Counterparts determination and classification in the all-sky surveys era

M. Salvato

with: Johannes Buchner, Tamas Budavari, Tom Dwelly, Andrea Merloni,
Marcella Brusa, Sotiria Fotopoulou, Arne Rau, and more

OUTLINE

★ What the ALL-SKY surveys can do for you (the case for WISE and GAIA)

★ Surveys are not ALL (a.k.a why we needed, e.g., NWAY)

★ application to ROSAT/2RXS and XMMSLEW2

★ Physical properties of the counterparts

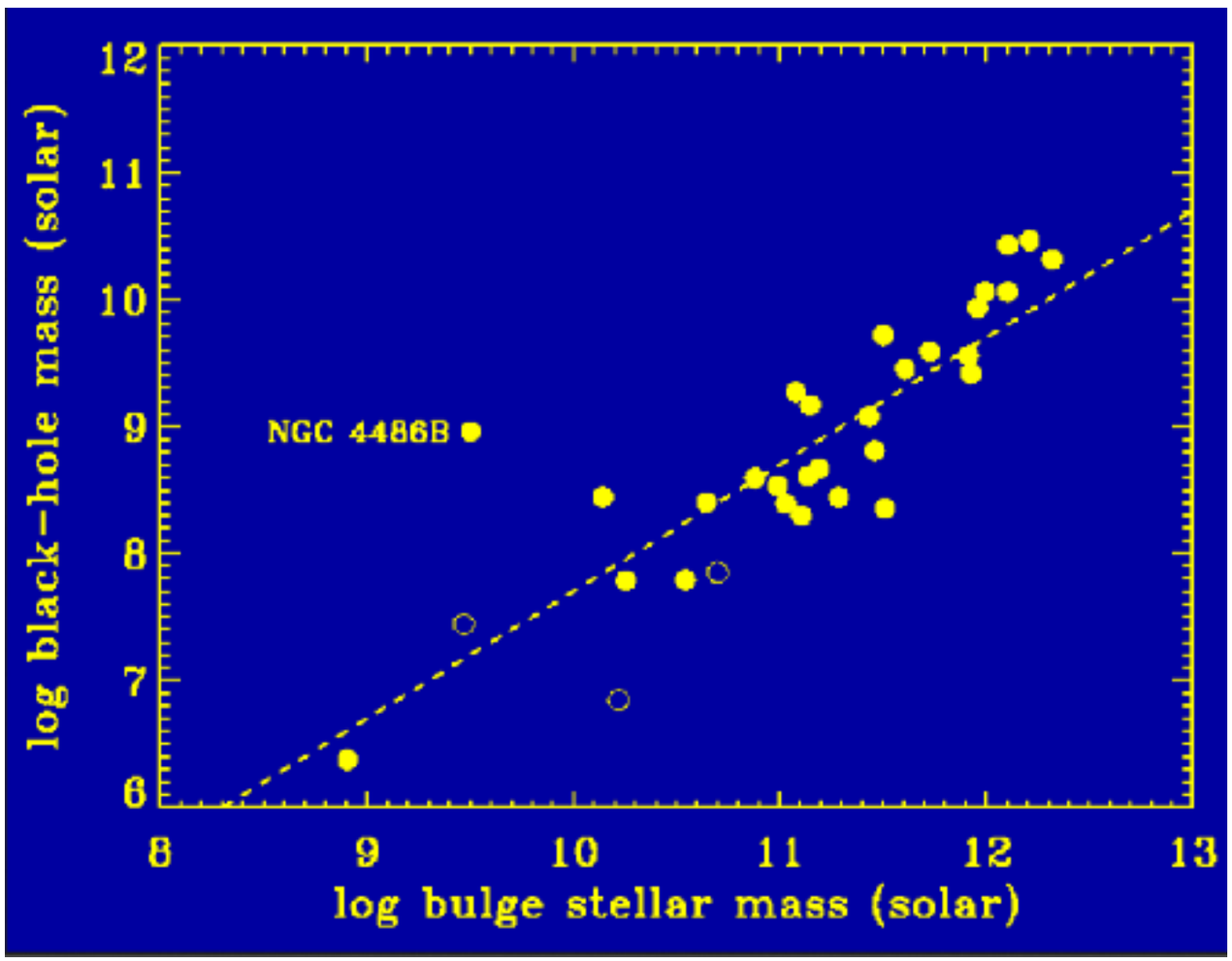
★ Another reason why you want ALL-SKY surveys (a.k.a. photoz!)

★ The power and the risks behind priors (also in view of eROSITA)

AGN: just interesting or actually important ?

BOTH, ACTUALLY!

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



Magorrian+98, Kormendi&Richstone95, Nuker team

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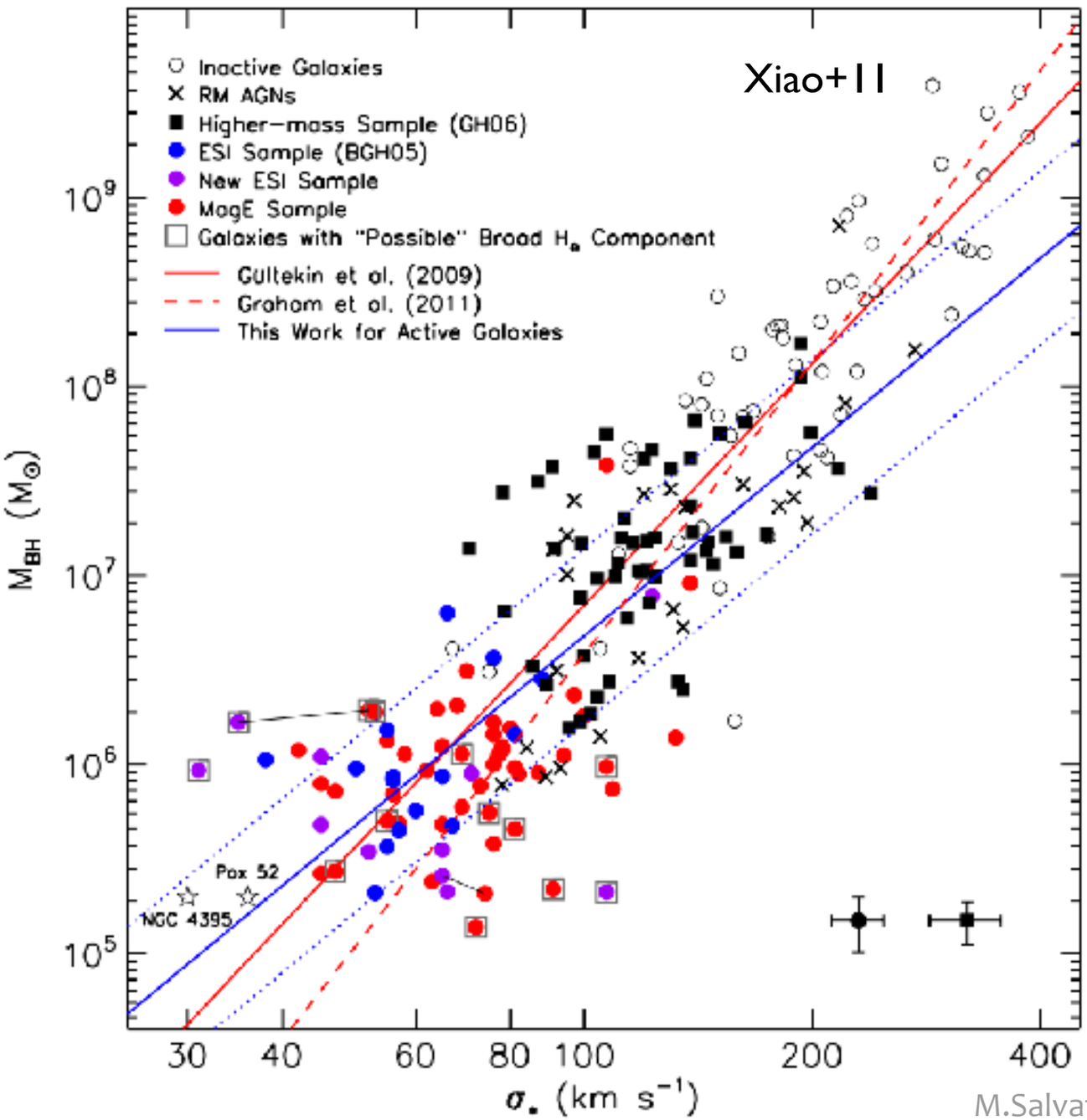

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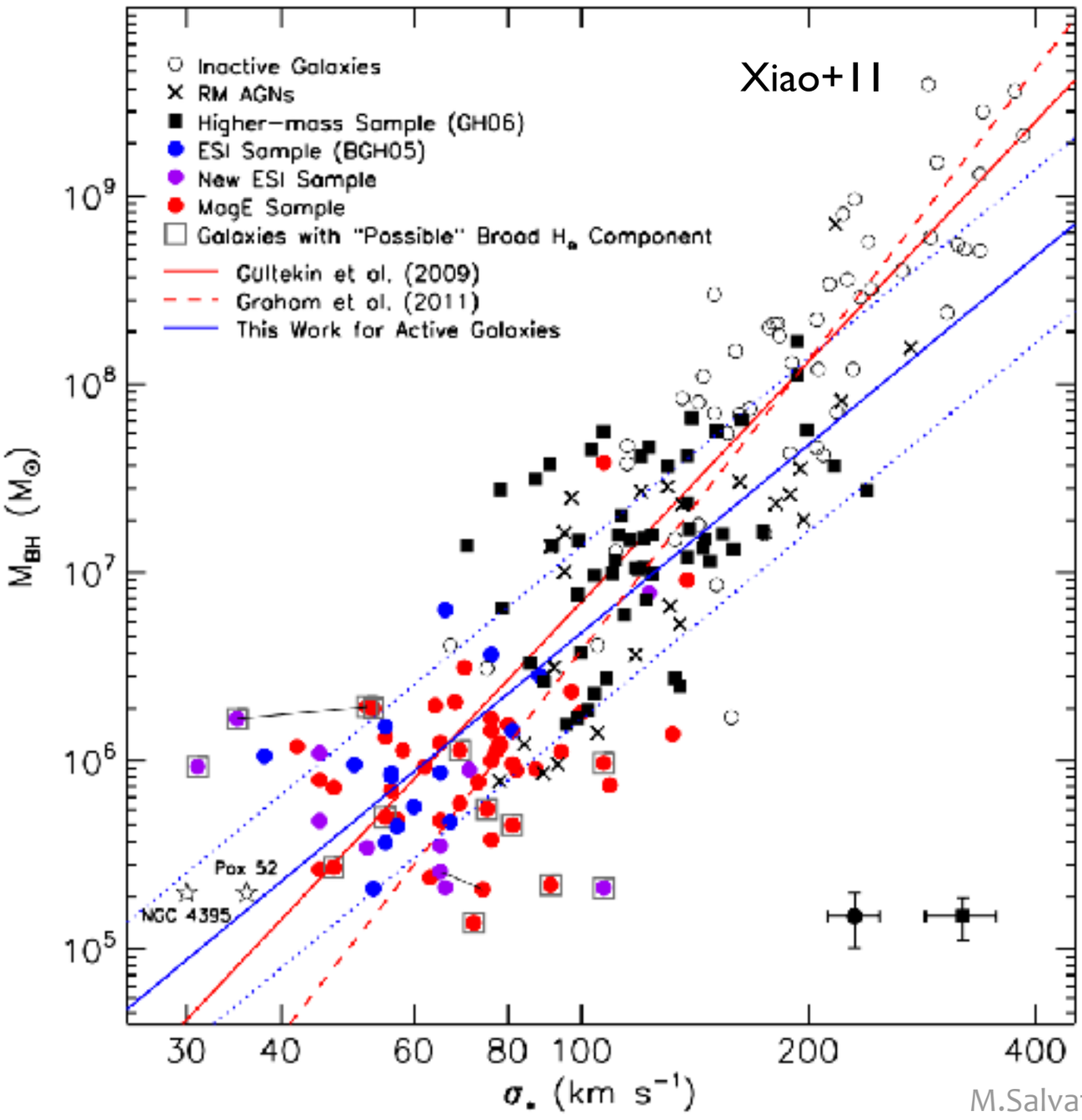
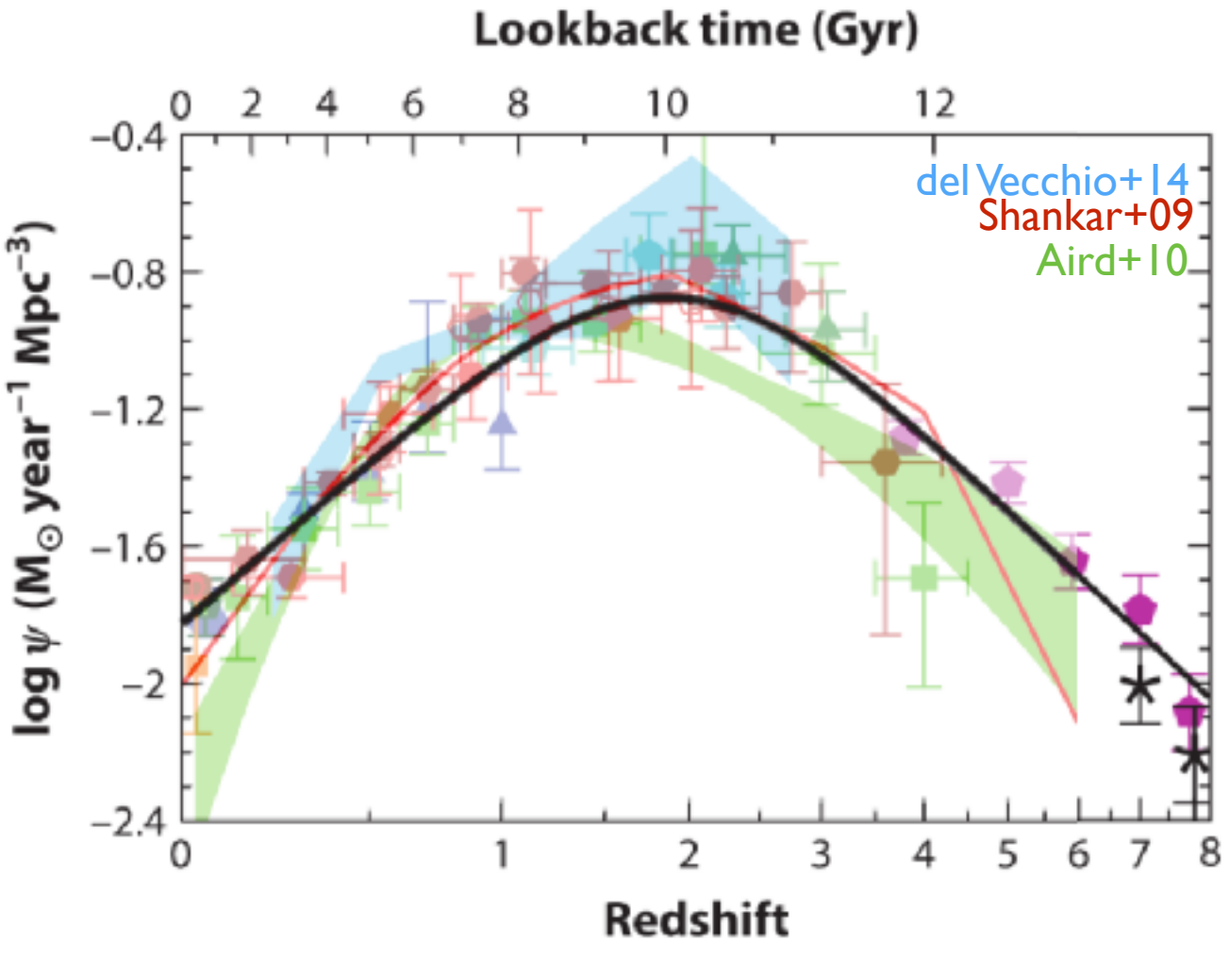
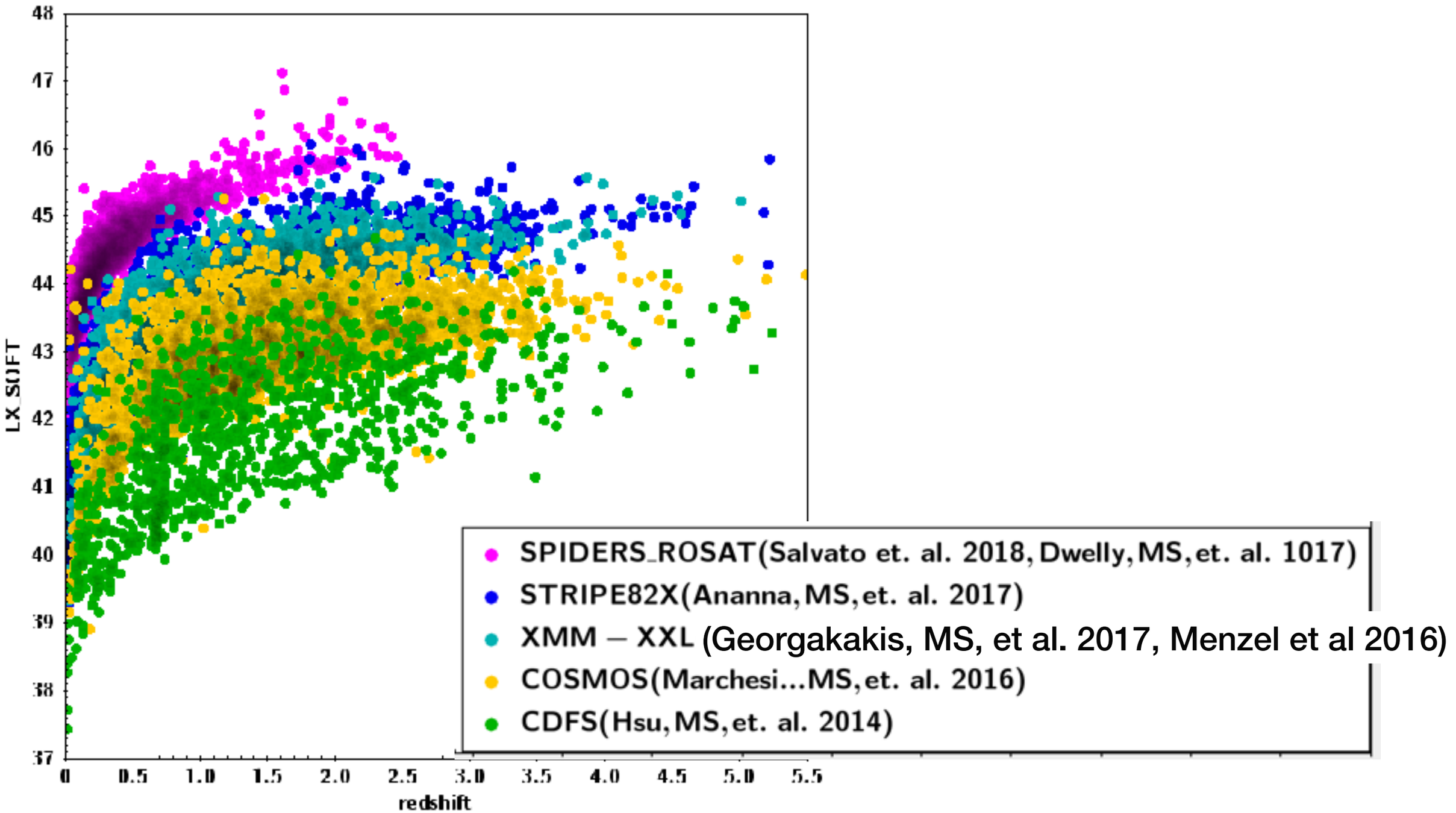




Madau& Dickinson+14

Census of BH growth requires sampling full luminosity-redshift plane



M.Salvato, Toulouse 2018

ROSAT survey missed in the counting because:

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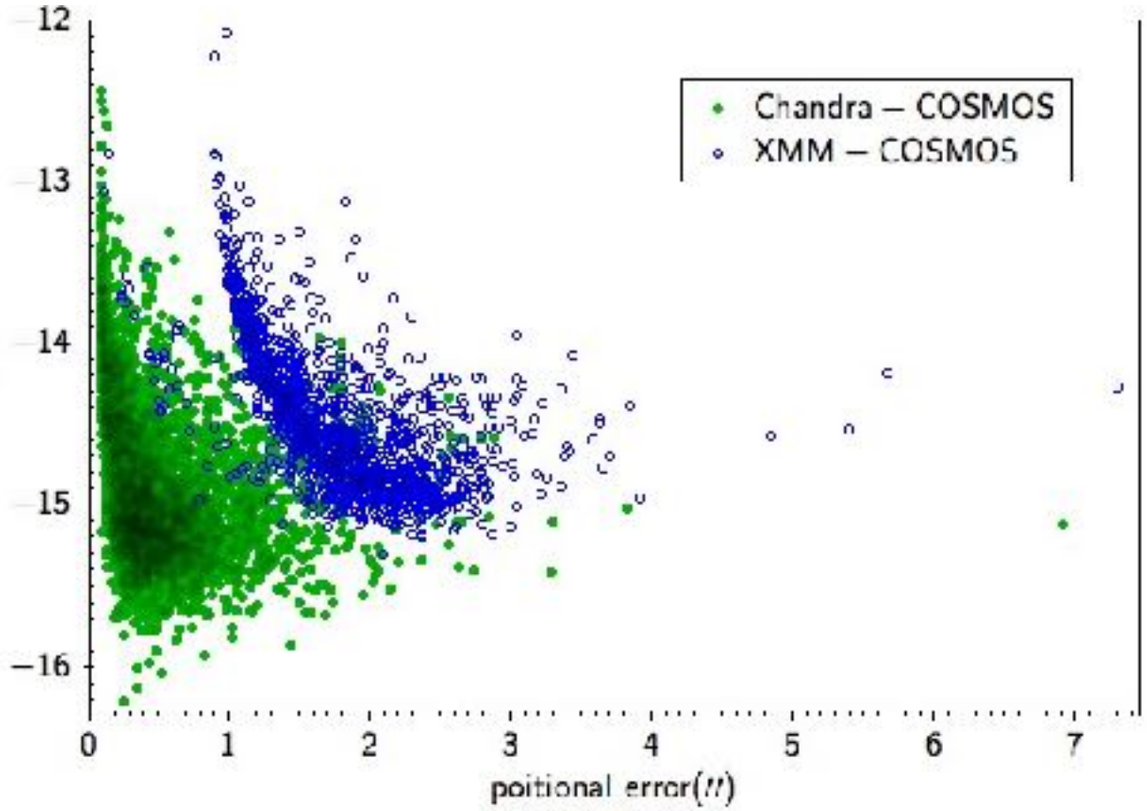

