Study of the Tail Catcher Muon Tracker (TCMT) Scintillator Strips and Leakage with Simulated Coil

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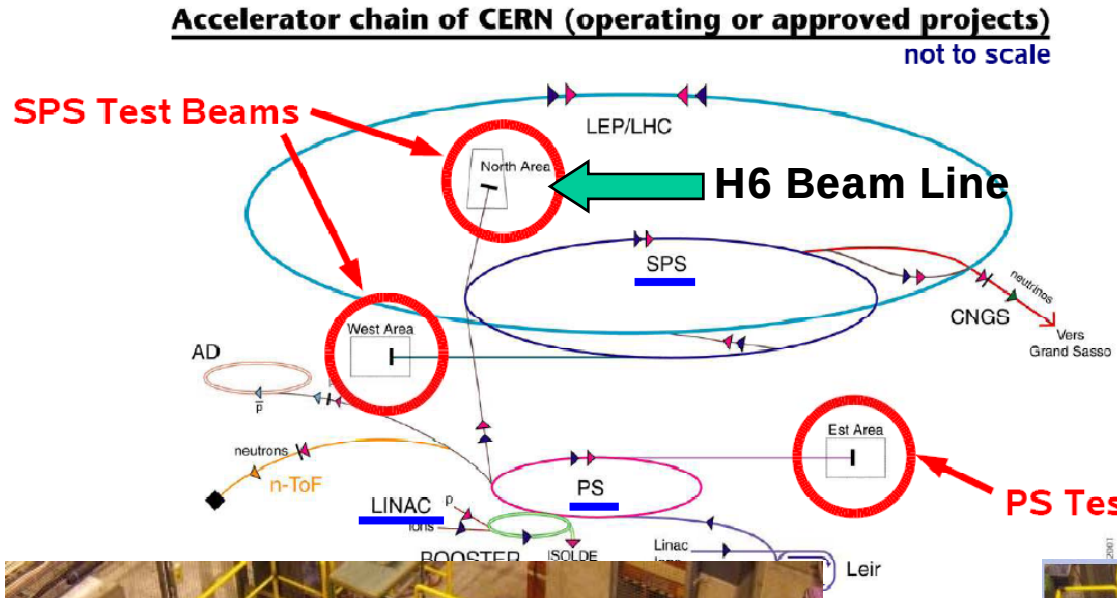
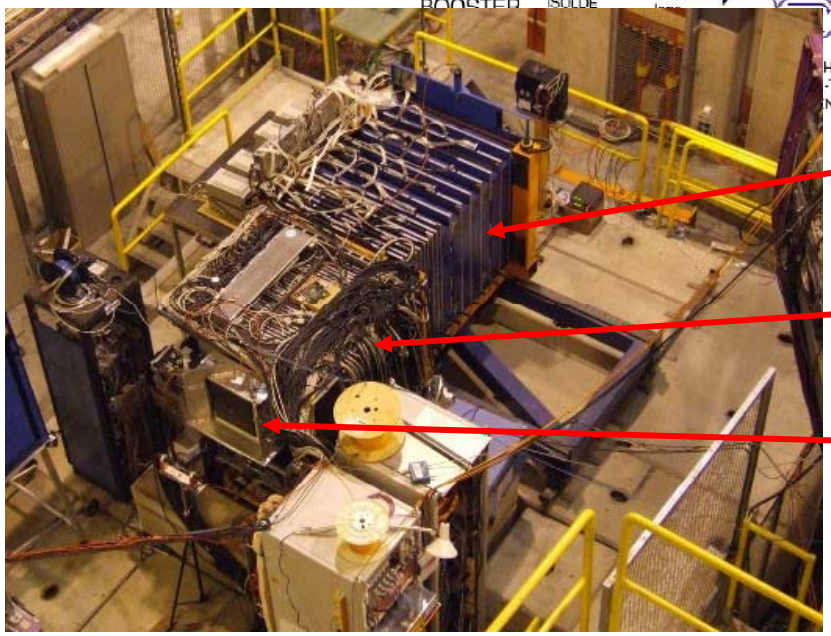
Introduction

- **The CALICE Tail-Catcher Muon-Tracker**
  - **Goals:**
    - **Prototype ILC muon detector using Silicon Photo Multipliers (SiPMs)**
    - **Correct for leakage due to thin calorimeters**
  - **Test Beam needed to:**
    - **Study end of hadronic showers & validate simulations available**
    - **Understand & address impact of coil**
    - **Understand TCMT in Particle Flow Algorithm (PFA) framework**
    - **Achieve good muon signature**
- **CALICE Detector Design and Test Beam**
- **Analysis**
  - **Crosstalk between Scintillator strips**
  - **Attenuation of Scintillator Strips**
  - **Effect of “Coil” and Tail Catcher on Energy Resolution**

CALICE @ CERN Test Beam



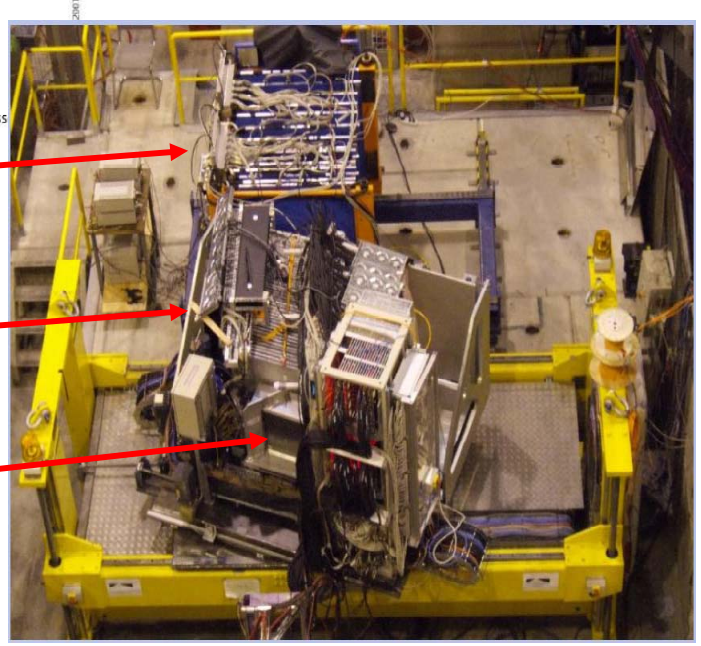
Portions of this slide thanks to
Erika Garutti and R. Pöschl



