

# eROSITA on SRG

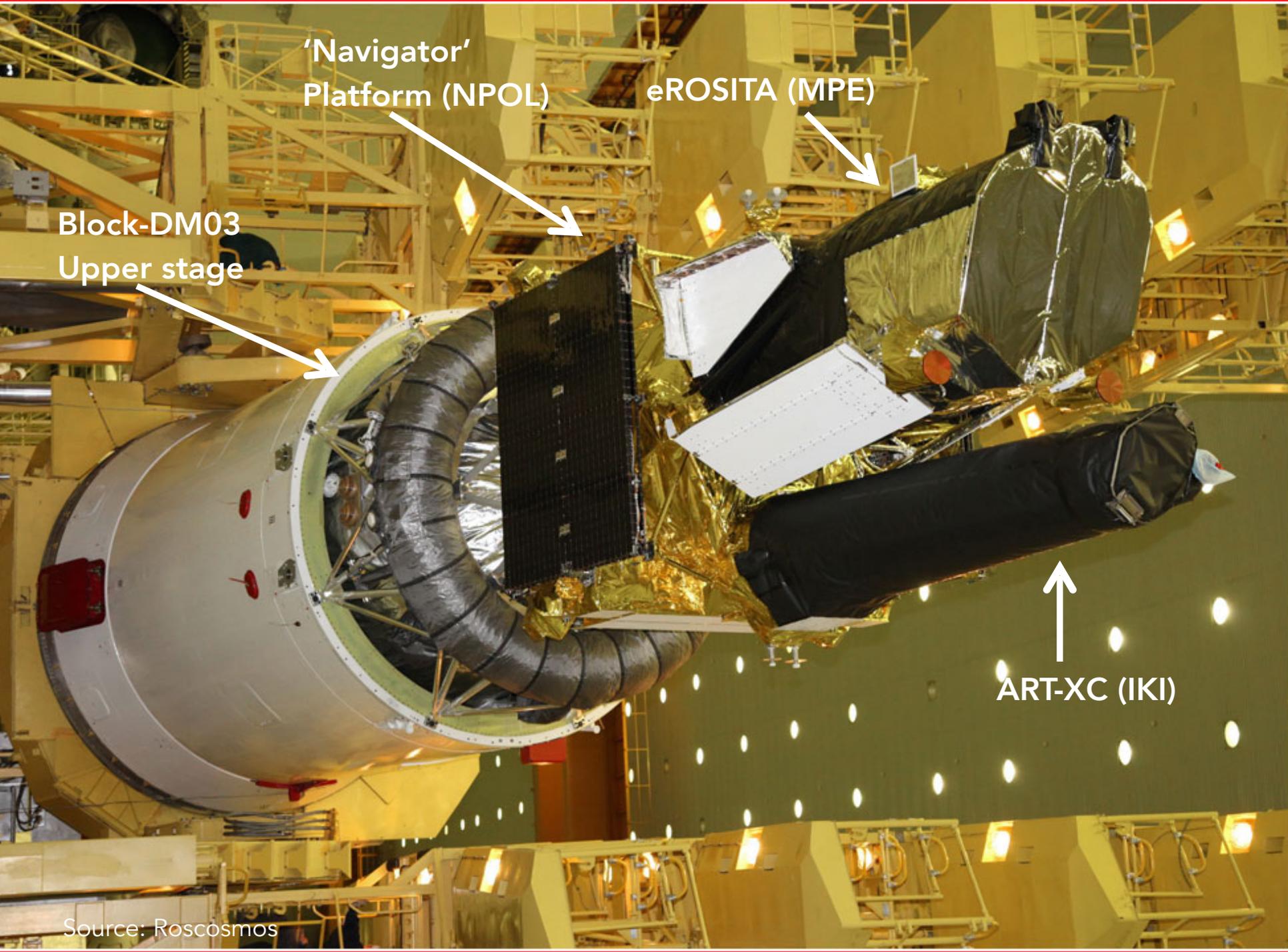
Andrea Merloni (MPE)



Baikonur, July 13<sup>th</sup>, 2019



Source: Roscosmos



'Navigator'  
Platform (NPOL)

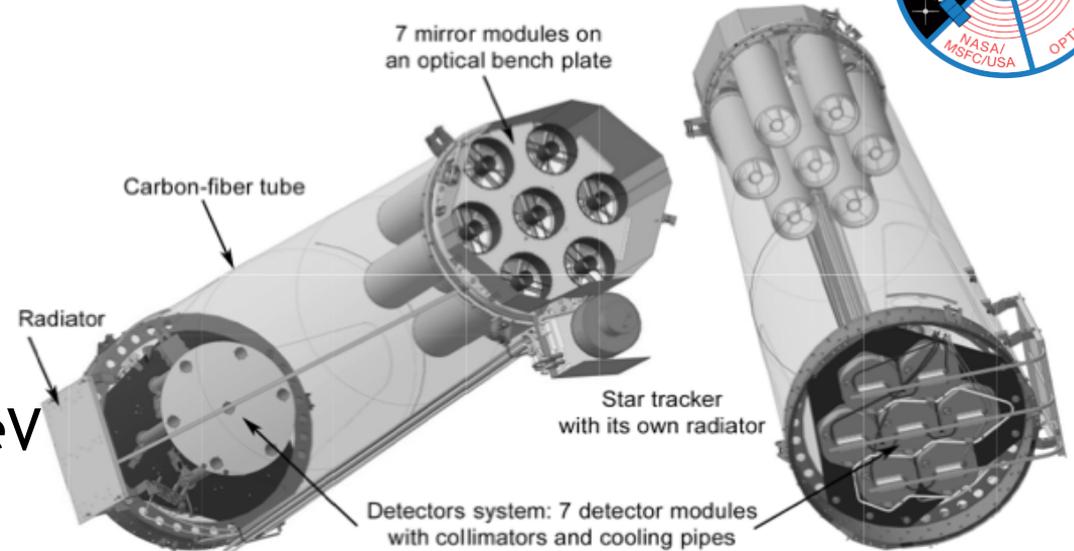
eROSITA (MPE)

