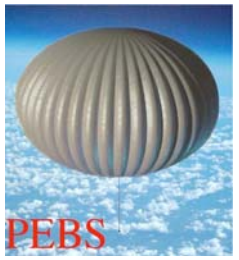


Status of AMS and PEBS

CHIPP Plenary Meeting
Appenberg, 24-25 August 2009

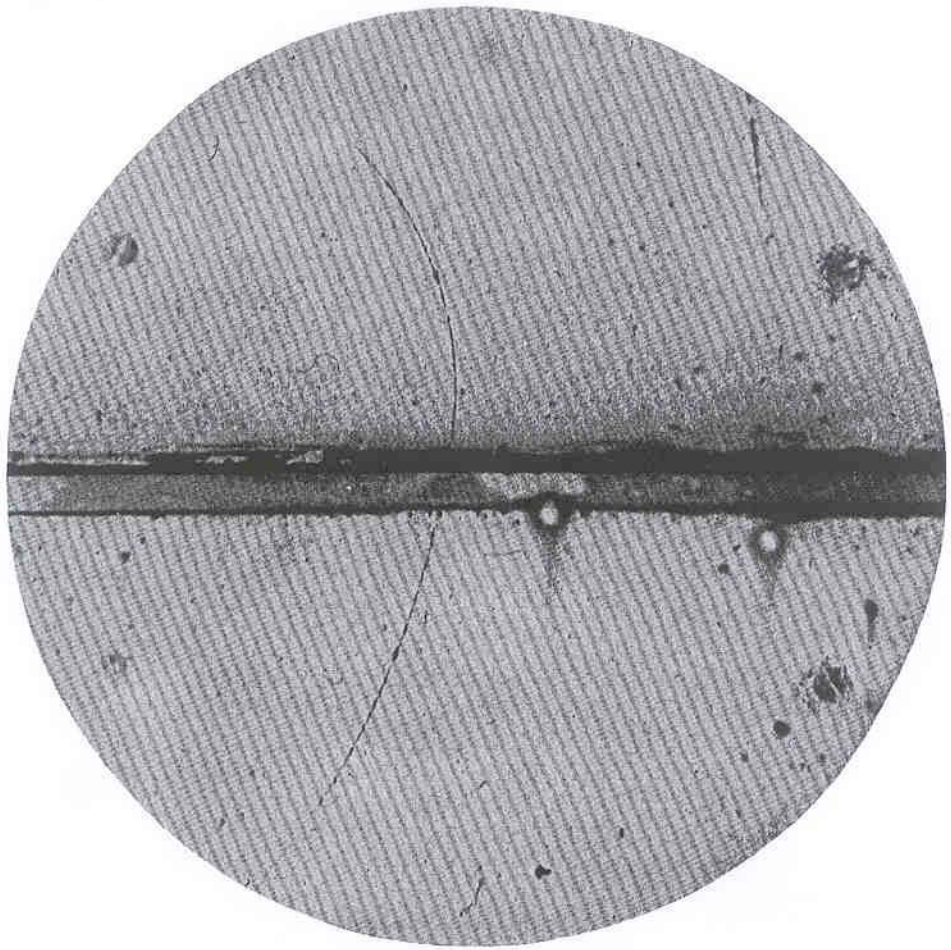
(thanks to Divic Rapin for the AMS information)

T. Nakada
EPFL-LPHE

EPFL LPHE

Antiparticle and cosmic rays

- Antiparticle was first discovered in the cosmic ray - positron seen by Anderson in 1932



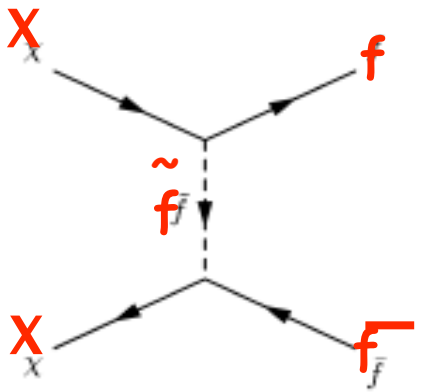
Antiparticles in the cosmic rays

- Any antimatter left in the universe?
  anti-nucleus (e.g. anti-He)
  → matter anti-matter asymmetry in the universe
- Origin of high energy anti-particles
  → indirect evidence of dark matter?

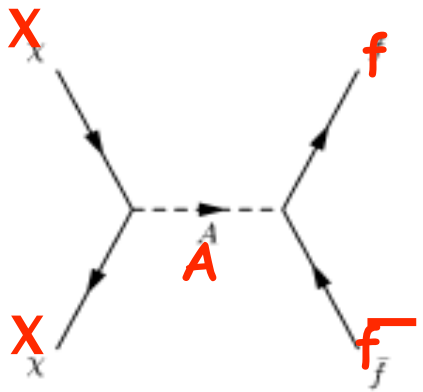
⇑

particularly interesting questions for particle physics

For example

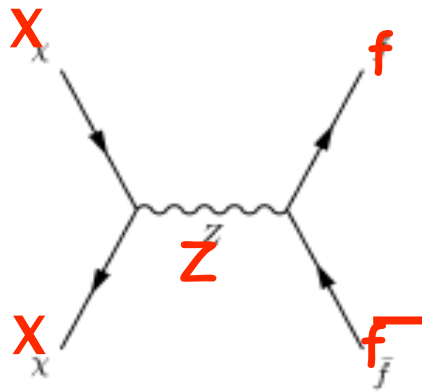


$$\propto \frac{m_\chi \cdot m_f}{m_{\tilde{f}}^2}$$

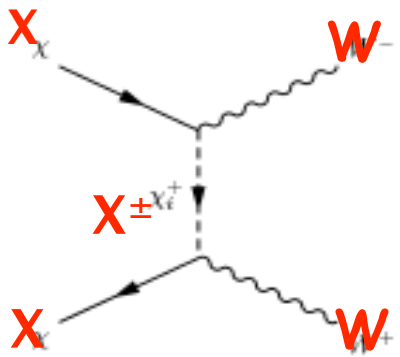


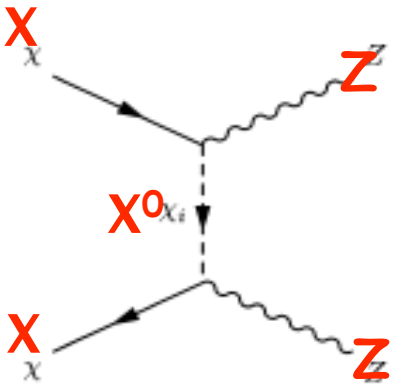
$$\propto \frac{\tan\beta \cdot m_{f_d}}{m_W}\left(\frac{m_\chi}{m_A}\right)^2 N_1 N_{3(4)}$$

$$\tan\beta \cdot m_{f_d} \leftrightarrow \frac{m_{f_u}}{\tan\beta}$$



$$\propto \frac{m_f \cdot m_\chi}{m_Z^2} N_{3(4)}^2$$





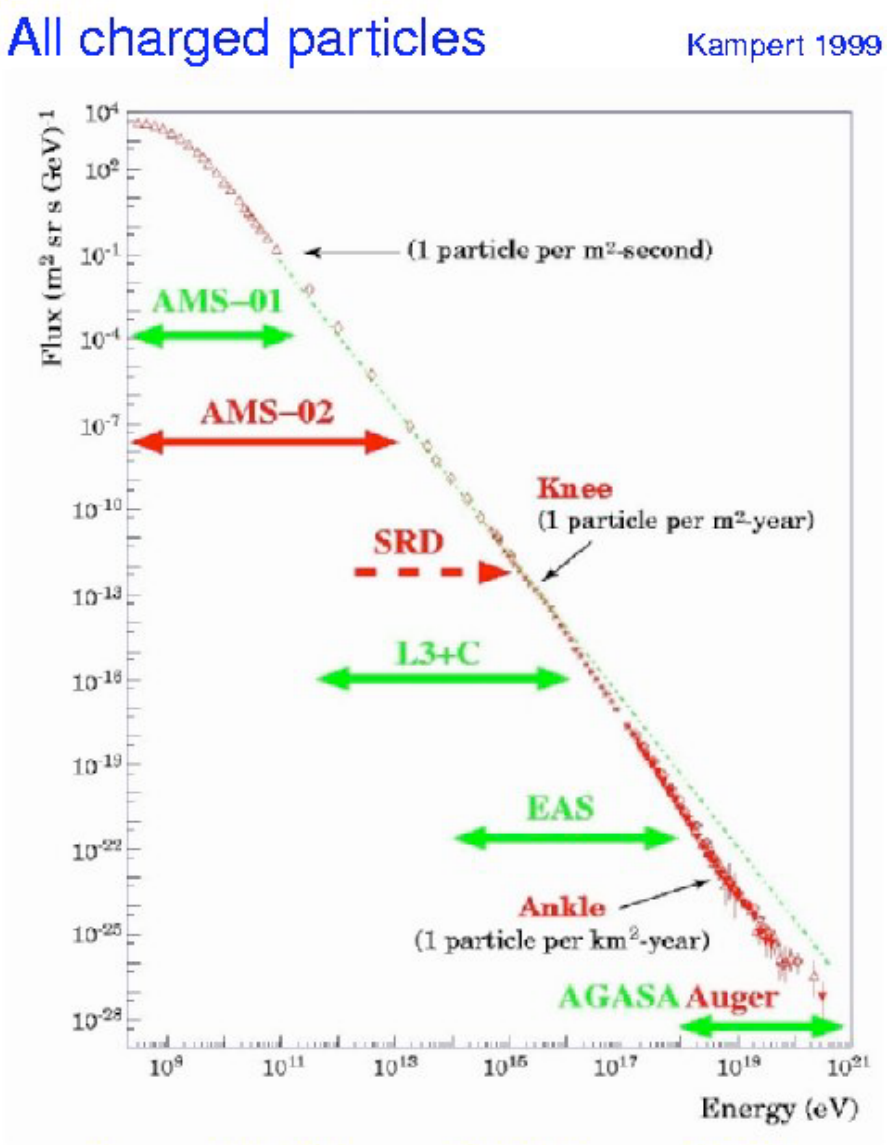
$$\propto \frac{1}{1+(m_{\chi_i^+}/m_\chi)^2-(m_W/m_\chi)^2}$$

