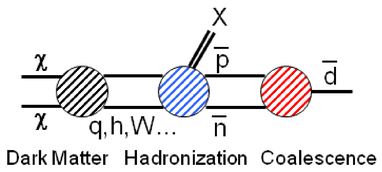
GAPS: A Novel Indirect Search for Dark Mater

S. A. Isaac Mognet for the GAPS Collaboration

UCLA

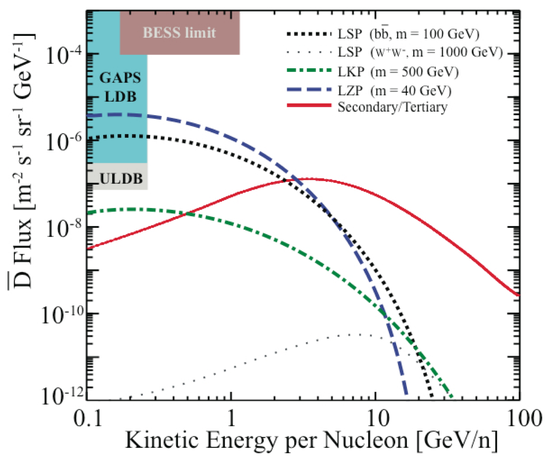
Antideuterons from Dark Matter

A number of promising theories for physics beyond the standard model (supersymmetry, Kaluza-Klein theory and universal extra dimension theories, etc.) produce candidate DM particles. These particles can annihilate or decay to standard model particles, and thus leave an imprint on gamma-rays or cosmic-ray species observed at Earth.[1][2][3]



A promising approach to detect evidence of DM is to probe cosmic-ray species not abundantly produced in normal astrophysical processes, such as antimatter species ($e+, \bar{p}, \bar{d}$ or heavier anti-nuclei).

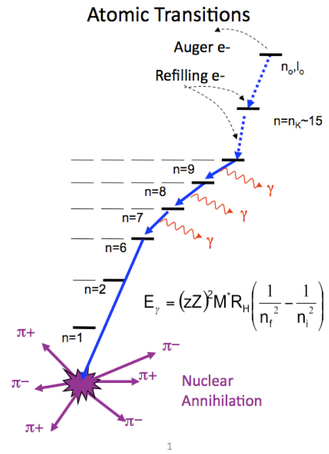
Antideuterons at Earth



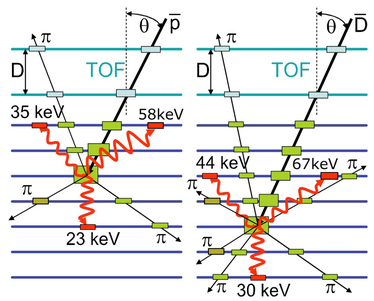
Predicted $\bar{d}$ fluxes from a sample of DM candidates are compared above to the expected flux from secondary production. Shown above is a $m = 100GeV$ neutralino from minimal supersymmetry (LSP), a lightest Kaluza-Klein particle (LKP) and a right-handed neutrino from a 5-dimensional, warped grand unified theory model (LZP)[4]

The GAPS Concept

Traditionally antimatter species are distinguished by magnetic deflection of the particle (HEAT,AMS, PAMELA, etc). This requires a heavy detector of limited size. An alternate method of detecting negatively charged antimatter species is to capture the particles in exotic atom states (in place of an atomic electron) in a target material and observe the resulting decay products.



Furthermore, antiprotons and antideuterons can be distinguished by a combination of stopping depth x-ray transition energies and pion multiplicity.

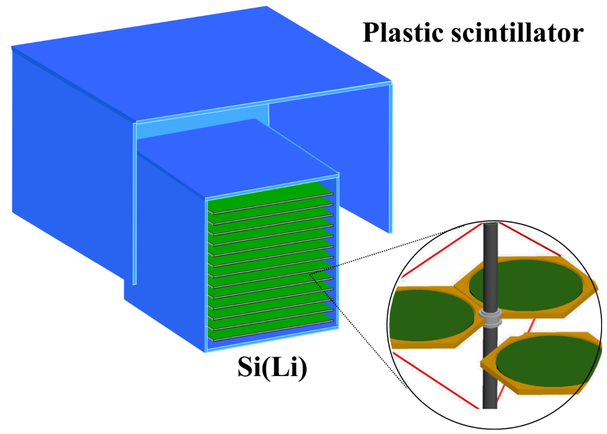


2004-2005 GAPS Prototype Tests

A GAPS prototype detector was tested in 2004 and 2005 using an antiproton beam at the KEK accelerator. The use of solid targets was validated and the identification of antiparticles from multi-pion and x-ray signatures was proven with excellent background rejection.[5]

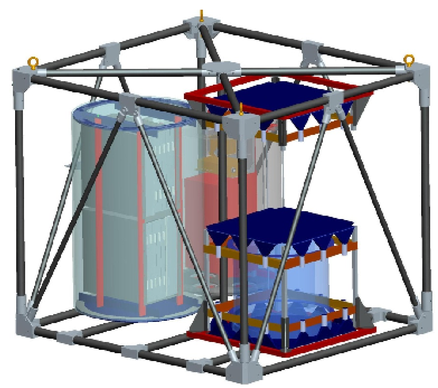
bGAPS: A Balloon-Born Antideuteron Detector

We are currently developing a large balloon-born GAPS payload to probe a significant portion of parameter space for evidence of DM. The first flight of bGAPS is scheduled for an Antarctic LDB balloon flight in 2014. The instrument concept consists of a plastic scintillator time-of-flight system (for particle β measurement and veto) hermetically surrounding a novel lithium drifted silicon (Si(Li)) system. The Si(Li) system serves as both a target for exotic atom formation, a tracker for both primary particle and decay products, and an energy sensitive x-ray detector.



2011 Test Flight

An engineering test payload known as pGAPS is scheduled to fly in 2011 from the JAXA/ISAS balloon launch facility in Taiki, Japan. This payload will consist of a plastic-scintillator based time-of-flight system and 6 commercially purchased Si(Li) detectors.



Acknowledgements

This work was supported in part by NASA and JAXA/ISAS.

References

[1] Y. Cui, J. D. Mason, and L. Randall, Journal of High Energy Physics **2010**, 17 (2010)

[2] F. Donato, Nuclear Physics B (Proc. Suppl.) **87** (2000), 445-447

[3] D. Hooper and S. Profumo, (2007),[arXiv: hep-ph 0701197v2]

[4] C. J. Hailey et al, Advances in Space Research **46**, 11 (2010), 1349-1353

[5] C. J. Hailey et al, Journal of Cosmology and Astroparticle Physics **01**, 007 (2006)