SiD ECal Geometry and Calibration Studies

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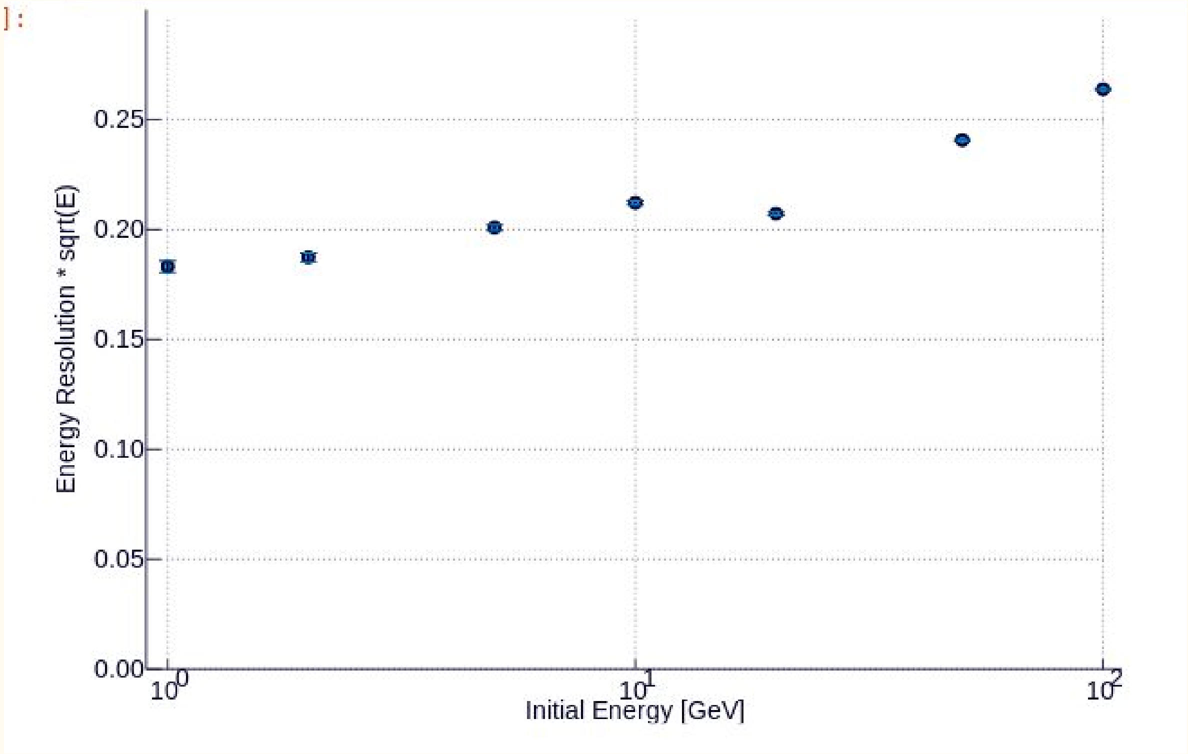
ECal Energy Resolution



Determine ECal calibration constant using only ECal information to preserve the energy resolution

