

CALICE Tail-Catcher Muon-Tracker(TCMT) Preliminary Test Beam Results

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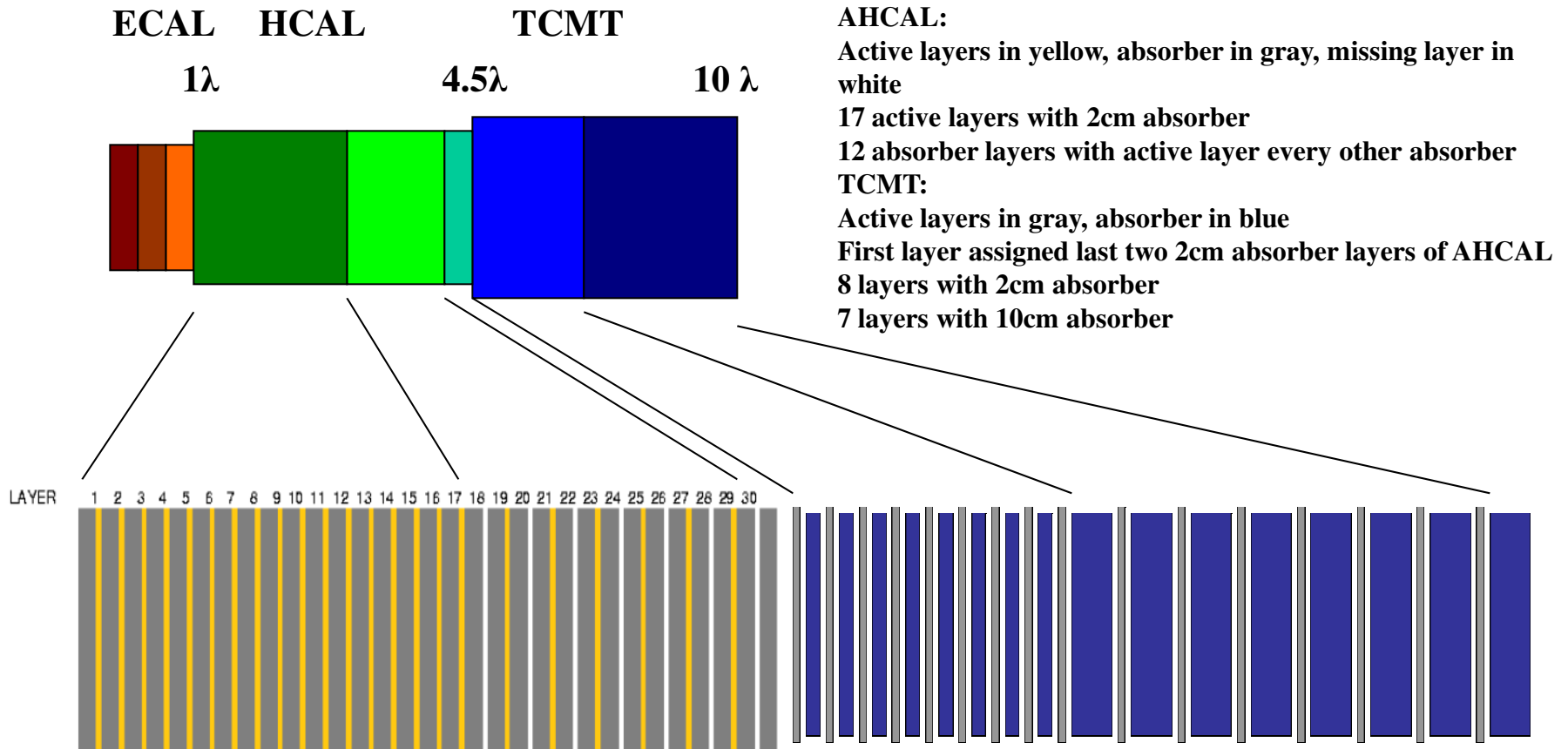
AHCAL MAIN MEETING
DESY, Hamburg
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Current Analysis

- The effect of TCMT and coil on leakage was studied
- Compared resolution of a calorimeter with a system with calorimeter, coil, and post coil sampling
- Used a subset of TCMT layers, leaving a gap equivalent to ~ 1.8 lambda to simulate magnetic coil
- Used CALICE October 2006 CERN data

CALICE Configuration, Oct. 2006



Would like to compare Energy Resolution of :

[ECAL + HCAL + n TCMT Layers]

Extended to:

[ECAL + HCAL + n TCMT Layers] + 1.8λ gap + remaining layers of TCMT
(or same calorimeter configuration but post magnet gap sampled)

Conditions & Cuts

- **Conditions**

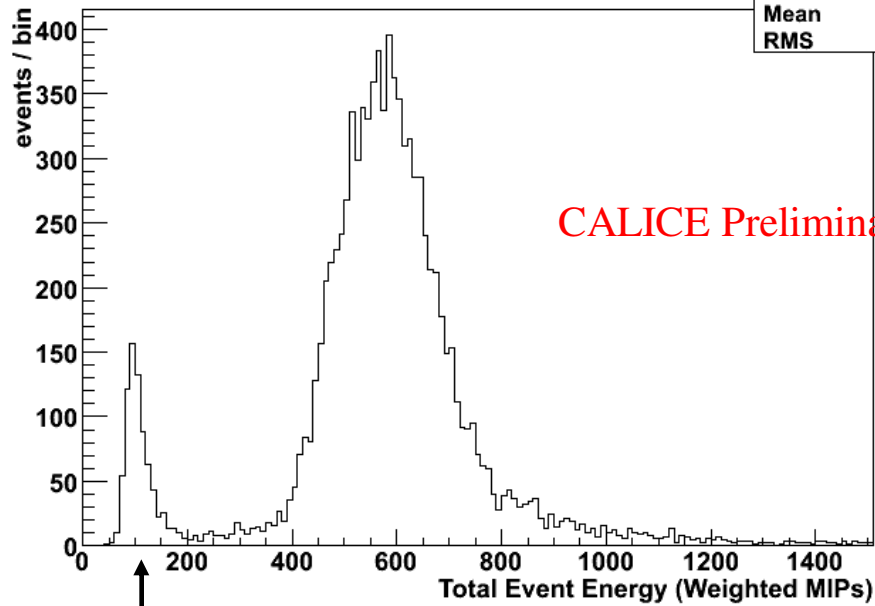
- **Saturation correction applied to correct for non-linear nature of Silicon photomultipliers**
- **No temperature correction**
- **Pion beams**
- **Sampling weights**
 - **Derived using least squares minimization procedure for the resolution**
 - **Five to eight weights used depending on the configuration**

- **Cuts**

- **0.5 MIP threshold**
- **electrons rejected with Cherenkov**
- **Double particle events rejected**
- **Muons rejected by:**
 - **1m x 1m veto counter behind TCMT**
 - **Energy sum cut (E of hits > 10 MIPs/total $E < 0.02$)**
 - pion detection efficiency of approximately 95% and a muon rejection of approximately 80%.
 - **Cut based on Low end tail -> MIP**

Effect of Cuts to Clean Pion Sample Full Detector

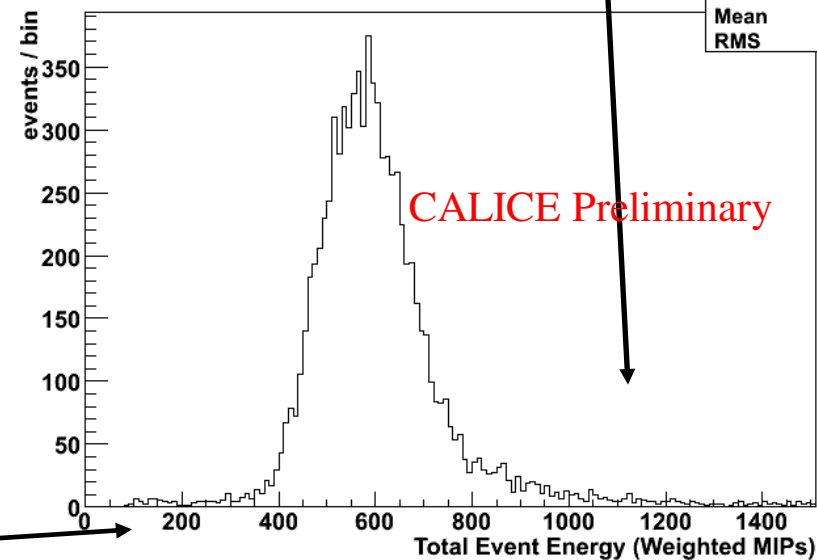
No Cuts



ecalhcaltcmt total	
Entries	10000
Mean	568
RMS	195.8

High energy tail due to
non-optimized weights
(used physical sf's)

