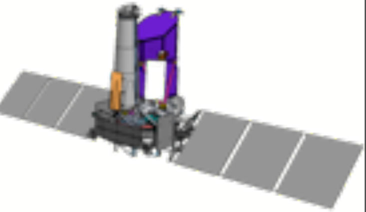
Mapping the active Universe with eROSITA

arXiv:1209.3114
Merloni et al. 2012

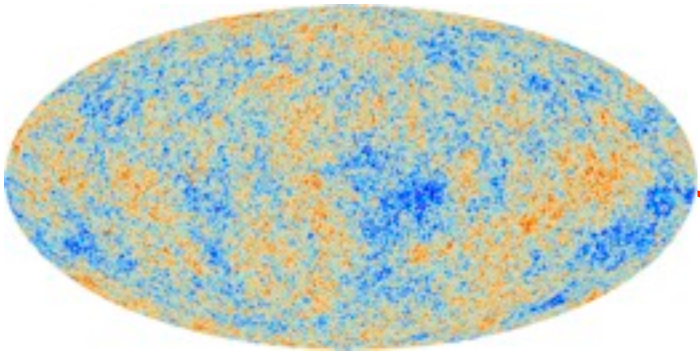
Mara Salvato (MPE)
on behalf of the eROSITA team



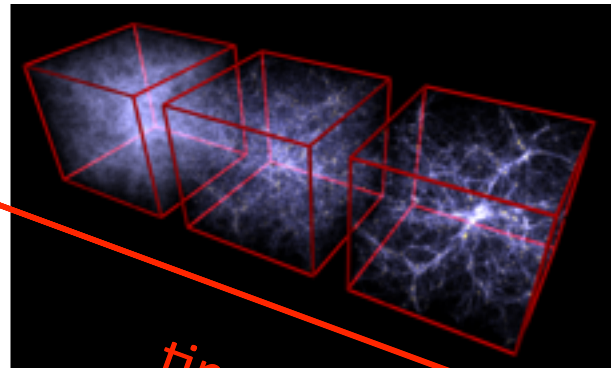
eROSITA Main science driver:

Cluster Cosmology and the growth of LSS

ESA/Planck, z > 1000

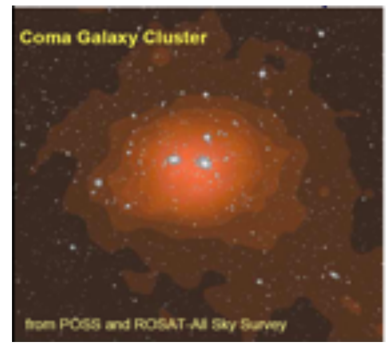


Millennium Simulation



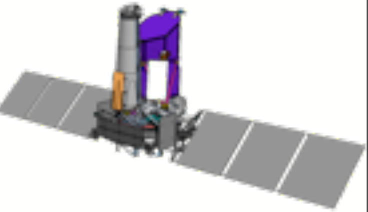
time

ROSAT, z < 0.1

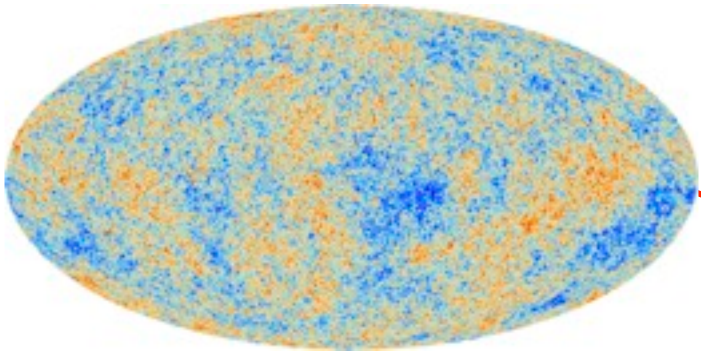


- Clusters of galaxies are the largest gravitational bound structures, sensitive tracers of LSS
- A signature of clusters is the existence of hot, X-ray emitting baryons
- Cosmological constraints with (well calibrated) ROSAT samples of <100 obj.
- **~100,000** galaxy clusters total Peak at $\boldsymbol{z \sim 0.3}$, $\boldsymbol{M_{500} \sim 10^{14} M_{sol}}$
- X-ray data alone will give: Sky position, Flux(L_X, z,…), Spectrum (T_X, z, abundances…), Morphology (R_{500}, z, M_{gas}, substruct…) >> **Not simply "a deeper ROSAT survey"!**

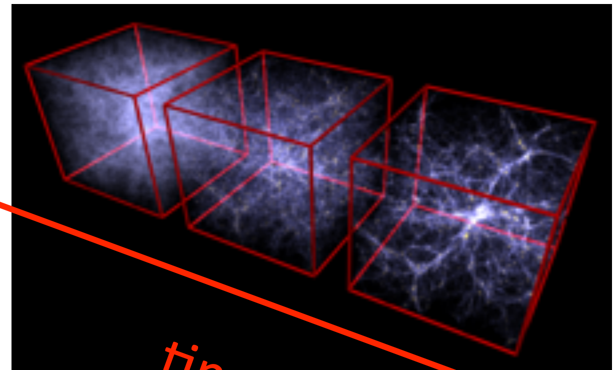
eROSITA Main science driver:



Cluster Cosmology and the growth of LSS

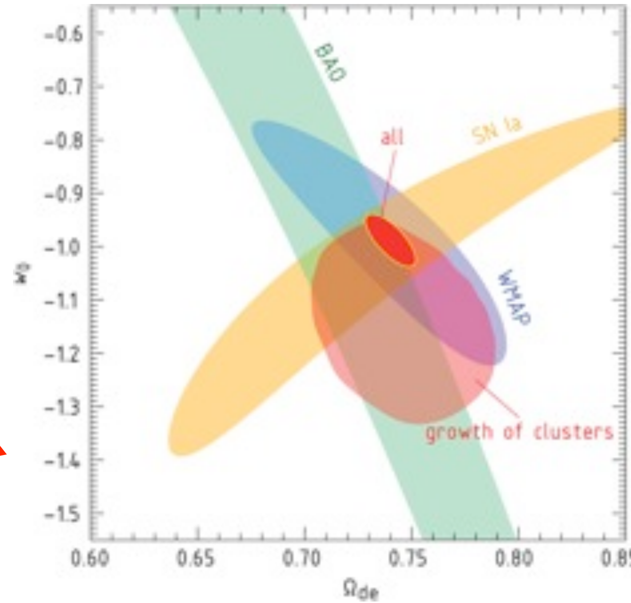


ESA/Planck, z > 1000



Millennium Simulation

Vikhlinin et al. 2009



time

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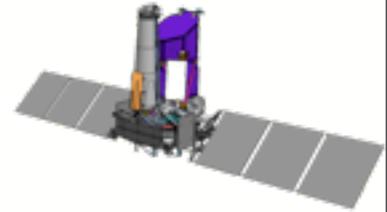
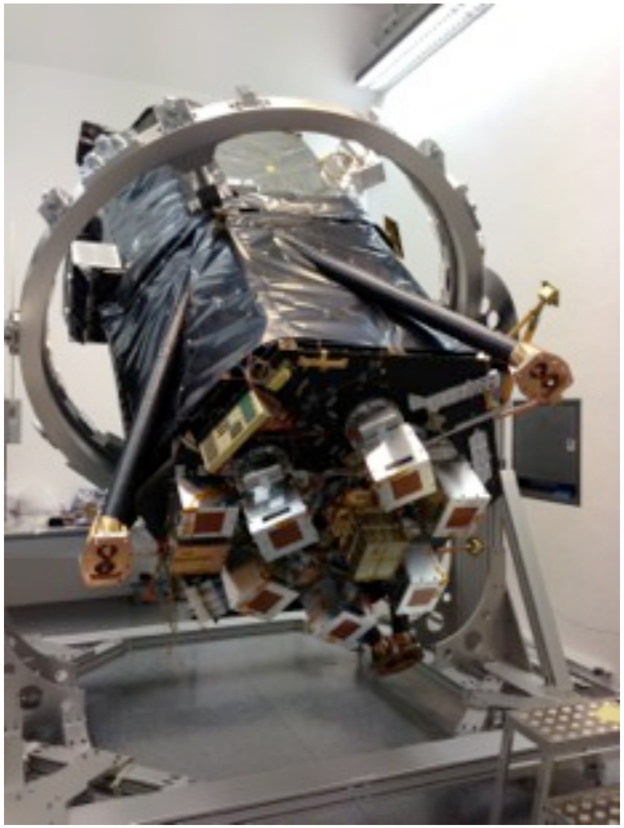
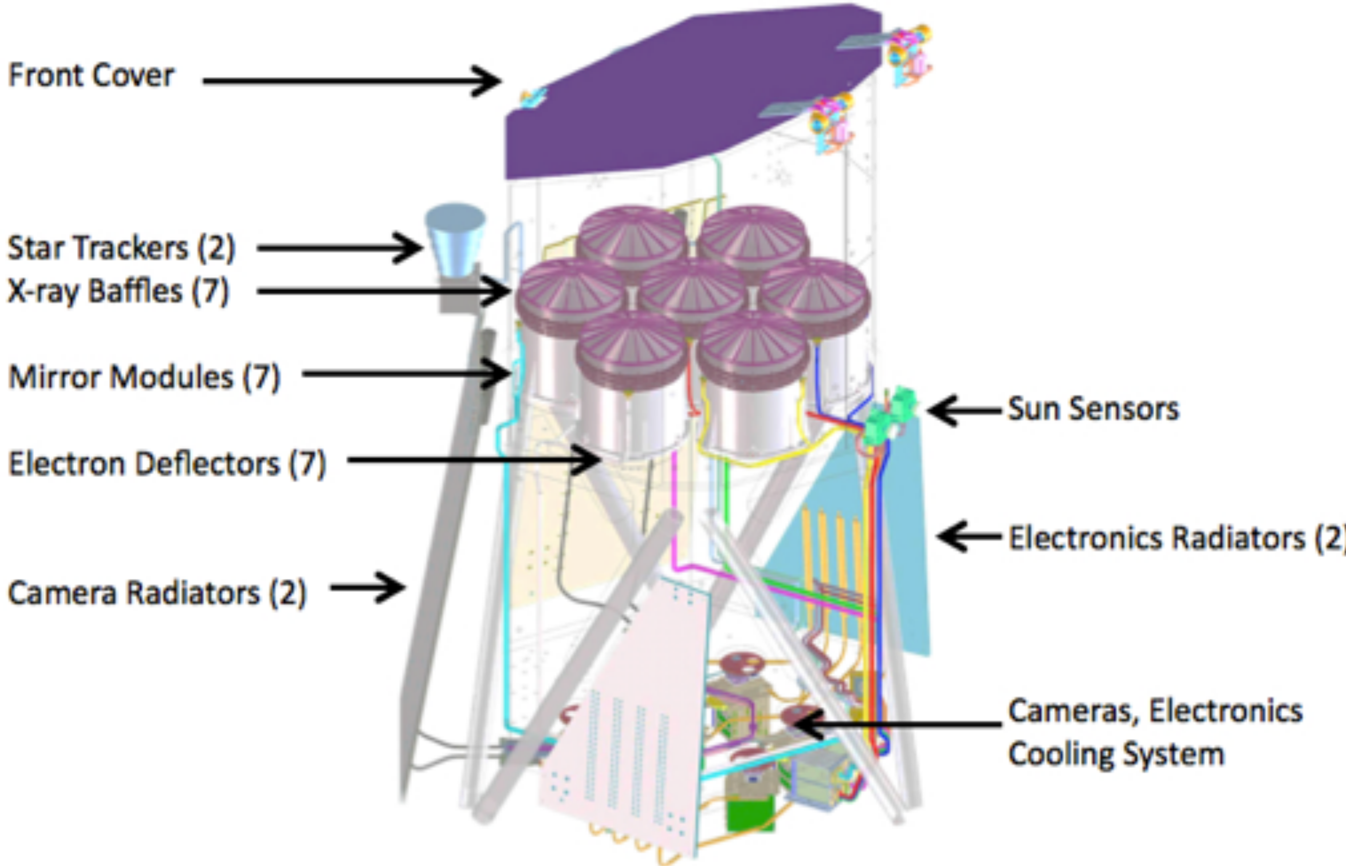
The eROSITA X-ray Telescope



www.mpe.mpg.de/eROSITA

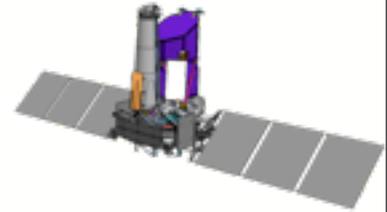


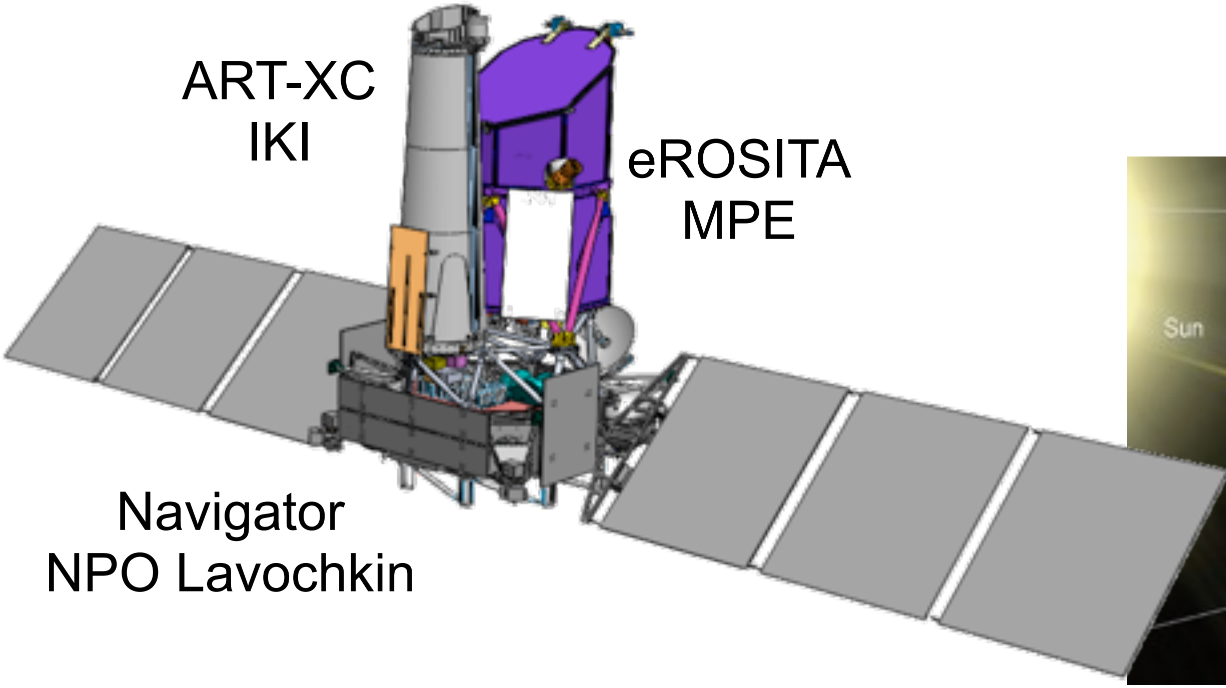


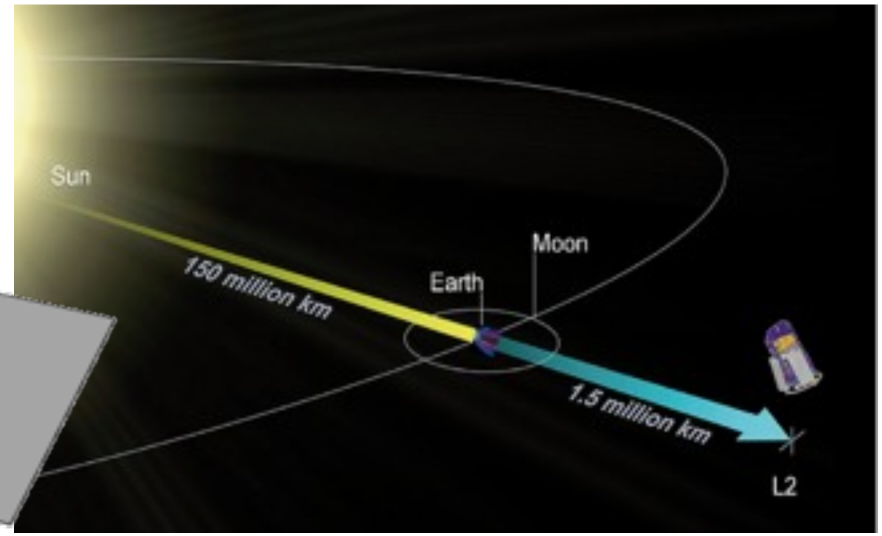
Focal length 1.6 m
F.o.V. = 0.81 sqdeg
54 nested mirror shells
Total weight ~800 kg