- Energy dependent

Calorimeter Geometry

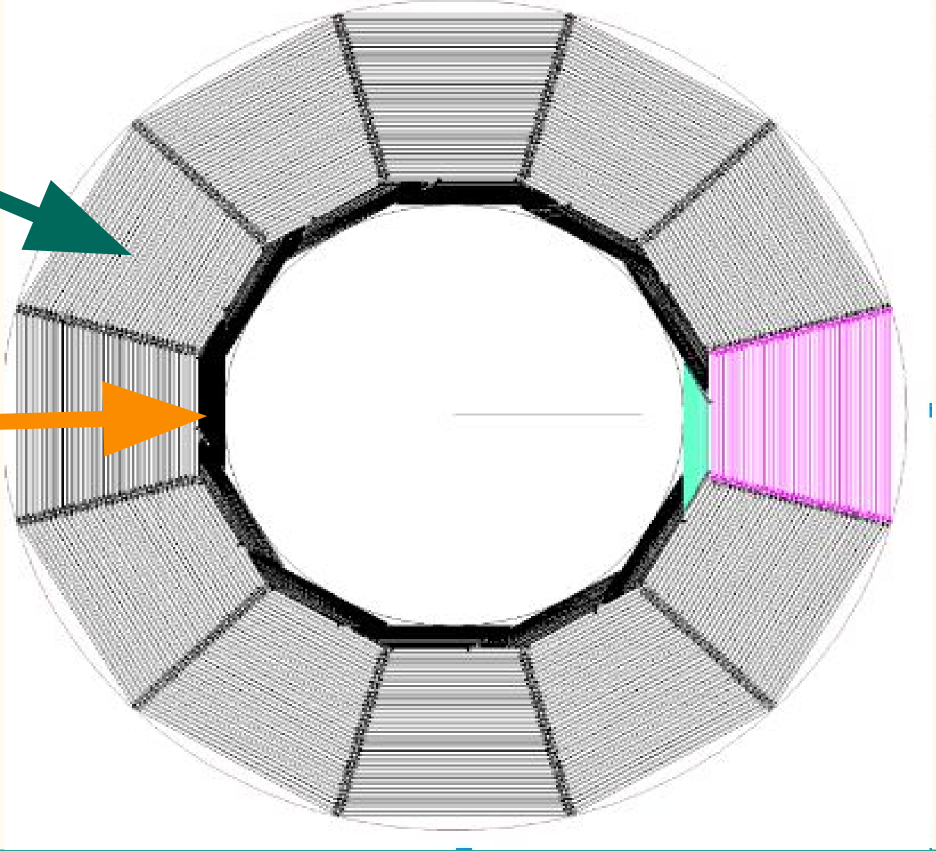
View from down the beamline

HCal

Scintillator sampling calorimeter
Steel/polystyrene

ECal

Solid state sampling calorimeter
Tungsten alloy/silicon

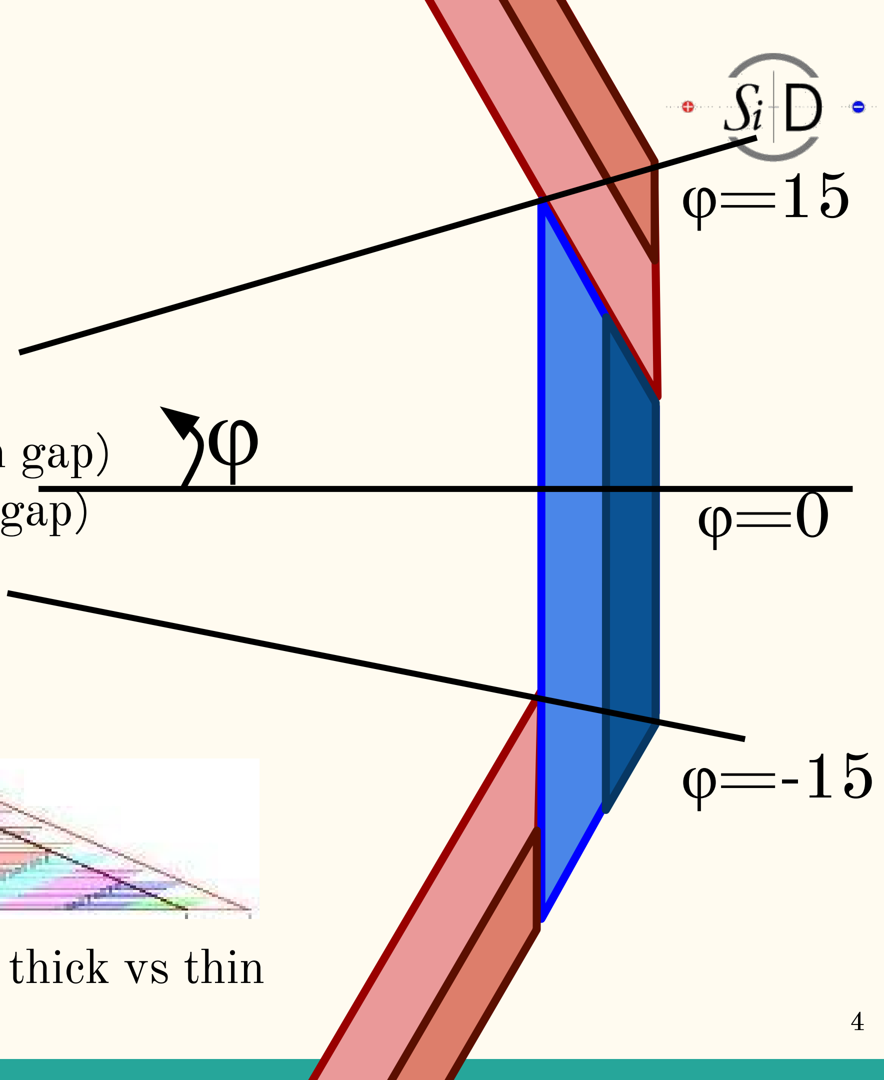


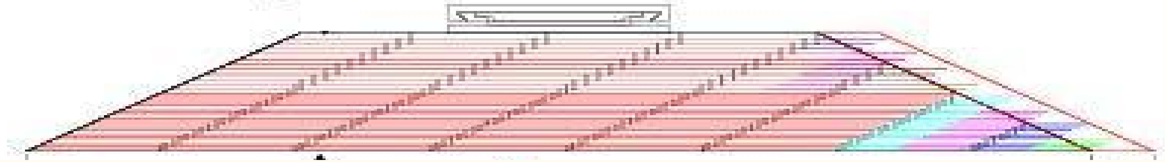
Module Design

Thin W layers

Thick W layers

- 12 identical
  - 20 thin (2.5 mm W, Si in 1.25 mm gap)
  - 10 thick (5 mm W, Si in 1.25 mm gap)
- Overlapping ends
  - No projective cracks





