A Decade of WHIM Searches: Where do we Stand and Where do we Go?

Nicastro, Krongold, Mathur and Elvis

https://arxiv.org/abs/1611.03722

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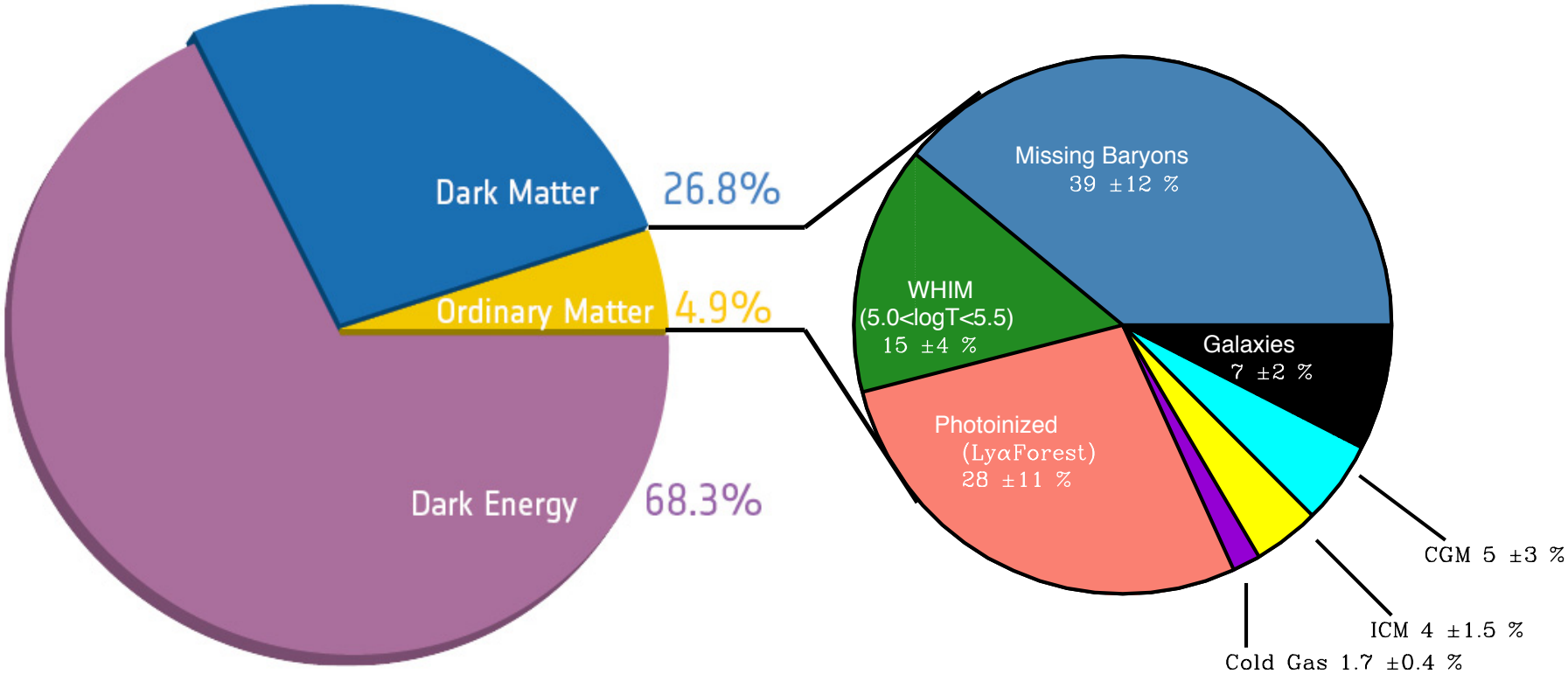
February 21st 2017

Baryon budget



Planck 2015
(observation @ z=1100)

This paper
(observation @ z=0)

Between z=1100 and z=3

Gunn Peterson relation for the Ly α forest

$$\tau = \frac{0.091}{\Gamma_{-12}} \left(\frac{\Omega_b h_{50}^2}{0.05} \right)^2 \left[\frac{5.2\, H(0)}{h_{50} H(z)} \right] T_4^{-0.7} \left(\frac{\rho}{\overline{\rho}} \right)^{\alpha} \left(\frac{1+z}{1+2} \right)^6 \times \left[1 + \frac{dv_{pec}}{H(z) dr} \right]^{-1}.$$

