News from the HEC Test Beam MC

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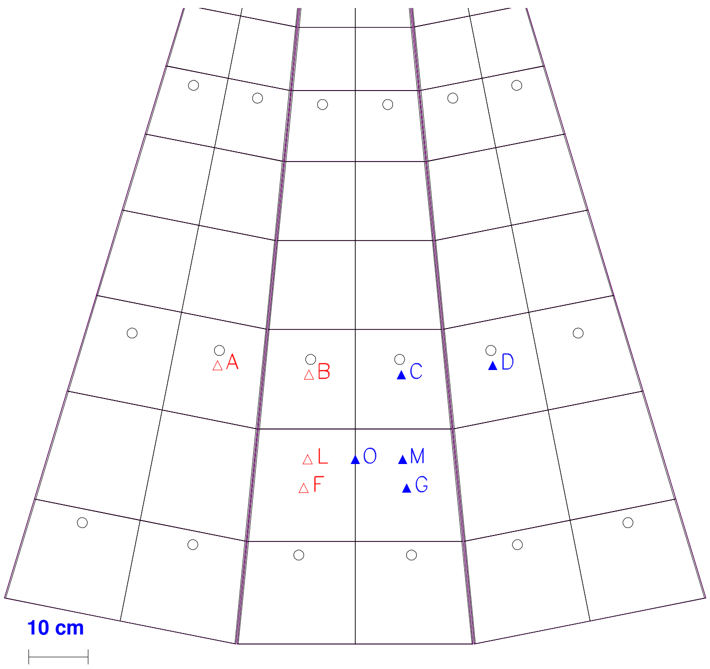
HEC/FCAL Test Beam Analysis Meeting, CERN

- **Simulation of 1999 HEC test beam with HEC-BEAM 3.1**

- **Simulation of 1999 HEC test beam with HEC-BEAM 3.2**

Simulation of 1999 HEC Test Beam with HEC-BEAM 3.1

- Package HEC-BEAM, version 3.1
- Simulated data:
  - pion (*G-CALOR*) energy scans (10-200 GeV): at points C, D, G, M and O
  - electron energy scans (10-193 GeV): at points C, G, M and O
  - muons energy scan (1-300 GeV): at point M
- Web page (status of simulation and access to files): *http://wwwatlas.mppmu.mpg.de/HEC/tb31.html*



Cut of volume BRYR at Z=−79.75 cm
(front face of the first LAr gap)

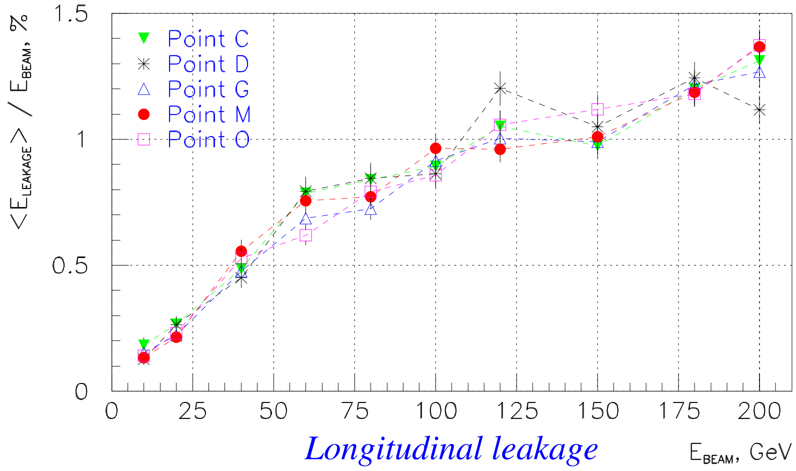
Analysing Procedure

- Event selection:
  - "Event trigger": only one hit in each MWPC plane
  - Good track reconstruction in MWPCs
  - MWPC cuts: hits in the range of $\pm\ 3r.m.s.$
  - Muon cut (for pions only):
    without low signal in all LAr gaps and
    without large back leakage
- Energy reconstruction in the whole module:
  $E_{REC} = E_{VIS}(HEC1) + 2 \times E_{VIS}(HEC2)$
- Energy $E_{REC} \rightarrow$ Beam energy E_{BEAM}
  - calorimeter information only: $E_i = E_{RECi} \times C$,
    $C(E_{BEAM}) = E_{BEAM} / < E_{REC} >$
  - calorimeter and leakage information: $E_i = E_{RECi} \times C_2 + E_{LEAKAGEi}$,
    $C_2(E_{BEAM}) = (E_{BEAM} - < E_{LEAKAGE} >) / < E_{REC} >$

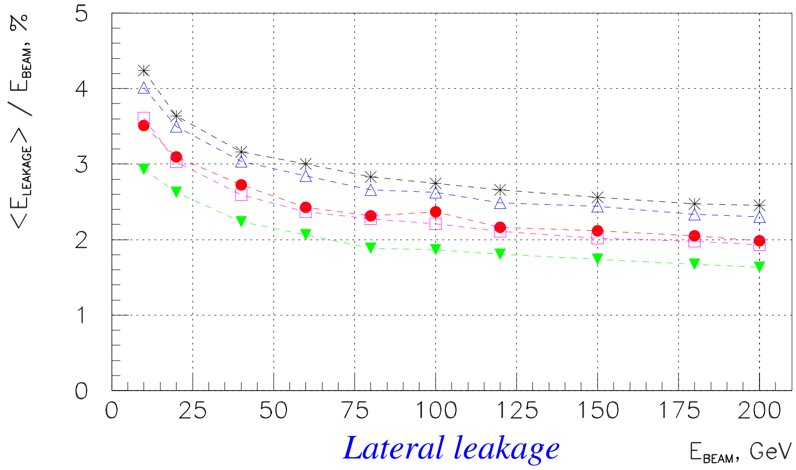
  Coefficients C and C_2, obtained for highest E_{BEAM}, are used
- Energy resolution and response (standard procedure):
  - Gaussian fit in the range $\pm\ 3\sigma$
  - $< E >$ and σ
  - Energy dependence of the resolution:

$$\frac{\sigma}{< E >}(E_{BEAM}) = \frac{P_1}{\sqrt{E_{BEAM}}} \oplus P_2$$

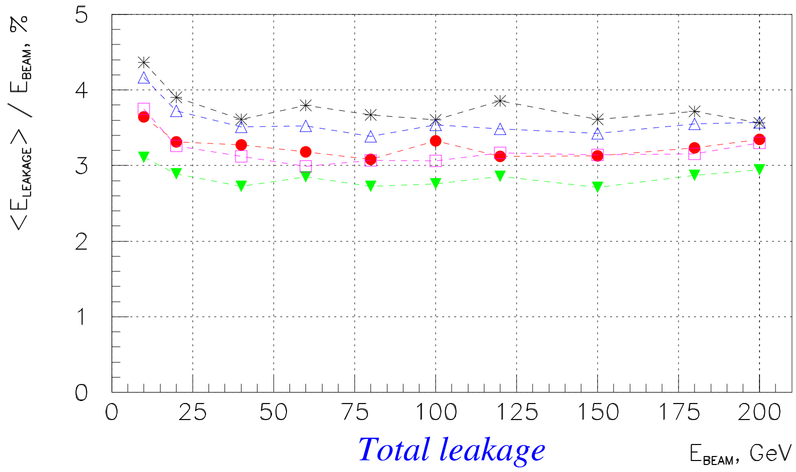
Pions: leakage energy



Longitudinal leakage

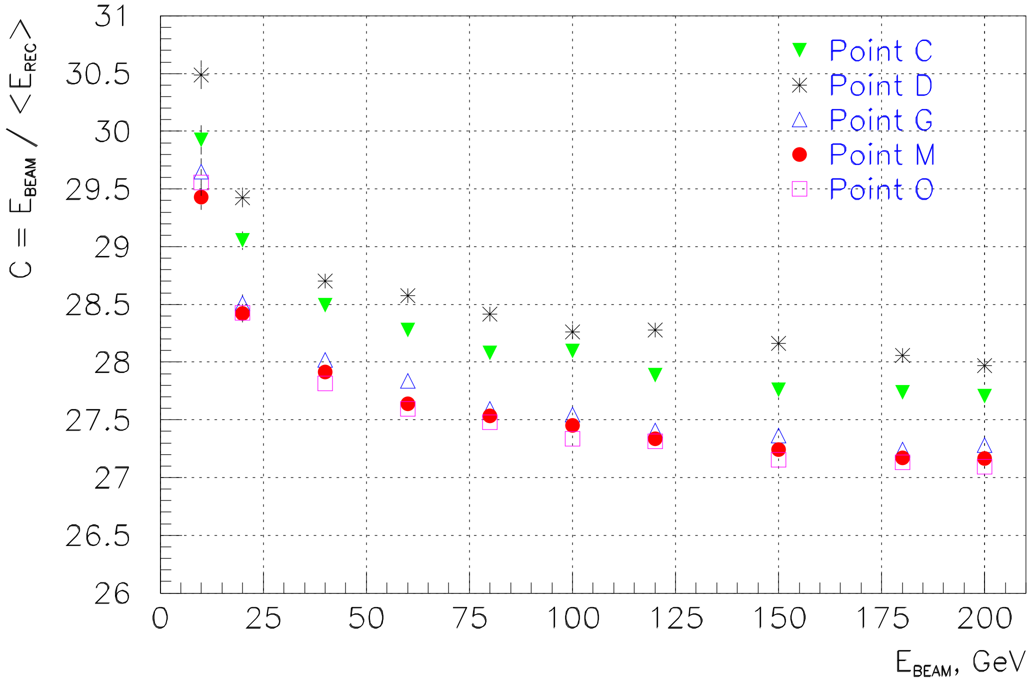


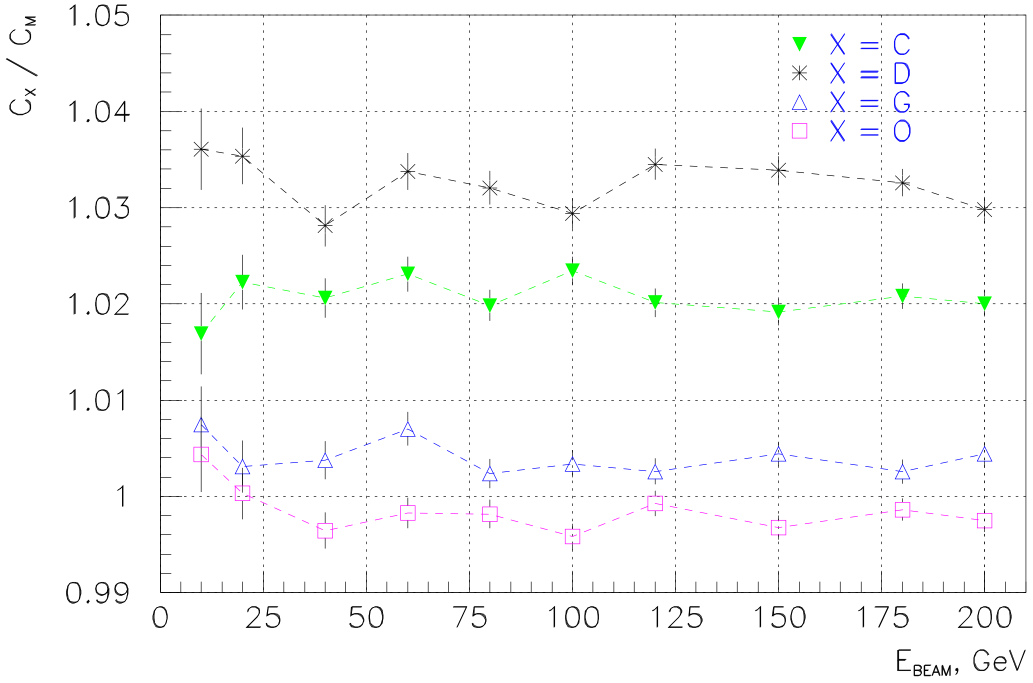
Lateral leakage



Total leakage

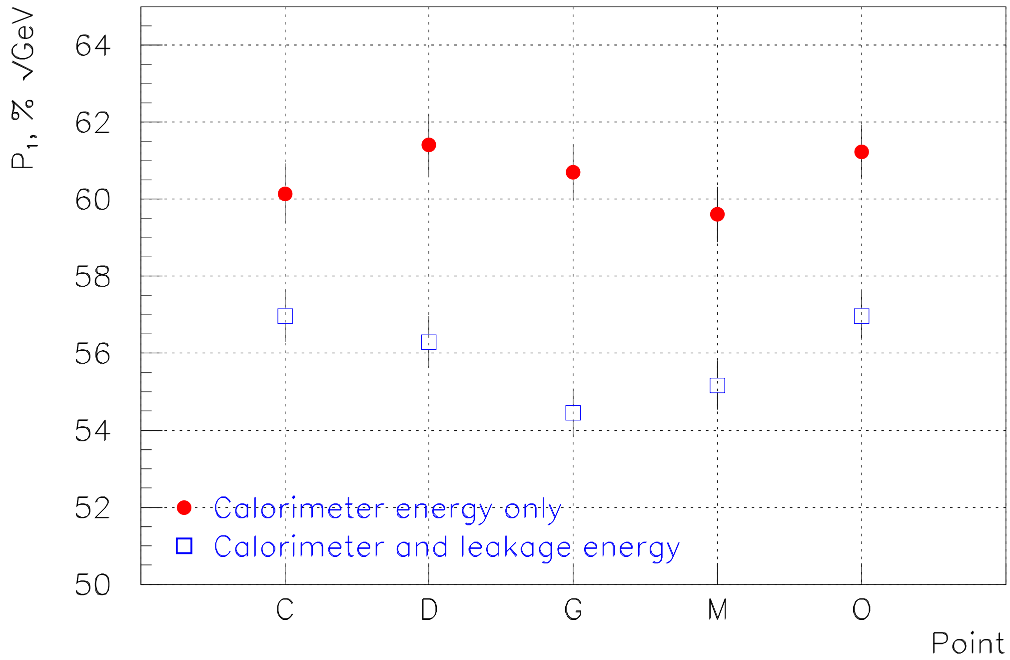
Pions: calibration constant



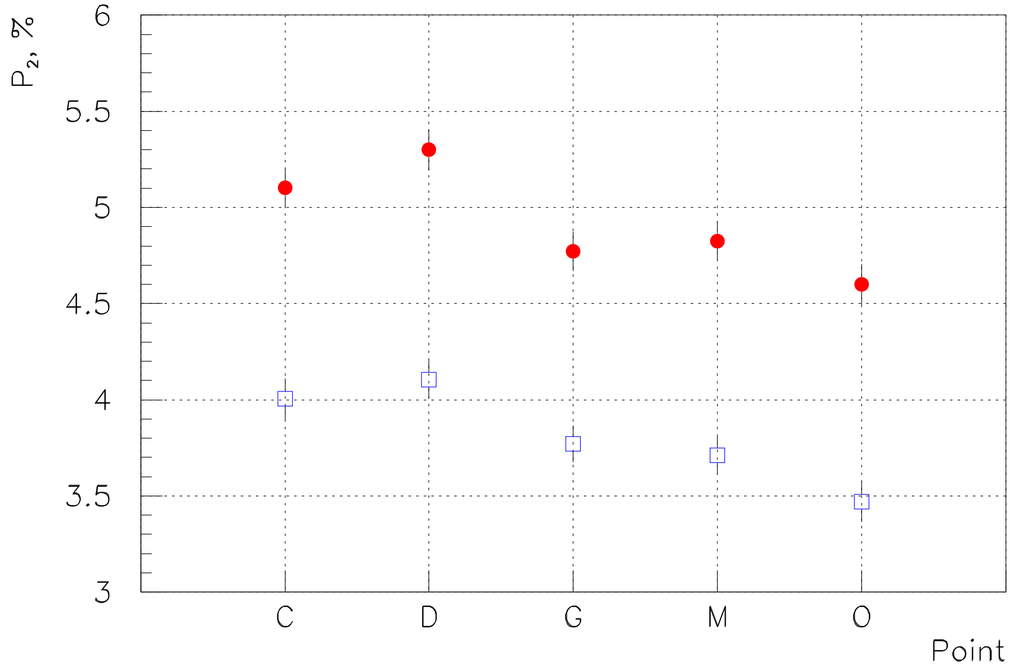


$C = E_{BEAM} / \langle E_{REC} \rangle$

Pions: energy resolution



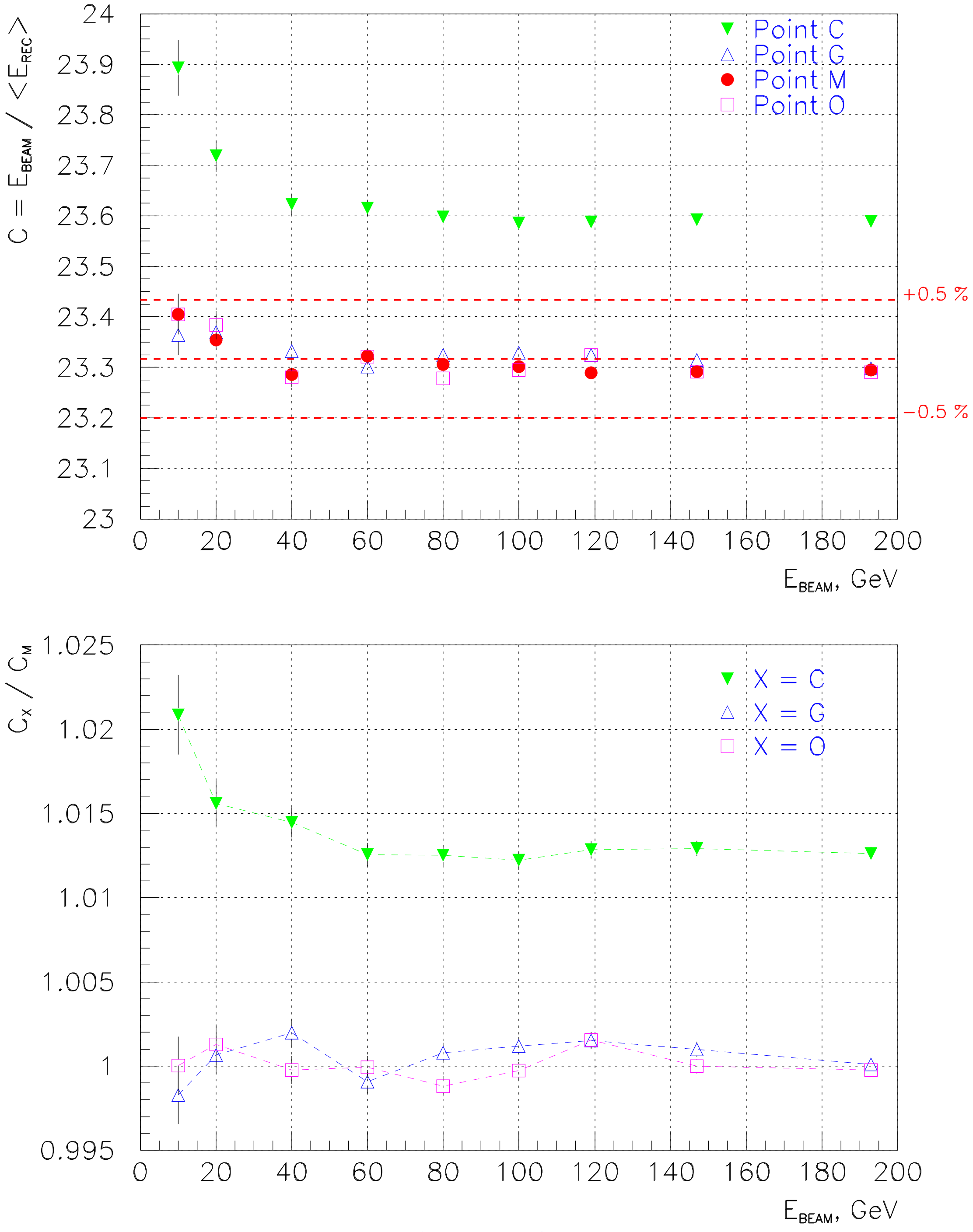
Sampling term



Constant term

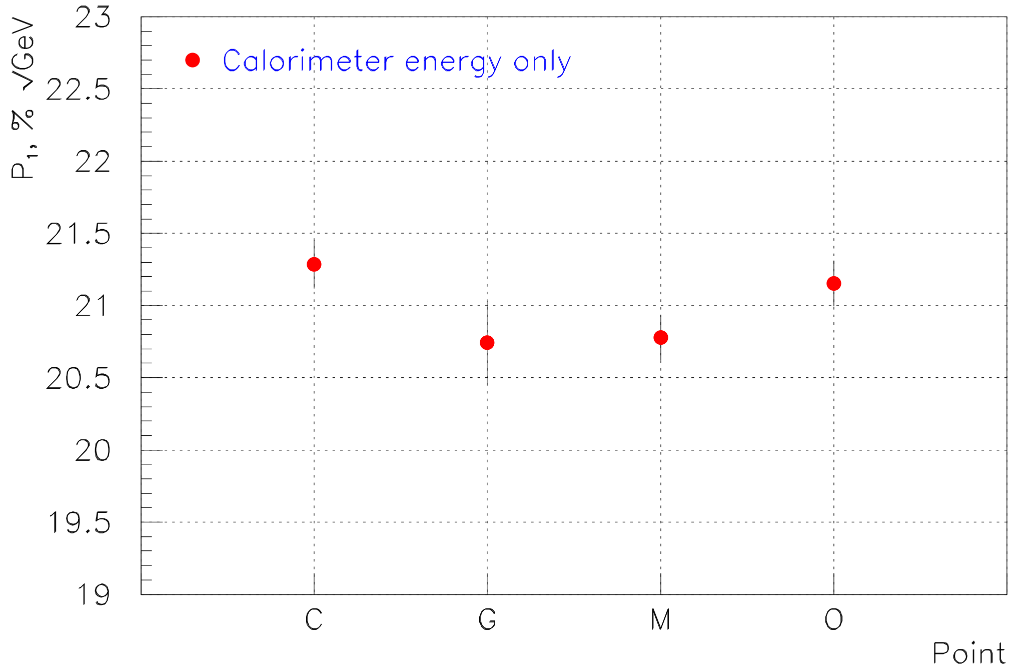
Simulation with HEC-BEAM 3.1

Electrons: calibration constant

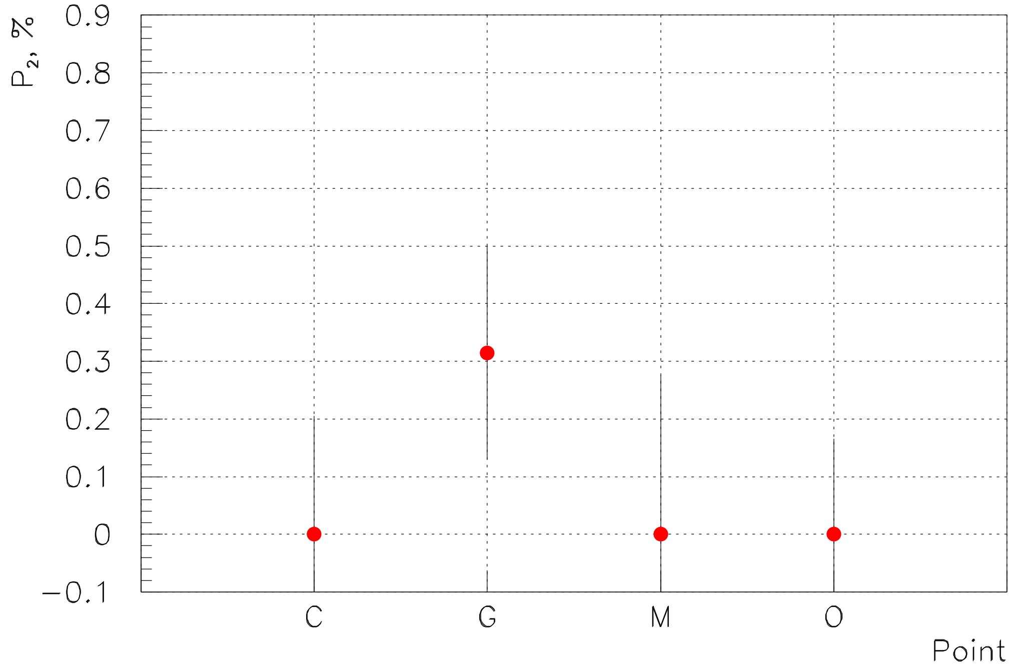


$C = E_{BEAM} / <E_{REC}>$

Electrons: energy resolution

