Leibniz-Institut für
Astrophysik Potsdam

XMM-Newton
SURVEY SCIENCE CENTRE

Exploring the deep and variable X-ray sky

The source catalogue from overlapping XMM-Newton observations

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Leibniz-Institut für Astrophysik Potsdam (AIP)

& the XMM-Newton Survey Science Centre

in collaboration with SOC / ESAC

Stuttgart, September 19, 2019

Background image: stacked observations of the Cosmos field

Exploring the deep and variable X-ray sky with XMM-Newton

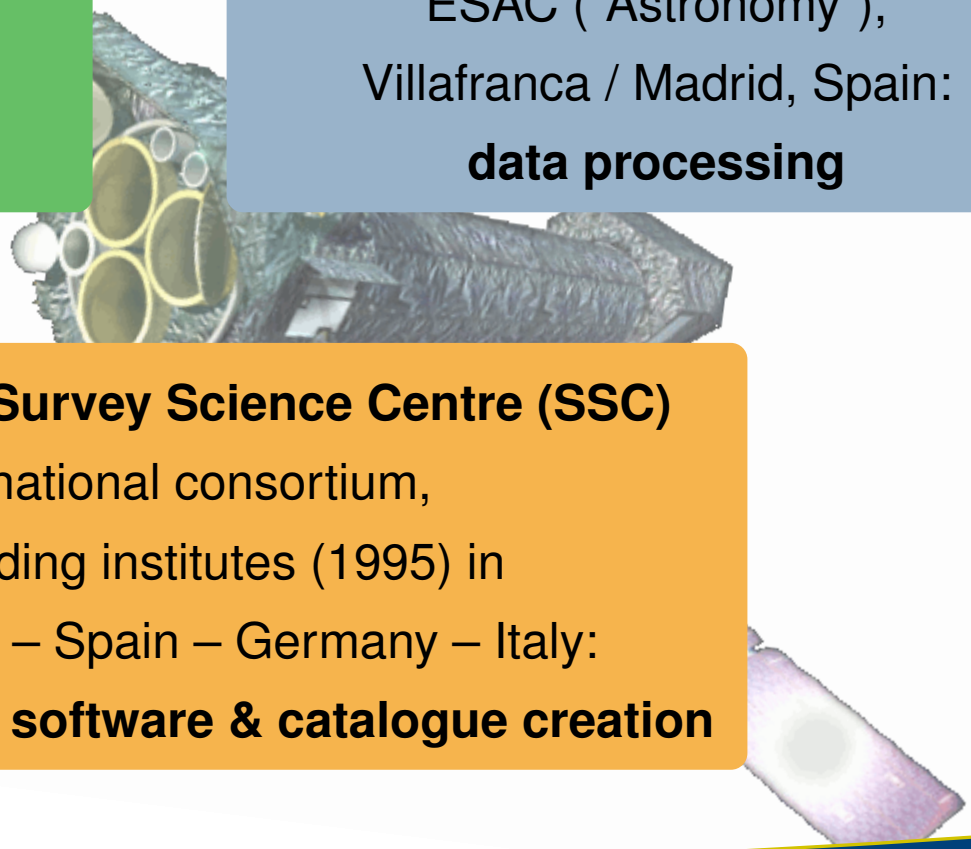
XMM-Newton: ESA's large X-ray space telescope

- observing the "hot" processes in the Universe since Dec. 1999
- built and operated by a consortium of 14 European countries
- carrying three X-ray Wolter telescopes (0.1 – 12 nm / 0.15 – 12 keV) and one UV/optical telescope(s)
- large field of view of half a degree
- more than 13,000 pointed observations so far – $>$ 1 100 square deg

The XMM-Newton team: behind the scenes

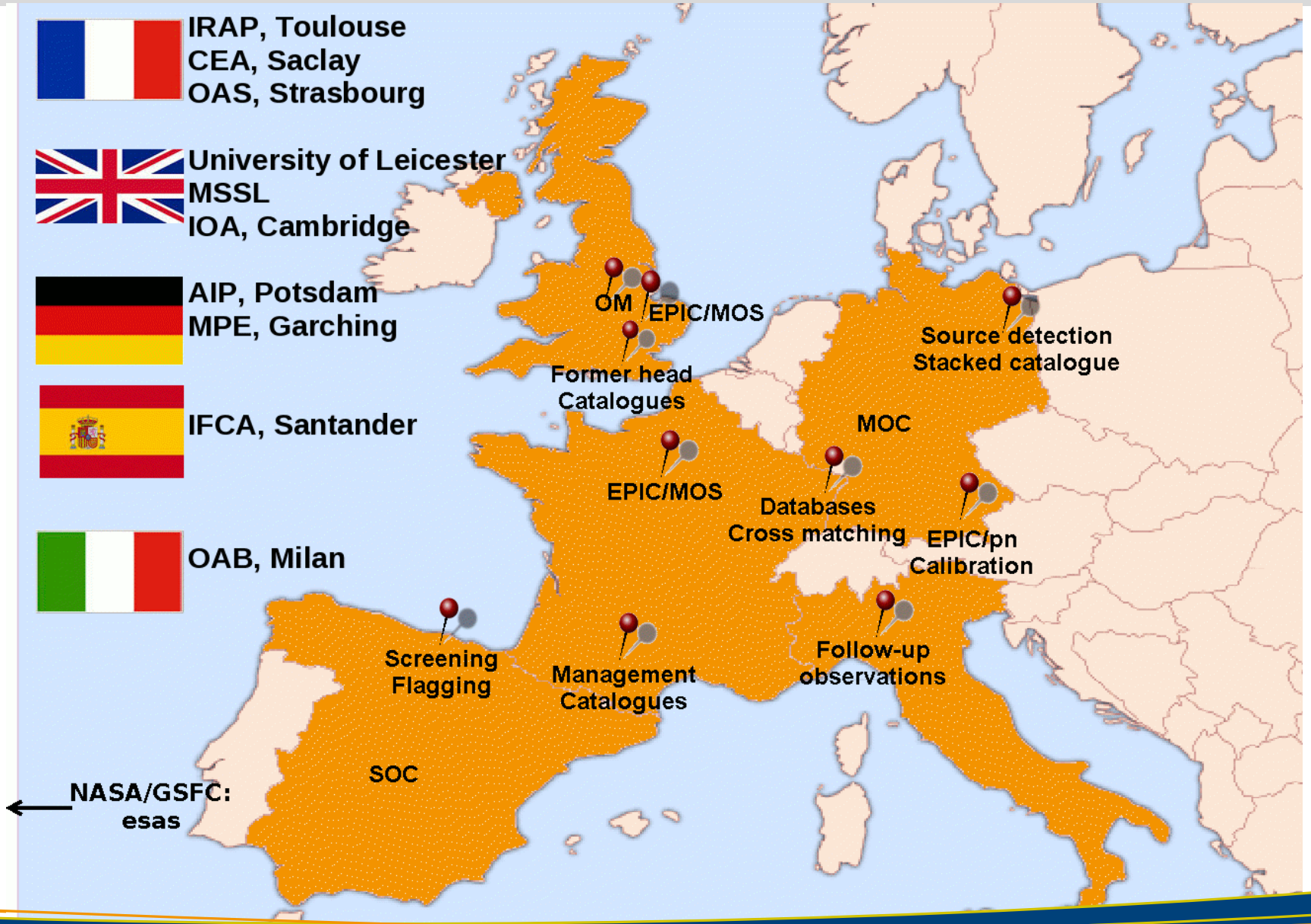
XMM-Newton
Mission Operations Centre (MOC)
ESOC ("Operations"),
Darmstadt, Germany:
flight control

