

PEBS - Positron Electron Balloon Spectrometer

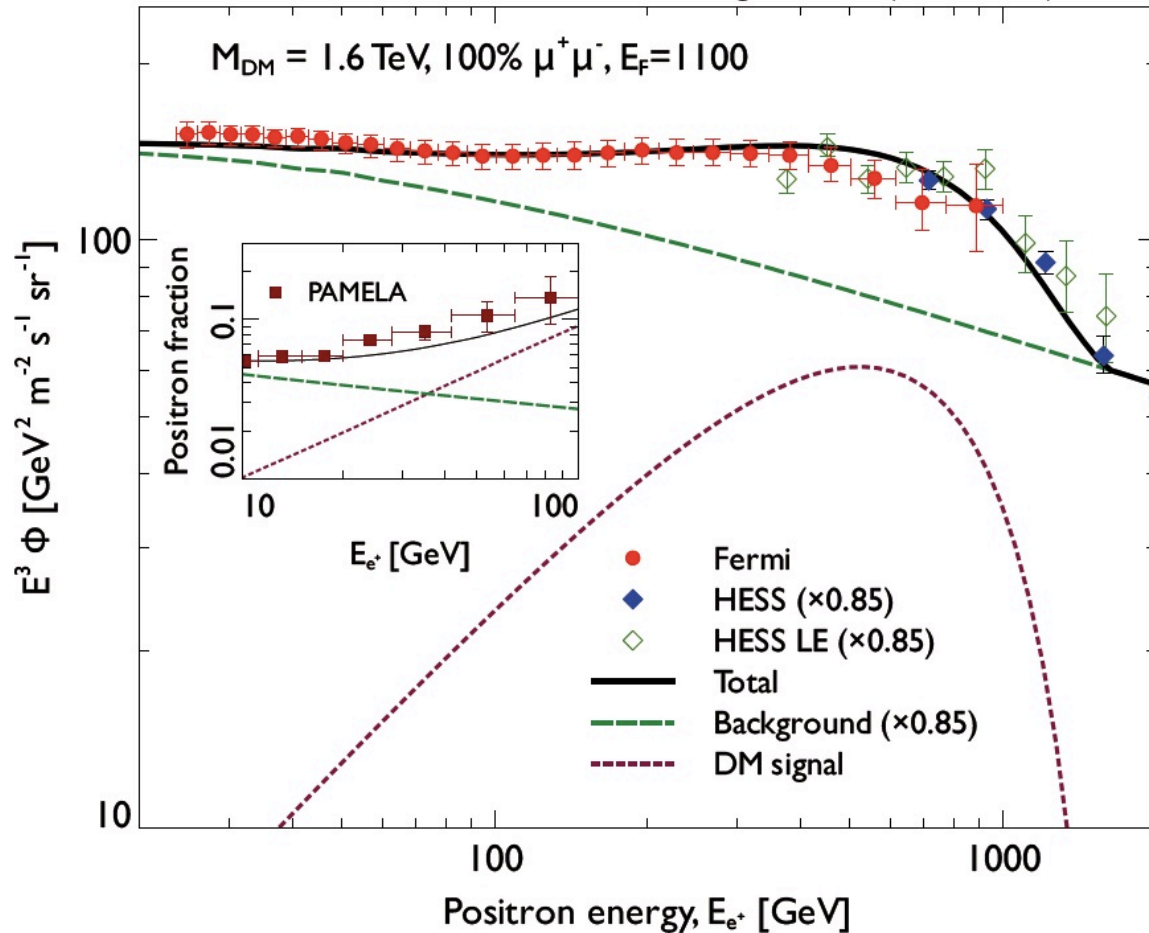
Stefan Schael
RWTH Aachen University



J. Beatty (Ohio State University), . G. Dissertori (ETH Zuerich), T. Nakada (EPF Lausanne)
S. Schael (RWTH Aachen University), S. Swordy (University Chicago)

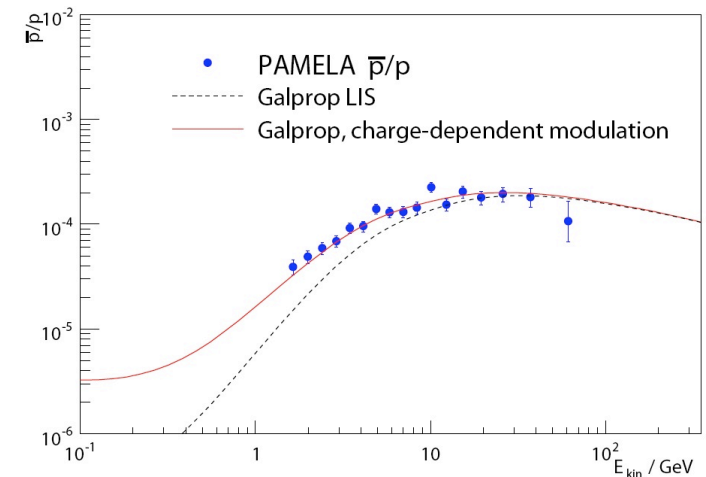
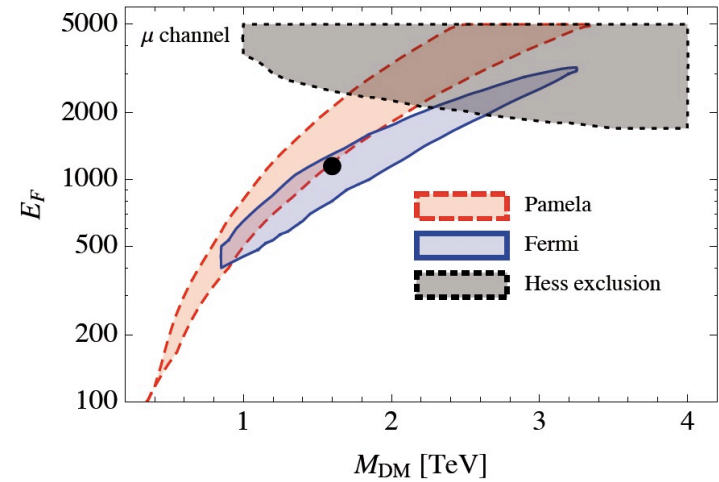
Cosmic Ray Spectra

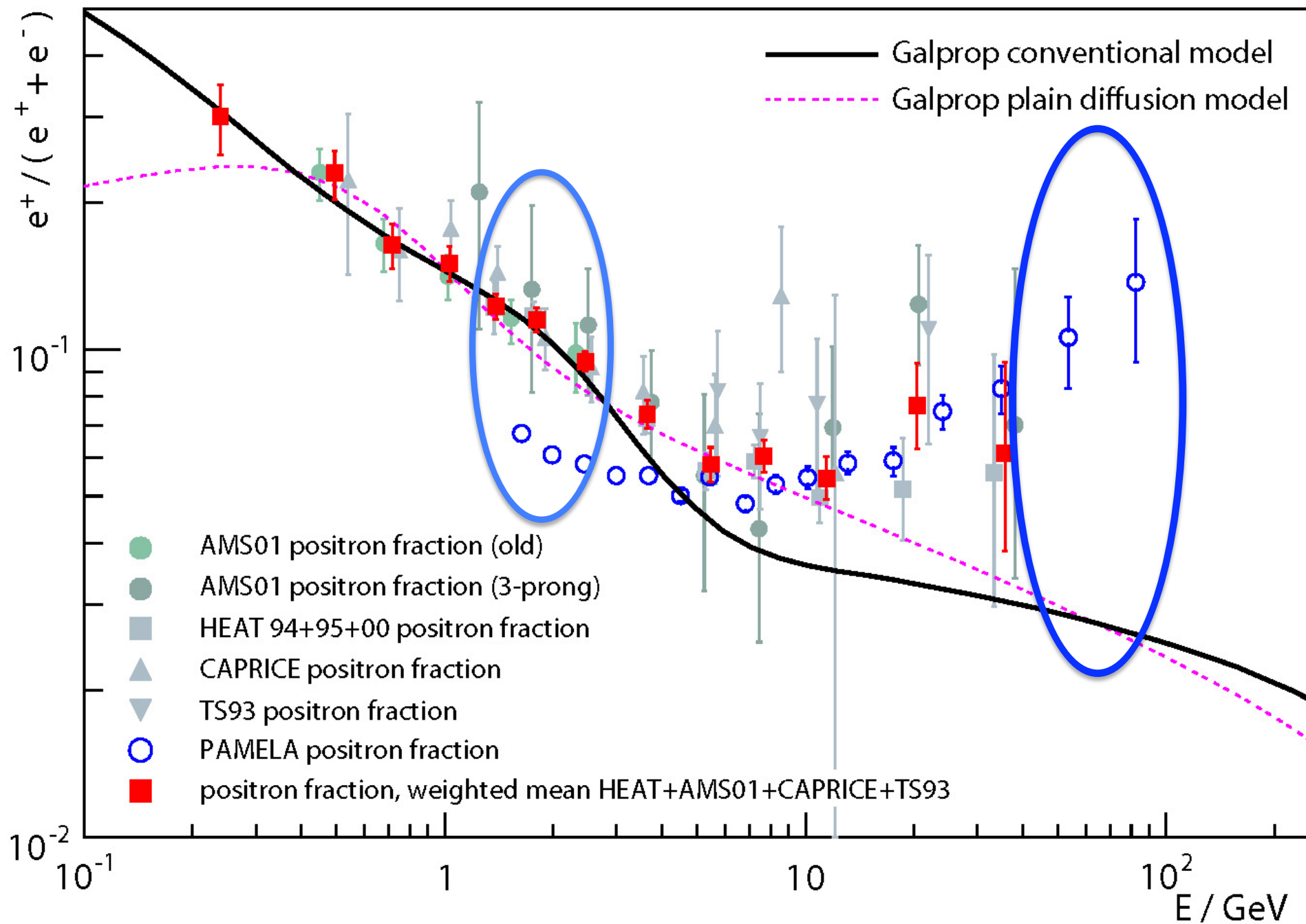
Bergström, Edsjö & Zaharijas 2009

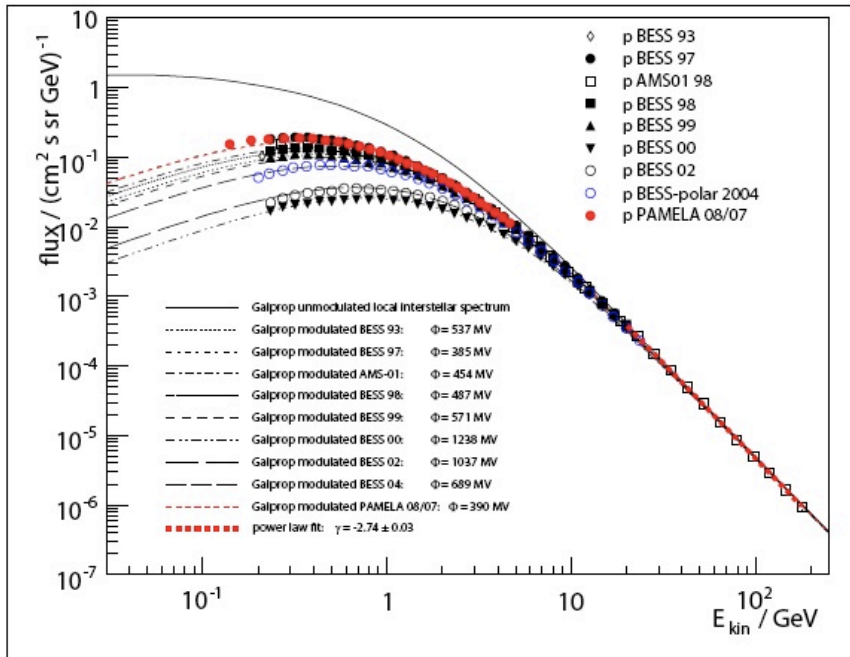


$$\langle \sigma v \rangle = 10^{-26} \text{ cm}^3 / \text{s}$$

$$E_F = \left(\frac{\rho_0}{0.3 \text{ GeV} / \text{cm}^3} \right)^2 \left(\frac{\tau_0}{10^{16} \text{ s} / \text{GeV}^2} \right) B_F$$





