IGM/Halos Panel

Missing Baryons, Warm-Hot IGM, Feedback, Galactic Halos, Joint UV/X-ray spectroscopy

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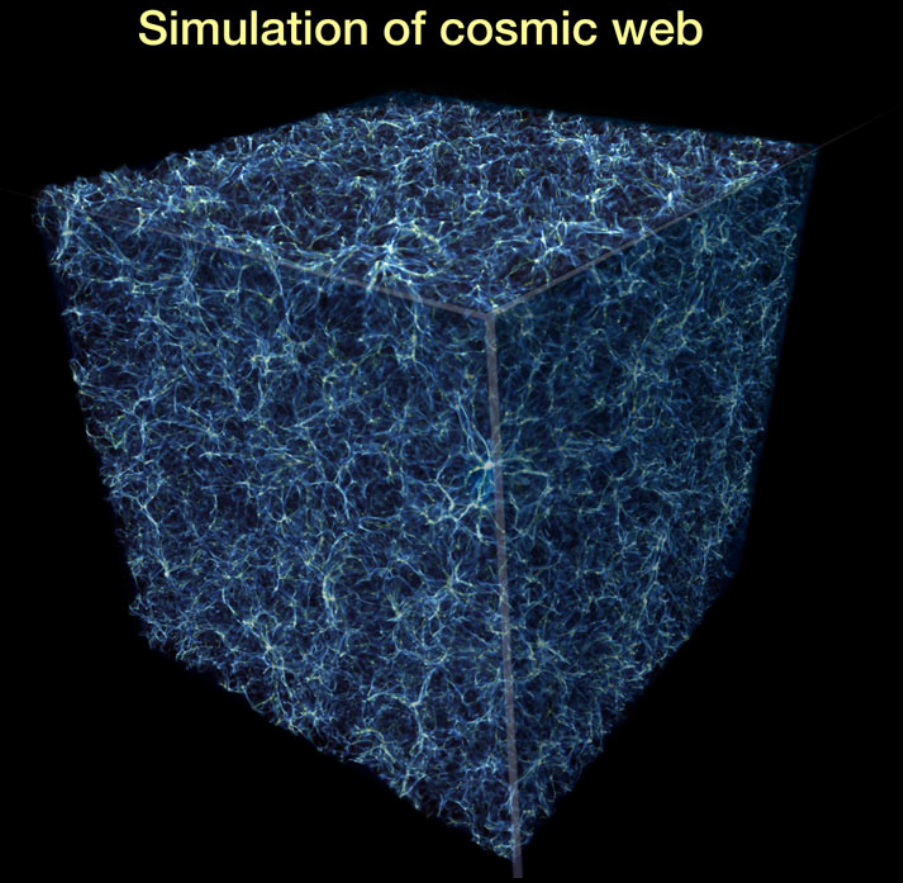
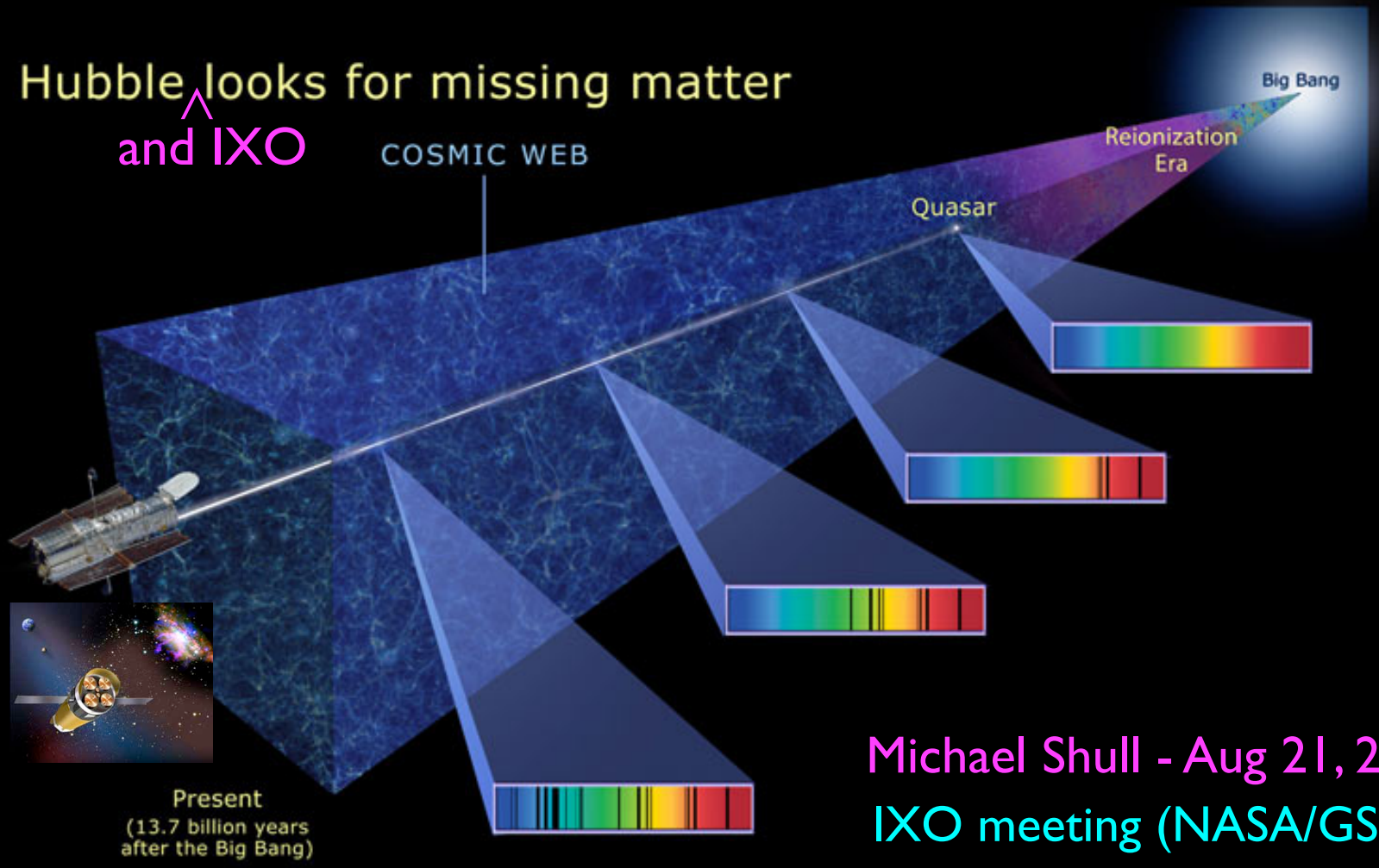