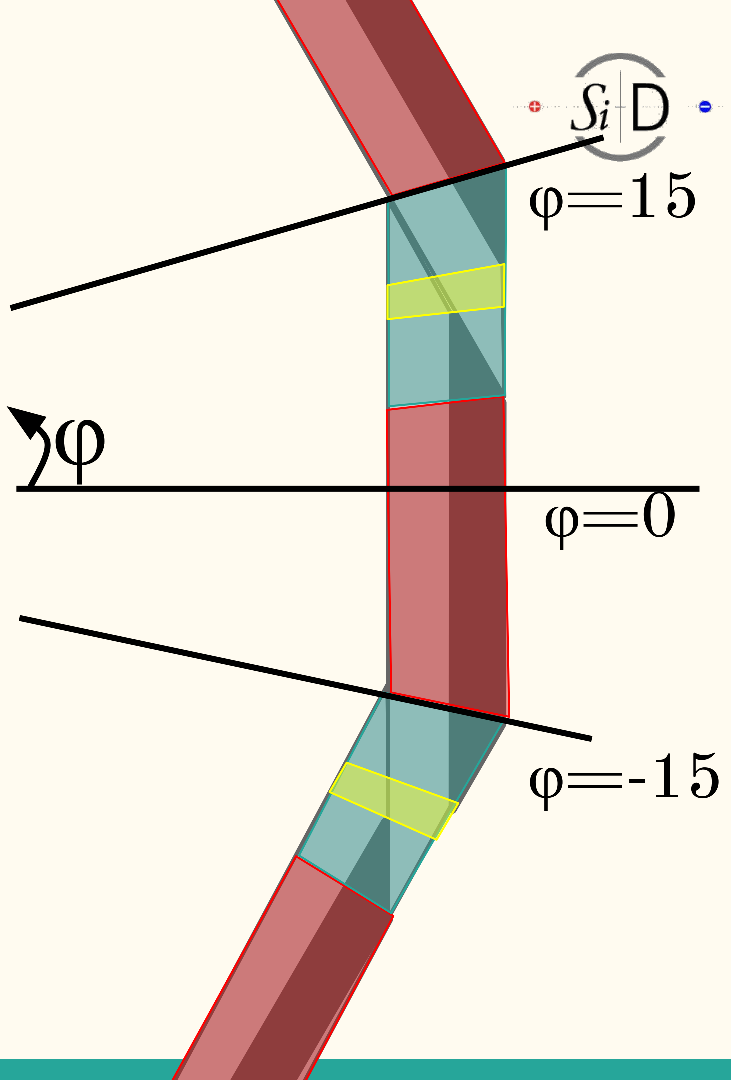
Calibration is different for silicon following thick vs thin tungsten layers