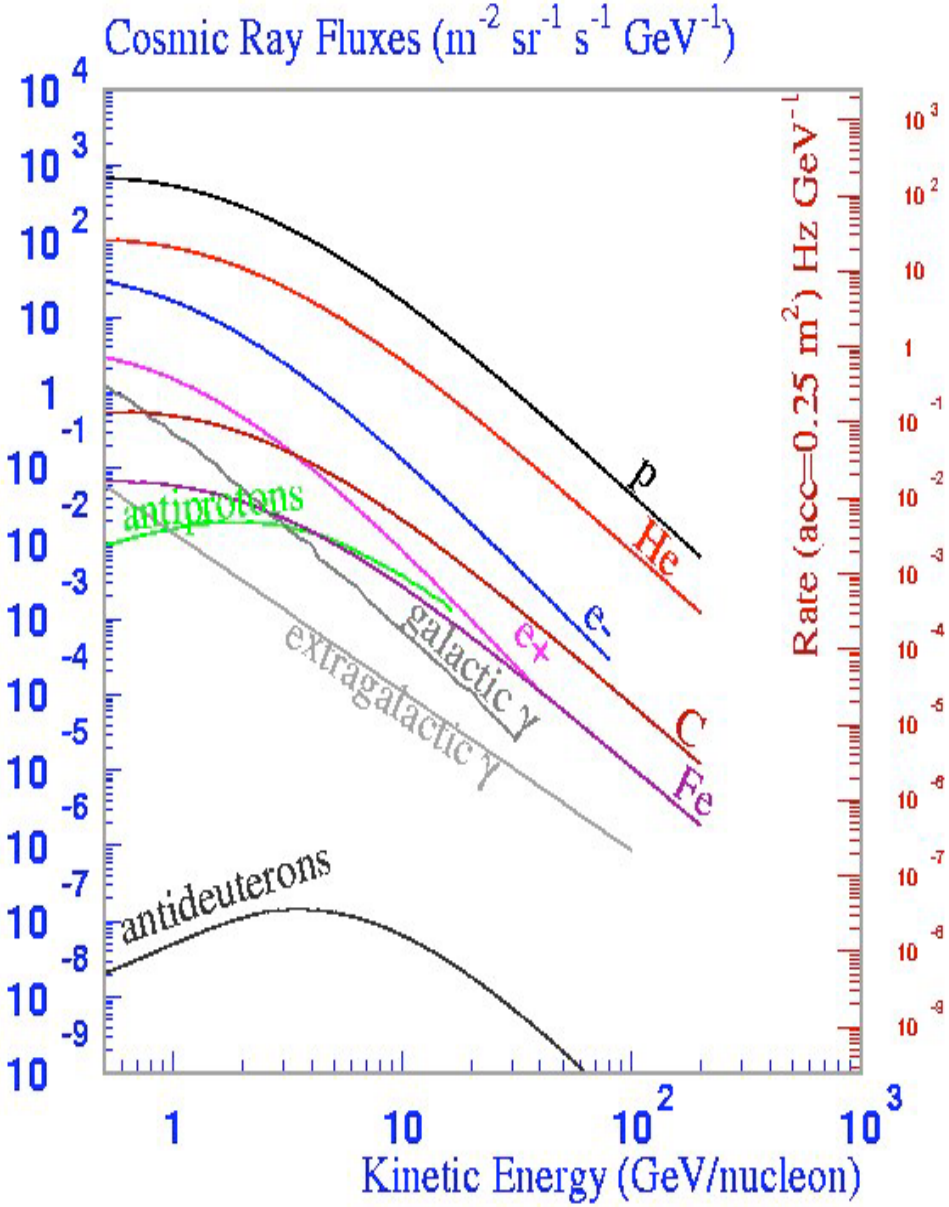
$$(m_{\chi_i^+}, m_W) \leftrightarrow (m_{\chi_i}, m_Z)$$

Detector requirements

- Minimising effect from atmosphere:
  → satellite or very high altitude balloon (~40 km)
- *E* measurement and
  particle identification: +/−, e/p, d/He/…
  → strong magnet with high precision tracker
  → EM-calorimeter and TRD
  → RICH

