High-throughput X-ray Spectroscopy
A look to few perspective studies
or ...
How and why ?

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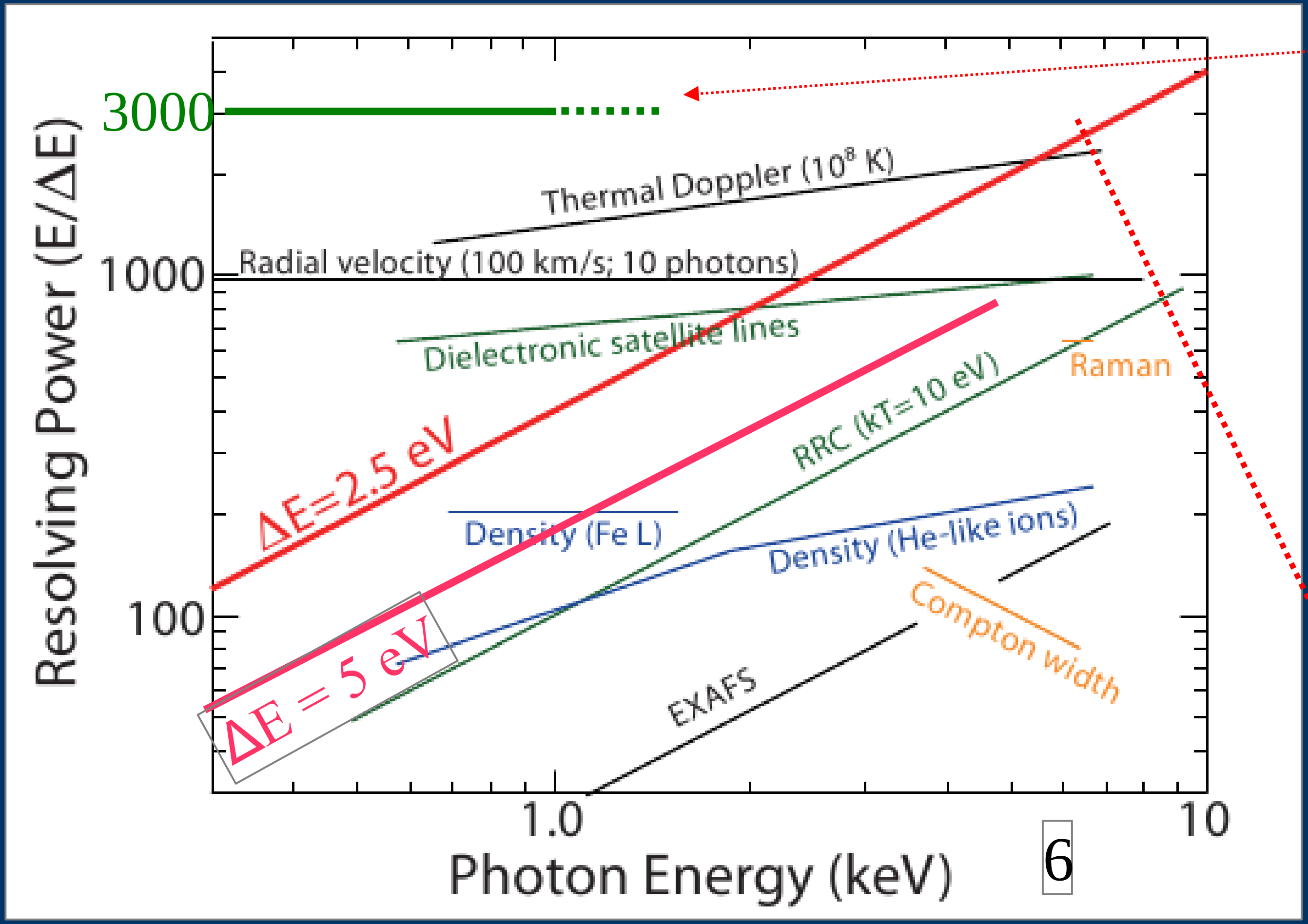
largely based on the IXO and ATHENA
Study Reports

Energy Resolution: Why ?



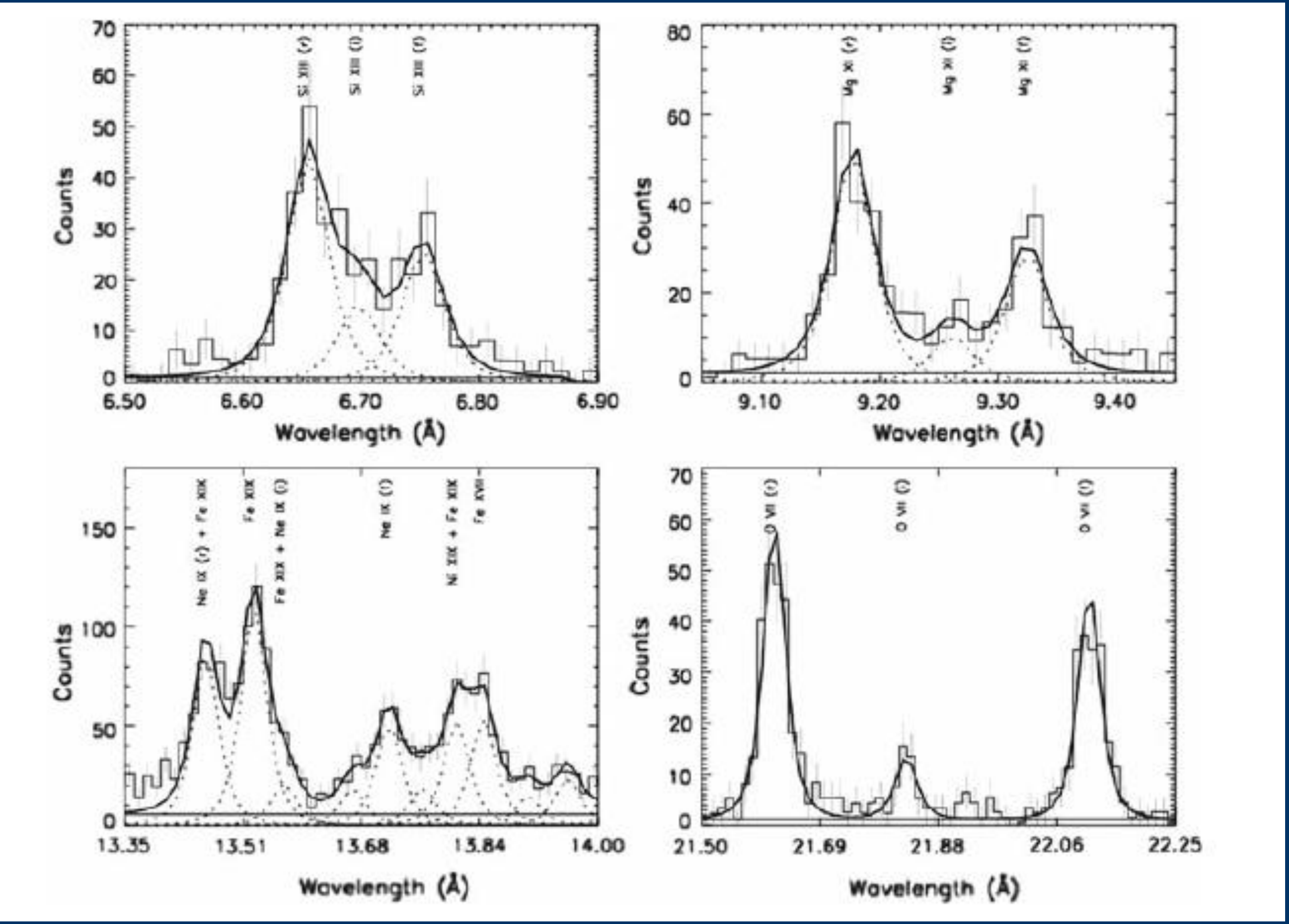
A lot of intersting lines in the 0.5- 2 keV range

