The AGN content of the COSMOS: the XMM-Newton view

Marcella Brusa (MPE)
on behalf of the XMM-COSMOS team

PI: **G. Hasinger**

INAF/Italy: **Comastri, Zamorani**, **Civano, Fiore, Gilli, Matt, Matute, Vignali**

MPE: Boehringer, Brunner, **Cappelluti**, Finoguenov, **Mainieri**, Silverman

Others: Elvis, Griffiths, Impey, Le Fevre, Lilly, Miyaji, Scoville, Urry

Motivation of the XMM-COSMOS project

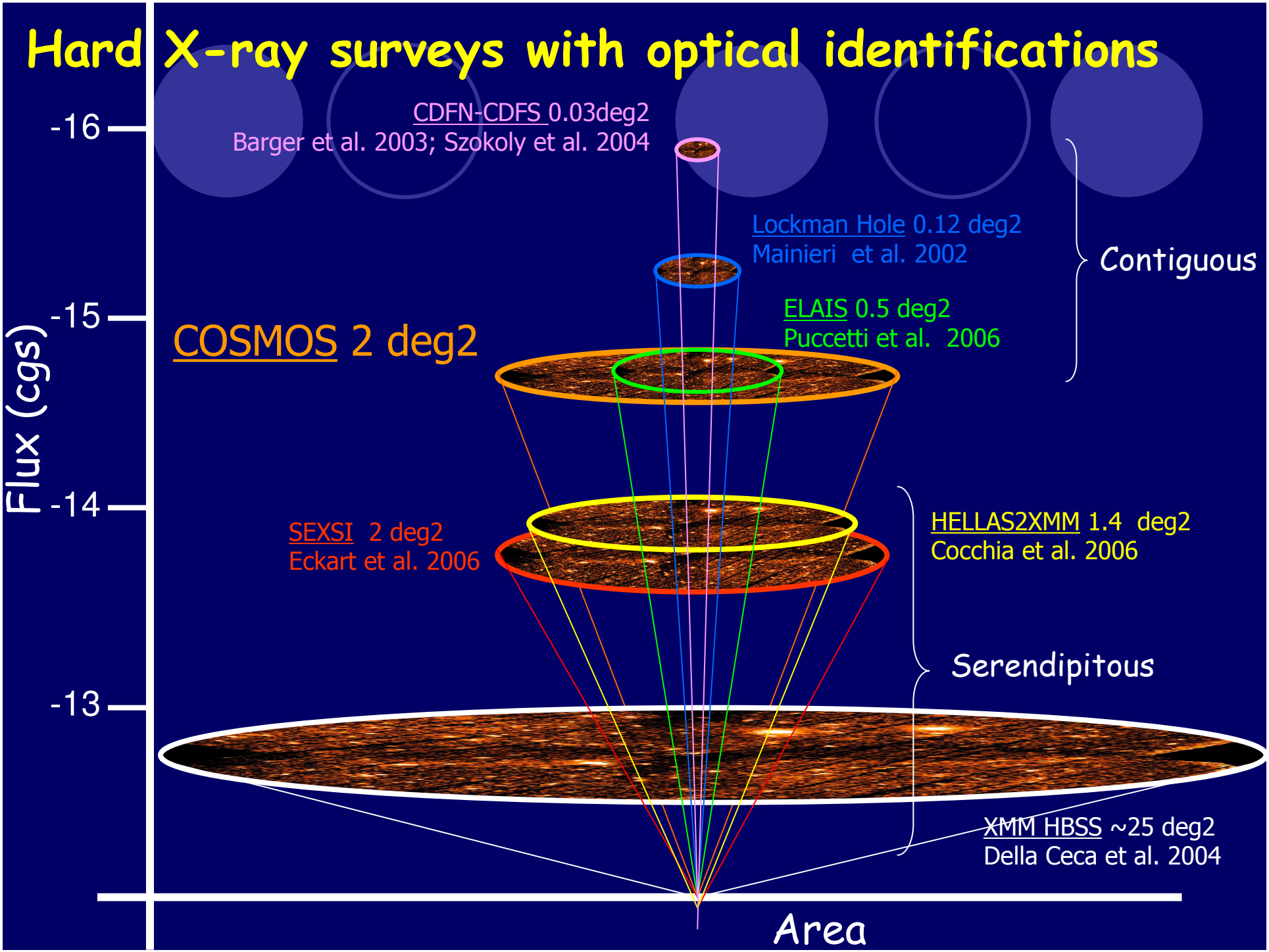
The main goal of the XMM-Newton Wide field survey in the COSMOS field is:
„the evolution of (obscured) Active Galactic Nuclei over the cosmic time and the dependence of black hole growth on galaxy morphology and environment"

Evolution of AGN → complete picture of galaxy(-AGN) (co)evolution
[see Alvio's review]