7 identical telescopes (Wolter-I/ pnCCD-cameras)
Energy range: 0.3-10 keV
Energy resolution: 138 eV @ 6 keV

eROSITA on SRG: the Mission



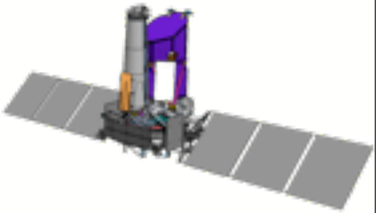




- **3 Months:** flight to L2, verification and calibration phase
- **4 years**: 8 all sky surveys (scanning mode: 6 rotations/day, 1 degree advance per day)
- **3.5 years**: pointed observation phase, including ~20% of GTO. 1 AO per year
- **Proprietary data** rights shared 50/50 between MPE (Germany) and IKI (Russia)

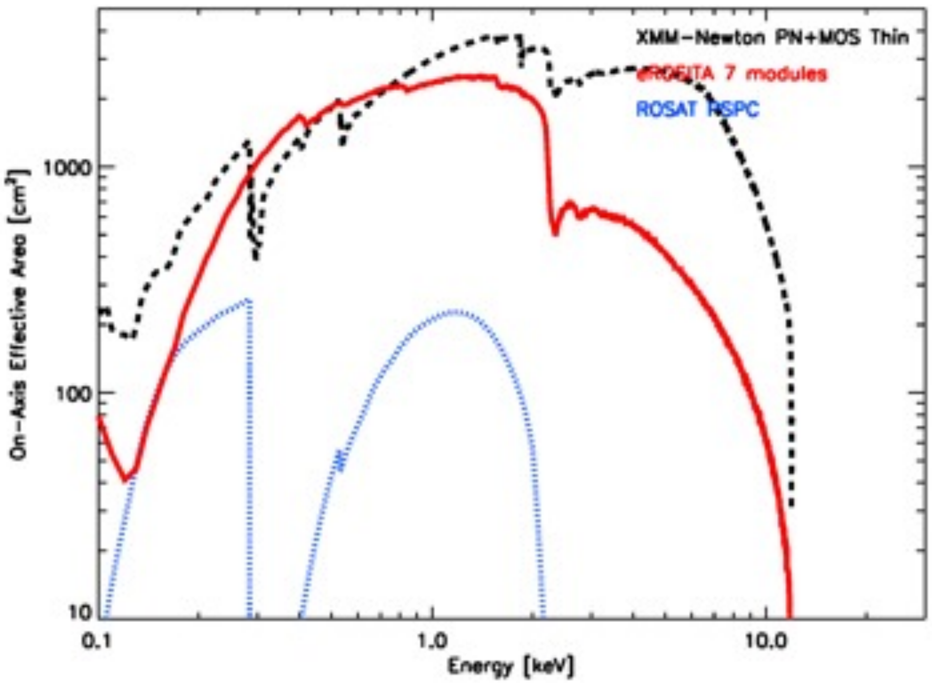
    German (MPE) half: proprietary period maximum **2 yrs**

    Periodic Release of German all-sky data

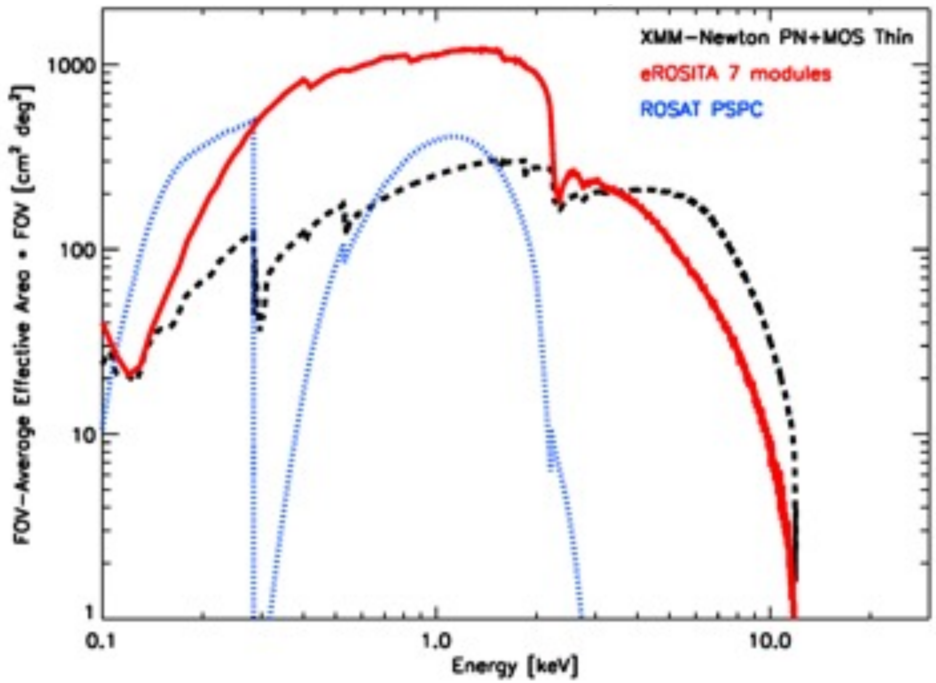


Effective area and grasp

Effective Area



Grasp

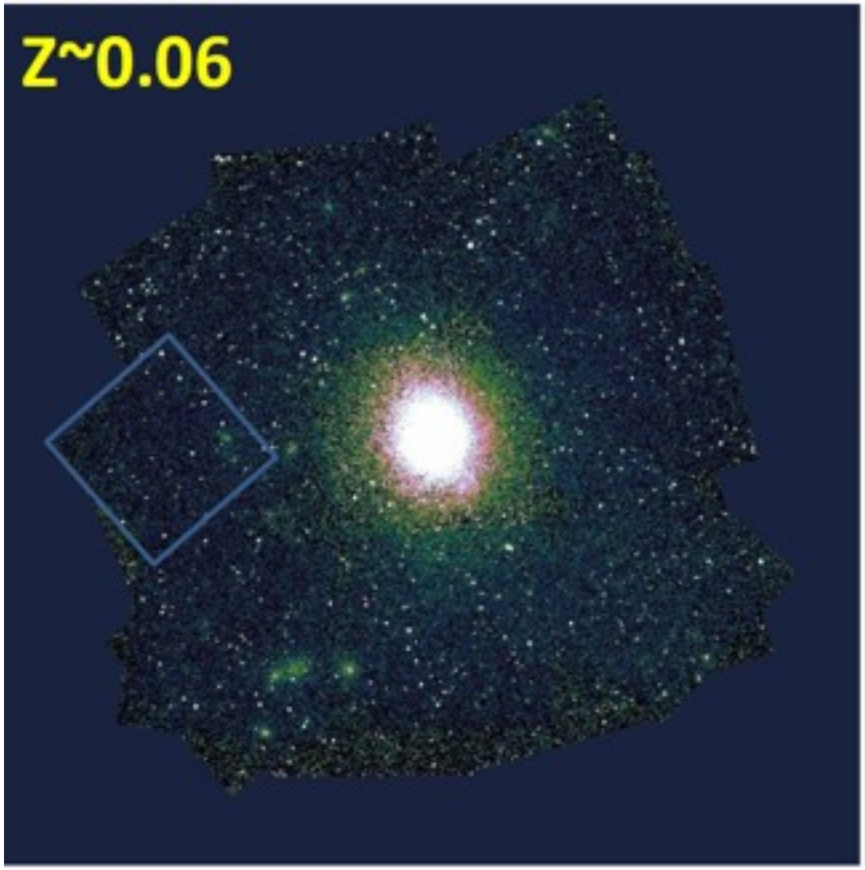


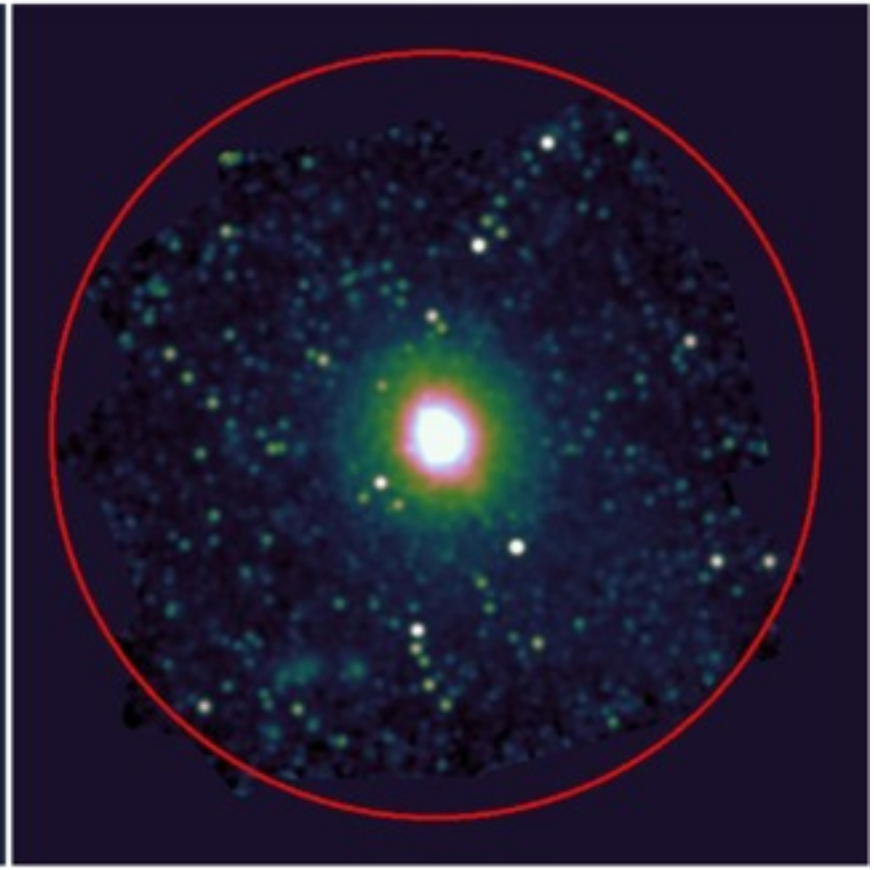
Effective Area: ~1400 cm^2 (@1keV)

M.Salvato, eROSITA

Grasp

Chandra	eRosita



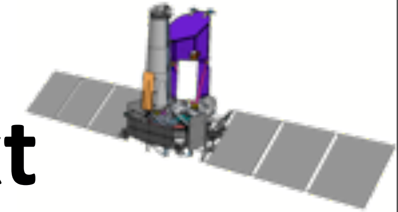


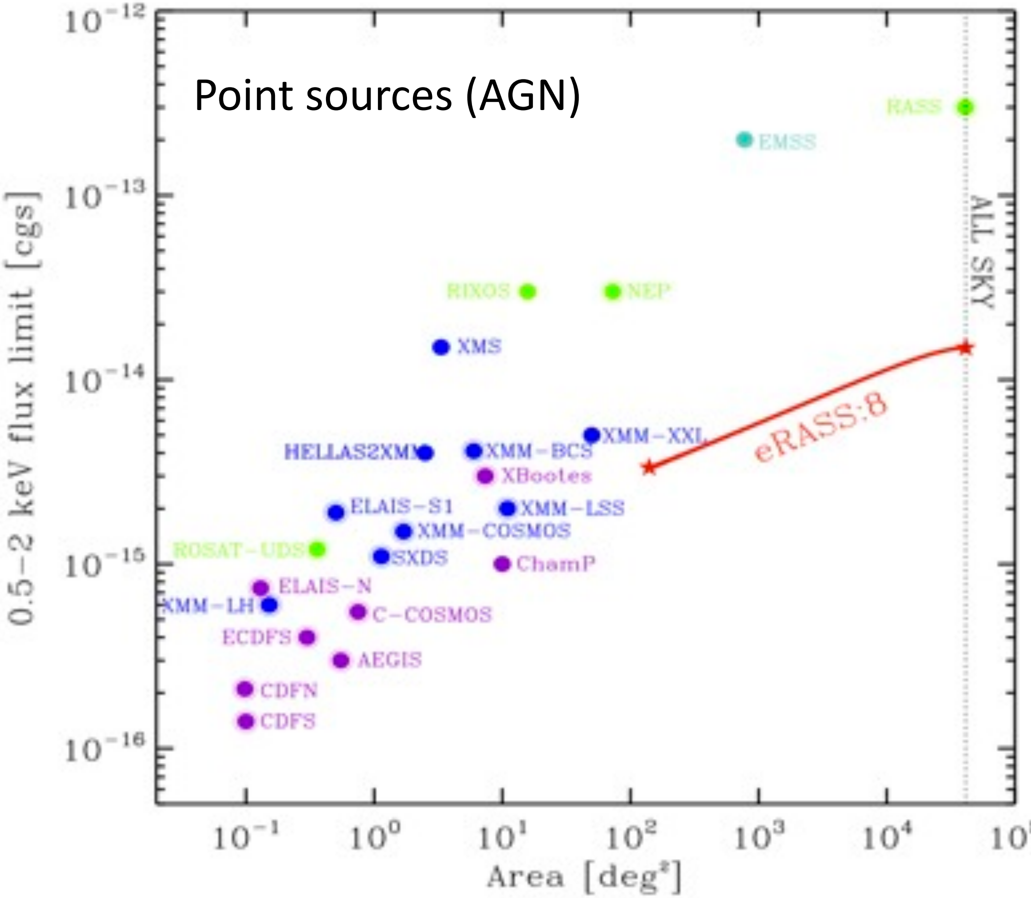
~30 pointings
~2 Msec

~1 pointing, ~4 Mpc
~80 ksec

Churazov, IKI, MPA

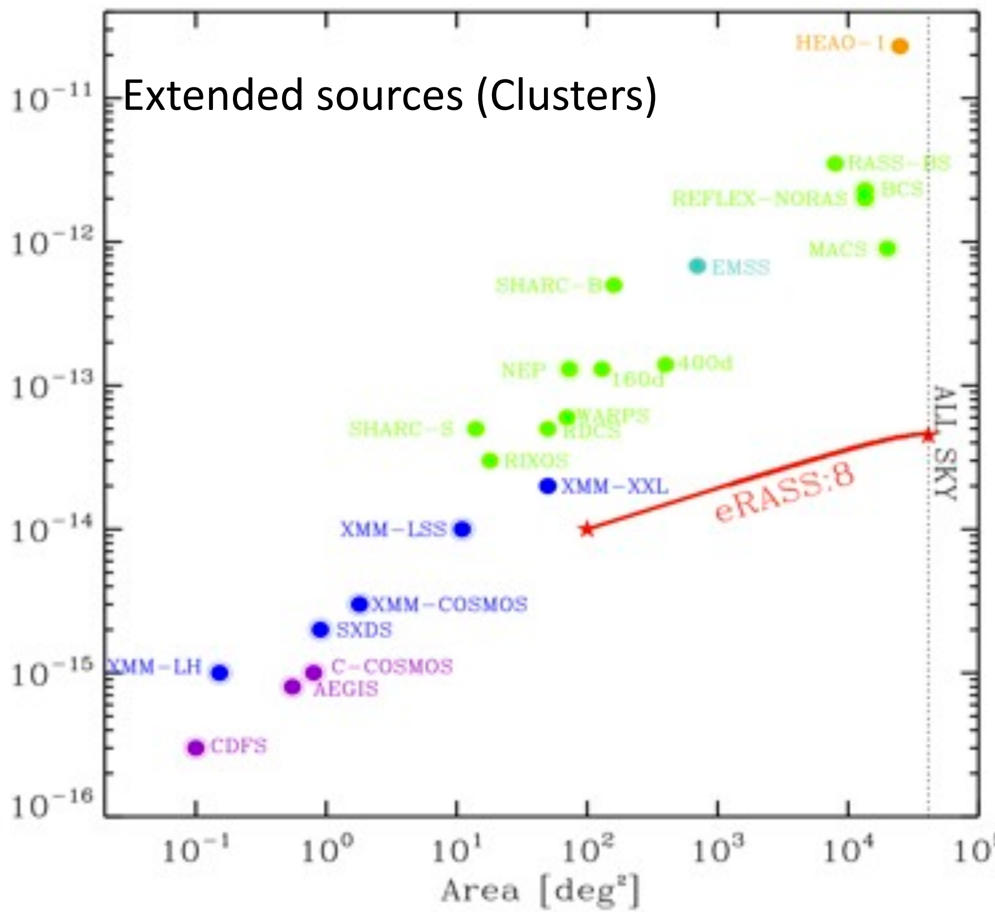
SRG/eROSITA surveys in context





All sky: 10^{-14} (0.5-2 keV)

