

Cosmic Antiproton and Properties of Elementary Particles over an 11-year Solar Cycle Measured by AMS



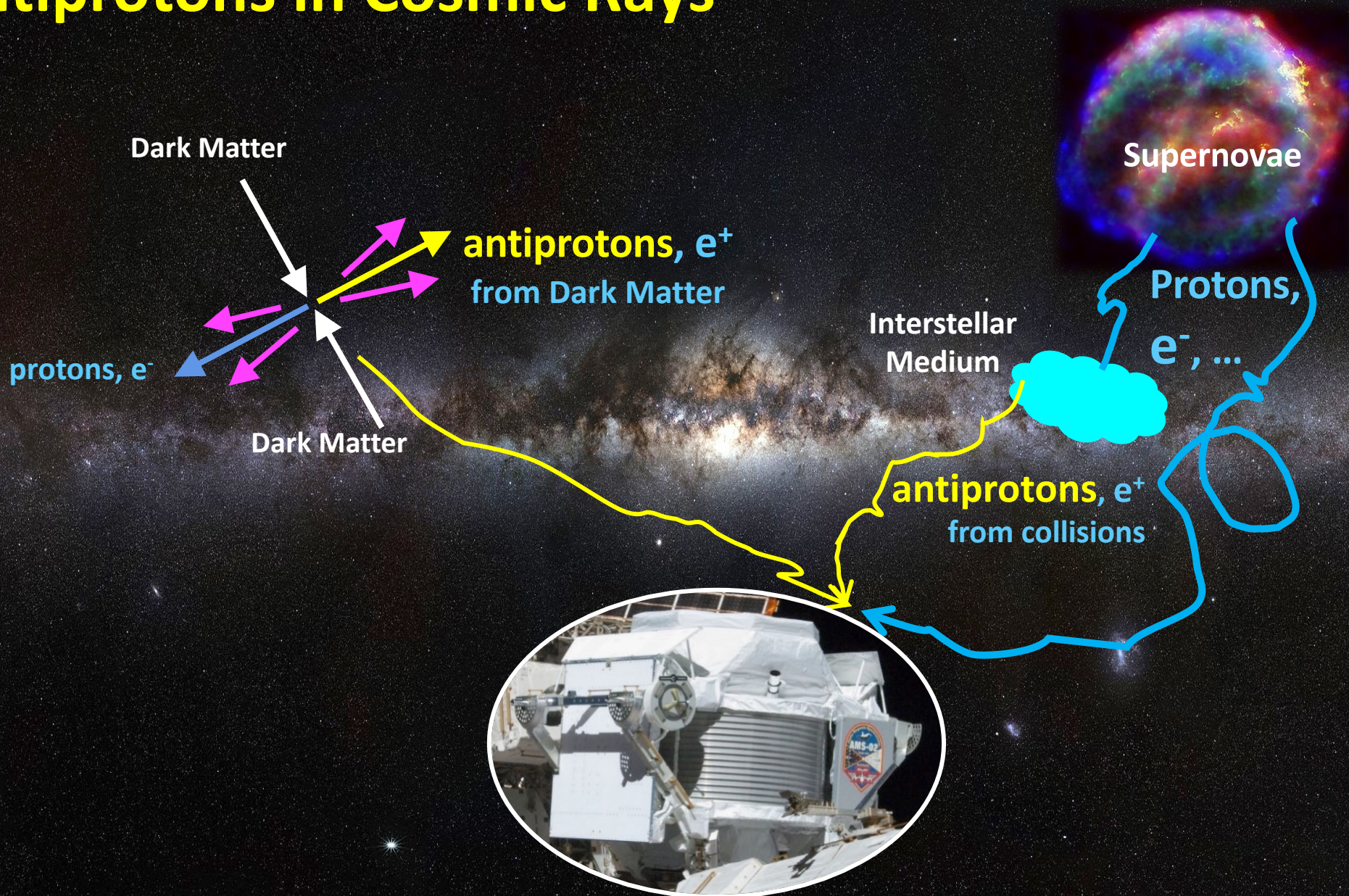
Senquan Lu on behalf of the *AMS* collaboration

