COSMIC ANTIDEUTERONS

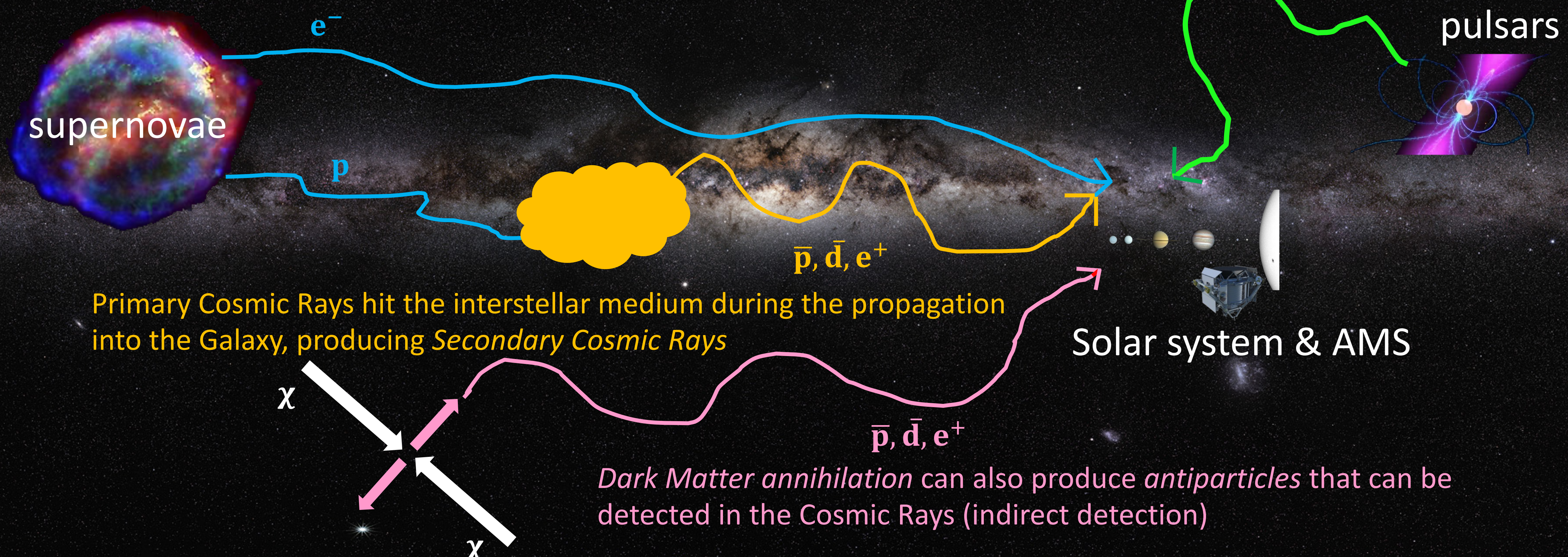
SEARCHING FOR ANTIDEUTERONS IN COSMIC RAYS WITH THE ALPHA MAGNETIC SPECTROMETER

International School for Subnuclear Physics, Erice, 14-23/06/2024

F. D'Angelo – University of Bologna – francesco.dangelo13@unibo.it

SECONDARY COSMIC RAYS

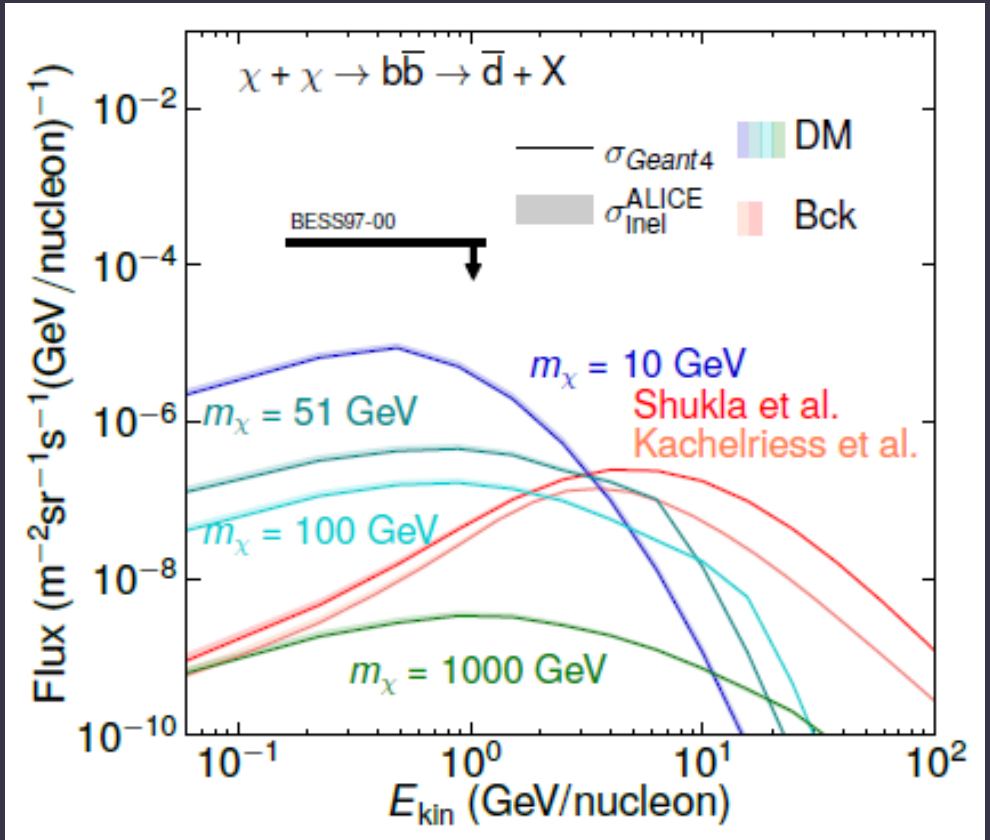
Primary Cosmic Rays are produced and accelerated in astrophysical sources, such as *supernovae* and *pulsars*



Primary Cosmic Rays hit the interstellar medium during the propagation into the Galaxy, producing *Secondary Cosmic Rays*

