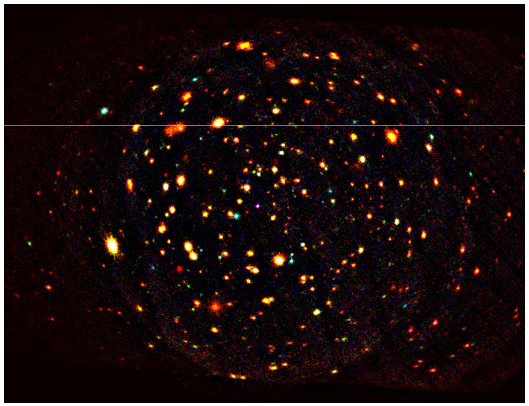
The growth of massive black holes in galaxy centres: Why should we care?

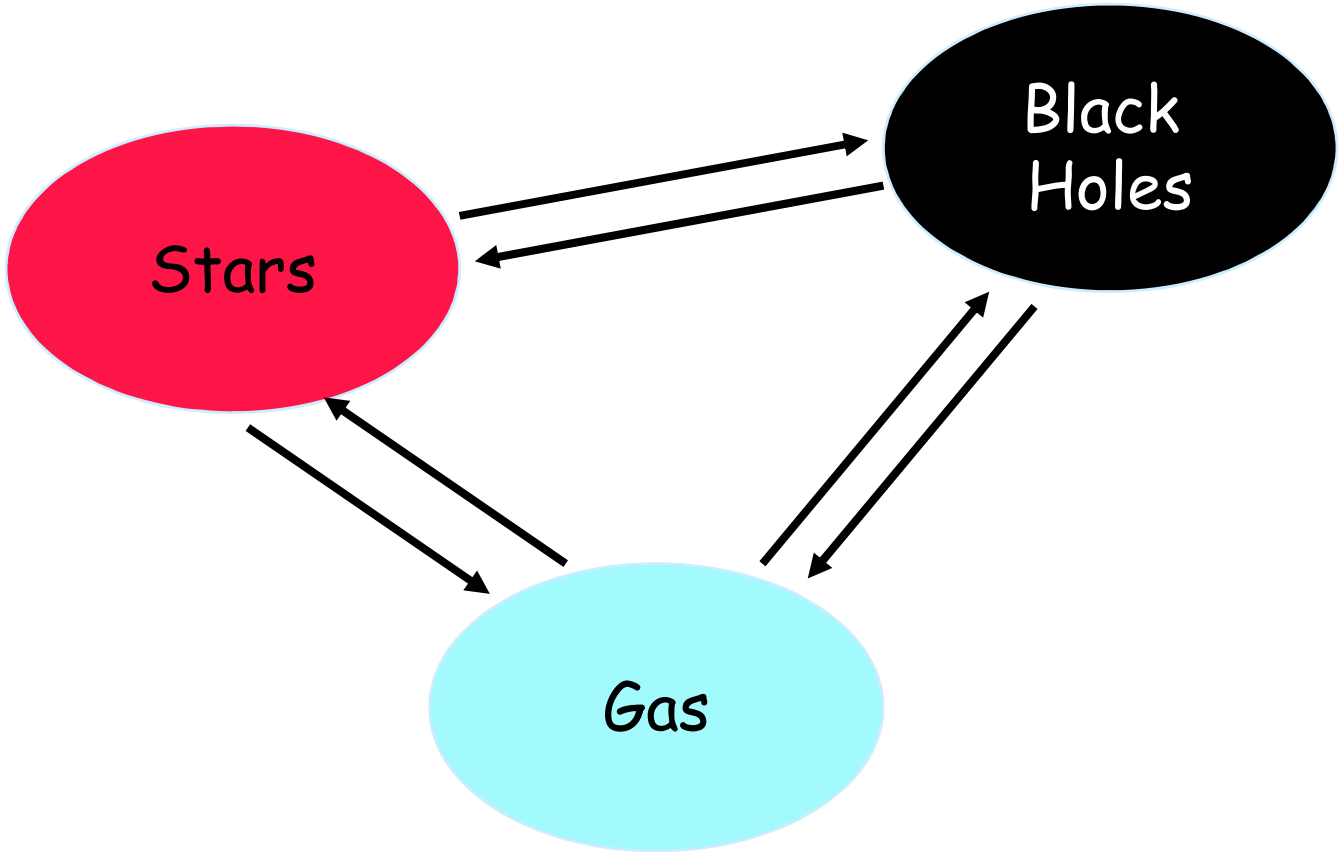


Xavier Barcons



CSIC
IFCA
Instituto de Física de Cantabria
UC
UNIVERSIDAD DE CANTABRIA

The observable Universe



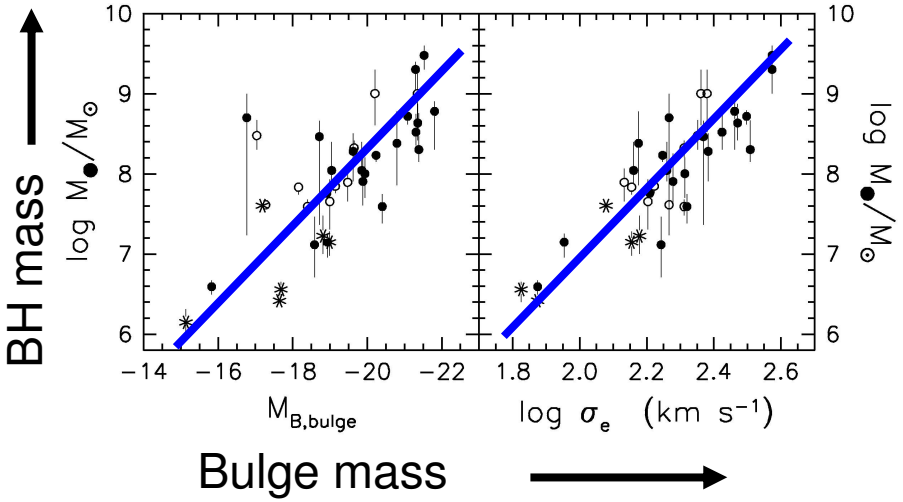
- X-ray surveys: mapping the growth of massive BHs by accretion
  - The XMM-Newton Medium sensitivity survey (XMS)
  - Obscured versus unobscured accretion
  - Efficiency of accretion
- Feedback at work!
- Star formation and BH growth in galaxies

X-ray surveys

Mapping BH growth by accretion

The formation of galaxies, stars and massive Black Holes (BHs)

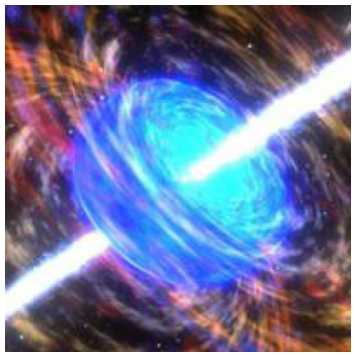
- Most (all?) of today's galaxies harbour a massive Black Hole (BH), with 0.4% of the bulge mass.
- BH is dormant in > 90% of galaxies, and often obscured

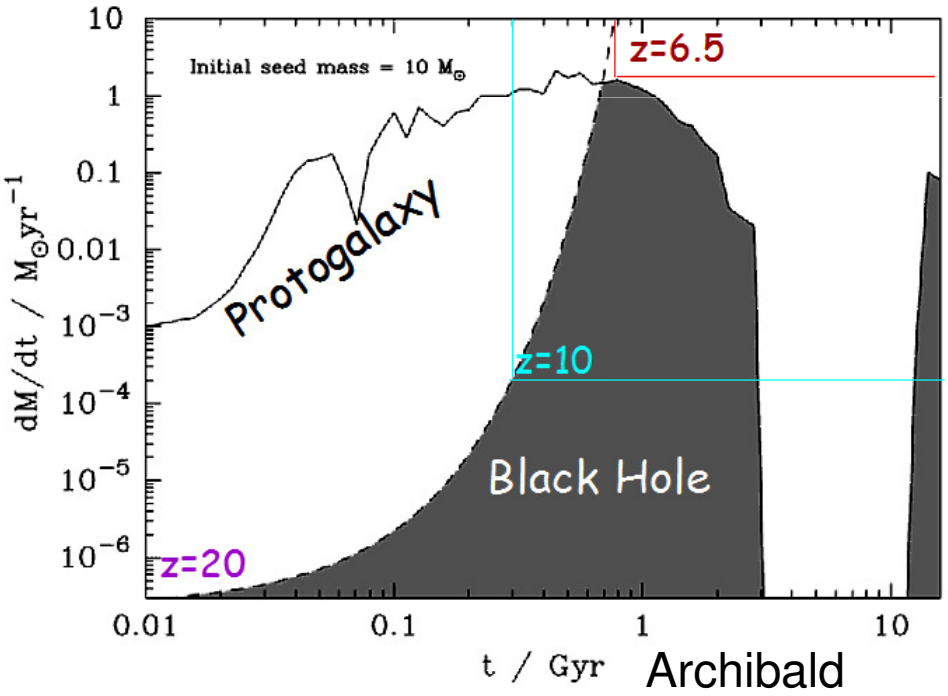


- When and how did the seed BHs form? Can they be detected?
- How did they grow to their current size?:
  - Accretion
  - Merging
  - Tidal capture
- How does "feedback" affect the formation of massive BHs and the formation of stars in galaxies?

The birth of massive Black Holes

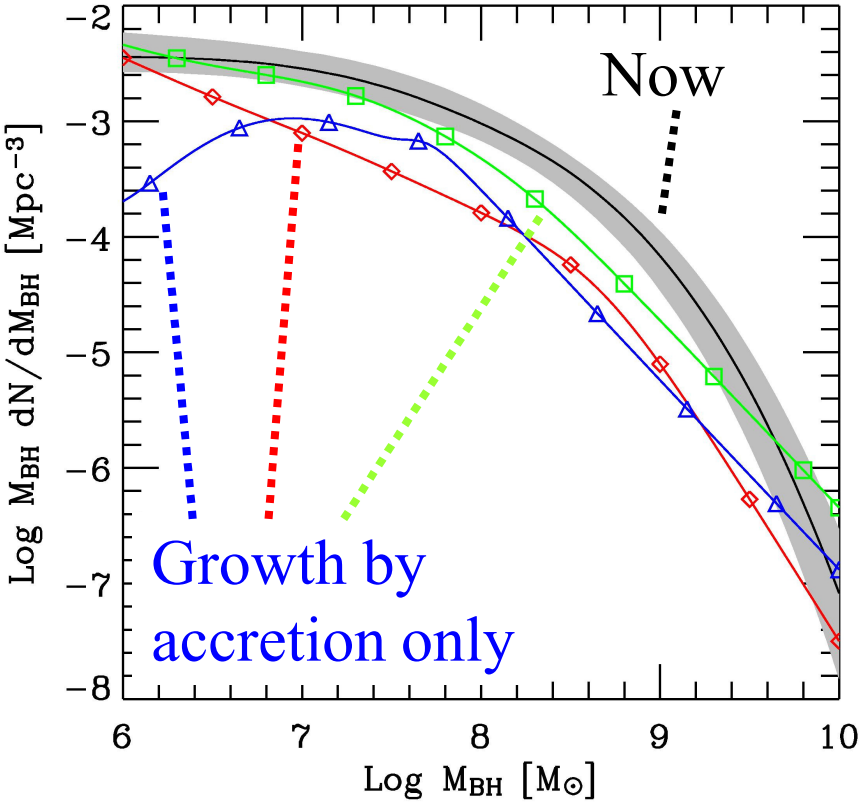
- First stars had 300 $M_\odot$, exploding after 1 Myr, probably in a Gamma Ray Burst (GRB), with copious emission of Gravity Waves
- Leave a ~ few 10 $M_\odot$ BH, which can grow very fast by accretion, if enough material can be found.
- Exponential feeding:
  - First mini-QSOs could have ~10^6 $M_\odot$ BH at z=10
  - Massive (10^8 $M_\odot$) QSOs in place by z~6.5





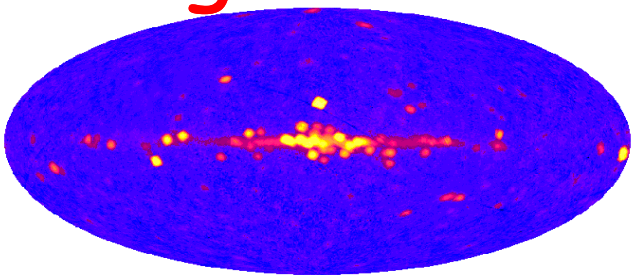
Massive BH growth by accretion

- Local BH mass distribution matches the energy released by accretion to the X-ray background. But three main "assumptions"
  - * Cosmic history
  - * Obscured/unobscured AGN ratio is large ~2-4
  - * Accretion efficiency is large ~10%: Rotating BHs