Rauch 1998

τ(z) from observations
Ω_b^2/Γ_{-12} from comparison with simulations

→ $\Omega_b h^2 > 0.017$ (Rauch et al 1997). → No missing baryons @ z=3

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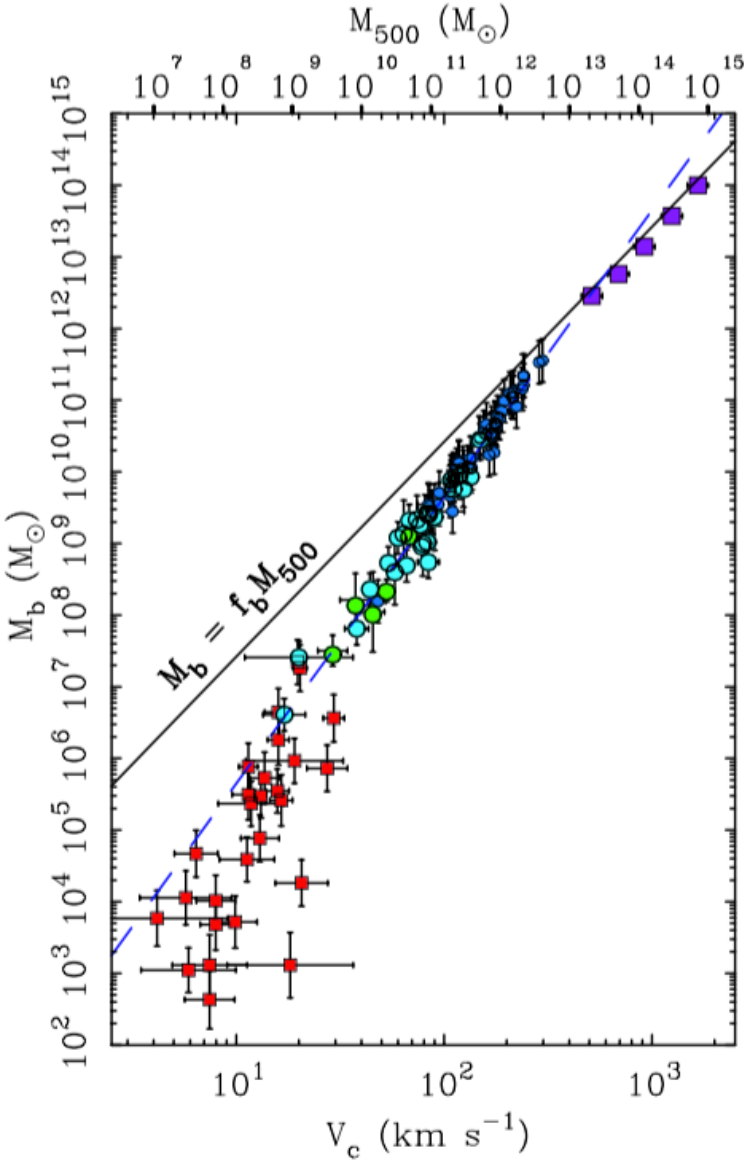
Ω_b^2/Γ_{-12} from comparison with simulations

