"Developments for shower reconstruction and composition analysis for CARPET-3 EAS array"

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Outline

Carpet EAS array

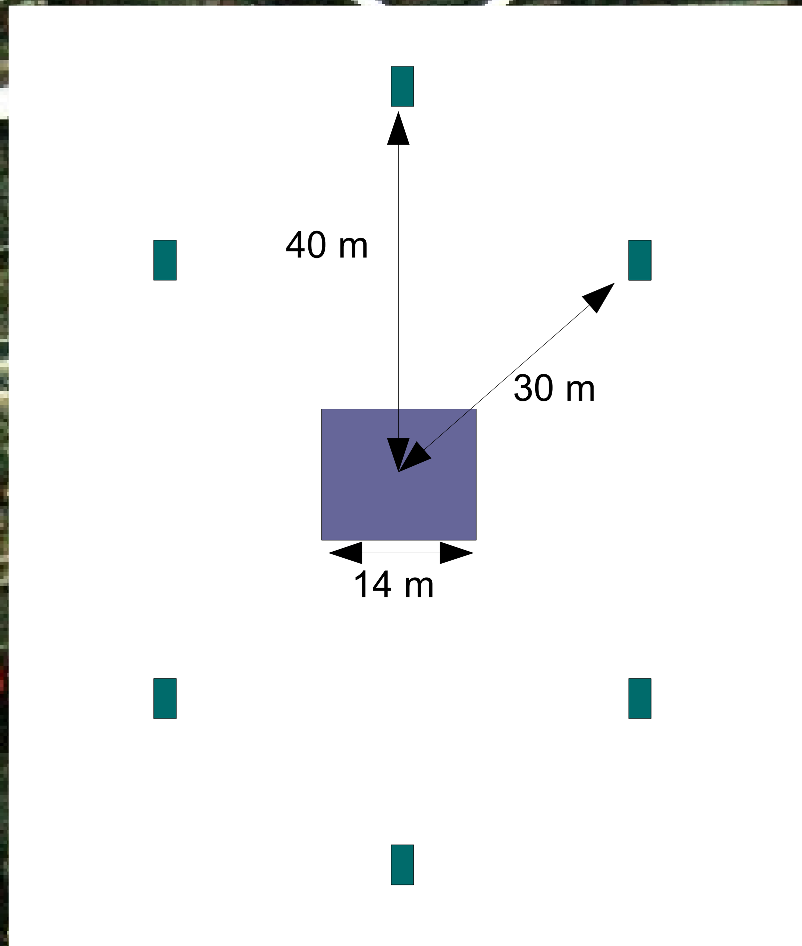
A study on the average lateral density distributions

Further developments

CARPET EAS ARRAY

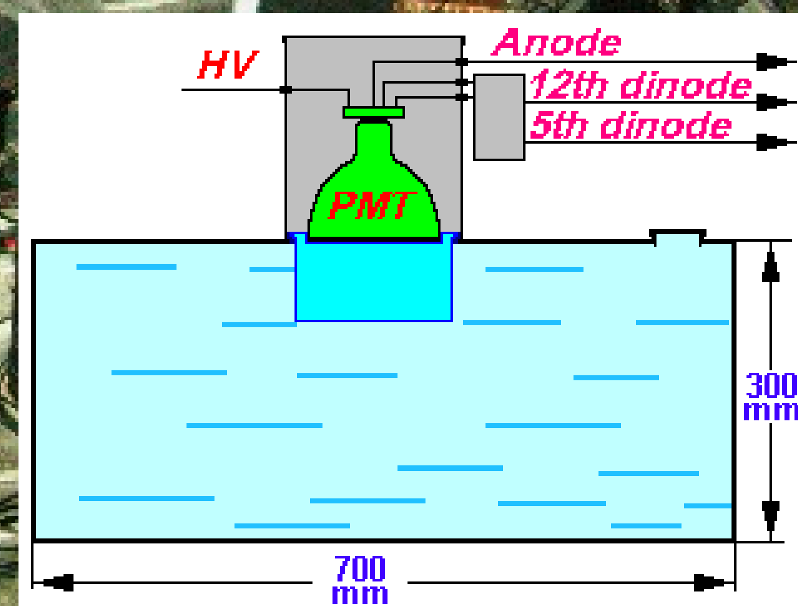
CARPET-EAS ARRAY **Locates in Baksan Russia (43.28° N, 42.69° E)**
1700 metres a.s.l., atmospheric depth 840 g/cm^2