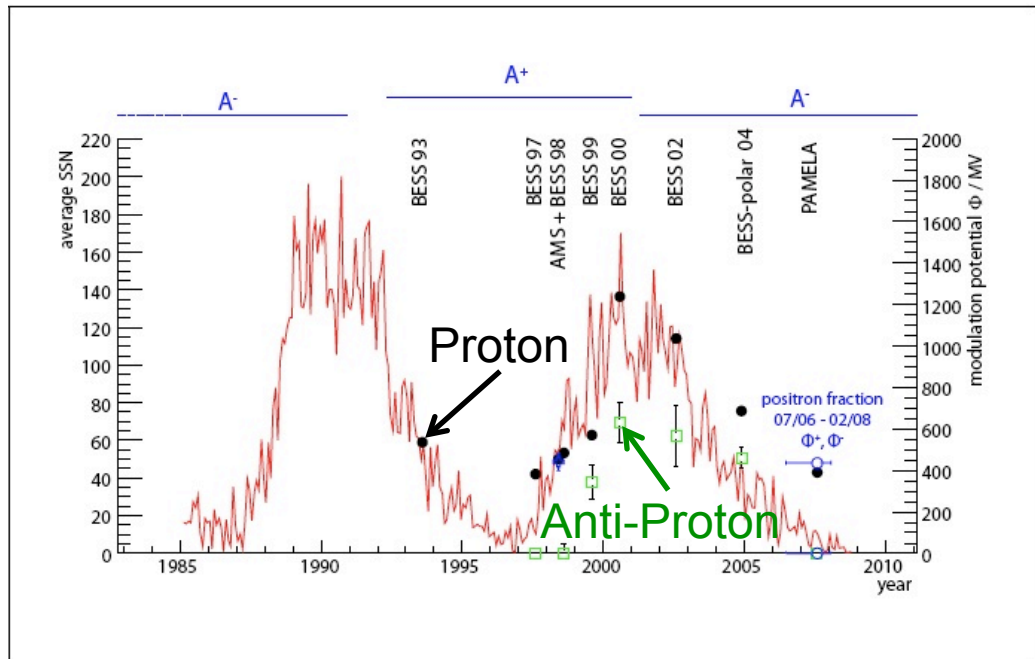
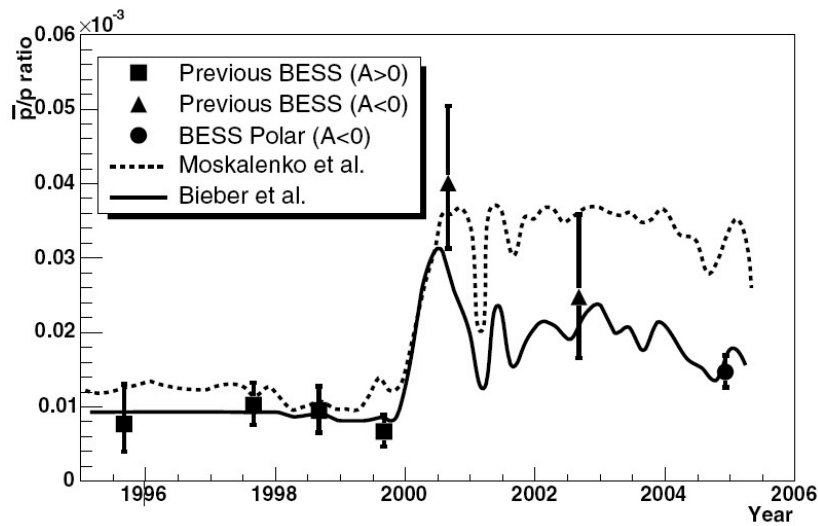


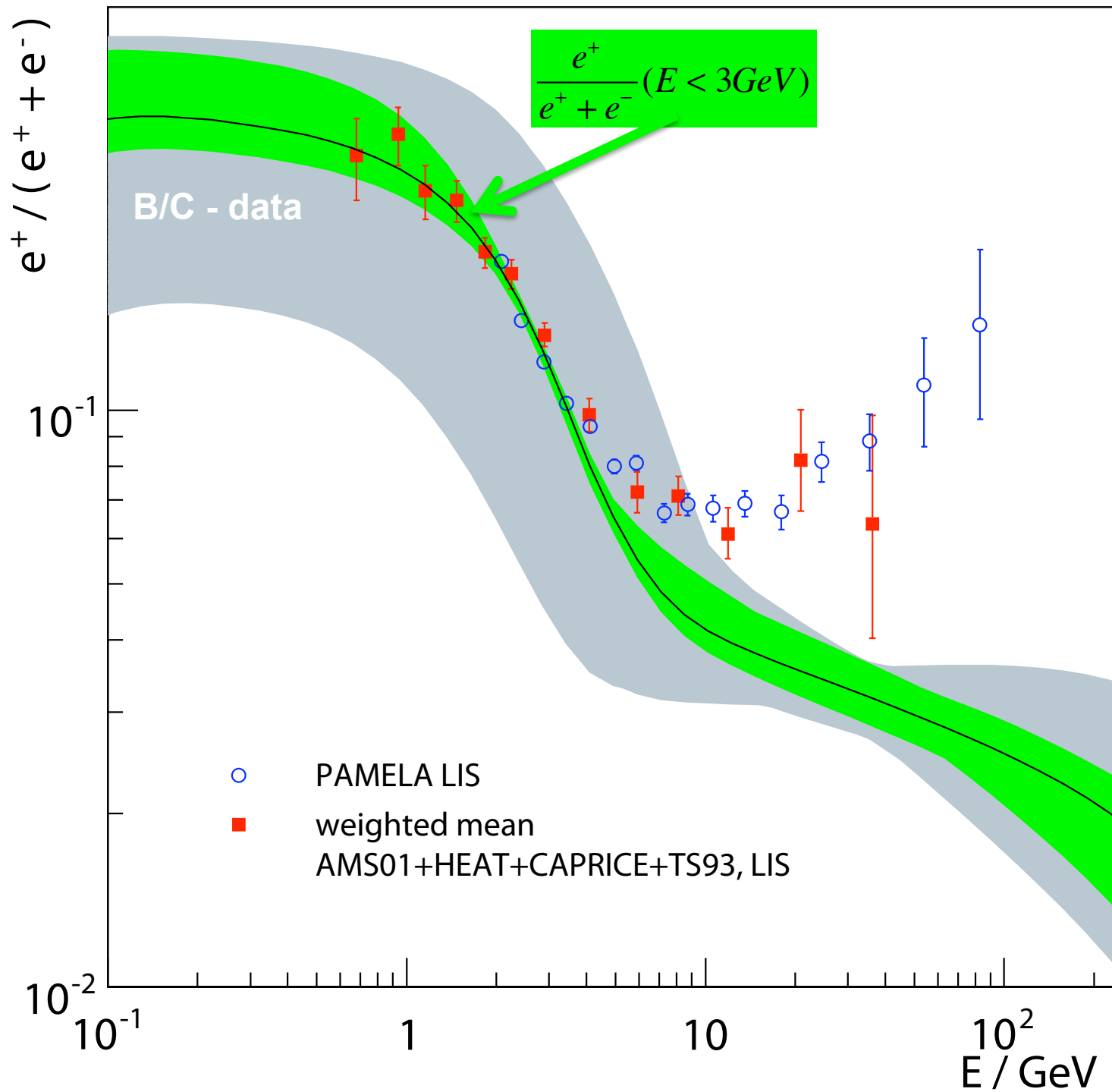
Charge-Sign dependent Solar Modulation ?

Force Field approximation:

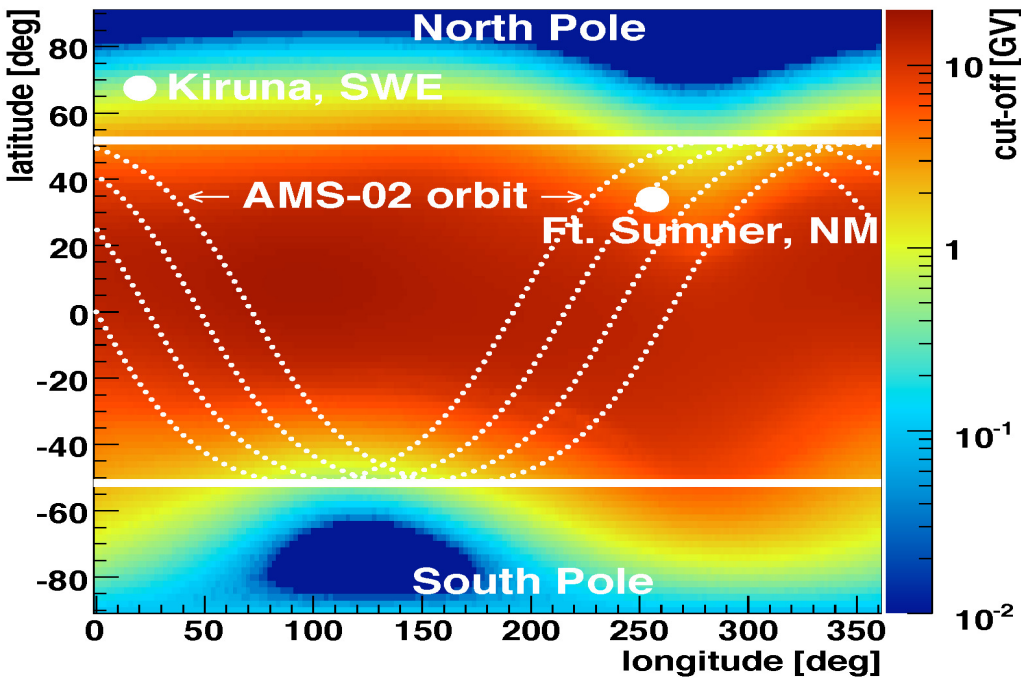
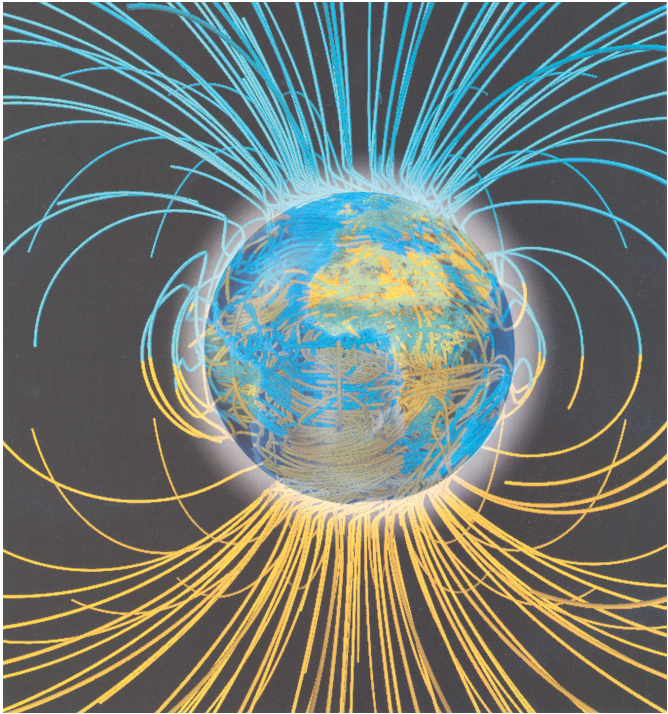
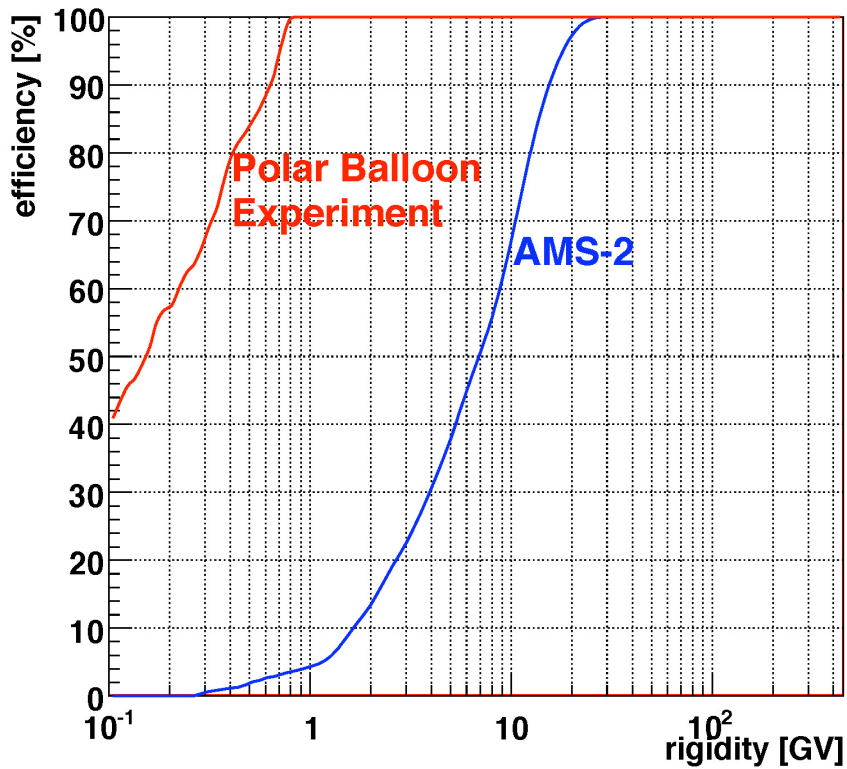
$$J(E) = \frac{E^2 - m^2}{(E + |Z|\phi)^2 - m^2} \cdot J_{IS}(E + |Z|\phi)$$

