AGN science
in the era of all-sky surveys (…or so)

M. Salvato (MPE)

For: COSMOS, CANDELS, LH, EGS, XUDS, STRIPE82X, ROSAT, eROSITA, EMU, EUCLID, PS, SPIDERS, SPLASH, Athena and more

The structure of the talk:

AGN: why bother ?

AGN: why do we need more ?

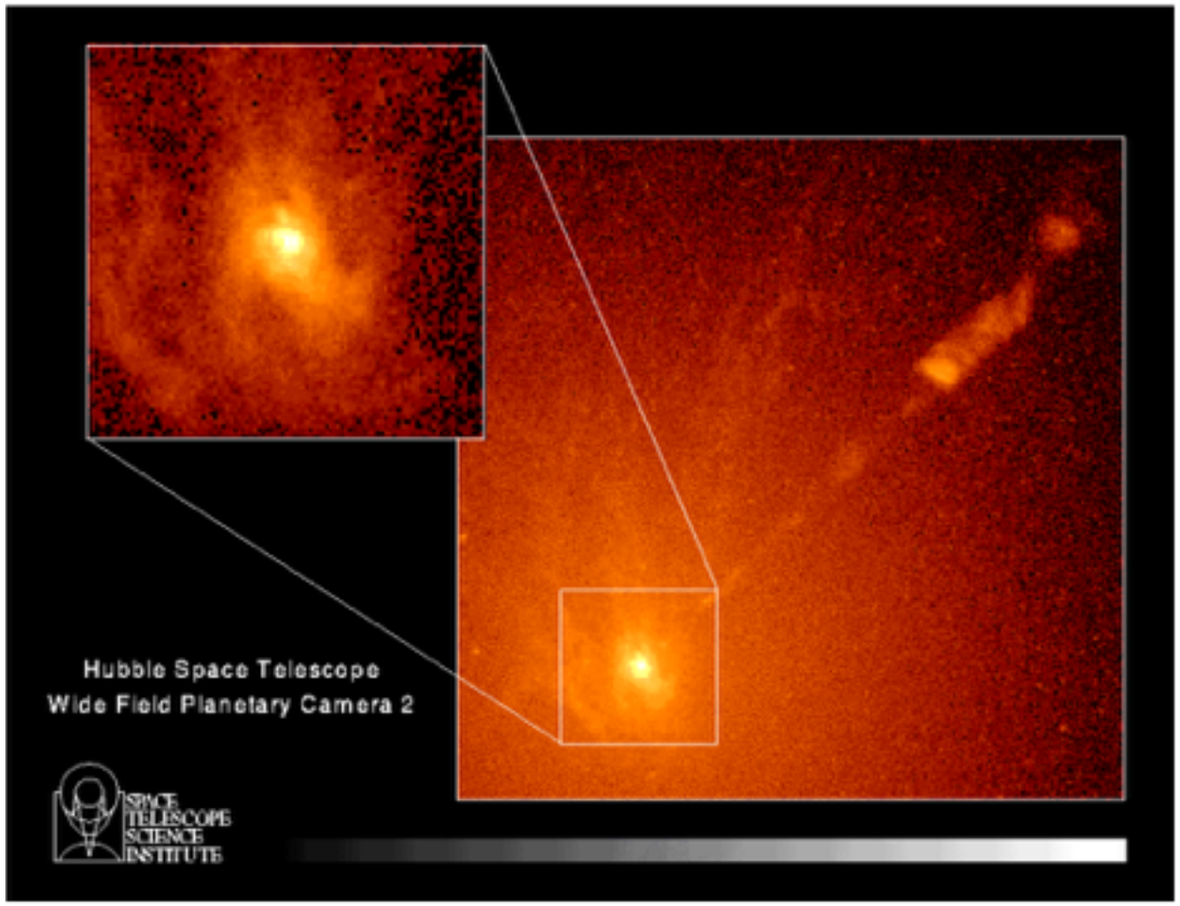
AGN: how do we find them ?

The challenges that we face (a.k.a my work)

how  can help

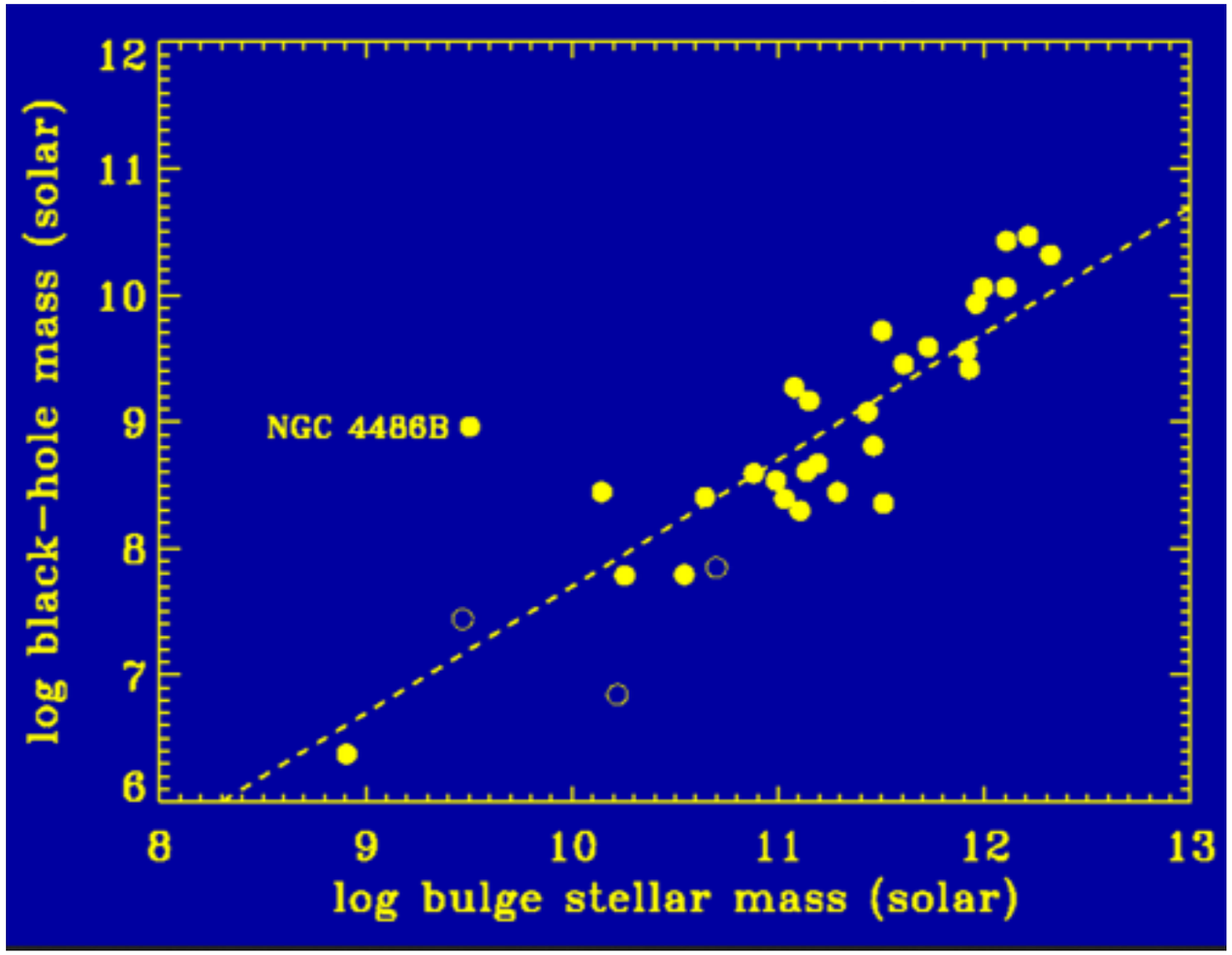
AGN: just interesting or actually important ?

(cit: J. Miller)



Interesting: A solar-region size up to several hundred time brighter than the entire galaxy

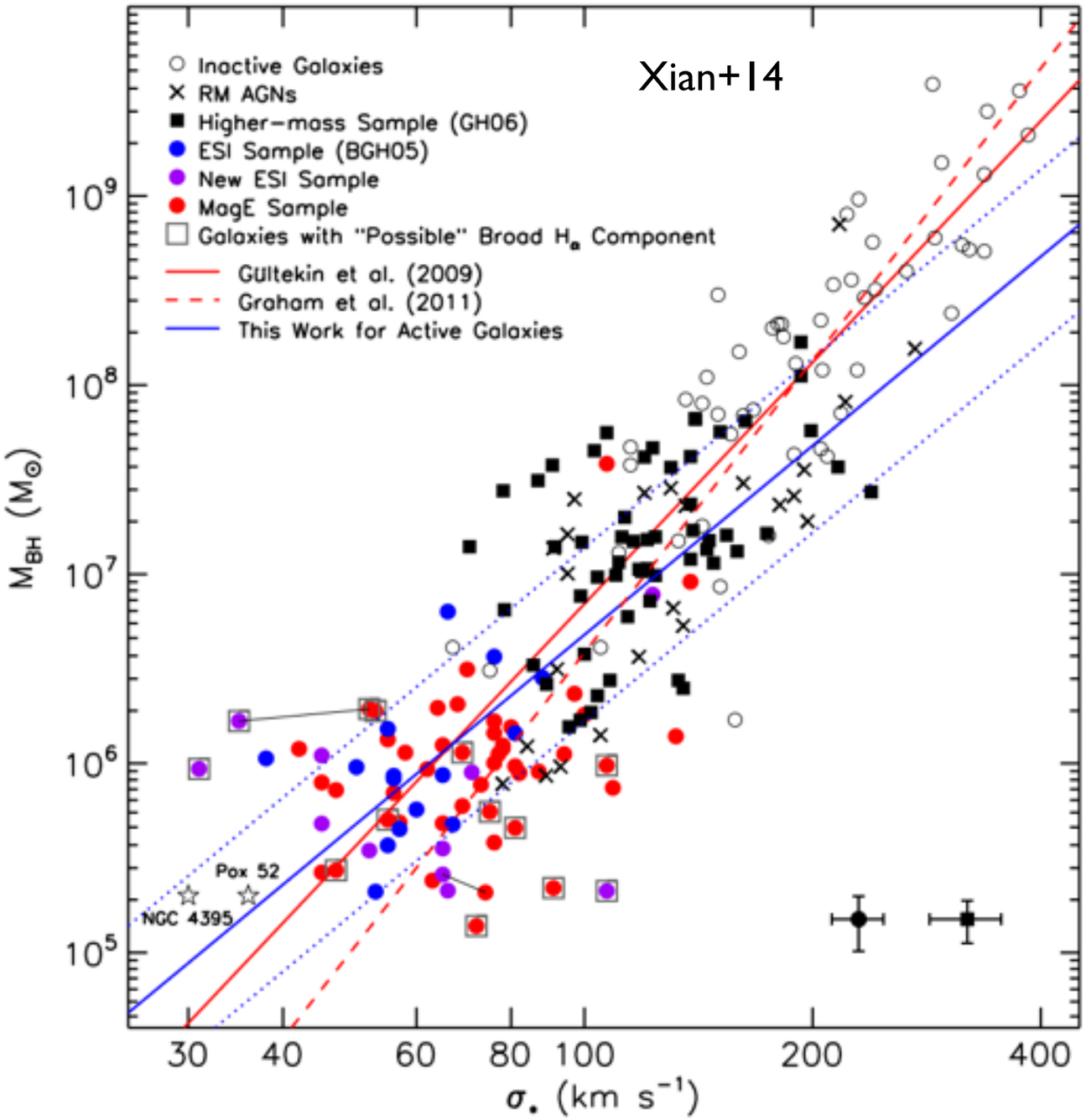
Important: every galaxy is/was/will be (?) an AGN

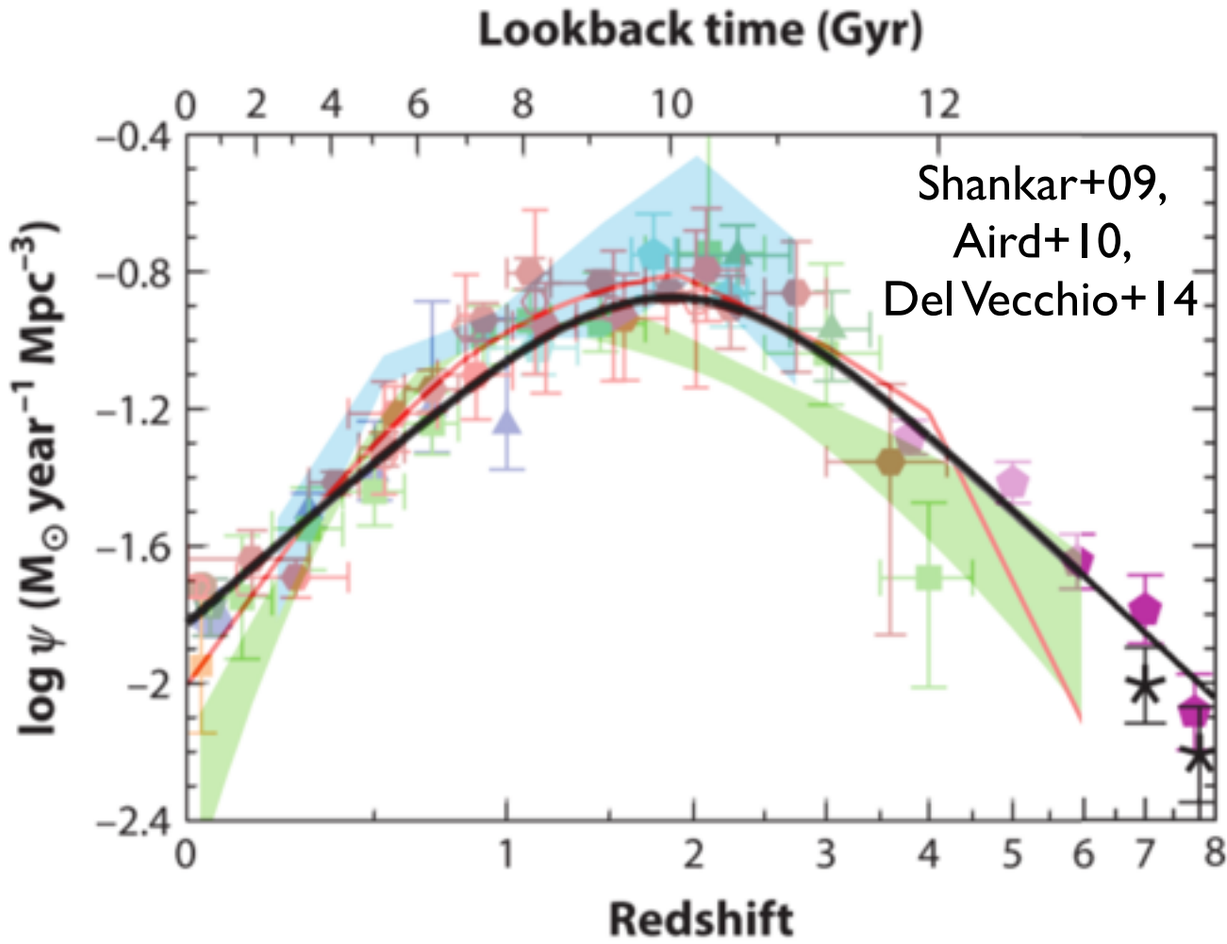


Magorrian+98, Kormendi&Richstone95, Nuker team

AGN: just interesting or actually important ?

BOTH, ACTUALLY!

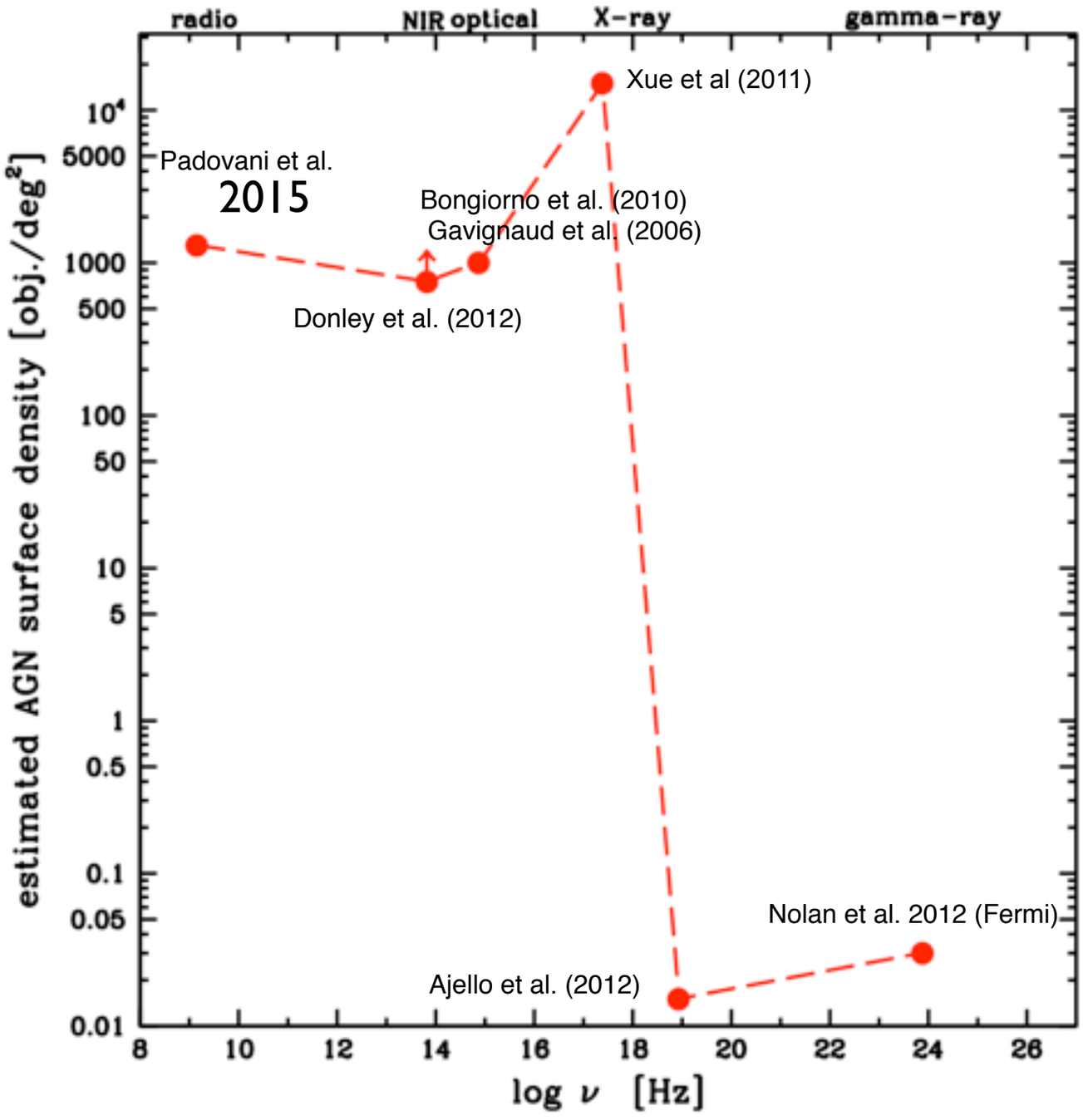




Madau& Dickinson+14

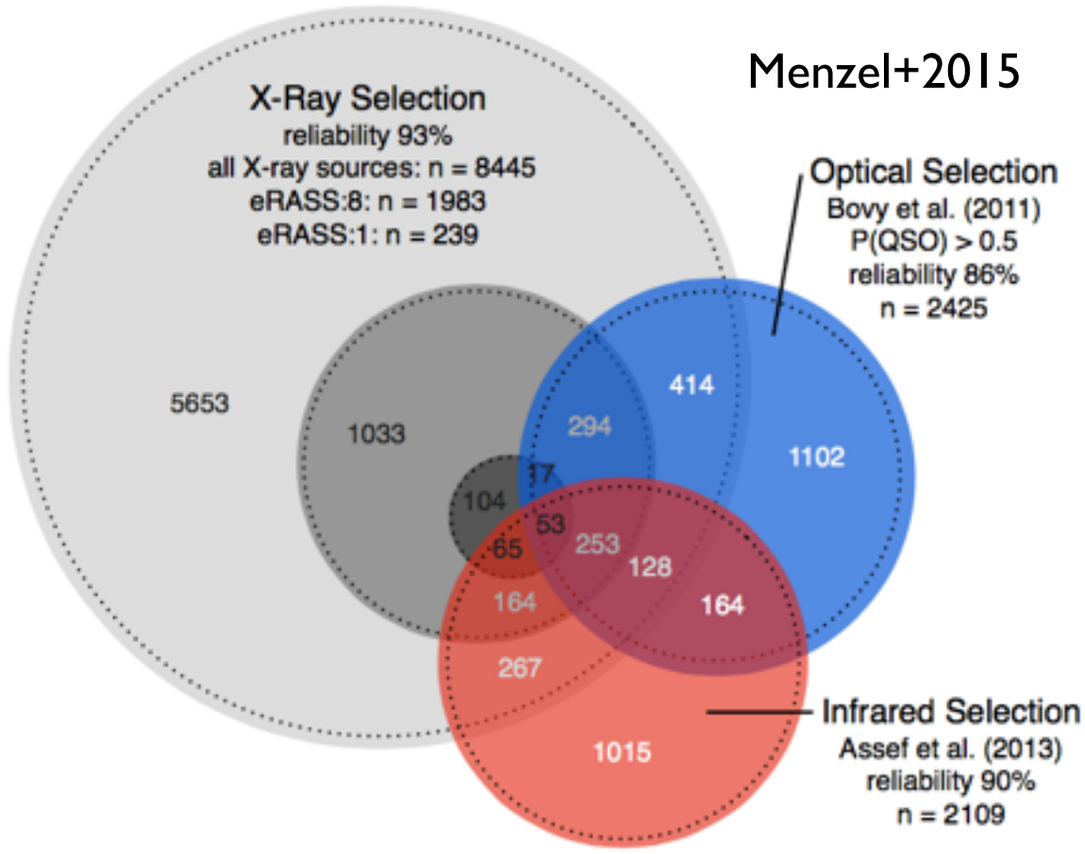
See also, Mclure&Dunlop 00 and following papers

AGN: A complete census is needed but… How do we find them?



courtesy:P. Padovani

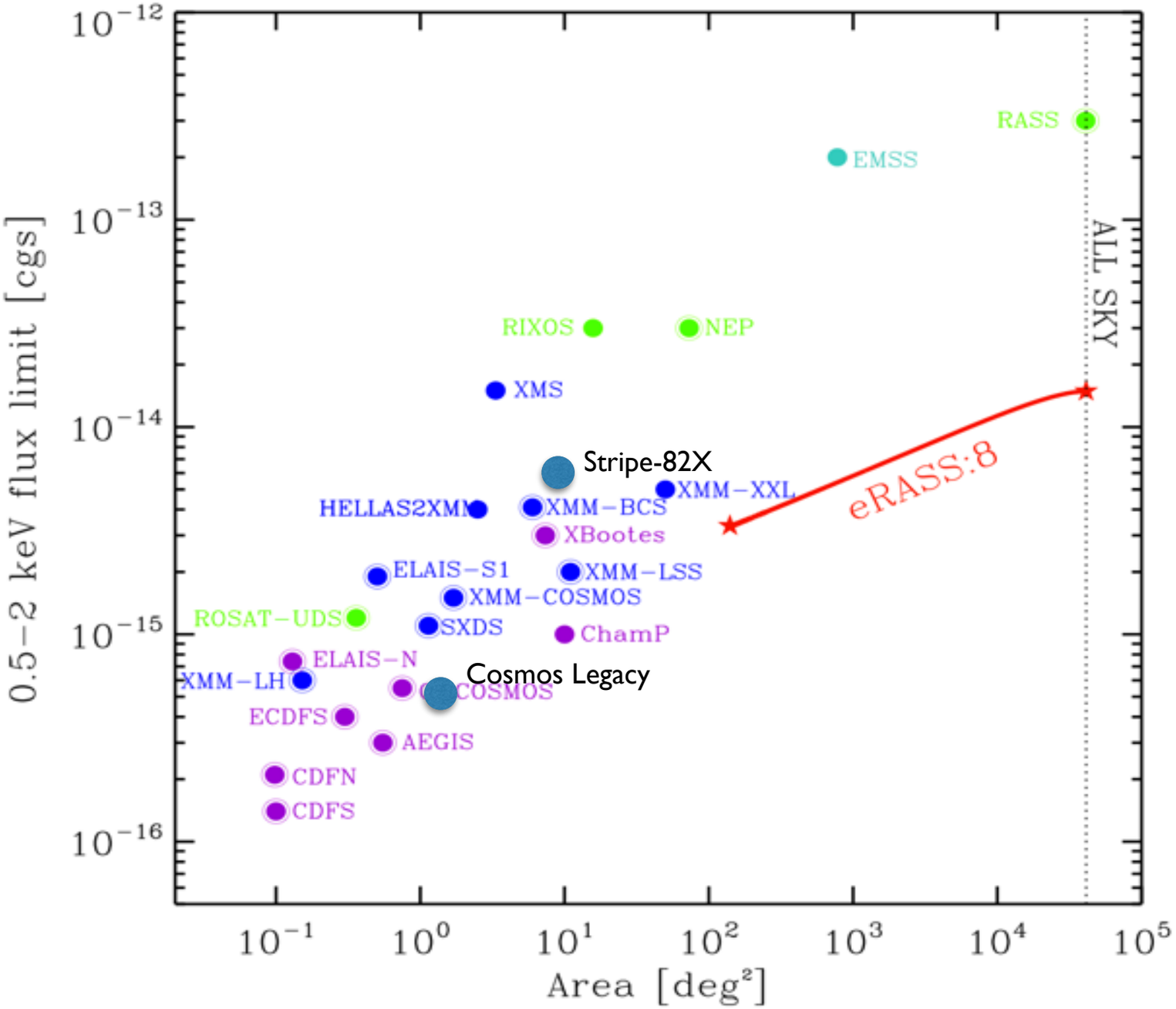
Depending on how we selected them, we have different number of sources.