TCMT

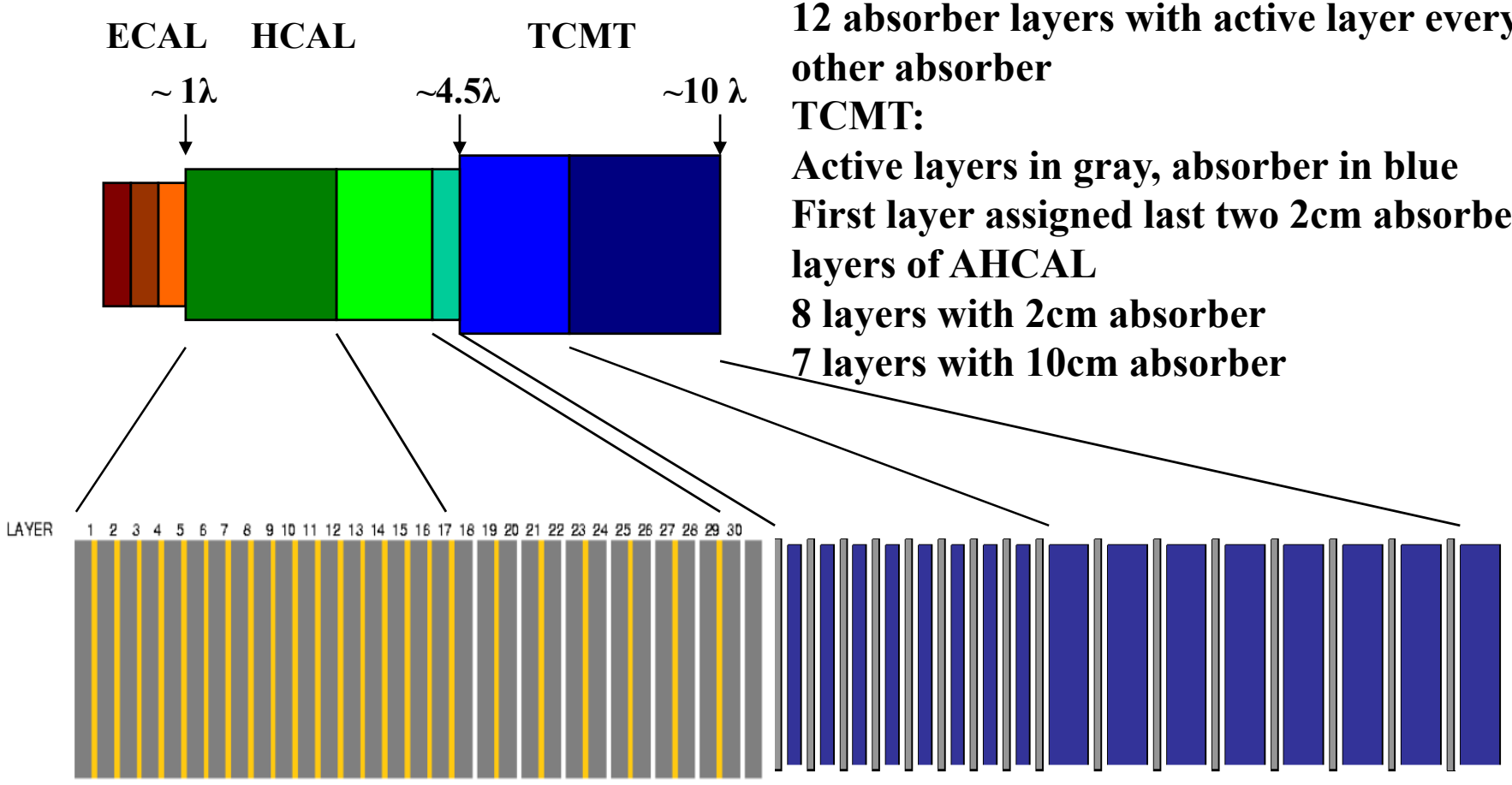
HCAL

ECAL



CALICE Configuration, Oct. 2006

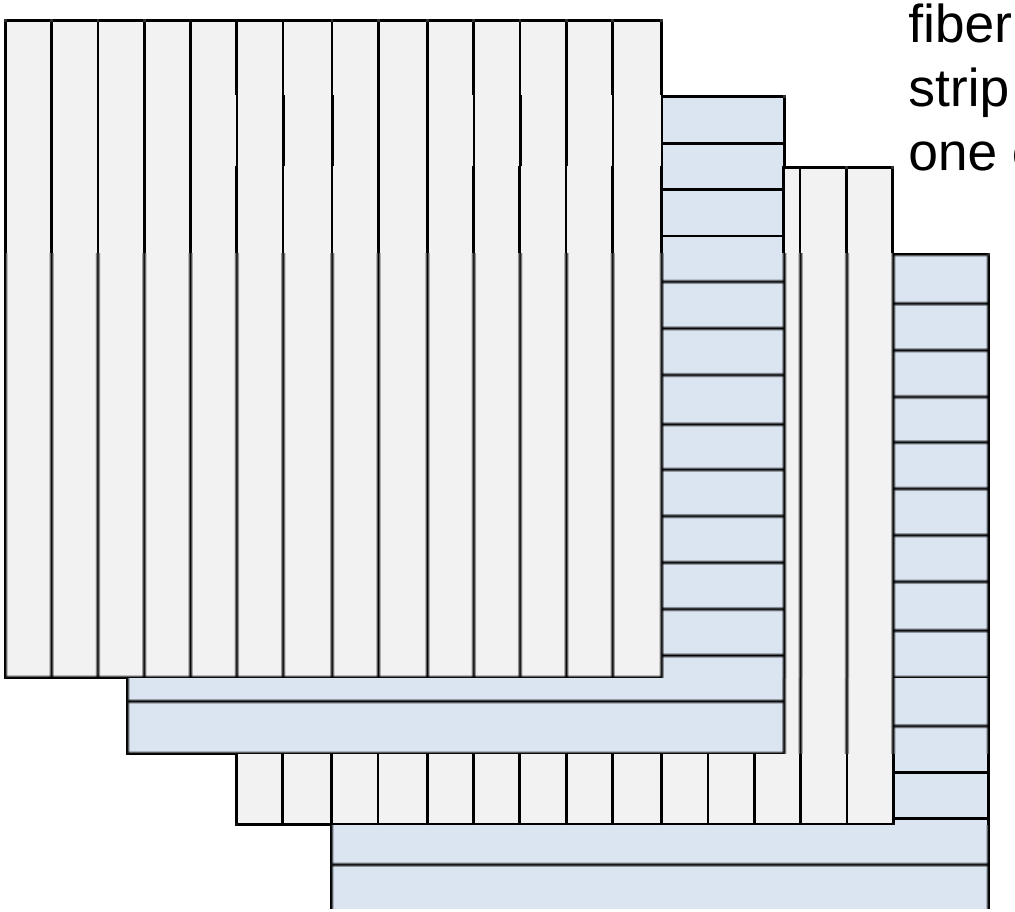
(Lengths Not To Scale)



AHCAL:
Active layers in yellow, absorber in gray, missing layer in white
17 active layers with 2cm absorber
12 absorber layers with active layer every other absorber
TCMT:
Active layers in gray, absorber in blue
First layer assigned last two 2cm absorber layers of AHCAL
8 layers with 2cm absorber
7 layers with 10cm absorber

