

G4 Hadronic Physics Validation

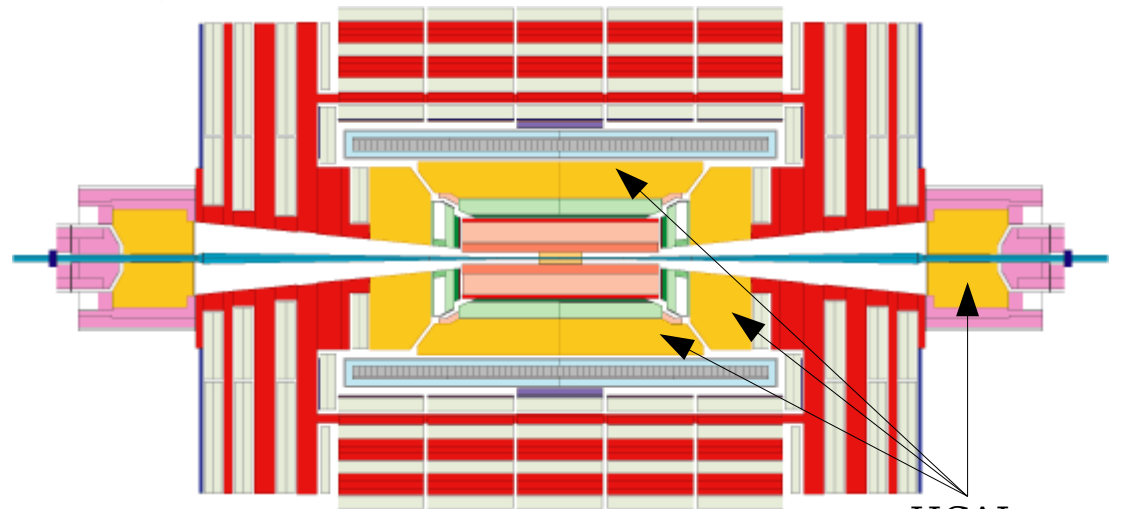
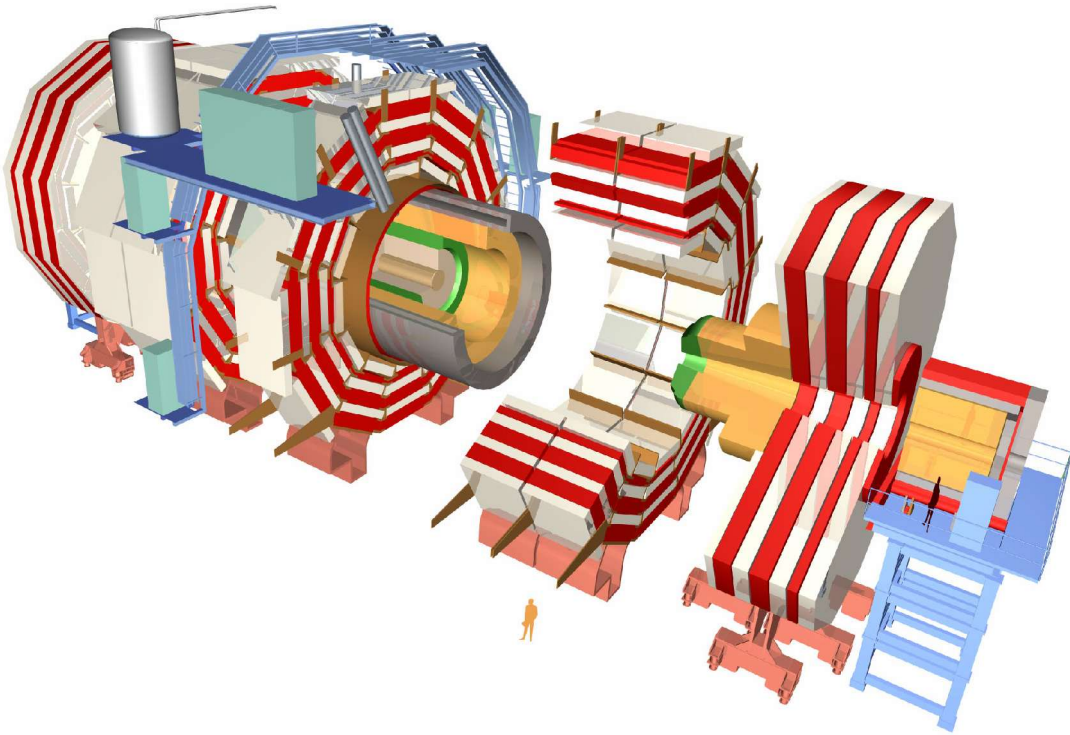
Based on CMS HCAL TB 2004

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on behalf of

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CMS Detector and HCAL Component (a reminder)



