eROSITA

Gabriel Pratt

on behalf of Peter Predehl and the eROSITA team:

Günther Hasinger (**PI**)
Co-Is: Hans Böhringer, Ulrich Briel, Hermann Brunner, Evgeniy Churazov, Michael Freyberg, Peter Friedrich, Eckhard Kendziorra, Dieter Lutz, Norbert Meidinger, Mikhail Pavlinsky, Elmar Pfeffermann, Peter Predehl, Andrea Santangelo, Jürgen Schmitt, Axel Schwope, Matthias Steinmetz, Lothar Strüder, Rashid Sunyaev, Jörn Wilms

Project Manager: P. Predehl
System Engineer: Josef Eder
Product Assurance: H. Bräuninger, M. Hengmith
Electronics Engineering: W. Bornemann, O. Hälker, S. Hermann, W. Kink, S. Müller, Th. Schanz, O. Hans
Mechanical Engineering: H. Huber, Chr. Rohé, L. Tiedemann, R. Schreib, B. Mican, K. Lehmann
Physical Engineering: N. Meidinger, E. Pfeffermann, M. Fürmetz, P. Friedrich
Attitude: A. Schwope
Calibration, Analysis, Simul. : G. Hartner, K. Misaki, M. Mühlegger, U. Briel, K. Dennerl, J. Elbs, R. Andritschke, Chr. Tenzer
Testanlagen, Labor, Tests: W. Burkert, M. Freyberg, B. Budau, M. Vongehr, L. Hirschinger, K. Dittrich
Ground Software: H. Brunner, N. Cappelluti, G. Lamer, J. Wilms, I. Kreykenbohm, Chr. Schmid
Mission Planning: J. Schmitt, N.N.
workshops (MPE, IAAT, AIP), HLL
Institutes:
Max-Planck-Institut für extraterrestrische Physik, Garching/D
Space Research Institute (IKI), Moscow/Ru
Univ. Tübingen/D
Univ. Hamburg/D
Univ. Erlangen-Nürnberg/D
Astrophysikalisches Institut Potsdam/D
Max-Planck-Institut für Astrophysik/D

What can you do with 100,000 clusters?

1. Cluster mass function *N(M,z)* depends mainly on the matter density Ω_m and the amplitude of the primordial power spectrum σ_8
2. Evolution *N(M,z)* gives sensitive constraints on DM and DE
3. Cluster power spectrum amplitude and shape depend on DM and DE
4. Baryonic wiggles due to acoustic oscillations at recombination give tight constraints on space curvature
5. Cluster baryon fraction as function of z gives constraints on DM and DE
6. Clusters provide direct distance measurements due to combined X-ray and SZ-measurements

Design driving science

- Detection of 100.000 clusters of galaxies, N(M,z), P(k), BAOs

{

- Extragalactic Survey (20,000 sqd, 2yrs)
- Deep Survey (200 sqd, ½ yr)
- Pointing (1 yr)

- Hidden AGN
- Additional science

{

- All-sky Survey (1 yr) + add. pointing (lifetime)

eROSITA

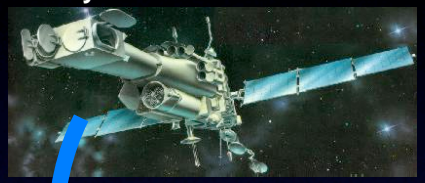
extended ROentgen Survey with an Imaging Telescope Array

⟸

- Increase of effective area
  - 27 → 54 mirror shells per module (7)
- Increase of Field of View
  - 2×2cm² → 3×3cm²

Historical Development

Spectrum-XG
Jet-X, SODART, etc.



Negotiations between Roskosmos and ESA on a "new" Spectrum-XG mission (2005)

Agreement between Roskosmos and DLR (2007)

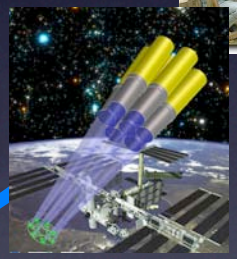
eROSITA

Spektr-RG
Launch: 2011

ROSAT

ROSAT 1990-1998
First X-ray all-sky survey with an imaging telescope

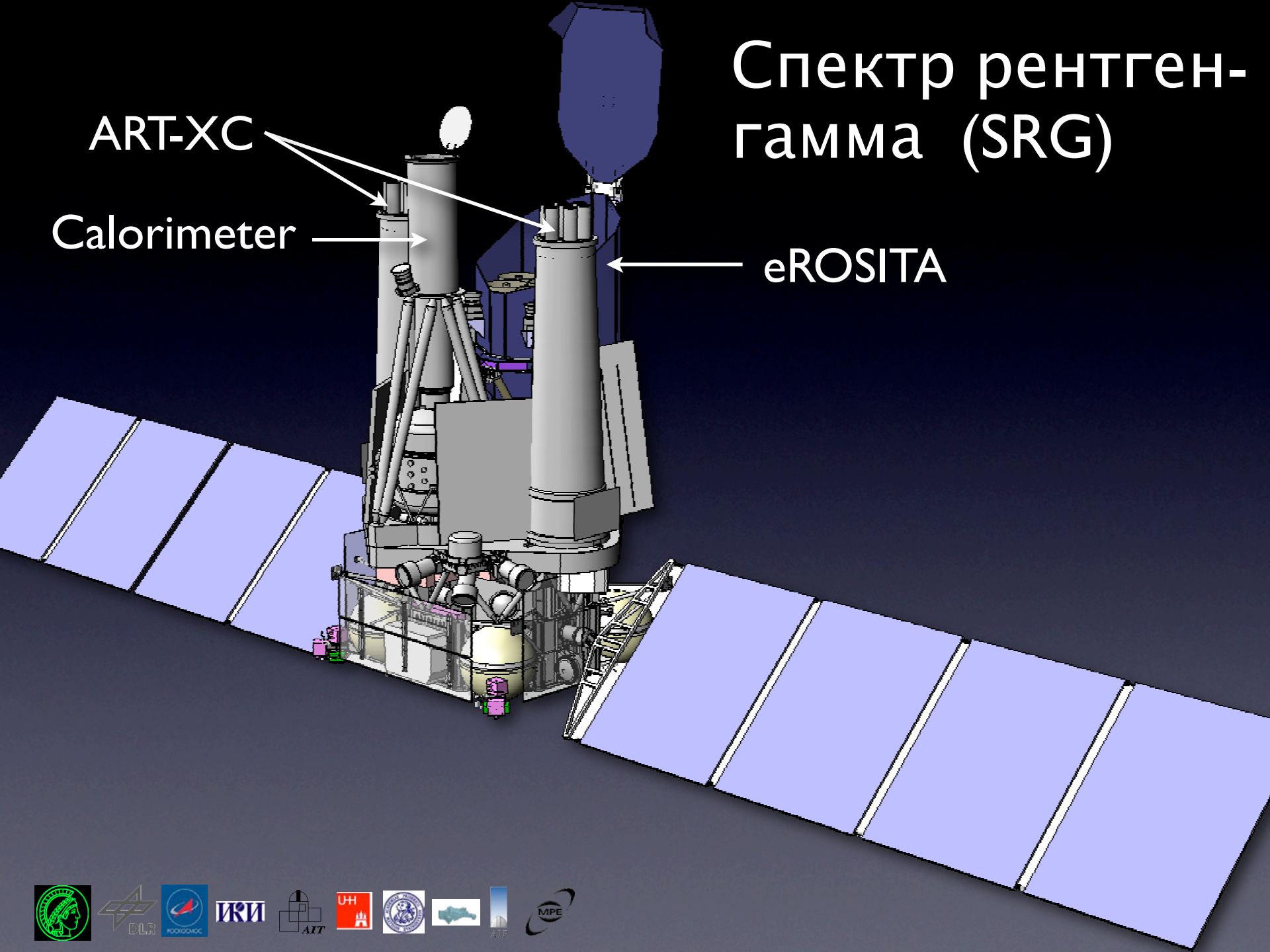
ABRIXAS 1999
To extend the all-sky survey towards higher energies