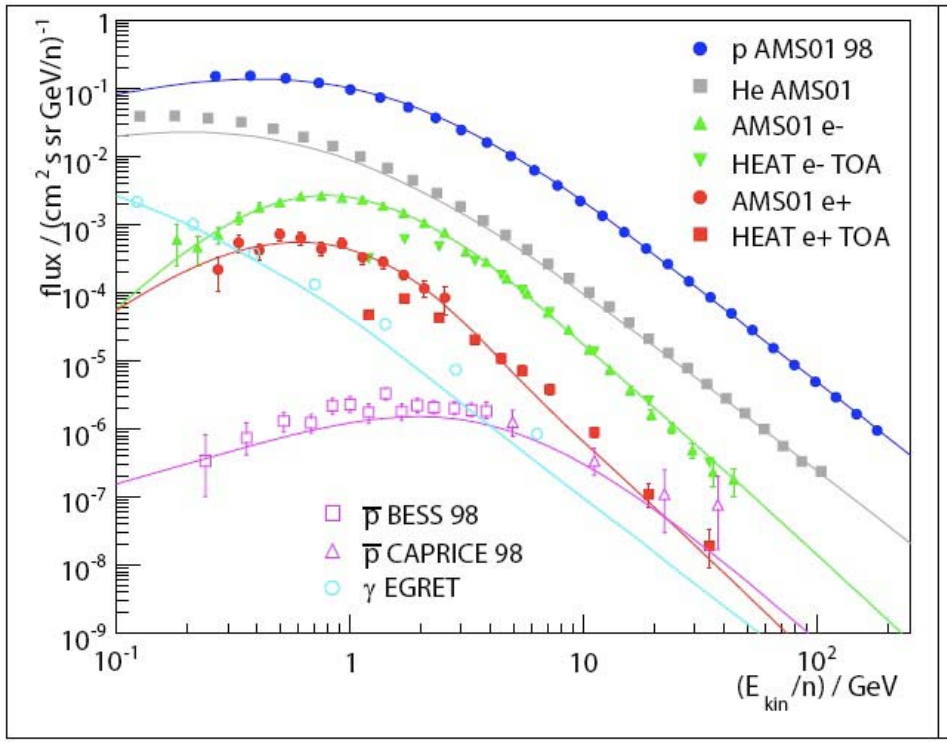
Steeply falling spectrum

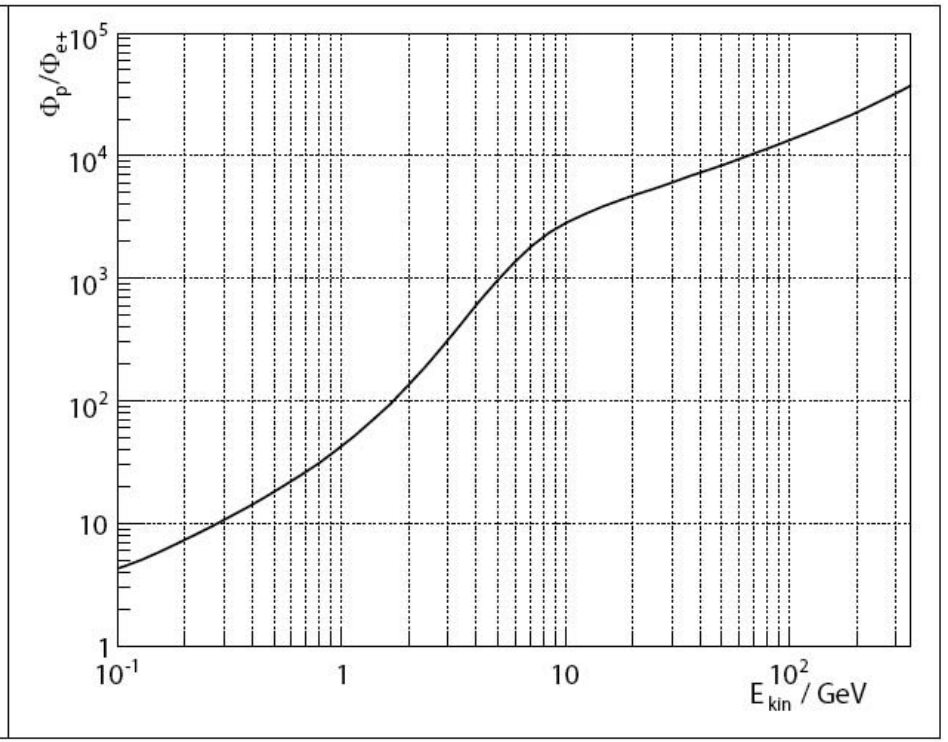




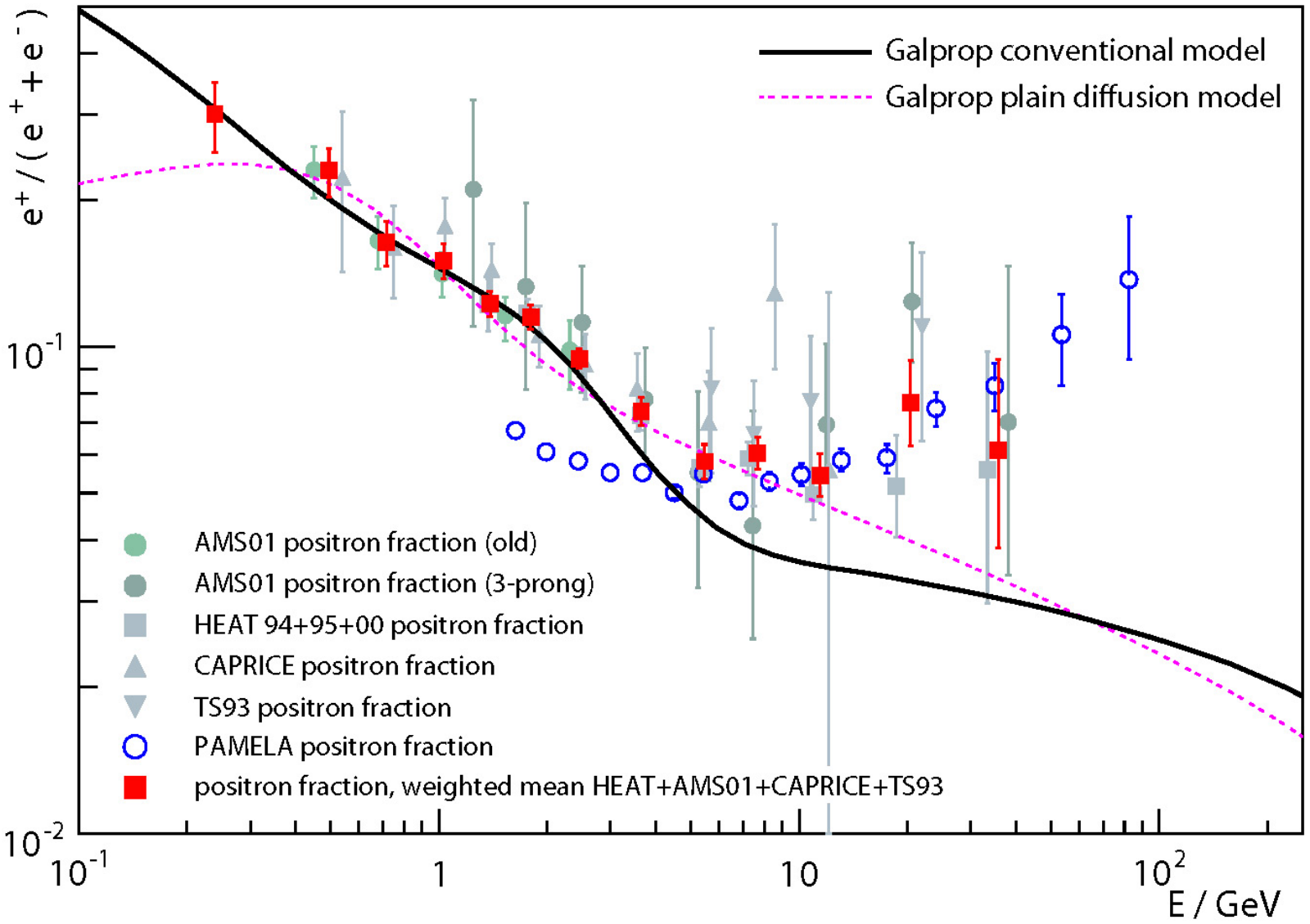
Proton background

- 10 to 100 GeV region: Miss ID ($p \rightarrow e^+$)<10^{-4} needed



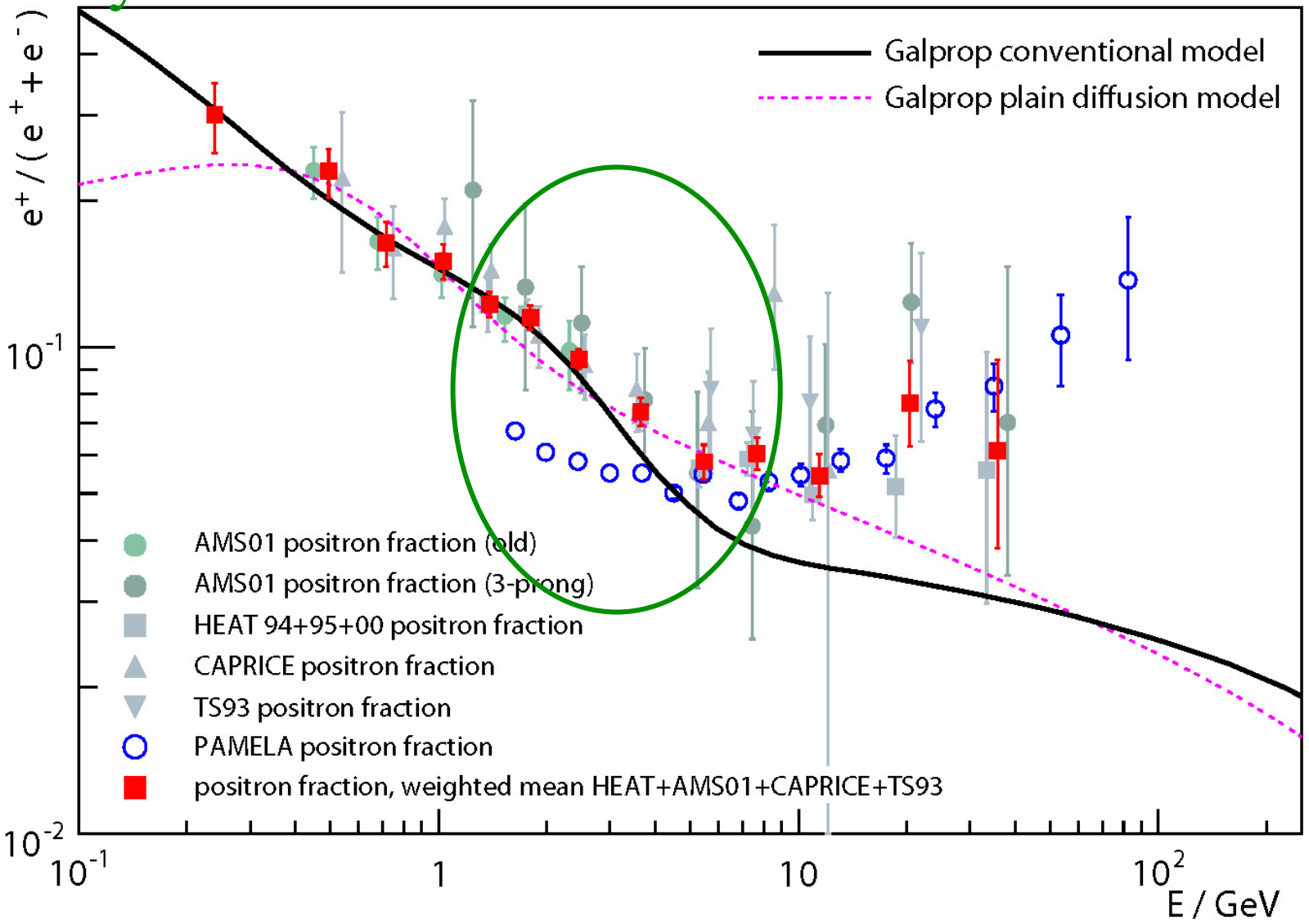


Interesting signature with e^+



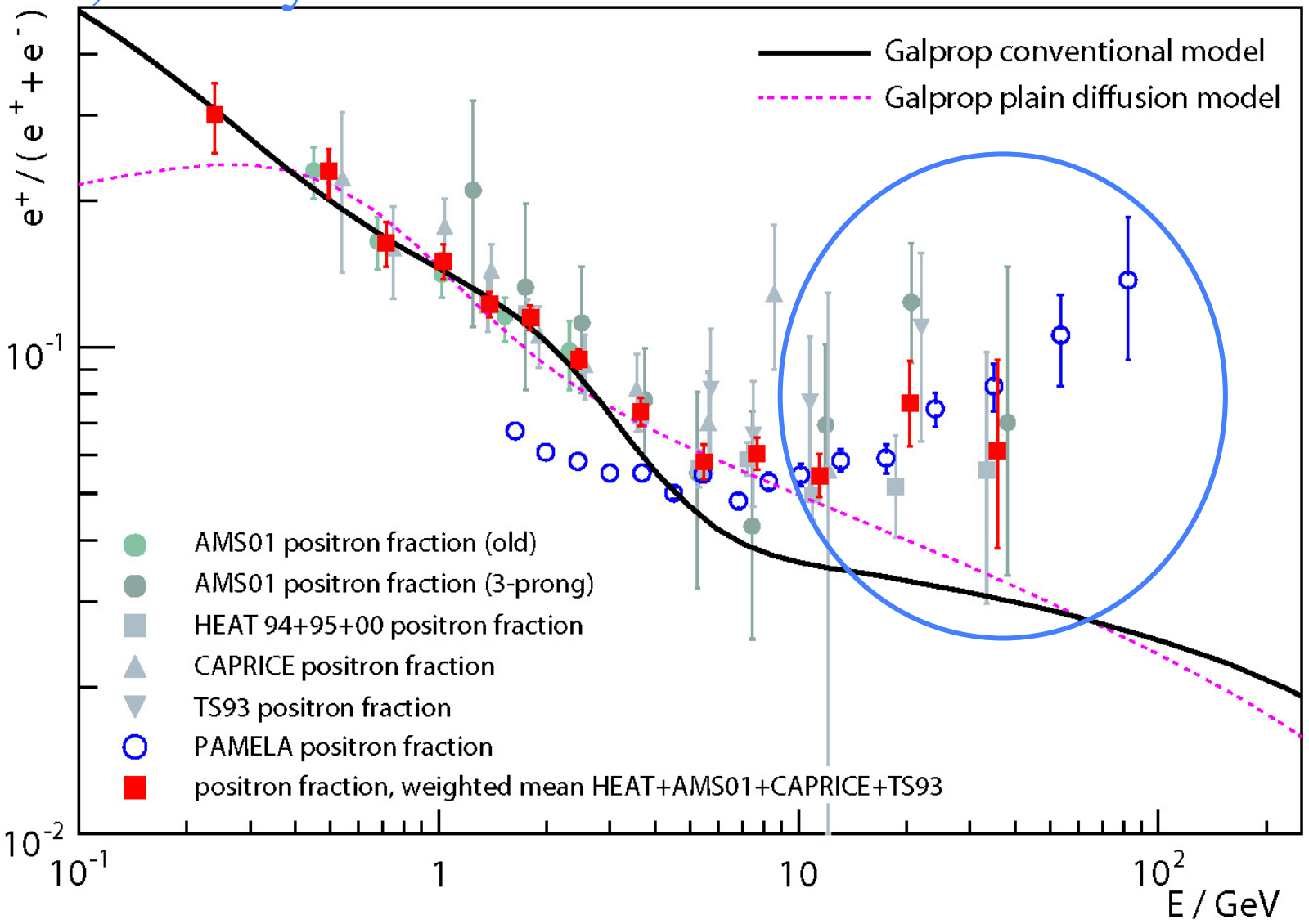
Interesting signature with e^+

- Solar cycle effect?