Block-DM03  
Upper stage

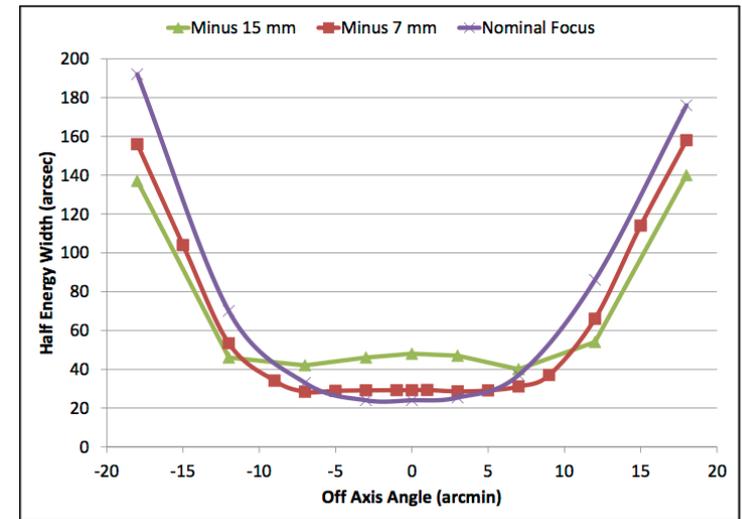
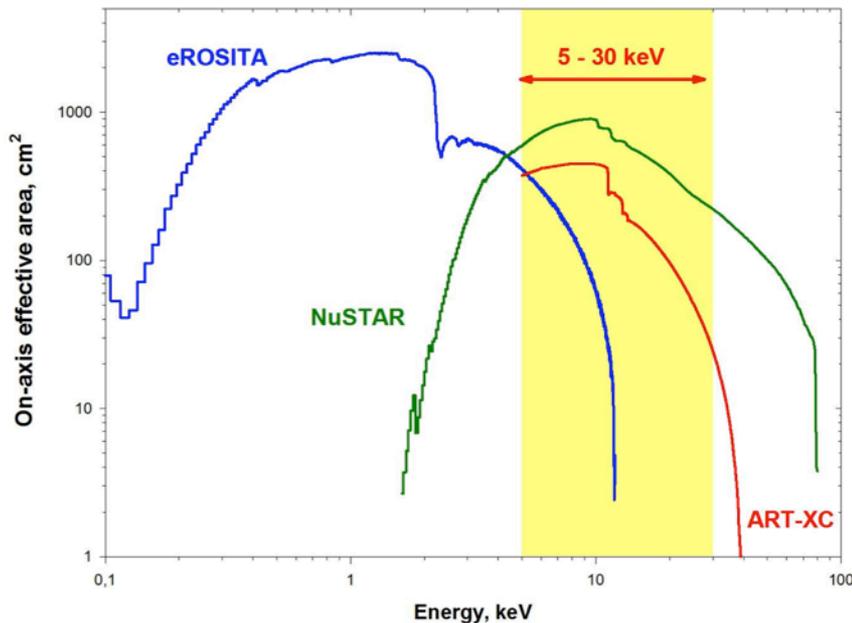
ART-XC (IKI)

PI: M. Pavlinsky (IKI)

- Energy range: 5-30 keV
- FOV:  $\approx 34^\circ$
- On-axis resolution  $\approx 1''$
- Energy resol. 10% at 14keV
- Time res. 1ms



On-axis effective area of eROSITA, ART-XC and NuSTAR





# eROSITA: the Project

**PI: Peter Predehl; PS: A. Merloni (MPE)**

**Core German Institutes (DLR funding):**

MPE, Garching

Universität Erlangen-Nürnberg

IAAT (Universität Tübingen)

HS (Universität Hamburg)

AIP Leibniz Inst. for Astrophysics Potsdam

**Associated Institutes:**

IKI, Moscow/Ru

USM (LMU München)/D

AlfA (Universität Bonn)/D

**Industry:**

Media Lario/I

Mirrors, Mandrels

Kayser-Threde/D

Mirror Structures

Carl Zeiss/D

ABRIXAS-Mandrels

Invent/D

Telescope Structure

MPG-HLL/pnSensor/D

CCDs

IberEspacio/E

Heatpipes

RUAG/A

Mechanisms

HPS/D,P

MLI

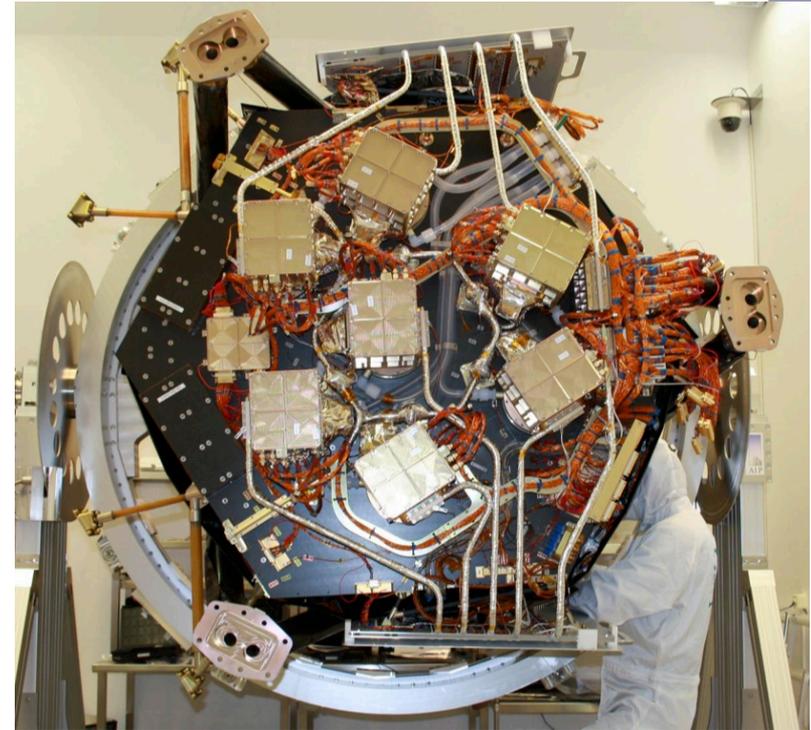
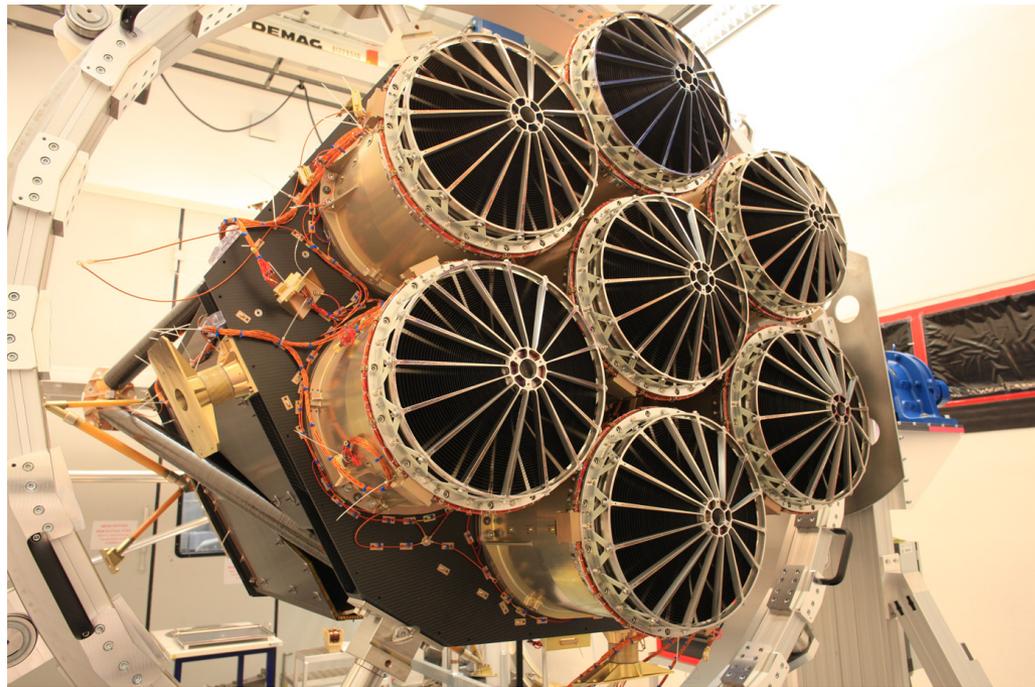
+ many more smaller companies



