AGN Outflows Role in Cosmological Structure Formation: The XMM angle

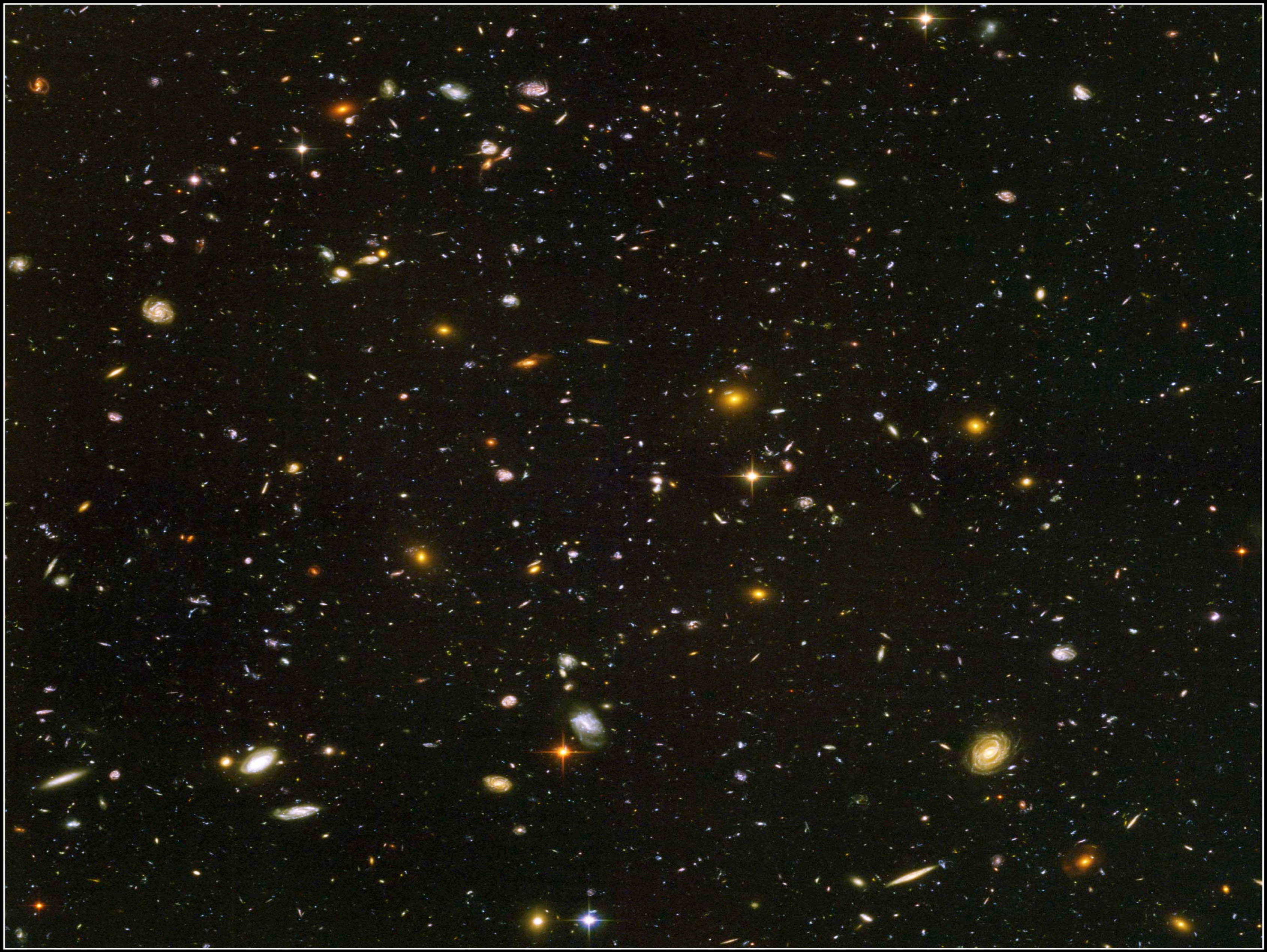
Nahum Arav

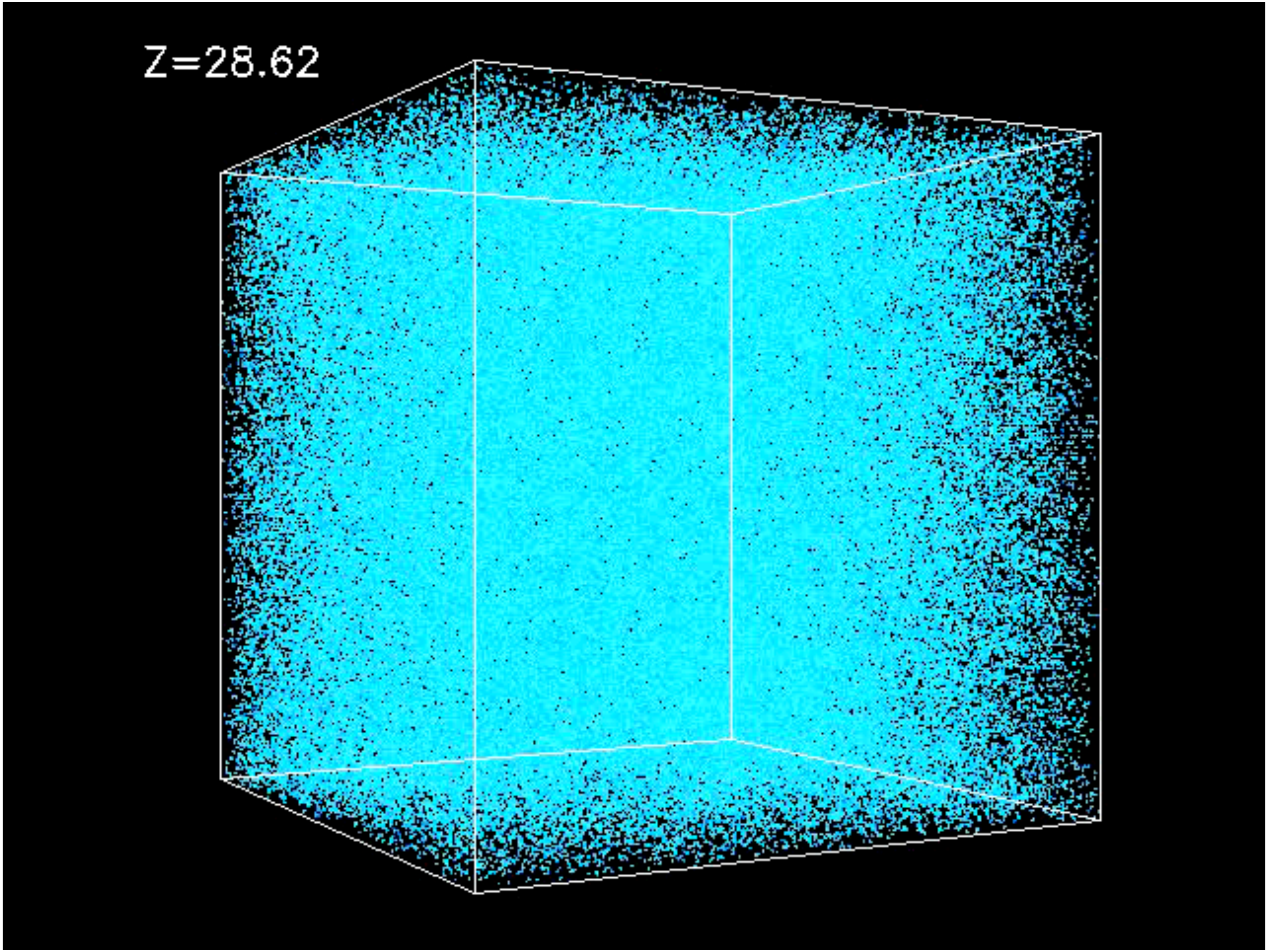
University of Colorado Boulder

Collaborators:

Jack Gabel,
