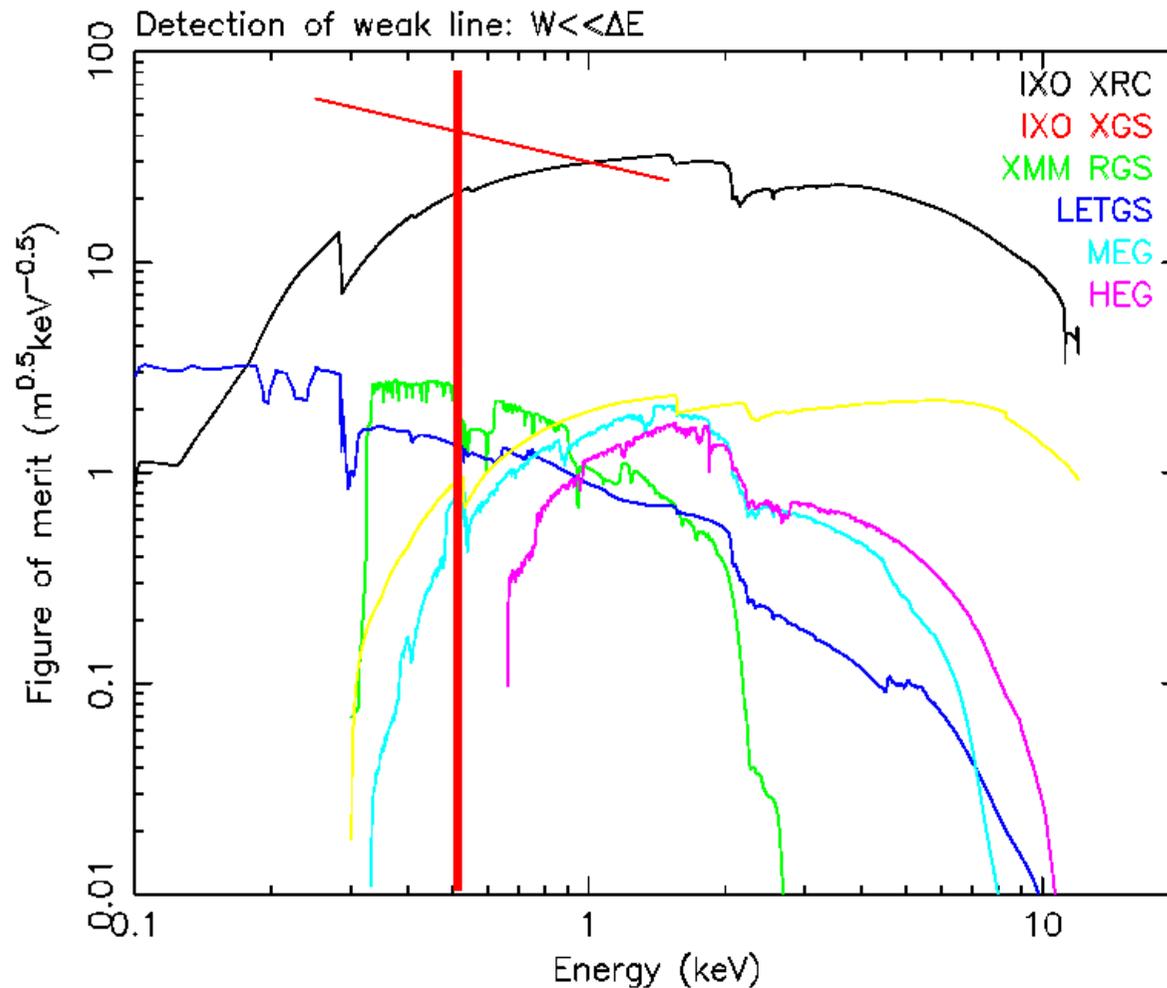
What significance is needed?

- Needs at least $\sim 5\sigma$ for detection strongest line:
- Large probability of having a second line (e.g. O VII & O VIII)
- Smaller chance fake detections due to unknown z
- \rightarrow allows astrophysics to be done

