

# eROSITA

Peter Predehl

An introduction to instrument and mission

- more about the mirrors: P. Friedrich
- more about the detectors: N. Meidinger
- more about science: rest of this week

# 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



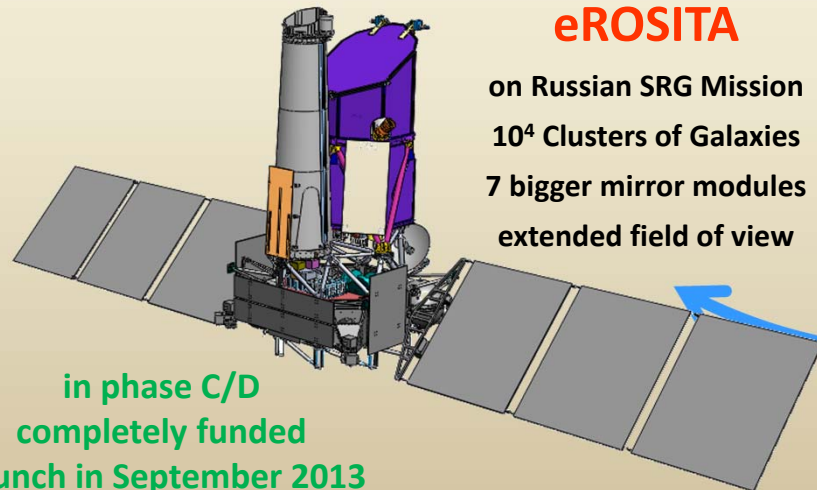
ABRIXAS science on the  
International Space Station

not realised due to Shuttle schedule

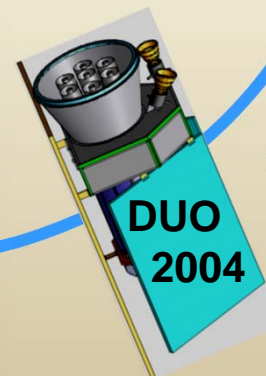


**eROSITA**

on Russian SRG Mission  
10<sup>4</sup> Clusters of Galaxies  
7 bigger mirror modules  
extended field of view



in phase C/D  
completely funded  
Launch in September 2013



**DUO**  
2004

**Dark Energy**

10<sup>4</sup> Clusters of Galaxies

SMEX-proposal,  
lost against NuStar

# eROSITA Team

**PI:** Peter Predehl

**Project Scientist:** Andrea Merloni

**Co-Is:** Hans Böhringer, Ulrich Briel, Hermann Brunner, Evgeniy Churazov, Michael Freyberg, Peter Friedrich, Günther Hasinger, Eckhard Kendziorra, Dieter Lutz, Josef Mohr, Norbert Meidinger, Kirpal Nandra, Mikhail Pavlinsky, Thomas Reiprich, Andrea Santangelo, Jürgen Schmitt, Axel Schwope, Matthias Steinmetz, Lothar Strüder, Rashid Sunyaev, Jörn Wilms

**Instrument Team:** Josef Eder, H. Bräuninger, M. Hengmith, W. Bornemann, O. Hälker, S. Hermann, W. Kink, S. Müller, O. Hans, Z. Zhang, G. Plasoianu, H. Huber, Chr. Rohé, L. Tiedemann, R. Schreib, B. Mican, H. Eibl, A. Schneider, F. Huber, K. Lehmann, P. Friedrich, W. Burkert, M. Freyberg, B. Budau, V. Burwitz, M. Fürmetz, A. Müller, E. Pfeffermann, A. Buron, N. Meidinger, G. Schächner, J. Elbs, S. Ebermayer, A. v. Kienlin, A. Schwope, G. Hartner, K. Dennerl, R. Andritschke, Chr. Tenzer, M. Vongehr, R. Gaida, K. Dittrich, Th. Burghart, T. Blasi, F. Schrey, K. Hartmann, H. Brunner, P. Guglielmetti, G. Lamer, M. Mühlegger, J. Wilms, I. Kreykenbohm, C. Schmid, M. Brusa, A. Finoguenov, M. Salvato, A. Giorgakakis, J. Schmitt, J. Robrade

## **Institutes:**

### **MPE, Garching/D**

Universität Erlangen-Nürnberg/D

Universität Tübingen/D

Universität Hamburg/D

Astrophysikalisches Institut Potsdam/D

Max-Planck-Institut für Astrophysik/D

Space Research Institute IKI, Moscow/Ru

Argelander Institut, Universität Bonn

Universitätssternwarte München (LMU)

