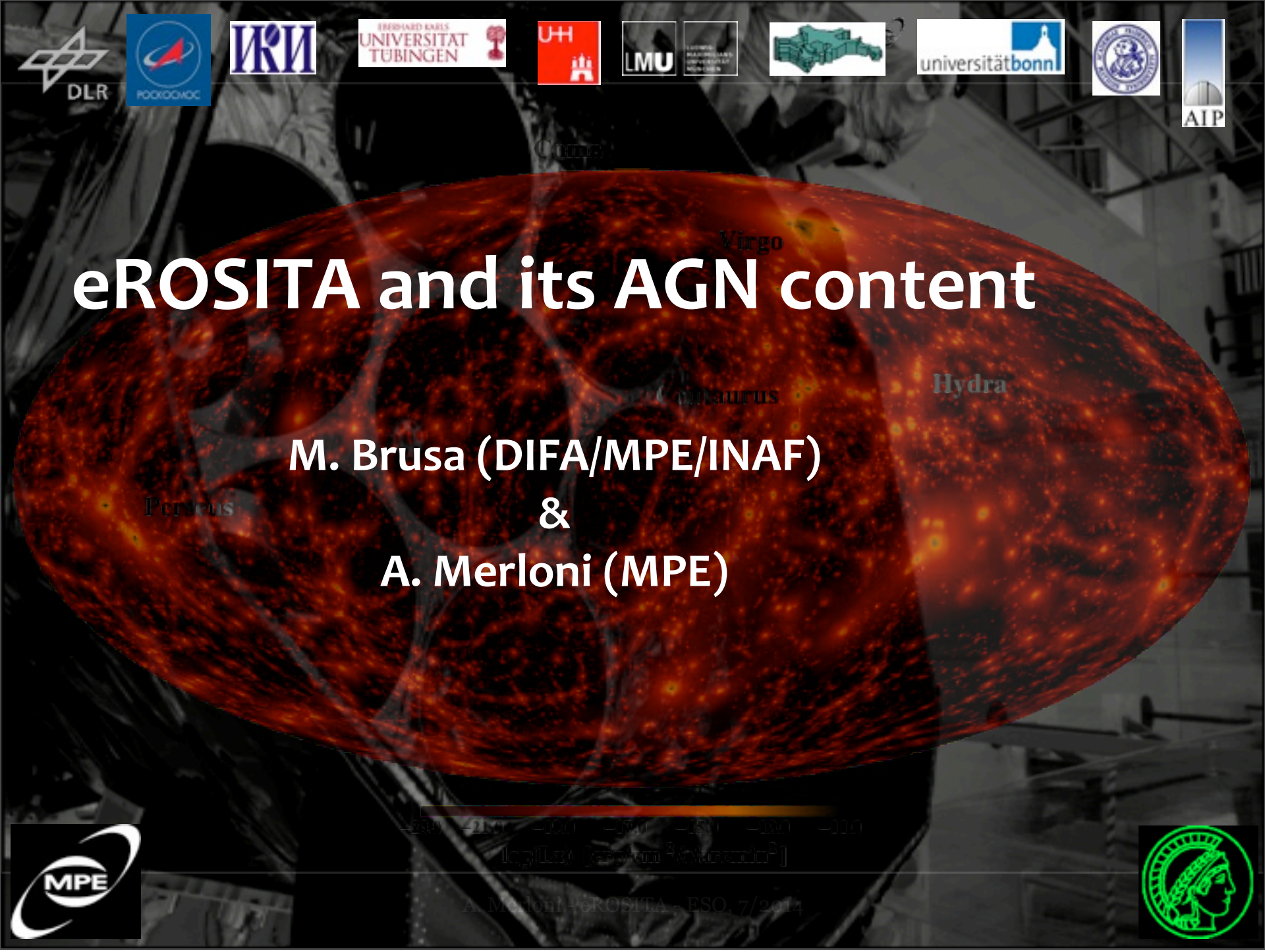

eROSITA and its AGN content

M. Brusa (DIFA/MPE/INAF)
&
A. Merloni (MPE)

eROSITA and its AGN content

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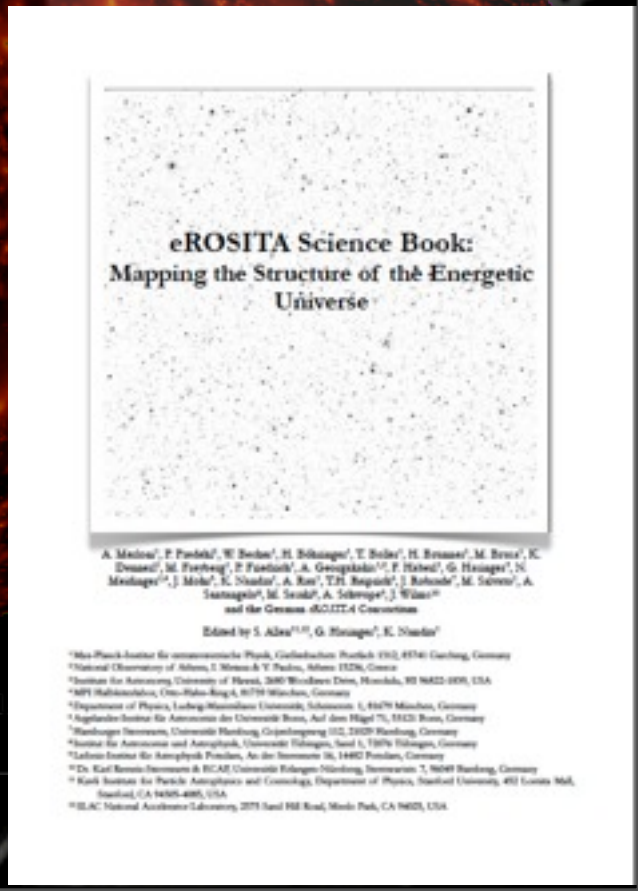


material from eROSITA Science Book
(Merloni et al 2012, arXiv:1209.3114)

eROSITA

eROSITA is a powerful X-ray telescope

(Next) (European) X-ray mission flying in 1.5 years (for 7.5 years)

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:

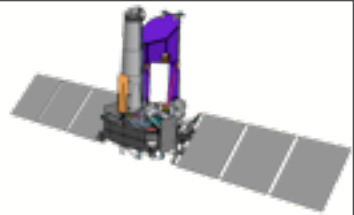
Media Lario/I	Mirrors, Mandrels
Kayser-Threde/D	Mirror Structures
Carl Zeiss/D	ABRIXAS-Mandrels
Invent/D	Telescope Structure
pnSensor/D	CCDs
IberEspacio/E	Heatpipes
RUAG/A	Mechanisms
HPS/D,P	MLI

+ many small companies

MPE: Scientific Lead Institute, Project Managment

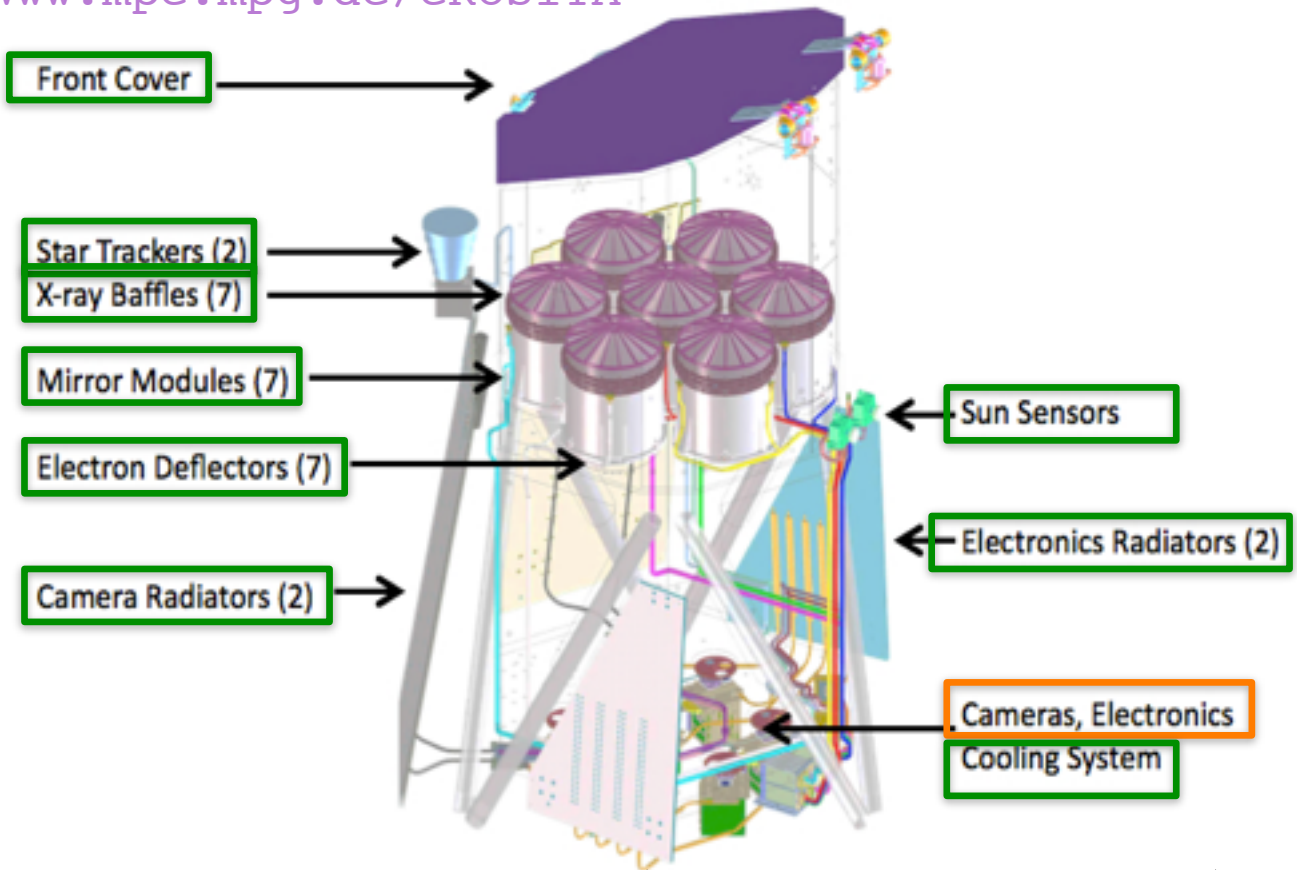
Instrument Design, Manufacturing, Integration & Test
Data Handling & Processing, Archive etc.

