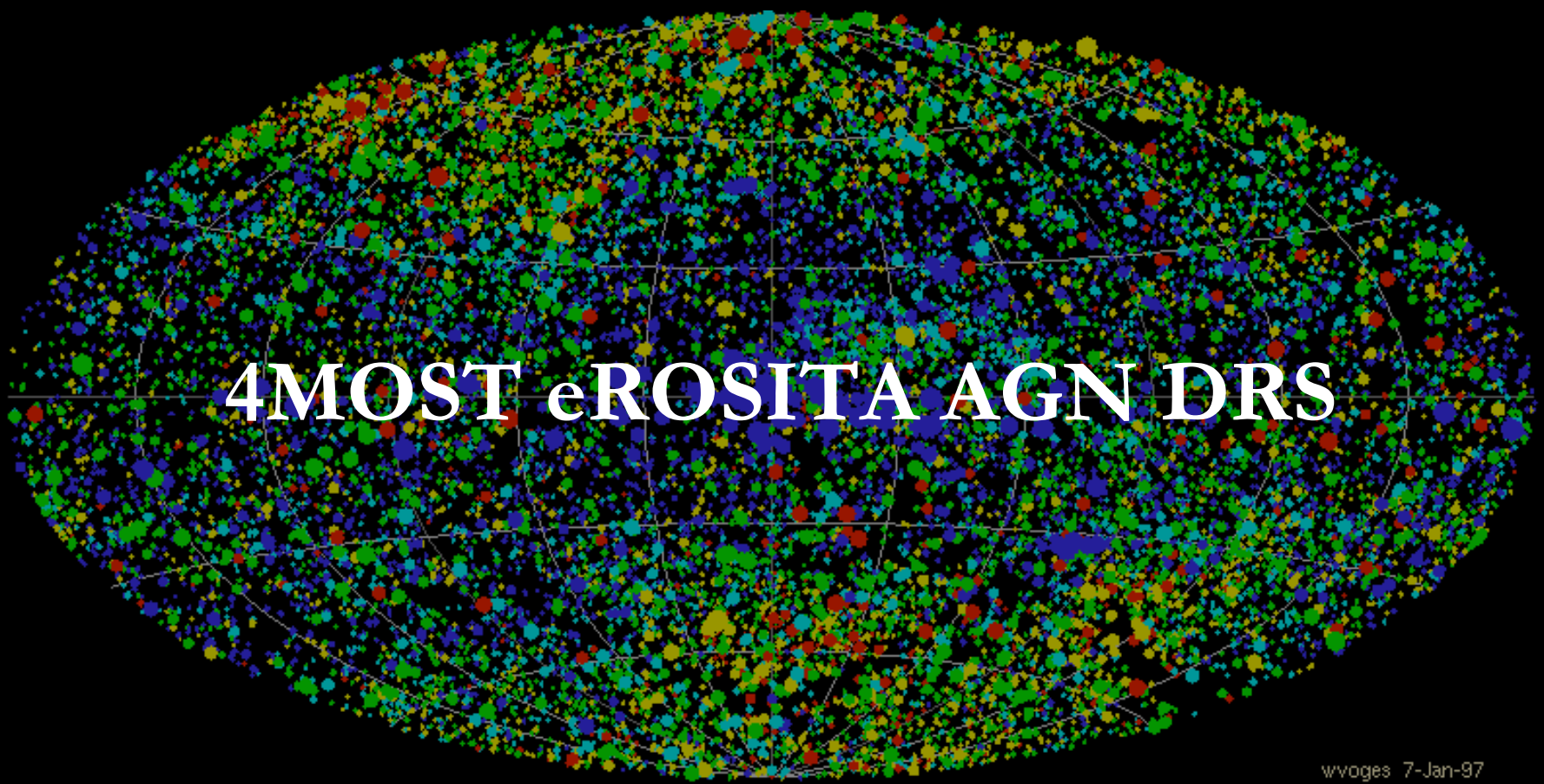
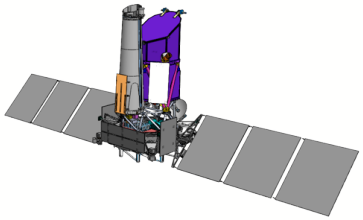
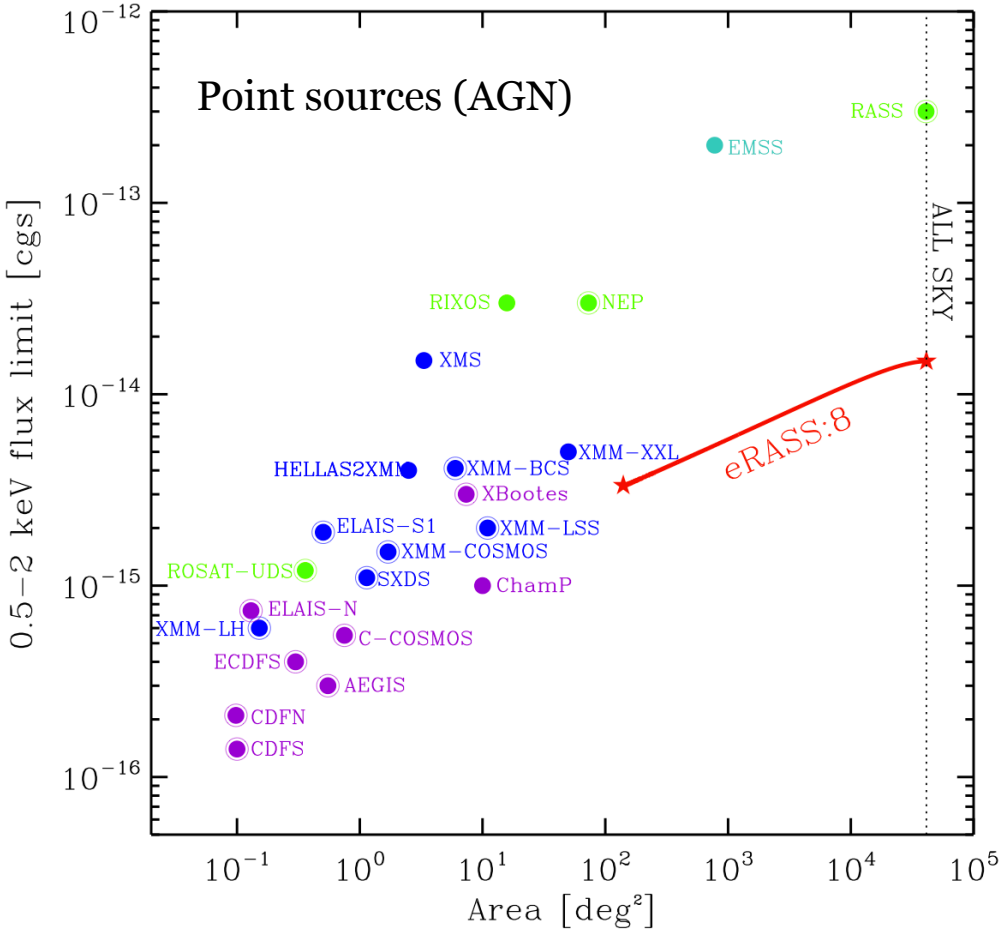


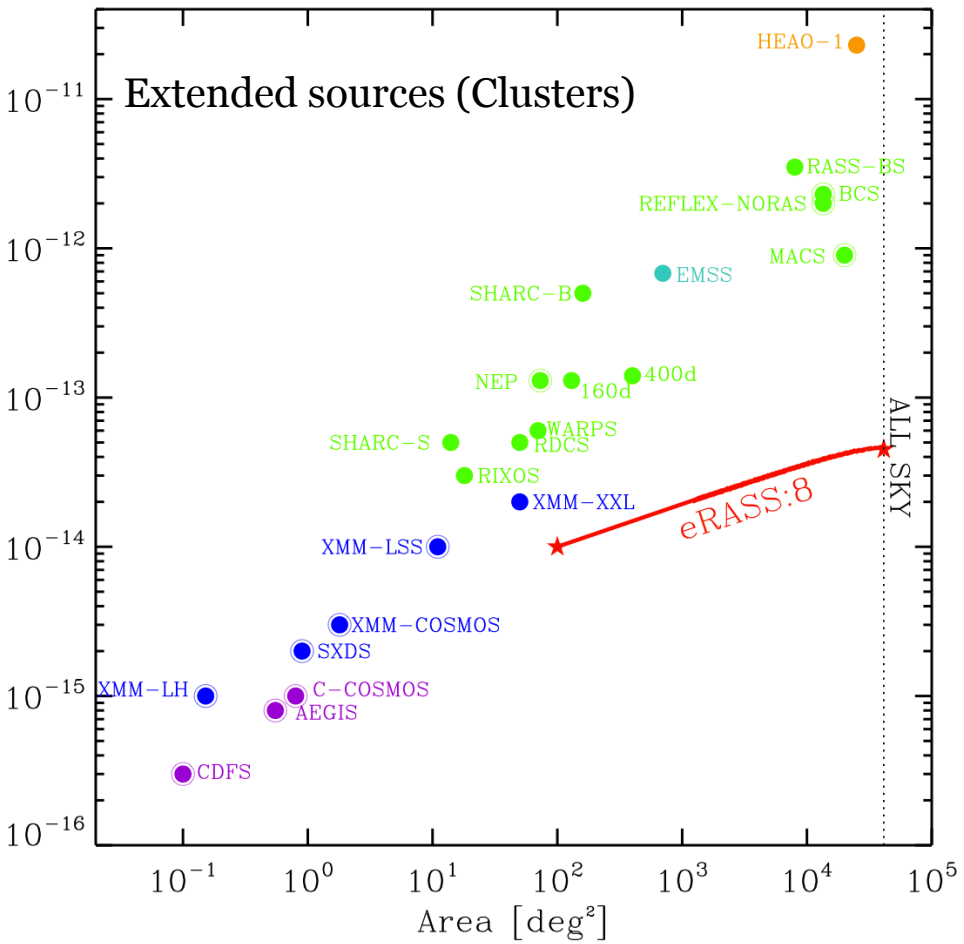
4MOST eROSITA AGN DRS

Andrea Merloni (MPE)

eROSITA surveys in context





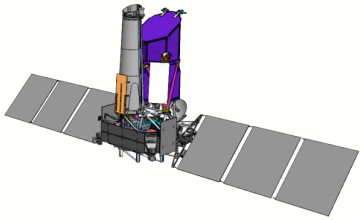


All sky: 10^{-14} (0.5-2 keV)
2×10^{-13} (2-10 keV) [erg/cm^2/s]

All sky: 3.4 x 10^{-14} (0.5-2 keV)

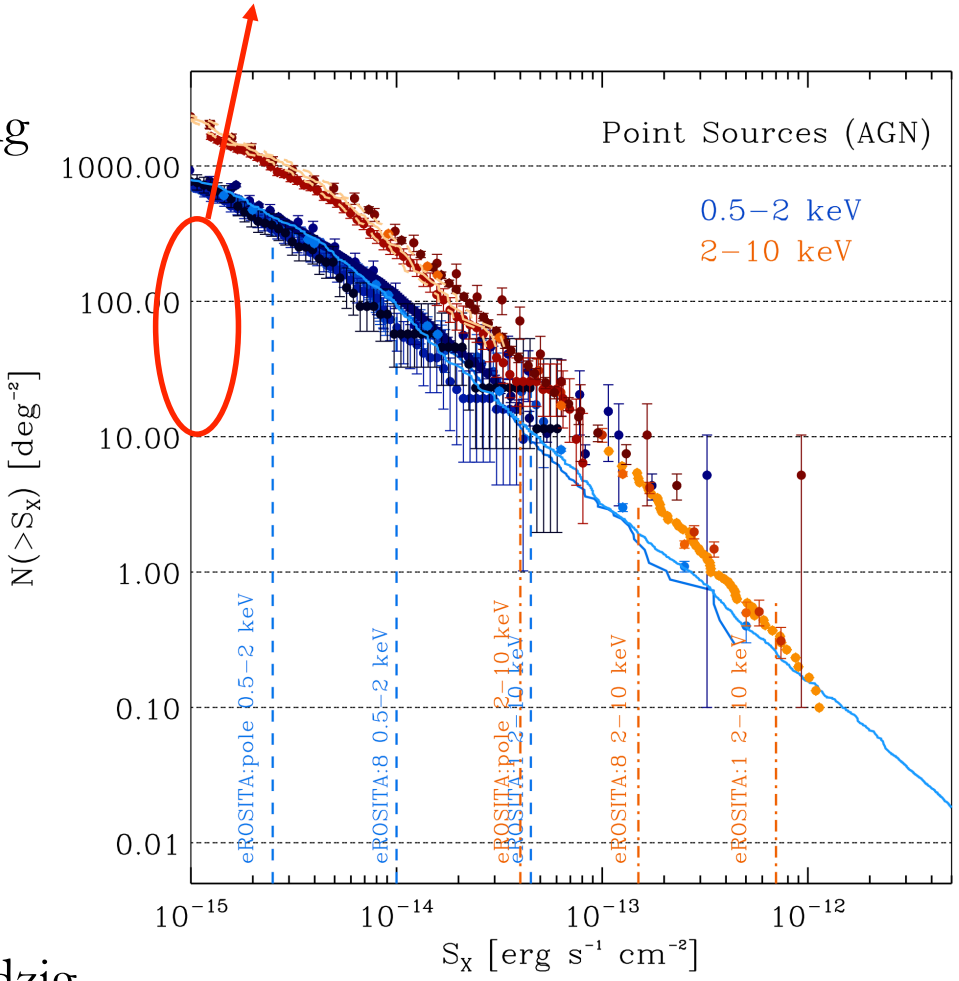
Merloni et al. 2012

~3M eROSITA AGN



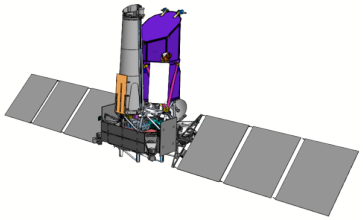
- First 2-10 keV all-sky survey after HEAO-1 (F_{lim} ~ 10^{-13} cgs full survey)
- AGN in Large-Scale Structure (clustering vs. z, L)
  - AGN ACF, AGN/Clusters CCF, AGN/Gal CCF
- Obscured vs. Unobscured AGN at z~2
- High-z (z>4) AGN
- Tidal disruption events
- AGN variability over >4 years
- Binary SMBH?

Source density: 15-250/sqdeg

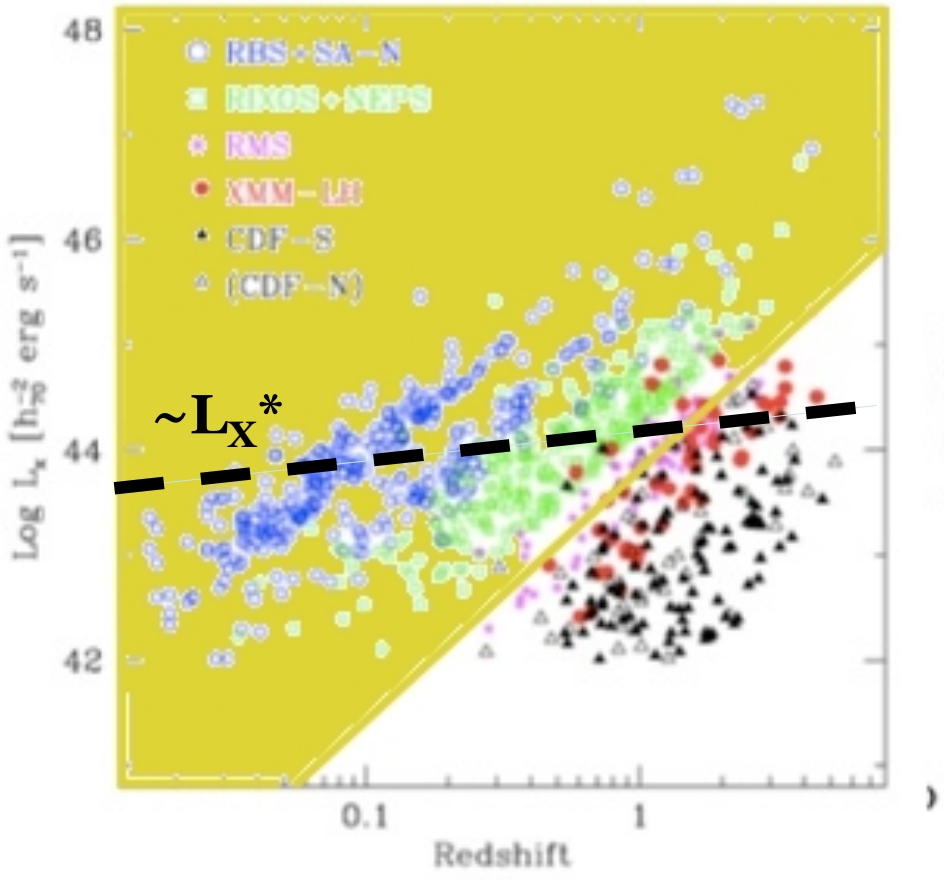


See talks by T. Boller, M. Krumpe, A. Klodzig

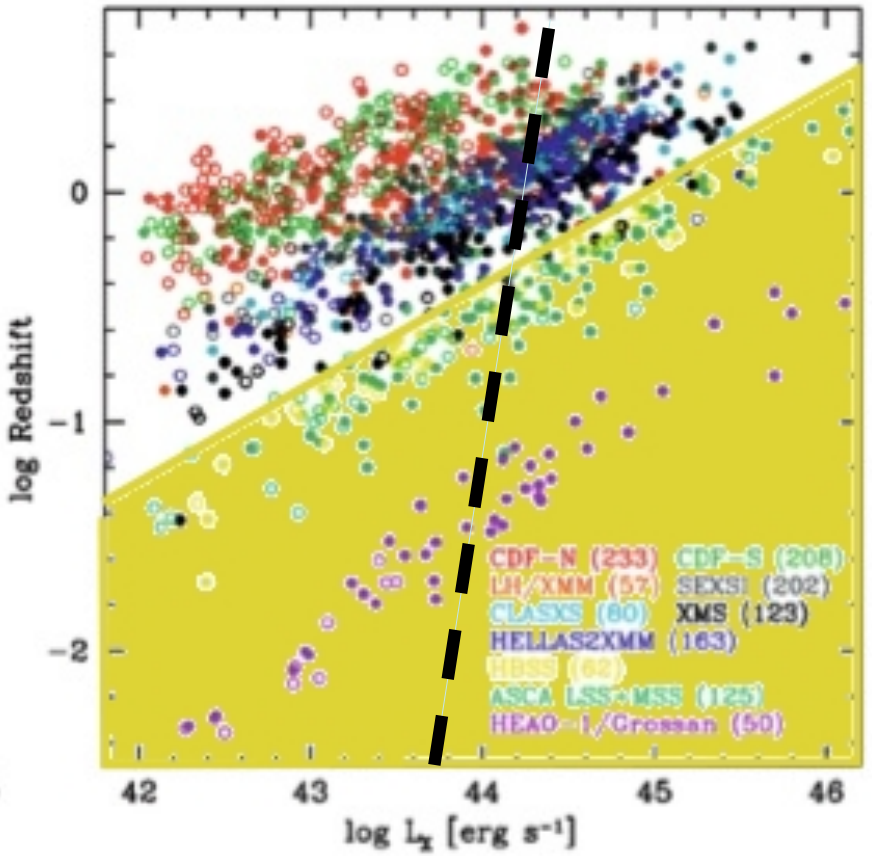
~3M eROSITA AGN



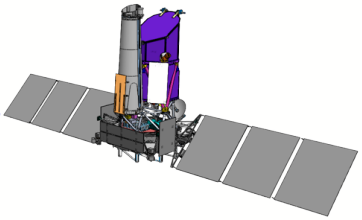
0.5-2 keV (Hasinger, Miyaji & Schmidt 2005)

