

# Shedding “X-ray light” on SMBH winds

**Marcella Brusa**

- 1) DIFA-Dipartimento di Fisica e Astronomia / Università di Bologna
  - 2) OAS-Osservatorio di Astrofisica e Scienza dello Spazio di Bologna / INAF
- on behalf of a large team of UFOs/outflows X-ray+mw astronomers  
*(G. Lanzuisi, M. Cappi, L. Zappacosta, S. Bianchi, A. Comastri et al.)*

# The Energetic Universe

- How do black holes grow and influence the Universe?
- The history of SMBH growth
- Obscured AGN census  $z \sim 1-3$
- AGN winds and outflows  $z \sim 0-3$
- SMBH growth: accretion vs. mergers
- BH & SMBH physics
- Luminous extragalactic transients

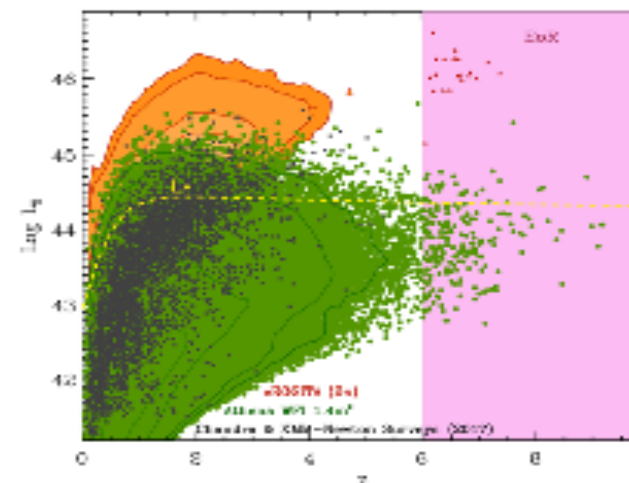
See talks by

Kirpal Nandra, Massimo Cappi



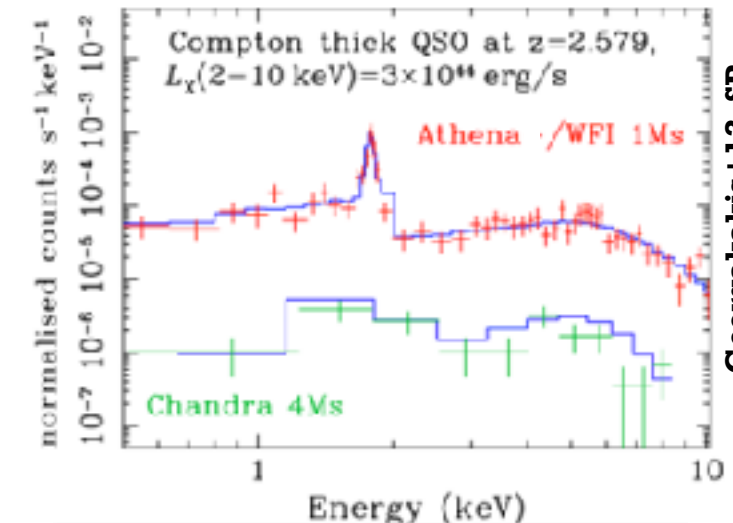
N.B: Slide taken from the  
“Athena Master Short presentation” template  
available on the Athena website !

Typical AGN  $z \sim 6-8$

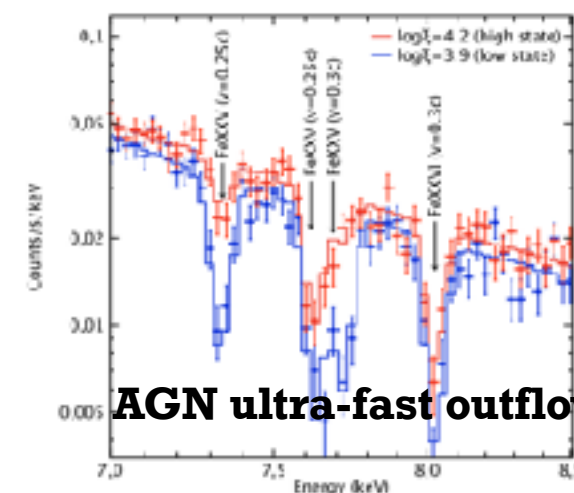


Aird+13, SP

Compton-thick AGN census

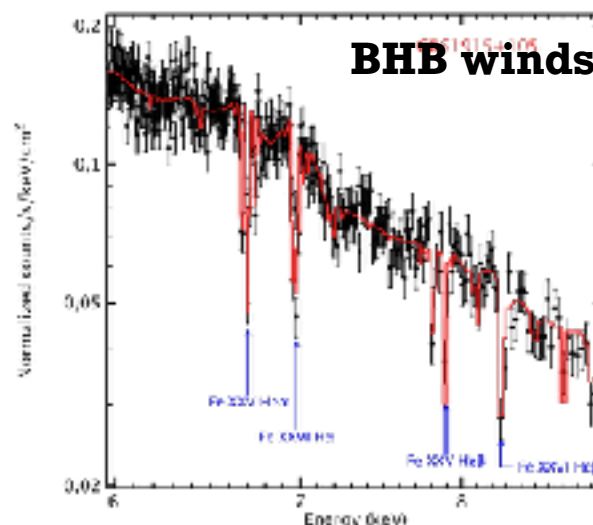


Georgakakis+13, SP



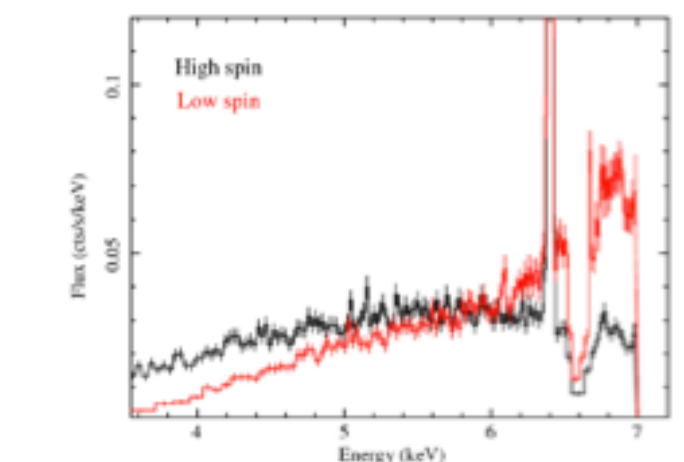
Cappi+13, SP

AGN ultra-fast outflows

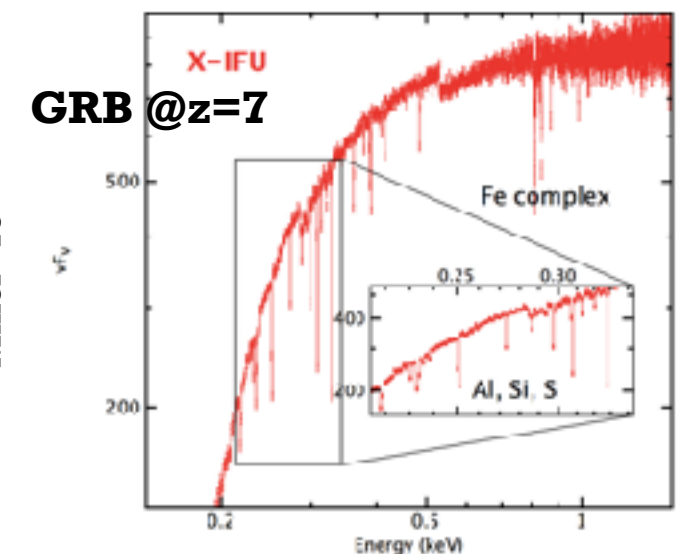


J.M.  
Miller+16

BHB winds



Dovciak+13, SP



Jonker, +13, SP



# The Energetic Universe

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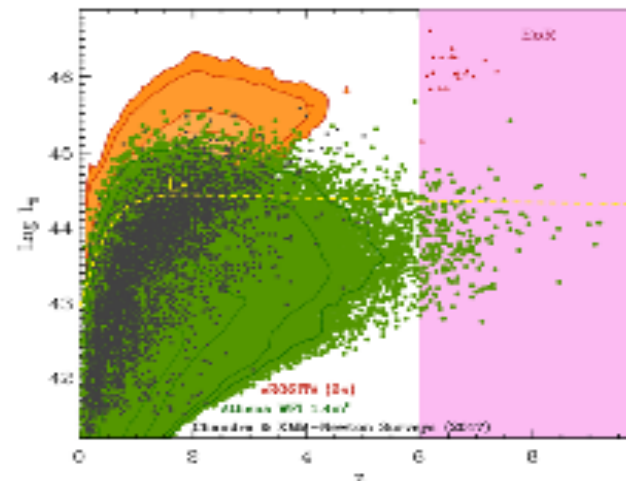
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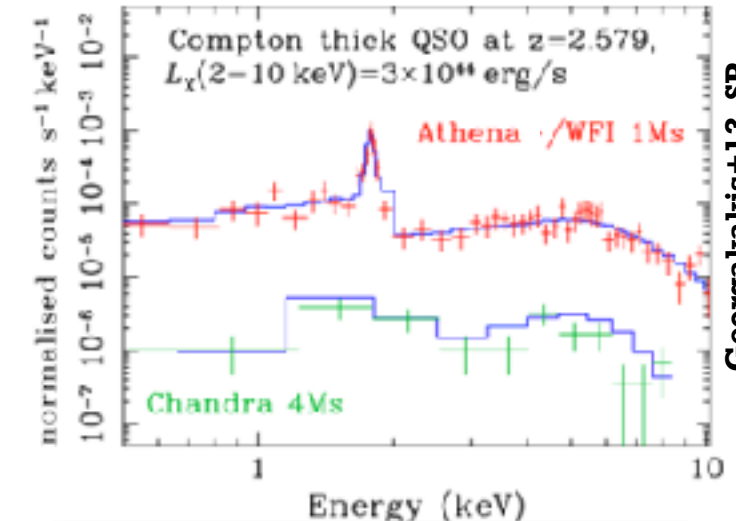
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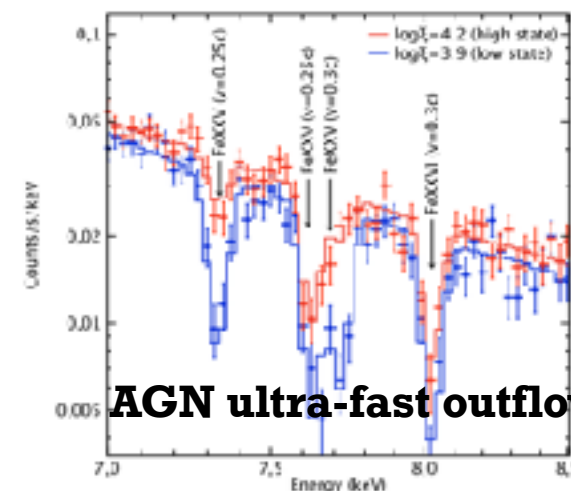