The eROSITA telescope



Telescope structure

www.mpe.mpg.de/eROSITA



Focal length 1.6 m

F.o.V. = 0.81 sqdeg

54 nested mirror shells

Total weight ~800 kg

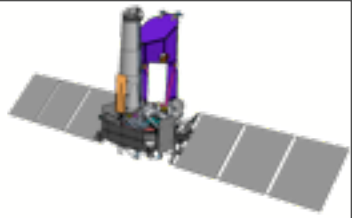
7 identical telescopes (Wolter-I/ pnCCD-cameras)

Energy range: 0.3-8 keV, PSF~15-30”

Effective Area: ~1400 cm2 (@1keV)

Energy resolution: 138 eV @ 6 keV

The eROSITA telescope



Telescope structure

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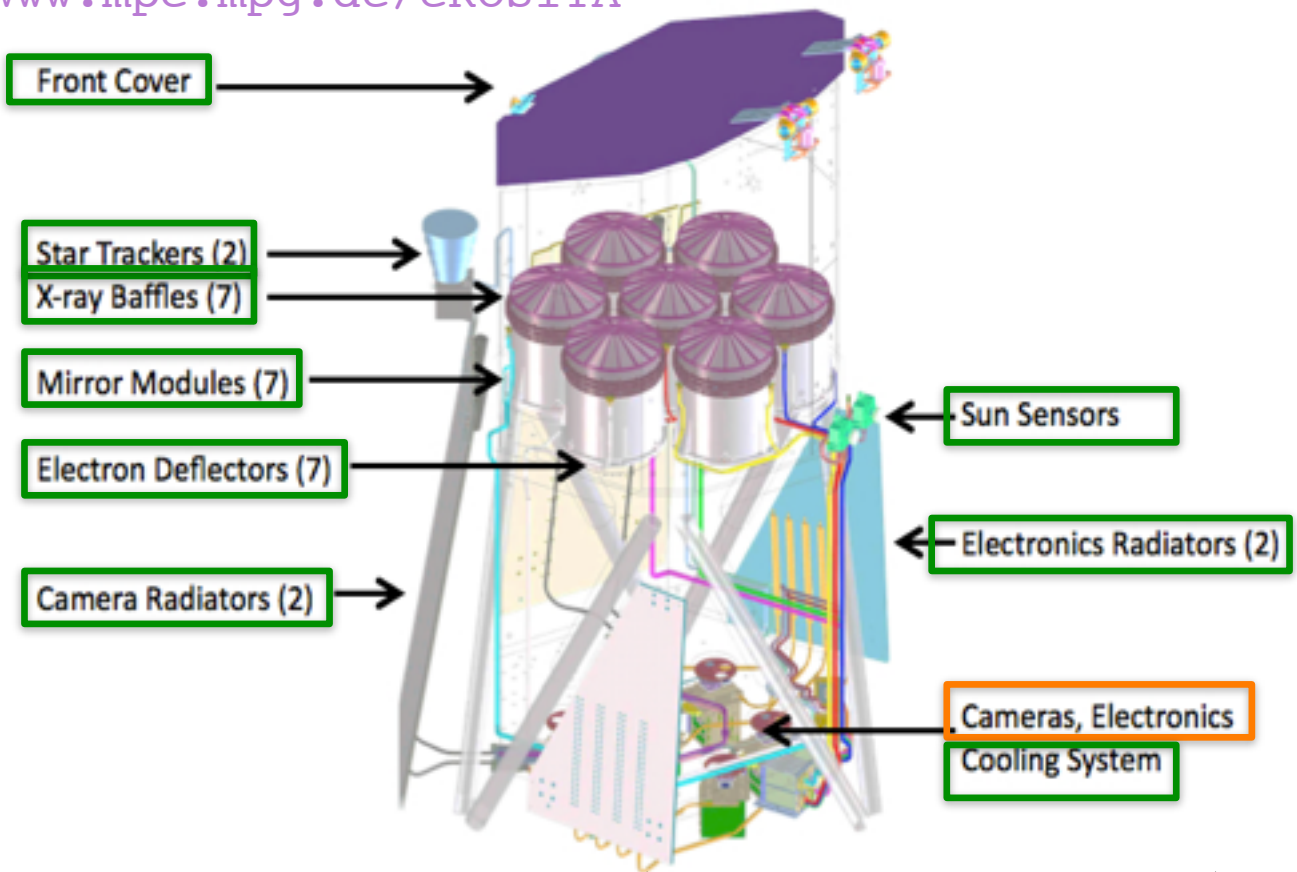

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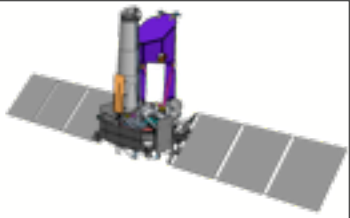
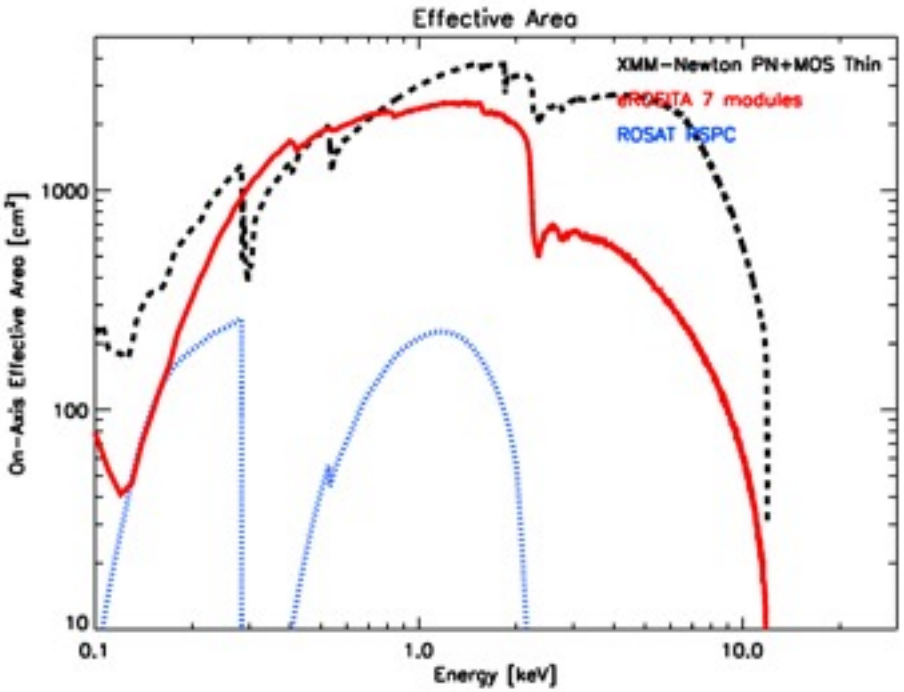
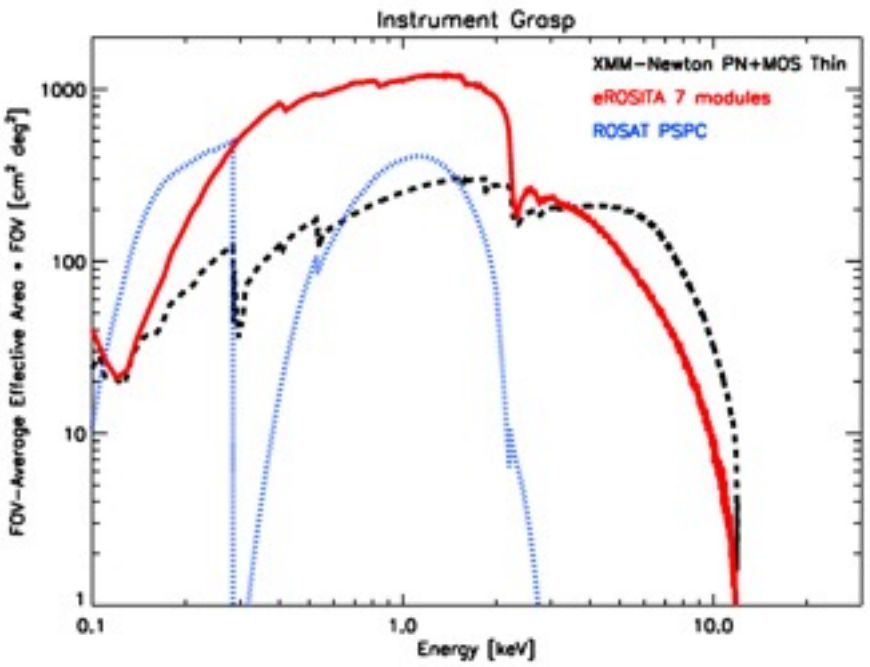
Effective Area and Grasp



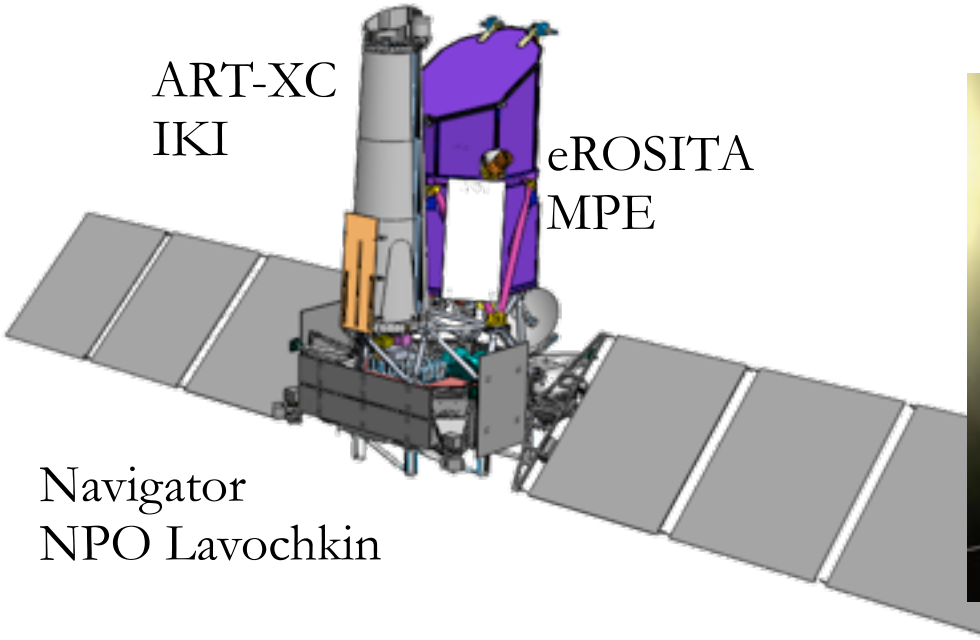


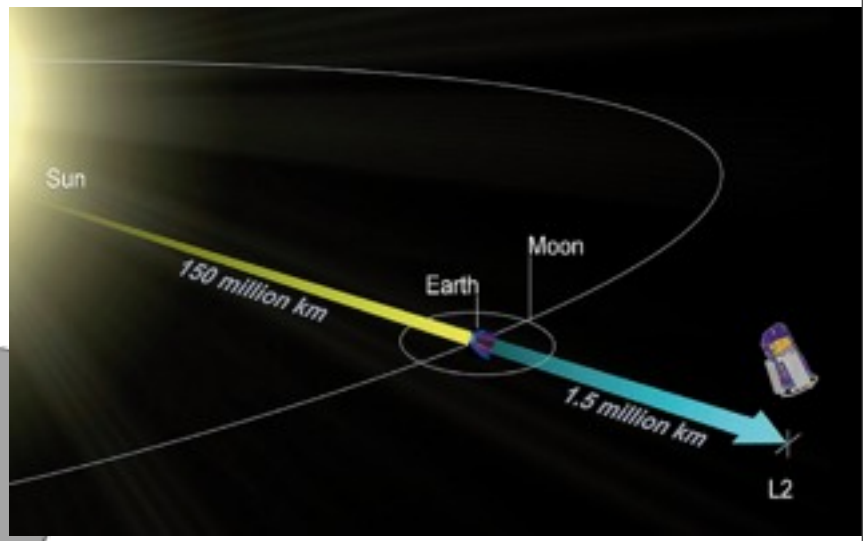


- Effective area at 1keV comparable with XMM/Newton
- Factor ~7-8 larger surveying speed --> **fast survey machine**