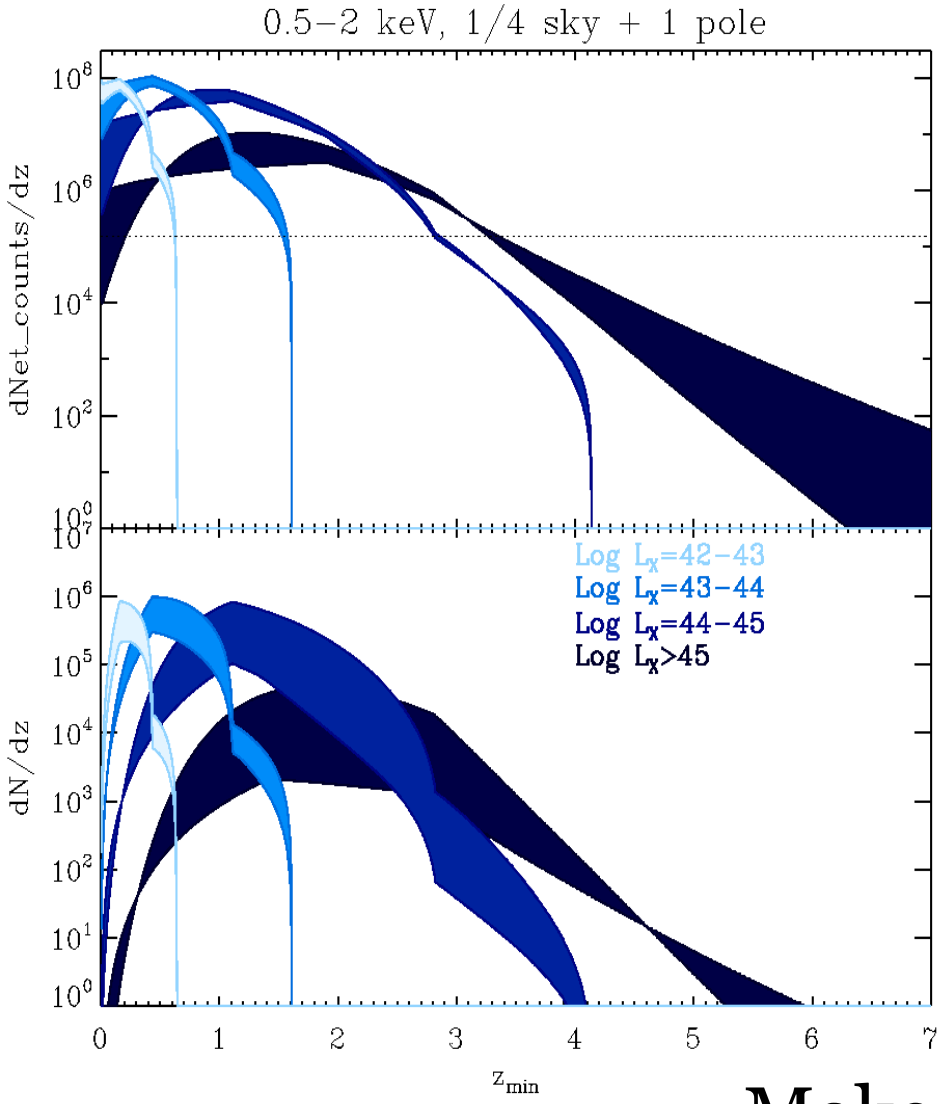


2-10 keV (Hasinger 2008)



eROSITA power for AGN physics

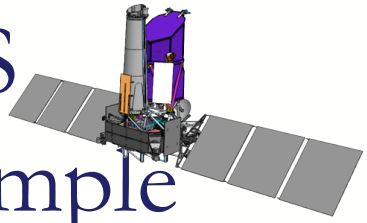




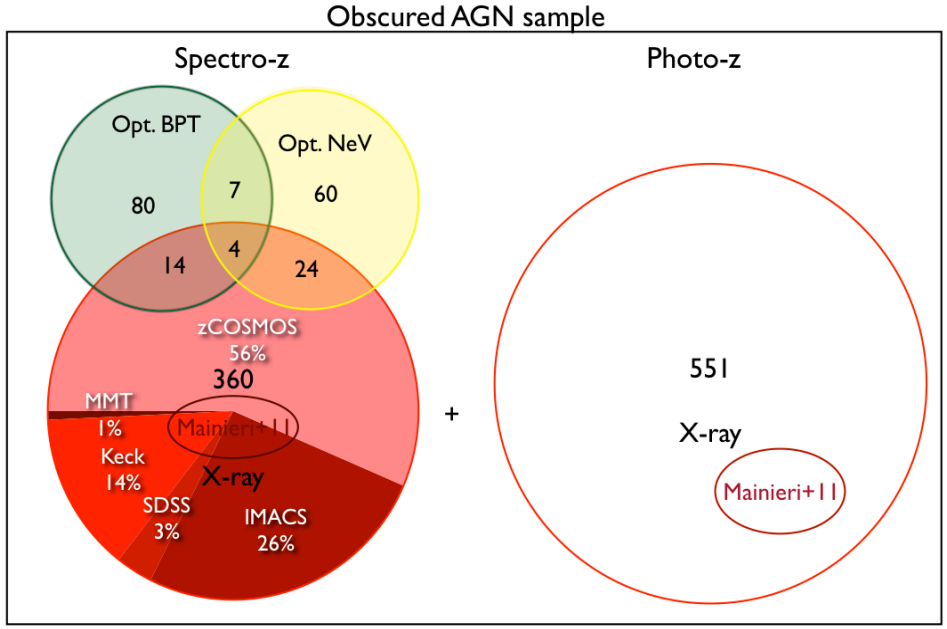
- Stacked AGN "templates" vs. L-z
- X-ray Baldwin effect: Narrow /Broad Iron Kα emission line vs. L_X
- High L/L_{edd}; QSO feedback via disk winds:
  - For log L_X>45 @z~1 >10^6 counts in 4-20 keV (rest frame)
  - For log L_X>45 @z~3 >10^6 counts in 2-8 keV (rest frame)

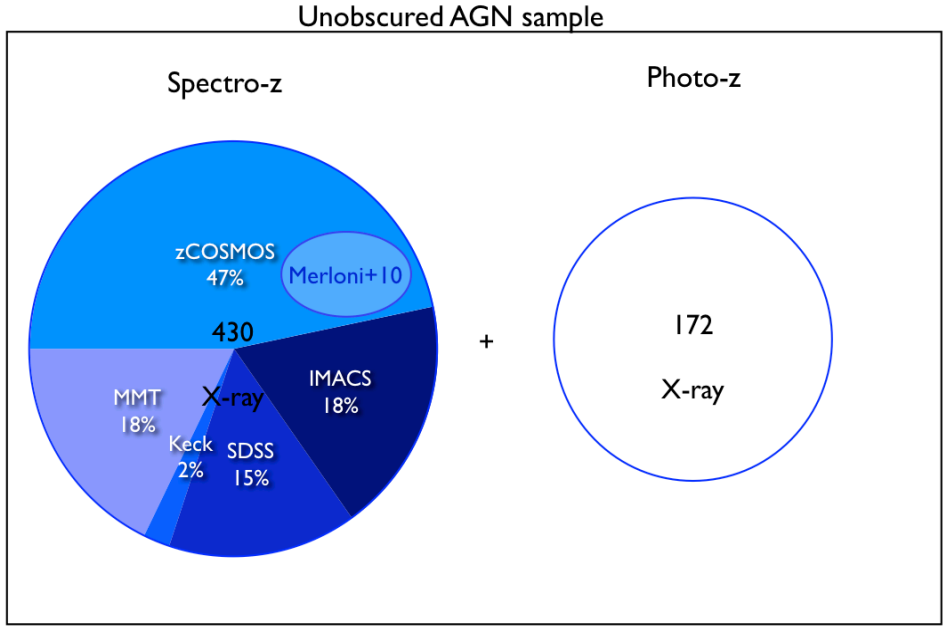
Make every X-ray photon count!

State of the art: XMM-COSMOS
A complete, X-ray selected, AGN sample



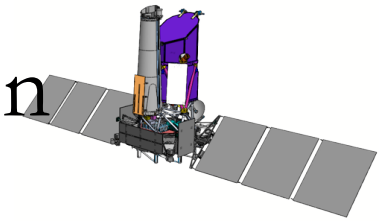
- 1555 X-ray selected AGN (XMM; f_{lim}~ **5×10^{-16}**[0.5-2]; **3×10^{-15}**[2-10])
- **100% redshift complete** (54% specz; 46% photoz)
- 602 Unobscured (71% specz; 29% photoz)
- 953 Obscured (42% specz; 58% photoz)
- **Parent sample** of ~200k IRAC galaxies (photoz, M_*; Ilbert et al. 2010)



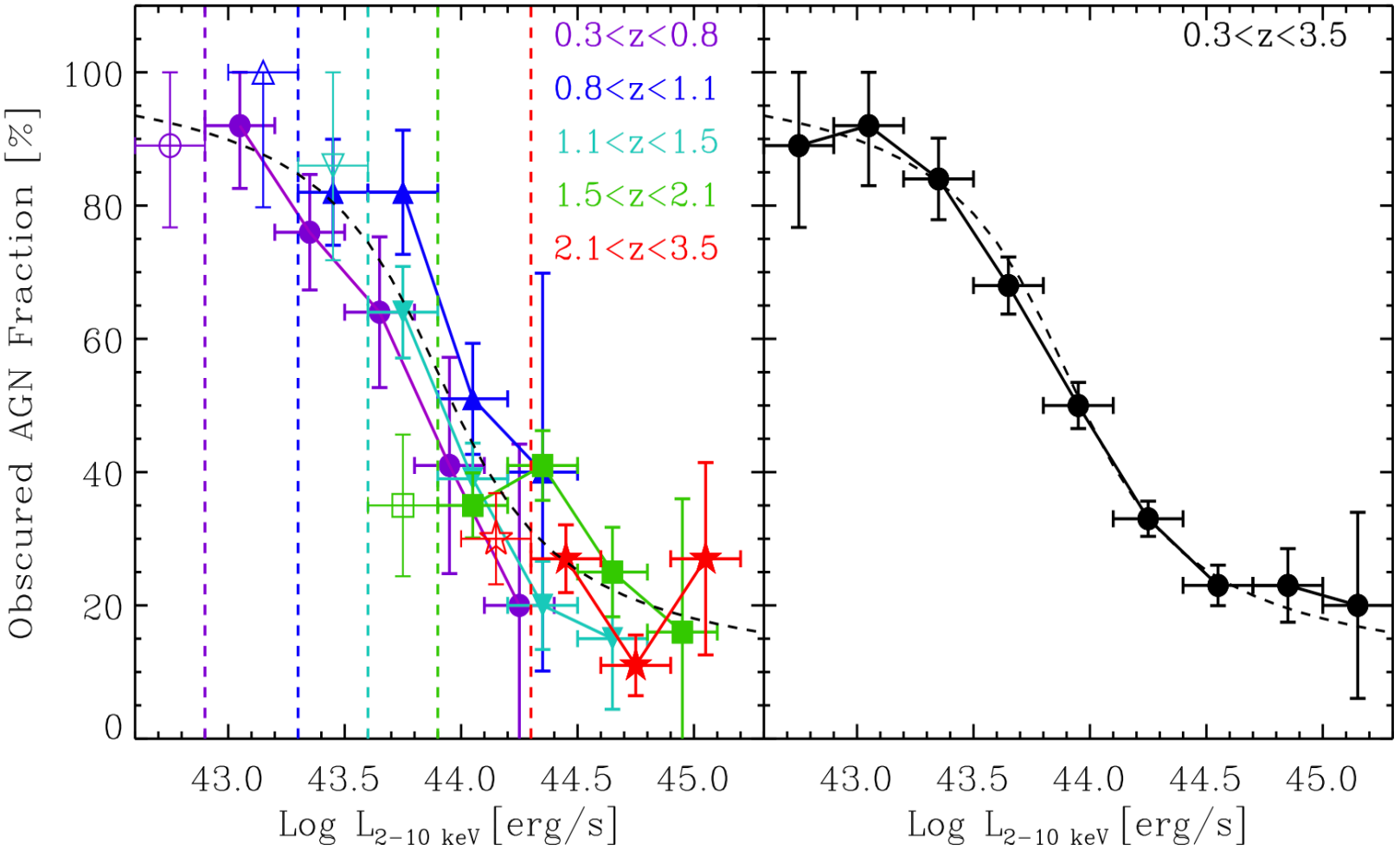


Bongiorno et al. 2012

AGN obscuration redshift evolution

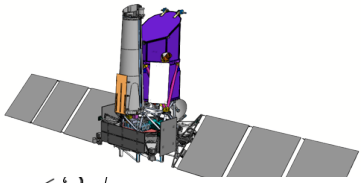


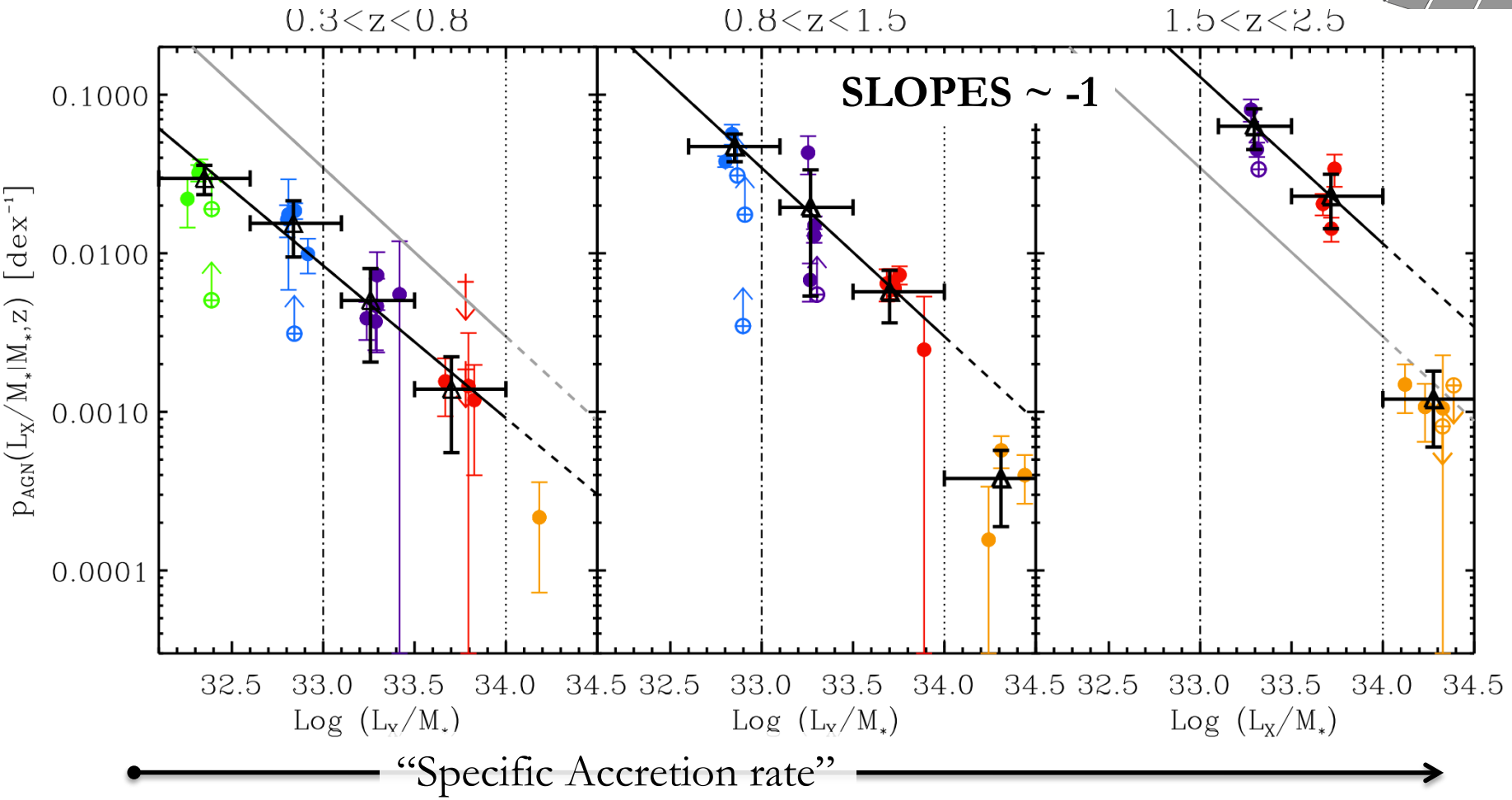
Using the redshift info, and the observed count rates, we extracted complete, **rest-frame 2-10 keV selected** sample ($f_{2\text{-}10}>1.8\times10^{-15}$; no N_H-z bias; 1030 X-ray selected AGN)



Merloni et al., in prep.

AGN fraction in XMM-COSMOS

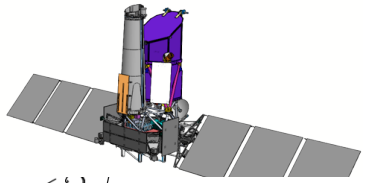


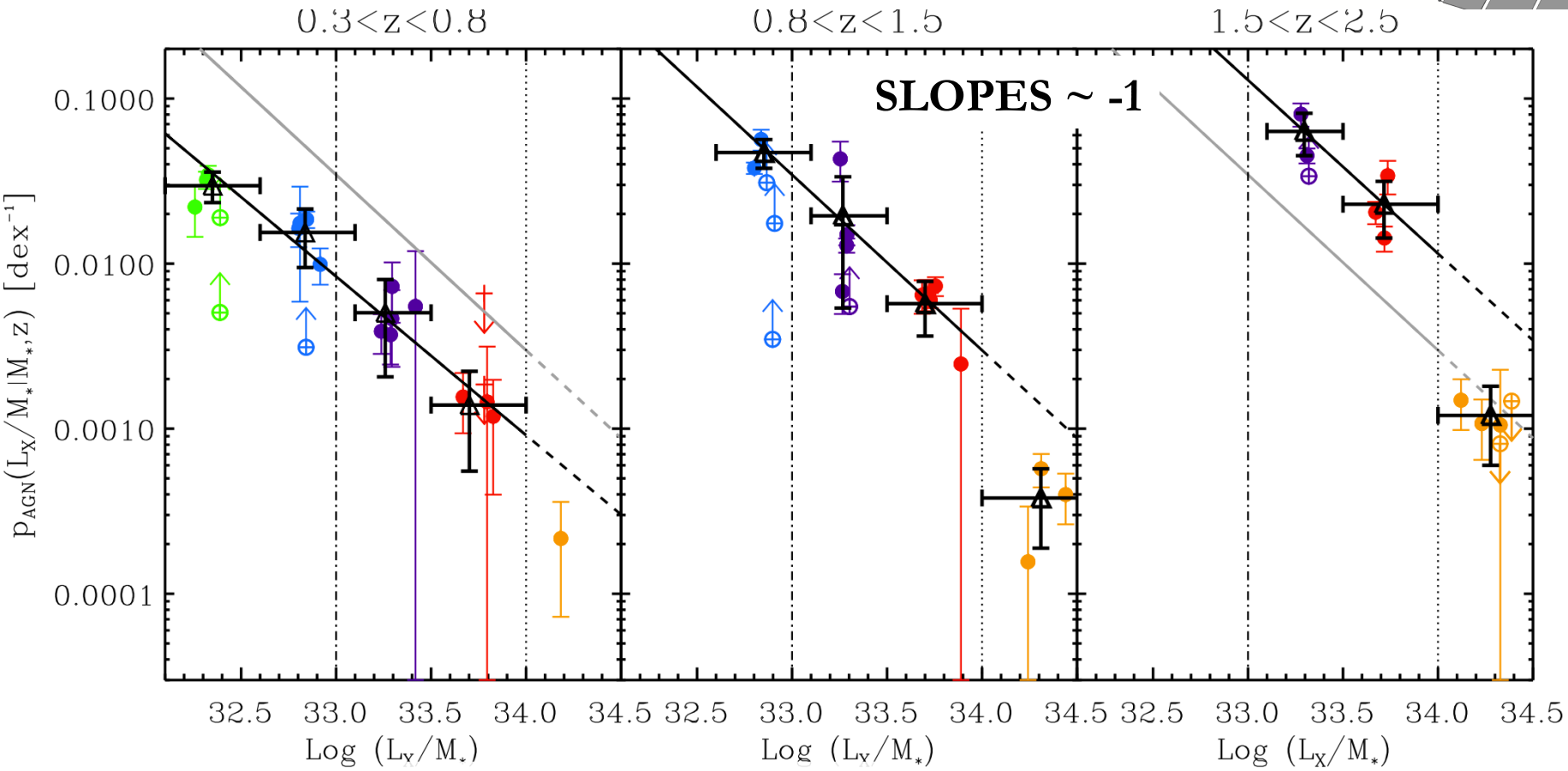


Its normalization increases as **~(1+z)^4** [cfr. sSFR density]
There appears to be a break consistent with **~Eddington limit**

