Simulation Study for the ScECAL Physics Prototype

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Results of TB at FNAL in 2009

ScECAL physics prototype

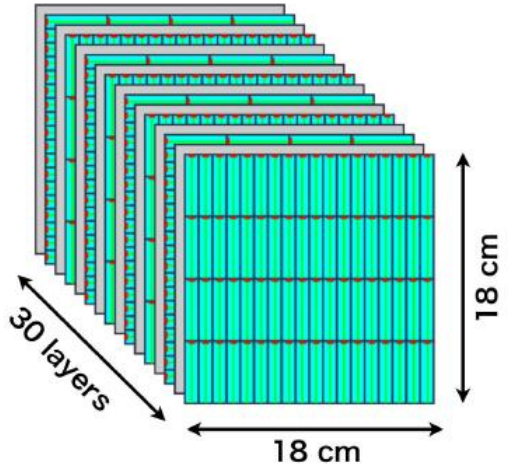
Absorber : 3.5 mm tungsten plate

Sensitive layer :

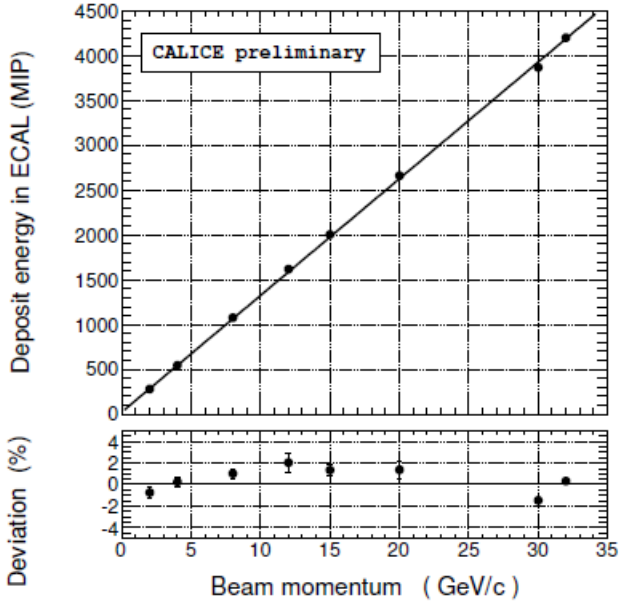
10x45x3 mm^3 Scintillator + WLSF + MPPC

Cross-section : 18x18 cm^2

Depth : 30 layers (~27 cm)