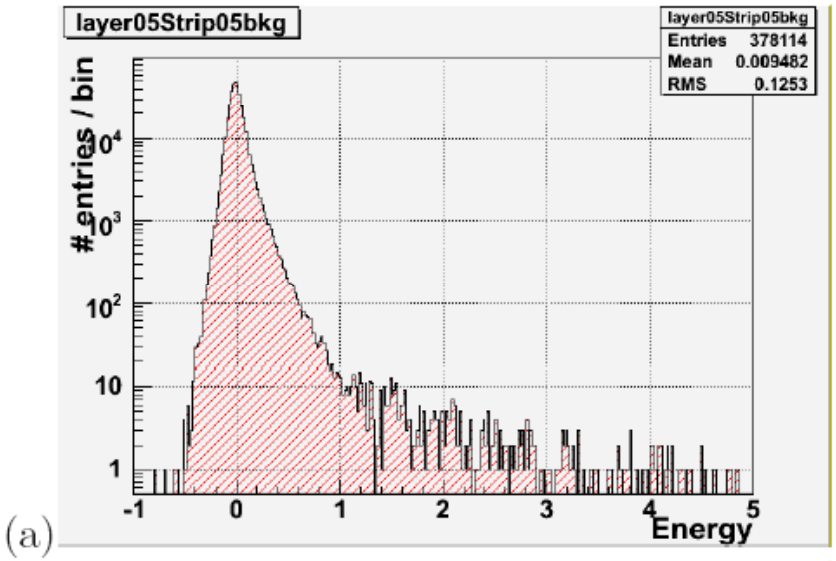
TCMT Cassette and Strips

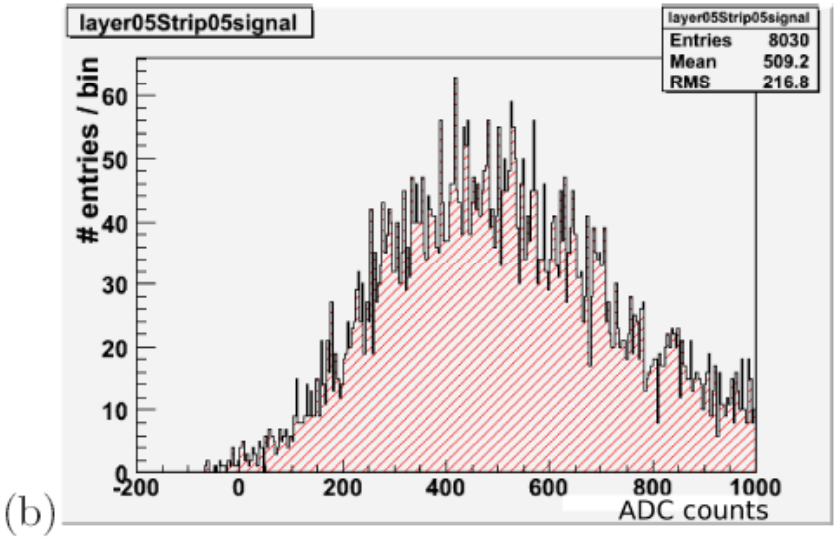
20 strips per layer

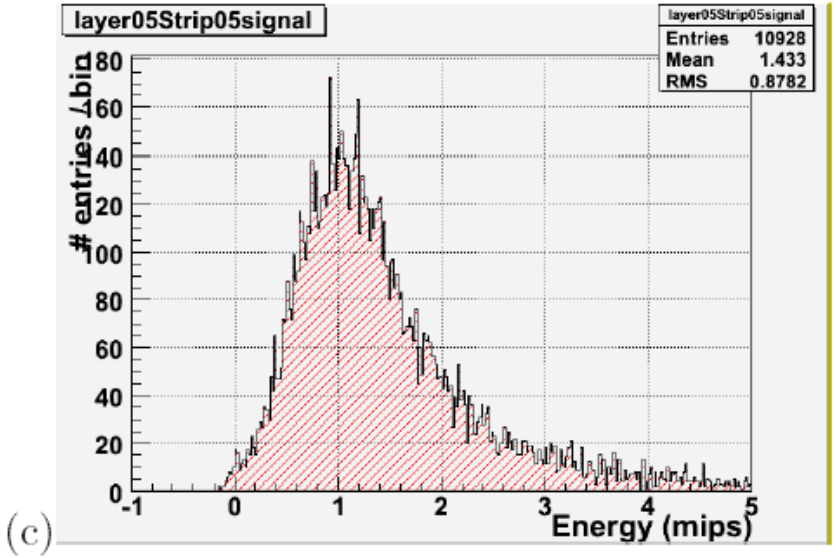


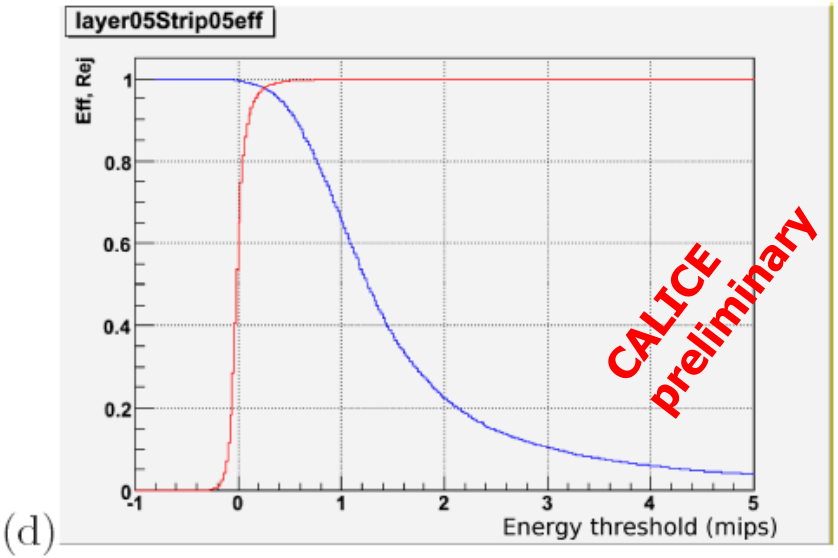
Scintillator strips 100cm x 5cm, 0.5cm thickness; wave shifting optical fiber through center of strip readout by SiPM at one end