All Cuts



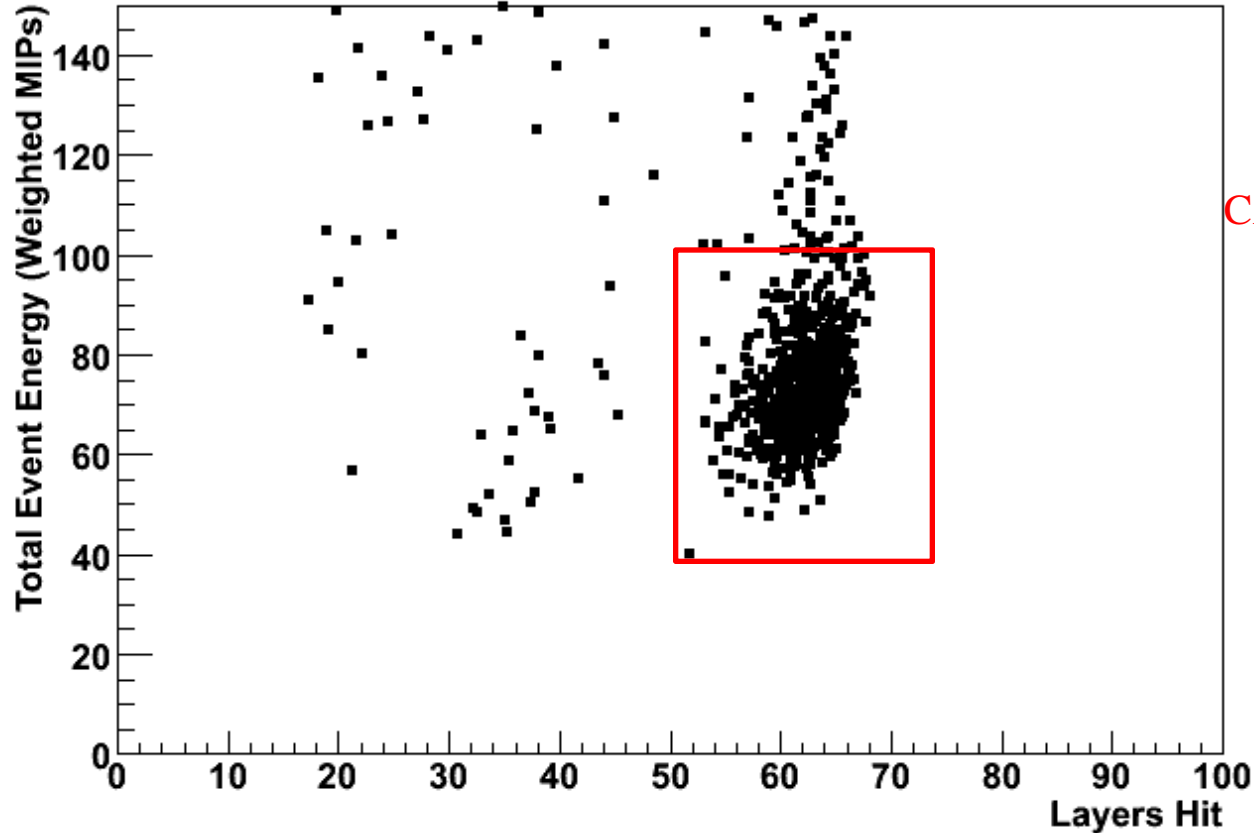
ecalhcaltcmt total	
Entries	8429
Mean	605.8
RMS	150.3

Low energy tail due to
electrons and muons

Cleaned up by using cherenkov
and muon ID cuts

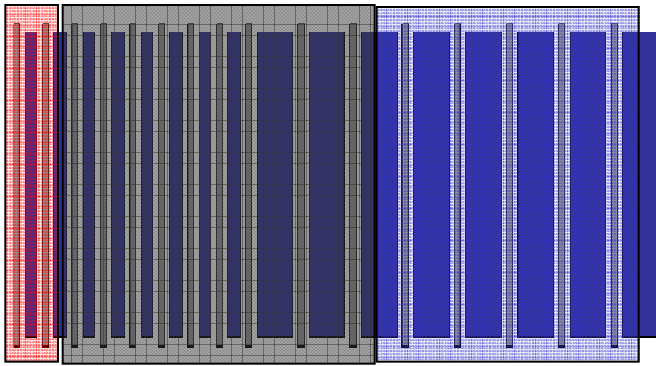
Cut Based on Number of Layers and Event Energy to Identify Muons

Layers versus Energy



CALICE Preliminary

Allocation of TCMT Layers



Example Configuration 2:
 2 layers to calorimeter
 9 layers for coil
 5 layers post coil sampling

Example Configuration 8:
Closest to SiD depth
 8 layers to calorimeter
 4 layers for coil
 4 layers post coil sampling

# TCMT Layers	Sim. Coil Thickness (cm)	Sim. Coil Thickness (λ)	End of coil/ First Layer Post-coil Sample	Layers in Post-coil Sample
0 (4.54)	29.2	1.78	10	6 (3.74)
1 (4.79)	26.0	1.59	10	6 (3.74)
2 (4.90)	34.0	2.08	11	5 (3.12)
3 (5.02)	32.0	1.96	11	5 (3.12)
4 (5.14)	30.0	1.83	11	5 (3.12)
5 (5.25)	28.0	1.71	11	5 (3.12)
6 (5.37)	26.0	1.59	11	5 (3.12)
7 (5.49)	34.0	2.08	12	4 (2.49)
8 (5.60)	32.0	1.96	12	4 (2.49)
9 (5.72)	30.0	1.83	12	4 (2.49)
10 (6.34)	30.0	1.83	13	3 (1.87)
11 (6.96)	30.0	1.83	14	2 (1.25)
12 (7.59)	30.0	1.83	15	1 (0.62)

Minimization of Weights

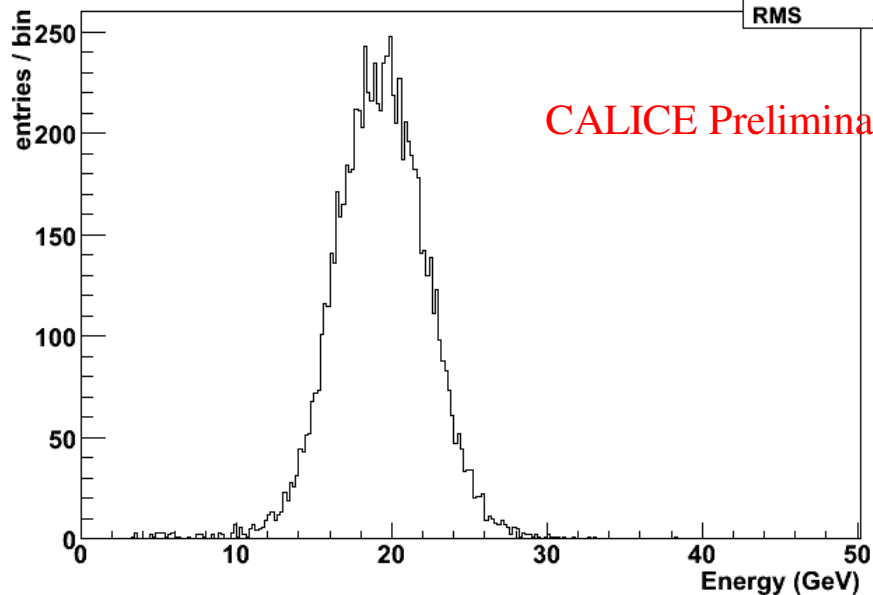
Resolution was minimized such that:

$$\chi^2 = (E_{beam} - \sum_{i=1}^N \alpha_i E_i)^2$$

A unique set of weights was determined for each configuration.

