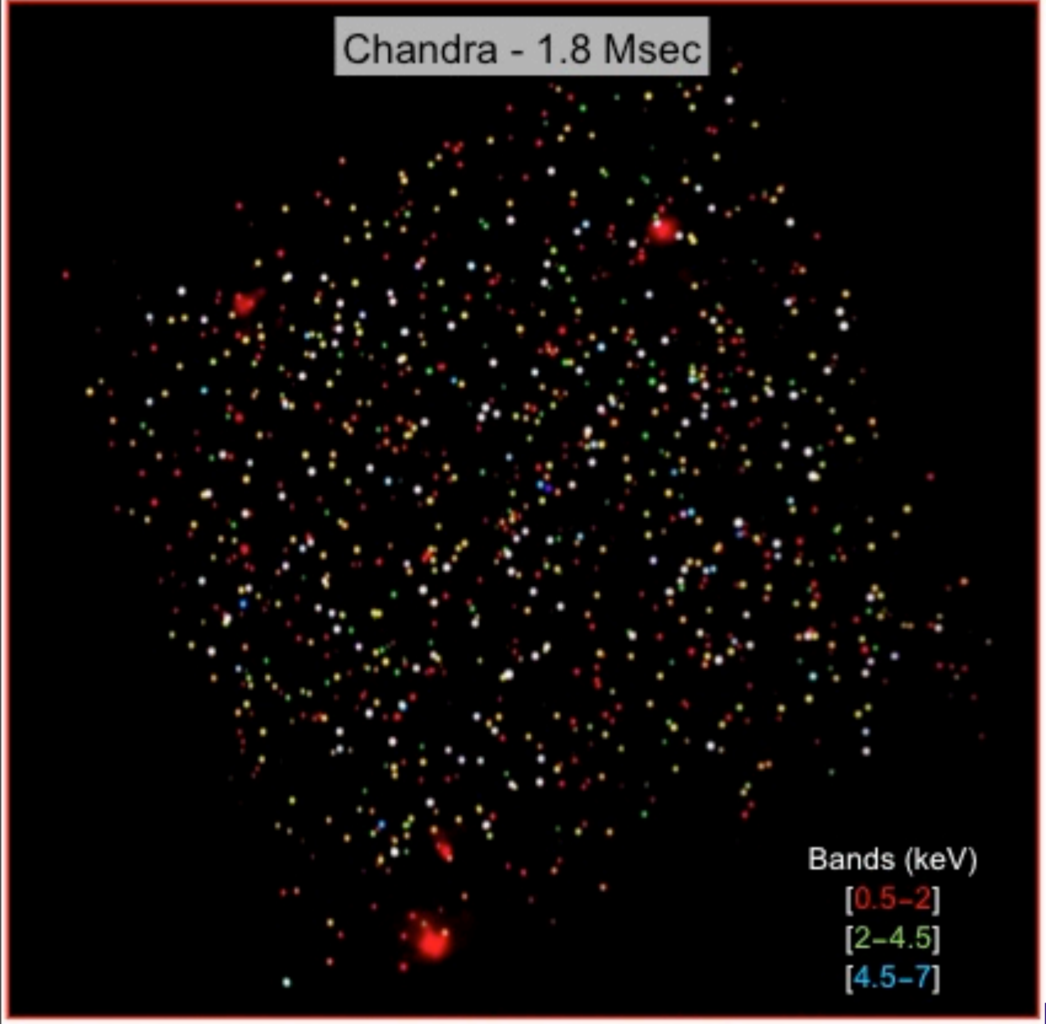
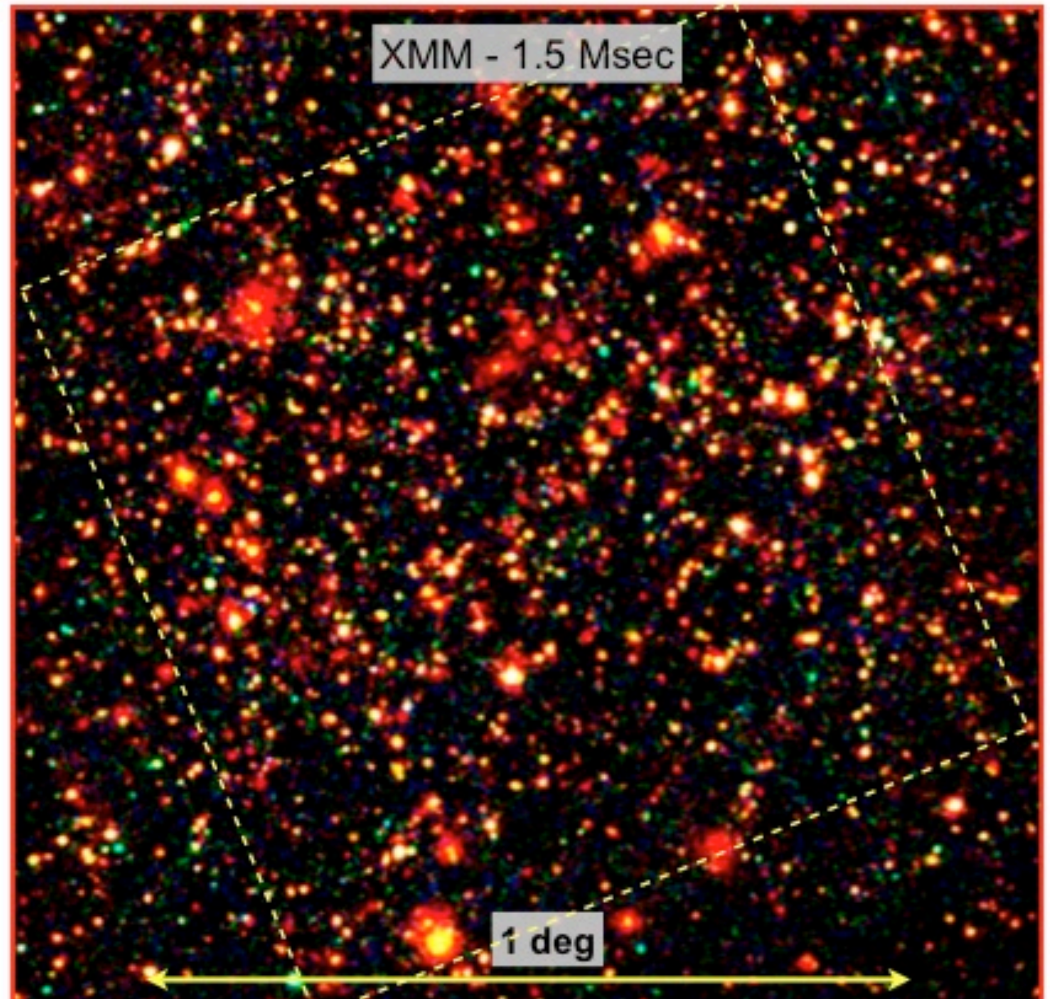
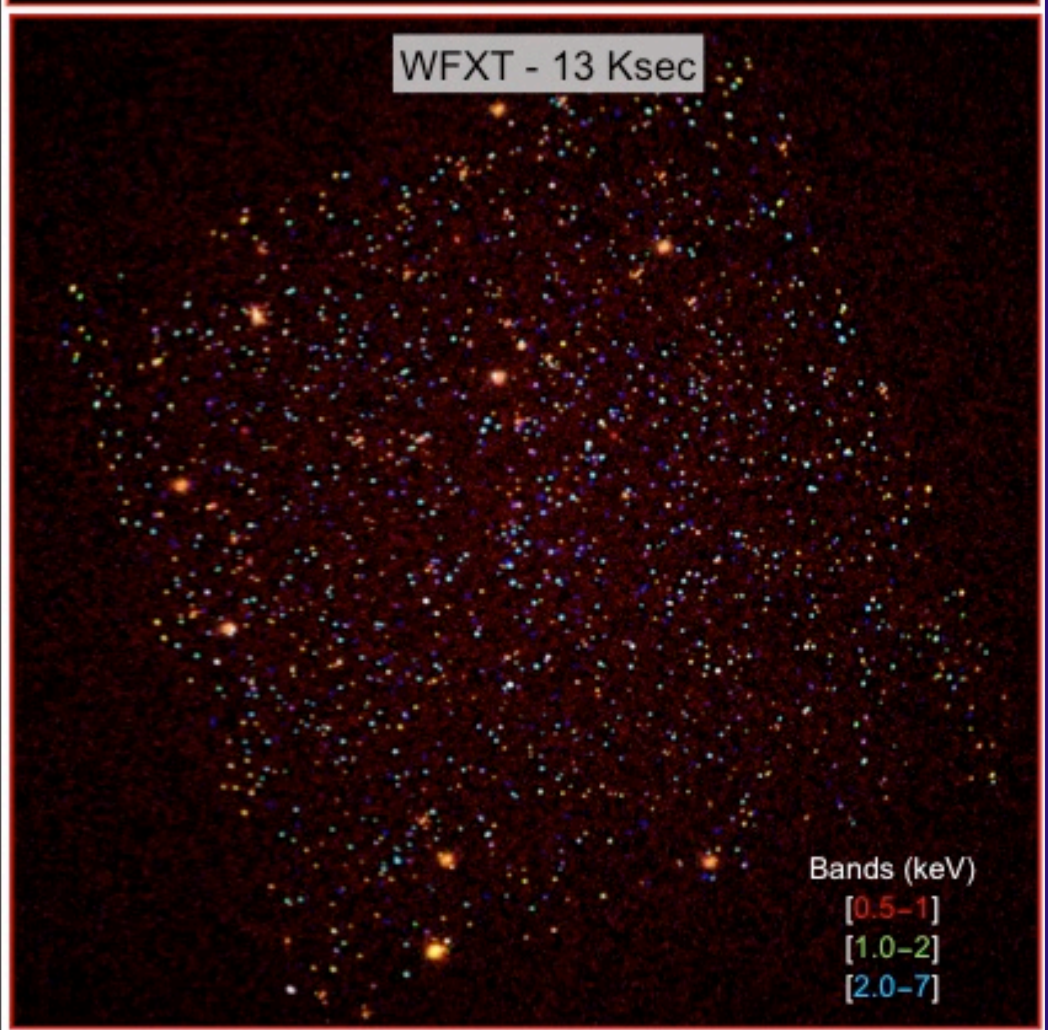






(Evolution) and identification of (high-redshifts) AGN: lessons for WFXT from COSMOS and CDFS

Marcella Brusa
MPE

contributions from many people
R. Gilli, A. Comastri, F. Fiore, P. Rosati, P. Tozzi, C. Vignali et al.

WFXT Goal: evolution of high-z sources

Current knowledge of high-z (> 3) AGN from X-ray (and optical) surveys (see talks by R. Gilli & F. Fiore)

Challenges:

1) Statistics --> large area surveys
2) Identifications --> lessons from XMM/Chandra surveys
3) Redshifts --> multiwavelength follow-up

Resources needed....

Number Statistics

X-rays from high-z Quasars

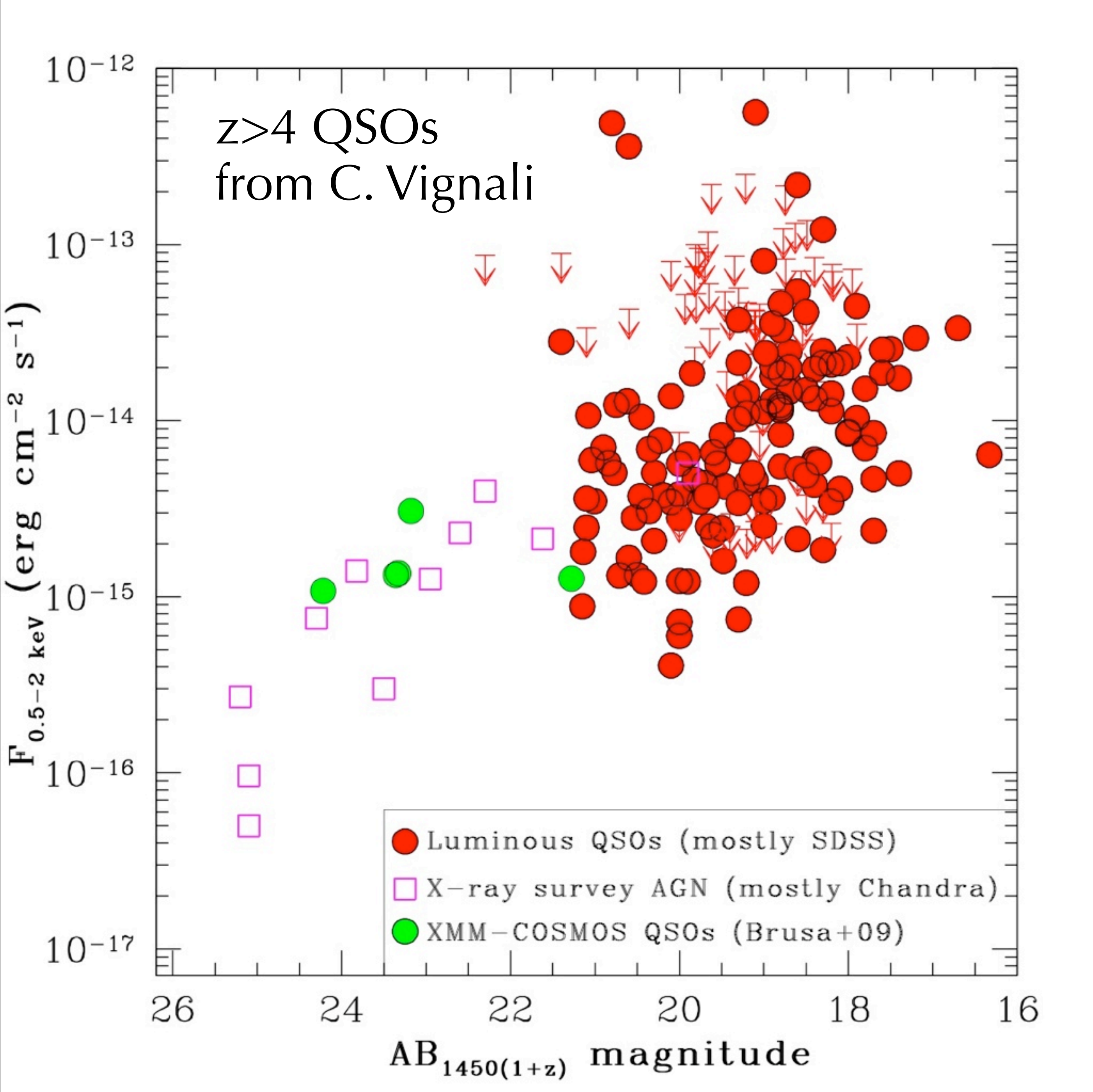
1990-1994:
pioneering works with ROSAT
Wilkes+92,Elvis+94, Bechtold+94
(record QSO z=4)