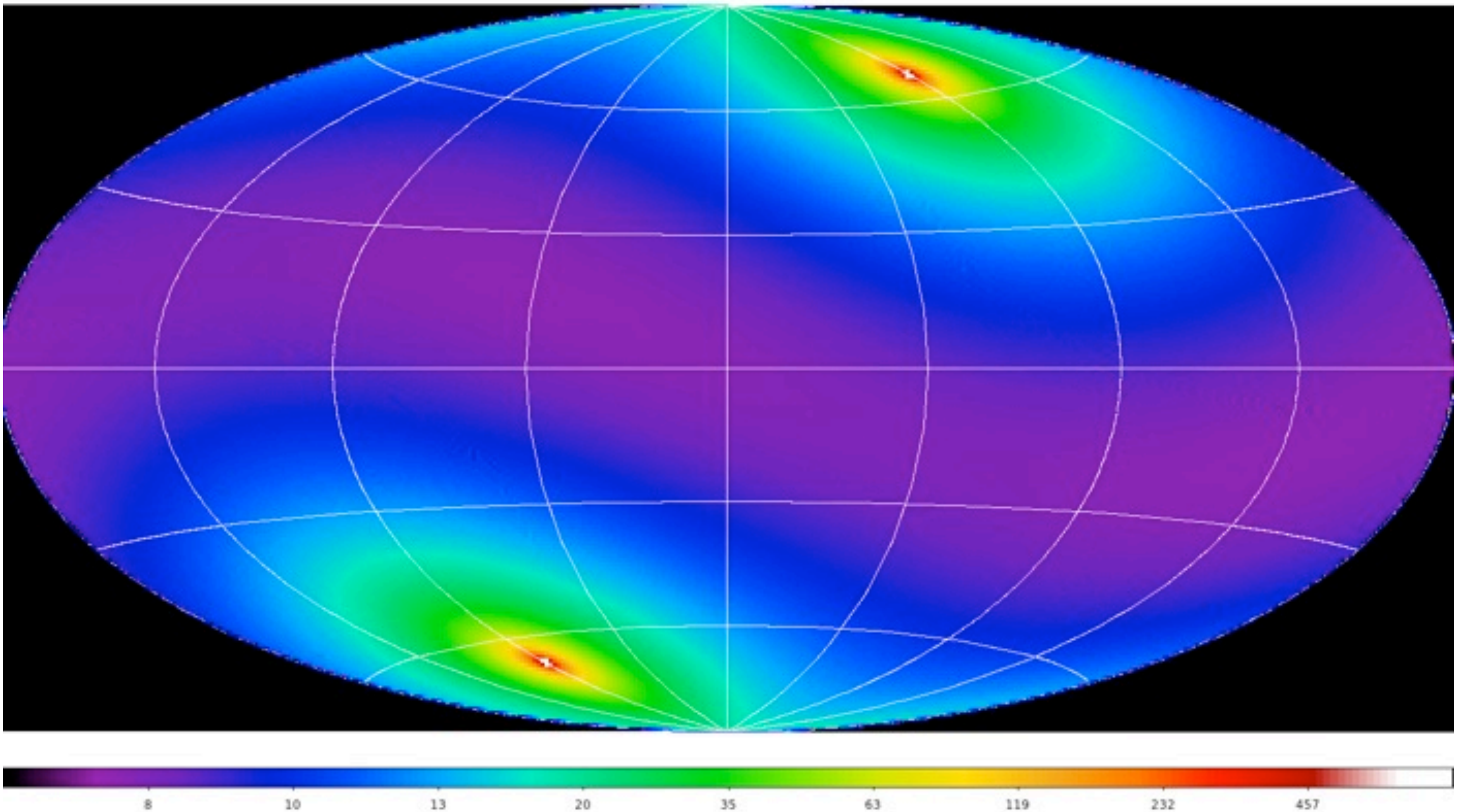
2×10^{-13} (2-10 keV) [erg/cm^2/s]



All sky: 3.4×10^{-14} (0.5-2 keV)

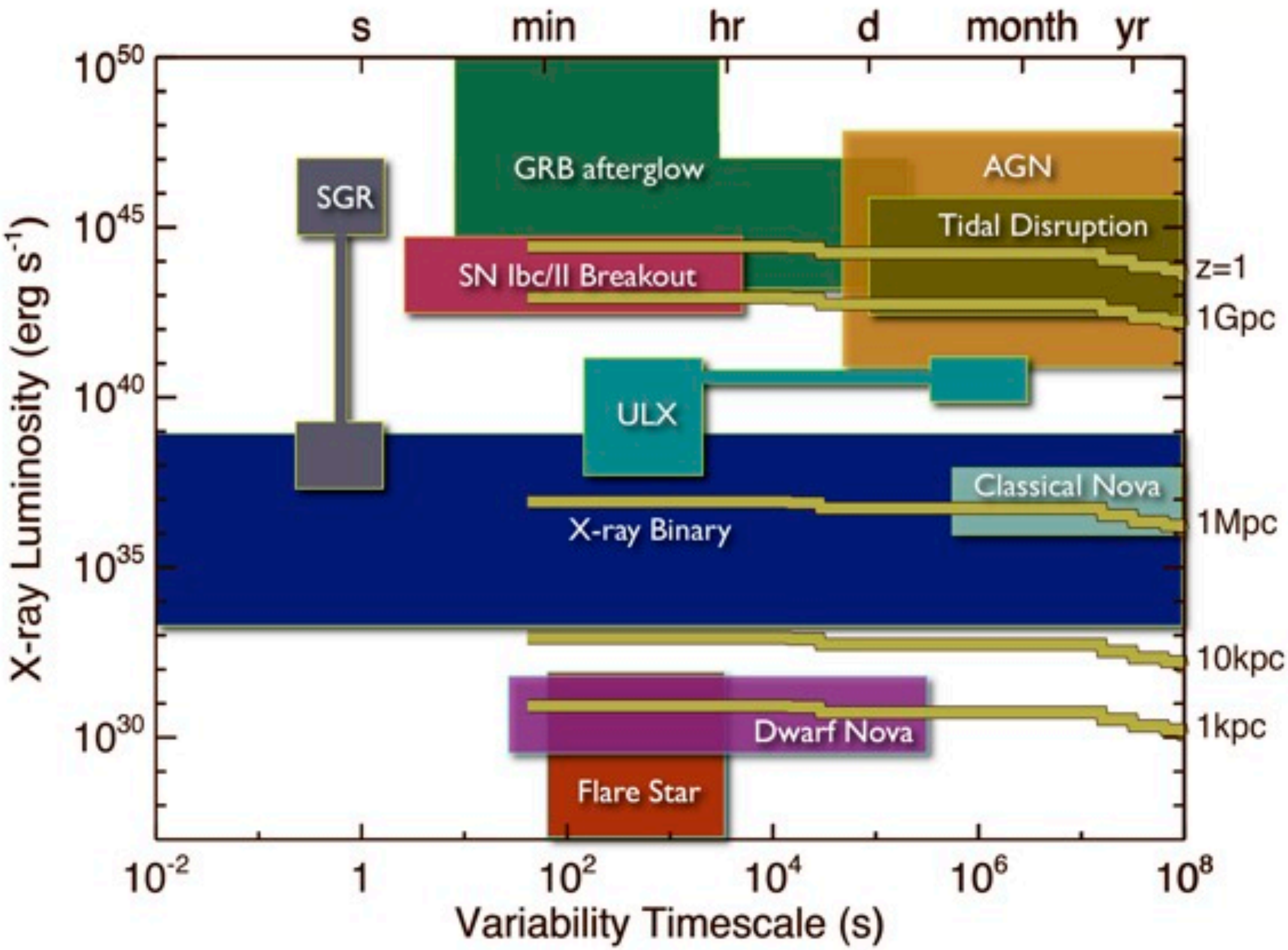
Merloni et al. 2012

Cadence Map



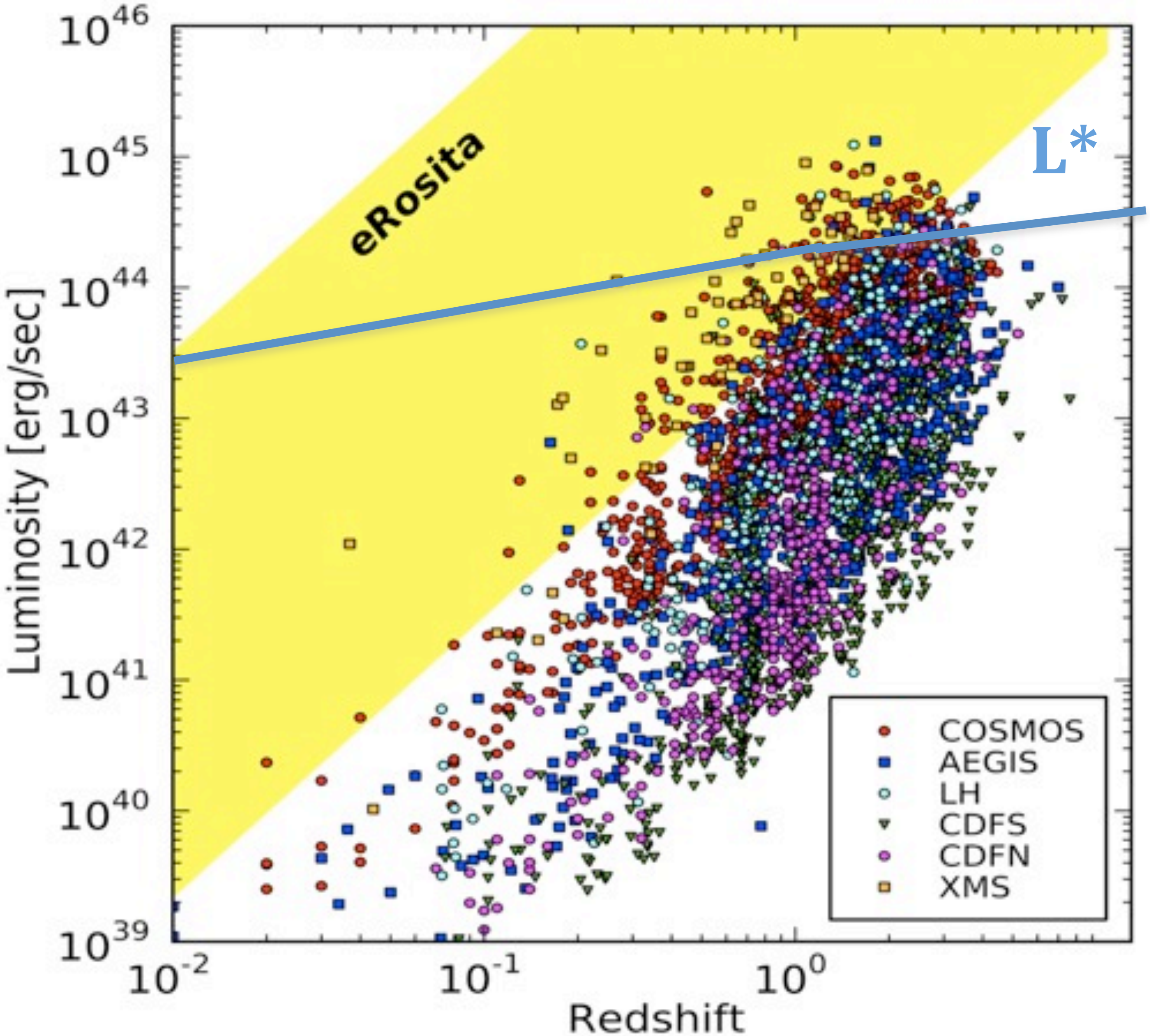
Merloni et al. 2012

eROSITA sensitivity to variable sources



Merloni et al. 2012

3 Millions eROSITA AGN



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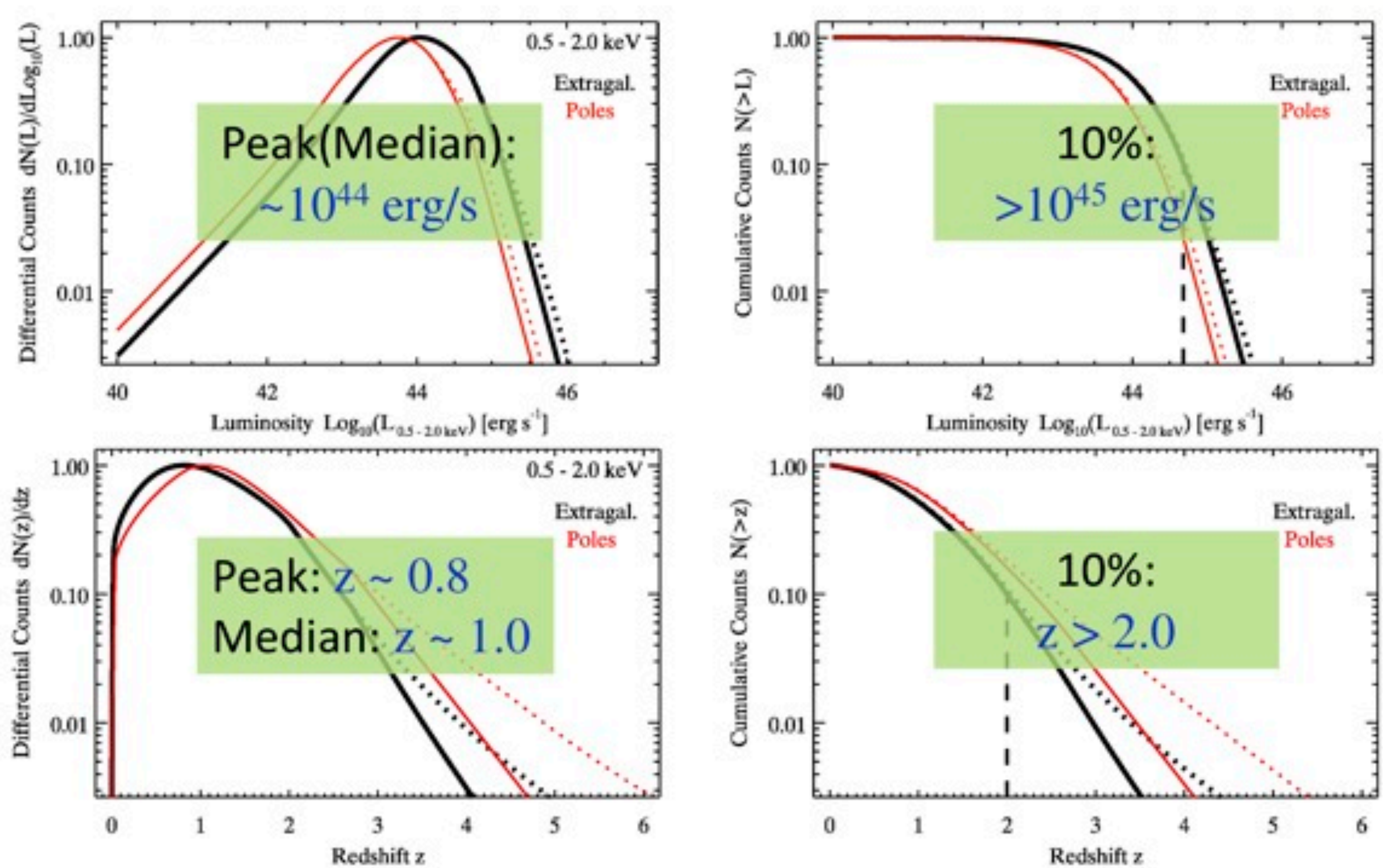
3 Millions eROSITA AGN