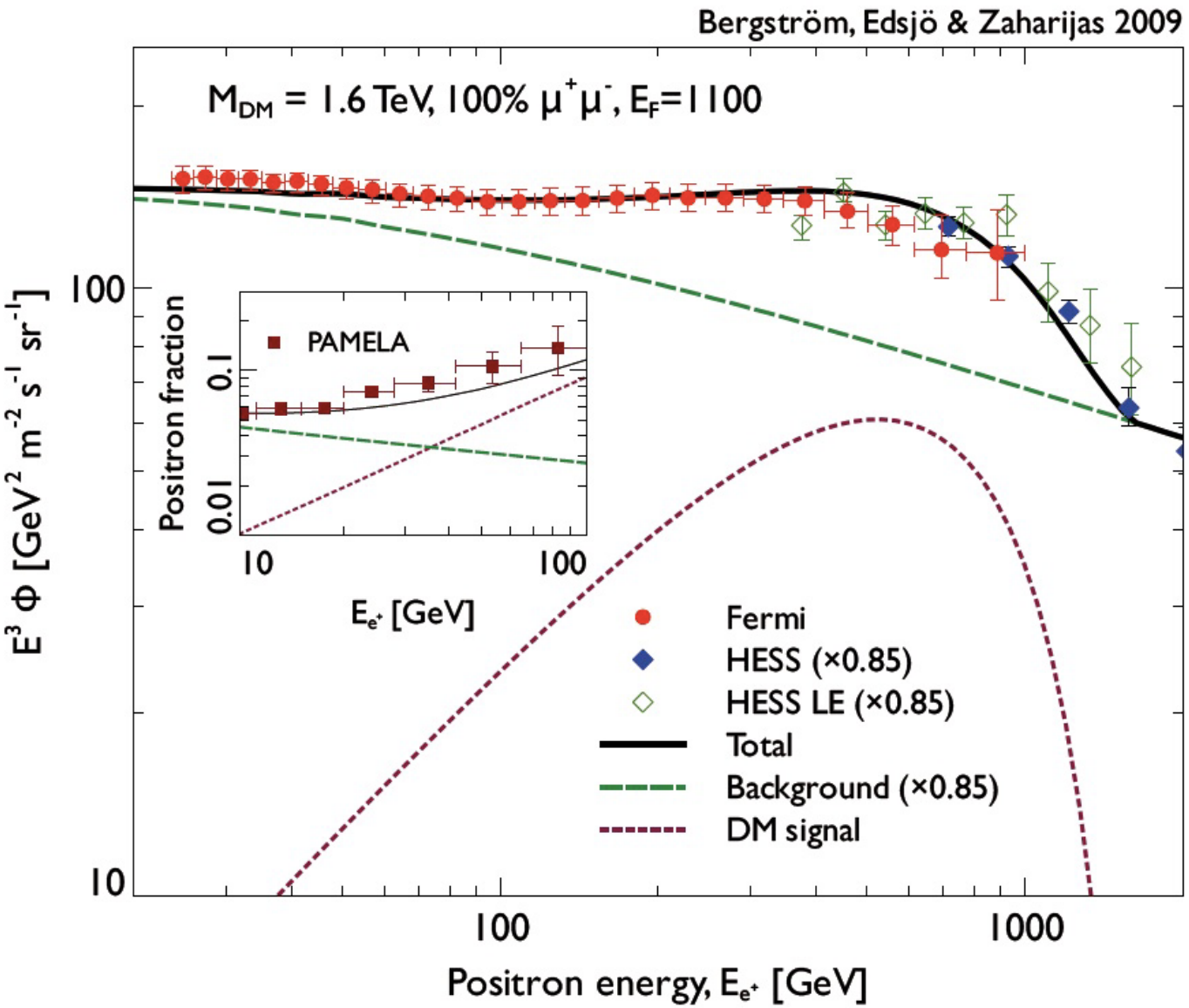


Interesting signature with e^+

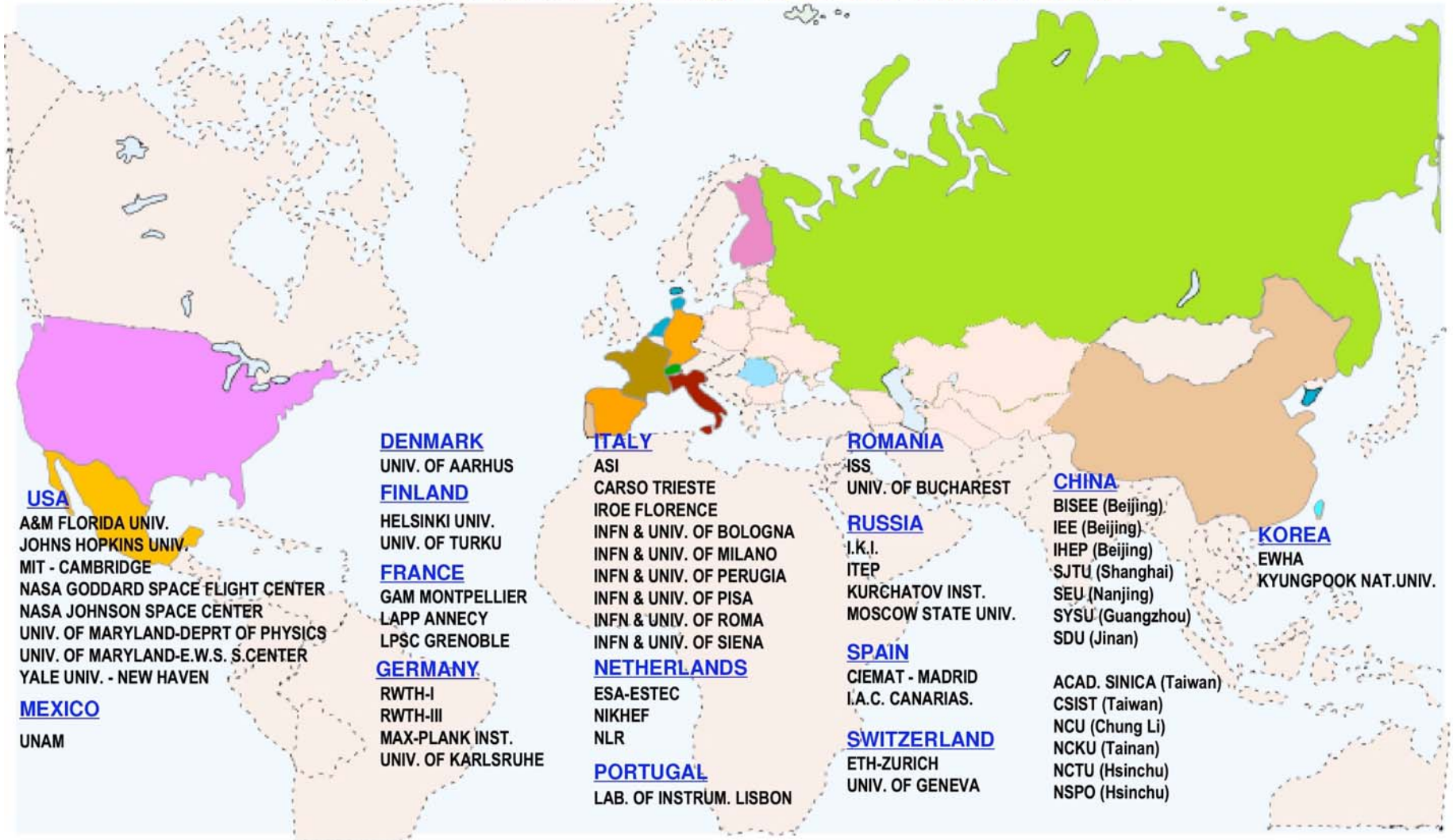
- Pulsar, or may be dark matter?



Interesting signature with $e^+ + e^-$



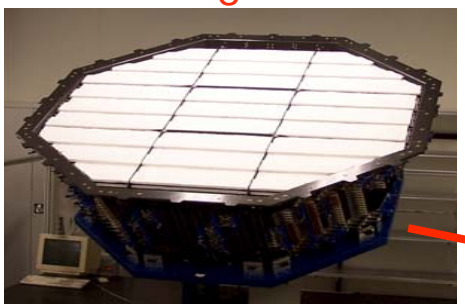
AMS collaboration
(from CH, ETHZ and Uni. Geneva)



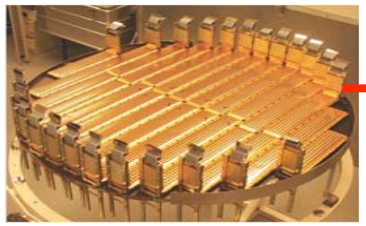
~ 500 Collaborators from 56 institutes

AMS detector

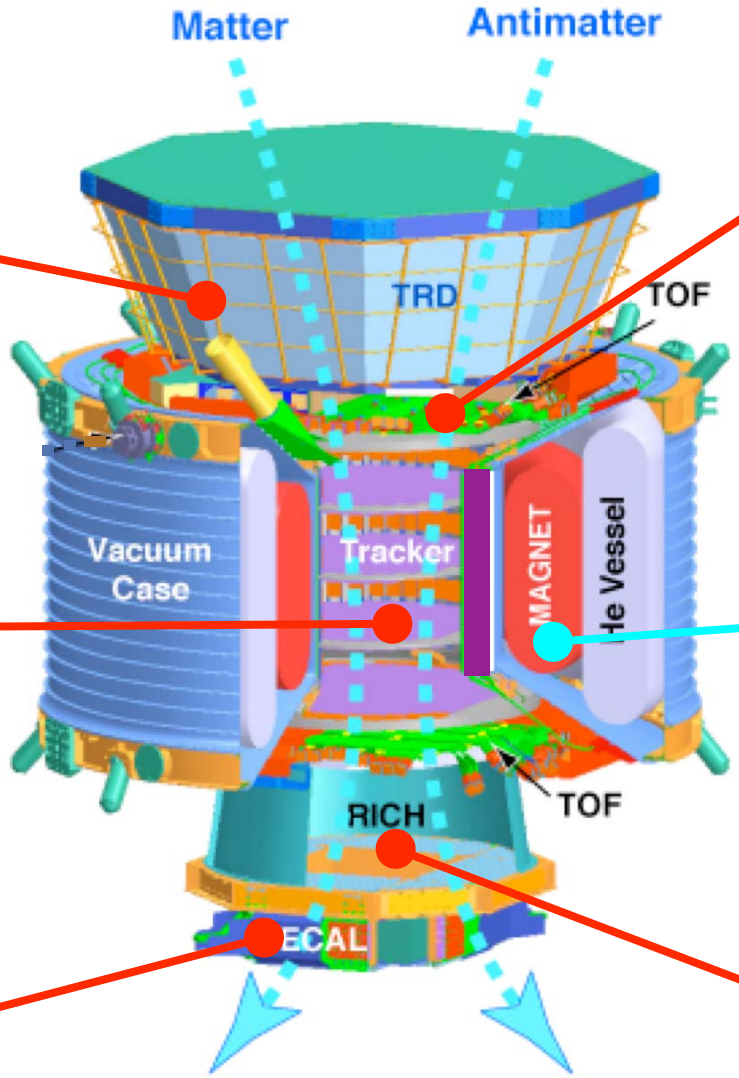
TRD
e



Silicon Tracker
Z, P

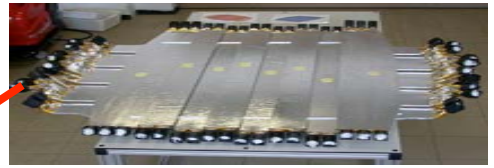


Calorimeter
e, γ

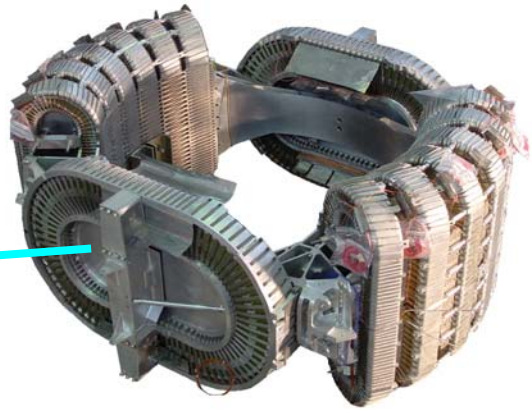


Size: 3m x 3m x 3m
Weight: 7 tons (0.8 T)

