Massive Spectroscopic surveys of X-ray selected AGN and Clusters: from SPIDERS to 4MOST

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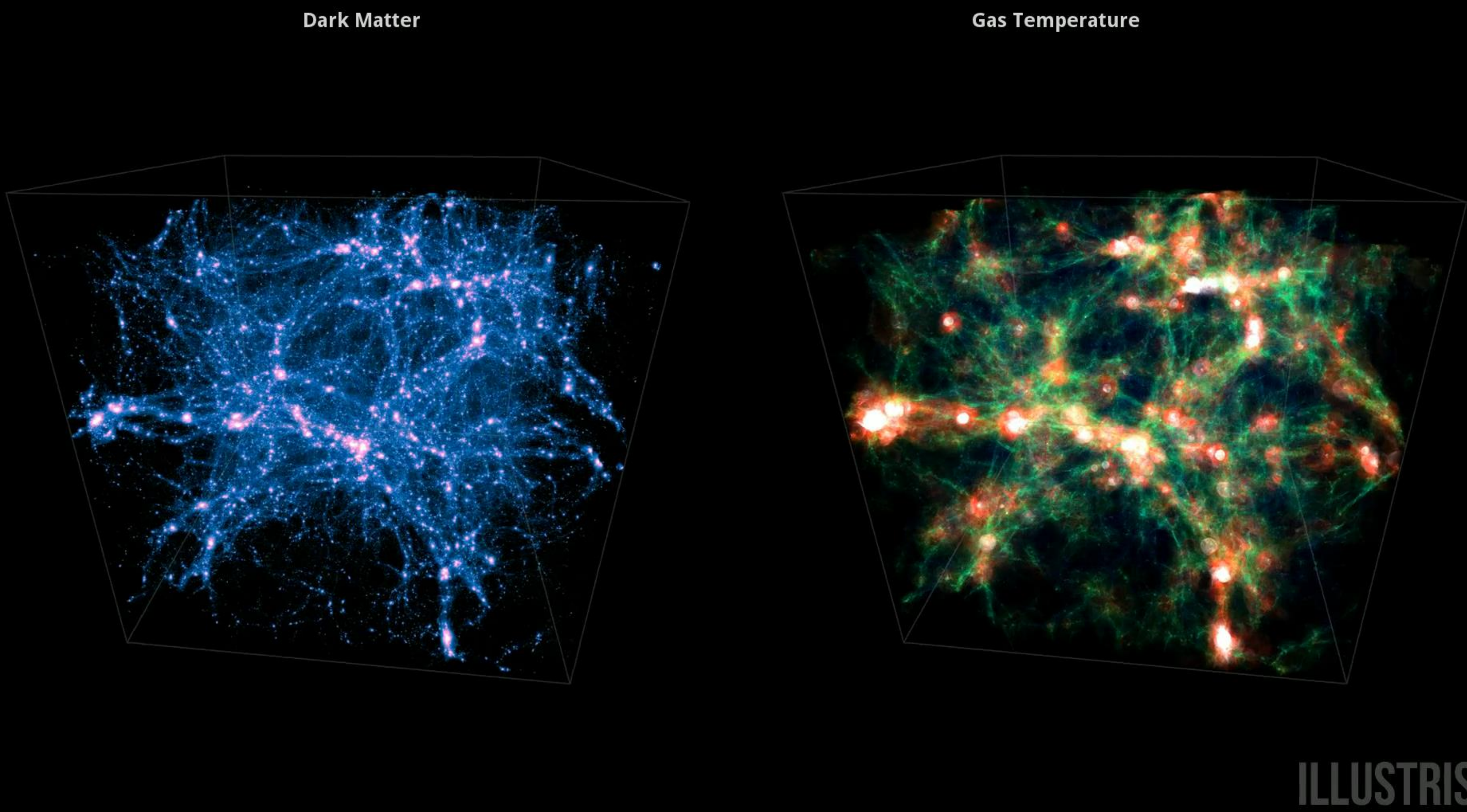
MPE, Garching

Outline

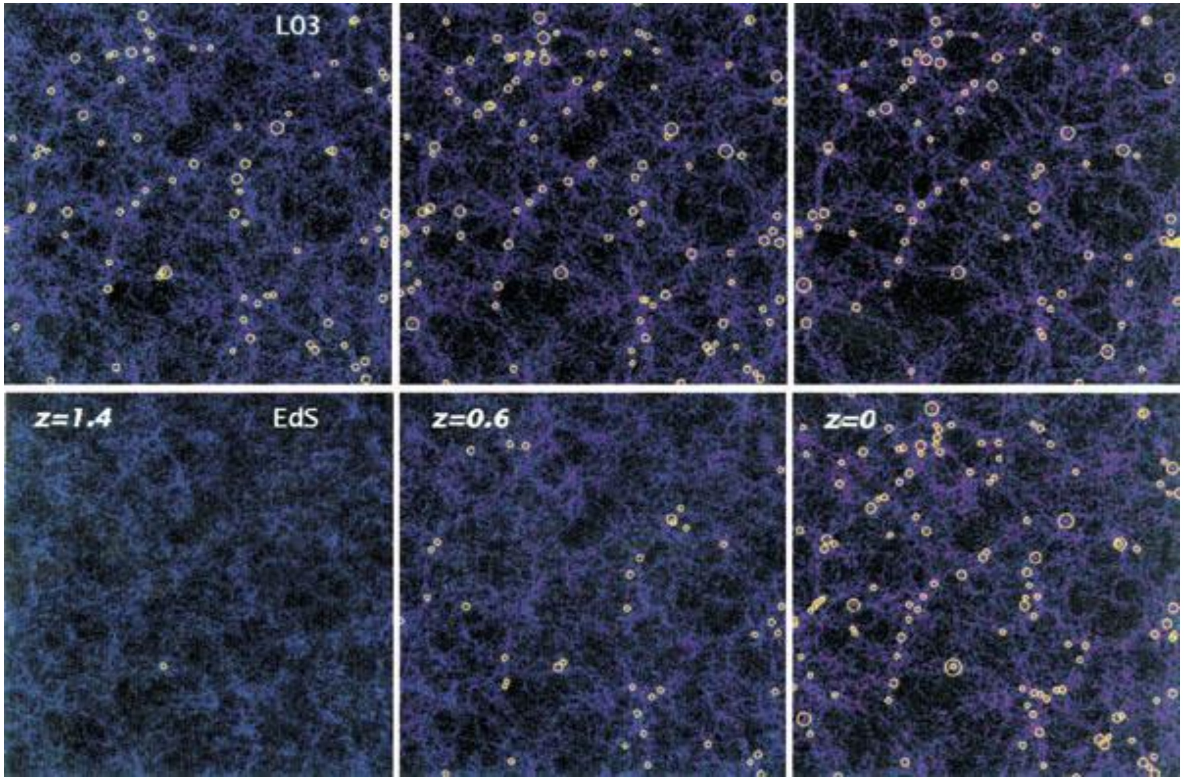
- Why surveying the (extragalactic) X-ray sky?
- eROSITA on SRG: Scientific drivers and perspectives
- Spectroscopic Follow-up Programs:
  - SPIDERS
  - 4MOST

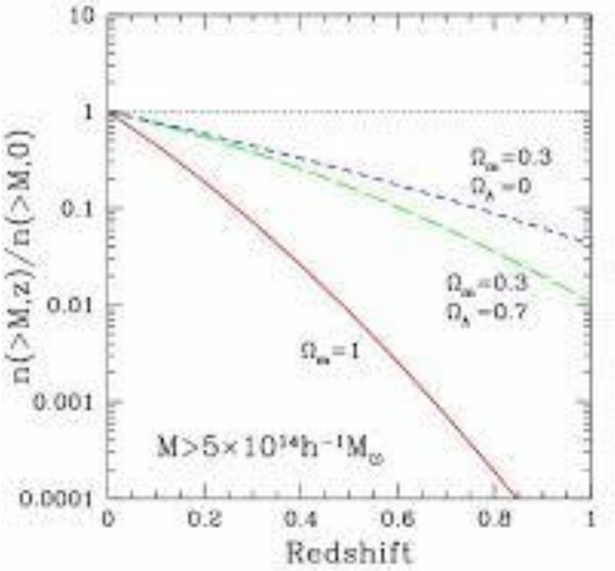
The hot web



The ILLUSTRIS Project, Vogelsberger et al. (2014) www.illustris-project.org

Clusters of galaxies, LSS and Cosmology





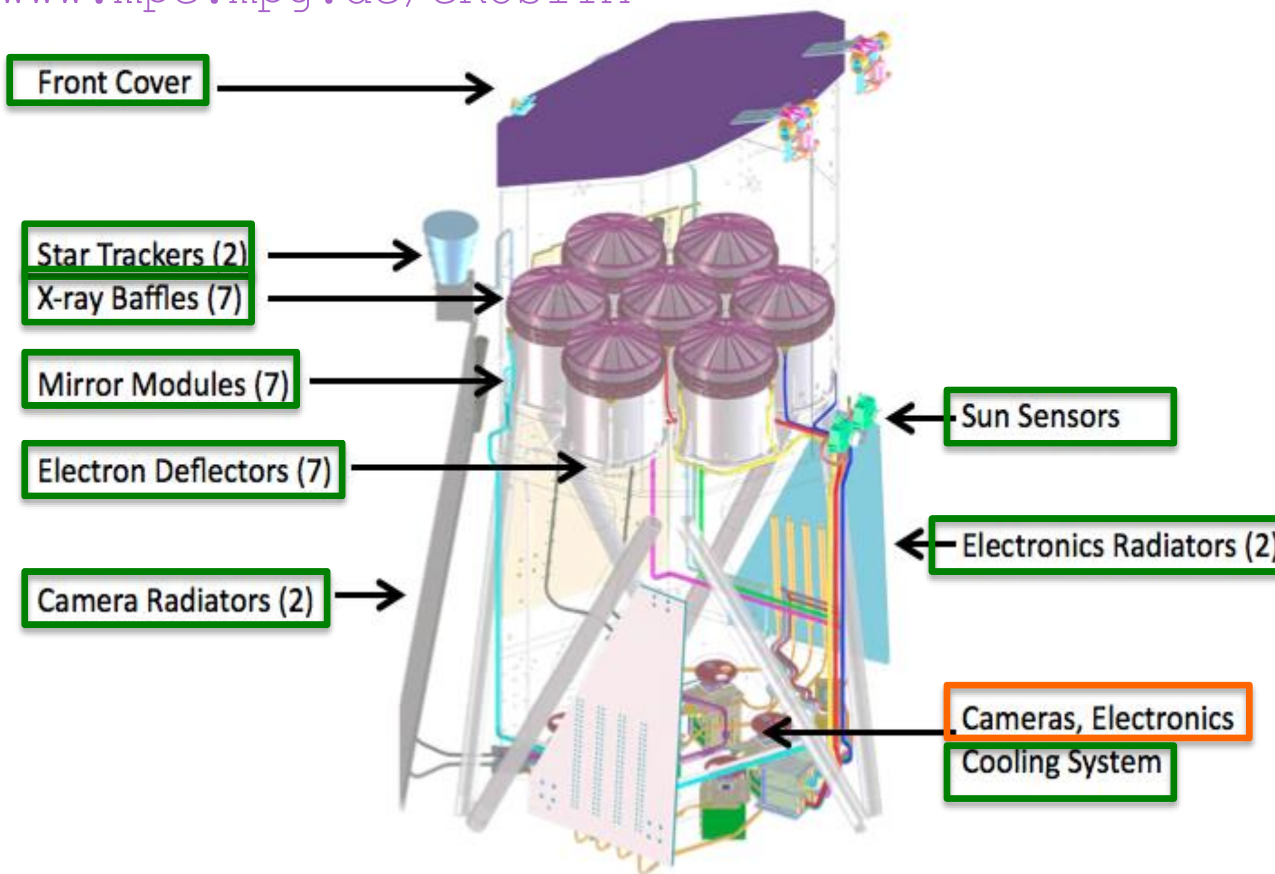
Rosati, Norman, Borgani 2002

- Clusters of galaxies are the largest gravitational bound structures
- They are *exponentially sensitive* tracers of **growth of structures**
- Cosmological constraints with (well calibrated) ROSAT samples of <100 obj.

The eROSITA telescope

Telescope structure

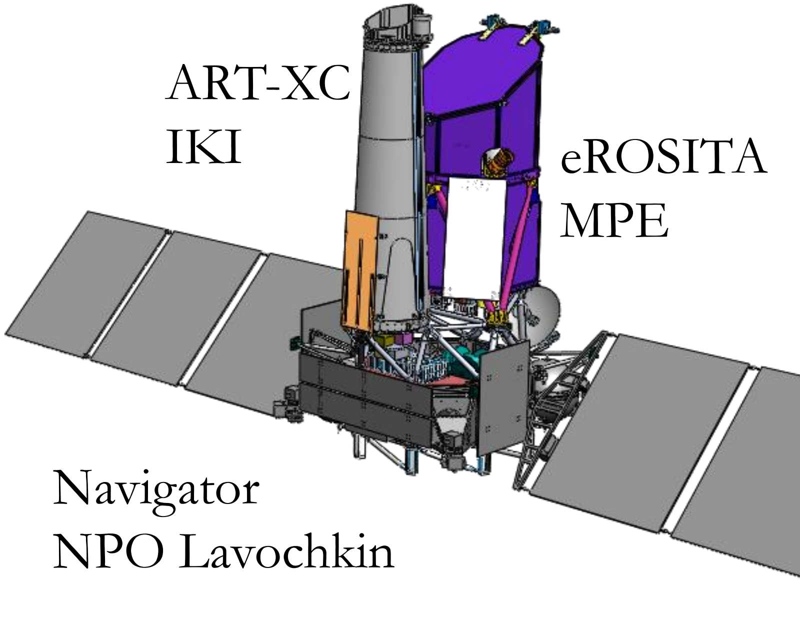
www.mpe.mpg.de/eROSITA

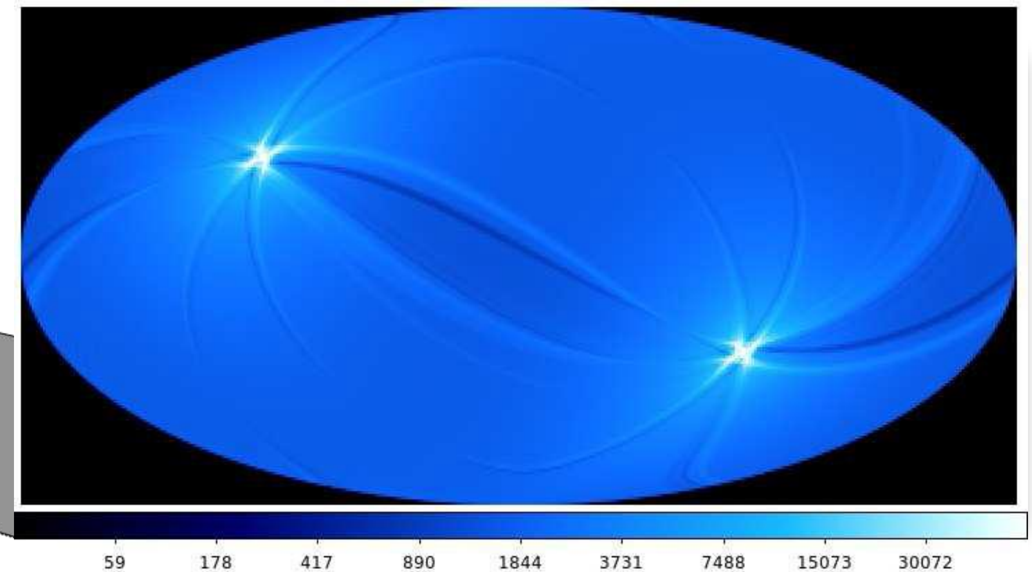


7 identical telescopes
(Wolter-I/ pnCCD-cameras)
Focal length 1.6 m
F.o.V. = 0.81 sqdeg
Total weight ~800 kg

HEW on axis ~16.5“, survey average ~26“
Energy range: 0.3-8 keV
Energy resolution: 138 eV @ 6 keV
Effective Area: ~1400 cm2 (~XMM @1keV)

SRG: the Mission

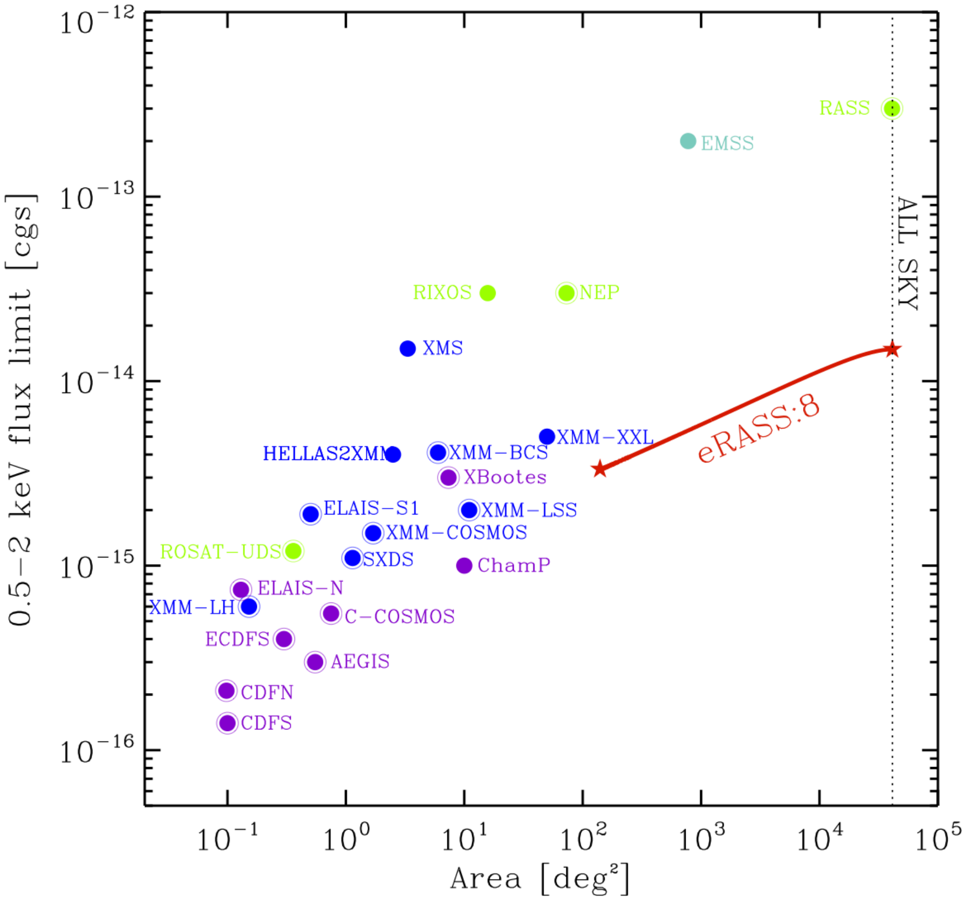




- eROSITA **hardware mostly completed**. Calibration/assembly till ~August
- **eROSITA delivery to Russia**: Fall 2015
- **Launch:** March or October 2016 from Baykonour (Zenit+Fregat)
- **3 Months:** flight to L2, verification and calibration phase
- **4 years**: 8 all sky surveys eRASS:1-8 (scanning mode: 6 rotations/day)
- **3.5 years**: pointed observation phase, including ~20% GTO. 1 AO per year

