# Tuning of G4 physics and detector description: What can be done with single pions?

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Foz do Arelho, Porutgal
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## Outline

The talk consists of two parts:

- E/p sensitivity to dead material
- Comparison different G4 physics list and impact on on absolute jet energy scale

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# E/p sensitivity to dead material

# Introduction

Can we do brief check of geometry description (our understanding) by using single charged pions in collision data?

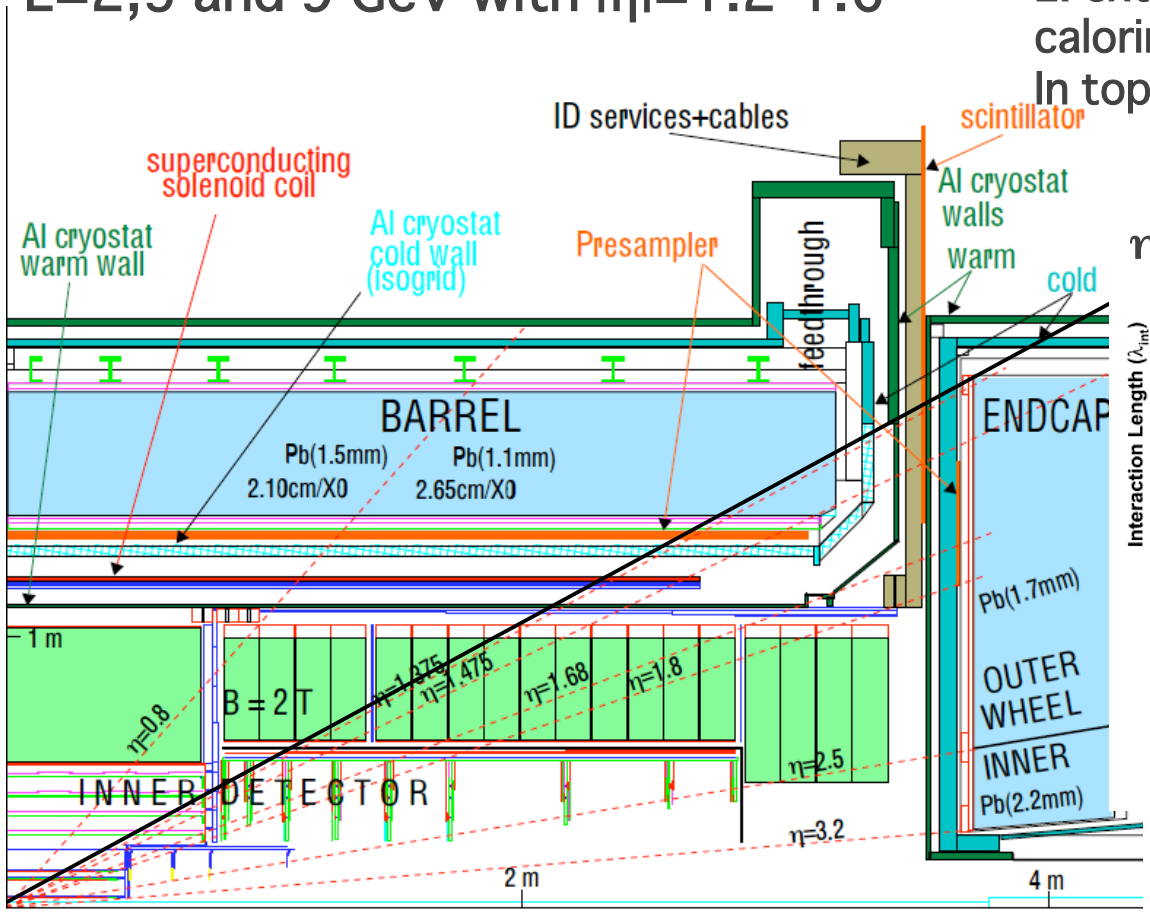
## Data used in this analysis

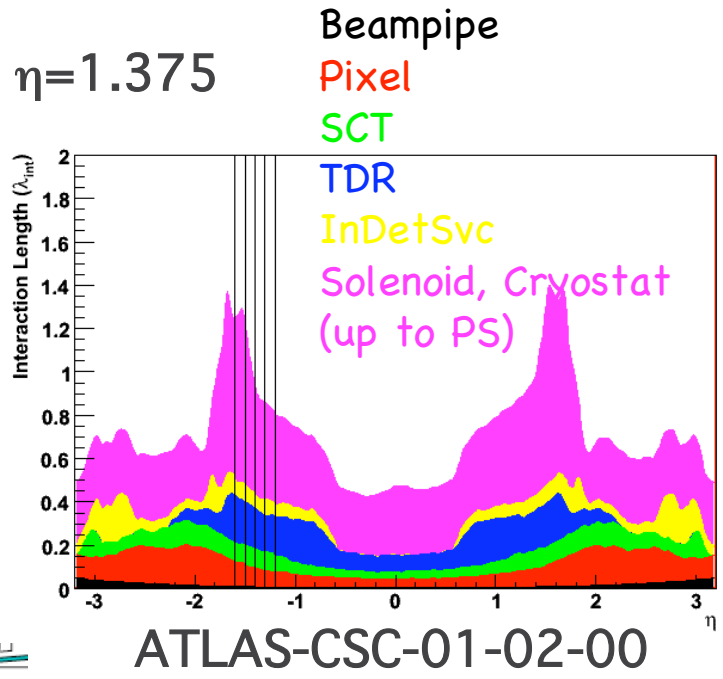
CSC sample (ATLAS-CSC-01-02-00)
(13.0.30.2 production, QGSP_EMV)
E=2,5 and 9 GeV with |η|=1.2-1.6

## Object selection

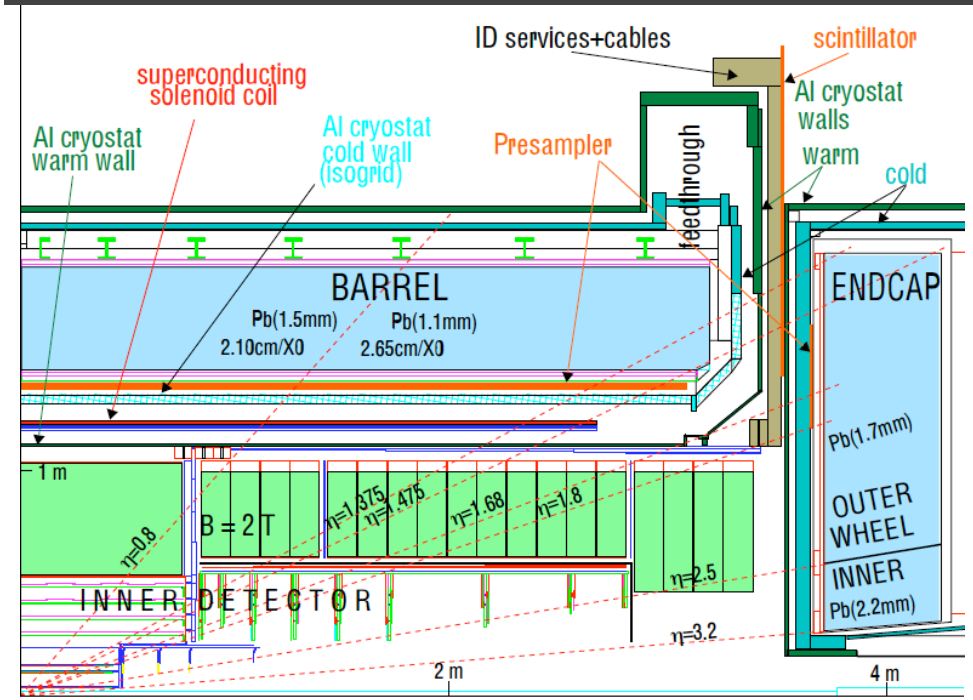
P: select reconstructed tracks associated with truth track (prob>80%)

