Direct Coupling Simulation

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CALICE Week, Manchester, UK

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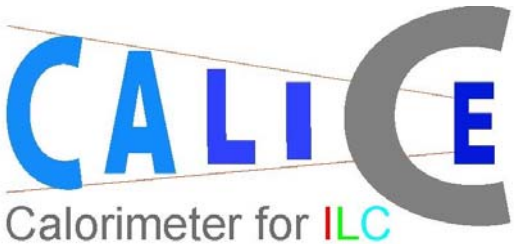
- Introduction to direct coupling
- The measurements at NIU/NICADD
- **Standalone simulation program**
- **Results**
- Outlook

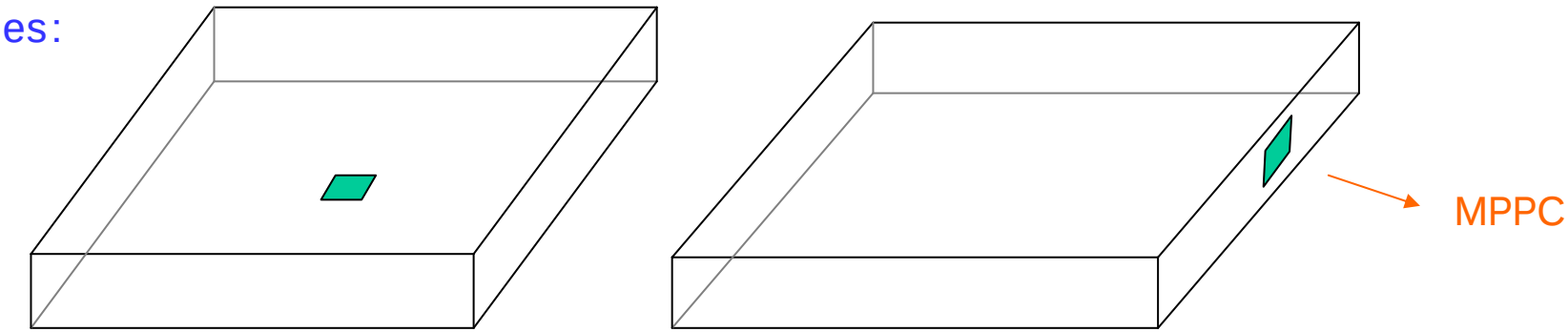


Direct Coupling

Attaching a MPPC device directly to a scintillator tile may simplify considerably the design of a calorimeter, its construction and lower the costs correspondingly.

No fiber would be required to transport the signal and dead space would be reduced.

Examples:



The simulation aims to understand the existing measurements and the responses to various options.

GEANT4 vs home-made MC

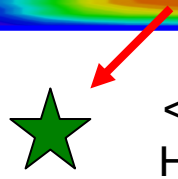
Geant4 code kindly provided by Valeri Saveliev, Obninsk State Univ., Russia

- The basic setup exists and runs under Scientific Linux, e.g. at DESY: a single tile surrounded by paper-thin surfaces to provide reflections, other properties, a MPPC and various incident beams.
- Unfortunately, this is not a standard GEANT4 setup and our lack of expertise was insufficient to make it run at Regina.

Standalone simulation by F.Corriveau and Z.Niu (summer student)

- C++ code
- Beam description matching the NIU/NICADD description
- Many rough approximations, some arbitrary fluctuations
- Several parameters available for understanding and tuning (next)
- Histograms drawn by ROOT