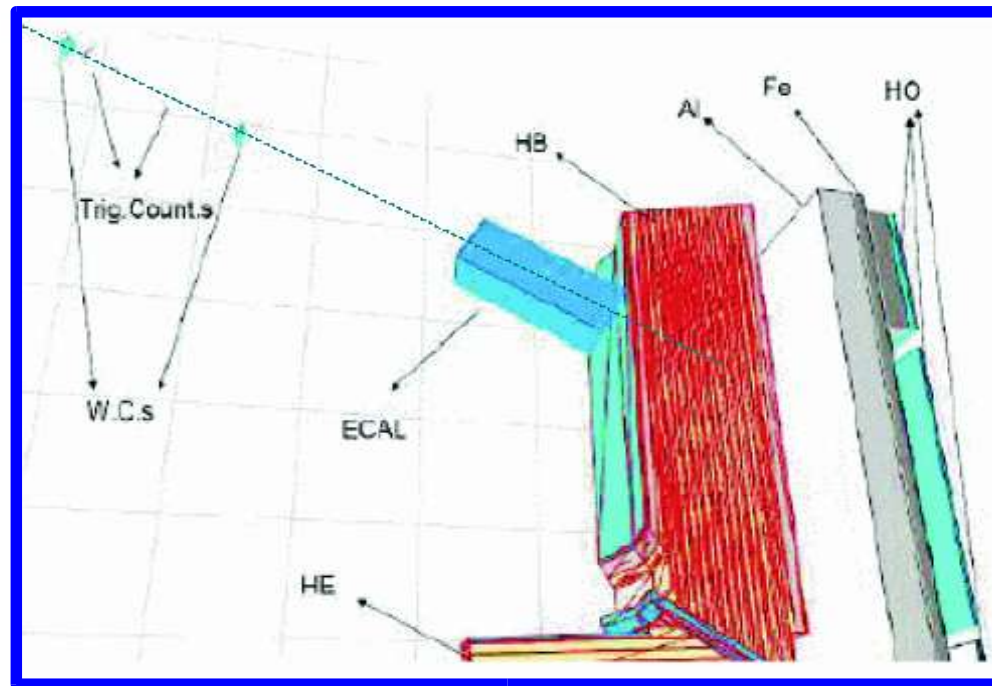
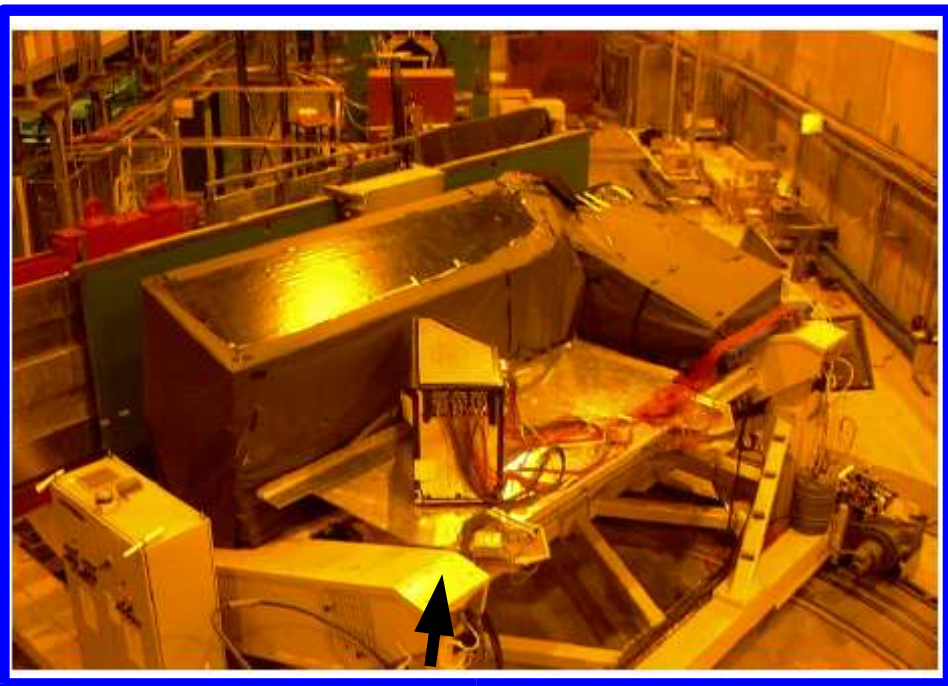
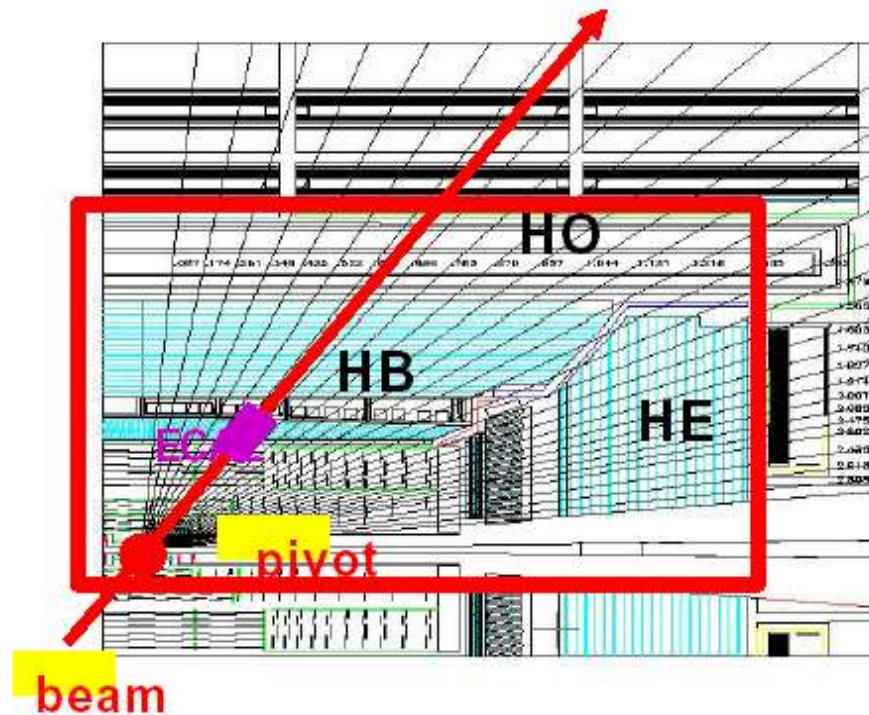
HCAL
System

HCAL Test Beam and Its Simulation

HCAL test beam setup consists of various detector segments to give full representation of the HCAL detector.

