The GAPS Experiment

A search for light cosmic ray antinuclei-221

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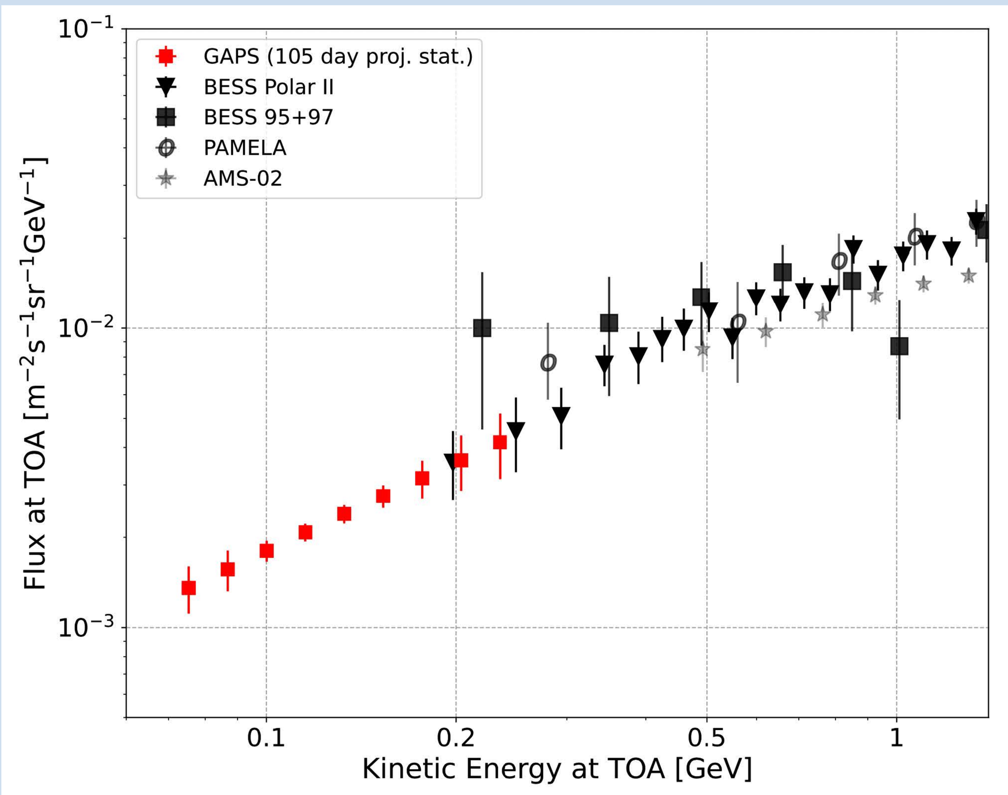
Introduction

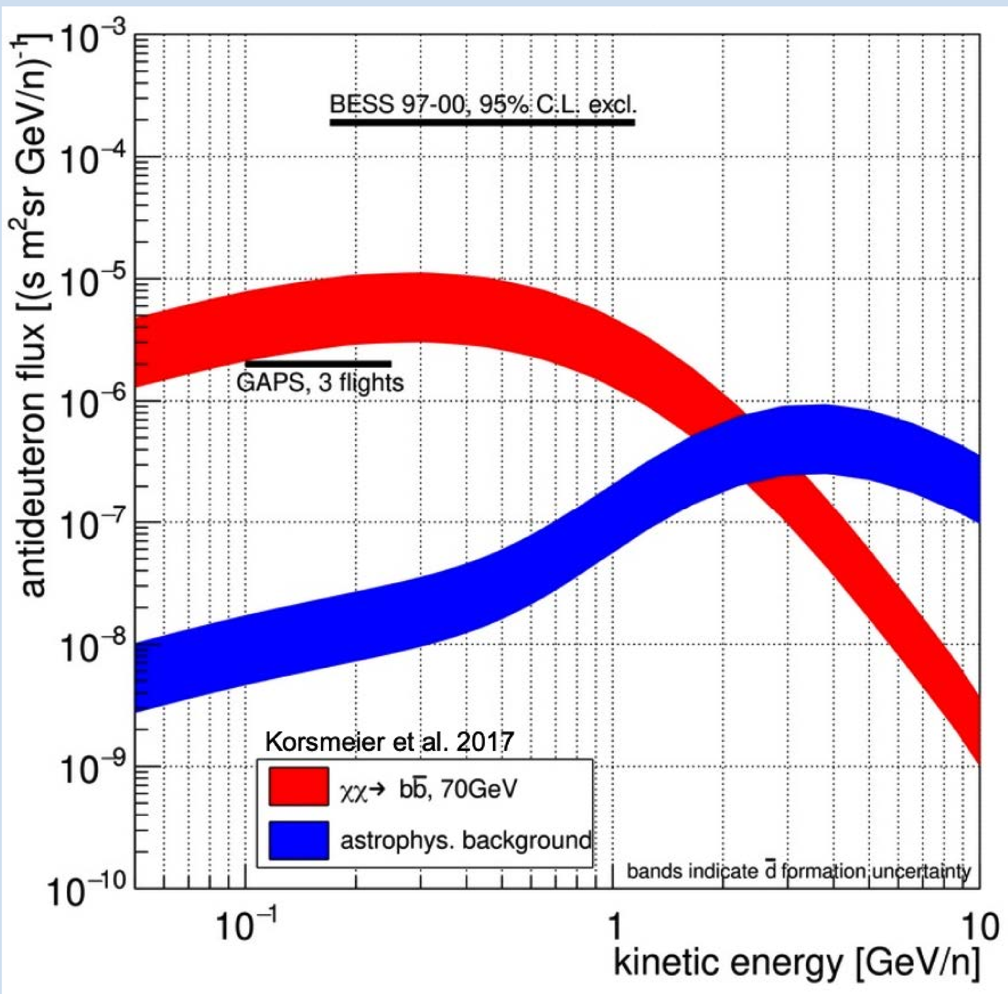
- The General AntiParticle Spectrometer (GAPS) is an experiment that indirectly detects cosmic ray (CR) antinuclei, aiming to find clues of Dark Matter (DM). Although antiparticles aren't considered DM candidates, many exotic theories suggest that antinuclei could be produced when DM particles annihilate or decay.
- GAPS seeks to address fundamental questions regarding the origin, properties of DM. The implications of such discoveries are profound, potentially reshaping our understanding of cosmology and particle physics.