$$\rightarrow J^\pm(E) = \frac{E^2 - m^2}{(E + |Z|\phi^\pm)^2 - m^2} \cdot J_{IS}(E + |Z|\phi^\pm)$$



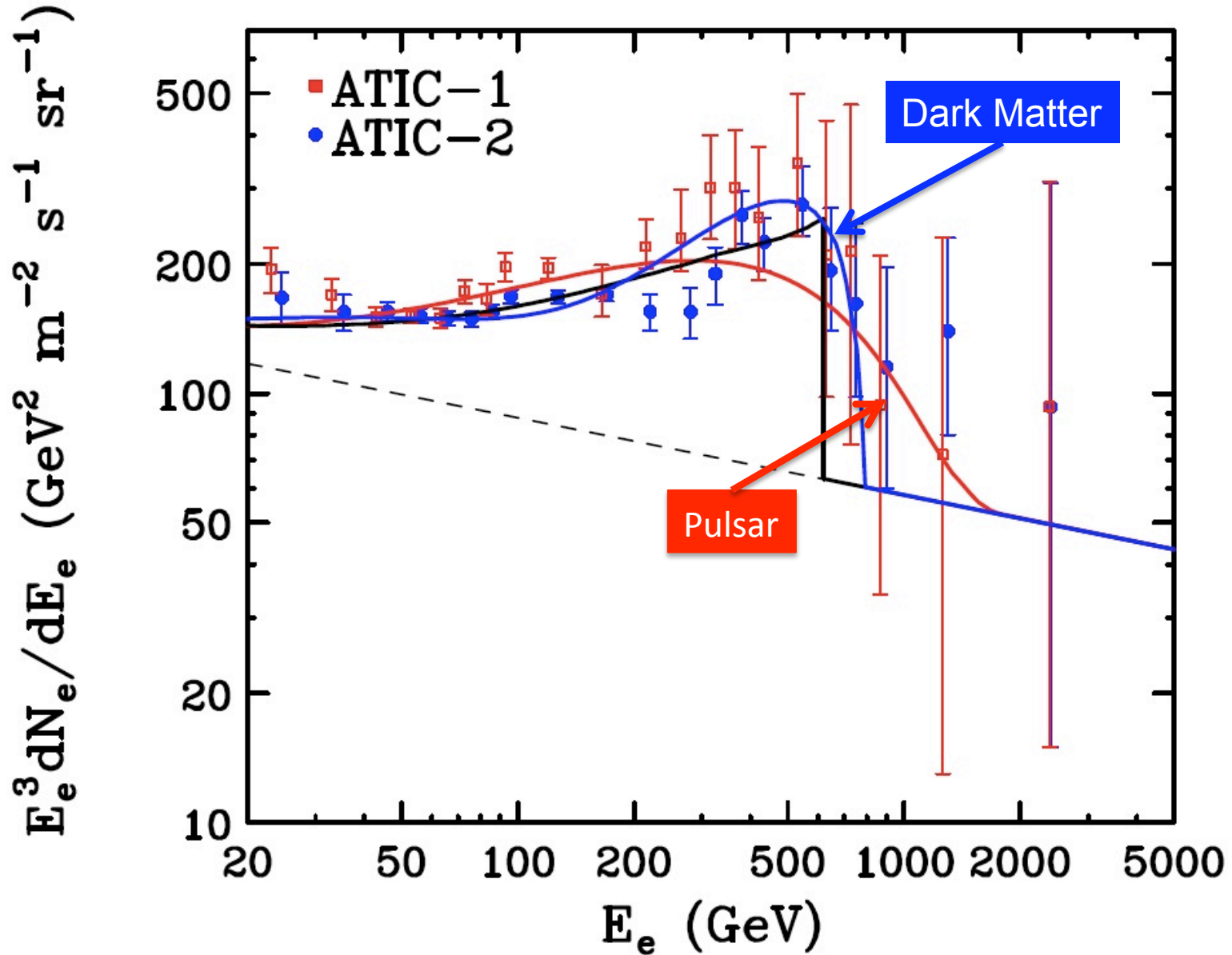


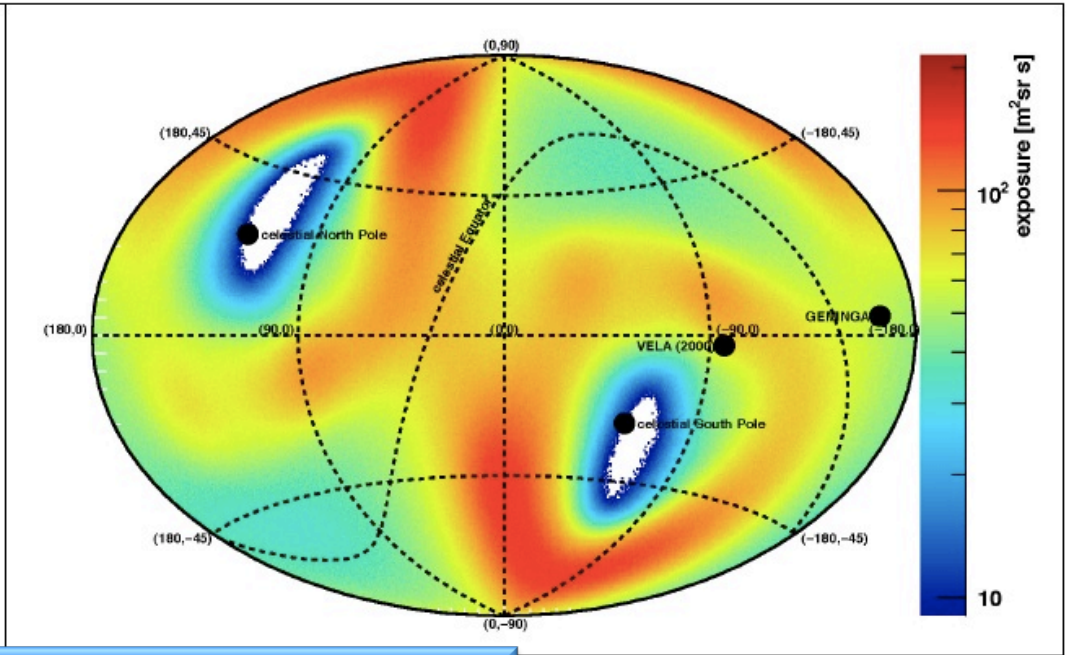
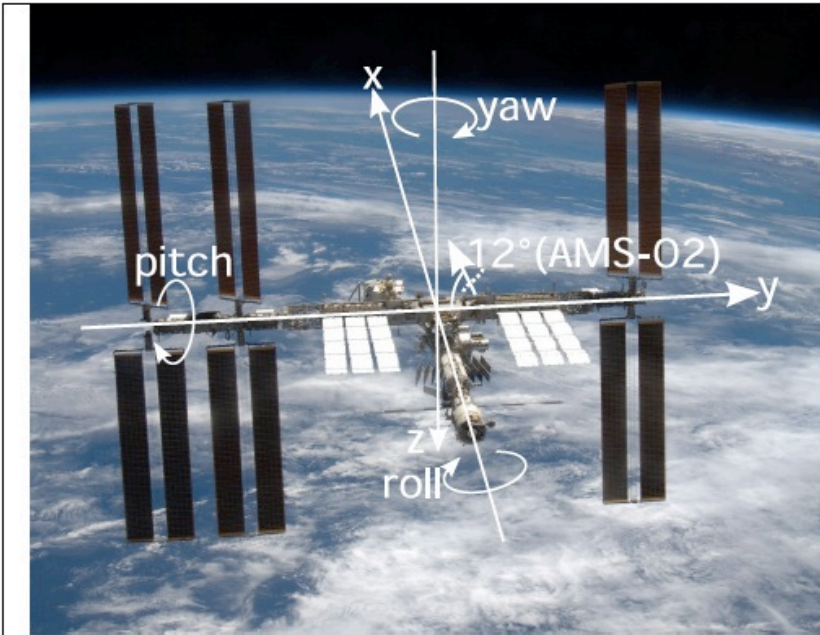
Geomagnetic Cutoff



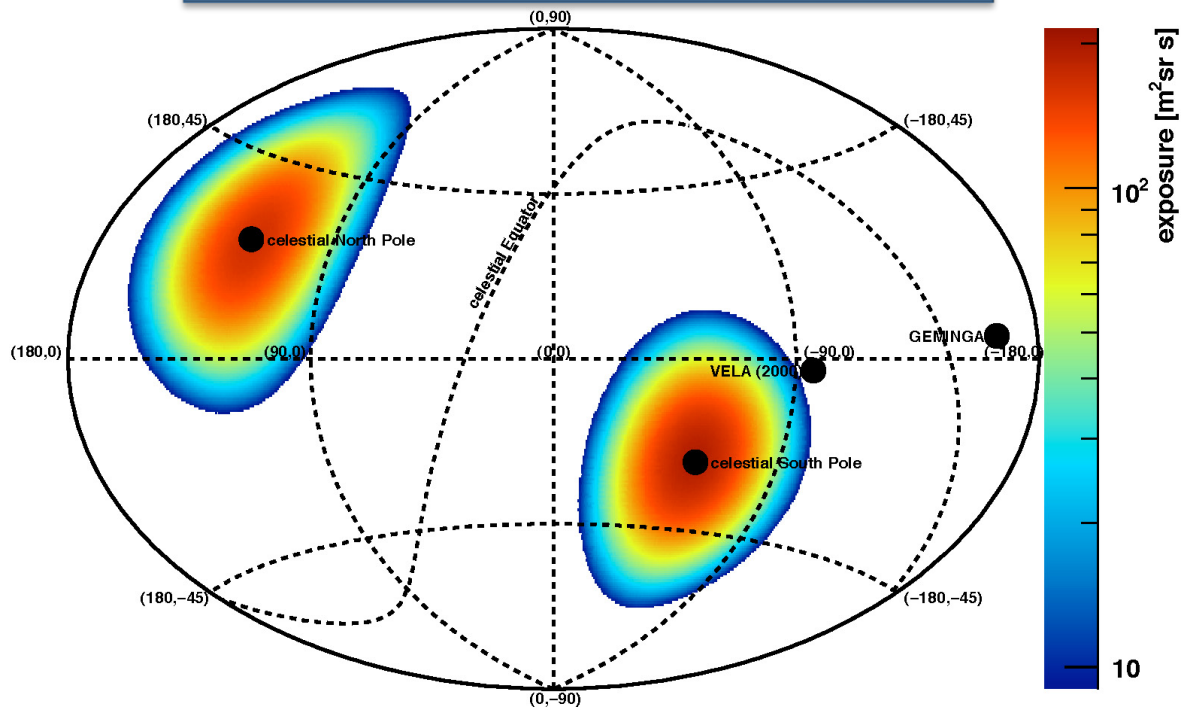
Pulsar or Dark Matter ?