(complementary to ATHENA: much larger area, smaller FoV)

Spektrum Röntgen Gamma (SRG)





- **eROSITA delivery to Russia**: June 2015
- **Launch:** March 26, 2016 from Baykonour (Zenit+Fregat)
- **3 Months:** flight to L2, verification and calibration phase
- **first 4 years**: all sky survey
- **then 3.5 years**: pointed observation phase, including ~20% GTO. (1 AO per year)
- **Proprietary data** rights s**hared 50/50** between MPE (Germany) and IKI (Russia)

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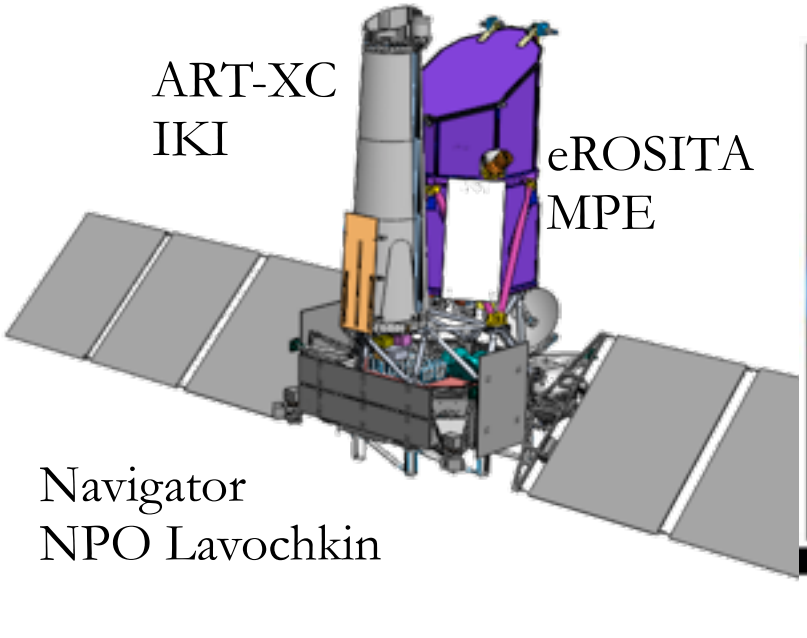

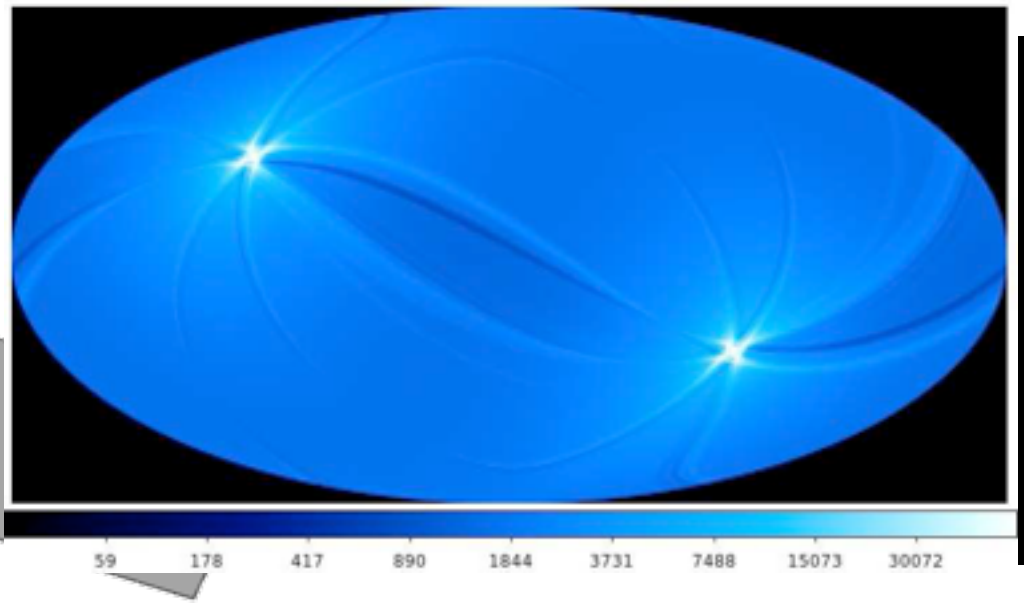

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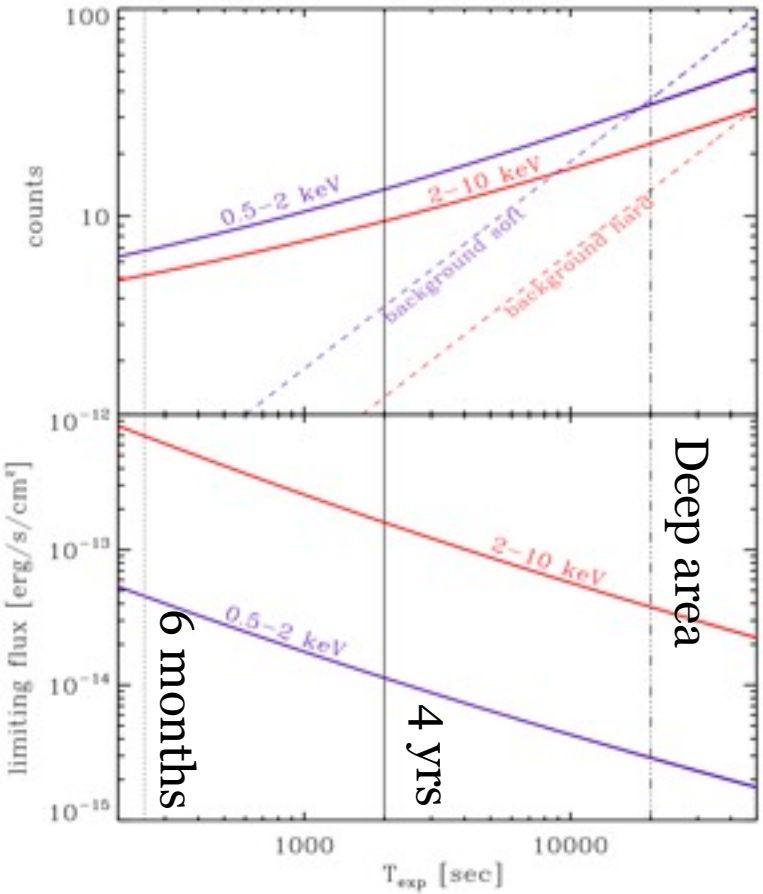
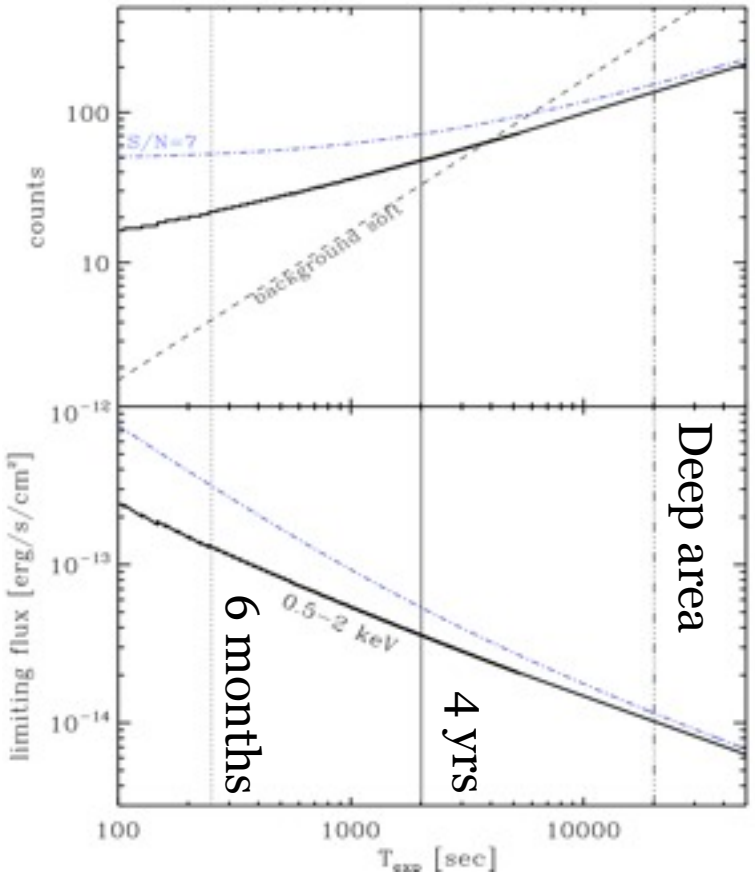
eROSITA sensitivity estimates

- 4 years dedicated to all sky survey
- 8 all sky passes (eRASS1:8), every six months

Point sources (AGN)

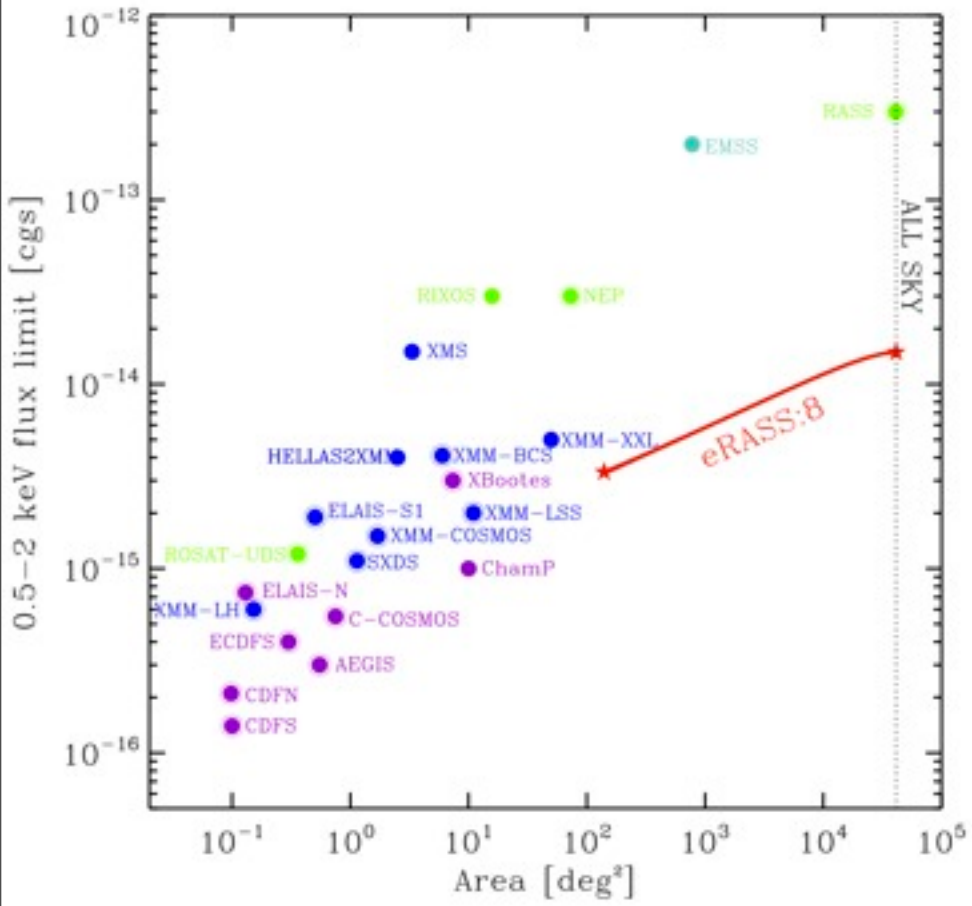


Extended sources (Clusters)