Institute of High Energy Physics (**IHEP**),

Chinese Academy of Science

ICHEP 2024 Prague, Czech Republic

Antiprotons in Cosmic Rays

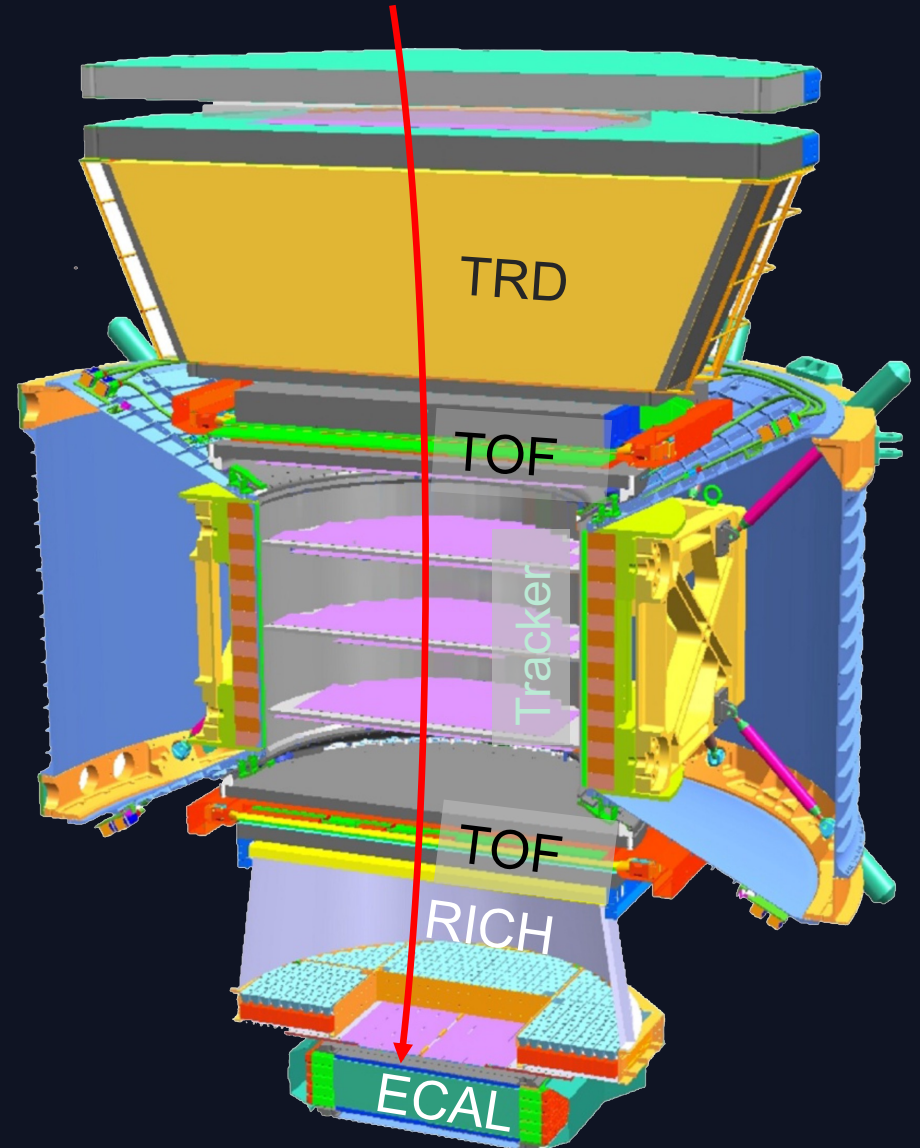


Measurement of Cosmic Antiprotons in AMS

The flux of antiproton is less than 10^{-4} of proton flux

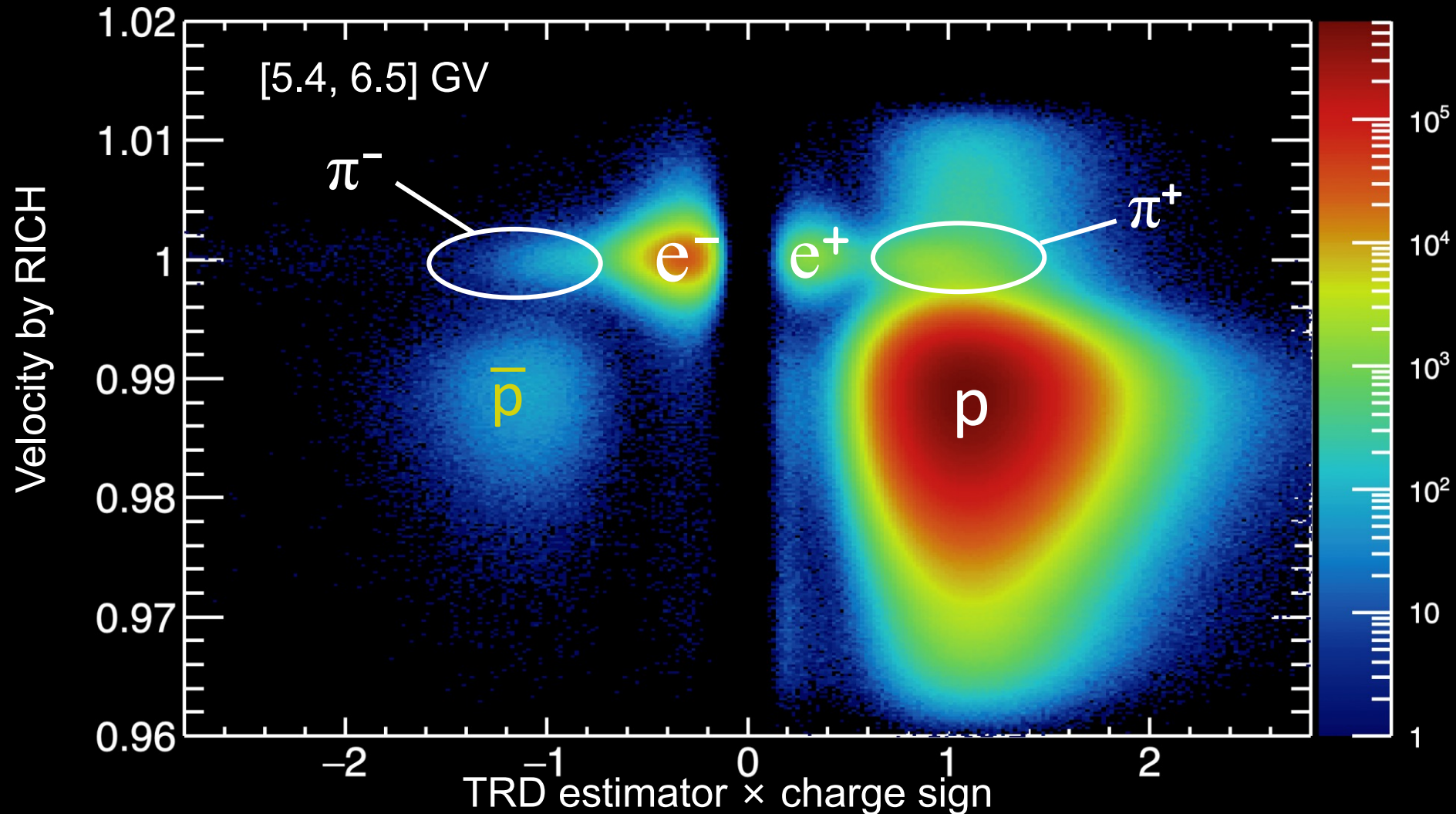
A percent level precision measurement requires background rejection close to 1 in a million

- TRD and ECAL:
reject electrons backgrounds
- Tracker and TOF:
separate protons backgrounds
- RICH and tracker:
identify antiprotons by mass