Dark Matter annihilation can also produce *antiparticles* that can be detected in the Cosmic Rays (indirect detection)

ANTIDEUTERONS IN COSMIC RAYS



Serksnyte et al, 2022, Phys. Rev. D 105, 083021

Detecting the antideuterons in Cosmic Rays is important for the Dark Matter indirect search.

The antideuterons can be produced in collisions between Primary Cosmic Rays and the interstellar medium. For the kinematics of these collisions, these antideuterons are produced at higher kinetic energies.

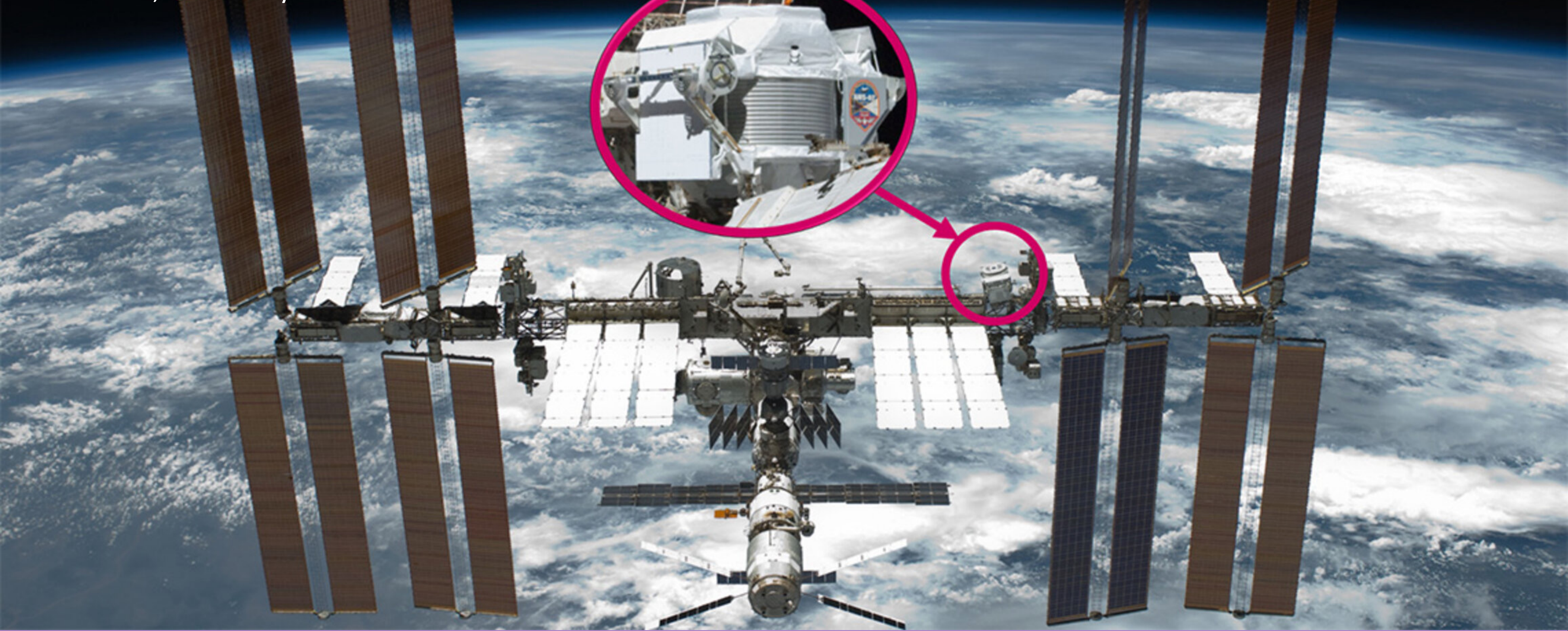
Dark Matter annihilation occur at rest and antideuterons can be produced with lower kinetic energies.