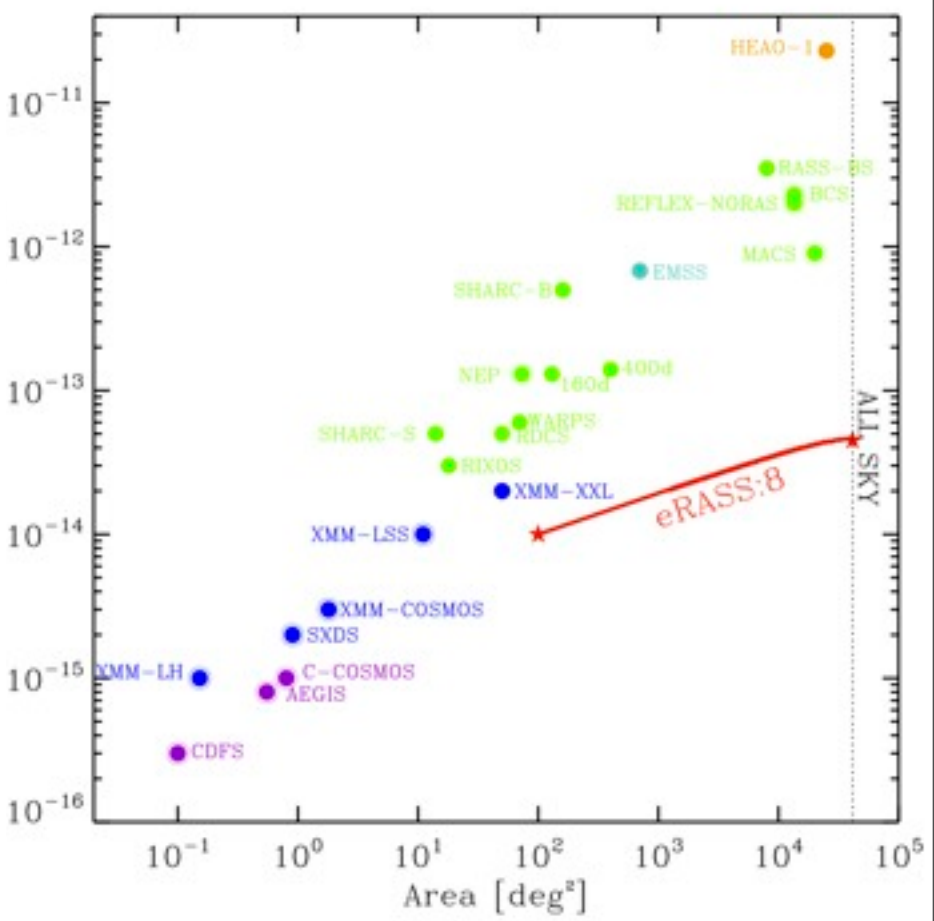
eROSITA surveys in context

Point sources sensitivity



All sky: 1.4×10^{-14} (0.5-2 keV)
2.0×10^{-13} (2-10 keV) [erg/cm²/s]

Extended sources sensitivity



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Merloni et al. 2012

eROSITA surveys in context

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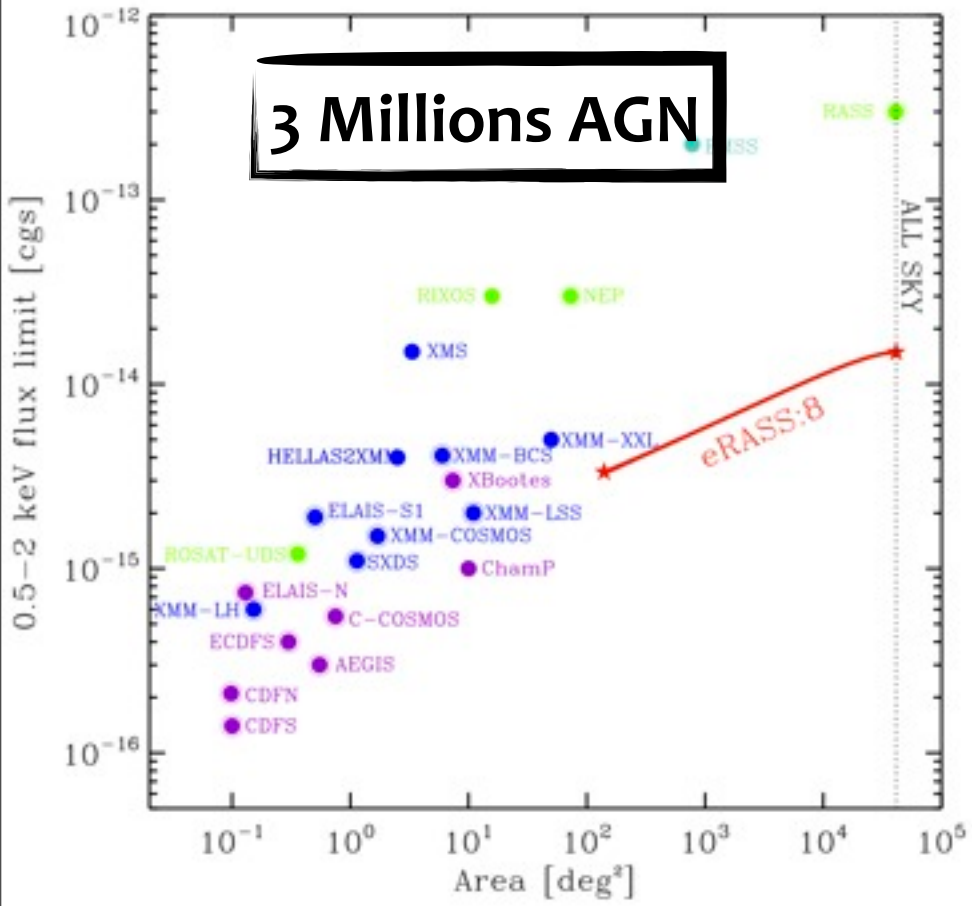

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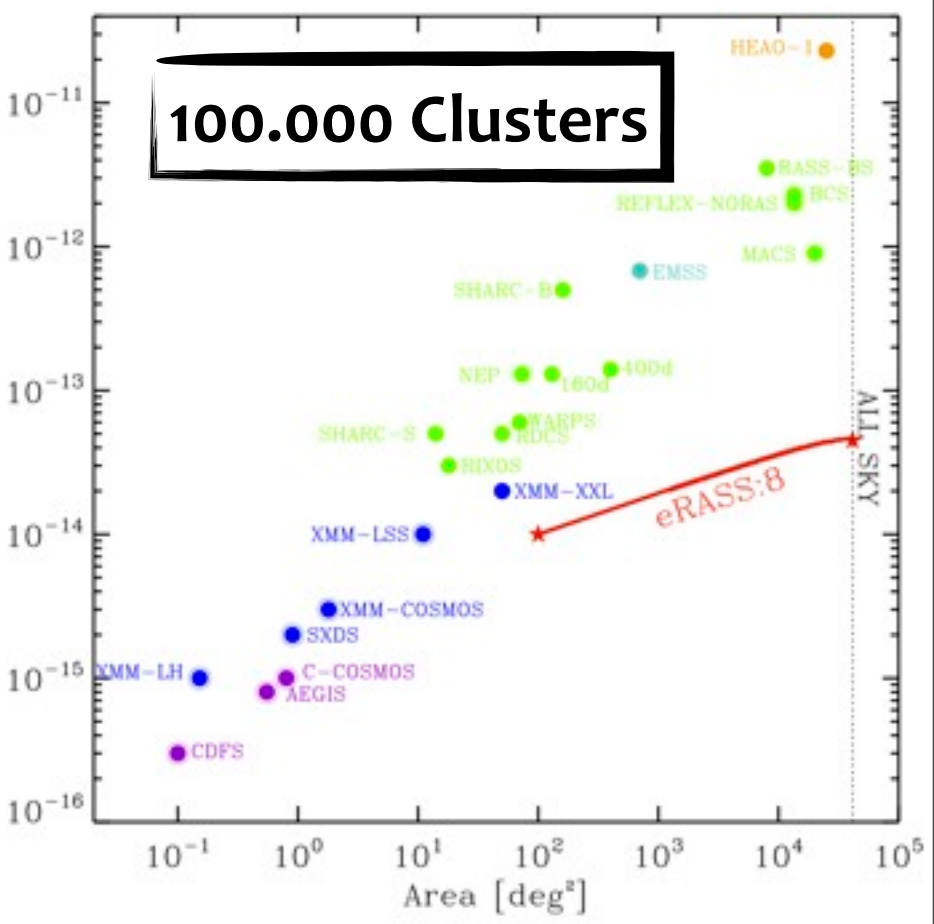

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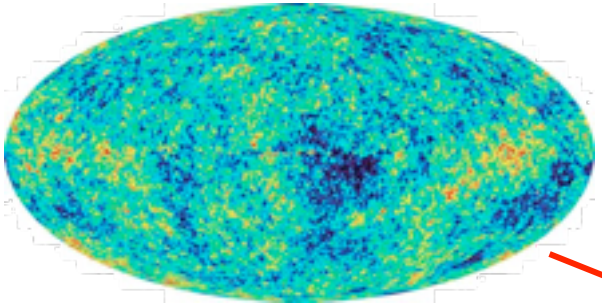
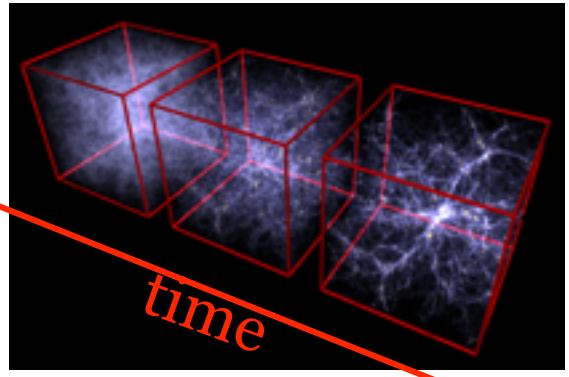
Merloni et al. 2012