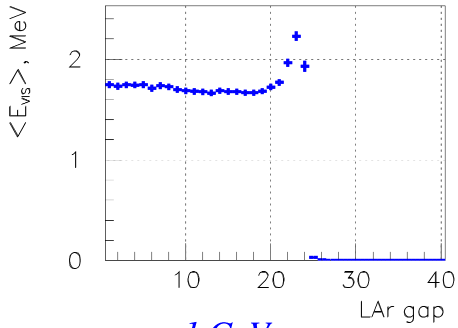


Sampling term

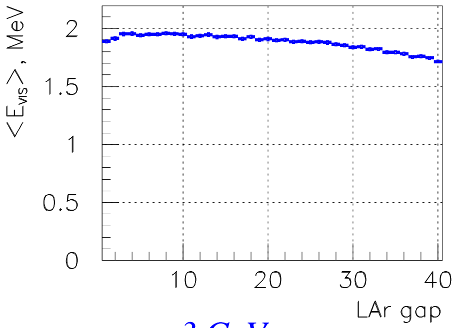


Constant term

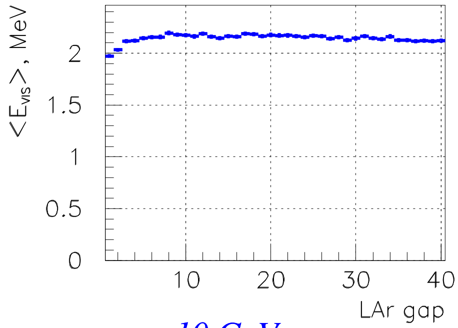
Muons: longitudinal energy profile



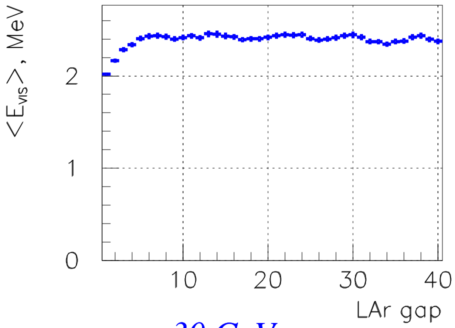
1 GeV muons



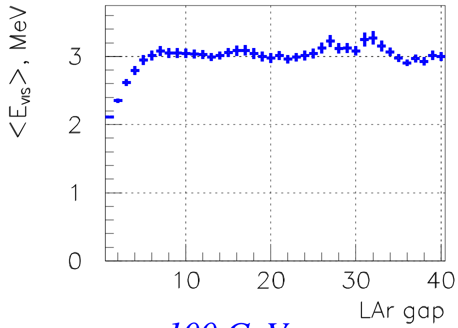
3 GeV muons



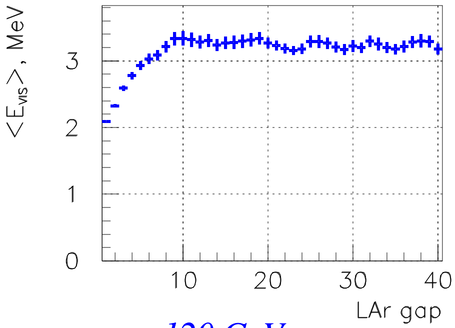
10 GeV muons



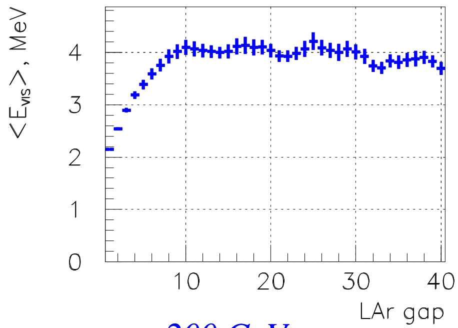
30 GeV muons



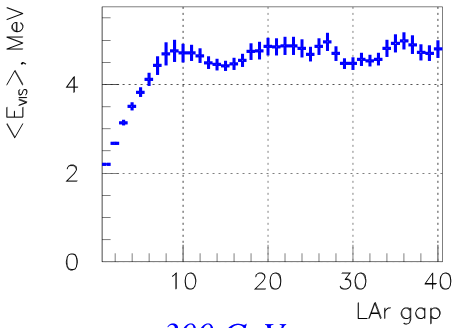
100 GeV muons



120 GeV muons



200 GeV muons



300 GeV muons

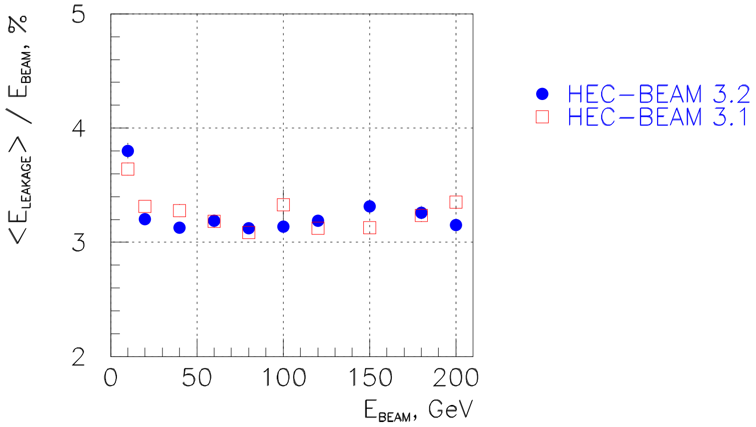
Simulation of 1999 HEC Test Beam with HEC-BEAM 3.2

- Missing information in HEC-BEAM 3.1 → missing studies:
  - "internal" leakage (in tie-rods, for example)
  - ratio e/μ
  - detailed comparison with Geant 4
