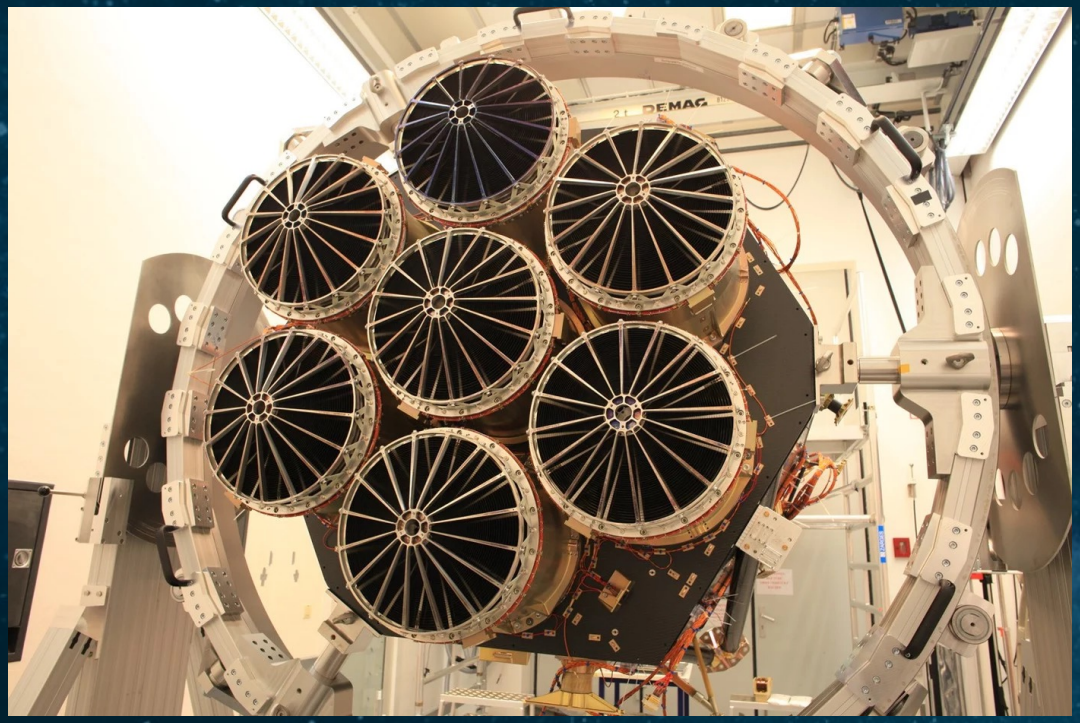
Results from SRG/eROSITA - XMM-Newton Observations

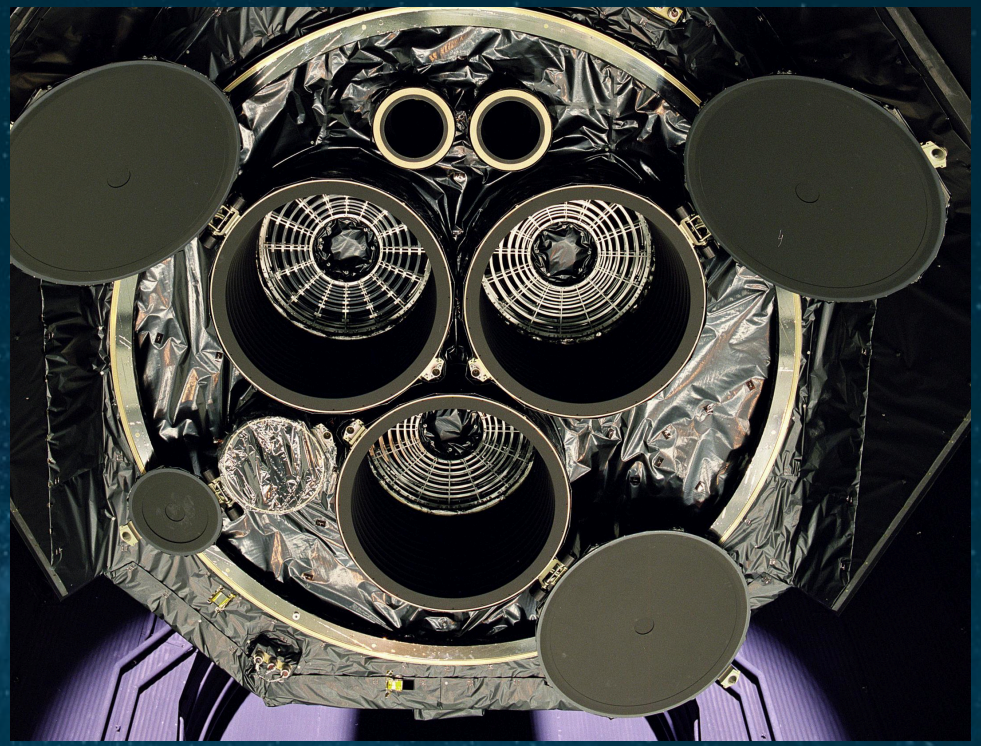
First Results from the SRG/eROSITA All-Sky Survey: From Stars to Cosmology
16 September 2024
Garching, Germany