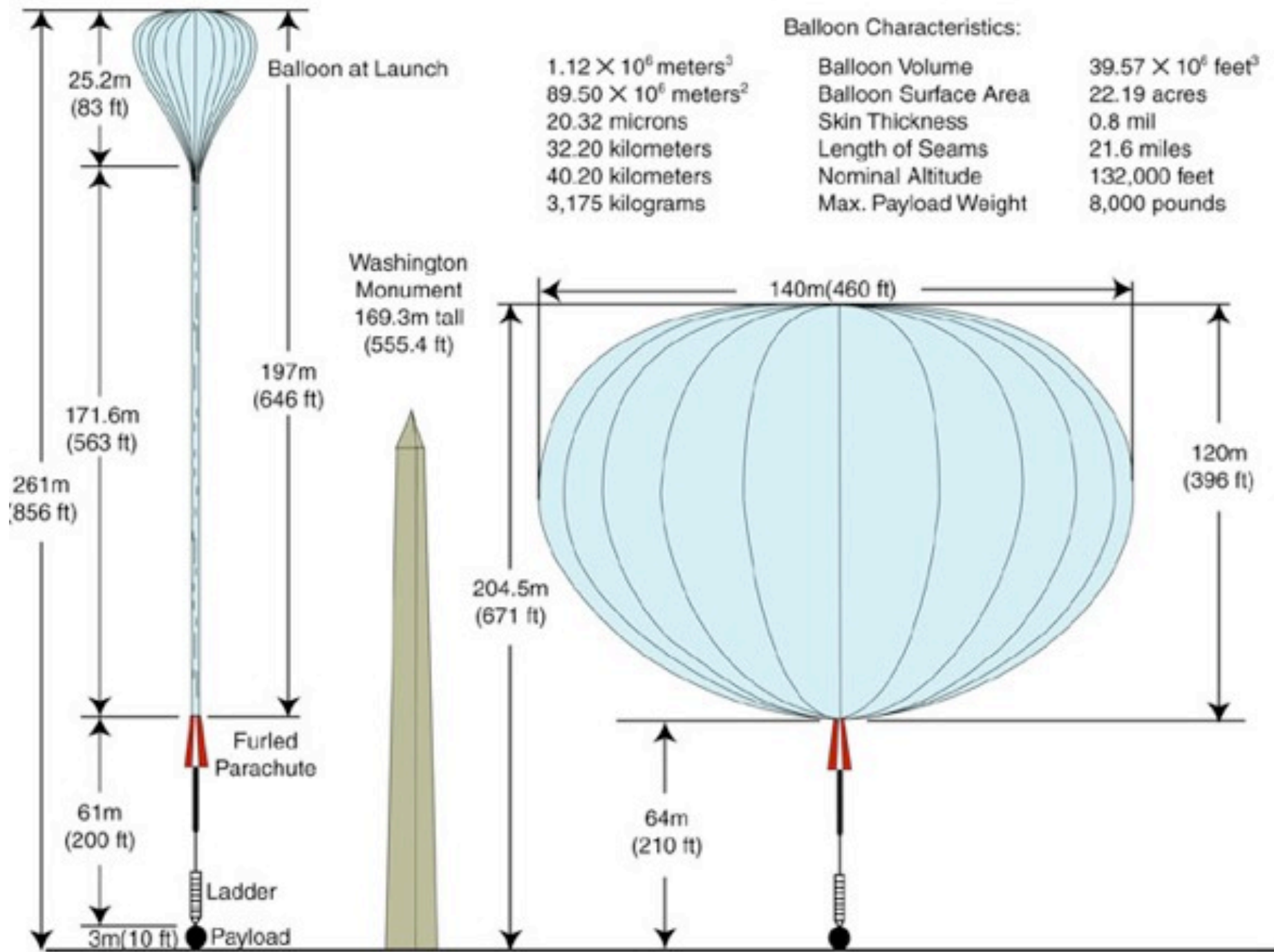
J.Hall and D. Hooper, astro-ph/0811.3362





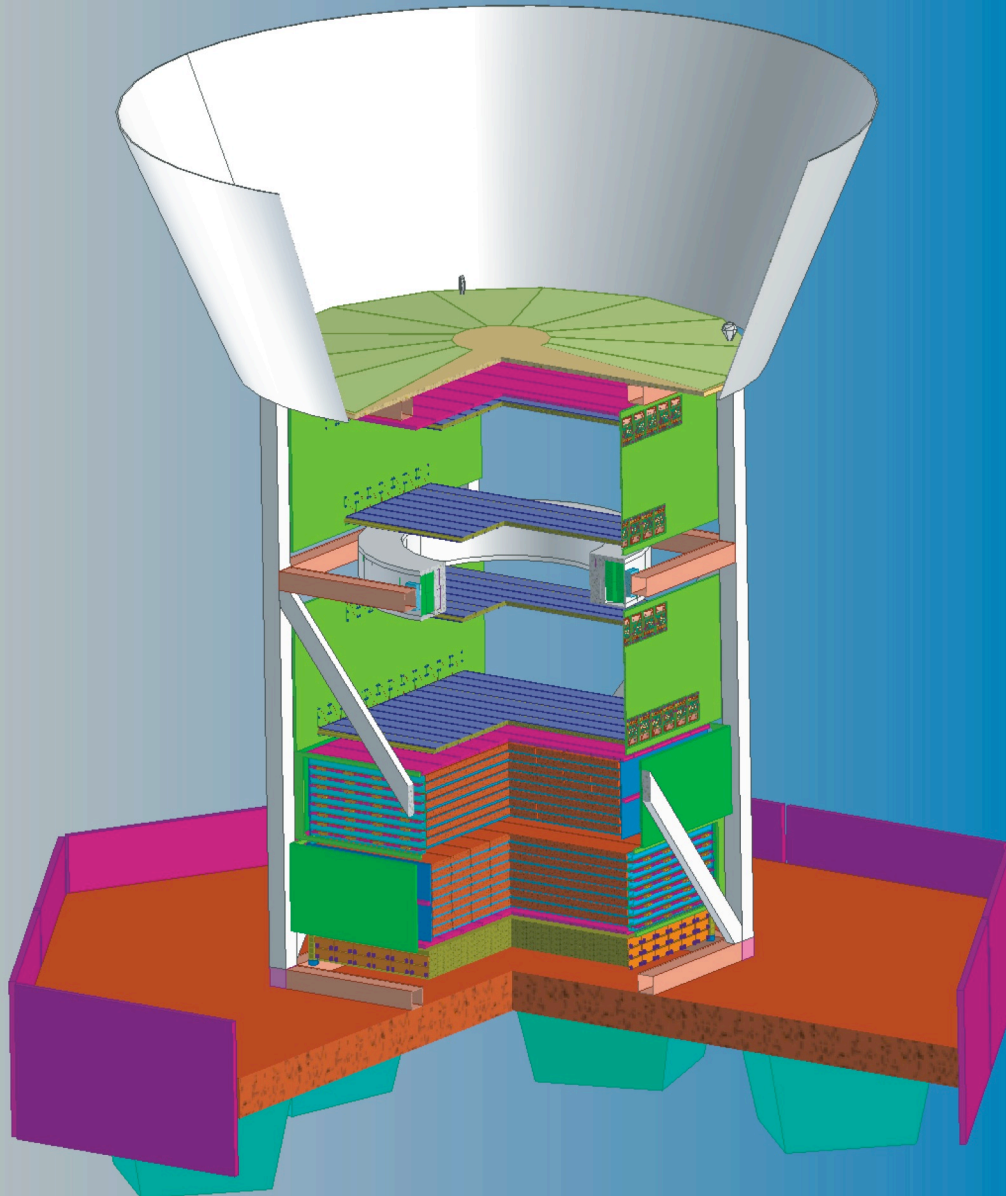
PEBS Skycoverage compared to AMS-2







PEBS-1 Experiment



Summer 2012
Kiruna, Sweden → Alaska

| | e^- | P | e^+ | \bar{P}, \bar{D} |
|---------|-------|-----|-------|--------------------|
| TRD | | | | |
| TOF | | | | |
| Tracker | | | | |
| ECAL | | | | |



