Beam test simulation of fine-granularity EM calorimeter

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JLC CAL Group Meeting
2002.08.07 at Tokyo U.

Outline

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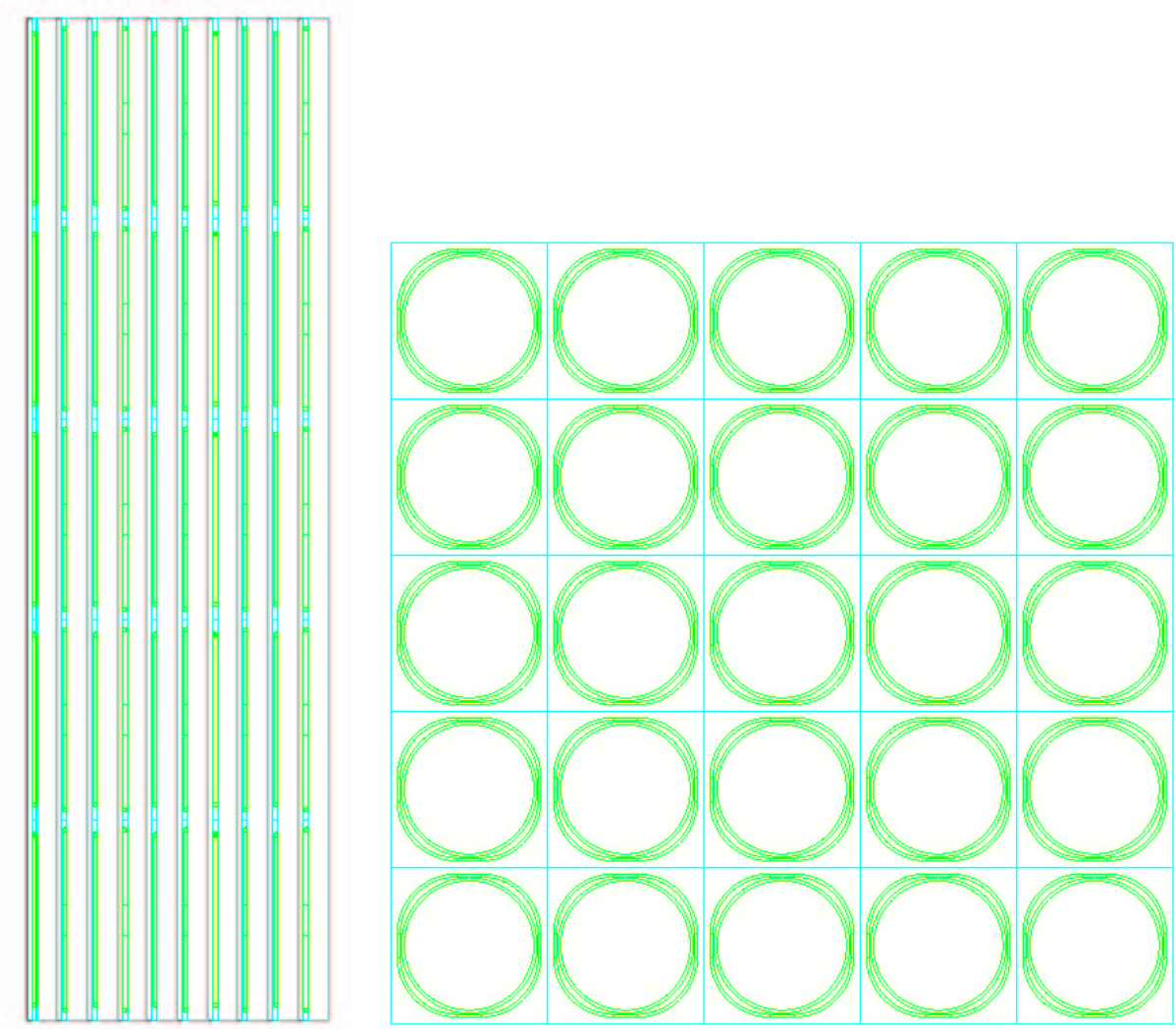
1. Beam Test EM CAL Module Simulation
2. Results
3. Summary and Future Plan