For ΔE ~2.5 ev,
R in the 250 - 1000 range much better than RGS, not far from LETGS

At 6 keV, R ~ 2400 much better than CHANDRA HETGS

With 1 sq. meter ==> 6000 cnts in 10 ks for fx ~ 2 x 10^-12 erg/s/cm^2

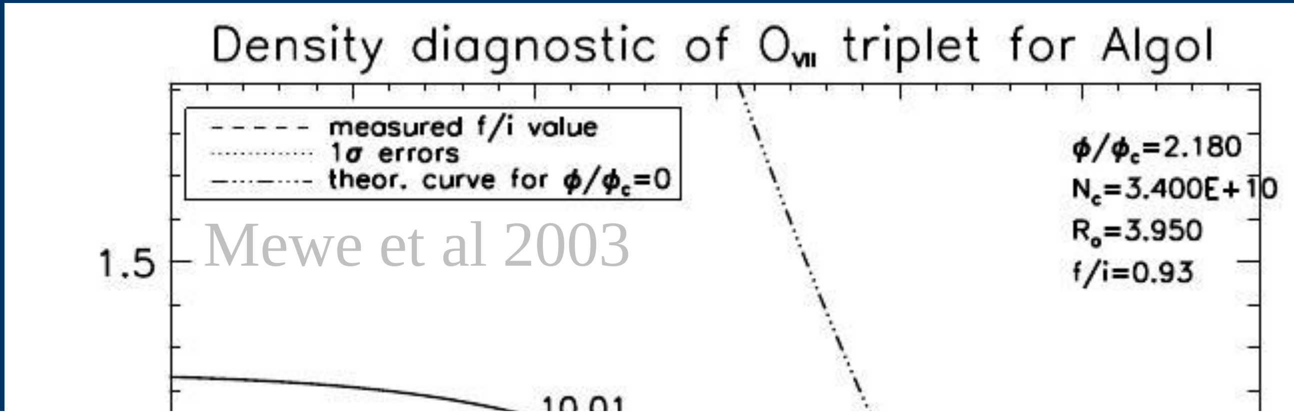
State of the art, an example: LETGS & Capella (Argiroffi et al. 2003)



fx ~ 8 10^-11 erg/s/cm^2

34 ks Positive order only

He-like Triplet: Density Diagnostic



$$f/i = \frac{R_o}{1 + \phi/\phi_c + N_e/N_c}$$

Radiation field intensity => Line formation radius

Table 1 Density-sensitive He-like triplets

Ion	$\lambda(r, i, f)$ (Å)	$\mathscr{R}_0$	N_c	$\log n_e$ range[a]	T range[b] (MK)
C V	40.28/40.71/41.46	11.4	6×10^8	7.7–10	0.5–2
N VI	28.79/29.07/29.53	5.3	5.3×10^9	8.7–10.7	0.7–3
O VII	21.60/21.80/22.10	3.74	3.5×10^{10}	9.5–11.5	1.0–4.0
Ne IX	13.45/13.55/13.70	3.08	8.3×10^{11}	11.0–13.0	2.0–8.0
Mg XI	9.17/9.23/9.31	2.66[c]	1.0×10^{13}	12.0–14.0	3.3–13
Si XIII	6.65/6.68/6.74	2.33[c]	8.6×10^{13}	13.0–15.0	5.0–20

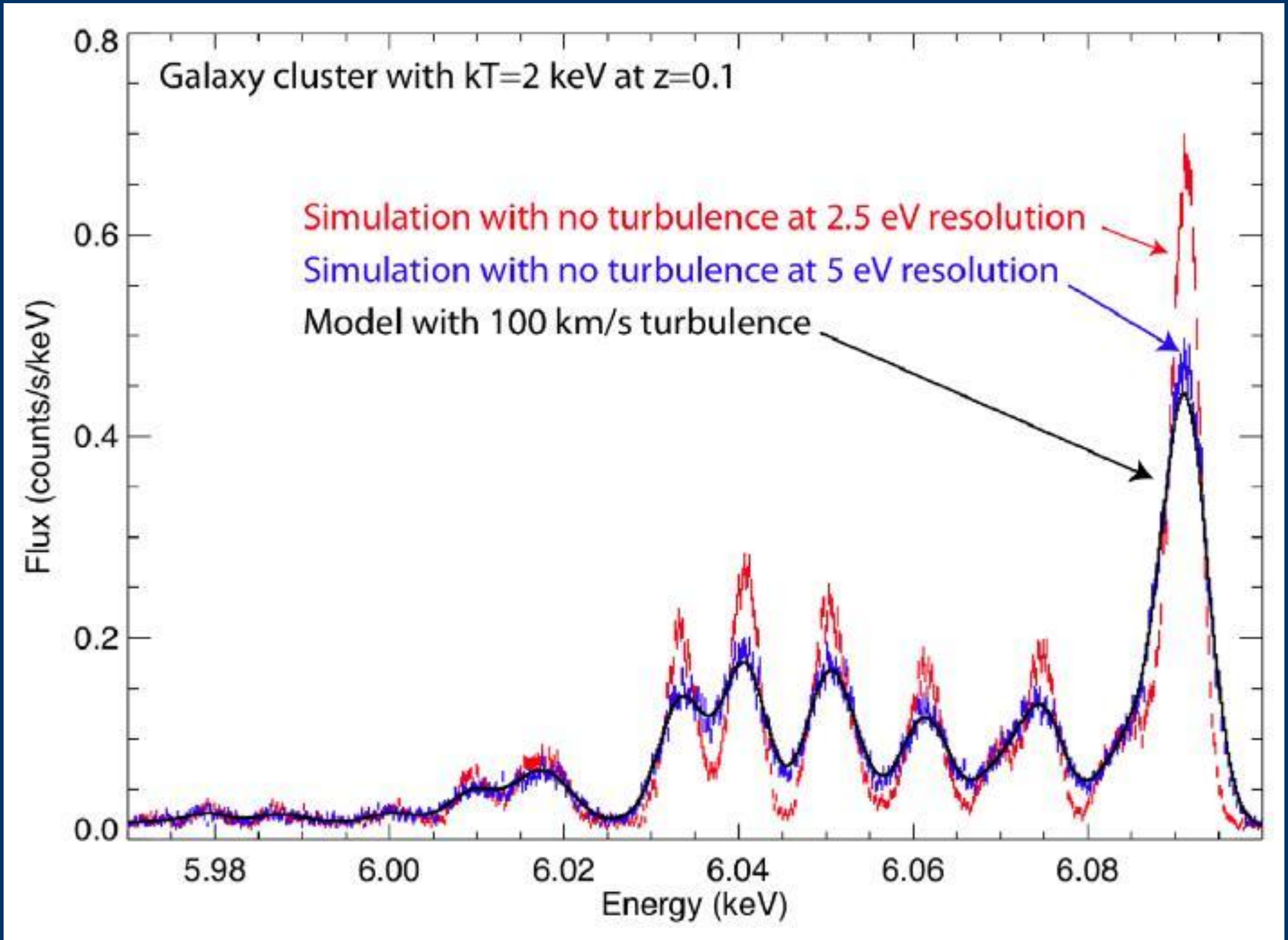
Data derived from Porquet et al. (2001) at maximum formation temperature of ion

