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

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For
CALICE Collaboration

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Outline

- The CALICE Tail-Catcher Muon-Tracker
  - Goals:
    - Prototype ILC muon detector using SiPMs
    - Correct for leakage due to thin calorimeters
  - Test Beam needed to:
    - Study end of hadronic shower & validate simulations available
    - Understand & address impact of coil
    - Understand TCMT in PFA framework
    - Achieve good μ ID and control fake rates
- Preliminary Results from CERN
- Analysis of depth of calorimeter system on Energy resolution and improvements due to added tail-catcher

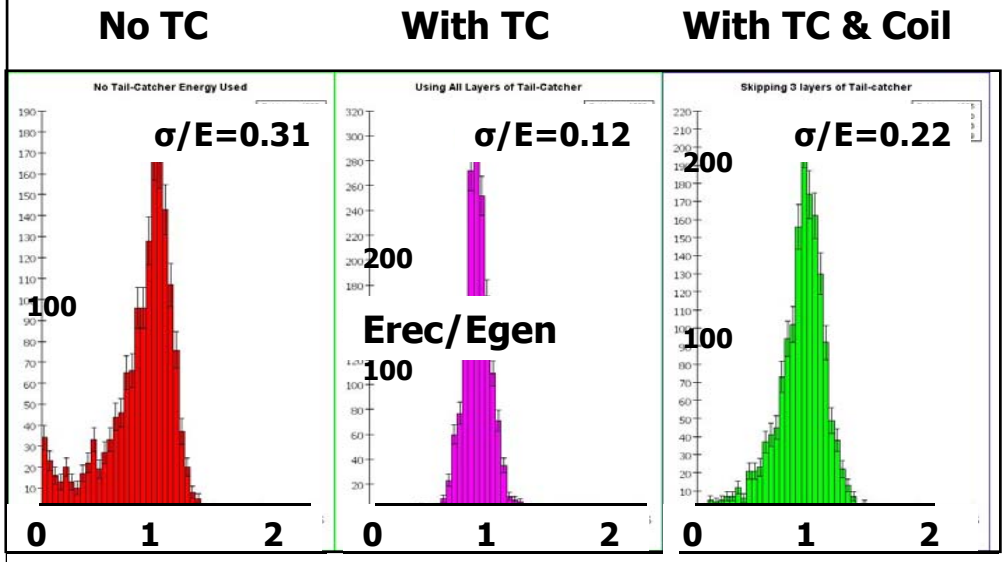
CALICE Tail-Catcher Muon-Tracker Prototype

- **Mechanical Structure/Absorber**
  - "Fine" section (8 layers)
    - 2 cm thick steel
  - "Coarse" section (8 layers)
    - 10 cm thick steel
  - Engineered and assembled by Fermilab PPD
- **16 Cassettes:**
  - Extruded Scintillator Strips
    - 5mm thick
    - 5cm wide strips
    - Tyvek/VM2000 wrapping
    - Alternating x-y orientation
  - Readout
    - WLS Fiber
    - SiPM photo detection
    - Uses common electronics (DESY) readout with CALICE HCAL
    - Uses common CALICE DAQ (Imperial college)

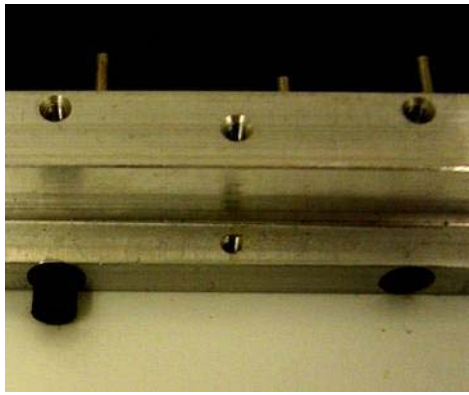
- **Dimensions:**
  - Length (along beam) - 142 cm
  - Height - 109 cm
- **Weight ~10 tons**

