

Towards the Low Energy Cosmic Ray Measurement with



On behalf of the PERDaix team
Lesya Shchutska, EPFL

Scope of the experiment

- the part of the German-Swedish Balloon-borne Experiments for University Students (BEXUS) program 10/11
- launch in October 2010 from Kiruna, Sweden
- 2 hours flight at 35 km altitude
- the detector is built at RWTH Aachen, supported by EPFL and Vacuumschmelze



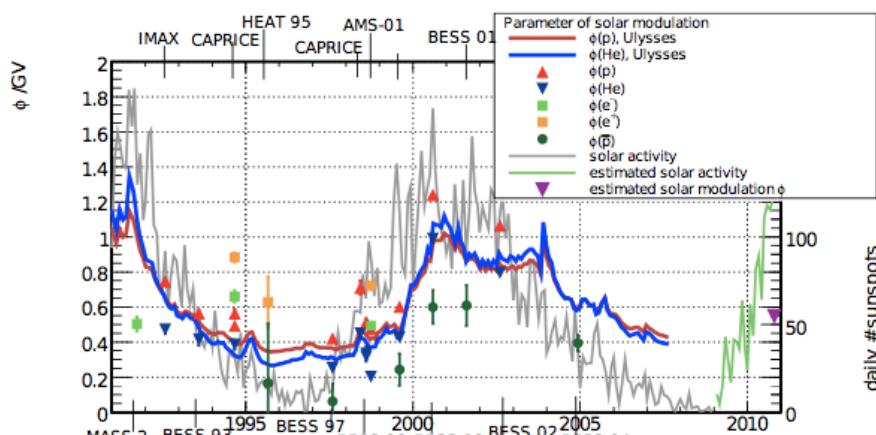
**RWTHAACHEN
UNIVERSITY**

EPFL
ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

VAC
VACUUMSCHMELZE

Goals

previous data

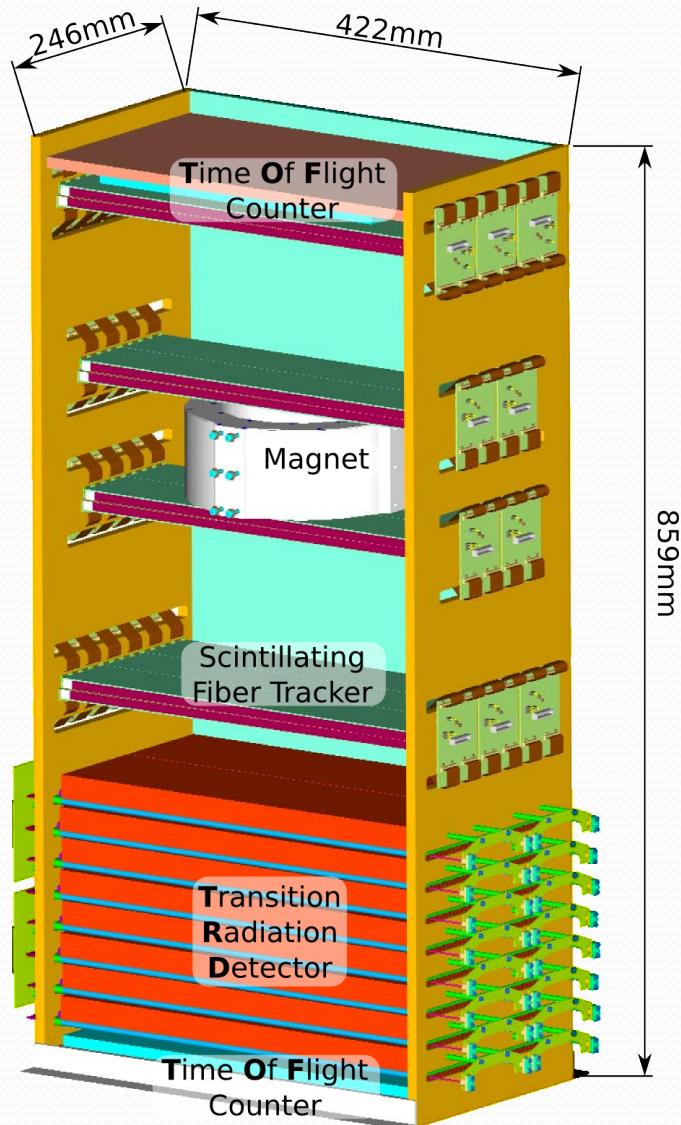


- measuring spectra for e^+ , e^- , p and He between 0.5 and 5 GeV
- the analysis of solar modulation of charged cosmic particles: fluxes are affected up to 10 GeV