Bongiorno et al., 2012

AGN fraction in XMM-COSMOS

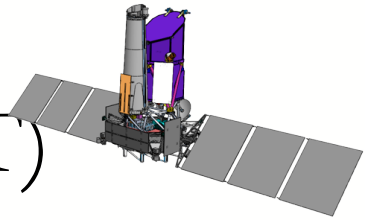




In the largest existing completely identified AGN sample (1000-2000 AGN), we **lack the statistics** to properly slice the sample in bins of L, z, NH, stellar (or BH) mass, etc.
Need >10k => a complete eROSITA follow-up program will be key

Bongiorno et al., 2012

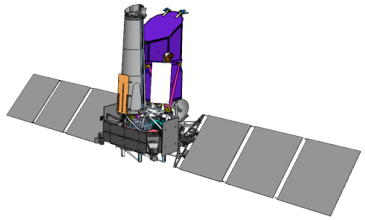
An AGN mock catalog (for 4MOST)

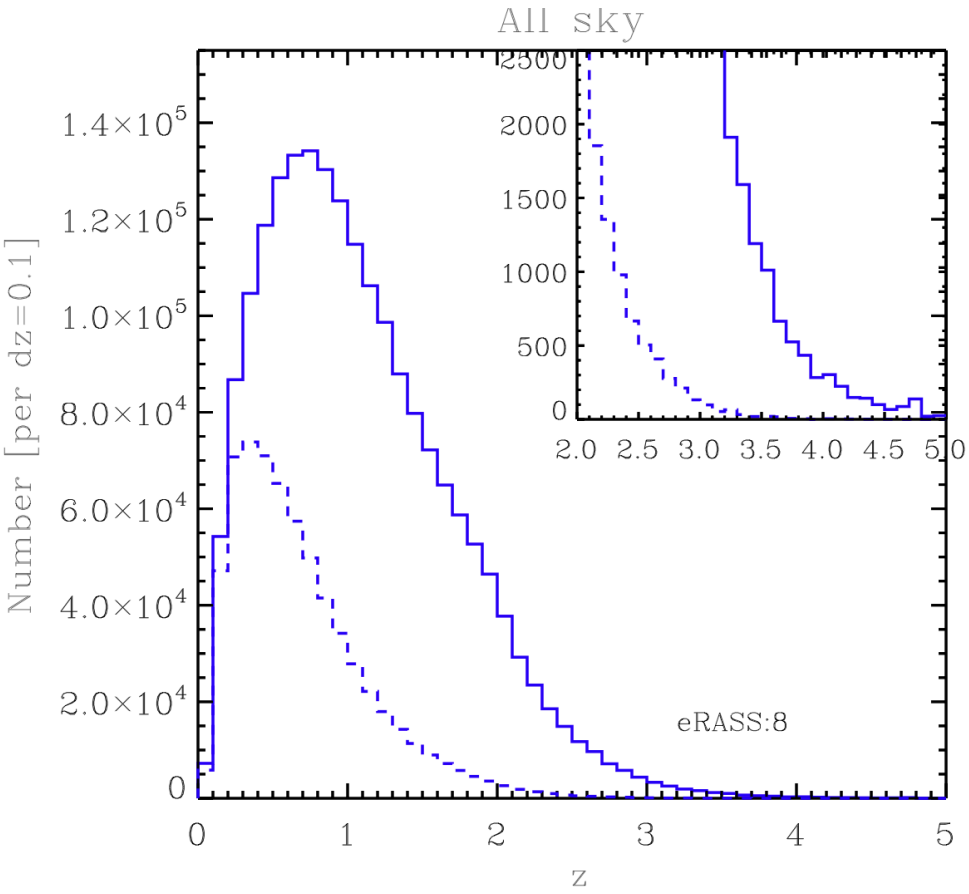


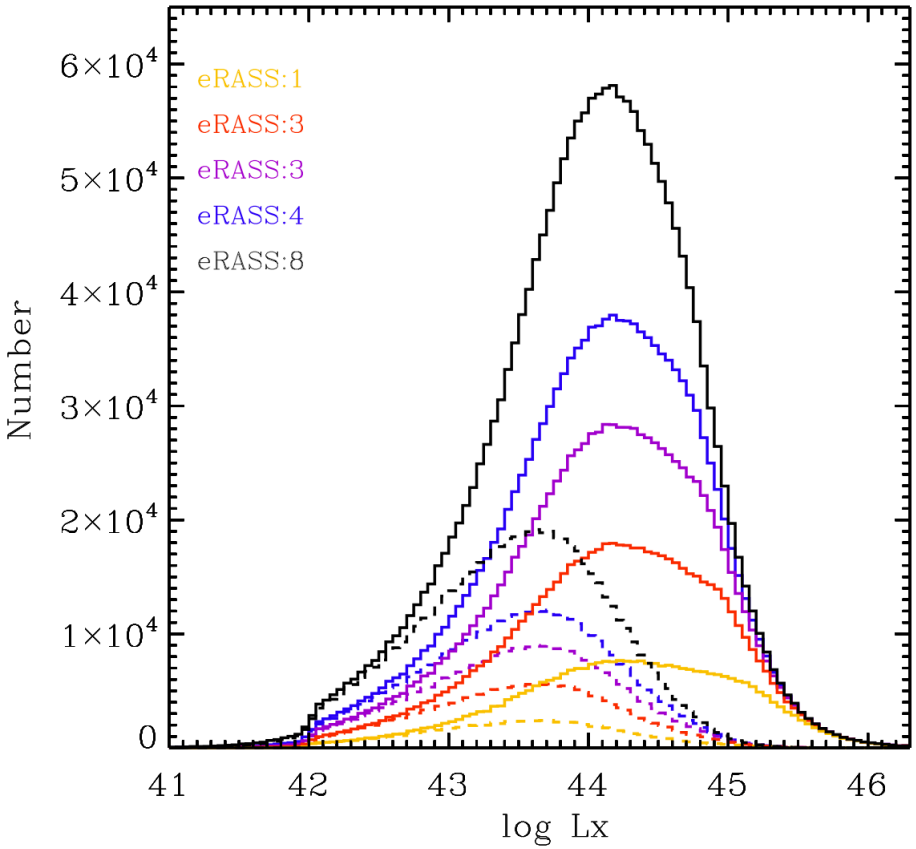
AGN 4MOST SWP: Banerji (IoA), Boller (MPE), Bongiorno (INAF-OAR), **Brusa (MPE)**, Krumpe (ESO), Lamer (AIP), Mainieri (ESO), McMahon (IoA), Merloni (MPE), Nandra (MPE), Salvato (MPE), Schwope (AIP), Wisotski (AIP)

1. Start from eROSITA exposure map
2. Use Galactic extinction map
3. Randomly distributed sources in RA and DEC
4. Fit AGN 0.5-2 keV LogN-LogS
5. Use X-ray background synthesis models of AGN LogN-LogS (fits luminosity function, N_H distribution vs. L and z, etc.)
6. Empirical X-ray to optical (X/O) ratio distribution (as a function of L)
7. Spectral type assignment
8. Spectral templates

Redshift and Lx distributions

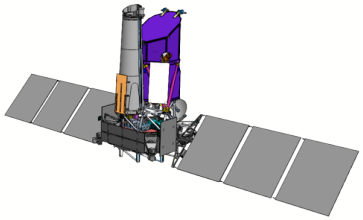


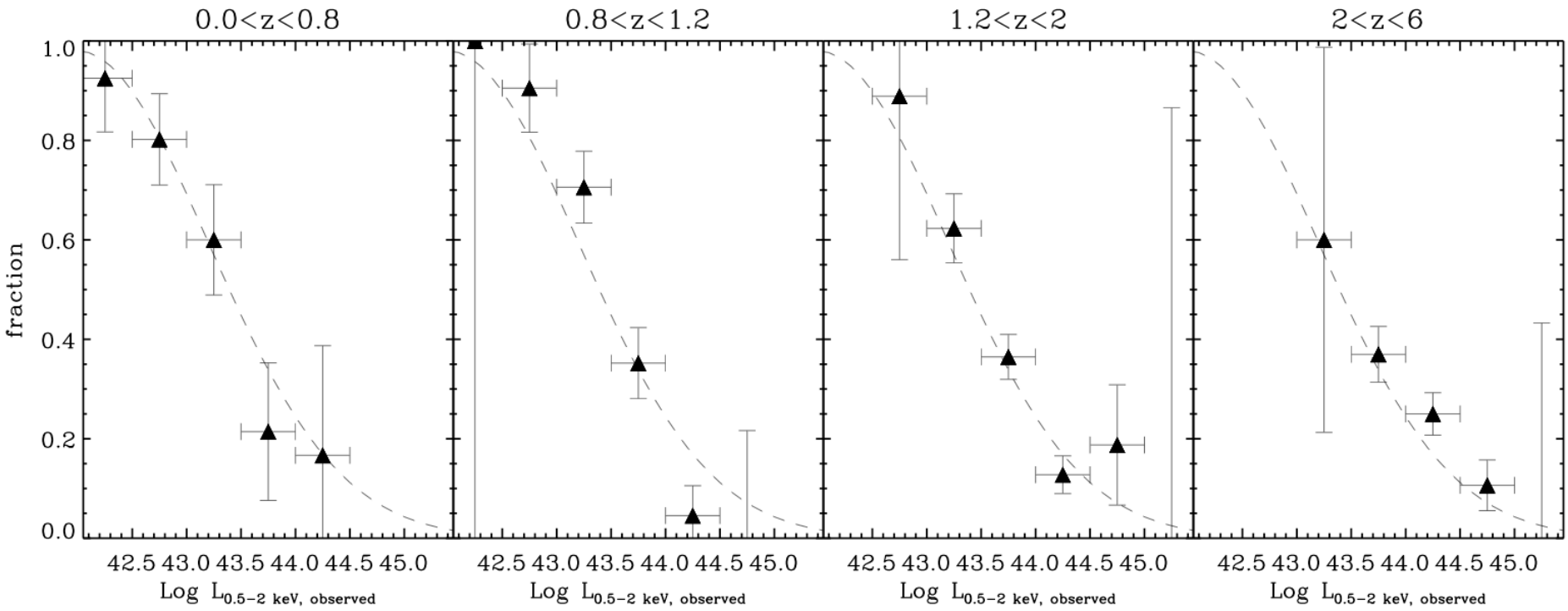




Based on Gilli et al. 2007 XRB synthesis model, and the Hasinger et al. 2005 XLF

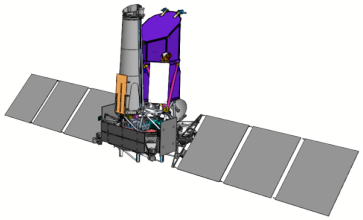
Obscured AGN fraction

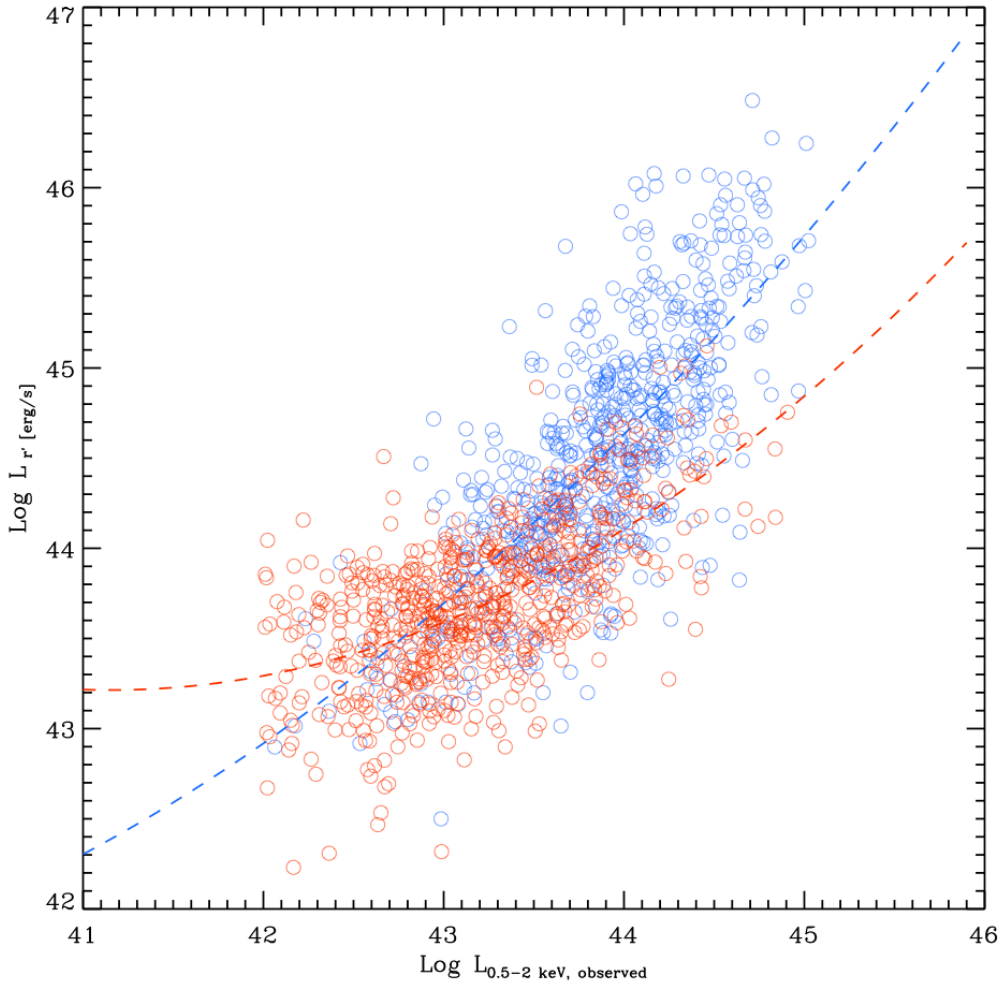


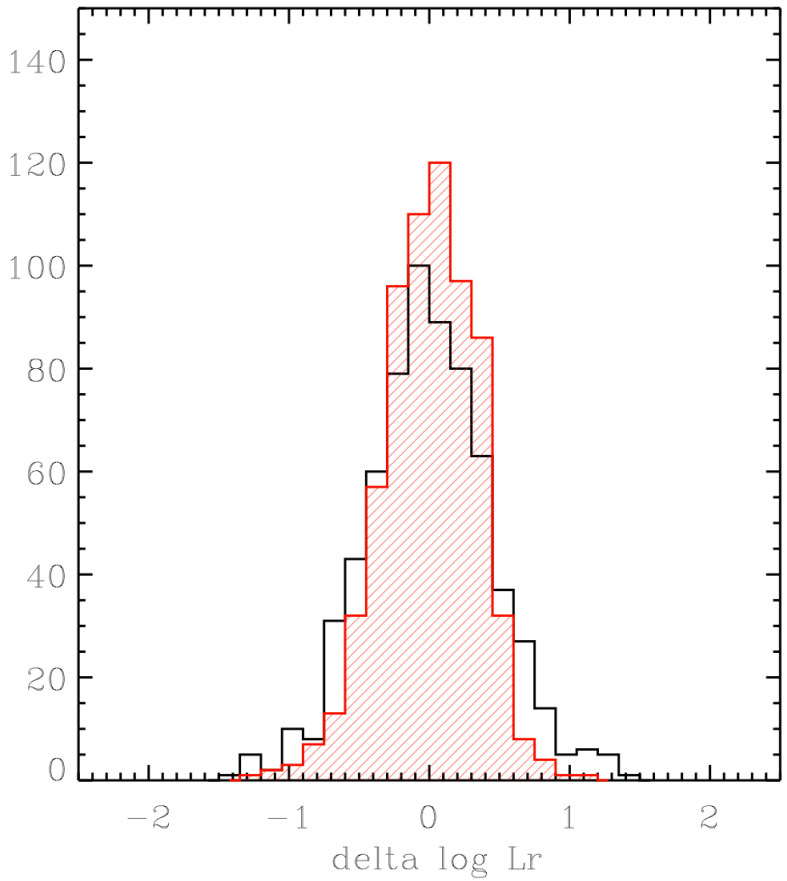


Based on XMM-COSMOS catalog of fully identified AGN, Brusa et al. 2010; Salvato et al. 2009

X-ray-to-optical ratios

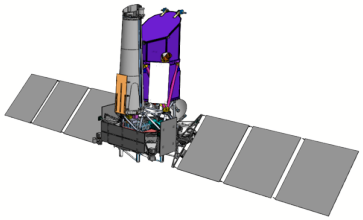


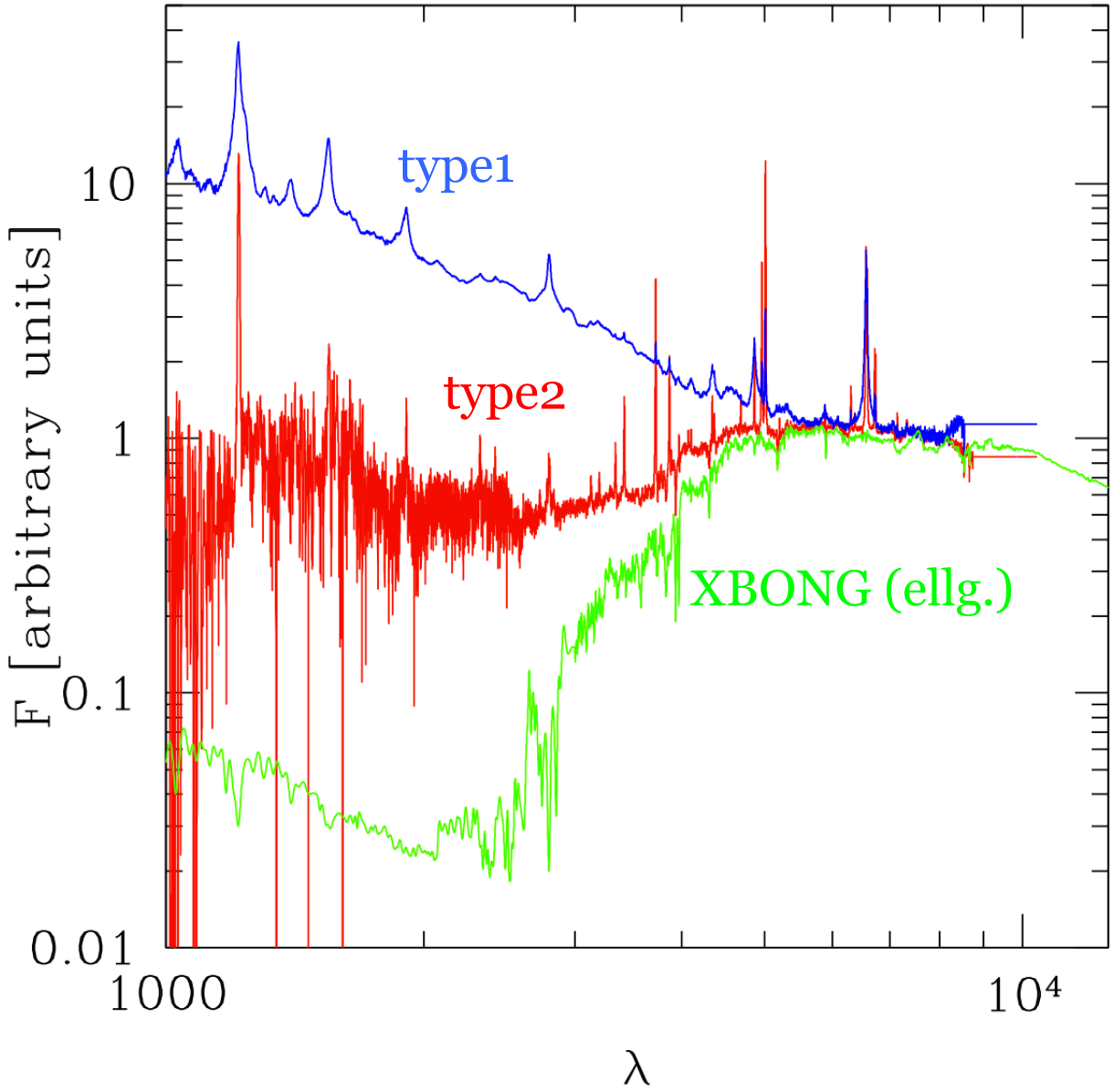




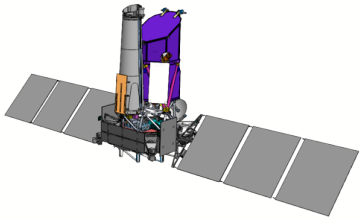
Based on XMM-COSMOS catalog of fully identified AGN, Brusa et al. 2010; Salvato et al. 2009

