Improving Jet Energy Resolution Using Tracks

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Outline:

- Introduction.
- TrackCalJet algorithm overview.
- Simulation results:
    - Single pion response.
    - Jet energy and mass resolution.
- Data results:
    - TrackCalJet kinematics.
    - Jet energy resolution.

Introduction

Jet energy resolution has two main contributions:

- Intrinsic calorimeter resolution:

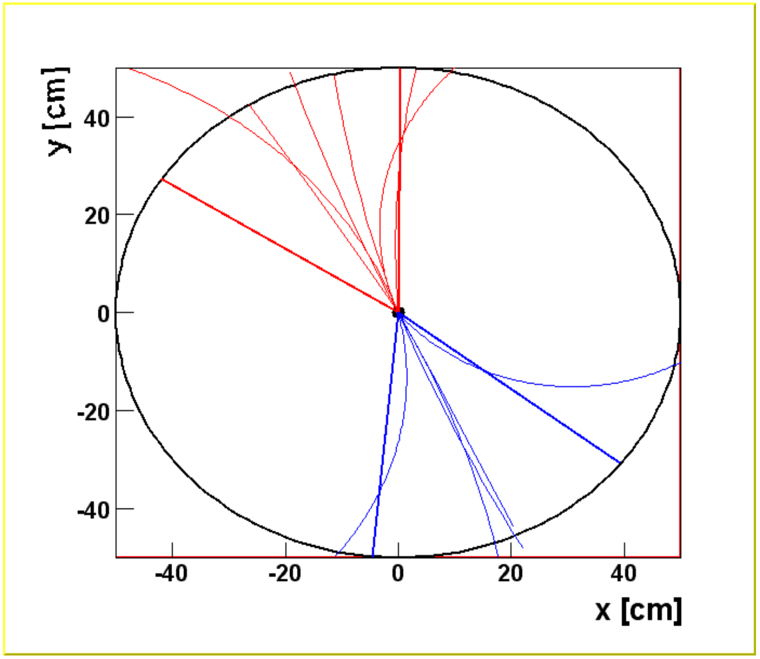
  Noise.

  Different responses of electrons/photons and hadrons.

  Magnetic field.

- Jet composition:

  Fragmentation.



Tracks in jets contain information about the jet composition that can be used to improve the energy resolution.

Method: for every charged hadron in a jet (track):

- *subtract* the expected energy deposited in the calorimeter and *add* the track momentum.
- *Add* the energy of out-of-cone tracks.

Based on Jet Plus Track CMS Algorithm technique.

Track-Cal-Jet Algorithm Overview

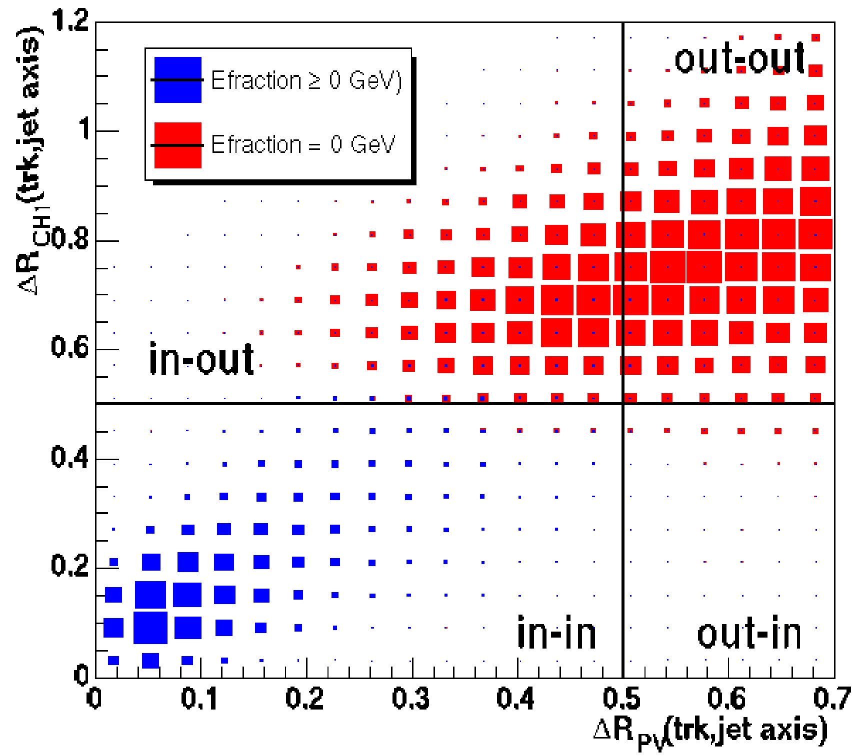
Propagate tracks to the calorimeter surface.

dca(xy) < 0.15cm, dca(z) < 0.20cm

Classify tracks:

DR(vtx)<0.5, DR(cal)<0.5 : IN jet

DR(vtx)<0.5, DR(cal)>0.5 : Out-of-cone



For each IN-jet track:

If Ecal(3x3) / Etrk > 0.5

Ejet -> Ejet + (1-R).Etrk

Otherwise,

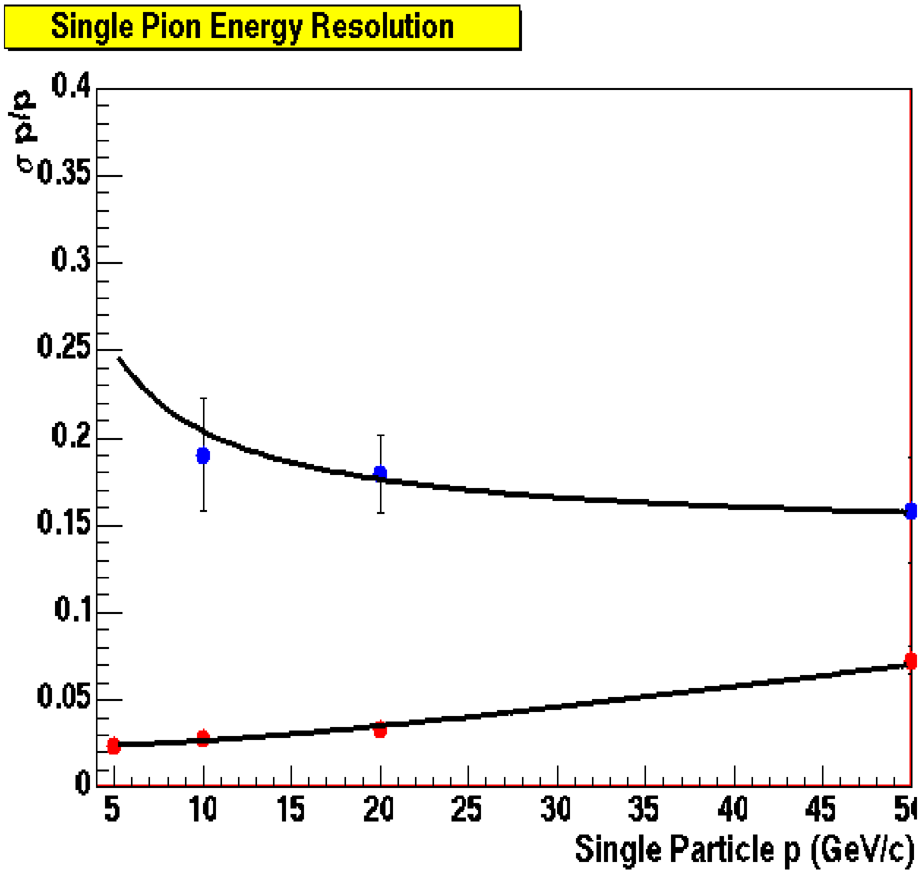
Ejet -> Ejet + Etrk

For each Out-of-cone track:

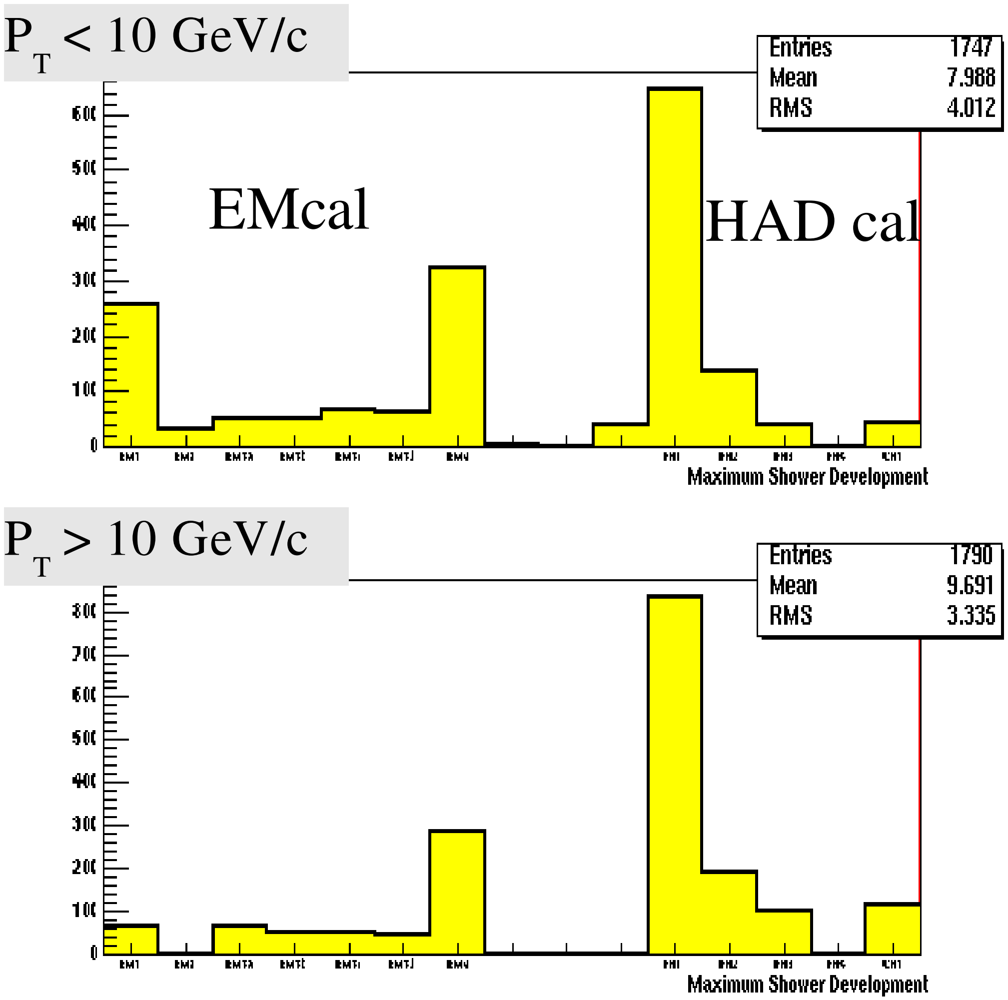
Ejet -> Ejet + Etrk

R = R(p) is the single pion response.