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

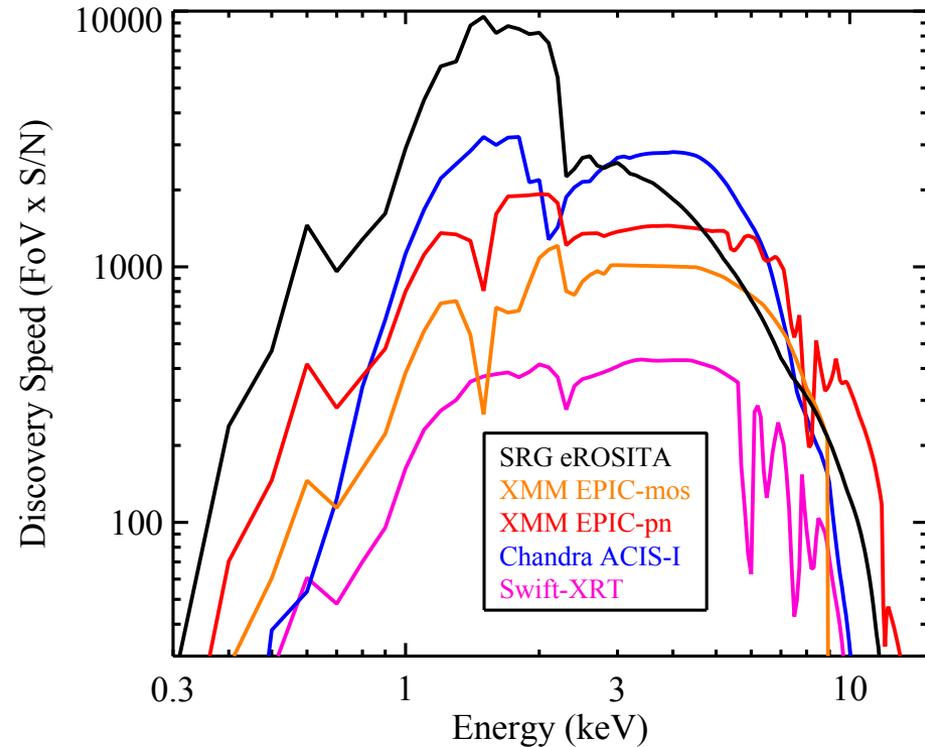
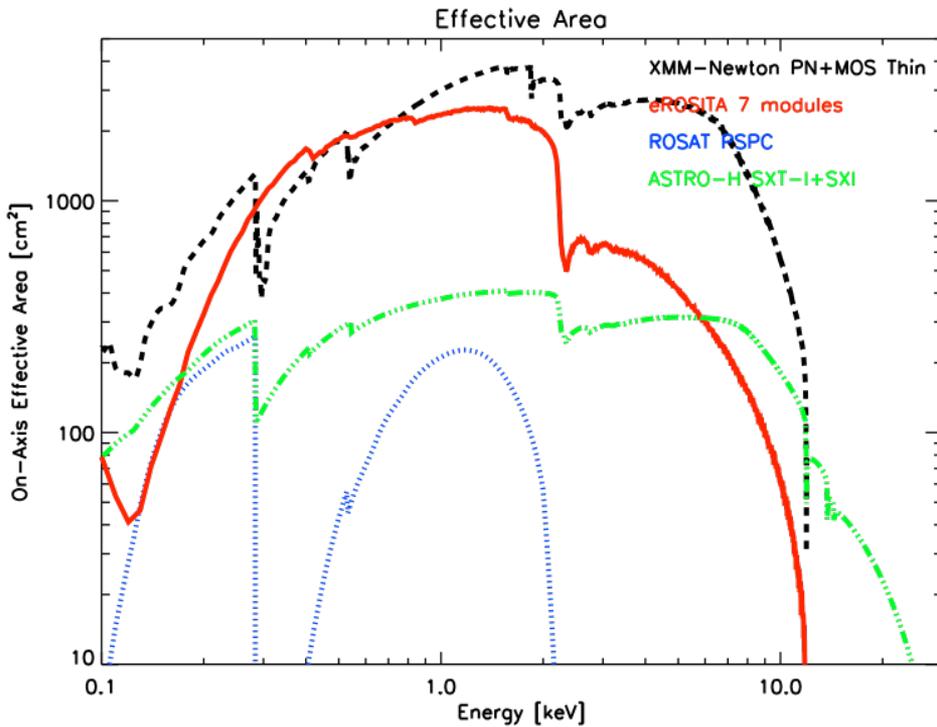


# 7 Mirrors + pnCCDs



- Focal length: 1.6 m, Field of view: 1 degree (diameter)
- Half-Energy width (**HEW**) ~**18"** (on-axis); **27"** (FoV avg.)
- Source location accuracy ~3-10"
- X-ray baffle (10 $\mu$ m precision alignment): 92% stray light reduction
- **Spectral resolution** at all measured energies within specs (~**80eV @1.5keV**)
- Extremely **good detector uniformity, no chip gaps**

Effective Area: ~1700 cm<sup>2</sup> (FoV avg. @1keV)



- Effective area at 1keV comparable with XMM-Newton
- Factor ~5-6 larger surveying speed
- Survey FoM  $\approx A_{\text{eff}} * \text{FoV} / (\theta * \text{Bkgn})$  (courtesy of Wik & Hornschemeier)



# Cosmology/Legacy survey



- All massive ( $> \text{few } 10^{14} M_{\odot}$ ) clusters along the past light cone
- $> 100,000$  groups and clusters  $\rightarrow$  Cosmology (Pillepich+ '18)
- $> 3$  Million AGN ( $\langle z \rangle \sim 1$  and  $\langle L_x \rangle \sim 10^{44}$ )
- Compact objects (NS, BH) population of the Milky Way
- Population study of 750k active (young, magnetic) stars
- Diffuse X-ray emission and the hot ISM in the Milky Way
- Nearby star-forming galaxies and galaxy groups
- Dynamical view of the X-ray sky and identify transients and variable sources, including 1000's TDEs
- Serendipity...

# SRG: Mission Profile

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## Russian-German "Spectrum-Roentgen-Gamma" SRG mission

**Mission:** All sky-survey in the X-ray band

**Location:** L2 orbit, 1.5 million kilometres from Earth

**Mission lifetime:** 7.5 years

- **4 Months:** flight to L2, PV and calibration phase
- **4 years:** 8 all sky surveys (eRASS:1-8; scanning mode: 6 rotations/day)
- **2.5 years:** pointed observations, including TBD GTO quota. 1 AO per year

ROSAT all-sky survey. Credit: MPE

# SRG: Mission Profile



## eROSITA

Primary instrument on-board SRG

X-ray band up to 10keV

Developed by Max Planck Institute for Extra-terrestrial Physics (MPE)

