Comparison between GEANT4, Fluka and the TileCal test-beam data

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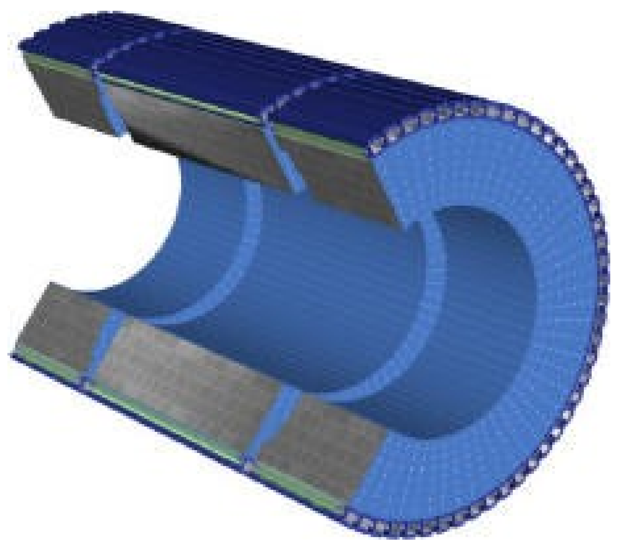
We present a study of the signal produced by charged pions of energies ranging between 20 and 350 GeV in modules of ATLAS Tile Calorimeter. The results from test beam data are compared to the predictions of different Monte Carlo simulations (GEANT4 and Fluka). The goal is to asses in a quantitative way how well different Monte Carlo can reproduce the distribution of visible energy in the calorimeter and the details of the hadronic shower.

TileCal the ATLAS hadronic calorimeter



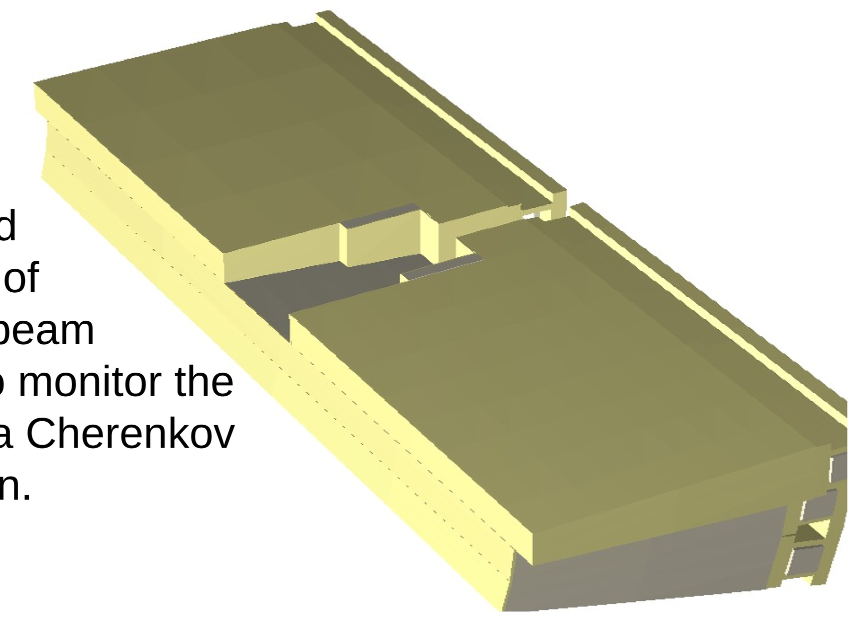
The ATLAS Hadron Tile Calorimeter (TileCal) is a iron-scintillator sampling calorimeter.

TileCal is divided into one barrel and two extended barrel sections. Each section is subdivided into 64 modules.

Modules are divided in "pseudo-projective" towers (0.1×0.1 in Δη × Δφ) segmented in three longitudinal sections.

The TileCal test beam

The TileCal test beam took place at CERN from 2001 to 2003.
Beam energies were between 20 and 350 GeV. The H8 beam is a mixture of pions, muons and electrons; on the beam line there were two wire chambers to monitor the beam, three trigger scintillators and a Cherenkov counter to assist particle identification.