[a] Range where $\mathscr{R}$ is within approximately [0.1, 0.9] times $\mathscr{R}_0$

[b] Range of 0.5–2 times maximum formation temperature of ion

[c] For measurement with CHANDRA HETGS-MEG spectral resolution

An example: Turbulent velocity “detection” vs. thermal broadening

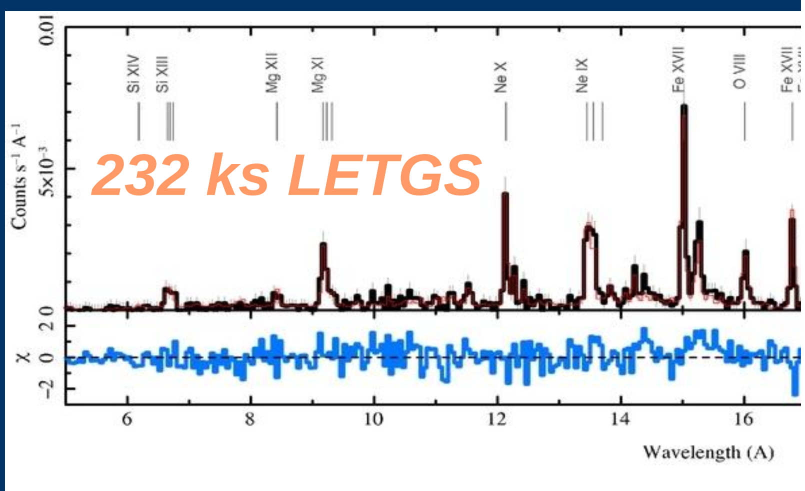


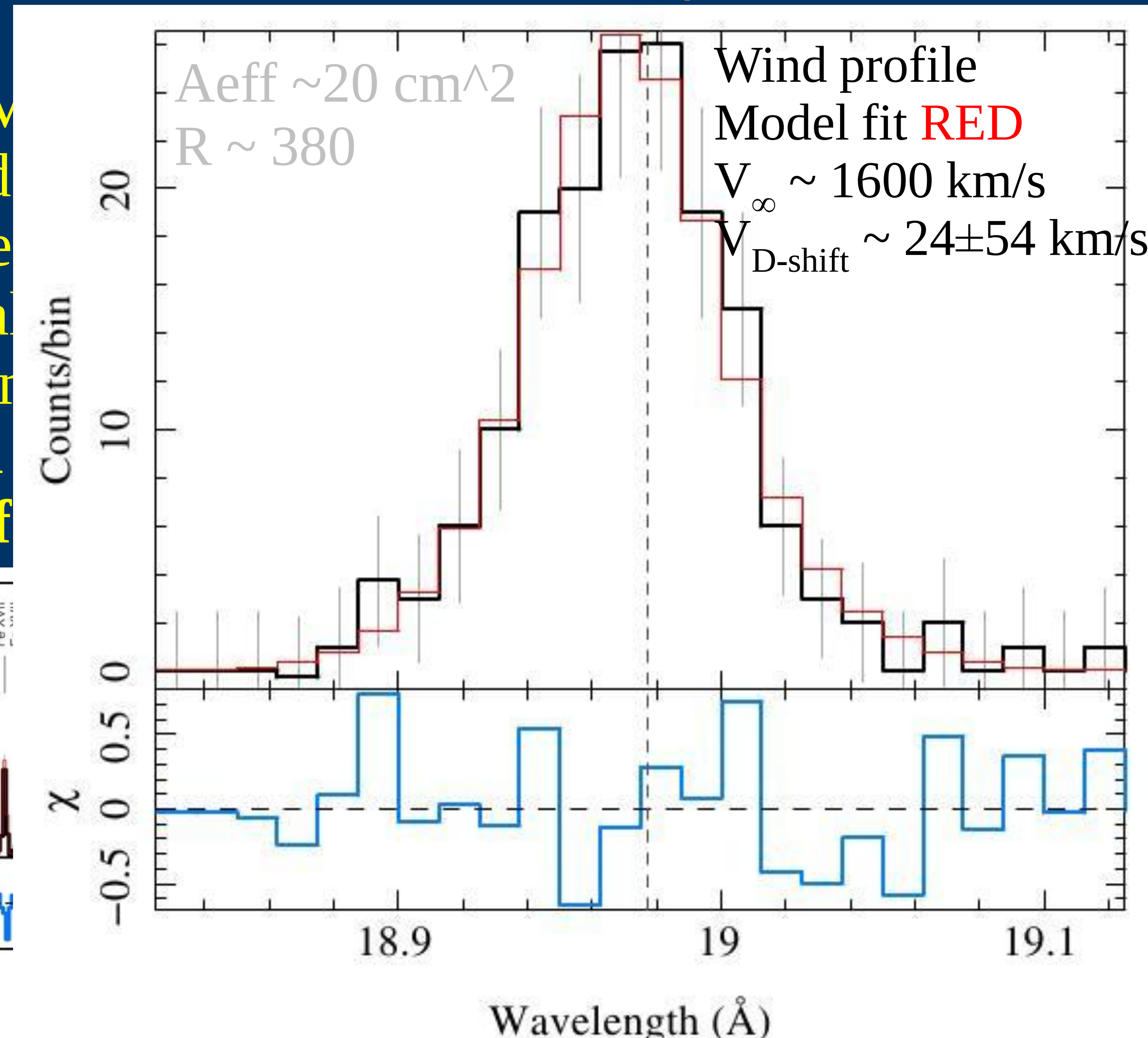
With a ~0.5 sq.m. Microcalorimter

100 km/s can be “detected” with ~ 2.5 ev res.
(200 km/s is the current XMM u.l.)