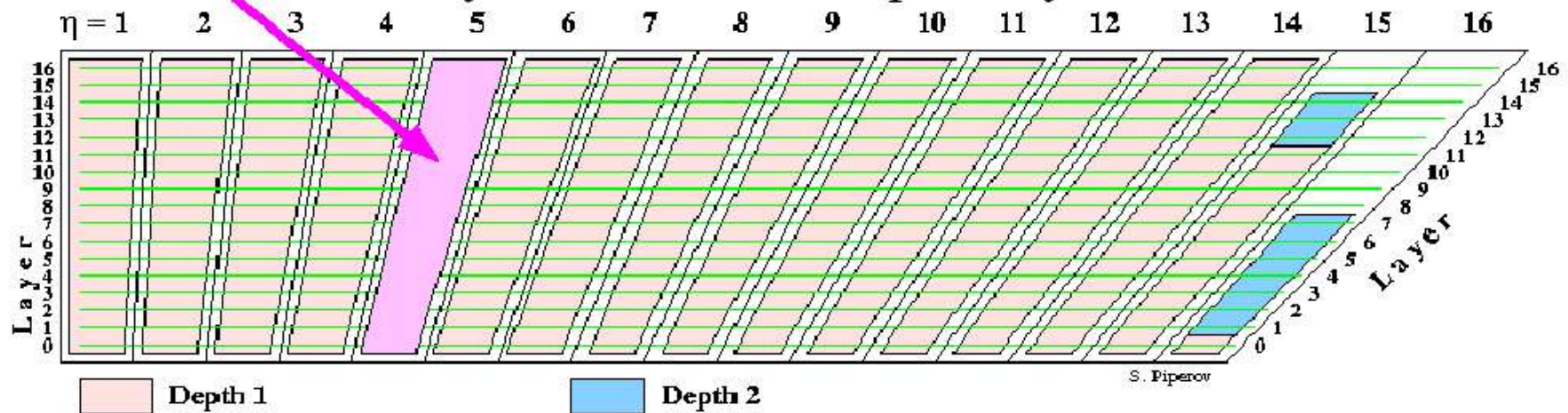
Test beam setup is at CERN-H2 site.

Simulation of the TB2004 is done with CMS OSCAR_3_7_0 package which is based on Geant4.6.2.p02(clhep1.9.1.2).

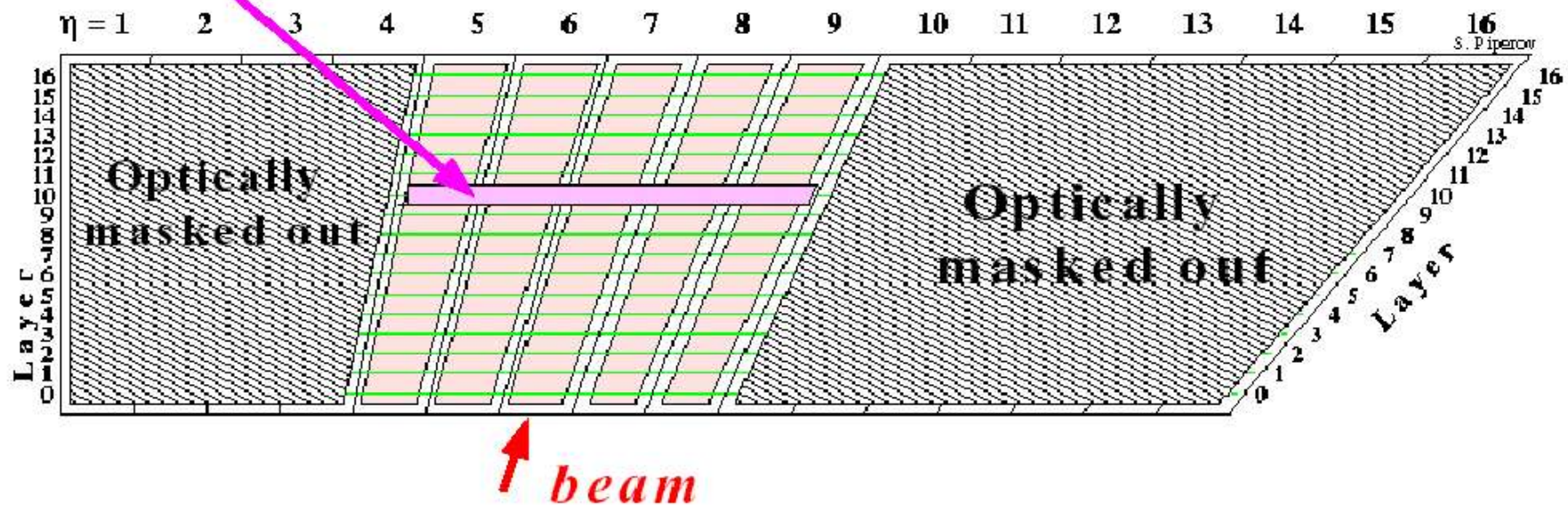


Readout of the Barrels

HB1: tower like – layers summed optically



HB2: layer like – longitudinal shower profile



Data Sets

Data:

- Very Low Energies (VLE)
 - 2,3,5,7,9 GeV mainly pion beam
 - with/without ECAL
 - HB1/HB2
 - with full particle identification
- Medium Energies (MED)
 - 10,15,20 GeV electron and pion beam
 - with/without ECAL
 - HB1/HB2
 - partial particle identification
- High energies (HIGH)
 - 30,50,100,150,300 GeV electron, pion beam
 - with/without ECAL
 - HB1/HB2

Simulation:

- Very Low Energies (VLE)
 - 2,3,5,7,9 GeV electrons, pions, protons and kaons
 - with/without ECAL
 - HB2
- Medium Energies (MED)
 - 10,15,20 GeV electrons, pions, protons and kaons
 - with/without ECAL
 - HB2
- High energies (HIGH)
 - 30,50,100,150,300 GeV electrons, pions, protons and kaons
 - with/without ECAL
 - HB2