Detecting antideuterons with low kinetic energy (few GeV) would be a "smoking gun" of the Dark Matter.

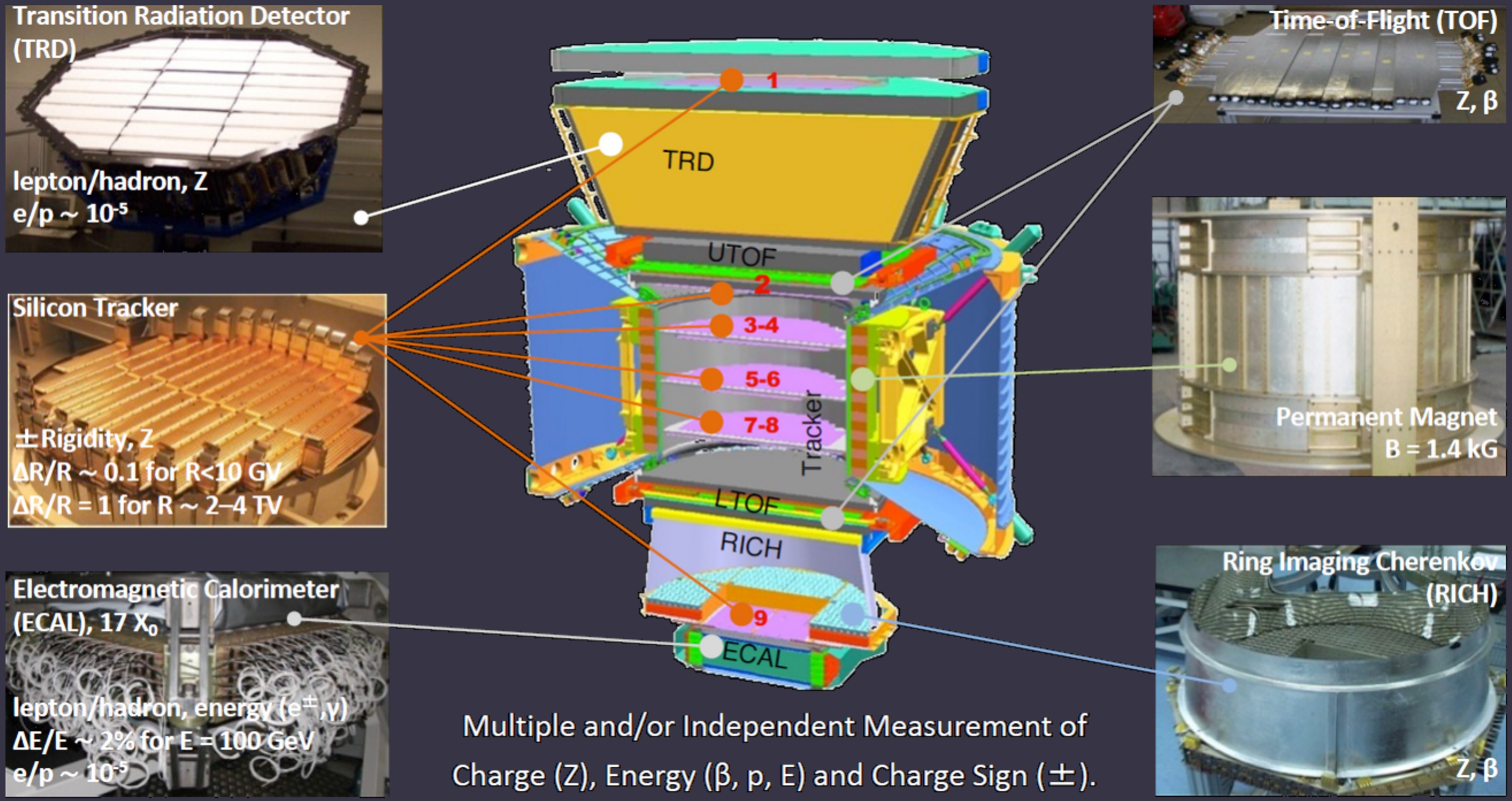
Antideuterons have never been seen in Cosmic Rays.

