JetEtmiss Working Group Meeting
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E/p calibration for low energy pions

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E/p method: Review

- Motivation:
  - The calorimeters response to single hadrons will need to be measured in-situ.
  - The goal is to know this energy scale to within 1% to that the hadronic calibration can be checked.
  - This work covers the low energy range (< 15GeV). Above this taus maybe used as a source of isolated pions.
- Method:
  - Charged pion momentum (p) from the inner detector should be very accurate for lower energies.
  - The hadronic calorimeter calibration can be checked by comparing to the cluster energy (E).
  - Eta coverage limited by Inner Detector range
  - Tracks are extrapolated to the 2^{nd} layer of the EM calorimeter. Those with a matching cluster within $\Delta R_{match}<0.05$ are used.
  - The energy E is taken as the sum of caloTopoClusters energies inside a cone of $\Delta R_{cone}=0.4$ and within $|\eta|<2.5$. Although other clusters type and calibration schemes could potentially be used

Datasets used

- Current work is based on ESD from Athena 12.0.6 official production.

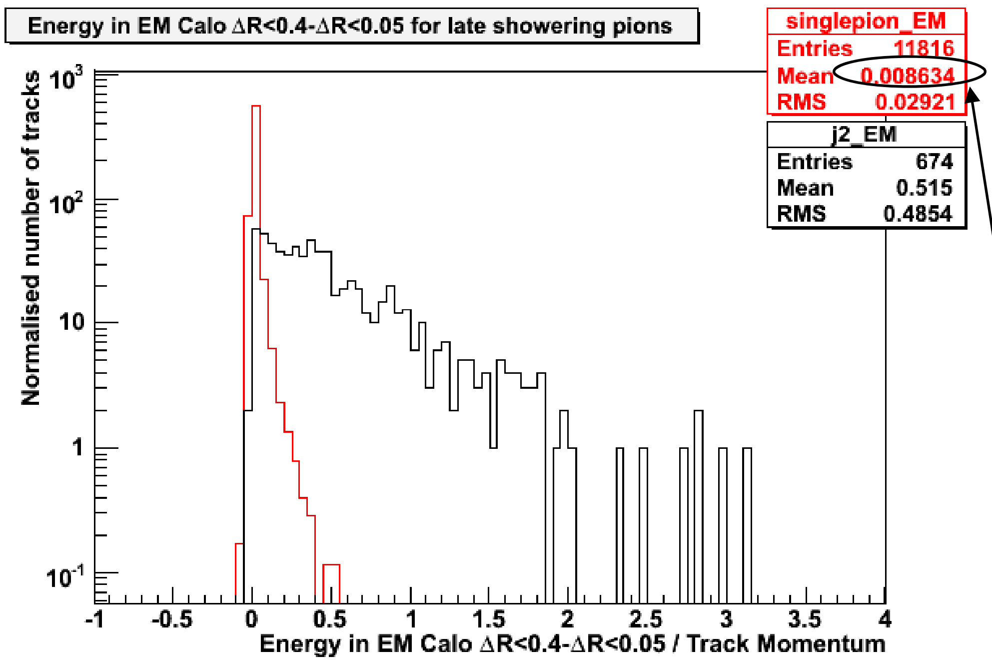
- Physics samples are compared to single particle samples to measure how effective the method is. Data samples being used for the current work are:
  - For study of 1GeV pions:
    - Minimum bias events.
      - trig1_misal1_mc12_V2.005001.pythia_minbias.recon.ESD.v12000604
    - Single pions with et=1GeV
      - trig1_misal1_mc12.007421.singlepart_singlepi_et1.recon.ESD.v12000604
  - For 10GeV pions:
    - J2 dijet events.
      - trig1_misal1_csc11.005011.J2_pythia_jetjet.recon.ESD.v12000601
    - Single pions with et=10GeV
      - trig1_misal1_mc12.007422.singlepart_singlepi_et10.recon.ESD.v12000601

Progress to date

- Previously was shows that isolated pions at 1GeV in minimum bias can be found with a cuts based method
- For 10GeV pions, there is a large amount of correlated background and isolated pions are much more difficult to find.
  - For example only 50/400,000 pions isolated by $\Delta R > 0.4$ from other particles in minimum bias.
  - Appears to also be true in other physics samples such as dijets.
  - Also a problem for pion of energy O(1GeV) when pile-up is considered (even a small amount).
- Currently work is looking into a subtraction technique to take into account the contaminating energy from close particles.