## **Industry:**

Media Lario/I

Kayser-Threde/D

Carl Zeiss/D

Invent/D

pnSensor/D

IberEspacio/E

RUAG/A

G&H Technology/USA

Tecnotron/D

Moog/USA

HPS/D,P

Alter/I

3Dplus/F

Mirrors, Mandrels

Mirror Structures

ABRIXAS-Mandrels

Telescope Structure

CCDs

Heatpipes

Cover-Mechanism

Cover-Separation

Circuit Boards

Valves

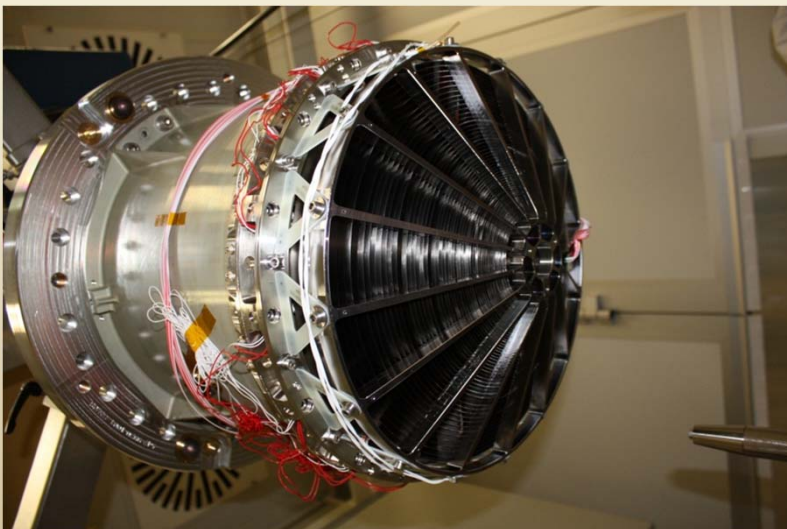
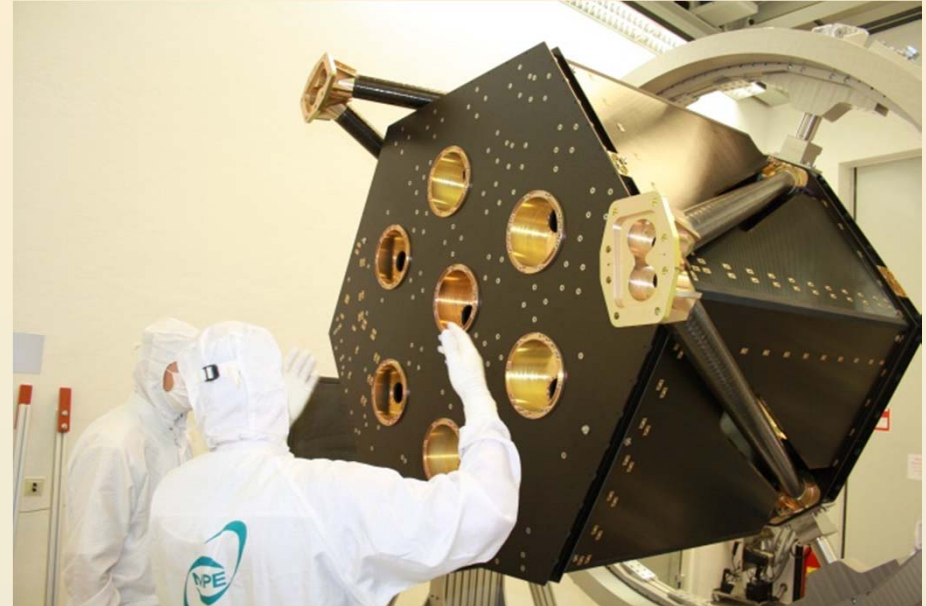
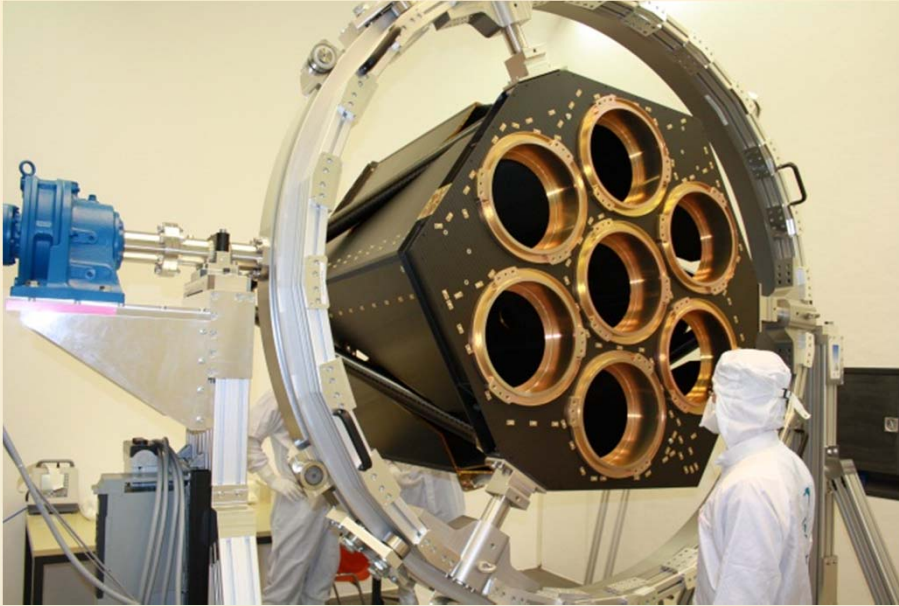
MLI

