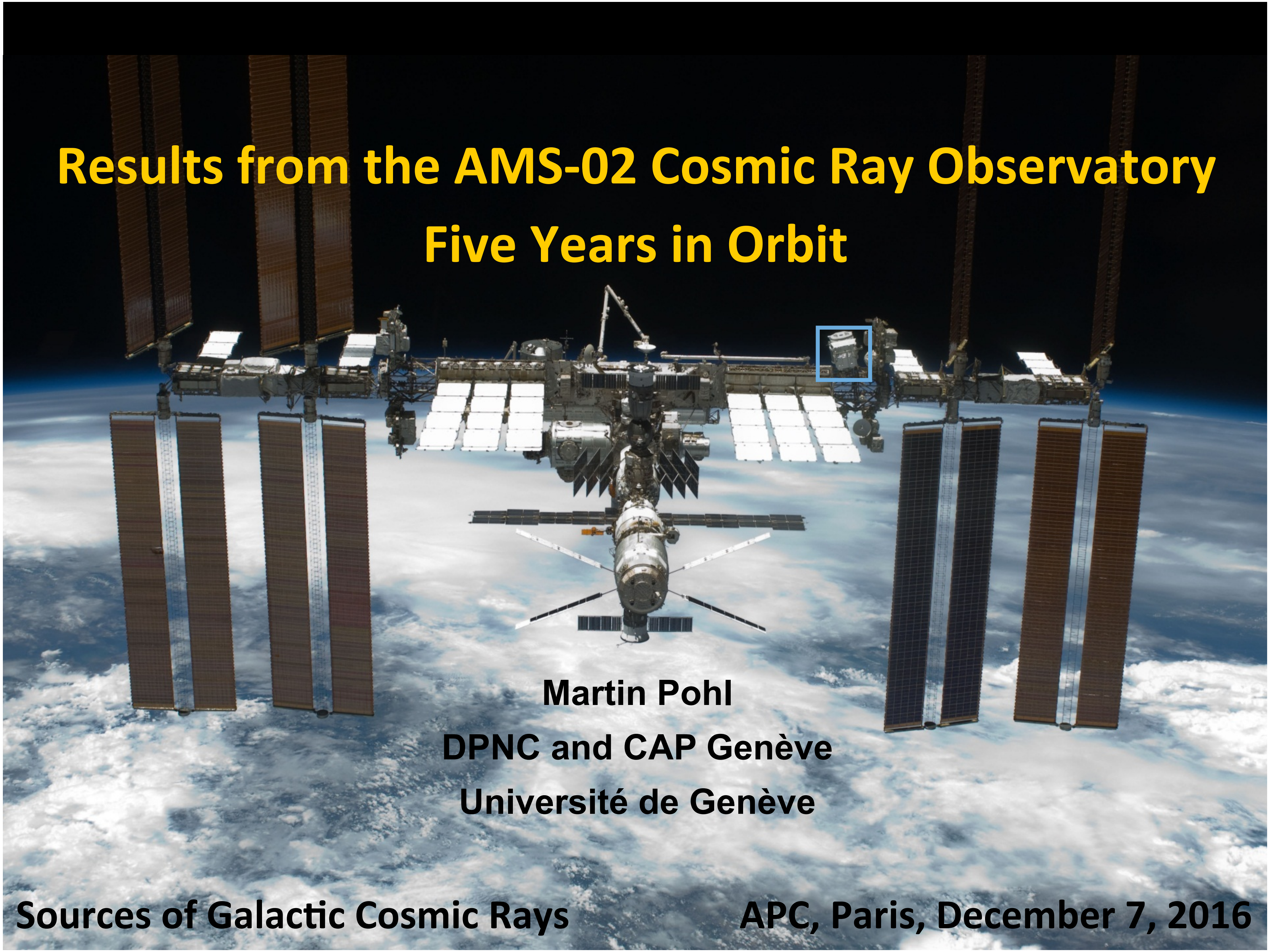


Results from the AMS-02 Cosmic Ray Observatory
Five Years in Orbit

Martin Pohl

DPNC and CAP Genève

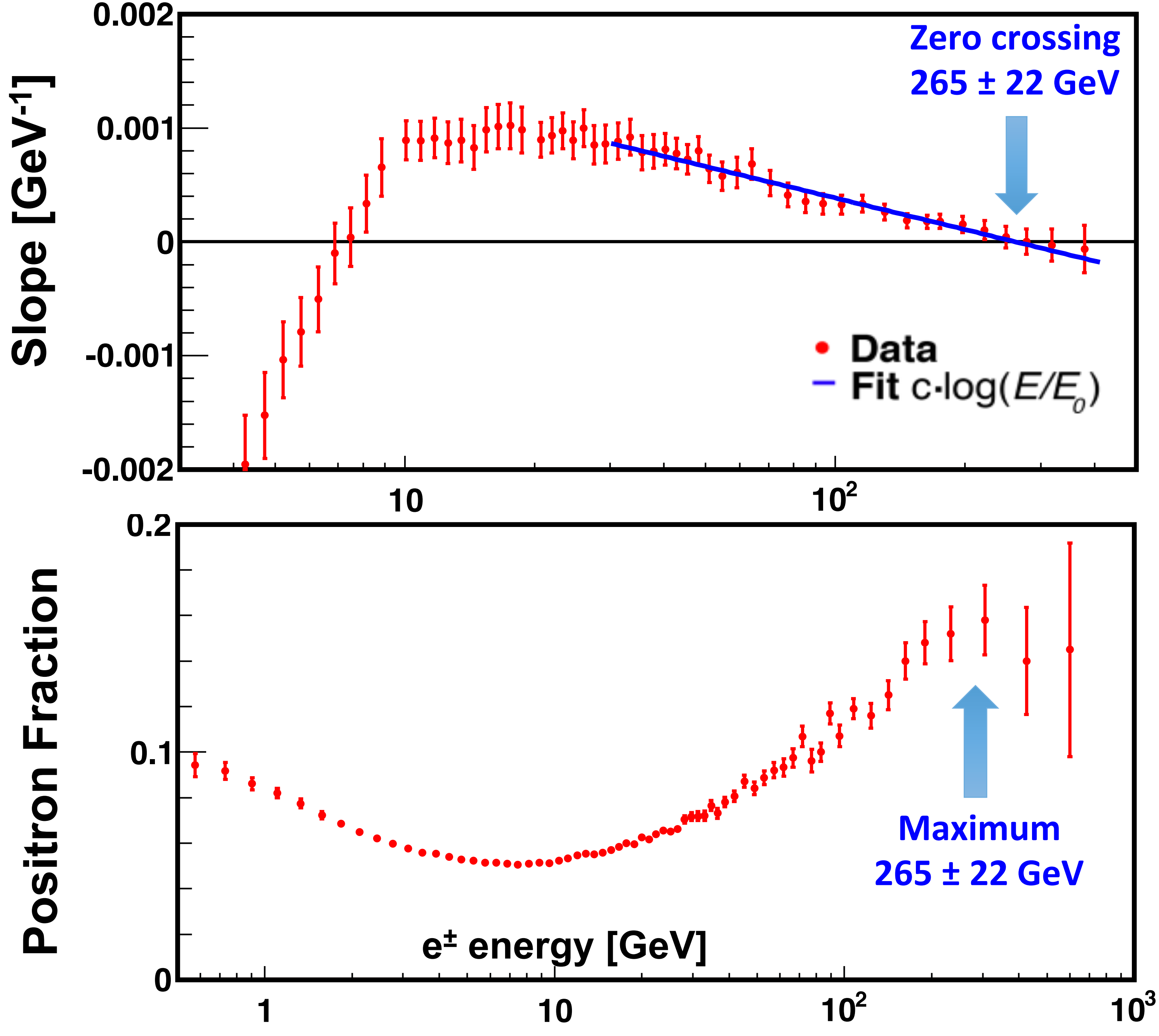
Université de Genève

Sources of Galactic Cosmic Rays APC, Paris, December 7, 2016

In 5 years on ISS, AMS has collected >85 billion charged cosmic rays.
AMS is a state-of-the–art particle detector with a lot of redundancy.
The data was analysed by at least two independent international teams

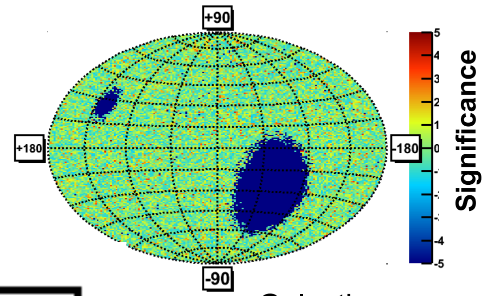
Positron fraction

Latest published result based on 20 million e^+, e^- events

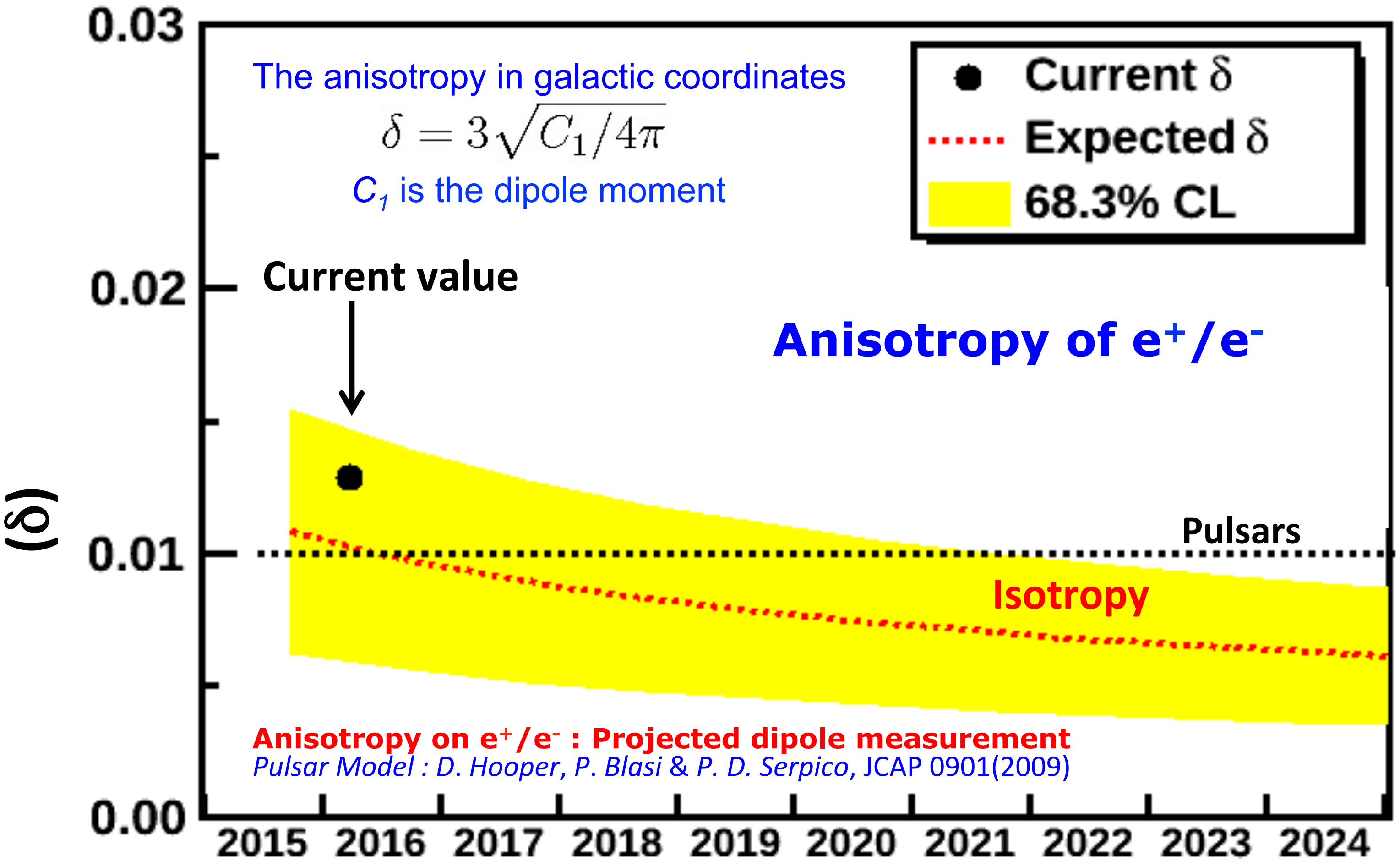


Anisotropy

The fluctuations of the positron ratio e^+/e^- are isotropic.



Galactic coordinates (b,l)



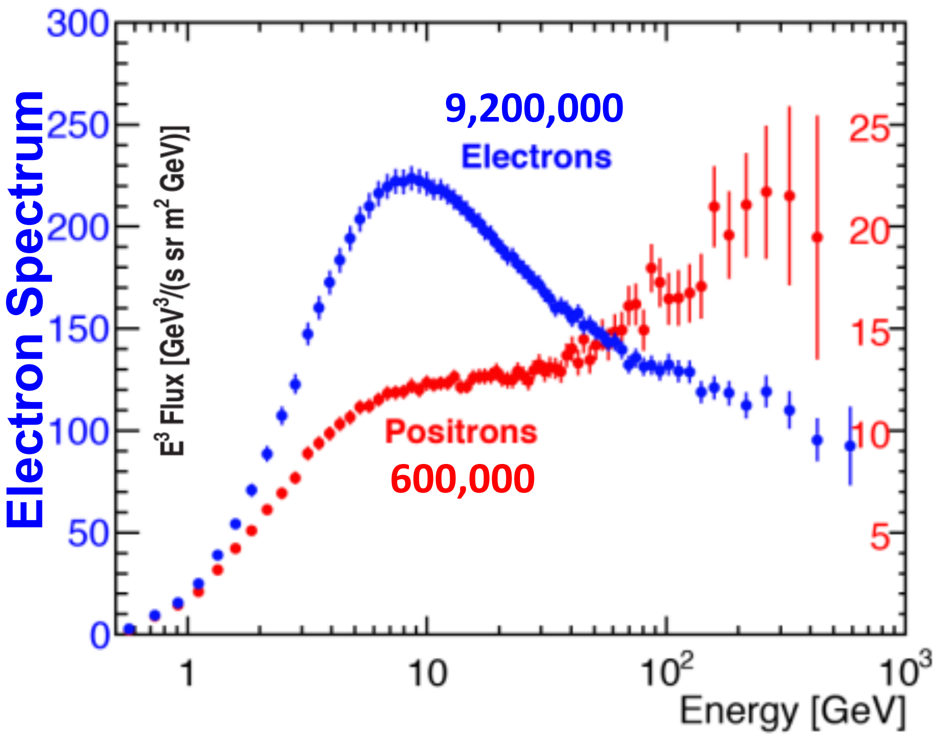
Data taking to 2024, will allow to explore anisotropies of 1%

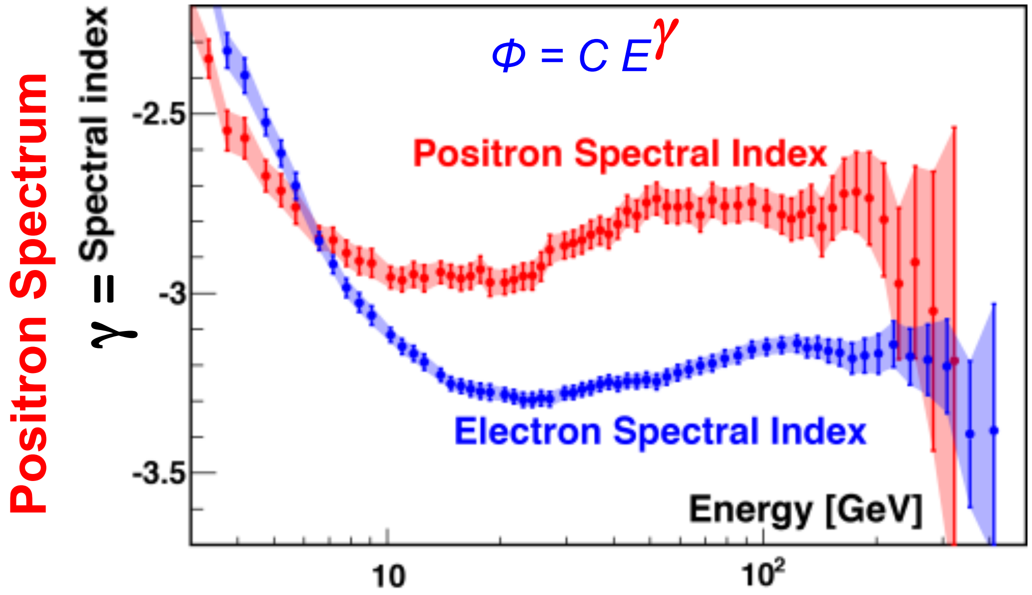
The Electron and Positron fluxes

PRL **113,** 121102 (2014) PHYSICAL REVIEW LETTERS week ending 19 SEPTEMBER 2014

Electron and Positron Fluxes in Primary Cosmic Rays Measured with the Alpha Magnetic Spectrometer on the International Space Station