XMM-Newton
Science Operations Centre (SOC)
ESAC ("Astronomy"),
Villafranca / Madrid, Spain:
data processing



XMM-Newton Survey Science Centre (SSC)
international consortium,
ten founding institutes (1995) in
UK – France – Spain – Germany – Italy:
science analysis software & catalogue creation

The XMM-Newton Survey Science Centre: Software & Catalogues



Map adapted from IRAP Toulouse & U. Leicester

The XMM-Newton Survey Science Centre: Software & Catalogues

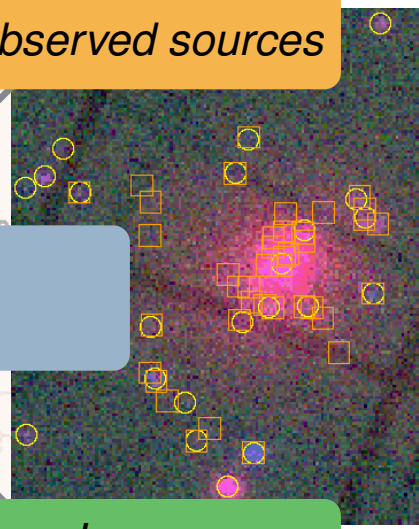
SSC

software service (SOC+SSC)

from the raw satellite data
to the science products

object catalogues

from the individual observations
to a full list of observed sources



SSC-AIP

source detection

community

research:

analyse PI data

analyse archival data

study individual objects

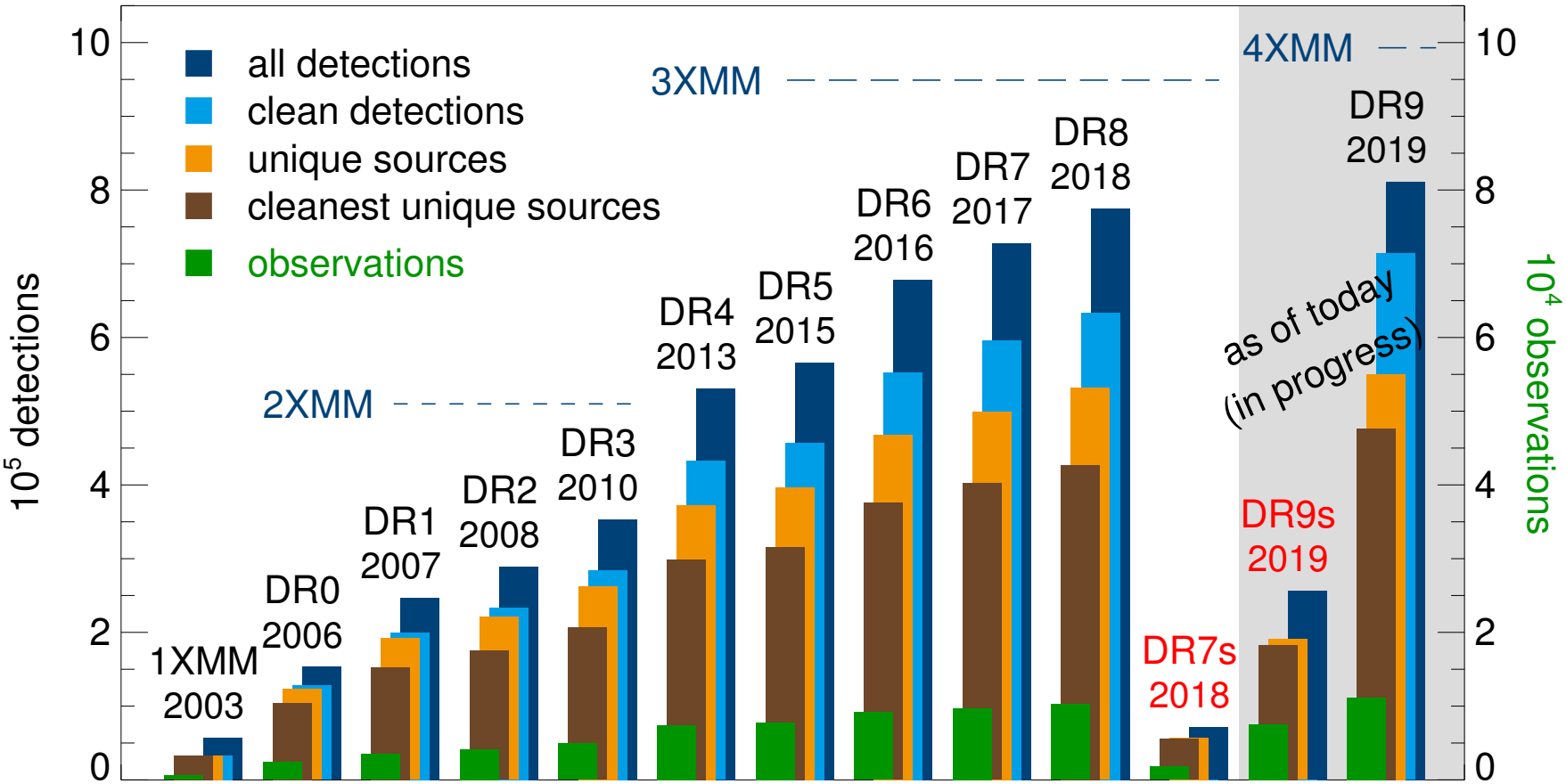
research:

survey science on samples

search for unknown objects

counterparts & SEDs

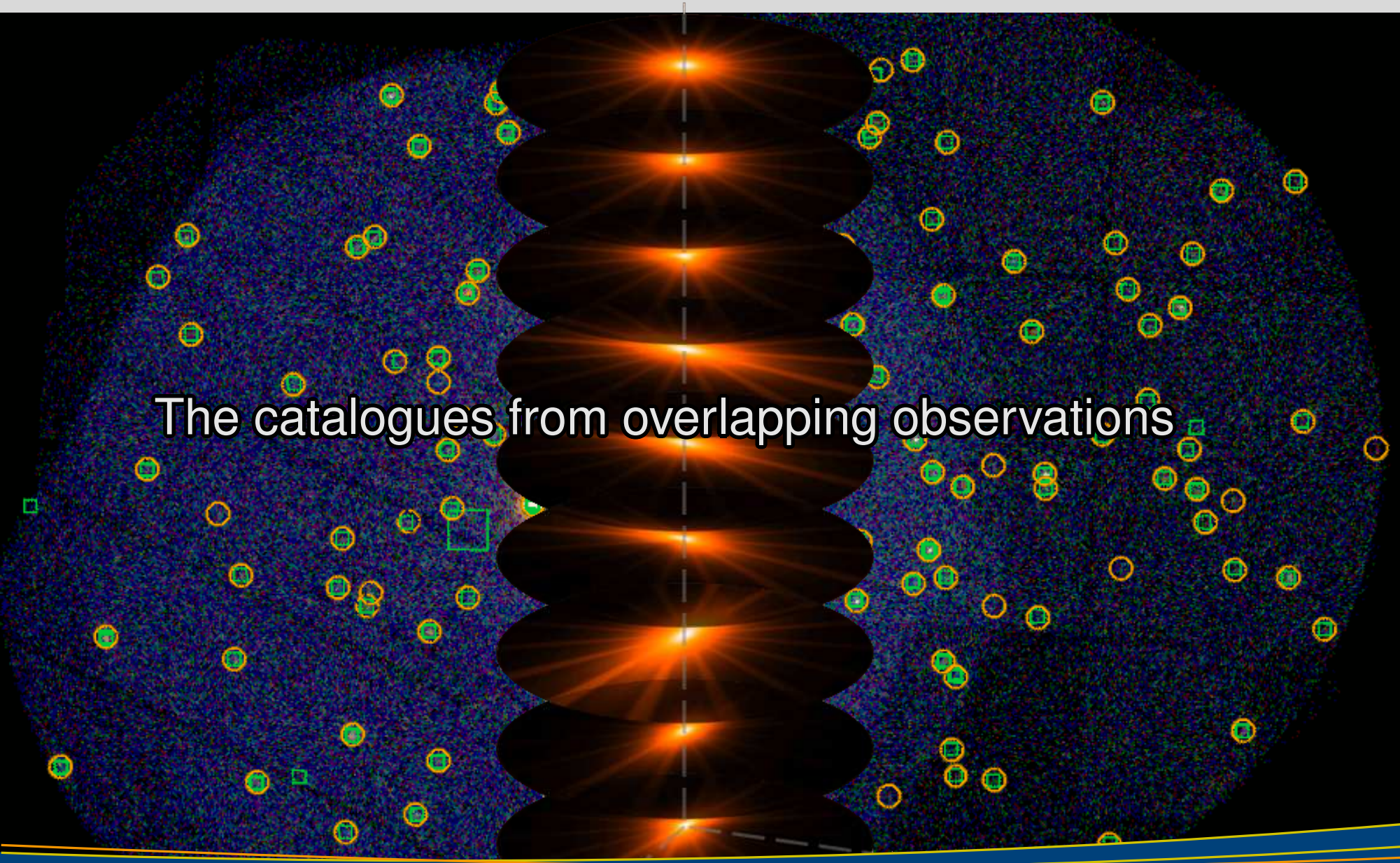
15 years of catalogues: The largest collections of X-ray sources



plus catalogues from slews (SOC, Saxton+ 2008) & OM UV sources (Page+ 2012)

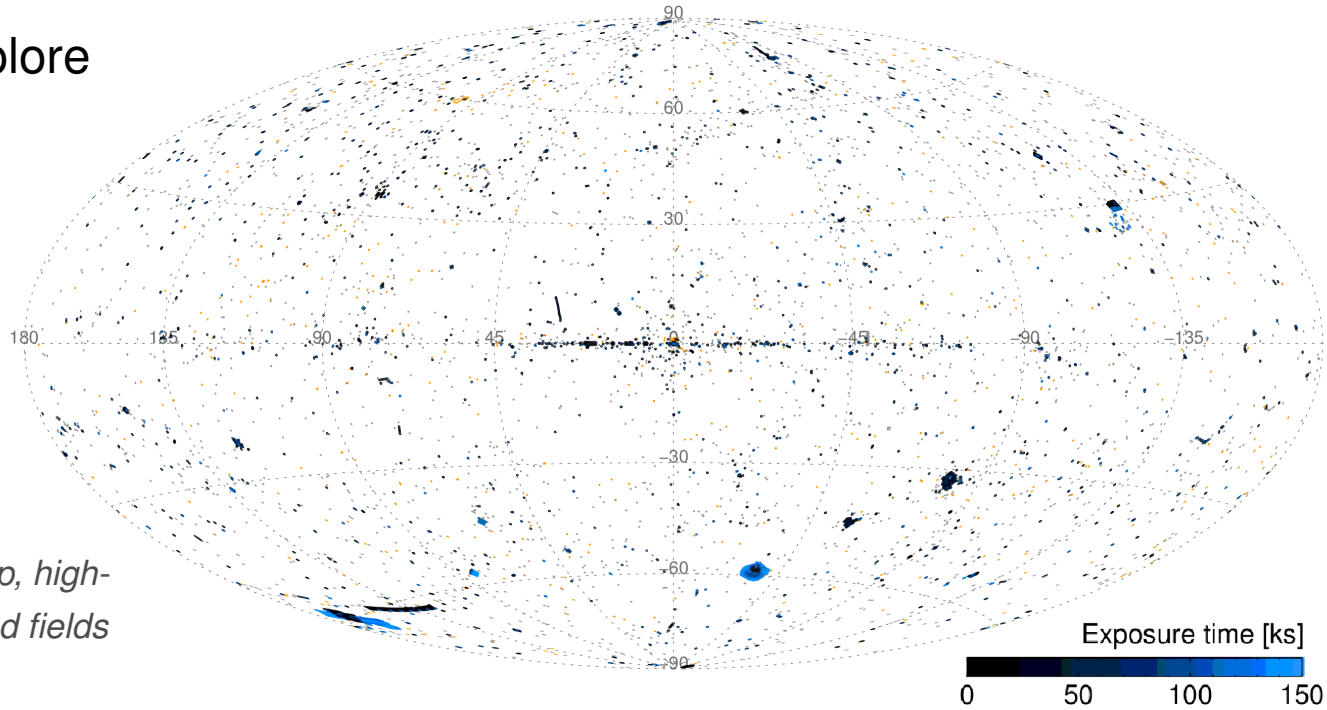
... and the next X-ray catalogues (Rosen+ 2016) – "4XMM" – just around the corner

Exploring the deep and variable X-ray sky with XMM-Newton



Motivation: Digging deeper in overlapping fields

Stacked catalogue to explore the multiply observed XMM-Newton sky



XMM-Newton sky map, highlighting repeatedly observed fields

Overlapping observations, intentionally or arbitrarily:

- so far: processed individually
- stacking observations: longer effective exposure time per source, higher sensitivity and accuracy plus long-term variability

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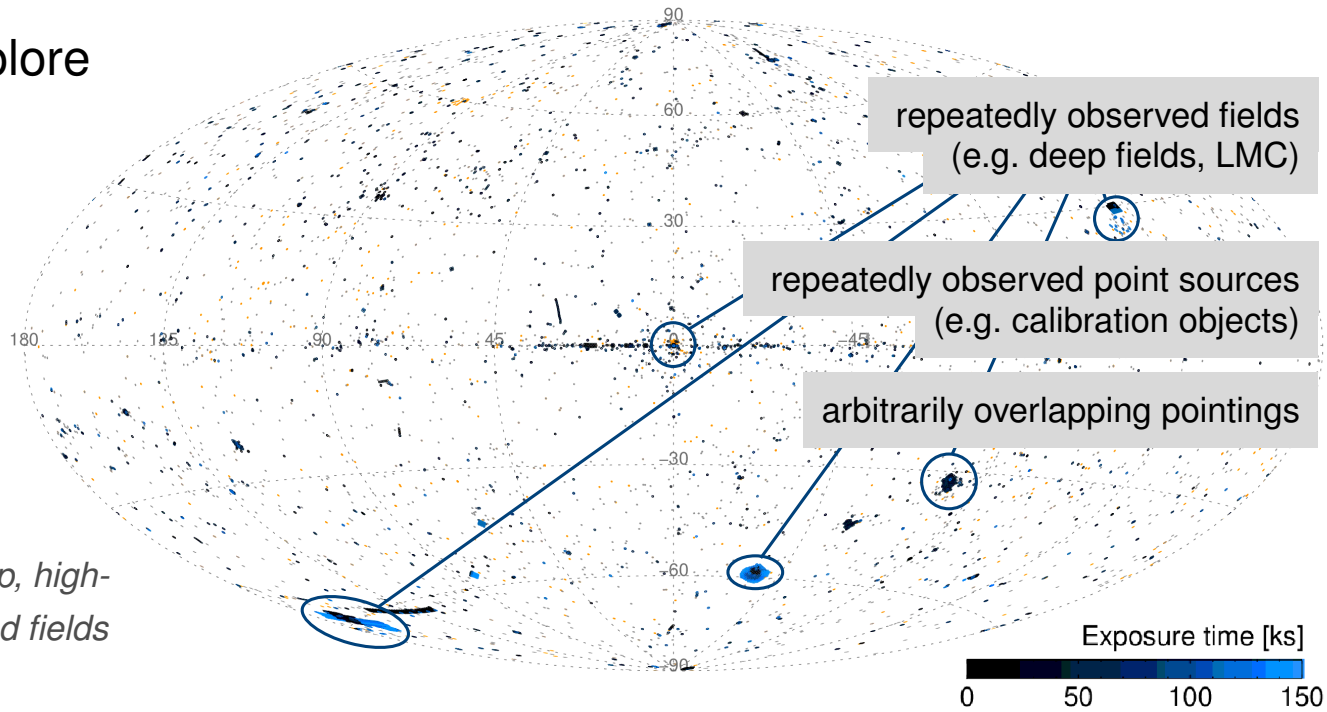