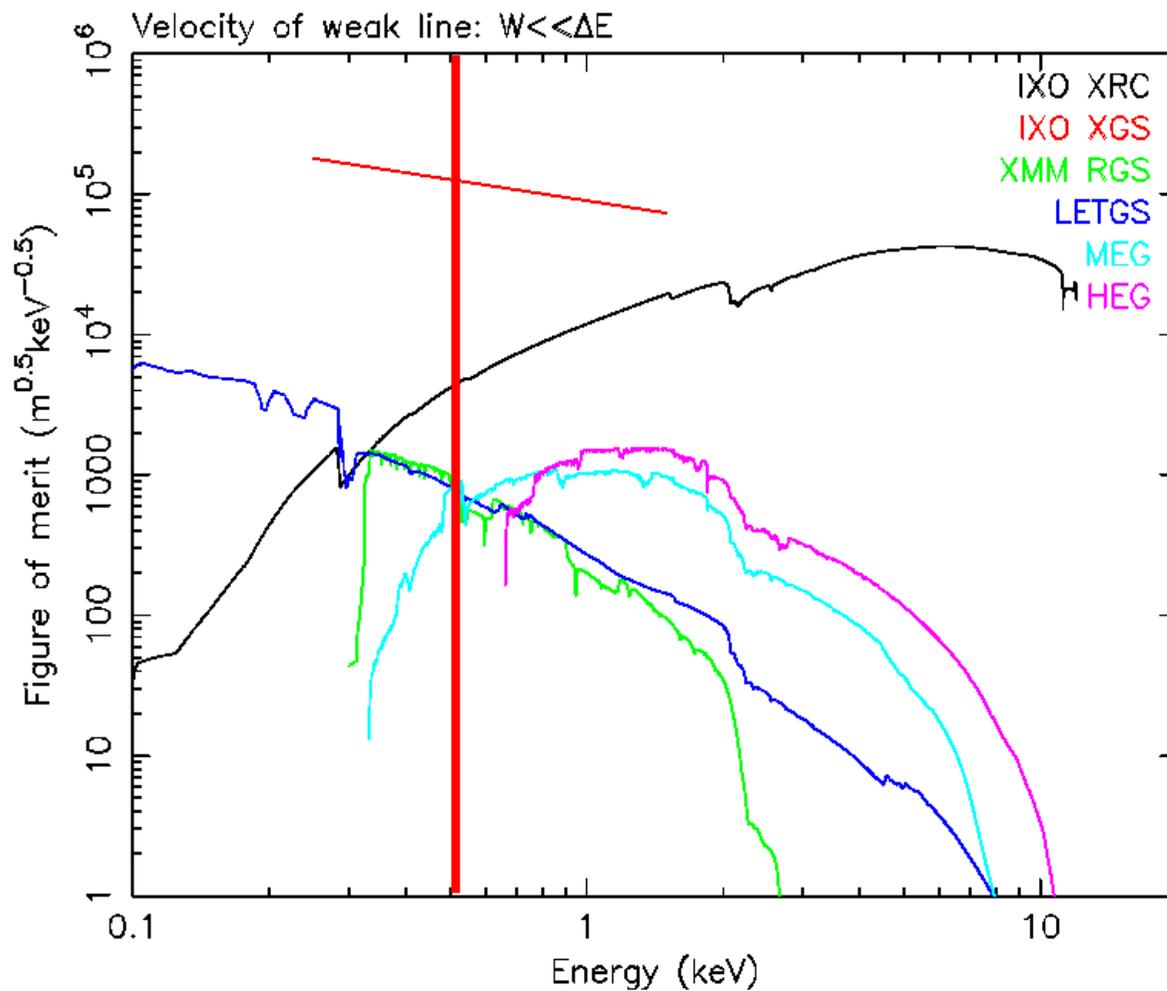
Feasibility: XGS versus XMS

@ 0.5 keV (O VII)	XGS	XMS
Flux at 0.5 keV / 25 Å	2 phot m ⁻² s ⁻¹ Å ⁻¹	
Exposure time	500 ks	
Δλ (mÅ)	8	125
Area (m ²)	0.1	1
Continuum (counts / Δλ)	800	125,000
Min EW @ 5σ (mÅ)	1.4	1.8
1 % systematics (mÅ)	0.08	1.3
Detections / unit z	10-20	8-16
idem @ >5x systematics	10-20	1-3