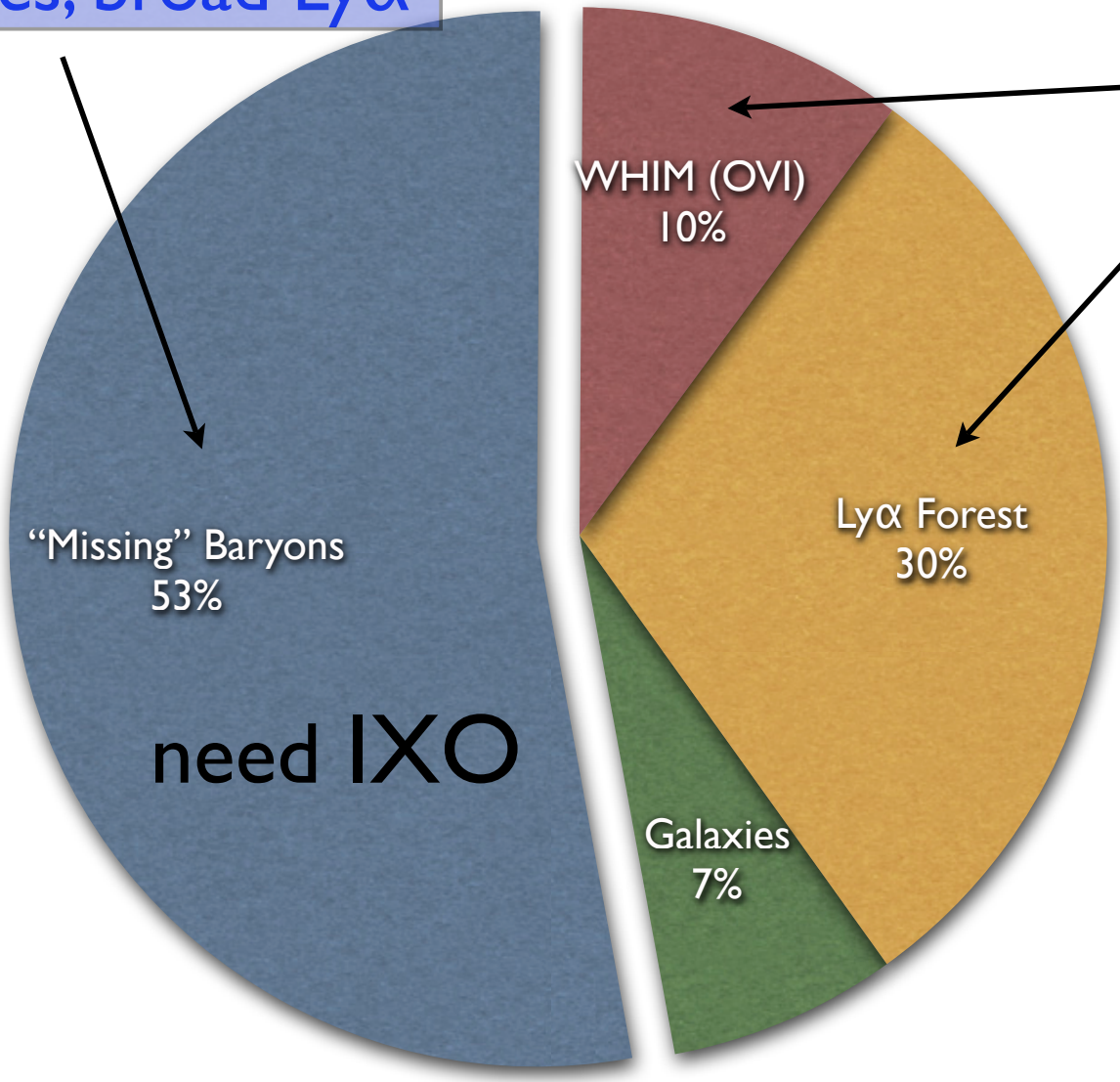
International X-Ray Observatory



Michael Shull - Aug 21, 2008
IXO meeting (NASA/GSFC)

