

## Validation of GEANT4 Version 7.0 with ATLAS HEC Testbeam Data

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- Beam tests of serial modules of ATLAS Hadronic End-Cap Calorimeter
- New round of GEANT4 simulations:  
version **7.0** + patch-**01** (February 2005)
- Simulated/analysed samples:
  - scan over the GEANT4 range cut with electrons
  - electron energy scan
  - pion energy scan
- Results were presented during the week of the ATLAS LAr calorimeter group in May 2005



## Simulation packages

- **GEANT4**

- |                         |                         |                         |
|-------------------------|-------------------------|-------------------------|
| – Version <b>5.2p02</b> | – Version <b>6.2p02</b> | – Version <b>7.0p01</b> |
| – Physics lists         | – Physics lists         | – Physics lists         |
| * LHEP 3.6              | * LHEP 3.7              | * LHEP 3.7              |
| * QGSP 2.7              | * QGSP 2.8              | * QGSP 2.8              |
| – PACK 2.3              | – PACK 2.4              | – PACK 2.4              |

- **GEANT3**

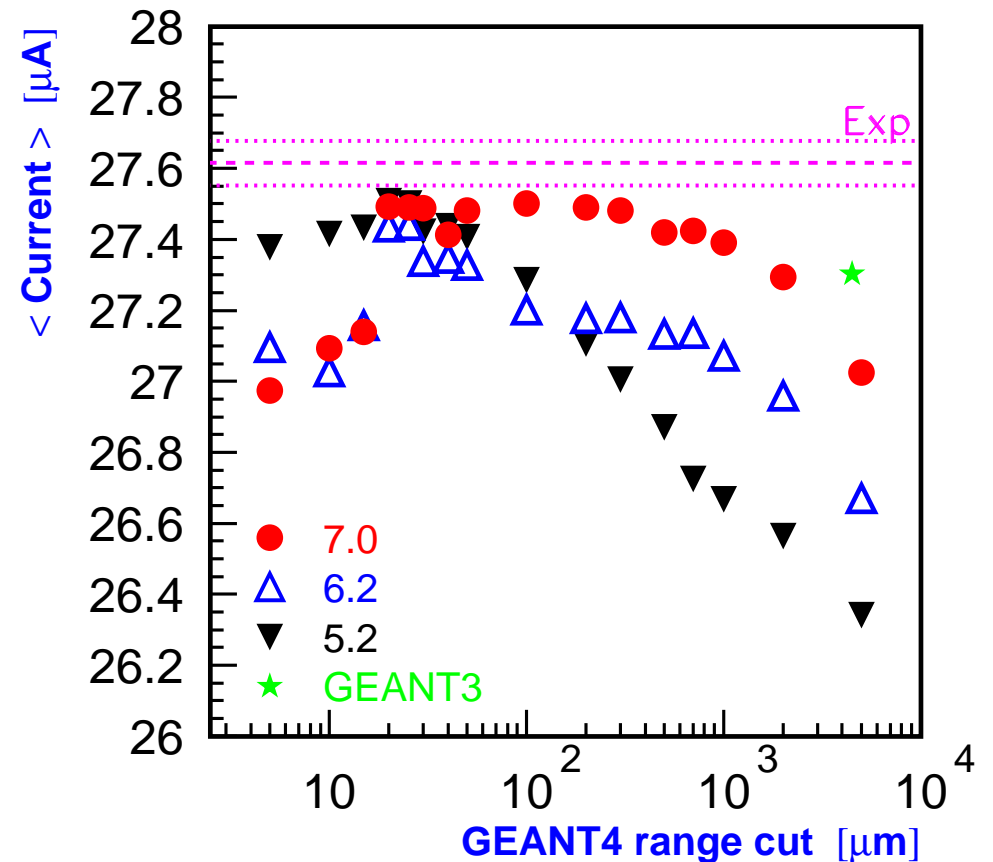
- Version 3.21
- G-CALOR (hadronic shower code)
- 100 keV transport cuts and 1 MeV process cuts

