Present and future opportunities for MWL observations from the point of X-ray astronomy

Prof. Dr. Thomas Boller
Max-Planck-Institut für extraterrestrische Physik, Garching

Statement I: The gain in information from MWL on accreting sources is limited; exception NLS1s

Statement II: MWL discrepancies in the Sy1/Sy2 unification scheme

Statement III: How to determine the SED of obscured and non-obscured sources

Statement IV: Dark Energy measurements via chemical evolution

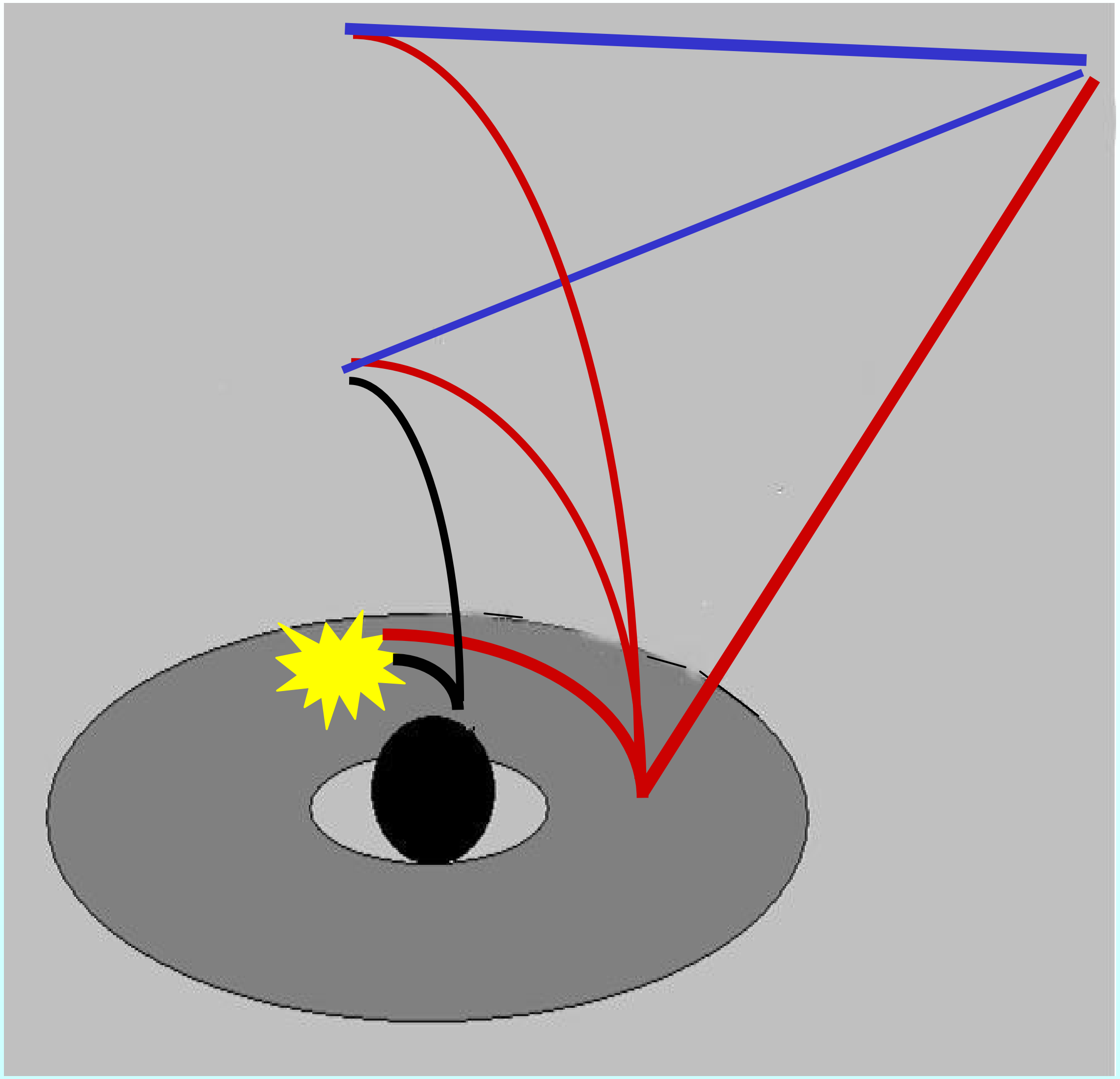
Statement V: Object classification of X-ray sources in the distant universe

Statement VI: MWL observations of cluster of galaxies are of great scientific interest

Main information gain from accreting sources from X-rays

$L\_X \sim 10^{43-48}$ erg s^{-1}

Δ $L\_X \sim 10^{44}$ erg s^{-1} within 100 ls



Miniutti 03, Fabian 04

Source height is very large:
standard picture, light bending not effective, half of the photons are intercepted by the disc and half reach the observer, PLC is recoverd

Source height increases:
Gravitational potential that power-law photons have to overcome is reduced, so that more photons reach infinity and PLC increases, reflection continuum increases slightly

Source height of power-law is small:
Most of the photons are bent towards the disc and lost in the BH reducing the PLC at inifinity, spectrum is reflection dominated

The basic physics of accreting sources

assumptions: NLS1 evolution starts in the slim disc regime ($L \sim L_{edd}$)
dM/dt remains constant for some time and then gradually decreases

FWHM of emission lines increases

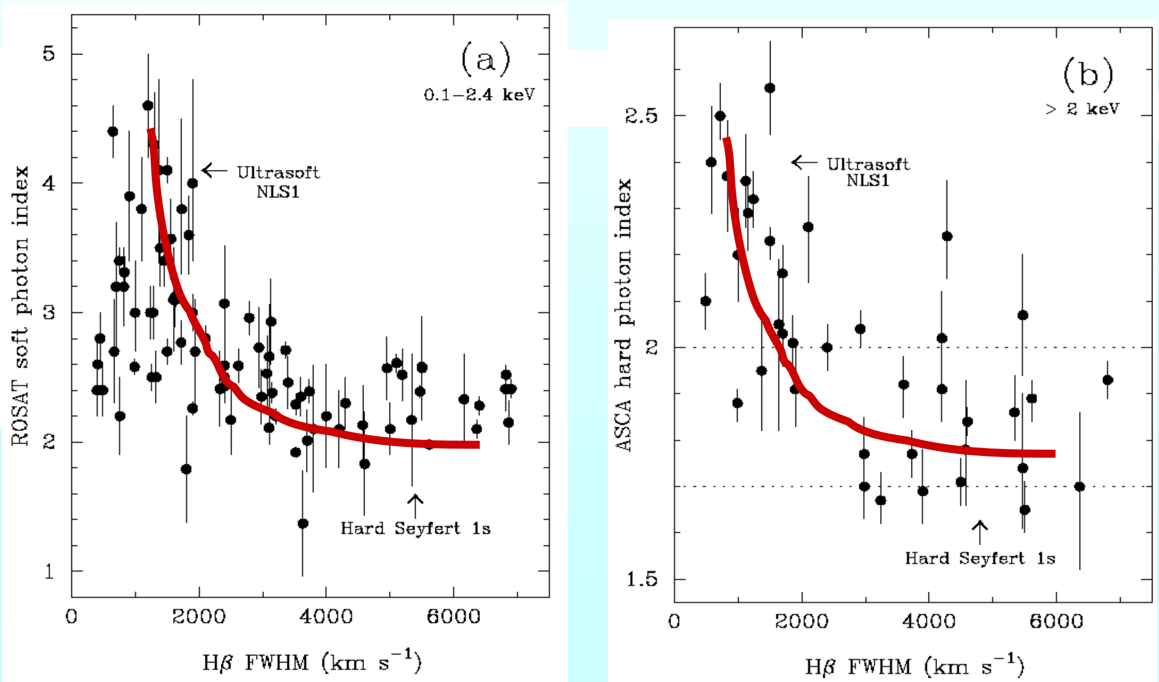
$$FWHM(t) \sim \left(\zeta n_e^{\frac{1}{4}}\right) \cdot 2\eta \left(\frac{M^2}{\dot{M}}\right)^{\frac{3}{16}}$$

Ionizing continuum decreases

$$T(t) \sim \zeta \left(\frac{M^2}{\dot{M}}\right)^{-\frac{1}{4}}$$

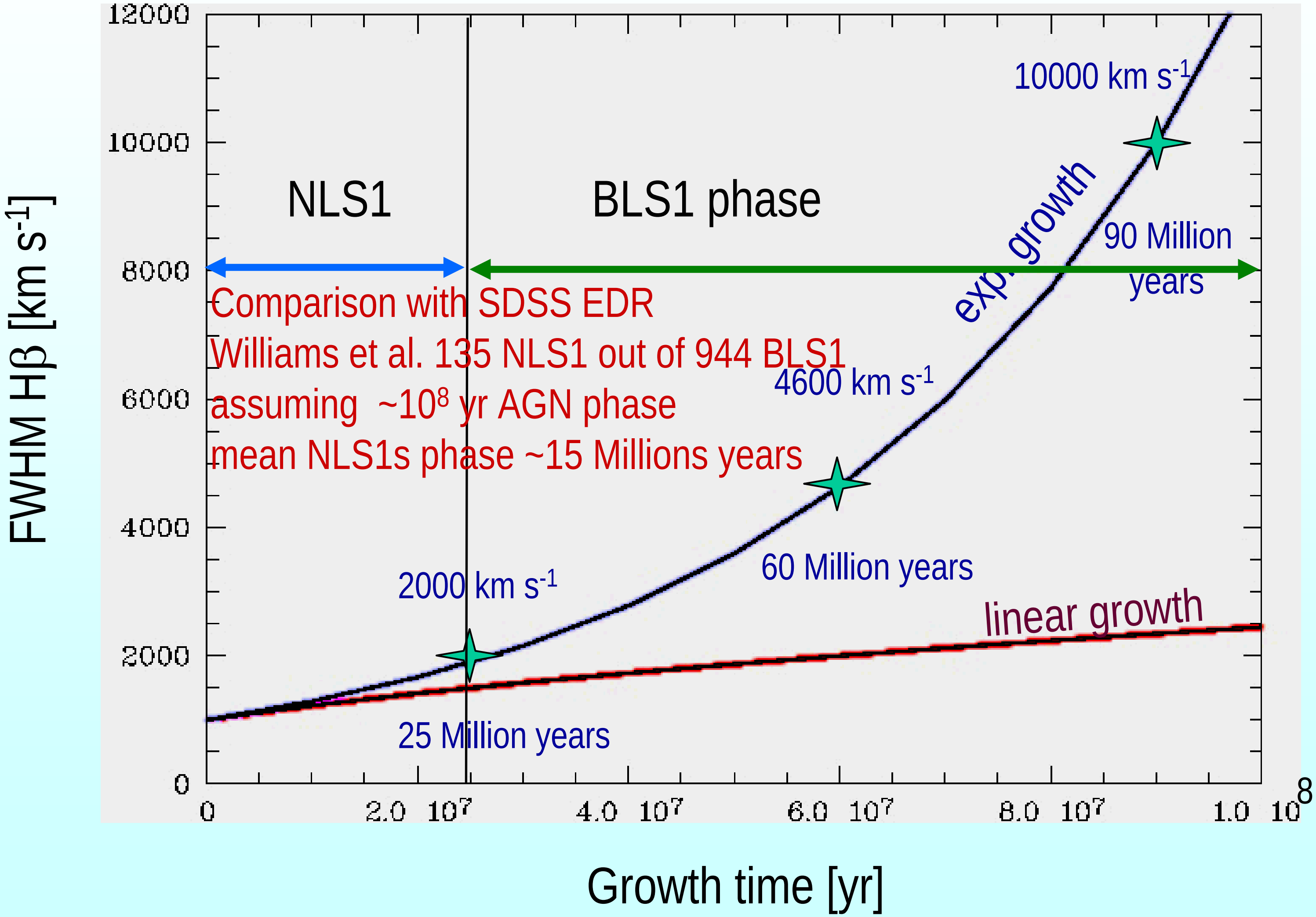
Soft and hard power-law indices decreases