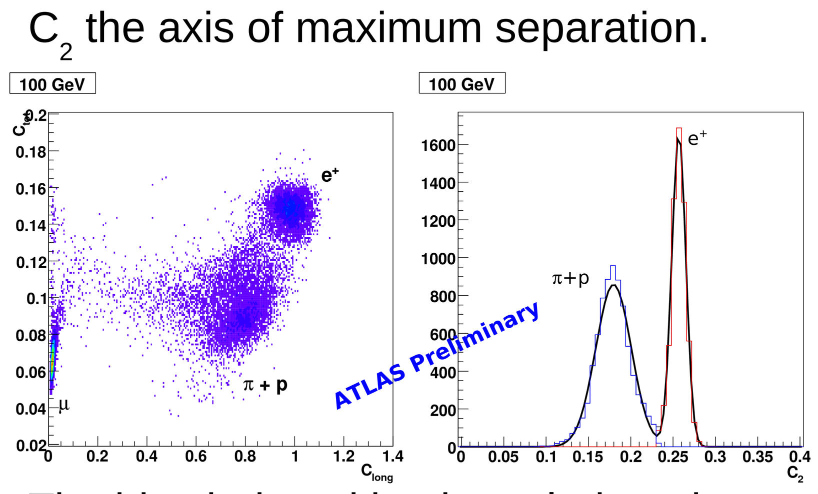


Particle selection

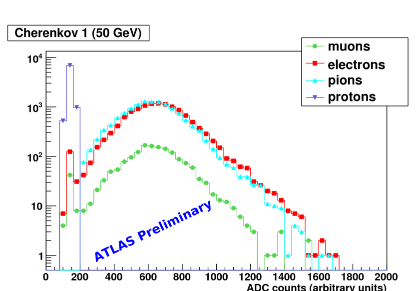
To separate electrons from hadrons we use a combination of two adimensional variables

$$C_{\rm long} = \sum_i \sum_{j=1}^{2} E_{ij}/E_{\rm beam} \qquad C_{\rm tot} = \frac{1}{\sum_c E_c^\alpha}\sqrt{\sum_c \frac{(E_c^\alpha - \sum_c E_c^\alpha/N_{\rm cell})^2}{N_{\rm cell}}}$$

C_{long} is the fraction of energy release in the the first two samples of TileCal and C_{tot} is related to the shower size.
The C_{long}-C_{tot} distribution is projected on C_2 the axis of maximum separation.