Jelle Kaastra,
Jerry Kriss,
Kirk Korista,
Jennifer Scott
Daniel Proga,
Katrien Steenbrugge,
Ehud Behar,
Elisa Costantini,
Ari Laor,
Masao Sako

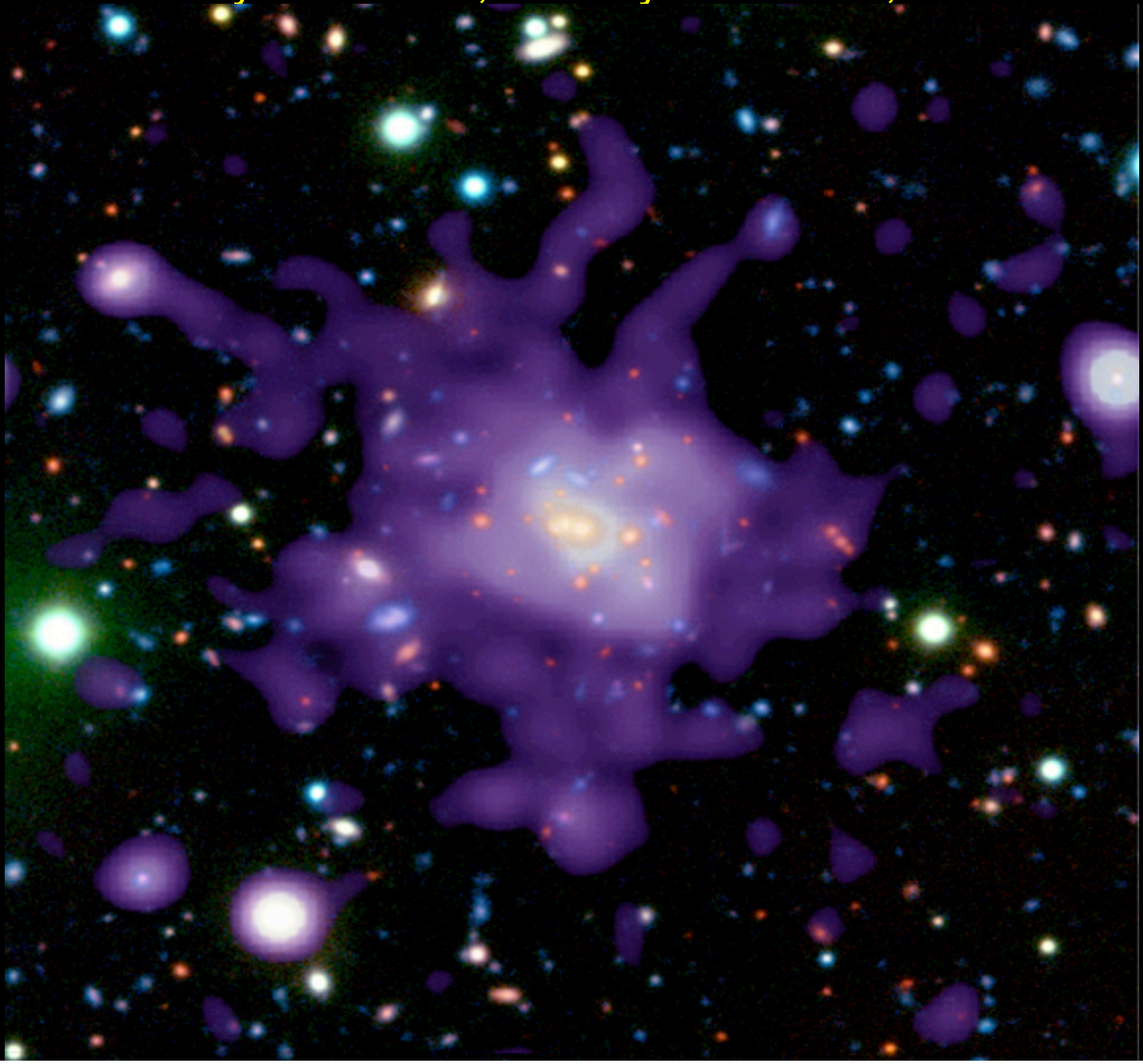
AGN Feedback and cosmological structure formation