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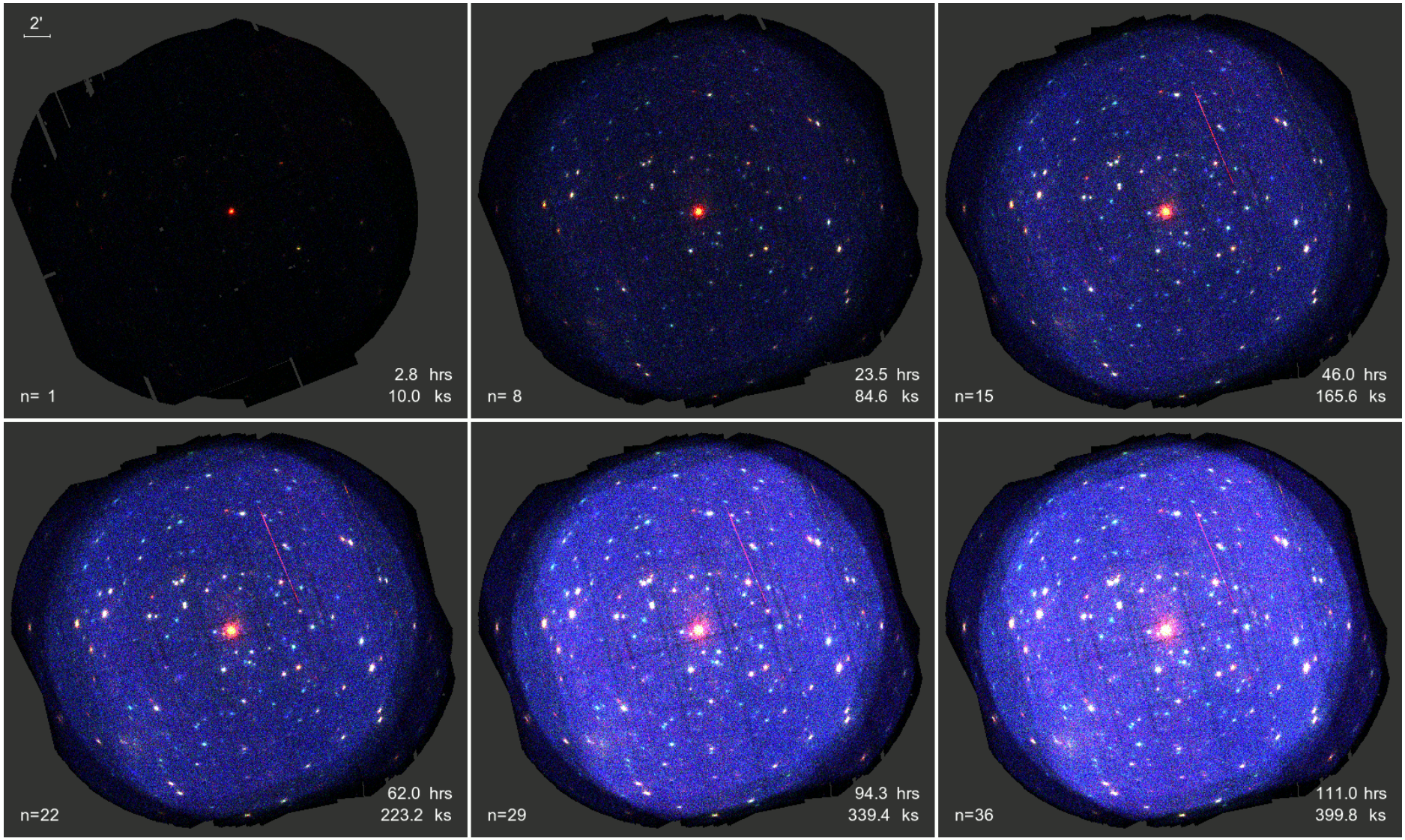
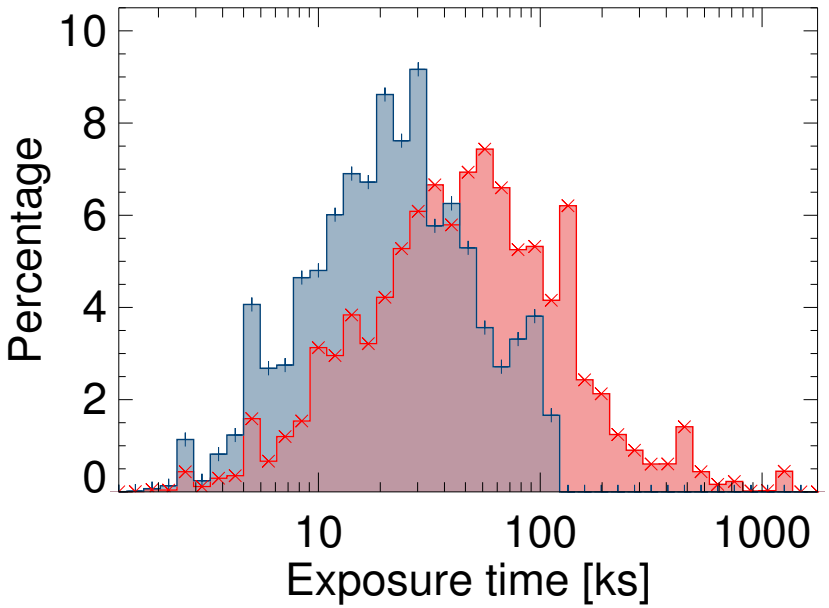
Digging deeper by stacking observations