Norbert Schartel

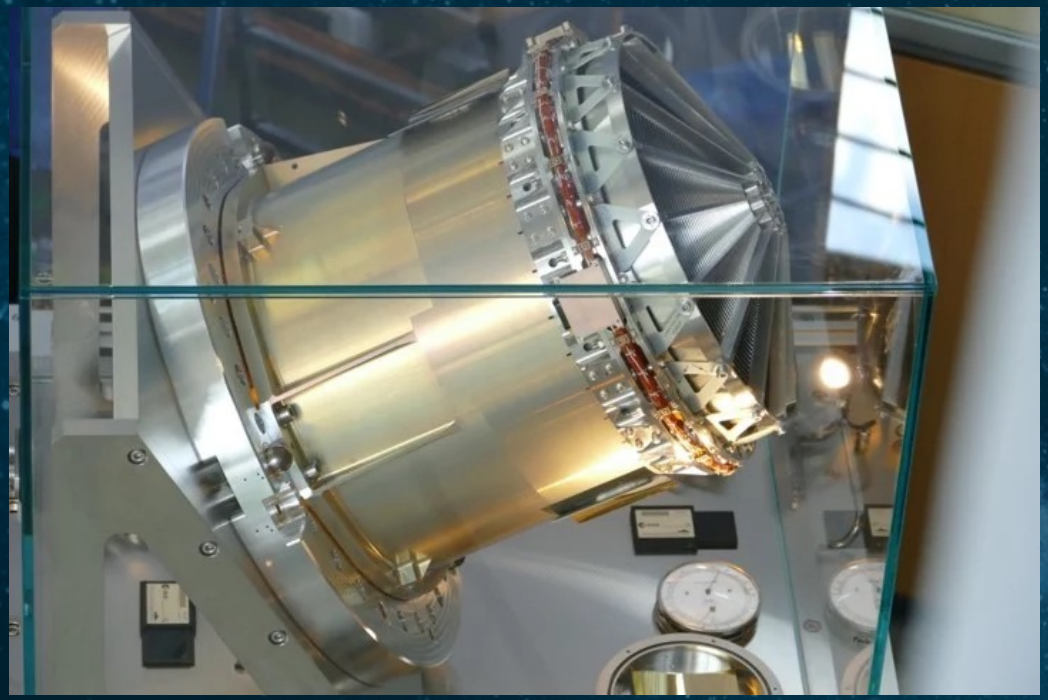
20/09/2024

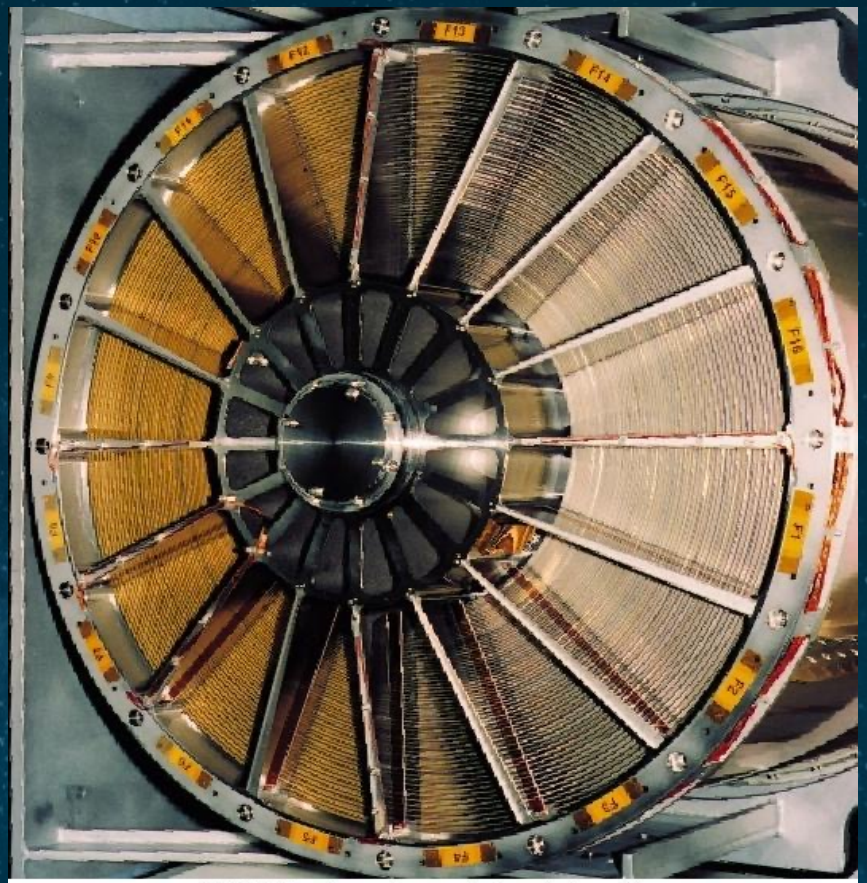
eROSITA & XMM-Newton





eROSITA & XMM-Newton



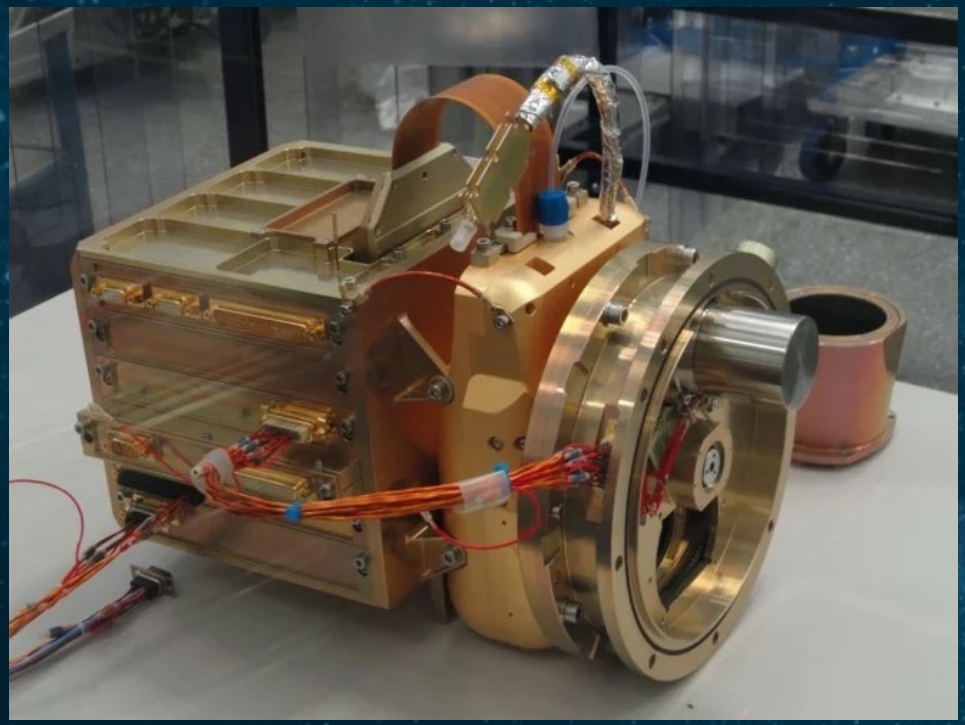


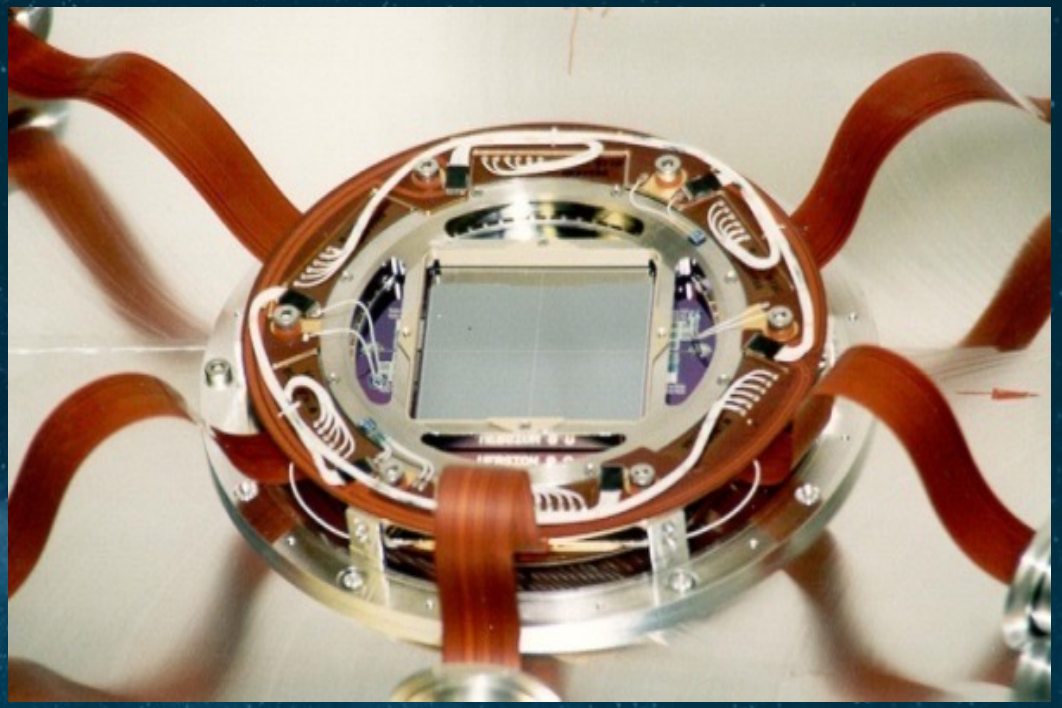
XMM-Newton mirrors during integration

Image courtesy of Dornier Satellitensysteme GmbH

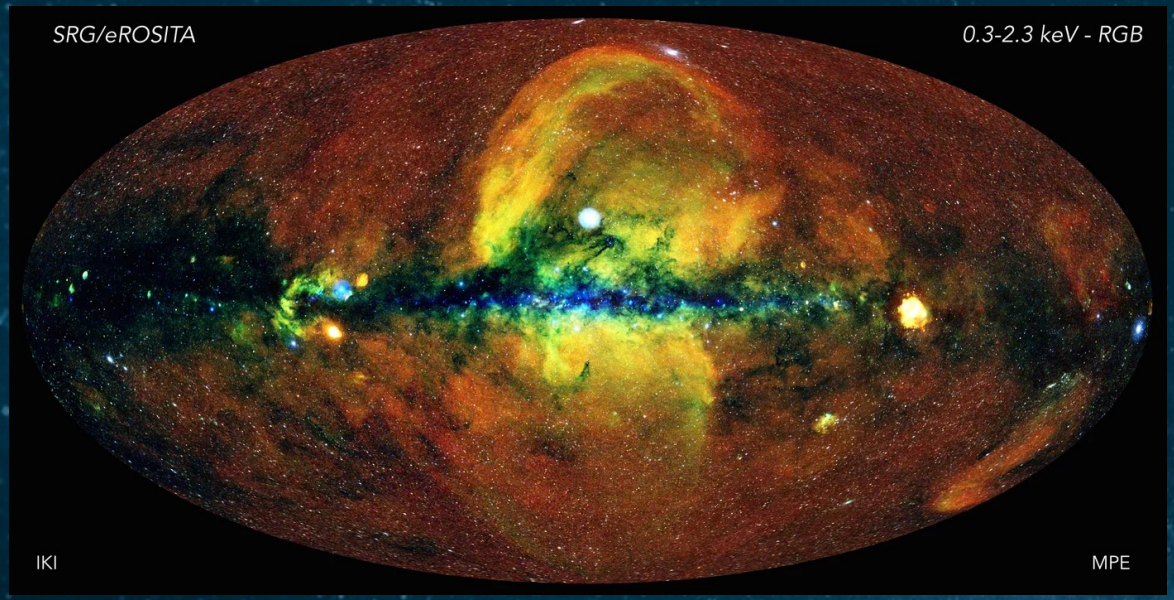
European Space Agency

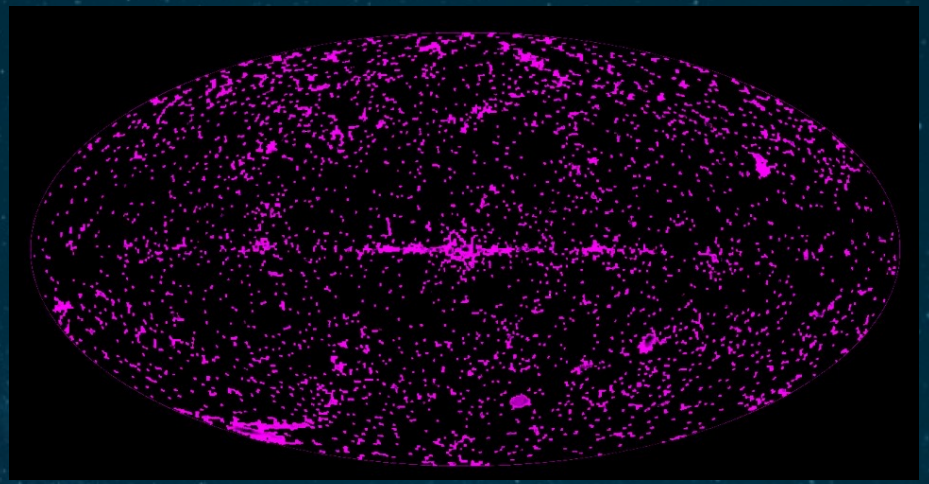
eROSITA & XMM-Newton

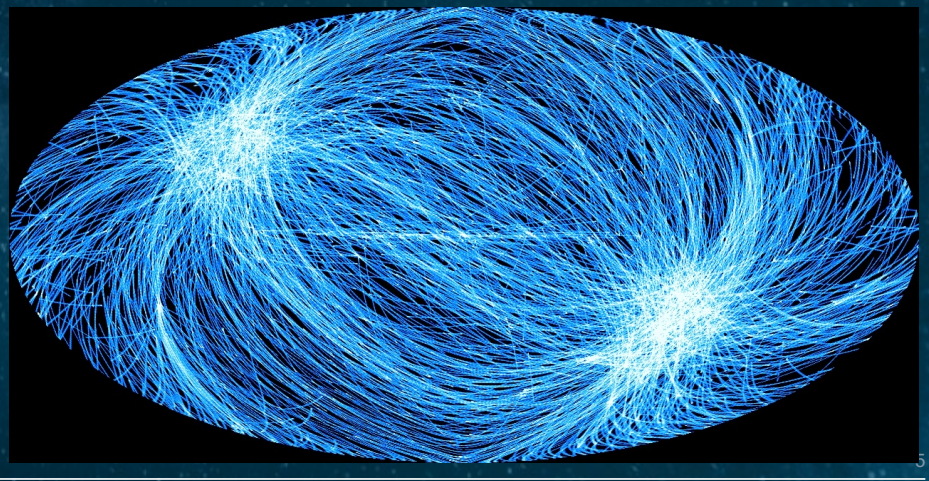




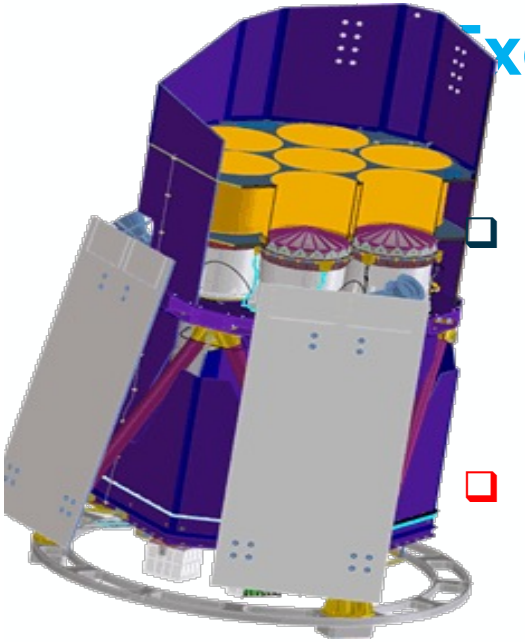
eROSITA & XMM-Newton







Exciting New Possibilities: eROSITA (9.6.2020)



