DHCAL Pion and Positron Analysis

Burak Bilki, University of Iowa
(José Repond, Argonne National Laboratory)

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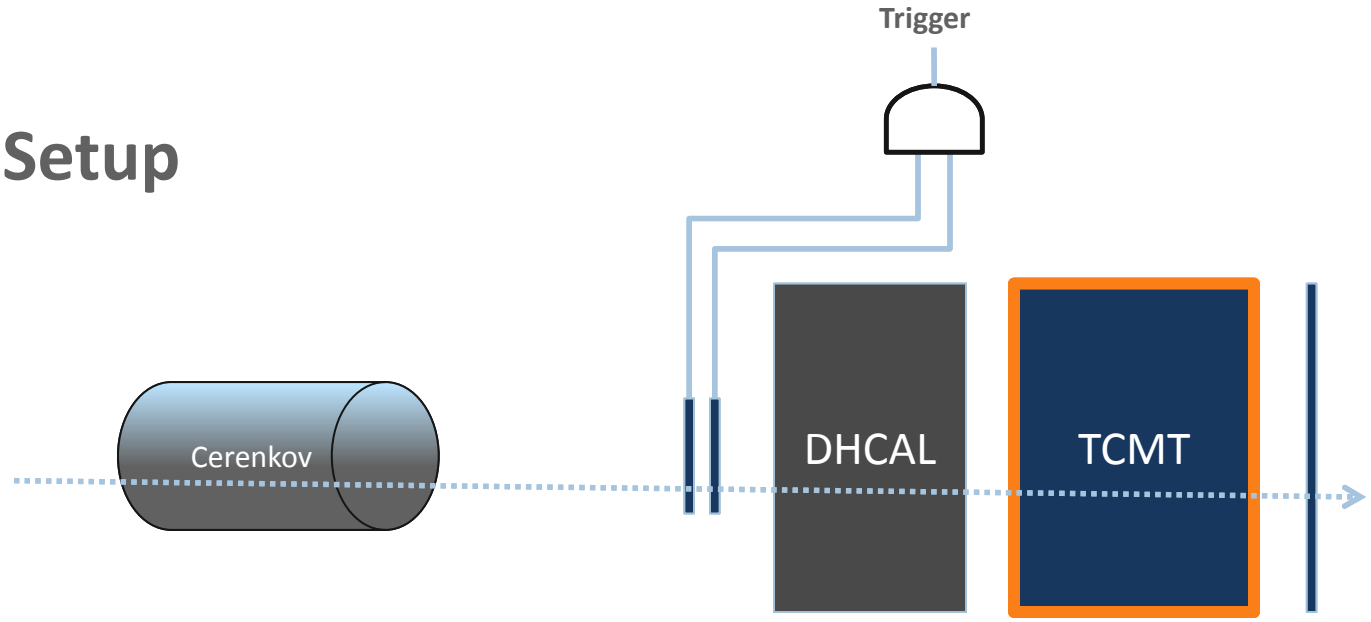
Test Beam Activities

Run period	Date	Configuration	Muon events [10^6]	Secondary beam events [10^6]	Secondary beam momenta [GeV/c]
1	Oct 2010	**DHCAL**	1.4	1.5	2,4,8,10,12,16, 20,25,32
2	Jan 2011	DHCAL **+ partial TCMT**	1.6	3.6	2,4,6,8,10,60
3	Apr 2011	**ECAL** + DHCAL + **TCMT**	3.5	4.8	4,8,12,16,20,25,32,40,50,60,120
TOTAL			**6.5**	**+ 9.9**	**= 16.4M**

Trigger and Setup



Preliminary Analysis

First look at data

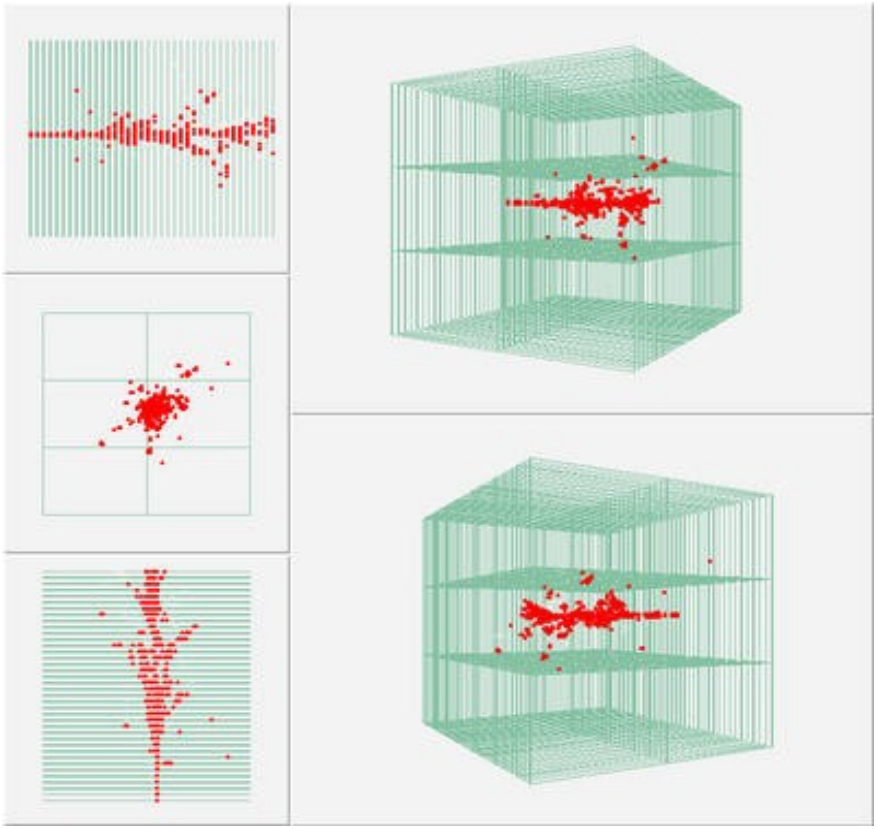
To provide possible feedback to data taking and setup
Speed is important!

Develop analysis tools

Final analysis will require large effort
This is the beginning…

Ultimate goals

Validate the DHCAL concept
Measure hadronic showers in great detail

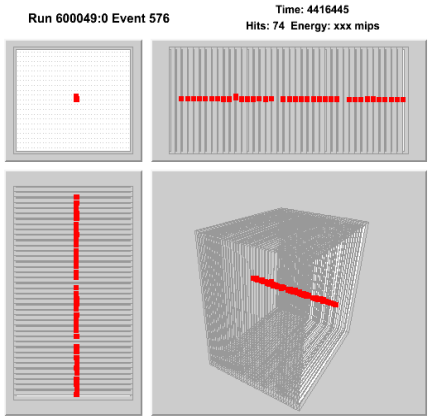


Analysis Strategy

Event selection

Cluster hits in each layer using closest-neighbor clustering (1 common side)

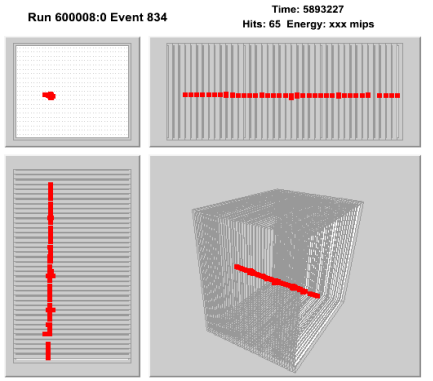
1) Exactly 1 cluster in layer 0 (←rejects multi-particle events)
2) Not more than 4 hits in layer 0 (← rejects upstream interactions)
3) At least 3 layers with hits (← rejects spurious triggers, cosmic rays)
4) No hits in outer 2 rows (← improves lateral containment of showers)