Spectral templates

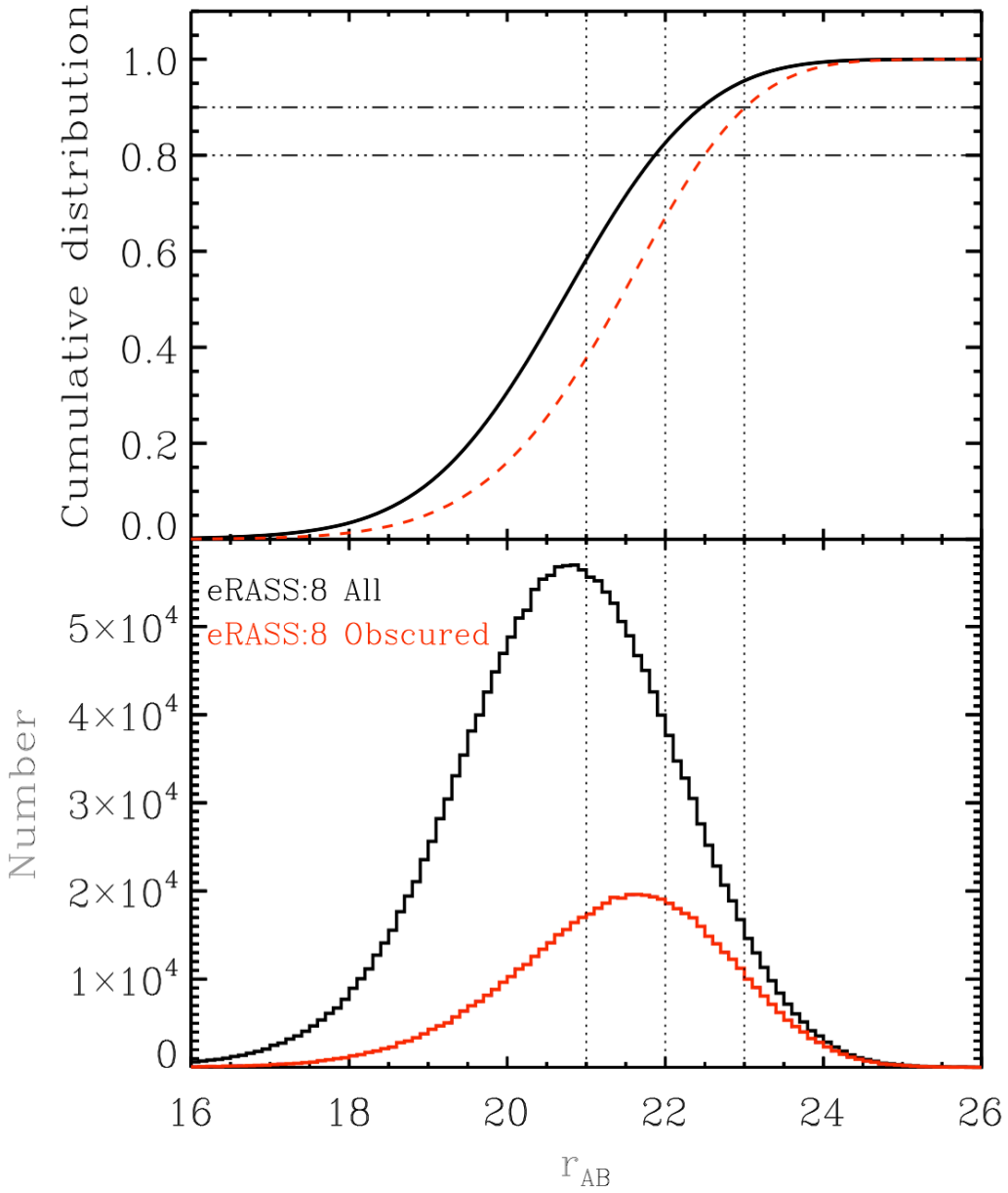




AGN: Can we follow them up?



CALIBRATED ON XMM-COSMOS

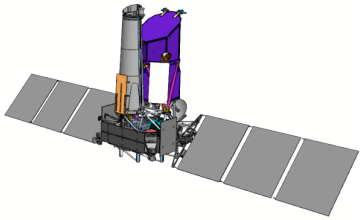


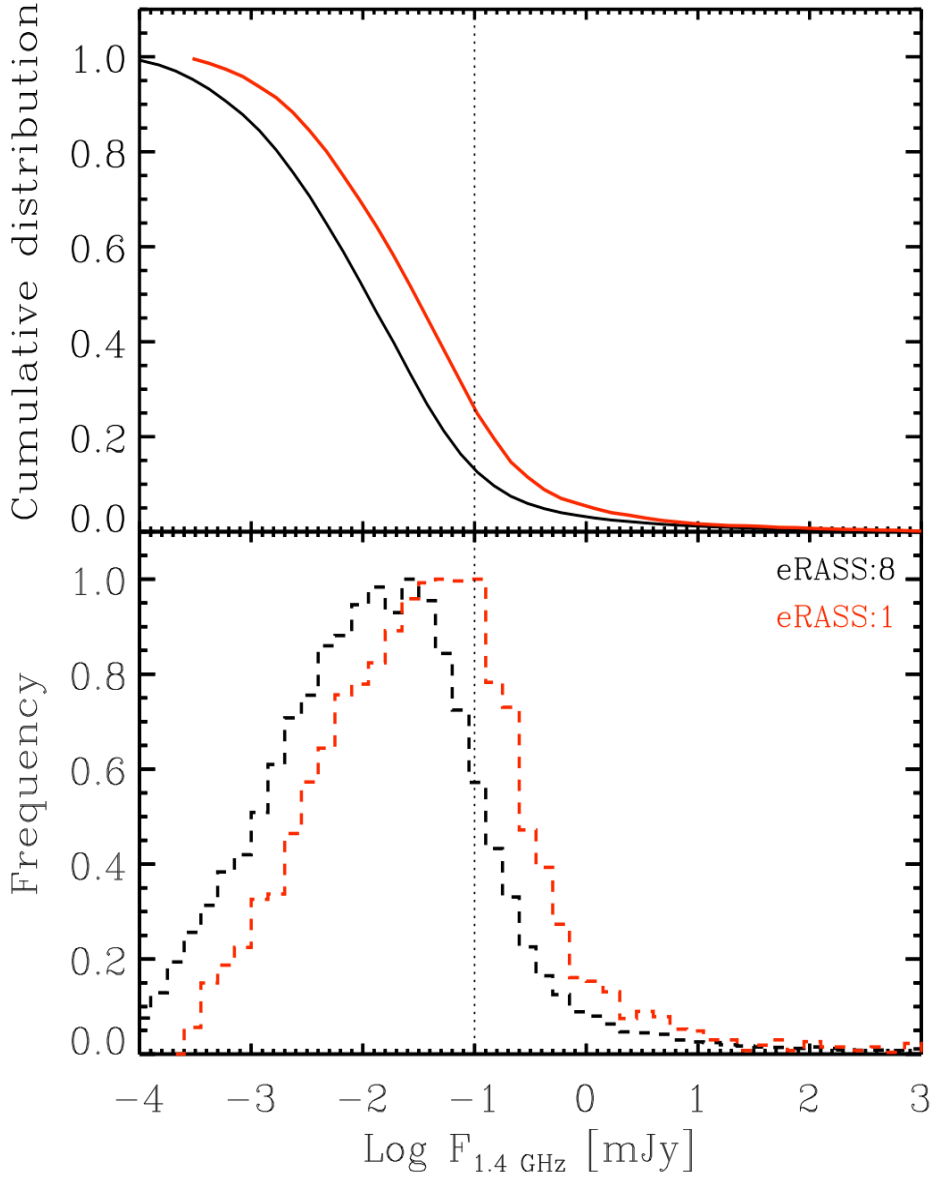
- At these relatively bright X-ray flux levels, X-ray positional uncertainty is an issue: test with (degraded XMMCOSMOS) = ~87 (+5)% secure ID at i=24 [~60-70% in VHS]

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

Merloni et al. 2012

[AGN: radio counterparts]





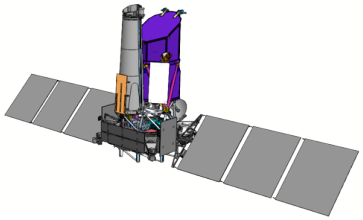
From the observed probability distribution of $L_{1.4\ GHz}$ as a function of X-ray luminosity and redshift (La Franca et al. 2010)

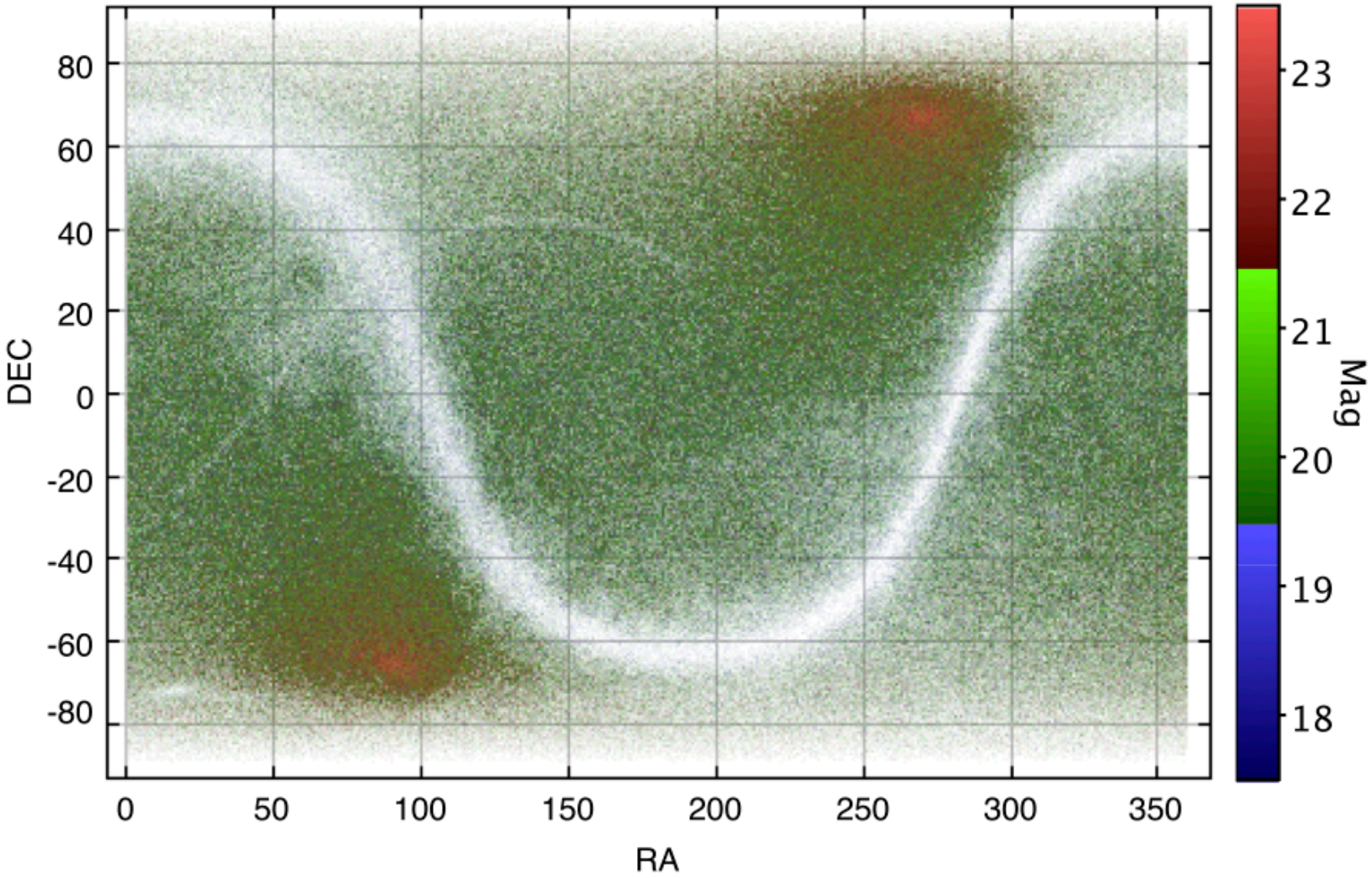
About ½ of eROSITA AGN will be fainter than 10 μJy

eRASS:1=6 months survey ($F_{0.5\text{-}2\ keV} > 4 \times 10^{-14}$ erg/s/cm^2)

eRASS:8=4 years survey ($F_{0.5\text{-}2\ keV} > 1 \times 10^{-14}$ erg/s/cm^2)

Simulated optical (r_{AB} band) sky





Run 5 simulation analysis

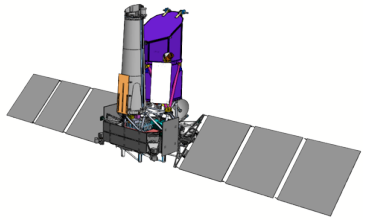
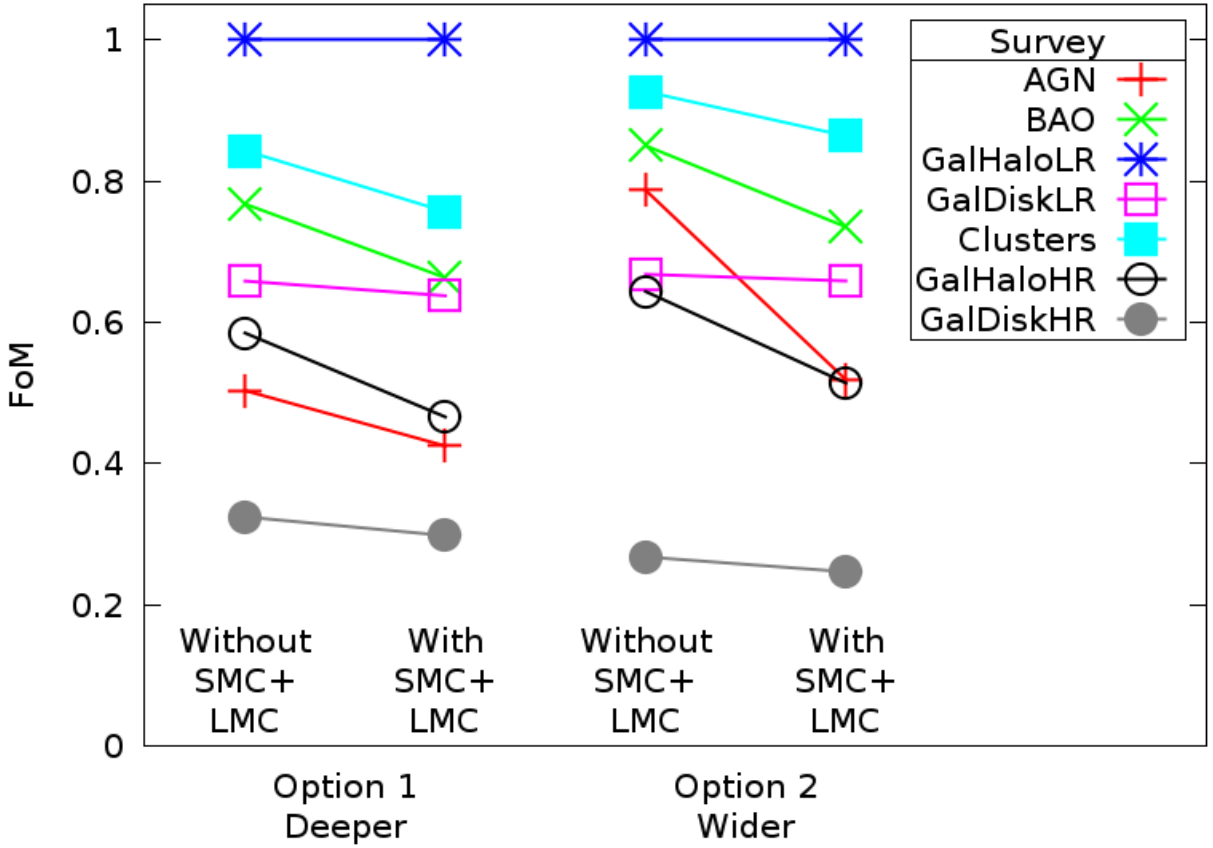
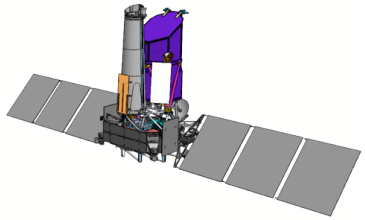


FIGURE of MERIT

FoM=0.5 correspond to 75% completeness (defined, in genral terms, as $N_{completed}/N_{input}$), and FoM=1 correspnds to 90% completeness.



Run 5 (wide) simulation analysis



b<70 & b>20
R<23

Nobj(input) = 1989497 → Nobj(output) = 965915

case (1), (2A),(2B)

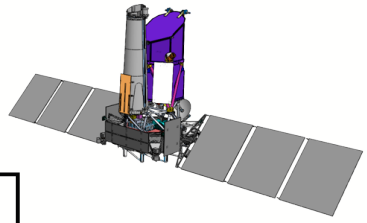
Nobj(observed) = 820260 → Nobj(successful) = 771479

case (3)

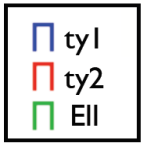
Why do we loose sources? What kind of sources?

