eROSITA on SRG

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on behalf of
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Max-Planck-Institut für extraterrestrische Physik

Transport to NPOL (Lavochkin), 25.1.2017

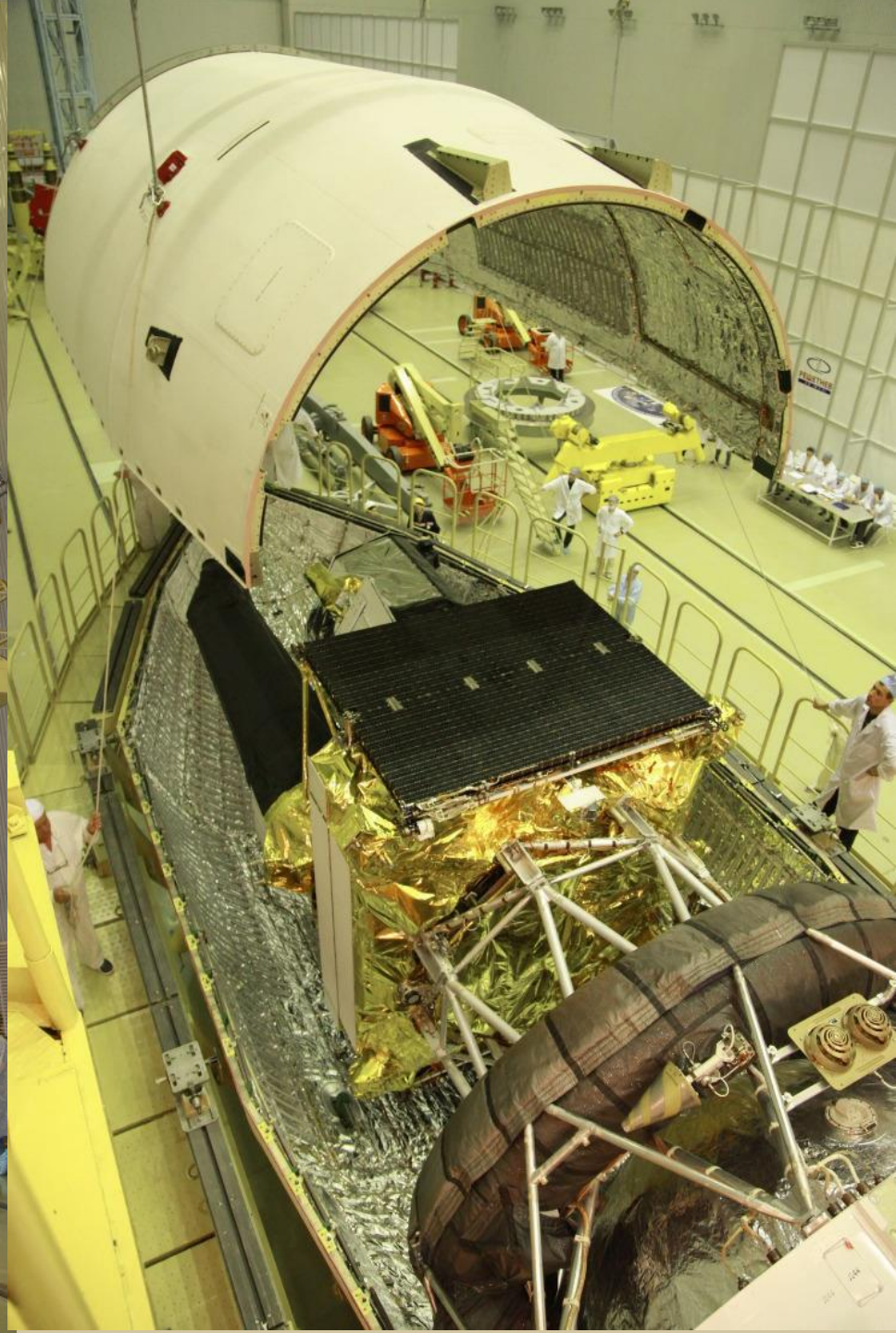
SRG just before shipment to Baikonur. Photo credit: S. Mamontov, RIA Novosti.

Spectrum-Roentgen-Gamma landed in Baikonur

Unloading...


НЕТТО 2,20 т
БРУТТО 17 т
14,80 т

Mounting of SRG on the Block DM-03 upper stage



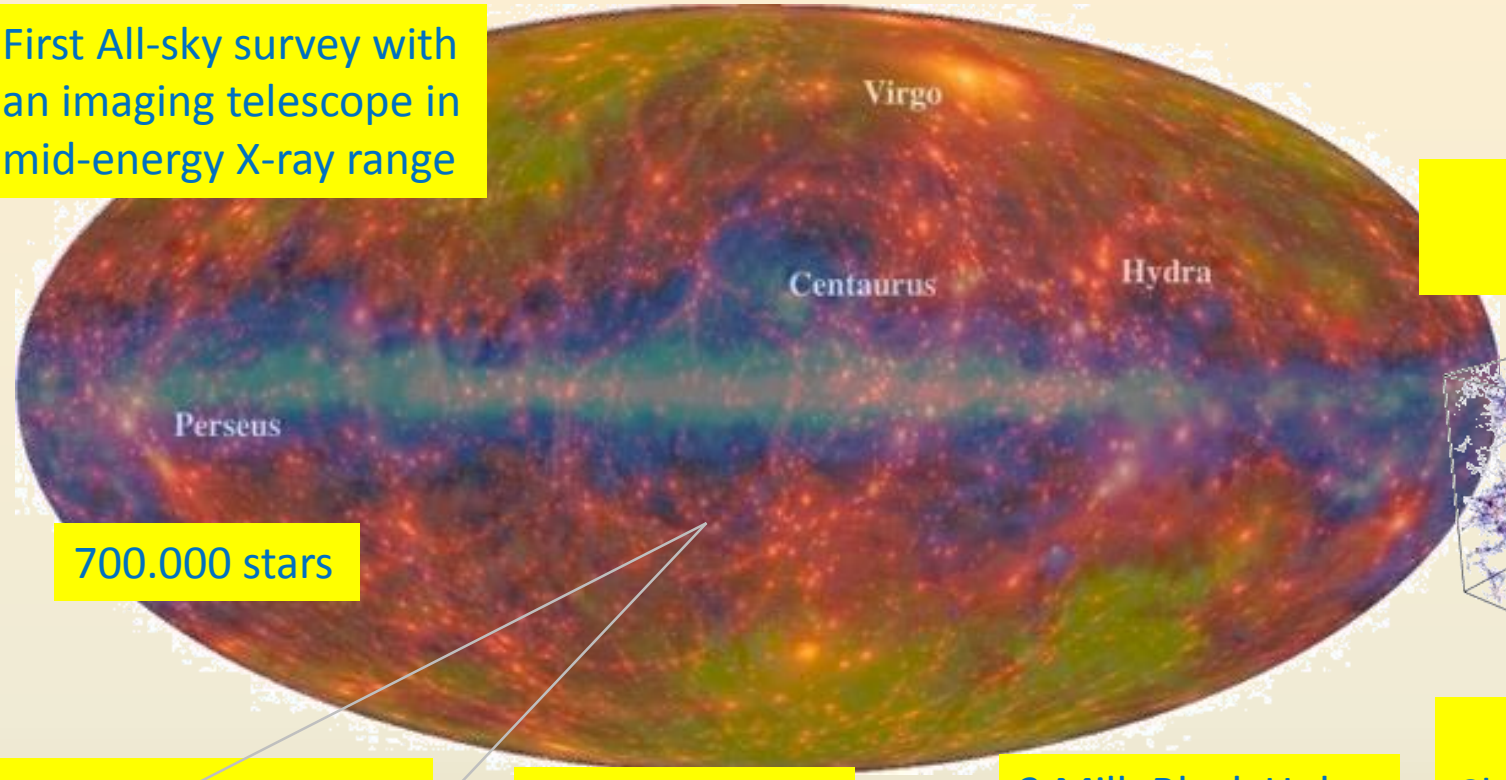
Docking of upper stage with Proton-M launch vehicle.
Moving of launch vehicle to launch site planned today!

eROSITA FAQs

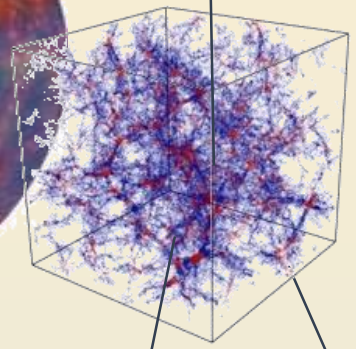
What is the launch date?	June 21, 2019
When gets data public?	D: Survey after 2 years, incrementally D: Pointed after 1 year, as usual
How are data shared btw Ru/D?	50:50 in galactic coordinates
Transient detections?	Yes, of course. But...
What is the sensitivity?	Point sources: 3 - 12 x 10^{-15} erg/s/cm^2 Ext. sources: 1 - 4 x 10^{-14} erg/s/cm^2

