



More on pions in TileCal

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Outline



- Pions at High Energy
 - Resolution
 - e/π
- e at VLE
 - Resolution
- Pions at VLE energy
 - Resolution
 - e/π
- Shower Profile for high energy pions



Data sets

- TestBeam data from July 2002 and August 2003 (low energies)
- Two different impinging directions have been analyzed for 5 different energies (high energy)
- $e^+\pi$ runs at $\eta=-0.35$ for Very Low Energy studies

$\theta=90^\circ$

energy (GeV)	run number
10	210720
20	210563
50	210487
100	210551
180	210054

$\eta=-0.65$

energy (GeV)	run number
10	210731
20	210612
50	210479
100	210311
180	210121

$\eta=-0.35$

energy (GeV)	run number
1	360213
2	360204
3	360167
5	360151
9	360188

Calibration and noise smearing



- Both Data and MC have been calibrated to the beam energy: **average electron visible energy normalized to beam energy**
- **Electronic noise** has been measured from data and added to simulation as a gaussian smearing
- **Photostatistic fluctuations** have been added as an additional source of noise in simulations (current value 53pe/GeV). Approximated as another gaussian smearing added to simulated data



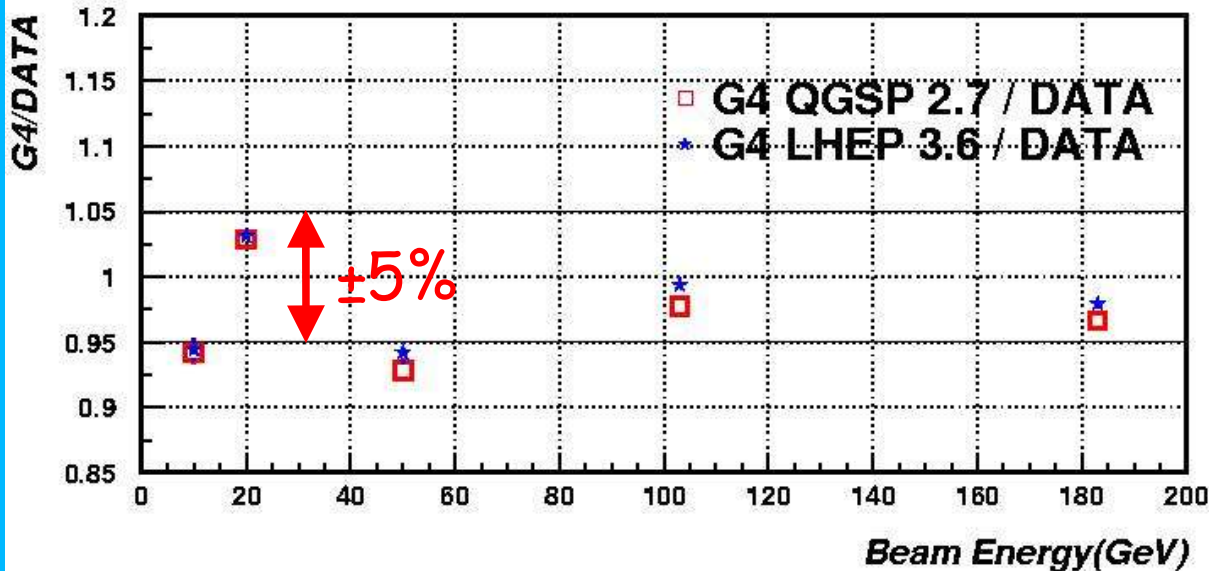
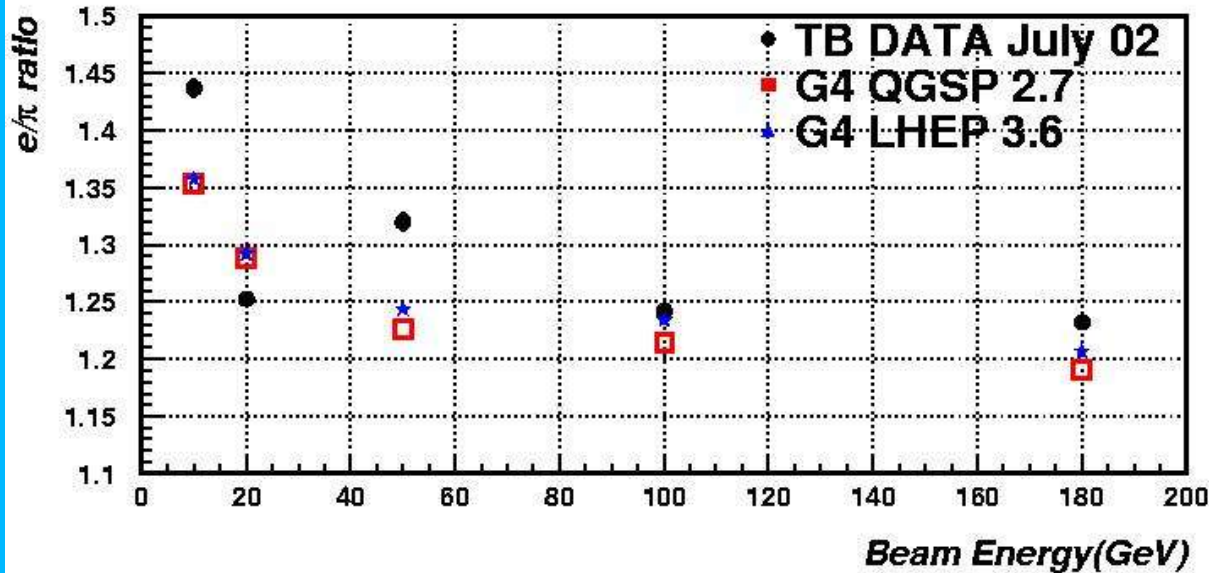
pions $\theta=90^\circ$
(tile row 5)