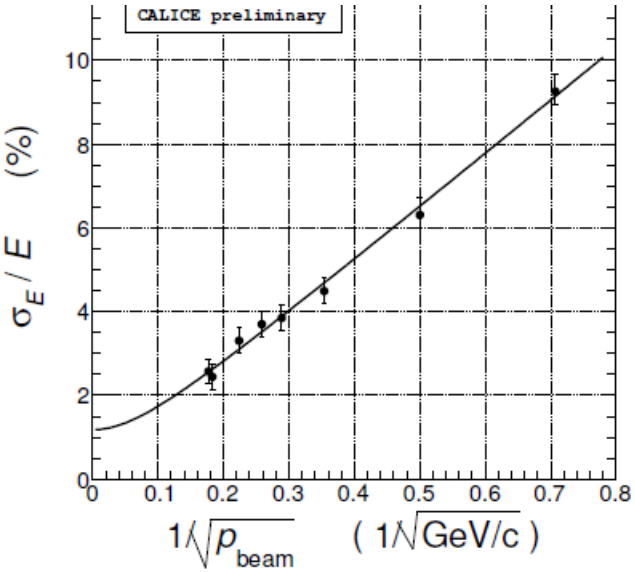


Electron beam



Deviation from linear response < 2%

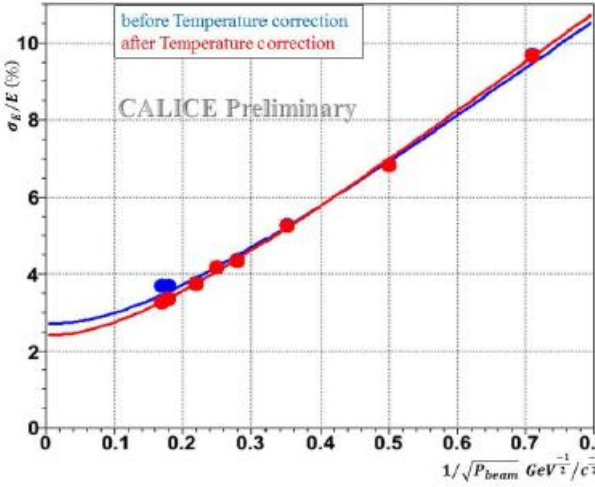
Subtracted P spread effect



$\sigma_{stoc.}$ (12.9 ± 0.5) %

$\sigma_{const.}$ $(1.2+0.5-1.2)$ %

Include P spread



$\sigma_{stoc.}$ 13.13 %

$\sigma_{const.}$ 2.41 %

Simulation with Mokka

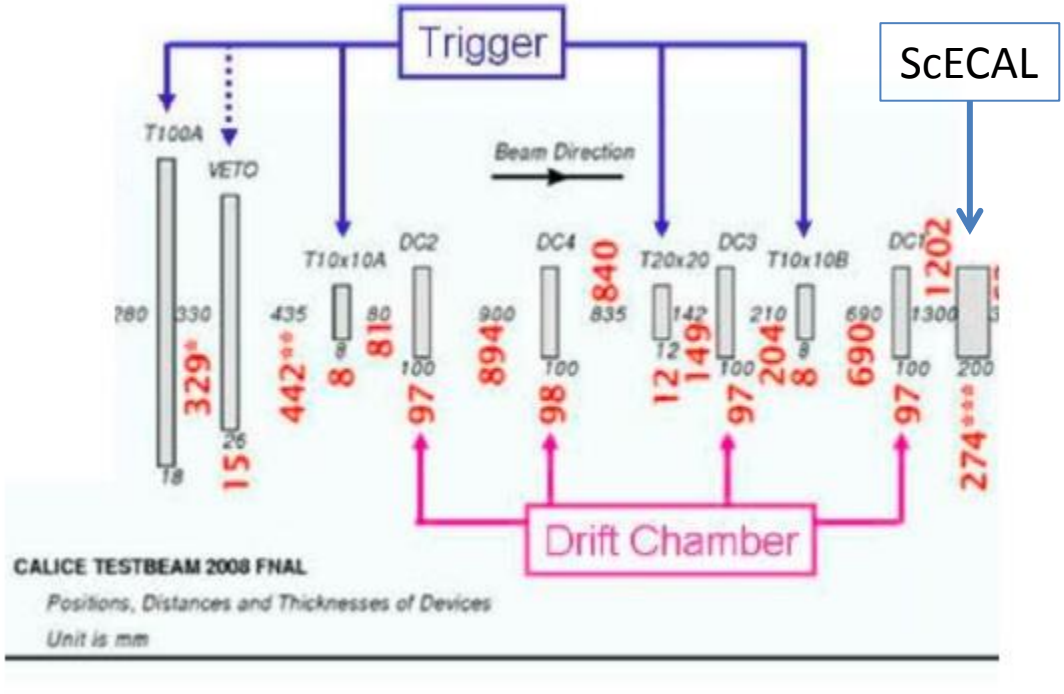
Event generation
Mokka : mokka-07-06-p02
Geant4 : geant4-09-04-pathc-01

Reconstruction
Ilcsoft : v01-11
Marlin : v01-00

We made 40k electron events par run
Number of run

P(GeV)	1	2	4	8	12	15	20	30	32
# of run	6	5	5	4	4	3	7	3	3

Materials in This Simulation



4(1) Trigger(veto) scintillator (are not used for event selection)

4 Drift chamber (are not used for event selection)

ScECAL physics prototype

Absorber : W+C+Co+Cr 3.49mm , 14.25 g/cm^3

Sci 10x45x3 mm^3

Event Selection

We apply same event selection except HCAL part
There is no HCAL in the simulation.

1. the shower maximum in the ScECAL should be upstream with respect to the 20th layer,

2. the deposited energy on the shower maximum layer in the ScECAL should be greater than:
   10 MIPs for 1 GeV/c,
   20 MIPs for 3 GeV/c,
   40 MIPs for 6 GeV/c,
   80 MIPs for 12 GeV/c,
   100 MIPs for 16 GeV/c,
   150 MIPs for 25 GeV/c,
   and 200 MIPs for 32 GeV/c,

~~3. the deposited energy on the shower maximum layer in AHCAL should be less than 20 MIPs,~~

~~4. the deposited energy on the most downstream layer of AHCAL should be less than 0.4 MIPs,~~