Science with eROSITA

First All-sky survey with an imaging telescope in mid-energy X-ray range



Dark Energy
Dark Matter



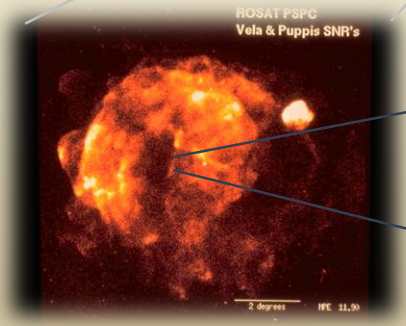
700.000 stars

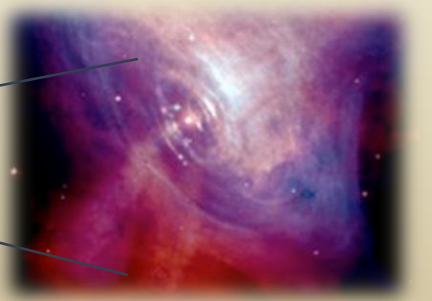
Supernova Explosions

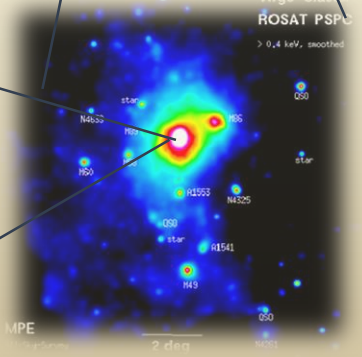
Neutron Stars

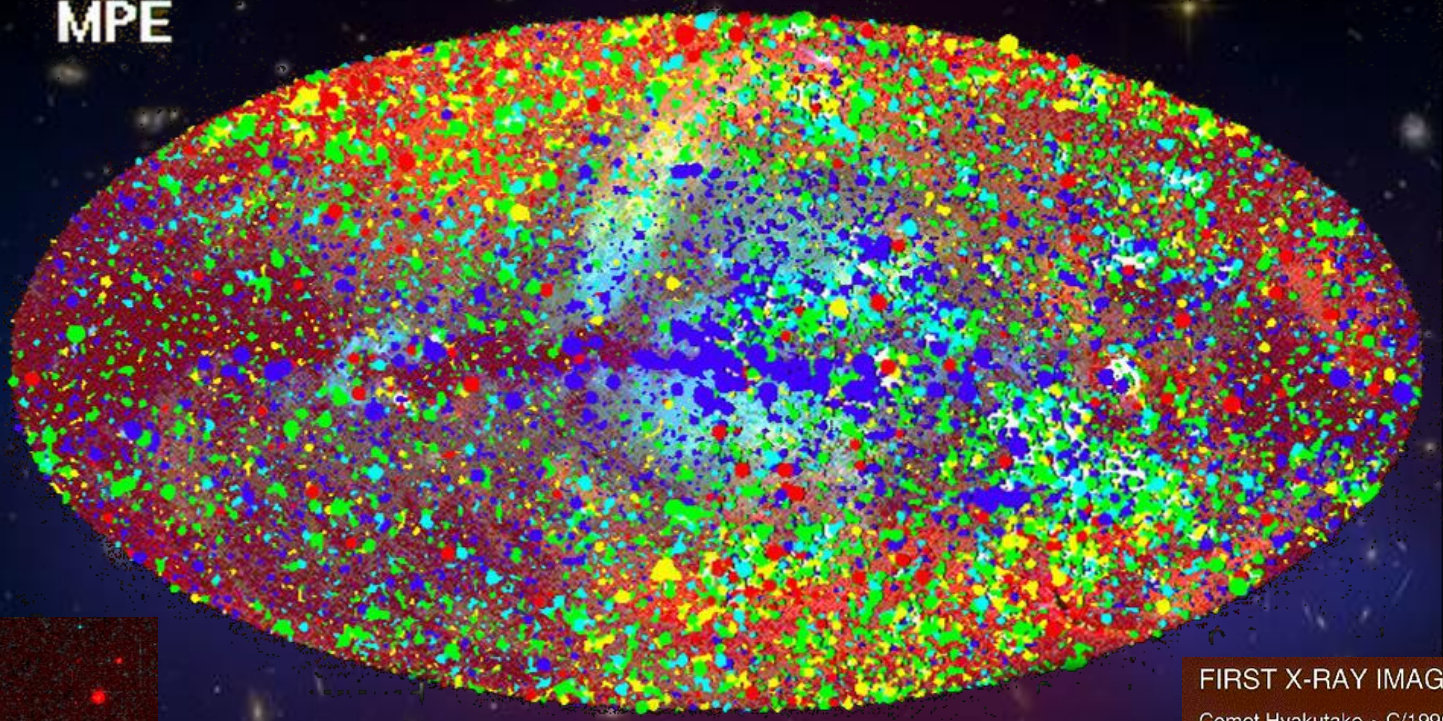
3 Mill. Black Holes

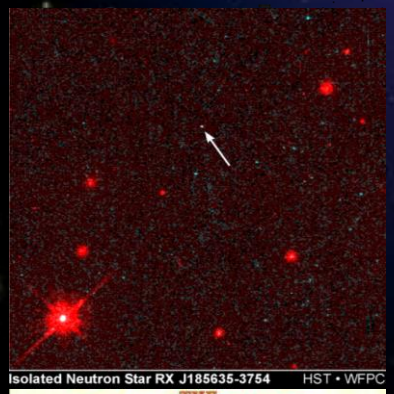
100.000
Clusters of Galaxies





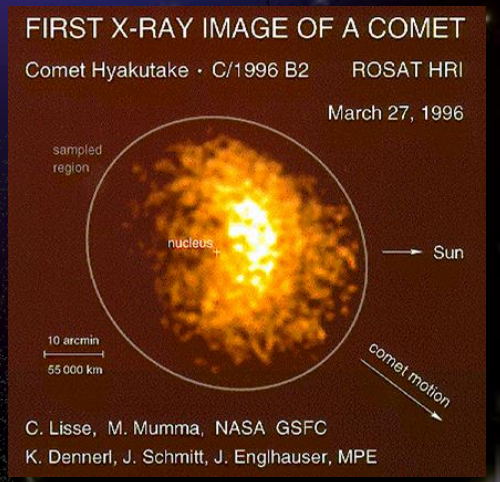



ROSAT PSPC All–Sky Survey Multispectral
MPE

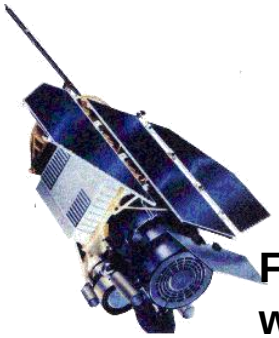

Isolated Neutron Star RX J185635-3754 HST • WFPC


THE MAGNIFICENT SEVEN
They fought like seven hundred


The Moon
June 29 1990


FIRST X-RAY IMAGE OF A COMET
Comet Hyakutake · C/1996 B2 ROSAT HRI
March 27, 1996
sampled region
nucleus
Sun
10 arcmin
55 000 km
comet motion
C. Lisse, M. Mumma, NASA GSFC
K. Dennerl, J. Schmitt, J. Englhauser, MPE

History



ROSAT
1990-1998

First X-ray all-sky survey with an imaging telescope

Bundle of 7 small telescopes
To extend the all-sky survey towards higher energies

failed shortly after launch

ABRIXAS science on the International Space Station

not realised due to Shuttle schedule and ISS contamination problems

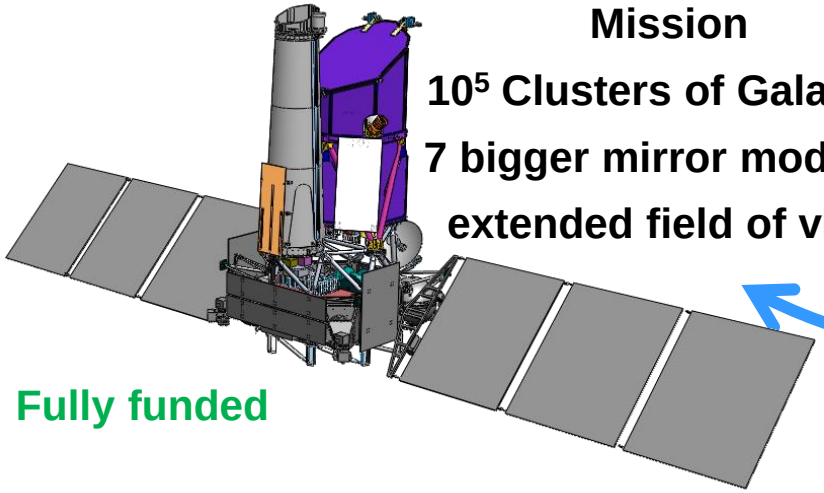
eROSITA

on Russian SRG Mission

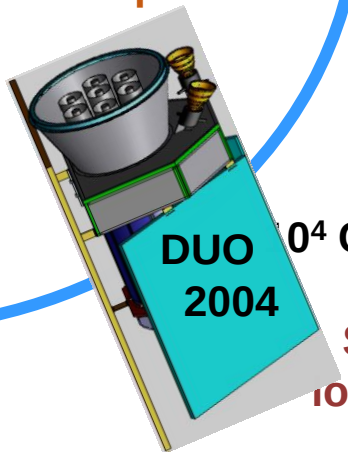
10^5 Clusters of Galaxies

7 bigger mirror modules

extended field of view



Fully funded



Dark Energy

10^4 Clusters of Galaxies

SMEX-proposal, lost against NuStar


August 2009
Detailed Agreement
DLR and Roscosmos
eROSITA

eROSITA Collaboration

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

Core Institutes (DLR funding):
MPE, Garching
Universität Erlangen-Nürnberg
IAAT (Universät Tübingen)
SB (Universität Hamburg)
Leibniz-Institut für Astrophysik Potsdam

Associated Institutes:
USM (LMU München)
AIFA (Universität Bonn)

Russian Partner Institute:
IKI, Moscow

Industry:

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

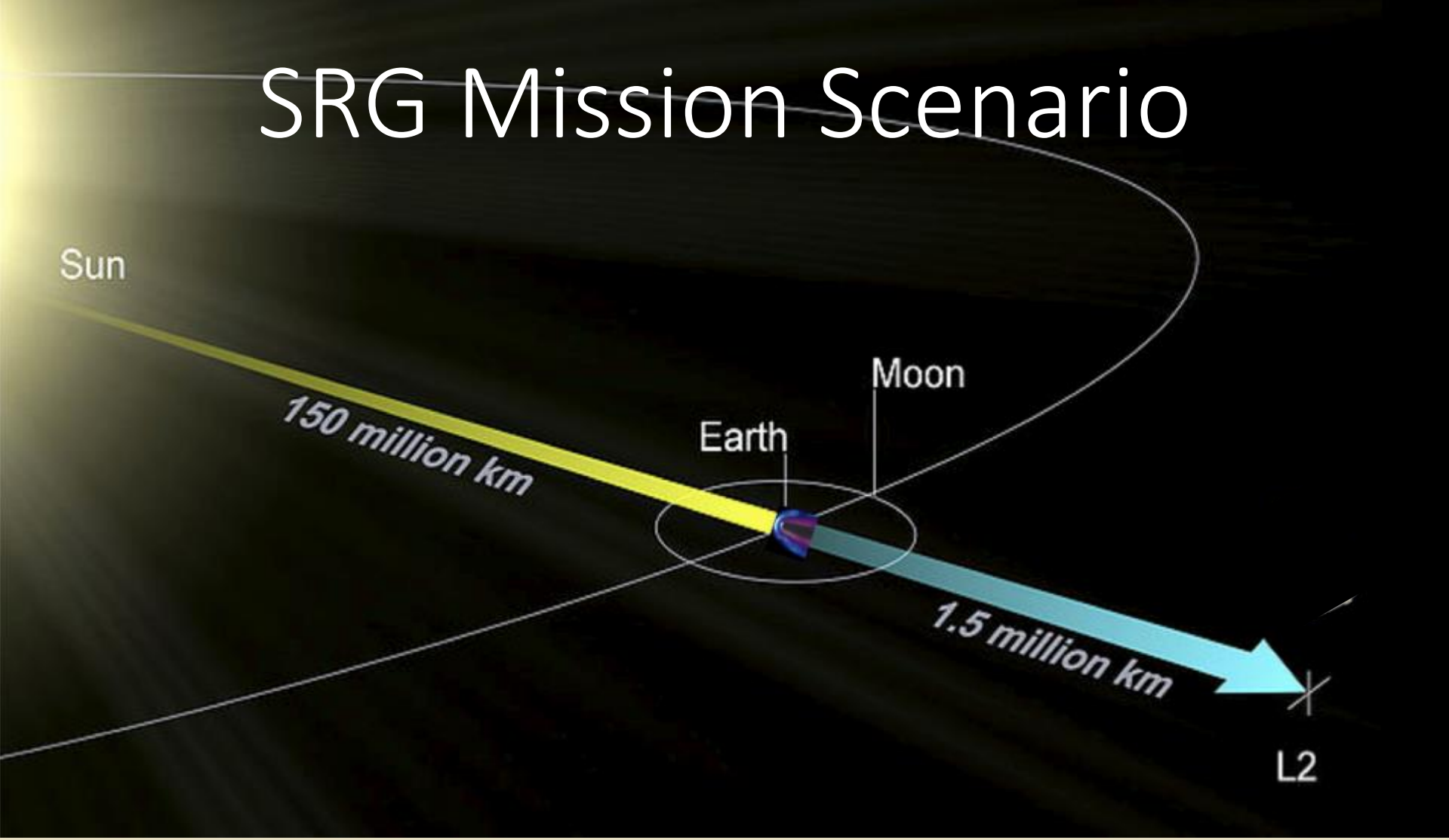
+ many small companies

COSTS: ~90 M€ (eROSITA)
~250-300 M€ (SRG)

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

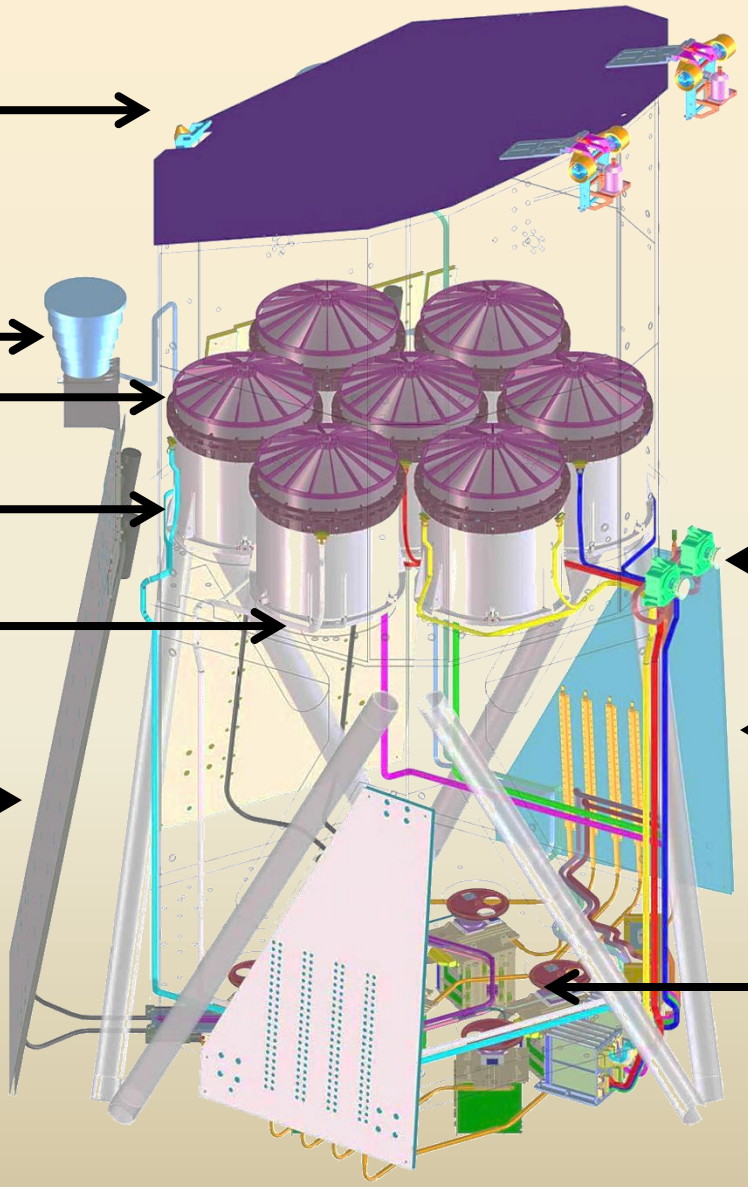
Funding: DLR:MPG ~50:50%

SRG Mission Scenario



Launch with PROTON/BLOK-DM from Baikonur
3-5 months, commissioning & CalPV (Cruise to Lagrange 2)
4 years survey, continuous rotation (~4hr)
3 years pointed observations

eROSITA - Schematic View



Front Cover

Star Trackers (2)

X-ray Baffles (7)

Mirror Modules (7)

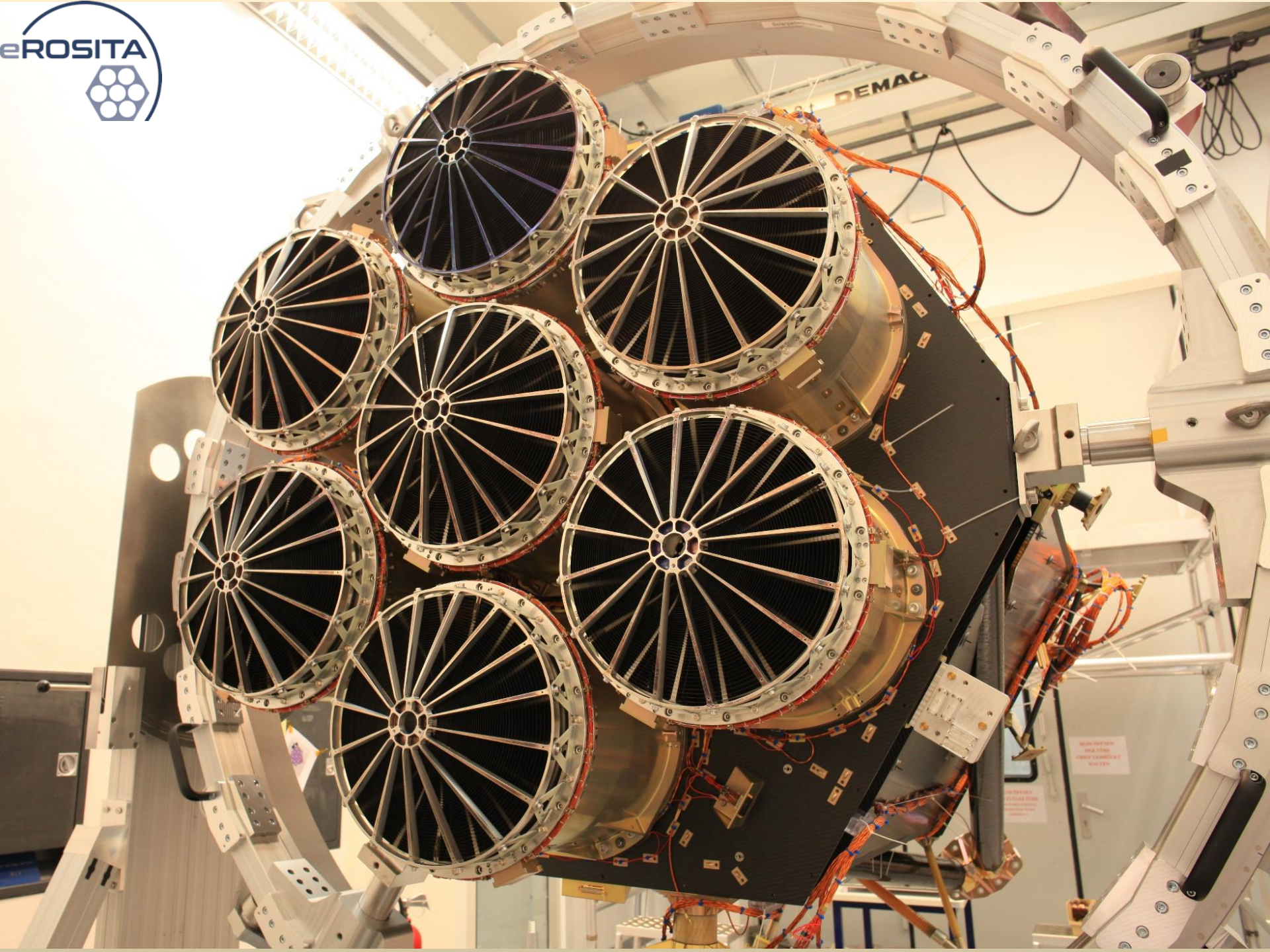
Electron Deflectors (7)