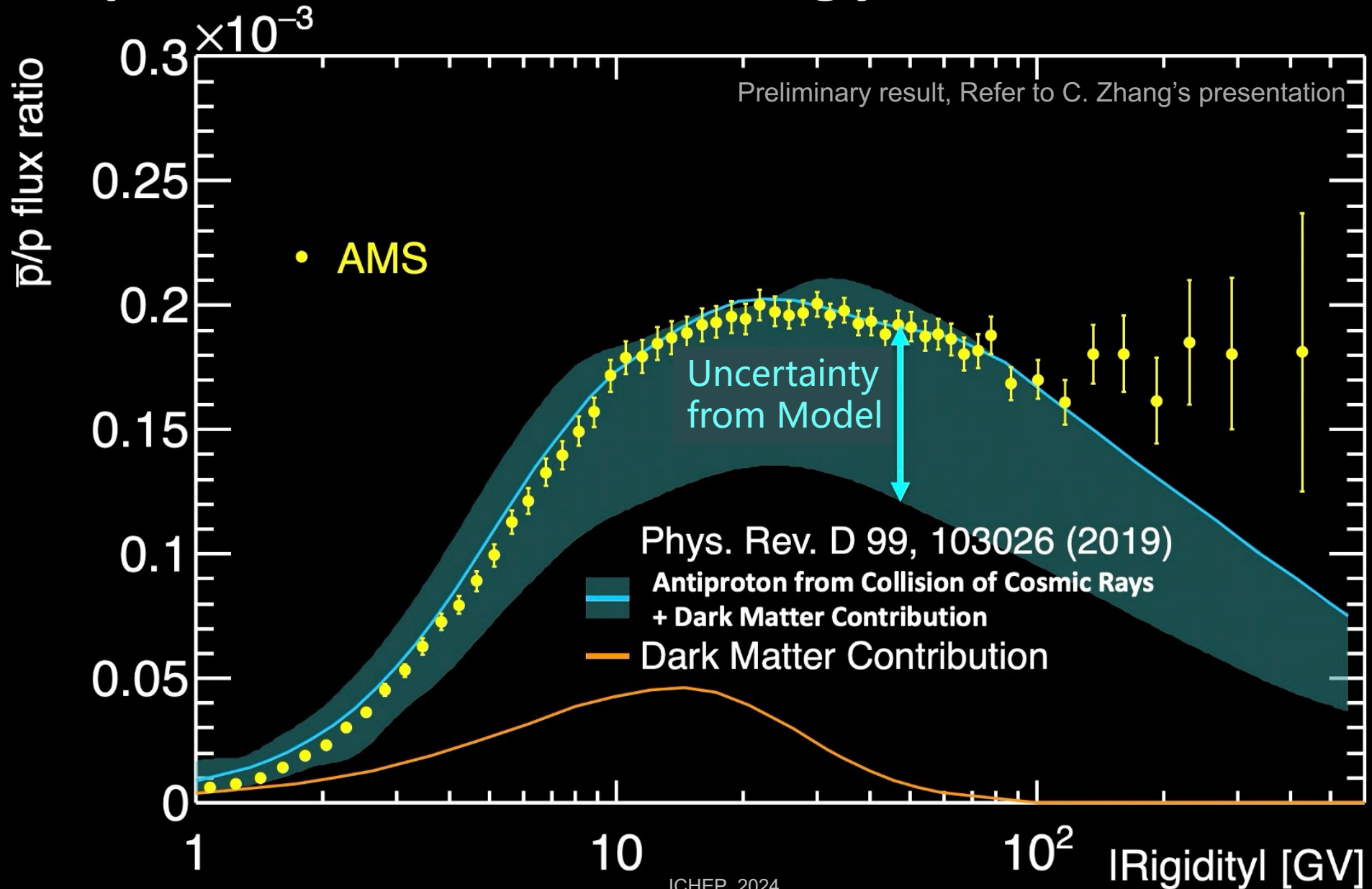


Antiproton Identification

AMS is able to identify particles precisely.
Antiproton signal are well separated from backgrounds (π^- produced in detector, e^- and protons)



Antiproton and Low Energy Dark Matter



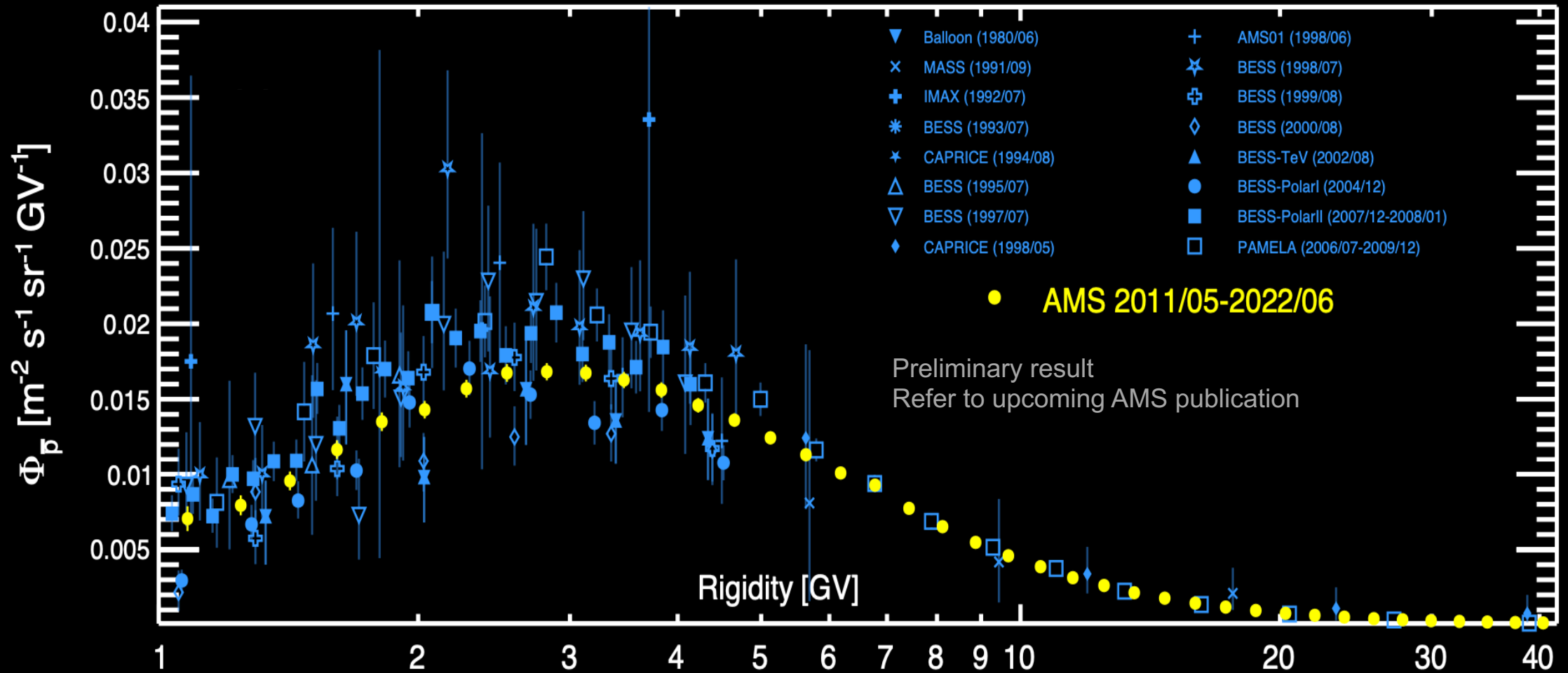
Time Variation of Antiprotons

AMS is the only experiment to measure precisely and continuously the time dependence of cosmic ray antiproton, providing important information to:

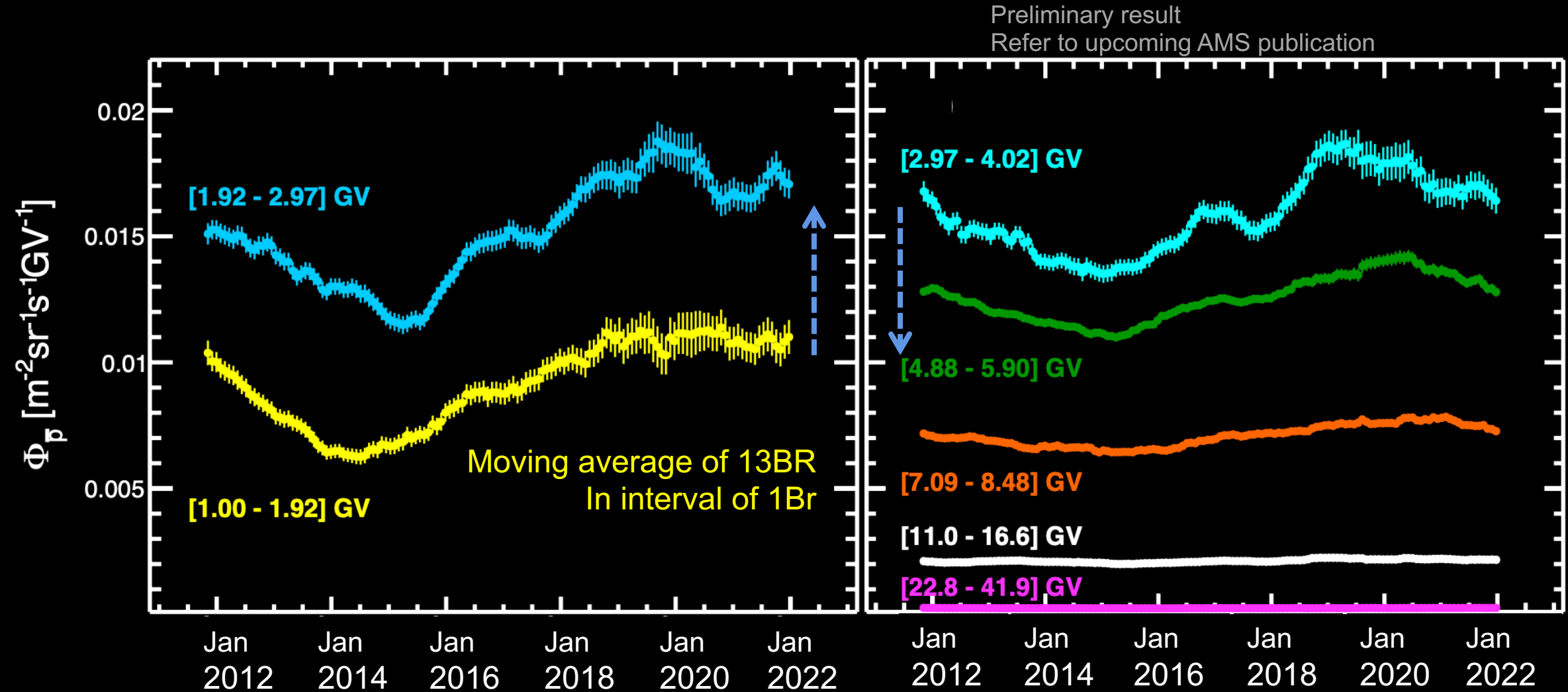
- Study the solar modulation: charge-sign, mass and spectrum shape.
- Understand the background for searching for new physics (e.g. dark matter) through antiproton measurements.

Together with already published p , e^+ , e^- fluxes from AMS, now, solar modulation can be studied with all four stable elementary particles in cosmic rays from the very same experiment.