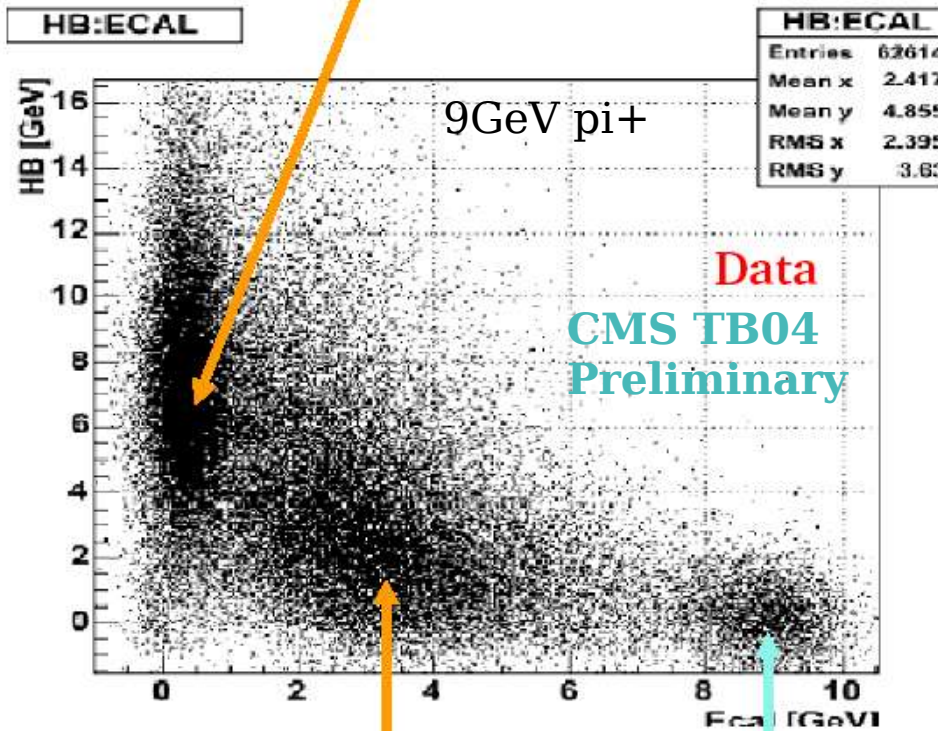
Simulation is repeated for different physics lists:
LHEP-3.7, QGSP-2.8, QGSC-2.9, FTFP-2.8 (Pack.-2.5)

there are some issues to be understood with the 2 GeV data, no results are shown.

Understanding of the Data

Beam contamination, calibration and cross-talk between the channels (due to non-existent B field) of hybrid photo-diode in readout system has to be understood beforehand.

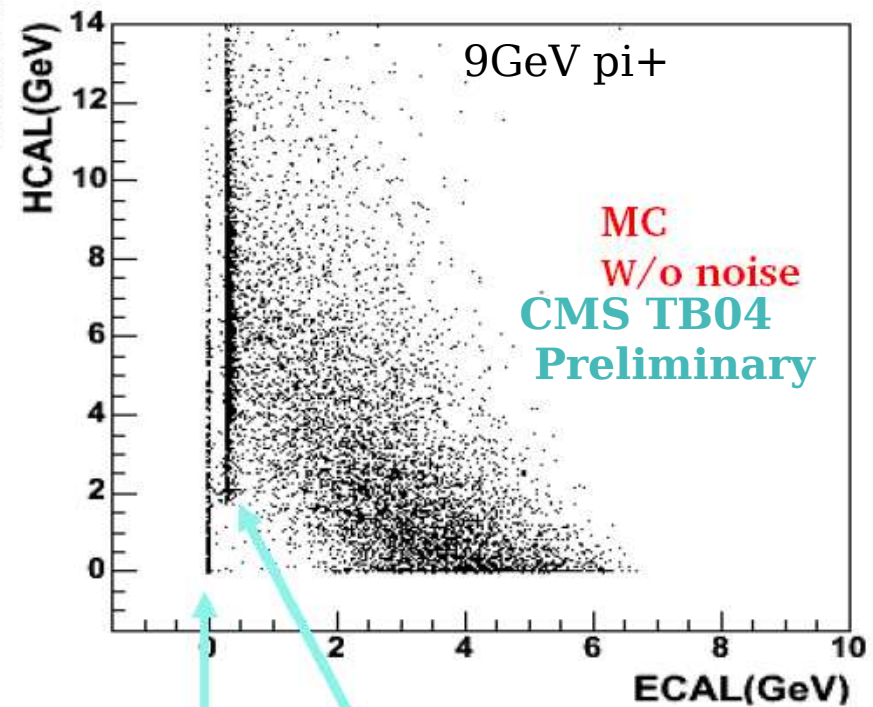
mip in ECAL, i.e. no-interaction in ECAL



Interactions in ECAL

e⁺

Need a lot of clean-up !

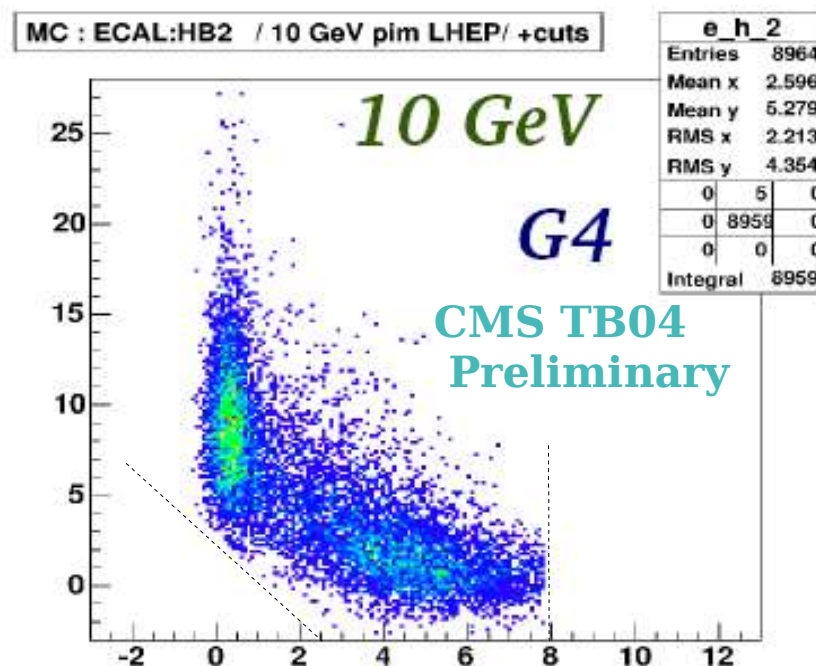
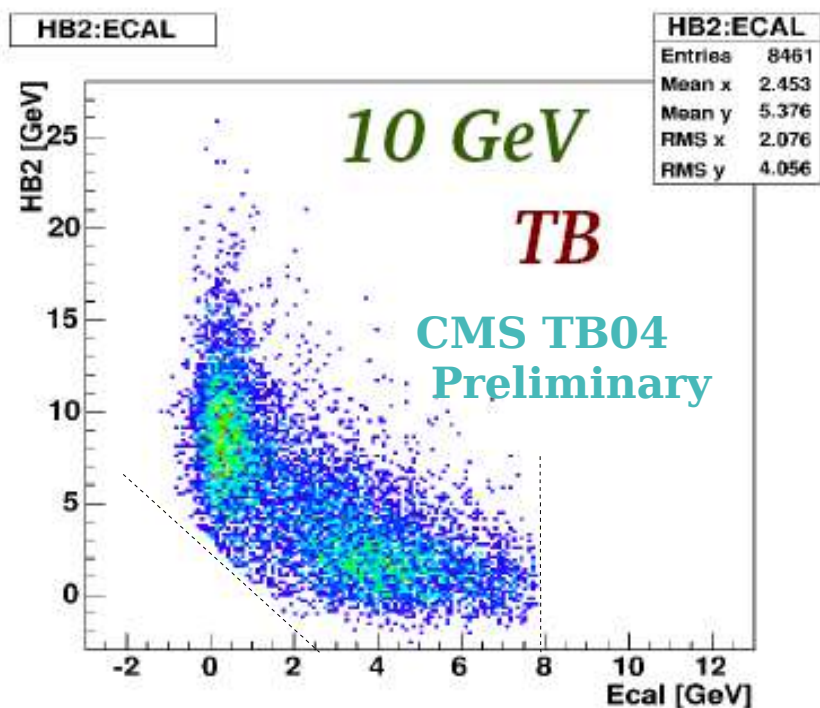