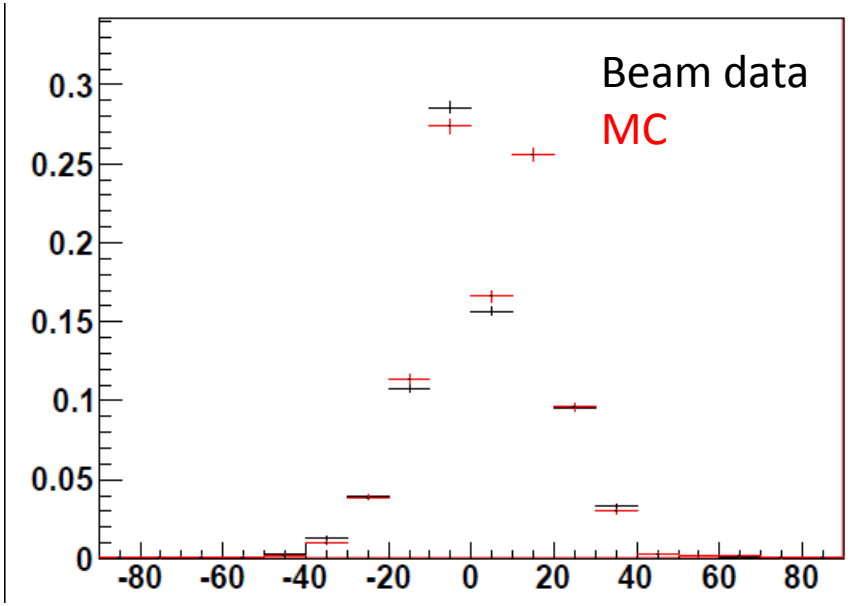
5. and 6. the gravitational center of the electromagnetic shower in ScECAL should be within ± 4 cm from the ScECAL center in the x and y direction, respectively.

Beam Position

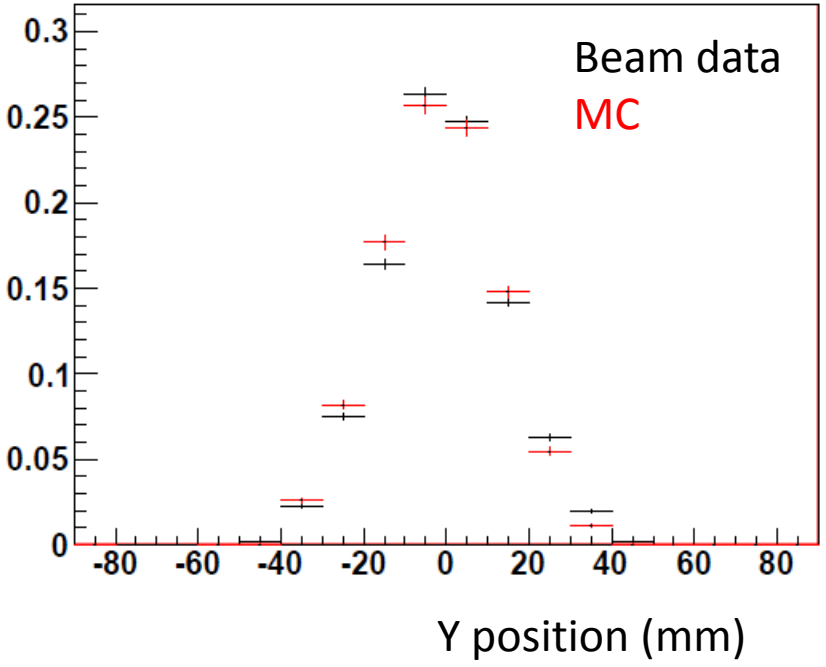
Adjust beam position and put dead channel run by run

Distribution of hit position (single hit in a layer)

