Hot Galactic Halos

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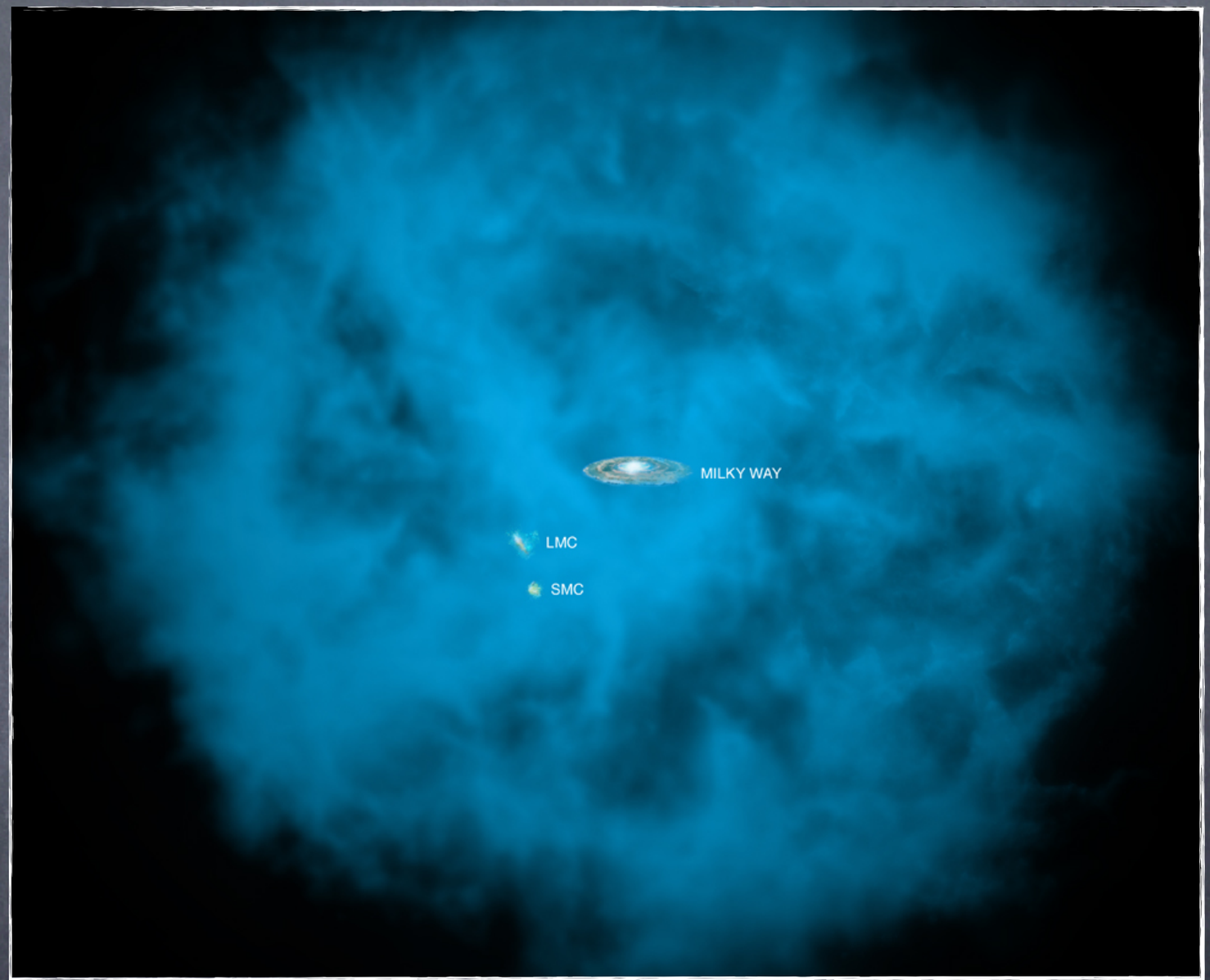


Credit: Chandra press release (2012)

Introduction: Evidence for Hot Gas

metals absorption

In the Milky Way

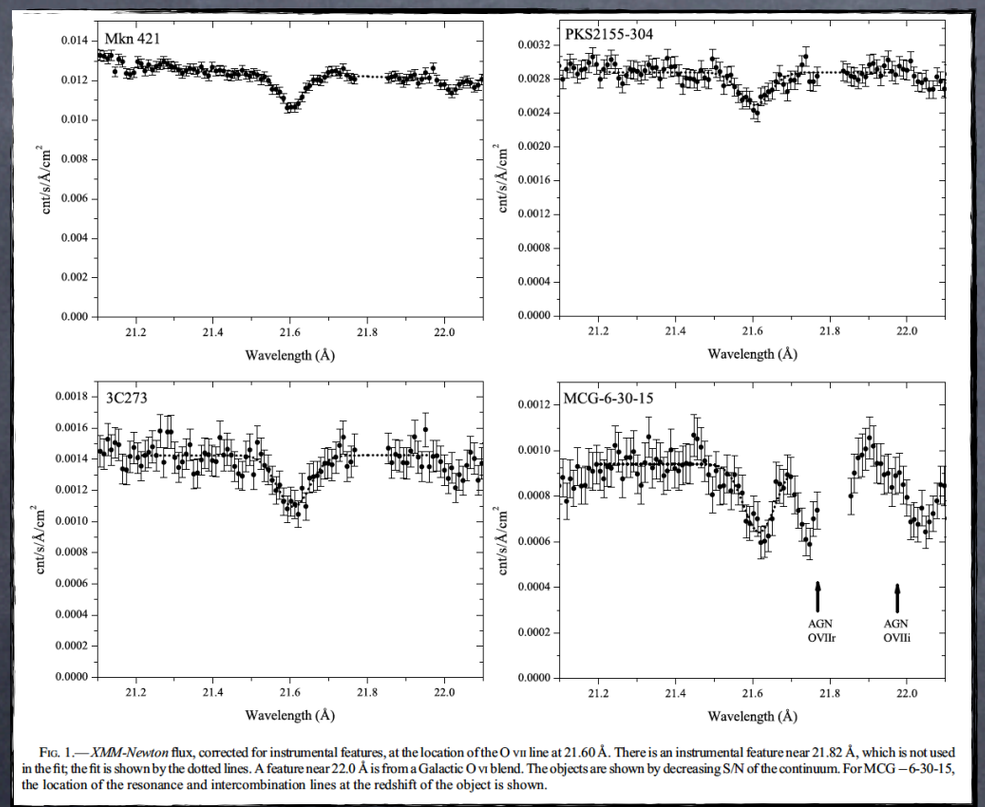
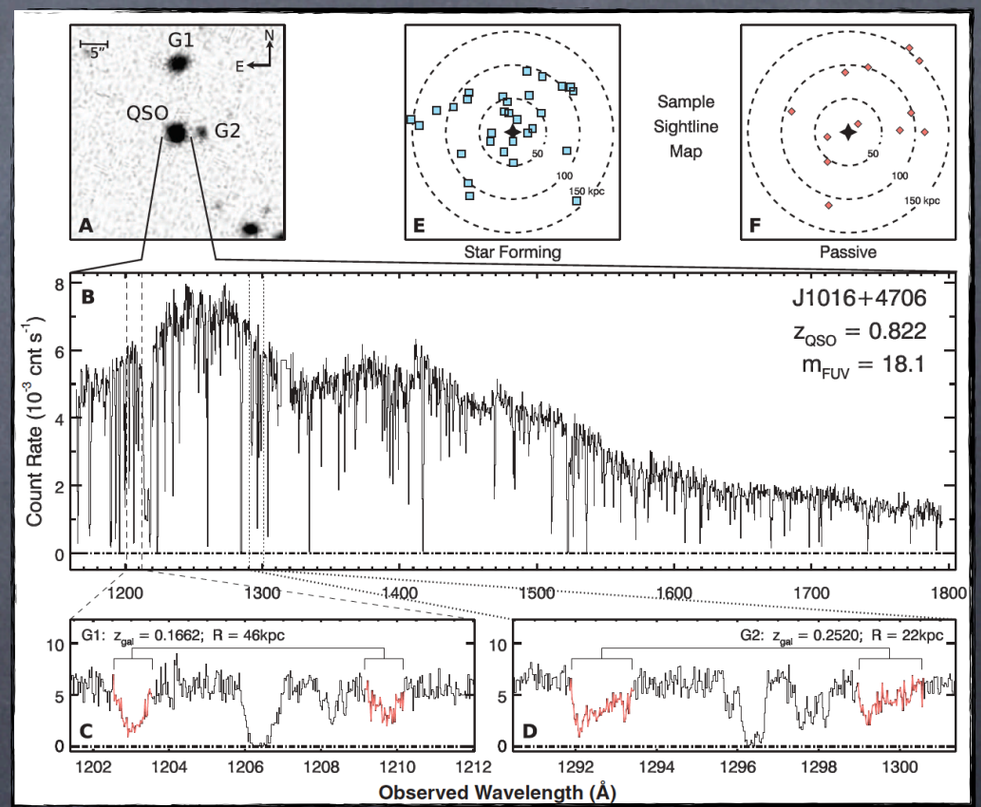