ARRAY

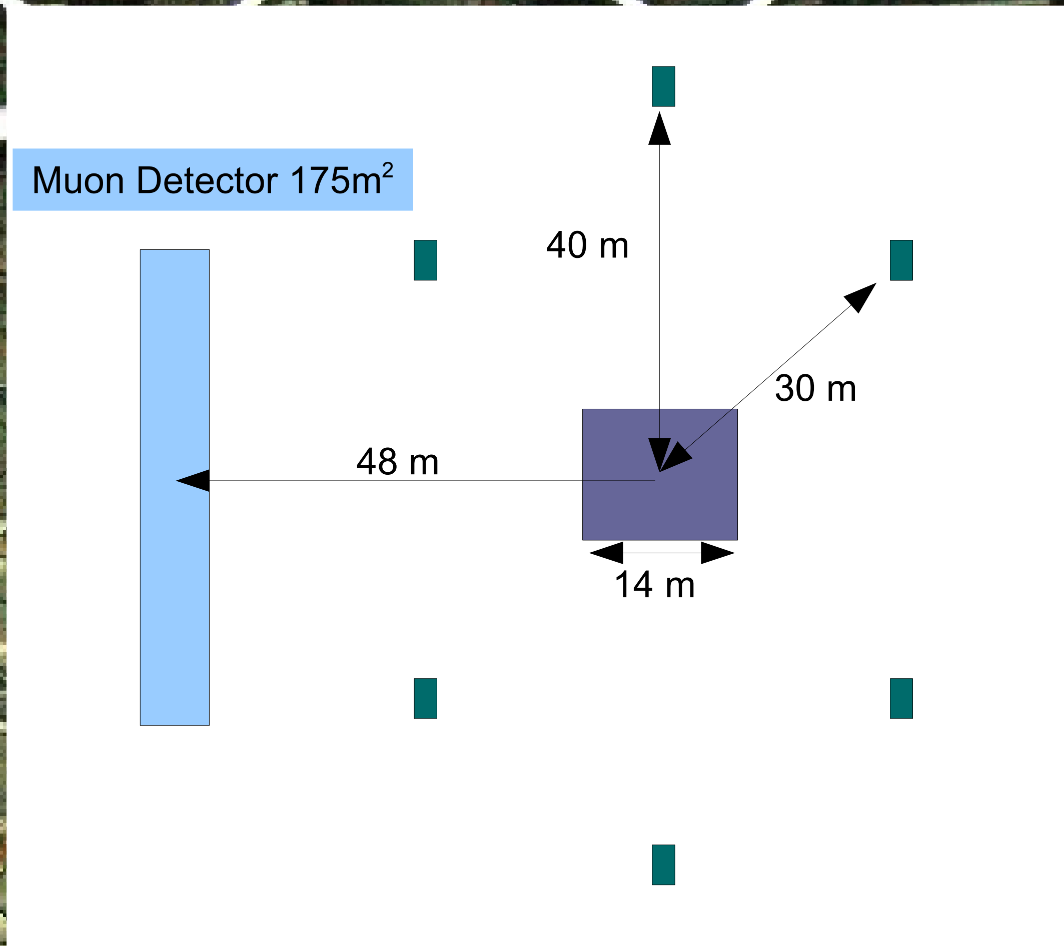


The Central Detector:
20 x 20 = 400 liquid scintillators of
700mm x 700mm x 300mm

Six (6) Outer Detectors
9 m^2 each



Muon detector



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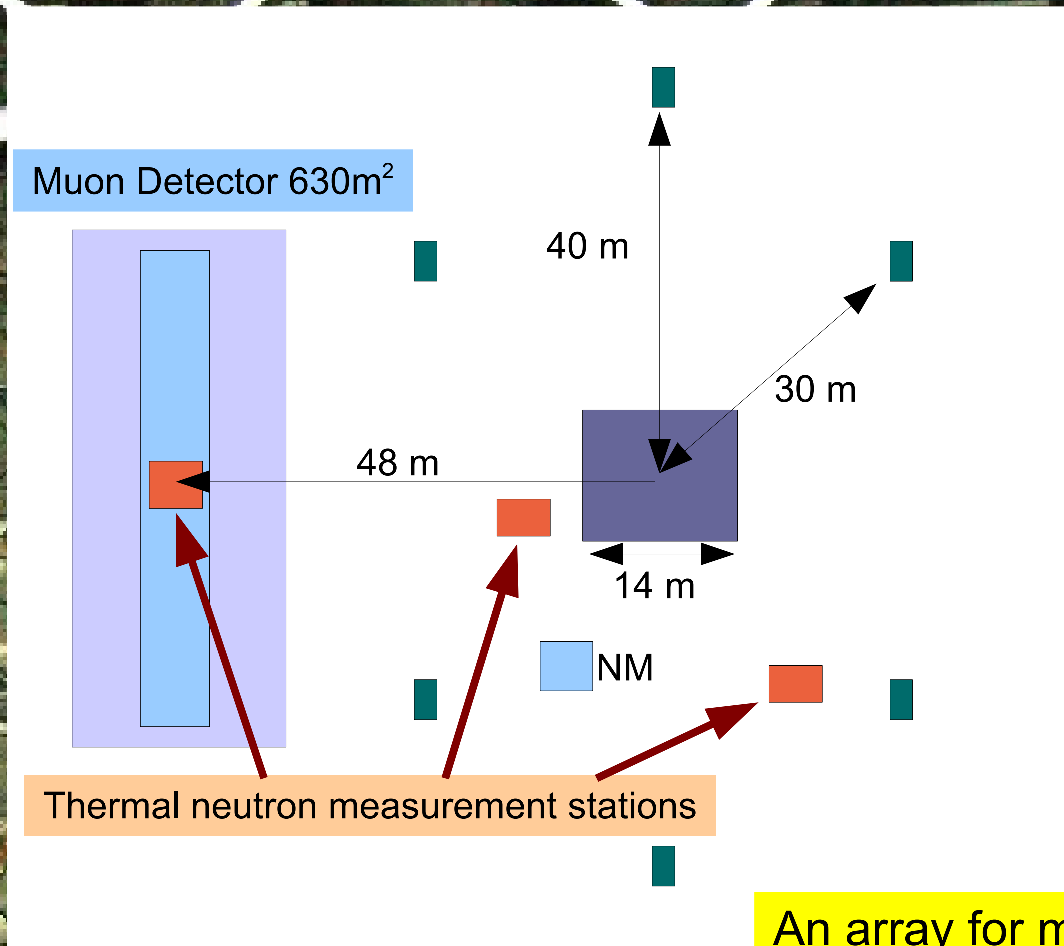
CARPET-3 PROPOSAL (Nucl. Phys. B (Proc.Suppl.) 196 (2009) 371-374)