GAPS's Target Antiparticles

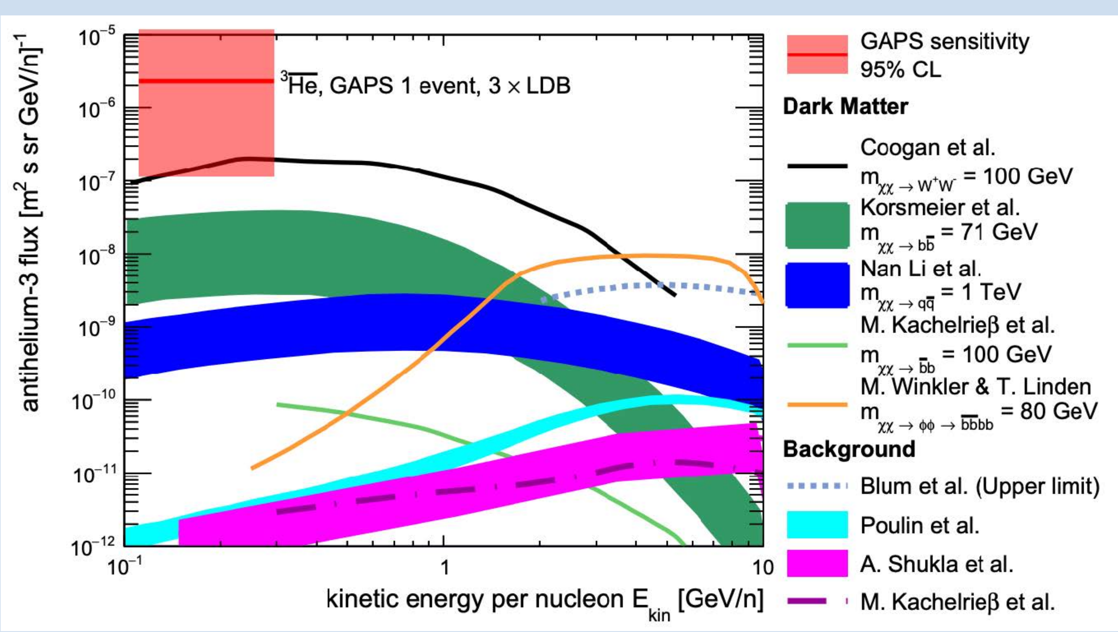
⇒ **Antiproton** - GAPS will provide a precision antiproton spectrum in a previously unexplored enengy range. GAPS is expected to measure about 500 antiprotons per 30-day flight in an energy range of ∼0.07-∼0.21 GeV/n at the top of the atmosphere.



⇒ **Antideuteron** - GAPS is designed to detect antideuteron as smoking-gun DM signature. It can explore a first-ever low-energy range below 0.25 GeV/n, covering a broad range of Dark Matter models.