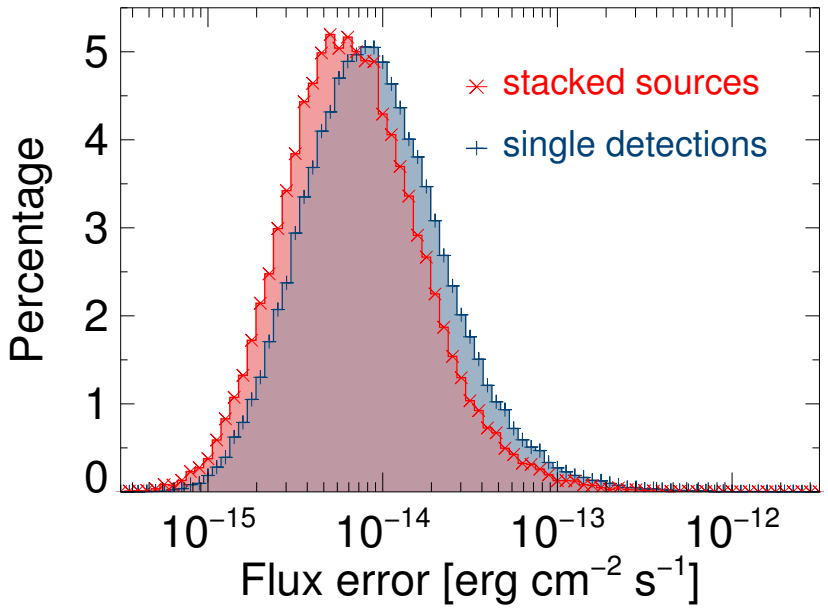


The first edition: 3XMM-DR7s (Traulsen+ 2019, A&A 624, A77)

1 789 good observations, 71 951 unique sources, 57 665 in overlap areas

- all-observation source parameters and for each contributing observation
- variability information directly from source detection
- auxiliary products: X-ray images, long-term light curves, optical finding charts
- about 15 % of the sources newly detected





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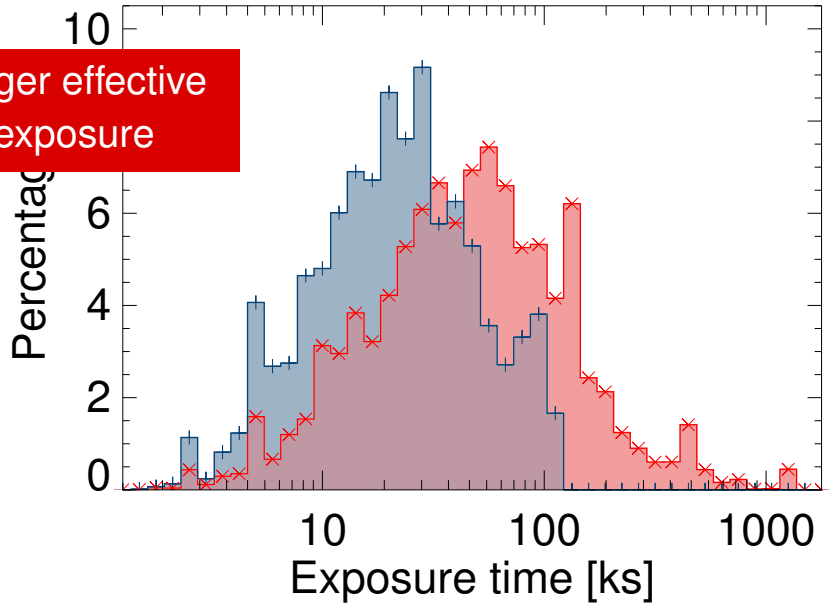
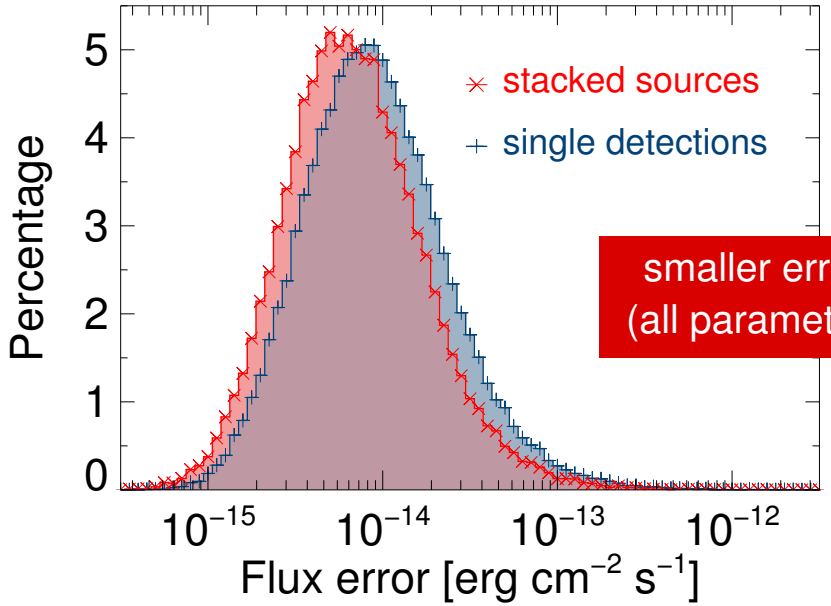
longer effective exposure