Identify muon tracks

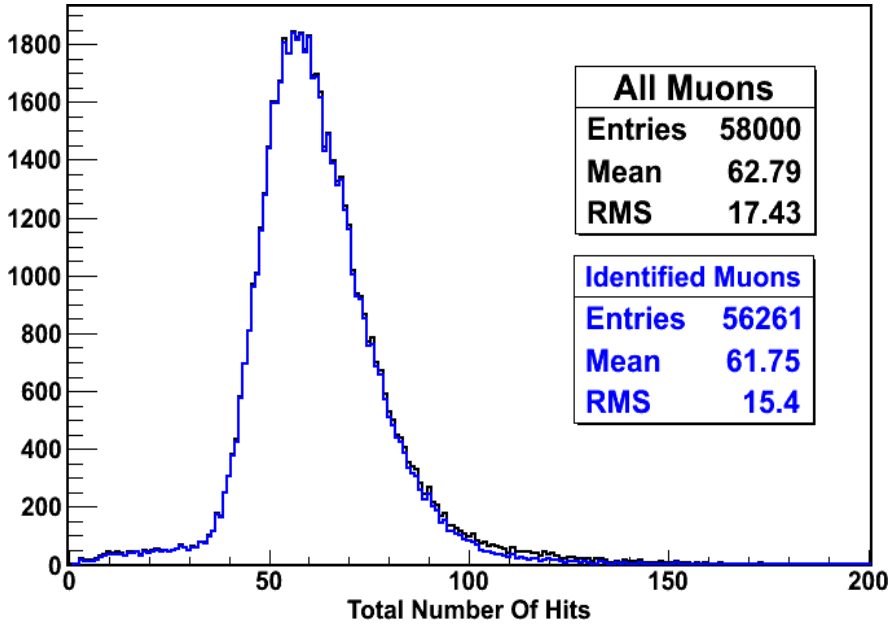
1) Count layers with at least 1 hit = N_{active}
2) Draw line from cluster in layer 0 with last cluster in stack
3) Count clusters in intermediate layers and within 2 cm of line = N_{match}
4) Identify layers with additional hits within a cylinder with 1.5 cm < R < 25 cm around line

If $N_{match} = N_{active}$ → **Identify as muon**
If $N_{match} > 0.8\ N_{active}$ and no 2 consecutive layers with additional hits → **Identify as muon**

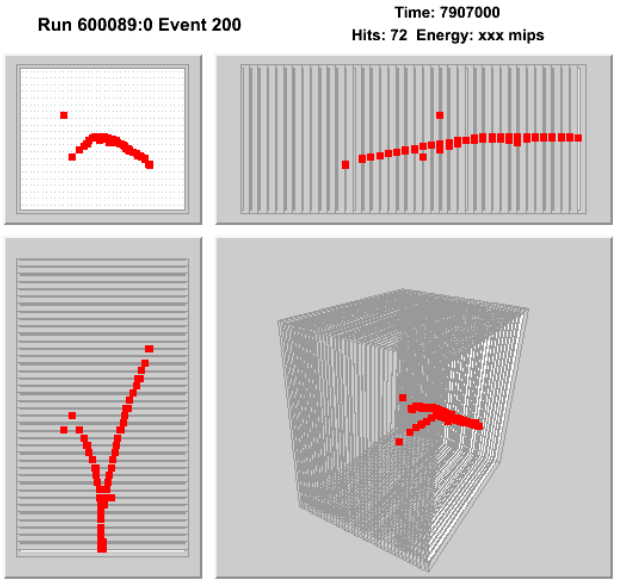


Test muon ID

Muon Run 600008
Efficiency ~ 97%
Remaining 3% not included in pion/positron sample, due to longitudinal containment cut



Pion ID



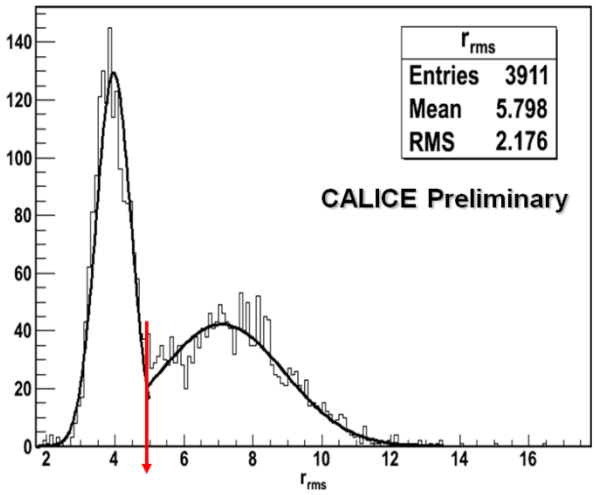
(Easy at high momenta, tough < 8 GeV/c)
Identify MIP segment starting from layer 0
Identify last cluster in stack and draw line to last MIP cluster
If at least 4 intermediate clusters → **Identify as pion**
If 2 track segments found with at least 3 layers and angle > 20^0 → **Identify as pion**

Pion and Positron ID

Only for events not already classified
Calculate

$$r_{rms} = \sqrt{\frac{\sum r_i^2}{N_{Hits}}}$$

where r_i … distance of hit i to average x/y in a given layer

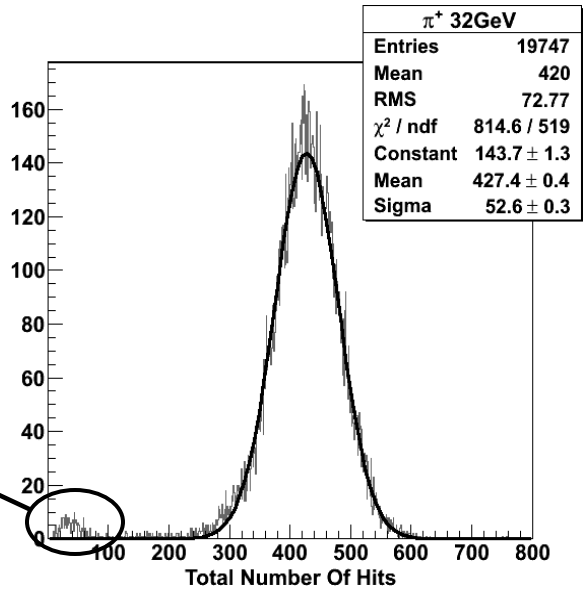


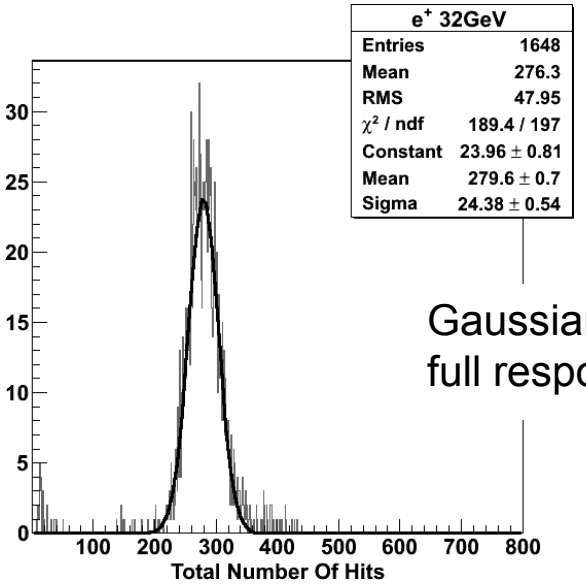
If $r_{rms} > 5 \rightarrow$ **Identify as pion** (this adds 4% of pions)
If $r_{rms} < 5 \rightarrow$ **Identify as positron** (this is the only positron selection)