PEBS-1 Experiment



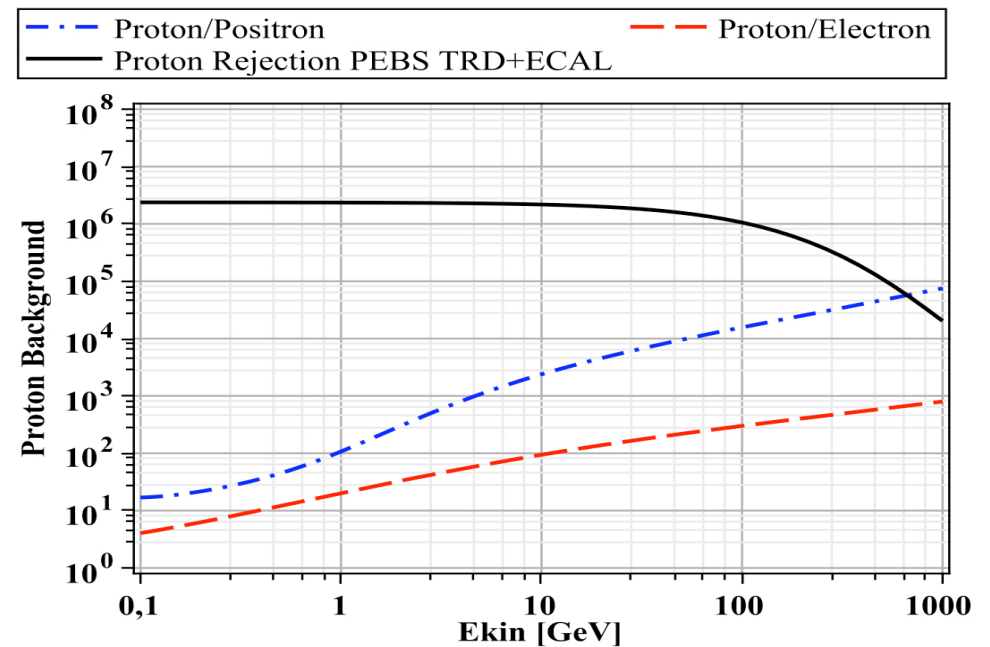
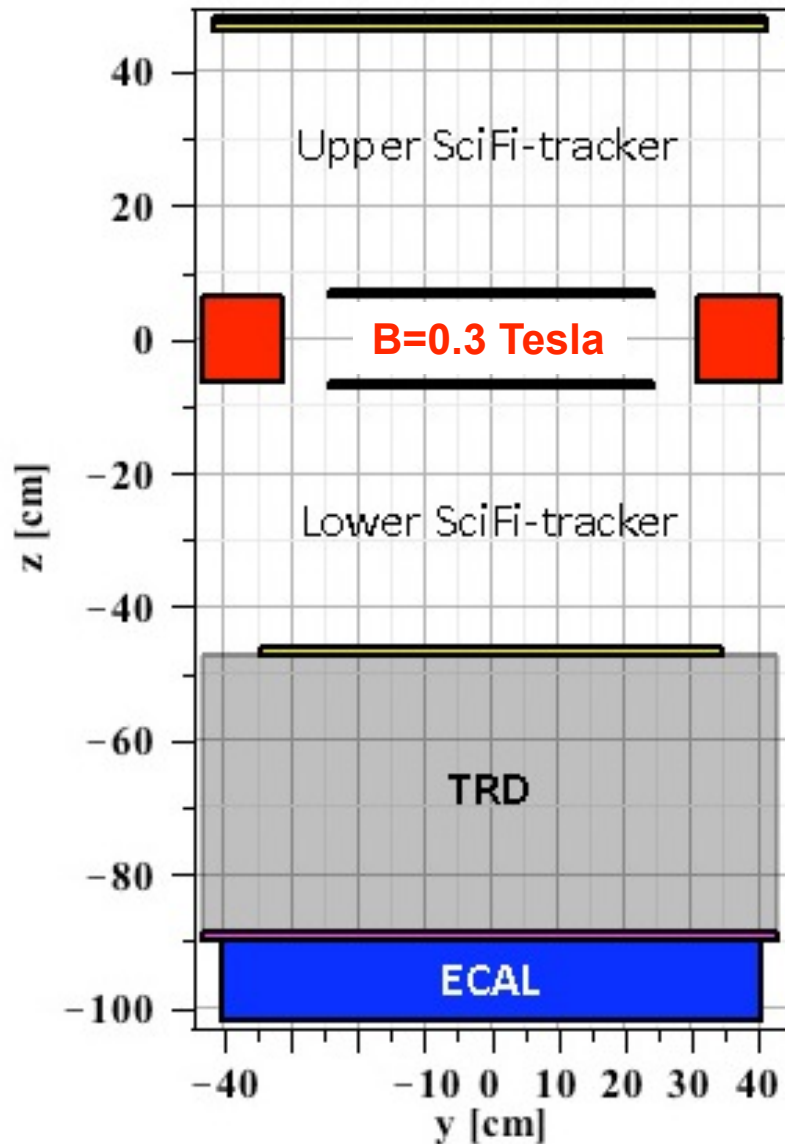
$$\frac{\sigma_p}{p} = 0.011 \cdot p \oplus 0.07$$

Acceptance:

Spectrometer: 1000 cm² sr

ECAL+TRD: 7500 cm² sr

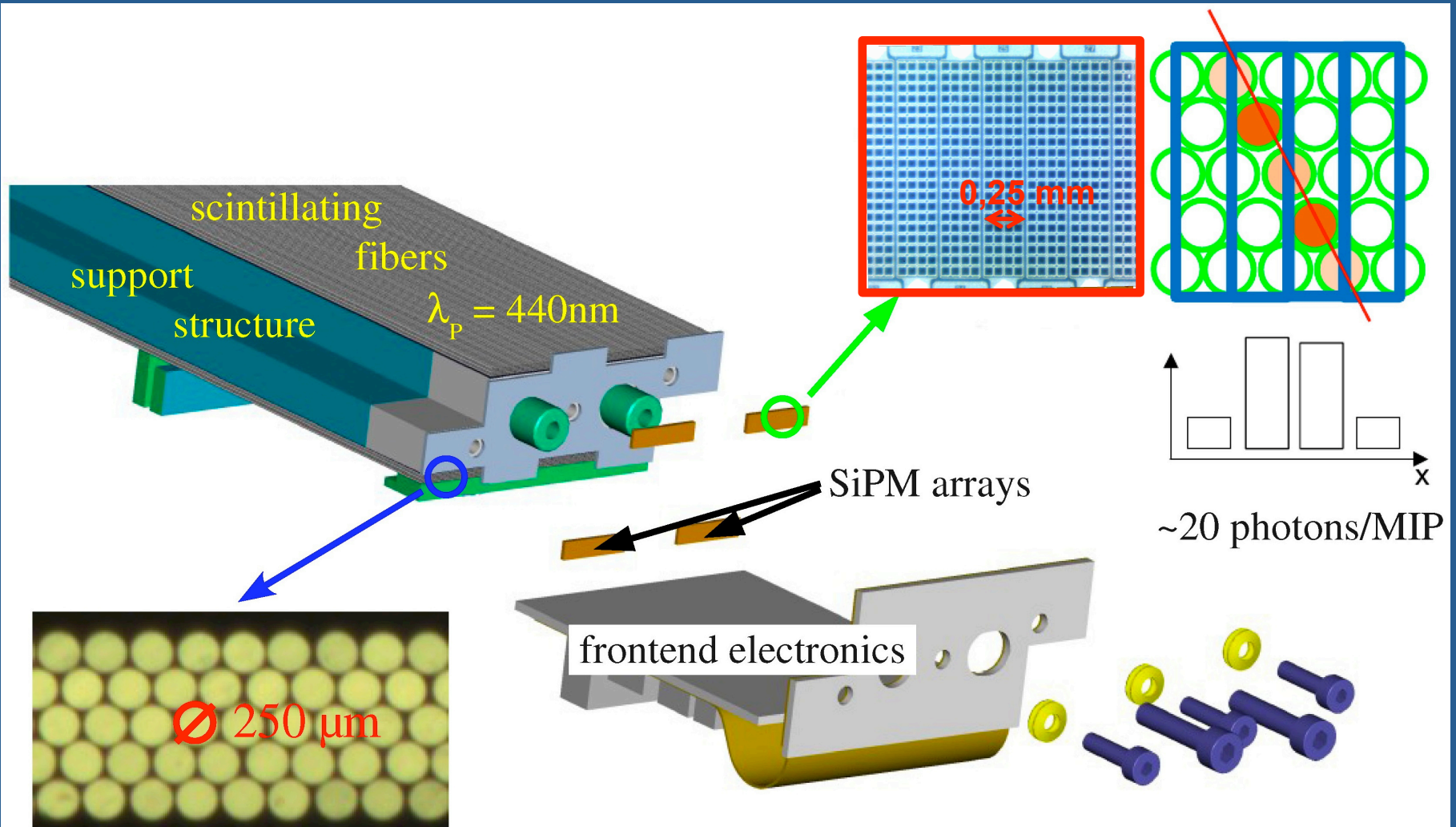
Weight: 1000 kg

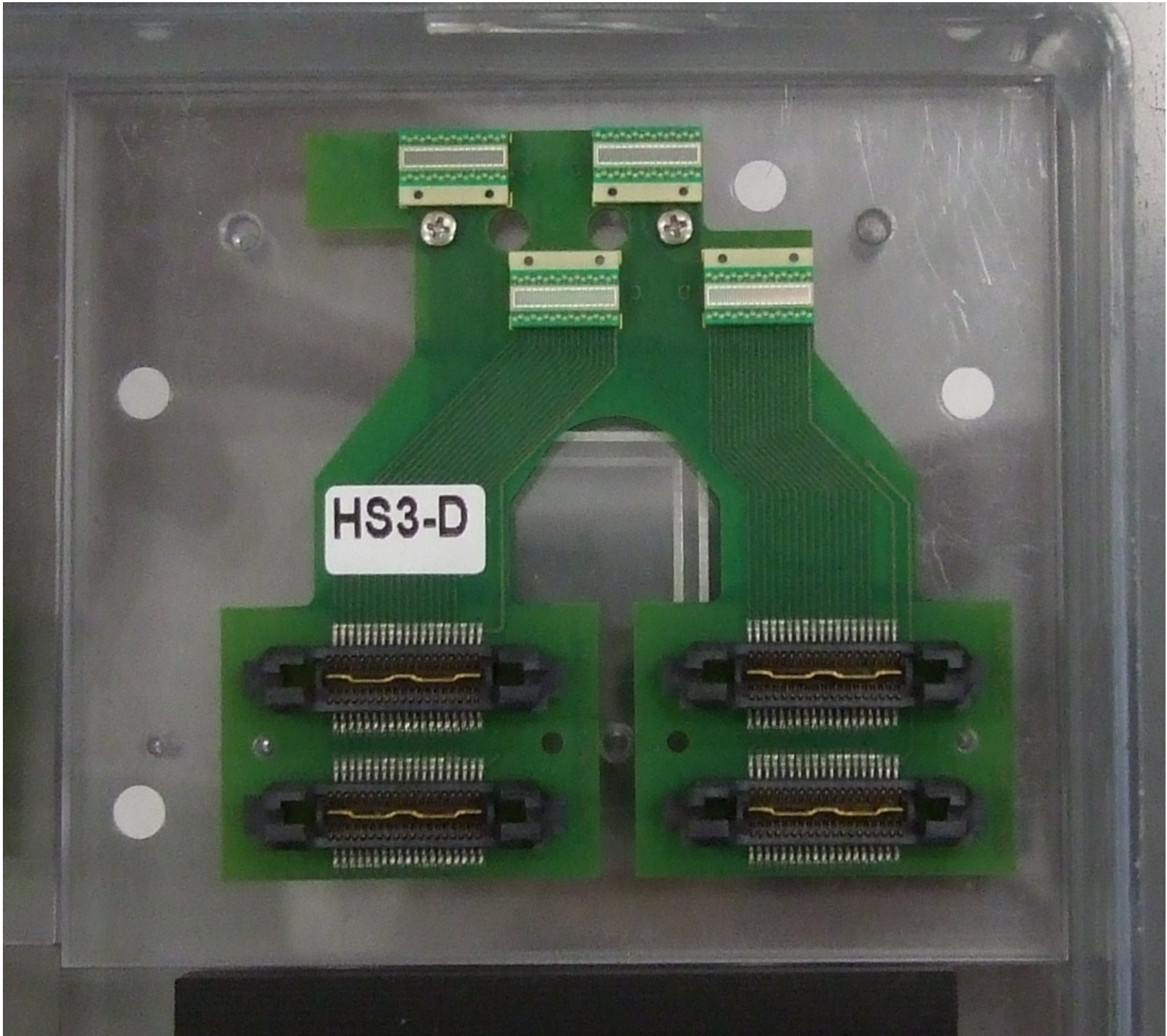


The PEBS ScFi Tracker

PEBS-1: 36 modules, $l = 86\text{cm}$, 80 km fibers, 576 MPPC arrays

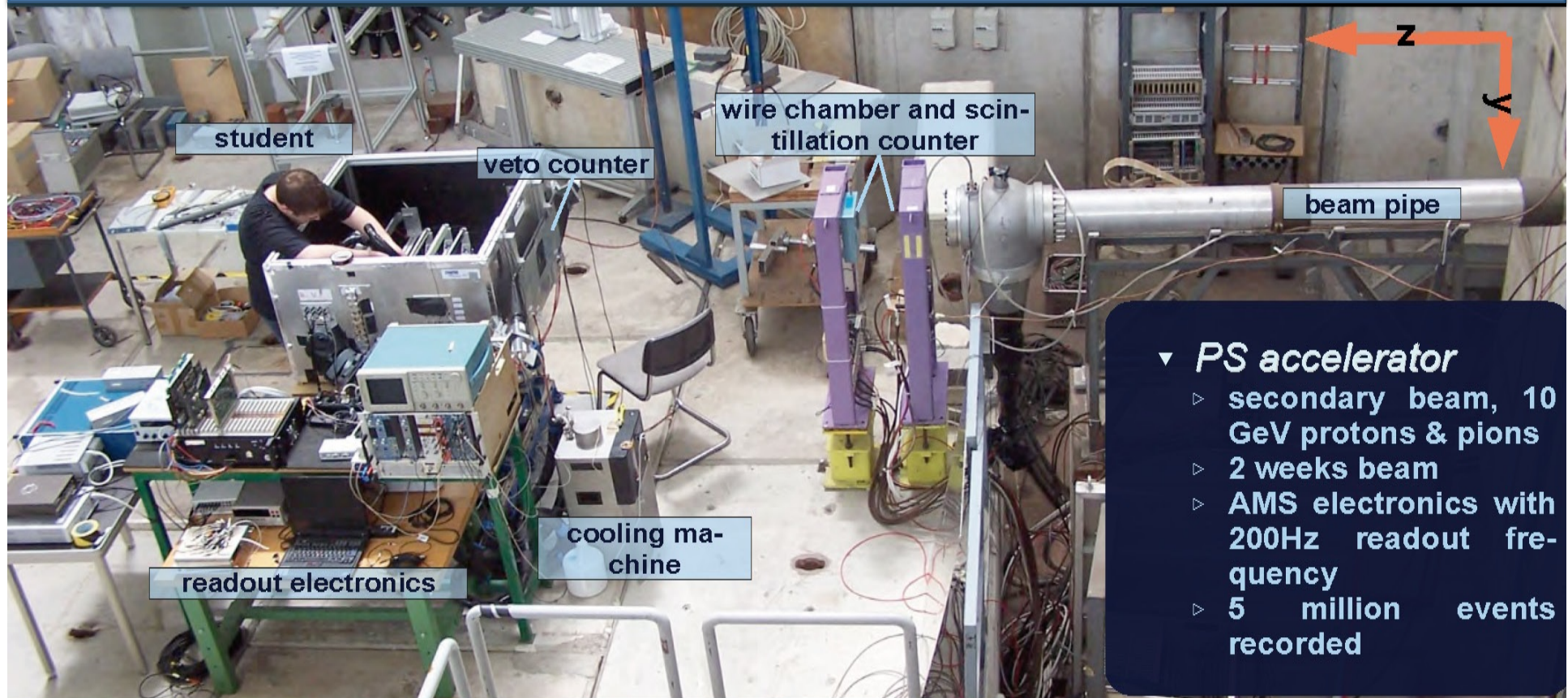
PEBS-2: 60 modules, $l = 2000\text{cm}$, 310 km fibers, 960 MPPC arrays





Testbeam at CERN

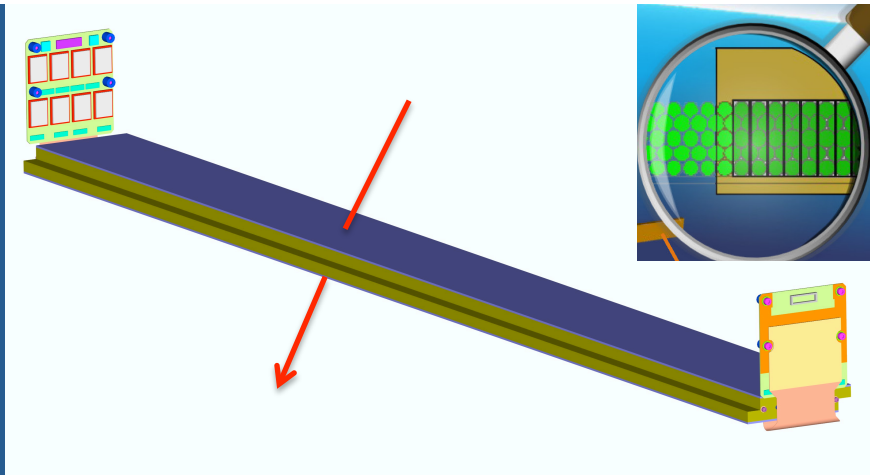
2006, 2007 und 2008



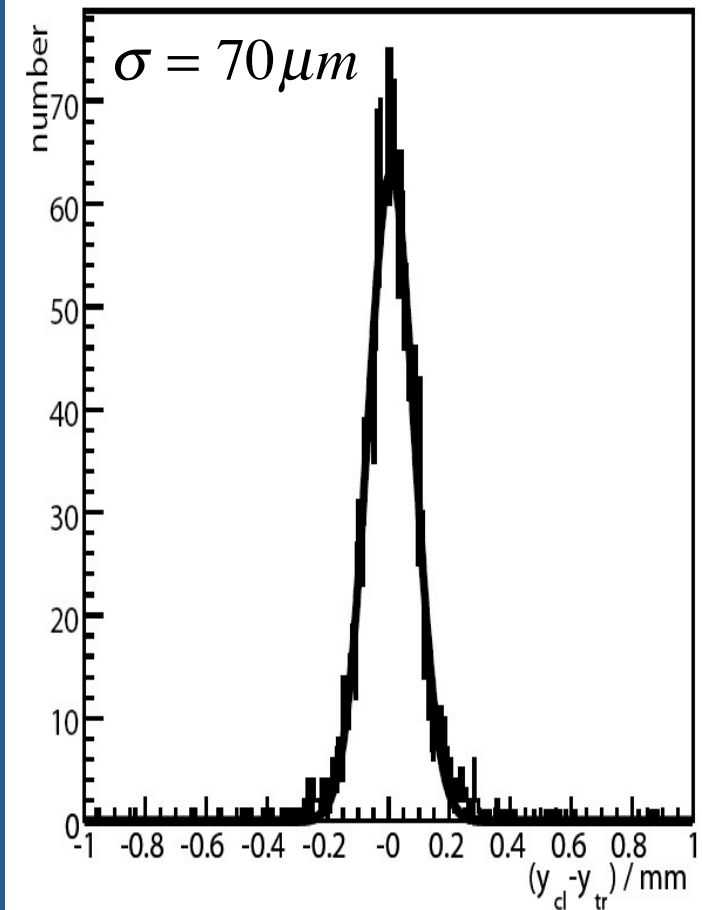
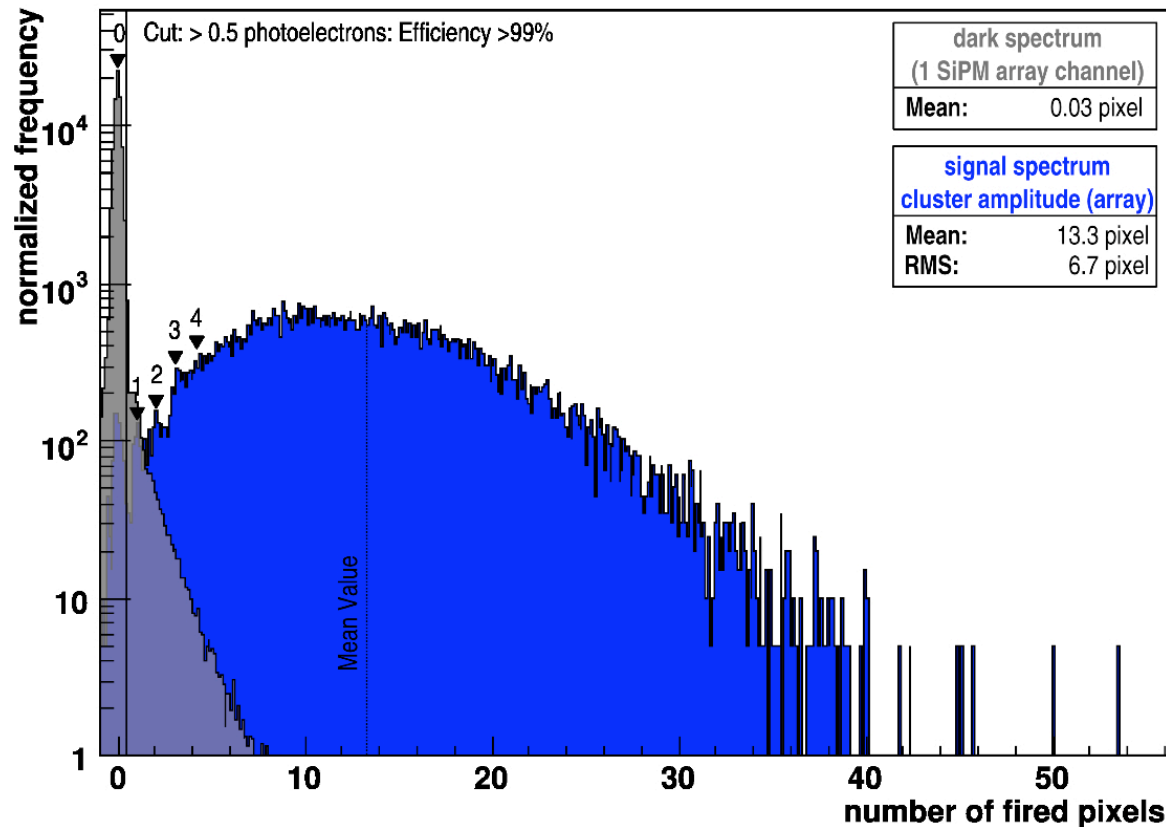
| tested combinations | Kuraray SCSF-81M (round) | Bicron BCF-20 (round) |
|-------------------------------|--------------------------|-----------------------|
| Hamamatsu MPPC S10362-11-100C | X | X |
| Hamamatsu MPPC 5883 Array | X | X |
| IRST SiPM Array | X | X |

Results

- MIP Signal 10 Photons
- Tracking Efficiency $\geq 99\%$
- Position resolution 0.07 mm (2008)
 \rightarrow 0.05 mm (2009)



Signal Plot Hamamatsu MPPC 5883 + Kuraray Fiber
 (central region \Rightarrow complete cluster amplitude contained)



ECAL layout

sandwich calorimeter for 3D-shower reconstruction:

20 layers in total:

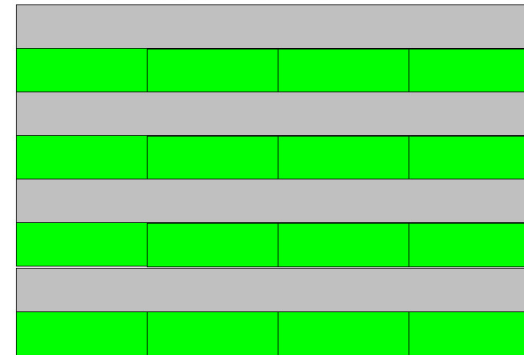
2 mm tungsten +

2 mm scintillator bar + WLS fiber +

2 SiPMs

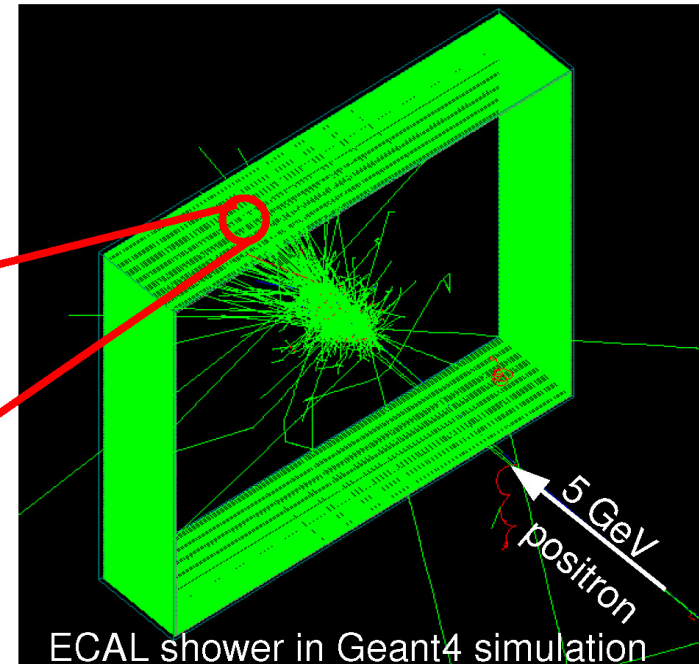
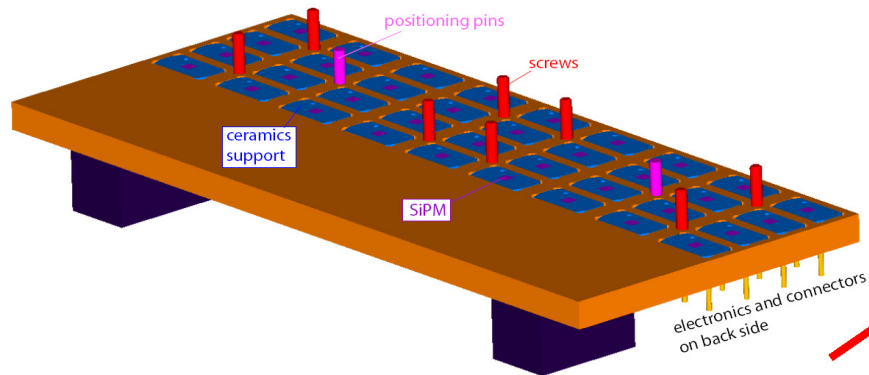
11.4 X_0 in total