Z=28.62

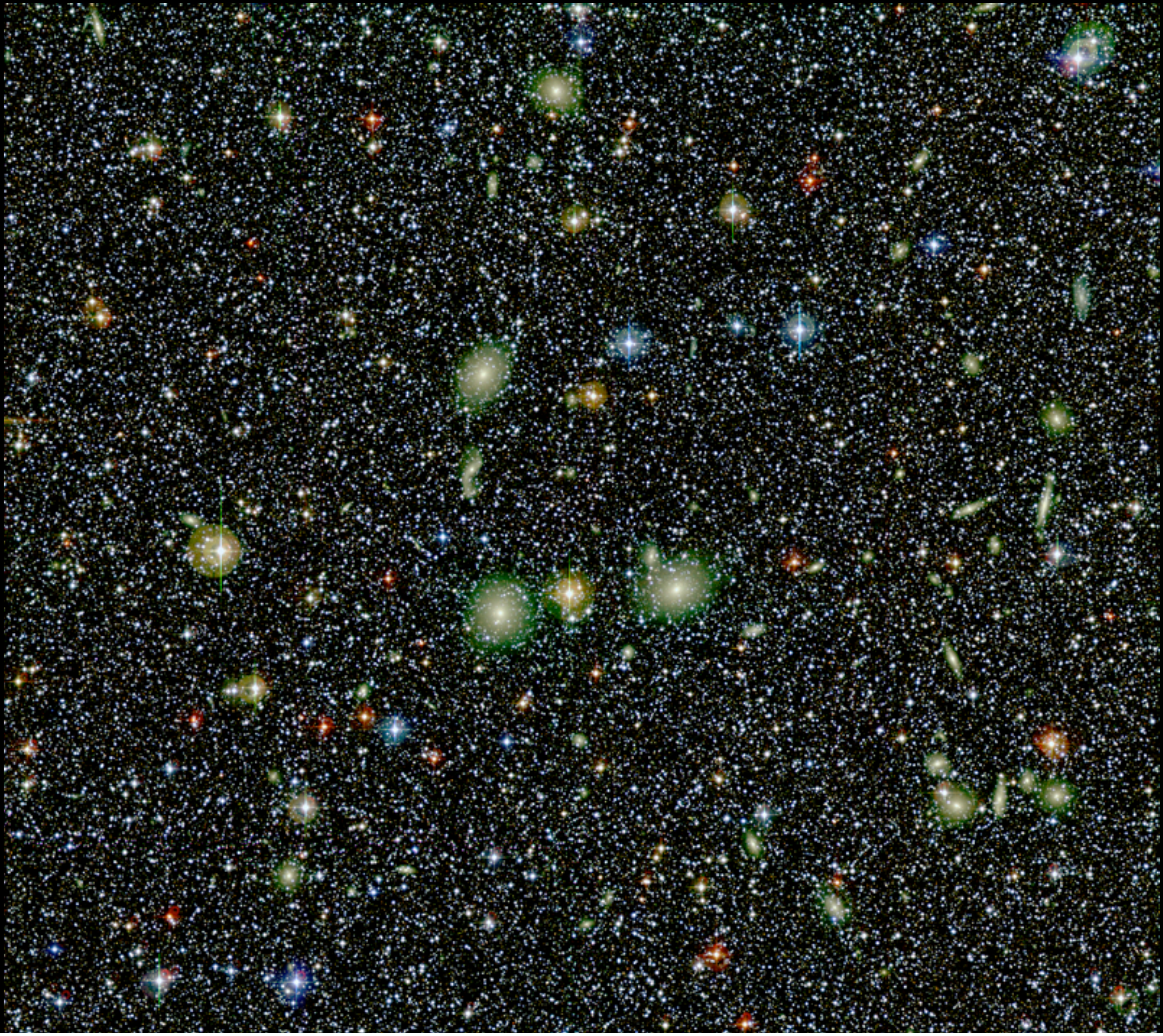
Cluster cooling flows:

Wu et al. 2000 ;Ciotti & Ostriker 2001; Bower et al. 2001 Borgani et al. 2002 Platania et al. 2002; Vernaleo & Reynolds 2006; Rafferty et al. 2006; Thacker et al. 2006



Enrichment of the intergalactic medium

Furlanetto & Loeb 2001; Cavaliere 2002 Yuexing et al.; 2006; D'Odorico et al. 2006



Evolution of the host galaxy

Scannapieco & Oh 2004; Granato et al. 2004; Di Matteo et al. 2005;

Hopkins et al. 2005 ,2006; Springel et al. 2005; Menci et al. 2006; Haiman et al. 2006