2002-2005:
Chandra/XMM contribution
Follow-up of optically SDSS QSOs
Brandt+02, Mathur+02,Vignali+03,05
(record QSO z=6.4)
XMM-COSMOS z>3 QSOs (Brusa et al. 09)

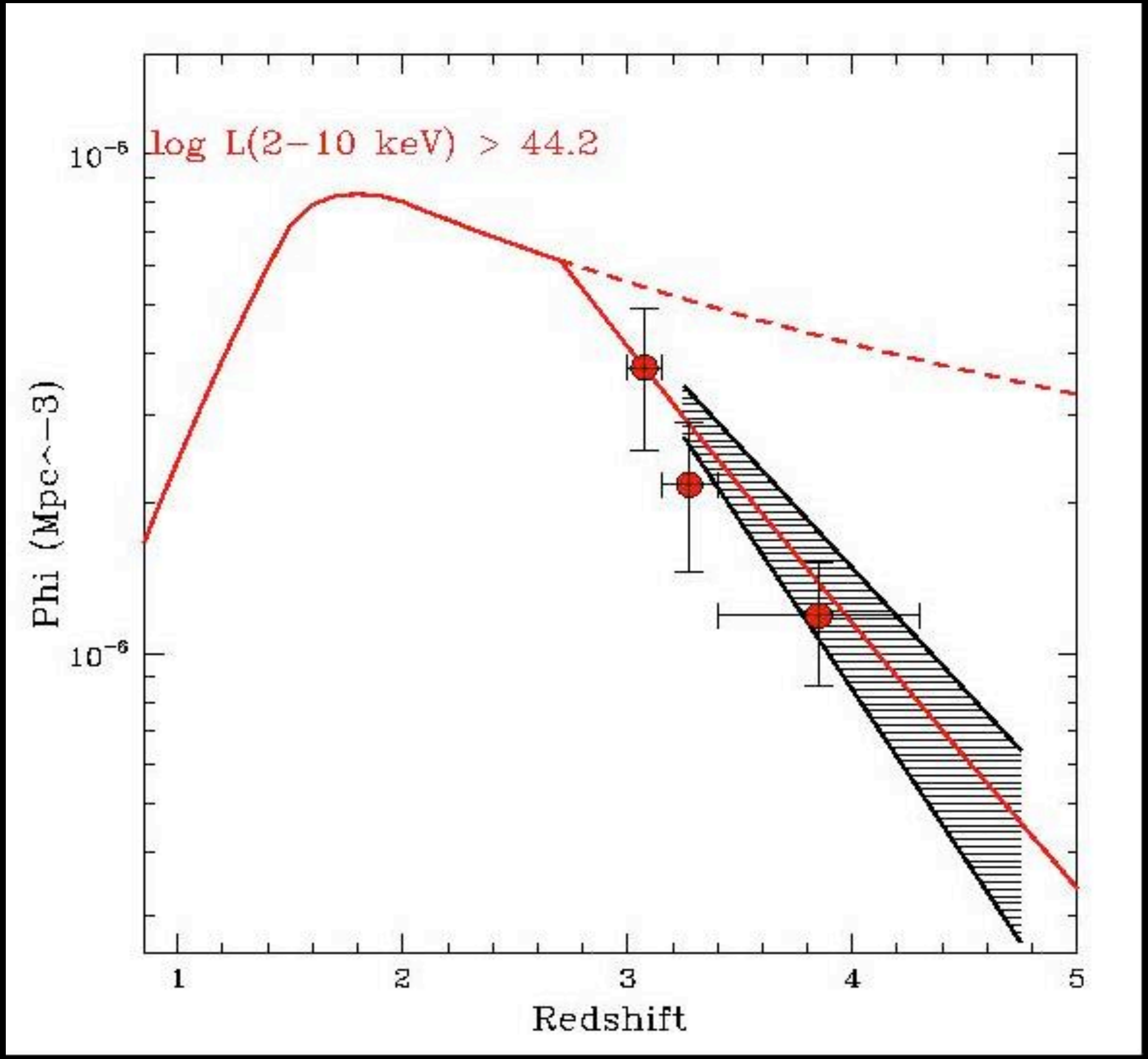
The number of high-z AGN detected so far

	SDSS*	X-ray sel.$
z > 3	8000	50-70
z > 4	1500	11-15
z > 5	150	3-5
z > 6	10	0

X-rays needed to get the LF faint end (more representative of the whole high-z population)



XMM and Chandra z>3 QSOs



Lg(Lx)>44 QSO:
same behaviour of optically selected bright QSOs (logLx~45)

based on 40 QSOs from XMM-COSMOS
Brusa, Comastri et al. 09, ApJ

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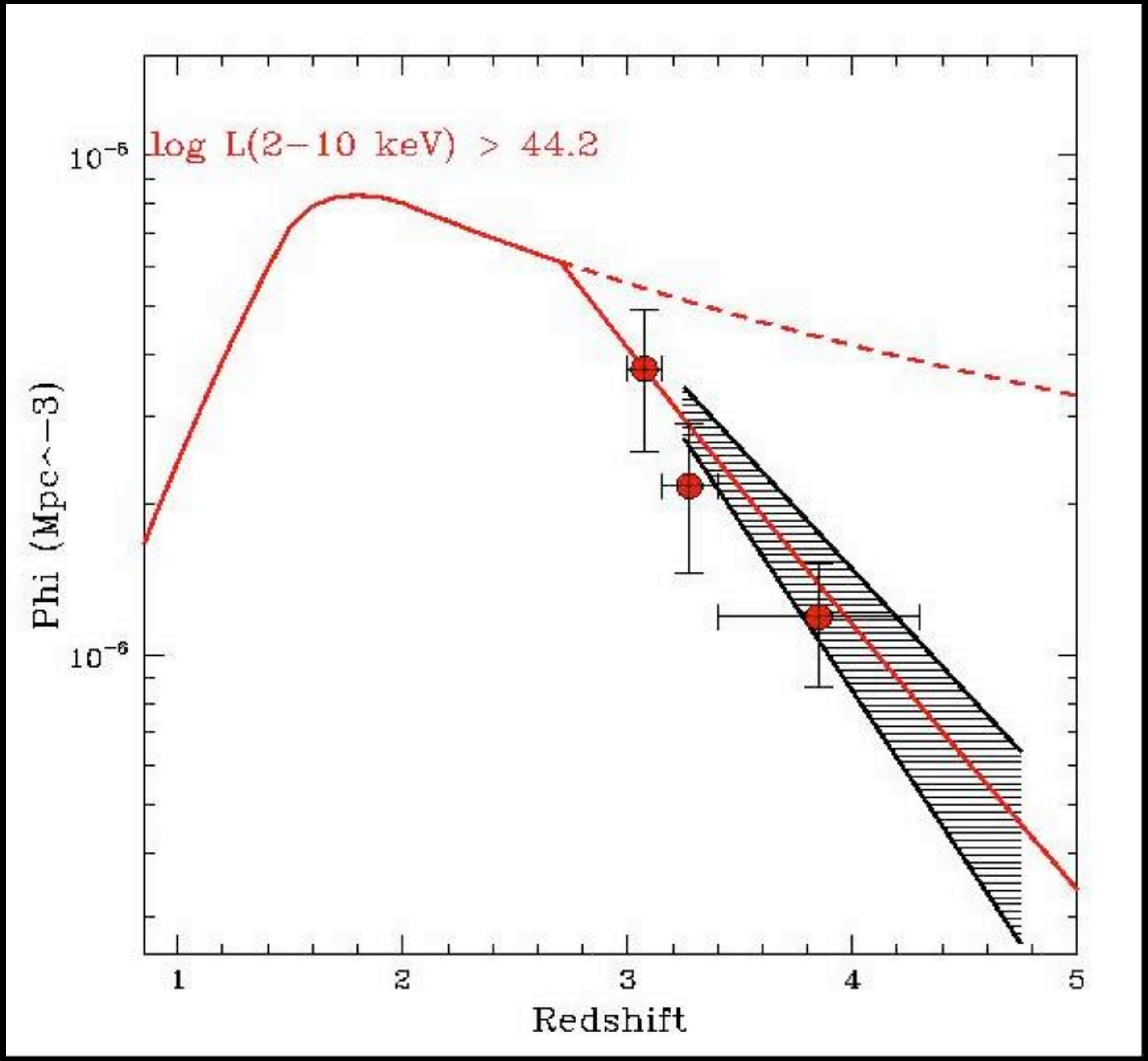

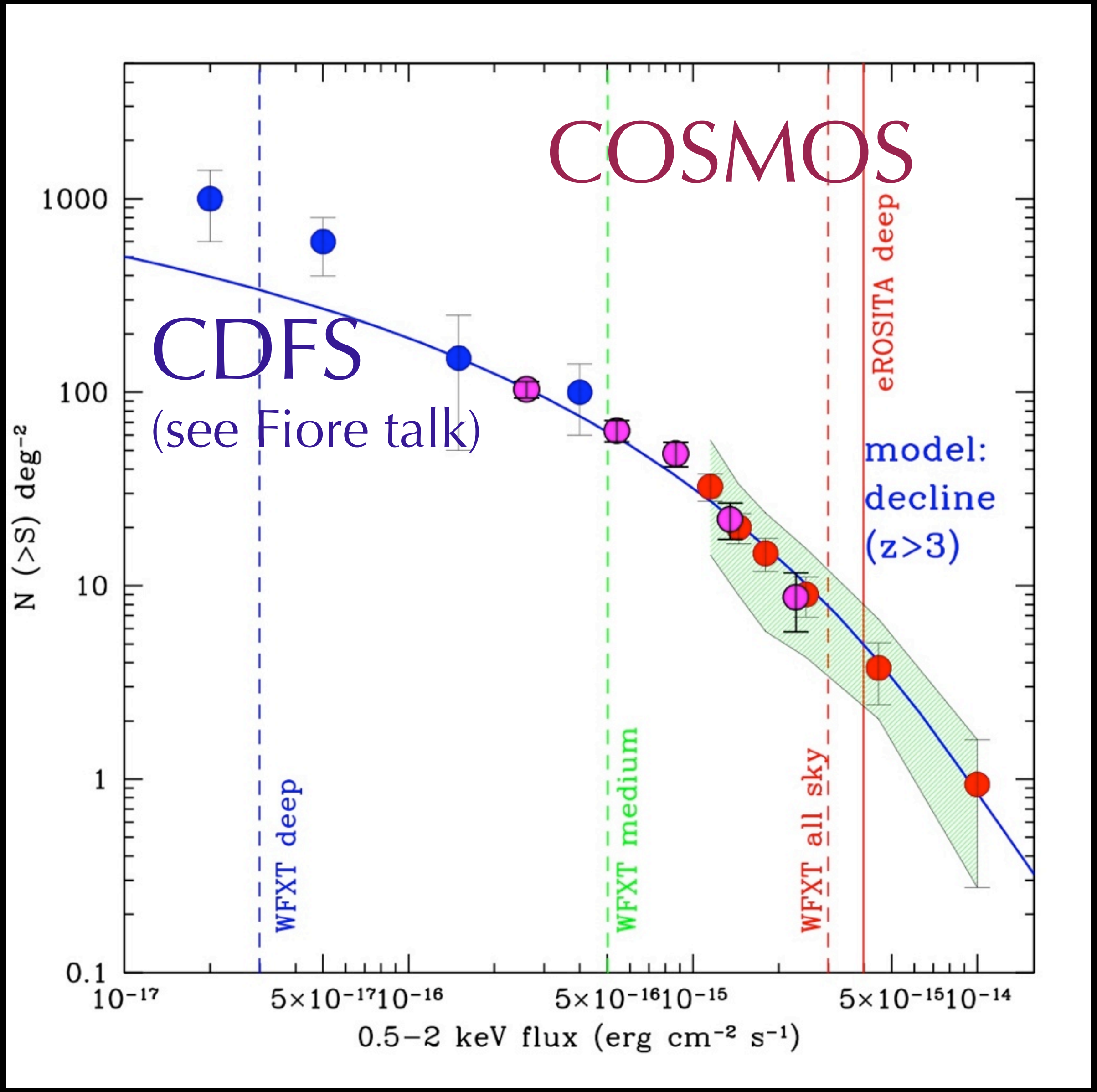

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High fluxes (>5x10^{-16} cgs):
data and predictions robust; to have same statistics of SDSS need to survey >200 deg2 at COSMOS depth
Low fluxes (<10^{-16}cgs):
data scarse, predictions uncertain [CDFS analysis predict a factor of ~2 more than extrapolations]