The Central Detector:
20 x 20 = 400 liquid scintillators of
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An array for multicomponent composition analysis

A STUDY ON LATERAL DENSITY DISTRIBUTIONS

A study was carried with the data recorded with the central and outer detector stations.

Here interest was on the N_e and shape of lateral density distribution.

Data selected

The showers recorded with CARPET-array (zenith angle < 30 degrees) were divided in three bins according to reconstructed shower sizes N_e, namely

$\mathbf{8.0\times10^5 < N_e}$	$\mathbf{N_{showers} = 100}$
$\mathbf{2.0\times10^5 < N_e}$	$\mathbf{N_{showers} = 665}$
$\mathbf{1.5\times10^5 < N_e < 2.0\times10^5}$	$\mathbf{N_{showers} = 166}$

The average lateral density distribution was produced for each shower size range.

A STUDY ON LATERAL DENSITY DISTRIBUTIONS

CORSIKA simulations

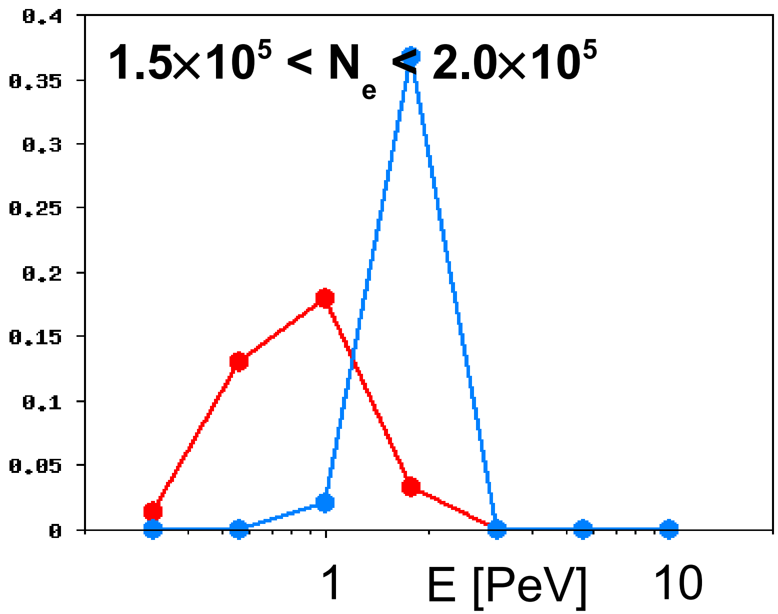
Extensive CORSIKA simulations were done in order to compare the measured average LDF to that expected from model.