Fe II multiplet emission decreases when ionizing continuum decreases

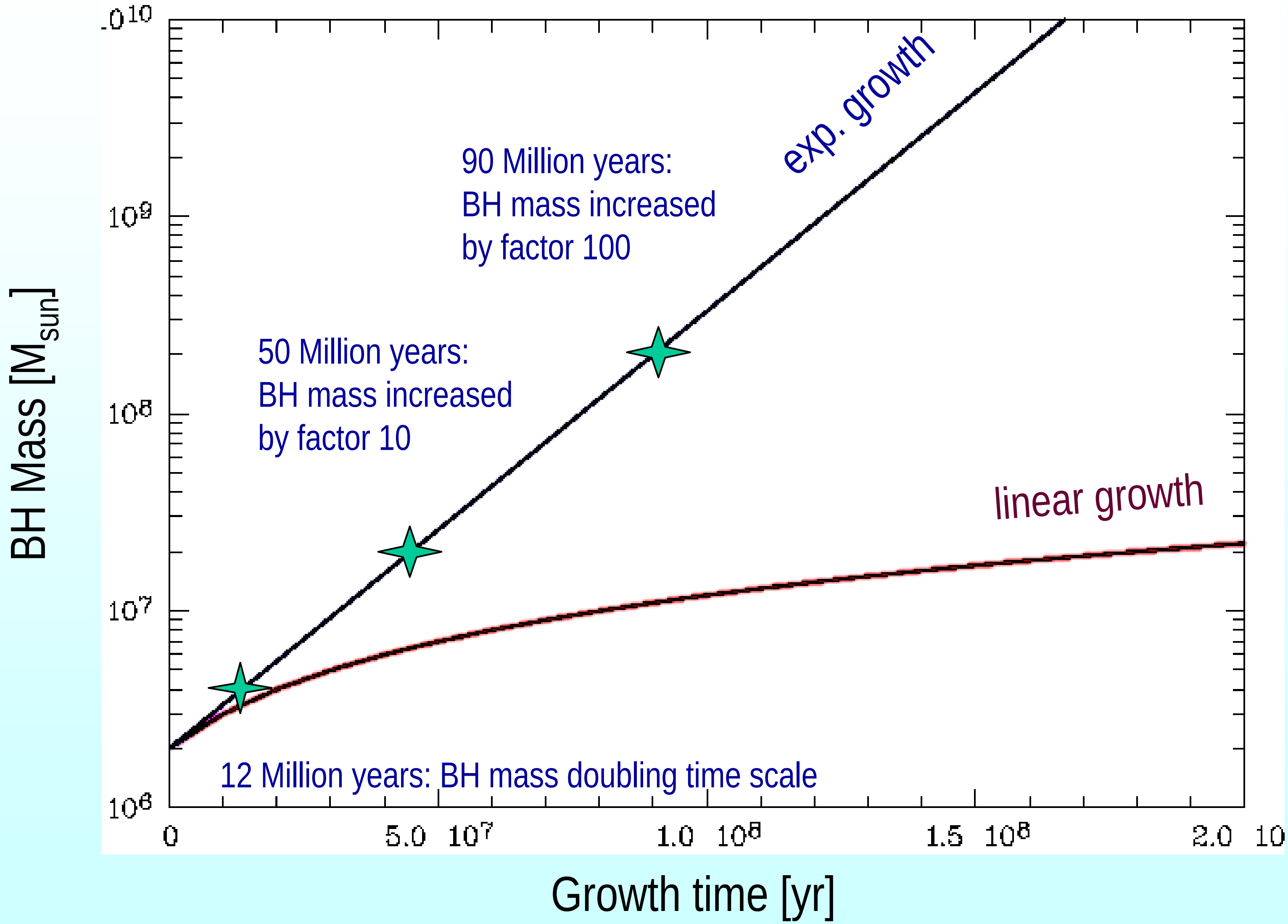


Simple picture for the optical line widths evolution of Seyfert 1s

Assumptions: the case for 1H0707 (a NLS1s starting with a small mass of ~$2 \cdot 10^6$ M_{sun})
accretion rate: $6 \cdot 10^{24}$ $g \cdot s^{-1}$ (10^{-3} earth mass per second) = 0.1 M_{sun}/ yr



The mass growth rate of 1H 0707-495

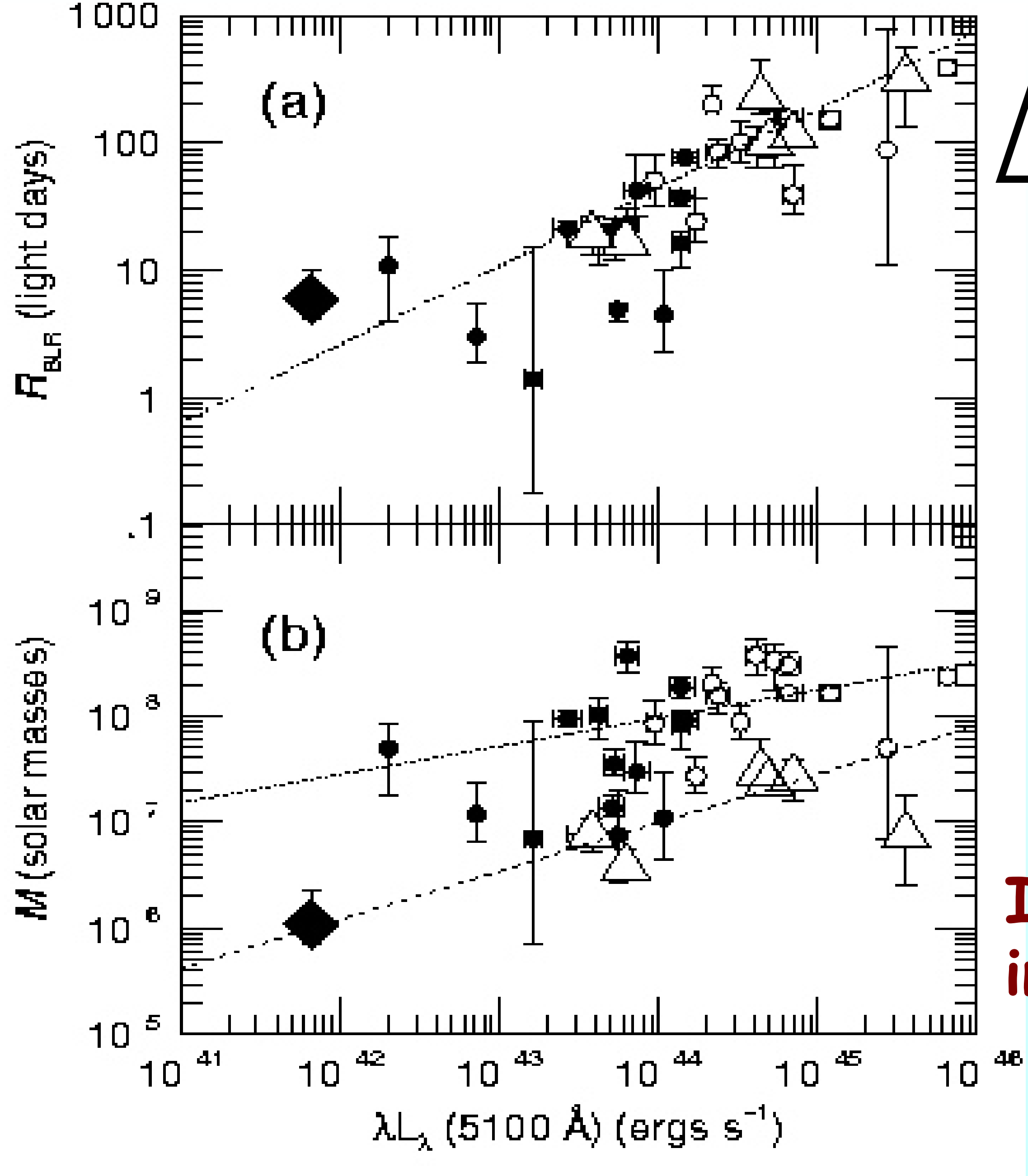


when high accretion rate ceased, NLS1s become normal Seyfert 1s within a few 10´s million yr

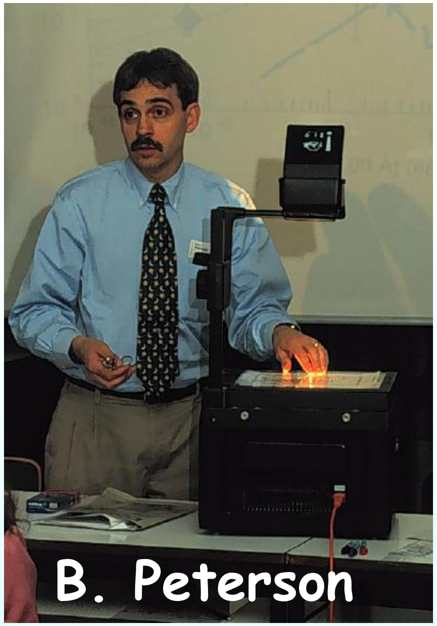
MWL implications of super-Eddington accretion rates

BLS1			NLS1
flat	dM/dt, M →	X-ray	steep power law
weak	Compton cooling →	X-ray	strong disk emission
broad	Ionizing photon density →	OPTICAL	narrow optical lines
strong	Photon screening →	OPTICAL	weak [OIII] emission
weak	Ionizing continuum →	OPTICAL	strong Fe II
moderate	Doppler boosting, light bending →	X-ray	extreme X-variability