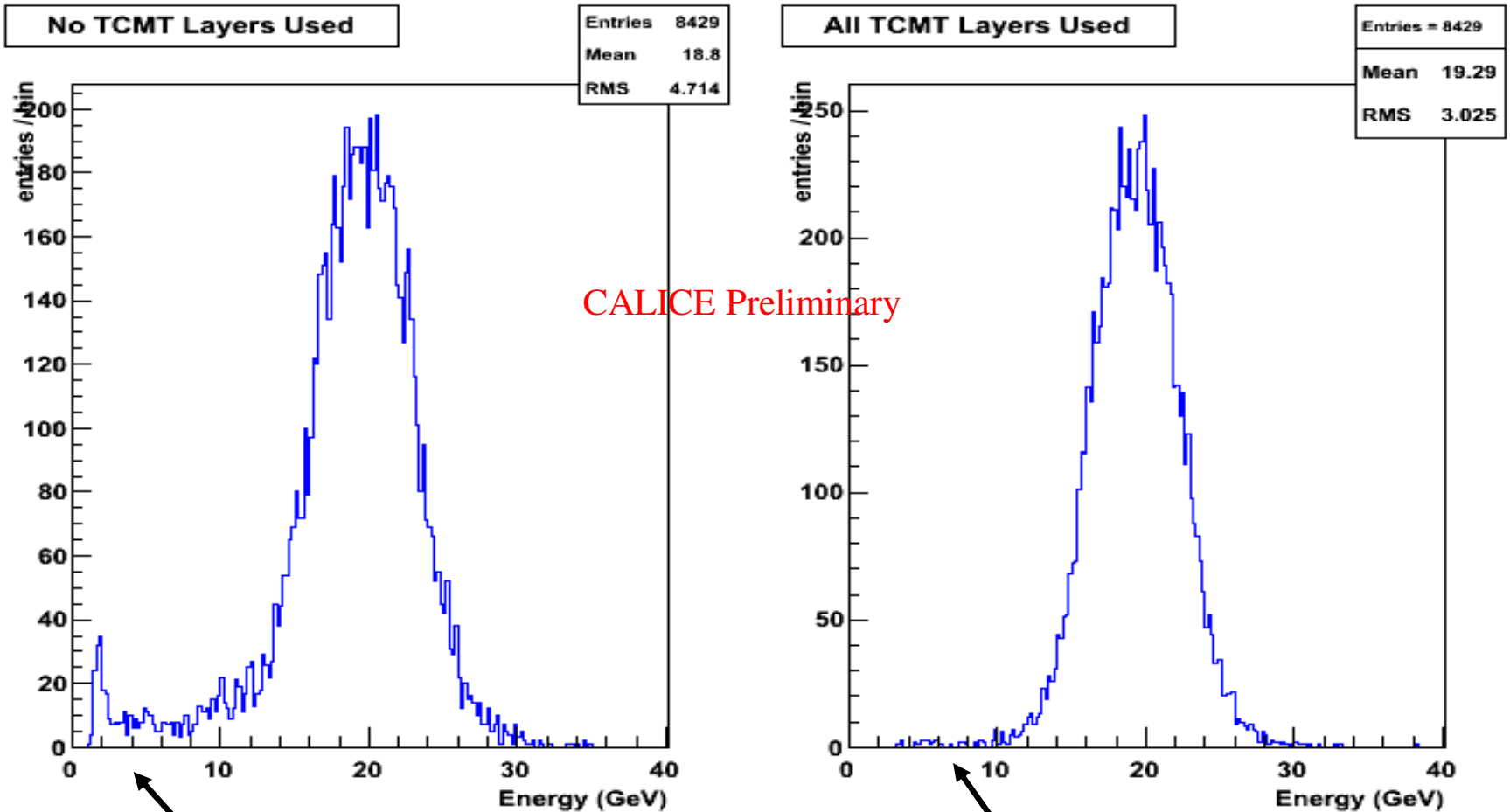
coil						TCMT	TCMT	TCMT
	ECAL	ECAL	ECAL	HCAL	HCAL	Thin	Thick	post-
Config.	1	2	3	1	2	XCAL	XCAL	coil
0	0.0089	0.0091	0.0133	0.0335	0.0811	0.0000	0.0000	0.2057
1	0.0090	0.0091	0.0132	0.0334	0.0655	0.1604	0.0000	0.1810
2	0.0089	0.0091	0.0132	0.0334	0.0631	0.1088	0.0000	0.2521
3	0.0089	0.0091	0.0132	0.0334	0.0622	0.0809	0.0000	0.2421
4	0.0089	0.0091	0.0132	0.0334	0.0615	0.0709	0.0000	0.2369
5	0.0088	0.0091	0.0132	0.0333	0.0616	0.0624	0.0000	0.2306
6	0.0088	0.0091	0.0132	0.0333	0.0613	0.0575	0.0000	0.2238
7	0.0088	0.0091	0.0132	0.0332	0.0615	0.0547	0.0000	0.2981
8	0.0088	0.0091	0.0132	0.0331	0.0613	0.0516	0.0000	0.2903
9	0.0090	0.0092	0.0134	0.0335	0.0628	0.0466	0.0000	0.1070
10	0.0089	0.0091	0.0133	0.0331	0.0613	0.0428	0.0980	0.2993
11	0.0089	0.0091	0.0133	0.0332	0.0614	0.0410	0.1042	0.3242
12	0.0089	0.0091	0.0133	0.0333	0.0616	0.0409	0.1021	0.4918

Energy Spectrum with Minimized Weights



Used 20GeV weights for all runs
They do not vary much for 10-80 GeV

Energy Spectrum without and with TCMT



CALICE Preliminary

Low energy tail due to uncontained events

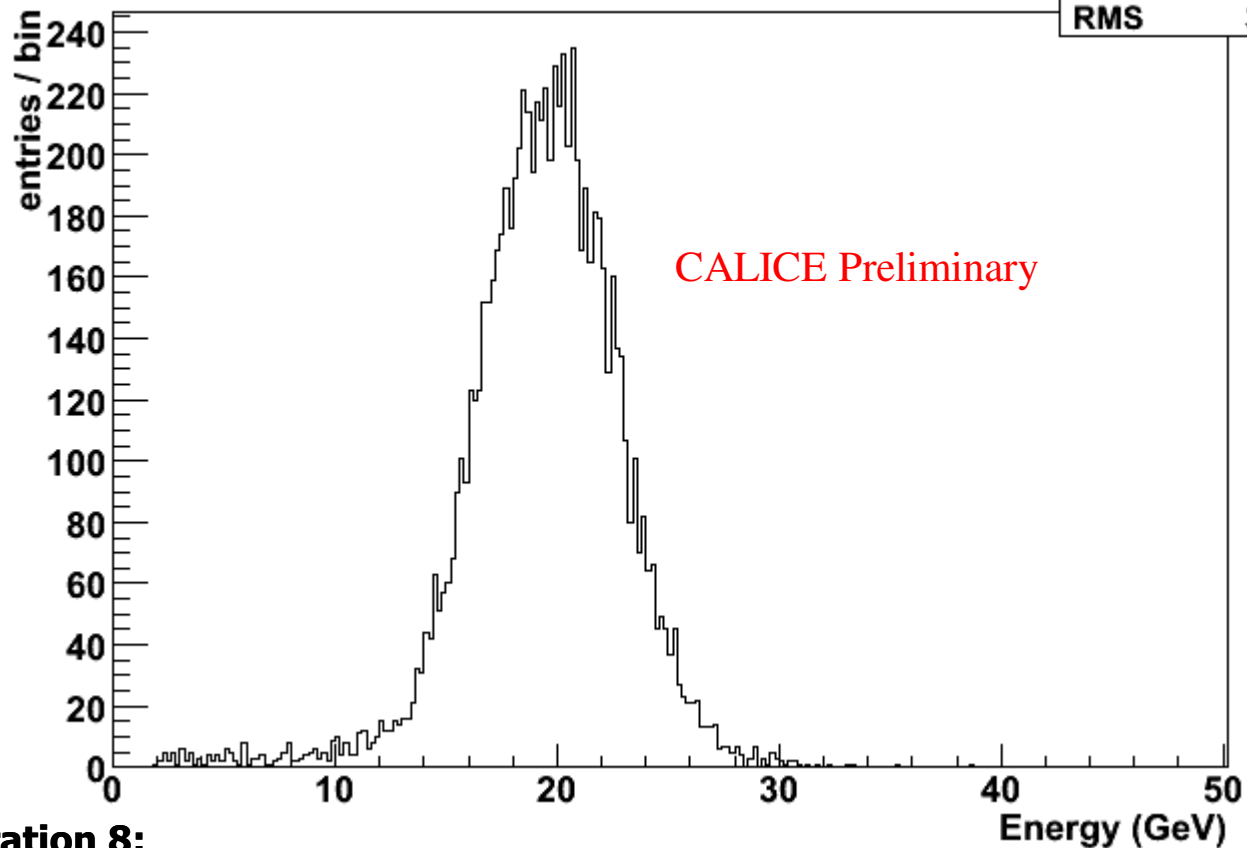
Tail greatly reduced when using full TCMT