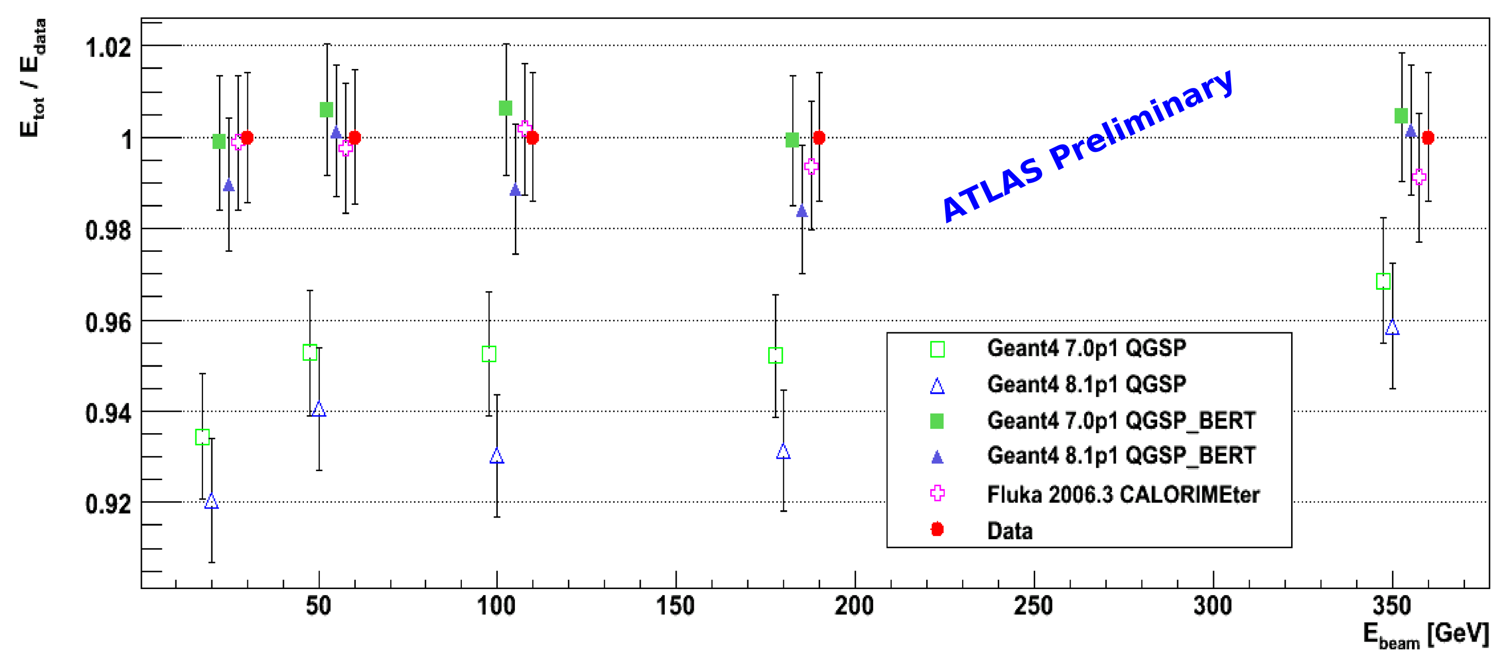


The bias induced by the calorimetric selection is estimated on the Monte Carlo simulations.

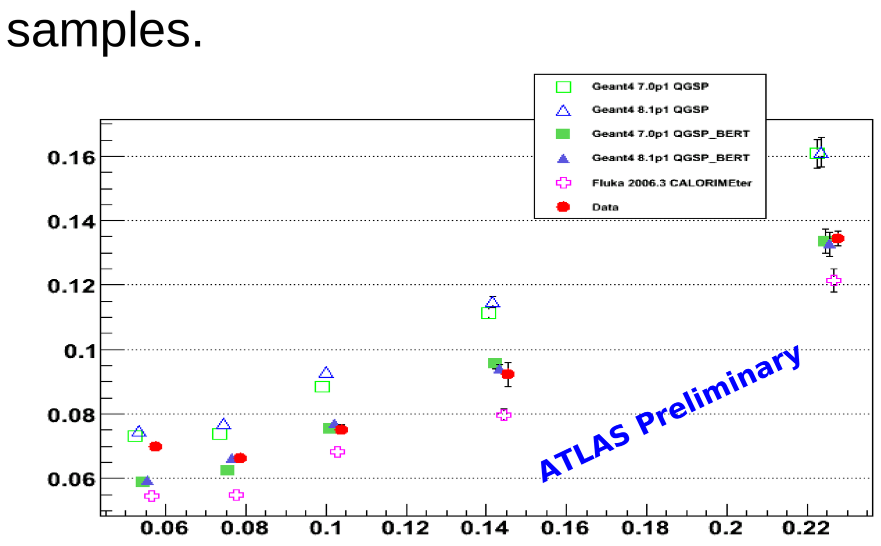


A threshold Cherenkov counter is used to separate electrons from hadrons at 20 GeV and pions from protons at 50 GeV. Muons are easily identified as they are MIP in TileCal.

Total Energy



Mean value of the energy released in TileCal by a pion beam for several energies at η=-0.35. The mean is extracted with a 2 sigma gaussian fit of the energy distribution. Experimental data and Monte Carlo simulations are calibrated to the electromagnetic scale using a sample of 20 GeV electrons. The exact beam composition is reproduced in the Monte Carlo samples.



Width of the total energy distribution energy resolution as a function of 1/√E.

The effect of the electronic noise and photostatics is added to the Monte Carlo simulations.

The Monte Carlo simulations

Geant4 and Fluka are two Monte Carlo particle simulations.

The impinging particle is generated reproducing the characteristics of the real beam profile.

The particle is tracked trough the detector, it interact loosing energy producing secondaries. The details of the processes simulated are described in the so called physics list.