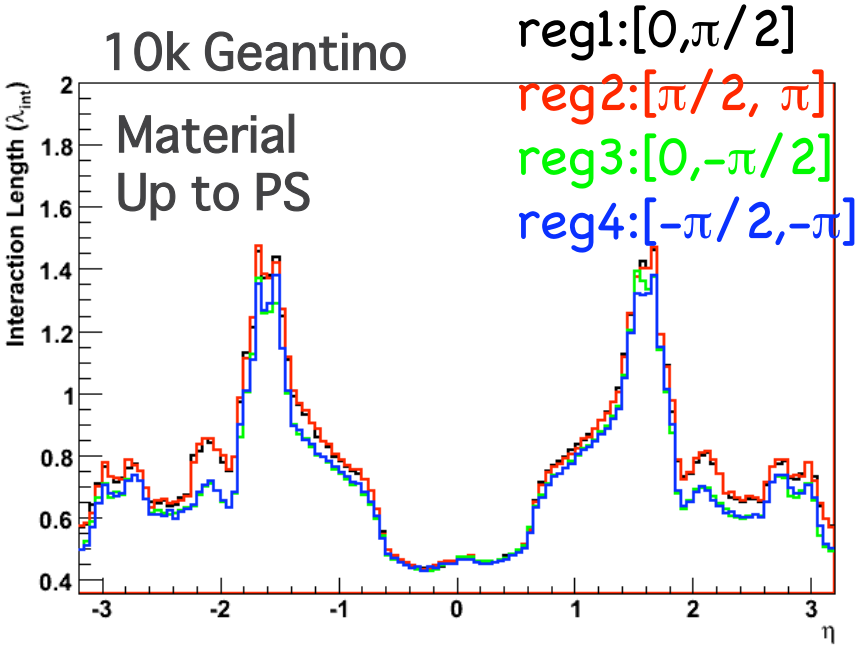
E: extrapolate tracks into each calorimeter layer, and sum up cells In topoCluster with in dR<0.4 (EM scale)

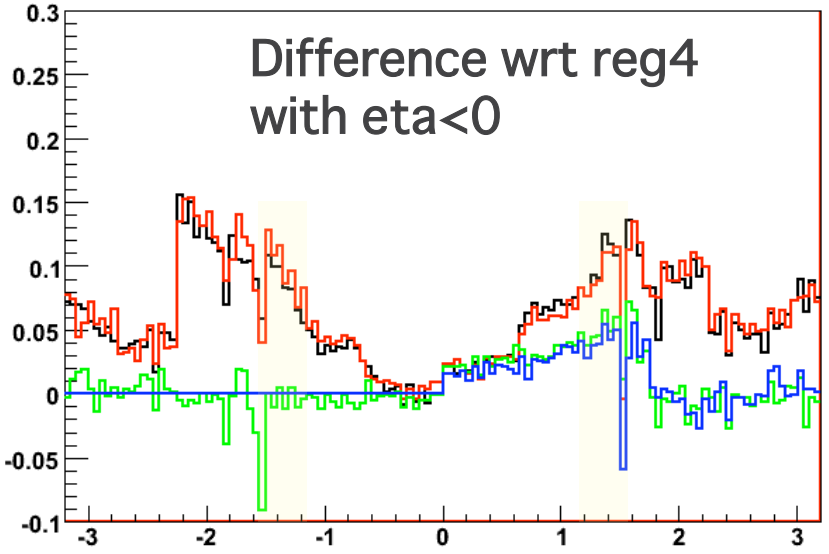


# CSC geometry



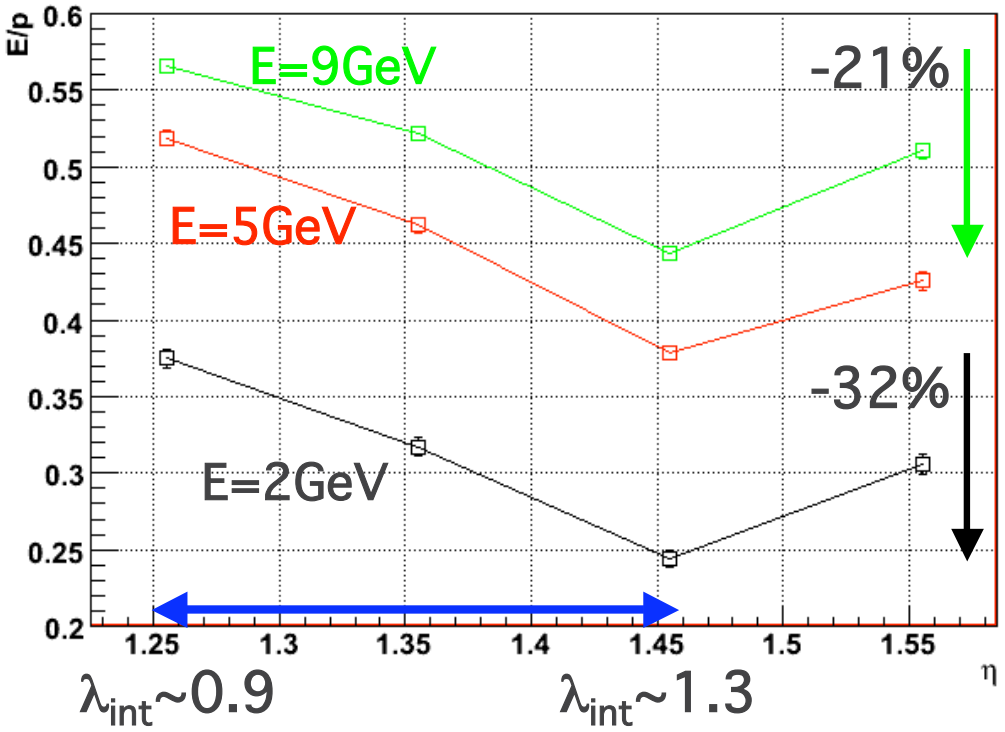



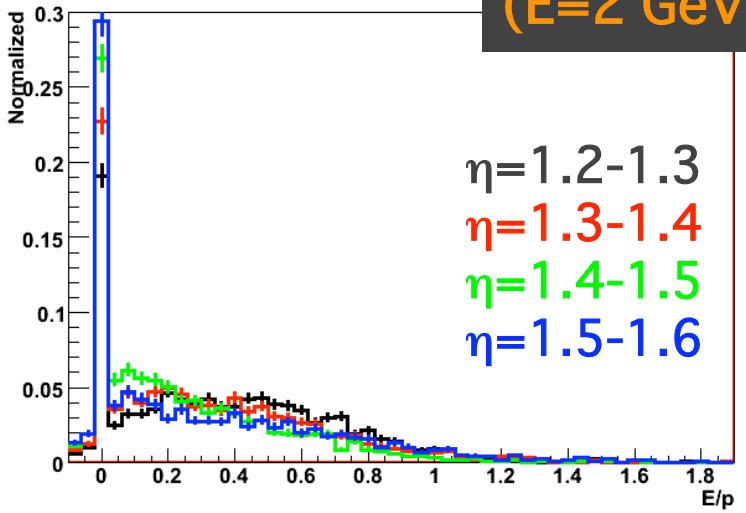

Region with phi>0 has more material by 5%-10% $\lambda_{int}$ comparing to region with phi