Other implications: Larger size of the BLR, lower BH masses



△ NLS1



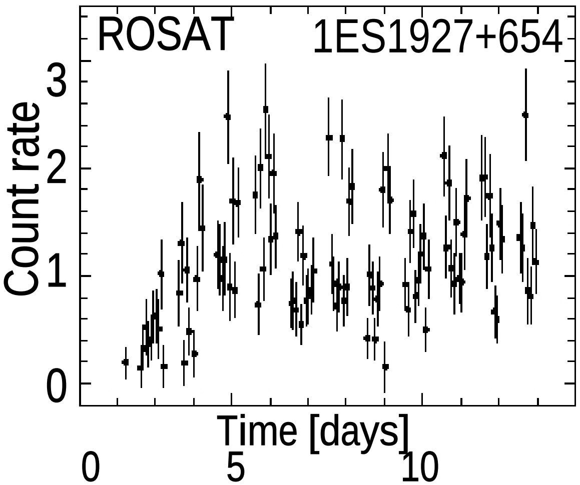
$M = FWHM^2 R / G$

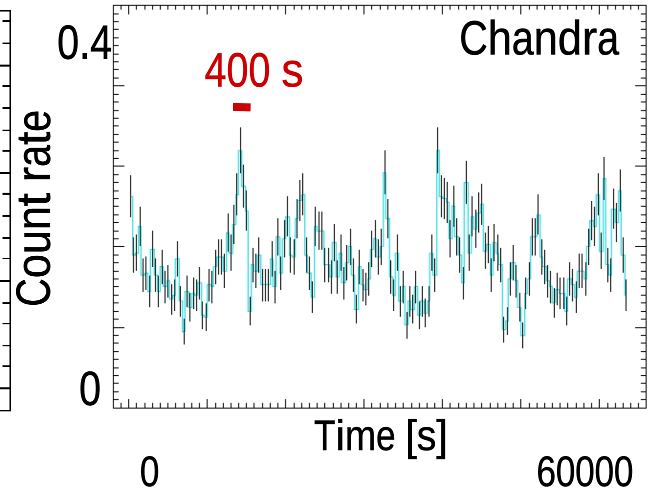
Indications for low M in NLS1

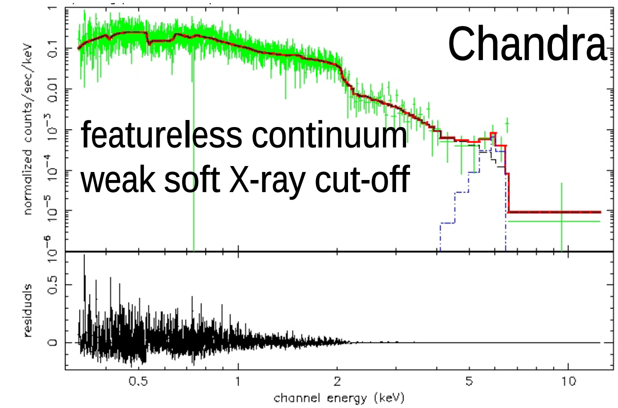
Statement II:

MWL discrepancies for the Sy1/Sy2 unification scheme

X-rays - direct view to central AGN







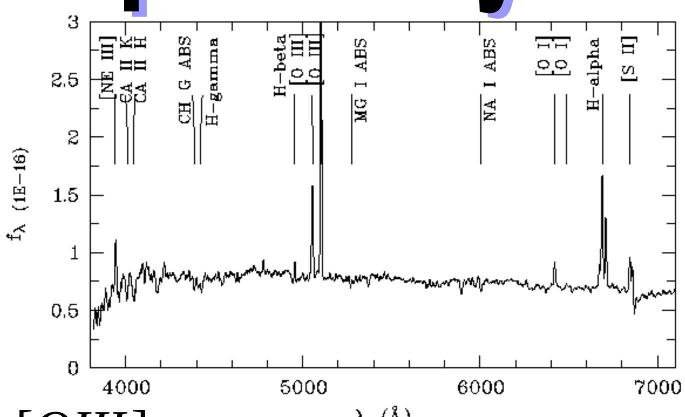
$N_H^{intr} = 3 \cdot 10^{20}\, cm^{-2} \Rightarrow A_V(X) = 0.15$

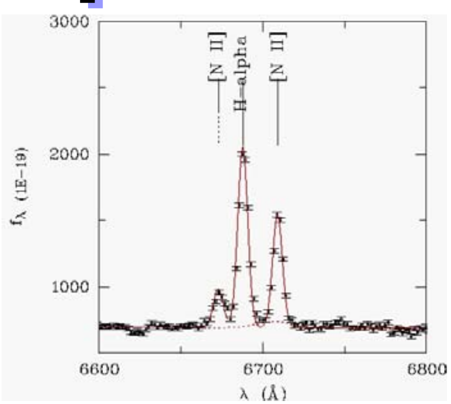
amplitude variability with factor of 17

type 1 nature at X-rays

low intrinsic neutral N_H

Optical Seyfert 2 spectrum - no broad wings





$A_V\ NLR) = 1.7$

$A_V(BLR) = 3.7 \Leftrightarrow A_V(X) = 0.15$

$\frac{[OIII]}{H_\beta} = 15$ no Fe multiplet lines no broad H_α line detectable

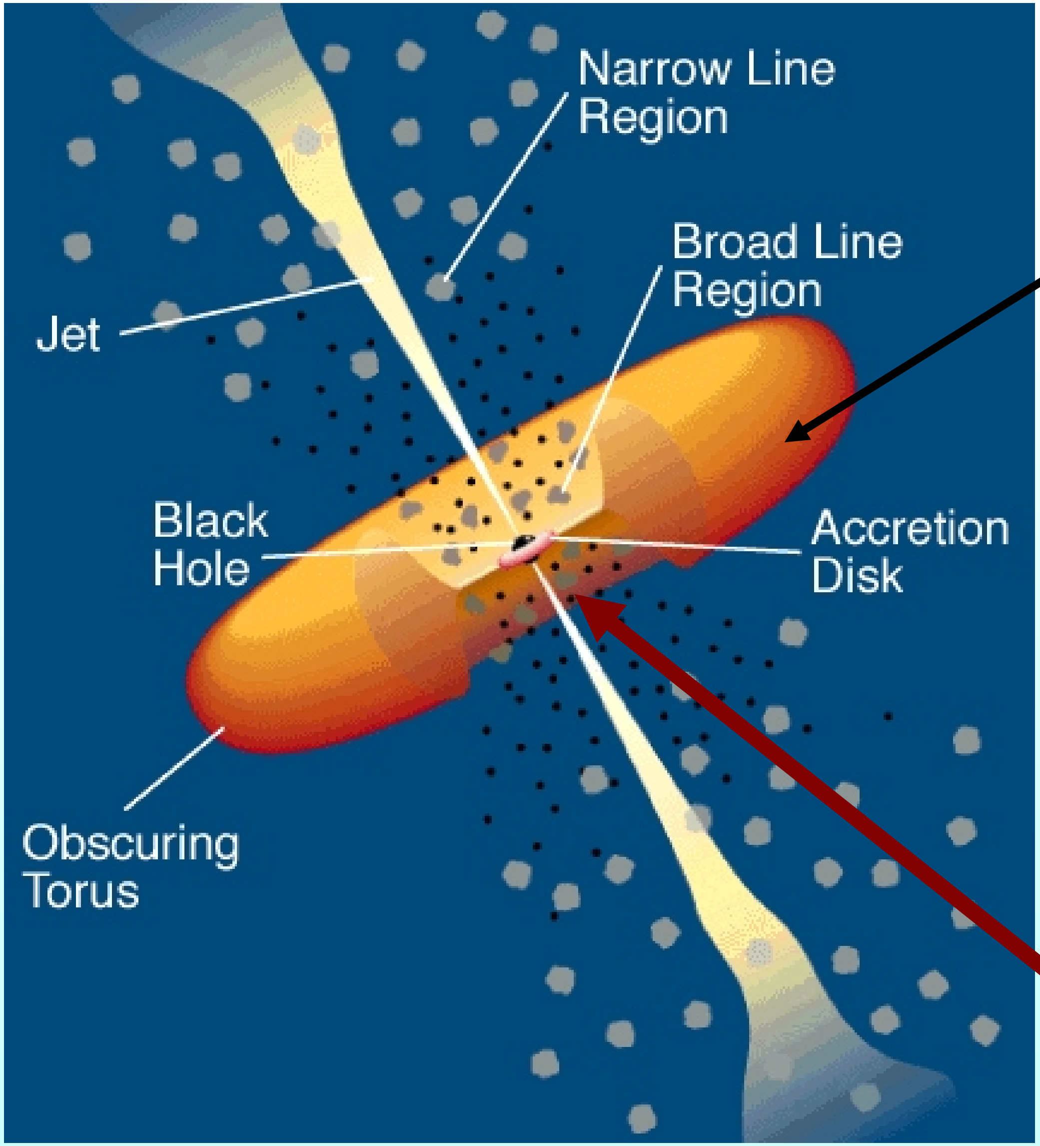
X-ray: direct view to central BH,
Optical: BLR not visible (view blocked)

Plausible scenarios:

Underluminous BLR

Dust optically thick for X-rays

High column ionized X-ray gas

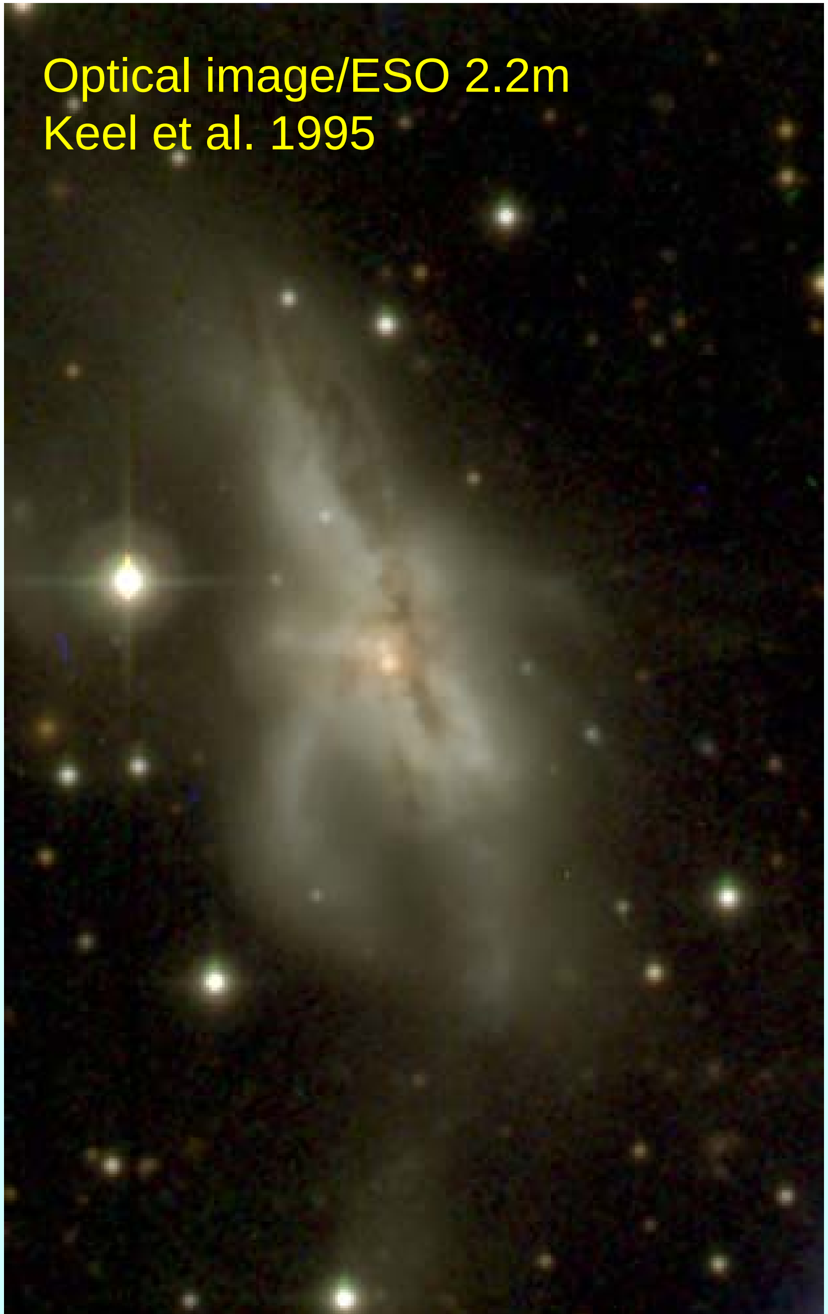


Seyfert 2

Seyfert 1

Statement III:

How to determine the SED of obscured and non-obscured sources?