Contamination Subtraction with Dijiets

- Example with 350k dijet events from J2 dataset
- Approx. 9,000 tracks with 8<Pt<12GeV which pass basics cuts:
  - $\eta|<2.5$, $\Delta R_{matching\ cluster} <0.05$, $\Delta R_{track\ isolation} > 0.2$, B layer Hits > 1
- Some extra cuts used to reduce the overall contamination from neutrals
  - Most of the jets energy away from the track:
    - Energy in ΔR=0.7 – Energy in ΔR=0.4 > 0.1*Jet Energy
  - Minimal energy in outer region of pion cone:
    - Energy in ΔR=0.4 – Energy in ΔR=0.2 < 0.5*Track P



Background energy in the EM calorimeter due to neutral particles can be estimated and subtracted using late showering pions.

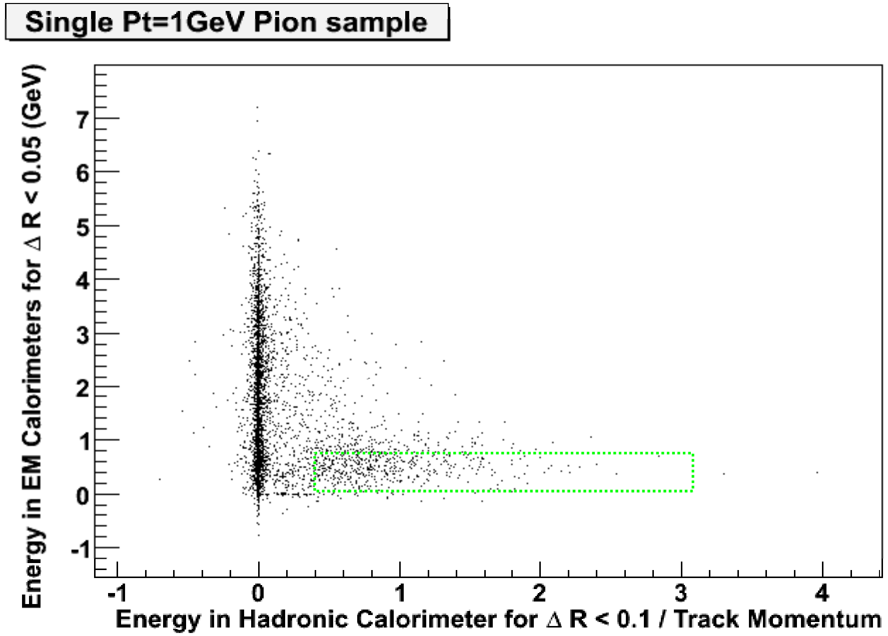
These pions deposit minimal energy themselves in the EM Calorimeter outside a cone of ΔR=0.05.

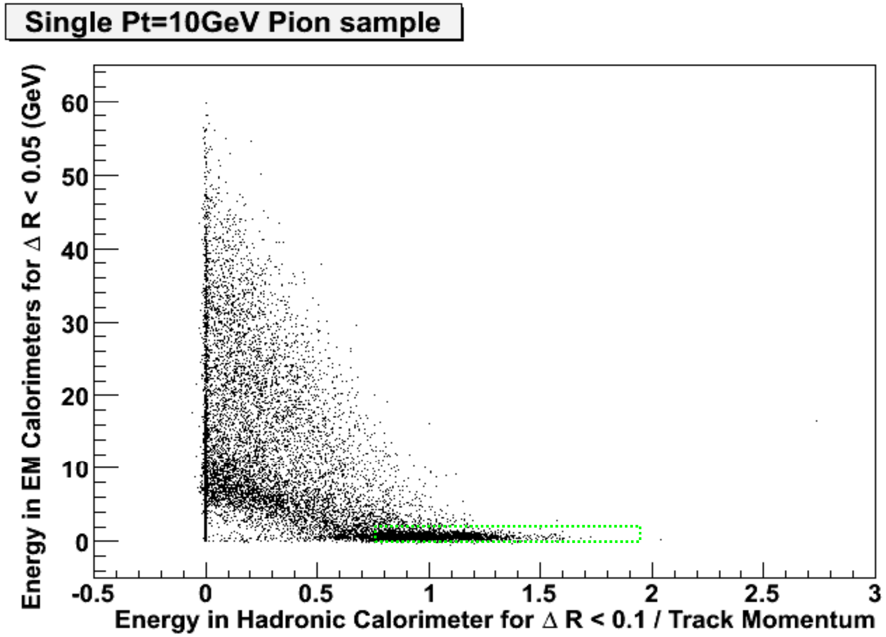
Contamination subtraction

- Late showering pions can be selected by the amount of energy left in the EM and Hadronic calorimeters

- For single particles, EM energy in ΔR<0.05 is generally less between 300-800MeV.