Module Design Con’t

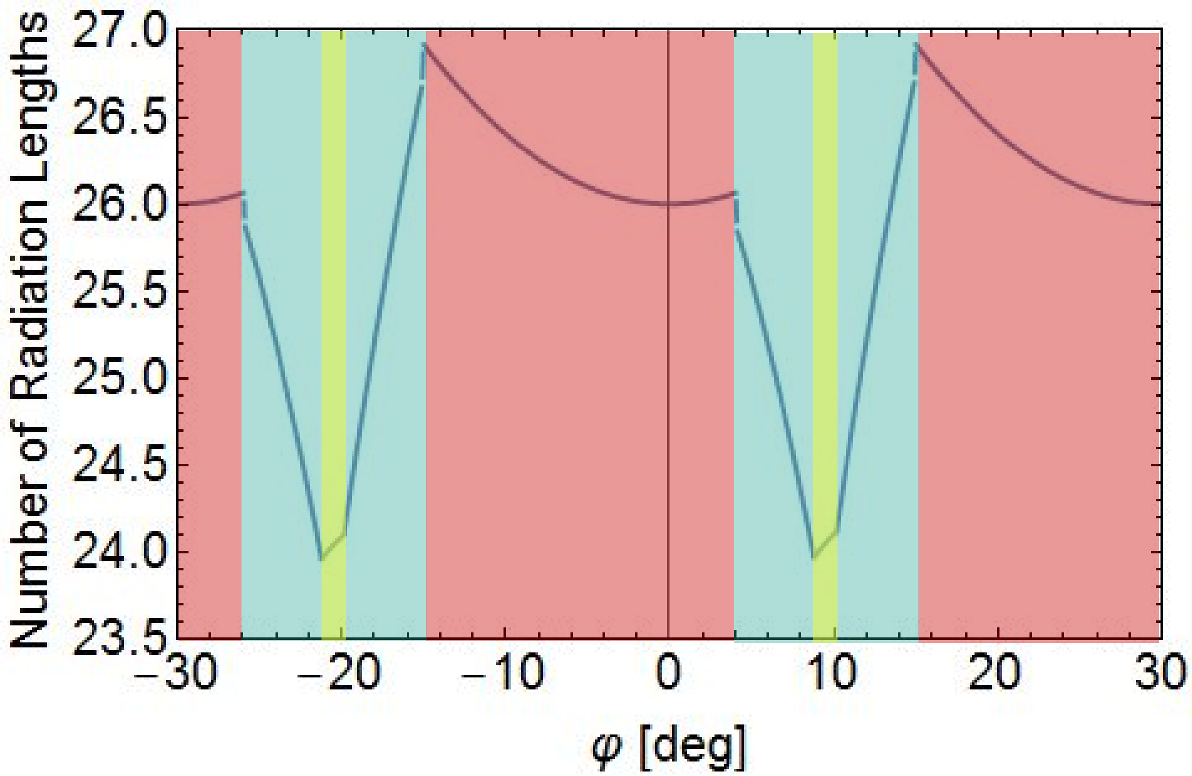
Thin W layers

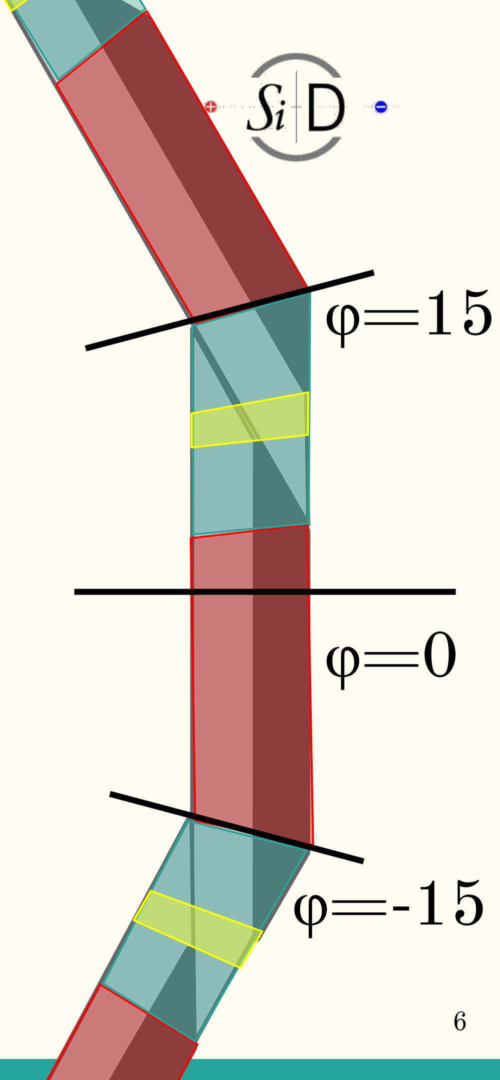
Thin W layers

- Periodic structure - φ = 30° increments
  - Beam goes through entire module between increments of $\varphi = -15^{\circ} \rightarrow 4.03^{\circ}$
  - Beam goes through overlap region between increments of $\varphi = 4.03^{\circ} \rightarrow 15^{\circ}$
  - Beam goes through thin overlap region between increments of $\varphi = 8.786^{\circ} \rightarrow 10.14^{\circ}$