8 GeV run0 2nd layer

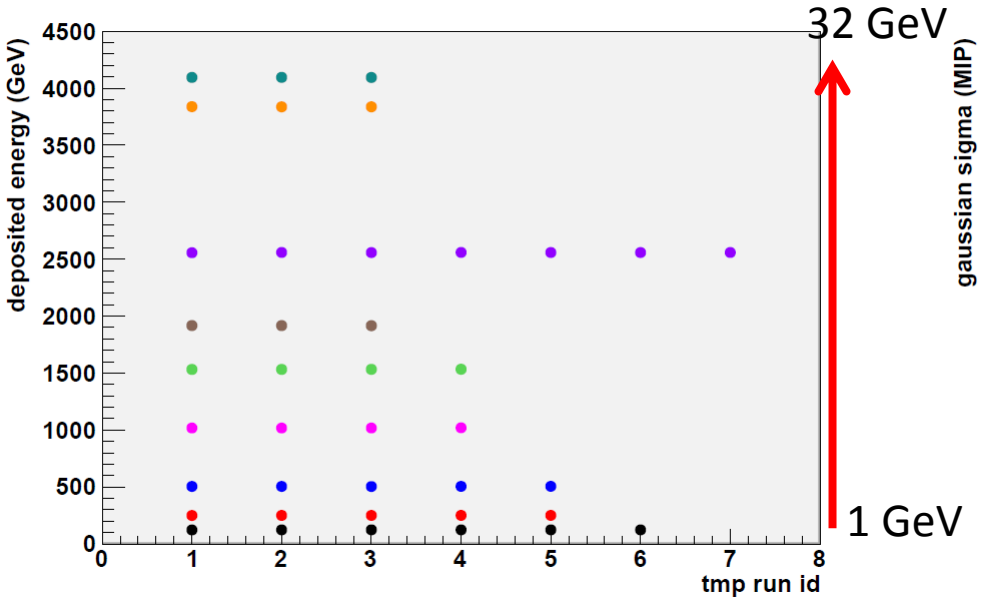


8 GeV run3 2nd layer

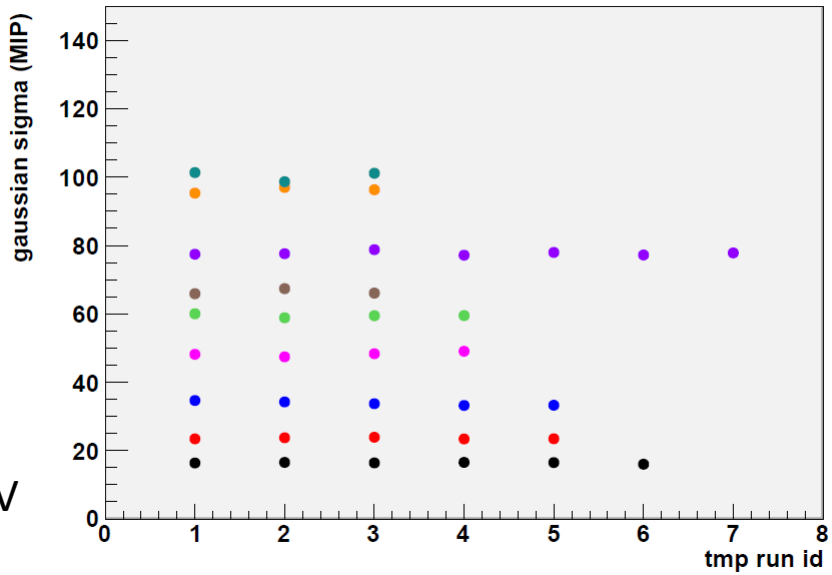


Beam Position Effect

Mean value of deposited energy



sigma



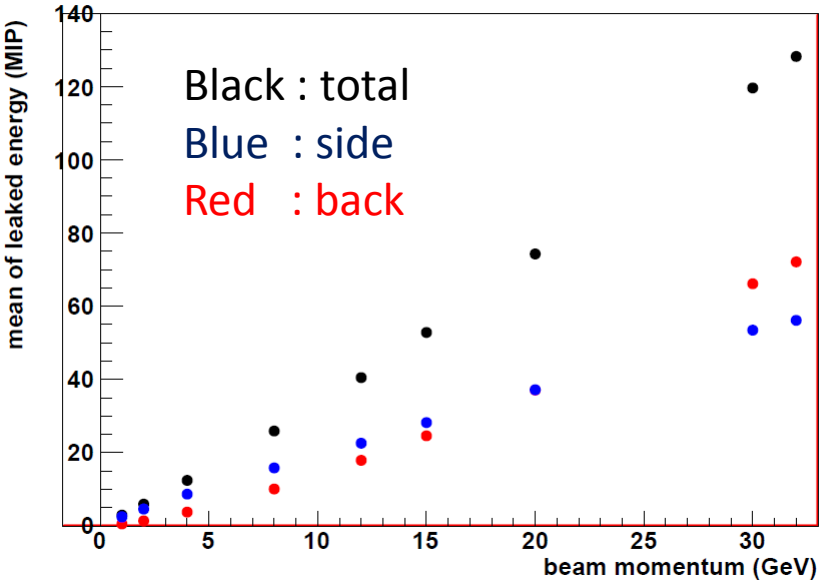
There are no dependence for beam position
(non-uniformity of scintillator is not included in this simulation)
For each energy, we combined all run