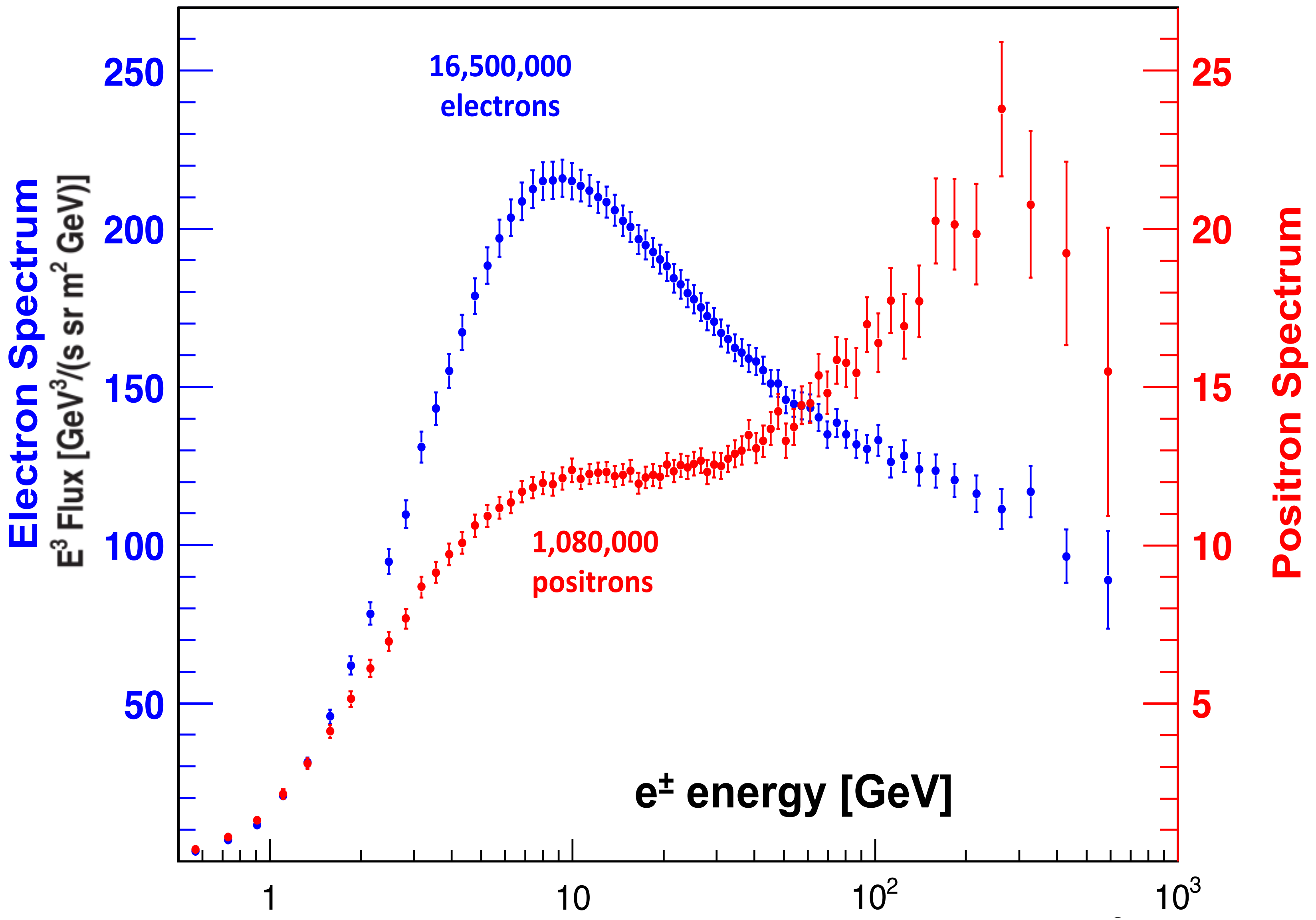
Based on 0.6 million positron events





Latest results based on 1.08 million positron events

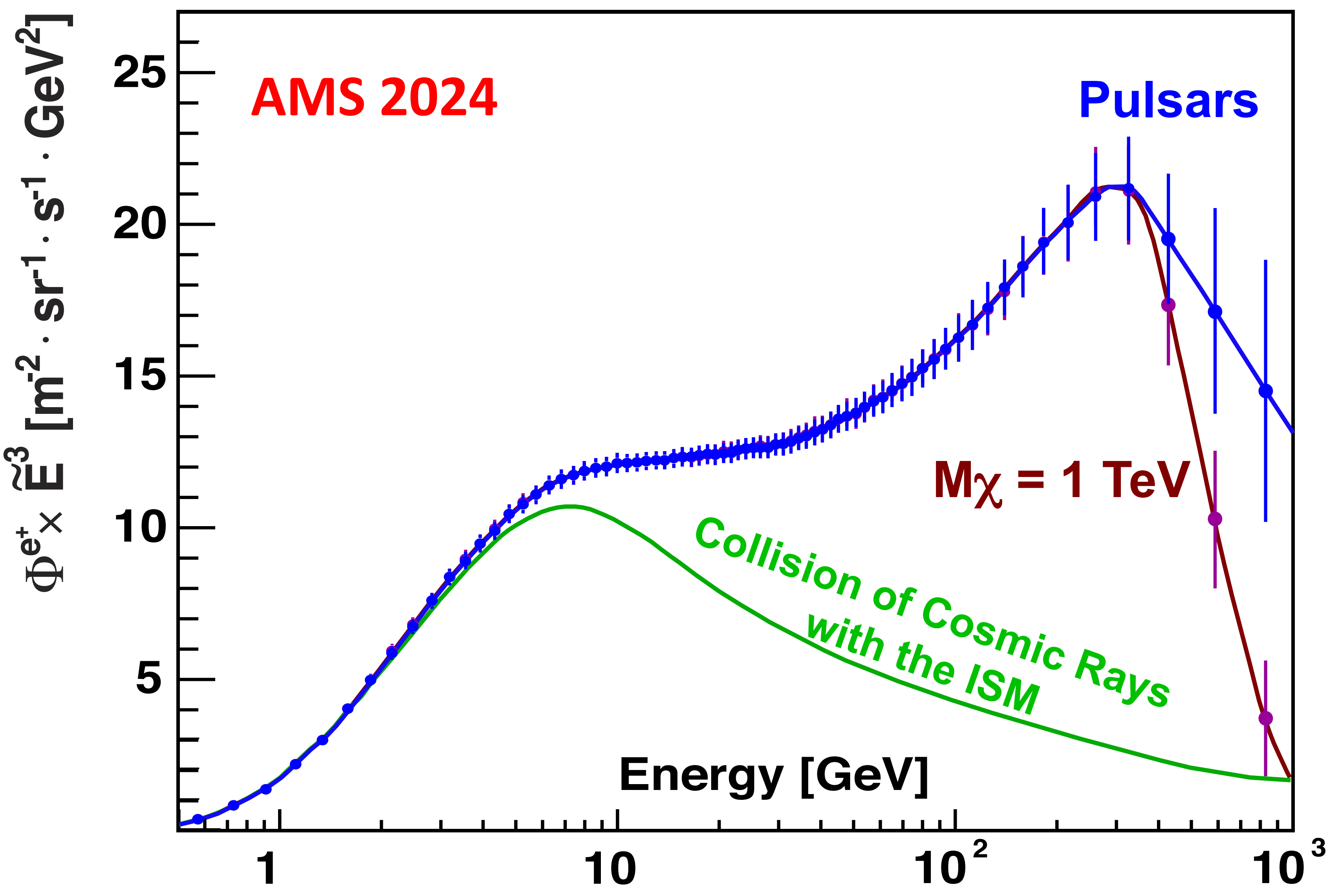
AMS 2016



19

2024: Extend measurement to 1 TeV

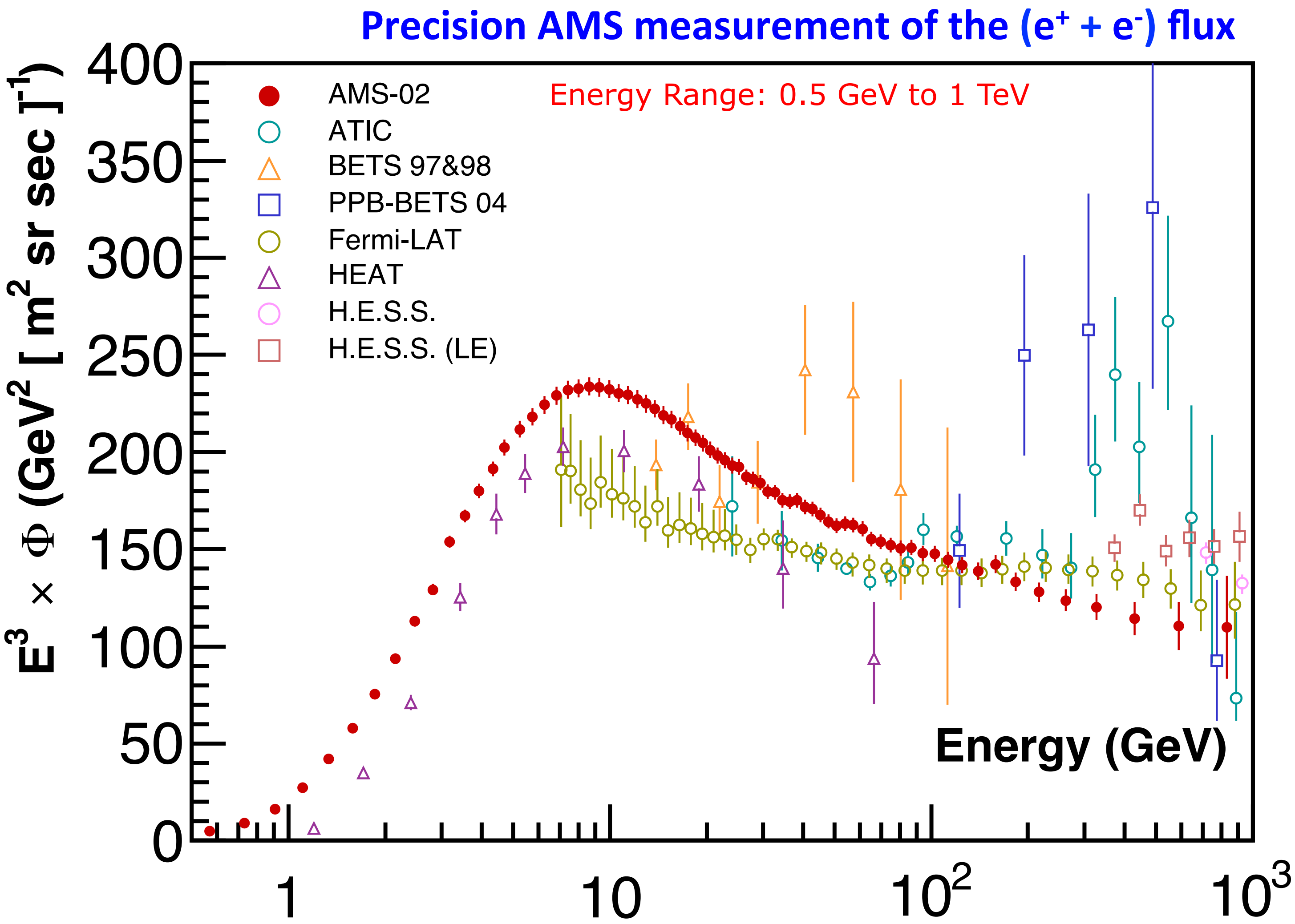
Extrapolation by Monte Carlo



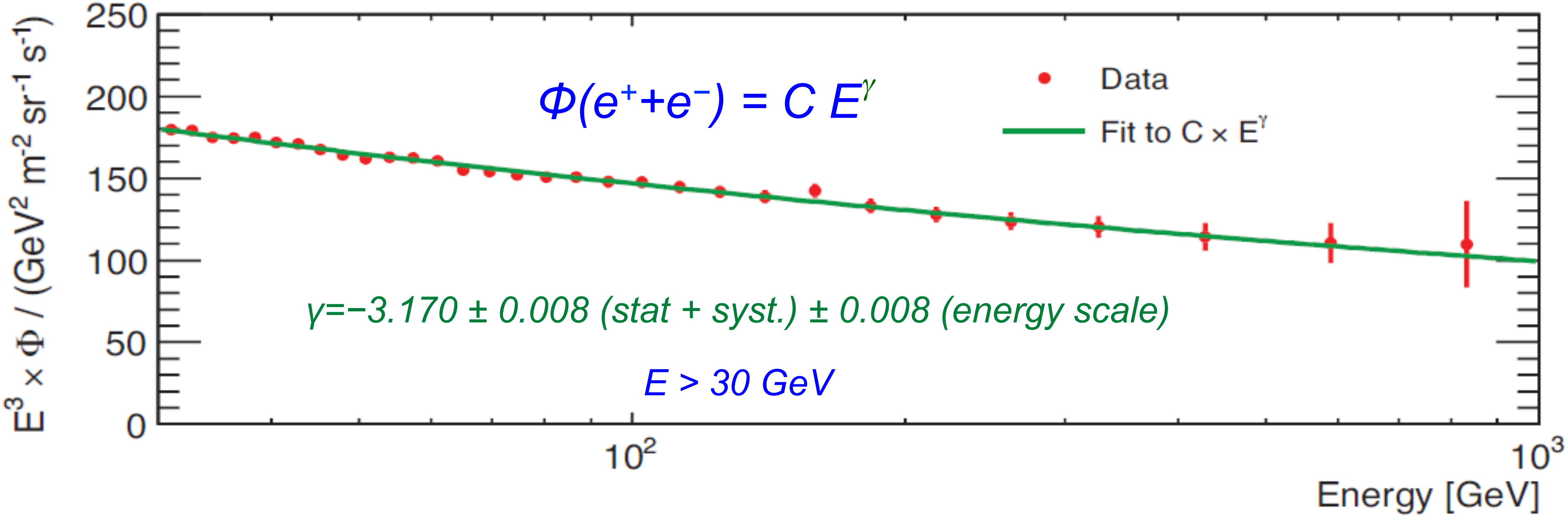
The ($e^+ + e^-$) flux

PRL 113, 221102 (2014) PHYSICAL REVIEW LETTERS week ending 28 NOVEMBER 2014

Precision Measurement of the ($e^+ + e^-$) Flux in Primary Cosmic Rays from 0.5 GeV to 1 TeV with the Alpha Magnetic Spectrometer on the International Space Station

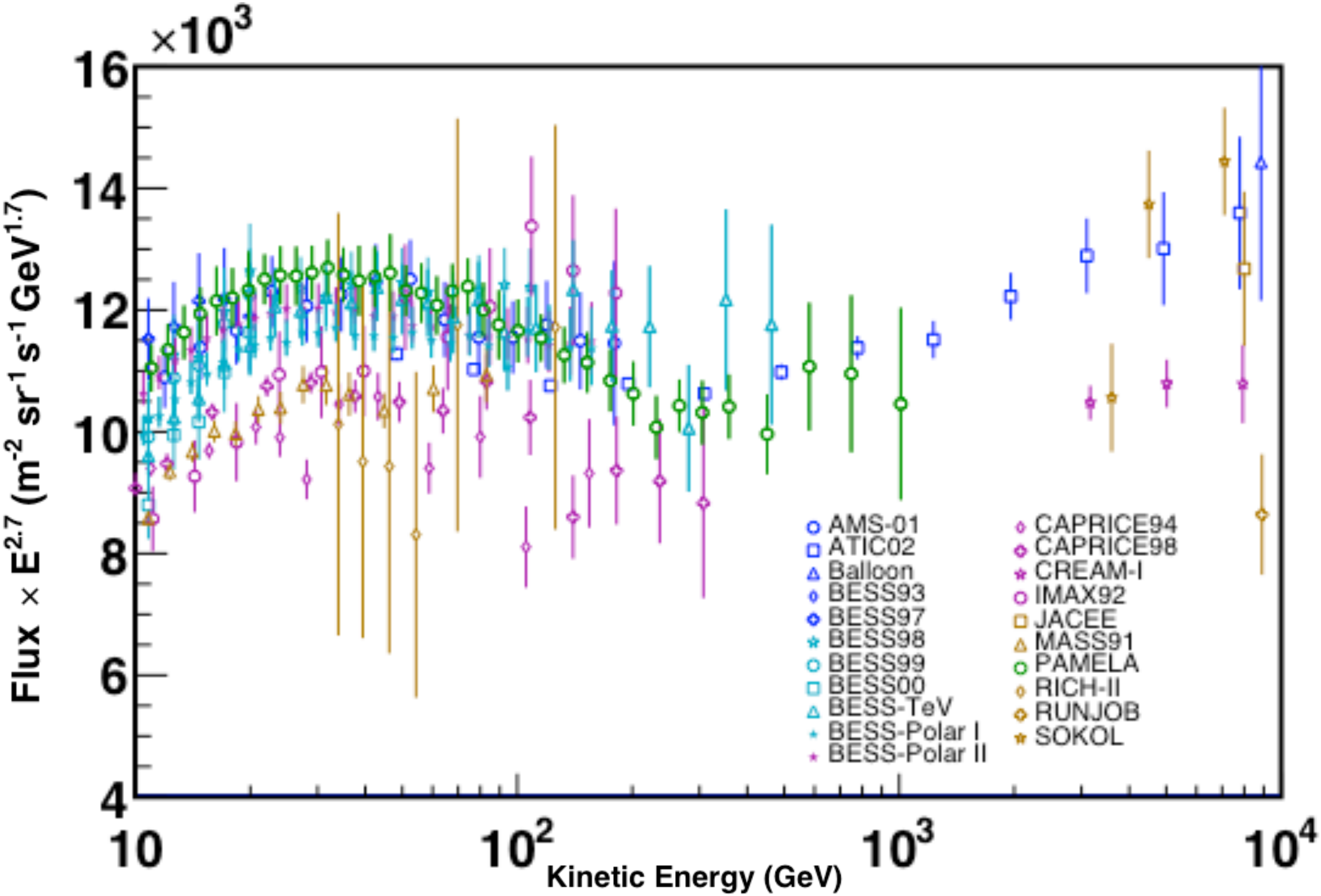


Spectral index of $(e^+ + e^-)$



The $(e^+ + e^-)$ flux versus the electron or positron energy and the result of a single power law fit above 30.2 GeV.