Single Pion Response in the Simulation

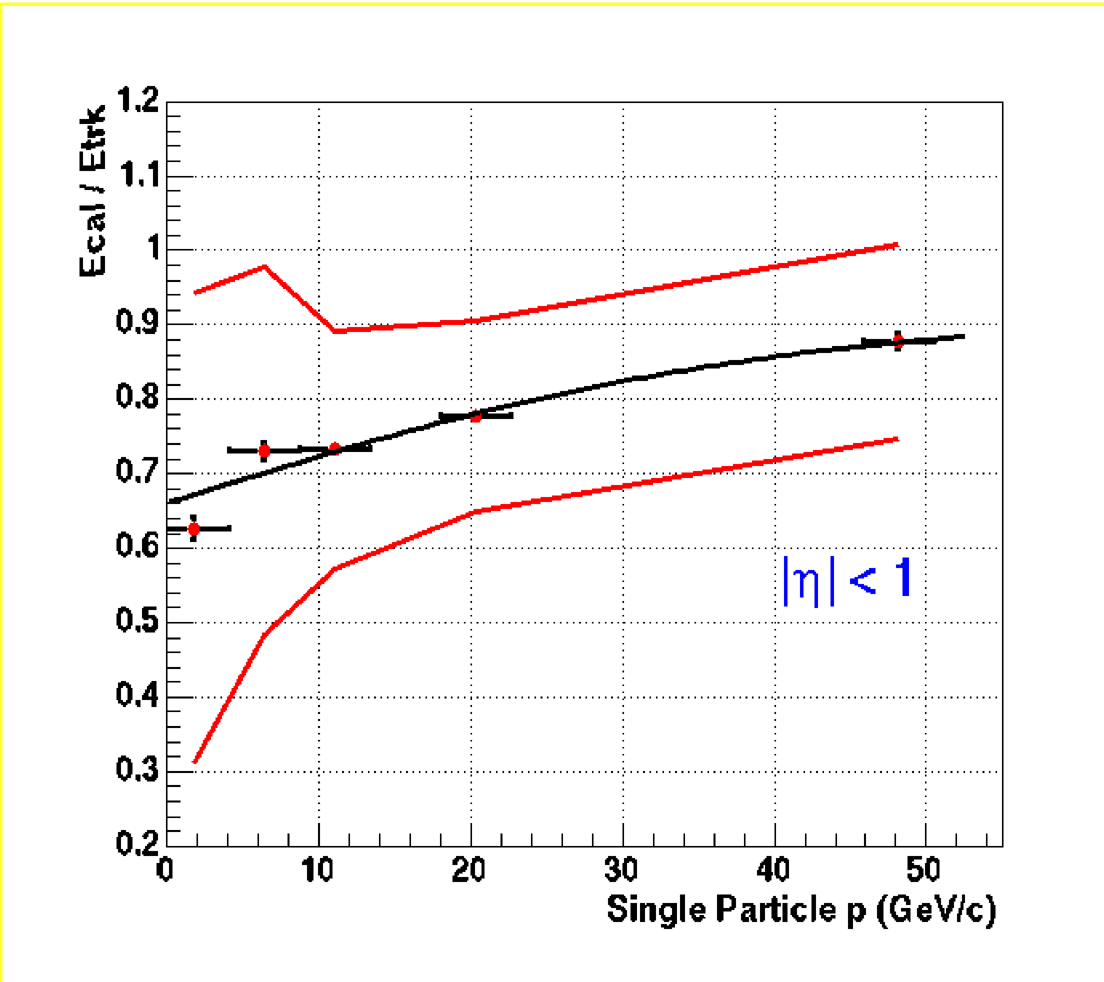


Single pion longitudinal shower profile for low and high pt tracks

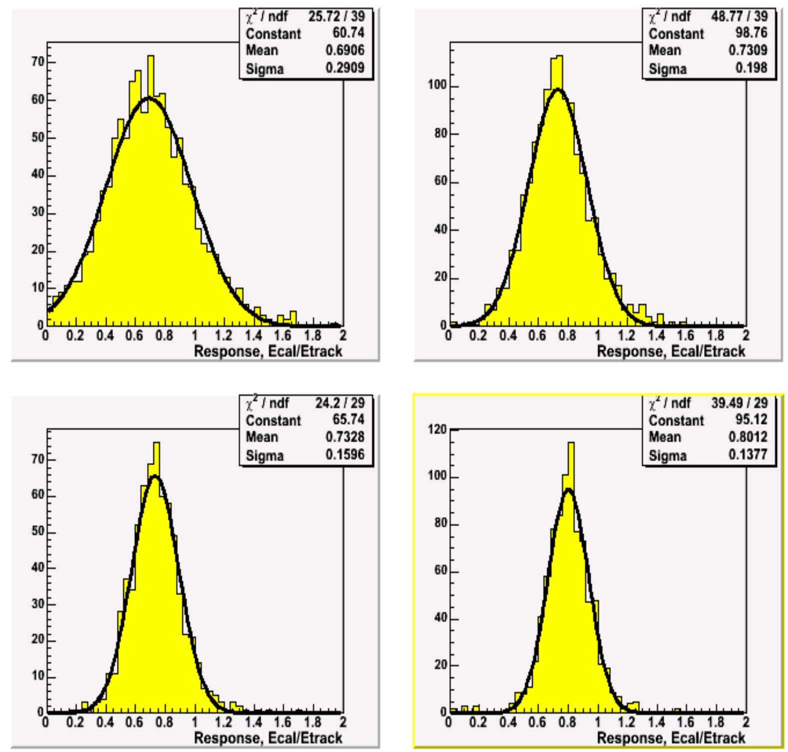


In the simulation, track momentum resolution is significantly better than calorimeter energy resolution.

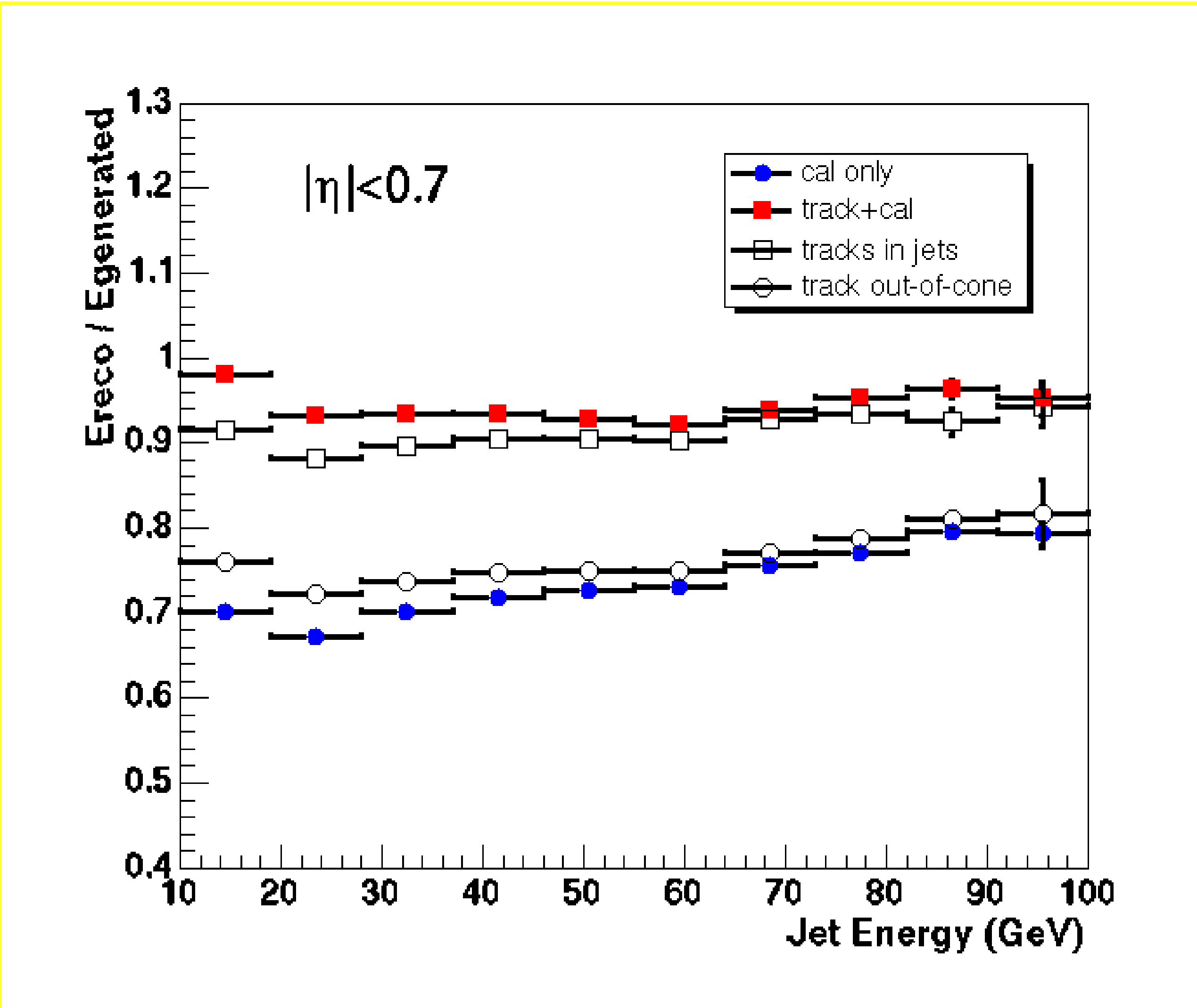
Single Pion Response in the Simulation



Hadronic E/p response in the Central Calorimeter as a function of track p.