1. Beam Test EM CAL Module Simulation

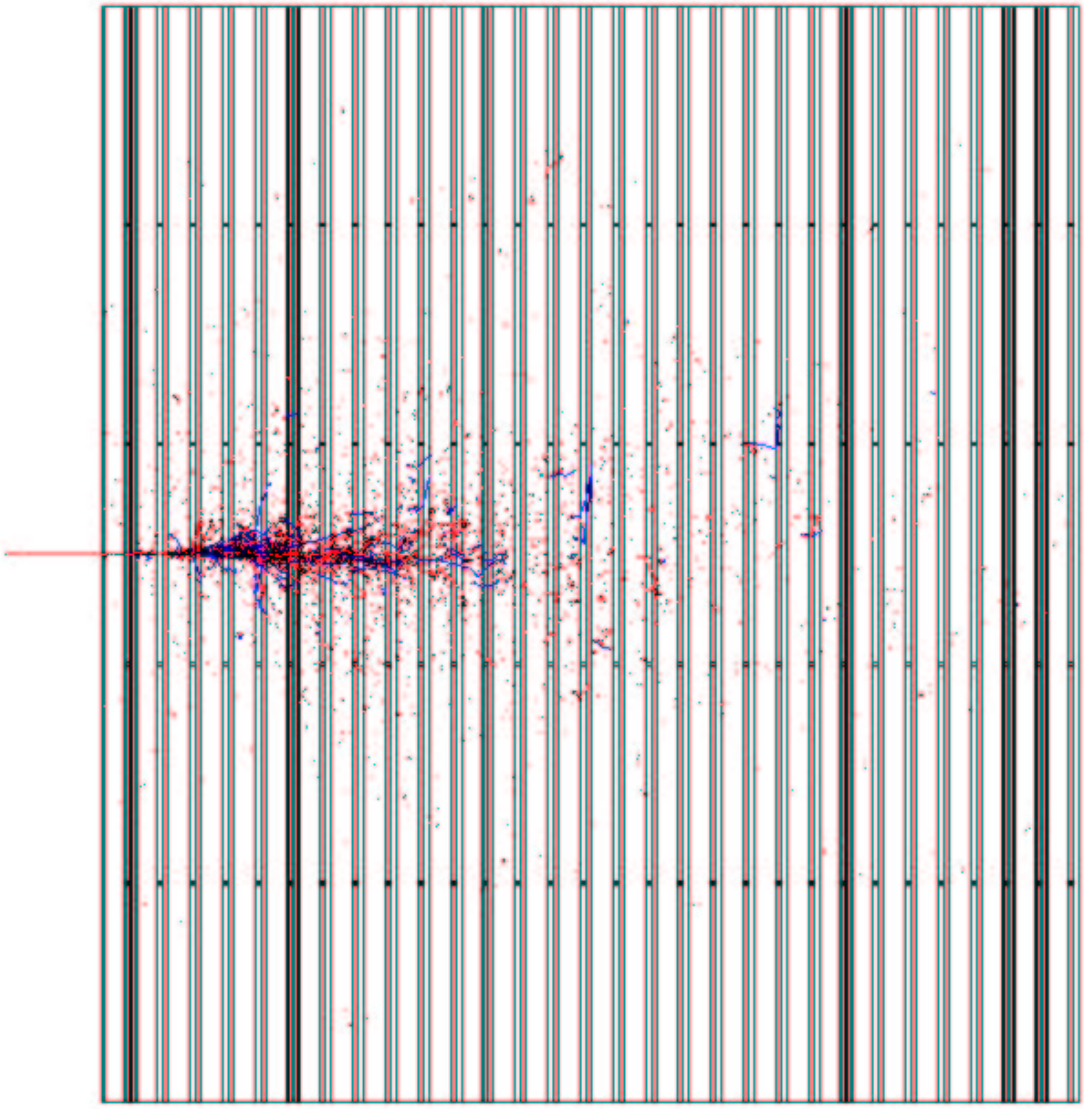
$\Rightarrow$ Sampling layer: 4mm Lead absorber, 1mm Plastic scintillator, 1mm Acryl plate.
$\Rightarrow$ 30 sampling layers $\equiv$ 6SL $\approx 21 X_0$.
$\Rightarrow$ At beam test, actually, only 2SLs.
$\Rightarrow$ 3 fiber configurations studied: alternating square and circle, square only, circle only.

