SAC or the art of turning the WFI Large Detector Array into the Anti-Coincidence of itself

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If you were to ask an X-ray astronomer what makes *Athena* such a great mission, she/he might answer the huge throughput of the telescope, the high spectral resolution of the X-IFU, and the large Field of View of the WFI. All very true, however, when it comes to faint and diffuse sources, such as distant AGNs and galaxy cluster outskirts, a seemingly innocuous component, like the instrumental background, ends up playing a pretty important role.

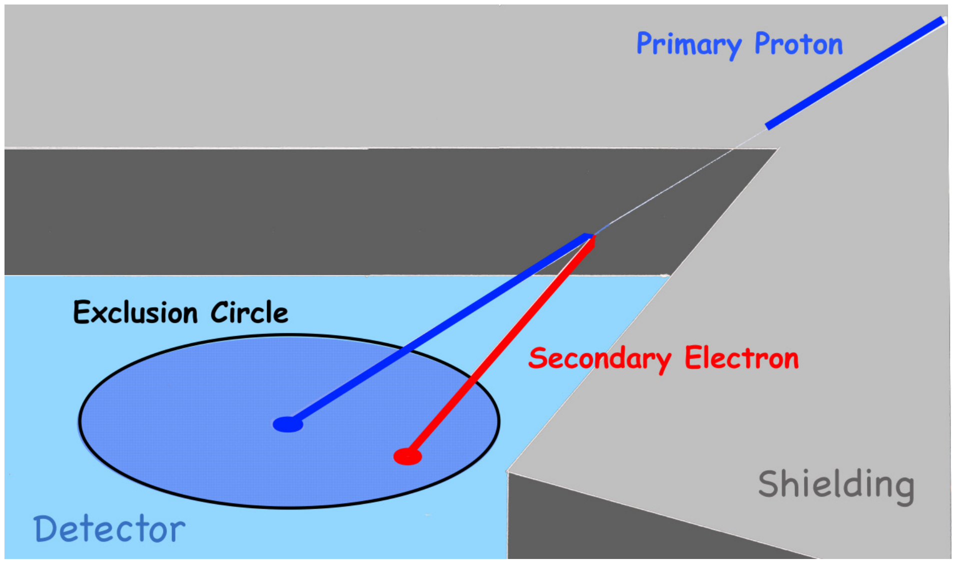
Anti-coincidence techniques, originally developed for particle physics applications, have been employed since the early days of X-ray astronomy to minimize the particle background. The idea is quite simple: you surround the main detector with auxiliary detectors so that particles reaching the former can be identified and removed through the track they leave while going through the latter. For a "thick" detector, like the Athena Wide Field Imager, impinging primary particles leave a signal that can be readily identified and used to remove secondary particles, with no need for any other detector. This new variant of the Anti-Coincidence technique was dubbed "Self-Anti-Coincidence" (SAC), as the coincidence trigger is provided by the detector itself.

There is one catch, the WFI is a very fast detector, probably the fastest of its kind to be employed in X-ray astronomy, but not quite fast enough: indeed if we were to remove all frames that include particles, as typically done when using the internal Anti-Coincidence, we would also be throwing away a lot of signal. The challenge of the WFI Background Working Group (BWG) has been confronted with is to remove as many of the particle events while retaining as much of the signal. Fortunately, the WFI BWG can rely on a varied set of skills: the team at MPE conducted the first simulations showing that SAC was viable; the team in Milano, using elementary statistics and simplified simulations, uncovered the general properties of SAC; the team at MIT, from the analysis of detailed Geant4 simulations provided by the teams at OU and MPE expanded the understanding of SAC to a more realistic set-up. The team at SAO, analyzing EPIC pn SW data, the most similar amongst existing data to that of the WFI, provided further insight.

A key issue that has been understood from this work is that: the closer the last surface the primary particle goes through before hitting the detector, the easier it is to reject secondaries produced by the primary.

Recently, an improved version of the WFI mass model, with last surfaces closer to the detector, allowed to improve the effectiveness of SAC background reduction. Indeed, with this configuration, the source to background ratio can be increased by as much as 35% by applying an exclusion radius of 300 pixels around primary particles.

Self-Anti-Coincidence is one of several innovative techniques being developed to minimize the background intensity and maximize its reproducibility. The overarching goal of these activities is to extend the scientific exploitation of data to background dominated regimes unexplored by previous X-ray missions.



Artistic rendering of Self Anti-Coincidence in Action. A cosmic ray proton (blue line) penetrates the shielding around the WFI Large Area Detector and, before impinging on the LDA itself, generates a secondary electron (red line) that hits the detector a short distance away from the primary. Since the secondary is within the exclusion radius of the primary it is rejected and will not contribute to the instrumental background. Background: Art Design by Viola Molendi.