(1) Nfield=0 not in the observed fields	TOT=28757 (3%)		N_{ty1}=19394
			N_{ty2}=7643
			N_{Ell}=1720
(2)Nfield≠0 & Ntil=0 not in the observed fields but still not observed	TOT=116898 (12%)	(2A) $t_{required}$>120min TOT=54724 (5.6%)	N_{ty1}=23811
			N_{ty2}=18233
			N_{Ell}=12680
		(2B) $t_{required}\leq$120min but priority low TOT=62174 (6.4%)	N_{ty1}=43641
			N_{ty2}=15623
			N_{Ell}=2910
(3) Nfield≠0 & Ntil≠0 & FrDone<1 observed but with a t_exp<required	TOT=48781(5%)	$t_{required}\leq$120min && $t_{done}<t_{required}$	N_{ty1}=24039
			N_{ty2}=16817
			N_{Ell}=7925

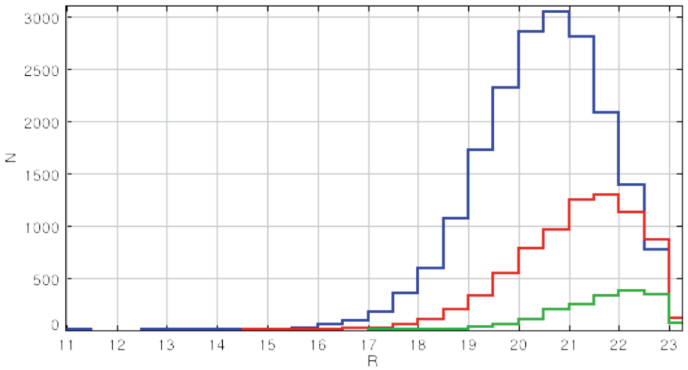
Run 5 (wide) simulation analysis



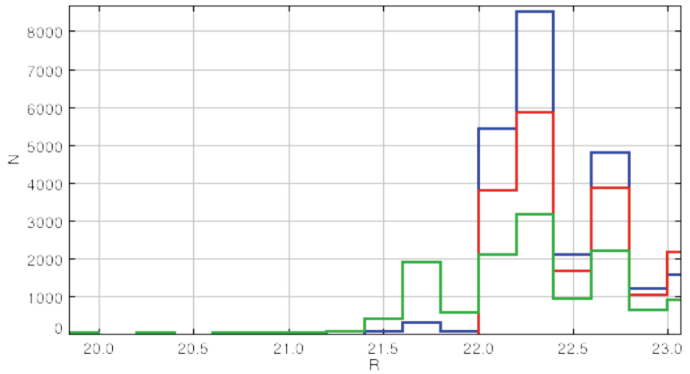
R-band magn distribution of the unsuccessful objects



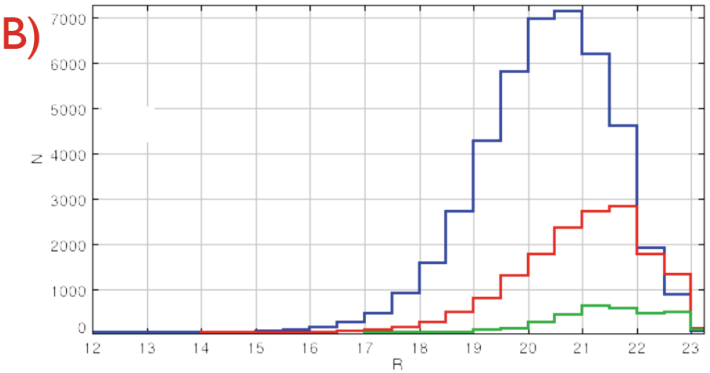
(1)



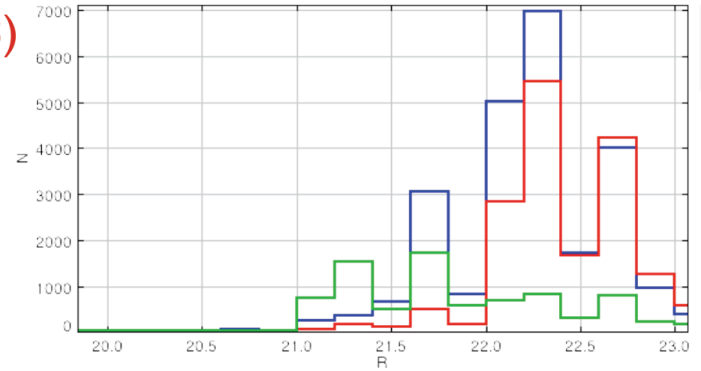
(2A)



(2B)

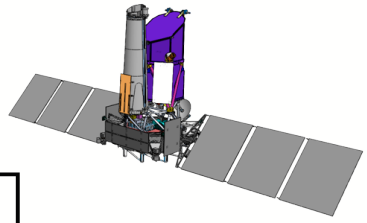


(3)

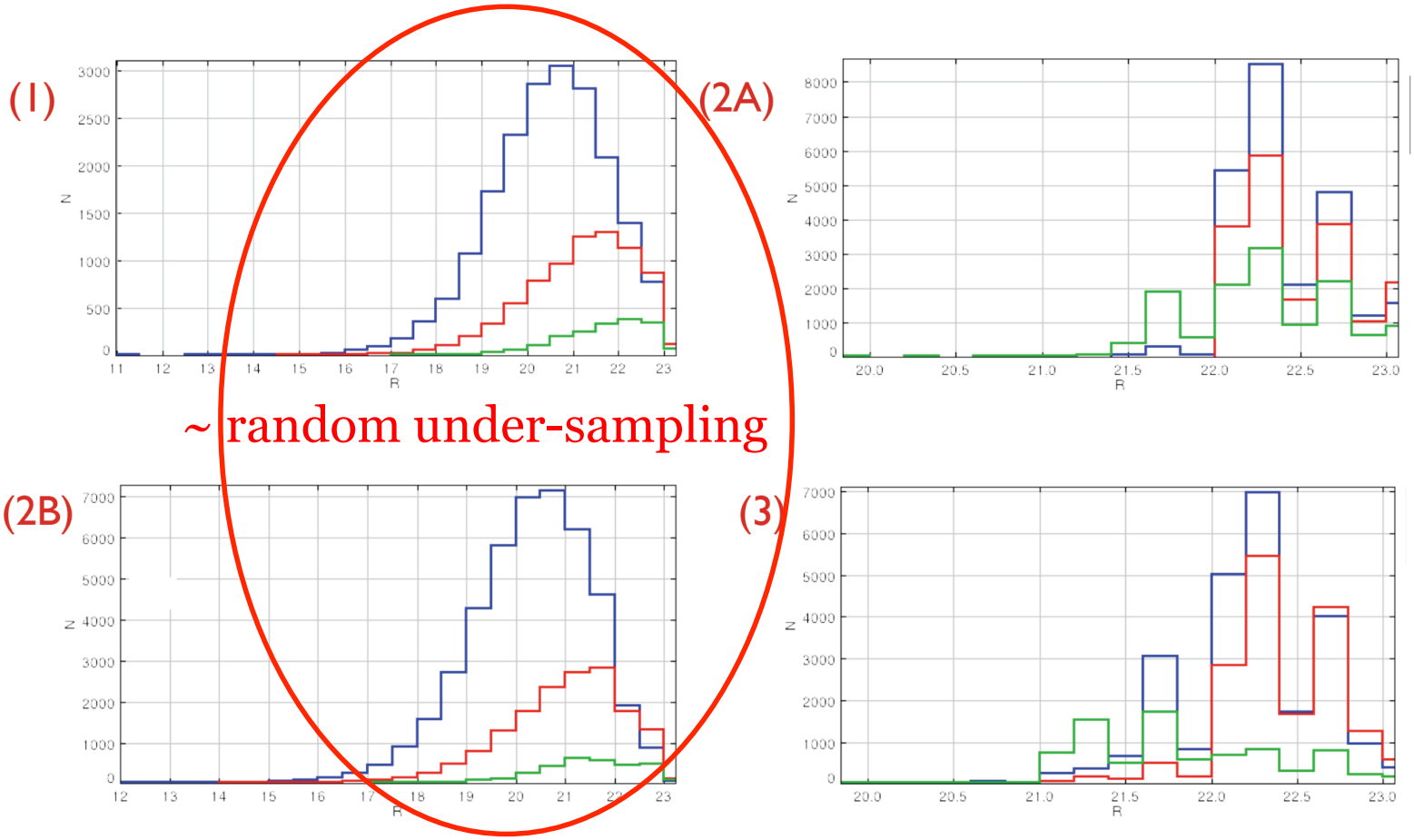


In each panel, type 1 AGN, type 2 AGN and elliptical galaxies templates are shown with blue, red and green lines, respectively.

Run 5 (wide) simulation analysis

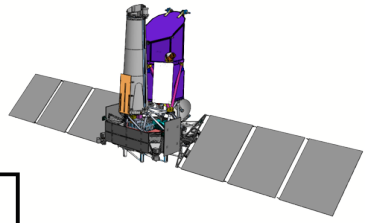


R-band magn distribution of the unsuccessful objects

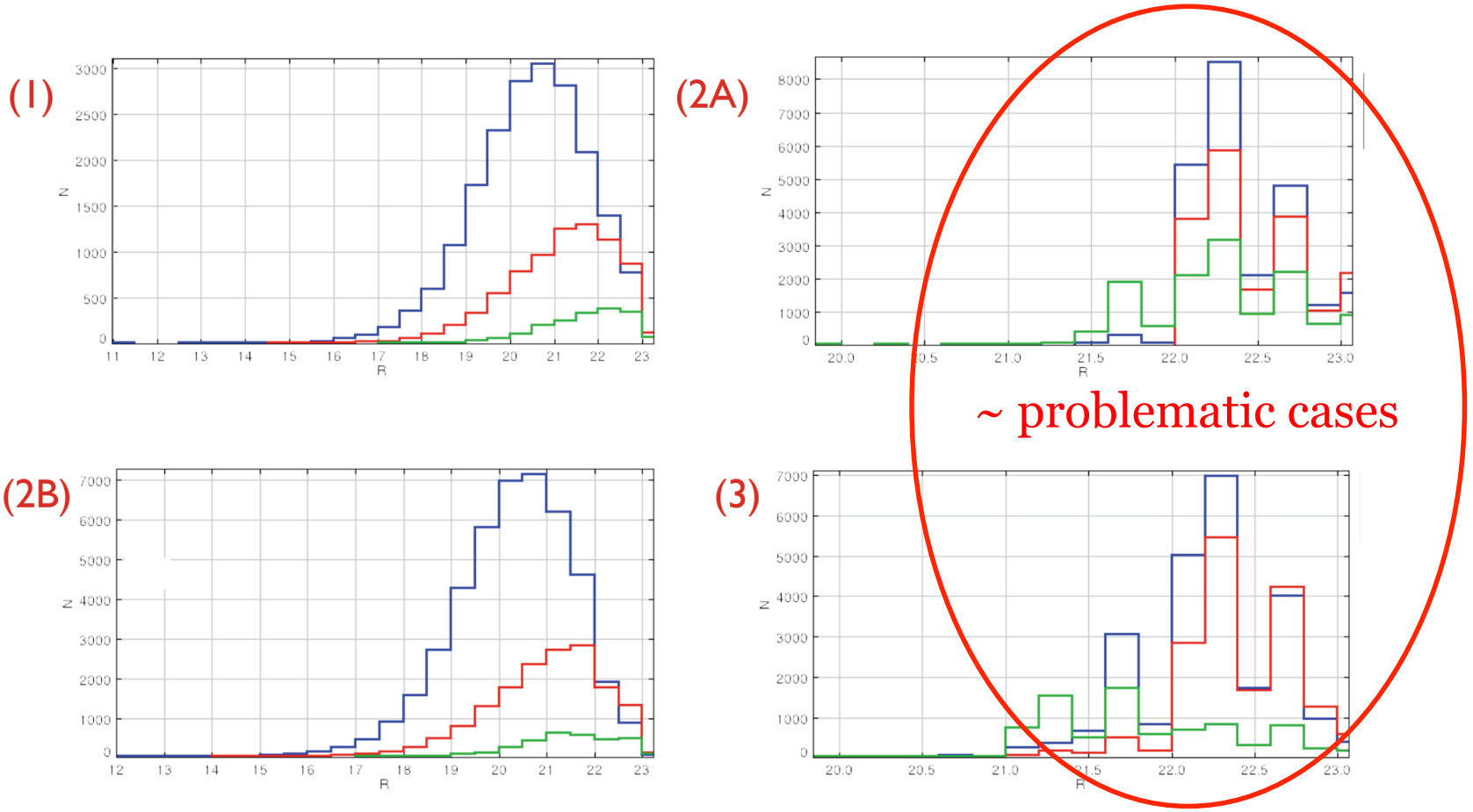


In each panel, type 1 AGN, type 2 AGN and elliptical galaxies templates are shown with blue, red and green lines, respectively.

Run 5 (wide) simulation analysis

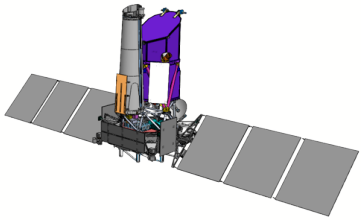


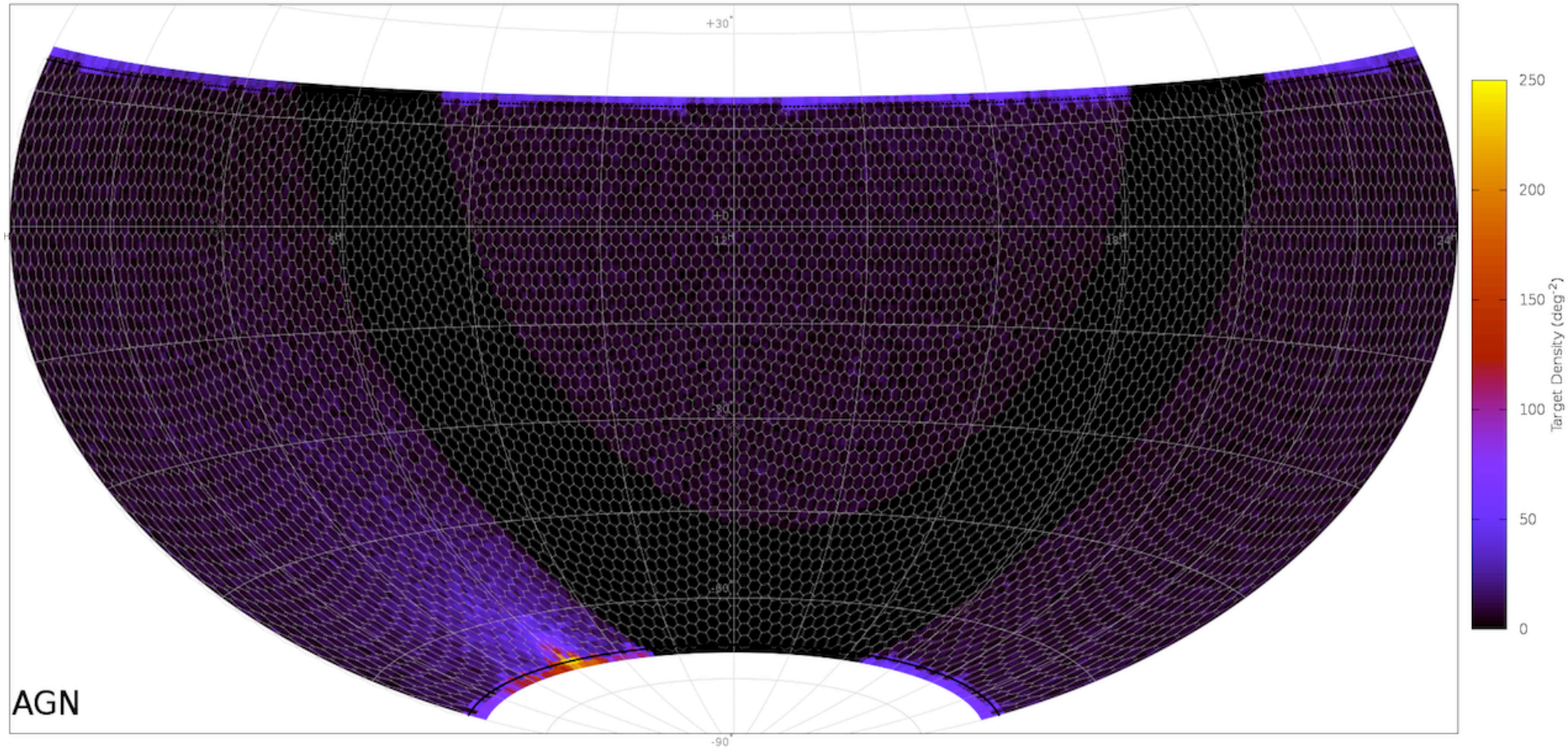
R-band magn distribution of the unsuccessful objects



In each panel, type 1 AGN, type 2 AGN and elliptical galaxies templates are shown with blue, red and green lines, respectively.

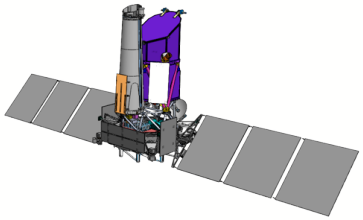
Run 5 (wide) simulation analysis



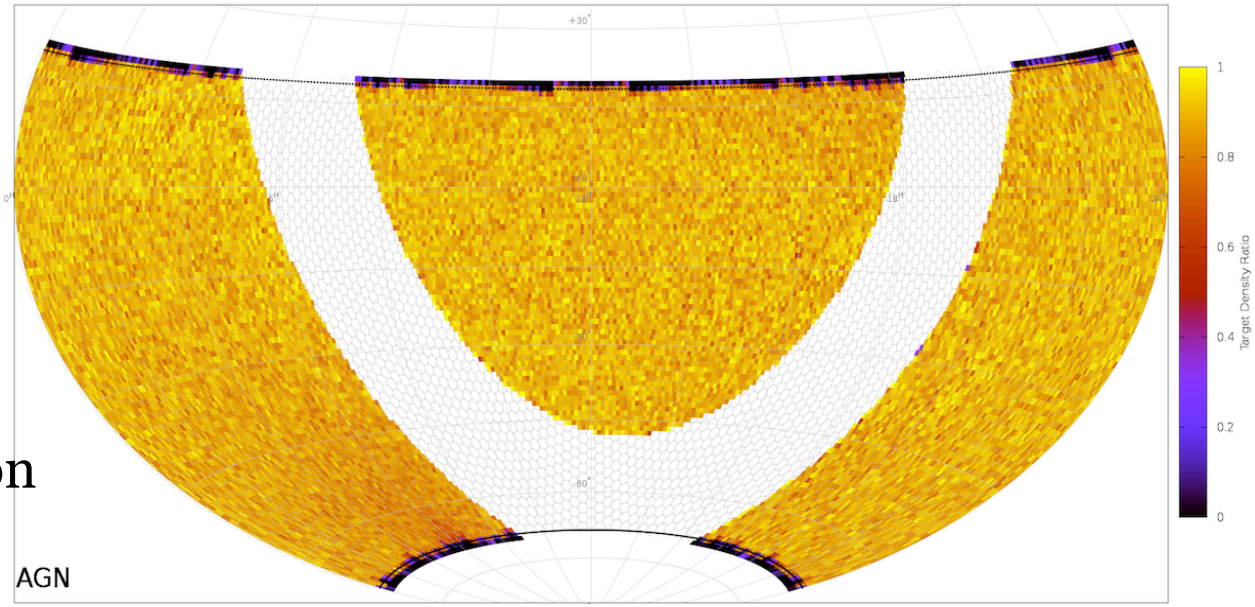


Sky density of unobserved targets (sum of FAILURE 1 and 2)