Antiproton Fluxes in an 11-Years Solar Cycle

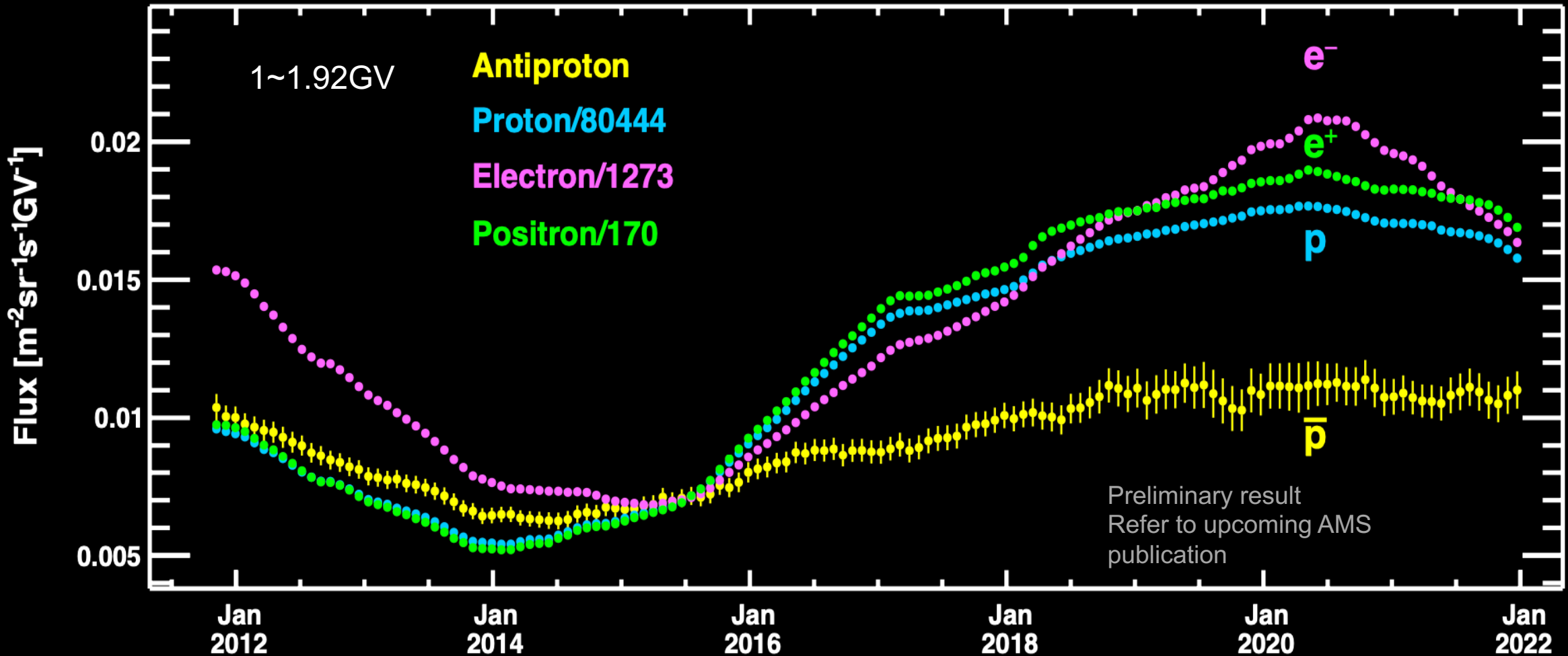


Time Dependent Antiproton Fluxes



Elementary Particles Fluxes Time Dependence

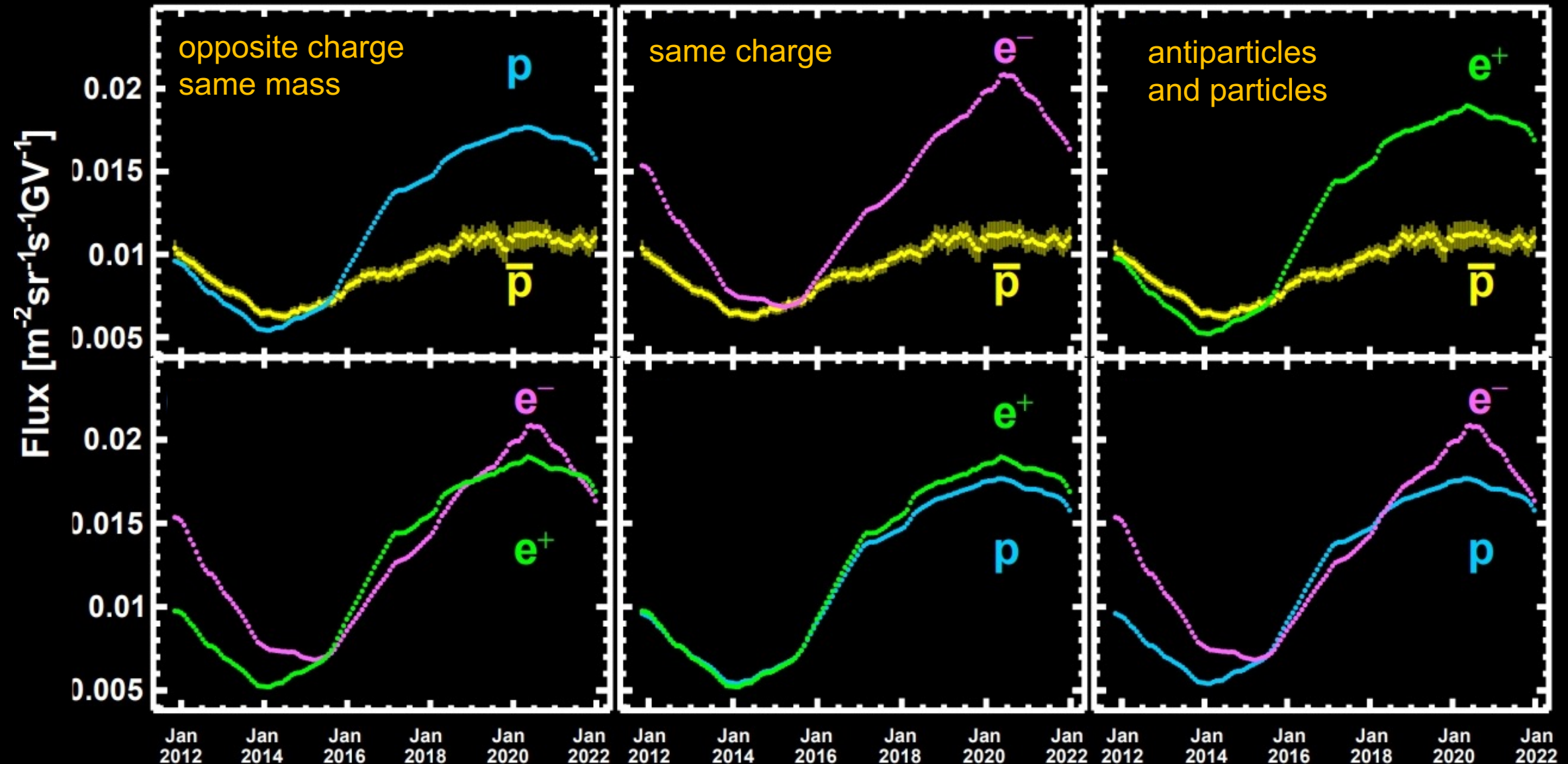
Antiproton flux is distinct to other particles



Refer to J. Casaus's presentation for details

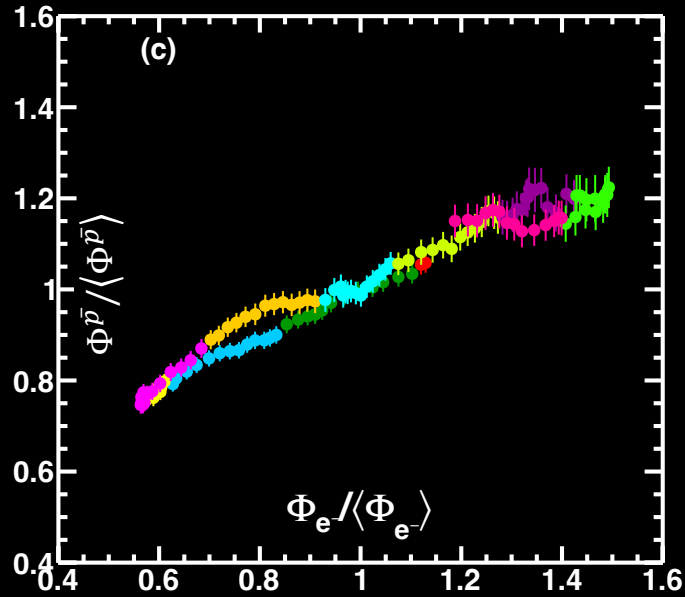
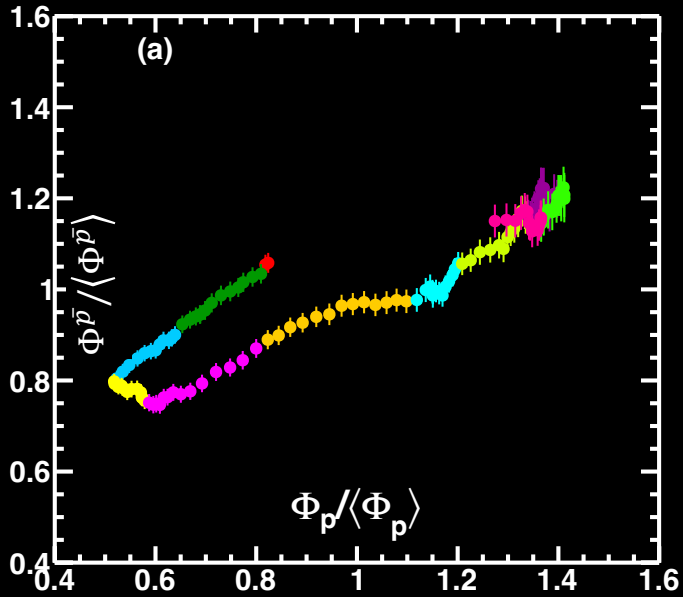
Elementary Particles Fluxes Time Dependence