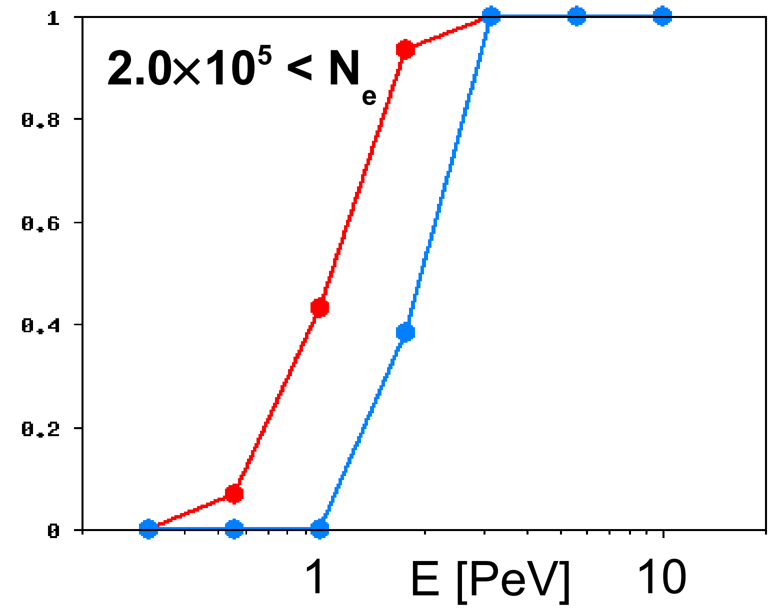
* Here models QGSJET01c + GHEISHA
* Shower size reconstruction was done in the shower plane by fitting the NKG function (R_M = 94m) with age parameter *s*=1.0 fixed
* Fit is done for bins of distance 20-50 m from shower axis
* The chosen method approximates the method used for reconstructing the measured air showers

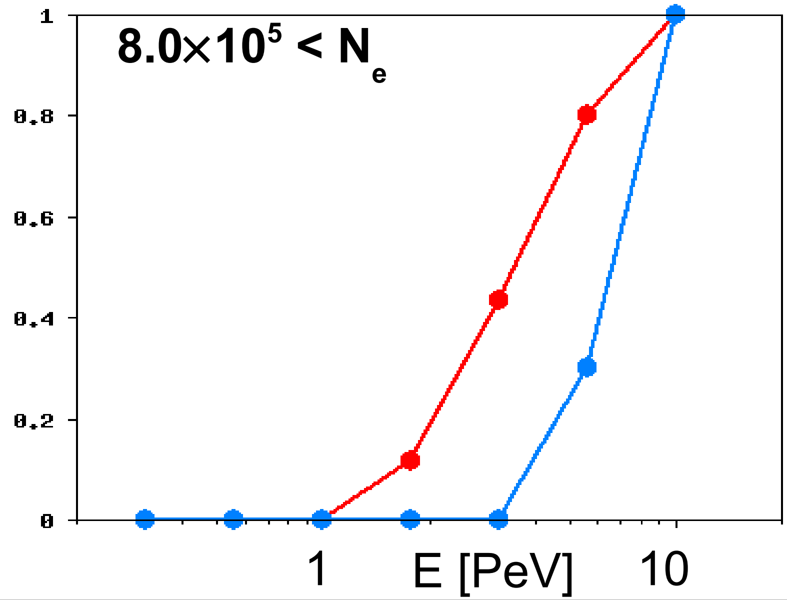
'Kuusi' – multiprocessor computer of University of Oulu was used to carry out the simulations.

SHOWER SIZE RANGES: Simulated energy thresholds

Relative yields of air showers for each shower size interval. Shown for discrete energies. Increasing shower size corresponds to increasing energy threshold.