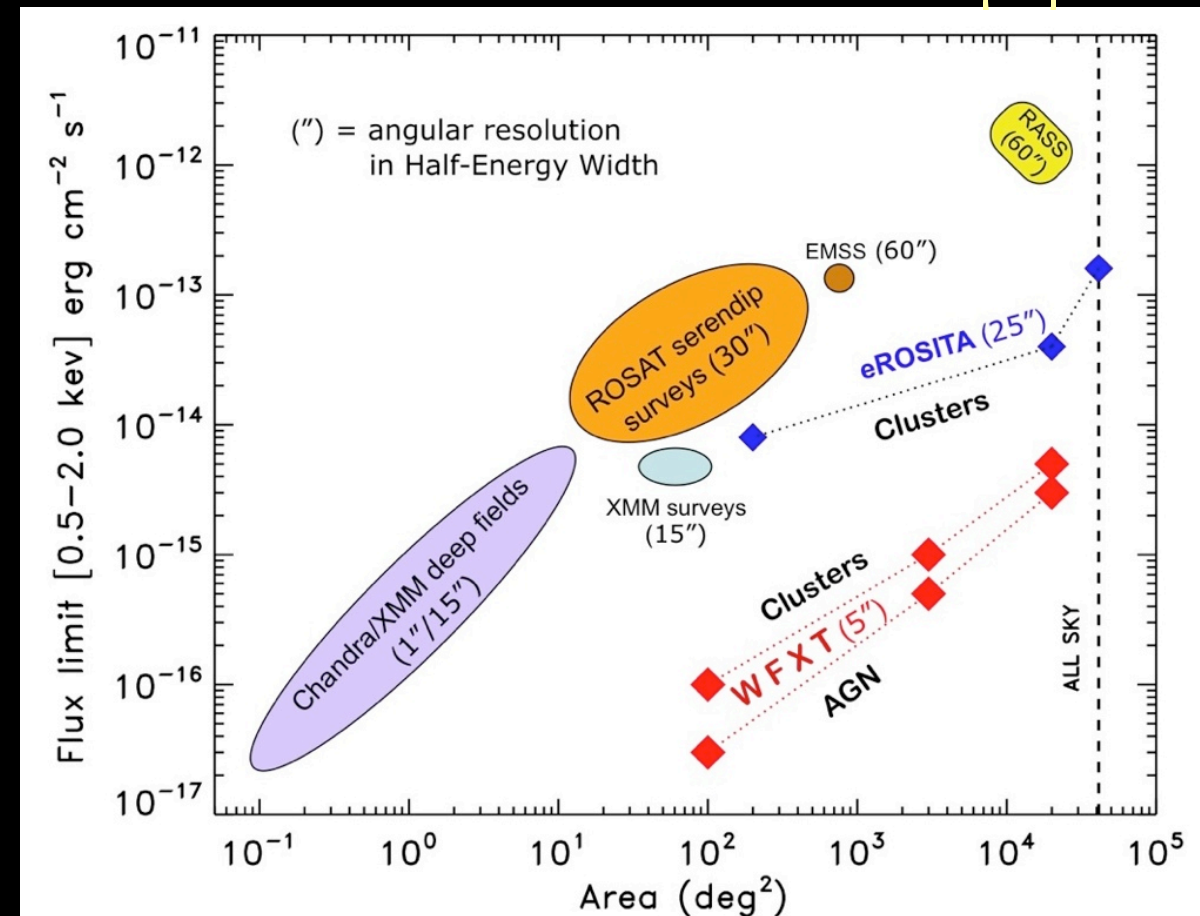
Expectations

From Brusa+09 [Gilli et al. 2007 model]

Table 3. Expected numbers of $z > 3$ QSOs

z range	limiting flux erg cm^{-2} s^{-1}	constant[a] deg^{-2}	decline[b] deg^{-2}
$z > 3$	$> 4 \times 10^{-16}$	330	75
	$> 10^{-15}$	80	30
	$> 4 \times 10^{-15}$	14	6.3
	$> 10^{-14}$	1.8	0.75
$z > 4$	$> 4 \times 10^{-16}$	80	13
	$> 10^{-15}$	30	7
	$> 4 \times 10^{-15}$	3	0.5
	$> 10^{-14}$	0.6	0.07

From WFXT white paper



WFXT	flux(lim)	deg2	z>3	z>6
wide	$4x10^{-15}$	20.000	$1.26x10^{5}$	500
medium	$5x10^{-16}$	3.000	$2.25x10^{5}$	1000
deep	$3x10^{-17}$	100	$3(6)x10^{4}$	300 (>300)

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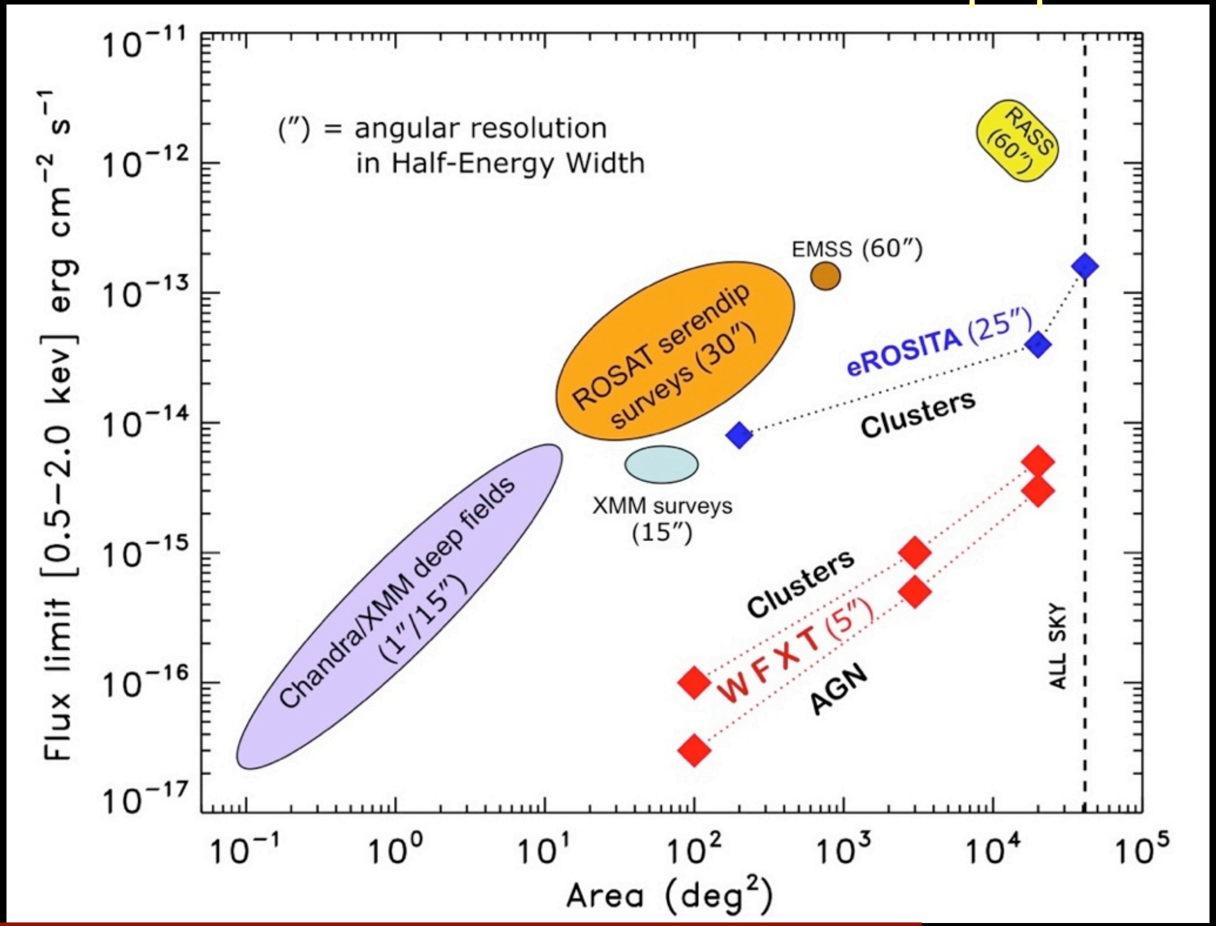

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medium	4x10^{-15}	400	2.5x10^{3}	4

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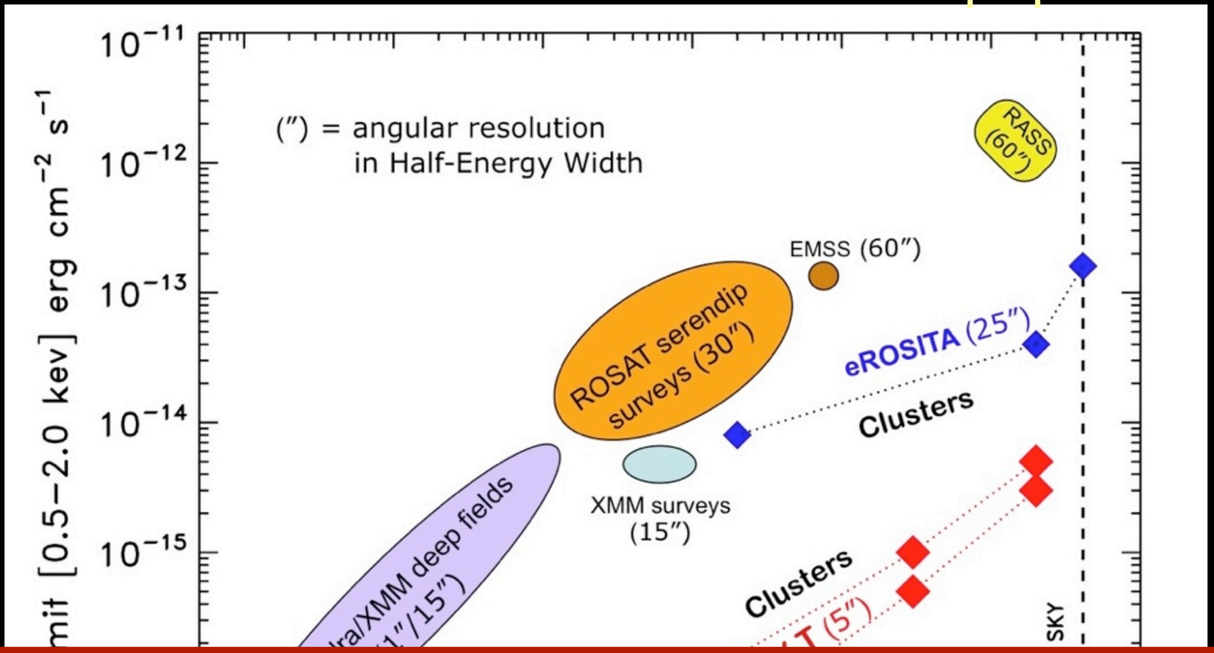

Message (1):

* High-z QSOs in WFXT--> statistics will be even few orders of magnitude ***larger*** than SDSS

A LOT OF HIGH-Z AGN!

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all sky	10^{-14}	30.000	2.25×10^{4}	30
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Identification issues
(whole X-ray population)

Counterparts Identifications

(some references: Sutherland & Saunders 1988, Ciliegi et al. 2003, Brusa et al. 2005)

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The LR is computed for ***each*** source in ***each*** band (I,K,3.6micron..)

The procedure gives, for each band, the most likely counterpart; in case of >=2 equally likely counterparts (in the same and/or from different bands) all the cp are considered ("ambiguous")

Important for XMM sources (at almost all fluxes) and Chandra sources mostly at $F<10^{-15}$

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XMM-COSMOS (note: XMM PSF worse than WFXT....)

BREAKDOWN:

85% unique associations; **15%** ambiguous associations at F>1e-15

95% unique + **5%** ambiguous associations at fluxes of the WFXT wide survey
statistical properties of primary and secondary within ambiguous sources are indistinguishable - in most cases the two sources have same optical / K-band magnitudes

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RELIABILITY* of the method ["a posteriori" test on XMM-COSMOS id using Chandra]

98.7% [only 9/712 unique sources resulted associated to the wrong optical cp]

99.6% [only 1/245 unique sources at fluxes of the WFXT wide survey]

(*see discussion in XMM-COSMOS ID paper; Brusa et al. to be subm)

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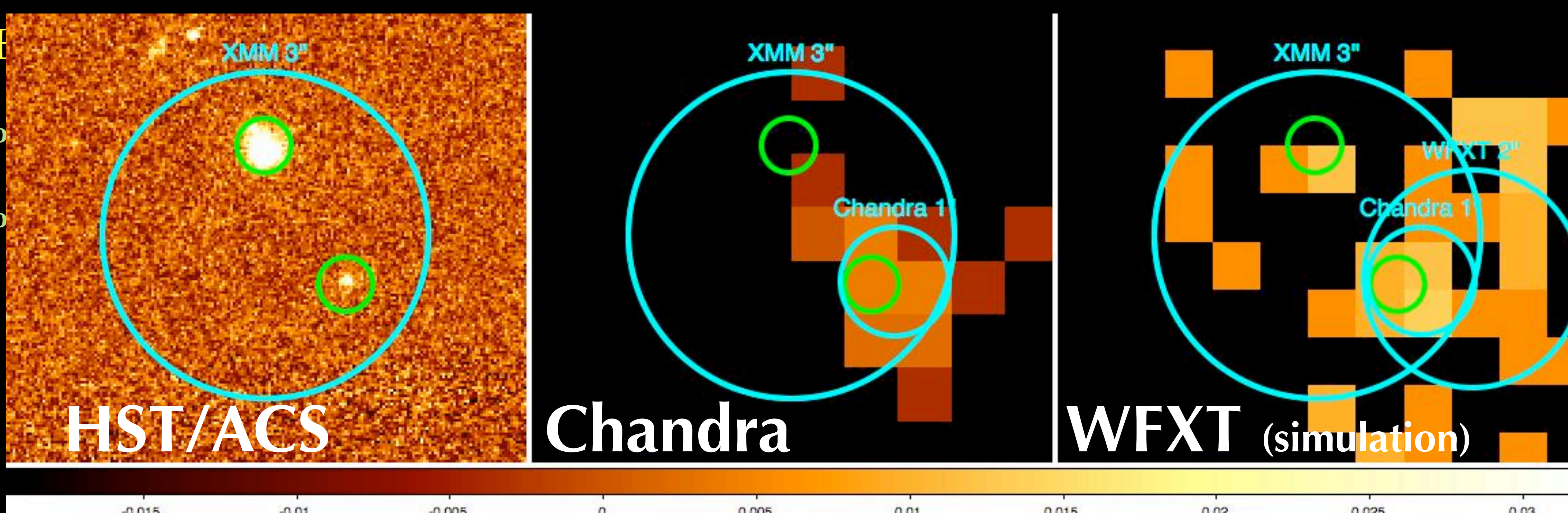