Kolodzig et al. 2012



M.Salvato, eROSITA

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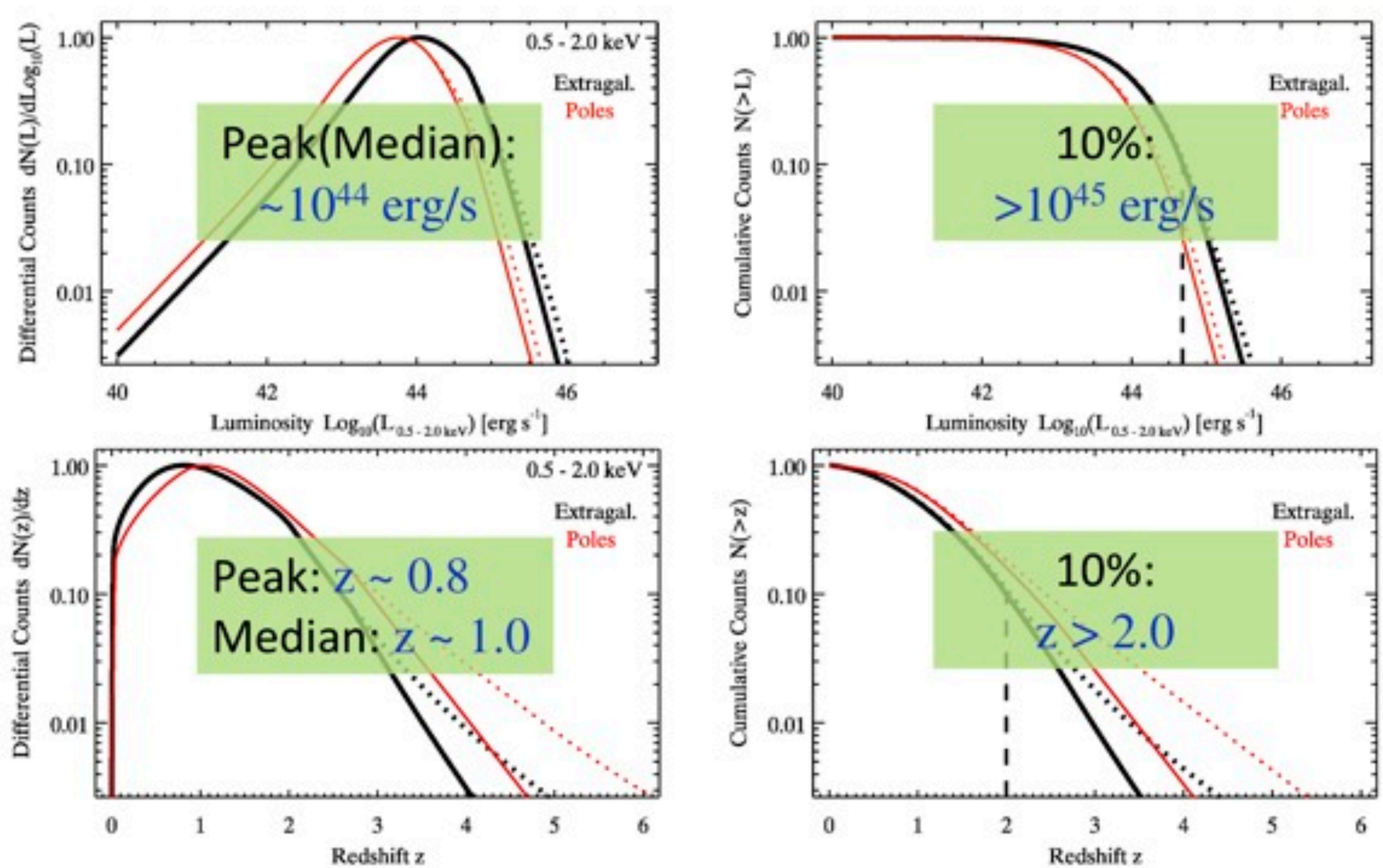
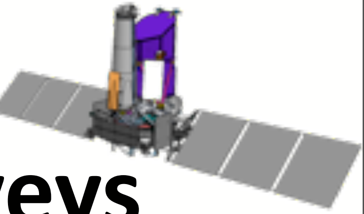


eROSITA will cover uniformly the redshift range 0<z<3

Ideal! Large samples available to study AGN at different L, z, N_H, M_*, SFR



The landscape of O/IR wide area surveys

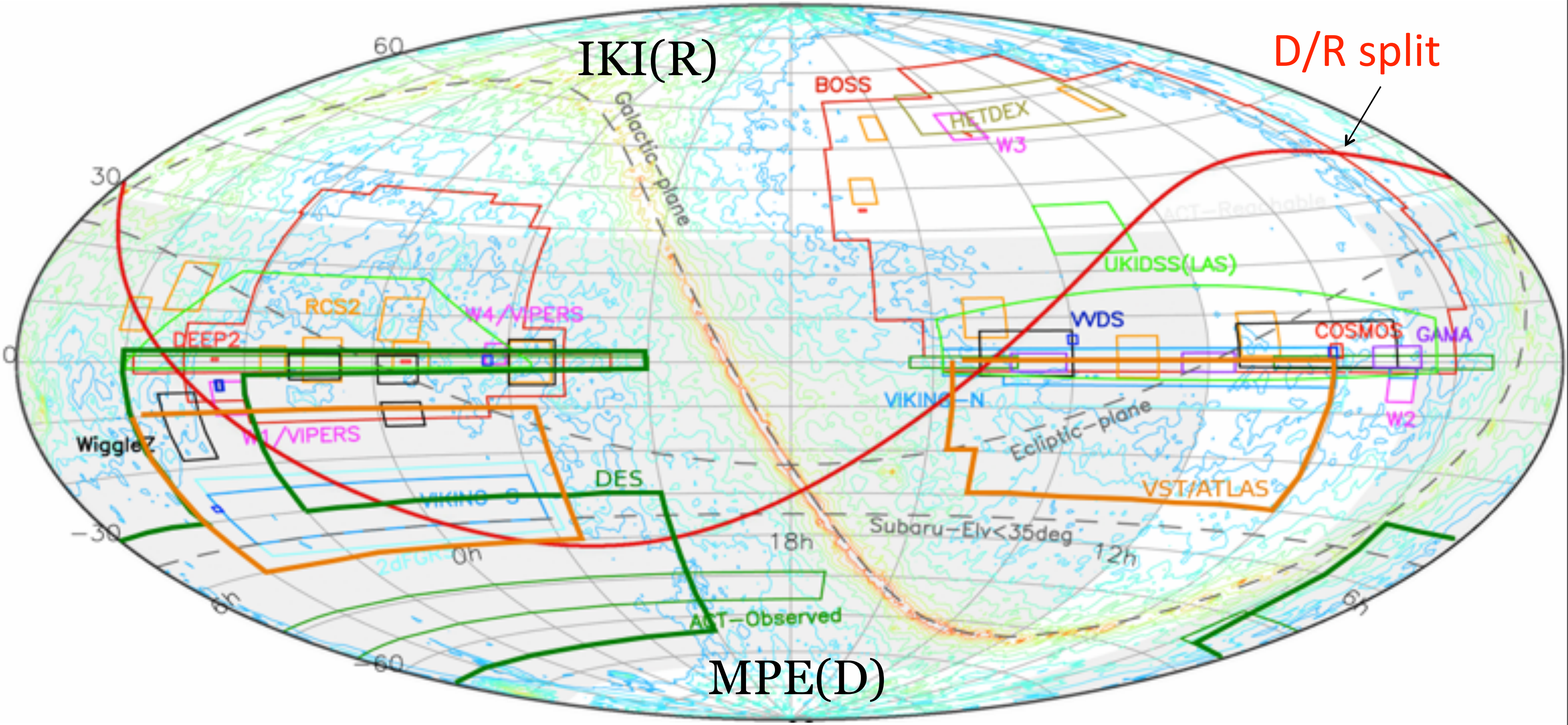
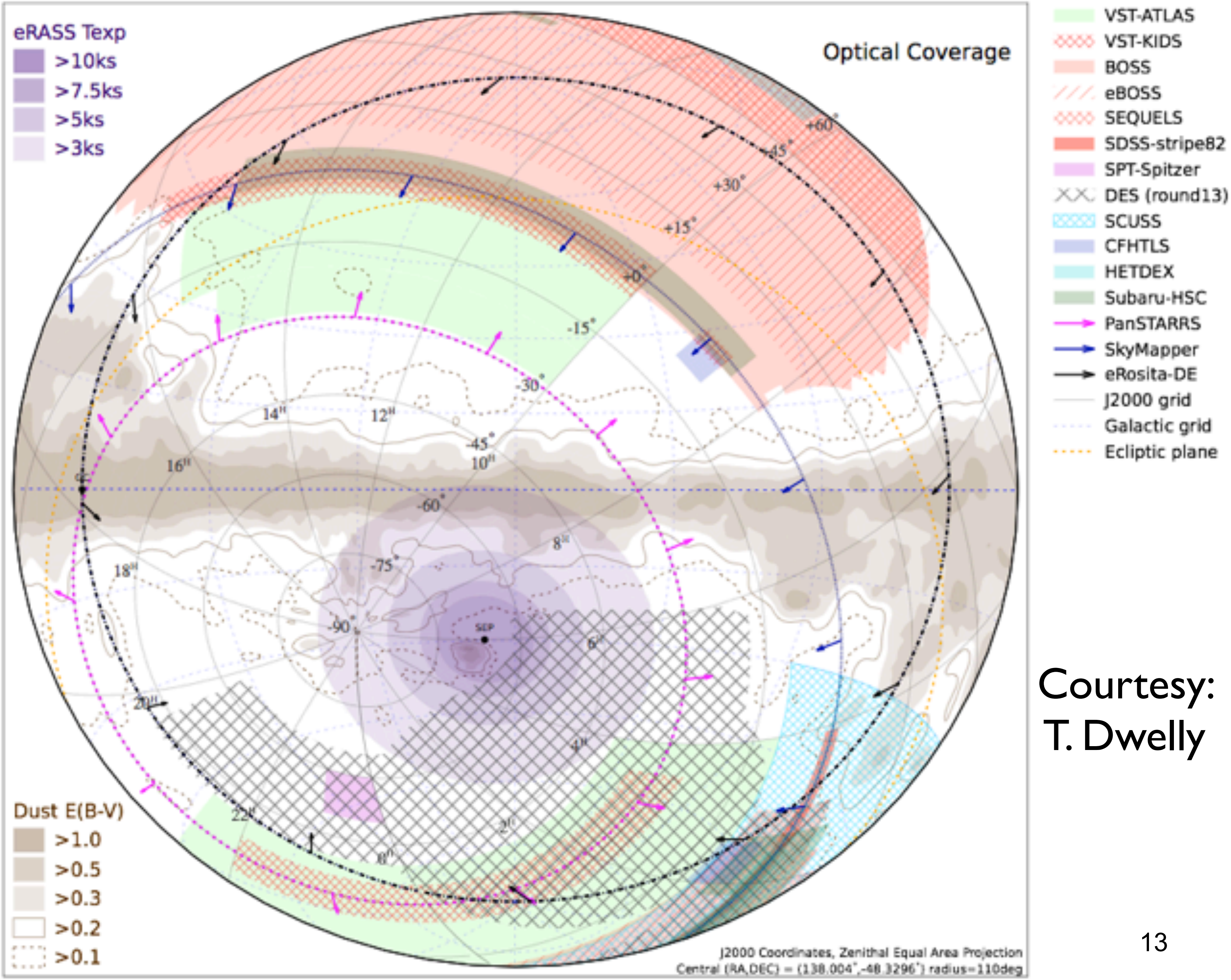


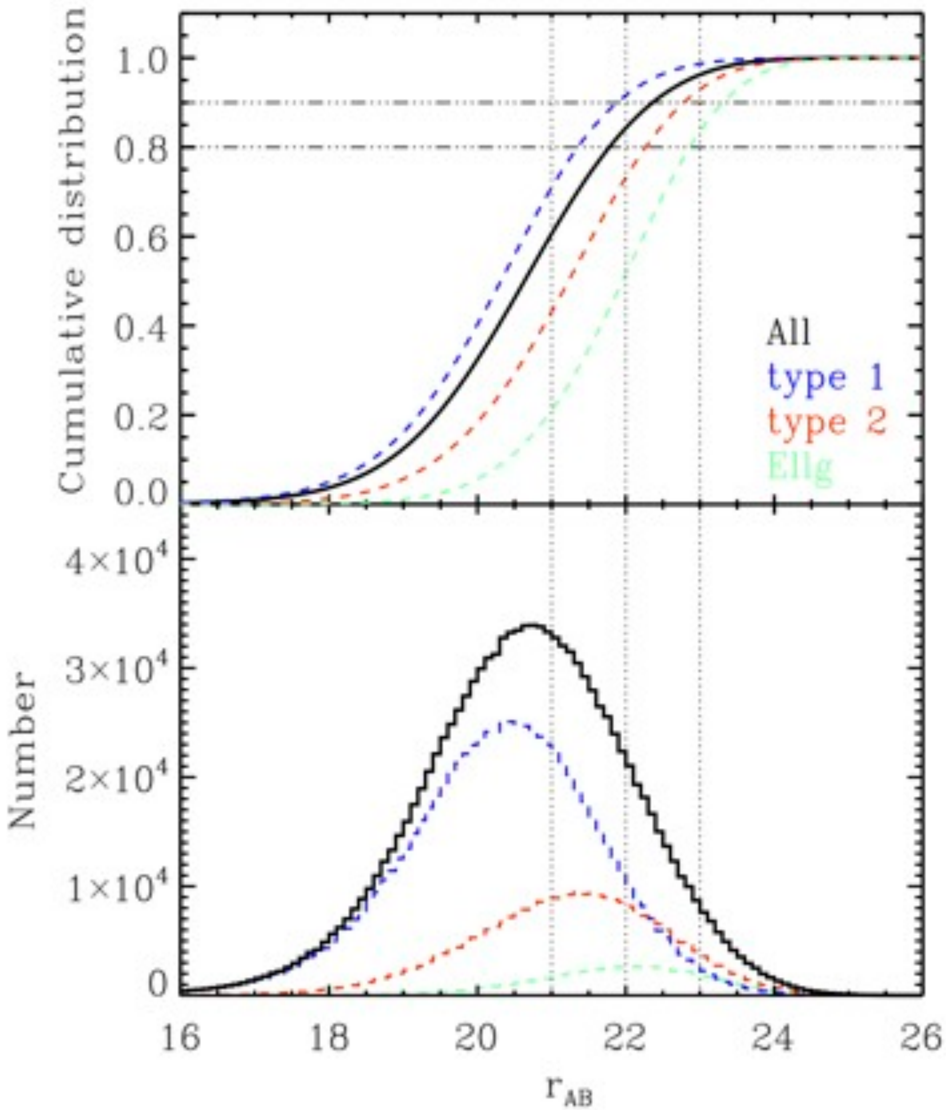
Image A. Nishizawa (IPMU), AM



Courtesy:
T. Dwelly

AGN: Can we follow them up?

CALIBRATED ON XMM-COSMOS



- IDENTIFICATION COUNTERPARTS:

•X-ray positional uncertainty is an issue: test with ML (degraded XMMCOSMOS) = ~87 (+5)% secure ID at i=24 [~60-70% in VHS]

•test on ROSAT with Bayesian statistics using more than 1 catalog and priors ~90% at r<23
•same test using ROSAT and 2D prior (W2 vs W1-W2) ~96% accuracy (Salvato et al, 2014, in prep)

-SPECTROSCOPY FOLLOW-UP:

•Expected r_{AB} magnitude distribution of 0.5-2 keV selected AGN in eROSITA surveys

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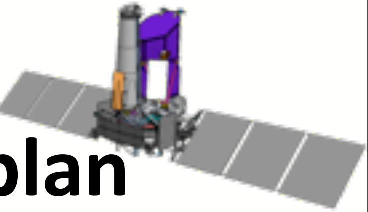
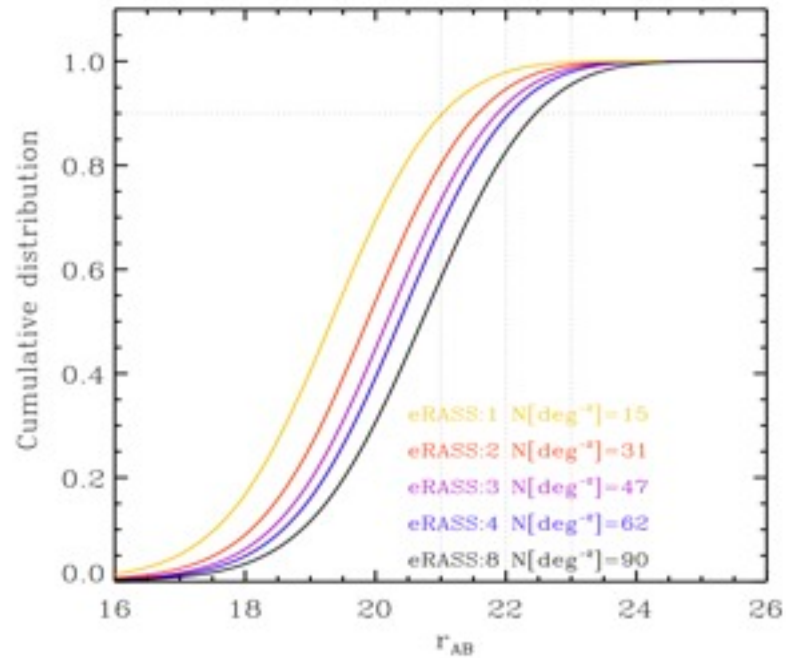