THE ALPHA MAGNETIC SPECTROMETER (1)

The Alpha Magnetic Spectrometer (AMS-02) is a magnetic spectrometer operating on International Space Station (ISS) since its launch, on 19 may 2011.



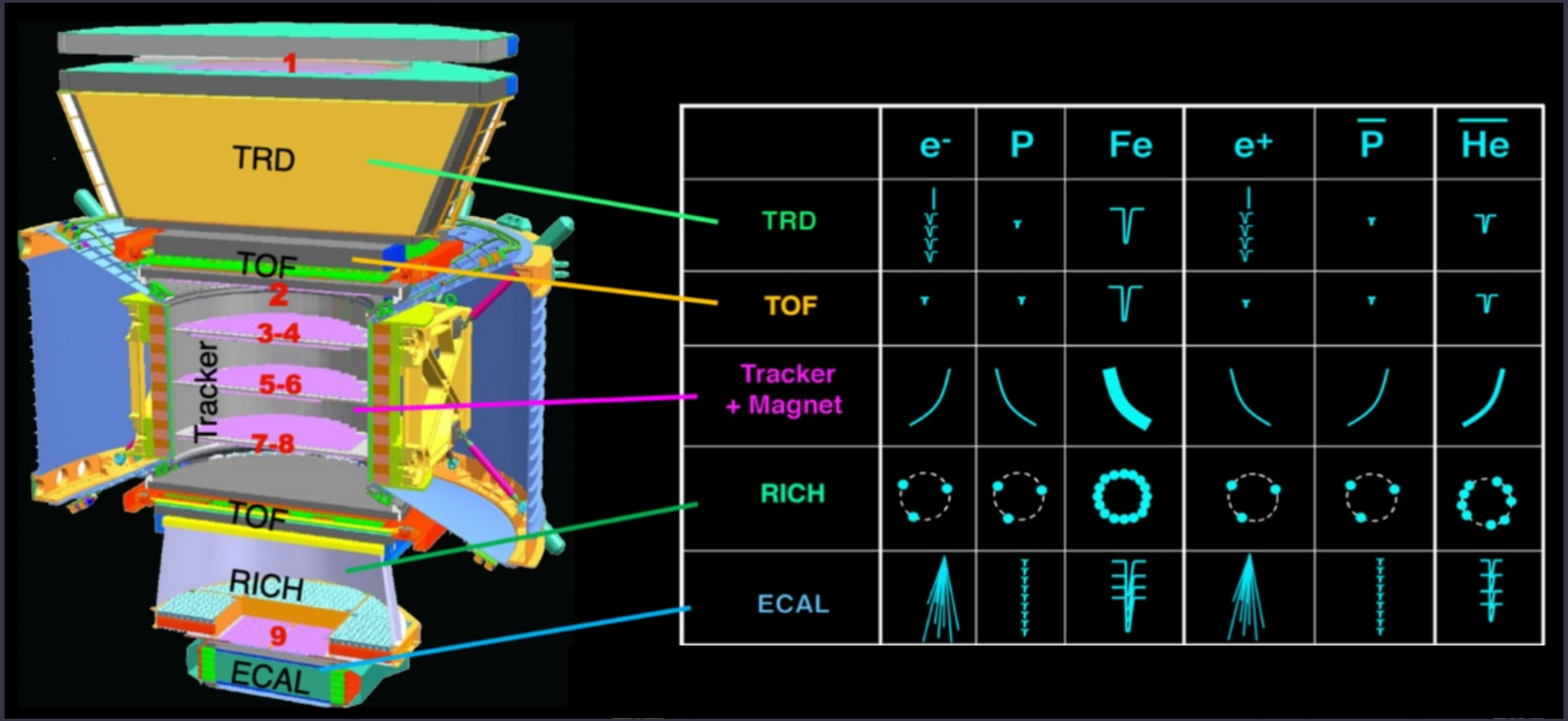
THE ALPHA MAGNETIC SPECTROMETER (2)