Results - October 2010 Data

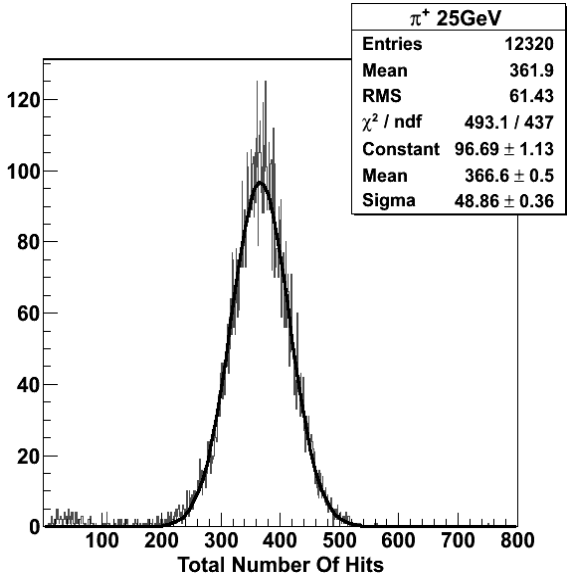
CALICE Preliminary

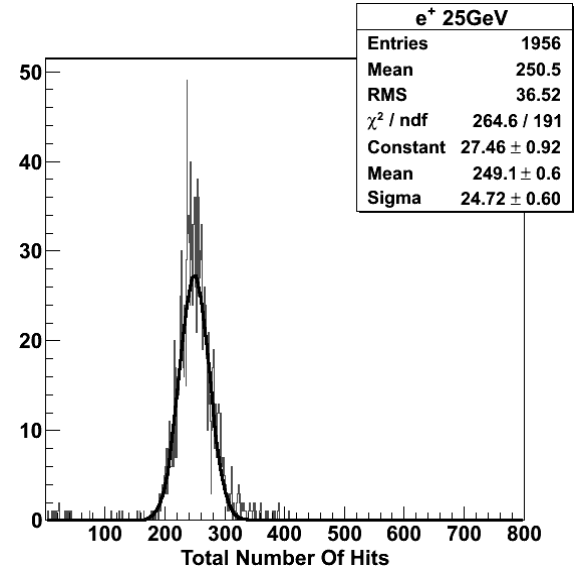
Unidentified μ's, punch through



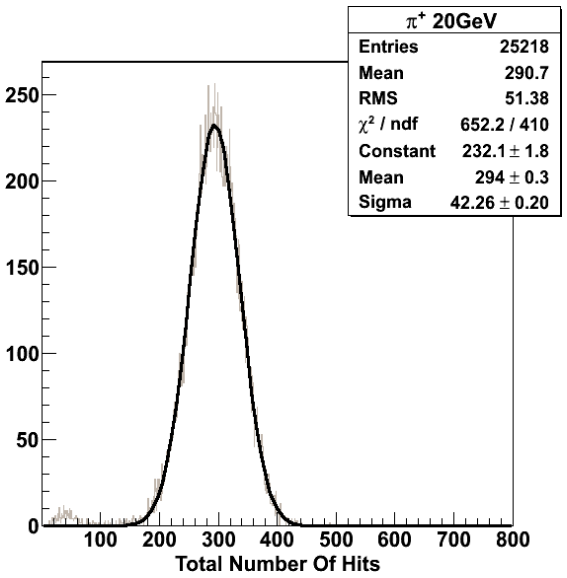


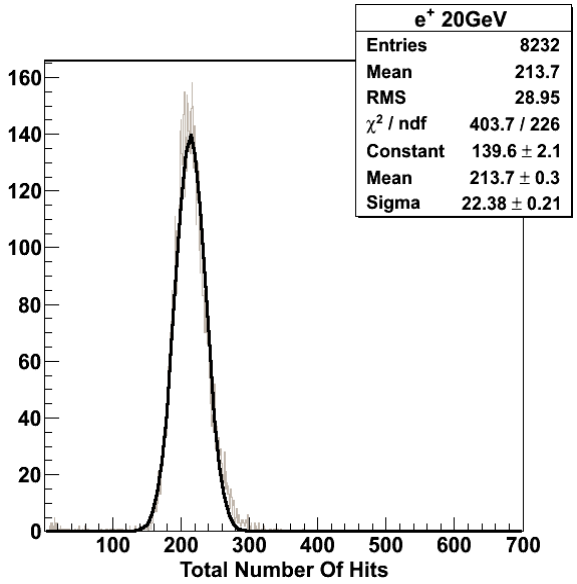
Gaussian fits over the full response curve