Growth of super-massive black holes

Silk & Rees 1998; Blandford & Begelman 1999, 2004; King 2003
Begelman & Ruszkowski 2004; Cattaneo et al. 2005; Hopkins et al. 2005; Hu et al. 2006

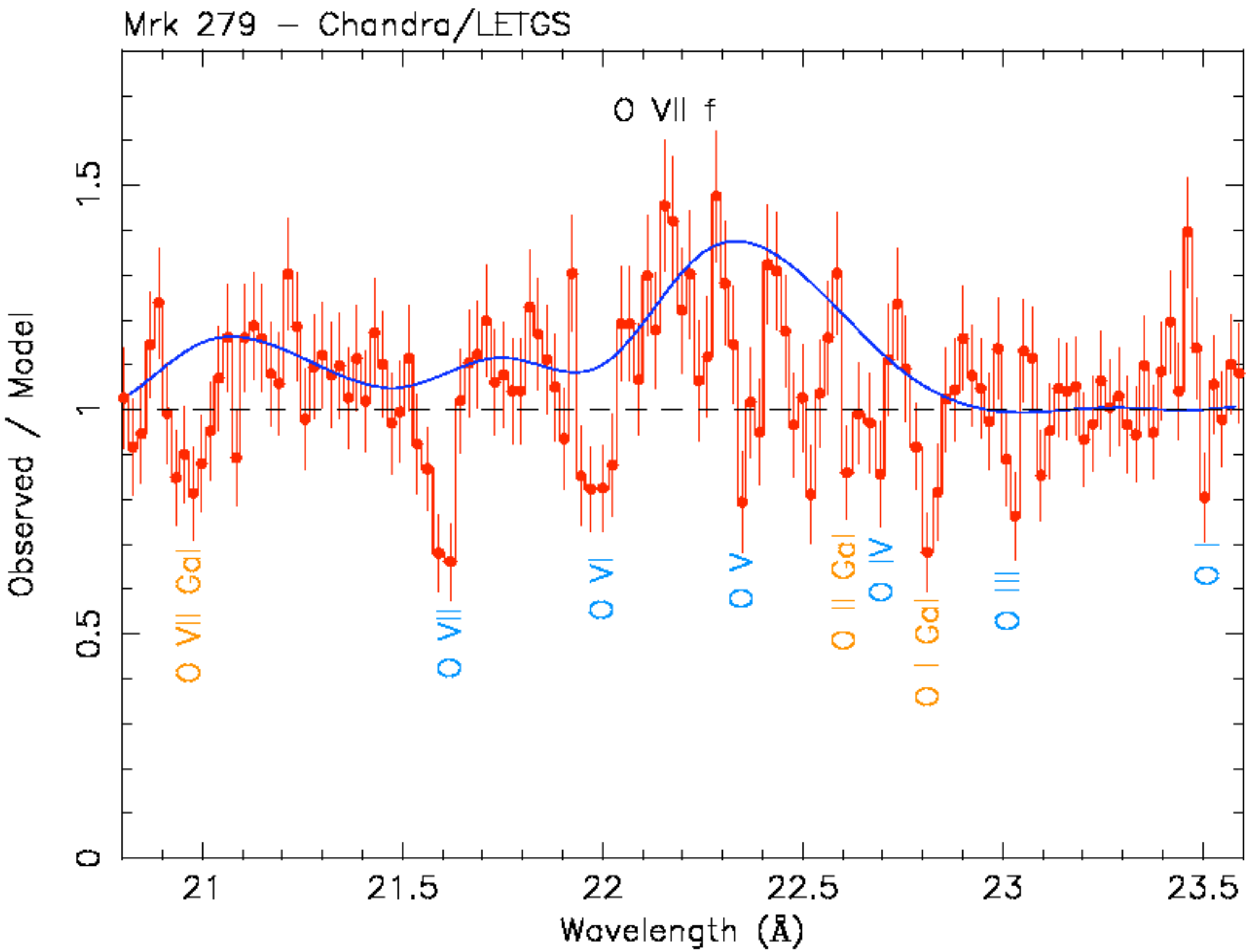
Do AGN outflows contribute significantly to feedback processes?

(more than 100 refereed **theory** papers in the past three years)