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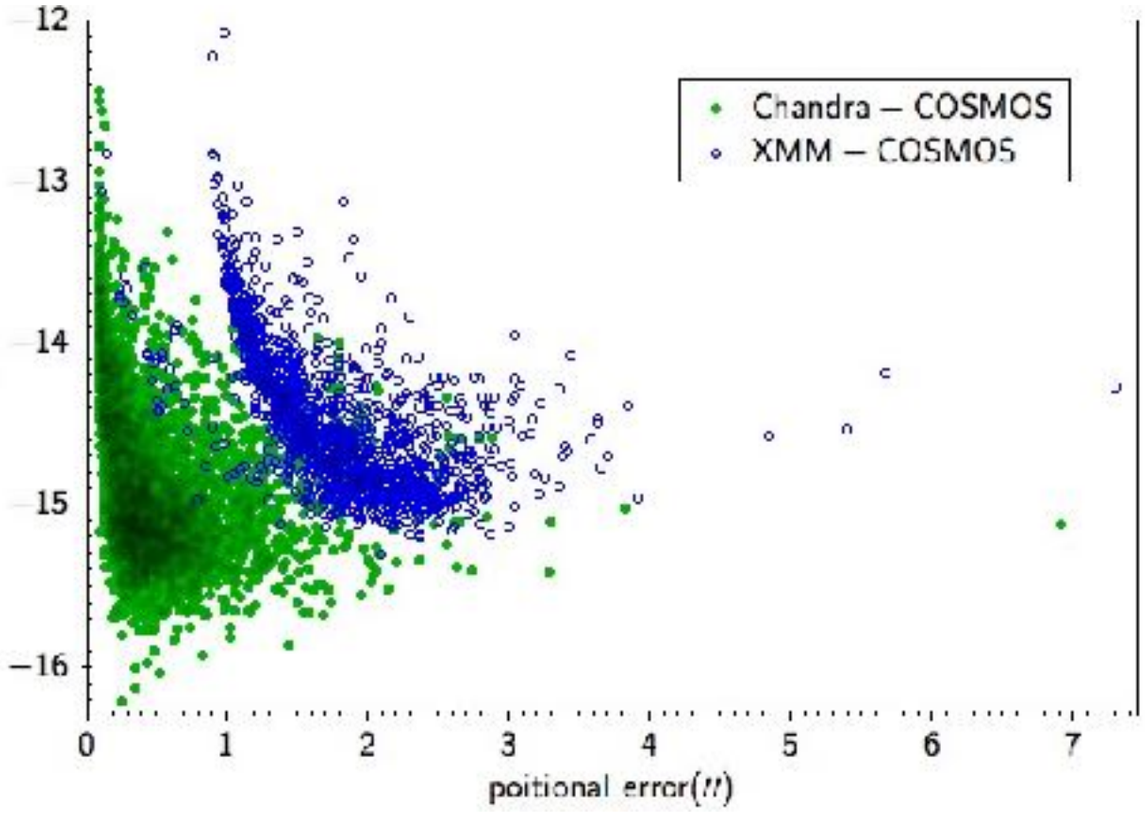

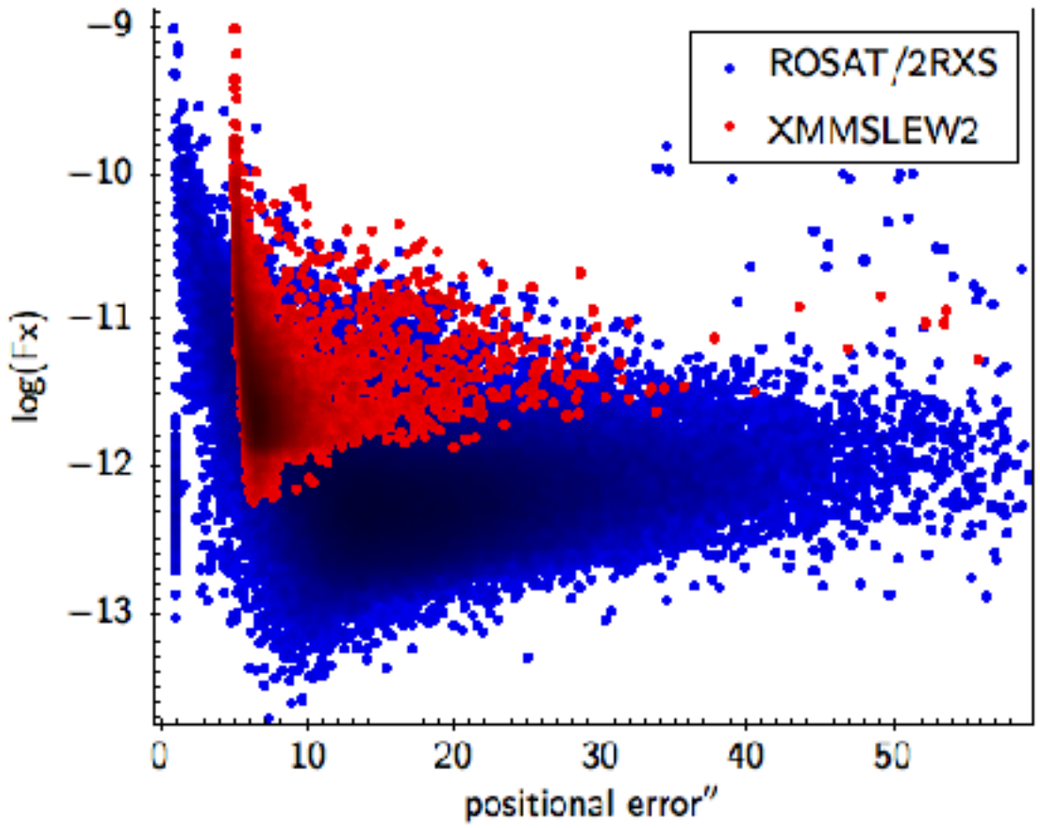

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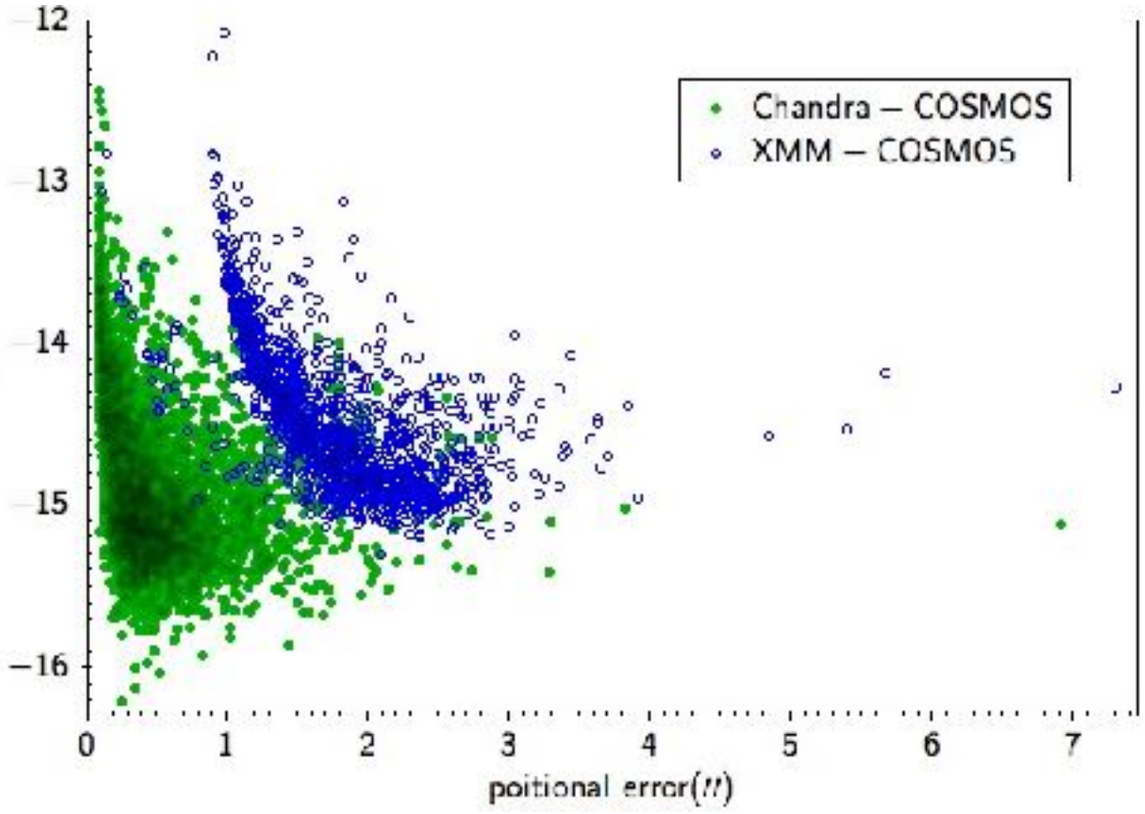

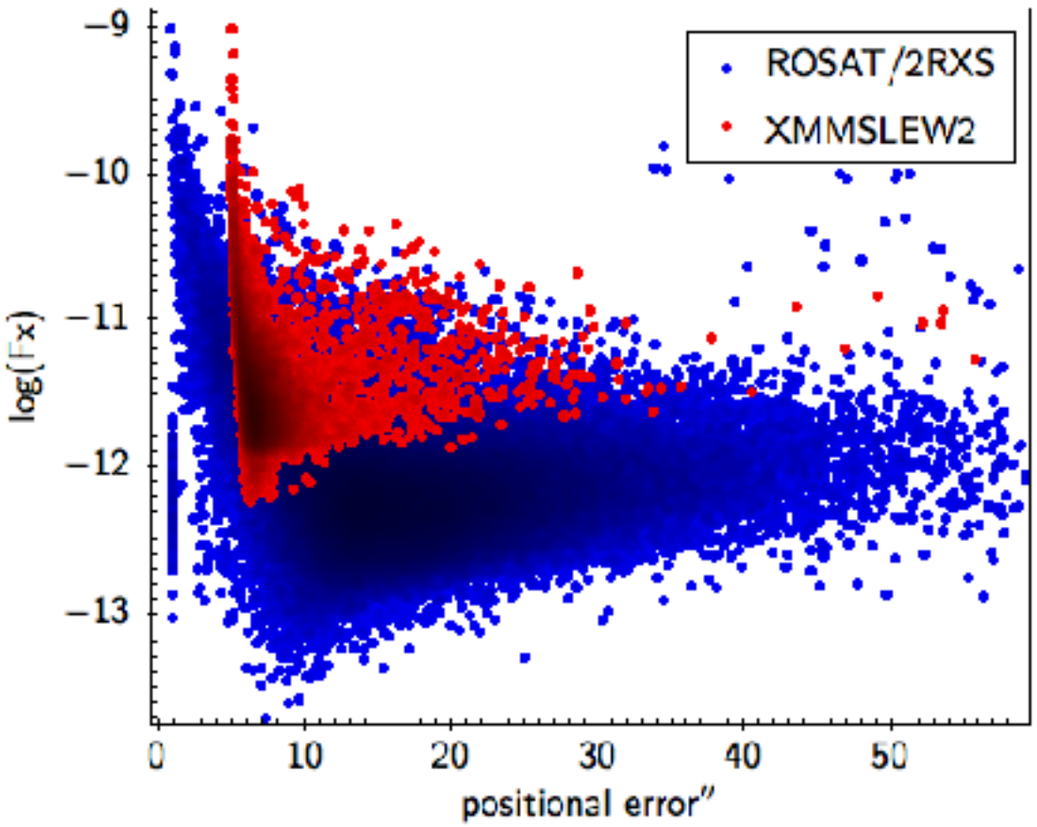

2) Lack of deep enough, homogeneous and wide surveys

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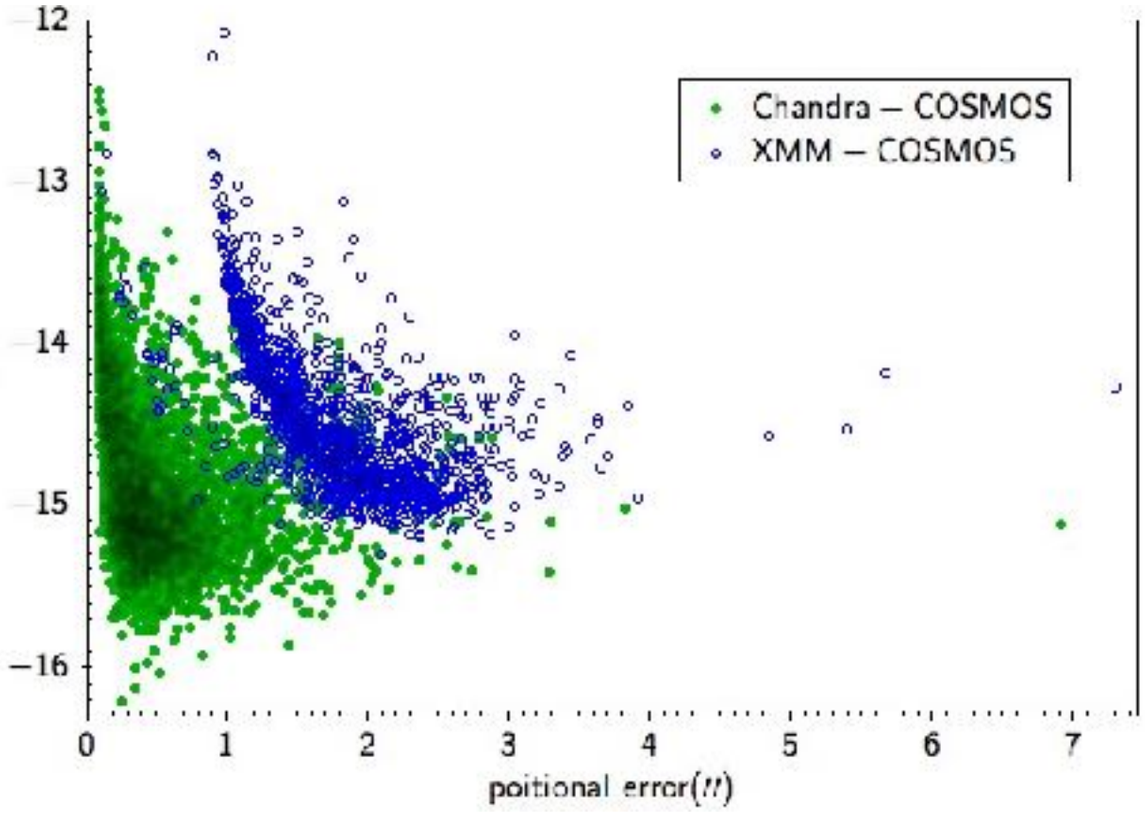
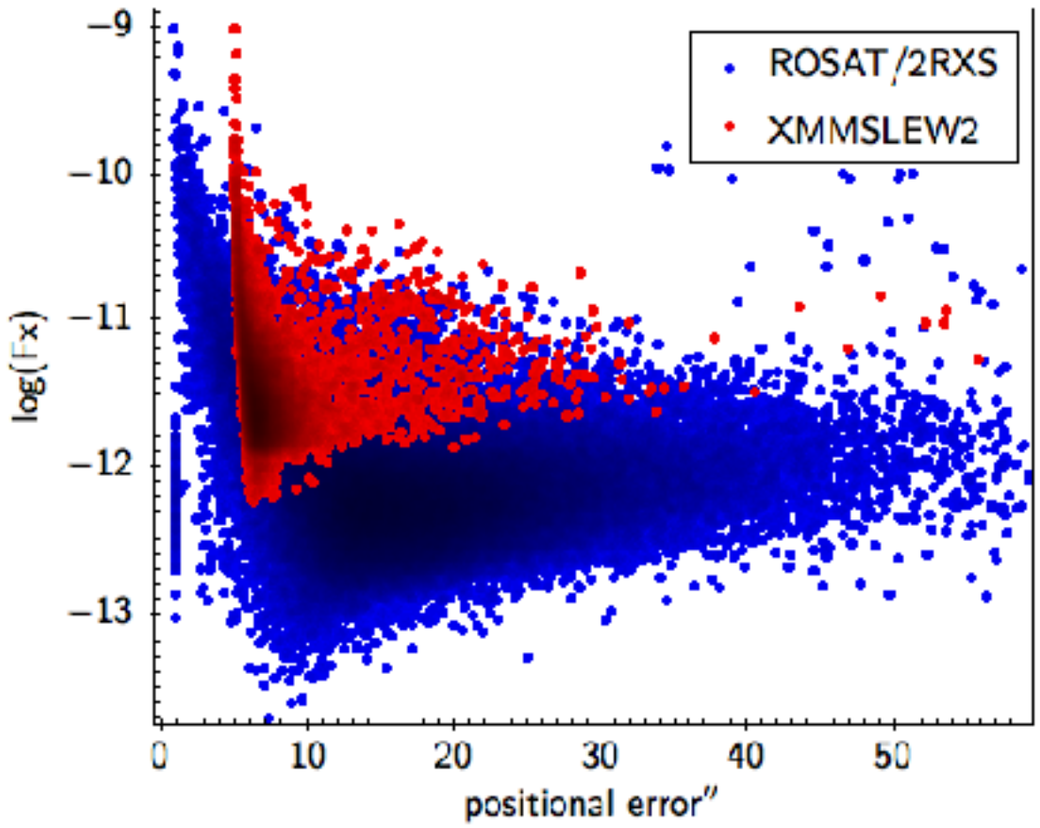


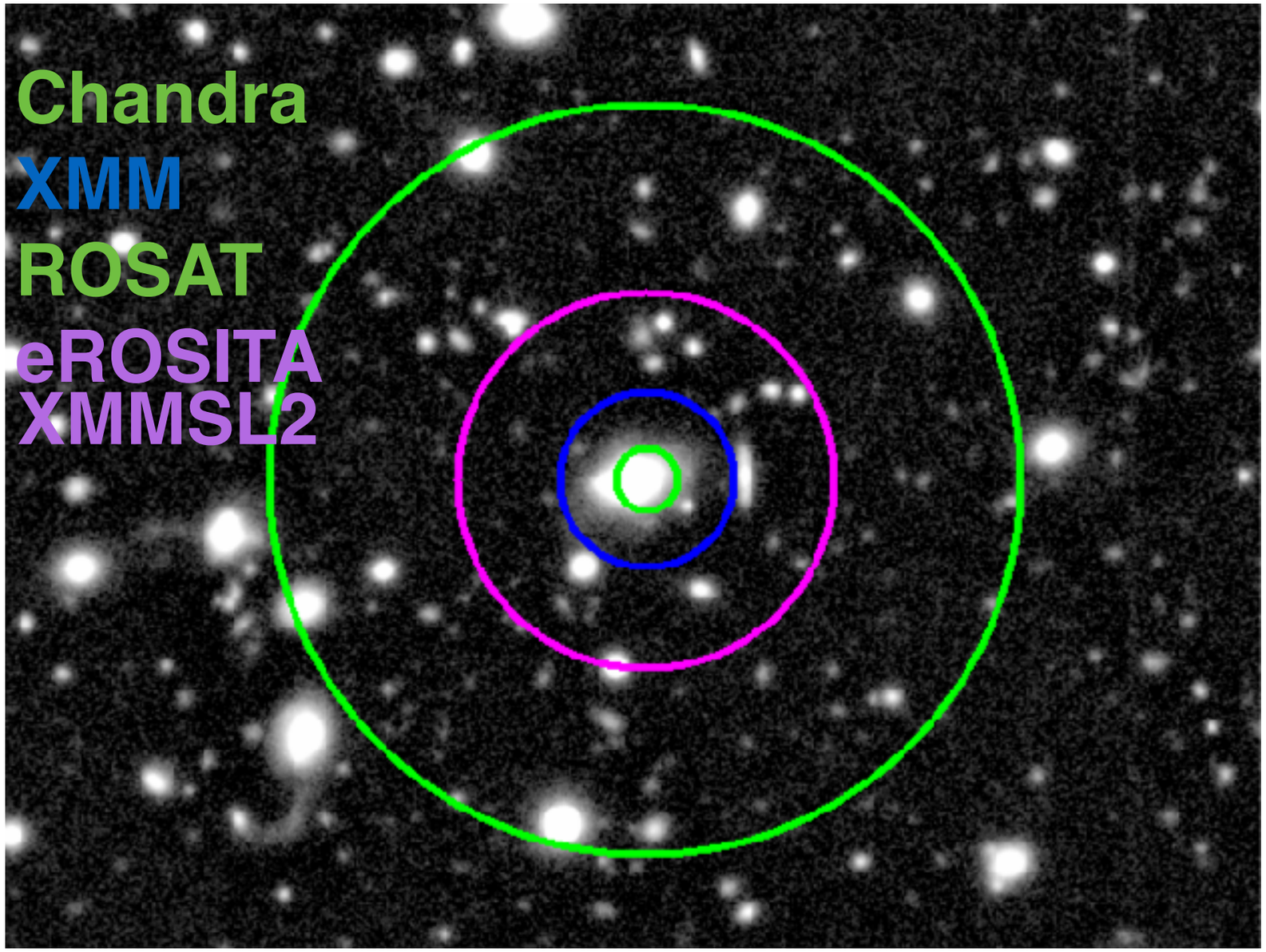


2) Lack of deep enough, homogeneous and wide surveys

Only the counteparts to bright ROSAT sources
in some part of the sky where known (e.g/ Schwope et al. 2000)

Then WISE was launched..

