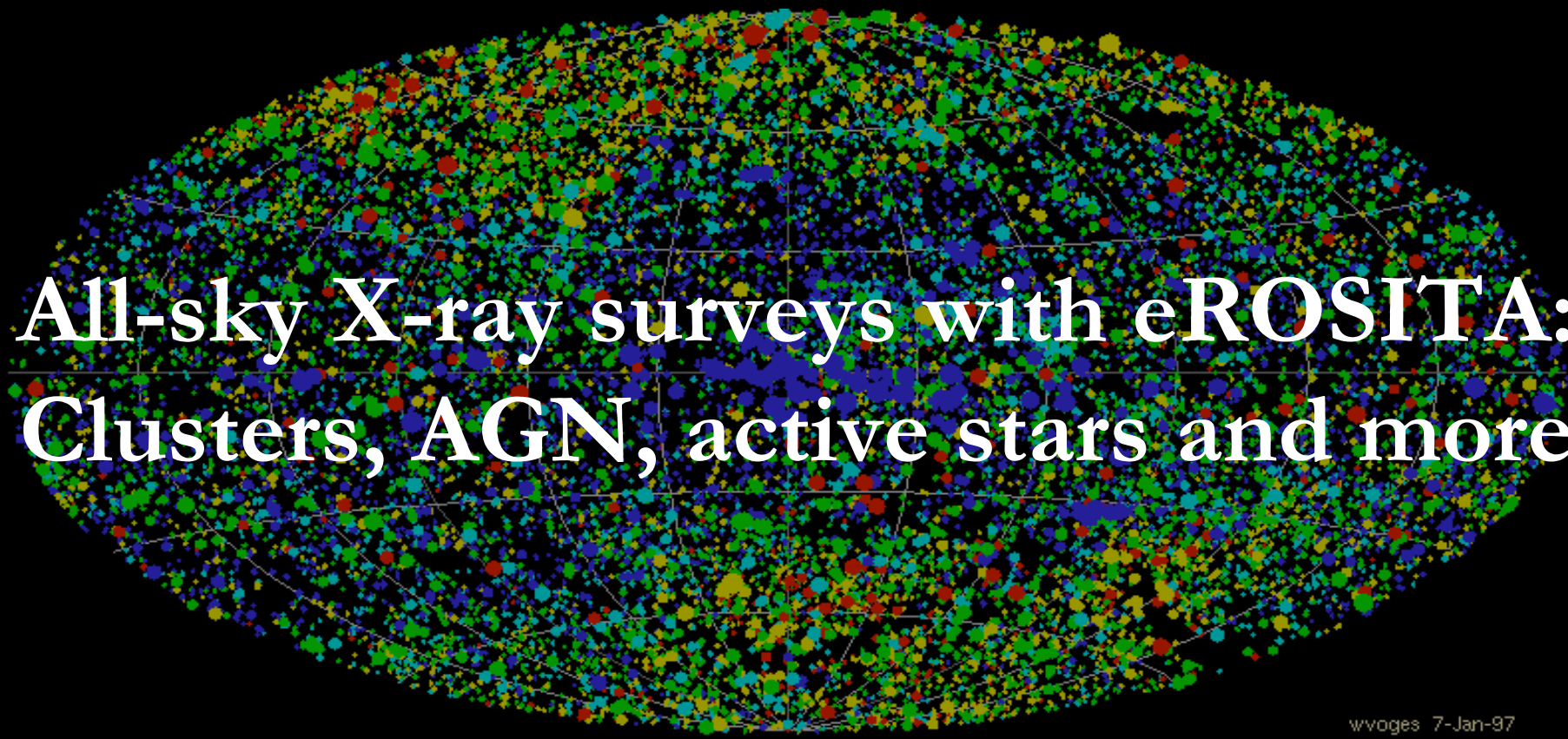
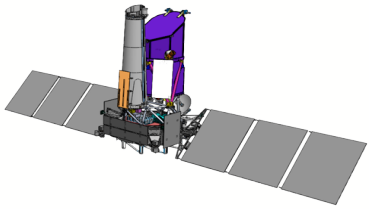
All-sky X-ray surveys with eROSITA: Clusters, AGN, active stars and more

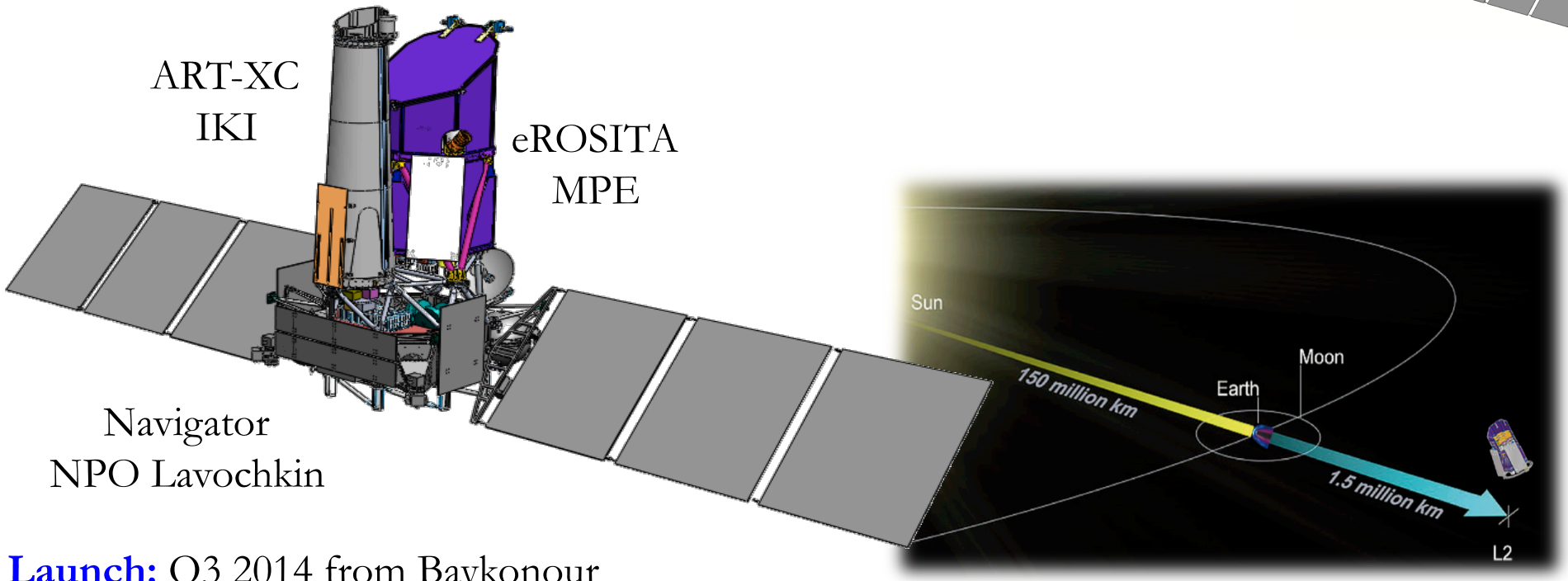


Andrea Merloni (MPE)

on behalf of the eROSITA team

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

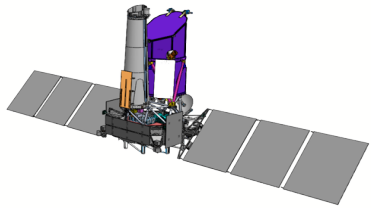
MPE: Scientific Lead Institute, Project Managment

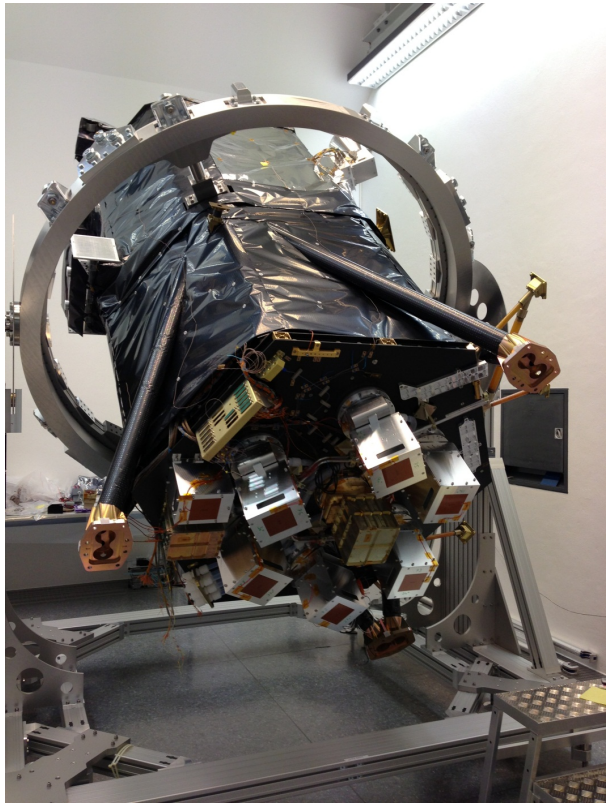
Instrument Design, Manufacturing, Integration & Test