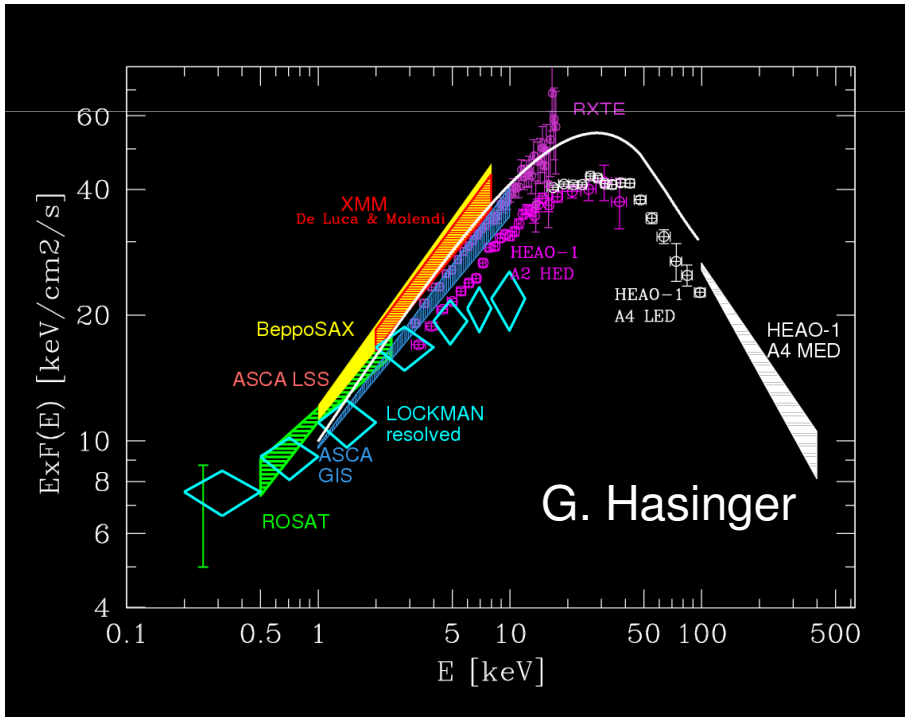


Marconi et al 2004

The Cosmic X-ray background: echo of the massive BH growth



- First discovery in X-ray astronomy (Giacconi et al 1962).
- Isotropic, energy density peaks at 30 keV
- Summed contribution from growing BHs by accretion
- Mostly resolved at energies < 8 keV, **implying most of BH growth occurs in "obscured"** mode
- **Large fraction of energy output by BH accretion at 30 keV, and largely unresolved**



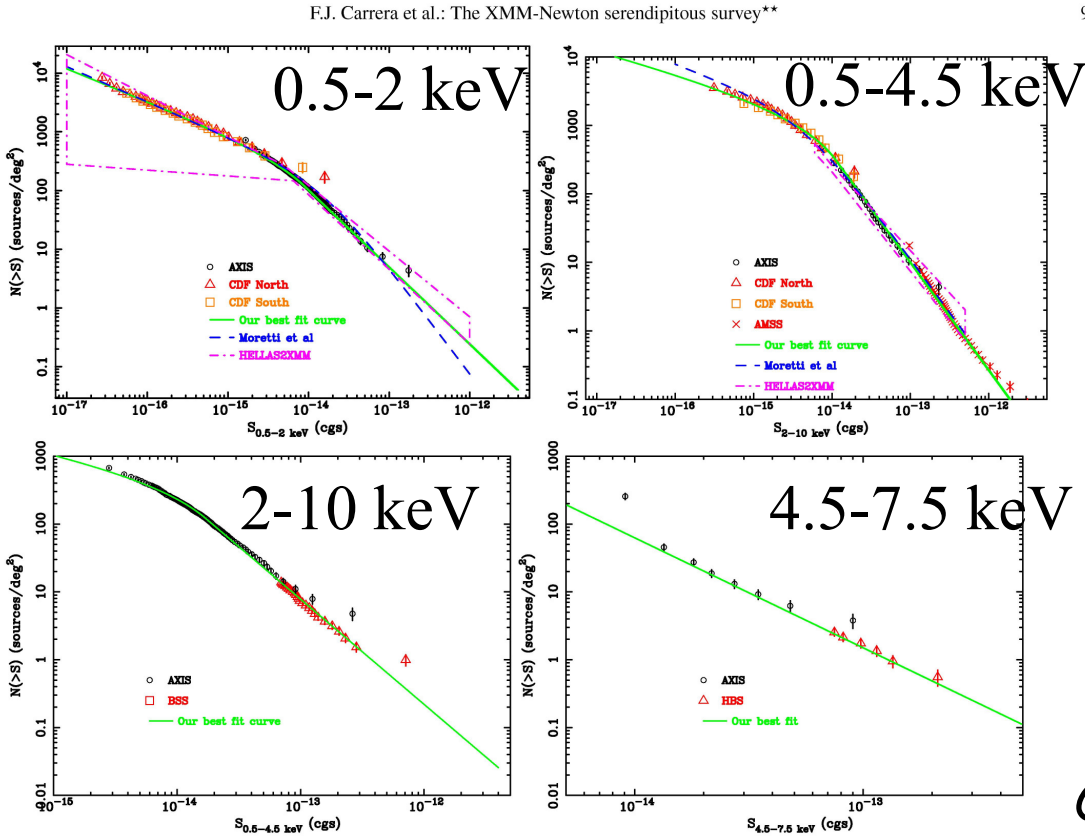
Resolving the X-ray background: X-ray source counts

Soft

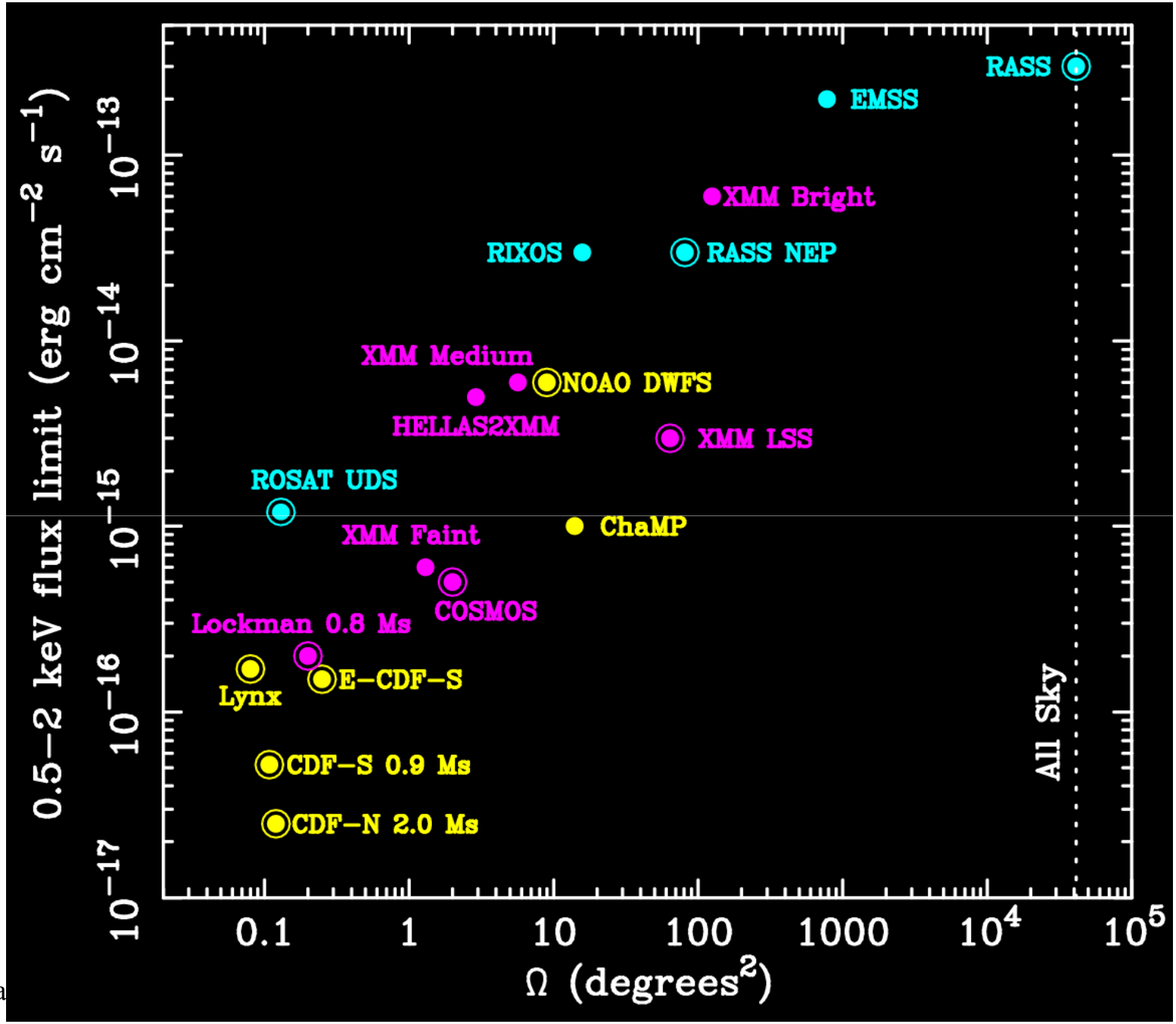
Hard

XID

Ultrahard

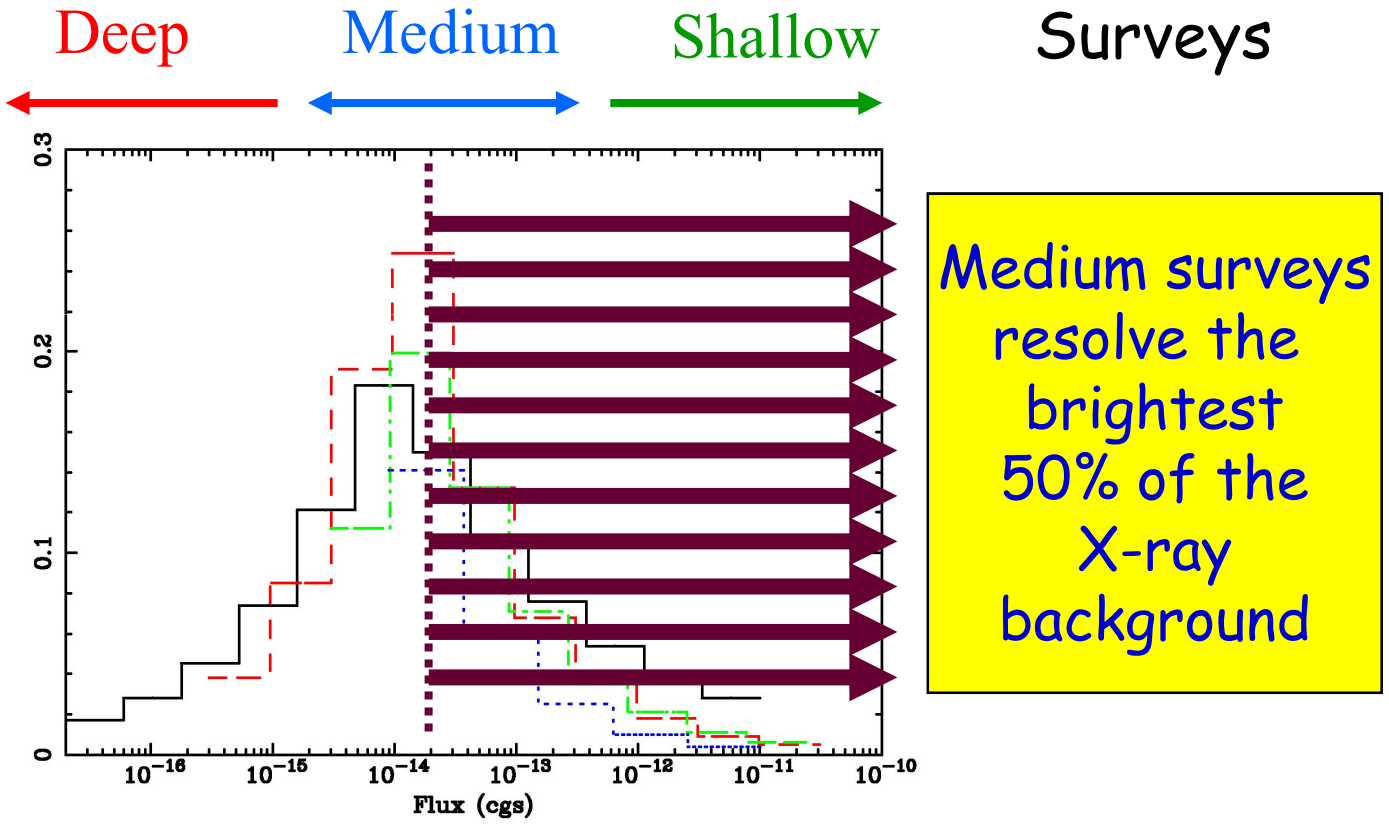


Carrera et al 06


RASS
EMSS
XMM Bright
RIXOS
RASS NEP
XMM Medium
NOAO DWFS
HELLAS2XMM
XMM LSS
ROSAT UDS
ChaMP
XMM Faint
COSMOS
Lockman 0.8 Ms
Lynx
E-CDF-S
CDF-S 0.9 Ms
CDF-N 2.0 Ms
All Sky
0.5-2 keV flux limit (erg cm^{-2} s^{-1})
10^{-13}
10^{-14}
10^{-15}
10^{-16}
10^{-17}
0.1
1
10
100
1000
10^4
10^5
Ω (degrees^2)