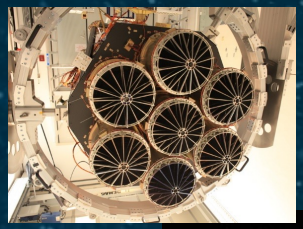
- **eROSITA is the primary instrument on-board the Russian led "Spectrum-Roentgen-Gamma" satellite**
- **First 4 years (8 scans) all-sky survey in the 0.5-10 keV energy range**

The main expectations are:

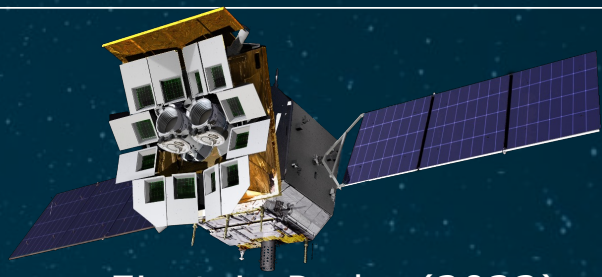
i. **Hundreds of thousands stars & X-ray binaries**
ii. **Hundreds of thousands galaxy clusters and groups**
iii. **Millions of AGNs**
iv. **Rare source classes and transients**

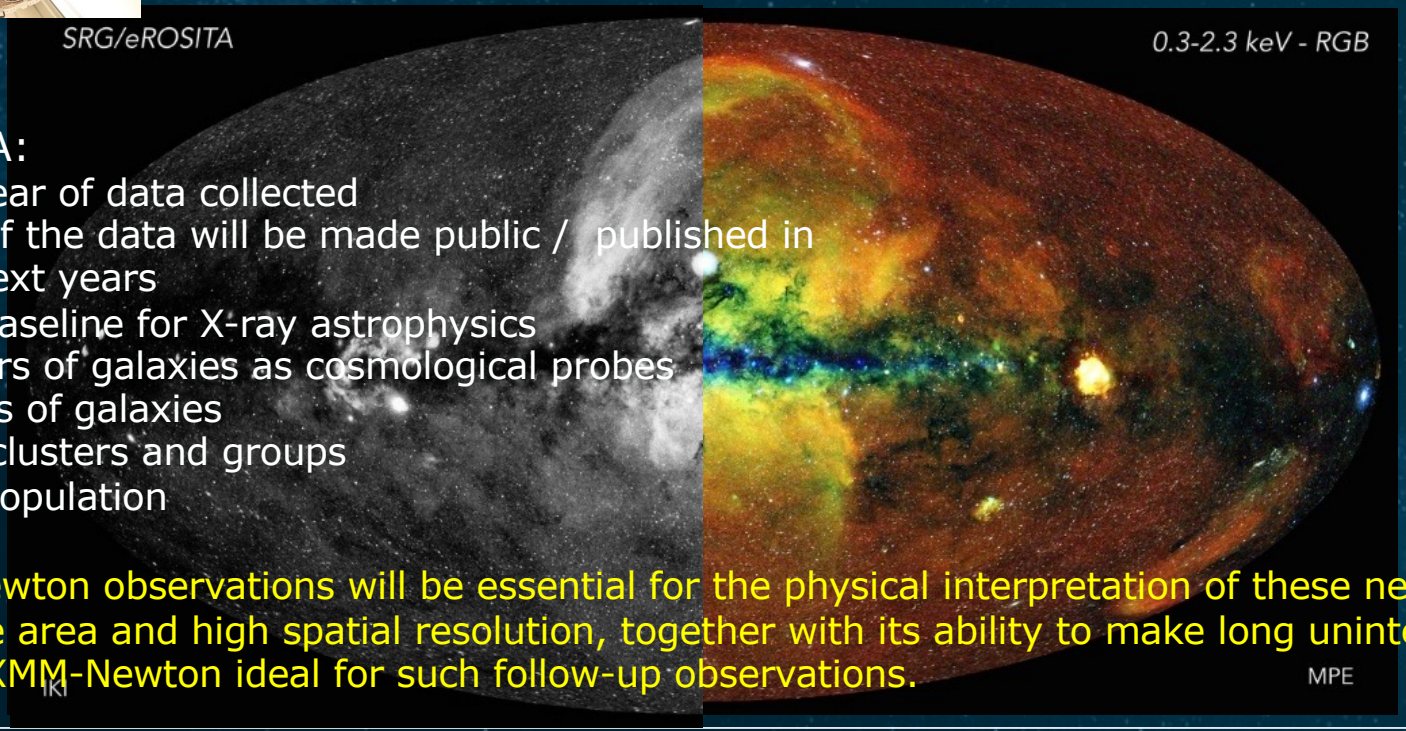
- There is a huge potential for XMM-Newton observations of new and transient sources while eROSITA continues scanning
- Observations with XMM-Newton will be fundamental in providing a physical interpretation and understanding of these detections; e.g. temperature of hot clusters of galaxies
- XMM-Newton's much higher effective area (2.5-10keV) and higher spatial resolution than eROSITA and its ability to make long uninterrupted observations, together make it ideal for follow-up observations.

A Revolution in the X-ray Sky (11.5.2022)



	ROSAT Survey	eROSITA Survey
Coverage	1 times (0.5 year)	5 times (2.5 years)
Grasp	1	2
Spatial resolution	1	~2–3 (conservative)
		~ 20 – 30 times deeper





eROSITA:
- ❑ 2.5 year of data collected
- ❑ Half of the data will be made public / published in the next years

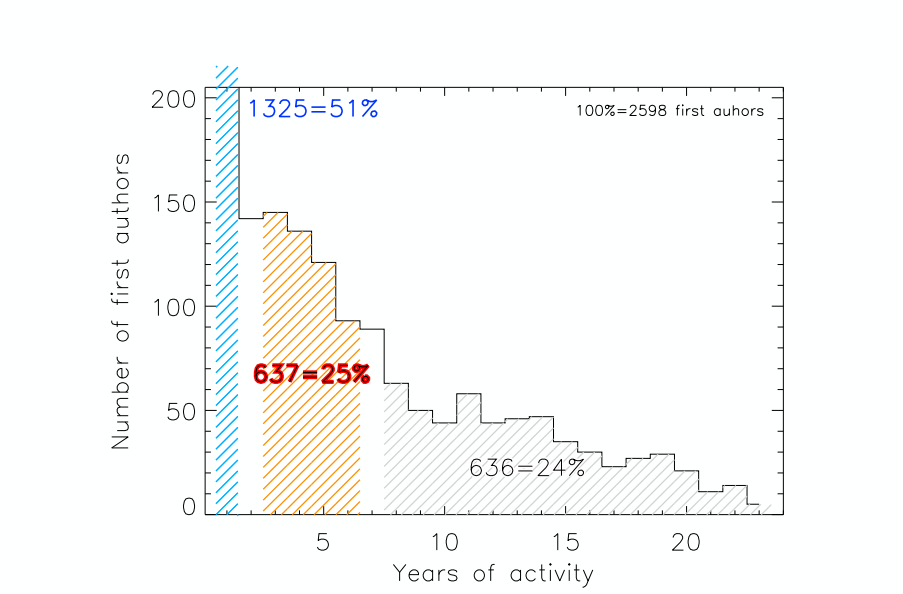
➔ New baseline for X-ray astrophysics
➔ Clusters of galaxies as cosmological probes
➔ Groups of galaxies
➔ Early clusters and groups
➔ AGN population

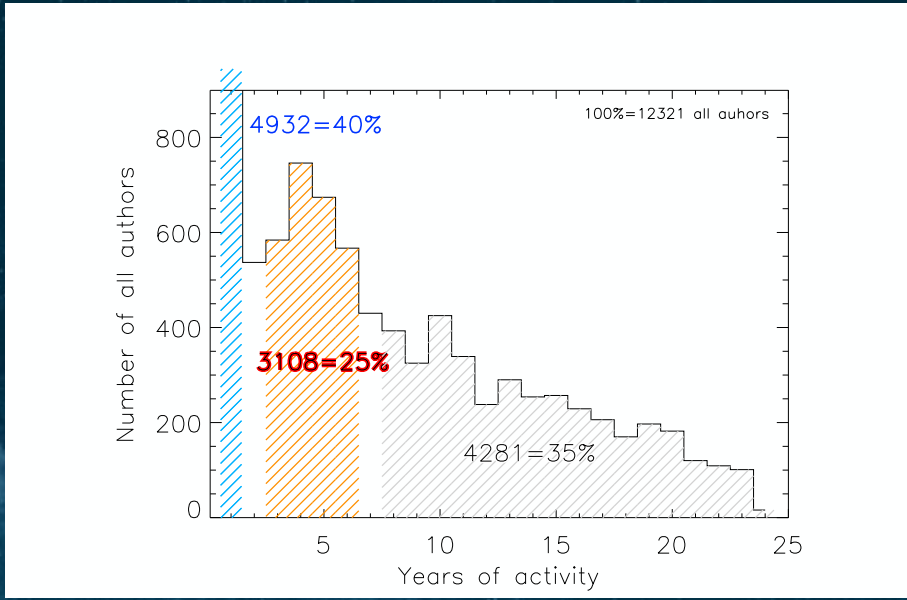
Einstein Probe (2023):
- ❑ first high-sensitivity transient monitor in the soft X-ray sky

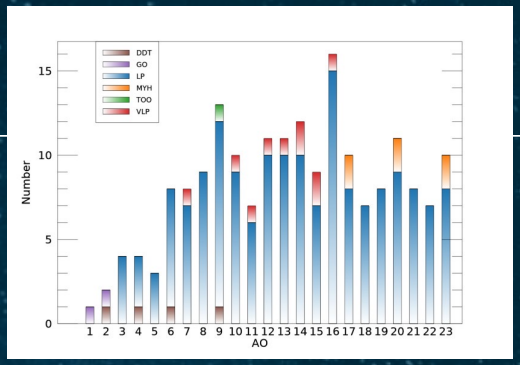
➔ New baseline for X-ray transients
➔ Bursting binaries and AGNs
➔ Tidal disruption events
➔ GW counterparts?

