# GAPS - Dark matter search using cosmic-ray antideuterons


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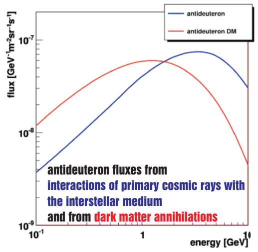
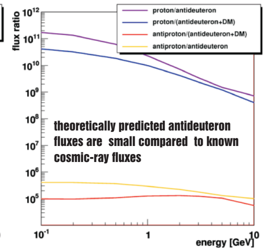
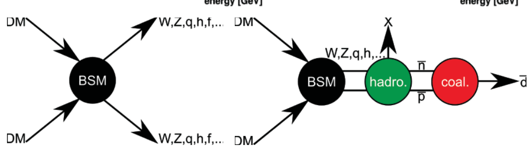
The General AntiParticle Spectrometer experiment is foreseen to carry out a dark matter search using cosmic-ray antideuterons at stratospheric altitudes using a novel detection approach. Dark matter theories predict large antideuteron fluxes at low energies coming from dark matter self-annihilations compared to the flux resulting from secondary interactions of primary cosmic rays with the interstellar medium. GAPS is designed to achieve its goals via a series of (ultra-)long duration balloon flights at high altitude in Antarctica, starting in 2014. To prove the performance of the different detector components at balloon altitudes, a prototype flight (pGAPS) will be conducted in 2011 from Taiki, Japan.


## Why searching for antideuterons?



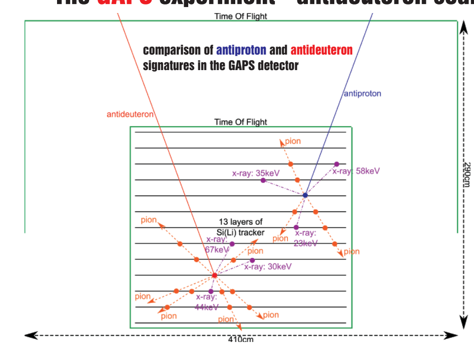

We know that dark matter exist, but we do not know its nature. Theories beyond the standard model of particle physics (e.g., supersymmetry, Kaluza-Klein extra dimensions) predict viable dark matter candidates. Those candidates could contribute to cosmic-ray fluxes due to self-annihilations.

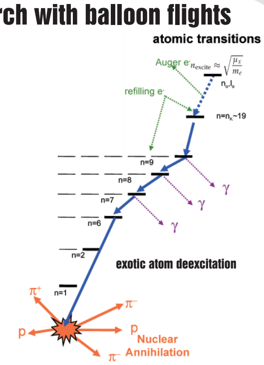
Cosmic-ray antiparticles do not have any known sources. Thus, the fluxes are smaller compared to their particle partners. This makes antiparticles good candidates for the search of extra contributions in cosmic-ray fluxes due to dark matter annihilations.

So far antideuterons have only been detected at collider experiments and not in cosmic rays.

Theories predict a high ratio of dark matter antideuterons to secondary antideuterons below 1GeV. As the antideuteron fluxes will be very small, a reliable discrimination against the background is crucial.

## The GAPS experiment - antideuteron search with balloon flights

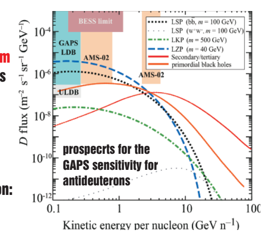


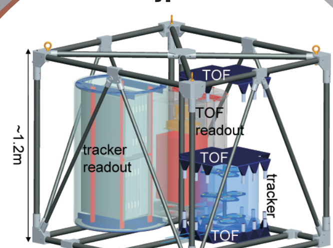

**Si(Li) tracker:**
- 13 layers composed of Si(Li) wafers are target and detector
- Lithium doped Silicon detectors for a good x-ray resolution
- circular modules segmented into 8 strips (total: ~3500)
- dual channel electronics for x-rays and charged particles