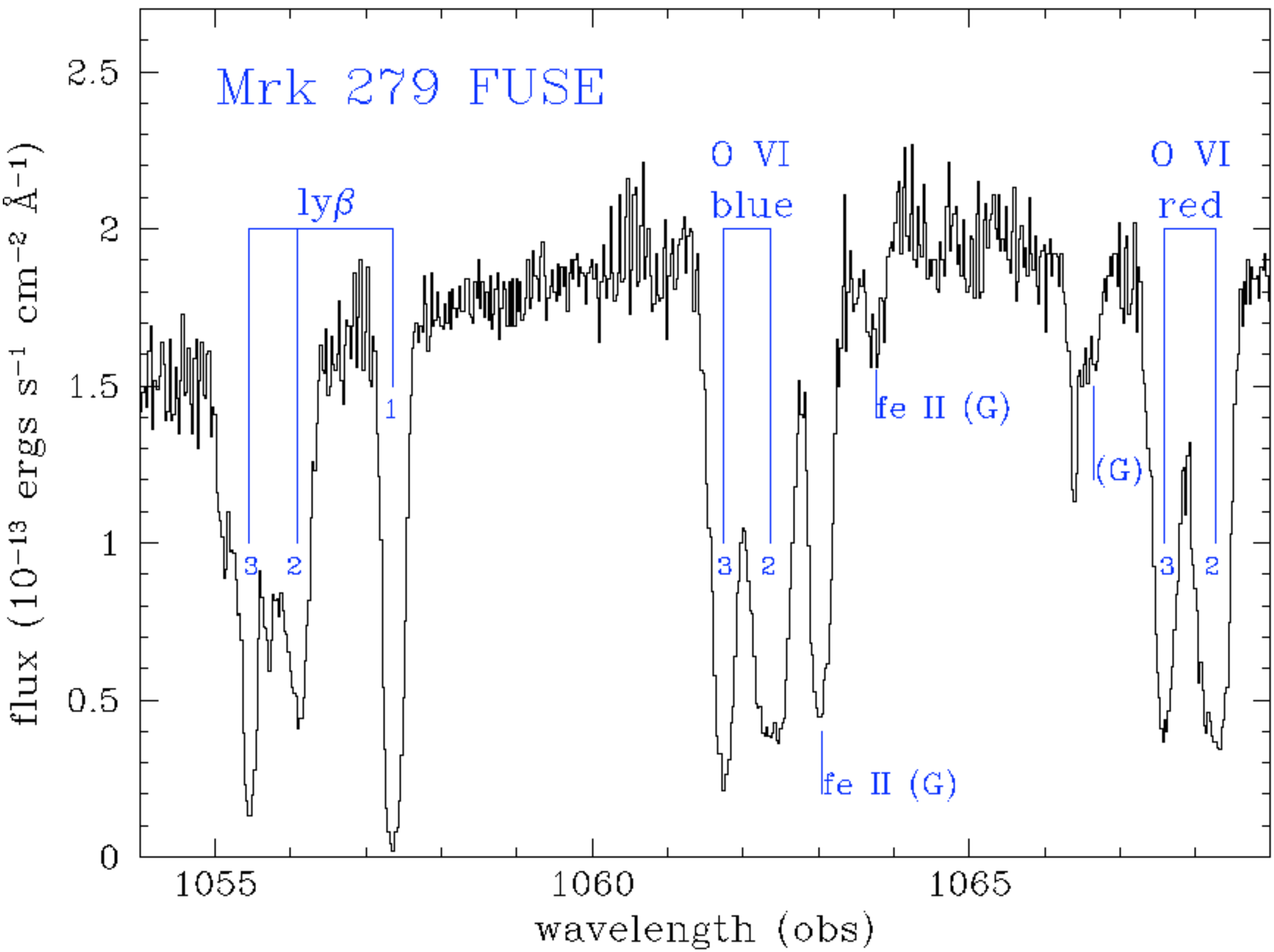
It will all depend on the:

Mass flux, Kinetic luminosity and Chemical abundances

of observed AGN outflows.



Mrk 279 – Chandra/LETGS
O VII f
O VII Gal
O VII
O VI
O V
O II Gal
O IV
O I Gal
O III
O I
Observed / Model
Wavelength (Å)
0
0.5
1
1.5
21
21.5
22
22.5
23
23.5



Mrk 279 FUSE
lyβ
1
3
2
O VI
blue
3
2
fe II (G)
fe II (G)
(G)
O VI
red
3
2
flux (10^{-13} ergs s^{-1} cm^{-2} Å^{-1})
wavelength (obs)

Chemical abundances in Mrk 279

From the Deep Simultaneous Chandra/HST/FUSE Campaign on the AGN outflow

- For solar abundances:
  $C=2.45\times10^{-4}$ $N=8.5\times10^{-5}$ $O=4.9\times10^{-4}$

C=2.2   N=3.5   O=1.6 times solar

90% Confidence interval

C= 1.5—2.9, N=2.4—4.6, O=0.9—2.4

Comparison between the X-ray and UV absorbers in Mrk 279

- **X-ray,** two components:
  Log(U)=-1.0 (0.1), N_H=1.2x10^{20} (0.2)
  Log(U)=+1.0 (0.1), N_H=3.2x10^{20} (0.8)

- **UV,** one components:
  Log(U)=-1.1 (0.1), N_H=1.0x10^{20} (0.1)

- The low ionization component matches the UV results amazingly well, for both U and N_H . There is even hint in the X-ray troughs that (N/C)~1.5 (0.5)

Kinetic luminosity

$$\dot{E}_k = \frac{1}{2}\dot{m}v^2 = \frac{1}{2}\Omega r N_H m_p v^3$$

Distance of the Outflow from the Central Source

- X-ray trough variabilty
- Number Density via Troughs from metastable levels
  Fe II* UV1, UV2…; C III* 1175; Si II* 1264, 1533…

$$U \propto \frac{L}{n_H R^2}$$

- Currently only done for a handful of objects:

NGC 4151, n=10^7-10^9 d~0.1 pc (Kraemer et al 2007)
NGC 3783, n=30,000 d~10 pc (Gabel et al 2003)
QSO 1044+3656, n=1000 d=1000 pc (De Kool et al 2001)
QSO 2359-1241, n=20,000 d=1000 pc (Arav et al 2007)