# Single pion response

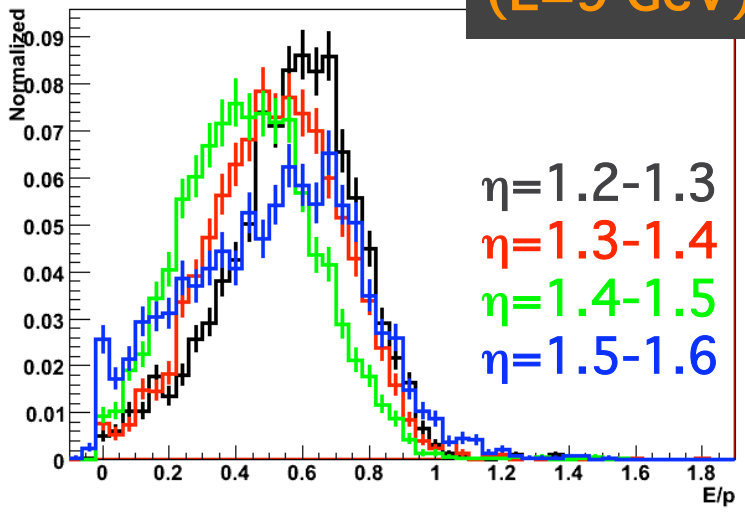
eta>0, phi=[0,-pi/2]




E/p (E=2 GeV)




E/p (E=9 GeV)

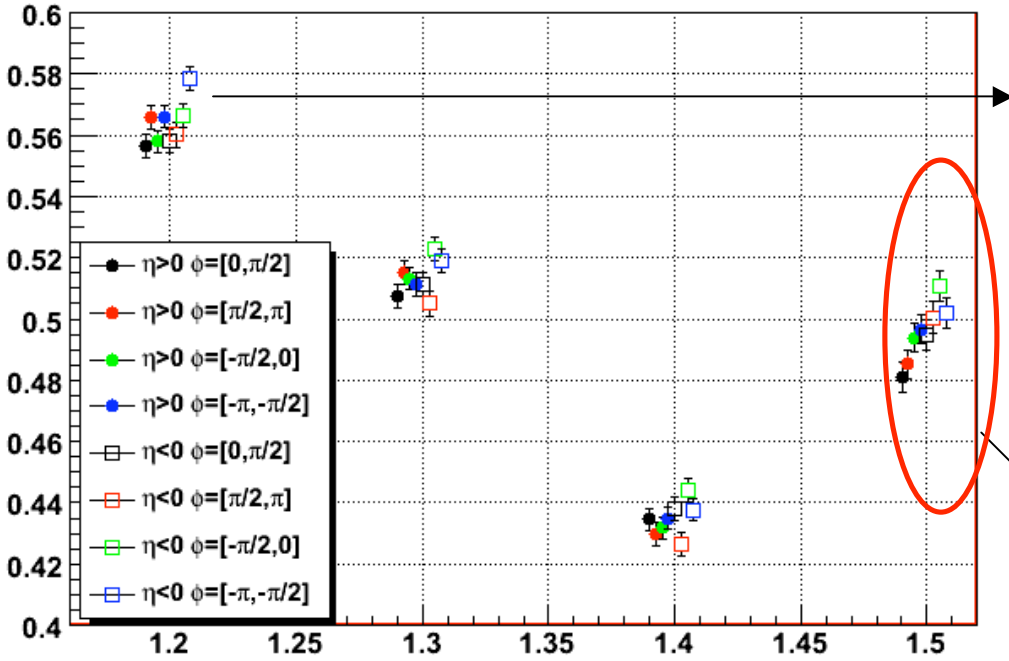


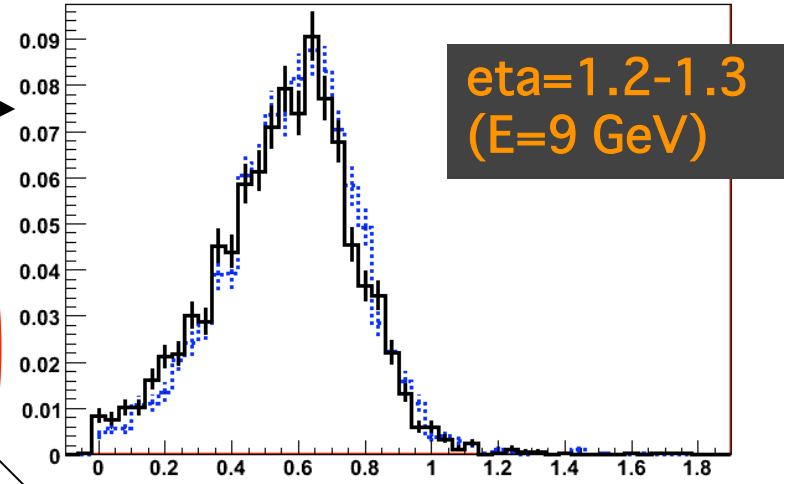

More difference is seen with lower energy pion although >20% pion does not reach to calorimeter (or suppressed by the topo clustering)

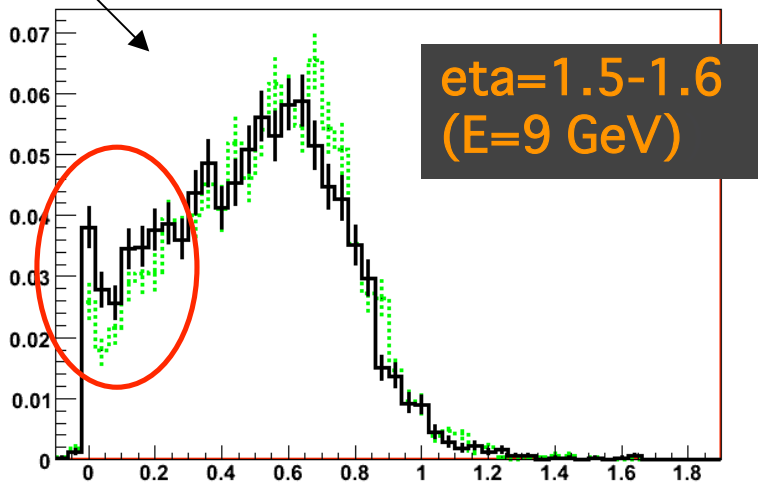
Complementary test to material test using EM-showering particle (e, γ)

# Single pion response (1)

E/p
(E=9 GeV)