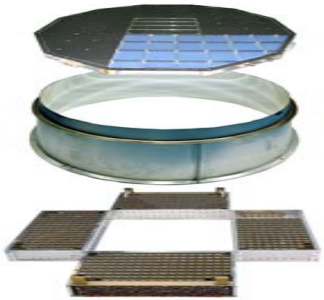
Time of Flight
v, Z



Magnet
P

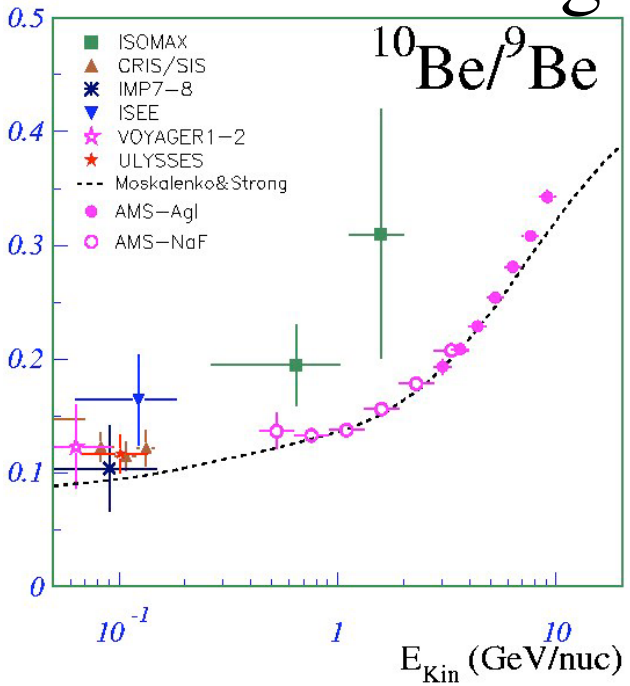


RICH
v, Z

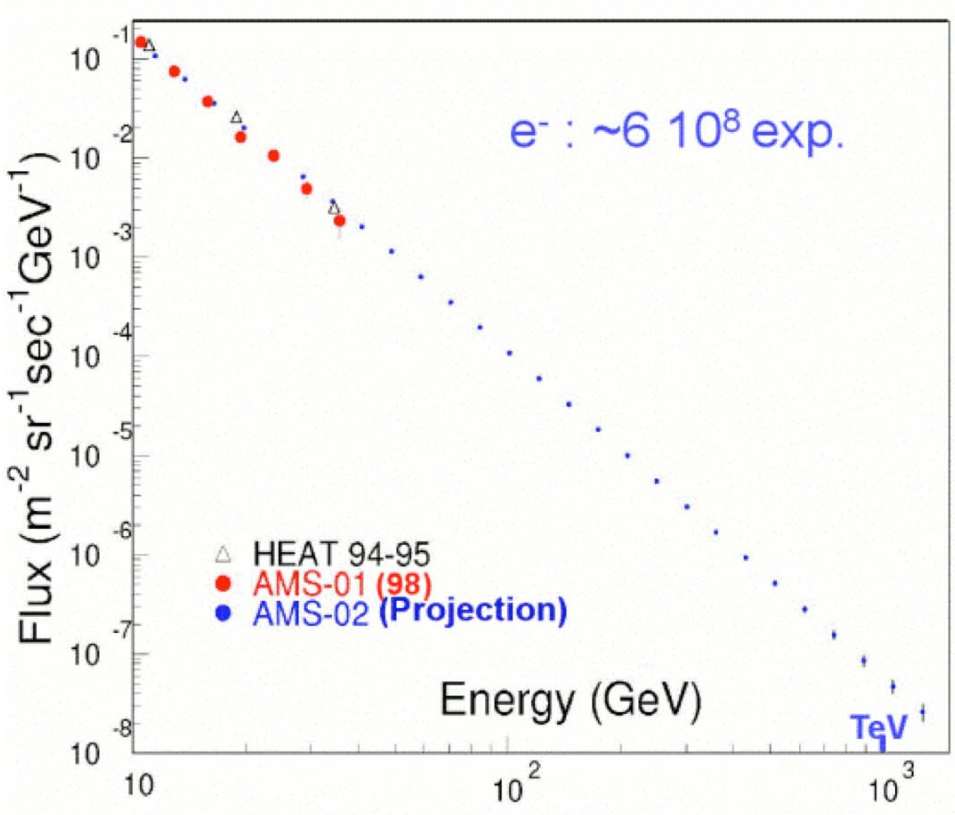


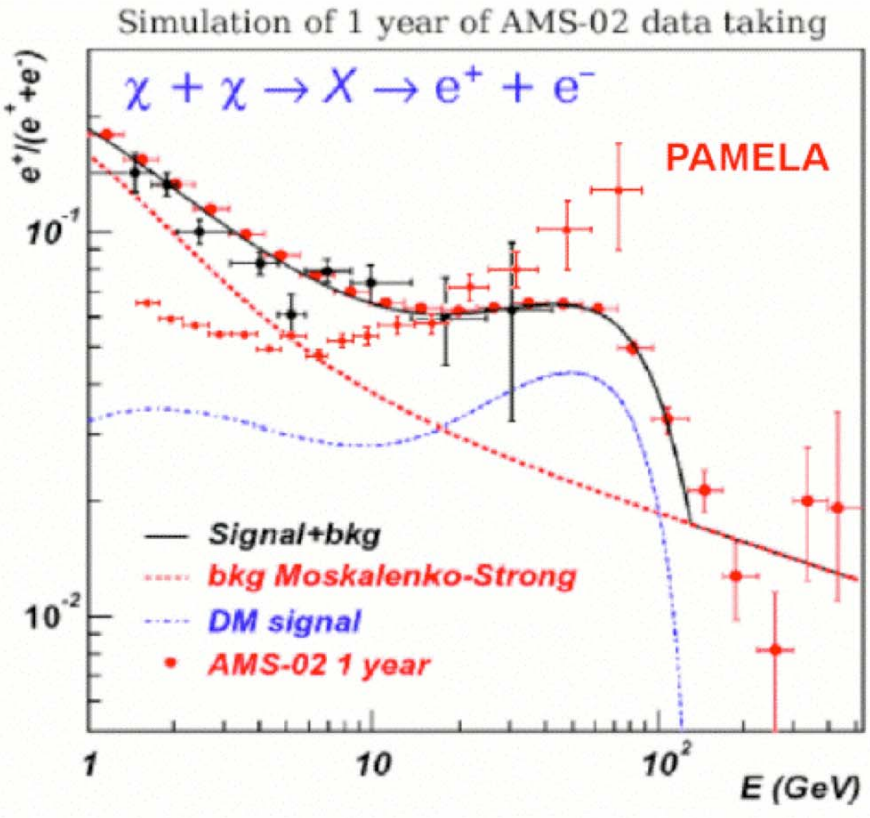
AMS-02

- The last component, superconductive magnet, being commissioned, and some modifications required.
- All the other subdetectors are ready
- Planned shuttle flight to the space station in Summer 2010 and ~3 years of data taking
- e^+ flux up to 300 GeV
- $^{10}Be/^{9}Be$, $^{3}He/^{4}He$ etc., up to 10 GeV (important to understand background for e^+)



AMS-02


e⁻ : ~6 10⁸ exp.
HEAT 94-95
AMS-01 (98)
AMS-02 (Projection)
Energy (GeV)
TeV
Flux (m⁻² sr⁻¹ sec⁻¹ GeV⁻¹)


Simulation of 1 year of AMS-02 data taking
χ + χ → X → e⁺ + e⁻
PAMELA
e⁺/(e⁺+e⁻)
Signal+bkg
bkg Moskalenko-Strong
DM signal
AMS-02 1 year
E (GeV)

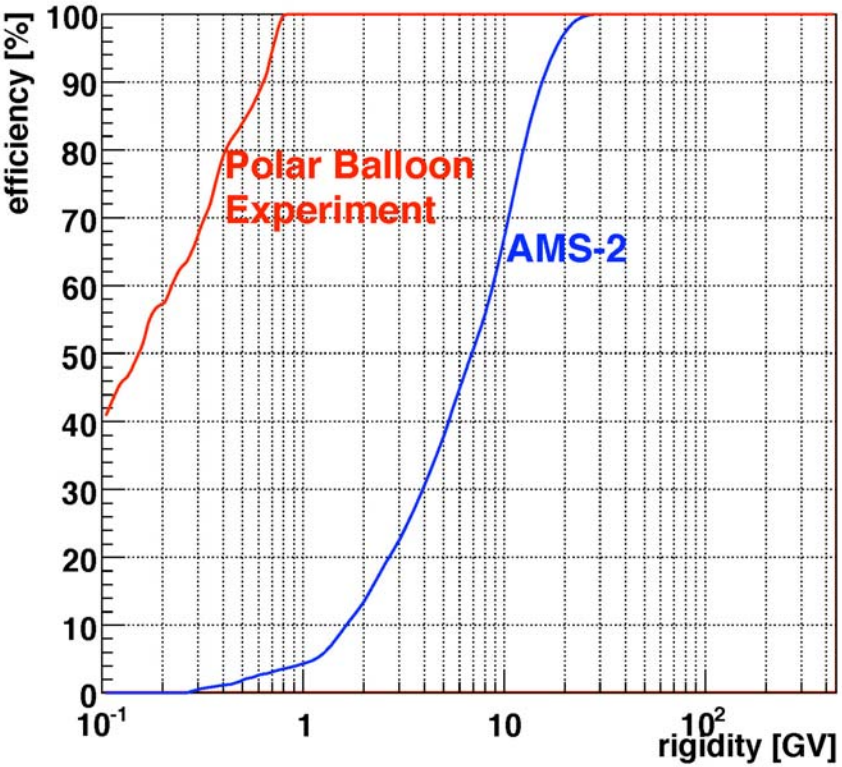
What is needed after AMS?