The power of NGC 6240

Fosbury&Wall 1979:two gravitational interacting nuclei

Genzel 1998: starburst dominated power-source infrared emission arises from warm absorbing dust, surroundinig the inner parts

Schulz 1998: execptionally high ROSAT luminosity 10^{43} erg s^{-1}; interpreted as AGN-starburst connection and evidence for hidden AGN

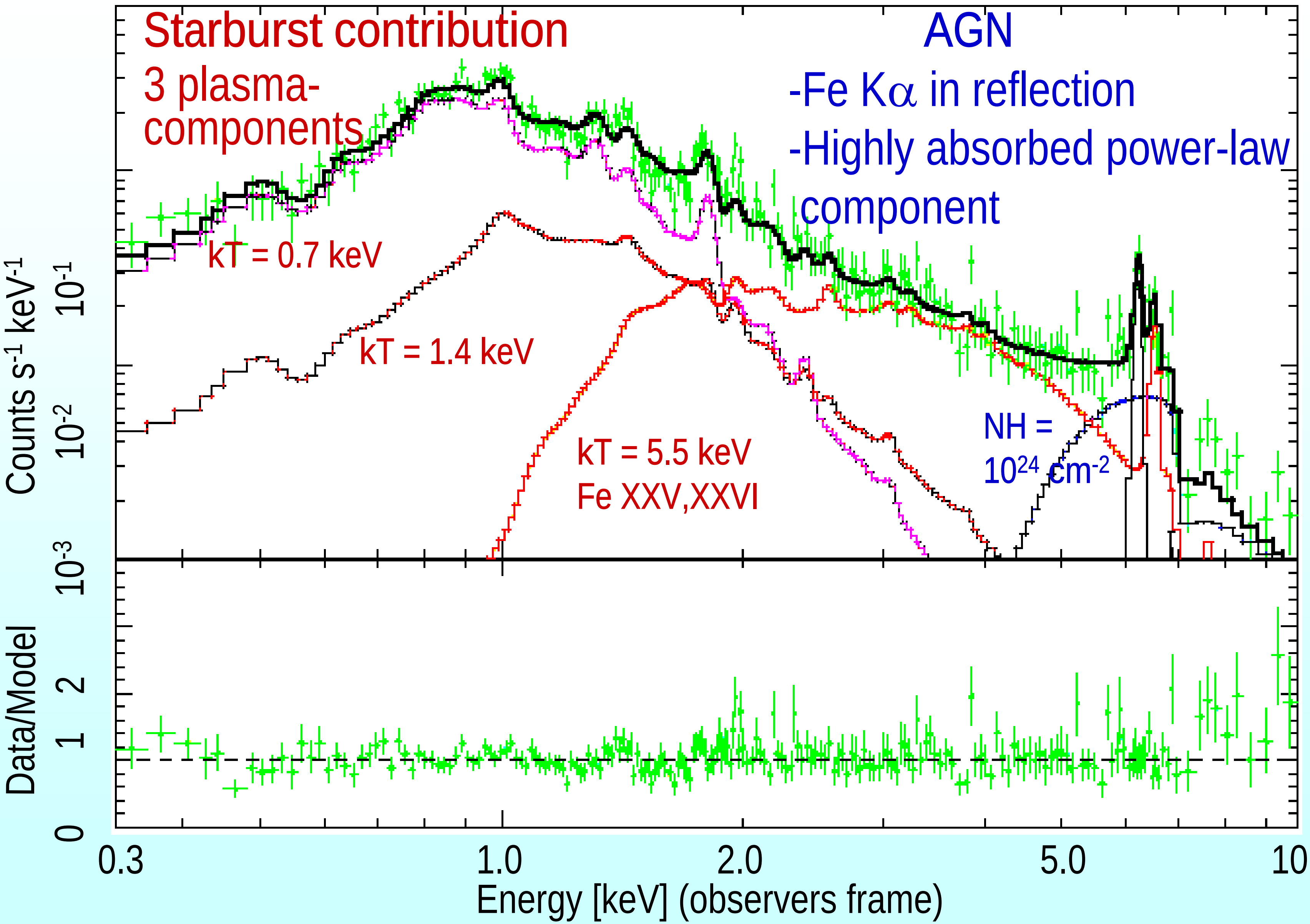
Komossa et al: 1998: Detection of extended soft X-ray emission with the ROSAT HRI

Mitsuda 1995: ASCA detection of Fe K lines and hard power-law emission; first solid proof for AGN activity

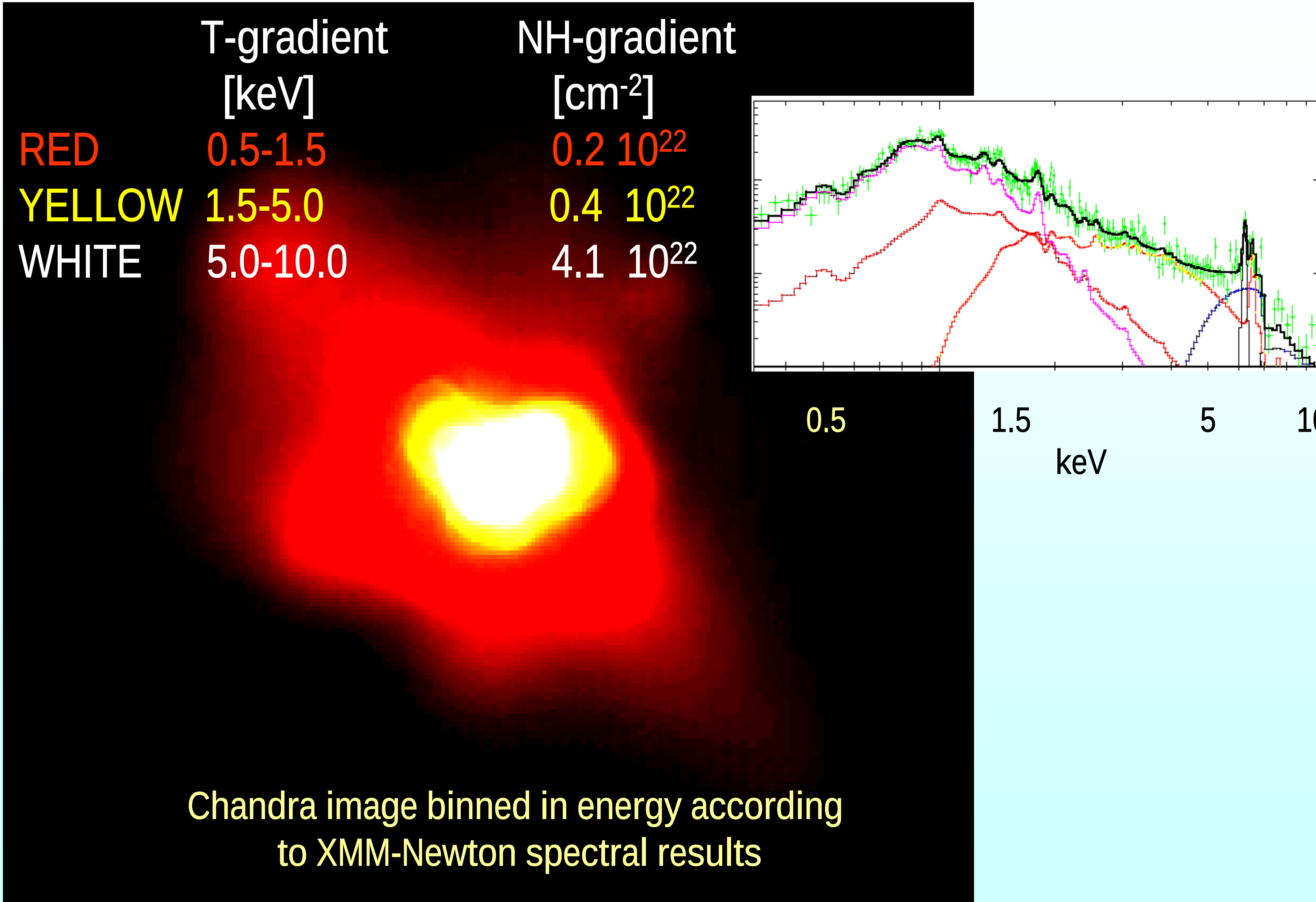
Vignati et al. 1999, Ikebe et al. 2001: BeppoSAX,RXTE detection of extremely Compton thick absorber NH = 10^{24} cm^{-2} and power-law emission from the corona