WEAK-WIND IN SINGLE MASSIVE STARS (Huenemoerder et al. 2012 ApJ 756 L34)

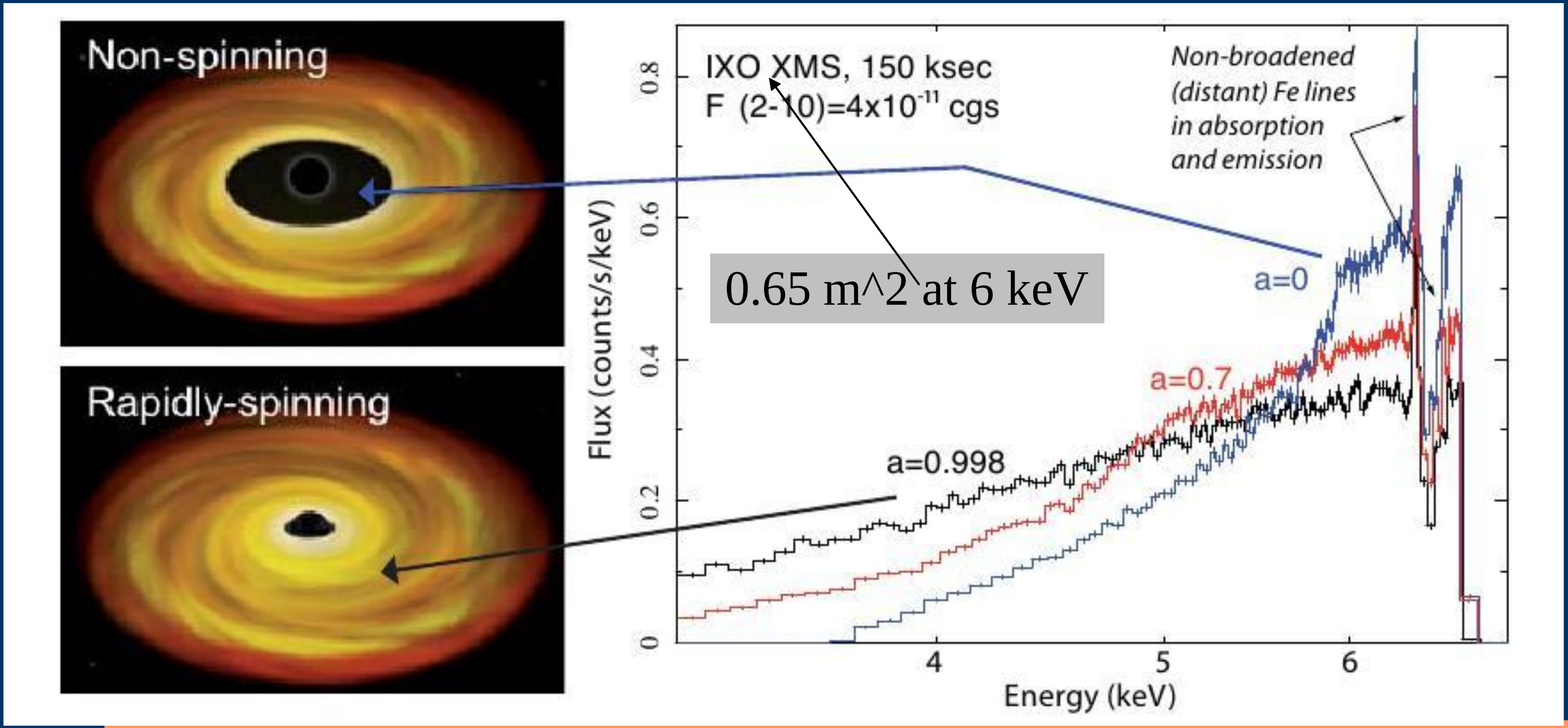
O Star Wind accelerated by UV
Detailed model and avaialble d
wind momentum-luminosity re
In a weak wind O star, classical
DISCREPANT from modeled r
Why important ? Factor of a
stellar evolution and cosmic f



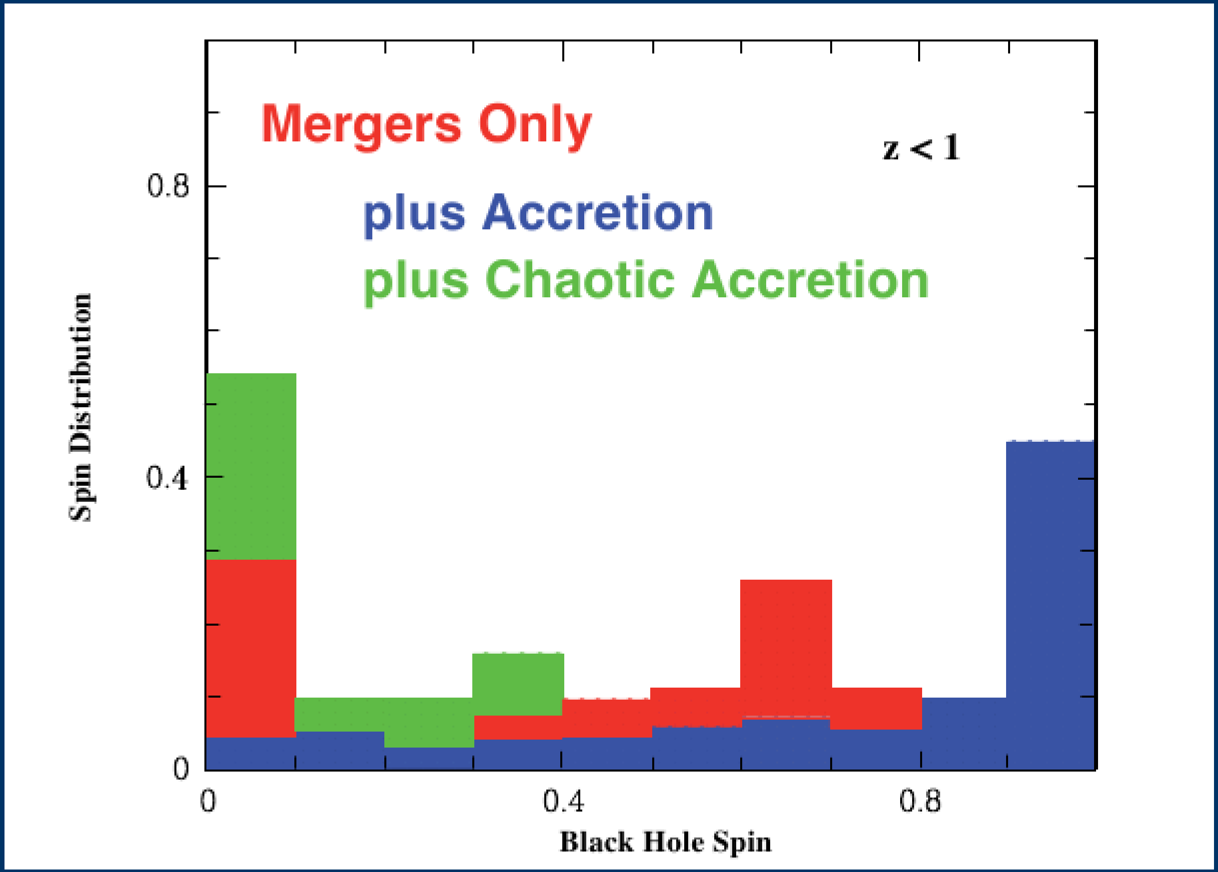


He-like triplets ==> X-rays forms at R ~ 2-5 Rstar, consistent with LWs
Detailed line-profile fits with wind model ==> X-ray inferred mass loss,
hot wind [Xray] has larger volume or greater density than cool wind [UV]

AGN inner accretion disk, Fe Kα line: somehow controversial interpretation. It is **crucial** the capability to assess truly Gen. Relativity broadening vs. reflection emission components from a "torus" of emitting gas sitting at larger distance from BH. Reflection emission should be characterized by narrow (ΔE ~ 10 ev) lines that can easily seen with an XMS (and only with an XMS ...)