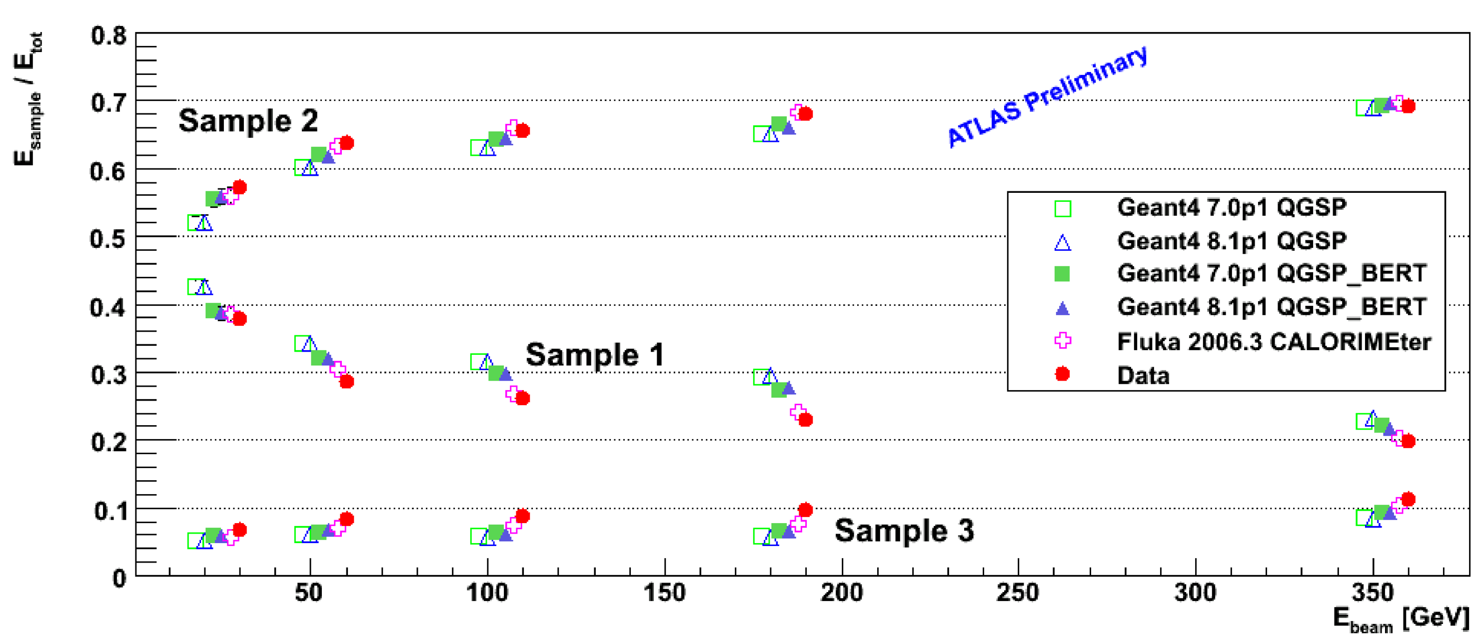
We have tested two different versions of Geant4 (7.0 and 8.1) and two different physics lists: QGSP (that uses the Quark-Gluon String model for hadronic interaction) and QGSP_BERT(like QGSP, but uses the Bertini Intra-Nuclear Cascade below ~10GeV)

We tested version 2006.3of Fluka with the CALORIMEter defaults.

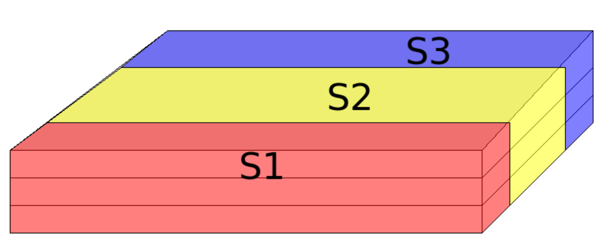
In Fluka hadronic interactions are based on resonance production and decay below a few GeV, and on the Dual Parton model above. Both modules include a form of Generalised Intra-Nuclear Cascade.

The same geometry is used in both simulations, also a special action is then inserted in Fluka to produce a Geant4 compatible output.