* Fiber geometry not implemented due to Geant4 tracking problem. Instead, the energy deposit at fiber location is simply scaled by 0.20.

Frontview of EM CAL module.

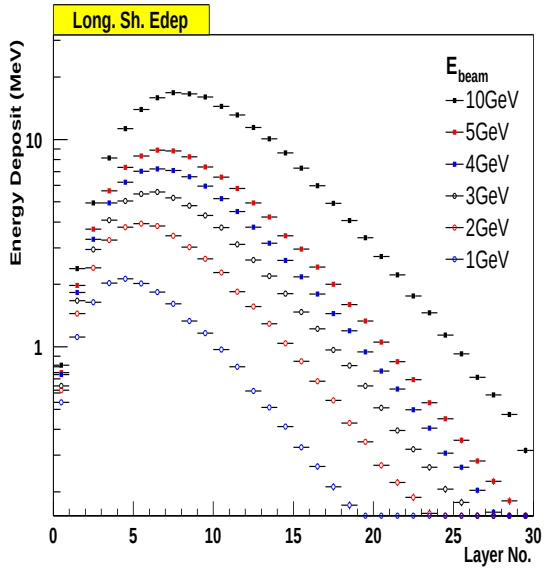


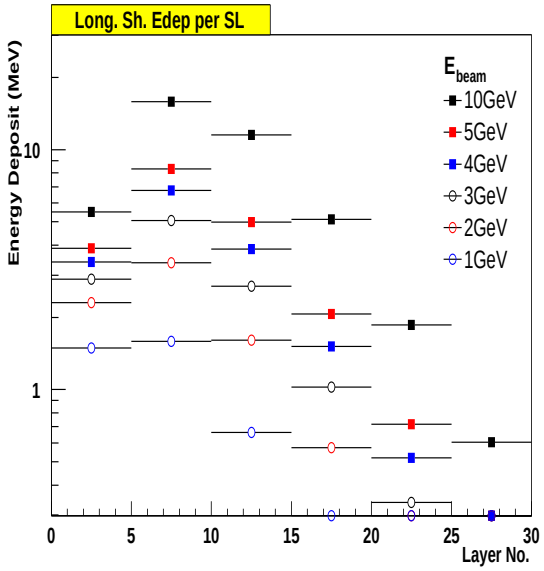
Typical 4GeV e^- Event (Charged particles only)

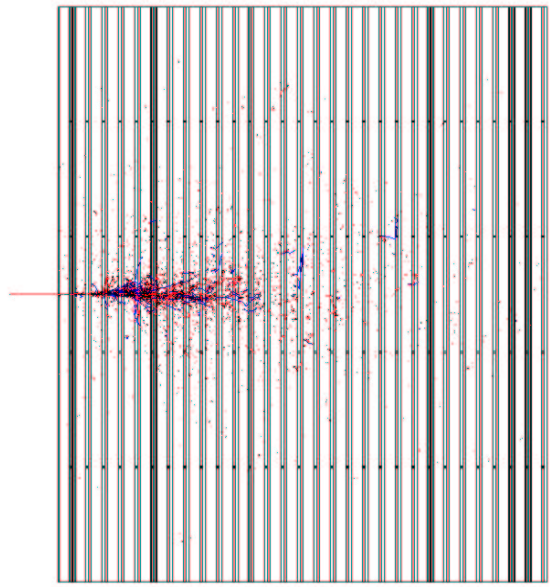


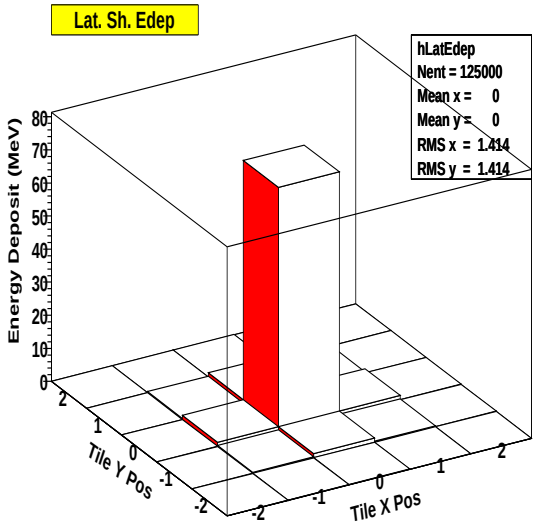
2. Results

Shower Profiles (Alternating Sq & Circ Config)

