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Anti-deuteron identification in cosmic rays with an Helium Calorimeter

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The possible presence of low energy anti-deuterons in cosmic rays is a golden channel to test the antimatter asymmetry in the Universe or to identify annihilating Dark Matter particles in the galactic halo.
The "PHeSCAMI"(Pressurized Helium Scintillating Calorimeter for AntiMatter Identification) project is aiming to study a new signature for the identification of anti-deuteron and anti-protons in cosmic rays.
In particular, when a Z=-1 relatively heavy particle is stopping in the detector, it can produce an exotic atom and for the particular case of the helium target, the captured antiparticle can orbit the helium nucleus for microseconds before the annihilation.
This characteristic "double-event"due to the delayed annihilation is a very distinctive signature able to identify the antimatter nature of the stopping particle and rejecting the large fraction of the ordinary matter particles in cosmic rays.
Thus a possible experiment searching for anti-deuterons in cosmic rays onboard a circumpolar balloon based on the "PHeSCAMI"signature would use pressurized helium scintillating calorimeters surrounded by plastic scintillator layers for the particle velocity measurement.
Anti-deuterons are identified by combining the spectrometric measurement of the mass of the stopping particle (velocity vs energy) with the number of delayed outgoing tracks due to charged pions emitted by the antiparticle annihilation.
A preliminary 1L stainless steel prototype of the pressurized calorimeter, filled by 200 Bar Helium acting as a scintillator, has been characterized with cosmic muons and with 70-240 MeV proton beam in the INFN-TIFPA laboratory. An energy resolution better than 10% and a time resolution better than 300ps has been achieved for this scintillating helium calorimeter.
The development and test of an advanced, calorimeter prototype, based on an automotive COPV (composite overwrapped pressure vessel) is ongoing in the INFN-TIFPA laboratory. This allows to store 40L of Helium with a pressure of 200 Bar by keeping the wall grammage within 1.5g/cm^2, permitting the detection of anti-deuterons in the 50-150MeV/n energy window.
The sensitivity of a possible detector based on the "PHeSCAMI"signature will be summarized and the results of the measured performance of Helium calorimeter prototypes will be shown.

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