Baryon Census (low-z)

Probed by X-ray lines, broad Lyα



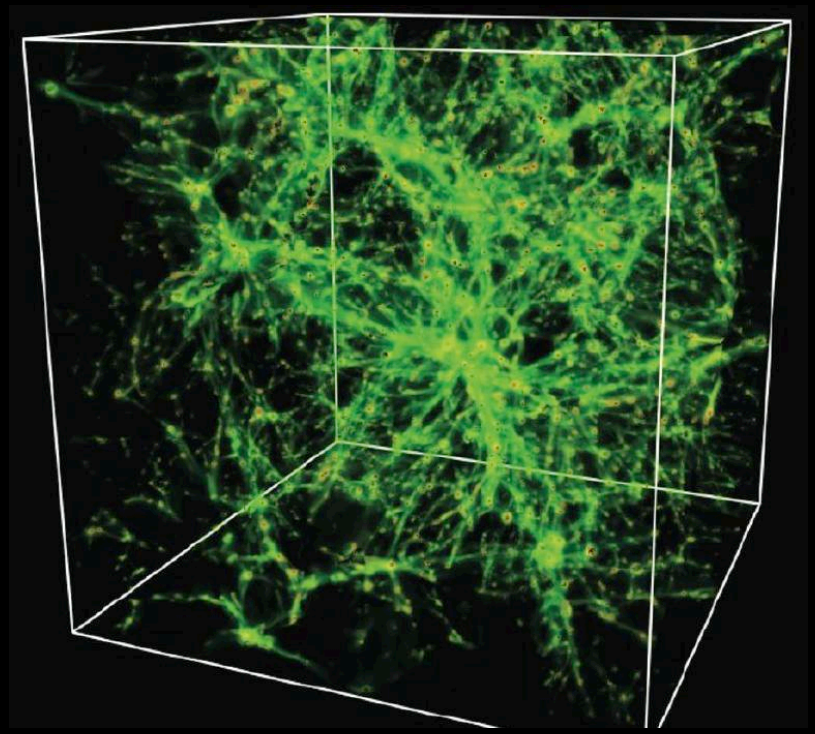
Both of these are uncertain

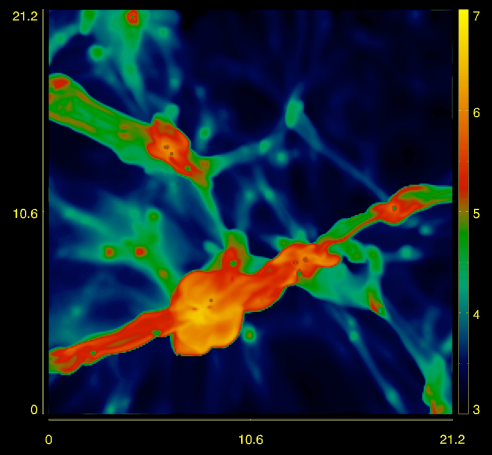
IGM Systematics:

- EUV radiation field
- Oxygen metallicity
- Ioniz corrections
- Cloud geometry

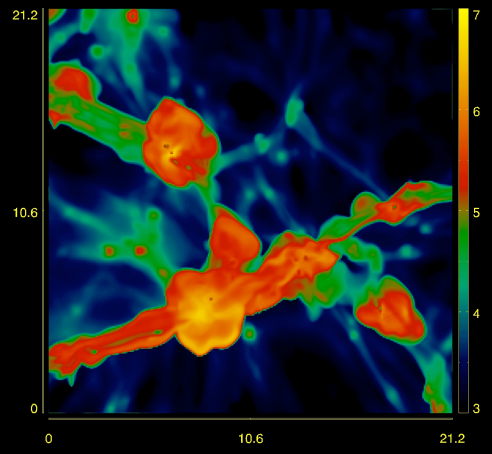
The shock-heated IGM

"Warm-Hot IGM" (WHIM)





no galaxy winds



with galaxy winds

Gravitational shocks (100-400 km/s)
⇒ gas at $10^{5.1}$ K to $10^{6.4}$ K

Mach numbers up to 200

Major Cosmological Issues

(1) Test theory of large-scale structure formation

baryons in Cosmic Web, shock-heated filaments

thermodynamics of IGM (heating, radiative cooling)

strength of feedback from galaxy winds?

20 AGN (100-300 ks each) = 4 Ms total

(2) How does gas accrete from the IGM into halos?

extent of hot gaseous halos?

cold accretion vs hot accretion?