XMM-Newton observations will be essential for the physical interpretation of these new sources. The large effective area and high spatial resolution, together with its ability to make long uninterrupted observations, makes XMM-Newton ideal for such follow-up observations.

X-Ray Astronomers are Young!



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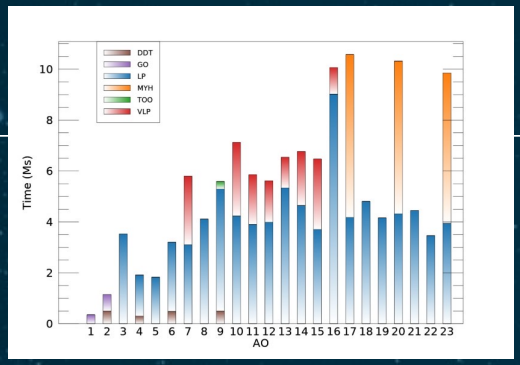
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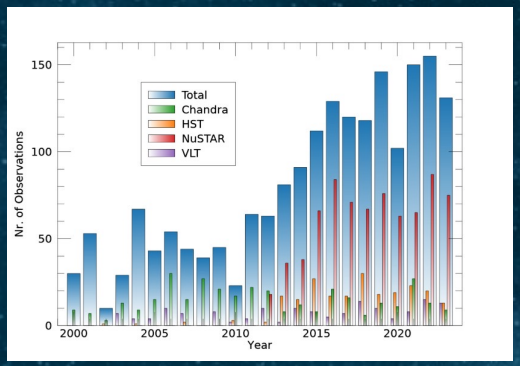
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Nr. of Observations
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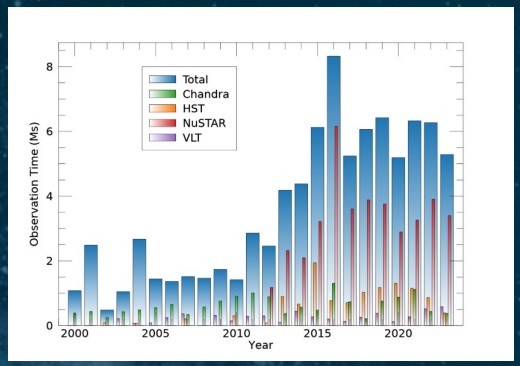
Total
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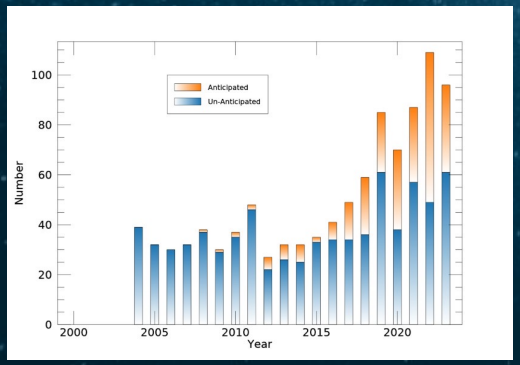
HST
NuSTAR
VLT
Observation Time (Ms)
Year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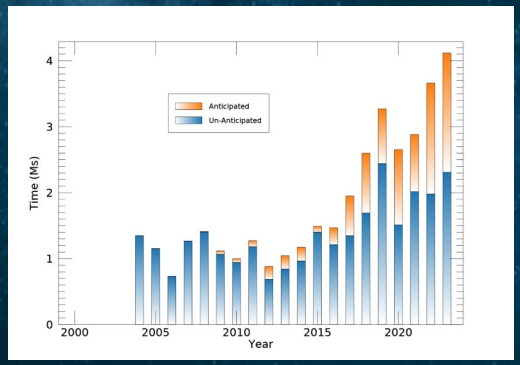
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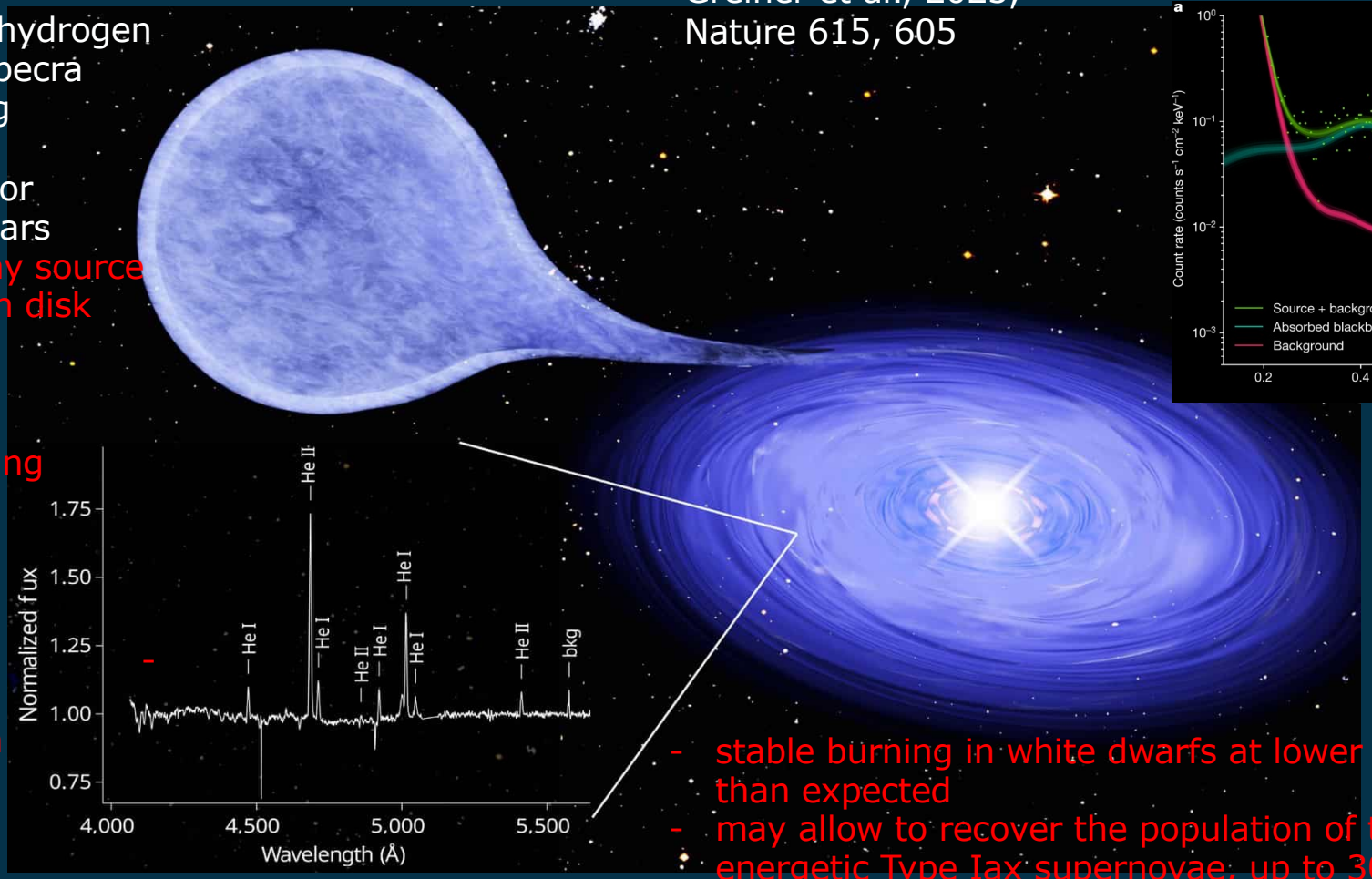
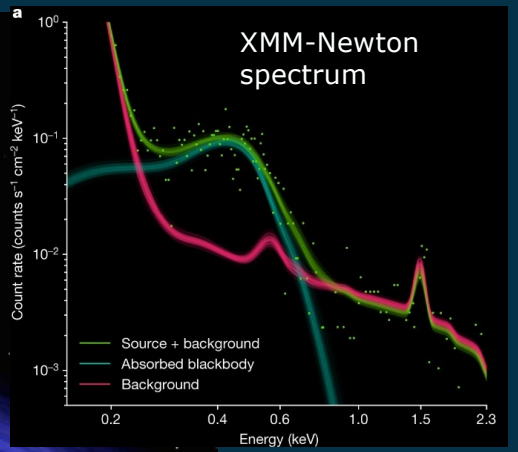
A helium-burning white dwarf binary as a supersoft X-ray source

Greiner et al., 2023, Nature 615, 605

- no evidence for hydrogen in Type Ia SN specra
- Helium-accreting WD have been predicted for more than 30 years
- ➔Supersoft X-ray source with an accretion disk whose optical spectrum is dominated by helium, suggesting a hydrogen-free donor star
- ➔ pathways towards Chandrasekhar mass explosions based on helium accretion





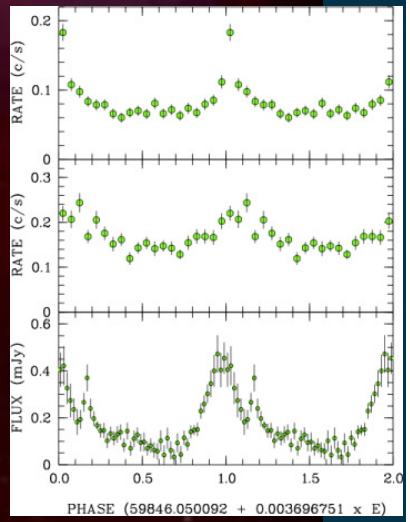
- stable burning in white dwarfs at lower accretion rates than expected
- may allow to recover the population of the sub-energetic Type Iax supernovae, up to 30% of all SN Ia

A 5.3-min-period pulsing white dwarf in a binary

- detected with eROSITA
- coincident with a G=17.1 stellar Gaia-source
- dedicated XMM-Newton observation
- simultaneous pulsations with a period of 319s at X-ray and UV

➔ second white-dwarf pulsar
➔ spin-down of rapidly rotating white dwarf provides enough energy to power the pulses
➔ exact driving mechanism is not fully understood