  - influence of disconnected HV lines
  - more precise event selection
- Package HEC-BEAM, version 3.2 (still under construction)
- HEC 1999 test beam set-up
- Stored information outside calorimeter:
  - MWPCs: coordinate of hit wires
  - scintillator counters F_1 and F_2:
    - energy depositions in counters
    - energy of particles, passed through
  - cryostat wall: information about particles, passed through
  - cryostat inner volume: energy depositions in
    - LAr excluder
    - gap between HEC module and leakage detectors
    - leakage detectors

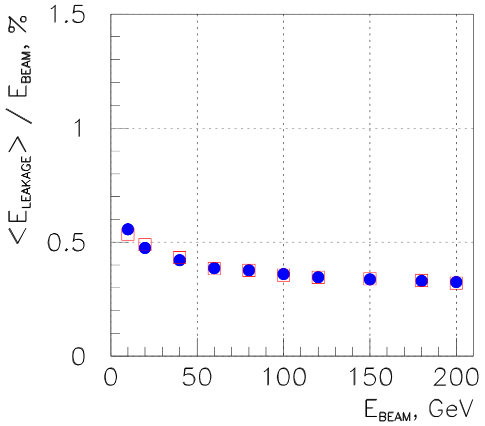
Simulation with HEC-BEAM 3.2

- Information about energy depositions in HEC module:
  - sub-gaps of working LAr
  - copper plates
  - kapton electrodes
  - copper pads inside PAD-electrodes