X-ray counterparts identification



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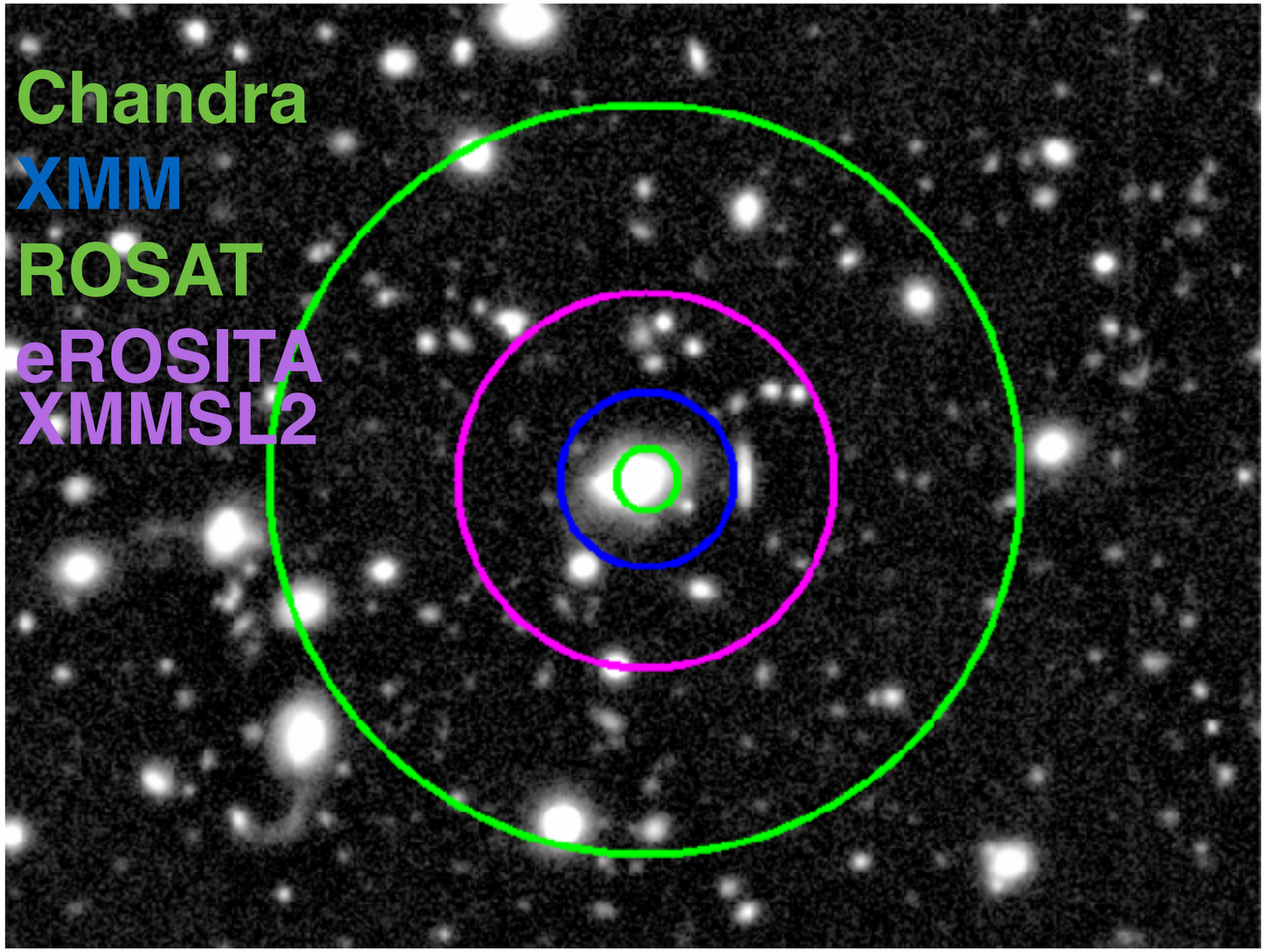

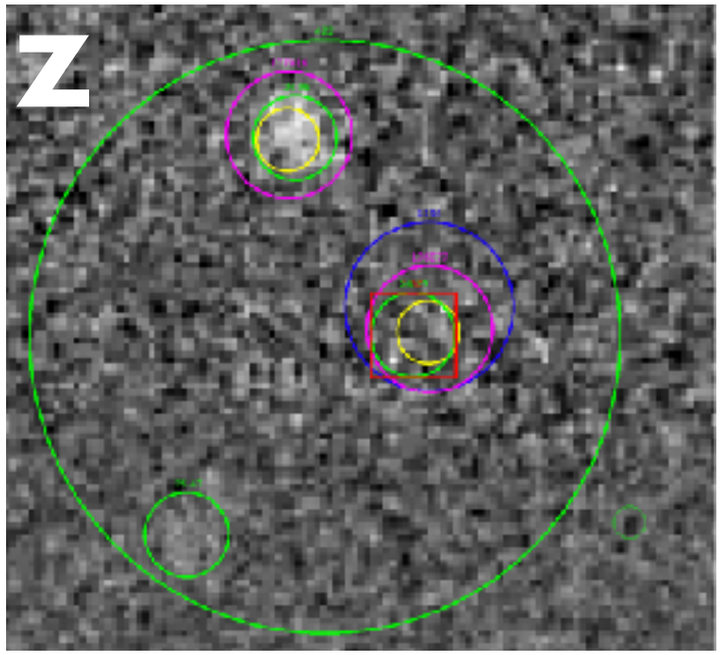

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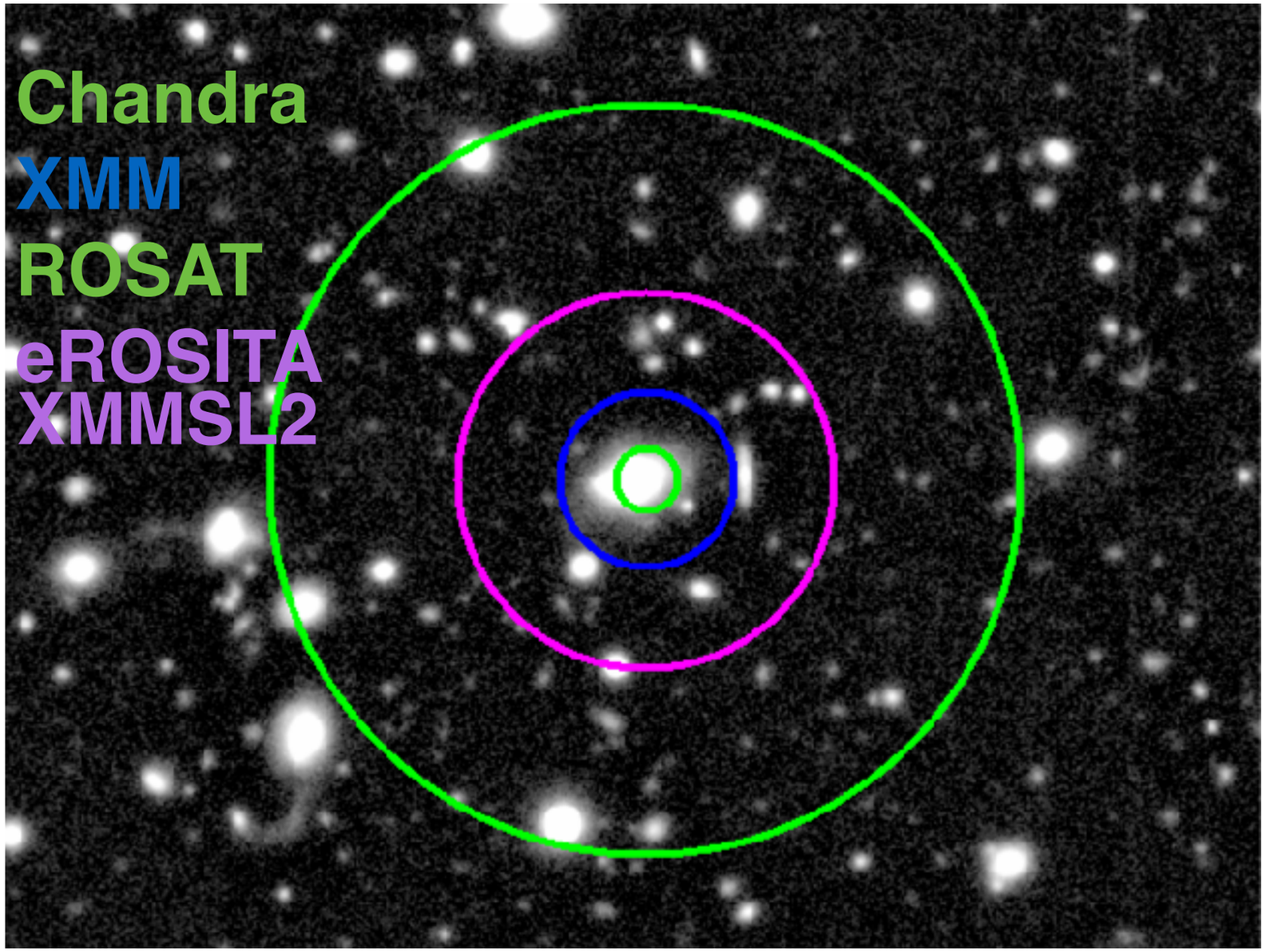

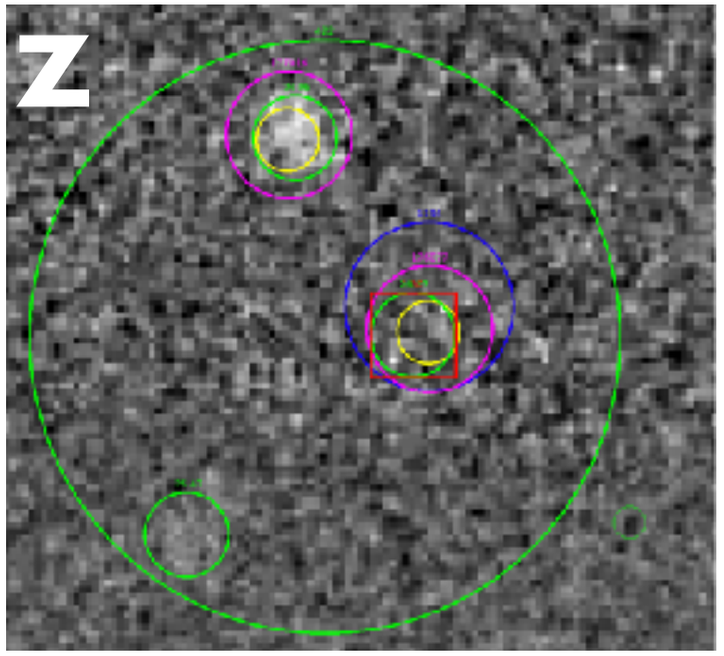

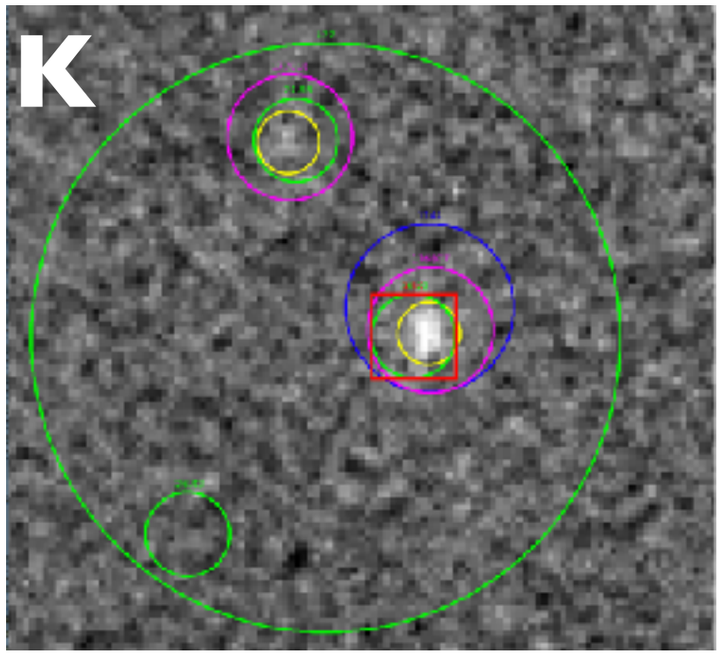

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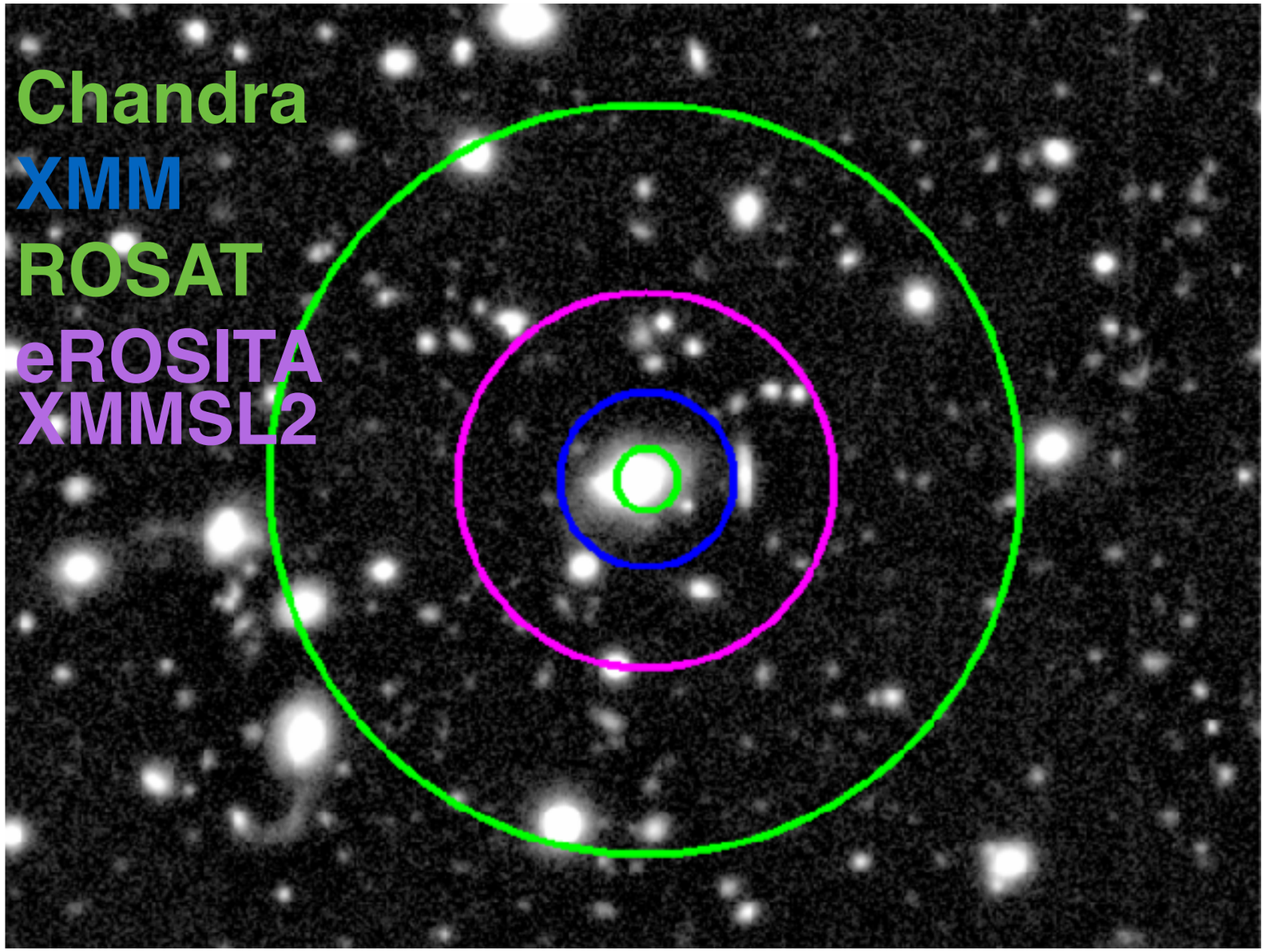
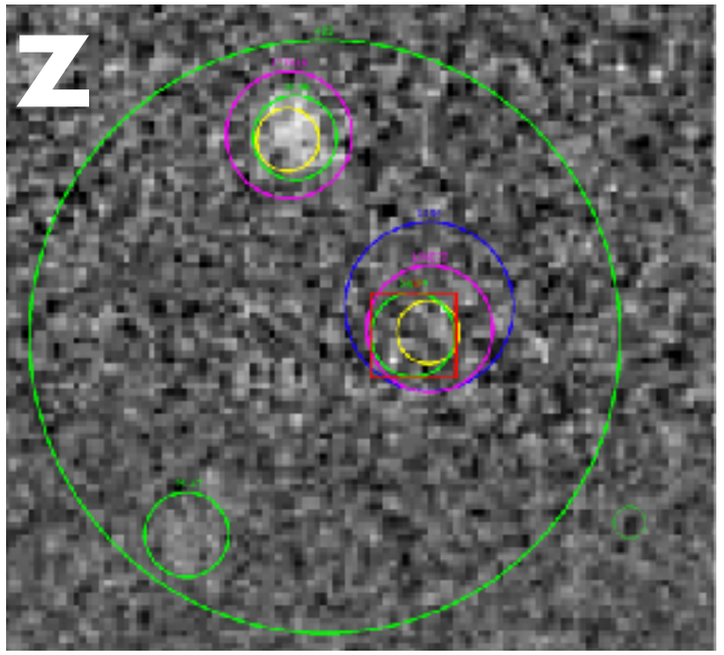
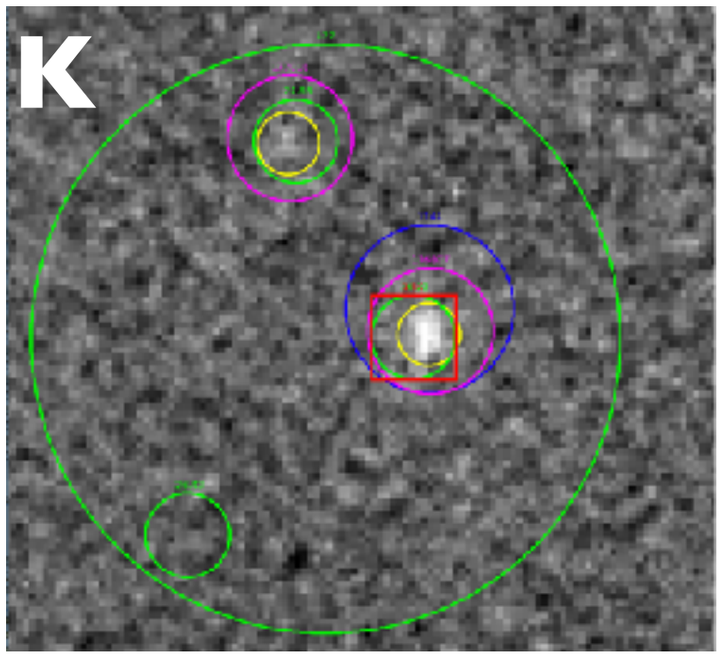
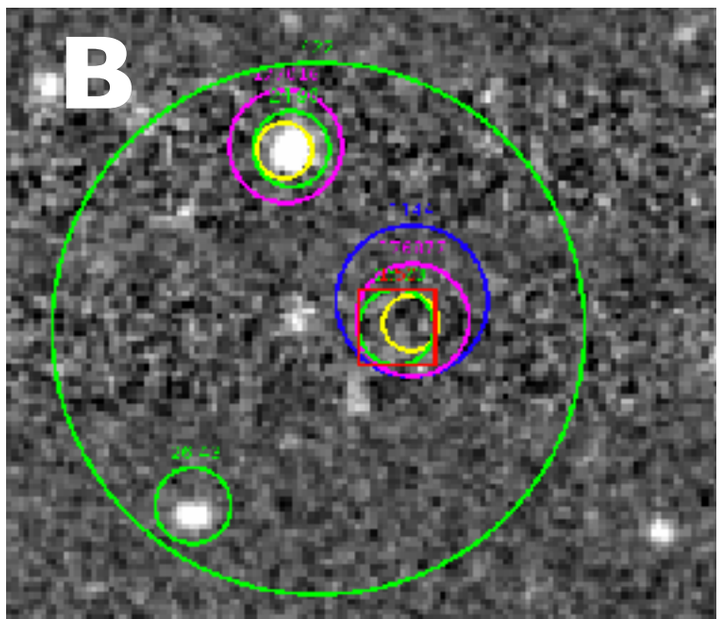






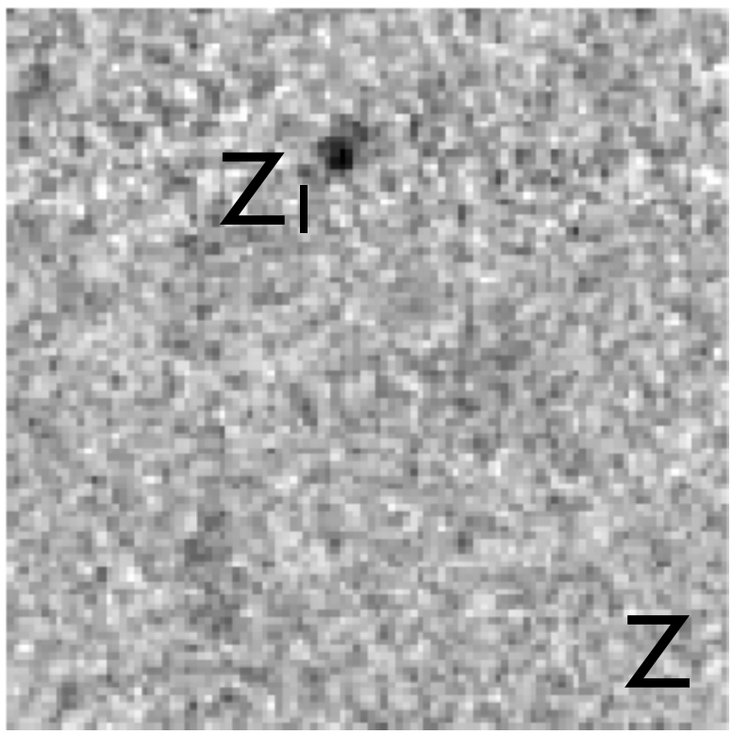


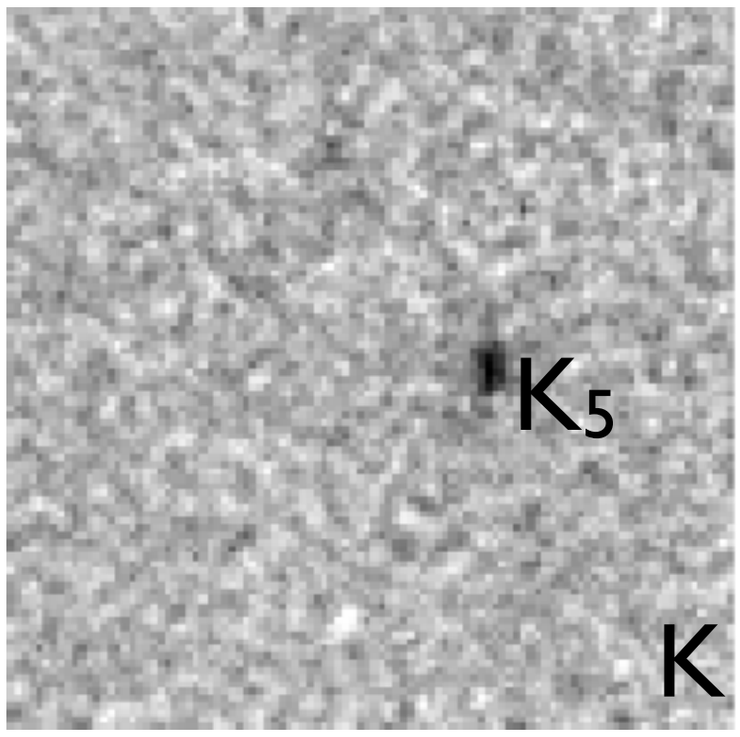
NWAY in a nutshell

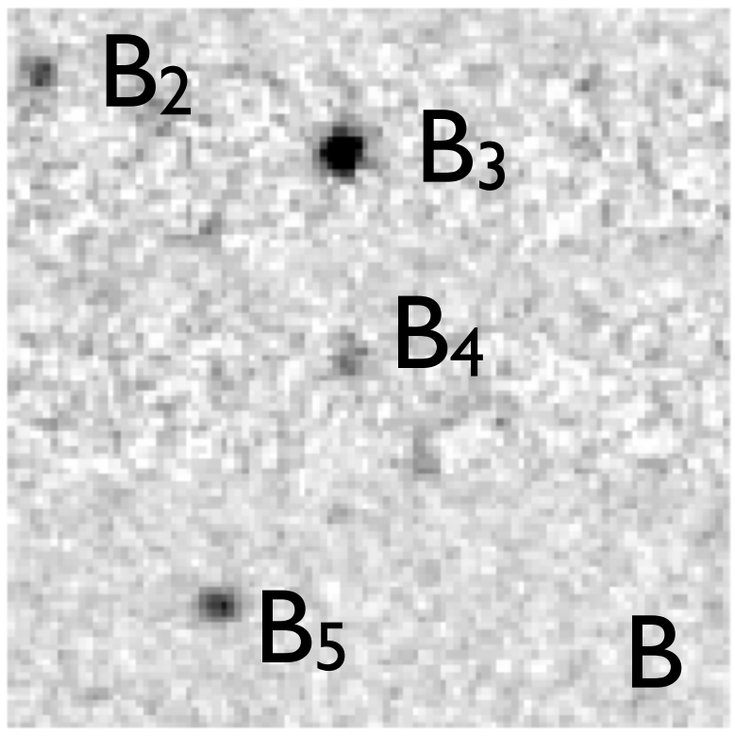
Salvato+ 2018, Dwelly+2017

https://github.com/JohannesBuchner/nway

(i) Matching of N catalogues simultaneously.
(ii) Computation of all combinatorially possible matches, including partial matches across catalogues, i.e. the absence of counterparts in some catalogues
(iv) Taking into account distances, positional uncertainties and the source number densities, computation of the probability of each possible match.
(v) Computation of the probability that there is no match.