Menzel+2015

very few are in common to all the selection criteria

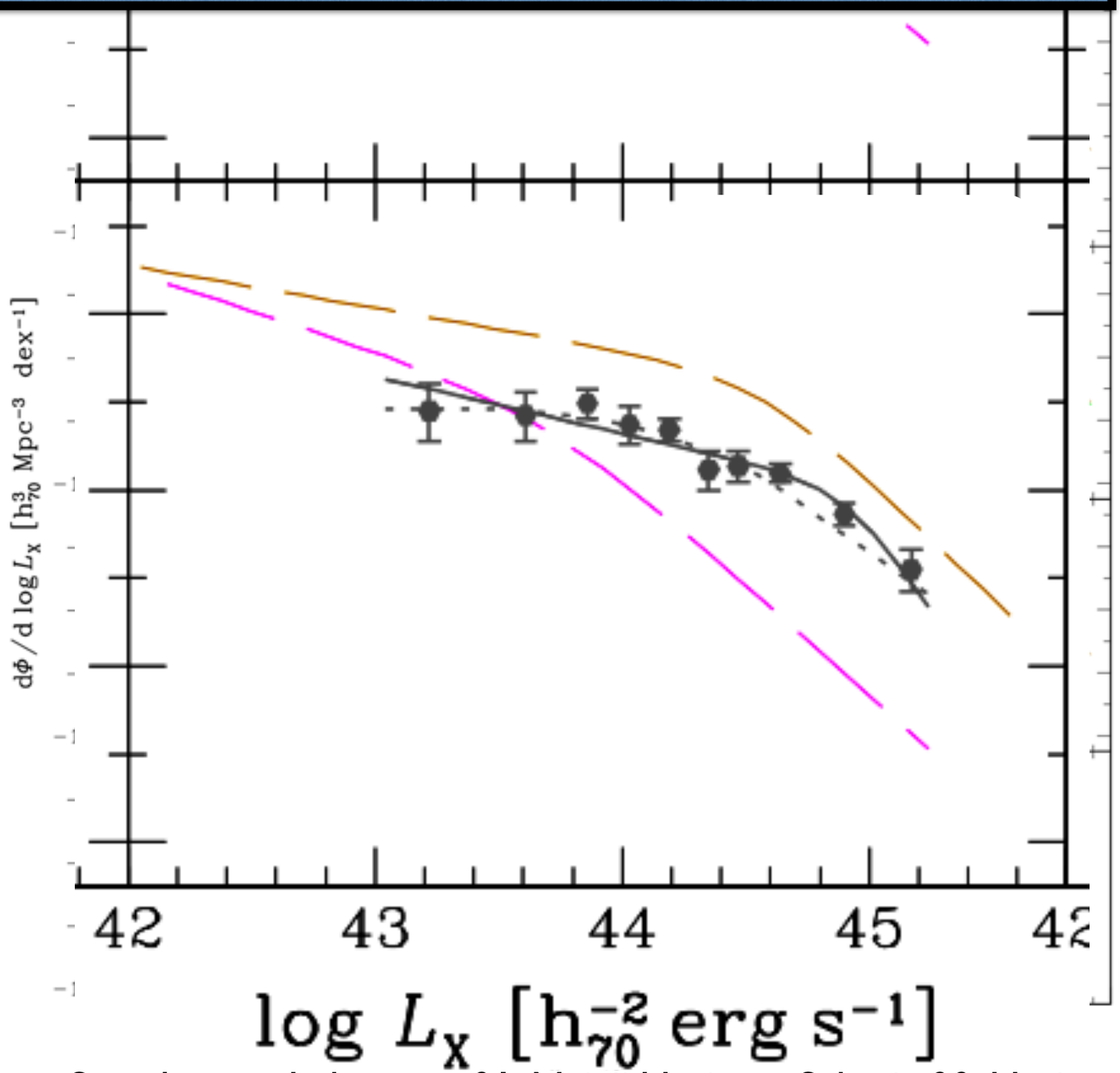
Keep it "simple": let's start from X-ray



Least effected by host galaxy emission and dust obscuration

More efficient in reaching the high redshift AGN where all began

X-ray AGN: how do they evolve ?



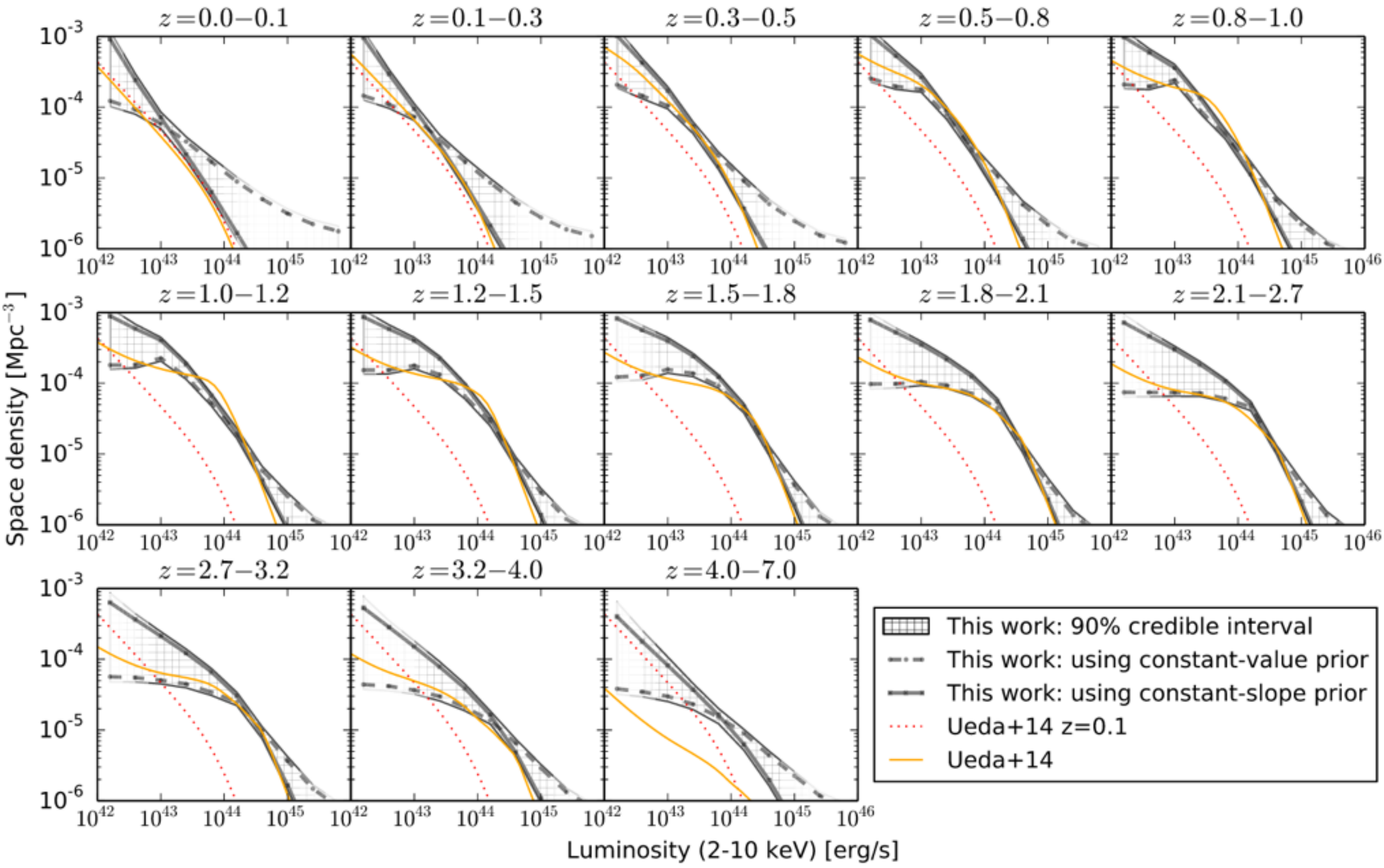
Yet, even using data combining the surveys we are not able yet to disentangle from different models

Miyaji+2015

See also e.g: Lehmann+01, Myiaji,Hasinger,Schmitt00, Hasinger+05, Gilli+07, Aird+10, Ueda+14, Buchner+15, Gerogakakis+15,Vito+14, Fotopoulou+15

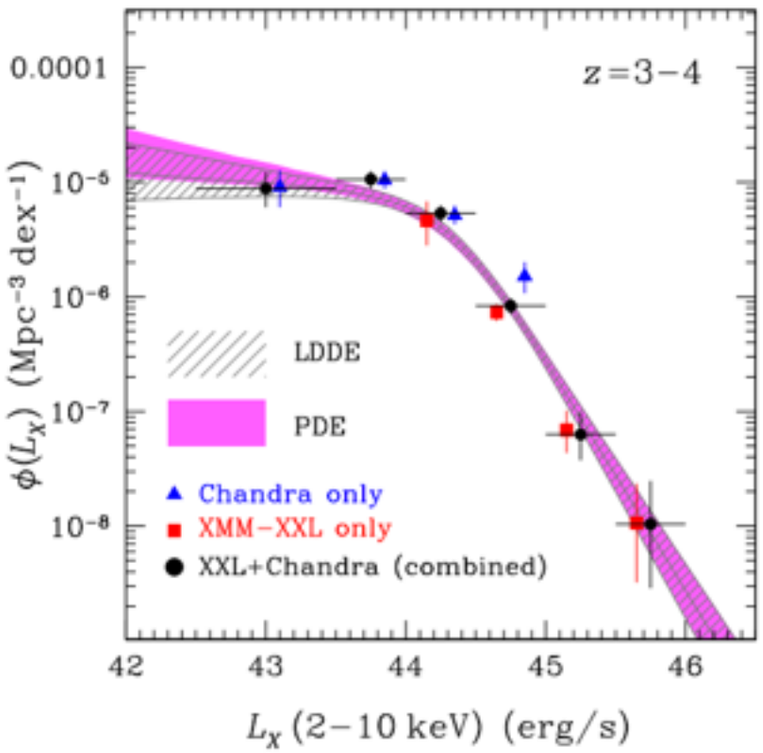
X-ray AGN: how do they evolve ?

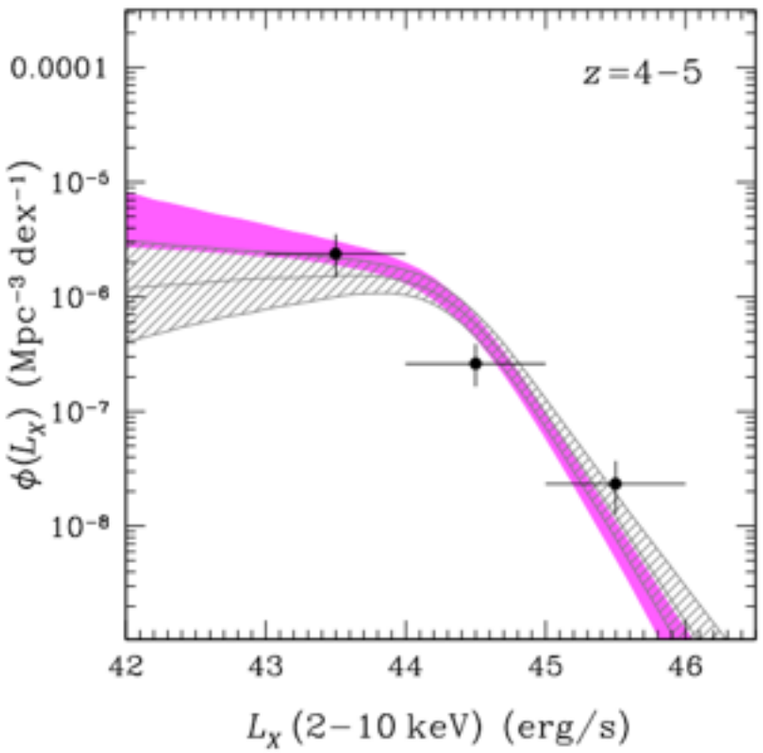
Buchner+2015 (but see also Aird+15)

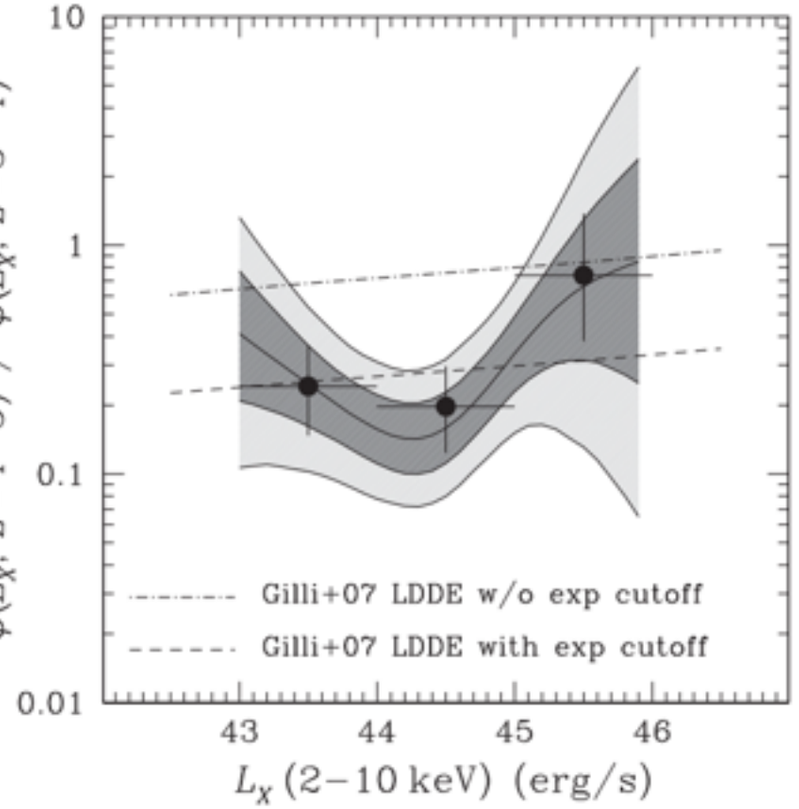


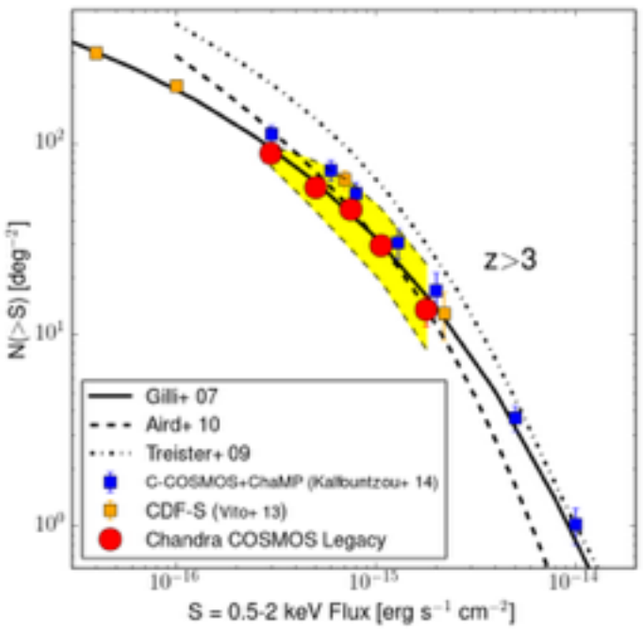
… and at high redshift ?