$\pi \rightarrow \mu \nu$ decays in beam line

Interactions in beam line

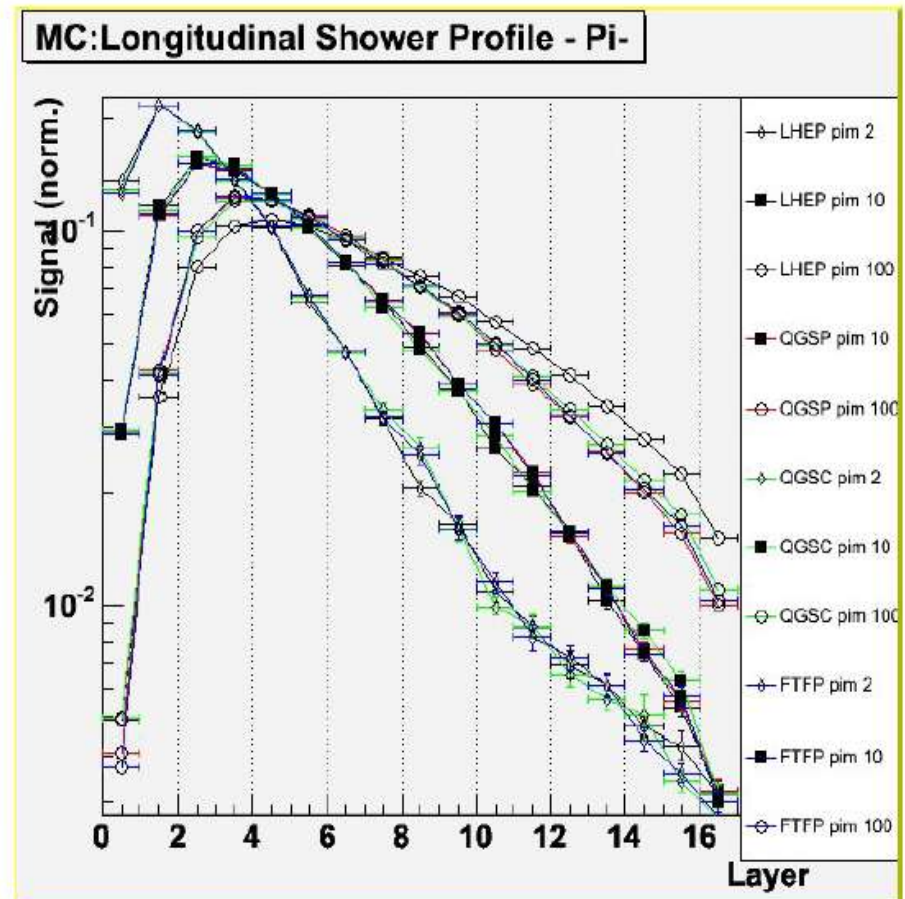
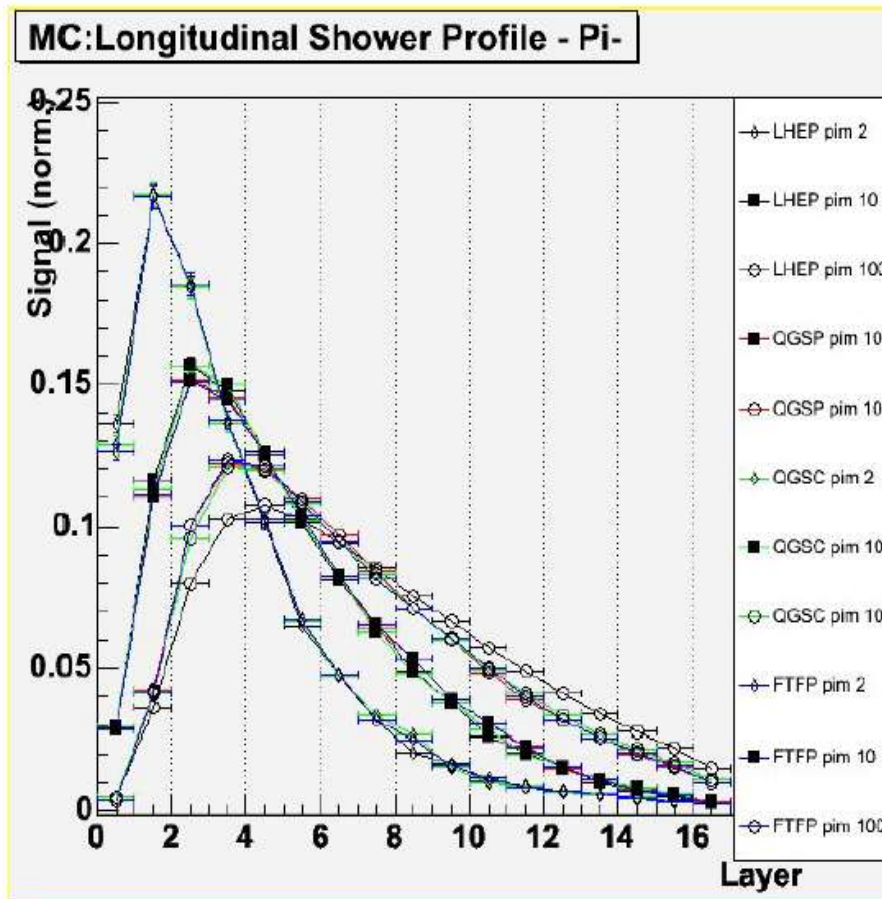
Handling TB2004 Data and Simulation