## ART-XC

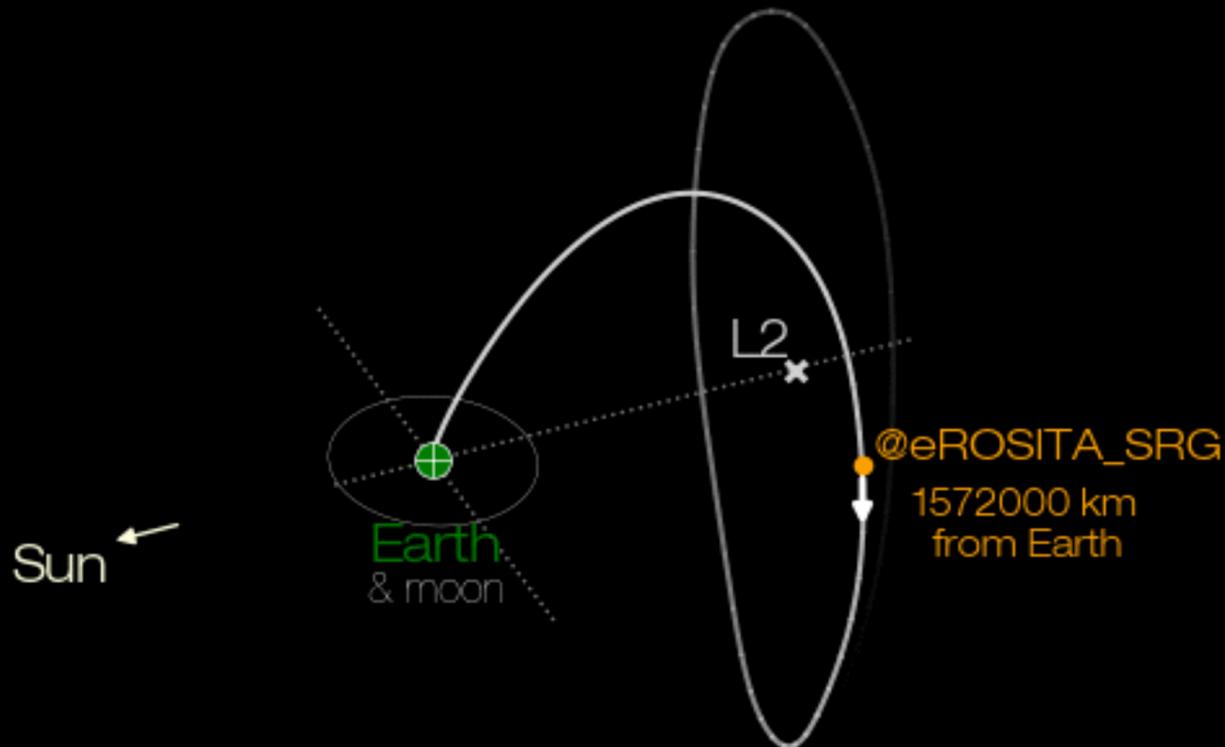
Secondary instrument on-board SRG

X-ray band up to 30keV

Developed by Russian Space Research Institute (IKI)

- **4 Months:** flight to L2, PV and calibration phase
- **4 years:** 8 all sky surveys (eRASS:1-8; scanning mode: 6 rotations/day)
- **2.5 years:** pointed observations, including TBD GTO quota. 1 AO per year

# SRG delivered Orbit

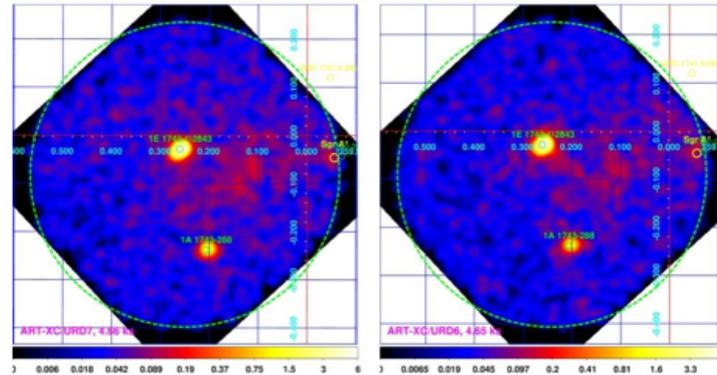


Semi-major axis  $\sim 400.000$  km

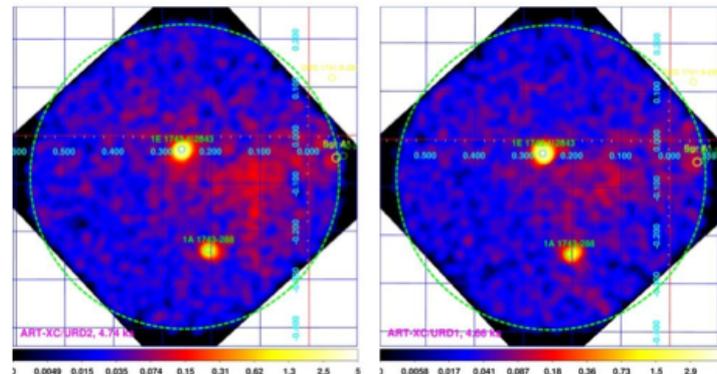
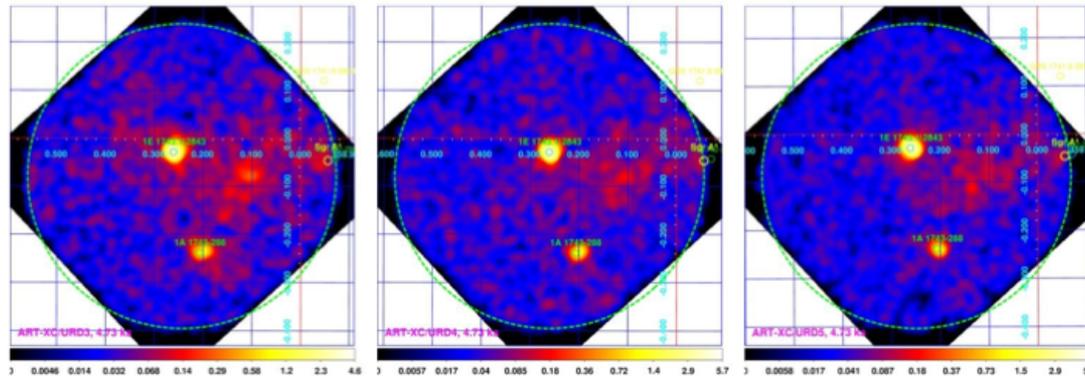
Semi-minor axis  $\sim 150.000$  km