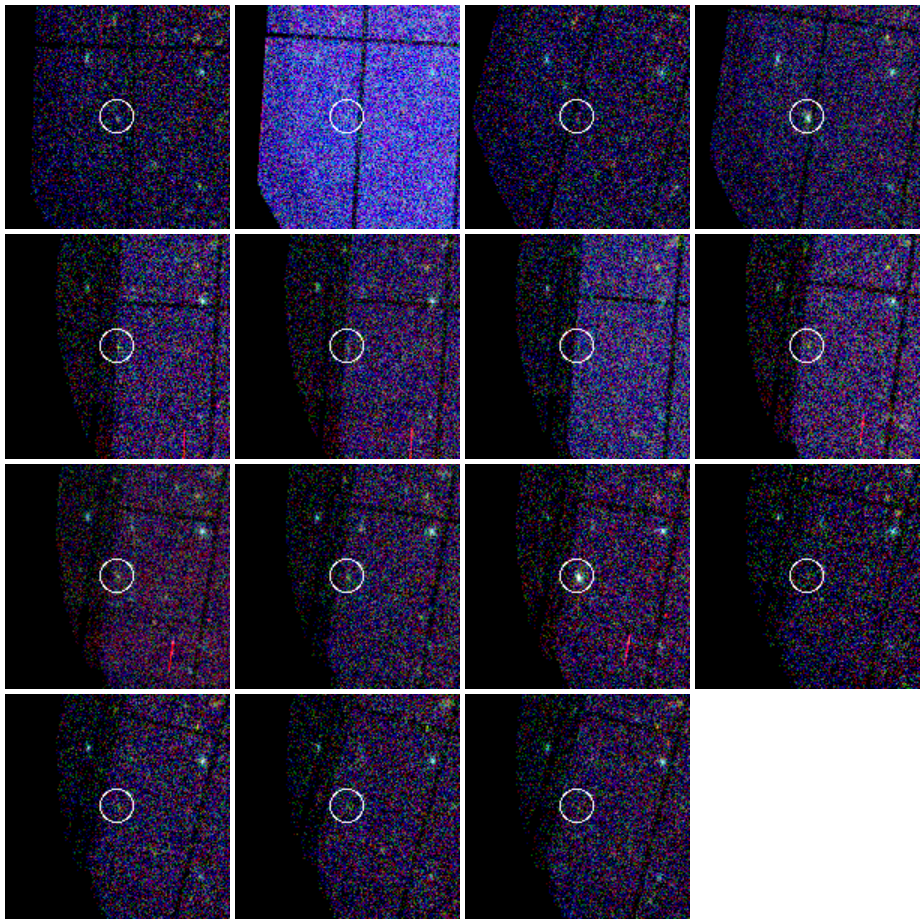


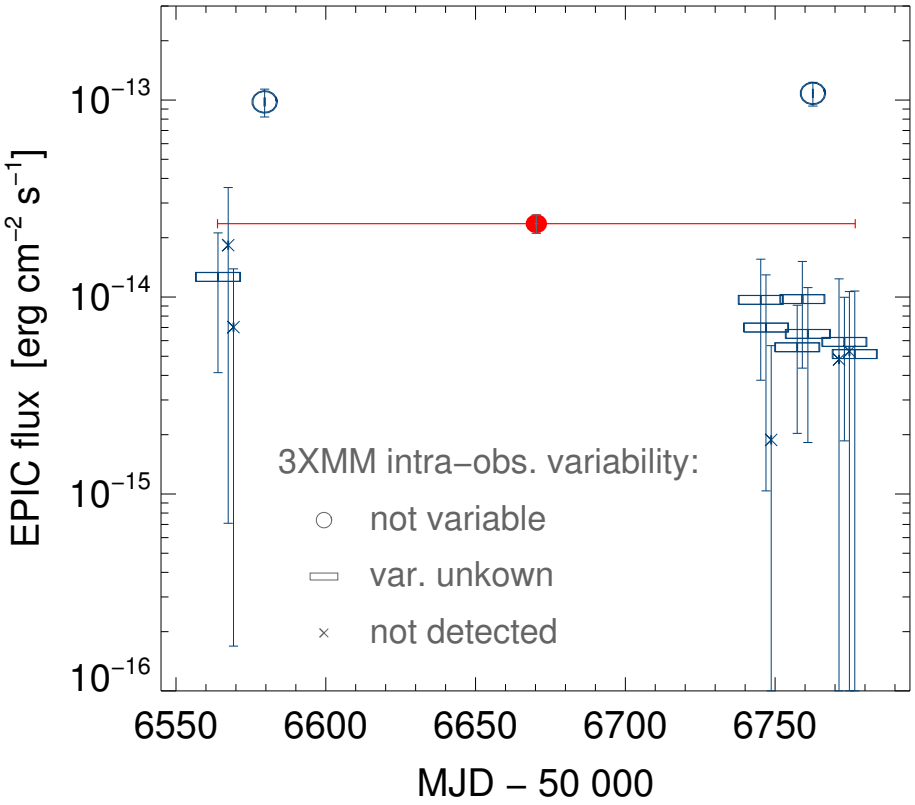


smaller errors (all parameters)

The first edition: 3XMM-DR7s – long-term variability

→ e.g. binary stars, AGNi, tidal disruption events, ...





Example: DR7s source without SDSS classification, not known to be variable so far

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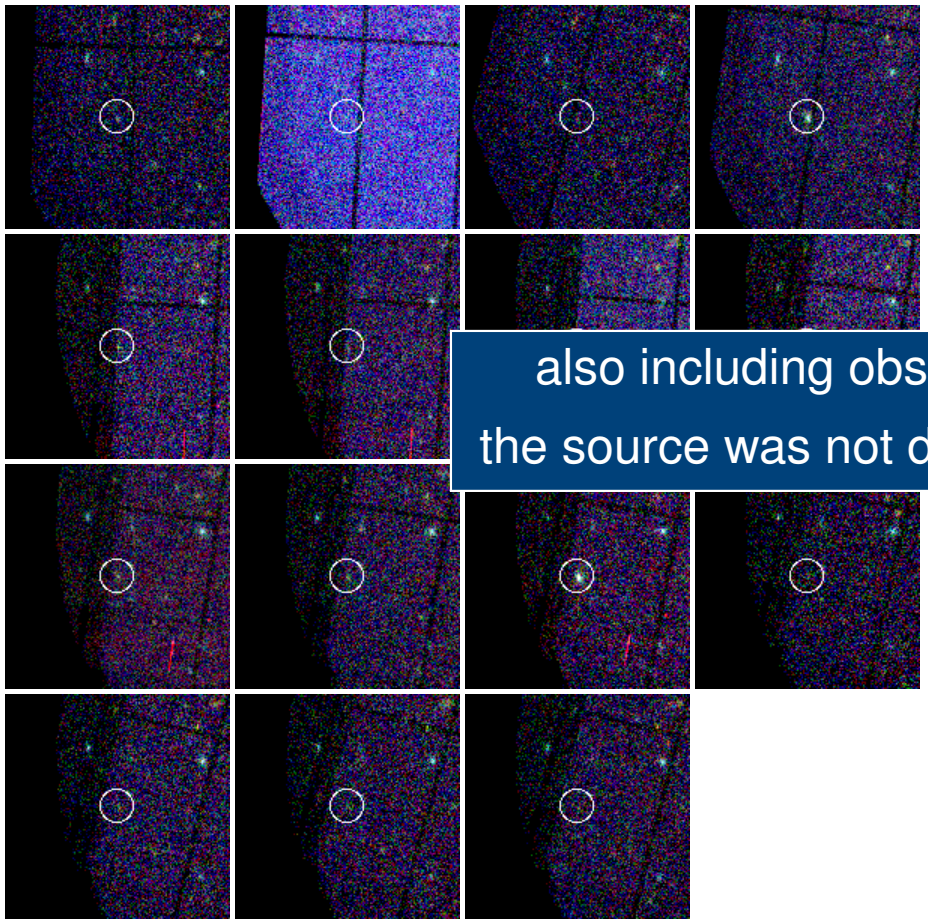
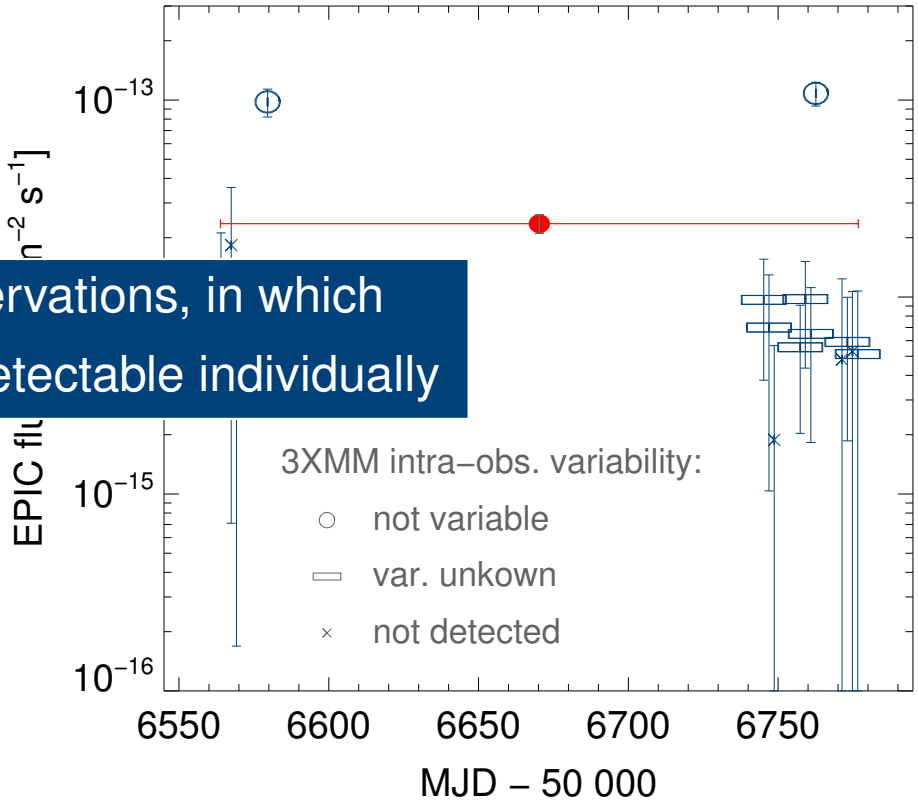