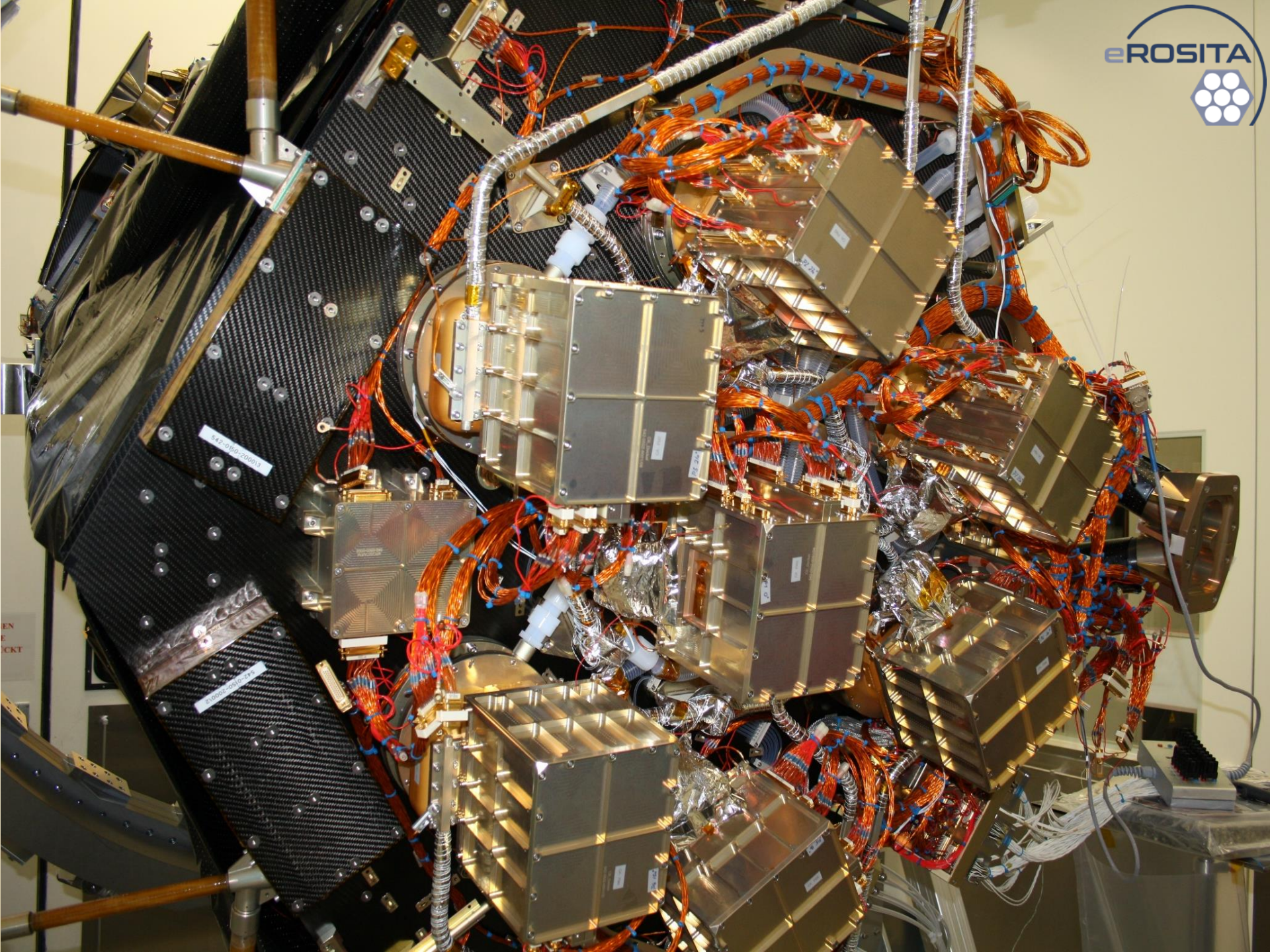
Camera Radiators (2)

Sun Sensors

Electronics Radiators (2)

Cameras, Electronics Cooling System


eROSITA


eROSITA

eROSITA Fact Sheet

Instrument

Size	1,9m Ø x 3.5m
Weight	810kg
Power	522W
Data volume	600MB/day
lifetime	> 7 years
Launcher	PROTON/BLOK-DM
Launch	March 2019
Mission	Orbit around L2

7 Mirror Assemblies

Wolter-I + X-ray Baffle + Electr. Div.

Diameter of outer shell	358mm
Number of shells	54
focal length	1600mm
PSF/HEW on axis (1.5keV)	18 arcsec
HEW average FoV	26 arcsec
Effective Area (1.5keV)	350 cm^2

7 Camera Assemblies

pnCCD + Filterwheel + E-Box

3 x 3 cm^2, pixelsize 75µm x 75µm

Time Resolution	50msec
Energy Resolution (1keV)	~ 70eV
Quantum Efficiency (1keV)	~ 95%

Performance

Energy Range	0.3-7keV
Point Source Sensitivity	1.2E-14
P.S. Sensitivity at poles	2.9E-15
Extended Source Sens	3.4E-14
ES. Sensitivity at poles	1.0E-14