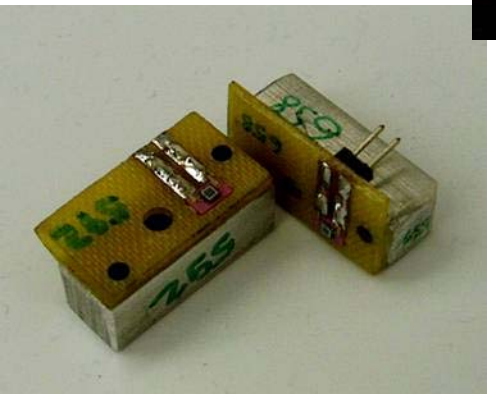
Design Motivations

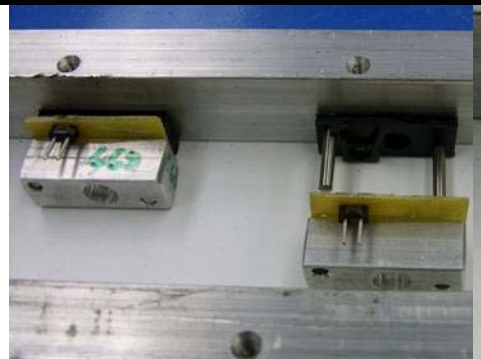
- TCMT required for sufficient depth to contain hadronic showers and validate Monte Carlos for PFA studies.
- For many ILC concepts calorimetry is thin and inside the coils. The outer solenoid flux return is composed of layers of Fe plates with gaps: consideration of a tail catcher is natural.
- Used SiD ECAL/HCAL simulation to understand effects:
  - 4.6 nuclear λ
  - 5T solenoid coil + cryostat 1.27λ.
  - HCAL outer radius is 2.37 m.
  - The muon system outside solenoid and cryostat at radius ~3.50 m.



