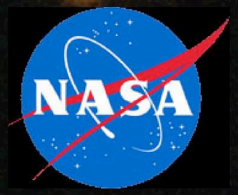
Baryonic Content in the Warm-Hot IGM at Low Redshift

George Sonneborn

FUSE Project Scientist , NASA/GSFC

Mike Shull & Charles Danforth (Univ. Colorado),
Warren Moos (Johns Hopkins Univ.)

Ken Sembach (STScI), Blair Savage & Bart Wakker (U. Wisconsin),
Todd Tripp (U. Mass), Ed Jenkins (Princeton),
Chris Howk (Notre Dame), Jason Prochaska (Lick Obs), and others



Cosmic Mass-Energy Density

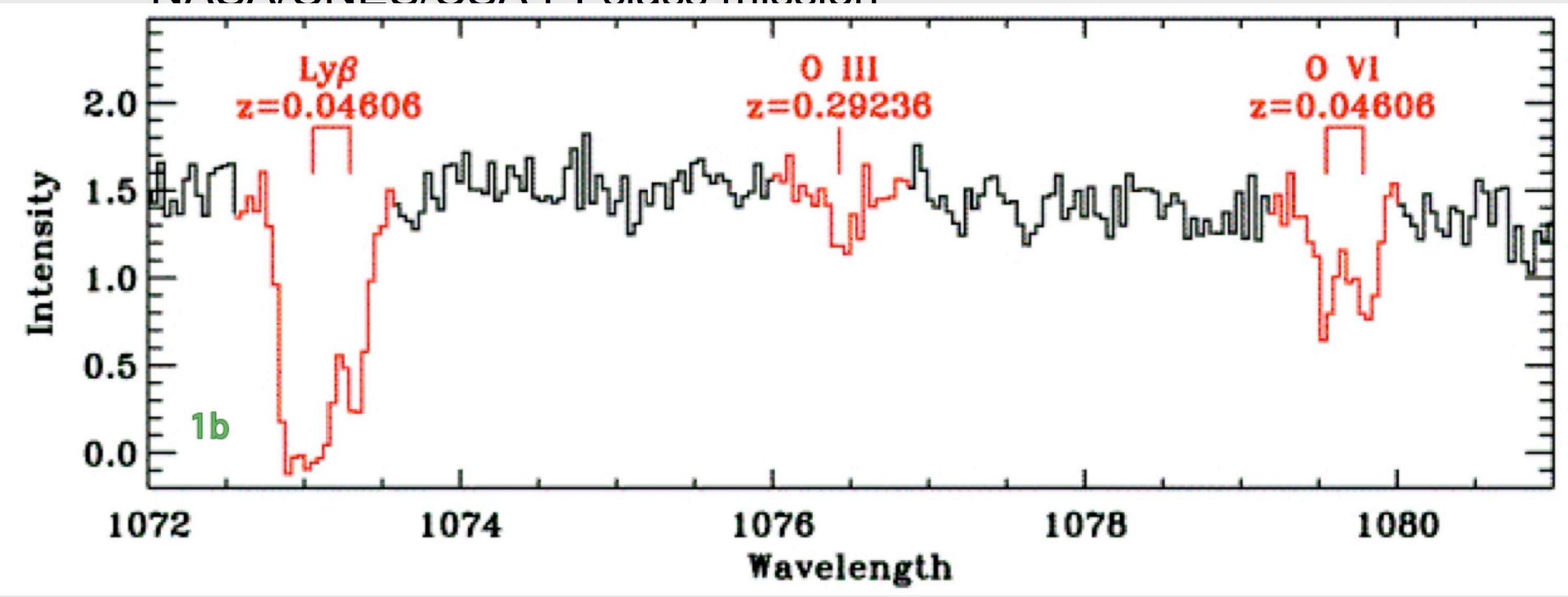
- WMAP & ΛCDM: Ω_b=4.4%
- Baryon census at z~0
  - Galaxies 5-10%
  - 21-cm H I ~1%
  - Lyα- forest (T~10^4 K) ~30%
  - WHIM (10^{5-7} K) ~50%?
- WHIM very low density (n~10^{-4}) not readily detectable in emission (~n^2)
- Absorption ~n more feasible, like Lyα forest

Far Ultraviolet Spectroscopic Explorer (1999-2007)