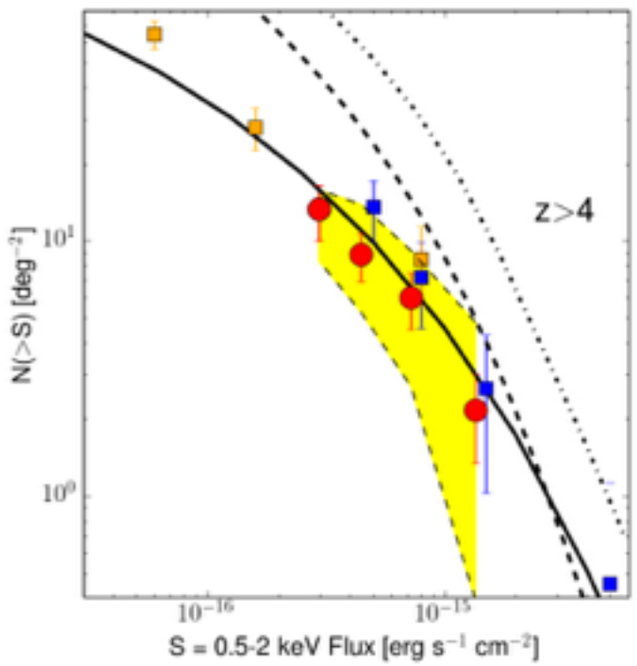
Georgakakis+2015







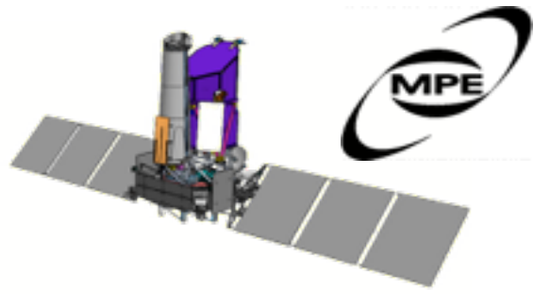




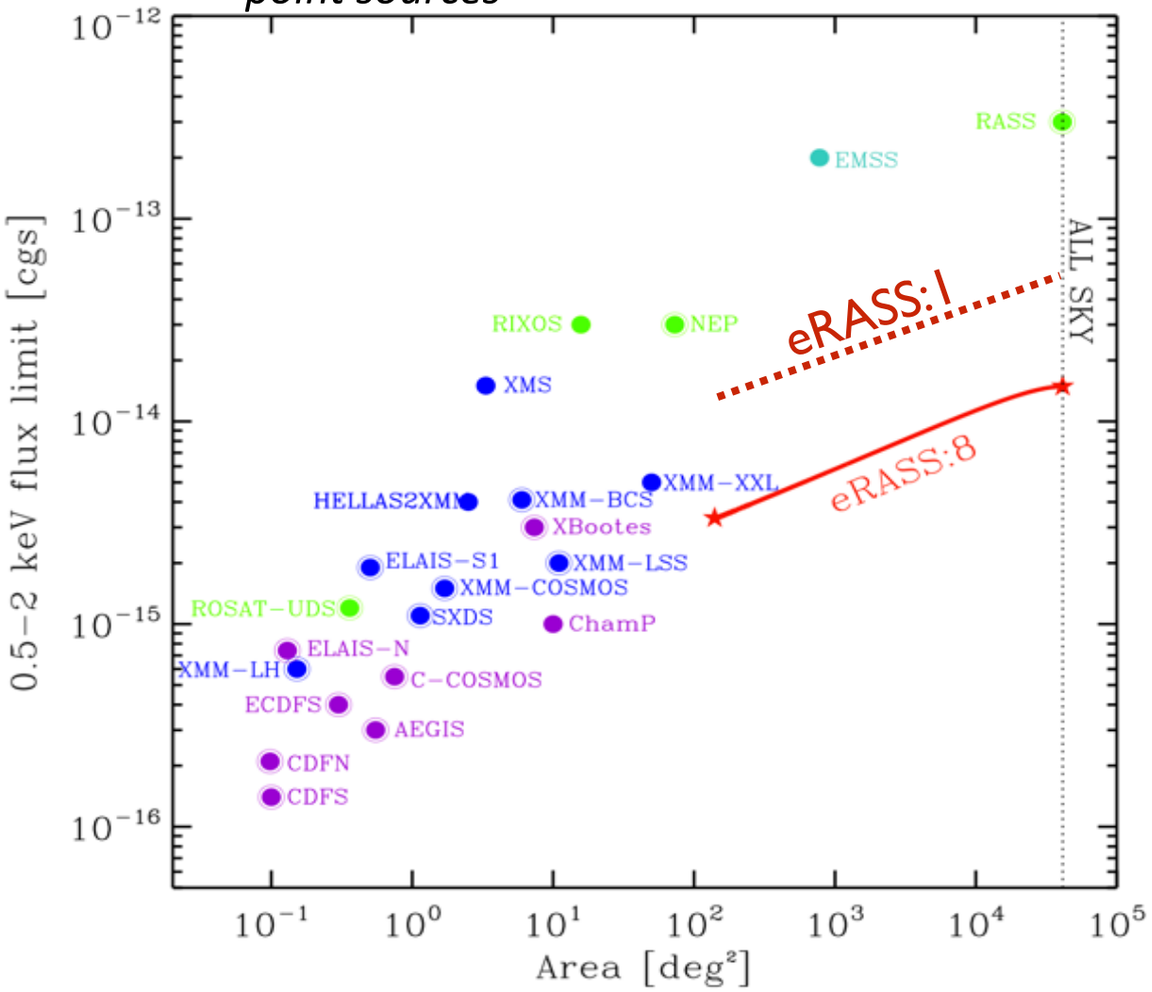
Marchesi+2015, to be submitted

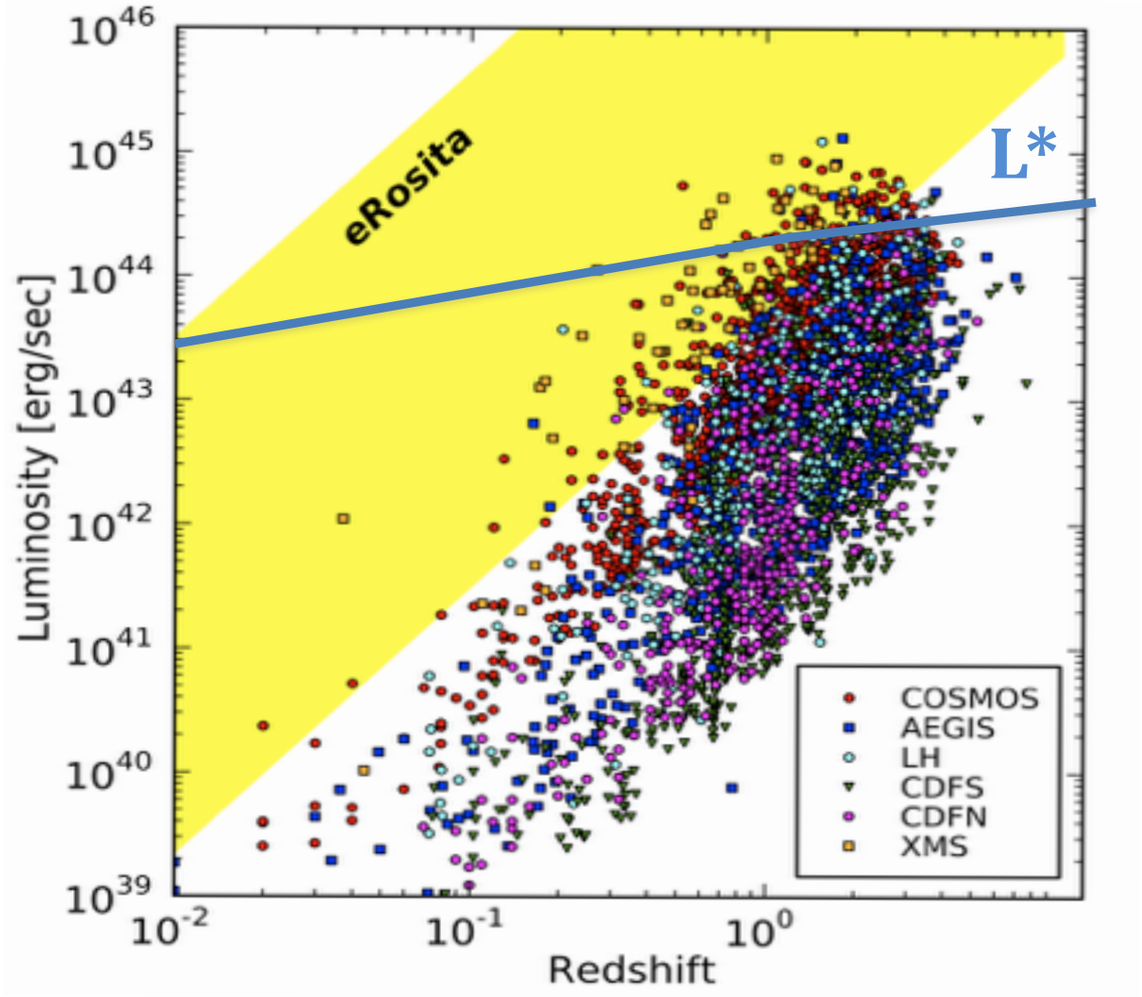
See also e.g.:
Brusa+09, Civano+11,
Master+12, Glikman+11,
…

eROSITA coming to rescue in the soft X-ray…



point sources



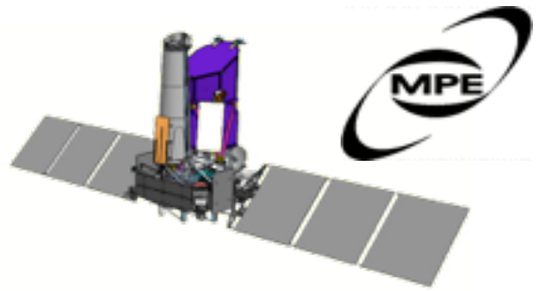


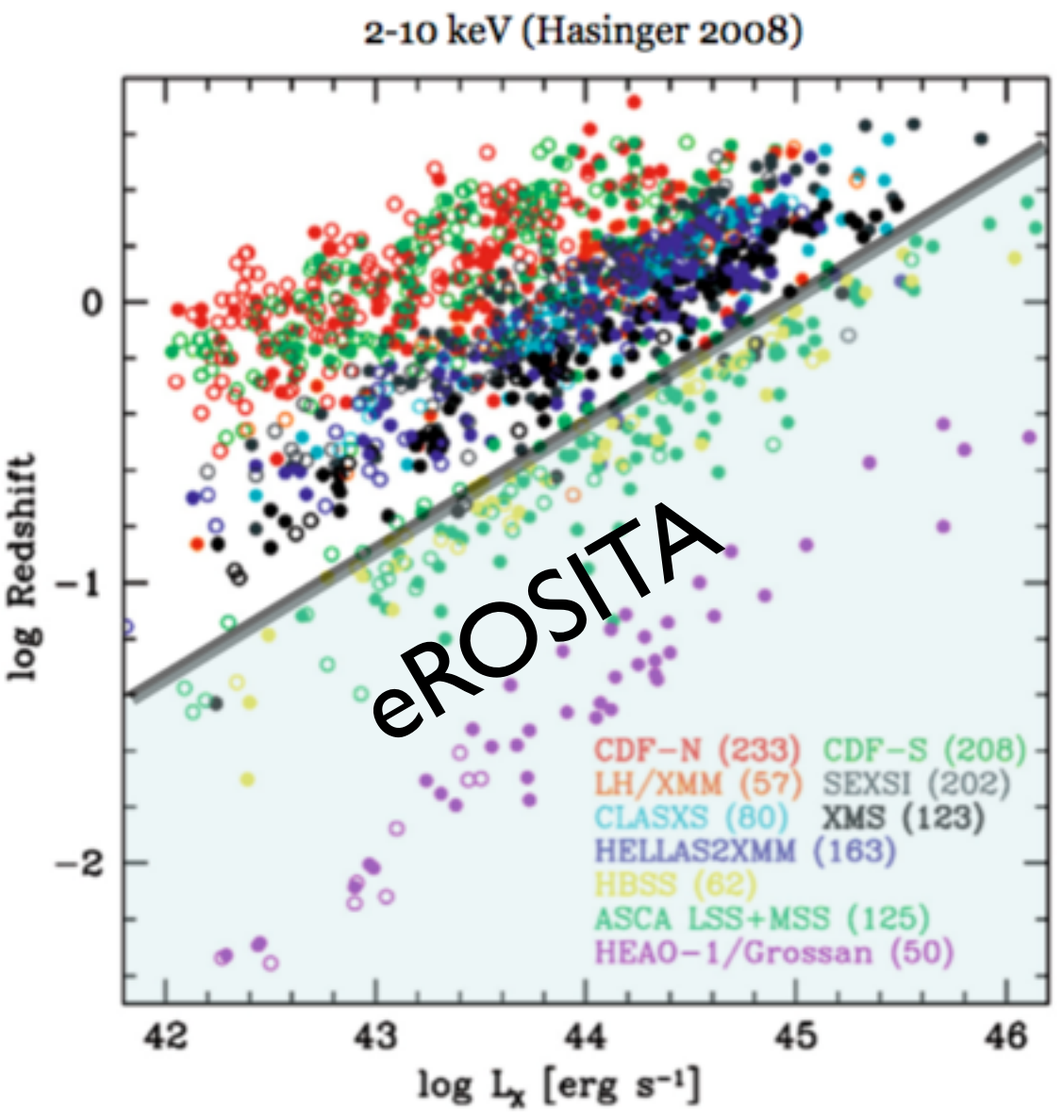
From Merloni+2012

All sky: ~10^{-14} (0.5-2 keV) [erg/cm²/s]

Poles: 3x10^{-15} (0.5-2 keV) [erg/cm²/s]

… and in the hard X-ray

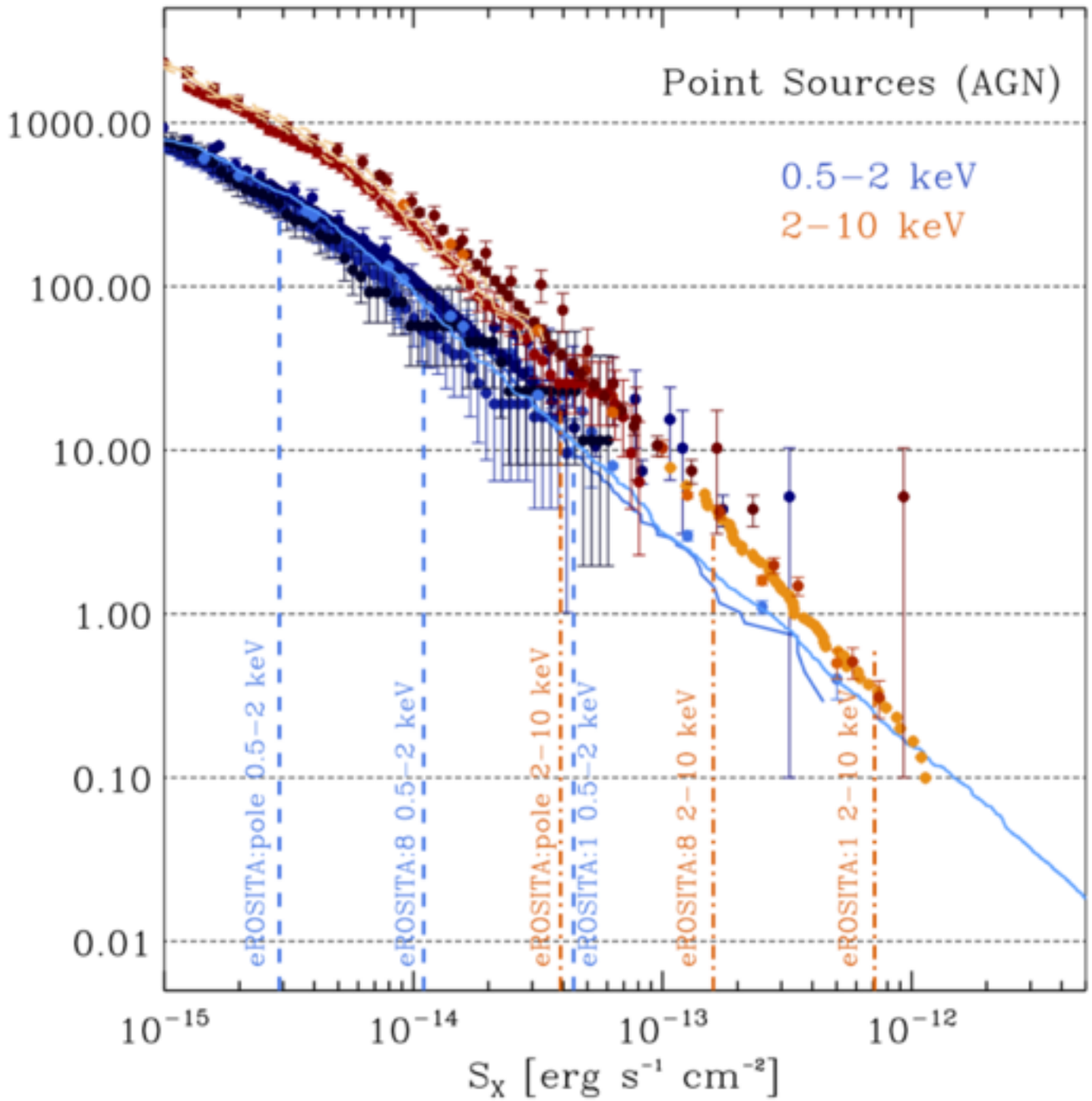




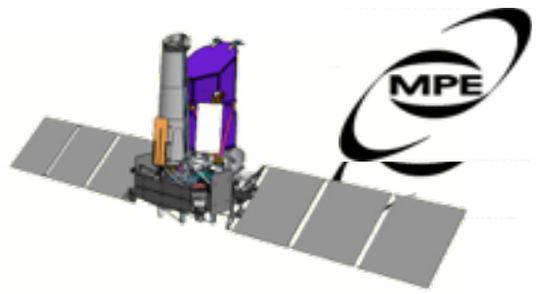
All sky: 2×10^{-13} (2-10 keV) [erg/cm²/s]

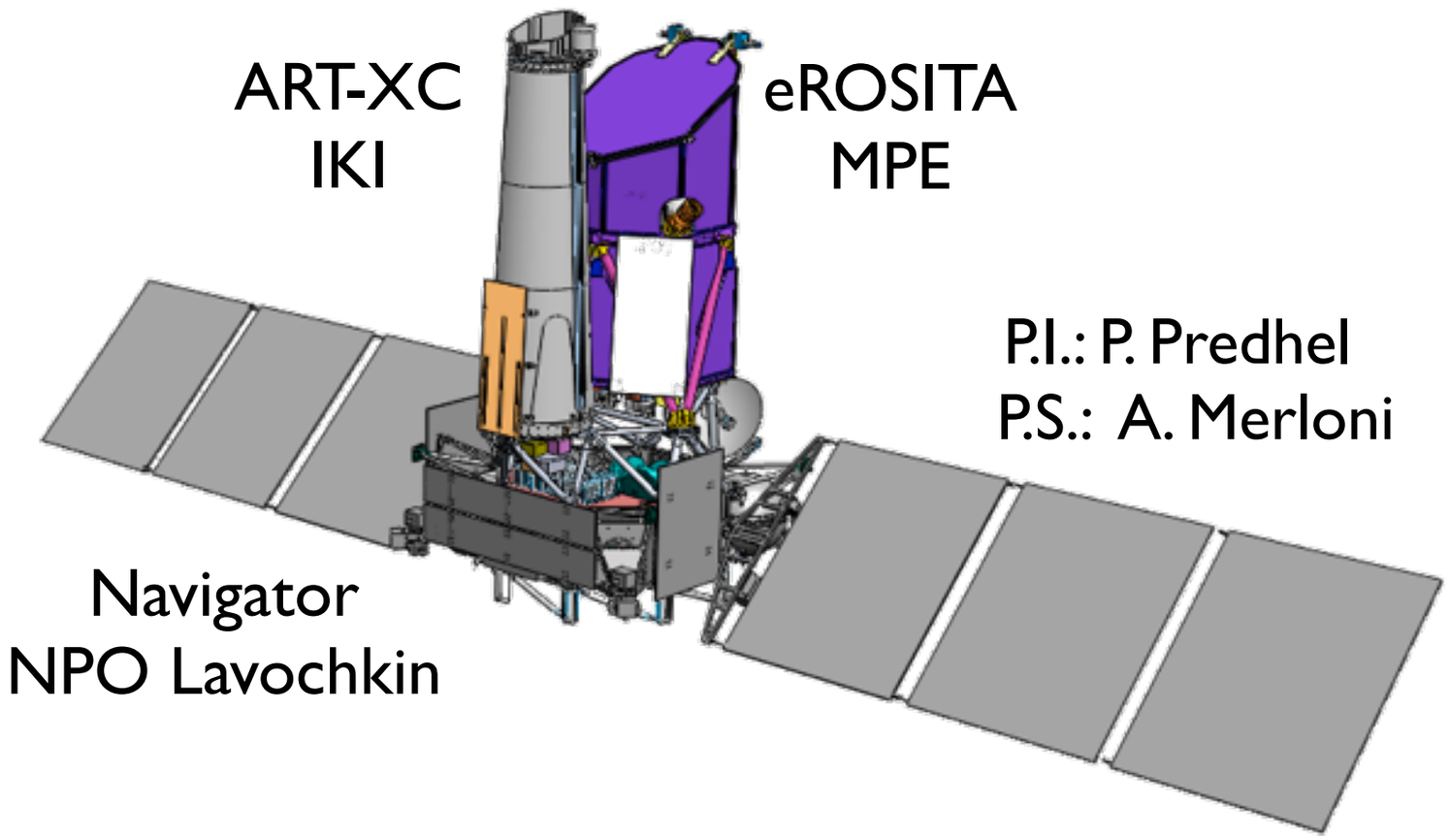
Poles: 4×10^{-14} (2-10 keV) [erg/cm²/s]

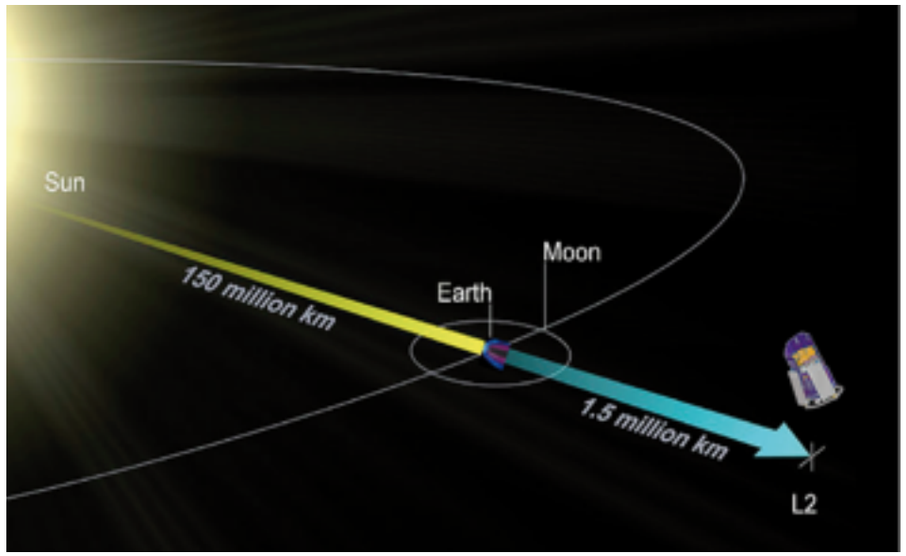
Compilation from Capelluti+09 and Mateos+08



eROSITA on SRG: The mission





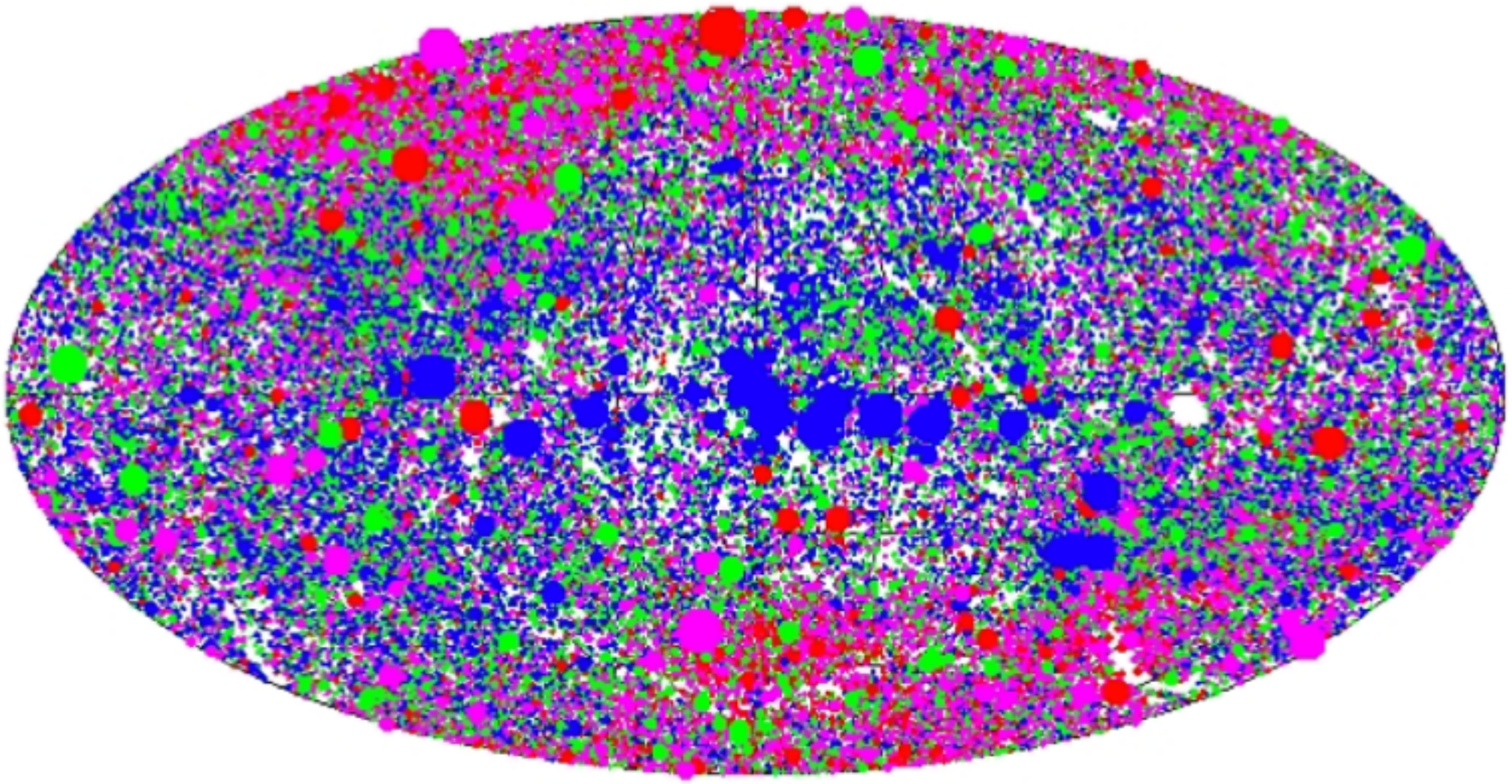


- eROSITA hardware mostly completed. Calibration/assembly/tests till ~December
- **Launch**: **Spring 2017** from Baykonour (Zenit+Fregat)
  - 3 Months: flight to L2, verification and calibration phase
  - 4 years: 8 all sky surveys eRASS:1-8 (scanning mode: 6 rotations/day)
  - 3.5 years: pointed observation phase, including ~20% GTO. 1 AO per year
- **Proprietary data rights** shared 50/50 between MPE (Germany) and IKI (Russia)