Aird+13, SP

Compton-thick AGN census

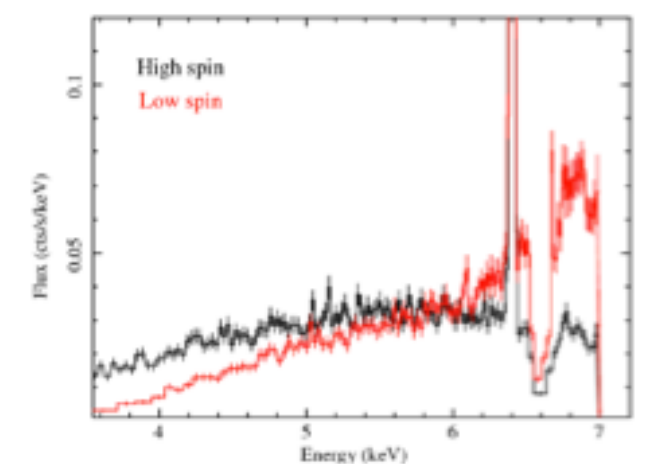


Georgakakis+13, SP

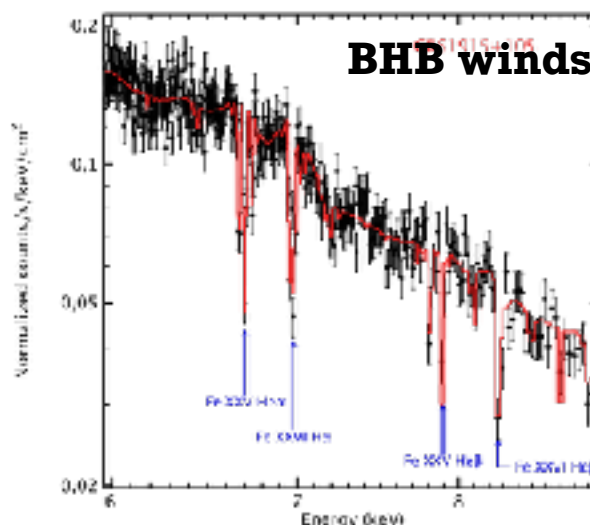


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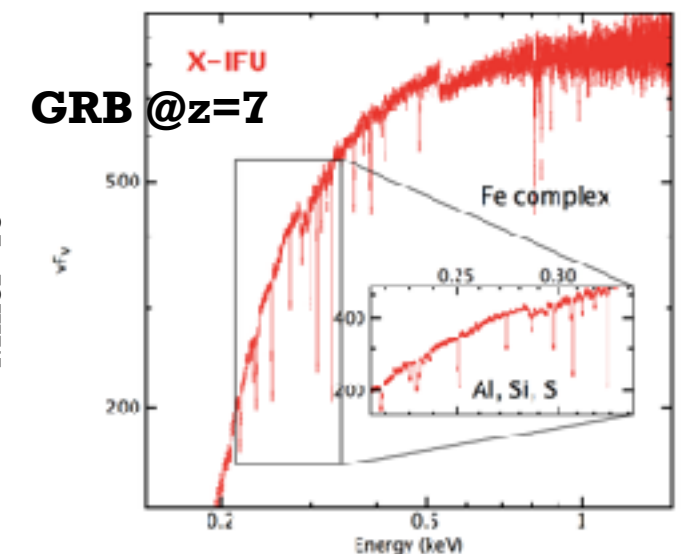