Reference Parameter Set

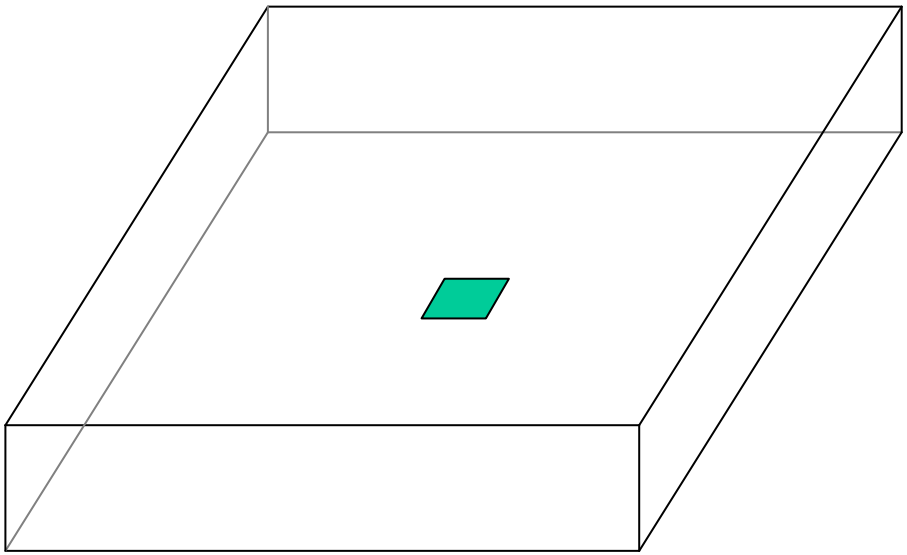


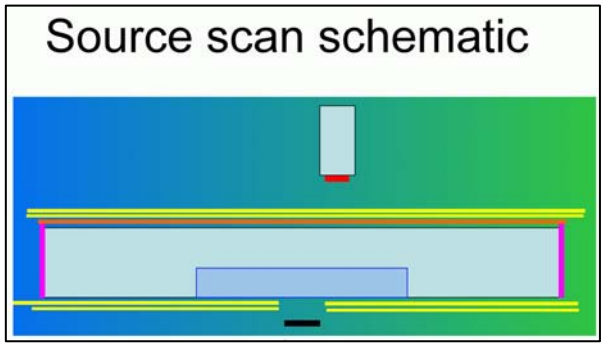
<Tile>				
Half Dimension (x y z) (mm):	15	15	2.5	30x30 mm^2
Corner Cut Length (mm):	0			
Light attenuation length (mm):	500			
Threshold energy where photon stops (MeV):	0.002			
Refractive index:	1.59			
Minimum Reflectivity:	0.95			
Maximum Reflectivity:	0.99999			
Minimum dE/dx (MeV/mm):	0.2052			
<MPPC>				
Lower left corner (x y z) (mm):	-0.5	15	-0.5	1x1 mm^2
Upper right corner (x y z) (mm):	0.5	15	0.5	
Absorption:	0.9			
<Sources>				
Position x components (min max step) (mm):	-20	20	1	40x40 mm^2
Position y components (min max step) (mm):	-20	20	1	
Position z components (min max step) (mm):	0.2	0.2	1	
Standard Deviation of particle spread:	0.6			
Number of particles at each source point:	500			
Ionization density along particle path (mm^{-1}):	70			
Number of photons emitted per ionization event:		1		
Standard deviation of energy distribution of single photons:			0.2	

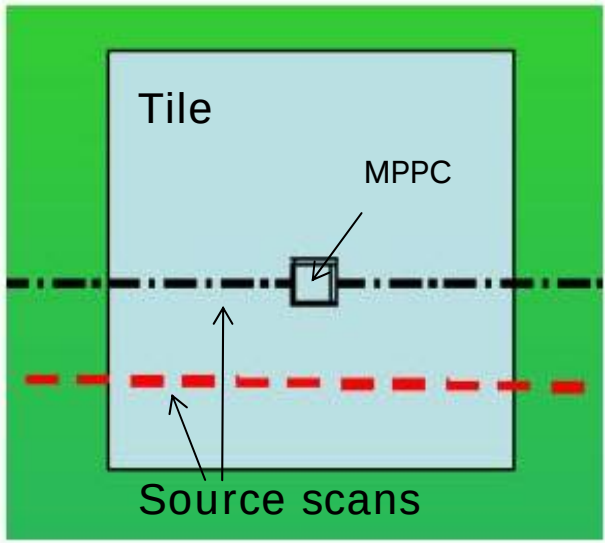
Simulations vs Measurements

A.Dyshkant, K.Francis, V.Zutshi: "Direct Coupling", CALICE Meeting, Prag, Sept. 2007

