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Using plastic scintillators to disentangle antiprotons annihilations from positron and positronium annihilations in AEgIS

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The AEgIS experiment, currently in progress at the CERN Antiproton Decelerator (AD), aims at producing antihydrogen (and ultimately measuring the effects of the Earth gravitational field on it) with an innovative method based on the charge exchange reaction between an antiproton ($\bar{p}$) and a highly-excited positronium atom:
+Ps* $\rightarrow \bar{H}^* + e^- While positronium (Ps) is produced by positron simplantation on a mesoporous silica target and subsequently exci ring Penning - Malmberg trap with a part of the electrodes replaced by a thin mesh, to let Ps^* in, and situated close to the region where Ps* is created.

After a summary of the current AEgIS status and of the milestones achieved so far by the Collaboration (from the antiprotons side as well as from the positronium side) and after a short description of the diagnostic tools developed to monitor particle manipulations, we will focus on the system of external plastic scintillators slabs, surrounding the 1 T superconducting magnet cryostat, read out by photomultipliers that were calibrated and equalised to be exploited as a whole detector with useful granularity to consistently detect single antiparticle annihilations. The whole set consists of 12 arc-shaped slabs, made by EJ-200 general-purpose plastic scintillator, each of them being 1 cm thick, 10 cm wide, $\sim$150 cm in length, situated as close as possible to the apparatus to maximise the overall solid angle (that was around 20\% for annihilations near the antiproton trap region). The slabs were read from both sides by two independent, high-gain photomultipliers to avoid spurious signals and to have good efficiency despite the light attenuation in the slabs.

In particular, periodic calibrations campaigns with cosmic rays and a detailed analysis of the system (also through a Geant4 simulation) has let us have the system constantly under control and therefore allowed us to identify antiprotons annihilations with good sensitivity and virtually unitary specificity over the significant background of positron/positronium annihilations.
This has also made it possible to use the system of external plastic scintillators for antihydrogen annihilations tagging.

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