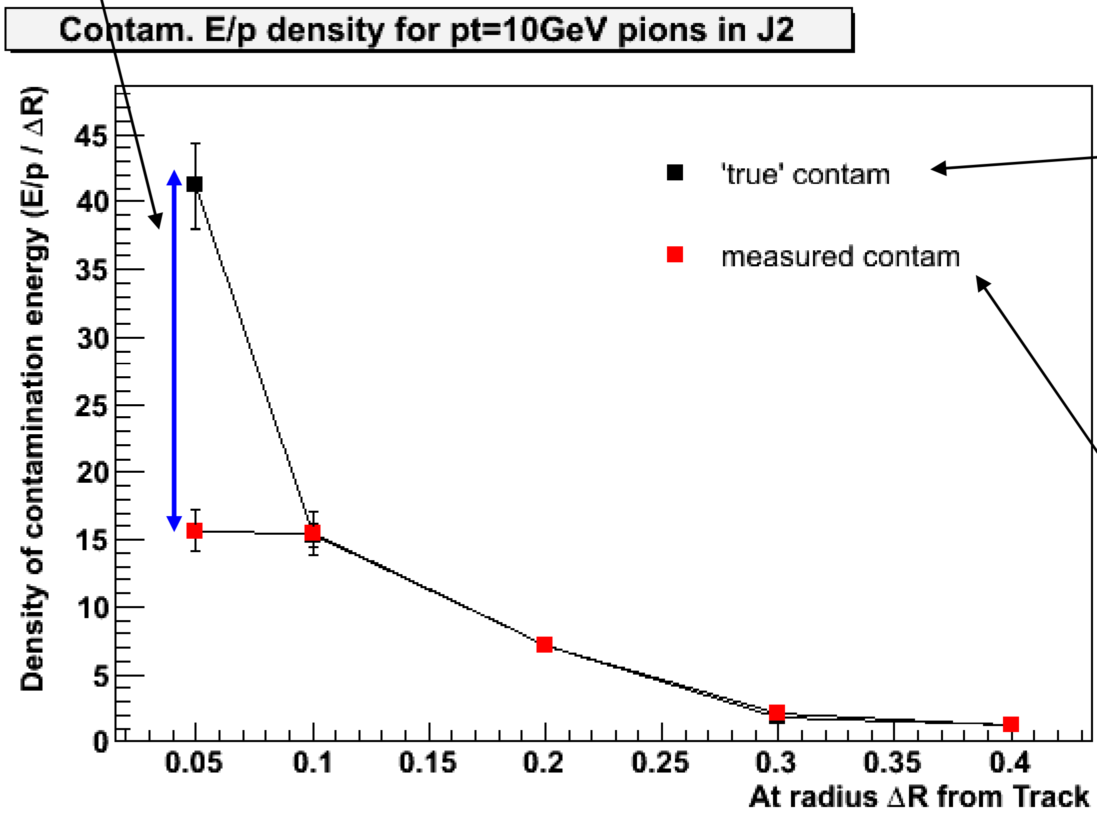
- But with a lot of background this needs to keep loose to ensure we don't choose pions will less contaminating particles close by.
  - EM calo energy in ΔR<0.05 around track is < 0.5 Track P
  - Energy in ΔR<0.1 in Hadronic Calorimeter > 0.5 x Track P





Results

- The subtraction gives good results for the region outside of the core ($\Delta R<0.4$-$\Delta R<0.05$)
- However it is difficult to account for the contamination within the core region.
- The previous assumption that the energy density is approx. that just outside does not work for this example.