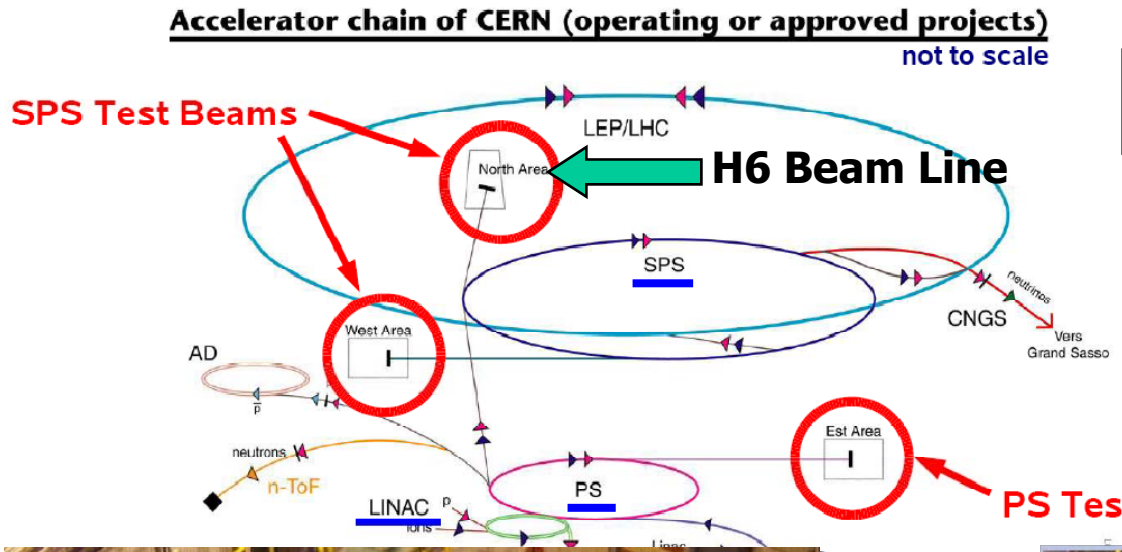
TCMT Cassette Components





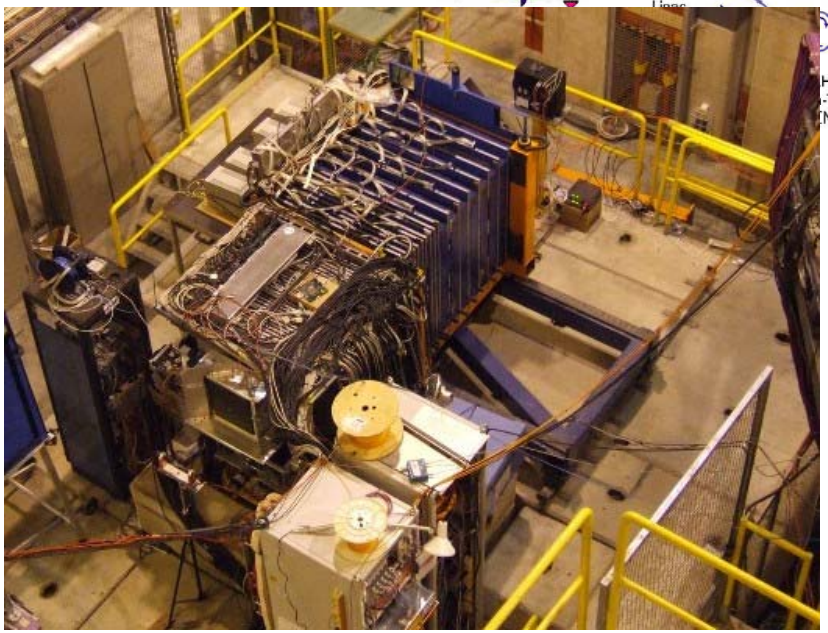


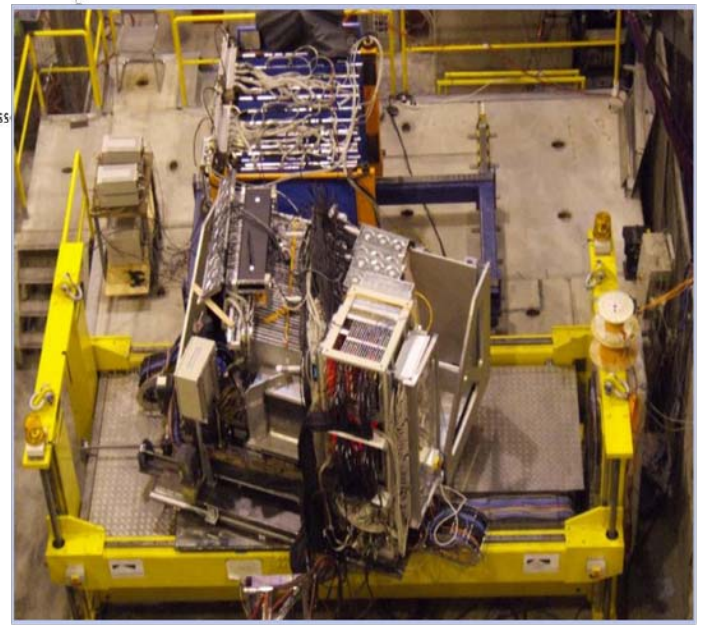
CALICE @ CERN Test Beam



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

- >5Tbyte 2006 data
- >14Tbyte 2007 data
- Available on Grid for analysis





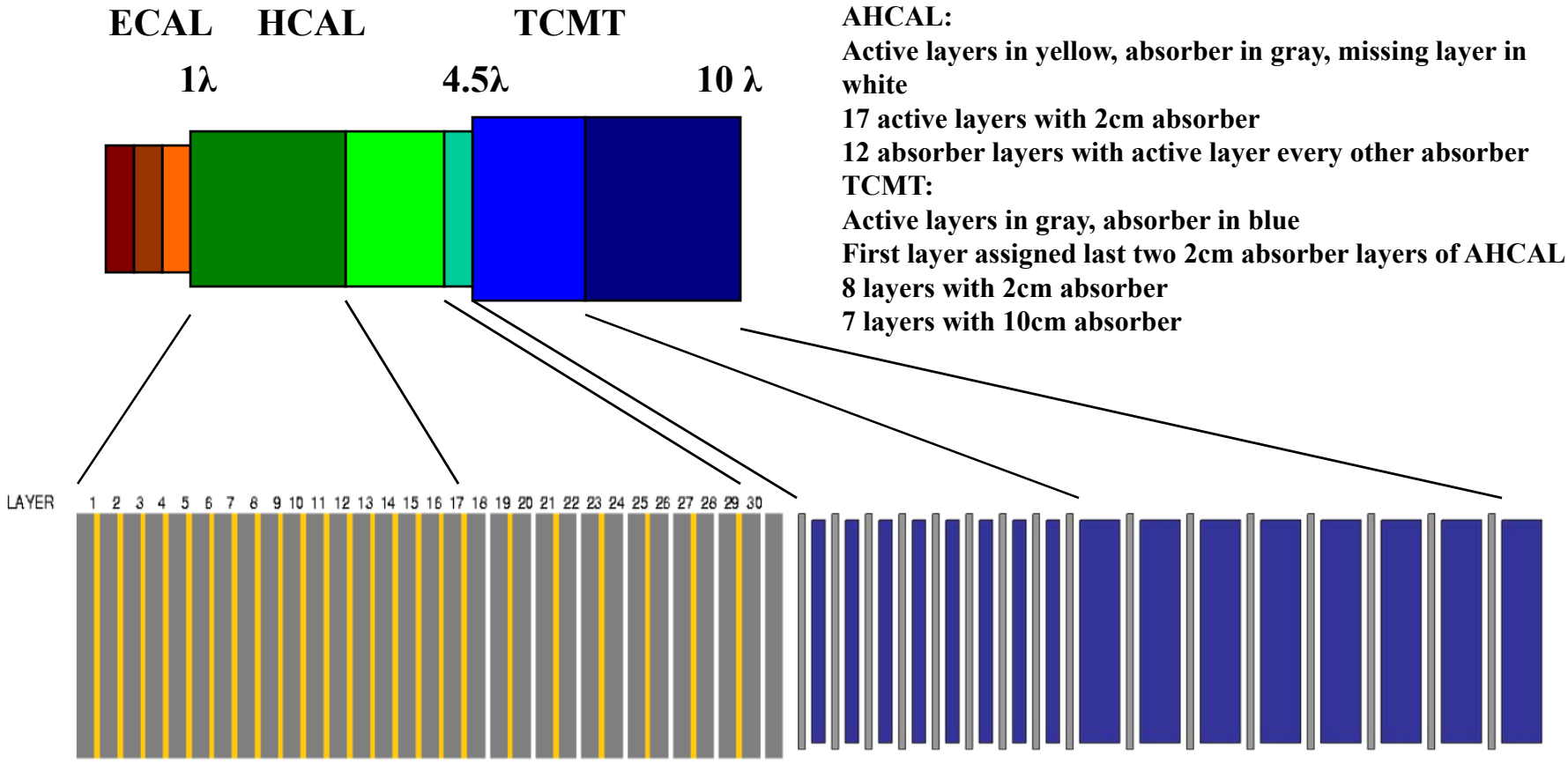
CALICE Calorimeters at Test Beam

- ECAL
  - 30 active layers of silicon diode pad detectors with ~10,000 channels
  - tungsten absorbers with thickness of 1.4mm to 4.2mm
  - total thickness $24X_0$ radiation length
- HCAL
  - Up to 38 absorbers (30 used in 2006) – 1.6cm thick steel
  - Gaps instrumented with 0.4mm thick modules with high granularity core (3x3cm^2)
    - During 2006 Run
      - Layers 1-17 - all instrumented
      - Layers 19-29 - every other layer instrumented
      - Total of 23 layers x 216 chan/layer = 4968 channels
    - During 2007 Run
      - Layers 1- 30 – all instrumented
      - Layers 31 – 38 without high granularity core scintillators
      - > 7500 channels
  - 4.5 interaction lengths
  - Rotating stage used for position and angle scans in 2007 run
- Test Beam Runs
  - 2006 August/September and October/November (discussed here)
  - 2007 June to August (still under analysis)

Current Analysis

- The effect of TCMT and coil on leakage was studied
- Compared resolution of a calorimeter as a function of thickness with a system with calorimeter, coil, and tailcatcher
- Used a subset of TCMT layers, leaving a gap equivalent to 1.8 +/- 10% lambda to simulate magnetic coil
- Used CALICE October 2006 CERN data