J. Buchner, P. Predehl, J. Robrade

# ART-XC CaKPV observations

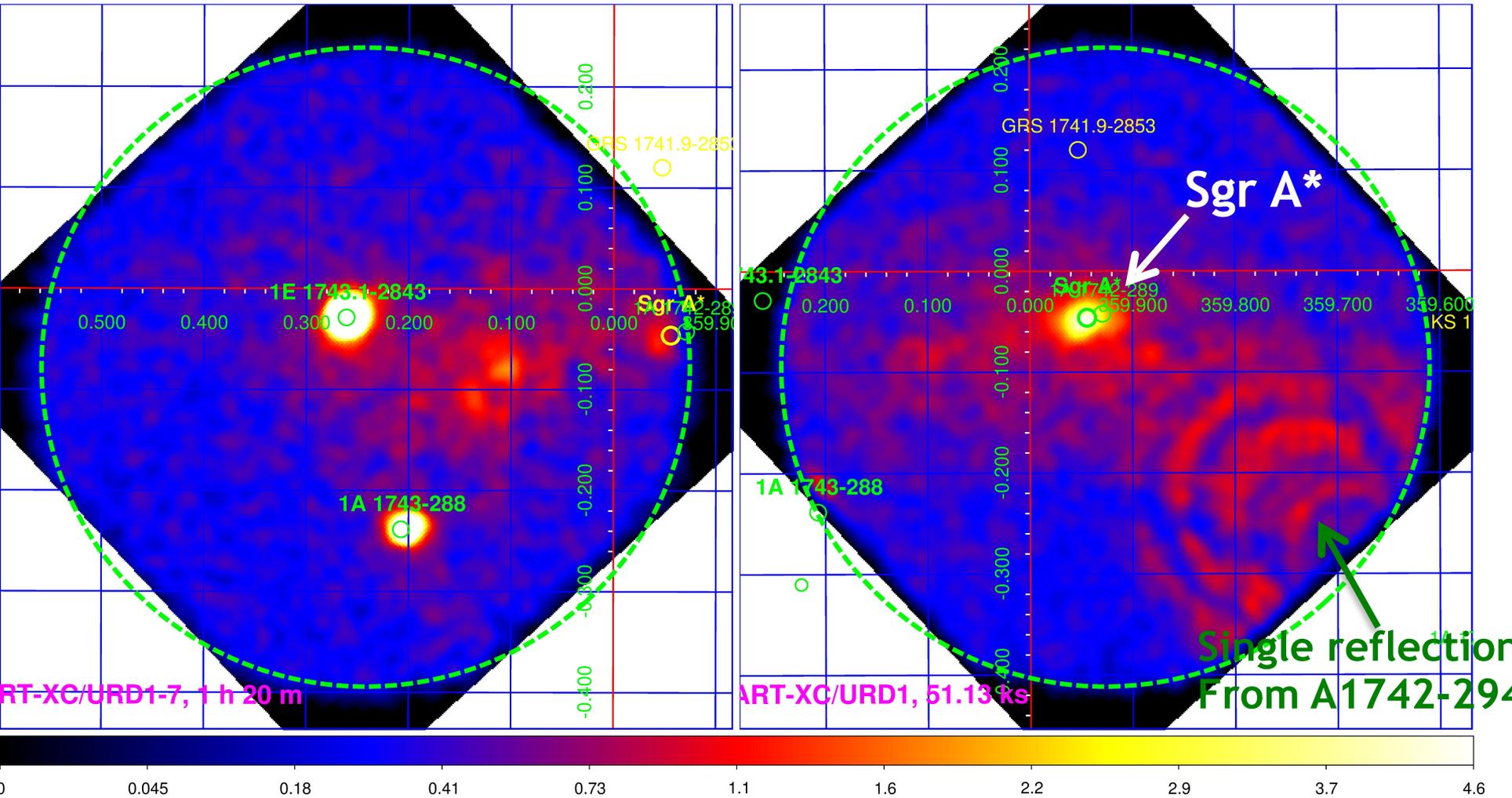


**ART-XC**  
**seven telescopes**  
**1E1743.1-2843**  
**4.7 ks exposure time**  
**5 – 16 keV**



Courtesy of  
M. Pavlinsky (IKI)

# ART-XC CaPV observations



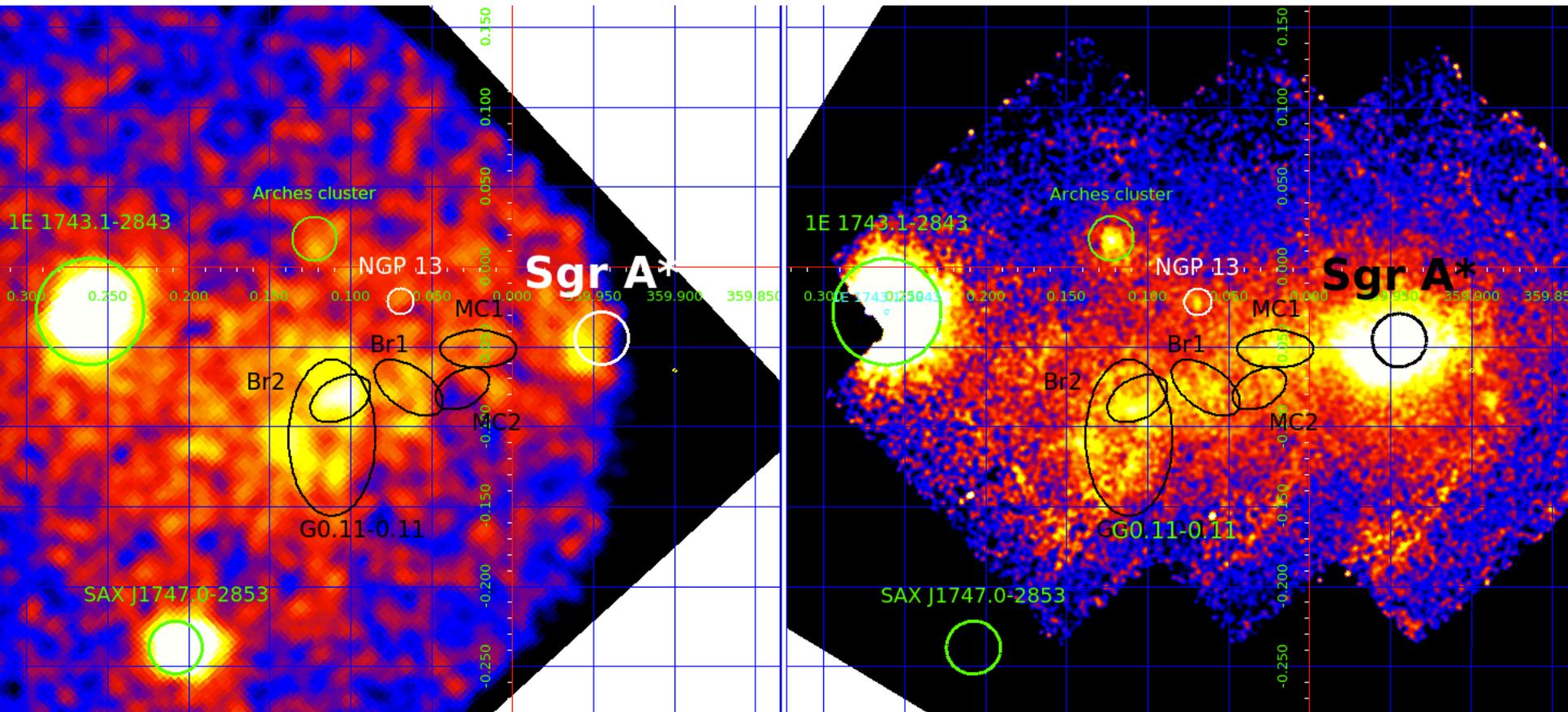
Courtesy of  
M. Pavlinsky (IKI)

50ks exposure; 5-16 keV (ATEL 13023)

# ART-XC CaIPV observations

ART-XC ~4.8ks

NuSTAR mosaic ~144ks



Courtesy of  
M. Pavlinsky (IKI)