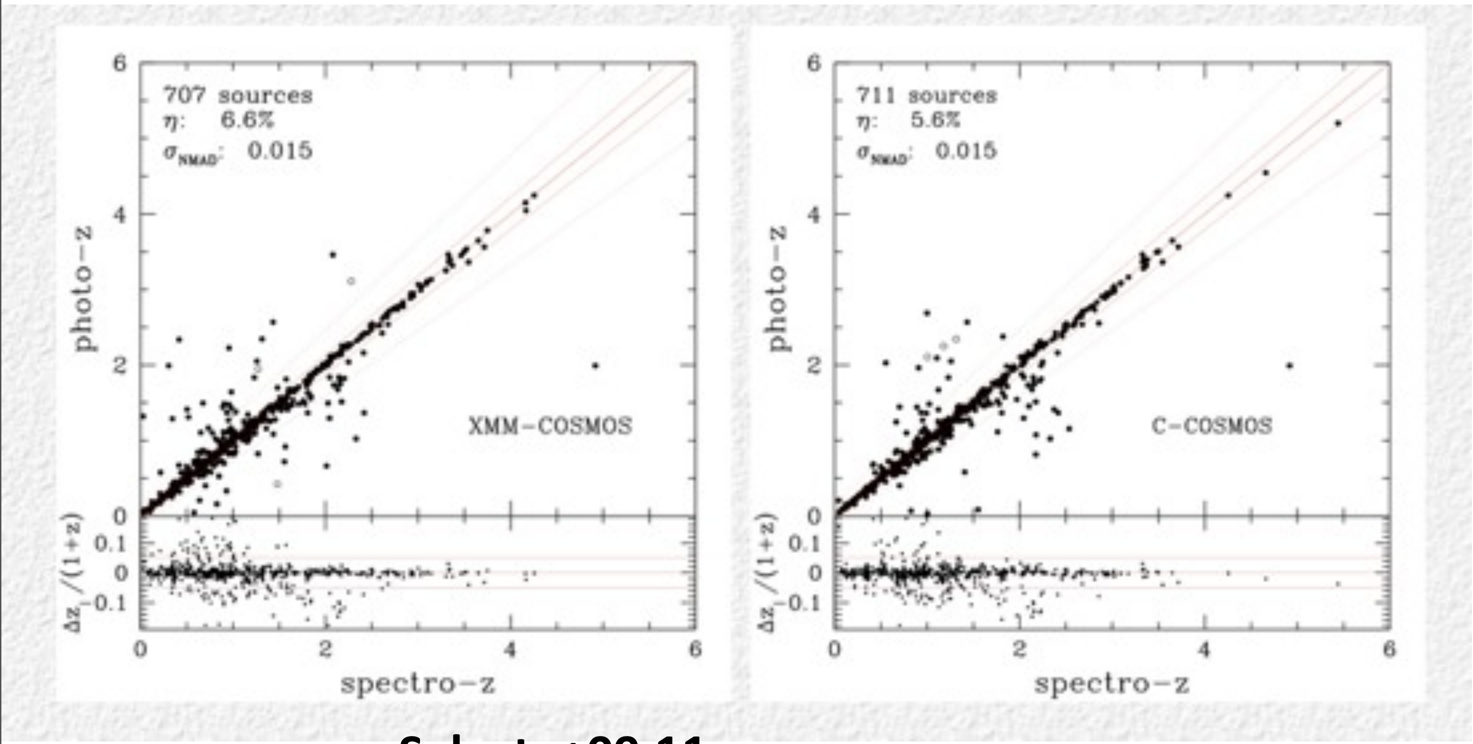
(German) eROSITA spectroscopic follow-up plan

- **VISTA/4MOST (2019-2024)**
- Complete, systematic follow-up of eROSITA Clusters/AGN/stars: reach >80% completeness for eRASS:8
- Approved after Conceptual Design Phase, will start Phase B in 2014



- **SDSS IV/SPIDERS (2014-2019)**
- Early follow-up over a ~9000 deg^2 area in the footprints of eBOSS/MANGA. Reach >80% completeness for eRASS:4, ~100,000 unique X-ray selected spectra

Photometric redshift accuracy

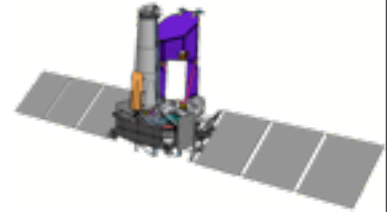


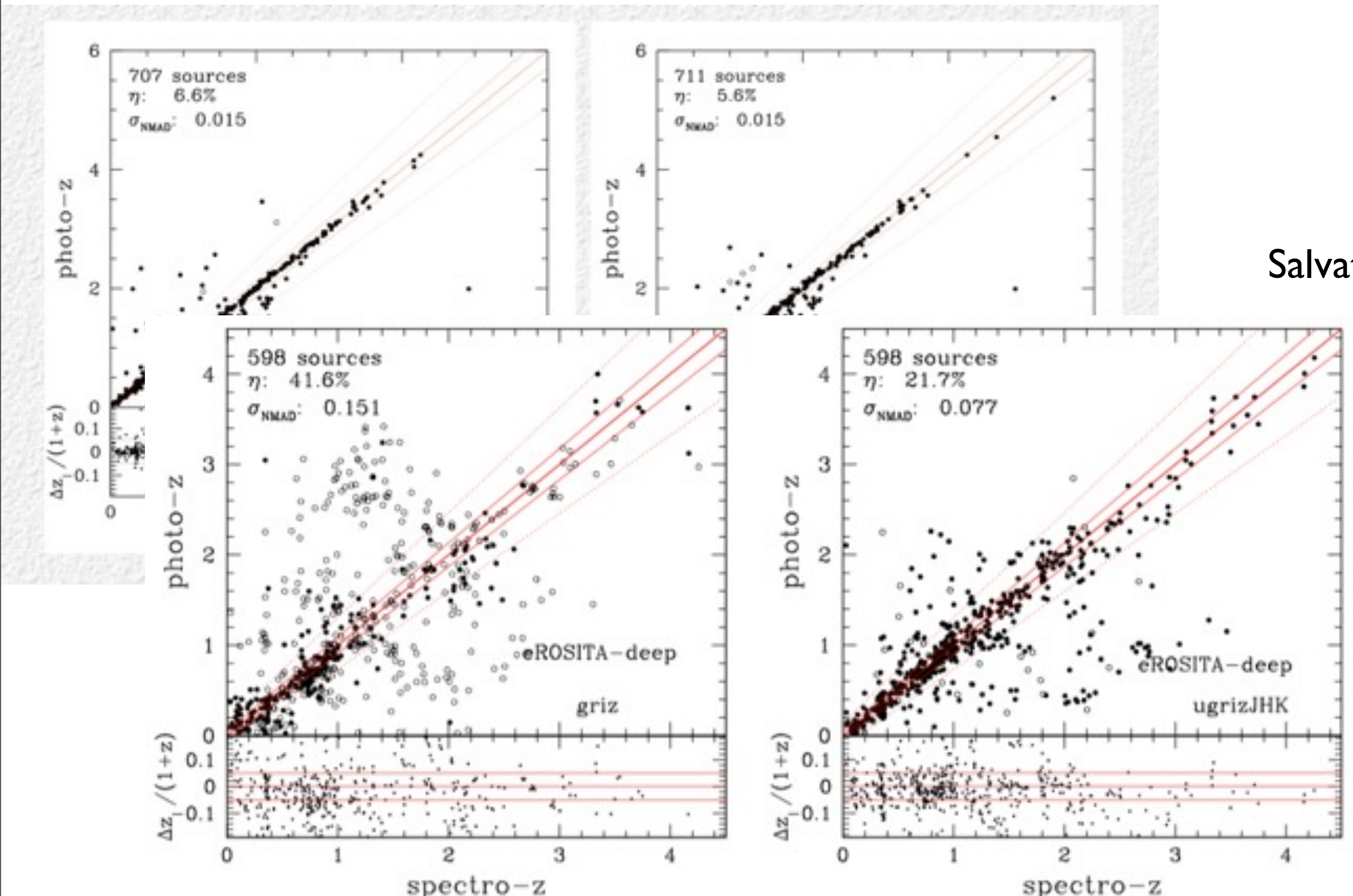
Salvato+09,11

Salvato +11

(COSMOS:see also Matute+11;
(E)CDFS: Luo+10, Cardamone+10,Hsu+14)

Photometric redshift accuracy





Salvato +11

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	-	22.5	22.0	20.9	20.6	-	-	-	-
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	-	-	-

60%-80% detection in u

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	-	22.5	22.0	20.9	20.6	-	-	-	-
KIDS+VIKING	-20	'11-	1500	24.8	25.4	25.2	24.2	22.4	21.6	21.4	20.8	20.5
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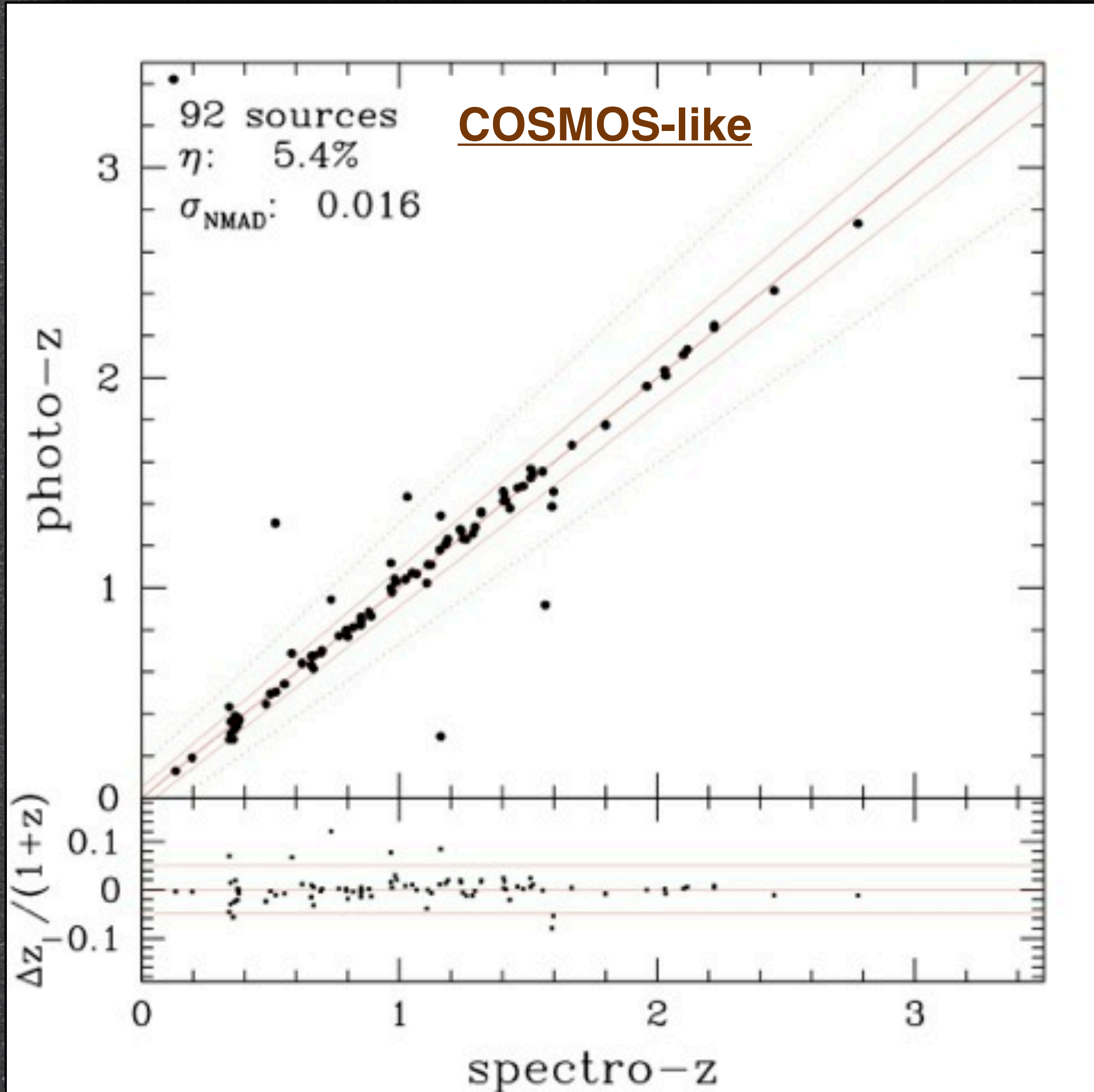
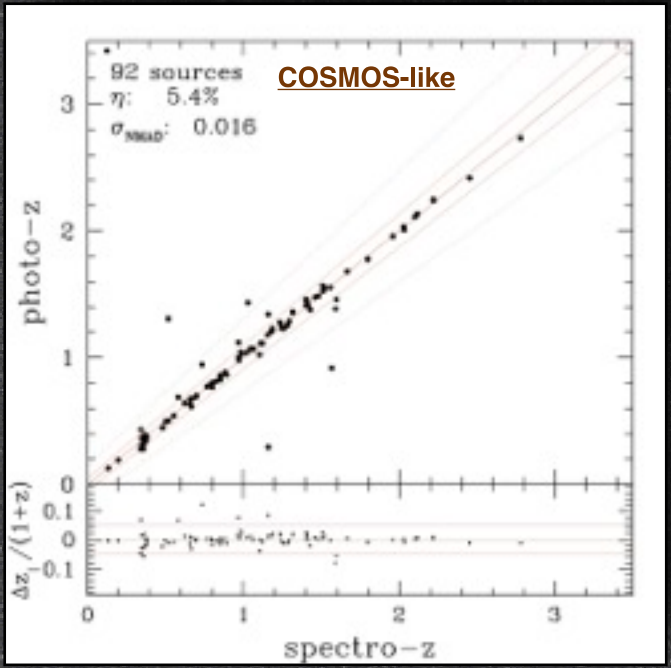
HSC	+20	'12-'16	1500	-	25.5	25.2	25.5	24.3	23.3	-	-	-
PS2	+20	'14-	10000	-	24.5	24.5	24.5	24.5	-	-	-	-
GAIA	-	'13-	41253			20						
Euclid	-	'19-'24	15000			24.5			24.0	24.0	24.0	-
LSST	-30	'20-'30	18000	24.0	26.0	26.0	26.0	26.0	26.0	-	-	-

GALEX (UV)	All Sky	20.5 3%
WISE (MIR)	All Sky	19.0, 18.8, 16.4, 14.5 51%
VHS (J,K)	20.000	21.2, 20.0 87.5%
SkyMapper(ugvriz)	30.000	21.5 21.3 21.9 21.6 21.0 20.6 (+1mag)

60%-80% detection in u



92 sources
η: 5.4%
σ_{NMAD}: 0.016
COSMOS-like
photo−z
spectro−z
$\Delta z/(1+z)$
0
1
2
3
0.1
0
−0.1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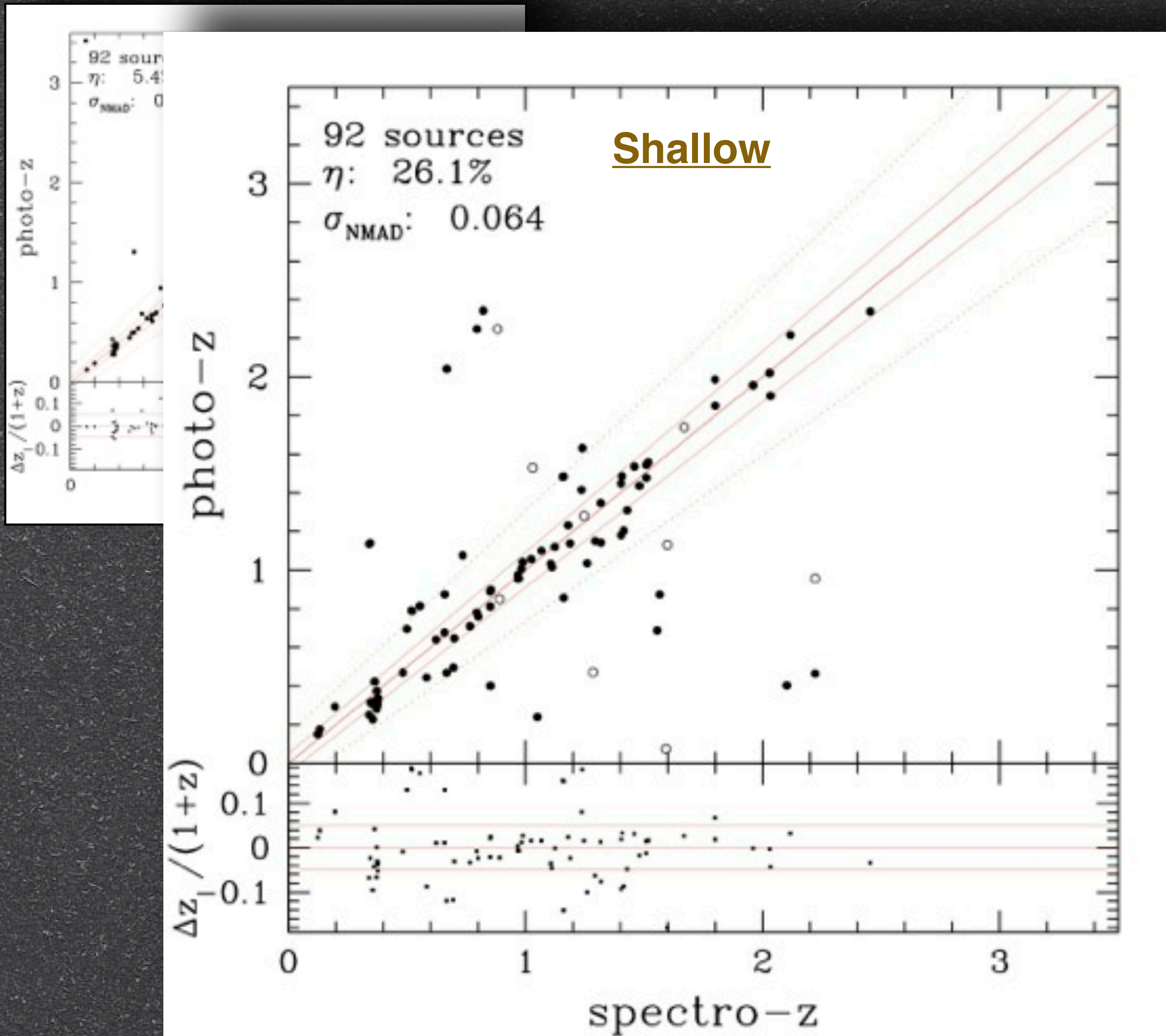
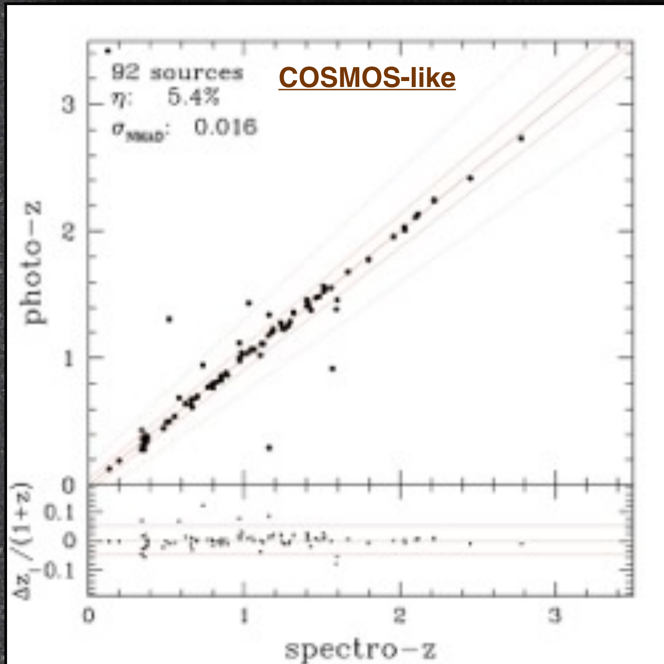