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[among identifications: **90%** “unique” associations; **10%** ambiguous associations]
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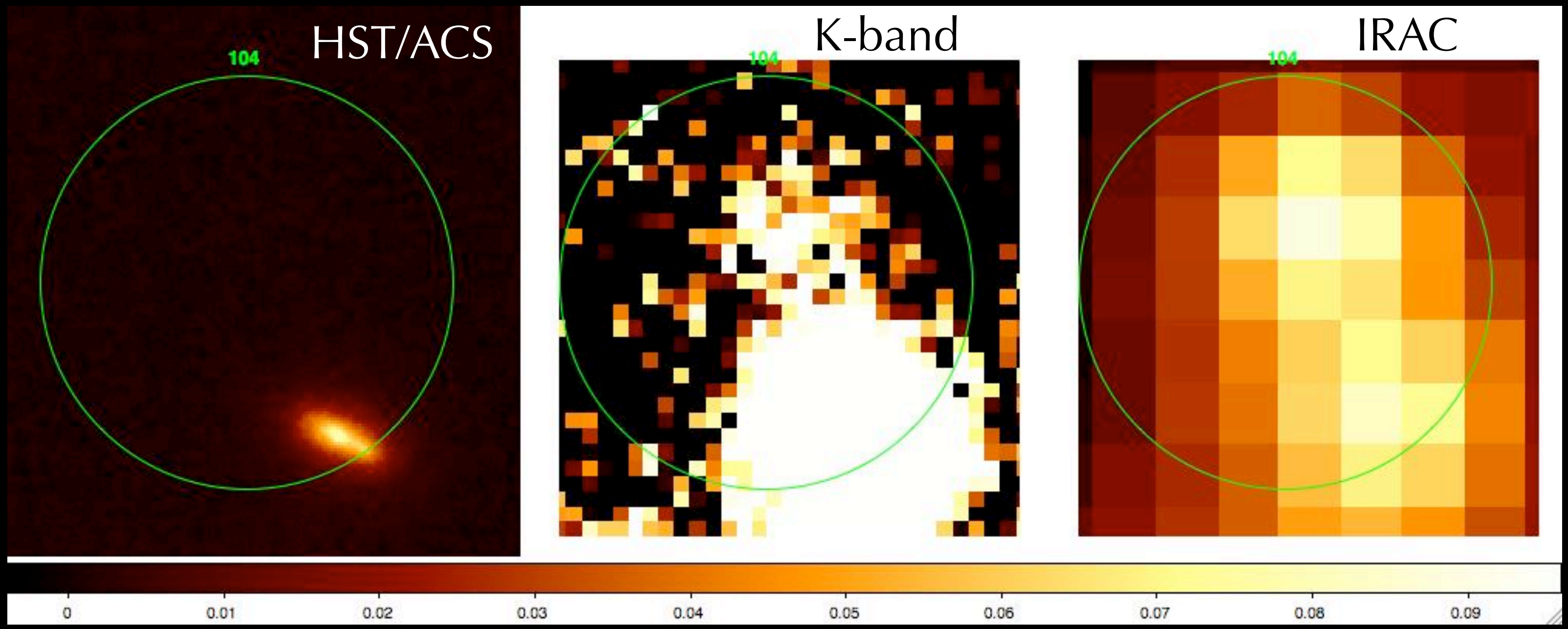

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96

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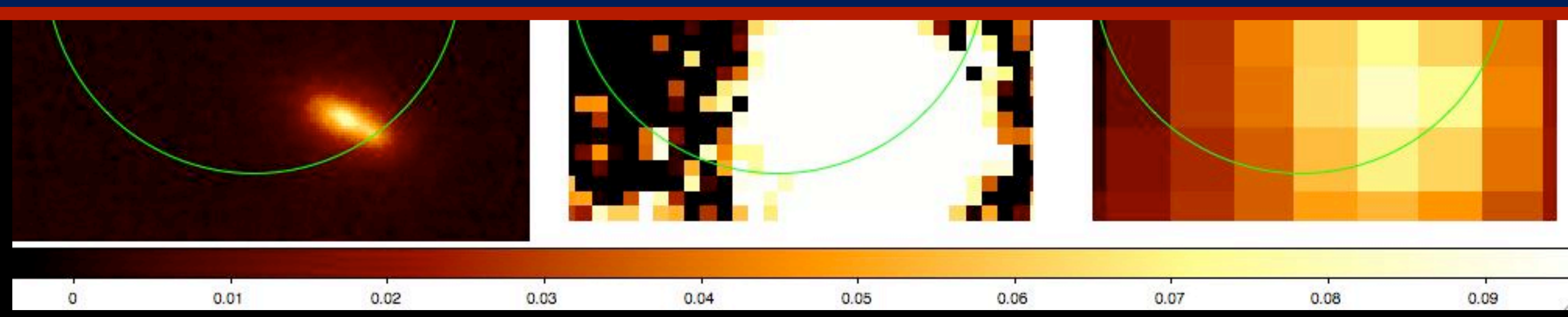
Message (2):

*WFXT wide --> ***identification "easy"*** (straightforward) [also for eROSITA...]

X-ray optical / X-ray - infrared correlations; low density of bkg sources

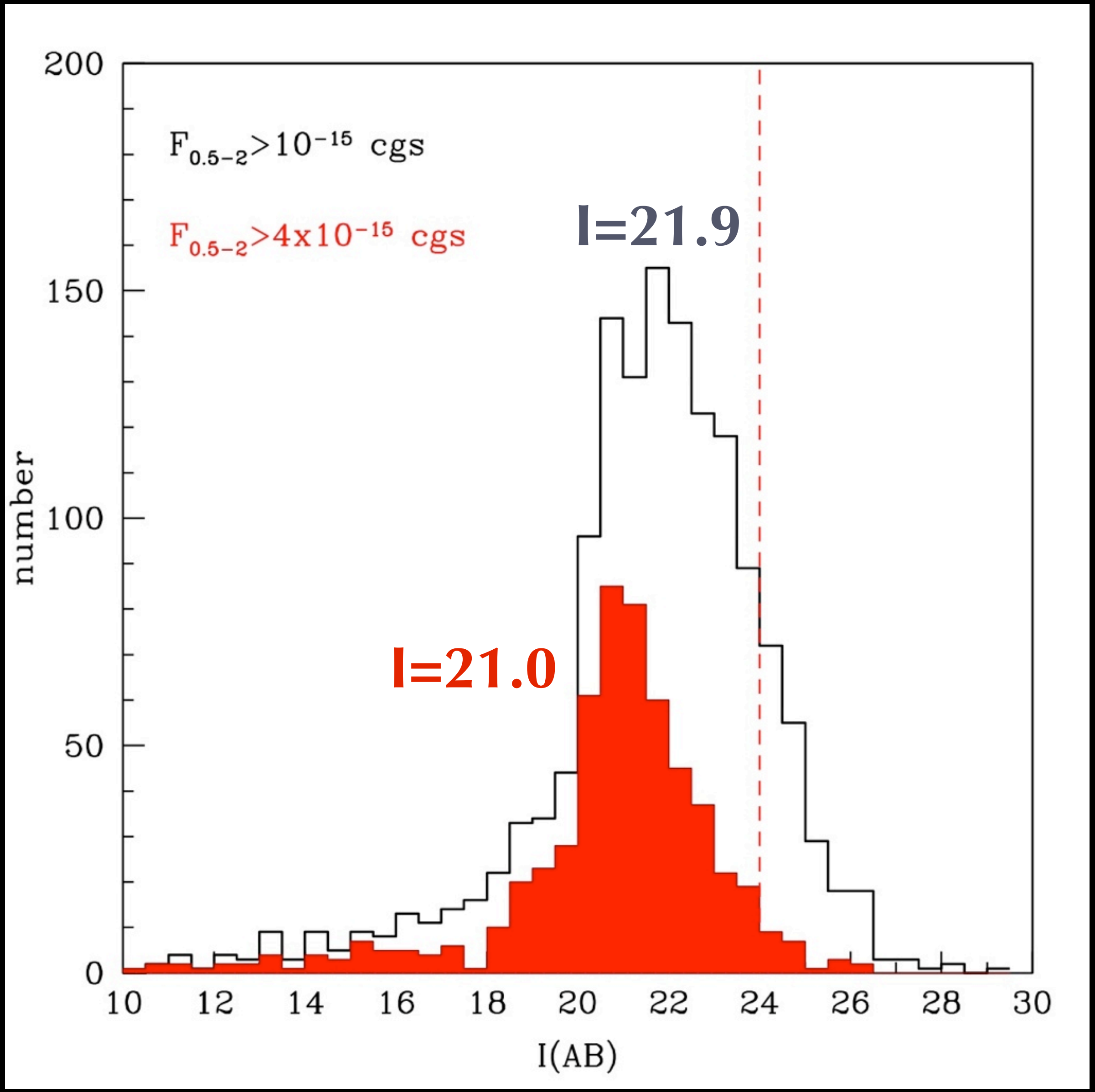
*WFXT deep --> secure identification ***not trivial***

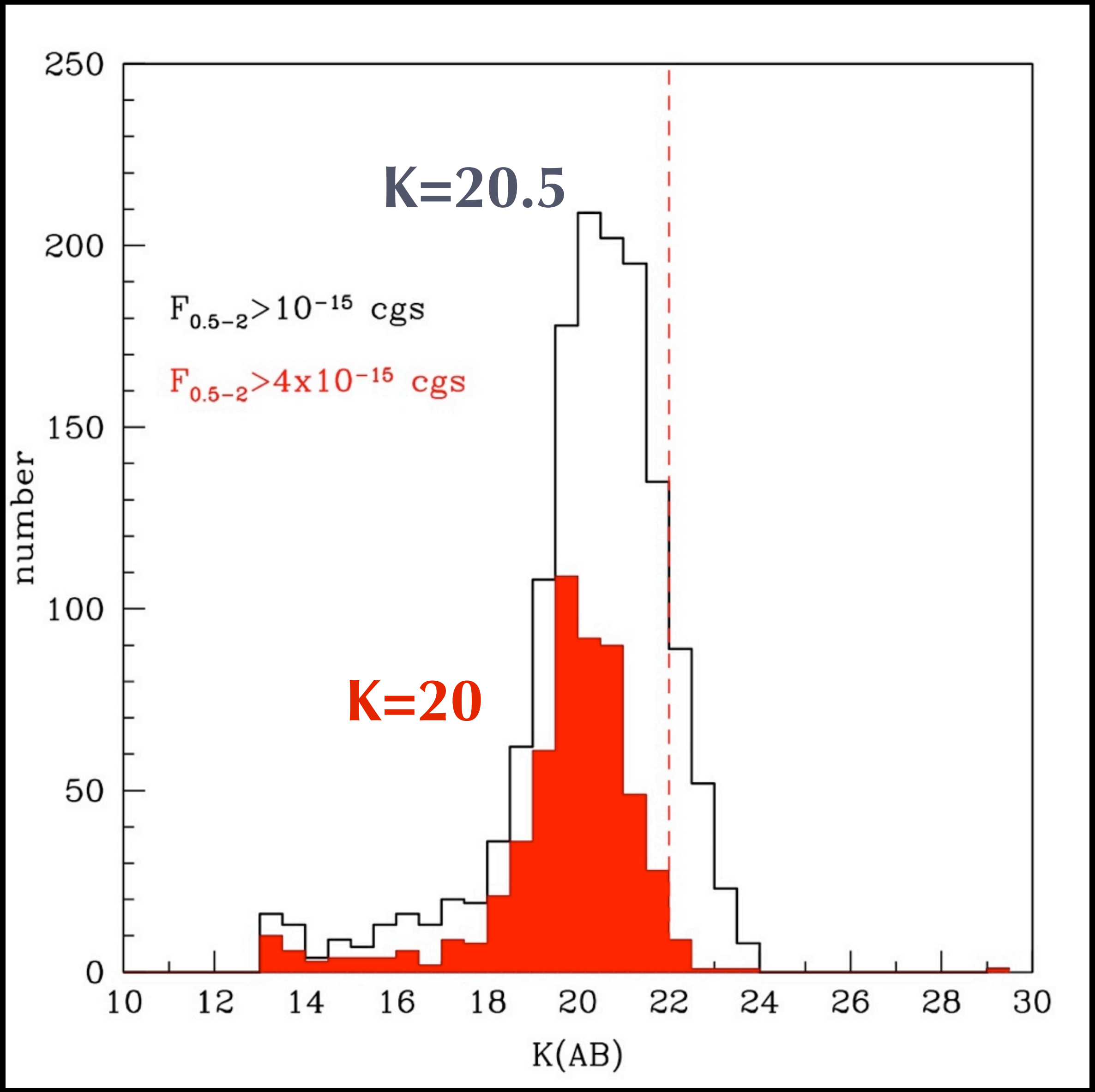
high density of bkg sources; different sources emerges in different bands;
5" HEW really auspicable



Depth of optical / infrared images (1): WFXT wide

From XMM-COSMOS (Brusa, Civano et al. to be submitted)





→At the limiting flux of the WFXT wide survey an optical coverage to I~24 and infrared coverage to K~22 would be enough…BUT this should be on the entire area…

Sensitivity of future large area surveys

~20000-30000 deg^2 – shallow sensitivity surveys

PanSTARRS:

I~24.2 (+grzy)

LSST:

I~25.5 (+ugrzy)