- Test beam data and OSCAR data are treated in the same way when the comparison of simulation with TB2004 is done: Calibration method used for data is used to calibrate OSCAR data, cuts applied to the data is also applied to the OSCAR data.

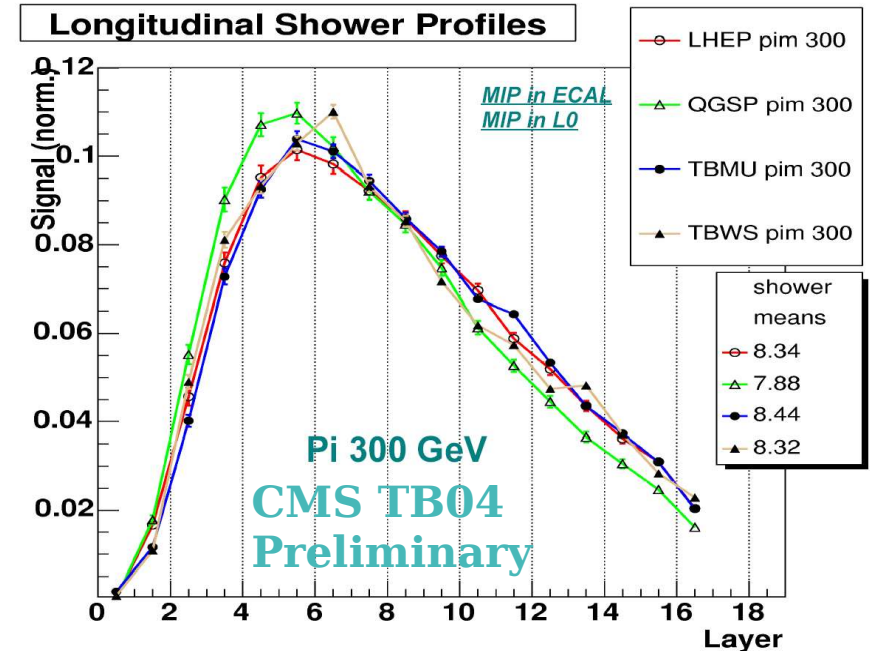
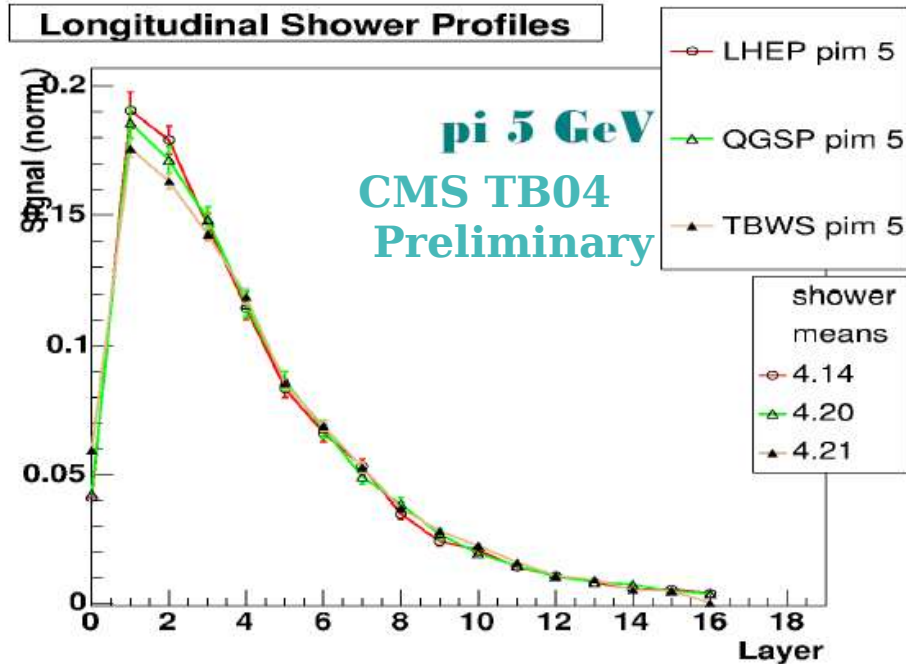
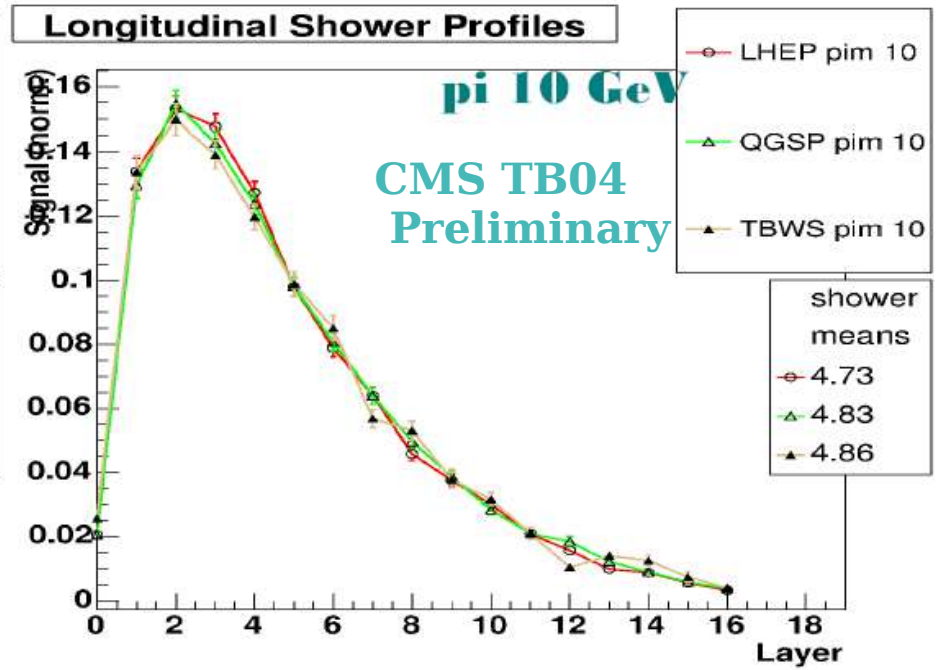
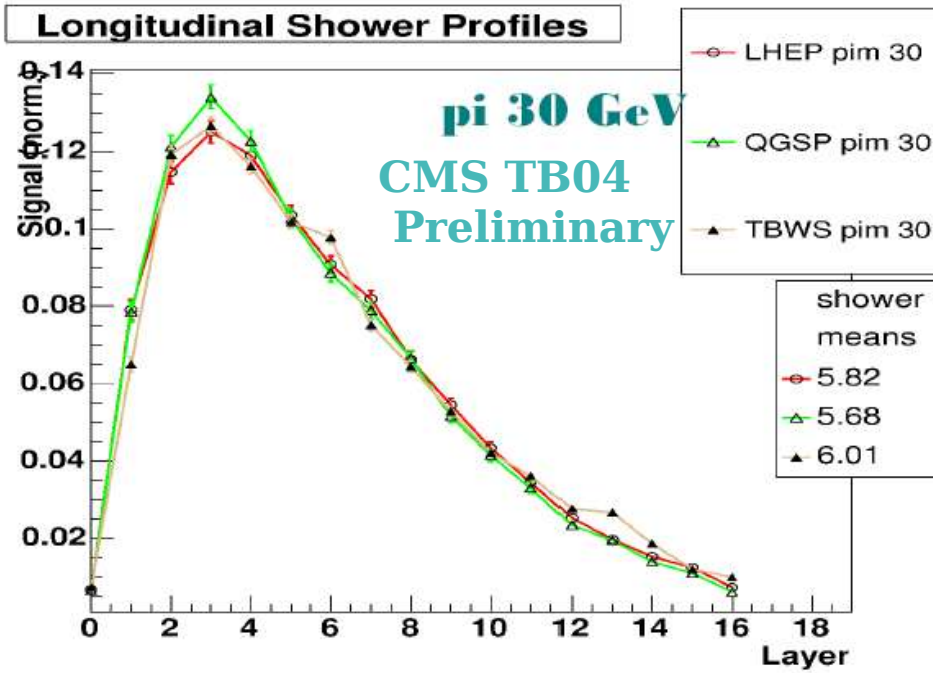