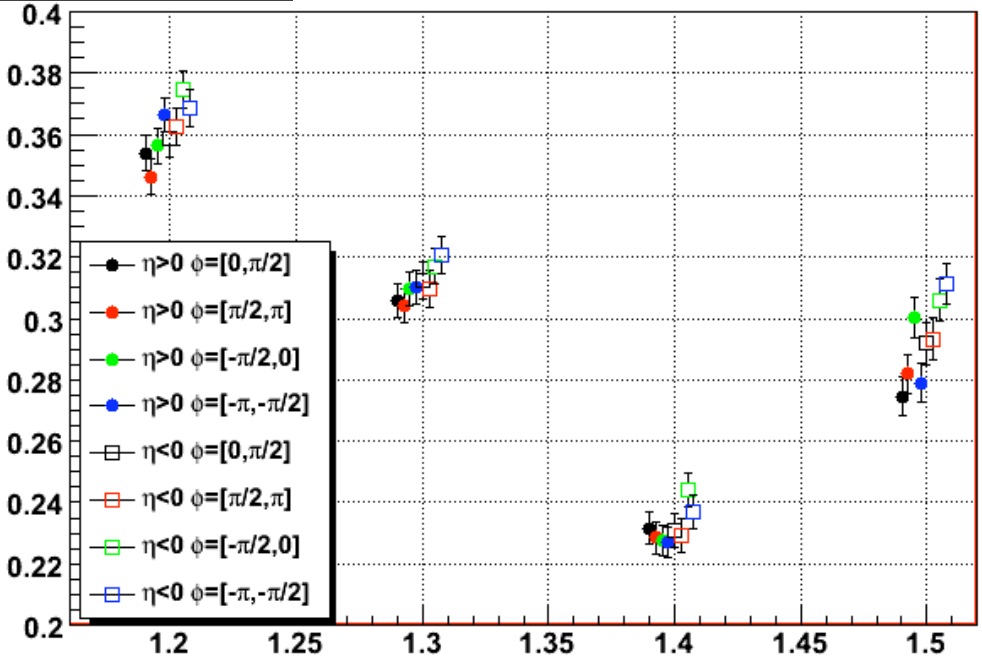



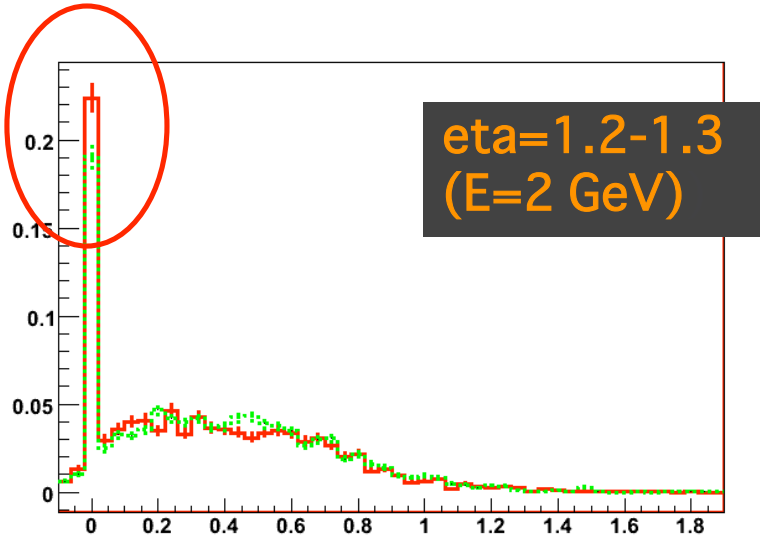

Difference is 5-10% in interaction length.

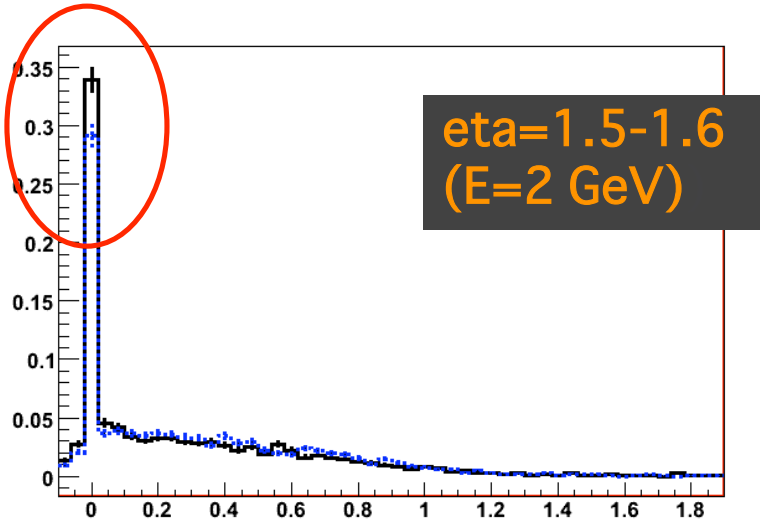
Result is as expected.
Need further work for quantitative result.

# Single pion response (2)

E/p
(E=2 GeV)