Energy resolution calculated with Eres = statistical RMS/statistical Mean
This is necessary to take into account the low end tail

Energy Spectrum With Coil and Post Coil Sampling

Energy Spectrum With Coil Start at 5.5 lambda

Entries	8429
Mean	19.39
RMS	3.507



Example Configuration 8:

Closest to SiD depth

8 TCMT layers added to calorimeter

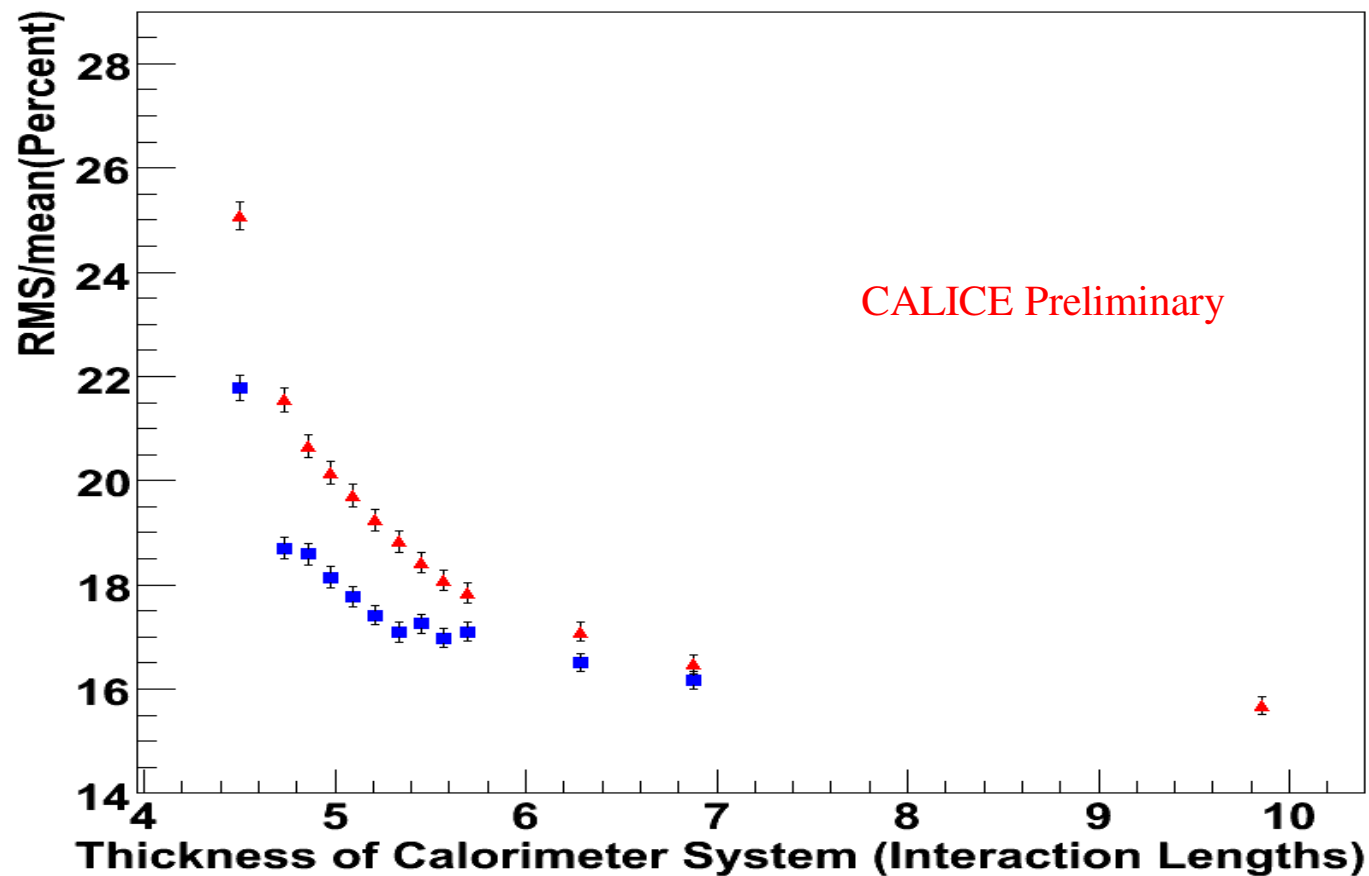
4 layers for coil

4 layers post coil sampling

12 out of 16 TCMT layers used

Energy Resolution as a Function of Calorimeter Depth

Energy Resolution 20GeV π^-

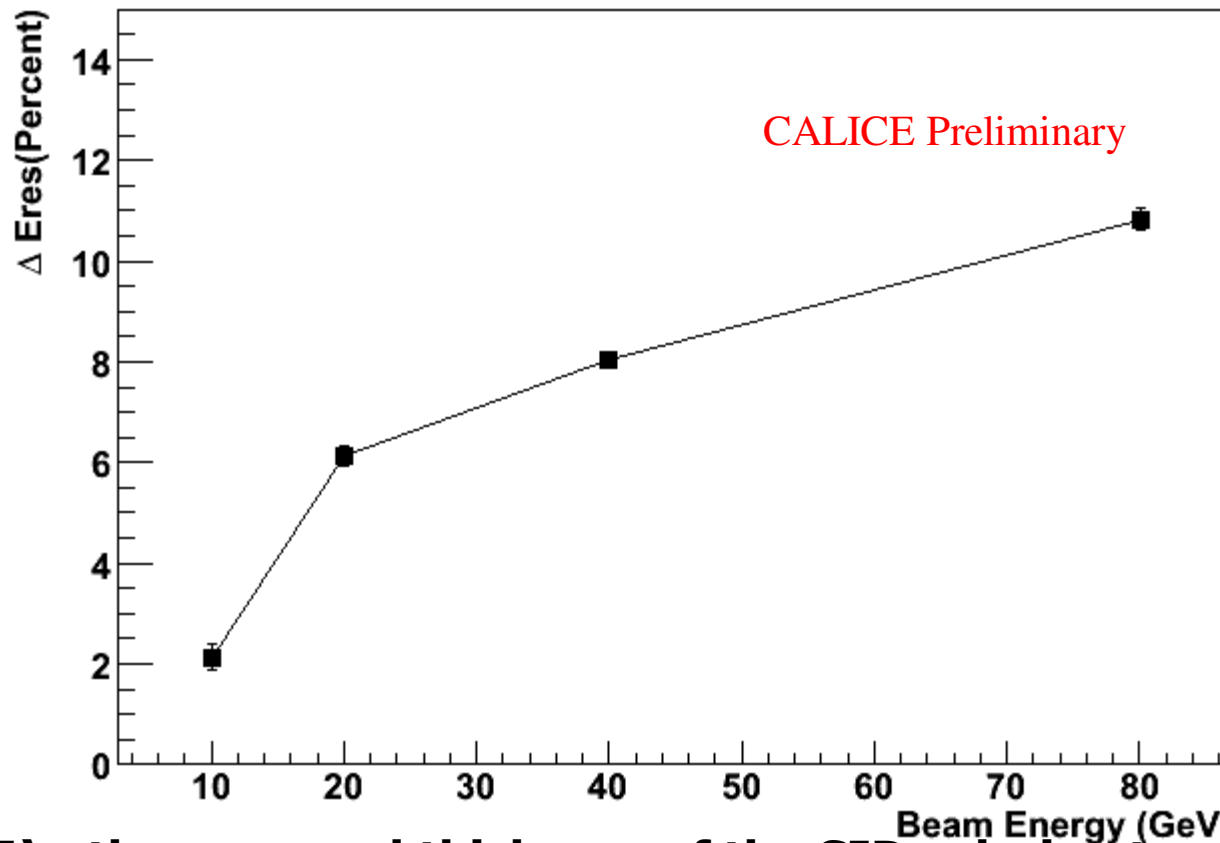


Red Triangles: Calorimeter

Blue Squares: Calorimeter+coil+post coil sample

Improvement in Energy Resolution as a Function of Beam Energy

Improvement in Energy Resolution with Coil at 5.5λ

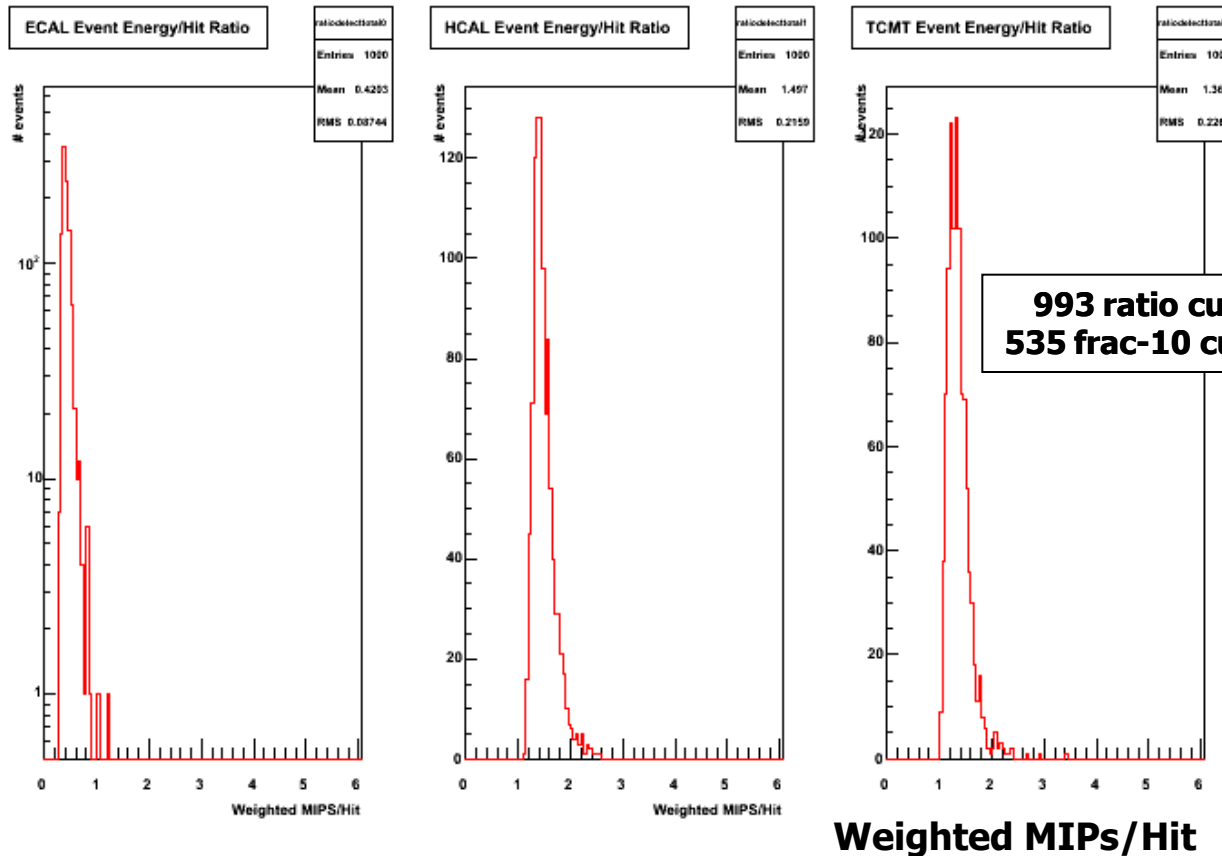


Coil at 5.5λ , the proposed thickness of the SID calorimeter plus post-coil sampling