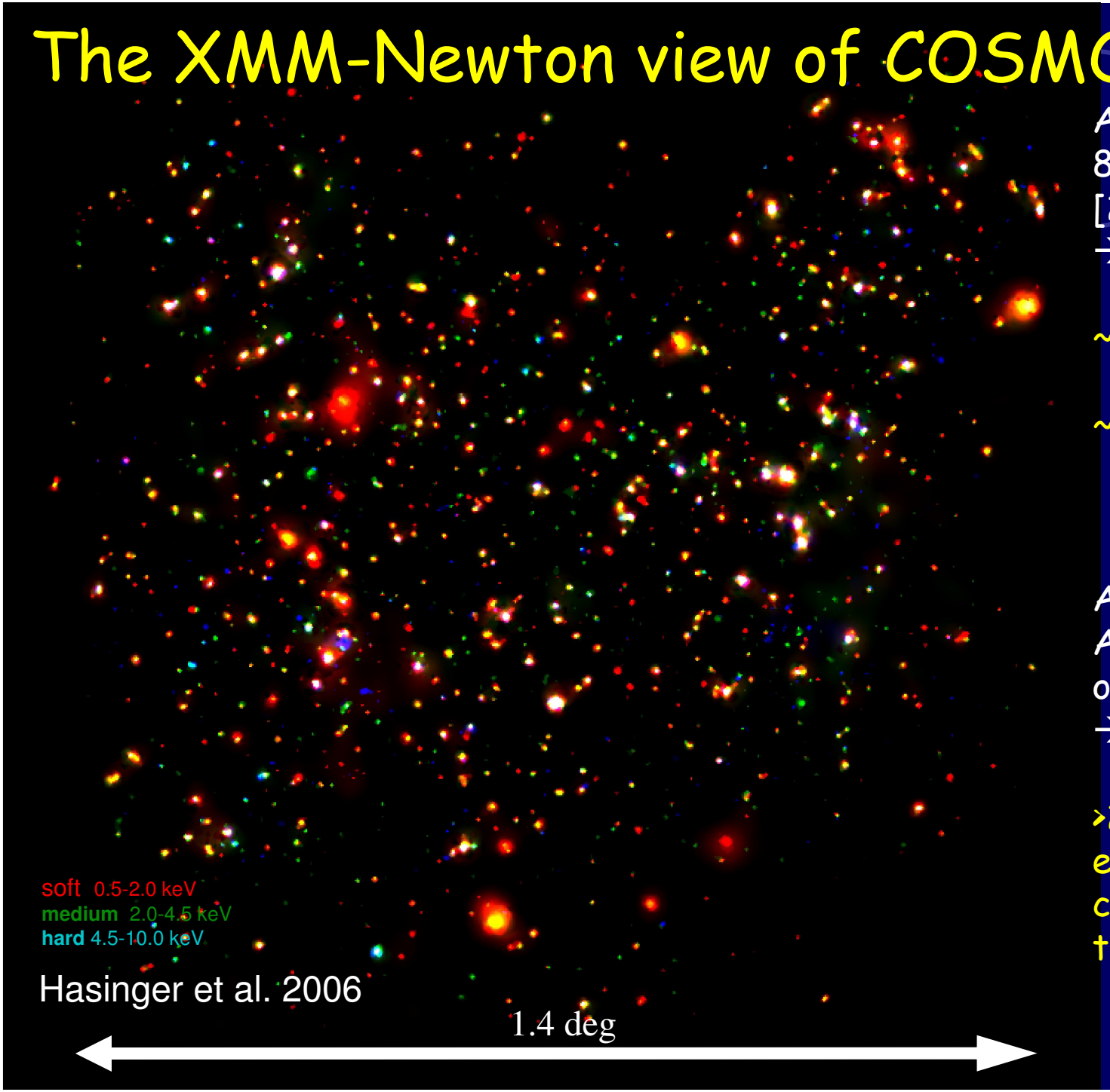
Obscured AGN needed:
- to reproduce the X-ray background peak
  (Setti & Woltjer 1989, Comastri et al. 1995 etc.)
- to reconcile local BH mass function with mass accreted on BH
  (Fabian & Iwasawa 1999, Merloni 2004, Marconi et al. 2004 and many others)

to place AGN in the environments → **large contiguous area**
to compute physical quantities / study galaxies → **DEEP multiwave coverage**

Select AGN → **Hard X-ray survey**


Hard X-ray surveys with optical identifications
CDFN-CDFS 0.03deg2
Barger et al. 2003; Szokoly et al. 2004
Lockman Hole 0.12 deg2
Mainieri et al. 2002
ELAIS 0.5 deg2
Puccetti et al. 2006
Contiguous
COSMOS 2 deg2
SEXSI 2 deg2
Eckart et al. 2006
HELLAS2XMM 1.4 deg2
Cocchia et al. 2006
Serendipitous
XMM HBSS ~25 deg2
Della Ceca et al. 2004
-16
-15
-14
-13
Flux (cgs)
Area