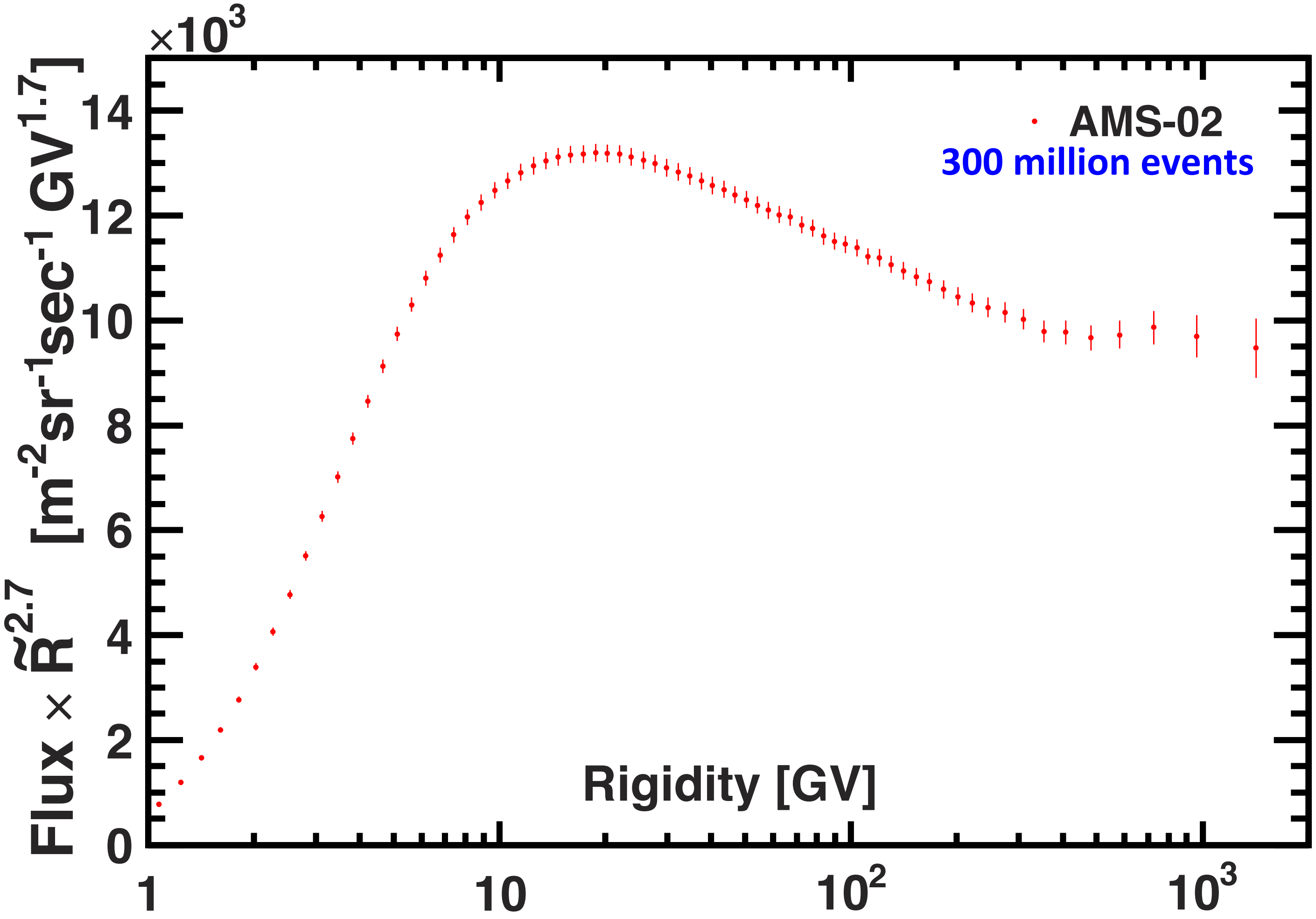
Measurements of the proton spectrum before AMS



The proton flux

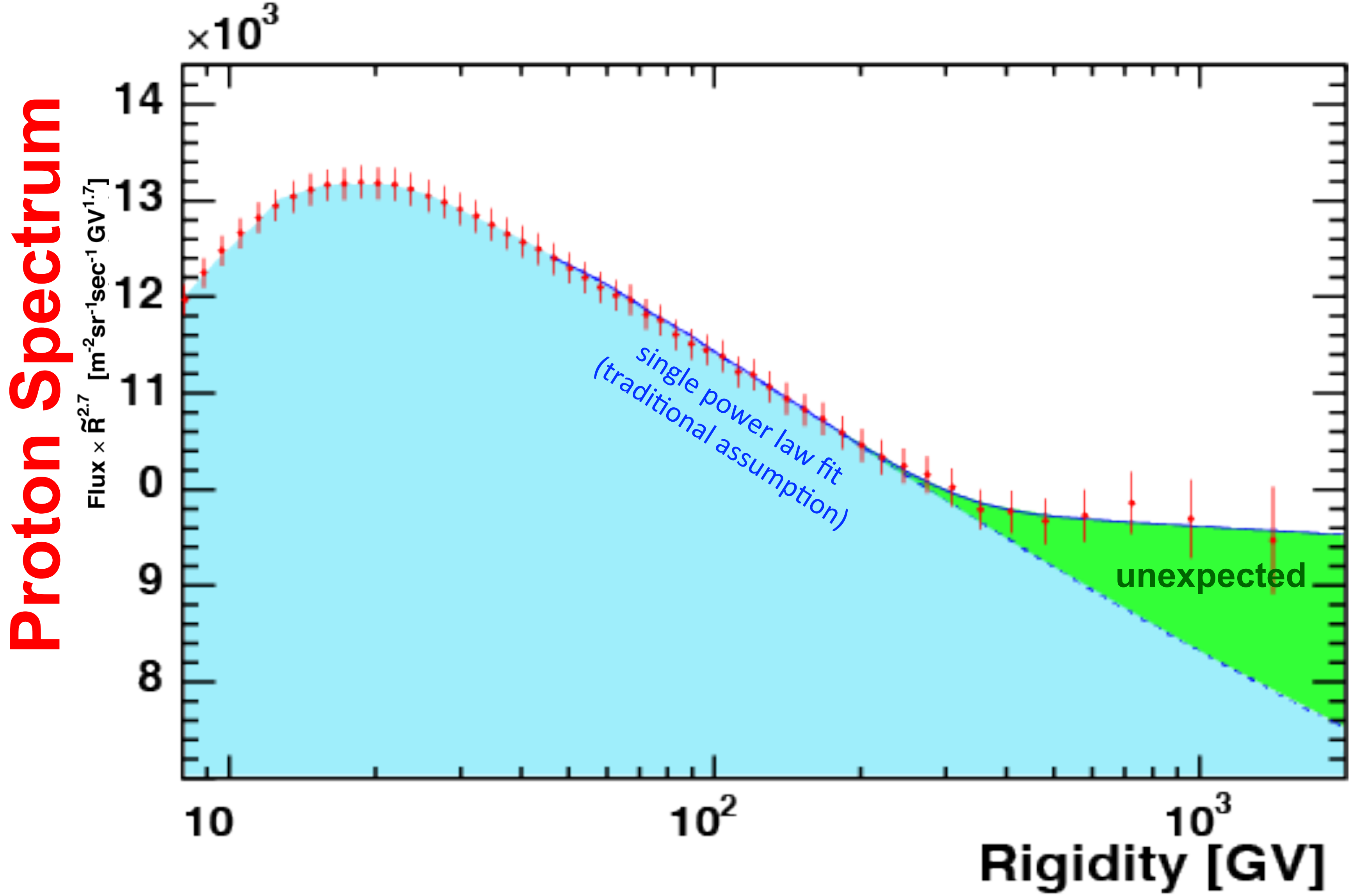
PRL **114,** 171103 (2015) PHYSICAL REVIEW LETTERS week ending 1 MAY 2015

Precision Measurement of the Proton Flux in Primary Cosmic Rays from Rigidity 1 GV to 1.8 TV with the Alpha Magnetic Spectrometer on the International Space Station

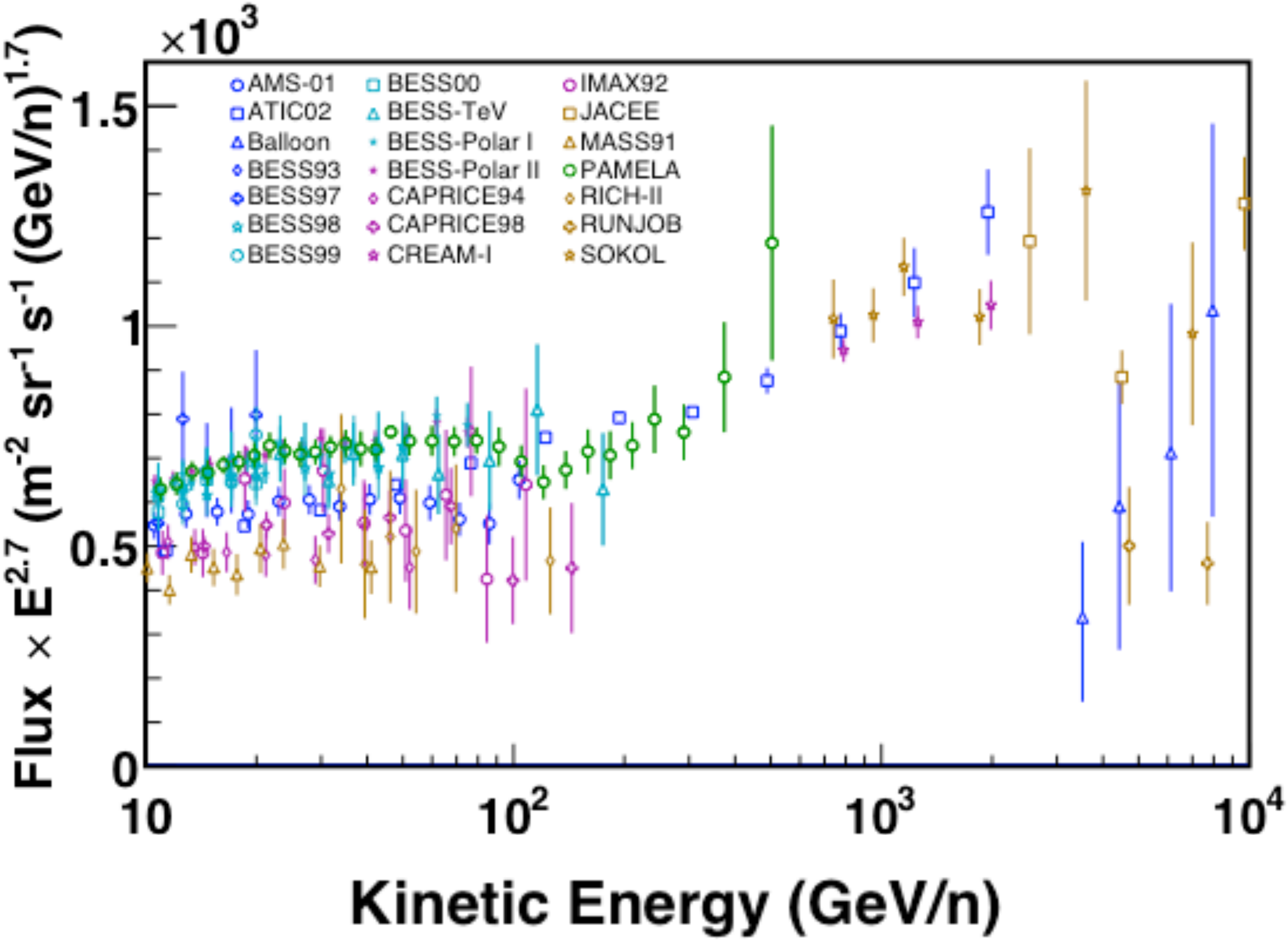


AMS proton flux

The spectrum cannot be described by a single power law.



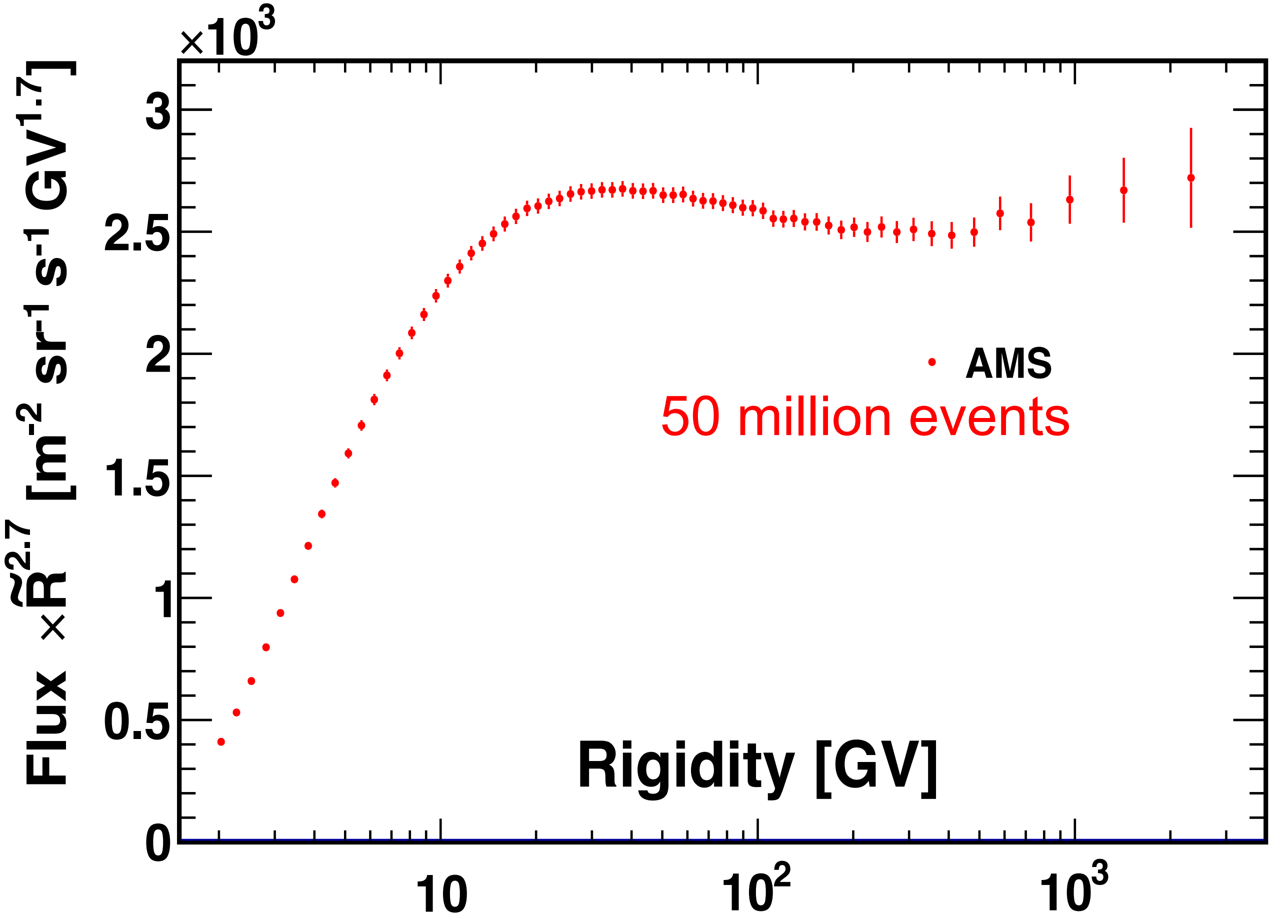
Measurements of Helium spectrum before AMS