Leaked Energy

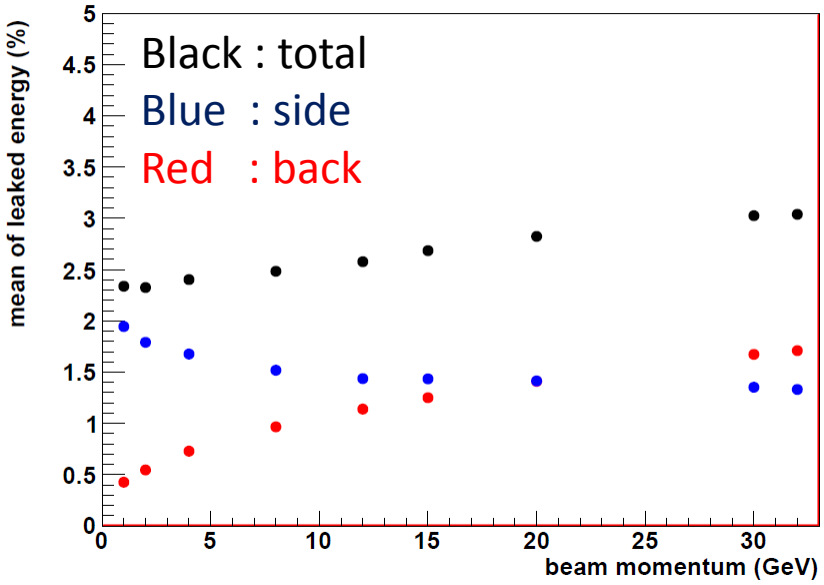
Leaked energy

Volume of the prototype is 18x18cm^{2}x30layer
We simulate with large volume ScECAL which is 54x54cm^{2}x90layer

Leaked energy (MIP)



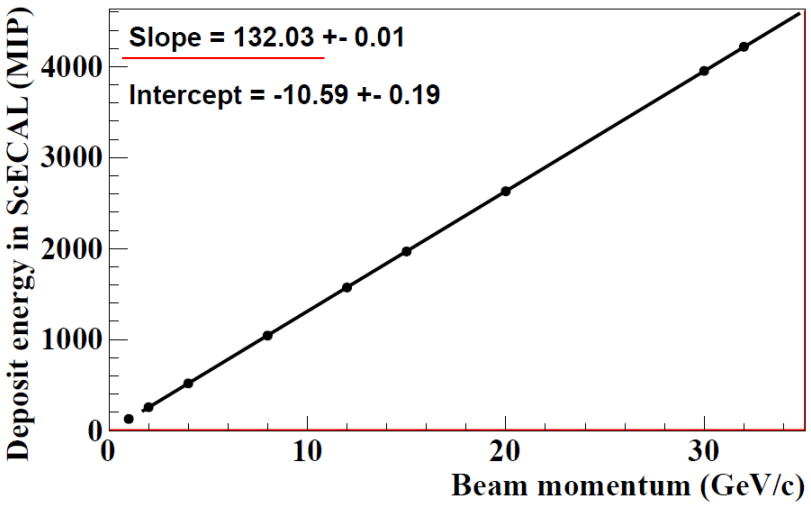
Leaked energy/Total (%)