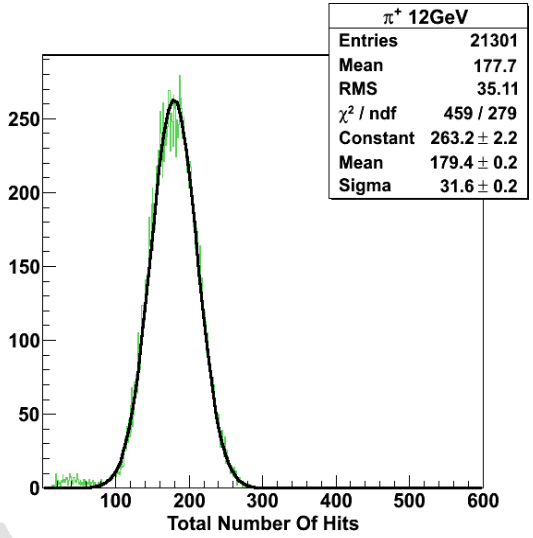


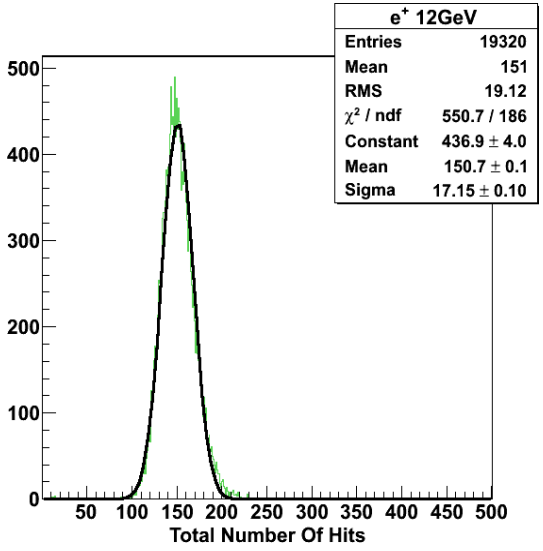


CALICE Preliminary

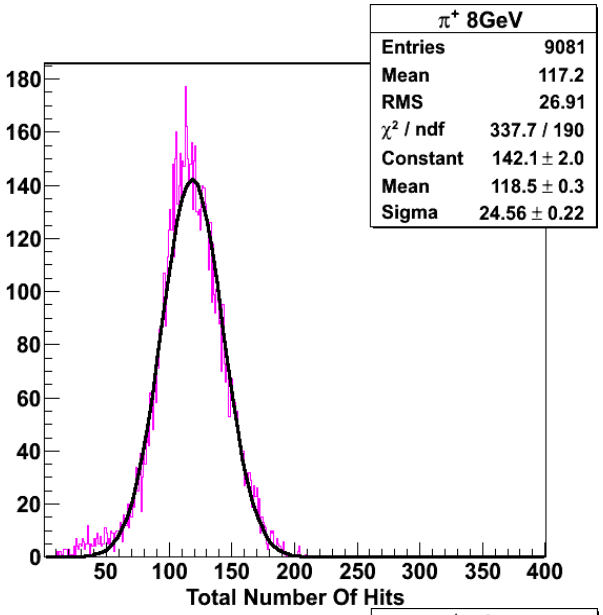


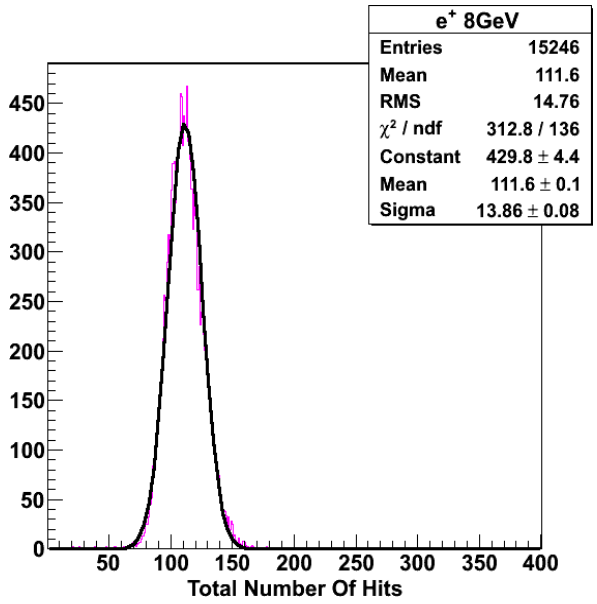


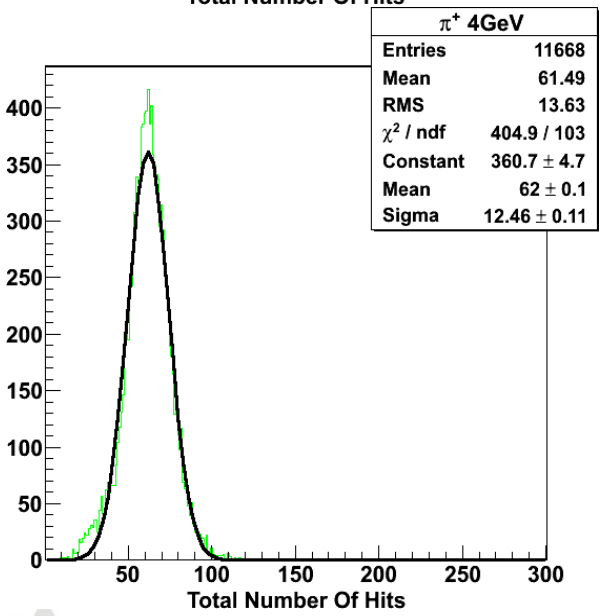


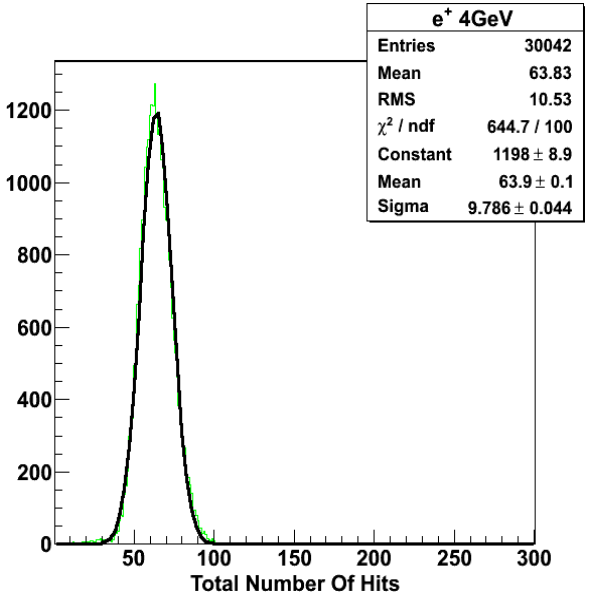


CALICE Preliminary

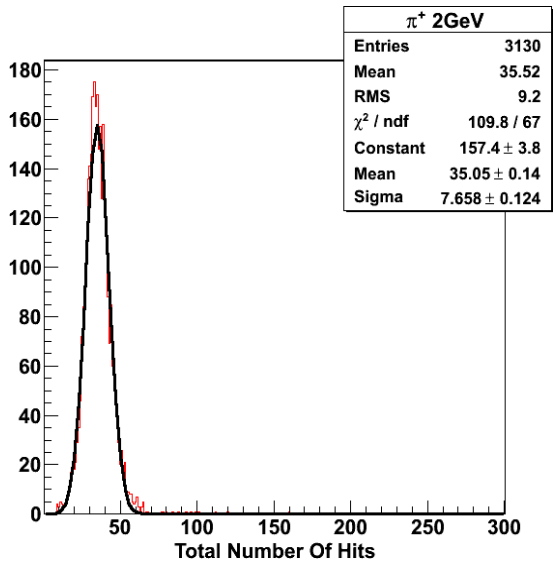


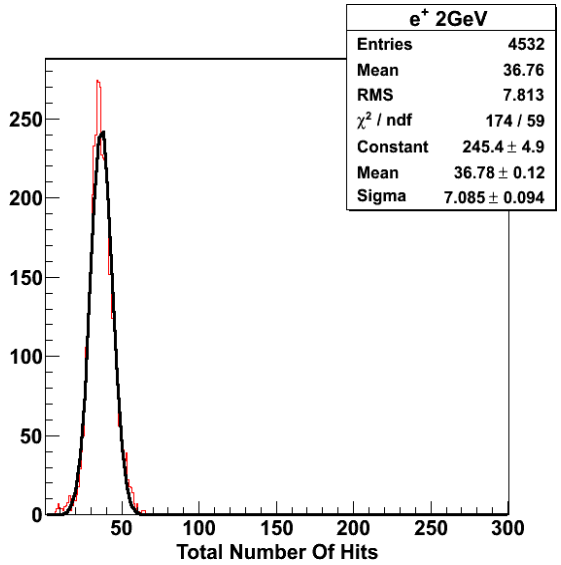






CALICE Preliminary

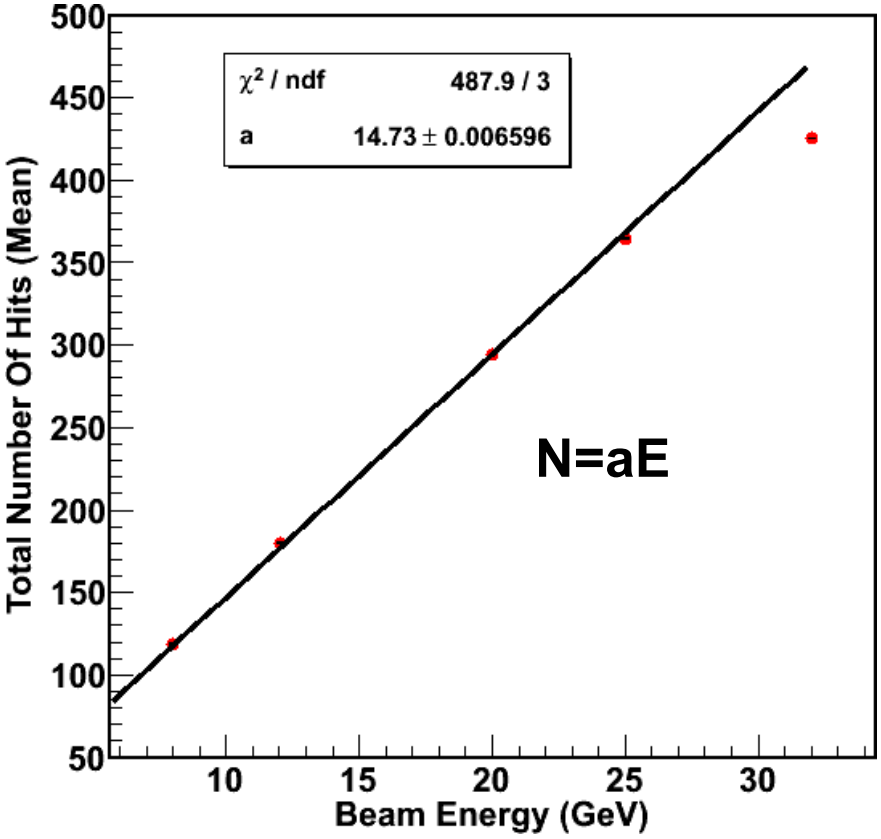




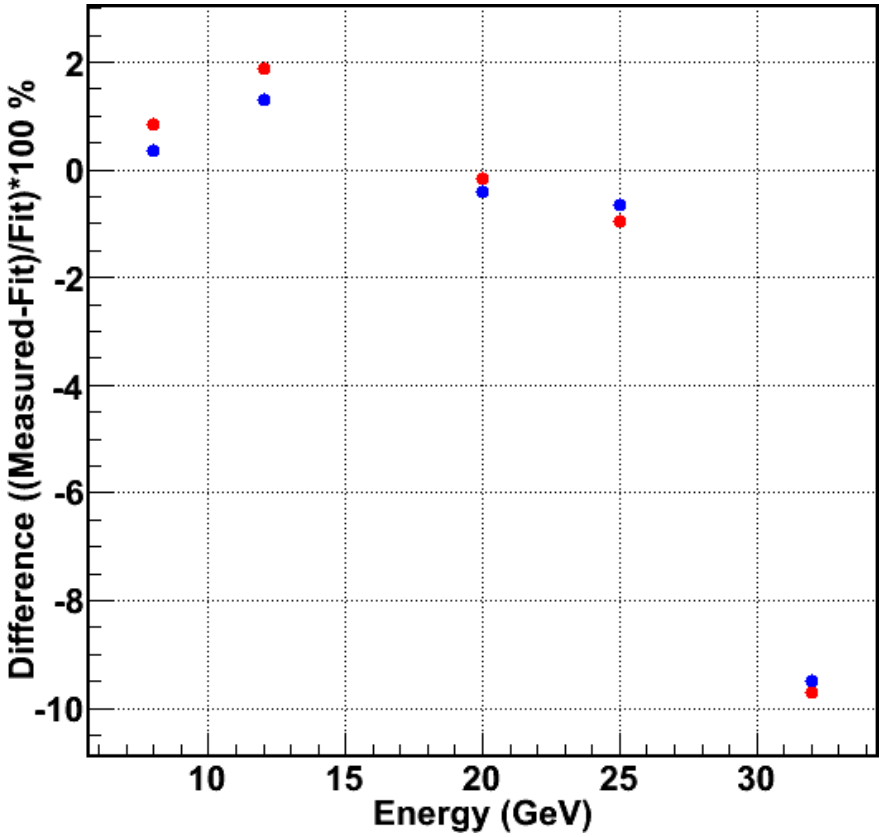
For p < 8 GeV/c

Beam dominated by positrons
DHCAL close to compensating
Pion ID not reliable → **more work needed**