FIG. 1.—*XMM-Newton* flux, corrected for instrumental features, at the location of the O VII line at 21.60 Å. There is an instrumental feature near 21.82 Å, which is not used in the fit; the fit is shown by the dotted lines. A feature near 22.0 Å is from a Galactic O VI blend. The objects are shown by decreasing S/N of the continuum. For MCG −6-30-15, the location of the resonance and intercombination lines at the redshift of the object is shown.

Bregman & Lloyd Davies 2007

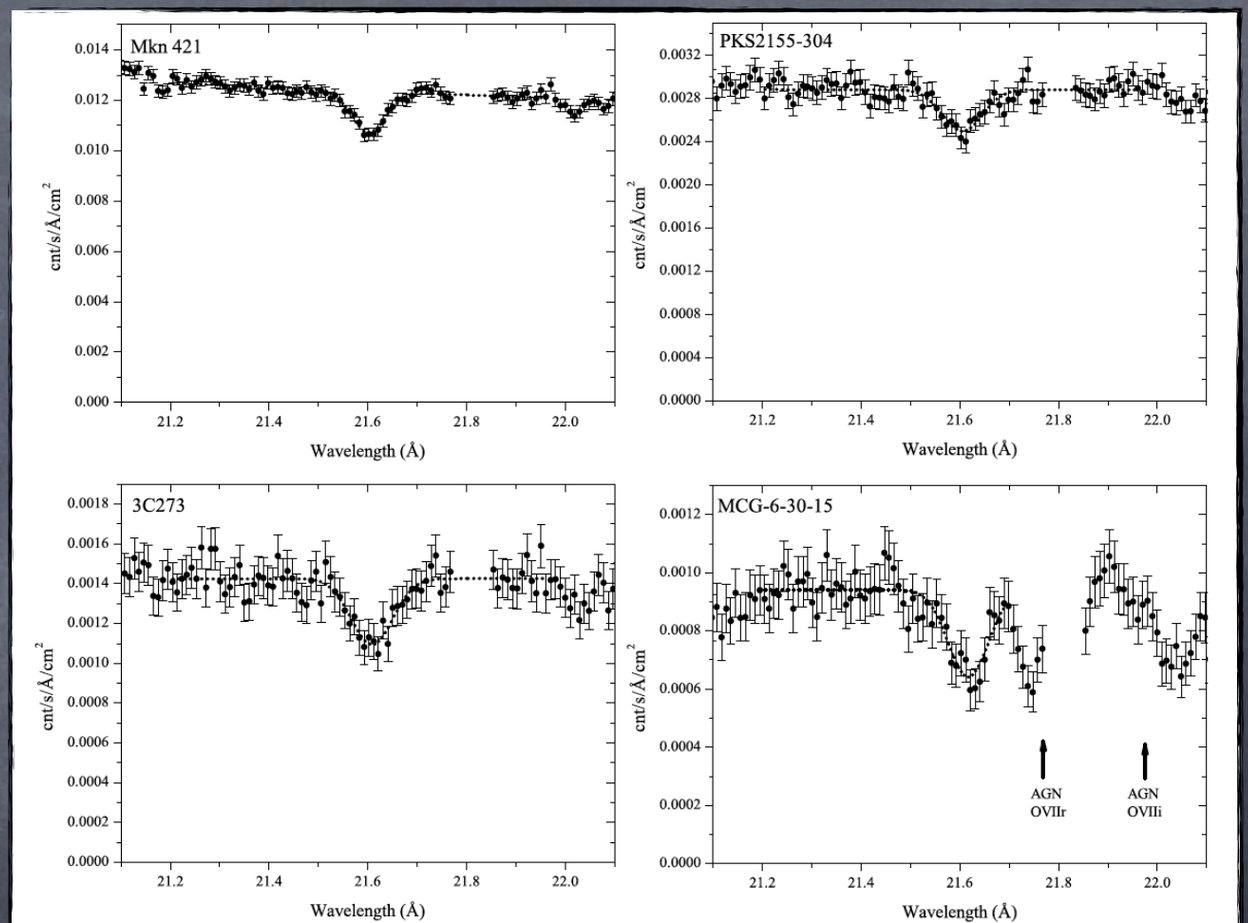
and in other galaxies



Tumlinson+ 2011

X-Ray absorption

- mainly OVII,
  some OVIII
- OVII - detection
  in ~30 QSO spectra
- large column densities
  ~5×10^{15} cm^{-2}