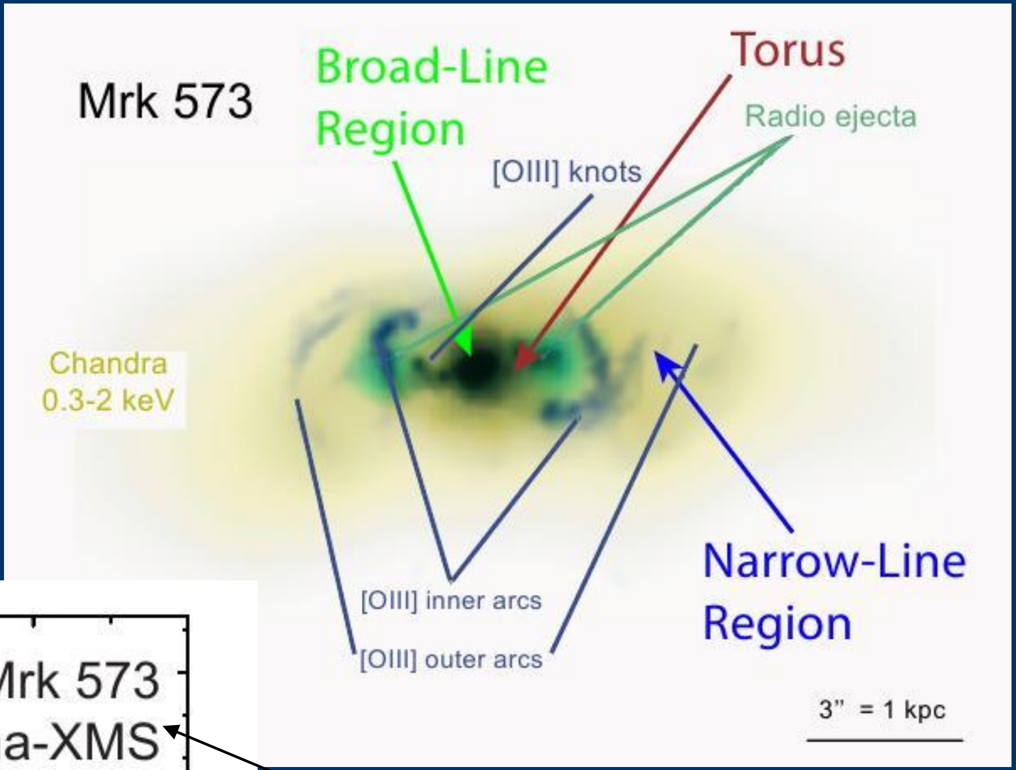


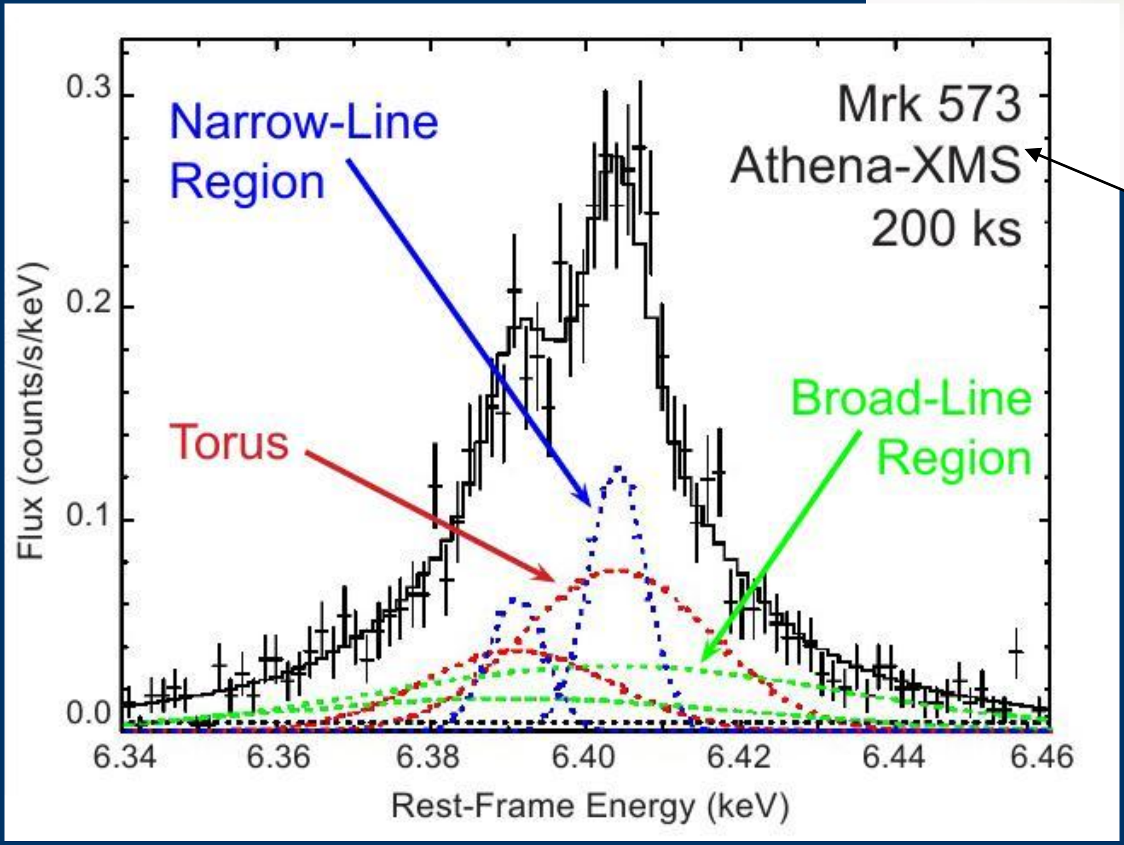
AGN Spin Distribution & growth history of SMBHs



Need to measure spin for about one hundred of AGN to build a constraining data sample