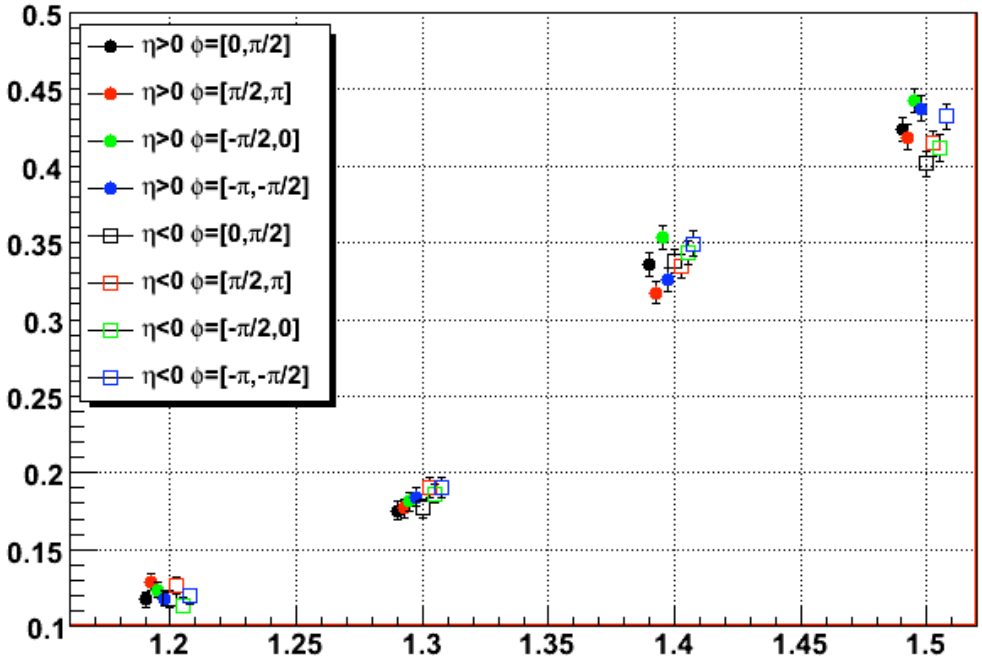



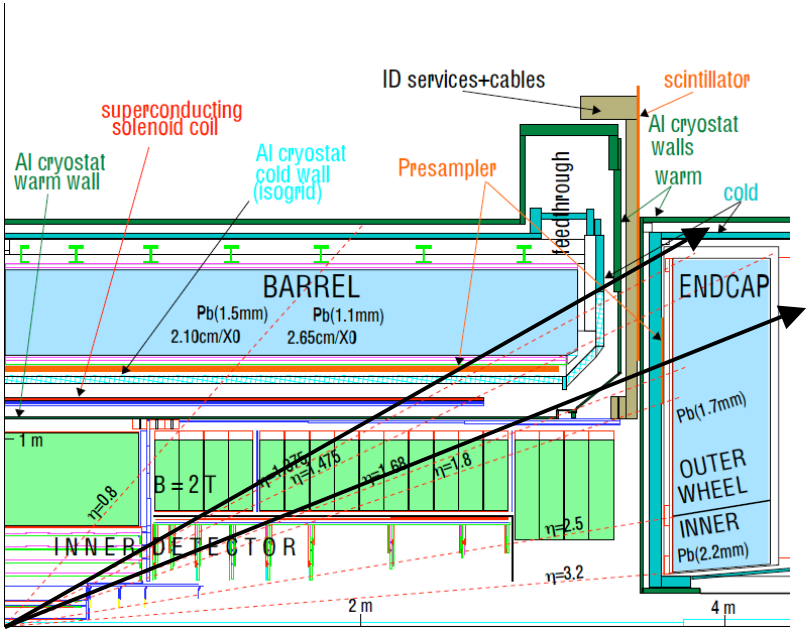

More sensitive with lower E pion.
Need to understand stability of fraction of E/p=0 (tracking quality etc)

# Single pion response (3)

**HAD/EM (E=9 GeV)**

HAD/EM will be sensitive to material between Barrel and endcap (Cryostat, cables…)




Depends on the EM and HAD calorimeter volume where single particle pass…

# G4 physics List and impact on JES

# Introduction

We need good MC simulation to describe calorimeter response to single particles, especially important for higher jet energy range.

Need to validate MC detector simulation by comparing to data as done in Testbeam.

QGSP_BERT gives the best description of Testbeam result, but slightly narrower and shorter shower.

- Impact on absolute jet energy scale.
- Comparison between QGSP_BERT and FTFP_BERT

<u>Data samples used in this analysis</u>

Produce single pions with two difference G4 physics list, QGSP_BERT and FTFP_BERT (v15.1.0.1)

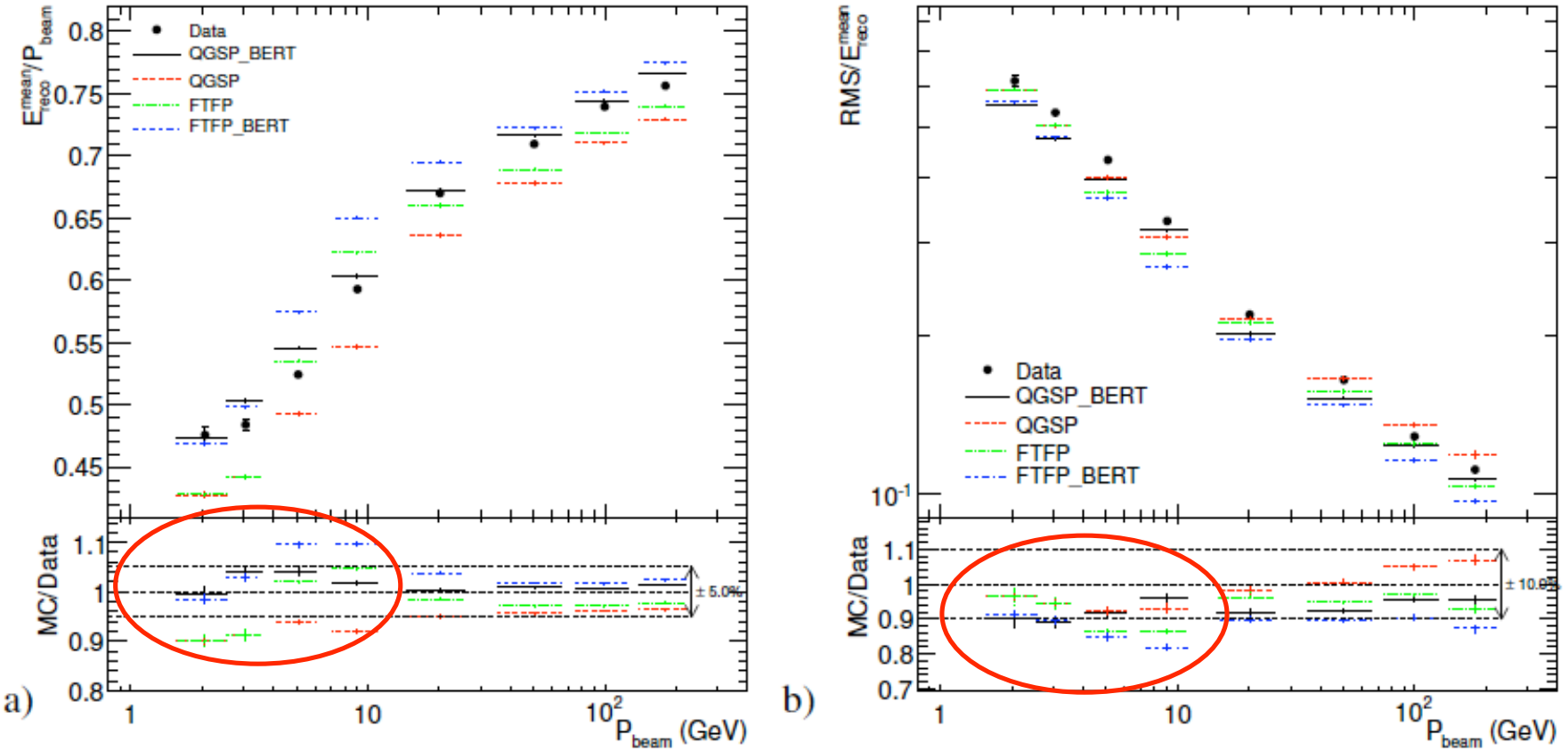
- 10k
- E=2,5 and 9 GeV
- eta=0.2-0.4
- ATLAS-GEO-02-01-00
- vertexPos.py