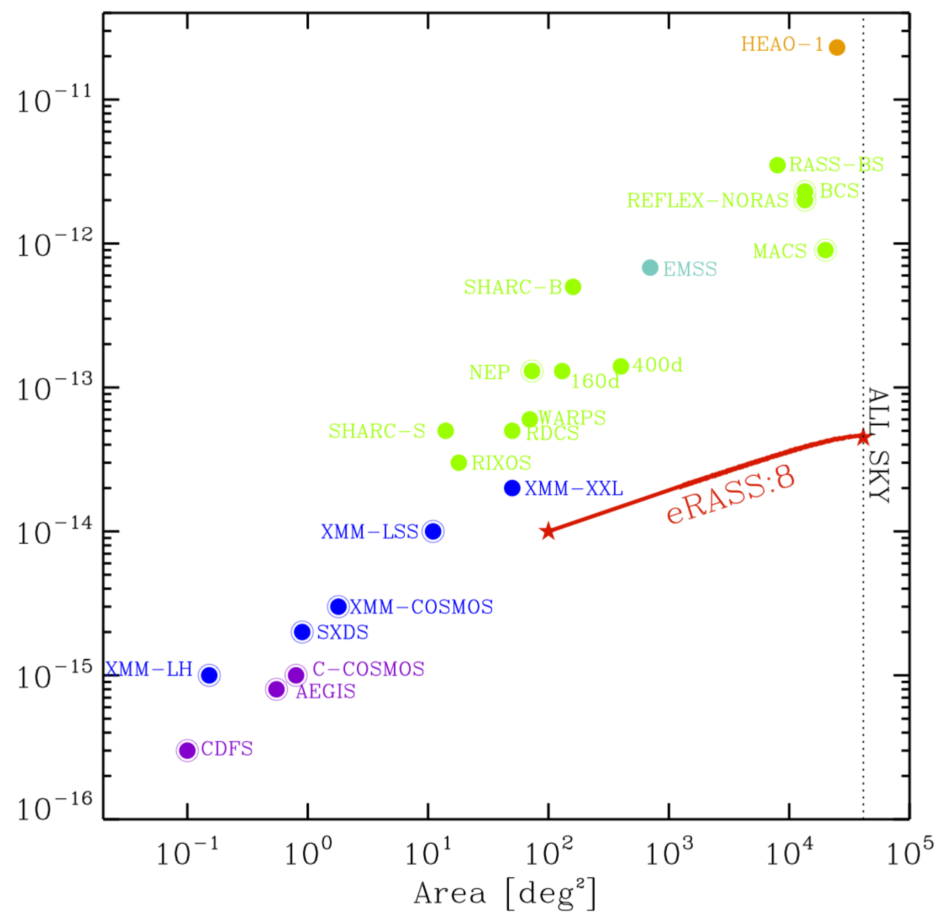
eROSITA surveys in context

Point sources sensitivity



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

Extended sources sensitivity

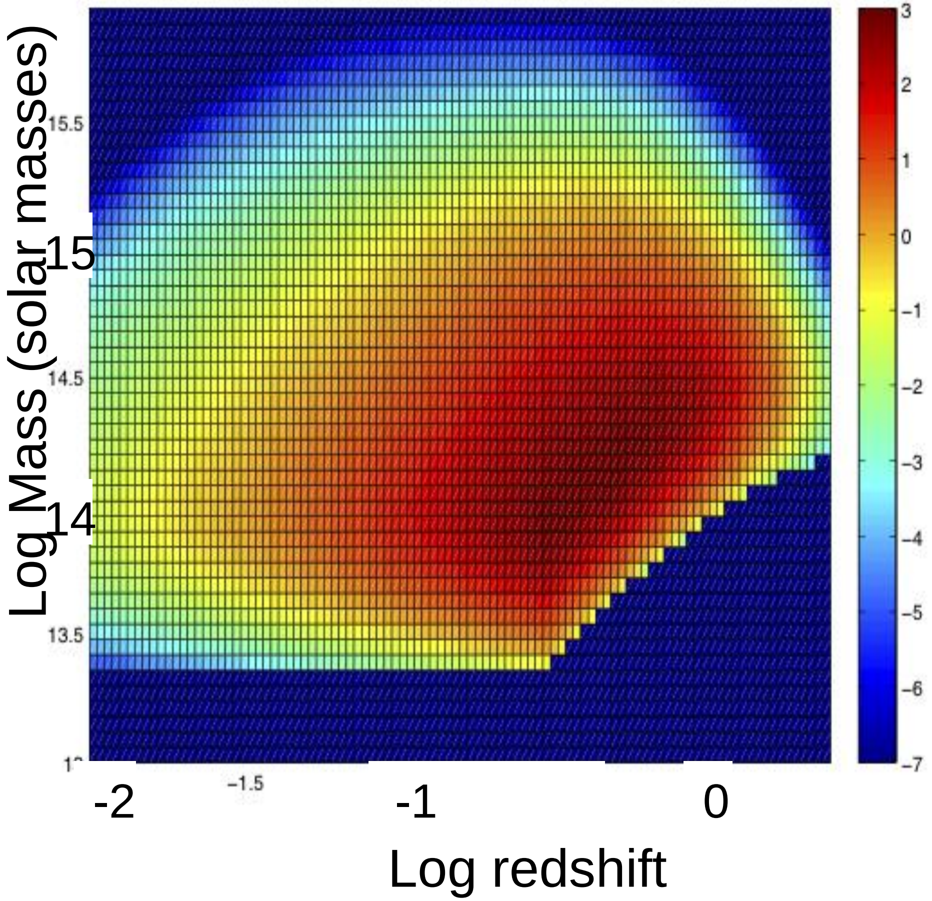


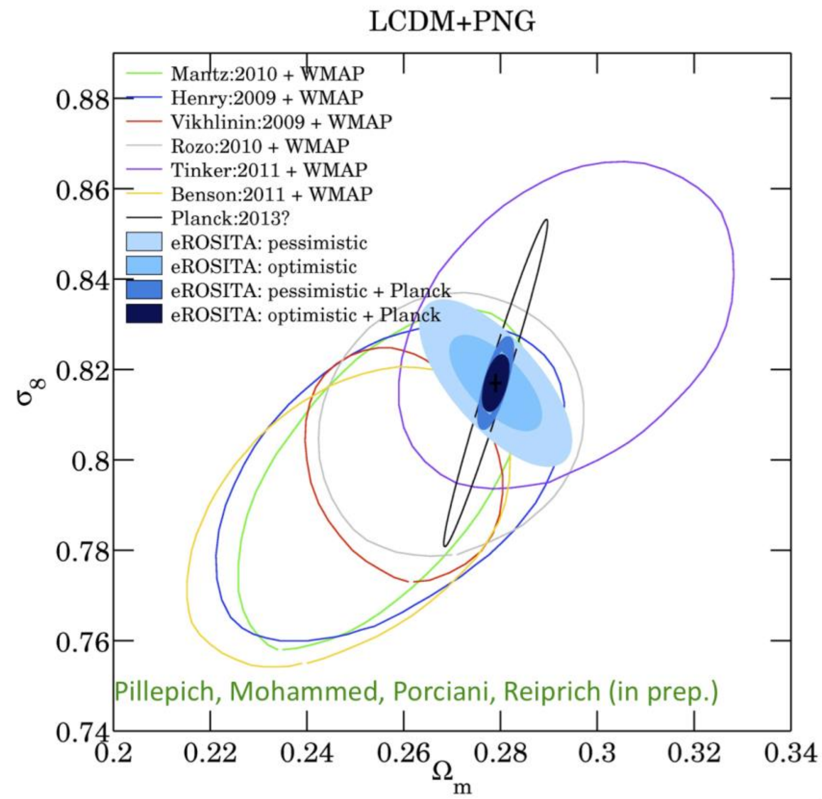
All sky: 3.4 x 10^{-14} (0.5-2 keV)

Merloni et al. 2012

ALL Massive Clusters

eROSITA will detect ~100k clusters with more than 50 net counts





~ 1,700 clusters with precise Temperature (to <10%), up to z~0.08

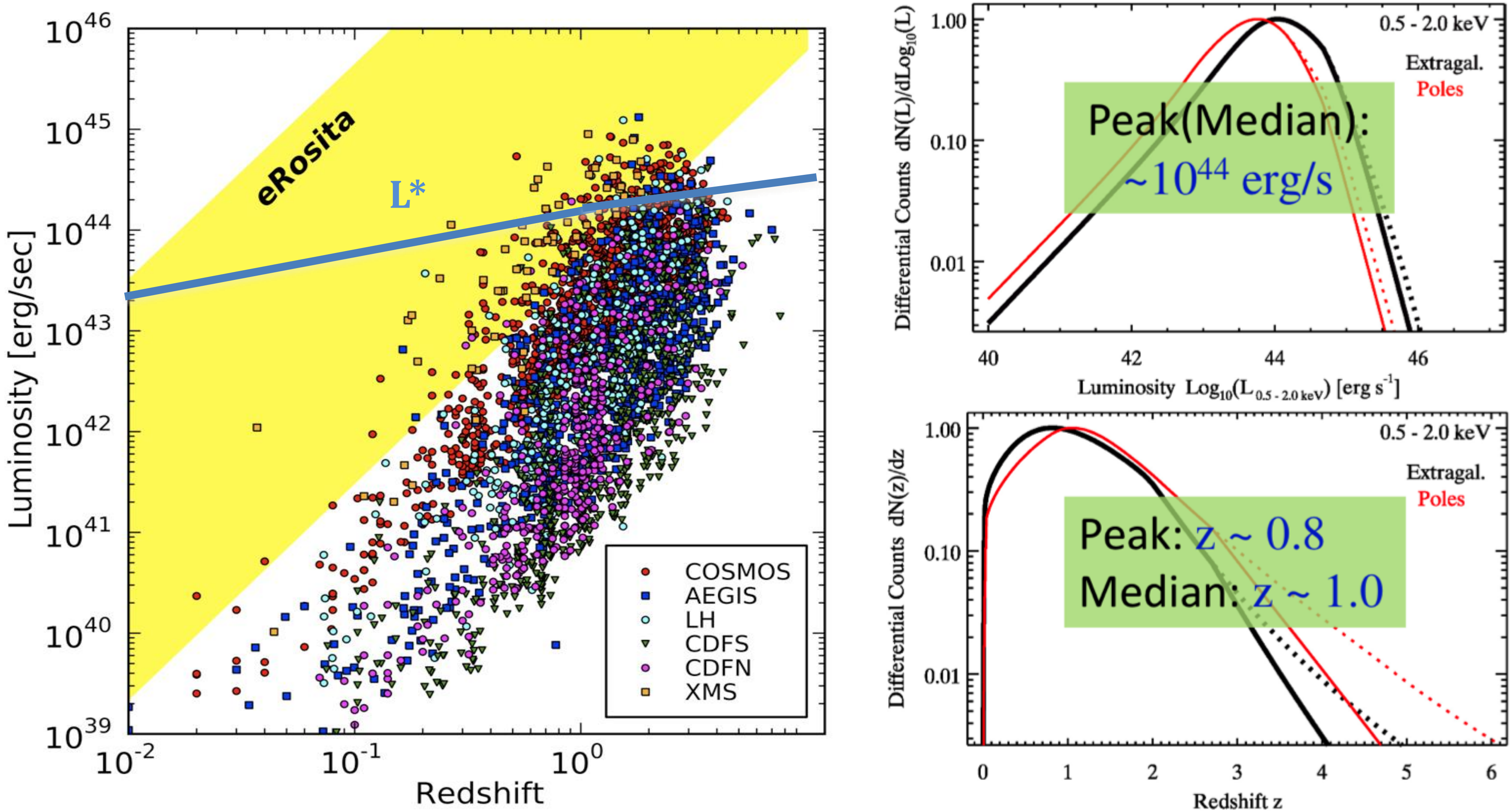
~23,000 clusters with accurate redshift determination, up to z~0.45

Borm et al. 2014; Pillepich et al. 2012

Legacy

- Sample size allows more than just hitting the systematics limit
- Provide all-sky LSS information (high-end of DMH mass function)
- The daunting task of "mass calibration" is a unique opportunity to study physics
- We will be limited by man-power (and creativity) in devising statistically significant sub-samples to combine/stack on
  - Redshift, Mass
  - X-ray luminosity & Temperature
  - SZ signal
  - Optical richness
  - Weak (and CMB) Lensing potential
  - Phase space denisty
  - Strong lensing
  - Radio relic/halos
  - …

3 Million eROSITA AGN



½ Million X-ray Stars

- Cool Stars (late A to late M-type, magnetic activity, coronae)
- Hot Stars (O to early B-type incl. WR Stars, wind shocks)
- Variables

log L_X	stars	distance limit
26.0	late M dwarf	10 pc
26.5	active VLM (M9) star	20 pc
27.0	Sun, Altair (A7), Prox Cen (M5)	30 pc
28.0	Procyon (F5), Eps Eri (K2)	100 pc
29.0	low-mass CTTS, active M dwarf	300 pc
30.0	EK Dra (active G2)	1 kpc
31.0	Algol, bright TTS, early B star	3 kpc
32.0	WR1, O type star	10 kpc
33.0	θ^1 Ori C (mag. O5)	30 kpc

Stellar population studies
- activity vs. age, rotation, mass, eff.temperature
- Lx/Lbol relation along hot star sequence

Dynamo theory
- study of (super-) saturation effects and Lx/Lbol evolution
- transition effects at fully convective boundary

Local star formation history & galactic structure
- young nearby stellar population
- early evolution of planetary systems

Properties of individual SFR
- masses, IMF, star formation history
- modes of star formation & scenarios

court. J. Robrade, J. Schmitt

And more…

See eROSITA science book (Merloni et al. 2012)

- Full census of Galactic XRB
- Isolated Pulsars, SNR
- Tens of thousans of CVs of all "flavors"
- Variability studies (from hours to years)
- "Quiescent" Black holes revealed by tidal disruption of stars (need rapid and long-term spectroscopic follow-up)
- Hot ISM of Milky Way (with spectroscopic information)
- Serendipity…

The complex landscape of O/IR wide area surveys

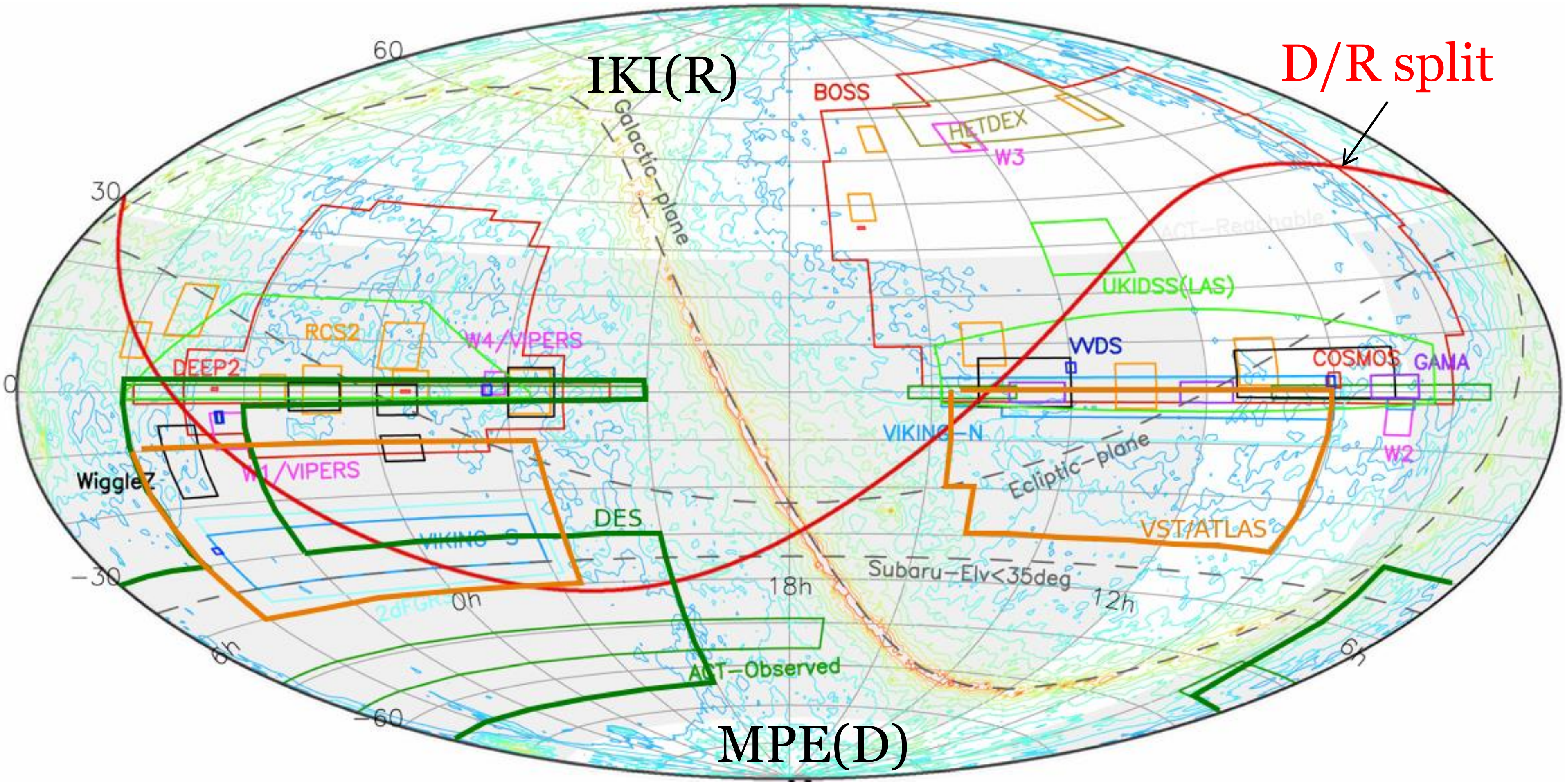
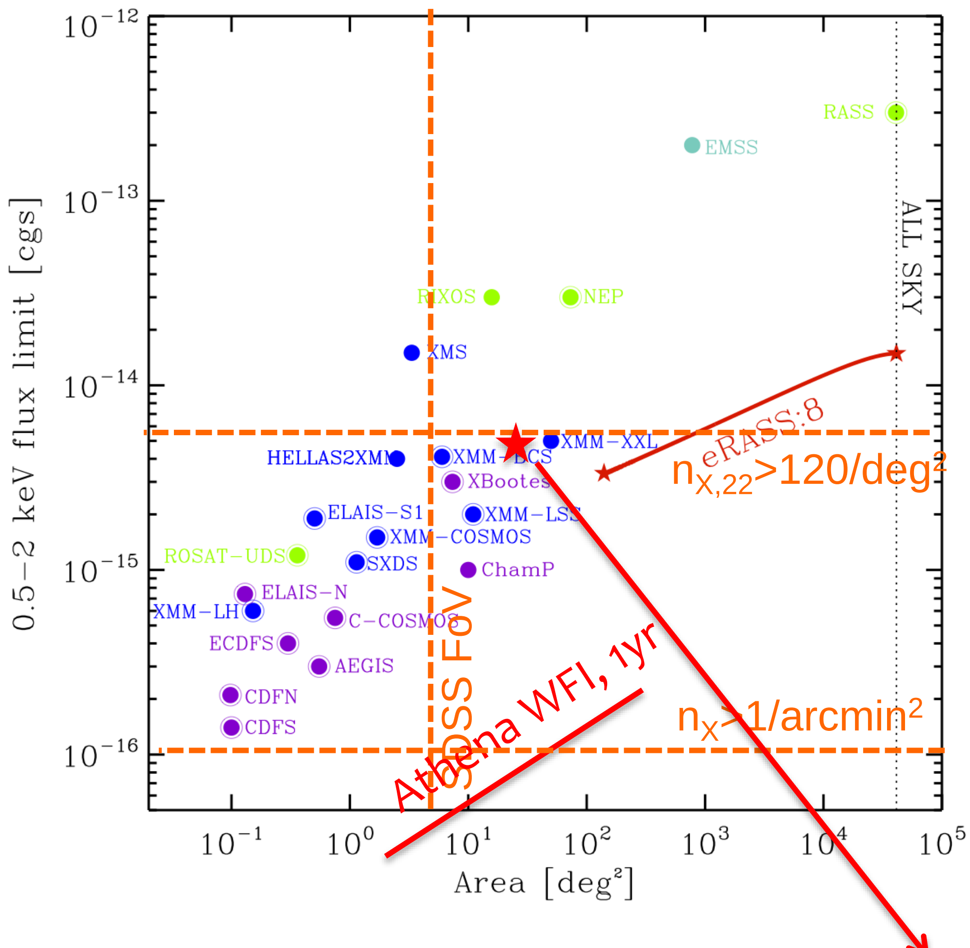


Image courtesy of K. Nishikawa (NAOJ)

Spectroscopy of X-ray AGN surveys



- The combination of X-ray selection and optical spectroscopy is critical
- Wide area X-ray surveys well matched to current (and future) multi-object spectrographs
- **eROSITA** and **Athena** will exploit such a vast potential for exploration

XMM-BOSS combination: the unique example of XMM-XXL (Menzel's talk)

eROSITA_DE and MOS

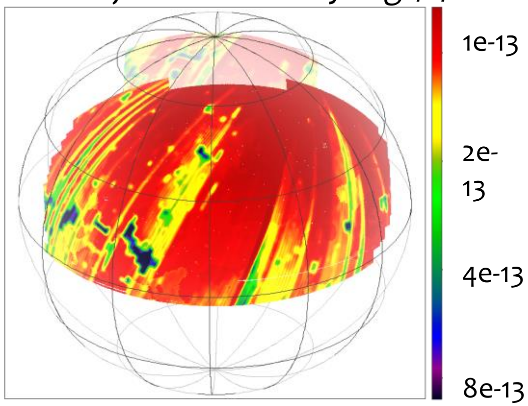
– **North: SDSS IV/SPIDERS (2014-2020)**
  A. ~8,000 redshifts of RASS & XMMSL AGN (adding in ~10k SDSSI,II,III sources, almost complete follow-up of r>17 RASS sources)
  B. eROSITA follow-up over a ~2000 deg^2 area in the NGC: reach >80% completeness for eRASS:4 (~50,000 spectra)

– **South: VISTA/4MOST (2021-2026)**
- Complete, systematic follow-up of both Clusters and AGN from eROSITA: reach >80% completeness for eRASS:8
- ~700k AGN spectra 0<z<6
- 1.4M galaxies in ~60k X-ray selected clusters (Clusters clustering, RSD, velocity dispersion, gravitational redshift)

Galaxy clusters in SPIDERS

(N. Clerc, A. Merloni, A. Finoguenov, J. Ridl, the SDSS collaboration)

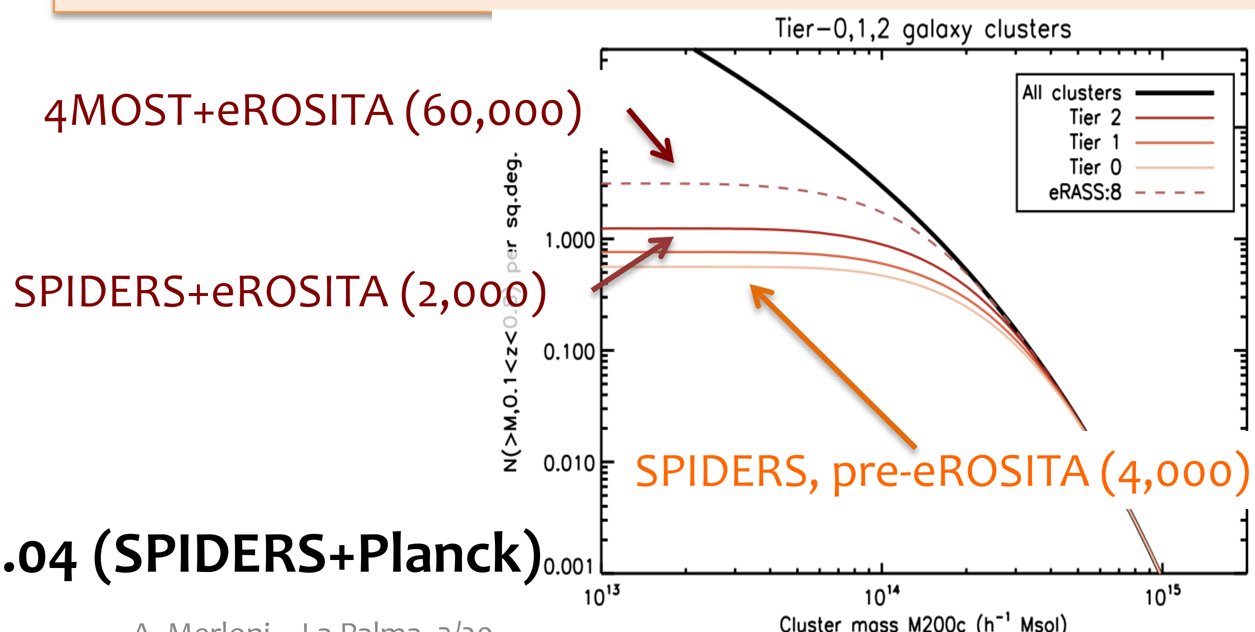
RASS-faint sensitivity ergs/s/cm²



SDSS ugriz+RedMapper

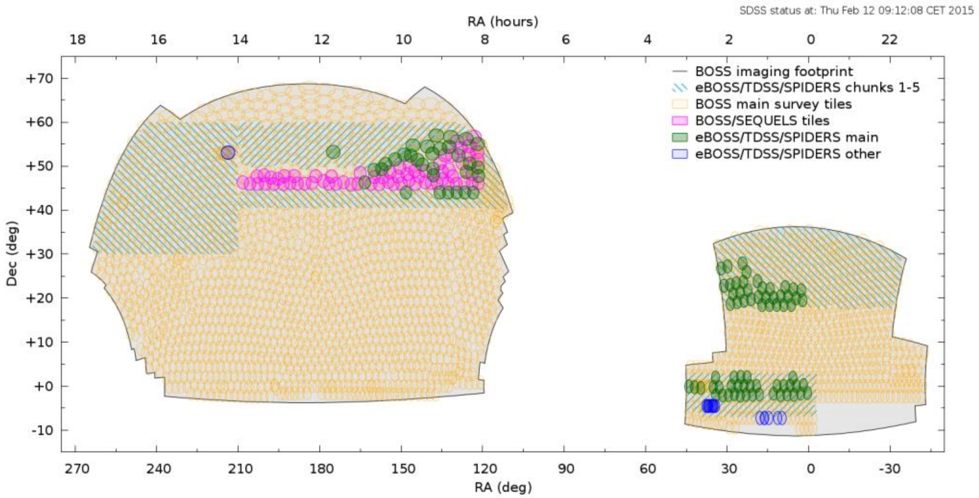
Goal: secure spectroscopic confirmation of >75% CODEX clusters (~4,000) + statistical velocity dispersion