*** $\Delta E_{res} = [E_{res}(w/coil) - E_{res}(cal. only)] / E_{res}(cal. only)$**

Studies of Energy/ #Hits Ratio

Monte Carlo Muons - 6Gev



These suggest
ratio cuts of:
ECAL ratio = 1.0
HCAL ratio = 2.5
TCMT ratio = 2.5

993 ratio cut/1000 total muons = 0.99
535 frac-10 cuts/1000 total muons = 0.54

Plan to switch to a cut derived from studying distribution of muons from in flight decay of pions in Monte Carlo runs (with truth information).
This is going slow because of technical difficulties.

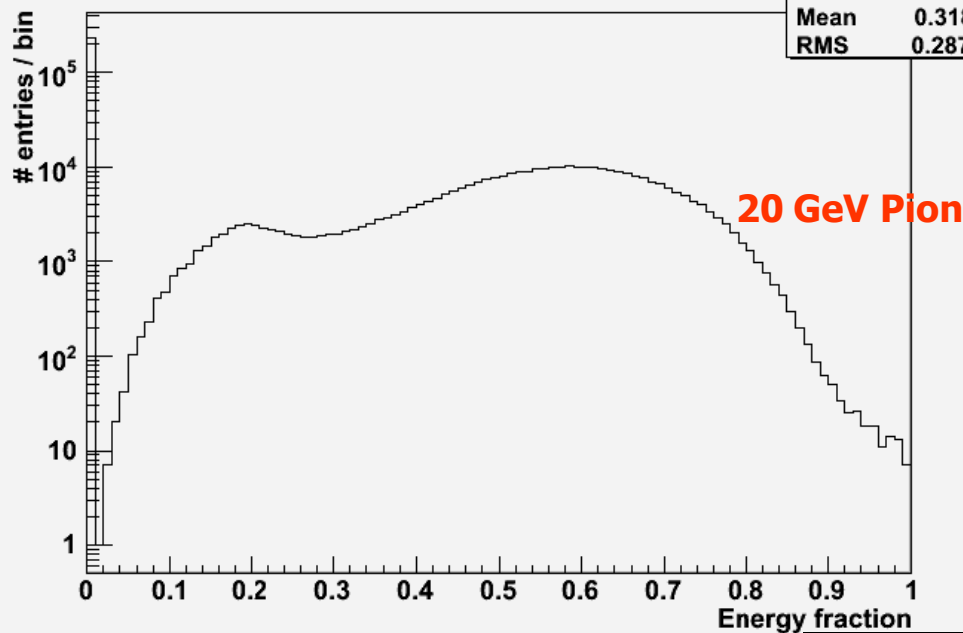
Summary

- **Detector performed well**
- **Analysis is underway and progressing**
- **Post coil sampling improves resolution for coil position from 4.5 to 6 λ .**
- **At a depth of 5.5 λ (the design thickness of the SID calorimeter), a tail-catcher improves energy resolution by about 6% for 20 GeV pions and 10% for 80 GeV pions.**
- **Studying new methods to reject muons**