1~1.92GV

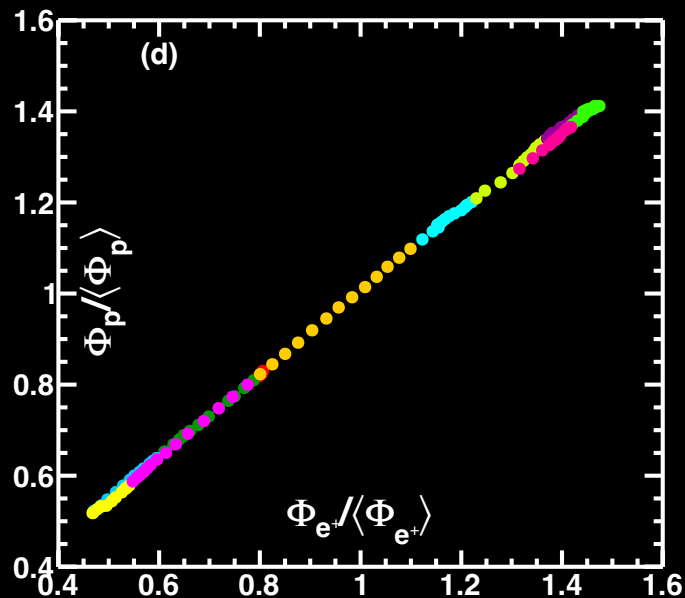
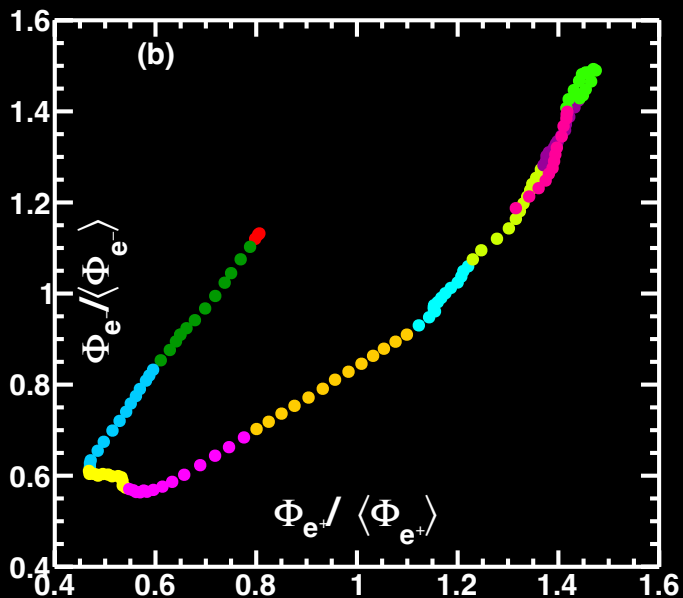


