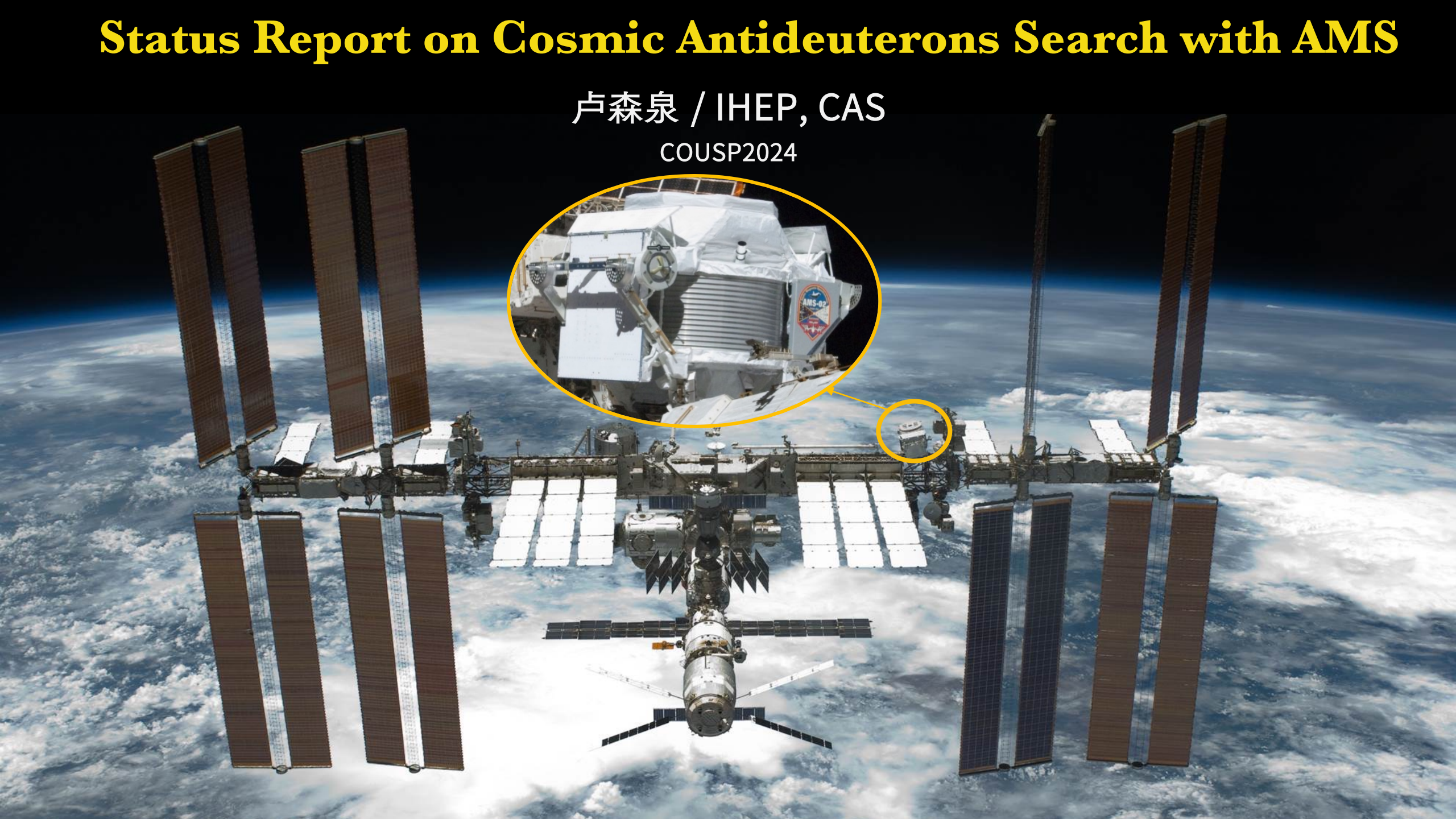
Status Report on Cosmic Antideuterons Search with AMS