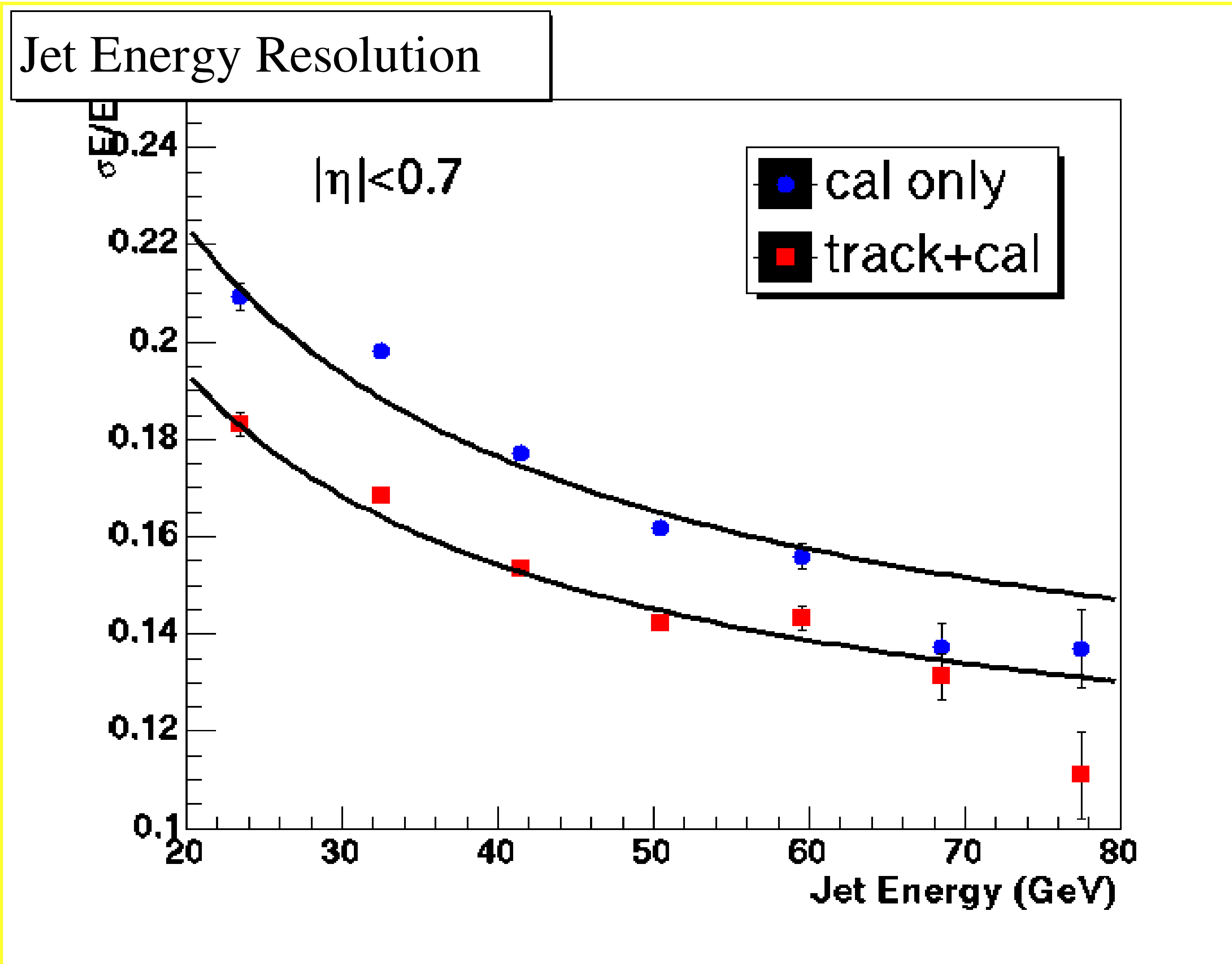
Algorithm Performance in Zqq Events



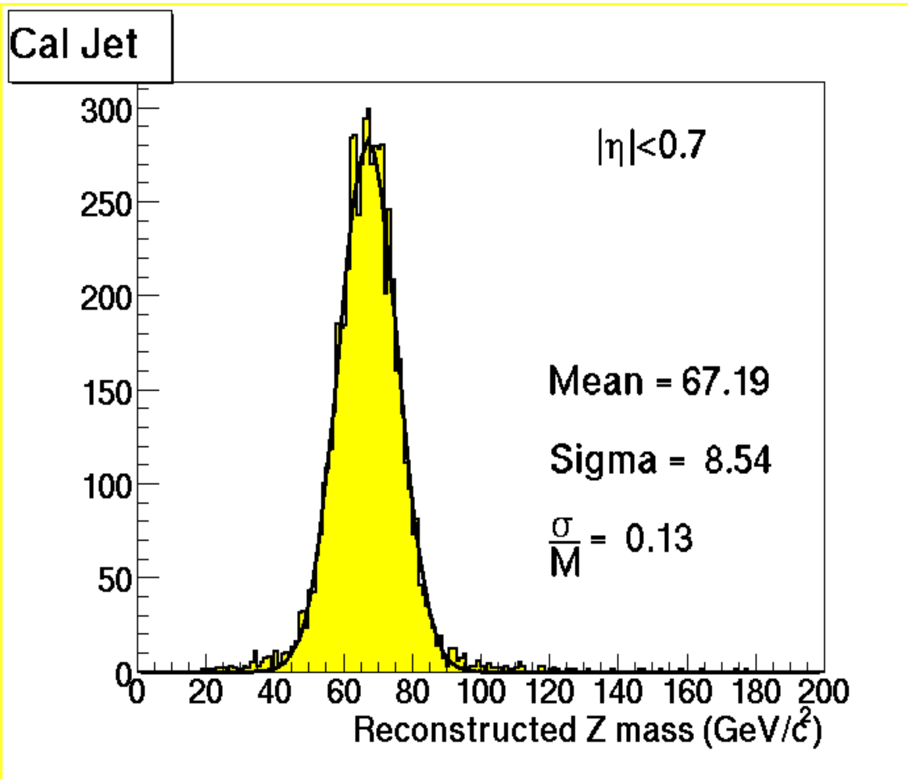
Jet energy scale is significantly improved with the use of tracks.

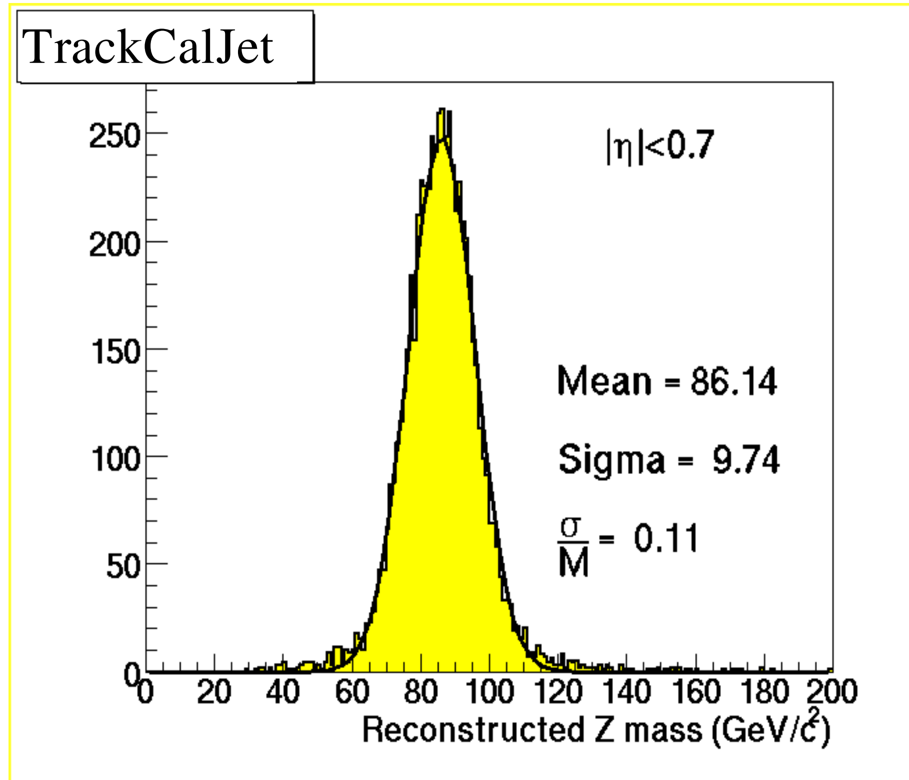
The largest improvement comes from tracks inside the jet cone.