  - dead LAr in inter-wheel cracks (4 cm)
  - dead LAr in azimuthal cracks (2/6 mm)
  - tie-rods
  - "unexpected" LAr volumes
- Segmentation:
  - longitudinal: very fine
  - transverse: very coarse (only azimuthal wedges)
  - no information about ADC channels
- Output — Column-Wise-Ntuple (no FZ-banks more)
- Simulations done so far:
  - for point M ($X_{cryostat}$=8.0 cm, Y_{table}=-1.0 cm)
  - pion (*G-CALOR*) energy scan: 10-200 GeV (4 000 events per energy)
  - electron energy scan: 10-193 GeV (2 000 events per energy)
  - muon energy scan: 1-300 GeV (20 000 events per energy)
- Analysis of simulated data is going on...

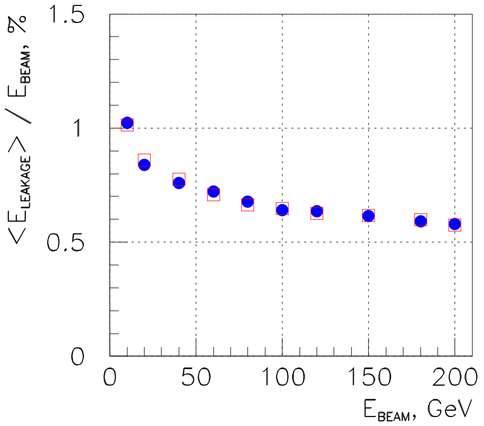
Comparison between HEC-BEAM 3.2 and HEC-BEAM 3.1: energy leakage for pions