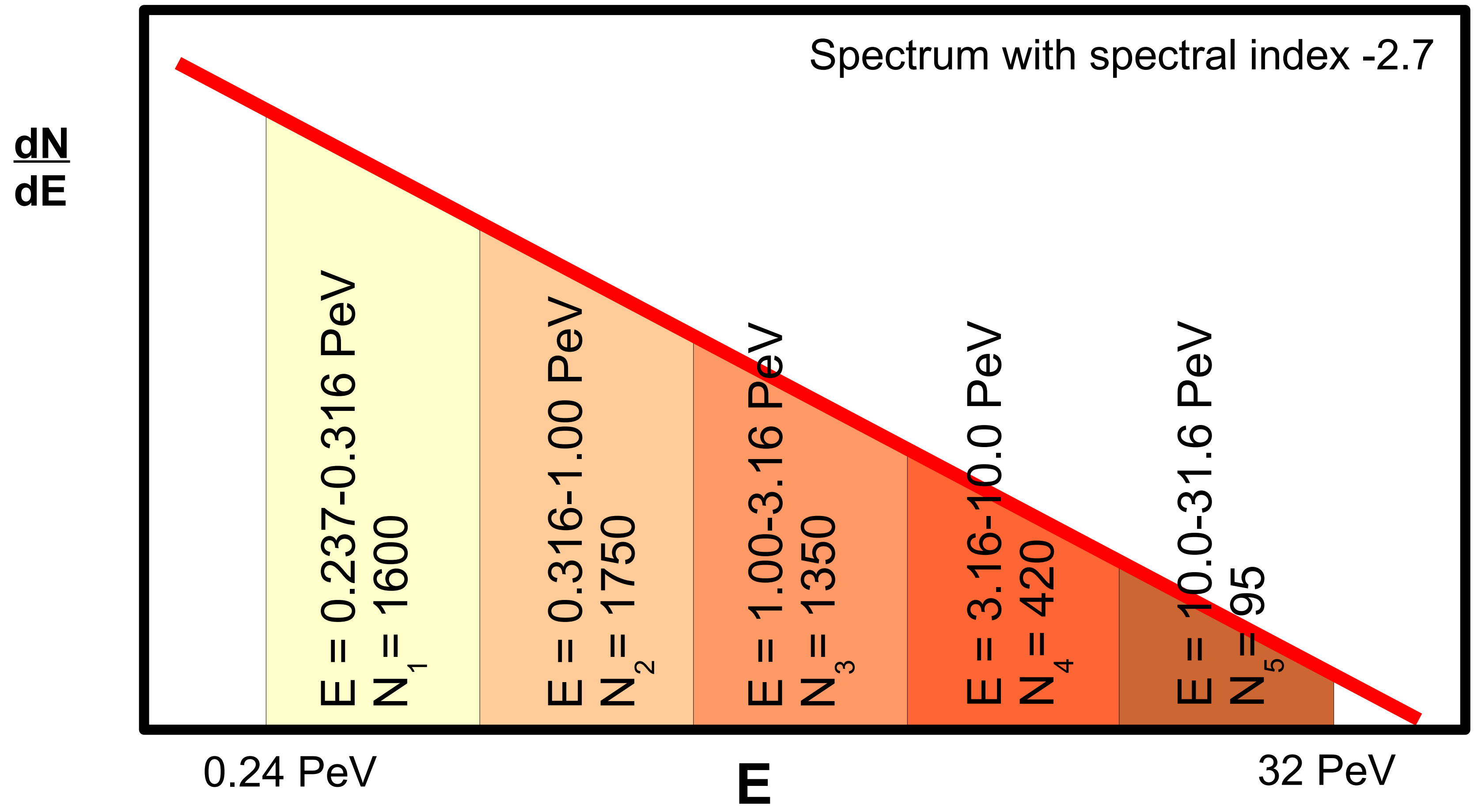






Red proton
Blue iron

METHOD OF SIMULATING CONTINOUS SPECTRUM

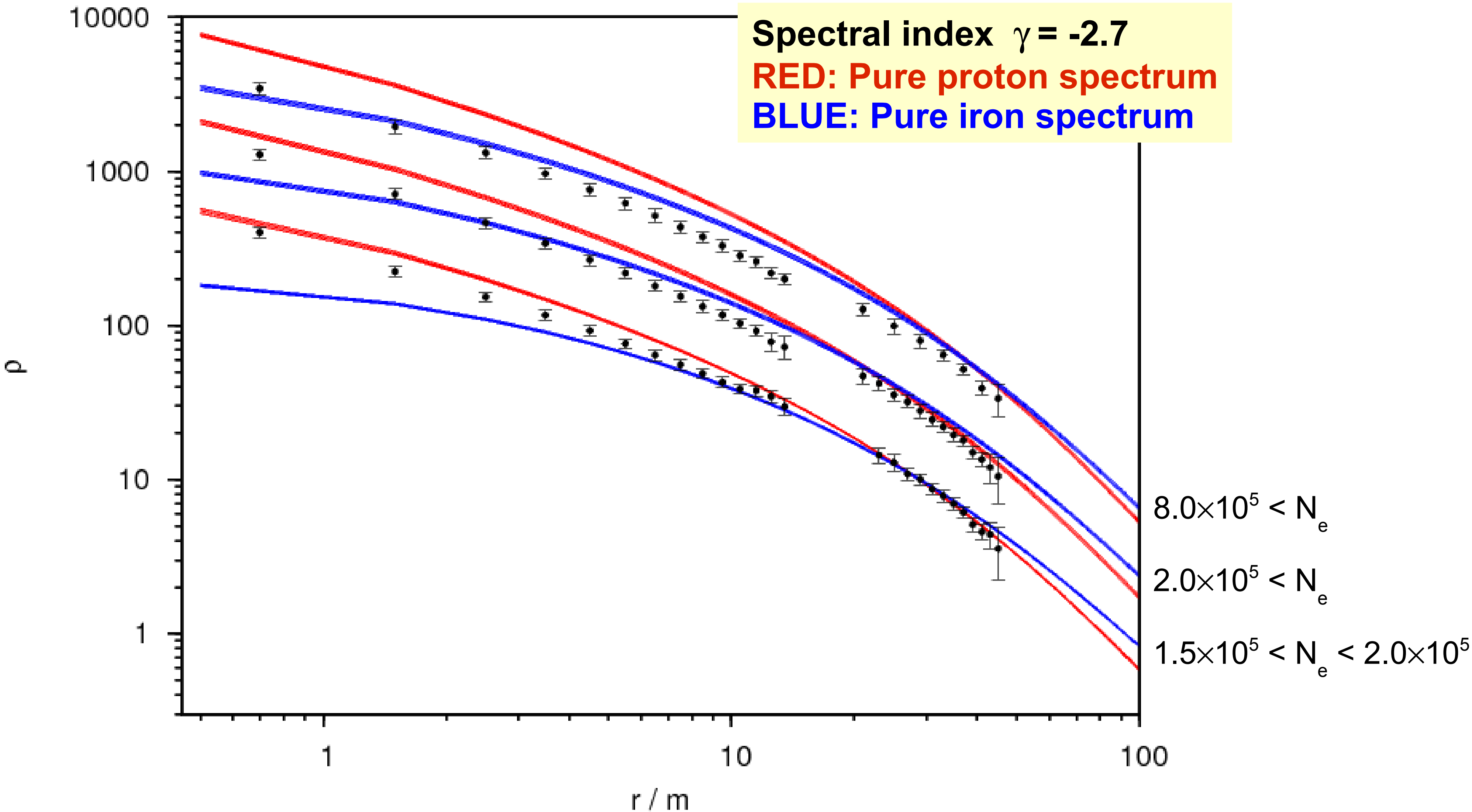


CORSIKA simulations were carried by dividing the energy range in to 5 intervals.
Simulation statistics ~ 3 x data.

The average LDF was then constructed as an weighted