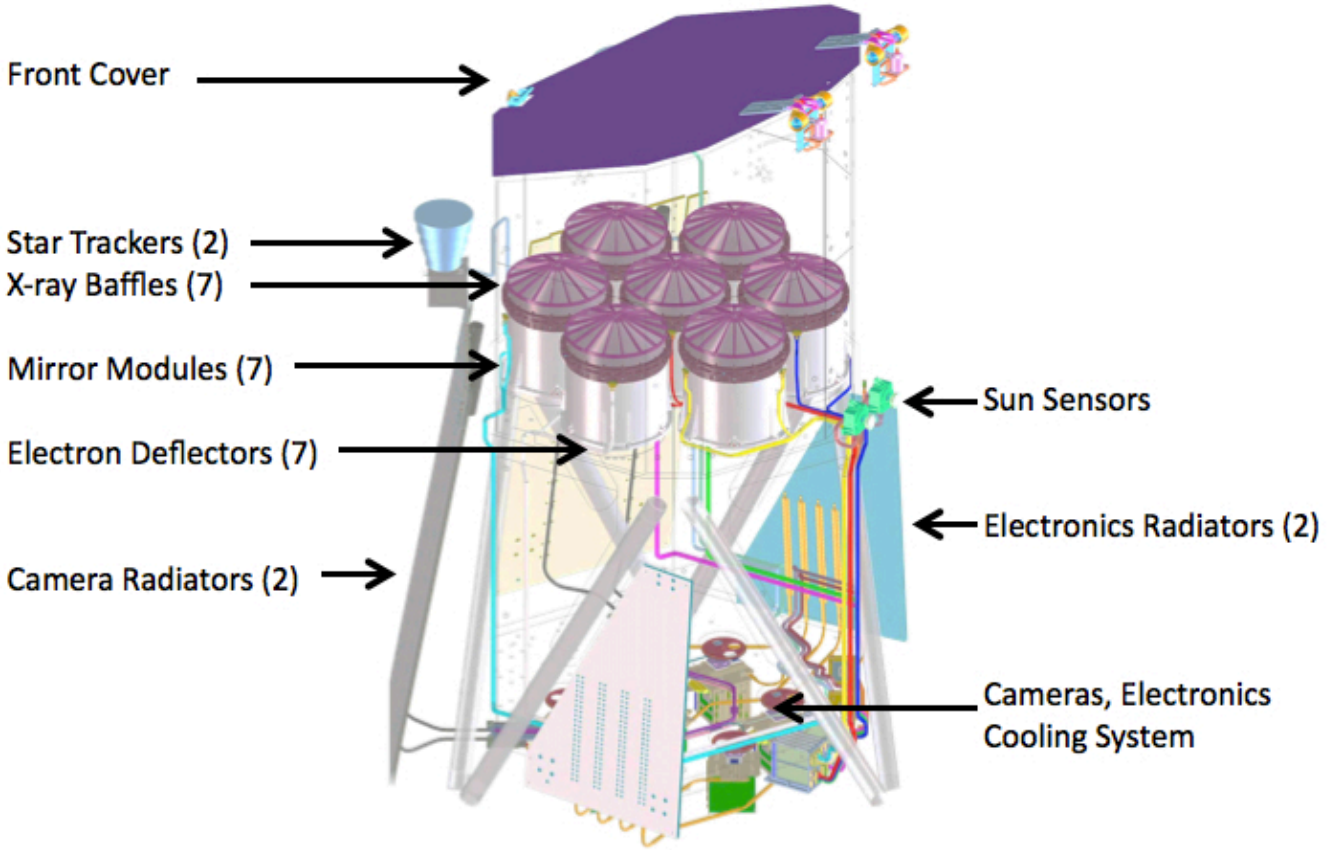
Data Handling & Processing, Archive etc.

eROSITA Telescope

www.mpe.mpg.de/eROSITA



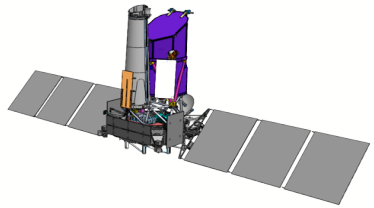




Focal length 1.6 m
F.o.V. = 0.81 sqdeg
54 nested mirror shells
Total weight ~800 kg

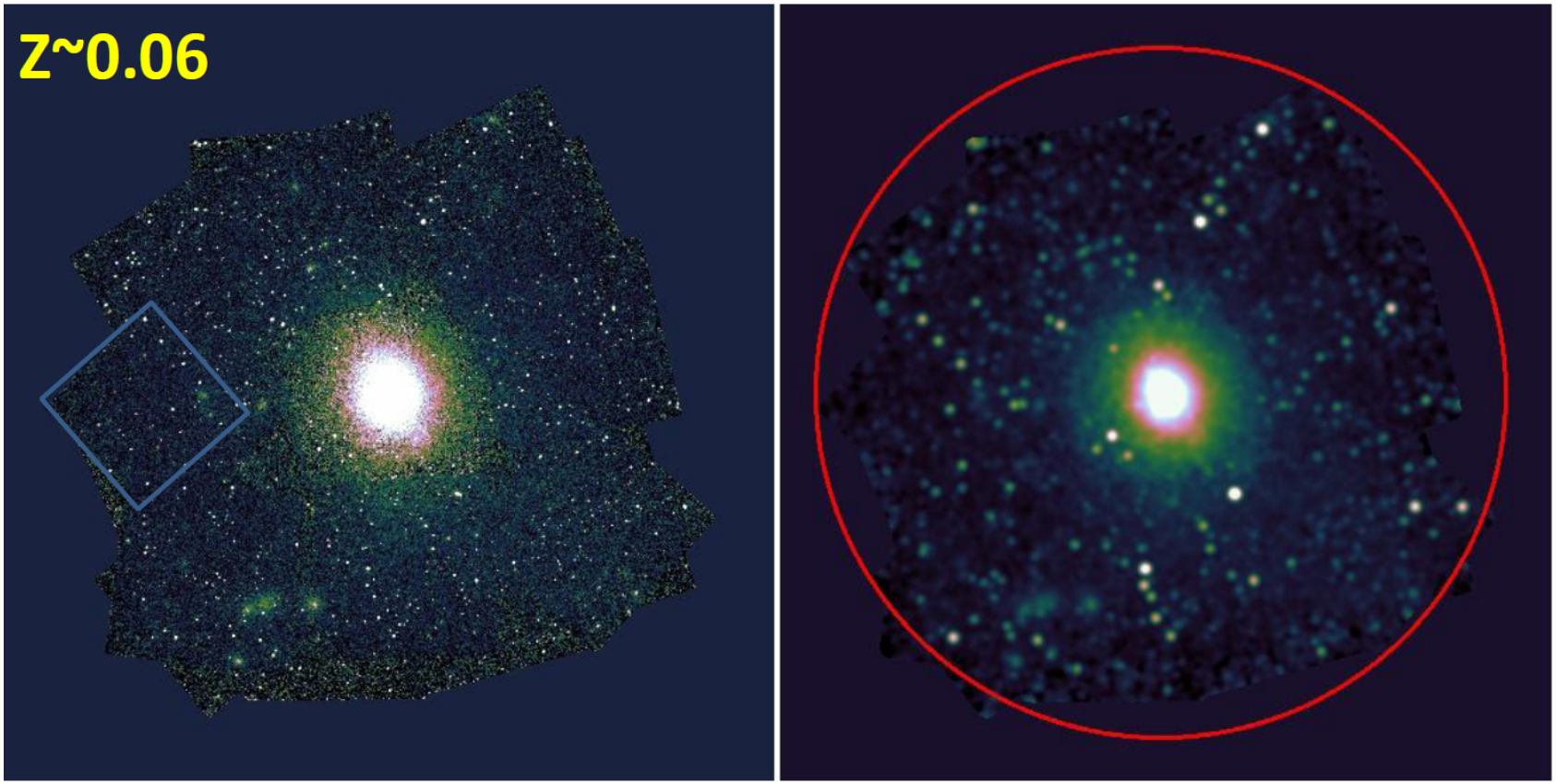
7 identical telescopes (Wolter-I/ pnCCD-cameras)
Energy range: 0.5-10 keV
Energy resolution: 138 eV @ 6 keV
Effective Area: ~1400 cm2 (@1keV)