Dovciak+13, SP



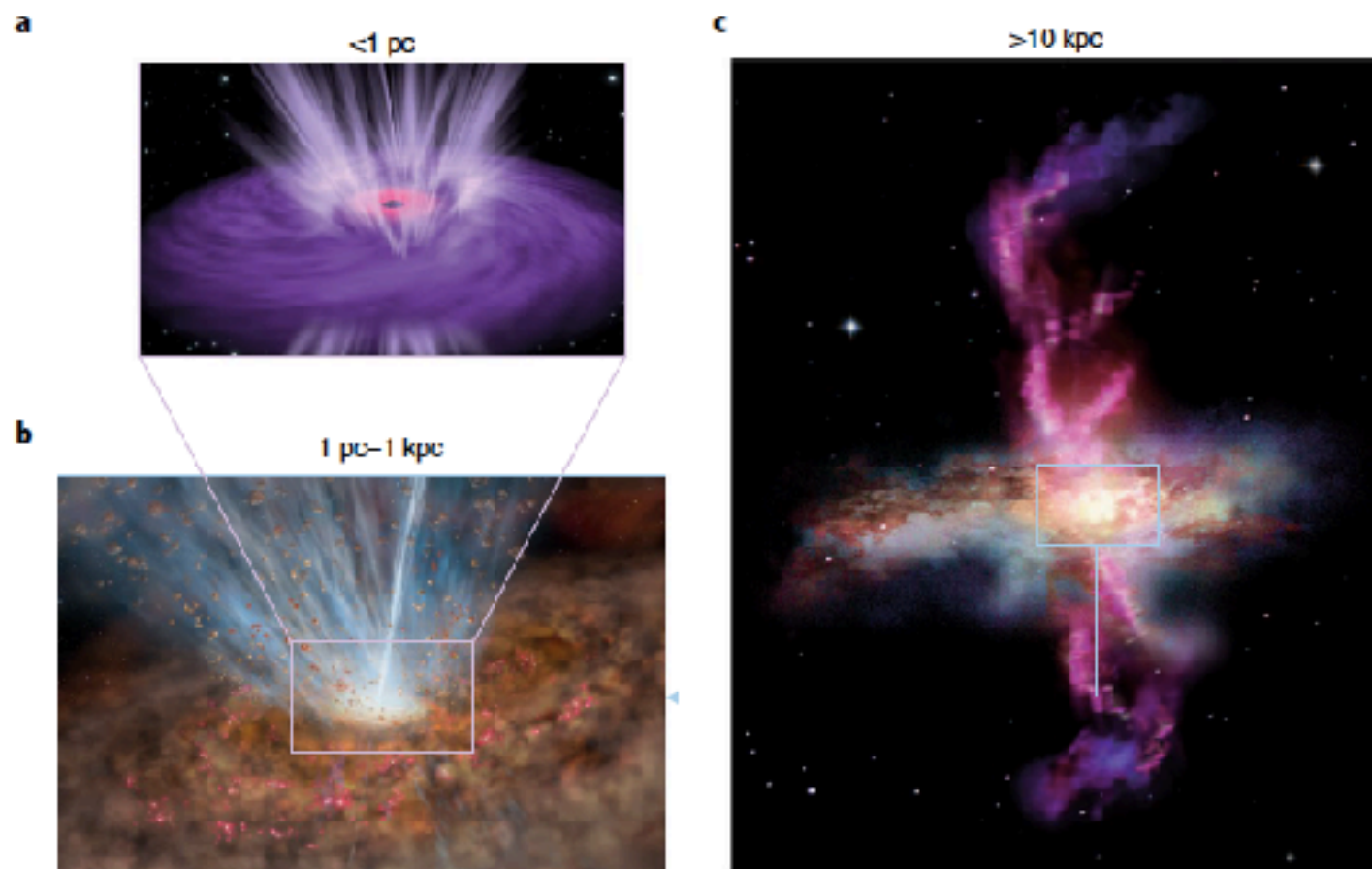
J.M. Miller+16

BHB winds



Jonker, +13, SP

# Feeding and Feedback cycle



## Expectations:

The activity of the SMBH influences the life of the galaxy

## MICRO vs. MACRO

## Heating vs. Ejecting

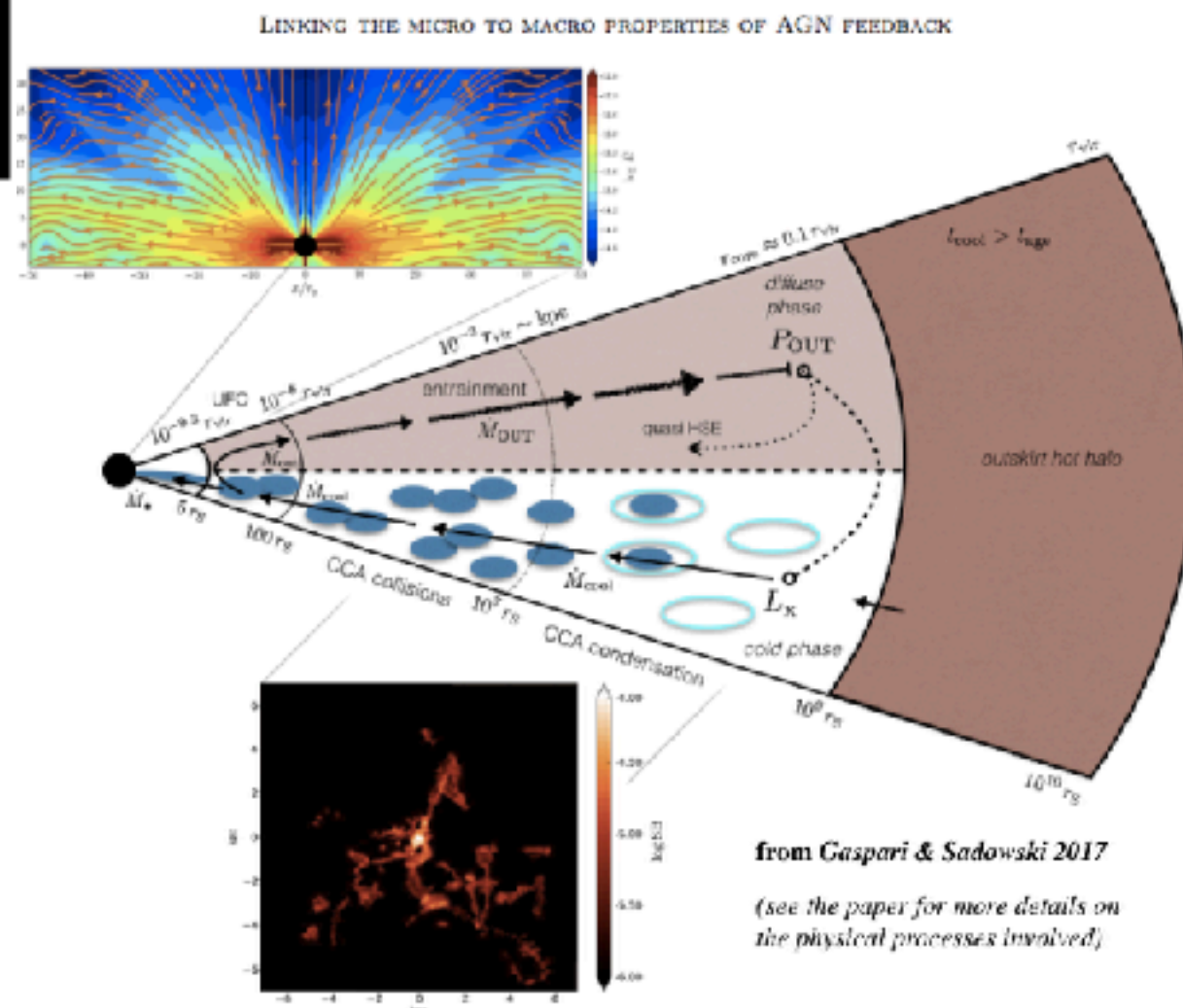
e.g. Croton+2006, Ciotti&Ostriker2007

## Radiative vs. Kinetic

e.g. Ciotti+2010, Tadhunter+2014  
see also Terashima and Pinto's talks

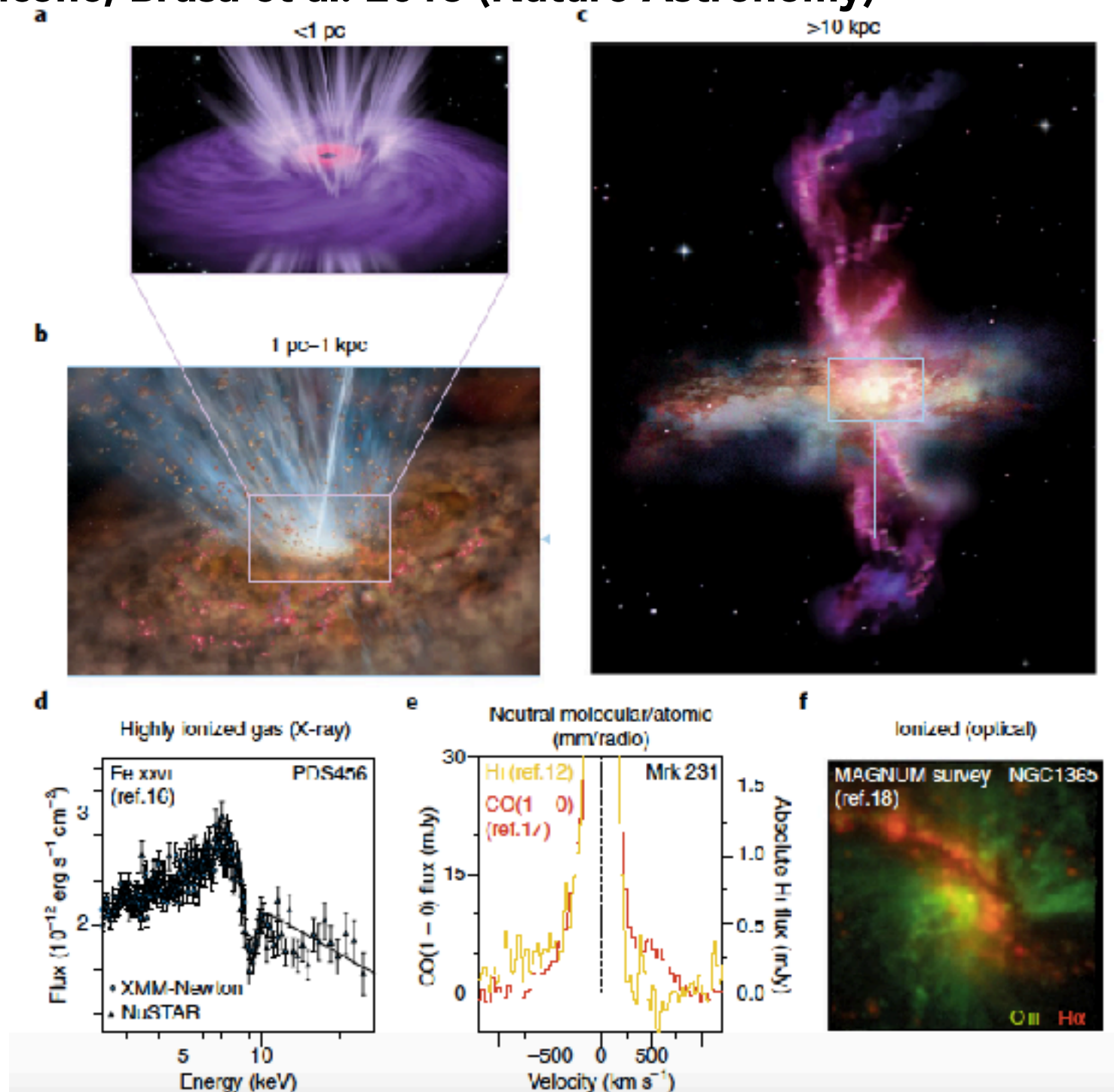
## Accretion disc vs. Chaotic Cold Accretion

e.g. Gaspari & Sadowski 2017



# QSO Feedback as “outflows”

Cicone, Brusa et al. 2018 (Nature Astronomy)



**highly-ionised  
gas (UFOs)**

Nardini+2015

**neutral gas  
molecular and  
atomic**

Morganti+2016, Cicone+2012

**ionised  
gas**

Venturi+2018

## Expectations:

**Winds from the central AGN  
propagate into the host galaxy**

## Observations:

**Winds are seen across the  
electromagnetic spectrum  
(ionization state, redshift...)**

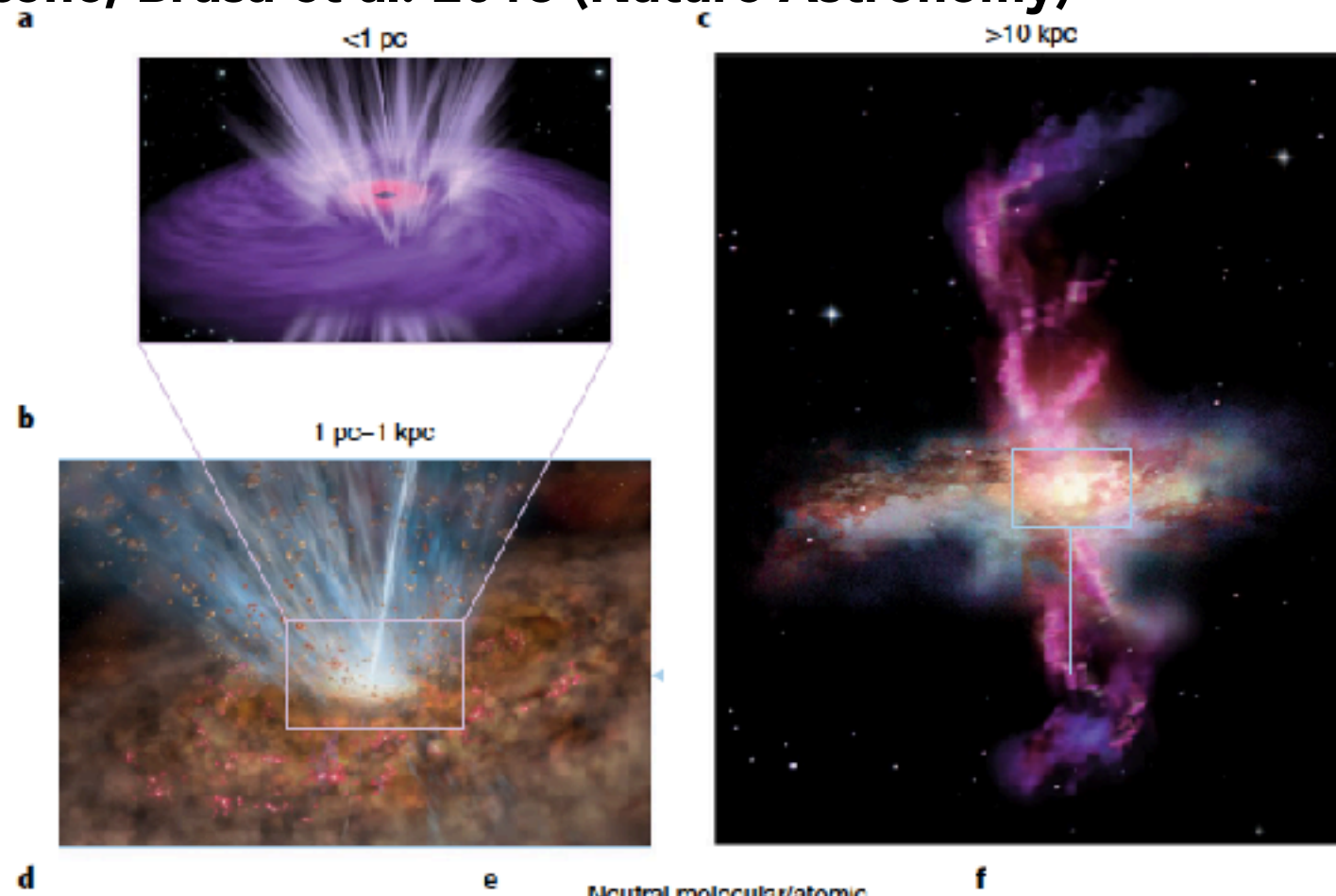
**Different tracers probe different  
phases and different scales**

Gas flows, winds = **velocity**  
**“disturbed” kinematics**



# QSO Feedback as “outflows”

Cicone, Brusa et al. 2018 (Nature Astronomy)



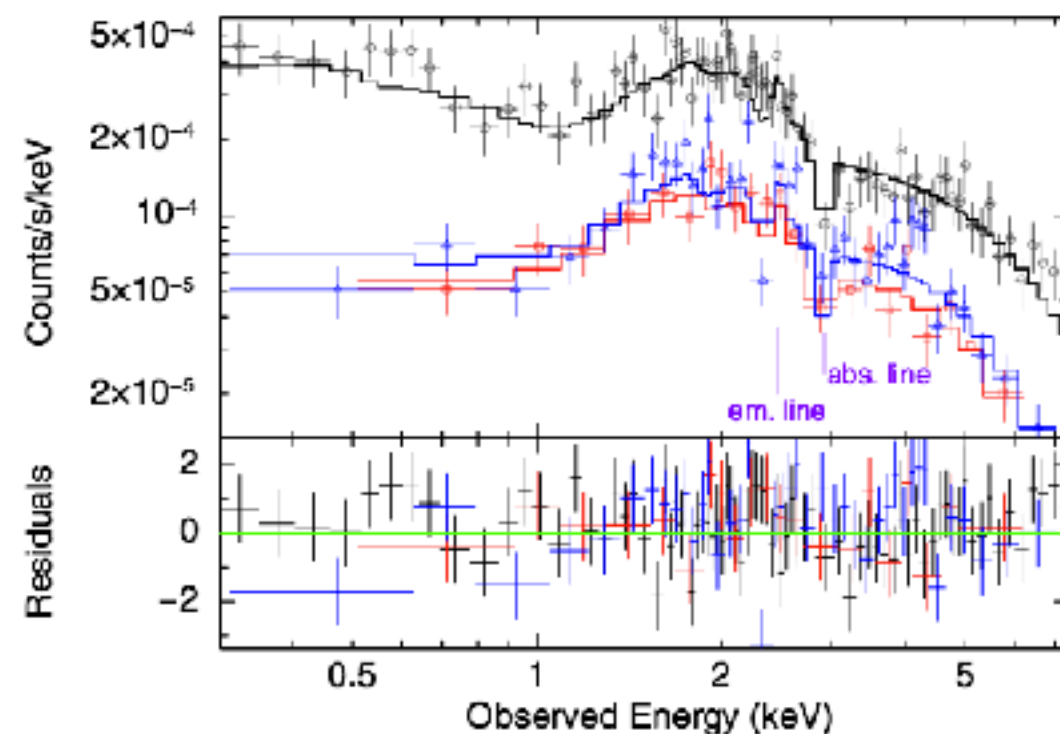
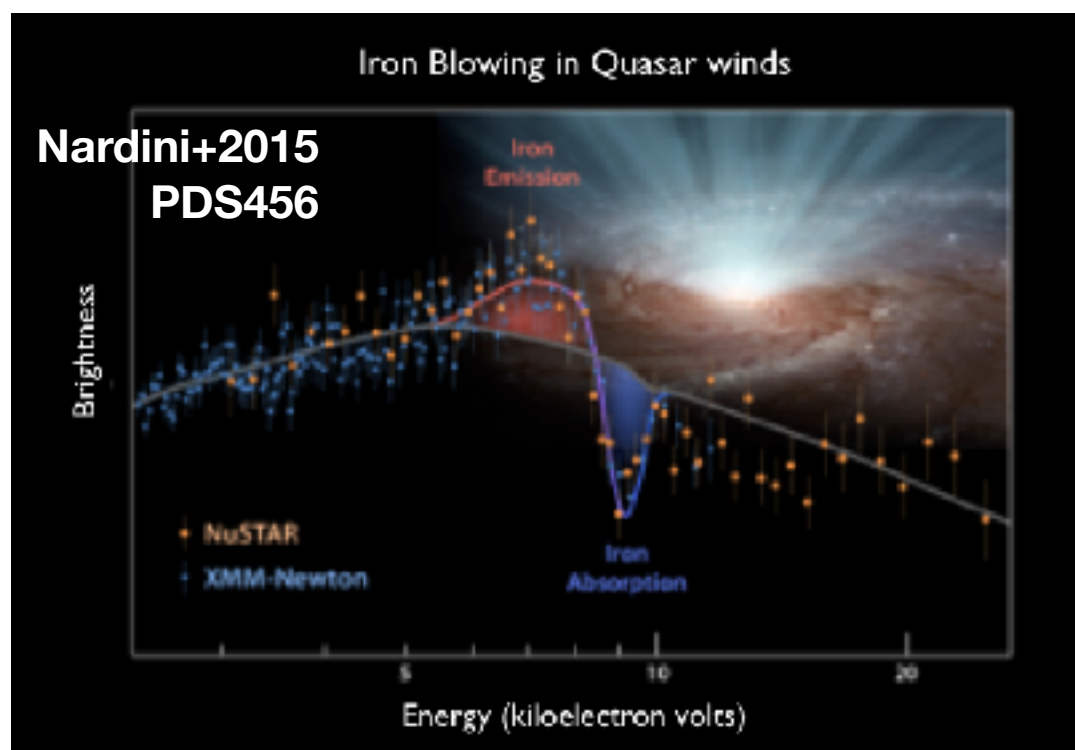
## Expectations:

**Winds from the central AGN propagate into the host galaxy**

## ULTRA FAST OUTFLOWS

**accretion disc winds of highly ionised hot gas with  $v \sim 0.05-0.5c$**

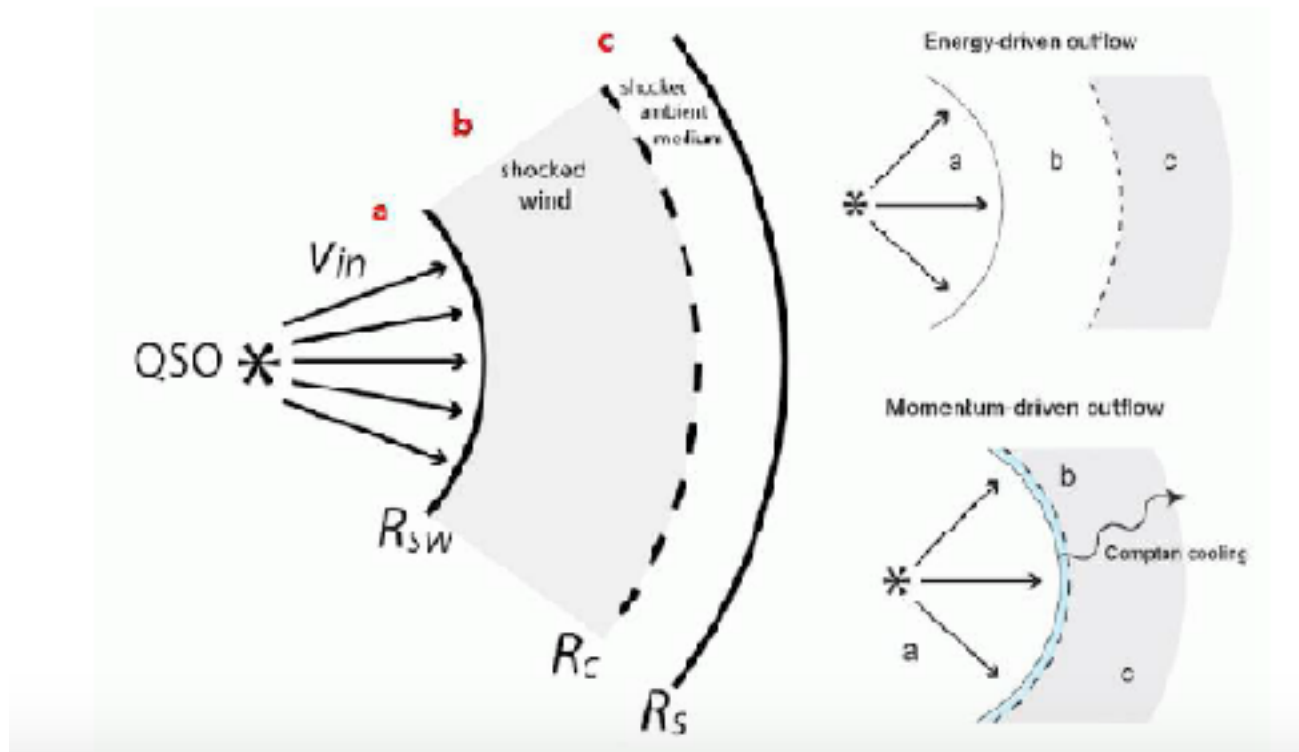
Vignali+2015, CDFS  
 $z=1.6$  obscured  
QSO



# Radiative feedback

## Radiative feedback

Wide-angle, wind-driven outflows, launched from the accretion disk and driven by **radiation pressure**



Faucher-Giguere+2012, King2012, Fabian2012  
Zubovas&King 2012...2016, Costa+2014

radiation pressure from the QSO  
accelerates accretion disc wind at  
 $\dot{P}(\text{AGN}) \sim L_{\text{AGN}}/c$  (King2012)

**momentum-conserving** wind bubble  
predicts large scale outflows with  
 $\dot{P}(\text{out}) \sim \dot{P}(\text{AGN}) \sim L_{\text{AGN}}/c$

**energy-conserving** wind bubble  
boosts the momentum by a factor  
 $\dot{P}(\text{out}) \sim 20 \times \dot{P}(\text{AGN}) \sim 20 \times L_{\text{AGN}}/c$

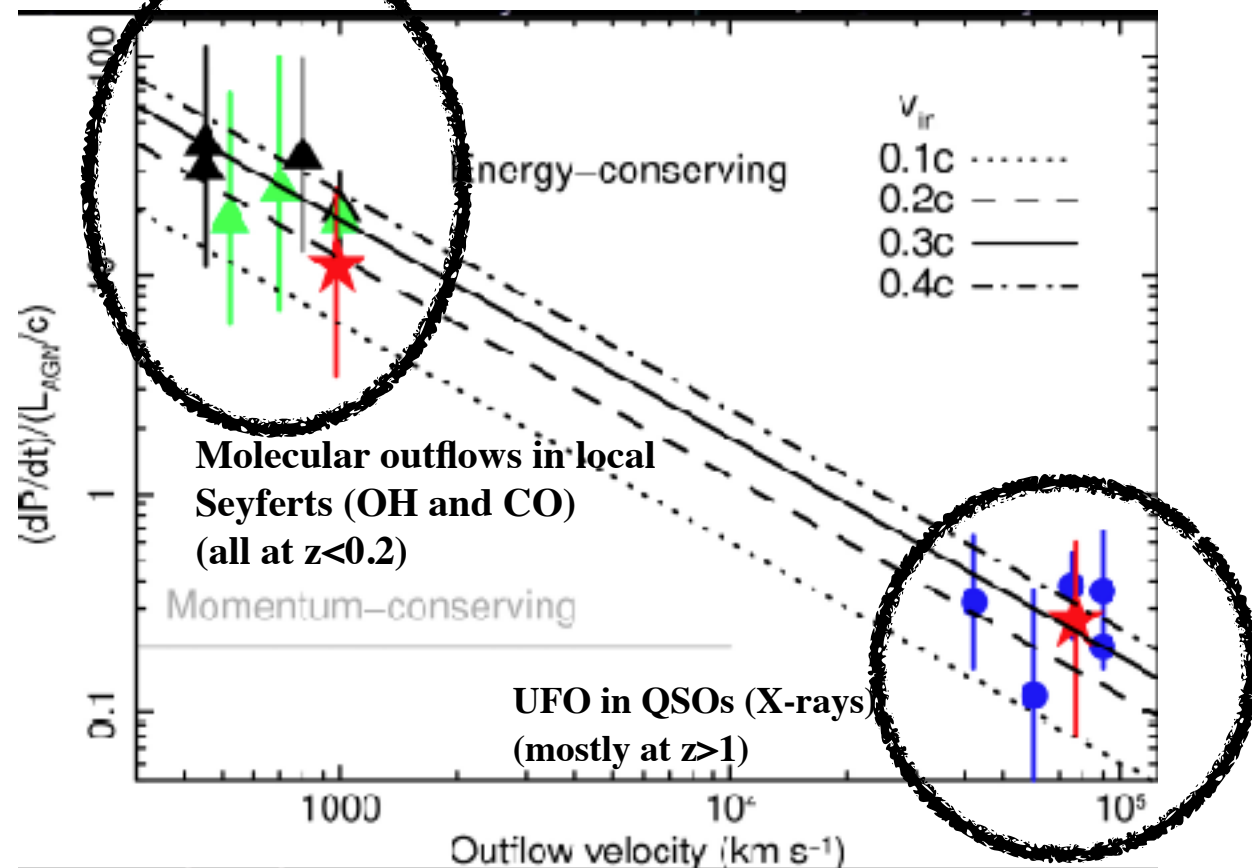
**Are we able to disentangle between different kinds of energy transfer on the ISM?**