* QGSP_BERT
  - BERT for E<9.9GeV
  - QGSP for E>12GeV

* FTFP_BERT
  - BERT for E<5GeV
  - FTFP for E>4GeV

# Testbeam result

ATL-COM-CAL-2009-04




E=2-10 GeV (primary pion)
QGSP_BERT : ΔE/p<5%
FTFP_BERT : ΔE/p<10%

E=2-10 GeV (primary pion)
QGSP_BERT : Δσ<10%
FTFP_BERT : Δσ<20%

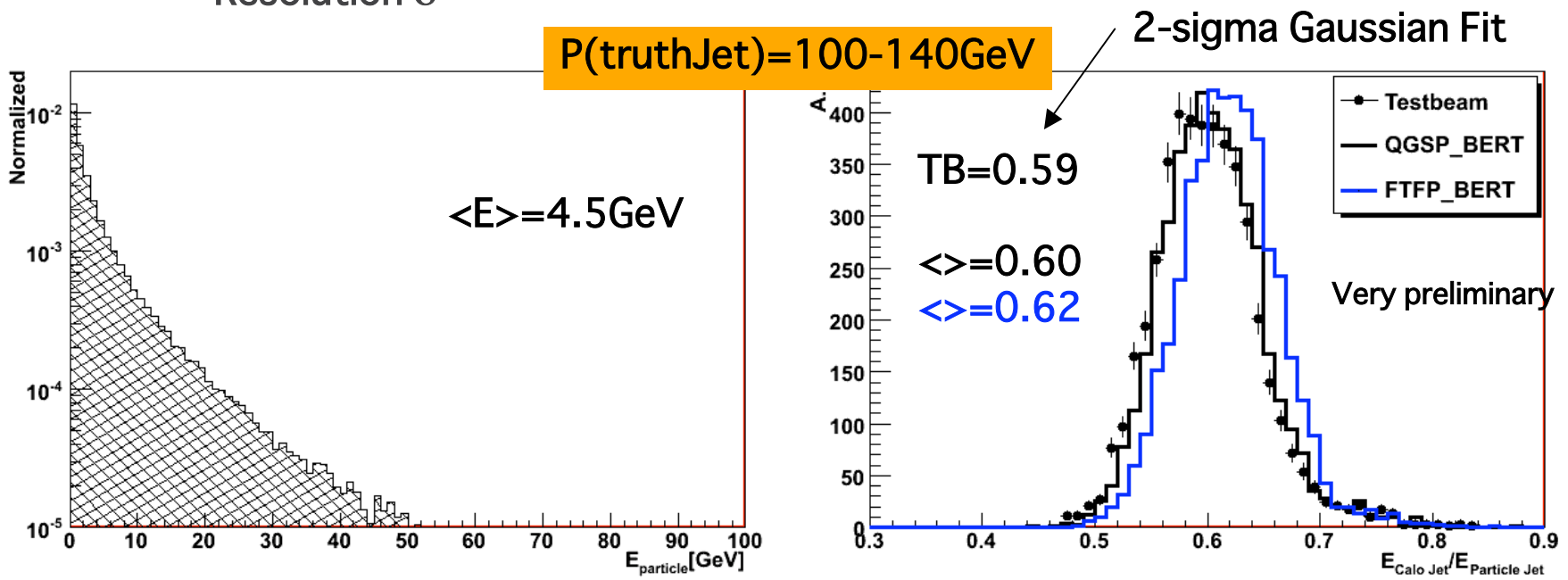
# Impact on absolute jet energy scale

## e.g. use PYTHIA Jx for fragmentation

Calorimeter response to single particles is Modeled by Gaussian pdf with a <E/p> and resolution as a function of E.

Very preliminary way…
Linear interpolation between data point in previous page.

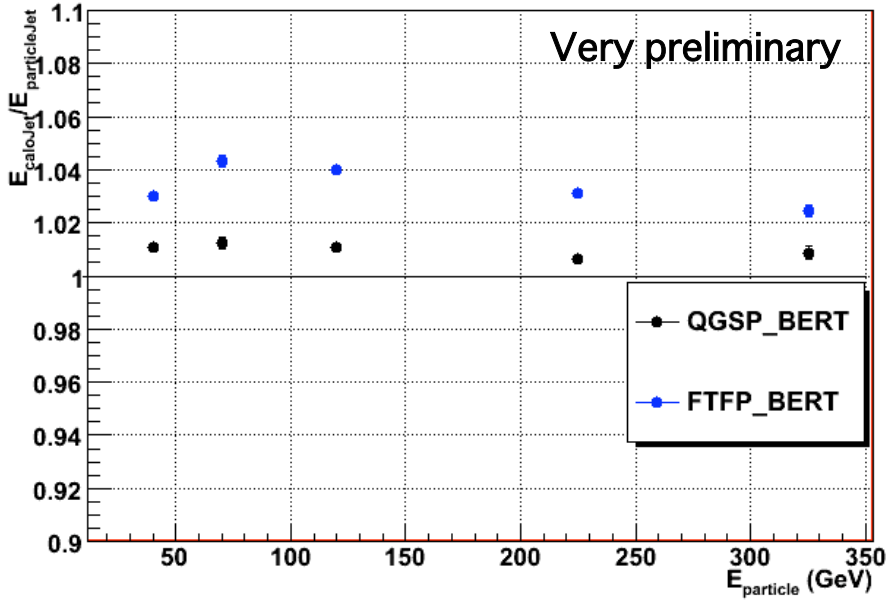
- 1/3 $\pi^0$ -Mean <E/p> (from Local Hardon Calibration note)
  -Resolution $\sigma = 10\%\sqrt{E}$
- 2/3 $\pi^{\pm}$ -Mean <E/p> (from previous page, linear interpolation between data)
  -Resolution $\sigma$




QGSP_BERT is already quite good, ~1%.

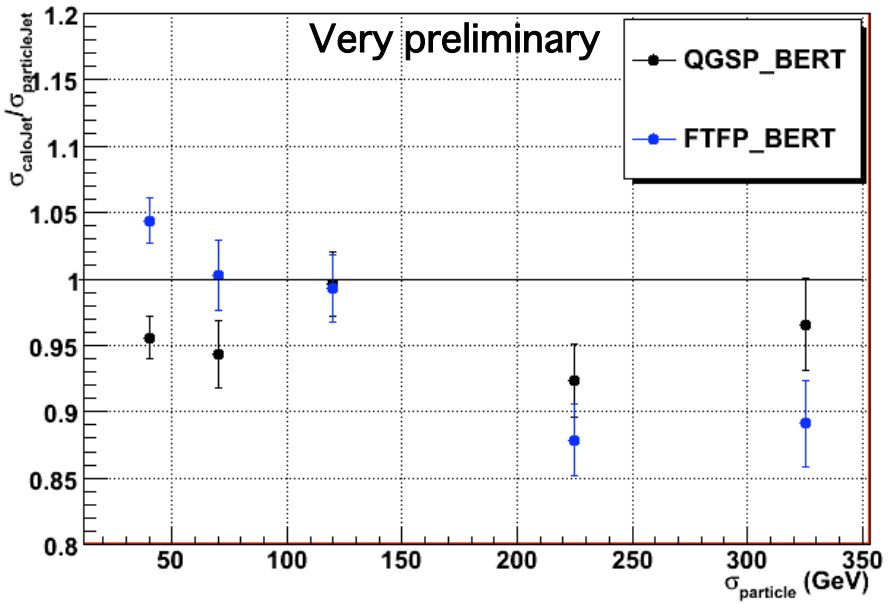
# Impact on absolute jet energy scale

## scale




QGSP_BERT ~+1%
FTFP_BERT=+2-4%

## resolution




QGSP_BERT~ -5%
FTFP_BERT=-10-5%

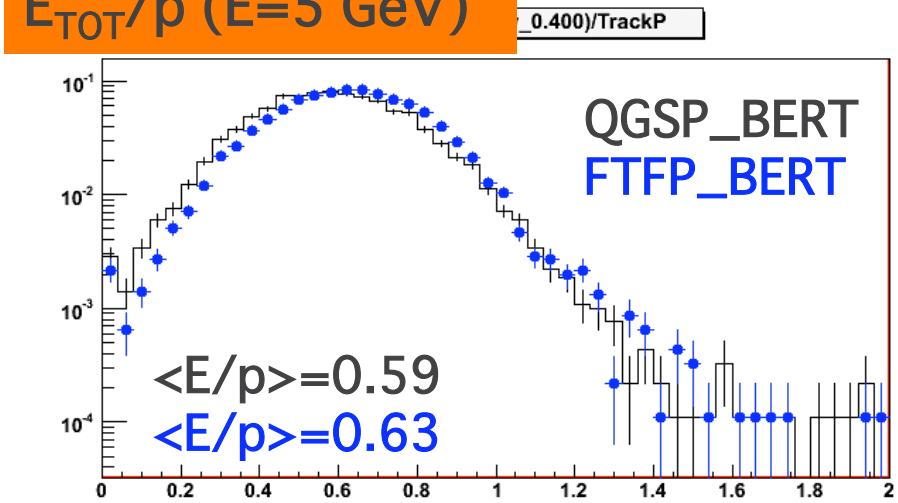
Will check difference in other region, e.g. HEC (eta~2)

Result in EM scale. More effect will come from calibration based on shower shapes…. Need to validate other shower variables.