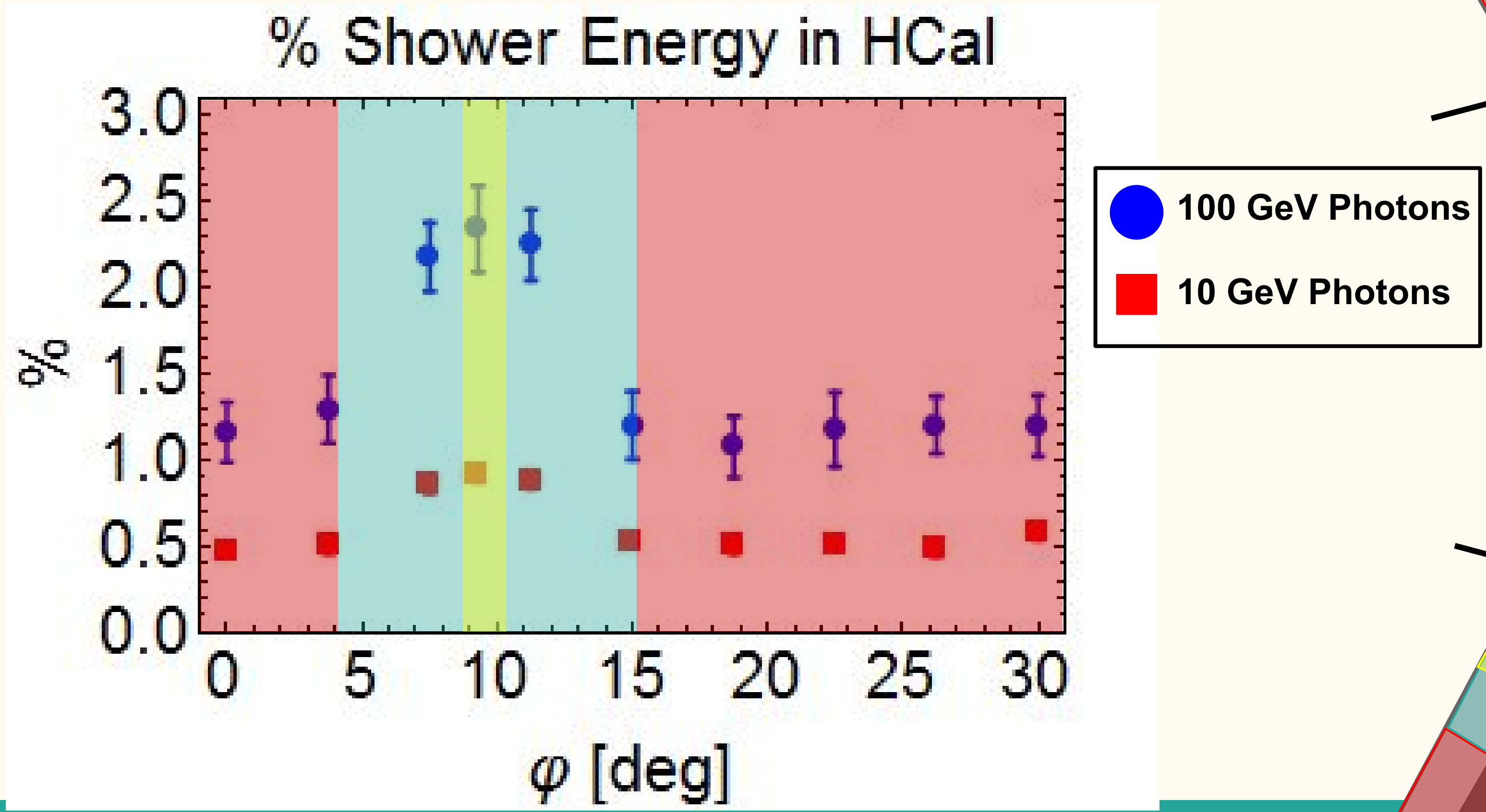


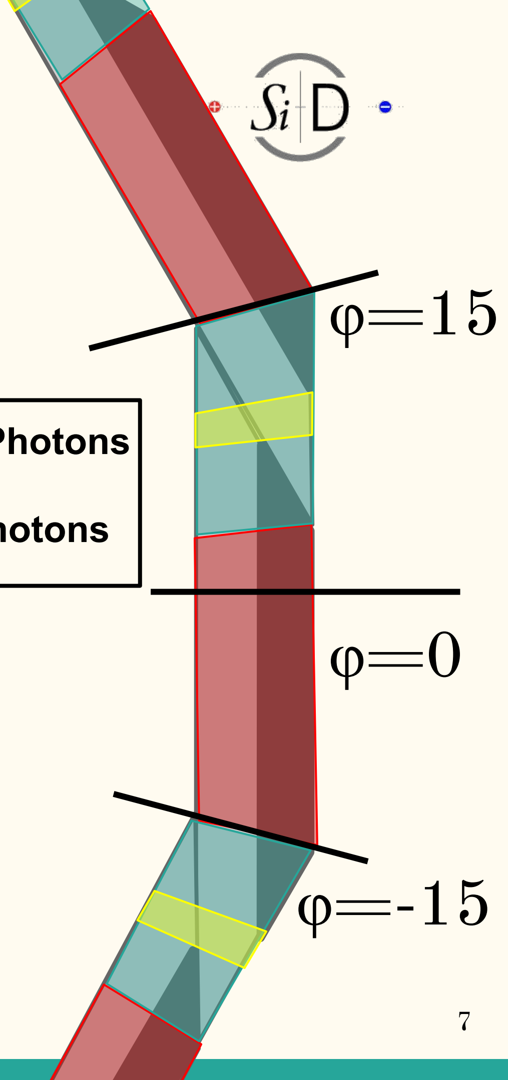
Geometry Effects Con't





Leakage into HCal





Simulation Information

- Full detector simulation features full DD4HEP integration
  - Current version : SiD_o2_v02
  - Active work toward SiD_o3_v01
  - Default ECal geometry driver features realistic geometry including overlapping module structure
  - Features standard Digitization and Reconstruction processors
    - RealisticCaloDigiSilicon
    - RealisticCaloRecoSilicon
- Presented studies largely involve 5000 photon showers through normal incidence of the SiD ECal
  - $\theta = 90^\circ$, $\varphi=0^\circ$