**What the scaling with luminosity? and Eddington ratio?**

**What the UFOs duty cycle (=efficiency of energy transfer)?**

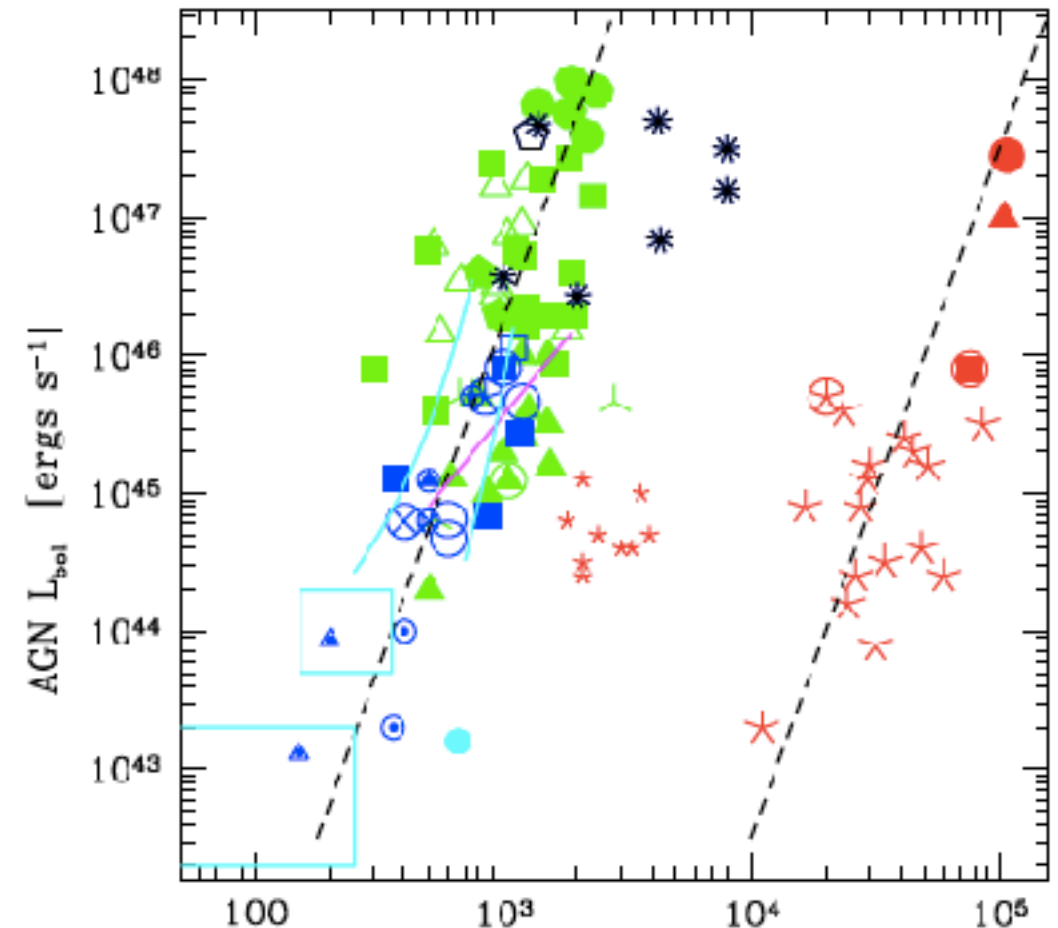
# Connecting winds

kpc and sub-pc outflows detected only in  
**IRAS F11119**, Mrk231, APM08279  
 (Feruglio+2015, Feruglio+2017)



Tombesi+2015

kpc and sub-pc outflows velocities  
 show **same trend with  $L_{\text{bol}}$**  ( $v \sim L_{\text{bol}}^{3.9}$ )

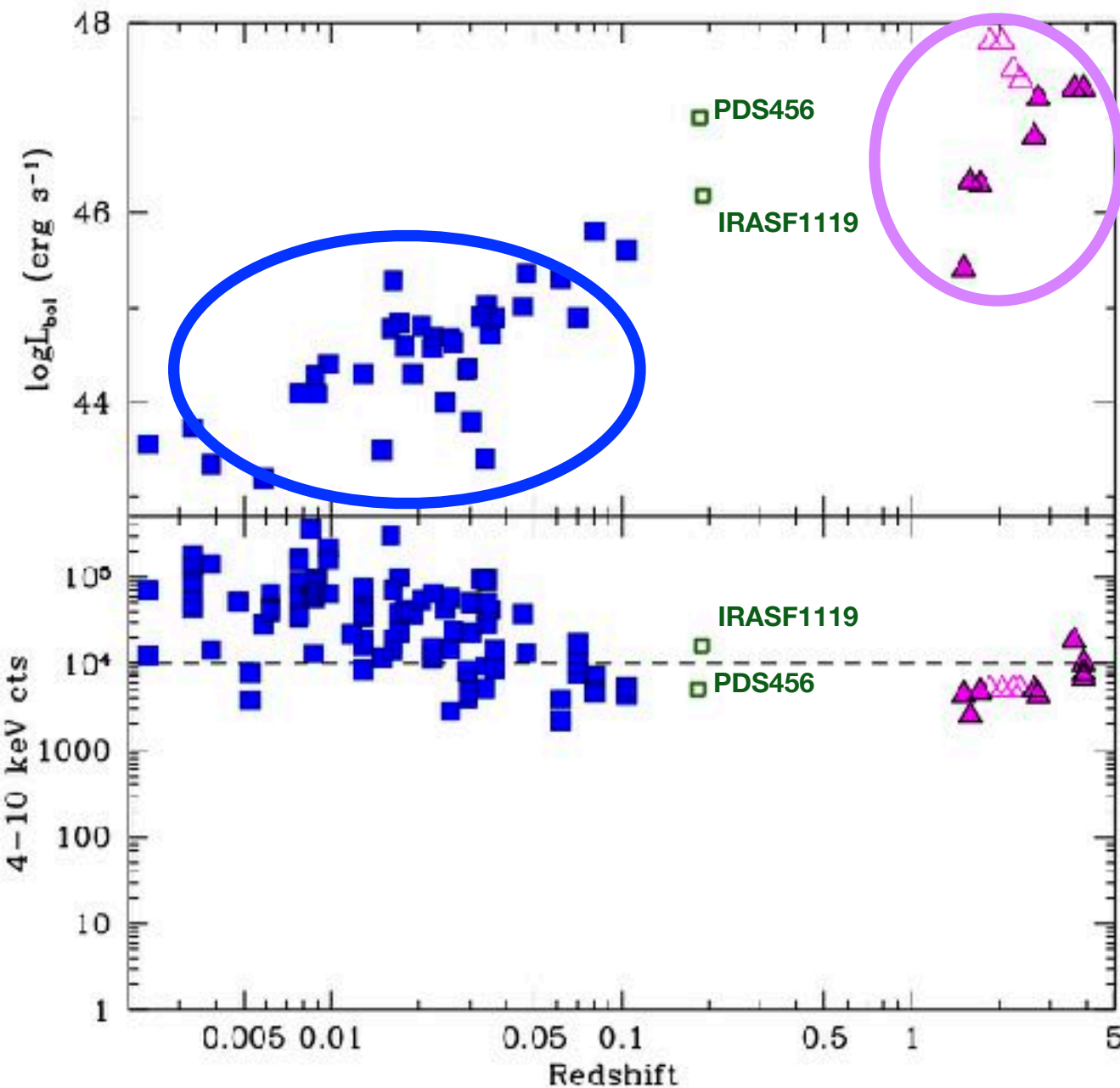


## Key observable needed

- UFO detected over a large Luminosity range
- range of Eddington ratios
- multiphase characterisation



# UFO studies: situation so far



**LOCAL SEYFERTS**  
(40% UFOs detection)  
Tombesi+2010

sparse, high-z samples/lensed  
(50-70% UFOs)  
Chartas+2003,2016, Dadina+2018,  
Lanzuisi+2012, Vignali+2012

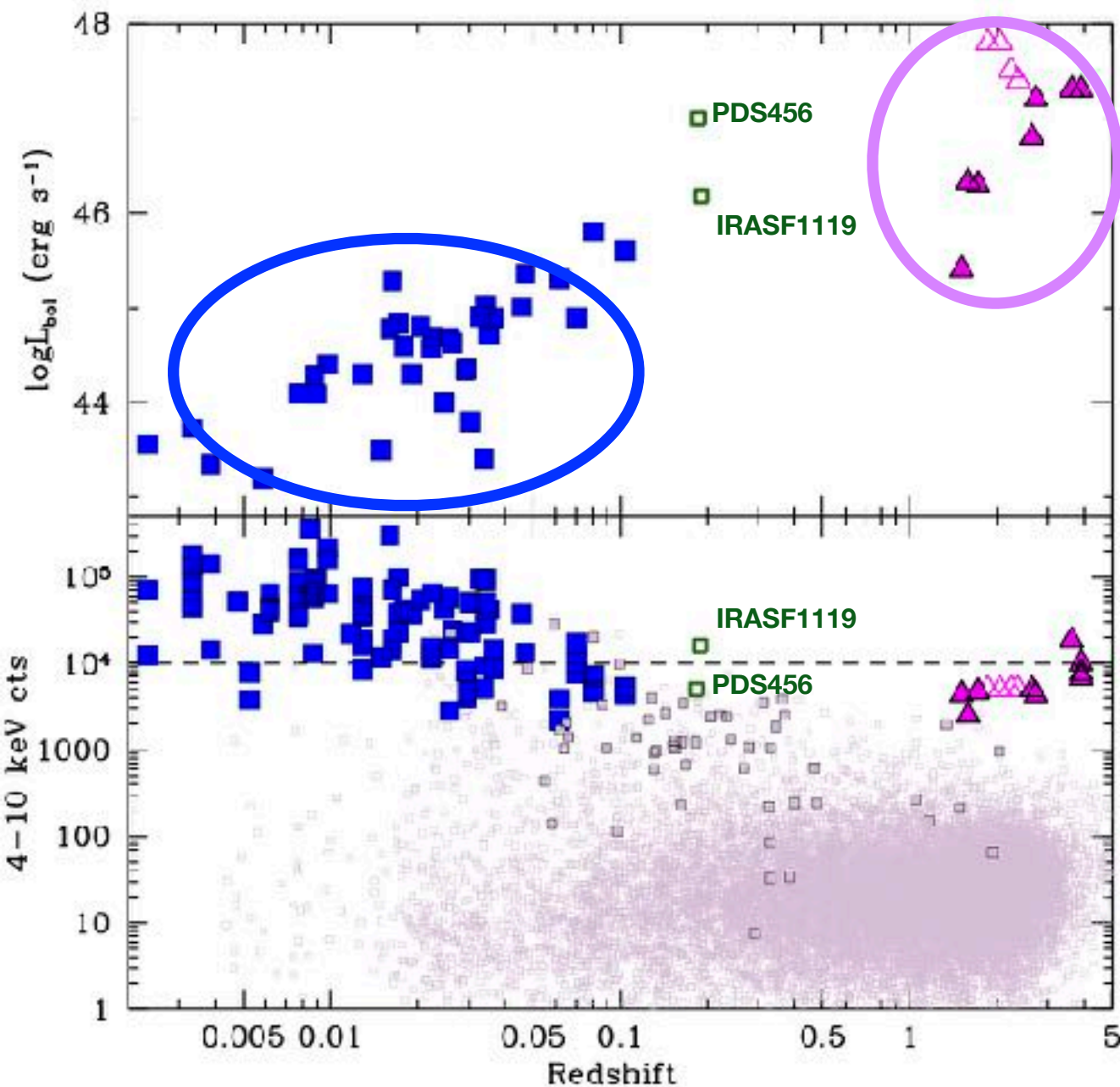
IRASF1119  
*UFO + molecular outflow detected*  
(Tombesi+2015)

PDS456  
*Best UFO detection as of today*  
(Nardini+2015)