- force field approximation:

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

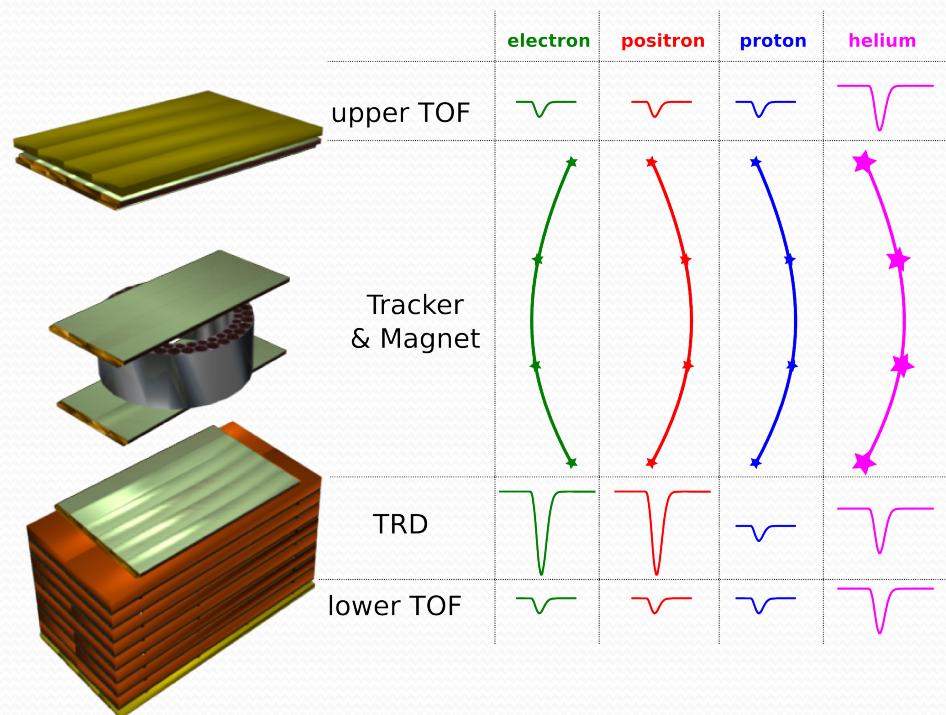
- described by single parameter: repelling potential ϕ
- also testing of a new concept of scintillating fiber tracker with MPPC readout in the operation conditions: the same system is going to be used in PEBS: Proton-Electron Balloon Spectrometer

Detector layout



- Time of flight system:
 - trigger
 - PID for $E < 1 \text{ GeV}$
- Transition radiation detector:
 - additional track direction information
 - PID for $E > 1 \text{ GeV}$
- Tracker and
- Permanent magnet
 - particle rigidity
- Total weight 30 kg (out of allowed max. 100 kg)
- Power consumption 60W:
 - 4×8 battery units can support the detector at 80 W for 12 hours