pions extracted from contamination in e run

e/π vs E



TB DATA JULY02, $\vartheta = -90$, tr 5

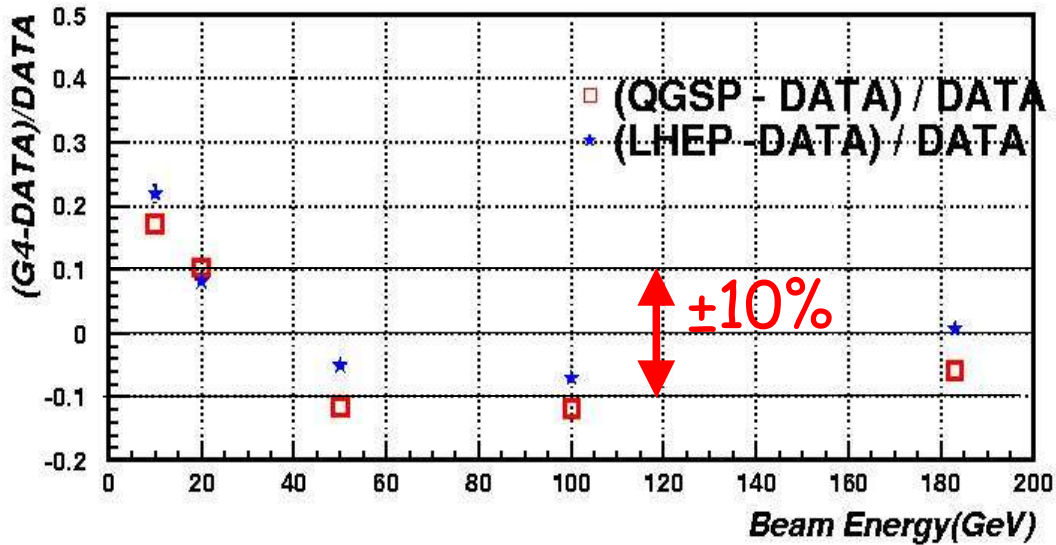
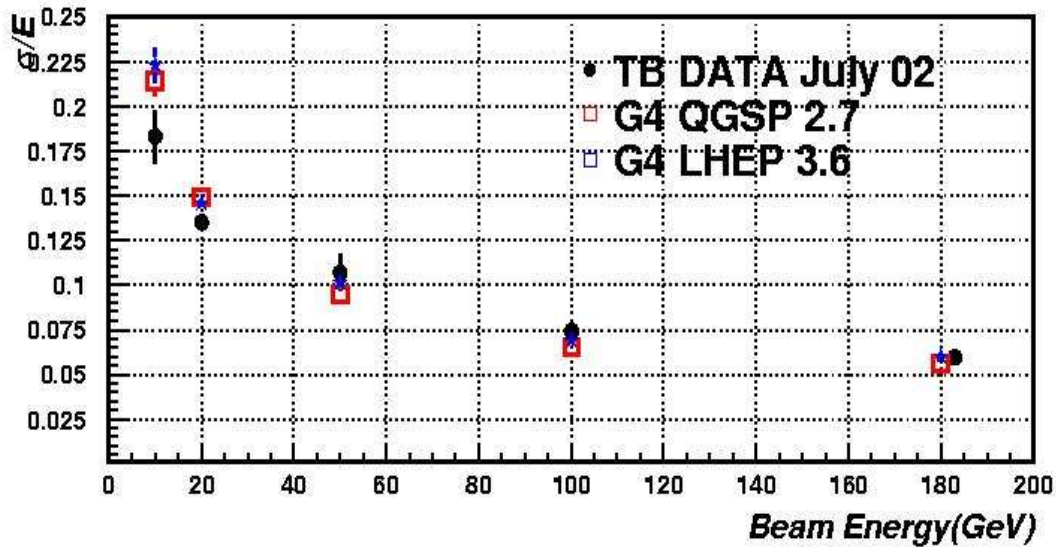


- Agreement between data and simulation is $\pm 5\%$ excluding 50 GeV point ($\sim 8\%$)



σ/E vs E

pions with $\vartheta = -90$, tr5



- Agreement between data and simulation $\pm 10\%$ for $E > 10$ GeV

Fit results

$$a/\sqrt{E} \oplus b$$

QGSP	$(63 \pm 1)\%$	$(2.6 \pm 0.3)\%$
LHEP	$(64 \pm 1)\%$	$(3.0 \pm 0.2)\%$
DATA	$(58 \pm 2)\%$	$(4.0 \pm 0.2)\%$