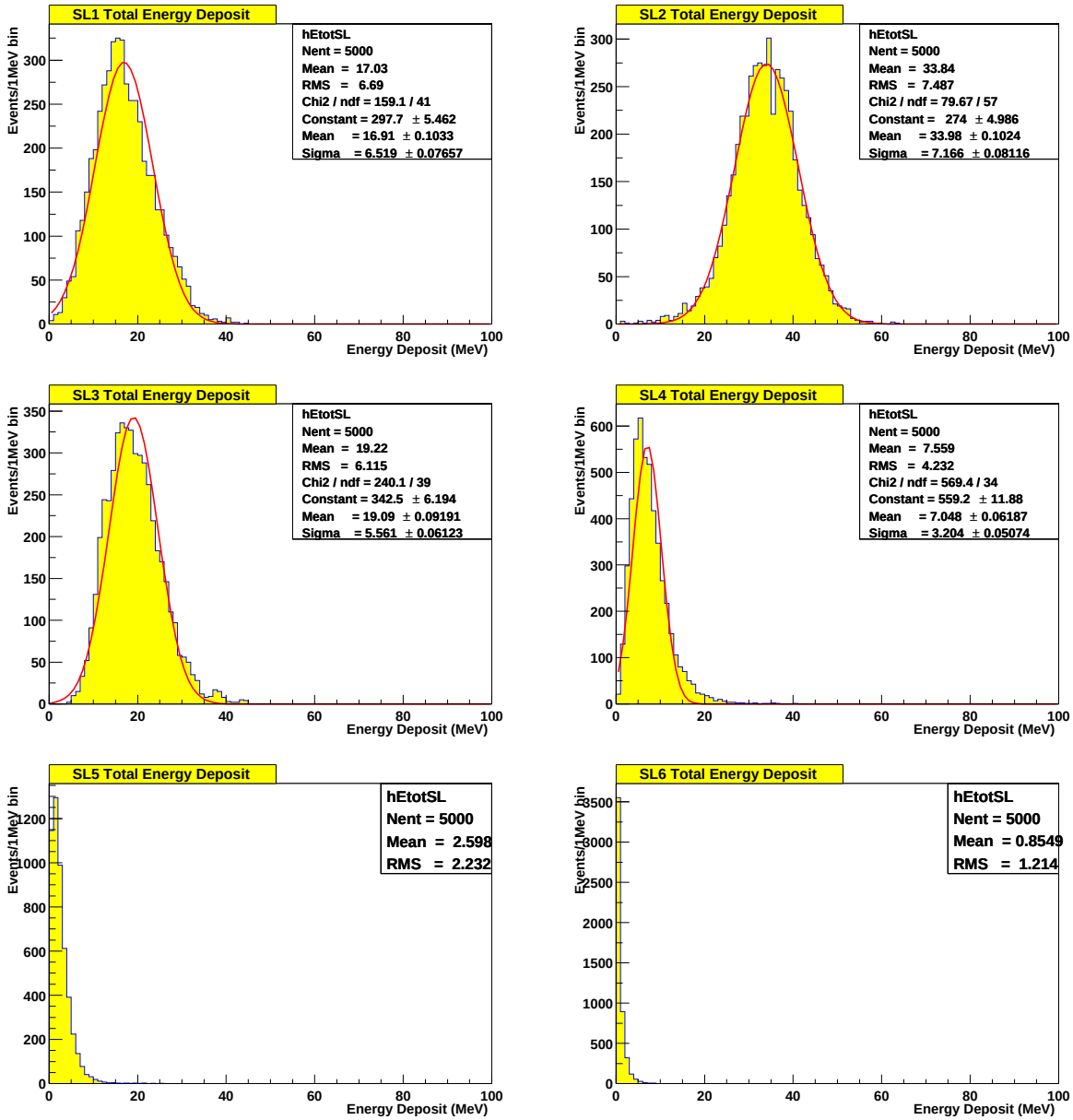








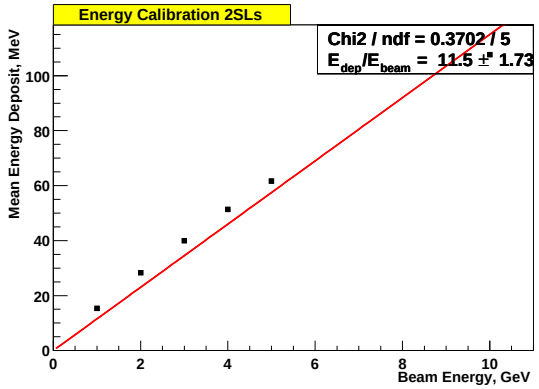
Energy Deposit per SL, $E_{beam} = 4\text{GeV}$

