Contribution ID: **33** Type: **oral**

The GAPS Detector: Design and Recent Developments

Thursday, March 28, 2019 9:15 AM (30 minutes)

The General AntiParticle Spectrometer (GAPS) is a balloon-borne cosmic-ray antimatter experiment. It will be sensitive to antideuterons with 0.05 < T < 0.25 GeV / nucleon and antiprotons with 0.07 < T < 0.25 GeV. Unlike a traditional cosmic ray detector, it has no requirement for strong magnetic fields but instead uses the exotic atom technique. The GAPS design is based on a lithium-drifted silicon (Si(Li)) tracker and plastic scintillator time of flight (TOF) system.

The TOF system includes an outer "umbrella"consisting of 132 counters covering an area of 38 m^2 and an inner "cube"with 64 counters and area of 15 m^2, in a near hermetic design. The counters will be mechanically secured to the gondola using an innovative carbon fiber structure. Each counter end will be read out using a silicon photomultiplier (SiPM) based analog front end designed to achieve ~500 ps resolution. The timing signals are sampled and digitized with a custom readout board that uses the DRS-4 ASIC. A local trigger monitors multiple programmable threshold levels for all 392 counter ends. A master trigger analyzes the local trigger hit patterns and initiates a TOF read out for an interesting event. A central computer analyzes the waveforms and estimates the primary's β, composition, and can be used to study decay product multiplicity.

The tracker system is comprised of ~1000 10 cm-diameter Si(Li) strip detectors, arranged in 10 planes. A custom fabrication technique was developed, in partnership with Shimadzu Corp., to satisfy the unique geometric, performance, and cost requirements of GAPS. To meet the formidable mission, requirements a custom ASIC has been developed to sample and digitize the 8-strips of each detector. The low noise design has a dynamic range of 10 keV to 100 MeV. For added efficiency and simplicity the tracker will be tightly integrated with balloncraft systems which inherit proven designs of past missions. To ensure the stability of the ~4 keV Si(Li) energy resolution at a relatively high operating temp of -40 C, the volume will be thermally regulated by a custom oscillating heat pipe system. This unique, low power design eliminates the need for traditional, heavy cryogenic systems. Tracker data analyzed by the flight computer provides essential information about the event vertex and annihilation products: as the exotic atom decays, antiprotons and antideuterons have characteristic and unique X-ray emission.

In this talk, I will review the history of the GAPS mission, and describe the instrument systems mentioned above in more detail.

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