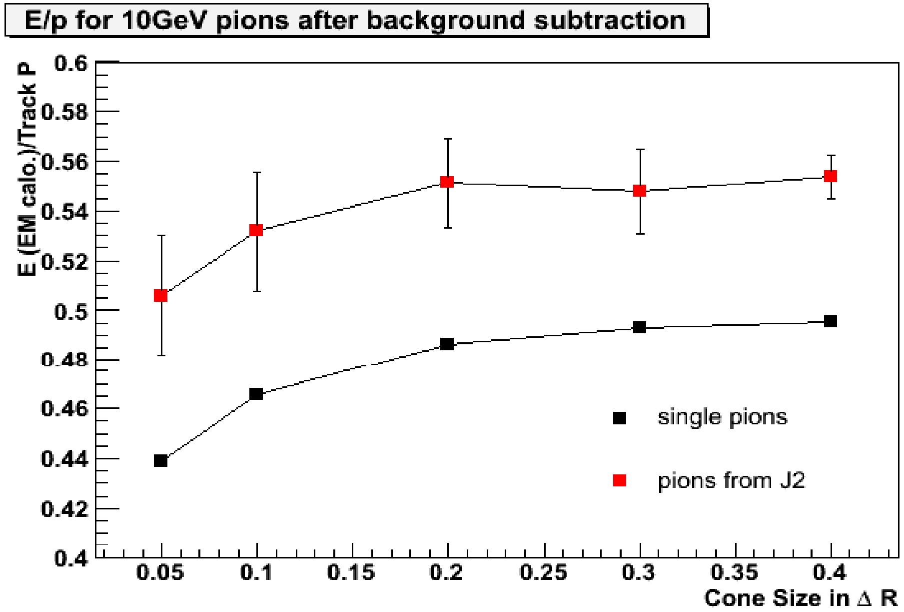


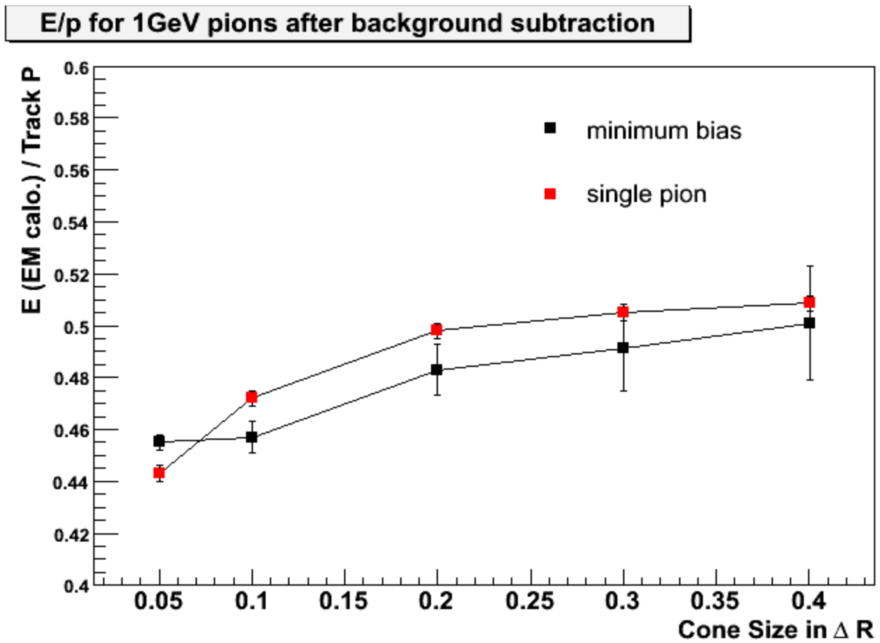
True contamination taken as the difference between dijet pion energies and single pion energies

Measured contamination is taken from the EM energy for Late showering pions

Results

- This extra energy in the core region results in an overall shift of the E_{EM}/p upwards by approx 0.07
- This is not seen in the 1GeV minimum bias case.
- Maybe possible to get better results if some more cuts are applied. This will be useful to:
  - Reduce contam. in the core region.
  - Reduce bias caused by late showering pion selection
  - Reduce contamination in the hadronic calorimeter. Which has not been accounted for yet.





Conclusions and plans

- Background estimation and subtraction is being examined to find the E/p in higher energy and pile-up cases.
- This is early work and I still need:
  - to look into accounting for correlated neutrals in the core region
  - look for a way of estimating the contamination to the hadronic calorimeter.
- Plan to look at more physics samples and different calibration schemes.
- No trigger effects have been looked at yet.

Extra Slides

Results of applying subtraction

Inside the cone ΔR<0.05 the contamination is estimated using the background energy density in the region outside it ΔR<0.1-ΔR<0.05.

This gives a poor result. More cuts, other physics samples will need to be studied to improve this.

Outside the central region the Estimate appers to be good

Contribution to E_{EM}/p for various cone regions:	After subtracting the estimated contamination in dijiets	From single pion dataset (error negligible)
ΔR<0.05	0.506 ± 0.009	0.439
0.1-0.05	0.026 ± 0.014	0.027
0.2-0.1	0.019 ± 0.016	0.021
0.3-0.2	0.004 ± 0.004	0.007
0.4-0.3	0.006 ± 0.004	0.003
<0.4 (total)	0.554 ± 0.023	0.496 ± 0.001

Background in hadronic calorimeter

- Also need to estimate the contamination in the hadronic calorimeter:
  - This can be measured in the area between R<0.4 and R<0.2 from the track as very little of the pions energy is deposited here on average.
  - Below R< 0.2 contam. should be small (approx 0.02, but still needs to be accounted for.
  - More investigation is required into this.
- In general more work will be done to see if this method can be used for pions where the cuts method can not be used.