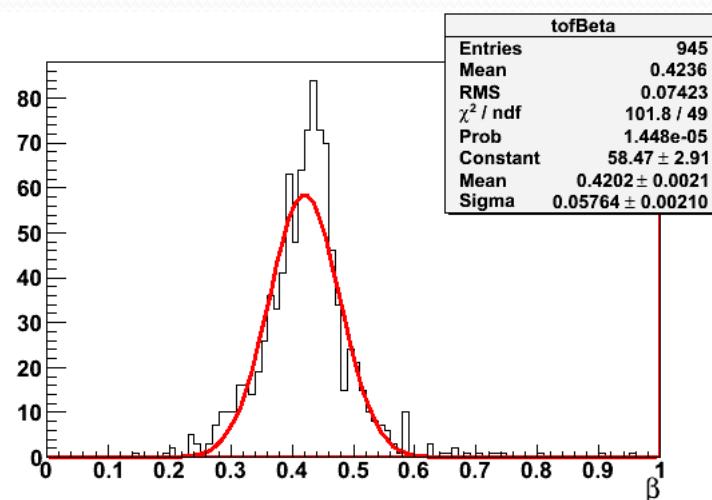
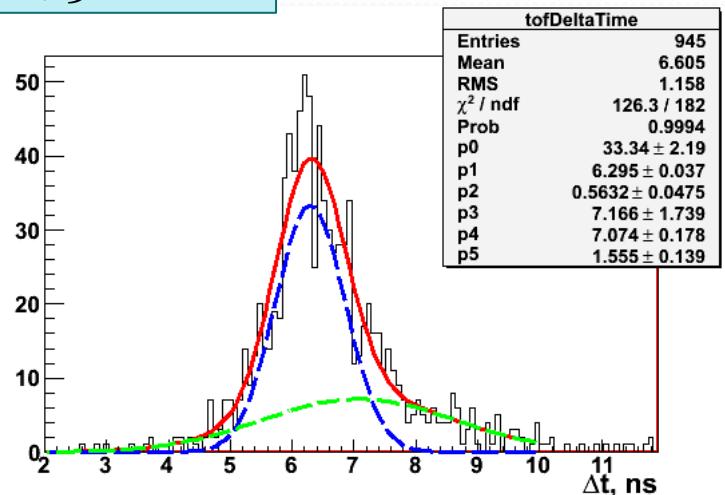
Measurements plan



- the main part is to perform data taking for at least 2 hours at 30-35 km height
- data taking will also be done during the ascending and descending phases
- the expected acceptance is $58.7 \text{ cm}^2 \text{ sr}$
- PERDaix will measure about 78940 primary CR protons, 162 primary CR positrons and 682 primary CR electrons