Komossa et al. 2002: Chandra detection of Fe Kα emission from both nuclei

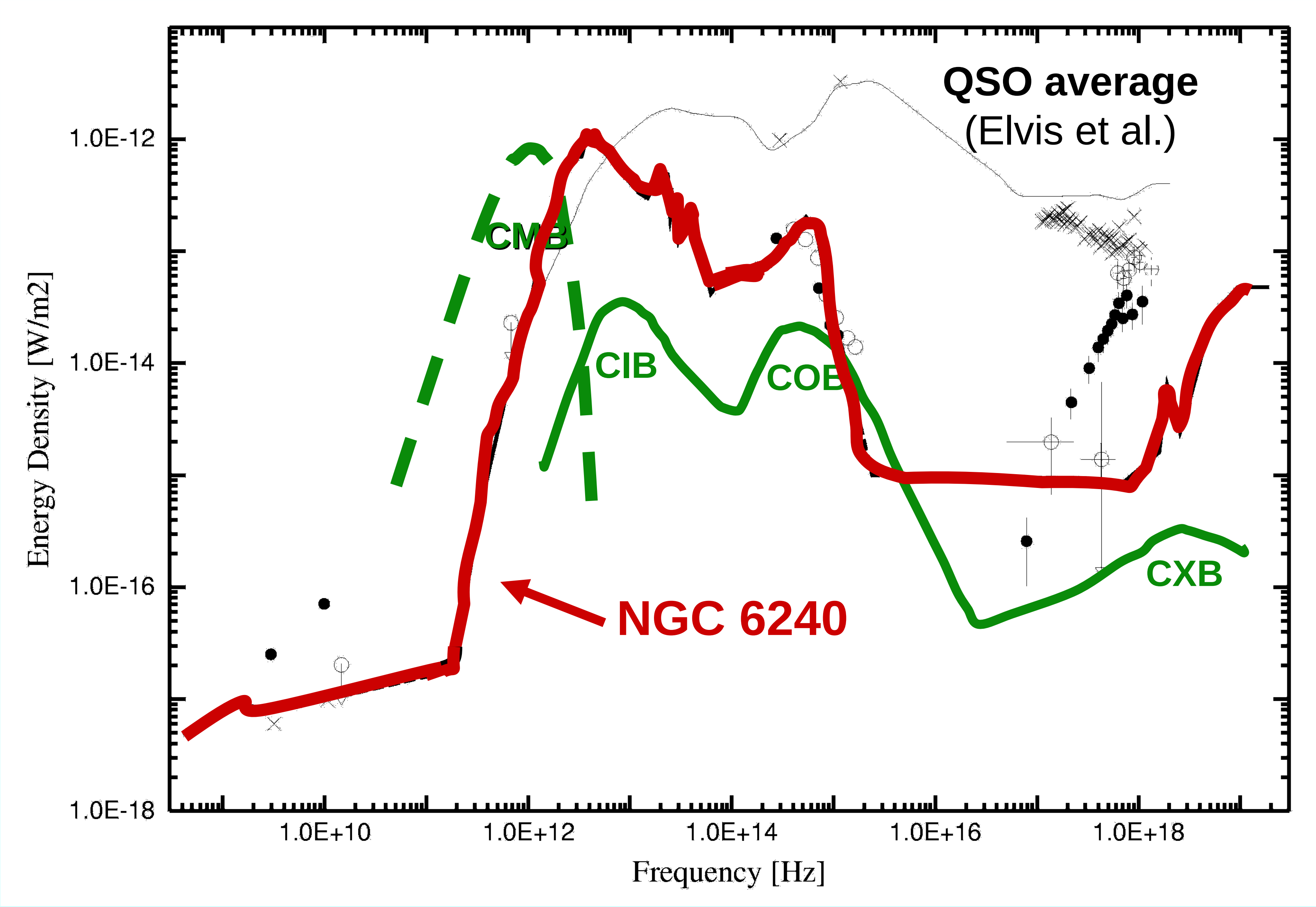
The basic physics of obscured sources



The power of combining Chandra with XMM-Newton



NGC 6240 as the prototype object of highly absorbed AGN in the local universe (Hasinger 2001)



Looking for obscured quasars:

a combined X-ray, optical, near infrared selection

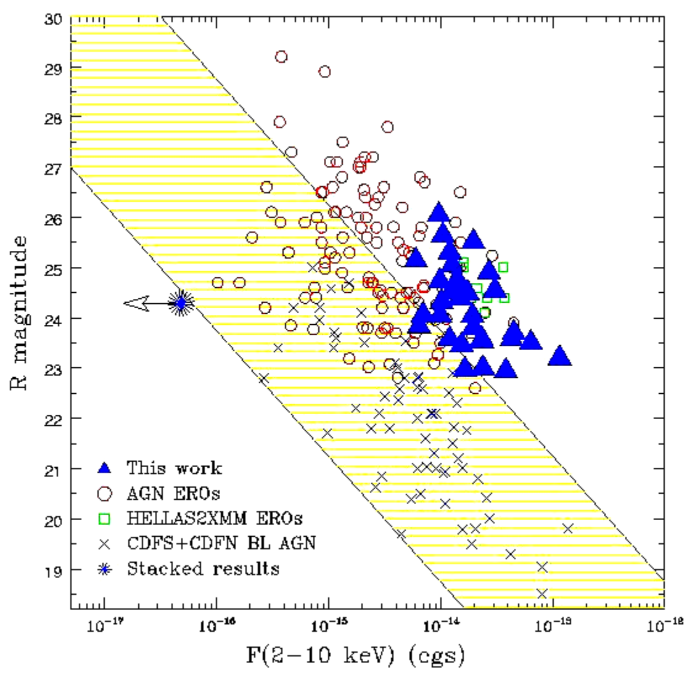
Shallow X-ray flux + large area → pick-up the most extreme sources

Selection of high-z obscured QSO:
from X-ray + photo-z catalog

•optical-to-near-infrared color (R-K)>4)

•X-ray-to-optical color (X/O>10)

•photometric redshift (zphot>1)

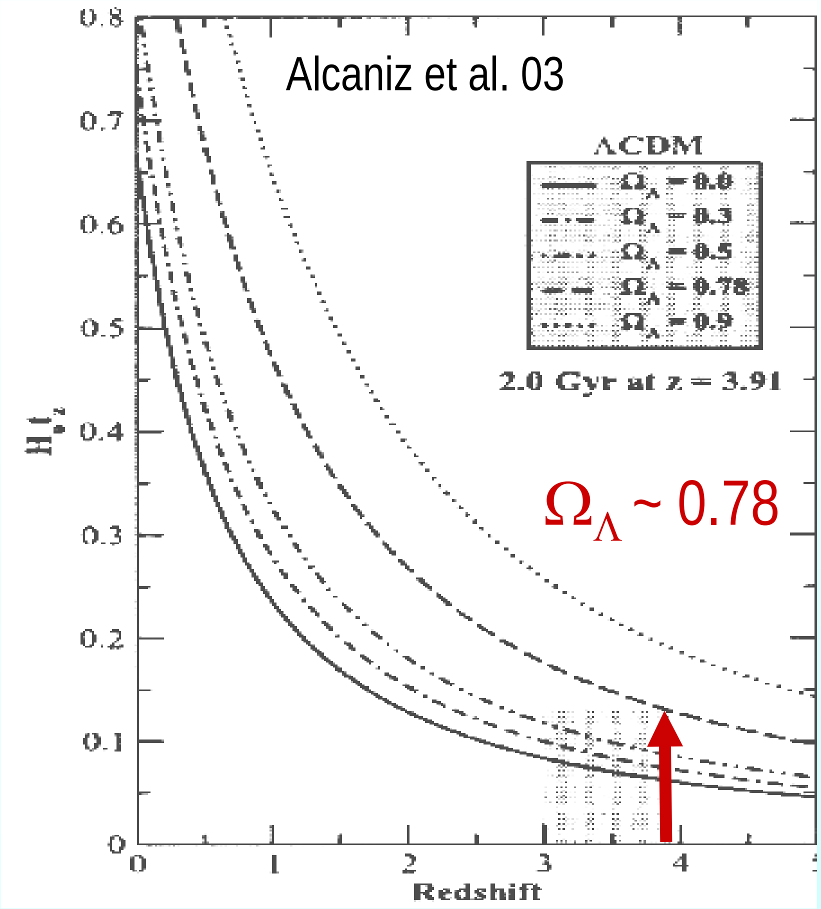


Statement IV: Dark Energy measurements via chemical evolution

Detection of a 2-Gyr-old quasar at z=3.91 (Hasinger et al. 2003) is of particularly interest as it constrains the amount of dark energy

requires
precise optical
line intensity
measurements
via line of growth
measurements

e.g.
Fe versus O



Statement V: MWL results of X-ray sources from deep field observations

Example: COSMOS field

- 50 pointing scheduled with XMM (1.4 Ms)
- 25 observed
- 2 failed due to particles flares
- Field complete in June 2006
- Chandra Proposal (P.I. M. Elvis)

- Need to go to larger and contiguous scales → 2 sq.deg.
- Need multiwavelength coverage