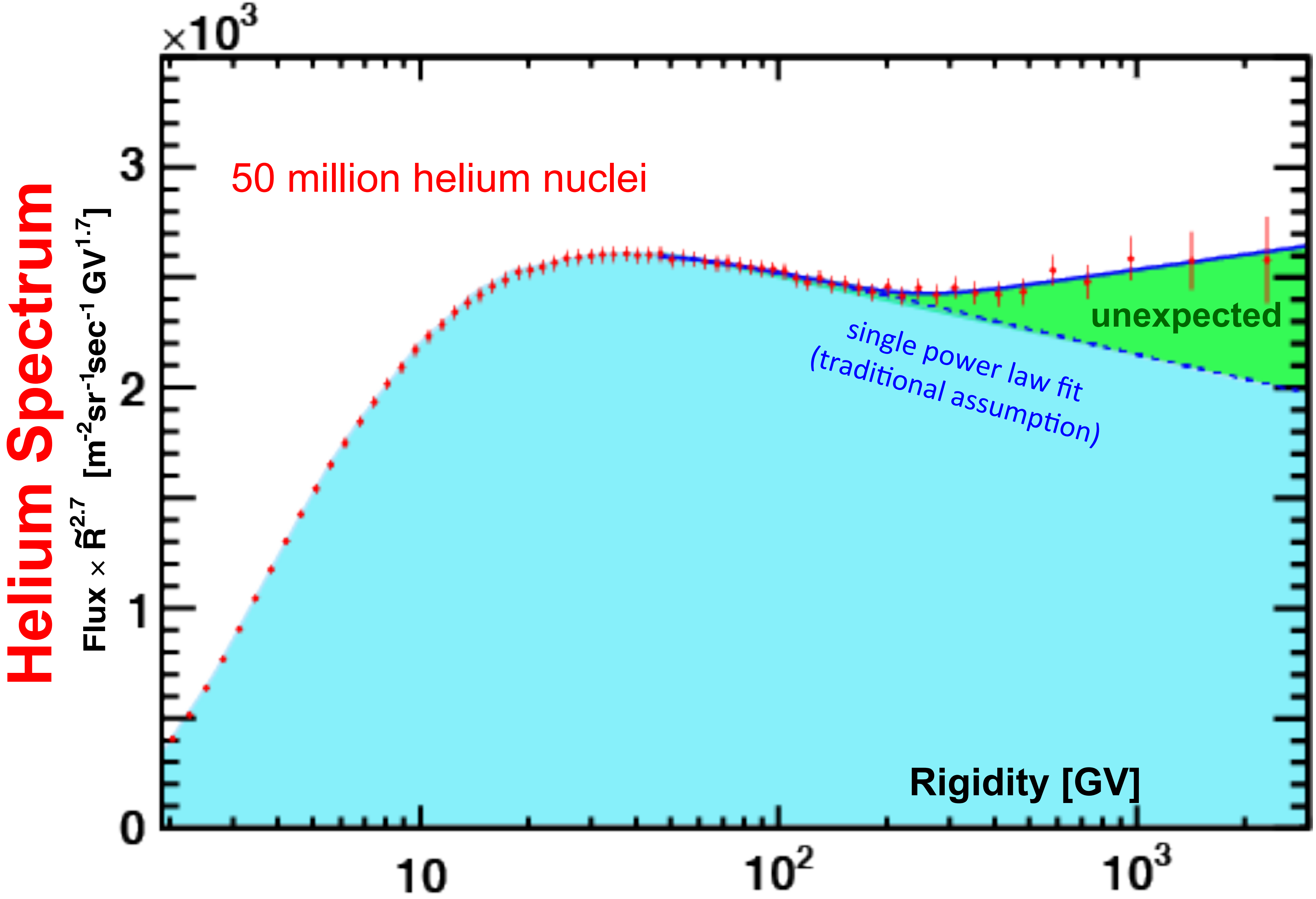
The Helium Flux

PRL 115, 211101 (2015) PHYSICAL REVIEW LETTERS week ending 20 NOVEMBER 2015

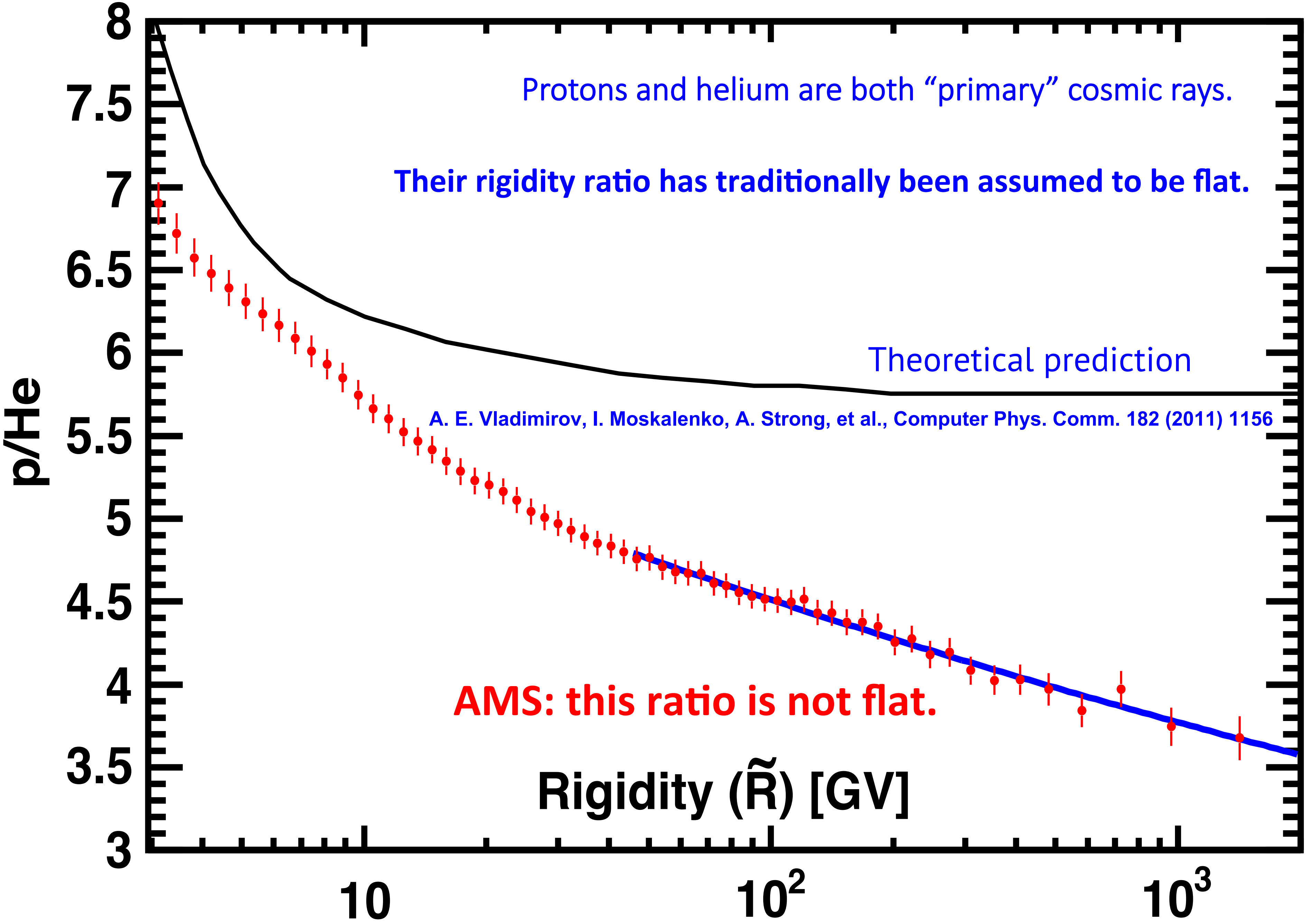
Precision Measurement of the Helium Flux in Primary Cosmic Rays of Rigidities 1.9 GV to 3 TV with the Alpha Magnetic Spectrometer on the International Space Station



AMS Helium Flux



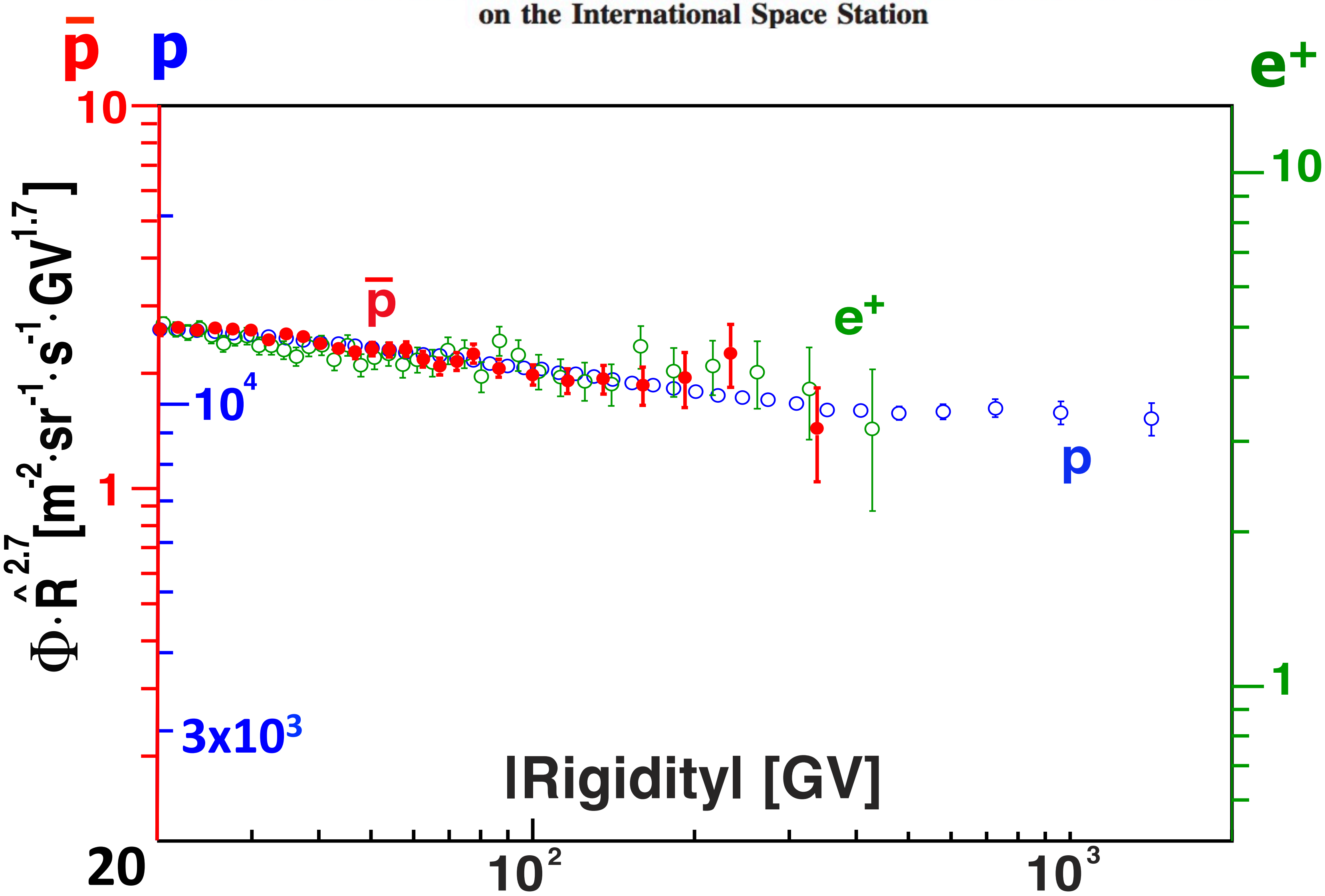
The AMS proton/Helium flux ratio



The antiproton flux compared to other particle fluxes

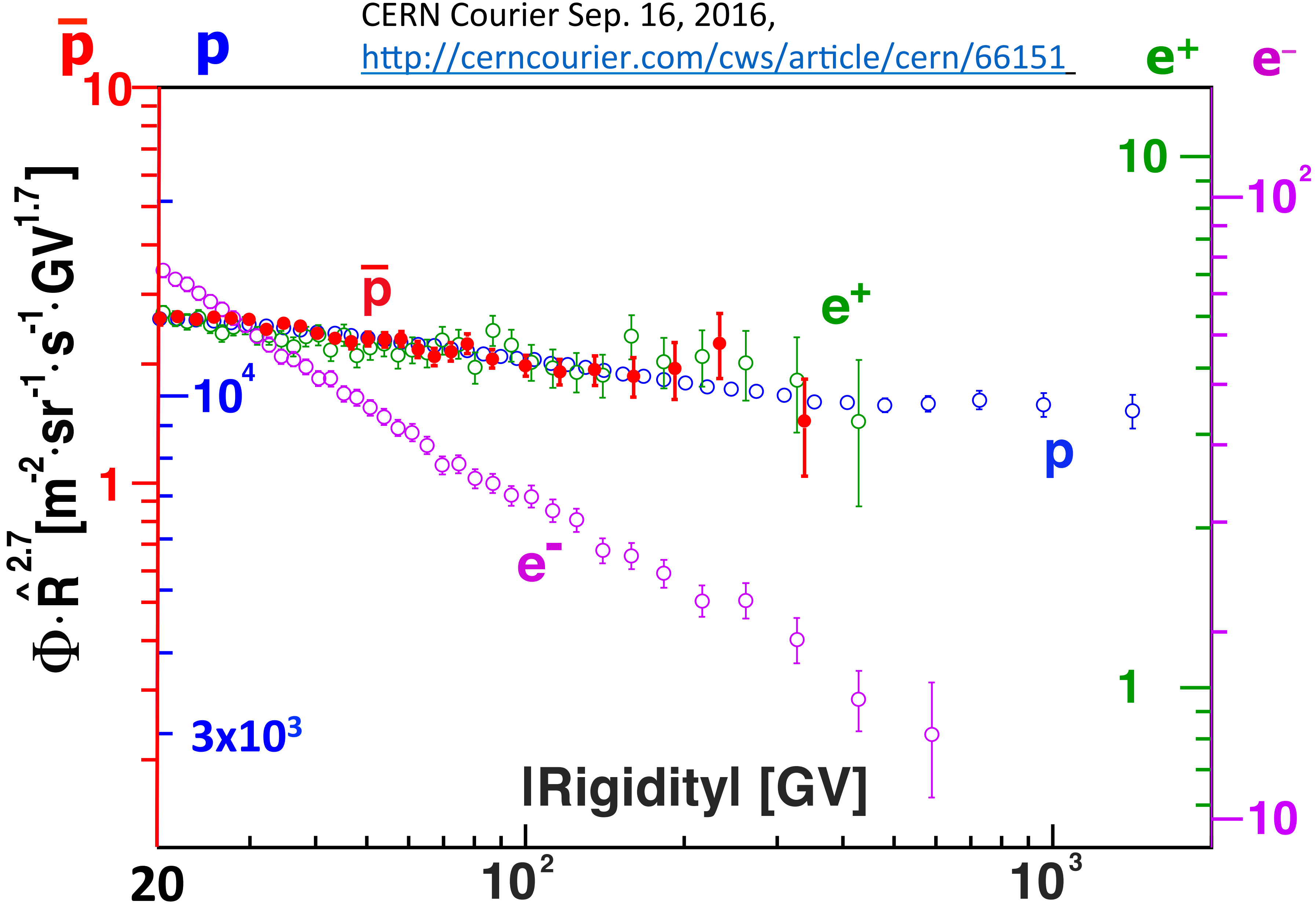
PRL **117,** 091103 (2016) PHYSICAL REVIEW LETTERS week ending 26 AUGUST 2016

Antiproton Flux, Antiproton-to-Proton Flux Ratio, and Properties of Elementary Particle Fluxes in Primary Cosmic Rays Measured with the Alpha Magnetic Spectrometer on the International Space Station