Run 5 (wide) simulation analysis

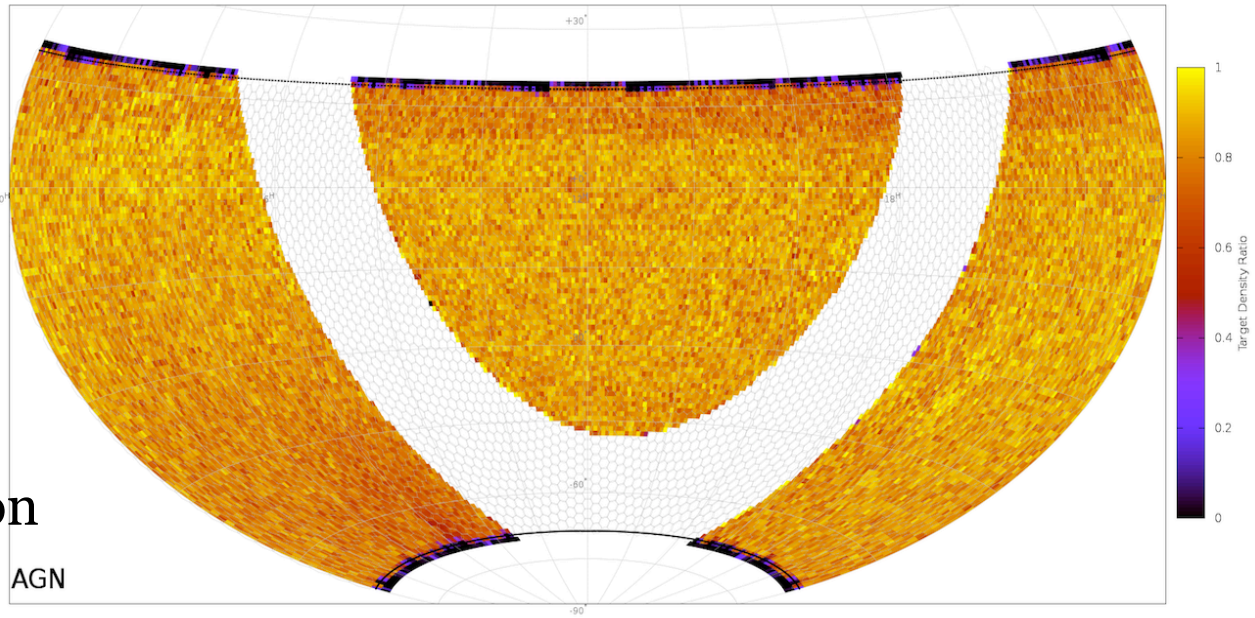


Observed
AGN fraction

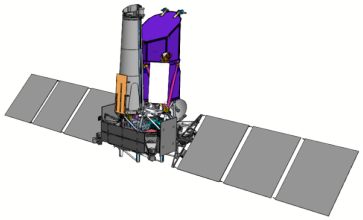


FAILURE 3

Successful
AGN fraction



The landscape of O/IR wide area surveys



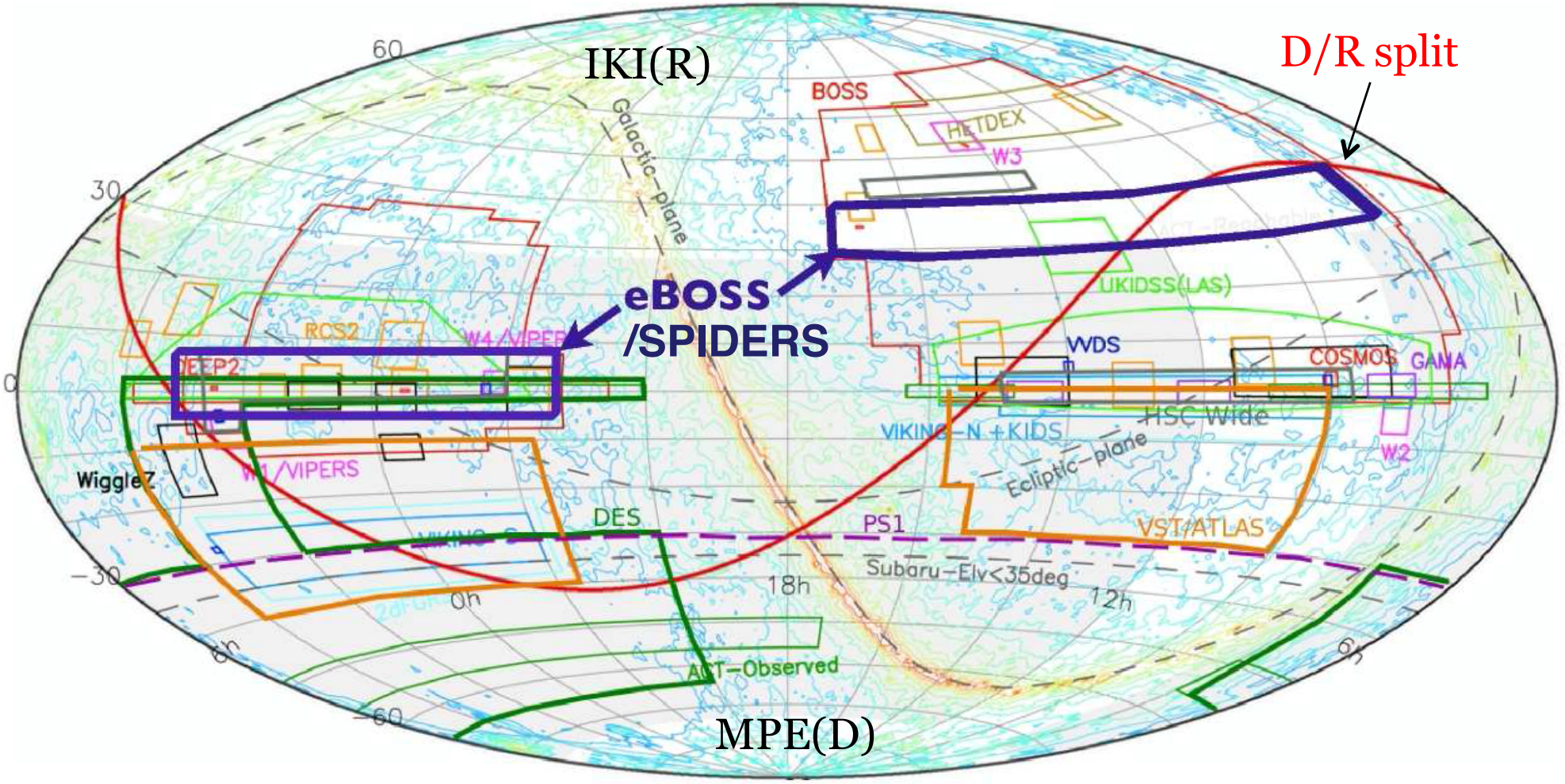
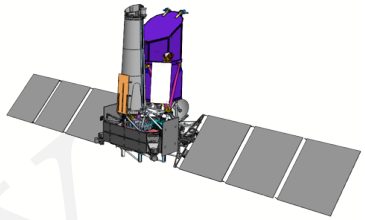


Image A. Nishizawa (IPMU), AM

BOSS SPIDERS pilot survey in the XMM-LSS



(1) Limiting flux 0.5-2 keV [erg/s/cm^2]	(2) Total #/dens. [deg^{-2}]	(3) Targetable 17<g<22.5	(4) Bright g<17	(5) Too faint (g>22.5 or unid)	(6) Targeted in ancillary + BOSS (sampling rate)	(7) Good_z (success rate)	(8) FoM (=Good_z/Total/sampling) /FoM*dens. [deg^{-2}]
6e-15	1159/166	752 (65%)	38 (3%)	369 (32%)	503+24 (0.70)	424 (80%)	0.52/86
1e-14	638/91	475 (75%)	26 (4%)	137 (21%)	324 (0.68)	280 (86%)	0.64/58
2e-14	210/30	175 (83%)	17 (8%)	18 (9%)	113 (0.65)	107 (95%)	0.78/23
4e-14	74/11	61 (82%)	9 (12%)	5 (7%)	42 (0.69)	40 (95%)	0.78/8.6

(1)= limiting flux in the soft X-ray band (0.5-2 keV) from A. Georgakakis's catalog in XMM-LSS

(2)= Total number of sources in the field/source density (deg^{-2})

(3)= # of sources that can be targeted by BOSS (i.e. with a reliably identified optical counterpart in SDSS, with 17<g<22.5)

(4)= # of sources that cannot be targeted by BOSS because too bright (mostly stars)

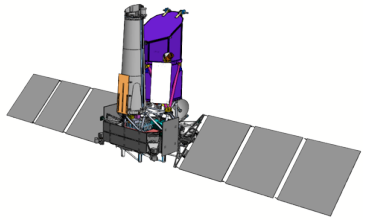
(5)= # number of sources that cannot be targeted by BOSS because without counterpart, or too faint

(6)= # number of sources actually targeted by BOSS (both in BOSS main and in SPIDERS pilot, TBC). Here "Sampling rate" is the ratio Targeted/Targetable (column 6/column 3)

(7)= # number of sources with ZWARNING=0 (good redshift measurements)

(8)= Figure of Merit=(good_z/total)*(1/sampling). This should approximate the true completeness of the redshift determination. FoM*n is the number density of a sample of x-ray AGN (per deg^2) for which we can obtain redhisft if sampling rate=100%

Conclusions

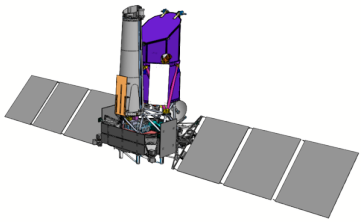


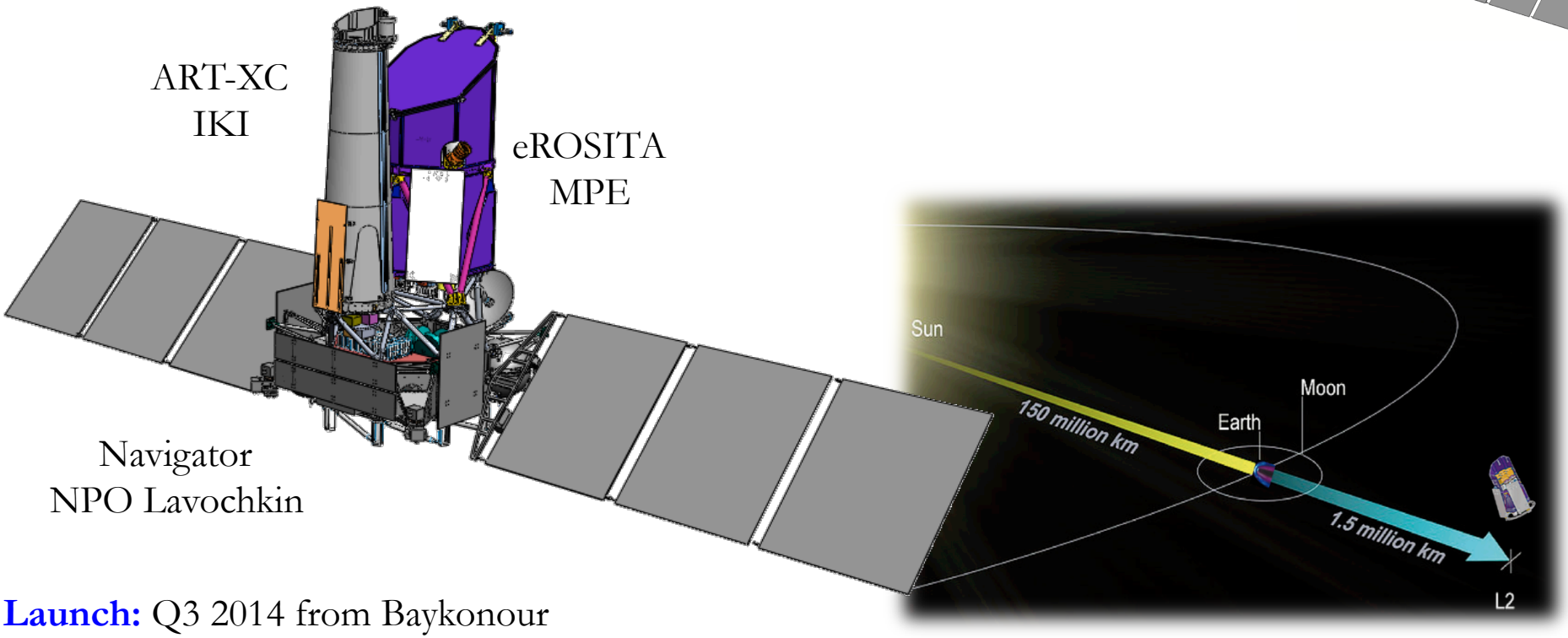
- A highly complete spectroscopically identified sample of ~10^6 X-ray selected AGN will be a revolution in the study of black holes
- 4MOST has the potential to fulfill this goal
- With a surface density <100/deg^2, we should aim at the highest possible completeness (simple FoM):
  - high priority in the extragalactic sky
- Wider survey strategy clearly preferred

Thank you!

eROSITA Science Book
arXiv:1209.3114

eROSITA on SRG: the Mission





- **Launch:** Q3 2014 from Baykonour
- **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 **2 yrs**
- Public Release of all-sky scan data ~ every year

eROSITA Collaboration

PI: Peter Predehl; PS: A. Merloni (MPE)

Core Institutes (DLR funding):

MPE, Garching/D
Universität Erlangen-Nürnberg/D
IAAT (Universät Tübingen)/D
SB (Universität Hamburg)/D
Astrophysikalisches Institut Potsdam/D

Associated Institutes:

MPA, Garching/D
IKI, Moscow/Ru
USM (Universität München)/D
AIA (Universität Bonn)/D

Industry:

Media Lario/I	Mirrors, Mandrels
Kayser-Threde/D	Mirror Structures
Carl Zeiss/D	ABRIXAS-Mandrels
Invent/D	Telescope Structure
pnSensor/D	CCDs
IberEspacio/E	Heatpipes
RUAG/A	Mechanisms
HPS/D,P	MLI

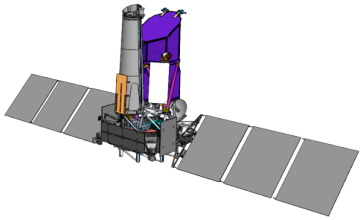
+ many small companies

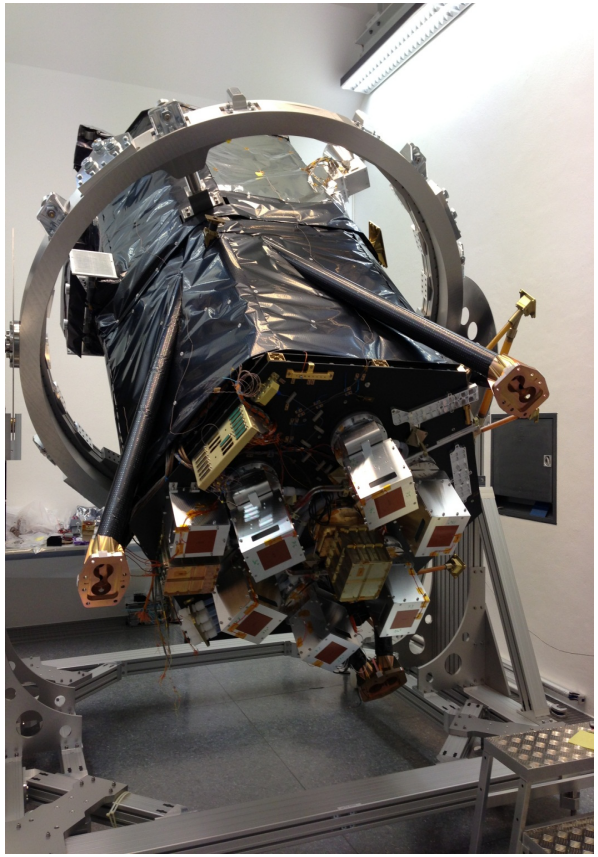
MPE: Scientific Lead Institute, Project Managment

Instrument Design, Manufacturing, Integration & Test
Data Handling & Processing, Archive etc.

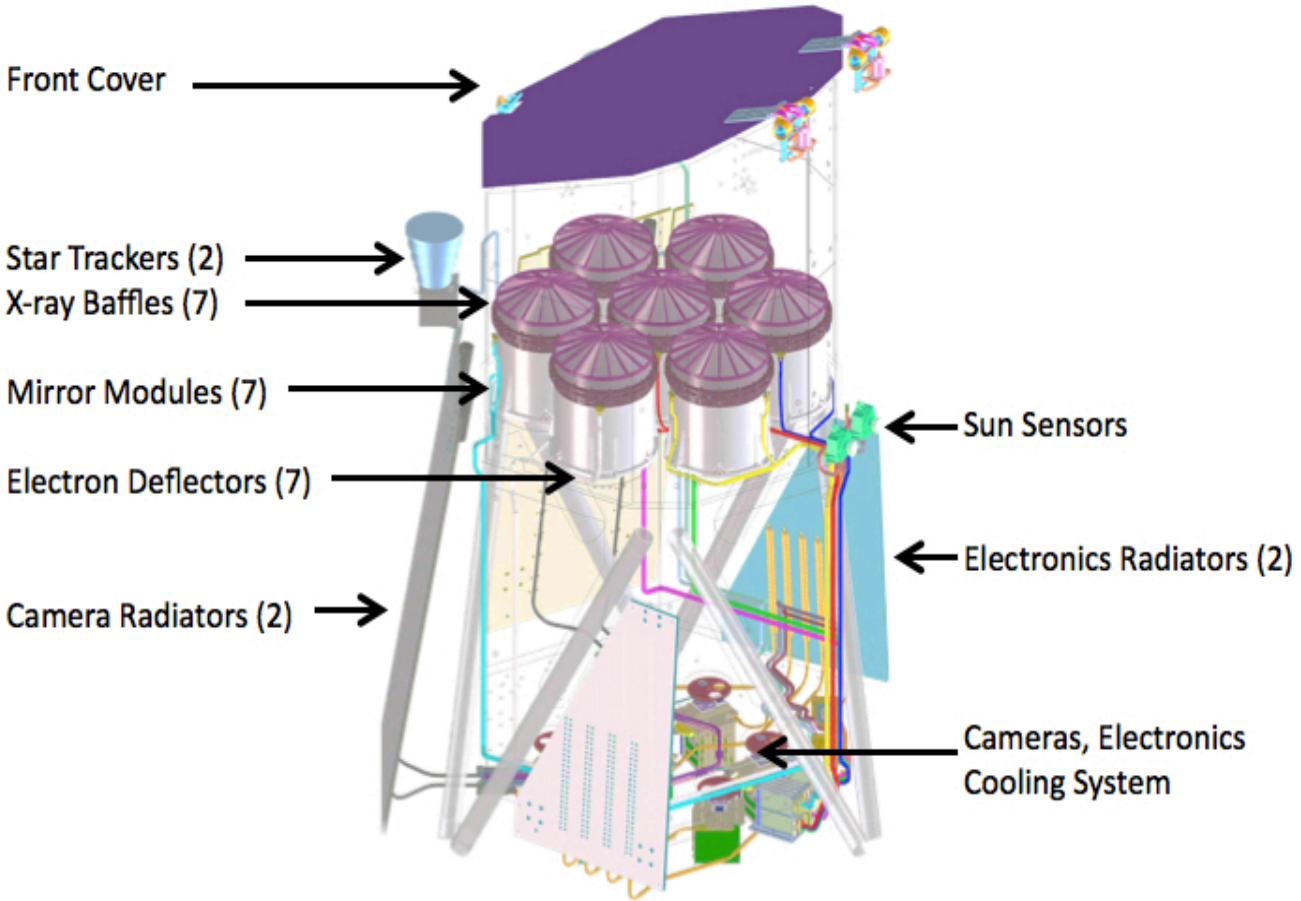
eROSITA Telescope

www.mpe.mpg.de/eROSITA



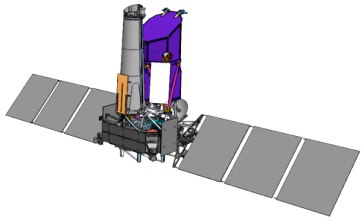


Focal length 1.6 m
F.o.V. = 0.81 sqdeg
54 nested mirror shells
Total weight ~800 kg



7 identical telescopes (Wolter-I/ pnCCD-cameras)
Energy range: 0.5-10 keV
Energy resolution: 138 eV @ 6 keV
Effective Area: ~1400 cm2 (@1keV)

