# A NOVEL CUBESAT-SIZED ANTIPROTON DETECTOR FOR SPACE APPLICATIONS

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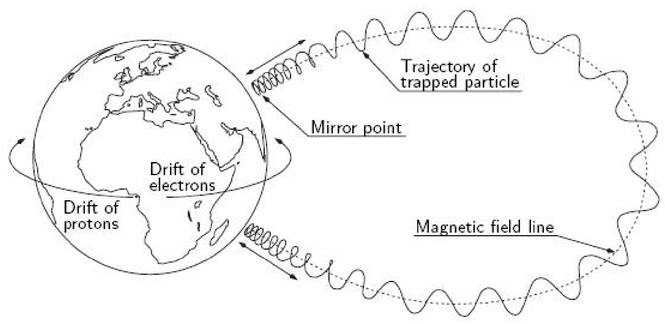
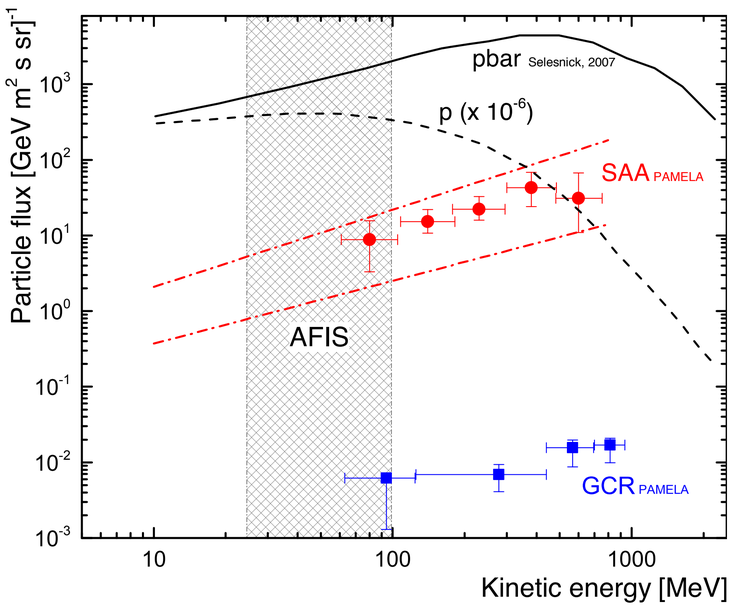
## THE ANTIPROTON FLUX IN SPACE MISSION

*» TO MEASURE THE FLUX OF TRAPPED LOW-ENERGY ANTIPROTONS INSIDE THE SOUTH ATLANTIC ANOMALY WITH A NOVEL CUBESAT-SIZED ACTIVE TARGET PARTICLE DETECTOR «*



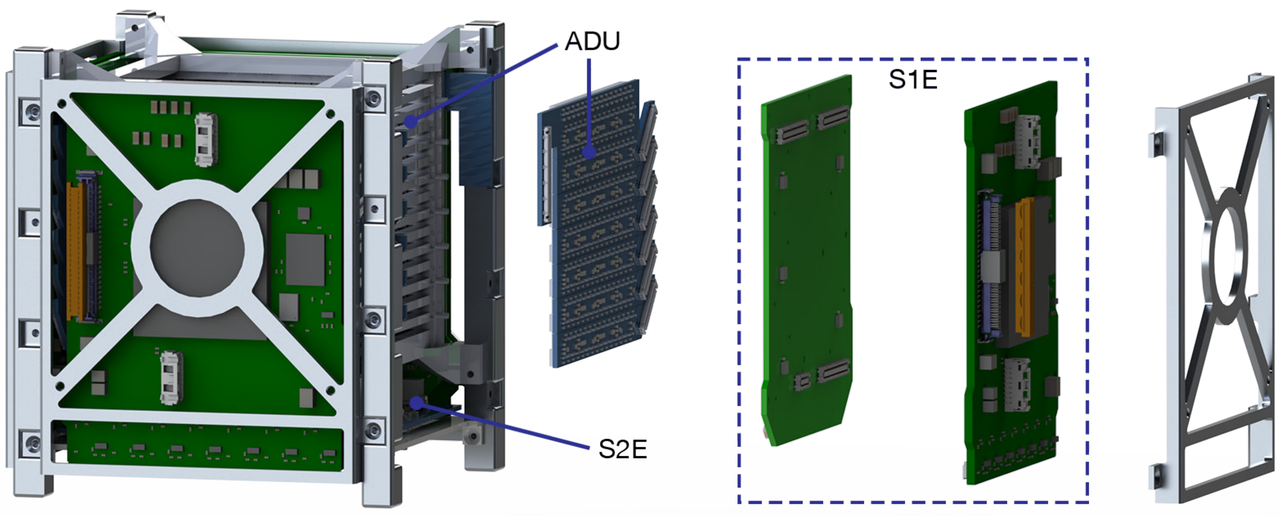

*Path of trapped particles along a field line of Earth's magnetic field.*

Antimatter created in Earth's upper atmosphere can be trapped in its magnetosphere. The antimatter particles accumulate in the Van Allen radiation belts and can be detected by spacecraft within the South Atlantic Anomaly (SAA). First discovered by the PAMELA experiment in 2011, there is no data available about the flux of trapped antiprotons at energies below 80 to 100 MeV. The Antiproton Flux in Space (AFIS) experiment aims to extend the measurement of trapped antiprotons in the SAA to energies in the range of 20 to 80 MeV using a detector with a large geometrical acceptance to provide a good statistical dataset.