The XMM-Newton view of COSMOS



AO3:
800 ks of XMM
[25x32 ks pointings]
→ completed

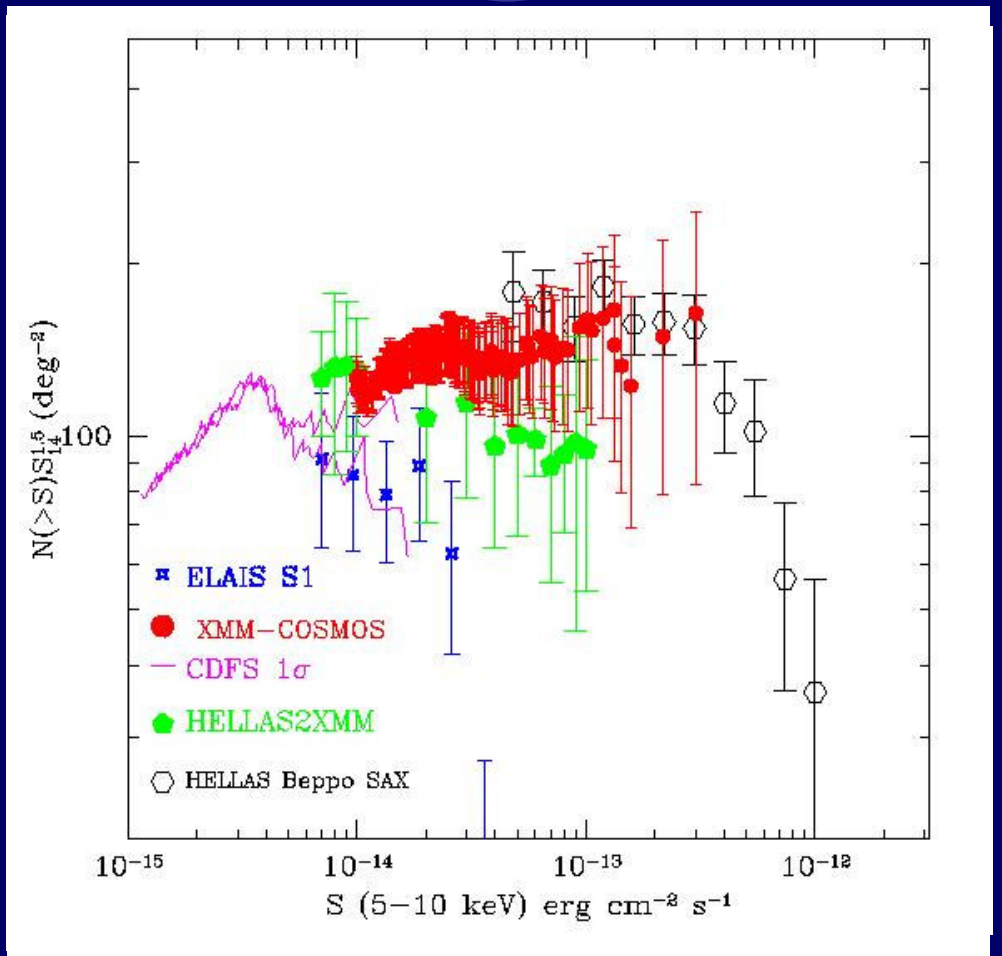
~1400 AGN detected

~70 clusters/diffuse sources

AO4:
Additional 600 ks of XMM
→on-going

>2000 sources expected at the completion of the survey

COSMOS source counts



logN-logS (normalized to Euclidean slope)

→Confirm all previous results with unprecedent accuracy in flux range

FLUX	ENERGY	#SOU
(-15.5,-12.5)	0.5-2 keV	~1200
(-14.5,-12.5)	2-10 keV	~700
(-14.0,-12.5)	5-10 keV	~150

Cappelluti et al. 2006

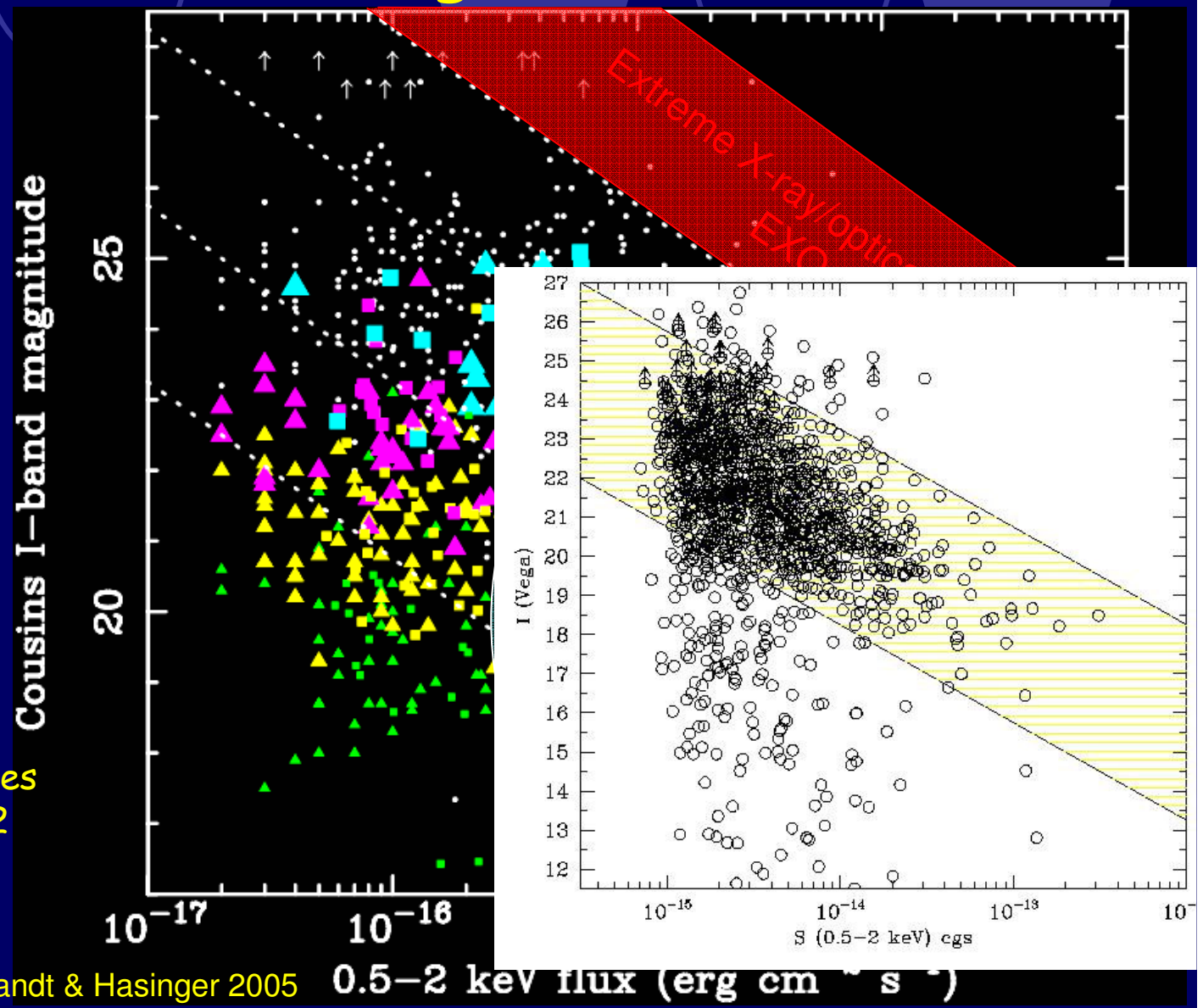
Optical identification X/O diagram

-"bright" sample
I≤24
secure identified
~1200 (85%)

statistical properties
- redshifts
- morphologies
- colors
- selection effects

-"faint" sample
I≥24
problems with ID
~200 (15%)