11 low-mass Galactic XRBs (150 ks total)

IGM, WHIM, Missing Baryons

Joint UV/X-ray Program

- We have accounted for ~50% of low-z baryons

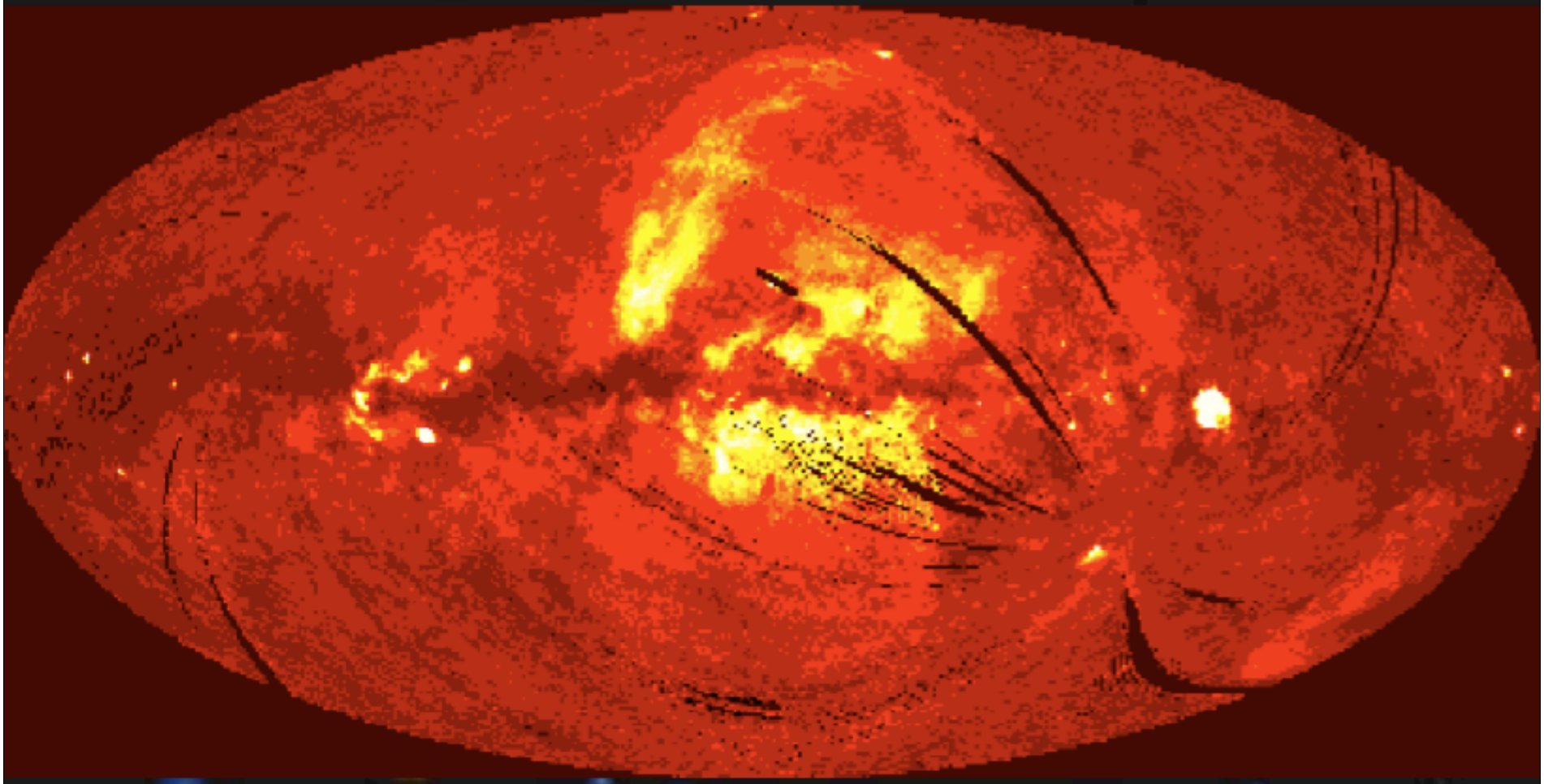
Are the rest (50%) in hotter gas (1-3 x10^6 K) ?

Crucial test of baryon shocks in LSS

HST/FUSE have found ~100 WHIM/OVI absorbers
These probe gas at 10^5 to 10^6 K down to
columns N(OVI) ~ 10^{13} cm^{-2}

X-ray absorbers (Con-X) are needed to complete the baryon surveys and to understand feedback to IGM in winds