eROSITA_DE

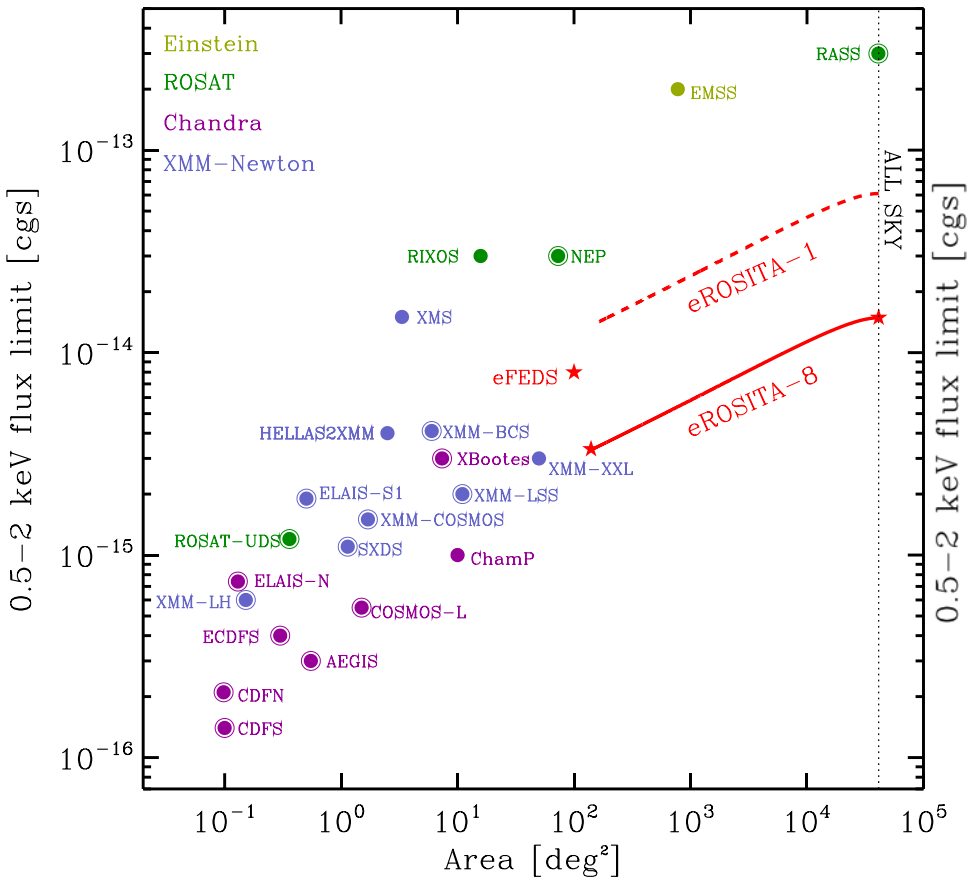
12 working Groups

135 Members

+ External Collaborators

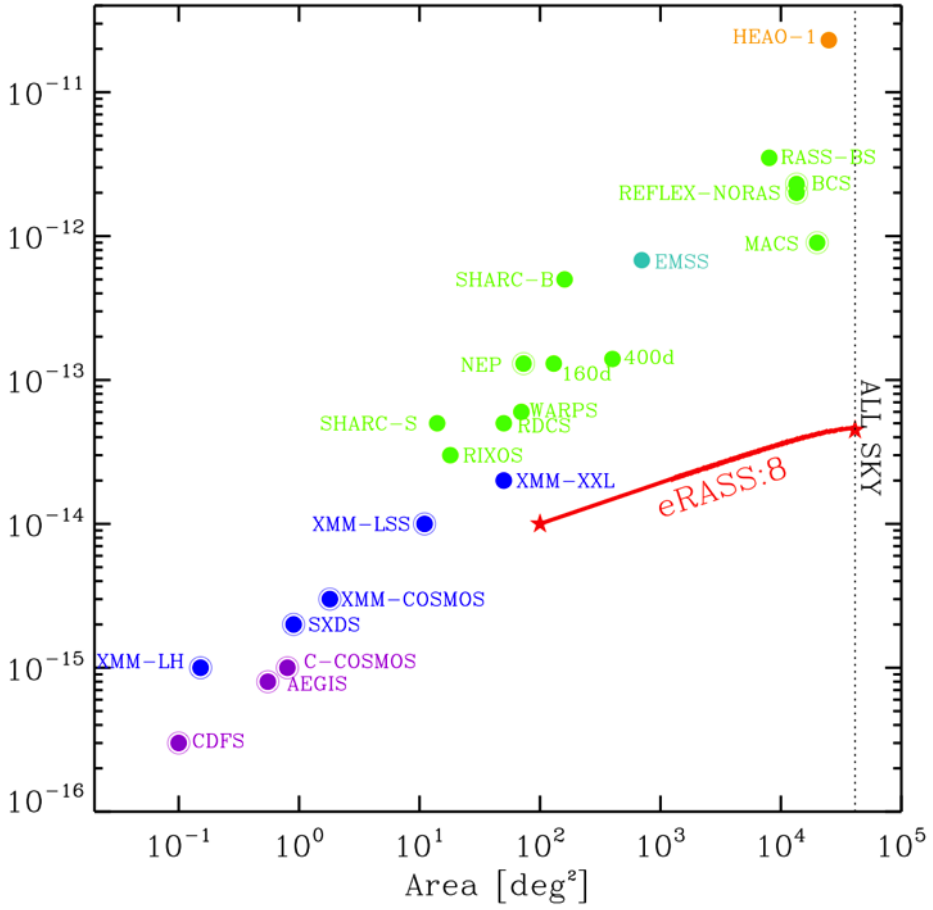
eROSITA surveys in context

Point sources sensitivity



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

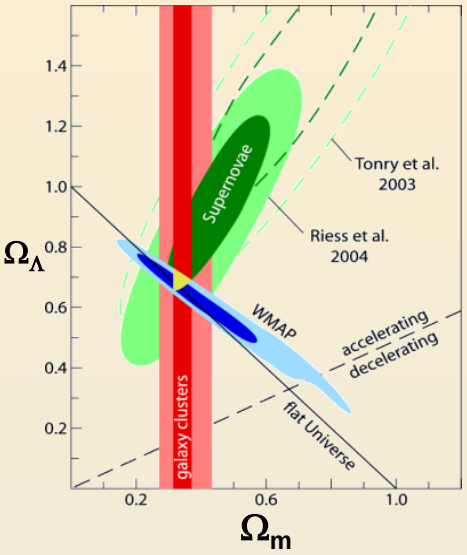
Extended sources sensitivity



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

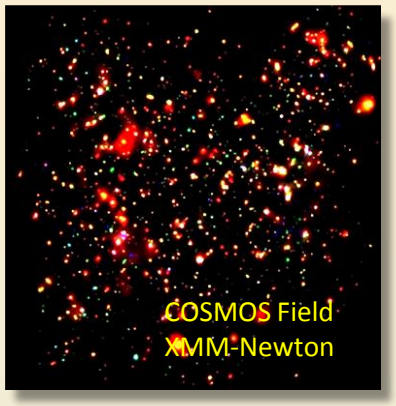
Merloni et al. 2012

“Design Driving Science” Cluster Cosmology



WMAP: Spergel et al. 2003
ROSAT: Schuecker et al. 2003

+



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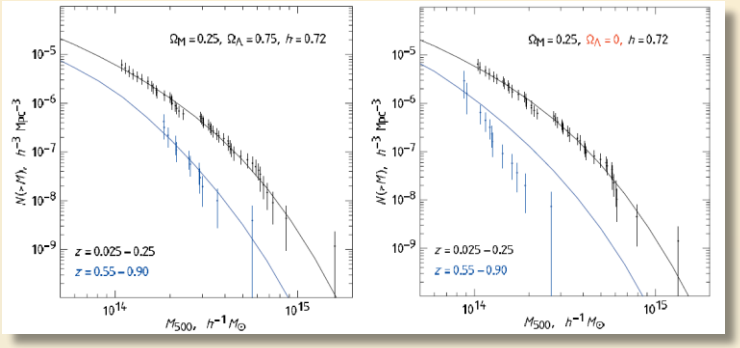


Vikhlinin et al., 2009

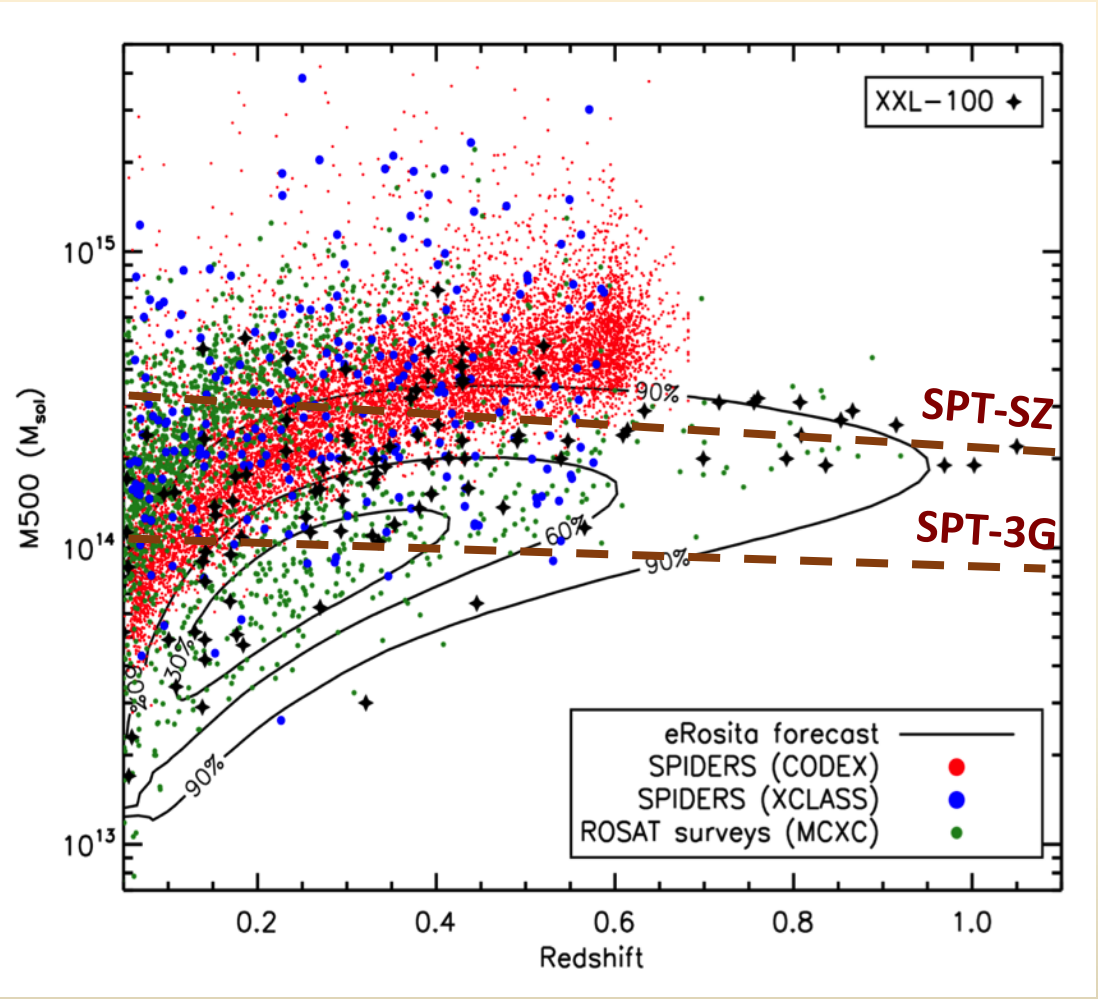
Clusters of galaxies are the largest gravitationally bound entities in the universe.

In X-rays we see clusters as one continuous entity.

Detectability of 100.000 Clusters of Galaxies, z < 1.5:

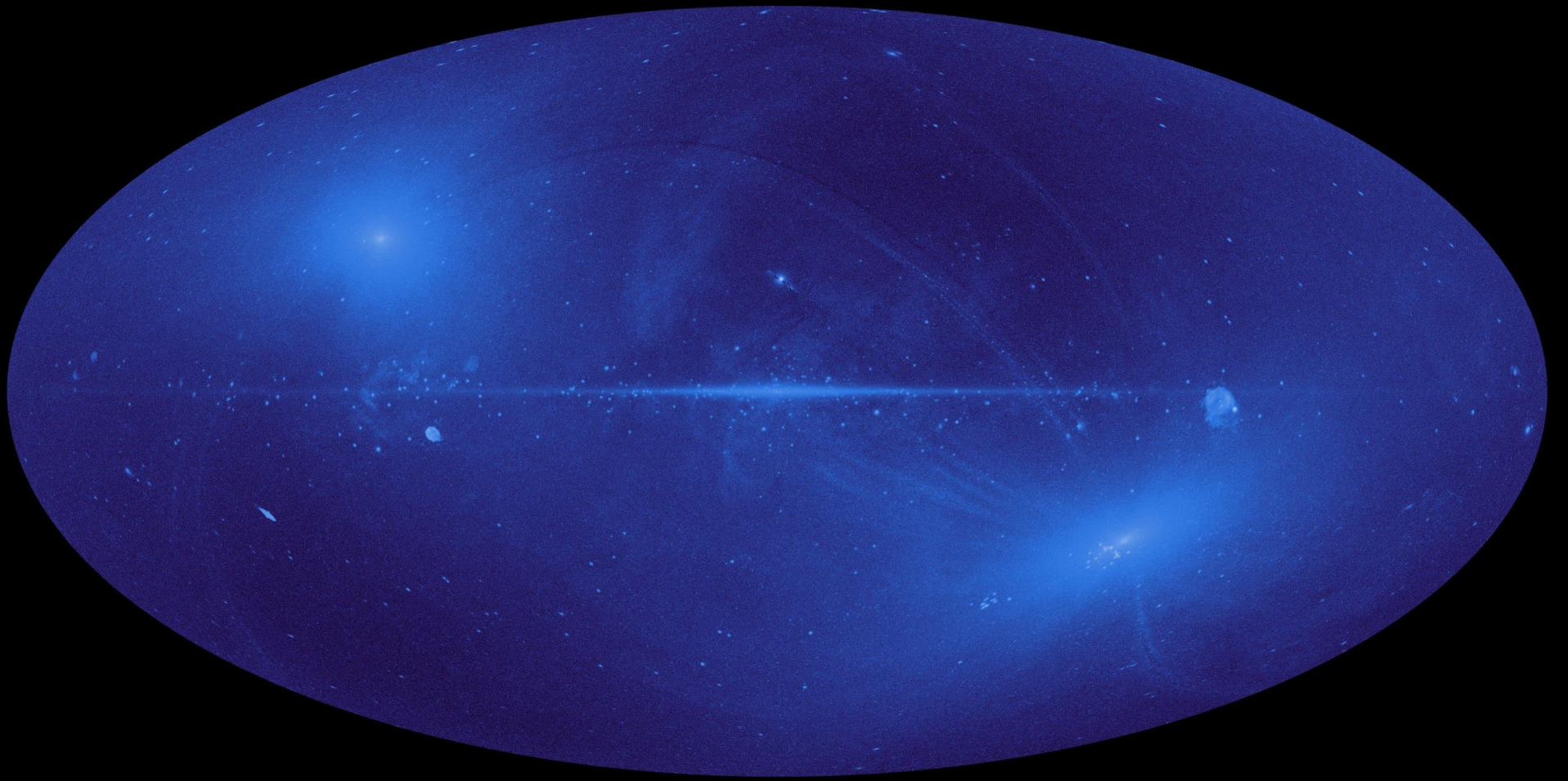
- All-sky survey with sensitivity 6×10^{-14} erg cm^{-2} s^{-1}
- Deep survey field(s) (~100 sqdeg) with 1×10^{-14} erg cm^{-2} s^{-1}
- Individual pointed observations
- Moderate angular resolution (< 28 arcsec, aver. over FoV)
- Large collecting area (> 2000 cm^2 @ 1keV)
- Large FoV (1° Ø)
- Long duration (survey 4 years ← → 1/2 year (ROSAT)