Calibration of Strips





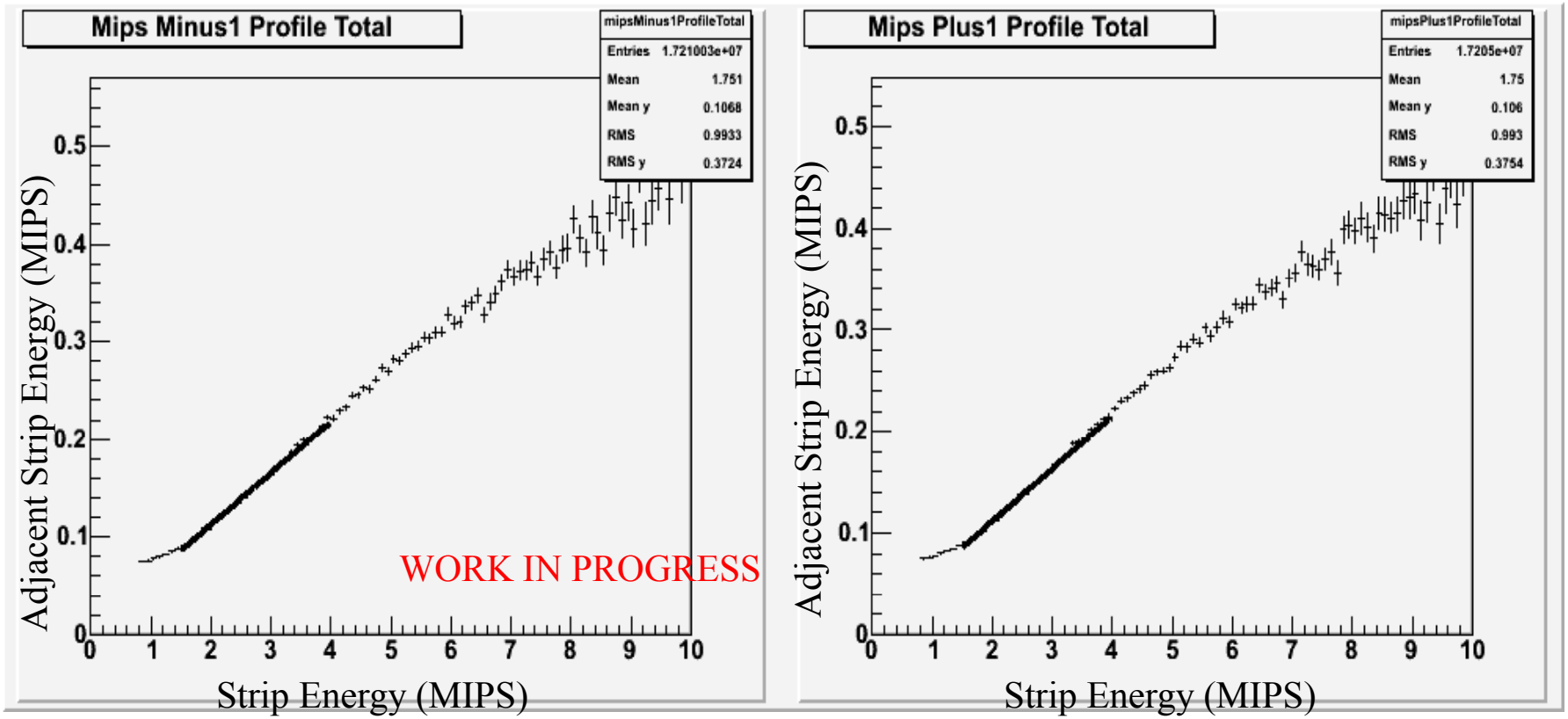




TCMT Strip Crosstalk

- Trigger Requirements
  - 6 of 8 parallel strips have hits (hit = >0.5 mips)
  - No double muons
  - No pion showers
  - For Crosstalk histograms, central strip has > 0.8 mips
- Profile Plots
  - When muon track found, profile plots filled to show the energy deposited in neighboring strips during the same event
  - Total plots created by combining data for all strips
  - Slope of profile plots taken to measure correlation
- Find slope of ‘total’ plots (data from all strips at once)
  - It should be noted that there was no delta-ray subtraction

Crosstalk Results

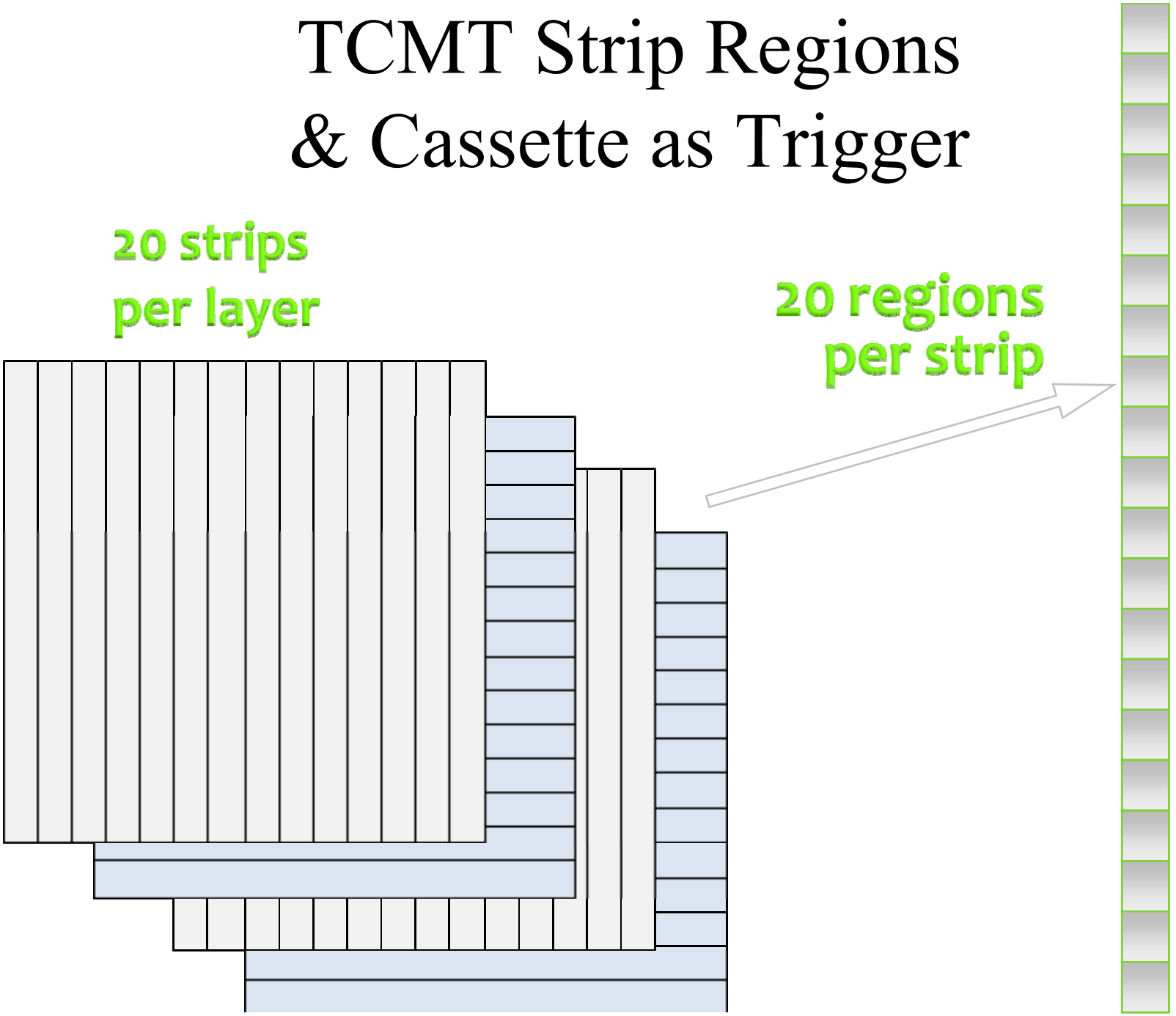


- Minus 1 means adjacent strip to the left was compared
- Plus 1 means adjacent strip to the right was compared
- Mean slope ~ 5%