→most interesting sources
- candidate high-z QSO2



Brandt & Hasinger 2005

Redshift distribution

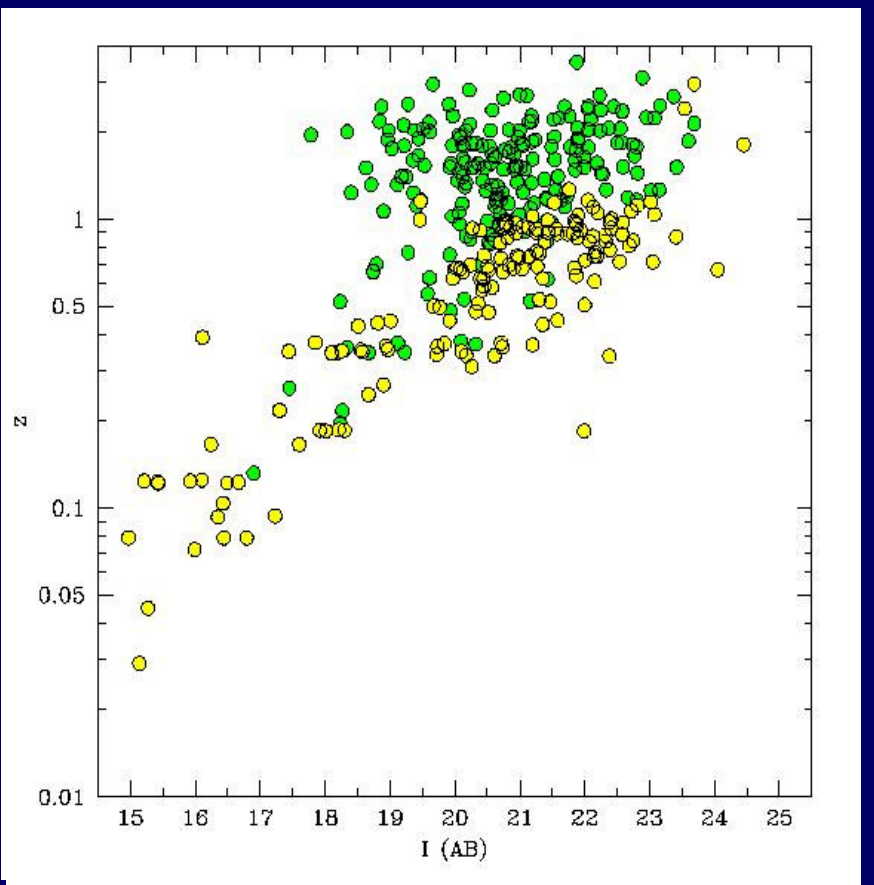
compilation from ongoing spectroscopic projects
[IMACS/zCOSMOS + SDSS + literature data]

- ~380 "secure" spectroscopic identifications (z>0)
  [25% of the full sample, 50% completeness in the I<22 sample]

- BL AGNs dominate at z>1
  → High redshift type 2 objects missing (partly selection effect)
  [see also results from HELLAS2XMM, Cocchia et al. 2006 and from the SEXSI survey, Eckart et al. 2006, astro-ph/0603556]

- Redshift spikes → follow photo-z spikes in the galaxy sample

- First results on clustering signal suggest 8σ detection
  (Gilli et al., in preparation
  see also results on ACF – Miyaji et al. 2006)



Brusa et al. 2006

ACS morphological information

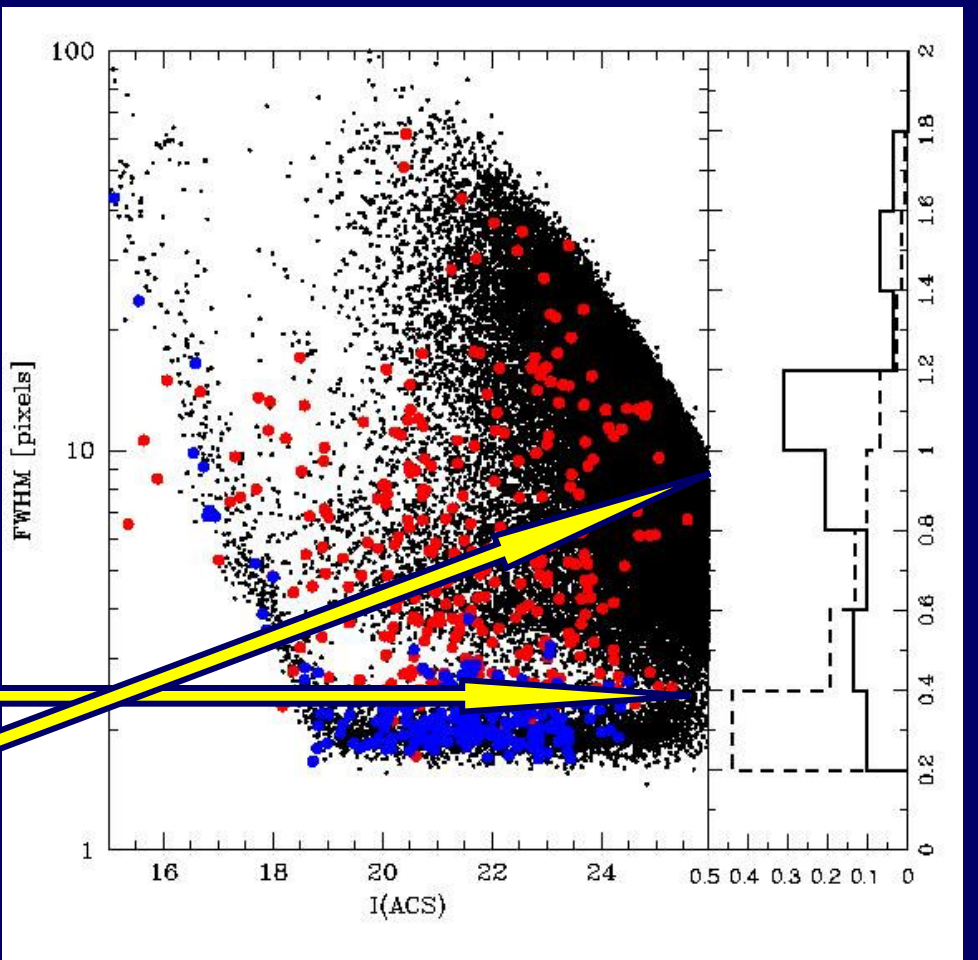
[First] morphological test on identifications