92 sources
η: 26.1%
σNMAD: 0.064
Shallow
photo−z
spectro−z
Δz1/(1+z)



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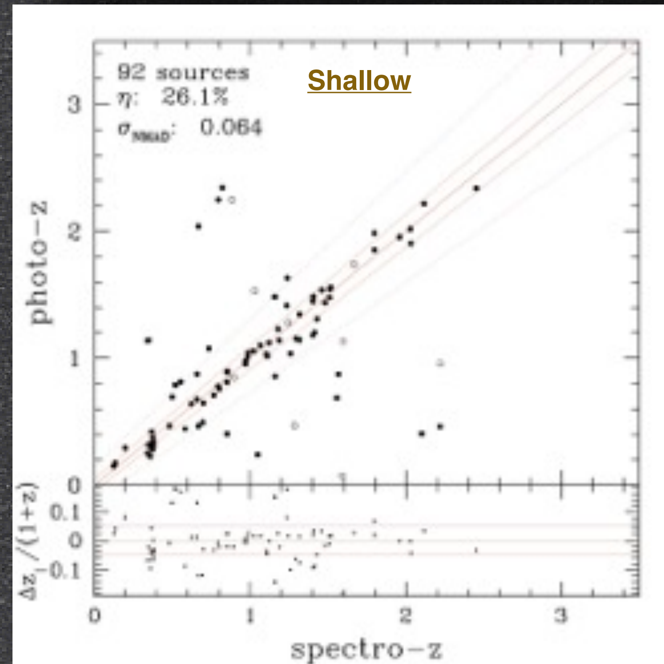

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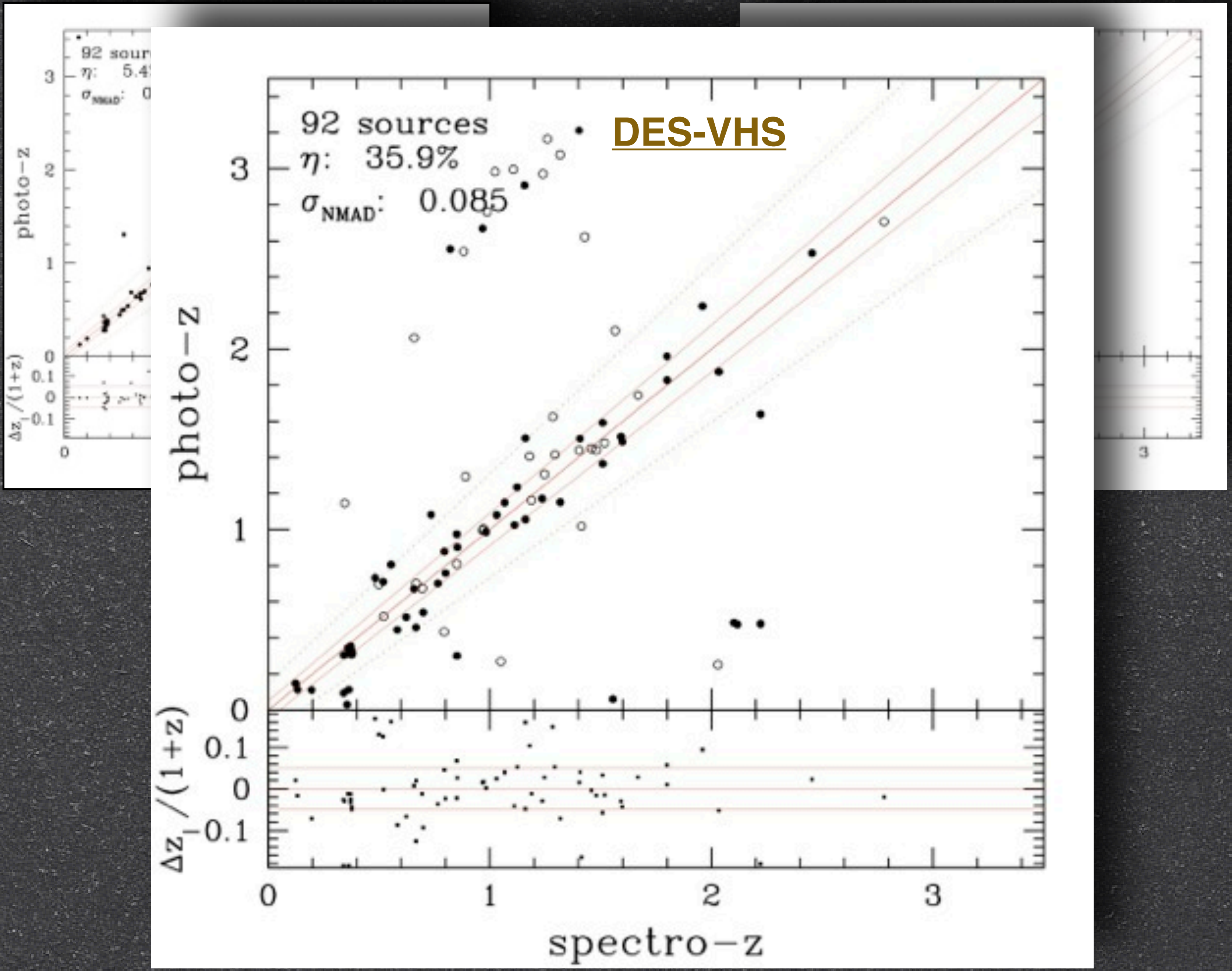
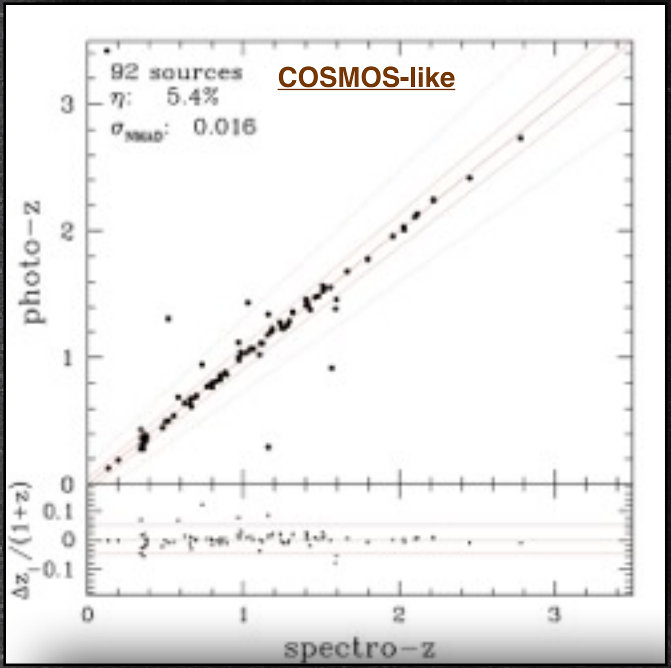
photo−z
spectro−z
$\Delta z_i/(1+z)$


92 sources
η: 35.9%
σNMAD: 0.085
DES-VHS
photo−z
Δz1/(1+z)
spectro−z


92 sources
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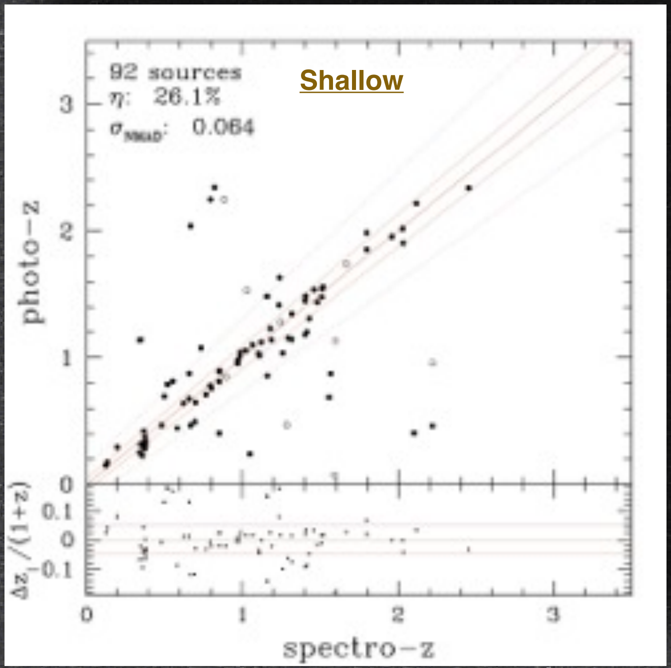
COSMOS-like
photo−z
spectro−z
$\Delta z_1/(1+z)$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photo−z
spectro−z
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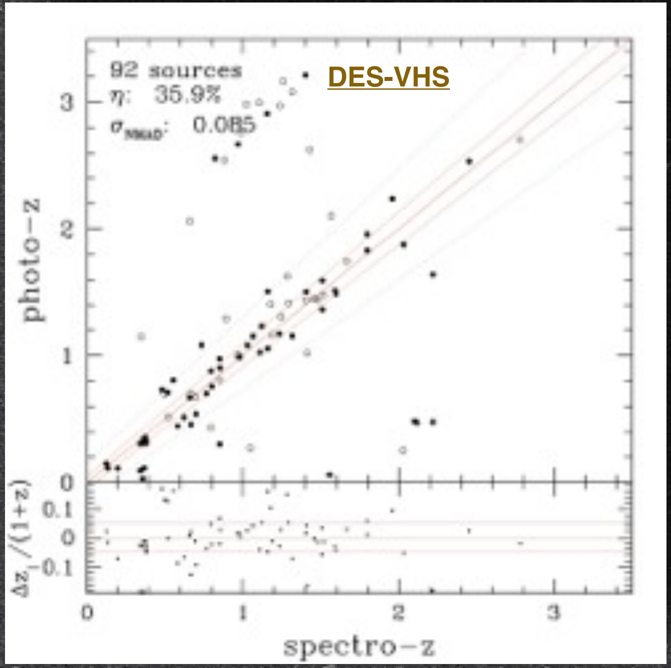
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DES-VHS
photo−z
spectro−z
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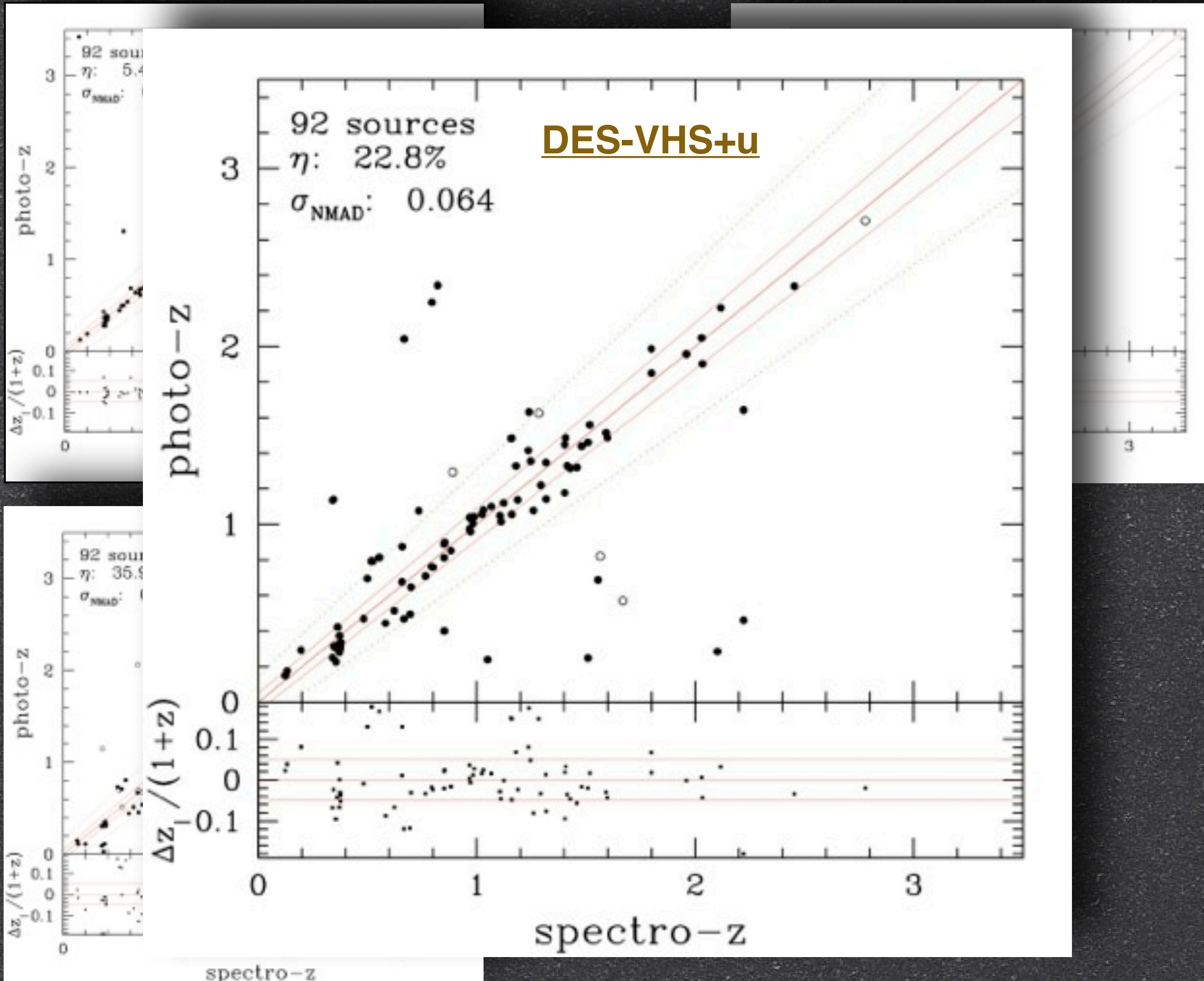
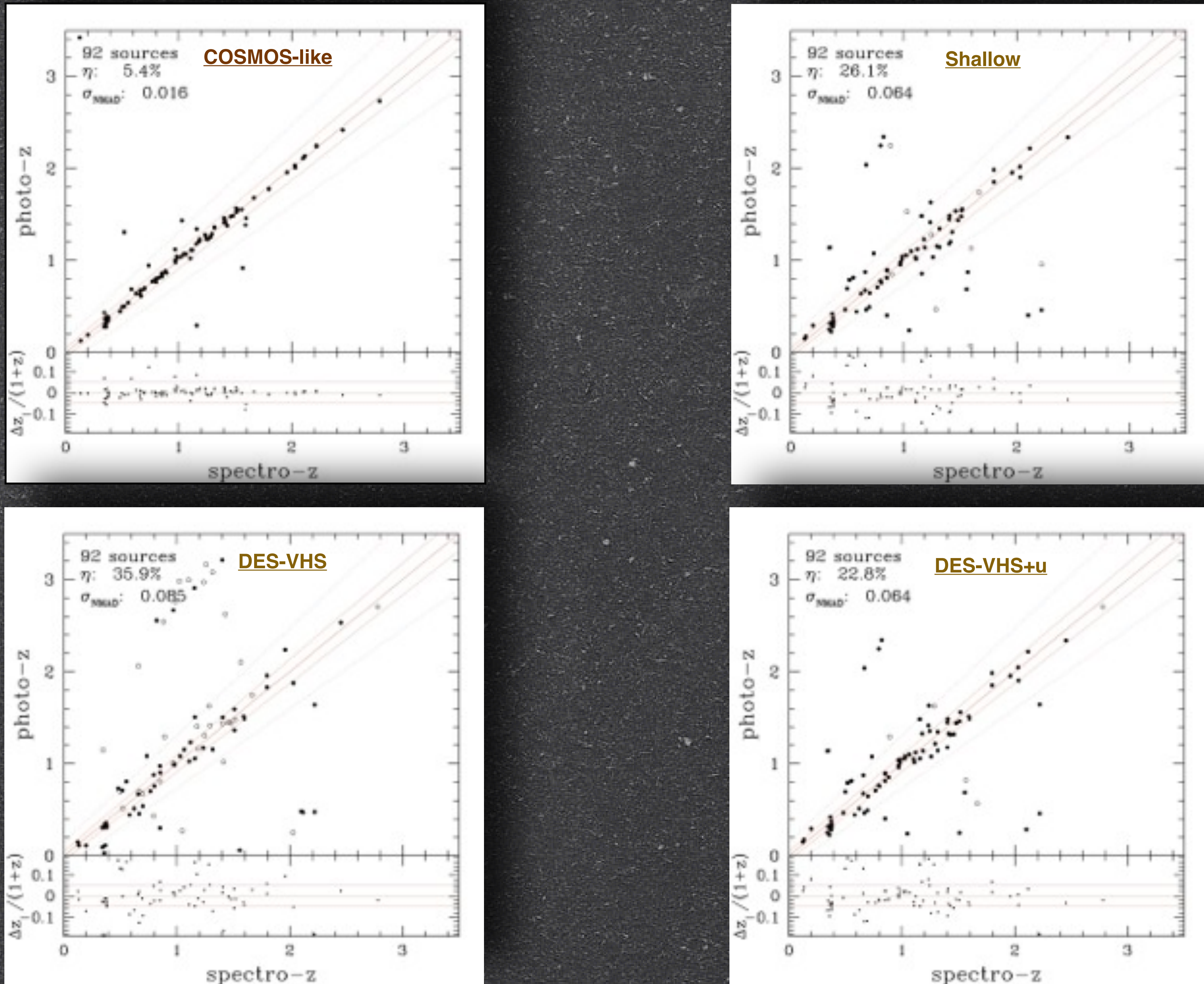