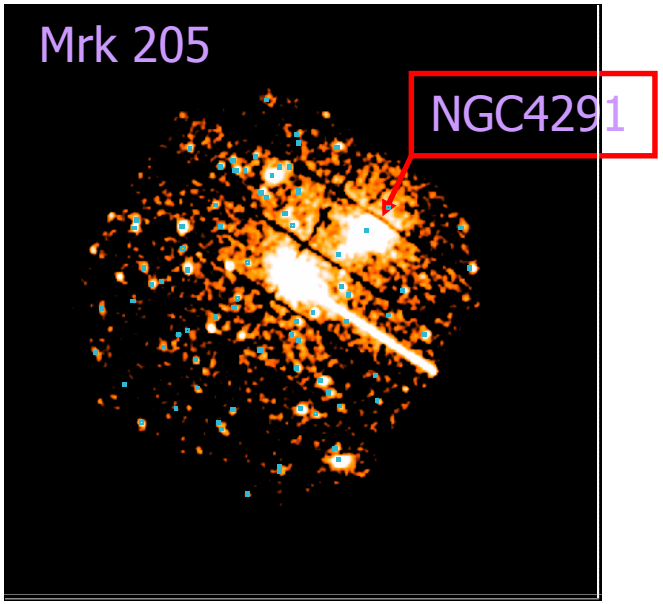
Gra

The contribution to the X-ray background



Medium surveys resolve the brightest 50% of the X-ray background

The XMM-Newton Medium sensitivity Survey (XMS)



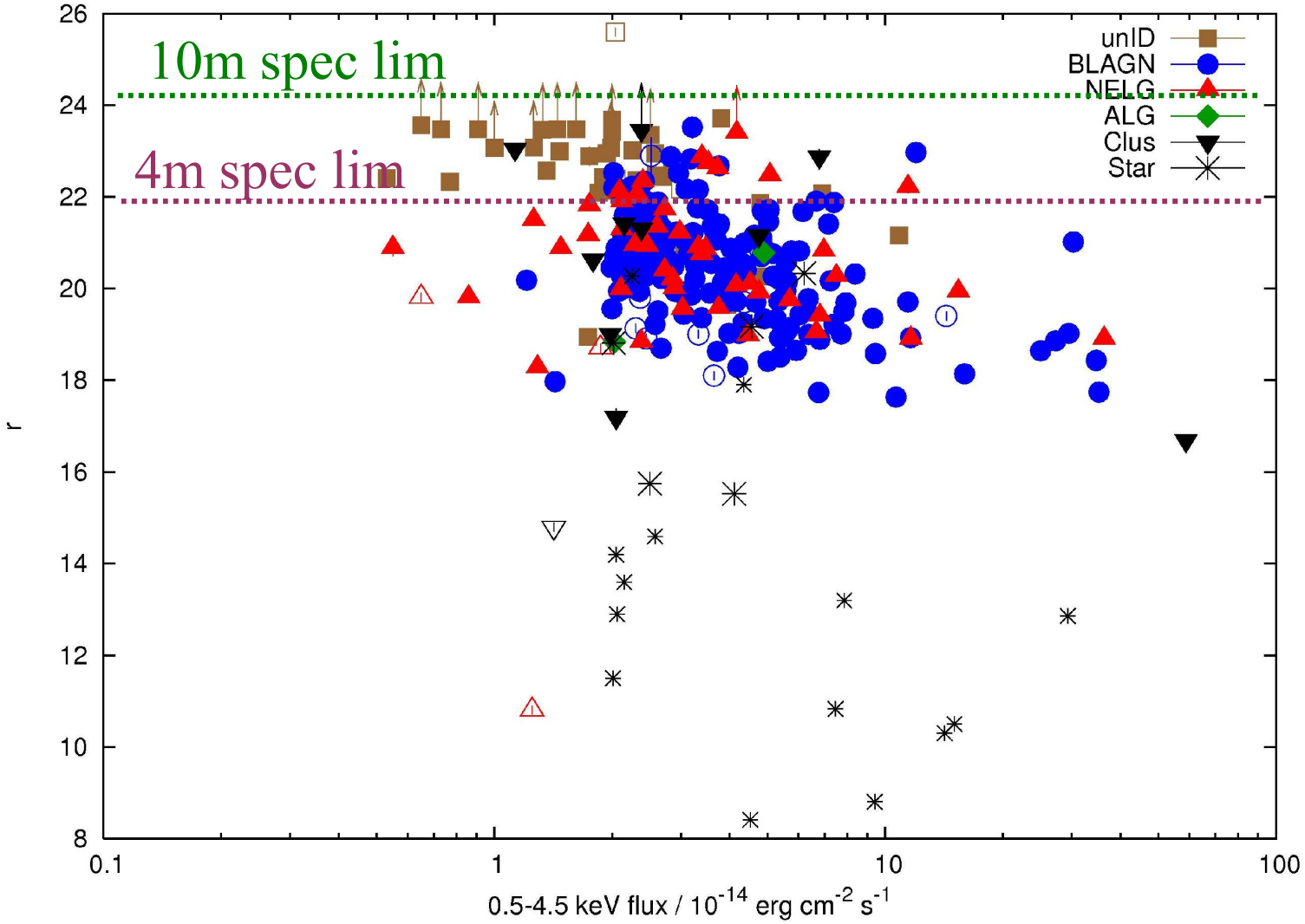
- 25 XMM-Newton target fields:
  - Galactic latitude |b|>20 deg
  - Avoided fields with bright and/or extended targets
  - Good time intervals > 10 ksec
- Solid angle ~3.3 deg^2
- Very detailed source screening
- Total of **318 distinct** X-ray sources selected for optical identification

• Good (low-resolution) X-ray spectroscopy
• Optical identification
Possible with current resources
• Representative of brightest 50% of the X-ray background

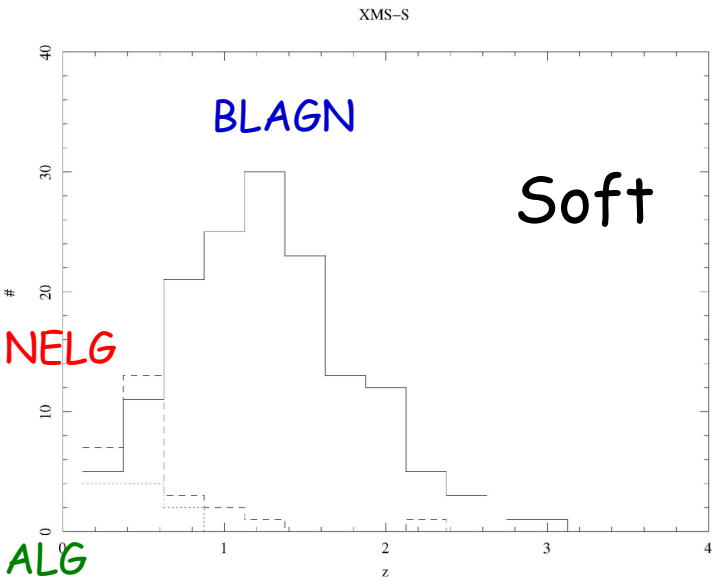
The XMS samples

Name	Band (keV)	Flux limit (10^{-14} cgs)	# sources (unique)	# identified (fraction)
Soft XMS-S	0.5-2	1.5	210 (1)	202 (96%)
Hard XMS-H	2-10	3.3	159 (20)	134 (84%)
XID XMS-X	0.5-4.5	2.0	284 (56)	261 (92%)
Ultrahard XMS-U	4.5-7.5	-	70 (2)	60 (86%)

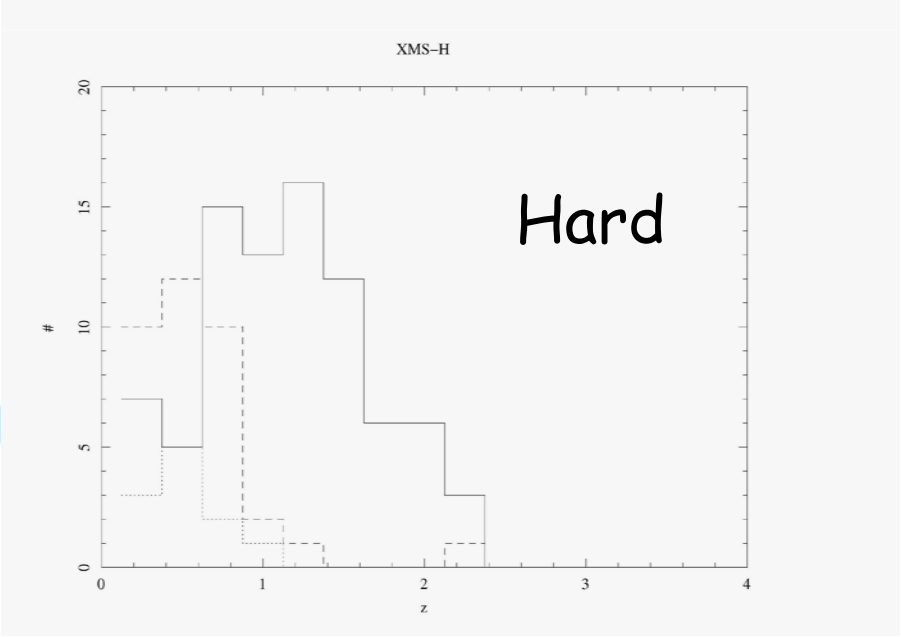
Deep Medium Shallow



Redshift distribution

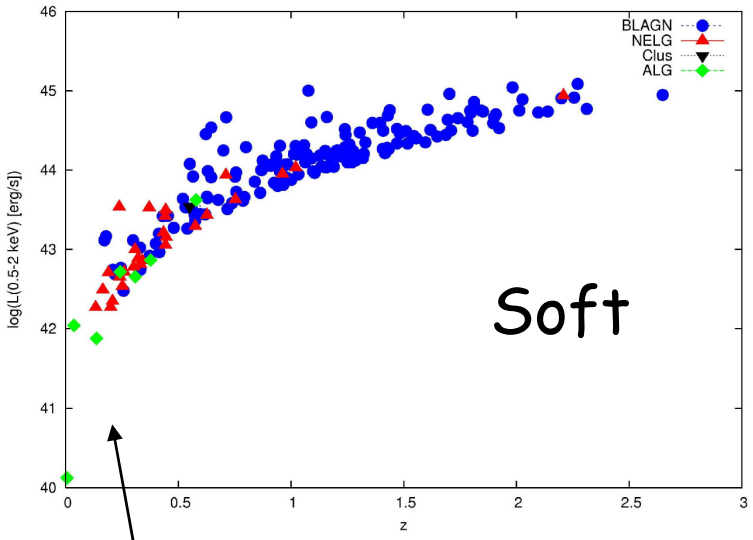


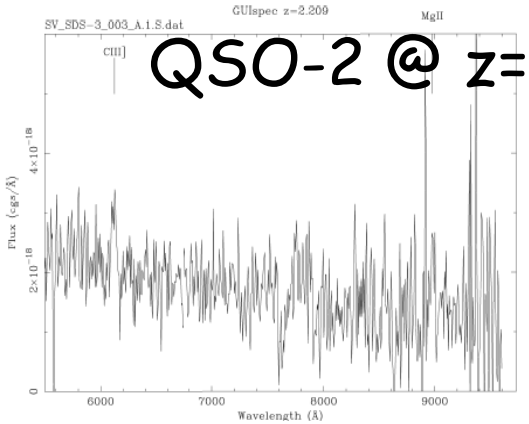
Obscured population out to z~1 in Hard sample



Peak of QSO distribution (z~1.5) well sampled.