  German (MPE) half: proprietary period maximum **2 yrs** Periodic Release of German all-sky data

The second ROSAT all-sky survey catalog

Boller et al. 2015



~135000 sources down to a detection likelihood of 6.5:

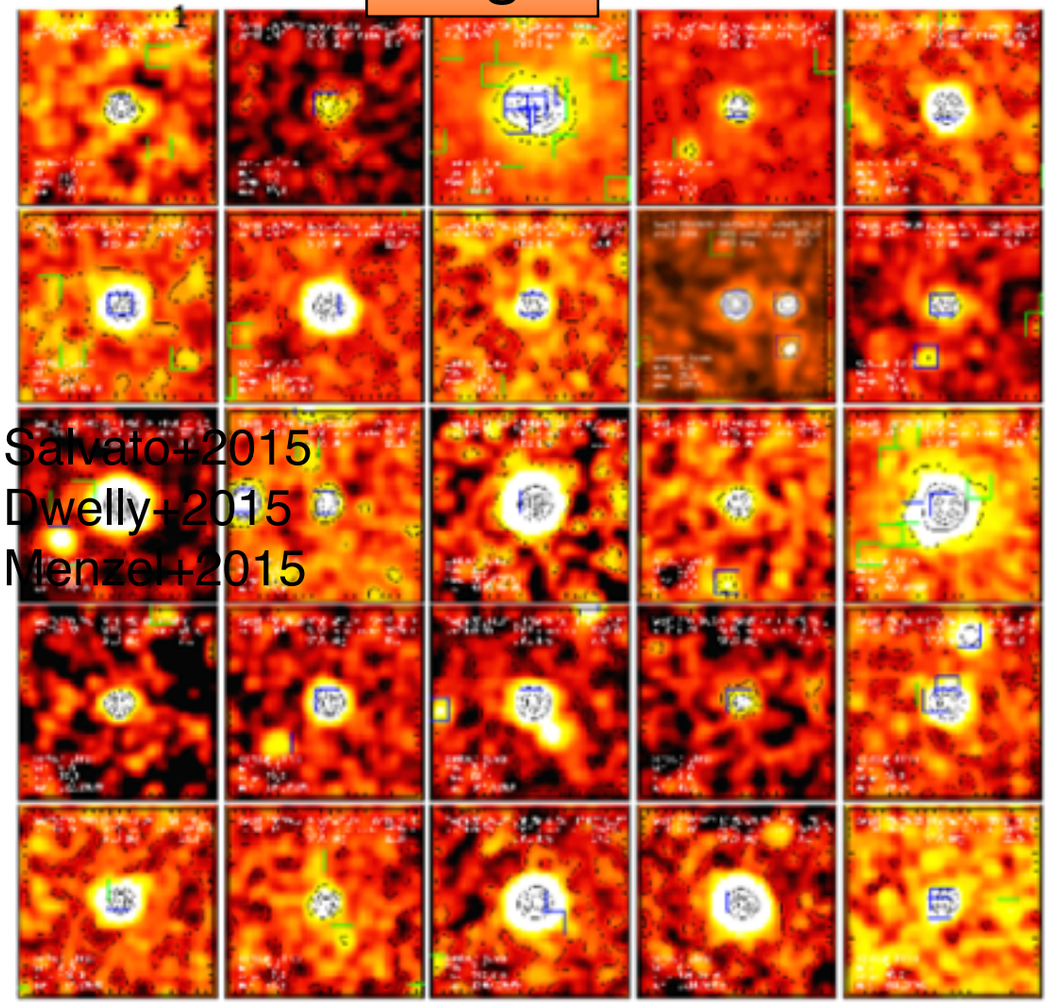
- Additional Bright sources and less
- more reliable Faint sources

The largest and most reliable X-ray All-sky survey before eROSITA

The largest and most reliable X-ray All-sky survey before eROSITA

Boller+2015

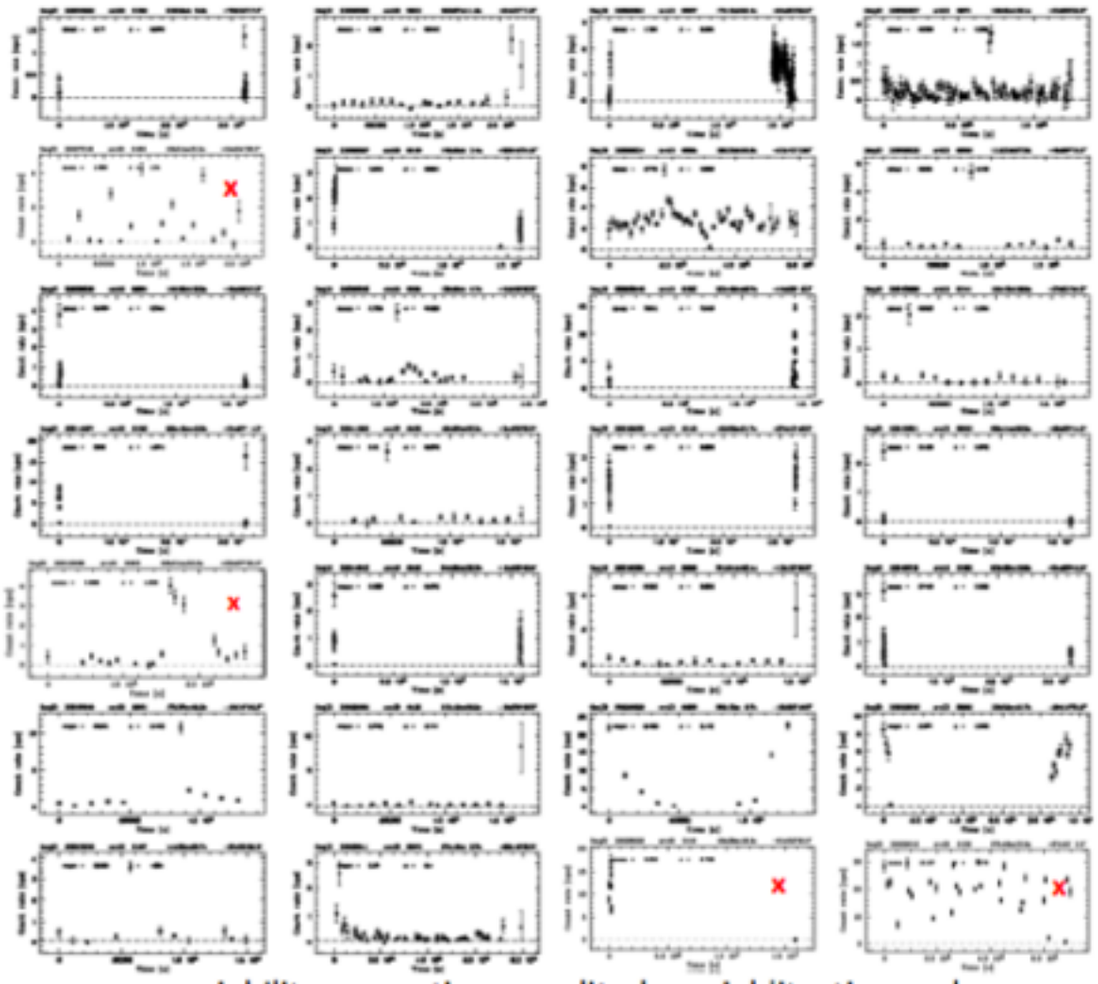
images



Salvato+2015
Dwelly+2015
Menzel+2015

standard SASS output: RA,DEC,CTS,HR,exposure, detection likelihood

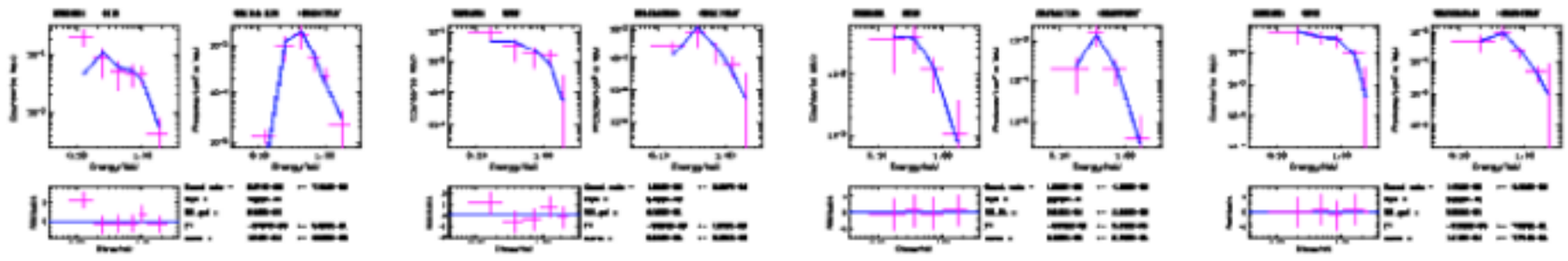
light curves



variability properties , amplitude variablity, timescales

Coffey et al,

spectral fits



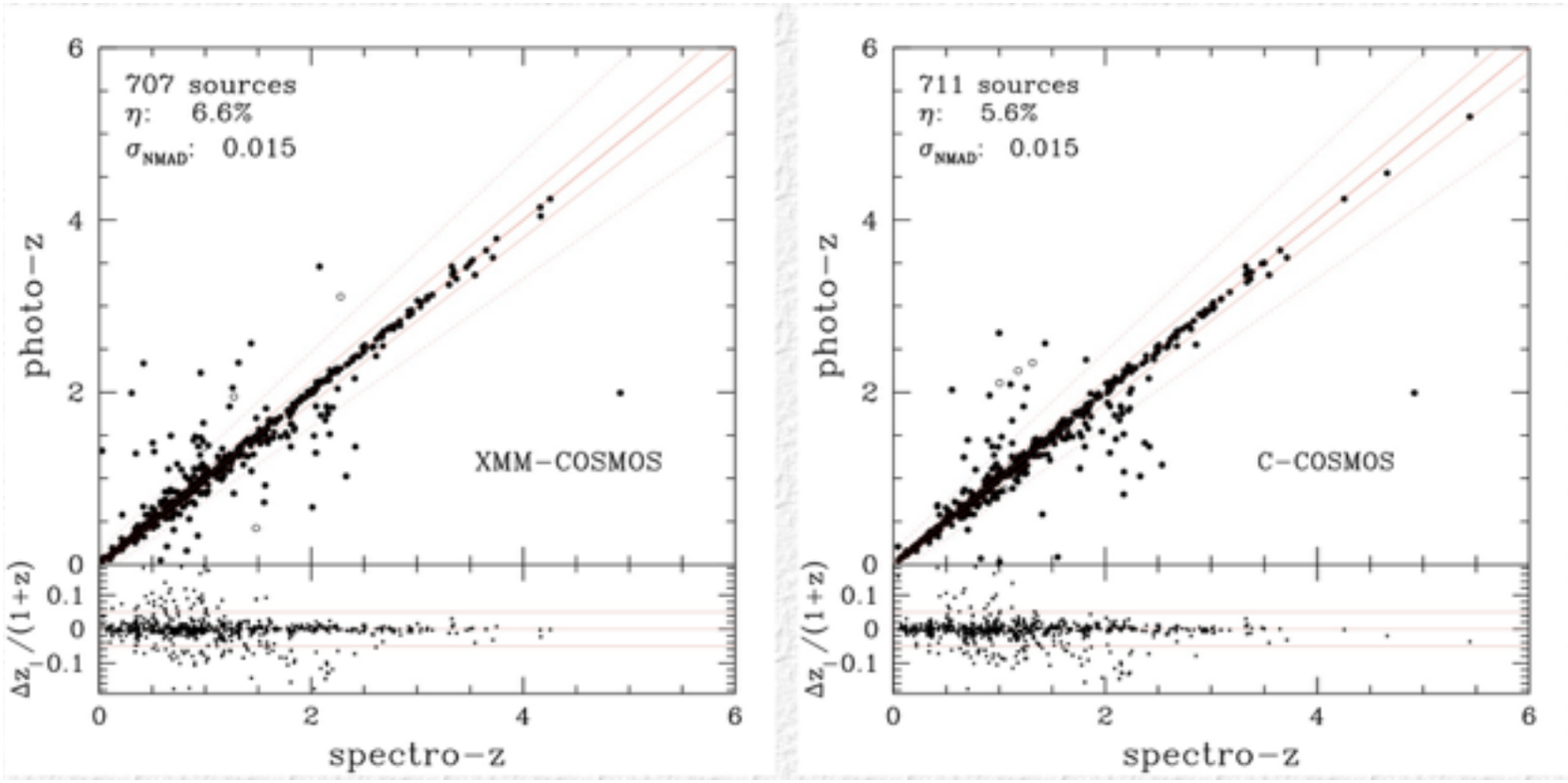
spectral fit parameters: Nh_fit, Γ, T, flux, χ^2

X-ray data alone are not enough
We need redshifts but:

Sources are rare and faint:
difficult to convince a TAC to use MOS for AGN only

FoV of Multi-Object spectrographs (MOS) are still small
(4MOST available only in 2021-2026)

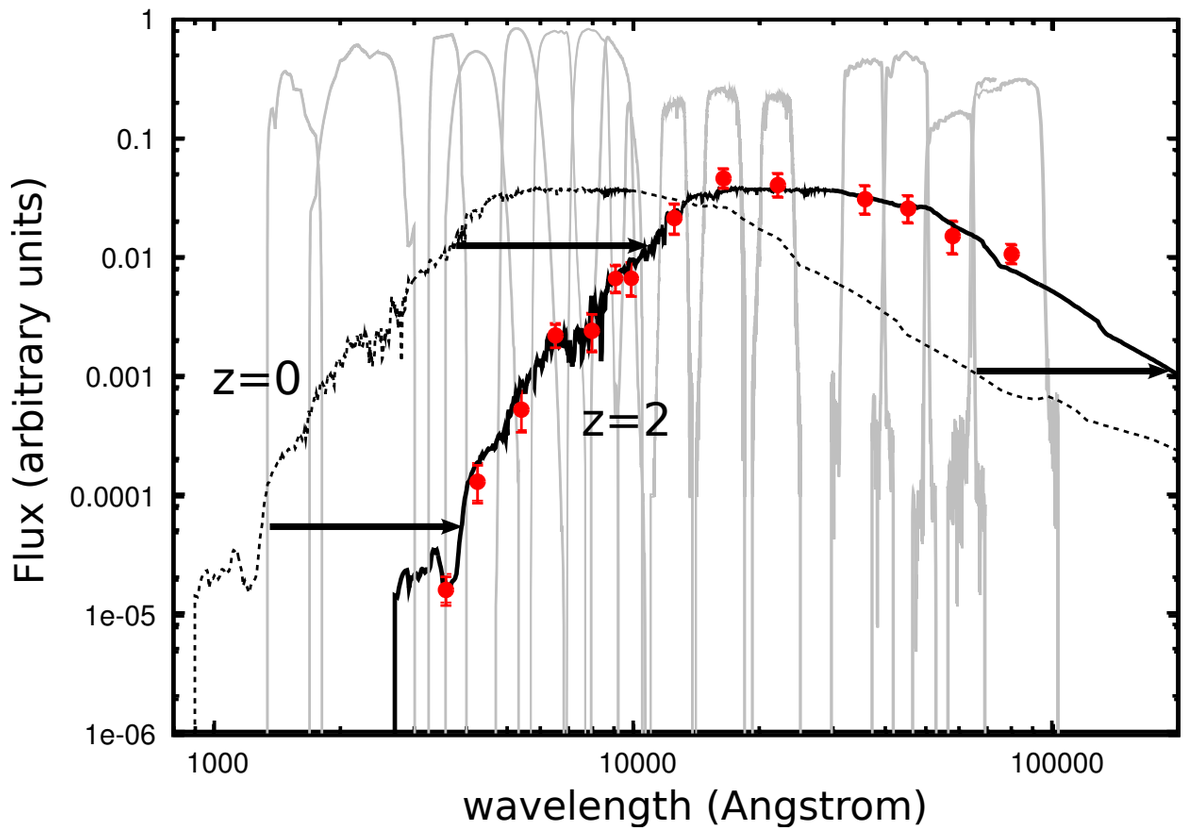
Sources at high-z have the lines used for identification in the NIR: still few MOS available at longer wavelength



Let's use photometric redshifts!

Salvato+09, Salvato+11

How photometric-redshift works:

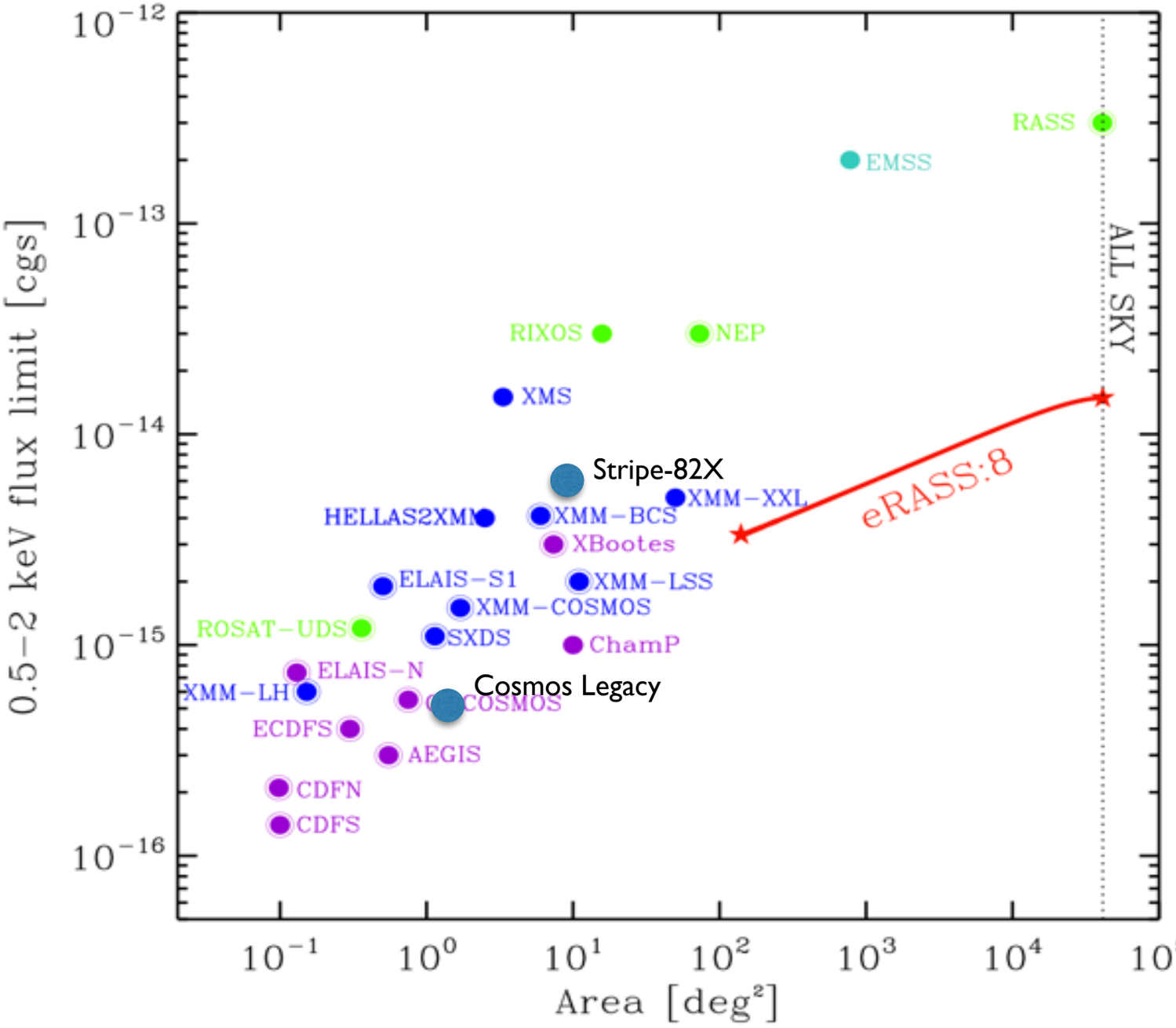


via SED fitting:
based on a grid of
templates+extinction+redshift

for galaxies see e.g.:
Bolzonella+00, Wolf+04, Ilbert+06,
Grazian+06, Dahlen+13 for a review

machine-learning: use a VERY large number of sources with precise redshift, to guess the redshift of sources with the SAME photometric set
(see e.g. Budavari+, results from SDSS collaboration, Brescia+, Cavuoti+…)

Easier for galaxies than for AGN!