Electronics

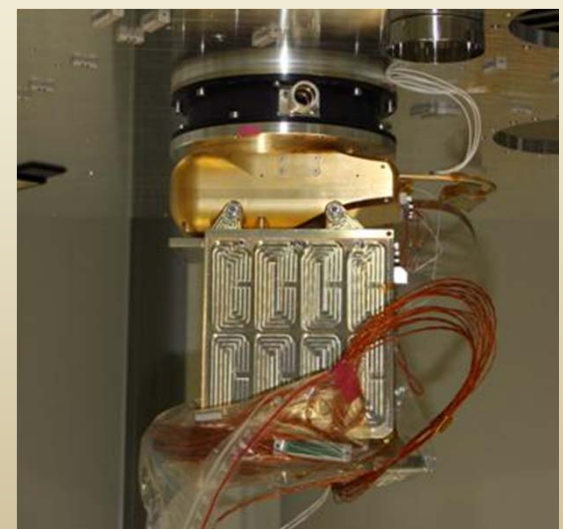
Electronics

+ many small companies

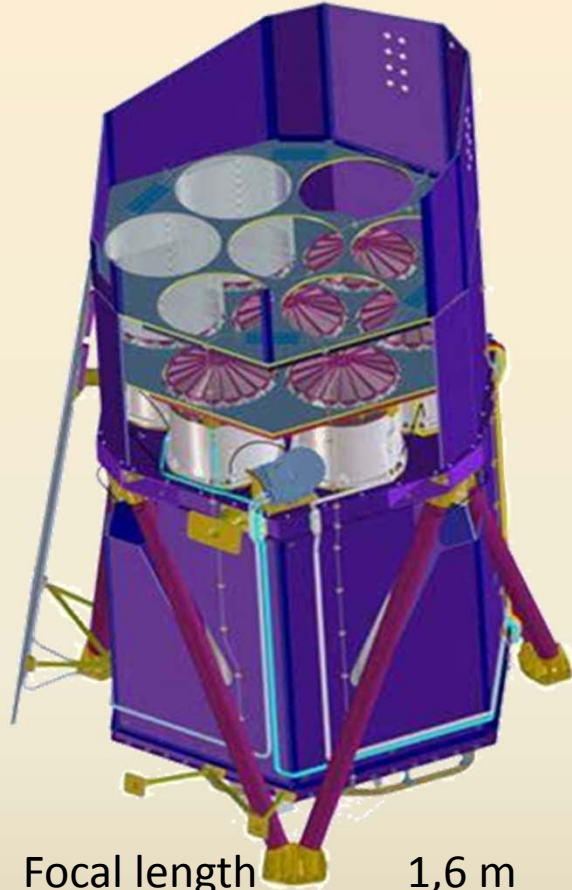
# eROSITA Instrument



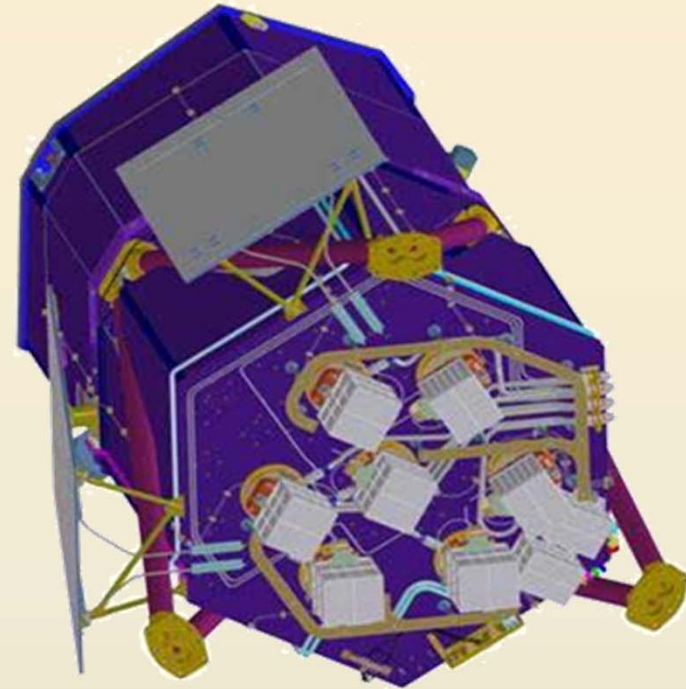
×7!



# Instrument



Focal length 1,6 m  
Field of View  $1^\circ \text{ } \emptyset$   
7 identical Mirror Modules  
54 nested Mirror Shells

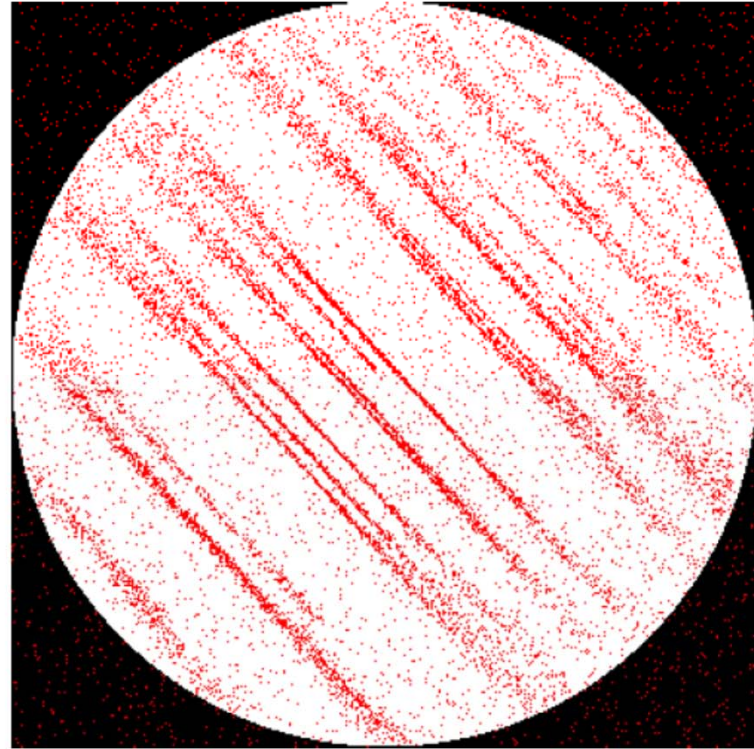
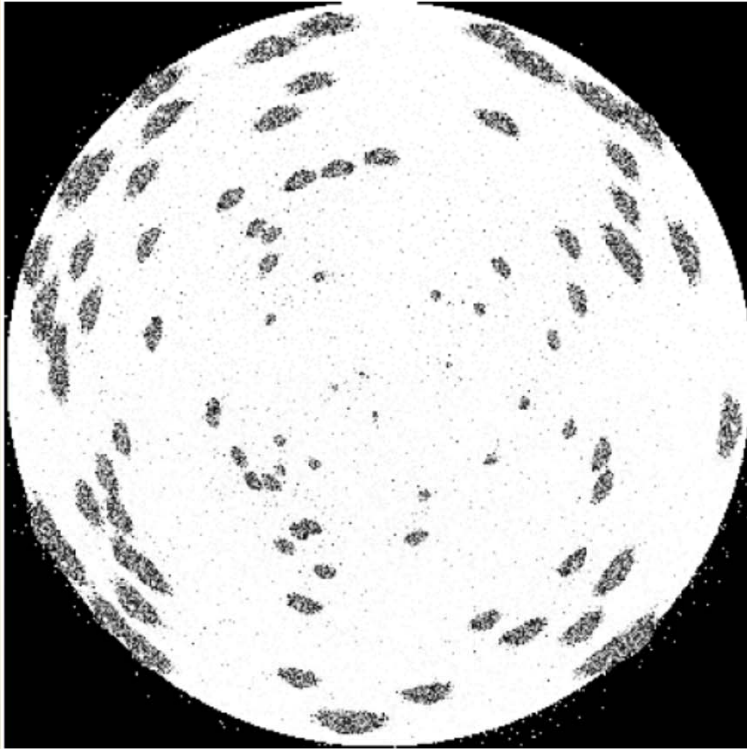


