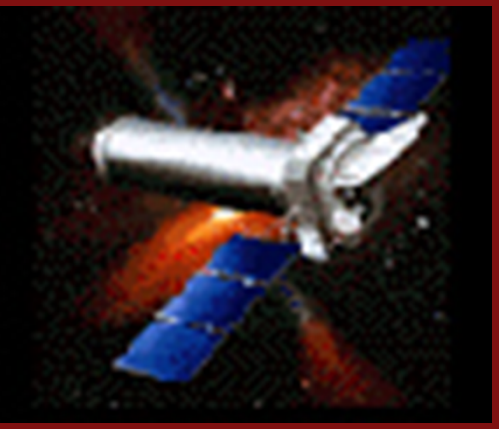
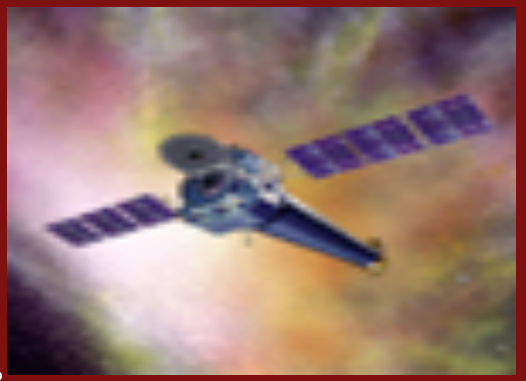
The relics of AGN feedback in our Milky Way

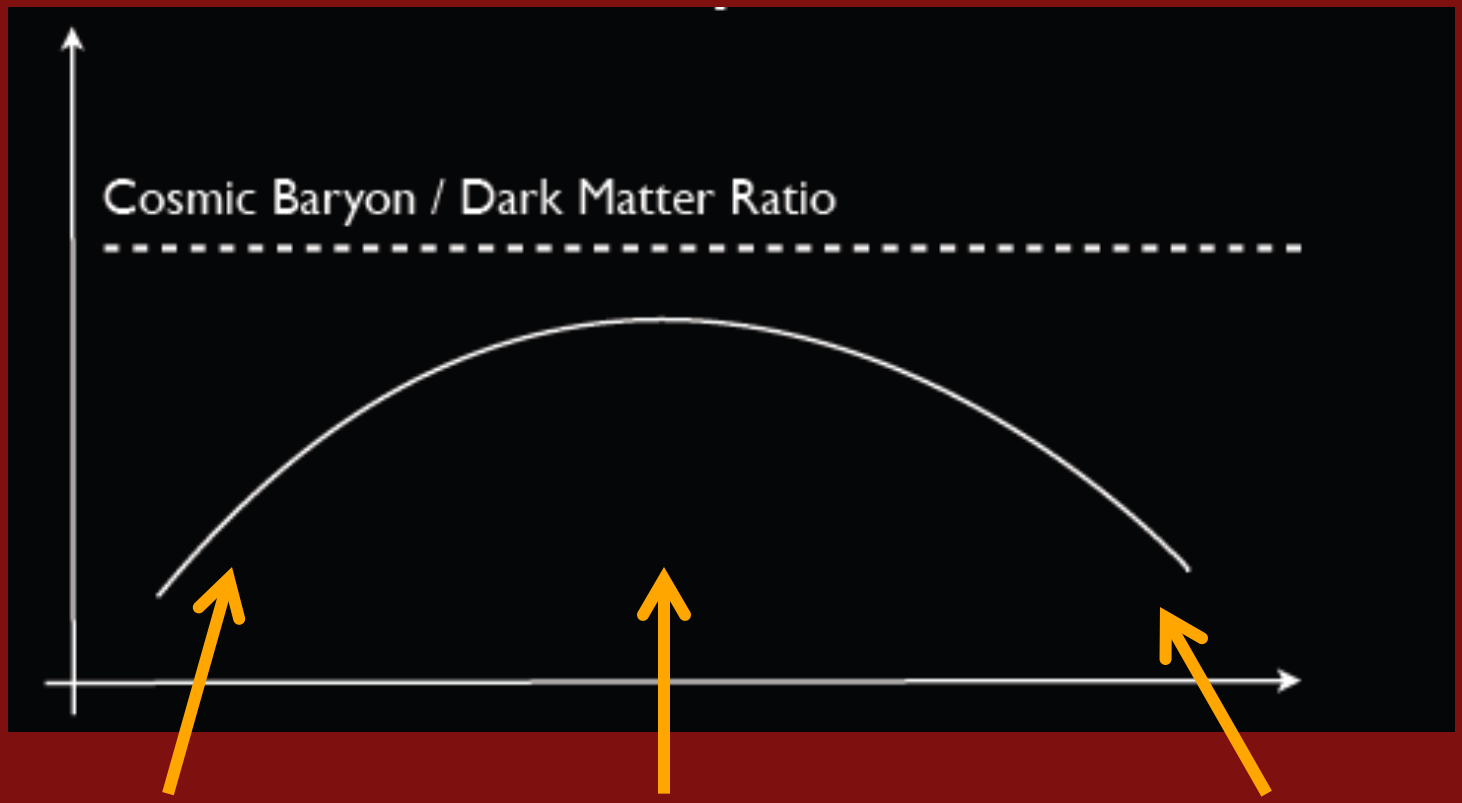




Smita Mathur
The Ohio State University

With
F. Nicastro, F. Senatore,
A. Gupta, Y. Krongold, M. Elvis

In the low-redshift Universe, baryons are missing on all scales



Circumgalactic medium (CGM)