ROSITA 2002
ABRIXAS science on the International Space Station

Dark Energy
10^5 Clusters of Galaxies

Спектр рентген-гамма (SRG)



SRG-Mission

Спектр рентген-гамма (SRG)

- Launch: 2011 from Baikonur
- Launcher: Soyuz-Fregat
- Platform: Navigator (Lavochkin)
- Orbit: 600 km, 30° inclination
- Payload: ART-XC (IKI)
  LOBSTER (LU+…)
  eROSITA (MPE+…)
  SRC (SRON, ISAS, GSFC, +MPE)
- Mission: 4 yrs survey + 1 yr pointing + …

eROSITA mirrors

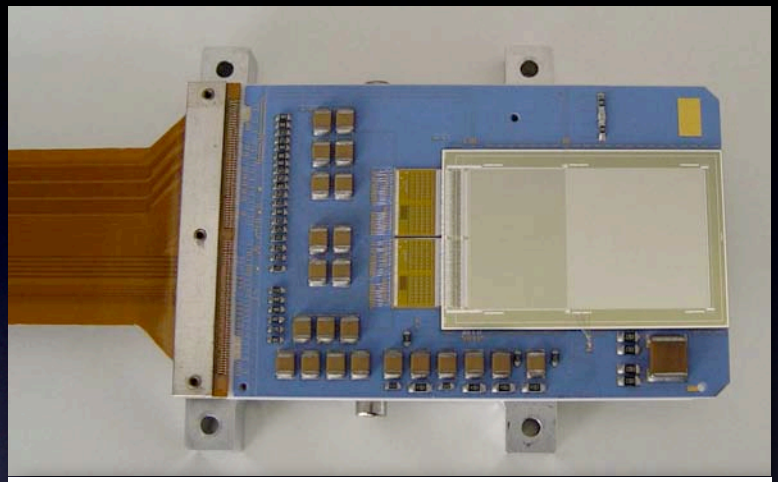
7 Wolter type-I mirrors

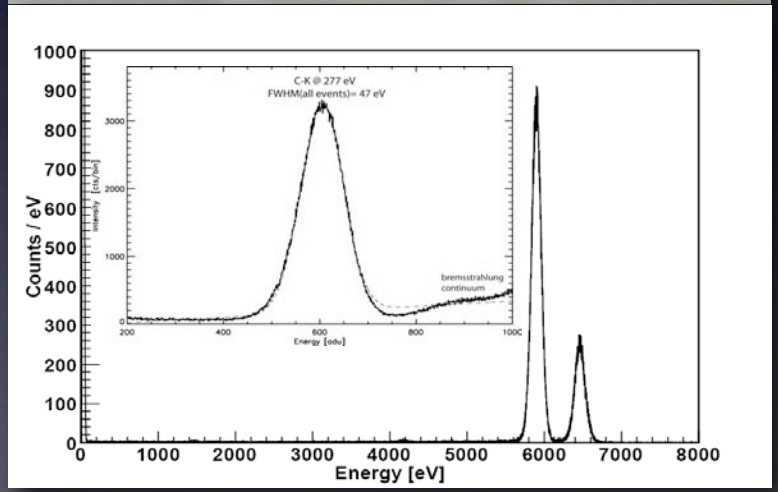
- 54 gold-coated nickel-shells
- PSF < 20 arcsec (HEW; goal 15 arcsec)
- A_{eff} ~ 2500 cm^2 (1.5 keV, on-axis)
- grasp ~700 cm^2 deg^2 at 1 keV