卢森泉 / IHEP, CAS

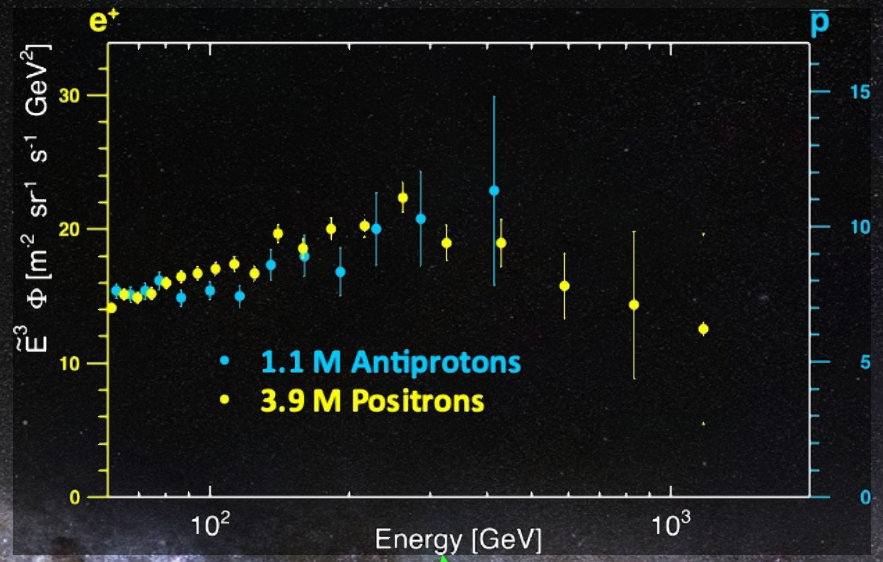
COUSP2024



Search for New Physics with Cosmic Antiparticles

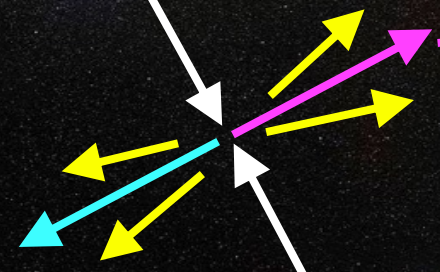
Protons,
Helium,
Electrons, …

Interstellar
Medium



Positrons,
Antiprotons,
Antideuterons
from Collisions

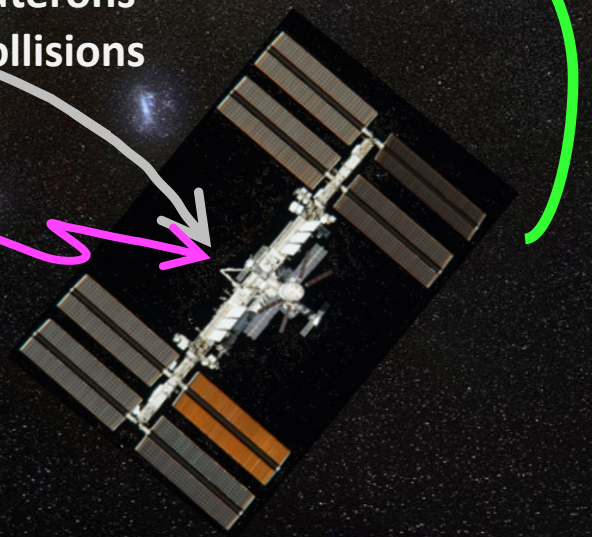
Dark Matter



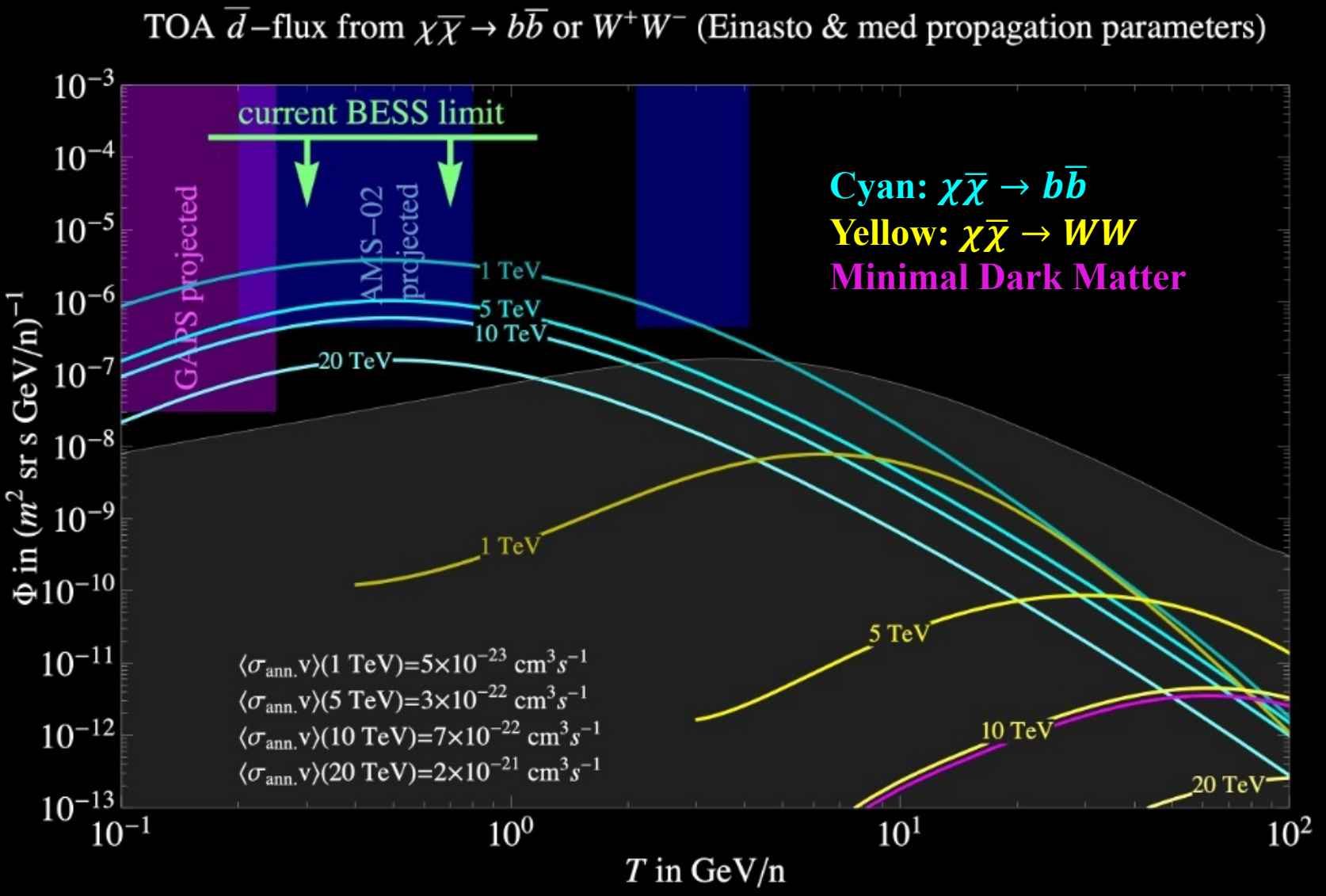
Electrons, …

Positrons, Antiprotons,