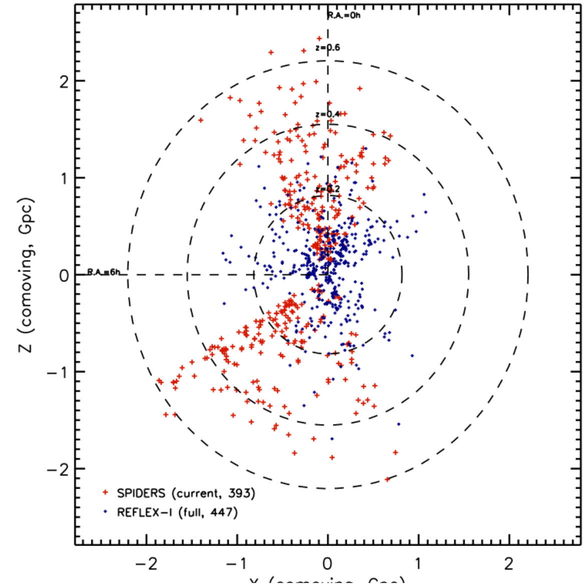
- $0.1<z<0.6$
- $0.7/deg^2$ (richness>10)
- Median mass ~4.10^{14} M_{sol}
- Optimized selection of targets
  - $17<i(2'')<21.2$
  - Red-sequence prioritization
  - Cluster richness penalty



- Expect Δσ8<0.01 Δw<0.04 (SPIDERS+Planck)

SPIDERS' web





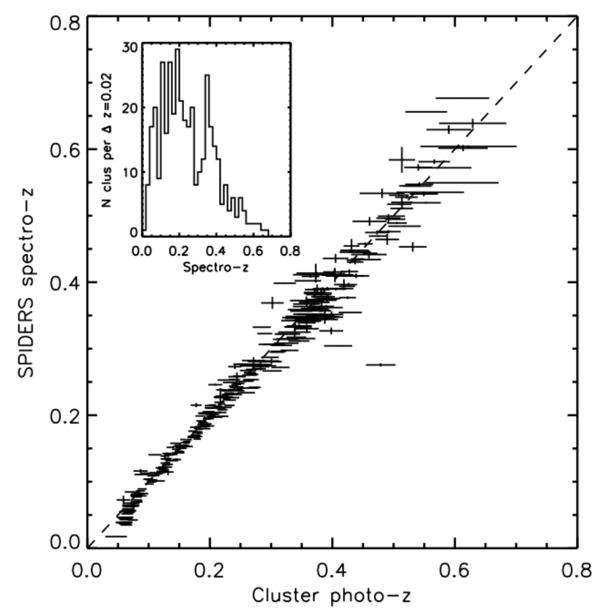
Status of SPIDERS/RASS Clusters, 2/3/2015

SEQUELS: 323 (Rich.>10)

- 222 (N_{spec} > 3)
- 125 (N_{spec} > 10)
- 66 (N_{spec} > 15)

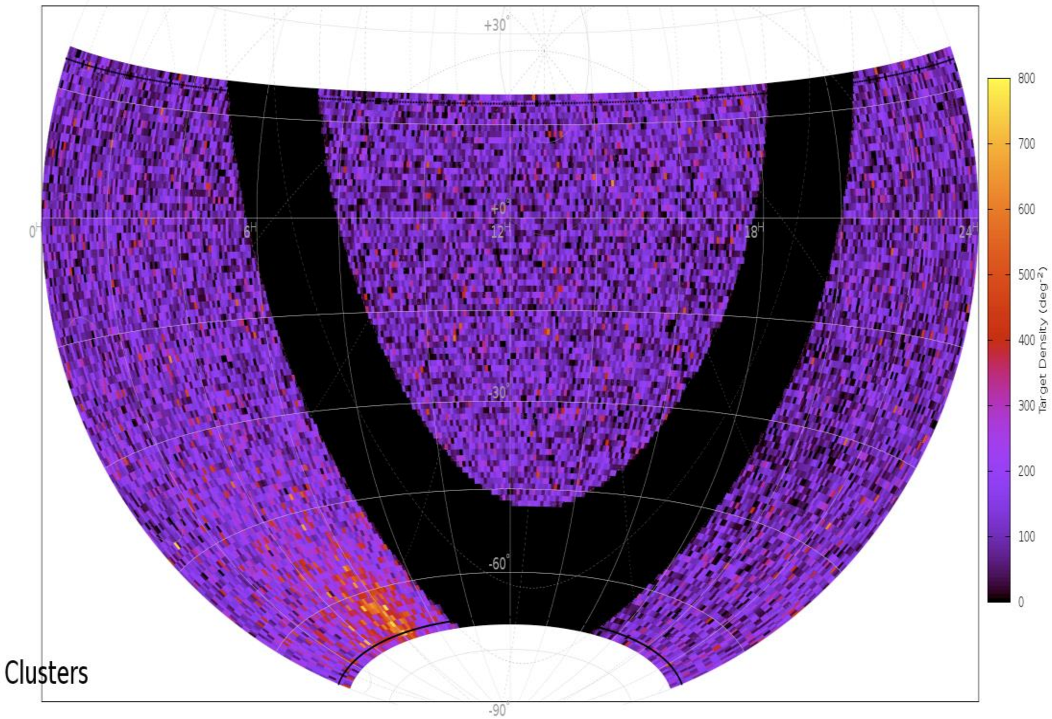
SPIDERS: 487 (Rich.>10)

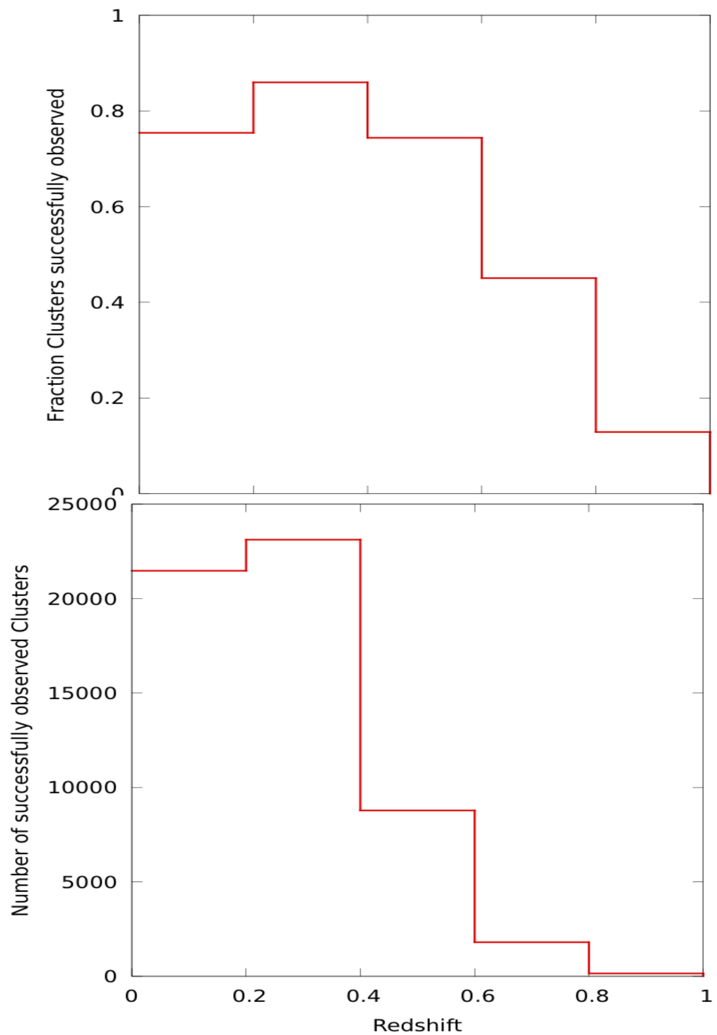
- 334 (N_{spec} > 3)
- 177 (N_{spec} > 10)
- 97 (N_{spec} > 15)



Clerc et al. in prep

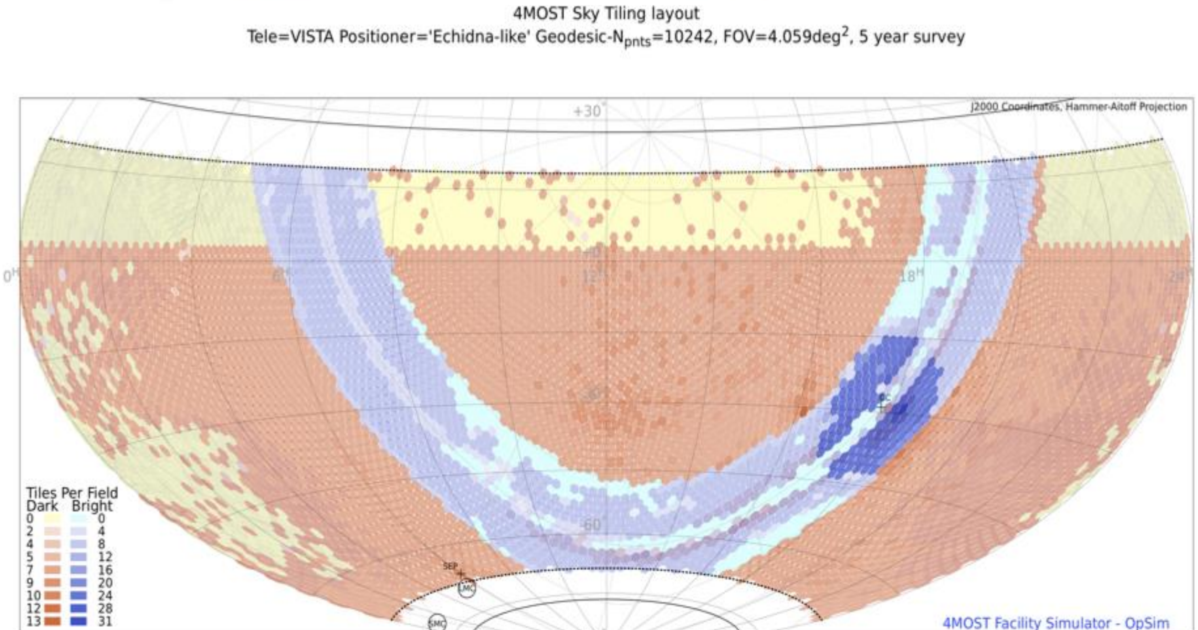
eROSITA+4MOST clusters detection efficiency



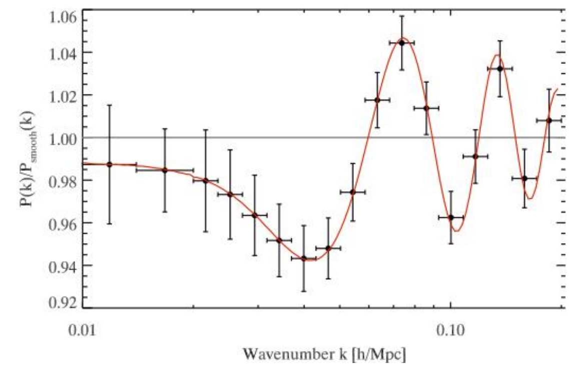


1.4 Million redshifts for 50-60k clusters:
- 24k/36k of richness λ>30 clusters, and 10.5k/14k with richness λ>50, will have **more than 20 spectra**

4MOST– 4-metre Multi-Object Spectroscopic Telescope



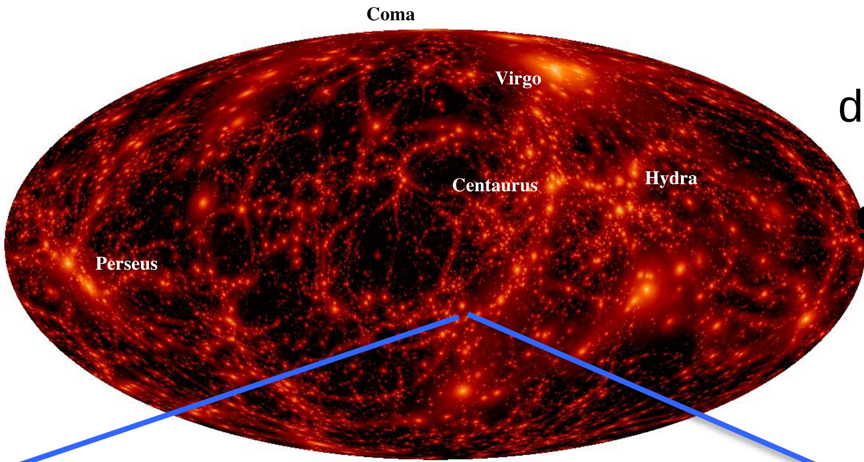
4MOST sky coverage 5 years survey simulation (4FS, MPE)



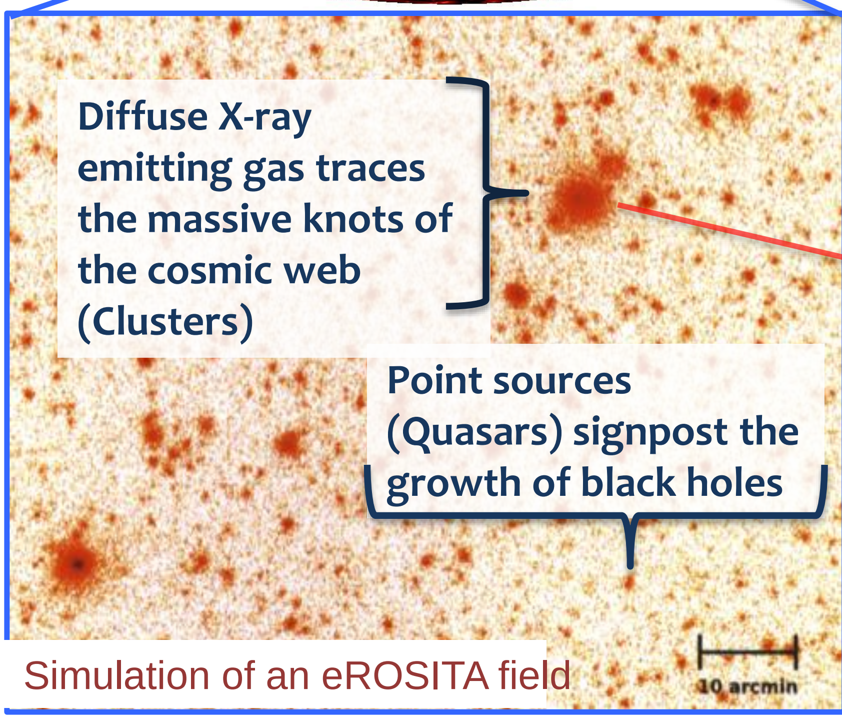
8σ BAO detection in 0.8<z<2
eROSITA+4MOST
Kolodzig et al. 2013

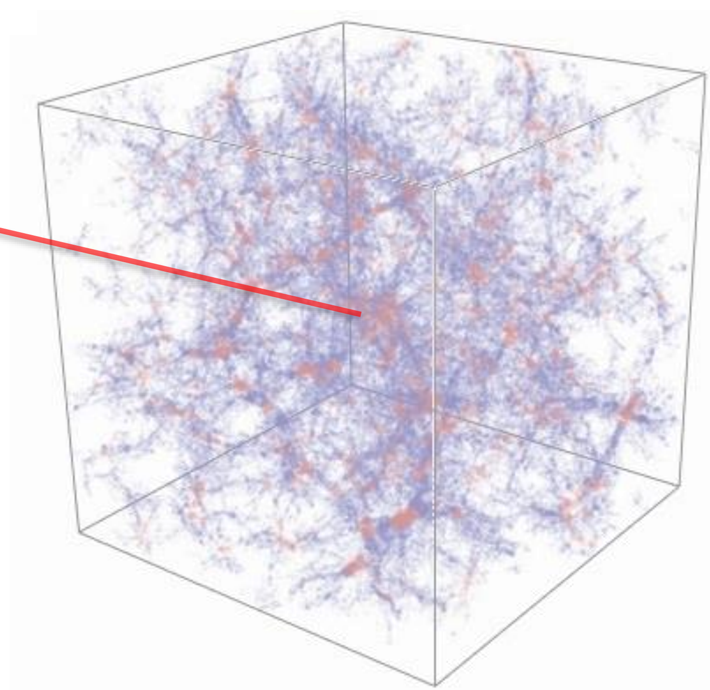
- AGN/QSO densities [deg^{-2}]
  - eRASS:8 only: **48** (**26** in 0<z<0.8; **22** in 0.8<z<2.5)
  - eRASS:8+XDQSO: **24** (0.8<z<2.2)
  - XDQSO only: **50** (0.8<z<2.2)
- Reach **~100/deg²** in 0.8<z<2.5 -> AGN BAO

Mapping the structure of the hot Universe



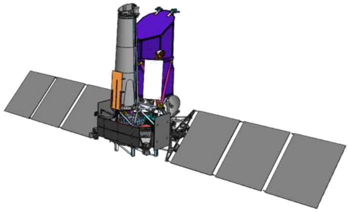
eROSITA will study Dark Energy by detecting diffuse emission from the hot gas in the largest structures of the Universe (**Clusters of galaxies**). Further, it will yield a full census of millions of **growing black holes** (Quasars). See: Merloni et al. 2012. arXiv:1209.3114



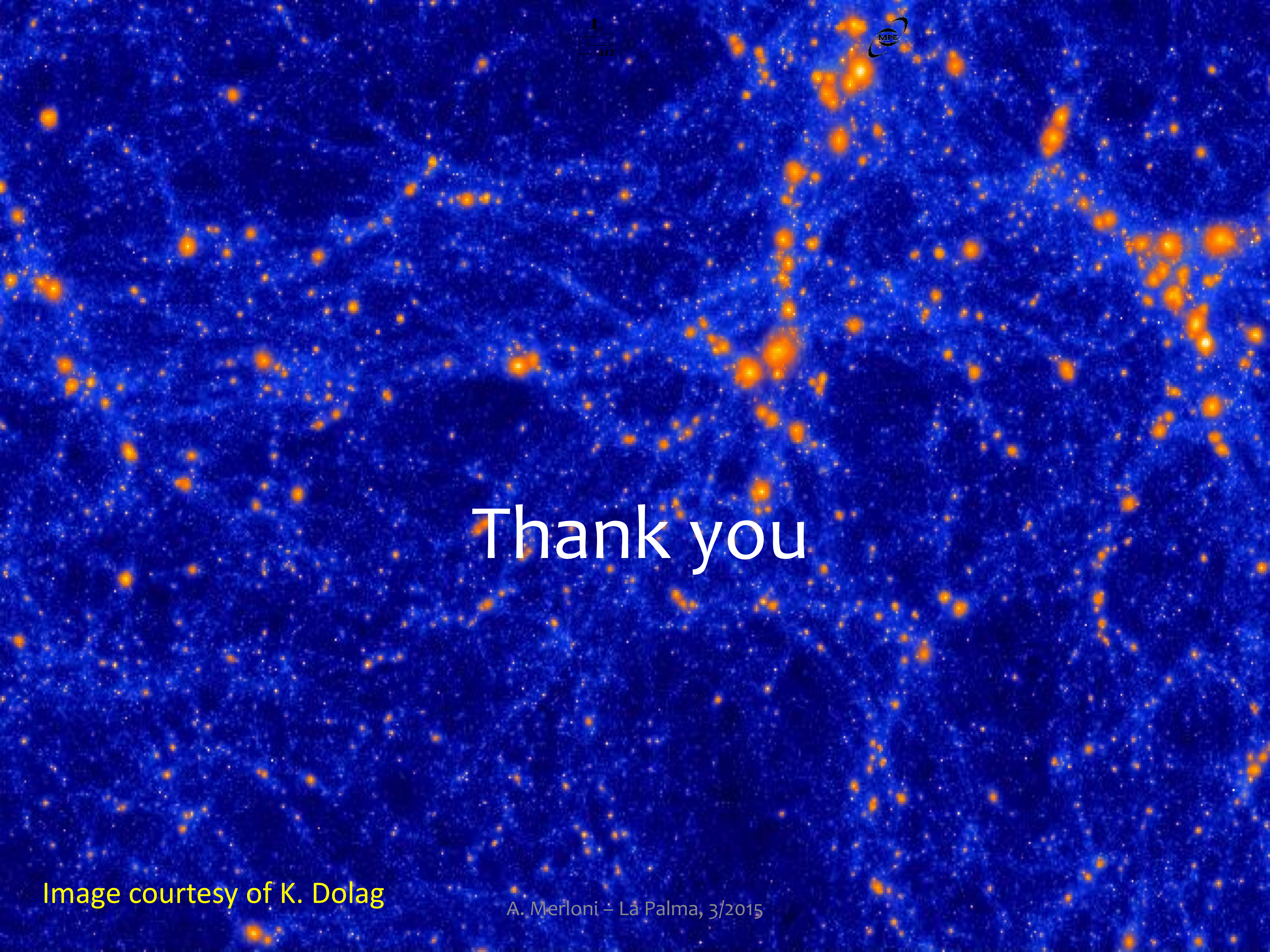


Images coutesy of K. Dolag (LMU), M. Mühlegger (MPE), O. Hahn (ETH)