AGN: Gas Flow at large scale





0.25 m^2 at 6 kev

Sizes and velocity structures of the emitting regions from line widths

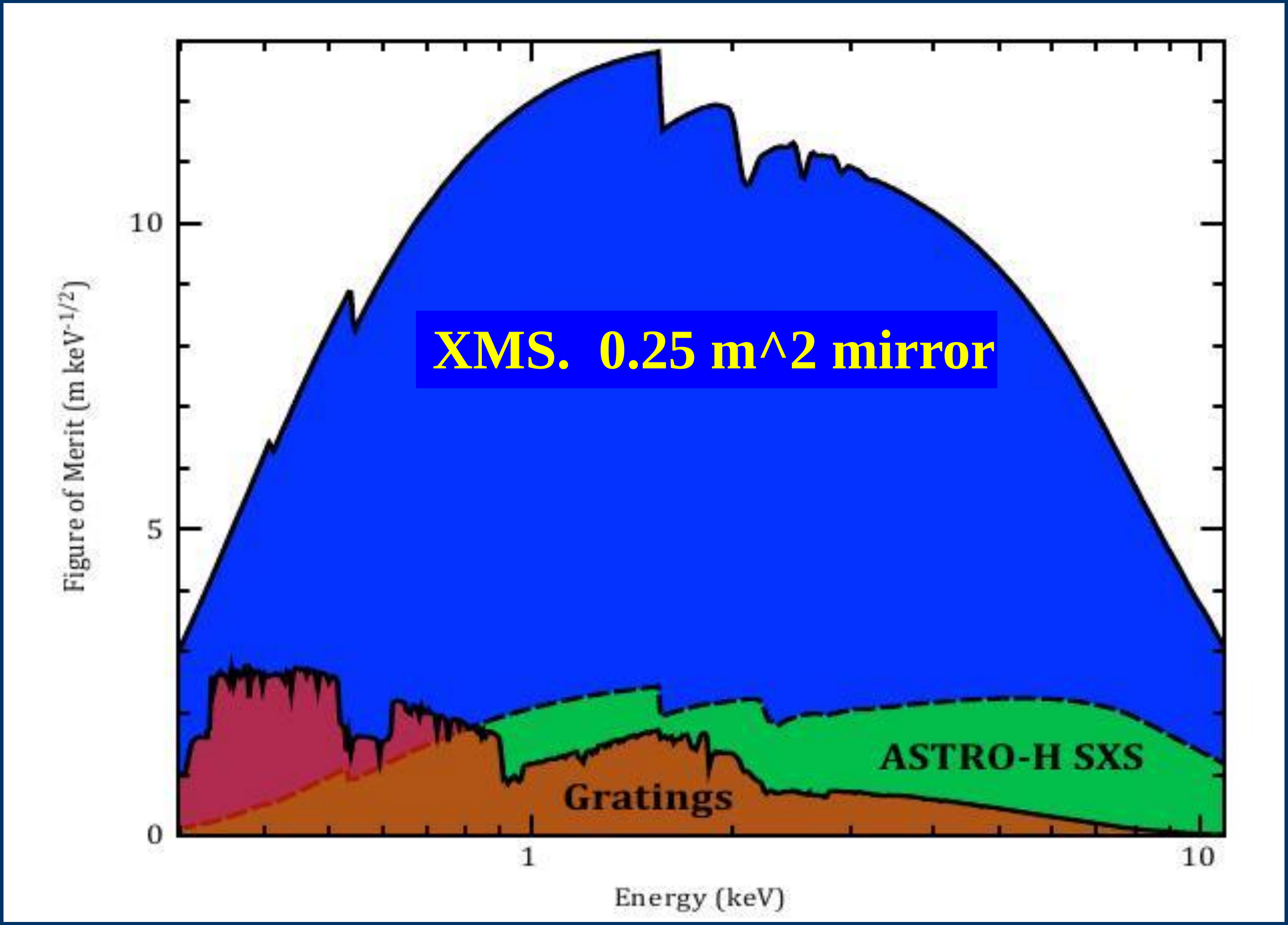
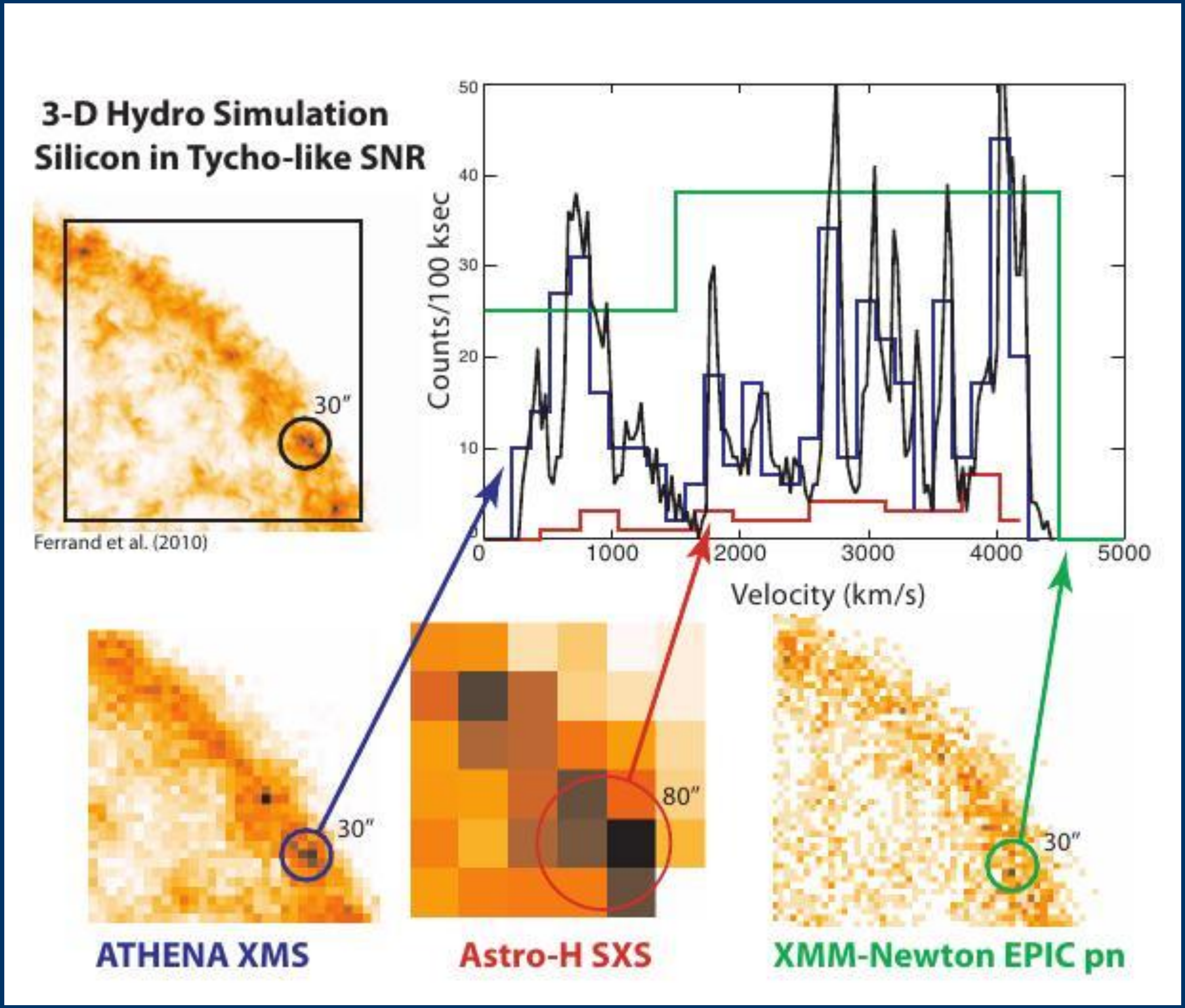
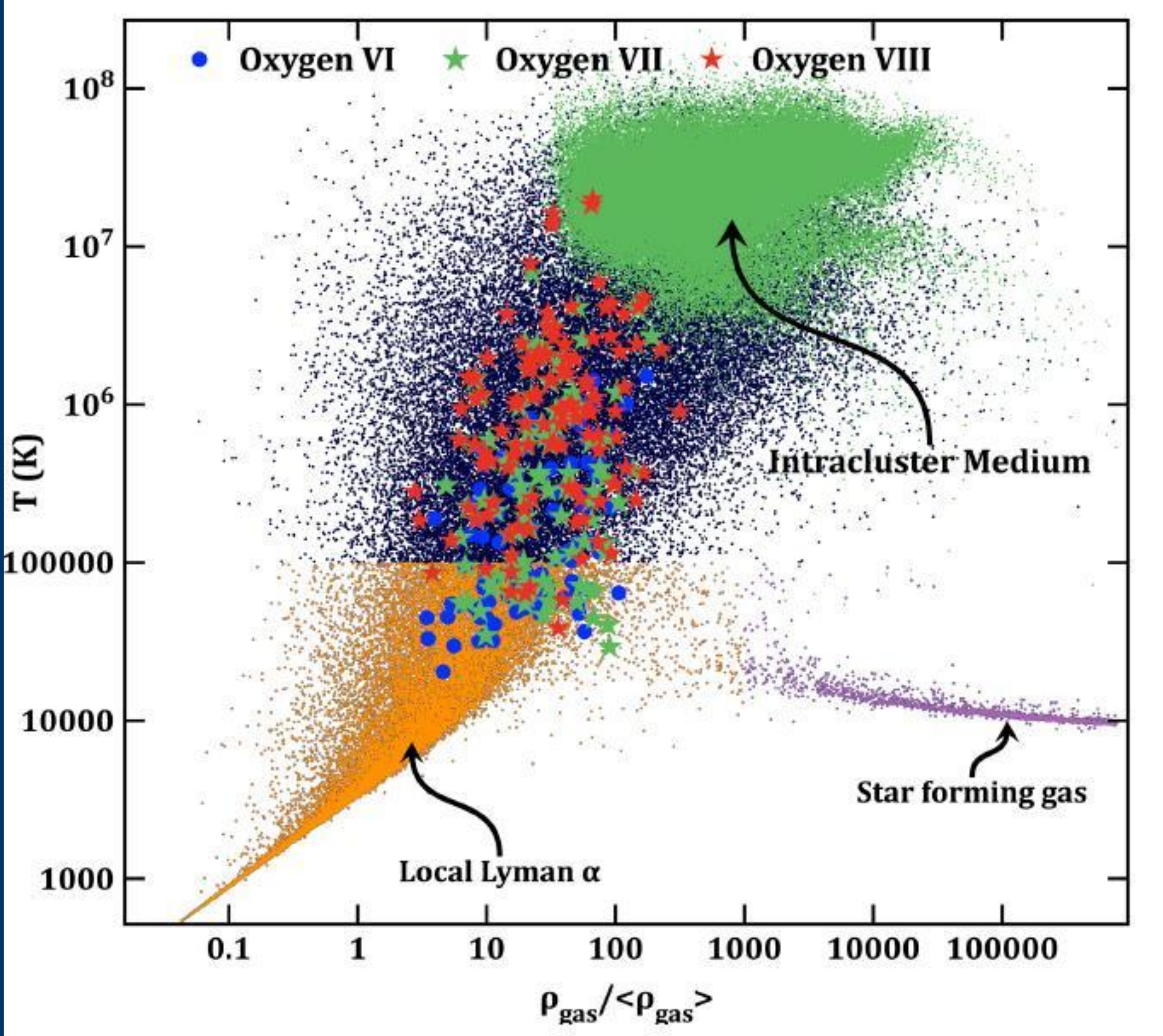


