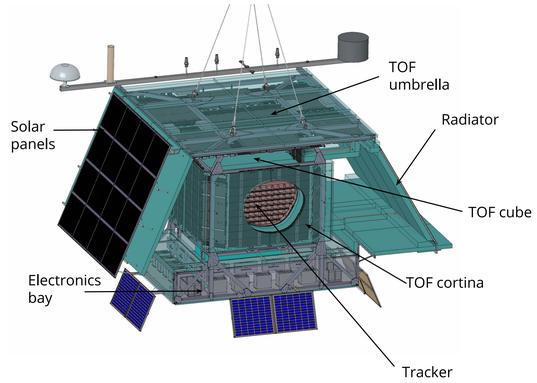
Searching for cosmic antihelium nuclei with the GAPS experiment

A. Stoessl

Department of Physics and Astronomy, University of Hawaii at Manoa, 2505 Correa Rd, Honolulu, HI 96822, USA.

The GAPS experiment



Two subsytems:

TOF time of flight system, plastic scintilaltor paddles, β measurement, trigger

Si(Li) tracker 1000 detecors in 10 planes, energy resolution at 4 keV for $20 - 100$ keV

Event selection

Likelihood techniqe for particle identification. Details in [1]. Analysis in 3 stages:

Preselection Ensure that the reconstructed stopping/annihilation vertex is inside the tracker volume and the and there are enough hits

Llh construction Use seven variables to construct 2d probability distributions together with the reconstructed velocity.

Final cuts Cuts on the calculated likelihood ratio optimized individually for three $\cos(\theta)$ bins together with a cut on the mean truncated energy to ensure the reconstruction is compatible with $|Z| = 2$ and a cut on reconstructed $0.3 < \beta < 0.6$

References

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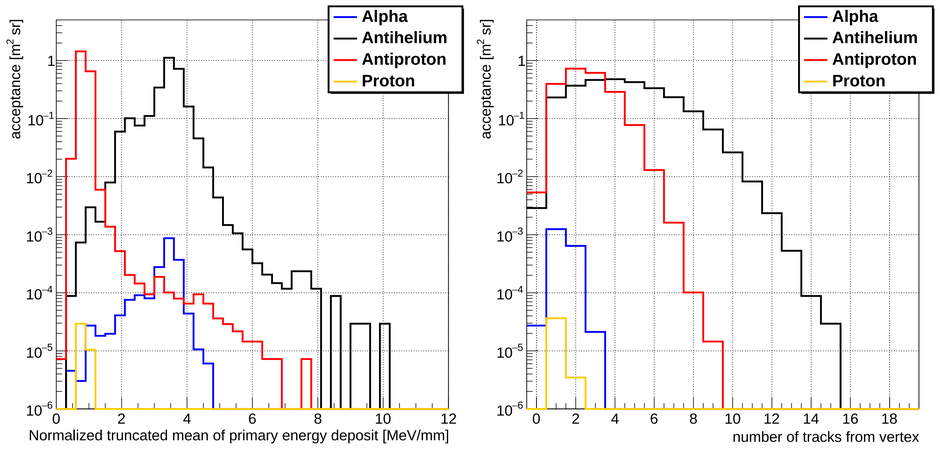
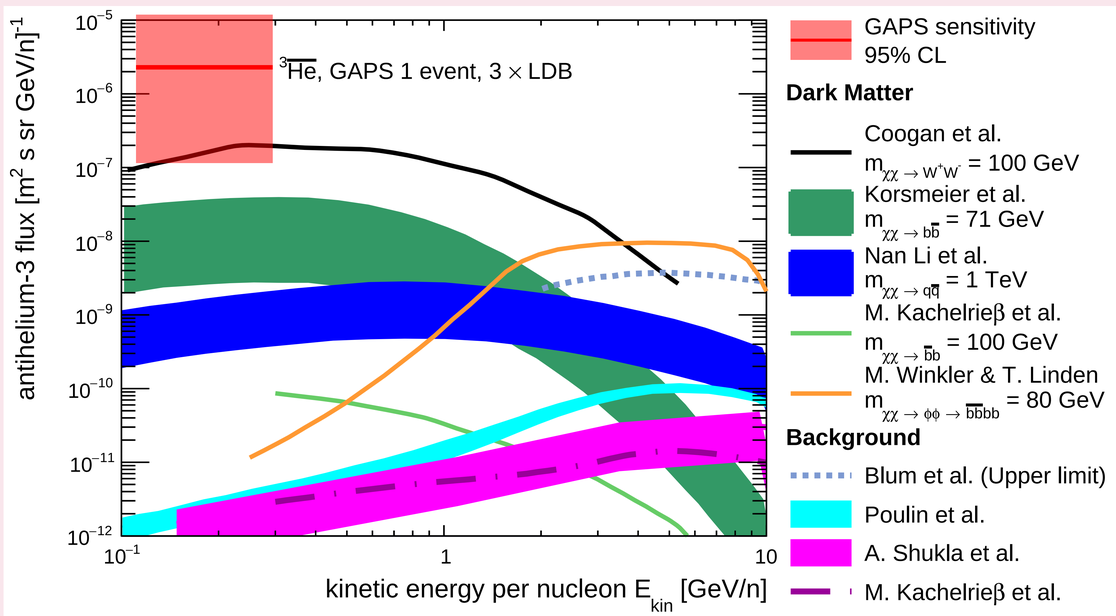
Variables



Truncated energy mean - separates primary particles with charge $|Z| = 1$ and $|Z| = 2$

Number of tracks from vertex - identifies antiparticles (annihilation exhibits "star" pattern)

GAPS anti He3 sensitivity



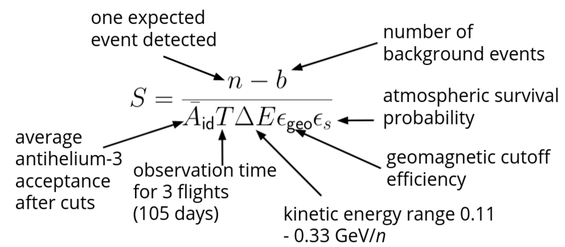
GAPS antihelium-3 sensitivity for three LDB flights of 35 days each (95% confidence level). Antihelium-3 flux predicted from dark matter taken from [3, 4, 5, 6, 7], standard astrophysical background predictions taken from [8, 9, 10].

Simulation & Reconstruction

- Simuation using `Geant4.10.7p02`
- `FTFP_BERT_HP` physics list
- Detailed model of GAPS geometry
- 10^{11} protons, $4 \cdot 10^9$ α-particles and $7 \cdot 10^8$ antiprotons generated for this study.
- Reconstruction of primary track + annihilation star specifically developed for GAPS [2].

Sensitivity

- Bayesian approach as in [11]
- Sensitivity for one detected event
- Sensitivity calculated for three 35days LDB flights
- Remaining background onn the order of 10^{-3}
- $2.29 \cdot 10^{-6}\,\text{m}^{-2}\text{sr}^{-1}\text{s}^{-1}(\text{GeV}/n)^{-1}$



Summary & Outlook

- Initial MC study of GAPS antihelium-3 capabilities
- LLh analysis exploiting primary event characteristics and annihilation star
- Unprecedendet sensitivity to antihelium-3 flux in an energy region inaccessible to AMS-02

Acknowledgements

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