Leibniz-Institut für Astrophysik Potsdam (AIP)

XMM-Newton SURVEY SCIENCE CENTRE

Digging deeper: Towards a catalogue of detections from stacked XMM-Newton observations

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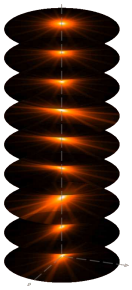
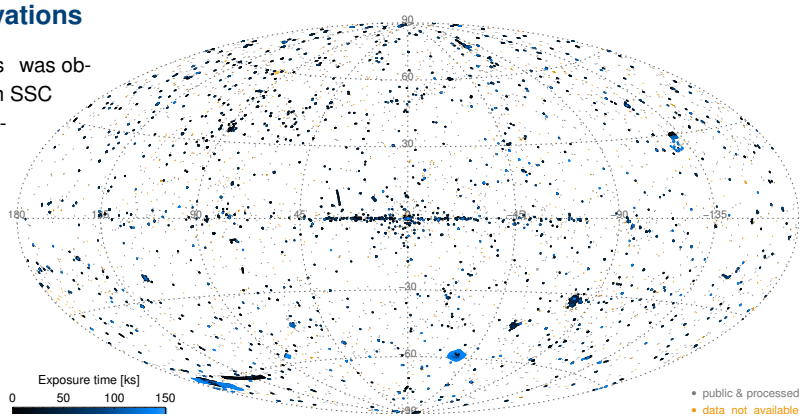
on behalf of the XMM-Newton Survey Science Centre Consortium

Expanding 3XMM source detection to overlapping observations

About one third of the sky area covered by the XMM-Newton X-ray telescopes was observed more than once. The XMM-Newton Survey Science Centre Consortium SSC has generated catalogues of individual detections in all publicly available XMM-Newton observations and published the most recent incarnation 3XMM-DR7 on June 1. To achieve ultimate sensitivity in repeatedly observed regions of the XMM-Newton sky, we have now developed a new standardized approach to source detection on images of multiple pointings, making use of a maximum likelihood fitting procedure as for 3XMM. Source parameters are derived from stacks of the empirical point spread function per involved instrument, energy band, and off-axis position (illustrated to the left). The method has entered the Science Analysis System SAS as a new task. It aims at higher detection reliability and improved source parameters and will be used to publish a catalogue of stacked detections.

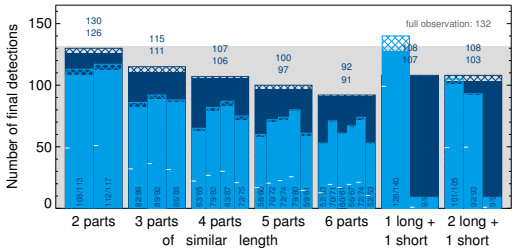




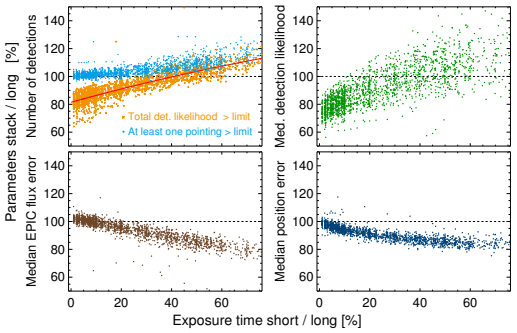
Potential for stacked source detection: overlapping observations in the XMM-Newton sky (blue), with exposure time coded as brightness. Hammer-Aitoff projection in galactic coordinates.

Testing stacked source detection on "pseudo-mosaics"

In order to investigate the performance of our stacking method, we construct "pseudo-mosaics" by splitting long observations into artificial sub-exposures and performing source detection on each sub-exposure and on their stack. As intended, more and fainter sources are detected in the stacks than in the individual sub-exposures, the detection likelihood increases, and the source parameters are determined with higher precision. Because of statistical effects, combining a long with a short observation may result in a loss of detections anyhow. A systematic analysis of stacks with different exposure time ratios reveals an increase in total detection likelihood from about 40 % on, when using all three instruments and five energy bands.

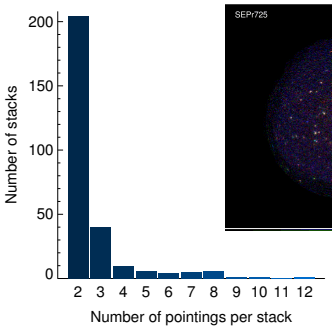


Decreasing number of detections with increasing number of pointings for constant total exposure time. Sub-exposures *(light blue)* of similar duration and of very different duration have been extracted from a 100 ks observation of the Chandra Deep Field South and stacked *(dark blue)*. Numbers denote all detections and those with valid 3XMM counterpart. *Shaded:* Detections without 3XMM match, which thus might be spurious. *White:* Percentage of total effective time per sub-exposure.

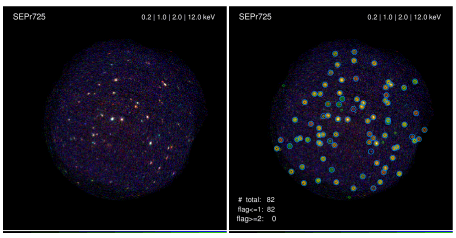


Detection efficiency and accuracy of the source parameters depend on exposure time ratios: stacked source detection combining a long sub-exposure of 50 % or 60 % of the total time with a short one of increasing duration. The tests are based on 55 XMM-Newton observations of at least 70 ks net.

A proto-catalogue of detections in largely overlapping observations

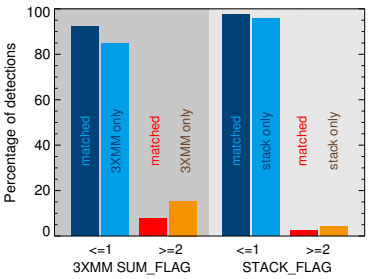


Contents of the proto-catalogue.



Example detection image. *Blue circles:* Stacked source detection. *Thin circles:* Individual pointings. *Boxes:* 3XMM. Stacked source detection uses a different method to model the background.

For our first proto-catalogue, we have selected full-frame observations with a minimum overlap of 80% in area, low background and more than 99 % usable chip area. 736 individual observations, grouped into 278 stacks, match the selection criteria. We detect about 26 000 unique sources, an increase of at least 5% over the joined detections of individual pointings before disregarding non-overlapping off-axis areas and spurious detections. The proto-catalogue shows that the new approach yields higher sensitivity, improved source parameters and likely fewer spurious detections.



Detection reliability: matching our proto-catalogue with unique sources in 3XMM. Those not recovered by stacked detection are more probably spurious than matching ones. Stack flags are set automatically only, 3XMM flags after additional visual screening.

The full catalogue of detections from overlapping pointings will be processed and made available soon. It will be based on the same set of OBS_IDs as 3XMM-DR7, selecting observations in full-frame mode only with reasonably low background level which overlap by 20 % or more in area, and comprise order of 1800 fields.