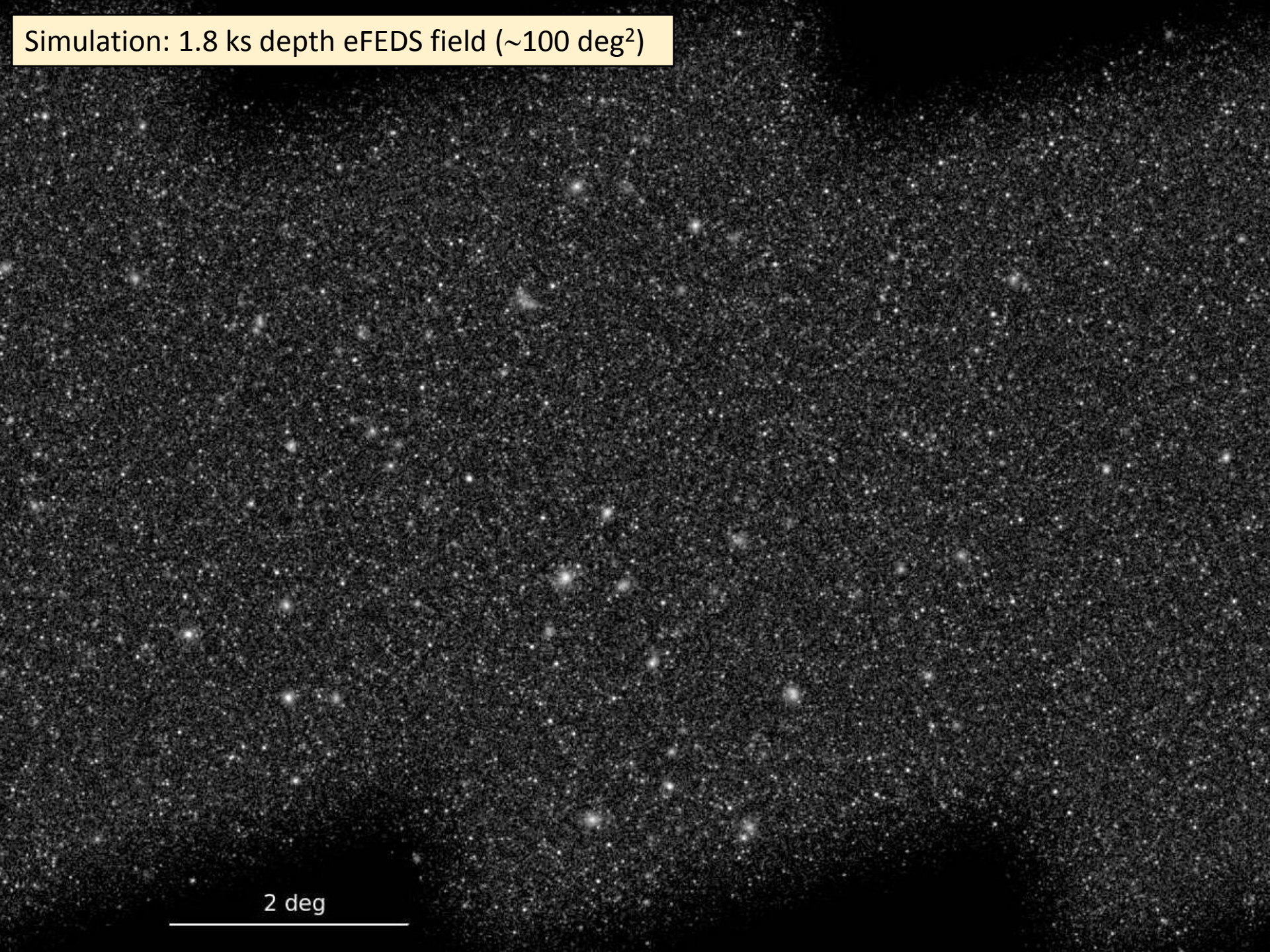
Will detect ALL Massive Clusters

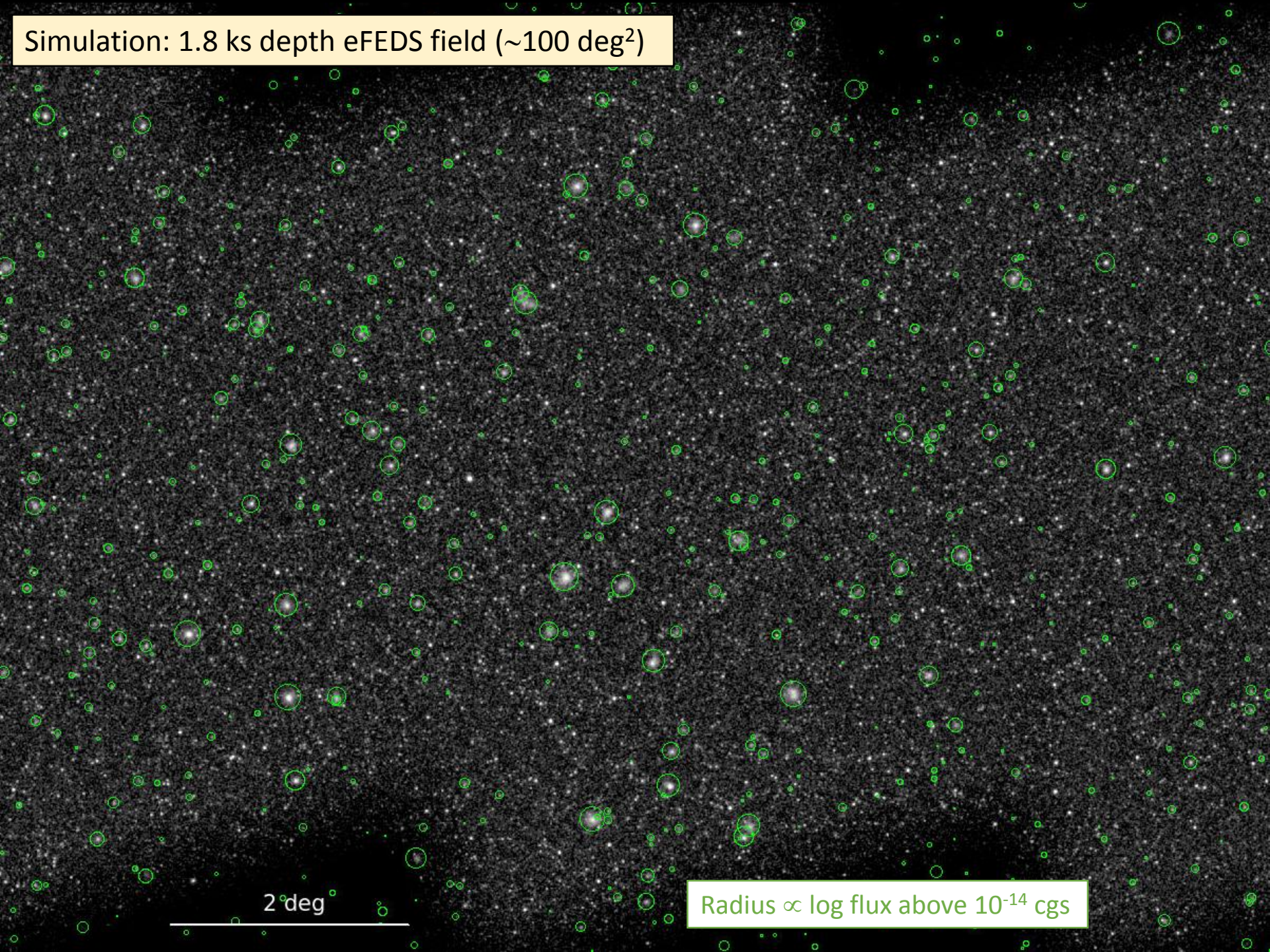


- eROSITA will detect ~ 110k clusters with more than 50 net counts; 2k with more than 1000 counts
- ~20k clusters with good redshift determination, up to z~0.45
- ~2k clusters with precise Temperature (to <10%)
- eROSITA PSF is good enough to resolve ~0.3R_{500} regions at z=1 for 10^{14} $M_{\odot}$ clusters
- For cosmology, M_{gas} and core-excised L_X are excellent mass proxies with very low scatter (~10%)

T. Dauser

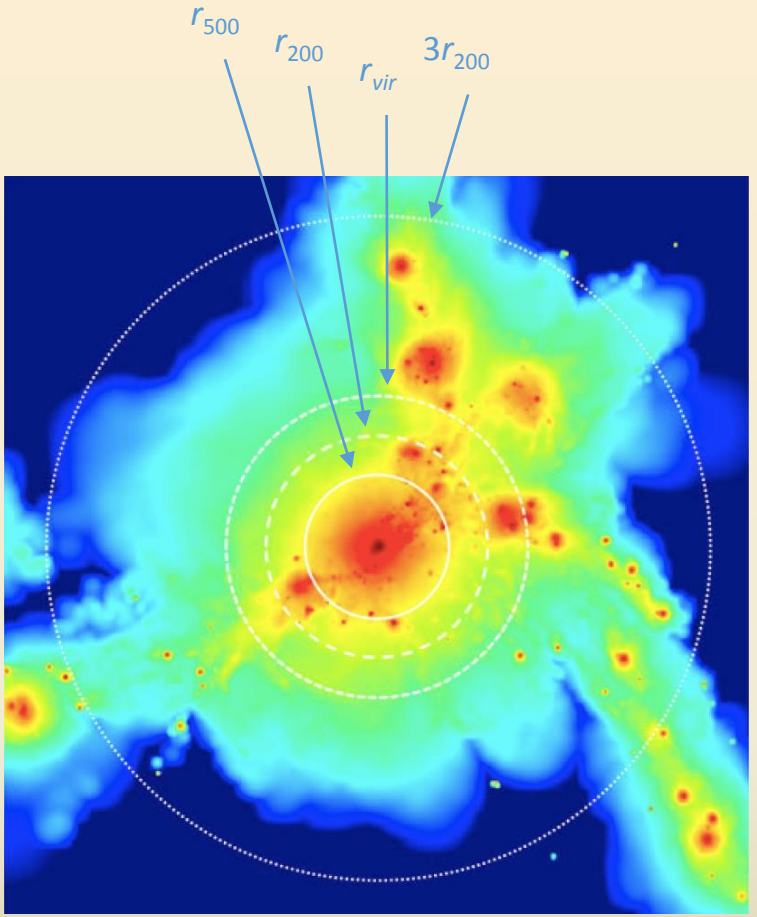



Simulation: 1.8 ks depth eFEDS field (~100 deg^2)
2 deg


Simulation: 1.8 ks depth eFEDS field (~100 deg^2)
2 deg
Radius ∝ log flux above 10^{-14} cgs