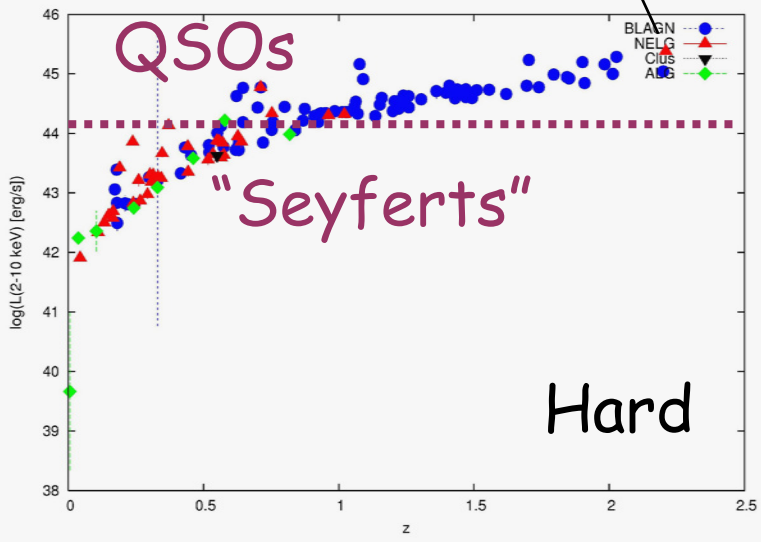
Luminosities and redshifts



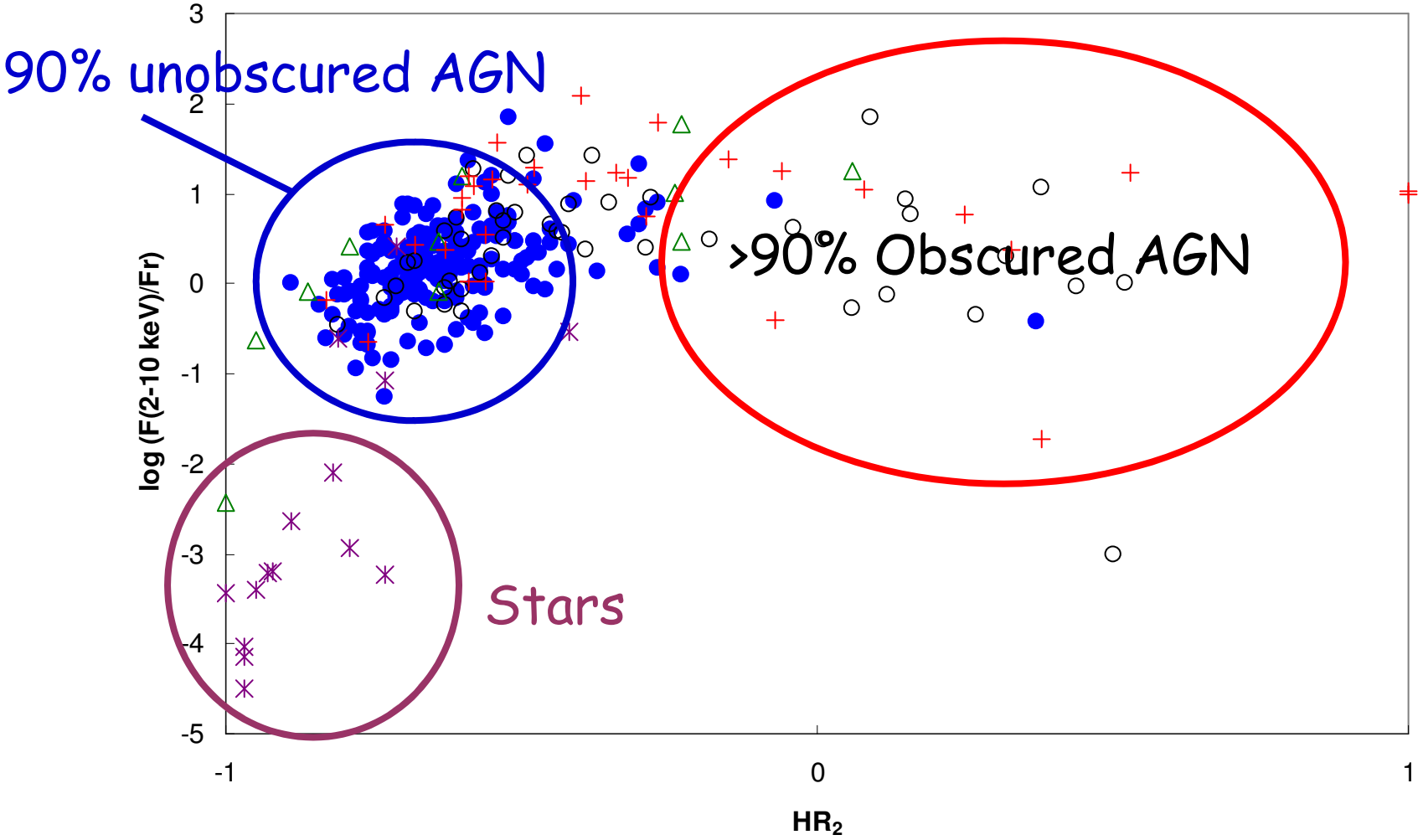


QSO-2 @ z=2.2

Virtually all galaxies likely host an AGN $L_X > 10^{42}$ erg/s



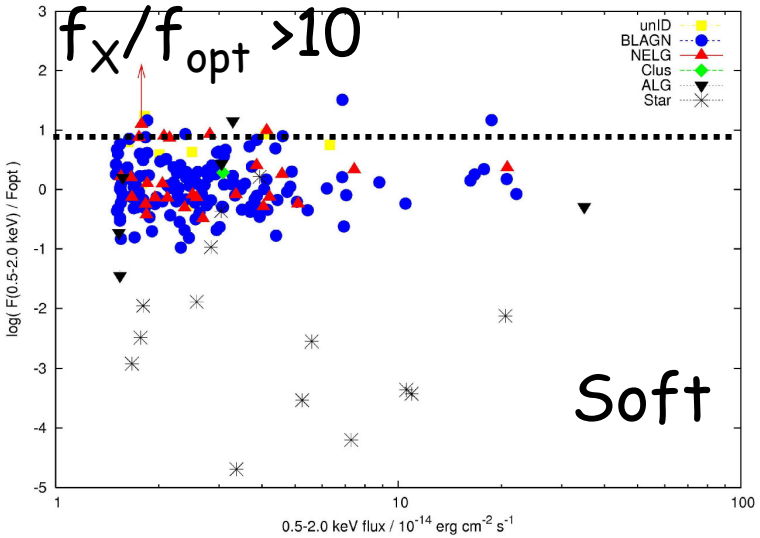
Tips for statistical identification



Overall properties of the XMS

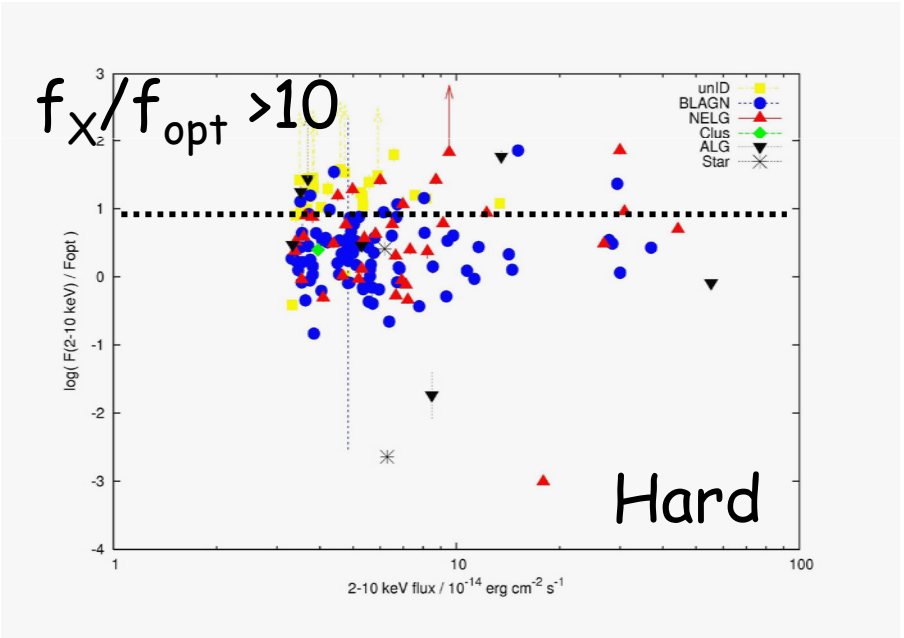
- Stars are only 7% of soft X-ray samples, and decrease towards fainter fluxes. No stars in hard X-ray selected samples.
- The fraction of **obscured** AGN among the extragalactic population is constant **~20%** at all fluxes from 10^{-13} to 10^{-15} erg cm^{-2} s^{-1}, when selected at soft X-ray energies.
- The fraction of **obscured** AGN among the extragalactic population is constant **~35%** at all fluxes from 10^{-13} to 10^{-15} erg cm^{-2} s^{-1}, when selected at hard X-ray energies.

X-ray to optical ratio: a proxy for obscuration?



- 20% of sources with f_X/f_{opt}>10
- 50-70% are obscured AGN

- 3% of sources with f_X/f_{opt}>10
- Only 1/3 are obscured AGN



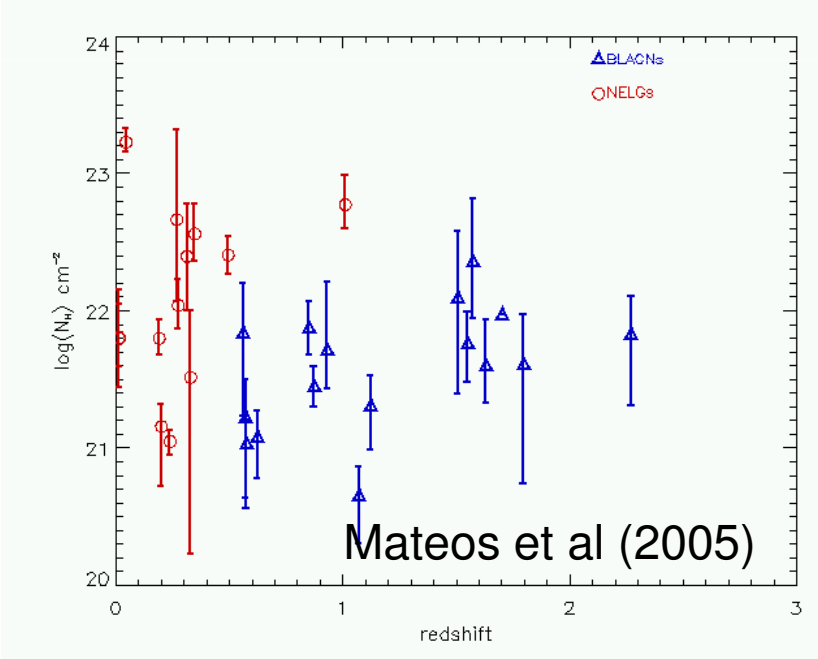
X-ray absorption vs obscuration: not equivalent

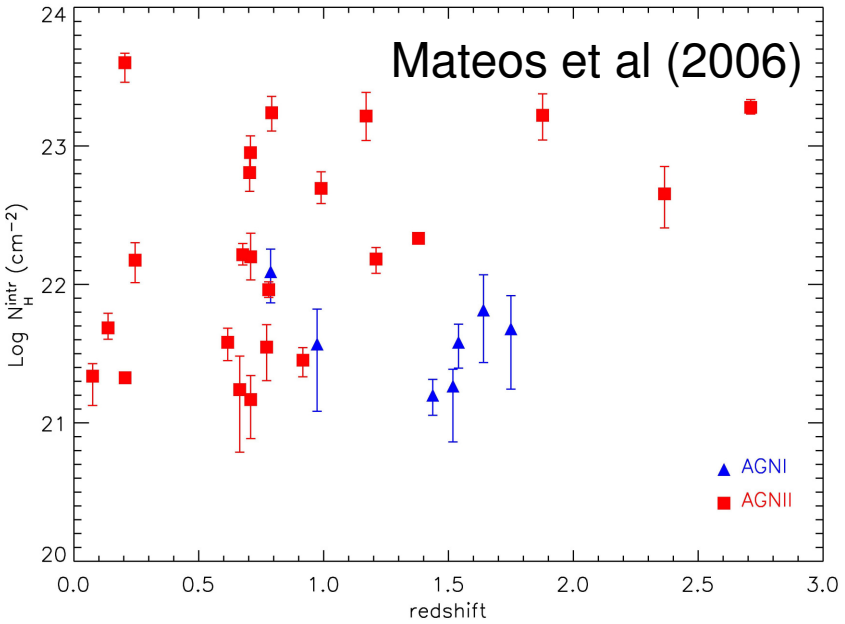
The XMS survey

- **10**% of type 1 AGN are absorbed (with $N_H<10^{22}$ cm^{-2})
- **>40**% of type 2 AGN are absorbed