XMM-COSMOS, C-COSMOS, Chandra-Legacy: Salvato+09, Salvato+11, Marchesi+15

AEGIS-X: Nandra+15

LH: Fotopoulou+12

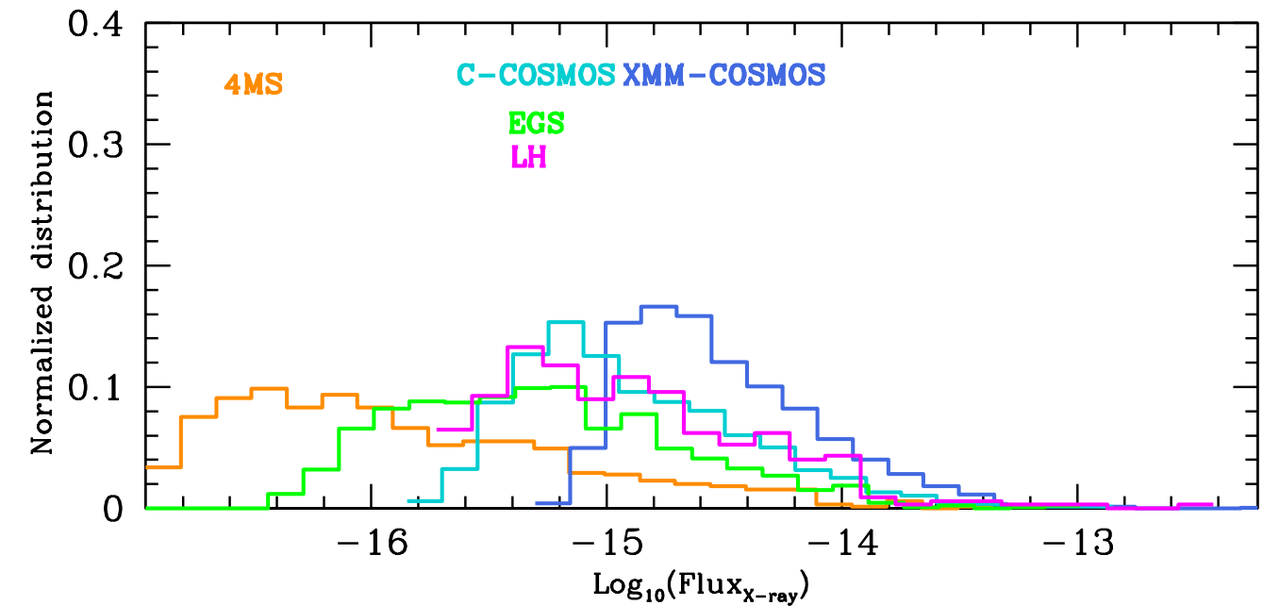
(E)CDFS: Hsu+14

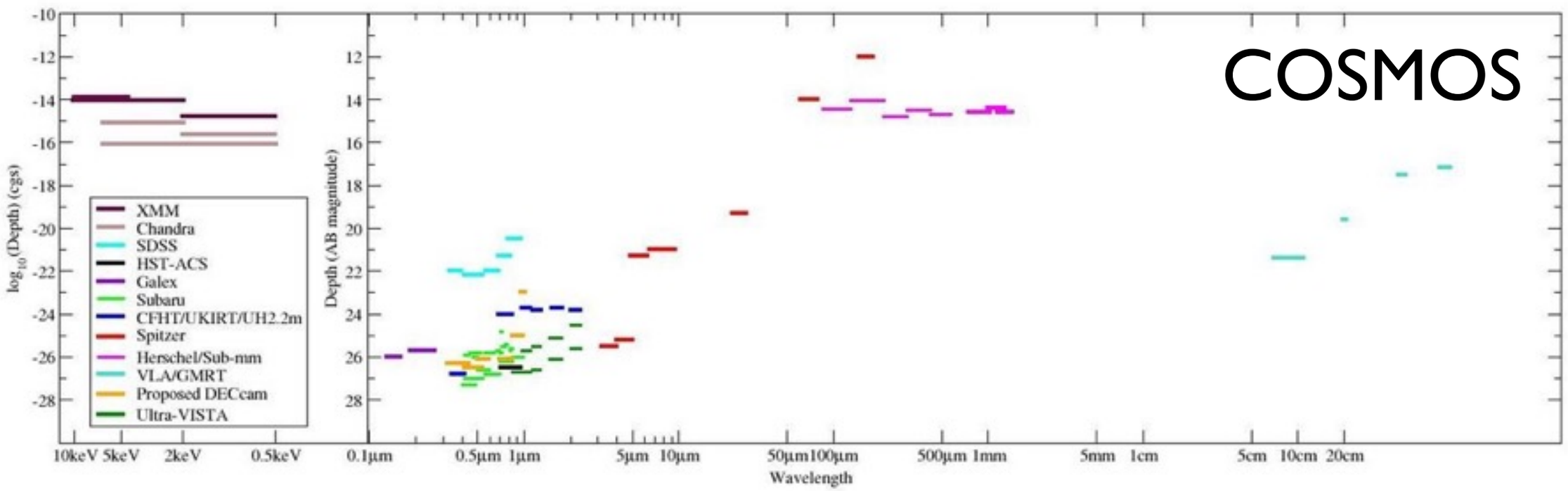
XMM-LSS: Melnyk+13

STRIPE-82X: Ananna+16

CDFN, XMM-XXL: started

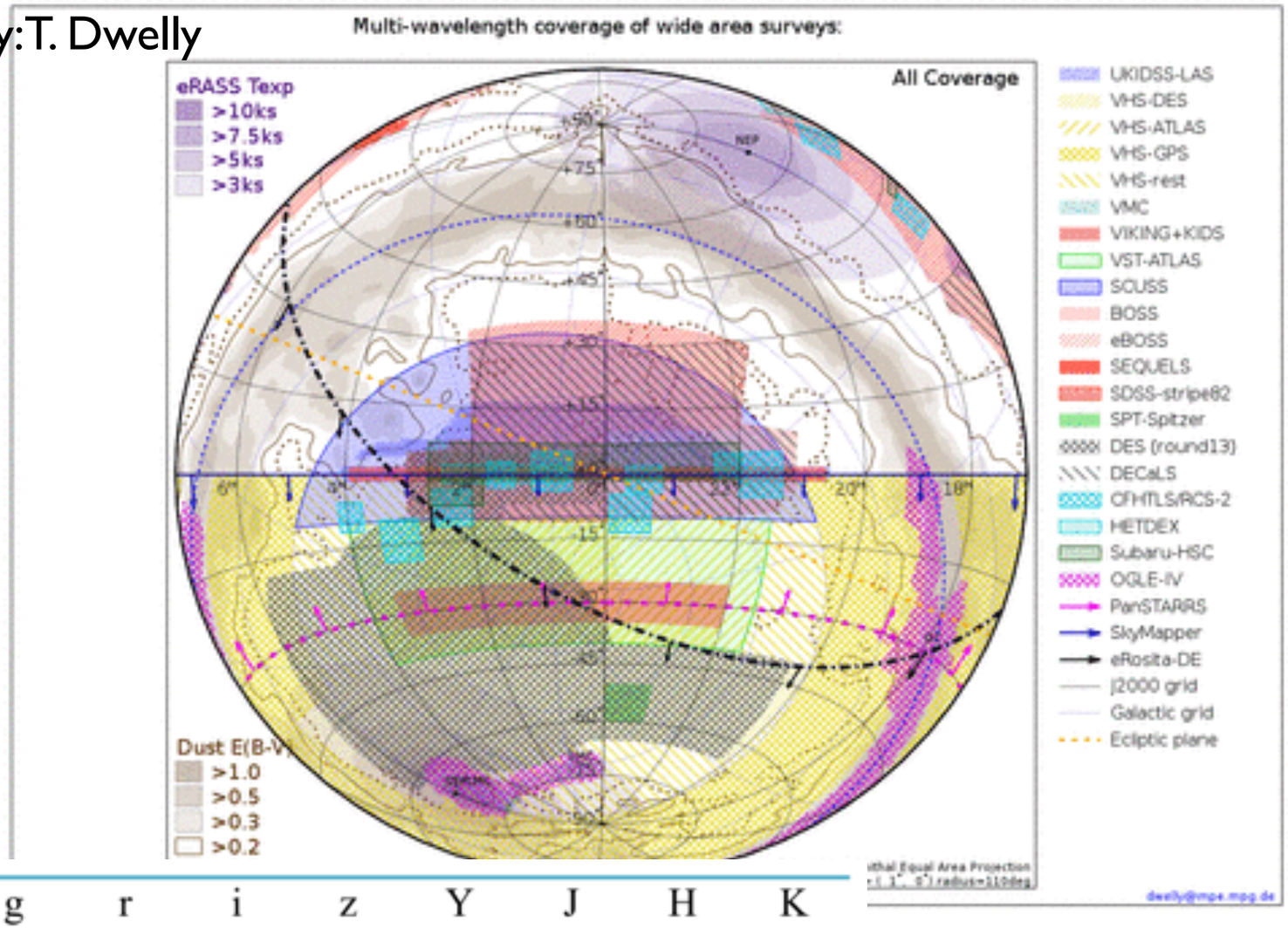
Lesson: every X-ray survey samples different population of AGN





Certainly not a COSMOS like survey!

Courtesy: T. Dwelly

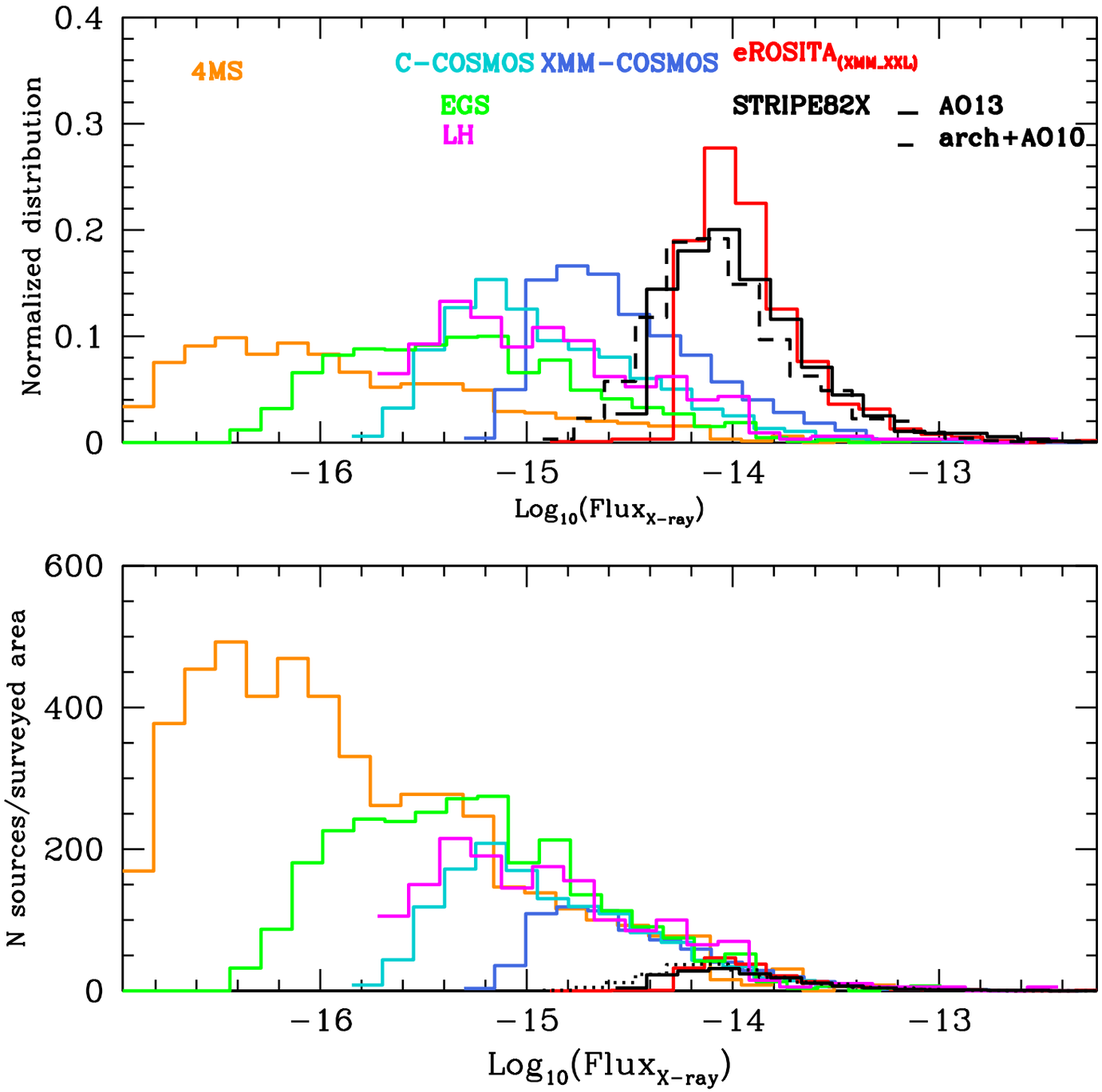


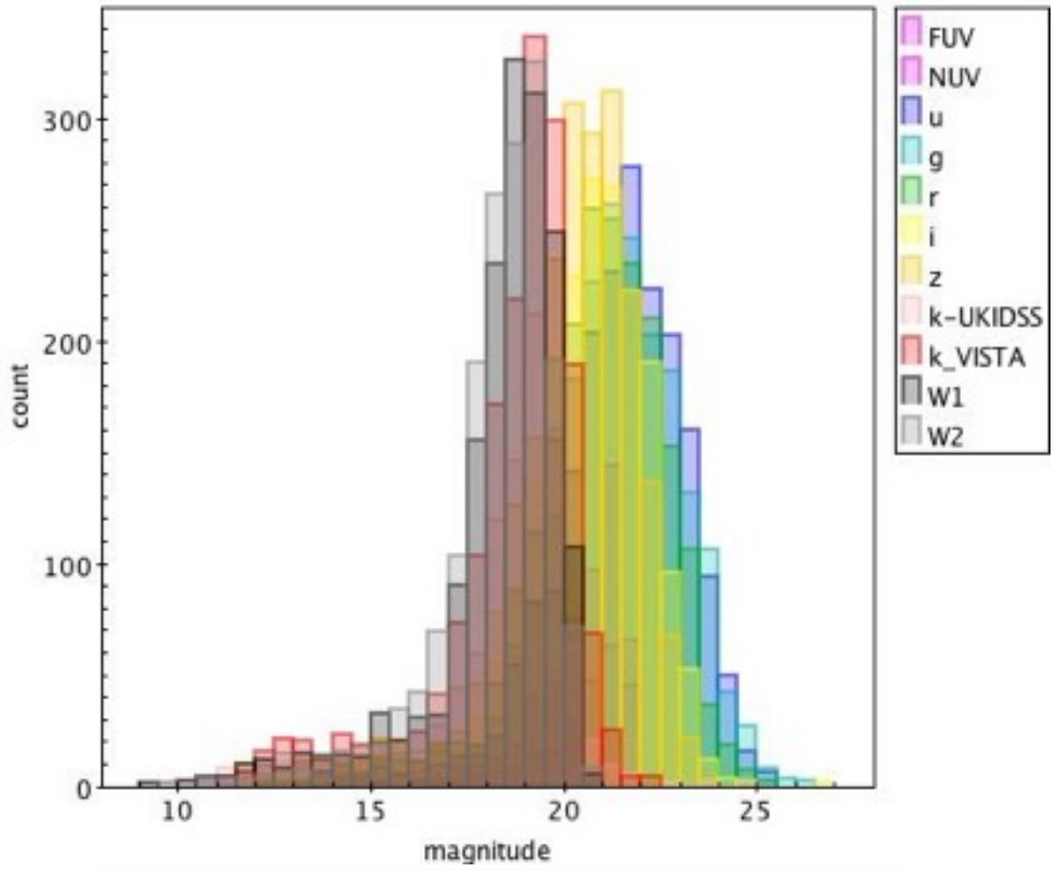
Survey	Lat	Date	Ω	u	g	r	i	z	Y	J	H	K
SDSS	+30	-‘10	10000	21.6	22.6	22.4	21.6	20.1	-	-	-	-
PS1	+20	’10-‘12	30000	-	22.6	22.4	22.1	21.1	-	-	-	-
SkyMapper	-30	11-	30000	21.5	22	22	21	20	-	-	-	-
KIDS+VIKING	-20	11-	1500	24.8	25.4	25.2	24.2	22.4	21.6	21.4	20.8	20.5
DES+VHS	-30	’12-‘16	5000	-	24.6	24.1	24.3	23.8	21.5	20.2	20.1	19.5
ATLAS+VHS	-20	11-	4500	22.0	22.2	22.2	21.3	23.8	21.5	20.5	19.9	19.3
HSC	+20	’12-‘16	1500	-	25.5	25.2	25.5	24.3	23.3	-	-	-
PS2	+20	14-	10000	-	24.5	24.5	24.5	24.5	-	-	-	-
GAIA	-	‘13-	41253			20						
Euclid	-	’19-‘24	15000			24.5			24.0	24.0	24.0	-
LSST	-30	’20-‘30	18000	24.0	26.0	26.0	26.0	26.0	26.0	-	-	-

+WISE
&
GALEX

adapted
from Merloni+12

Using STRIPE-82X as proxi for eROSITA





Less photometric points, shallower, non homogenized data: this is the future

Same approach used for previous surveys does not work

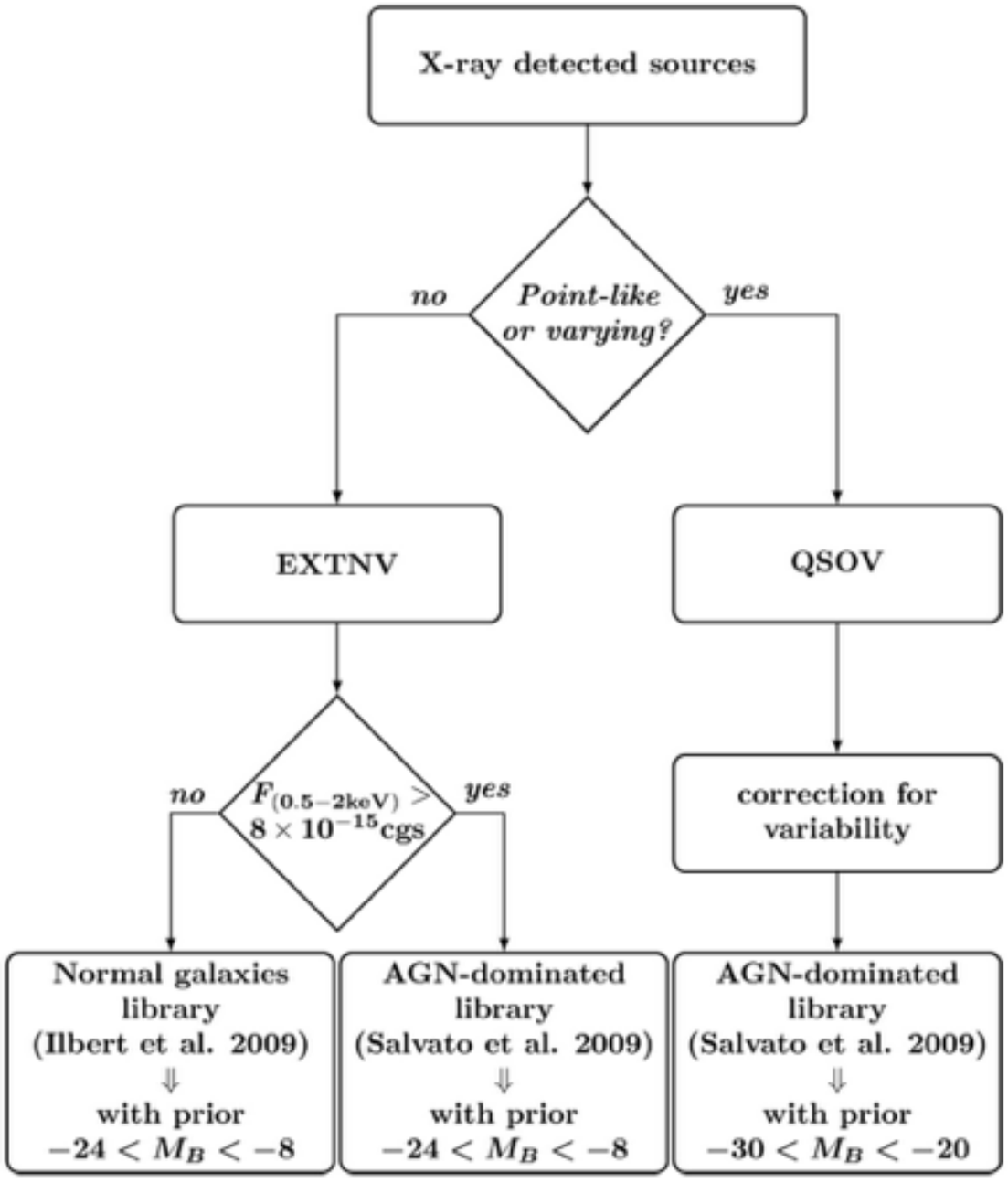
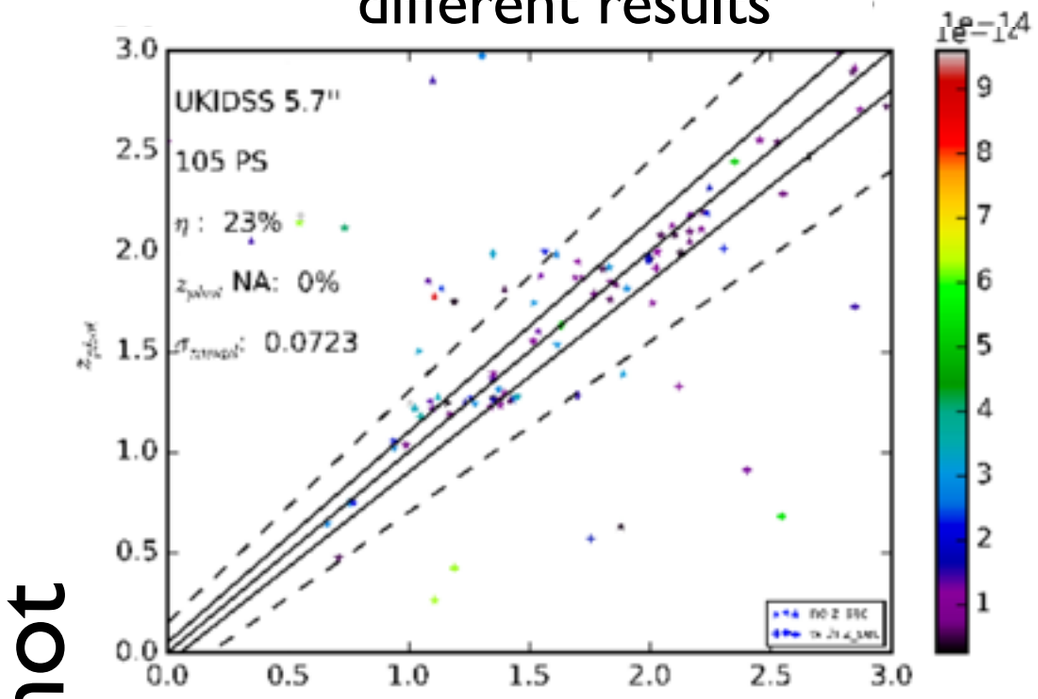
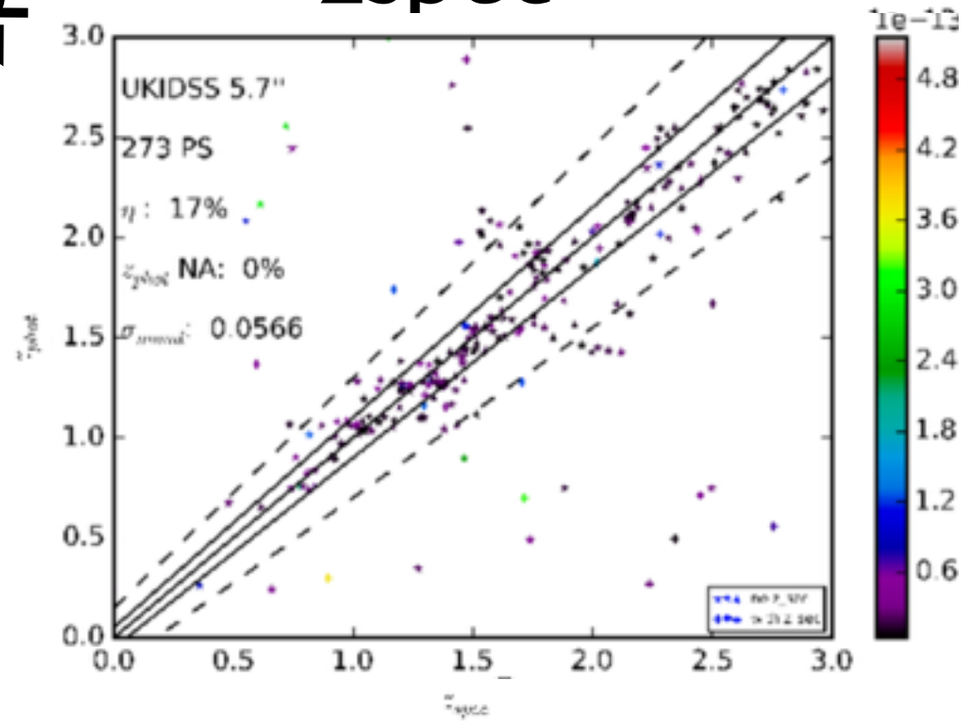


Figure 8. Flow chart of the procedure adopted to compute photo-z for X-ray-detected sources.