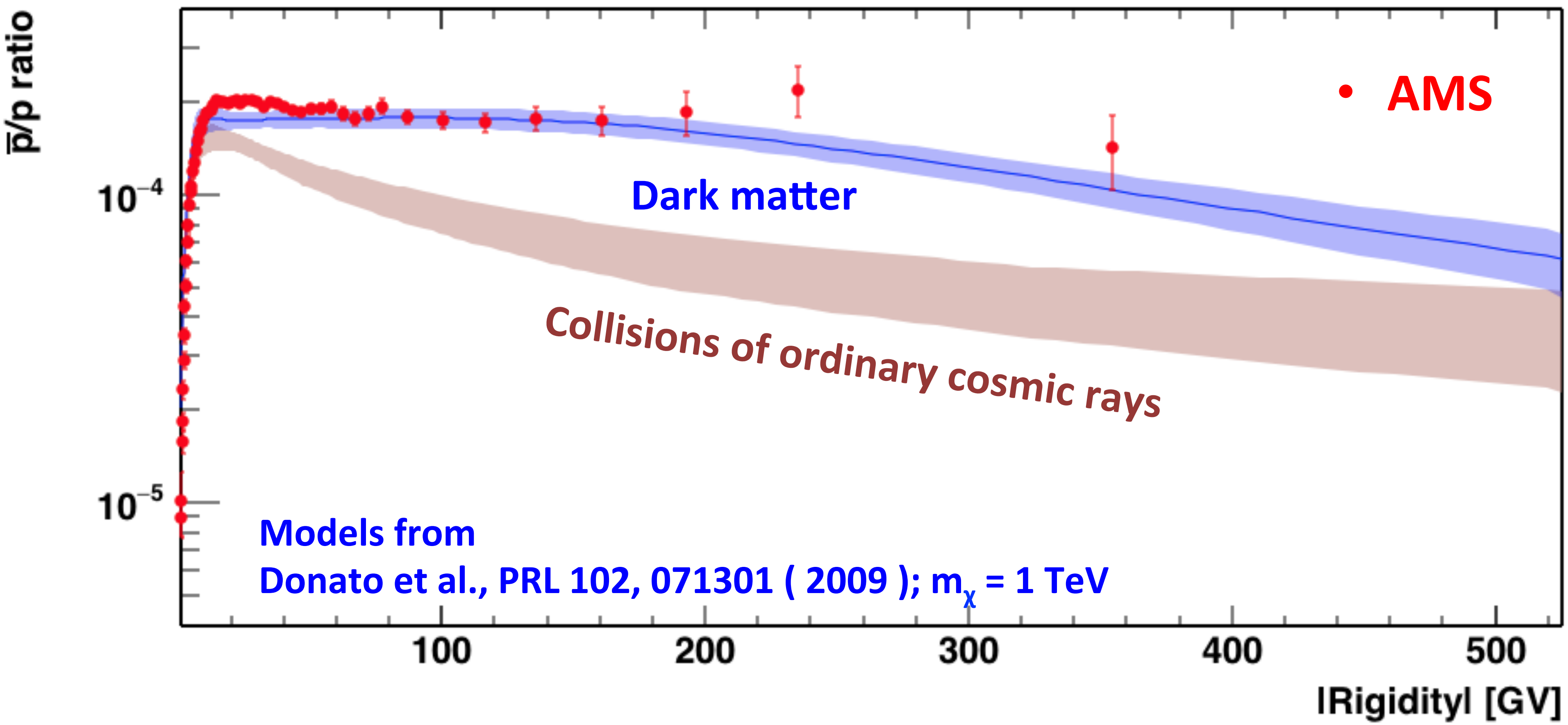


The spectra of elementary particles e^+, $\bar{p}$, p have the same energy dependence above 60 GeV, e^- does not

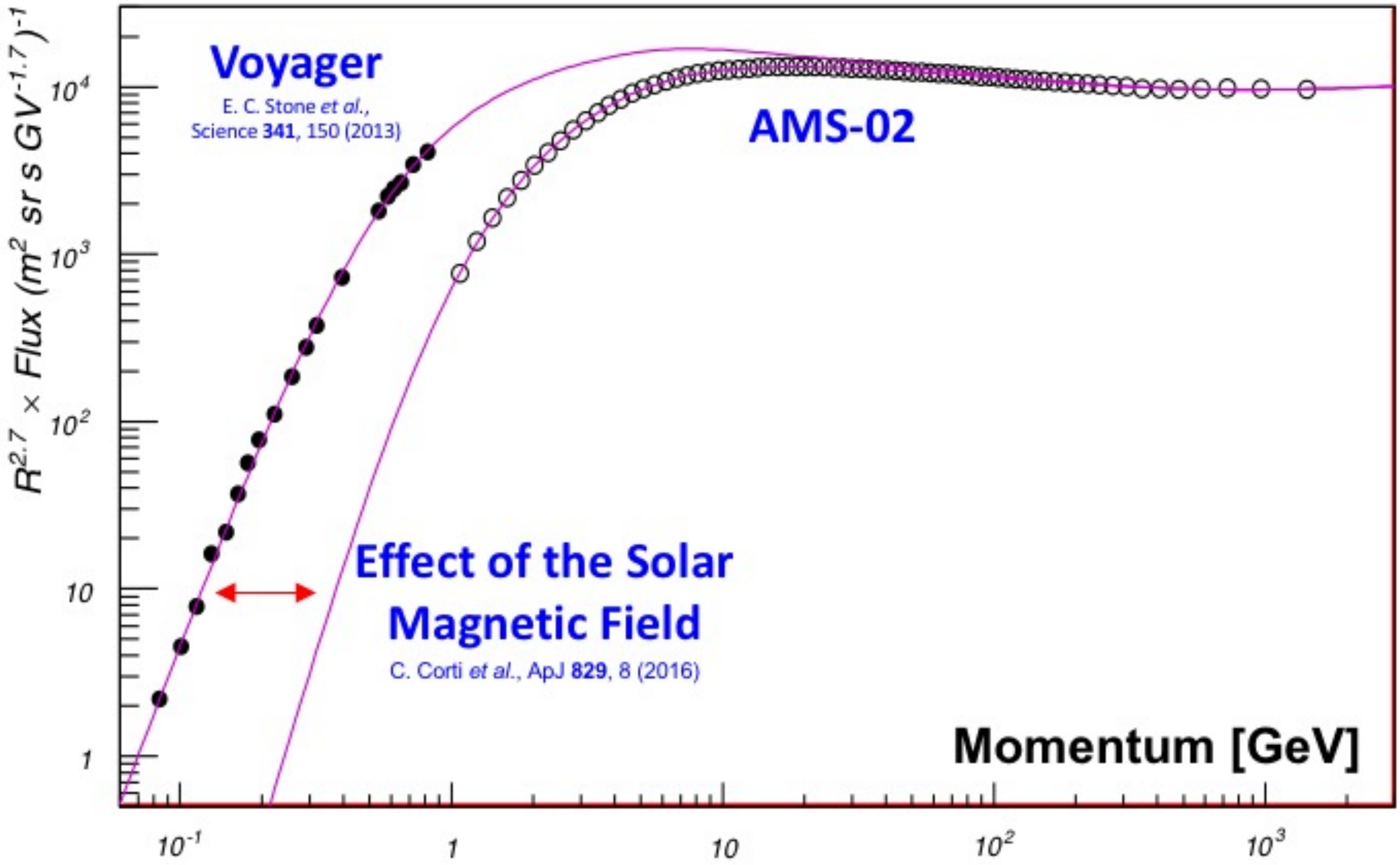
CERN Courier Sep. 16, 2016, http://cerncourier.com/cws/article/cern/66151