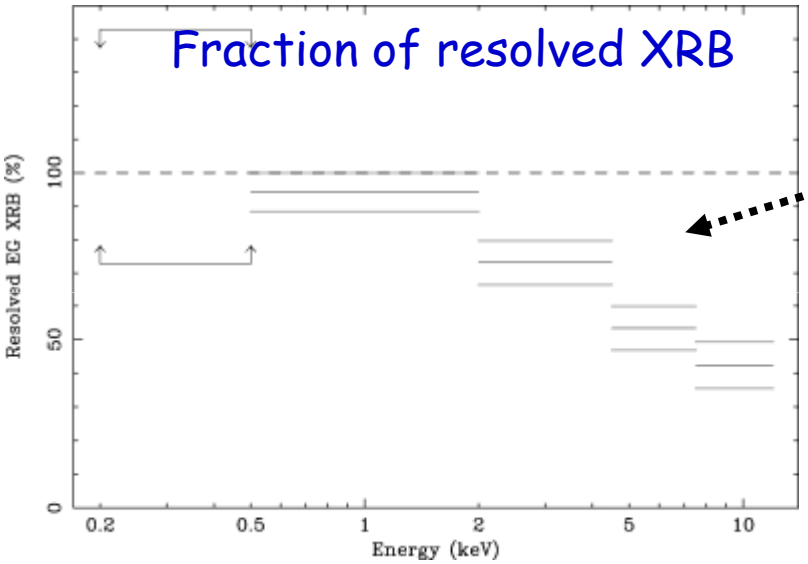
The Lockman Hole survey

- **15**% (<30% at 3σ) of type 1 AGN are absorbed (with $N_H<10^{22}$ cm^{-2})
- **80**% (>50% at 3σ) of type 2 AGN are absorbed. But 5/28 are unabsorbed

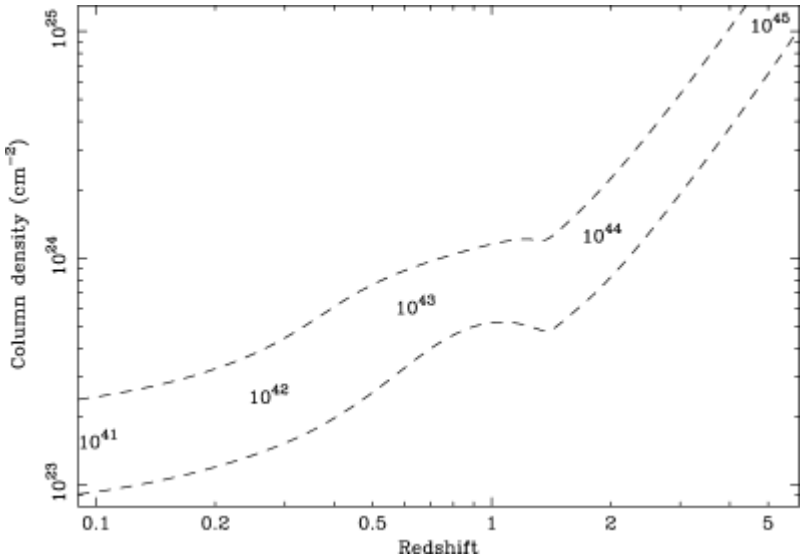




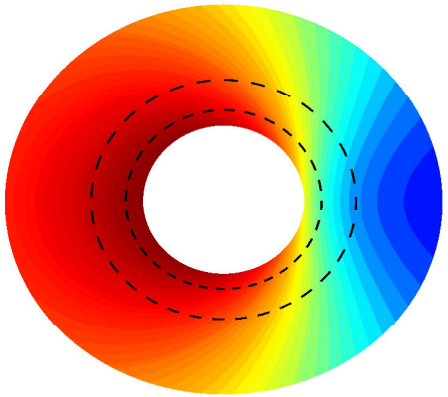
Where are the other "obscured" accreting BHs?



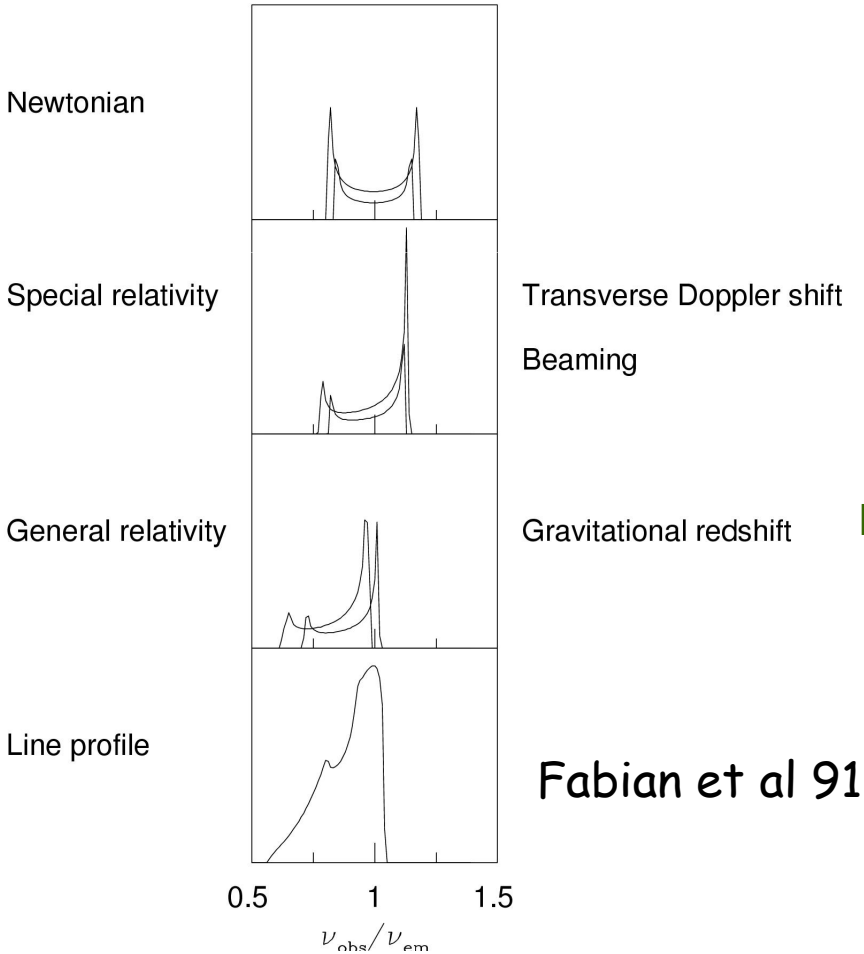
New population of heavily obscured AGN ?



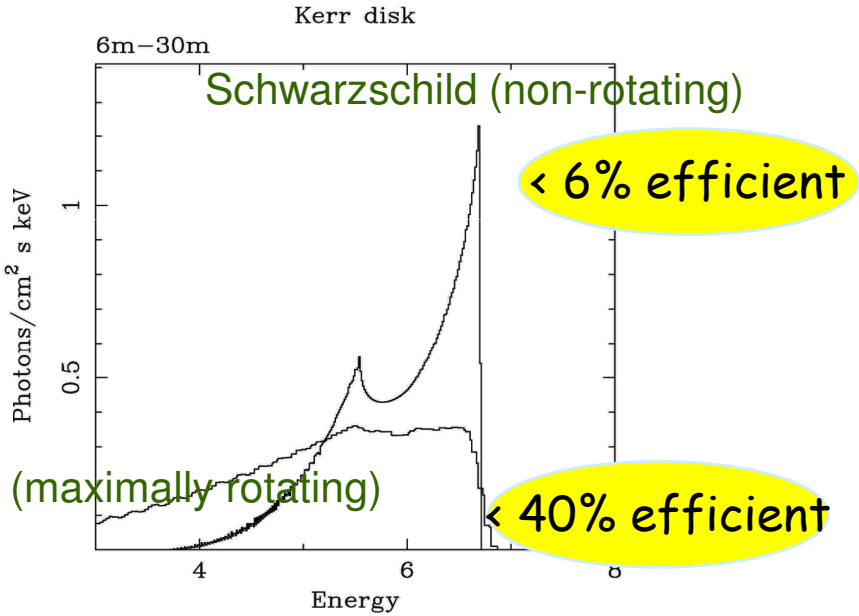
M.A. Worsley et al (2005)