Antideuterons
from Dark Matter

Dark Matter

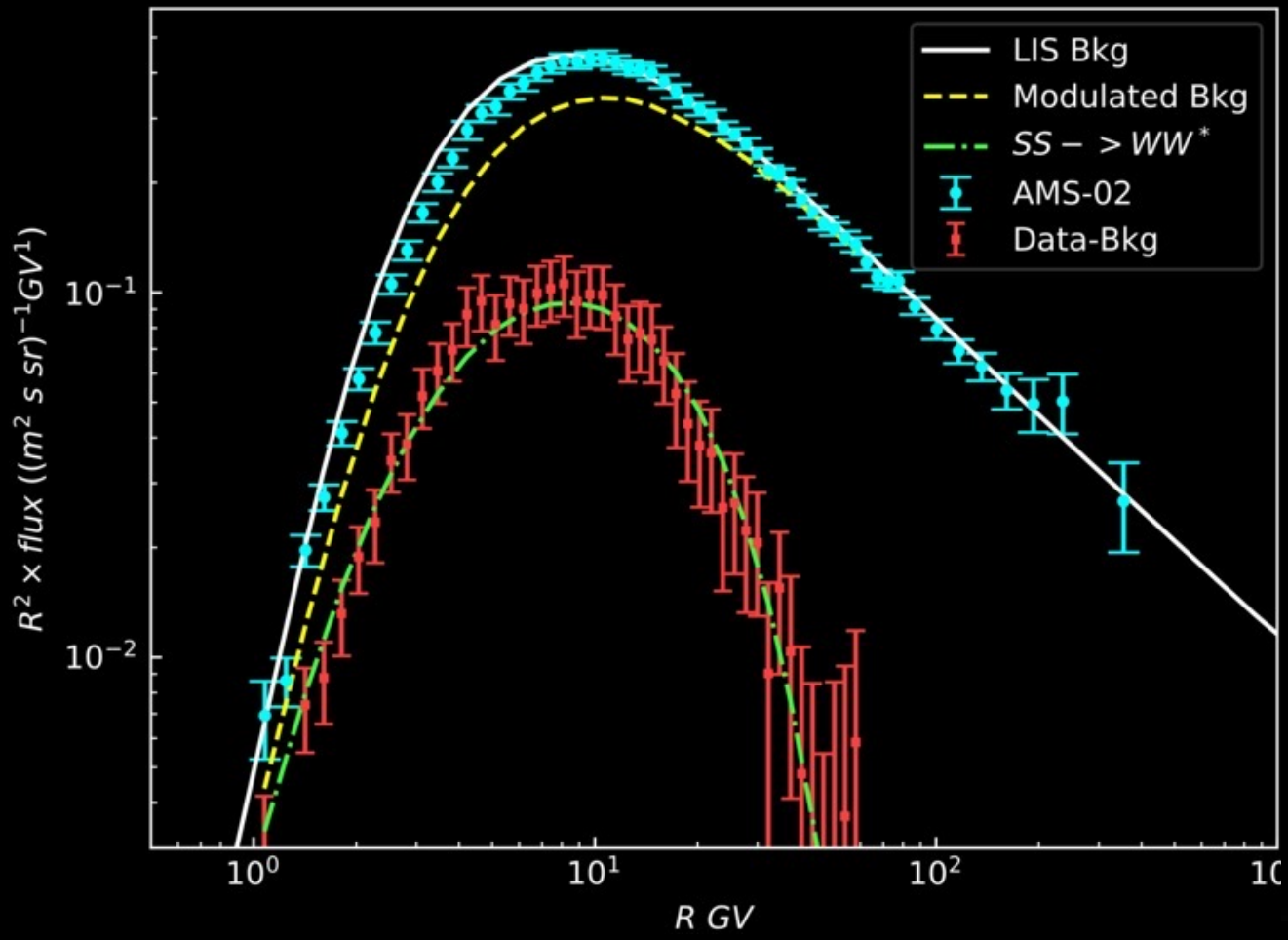


Antideuteron from heavy Dark Matter

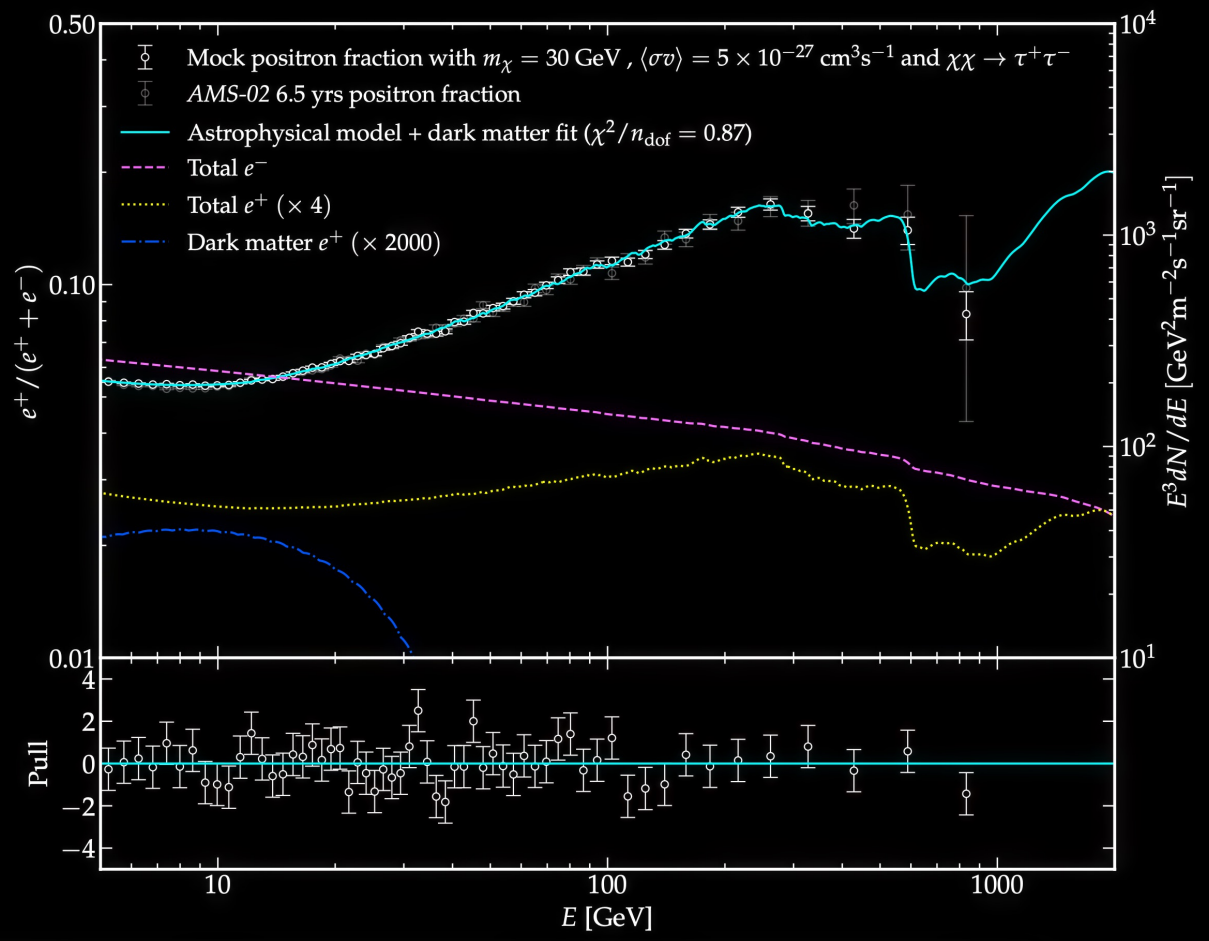


Phys.Lett.B 678 (2009) 20-31

Dark Matter signals at Low Energy

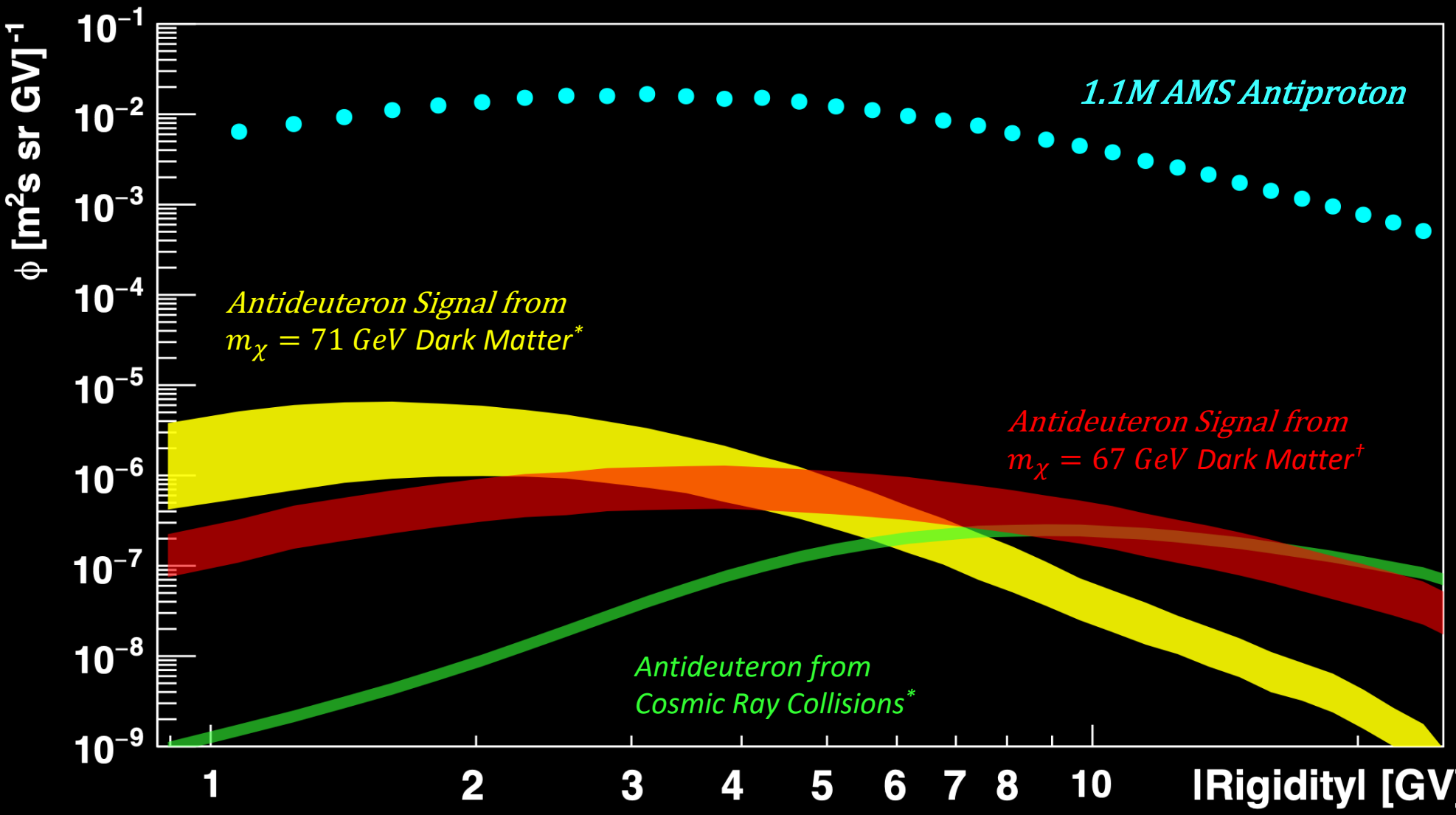


Phys. Rev. Lett. **129**, 231101



Phys. Rev. D **107**, 023003

Antideuteron Signals from Dark Matter Models



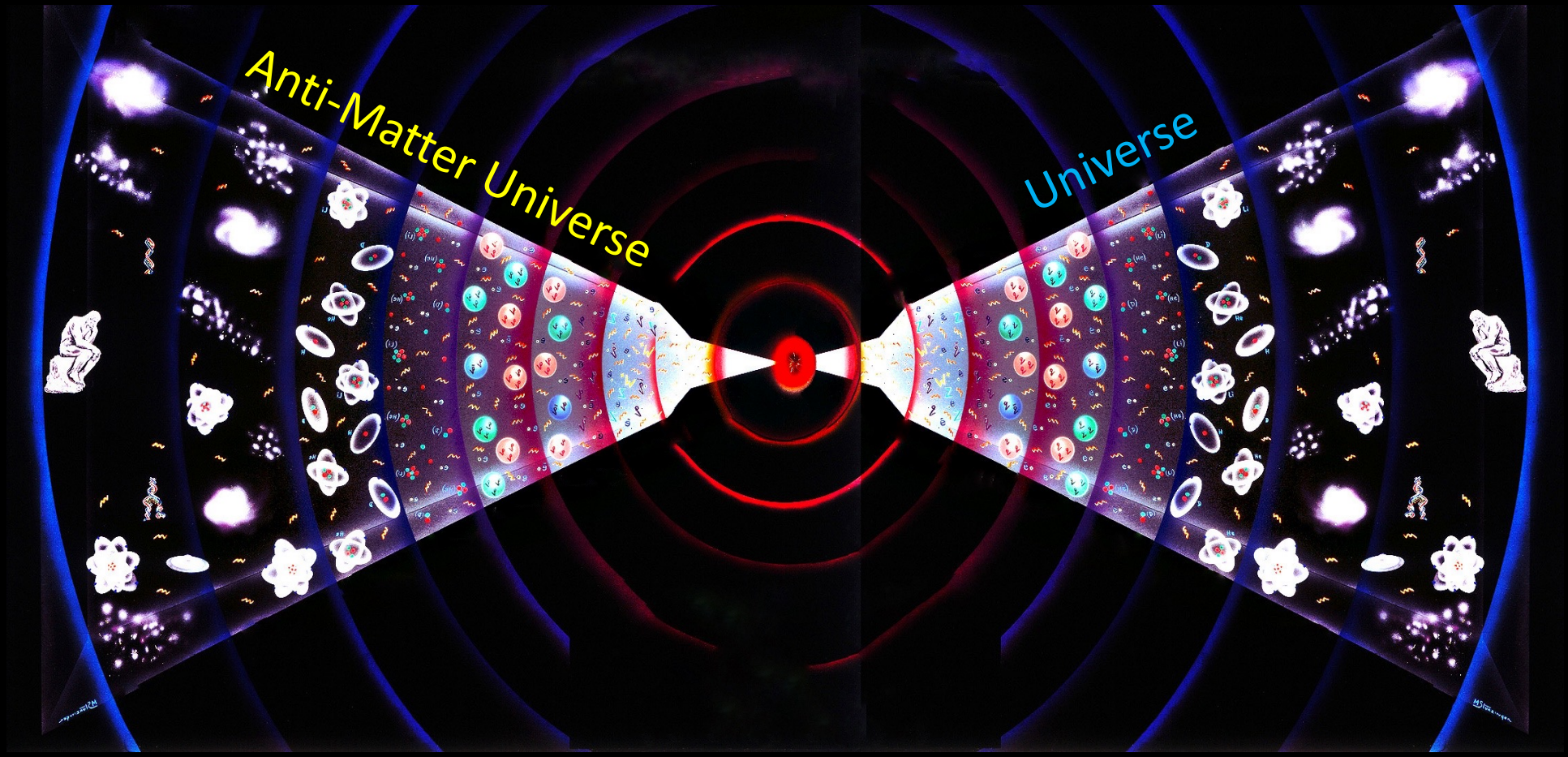
- The Antideuteron Flux is <10^{-4} of the Antiproton Flux
- High Signal-to-Background Ratio at low energy

* M. Korsmeier, et al, Phys.Rev.D (97) 103011
† I. Cholis et al., Phys. Rev. D. 102 (2020) 103019

Matter-Antimatter Asymmetry

According to the Big Bang Theory, matter-antimatter should be symmetry in the very early universe.

However, we observed clear dominance of matter over antimatter.