About 50% of the IDs have stellar (or almost stellar; FWHM<3 pixels) profile on ACS data

blue points = pointlike
red points = extended

Very soft (HR=-1) sources are mostly point-like (dashed histogram)

Very hard (HR=1) sources are preferentially associated with extended objects (solid histogram)

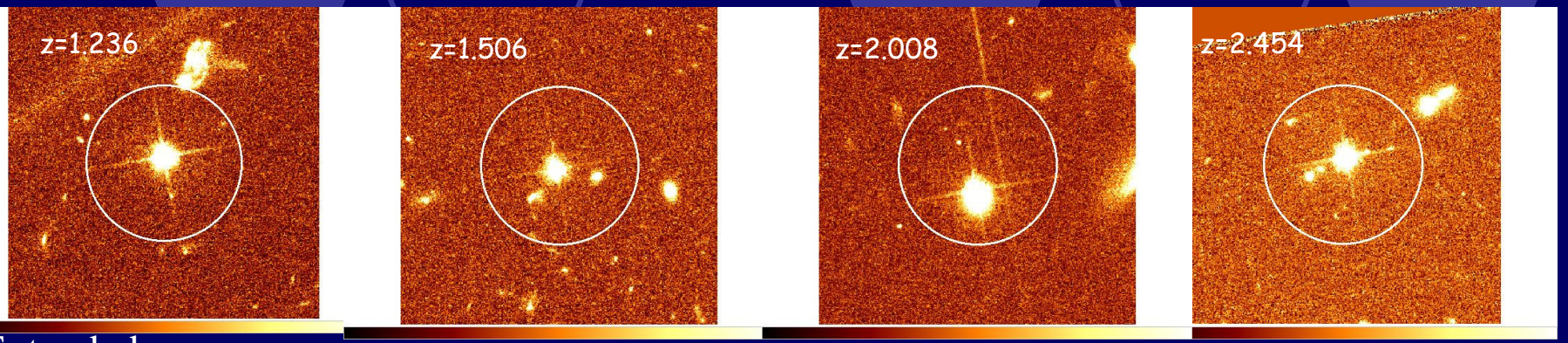


Brusa et al. 2006

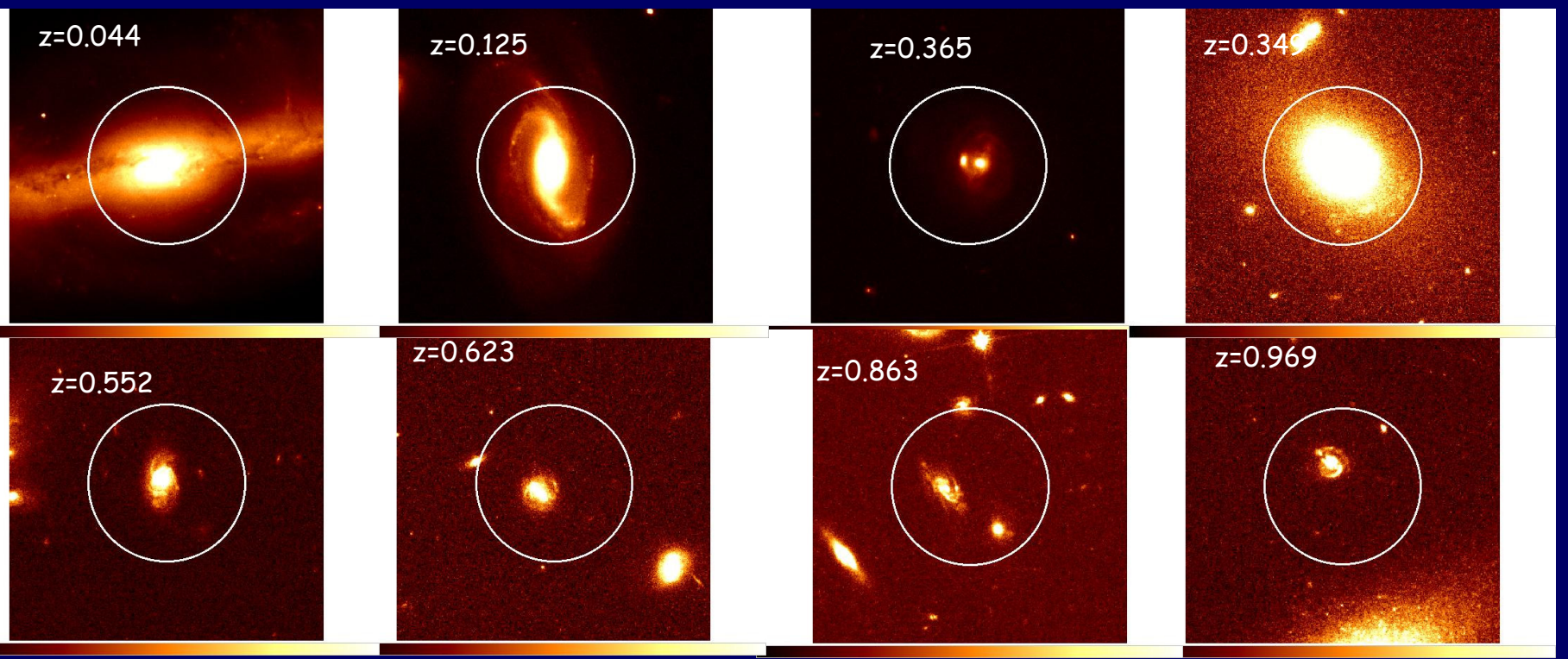
First look at ACS morphologies

Pointlike

Images: 20“ x 20“ in size



Extended



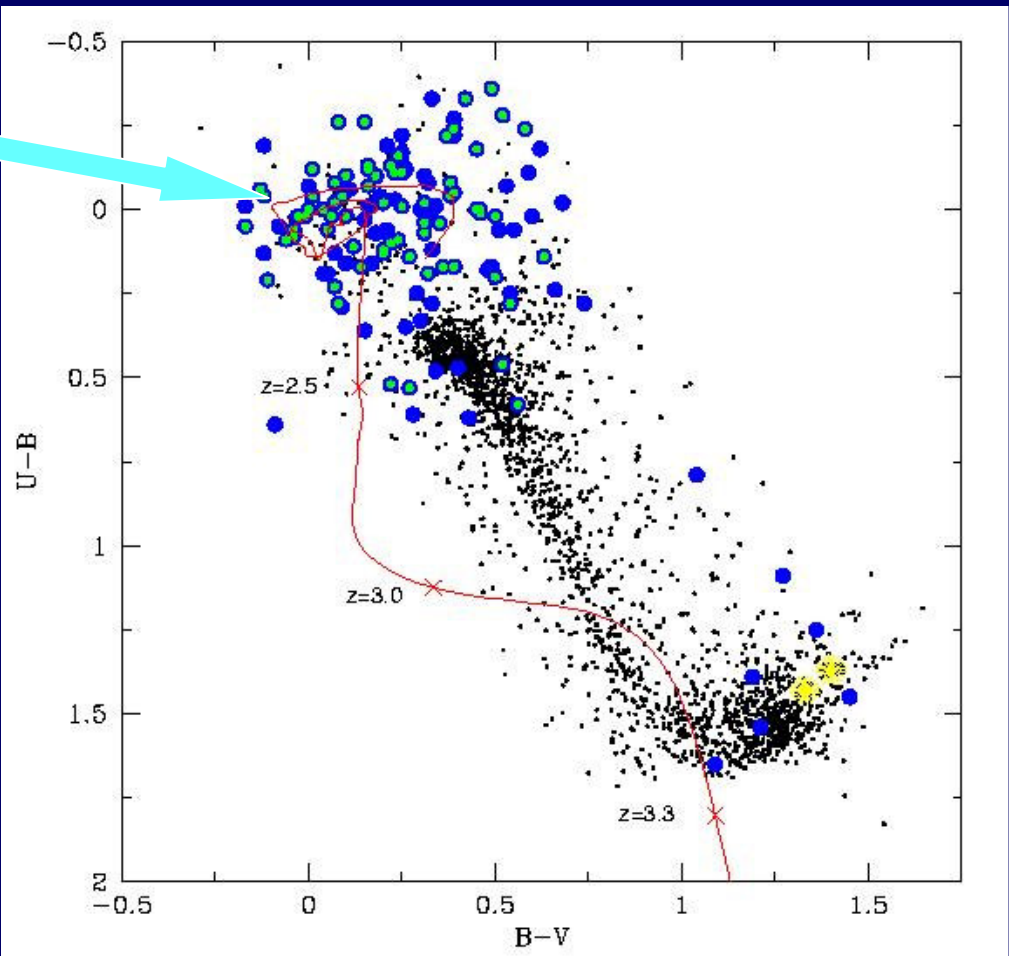
Colors of X-ray sources (1)

U-B vs. B-V diagram

The majority (80%) of stellar-like objects from ACS occupy the locus of quasars in the U-B vs. B-V diagram

Conversely, >70% of UBV selected objects recovered in the X-rays (90-100% expected with the completion of XMM-COSMOS)

Additional 50% (not shown) classified as extended → missed in color selected diagrams



