A new approach for measuring antiproton annihilation at rest with Timepix3

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Ultra precise tests of CPT (charge, parity, time) symmetry, in view of the baryon asymmetry in the Universe is the main motivation for the experiments at the Antiproton Decelerator (AD) at CERN. Most of them focus on studying antihydrogen - the only stable, neutral antimatter system available for laboratory study. Crucial to the success of these experiments is the efficient detection and correct tagging of antiprotons and antihydrogen. Mostly it is achieved with tracking detectors, through the reconstruction and extrapolation of the trajectories of charged pions produced in the annihilation process [1,2,3,4]. These detectors determine the time and position of antiproton annihilations and usually consist of layers of silicon strip modules [1,2] or scintillating bars and fibres [3,5].

We present here a different detection method, using a pixel detector, where the antiprotons annihilate inside the detector volume or in a thin foil in front of it. This approach gives high resolution on the annihilation position (tens of μm), making it dominant for experiments with such requirement [6]. When integrated with a conventional tracking detector, the method makes possible to detect and identify most of the products in antiproton-nucleus annihilation (charged pions, protons, alphas and heavy fragments). A detailed study of their multiplicity and energy distributions is essential for tuning the physics models in the Monte Carlo simulations (e.g. GEANT4) in the low-energy region.

This work incorporates studies from two AD experiments, employing the Timepix3, an ASIC hybrid detector developed by CERN's Medipix3 collaboration, characterised with high spatial resolution and nanosecond precision on the Time-of-Arrival and Time-over-Threshold [7]. Direct detection of antiprotons was performed on a dedicated beam line within AEgIS [8], providing quantitative results on the tagging efficiency and the position resolution of the annihilation point, which will be discussed [9]. The measurement of the multiplicity and energy distributions of the prongs in antiproton annihilations in different materials was set up in ASACUSA, where the information from a quad array of Timepix3 and the existing hodoscope was combined [3]. The advantages of having two detectors and a first glimpse on the results will be presented.

References

[1] M. Amoretti et al., Nucl.Instrum.Meth. A **518** 679-711 (2004)
[2] G.B. Andresen at al., Nucl.Instrum.Meth. A **684**, 73-81 (2012)
[3] C. Sauerzopf et al., Nucl.Instrum.Meth. A **845**, 579-582 (2016)
[4] B. Radics et al., Rev. Sci. Instrum. **86**, 083304 (2015)
[5] J. Storey et al., Nucl.Instrum.Meth. A **732**, 437-441 (2013)
[6] M. Doser et al., Class. Quantum Grav. 29 184009 (2012)
[7] T. Poikela et al., Journal of Instrumentation **9** C05013 (2014)
[8] N. Pacifico et al., Nucl.Instrum.Meth. A **831** 12-17 (2016)
[9] S. Aghion et al., *Antiproton tagging and vertex fitting using a silicon pixel detector with a Timepix3 readout*, in preparation