- HEC geometry: the same in GEANT4 and very similar in GEANT3



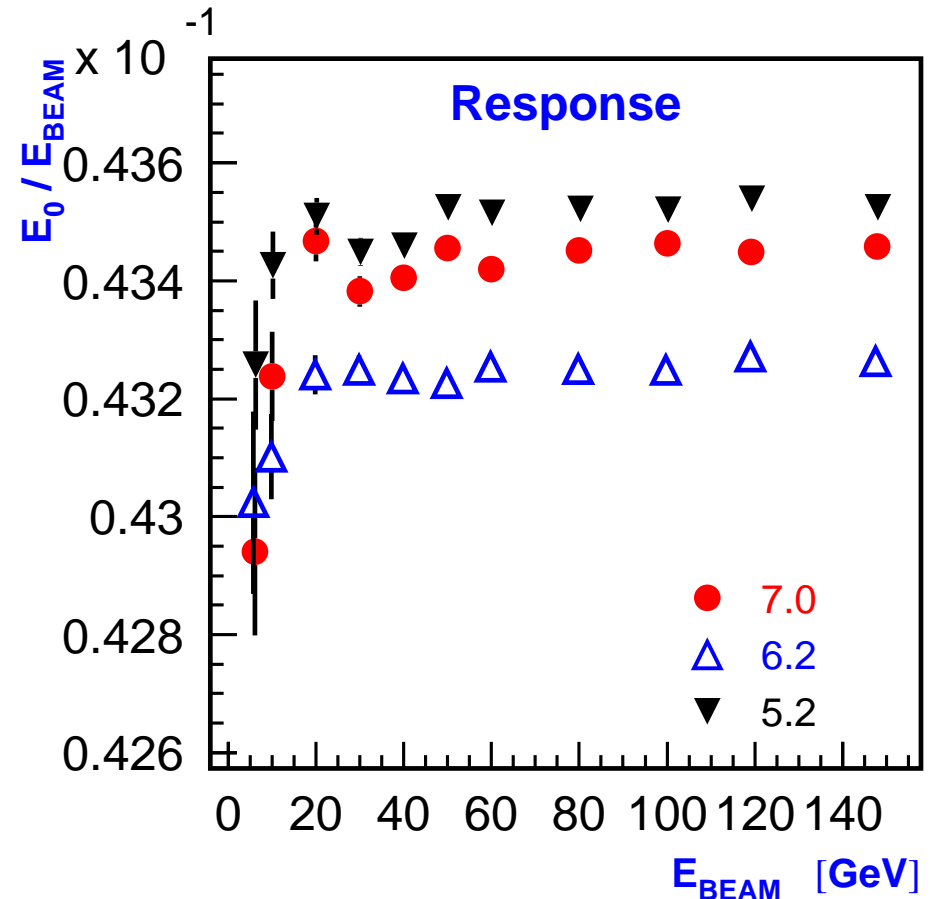
## Electrons: Scan over the range cut

- 100 GeV electrons
- GEANT4 range cut: 5  $\mu\text{m}$  - 5 mm
- Cell with the maximal average signal
- $\text{Current} = \text{Visible Energy} \times 7.135 \mu\text{A/GeV}$
- Different behaviour from one version to another
- Plateau between 20 and 300  $\mu\text{m}$  for version **7.0**
- Still **20  $\mu\text{m}$**  range cut selected for further simulations

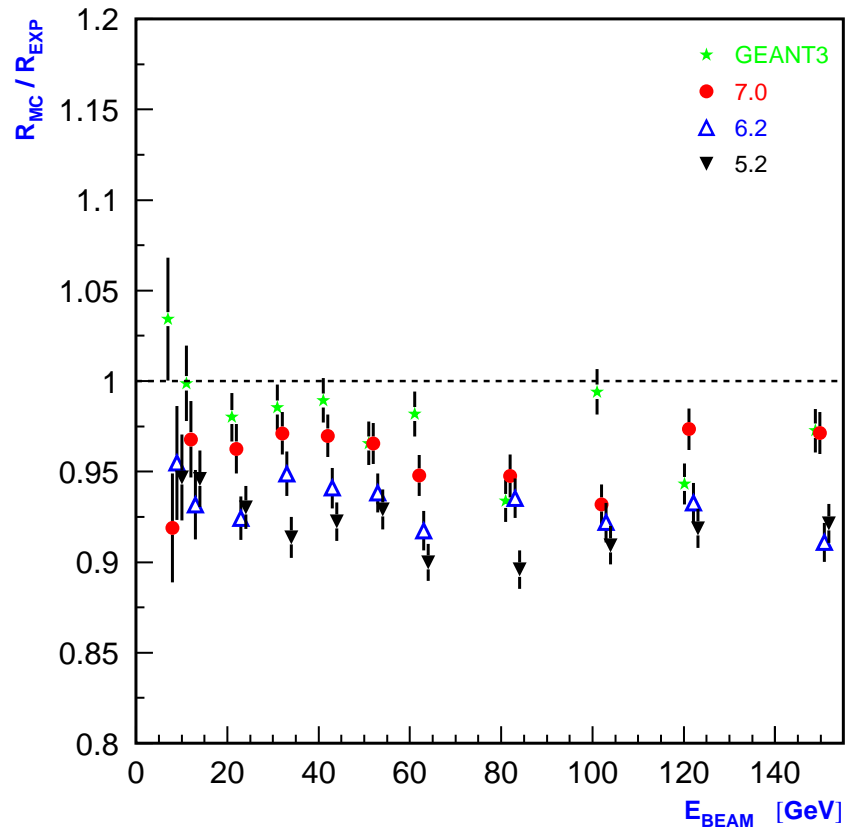
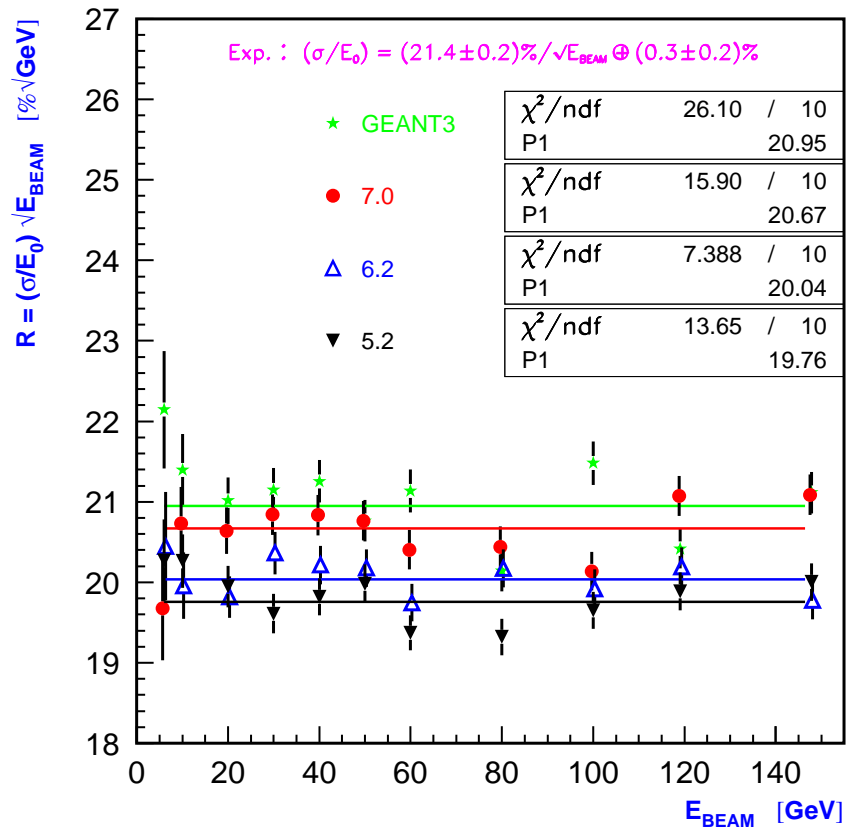