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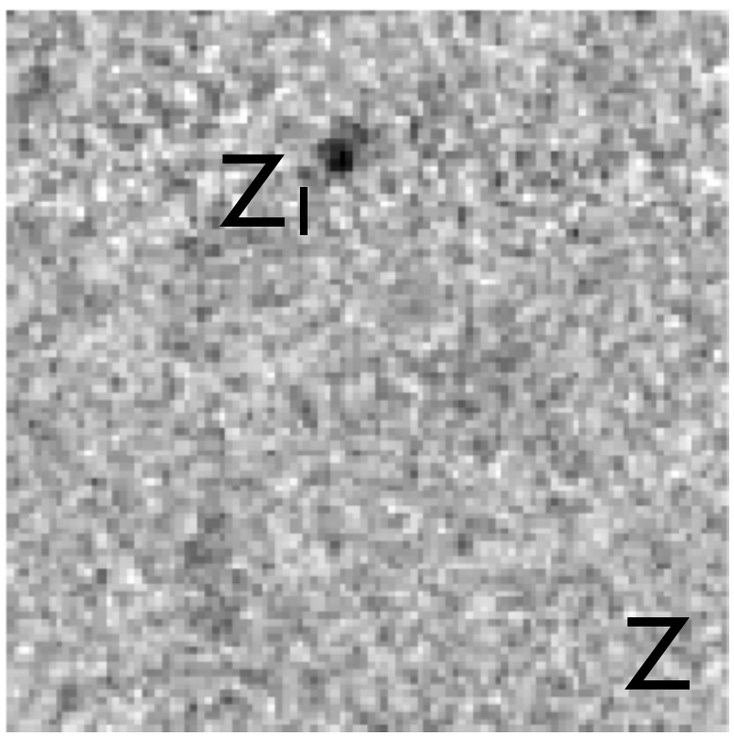

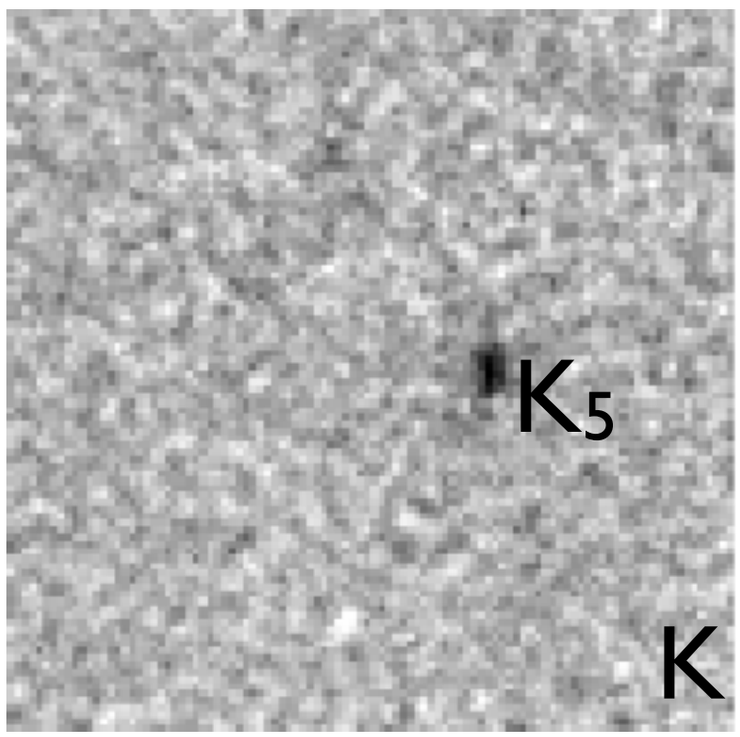

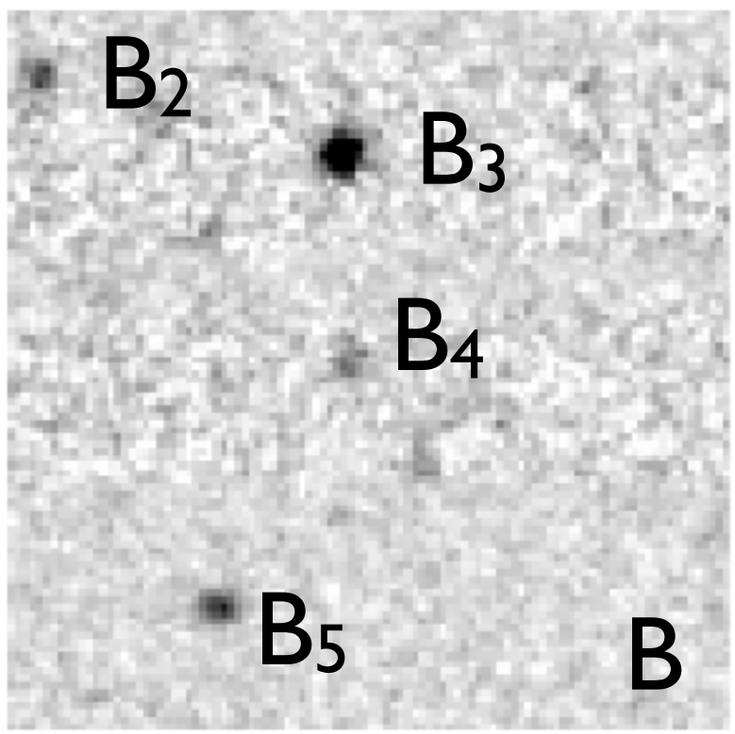

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(vi) Incorporating magnitude distribution, colors, magnitude&colors or other information about the sources of interest, refining the match probabilities.

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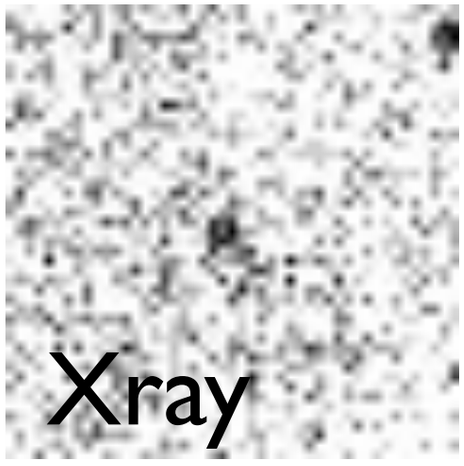
For each source of the primary catalogue (in the application from this paper: for each the X-ray source), compute (a) the probability that this source does not have a counterpart and (b), assuming this source has a counterpart, compute the relative probability for each possible match.

Input to NWAY

X_I RA_I Dec_I σ_I



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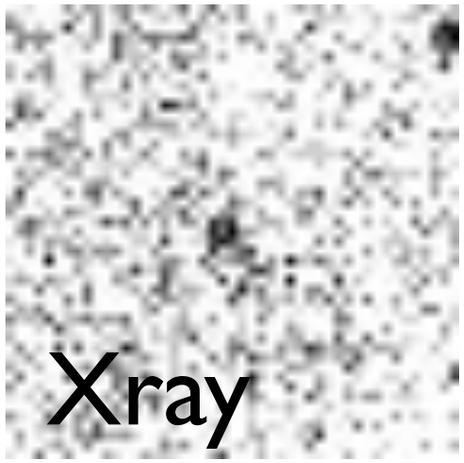

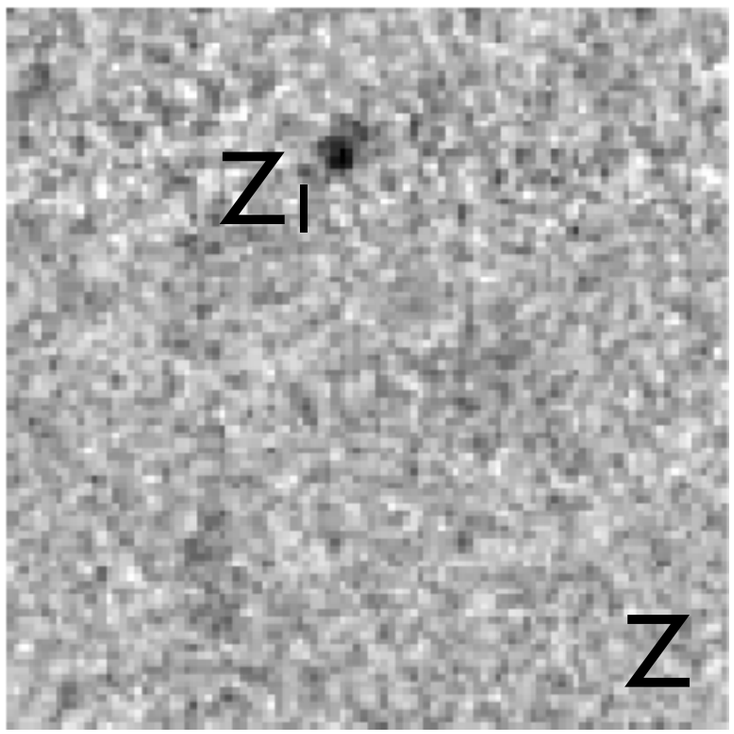

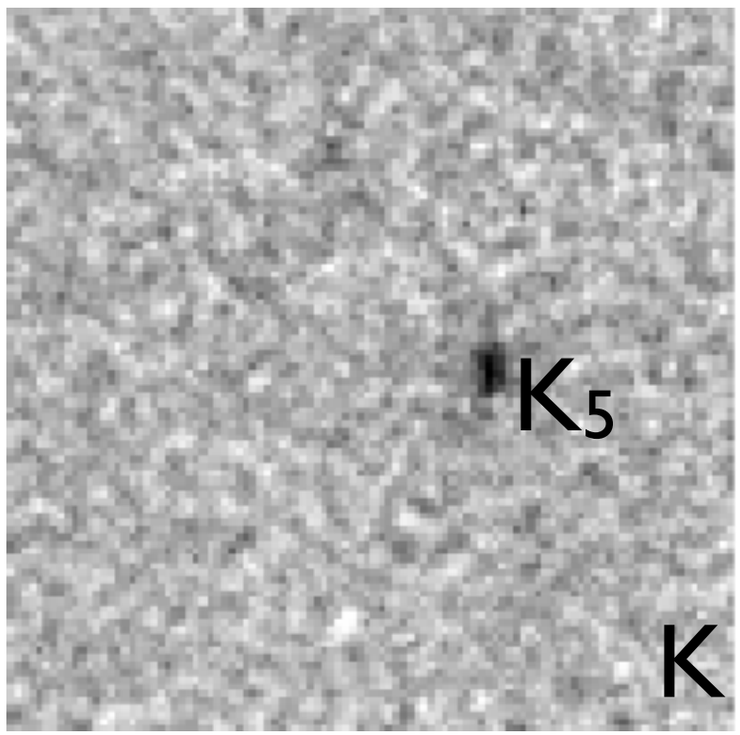

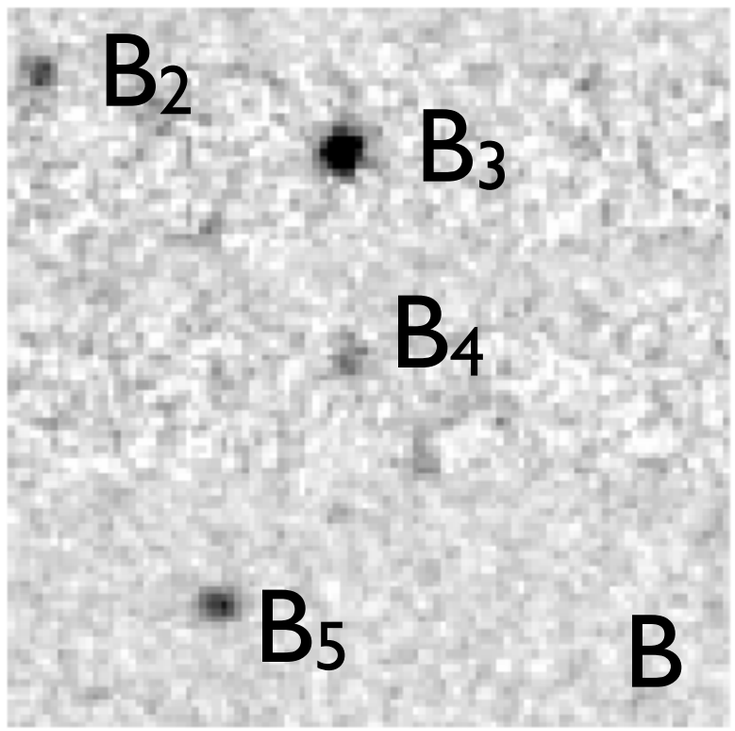

Z_I RA_{zI} Dec_{zI} σ_{zI} mag_{zI} K_5 RA_{k5} Dec_{k5} σ_{k5} mag_{k5}

B_2 RA_{B2} Dec_{B2} σ_{B2} mag_{B2}
B_3 RA_{B3} Dec_{B3} σ_{B3} mag_{B3}
B_4 RA_{B4} Dec_{B4} σ_{B4} mag_{B4}
B_5 RA_{B5} Dec_{B5} σ_{B5} mag_{B5}

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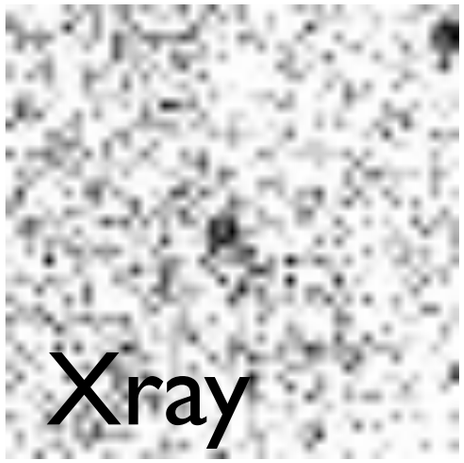

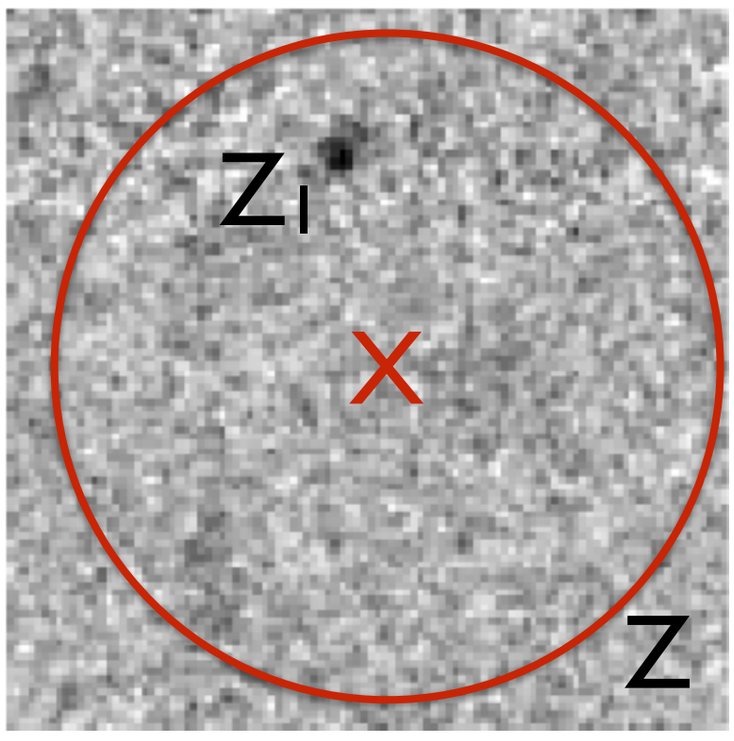

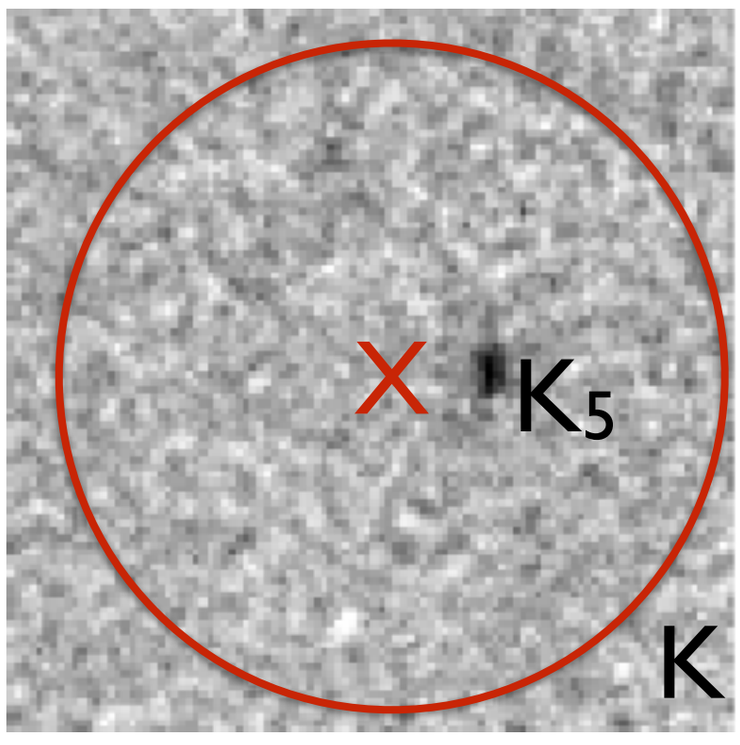

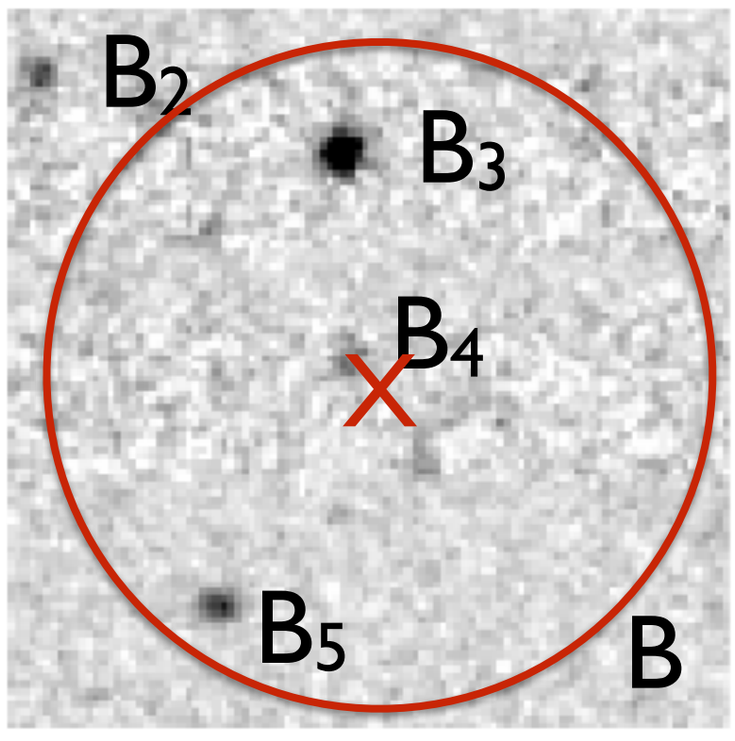

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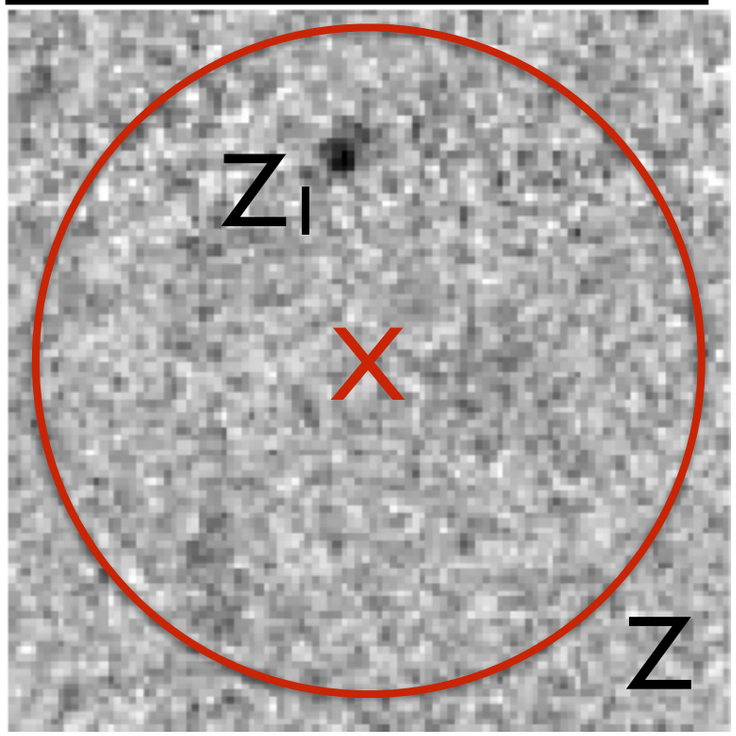
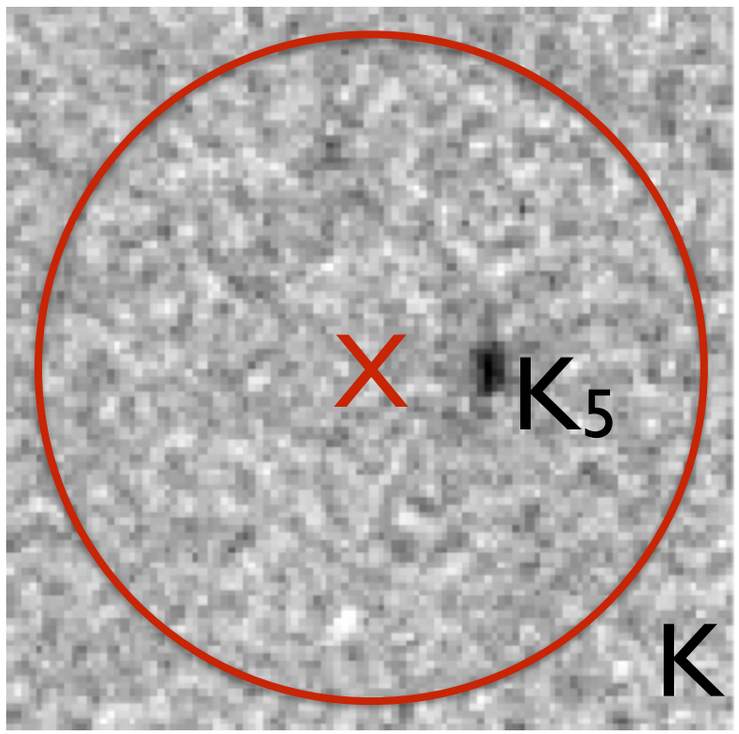
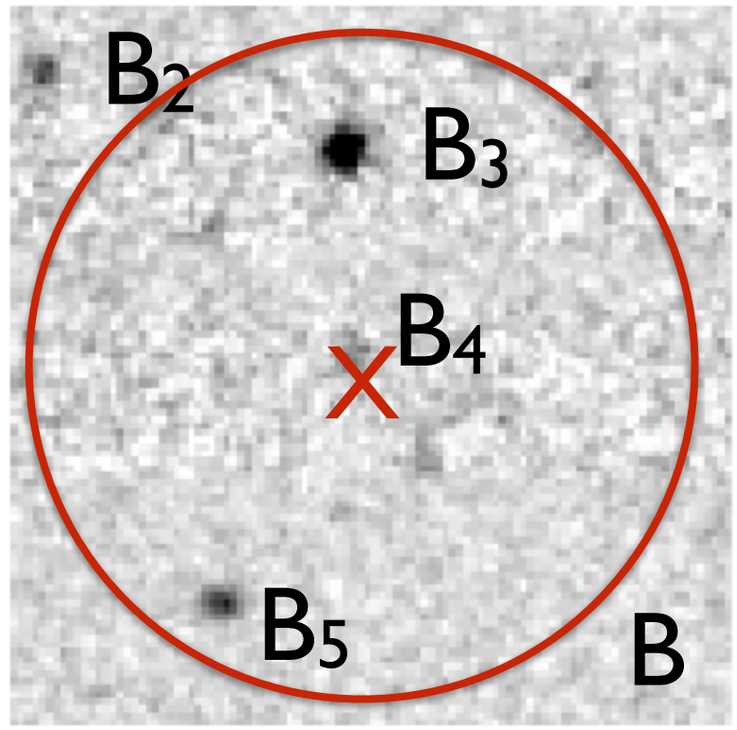
NWAY output