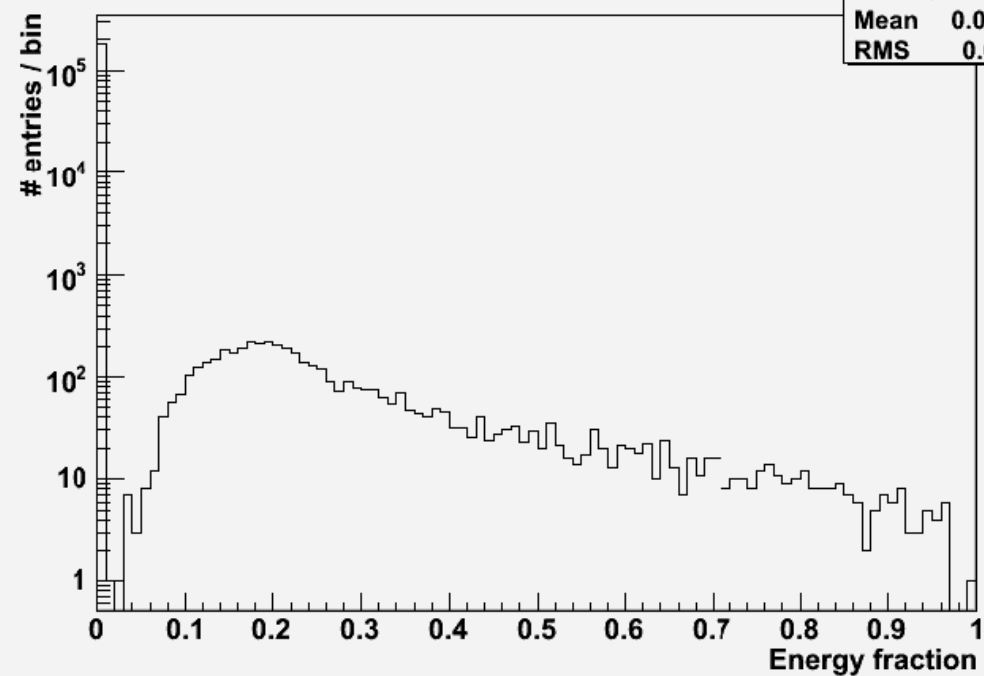
Additional Slides

EmcCalorimeter_HitsEfrac10mips

EmcCalorimeter_HitsEfrac10mips	
Entries	573843
Mean	0.3181
RMS	0.2876

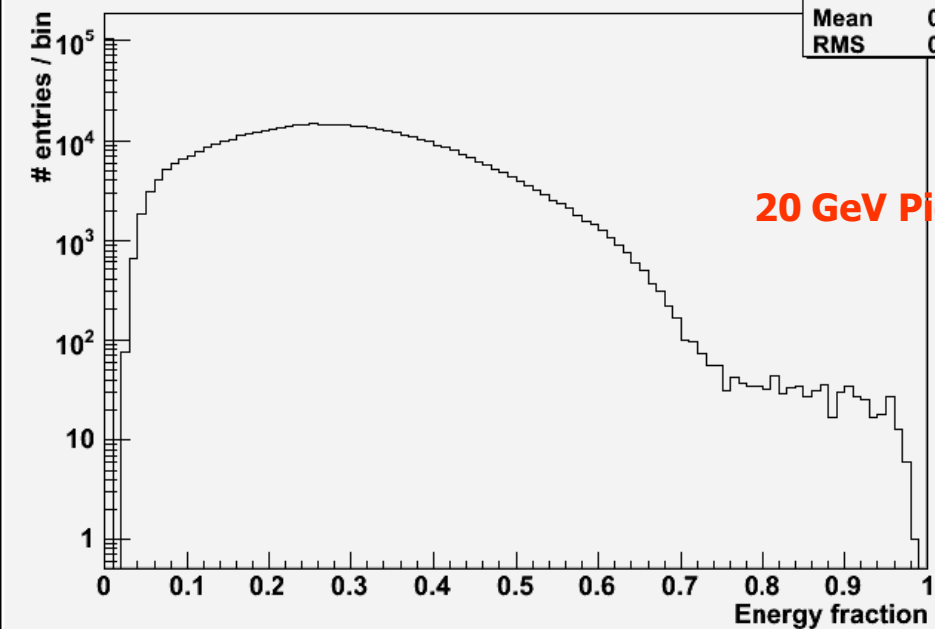
**EmcCalorimeter_HitsEfrac10mips**

EmcCalorimeter_HitsEfrac10mips	
Entries	187751
Mean	0.006971
RMS	0.05203



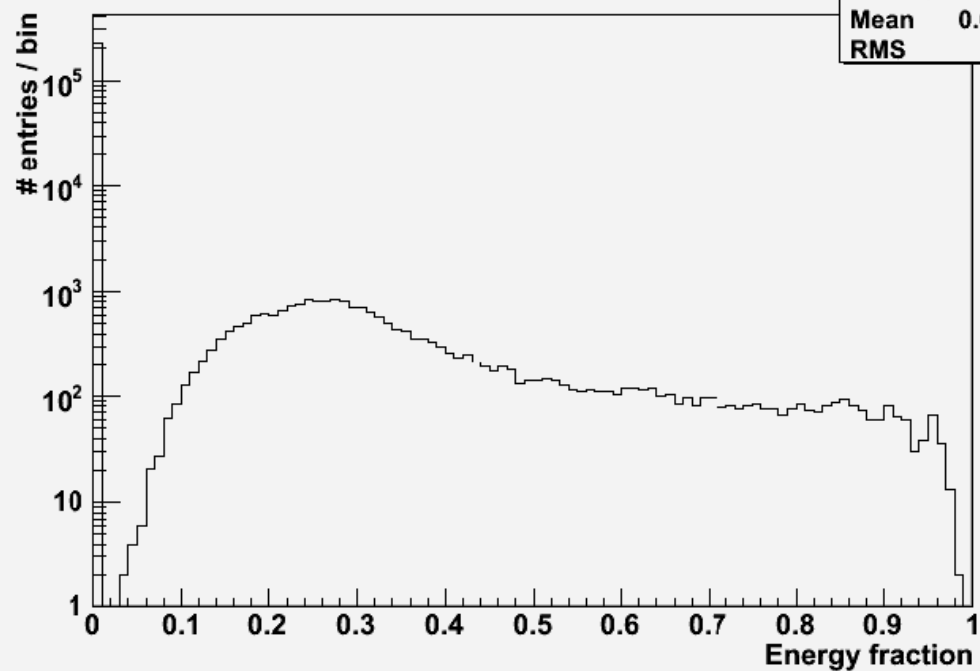
AhcCalorimeter_HitsEfrac10mips

AhcCalorimeter_HitsEfrac10mips	
Entries	587445
Mean	0.2415
RMS	0.1617



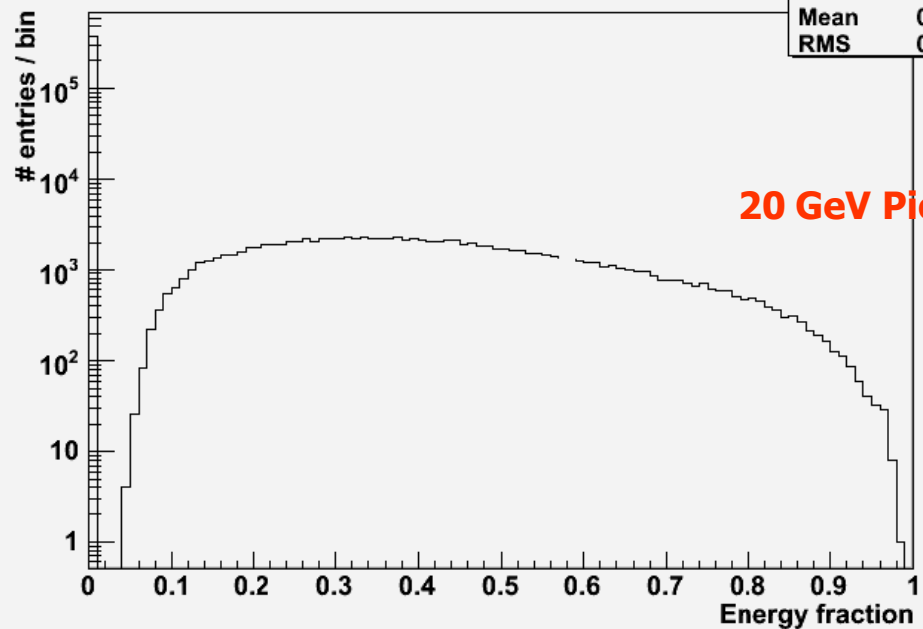
AhcCalorimeter_HitsEfrac10mips

AhcCalorimeter_HitsEfrac10mips	
Entries	243694
Mean	0.03248
RMS	0.118



TcmtCalorimeter_HitsEfrac10mips

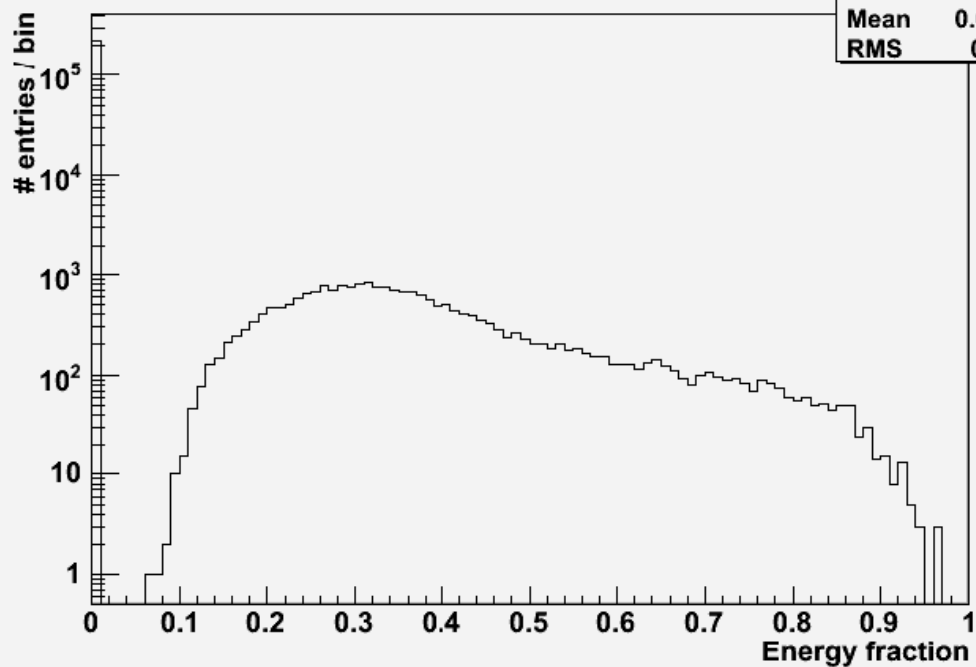
Entries	485020