*Flux of geomagnetically trapped antiprotons measured by the PAMELA experiment and the expected measurement range of the AFIS mission (Adapted from Adriani et al., APJ L29,5 (2011)).*

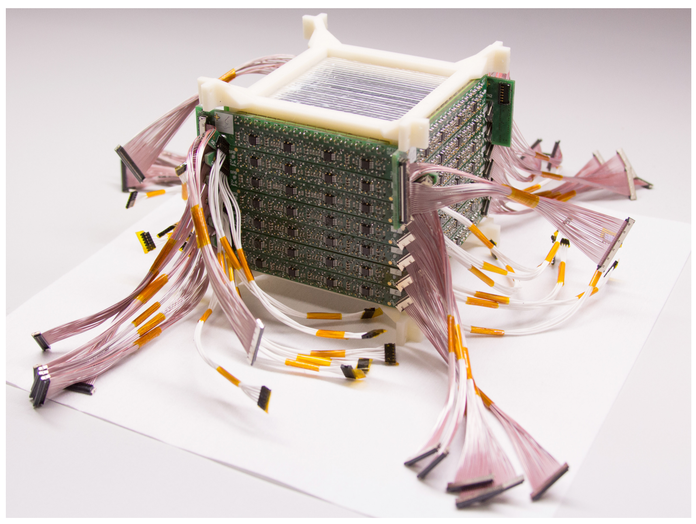
## THE MULTI-PURPOSE ACTIVE-TARGET PARTICLE TELESCOPE (MAPT)



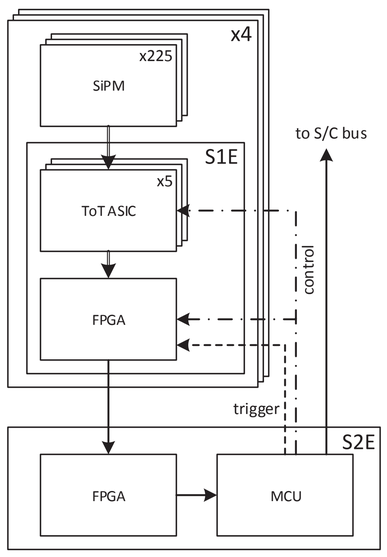

*Stuctural layout of the multi-purpose active-target particle telescope (MAPT). The active detector unit (ADU) made of scintillating fibers and silicon photomultipliers (SiPMs) is symmetrically surrounded by the front-end electronics (S1E and S2E).*

### ACTIVE DETECTOR UNIT (ADU)

- 900 channel active-target particle detector
- **active volume**: scintillating plastic fibers
- silicon photomultipliers for light detection
- allows **3D tracking** of charged particles
- particle identification based on:
  - ◊ reconstruction of energy depositition along the particle's track: **Bragg curve spectroscopy**
  - ◊ detection of secondaries following **annihilation** for particle-antiparticle discrimination



*The active detector unit (ADU).*



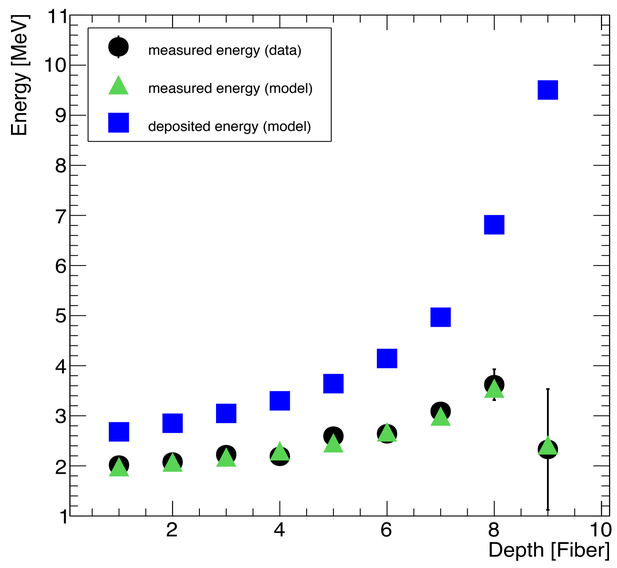

### STAGE-1 ELECTRONICS (S1E)

- fully parallel time-over-threshold measurement
- **time-over-treshold ASICs** developed by University of Tokyo (K. Shimazoe)
- Xilinx FPGA for time-to-digital conversion (resolution 350 ps max.)

### STAGE-2 ELECTRONICS (S2E)

- combination of signals and trigger decision
- **on-line event reconstruction**
- FPGA- and microcontroller-based
- MRAM storage

## PROTOTYPE TEST




*Comparison of deposited and measured energies for 325-MeV/c protons.*

Measurement of stopping protons at Paul Scherrer Institute using a scaled-down prototype

### RESULTS

- good signal-to-noise seperation
- identification of the Bragg curve of stopping protons
- quantitative description of **signal loss mechanisms**:
  - ◊ extraction of Birks' coefficient:
    **kB = (0.13 ± 0.03) mm/MeV**
  - ◊ saturation of SiPMs: ~220 photons at SiPM per MeV of energy deposition
- reconstruction of beam energies with **sub-MeV precision** (at 30 MeV to 60 MeV)

## TIMELINE