average of individual showers, where weights were given for both the assumed cosmic ray spectrum w_k and simulation statistics N_k.

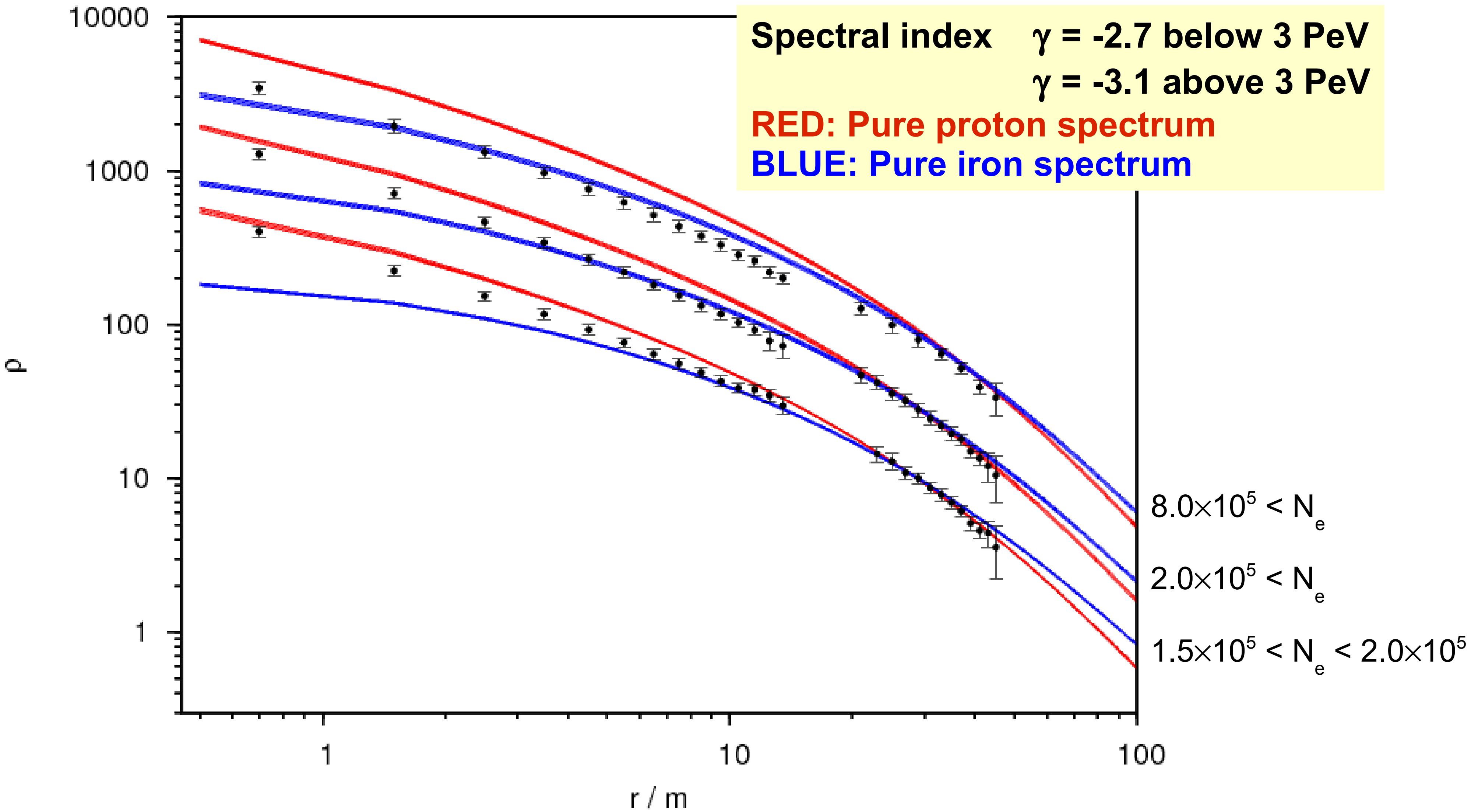
$$\bar{\rho}_j(r) = \frac{\sum_{k=1}^{4} w_k \times \frac{1}{N_k} \sum_{i=1}^{n_{jk}} \rho_{ijk}}{\sum_{k=1}^{4} w_k \times n_{jk}/N_k}$$

