Canadian Association of Physicists

Association canadienne des physiciens et physiciennes

Contribution ID: **2728** Type: **Oral (Non-Student) / Orale (non-étudiant(e))**

Commissioning the Radial Time Projection Chamber for the ALPHA-g antimatter gravity experiment

Thursday, 6 June 2019 14:15 (15 minutes)

Antimatter is believed to be affected by gravity in exactly the same way as ordinary matter for a variety of good reasons, however this has never been measured directly. This will be tested by the ALPHA-g project, which uses a new vertical antihydrogen trap based on the previous ALPHA design (Antihydrogen Laser Physics Apparatus, the first experiment to trap antihydrogen in 2010). As in previous ALPHA experiments, the trapped antihydrogen is detected via its charged annihilation products after switching off the trap. In order to be sensitive to small gravitational effects, the setup extends more than 2 metres in the vertical direction, requiring the particle detection system to cover a large volume with good tracking accuracy. The design chosen to replace the previous experiments' silicon strip detectors is a radial time-projection-chamber (rTPC) filled with an Argon/CO2 gas mixture.
The circumstances of the experiment necessitate the recording of a large number of signals that need to be digitized and extracted with very little space for electronics and cabling. Dedicated electronics were developed at TRIUMF to address this problem. The specific parameters of the chamber together with the requirement to observe minimum-ionizing particles leads to relatively complex signals on the detector electrodes, which have to be deconvolved in an iterative process.
Following successful tests with a smaller prototype, the full-scale chamber was completed in early 2018 and the basic functionality of the detector was established at TRIUMF. Soon after, initial tests with cosmic rays lead to the observation of charged particle tracks. In July 2018 the detector was moved to CERN and commissioned with cosmic rays, after which it was combined with a plastic scintillator barrel and the rest of the experimental setup, consisting of a large 1T superconducting solenoid magnet and the inner cryostat containing the antihydrogen trap. The whole system was tested in its final vertical position with antiprotons annihilating in the trap and the rTPC tracking the resulting pions.

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Session Classification: R2-5 Detectors for Discovery (PPD/DAPI) | Détecteurs pour la découverte (PPD/DPAI)

Track Classification: Particle Physics / Physique des particules (PPD)