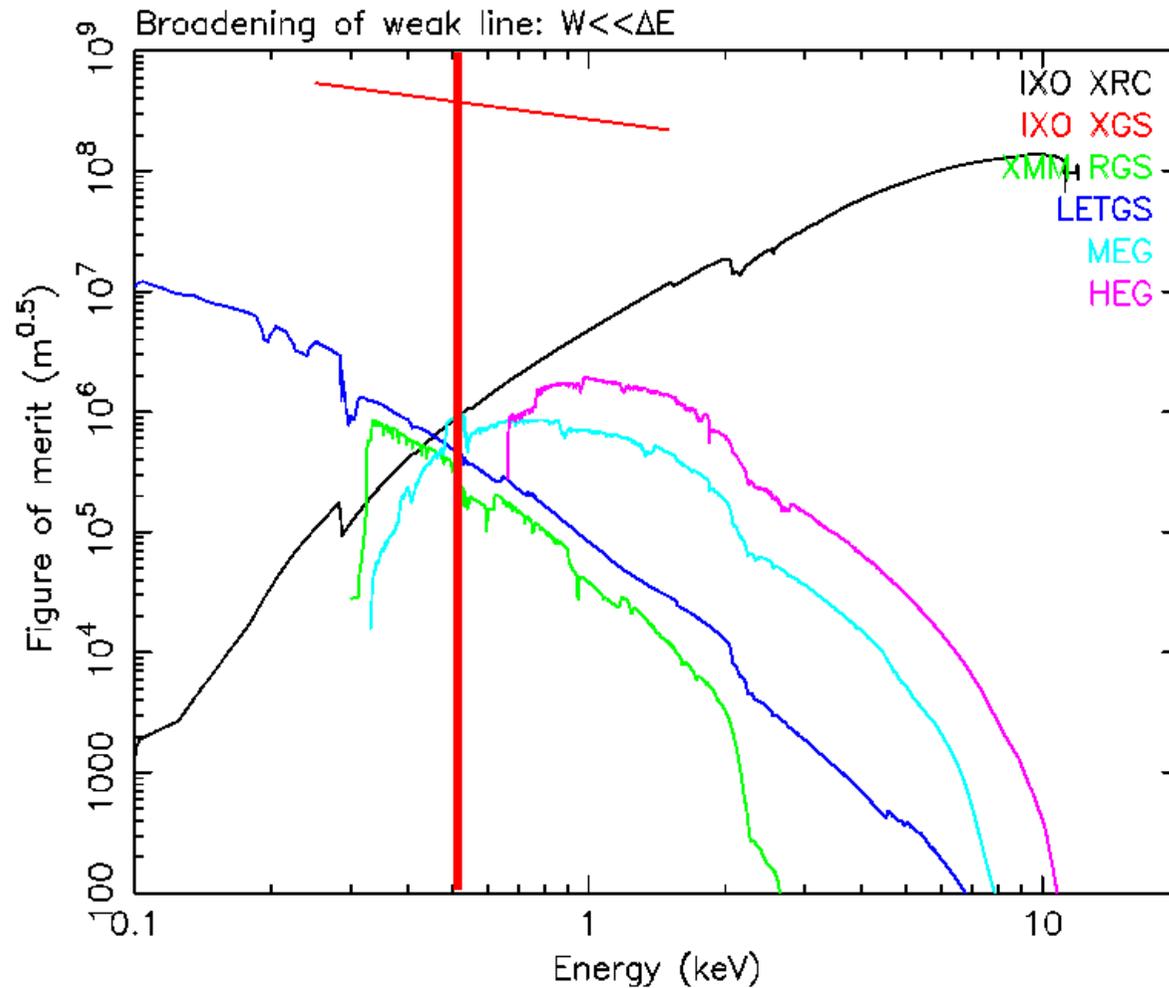
There is more than detection... (called astrophysics)