Pion Selection



CALICE Preliminary
(response not calibrated)

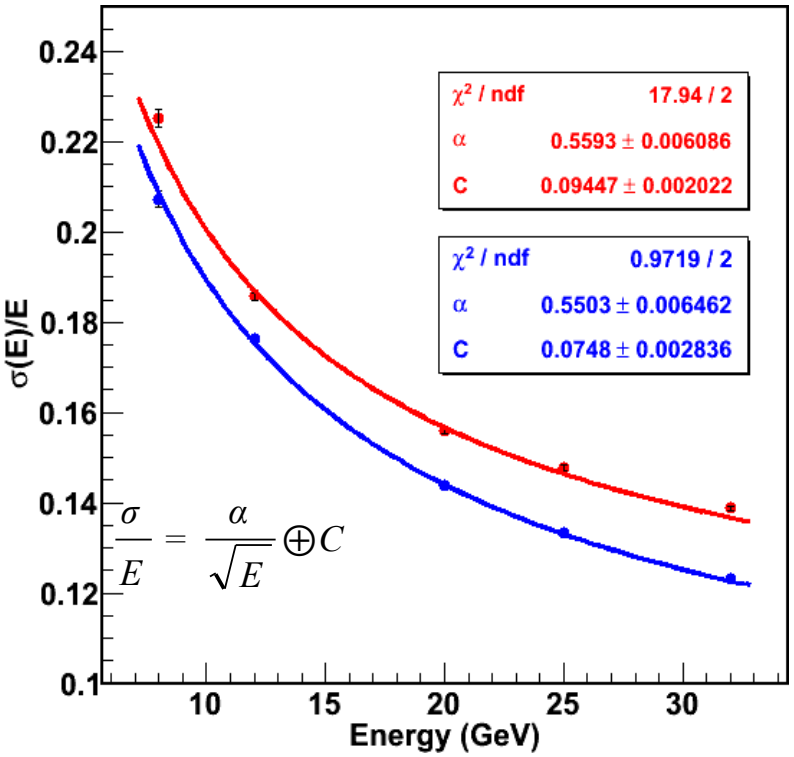


16 (off), 32 GeV/c (effects of saturation expected) data points are not included in the fit.

Standard pion selection
+ No hits in last two layers
(longitudinal containment

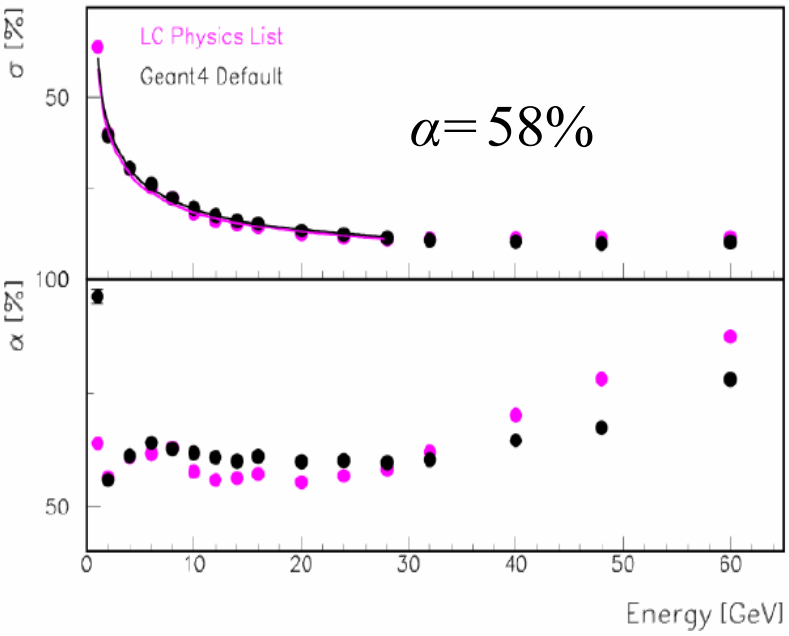
Pion Selection

CALICE Preliminary
(response not yet calibrated)



32 GeV data point is not included in the fit.

B. Bilki et.al. JINST4 P10008, 2009.

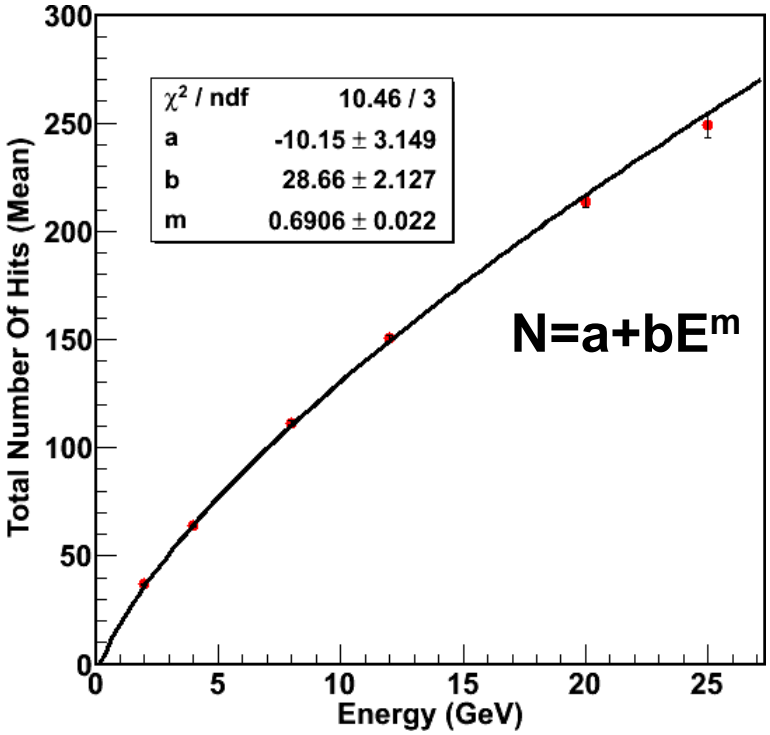


MC predictions for a large-size DHCAL based on the Vertical Slice Test.