schematic view of ECAL multilayer



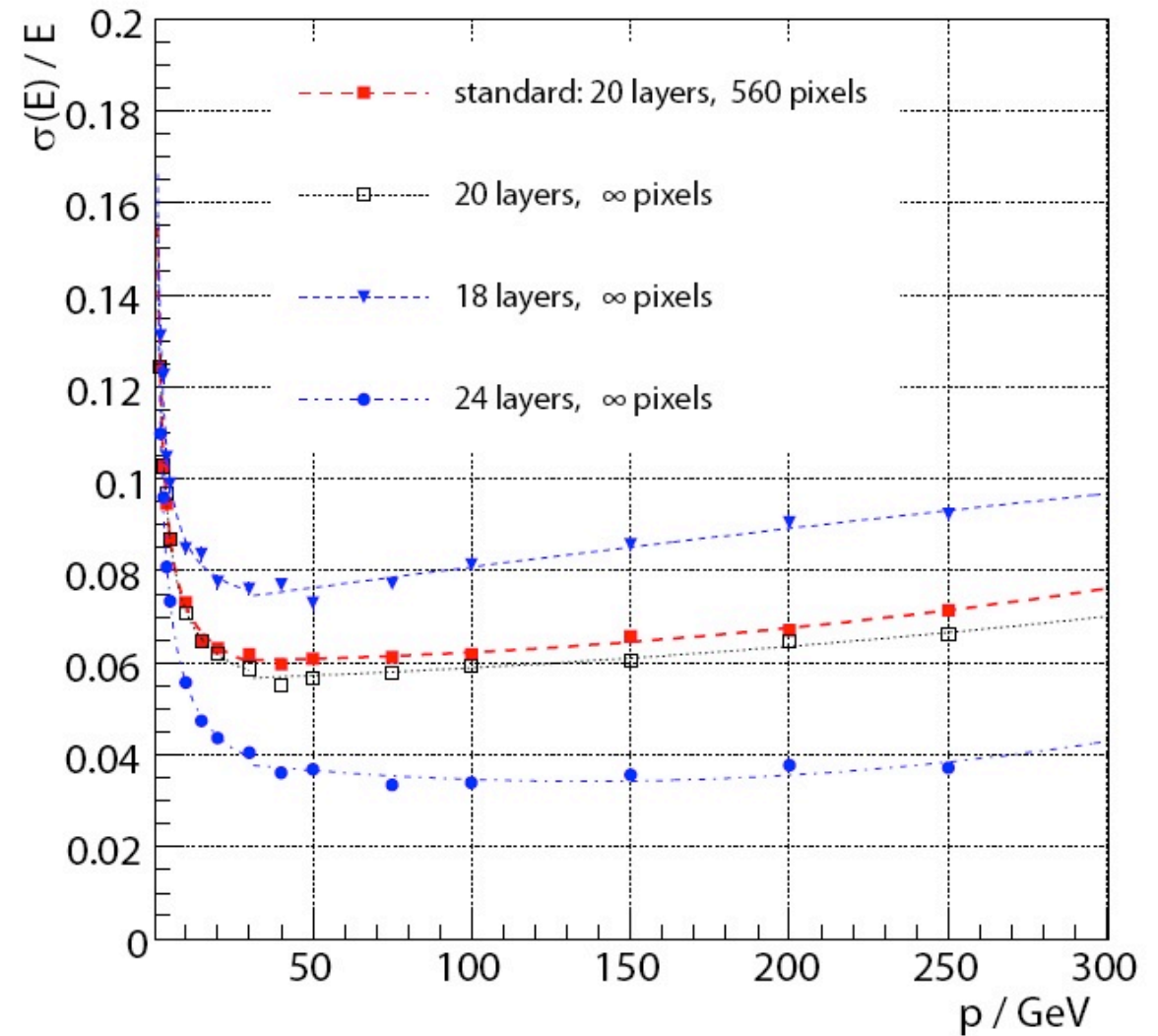
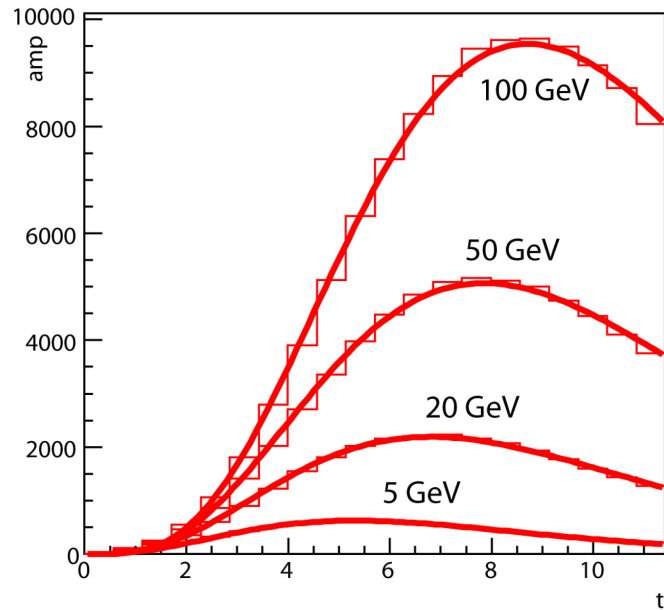
absorber
fibers

multilayers
alternately
placed in
x- and y-direction

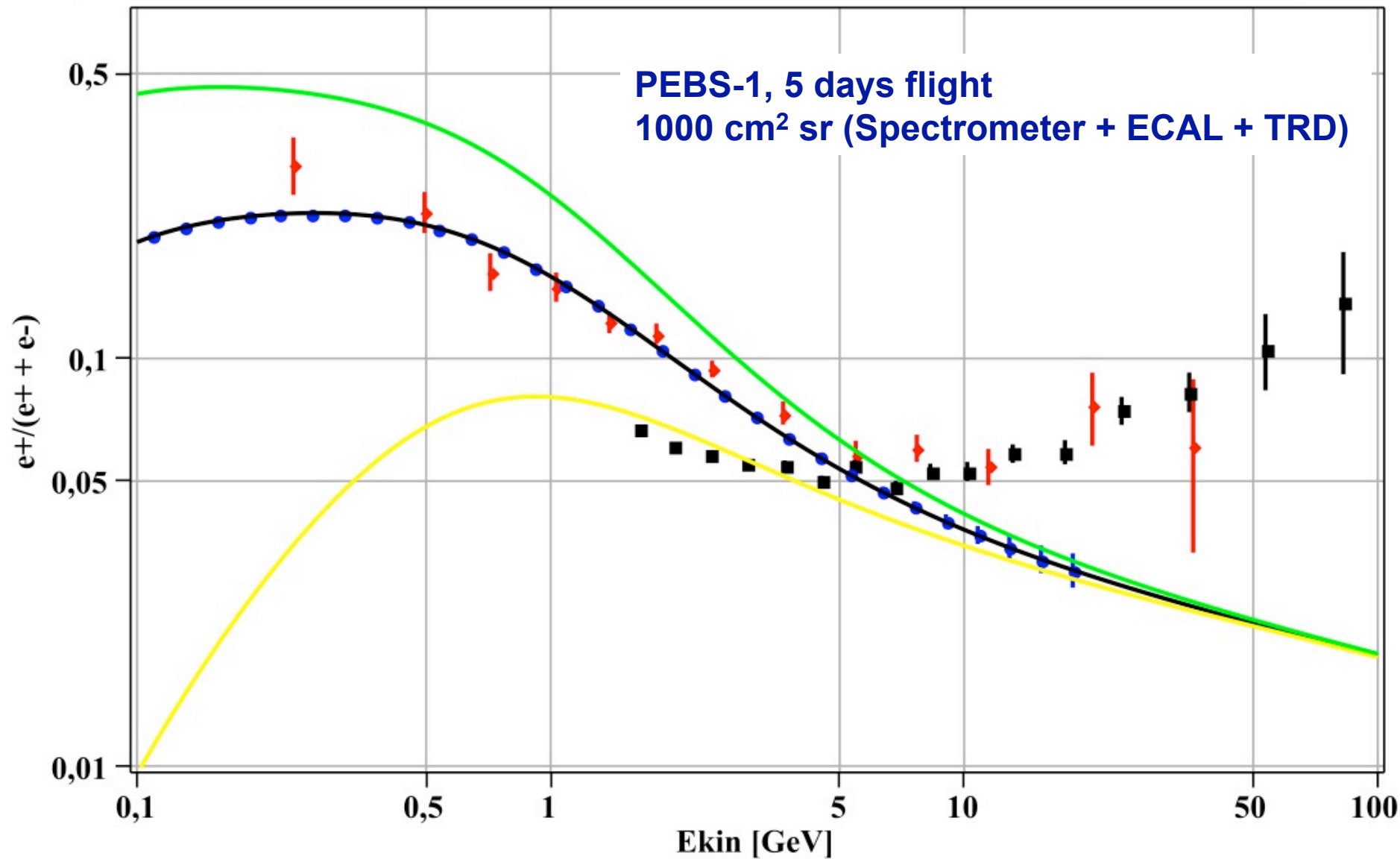
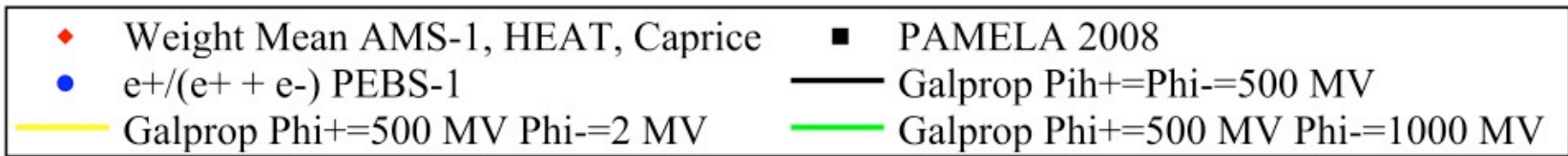