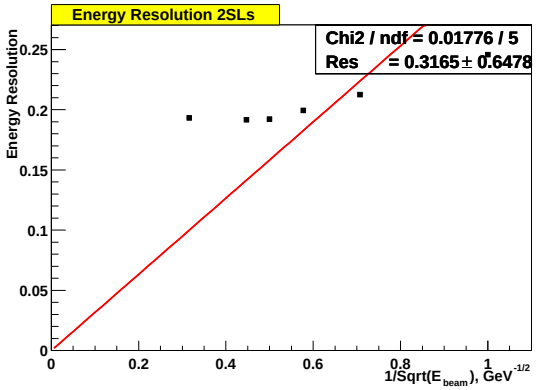


Edep near Shower Max is gaussian.

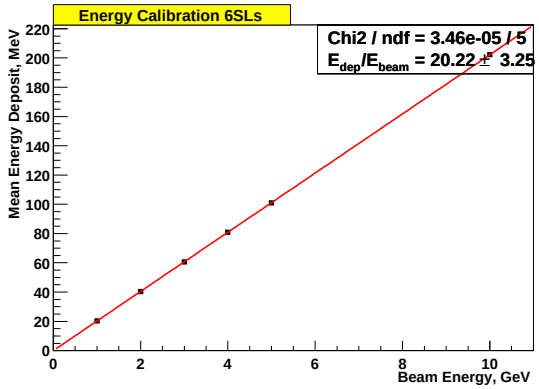
Energy Calibration and Resolution, $E_{beam} = 1 \sim 10$GeV