COMPARISON OF DATA and SIMULATION 1/2



To first order, the simulations are well describing the overall shape of the measured LDF. However some inconsistencies exist: namely the measured shape falls under the simulated around 10 m, and for the largest shower sizes the simulated LDF lies above the measurement.

COMPARISON OF DATA and SIMULATION 2/2



The effect of knee (steeper spectrum above 3 Pev) is small, but observable in the highest shower size intervals.

FURTHER PROGRESSES

For further analysis it was then concluded that there exists a need for a development of a more refined shower reconstruction methods for CARPET-3

1) **Investigation of fit methods for N_e reconstruction**

2) **Implementation of an accurate array geometry in analysis of simulated showers**

3) **Modifying the shower reconstruction procedure for CARPET array data**

4) **Applying a Monte Carlo generator for detector response (namely: MC generated roof effect on event-by-event basis)**

These developments are crucial before proceeding for multicomponent analysis.

TO CONCLUDE

* A study on the lateral density function recorded with CARPET EAS ARRAY was carried out.

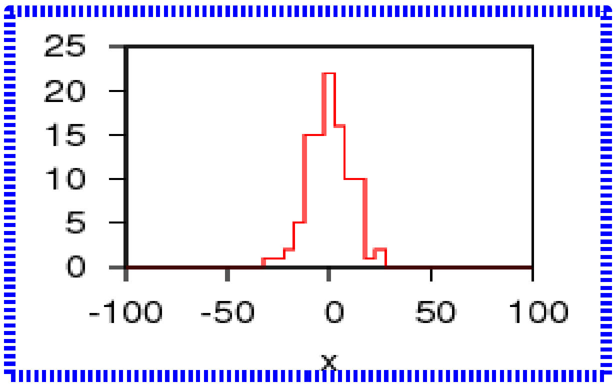
* The measured LDF in the shower size intervals corresponding to the knee energies was compared with extensive CORSIKA simulations.

* Before arriving to conclusions, and physics claims, it is important to understand and refine the shower reconstruction methods. Systematics are important here as was indicated by the comparison study.

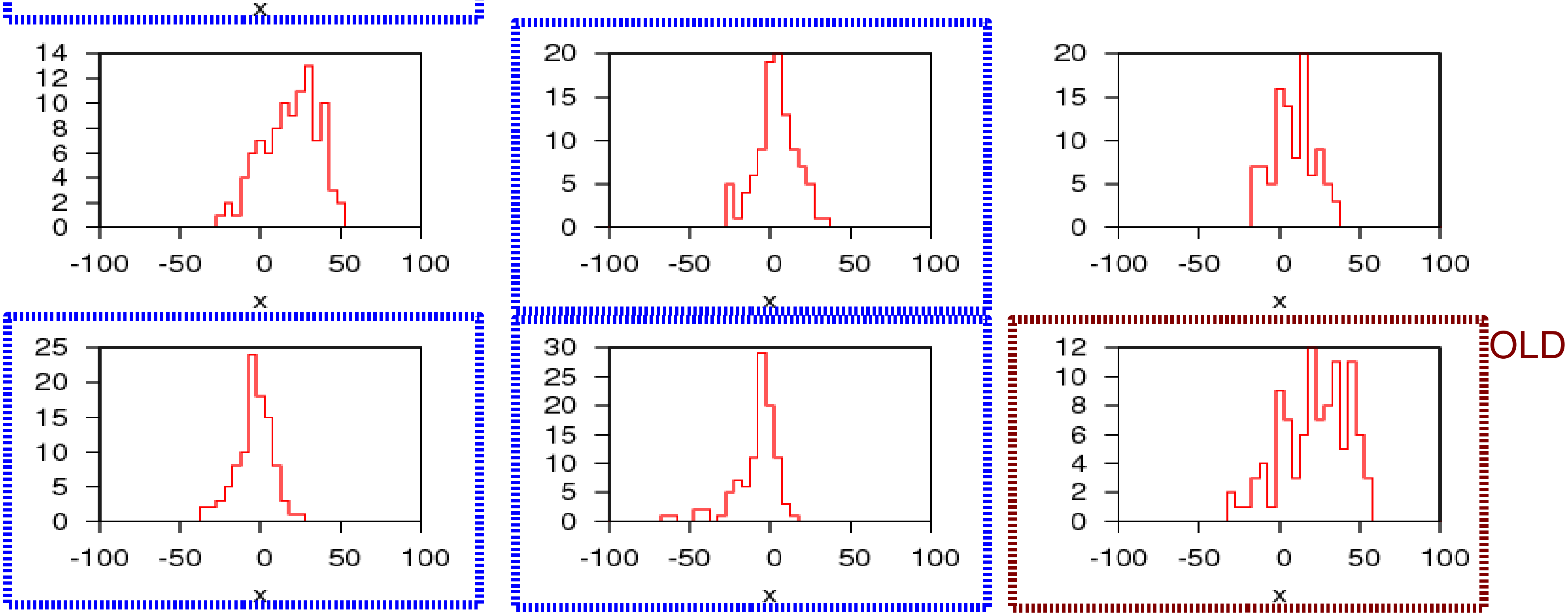
* These developments are foreseen in the implementation of new shower reconstruction algorithms for new samples of CARPET data and also for CARPET-3.