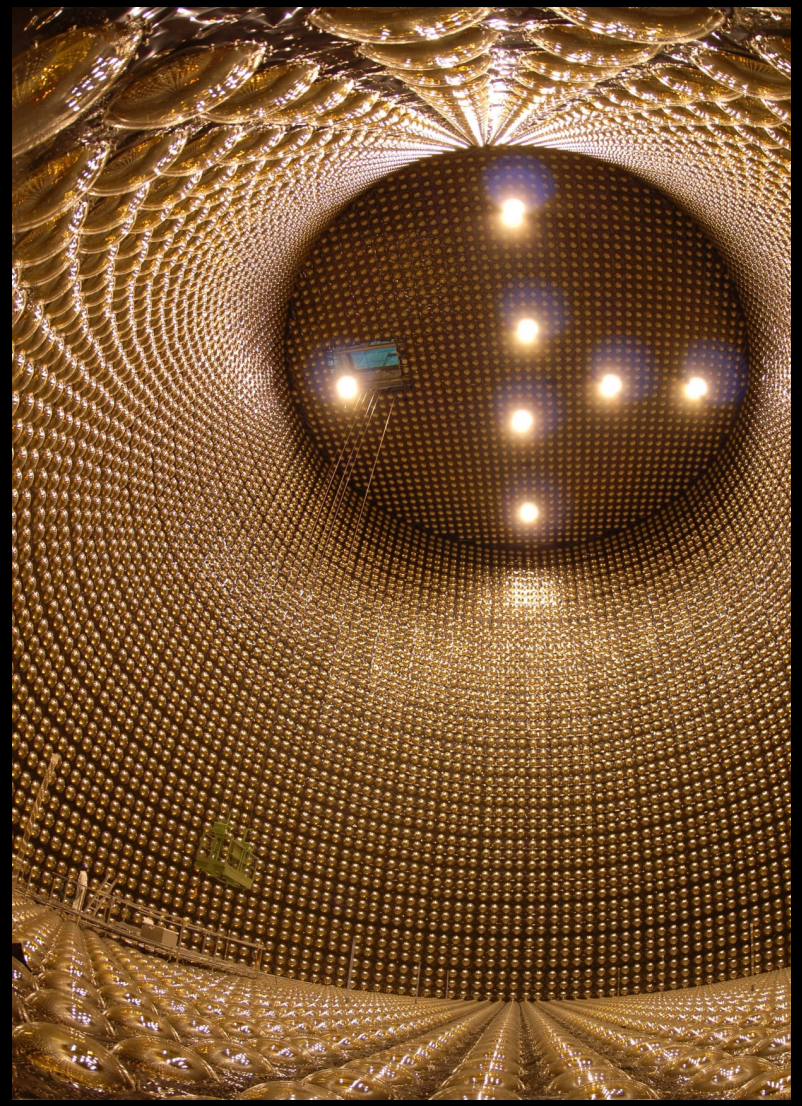


Search for Baryogenesis

Search for new symmetry breaking

LHC-b, ATLAS, CMS

Proton Decay

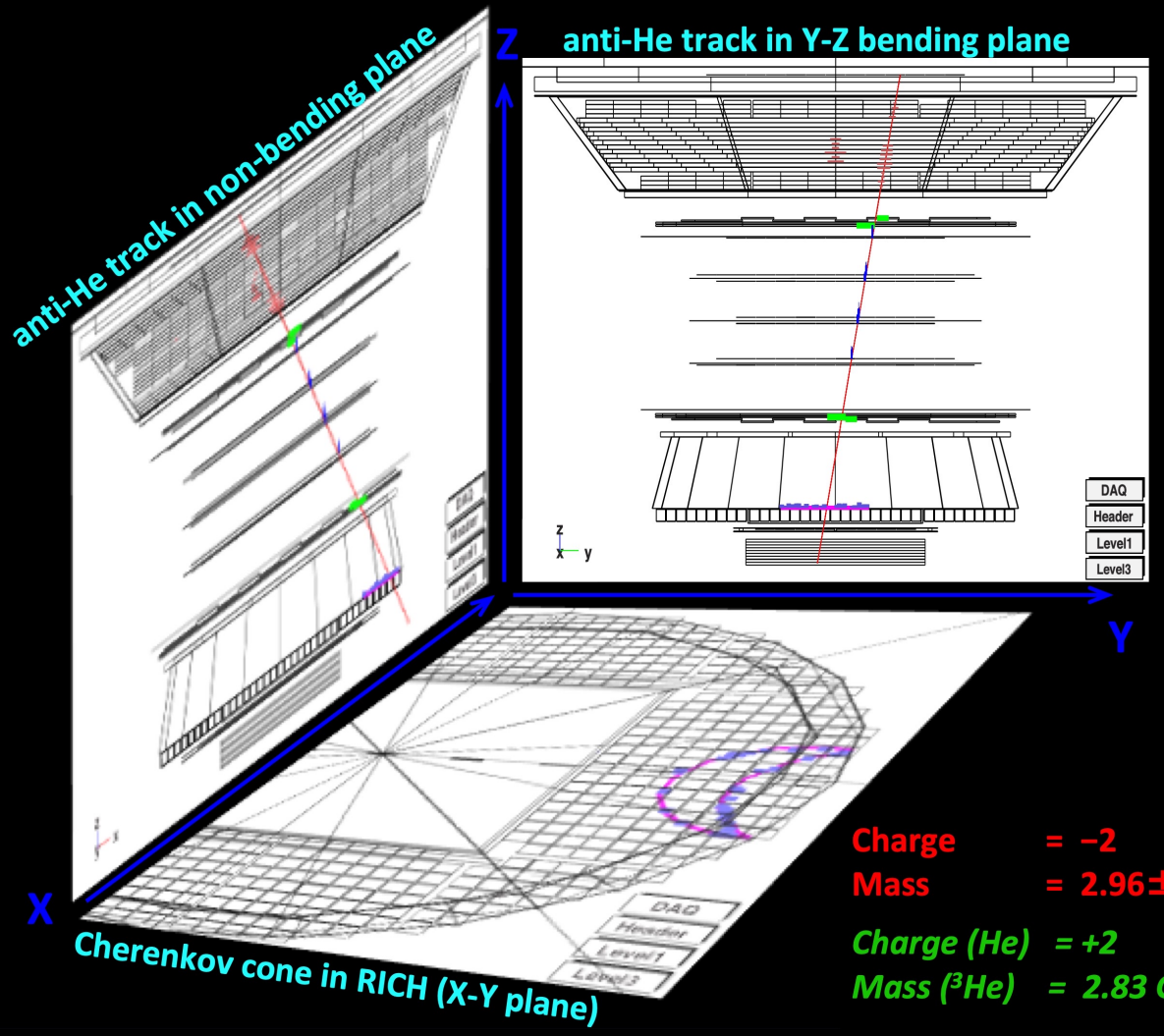


Super-Kamiokande

Cosmic Antihelium Candidates with AMS

AMS previously reported the rate of cosmic antihelium candidates is one event per year.

Simultaneously measuring antihelium and antideuteron provides crucial information on the origin of complex antiparticles.