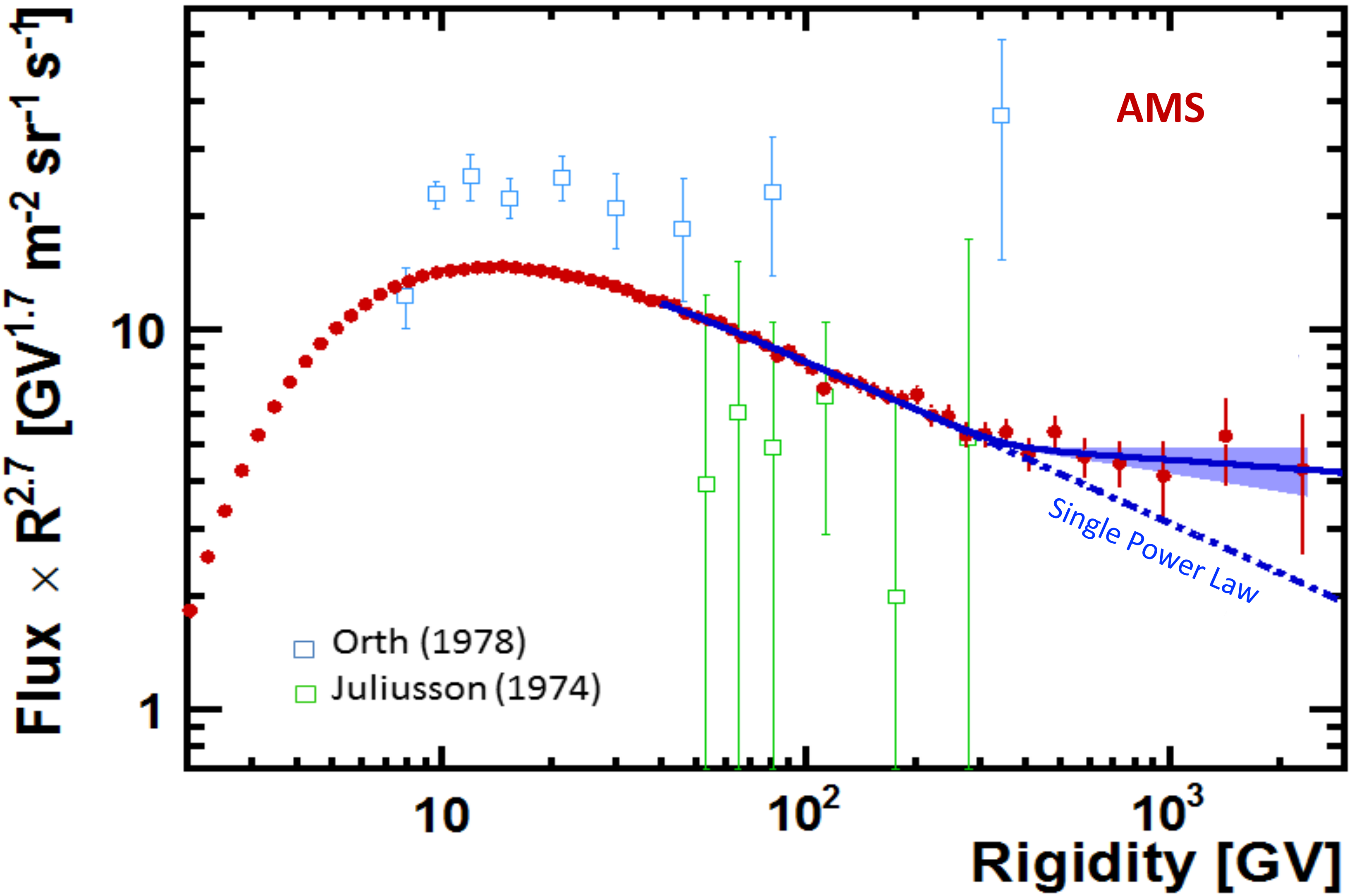
Antiproton-to-proton ratio



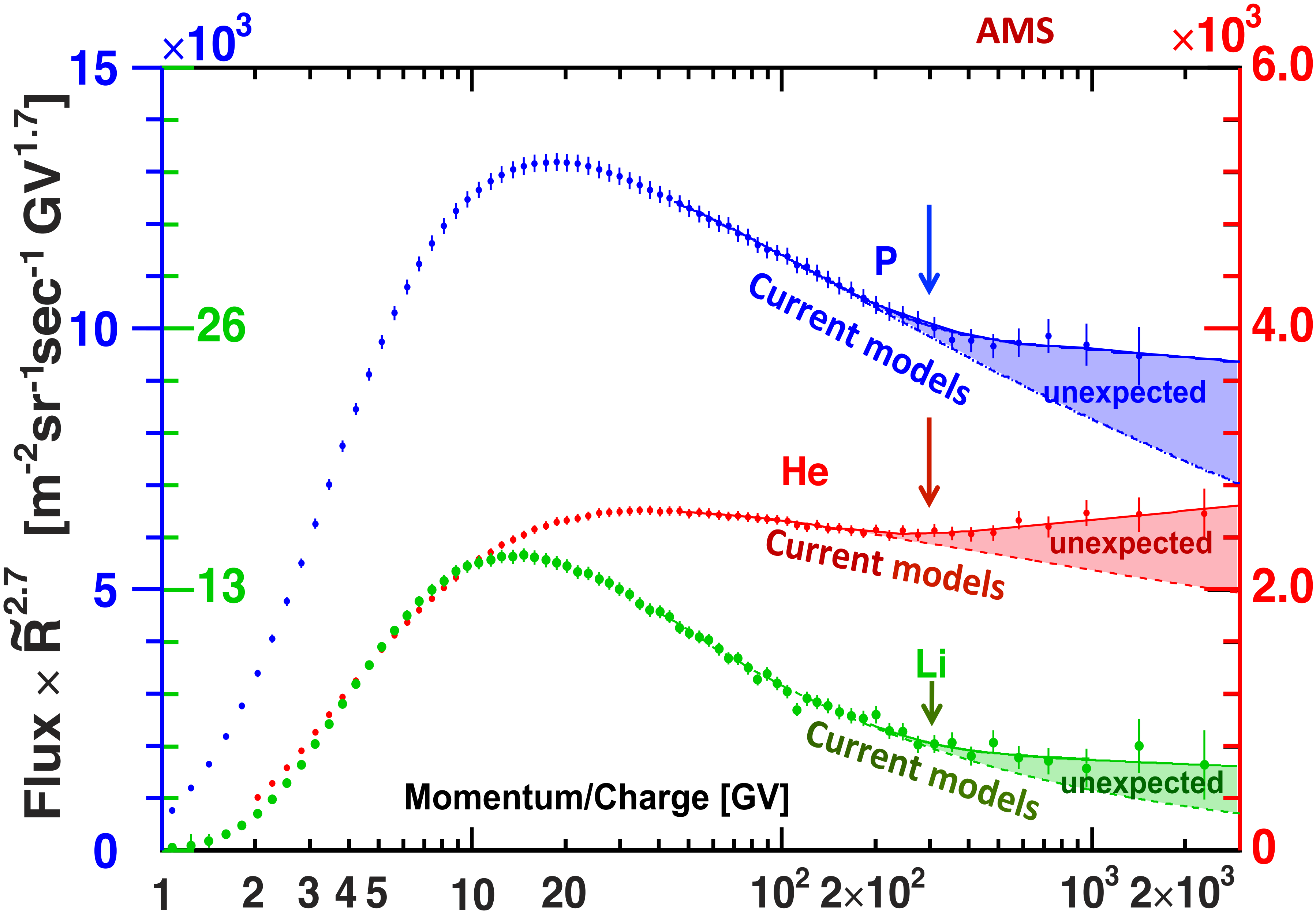
Proton flux, effect of Solar B-field



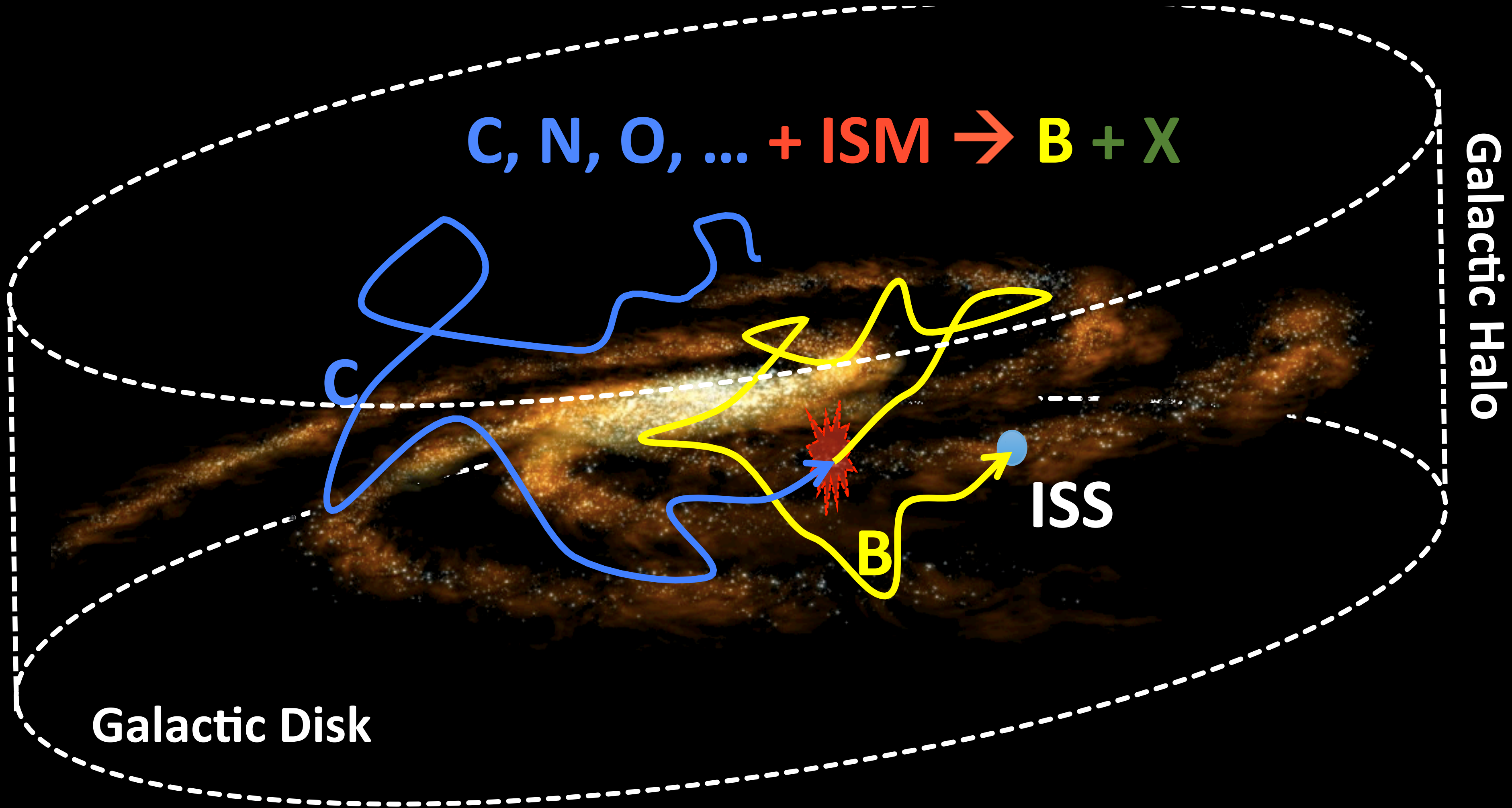
The Lithium flux



Light nuclei fluxes



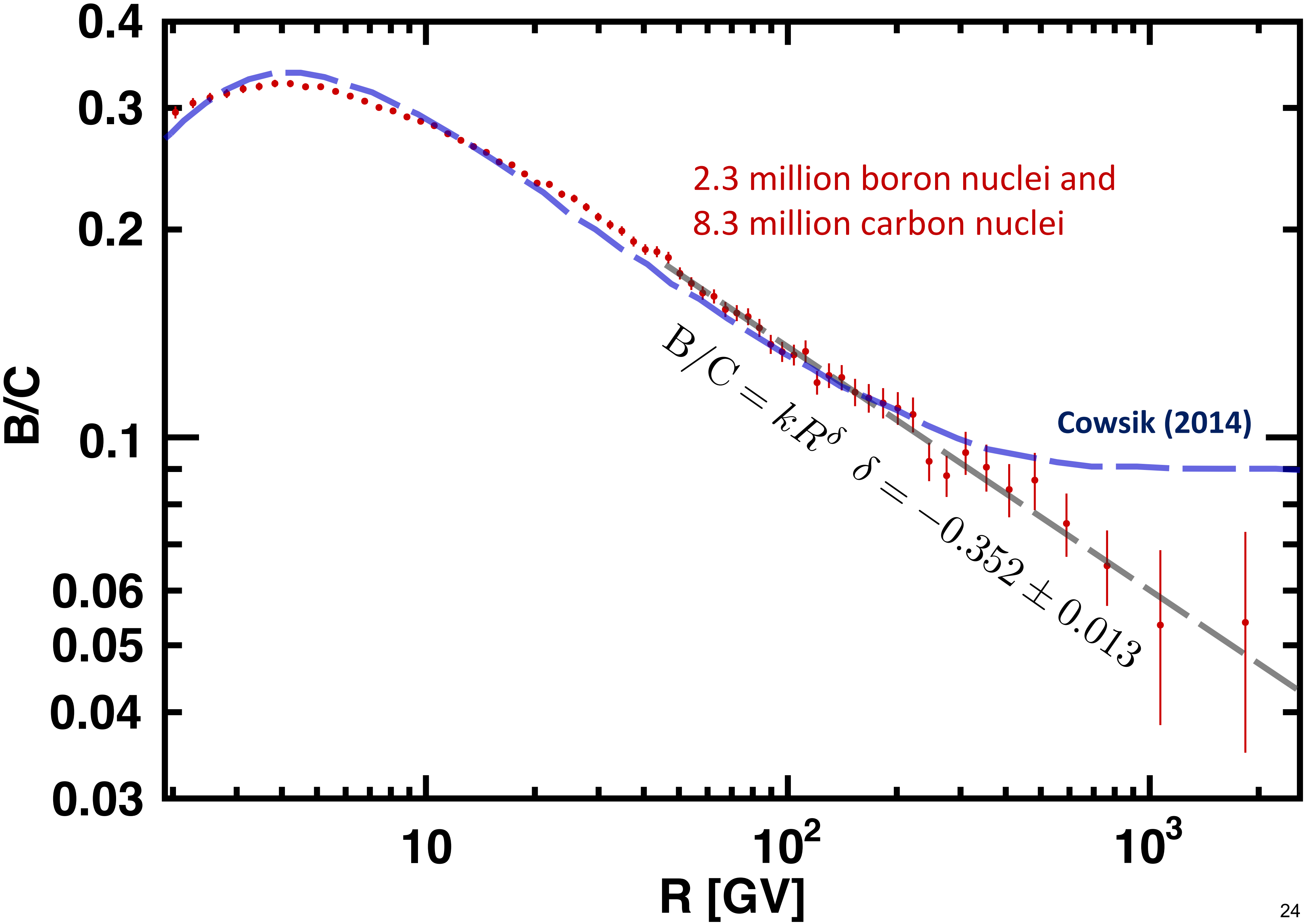
Flux Ratios: Boron/Carbon and propagation



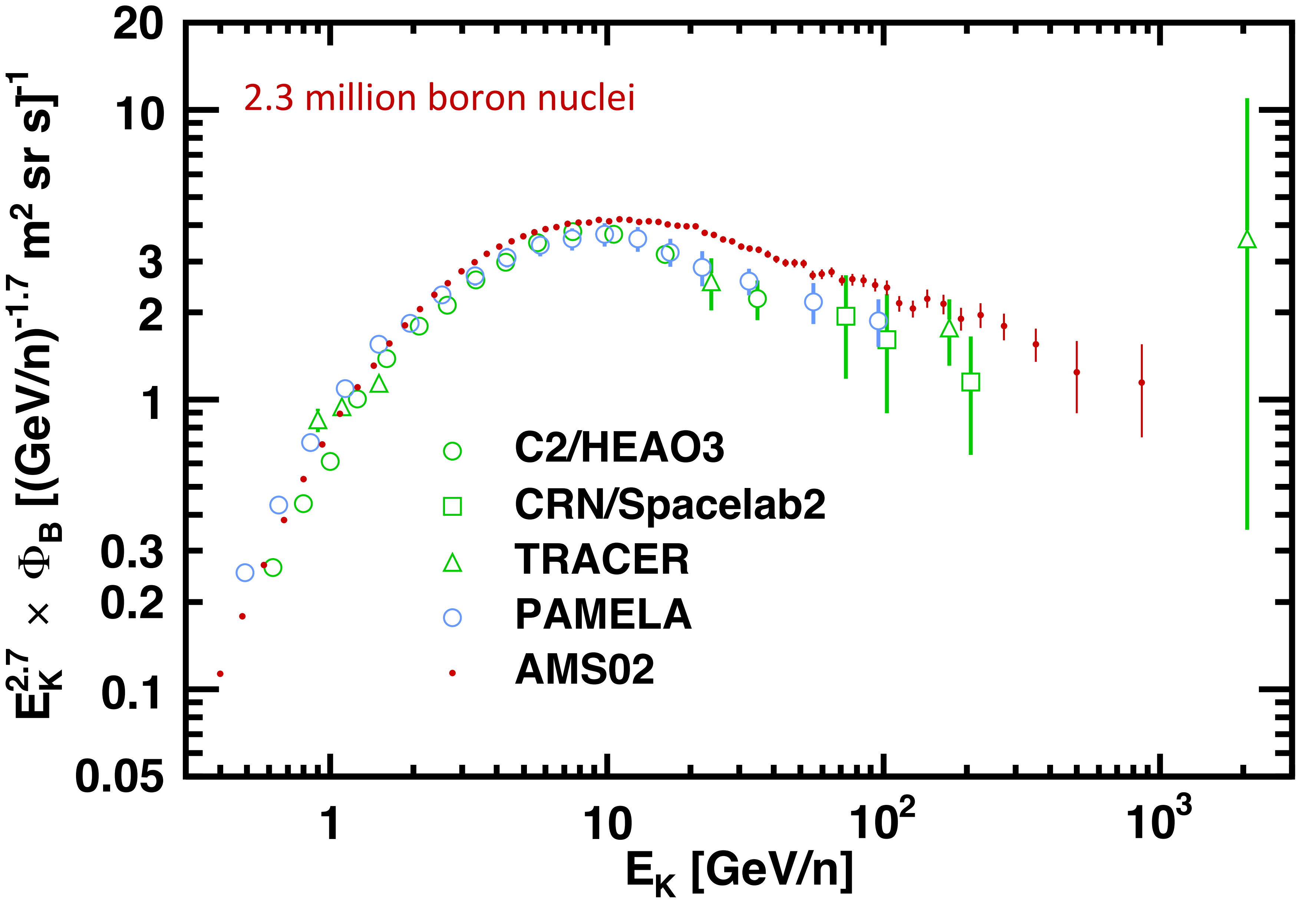
Cosmic Rays are commonly modeled as a relativistic gas diffusing through a magnetized plasma.

Models of the magnetized plasma predict different behavior for B/C = $k\,R^{\delta}$. With the Kolmogorov turbulence model $\delta = -1/3$ is expected, while the Kraichnan theory leads to $\delta = -1/2$.