Comparisons of the Shower Profiles: “Parametrized” vs. “Calculated” Physics Lists

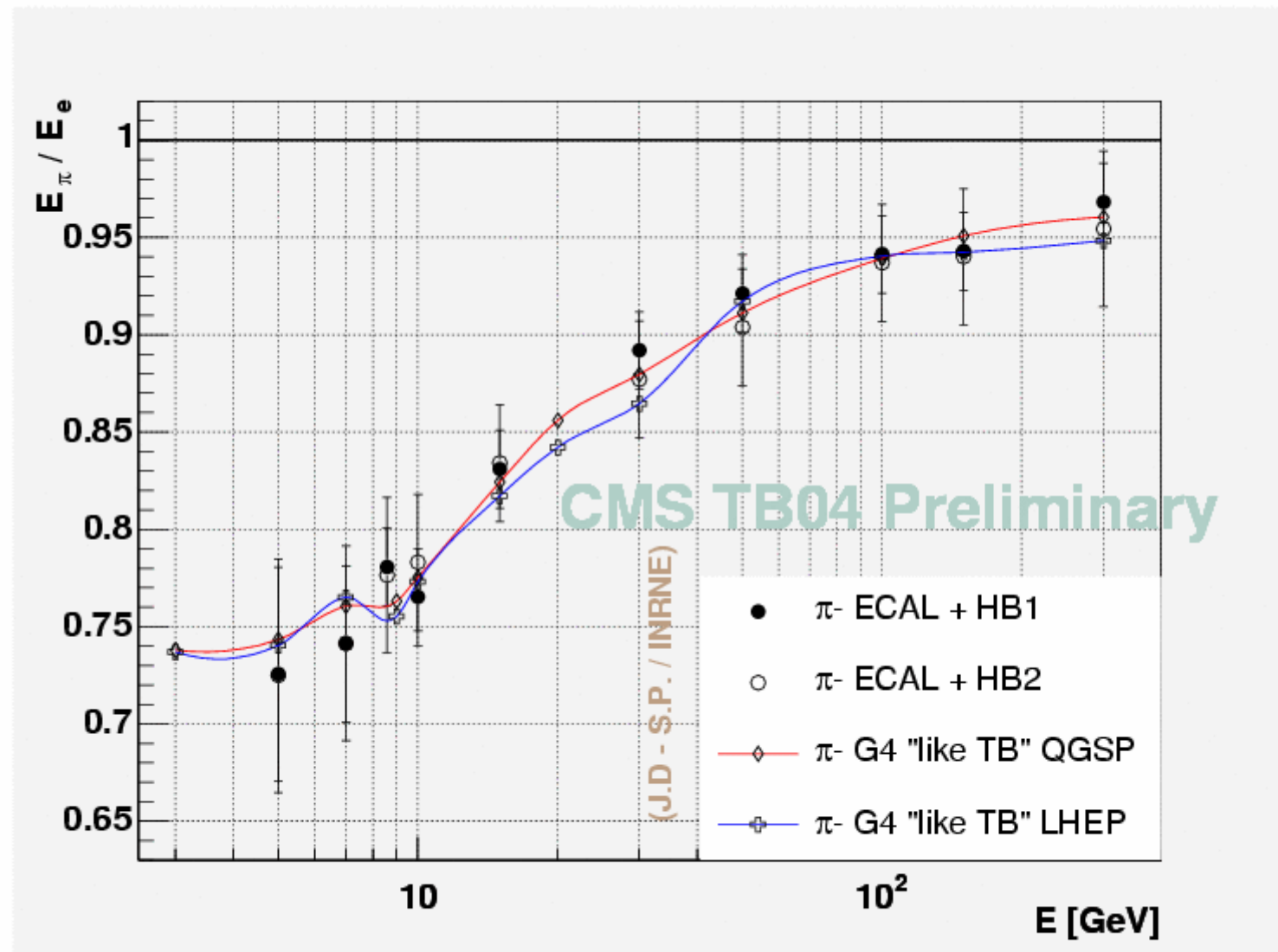
The shower profile (amount of signal collected in each layer) is shown with respect to the layer number for 2,10,100 GeV pi- beam for all physics lists. At low energies four physics lists are in agreement but in high energies all calculated physics lists (QGSP, QGSC, FTFP) predict shorter shower profile.