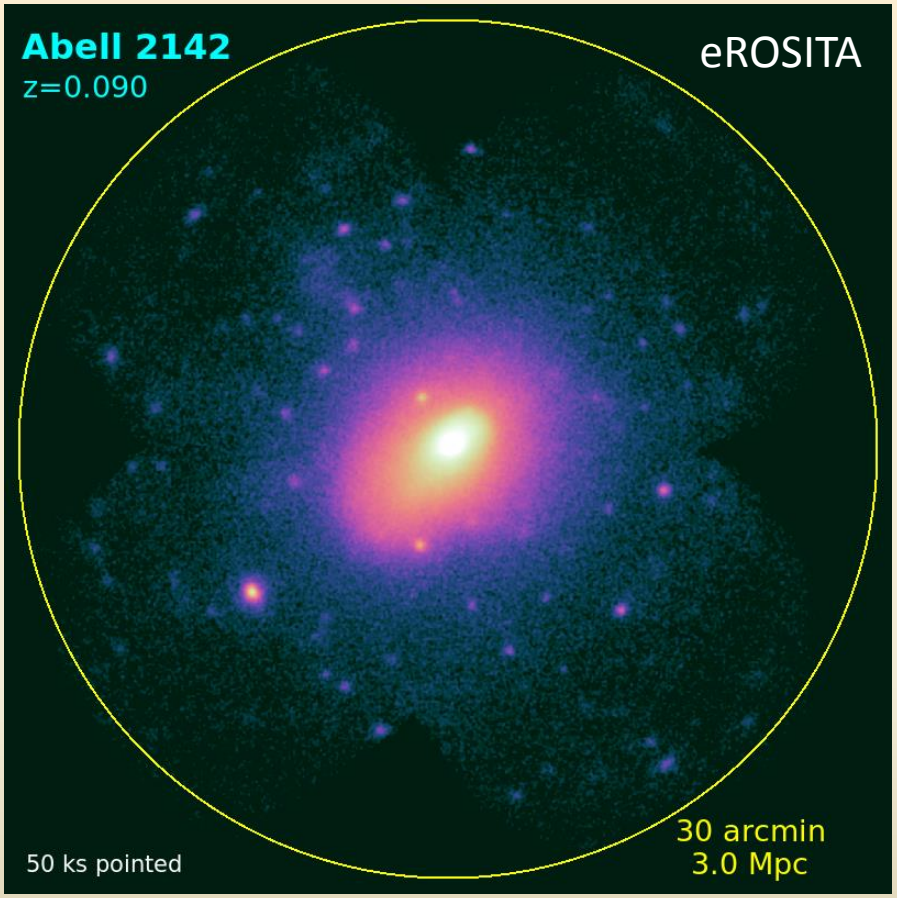
Examining cluster outskirts

- Outer parts of a cluster probes many physical processes:
  - State of WHIM
  - Gas clumping
  - Deviations from hydrostatic equilibrium
  - Non-equilibrium ionisation
  - Stripping and hydrodynamics
  - Chemical process and history
  - Cold fronts and sloshing
  - Entropy profile vs theory
  - …

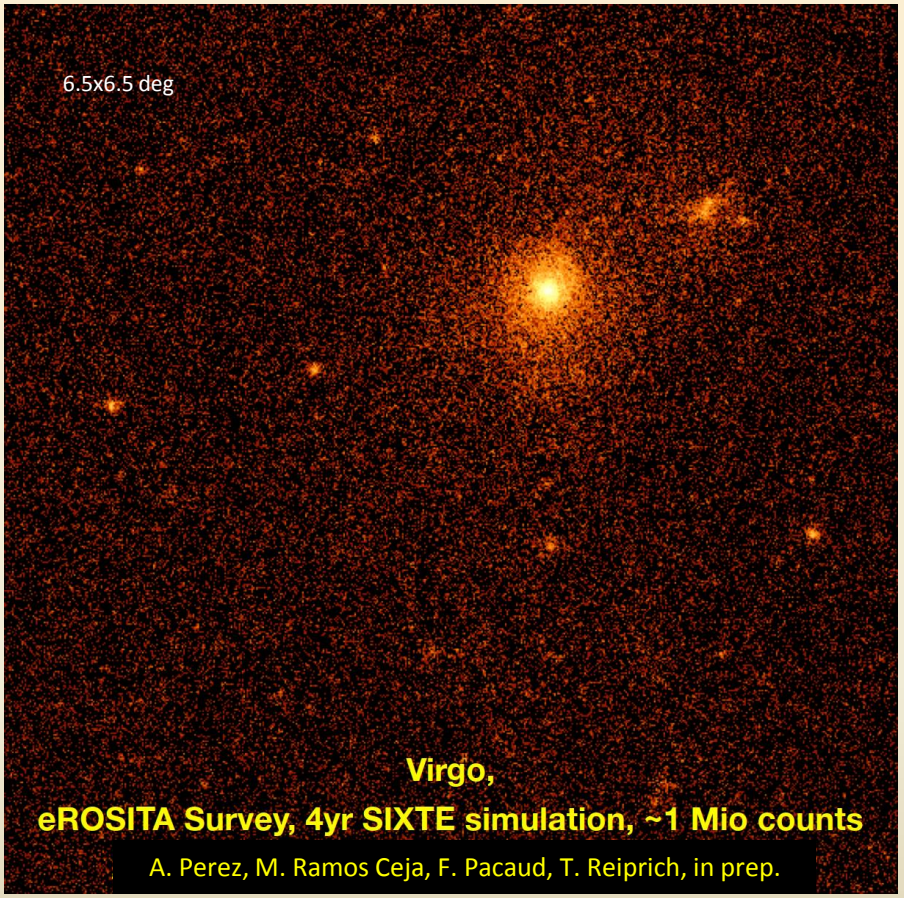


Reiprich+13

Examining cluster outskirts

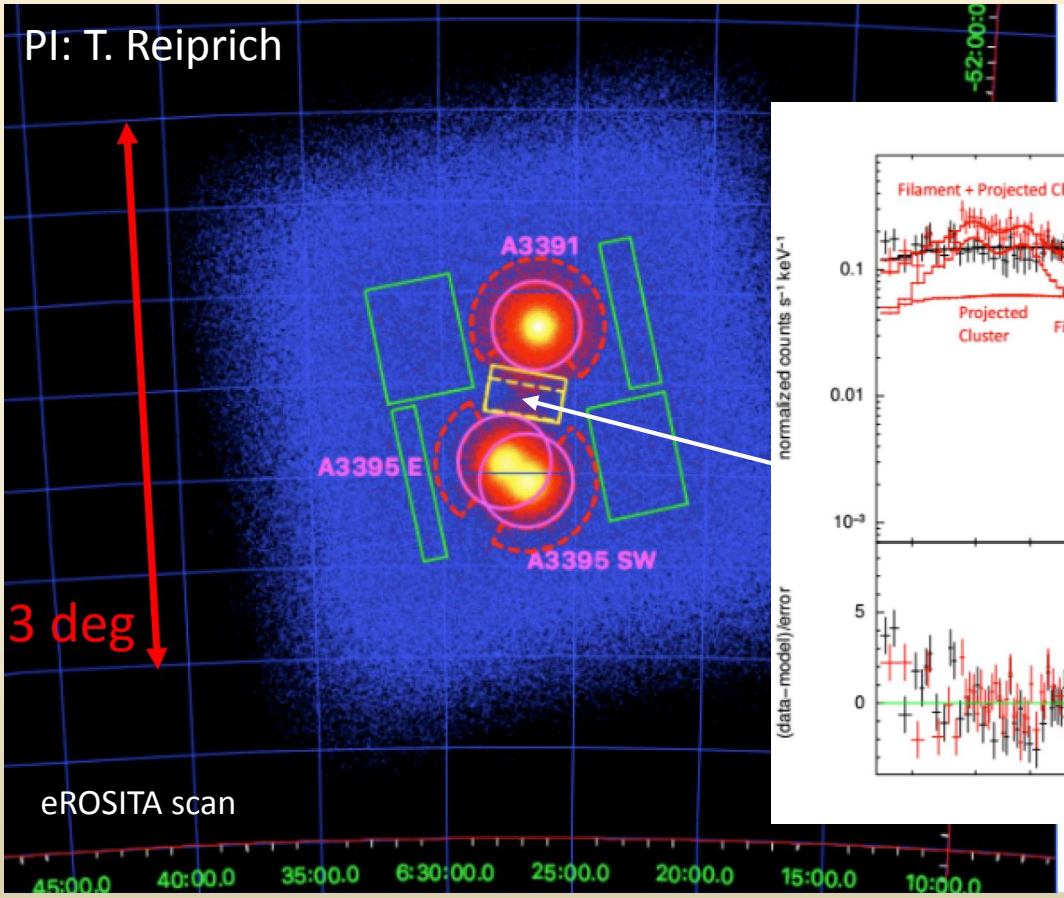


R_{500}=1.4 Mpc, R_{200}=2.2 Mpc (Ettori+18)