Working with eROSITA



- **eROSITA is a PI instrument**
  - Data split 50% MPE and 50% IKI West/East (gal. coord.)
  - German data public after 2 years, 2 or 3 periodic releases (2018/2019-2022)
  - Proprietary access via eROSITA_DE consortium
  - Projects/papers regulated by working groups
- **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)



Thank you

Image courtesy of K. Dolag

AGN selection basics: contrasts

Assume: (1) $M_{BH}/M_* = A_0$; (2) $\log SFR = \alpha(z)(\log M_* - 10.5) + \beta(z)$

(BH-galaxy scaling relation) ("Main sequence" of star formation)

Eddington rate λ_{limit} *(z=1, z=0)*

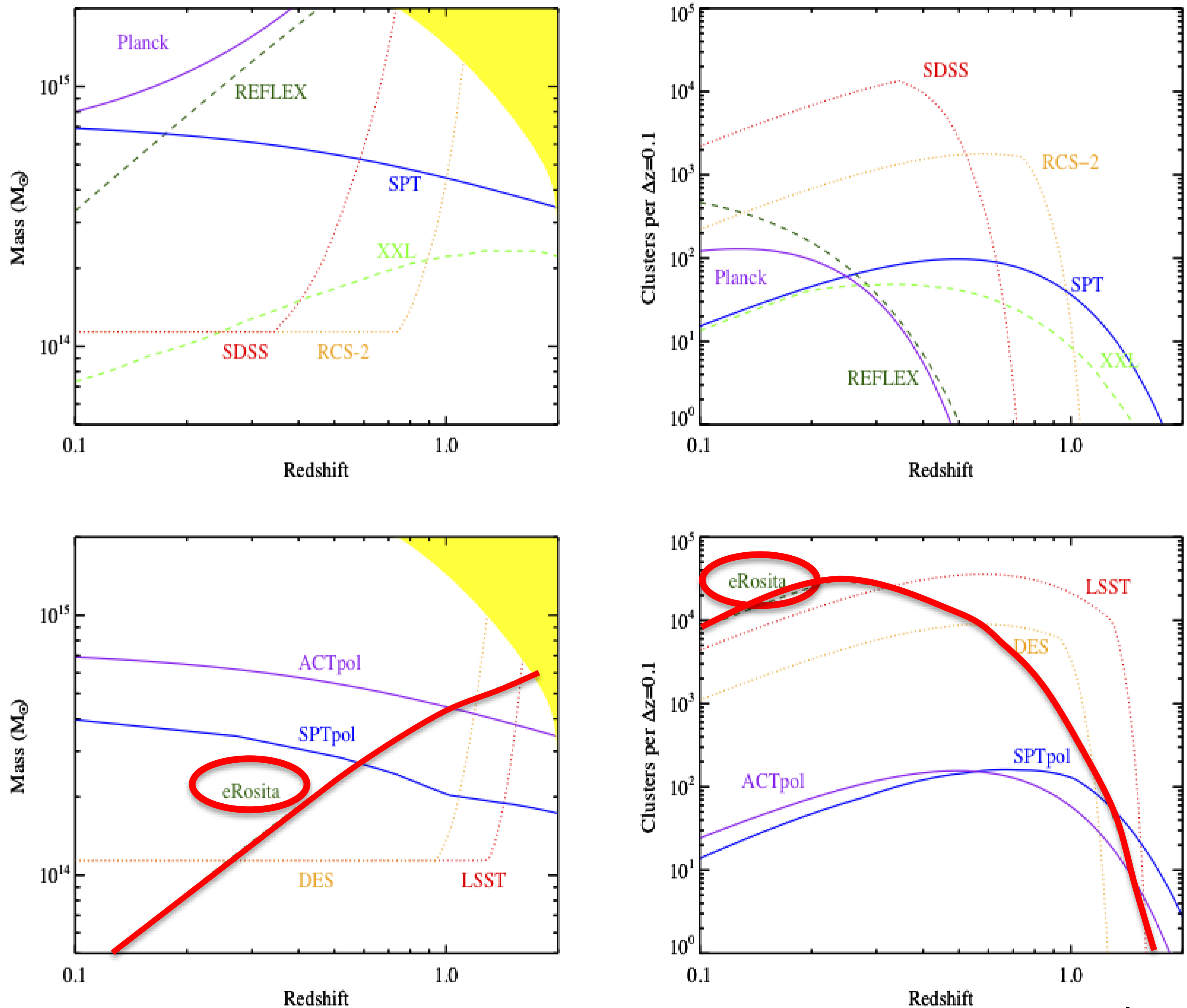
$$\frac{L_{X,AGN}}{L_{X,SF}} \approx 10^5 \lambda\, 10^{-\beta(z)} \left(\frac{f_X}{0.03}\right) \left(\frac{A_0}{0.002}\right) \left(\frac{M_*}{10^{10.5} M_\odot}\right)^{1-\alpha(z)}$$ → *(2 × 10^-4^, 2 × 10^-5^)*

$$\frac{L_{IR,AGN}}{L_{IR,SF}} \approx 160 \lambda\, 10^{-\beta(z)} \left(\frac{f_{24}}{0.1}\right) \left(\frac{A_0}{0.002}\right) \left(\frac{M_*}{10^{10.5} M_\odot}\right)^{1-\alpha(z)}$$ → *(0.13, 0.015)*

$$\frac{L_{B,AGN}}{L_{B,host}} = 39 \lambda \left(\frac{f_B}{0.1}\right) \left(\frac{A_0}{0.002}\right) \frac{(M_*/L_B)_{host}}{3(M_\odot/L_\odot)}$$ → *(0.025)*

Merloni (2015)

Clusters-finding experiments



Weinberg et al. 2012

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

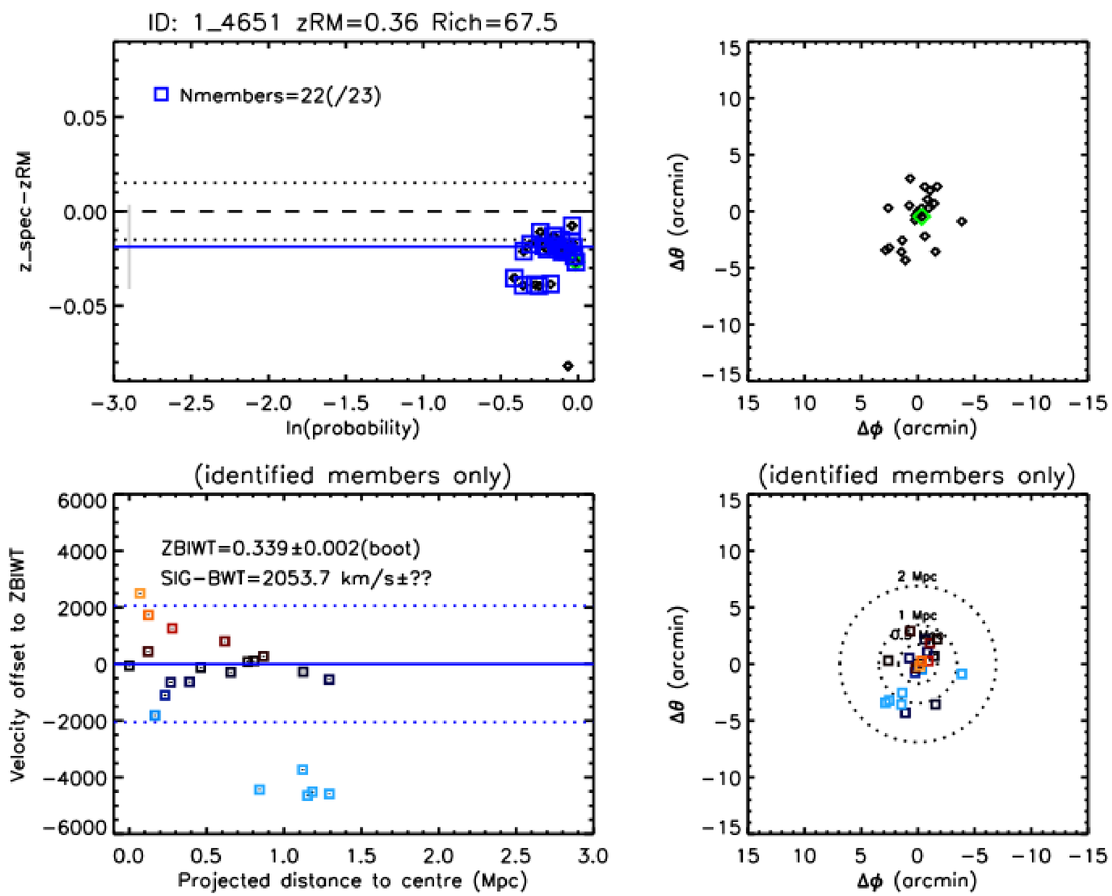
Industry:

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

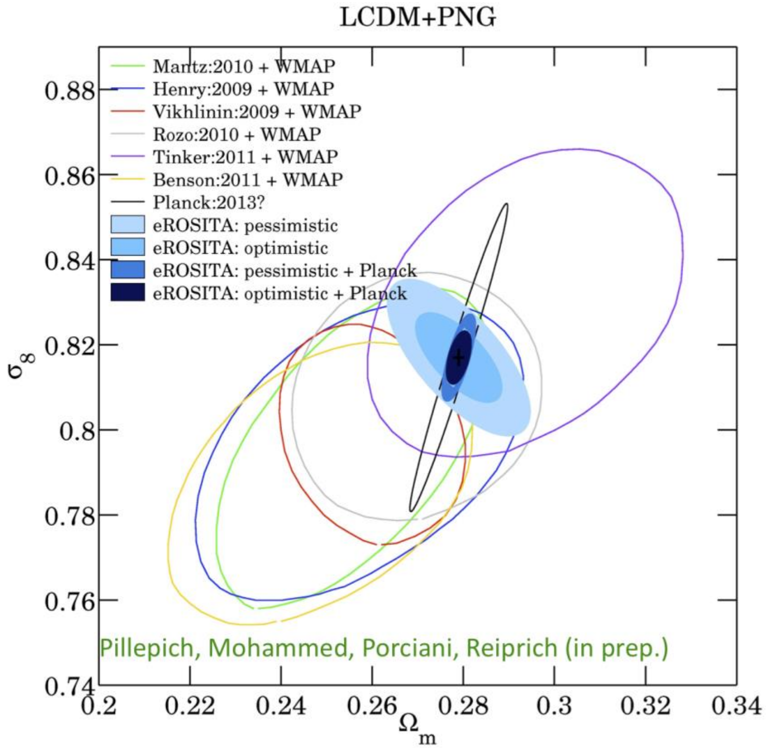
MPE: Scientific Lead Institute, Project Managment
Instrument Design, Manufacturing, Integration & Test
Data Handling & Processing, Archive etc.

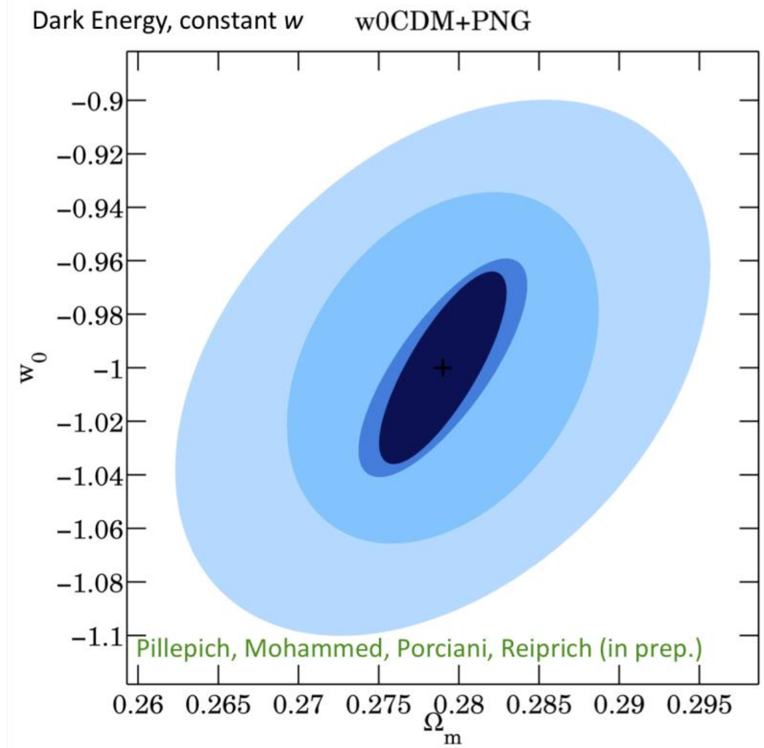
Clusters dynamics



Clerc et al. in prep

Cosmology Forecasts

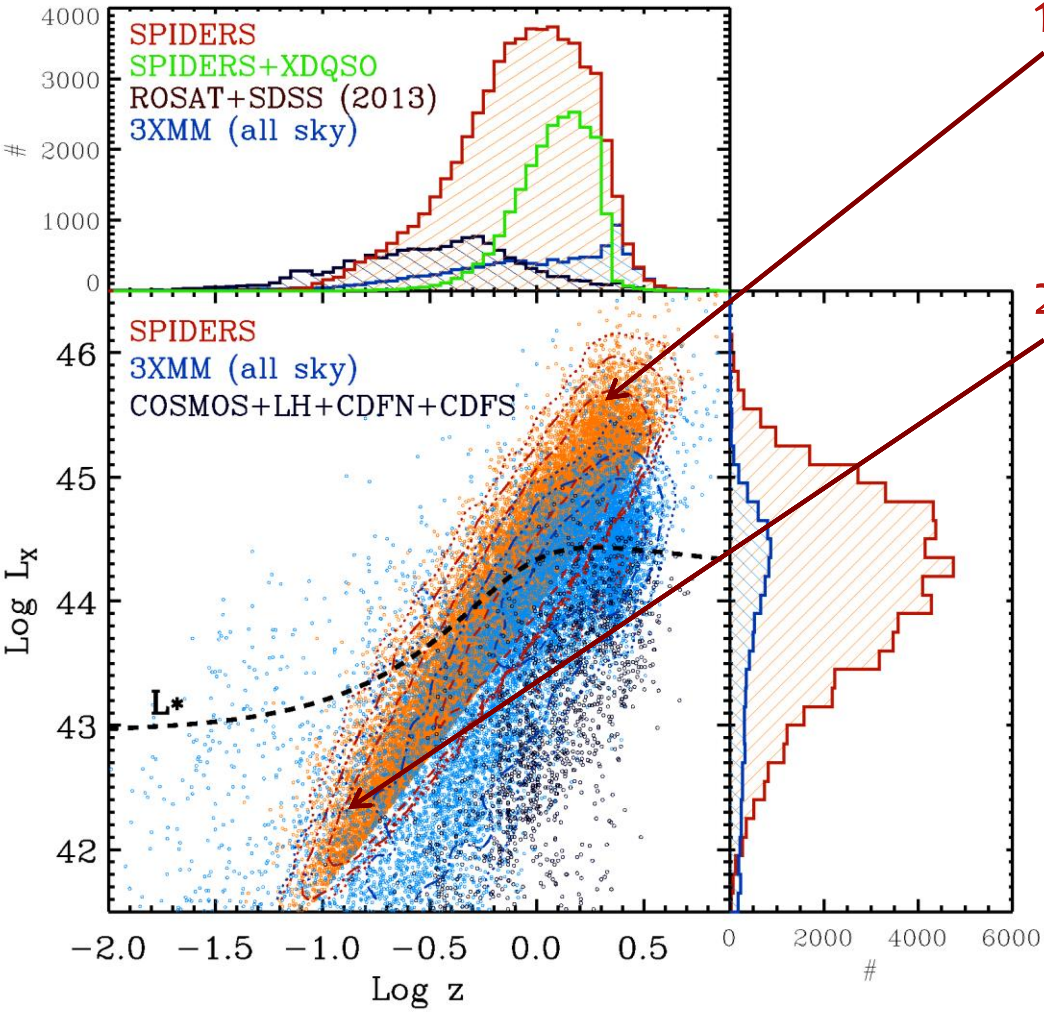




- Photons registered at detector; detection threshold fixed at **50 counts**.
- Include scatter in L_X–M relation; “self-calibration”.
- Include expected redshift uncertainty.
- Apply two cosmological tests simultaneously; evolution of (i) cluster **mass function** and (ii) **angular clustering**.
- Assume: hardware works, flat Universe, fiducial cosmology and L_X–M relation, redshifts (either specz or photoz), one sky for all, etc.

Pillepich+2012; Merloni+2012

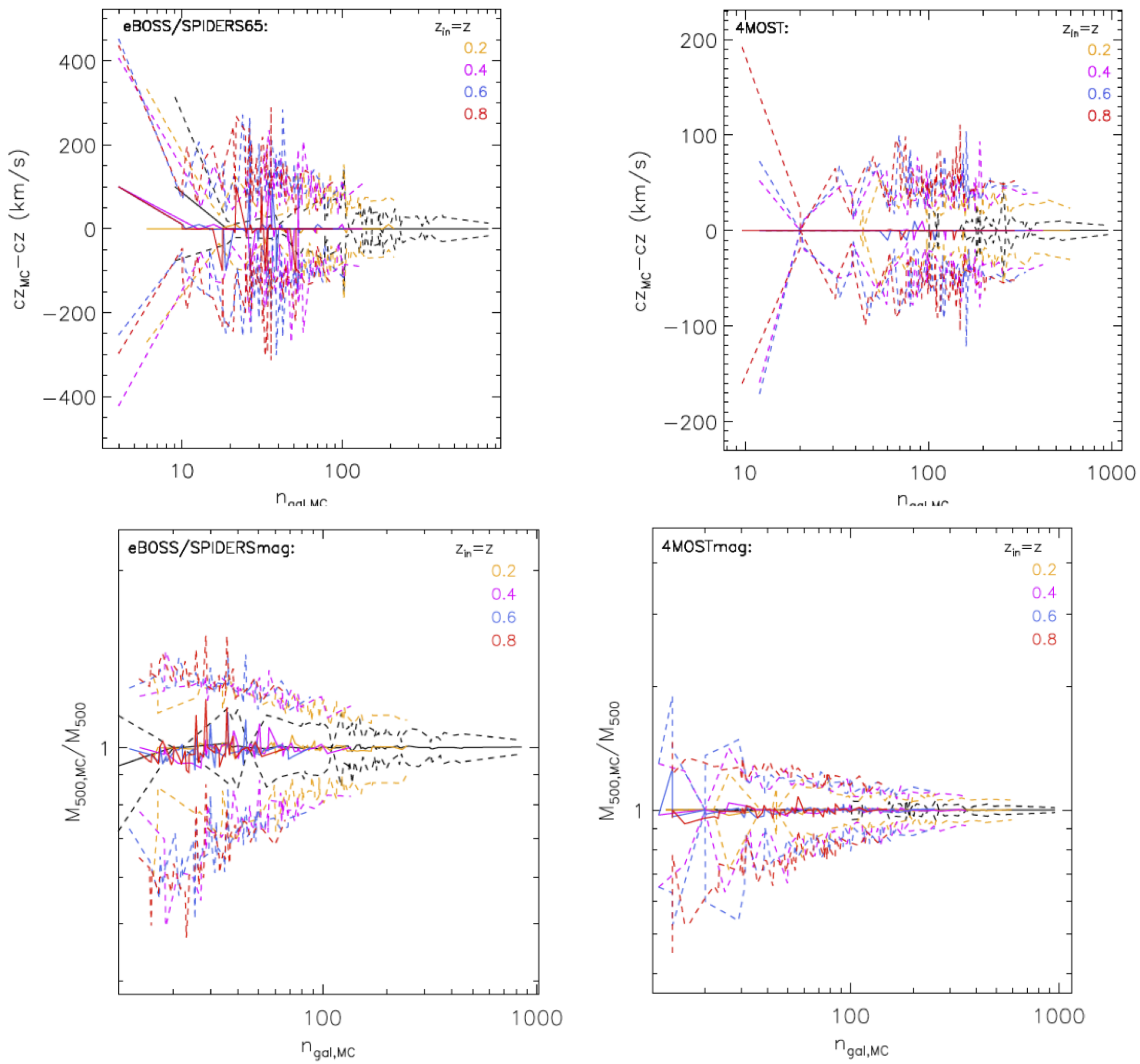
SPIDERS AGN



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

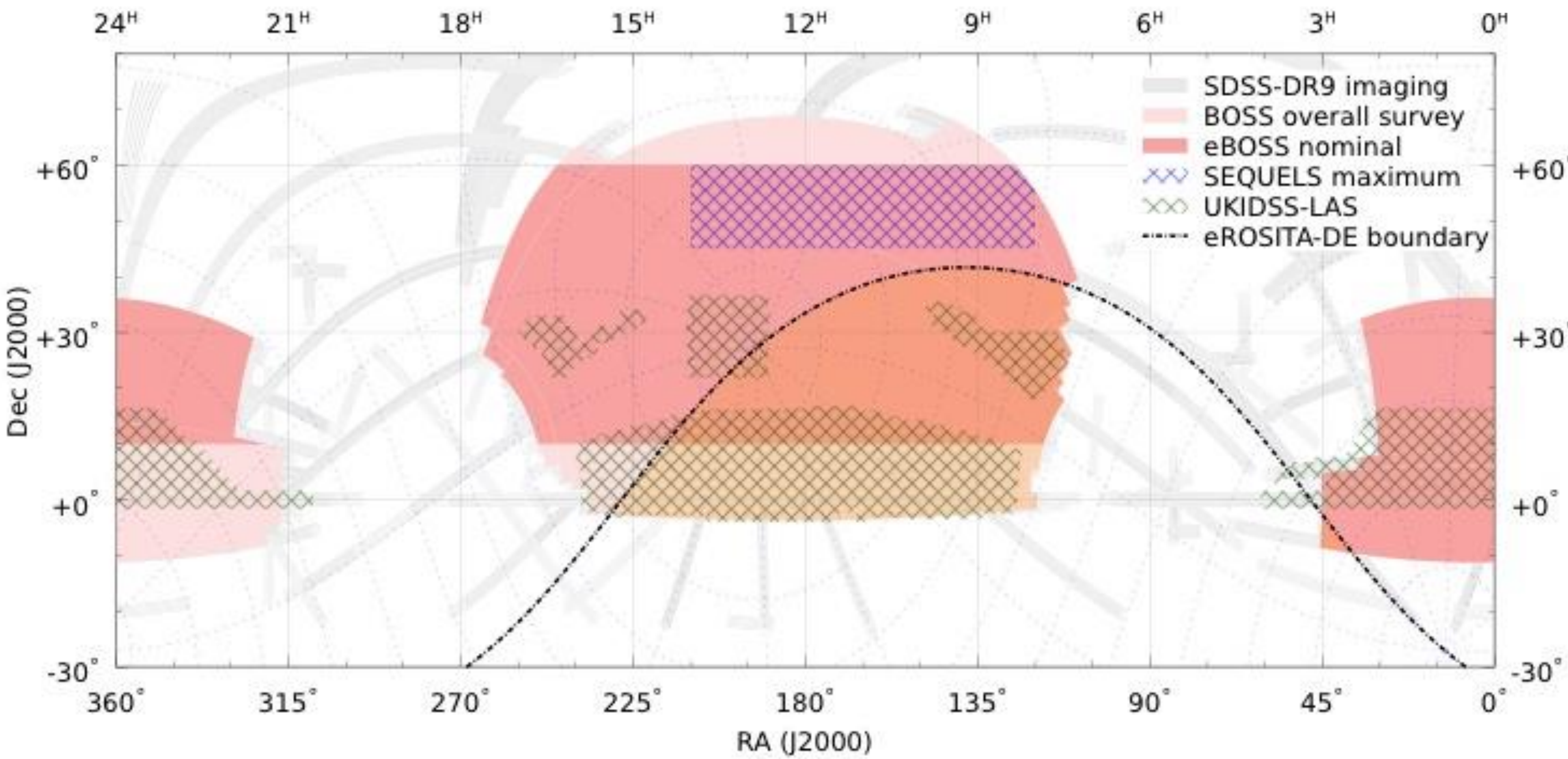
In both areas, SPIDERS will deliver spectroscopic samples ~1 order of magnitude larger than anything done before!