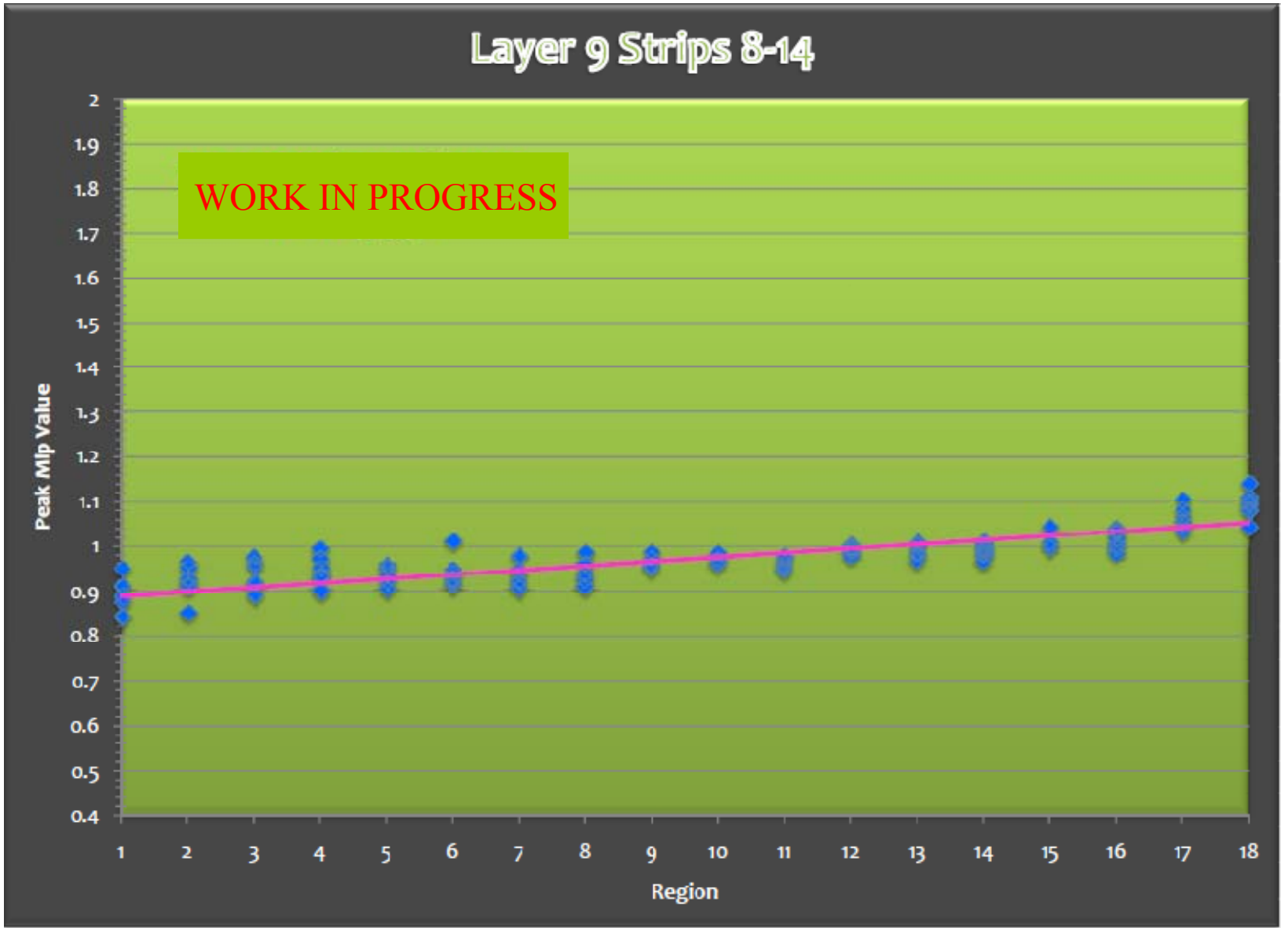
TCMT Strip Attenuation

- Strips are divided into 20 ‘regions’
- Used adjacent cassette as trigger
  - Strips in adjacent cassette are perpendicular and coincide with each region on strip being studied
- Applied proper cuts (no doubles, no pions), similar to Crosstalk Analysis
- Gaussian fits applied and MPV used
- Plot MIP energy as a function of region

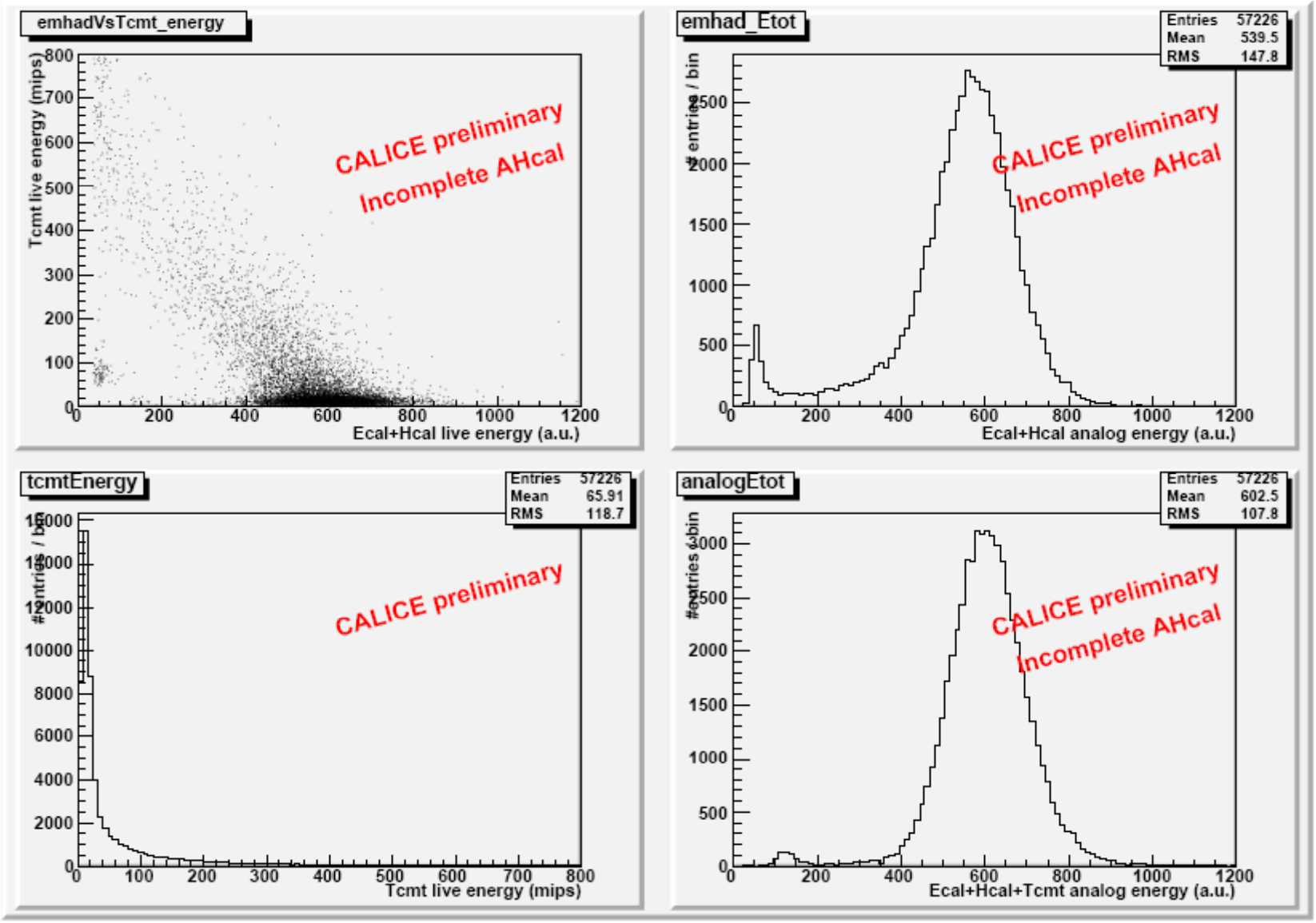
TCMT Strip Regions & Cassette as Trigger