eROSITA cameras

7 individual cameras

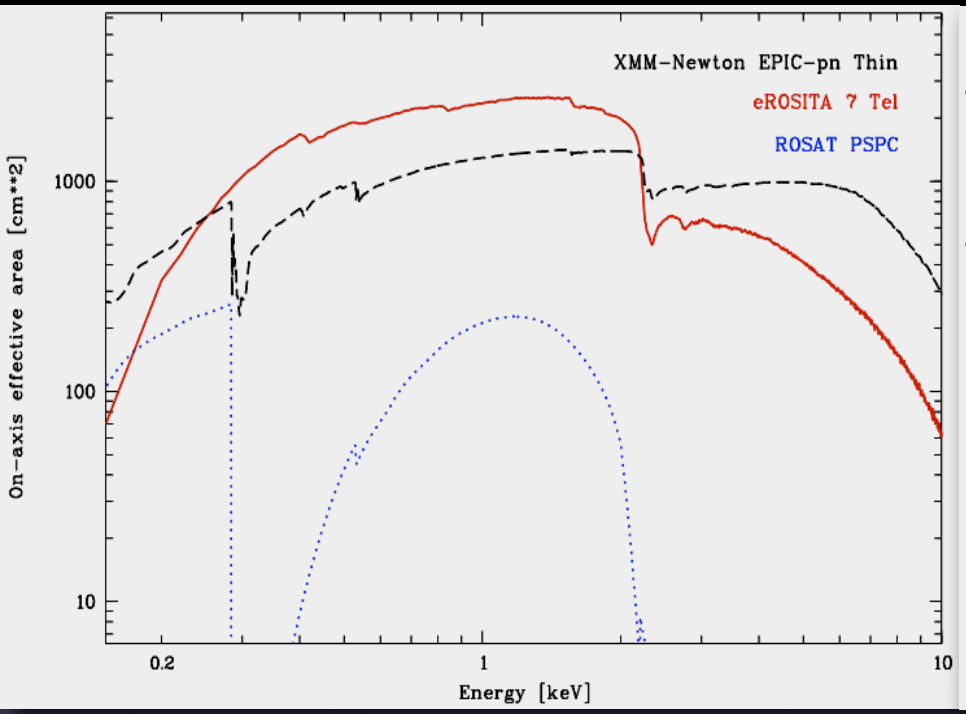
- new generation pn CCD technology
- higher QE
- energy range 0.2-12 keV
- energy resolution 130 eV at 6 keV
- 384 × 384 pixel, 75µm physical size
- framestore area (faster readout, fewer OOT)
- cycle time 50 msec
- ~1 deg^2 FoV