Mean	0.0961
RMS	0.1971



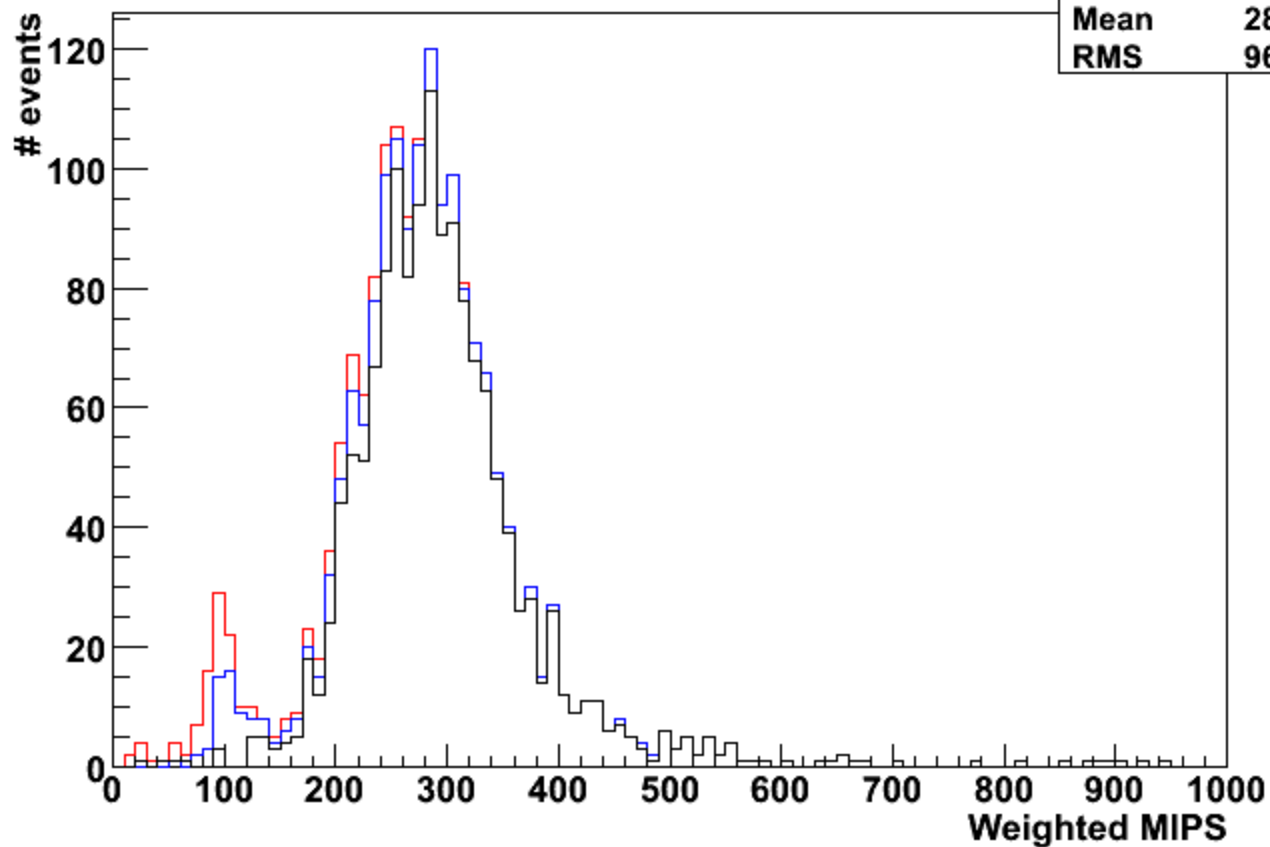
TcmtCalorimeter_HitsEfrac10mips

Entries	244182
Mean	0.03479
RMS	0.1192

Beam Dump
Muon



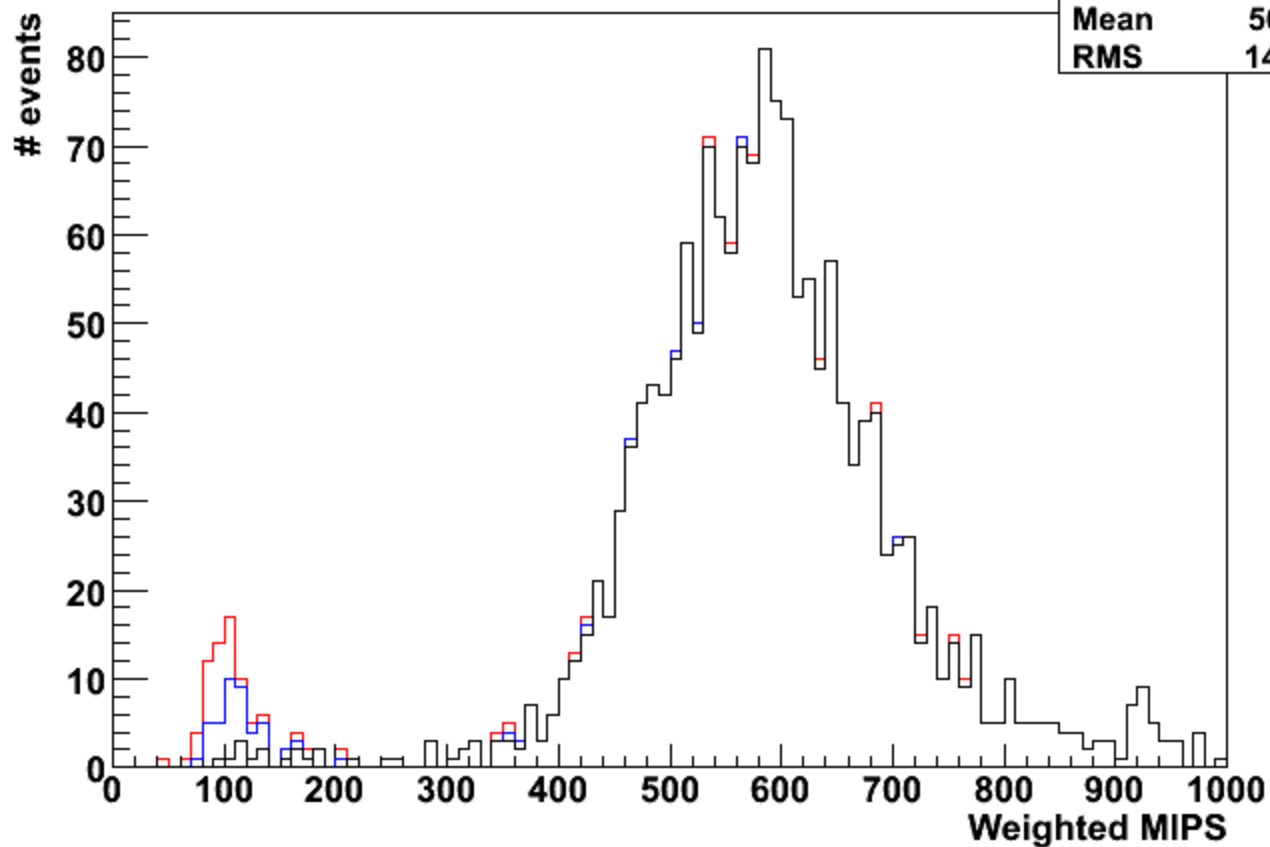
Weighted MIP Spectrum



10GeV Pion Run

Red: No muon cuts RMS=97 MEAN=281 RESOLUTION=0.34
Blue: After Frac-10 and Counter RMS=91 MEAN=289 RESOLUTION=0.32
Black: After Ratio cut and Counter RMS=88 MEAN=298 RESOLUTION=0.30

Weighted MIP Spectrum

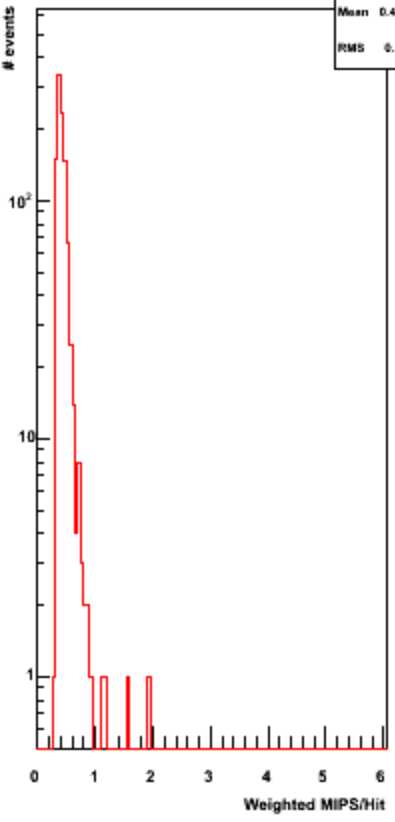


20GeV Pion Run

Red: No muon cuts RMS=149 MEAN=568 RESOLUTION=0.26
Blue: After Frac-10 and Counter RMS=134 MEAN=578 RESOLUTION=0.23
Black: After Ratio cut and Counter RMS=117 MEAN=588 RESOLUTION=0.20