Comparisons of the Shower Profile with TB2004 Data



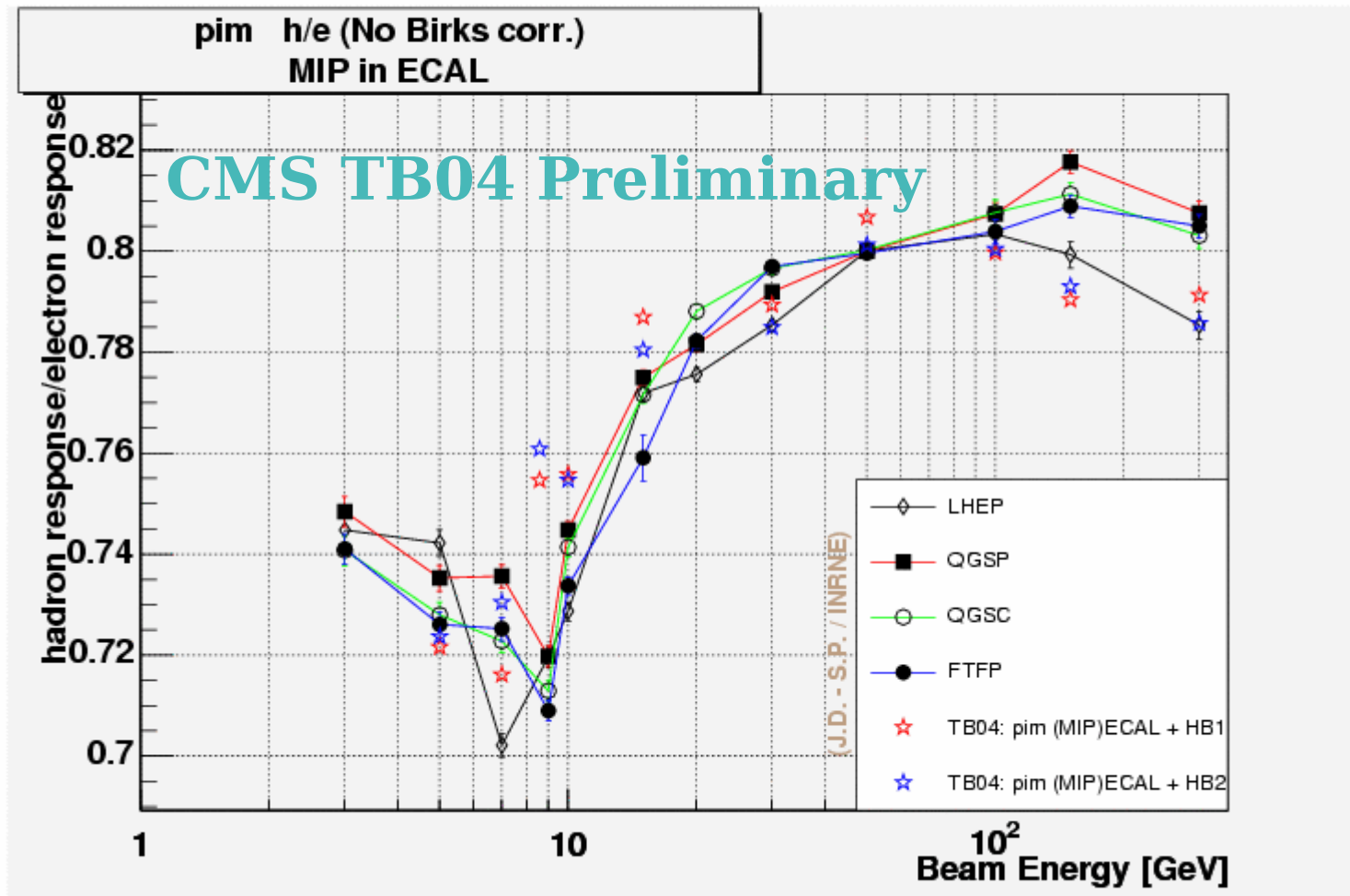
Comparisons of the pi/e Ratio



* Error bars are coming from statistical errors and estimation of systematical errors.

In combined system (HB+ECAL) QGSP and LHEP models the data within the errors.

Comparisons of the pi/e Ratio with MIP in ECAL



There is leakage to the HO when energy of the beam increases as can be seen from the drop in the plot. Only LHEP represents this leakage because of longer shower development.

Conclusions and Outlook

- Monte Carlo predictions agree well with the TB2004 data.
- LHEP seems to model shower profile better than the other physics lists.
- The analysis of TB2004 data and comparison with simulations is not finalized yet. Some possible improvements on calibration, cross-talk and better estimation of the systematical errors are being studied.
- There will be another test beam in 2006. Some feed-backs are given to make plans for better studies of beam purities/selection for VLE, calibration etc.