Standard pion selection
+ No hits in last two layers (longitudinal containment)

Positron Selection

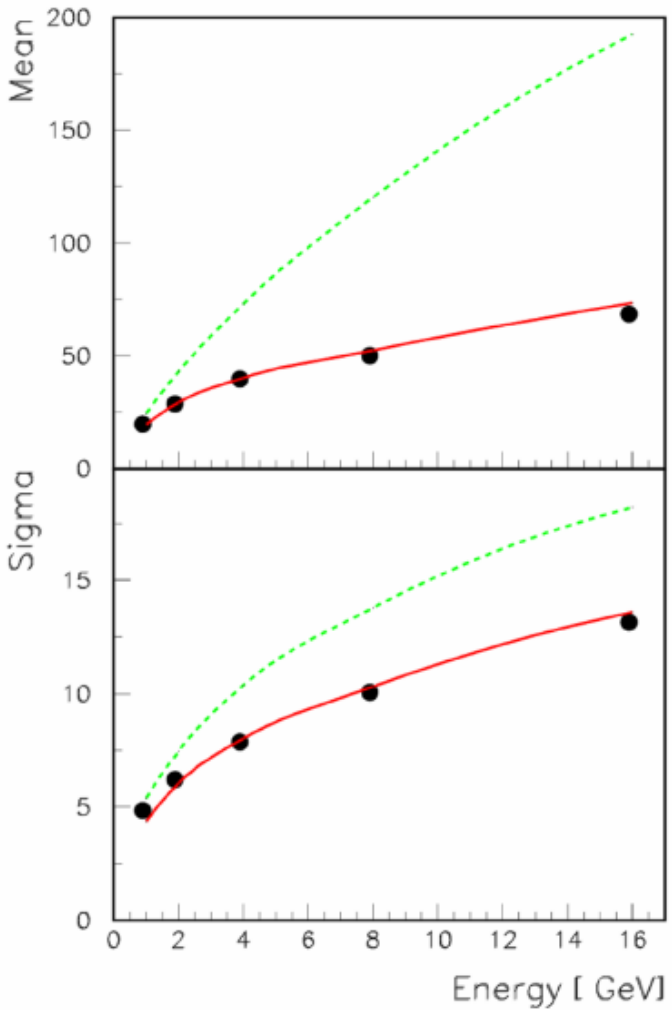
CALICE Preliminary
(response not yet calibrated)



Correction for non-linearity

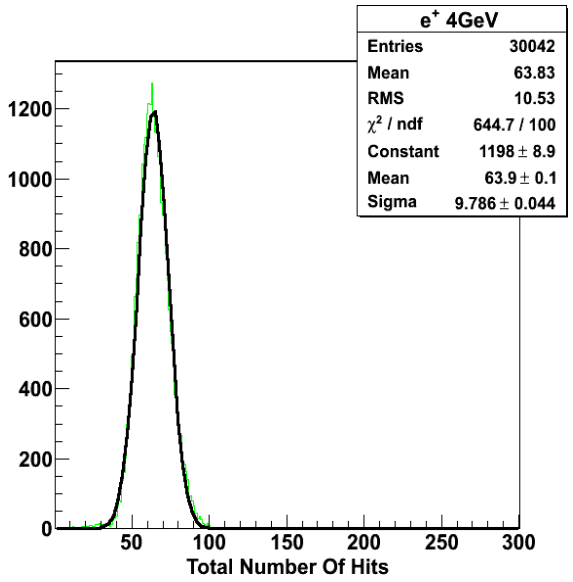
Needed to establish resolution
Correction on an event-by-event basis

B. Bilki et.al. JINST4 P04006, 2009.

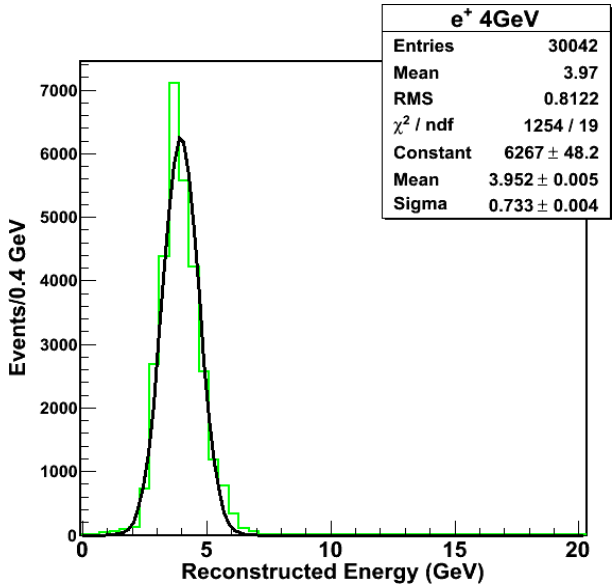


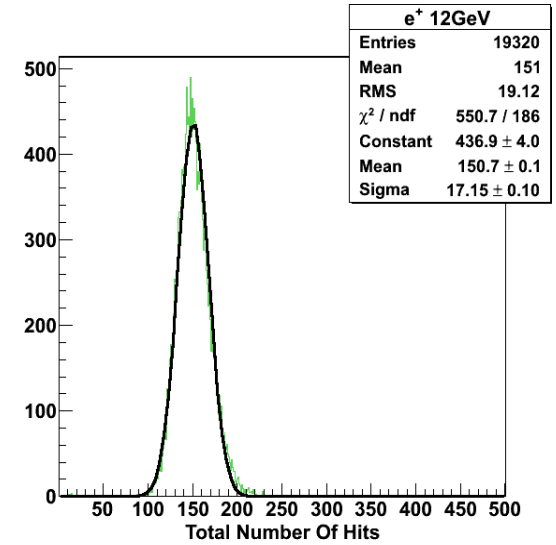
Data (points) and MC (red line) for the Vertical Slice Test and the MC predictions for a large-size DHCAL (green, dashed line).