# RASS vs. eROSITA vs. XMM

## from simulations...

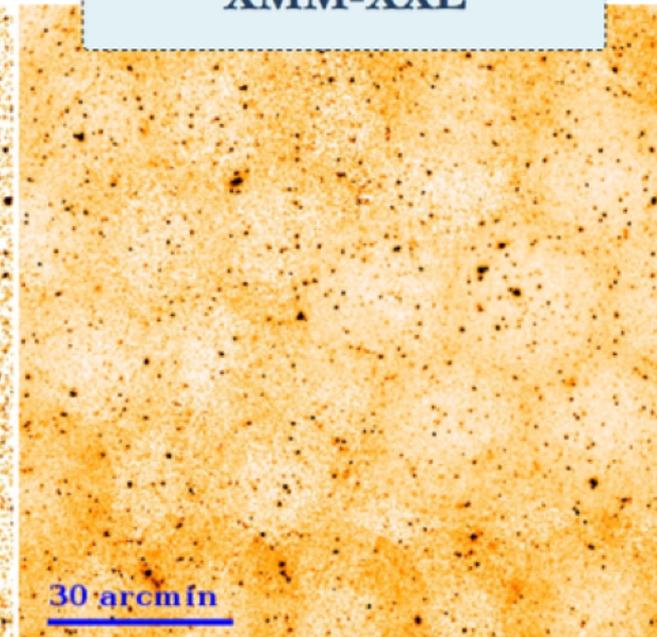
ROSAT all-sky survey



eRASS:8 (simulated)



XMM-XXL

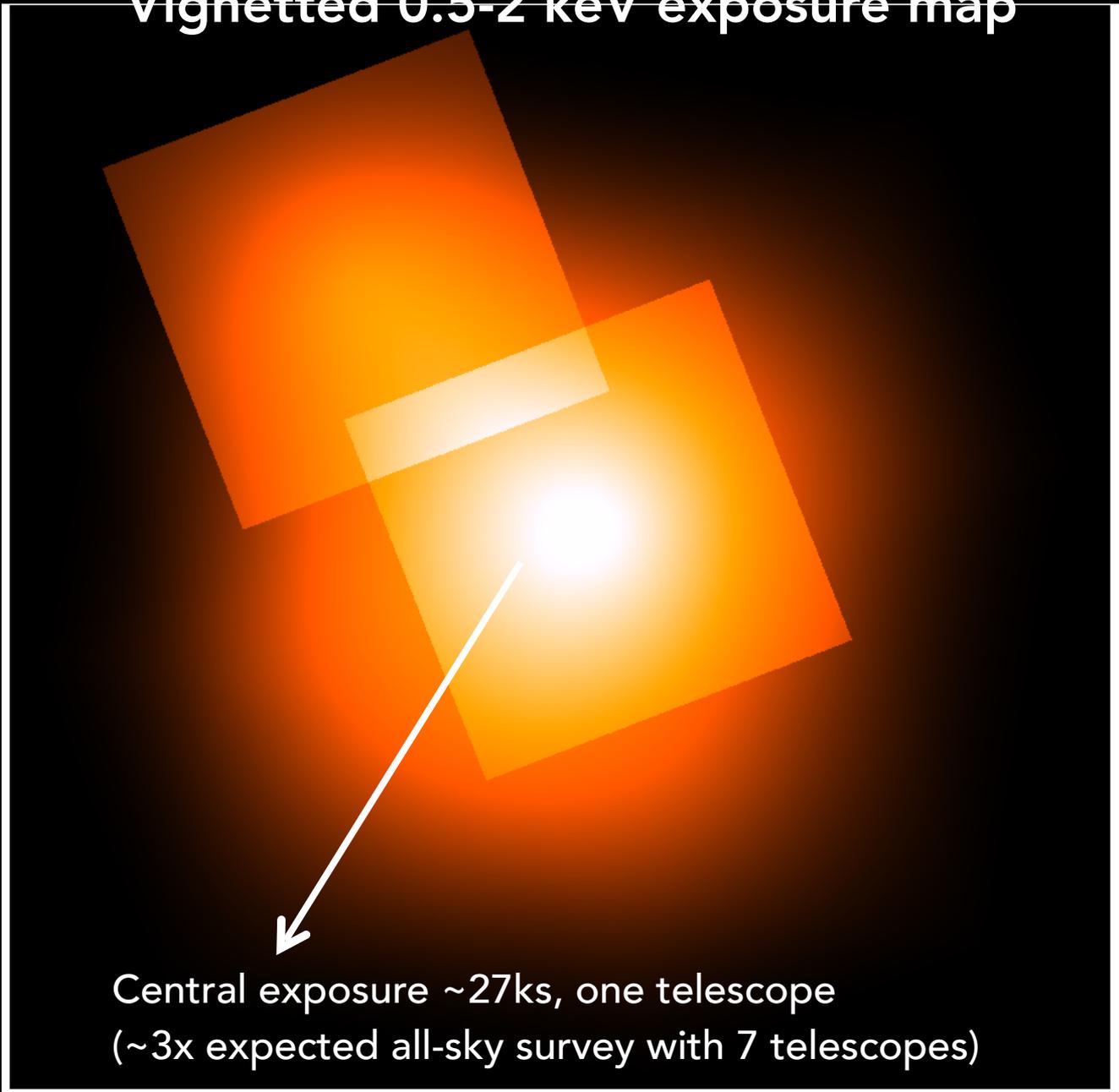


*Image credits MPE, eRosita\_DE consortium, XMM-XXL*

# ...to first Commissioning light: UDS field (ART-XC PV target)

- Ultra Deep Survey (UDS) area:
  - RA: 34.525, DEC: -4.7833
  - Part of XXL-North
- Only telescope module 6 (TM6)
- Observed on August 26/27 (about 24 hours)
- Series of pointed and scan observations
- No soft proton flares observed (TBC)
- All images reduced with eSASS software (Credit: H. Brunner, C. Großberger, G. Lamer, M. Ramos, J. Sanders, C. Maitra and eSASS team)