Charge = −2

Mass = 2.96±0.33 GeV/c^2

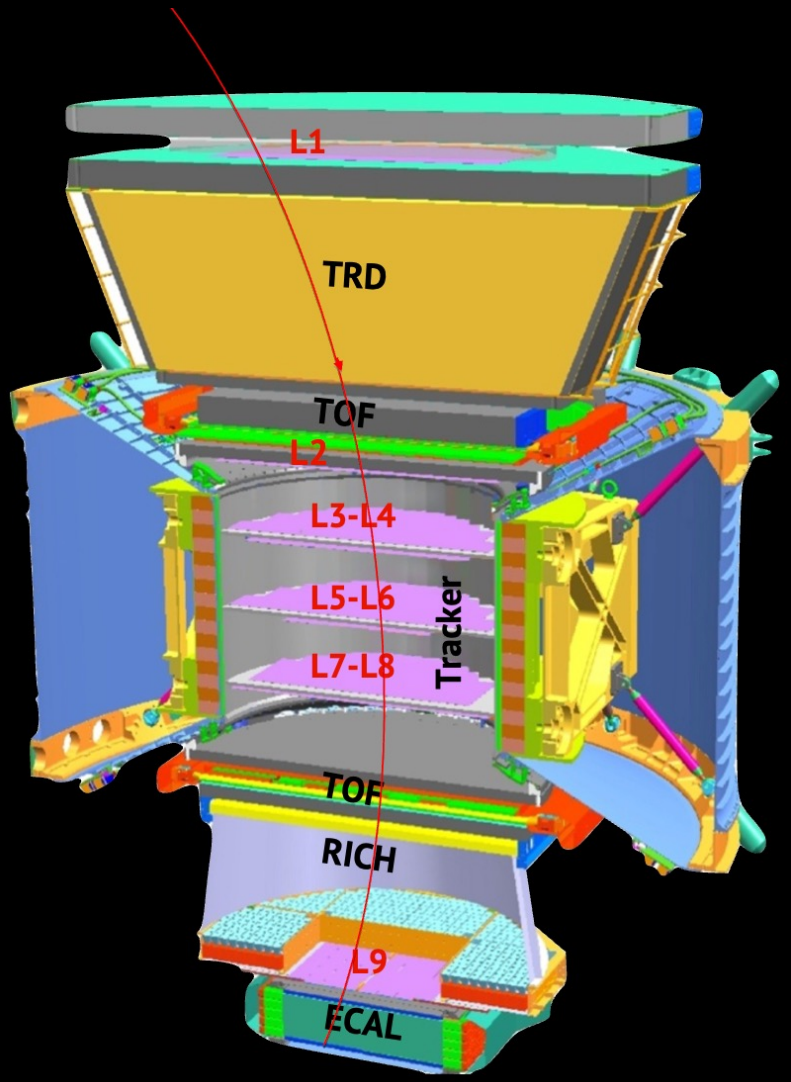
Charge (He) = +2

Mass (^{3}He) = 2.83 GeV/c^2

AMS Measurement of |Z| = 1 Particle to Identify Antideuteron

$e^{\pm}$ identified by the TRD

To distinguish $p^{\pm}$, $d^{\pm}$ the mass $M = RZ/\beta\gamma$ is reconstructed



Tracker + Magnet

Rigidity (R) and Charge Sign

R*Δ(1/R) ≈ 10% at 10GV

ToF

Velocity(β) and Direction by ΔT

$\Delta\beta/\beta^2 \approx 4\%$ (Z=1)

RICH

Velocity(β) by Cherenkov light

$\Delta\beta/\beta \approx 0.1$ - 0.4% (Z=1)