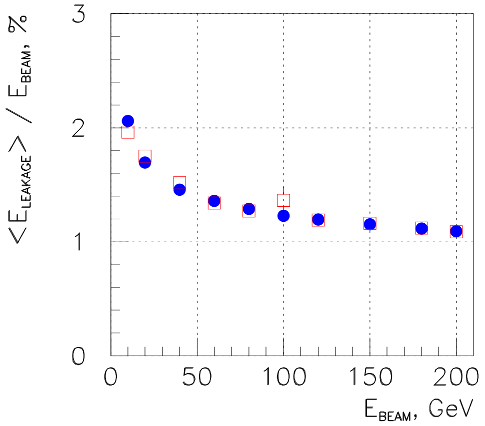
Total leakage



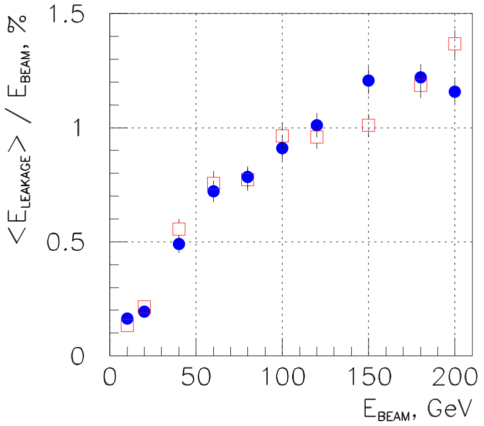
Leakage at X>0



Leakage at X<0

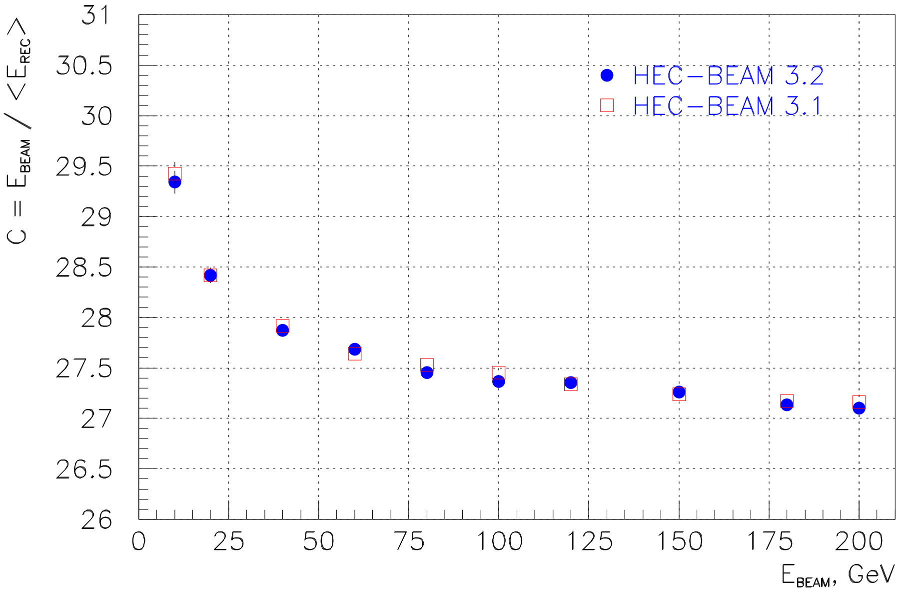


Leakage through the bottom

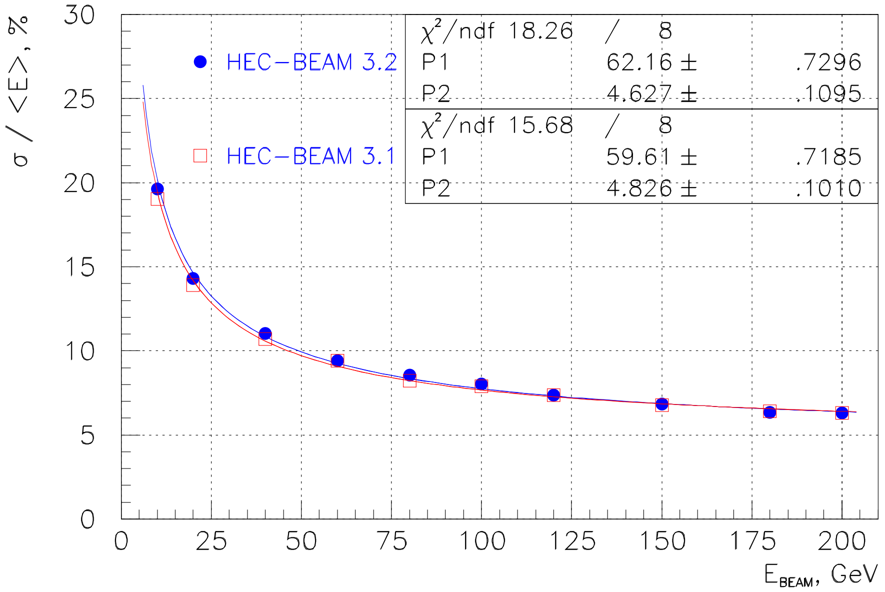


Leakage through the back

Comparison between HEC-BEAM 3.2 and HEC-BEAM 3.1: pion response and resolution

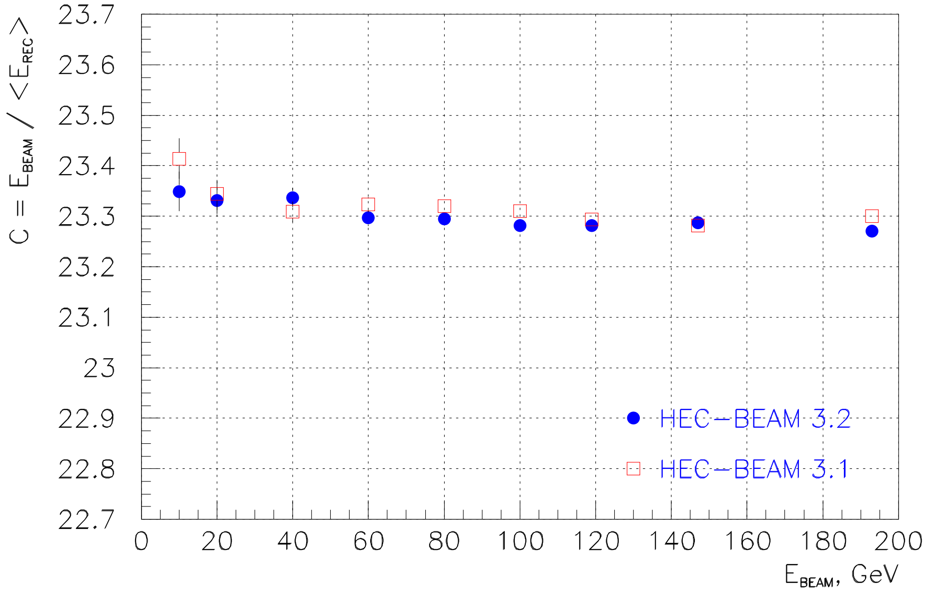


Calibration constant

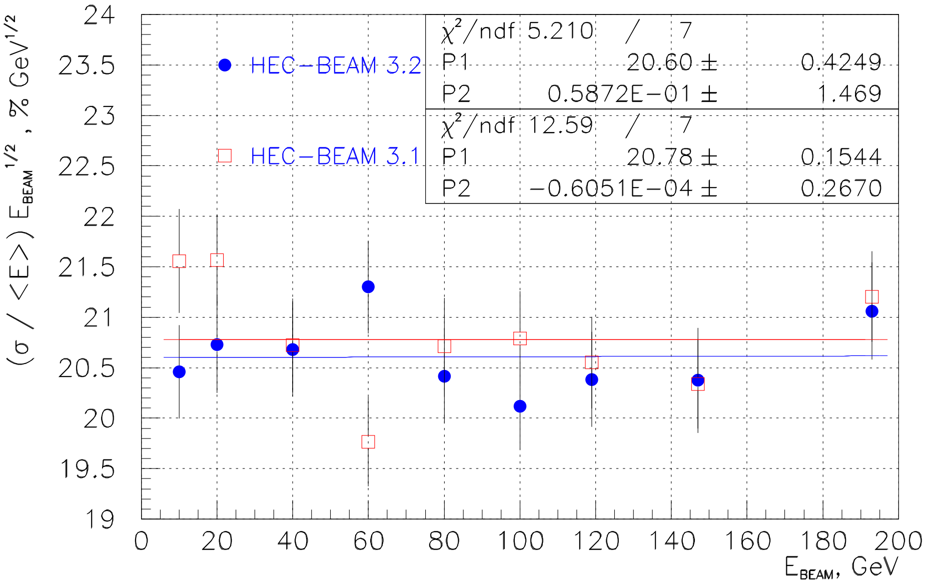


Resolution

Comparison between HEC-BEAM 3.2 and HEC-BEAM 3.1: electron response and resolution