Accretion efficiency: Relativistic broadening of the Fe Kα line



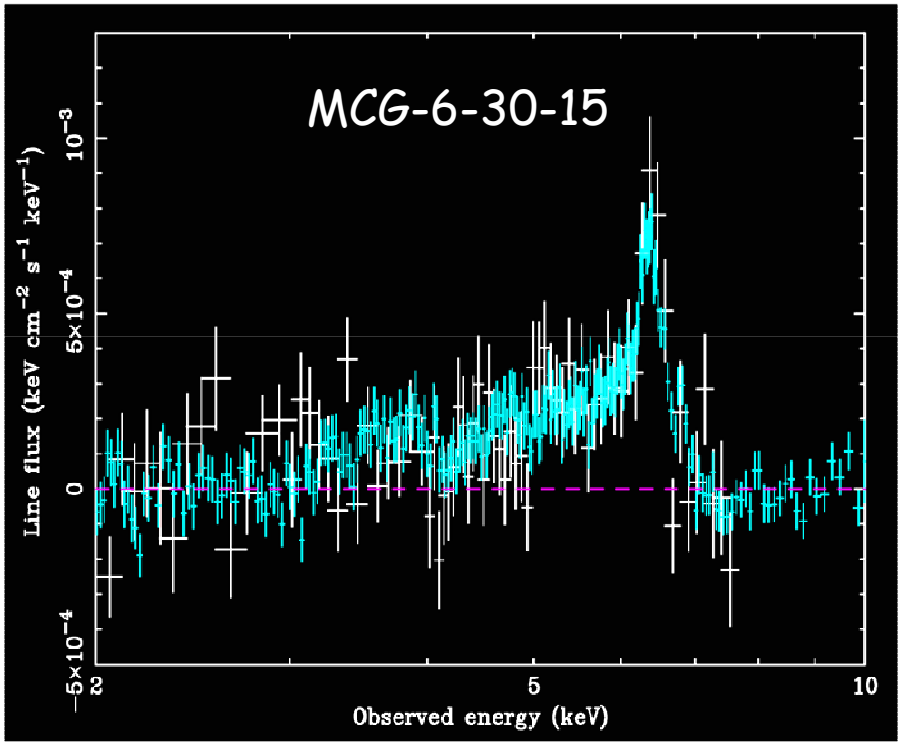
Fabian et al 91

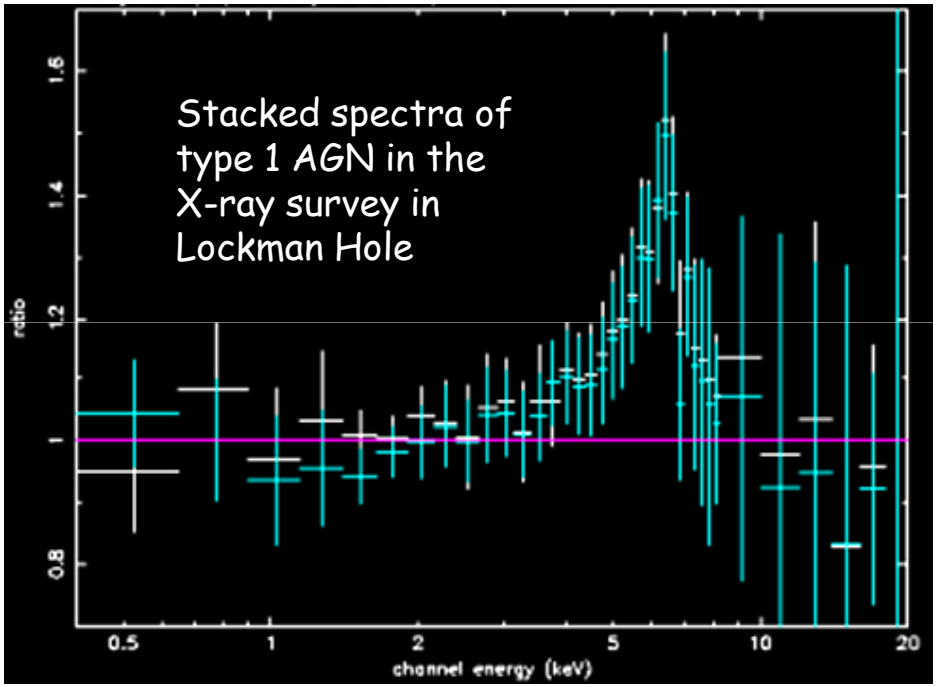


Evidence for efficient accretion: spinning BHs

In nearby active galaxies

In most distant active galaxies



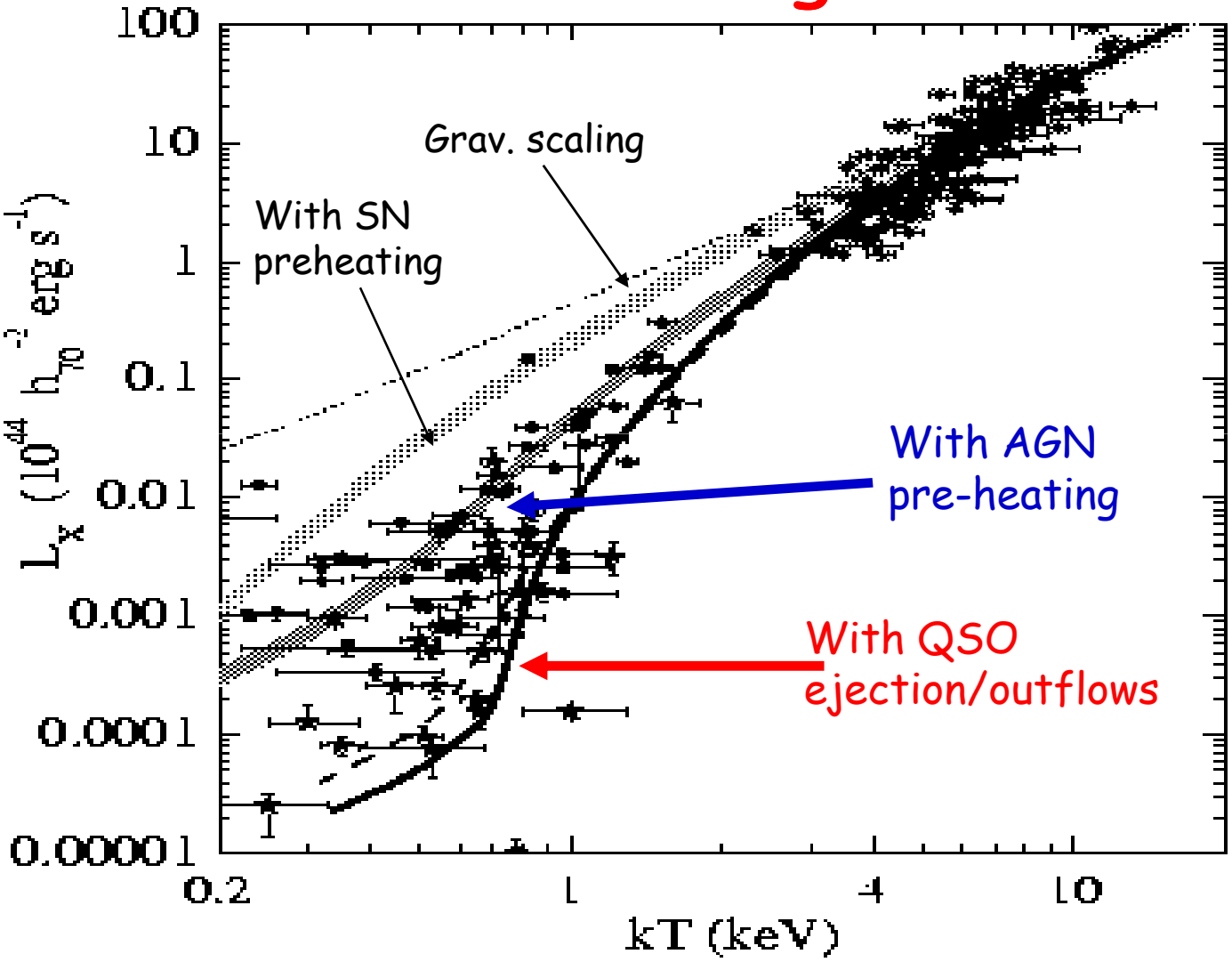


Tanaka + Wilms + Fabian et al

Streblyanska, Hasinger, Barcons, Fabian et al

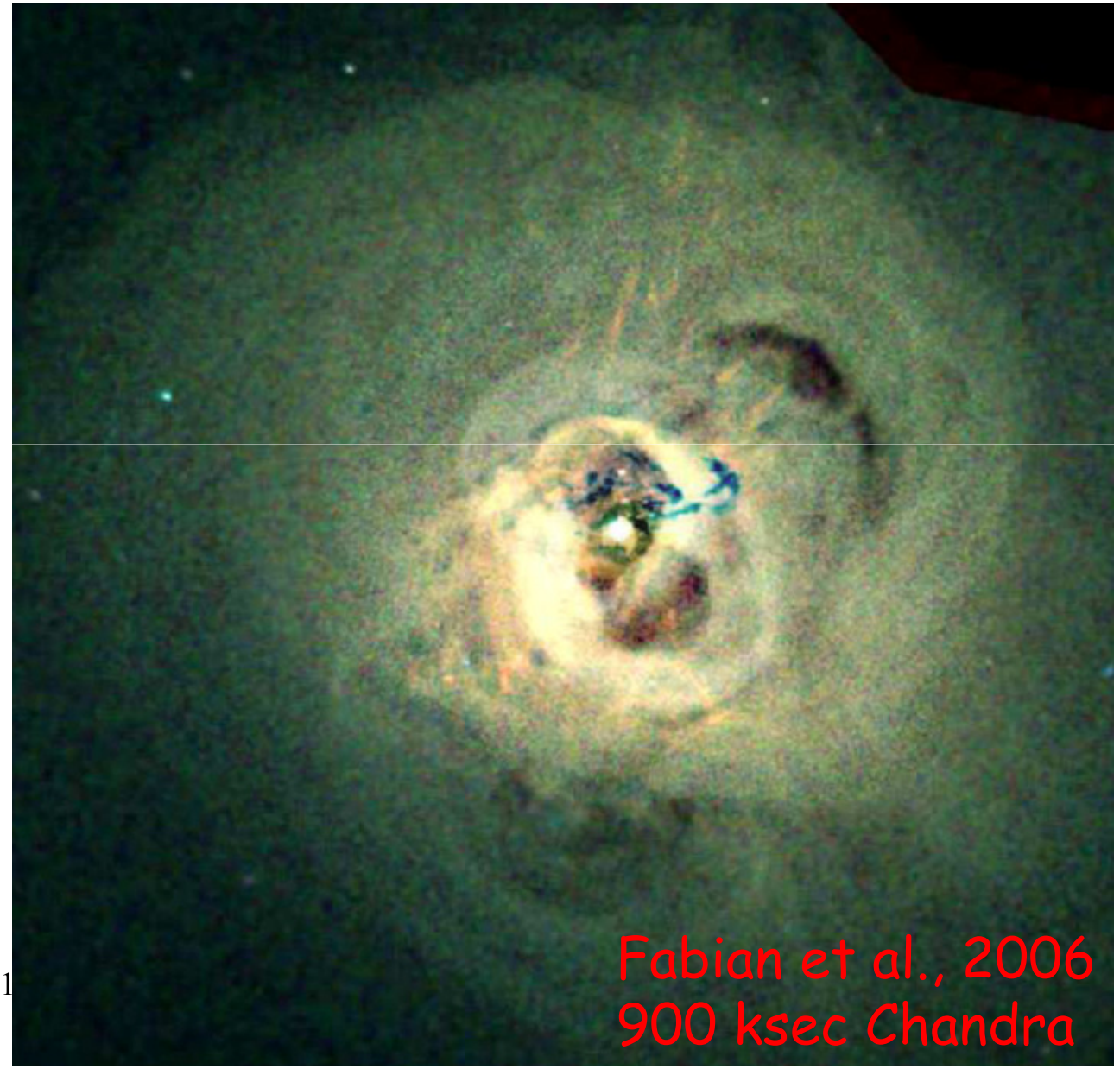
Feedback at work!

Importance of AGN feedback in intracluster gas!



Lapi, Cavaliere & Menci, 2005

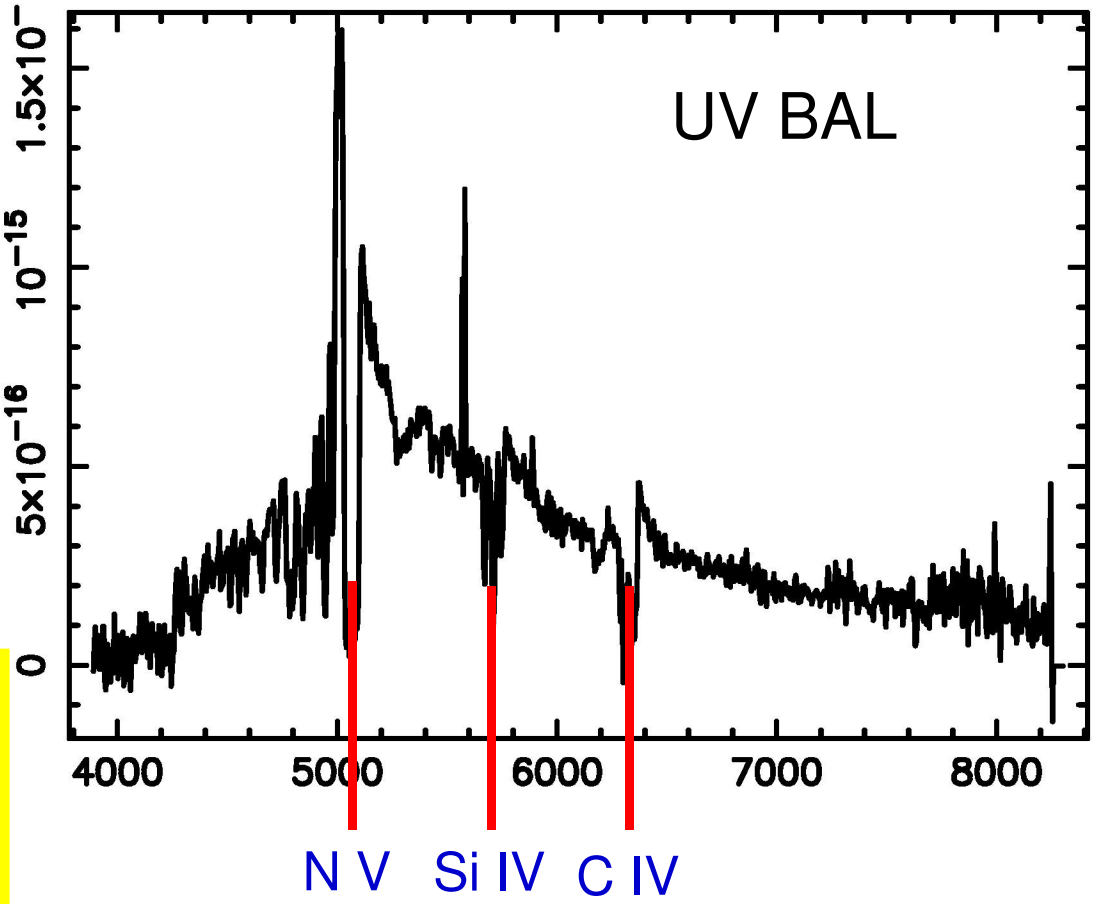
AGN feedback in Perseus Cluster



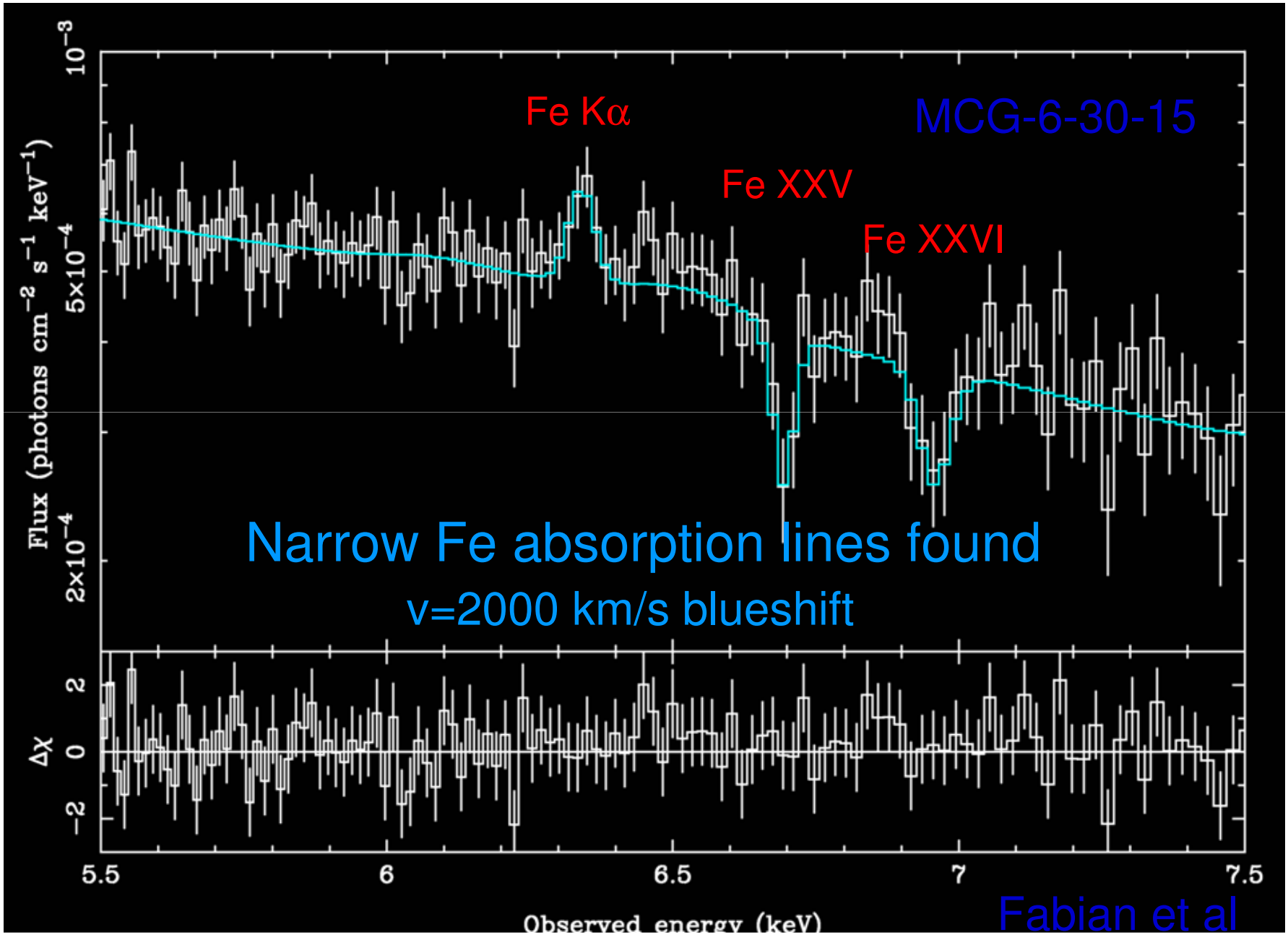
Broad Absorption Line Quasars

- UV BALs in 15% of all QSOs
- BAL are very faint in X-rays: heavily absorbed
- CIV 6x more common than MgII
- Higher ionisation lines only visible in X-rays