Grasp



Chandra

eRosita

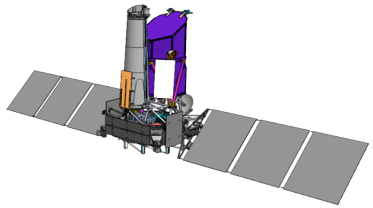


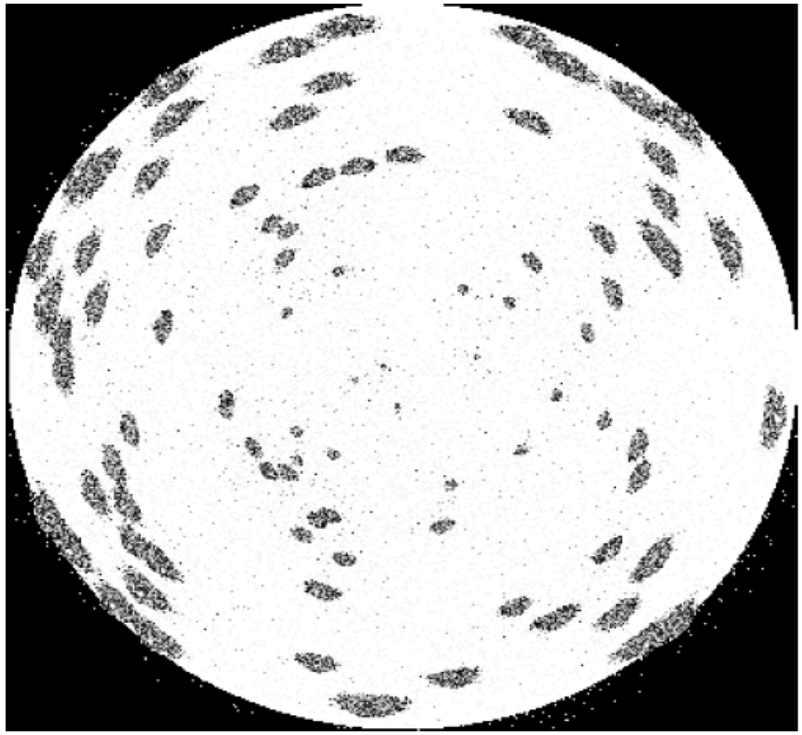
~30 pointings
~2 Msec

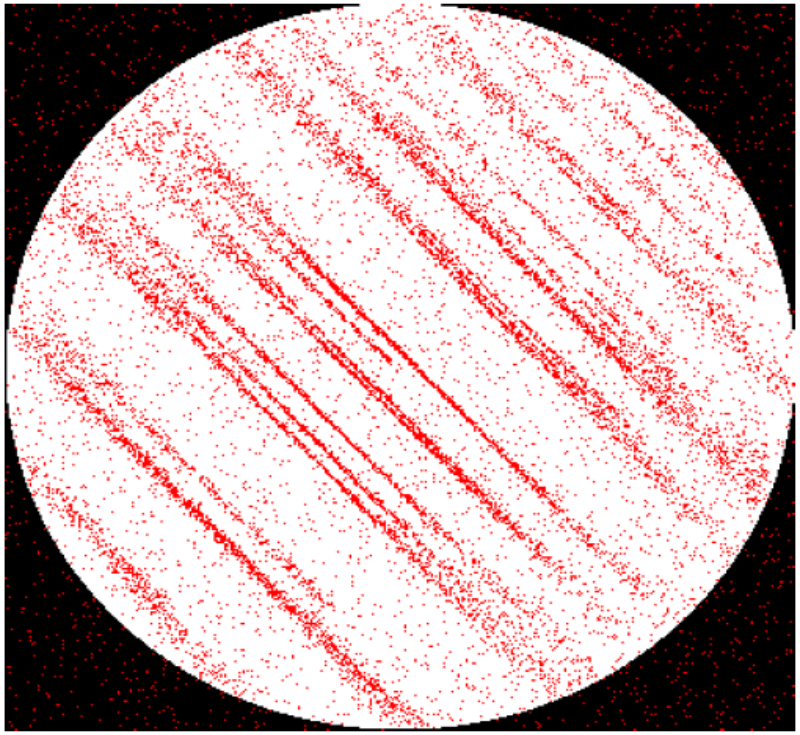
~1 pointing, 1.9 Mpc
~80 ksec

Churazov, IKI, MPA

eROSITA PSF





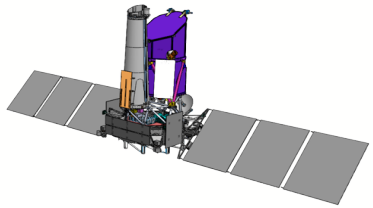


Pointing **Survey**

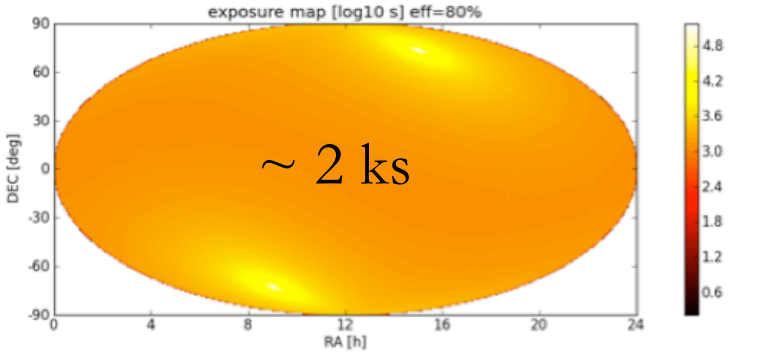
Off-axis blurring of a Wolter-I telescope:
PSF has to be averaged over the FoV

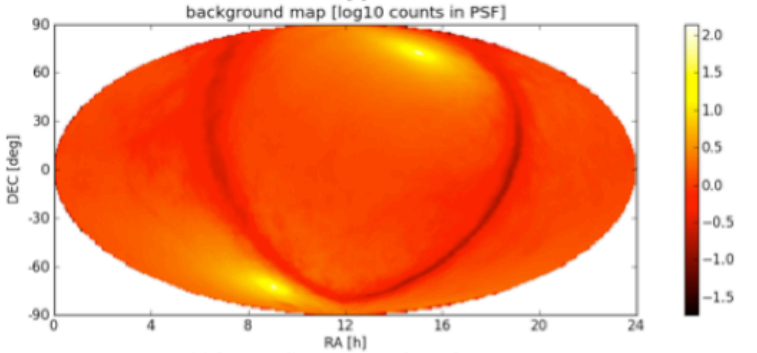
15-17 arcsec on-axis ➔ 28-25 arcsec averaged