**At least ~10.000 cts used to constrain physical parameters of UFOs**

**LACK of sources around  $L^*$  ( $L_{bol} \sim 45.5-46$ )**

# UFO studies: situation so far



**LOCAL SEYFERTS**  
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sparse, high-z samples/lensed  
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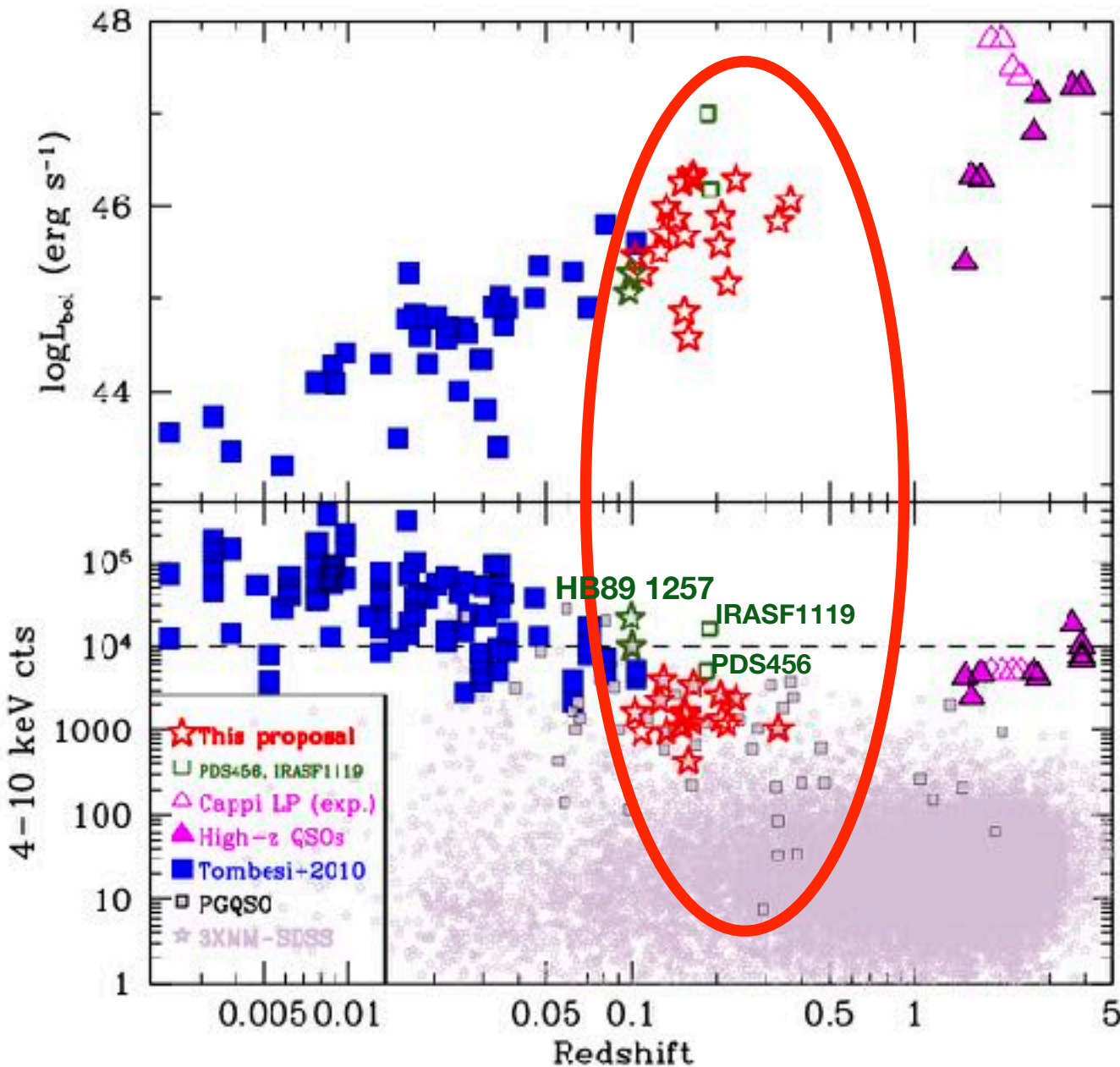
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sources in 3XMM matched with  
SDSS or PG QSO samples



# A unique QSO sample for UFO studies



## New sample

sources in 3XMM+SDSS or PG QSO with

\*  $z \sim 0.1-0.5$

\* *rest frame* 4-10 keV counts rate  $> 0.14$  cts/s

\* Not radio loud/in clusters

—> 20 sources (only!)

HALF of them have evidence of *ionised* outflows from optical spectra

—> connection of UFOs and ionised outflows can be investigated for the first time

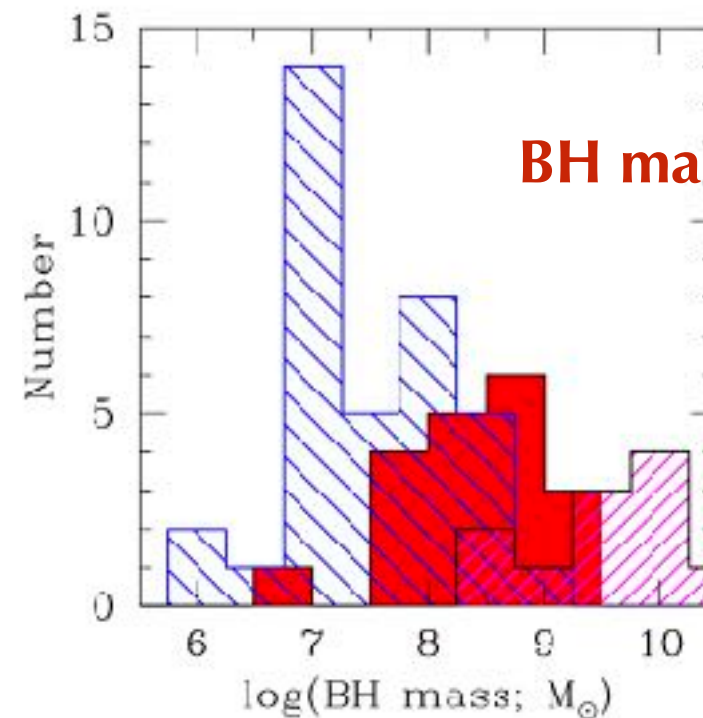
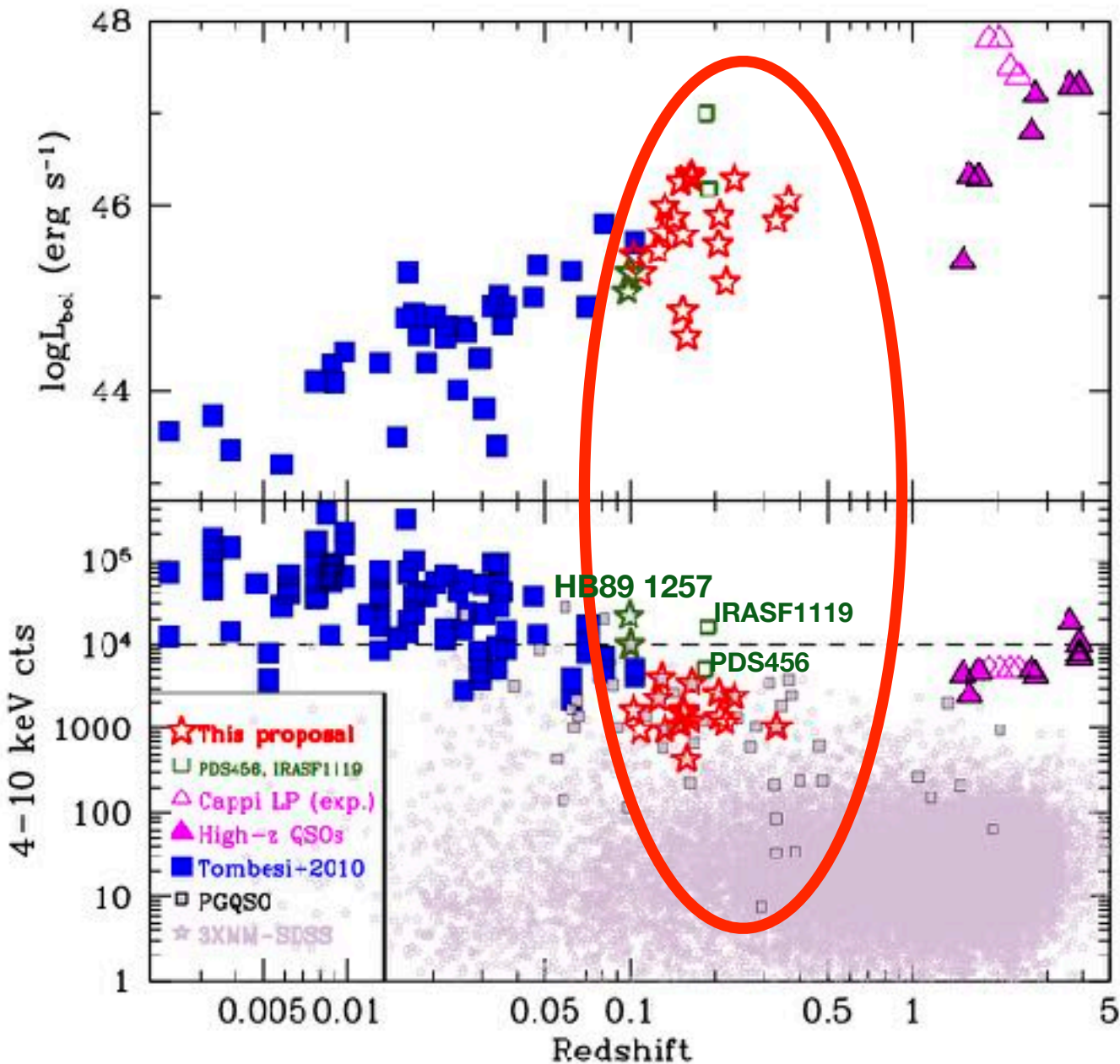
All of them have optical spectra

—> measure of BH mass

WISE (100%) and Herschel (80%) detected

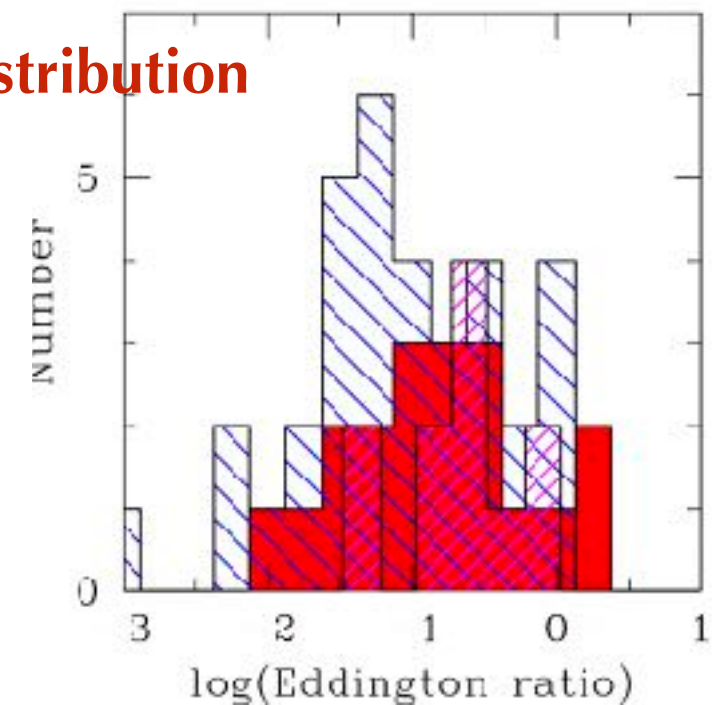
—> good handling of  $L_{\text{Edd}}$ ,  $L_{\text{bol}}$ , SFR and extinction