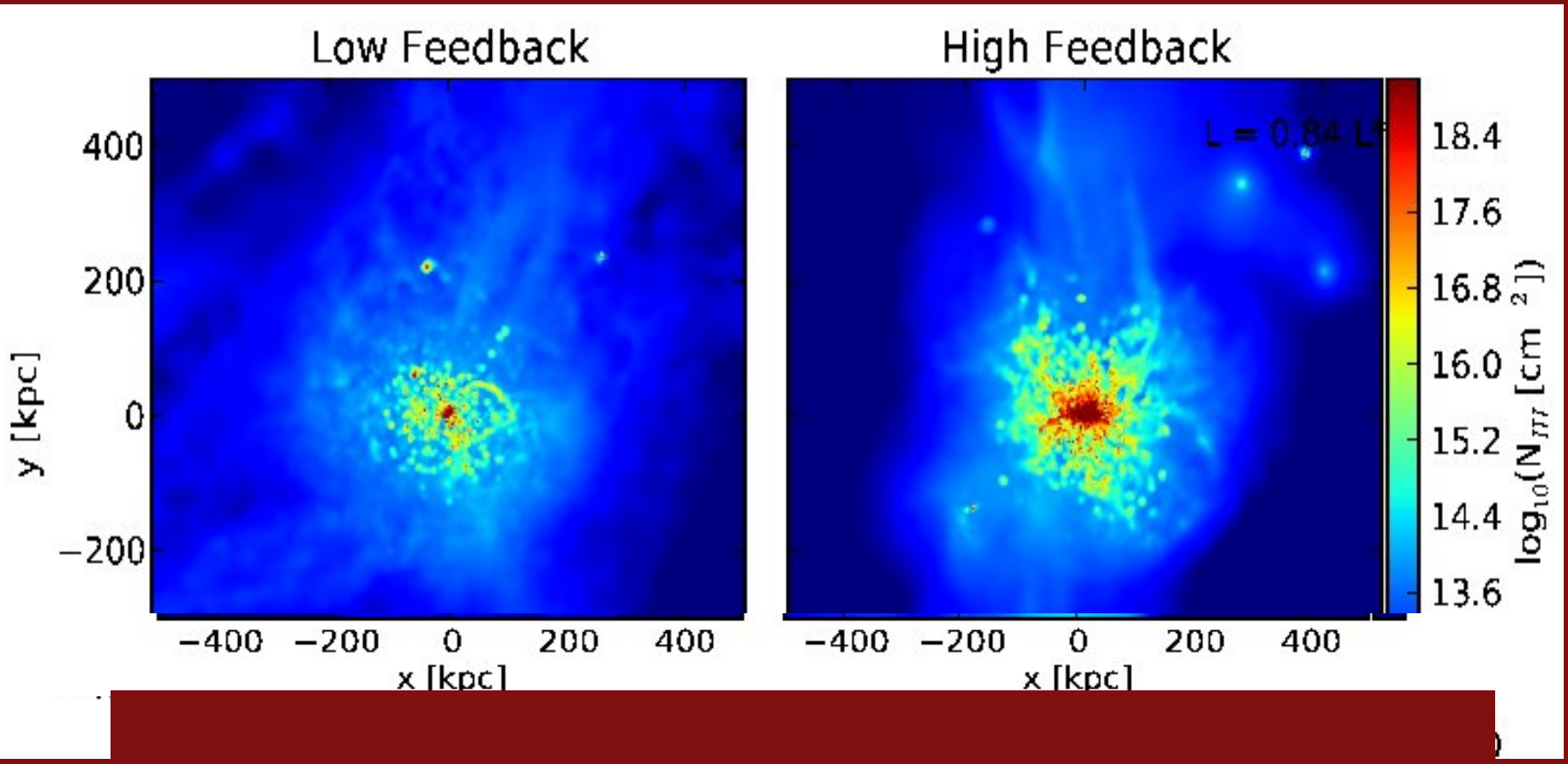
=

Galactic corona

=

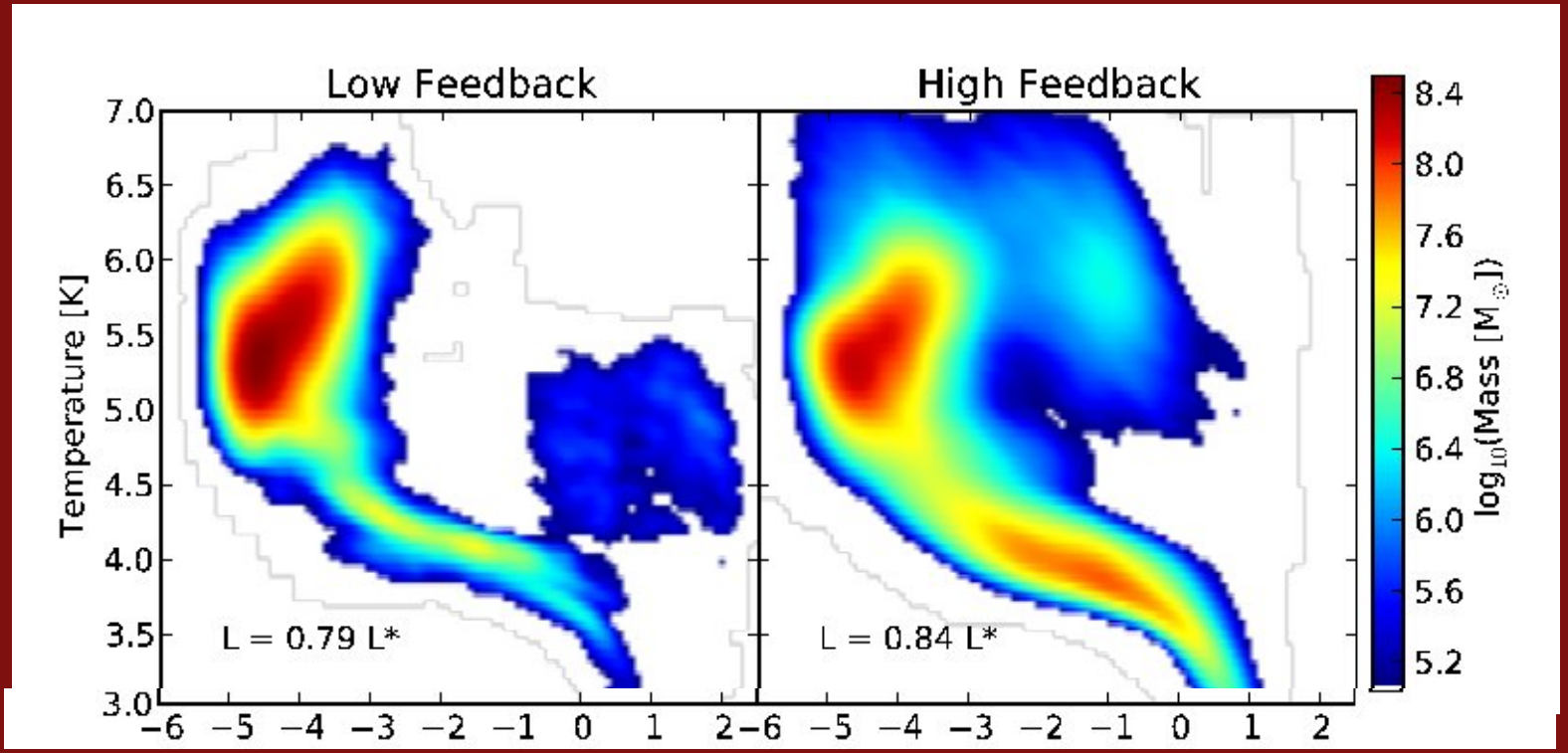
Gaseous halo

Simulations of the CGM



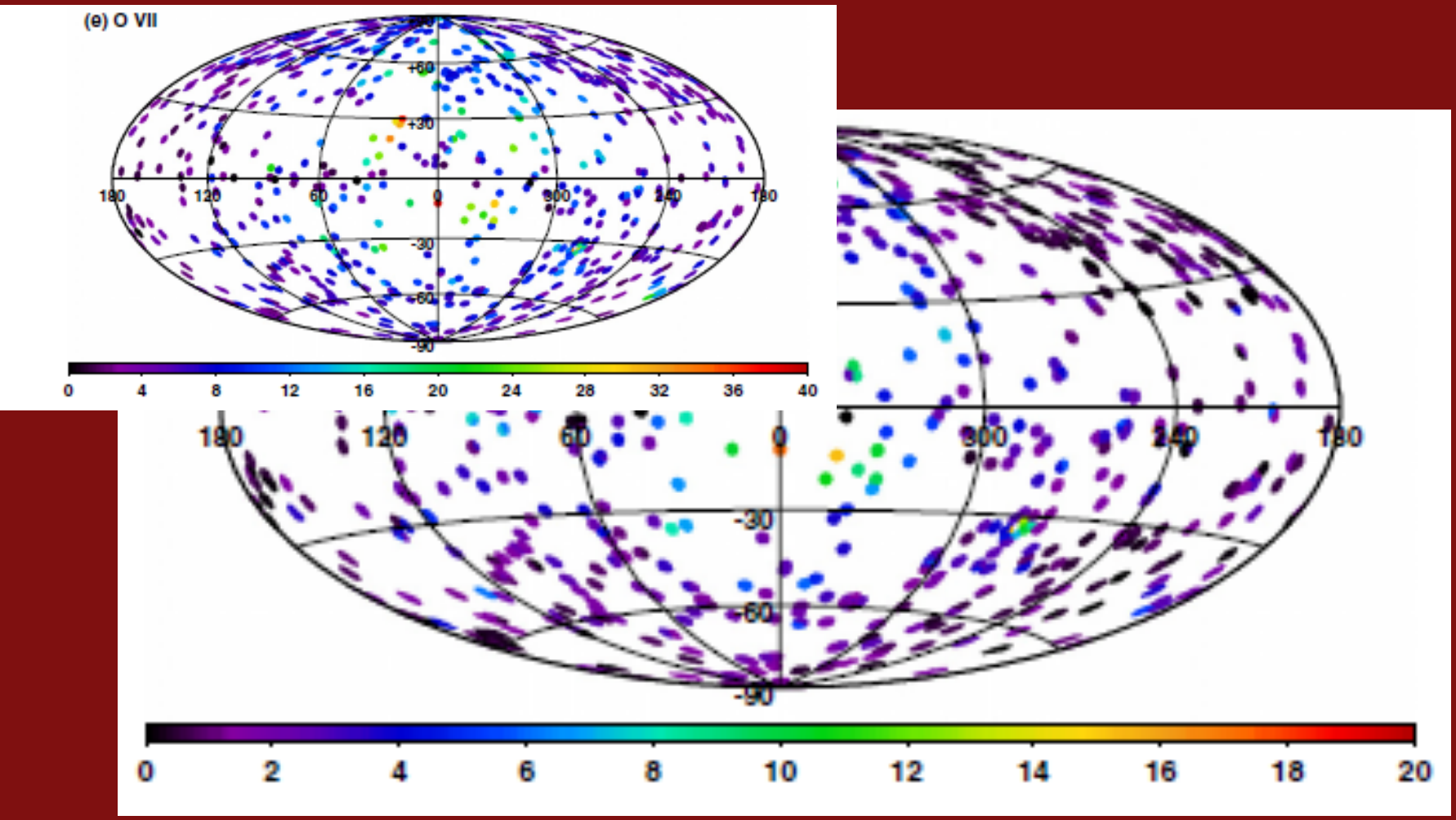
Stinson et al. 2011

Diffuse Warm-hot CGM



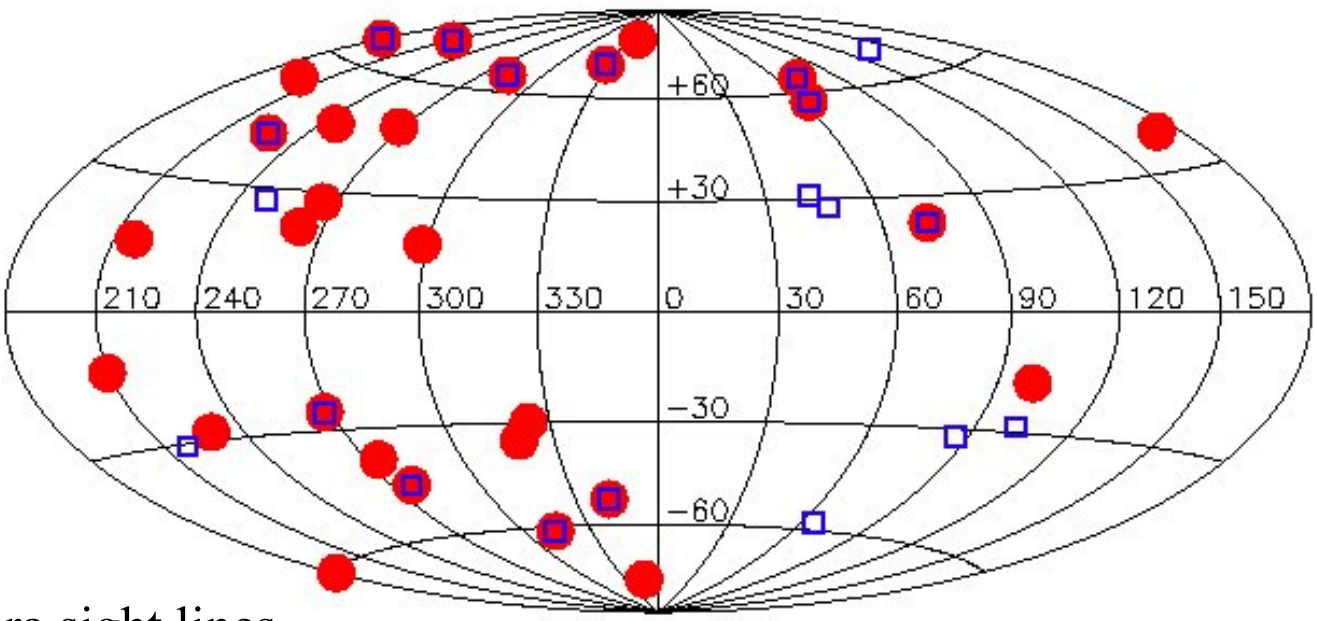
Log Density

Galactic Halo Emission



Henley & Shelton

Our Chandra Survey of OVII and OVIII



Chandra sight lines

Previous OVII detection

Mass Probed by OVII and OVIII X-ray Absorbing/Emitting Gas Phase

$$M_{total} > 1.7 \times 10^{9}\ (fc/0.72)\ (8.51 \times 10^{-4}/(A_O/A_H))^3 (0.5/f_{OVII})^5 (Z_\Theta/Z)^3 M_\Theta$$