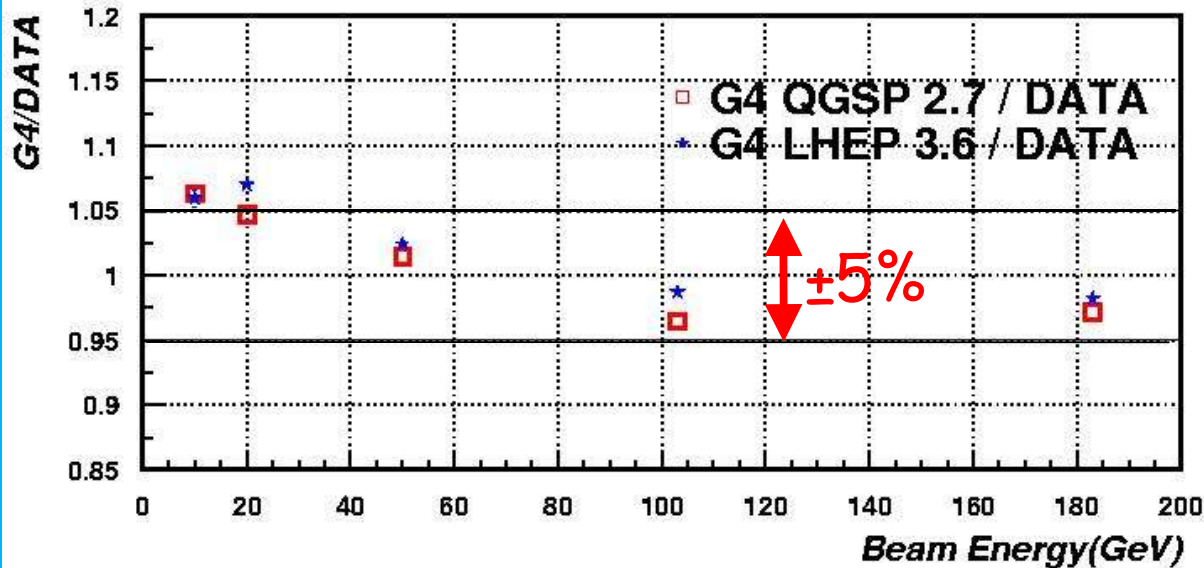
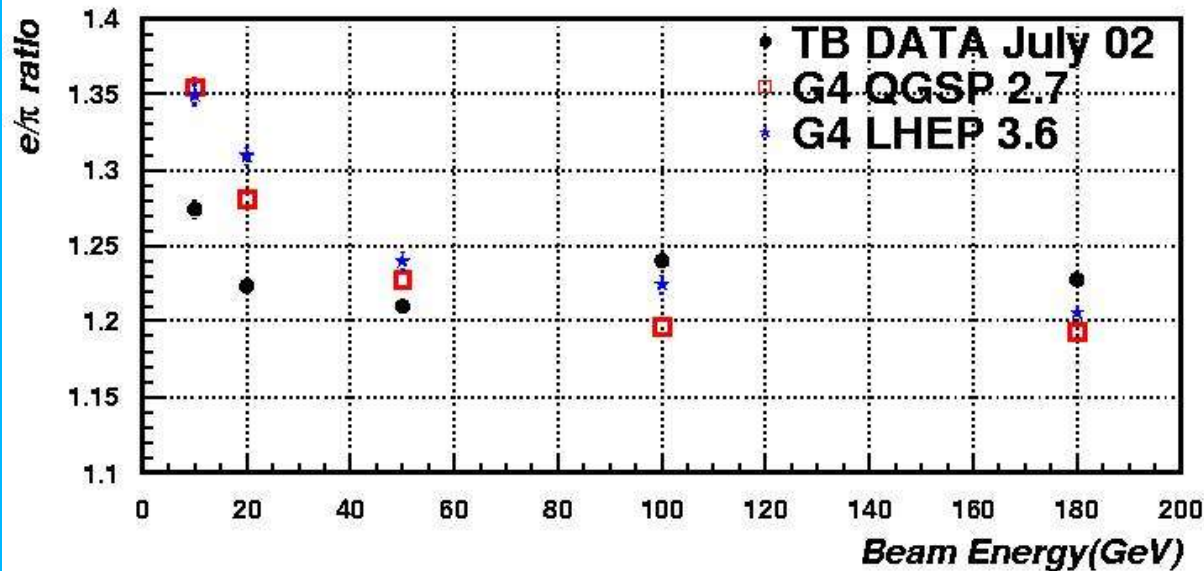
pions $\eta = -0.65$