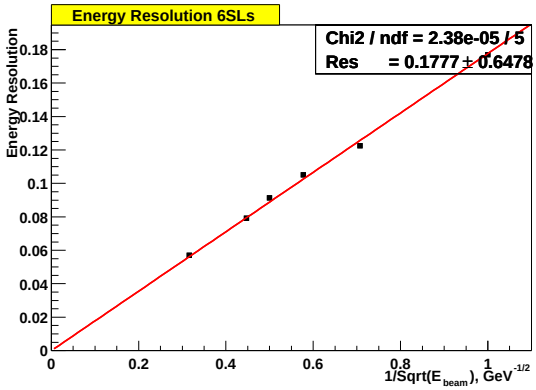
2 SL module





6 SL module





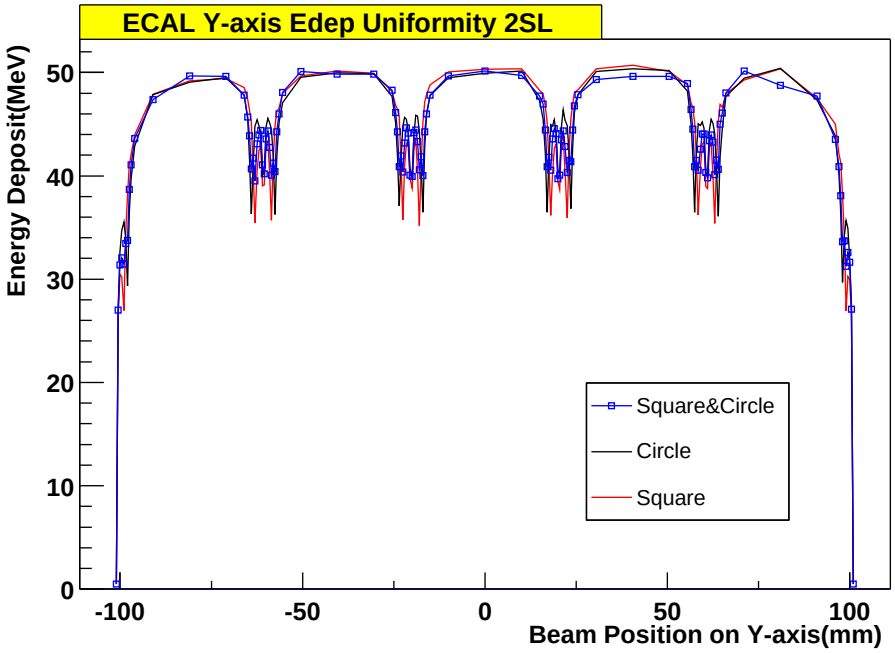
Fits are constrained at the origin. 6 SLs are needed to contain 4GeV shower.

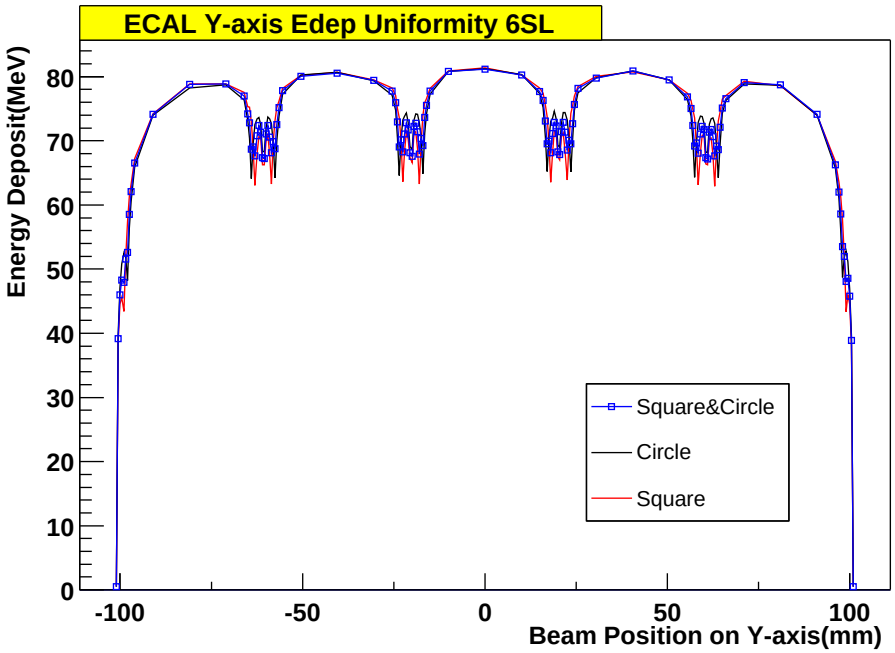
Uniformity Test

$\Rightarrow$ e^- beam, $E_{beam} = 4$GeV
$\Rightarrow$ Y-axis Points: $\pm$0, 10, 15, 16, 16.5, 17, 17.5, 18, 18.5, 19, 19.5, 20 mm
$\Rightarrow$ Fiber located at $\pm$18 mm for square fiber config (and $\pm$17mm for circle fiber config)
$\Rightarrow$ Effect of increased light collection efficiency near the fiber location is not included.