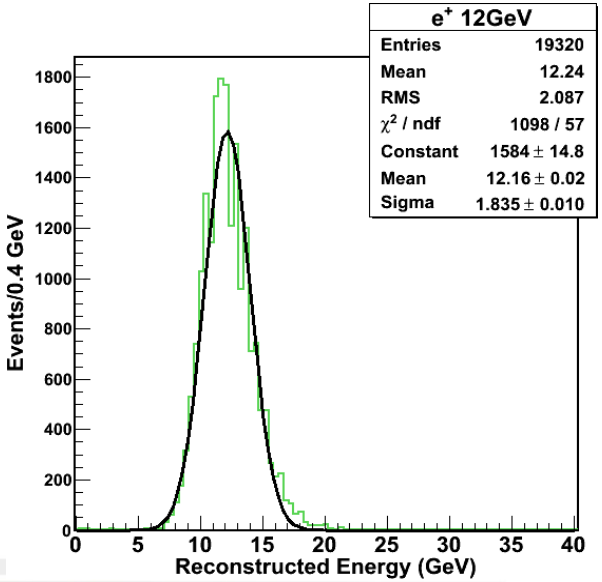
Positron Selection



Correction for Non-Linearity

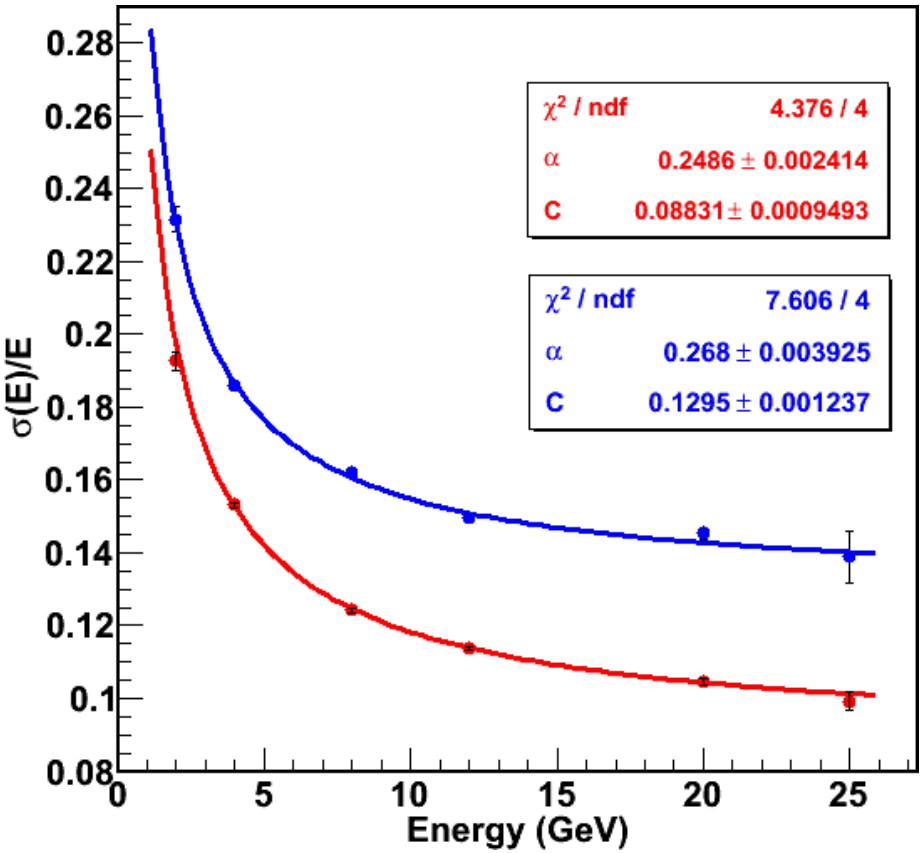






Positron Selection

CALICE Preliminary
(response not calibrated)



$$\frac{\sigma}{E} = \frac{\alpha}{\sqrt{E}} \oplus C$$

Uncorrected for non-linearity
Corrected for non-linearity

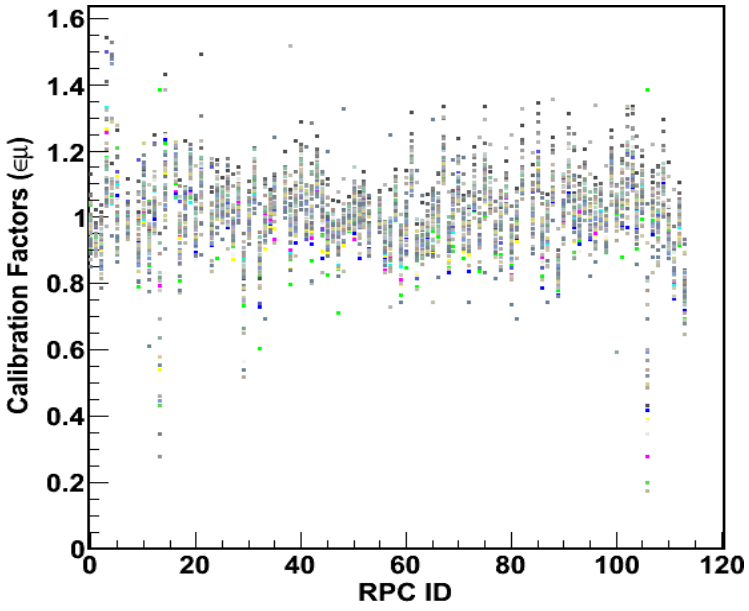
1st Attempt at Calibration

Track segment analysis

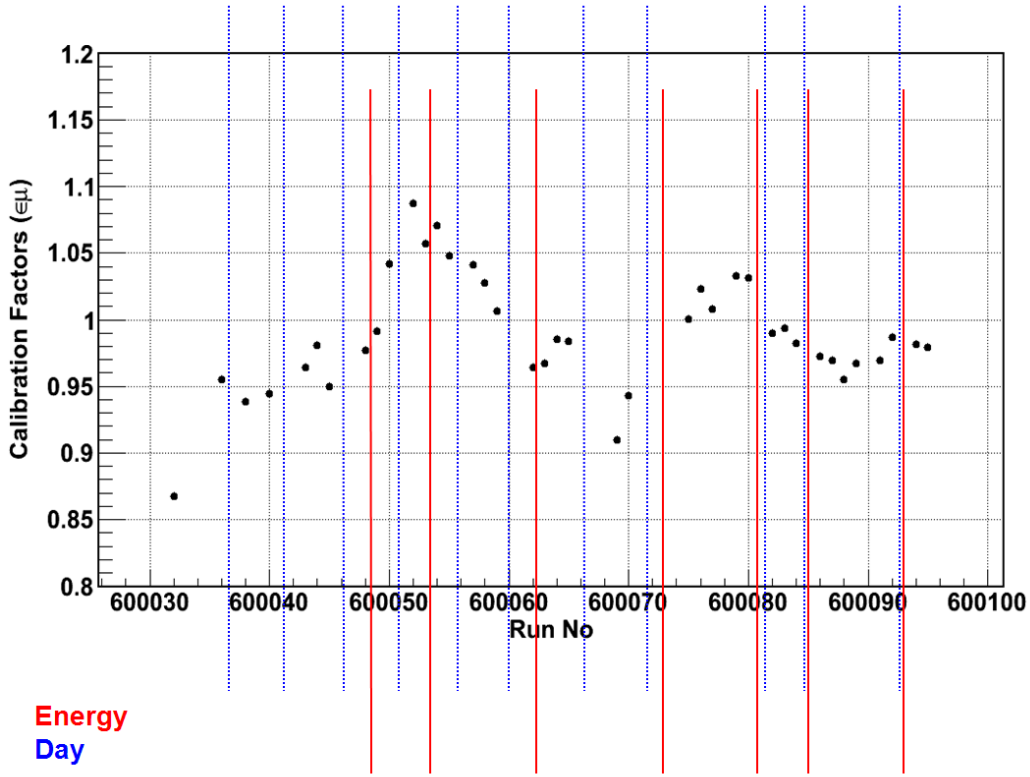
Use neighboring layers to reconstruct track segments
Measure response εμ **= calibration factor**