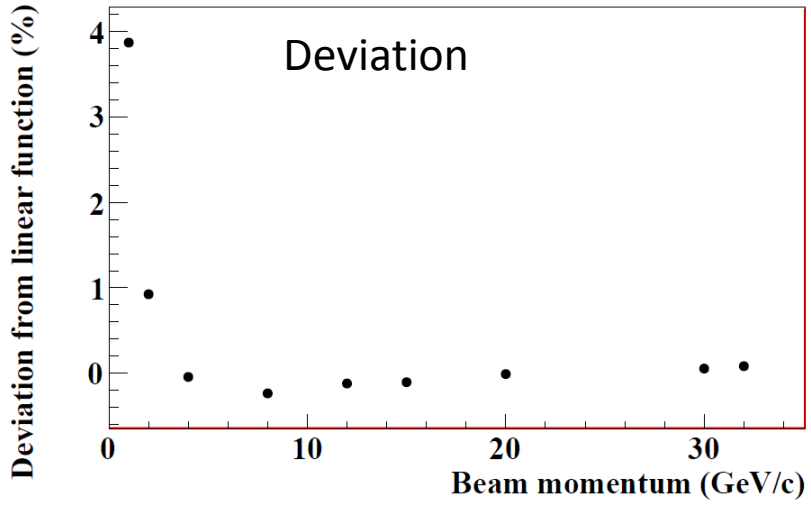


2.3 – 3 % of total energy leaked outside of the prototype volume

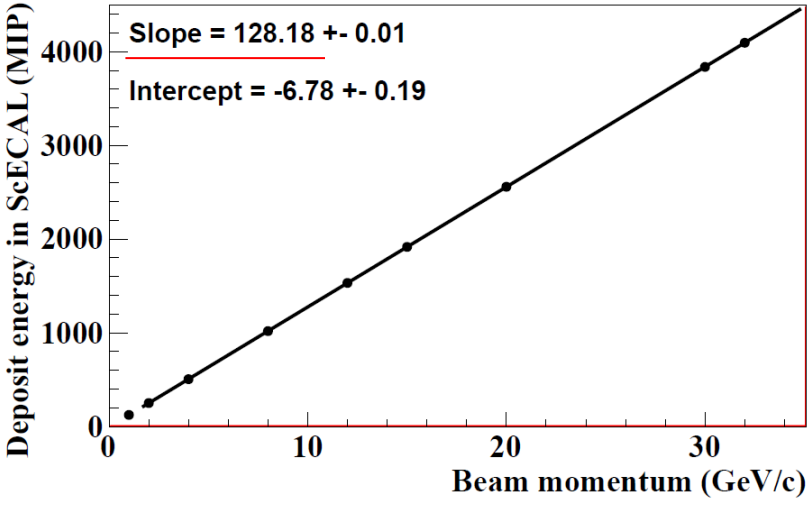
ECAL Response and Deviation

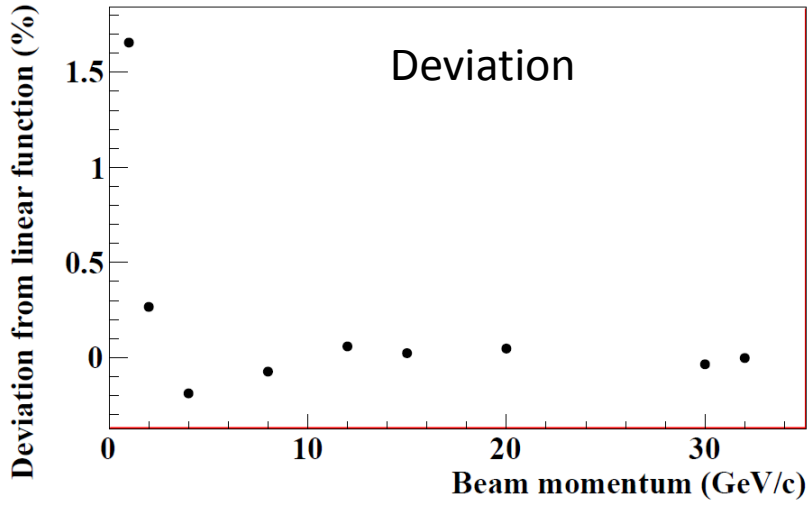
Large Volume





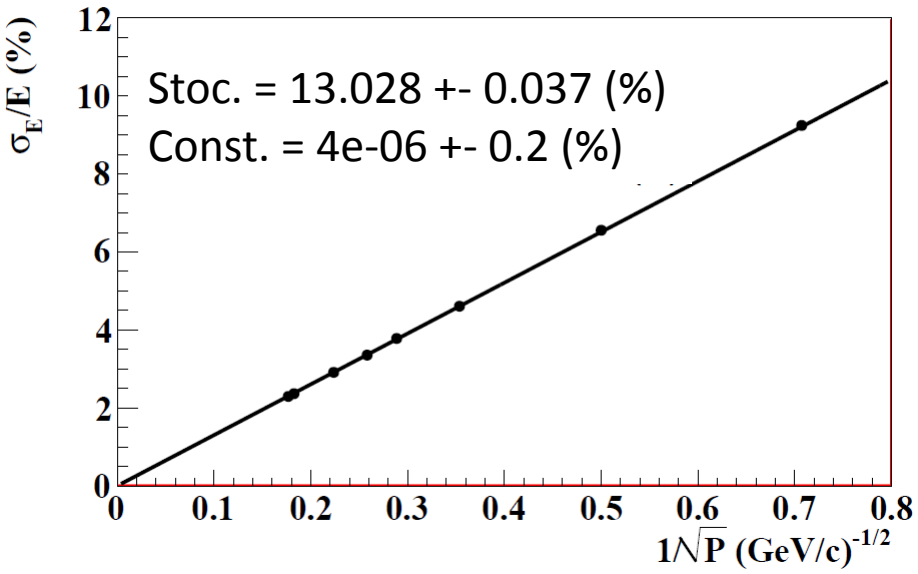
Prototype Volume



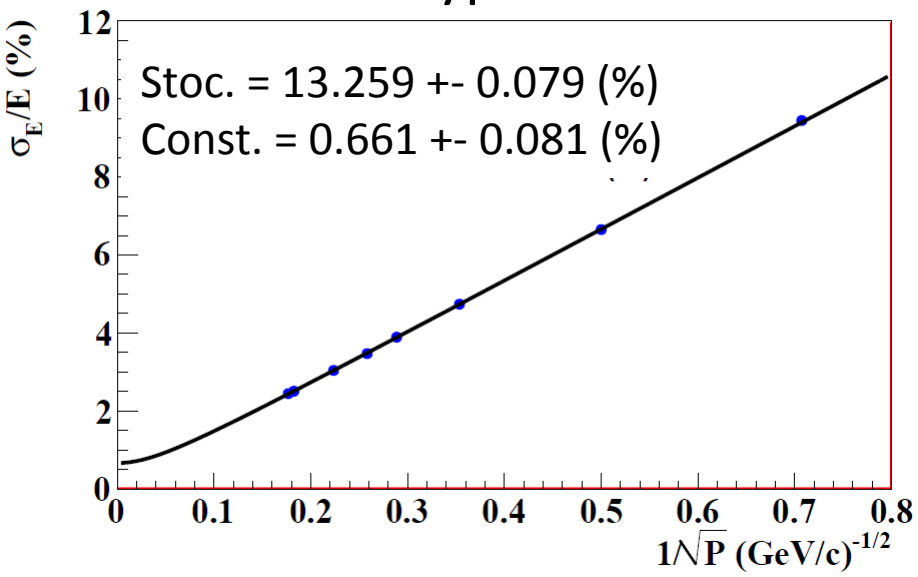


Energy Resolution

Large Volume



Prototype Volume



~ 3% energy leakage makes 0.66% constant term of energy resolution.

Stochastic term is also increase ~ 0.2%

We estimate systematic uncertainty with leakage $\pm$ 1 sigma

+ 1σ : const. = 0.676, -1 σ = 0.657

Δconst $\pm$ 0.02%

$\Delta\sigma_{const.} \pm 0.085\%$ ($\Delta\sigma_{const.}$ is dominated by fitting error)