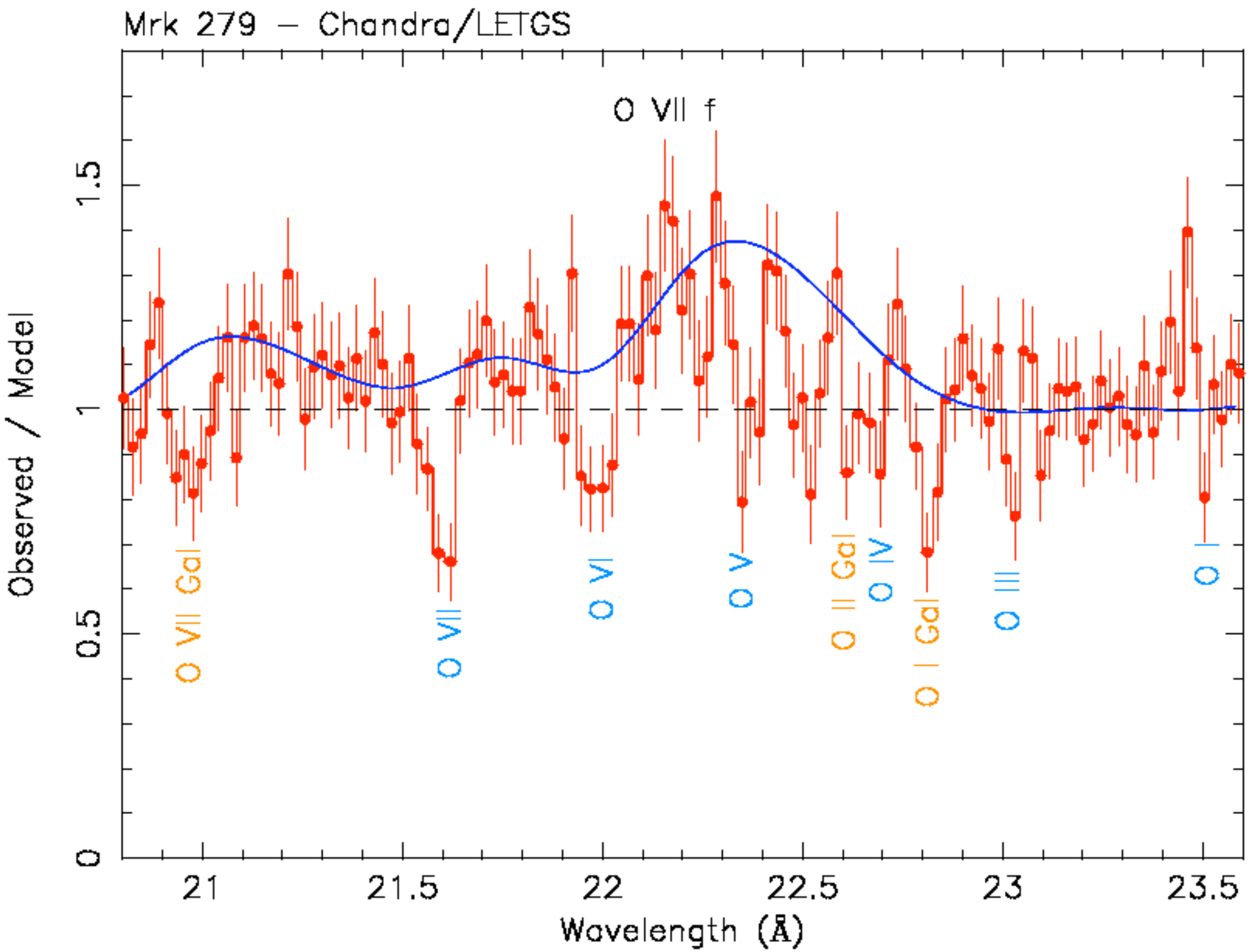
The next 10 years

(or my 10 Msec pie in the sky)

To make a qualitative leap in XMM contribution to the study of AGN feedback from outflows we need the following strategy:

1. Following the installation of COS onboard HST we should execute Deep Simultaneous COS/XMM Spectroscopic campaigns on nearby Seyfert 1.