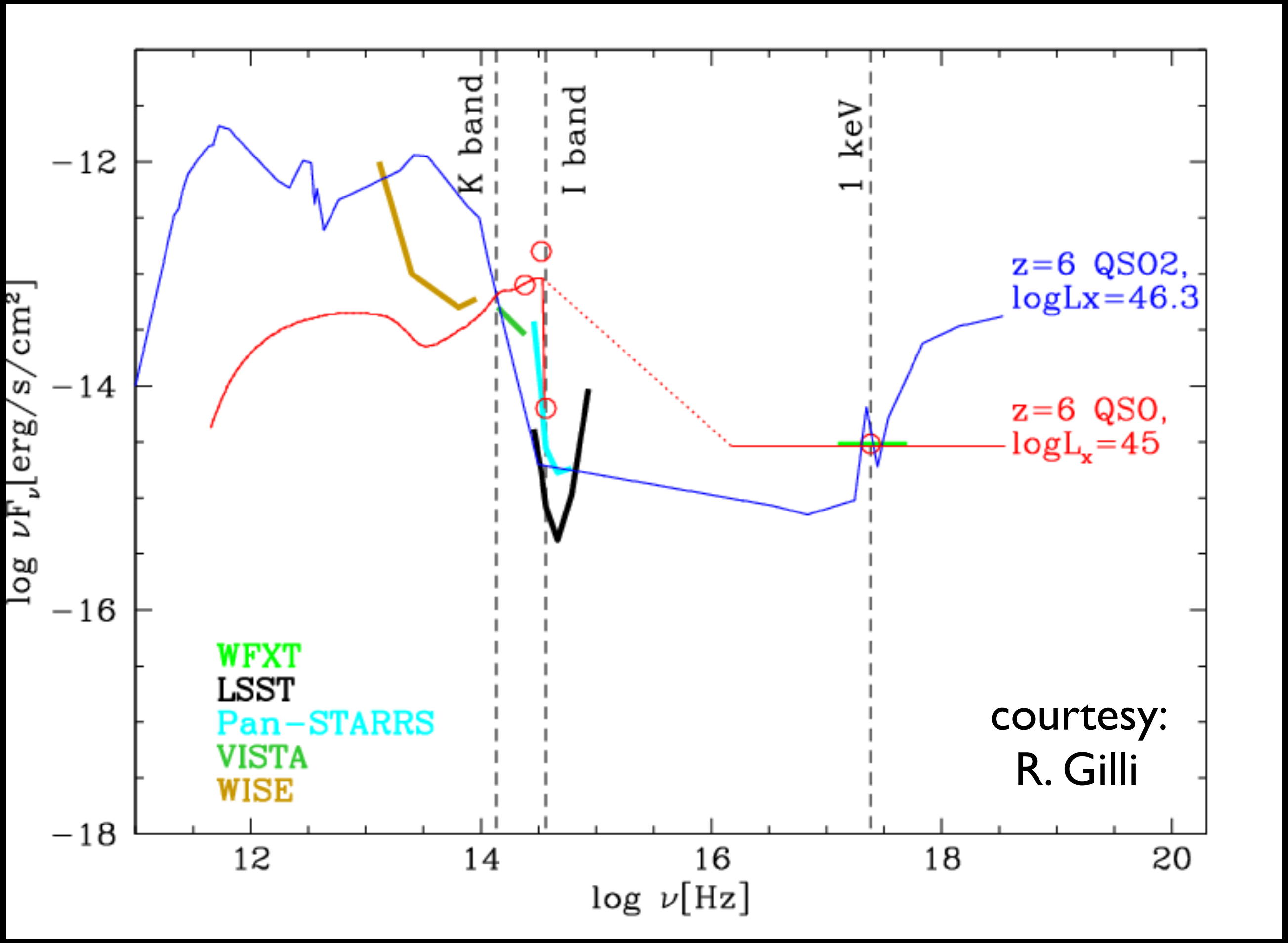
EUCLID:

K~23.5 (+zJH)

LOFAR:

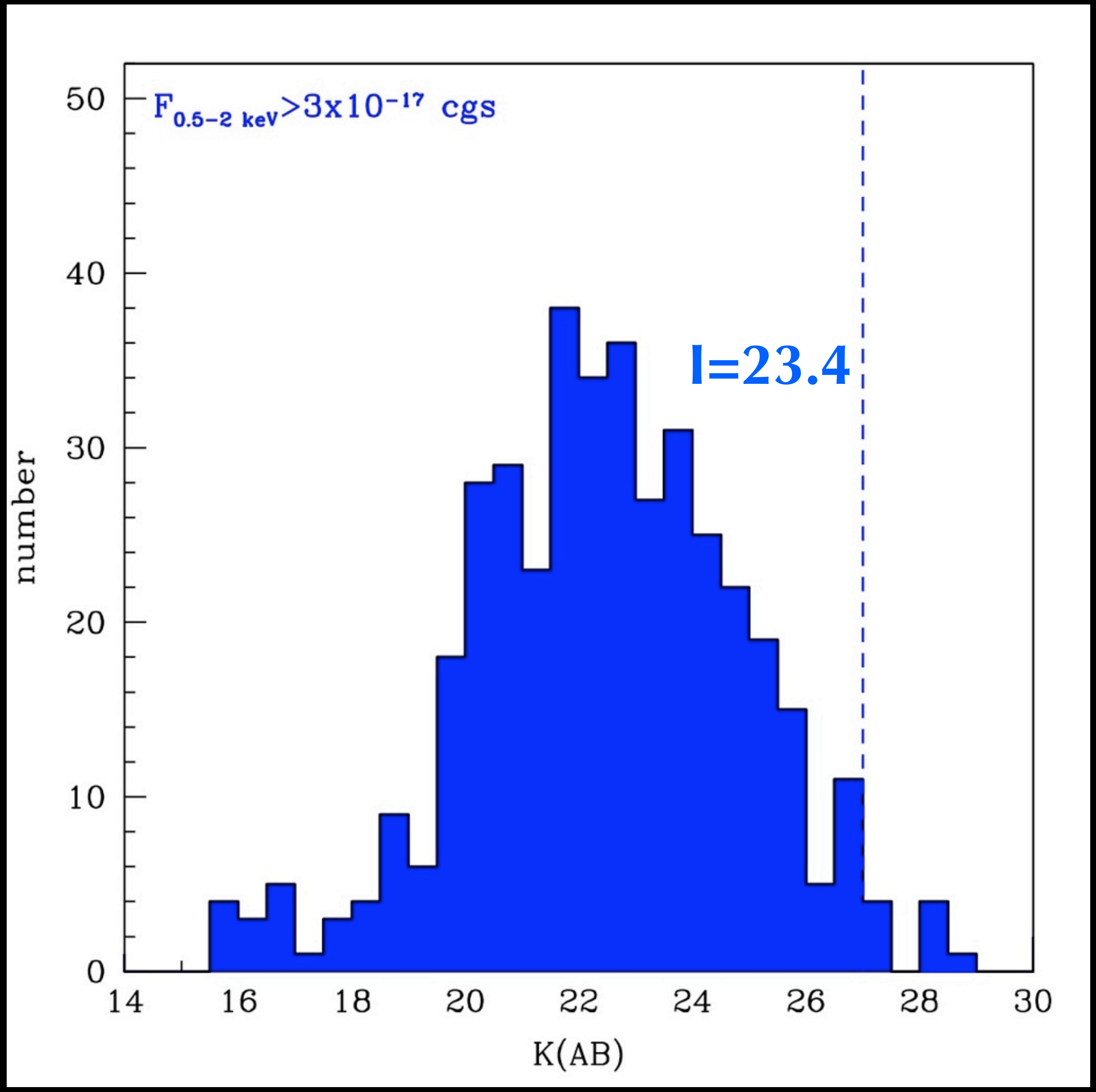
0.8 mJy at 120 MHz (= 0.1 mJy at 1.4 GHz)
"radio" emitters (AGN and starburst)

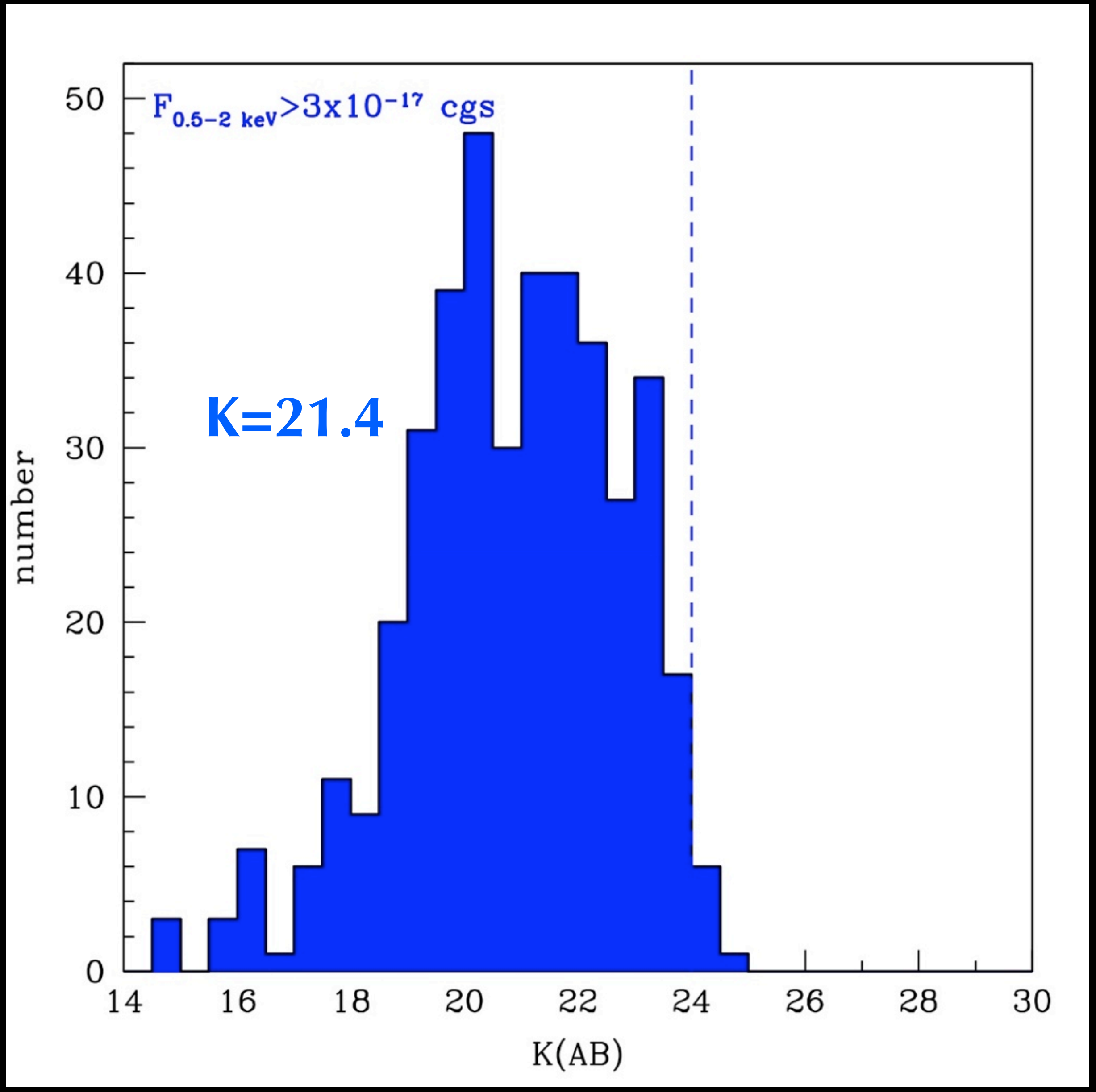
(VISTA VHS, K=20, not enough..)



Depth of optical / infrared images (2): WFXT deep

From 2Ms CDFS (Luo et al. AJ, submitted; see also Brusa, Fiore et al. A&A, arXIv:0910.1007)





→At the limiting flux of the WFXT deep survey an optical coverage to I~27 and infrared coverage to K~24 over 100 deg2 is needed

Sensitivity of future deep surveys

~20-100 deg2 – deep sensitivity surveys
[need more coordination…]

LSST:

I~26.7 (+ugrzy) - over 500 deg^2
cp for 90% of the sources

EUCLID:

K~25 (deep survey, on 50 deg^2 …)

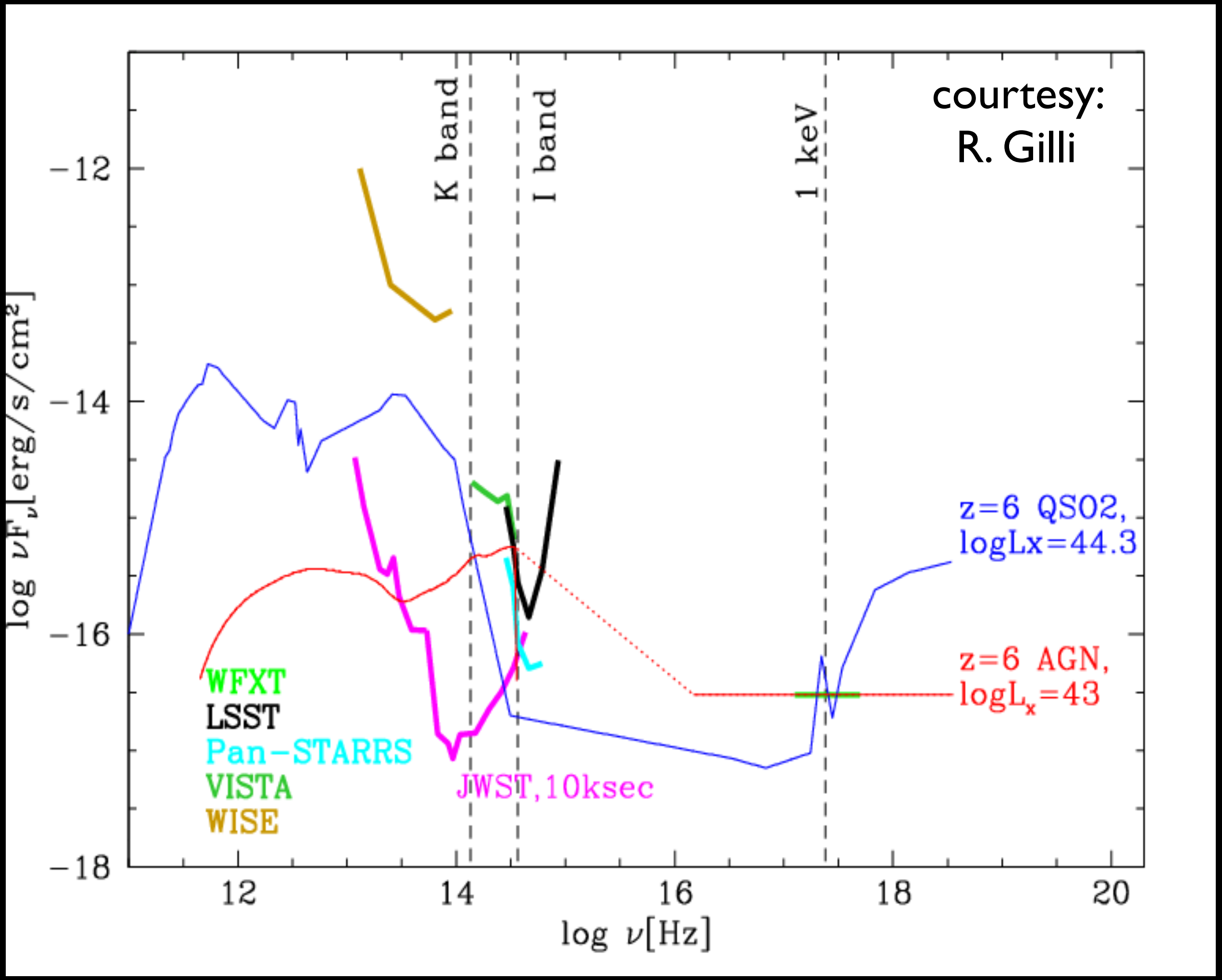
PanSTARRS:

I~28 (+grzy) - over 28 deg^2

VISTA VIDEO:

K=23.5 (+zYJH) - over 15 deg^2

JWST



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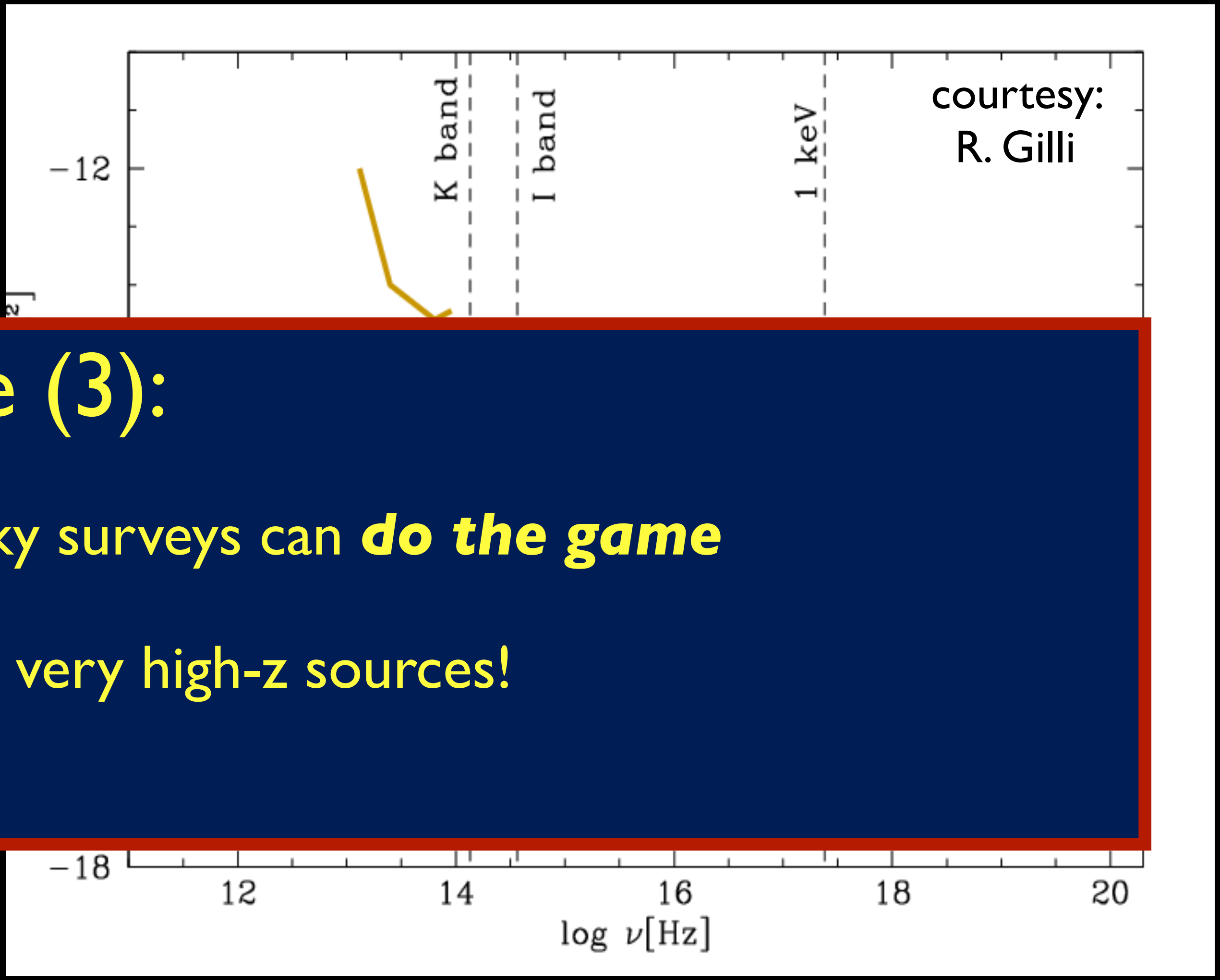


Message (3):

* currently planned and ongoing optical / IR all sky surveys can ***do the game***

* IR ***more important*** than optical for faint and very high-z sources!

VISTA VIDEO:

K=23.5 (+zYJH) - over 15 deg^2

JWST

Redshift determination:

how to pick up z>3 (or z>6) QSOs among million sources?

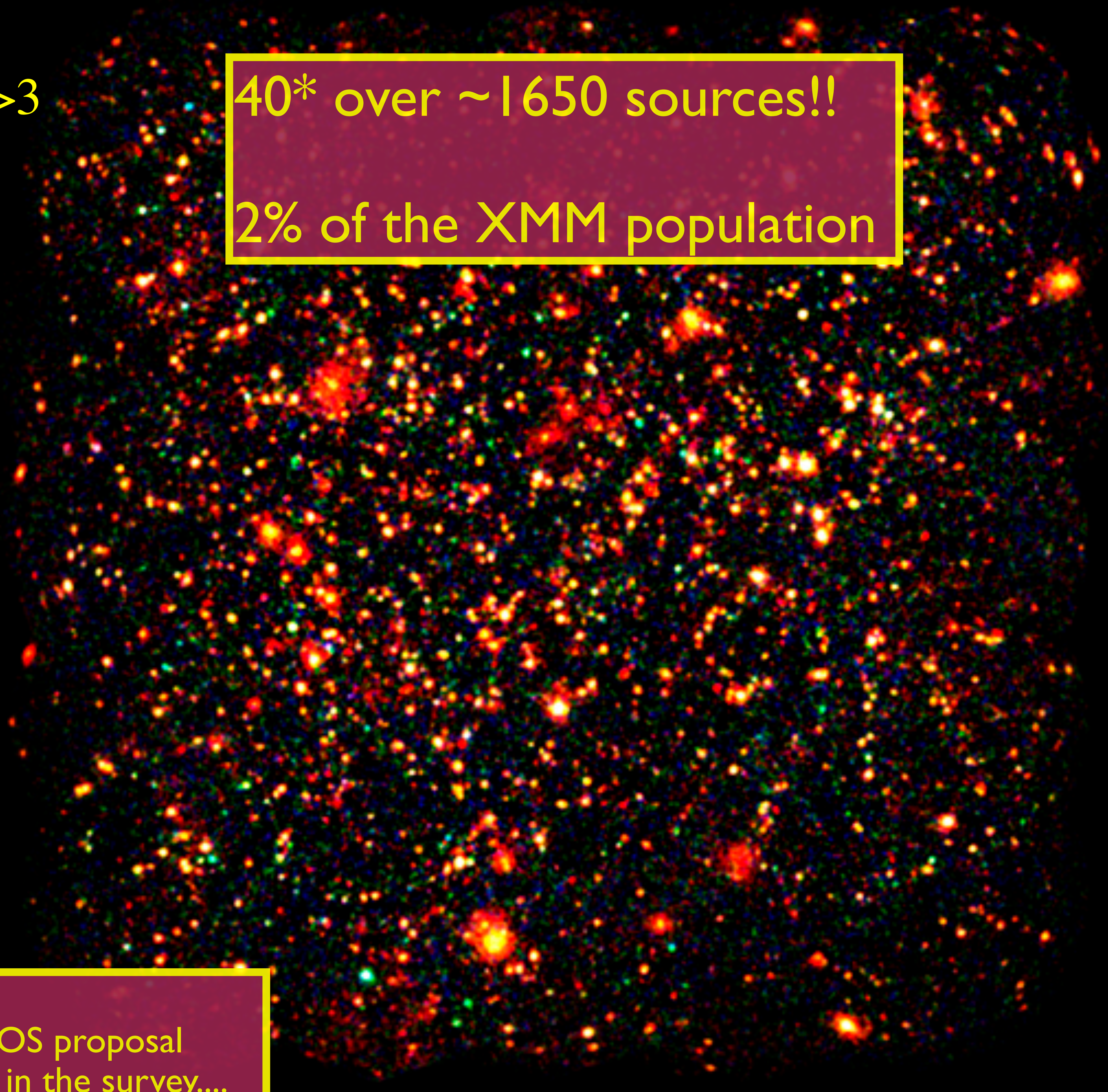
XMM-COSMOS z>3 QSOs

How to isolate them?

1) Get spectroscopy or photometric redshifts for all the (million) sources

2) Impose color pre-selection

3) Get redshifts from Iron line.... (only a fraction)



40* over ~1650 sources!!

2% of the XMM population

* historical note:
the original XMM-COSMOS proposal claimed ~160 QSOs at z>3 in the survey....

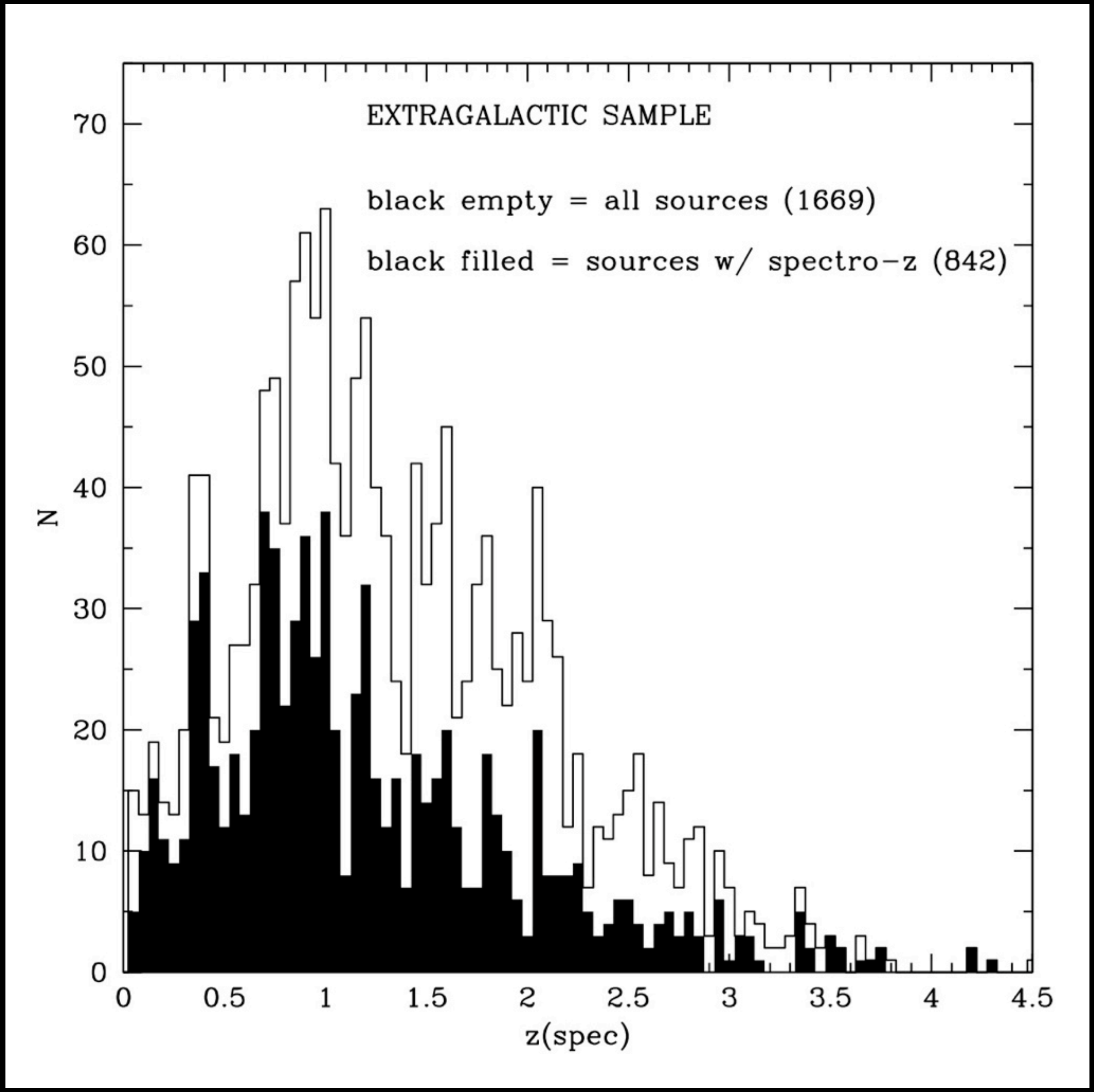
“complete” redshifts sample

XMM-COSMOS (almost 100%)

1640 XMM sources at 10^{-15} cgs

~840 “secure” spectroscopic redshifts (>50%)

~800 “good” photometric redshifts (Salvato et al. 2009)



(Brusa et al. 2009, to be submitted)