The MPPC is located in the center of the bottom face

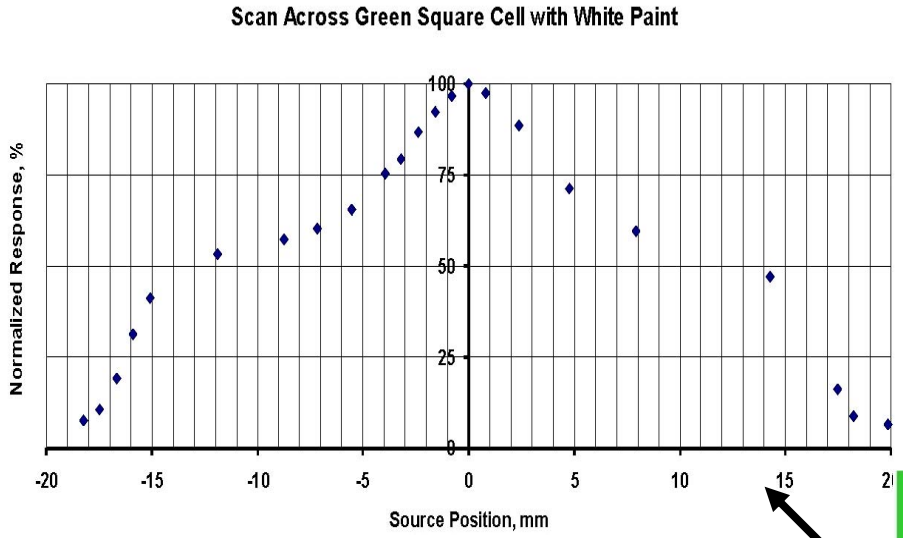


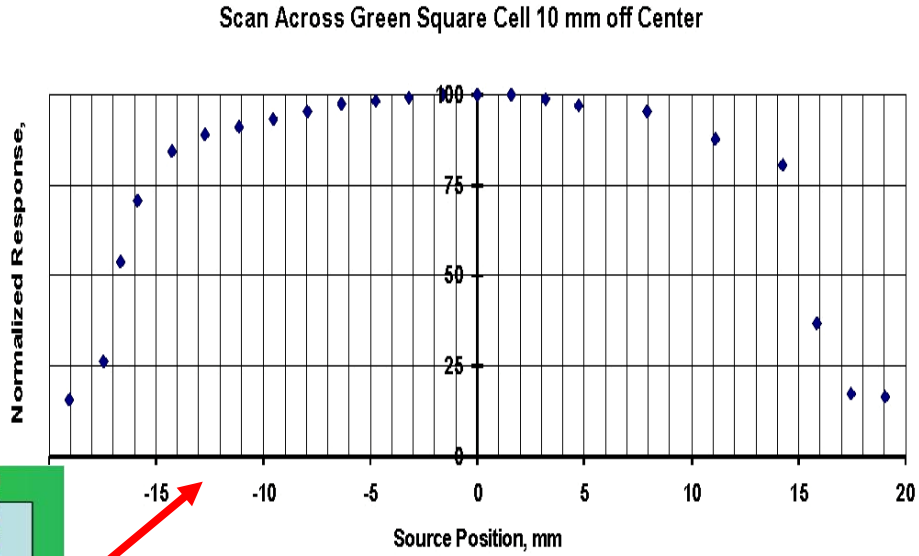


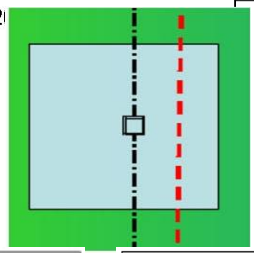


Response Uniformity

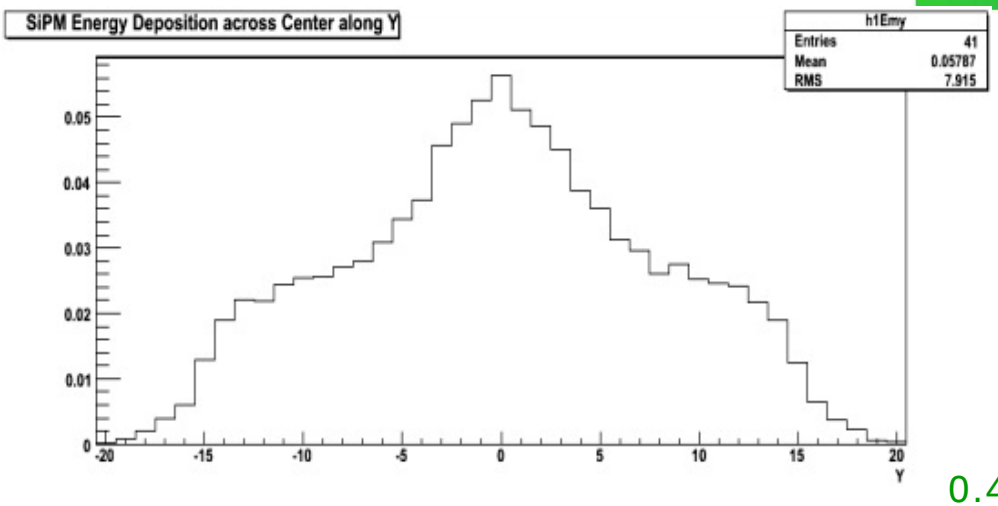
Measurement

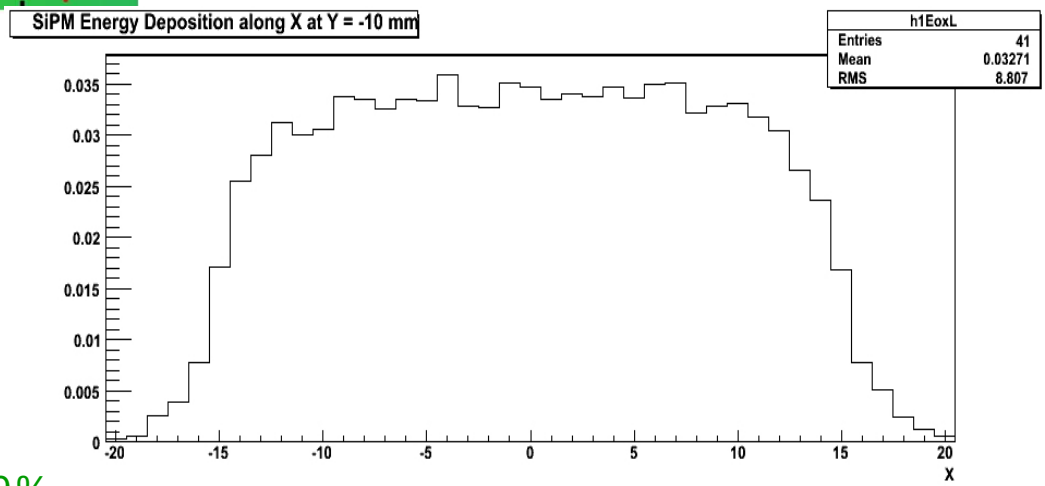