Multiple and/or Independent Measurement of Charge (Z), Energy (β, p, E) and Charge Sign (±).

The AMS-02 experiment is composed by many subdetectors and provides precise data on many cosmic rays species.

SEARCH FOR ANTIDEUTERONS WITH AMS-02



$$mass: m = \frac{ZeR}{\gamma\beta}$$

Measuring Z, R and β it's possible to calculate the mass of the reconstructed particle.

The Rigidity R is reconstructed using the Silicon Tracker and the magnet

$$\frac{\Delta R}{R} \approx 0.1, \qquad R < 10\ GV$$

The velocity β is reconstructed using the Time Of Flight (TOF) and the Ring Imaging Cherenkov detector (RICH) with two different radiators (NaF and aerogel)

$$\Delta\beta_{TOF} \approx 0.04, \qquad \beta = 1$$

$$\Delta\beta_{RICH-NaF} \approx 0.004, \qquad \beta = 1, \quad \beta_{threshold} \approx 0.75$$

$$\Delta\beta_{RICH-aerogel} \approx 0.001, \qquad \beta = 1, \quad \beta_{threshold} \approx 0.96$$

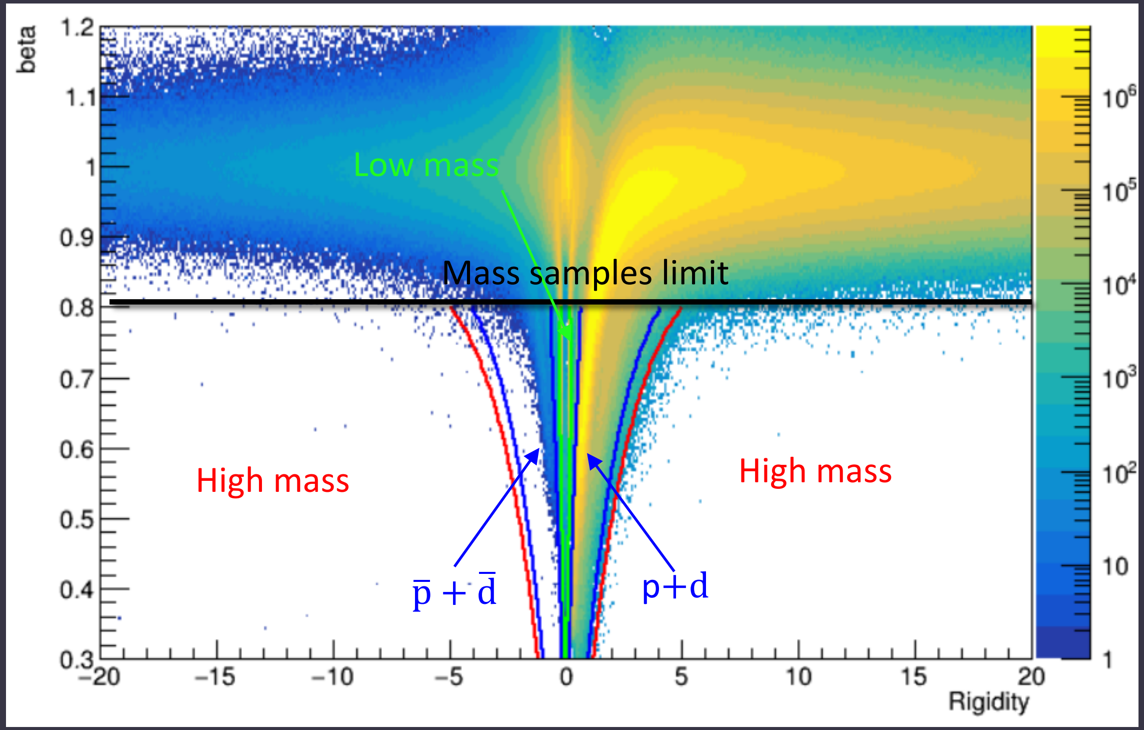
The Charge Z is reconstructed using the Silicon Tracker