ECAL Energy Resolution

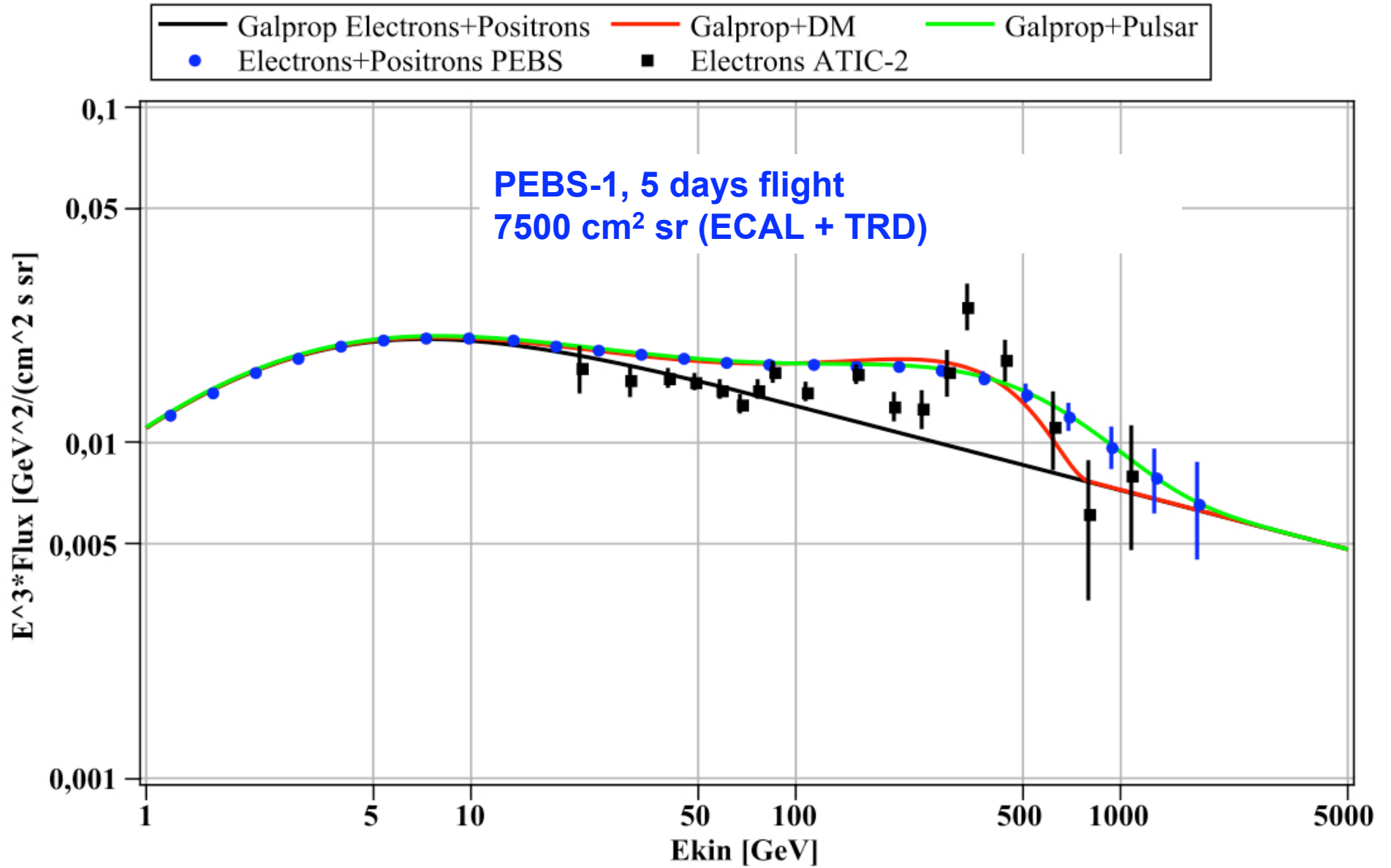
$$\frac{dE}{dt} = E_0 \frac{b^{\alpha+1}}{\Gamma(\alpha+1)} t^\alpha e^{-bt}$$



Positron fraction

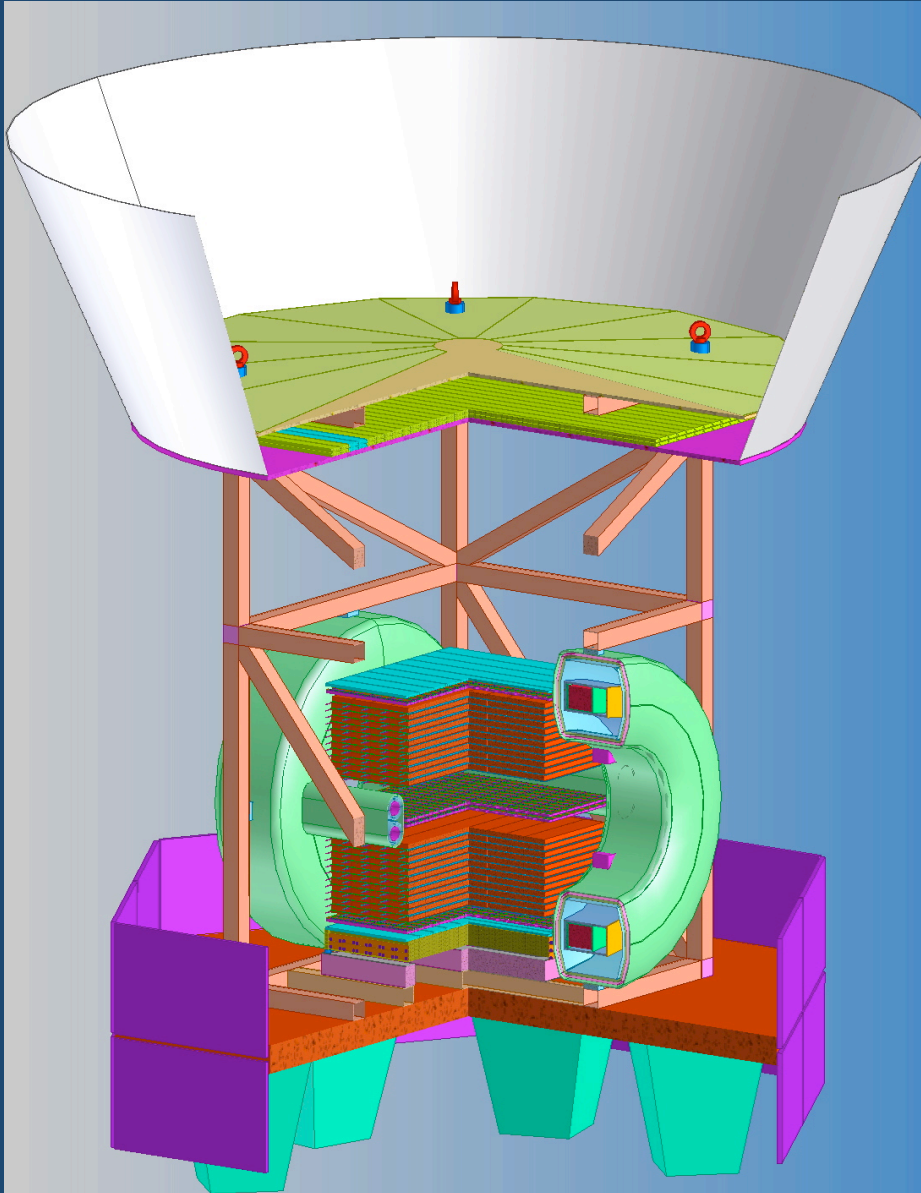


Electron+Positron Flux





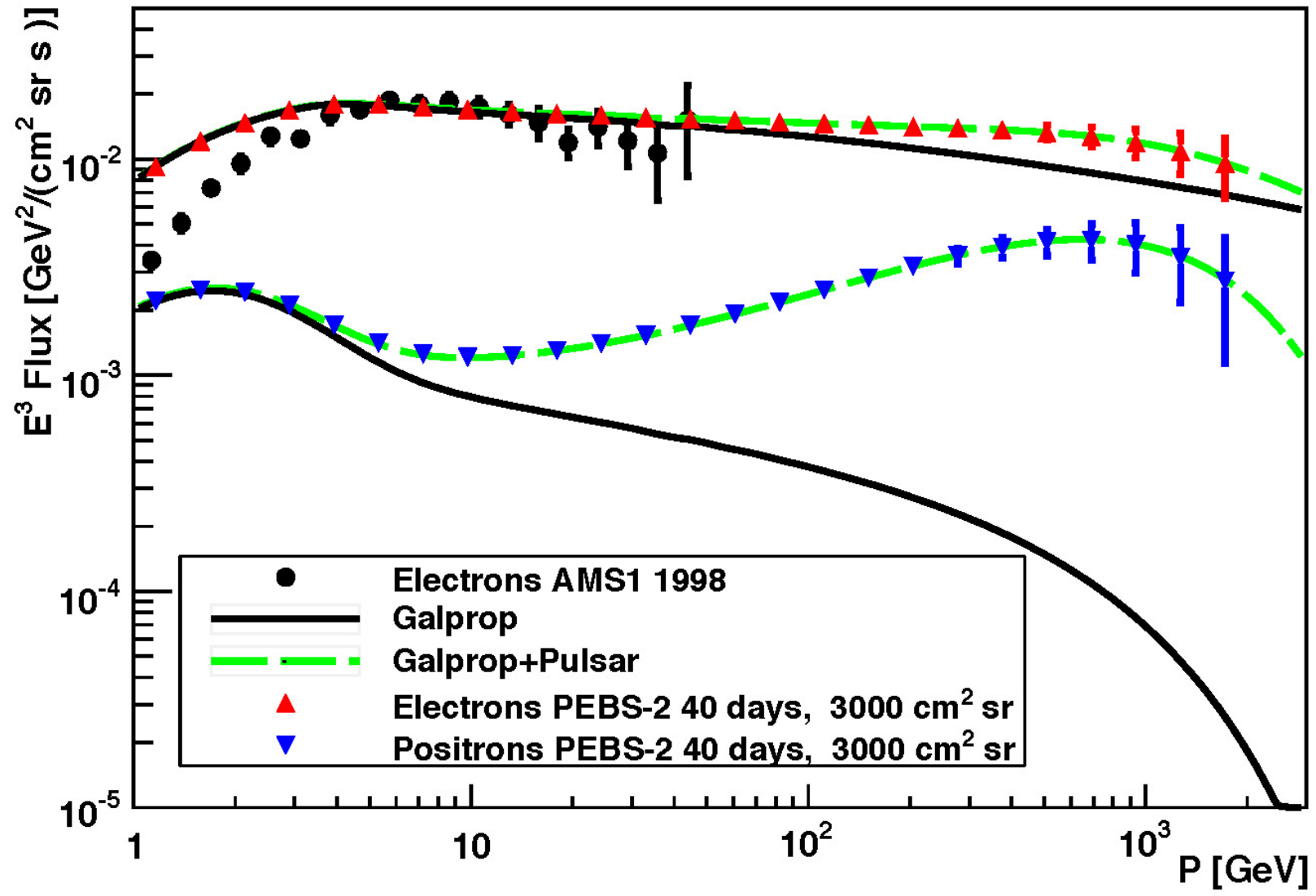
PEBS-2 Experiment



Antartica, 2014/2015

| | e^- | P | e^+ | \bar{P}, \bar{D} |
|---------|-------|-----|-------|--------------------|
| TRD | | | | |
| TOF | | | | |
| Tracker | | | | |
| ECAL | | | | |

$$\frac{\sigma_p}{p} = 1.8 \cdot 10^{-4} \cdot p \oplus 0.008$$



PEBS Summary

- A dedicated balloon experiment could provide a competitive measurement of the cosmic ray electron & positron flux.
- A novel scintillating fiber tracker with SiPM readout allows the construction of large area, high resolution (0.05 mm), low power and low weight tracking detectors.
- The proton rejection of $\sim 10^6$ can be achieved by a combination of ToF, TRD, ECAL and Tracker.
- Key parameters:
 - Acceptance: $\sim 3000 \text{ cm}^2 \text{ sr}$
 - Weight: $\sim 2000 \text{ kg}$
 - Power: $\sim 900 \text{ Watt}$
- R&D Phase:
2006 – 2009
- Construction Phase:
2010 - 2012
- **First Flight: Summer 2012 from Kiruna, Sweden**