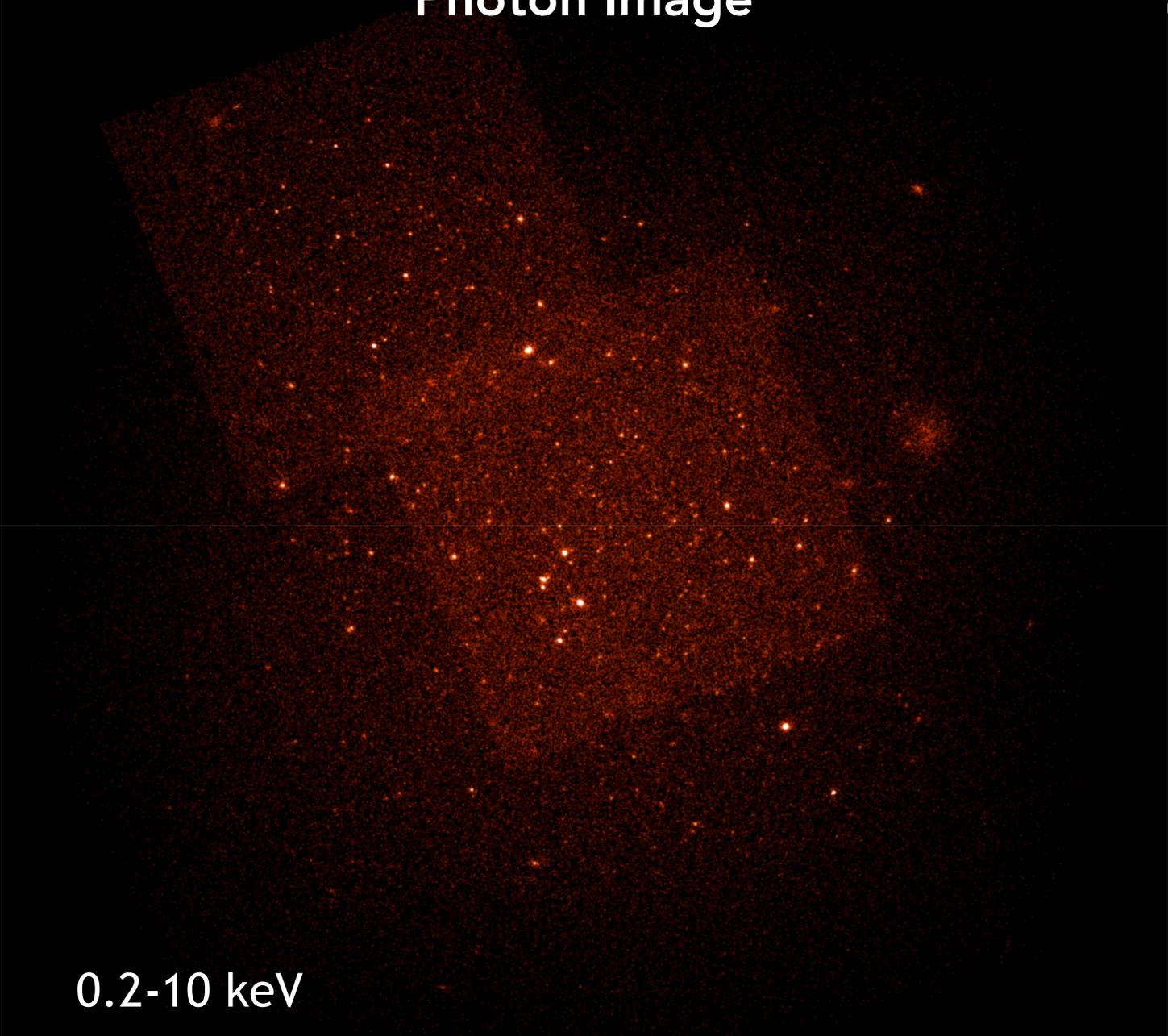
# Vignetted 0.5-2 keV exposure map



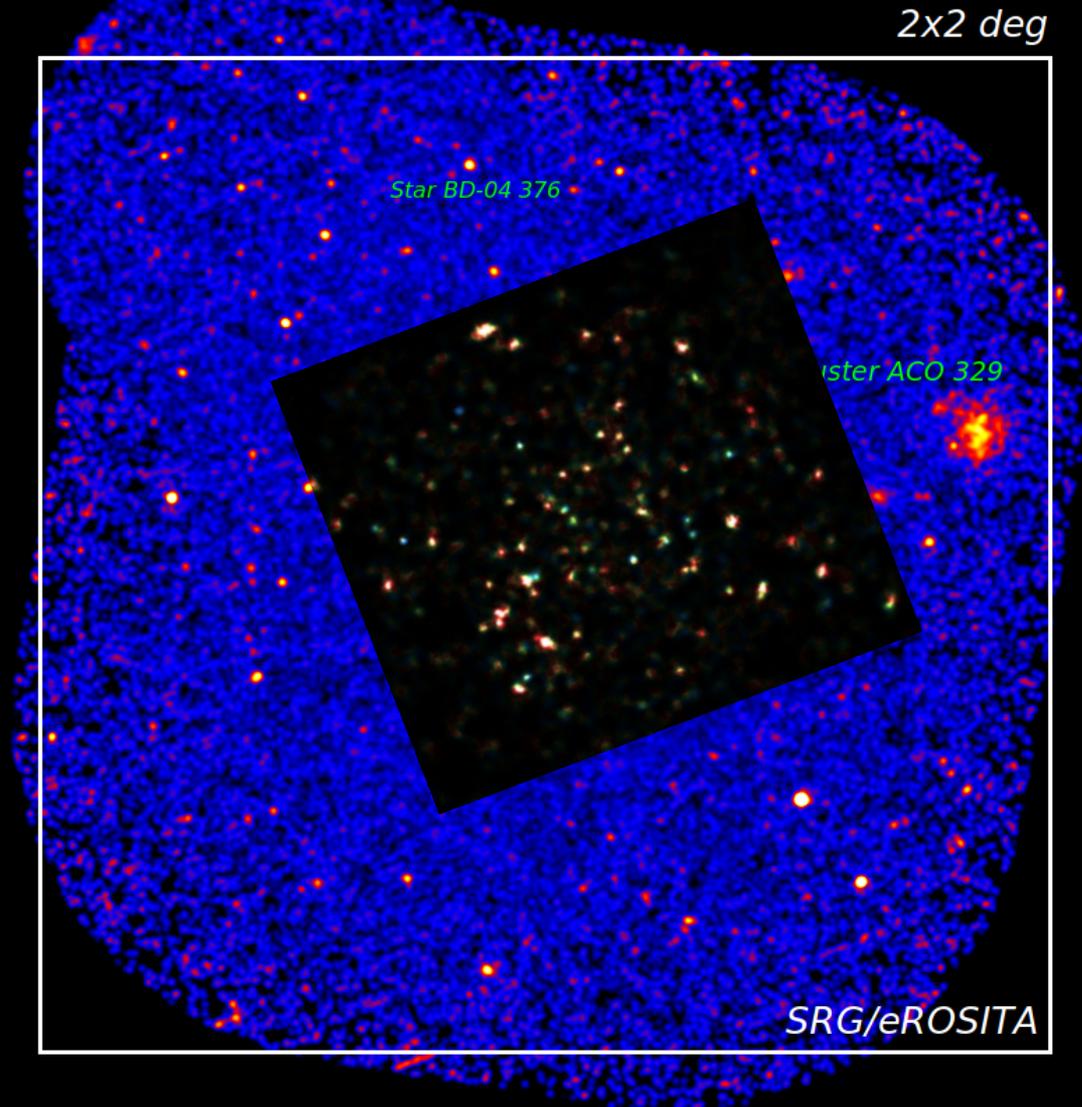
Central exposure ~27ks, one telescope  
(~3x expected all-sky survey with 7 telescopes)