Hysteresis of Elementary Particles

opposite charge



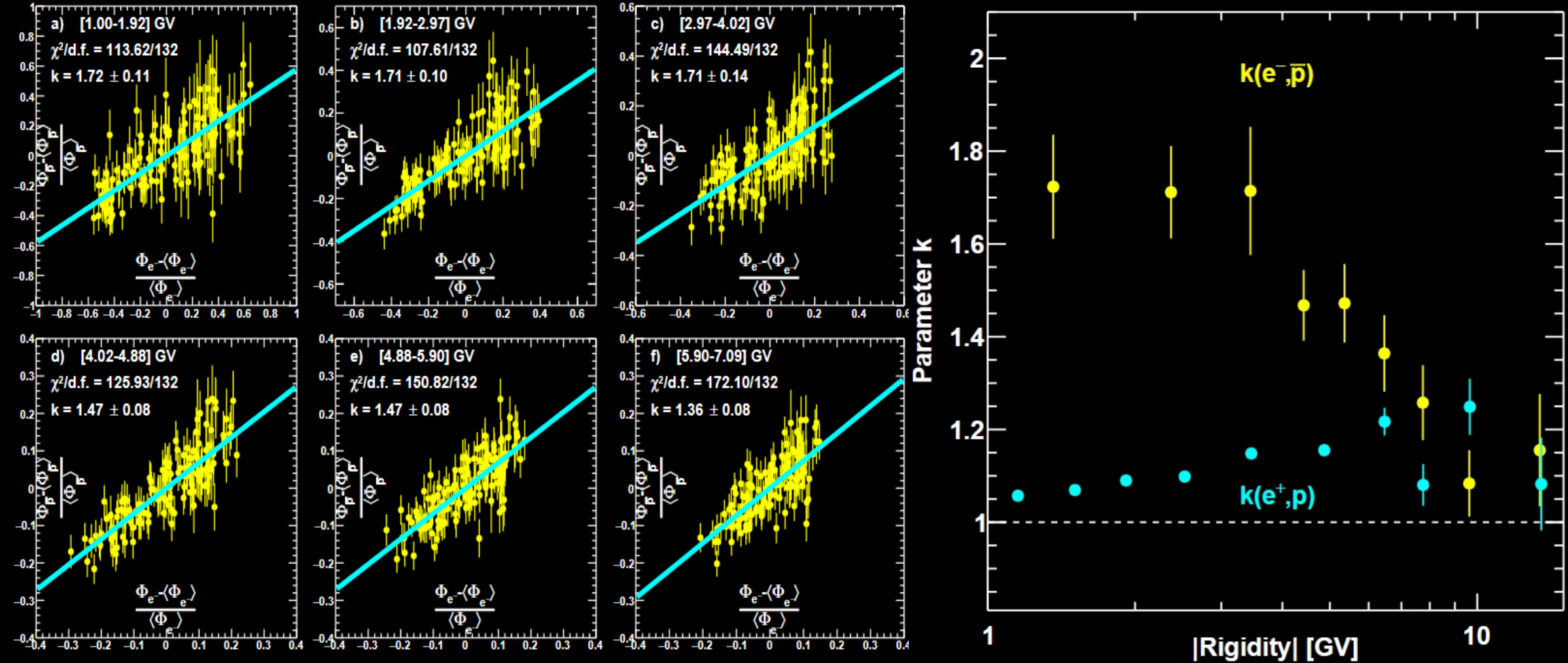
same charge



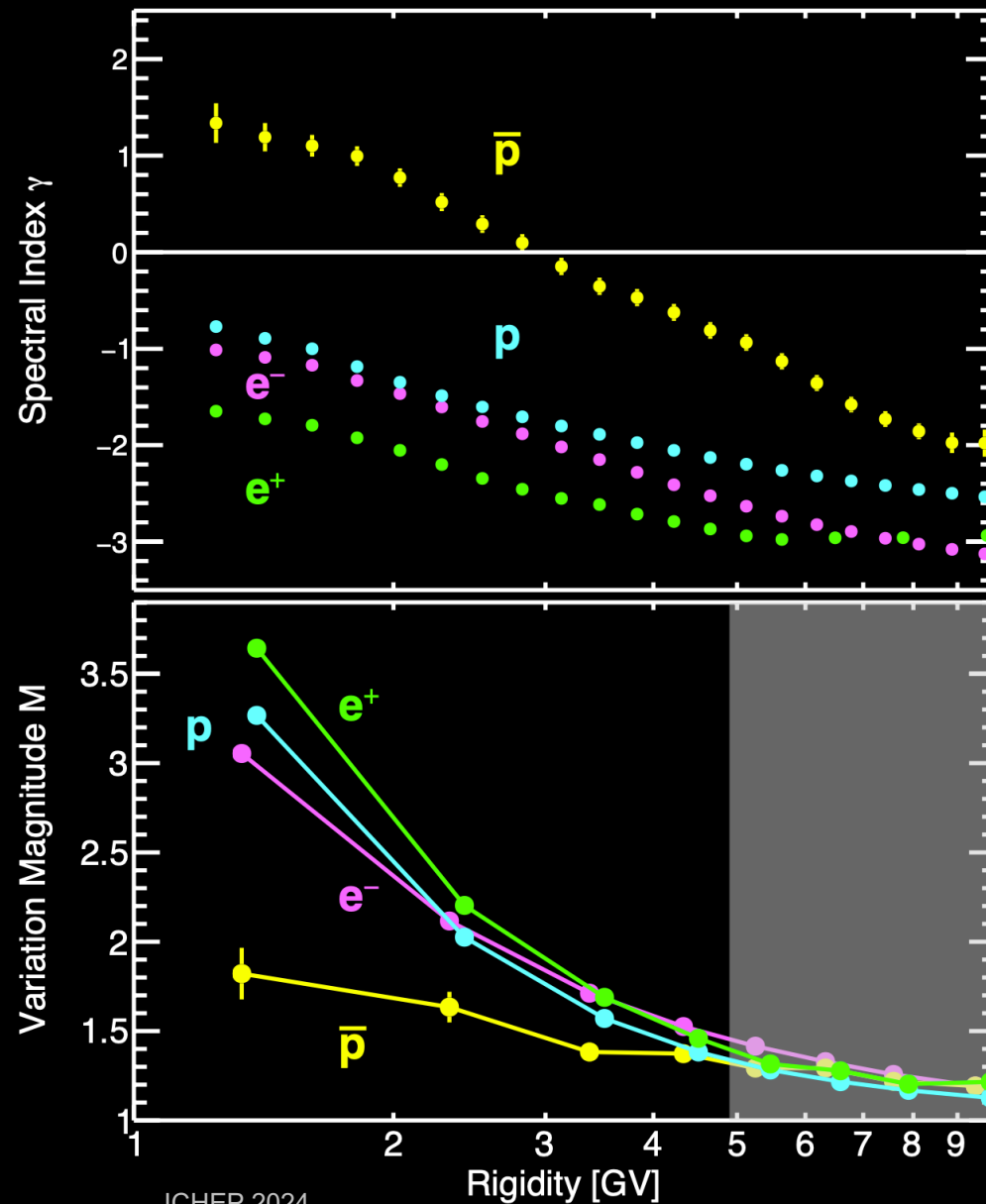
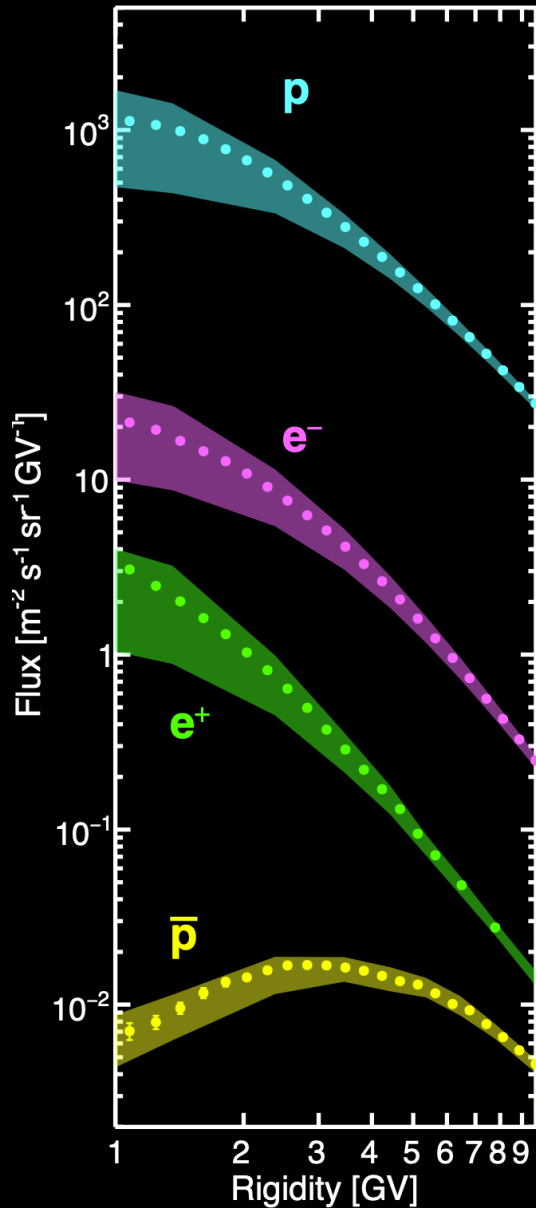
- 2011
- 2012
- 2013
- 2014
- 2015
- 2016
- 2017
- 2018
- 2019
- 2020
- 2021