## Electrons: Energy scan

- Beam energies: 6 - 147.8 GeV
- 20  $\mu\text{m}$  range cut
- Energy reconstruction at the **visible scale**
- Cluster of the **fixed size**
- Gaussian fit:  $E_0$  and  $\sigma$
- Studied variables
  - response:  $E_0/E_{BEAM}$
  - resolution:  $\sigma/E_0$
  - **one-term fit** of the energy dependence of the resolution



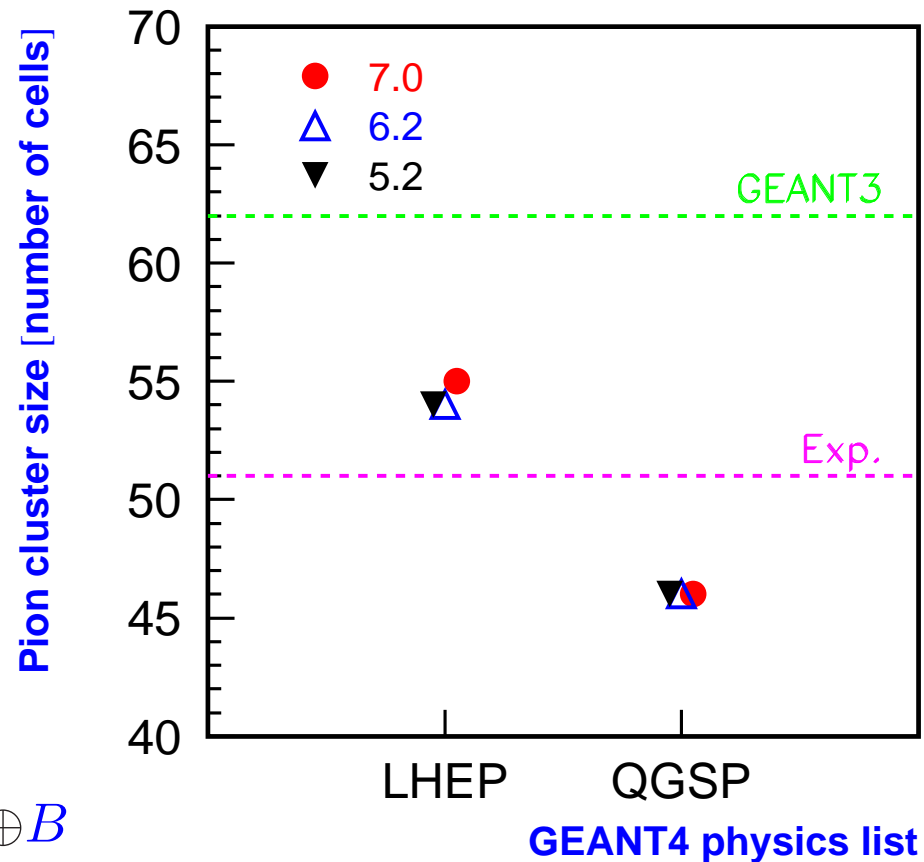