Calibration Constant Formulation

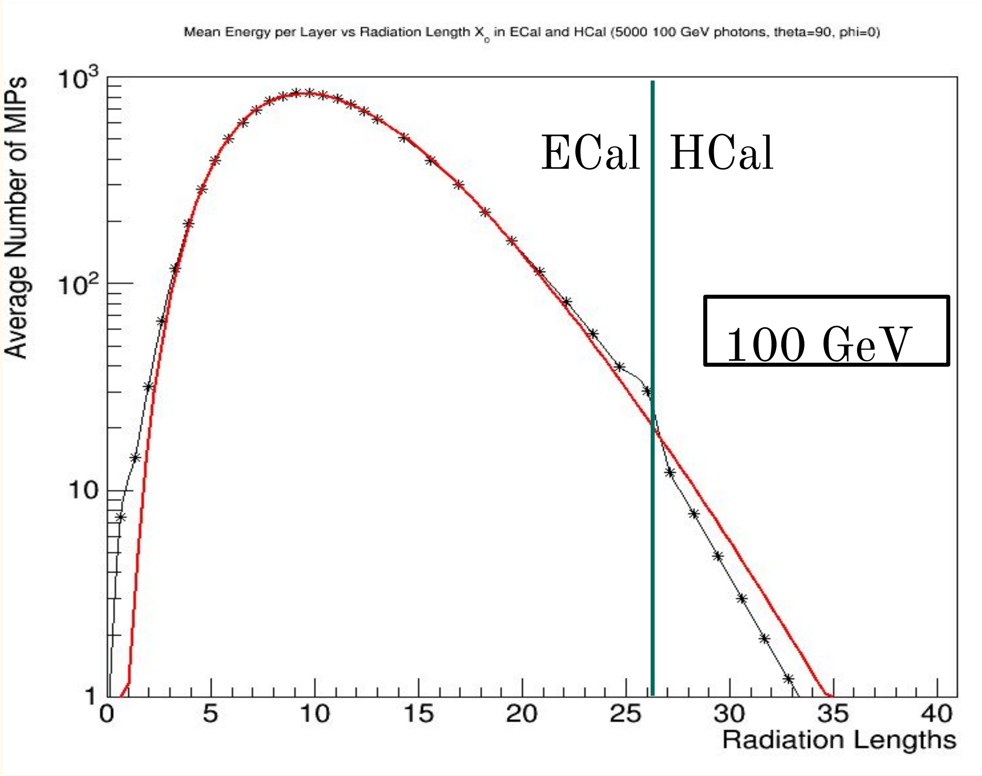
Determine ECal calibration constant using only ECal information to preserve the energy resolution

$$E_{calibrated} = aE_{measured} + bE_{leakage} = E_{measured}\left(a + bE^{n}{}_{measured}\right)$$

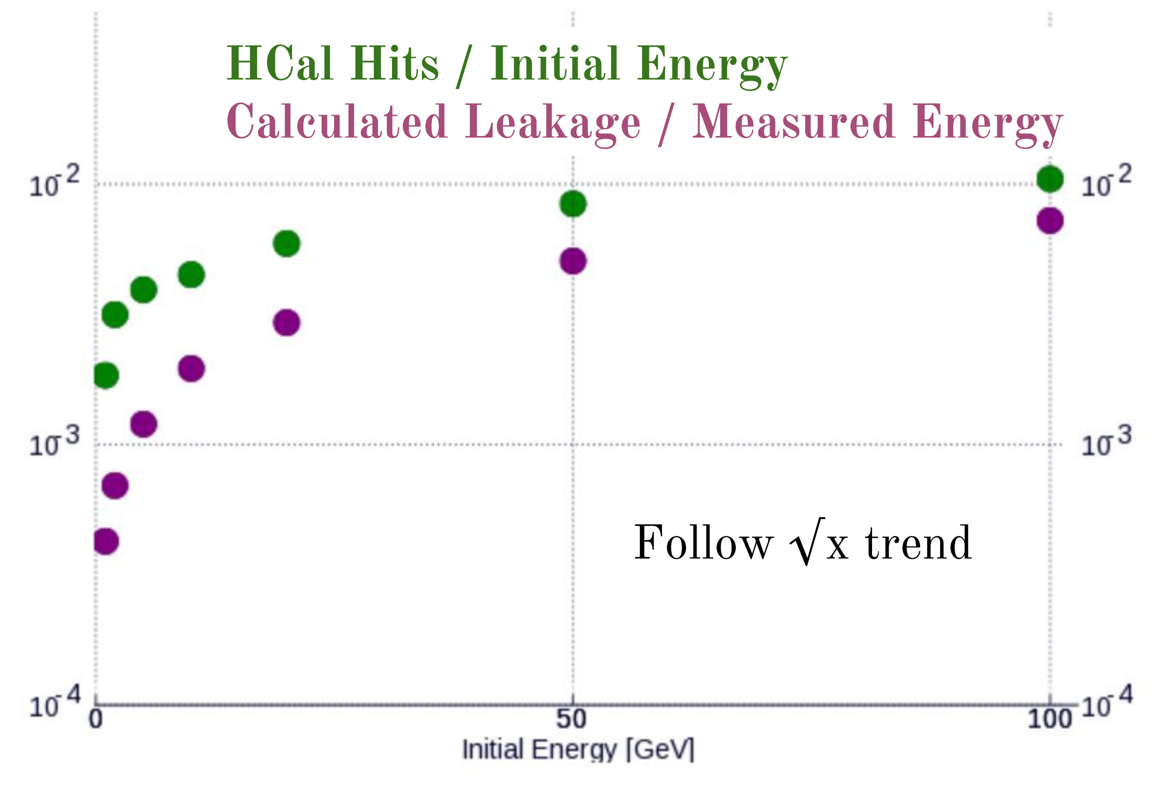
- Energy dependent
- Need different values for silicon layers that follow thin absorber and silicon that follows thick absorber
- Angle dependent