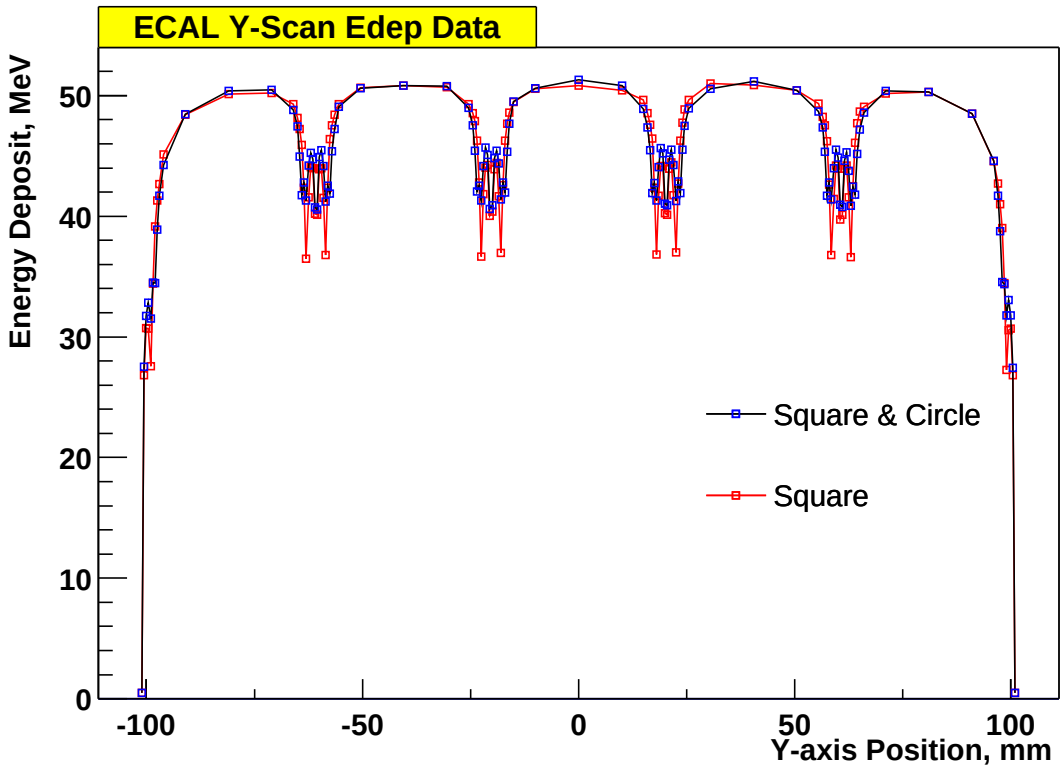
Module Uniformity

(E_{beam} = 4GeV, 1000 evts, 2 SLs & 6SLs)





Module Uniformity
(2 SLs, $E_{beam} = 4$GeV, 5000 evts)