## Electrons: energy resolution



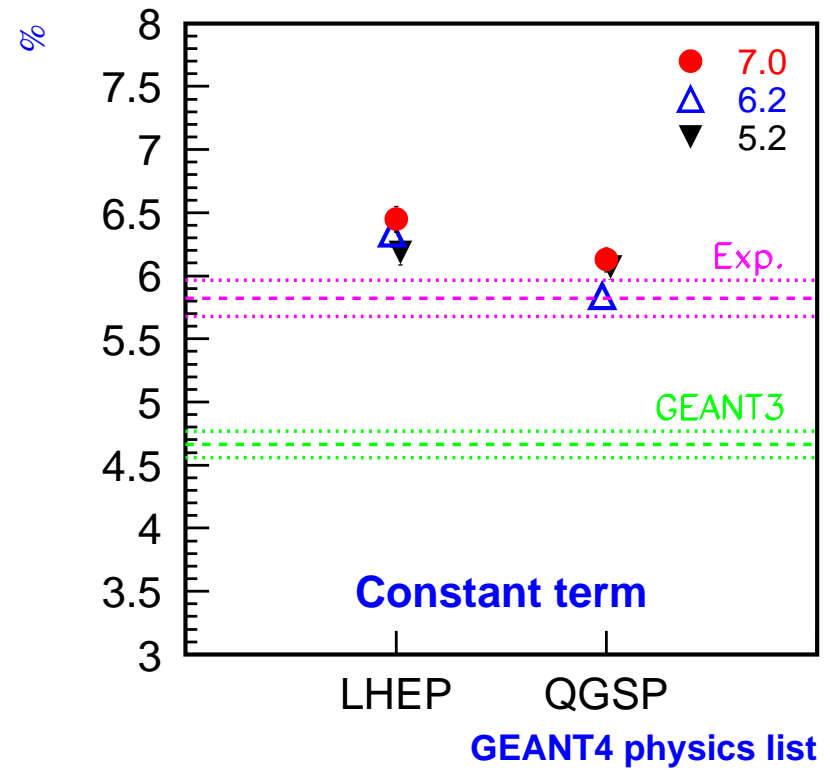
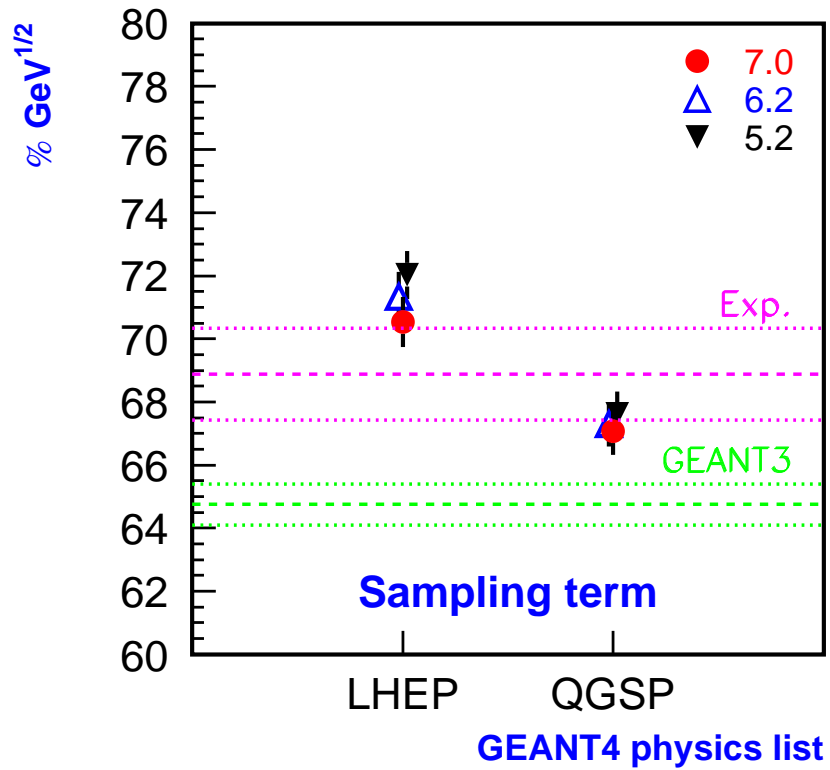
## Pions: Energy scan

- Beam energies: 10 - 200 GeV
- 20  $\mu\text{m}$  range cut
- Energy reconstruction and analysis procedure: similar to electrons
- Energy dependence of the resolution:

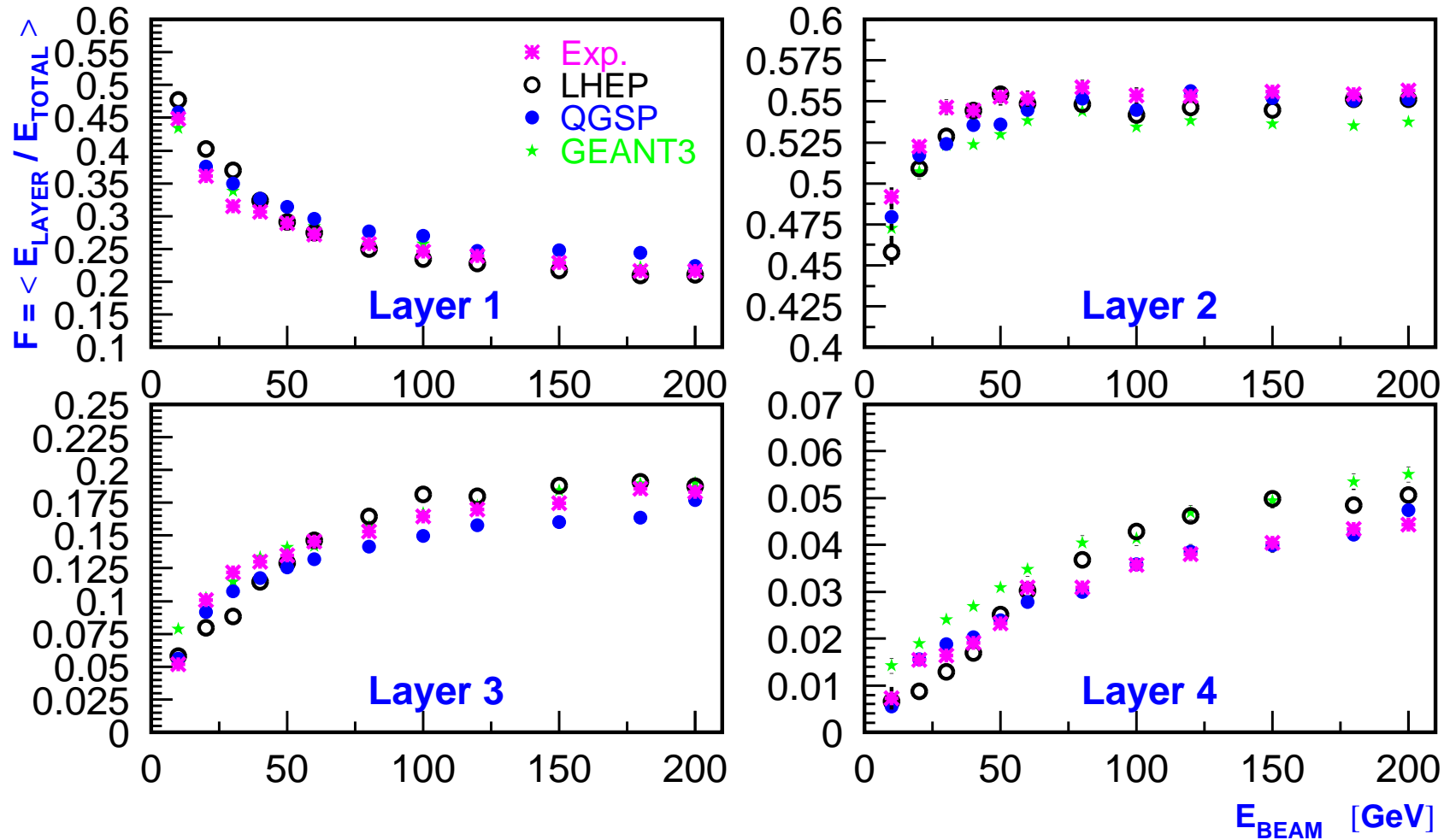
$$\sigma/E_0(E_{BEAM}) = A/\sqrt{E_{BEAM}} \oplus B$$