X cat. entry	Z cat. entry	K cat. entry	B cat. entry	various Probs.		P (X has a ctp)	P (this is the correct ctp)
1	1	—	3	…	…	0.8	0.2
1	—	5	—	…	…	0.8	0.6
1	—	—	4	…	…	0.8	0.1
1	—	—	5	…	…	0.8	0.1
2	…	…	…	…	…	…	…
2	…	…	…	…	…	…	…

The beauty of NWAY

prior
(e.g due to depth of data)

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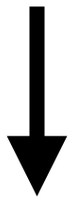

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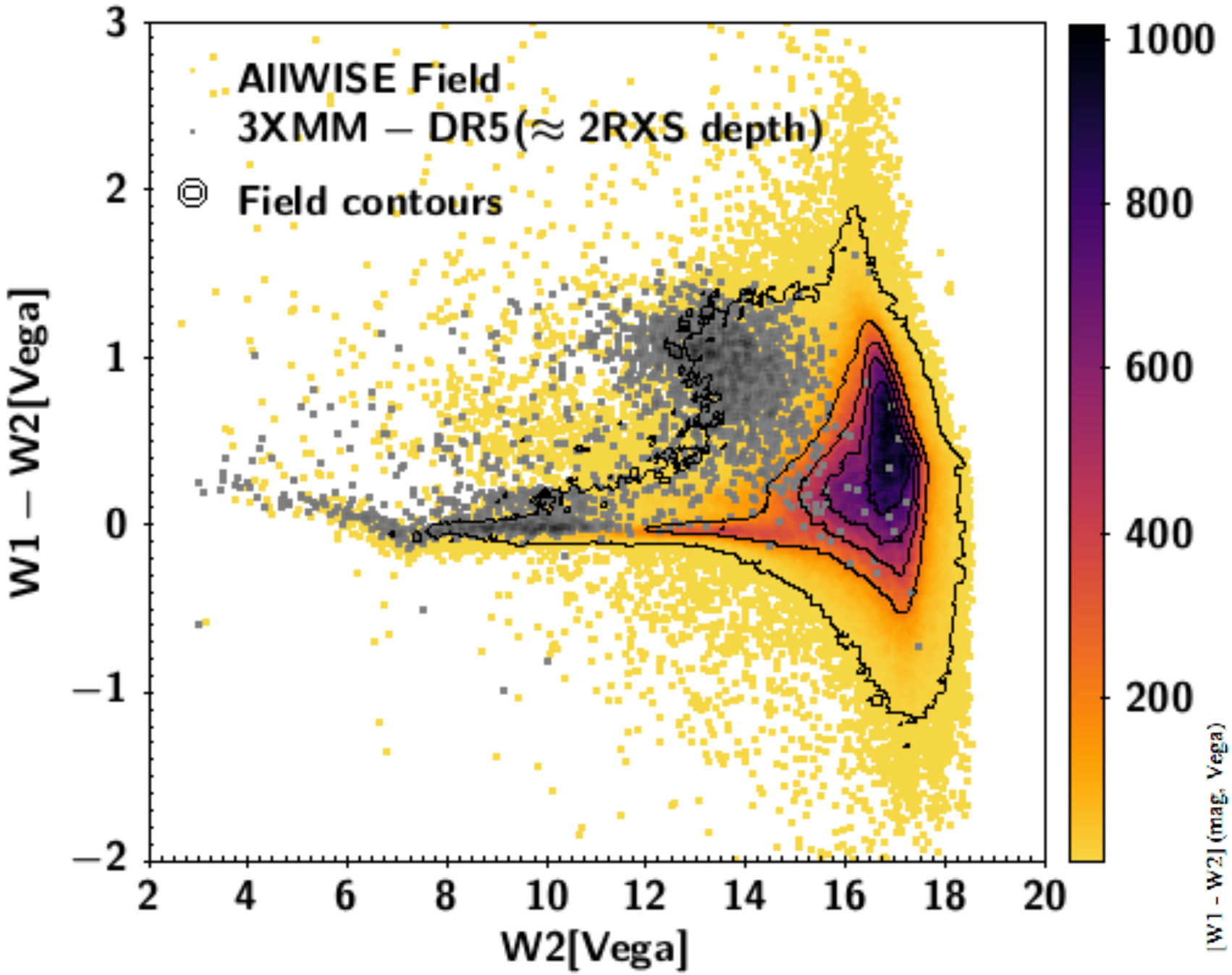
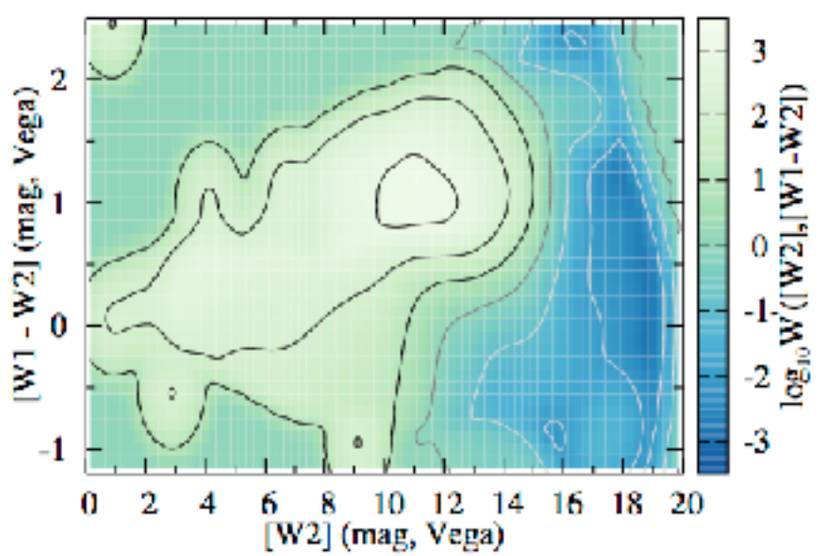
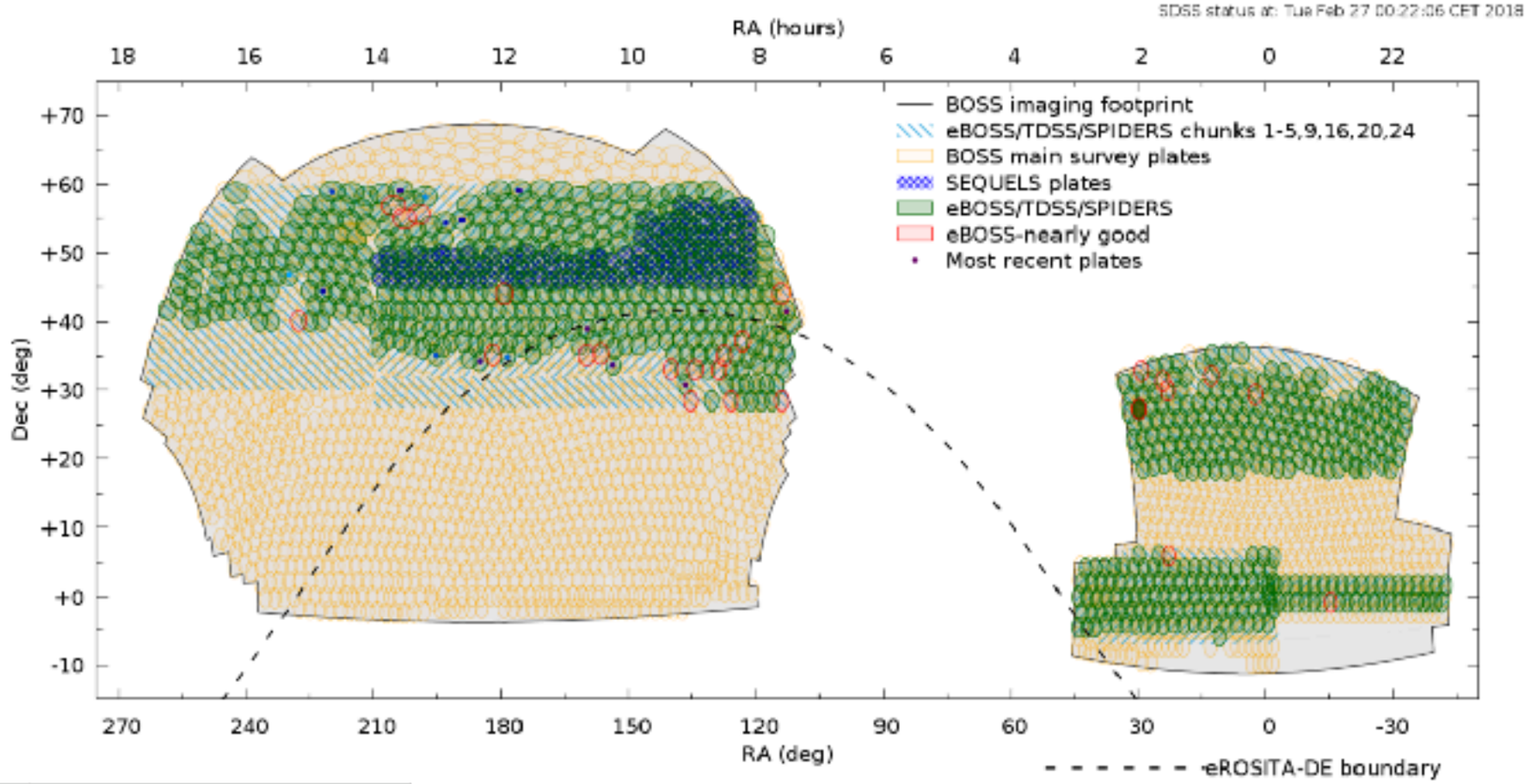
For extragalactic ROSAT/2RXS (Boller+16) and XMMSLEW2: a MIR color-magnitude prior





SPectral **ID**entification **ER**osita **S**ources

PI: Merloni, Nandra



	ROSAT QSO/GAL/Stars	XMMSLEW2 QSO/GAL/Stars
SDSS I/II/III	9062/2580/271	1193/265/24
SDSS IV (eBOSS)	1790/872/321	184/80/34
TOT	**10852/3452**/592	**1377/345**/58

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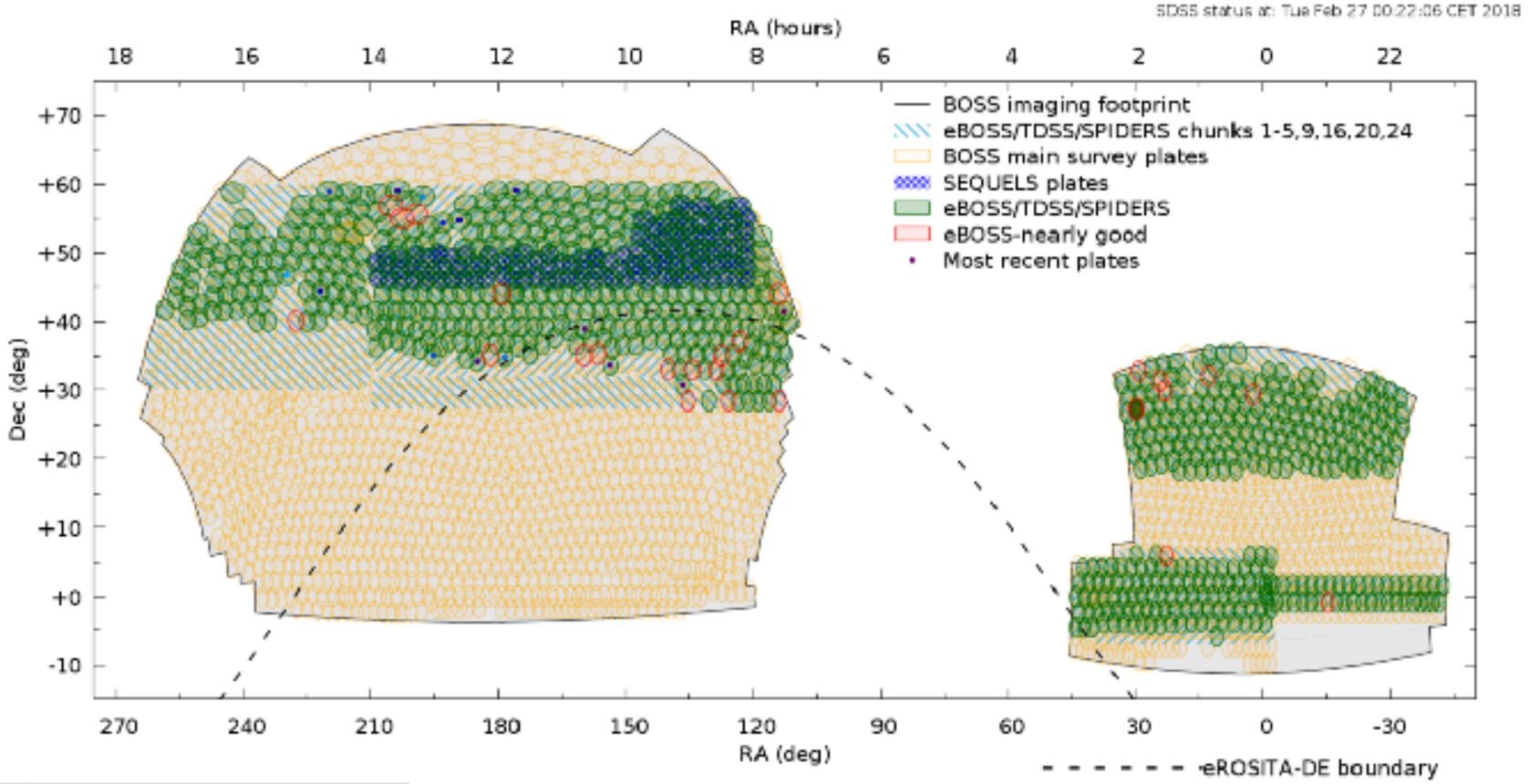

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Bright AGN up to high-z in comparable number as from pencil beam surveys !

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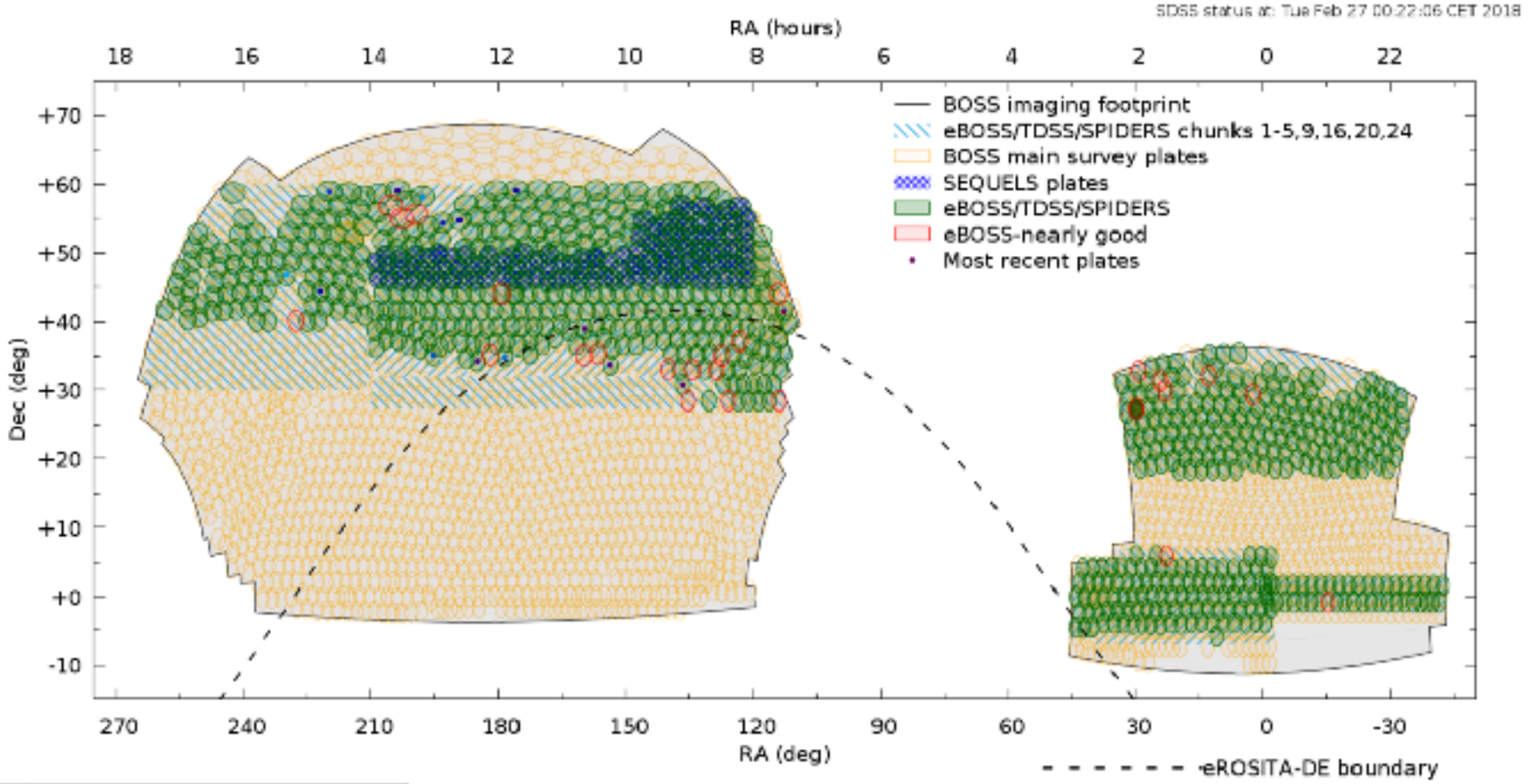