Preliminary result
Refer to upcoming
AMS publication

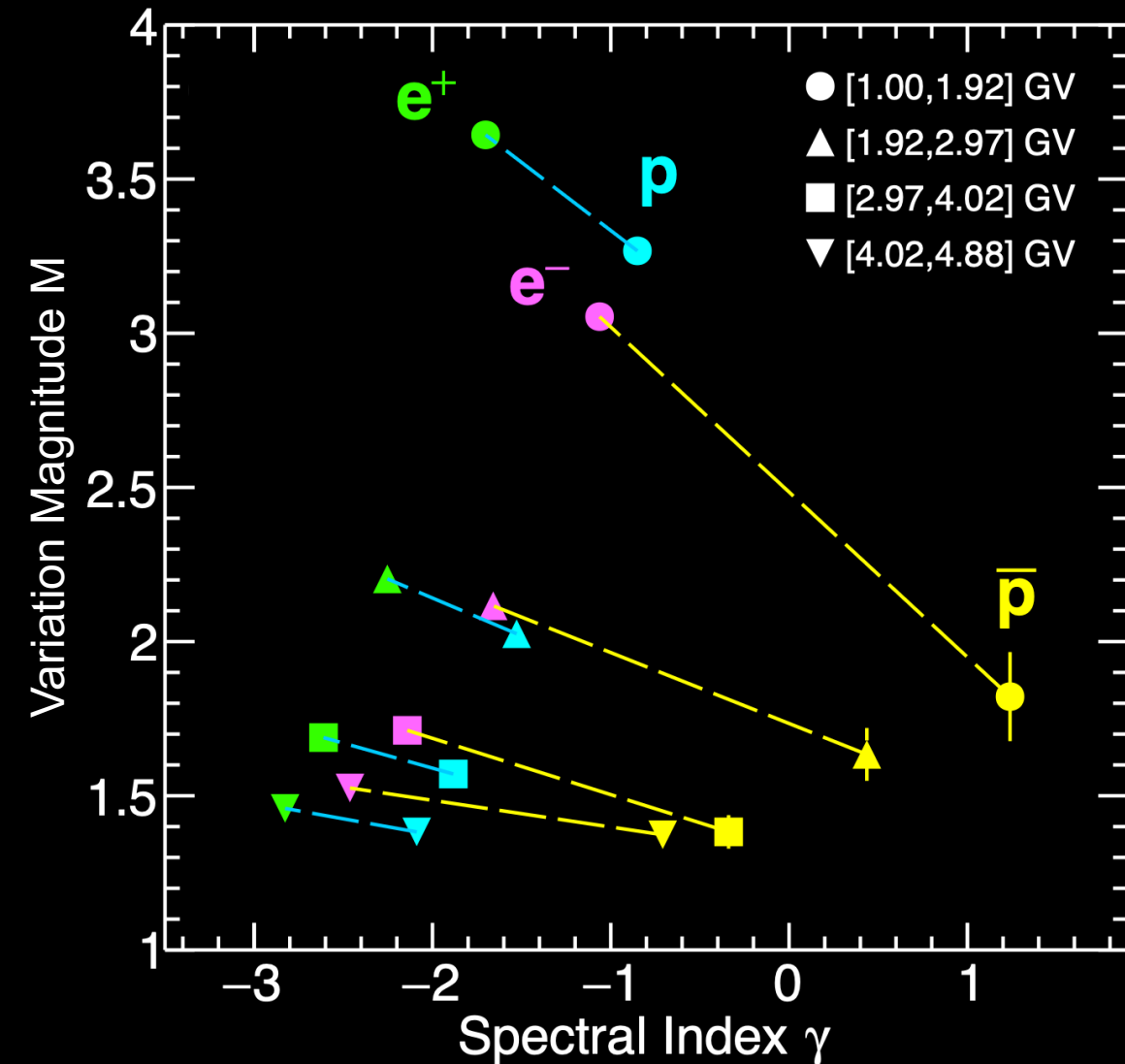
Linear Relation of Antiprotons and Electrons



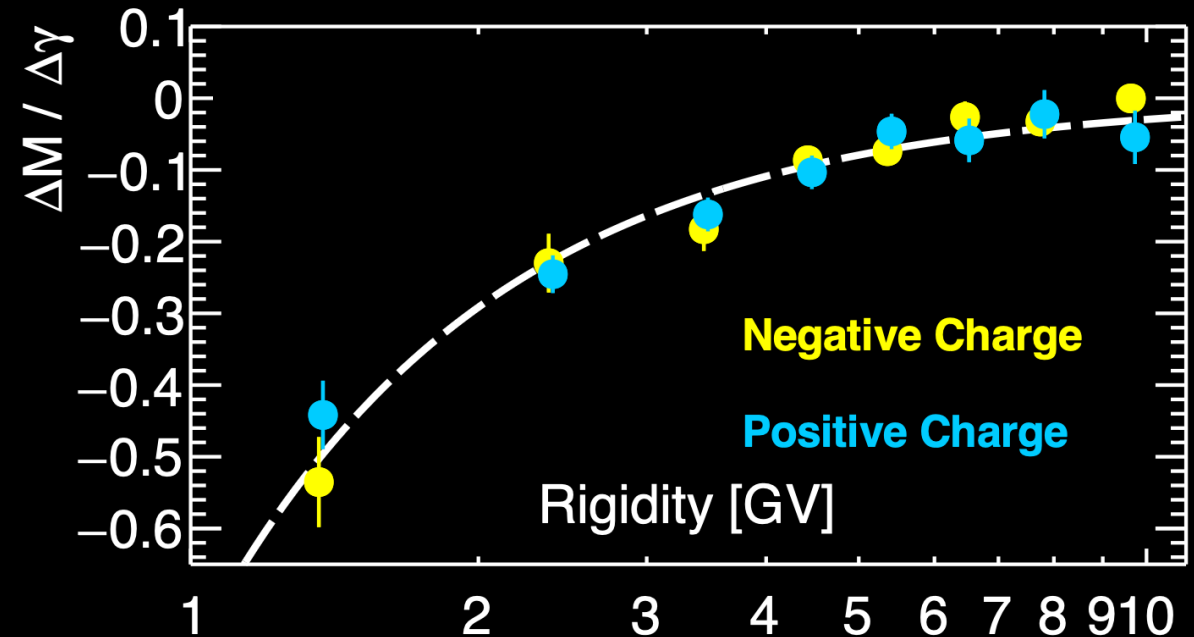
Variation Magnitudes and Flux Spectra



Variation Magnitudes and Spectrum Indexes



- Clear relationship between γ and M for both positive and negative particles in each rigidity bin
- The ratio approaches zero at high rigidity
- **Most importantly the ratios for positive and negative particles are consistent**



Summary

- Cosmic antiproton fluxes and time variation have been measured using the first 11 years of AMS data
- Temporal variations of all four cosmic-ray stable elementary particles p , e^- , e^+ , and \bar{p} are studied simultaneously over an solar cycle
- A hysteresis between \bar{p} fluxes and p fluxes is observed. In contrast, \bar{p} and e^- fluxes show a linear correlation but \bar{p} fluxes change significantly less than e^- fluxes.
- Remarkably, a clear correlation between the magnitude of flux temporal variation over an 11-year solar cycle and the shape of their rigidity spectrum universal for both positively charged and negatively charged particles are found
- By continuously operating to 2030, AMS measurement will cover two solar cycles and provide unique contribution to the understanding of solar modulations