pions extracted from contamination in e run

e/π vs E



TB DATA JULY02, $\eta=-0.65$

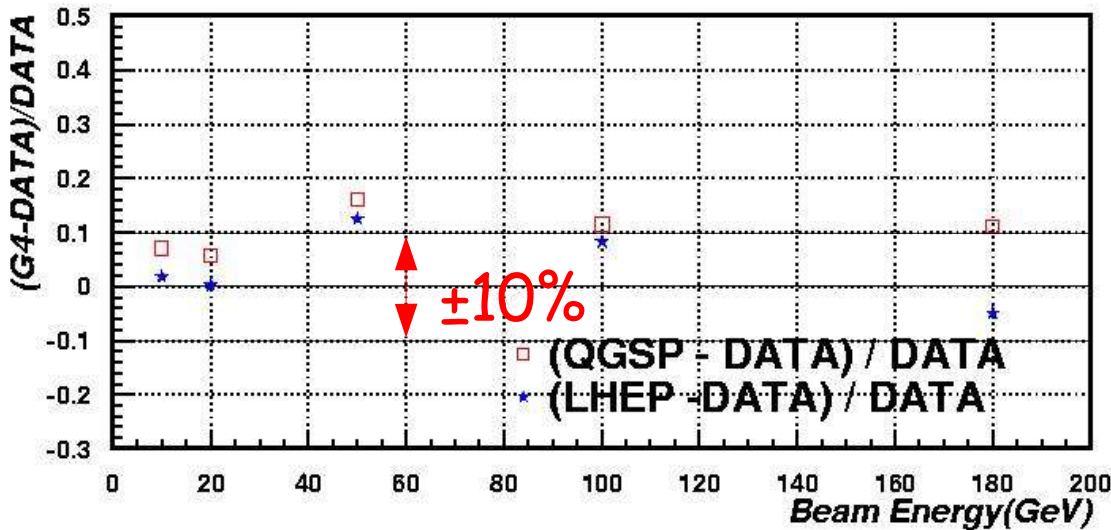
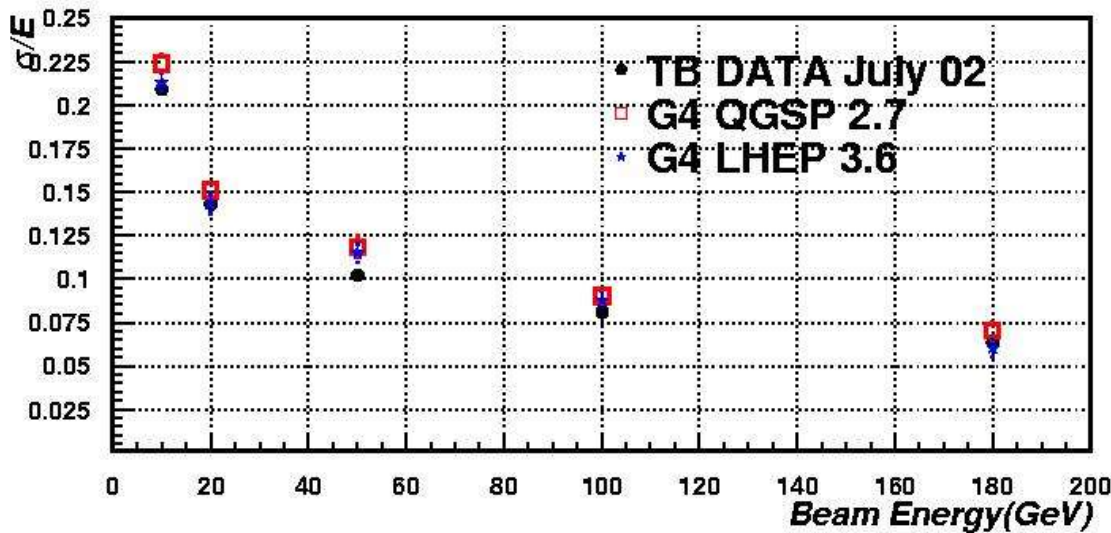


- Agreement between data and simulation $\pm 5\%$ excluding 10 GeV point ($\sim 7\%$)
- Problems at 10 and 20 GeV related to low e deposit: problem under study



σ/E vs E

pions with $\eta=-0.65$



Agreement between data and MC is ~10% (except point at 50GeV 15%)

Fit results

a/\sqrt{E} ⊕ b

QGSP	$(65 \pm 2)\%$	$(5.7 \pm 0.5)\%$
LHEP	$(65 \pm 2)\%$	$(5.0 \pm 0.6)\%$
DATA	$(60.6 \pm 0.7)\%$	$(5.3 \pm 0.2)\%$

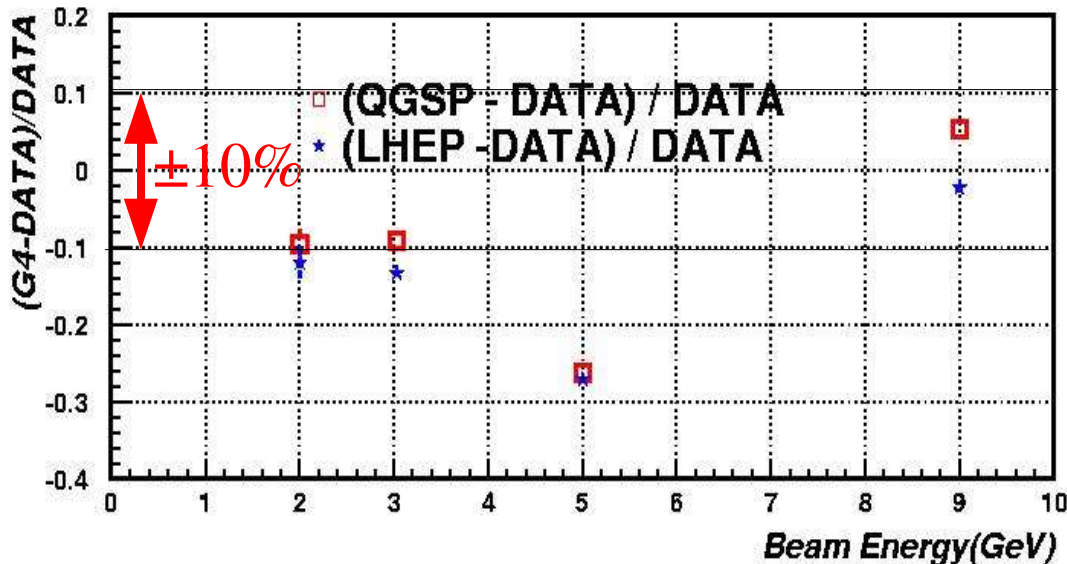
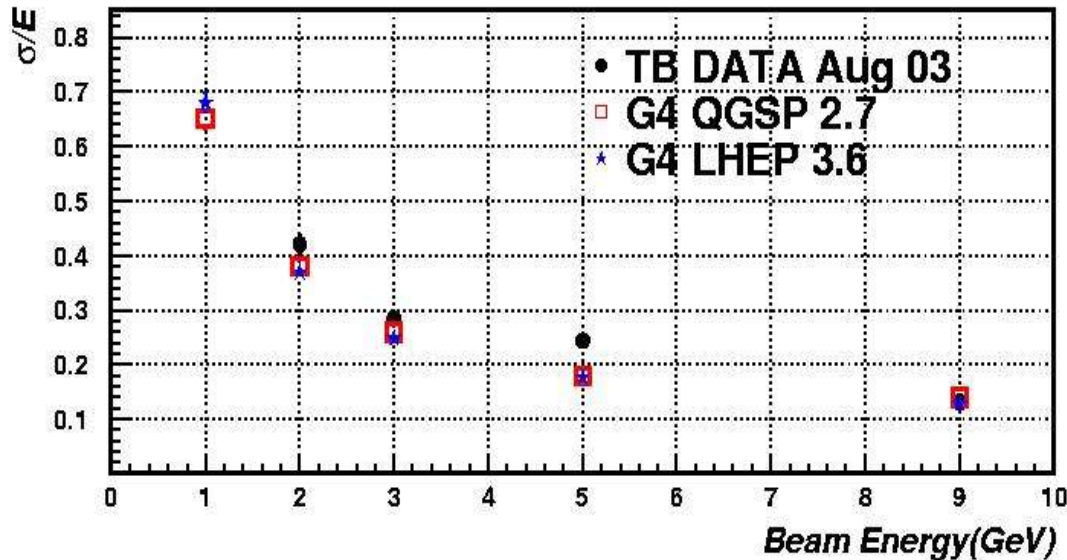