Simulation

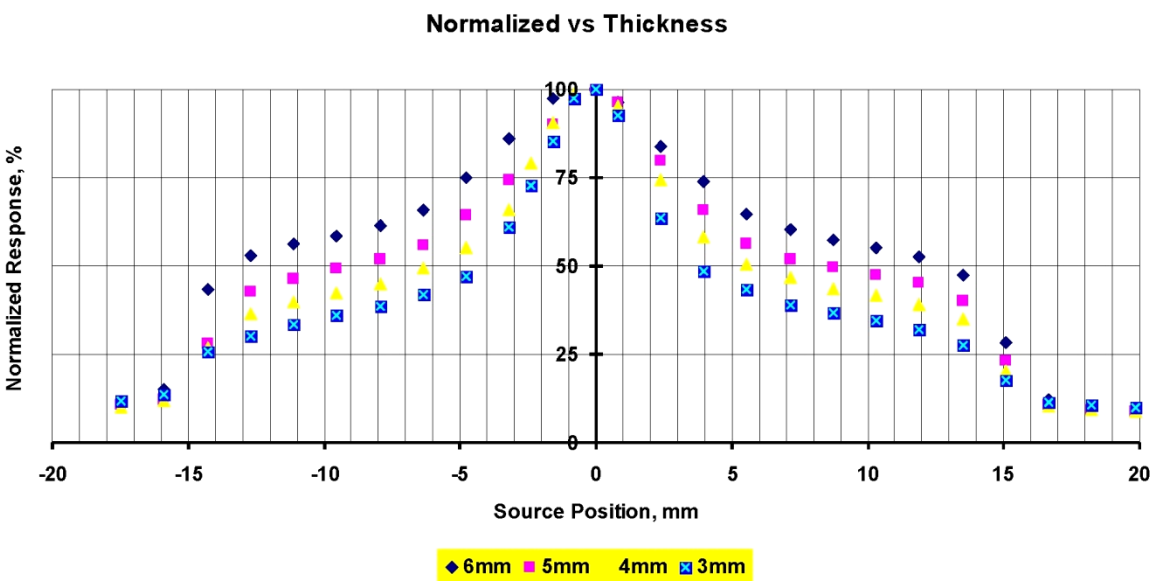


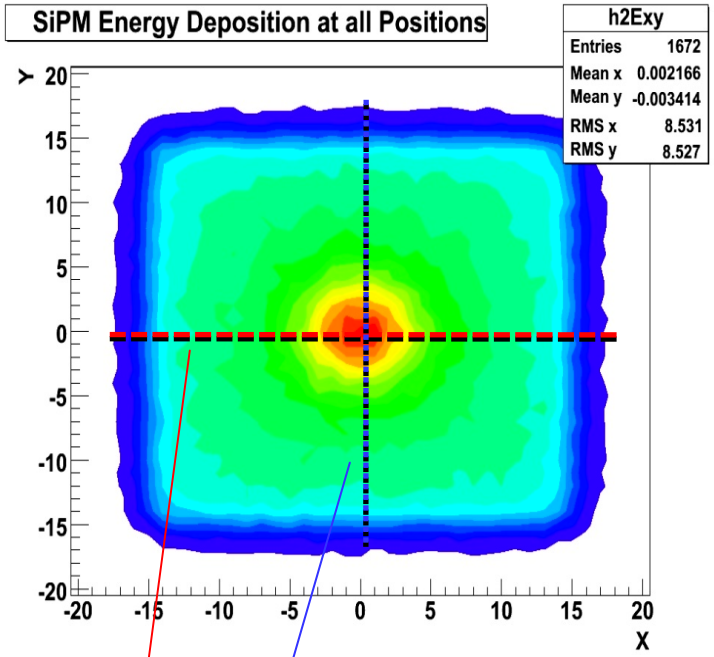


0.49%

vs Thickness

Measurement





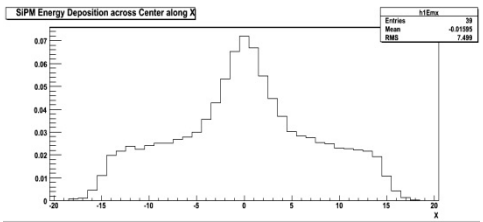
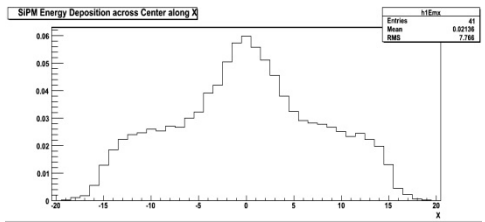
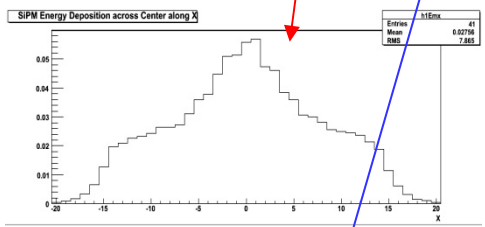
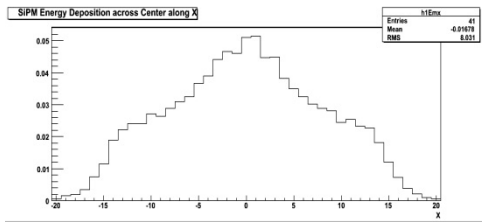
Simulation