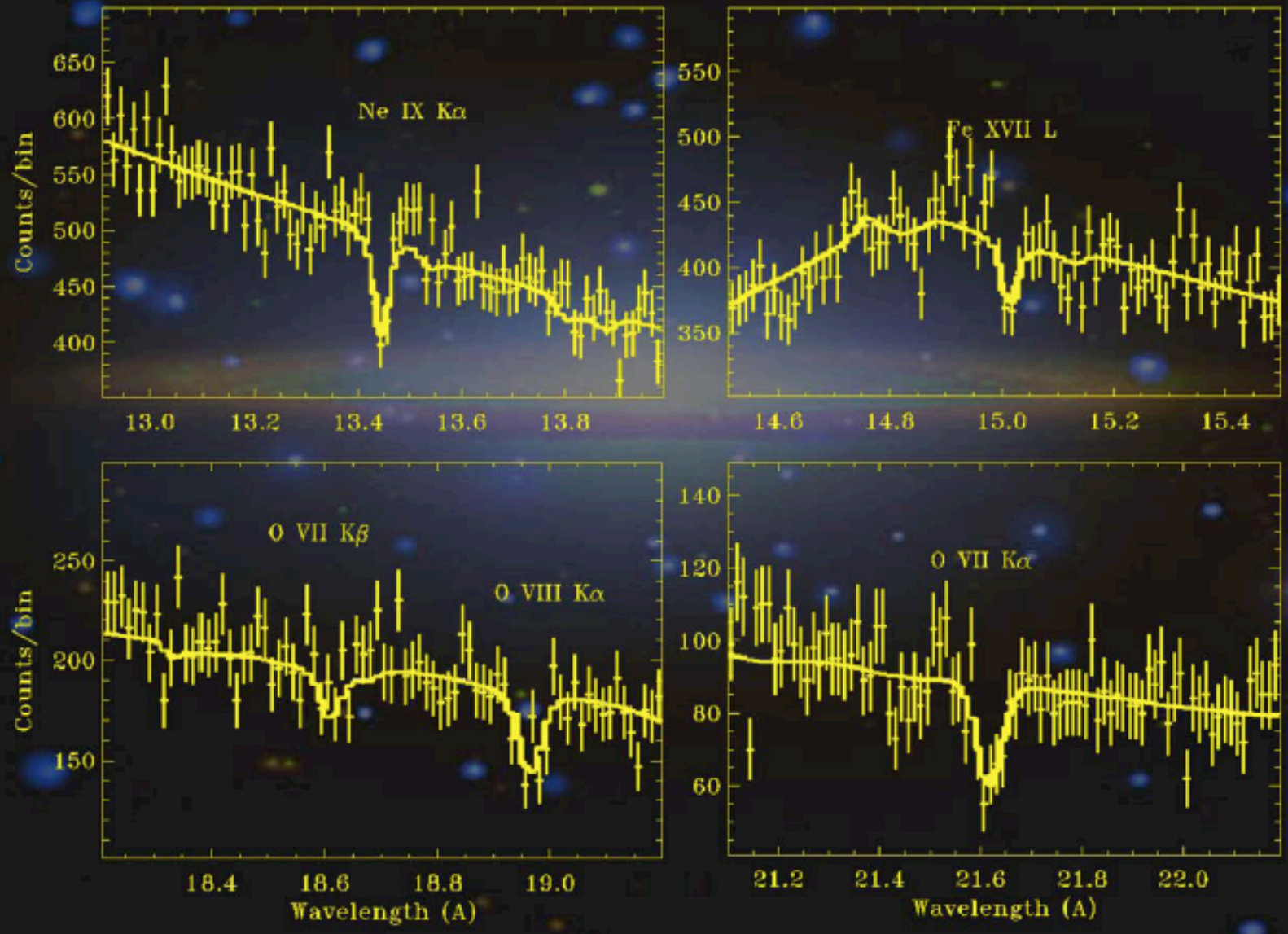
The hot gas in and around the Milky Way



3/4-keV (0.47-1.21 keV) Soft X-ray background map
(Snowden et al. 1997)

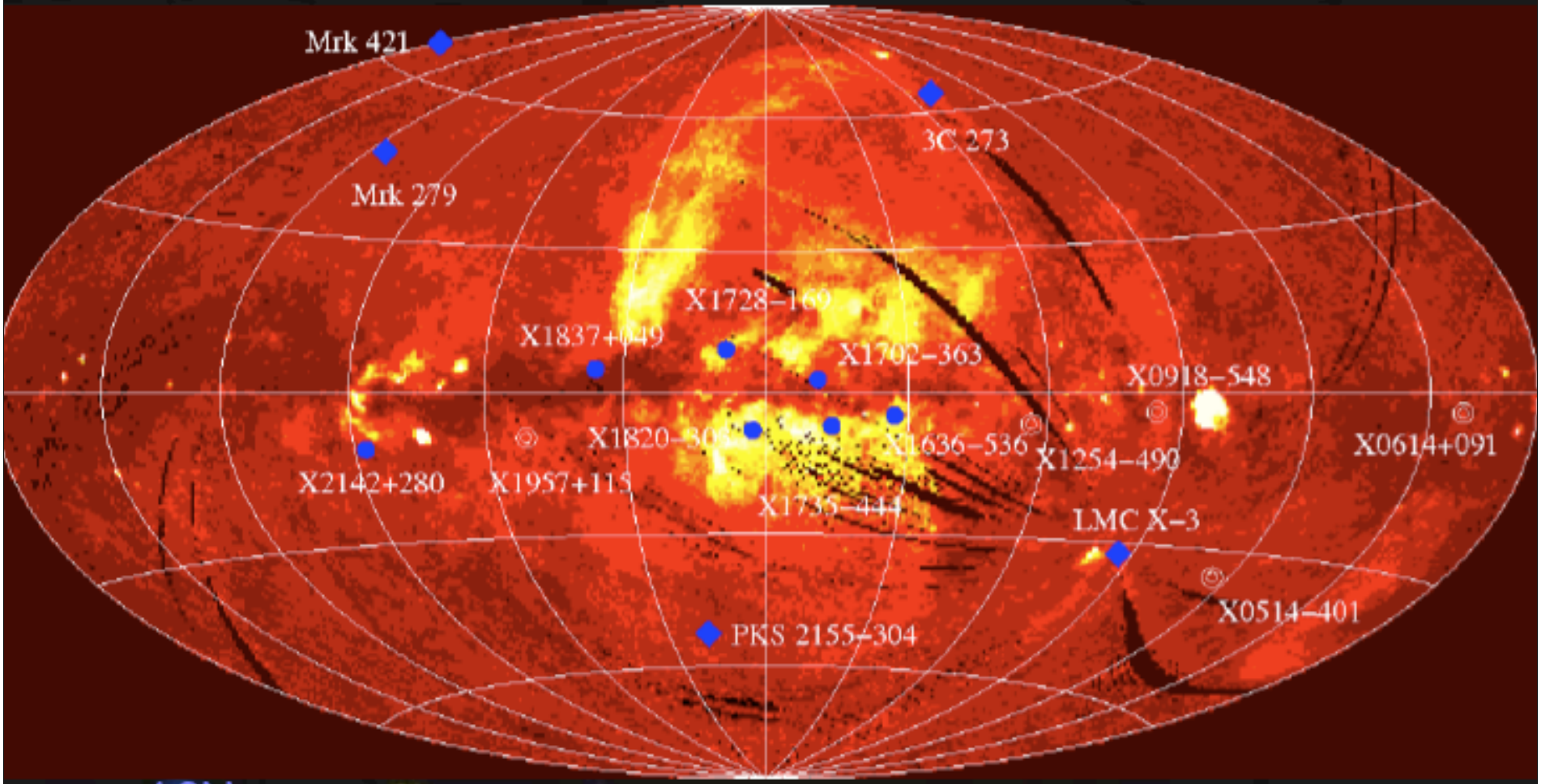
Absorption lines toward Galactic src: 4U 1820-303