- 905 - 1187 Å, δv ~ 15 km/sec
- NASA/CNES/CSA PI-class mission
  - PI is Warren Moos, JHU
- >150 QSO/AGN observed at high S/N, t>6 Msec
- O VI 1032-38 Å resonance lines are most sensitive tracer of hot gas longward of Lyman limit
  - Traces gas at 10^{5-6} K
  - Hot Milky Way halo and Galactic “corona”
  - Detected in IGM on many QSO sight lines (z<0.15)
- Limiting flux for IGM (high S/N) studies with FUSE was ~1×10^{-14} erg/cm^2/s/Å at 1030 Å

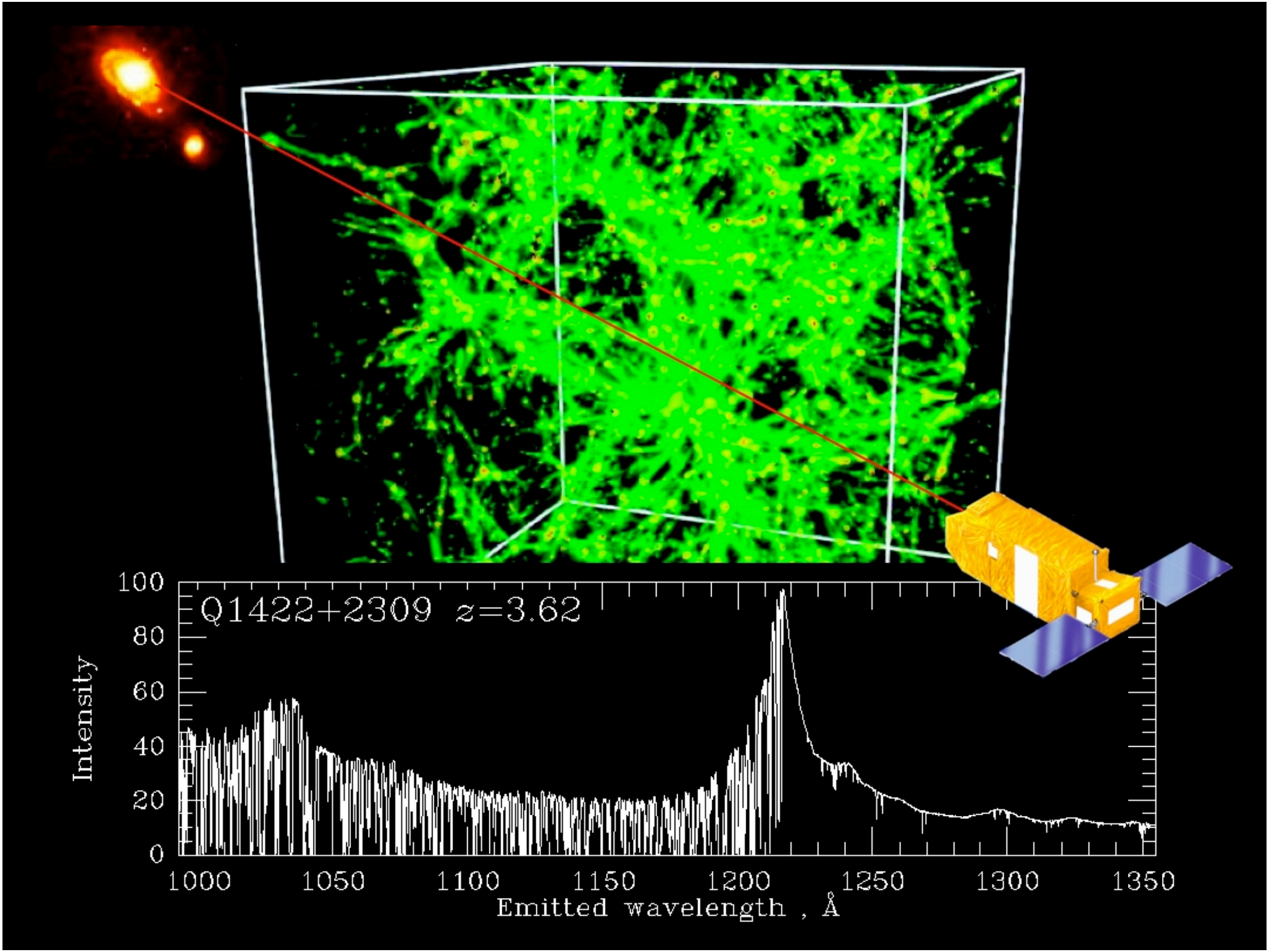
Far Ultraviolet Spectroscopic Explorer (1999-2007)