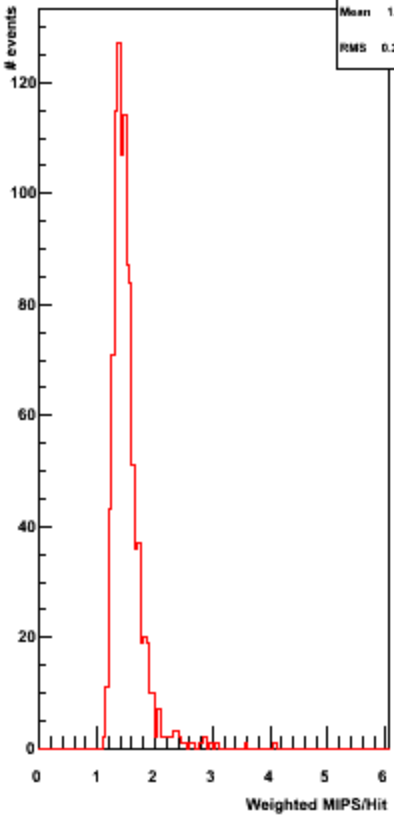
ECAL Event Energy/Hit Ratio

fatocdetector0
Entries 1000
Mean 0.4243
RMS 0.107



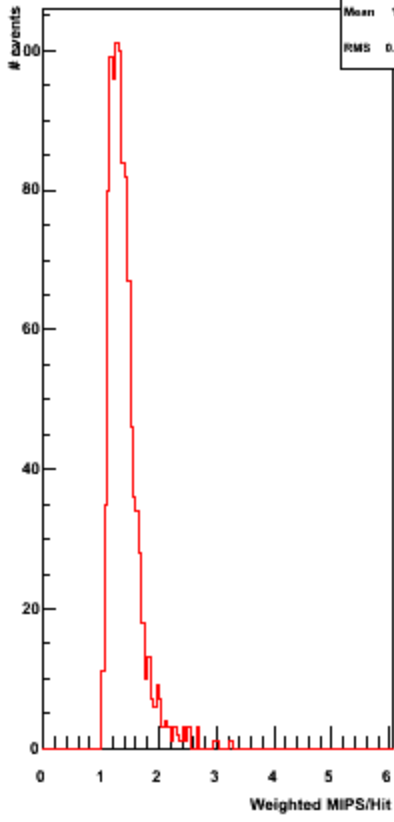
HCAL Event Energy/Hit Ratio

fatocdetector1
Entries 1000
Mean 1.513
RMS 0.2629



TCMT Event Energy/Hit Ratio

fatocdetector2
Entries 1000
Mean 1.399
RMS 0.2793



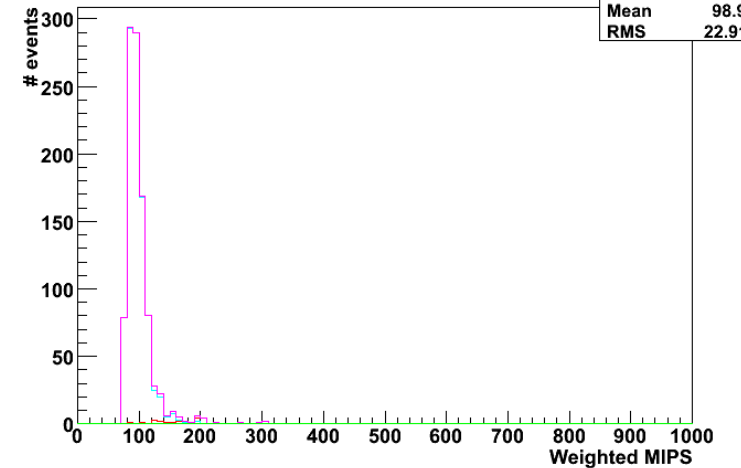
Monte Carlo Muons - 10GeV

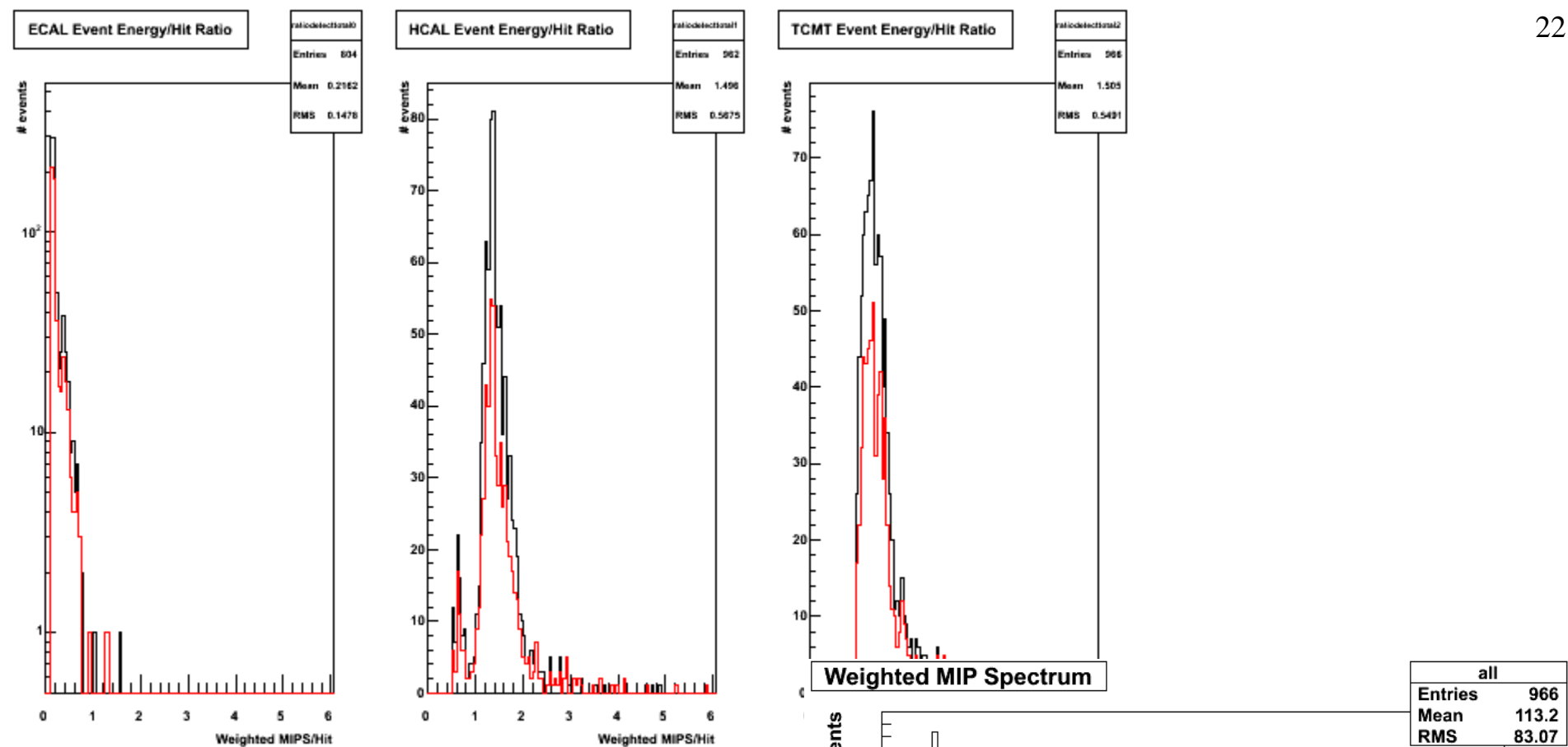
10GeV

975 ratio cut/1000 total muons = 0.98
 565 frac-10 cuts/1000 total muons = 0.57

Weighted MIP Spectrum

all
Entries 1000
Mean 98.9
RMS 22.91





Run300778 Beam Muons

484 ratio cut/543 total muons = 0.89
 324 frac-10 cuts/543 total muons = 0.60

Events that don't pass through ECAL are ignored