Main science driver: Cluster Cosmology and LSS

WMAP, z = 1100



Millennium Simulation



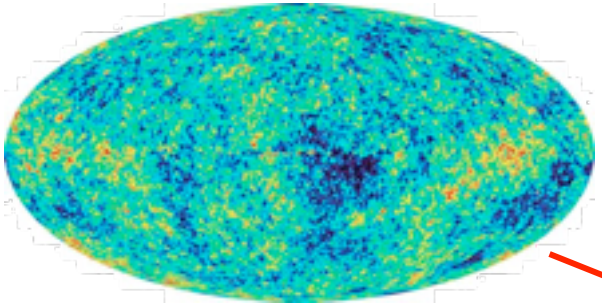
ROSAT, z < 0.1

- Clusters of galaxies are the largest gravitational bound structures
- They are exponentially 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.
- eROSITA Designed to **detect ALL clusters more massive than ~3x10^{14} M$_{\odot}$**

--> "Mapping the Structure of the energetic Universe"

Main science driver: Cluster Cosmology and LSS

WMAP, z = 1100



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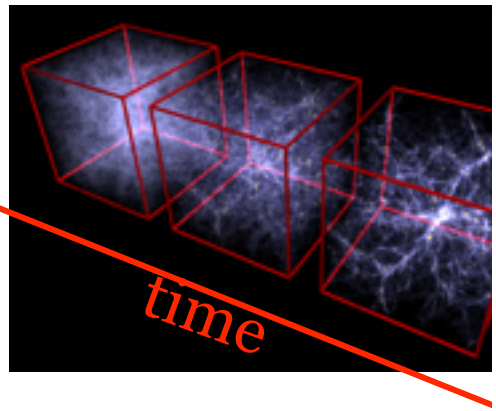

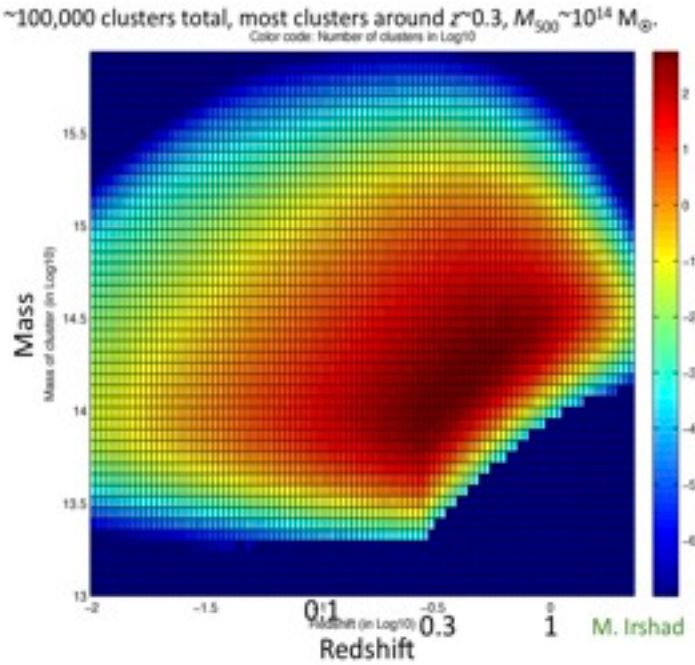

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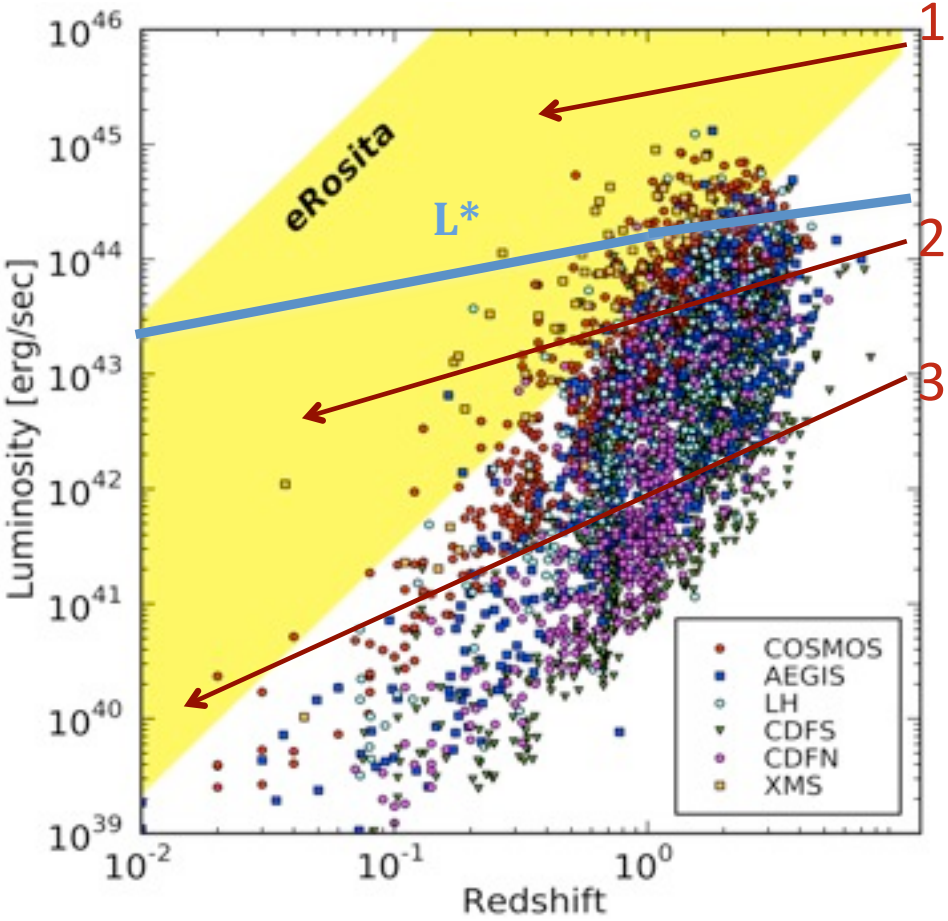
--> "Mapping the Structure of the energetic Universe"

And More…

- Provide a detailed view of the **compact objects** (NS, BH) population of the Milky Way
- Survey of **700k active (young, magnetic) stars**
- Map the **diffuse X-ray emission** and the **hot ISM** in the Milky Way and in the Solar neighborhood
- Study **nearby star-forming galaxies** and galaxy groups
- Provide a dynamical view of the X-ray sky and identify **transients and variable sources**
- Serendipity…

A legacy sample of 3M AGN

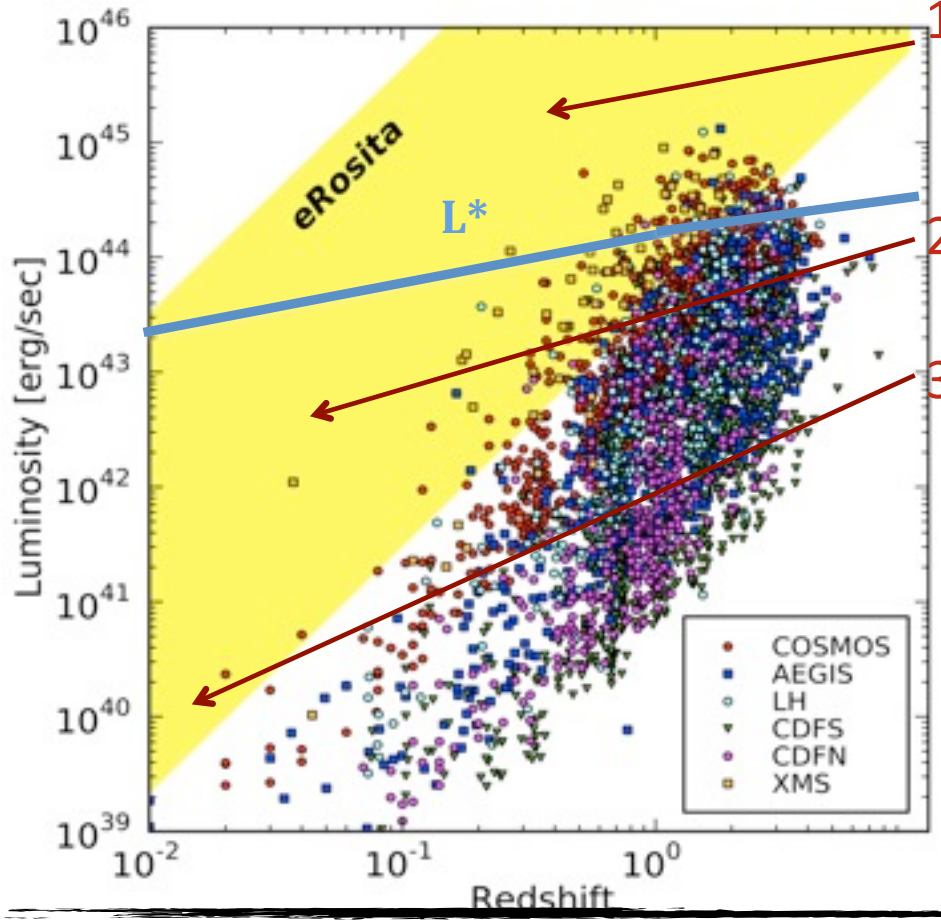


1. The most luminous AGN, tracers of large scale structure: the “quasar” mode of AGN feedback
2. Nearby LLAGN: the “kinetic (radio)” mode of AGN feedback
3. “Quiescent” Black holes revealed by tidal disruption of nearby stars

Physics and Cosmology

Clustering

A legacy sample of 3M AGN



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Physics and Cosmology

Clustering

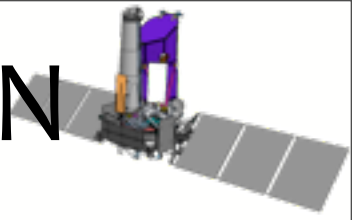
HARD BAND

~100.000 AGN and QSOs selected in the **2-10 keV** band down to ~2×10^{-13} cgs

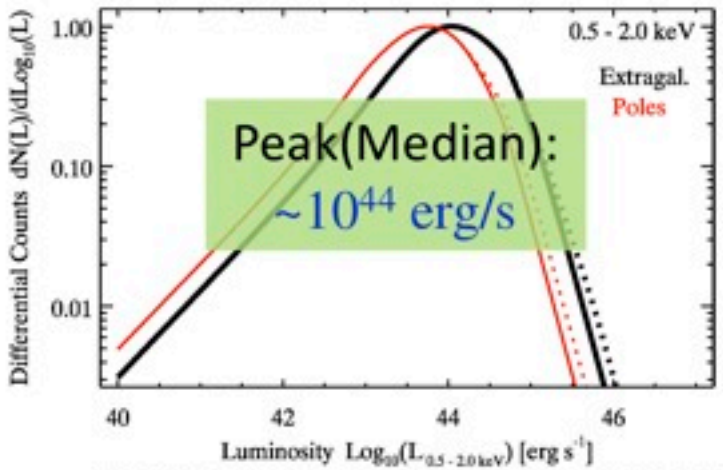
[previous hard band all sky survey down to ~2×10^{-11} cgs: HEAO-1 (AGN sample: few dozens)]