z and M_{dyn} calibration



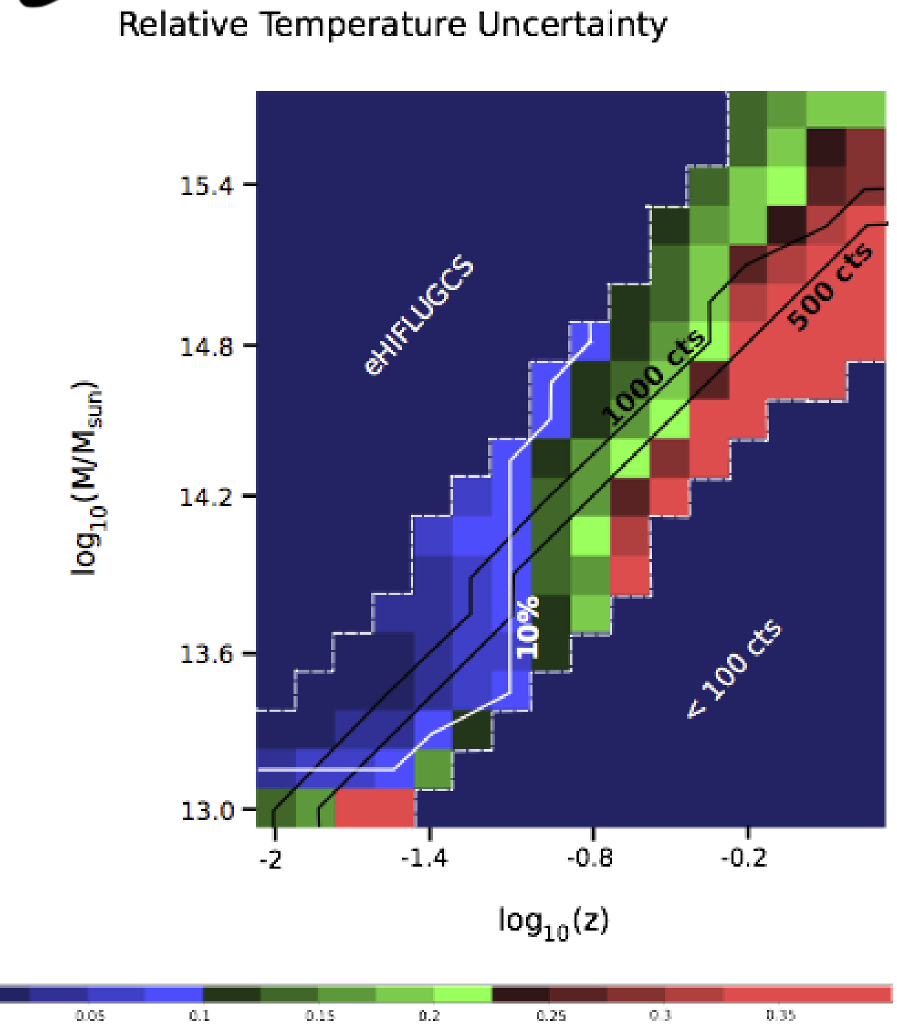
Courtesy of Y. Zhang, Bonn Univ.

SPIDERS/SEQUELS



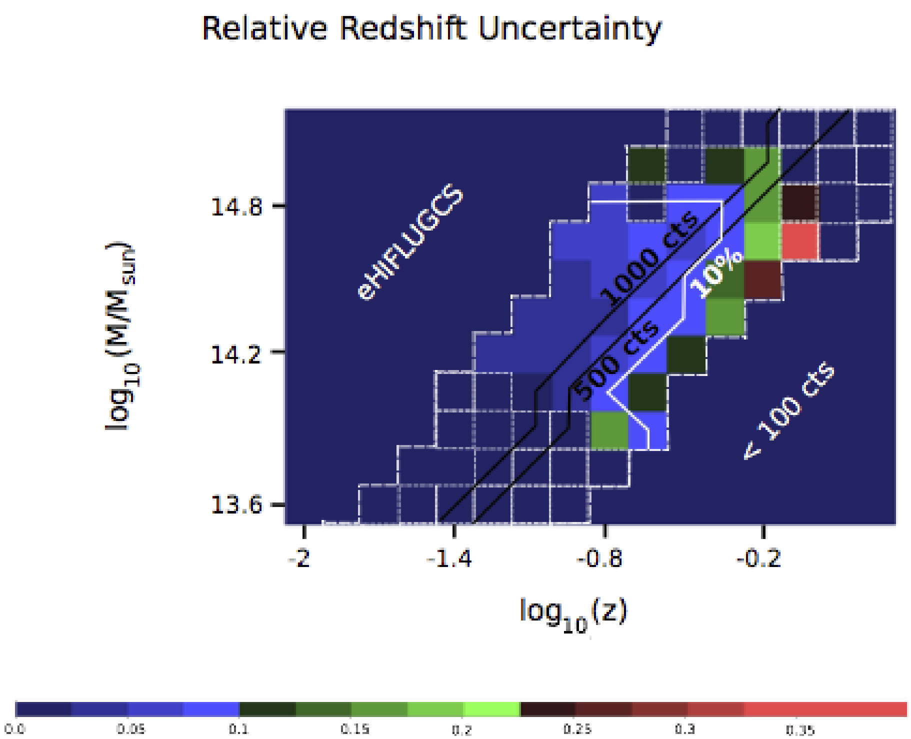
Early (eRASS:1-4) spectroscopic follow-up over most of the eROSITA_DE/eBOSS overlap region (2000-3000 deg^2)
+ complete follow-up of RASS AGN and clusters
(PI: Merloni & Nandra)

Clusters astrophysics



Borm+2014

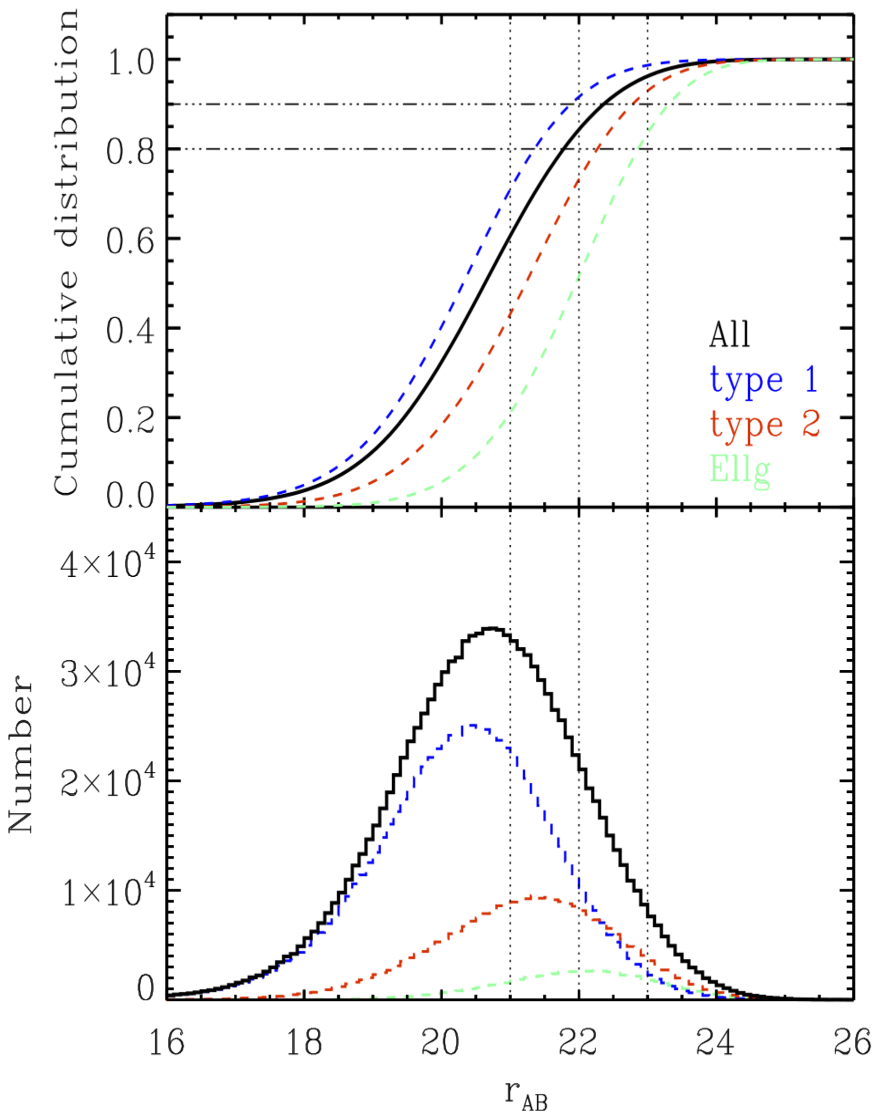
eRASS:8 simulation, T_{exp}=1.6 ksec



~ 1,700 clusters with precise Temperature (to <10%), up to z~0.08
~23,000 clusters with accurate redshift determination, up to z~0.45

AGN: Can we follow them up?

CALIBRATED ON XMM-COSMOS



- **IDENTIFICATION COUNTERPARTS:**

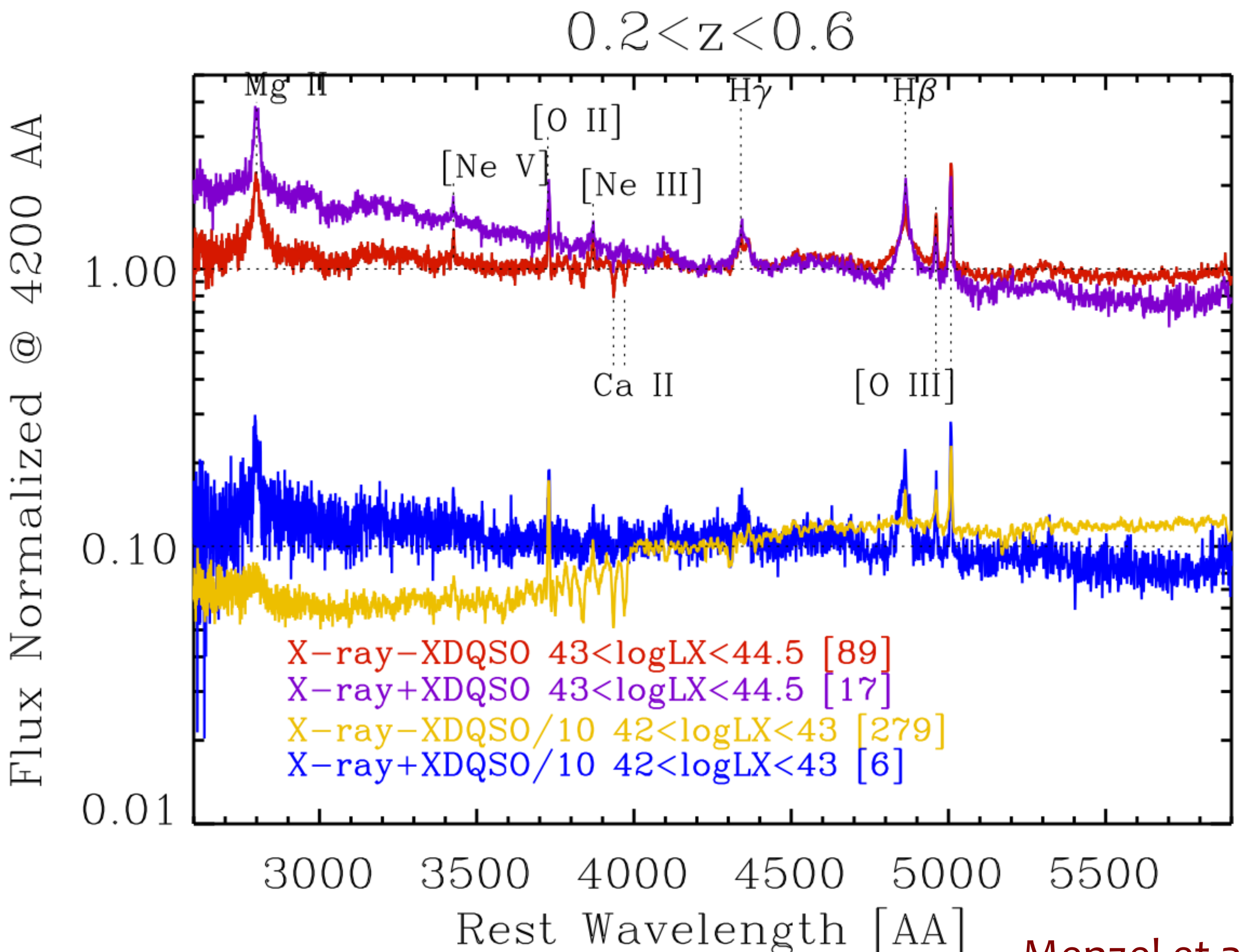
•X-ray positional uncertainty is an issue: test with ML (degraded XMMCOSMOS) = ~87 (+5)% secure ID at i=24 [~60-70% in VHS]

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

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

Merloni et al. 2012

Uniqueness of X-ray selected AGN



Menzel et al. 2015

www.mpe.mpg.de/eROSITA

The eROSITA Bulletin

No.5, November 2014

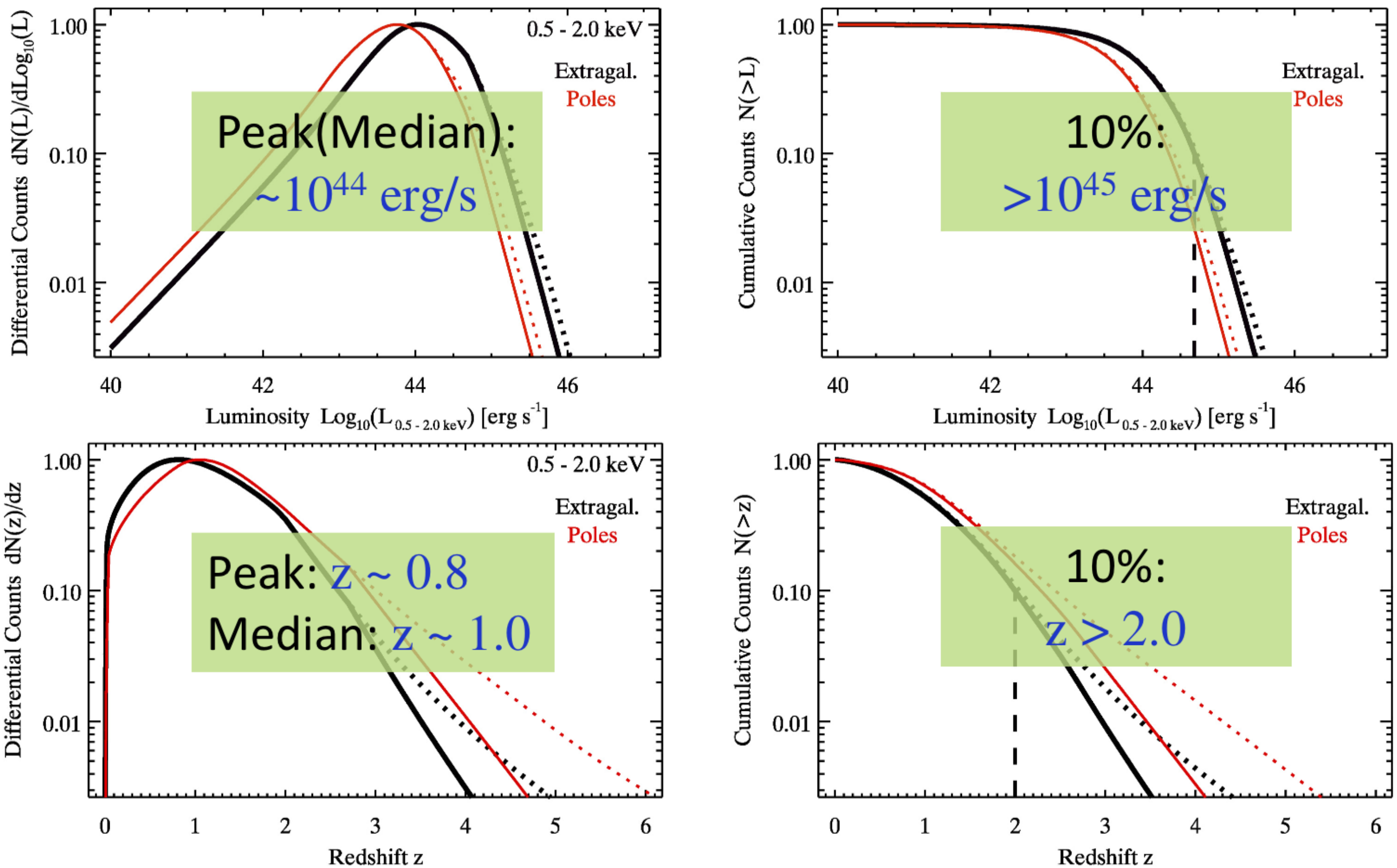
Between September 15 and 17, 2014, more than 70 members and guest of the German eROSITA Consortium gathered at the Leibnitz Institut für Astrophysik (AIP) in sunny Potsdam for the yearly Consortium meeting. Alongside plenary sessions and working group splinter meetings, special dedicated parallel sessions devoted to time-domain astrophysics, imaging and spectroscopic follow-up plans and the 'cosmology challenge' were also scheduled.
More information, and all the presentations are available on the eROSITA_DE Wiki pages.

1. Overall project status and milestones

The tests with the eROSITA Technological Model performed at Lavochkin Association (LA) last October were successful. eROSITA and the 'Navigator' platform were able to communicate as required. The clearing of this critical hurdle allows now the work on the interface and control electronics to proceed as planned.