VLE electrons $\eta = -0.35$



σ/E vs E

electrons with $\eta = -0.35$



- At 1 GeV in Data is not possible to separate e from π
 - Agreement is about $\pm 10\%$ (except 5 GeV point), we have systematic lower values for G4
 - Only a/\sqrt{E} is quoted, b is difficult to extract at these low energies
- Fit results
 a/\sqrt{E}

QGSP	$(62 \pm 2)\%$
LHEP	$(63 \pm 2)\%$
DATA	$(72 \pm 2)\%$

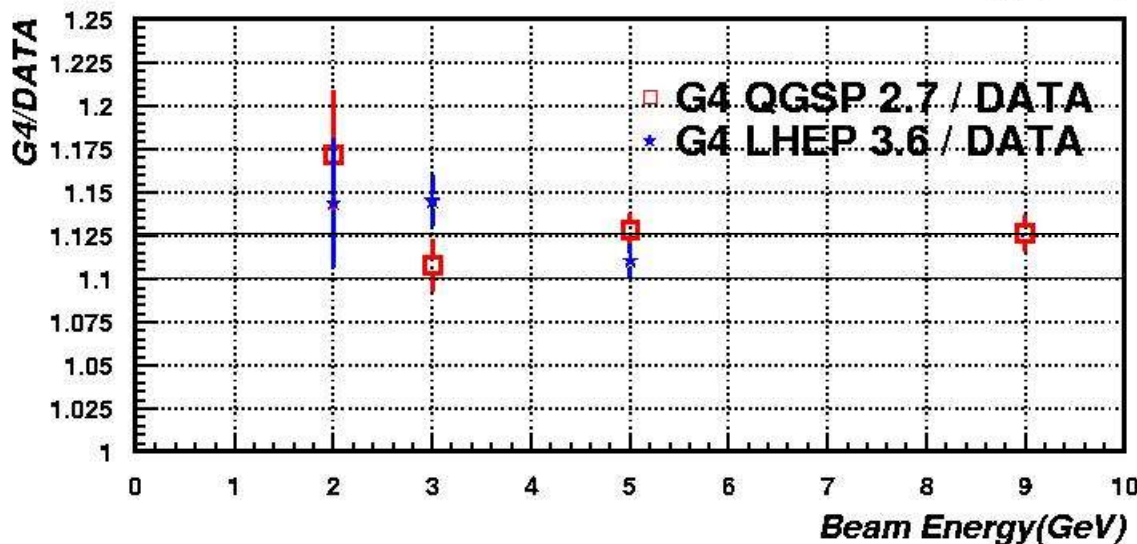
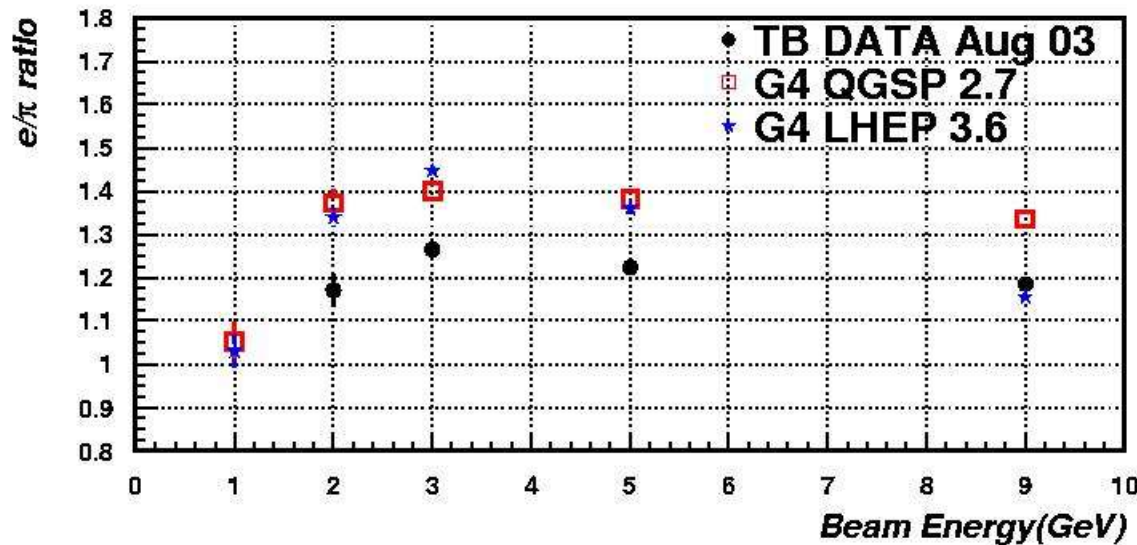