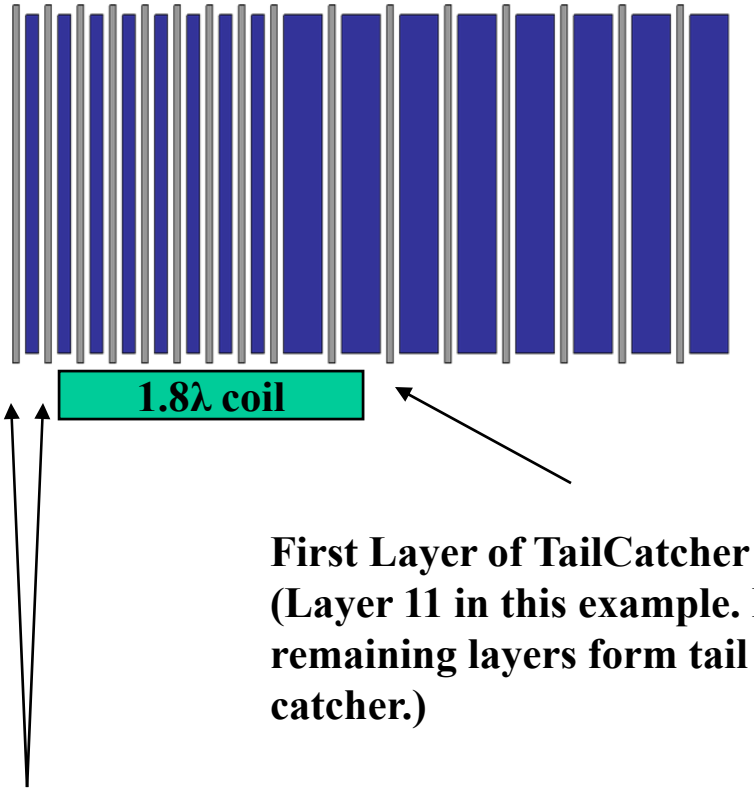
CALICE Configuration, Oct. 2006



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

Would like to compare Energy Resolution of :
ECAL + HCAL + n TCMT Layers
With:
ECAL + HCAL + n TCMT Layers + 1.8 λ gap + remaining layers of TCMT