## Pions: terms of energy resolution



## Pions: fraction of energy in HEC layers

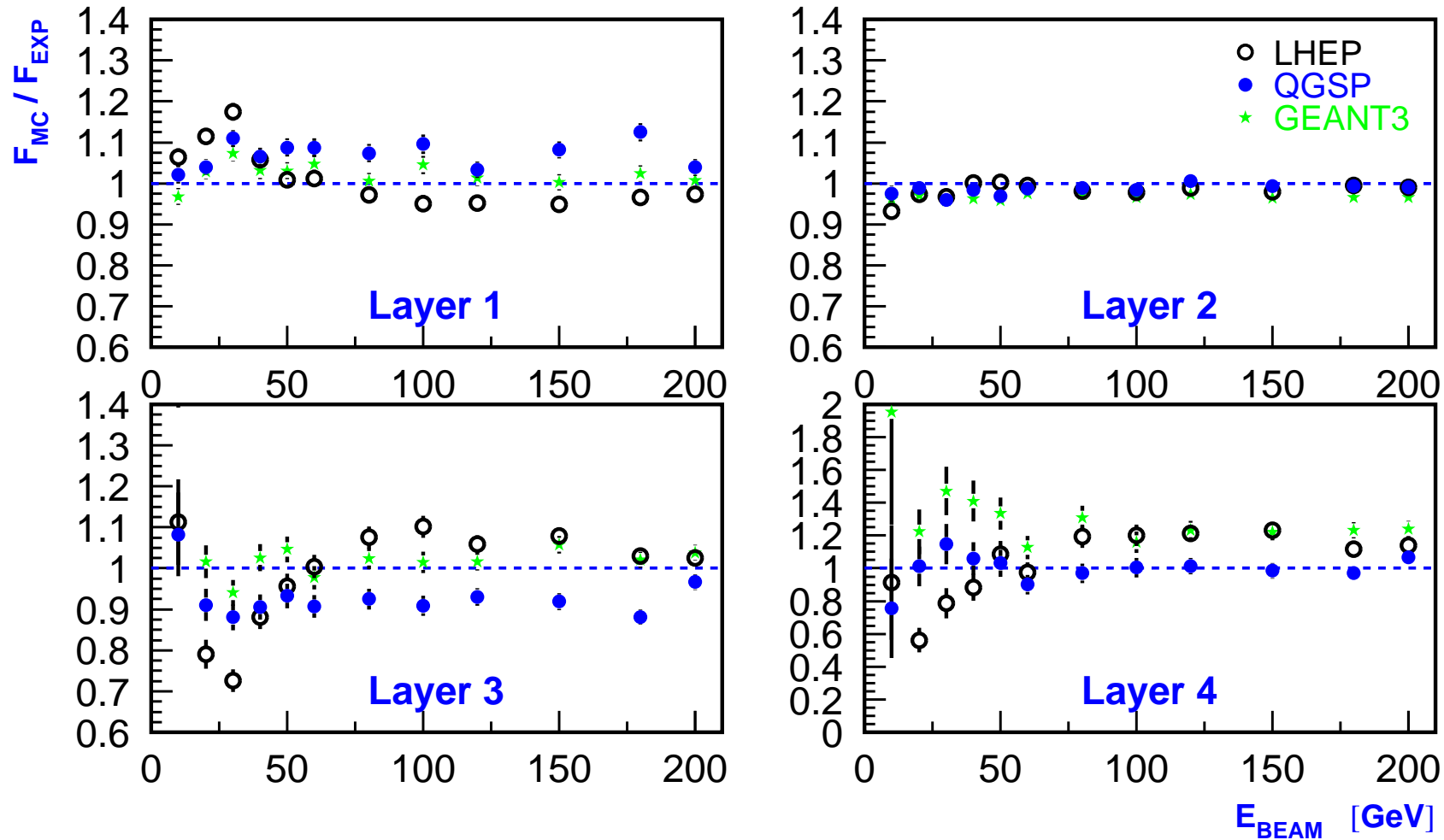


GEANT4 — version 7.0





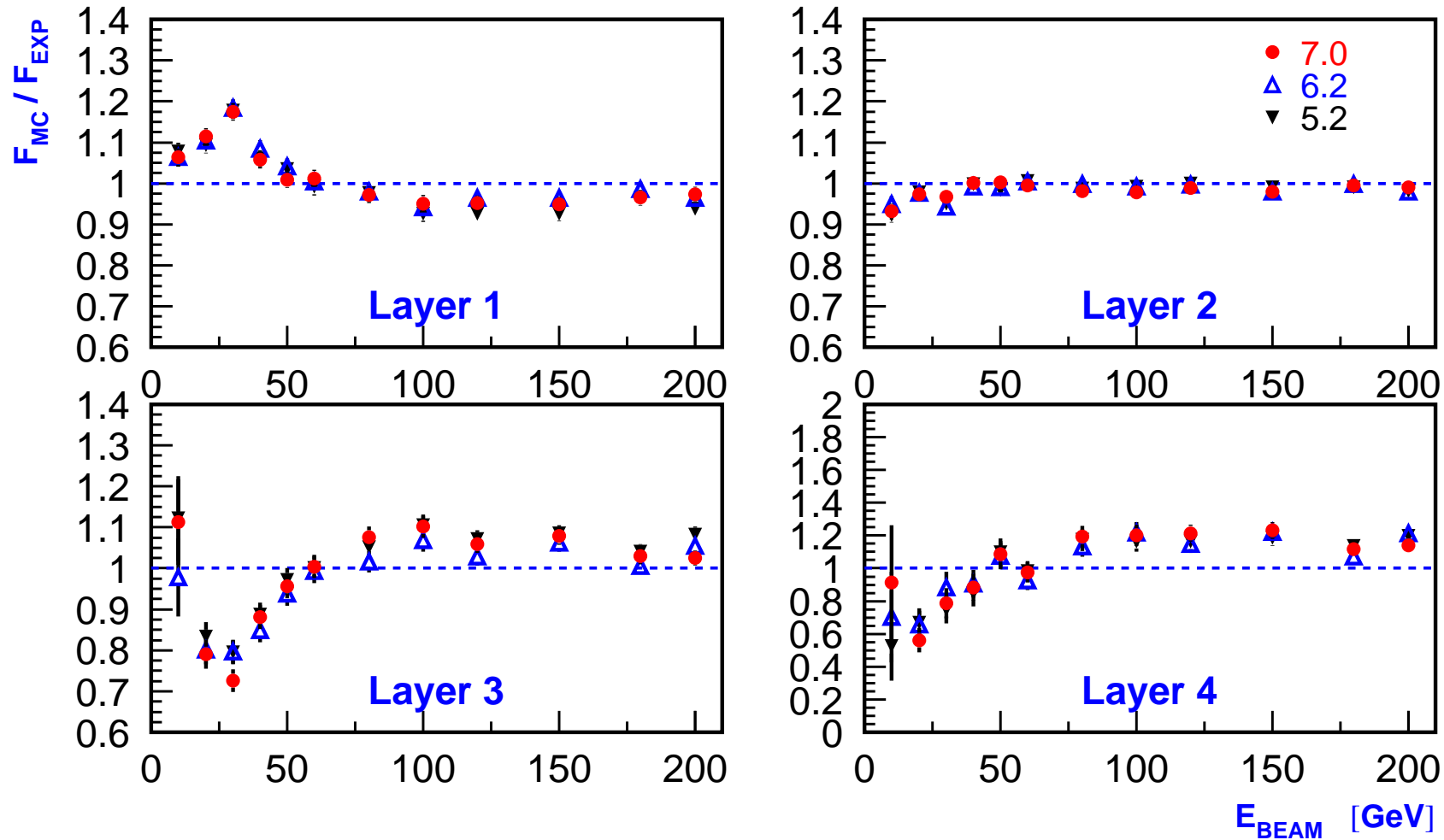