Brusa et al. 2006

Colors of X-ray sources (2)

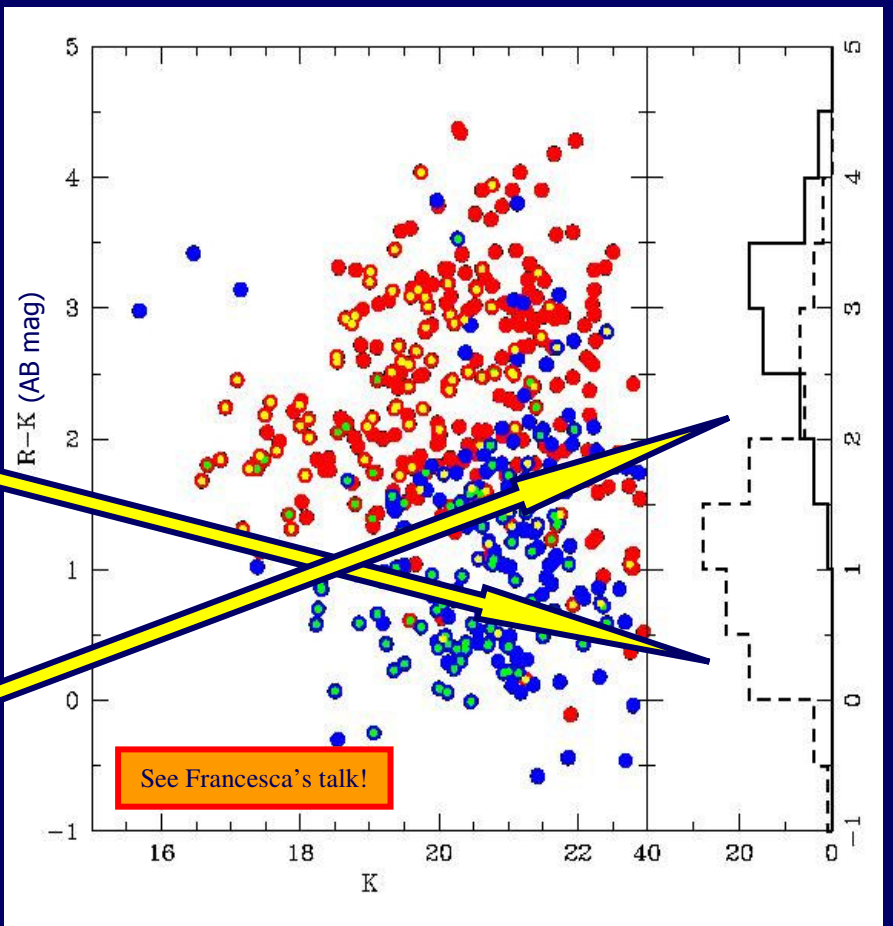
R-K vs. K

Extended sources are significantively "redder" than point-like and associated with NOT BL AGN

Very soft (HR=-1) sources are mostly associated with "blue" sources (dashed histogram)

Hard sources (HR>-0.3) are preferentially associated with red objects (solid histogram)

("dichotomy" confirmed by spectral analysis Mainieri et al. 2006)



Brusa et al. 2006

Optically faint sample

- optically faint (I>24) → difficult to identify using optical bands only [see also Alexander et al. 2001]
- ~200 sources in the XMM-COSMOS sample:
  candidate high-z (z>1) obscured QSO, z>4 QSO…
- Efficiency of combination of IR+hard X-ray surveys
  [Mignoli et al. 2004, Koekemoer et al. 2004, Brusa et al. 2005, Severgnini et al. 2005, Maiolino et al. 2006 and many others!]