- XMM exposures should be 0.5-1 Msec for each target (3-5 targets)
- This will allow us to measure distances and column densities for these outflows, thus determining their kinetic luminosity.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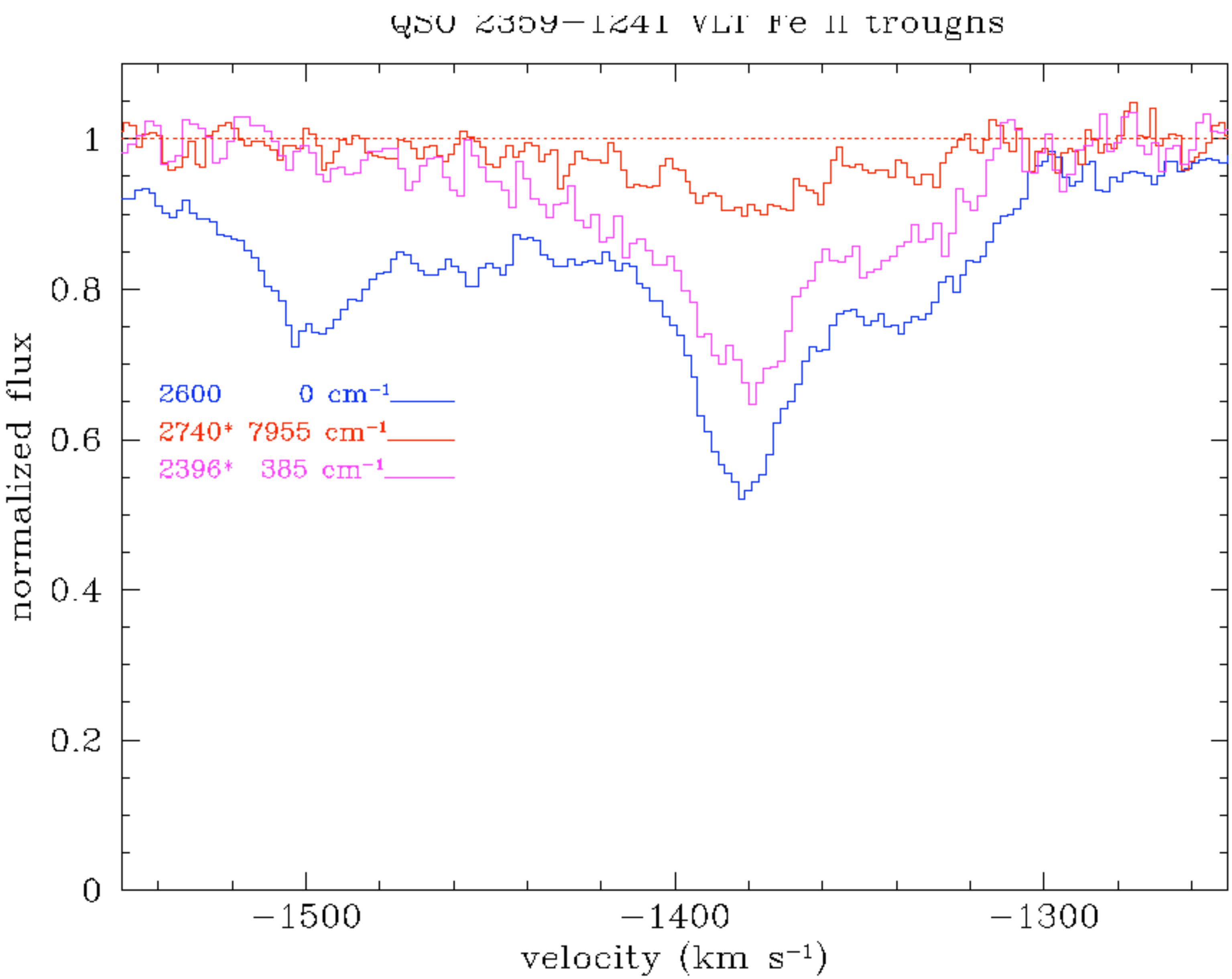
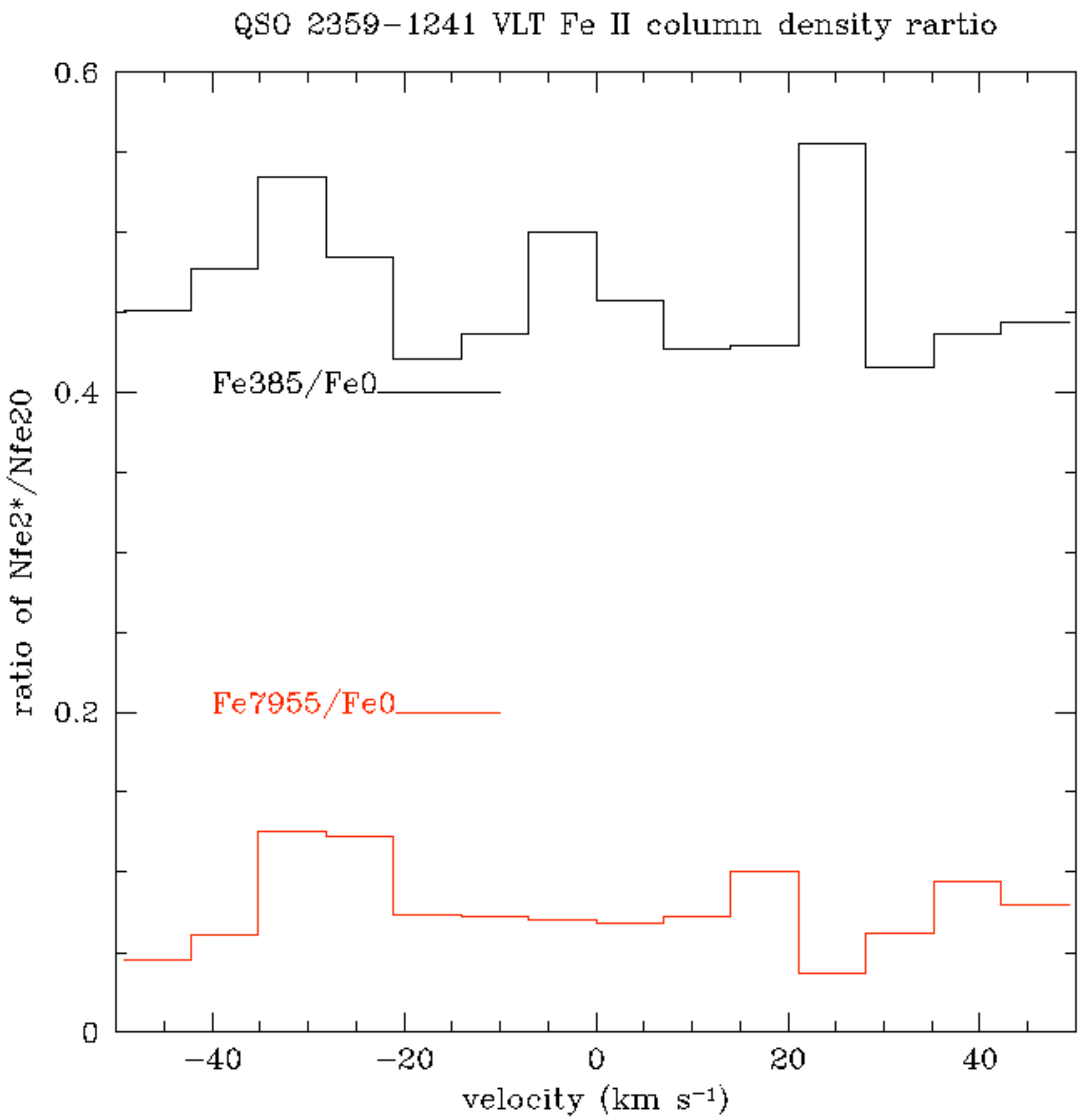
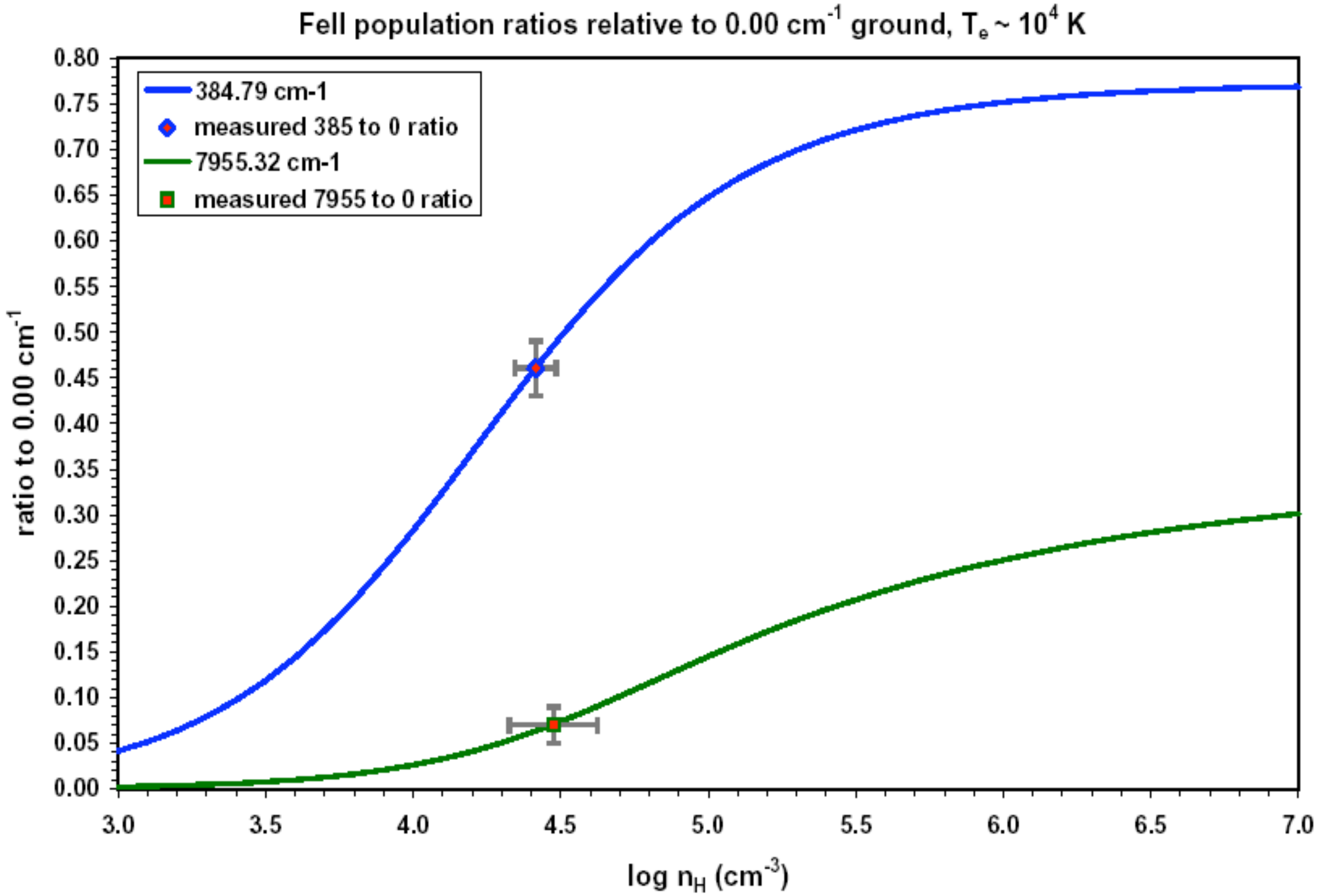
3. Observing 2-3 BALQSOs with ~1 Msec each, to detect and study X-ray BALs