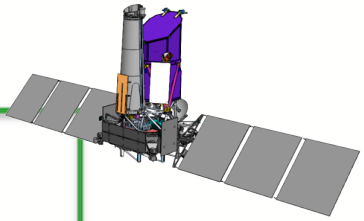
Status



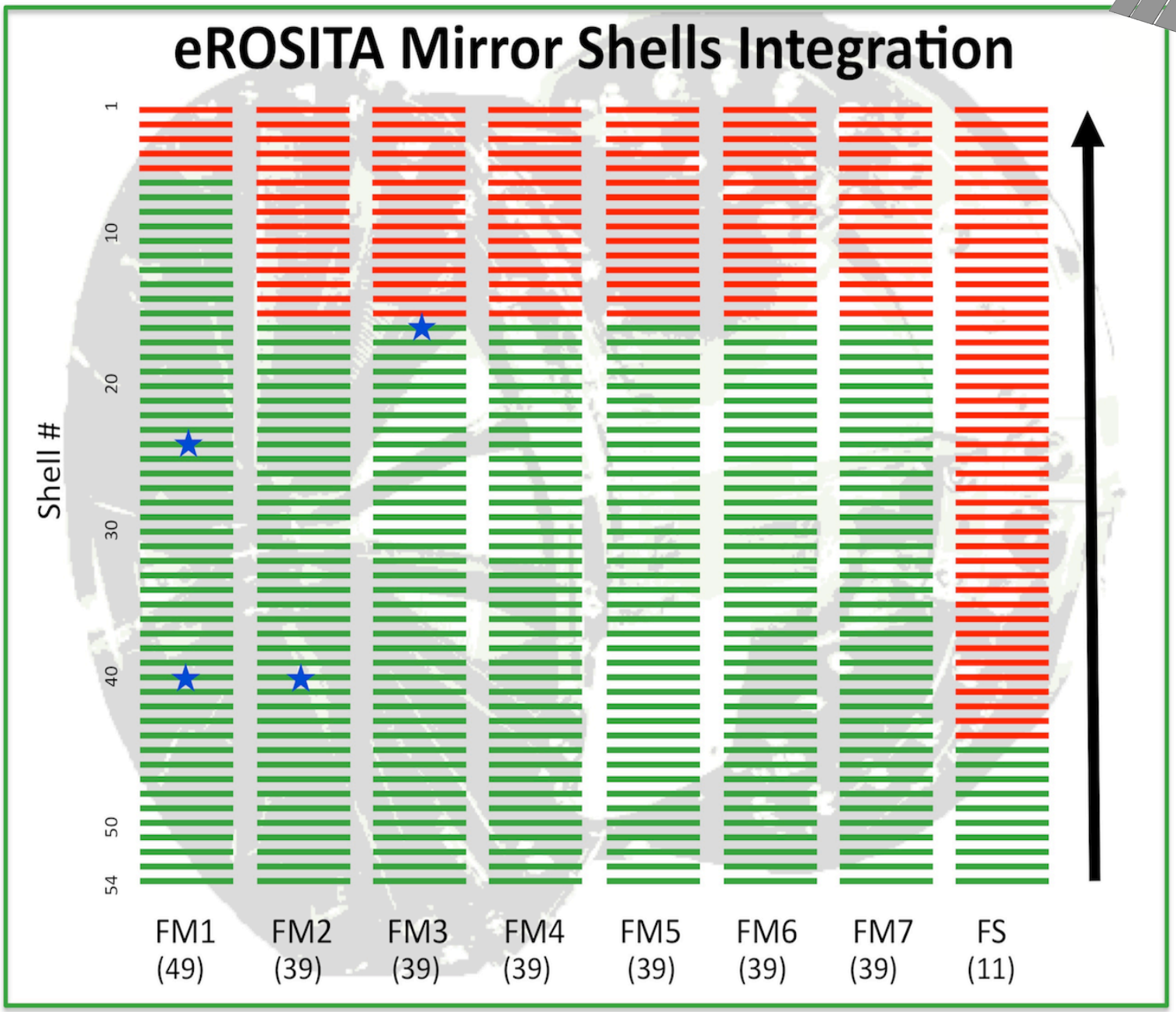
- Telescope Structure: PFM Complete
- Mirrors: Qualified, 68% of all shells integrated, in spec (15“)
- Cameras: Qualified (incl. p-radiation), in spec, CCDs 100%, FM Cooling System: PFM complete
- X-ray Baffles, Electron Deflector, Filterwheels etc: qualified, in manuf.
- FM-Electronics: Behind schedule

Next Steps

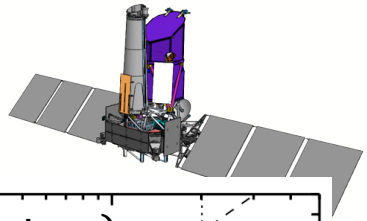
• Qualification Tests of complete instrument	Oct-Dec 2012
• Delivery of a Technological Model to Lavochkin	Oct 2012
• FM-1 Mirror Module complete	Dec 2012
• Electronics, speeding up	Nov 2012
• FM Mirror Modules tests and integration	Jan-Sep 2013
• Delivery to Lavochkin	November 2013
• SRG Launch	Q3 2014

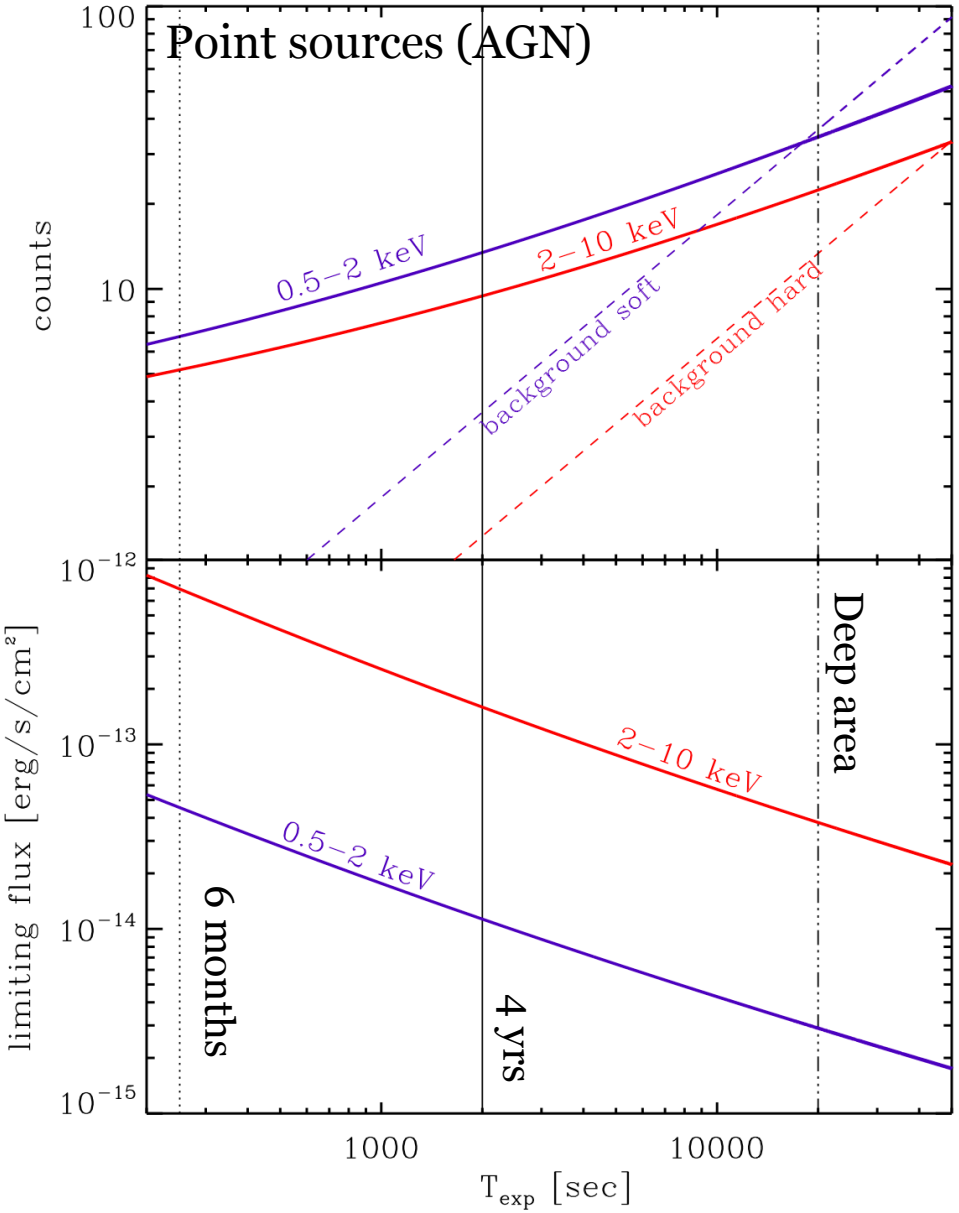


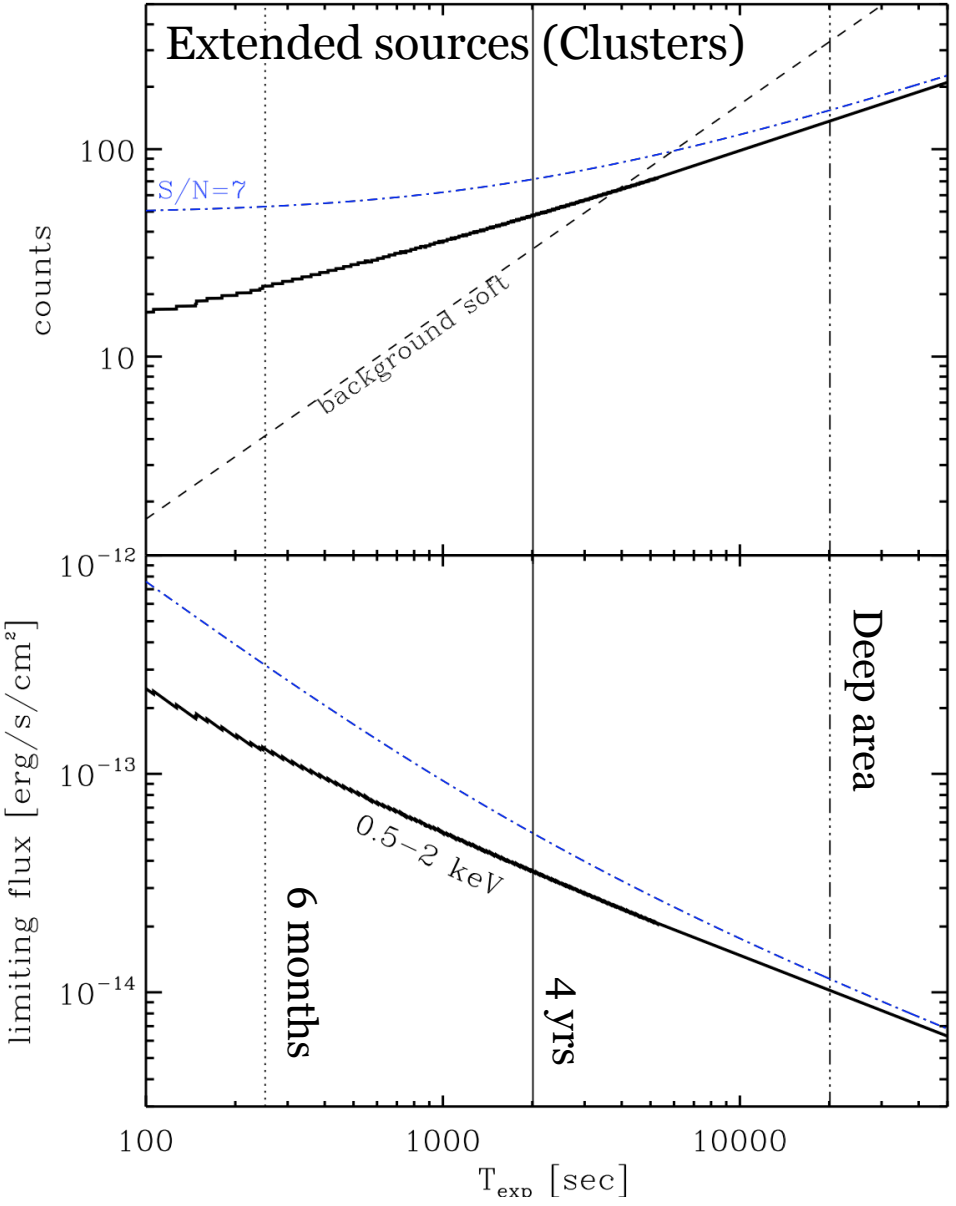
eROSITA Mirror Shells Integration



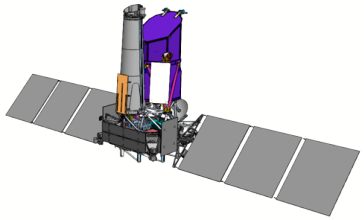
eROSITA sensitivity estimates





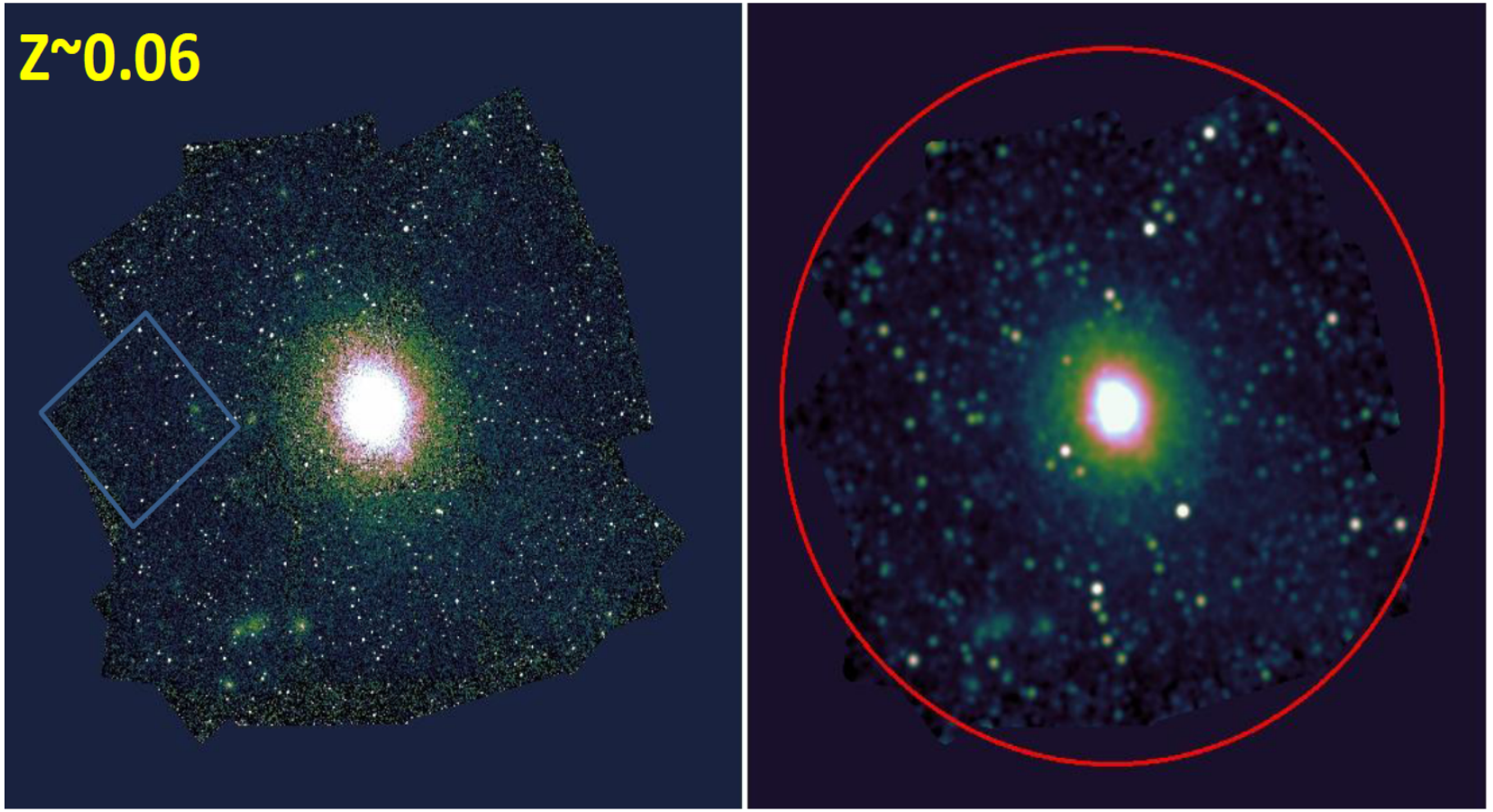


Grasp



Chandra

eRosita

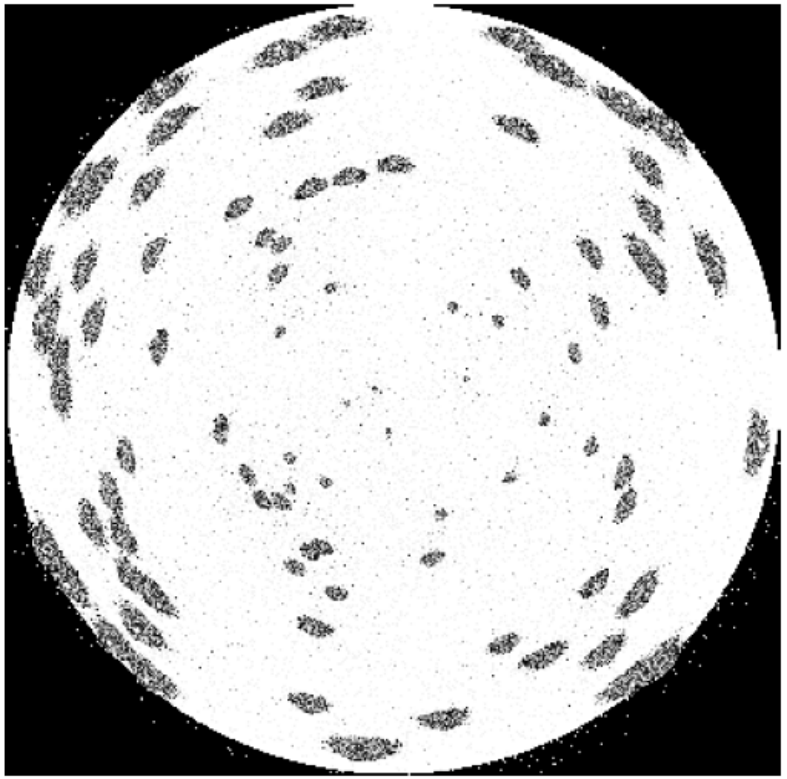


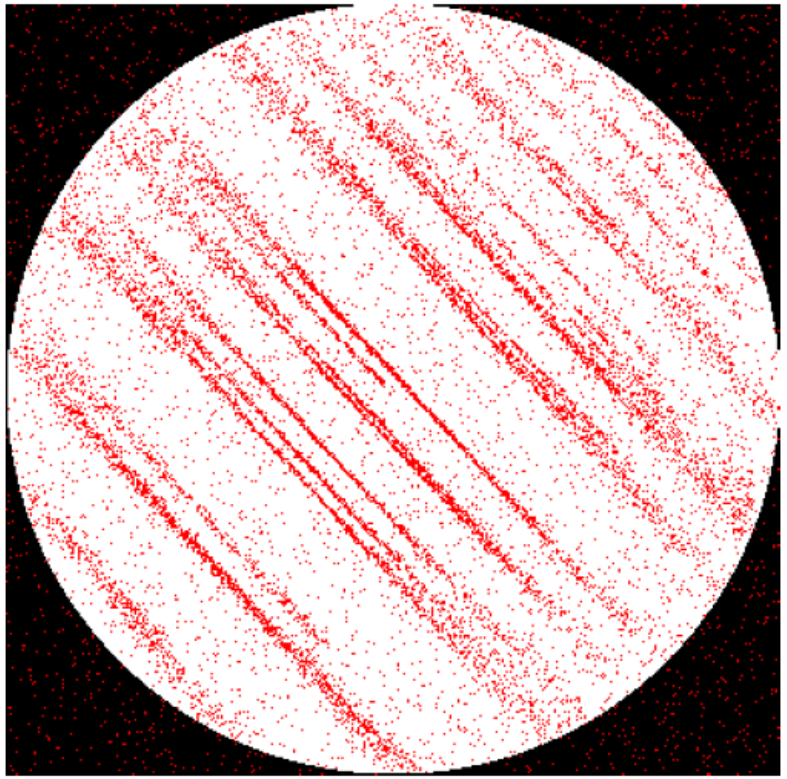
~30 pointings
~2 Msec

~1 pointing, 1.9 Mpc
~80 ksec

Churazov, IKI, MPA

eROSITA PSF

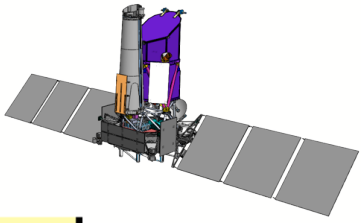




Pointing **Survey**

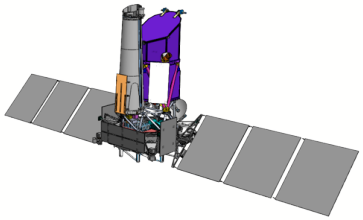
Off-axis blurring of a Wolter-I telescope:
PSF has to be averaged over the FoV
15-17 arcsec on-axis ➔ 28-25 arcsec averaged