Figure of merit for weak spectral line detection ==>
Number of counts per independent spectral bin.

A clear cut example



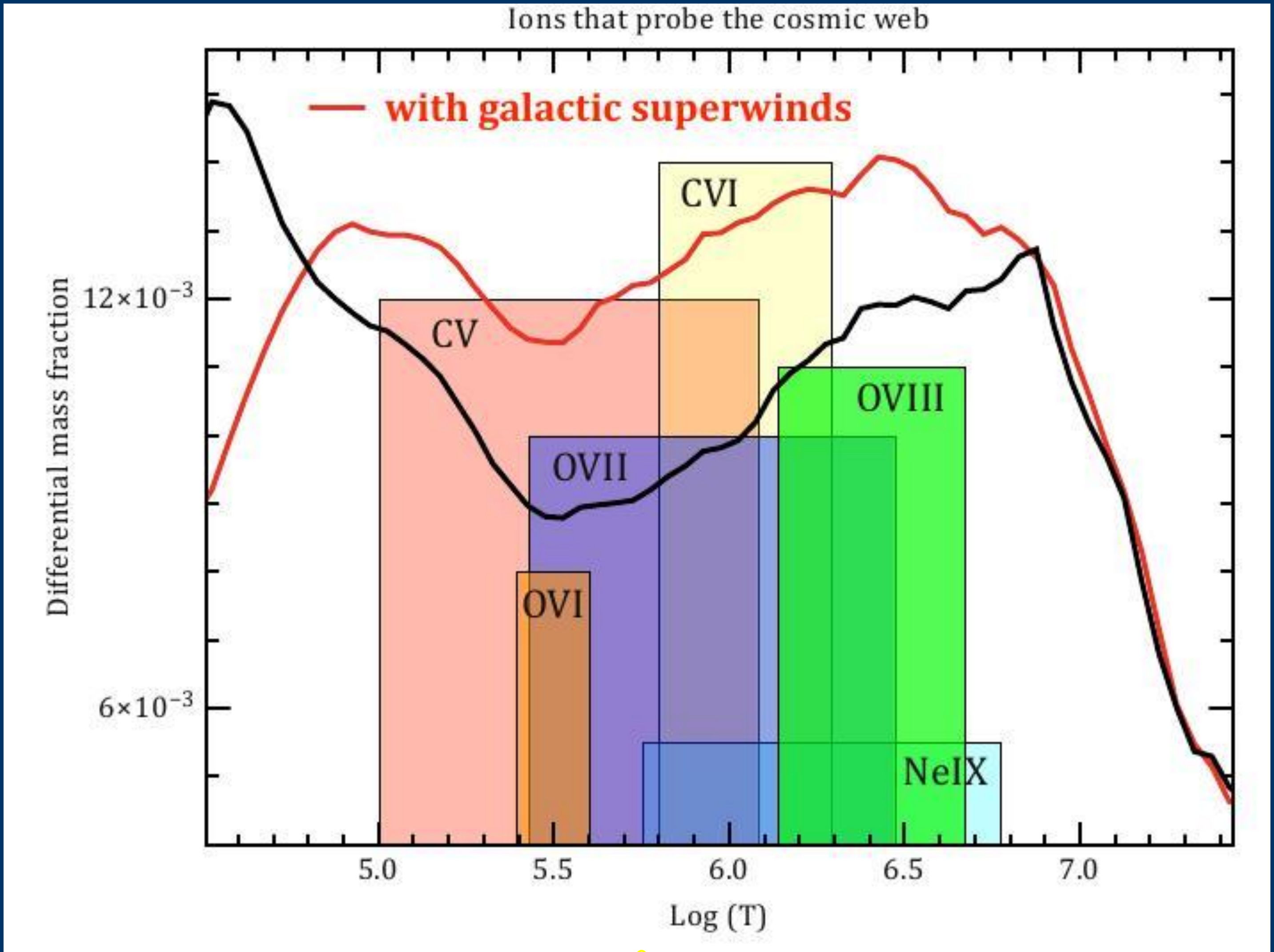
Missing Baryons



Phase diagram of baryons in the nearby Universe. Today observations probe the central region of galaxy clusters [green]and somehow the outskirts..