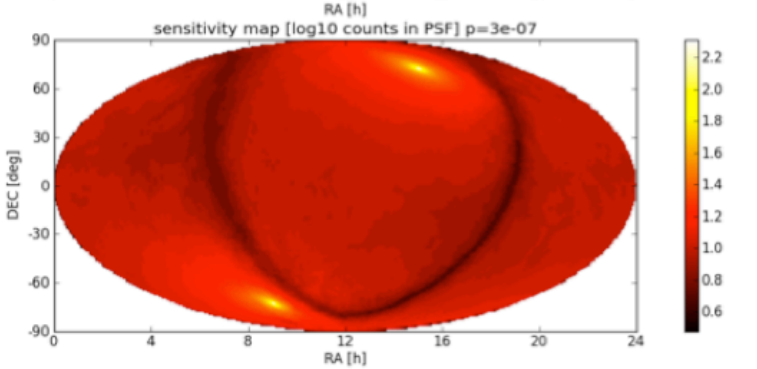
The eROSITA All-Sky Survey



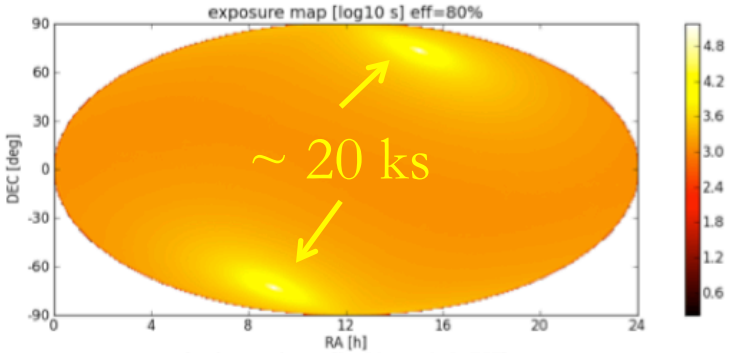
Soft Band

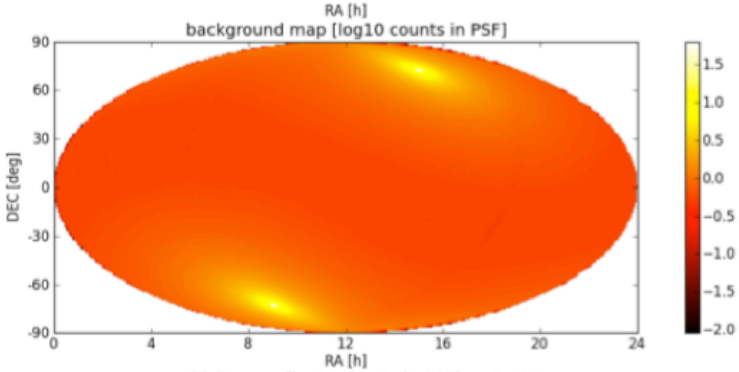


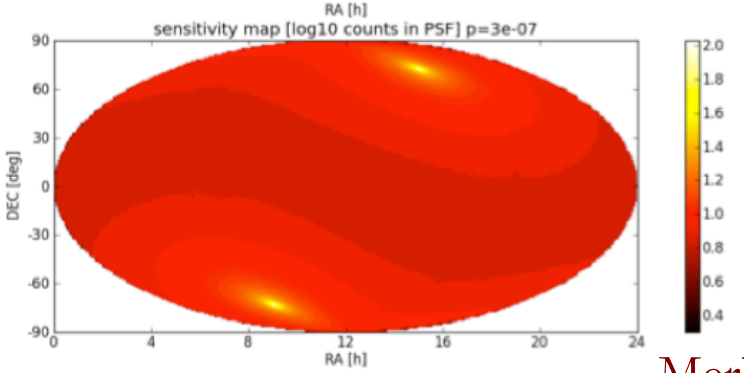




Hard Band







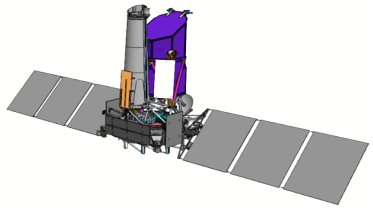
exposure

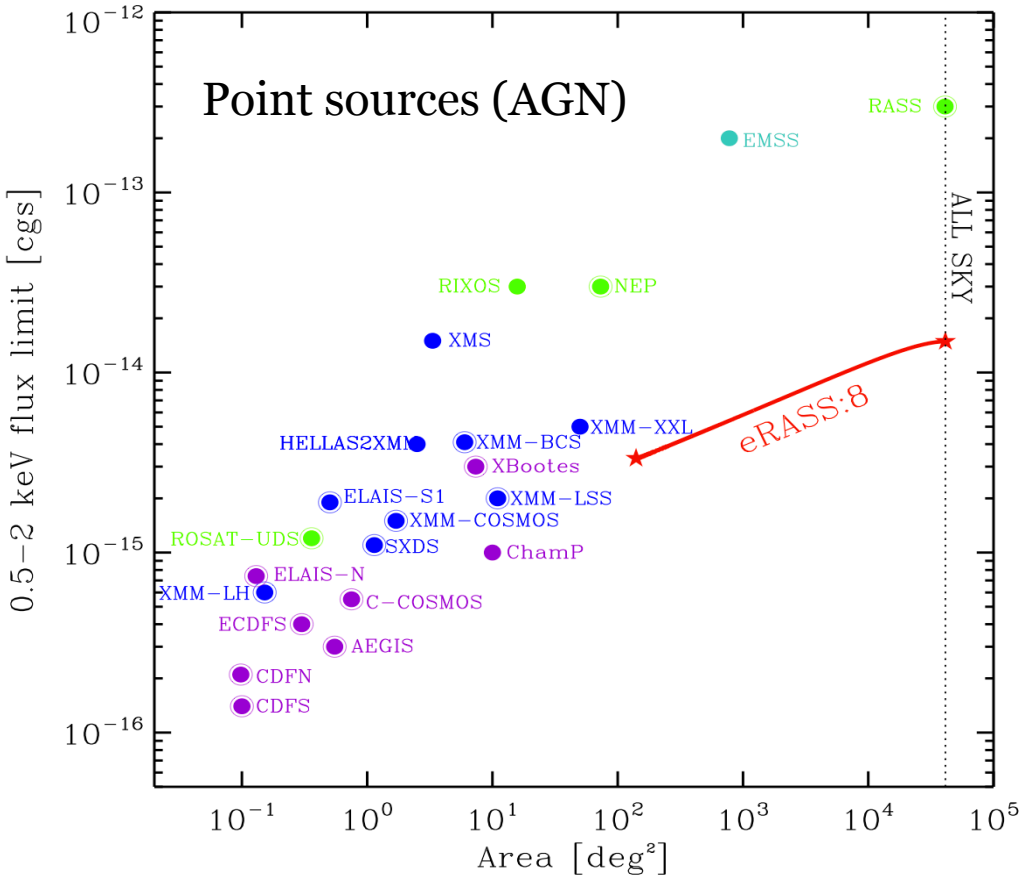
background

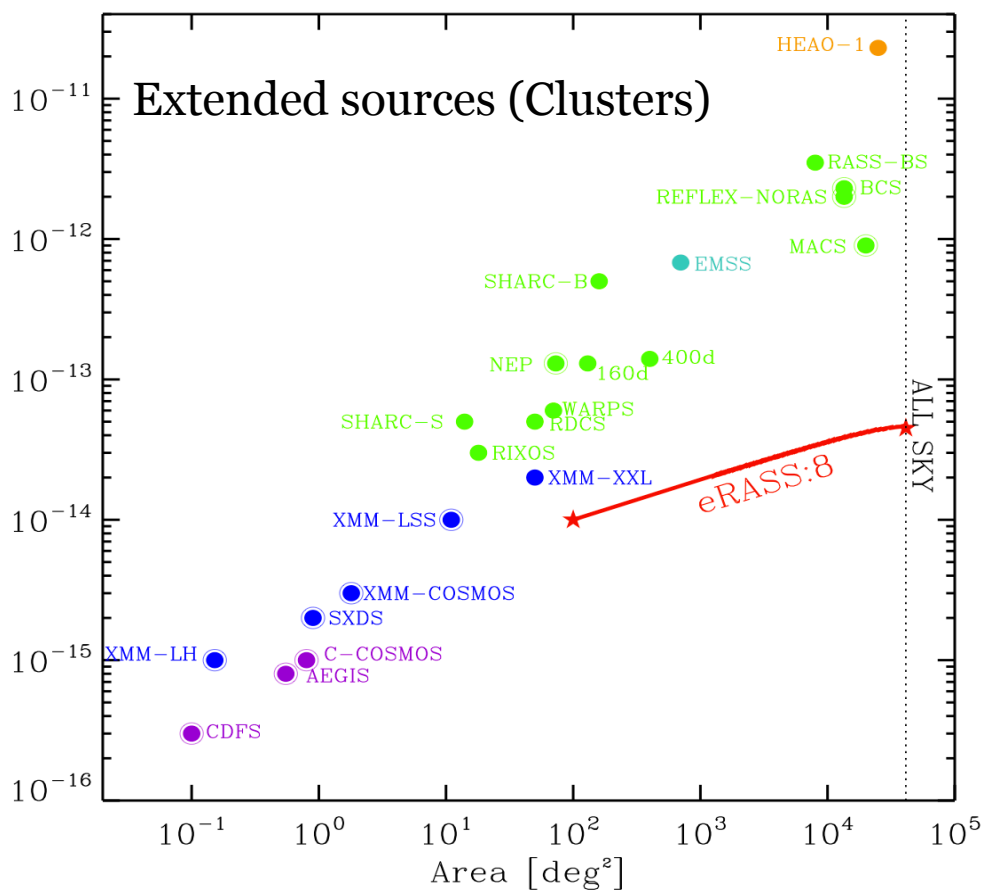
sensitivity

Merloni et al. 2012

eROSITA surveys in context





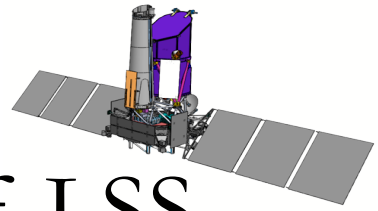


All sky: 10^{-14} (0.5-2 keV)
2×10^{-13} (2-10 keV) [erg/cm^2/s]