Algorithm Performance in Zqq events

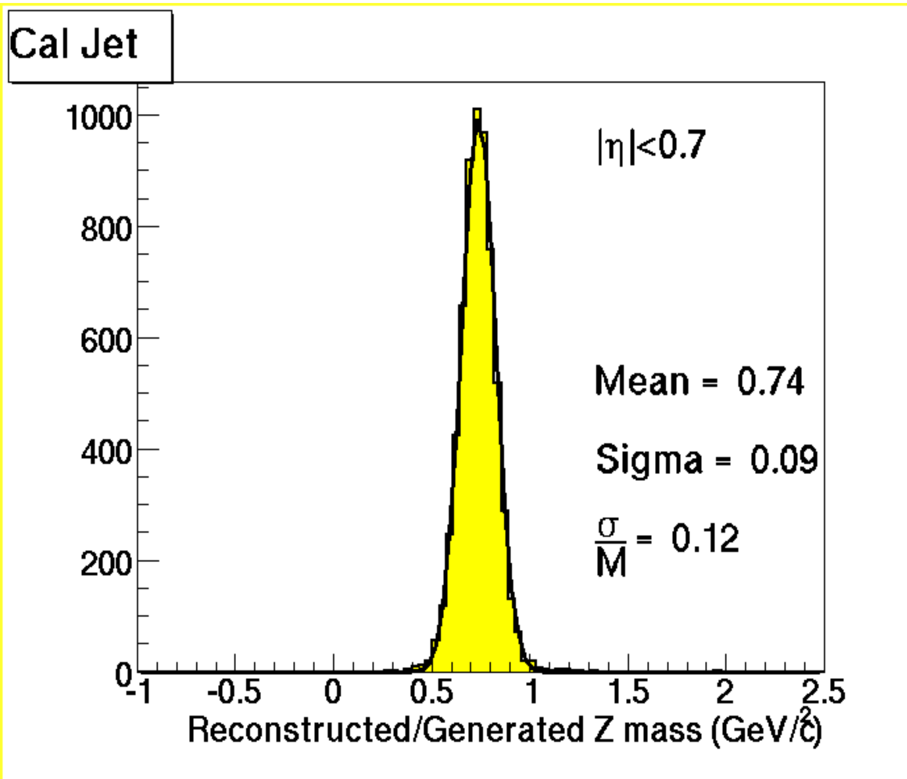


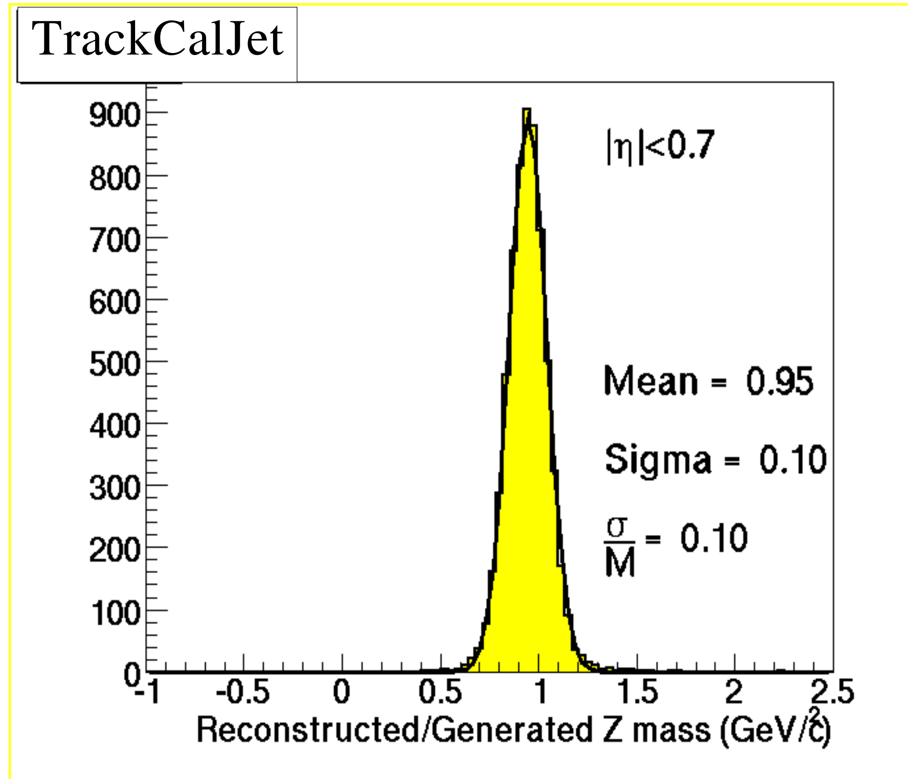
Dijet Mass Resolution in Zqq events (I)





Dijet Mass Resolution in Zqq events (II)





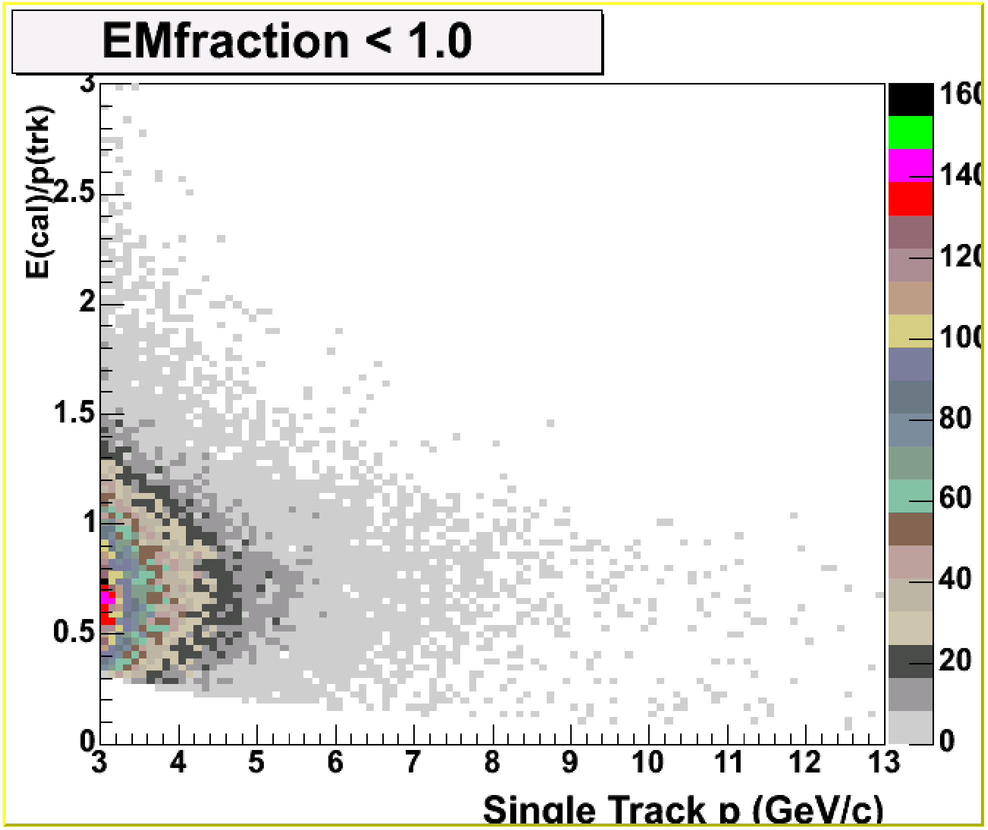
15% mass resolution improvement.

Single Pion Response in the Data

- Minimum bias triggered events.
- Tracks are propagated to the calorimeter.
- **p > 3 GeV, dca(z)<1cm**

- Compute calorimeter isolation in 3x3 and 5x5 roads around the tracks.
- **E(5x5)-E(3x3) / E(3x3) < 1%**
- **Ecal(3x3) > 1 GeV/c**

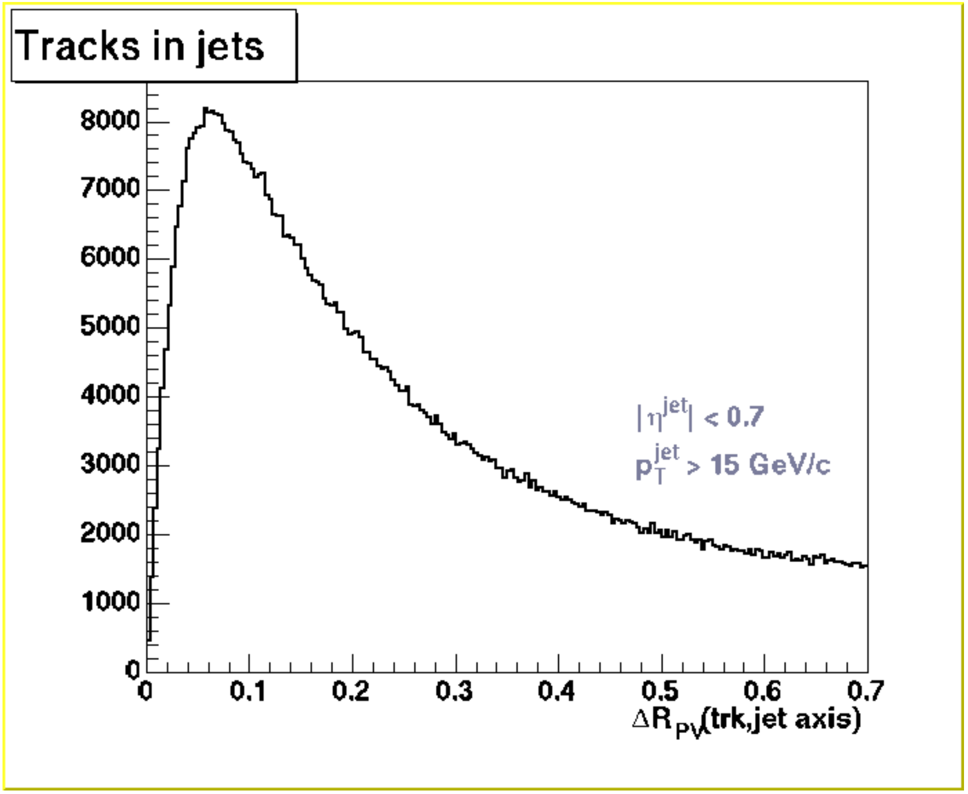
- Require track isolation (DR>0.3)