Allocation of TCMT Layers

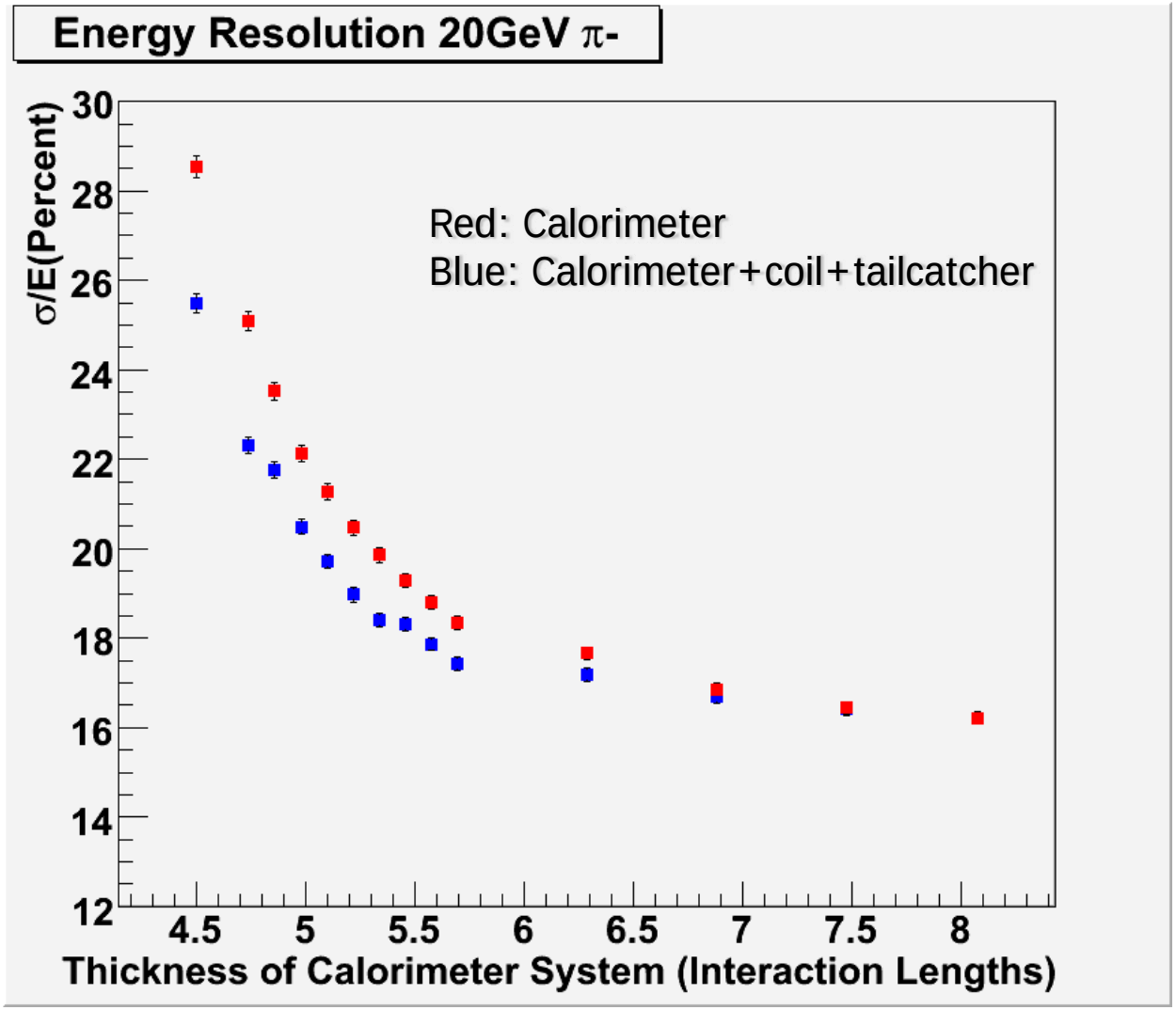


Layers of TCMT added to calorimeter	End of simulated coil/ first layer of tailcatcher	TCMT layers used behind coil
0	10	7
1	10	7
2	11	6
3	11	6
4	11	6
5	11	6
6	11	6
7	12	5
8	12	5
9	12	5
10	13	4
11	14	3
12	15	2
13	16	1

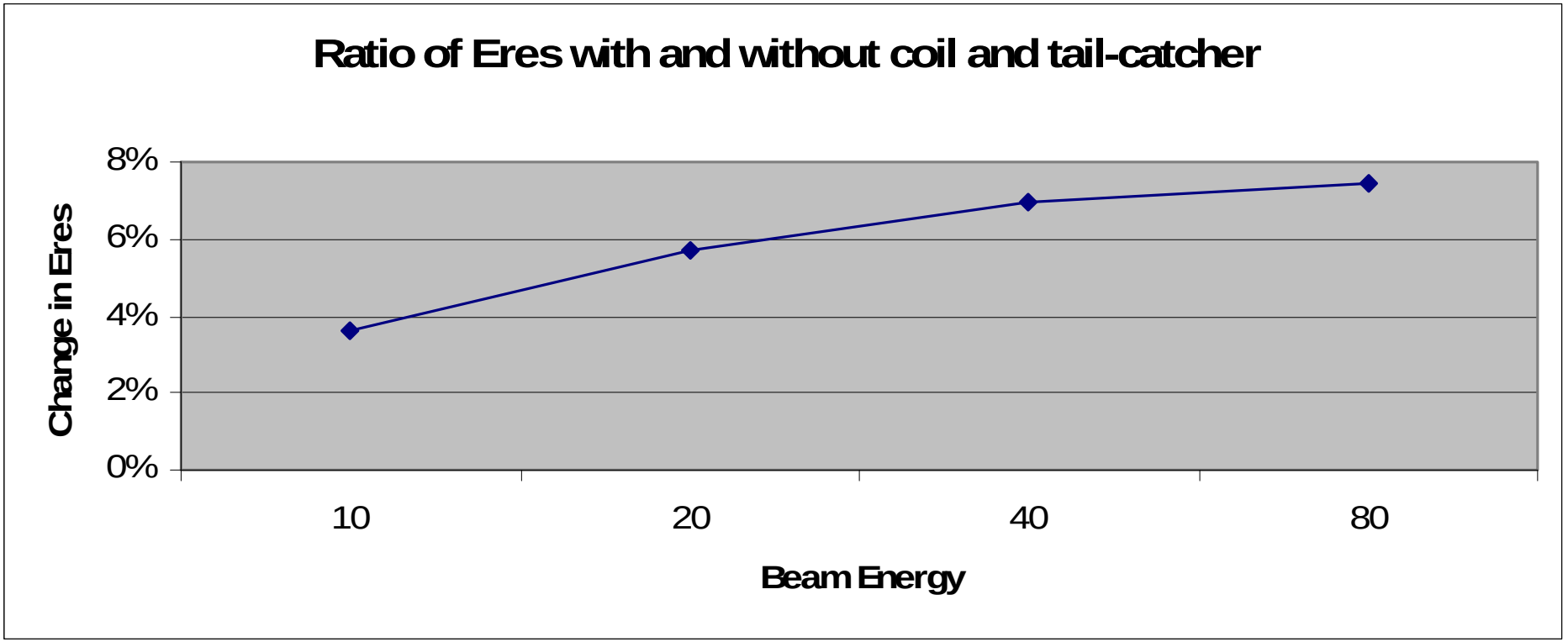
Allocation of TCMT Layers (cont.)