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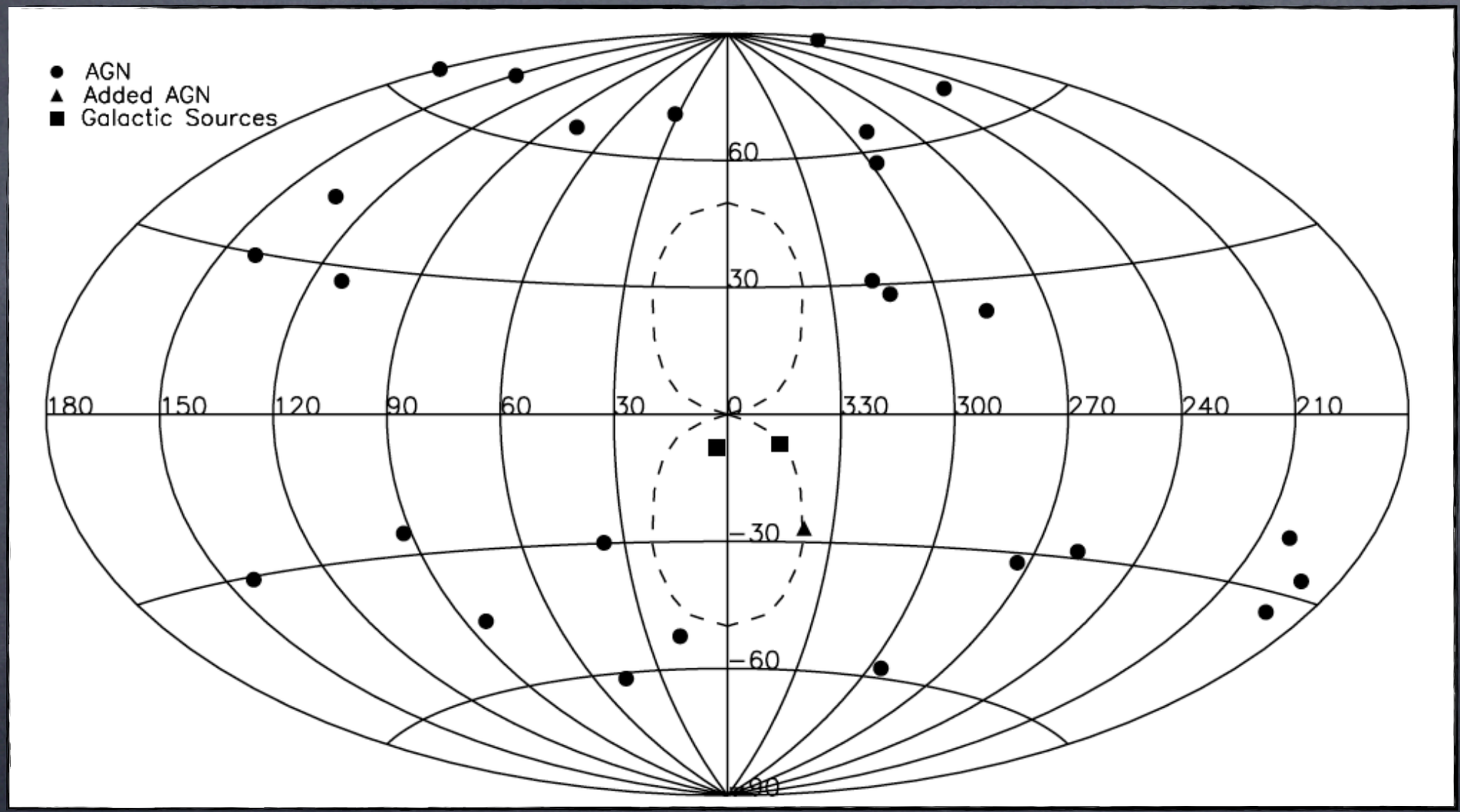
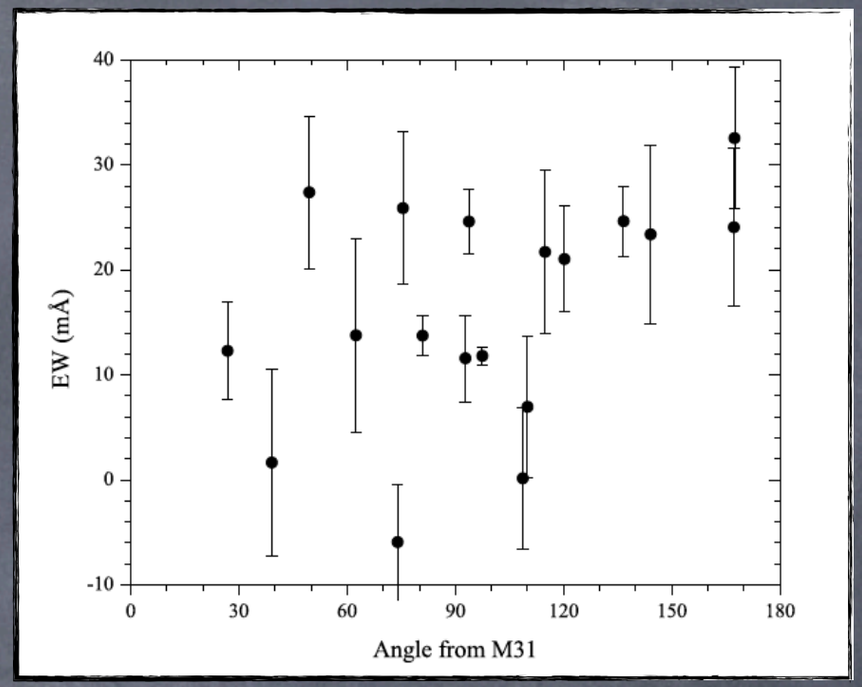
X-Ray absorption

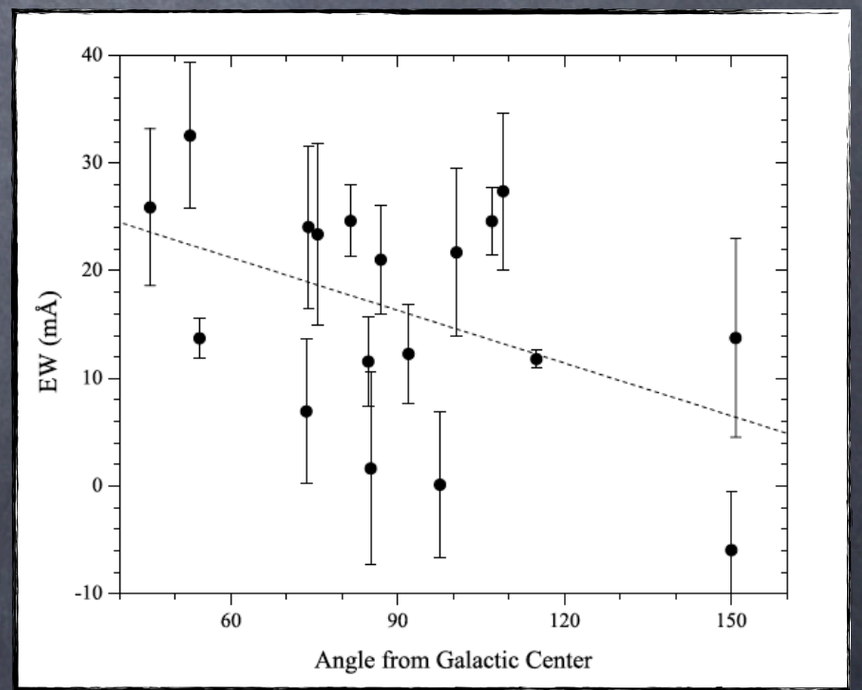


Miller & Bregman 2013

Where is the gas?

- z=0 - local medium
- Low spectral resolution - absorption origin unknown
- Local Group vs. Milky Way scenario (But maybe even in the disk ?)
- Bregman & Lloyd Davies 2007 - Milky Way origin





UV Absorption

COS-Halos Survey

Cosmic Origins Spectrograph (HST)