⇒ **Antihelium** - GAPS will Follow up on antihelium candidate events reported by AMS-02. Low-energy sensitivity of GAPS can help distinguish the origin of AMS-02 ^{3}He candidates.

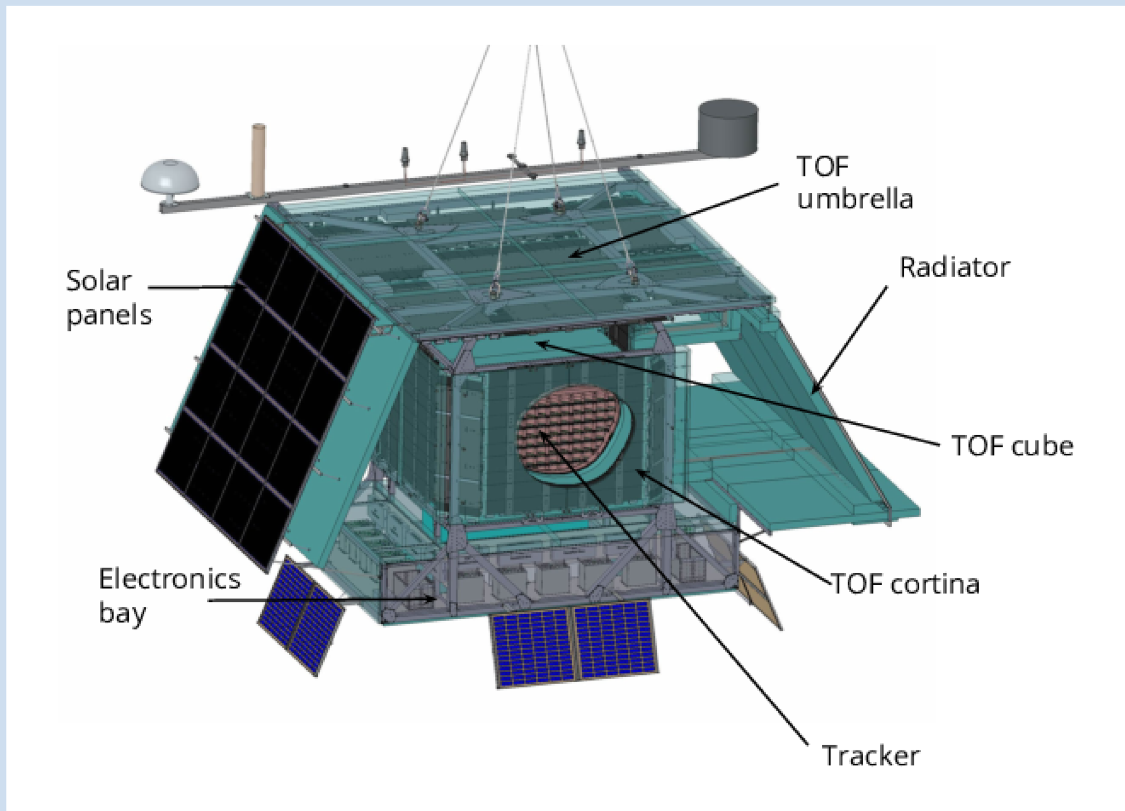


GAPS Instrument

The GAPS scientific instrument, weighing approximately 2300 kg, is set to be mounted onto a balloon designed for long-duration flights (LDB) for 31 days departing from McMurdo Station, Antarctica. The launch is scheduled for December 2024. It consists of two major parts: Tracker and Time-of-Flight (TOF) system.