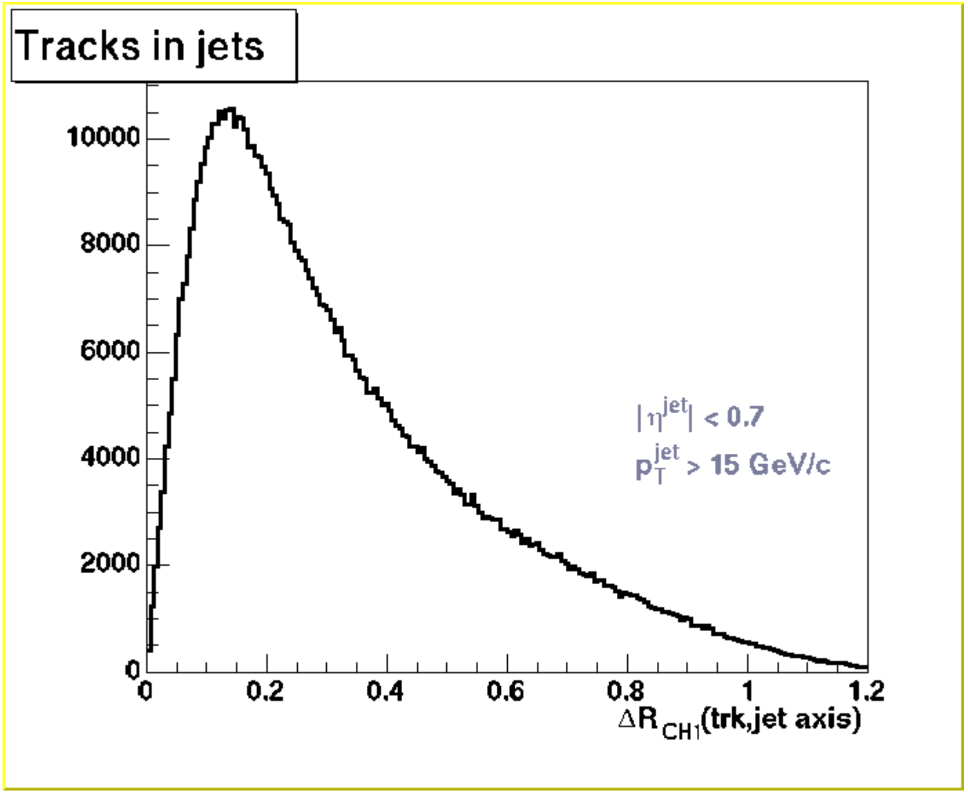


Work in progress.
Currently, Monte Carlo derived response is used.

TrackCalJet Kinematics in the Data (I)

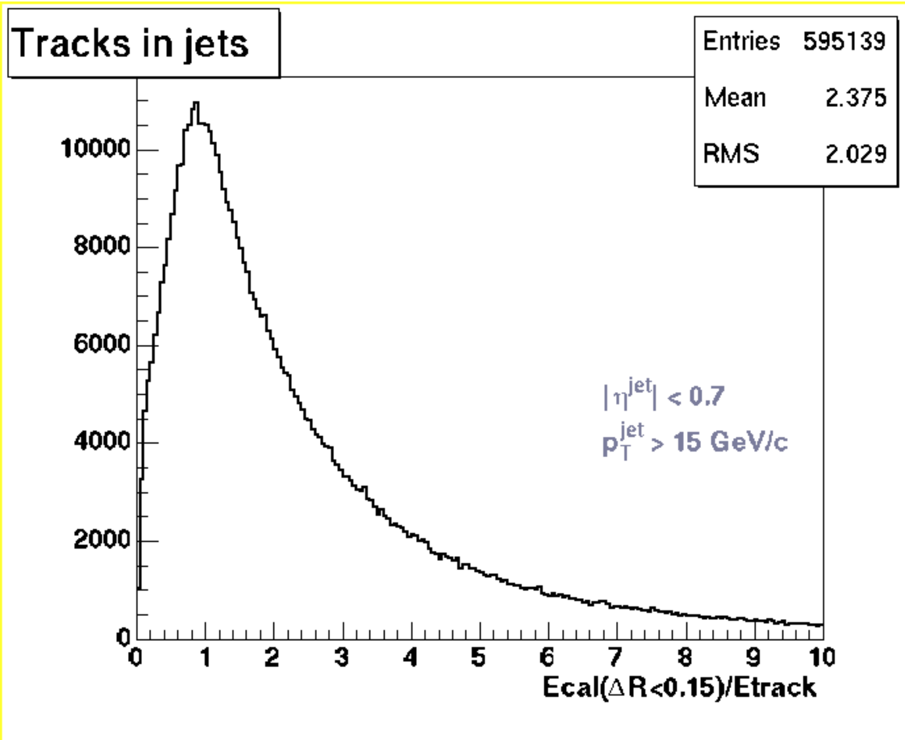
Photon + Jet event selection. Use photon p_T as true jet energy.

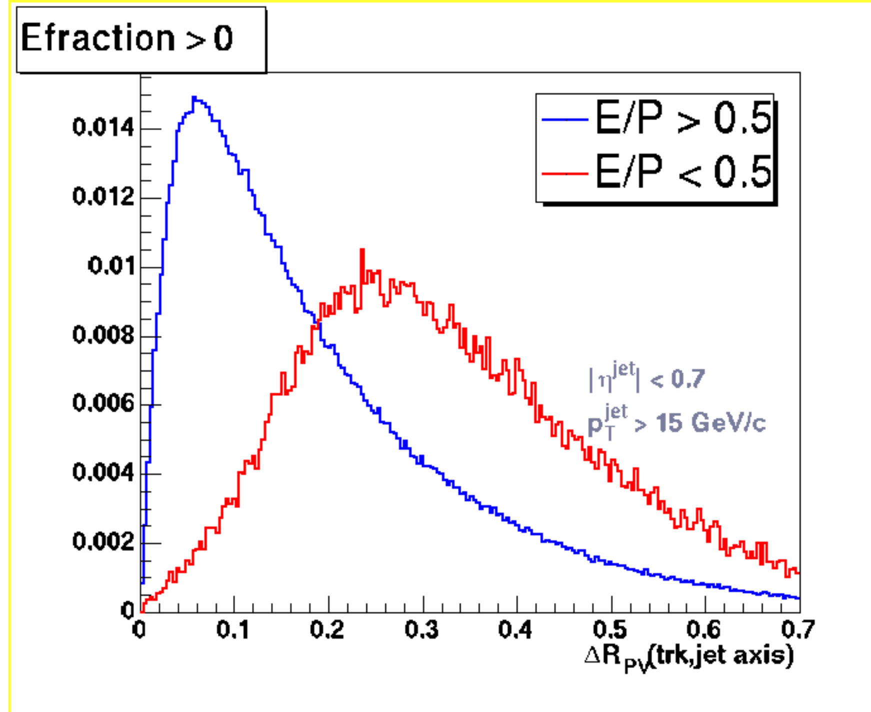


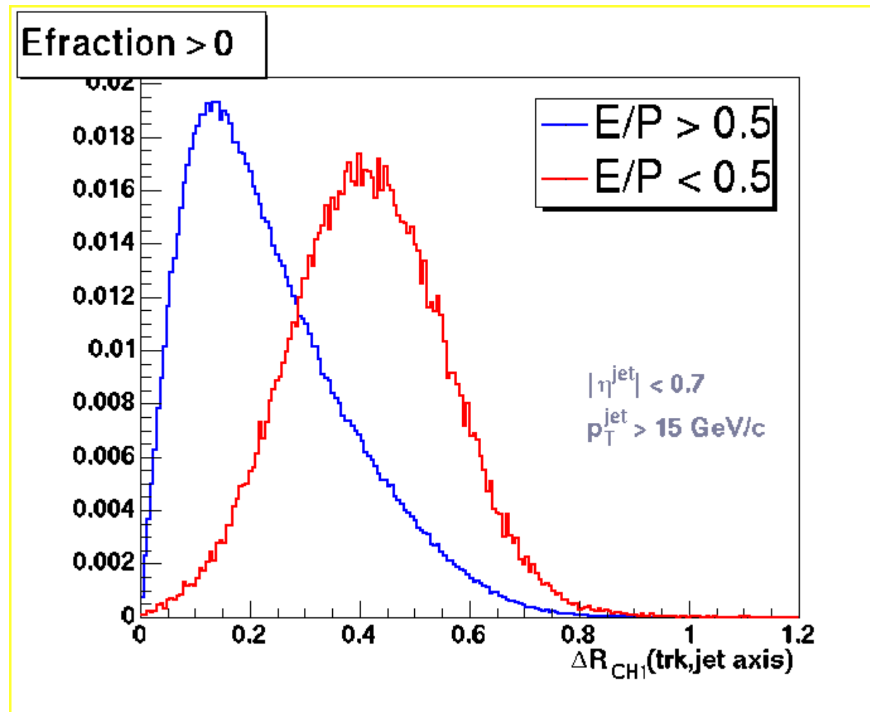


Distribution of eta-phi distance between tracks and jet-axis at the vertex and at the calorimeter surface.