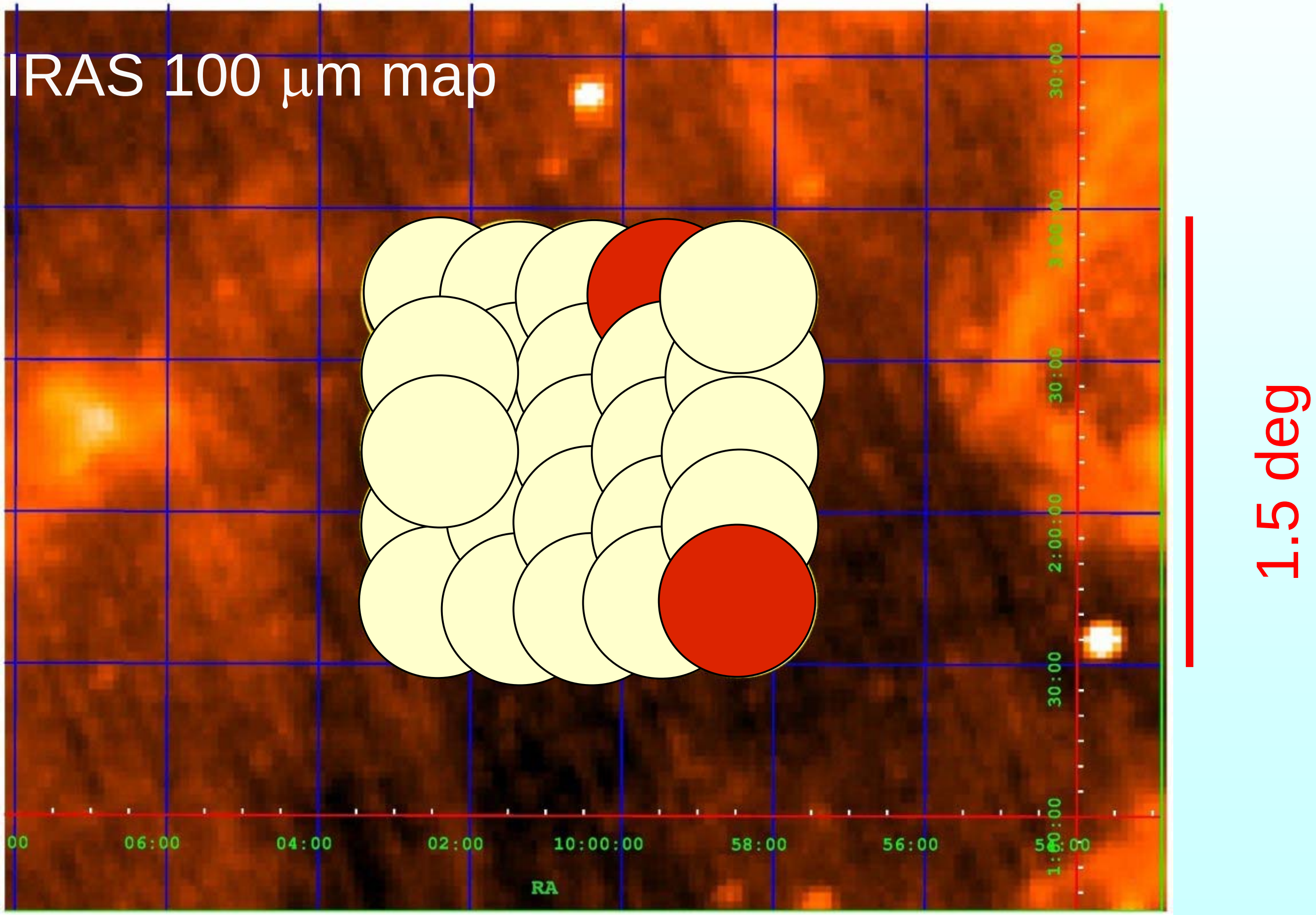
Cosmos Survey

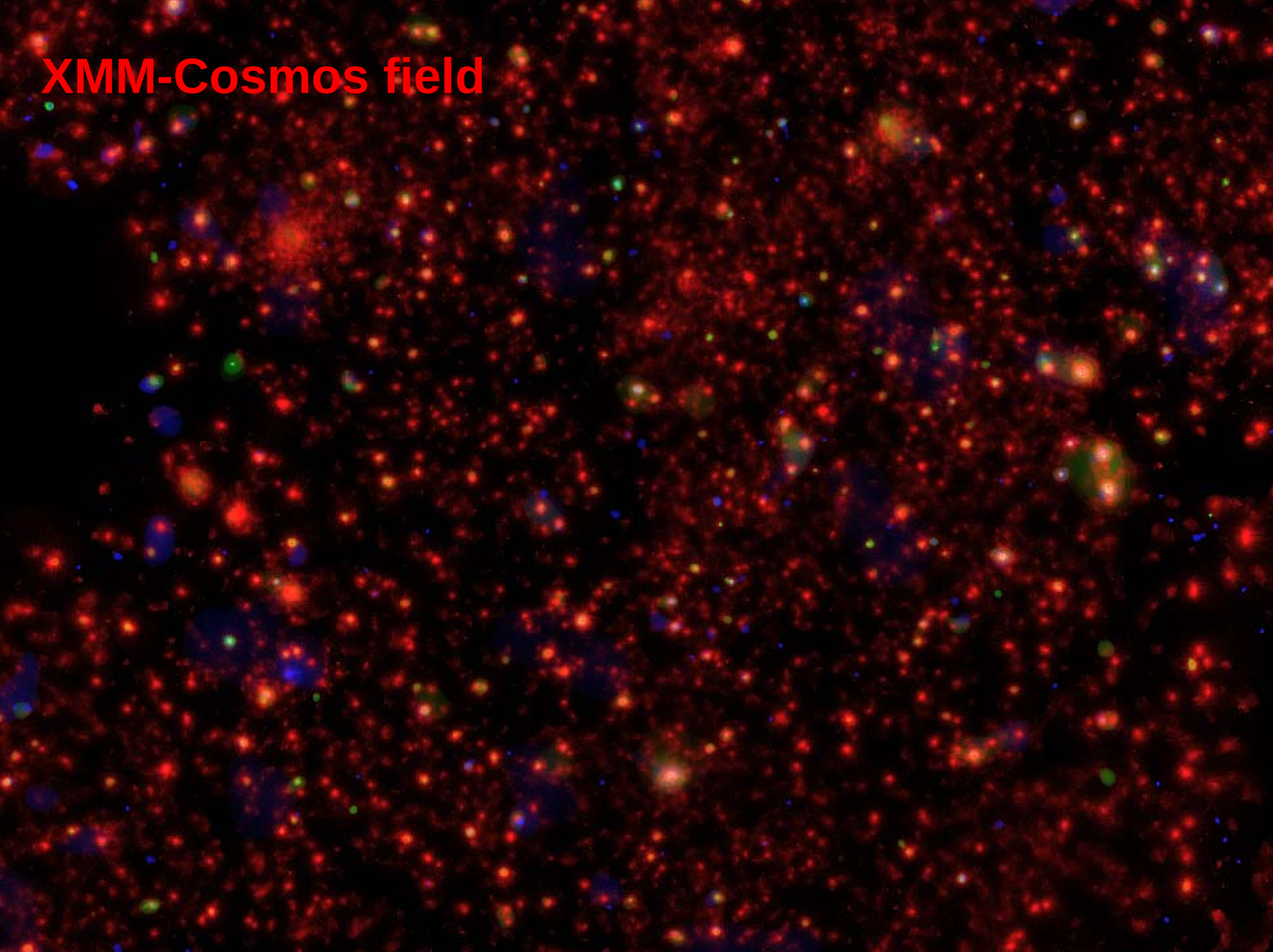
2 degrees

→ 25 XMM-Newton Pointings

(15.06 05)

RA: 10^{h}00^{m}26^s DEC: 2°12'36''




XMM-Cosmos field

COSMOS major components :

HST (i-band – 590 orbits)

Subaru imaging (~25 nights, b,v,r,i,z,)

VLT (540 hours) & Magellan (12 nights)

XMM-Newton (1.4 Ms)

VLA (265 hours)

GALEX deep (200 ks, AB~25)

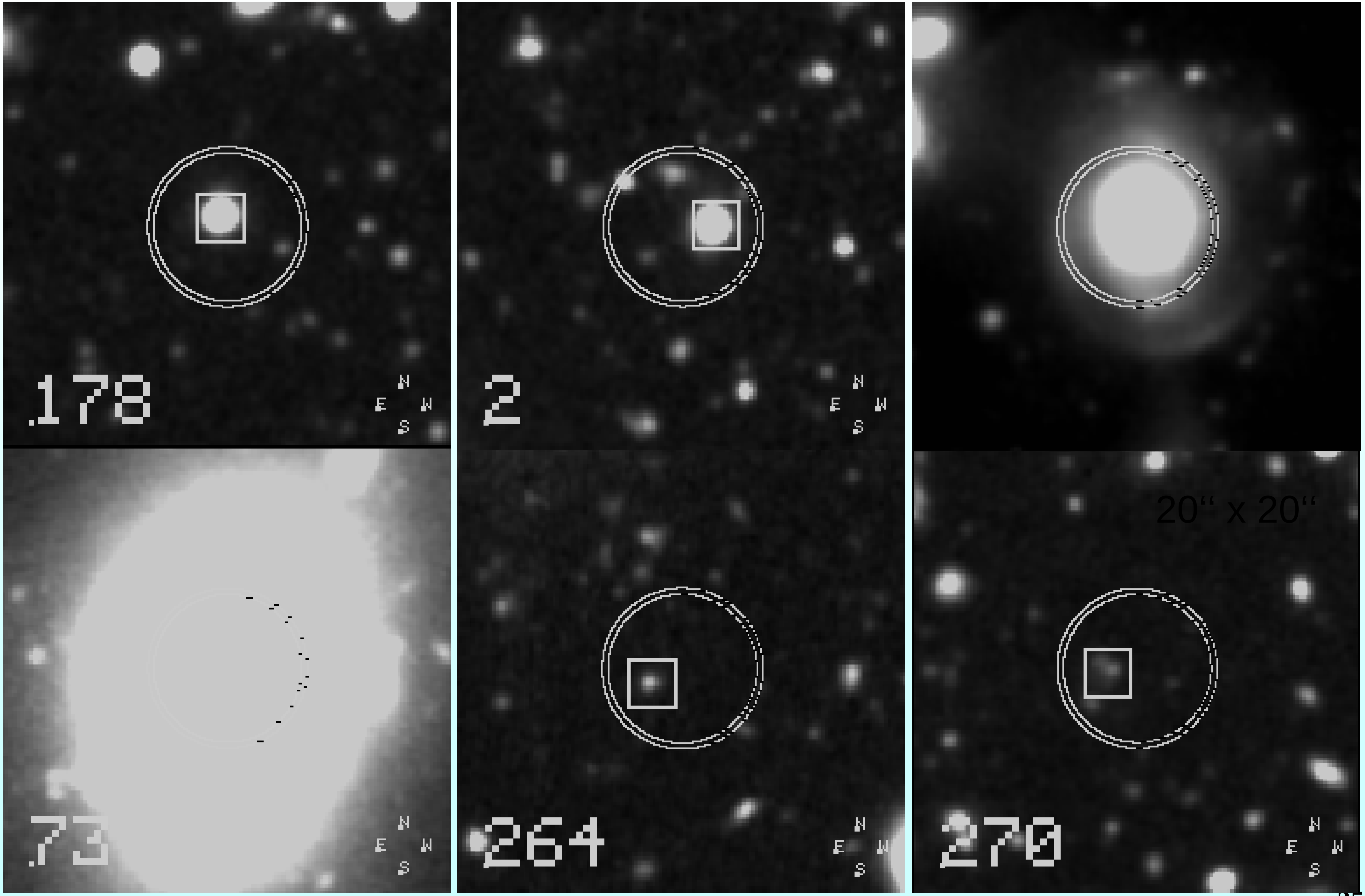
+ MAMBO, CFHT and others

http://www.astro.caltech.edu/cosmos/

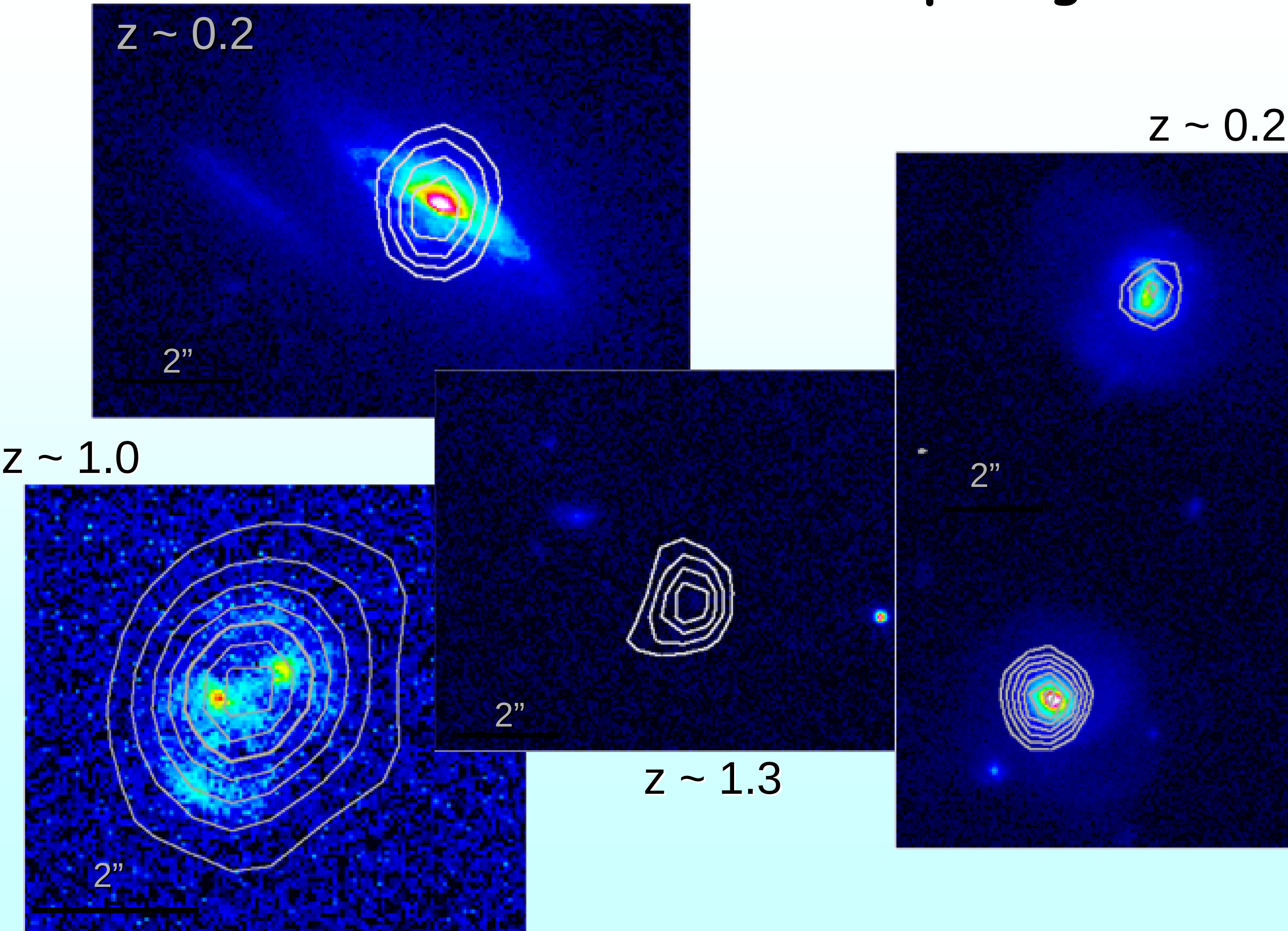
all underway !