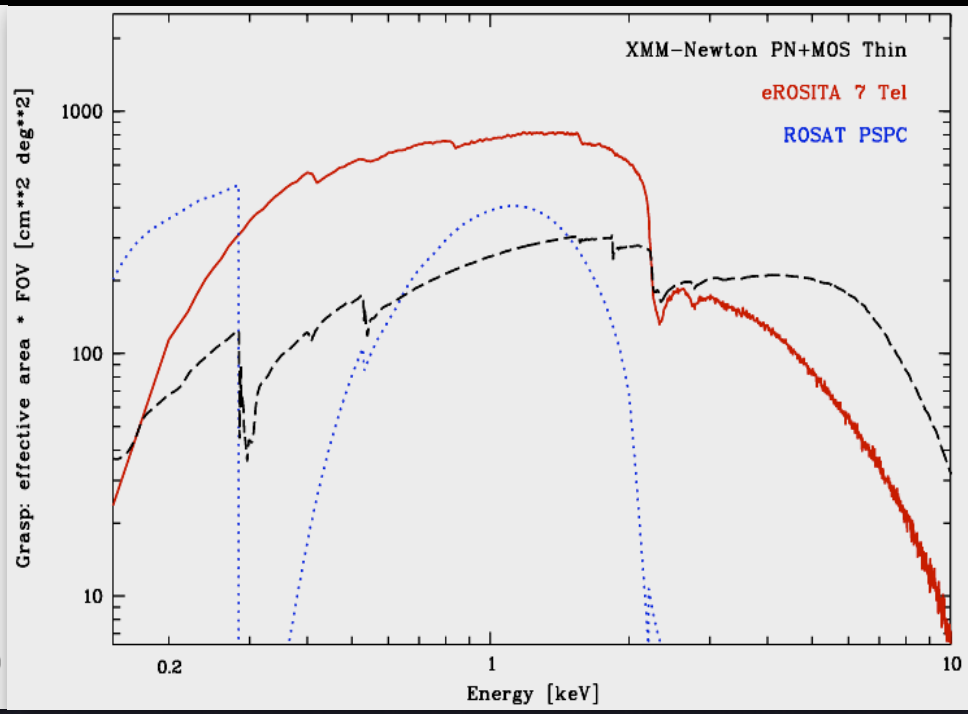




Effective area and grasp

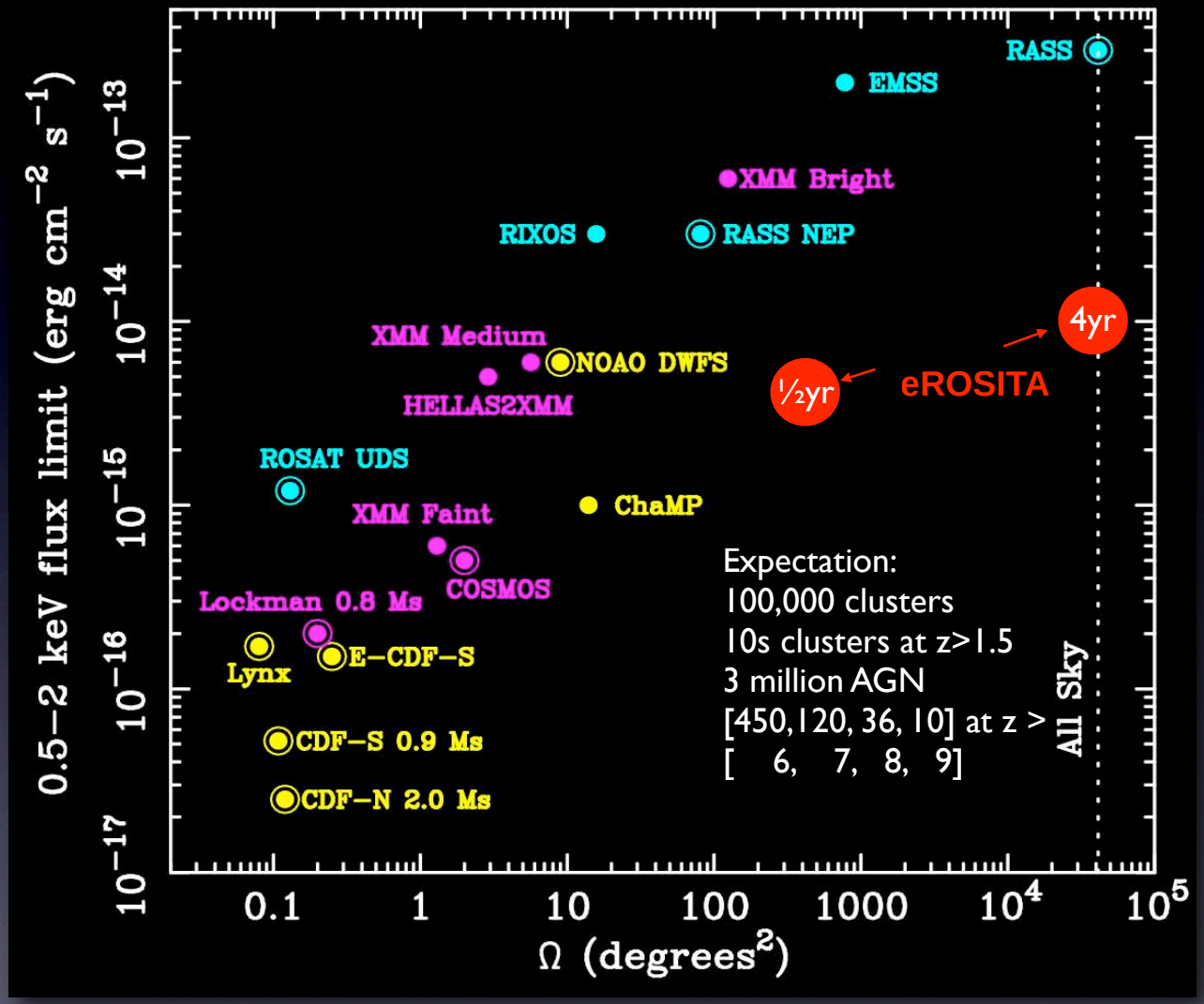
effective area [cm^2] grasp [cm^2 deg^2]





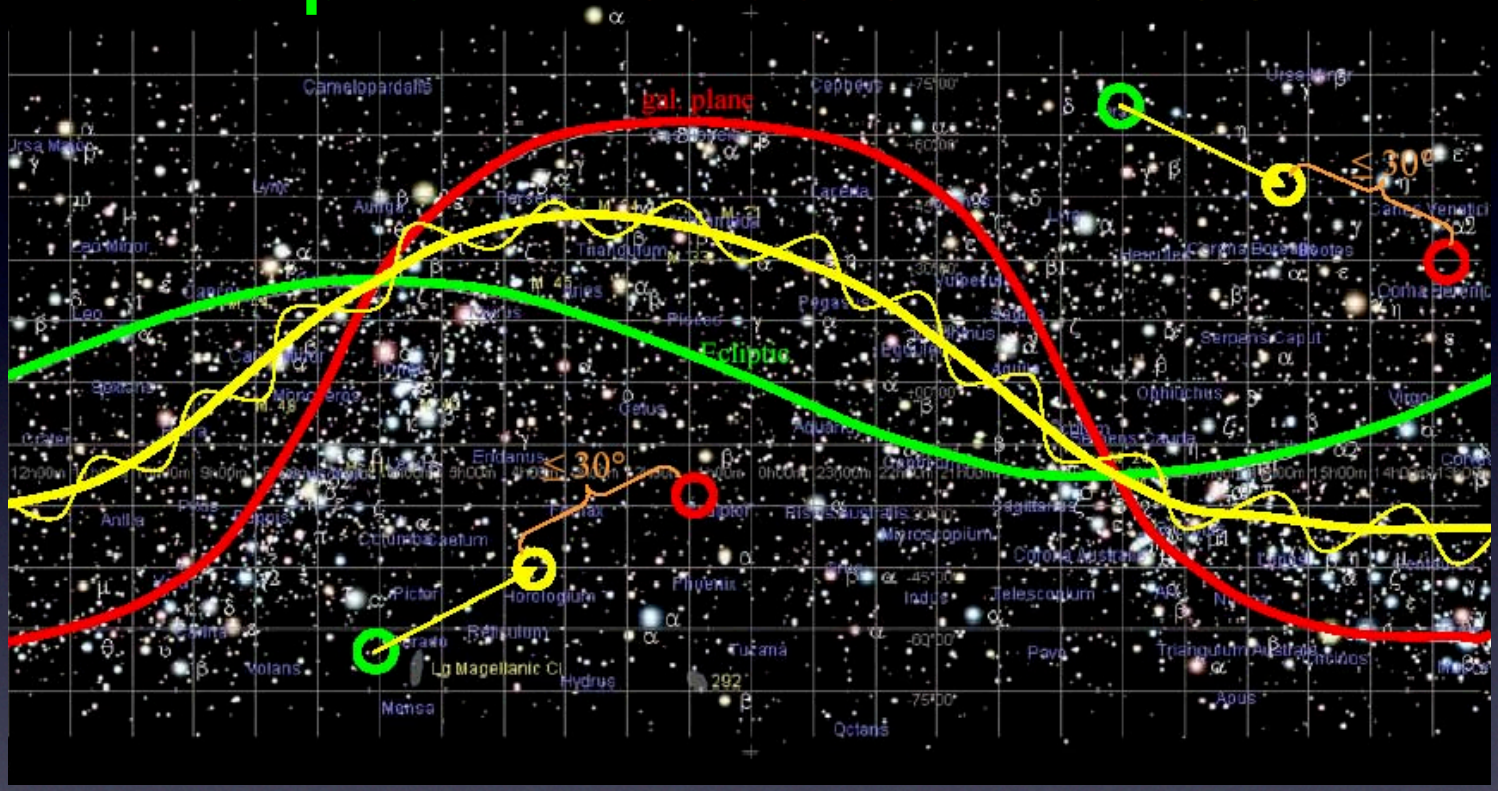
Grasp of 7 eROSITA telescopes is 3-4 x higher than 3 XMM-Newton telescopes in the energy range 0.3-2 keV