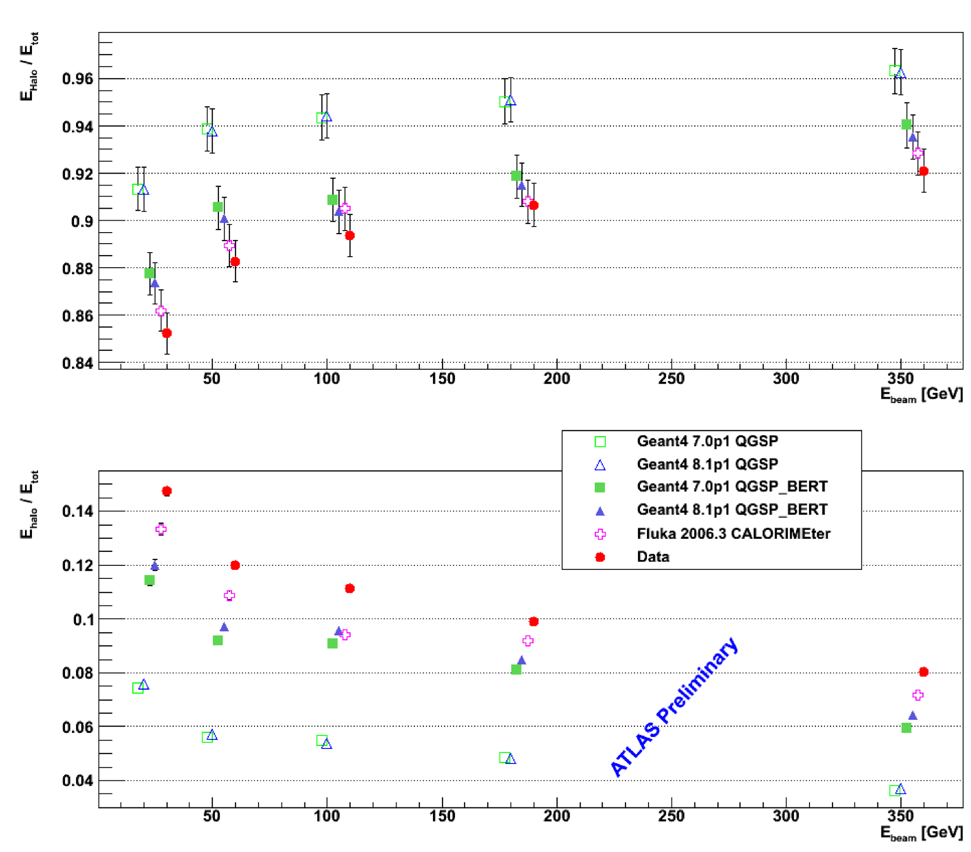
Longitudinal shower development



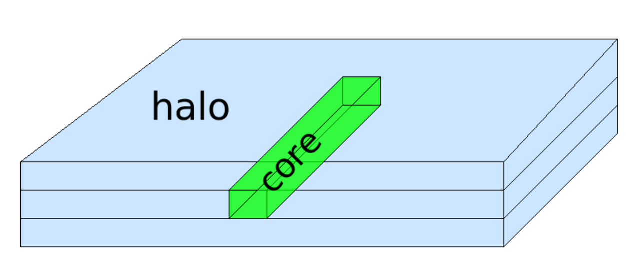
Fraction of the total energy released by a pion beam in each longitudinal sample of the Tile calorimeter. The section depth is 1.5, 4 and 2 interaction lengths respectively



Lateral shower development



Lateral profile of the hadronic shower from a pion beam in TileCal. E_{core} is the energy released in the projective tower hit by the pion beam (0.1x0.1 in ΔηxΔϕ). The rest of the volume contains the halo.



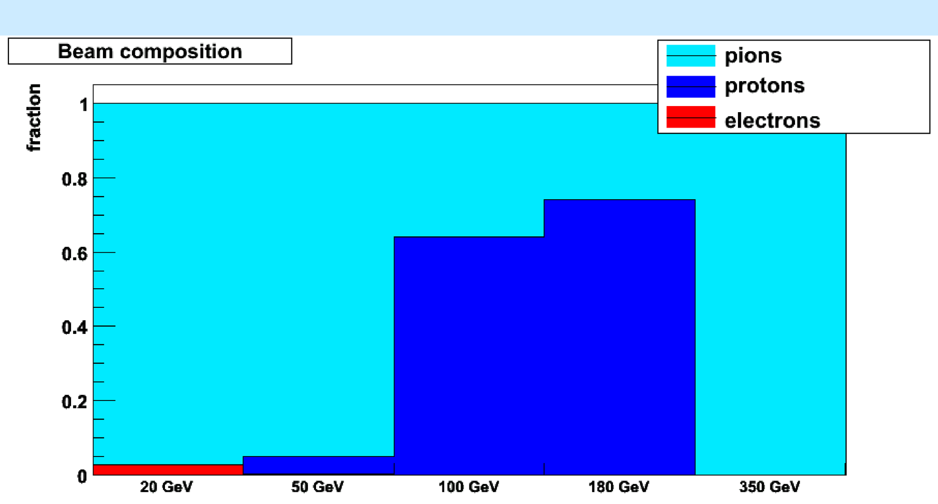
Beam composition

Composition of the beam after particle selection.

Electrons are rejected using the Cherenkov counter at 20 GeV while a calorimetric selection is used at 50 and 100 GeV.

At 50 GeV protons are separated from pions using the Cherenkov detector.

The 20 and 350 GeV beams have negative polarity and the anti proton contamination is negligible.



References

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