A legacy sample of 3M AGN

Kolodzig et al. 2012



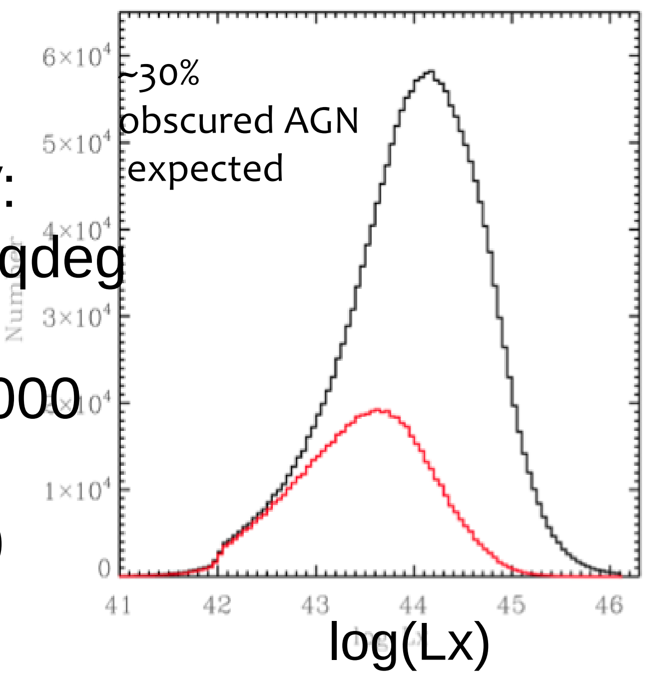
Unobscured/obscured AGN

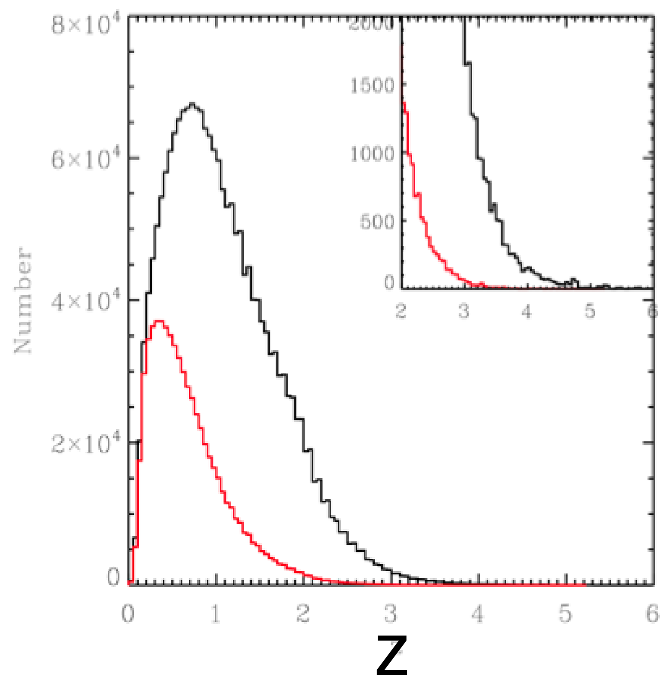
logNH>21		Log X-ray (0.5-2 keV) Luminosity [erg/s]		
		44-45	**45-46**	**46-47**
Redshift range	**0-1**	2.20×10^{5} (4.90×10^{4})	2.02×10^{3} (8.15×10^{2})	12 (7)
	1-2	1.00×10^{6} (1.13×10^{5})	4.14×10^{4} (1.29×10^{4})	355 (200)
	2-3	1.81×10^{5} (2.37×10^{4})	7.90×10^{4} (2.32×10^{4})	765 (400)
	>3	3.20×10^{3} (3.32×10^{2})	2.14×10^{4} (5.50×10^{3})	472 (3)

using XBG models from Gilli+07

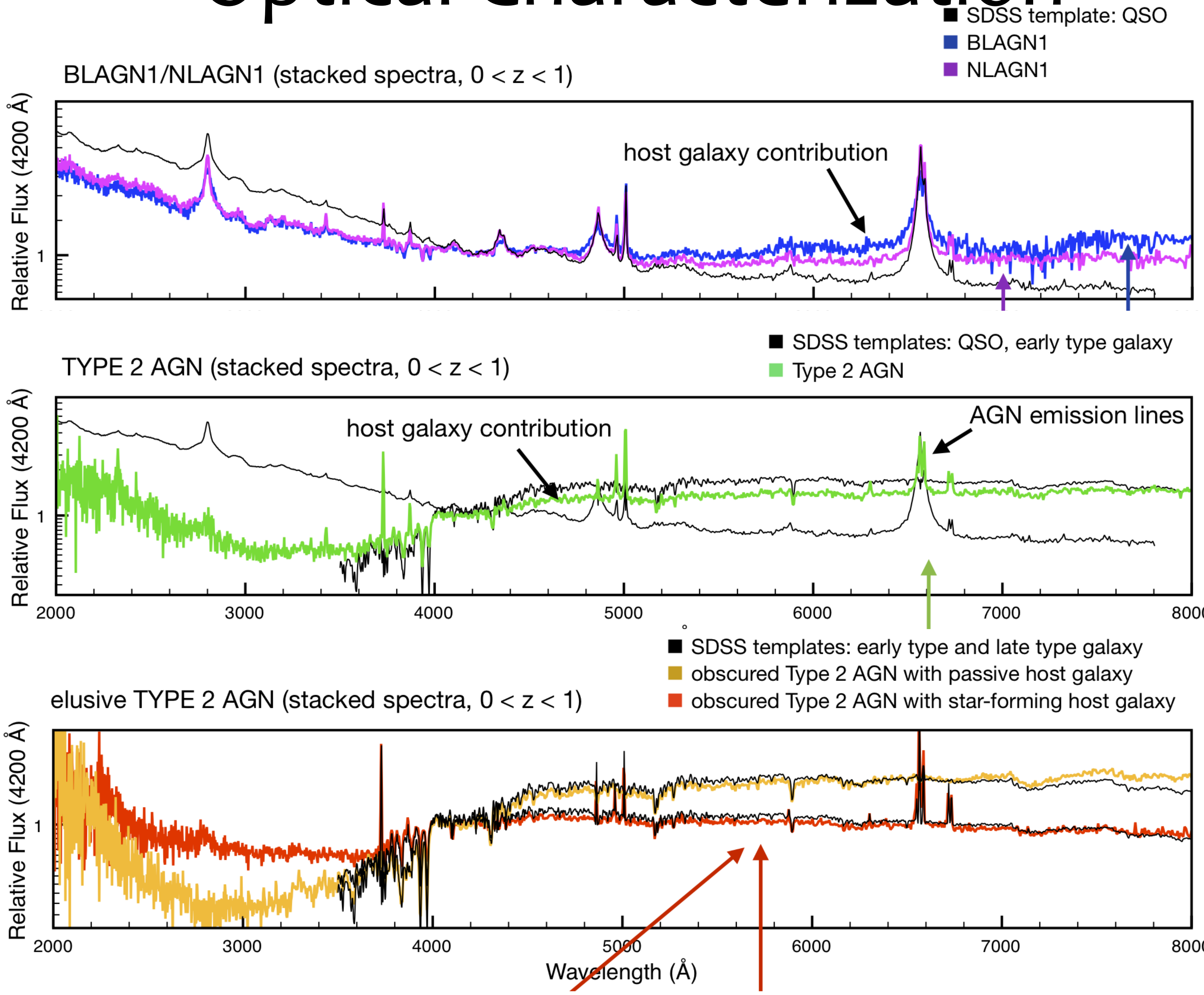
See also Kolodzig et al. 2013

0.5-2keV:
0.2-0.5/sqdeg
CT AGN
6000-15000
all sky!
(Akylas+12)



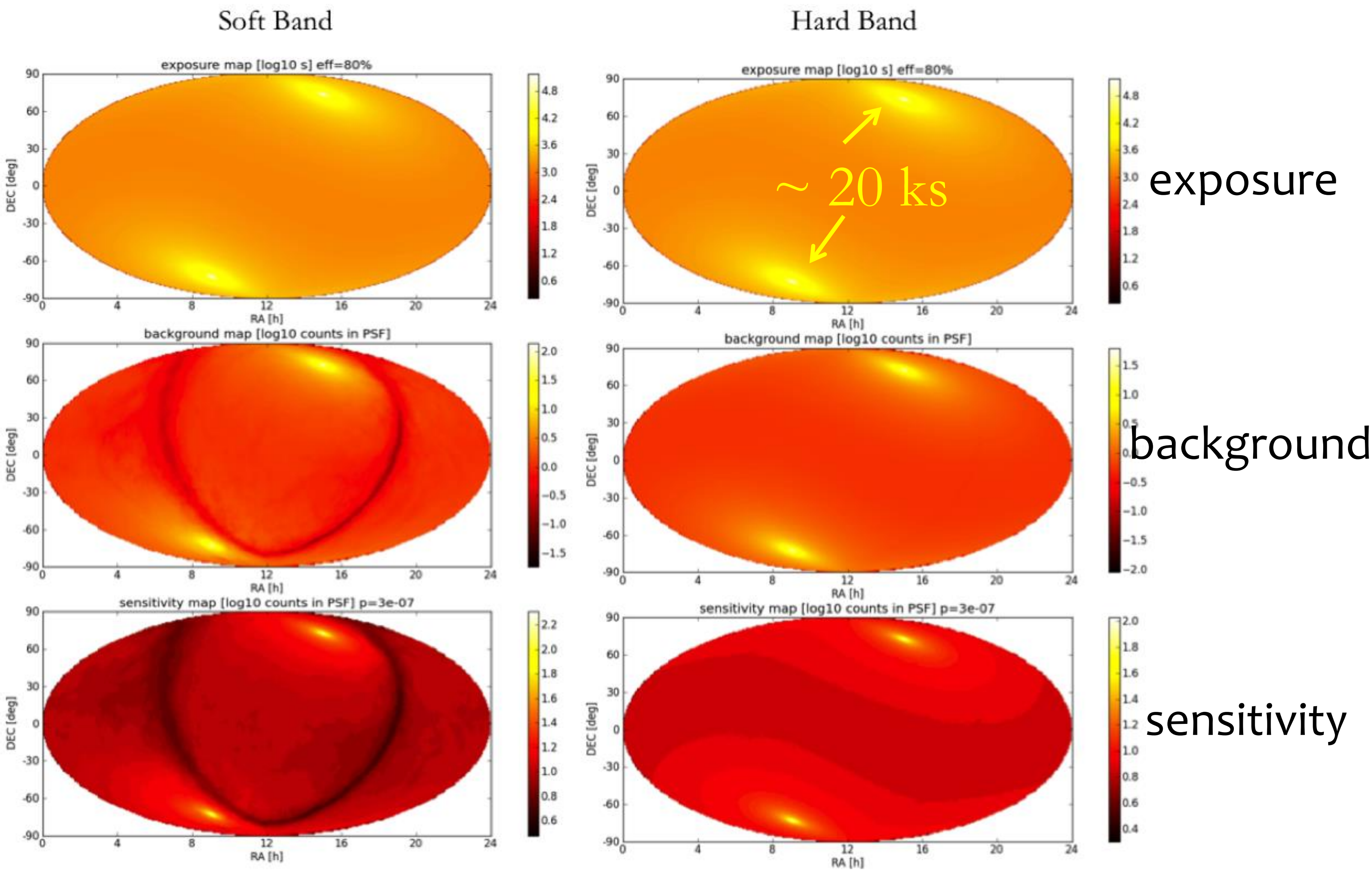


Optical Characterization

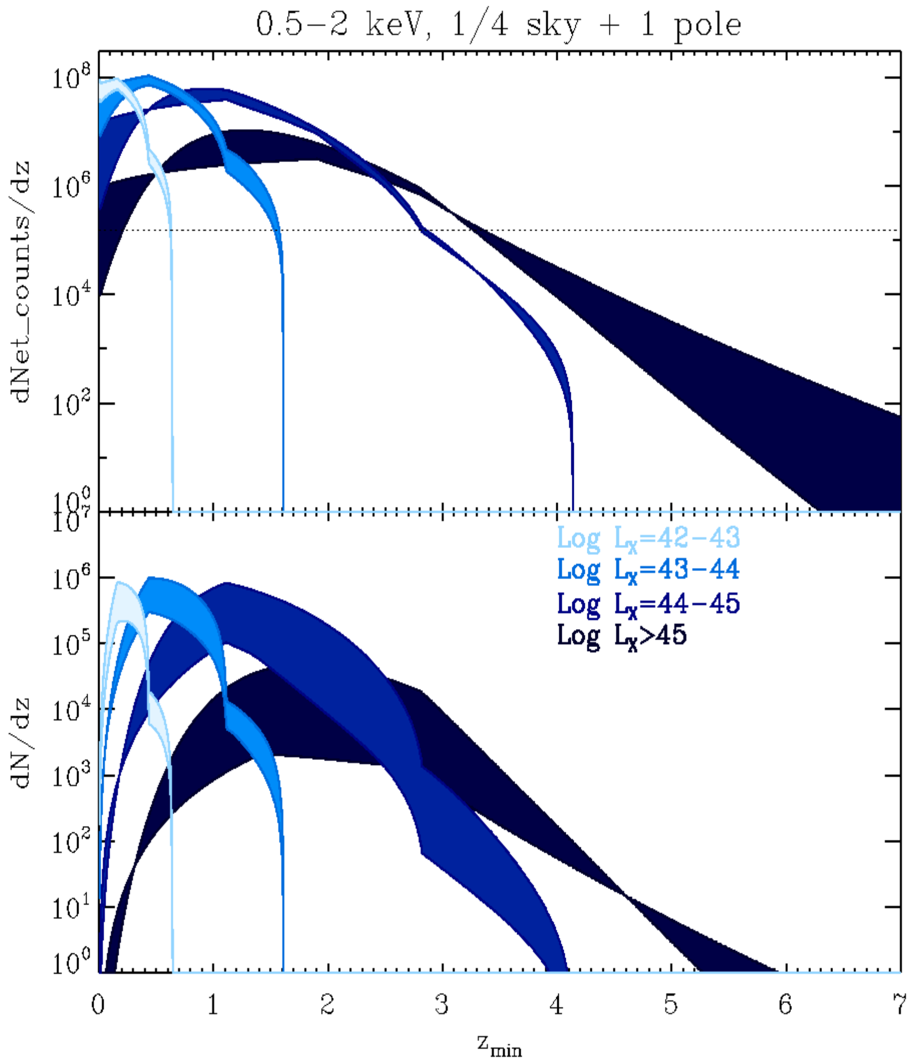


Menzel et al. in prep

A fast survey machine

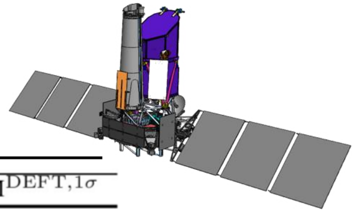


eROSITA power for AGN physics



- Only samples of this size will allow studying AGN vs. L, z, N_H, M, SFR, etc.
- 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)

Cosmology Forecasts II



Data	Redshifts	Prior Scenario	Model	Δf_{NL}^{local}	$\Delta\sigma_8$	$\Delta\Omega_m$	Δw_0	Δw_a	$FoM^{DEFT,1\sigma}$
eROSITA	photo-z	Pessimistic	LCDM+PNG	8.1	0.012	0.0101	-	-	-
eROSITA	spectro-z	Optimistic	LCDM+PNG	6.4	0.007	0.0060	-	-	-
eROSITA + Planck	photo-z	Pessimistic	LCDM+PNG	6.5	0.006	0.0021	-	-	-
eROSITA + Planck	spectro-z	Optimistic	LCDM+PNG	5.0	0.004	0.0015	-	-	-
eROSITA	photo-z	Pessimistic	w0CDM+PNG	8.2	0.016	0.0109	0.066	-	-
eROSITA	spectro-z	Optimistic	w0CDM+PNG	6.6	0.009	0.0063	0.043	-	-
eROSITA + Planck	photo-z	Pessimistic	w0CDM+PNG	6.9	0.007	0.0034	0.026	-	-
eROSITA + Planck	spectro-z	Optimistic	w0CDM+PNG	5.6	0.005	0.0025	0.023	<1%, <3%	-
eROSITA	photo-z	Pessimistic	wCDM+PNG	8.2	0.018	0.0120	0.098	0.27	57.4
eROSITA	spectro-z	Optimistic	wCDM+PNG	6.6	0.011	0.0066	0.075	0.23	103.1
eROSITA + Planck	photo-z	Pessimistic	wCDM+PNG	7.0	0.007	0.0036	0.059	0.21	179.4
eROSITA + Planck	spectro-z	Optimistic	wCDM+PNG	5.7	0.006	0.0026	0.048	0.16	263.3
DES	photo-z	WL+2D photometric	wCDM+PNG	8.6	0.009	0.0082	0.093	0.61	-
DES + Planck	photo-z	WL+2D photometric	wCDM+PNG	8.2	0.009	0.0074	0.090	0.35	-
Euclid	photo-z	WL+2D photometric	wCDM + PNG	4.7	0.005	0.0048	0.054	0.32	-
Euclid	spectro-z	WL+2D spectroscopic	wCDM + PNG	5.7	0.005	0.0051	0.051	0.35	-
Euclid + Planck	photo-z	WL+2D photometric	wCDM + PNG	4.5	0.005	0.0044	0.052	0.20	-
Euclid + Planck	spectro-z	WL+2D spectroscopic	wCDM + PNG	5.3	0.005	0.0037	0.035	0.15	-

Stage IV (eROSITA)

>300 for f_{NL}=0

Stage III (DES)

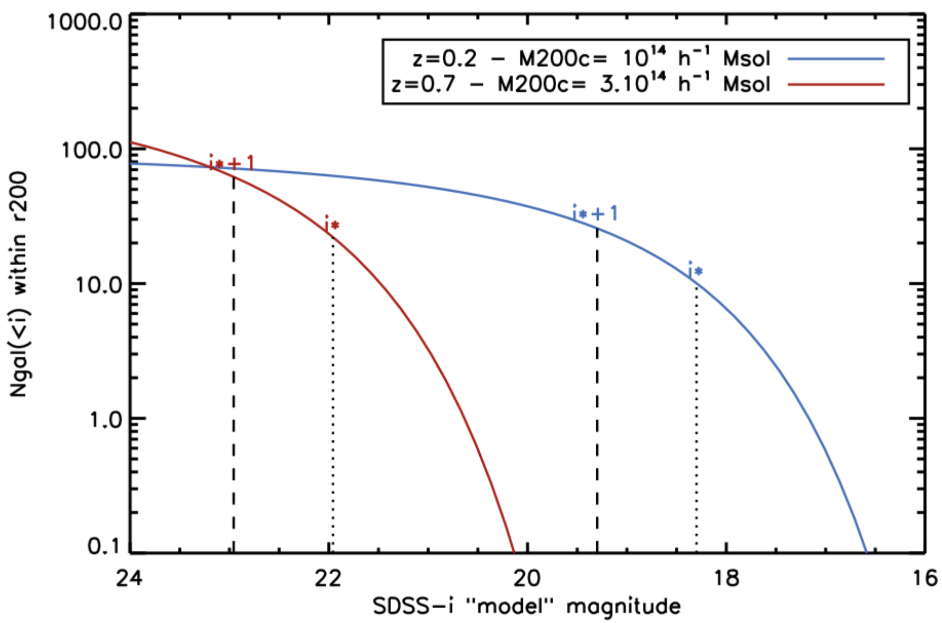
Stage IV (Euclid)

- Photons registered at detector; detection threshold fixed at **50 counts.**
- Include scatter in L_X–M relation; "self-calibration".
- Include expected redshift uncertainty.
- Apply two cosmological tests simultaneously; evolution of (i) cluster **mass function** and (ii) **angular clustering**.
- Assume: hardware works, flat Universe, fiducial cosmology and L_X–M relation, redshifts (either specz or photoz), one sky for all, etc.

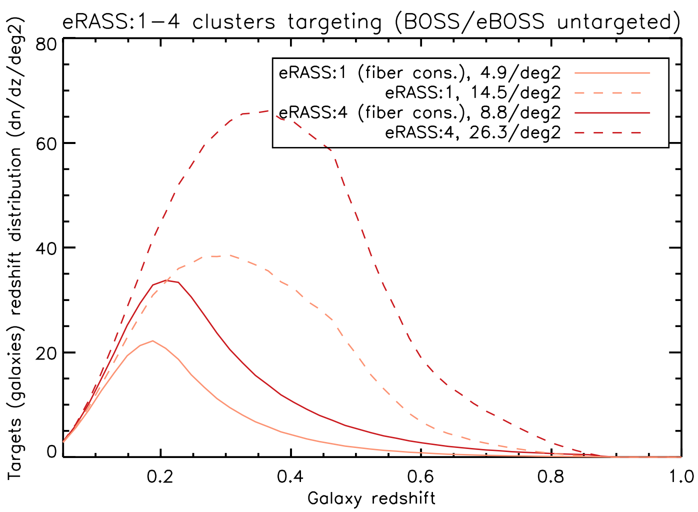
Pillepich+2012; Merloni+2012

eROSITA clusters

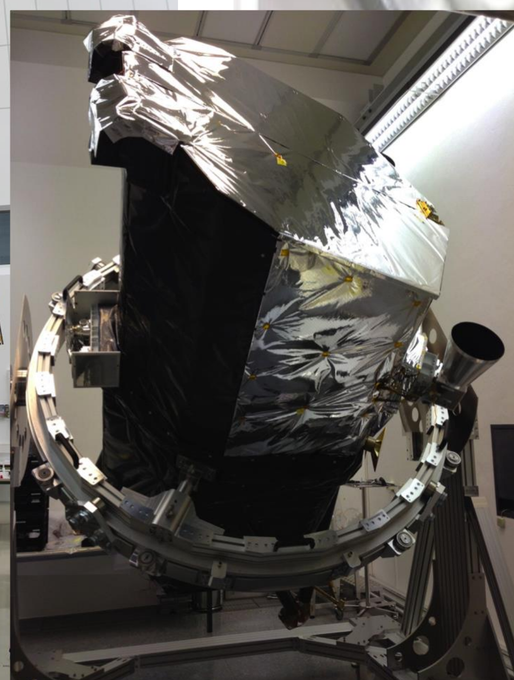
- Confirmation
  - Best: > 10 similar z
  - Average: 3 similar z
  - Extreme case: 1 z (BCG)+photo-z



- Velocity dispersions
  - ~10 members: scatter and bias (understood with simulations)
  - Stacking in M (or Lx/z) → accurate scaling relations
- Completeness
  - X-ray selection well-handled
  - Sampling ok if unrelated to X-ray properties



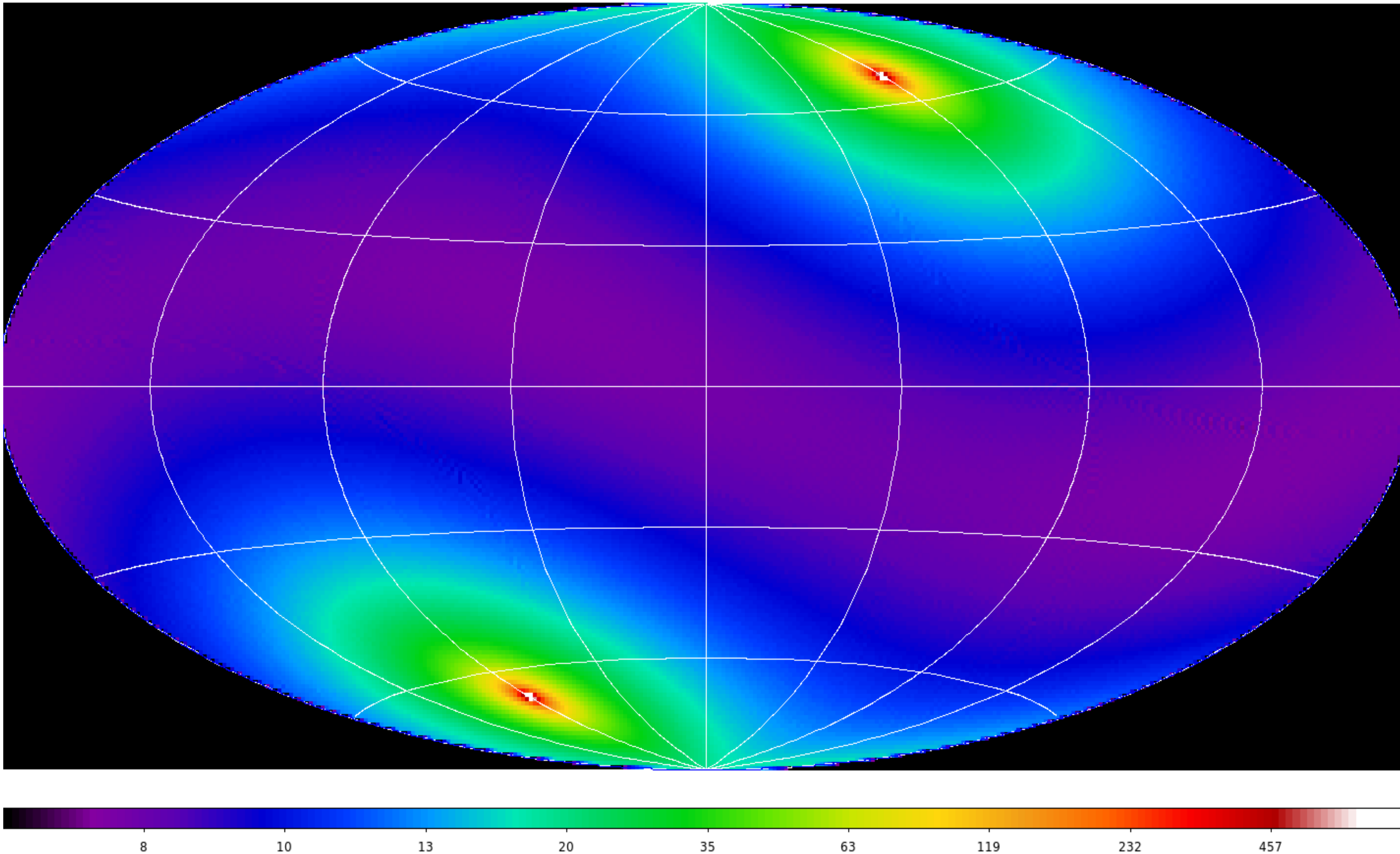
Telescope structure



Wide area surveys

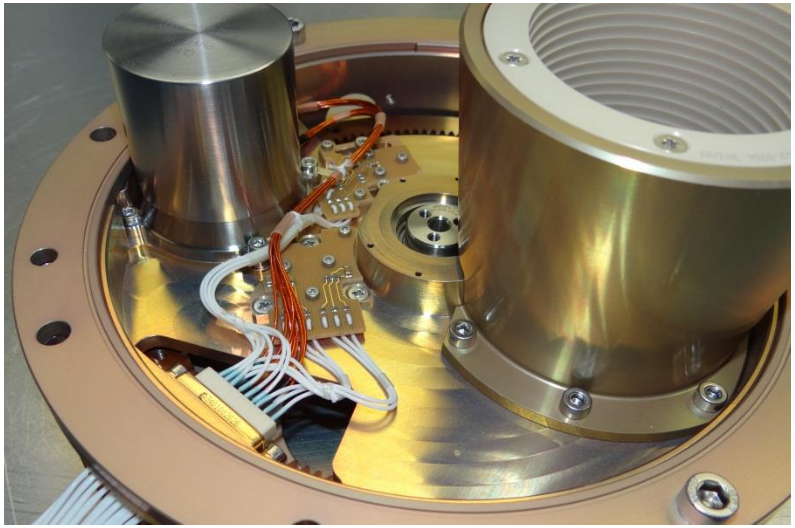
Survey	Lat	Date	Ω	u	g	r	i	z	Y	J	H	K
SDSS	+30	-‘10	10000	21.6	22.6	22.4	21.6	20.1	-	-	-	-
PS1	+20	’10-‘12	30000	-	22.6	22.4	22.1	21.1	-	-	-	-
SkyMapper	-30	‘14-	30000	22.5	22.5	22	20.9	20.6	-	-	-	-
KIDS+VIKING	-20	‘11-	1500	24.8	25.4	25.2	24.2	22.4	21.6	21.2	20.7	20.5
DES+VHS	-30	’12-‘16	5000	-	24.6	24.1	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	-	-	-