Schwope et al., 2023, A&A 674, L9
Pelisoli et al., 2023, Nature Astronomy 7, 931

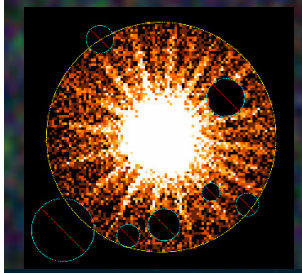


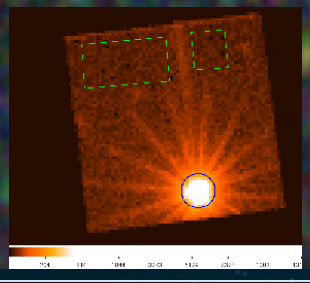
EPIC-pn X-ray, OM/UVM2 & ULTRACAM g-band light curves folded over the spin phase

Phase-resolved X-ray spectroscopy of PSRB0656+14

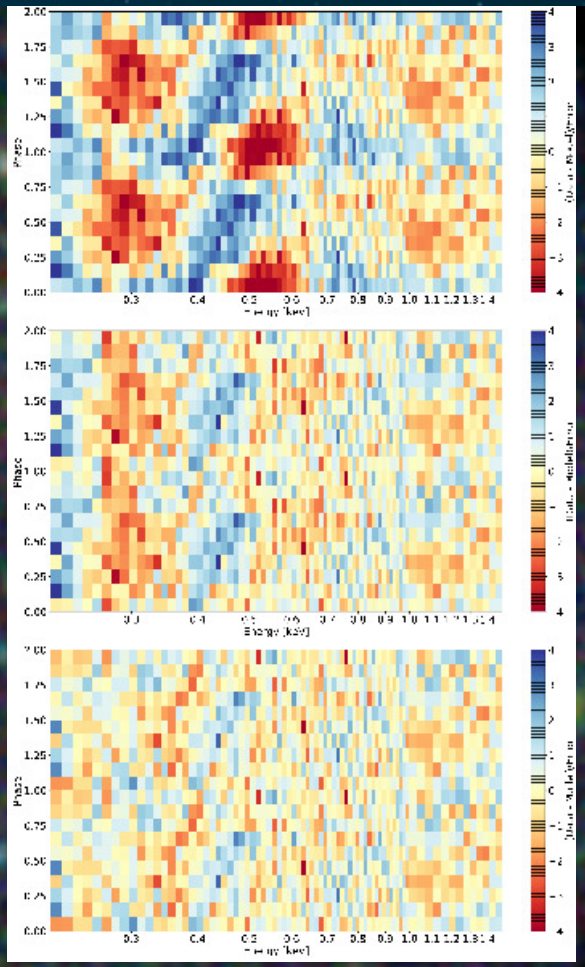
Schwope et al., 2022, A&A 661, A41

- PSR B0656+14 observed by eROSITA and XMM-Newton during calibration and performance verification
- mean eROSITA spectrum: absorption feature at 570 eV with a Gaussian of ~70 eV that was tentatively identified in a previous XMM-Newton observation.
- second feature at 260–265 eV described as an absorption edge
- these absorption features are superposed on emission components that are phenomenologically described as the sum of hot (120 eV) and cold (65 eV) blackbody components, both of photospheric origin, and a power law with photon index = 2 from the magnetosphere

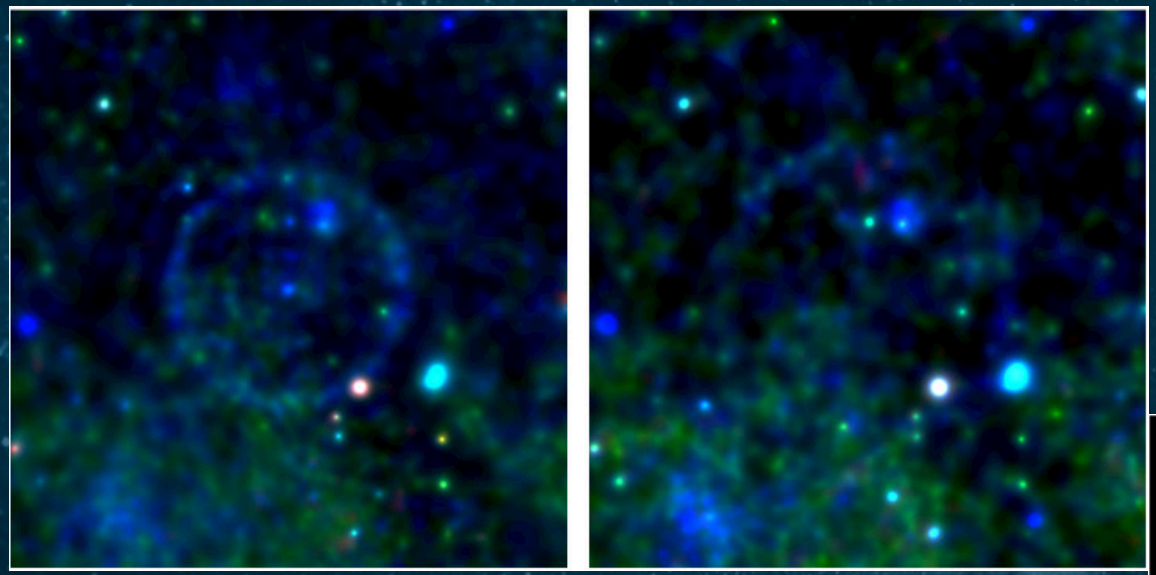




- Phase-resolved spectra: the Gaussian absorption line at 570 eV throughout 60% of the spin cycle,
- The Gaussian absorption may be interpreted as proton cyclotron absorption in a field as high as 1014 G, which is significantly higher than the field derived from the moderate observedspin-down.

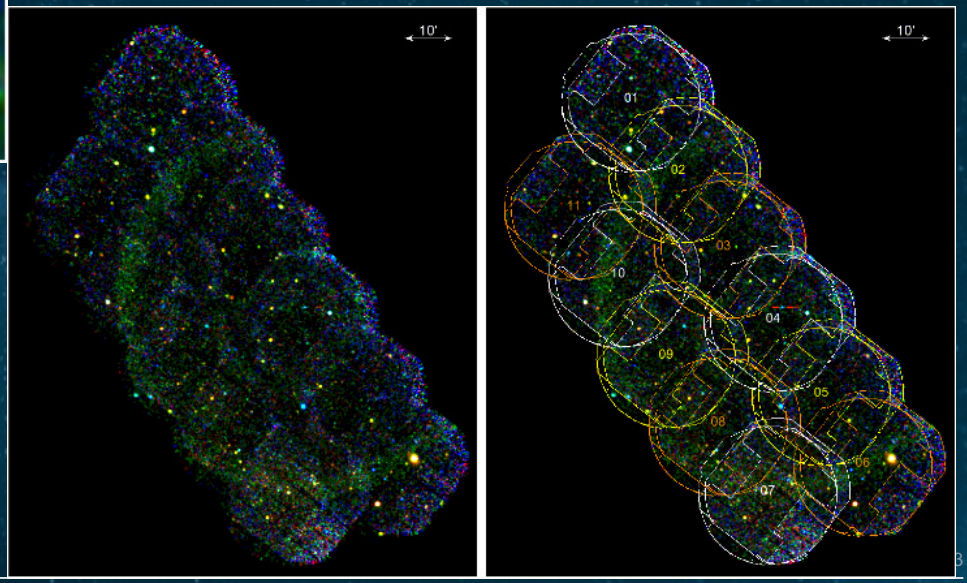


A giant X-ray dust scattering ring from the black hole transient MAXI J1348–630



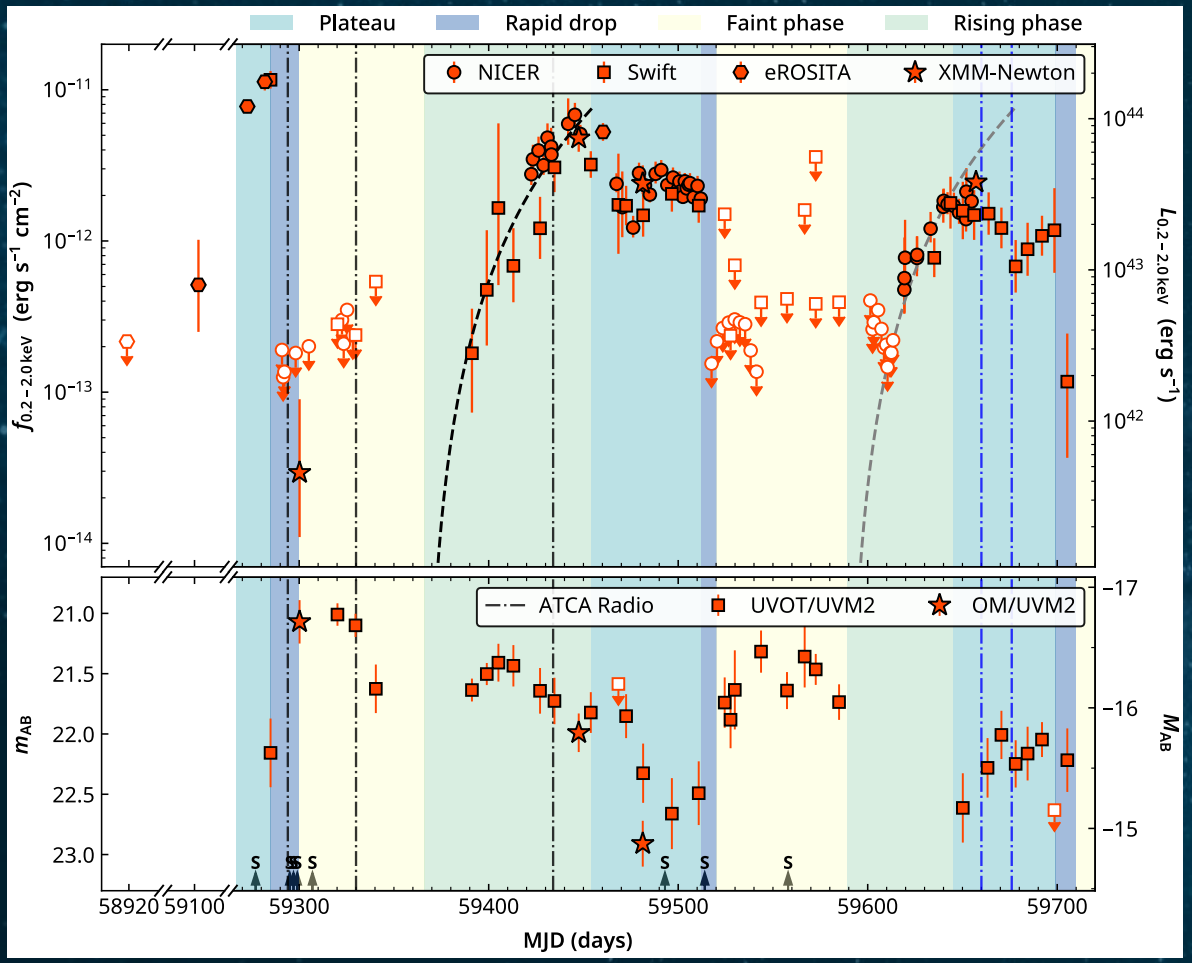
Lamer et al., 2021, A&A 647, A7

- giant dust scattering ring around transient BH MAXI J1348-630 with SRG/eROSITA
- February 2020, the ring had an diameter of 1.3 deg, growing to 1.6 deg im August 2020
- far the largest X-ray scattering ring observed



