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The Barrel Scintillator Veto for the ALPHA-g experiment

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The main objective of the ALPHA-g experiment is to determine the behavior of the anti-matter when it is subjected to the Earth's gravitational field. At the center of this experimental setup, anti-hydrogen atoms are created and trapped in the magnetic field produced by an octupole magnet. Once the magnetic field is lowered, these anti-atoms are released and move in accordance with gravity. Annihilation occurs when anti-atoms meet the walls of the trap. This annihilation produces pions, which are tracked by the second layer of the experiment: a radial Time Projection Chamber (rTPC) filled with an Argon/CO2 mixture. This first detector determine the path of the pions, and thus the original position of the annihilations.

The rTPC is sensitive to other energetic particles coming from outside of the experiment, like muons produced by cosmic rays which cross the rTPC at a significant rate. In order to distinguish the tracks produced by these particles from the annihilation products, a barrel scintillator has been installed around the rTPC to act as a veto.

This second detector is constituted by 64 plastics scintillator bars. Each bar has a length of 2.6m and a trapezoidal cross-section. When a particle crosses this barrel, scintillation light is produced by the scintillator and propagates up to the ends of the bar where Silicon Photomultipliers (SiPM) transform it into an electrical signal. This signal is then processed by the electronic read-out to determine the arrival time of the light on the SiPM, and the amount of photons received. This information allows us to determine when and where a particle has interacted with a bar, and thus if it comes from inside (annihilation) or outside of the barrel.

The design and realization of this scintillator apparatus were punctuated by several challenges. The space constraints were high and the barrel had to be self-supported without external structure. To ensure a proper rejection of the external particles, the read-out electronics had to be optimized to obtain a time resolution of the order of 200 ps.

This barrel scintillator was designed and assembled at TRIUMF, before being moved at CERN for its commissioning in September 2018. After being integrated to the rest of the experiment, the whole set-up was tested with antiproton annihilations.

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