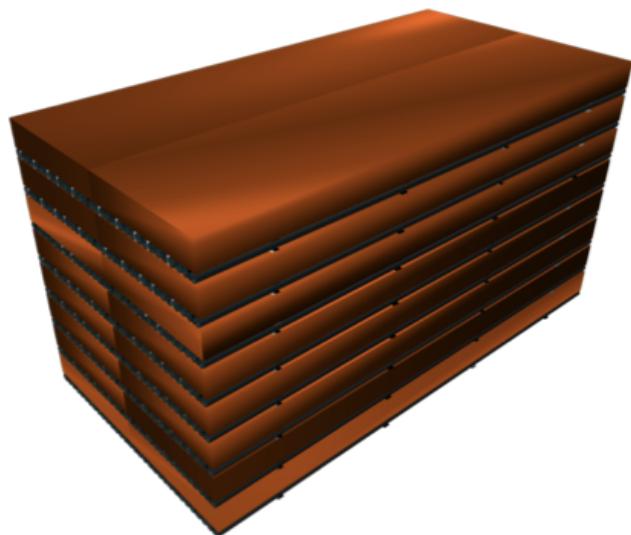
Time of Flight System

protons, 500 MeV

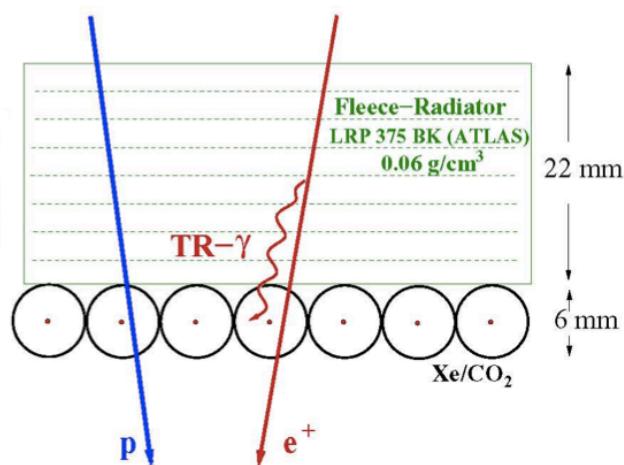


- 4 layers each comprising 4 scintillator bars
 - $50 \times 6 \times 395 \text{ mm}^3$
- SiPM readout:
 - $3 \times 3 \text{ mm}^2$ Hamamatsu MPPC
 - 2×2 SiPMs per bar
- main trigger + upward particles rejection
- heavy particles ID and beta measurement for $E < 1\text{GeV}$
- resolution found from the simulation 600 ps

Transition radiation detector

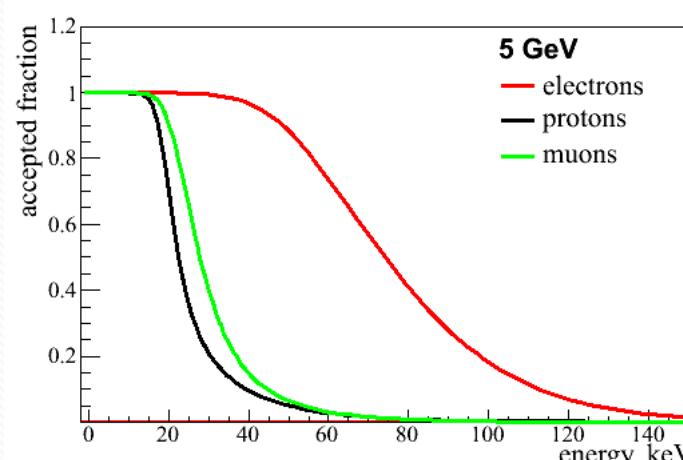
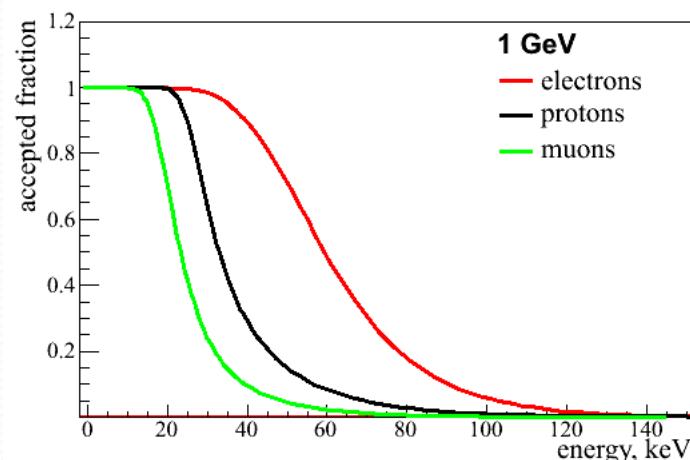
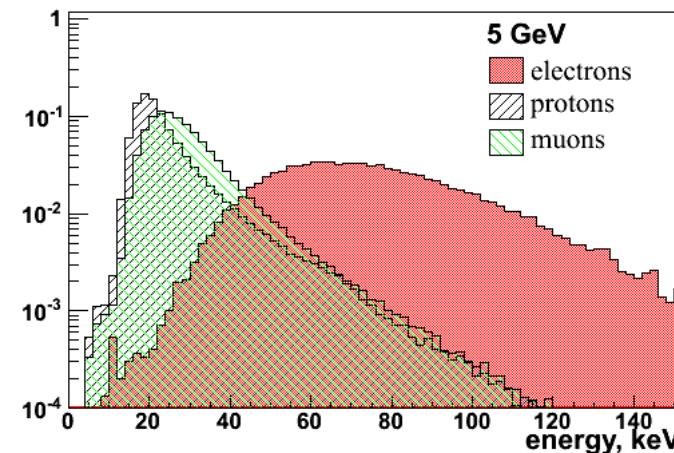
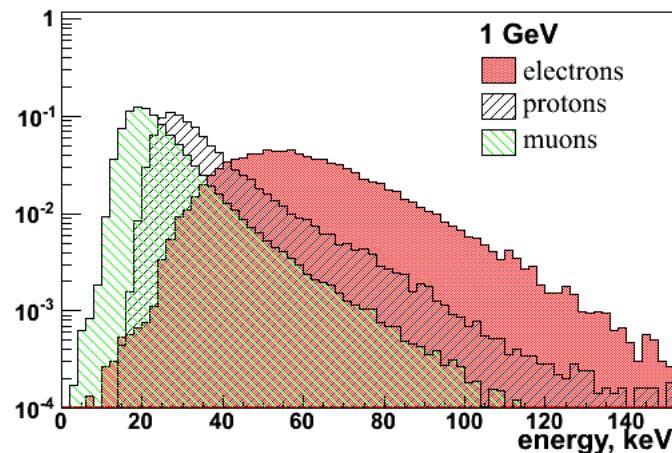