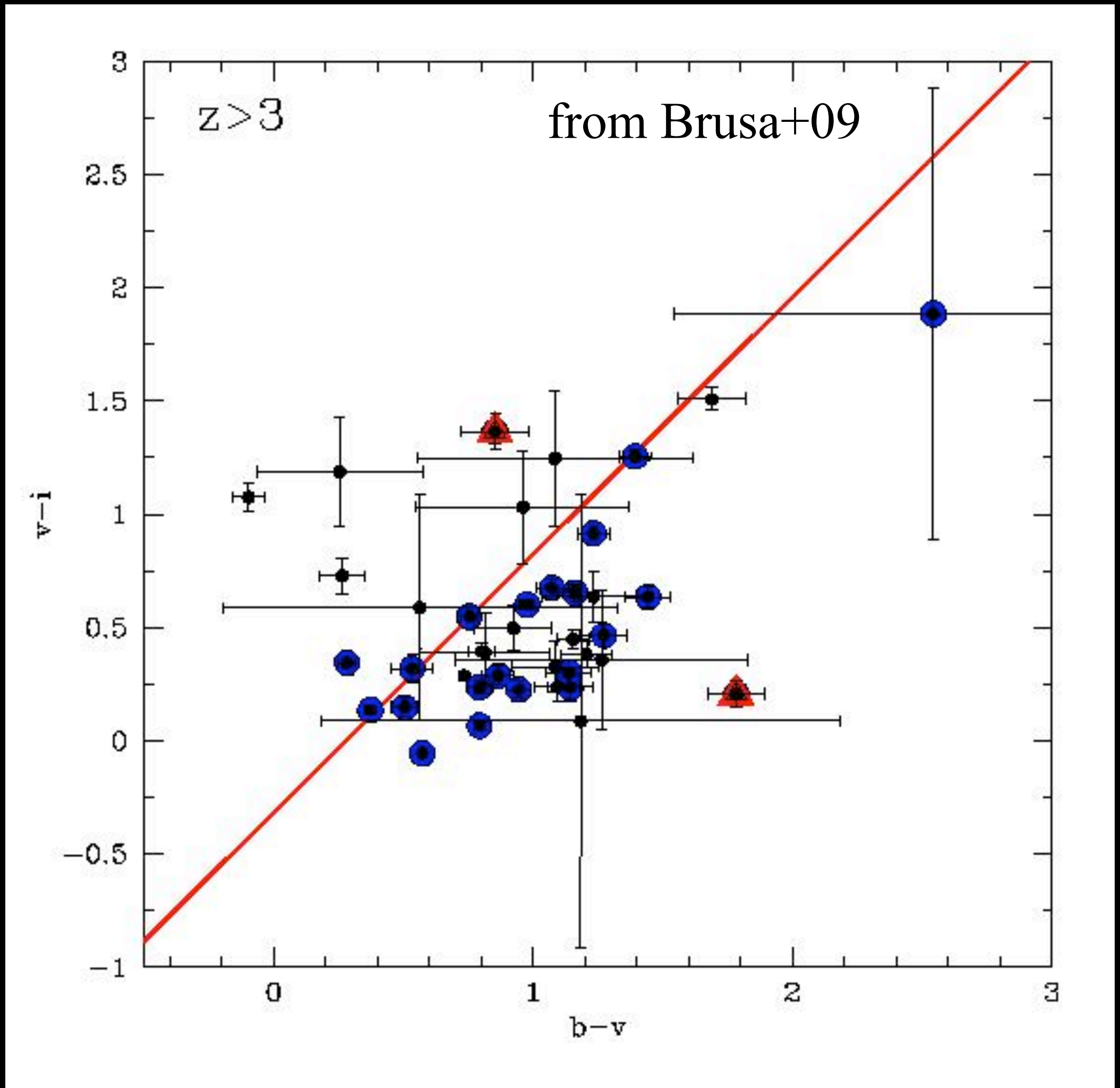
Feasible only for small samples and/or when many optical/infrared filters are available.. SDSS-like survey needed

key resources:

LSST (optical photometry);
EUCLID (IR photometry & spectra);
SDSSIII-BOSS (spectra)

Are depth/#of bands enough to get photz?

Pre-selection based on colors
(feasible from PanSTARRS and LSST multi-band photometry)



z>3 color-color selection v-I vs. b-v (proposed, e.g. in Casey et al. 2008, Siana et al. 2007)
U-dropout techniques (see Fabrizio talk)

8 objects would not have been selected

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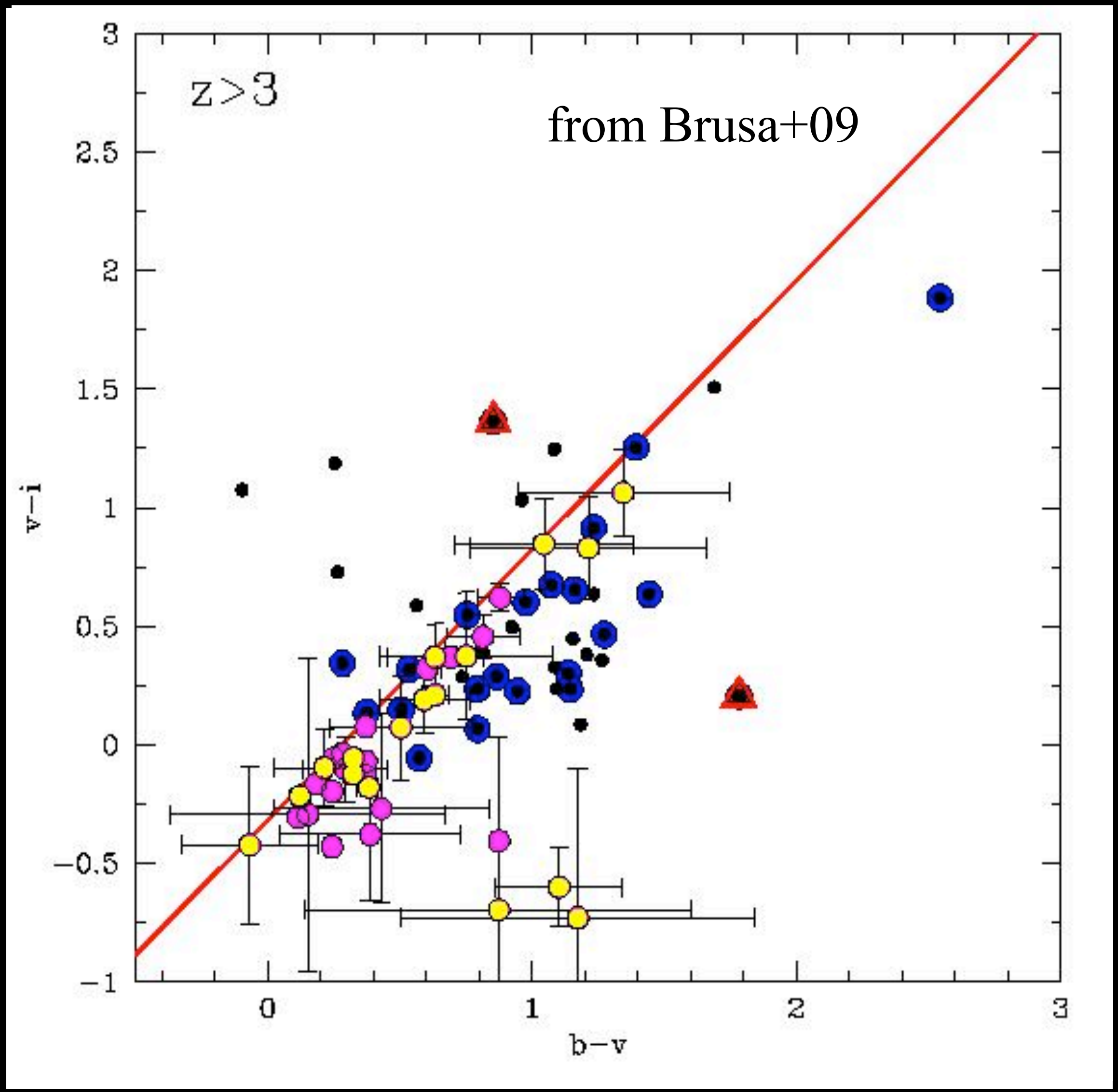

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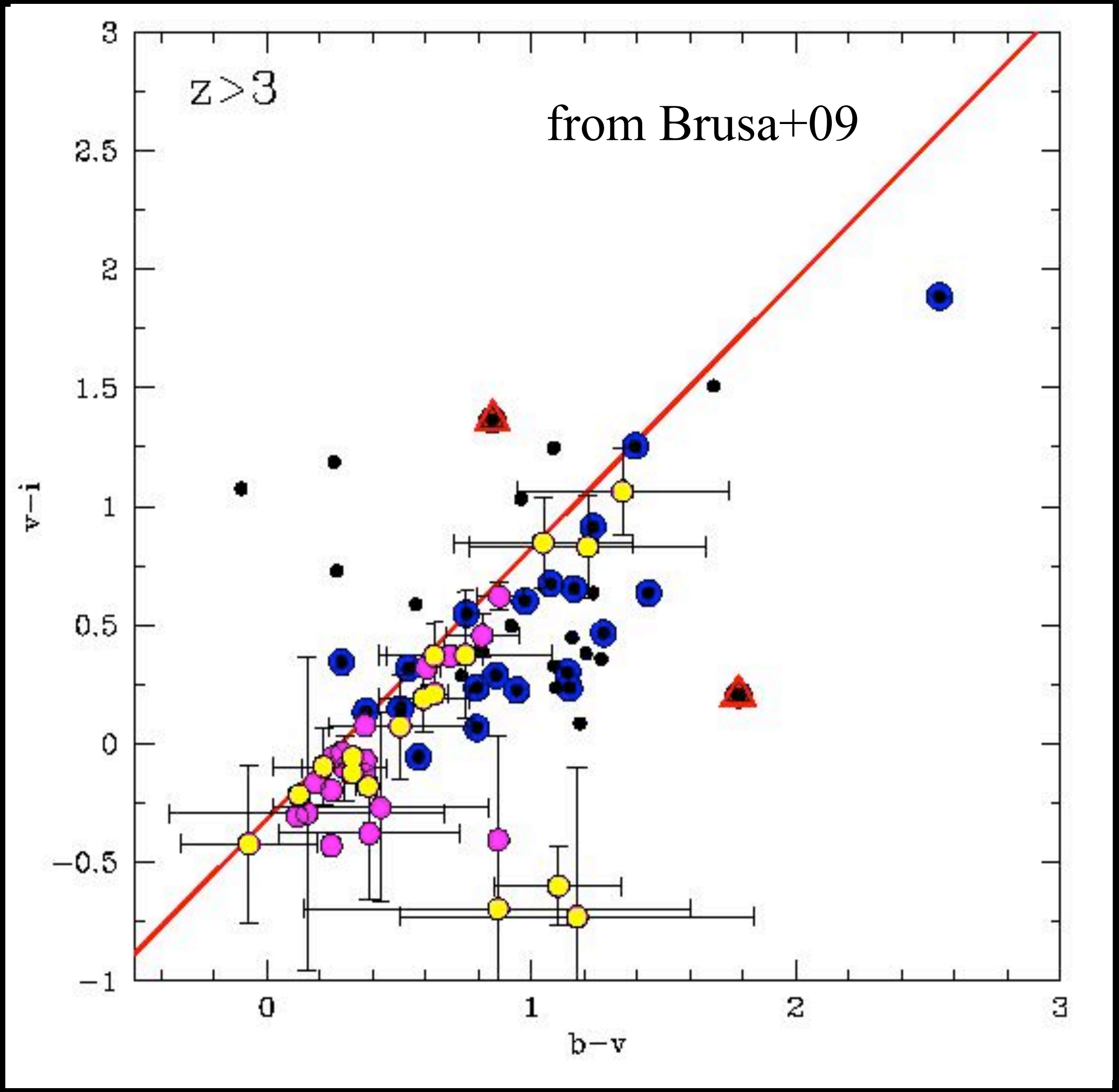

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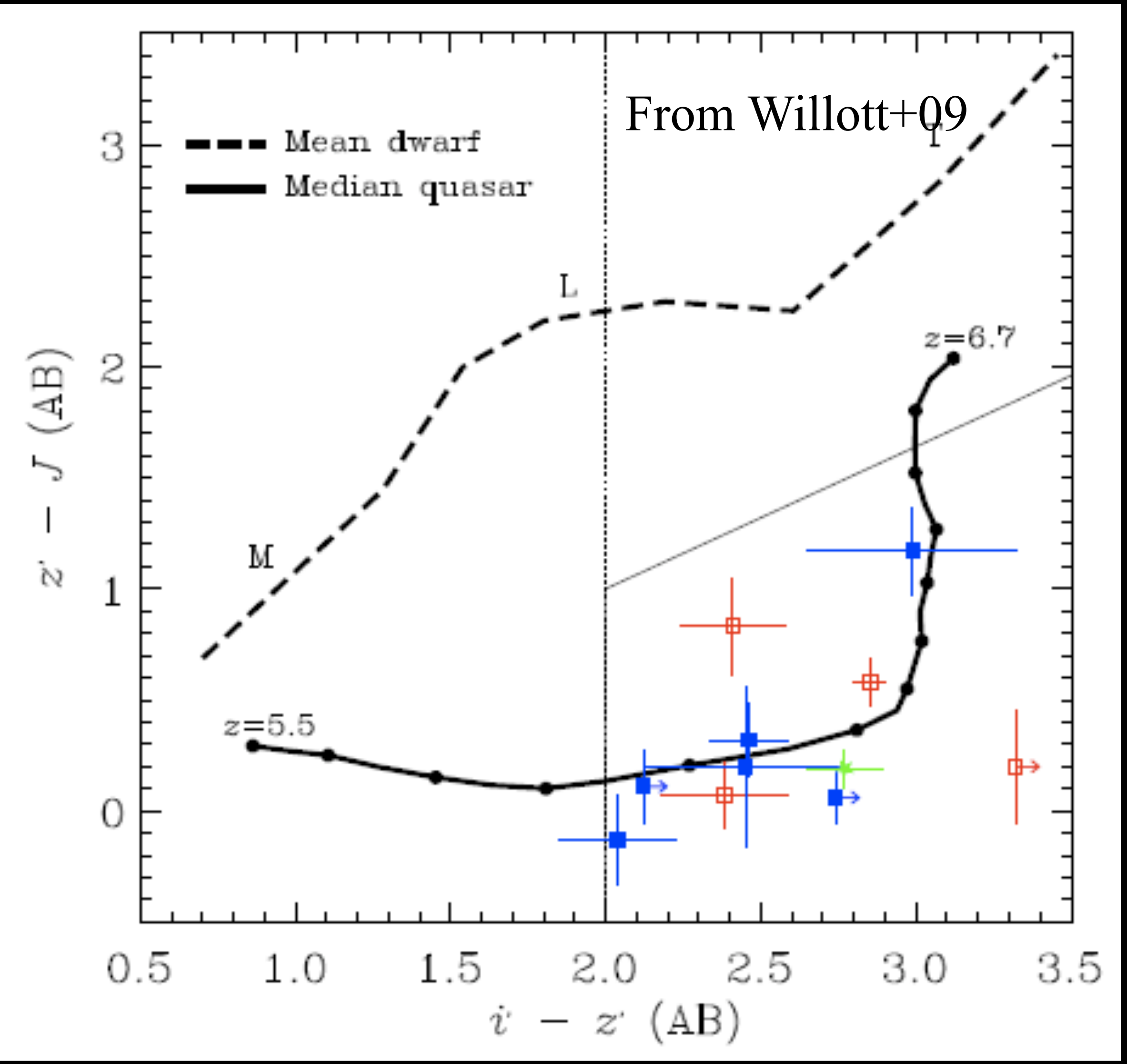

z>6 (optical): contaminants overwhelmingly more abundant (e.g. brown dwarfs 15x QSOS)