- 905 - 1187 Å, δv ~ 15 km/sec
- NASA/CNES/CSA PI-class mission



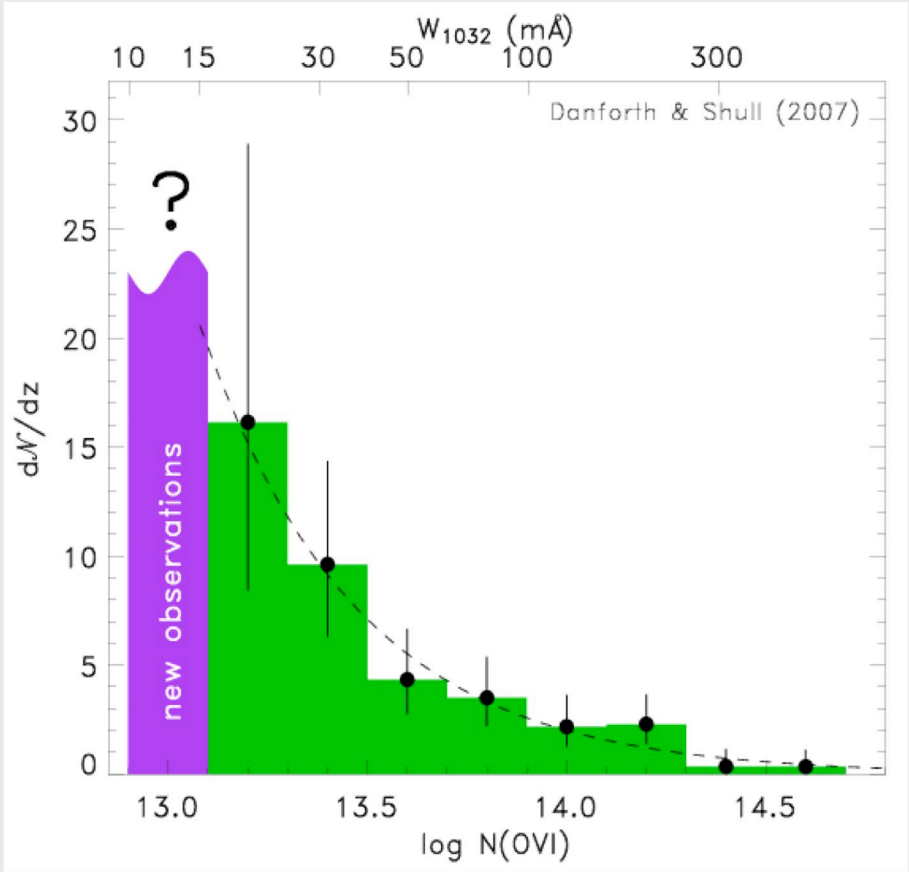
Far Ultraviolet Spectroscopic Explorer (1999-2007)

- 905 - 1187 Å, δv ~ 15 km/sec
- NASA/CNES/CSA PI-class mission
  - PI is Warren Moos, JHU
- >150 QSO/AGN observed at high S/N, t>6 Msec
- O VI 1032-38 Å resonance lines are most sensitive tracer of hot gas longward of Lyman limit
  - Traces gas at 10^{5-6} K
  - Hot Milky Way halo and Galactic “corona”
  - Detected in IGM on many QSO sight lines (z<0.15)
- Limiting flux for IGM (high S/N) studies with FUSE was ~1×10^{-14} erg/cm^2/s/Å at 1030 Å