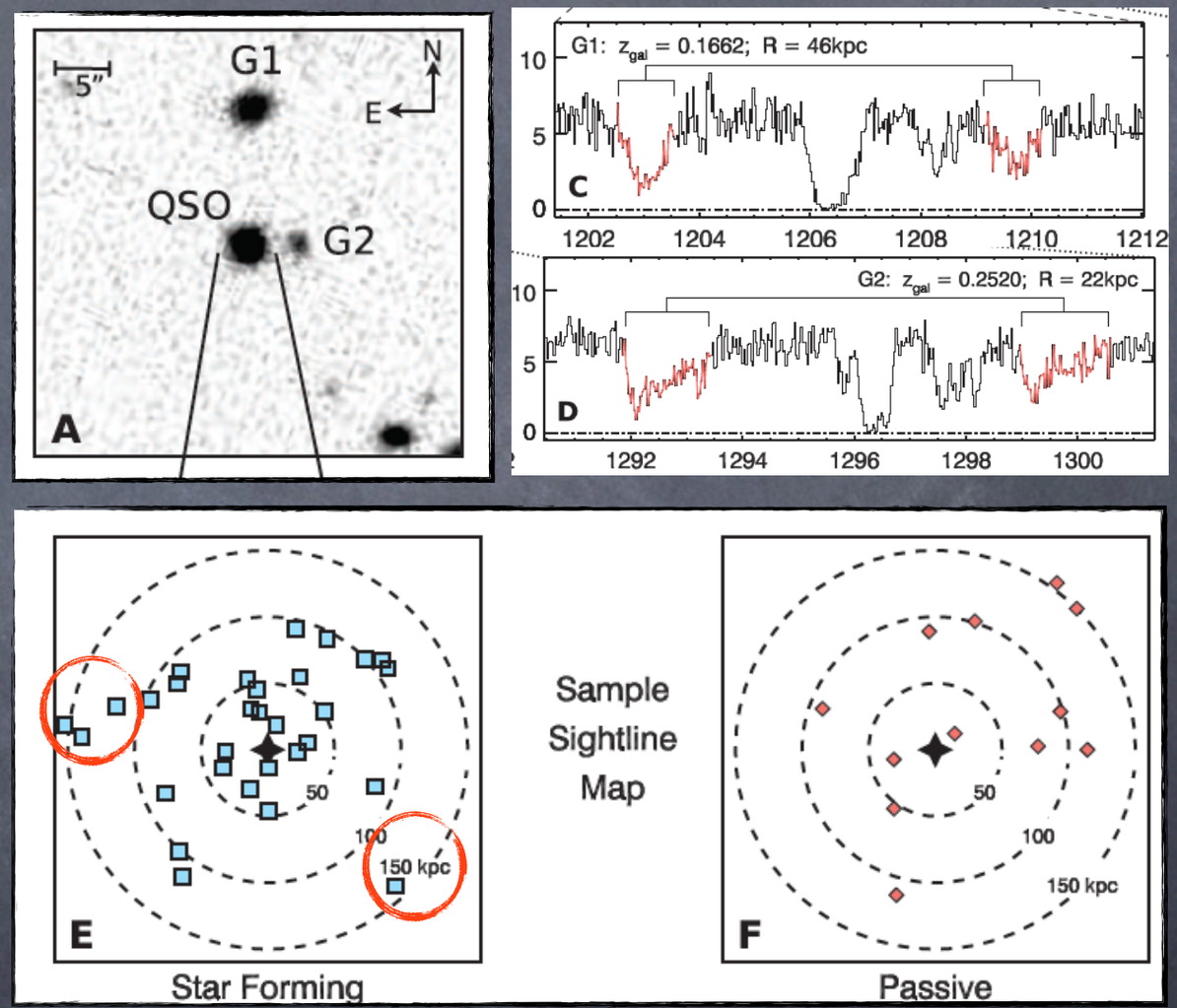
~40 galaxies at 0.1<z<0.4

OVI absorption at large radii !

Other properties from

Keck and Magellan Clay telescopes

(z, SFR, stellar mass)



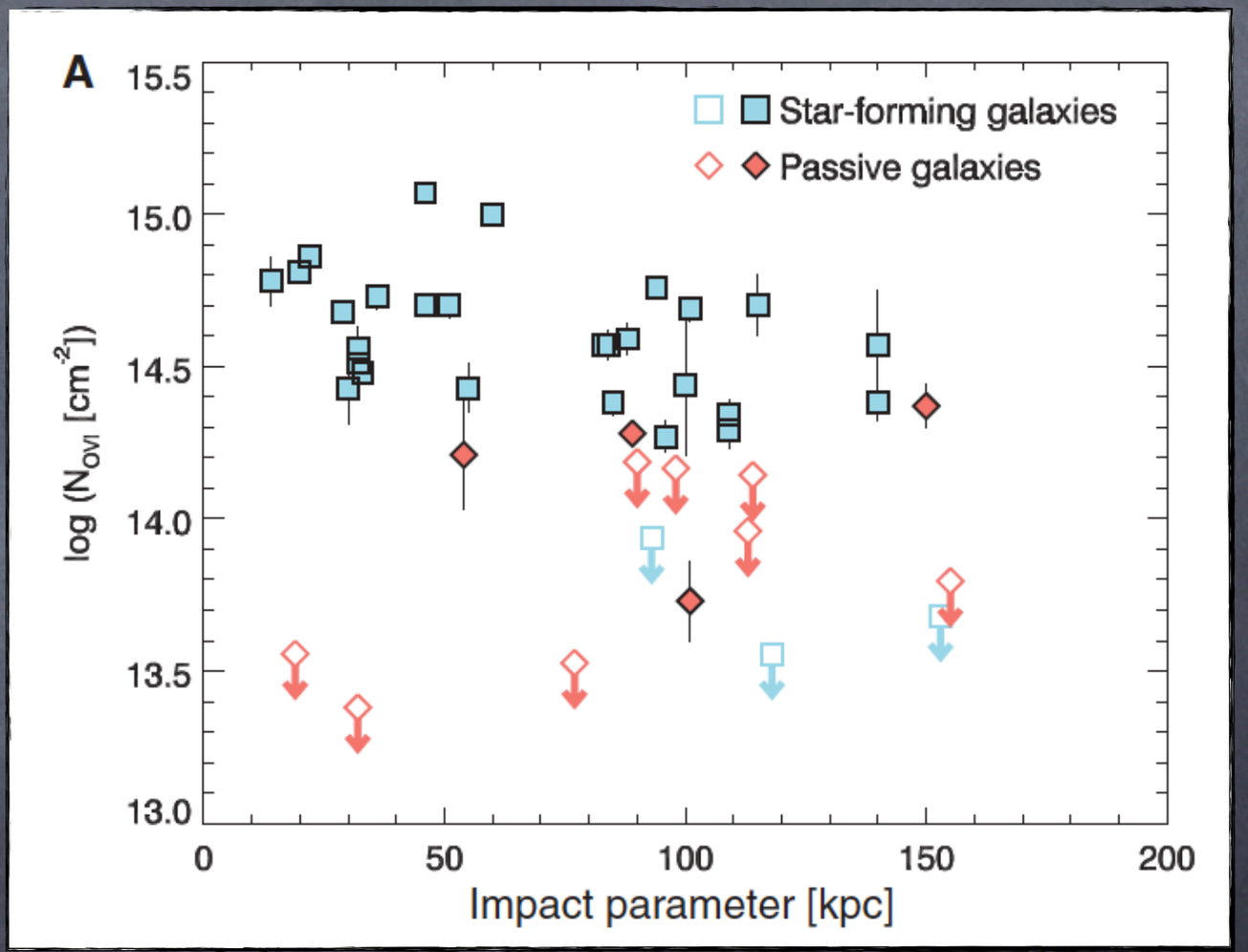
Tumlinson+ 2011

UV Absorption

- Unambiguous -
  large scale structure

- Large column densities → Significant baryonic mass

$$M_{\rm gas} = 177\left(\frac{Z_\odot}{Z}\right)M_{\rm O}$$
$$= 2\times10^9\left(\frac{Z_\odot}{Z}\right)\left(\frac{0.2}{f_{\rm OVI}}\right)M_\odot \quad (2)$$