J-band used to discriminate between brown dwarfs and z=6 QSOs, still spectroscopy success rate is ~20% (Jiang+09):

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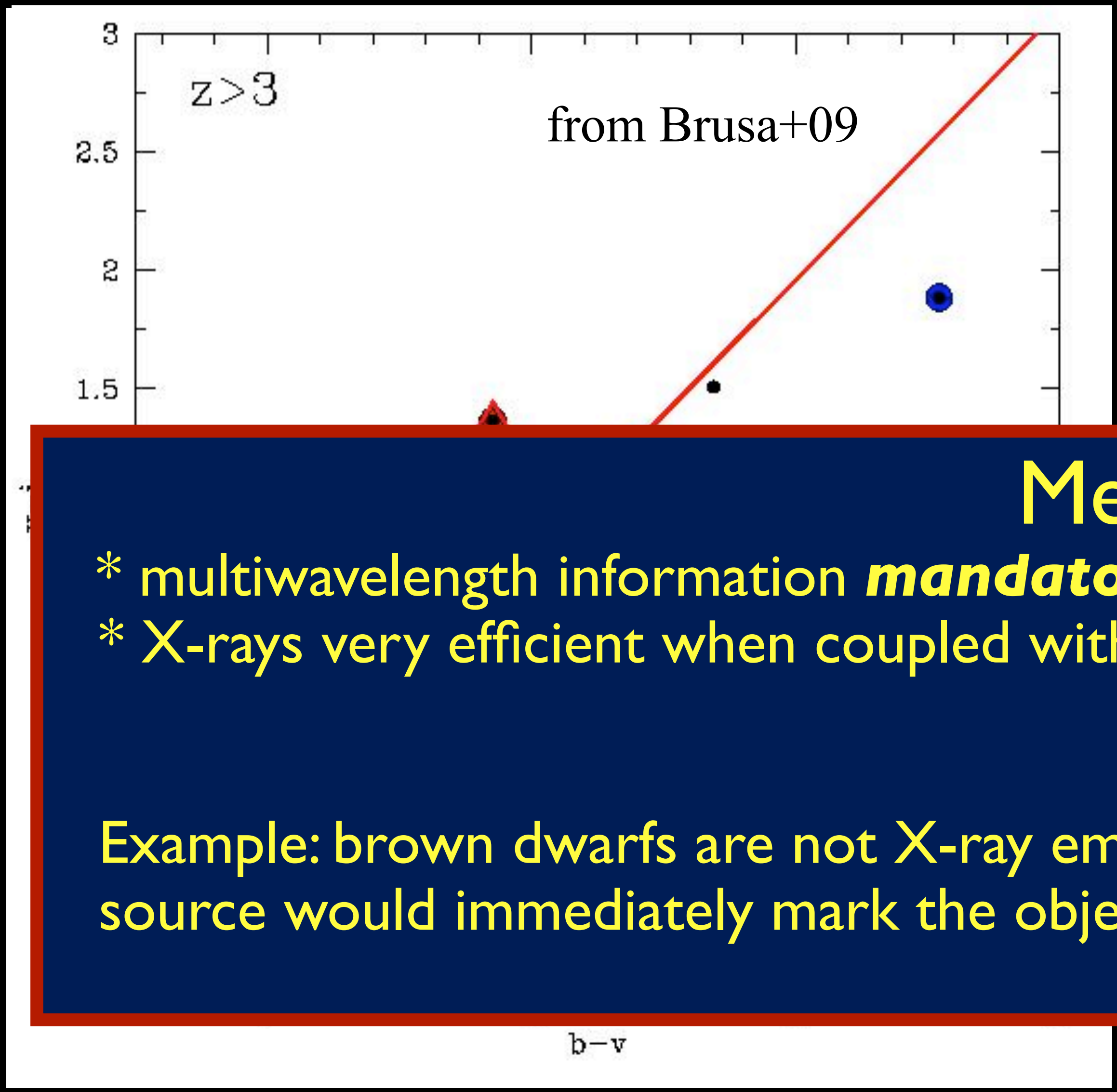

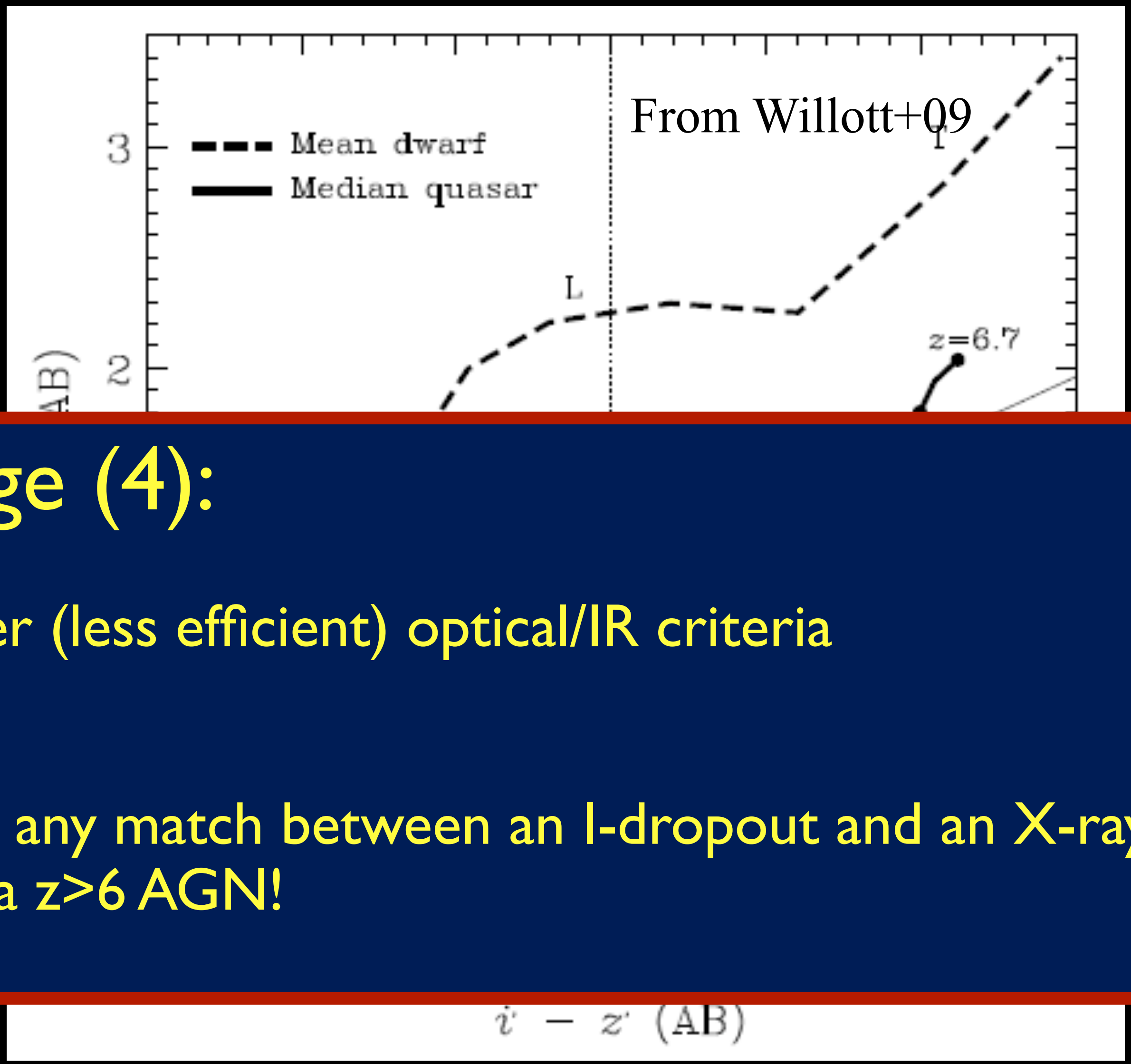

Message (4):
* multiwavelength information ***mandatory***
* X-rays very efficient when coupled with other (less efficient) optical/IR criteria

Example: brown dwarfs are not X-ray emitters any match between an I-dropout and an X-ray source would immediately mark the object as a z>6 AGN!

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* currently planned and ongoing optical / IR all sky surveys can ***do the game*** (PanSTARRS, LSST, EUCLID, JWST...); deep coverage need coordination
* ***IR more important than optical*** for faint and very high-z sources!

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LSST coverage (from Science book)

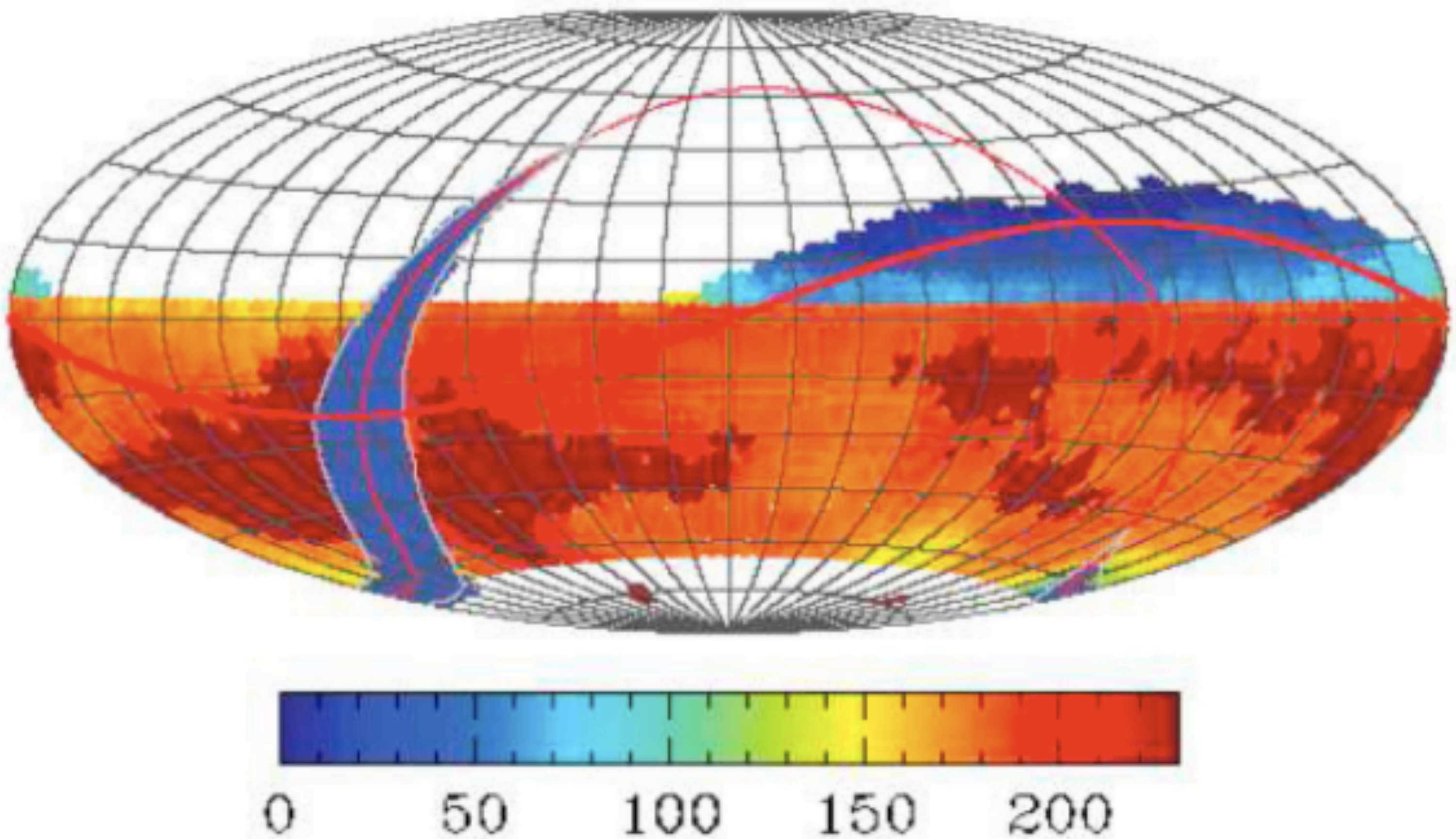

Figure 2.1: The distribution of the r band visits on the sky for one simulated realization of the baseline main survey. The sky is shown in Aitoff projection in equatorial coordinates and the number of visits for a 10-year survey is color-coded according to the inset. The two regions with smaller number of visits than the main survey ("mini-surveys") are the Galactic plane (arc on the left) and the so-called "northern Ecliptic region" (upper right). The region around the South Celestial Pole will also receive substantial coverage (not shown here).