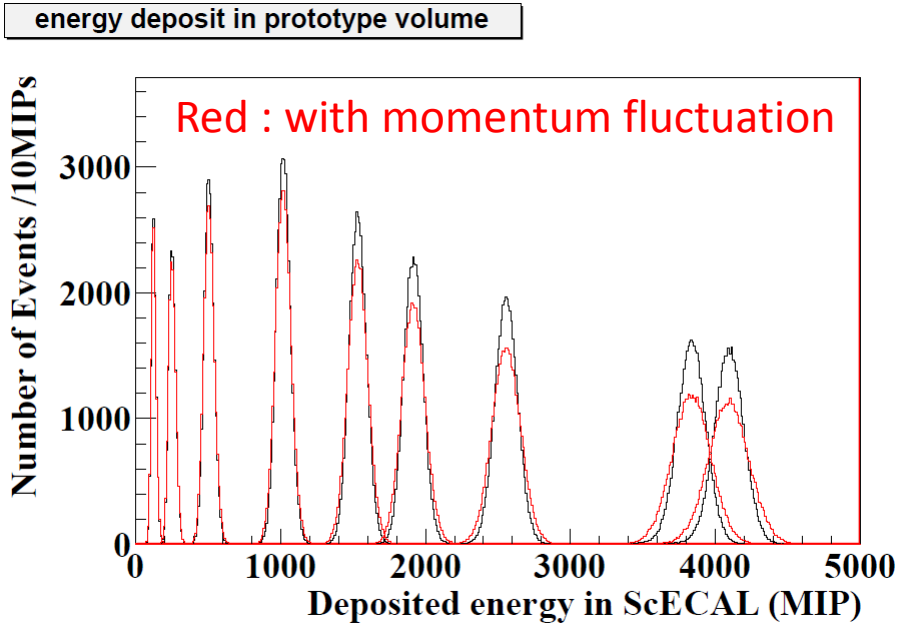
Beam Momentum Spread

Momentum Spread

Fluctuation of beam momentum at FNAL MT6

2.7 $\pm$ 0.3 % 1-4 GeV

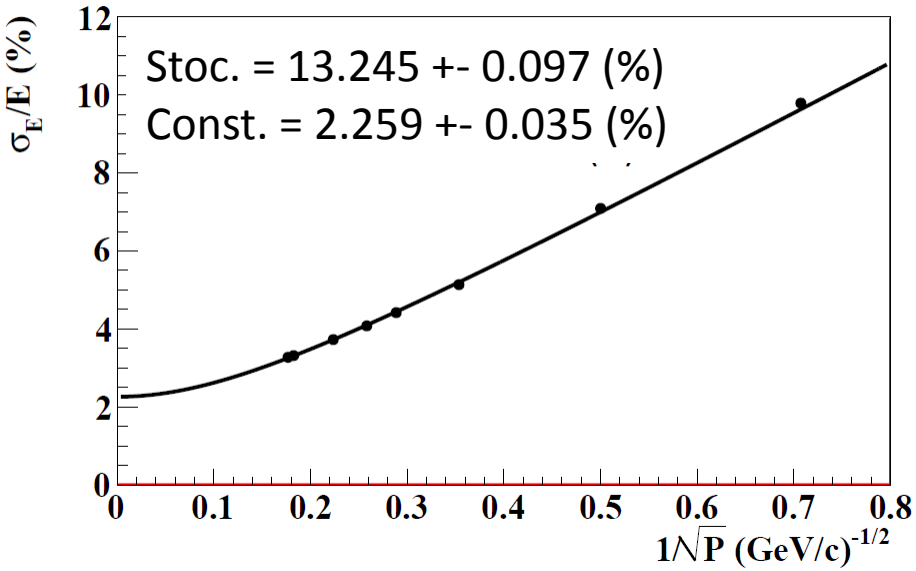
2.3 $\pm$ 0.3 % > 8 GeV



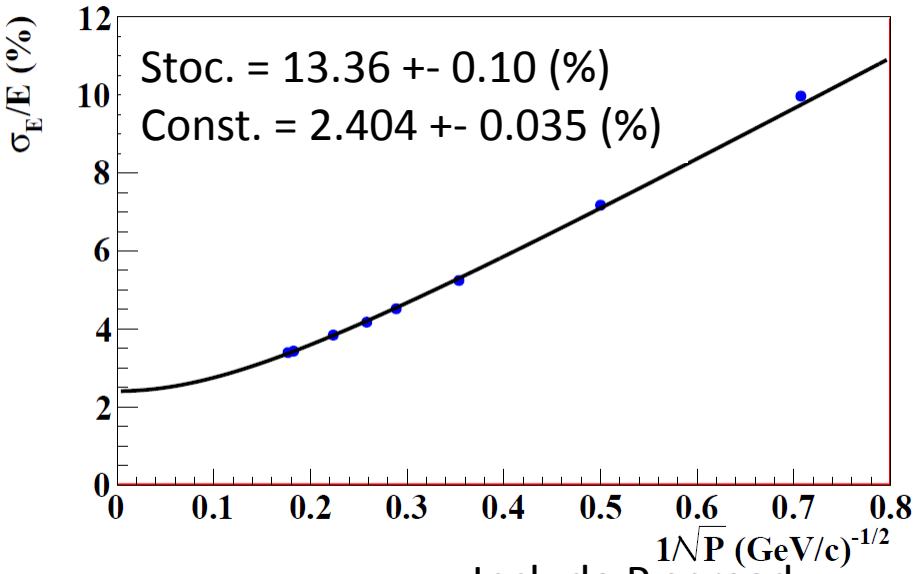
Momentum spread makes broader shape ,
but does not change mean value.

Energy resolution

Large Volume

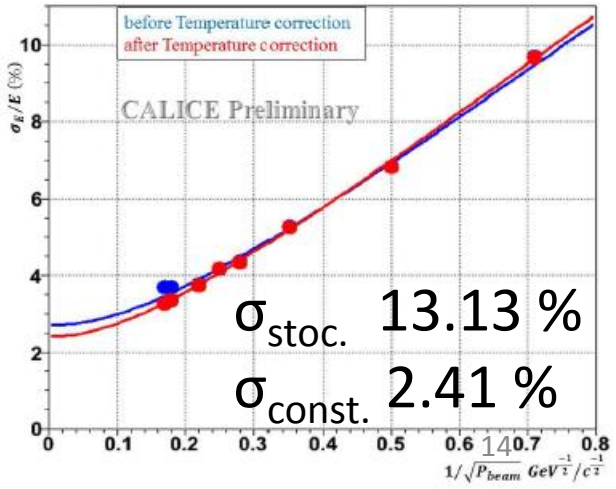


Prototype Volume



Momentum spread makes
2.26 % constant term
P spread and energy leakage are dominant source of constant term of energy resolution.

Include P spread



Summary

- We simulated ScECAL physics prototype TB in 2009.
- Beam position does not change mean value and sigma.
- Energy leakage makes 0.66 % constant term of energy resolution
- Beam momentum spread makes 2.26 % constant term of energy resolution
- P spread and energy leakage are dominant source of constant term.