Characterizing Particle Background of Athena WFI for the Science Products Module: Swift XRT Full Frame and XMM-PN Small Window Observations

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Swift XRT Full Frame Data Analysis

The Wide Field Imager (WFI) is one of two focal plane detector systems of ESA's Athena X-ray observatory. The Science Products Module (SPM; PI D. Burrows), under consideration at present as a US contribution to the WFI. Reducing Athena WFI particle background level by improving background rejection on board is one of the primary goals of the SPM. We examine the Swift XRT Full Frame and XMM-Newton Small Window Mode observations to

1) understand and characterize the physics of the particle background

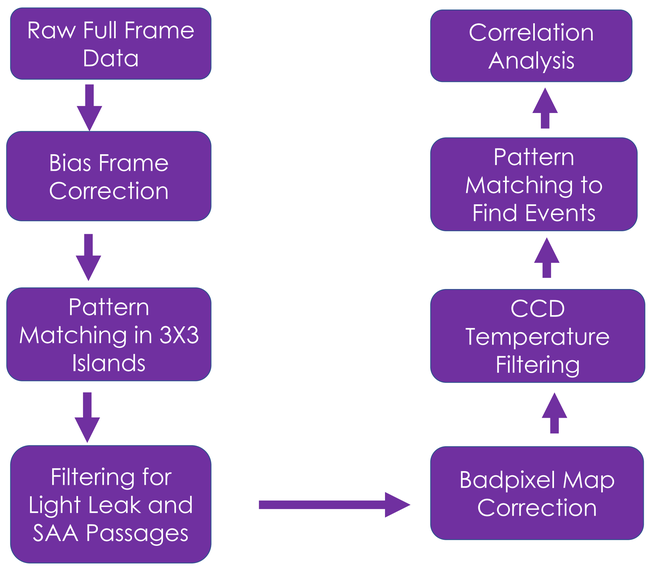
2) determine phenomenological correlations between high energy particle events and X-ray events to improve the rejection of particle background events.

3) extend these results to reduce the expected background in Athena WFI observations by the SPM processing.

4) develop an algorithm to either reduce or better characterize the background in the WFI

Swift XRT Full Frame Data Analysis

- Swift XRT transfers 2 full frames (FF) of data to the ground each day taken at 00:00 GMT during their science observations
- We have analyzed a total of 3600 clean frames spanning 11 years (2005 - 2016)



Steps of XRT Full Frame Data Analysis

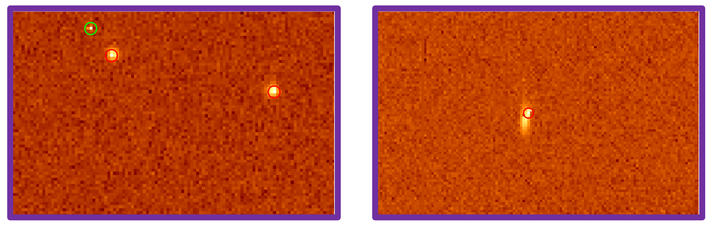


Fig1: Examples of XRT FF Images after filtering. Pattern Matching algorithm is applied to flag good and rejected events. Events which are flagged as valid X-rays are marked in green, particle tracks (rejected events) are marked in red circles

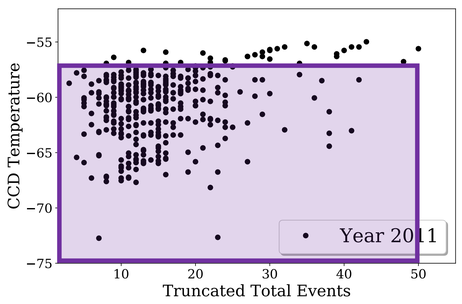


Fig 2: Frames filtered for T_{CCD}<-58 and total events 50 (shaded area) are used in this analysis

Failure of the thermo-electric cooler early in mission operation makes the XRT analysis challenging. To avoid the contamination due to thermal noise in the data we applied an extra filtering.