## Pions: fraction of energy in HEC layers w.r.t. experiment



GEANT4 — version 7.0



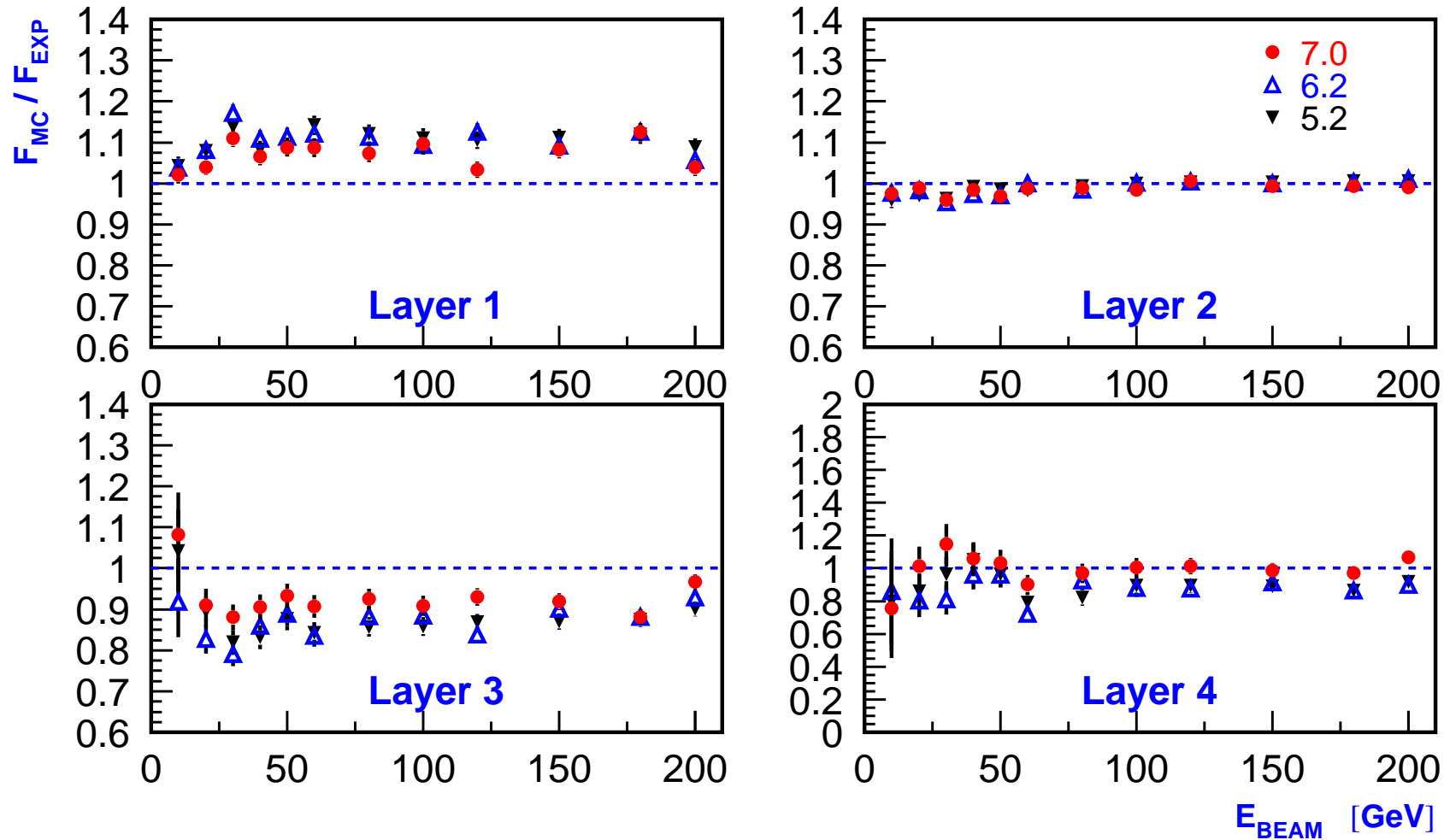
## Pions: fraction of energy in HEC layers w.r.t. experiment