- 16 modules in 8 layers out of 20 mm thick PP/PE fleece radiator
- 16 straw Ø6 mm tubes per module
- filled with Xe/CO₂ gas
- Provides e⁺-e⁻/p separation for E>1 GeV

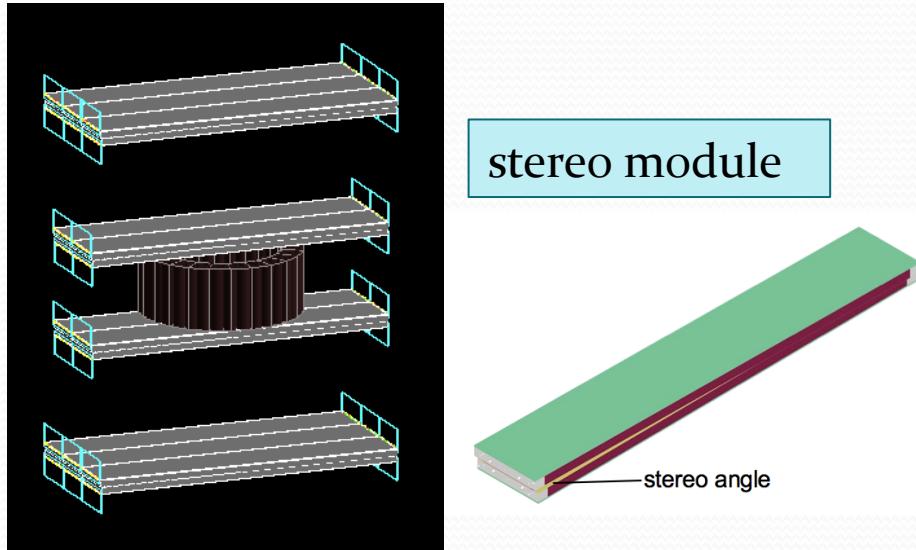


TRD simulation

- Top plots: energy deposits along TRD track in 8 layers for p , e^- , μ^-
- Bottom plots: acceptance of each particle depending on the cut