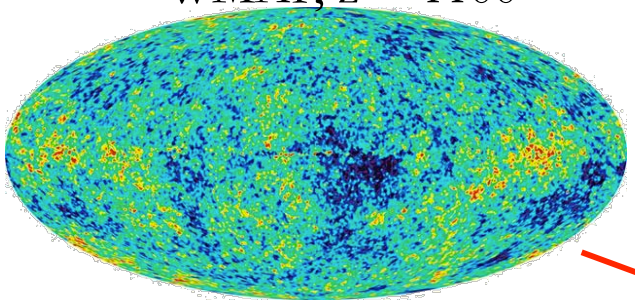
All sky: 3.4 x 10^{-14} (0.5-2 keV)

Merloni et al. 2012

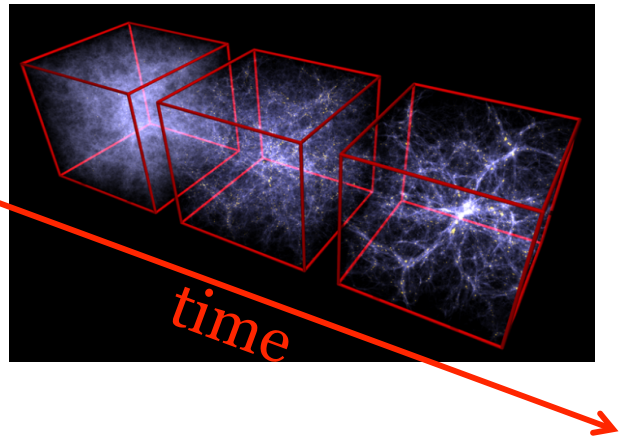
Main science driver:
Cluster Cosmology and the Growth of LSS



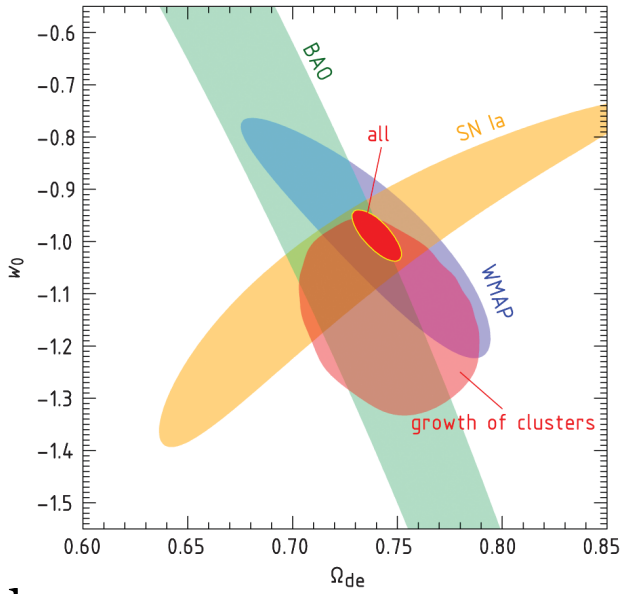
WMAP, z = 1100



Millennium Simulation

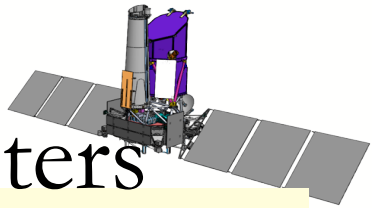


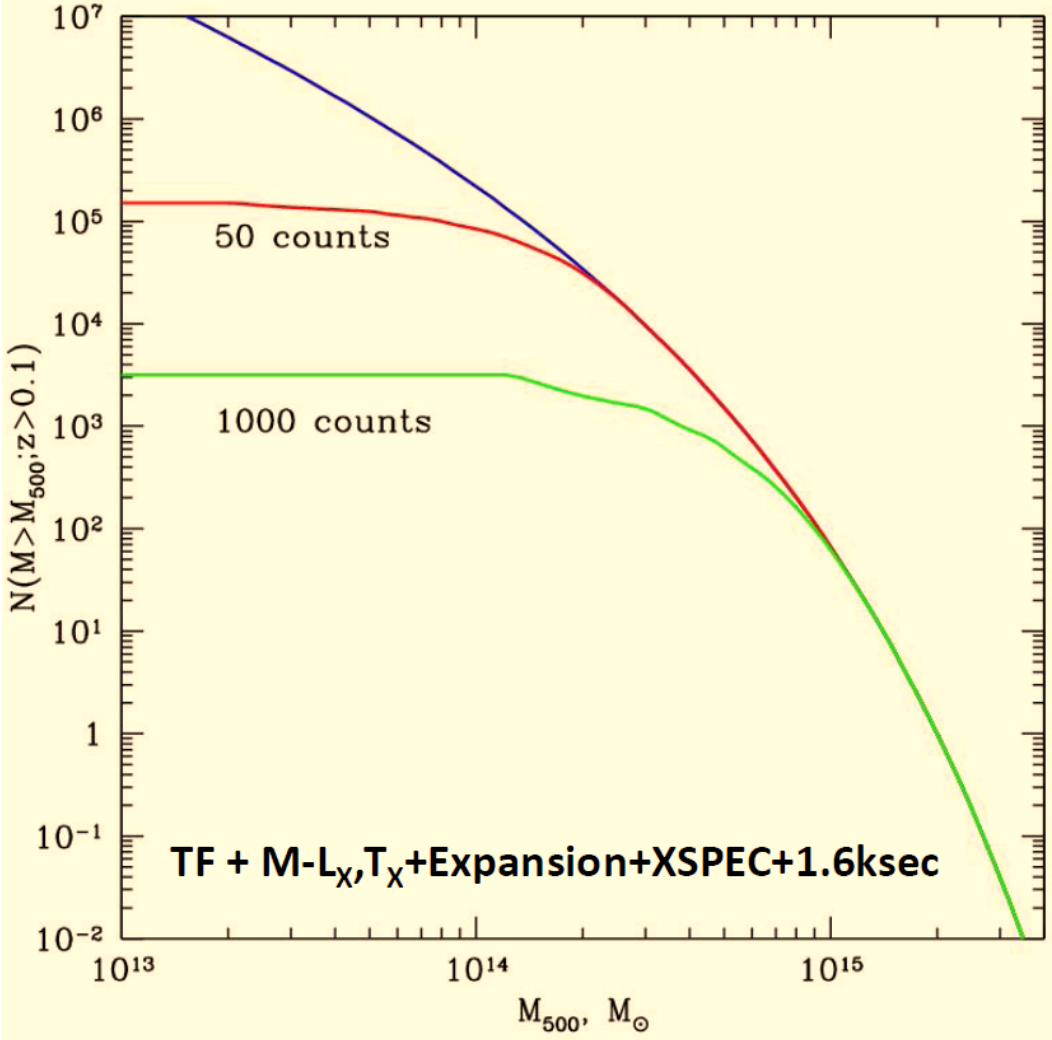
Vikhlinin et al. 2009



- 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 will detect all massive clusters



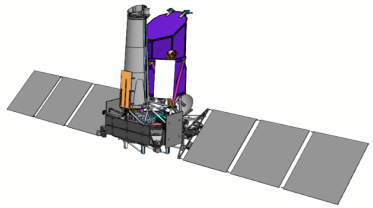


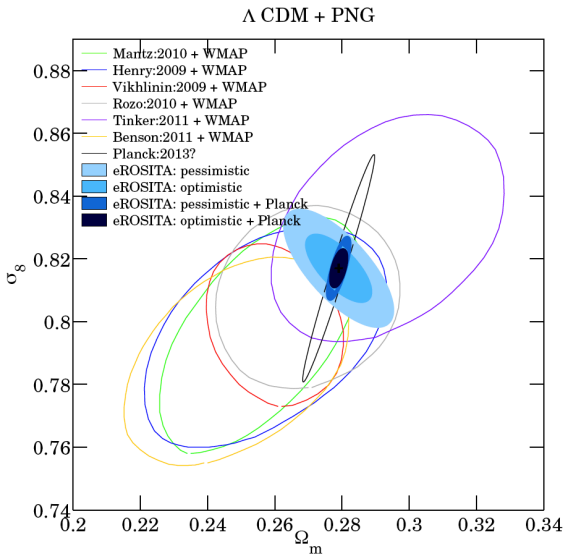
M	z	N	eRosita
10^{14}	~3	$8\ 10^4$	40%
$3\ 10^{14}$	~2	$8\ 10^3$	100%
10^{15}	~1	50	100%