92 sources
η: 22.8%
σNMAD: 0.064
DES-VHS+u
photo−z
spectro−z
Δz1/(1+z)


92 sources
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COSMOS-like
92 sources
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Shallow
92 sources
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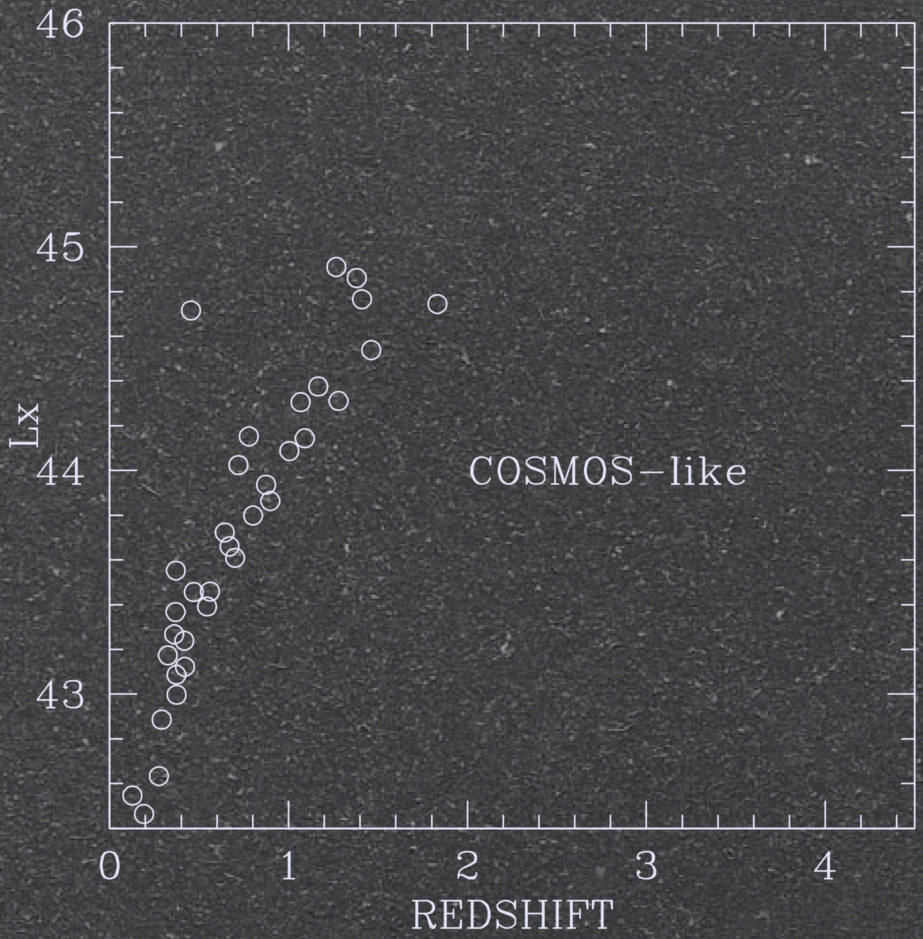
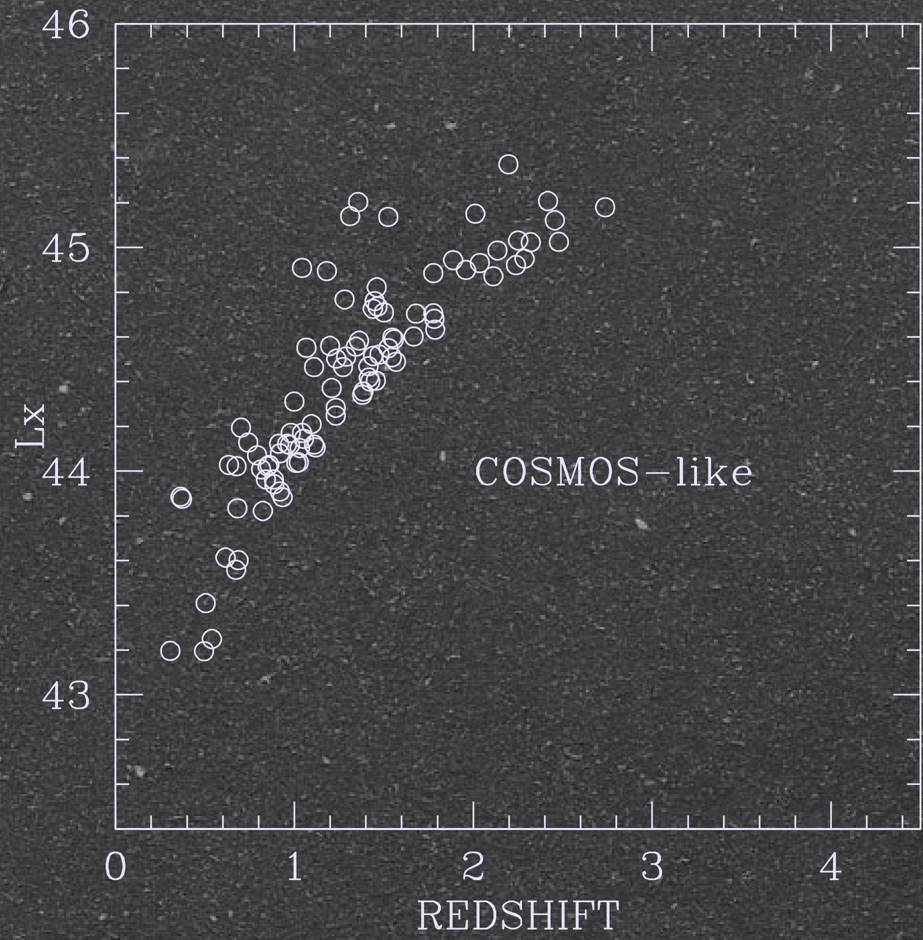
DES-VHS
92 sources
η: 22.8%
σ NMAD: 0.064
DES-VHS+u
photo−z
spectro−z
Δz/(1+z)