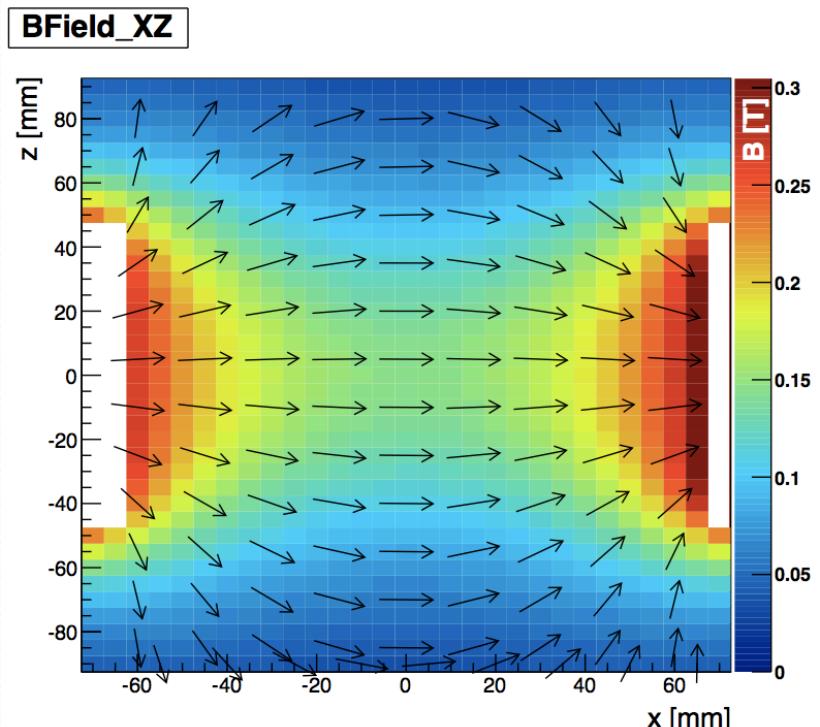


Tracker and Magnet



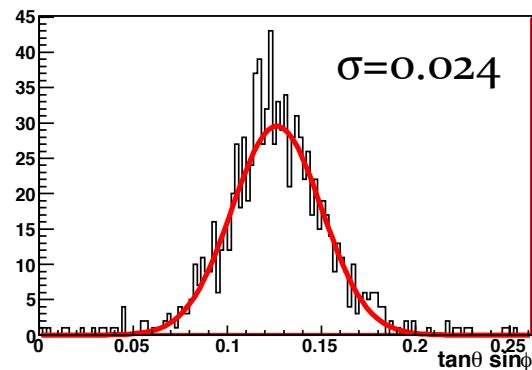
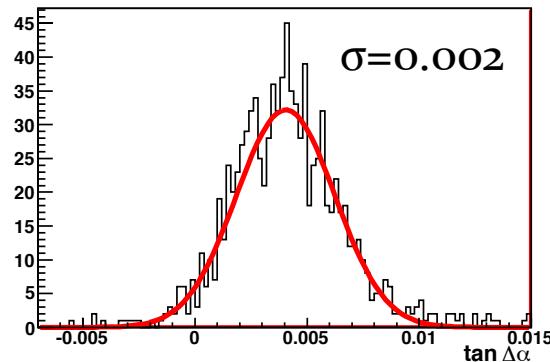
- scintillating fiber tracker
- 4 super layers of 10 stereo modules
- stereo module: 2 rotated by 1° fiber ribbons
- ribbon: 5 layers × 128 tubes of ø0.25 mm
- read out by 32-channel SiPM arrays
- provides 0.05 mm spatial resolution

- Halbach-array permanent magnet
- $\int \mathbf{B} d\mathbf{l} = 1.5 \text{ Tesla} \times \text{cm}$