3 mm | 4 mm | 5mm | 6mm

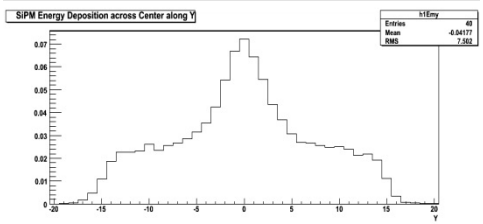
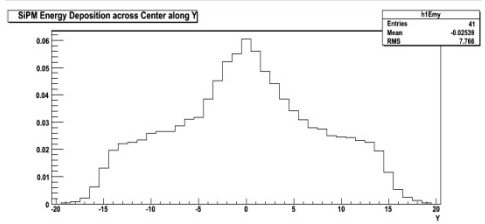
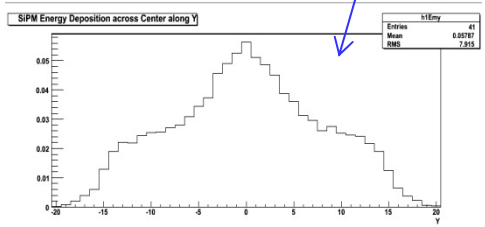
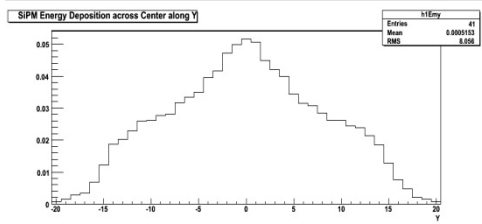
X scan