VLE pions $\eta = -0.35$

e/π vs E



TB DATA AUG03, $\eta=-0.35$

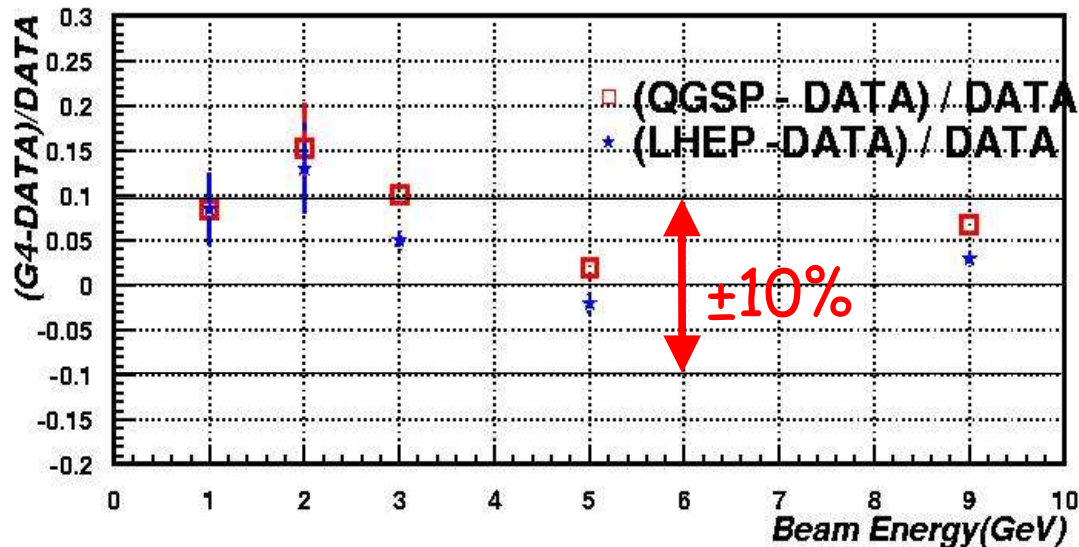
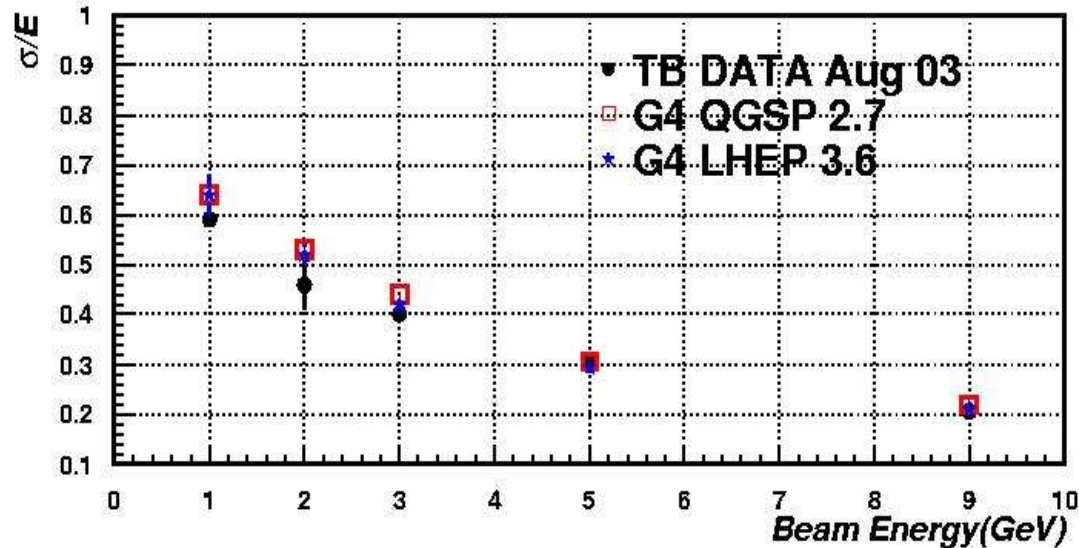


- Simulation gives e/π ratio higher of about ~12%
- For $E < \sim 5$ GeV e/π begins to become smaller both for MC and Data
- In data is not possible to separate e and π at 1 GeV (MC gives $e/\pi=1.05$, TileCal granularity is not enough high to distinguish using shape profile methods)



σ/E vs E

pions with $\eta = -0.35$



- For this study run at 1 GeV have been considered pions: from previous plots: $e/\pi \approx 1$, $\sigma/E(e) \approx \sigma/E(\pi)$
- Agreement is $\pm 10\%$ (for 2 GeV is $\sim 15\%$).