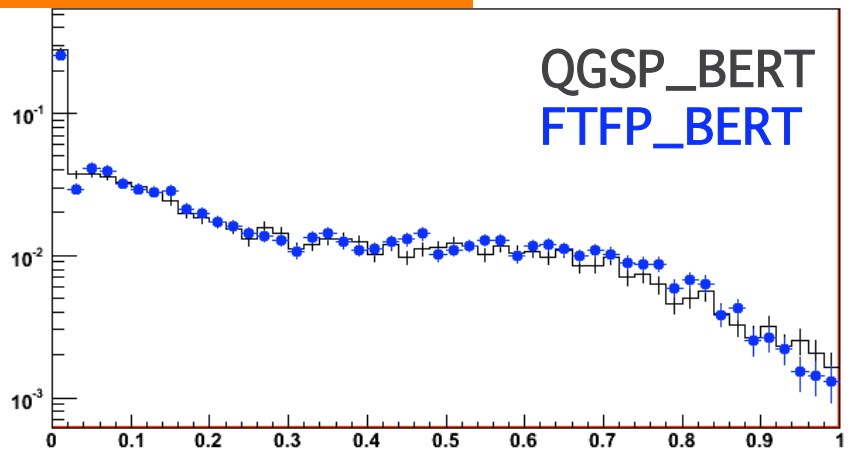
# QGSP_BERT and FTFP_BERT

We should perform similar comparison between data and MC as done in Testbeam using collision data (for double check, too).

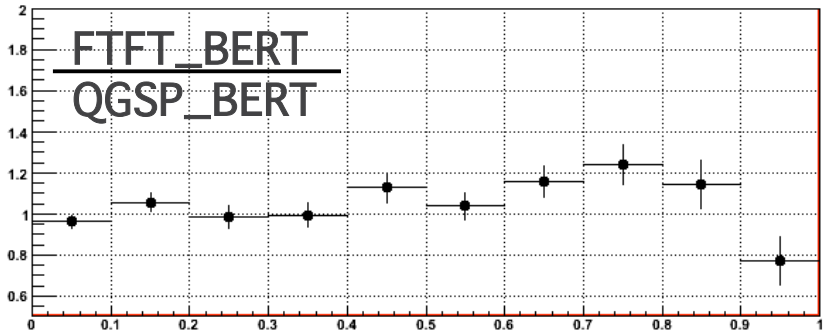
$E_{TOT}/p$ (E=5 GeV)




$E_{HAD}/p$ (E=5 GeV)

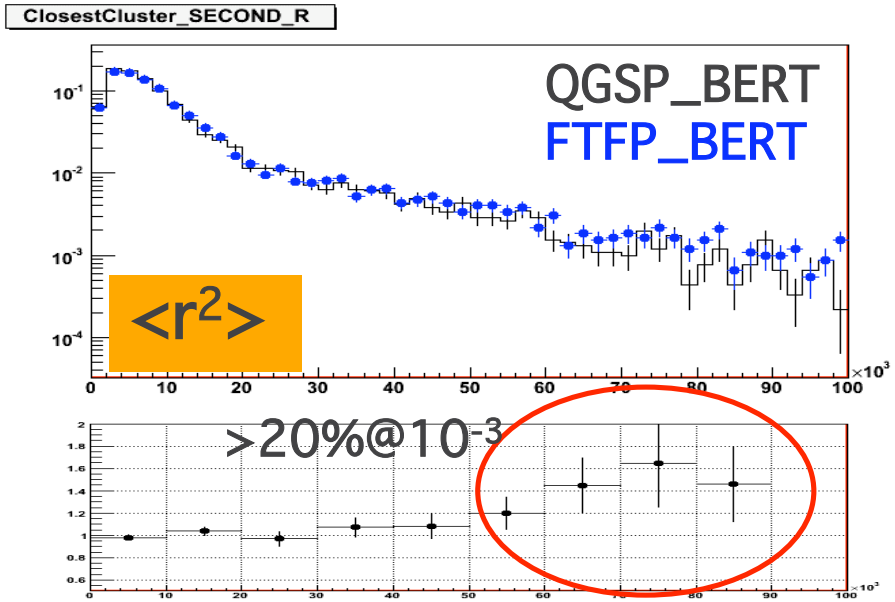


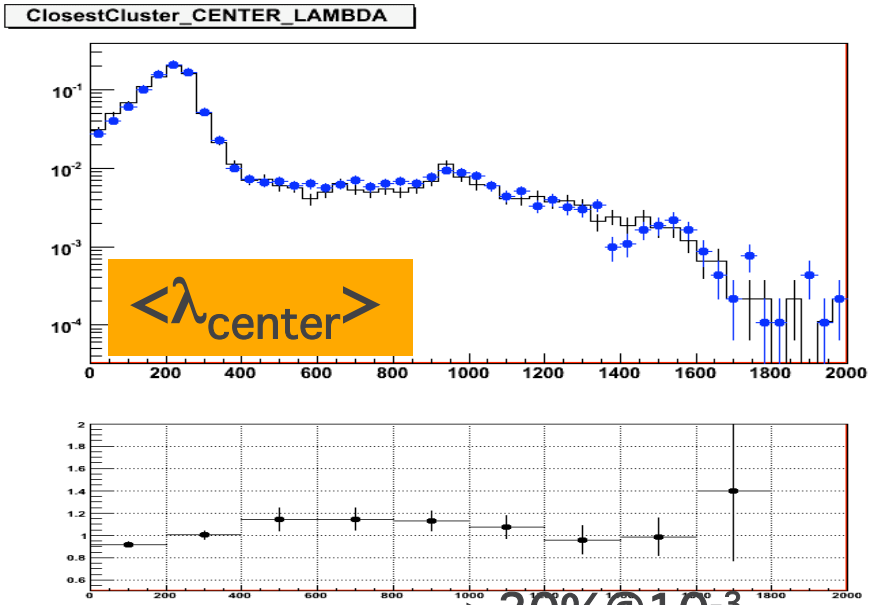

FTFP_BERT give higher calorimeter Response than QGSP_BERT (and Testbeam data)