**Time of flight:**
- plastic scintillators with PMTs
- track charged particles
- velocity and charge measurement

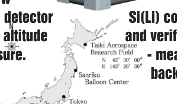
**Particle identification:**
- antideuteron slows down and stops in material
- creation of an excited exotic atom
- fast ionisation of bound electrons
- complete depletion of bound electrons
- Hydrogen-like exotic atom radiative deexcitation with characteristic x-ray transitions
- nucleus-antideuteron annihilation: pions and protons




## Prototype GAPS

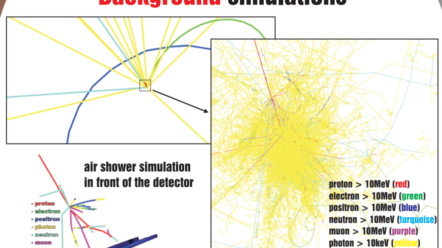


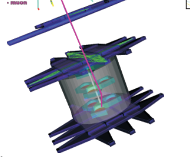

- demonstrate stable, low noise operation of the detector components at float altitude and ambient pressure.
- demonstrate the Si(Li) cooling approach and verify thermal model
- measurement of background



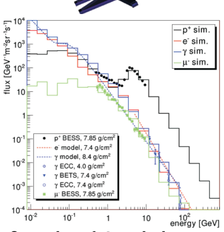

flight from Taiki, Japan 2011

## Background simulations

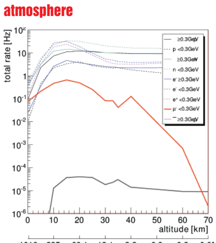


Atmospheric and geomagnetic simulations with PLANETOCOSMICS based on GEANT
- cosmic rays are deflected in the magnetic field
- cosmic rays interact with the atmosphere

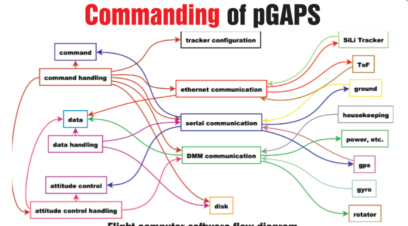



Comparison of atmospheric simulations shows good agreement with BESS, ECC, BETS, PPB-BETS, CAPRICE measurements and models.




Particle rate at 33km at Taiki is ~30Hz. The strongest backgrounds are neutrons, protons, electrons, positrons and photons.

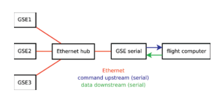
## Commanding of pGAPS




Flight computer software flow diagram

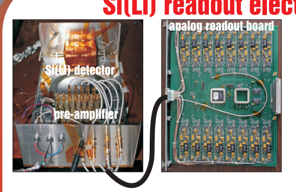

The flight computer is the central computing unit for receiving commands and sending data during flight from/to ground as well as for the rotation calculation of the gondola. The gondola communication is handled by Ethernet communication and the ground communication via serial lines. For an efficient way of handling the various tasks a multi-threaded approach was chosen.

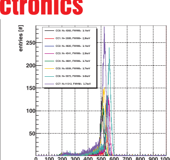
On ground a central unit will pick up the data from the serial line and store it on disk. Monitoring programs will display this data. Commands can be send to react to the data.




Ground support equipment structure

## Si(Li) readout electronics




Tests of the x-ray channel with Am-241

The Si(Li) detectors will be readout by modified prototype NCT electronics. As the detectors are not yet passivated, tests in a thermal vacuum chamber are ongoing. The results so far show that a resolution of ~3keV for 60keV x-rays can be reached while at the same time also energy depositions of atmospheric muons can be resolved.

## Take home

- antideuterons are a promising way for indirect dark matter search
- GAPS uses exotic atoms as identification technique
- (U)LDB flights from South Pole starting in 2014
- prototype experiment is currently under construction and will fly from Taiki, Japan in Summer 2011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