# A unique QSO sample for UFO studies



BH mass distribution

Eddington ratio distribution



most of them bright enough (justify count rate selection)

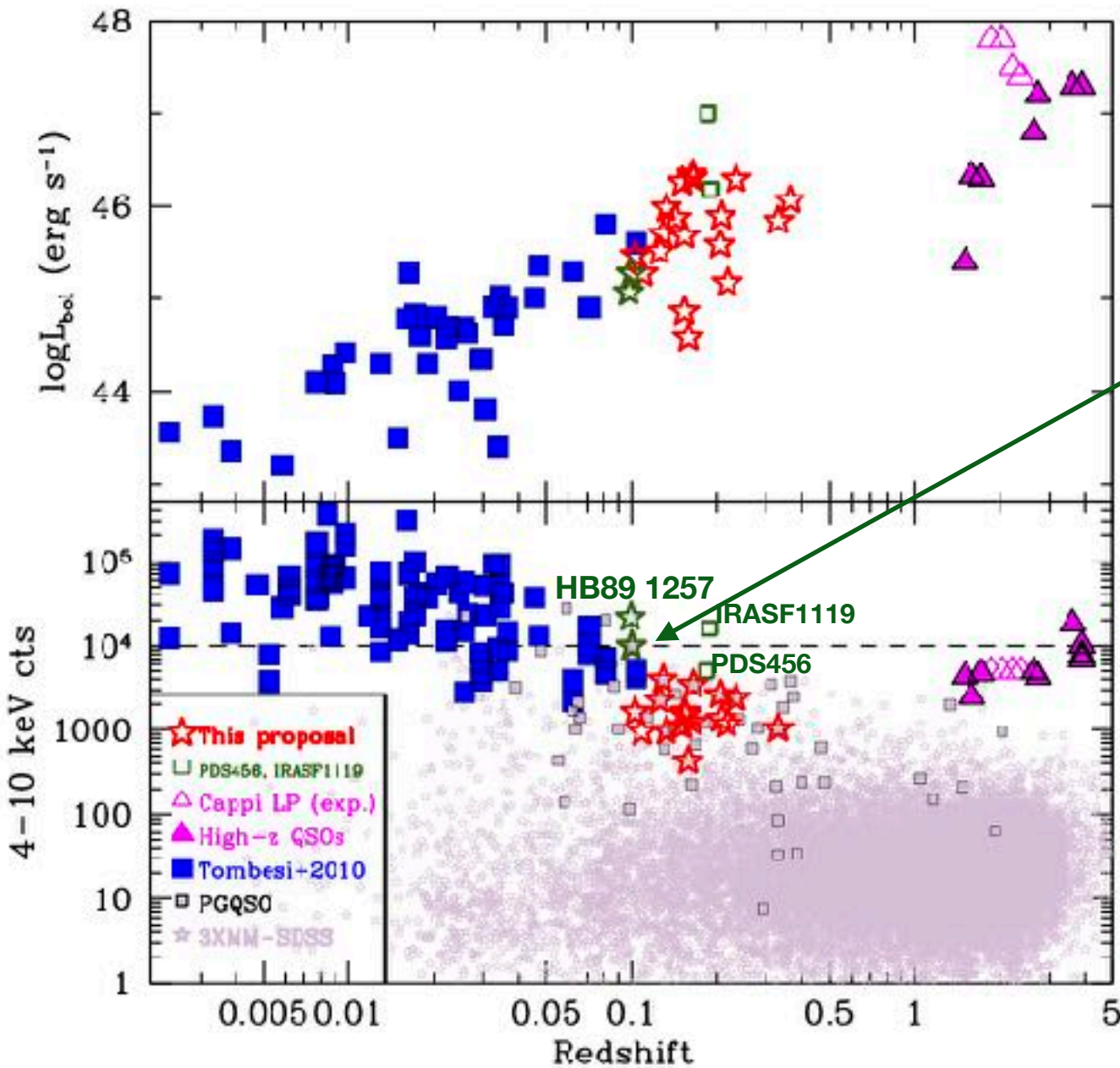
~10.000 cts reachable with 50-100 ks of XMM time

most of them are underexposed so far

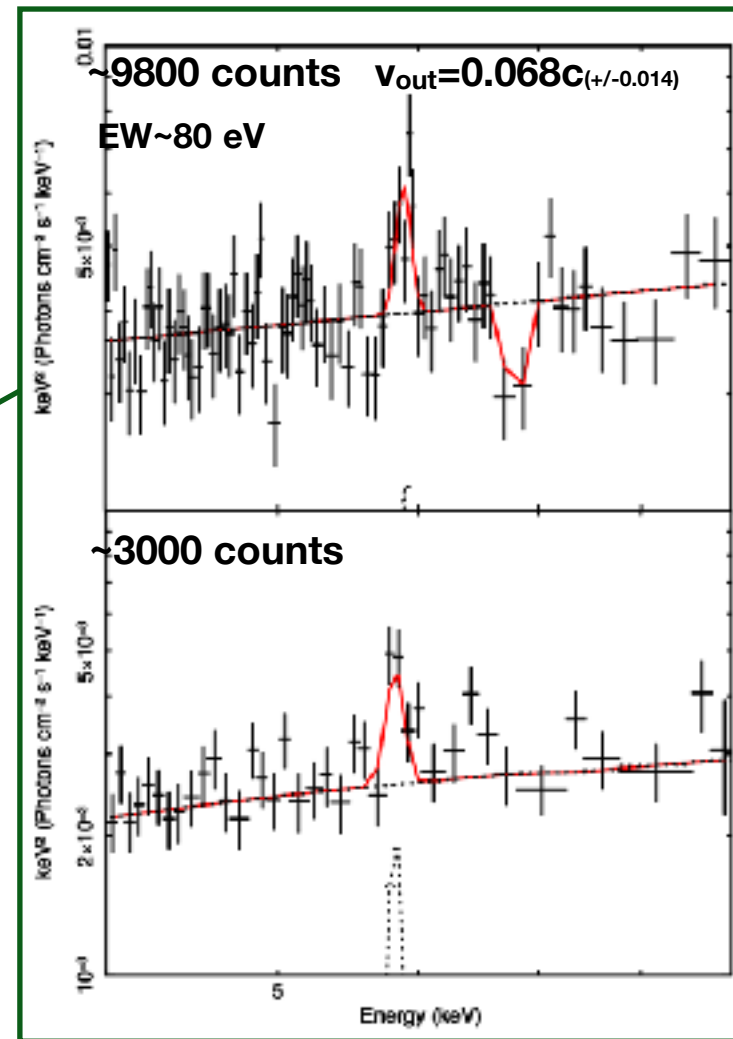
~2000 cts vs. ~10.000 cts needed to constrain physical parameters of UFOs



# A unique QSO sample for UFO studies



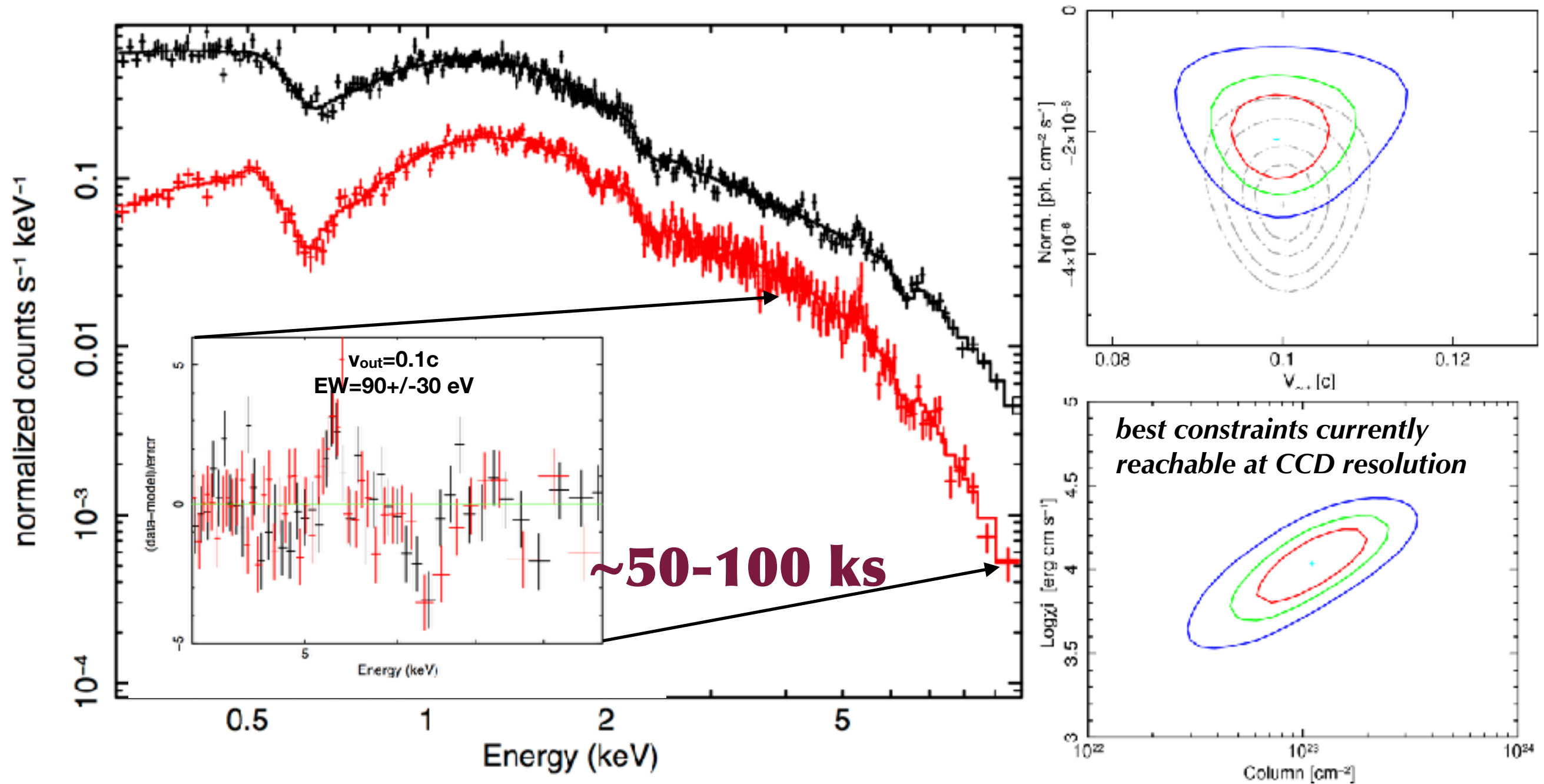
PG0804+761



Already available in XMM archive  
(with >10000 counts)