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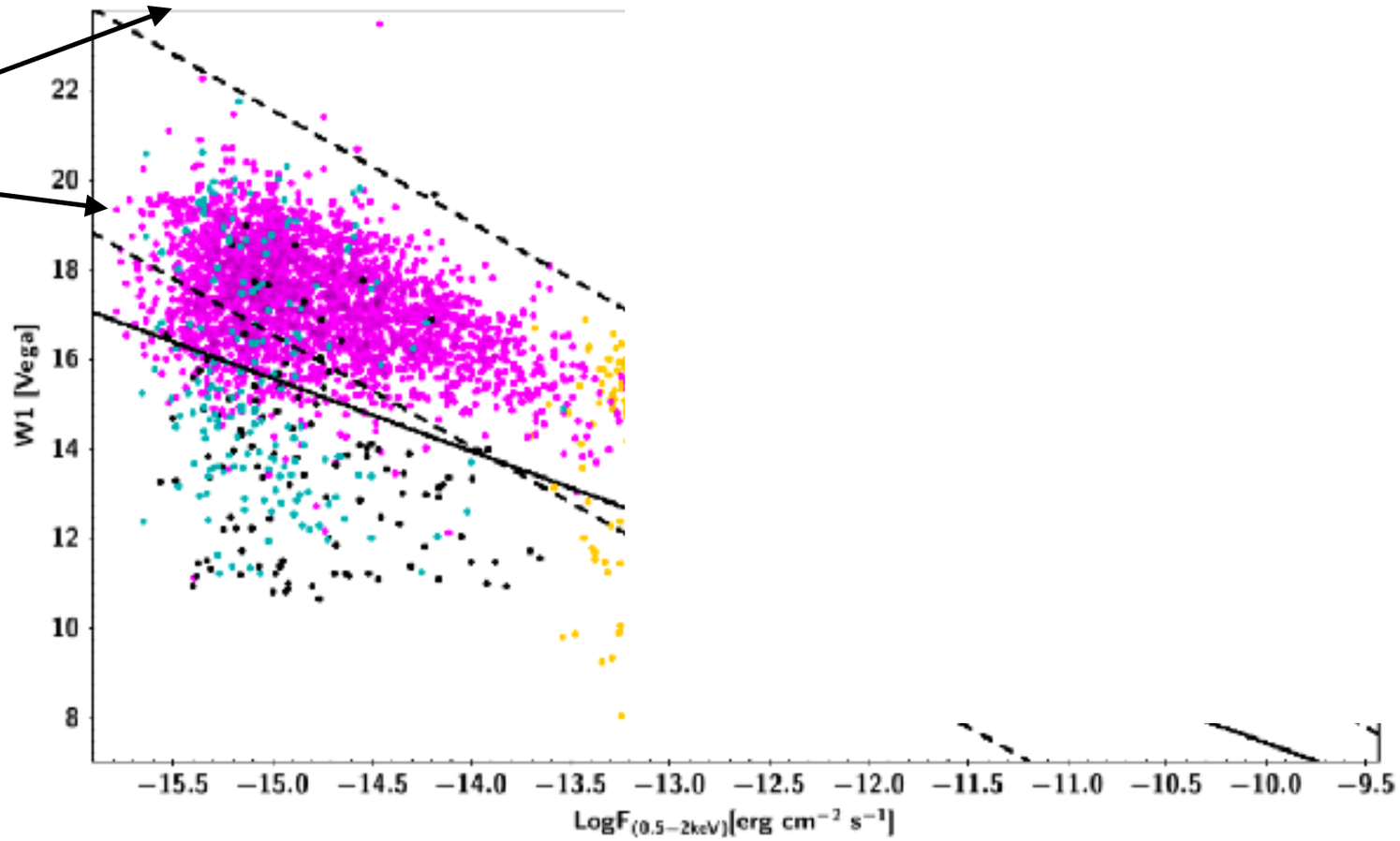
Coffey, MS et al. 2018: SPIDERS DR14 release with physical properties

first star/AGN classifications (usefull for spectroscopic follow-up)

Salvato+18

Maccacaro+88

See also Mainieri+, Berger+, Civano+



Not-so-subliminal message: give a try to NWAY

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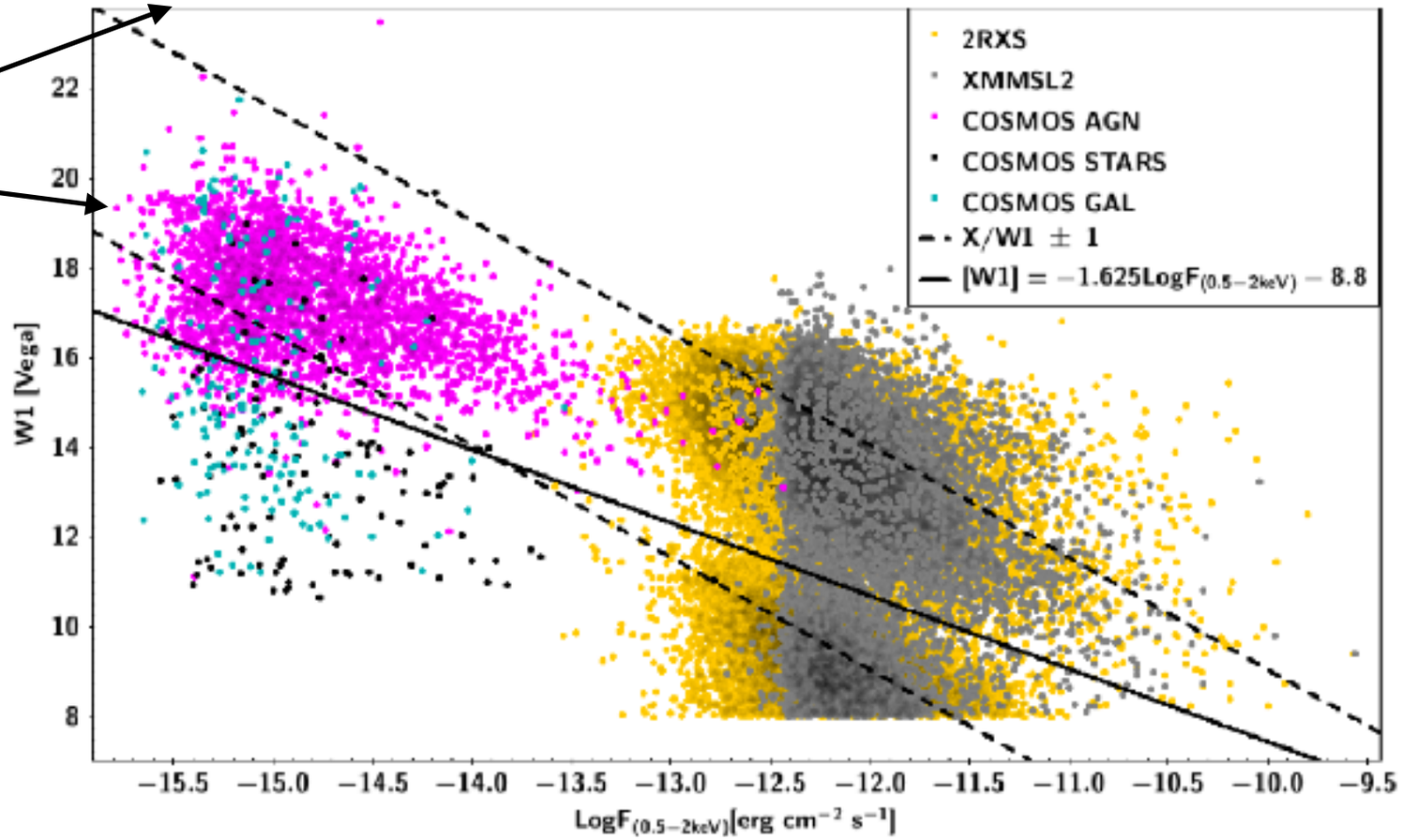

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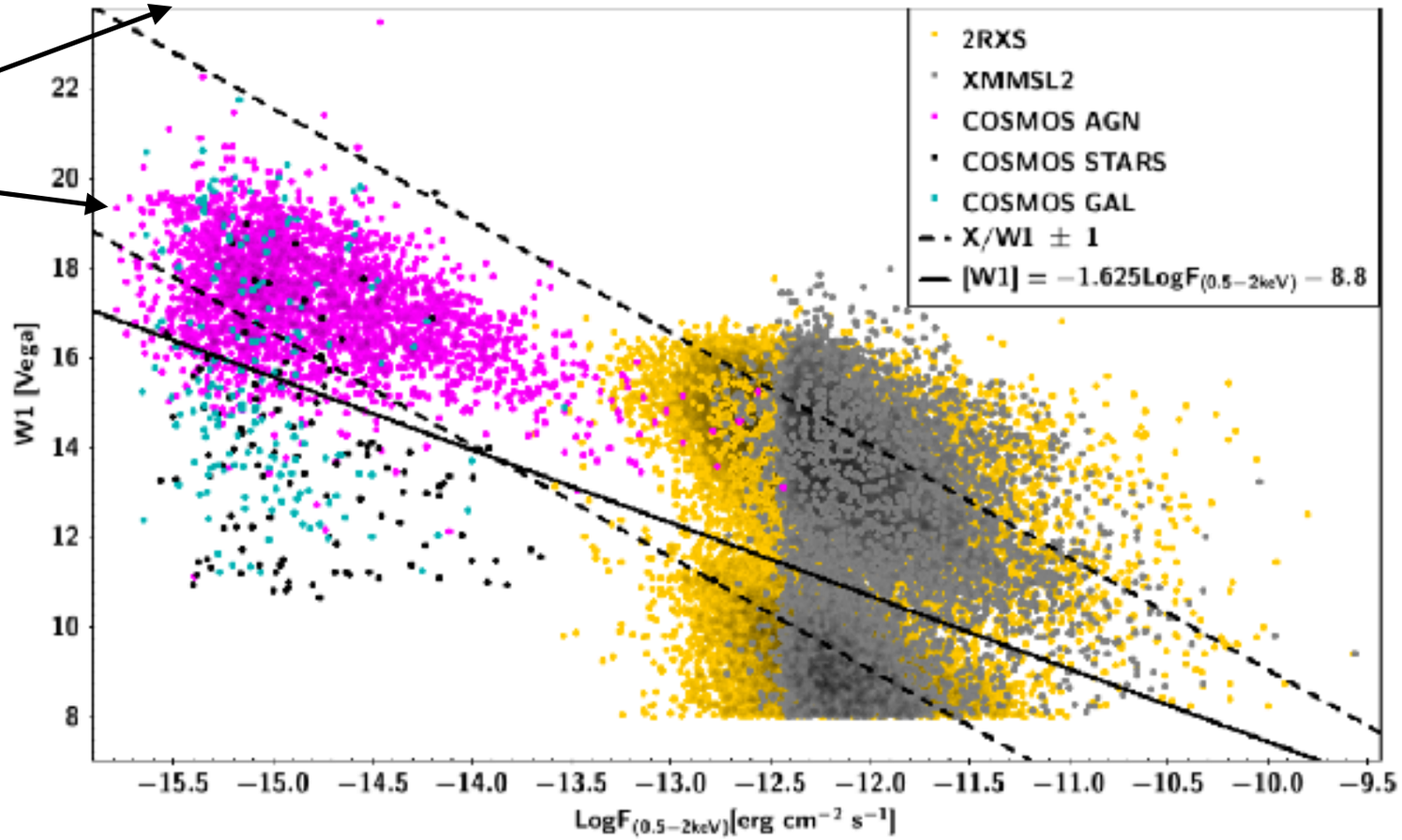
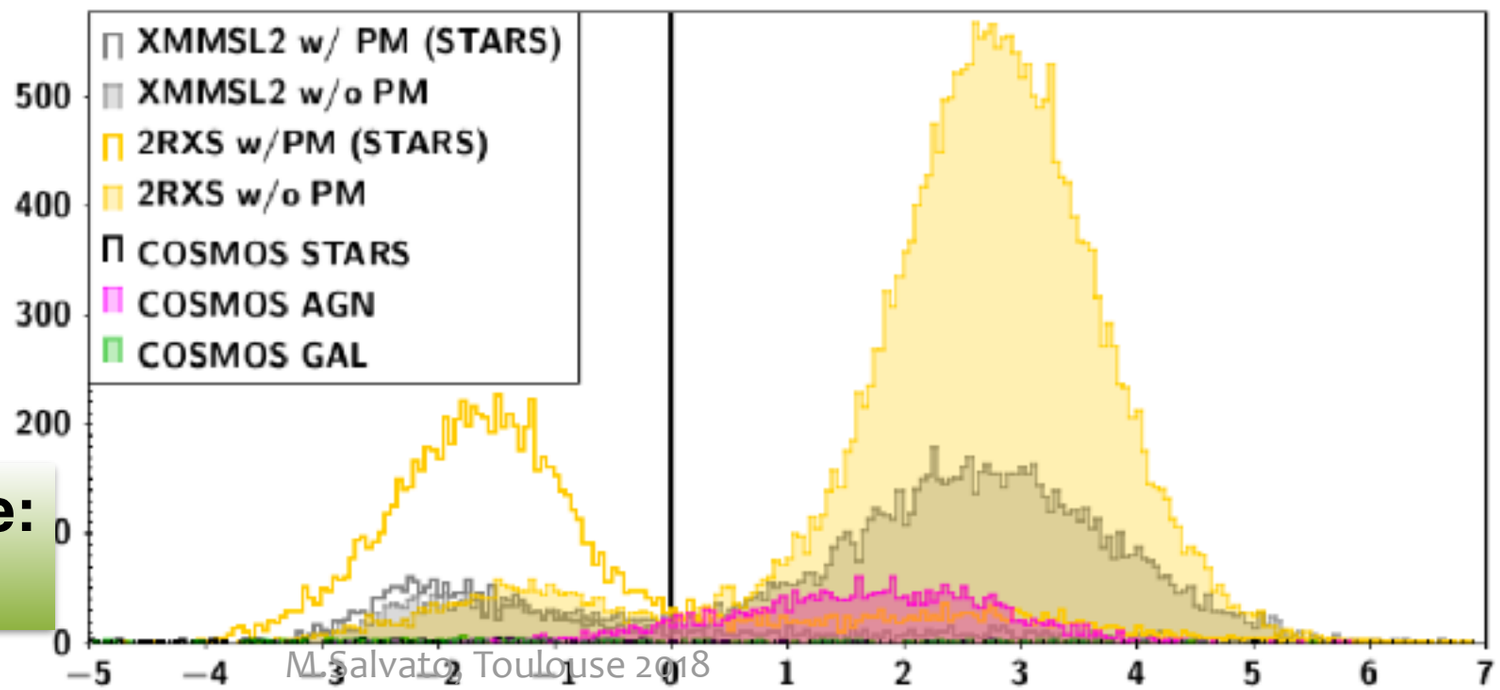
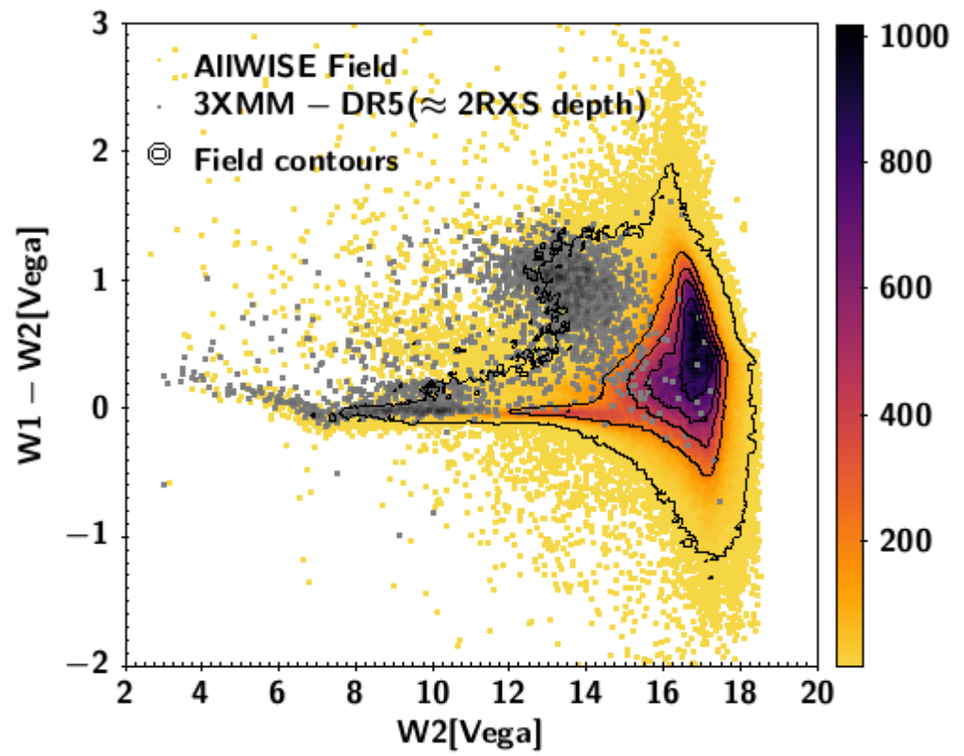


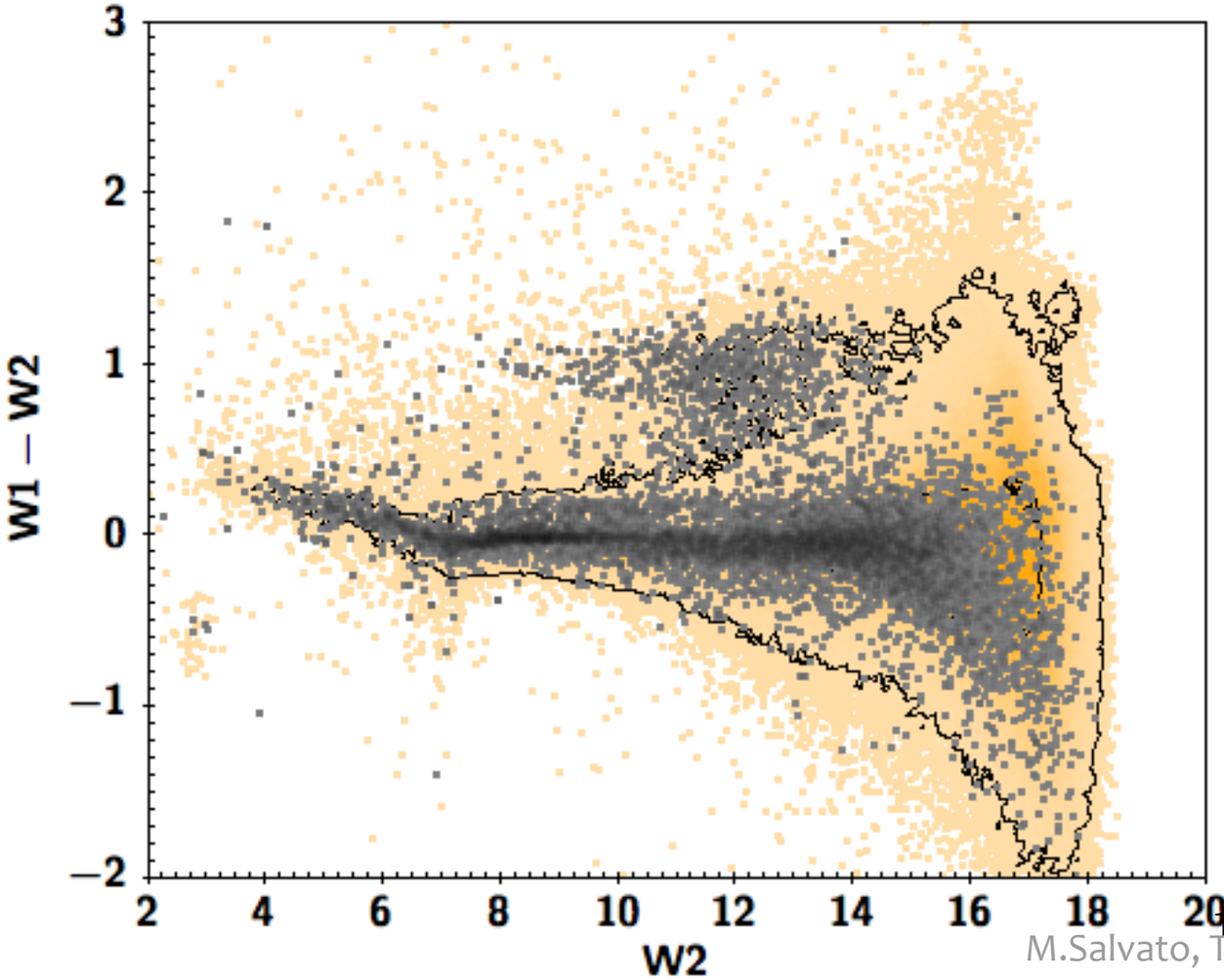


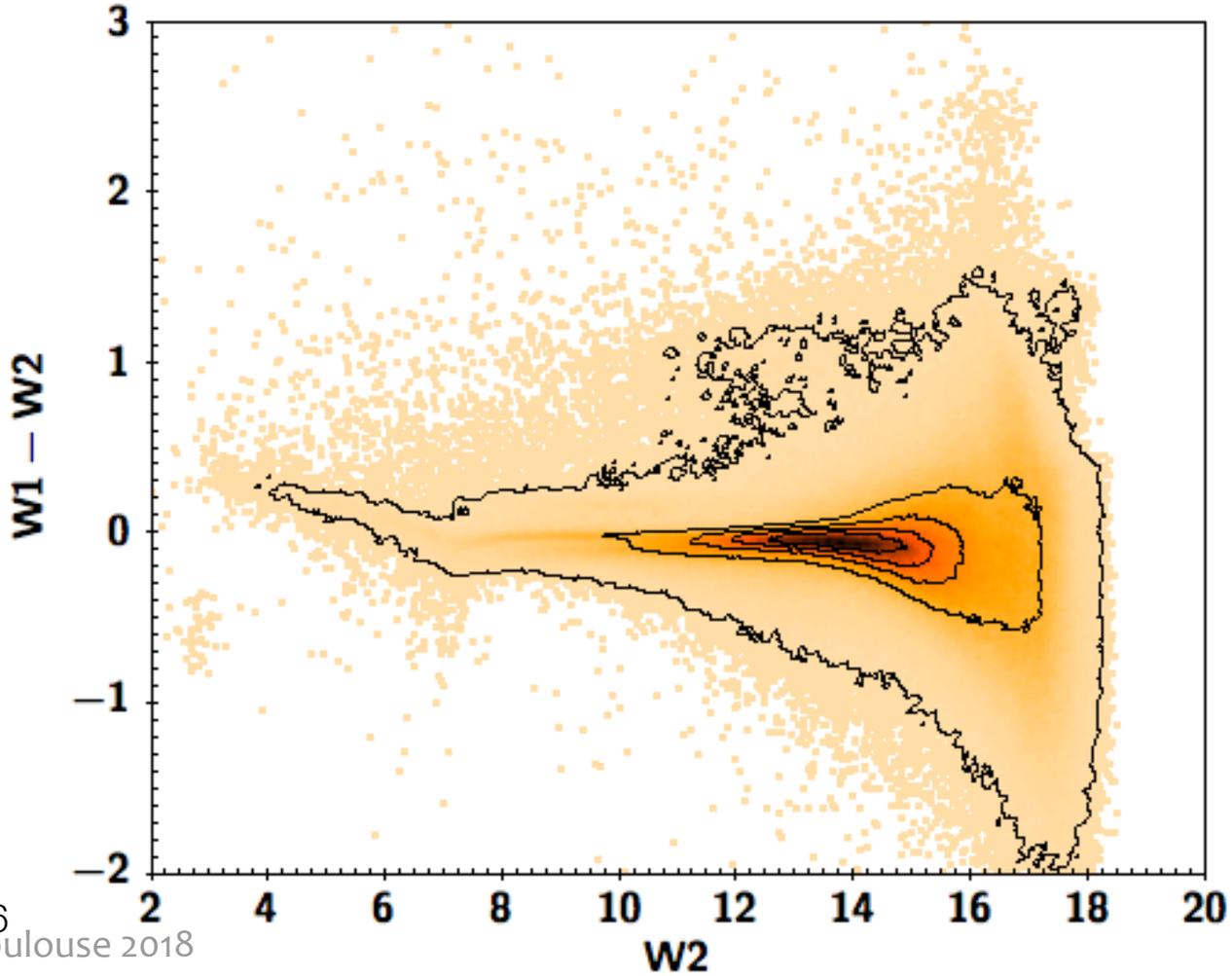
Not-so-subliminal message: give a try to NWAY