(>50 members from US, Japan, Europe and Canada)

Subaru r band



VLA-COSMOS vs. HST morphologies



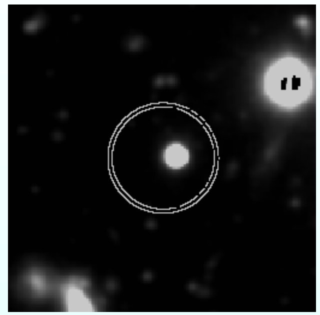
I. Matute + V. Mainieri

VIMOS P73 spectra of XMM sources

XMM-5

log $L_{0.5-2.0\,keV}$= 43.8

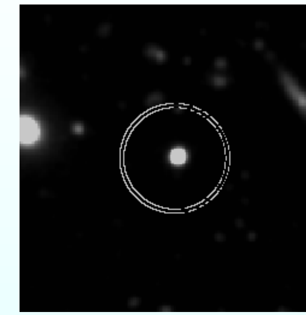
type-2 Quasar ?

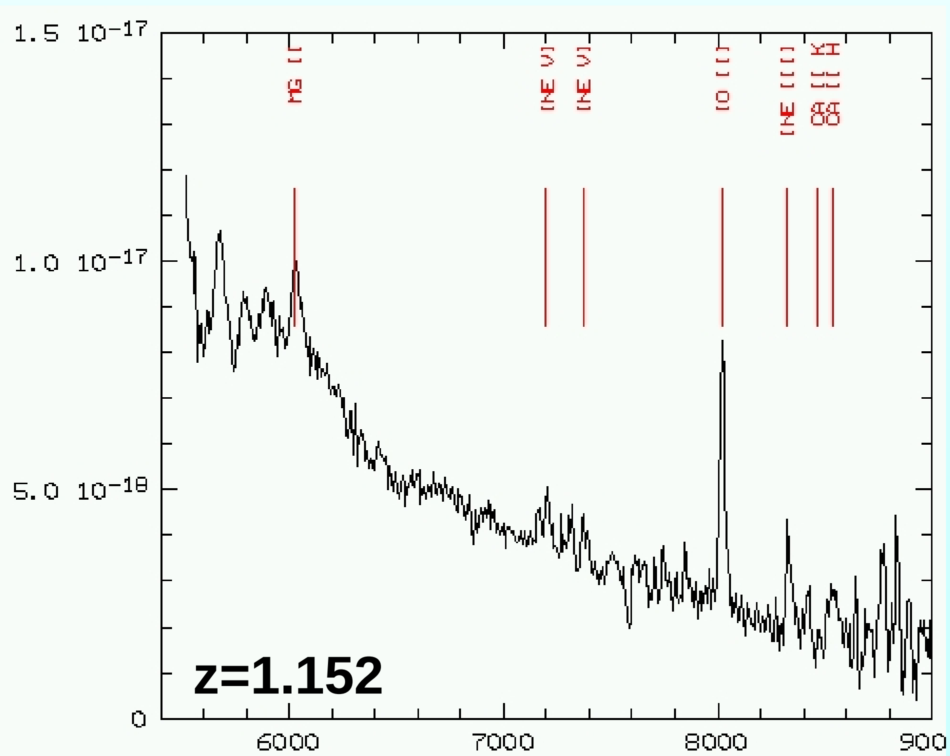


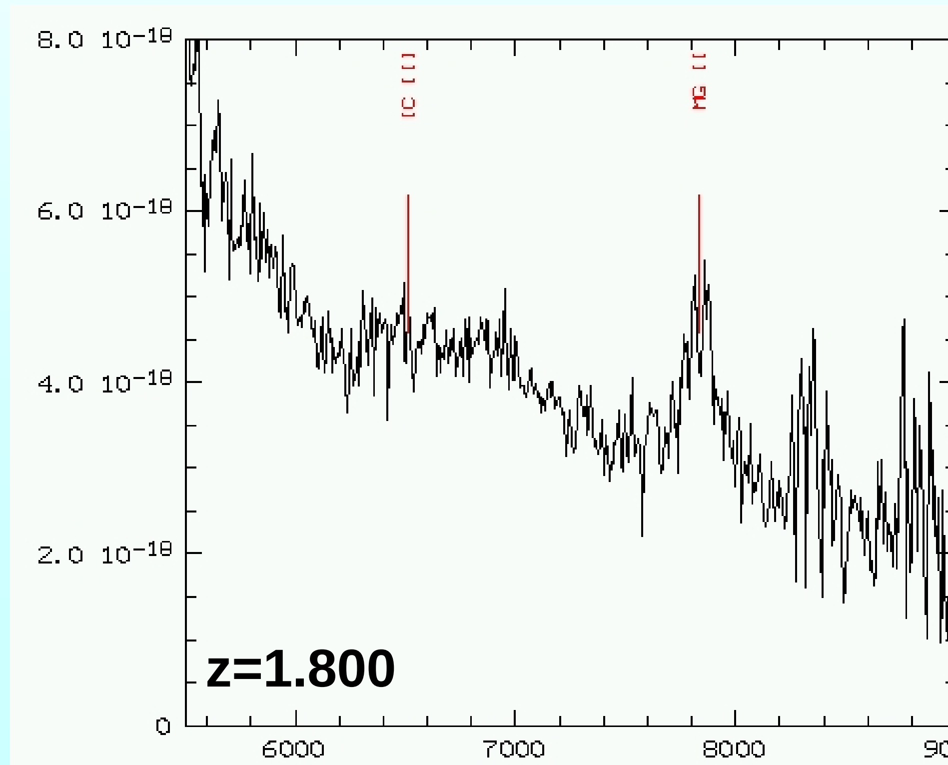
XMM-137

log $L_{0.5-2.0\,keV}$= 43.9

type-1 AGN



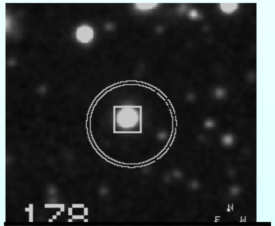


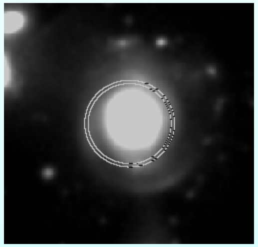


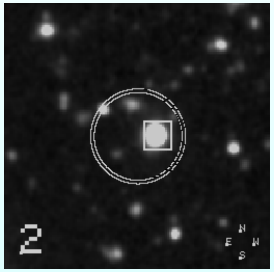
A few numbers on optical SUBARU identification

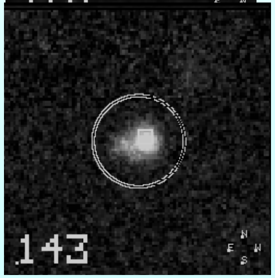
N(X-ray sources) 695	
N(with opt ID) 626	90%
N(ambiguous opt ID) 28	7%
N(no opt ID) 41	3%

Images: Subaru R-band
20“ x 20“ in size



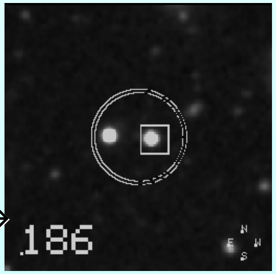


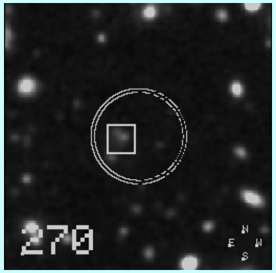


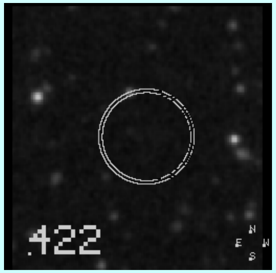


← check with K detections

Case for Chandra proposal →







Empty fields
or very faint objects

Future :

ApJ special issue: Fall 2005

HST-ACS - g band (proposed)