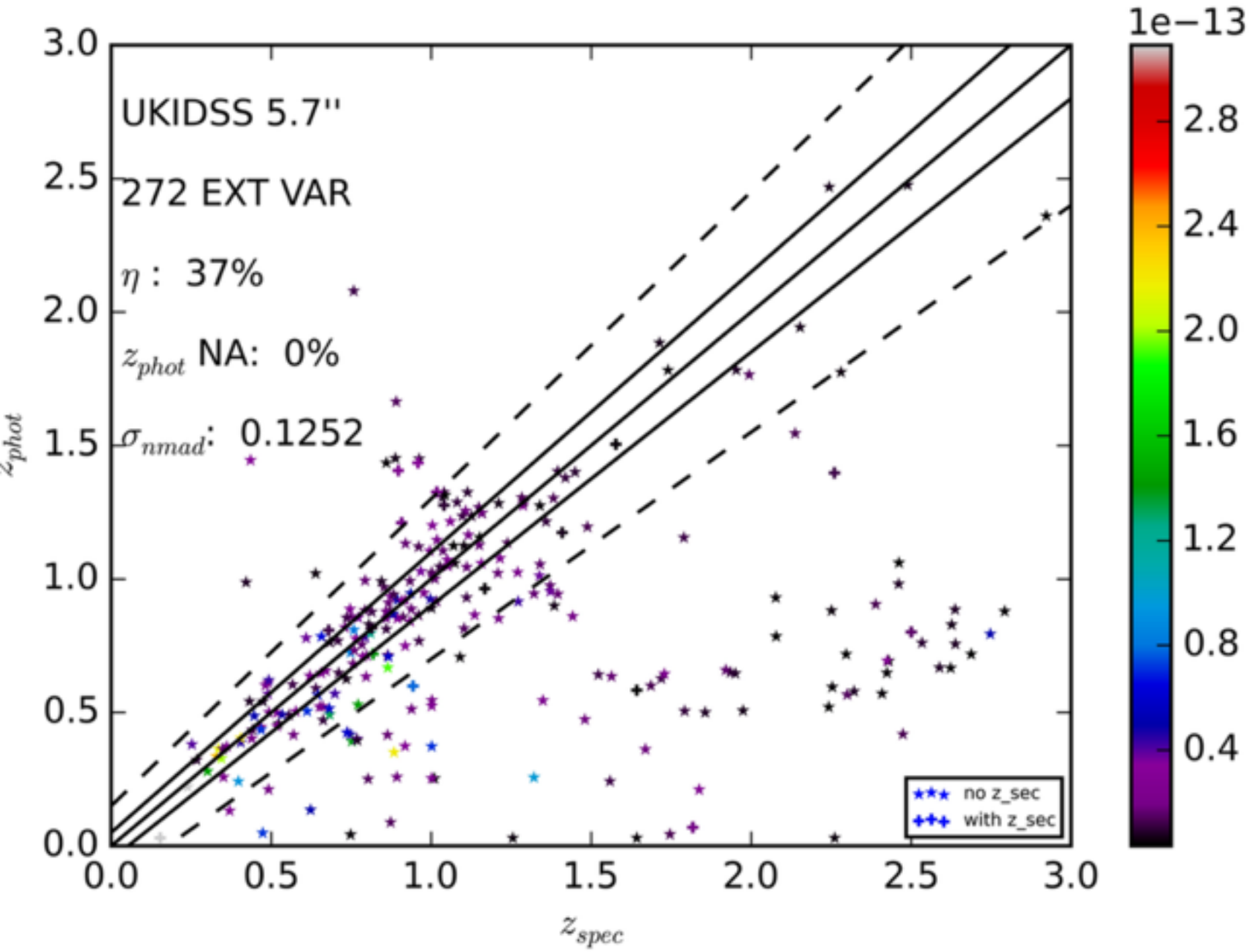
Salvato+09, Salvato+11

different library,
different results





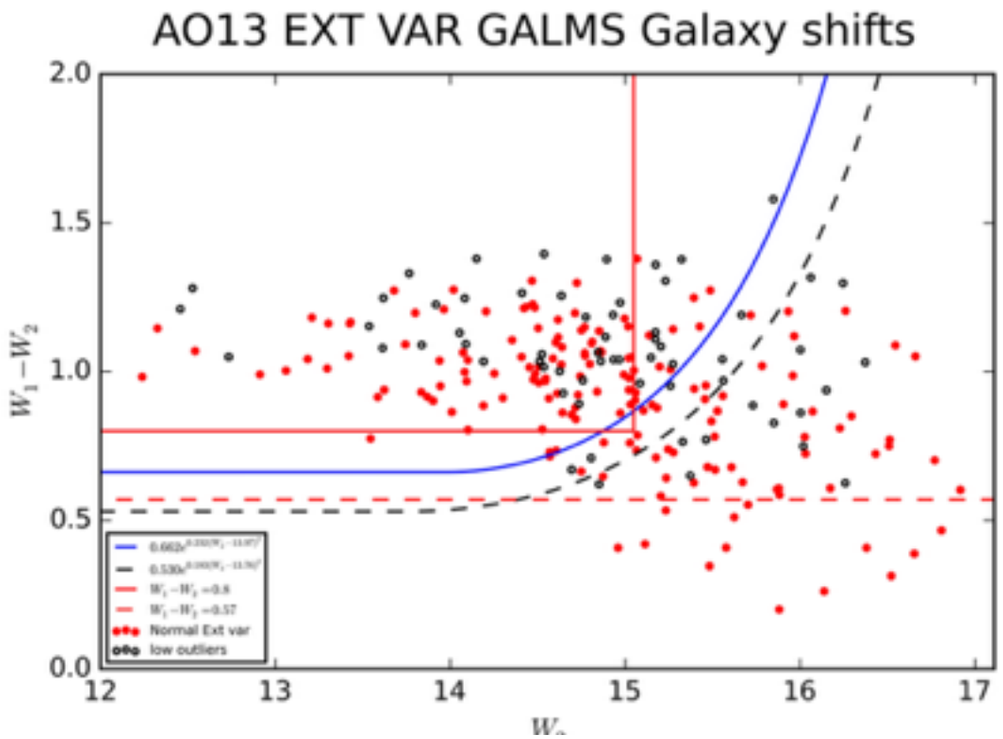
Morphological analysis on ground-based data is an issue. And P(z) will not help!



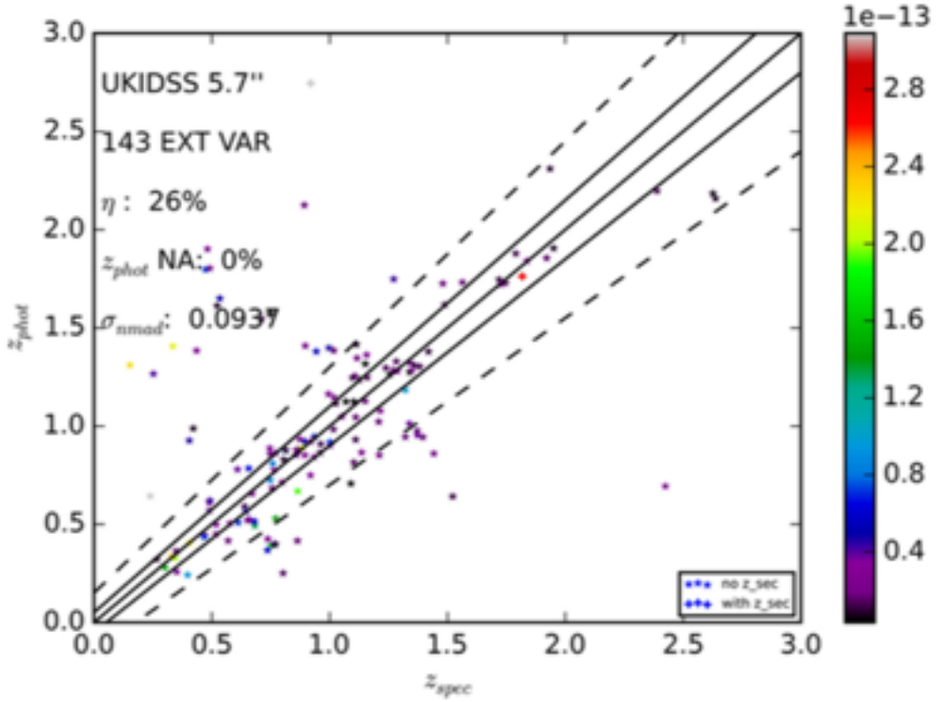
Hsu+14: 30% of point-like sources in HST are classified as "extended" in ground images

Figure 2: GALMS, extended varying, mag absolute between -8 and -24

Then change strategy, from scratch



We are getting there!
work in progress
(Ananna+16)



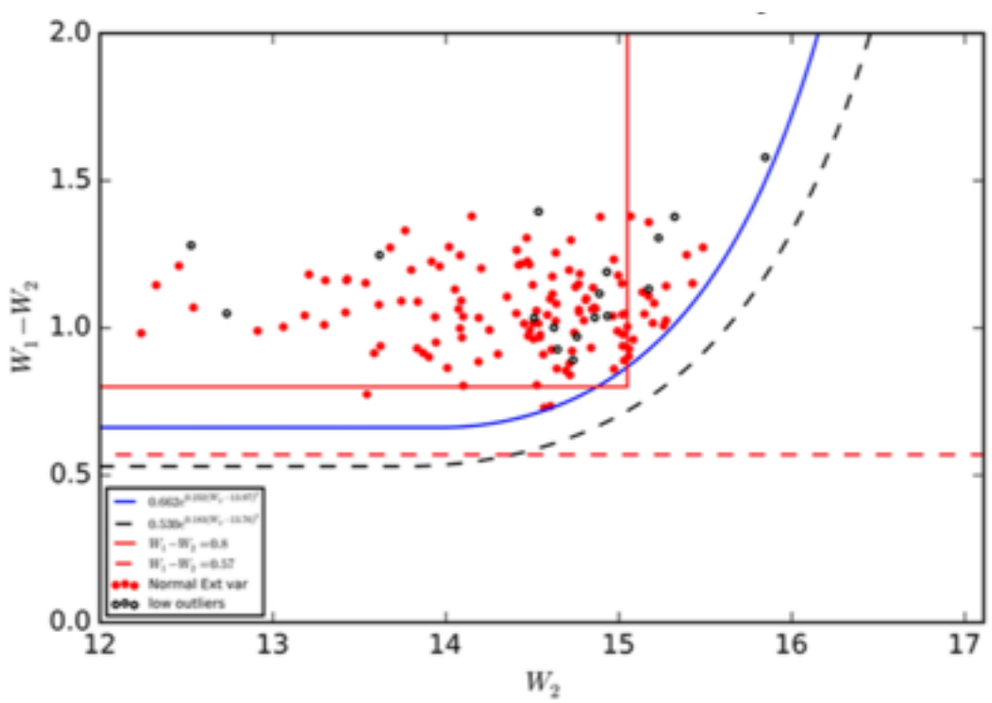
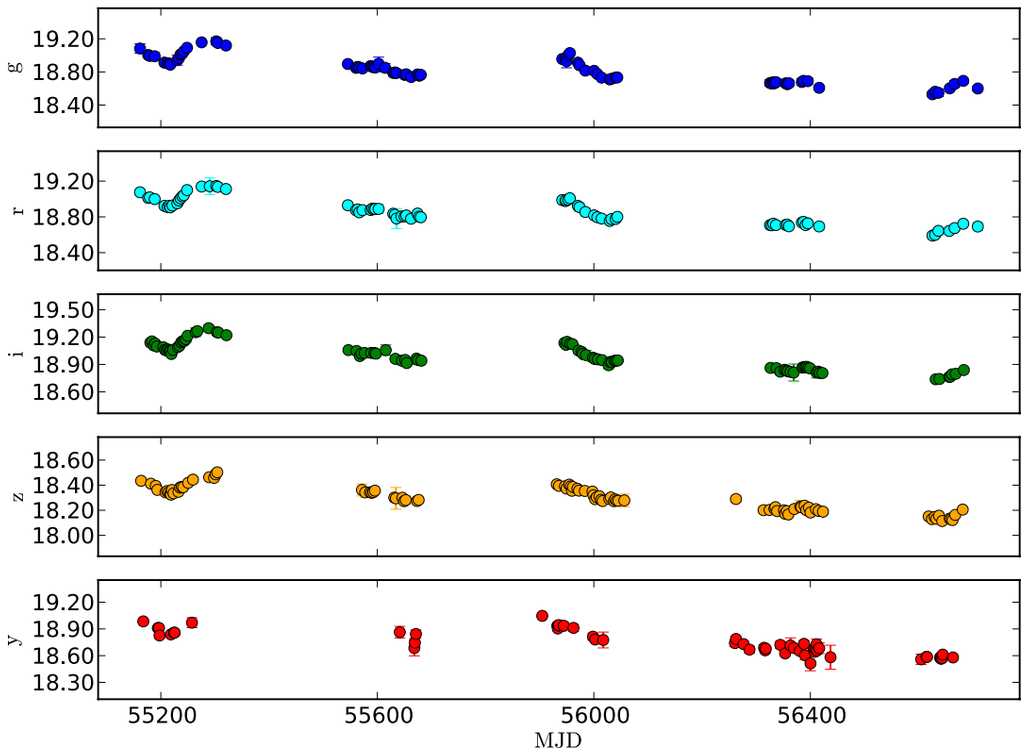
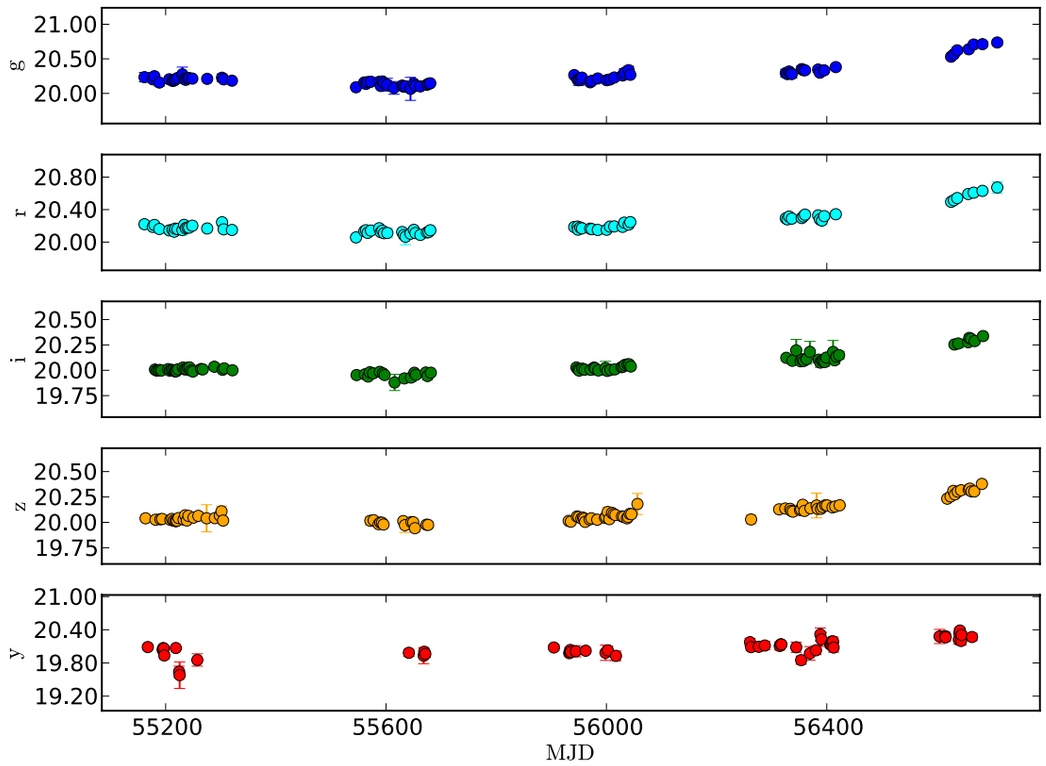


Figure 2: GALMS, -20 to-30, galaxy shifts

Variability will also be an issue

~25% of point like, isolated XMM-COSMOS sources are varying in at least one band, in Pan-STARRS