GEANT4 — LHEP



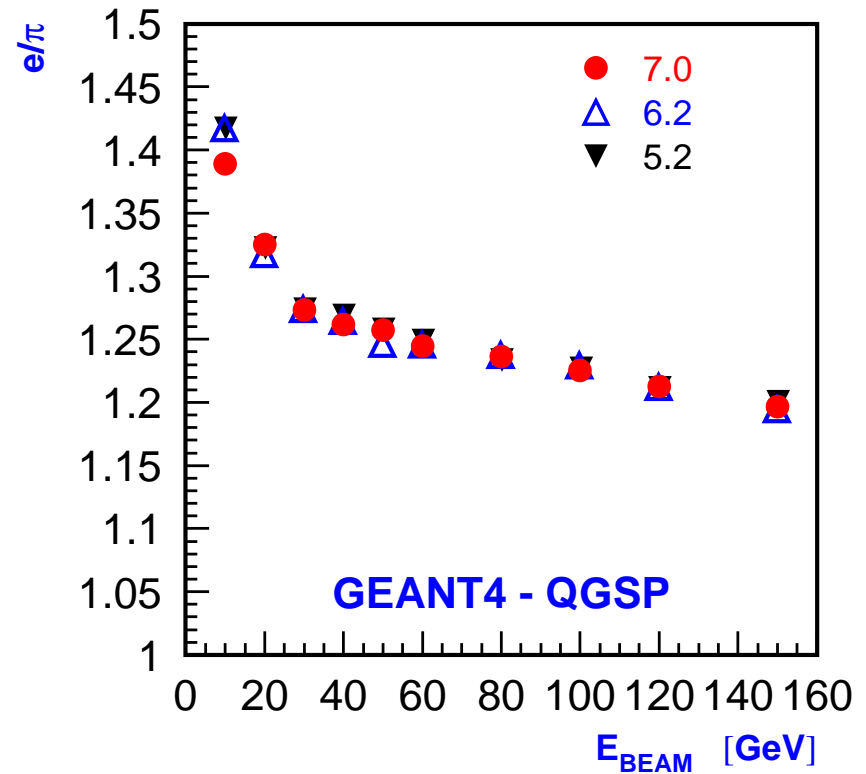
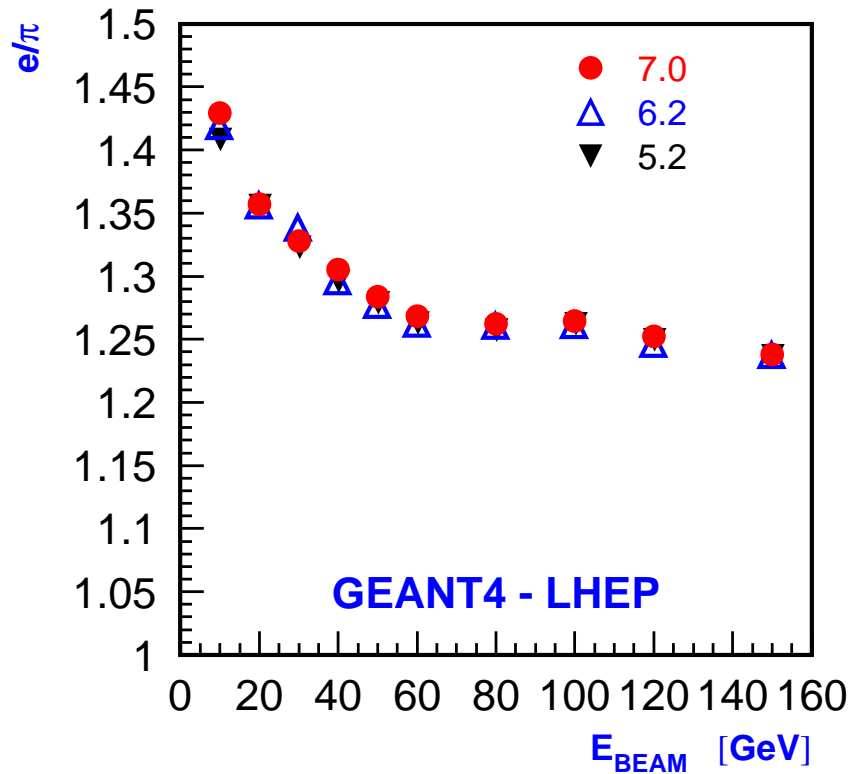
## Pions: fraction of energy in HEC layers w.r.t. experiment