- SRG/eROSITA, XMM-Newton, MAXI , and Gaia data to measure the geometrical distance of MAXIJ1348-630
- The Gaia data place the scattering dust at a distance of 2050 pc
- MAXI J1348-630 at a distance of 3390 pc with a statistical uncertainty of only 1.1% (systematic uncertainty of 10% cause by parallax offset of Gaia)
- black hole of 11+/-2 M

eRASSt J045650.3□203750: Repeating Partial Tidal Disruption Event



Liu et al., 2023, A&A A75

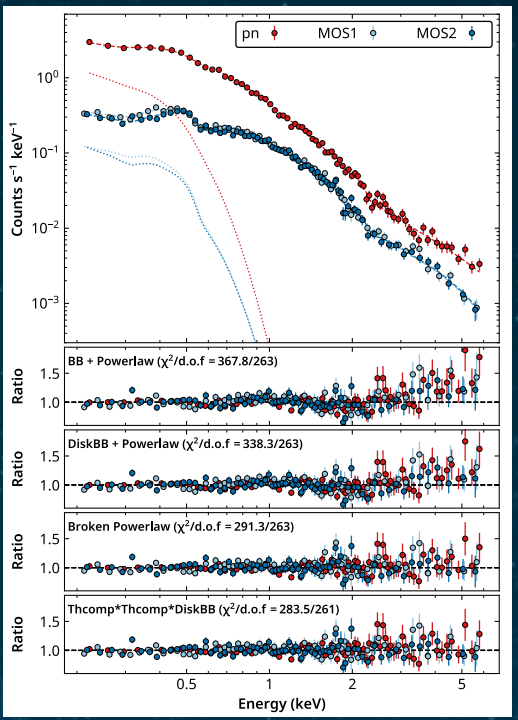
eRASSt J045650.3 - 203750 uncovered by SRG/eROSITA

-- repeating X-ray nuclear transient,

-- tentative recurrence time of 223 days

-- in a quiescent galaxy at z=0.077

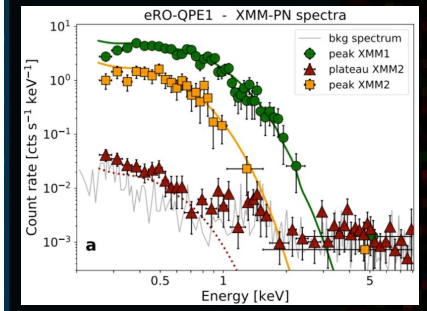
-- four phases: rise, plateau, drop, faint



XMM-Newton: a warm and hot corona during plateau phase and end of the rising phase.

➔ repeating partial tidal disruption

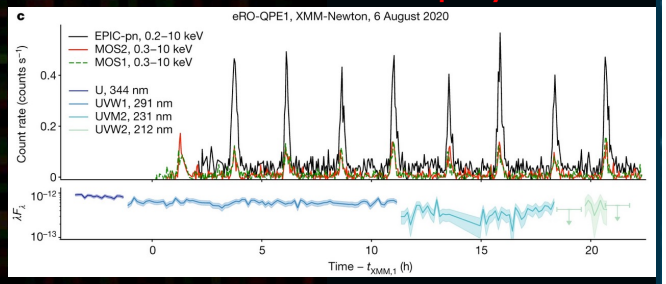
Quasi-Periodic Eruptions from Quiescent Galaxies



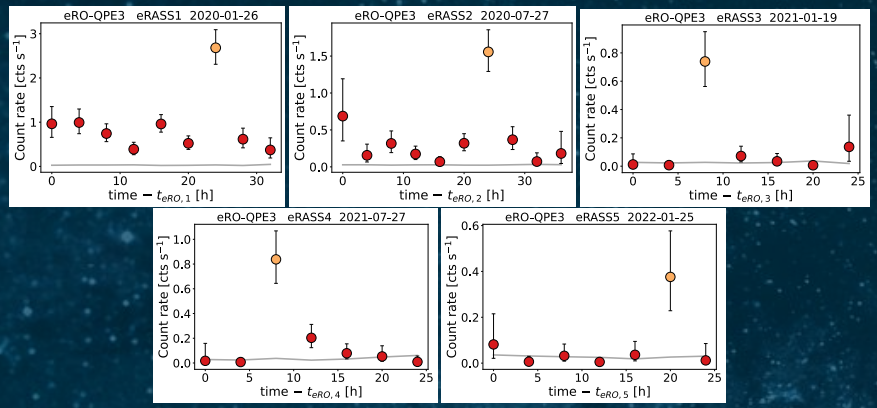
- 2 sources detected by SRG/eROSITA
- Characterization with XMM-Newton and NICER
  - Quasi-Periodic Eruptions (QPEs)
  - No pre-existing active nuclei, i.e. quiescent galaxies
  - Inconsistent with accretion disk instabilities.
  - QPEs likely driven by an orbiting compact object.
  - Secondary object is much smaller than the main body

R. Arcodia et al. (2021, Nature 592, 704)

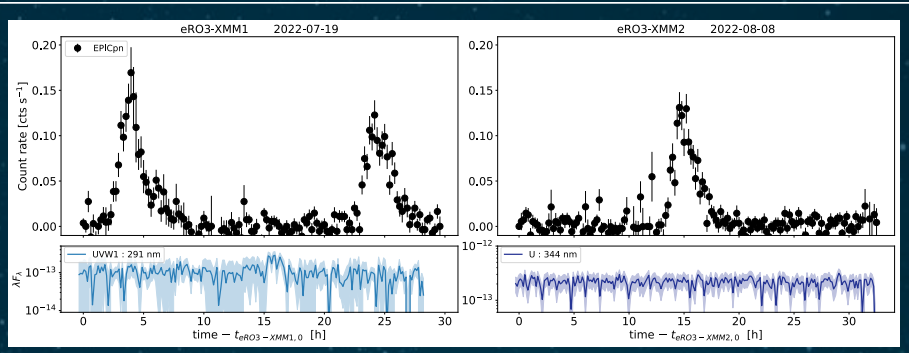
QPEs are viable candidates for the electromagnetic counterparts of extreme mass ratio inspirals with considerable implications for multi-messenger astrophysics.



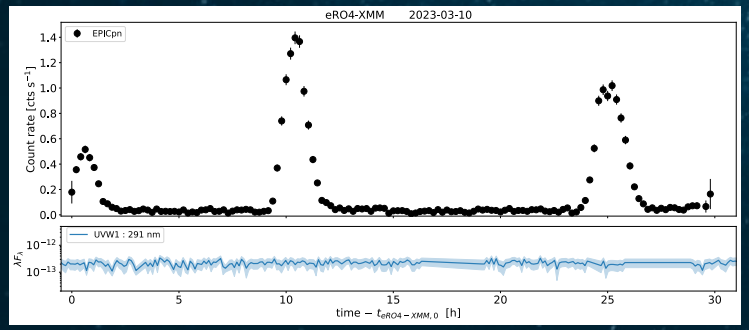
SRG/eROSITA discovers 2 further X-ray quasi-periodic eruptions

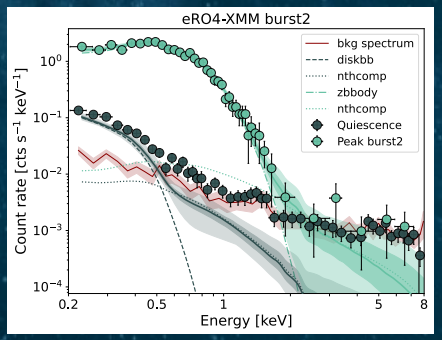


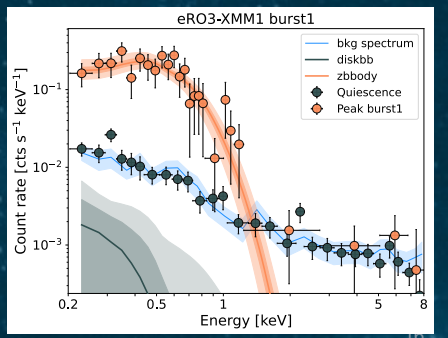
Arcodia, 2024, A&A 684, A64



- eRO-QPE3: eruptions on top of decaying quiescence flux ➔ connection between QPEs and TDE
- eRO-QPE3 exhibits the longest recurrence times and faintest peak luminosity of known QPE
- eRO-QPE4 transient component is harder, albeit much fainter, than the thermal QPE spectrum
- eRO-QPE4 displays a significant brightening of the quiescence disk component after the detection of QPE