TrackCalJet Kinematics (II)

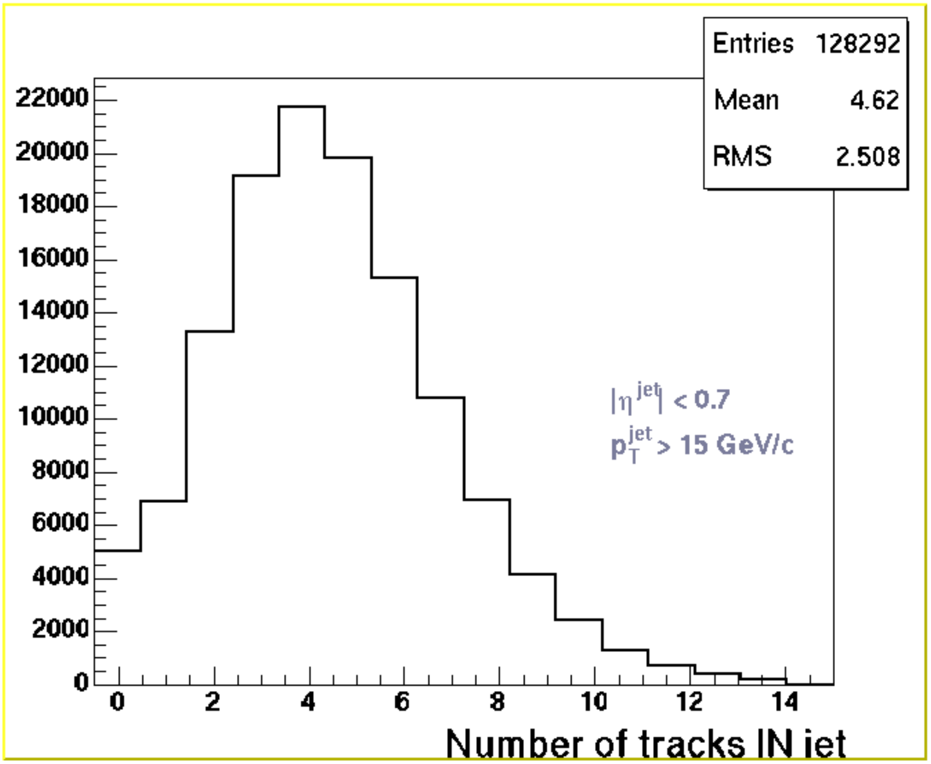


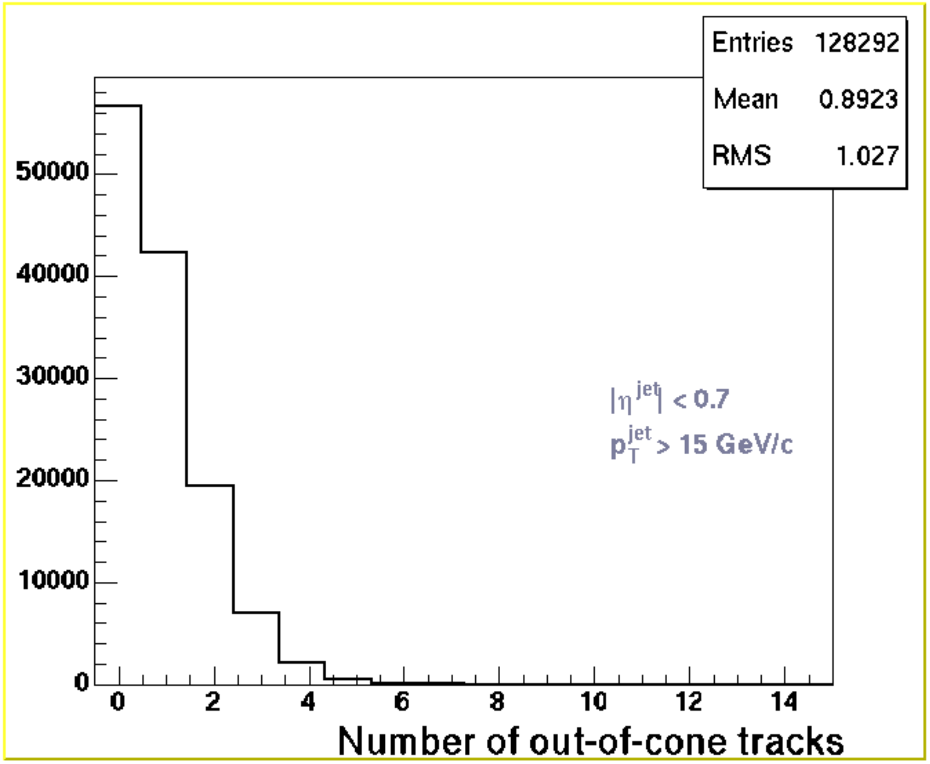




E/p distribution of tracks in jets.
Lower response at jet cone edges.

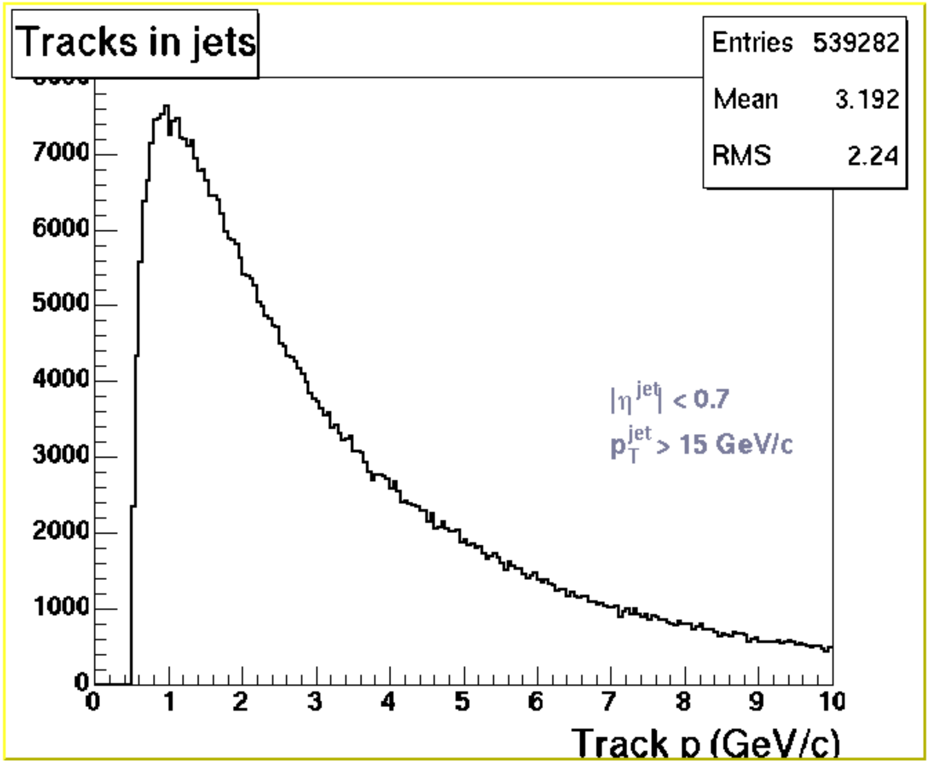
TrackCalJet Kinematics (III)

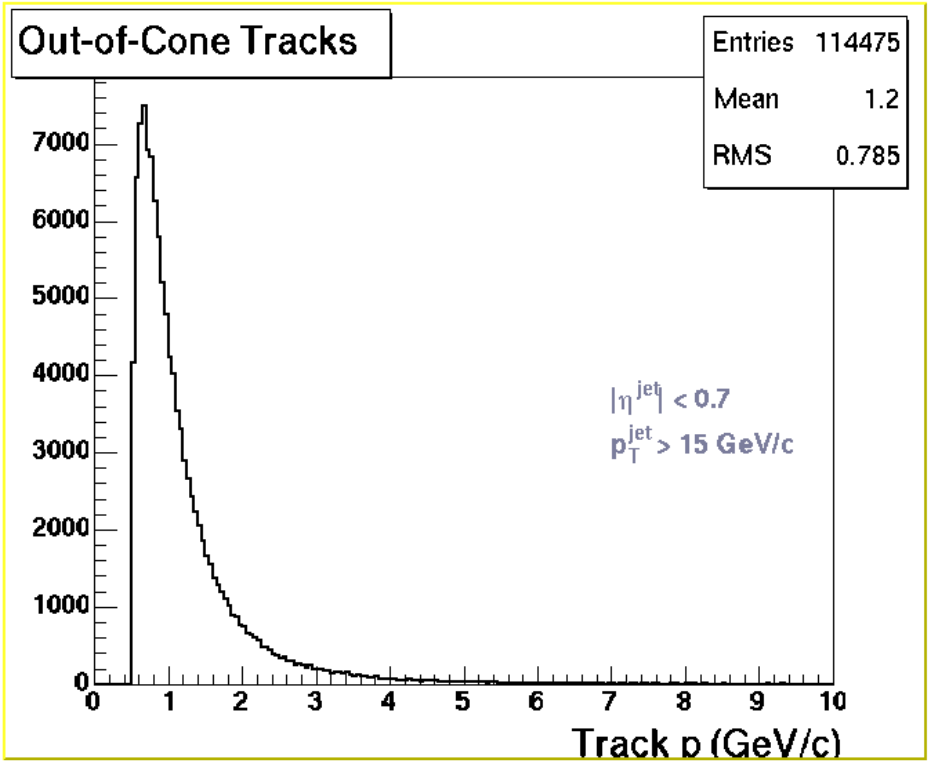




Distribution of number of tracks classified as IN-jet and Out-of-cone.