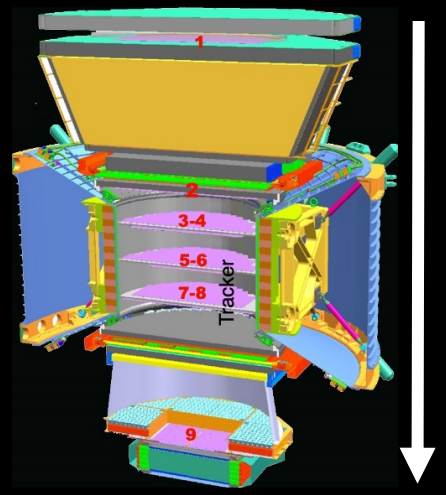
TRD, Tracker, TOF, RICH

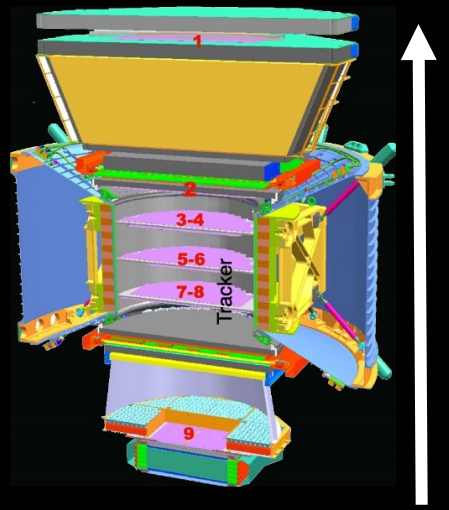
Charge Magnitude

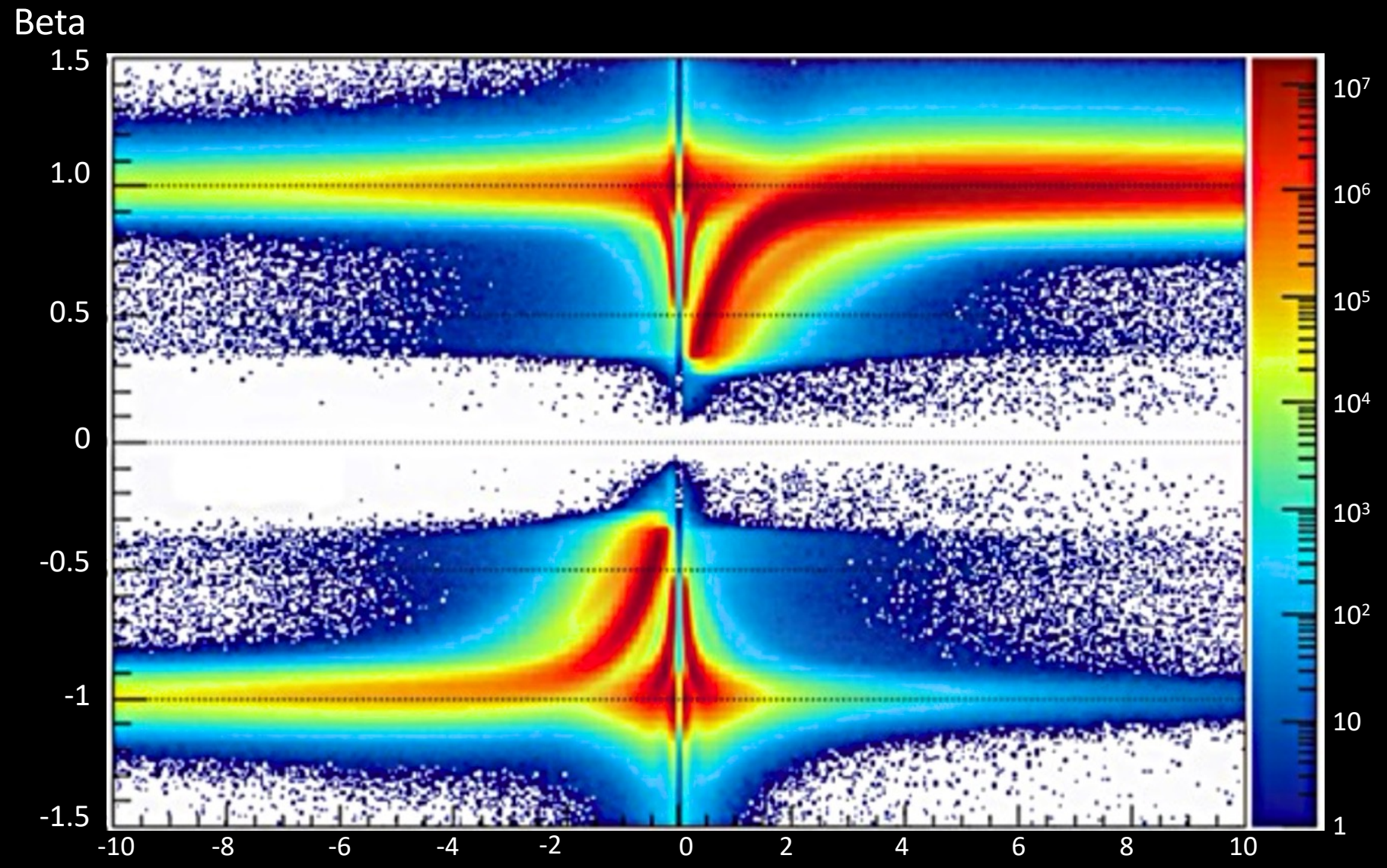
Along Particle Trajectory

ΔZ (Z=1) ≈ 0.05-0.1

Velocity and Rigidity Measurements of |Z|=1 Particles by AMS

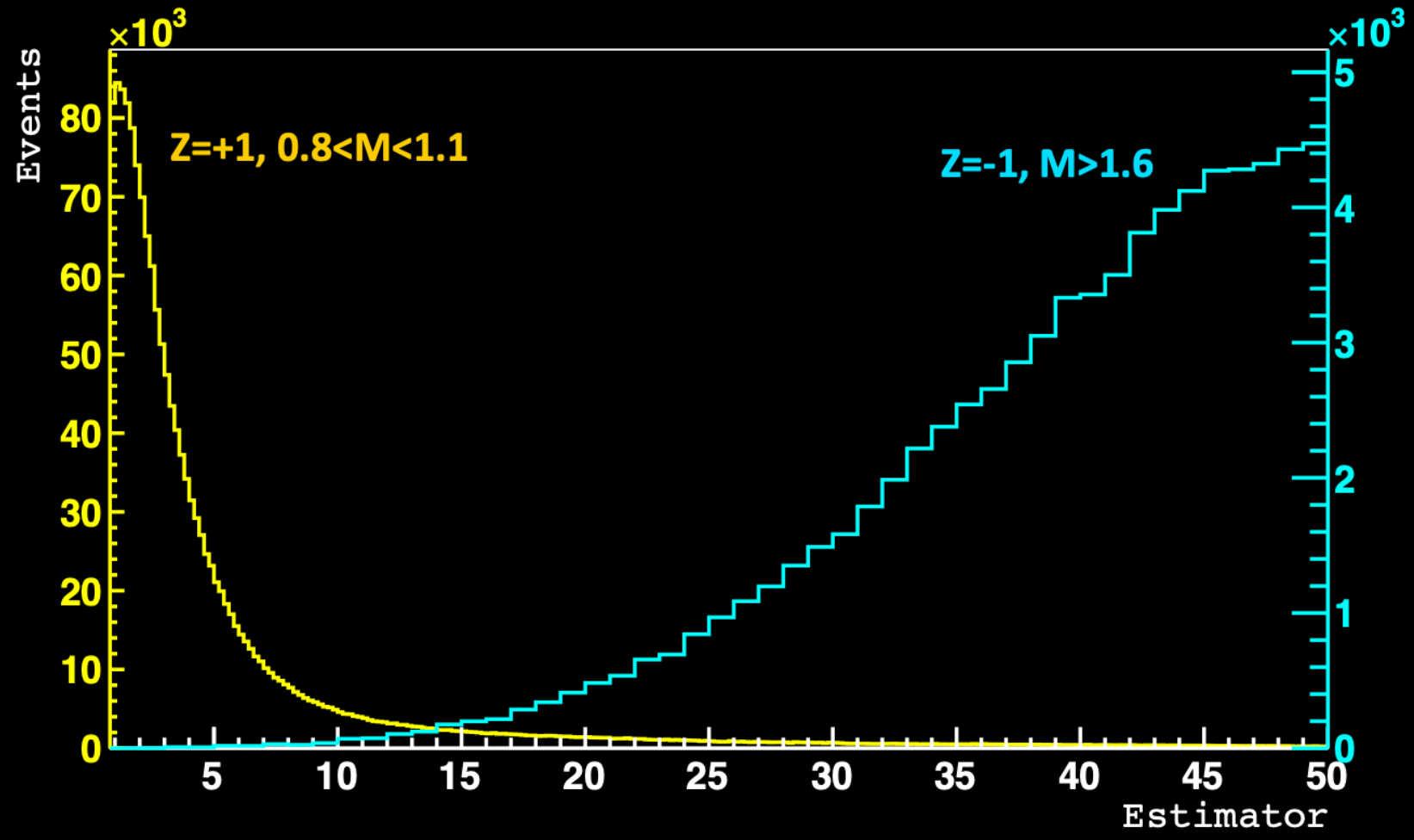






Data-Driven Method: Mass Quality Estimator

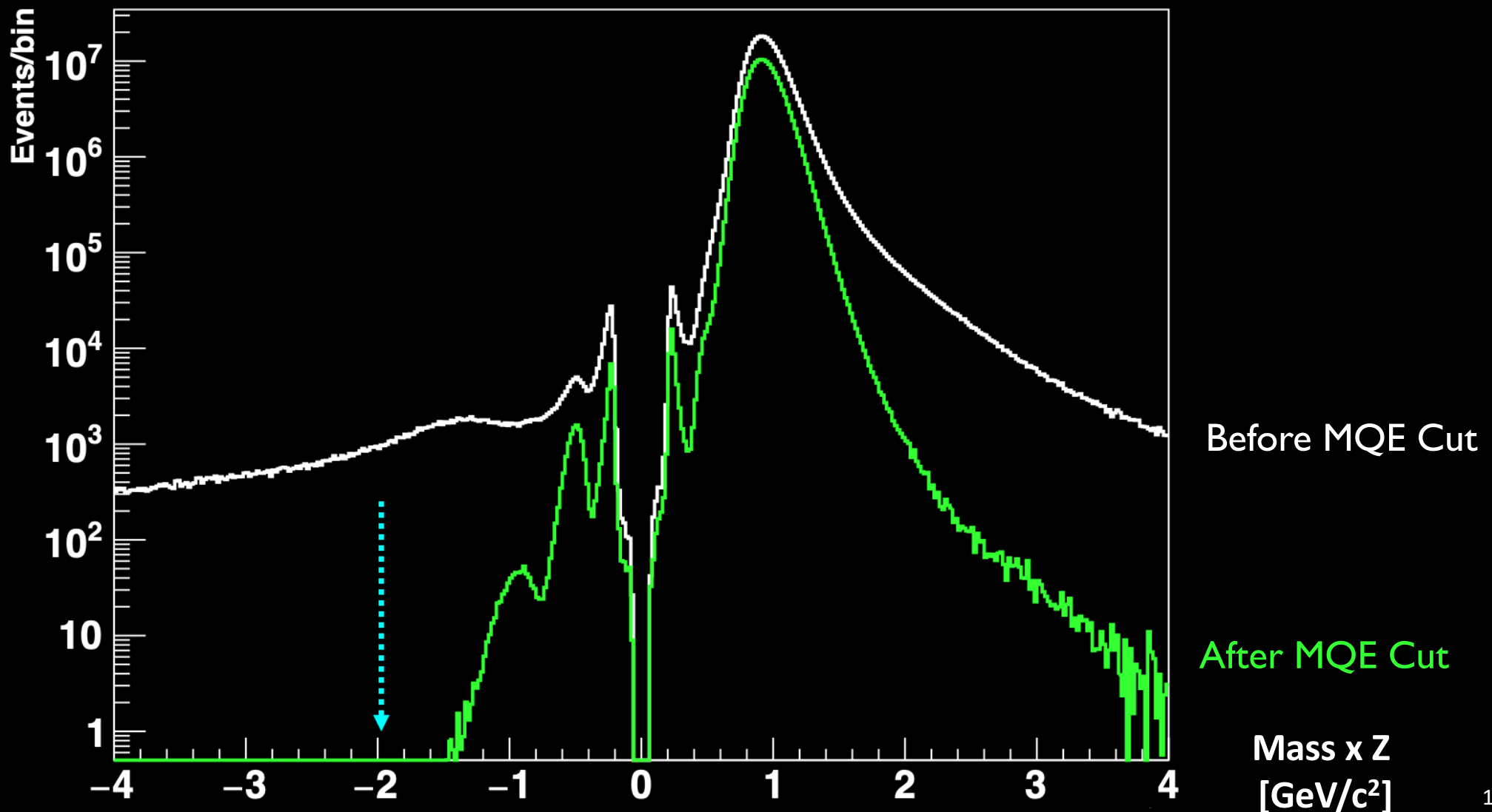
Use the sum of log-likelihood $E = -\sum \log P(v_i)$ for variables (v_i)
from ***TOF, Tracker, RICH, TRD*** to build the Mass Quality Estimator (MQE)