An extremely X-ray luminous quasar at z = 6.18

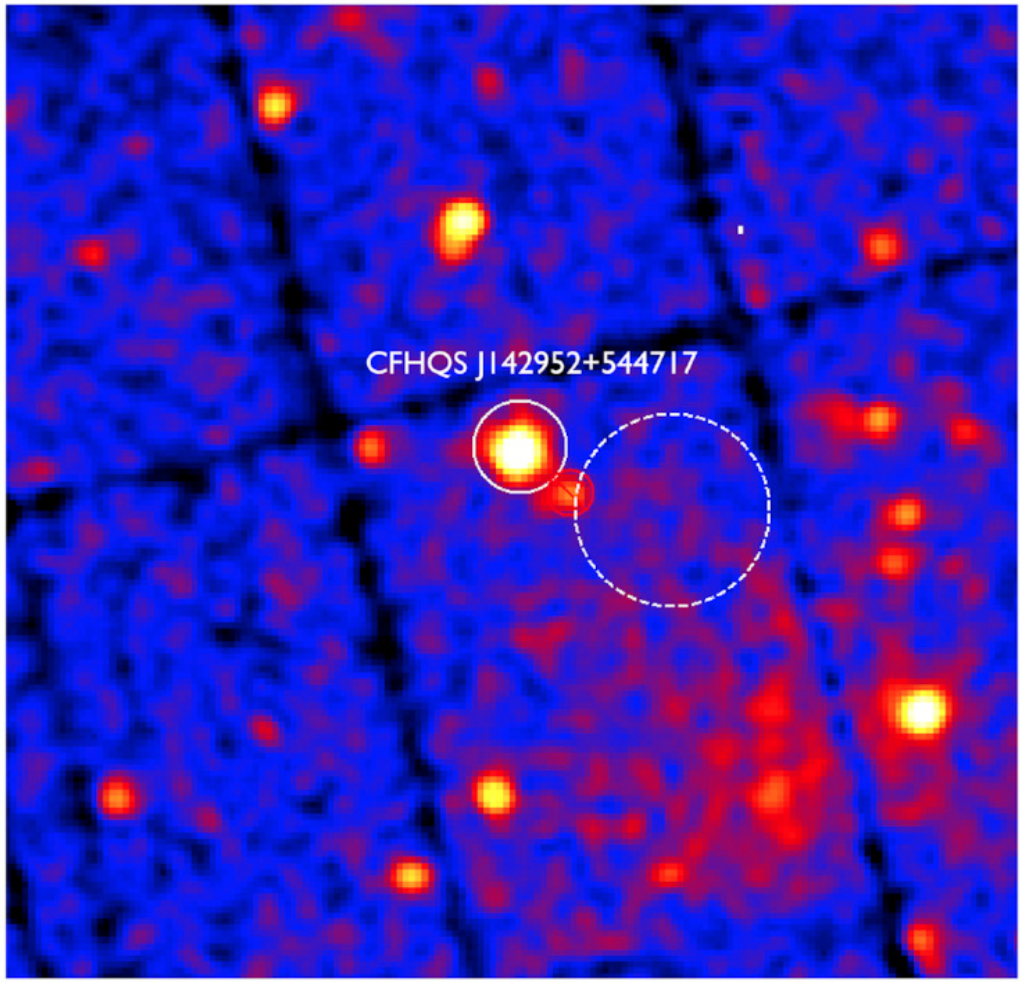
- 20 ks XMM–Newton observation of the radio-loud quasar CFHQS J142952+544717 at z=6.18

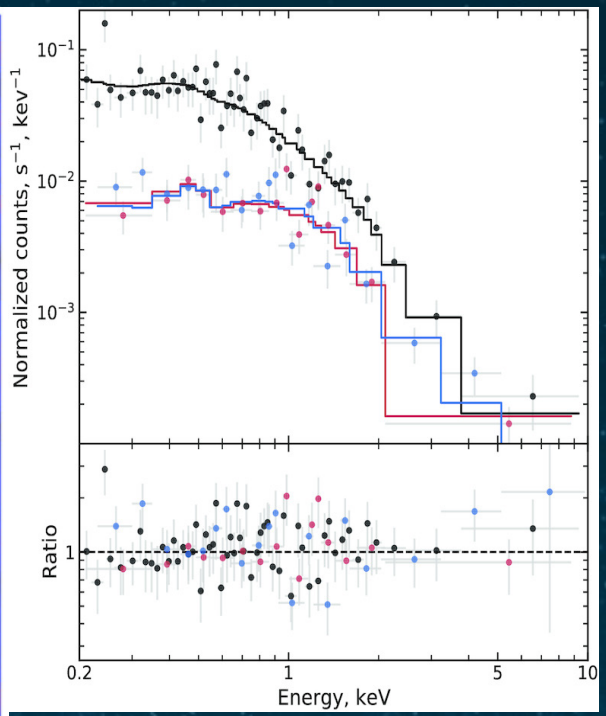
➢~1400 net counts in the 0.2–10 keV energy band (1.4–72 keV in rest frame)

➢absorbed power-law with Γ= 2.5 ± 0.2.

➢extreme properties due to inverse Compton scattering of cosmic microwave background (CMB) photons in the relativistic jets

➢ CMB ~ (z+1)^4

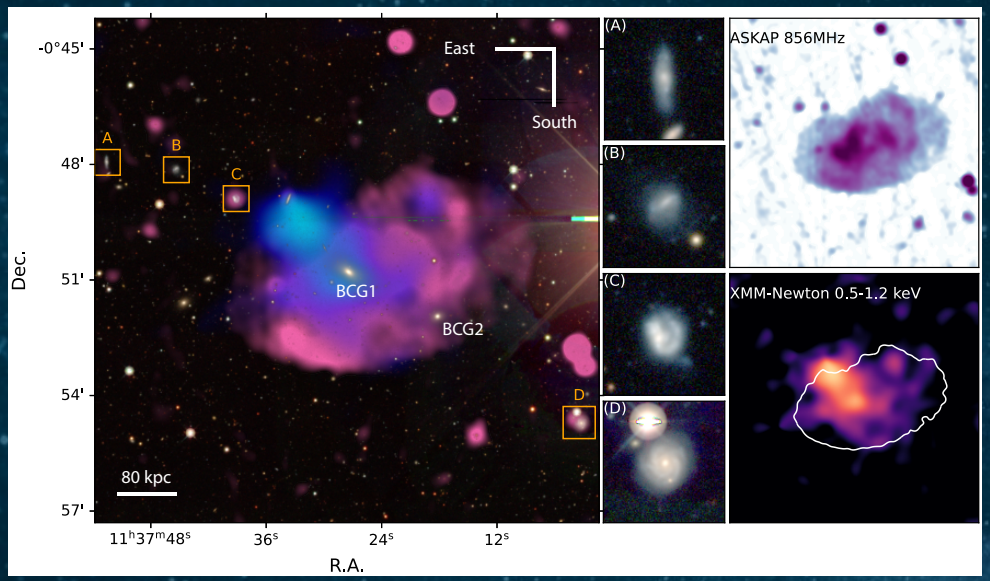




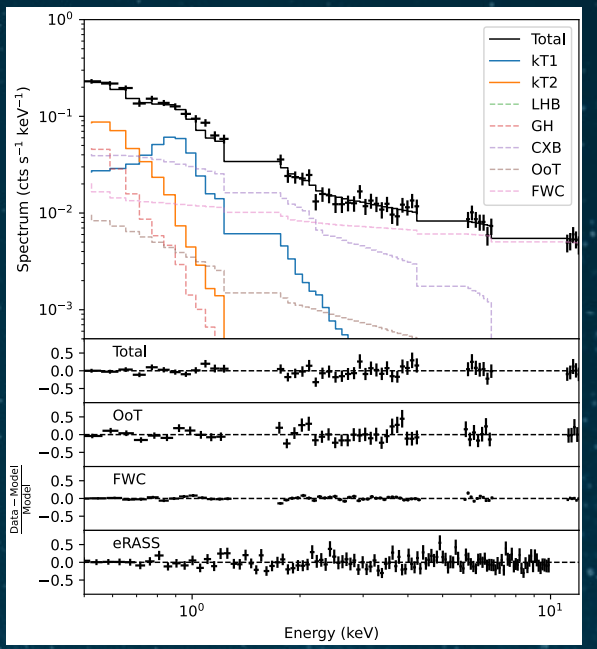
EPIC-PN (black) and EPIC-MOS (red and blue) spectra of CFHQS J142952 + 544717. The solid lines show an absorbed power-law model.