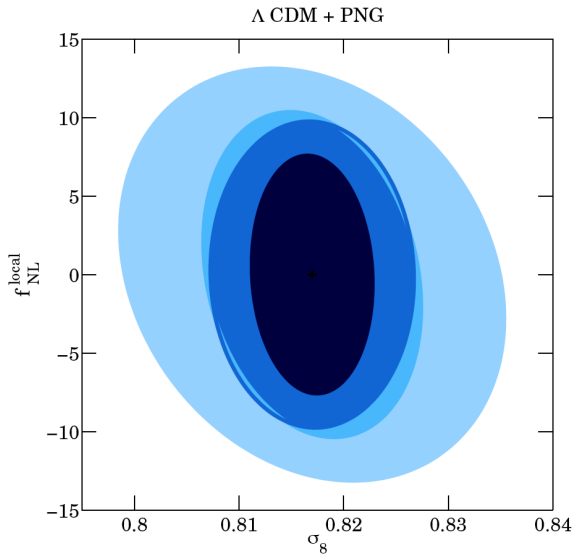
Z_{max}~2, M~3 10^{14} M_{Sun}

Courtesy of E. Churazov (MPA)

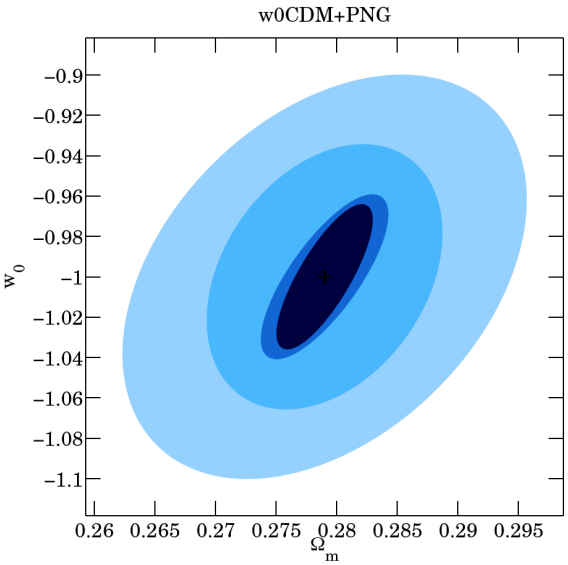
A Stage IV DE experiment

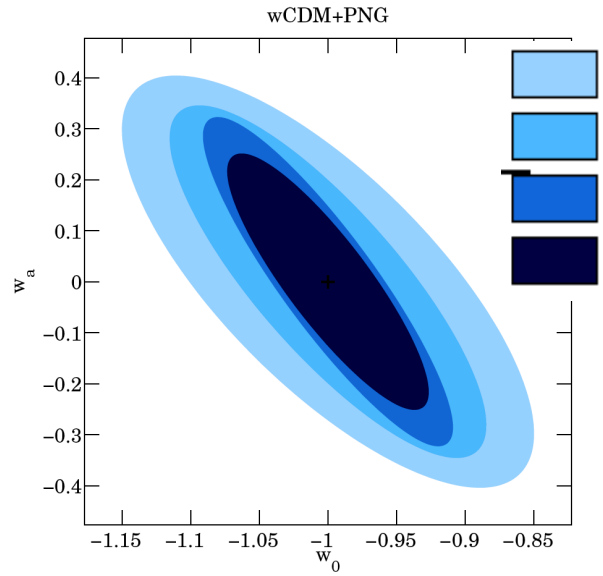






- X-ray (eROSITA) selection
- Redshift determination
- Mass calibration (dedicated follow up)
- Cluster Mass function vs. z
- Cluster Power Spectrum vs. z

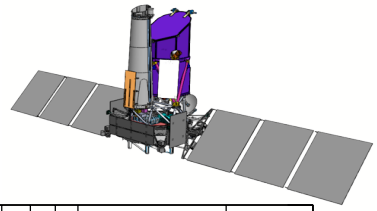


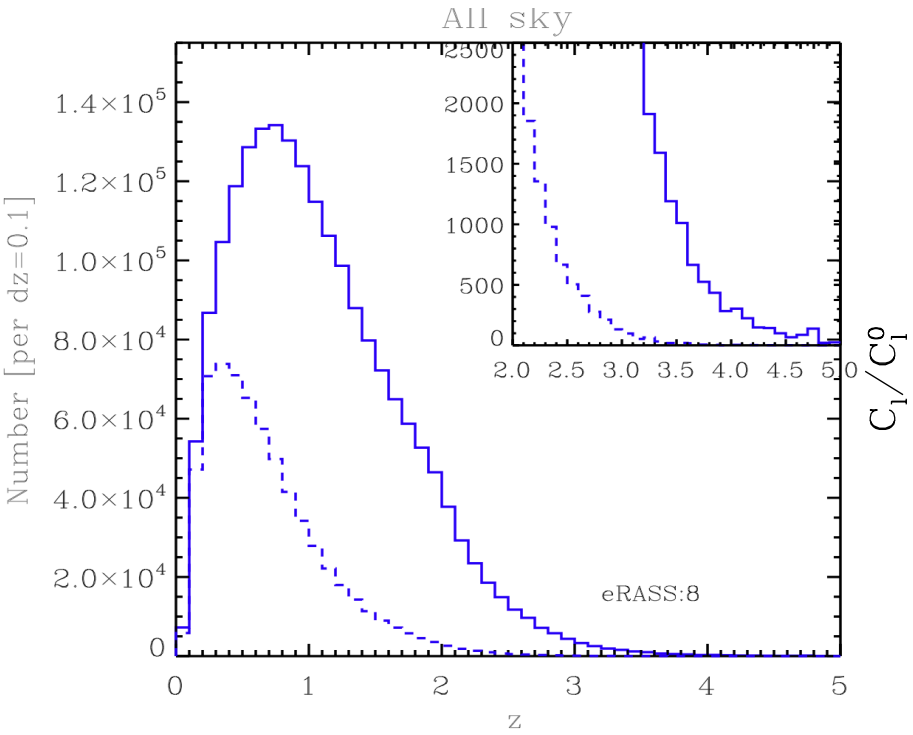


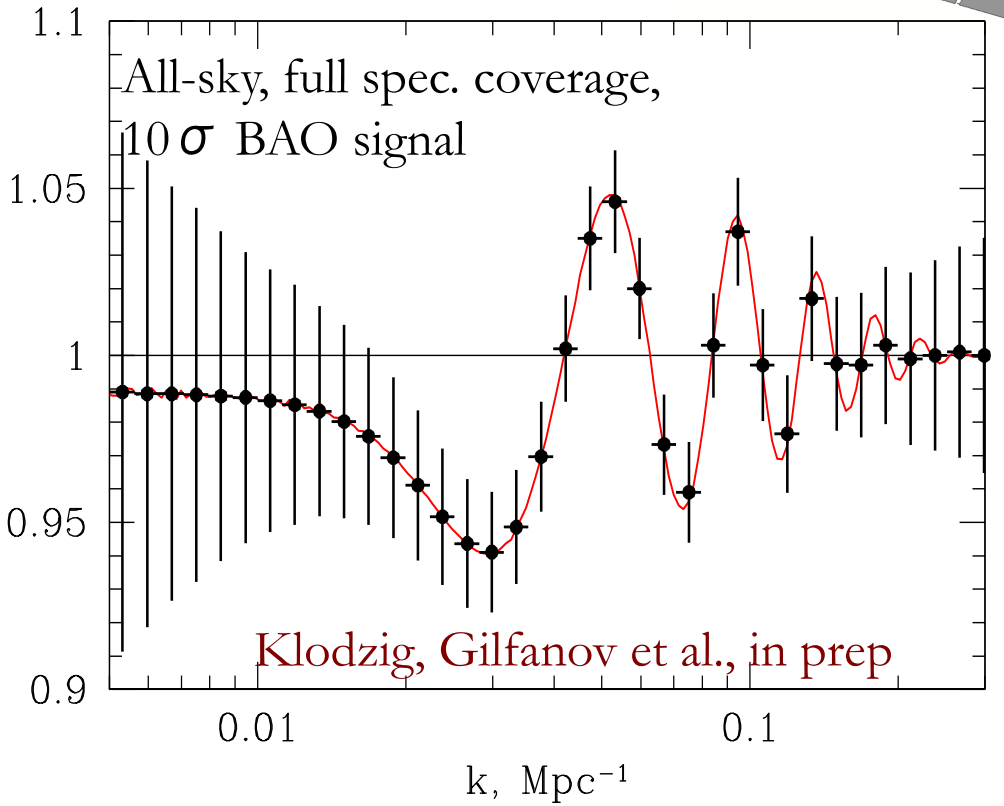
	DETF FoM
eROSITA: pessimistic (photo-z)	57
eROSITA: optimistic (spec-z)	103
eROSITA: pessimistic + Planck	174
eROSITA: optimistic + Planck	263