* Carpet-array:
  Poster 4.31: Hadrons with energies of Eh > 50 MeV in EAS with Ne = 10^5-10^7

FIT METHODS FOR SHOWER SIZE ESTIMATION



$$x = \frac{N_e^{true} - N_e^{reconstructed}}{\sqrt{N_e^{true}}}$$



Comparison of seven N_e reconstruction methods for simulated 1 PeV showers

Refining the fit method gives a more accurate shower size estimate.

ARRAY GEOMETRY AND SHOWER RECONSTRUCTION

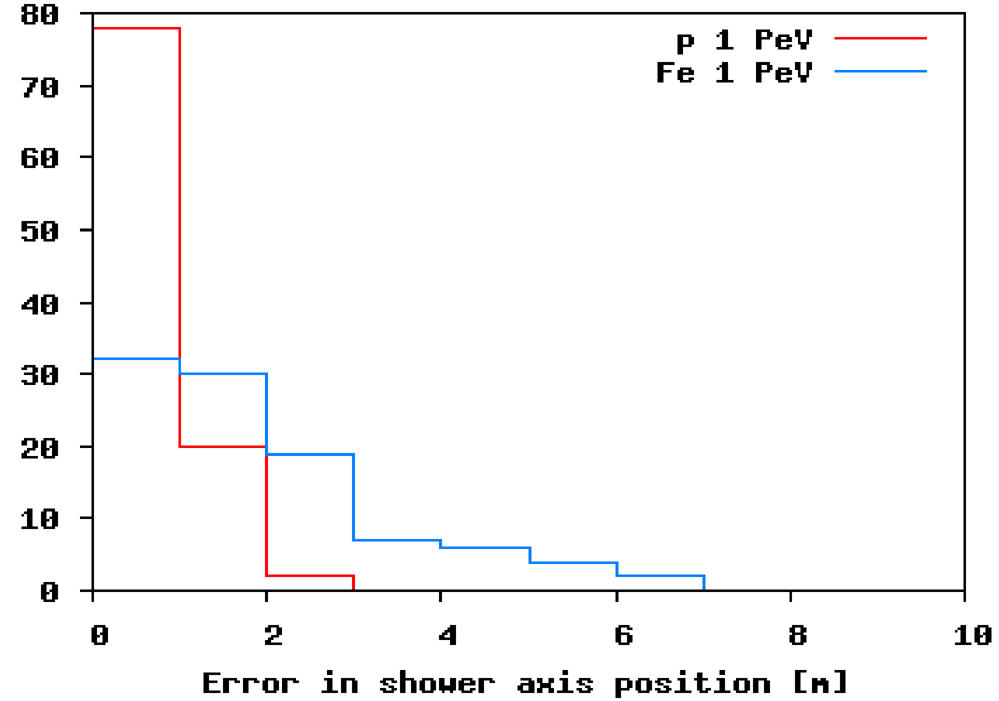
* Algorithms for the shower axis reconstruction

  * Shower axis reconstructed as
    a) highest particle density

    b) weighted average over detector particle densities and positions

    c) a combined fit of NKG N_e, s , x and y

Shower axis uncertainty. Method (a)



* Monte Carlo generator for roof effect

  CARPET central detector is situated in a building. The roof structures overlaying the detectors are a source of local cascades. In previous analysis the effect on recorded particle densities was taken into account only on average. We are looking towards an implementation of specially designed MC generator (D.Dzhappuev).