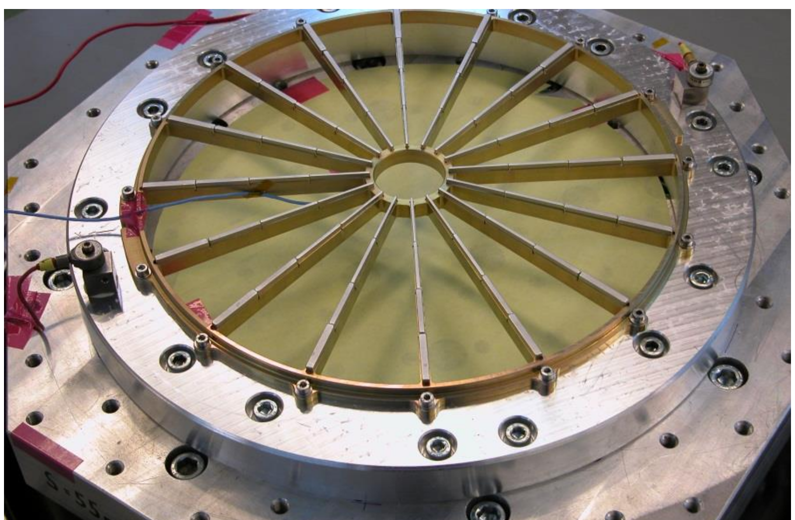
Cadence Map



Merloni et al. 2012

eROSITA Hardware

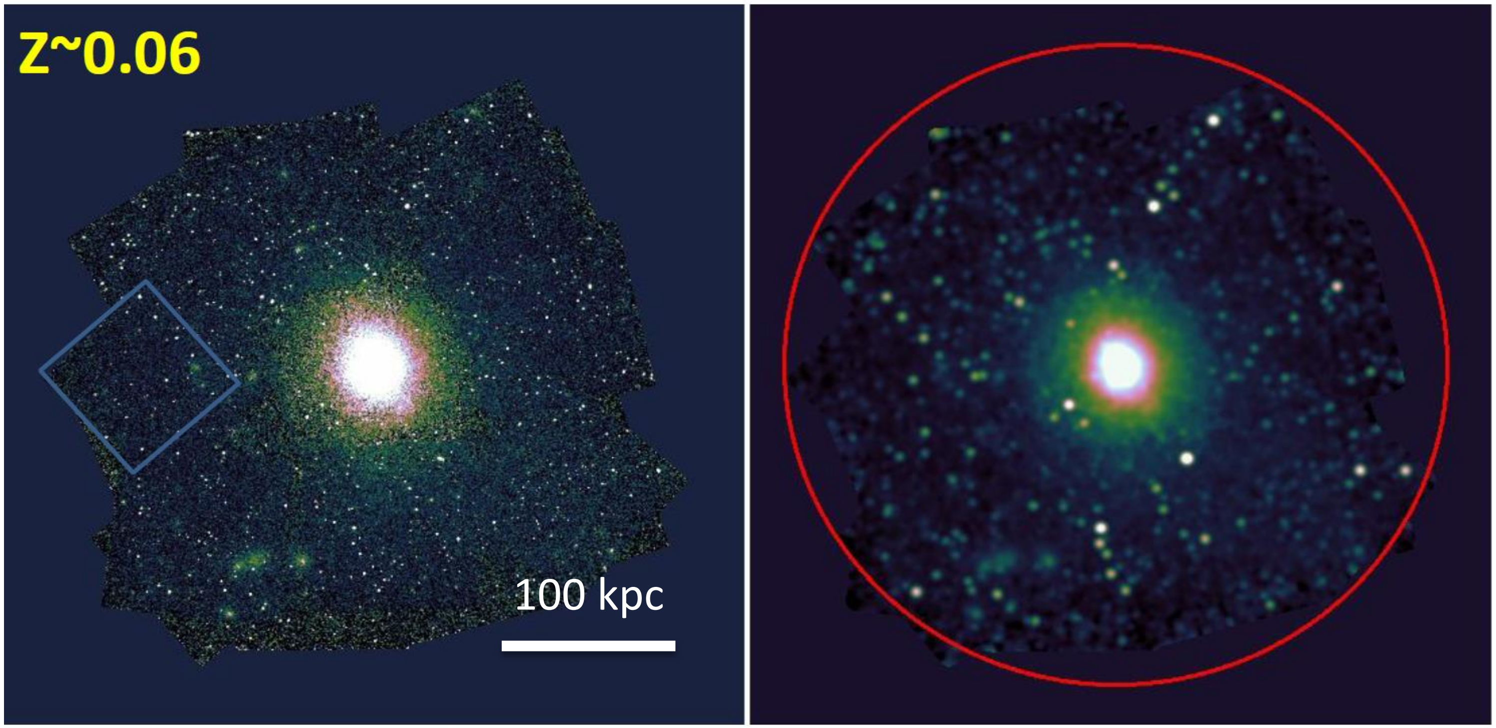




Friedrich et al, 9144-185

A fast survey machine

Chandra | **eRosita**



~30 pointings
~2 Msec
[0.5” HEW]

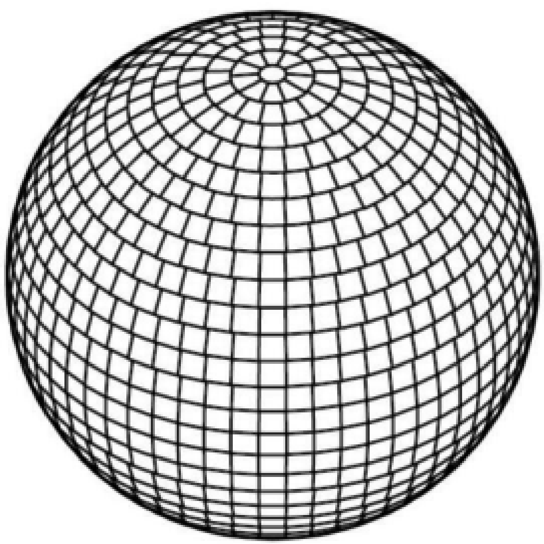
~1 pointing
~80 ksec
[28” HEW (FoV avg)]

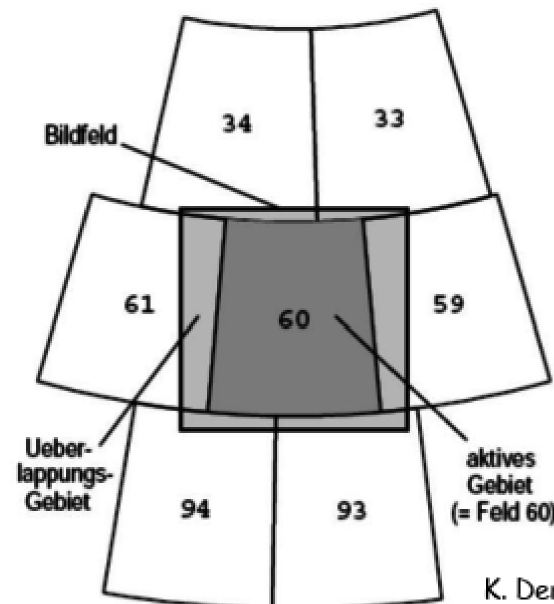
Churazov, IKI, MPA

The SASS pipeline processes all-sky survey and pointed data:

All-sky survey:

- Sky is divided into 5839 equatorial equal-area fields of approx. 3°x3°
- After event-calibration, incoming data stream is split and accumulated in same number of overlapping 3.6°x3.6° fields, centred on each of these fields (local, parallel projection sky maps)
- Source detection and further source-level analysis is performed on these sky maps



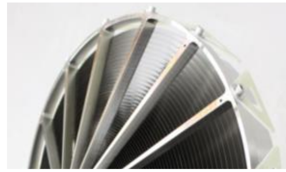


K. Dennerl,
Survey II Concept

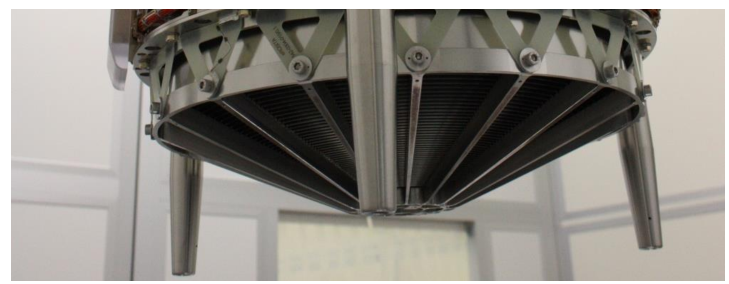
Pointed observations:

- Incoming data stream is split in different pointings (←timeline)
- Source detection is performed on 1.6°x1.6° fields, centred on pointing

7+1 Mirror Modules


	Goal	FM1	FM2	FM3	FM4	FM5	FM6	FM7	FM8
HEW Al-K @ 1.49 keV	15”	16.1	16.8	15.7	16.0	16.2	16.3	15.6	17.1
HEW Cu-K @ 8.04 keV	20”	15.2	15.4	16.7	16.4	16.2	16.2	16.6	18.4
Eff. Area @ Al-K	364 cm^2	391	391	393	369	388	378	392	390
Eff. Area @ Cu-K	21 cm^2	24.8	24.8	25.1	23.8	24.1	25.1	25.0	24.2
Scattering @ Cu-K	15.5%	10.8	11.2	10.7	12.0	13.3	11.3	11.7	11.4

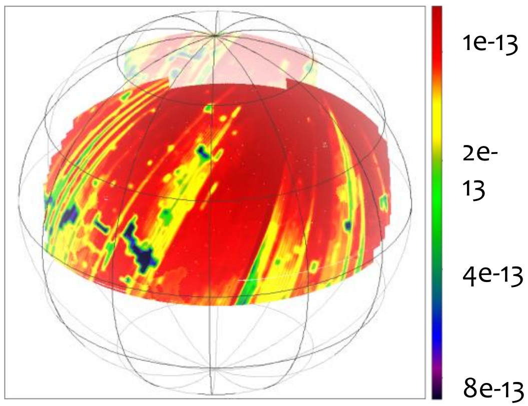
- 54 nested gold-coated nickel mirror shells
- Mirror modules competed and accepted in 12/2013
- Mirror assemblies (mirror + baffles) integrated & tested in 2014
- Calibration of all 8 telescopes at PANTER until summer-2015

Galaxy clusters in SPIDERS/SEQUELS

(N. Clerc, A. Merloni, A. Finoguenov, J. Ridl, the SDSS collaboration)

Pre-eRosita: CODEX (RASS+RedMapper)

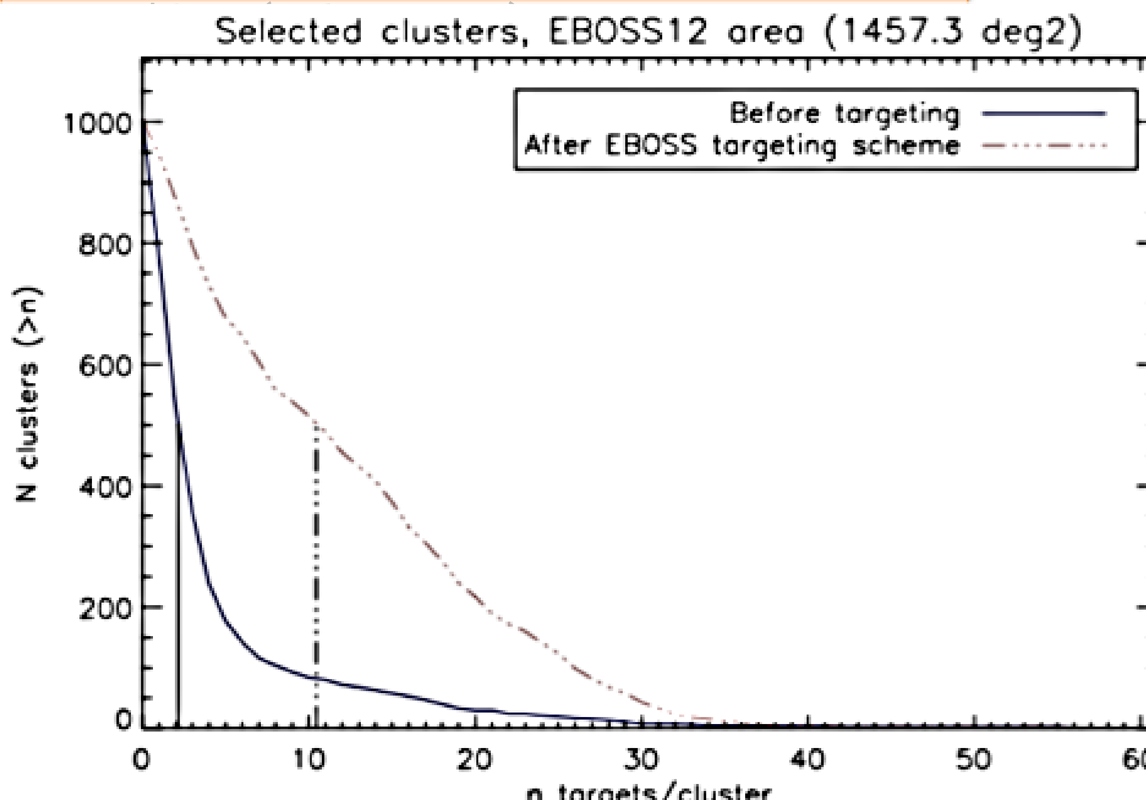
RASS-faint sensitivity ergs/s/cm²



SDSS ugriz+RedMapper

Goal: secure spectroscopic confirmation of 75% CODEX clusters (~4,000) + statistical velocity dispersion for massive subsamples

- 0.1<z<0.6

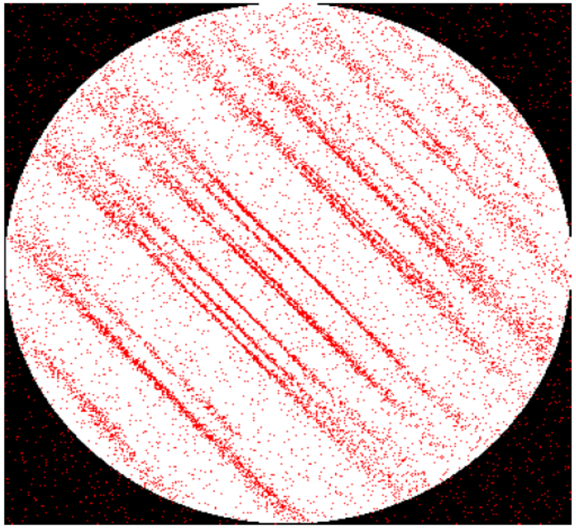


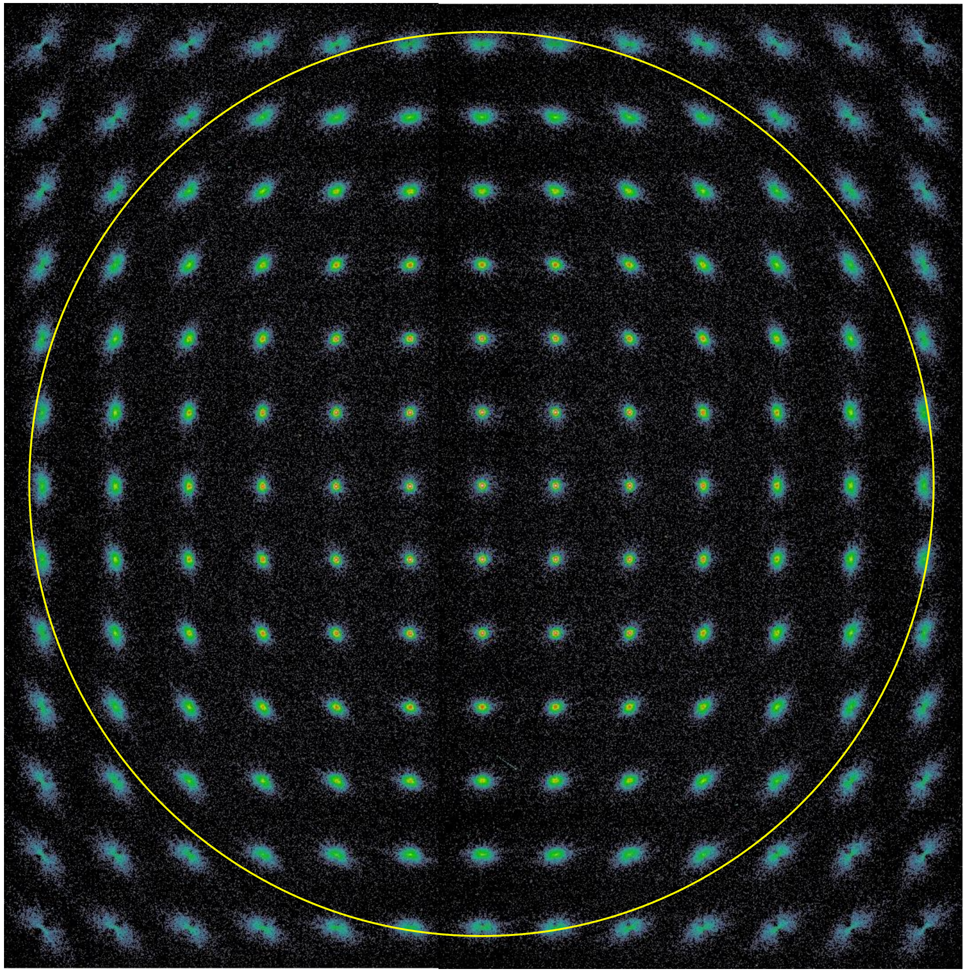
eRosita PSF

- 16”/**18”** on-axis HEW (@ 1.5 keV)