QSO 2359−1241 VLT Fe II troughs
normalized flux
1
0.8
0.6
0.4
0.2
0
−1500
−1400
−1300
velocity (km s−1)
2600 0 cm−1
2740* 7955 cm−1
2396* 385 cm−1



QSO 2359-1241 VLT Fe II column density rartio
0.6
0.4
0.2
0
ratio of Nfe2*/Nfe20
Fe385/Fe0
Fe7955/Fe0
-40
-20
0
20
40
velocity (km s^{-1})



FeII population ratios relative to 0.00 cm^{-1} ground, $T_e \sim 10^4$ K
384.79 cm-1
measured 385 to 0 ratio
7955.32 cm-1
measured 7955 to 0 ratio
ratio to 0.00 cm^{-1}
log n_H (cm^{-3})
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
0.50
0.55
0.60
0.65
0.70
0.75
0.80
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0

Summary

AGN feedback is currently invoked to explain many issues in cosmological structure formation, Quasar outflows are a major component of this feedback.

Analyzing AGN outflows is complicated by the influence of geometry and dynamics on the resulting absorption.

By using innovative analysis techniqiues, choosing the right objects and observation strategy (UV/X-ray campaigns Spectroscopy on 10 meter class telescopes…), we can overcome these obstacle.

Determine the Mass flux, Kinetic luminosity and Chemical abundances of real Outflows. Thus, quantify experimentaly AGN feedback mechanisms