Merloni et al. 2012
Pillepich et al. 2012

3 Millions eROSITA AGN



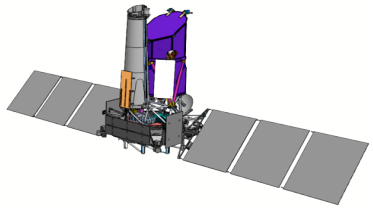




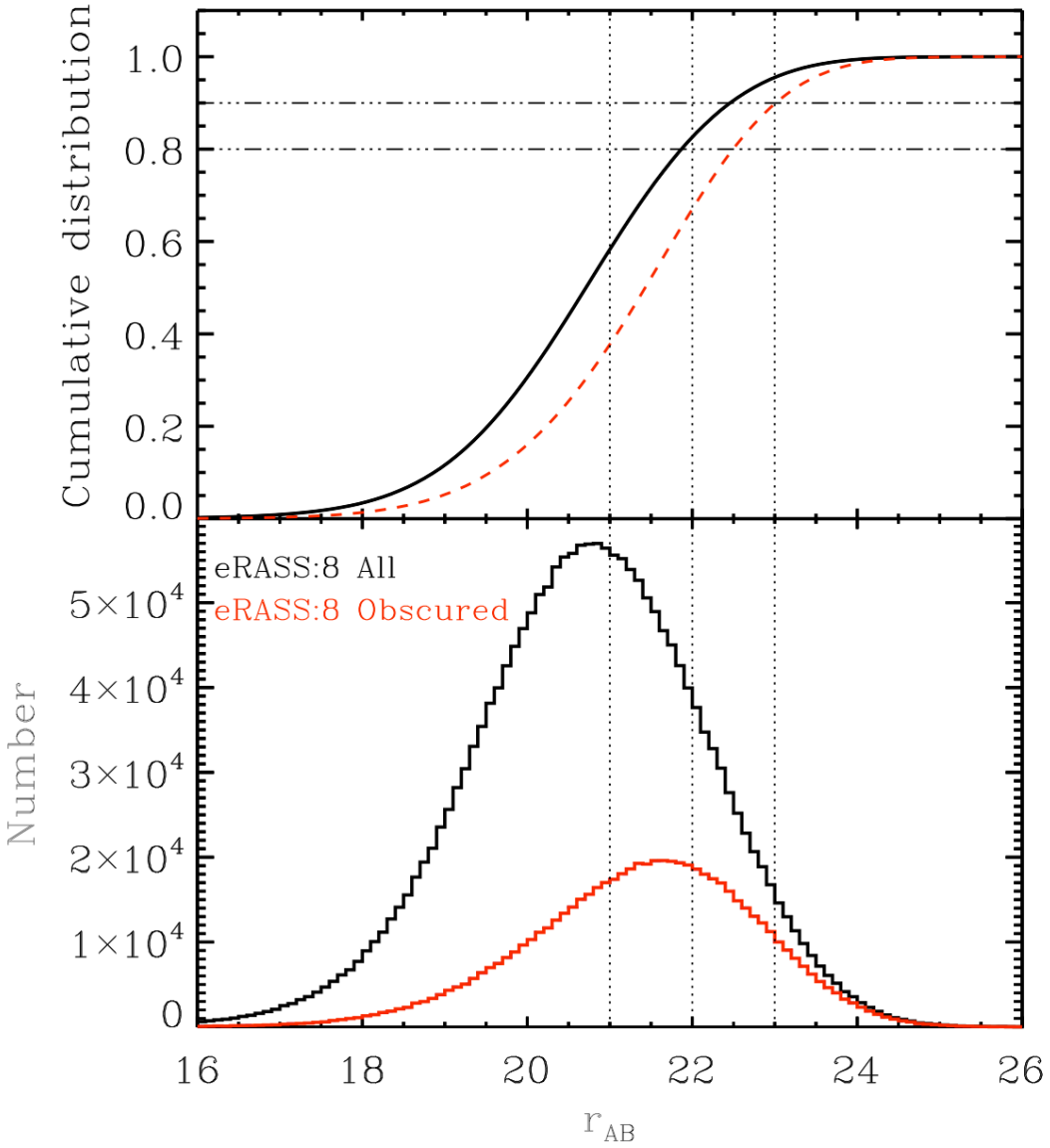
- First 2-10 keV all-sky survey after HEAO-1
- Obscured vs. Unobscured AGN at z~1-2
- High-z (thousands at z>4) AGN
- Tidal disruption events
- AGN variability over >4 years
- Binary SMBH?

eROSITA will cover uniformly the redshift range 0<z<3
A 3-D map of the "active Universe"

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]

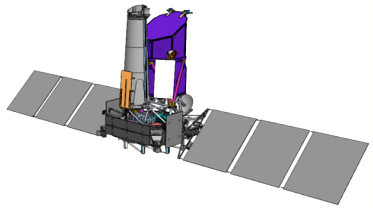
- Expected r_{AB} magnitude distribution of 0.5-2 keV selected AGN in eROSITA surveys

- Latest 4MOST simulation: close to 90% completeness over the extragal. accessible sky

- Looking forward to a highly complete spectroscopic sample of >800k X-ray selected AGN

Merloni et al. 2012

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

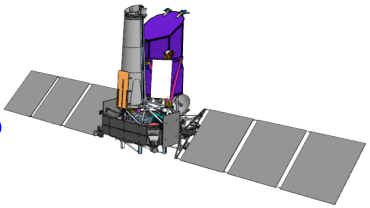
Dynamo theory
- study of (super-) saturation effects and Lx/Lbol evolution
- transition effects at fully convective boundary

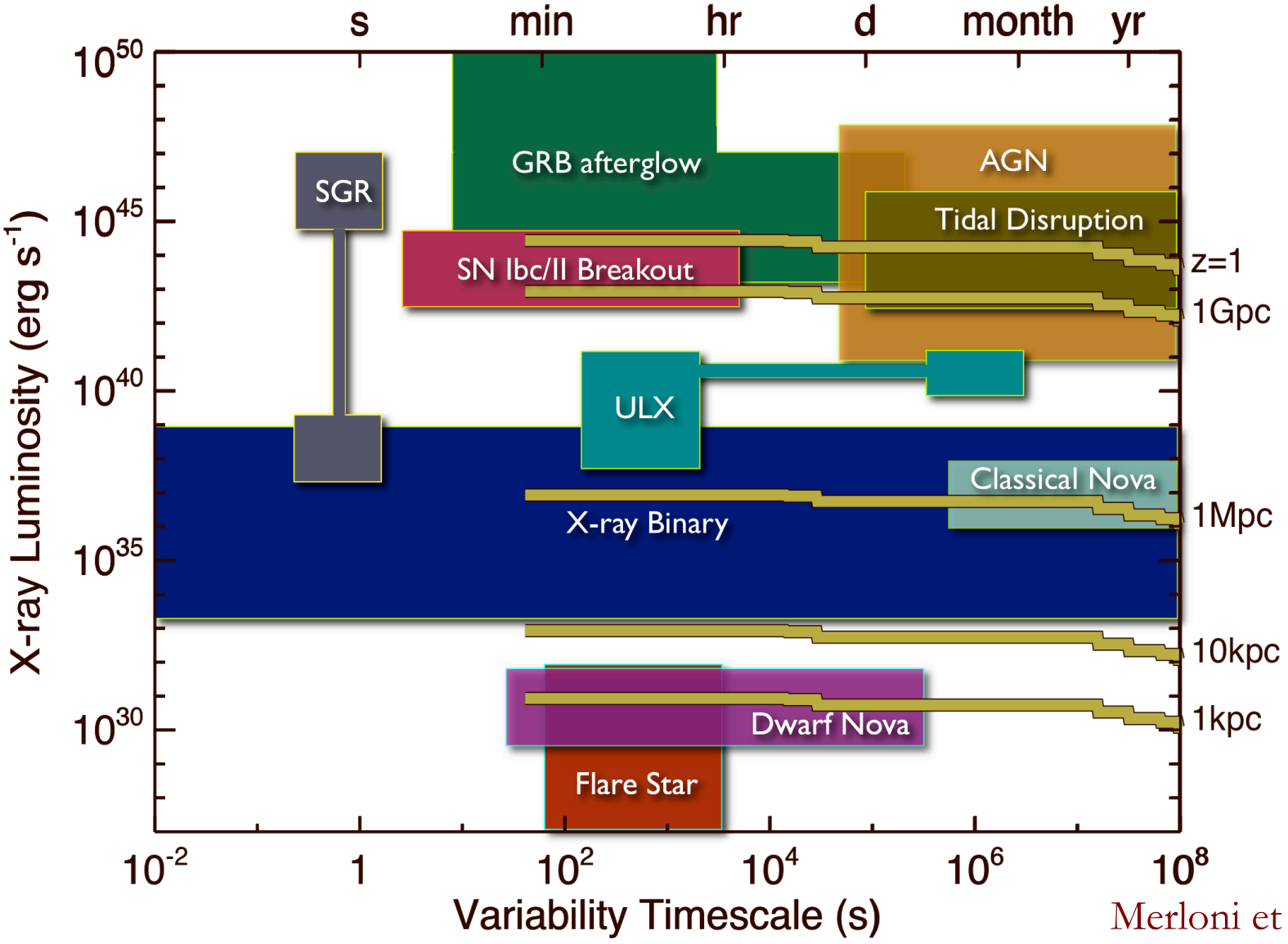
Local star formation history & galactic structure
- young nearby stellar population
- early evolution of planetary systems