Y scan

X

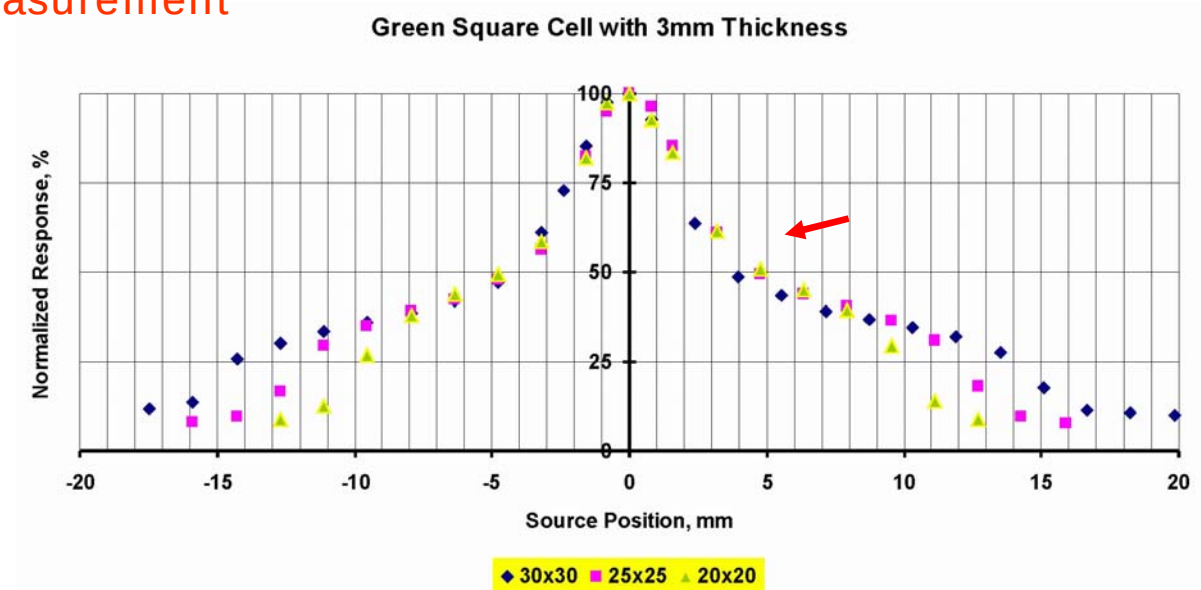
Y

0.79% | 0.65% | 0.49% | 0.40%

vs Size Length

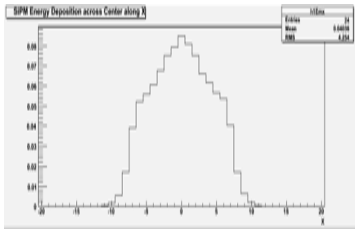
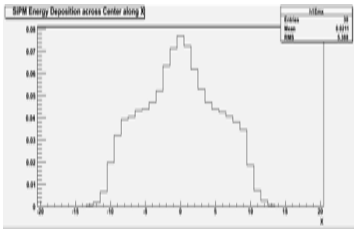
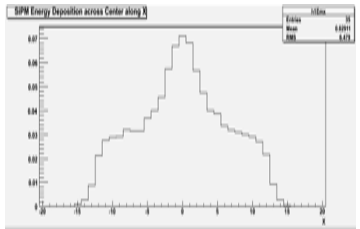
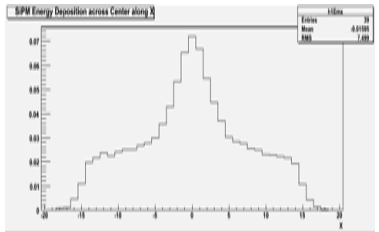
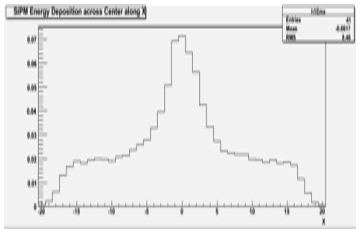
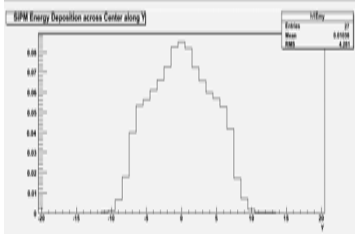
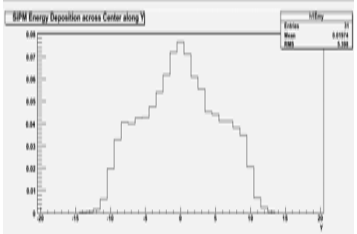
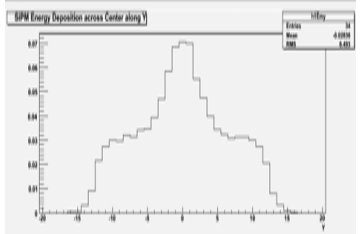
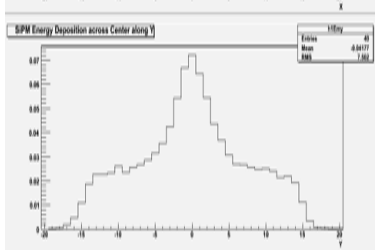
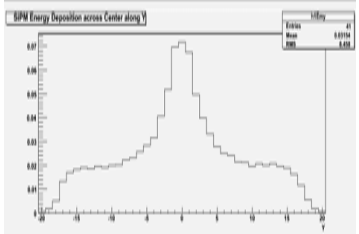
Measurement



Level = (dark current)

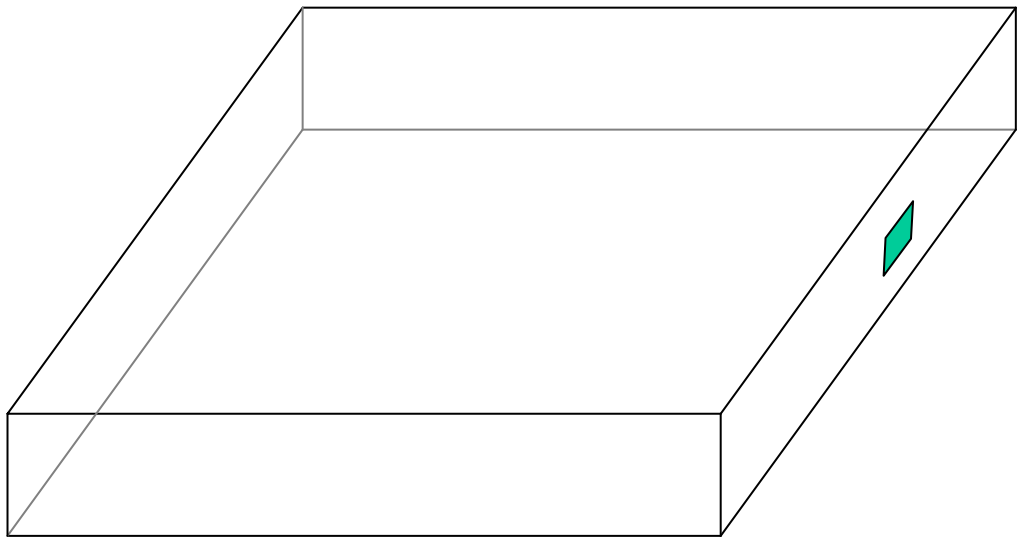
.. lots of tuning to do

Simulation

	15x15 mm^2	20x20 mm^2	25x25 mm^2	30x30 mm^2	35x35 mm^2
X					
Y					
	2.91%	1.69%	1.12%	0.79%	0.59%