Survey sensitivity



Survey geometry

Ecliptic **Galactic** **eROSITA**

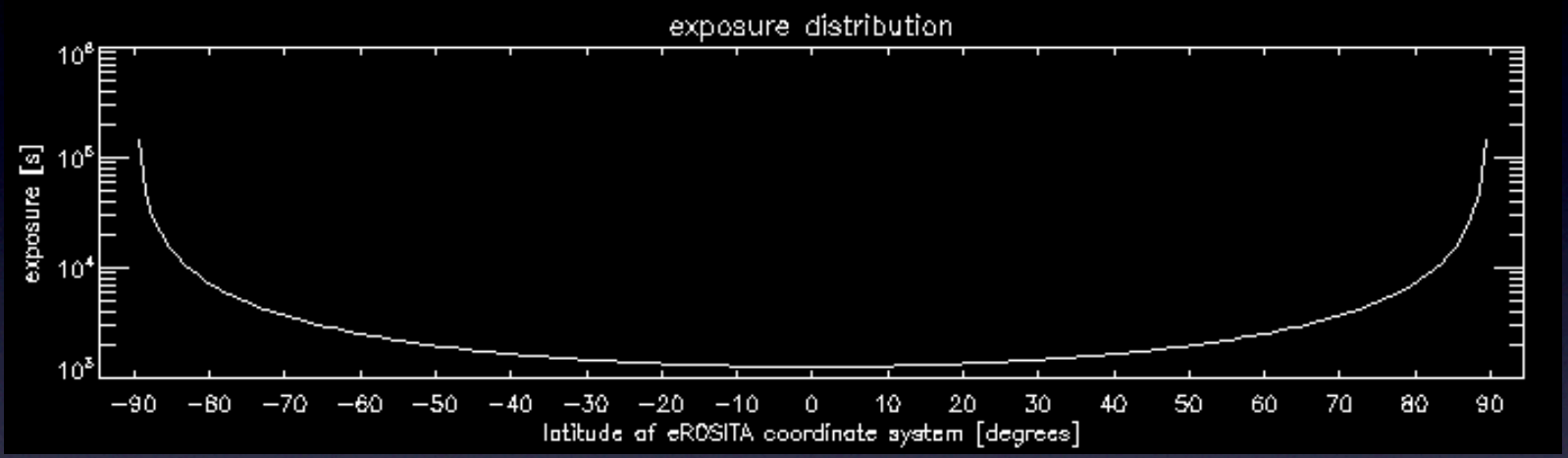


4 year survey

optimised for extragalactic sky (30,000 deg^2)

significant survey of Galactic plane (10,000 deg^2)

Exposure map

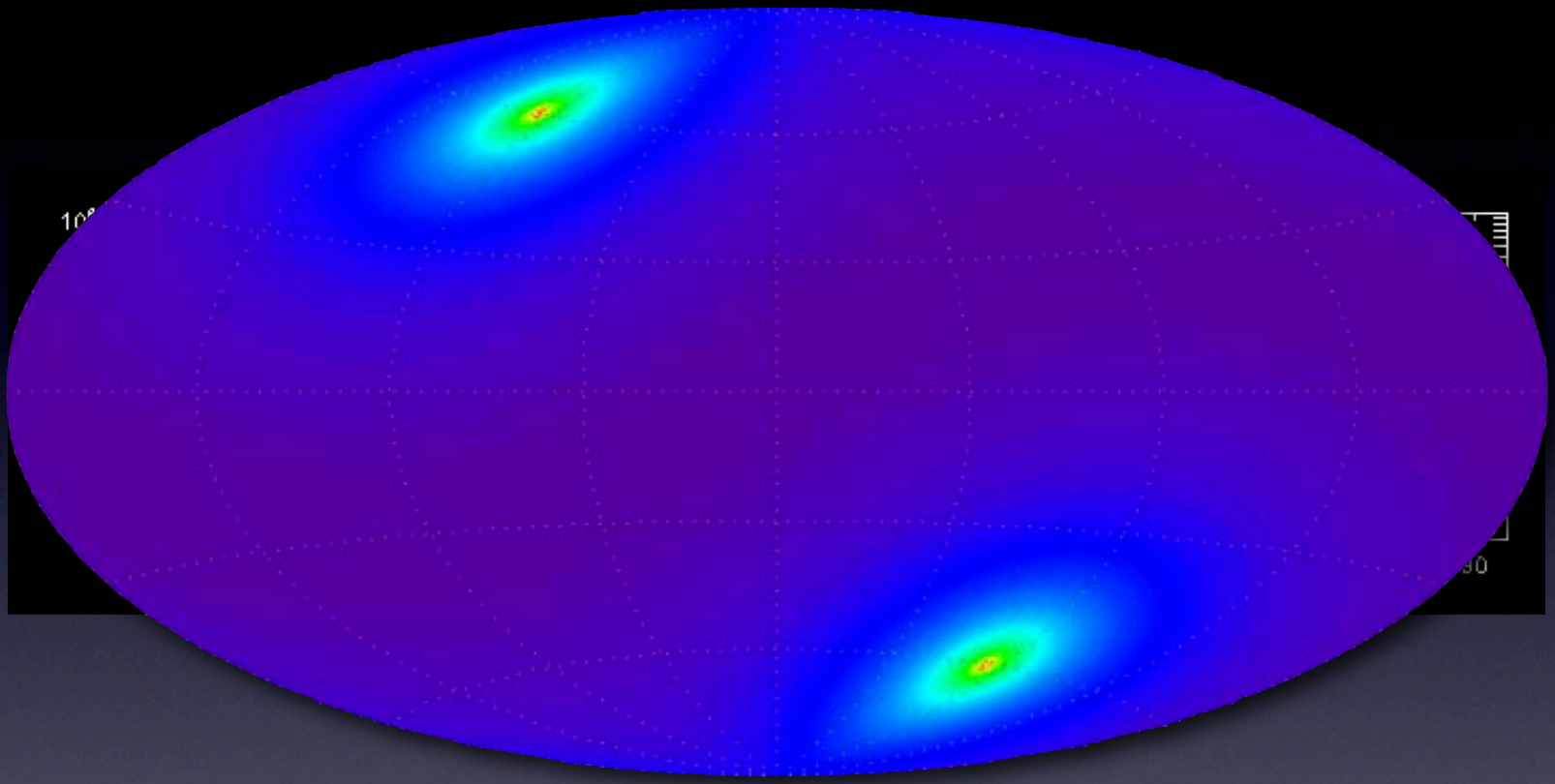


Exposure rises towards the poles

Average exposure:

~ 1.5 ksec at equator, ~ 32 ksec at poles (2 x 200 deg^2)

Exposure map



Exposure rises towards the poles

Average exposure:

~ 1.5 ksec at equator, ~ 32 ksec at poles (2 x 200 deg^2)

Simulations
(by Martin Mühlegger)

Including:

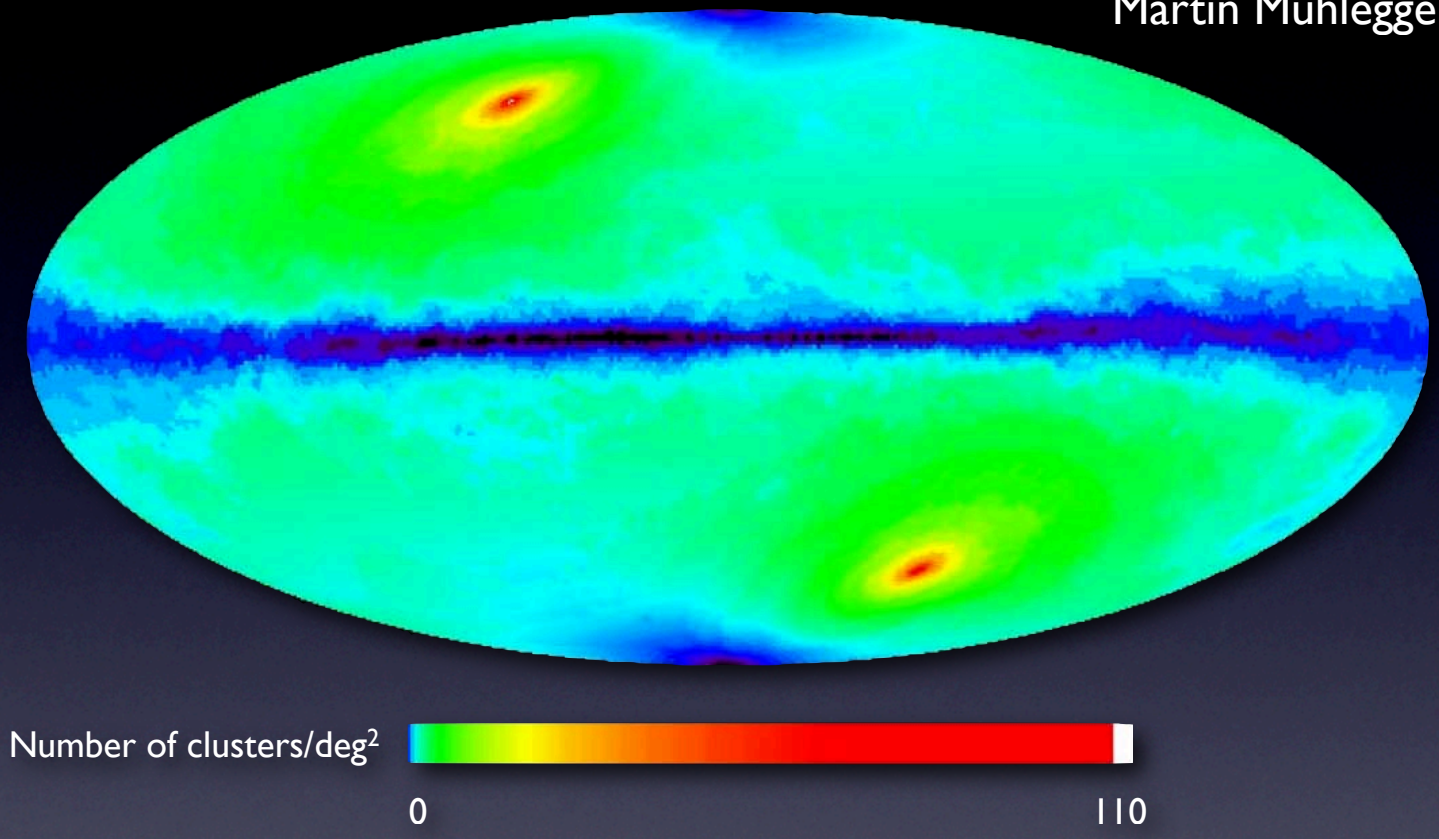
- Mass function N(M,z) → N(L_X,z), assuming given L_X-M relation
- nH distribution
- L_X-T relation: C(T,z,n_H) → C(L_X,z,n_H) → counts

Not including (so far):