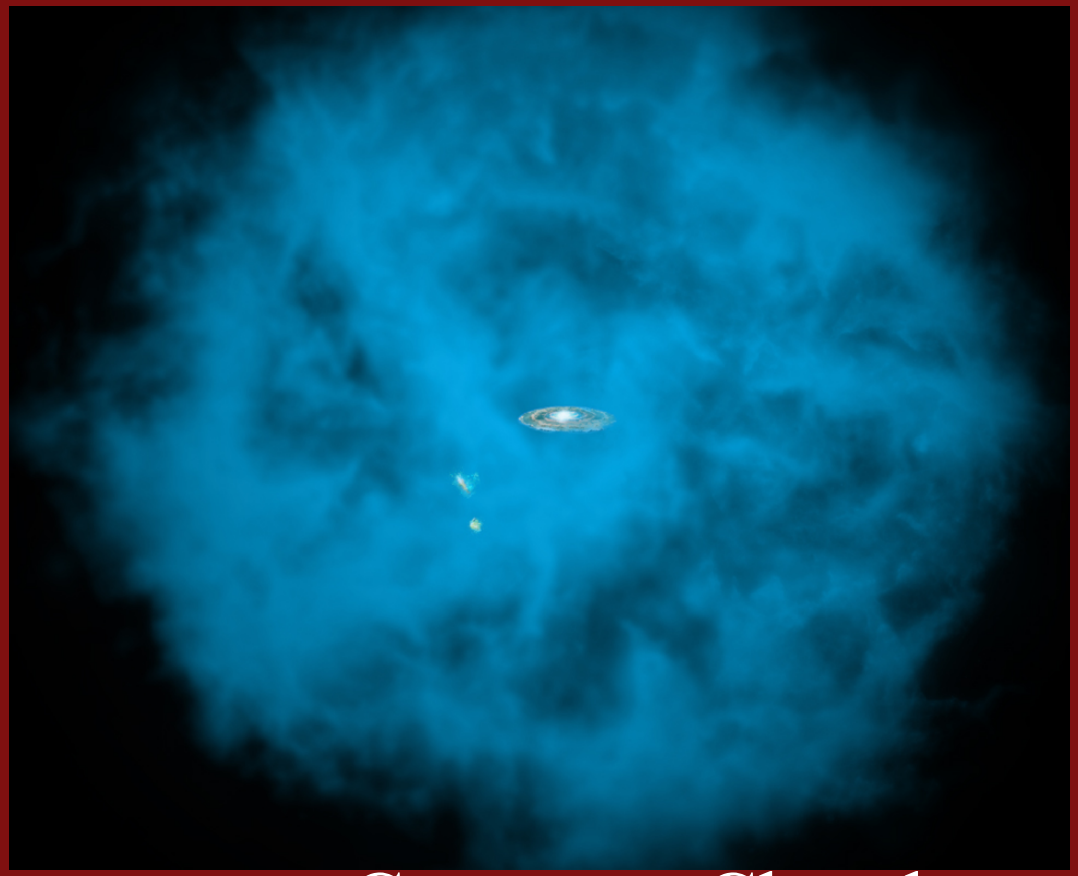
For $Z = 0.3 Z_\Theta$

$L > 138$ kpc

$M_{total} > 6.1 \times 10^{10}\ M_\Theta$

Gupta, Mathur + 2012, 2014,2016

Massive, Extended Galactic halo

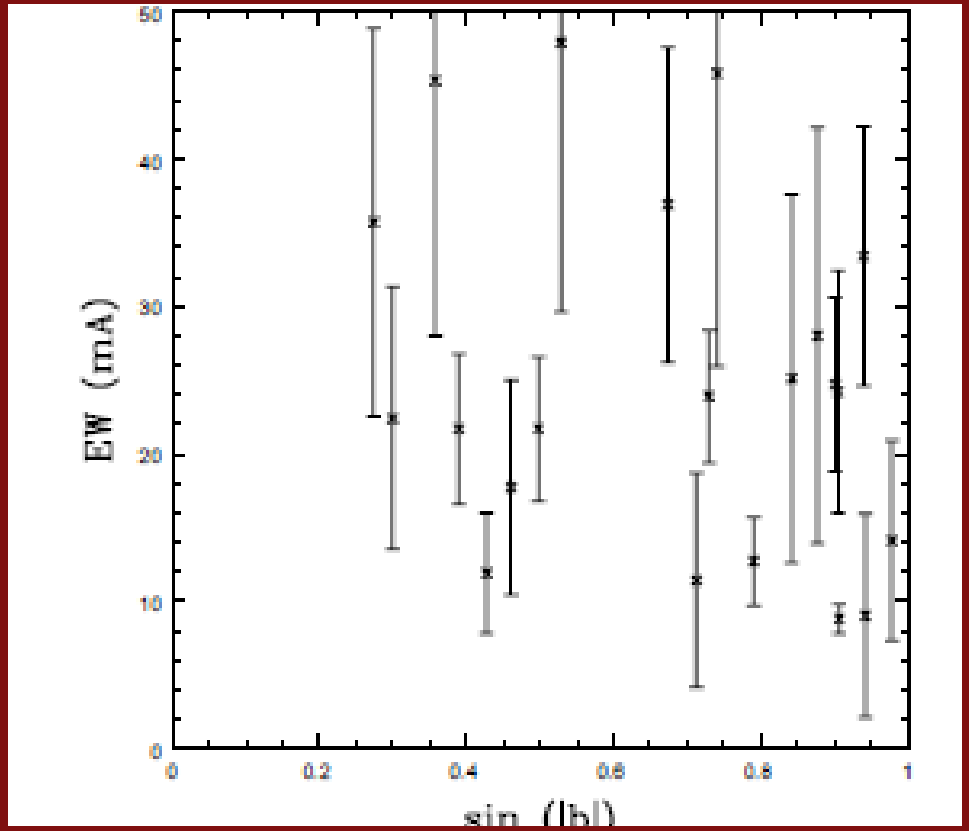


Courtesy: Chandra presss office

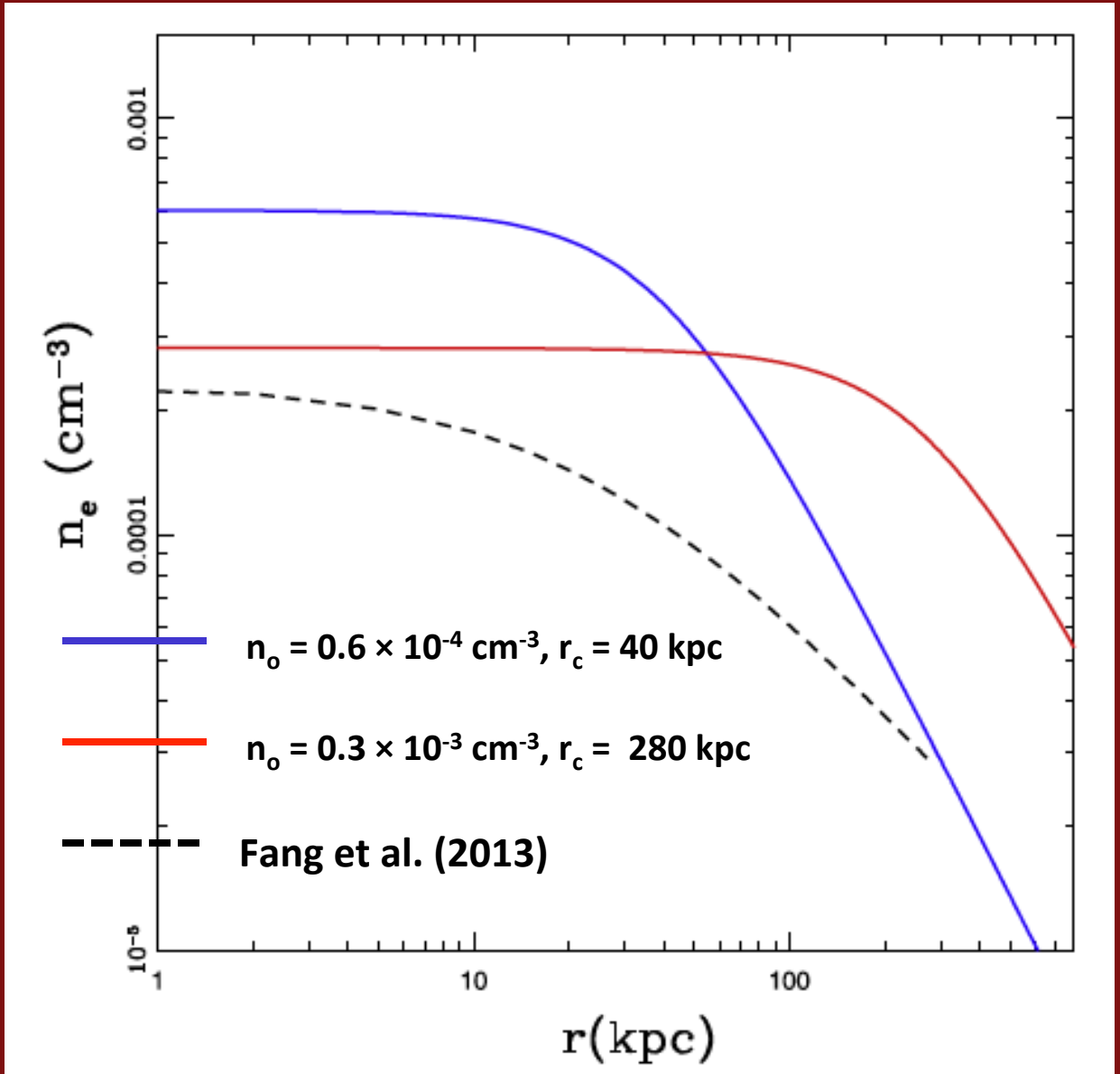
How robust is this result?