PG0804+761, HB 1257+286

# Expected XMM EPIC spectra



**Total XMM time needed to observe  $\sim 20$  sources: 1.5 Ms\***

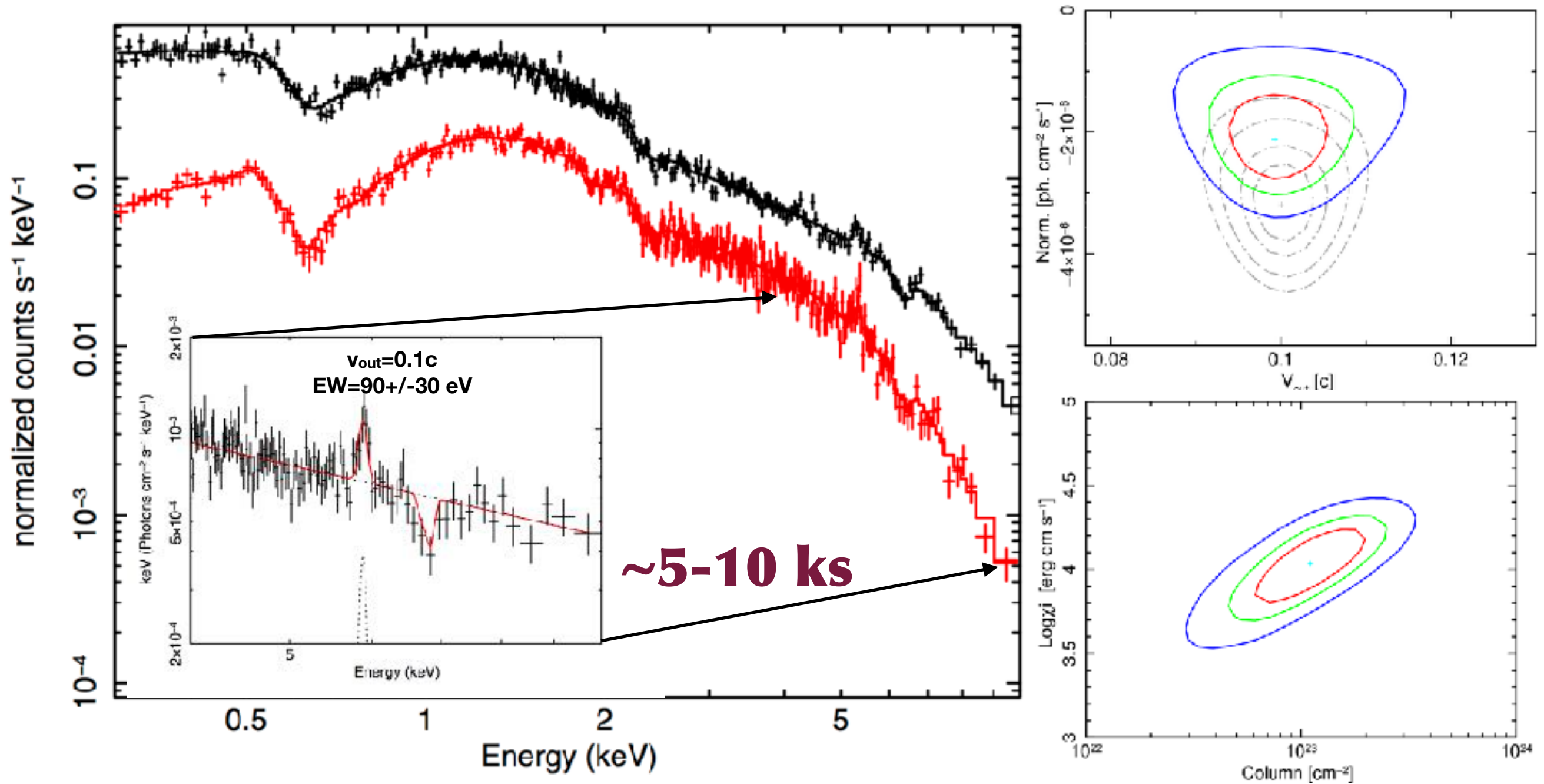
*a lot of interesting science can be explored even in the sources without UFO detection:  
 $\alpha_{\text{ox}}$  (OM), WA, thermal component, relation of large scale outflows with  $N_{\text{H}}/L_{\text{bol}}/\text{dust}$ .*

**\*submitted ad an XMM-Heritage program in 2017**

*e.g. Laha+2018, Martocchia+2017*



# Expected Athena WFI spectra



Total XMM time needed to observe ~20 sources: 1.5 Ms

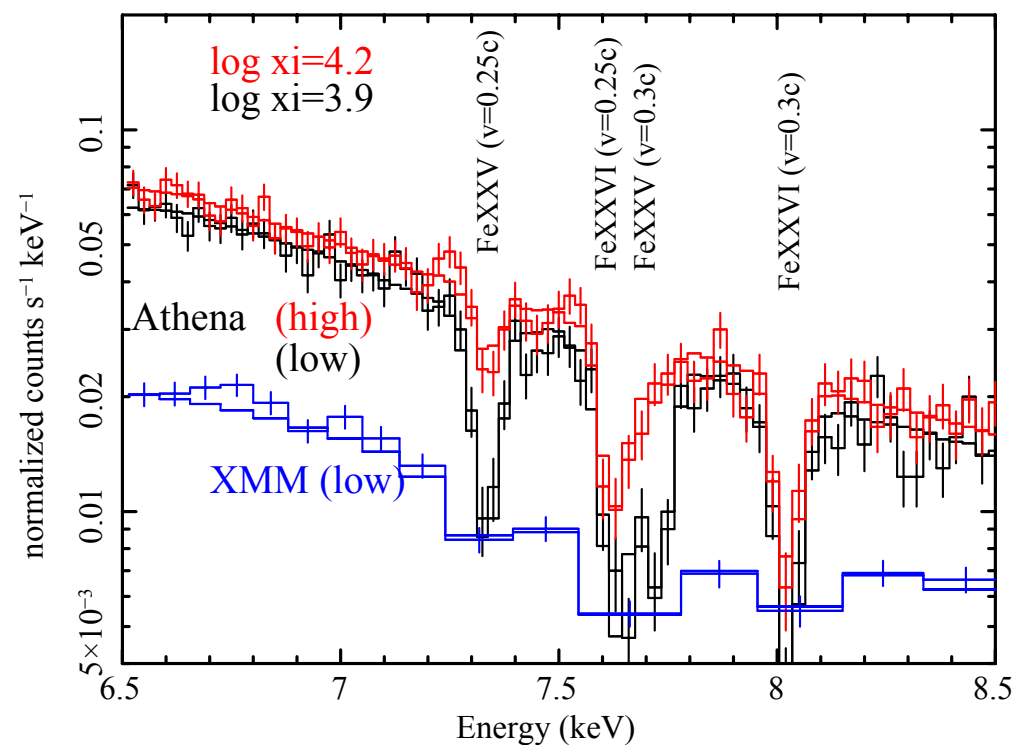
Total Athena WFI time needed to observe ~20 sources: 150 ks

# AGN winds and outflows

**Mechanical energy released  
in ultra-fast outflows  $\propto v^3$**

**XIFU energy resolution  
crucial to assess energetics and  
reveal plasma properties**

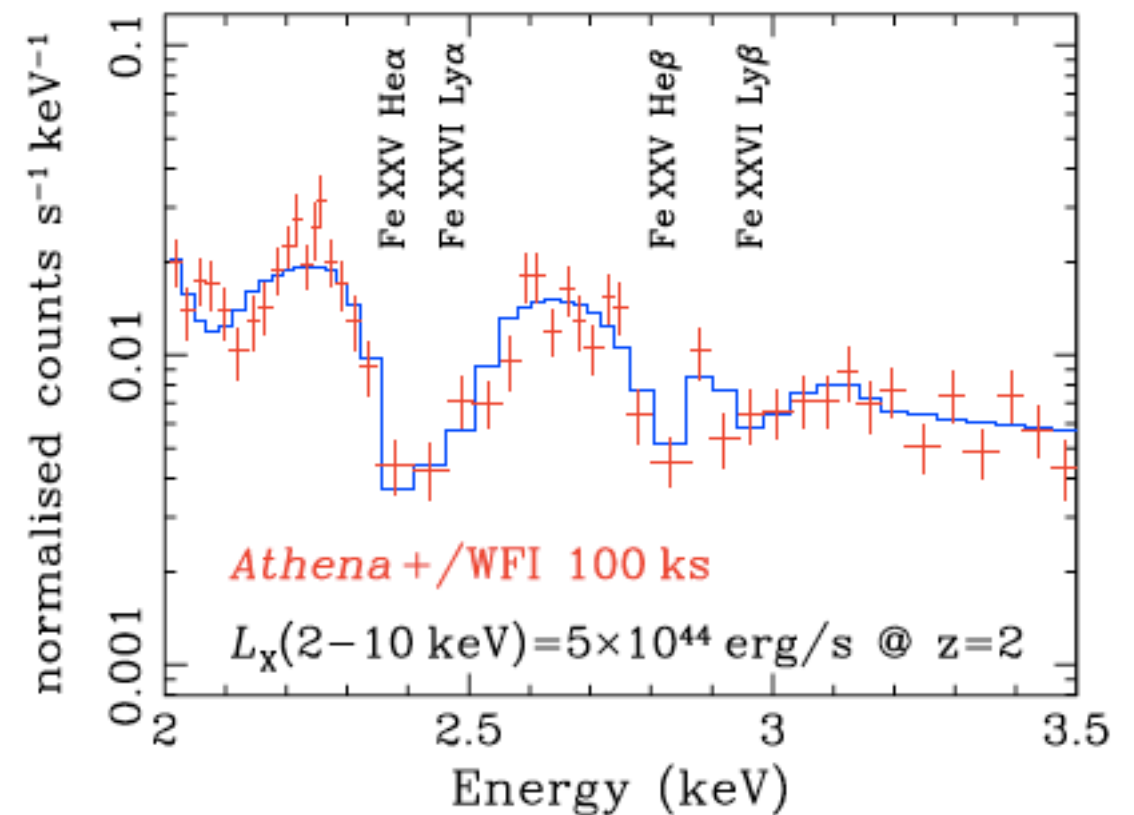
**See talks by Cappi & Terashima**



**Cappi, Done et al. 2013, arxiv:  
1306.2330**

**WFI survey crucial to reveal  
outflows at high-z**

**See talk by Carrera**



# Summary

## Ultra Fast Outflows:

- > key *observables* to constrain AGN feedback models but...
  - ★ duty cycle/energetics vs. AGN properties (e.g.  $L_{\text{Edd}}$ ) unexplored for sources with  $L \sim L^*$
  - ★ relation between larger scale (molecular/ionised) outflows to be explored on *statistical samples*

## Athena will revolutionise this field (in ~15 years)

- > at  $z \sim 0$ : factor of 10 lower expo time (WFI), unique energy resolution (X-IFU)
- > extend up to  $z \sim 3-4$  (WFI survey + X-IFU pointings)

## Natural Synergies with longer wavelengths facilities in the 2020-2030 landscape (see Padovani talk on ESO-Athena synergies)

- > X-ray detected UFOs primary targets for ALMA & NOEMA (molecular)  
*this already happened with APM08279, PDS456 + IRAS F1119, Mrk231,*
- > X-ray detected UFOs primary targets for VLT & E-ELT IFUs (ionised)  
*no connection established yet*
- > AGN/QSOs with molecular/ionised outflows primary targets for Athena (XIFU)

## In the meantime...

### significant progresses can be made with a large XMM-Newton time investment

- > ~1.5 Ms to observe a unique QSO sample of ~20 sources !
- > Ideal targets for X-IFU follow-up with Athena!