# Photon Image



0.2-10 keV



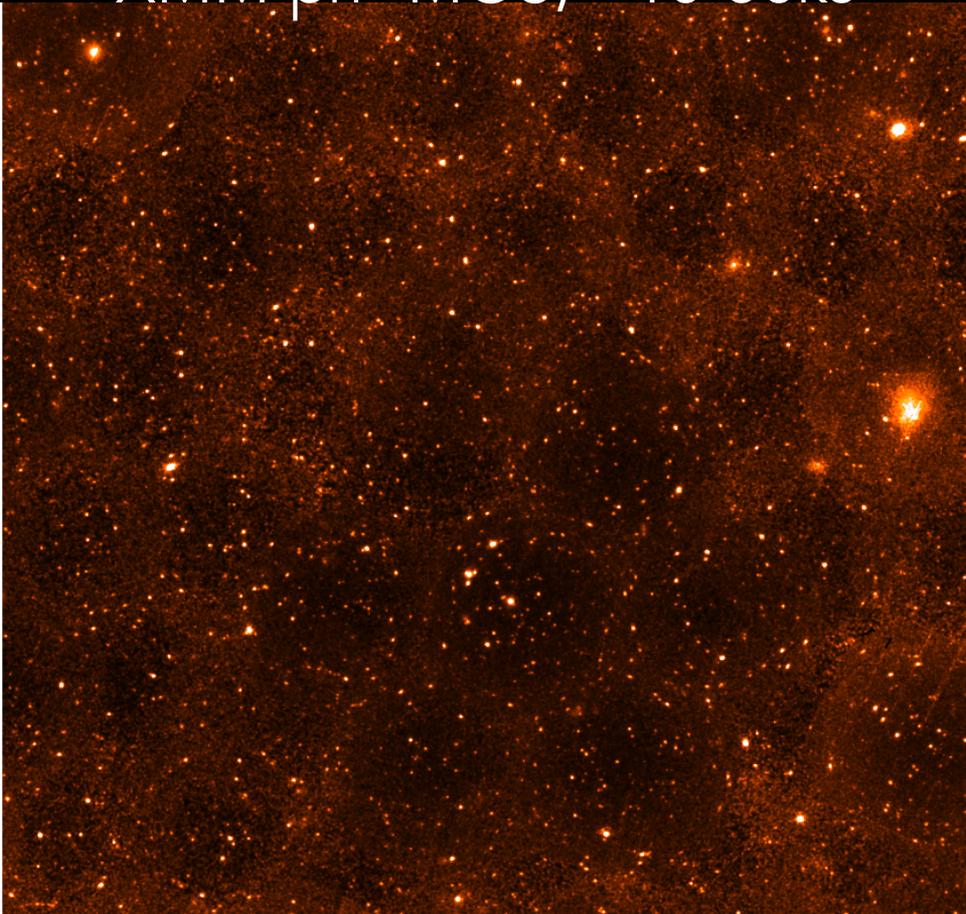
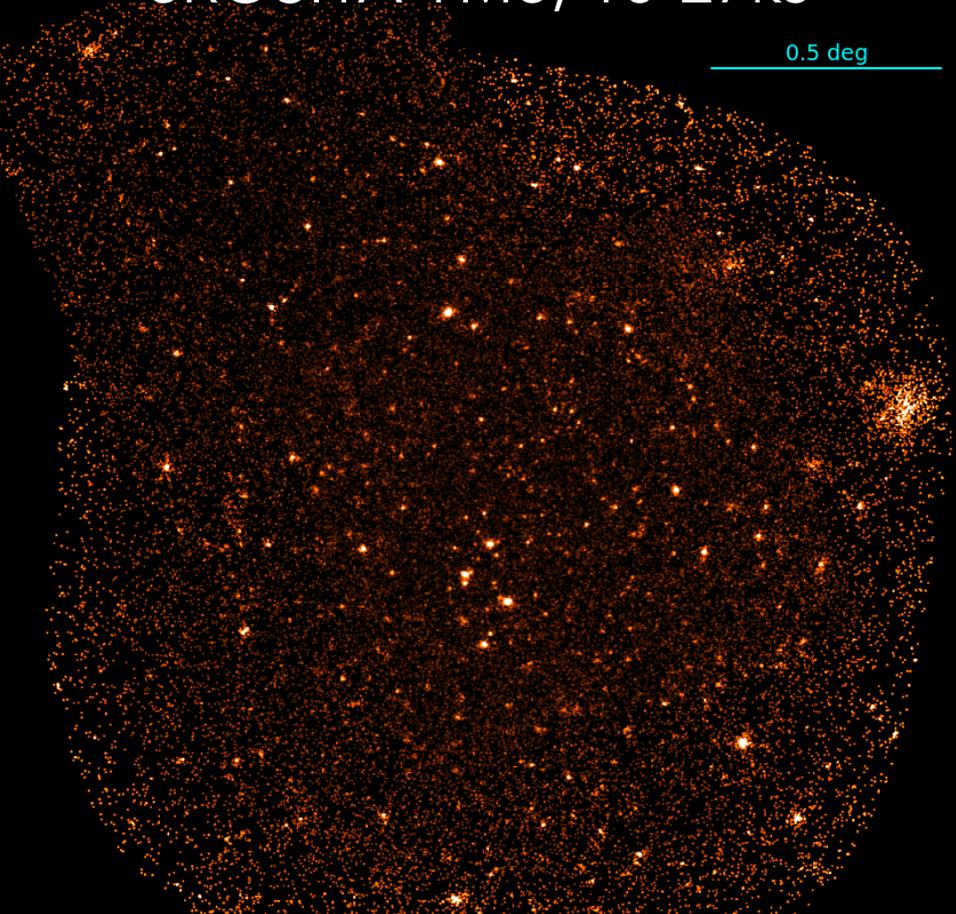


# Comparison with XMM-Newton Smoothed, exposure corrected image



eROSITA TM6, 10-27ks

XMM pn+MOS, ~10-50ks



2.03e-05 4.06e-05 6.11e-05 8.14e-05 1.02e-04 1.22e-04 1.42e-04 1.63e-04 1.83e-04

0.5 - 2 keV



# eROSITA status update



- Commissioning of the cameras started on August 20
- So far successfully checked-out TM6, TM5, TM7, TM1 and TM2
- Excellent pointing stability ( $<1''$  rms) of the telescope/spacecraft
- Background level within 30-50% of expectations (preliminary)
- Cameras performance (spectral resolution, noise) fully consistent with on-ground tests (N. Meidinger, G. Hartner)
- Both Science Analysis Software (eSASS; Brunner et al.) and Near Real-Time Analysis (NRTA; Kreykenbohm, Wilms et al.) worked from day 1 without major issues
- **PROBLEMS:**
  - Not yet understood 'erratic' behaviour of Cameras Electronics. Possibly due to on-board software
  - The two cameras without on-chip filter show direction-dependent increased noise level (stray light? Light leak?)
  - Zero-gravity behaviour of thermal system not fully characterized
- Commissioning/Calibration work will continue until the end of September with no more than 2 TMs simultaneously
- Official "First Light" CalPV start (probably) in early October

# OPENING SOON:

'Mapping the X-ray sky with SRG: First Results from  
eROSITA and ART-XC'

Garching, Germany, March 16-20, 2020

- Galaxy clusters and cosmology
- Active galactic nuclei
- Galactic compact objects, stars and planets
- The Transient X-ray sky
- Diffuse X-ray emission
- Synergy with multi-wavelength surveys

**Special Thanks to:**

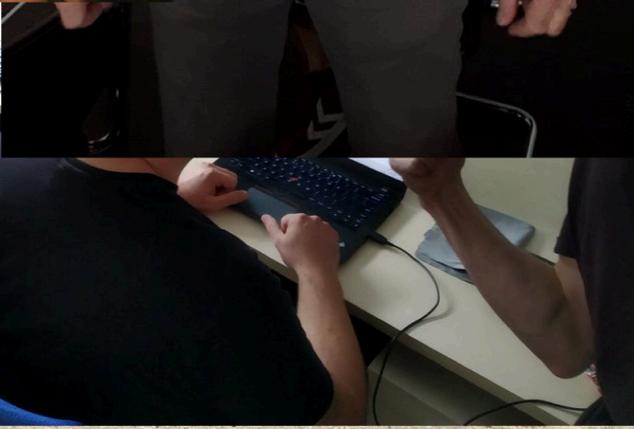
**eROSITA Instrument, Operations, Commissioning  
and Software teams**

**All those involved in Mission Control center at IKI  
and NPOL Lavochkin in Moscow**



Manuela Magli...

wilfried





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Thank you!