➔ 29”/**26”** survey-averaged

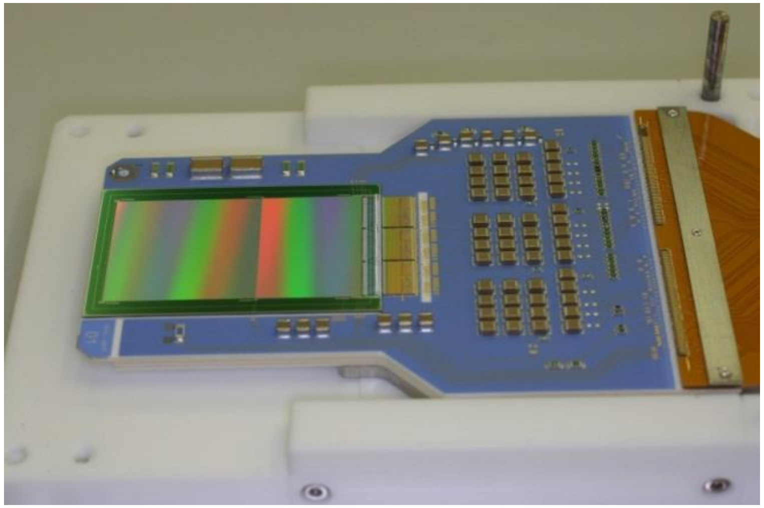
➔ 4”-6” Localization accuracy

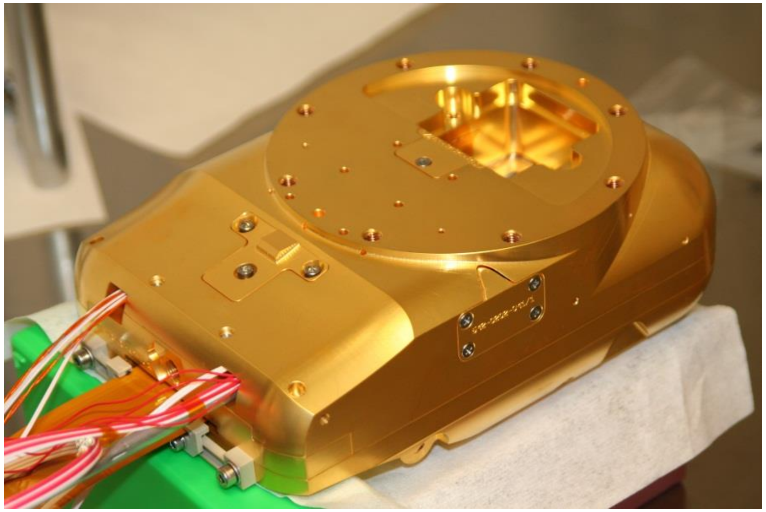


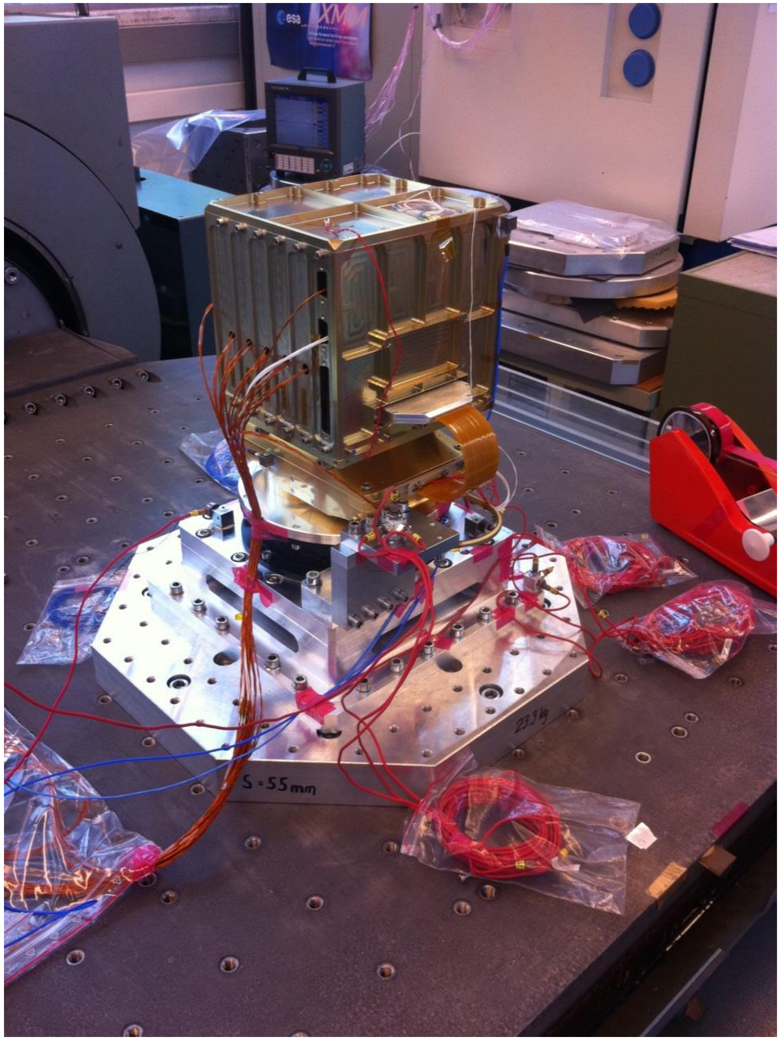


PANTER FM2 focal plane measurements @ 1.49 keV (*image NC, Panter-MPE*)

7+1 pnCCD cameras



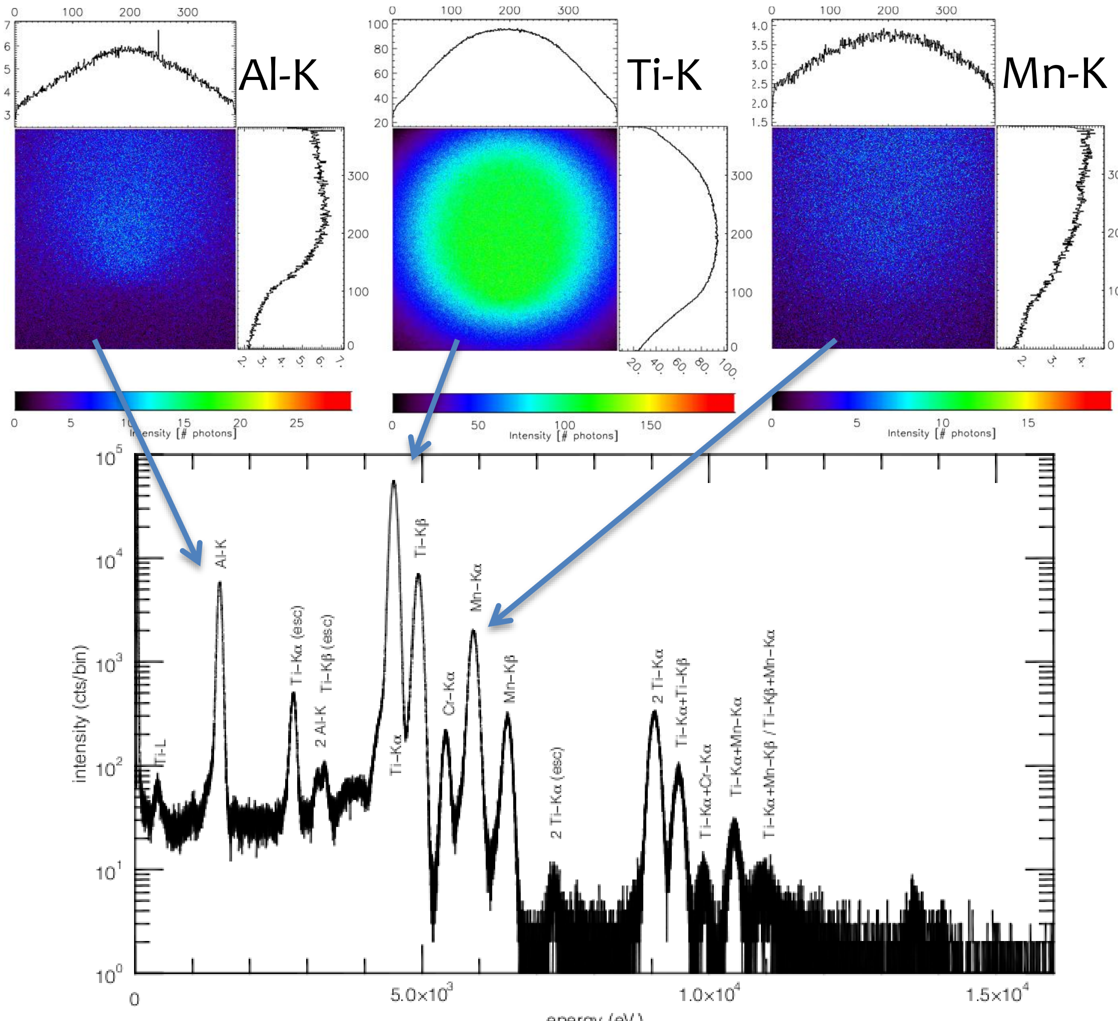


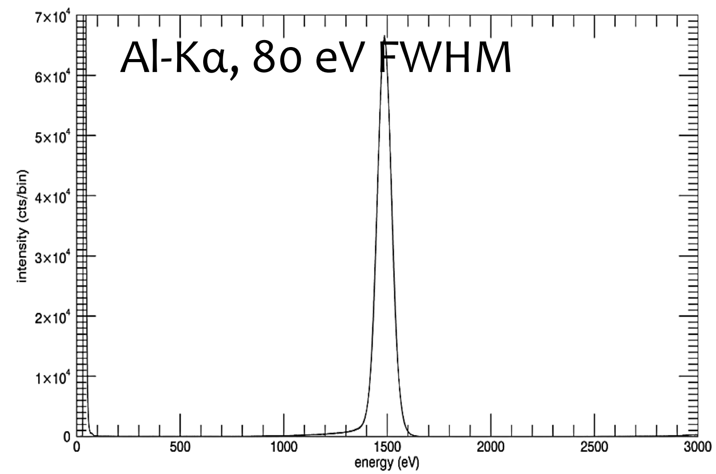


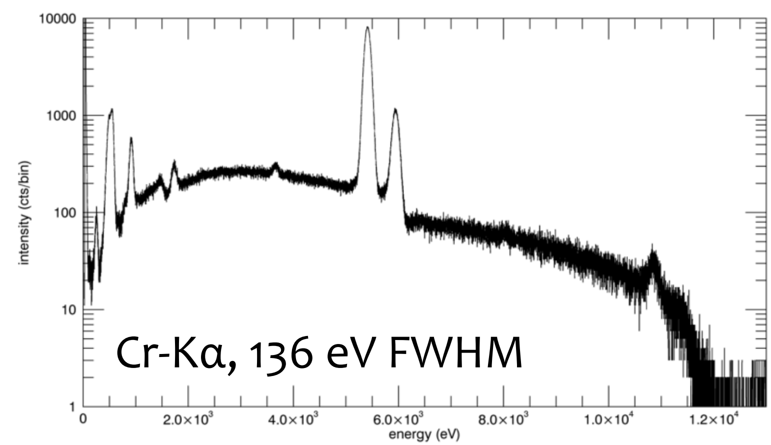
- 384×384 pixels or an image area of 28.8mm × 28.8mm
- Frame store area to reduce out-of-time events

Spectral resolution, calibration

On-board calibration source, uniform illumination

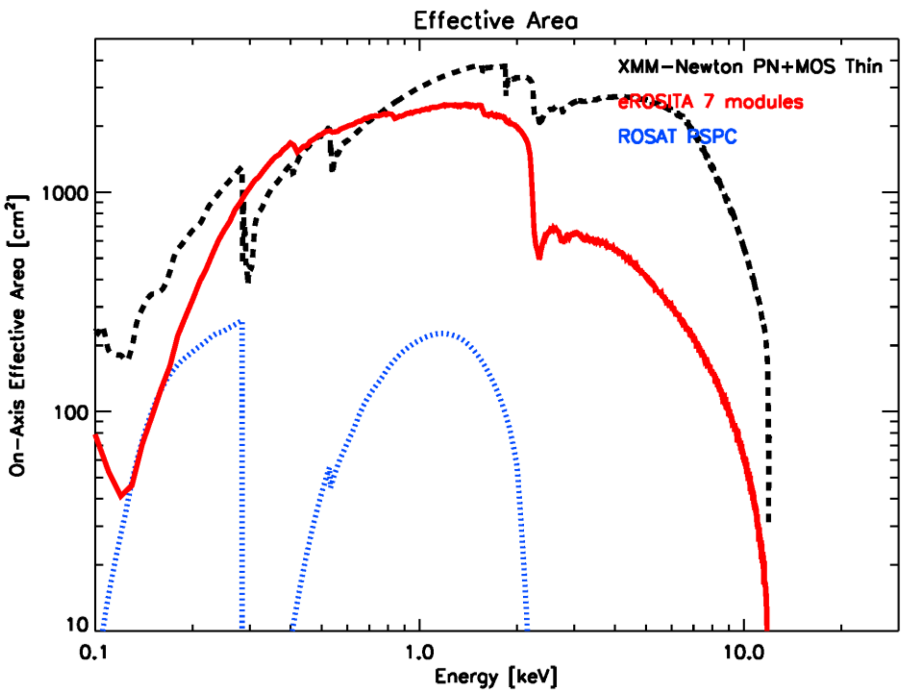


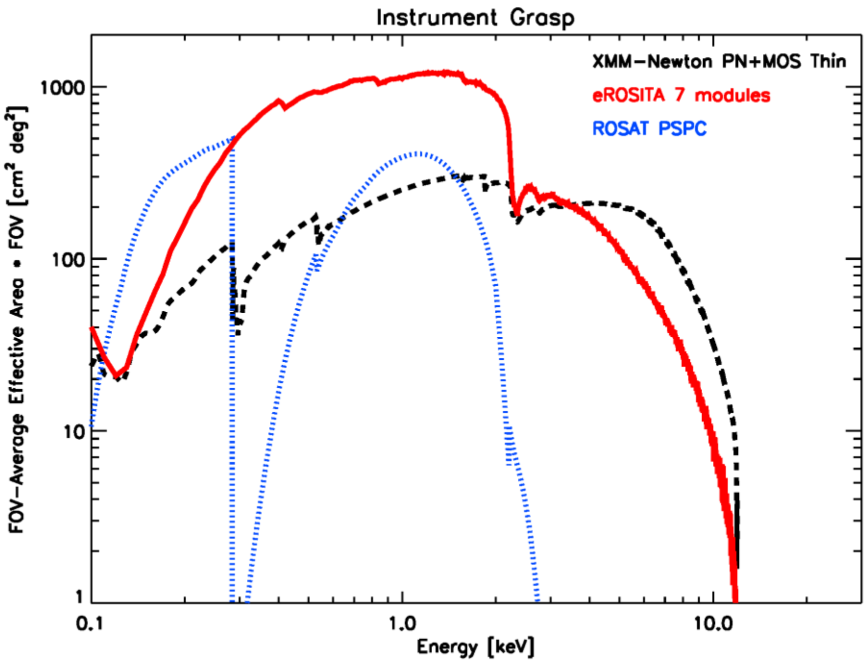




Spectral resolution ~80 eV @1.5 keV; 136eV @6keV

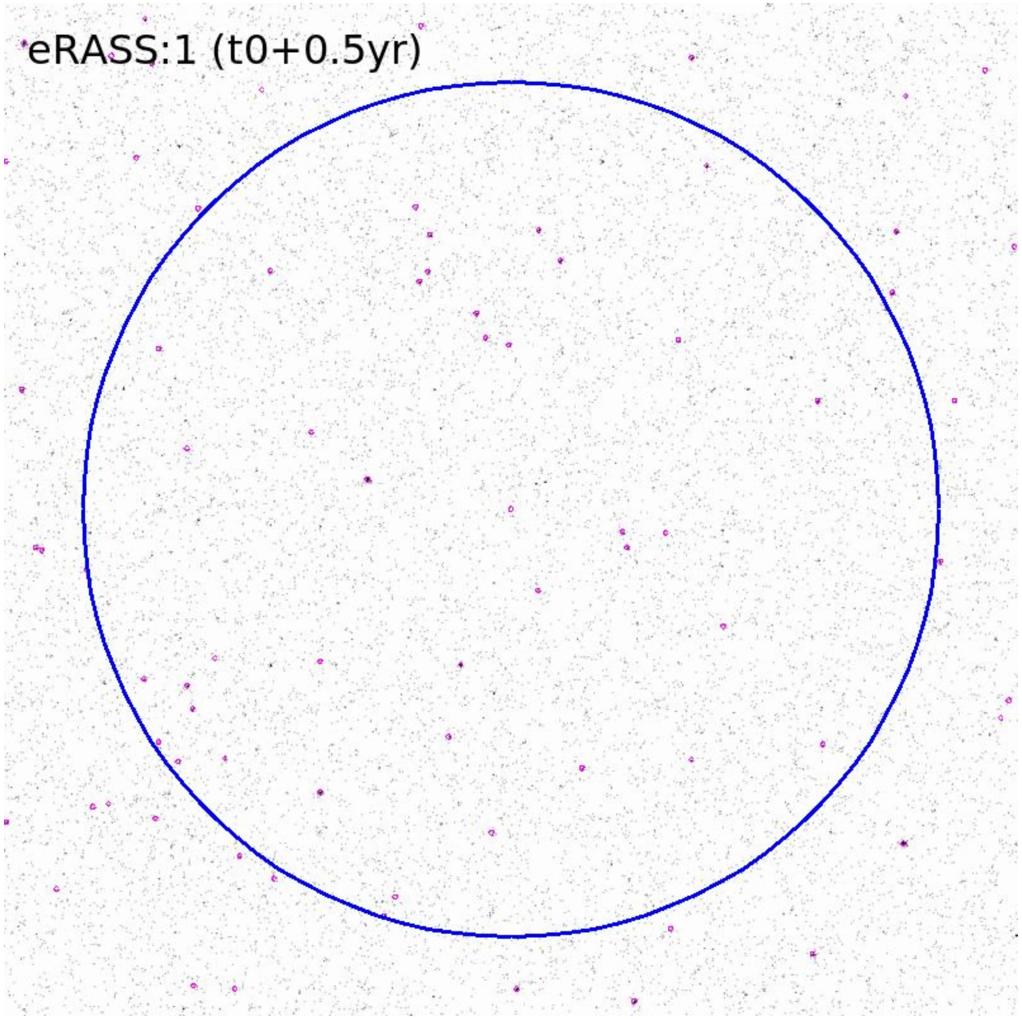
Effective Area and Grasp





- Effective area at 1keV comparable with XMM/Newton
- Factor ~7-8 larger surveying speed
- 4 years dedicated to all sky survey (with estimated 70-80% efficiency)

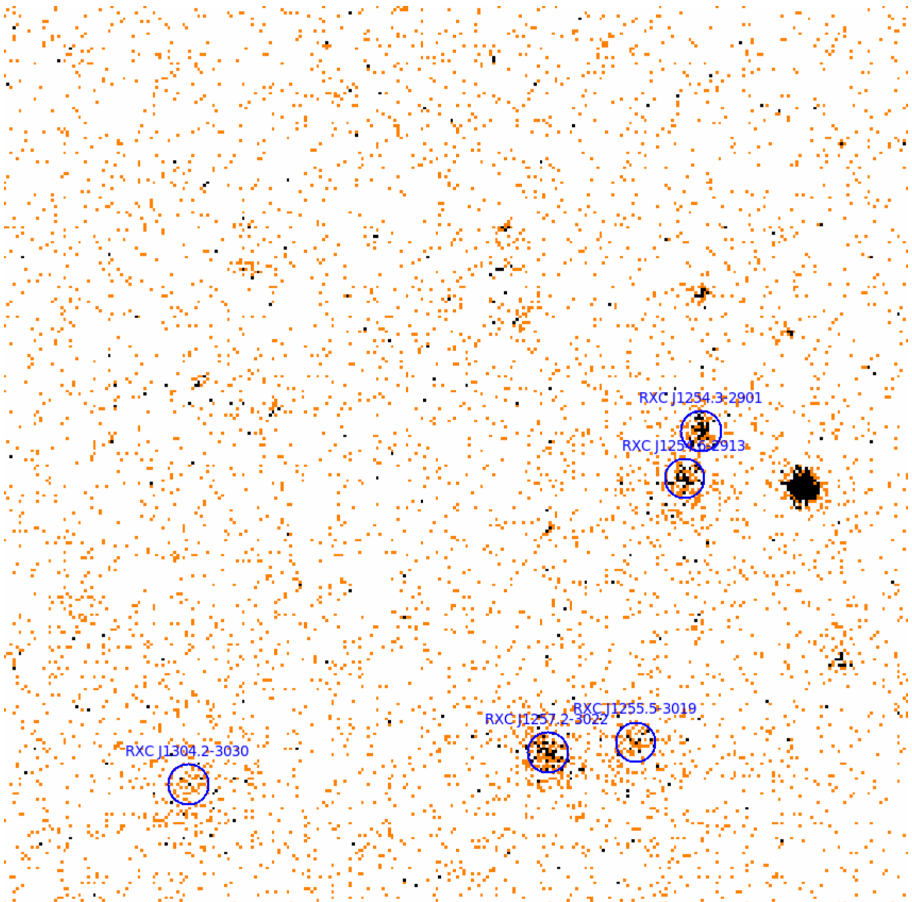
eRASS:1-8



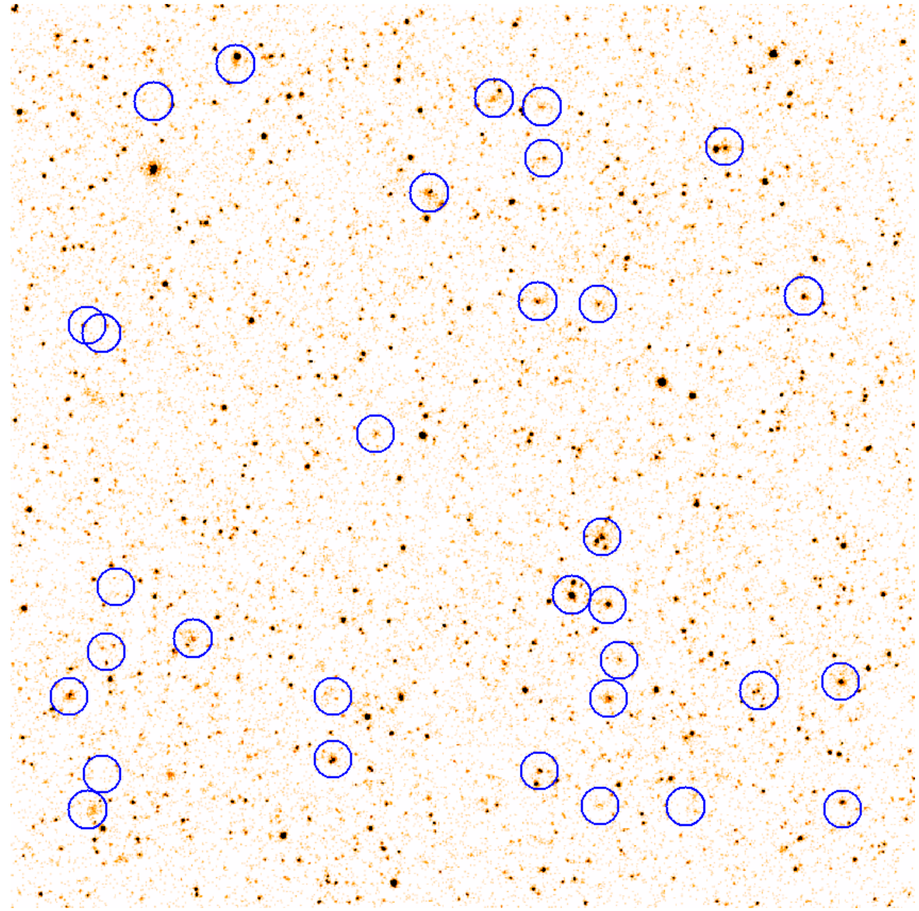
Simulated eROSITA field point-sources (no cluster)
Animation: 1 frame=6 months
N. Clerc, C.Schmid, H.Brunner…

(circle Ø=3 deg)

RASS (ROSAT) vs. eRASS:8



ROSAT 3x3 deg² field with REFLEX detections (Böhringer 2005)



eROSITA all-sky survey 3x3 deg² Simulation (N. Clerc, C.Schmid, F.Pace, M.Roncarelli)