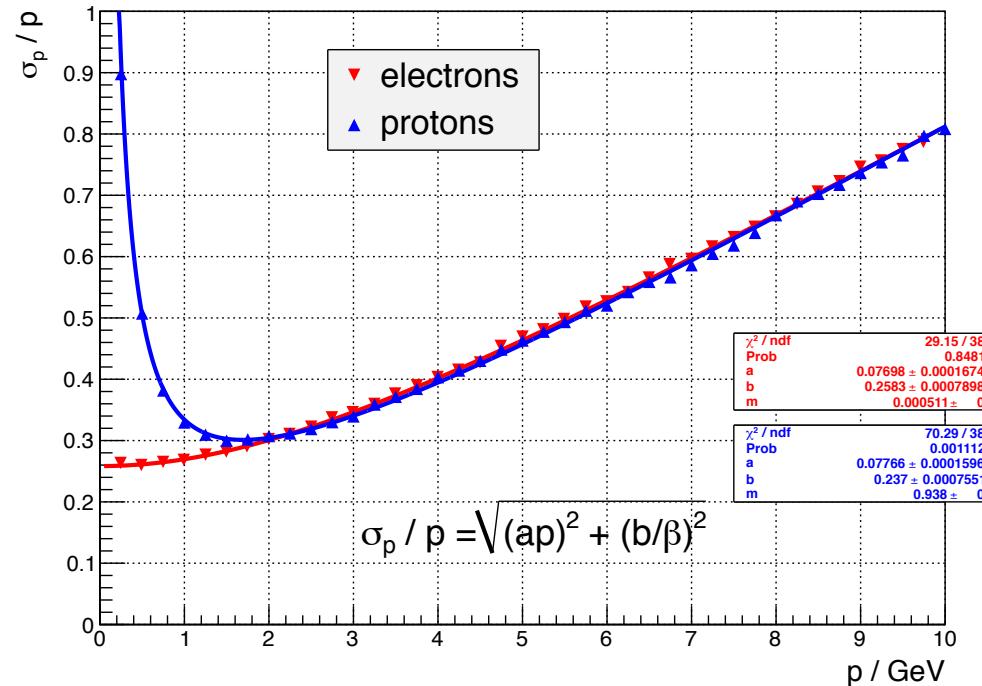
Momentum measurement

electrons, 1 GeV

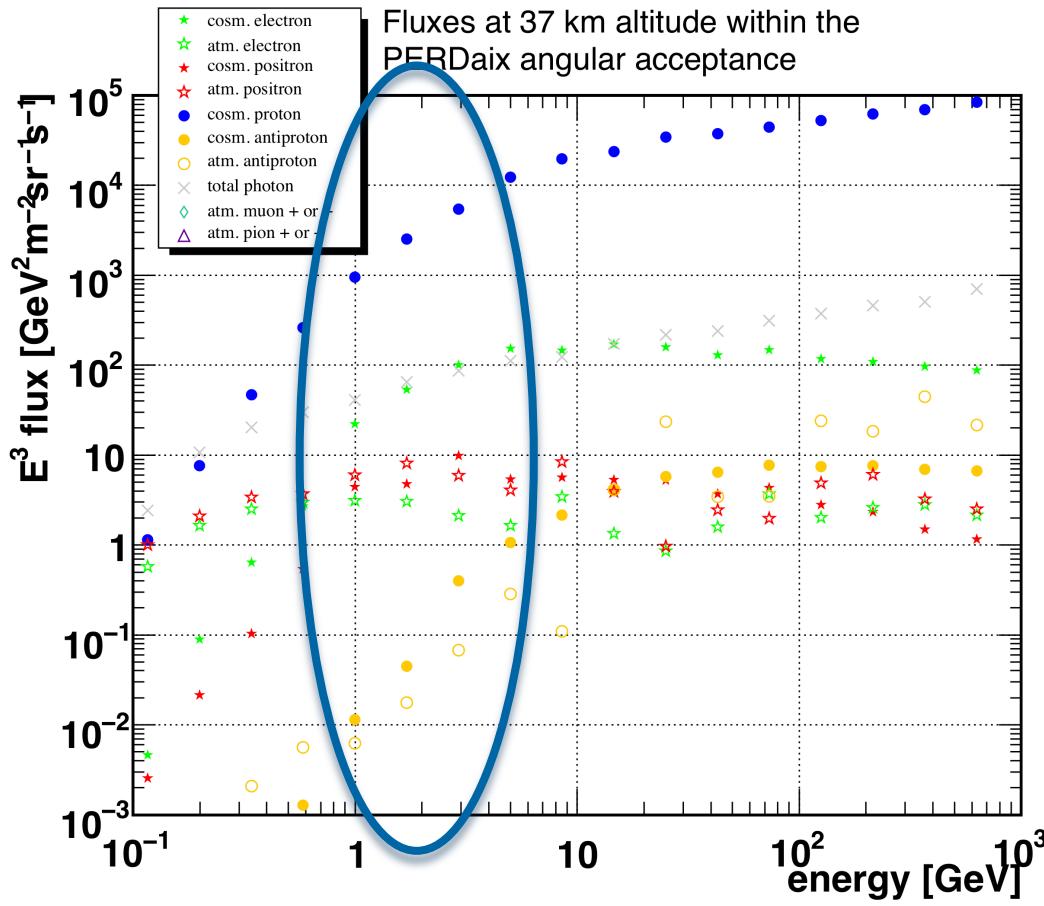


- track direction is found in both bending and non-bending planes:
 - spatial resolutions are order of magnitude different
 - 0.05 mm (bending) and 1 mm (non-bending)
- found rigidity resolution for the tracker:
 - $\sigma_p/p = p/\text{GeV} \times 7.7\% \oplus 25\%$

PERDaix momentum resolution (simulation)



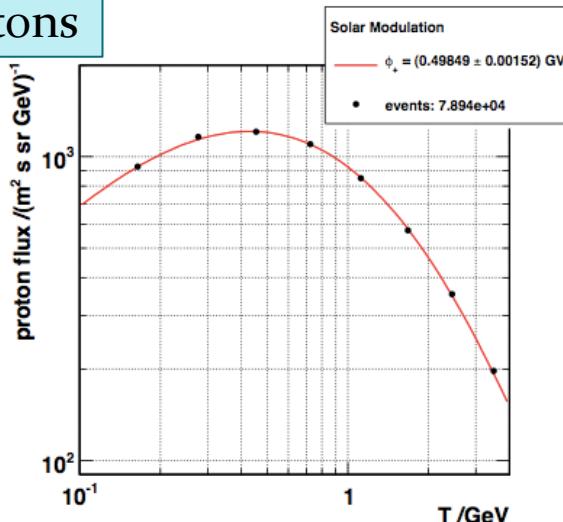
Simulated atmospheric fluxes



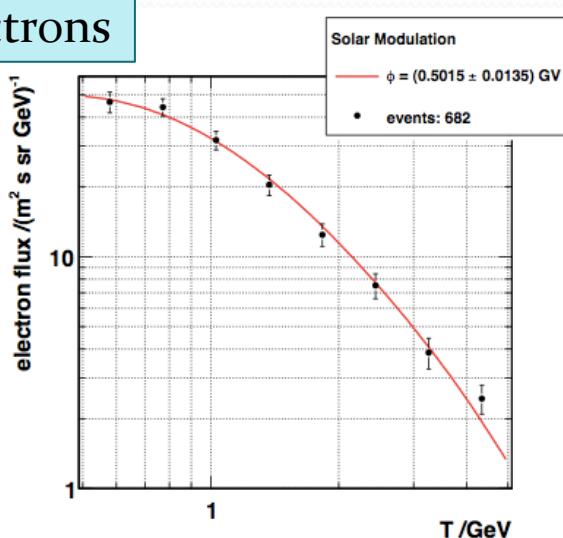
- positrons:
 - achievable only at 35 km
 - p with up to 10^3 higher flux suppressed by TRD
 - e^- up to 5 GeV rejected by the bending direction in the tracker
- electrons:
 - 10 times higher flux than e^+
- protons:
 - the most abundant
 - achievable at smaller altitudes

Projected PERDaix measurement

protons



electrons



- the expected results after atmospheric background subtraction
- three ϕ parameters can be measured
- the estimated statistical error on ϕ for different species of particles:
 - protons: 0.3%
 - electrons: 2.7%
 - positrons: 4.4%

Additional information

- <http://www.rexusbexus.net/>
- <http://accms04.physik.rwth-aachen.de/~perdaix/>
- <http://en.wikipedia.org/wiki/PERDaix>
- <http://www.youtube.com/user/PERDaix>