Same prior will not work in the Galactic plane

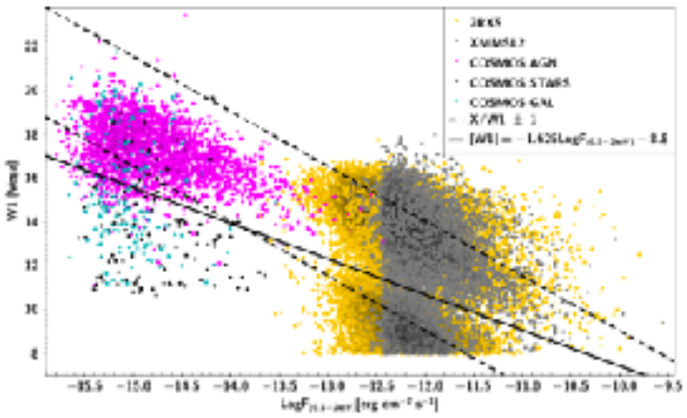


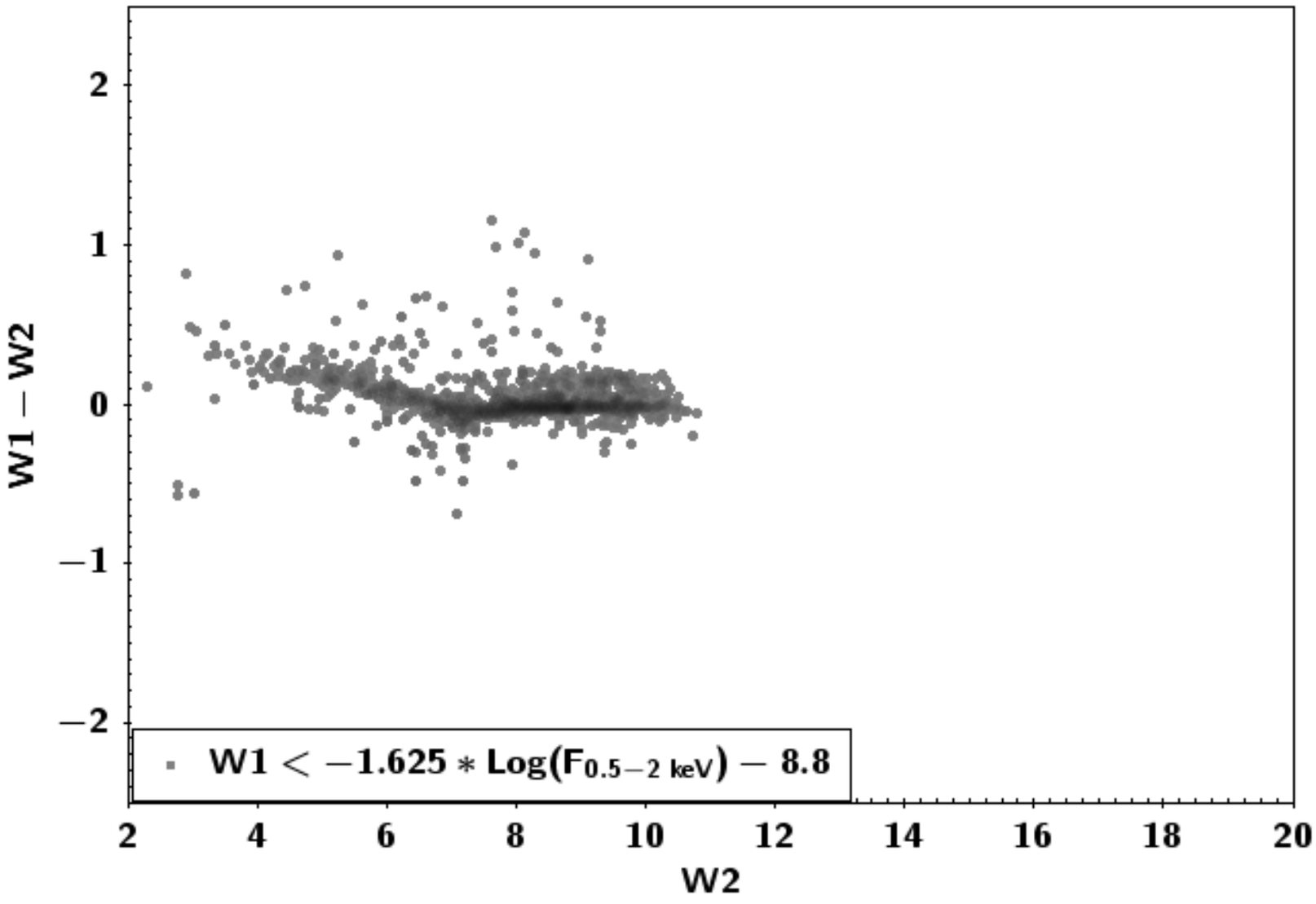
XMMSL2 in the galactic plane





XMMSLEW2 GAIA Counterparts classification in the galactic plane





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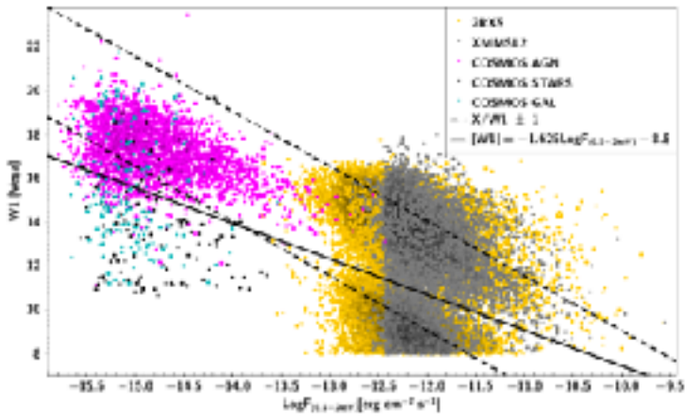

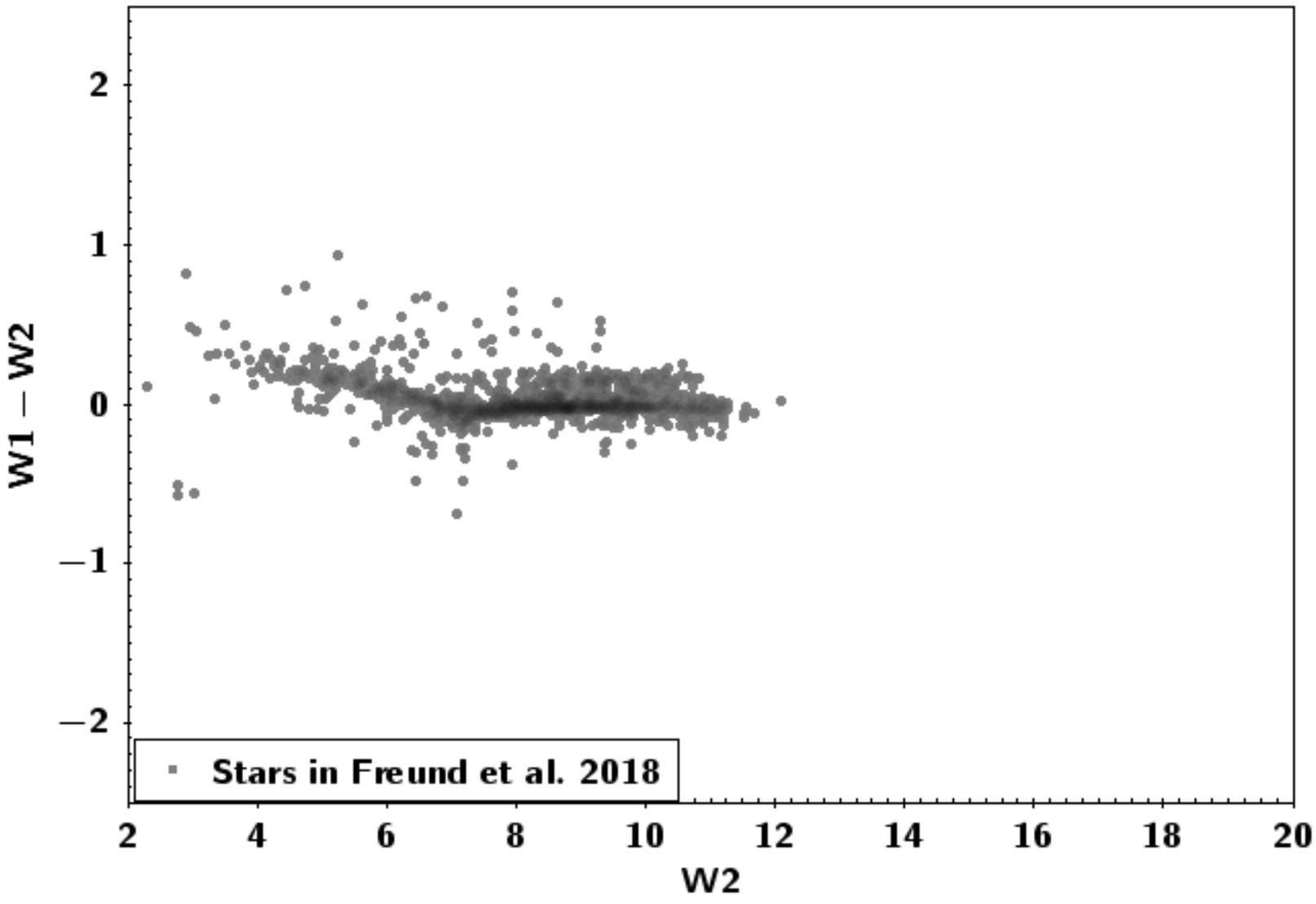

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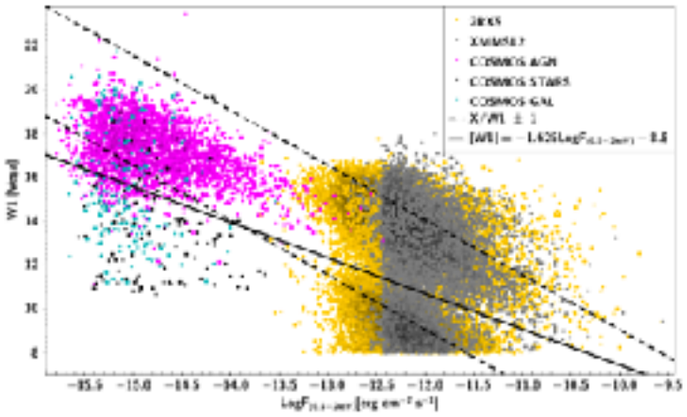

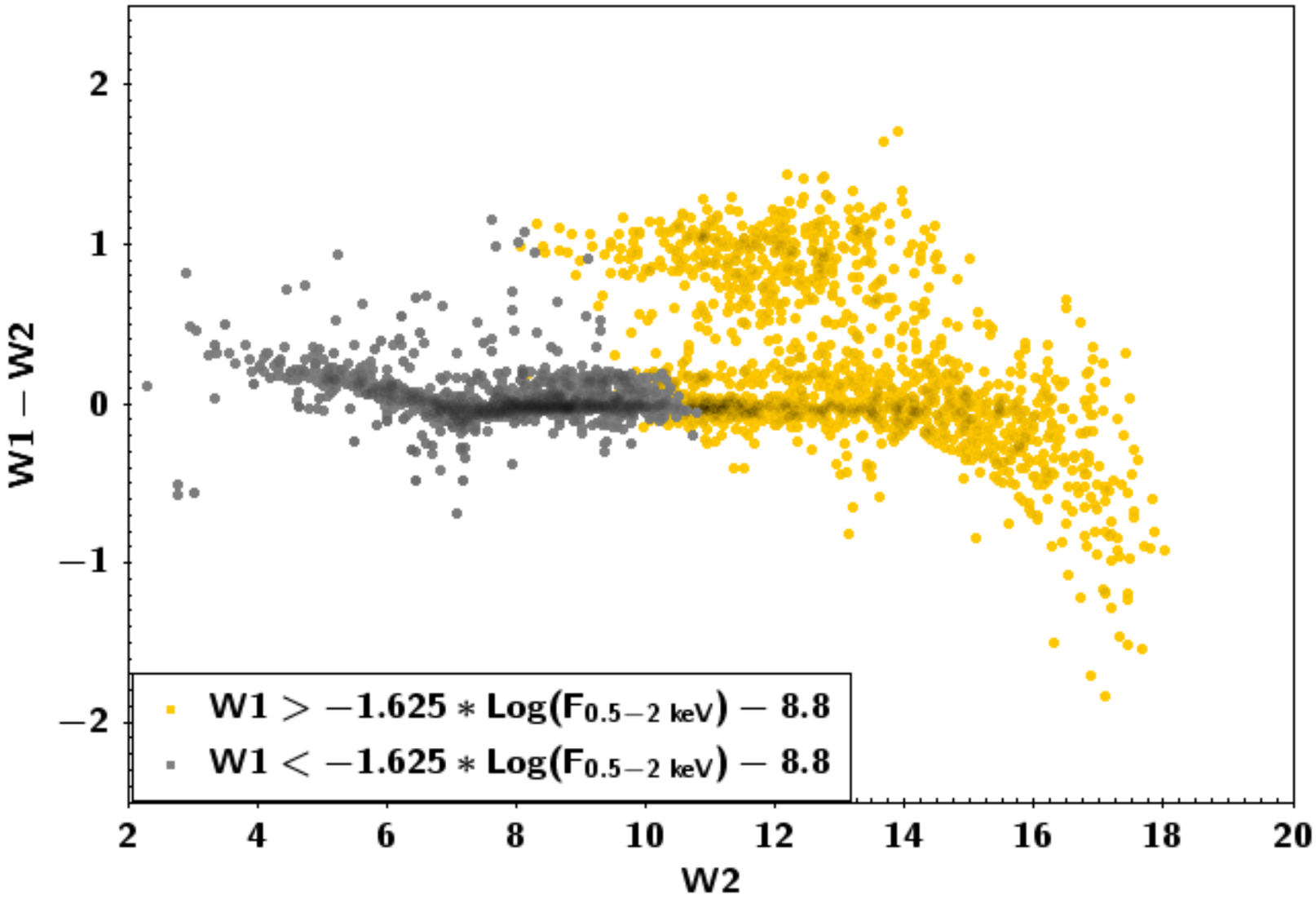

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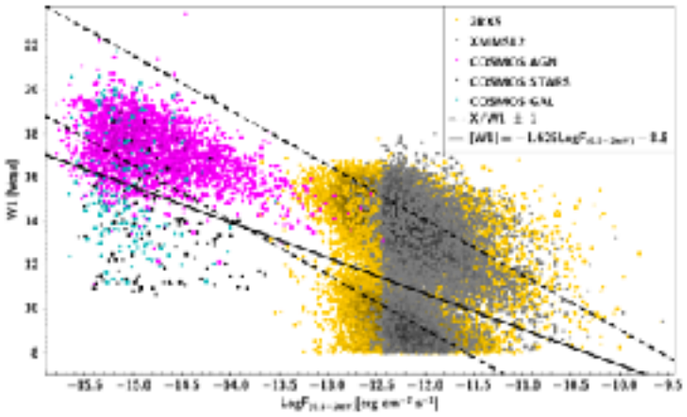
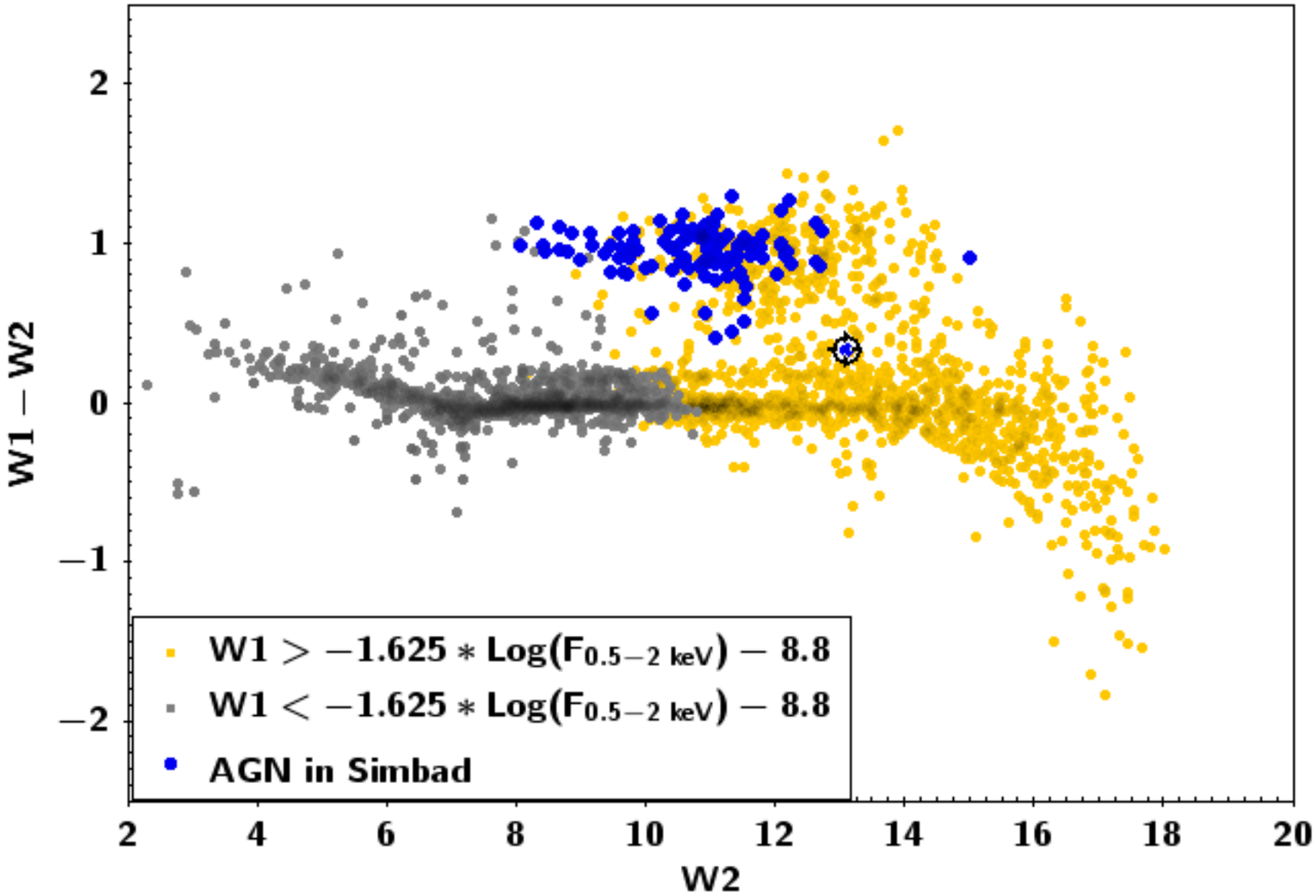
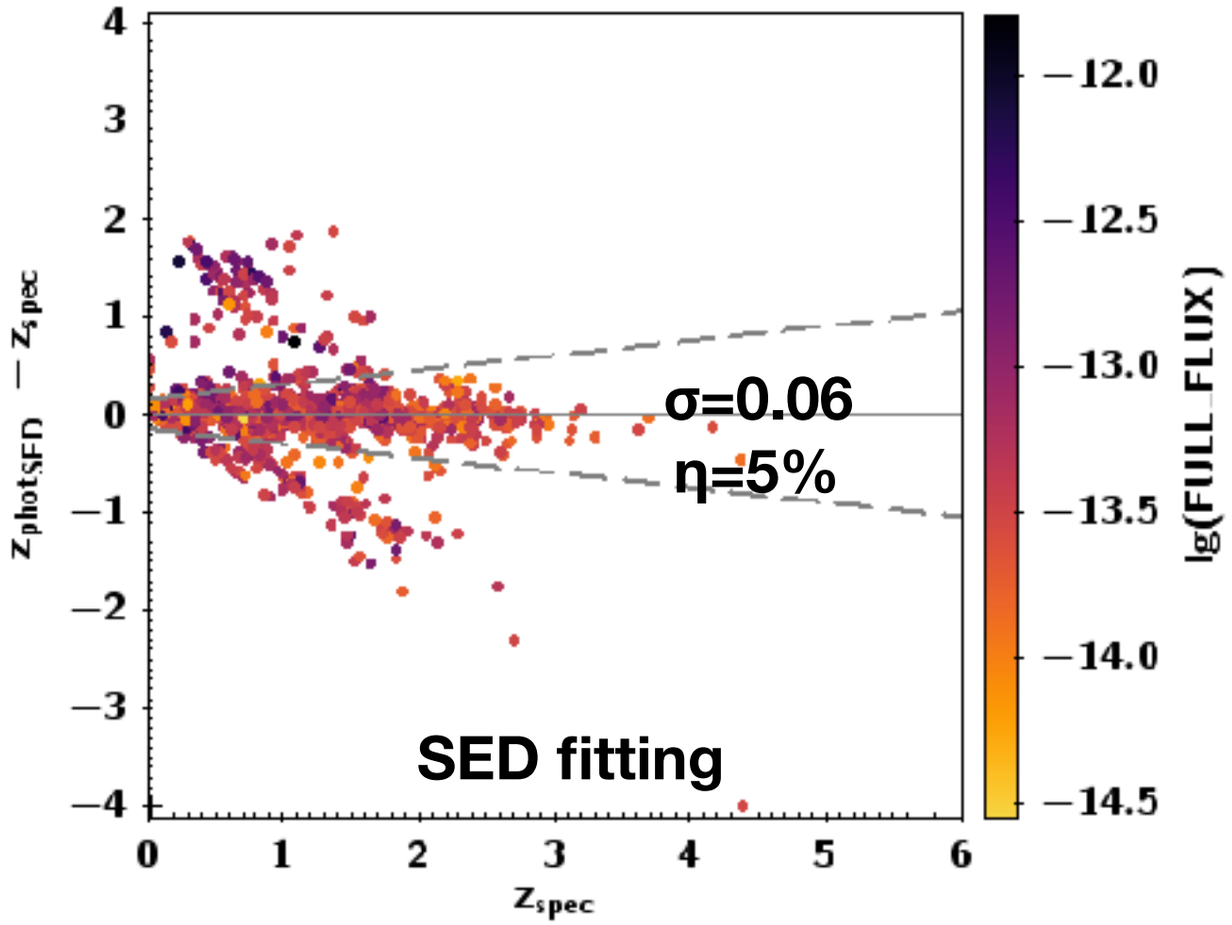