Futamoto et al. 2004; Yao & Wang 2005, 2006; Yao et al. 2006



Target sight-lines

(and many more AGN)



◆ AGN

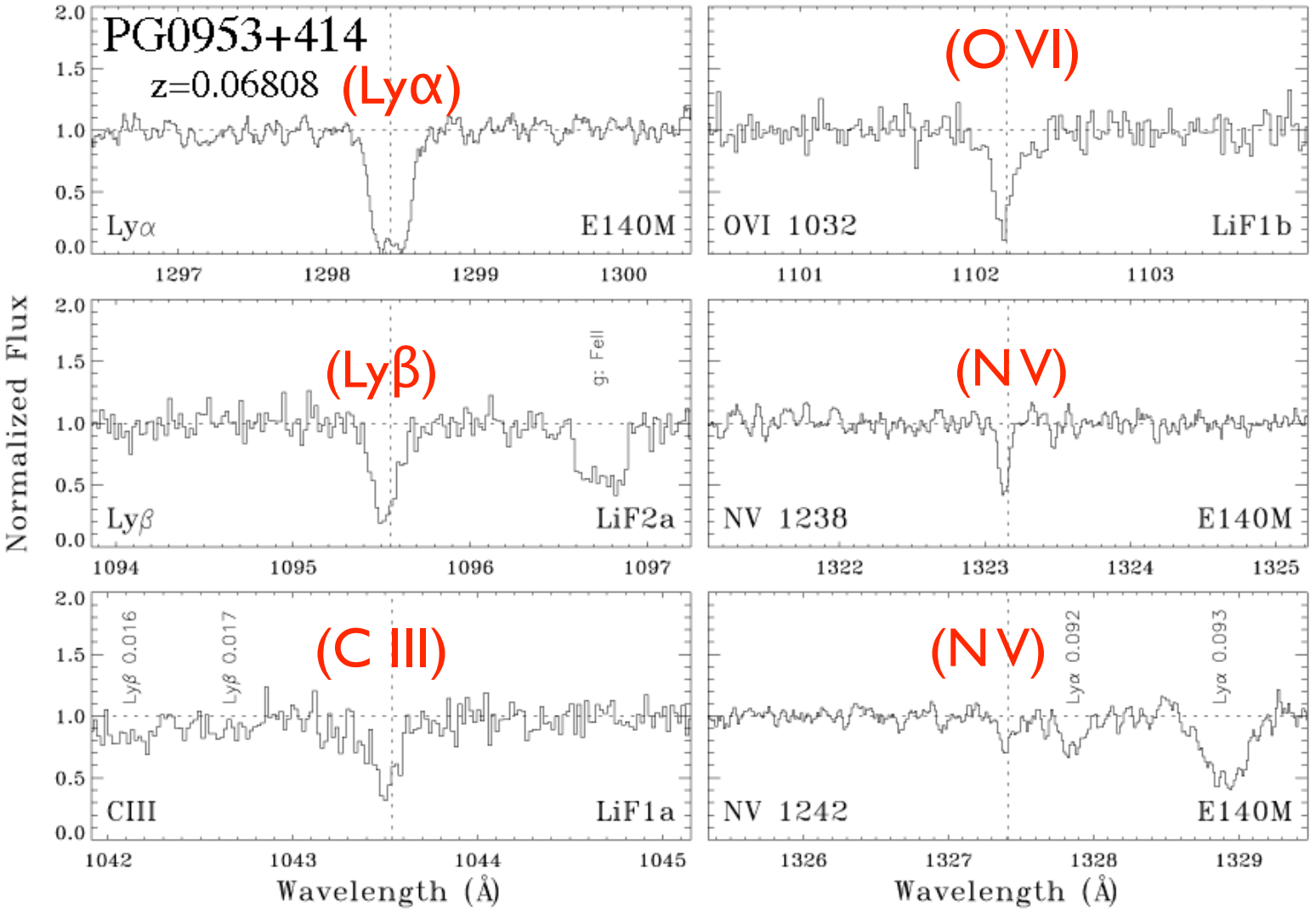
● Galactic X-ray binary

◎ Galactic X-ray binary: obs. nedded

Yao & Wang (2005)