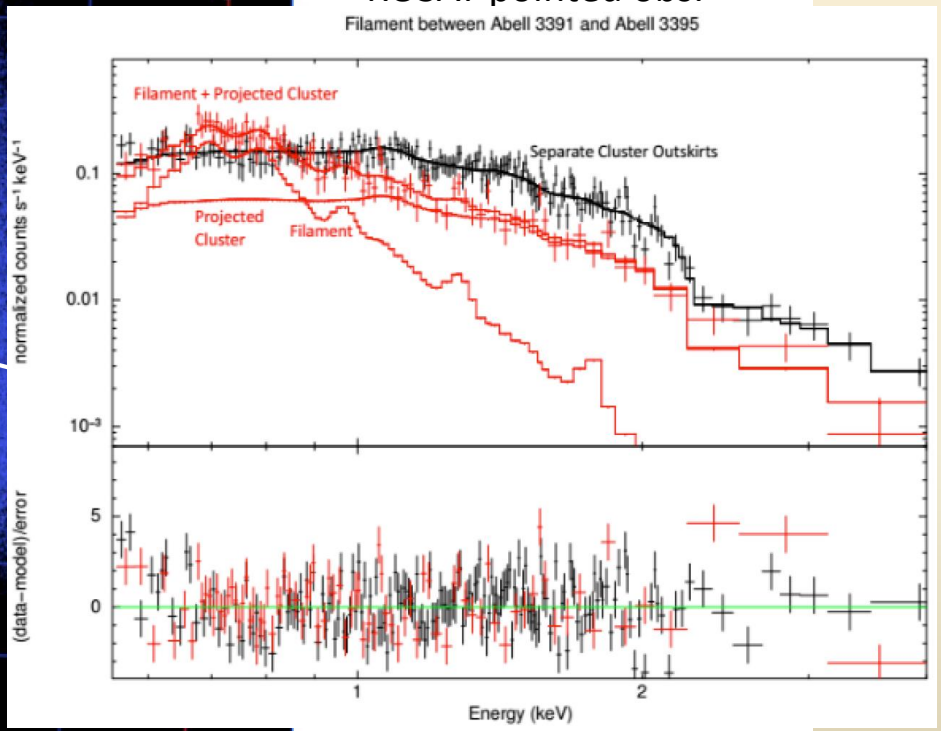
- Several nearby clusters and groups will have deep survey coverage (plus PV and calibration data)
- Field of view covers beyond R_{200} at moderate redshifts

PV observation: filament between A3391/95



Credits: C. Zhang, F. Pacaud, M. Ramos-Ceja, T. Reiprich

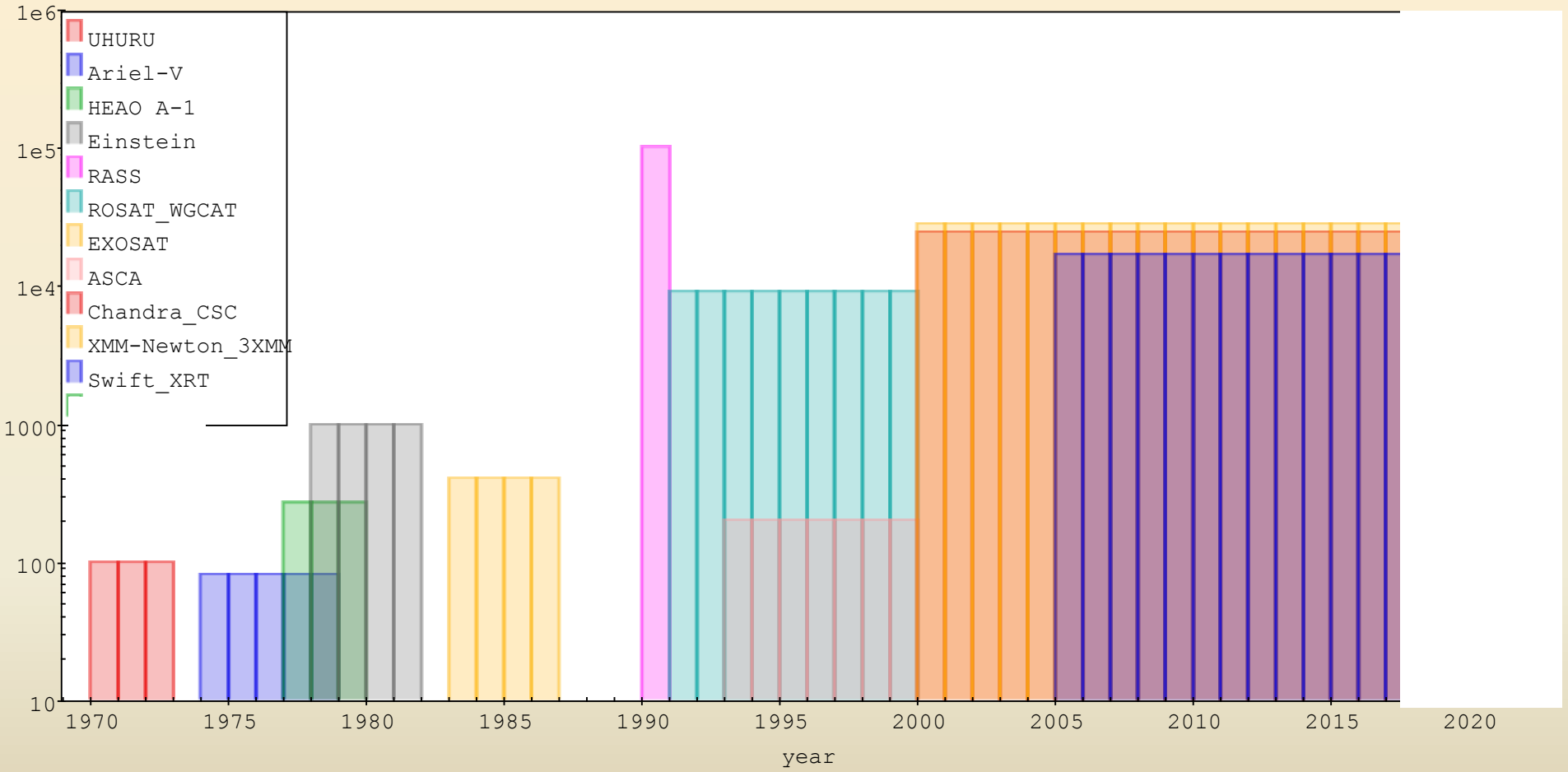
ROSAT pointed obs.



Credit: D. Eckert

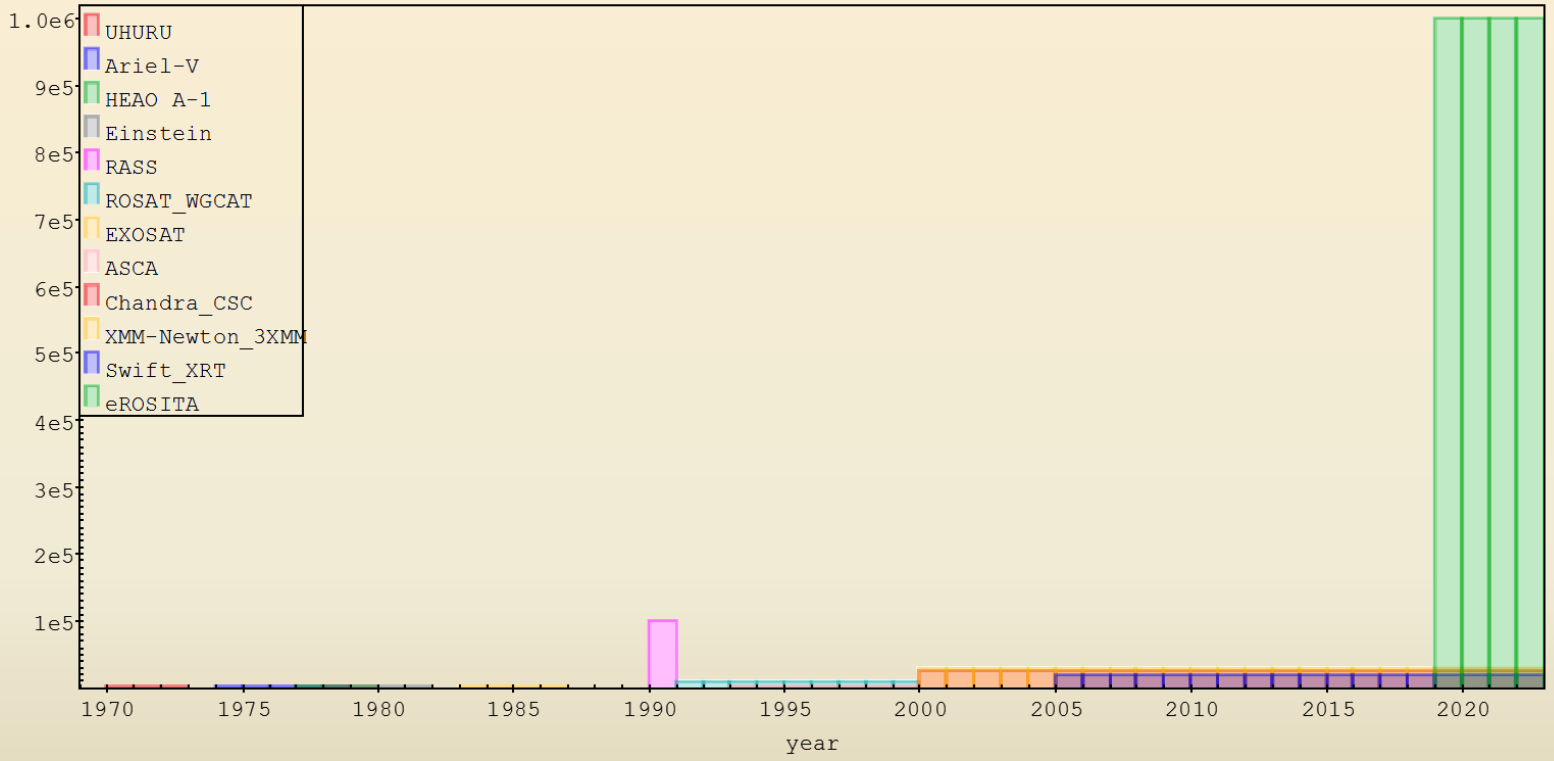
eROSITA surveys in context

Logarithmic scale!



Approx. Number of X-ray sources detected per year (from published catalogs, not corrected for duplications)

eROSITA surveys in context



At the end of its first year of operations, eROSITA will have detected as many new sources as have been catalogued in 50 years of X-ray astronomy.