- Is the z=0 absorption mostly from the Galactic disk?
- Large range of absorption and emission measures.
- What about the uniform density profile?
- Are the emission and absorption at different temperatures?

….. no anticorrelation between EW and sin(b)



β- Model

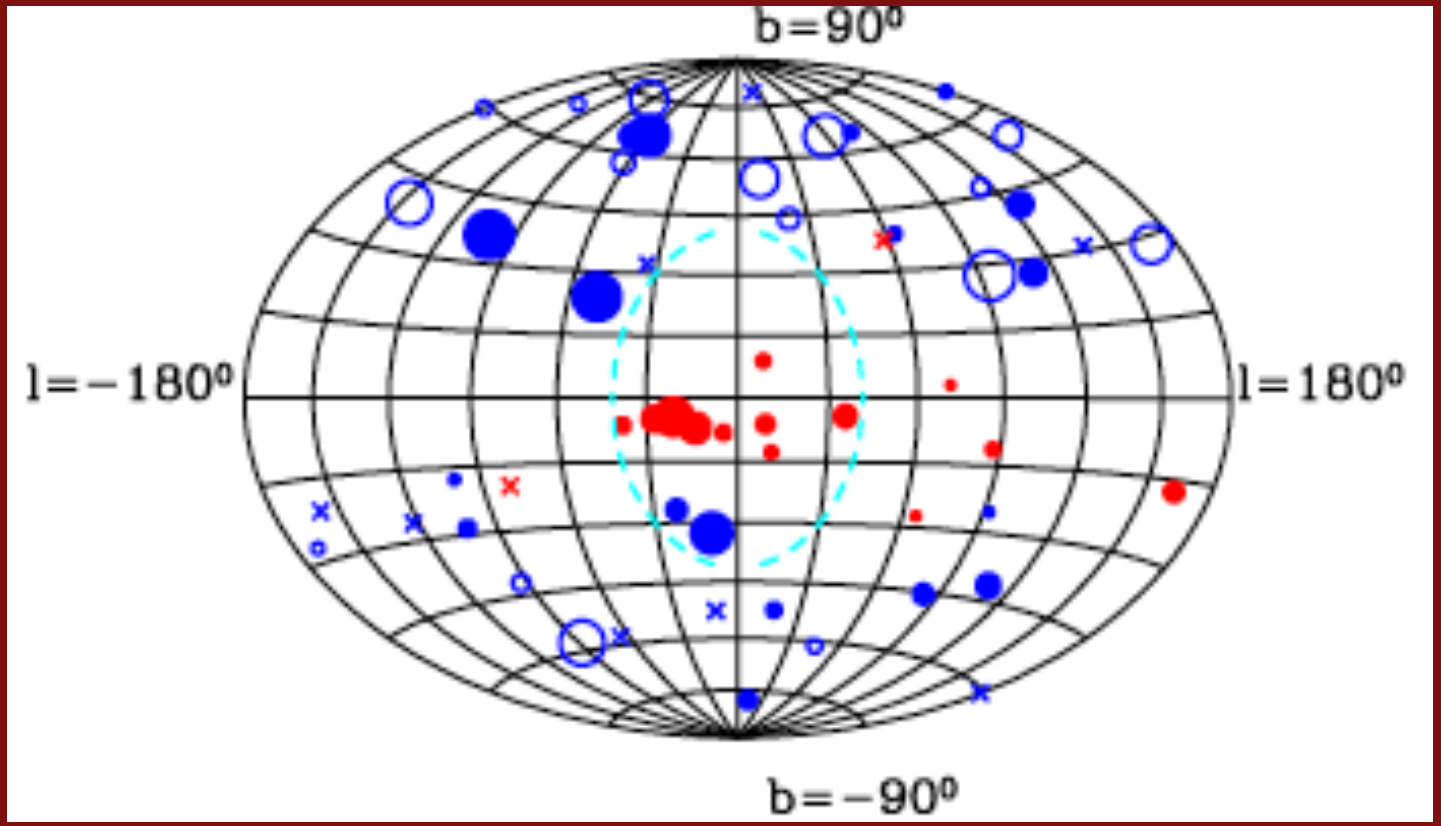

0.001
0.0001
10^{-5}
n_e (cm^{-3})
1
10
100
r(kpc)
$n_o = 0.6 \times 10^{-4}$ cm^{-3}, $r_c = 40$ kpc
$n_o = 0.3 \times 10^{-3}$ cm^{-3}, $r_c = 280$ kpc
Fang et al. (2013)

This is a robust result!

- Is the z=0 absorption mostly from the Galactic disk? **No**.
- What about the uniform density profile? **No problem: gives a lower limit on mass**.

  β- Model shows extended profile.
- Are the emission and absorption at different temperatures? **No**.