Layers of TCMT added to calorimeter	Thickness (cm)	Thickness (interaction lengths)	End of simulated coil	TCMT layers used behind coil
0	29.84	1.82	10	7
1	25.85	1.58	10	7
2	33.68	2.06	11	6
3	31.68	1.94	11	6
4	29.68	1.81	11	6
5	27.68	1.69	11	6
6	25.68	1.57	11	6
7	33.52	2.05	12	5
8	32.52	1.99	12	5
9	29.52	1.80	12	5
10	29.52	1.80	13	4
11	29.52	1.80	14	3
12	29.52	1.80	15	2
13	29.52	1.80	16	1

Energy Resolution as a Function of Calorimeter Depth



Improvement in Eres as a Function of Beam Energy



At 5.5λ , the proposed thickness of the SID calorimeter

Summary

- The CALICE TCMT behaves as expected to track muons and capture HCAL tail
- Detector is very stable
- Analysis is underway and progressing well
- SiPMs show good potential for calorimetry and muon detection
- At a Depth of 5.5λ (the design thickness of the SID calorimeter), a tai-lcatcher improves energy resolution by about 6%

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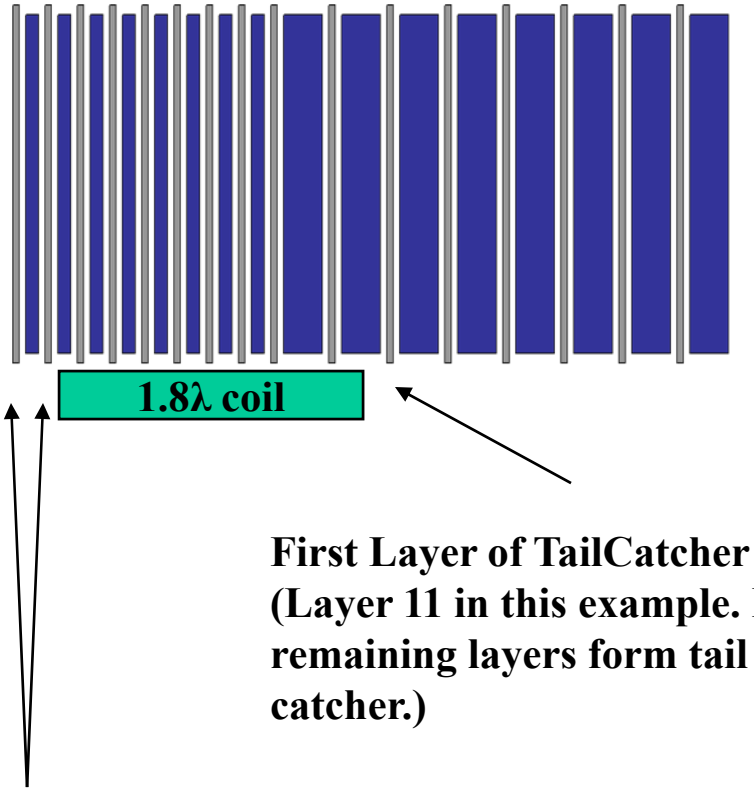

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