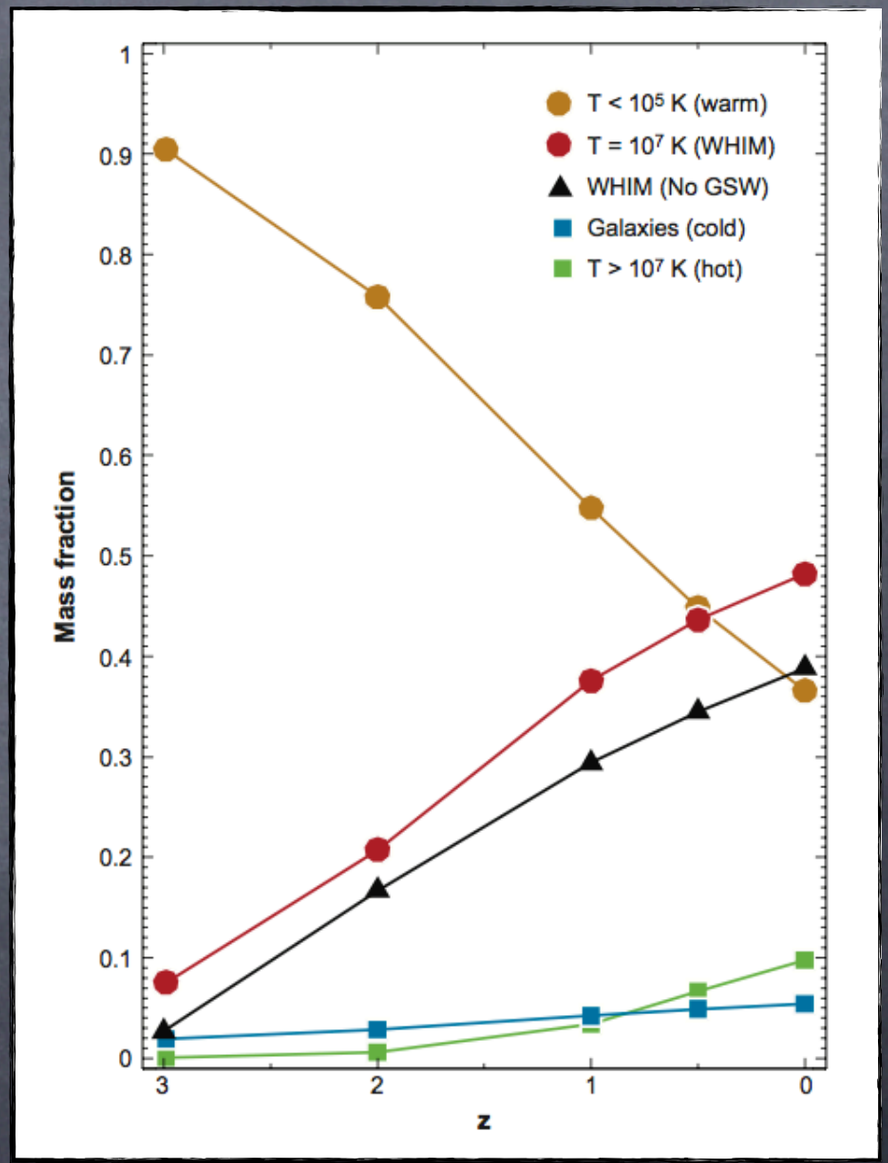


Tumlinson+ 2011

Theoretical Motivation

- Predicted by Spitzer 1956 (ApJ 124 20S)
- How does it form?
  - Gas accretion and shock heating
  - Galactic fountain - winds
    powered by stellar/AGN feedback
- Local Universe -
  possible source of missing baryons
- Previous models
  Miller & Bregman 2013 -
  β-model, small baryonic mass

Cen & Ostriker 2006
Bregman 2007 rev.



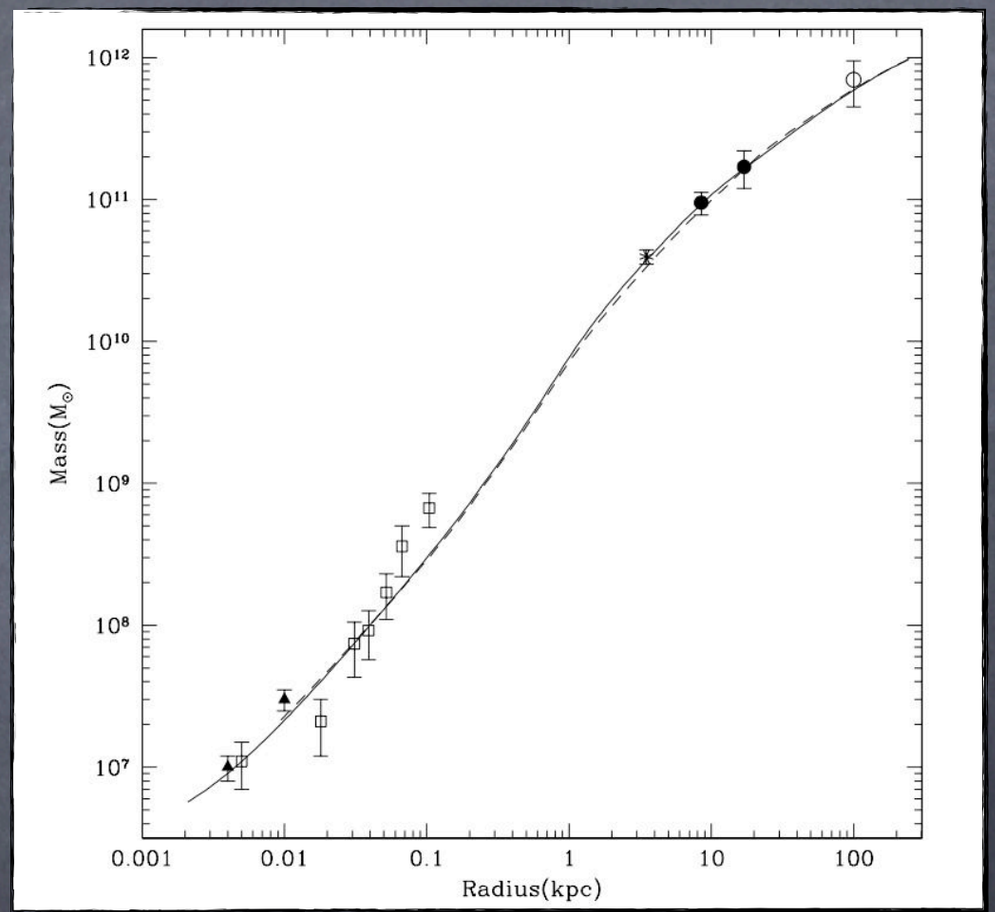
What do we do? (Faerman, Sternberg & McKee)

Assumptions

- Ions are produced in the halo
  large scale length (~100 kpc)
- Hydrostatic equilibrium
  (Gravitating mass - dark matter halo)
- Spherical symmetry

Goals

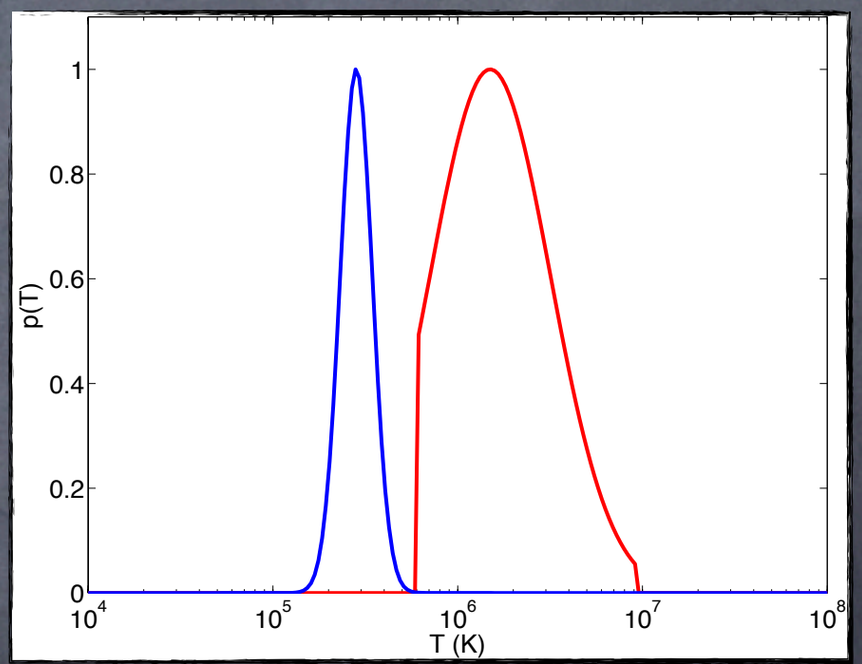
- Oxygen column densities
- X-ray luminosity constraints