STIS Echelle (E140M) and FUSE spectra

"UV Signposts"



Danforth & Shull 2008

Status of UV and X-Ray Spectroscopy

Hubble (STIS and COS) and FUSE:

Resolution R ~ 20,000-40,000 (7-15 km/s)

Sensitivity to $N_{OVI} > 10^{13}$ cm^{-2}

Chandra/XMM:

Resolution R ~ 300-400 (600-1000 km/s)

Sensitivity to $N_{OVII} > 10^{16}$ cm^{-2}

IXO (X-ray gratings):

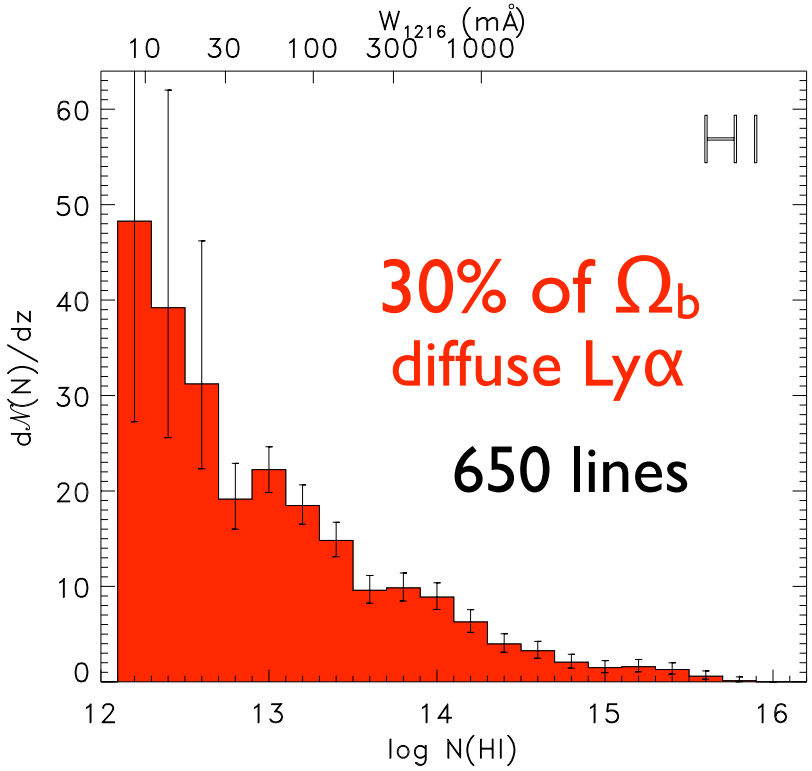
R > 1250 (goal should be R > 3000)