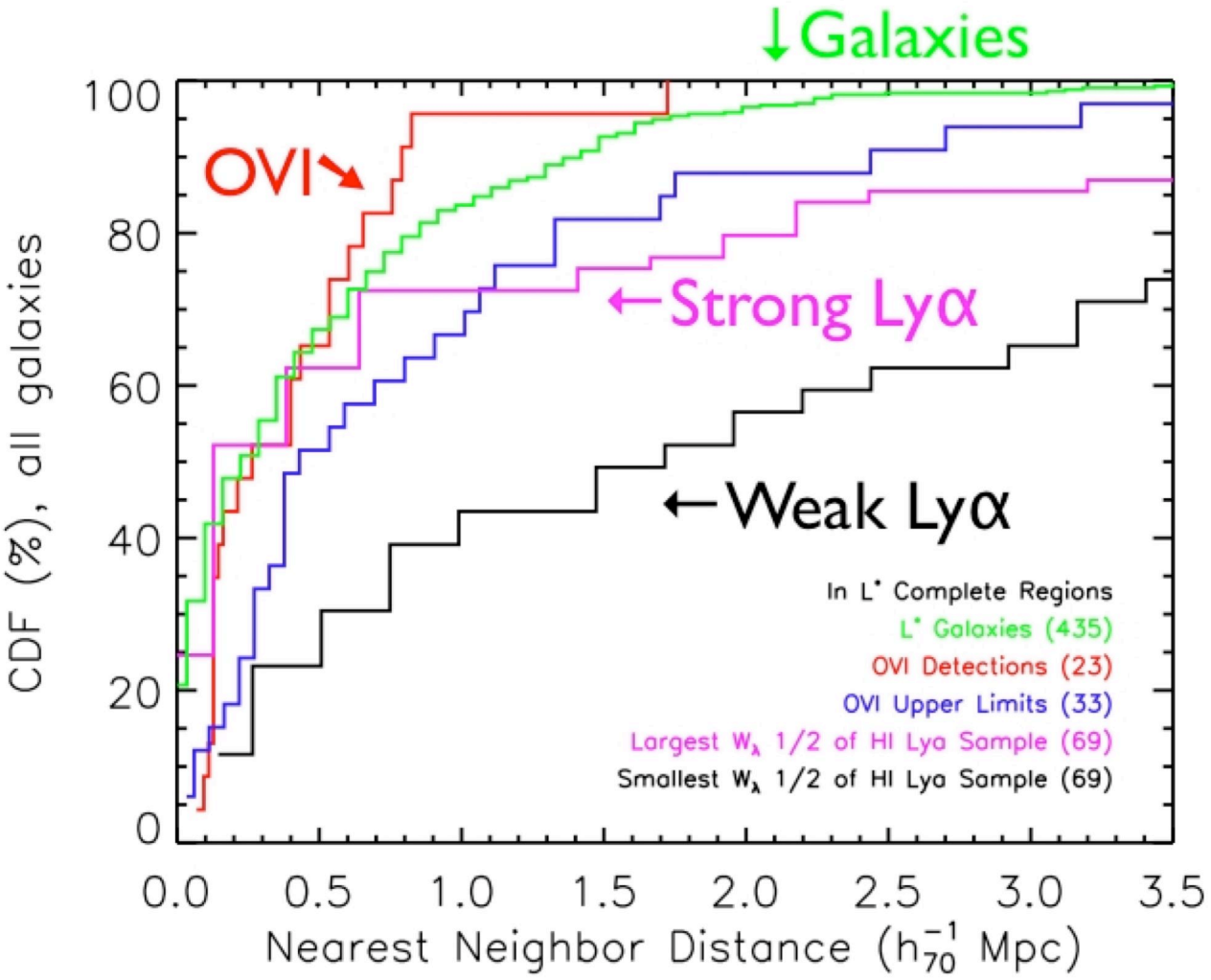

Q1422+2309 z=3.62
Intensity
100
80
60
40
20
0
1000
1050
1100
1150
1200
1250
1300
1350
Emitted wavelength , Å

O VI IGM Results from FUSE

- WHIM predicted to be T~10^7 K
  - O VI best available tracer of WHIM (T~ $10^{5\text{-}6}$ K)
- dN/dz ~ N^{-2}
  - Steep rise toward low N(OVI)
  - 39 IGM absorbers; more on the way
- Ω(OVI) = 0.0031 +/- 0.0004
  - ~7% of baryons
  - Consistent with O VII-VIII being dominant ionization state in WHIM
- Much of the WHIM resides in structures at low column density



Danforth & Shull (2005; 2007 in prep)



Nearest-galaxy distributions (Stocke et al 2006)

OVI tracks the galaxies:

O VI absorbers lie within 800 kpc of L* galaxies

within 200 kpc of 0.1 L* galaxies

Metallicity of O VI absorbers ~9% Solar

Future Steps

- FUSE mission ended this summer due to failure of last reaction wheel
  - Plans to obtain data for >400 additional low N absorbers over next 2 years had to be abandoned
  - Analysis of existing FUSE QSO spectra in progress
- WHIM is major objective of Cosmic Origins Spectrograph (1150 - 3000 A)
  - SM4 in Sept. 2008
  - O VI at z>0.14
- Principal goal of Con-X mission is to study WHIM via X-ray lines (O VII and O VIII)