Klypin et al. 2002

Our model

- 2-component corona
  - “Hot gas” - matter accreted from the IGM, shock heated to $T_{vir} \sim 2 \times 10^6$ K
  - “Warm gas” - rapidly cooling gas from the hot component ($t_{cool} < t_{dyn}$)
- Log-normal temperature distribution
  (arises in turbulent and shocked gas -
  McCourt et al. 2012, Konstandin et al. 2015)
- Hydrostatic equilibrium
  (suggested by results from the “Illustris” simulation)
  Line broadening - thermal + turbulent

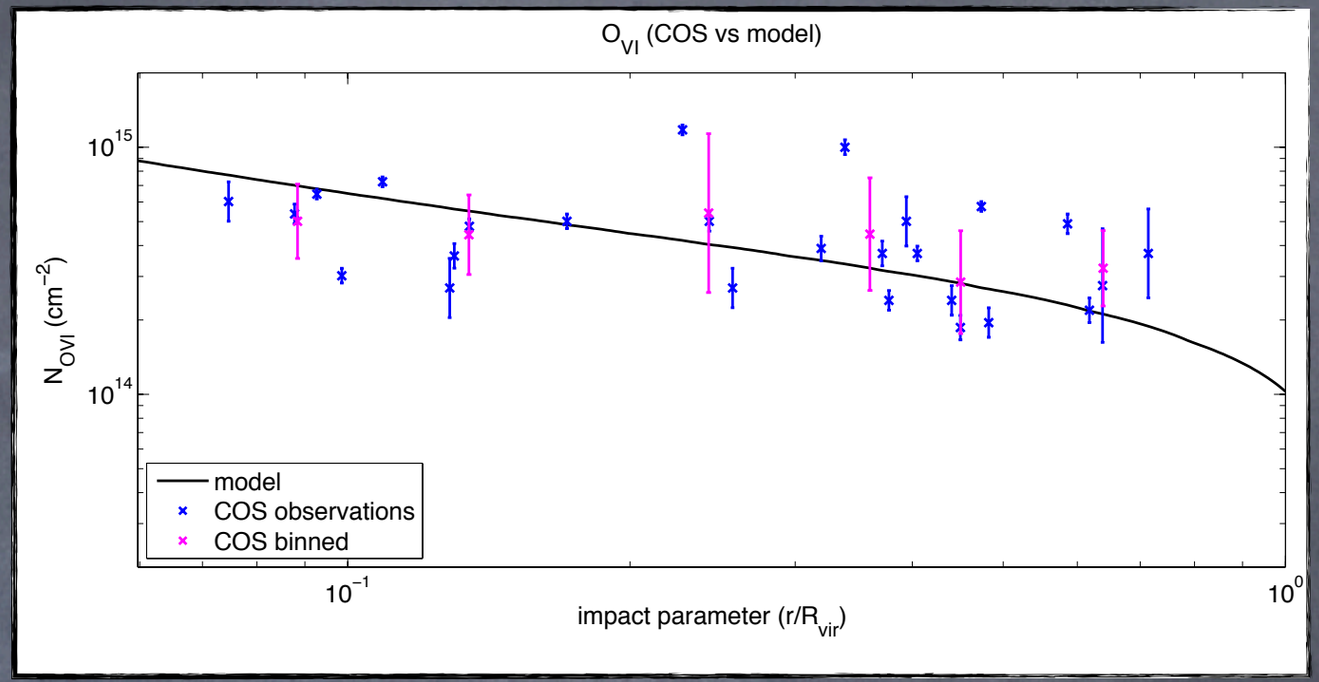


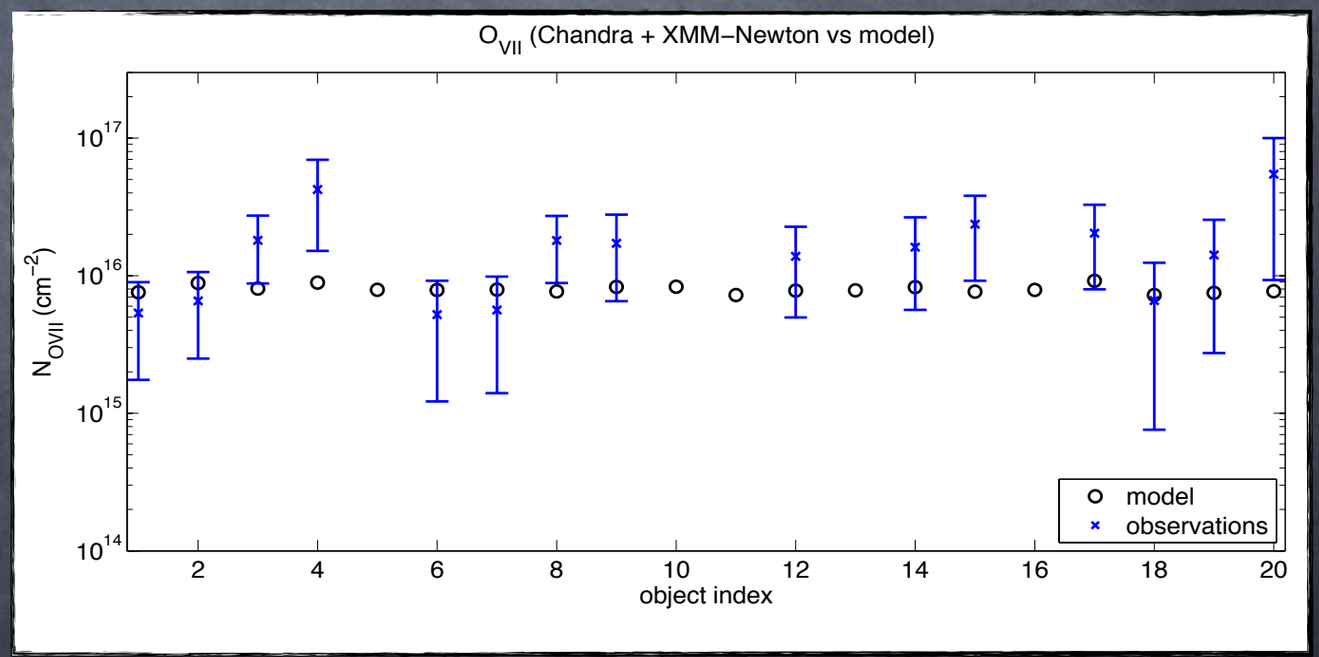
Results

Parameters

- T_{hot} = 1.5 x 10^6 K
- T_{warm} = 3 x 10^5 K
- Z = 0.5 solar

Main result -
High O column densities!