→ $\Omega_b h^2 > 0.017$ (Rauch et al 1997). → No missing baryons @ z=3

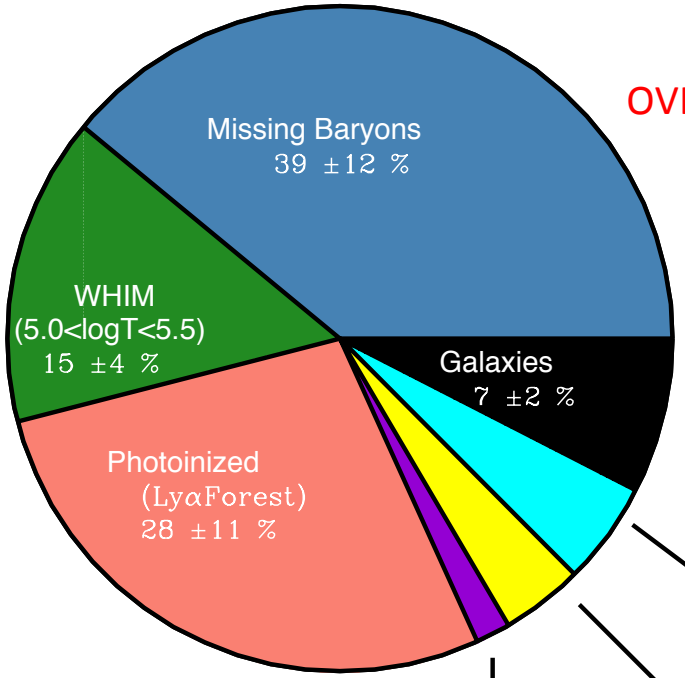
→ $\Omega_b h^2 = 0.02230 \pm 0.00014$ (Planck 2015) Note: 0.017/0.02230=0.76

Missing baryons



McGaugh et al. 2010

Between z=3 and z=0



log T>5.5 WHIM?
OVII and OVIII absorbers?

OVI absorbers
and BLA (HI)
OR
BLA (CV and OVII)