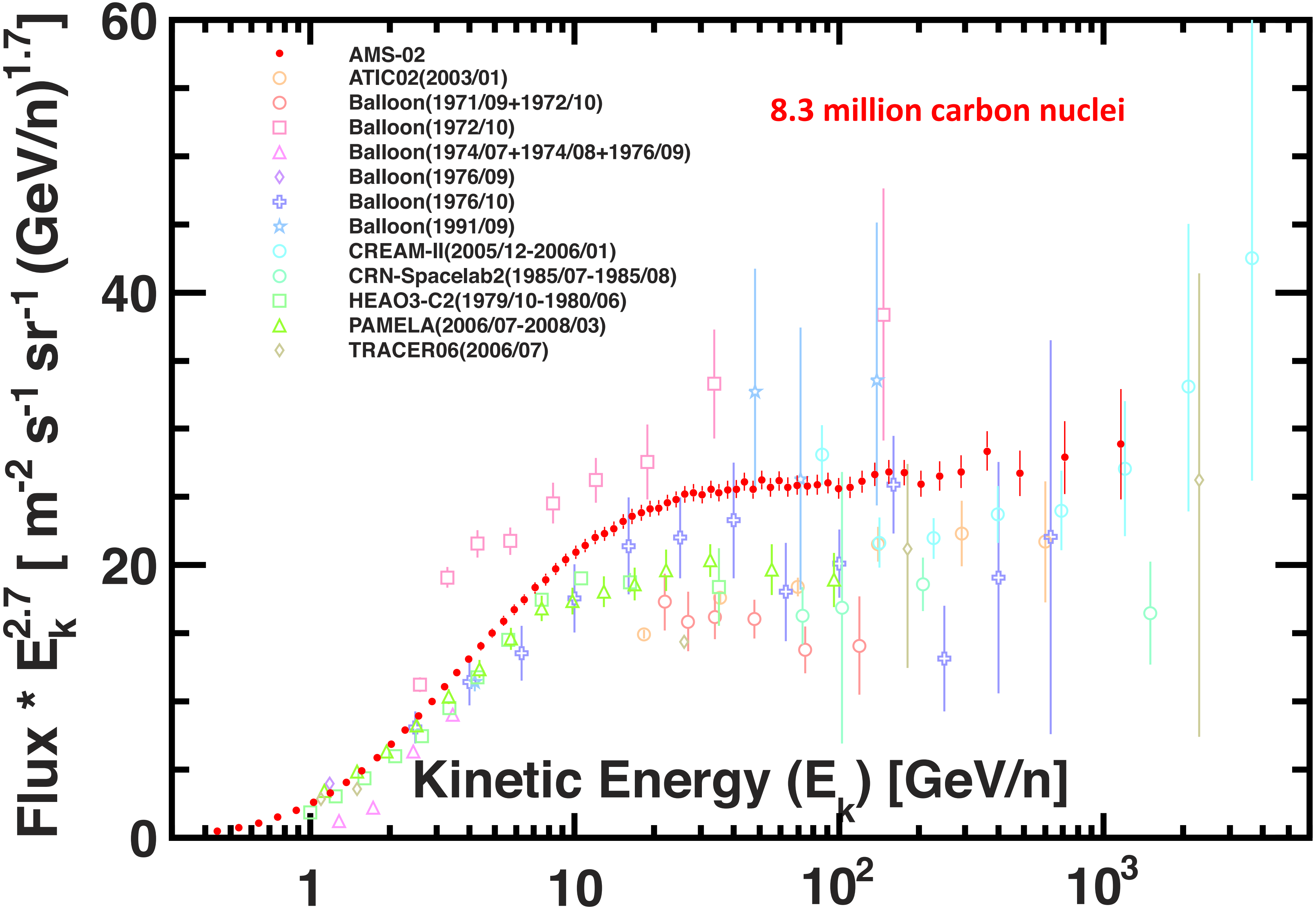
The Boron-to-Carbon (B/C) flux ratio



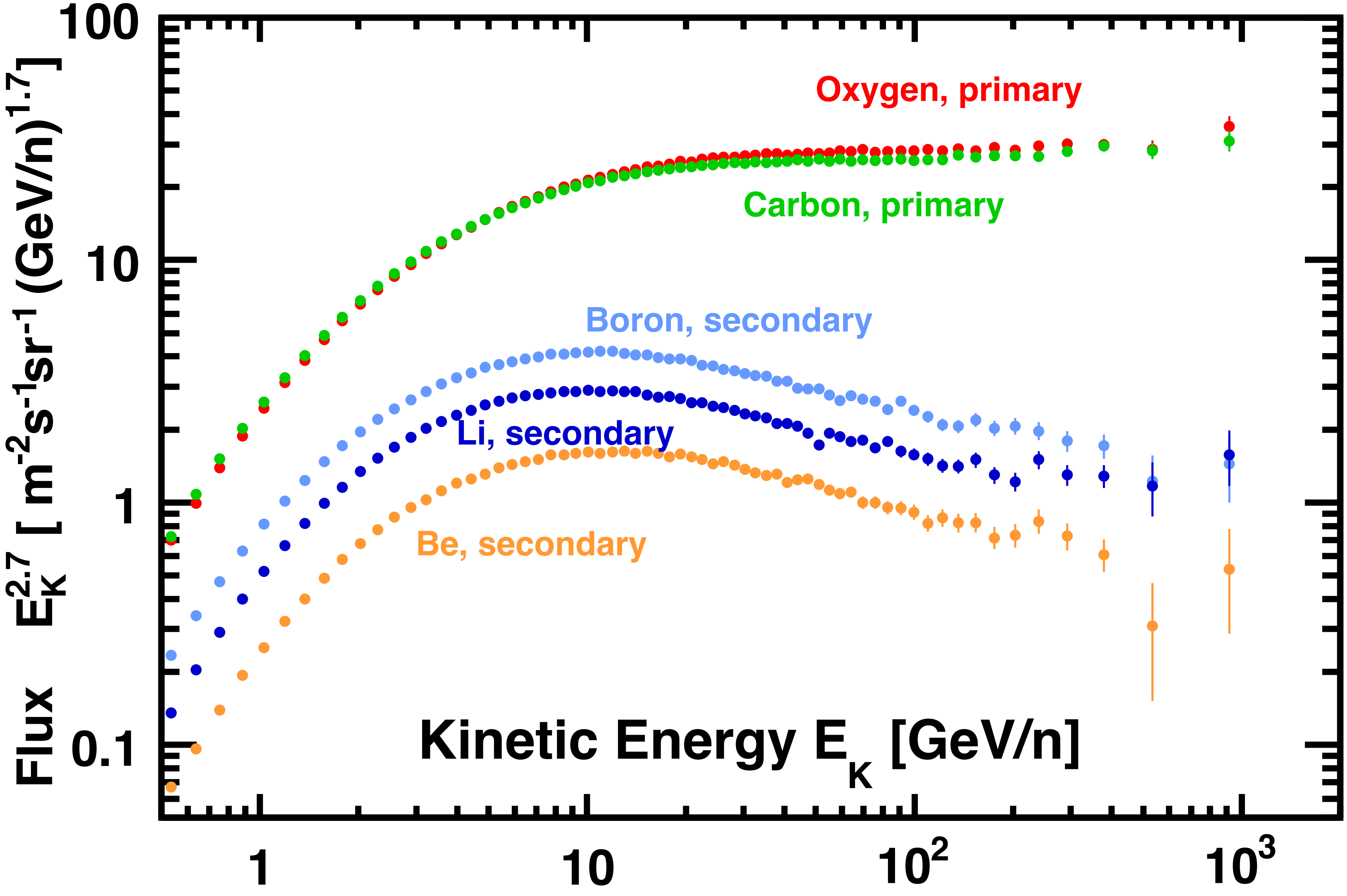
The Boron flux



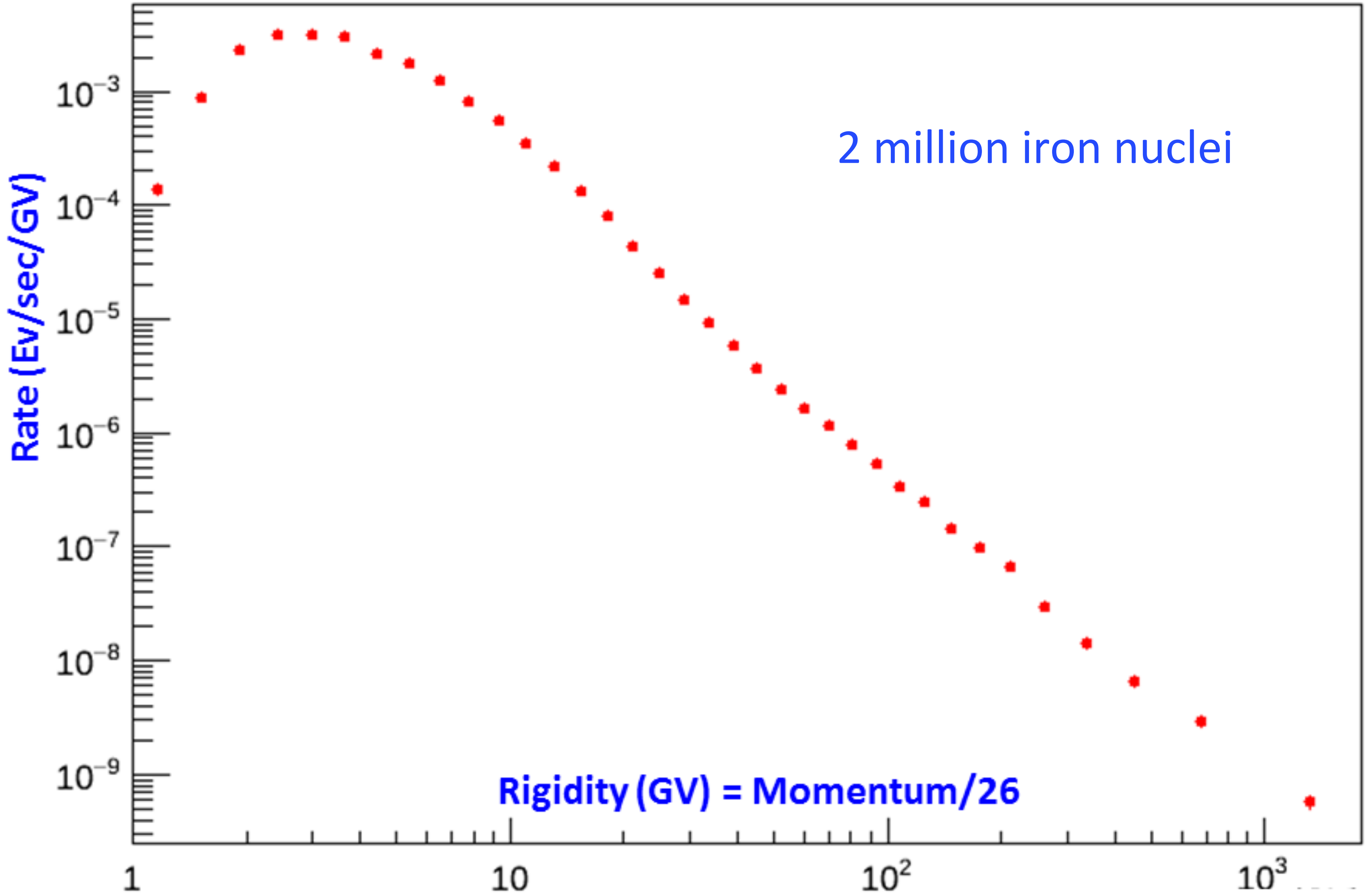
The Carbon flux



Primary vs. secondary nuclei

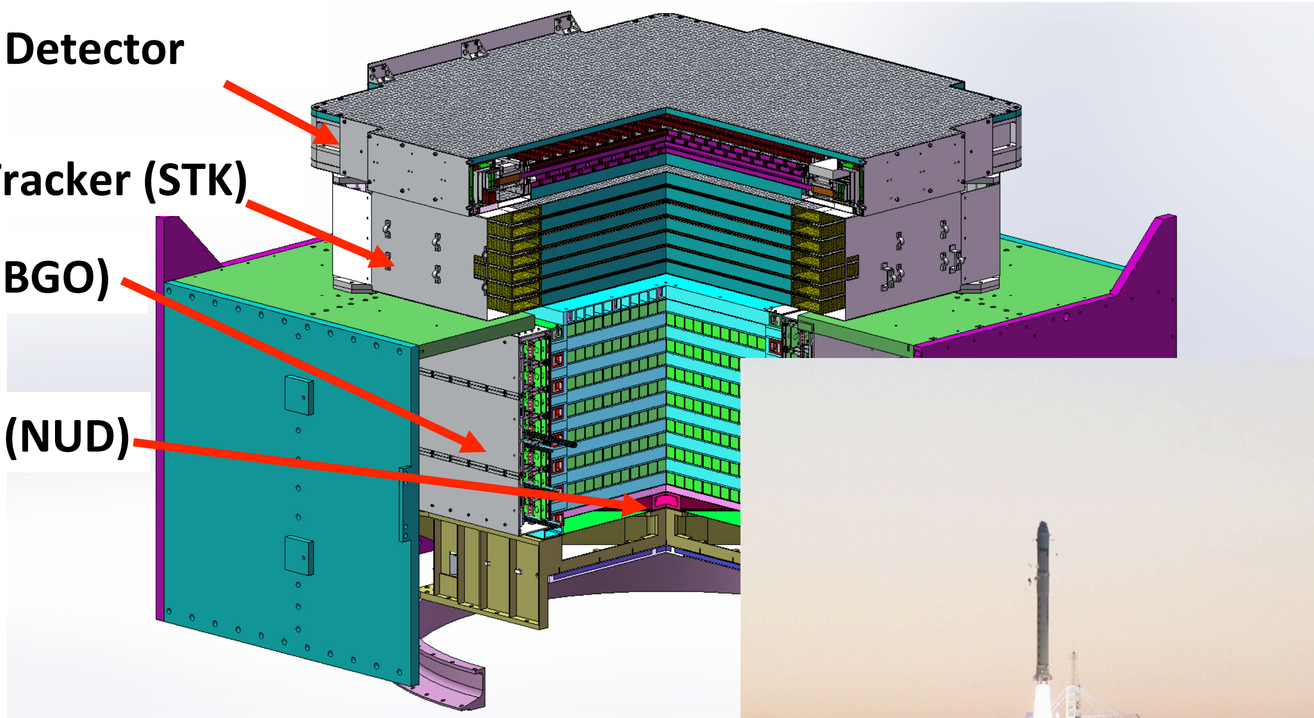


Iron rate

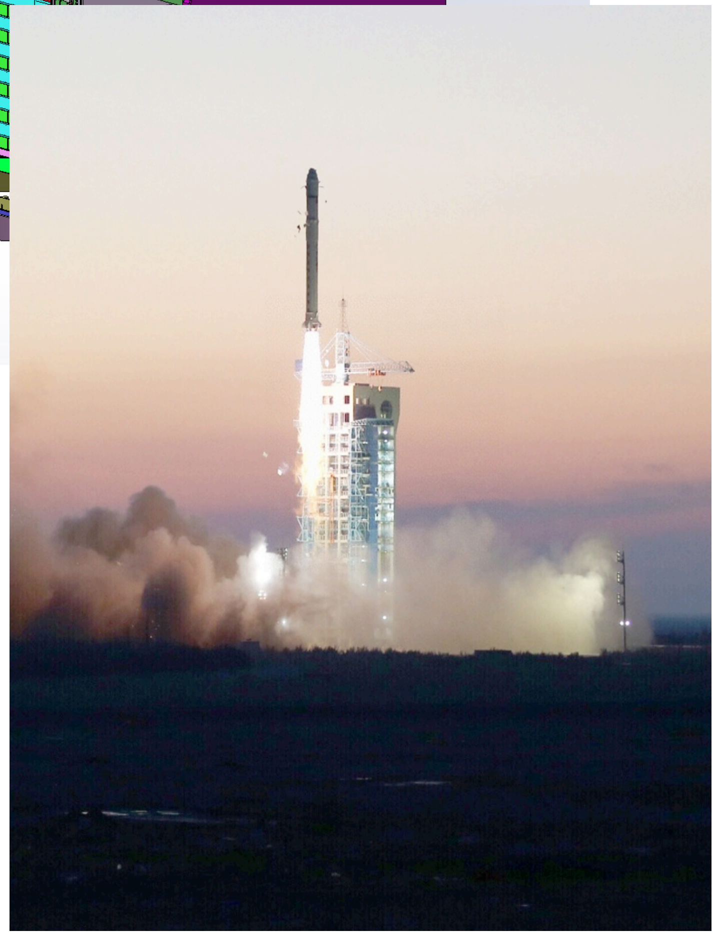


2 million iron nuclei
Rate (Ev/sec/GV)
Rigidity (GV) = Momentum/26
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-9}
1
10
10^{2}
10^{3}

The DAMPE detector

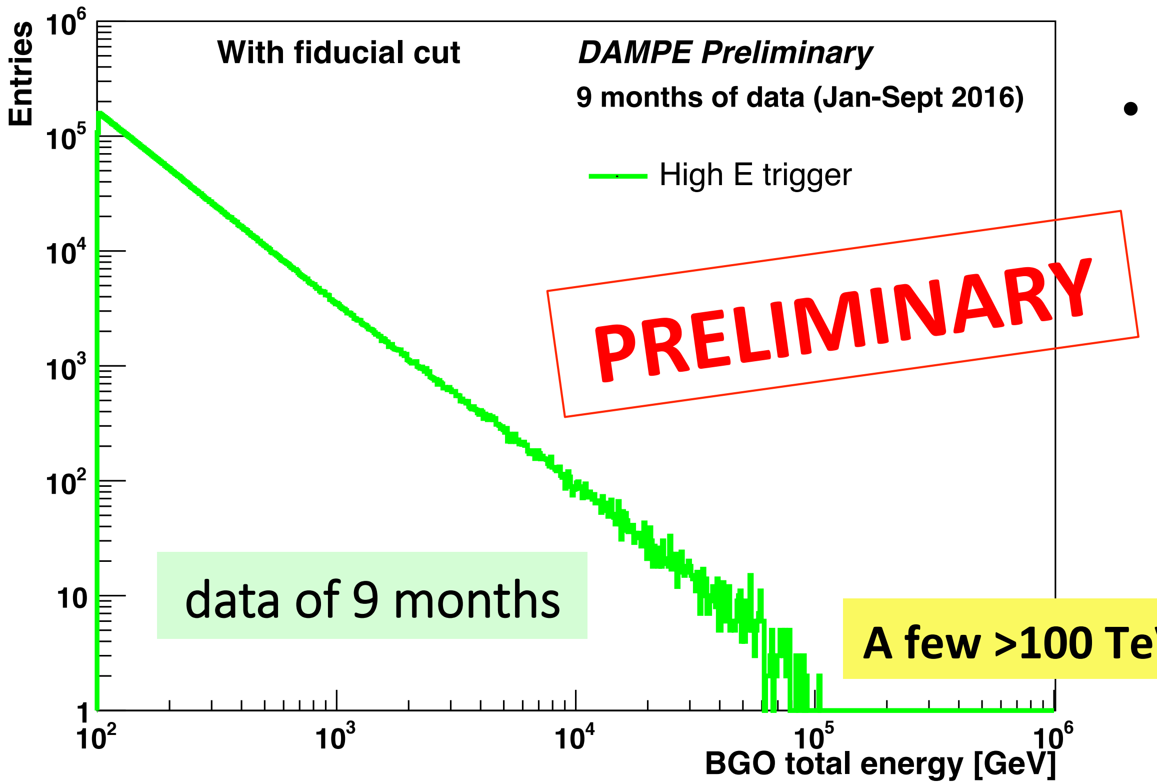


- ✓Thick imaging calorimeter (BGO of 32 X_0)
- ✓Precise tracking with Si strip detectors (STK)
- ✓Tungsten photon converters in tracker (STK)
- ✓Charge measurements with PSD and STK
- ✓Extra hadron rejection with NUD



Launched December 17, 2015

Raw energy distribution, with fiducial cut



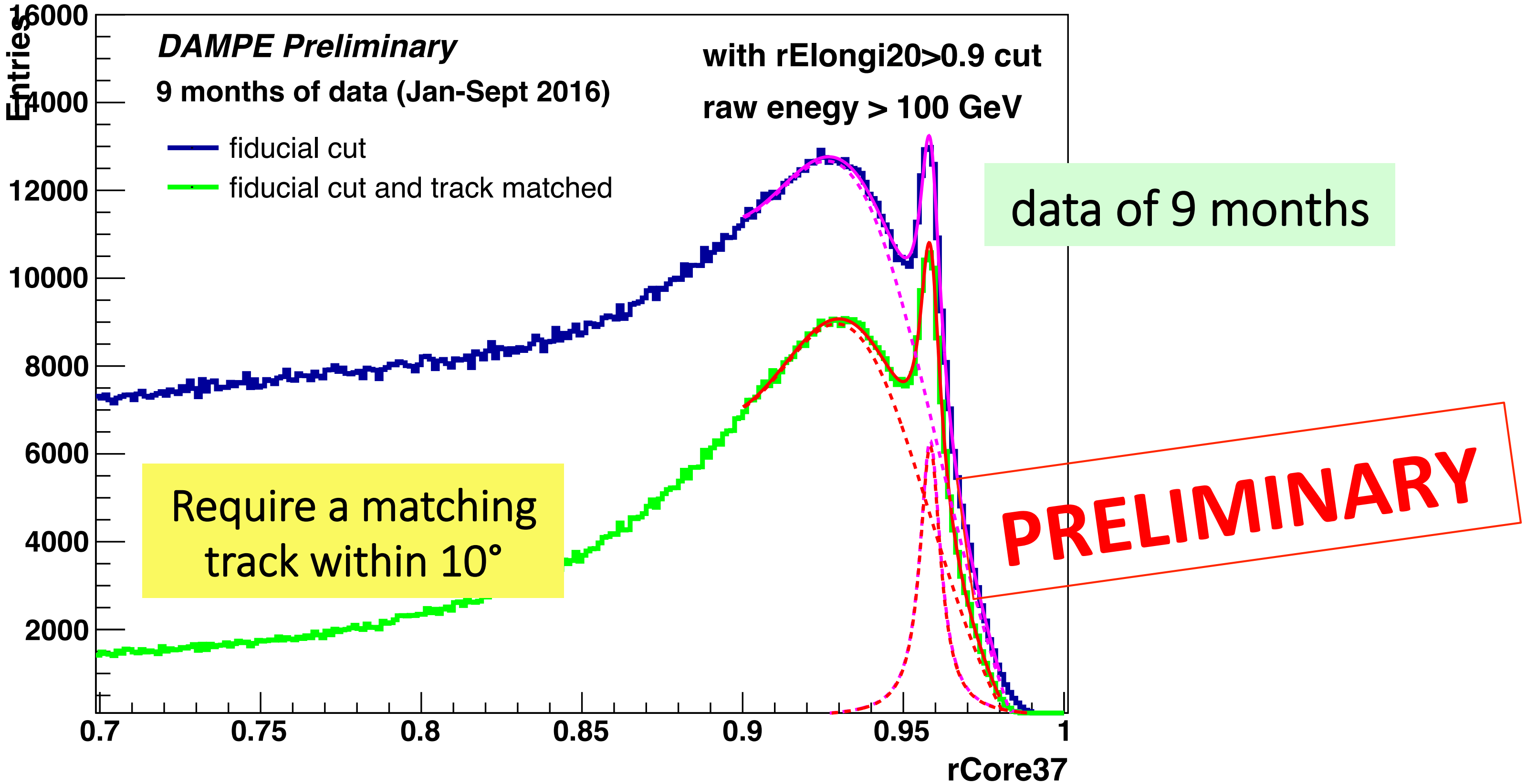
- Simple fiducial cuts
  - Direction reconstructed in BGO points to the top of the BGO and PSD
  - BGO bar with highest energy is at least 2 bars away from the 4 sides