Leakage Studies

- 5,000 photon-event runs at normal incidence
- Use theoretical shower development (gamma distribution) to estimate leakage
  - Fit to ECal
  - Extrapolate into HCal
  - Estimate leakage by integrating under HCal portion of curve



Leakage Studies, Cont'd

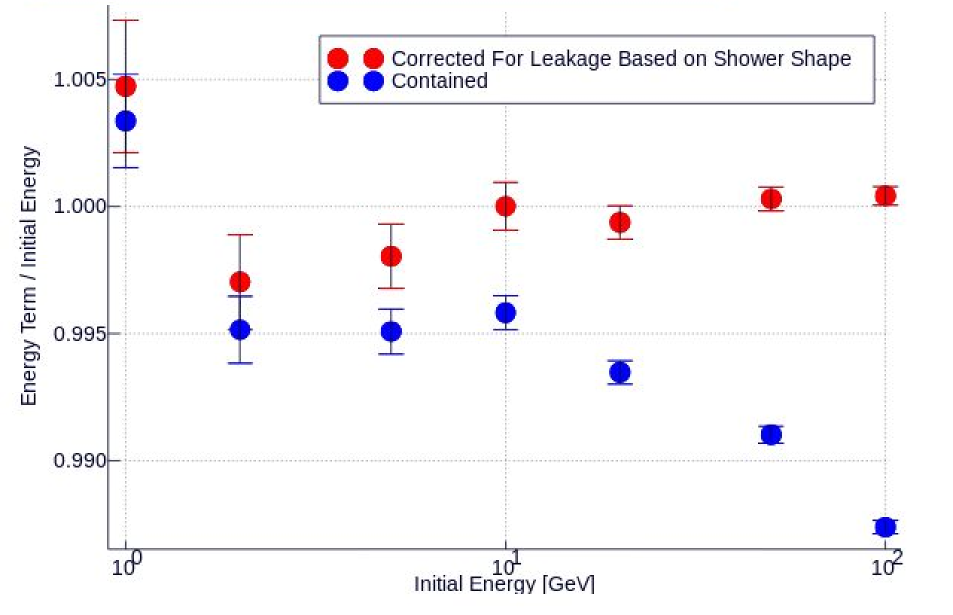


½ Calibration Term

$$E_{calibrated} = aE_{measured} + bE_{leakage} = E_{measured}\left(a + bE^{(1/2)}_{measured}\right)$$

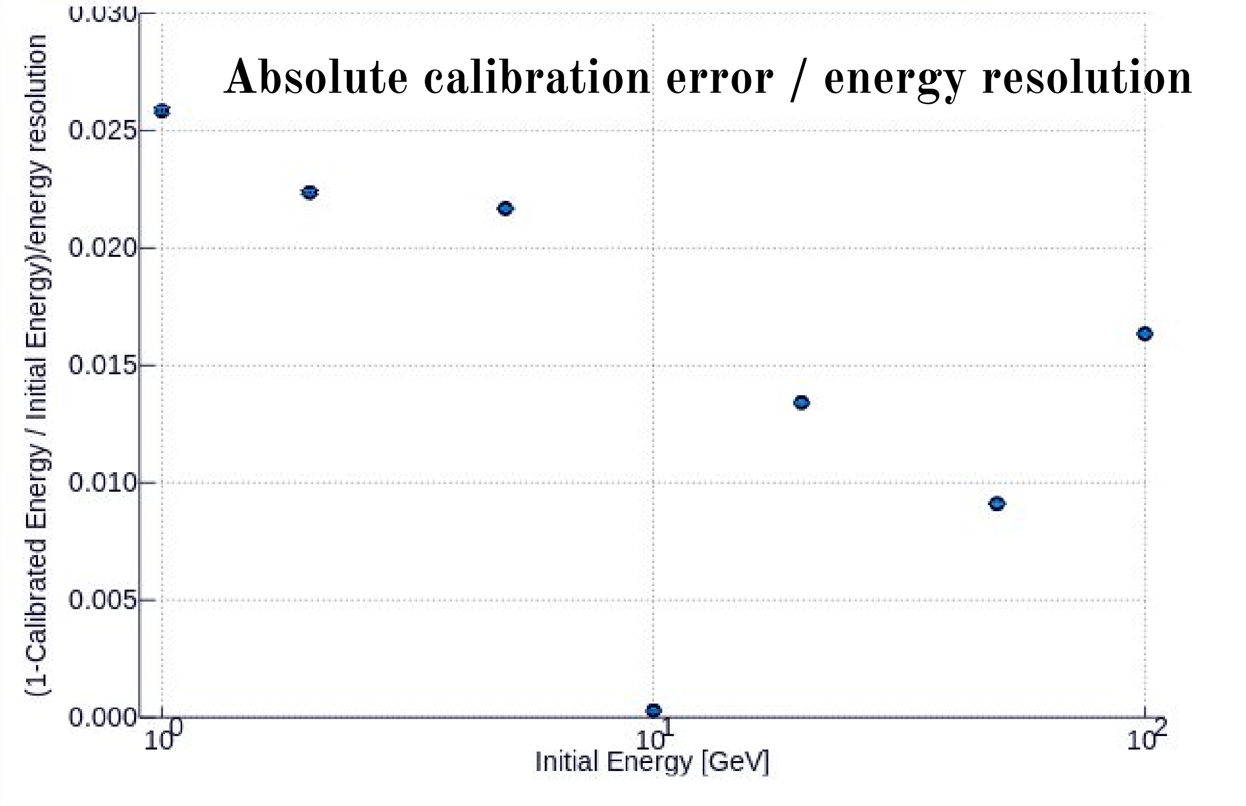
$$a = 58.464 \pm 0.204$$
$$b = 0.594 \pm 0.303$$