The other 85% QSOs could have fast outflows at higher ionisation, only detectable in X-rays

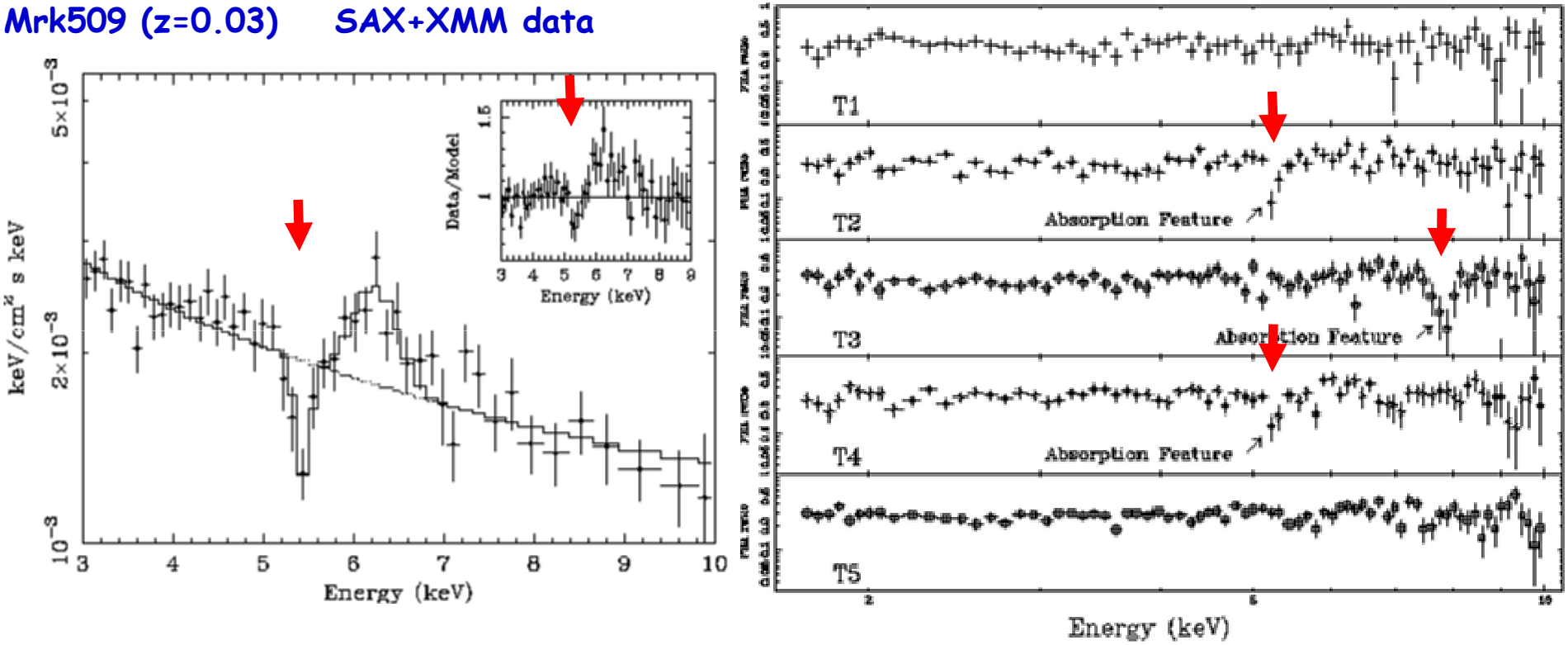


Outflows in Seyfert Galaxies



Transient red/blueshifted absorption

Mrk509 (z=0.03) **SAX+XMM data**

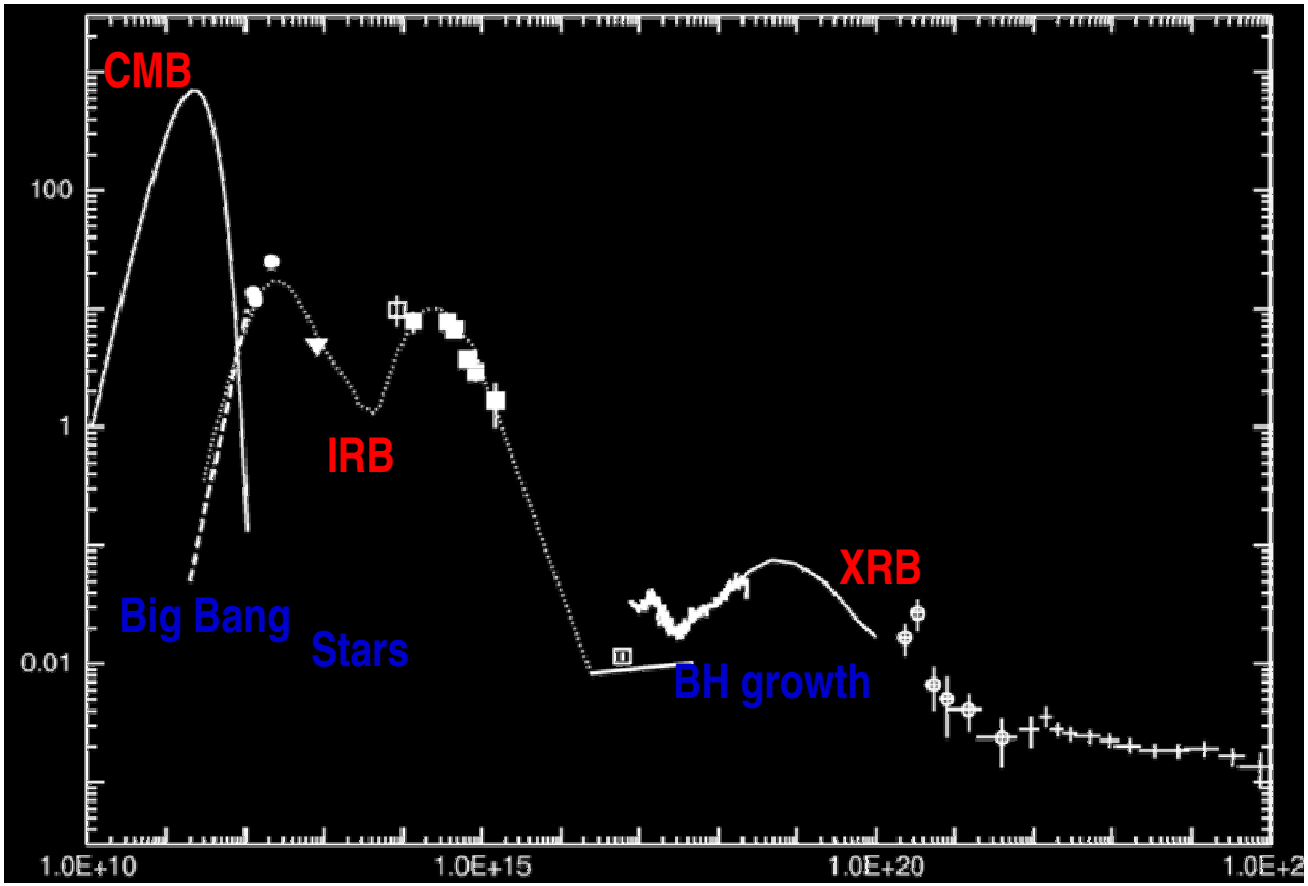


Dadina et al (2005)

Transient inflows/winds with v~0.2c might be common in AGN:
Important for AGN feedback

Star formation
and
BH growth in galaxies

The extragalactic background light

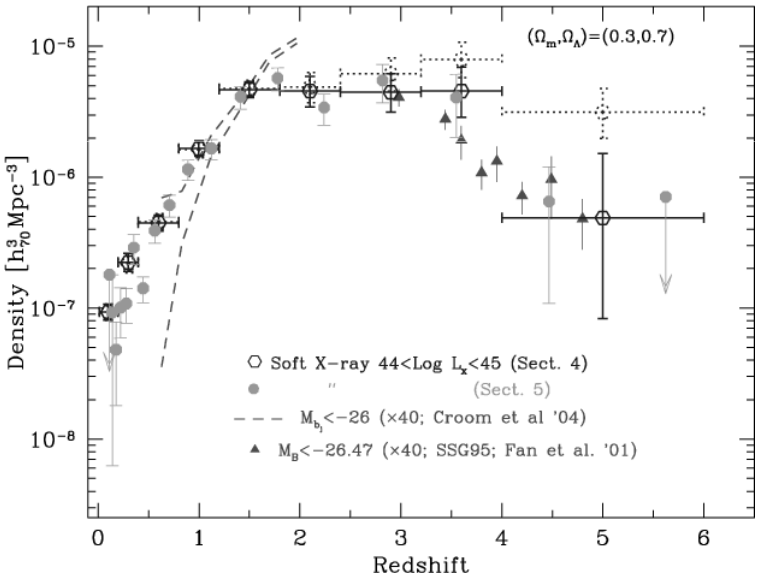


Why should they be related?

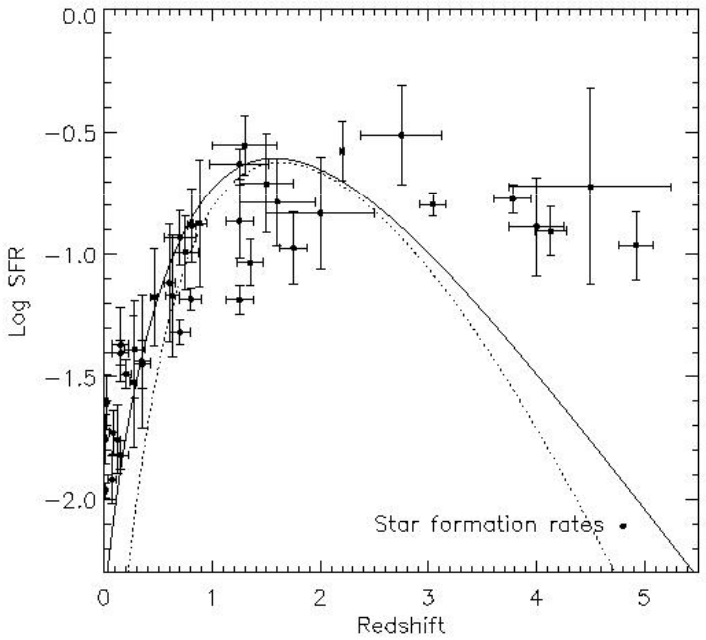
- Massive BH in most (all) galaxy centres
- M_{SMBH} ~0.4% M_{bulge}. A coincidence?
- History of star formation and QSO density have a similar redshift dependence
- QSO phase in galaxy evolution sterilises surroundings for star formation.