P. Medvedev, et al., 2021, MNRAS 504, 576

Origin of the Cloverleaf odd-radio circle system



Bulbul et al., 2024, A&A 685, L2

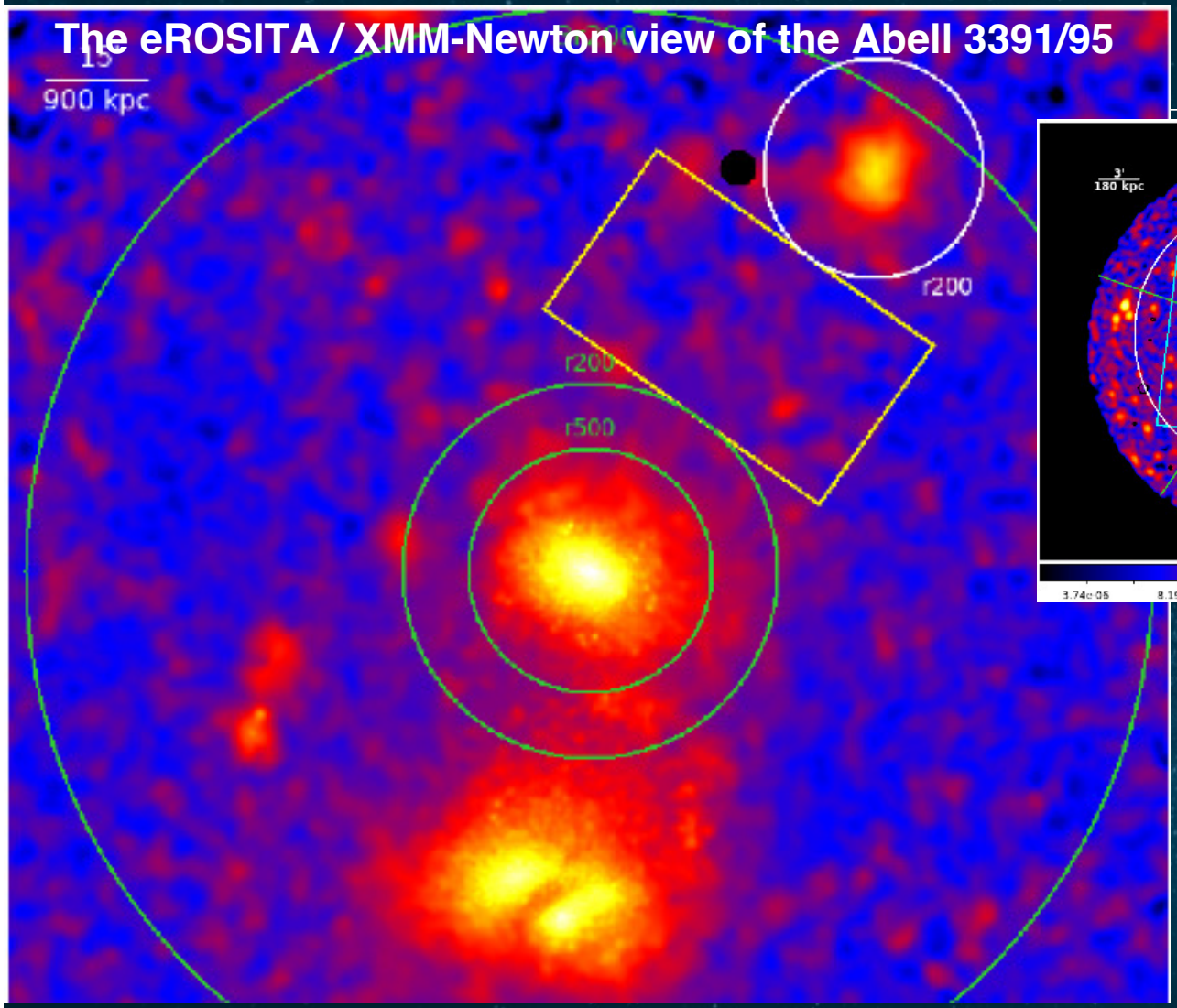


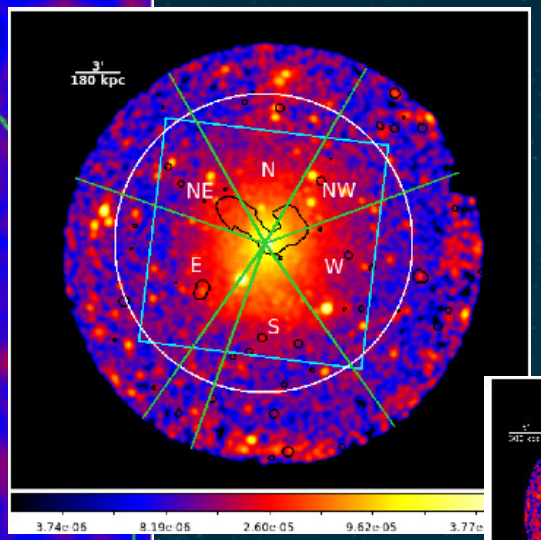
XMM-Newton spectrum in black. the best-fit two-temperature in blue and orange, the foreground and background models dashed lines.
The bottom panels indicate good fits after the background modeling, including NXB with the foreground modeling of the eRASS1 data.

Odd radio circles (ORCs) are a newly discovered class of extended faint radio sources

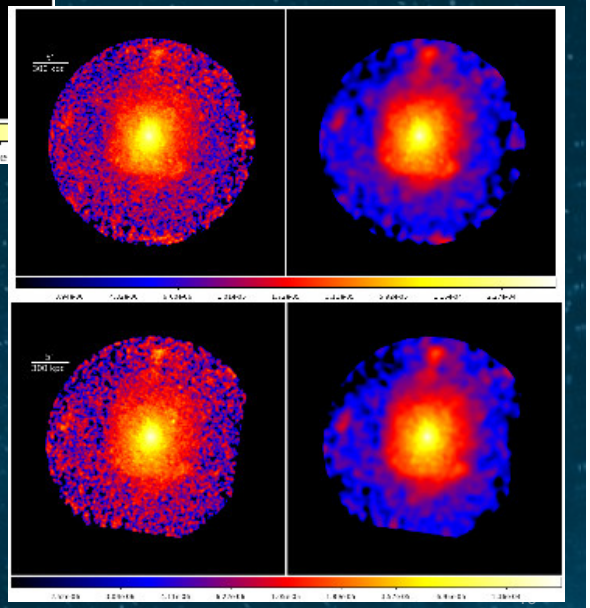
- ➔ first detection of difuse X-ray gas at low-redshift ORC (z = 0:046) known as Cloverleaf
- ➔ 230 kpc by 160 kpc, lying perpendicular to the radio emission
- ➔ thermal multiphase gas
- ➔ Cloverleaf ORC resides in a low-mass galaxy group
- ➔ system is undergoing a galaxy group merger
- ➔ radio power by shock reacceleration of fossil cosmic rays generated by a previous episode of black hole activity in the central AGN.

The eROSITA / XMM-Newton view of the Abell 3391/95 field: The Northern Clump

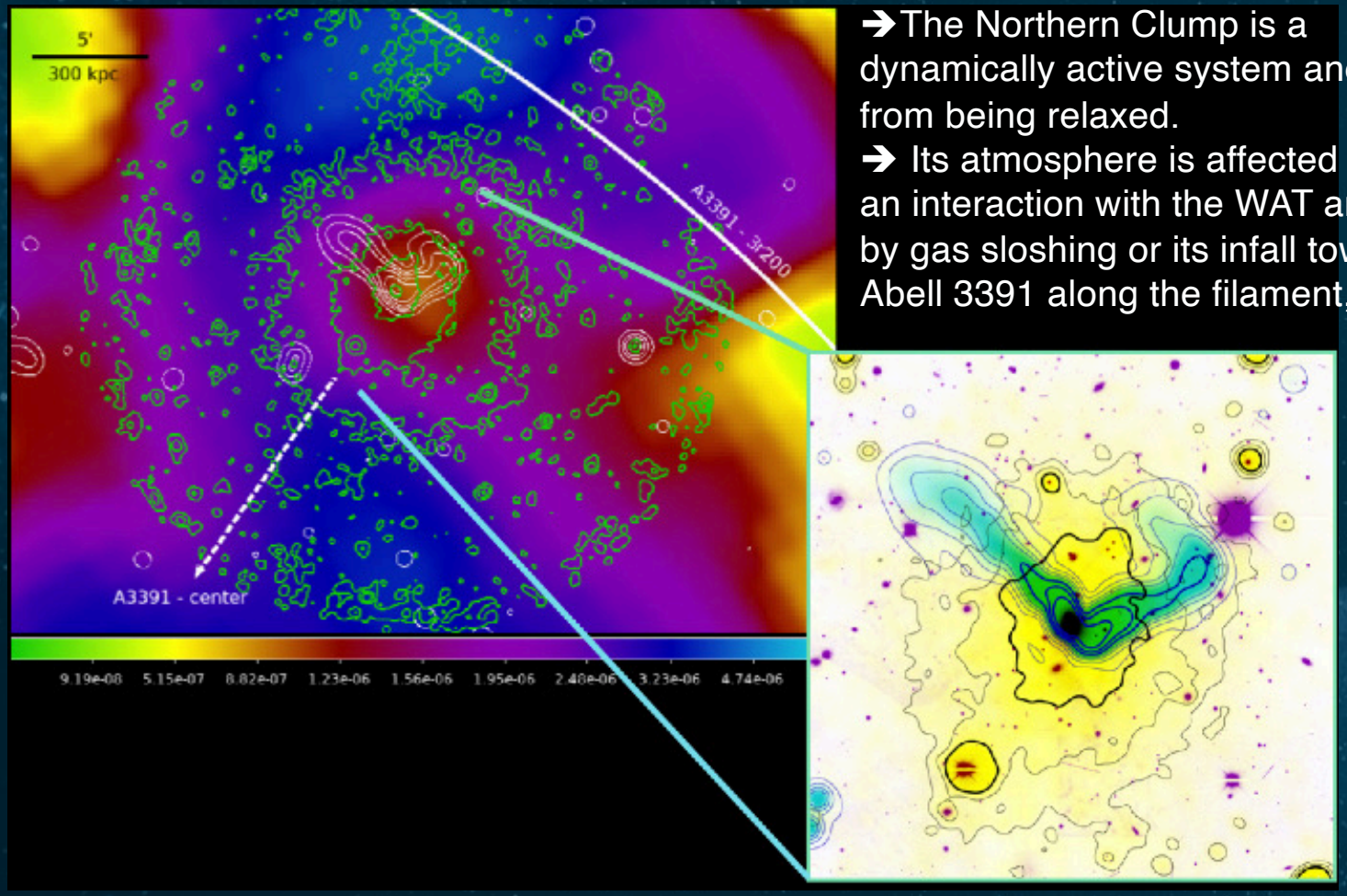




Veronica et al., 2022, A&A 661, A46



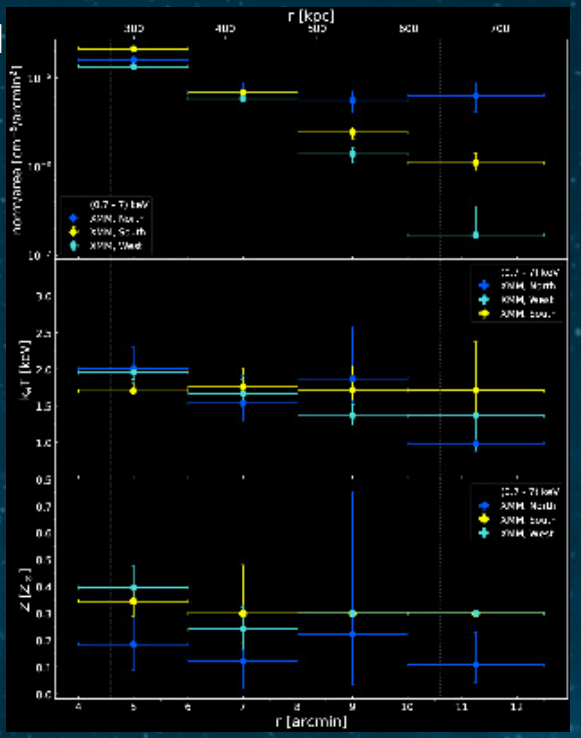
The eROSITA / XMM-Newton view of the Abell 3391/95 field: The Northern Clump



➔The Northern Clump is a dynamically active system and far from being relaxed.

➔ Its atmosphere is affected by an interaction with the WAT and by gas sloshing or its infall toward Abell 3391 along the filament,

Veronica et al., 2022, A&A 661, A46



XMM-NEWTON TWENTY-FOURTH ANNOUNCEMENT OF OPPORTUNITY (AO-24)

AO-24 TIMETABLE

Key milestones for AO-24 are

Announcement of Opportunity	20 August 2024
Due date for Proposals	**11 October 2024 (12:00 UT)**
Final OTAC approved programme	mid December 2024

Thank you!