also including observations, in which the source was not detectable individually



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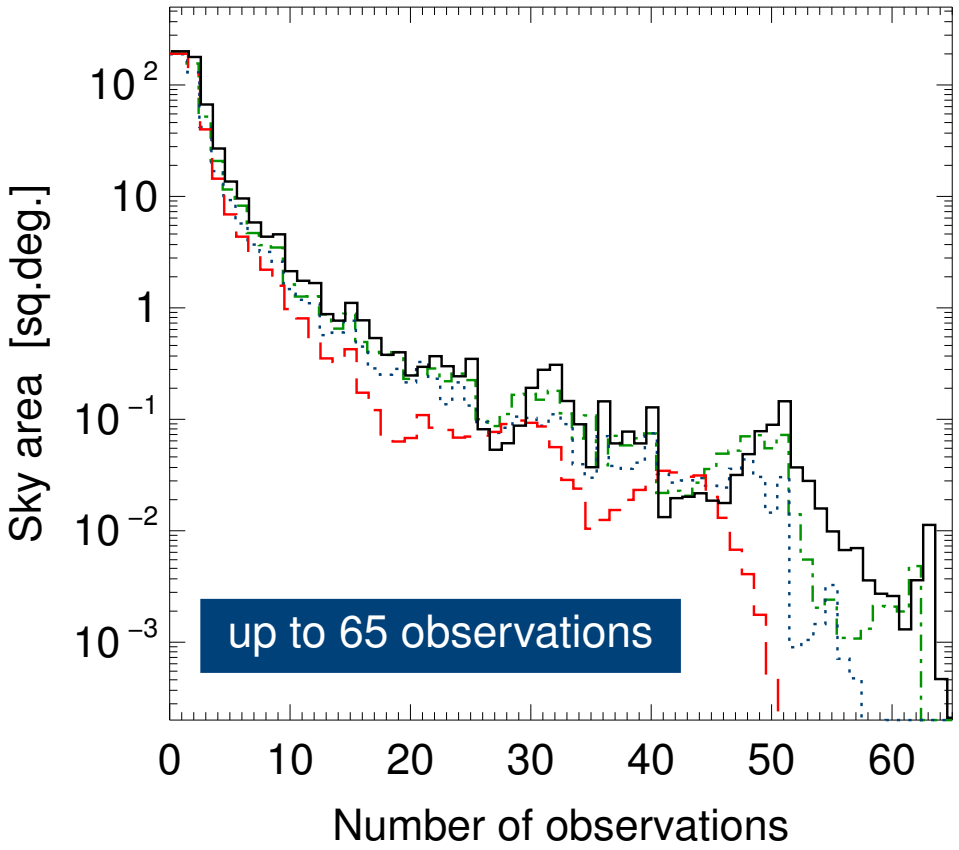
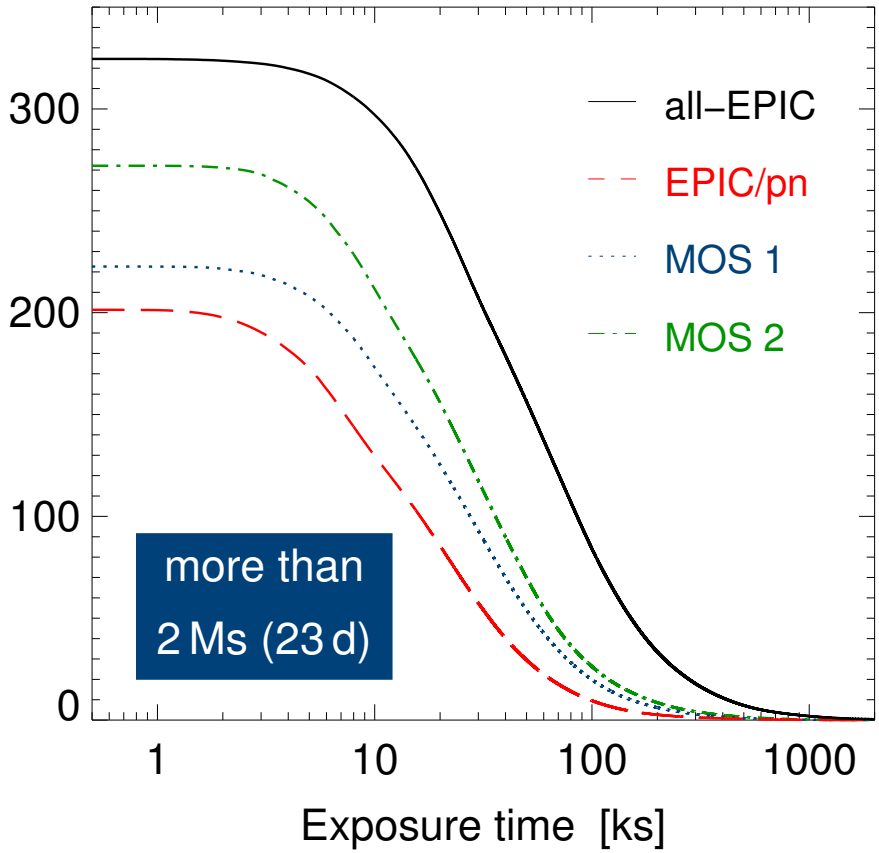
The next large edition: 4XMM-DR9s – release in 12/2019