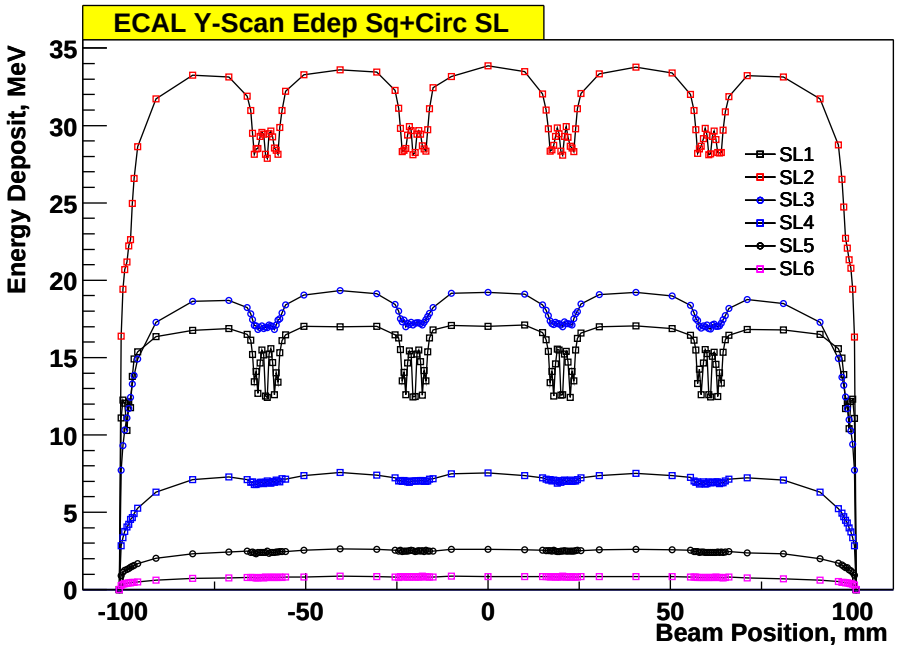


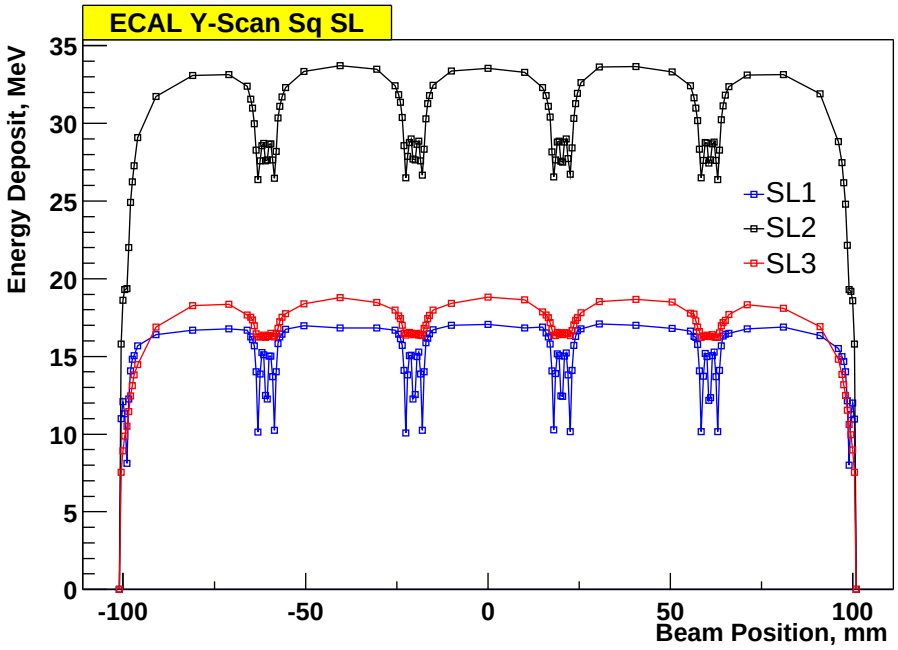
Largest E_{dep} deviation in inner tiles is at fiber positions.

Superlayer Uniformity

($E_{beam} = 4\text{GeV}$, 5000 evts)

For $|y| \leq 15mm$, $1 - \frac{E_{fiber}}{E_{center}} \lesssim 4\%$





Comparison of E_{dep} ($E_{beam} = 4$GeV) at $y_c = 0$ and $y_f = 18$mm locations. (Note: $\Delta E = 1 - \frac{E_f}{E_c}$)

Alternating Square & Circle Configuration

SL No	E_c (MeV)	E_f (MeV)	ΔE (%)	E_c^{accum} (MeV)	E_f^{accum} (MeV)	ΔE^{accum} (%)
1	16.91	12.42	26.55	16.91	12.42	26.55
2	33.99	28.75	15.42	51.30	41.32	19.45
3	19.04	17.05	10.45	70.31	58.45	16.87
4	7.559*	7.081*	6.32	77.60	65.45	15.66
5	2.598*	2.553*	1.73	80.09	67.92	15.20
6	0.855*	0.834*	2.44	80.97	68.77	15.07

*Data point is E_{dep} histogram mean, not from gaussian fit data

Square Configuration

SL No	E_c (MeV)	E_f (MeV)	ΔE (%)	E_c^{accum} (MeV)	E_f^{accum} (MeV)	ΔE^{accum} (%)
1	17.04	10.19	40.20	17.04	10.19	40.20
2	33.68	26.54	21.20	50.82	36.87	27.45
3	18.69	16.16	13.54	69.65	53.24	23.56
4						
5						
6				81.37	63.55	21.90

$\Rightarrow$ Alternating configuration has better uniformity!

3. Summary and Future Plan

⇒ EM CAL beam test module was simulated for 2 and 6 superlayers and using different fiber configurations.

⇒ Linearity is good for a 6SL module up to 10 GeV, with an energy resolution fit of 17.8% at 1GeV. On the other hand, a 2SL module suffers from too much longitudinal leakage, yielding a resolution fit of 32%.

⇒ Alternating square and circle fiber configuration gives better uniformity.

⇒ Bench test mapping results must now be integrated into the simulation to account increased light collection efficiency near the fiber positions.