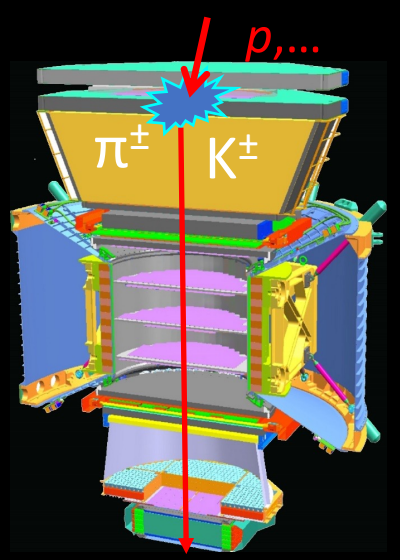
MQE is built with only AMS data collected in space

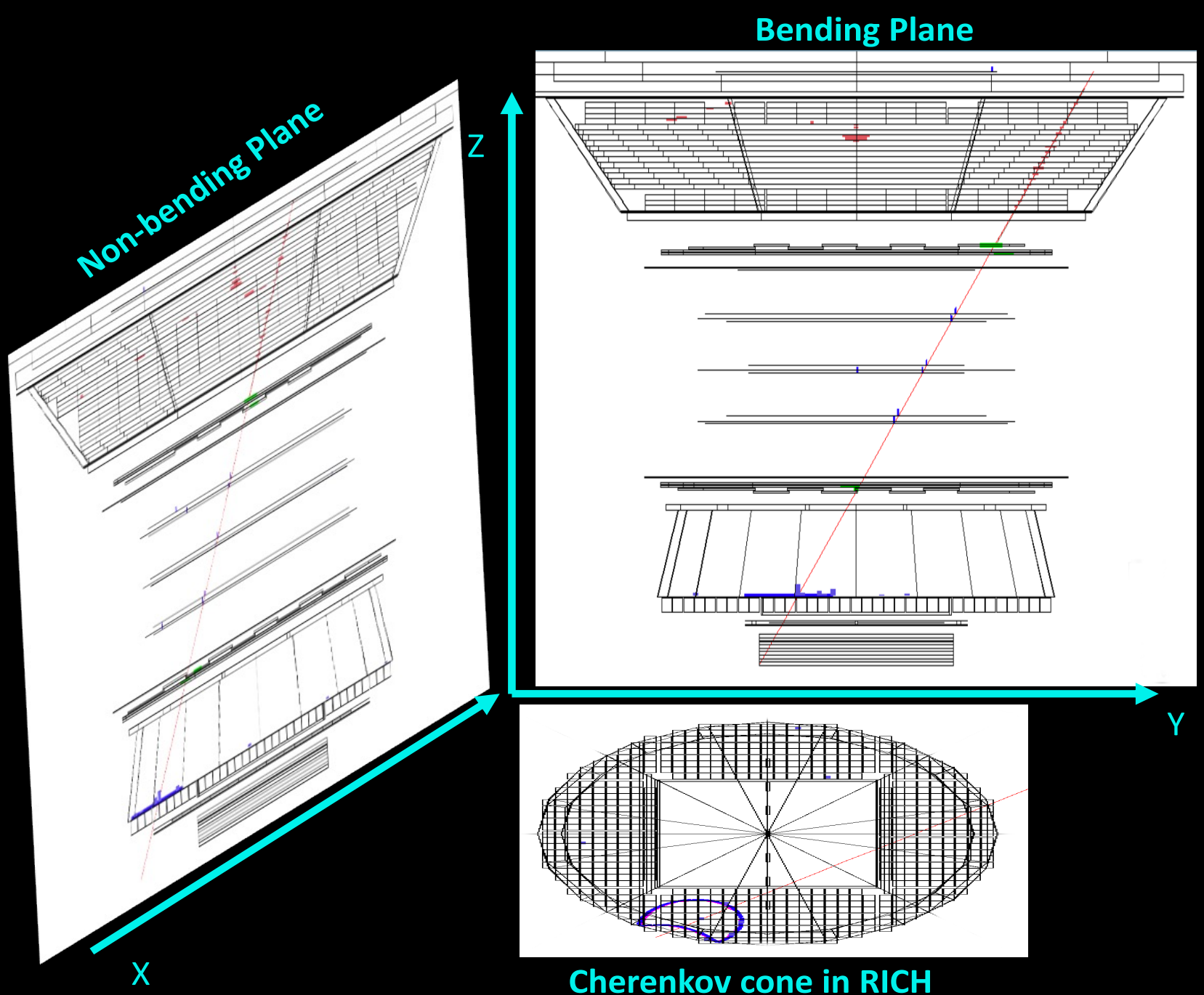
Performance Validation with Proton Monte Carlo

Background events are rejected with high efficiency



Current AMS Anti-Deuteron Status





Cherenkov cone in RICH

Anti-deuteron Candidate
Charge = -1.02 ± 0.05
Mass = 1.9±0.1 *GeV/c²*

Deuteron
Charge = +1
Mass = 1.88 *GeV/c²*

A few antideuteron candidates has been observed with AMS.

AMS will continue to take data for the ISS lifetime, exploring the origin of the cosmic ray antiparticles.