TrackCalJet Kinematics (IV)

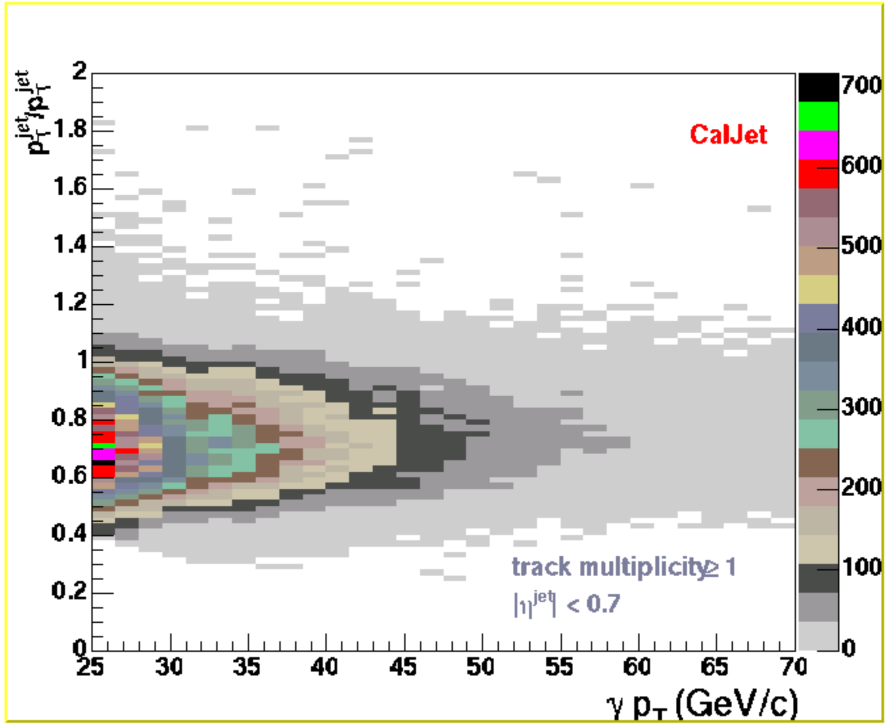


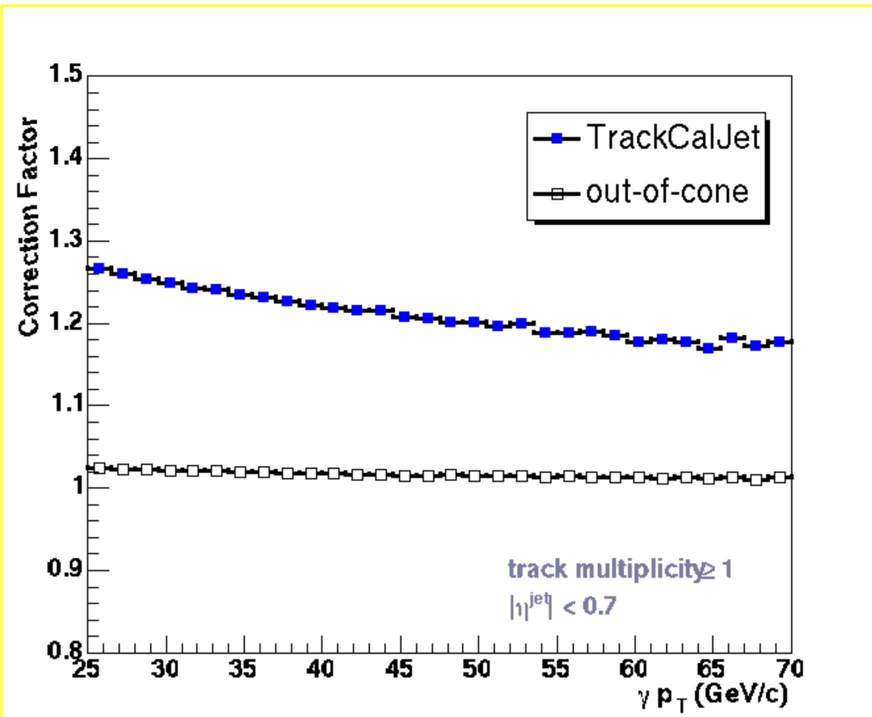


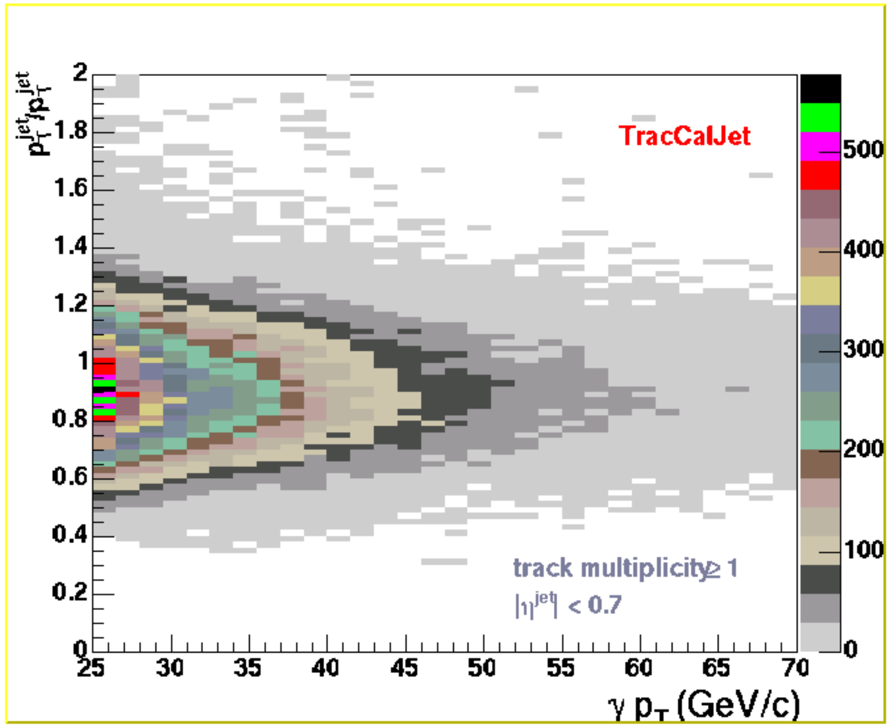
Momentum distribution of tracks classified as IN-jet and Out-of-cone.

TrackCalJet Performance

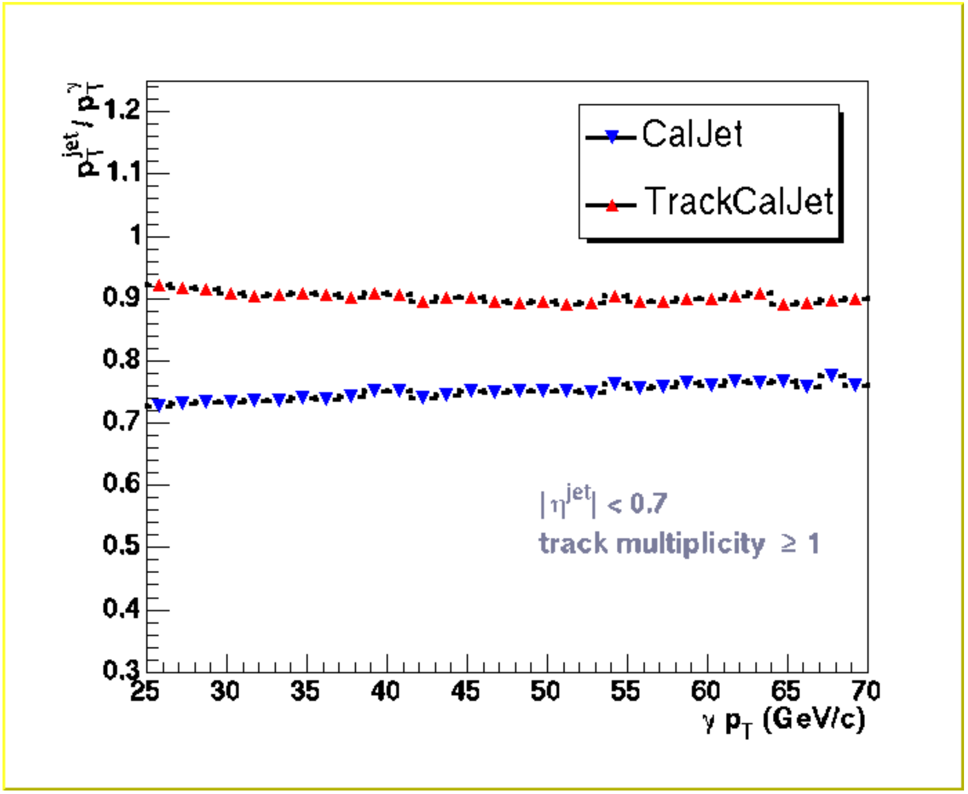
- Jet energy scale is improved by the use of tracks.
- Average correction factor between 20% and 25%, mostly from IN-jet tracks.