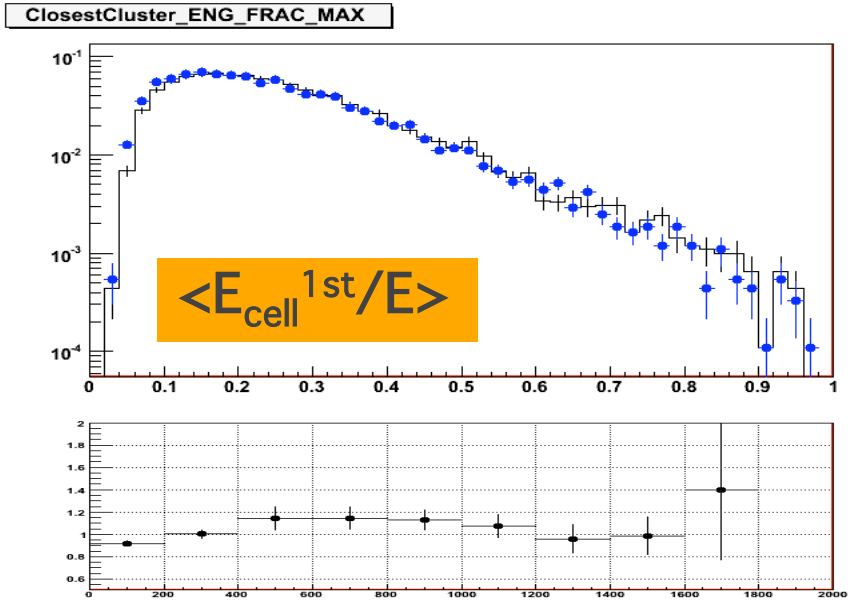


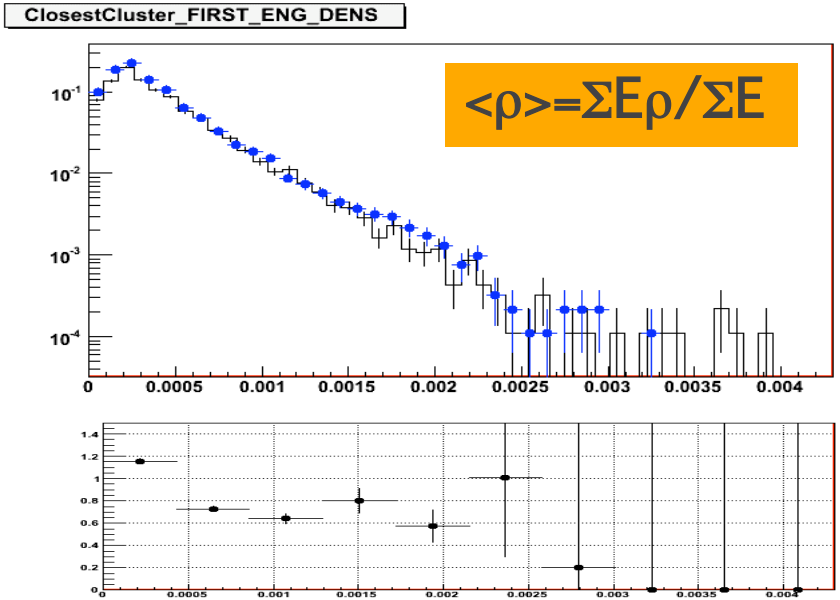
# QGSP_BERT and FTFP_BERT

QGSP_BERT/FTFP_BERT
E=9GeV(eta=0.2-0.4)



# Summary & Outlook

(1) Sensitivity to dead material in front EM calorimeter and between barrel and endcap.

- Can be a complementary to test using EM-showering particle.
- Lower E has more sensitivity to the material, but need to control stability of event fraction with E/p=0.
- Resolve effect of EM/HAD calorimeter volume for material between barrel and endcap (large uncertainty is expected)

(2) Impact on absolute jet energy scale correction (calorimeter jets -> particle jets)

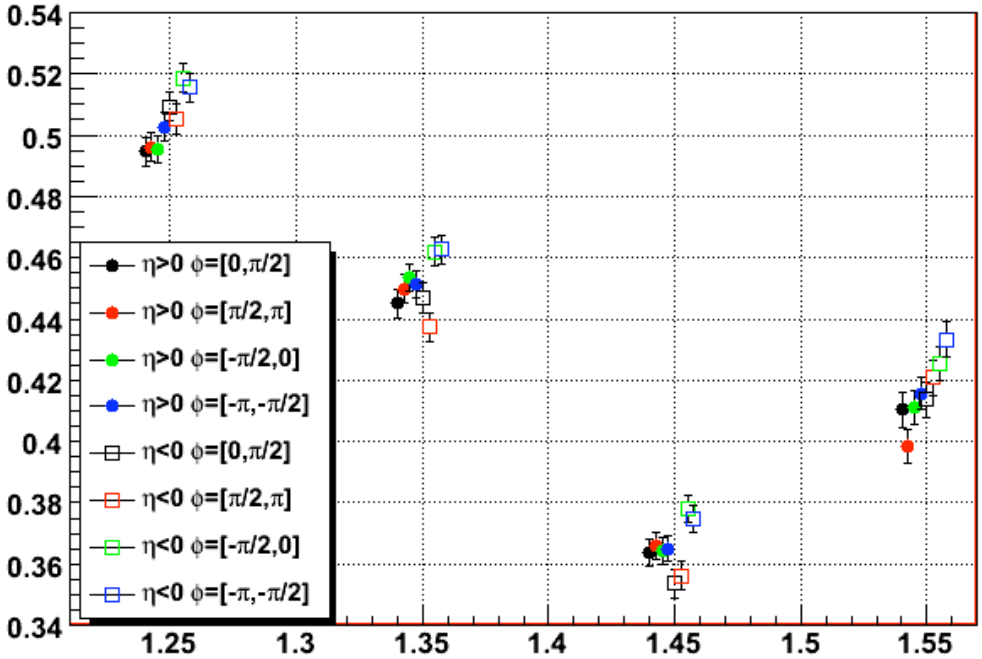
- ~1% effect in QGSP_BERT case (very preliminary check)
- Find other shower variable sensitive to G4 physics list (under presence of background)
- Check E/p in other region (EMEC/HEC)

Need more work for quantitative result…

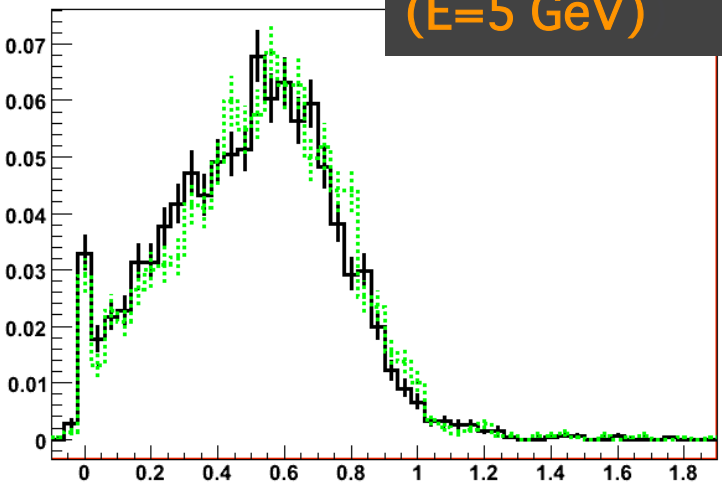
# Backup Slides

# Single pion response

## E/p (E=5 GeV)




## eta=1.2-1.3 (E=5 GeV)



## eta=1.5-1.6 (E=5 GeV)