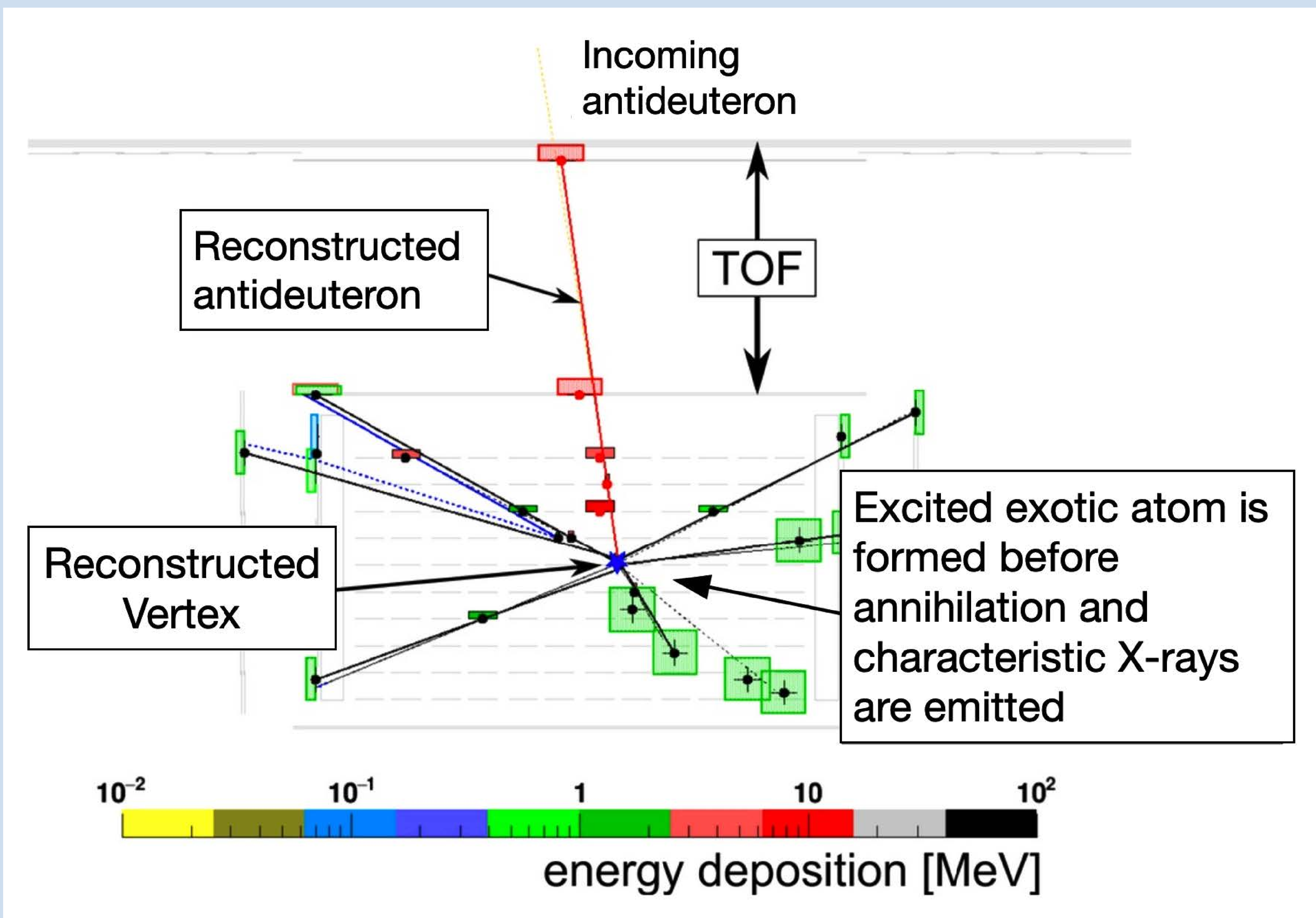
– **Time-of-flight (TOF) system**:
- 5 mm thickness
- 180 (160)×16 cm^2 for Outer (Inner) TOF
- ∼220 paddles with 6×6 mm^2 PM readout
- Timing resolution: < 400 ps
- Spatial resolution: < 40 mm

– **Si(Li) tracker**:
- Annihilation target
- 10 layers (6*6 modules/layer)
- 4 wafers (=10 cm, T=2.5 mm) / module
- 4 keV FWHM for X-ray < 100 keV
- Large dynamic range up to 100 MeV



New Detection Technique

Exotic atom formation by stopped incoming antiparticle. Secondary particles (pions, protons, and X-rays) are produced from the decay of an exotic atom. The primary track is reconstructed on the basis of the TOF and associated Si(Li) tracker hits. Secondary tracks are then reconstructed from the remaining hits together with the annihilation vertex reconstruction. Physical quantities associated with the reconstructed objects are calculated for particle identification.



Conclusions

- The GAPS experiment has the potential to expand our understanding of low-energy antinuclei in cosmic rays significantly: its large acceptance, as well as its novel detection principle, provide sensitivity to antideuteron and antihelium fluxes, which are predicted by current DM models and extend the antiproton spectrum with a high statistics spectrum towards low energies.
- Its unique approach to antiparticle identification, employing the formation of an exotic atom, will provide complimentary systematics to current experiments searching for cosmic antinuclei.

References

[1] A. Stoessl. The gaps experiment - a search for light cosmic ray antinuclei. In *38th International Cosmic Ray Conference (ICRC2023) - Dark Matter Physics (DM)*, 2023.

[2] Alex Lennib Riccardo Munini. The identification of the cosmic-ray light nuclei with the gaps experiment.