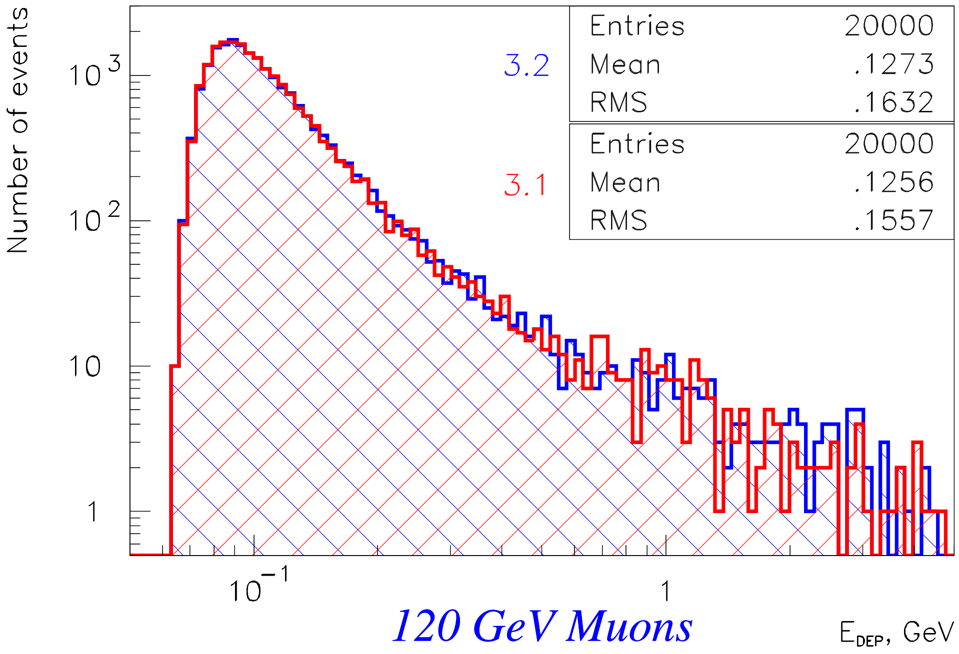


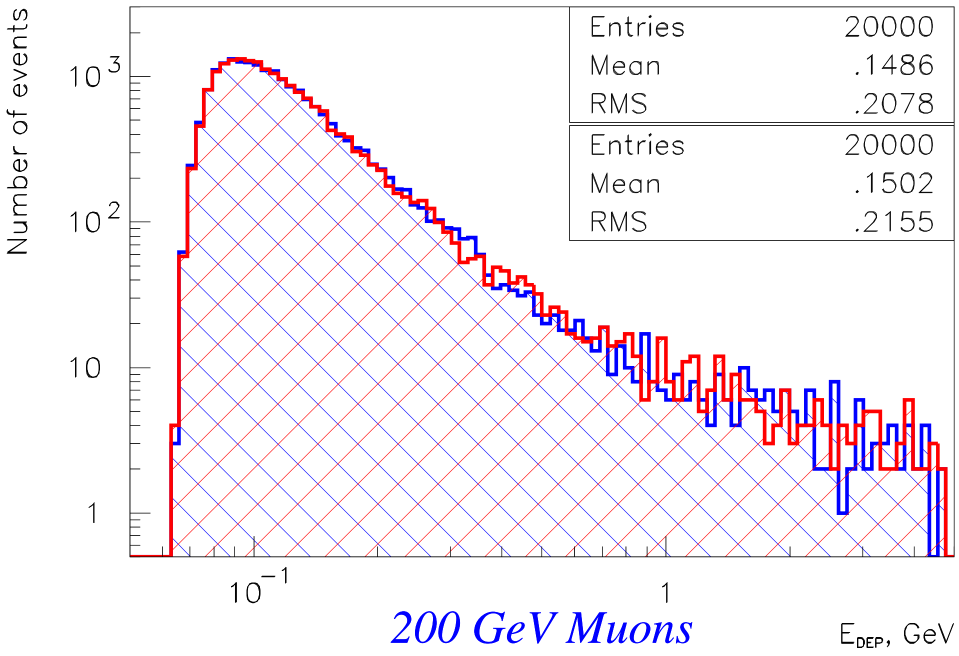
Calibration constant



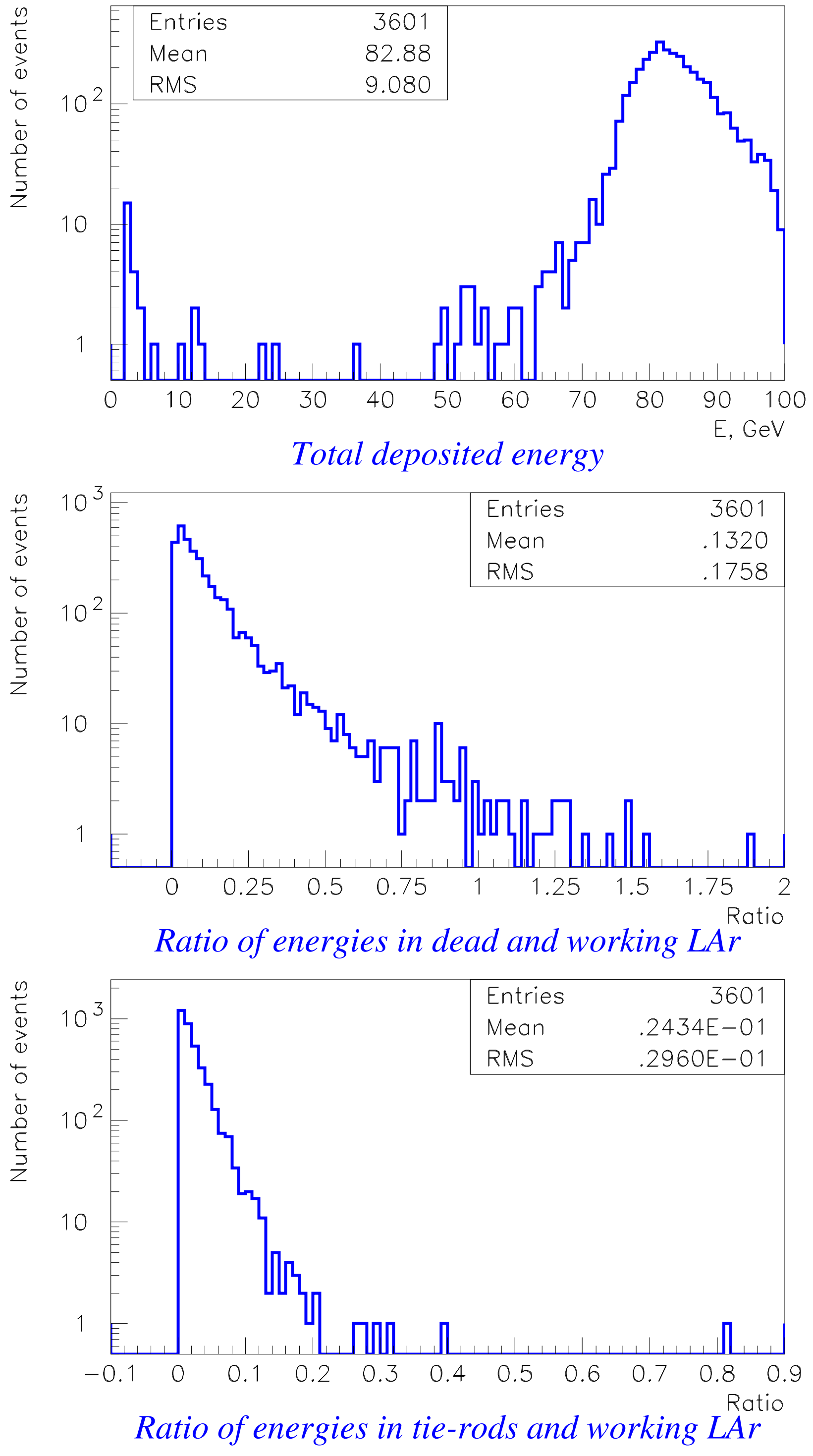
Resolution

Comparison between HEC-BEAM 3.2 and HEC-BEAM 3.1: muon spectra





100 GeV pions: energy distributions

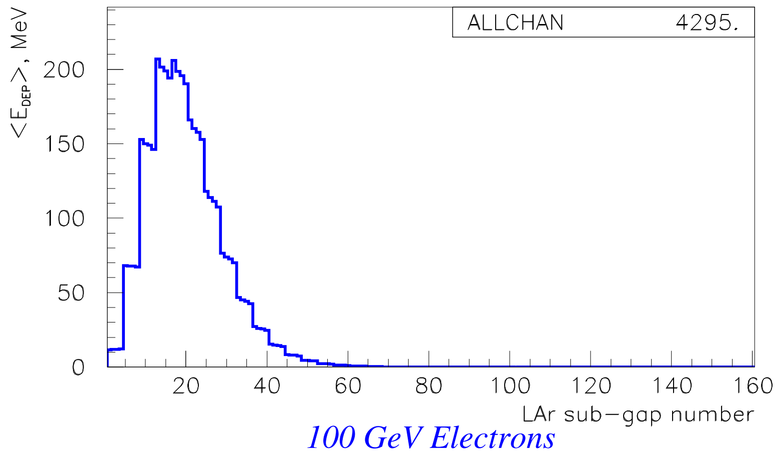


Total deposited energy

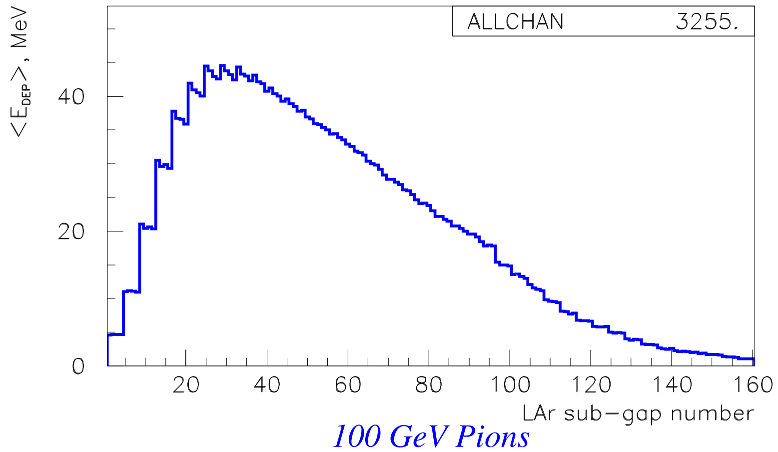
Ratio of energies in dead and working LAr

Ratio of energies in tie-rods and working LAr

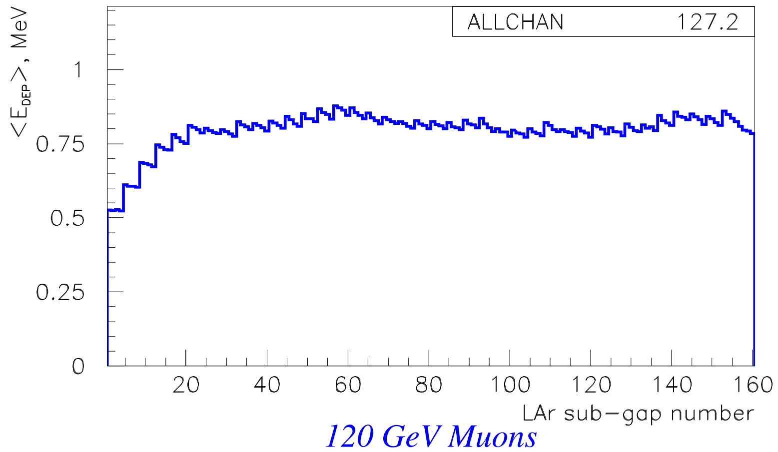
Longitudinal energy profiles for working LAr (average energy deposited in a sub-gap)



100 GeV Electrons



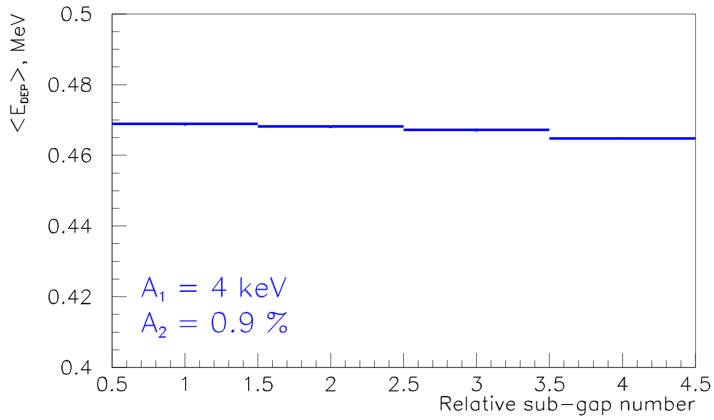
100 GeV Pions