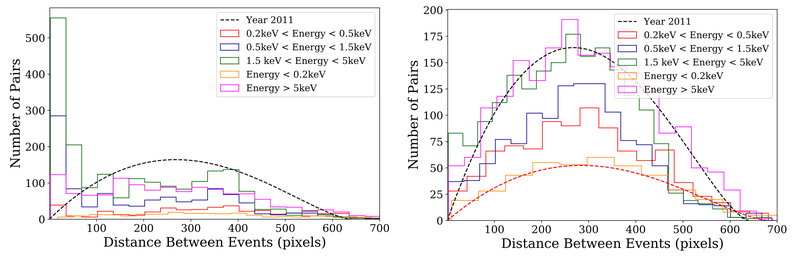
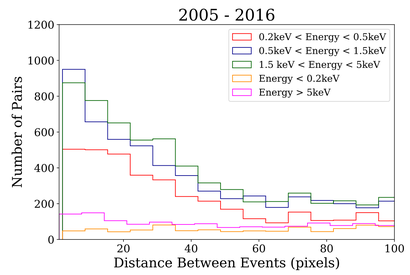


Fig 3: Strong Correlation is present in small spatial scales between good events with energies of < 5 keV in 2011 data (left panel), The analysis of good to rejected events lack a strong correlation (right panel). The dashed line indicates a random uniform distribution of events.



Similarly, strong correlation is present in small spatial scales between good events in the cumulative data spanning 11 years. In most cases, these correlations are due to X-ray sources being targeted during the FF observations.

XMM-Newton PN Small Window Data Analysis

XMM-Newton PN Small Window (SW) slew data are taken with the **filter wheel closed** setup. 316 observations, with 187 million frames and 1 Ms total exposure, have been collected since 2007 in a 64x64 pixel region of CCD-4.

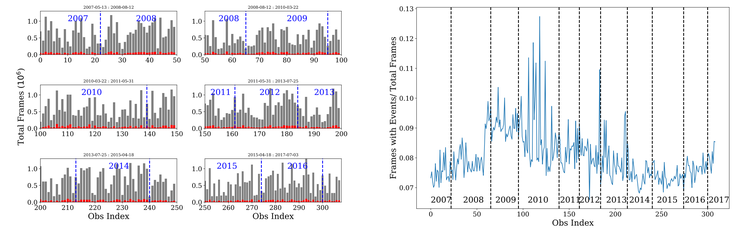


Fig 5: Frames with events are displayed in red, while the total number of frames are shown in grey on the left panel. Right panel displays the ratio of frames with events to total frames. A significant increase in the fraction of frames with events is observed in 2009-2010.

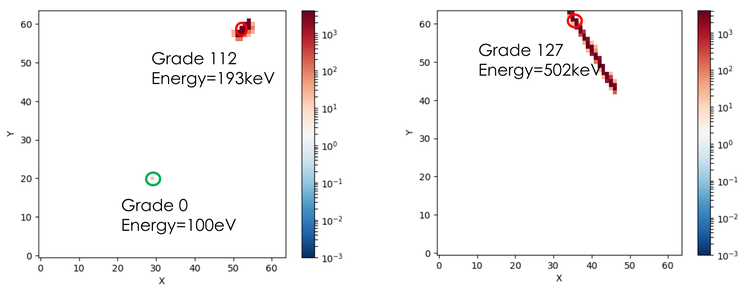


Fig 6: Examples of XMM-PN SW frames. The color bar indicates pixel charge in adu. The events with green circles indicate valid events with (pattern< 12), while the local maximum of particle tracks (rejected events) are shown with red circles.

Summary:

- Strong correlation between good events observed in Swift XRT data are mainly due to bright point sources within the FOV. A similar analysis shows lack of strong correlation between the good and rejected event pairs.
- XMM-Newton PN data provide a powerful statistical test for searches of event correlations.
- Initial analysis shows that temporal variability is observed during 2009-2010.
- Furthermore, events detected in the XMM-PN SW mode are predominantly single pixel events.

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