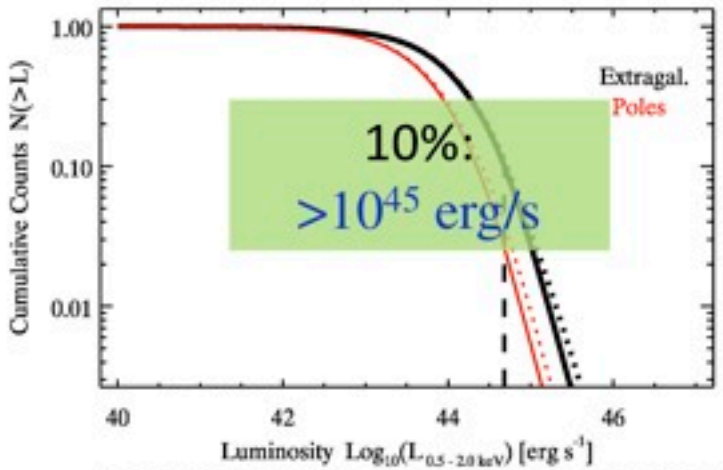
REAL NOVELTY WITH RESPECT TO ROSAT

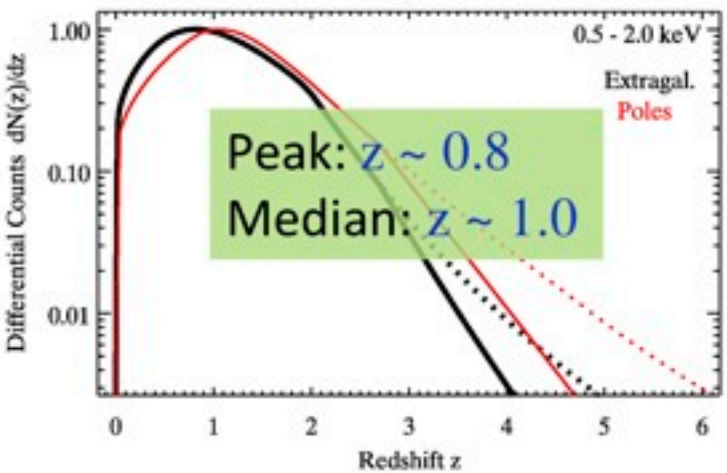
A legacy sample of 3M AGN

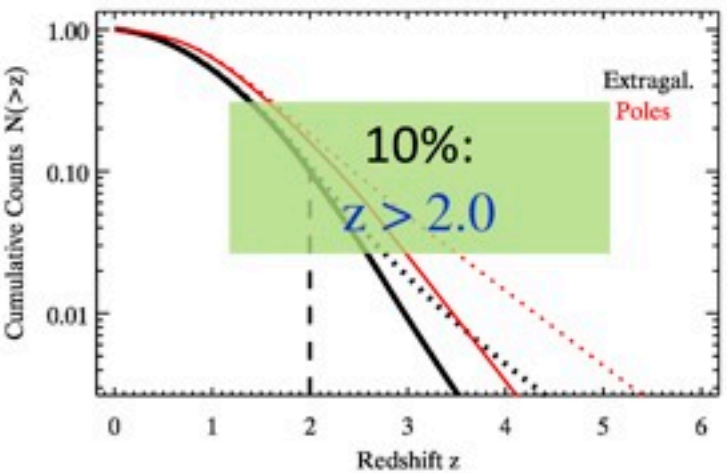


Kolodzig et al. 2013









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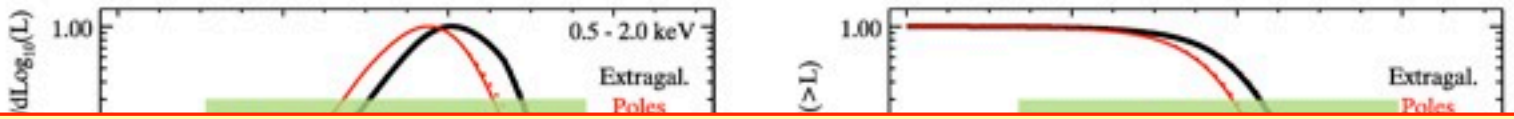
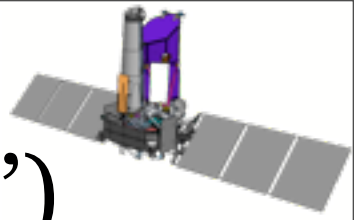


eROSITA will cover uniformly the redshift range $0<z<3$
Large samples needed to study AGN at different **L, z, N_H, (M_*, SFR)**

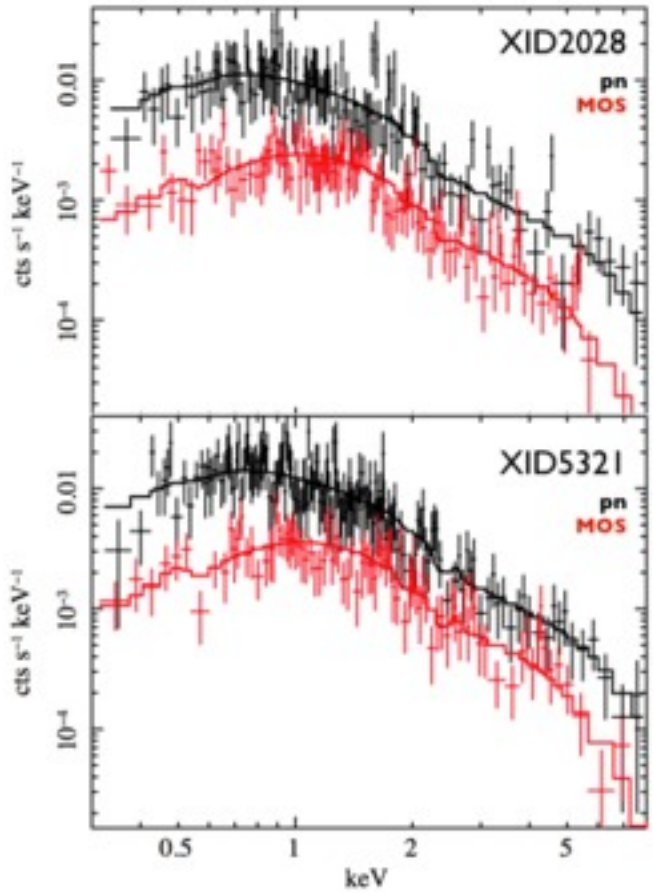
--> eROSITA will be unique for the detection and characterization of the most luminous (and rare) AGN populations in terms of AREA

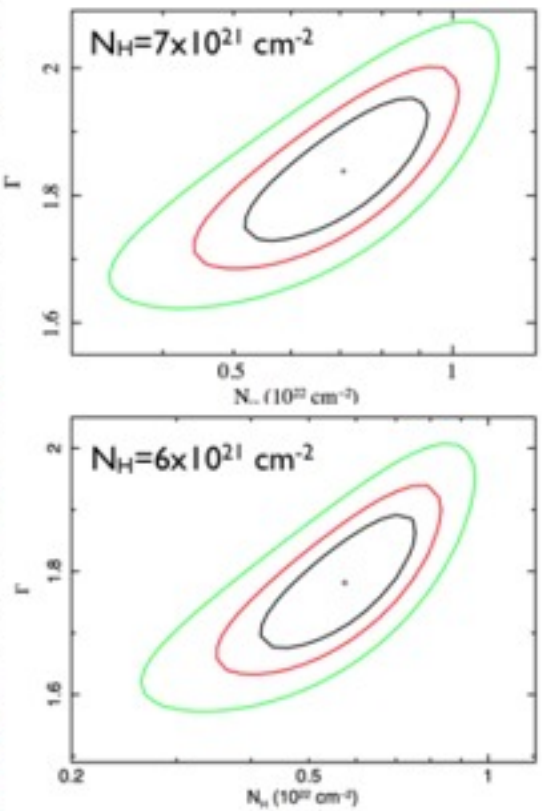
see Section 5.2 in the "eROSITA Science Book"
(high-z QSOs, high L/Ledd sources, luminous obscured QSOs)

QSO in feedback phase ("where BHs and galaxies meet")



Objects in the "outflow" phase are RARE (see talks by Cresci, Perna, Piconcelli)
only moderately absorbed, logNH~21-22
Perna et al. 2014, submitted (see also Banerji et al. 2014)