Fit results

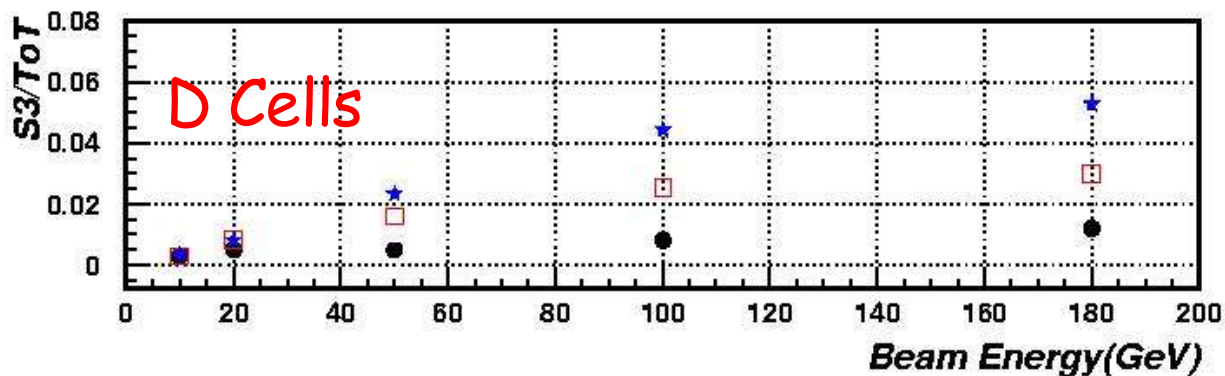
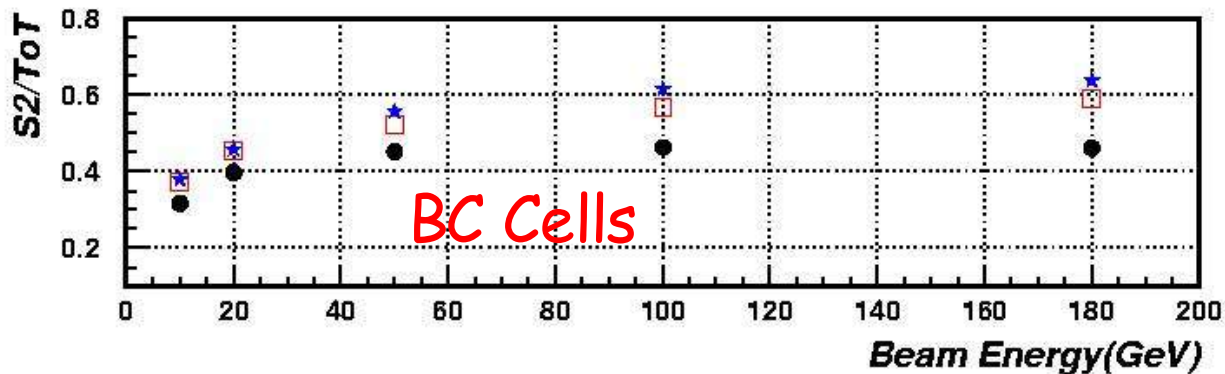
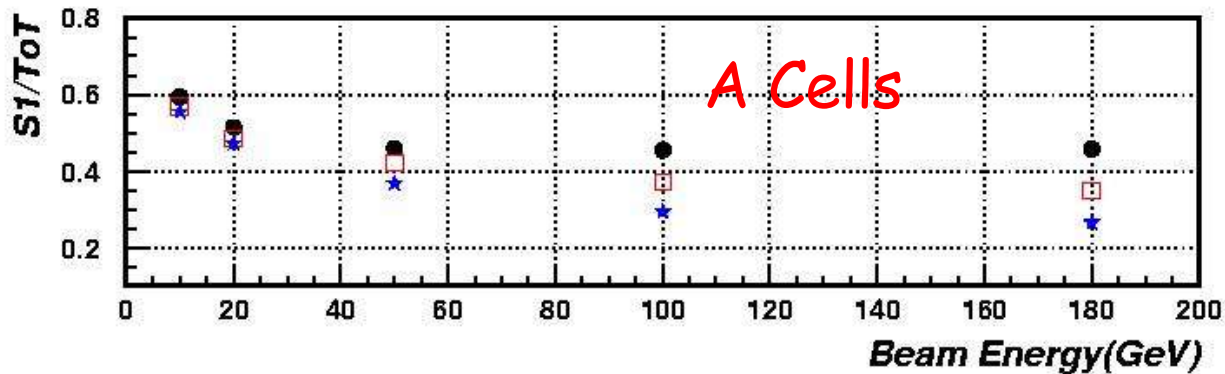
a/\sqrt{E}