extended/low z

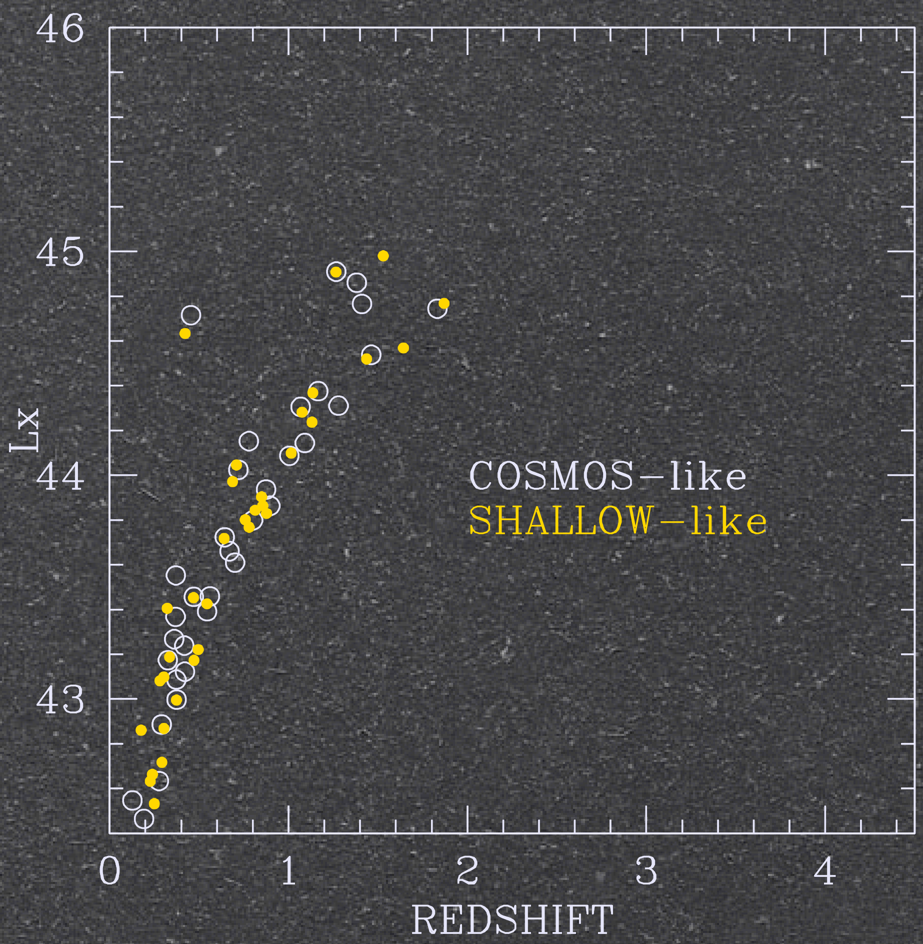


point-like/high z

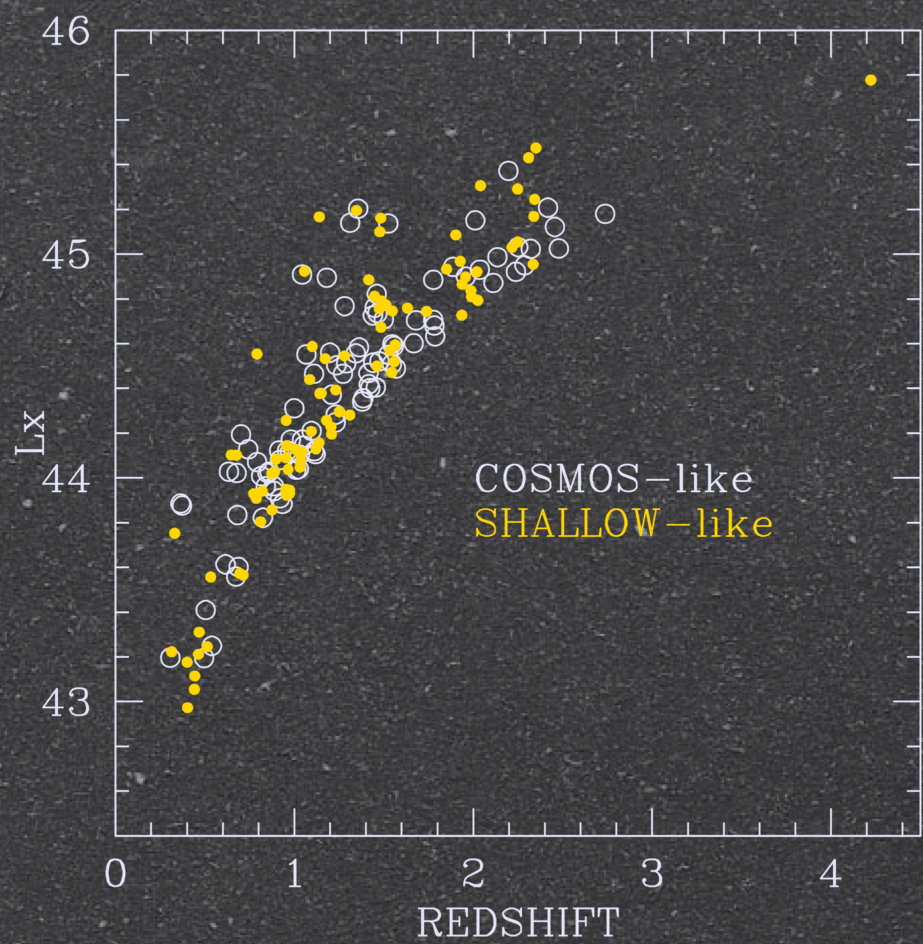


eROSITA all-sky

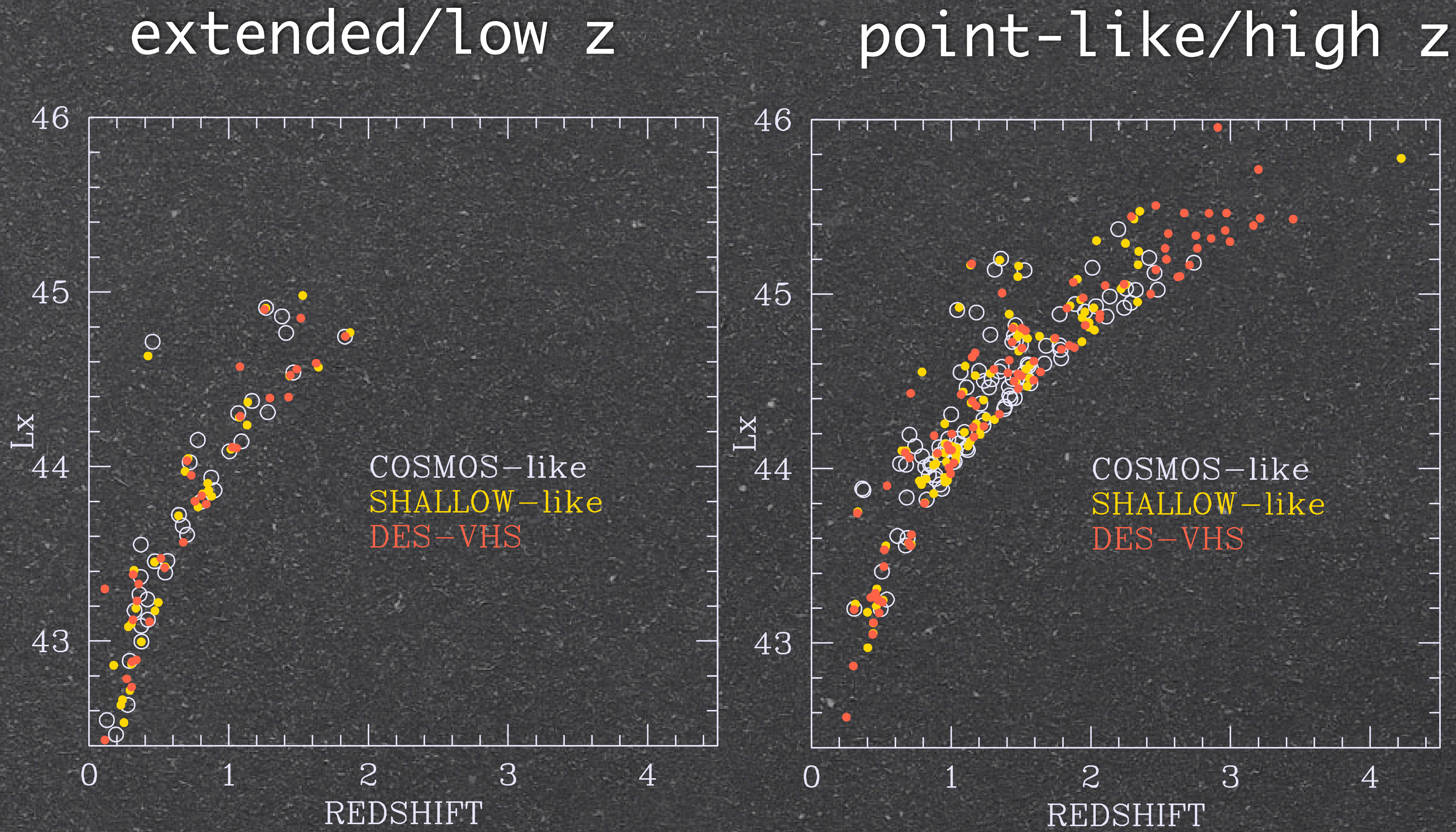
extended/low z



point-like/high z

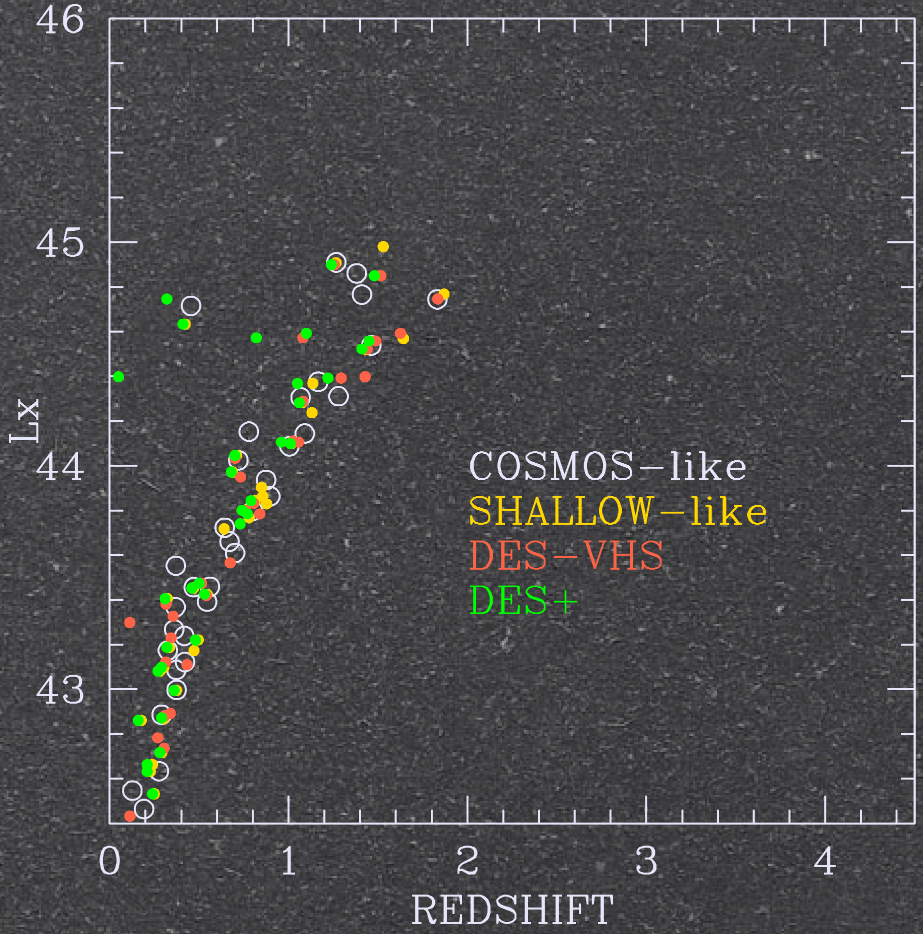


eROSITA all-sky

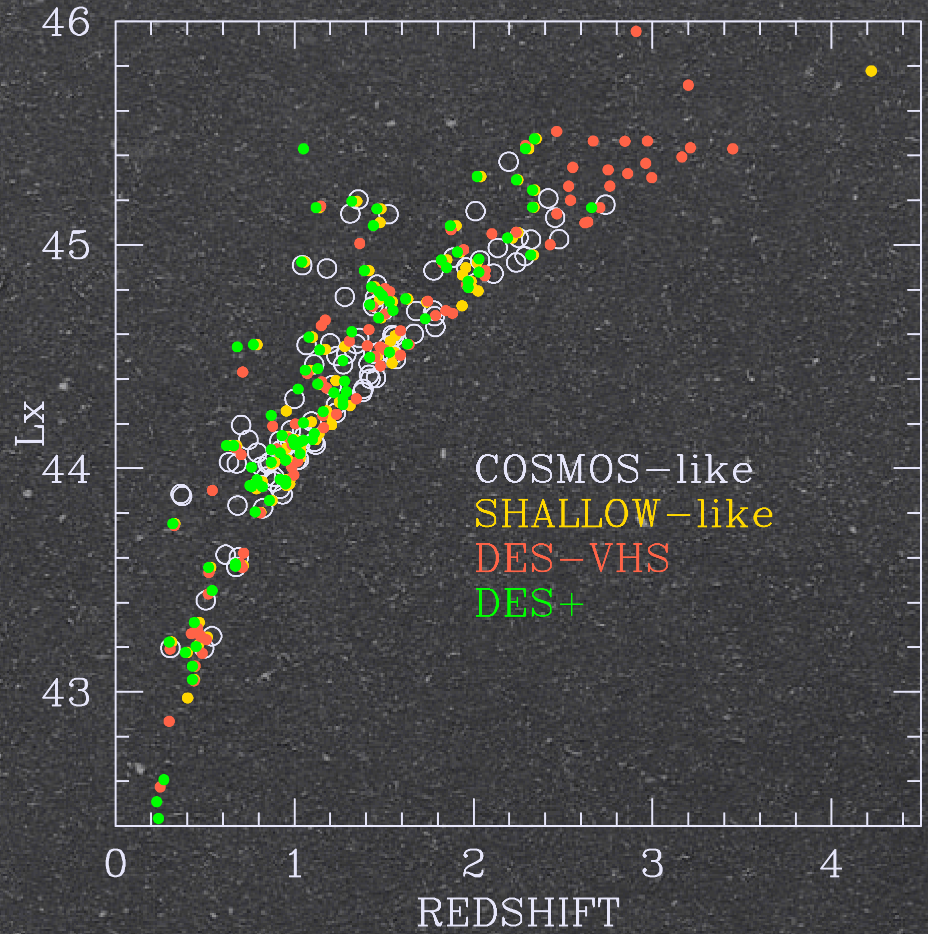


eROSITA all-sky

extended/low z



point-like/high z

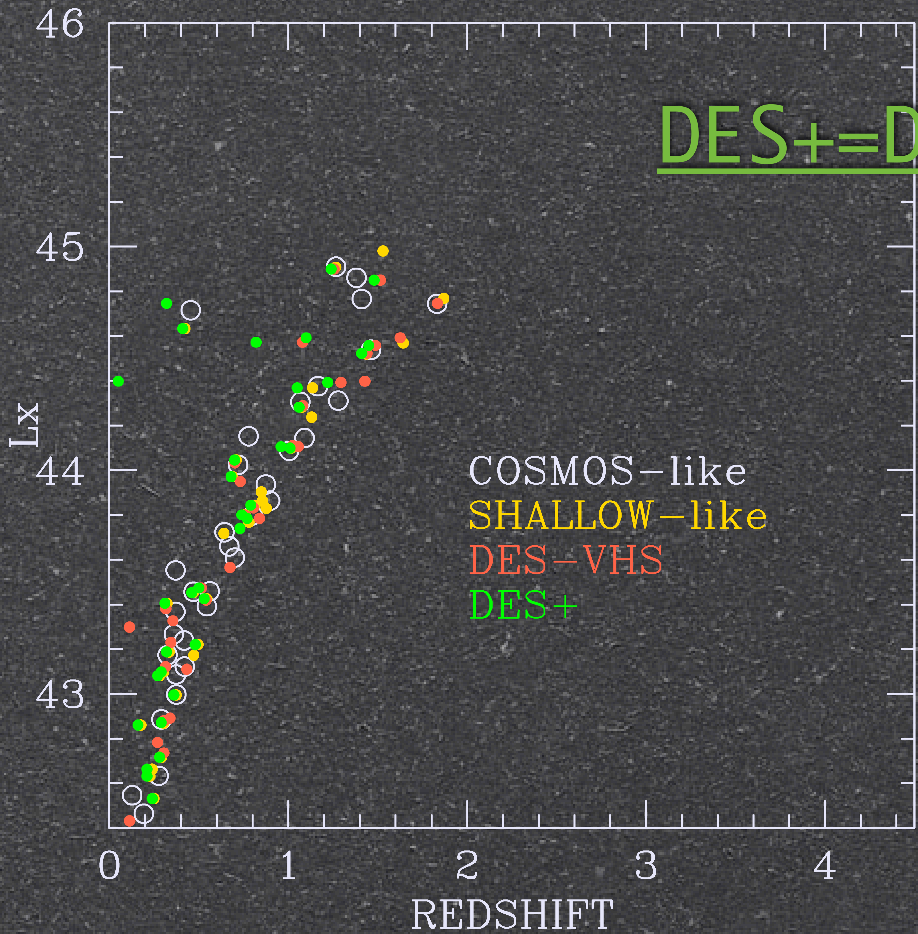


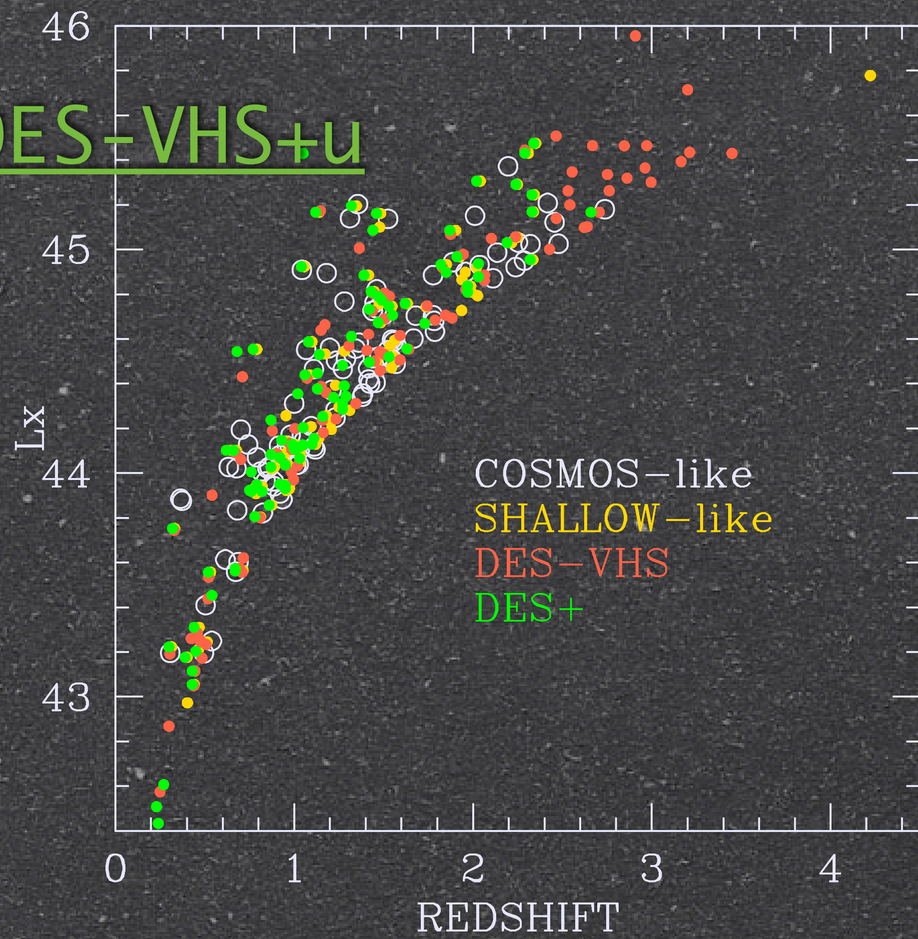
eROSITA all-sky

extended/low z

point-like/high z

DES+=DES-VHS+u





eROSITA all-sky

eROSITA-skyMapper synergies

- CLUSTERS: identification in the areas where no other data are available
- AGN: X-ray to Optical identification of counterparts,

- use of variability in the complicated cases where more than one plausible counterpart is present

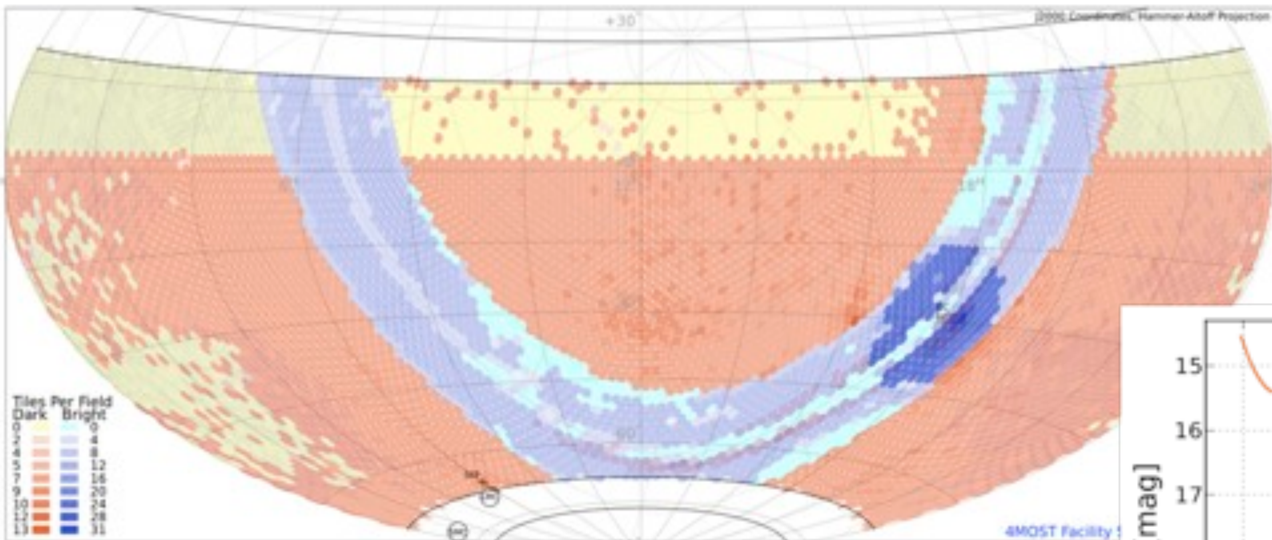
- improvements on photoz using all the bands and particularly u band added to the DES and VHS data

- improvement on SED fitting for disentangling galaxy/AGN contribution

- All this helps any survey lead by Australian facilities in the Southern Emisphere (EMU, SkyMapper etc)

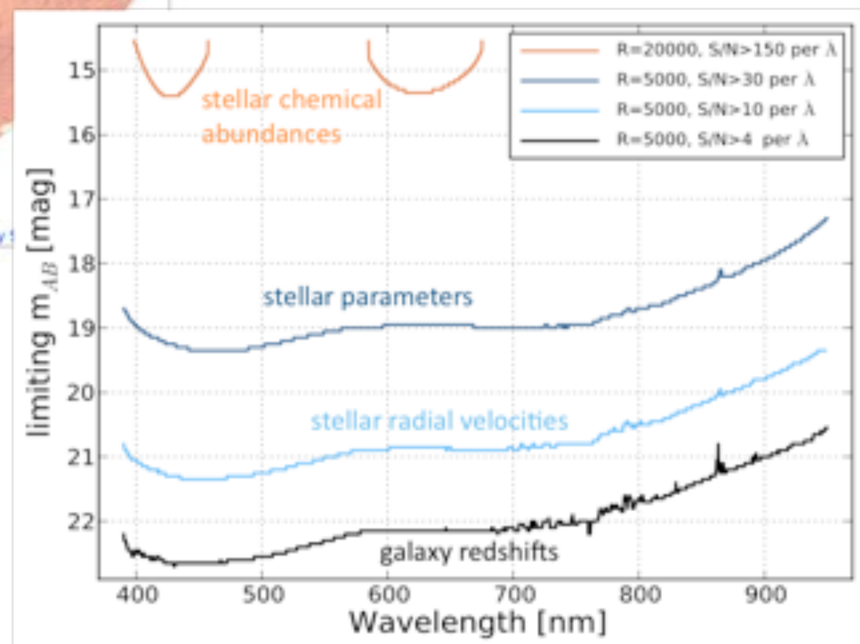
4MOST– 4-metre Multi-Object Spectroscopic Telescope

4MOST Sky Tiling layout
Tele=VISTA Positioner='Echidna-like' Geodesic-N_{pnts}=10242, FOV=4.059deg^2, 5 year survey

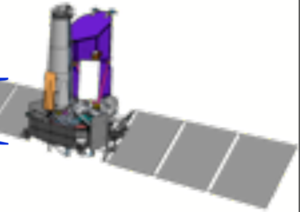


4MOST sky coverage 5 years survey simulation (4FS, MPE)

4MOST sensitivity,
1hr exposure, 1.1” seeing



4MOST Mocks, Simulations, FoM



	Clusters of Galaxies	AGN	Galaxies
Redshift range	$0<z<1$	$0<z<5$	$0<z<1.4$
selection	X-ray (eROSITA)	X-ray (eROSITA)	Optical/IR colors
Mock source	Clusters Mass function (theory) + LX-M relation+ observed mass-richness (SDSS)	AGN X-ray luminosity function + X-ray optical ratio distribution from COSMOS	Mock galaxy sample from millennium simulations + SAM
# of objects in Mock	~72k clusters ~2.5M galaxies [?]	~1M	~25M
Spectral templates	Ellipticals	Type1 QSO, type 2 QSO, Ellipticals	LRG + ELG
FoM	Cluster mass function (# of clusters z-weighted)	Completeness over 13k deg^2	Surveyed area + Total number of galaxies