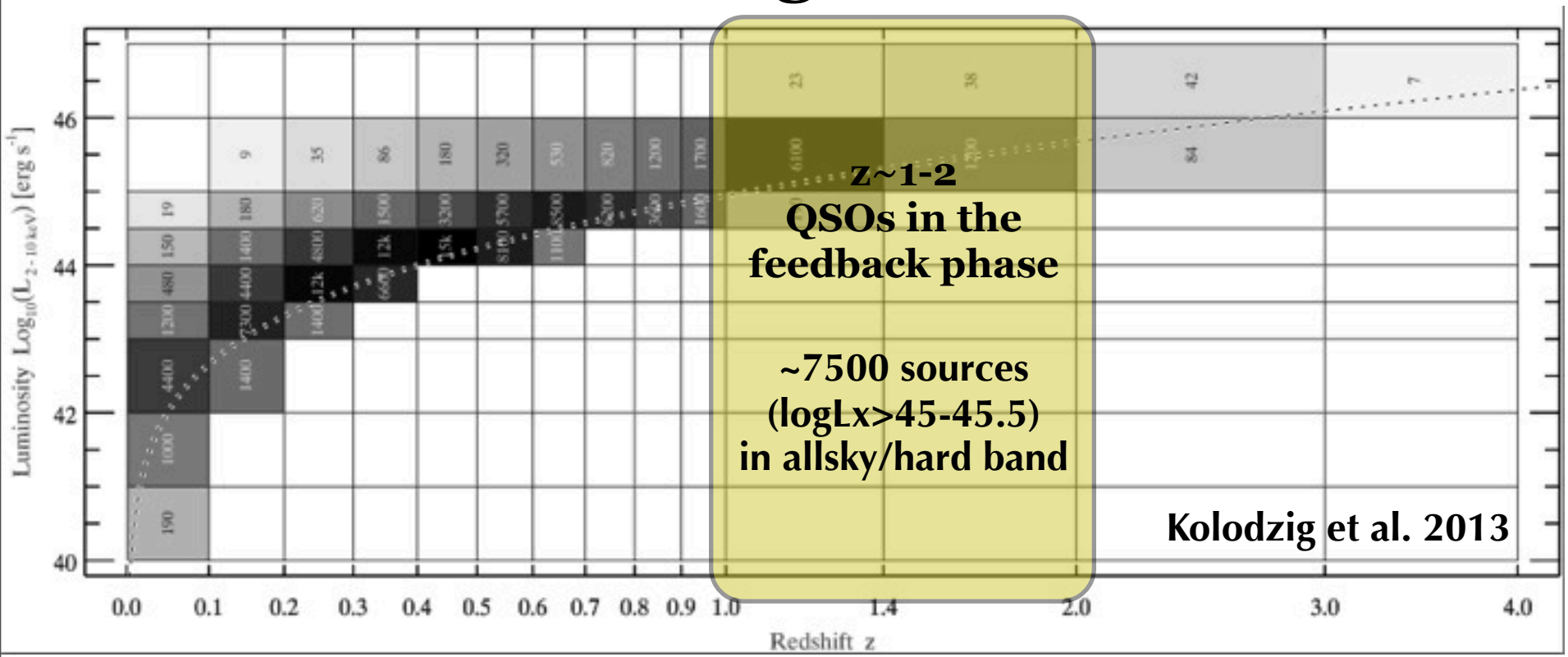
0.5-2 keV

flux~3.3e-14 cgs

flux~6.2e-14 cgs

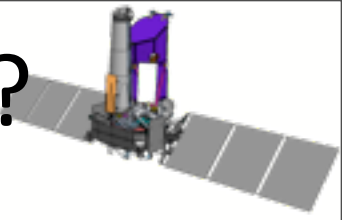
well above eRASS:8 (and also eRASS:2!) limiting fluxes

QSO in feedback phase ("where BHs and galaxies meet")

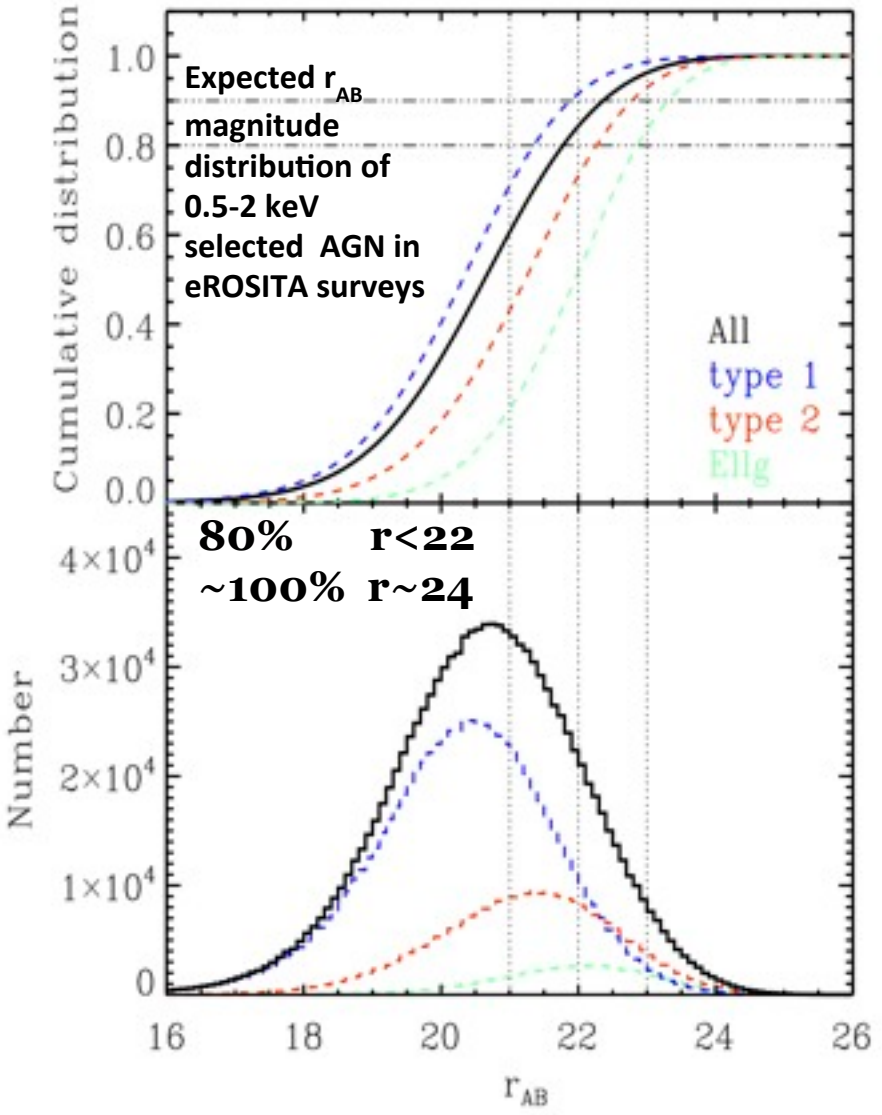


Synergies with XMM/Chandra folllow-up (still operating in few years)
complementary to WISE selection (unbiased wrt accretion)
ALMA/NOEMA best targets
unique targets for Athena XIFU!(e.g. Georgakakis+2013 simulations of z~2 outflows)

AGN: Can we follow them up?



CALIBRATED ON XMM-COSMOS



- **IDENTIFICATION COUNTERPARTS:**

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

•test on ROSAT and XMM with Bayesian statistics using more than 1 catalog and priors (Salvato et al, in prep.) ~90% at r<23

Merloni et al. 2012

The landscape of O/IR wide area surveys

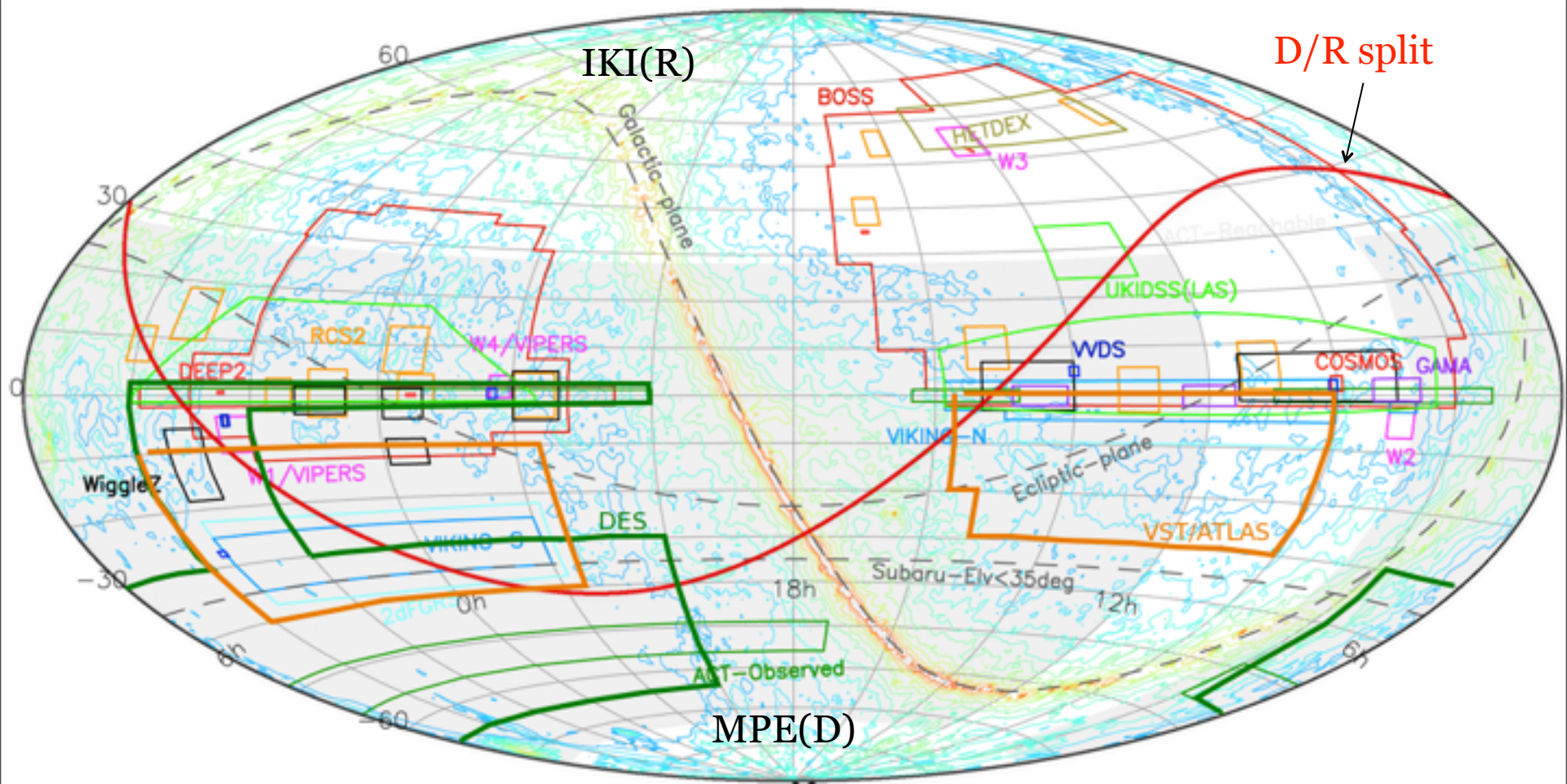
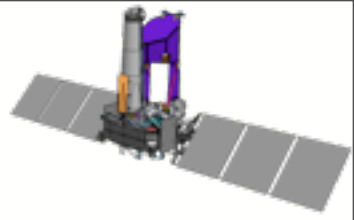


Image A. Nishizawa (IPMU), AM

Synergies over large areas (>1000 sq. degs)



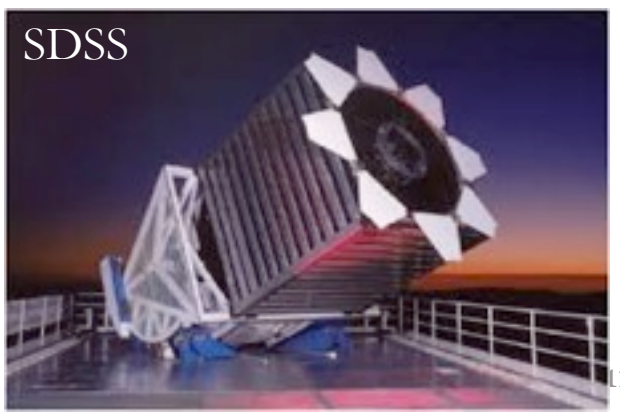
Survey	Lat	Date	Ω	u	g	r	i	z	Y	J	H	K
SDSS	+30	-'10	10000	21.6	22.6	22.4	21.6	20.1	-	-	-	-
PS1	+20	'10-'12	30000	-	22.6	22.4	22.1	21.1	-	-	-	-
SkyMapper	-30	'14-	30000	22.5	22.5	22	20.9	20.6	-	-	-	-
KIDS+VIKING	-20	'11-	1500	24.8	25.4	25.2	24.2	22.4	21.6	21.2	20.7	20.5
DES+VHS	-30	'12-'16	5000	-	24.6	24.1	24.3	23.8	21.5	20.5	20.1	19.5
ATLAS+VHS	-20	'11-	4500	22.0	22.2	22.2	21.3	23.8	21.5	20.2	19.9	19.3
HSC	+20	'14-'18	1500	-	25.5	25.2	25.5	24.3	23.3	-	-	-
DECcam Legacy	-30	'14-'18	6000	-	24	23.6	-	23	-	-	-	-
GAIA	-	'13-	41253			20						
J-PAS	+40	'15-'20	8500	22.7	23.2	23.5						
Euclid	-	20-'25	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	-	-	-

eROSITA "monsters" at z~1-2 will have spectra and imaging from Euclid!