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

court. J. Robrade, J. Schmitt

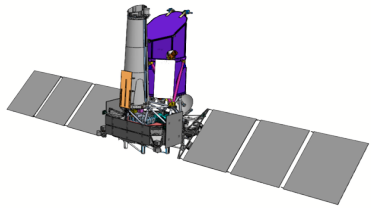
eROSITA sensitivity to variables





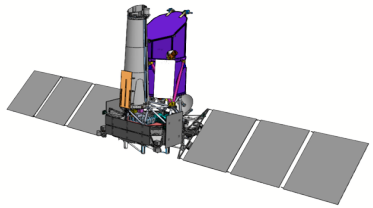
Merloni et al. 2012

Legacy value



- Galactic XRB, CV, Isolated Pulsars, SNR
- GRB afterglows (a few tens at most)
- The "cold" universe: Solar system bodies, comets, Charge exchange emission, interstellar dust
- The "hot" universe: diffuse hot plasma emission in the MW and in the local group, Fermi bubbles, etc.
- Serendipity

The landscape of O/IR wide area surveys



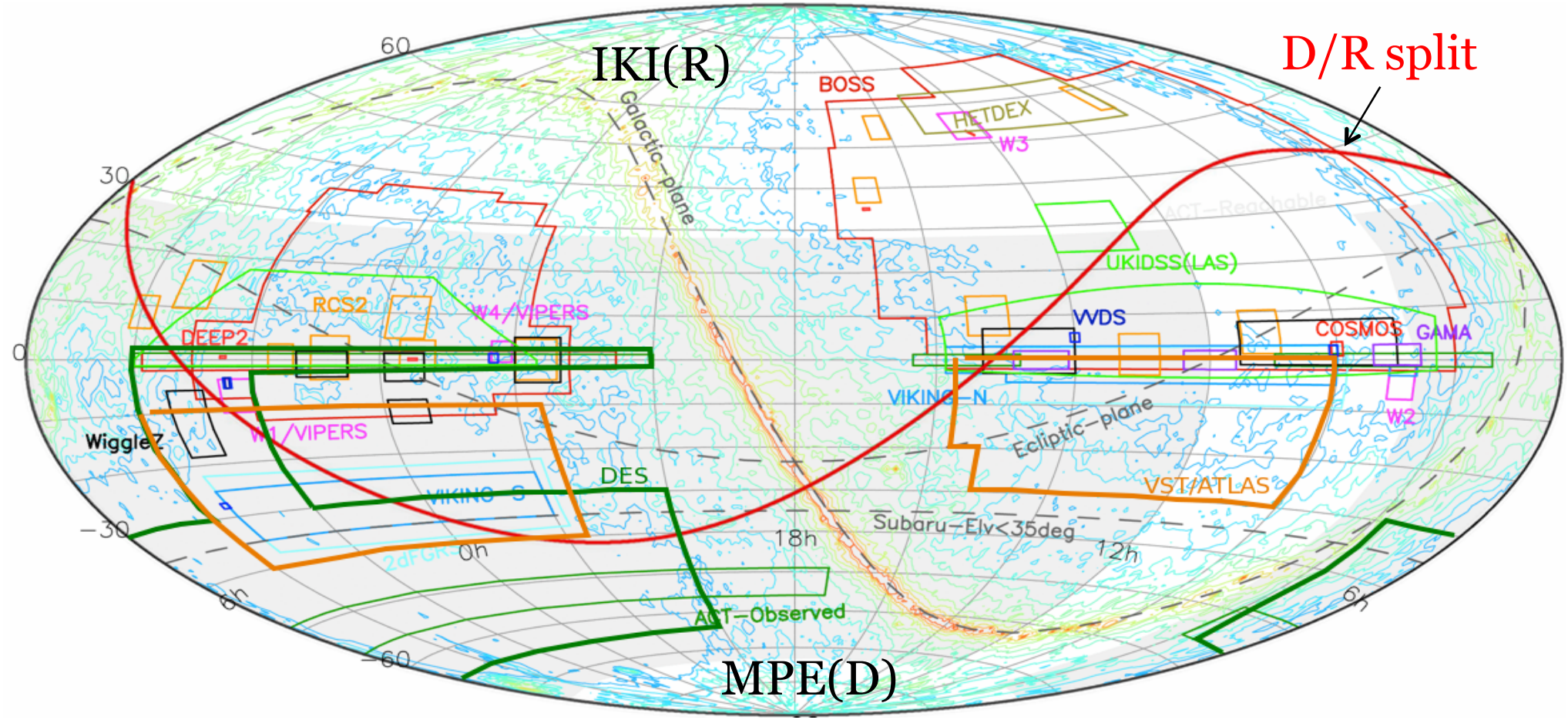
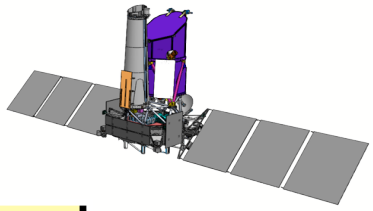
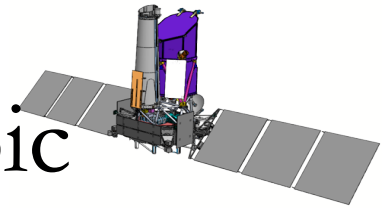


Image A. Nishizawa (IPMU), AM

Tentative timeline



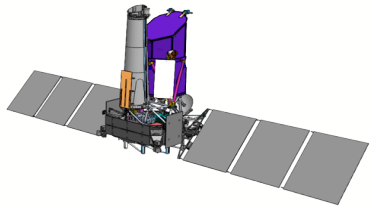
(1) Survey	(2) f_{lim} (0.5-2 keV) [erg/s/cm^2]	(3) AGN density [deg^{-2}]	(4) $r_{AB,90}$	(5) Catalog ready	(7) Public Release date (TBD)
eRASS:1	4.5×10^{-14}	~14	21	July 2015 (T_0 +10m)	July 2017
eRASS:2	2.8×10^{-14}	~30	21.6	January 2016 (T_0 +16m)	July 2018
eRASS:3	2.1×10^{-14}	~45	21.9	July 2016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



(German) eROSITA spectroscopic follow-up plan

- **Southern hemisphere: 4MOST (2019-2024)**
  - Complete, systematic follow-up of both Clusters and AGN from eROSITA: reach >80% completeness for eRASS:8
  - Currently in Conceptual Design Phase (till 2/2013)
- **Northern hemisphere: SPIDERS (AS3; 2014-2019)**
  - Early follow-up over a small (~1500 deg^2) area in the NGC: reach >80% completeness for eRASS:4

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

Thank you!

eROSITA Science Book
arXiv:1209.3114