Simulated Energy [GeV]	Measured Charge [GeV]	Calibrated Charge [GeV]
1	0.01716	1.0047
2	0.03404	1.9940
5	0.08510	4.9903
10	0.17033	10.0002
20	0.33986	19.9876
50	0.84755	50.0155
100	1.6889	100.0431



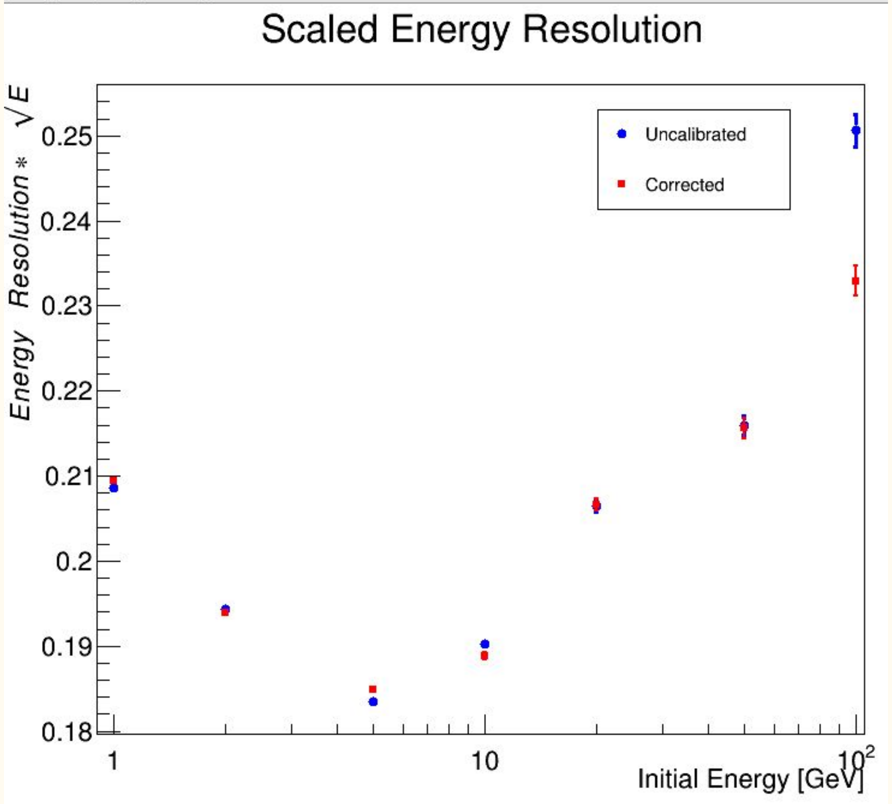
½ Calibration Term Compensates for Leakage

~2% of 23%/√E



Event-by-Event Leakage Correction

- Each event fit independently with gamma distribution
- Leakage calculated for each event by integrating under HCal region
- Extrapolated leakage added back into total shower energy
    - Typically, larger mean and smaller width of collection



Summary

- SiD ECal is fully integrated into the actively-developing full SiD simulation with appropriate geometry
- ECal geometry with overlapping modules creates physically significant effects
- Calibration must be energy- and angle-dependent
  - Leakage is energy and angle-dependent
  - Calibration can compensate for leakage with "½ term"
- Angle dependence still must be factored in