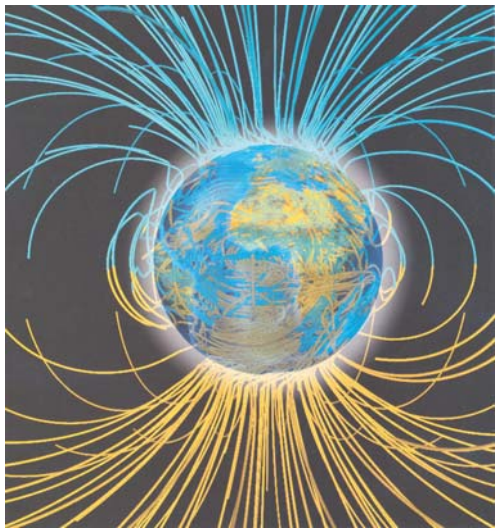
- e^+ flux measurement from ~1 GeV to >1 TeV
- $^3He/^4He$ measurement up to 100 GeV for better background understanding

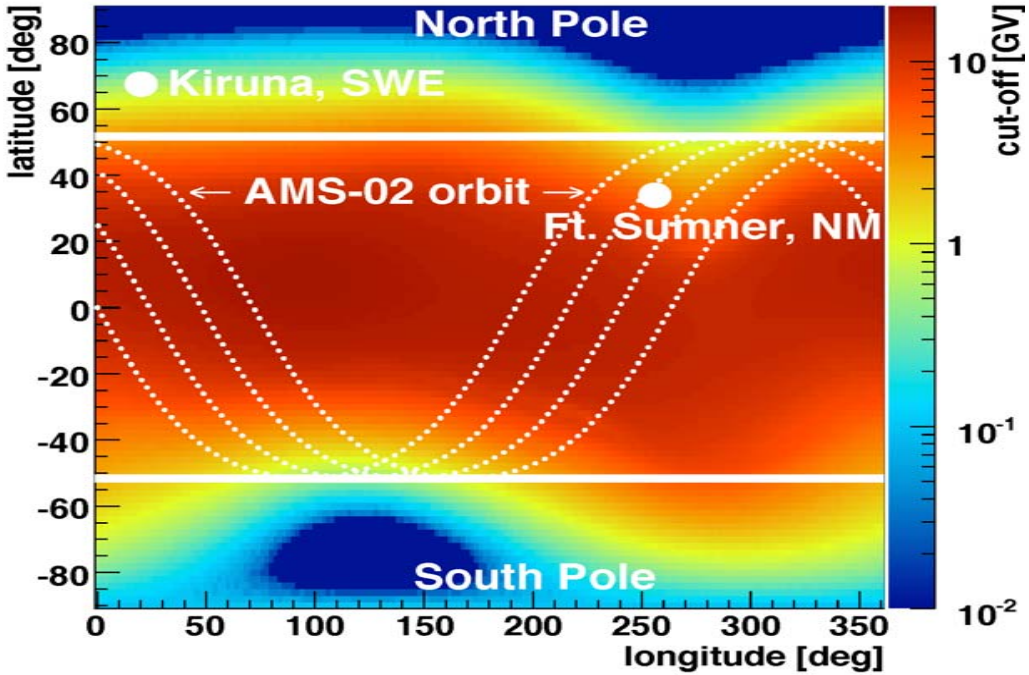
They require

- A tracking system with much better $\Delta p/p$ than AMS
- Well understood energy calibration
- Data taking in the polar region for low energy e^+