Energy Range 0.3-10 keV  
Energy Resolution 138 eV @ 6 keV  
Dimensions 3,2m  $\times$  1,9m  $\emptyset$   
Weight 750 kg

# H/W Inventory

- 7 Mirror Modules including X-ray baffles
- 7 Cameras including filter wheels and electronics boxes
- 7 Magnetic Electron Deflectors
- 2 (redundant) Interface & Thermal Controller Electronics boxes
- Cooling system incl. 7 camera heatpipes, 2 distribution heatpipes, 4 variable conductance heatpipes, two radiators
- Telescope Structure incl. Hexapod
- Front Cover (to be opened once in orbit)
- 2 Startrackers (belong to S/C)
- 2 Sun sensors (belong to S/C)

# Simulations



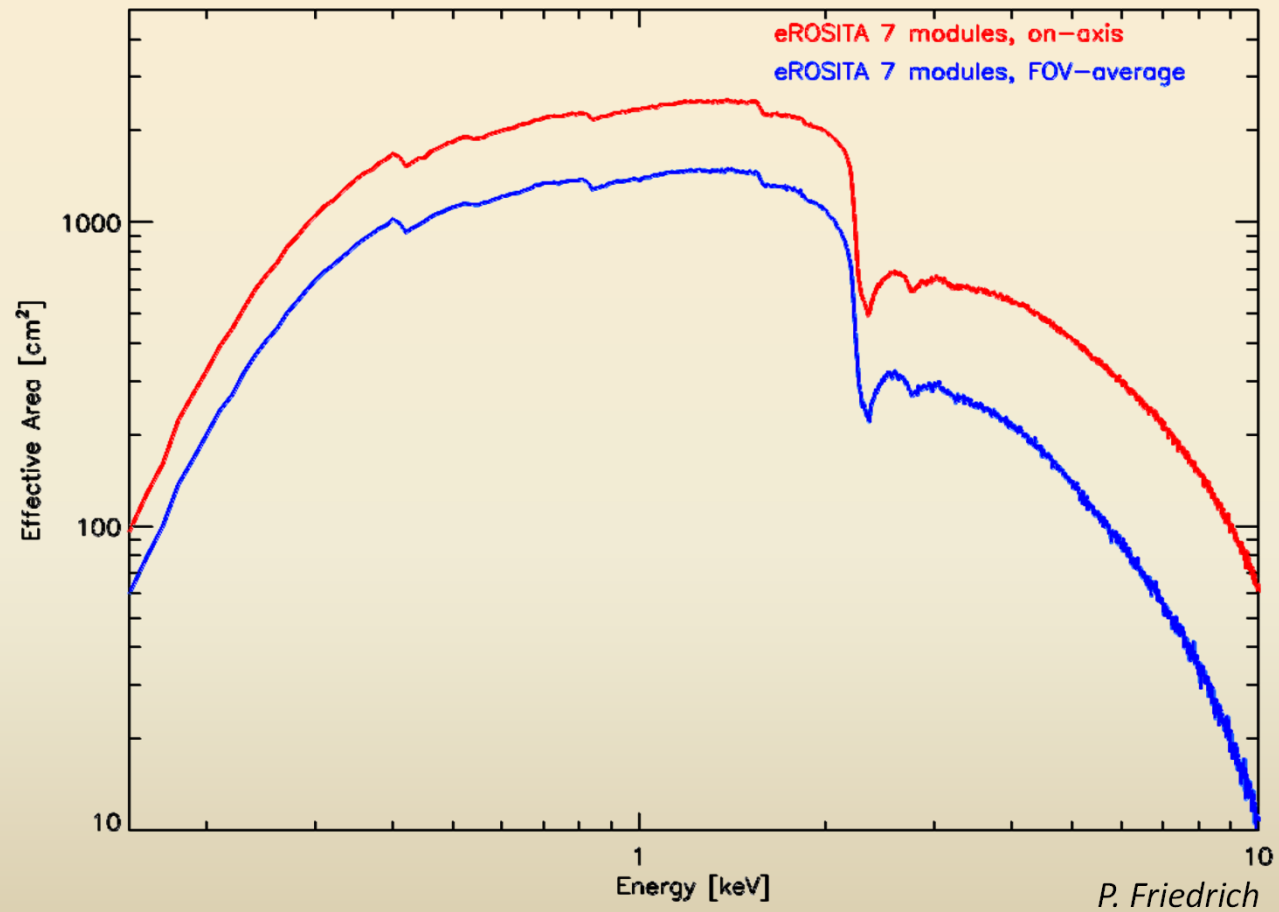
## Pointing

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

## Scan

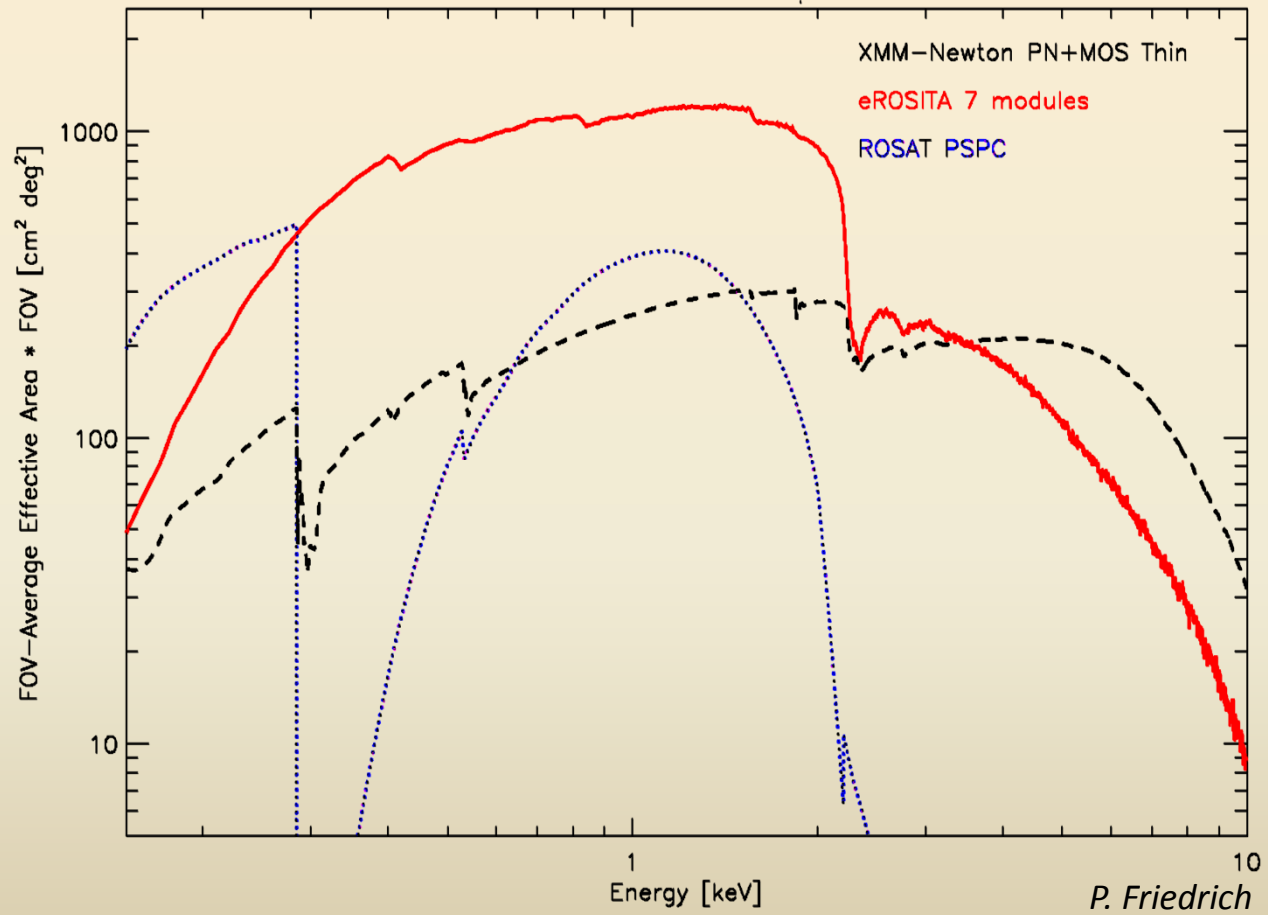
*Ch. Schmid*

# Effective Area

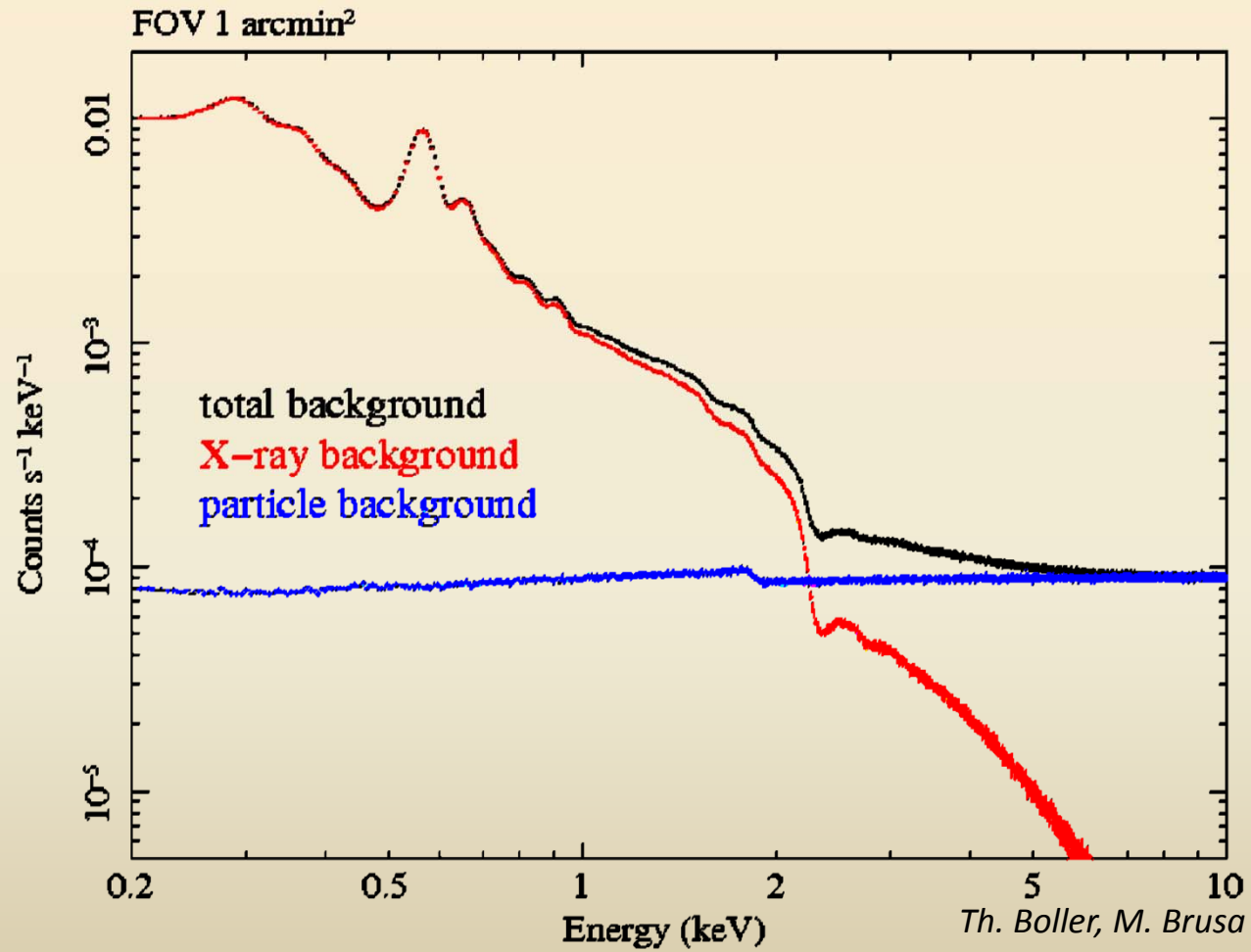




# Grasp



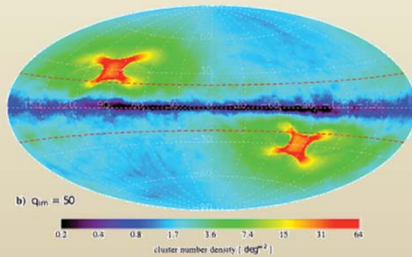
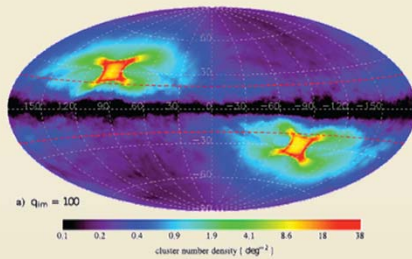
# Background



# eROSITA Core Science

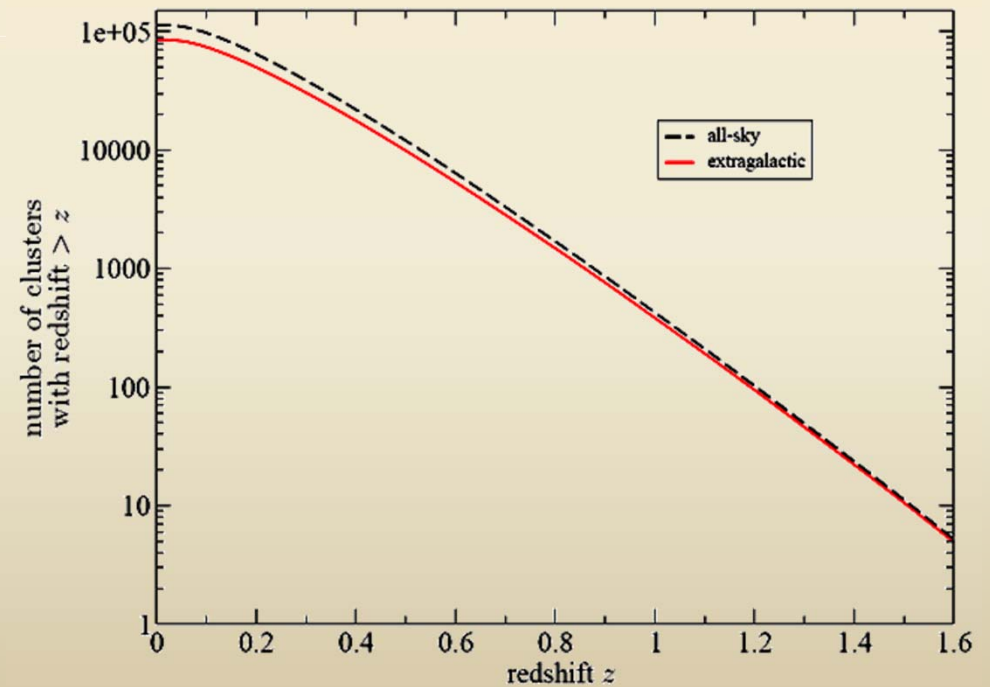
## 100.000 GCs in eRASS

- Cluster mass function evolution with redshift for different cosmologies  