Half of the baryons could hide in a tenuous warm/hot phase ICM. They can be found either in absorption or in emission in the denser filaments.
OVIII & OVII absorption lines will allow probing the lower density regions.

Differential Gas Mass Fraction



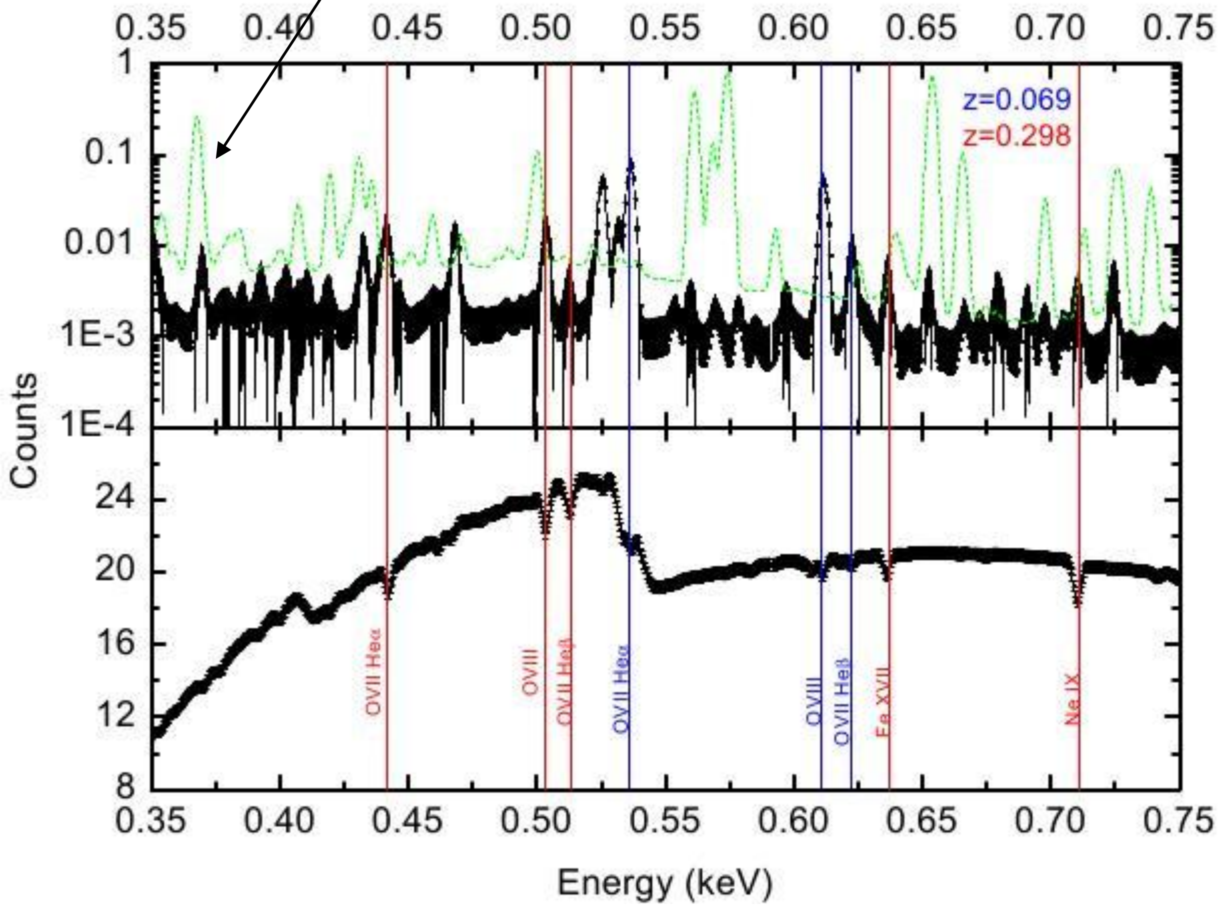
Apart from OVI (UV line) the other lines fall in the 0.5-2 keV X-ray bandpass

Reported X-ray detections controversial and in any case with low significance

2.9σ Abs. Line at 44. 8 Å in a ~ 600 ks Chandra HRC-S/ LETG ==> Cv–Kα absorption, at z ≈ 0.112, produced by a warm (log T = 5.1 K) intergalactic absorber (Zappacosta et al. 2012)

WHIM – How to measure it ...

Galactic foreground emission



Fluence 3 10^-6 erg.cm^2, 0.5 m^2 area

Either in emission or in absorption against a bright, distant, bkg source: AGNs (z >0.3), GRBs (z> 1)

- With an XMS it will be possible to detect the "missing baryons"
- Multiple line detections (~30-50% of cases) → T, density and metal content

However no study of dynamics will be possible This requires R > 4000, Aeff > 1000 cm^2 and Msec long exposures

~ 1 sq.m. Telescope with an XMS in the focal plane can do ...

- Spectroscopy of faint, moderate and/or diffuse sources
- This can ONLY be achieved with a X-ray IFS: XMS
- This enables:
- Large scale structures (formation and evolution of cluster, missing baryons whim, snr, sn and connection with explosion mechanisms)
- Feedback in cluster/galaxies/agn
- Physics of intense source and transients (galactic, extragalactic, grbs) with time resolved spectra

~ 1 sq.m. Telescope with an XMS in the focal plane can do ...

- **Intense Sources** (fx~10^{-11}– few x10^{-12} erg/s/cm^2)
  - *Physics of (relatively) fast phenomena (i.e. raising phase of flares)* ➎ ***Time-resolved Spectra*** *(few ks)*

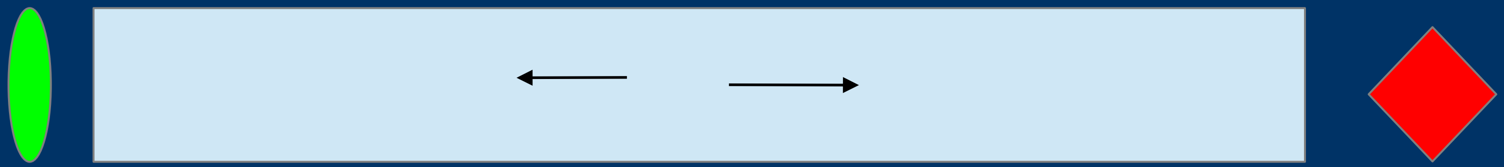
- **Moderate Sources** (fx~5 10^{-12} – 10^{-14} erg/s/cm^2)
  - *Physics of emitting plasma* ➎ ***Spectra***

X-RAY IMAGING/SPECTROSCOPIC MISSION in a NUT

Mirror

Structure (with extensible bench ?)
& various service subsystems

Focal Plane Assembly
With 1 or more Detectors



+ Launcher and orbit -> Mission Duration and background level

In the ESA scenario the largest fairing launcher is the Arianne 5.
-> A fixed structure -> 12.5 m maximum focal length.
-> The largest possible diameter is 2624 mm, dictated by available adapter. **This poses a constrain on mirror size and collecting area**.

In any realistic scenario, max area (1 kev) < ~ 1.5 sq. m.
Increase of the area at 6 keV ->
small radius mirror element, but gain up to ~ 10% maximum
Longer focal length -> ext. bench (angular resolution ??)

DONE