The cosmic history of BH growth and of star formation

Black Hole growth

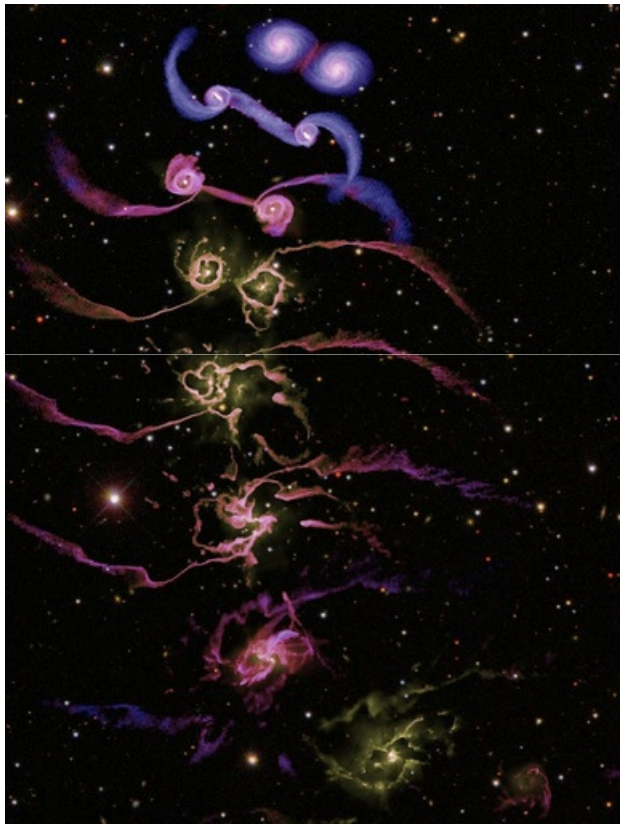


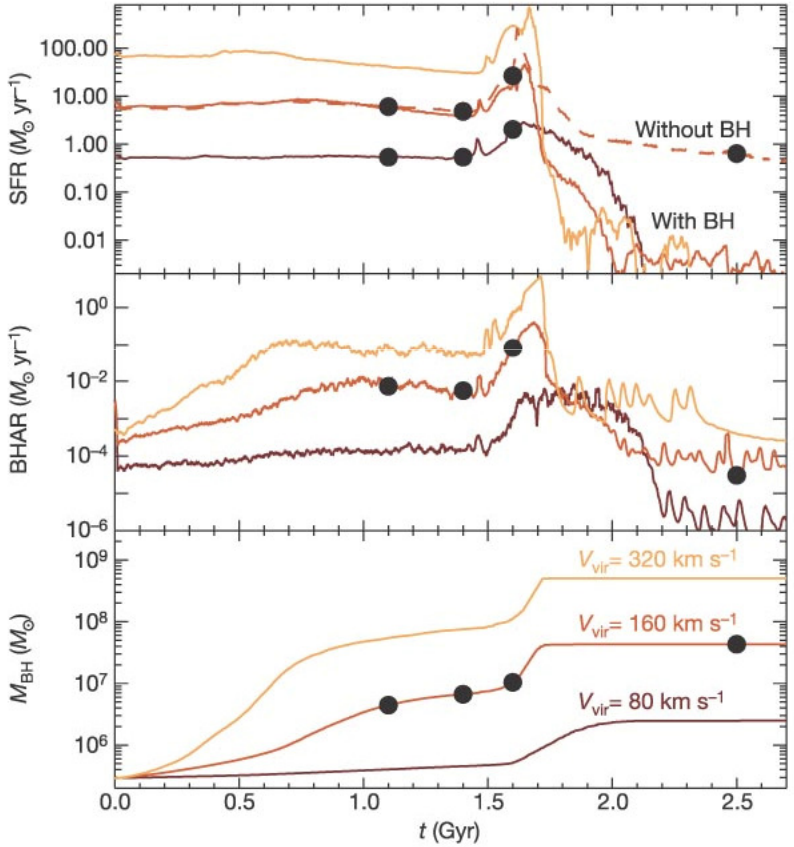
Star formation rate



Hasinger et al 2005

The effect of accreting BHs in galaxy mergers

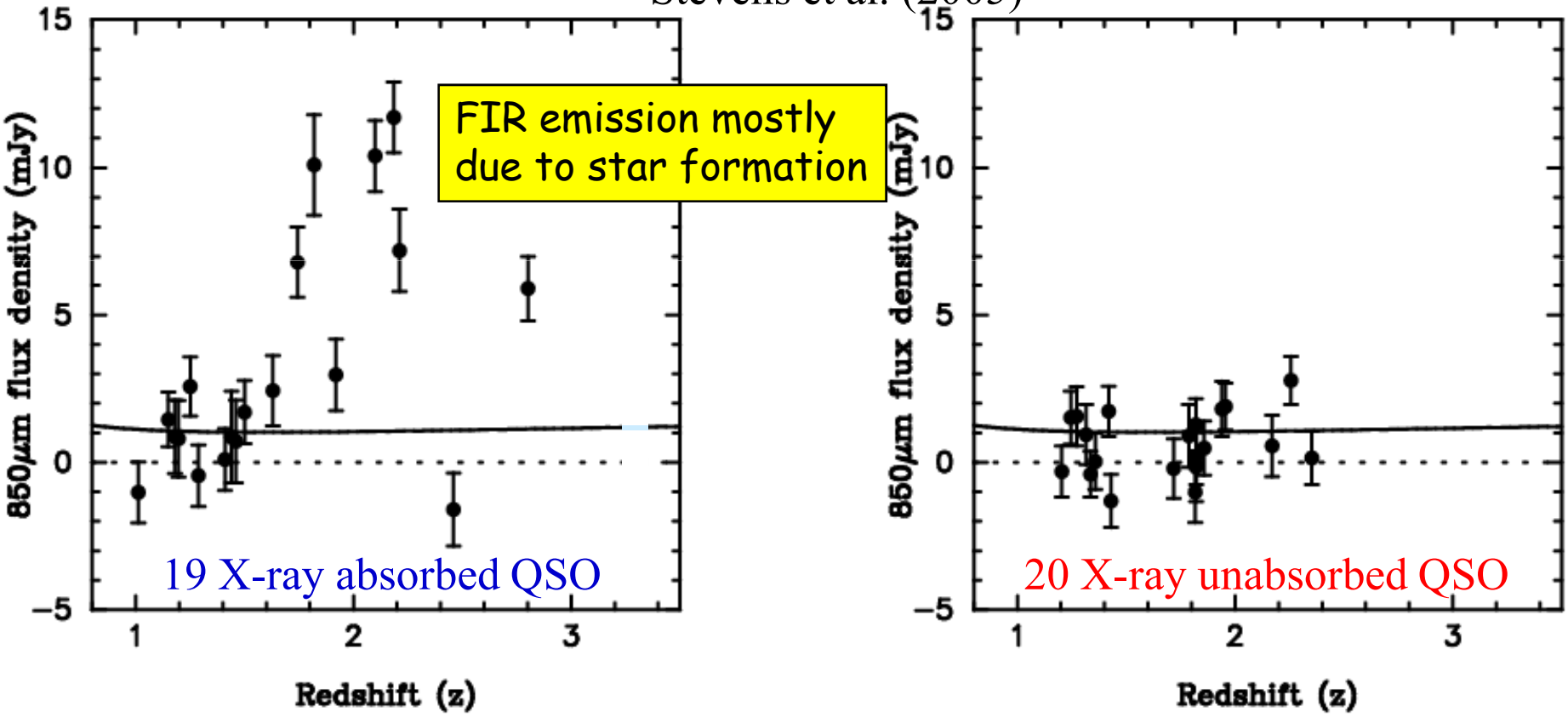




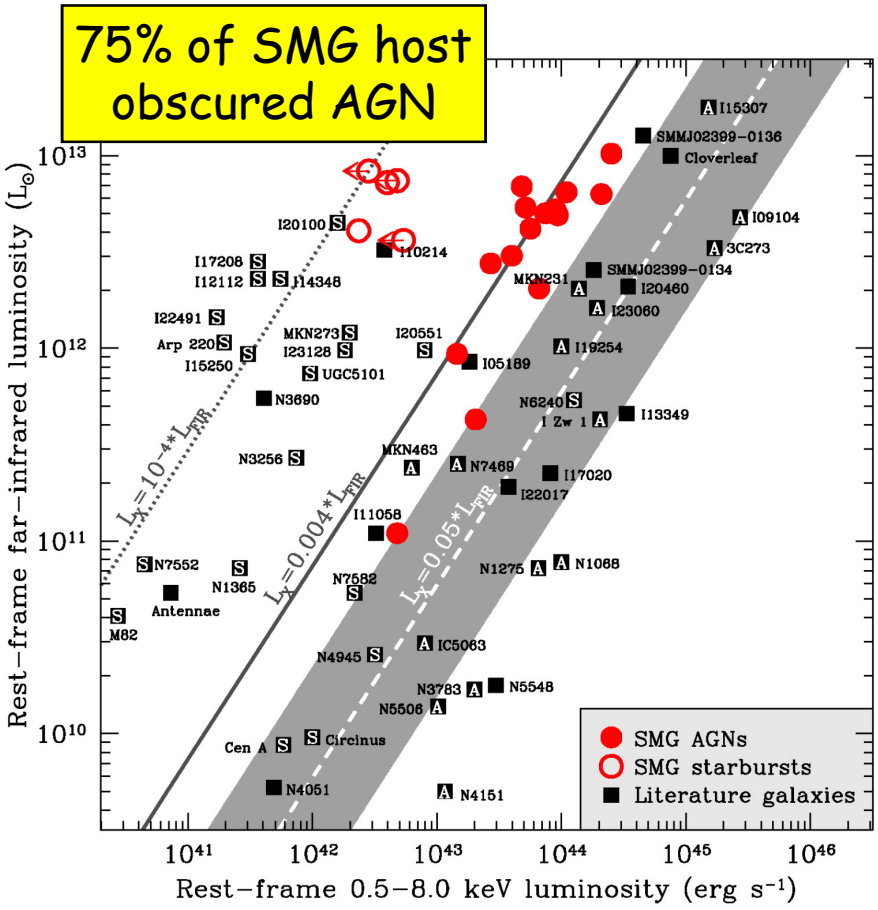
Di Matteo, Springel, Hernquist (2005)

Submm/FIR emission mostly in absorbed QSOs

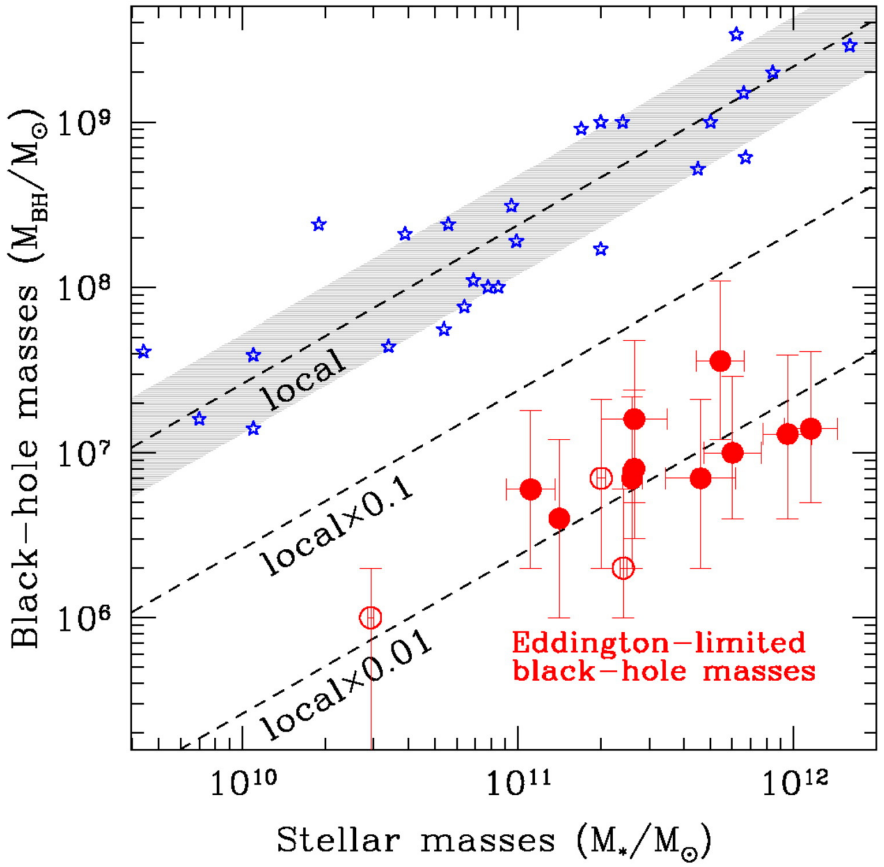
Stevens et al. (2005)



Star formation vs BH growth in Sub-Millimetre Galaxies



Alexander et al (2005)



Borys et al (2005)

In summary

- BH growth occurs mostly in obscured objects, but most of them remain to be found in hard X-ray surveys
- BH growth influences gas and the possibility of star formation around them, through inflow, winds etc.
- The galaxies where the SFR is largest at high z also host a growing BH. The FIR emission is dominated by star formation and the X-ray emission by the accretion onto the BH.
- Need large X-ray and FIR observatories to study not only the "peaks of the iceberg" along cosmic-history.

Thanks to:

- Francisco Carrera
- Maite Ceballos
- Silvia Mateos
- Amalia Corral
- Francesca Panessa
- Jacobo Ebrero
- Mat Page
- Günther Hasinger
- Mike Watson
- Andy Fabian
- Javier Bussons-Gordo
- Angel Ruiz
- And many more…