THE MASS SAMPLES

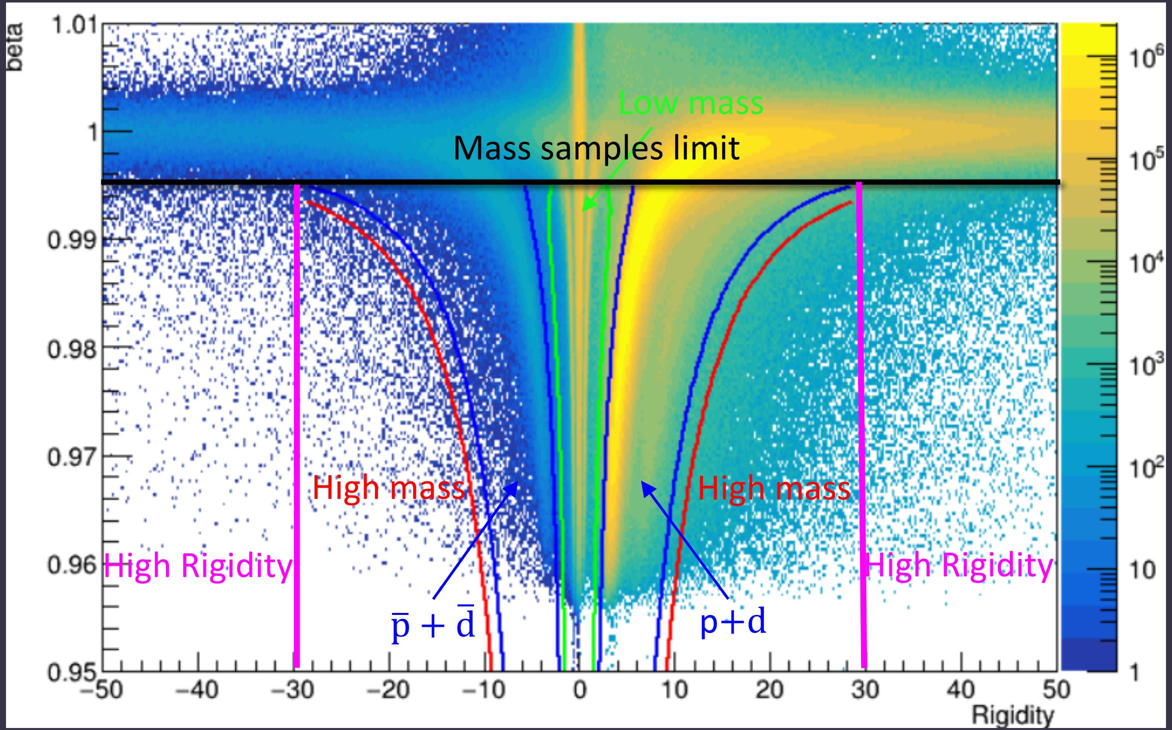
$$mass := \frac{ZeR}{\gamma\beta}$$

Different mass samples have been defined (except for the highest β region) to distinguish between the interesting particles (*correct mass range*) and events with a wrong mass (*high mass range* and *low mass range*).

The *correct mass range* for negative events includes events with antiproton mass, the antiproton high mass tail and the region corresponding to the antideuteron mass.



TOF analysis range



RICH aerogel analysis range

SUMMARY

- Antideuterons are crucial observable for the indirect search of Dark Matter in Cosmic Rays.
- AMS-02 is able to measure antideuterons in a large kinetic energy range.
- The ongoing analysis is developing methods (Machine Learning algorithms) to separate the possible rare antideuteron component from the experimental backgrounds.