Line centroiding: comparing with UV

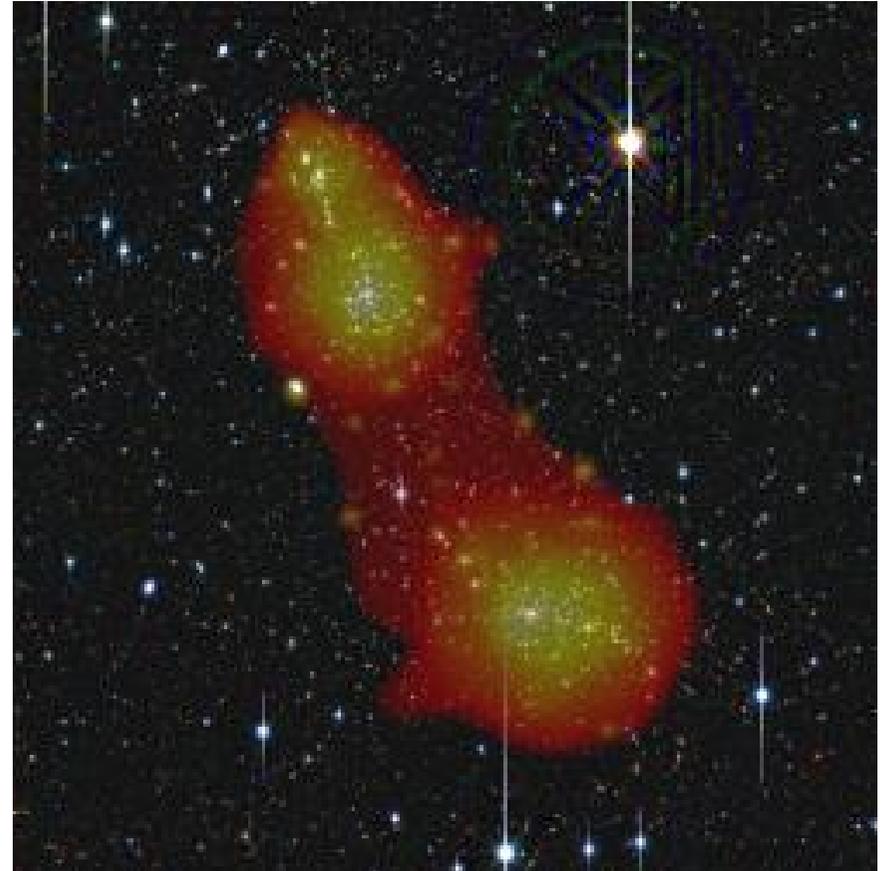


Line broadening



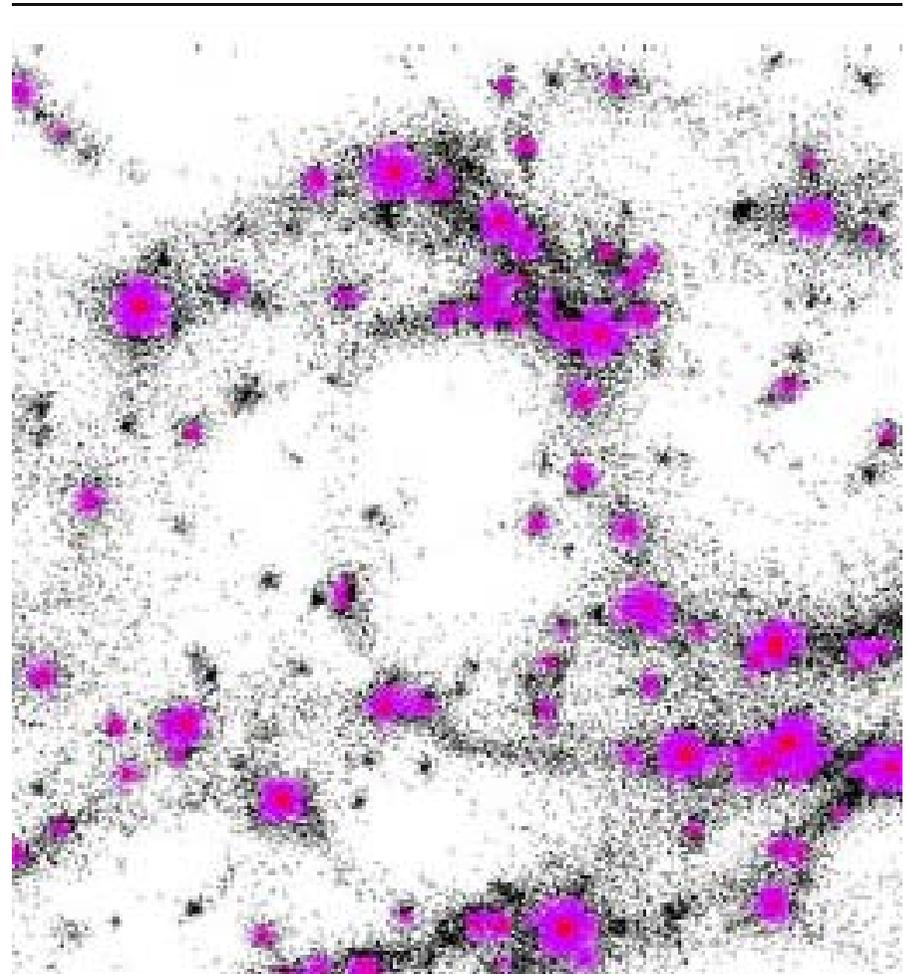
Observing the WHIM in emission: near and between clusters

- Significant detection
60 ks XMM-Newton of
bridge between
clusters (Werner et al.
2008)
- A 222/223 bridge:
6'x6', $kT=0.9$ keV
- IXO XMS: 10 x EPIC
area, FOV 2'x2', but
much higher spectral
resolution



Observing the WHIM in emission: near groups and filaments

- Study EDGE (Piro, Takei et al. 2009):
 - $\delta > 1000$ / $\delta < 1000$
 - Region 125'x125'
 - Colored regions:
 - $\sim 1\%$ sky, 5σ detections in 1 Ms (EDGE) = 100 ks (IXO)
 - \rightarrow IXO should target at promising selected regions



Conclusions

- IXO important for study WHIM
- In particular strong tool using XGS with absorption studies
- But also in emission exciting opportunities