Energy cut-off

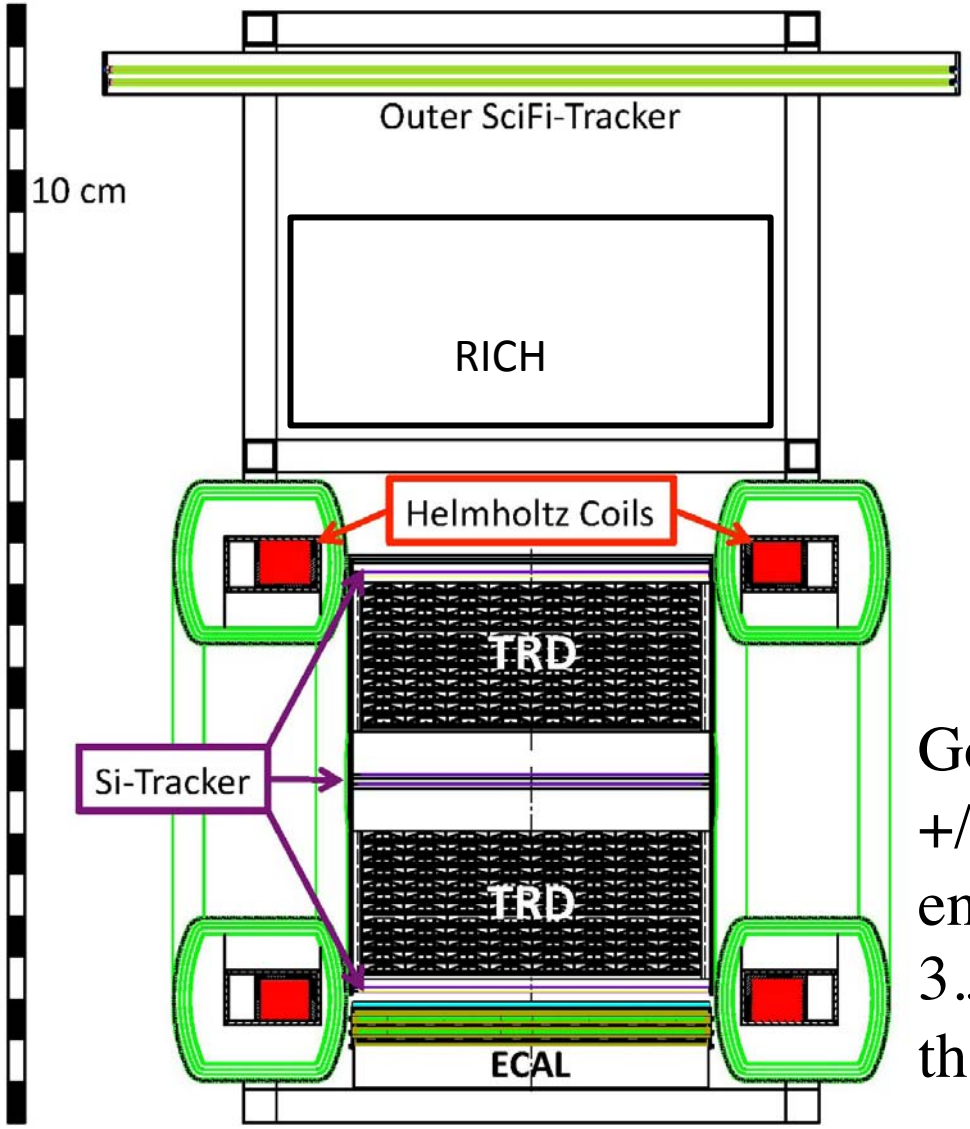


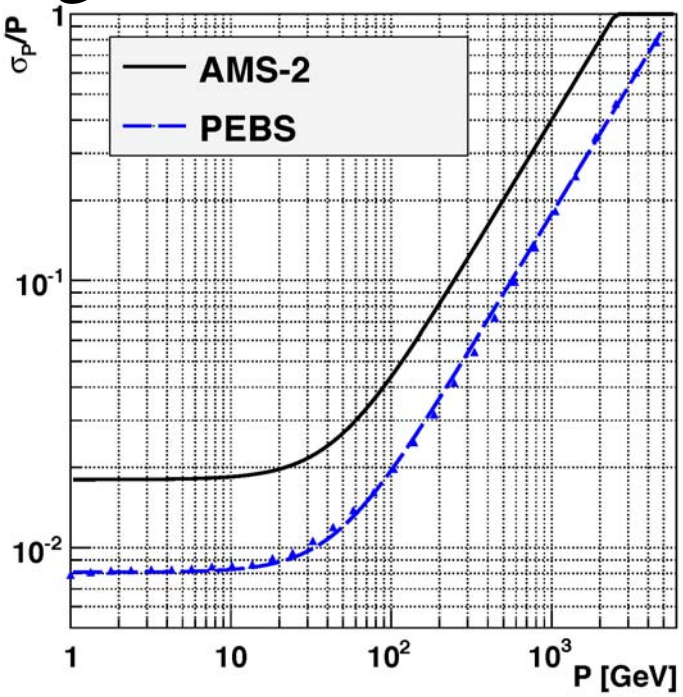




Positron Electron Balloon Spectrometer

Combination of Si and scintillating-fibre trackers





Good $\Delta p/p$ due to a large lever-arm

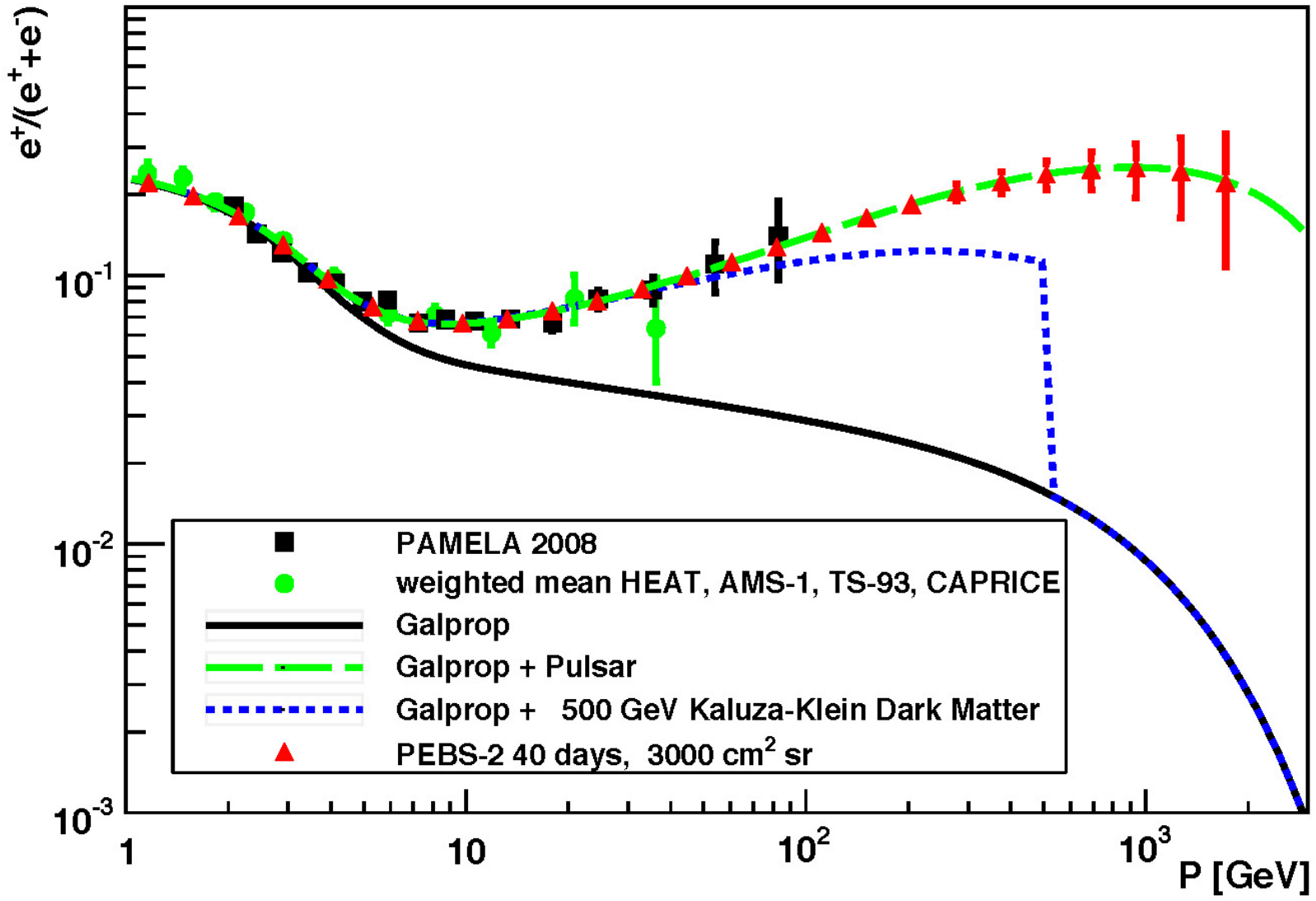
+/− separation up to 1 TeV

energy measurement with Ecal

3.5 (150) times larger acceptance than AMS-2 (PAMELA)

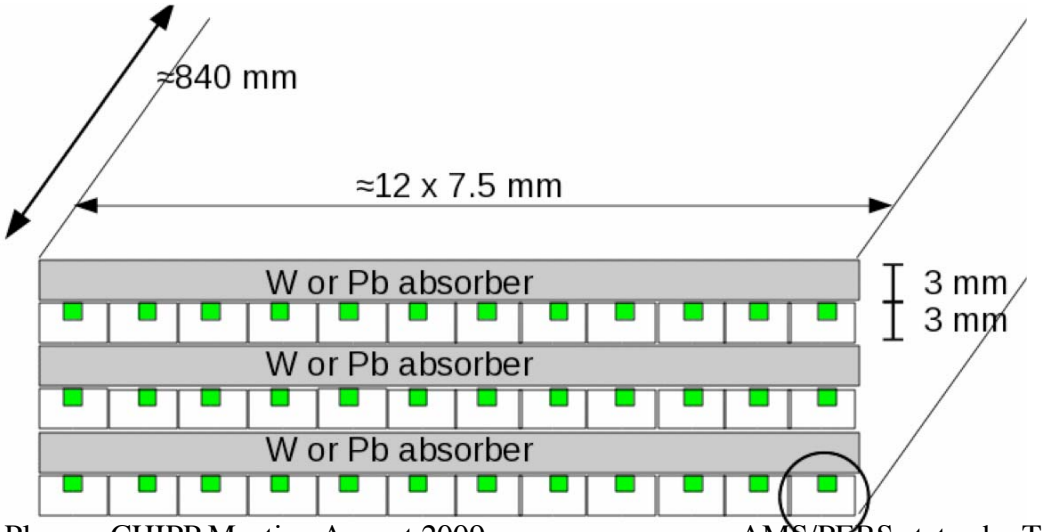
PEBS expectation

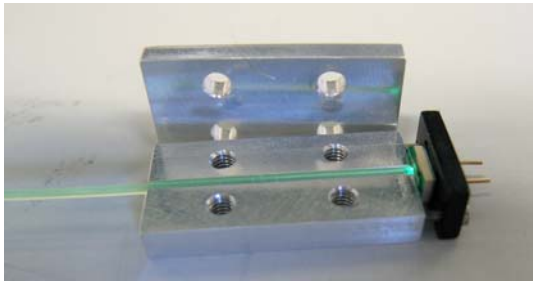
Spectra corrected for solar modulation



PEBS CH contribution

- Collaborating institute for PEBS
  - China (Tsinghua University)
  - CH (EPFL, ETHZ)
  - DE (Aachen)
  - US (Chicago, Ohio)
- CH contribution: W+scintillator E-cal with MPPC (Si-PMT) readout





PEBS Status

- Proposal to NASA has been submitted: if accepted, NASA will cover all the cost for the balloon launch plus US detector contribution (5-year programme)
- For the non-US participants, NASA demands a guarantee for their contribution in the proposal. We cannot ask funding unless the balloon would fly…
- Our proposal consists of
  PEBS Phase-1 with permanent magnet and only scintillating-fibre tracker, not better than AMS but "can be financed" locally, and Phase-2, full programme requires extra funding

Summary

- With PAMELA, and recently ATIC and Fermi, e^+ or $(e^+ + e^-)$ flux indicates an interesting signature, which might be related to dark matter.
- AMS-02 will improve the PAMELA result and provide nucleus ratios to understand the background spectrum
- PEBS is designed to measure e^+ flux from ~1GeV to >1TeV to provide much clearer picture to understand whether there is a sign of dark matter.