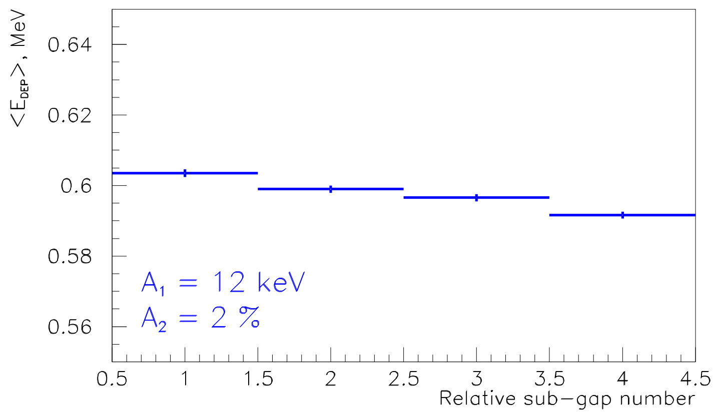
120 GeV Muons

Average energy deposited in sub-gaps for muons

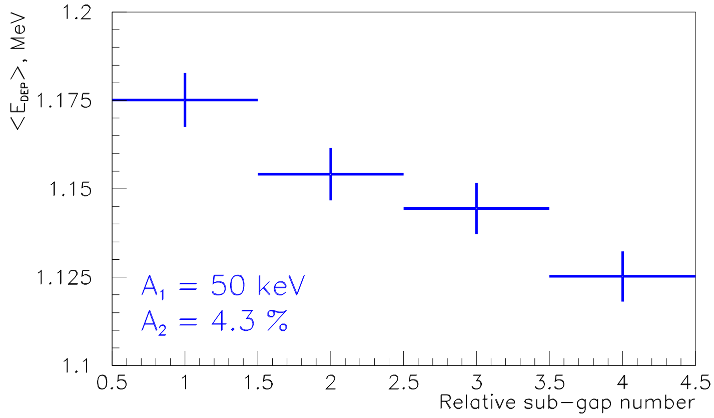
$$A_1 = E_1 - E_4, \qquad A_2 = \frac{A_1}{< E >}$$



3 GeV muons



30 GeV muons



300 GeV muons

Simulation with HEC-BEAM 3.2

Problems

- **Hits in unexpected volumes:**
  in 2.5 % of events with 0.03 % of energy, deposited in working LAr (for 100 GeV pions)
- **Muon "sees" 30 μm copper pads only in 20 % of cases**

Plans

- **Continue tests and analysis of simulated data to understand their quality**
- **After all checks: make data available (via Web, as usual)**

Are there other ideas: what to be stored in addition?