Galactic and extragalactic sightlines

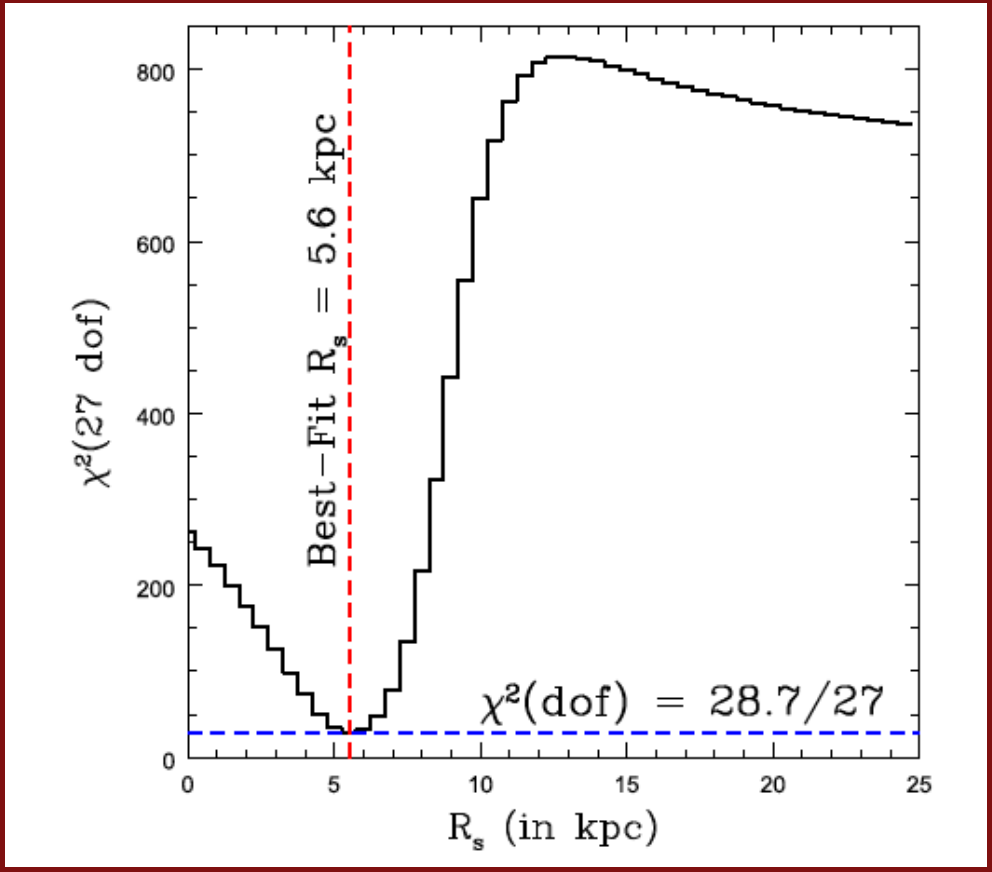


Nicastro et al. 2016

A symmetric β-model did not yield an acceptable solution!

$$n(R) = n_0[1 + (R - R_s)^2/R_c^2]^{-3\beta/2}$$

A 6-kpc offset radius is required!



- Both the Galactic plane and the halo are filled with million degree hot gas
- There is a hole in the middle. A bubble of radius 6kpc centered on the Galactic center.
- Relic of the AGN activity few million yrs ago
- The mass reservoir in the hot halo is huge.