QGSP	$(69.9 \pm 0.8)\%$
LHEP	$(68.1 \pm 0.7)\%$
DATA	$(66.9 \pm 0.5)\%$



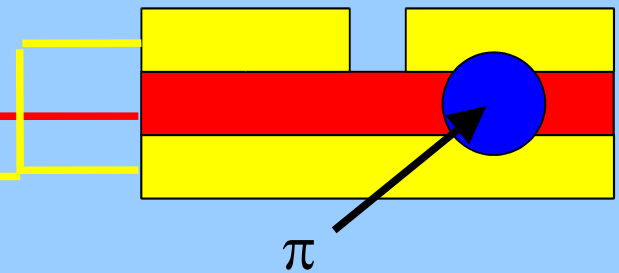
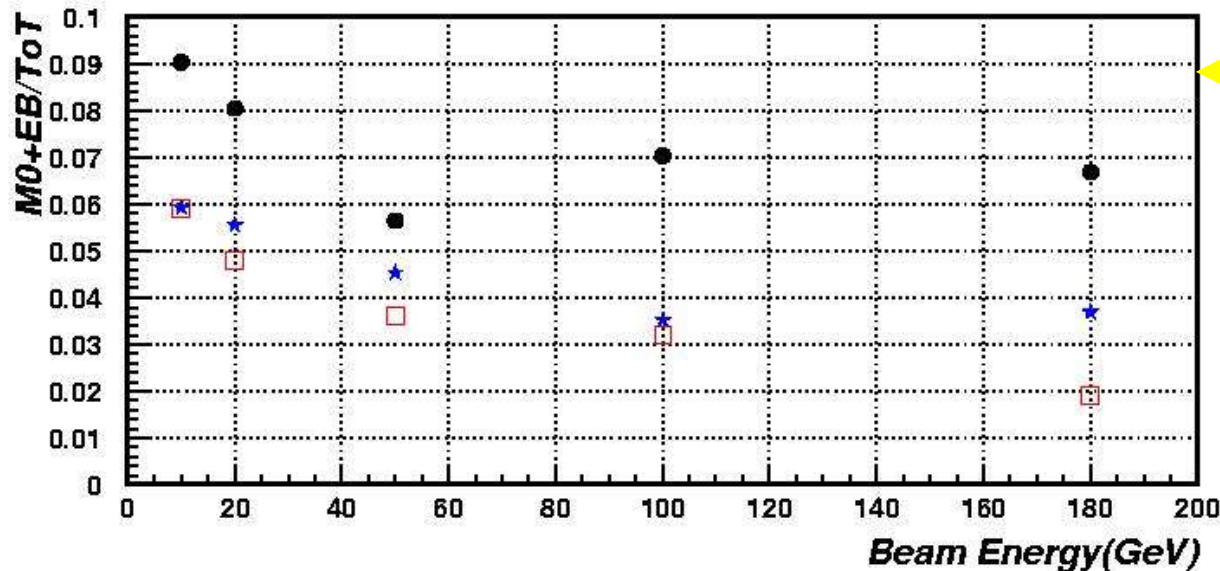
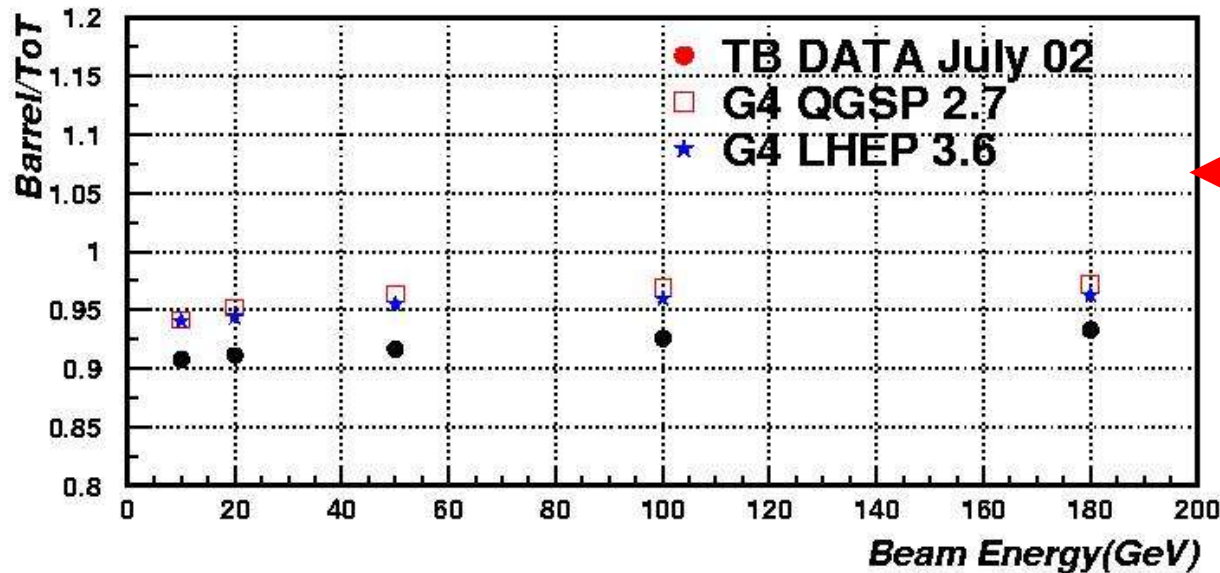
Shower Profile pions at $\eta = -0.65$

Longitudinal Shower Profile



- Single Sample energy response over the total response is plotted
- Geant4 seems to produce longer showers, especially in sample D where MC gives 6% of Energy deposit and data have only 1%
- QGSP, however, better simulates data

Partial Transverse Shower Profile



- Only lateral deposit in M0 and EB is considered
- Geant4 produces more compact showers, particularly QGSP
- ~7% of signal from data is in EB+M0, while for G4 is ~3%

Conclusions (1/2)



- π resolution is in sufficient agreement for $\theta=90^\circ$, $\eta=-0.65$ and VLE, but some systematic problems must be studied in more detail
- e/π ratio is simulated quite well ($\pm 5\%$) for high energy pions, at VLE MC simulation is too high, for $E < 5 \text{ GeV}$ e/π goes down to 1 ($e/\pi(1\text{GeV}) = 1.05$)

Conclusions (2/2)



- G4 predicts too long π showers with higher energy deposit in BC and D sample, while seems to simulate too compact showers in transverse dimension. QGSP better simulates the longitudinal profile, and LHEP better simulates the partial transverse profile

Summary of work done up to now



- Two different groups (INFN-Pisa and IFIN-HH) analyzed the data obtaining sufficient agreement (some dataset are more difficult: comparison still going on)
- e : (1GeV- \rightarrow 180GeV) linearity and resolution (My presentation at previous meeting and at this one)
- π : (1GeV- \rightarrow 180GeV) resolution and e/π (Calin and Me at this and last meetings)
- protons: resolution, response p/π (Calin's December presentation)