→ constraints on  $\Omega_m$ ,  $\Omega_\lambda$ ,  $\sigma_8$



Nphot.	all sky	extragal sky
30	393810	293767
50	236503	176946
100	113227	85139
500	17272	13159
1000	7191	5514

M. Mühlegger



# ... hundreds of tests

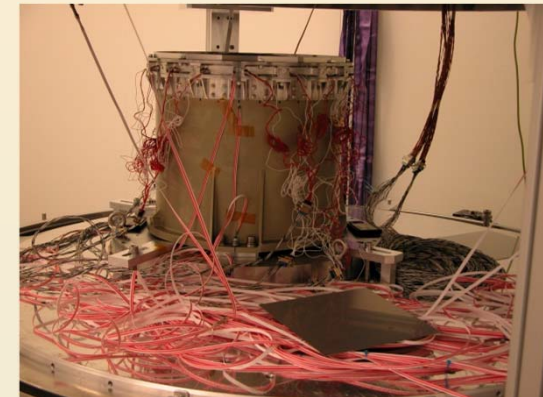
function, vibration, acoustic, thermal, calibration



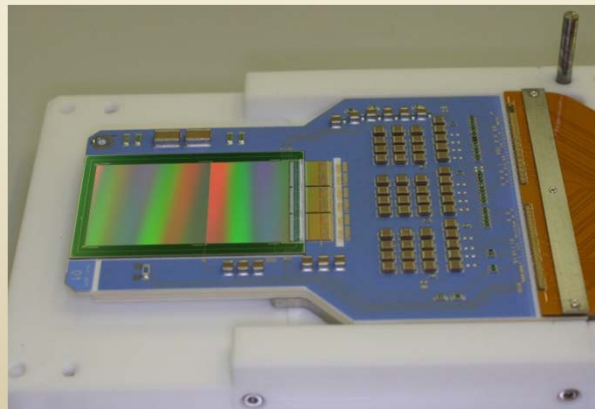
Mirror Modules  
PANTER X-ray testfacility

FM1 (31 shells) in spec.  
FM2 (15 shells) in spec.  
FM2 (31 shells) inspec.  
Shell #12 in spec.