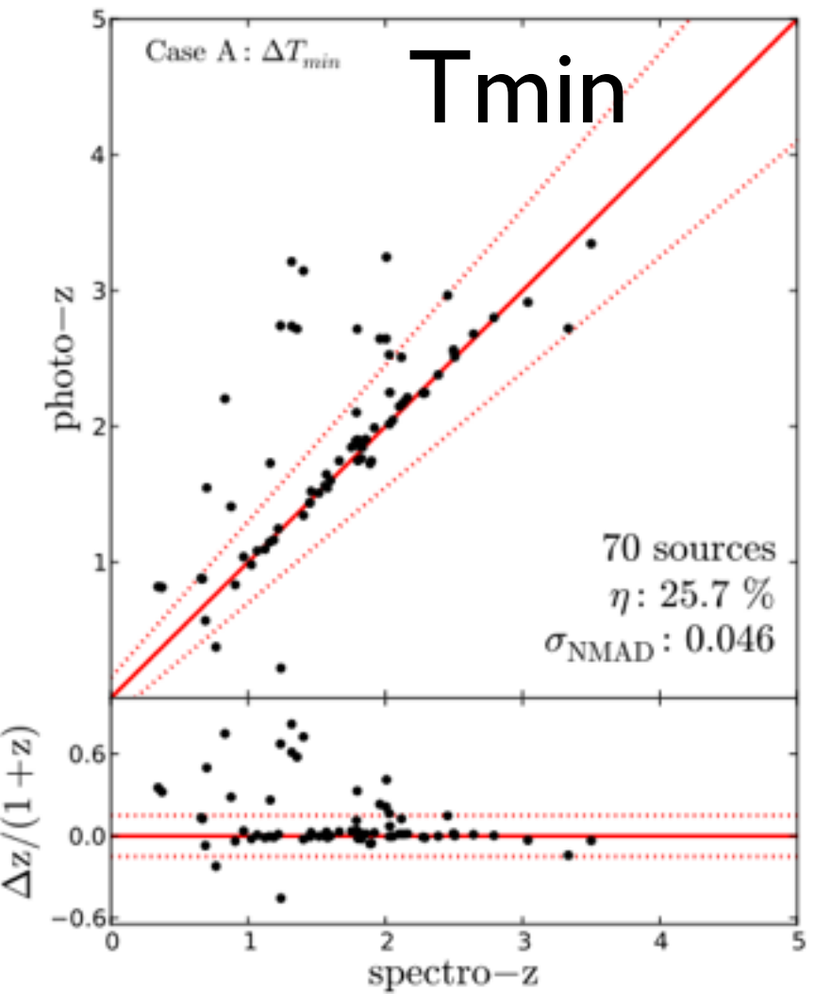




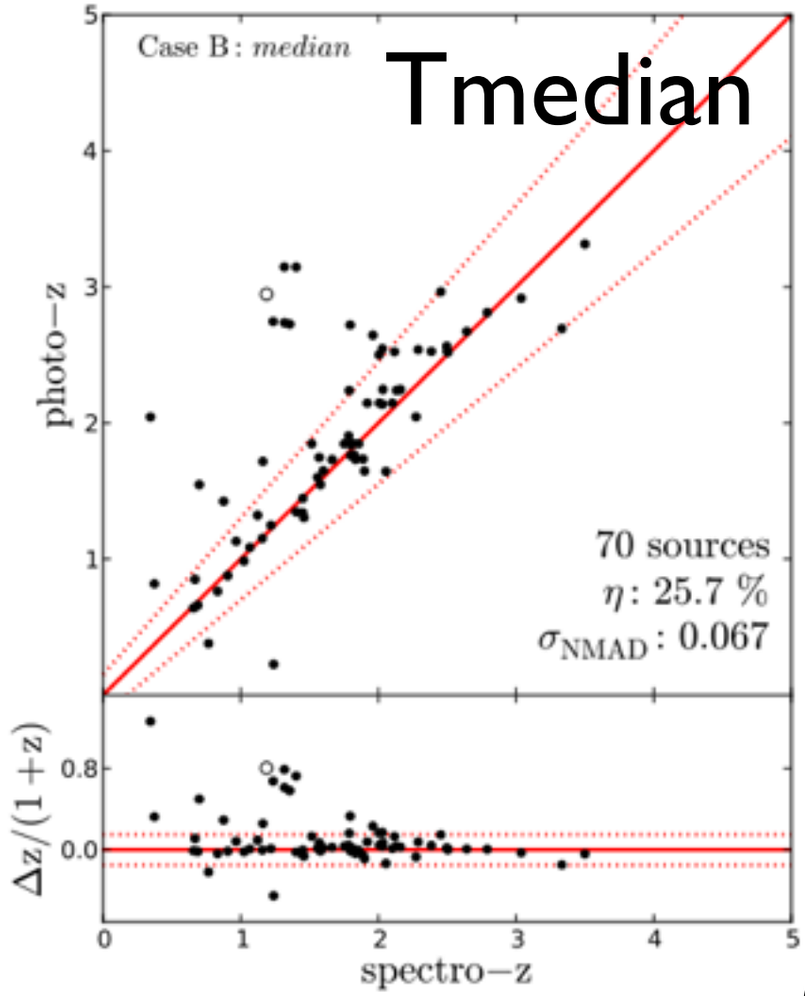
Simm+15a

Assembling data over years: bad idea…

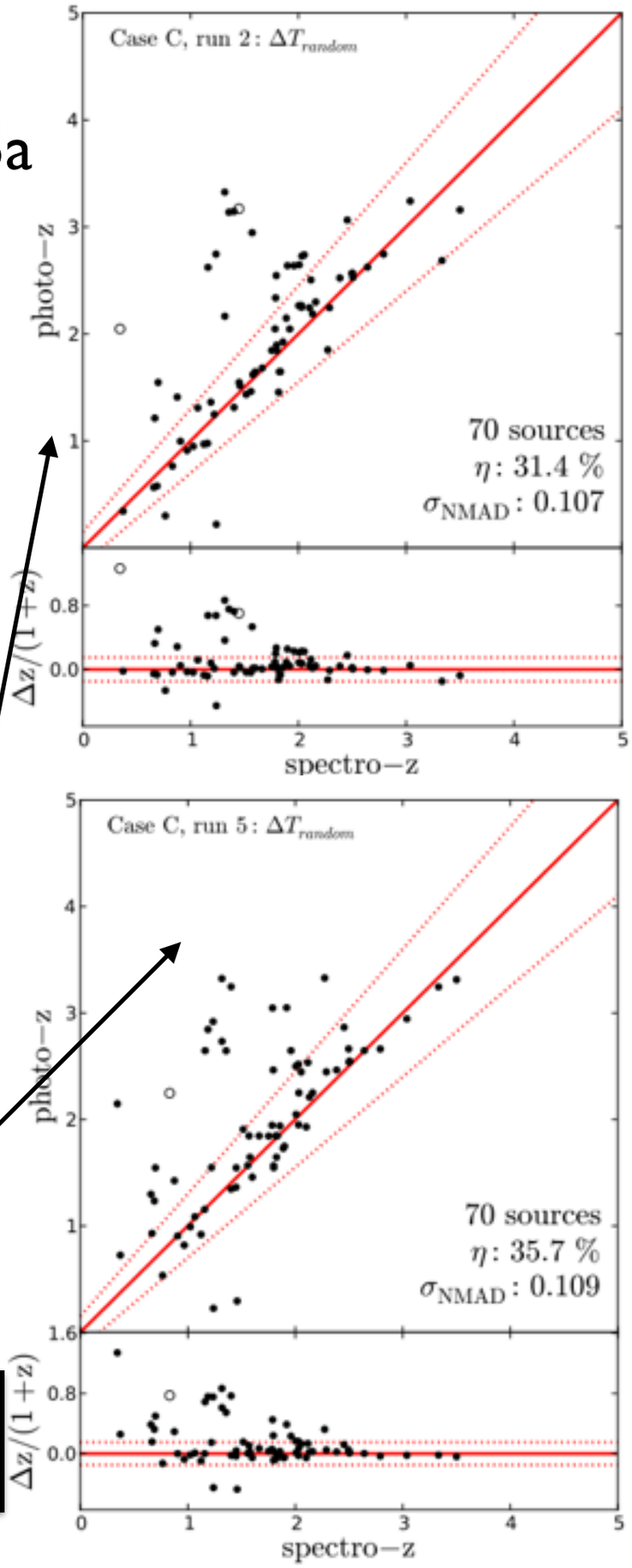
Simm+15a



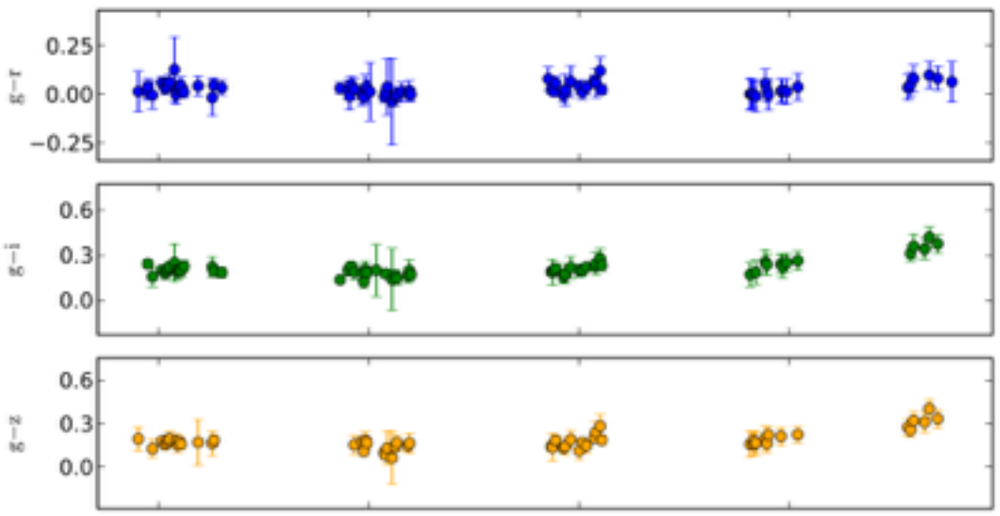
Tmin



Tmedian

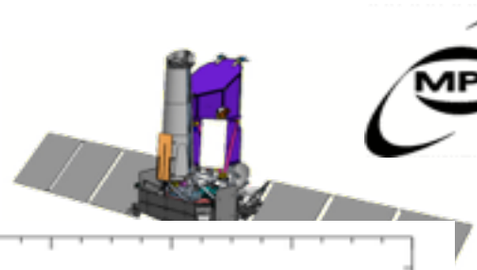


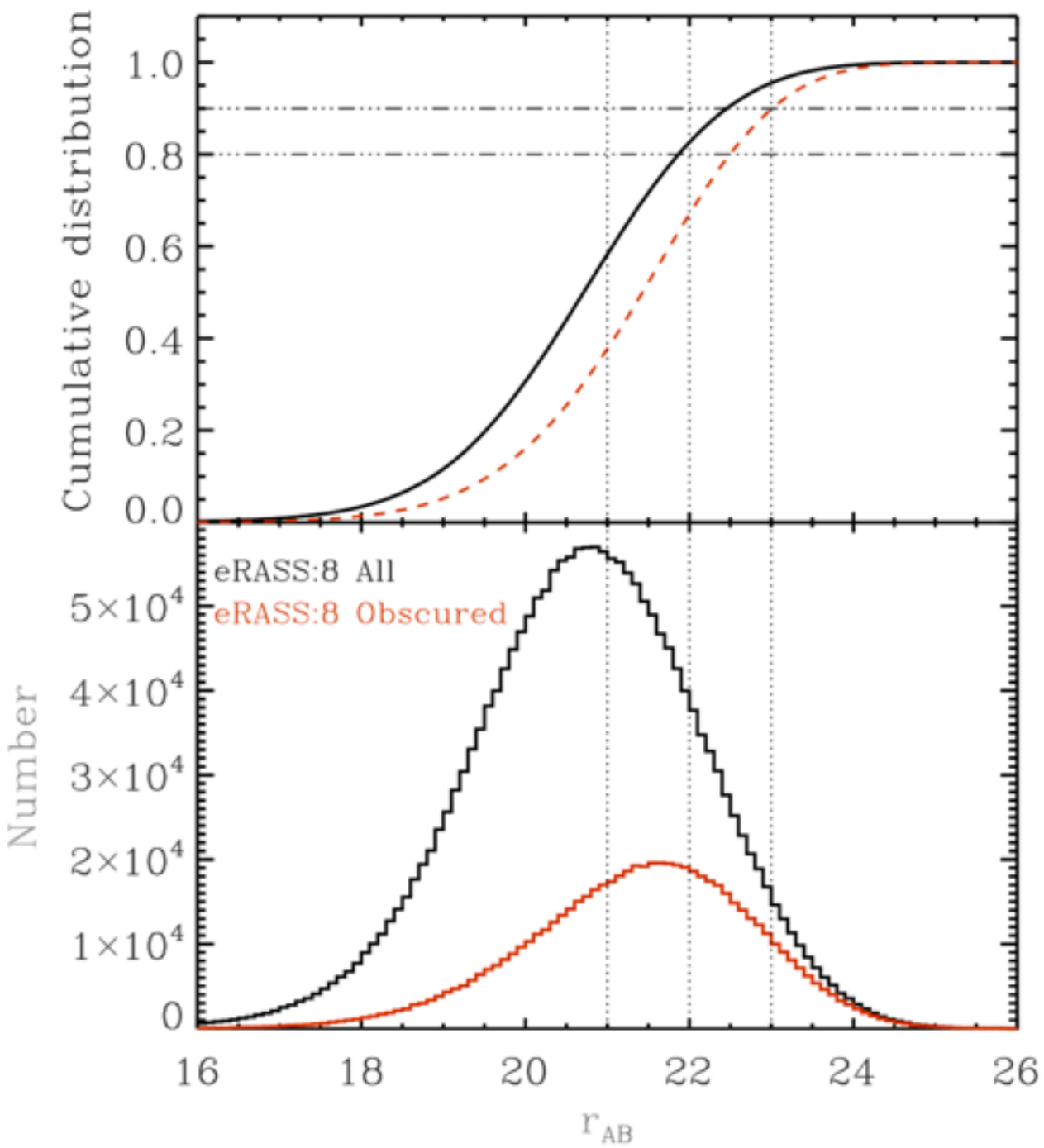
Trandom



Unless is LSST

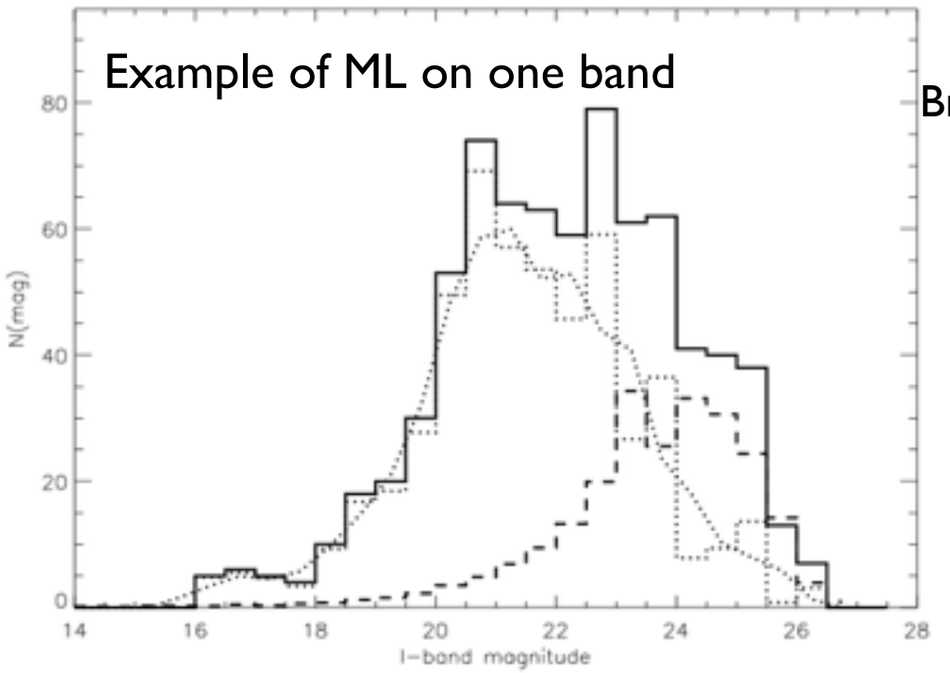
… but do we know which is the right counterpart?



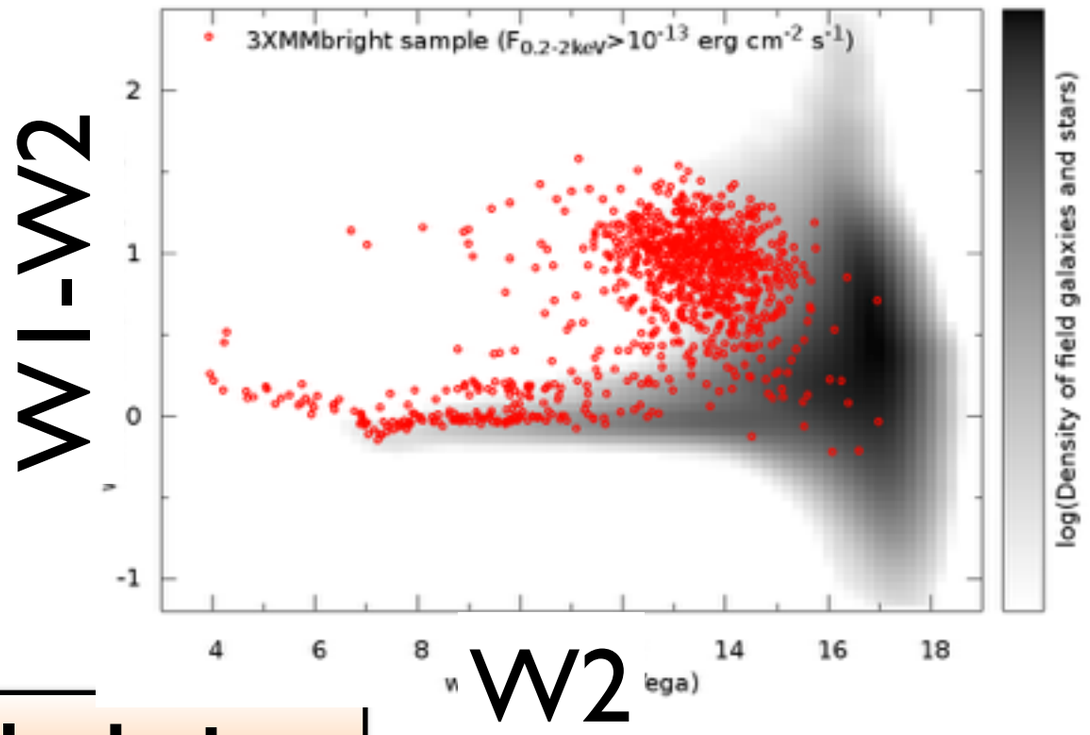


Example of ML on one band

Brusa+07



See also Sutherland&Sanders98, Ciliegi+02, and more



We tend to not use all what we already know!

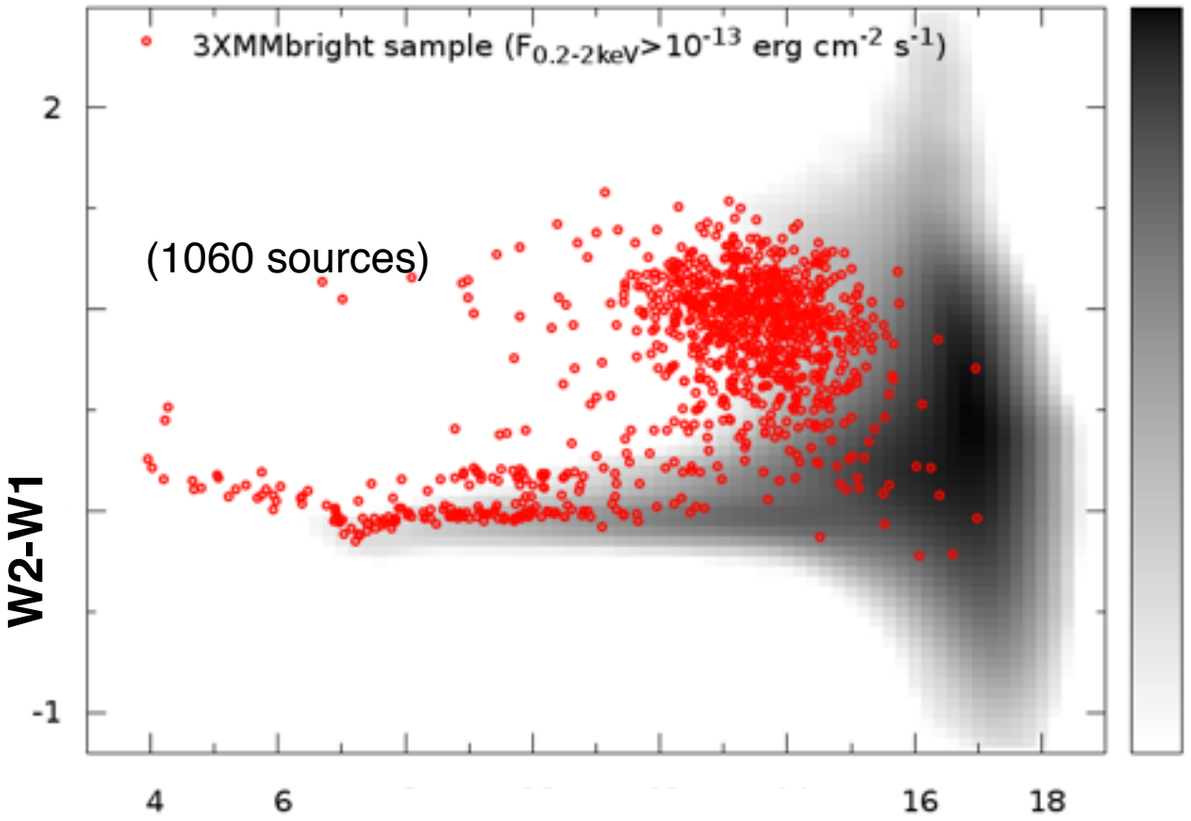
X-ray to multi-wavelength association

Salvato, Buchner + 2015

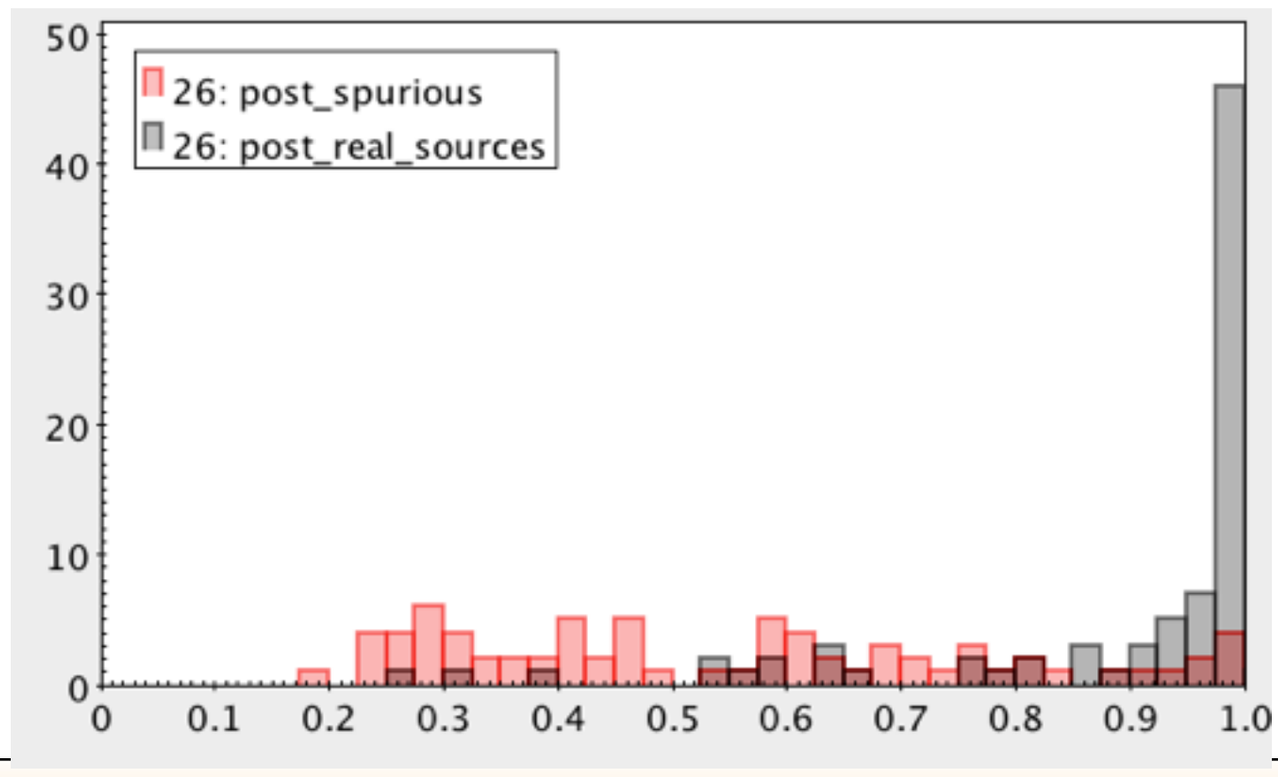
See also Pineau+ for ARCHES

- eROSITA positional error improved on ROSAT but still not optimal for a easy multi-wavelength association

- New code:
- based on Budavari & Szalay (2008) expression of Bayesian approach on distance
- applicable to **N catalogs simultaneously,** with the
- possibility to use **PRIORS (Magnitude, colors…)**



See Yan+11, Stern+12, Assef+ , LaMassa+13 etc, for different WISE representations



Estimated reliability ~90%,

- Release of all-sky 2RXS WISE ctps.
- including post value for estimating spurious X-ray detection