A few >100 TeV (raw) events observed

- ~200k TeV (raw) events/year
- ~250 >50 TeV (raw) events/year

→ Mostly p and nuclei, for high energy CR physics

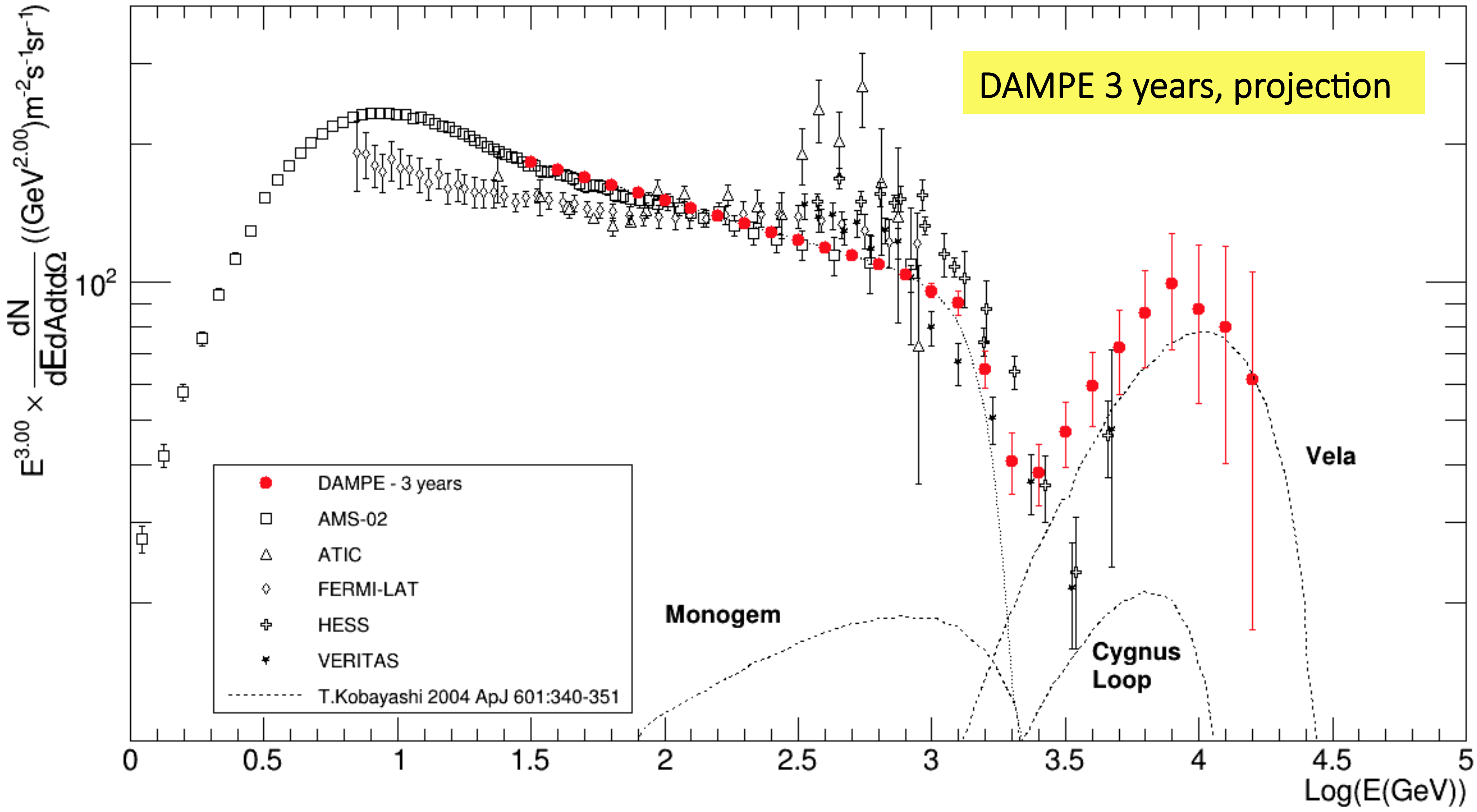
High energy electrons/photons



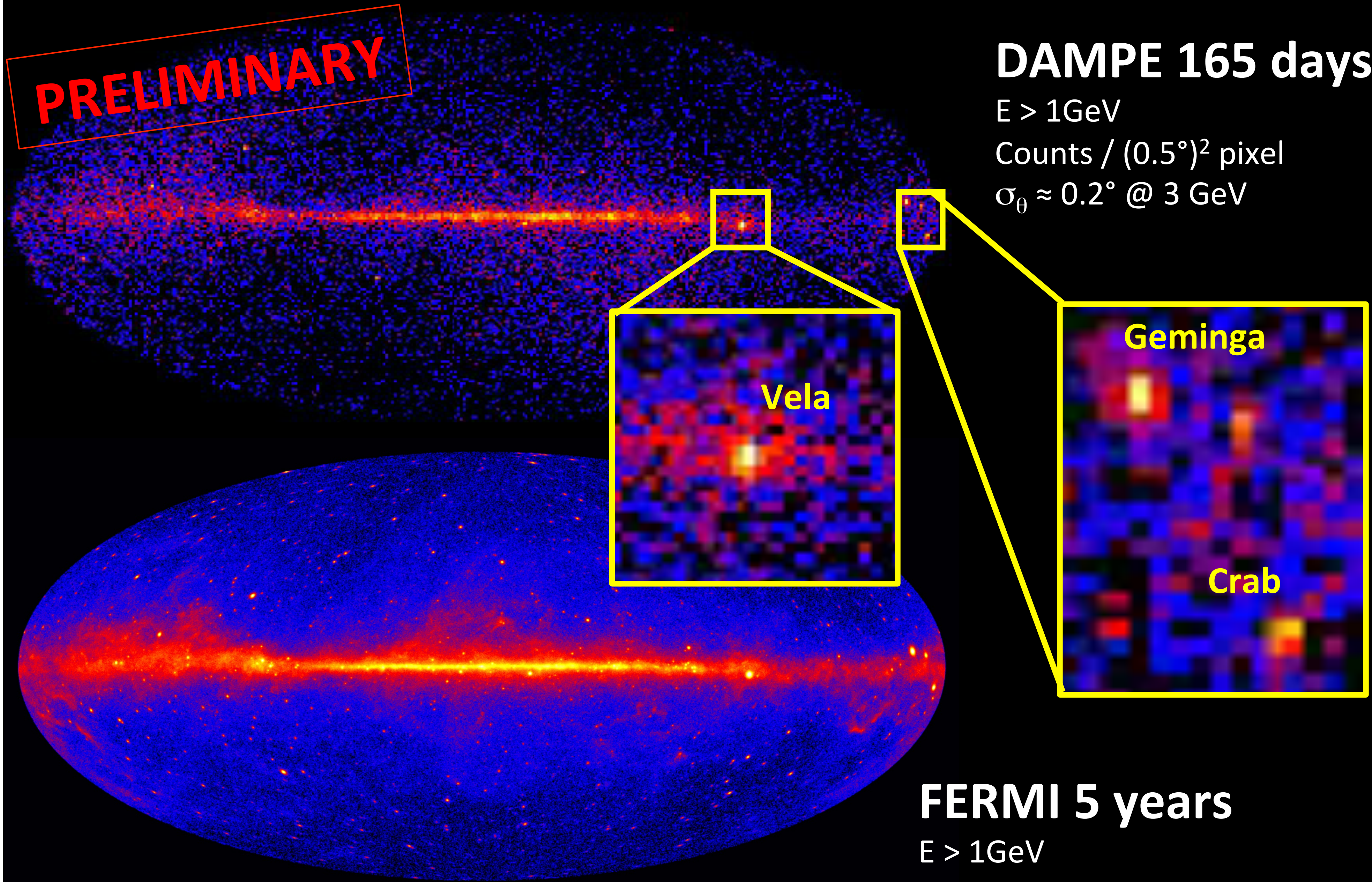
- **~52k events in fitted signal (2σ) with E>100 GeV in 9 months**
  - **Signal stable with track match cut, s/b improved**
  - **Assume γ = 2.7, >450 events above 1 TeV in 1 year**

More powerful methods exploiting the full detector capability, and with ML algorithms, are being developed

Expected ($e^{+}+e^{-}$) flux, DAMPE 3 years



Gamma rays observed!

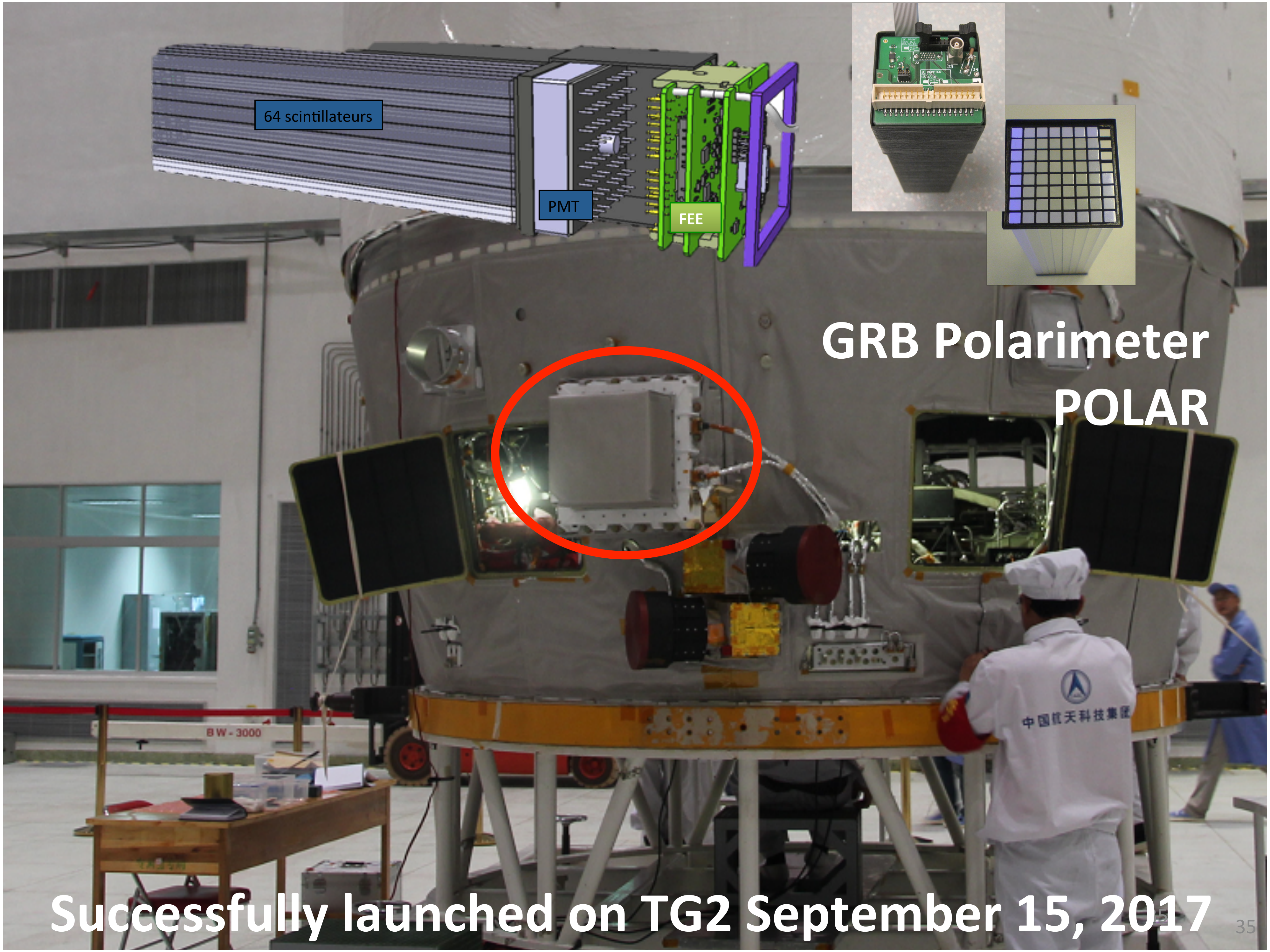


In the past hundred years, balloons and satellites have measured charged Cosmic Rays with ~30% accuracy.

AMS is providing cosmic ray information with ~1% accuracy. This accuracy provides a new understanding of the nature of Cosmic Rays.

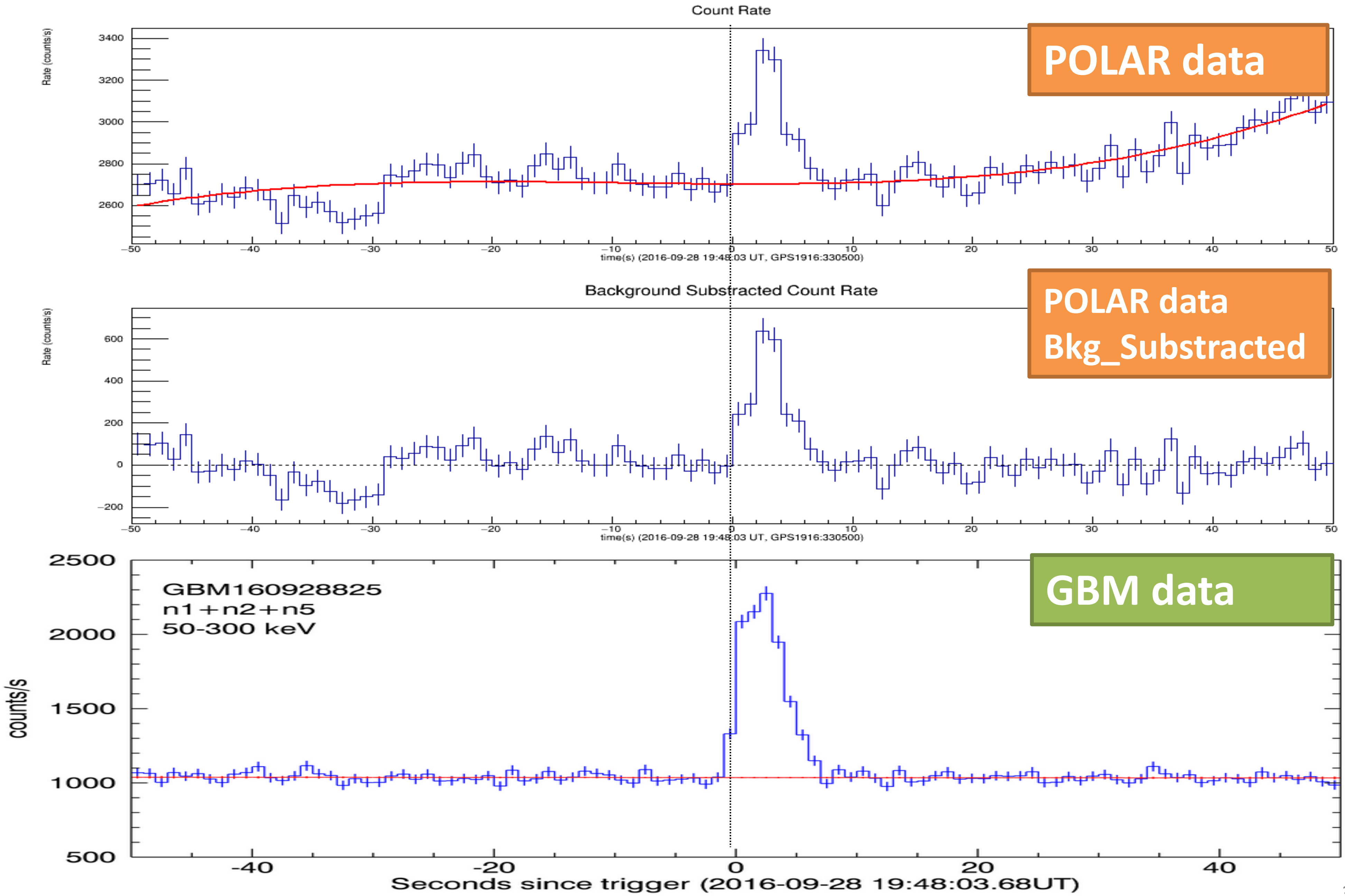
And there is a lot more to come…

See CERN seminar by S.C.C. Ting tomorrow afternoon


64 scintillateurs
PMT
FEE
GRB Polarimeter
POLAR
Successfully launched on TG2 September 15, 2017

GBM 160928825

2016-09-28 19:48:03UT   max_SNR=15.7816   maxSN_timestart=-0.55s   maxSN_duration=4.35s



GBM 160928825

2016-09-28 19:48:03.68UT   max_SNR=15.7816   maxSN_timestart=-0.55s   maxSN_duration=4.35s