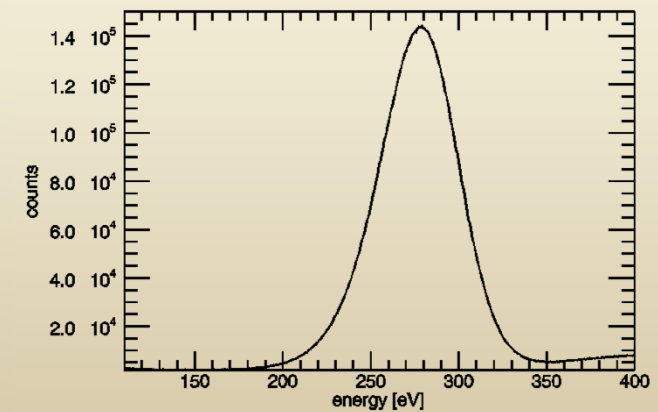
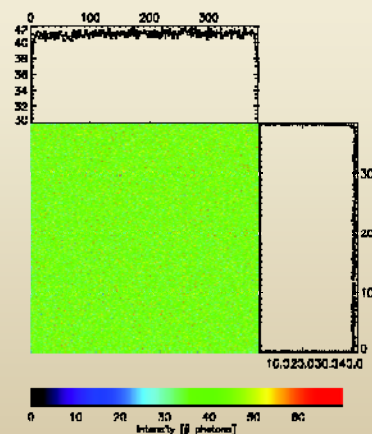
15 arcsec HEW, on-axis



Mirror Module Thermal Cycling



CCD-Module. in spec.



# ... hundreds of tests

current: thermal-vacuum in PANTER facility



# Calibration

<i>device</i>	<i>process</i>	<i>signal</i>	<i>characteristic properties</i>	
<b>telescope</b>	reflection (scattering)	<i>photon [eV]</i>	effective area (E,φ) point spread function (E,φ) field of view (FOV) boresight	collecting area, reflectivity, vignetting mirror quality focal length, detector geometry, plate scale alignment
	<b>filter</b>		absorption	transmission (E) contamination (E,t)
<b>CCD</b>	charge release	<i>charge [e<sup>-</sup>]</i>	charge splitting low energy threshold	patterns (singles, doubles, triples, quadruples, invalid..)
			contaminating effects	pile-up (single pixel, pattern) photon background (fluorescence, optical loading) particle induced background (soft protons, MIPs) detector induced background (noise, bright pixels)
	charge transfer		quantum efficiency (QE) energy resolution (ΔE)	trap saturation due to photons and particles charge transfer noise threshold induced charge loss reemission, charge diffusion, charge splitting
	charge readout	<i>pulse height amplitude [adu]</i>	charge transfer loss (CTI) pattern migration	readout noise amplification ('gain')
<b>on-board data processor</b>	signal processing	<i>event [bit]</i>	energy offsets (offset map) common mode correction signal extraction MIP suppression	non-linear gain, also dependence of the "apparent" gain on threshold(!) dependence on energy, temperature, time
				restrictions likely due to limitations in on-board computing power and telemetry (low energy threshold, MIPS..)

K. Dennerl

# NRTA & SASS & Catalogues

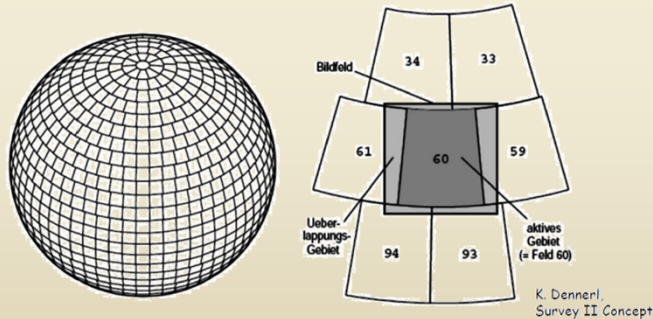
- NRTA (Near Real Time Analysis)
- SASS (Standard Analysis Software System)
- Tests of all software systems

work in progress  
work in progress  
starts mid 2012

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

## All-sky survey:

- Sky is divided into 5839 equatorial equal-area fields of approx.  $3^\circ \times 3^\circ$
- After event-calibration, incoming data stream is split and accumulated in same number of overlapping  $3.6^\circ \times 3.6^\circ$  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