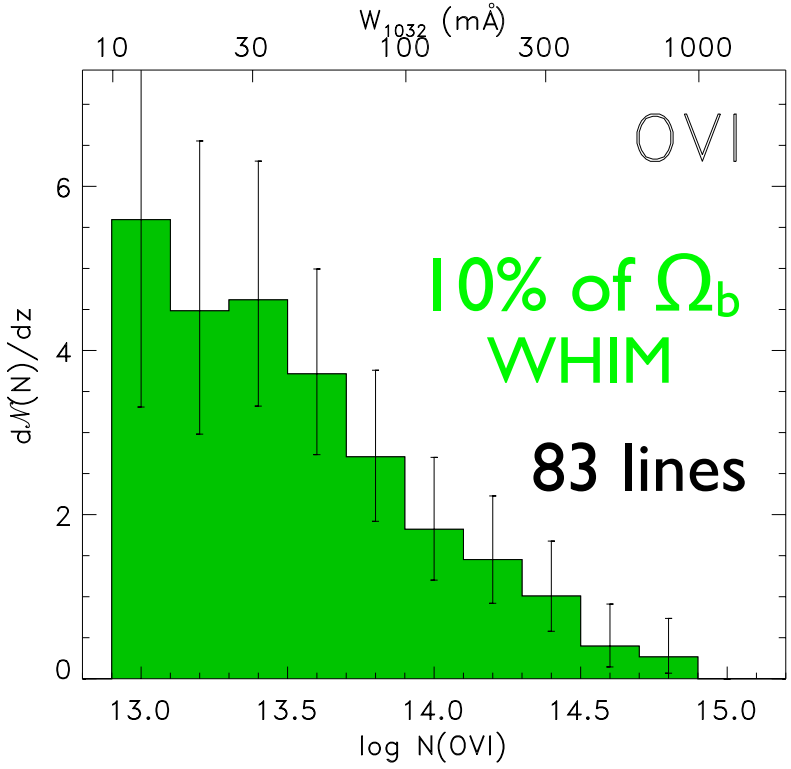
100 km/s resolution

Survey of the IGM at redshifts z < 0.4

Danforth & Shull 2008, ApJ, 679, 194

Column-Density Distributions: $f(N) \sim N^{-\beta}$



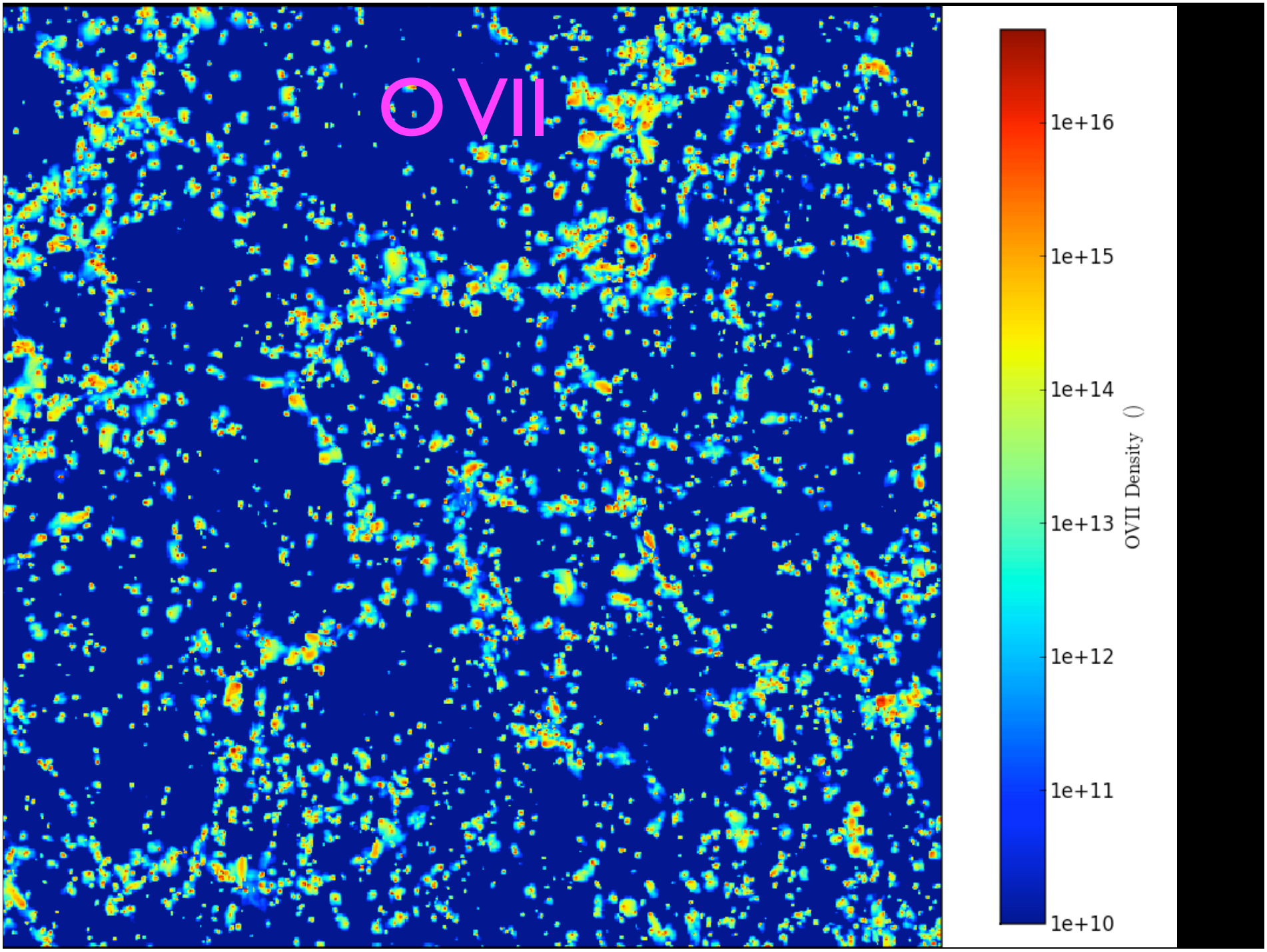


β=1.73±0.04

β=1.98±0.11

different slopes

Other O VI surveys (Tripp et al. 2008; Thom & Chen 2008)


O VII
1e+16
1e+15
1e+14
1e+13
1e+12
1e+11
1e+10
OVII Density ()

Plans for Con-X in IGM/Halo Studies

Need sensitivity and spectral resolution below 1 keV to trace key diagnostic lines (O VII, O VIII, Ne, N, C ions) in the hot (shock-heated) IGM and intervening galactic halos.

69 AGN with $F_x > 4 \times 10^{-12}$ erg cm^{-2} s^{-1} (0.2 mCrab)
20 bright X-ray binaries (Galactic Halo, Local Group) that are ten-times brighter ($F_x > 4 \times 10^{-11}$)

Resolution R = 1250 (minimum) and 3000 (goal) in order to match 100 km/s thermal line widths and increase sensitivity to 10^6 K gas with $N_{OVII} \geq 10^{14}$ cm^{-2}

Good News: With HST/COS, we should have ~10^4 Lyα lines and 500 O VI lines that serve as "UV signposts" to IGM filaments