Calibration factor

One entry per RPC per run

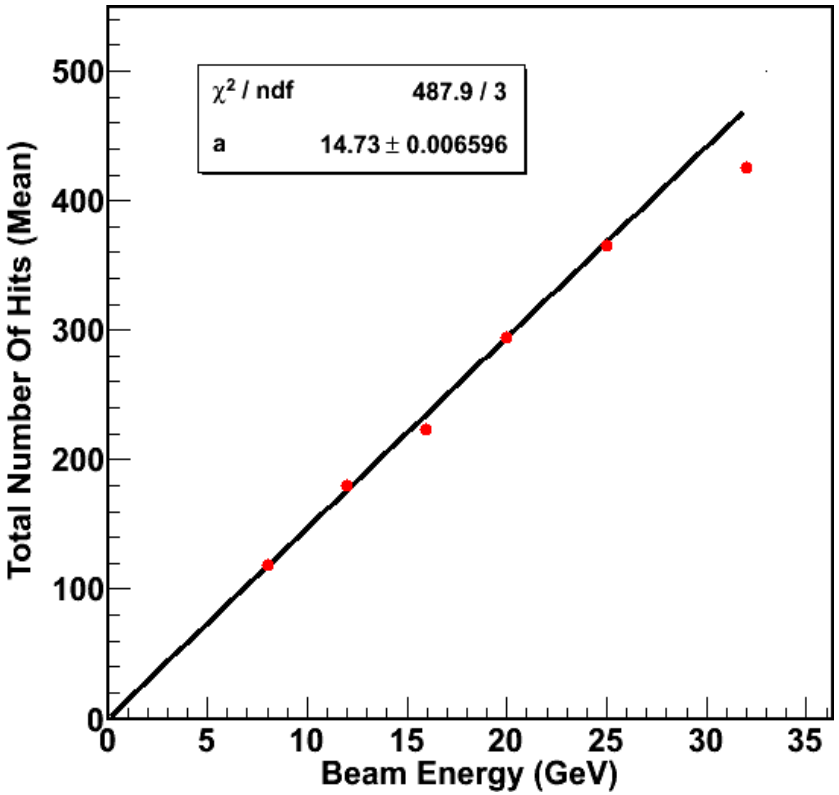


One entry per run



Longitudinally contained π^+ showers

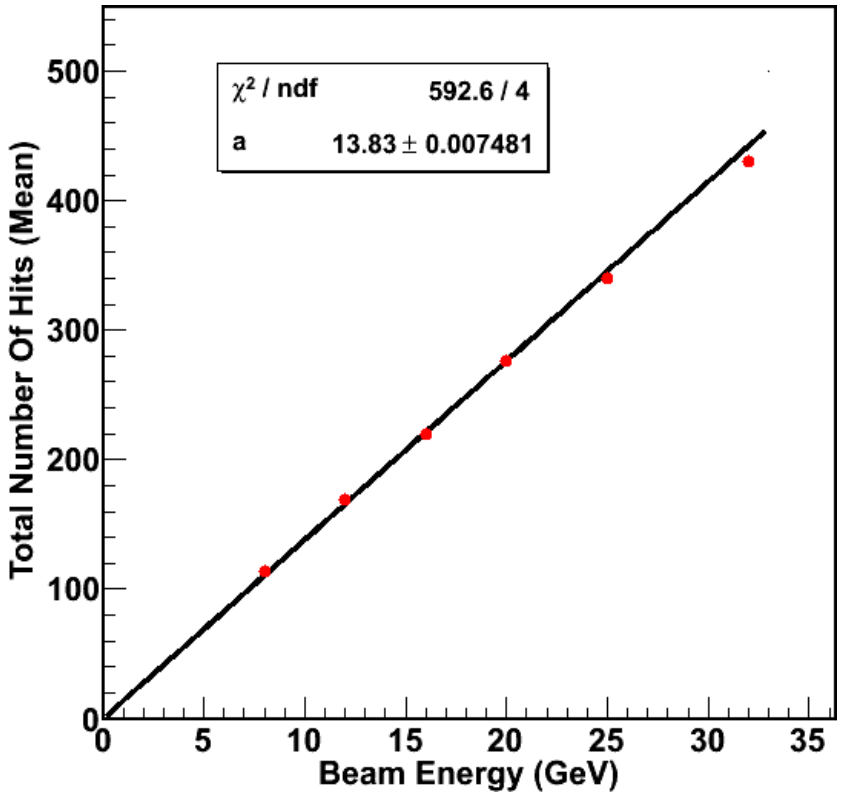
Before Calibration



Fit

16 and 32 GeV not used

After Calibration

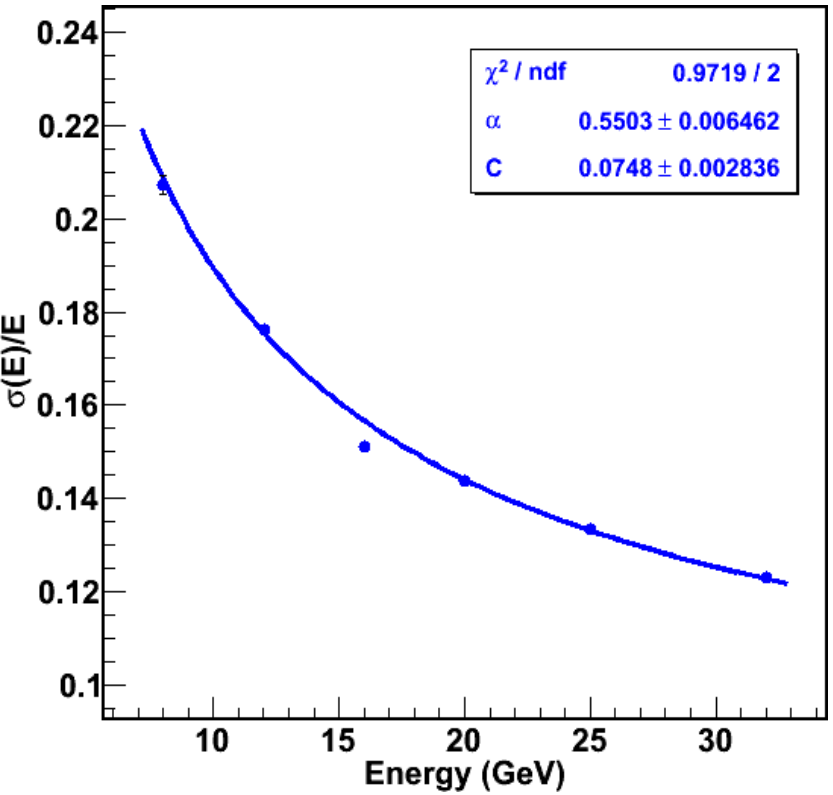


Fit

All points used
32 GeV point close to line (as expected)

Longitudinally contained π^+ showers

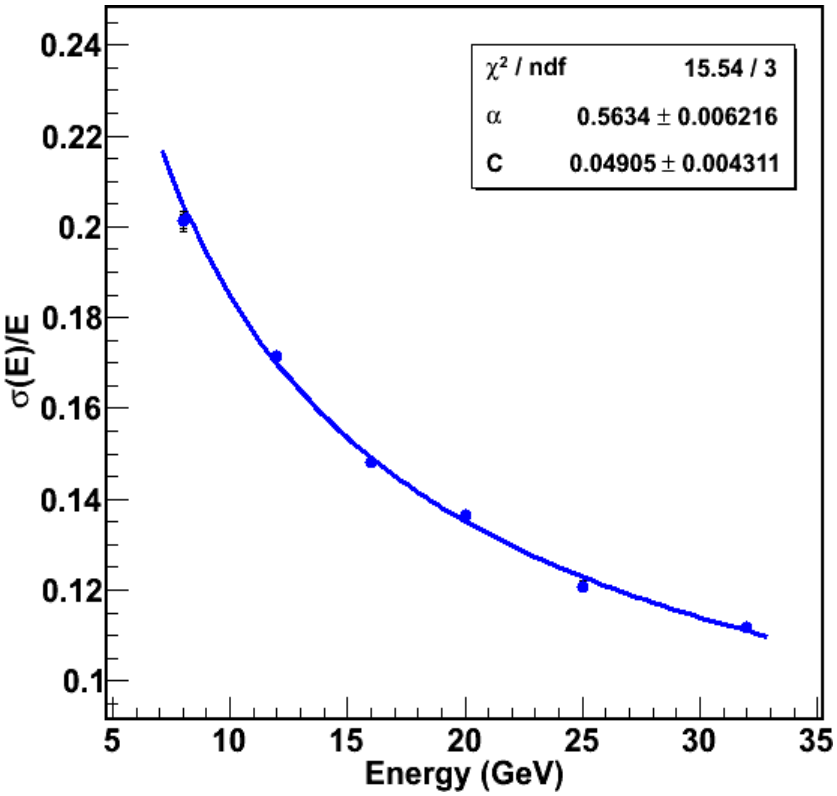
Before Calibration



Fit

16 and 32 GeV not used

After Calibration



Fit

All points used
Constant term somewhat reduced (as expected)

Result strikingly similar to AHCAL w/out SW compensation

Conclusion

Preliminary analysis

Developed particle ID
1st attempt at implementing calibration

Results

Response appears to be quite linear (perhaps some saturation at 32 GeV/c)
Resolution as expected

Lot's to do

Include low momentum runs: 2,4,6 GeV/c
Improve particle ID (e.g. use Cerenkov)
Study effect of noise…

The DHCAL at 120 GeV

In average ~1400 hits

Combined system in 3D