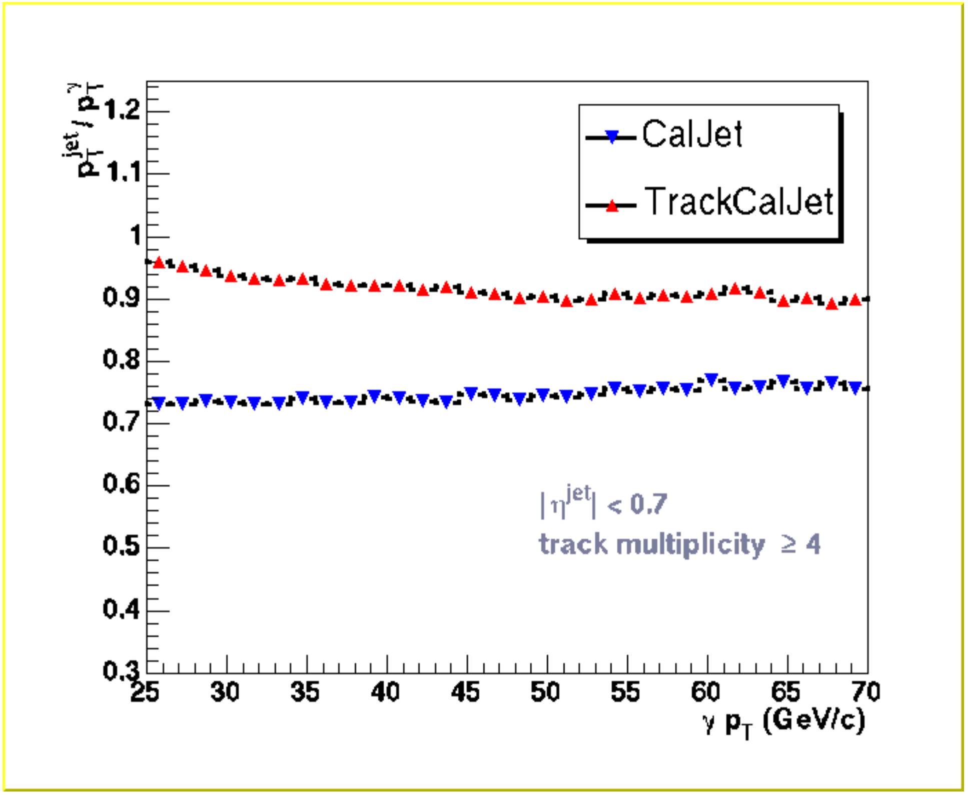






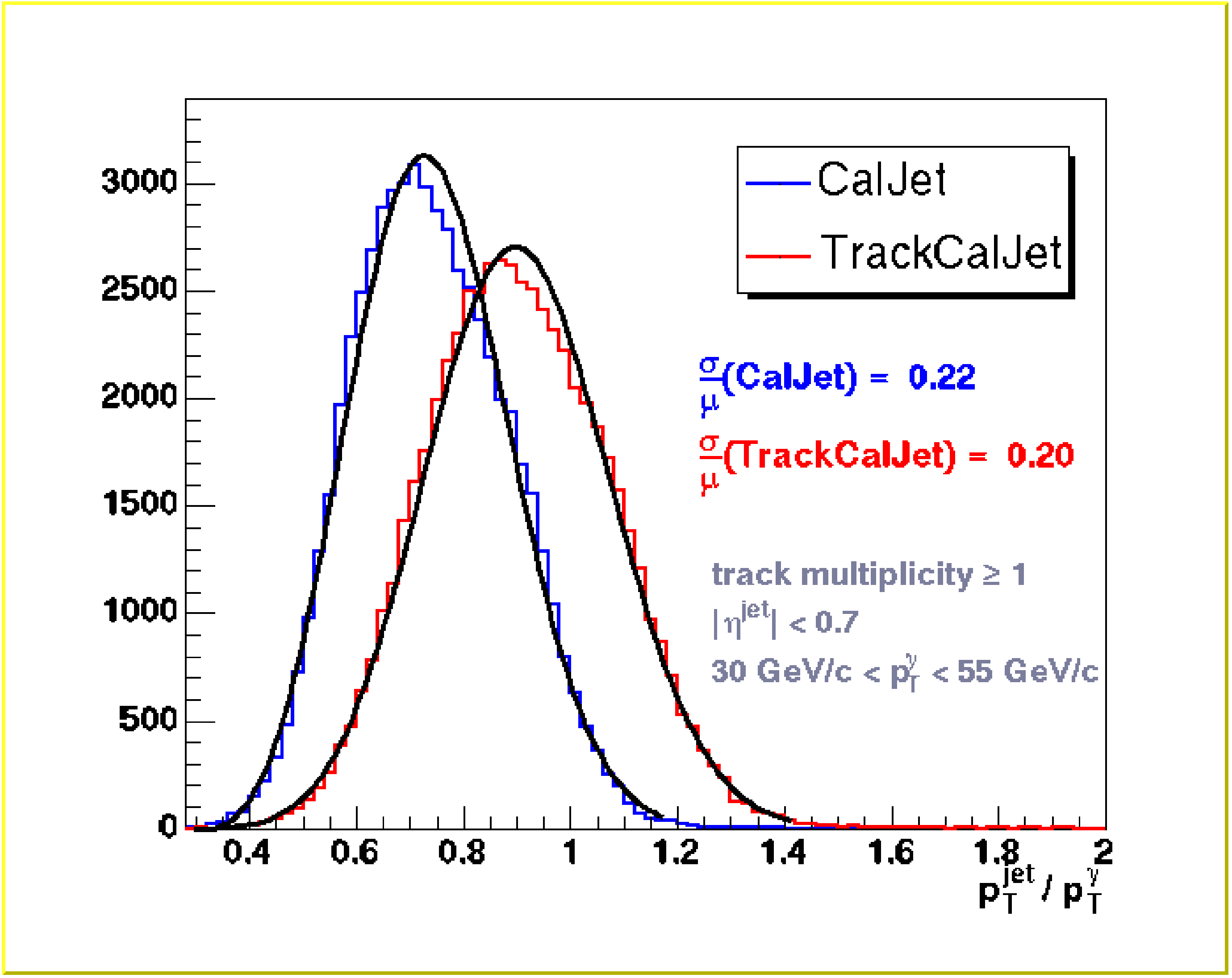
Jet Energy Scale





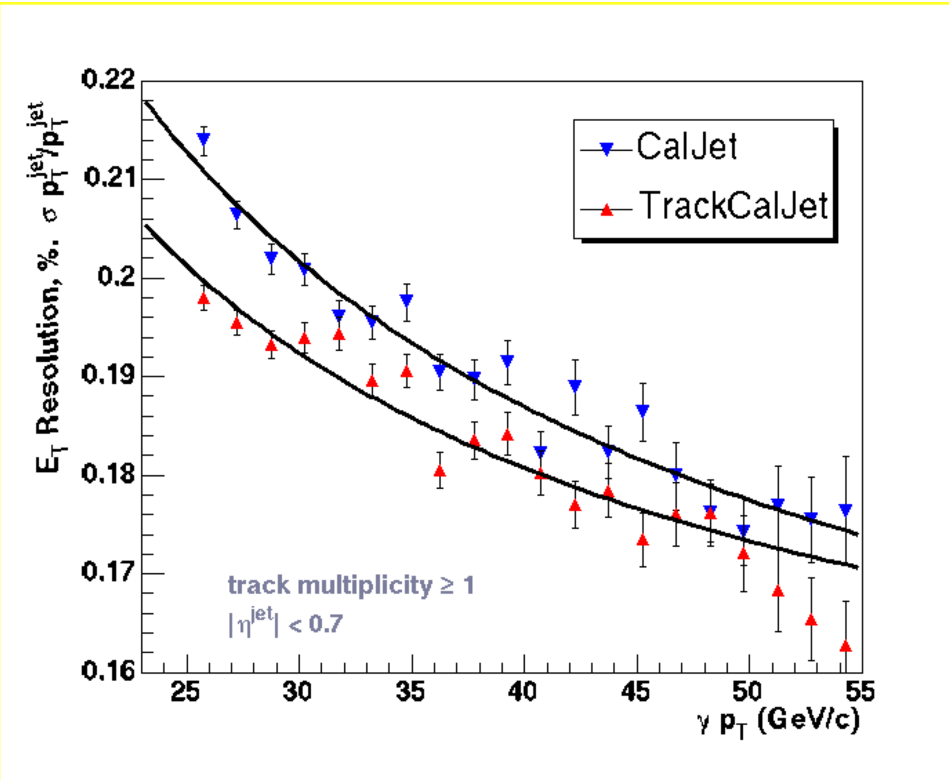
Jet offset is larger than in the simulation:
- Smaller number of tracks used.
- Single pion response in data is lower than in Monte Carlo.

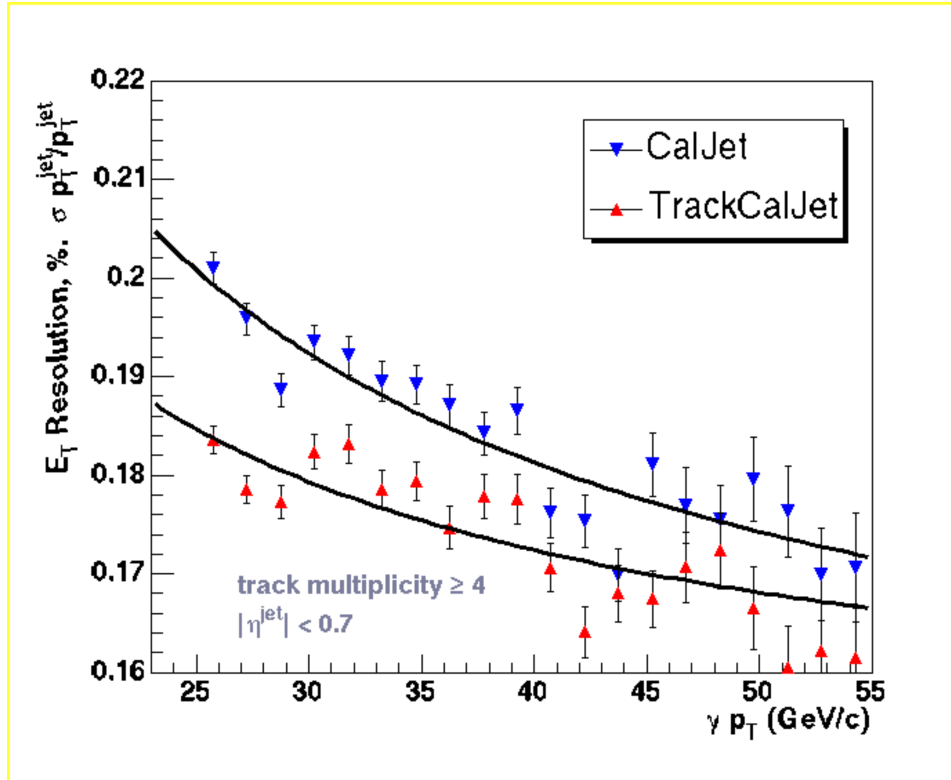
Jet Energy Resolution (I)



10% resolution improvement.

Jet Energy Resolution (II)





Jet energy resolution dependence on Jet p_T for low and high track-multiplicity jets.

Summary and Conclusions

New technique for combining tracks and jets has been implemented.

- 15% jet energy and mass resolution improvement in the simulation.
- 10 % jet energy resolution improvement in photon+jet data.

Largest improvement comes from considering tracks in-jets.

This techniques relies in a accurate single pion response determination.

Currently, a Monte Carlo derived response is used.

Next steps:

- Single pion response measurement in the data.
- Algorithm optimization (track quality, matching criteria)
- Jet energy scale determination.