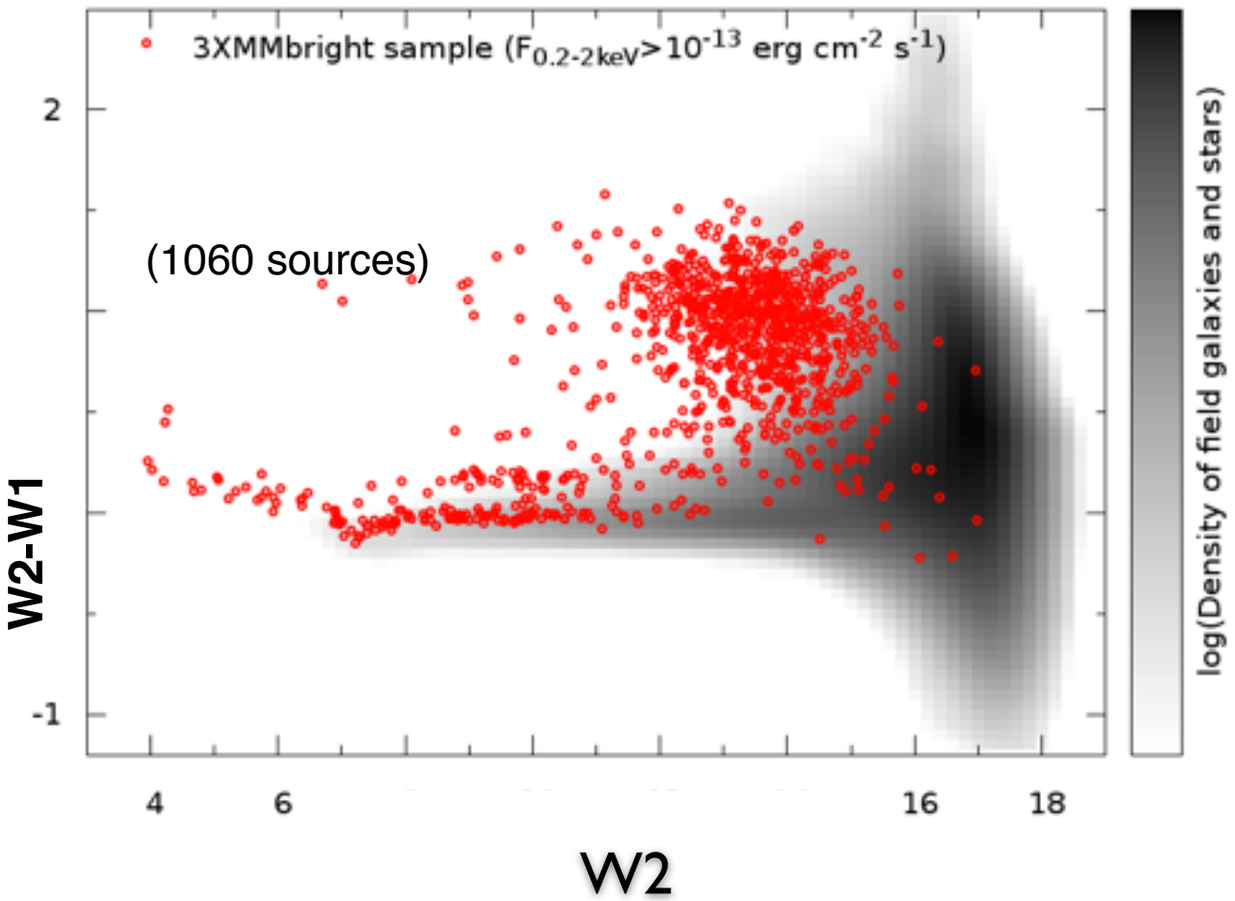
X-ray to multi-wavelength association

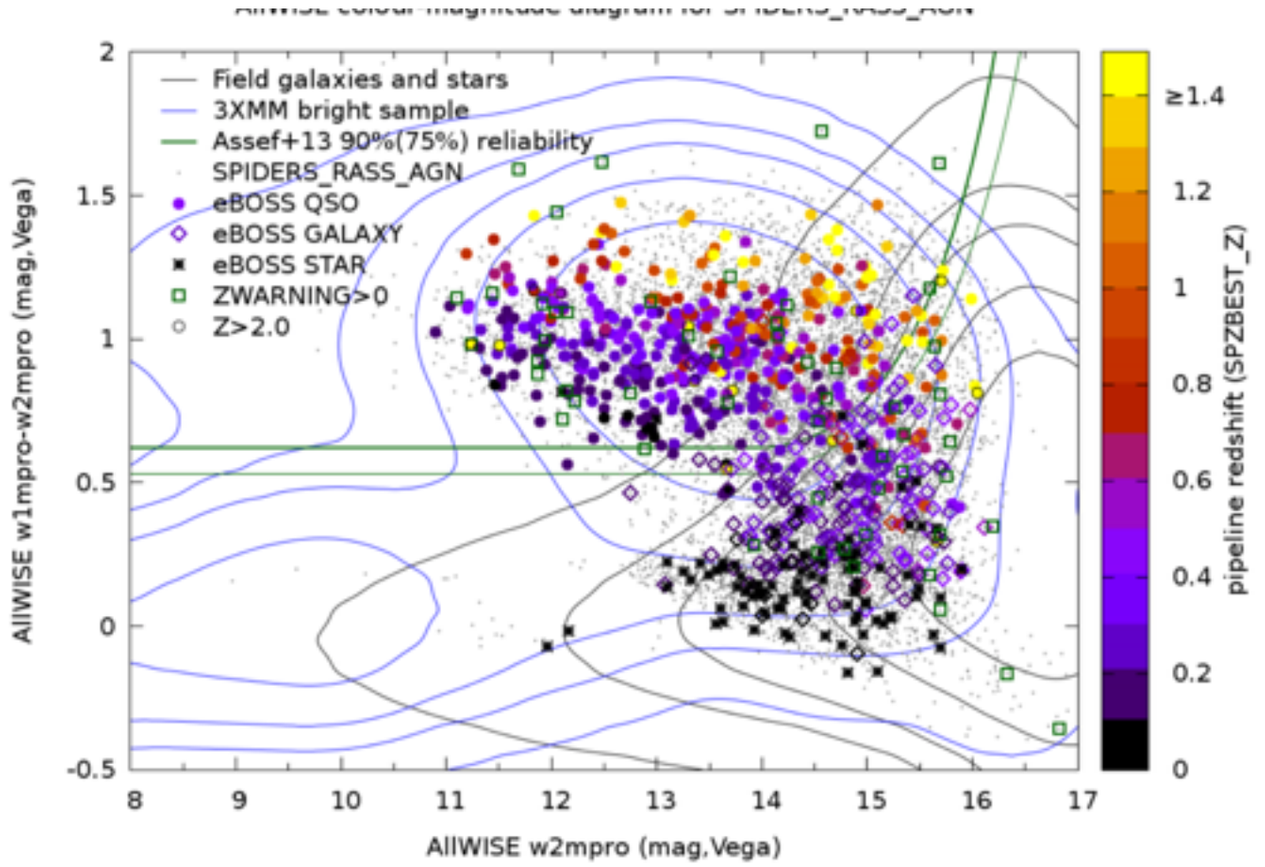
Salvato+ 2015
Dwelly+ 2015
See also Pineau+ for ARCHES

- eROSITA positional error improved on ROSAT but still not optimal for a easy multi-wavelength association

- New code:
- based on Budavari & Szalay (2008) expression of Bayesian approach on distance
- applicable to **N catalogs simultaneously,** with the
- possibility to use **PRIORS (Magnitude, colors…)**

11643 ROSAT ctp in DR12
- 9026 QSO
- 240 AGN
- 2200 GAL with Em.Lines
- 280 Stars

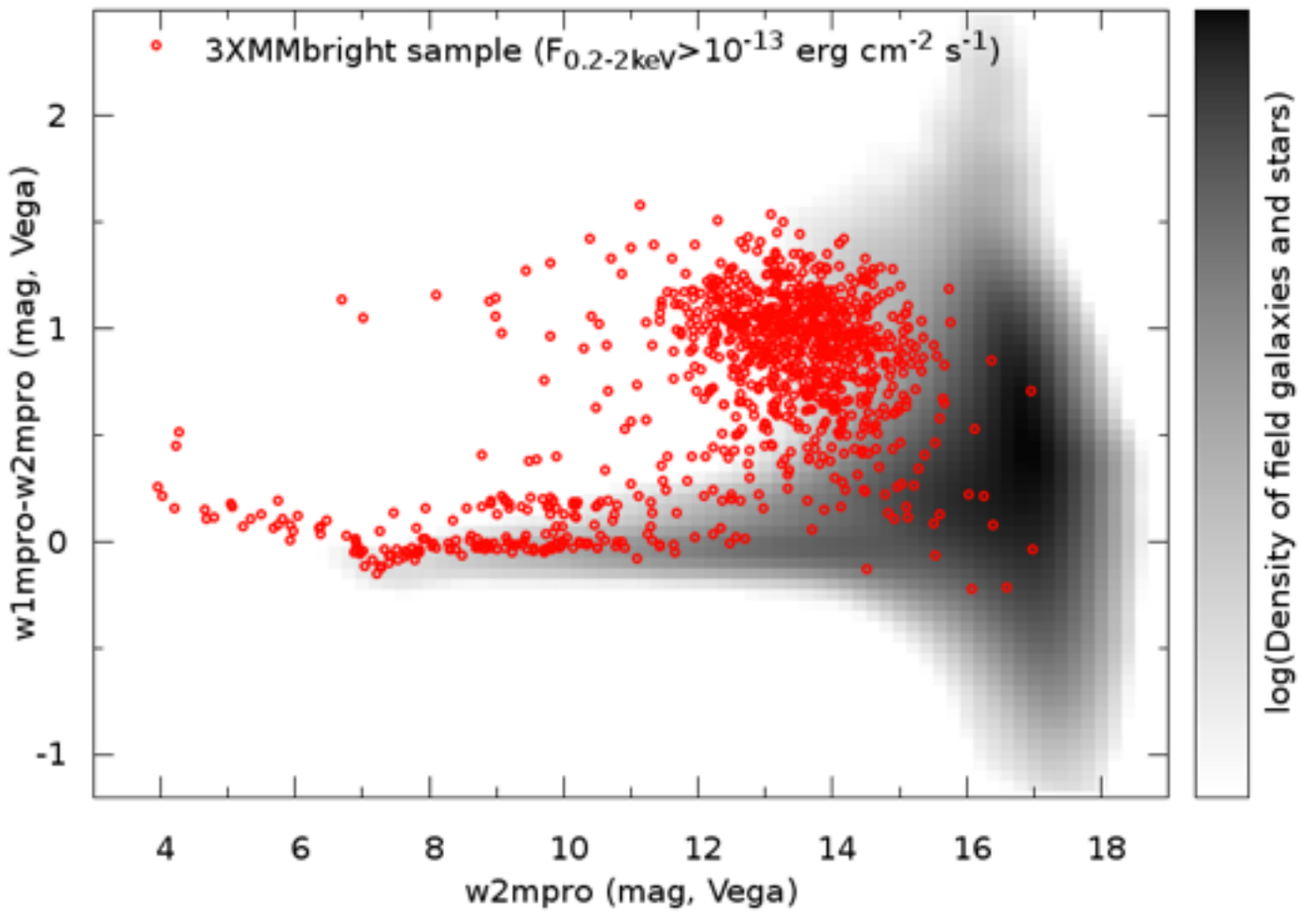




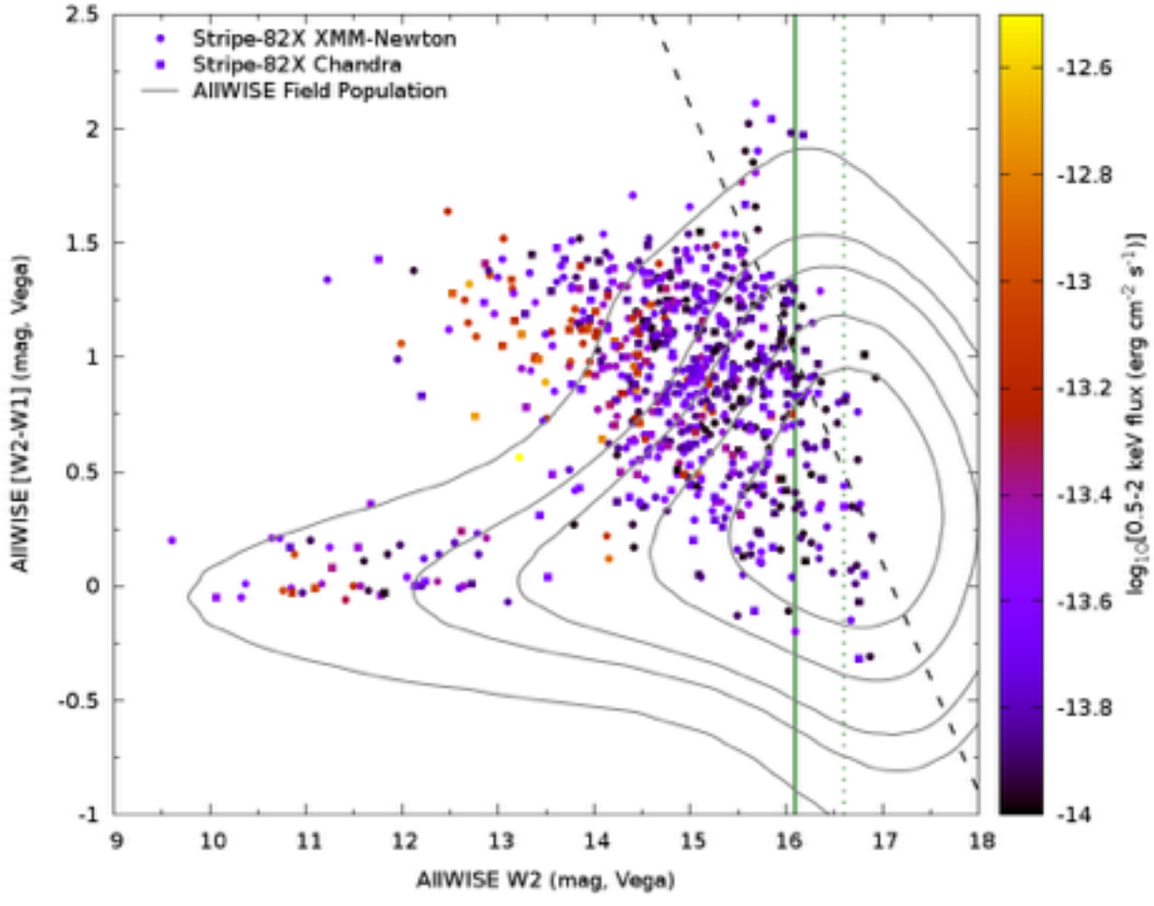
See Yan+11, Stern+12, Assef+ ,
LaMassa+13 etc, for different WISE representations

Association getting more difficult from eRASS:1 to eRASS:8

ROSAT



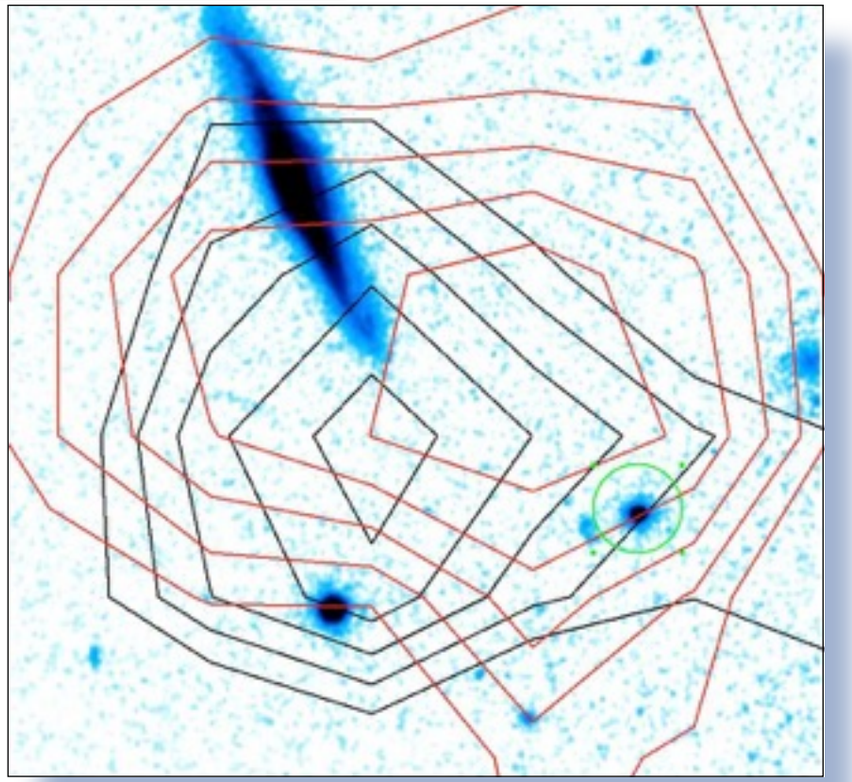
eROSITA

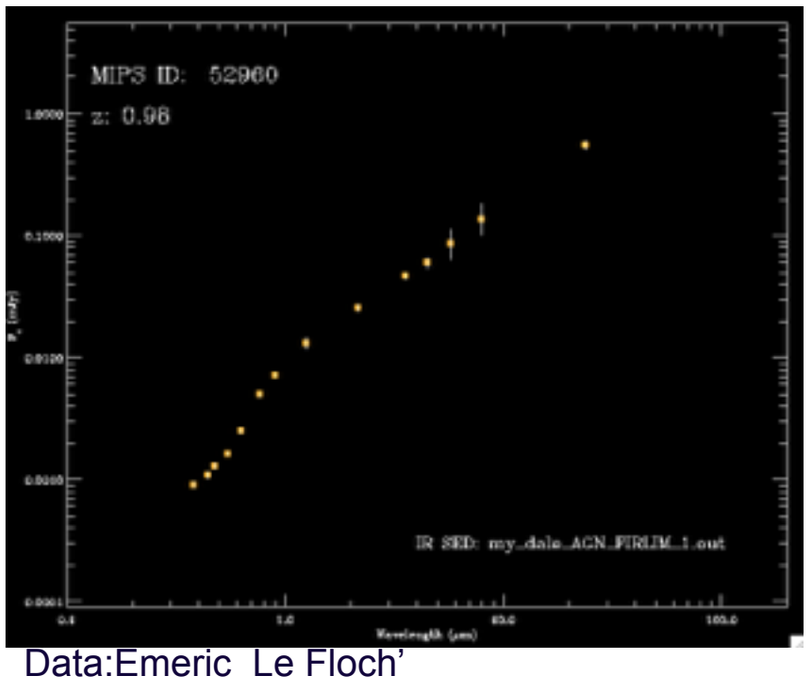


WISE gets too shallow for eROSITA: we need to find other priors for increasing the probability to get the right counterpart:

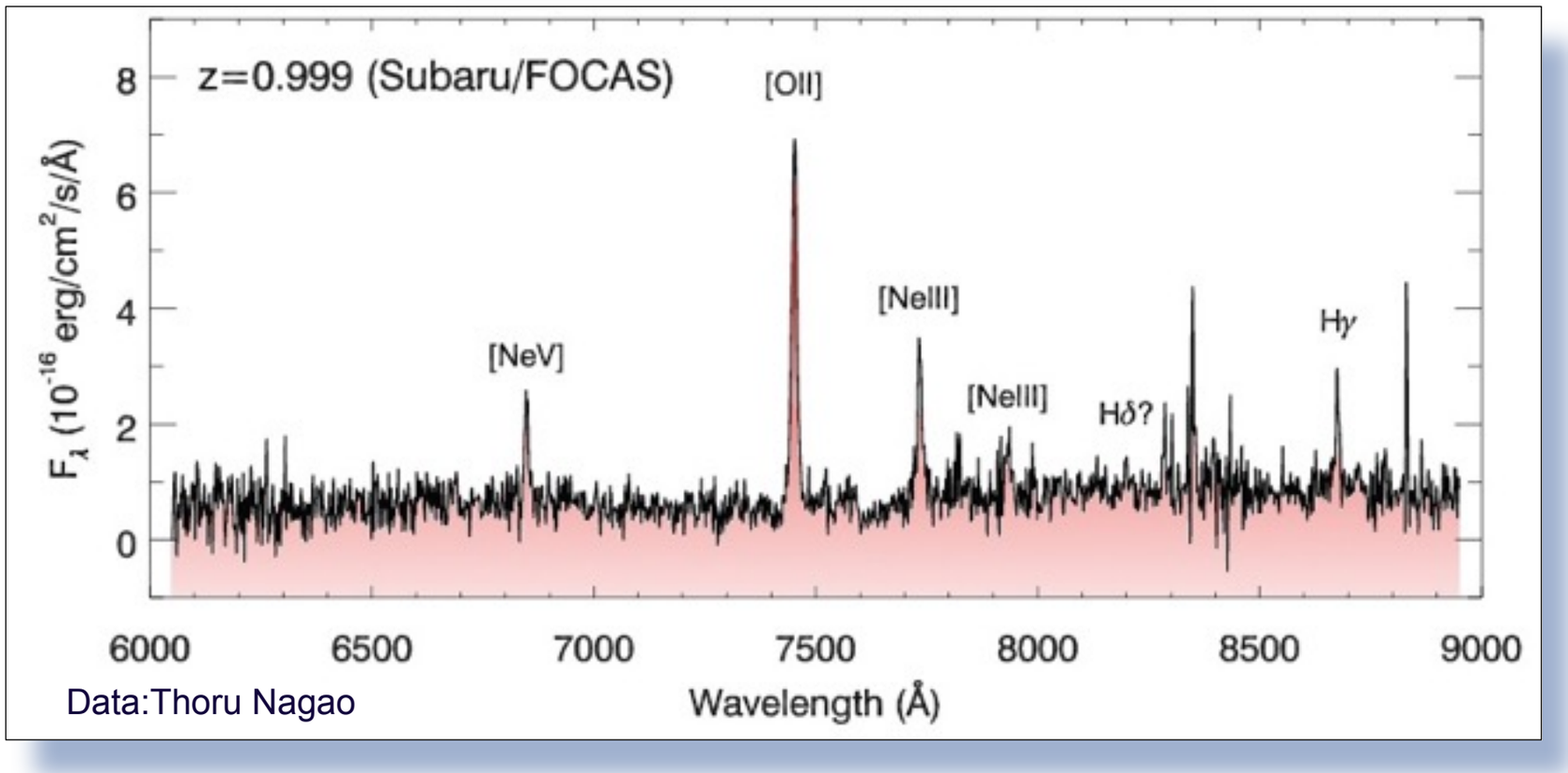
<u>P.S.:What will we do for Athena???</u>

Resolution will be a problem as well





Data:Emeric Le Floch'



Data:Thoru Nagao

The Summary

eROSITA(2017+) and later ATHENA(2028+)
will deliver samples of AGN large enough to study evolution as a function various properties, from z, to, L, N_H, M_*, SFR

However, we need to prepare for the challenges:

1)identify the counterparts
2)measure the redshift
3)decompose the SED

For you : There are opportunities for developing new methods: get involved!

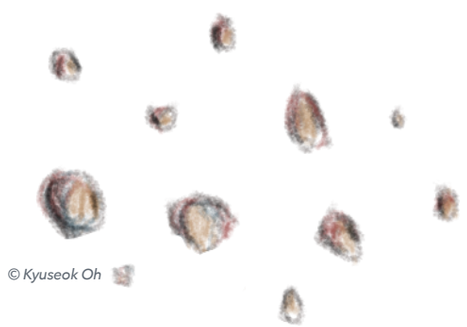
THE X-RAY VIEW OF BLACK HOLE ACTIVITY IN THE LOCAL UNIVERSE

17 - 19 Feb. 2016

ETH ZURICH, SWITZERLAND

http://sites.google.com/site/xrayuniverse2016/

SOC MICHAEL KOSS (ETHZ, chair)
KEVIN SCHAWINSKI (ETHZ)
ANDREA COMASTRI (INAF OABO)
DAN STERN (NASA JPL)
FIONA HARRISON (CALTECH)
FRANZ BAUER (PUC)
MARA SALVATO (MPE)
MEG URRY (YALE)
NEIL GEHRELS (NASA GSFC)
POSHAK GANDHI (SOUTHAMPTON)



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Swiss Federal Institute of Technology Zurich

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FONDO NAZIONALE SVIZZERO
SWISS NATIONAL SCIENCE FOUNDATION

ETH black hole group

Active Galactic Nuclei: what's in a name?

To be held at ESO, Garching, June 27 – July 1, 2016

SOC: *Evanthia Hatziminaoglou* (ESO), *Ryan Hickox* (Dartmouth), *Lisa Kewley* (ANU),
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