Attenuation: MIP value vs Region



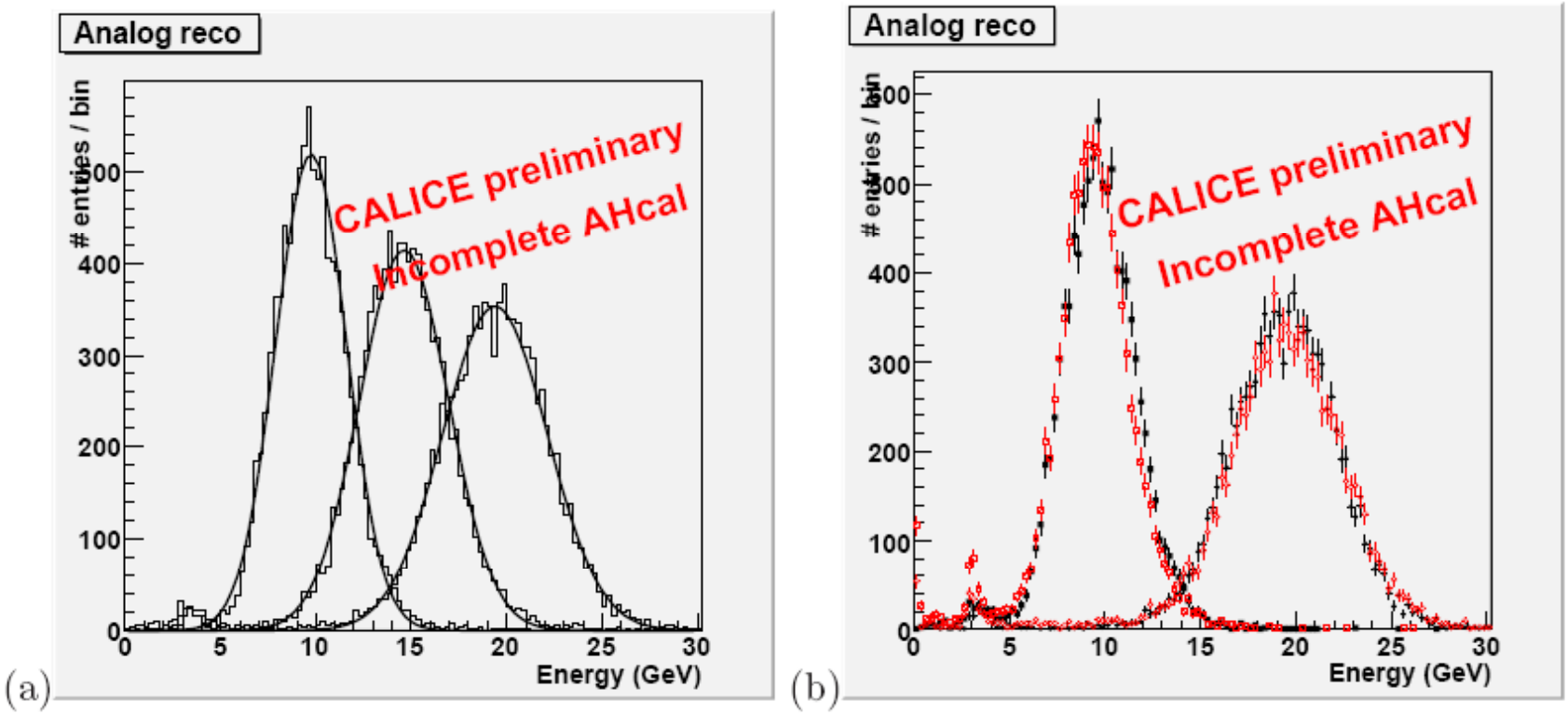
Analog Energy Response -20 GeV pion run



Using the -20 GeV pion run, the intra-component weights are found using the anti-correlation plots: ECAL vs AHCAL (not shown) and ECAL + HCAL vs TCMT (upper left)

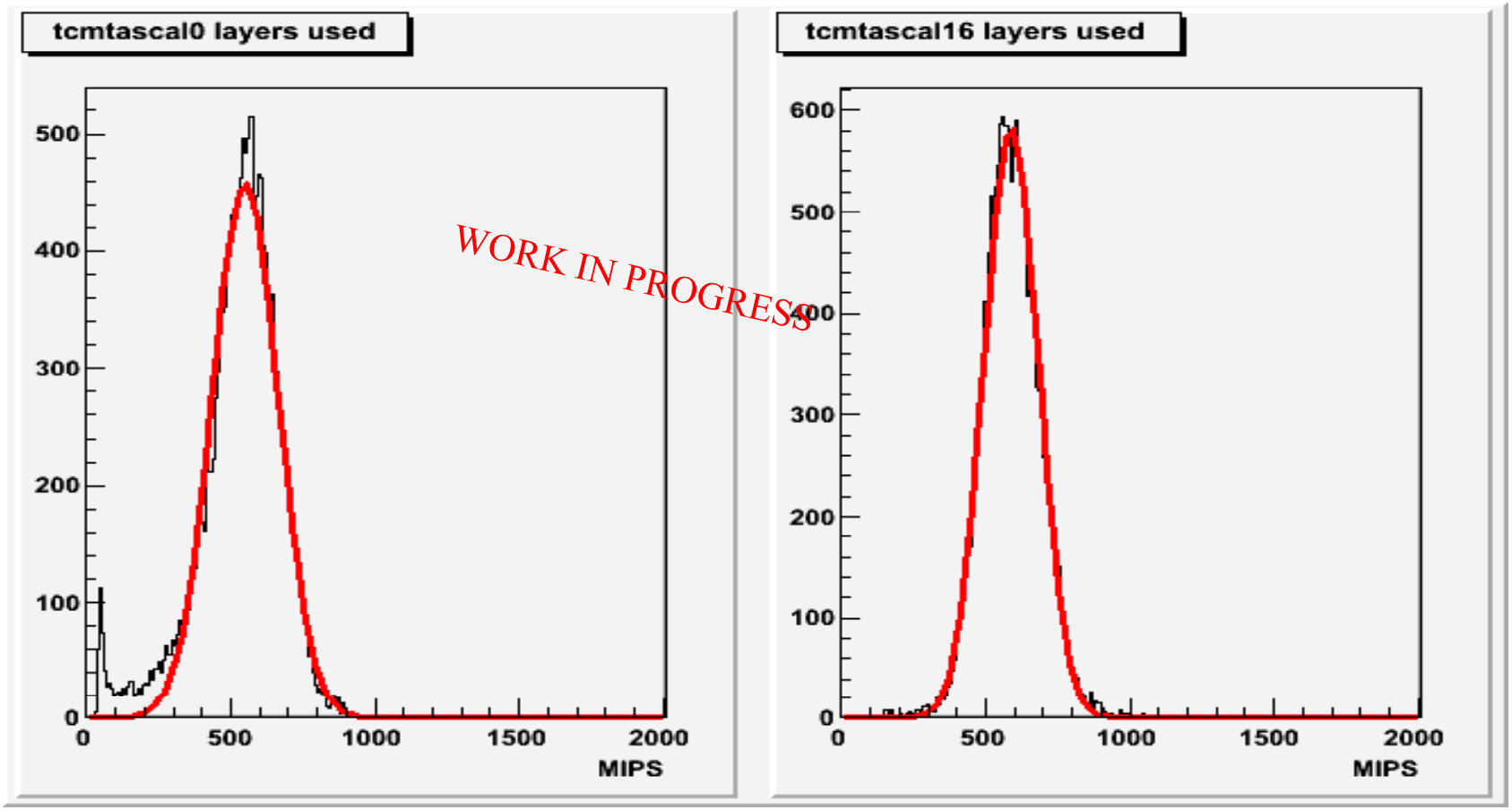
Energy Reconstruction

- Energy Reconstruction using analog readout
  - (a) for pion beams with different energies 10,15,20 GeV
  - (b) comparison between test beam and Monte Carlo (red) 10,20 GeV