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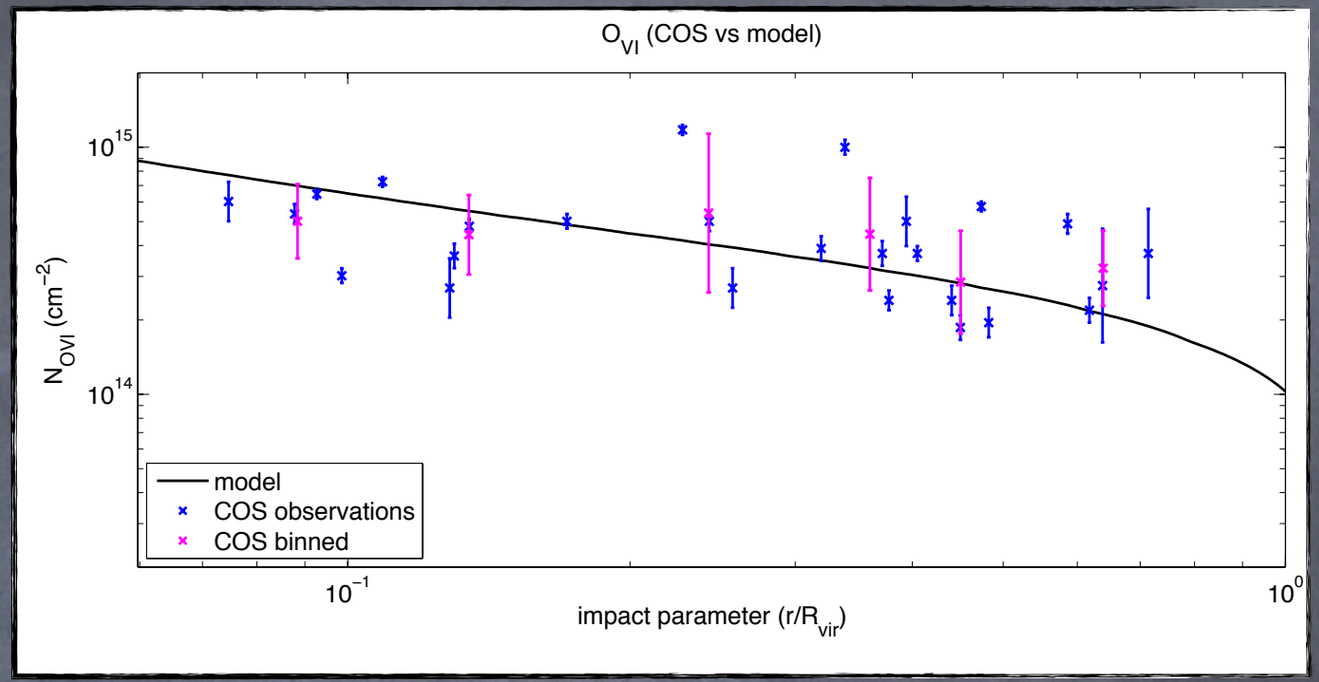
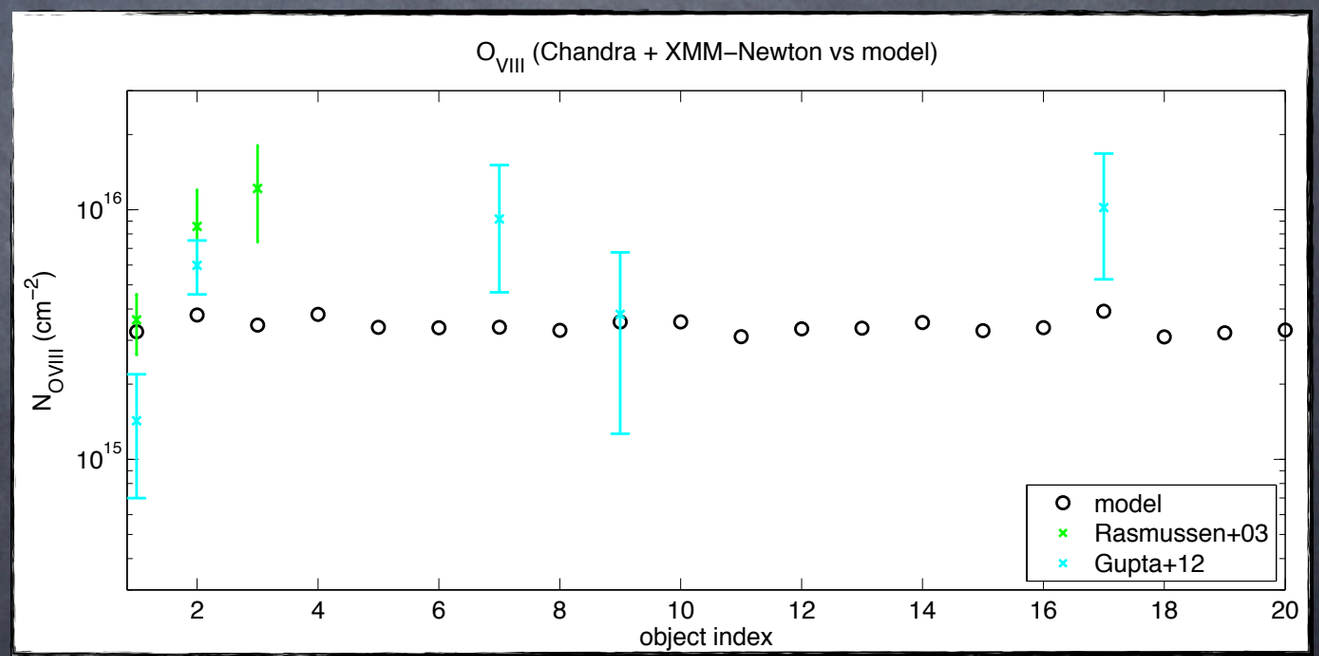
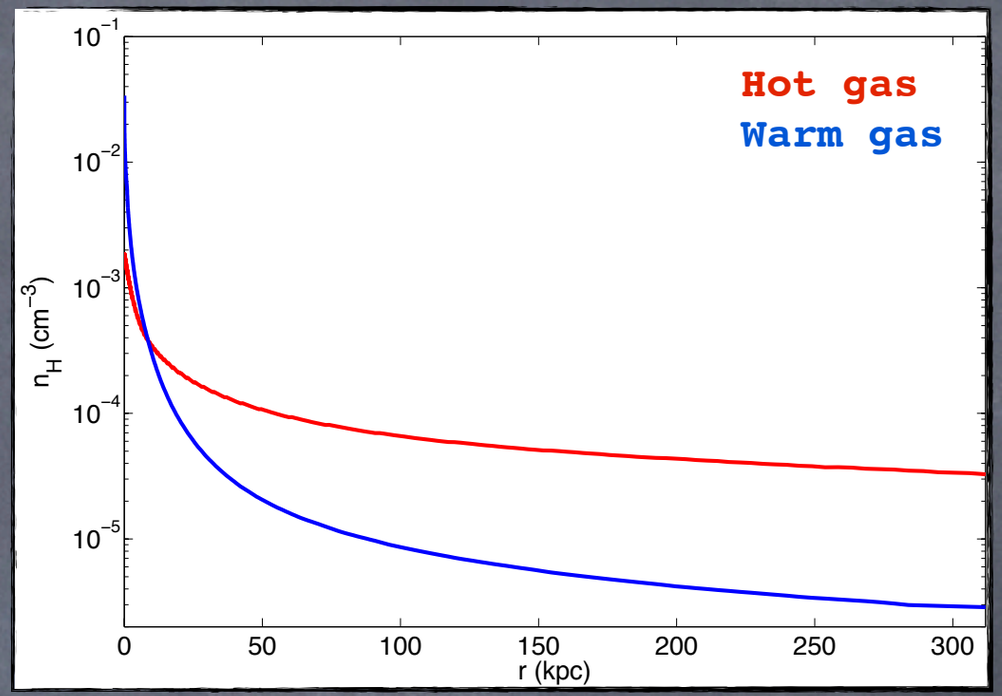
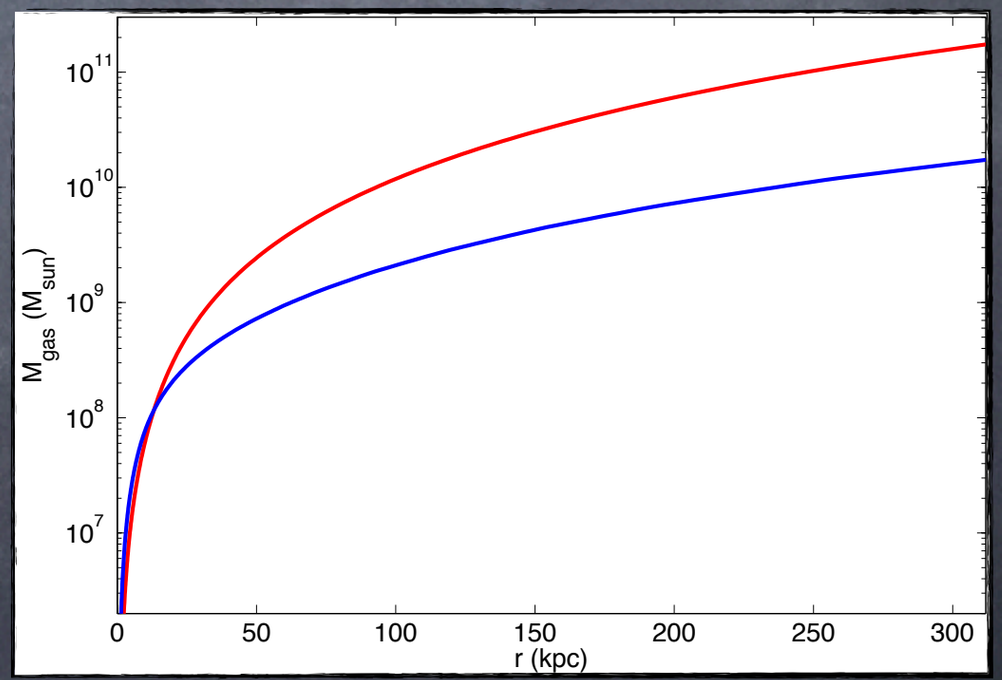