around galaxies

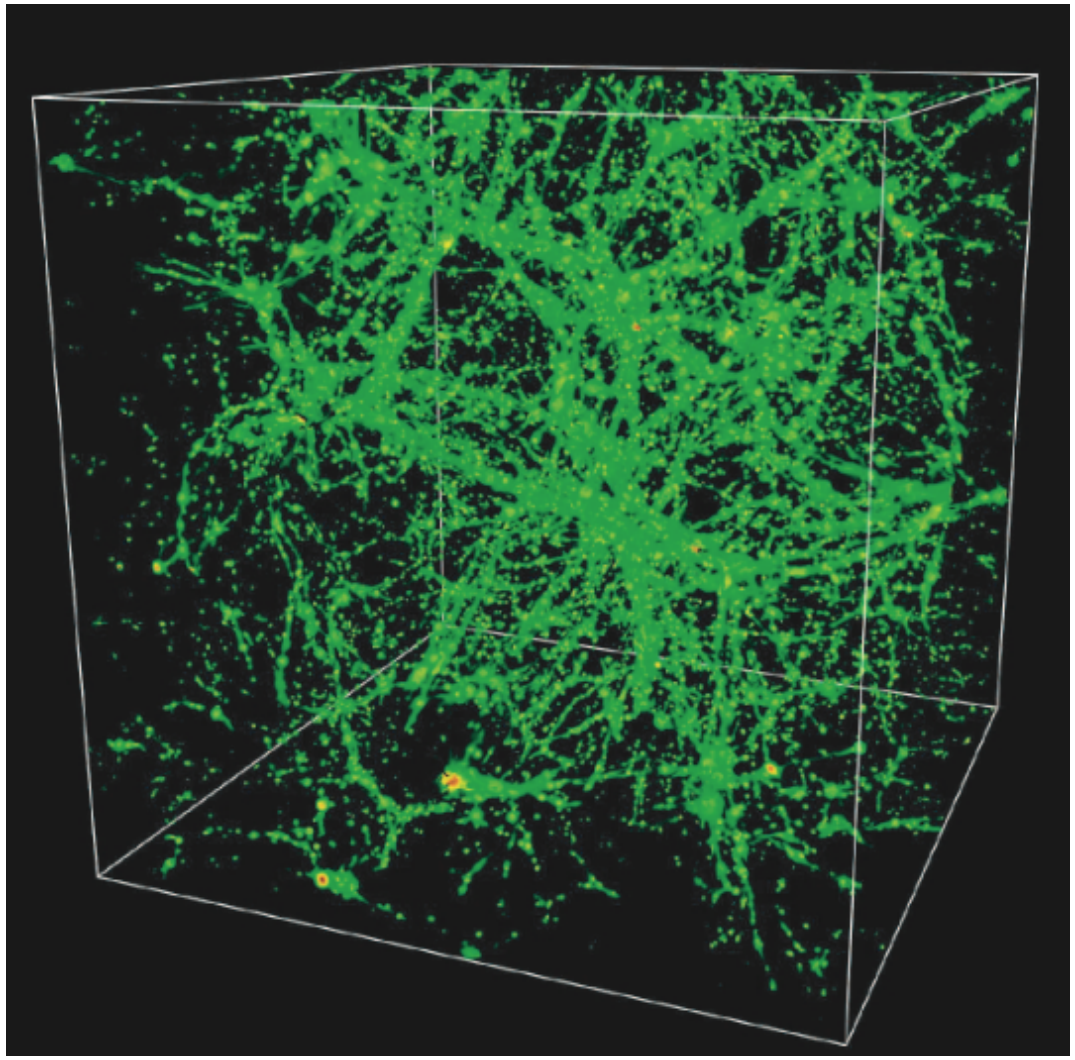
in clusters and groups

HI, HeI and H_2

This paper
(observation @ z=0)

See also Shull, Smith & Danforth 2006

WHIM



$T = 10^5 – 10^7$ K

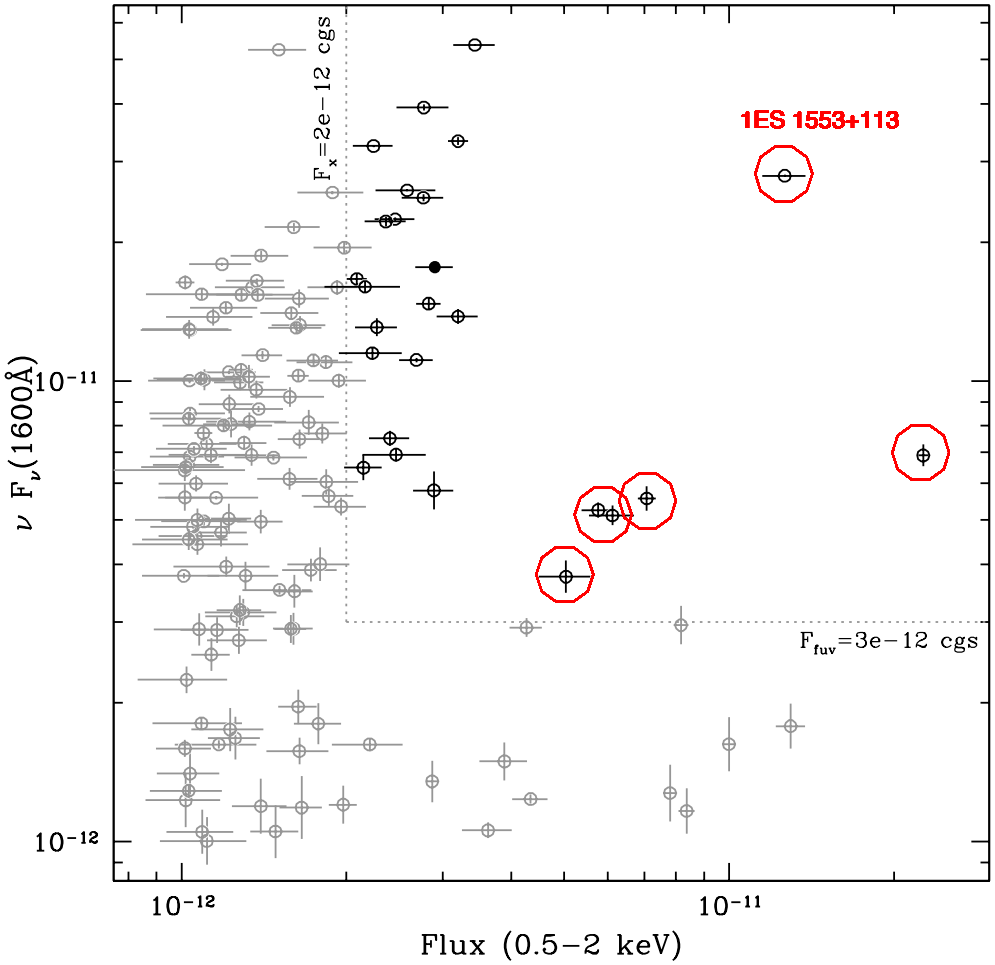
$n_b = 10^{-6} – 10^{-4}$ cm^{-3}

Absorption lines
in X-ray spectra
of distant astro sources

(*Chandra*, *XMM*)