TCMT data is combined into ECAL+AHCAL data using weights determined from the -20 GeV pion run

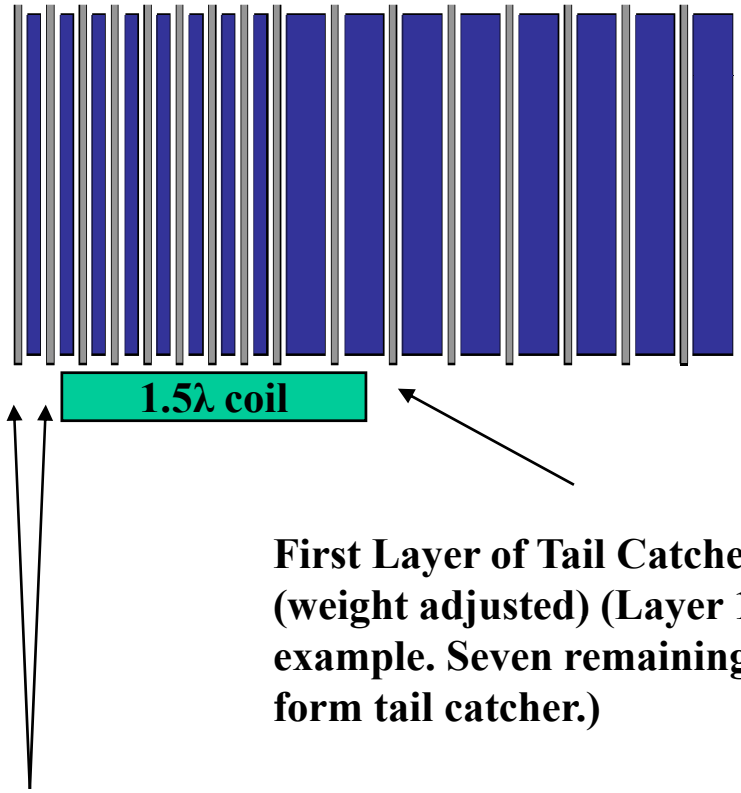
After Additional MIP Track Cuts



ECAL + AHCAL

ECAL + AHCAL + Full TCMT

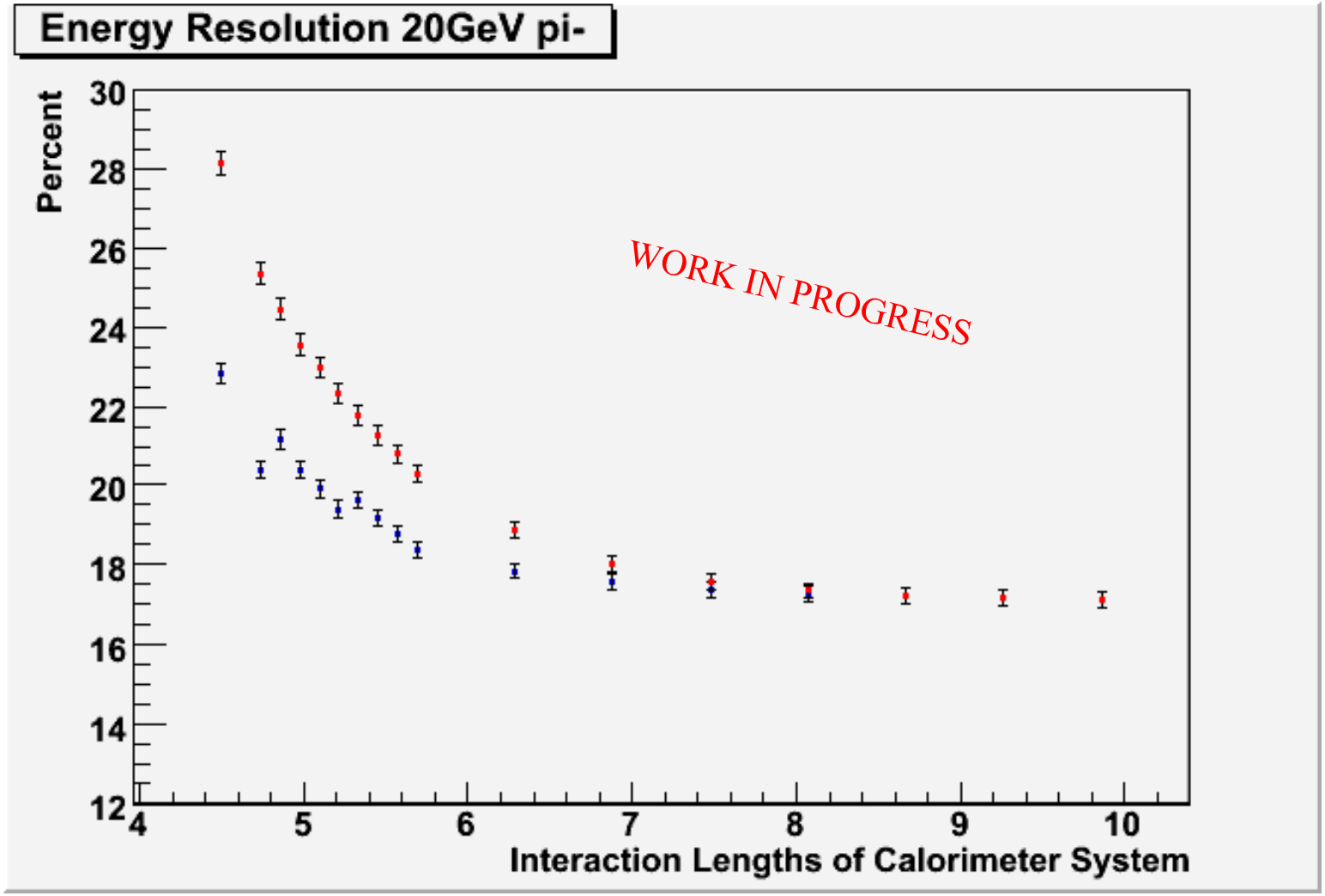
Allocation of TCMT Layers



Layers of TCMT added to calorimeter	End of simulated coil/ first layer of tailcatcher	TCMT layers used behind coil
0	10	7
1	10	7
2	11	6
3	11	6
4	11	6
5	11	6
6	12	5
7	12	5
8	12	5
9	12	5
10	13	4
11	14	3
12	15	2
13	16	1