Results

- Mean density - ~5 x10^{-5} cm^{-3}
- Gas mass ~ 10^{11} $M_\odot$
- Luminosity ~ 10^{42} erg/s
  - 0.3-2 keV (r<50 kpc)
    ~ 3 x 10^{38} erg/s/sr
- Cooling time
  - Hot gas ~ 10^{10} years
  - Warm gas ~ 10^{8} years





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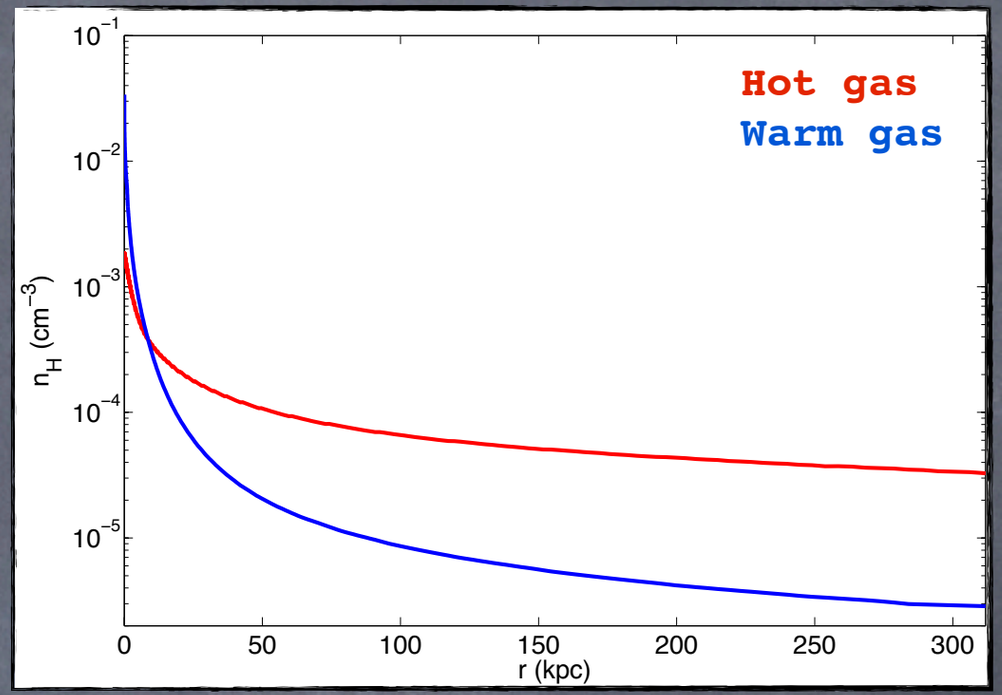
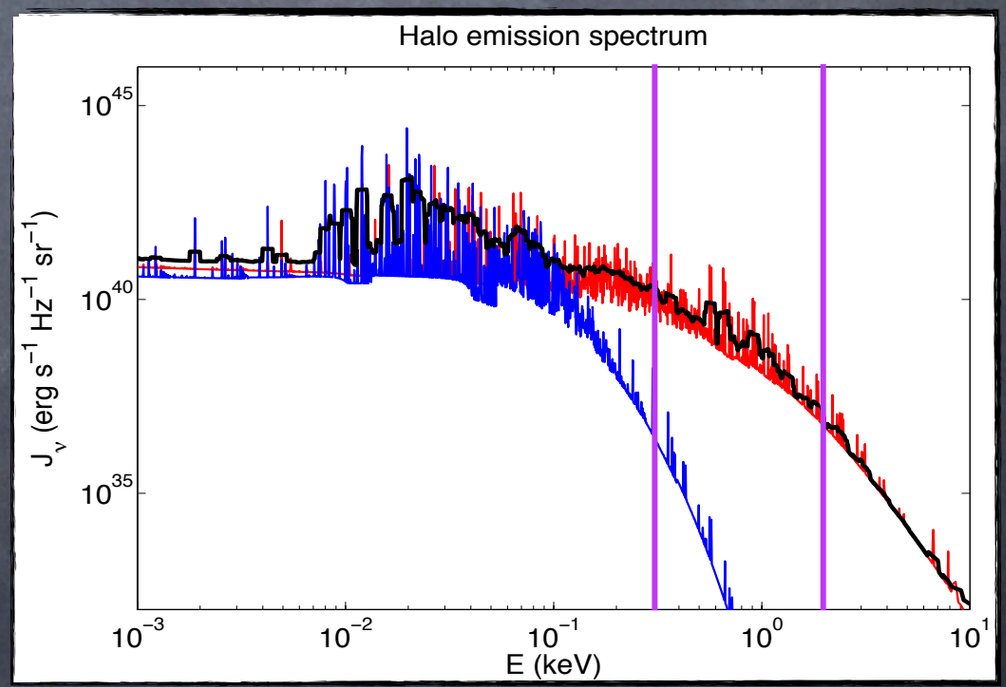
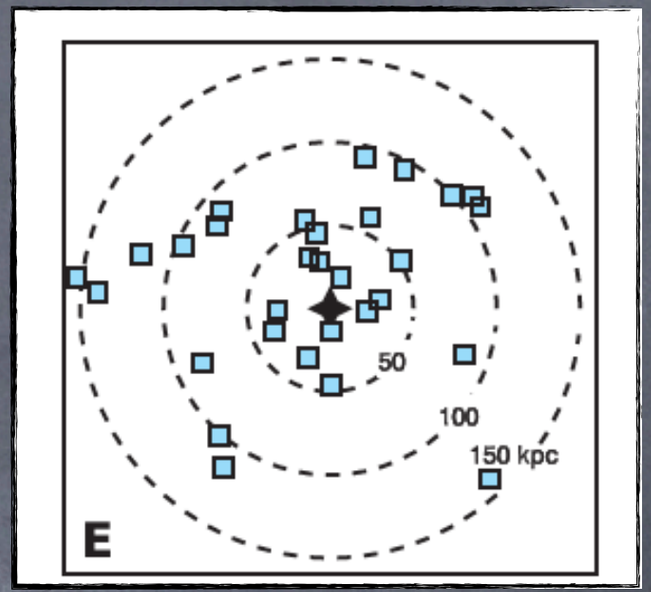




Summary

Hot halos around galaxies

- Evidence from X-ray & UV absorption
- Large radii and high column densities



Our model

- Simple and analytic
  supported by results from full hydrodynamical simulations
- Reproduces the wide range of observed ions
- Significant mass of baryons
  Gas reservoir for star formation