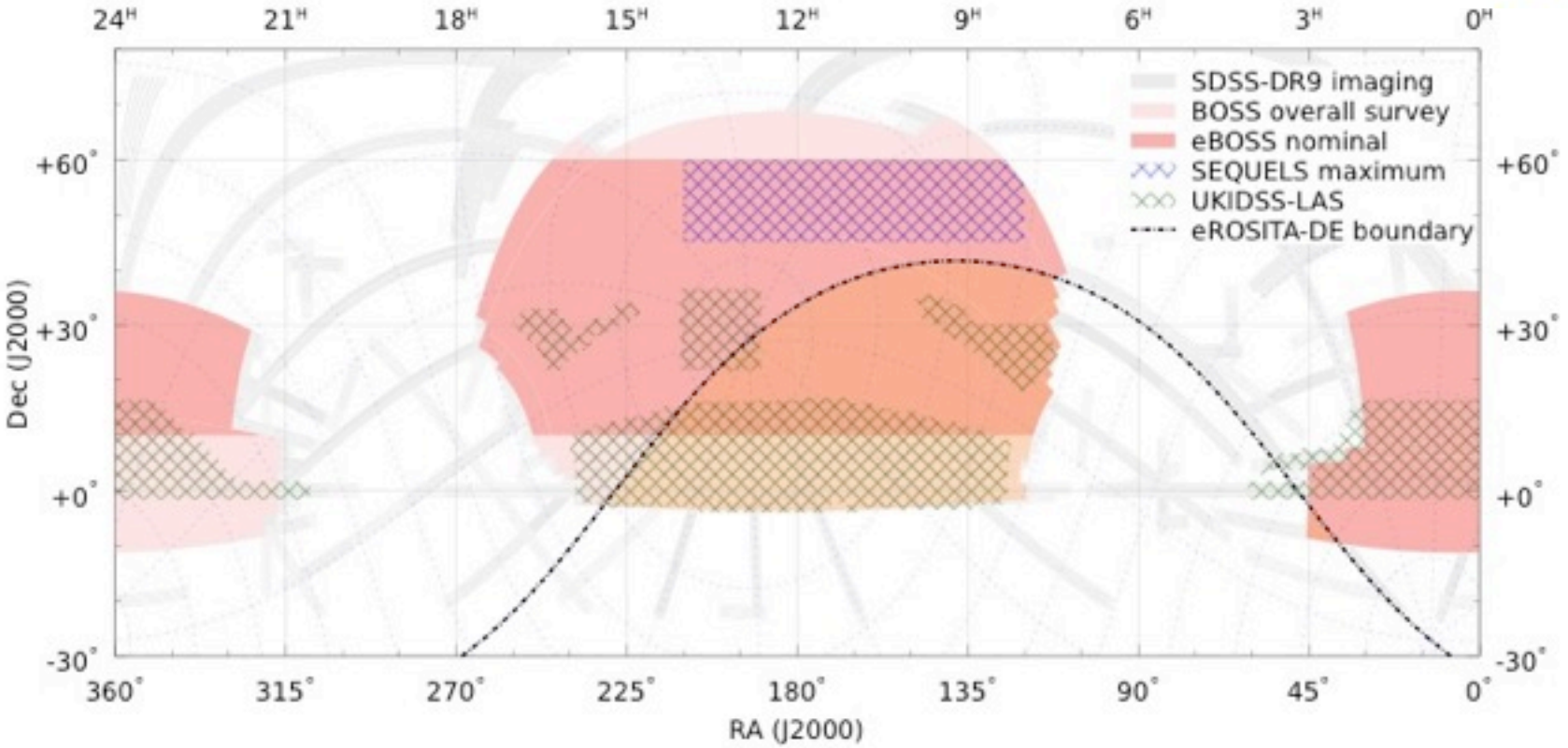
eROSITA_DE
Spectroscopic follow-up plans

- **North: SDSS IV/SPIDERS (2014-2020)**
  - Early follow-up over a ~2000 deg² area in the NGC: reach >80% completeness for eRASS:4, up to ~60,000 X-ray selected spectra

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

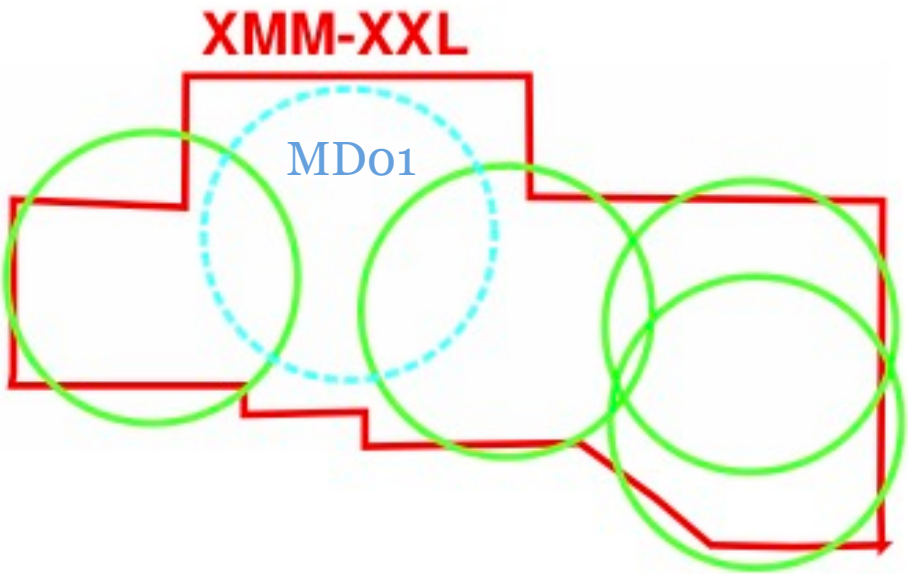


SPIDERS

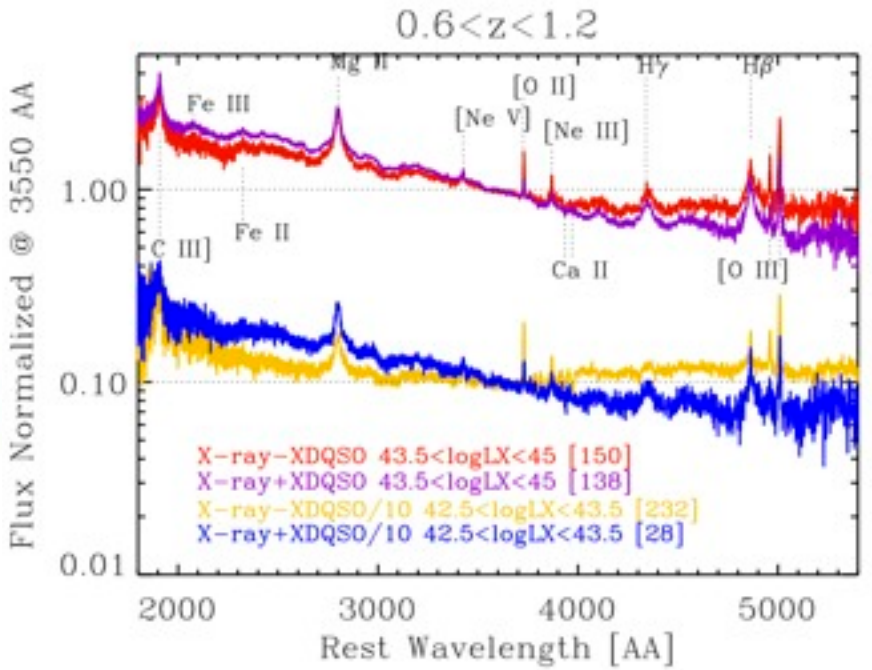


Early (eRASS:1-4) spectroscopic follow-up over most of the eROSITA_DE/eBOSS overlap region (2000-3000 deg^2)
+ complete follow-up of RASS AGN and clusters
(PI: A. Merloni, co-PI: K. Nandra)

A SPIDERS pilot in XMM-XXL

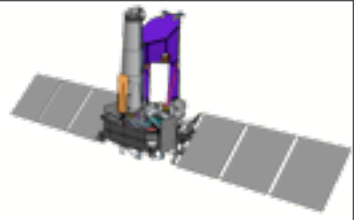


Menzel, Merloni et al. in prep



- A PanSTARRS Medium deep 7 deg² filed (MD01) over the **XMM-LSS Survey**
- Point-like X-ray sources above a given flux (SPIDERS targets) and variable sources from multi-epoch PS imaging (TDSS targets)
- Additional 4 SDSS plates fully dedicated to XMM point-sources follow-up over XMM-XXL northern area (PI: Georgakakis, MPE)
- **~2600 reliable redshift of X-ray selected AGN over ~22 deg²**
- **THE LARGEST CONTIGOUS SPECTROCOPIC FOLLOW-UP of X-ray AGN**

Working with eROSITA



- **eROSITA is a PI instrument**
  - Data split 50% MPE and 50% IKI West/East (gal. coord.)
  - German "survey" data public after 2 years, 2 or 3 periodic releases (2018/2019-2022)
  - Proprietary access via eROSITA_DE consortium
  - Projects/papers within allsky survey regulated by working groups
  - after the survey, 3.5 years of observations, **Public AOs**
- **Working Groups:**
  - **Science**: Clusters/Cosmology, **AGN**, Normal galaxies, Compact objects, Diffuse emission/SNR, Stars, Solar System
  - **Infrastructure**: Time Domain, Data analysis and catalogues, Multiwavelength follow-up, Calibration, Background
- **Collaboration policy:**
  - Individual External Collaborations (proposal to WGs)
  - Group External Collaborations (team-to-team MoUs)

Summary

www.mpe.mpg.de/eROSITA; Merloni et al. 2012

- A powerful X-ray telescope, flying in 2016
- Strength: **AREA / All-sky survey**
  - 0.5 -2 keV: 30x deeper than ROSAT
  - 2-10 keV: 100x HEAO-1
- Driving science: 100,000 clusters (LSS, cosmology)
  - **3 million AGN** including **all** (luminous) rare sources

--> Will provide the (hard) X-ray selection needed to probe the accretion mechanisms over the full sky, and the best targets where to study AGN Physics and effects on host galaxies through follow-up observations