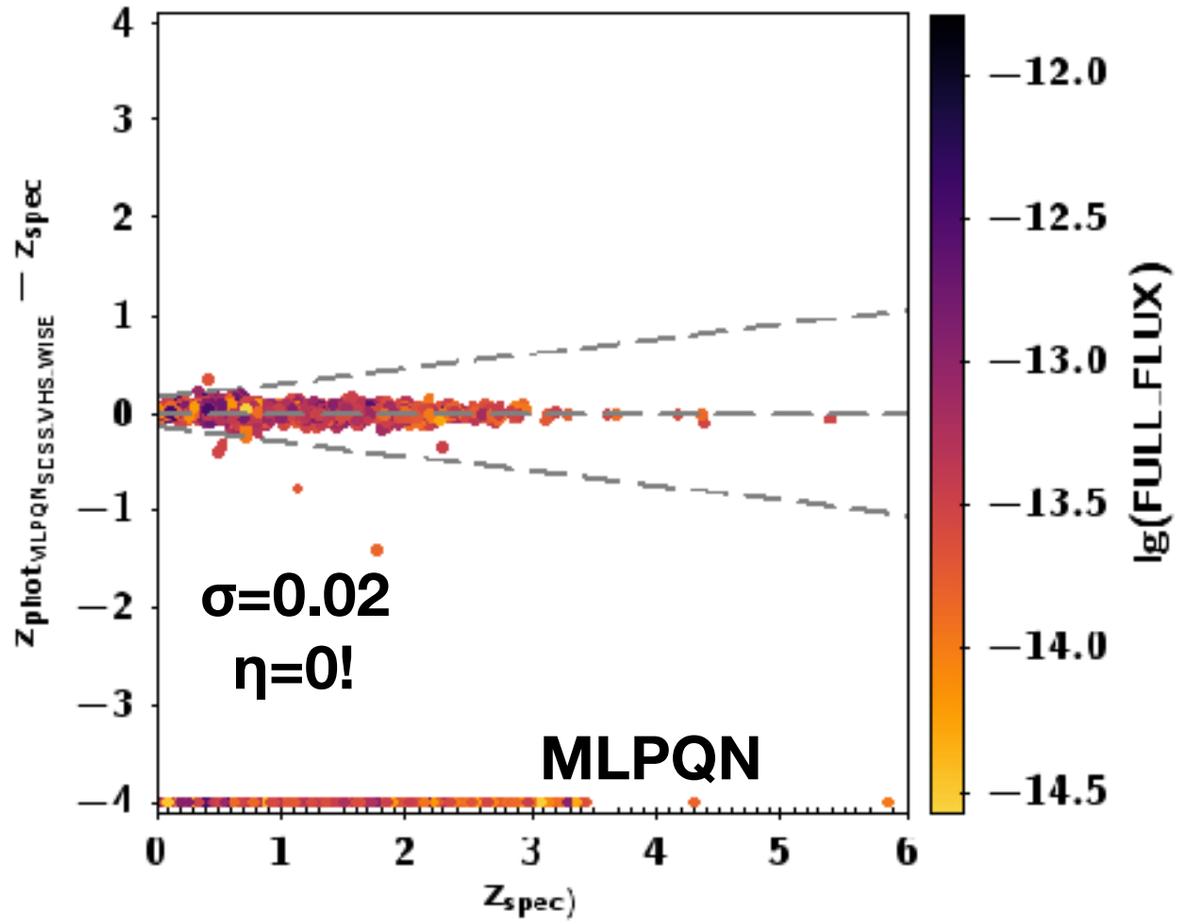


Accuracy in STRIPE82X photoz comparable to Legacy-COSMOS with SDSS+VHS+WISE (10 bands only)

Ananna, MS et al 2017

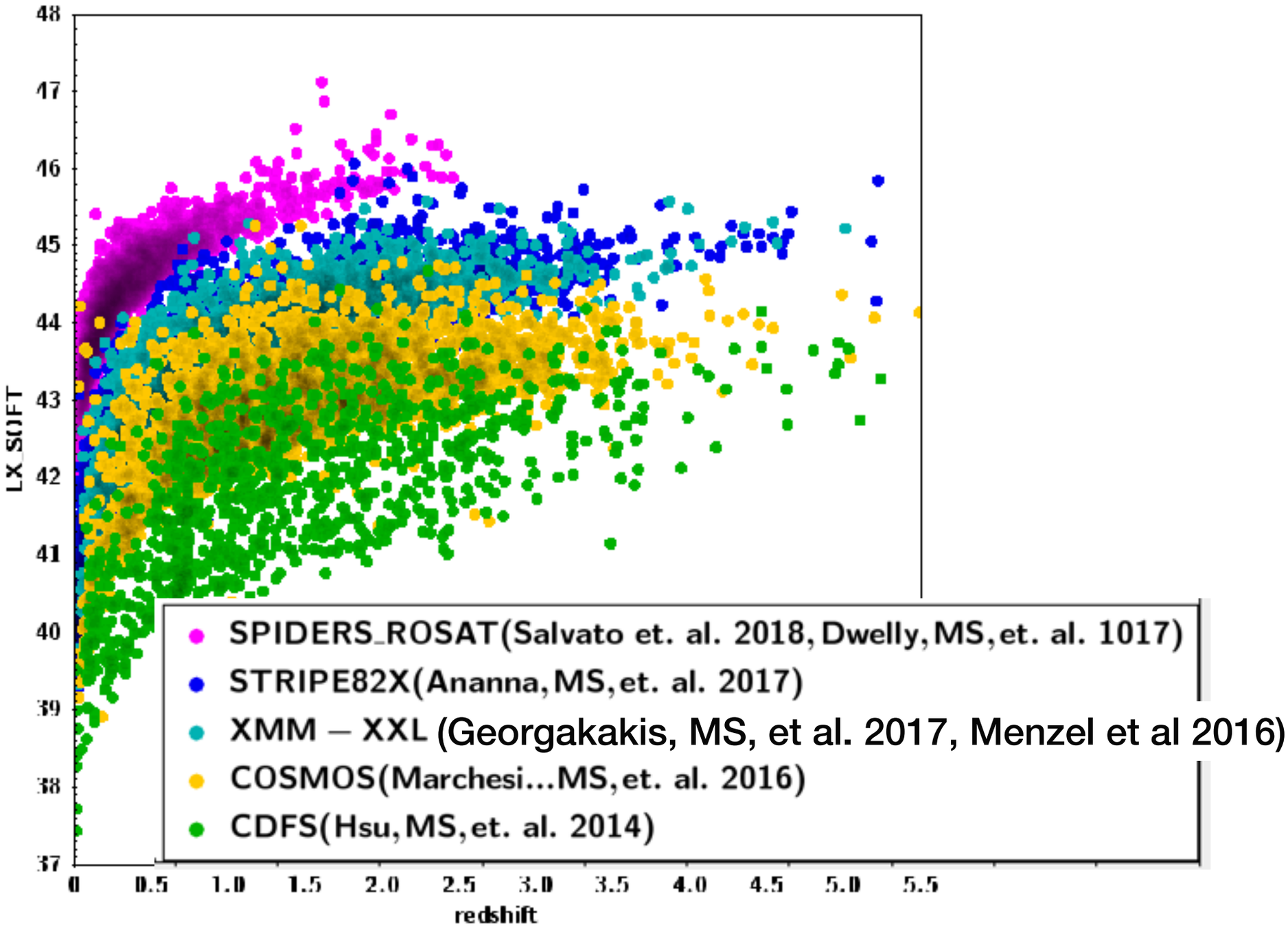


Brescia, MS et al 2018



All the best to SPHEREx (Dore' et al 2018), Euclid and LSST !

Next challenge:
the 4 million eROSITA point-like sources



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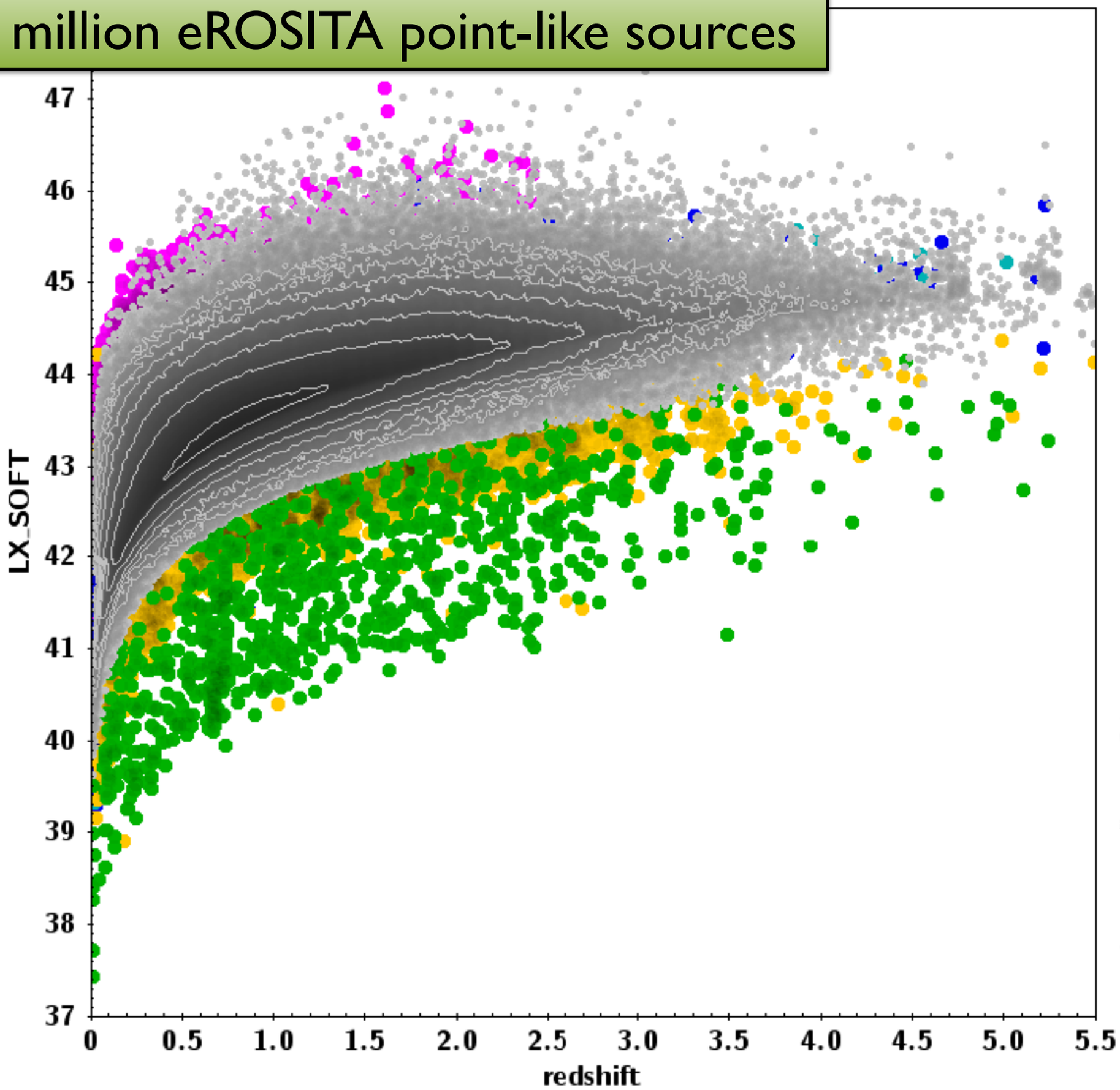

MS, et. al. 1017)

', Menzel et al 2016)

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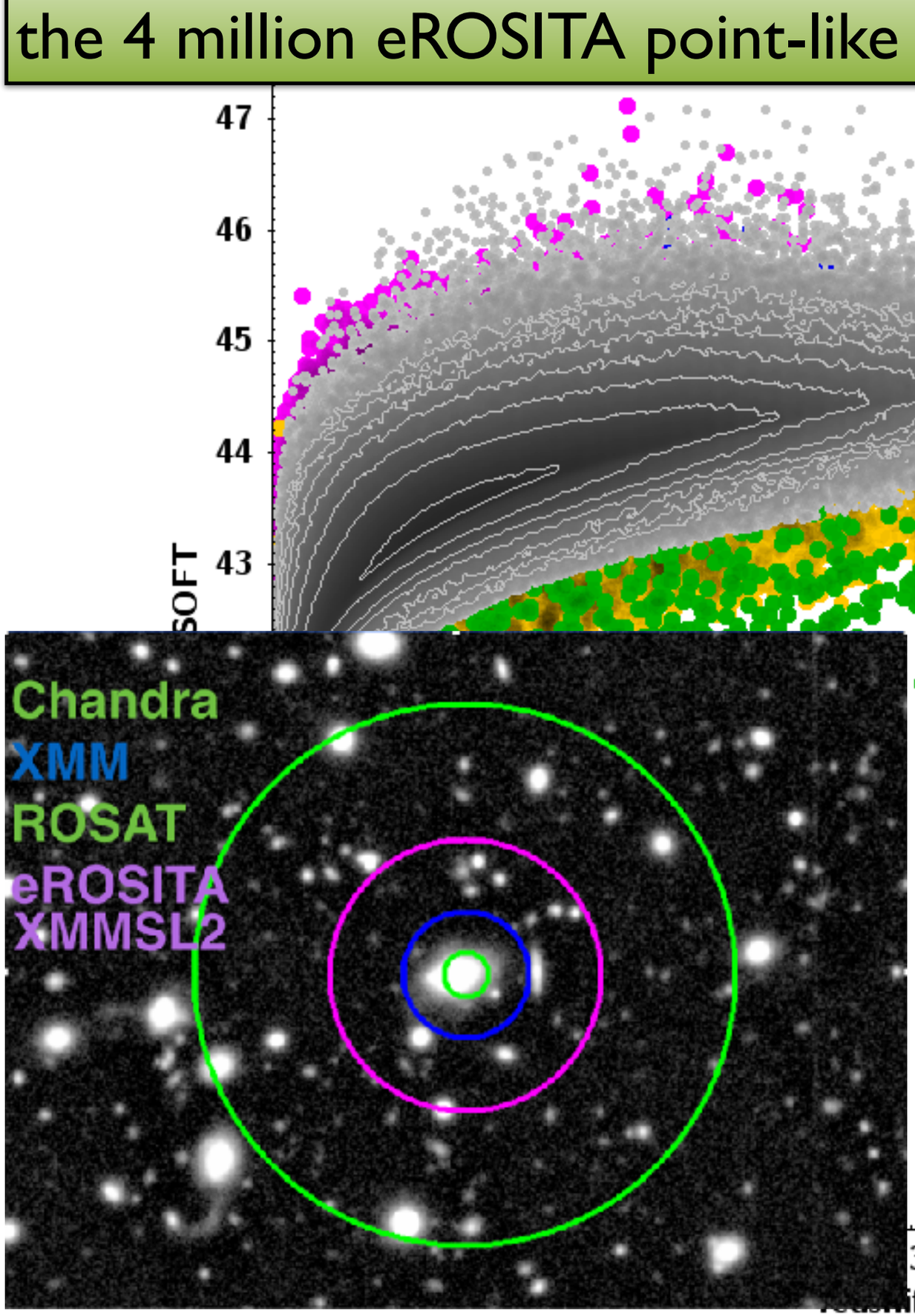
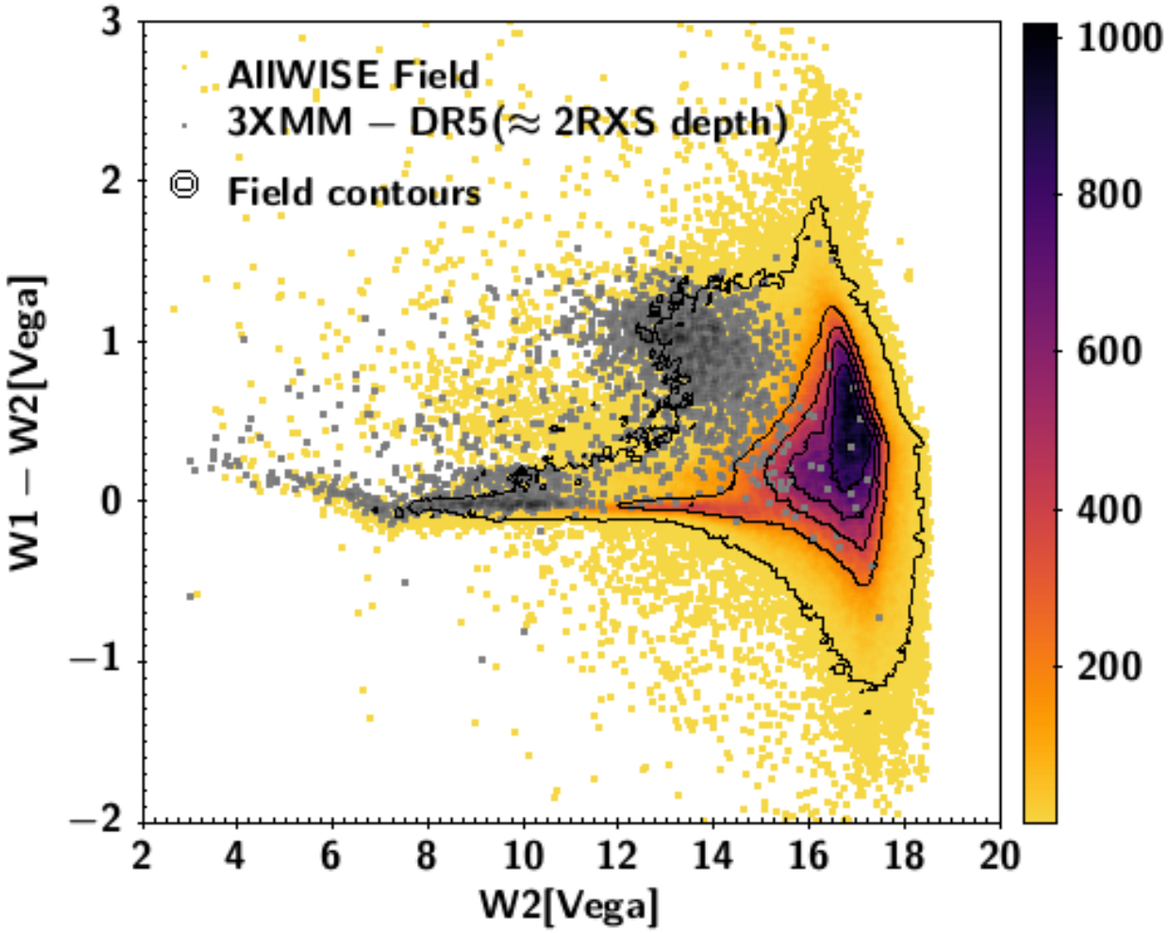
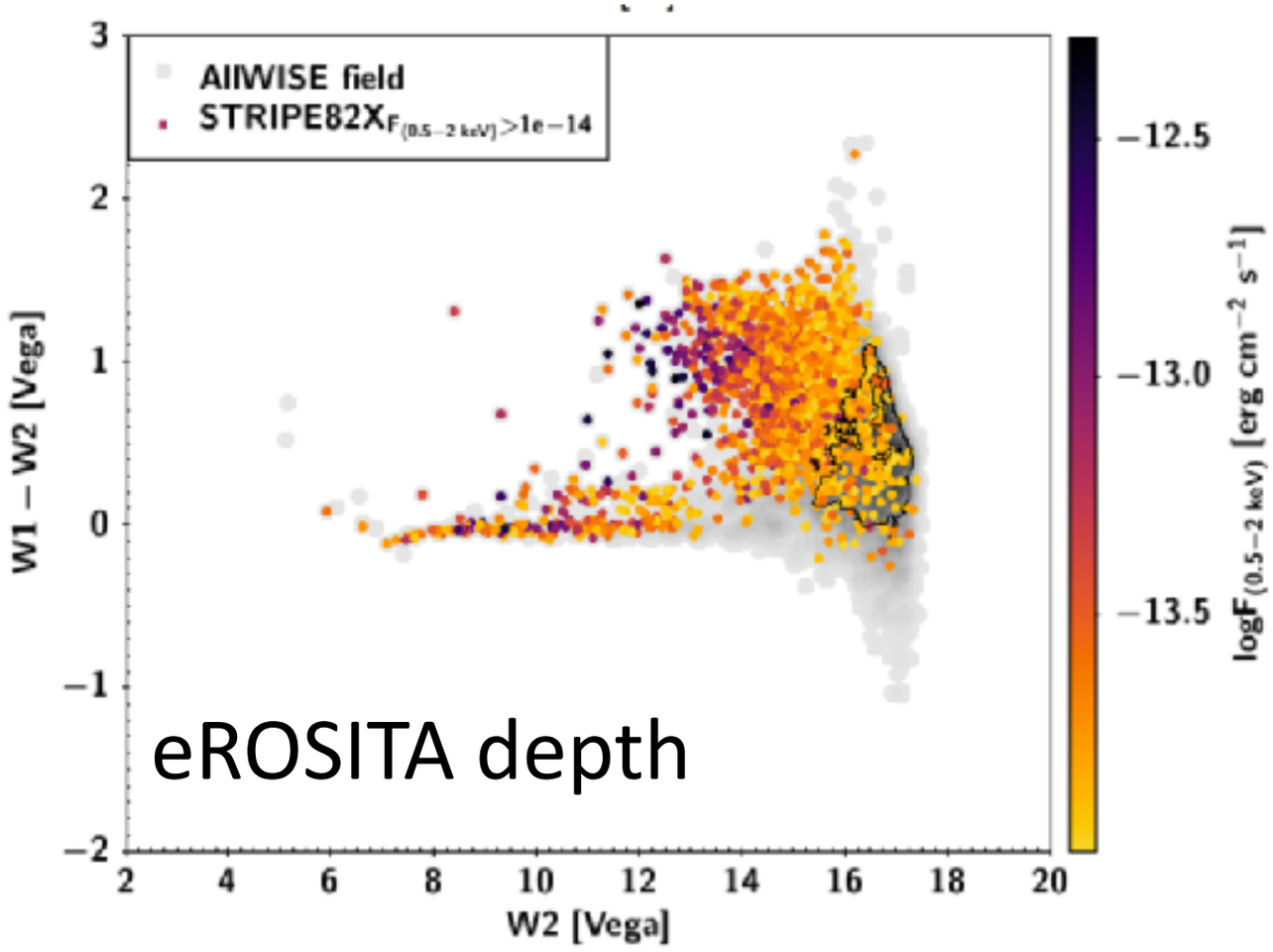


Prior must be adequate to the depth





I am working on the new prior (stay tuned!)

Summary

We developed and released Nway, a code that based on Bayesian statistics allow to consider at once, astrometry, distribution and physical properties of candidate counterparts, opposed to those of field sources. Works also in radio.

For 2RXS (XMMSL2) we defined a MIR color-magnitude prior. Based on a well understood spectroscopic sample we claim a reliable counterpart for at least ~97% of the 106 573 (17 665) X-ray sources, with a small fraction of spurious associations.

The combination of deep pencil beam and shallow all-sky area allowed to determine a better separation between stars ans AGN dominated object in the W1 and Fx plan.

GAIA allowed the determination and classification of the XMMSLEW2 sources in the galactic plane.

For eROSITA, depeding on depth and location (e.g. extragal/gal/poles) different discriminators need to be defined (work in progress). NWAY will be also slightly modified.