Cen & Ostriker 2006

Targets



OVII Heα absorbers

Only a few EW~3mÅ
XMM spectro Δλ~70mÅ

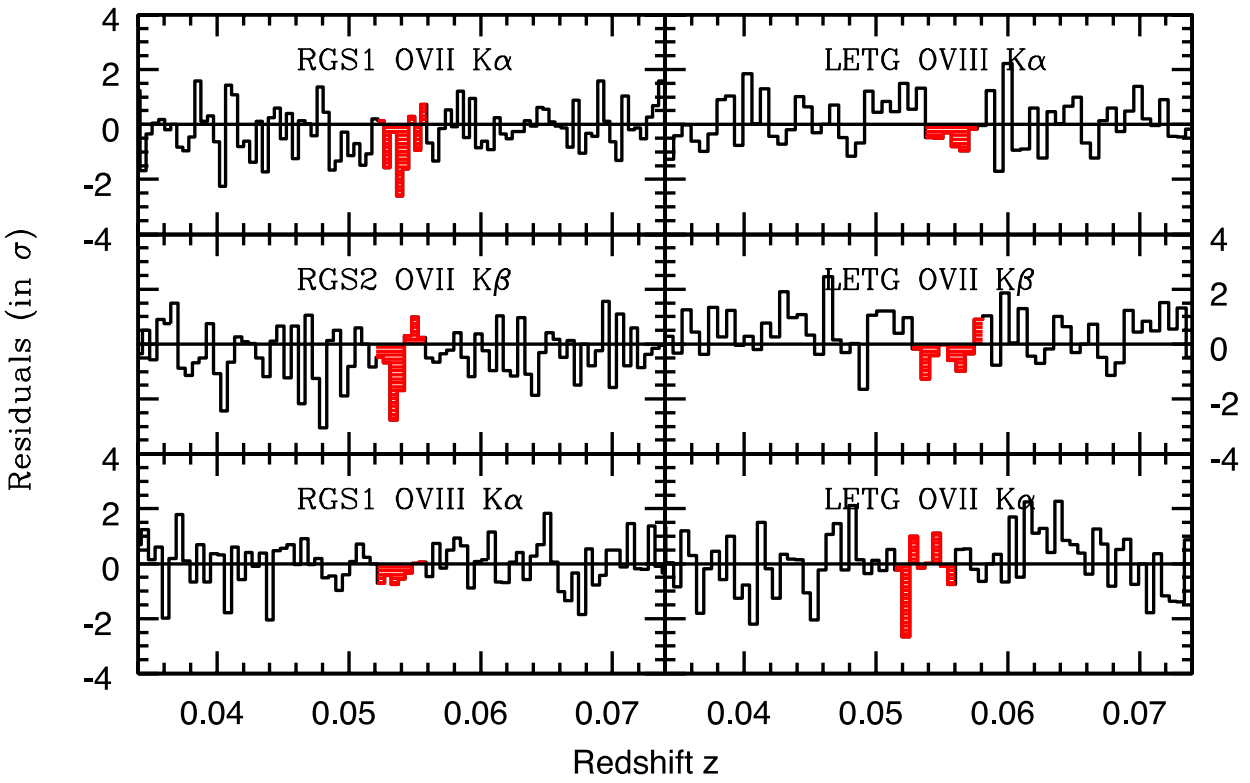
EW/Δλ~4%

syst. ~ 2%

Long observing time
Very bright targets

Sensitivity

Blazar 1ES 1553+113 → 1.6 Ms observation with XMM

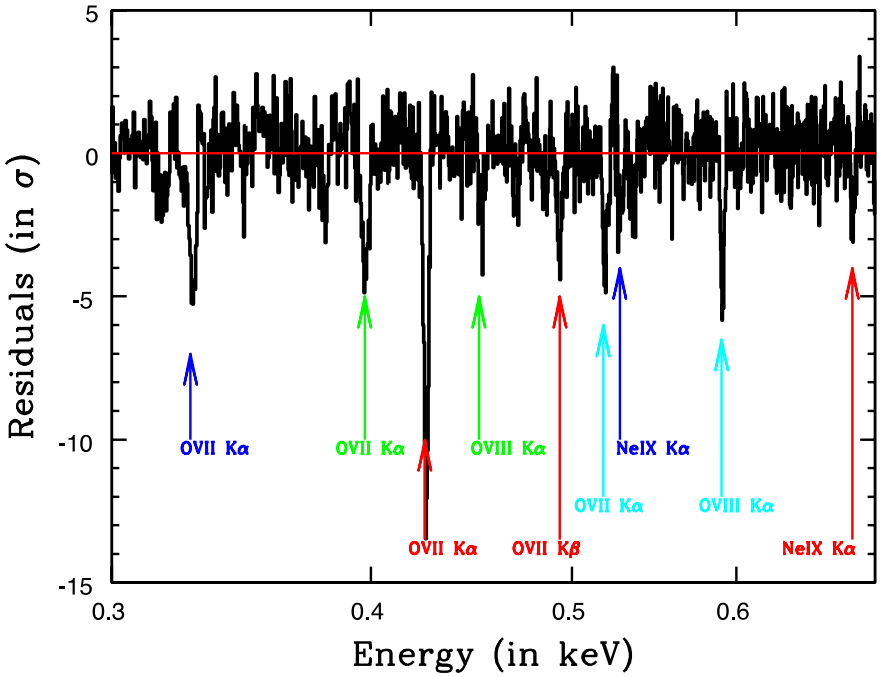


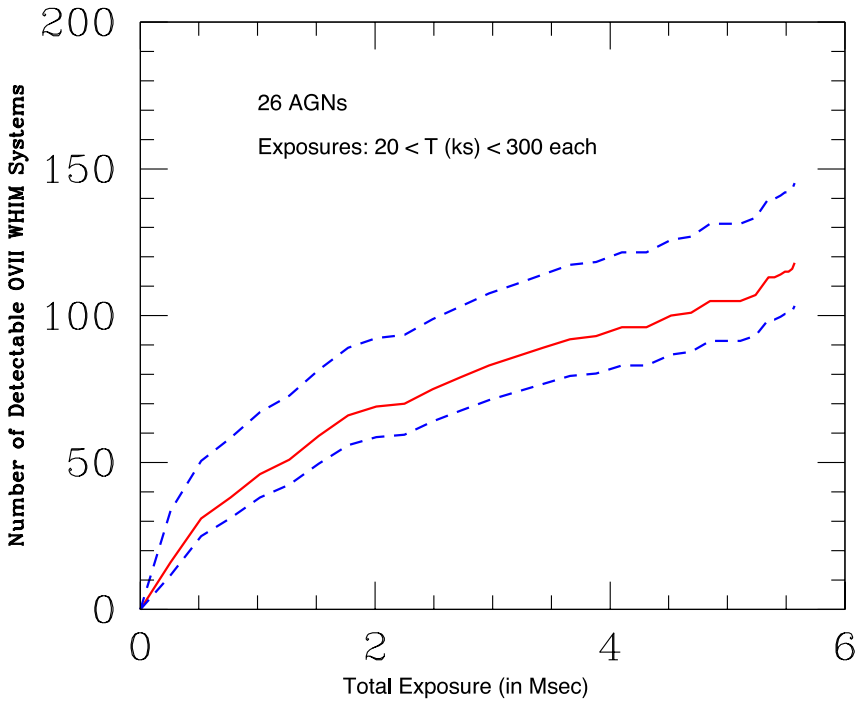
2.2σ

XMM 740ks

Chandra 500ks

Future: Athena





Conclusions

- Firm detection of logT>5.5 WHIM not done yet despite strong efforts and controversies
- Second half of the observation of 1 ES 1553+113 this year
- But not sufficient (variation from line-of-sight to line-of-sight)
- XMM-Newton Legacy program (11Ms on 5 other targets) + HST (150 additional orbits)
- Future: HST and Athena