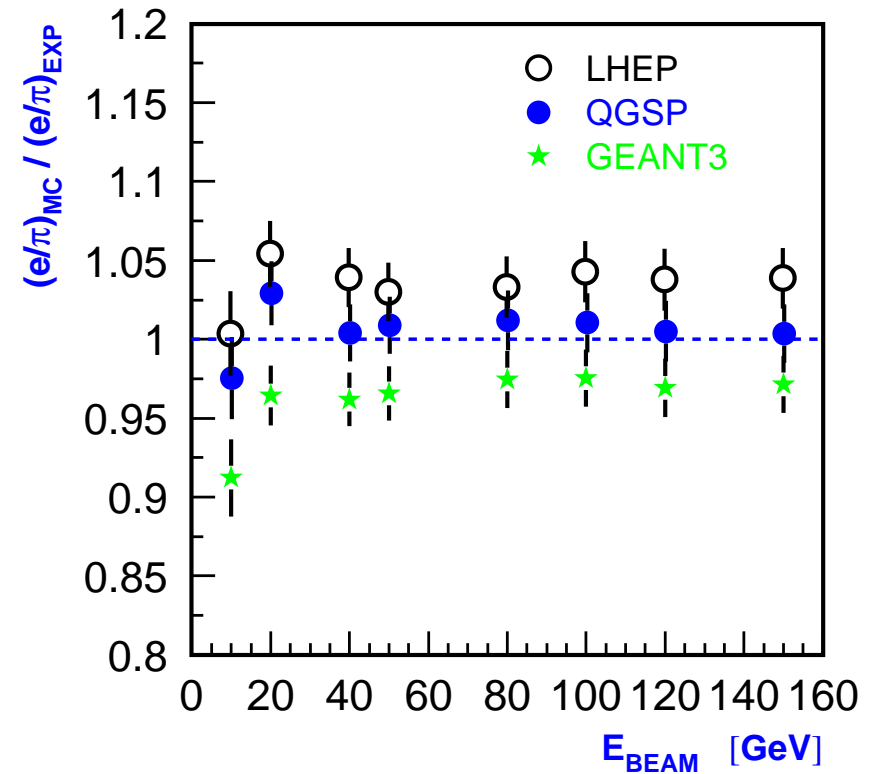
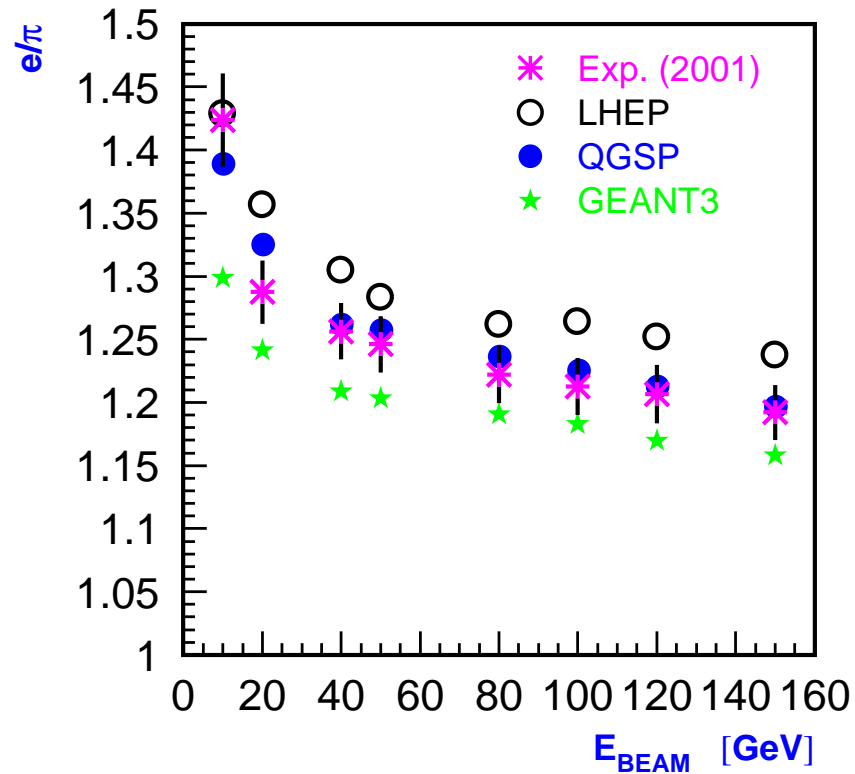
GEANT4 — QGSP



### Ratio $e/\pi$ : LHEP and QGSP



## Ratio $e/\pi$ : Simulations vs Experiment



GEANT4 — version 7.0

## Some conclusions

New round of GEANT4 based simulations with version **7.0p01** was carried out for the HEC stand-alone testbeam. Comparison with experimental results and results of previous simulations (GEANT4 versions **6.2p02** and **5.2p02**, GEANT3) was done.

- GEANT4 gives **good description** of HEC testbeam data:
  - pion energy resolution (QGSP and LHEP)
  - $e/\pi$ -ratio (QGSP)
- **Open questions** (from previous studies)
  - energy resolution for electrons:  
improvement w.r.t. previous GEANT4 versions
  - longitudinal development of hadronic showers:  
step in the right direction for QGSP



## Other GEANT4 validation issues

- Paper “GEANT4 Physics Evaluation with Testbeam Data of the ATLAS Hadronic End-Cap Calorimeter” [submitted to NIM](#)
  - 20 pages, 21 figures, 1 table
  - beam tests of HEC serial modules
  - GEANT4 version 6.2p02
- GEANT4 physics validation with [combined EMEC/HEC testbeam data](#): work is going on