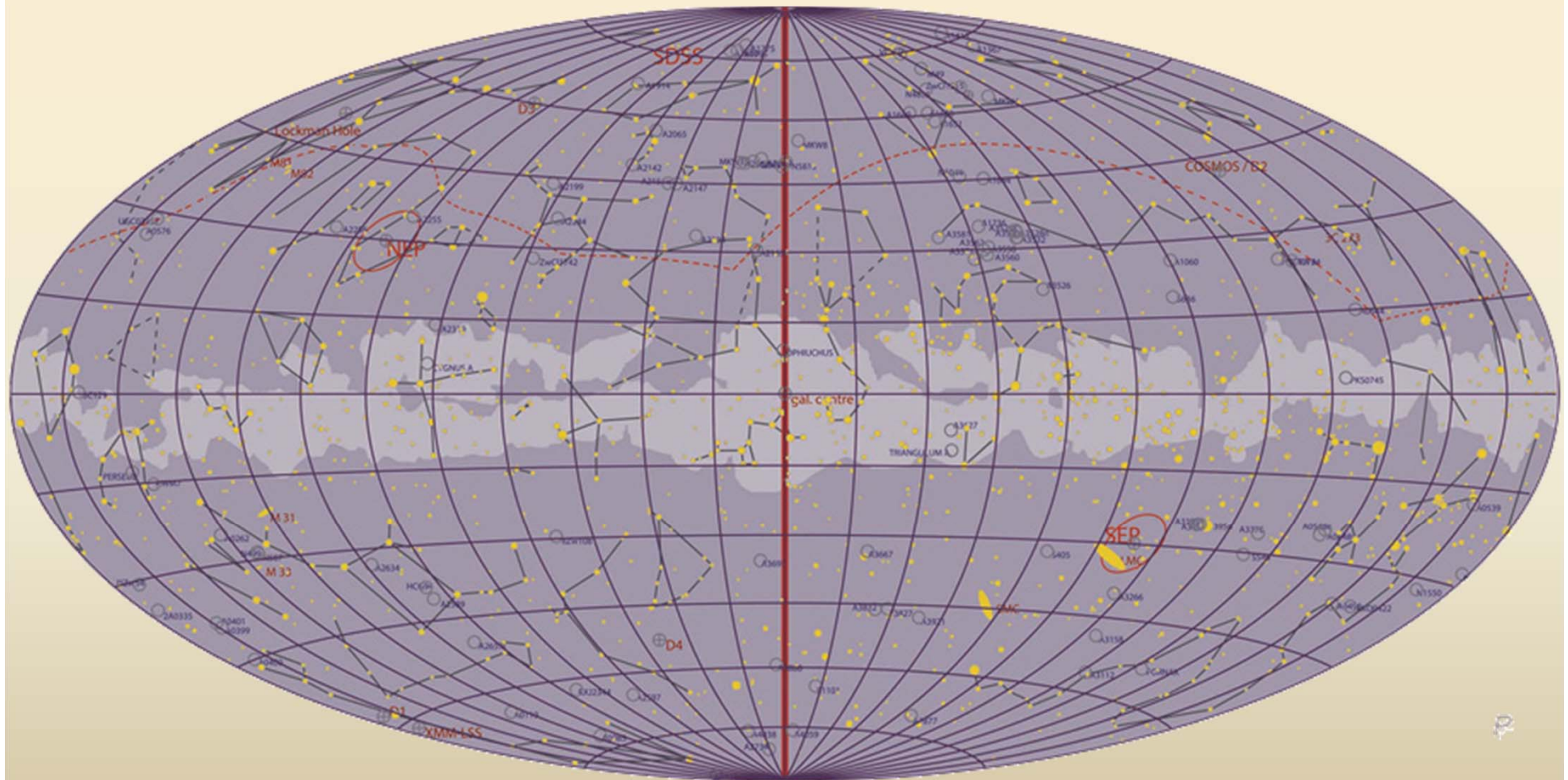


## Pointed observations:

- Incoming data stream is split in different pointings ( $\leftarrow$  timeline)
- Source detection is performed on  $1.6^\circ \times 1.6^\circ$  fields, centred on pointing

- **Calibrated event files**  
FITS extensions: EVENTS, EXPOSUREn, GTIn, BADPIXn, OFFSETn
- **Image products**  
Sky image in four non-overlapping energy bands ( $E_{\min}$ -0.5, 0.5-2, 2-5, 5-10 keV); energy bands should be science driven (to be discussed in WG)  
  
Image pixel size: 4" (tbd)  
Image size survey:  $3.6^\circ \times 3.6^\circ$   
3240 x 3240 pixels  
pointed obs.:  $1.6^\circ \times 1.6^\circ$   
1440 x 1440 pixels  
  
Corresponding exposure & backgr. maps
- **Source specific products**  
Extracted spectra (source & backgr., suitable for spectral fitting) and time series for all sources with more than tbd counts (FITS & PDF); under discussion: include simple model fits (PL?)
- **Index or summary file (ASCII)**  
Observation and instrument config. summary, high background warning, important warnings and errors from pipeline processing, automatic & interactive quality screening flags, list of files in dataset
- **Pipeline parameter file**  
Allows the user to re-run the pipeline
- **Source Lists**  
XMM-style (emldetect) source lists  
ds9 region files of detected sources
- **Other products**  
Attitude file (FITS) & histogram plot, backgr. Lightcurve (FITS/PDF), opt. cross-ID products, selected HK files

# Sky Division







# Follow-up Observations

## 1. Needs for followup:

- Enabling studies of cosmology and cluster physics:  
Redshift: phot-z + spec-z, Mass Estim.: weak lens. + velocity disersions
- Evolution of AGN Population  
Redshift estim., phot-z, spec-z
- Galactic Sources

## 2. Follow up Context for eROSITA

(List not complete!)

- Shallow Multiband OIR Surveys 2MASS, PanSTARRS, SDSS
- Deep Multiband OIR Surveys VISTA, DES
- Optical Spectroscopic Surveys SDSS, BOSS
- Proposed Optical Spectroscopic Surveys 4MOST, BigBOSS, SPIDERS, WEAVE
- Future OIR Imaging Surveys LSST, Euclid

## 3. Radio, MM Surveys

# Working Groups (D)

## „Science Working Groups“:

Clusters and Cosmology

AGN, Blazars

Normal Galaxies

Compact objects

Stars

Solar System

Diffuse emission, SNR

## „Infrastructure Working Groups“:

Time Domain Astrophysics

Data analysis, source extraction, catalogs

Multi-wavelength followup

Calibration

Background

## Chairs

H. Boehringer, J. Mohr, T. Reiprich

K. Nandra

F. Haberl

A. Schwope, A. Santangelo

J. Robrade, J. Schmitt

K. Dennerl

W. Becker, M. Freyberg, M. Sasaki

J. Wilms, I. Kreykenbohm

H. Brunner

J. Mohr

K. Dennerl

M. Freyberg

Opportunity and rules for collaborations