Tentative timeline



(1) Survey	(2) f_{lim} (0.5-2 keV) [erg/s/cm^2]	(3) AGN density [deg^{-2}]	(4) $r_{AB,90}$	(5) Catalog ready	(7) Public Release date (TBD)
eRASS:1	4.5×10^{-14}	~14	21	July 2015 (T_0 +10m)	July 2017
eRASS:2	2.8×10^{-14}	~30	21.6	January 2016 (T_0 +16m)	July 2018
eRASS:3	2.1×10^{-14}	~45	21.9	July 2016 (T_0 + 22m)	
eRASS:4	1.8×10^{-14}	~60	22.1	January 2017 (T_0 + 28m)	July 2019
eRASS:8	1.1×10^{-14}	~90	22.6	January 2019 (T_0+52)	Jan 2021

Data Rights and Policies



- German eROSITA data made public after 2 yr proprietary period
- Periodic data releases envisaged (e.g. 6, 18, 30, 48 months)
- Proprietary data via German eROSITA Consortium
- Projects/Papers regulated by Working Groups
- Individual External Collaborations
- Group External Collaborations (negotiations/discussions underway with DES, CAASTRO, HSC)

Science Working Groups:
Clusters and Cosmology

AGN, Blazars

Normal Galaxies

Compact objects

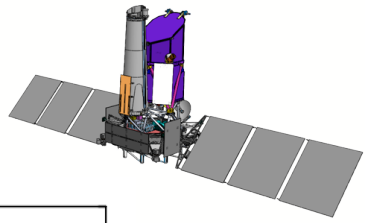
Diffuse emission, SNR

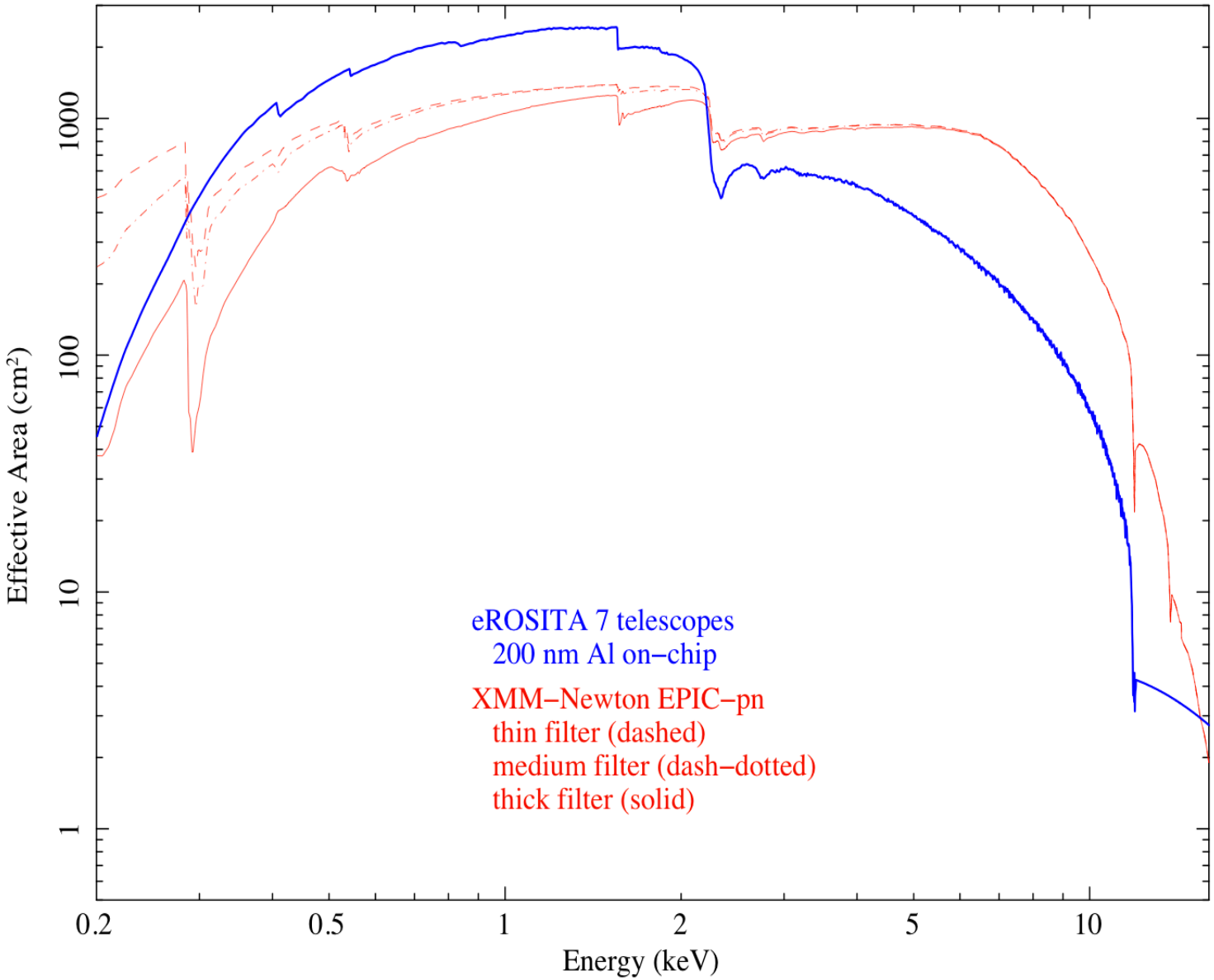
Stars, Solar System

Infrastructure Working Groups:
Time Domain Astrophysics
Data analysis, source extraction, catalogs
Multi-wavelength follow-up
Calibration

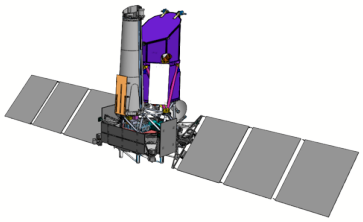
Background

Effective area vs. XMM

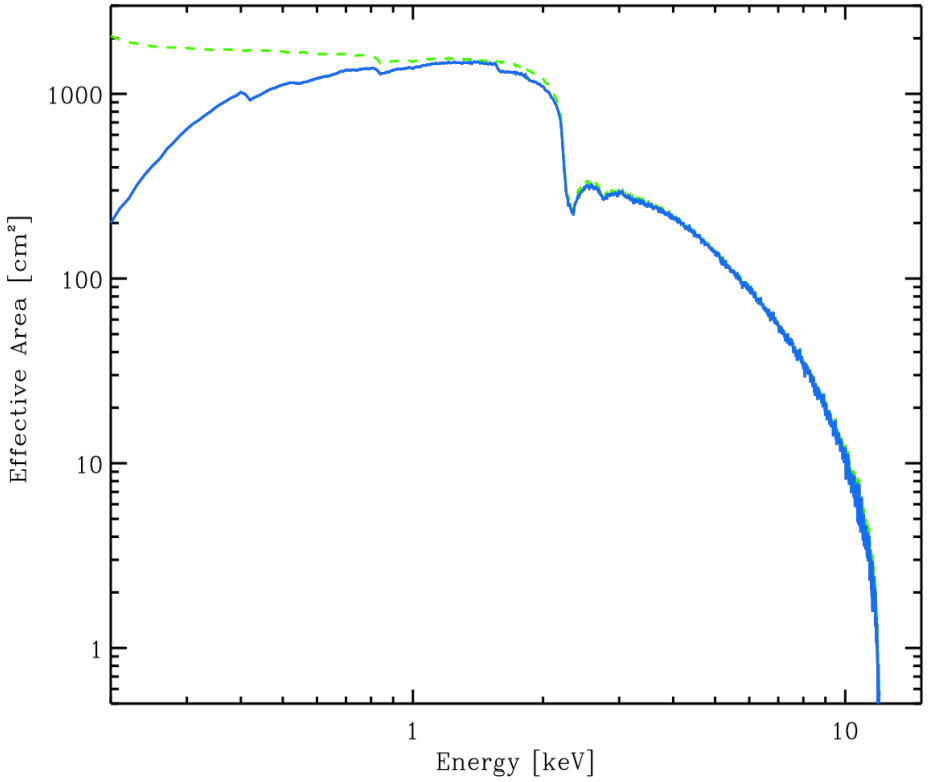




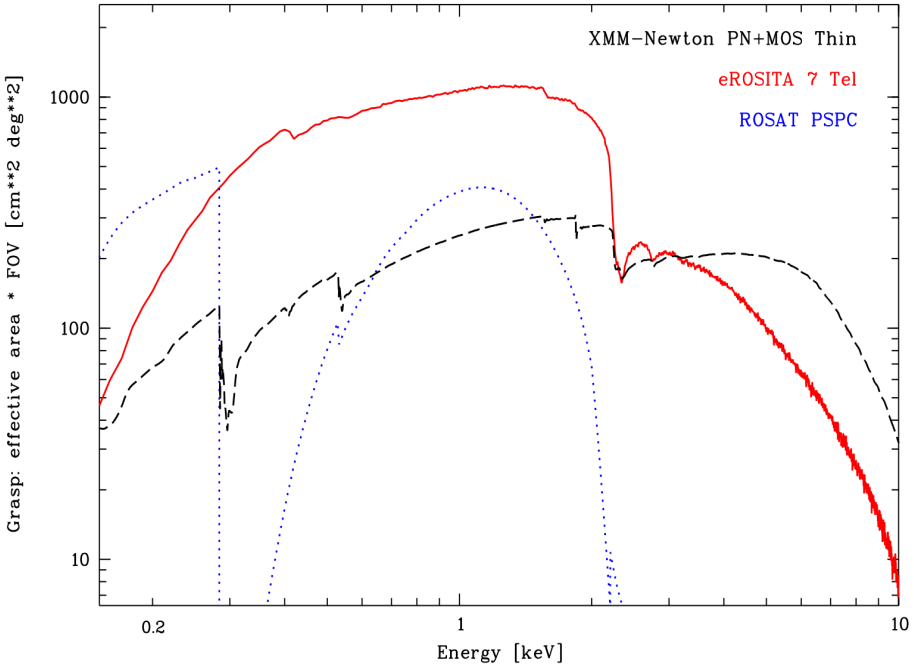
Effective area and grasp



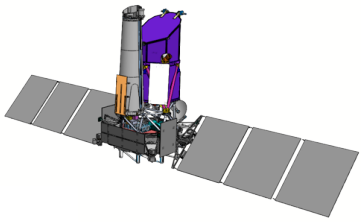
FoV average Effective Area

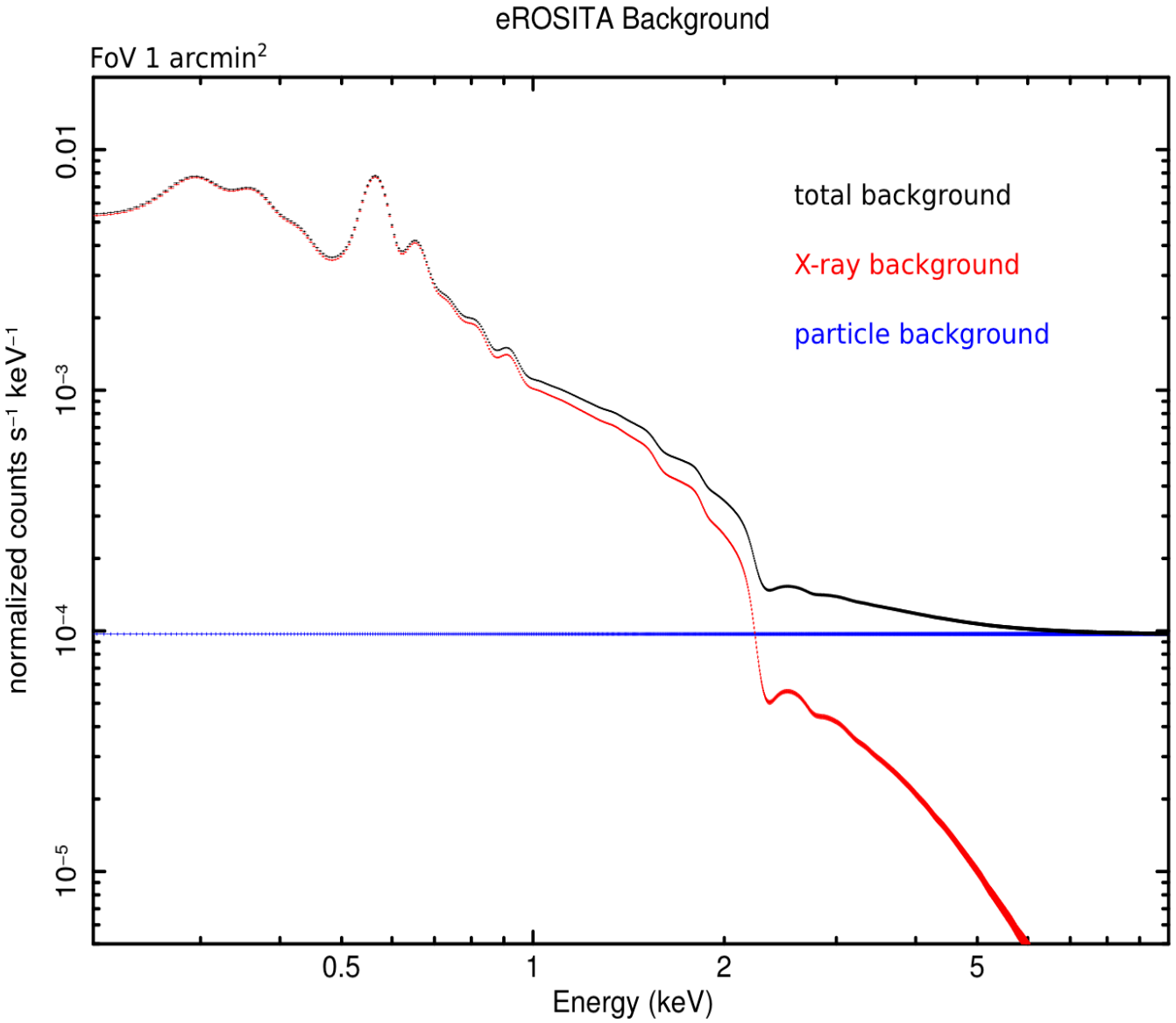


Grasp

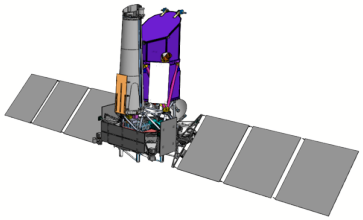


Background



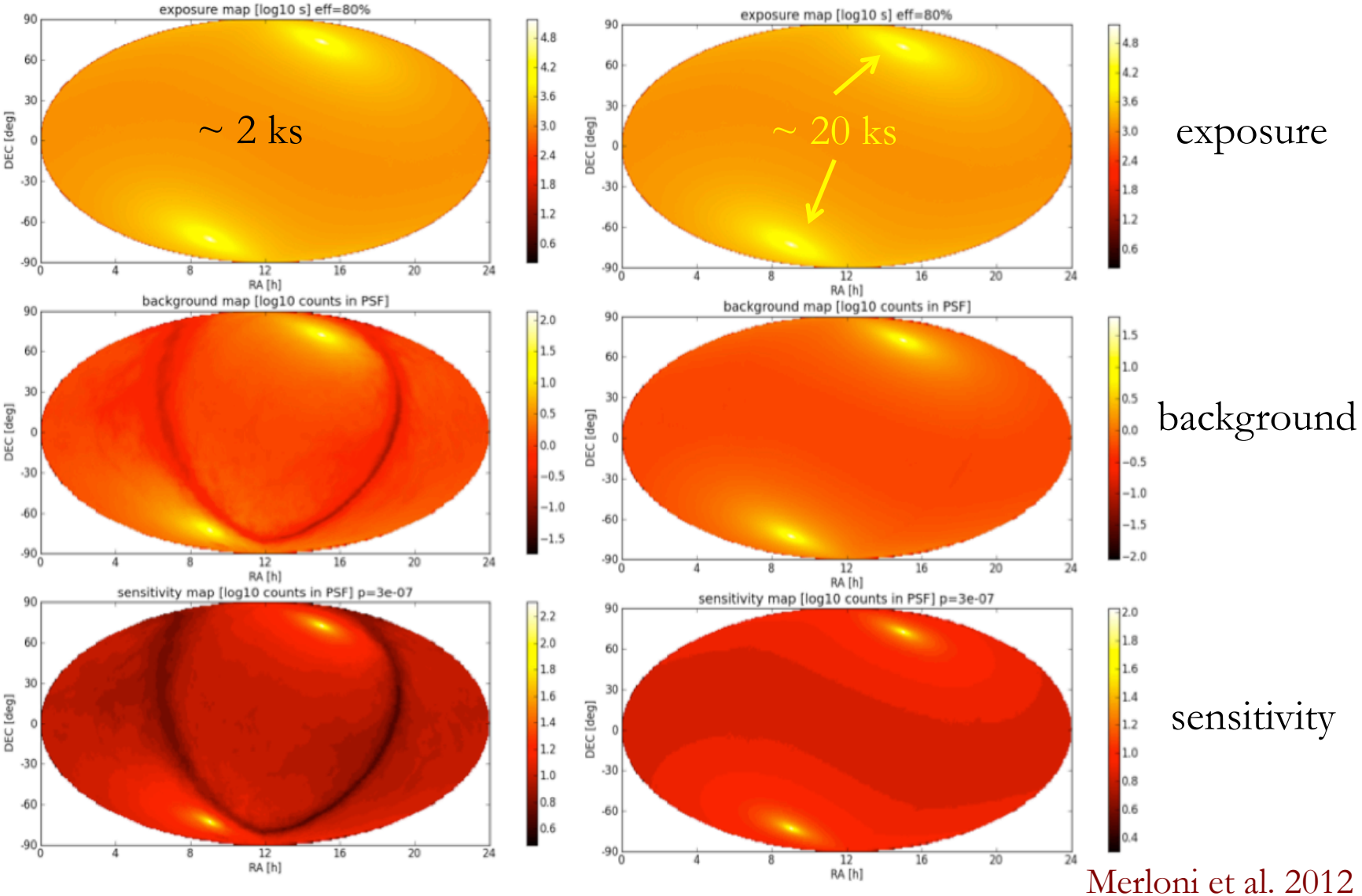

eROSITA Background
FoV 1 arcmin^2
total background
X-ray background
particle background
normalized counts s^{-1} keV^{-1}
0.01
10^{-3}
10^{-4}
10^{-5}
0.5
1
2
5
Energy (keV)

The eROSITA All-Sky Survey



Soft Band

Hard Band



exposure

background

sensitivity

Merloni et al. 2012