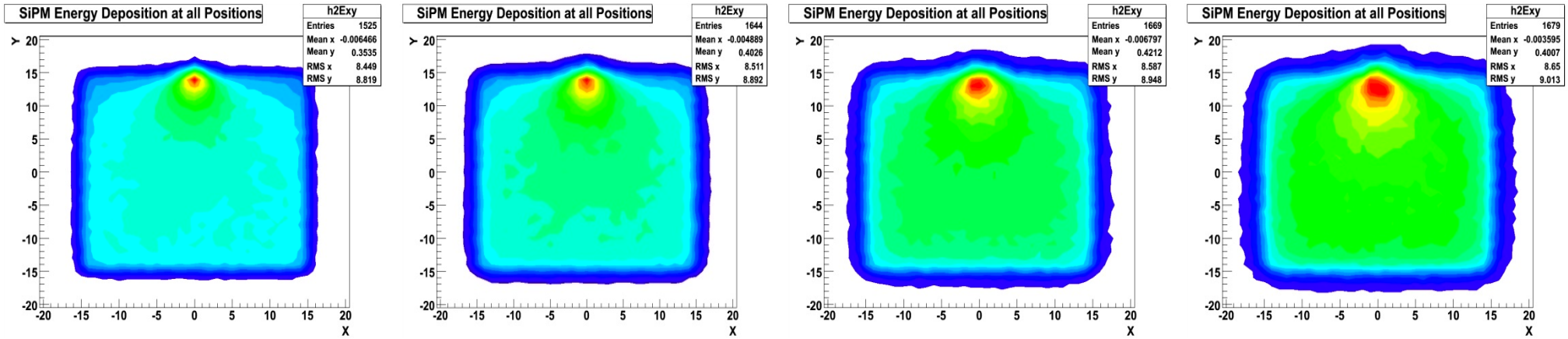
More Simulations

The MPPC is located in the center of a side face



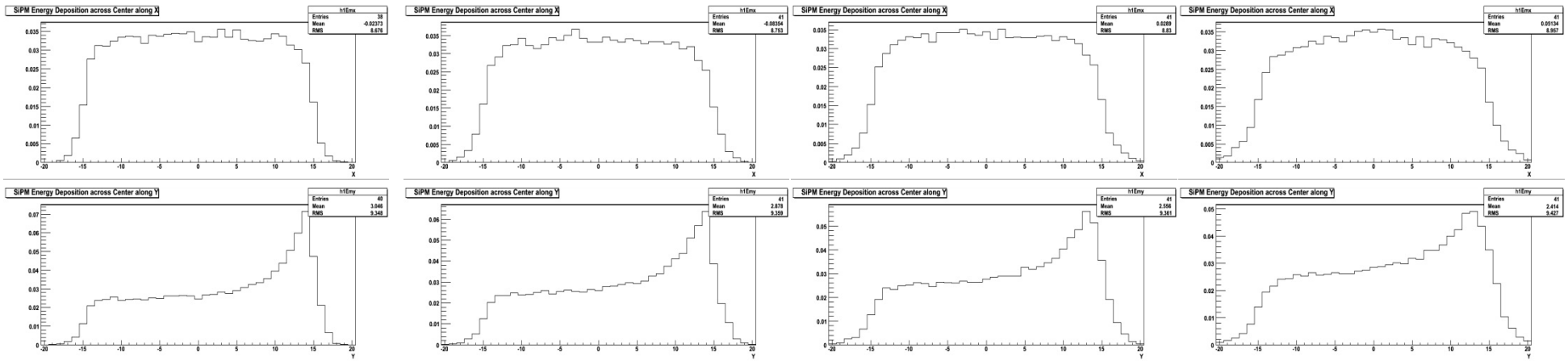
vs Thickness

Scan



Projections

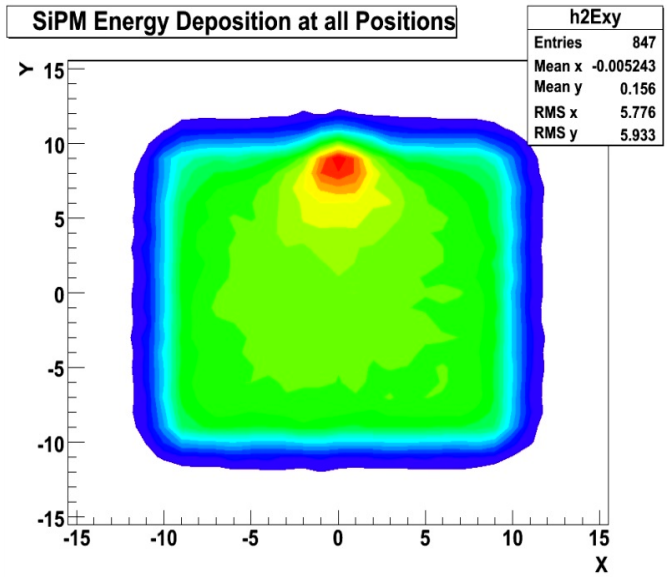
3 mm | 4 mm | 5mm ★ | 6mm

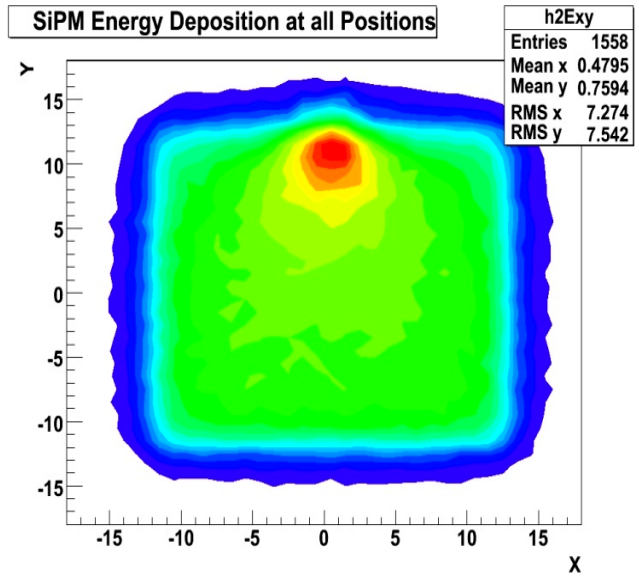


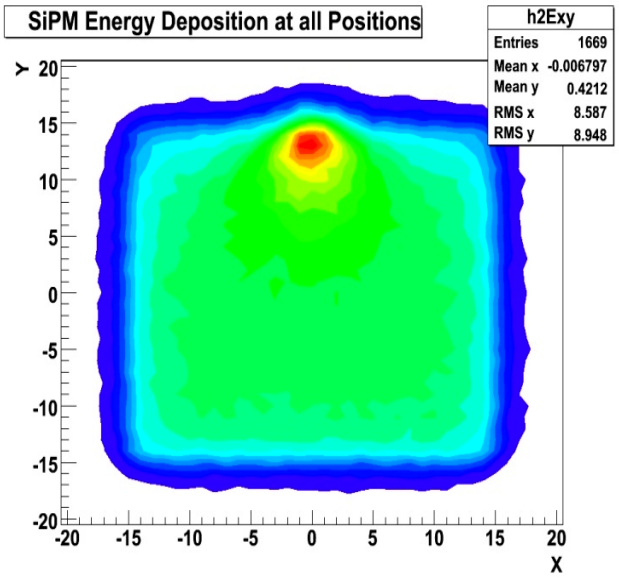
1.09% | 0.79% | 0.62% | 0.51%