all usable exposures, improved background determination, astrometric correction





→ 300 sq.deg. 1 340 stacks, 7 500 observations, more than 190 000 sources

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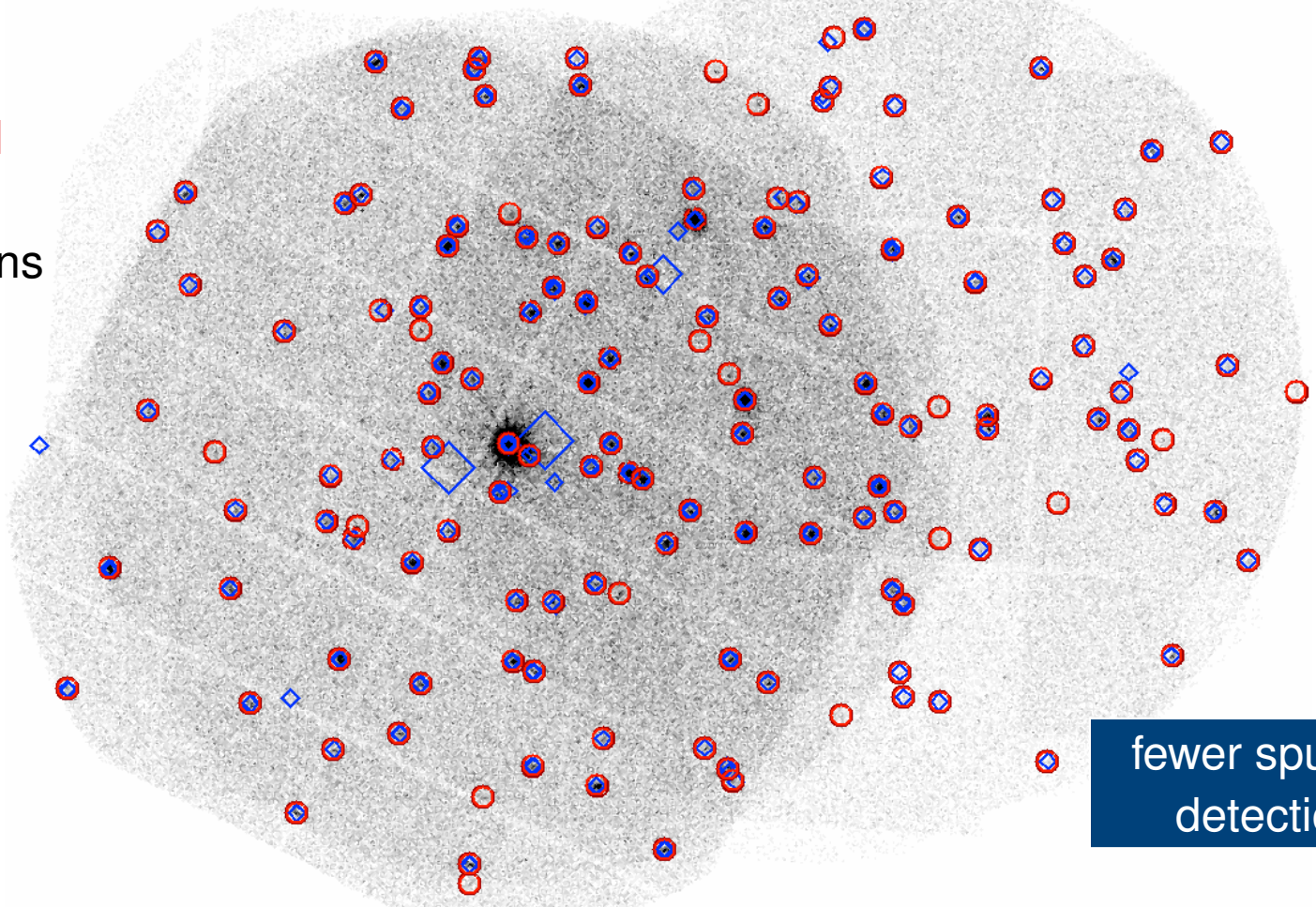
o stacked
◇ single
observations



fewer spurious detections

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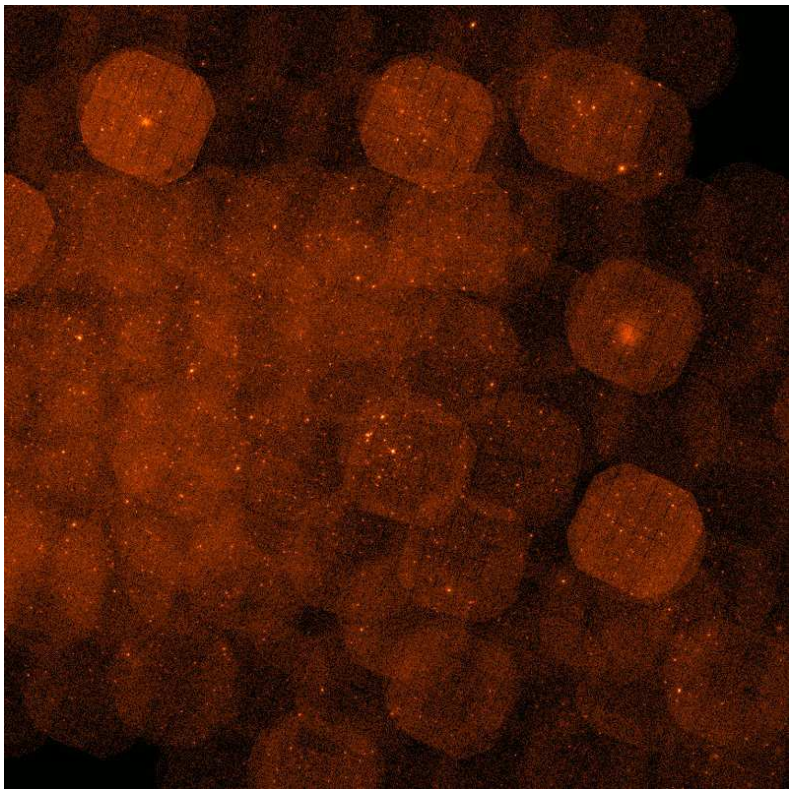
Exploring the deep and variable X-ray sky with XMM-Newton

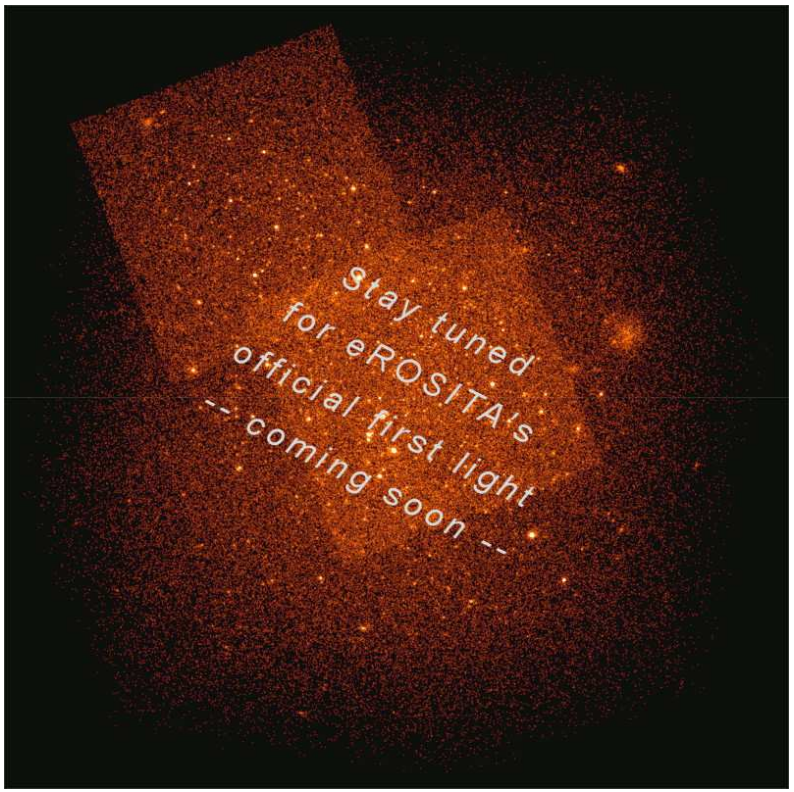
Future opportunities – XMM-Newton still going strong

→ variability studies

→ synergies with the upcoming eROSITA all-sky survey

XMM-Newton XXL field, $\sim 3^\circ$ cutout





eROSITA first photons (eROSITA_DE consortium)

→ cross-identifications with multi-λ surveys

→ and ideally operating throughout the 2020s: Athena 2030s

Summary

Catalogue paper: Traulsen+ 2019

The stacked catalogues: now $\sim$300 sq.deg.

- $\rightarrow$ improved source parameters and positions
- $\rightarrow$ higher sensitivity, more detections
- – caveats: statistical effects, high-proper motion objects
- $\rightarrow$ fewer spurious detections
- $\rightarrow$ inter-observation variability

Release with XMM20: SSC, XCatDB, XSA, CDS

The future:

- $\rightarrow$ yearly catalogue releases
- $\rightarrow$ go even deeper