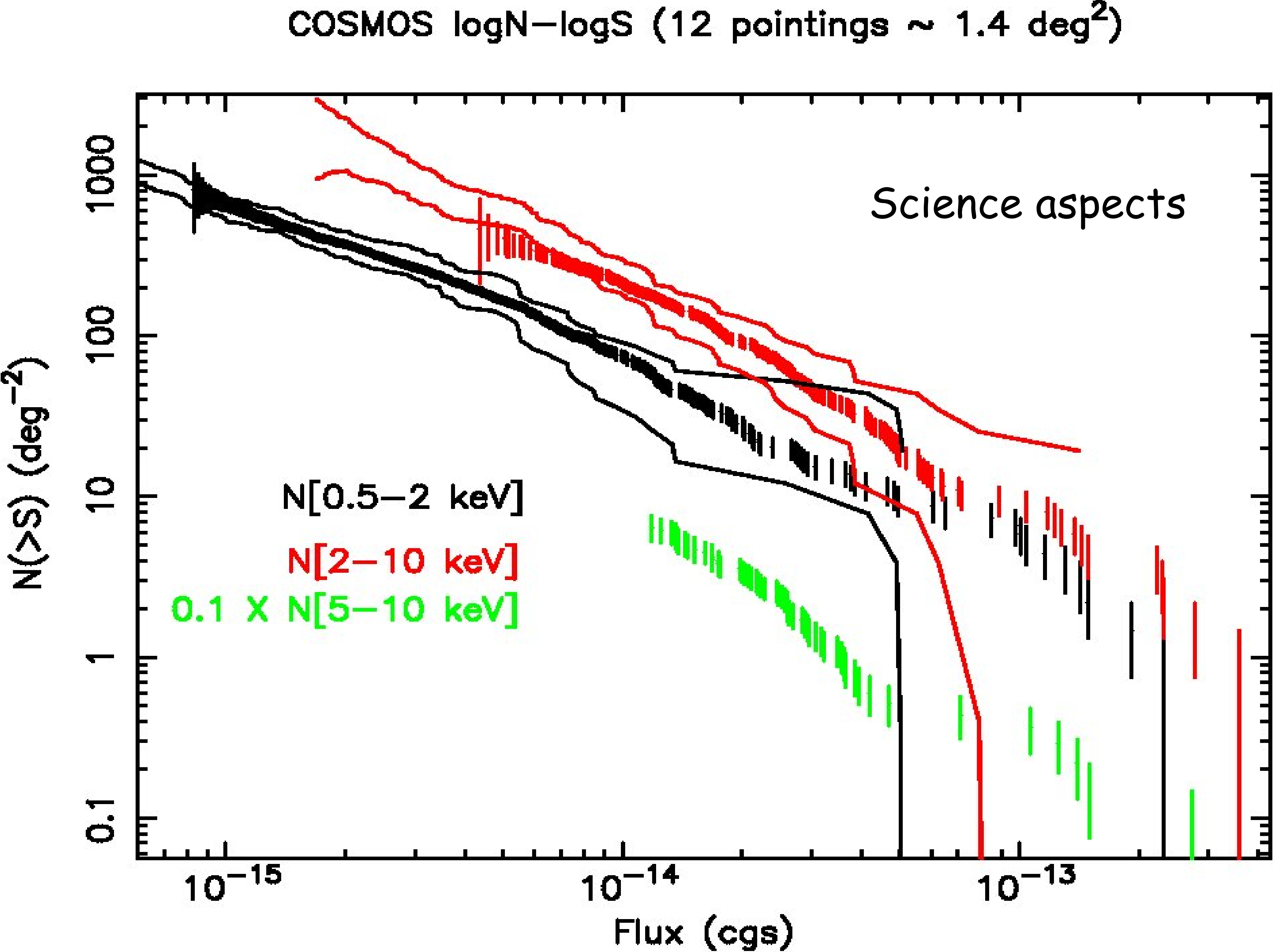
Chandra 1.4 Ms (proposed)

Spitzer IRAC & MIPS (proposed)

Subaru : COSMOS-18 ==> improved phot-z
emission line survey

SCUBA-2→ submm
deeper J,H, K

next: ALMA

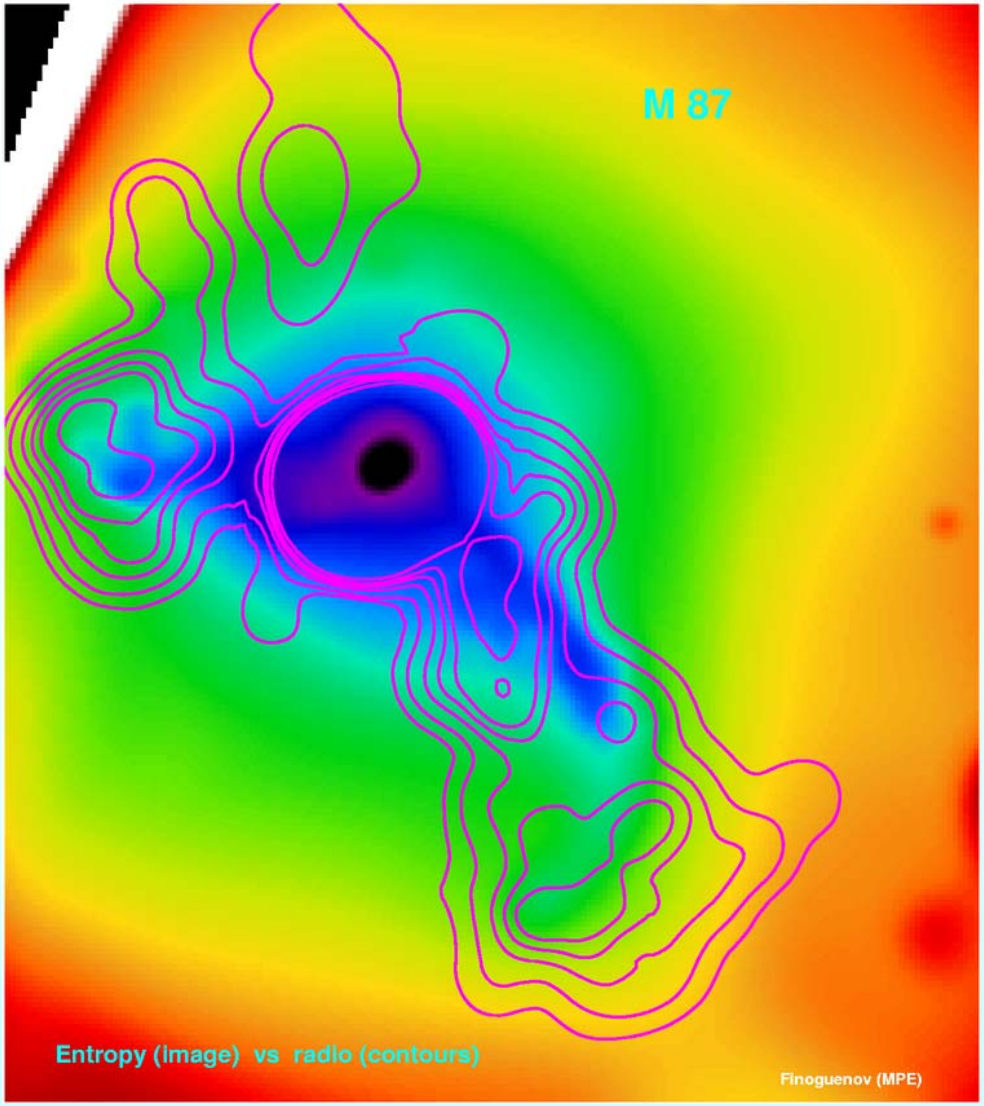


COSMOS logN-logS (12 pointings ~ 1.4 deg^2)
Science aspects
N[0.5-2 keV]
N[2-10 keV]
0.1 X N[5-10 keV]
N(>S) (deg^{-2})
1000
100
10
1
0.1
10^{-15}
10^{-14}
10^{-13}
Flux (cgs)

Statement VI:

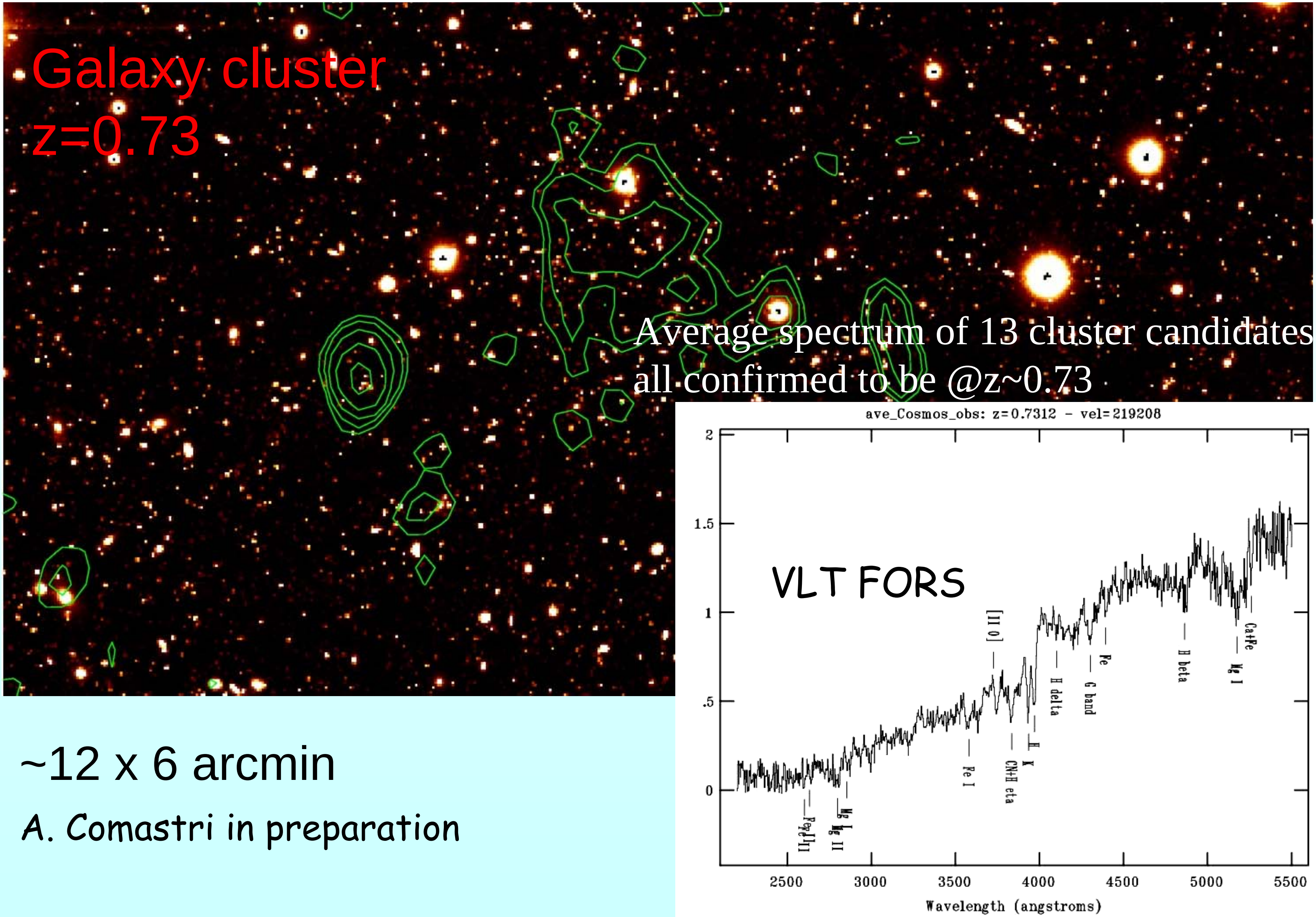
MWL observations of cluster of galaxies are of great scientific interest

MWL observations of X-ray clusters



Entropy map with RADIO contours overlaid

Galaxy cluster X-ray - Optical



~12 x 6 arcmin

A. Comastri in preparation

Statement I: The gain in information from MWL on accreting sources is limited; expception NLS1s

Statement II: Open problems in the Sy1/Sy2 unification scheme

Statement III: How to determine the SED of obscured and non-obscured sources

Statement IV: Dark Energy measurements via chemical evolution

Statement V: Object classification of X-ray sources in the distant universe

Statement VI: MWL observations of cluster of galaxies are of great scientific interest