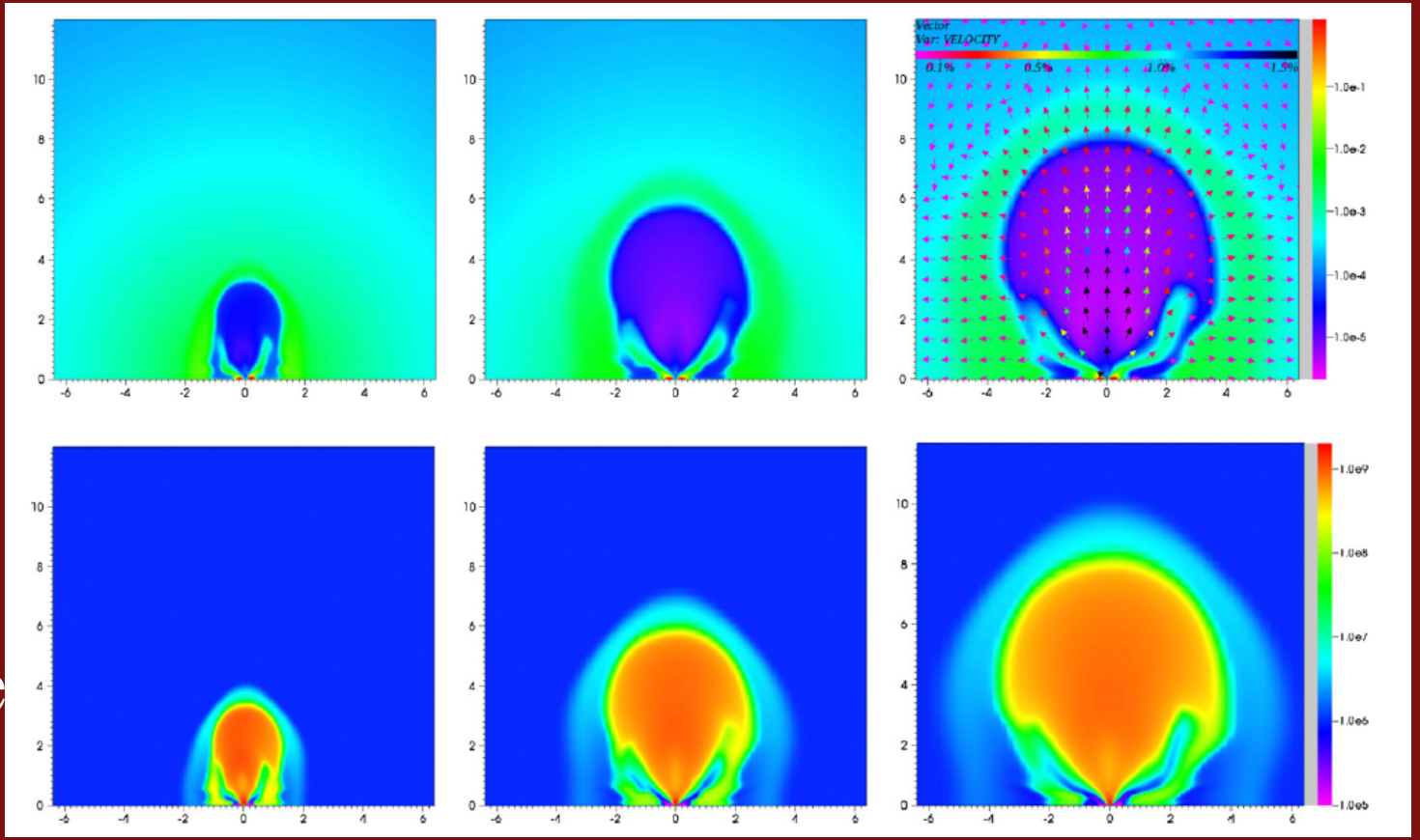
Fermi bubbles

-- a relic of past AGN activity

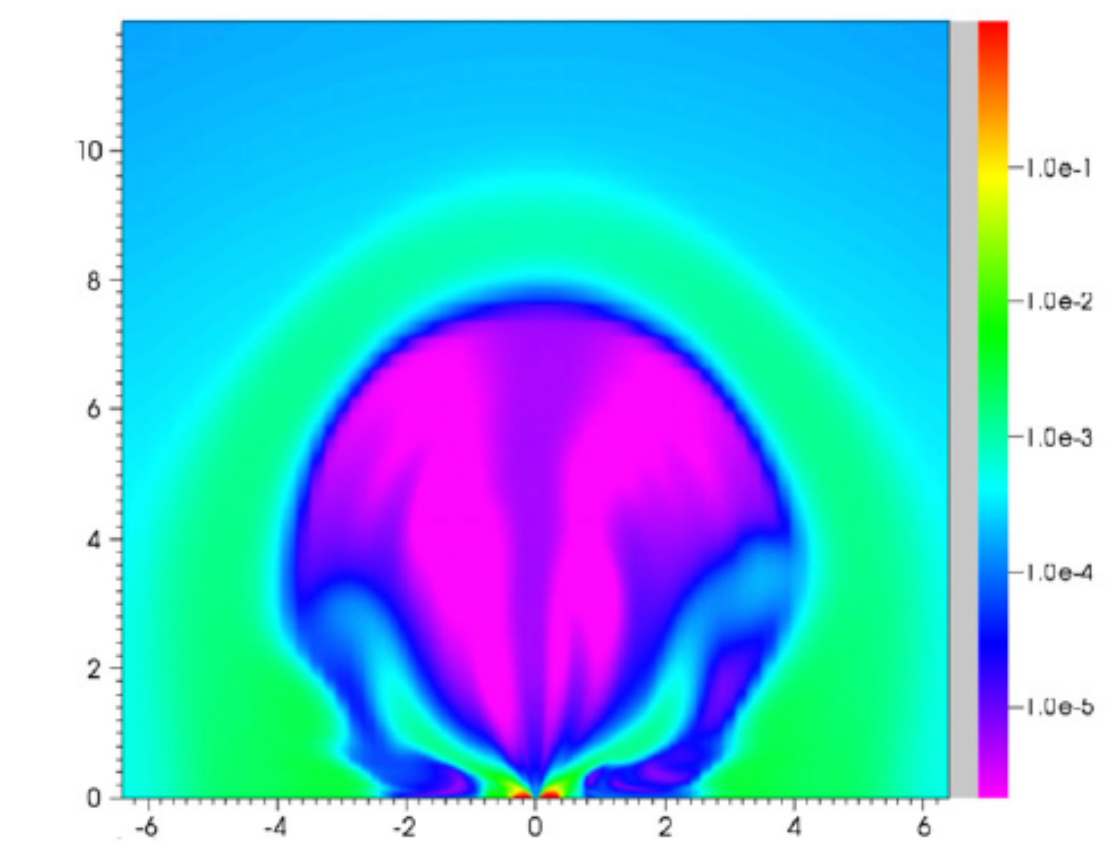
4 Myr 8 Myr 12.3 Myr

Density

Temperature



Mou et al. 2014



Number density distribution. Mou et al. 2014.

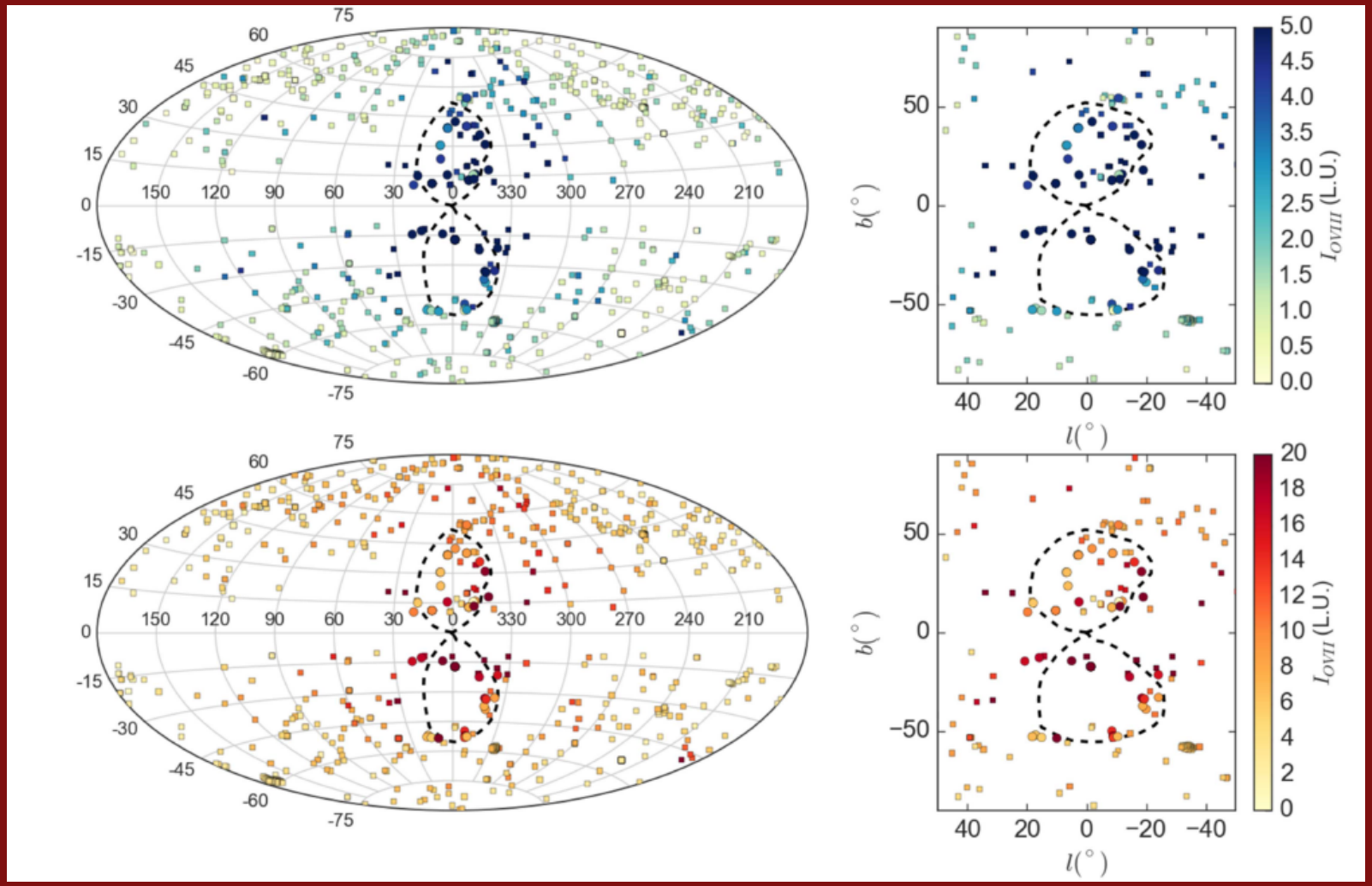
Future directions

- Probing the anisotropy: emission and absorption along the same sightline.

  -- New Suzaku observations (Done!)

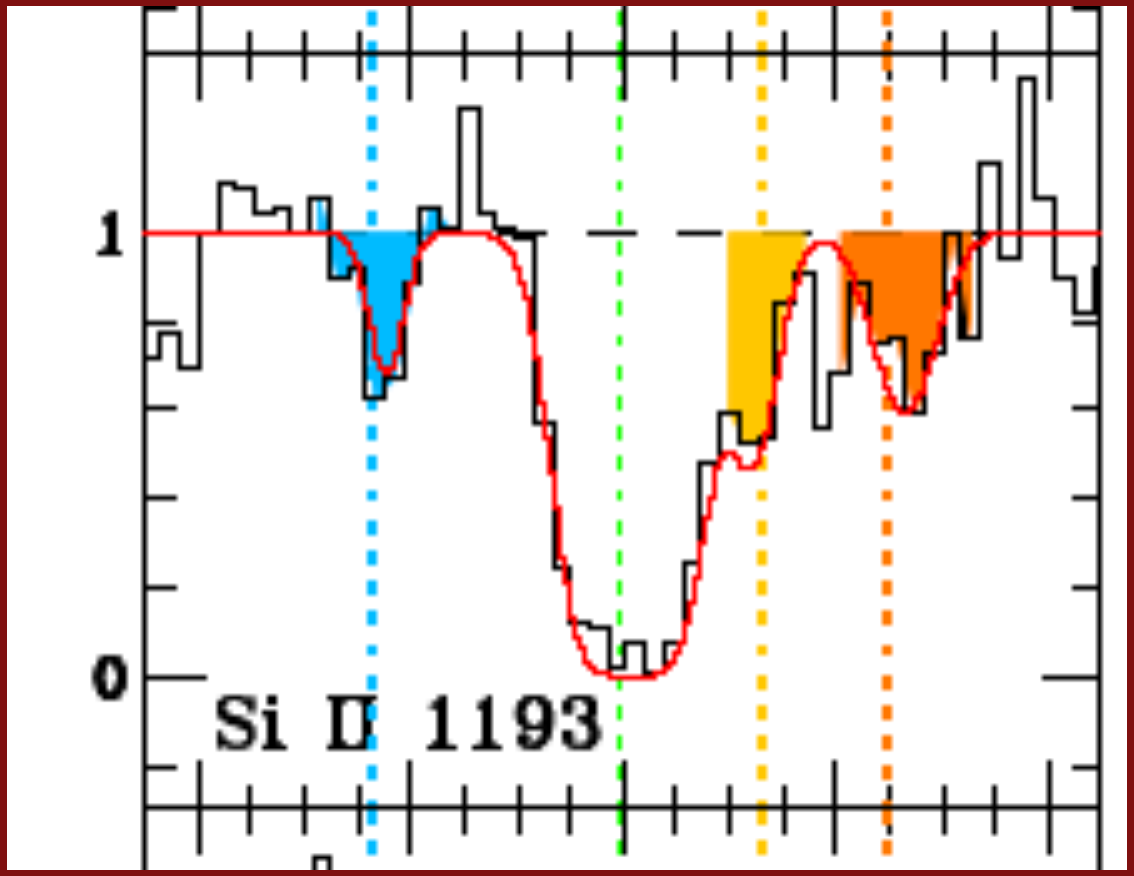
  -- New XMM-Newton Observations (Done!)
- Different density and temperature profiles: e.g. Maller-Bullock profile in NFW halo.
- Probing the multi-phase medium: other ions dominant at different temperatures.