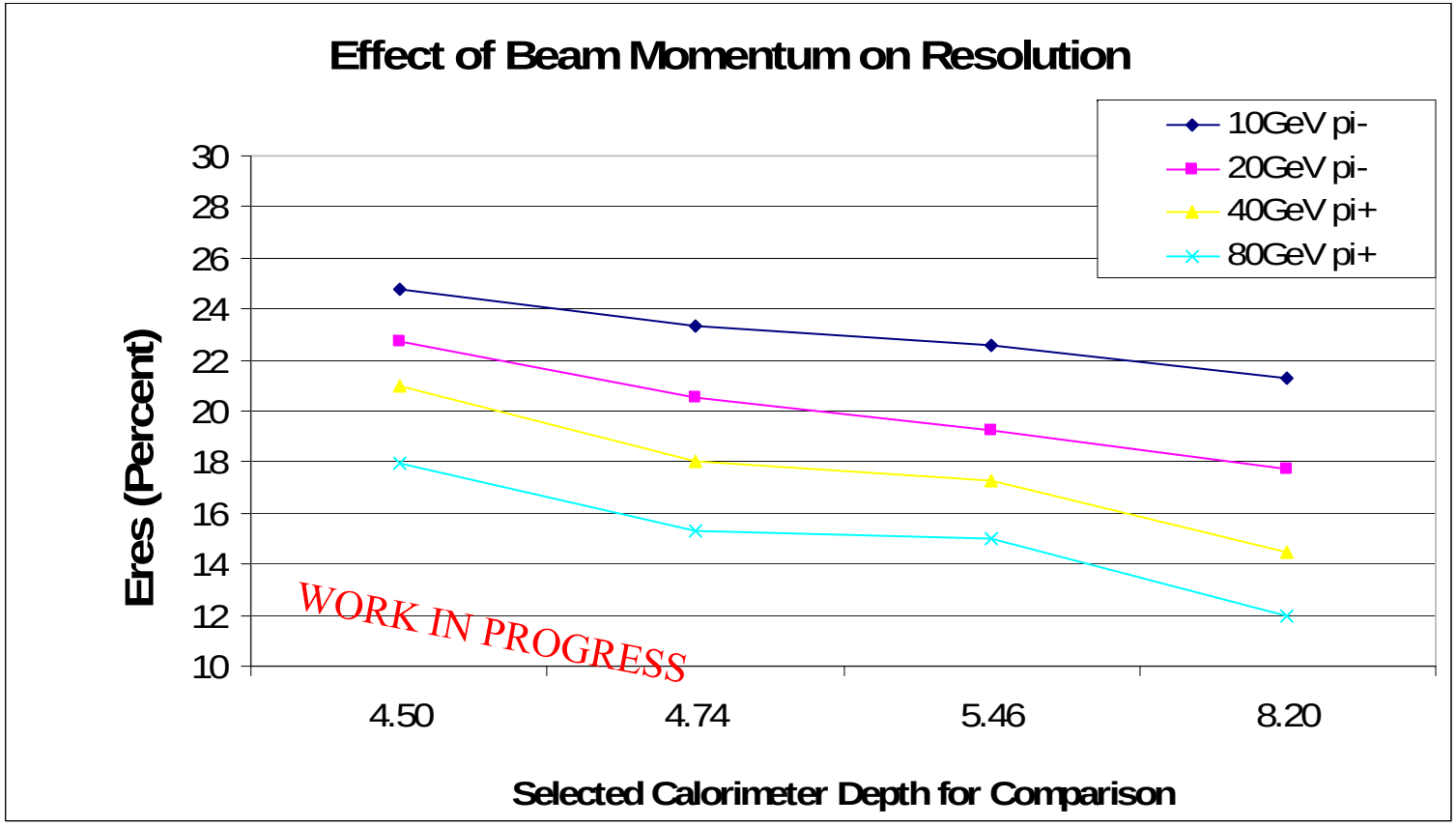
Note: Weight of first layer after gap is adjusted

-20 GeV pion

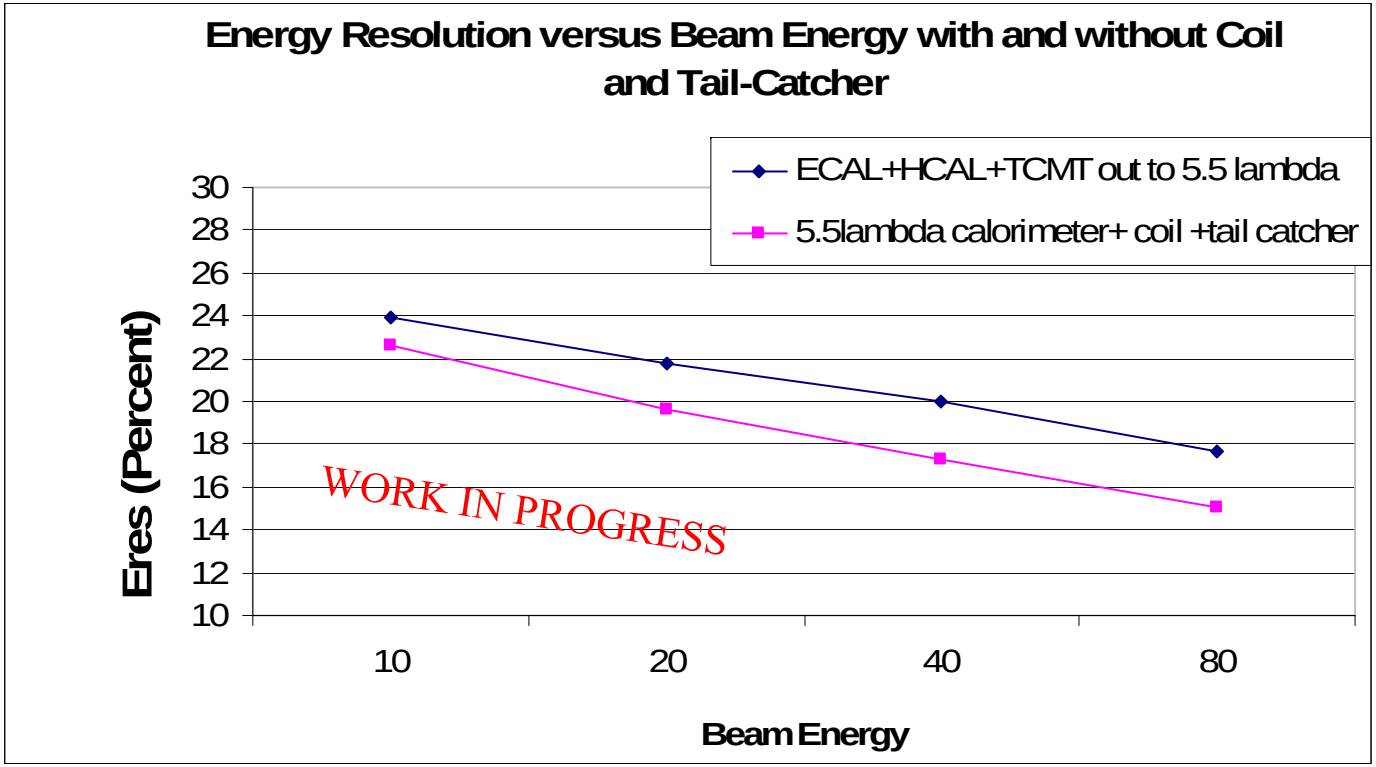


RED: ECAL + HCAL + n TCMT Layers
BLUE: ECAL + HCAL + n TCMT Layers + 1.5 λ coil + remaining layers of TCMT

Single Particle Resolution



Single Particle Resolution (cont)



Summary

- Attenuation of response over a 1m long strip was found to be approximately 10-15%
- Strip Crosstalk approximately 5%
- Adding remaining TCMT layers after a simulated coil of 1.5λ improves energy resolution and contains leakage
- For a calorimeter depth of 5.5 λ , the TCMT improves energy resolution by 2.2%, a relative improvement of 11% for the -20 GeV Pion run
- FUTURE PLANS:
  - Analyze 2007 CERN Test Beam Data
  - Compare with Monte Carlo models