Examples of XMM/IRAC coincidences

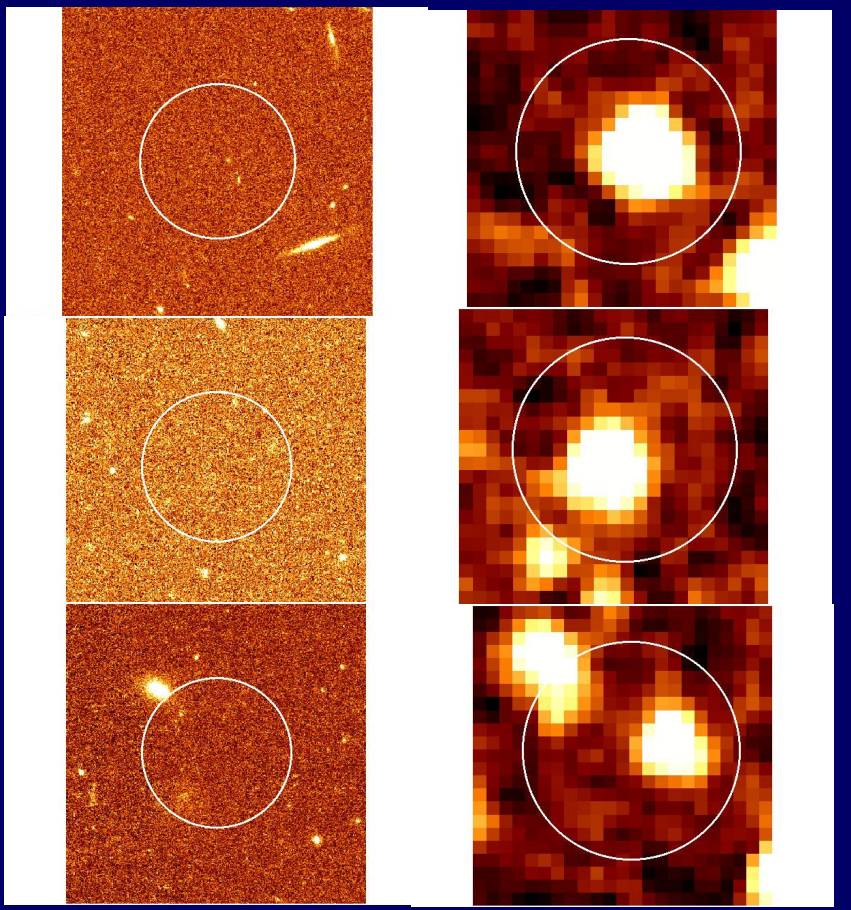
- ~120 objects in XMM-COSMOS identified through K and/or IRAC (most of them EROs)
- Very hard to get redshift from optical → alternative approaches: ISAAC/IRS spectroscopy and/or SED fitting

  [Maiolino et al. 2006, Koekemoer et al. 2004]

  [Cfr. Also sample of highly obscured objects in Martinez Sansigre et al. 2005]

ACS IRAC 3.6 micron

(Courtesy M. Salvato, D. Sanders)

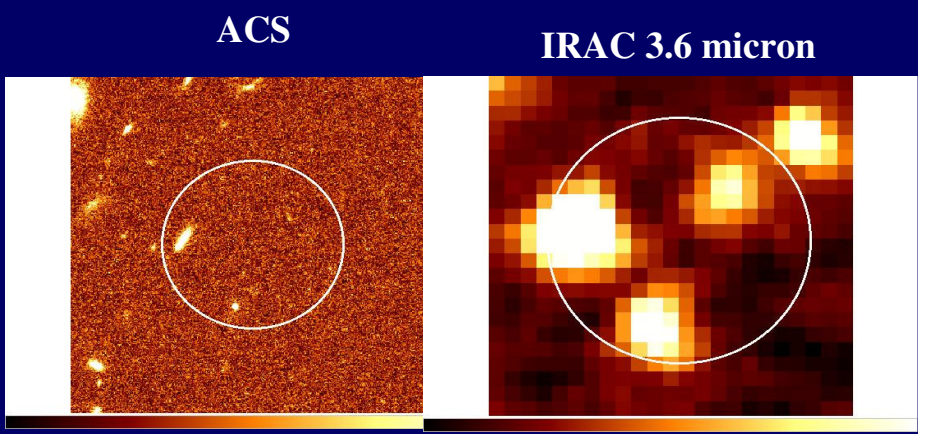


Examples of XMM/IRAC coincidences(2)

- ~80 objects in XMM-COSMOS with multiple/none IRAC cps

  → more accurate X-ray positions are the only way to pick up the right cp

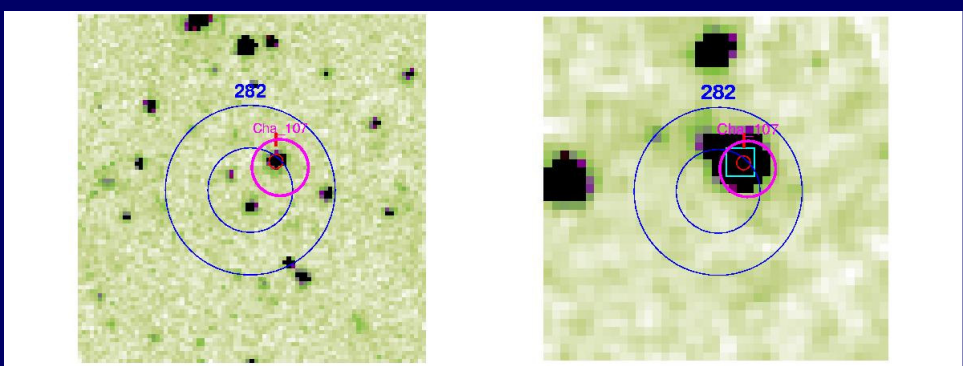
  → Chandra proposal on COSMOS



- XMM+Spitzer+Chandra:

  → test the XMM/optical/NIR association in ELAIS-S1

  → ~80% Chandra points to IRAC counterpart



(Courtesy C. Feruglio, F. Fiore ELAIS-S1)

Summary

- Full multiwavelength coverage needed to properly study and characterize AGN population as a whole
  → Check for selection criteria **(X-ray vs. optical vs. IR)**
  → Determine the bolometric output of the most important (numerous) population: obscured sources and low-L objects
  (not included in the Elvis et al. 1994 SEDs compilation)

- First results from XMM-COSMOS

- multicolor analysis of the "optically bright sample" suggests 80% agreement between spectroscopic, morphological and X-ray properties (as expected from unified schemes)

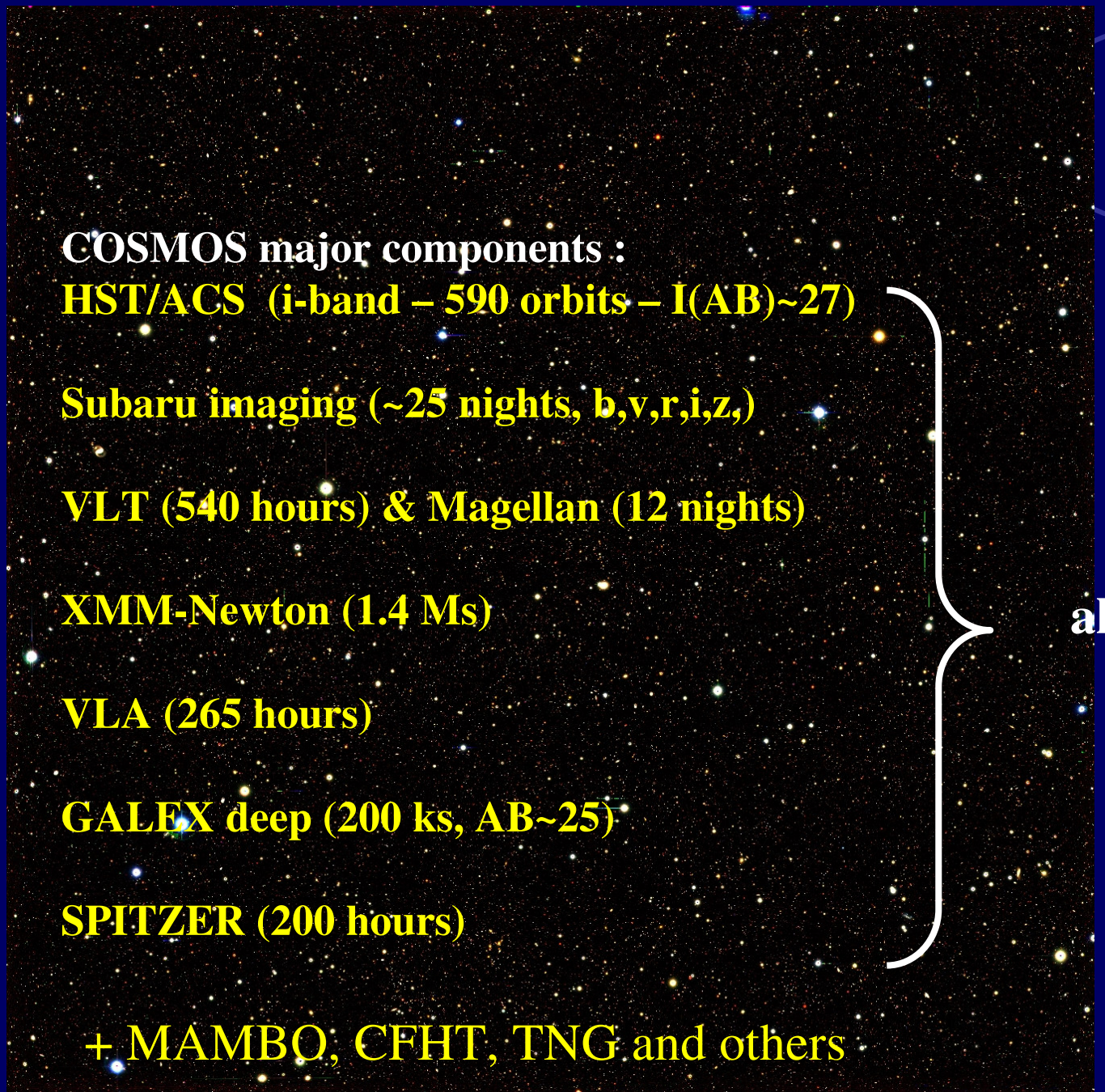
- candidate obscured QSOs isolated through K/IRAC photometry among the optically "unidentified" (faint) sources

XMM-COSMOS on-going projects

- Brusa, Zamorani, Comastri, Hasinger et al. 2006
  X-ray sources (AGN) identification and classification including morphological info
- Hasinger+2006
  Survey description and X-ray properties
- Cappelluti+2006
  Source counts, LogN-LogS
- Mainieri+06
  X-ray spectral analysis of point-like sources
- Miyaji+06
  Angular Correlation Function
- Finoguenov+06
  Study of groups and clusters in XMM-COSMOS

→ to appear in an ApJS special issue (Spring 2006)
http://www.mpe.mpg.de/XMMCosmos/PAPERS/

..and many others projects on-going!
including X-EROs (F. Civano), 3-D correlation function (R. Gilli), EXOs (A. Koekemoer), photoz (M. Salvato), Type 1 QSO host (K. Jahnke) etc.



all underway !

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

2-10 keV surveys with optical identifications