- Variable CXB
- Image simulations
- Source detection tests
- Completeness

Cluster number map

Martin Mühlegger

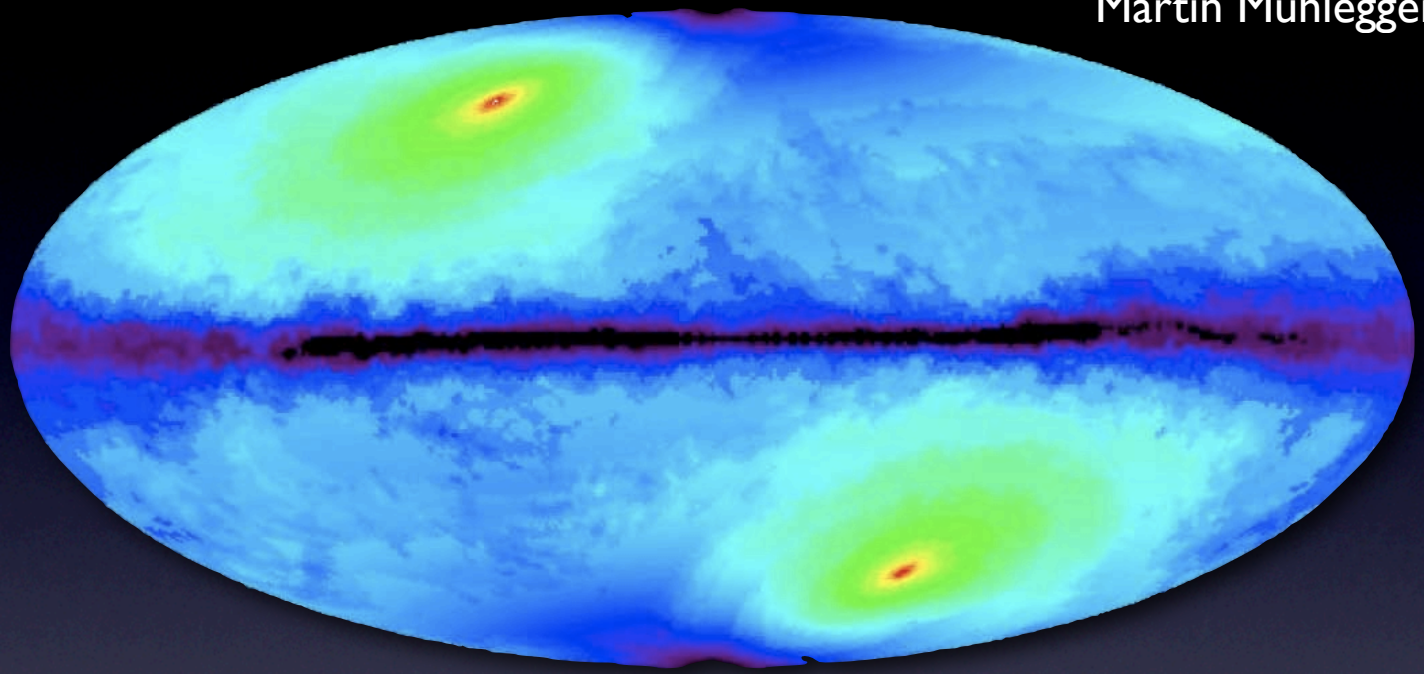


Count limit 50 counts

⇒ 179,484 clusters; 155,182 with |b| > 20°

Cluster number map

Martin Mühlegger

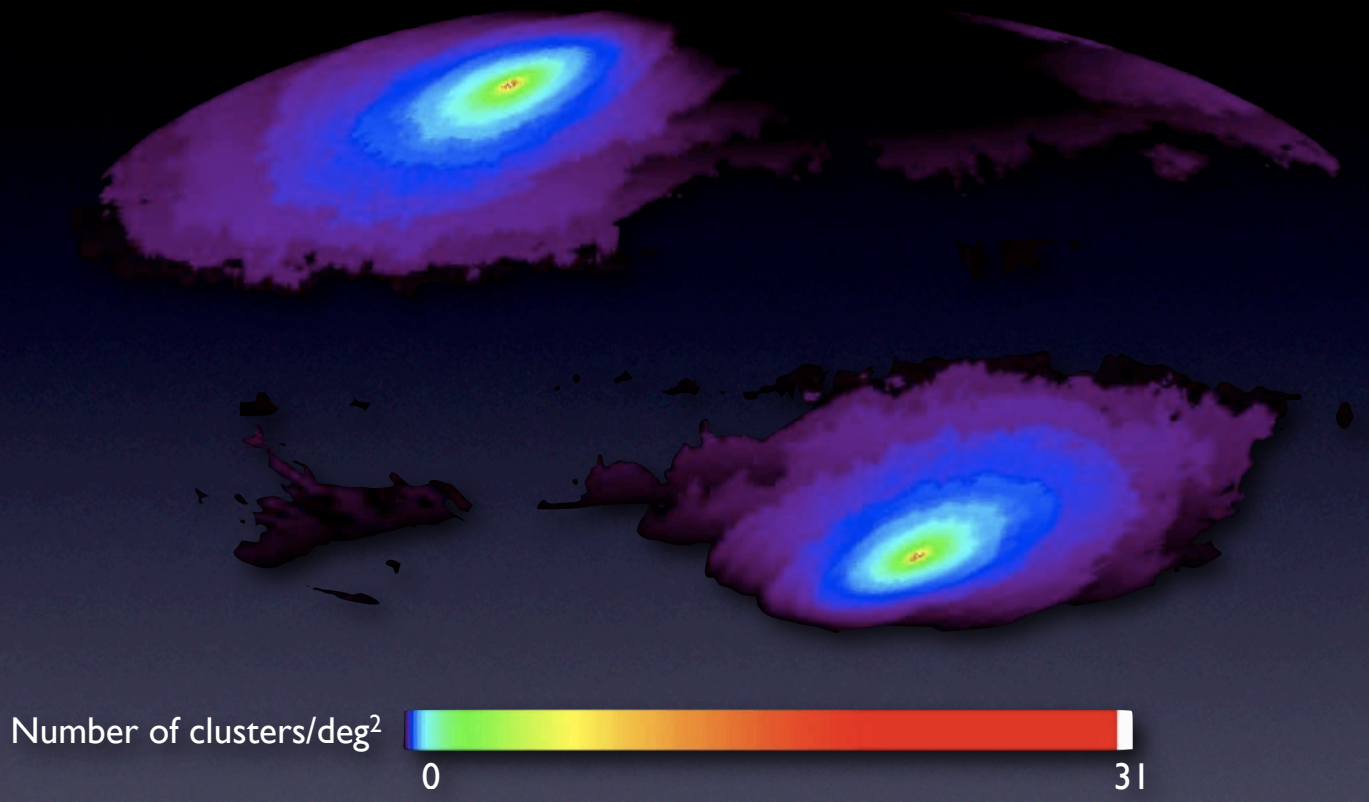


Count limit 100 counts

⇒ 79,912 clusters; 69,809 with |b| > 20°

Cluster number map

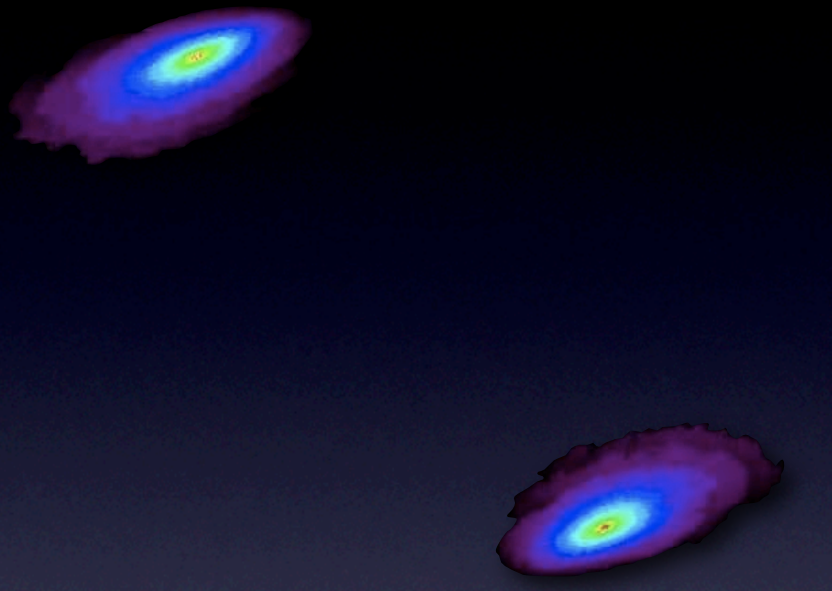
Martin Mühlegger



Count limit 500 counts (measure kT)
⇒ 9,935 clusters; 8,910 with |b| > 20°

Cluster number map

Martin Mühlegger

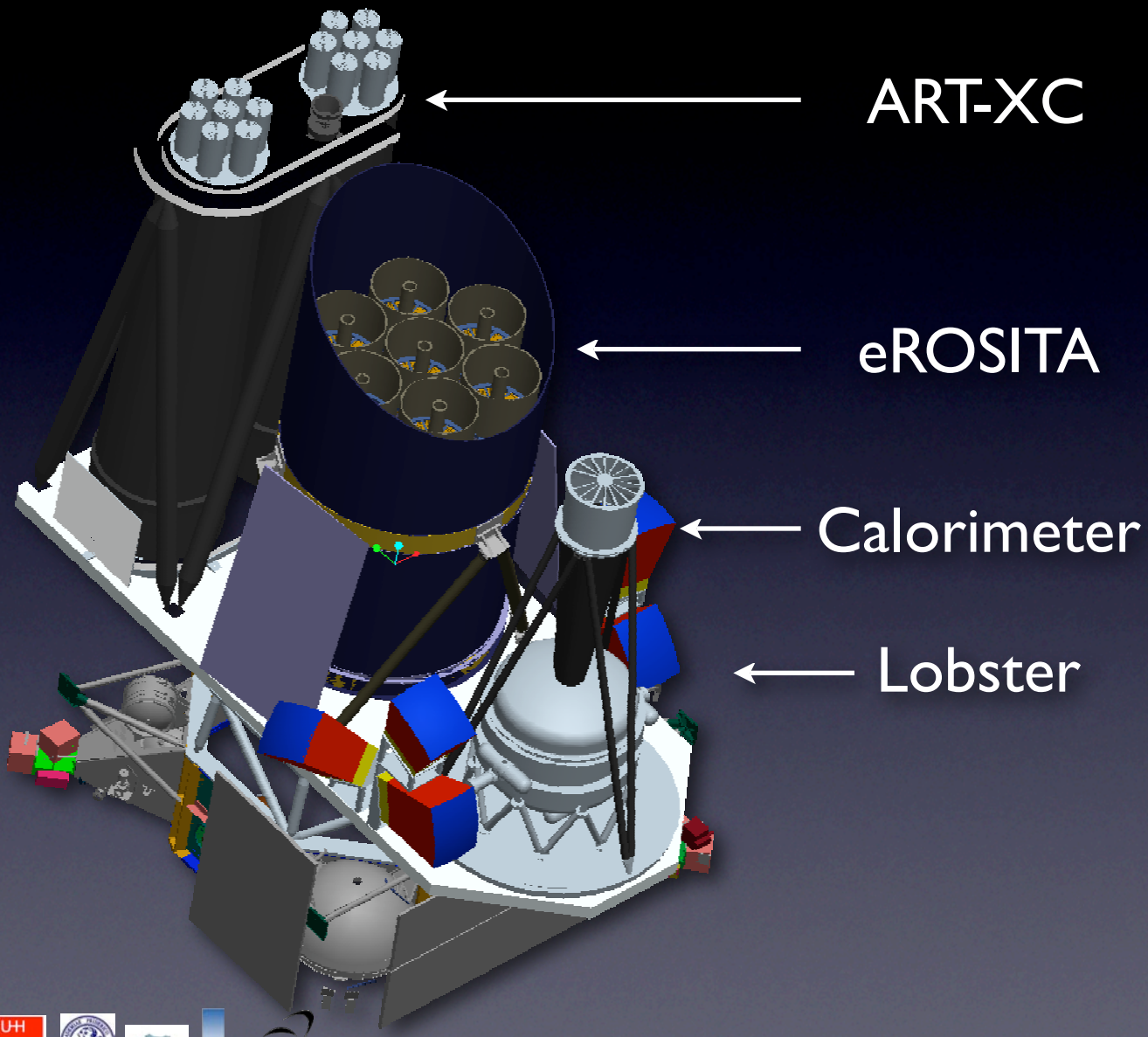


Count limit 1000 counts (measure kT, measre z from Fe line)
⇒ 3,675 clusters; 3,343 with |b| > 20°

Concluding remarks

- Clusters of galaxies provide a very good probe of Dark Matter and Dark Energy
- X-ray surveys are an efficient means to find clusters of galaxies
- eROSITA is optimised to detect almost all clusters in Universe
- Technology is ready, mission scope very moderate, launch 2011
- Potential for new physics (e.g. clustering of DE)
- Important to calibrate cluster mass scaling relations (e.g. detailed X-ray pointings & lensing!)

Spektr-RG



Follow-up

- Optical follow-up requires photometry of very large fields in preparation (e.g. PanSTARRS, DES, DUNE)
- Significant synergies and complementarity with surveys in other wavebands (JDEM, SZ, PanSTARRS, LSST, DUNE, Planck)