Bubble shells in X-ray emission



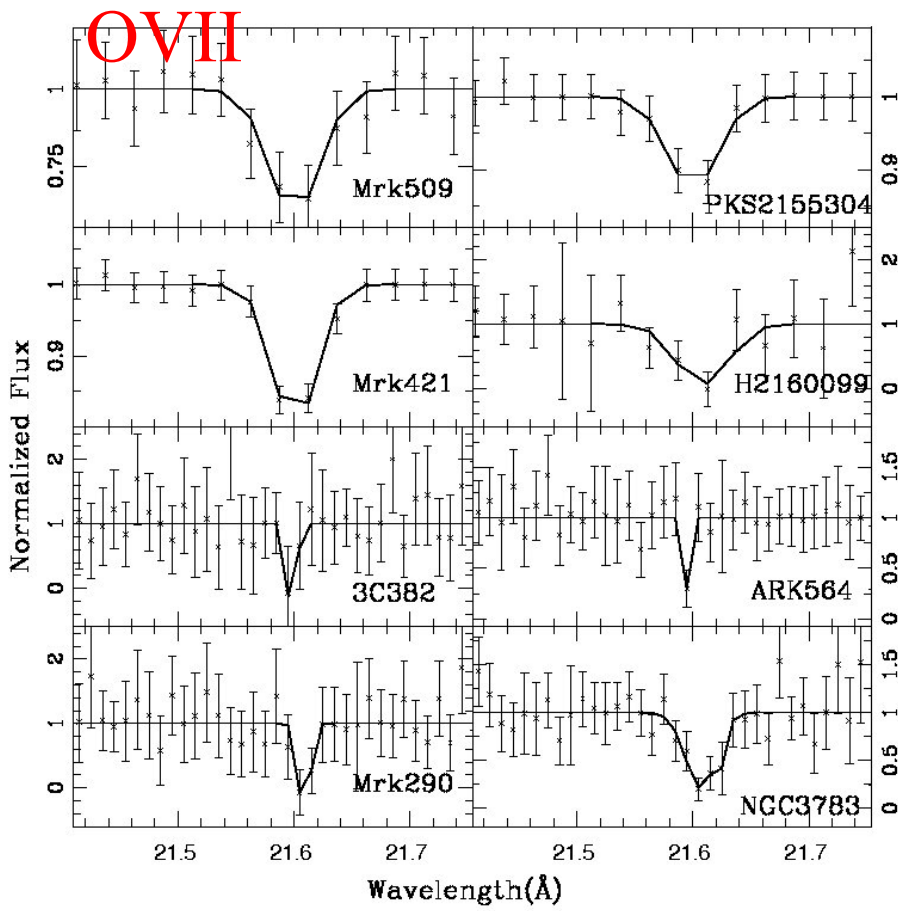
Miller et al. 2016

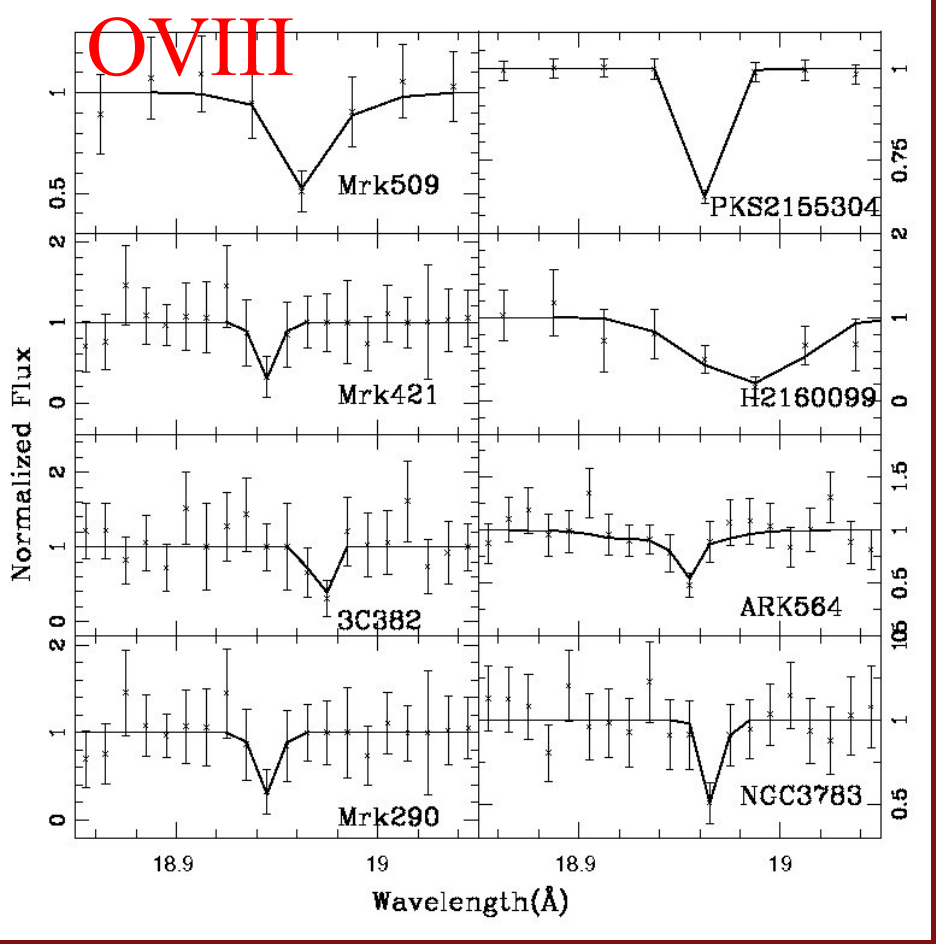
Outflow in UV absorption lines



Fox et al. 2015

OVII and OVIII z=0 Absorption





- *Log T = 6.1-6.4 K*