vs Side Length

Scan







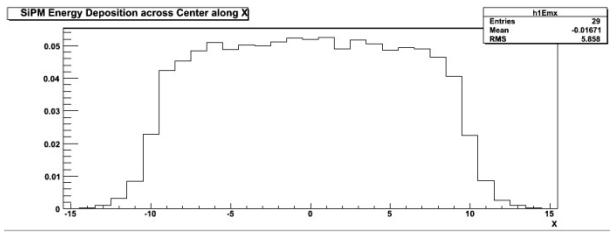
Projections

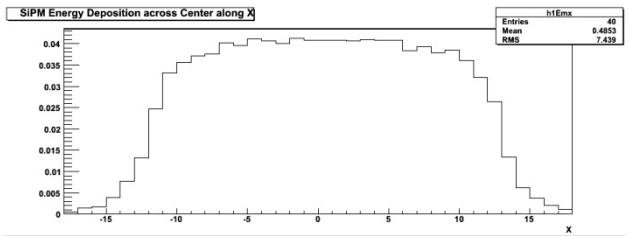
20x20 mm²

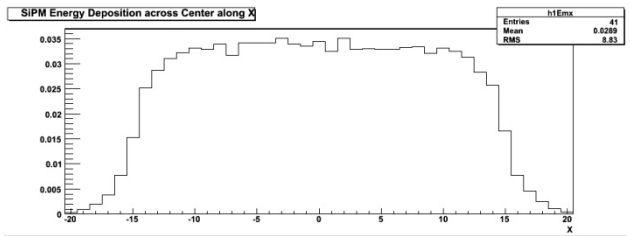
25x25 mm²

30x30 mm² ★

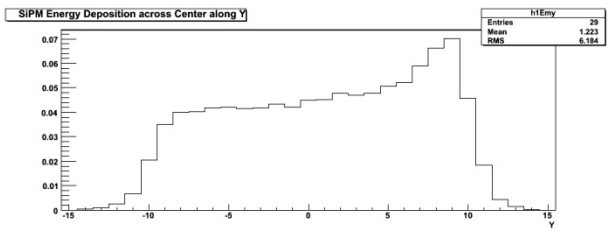
X

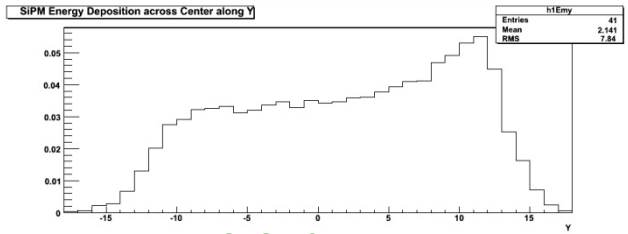


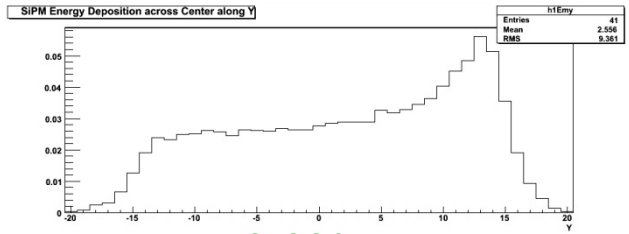




Y







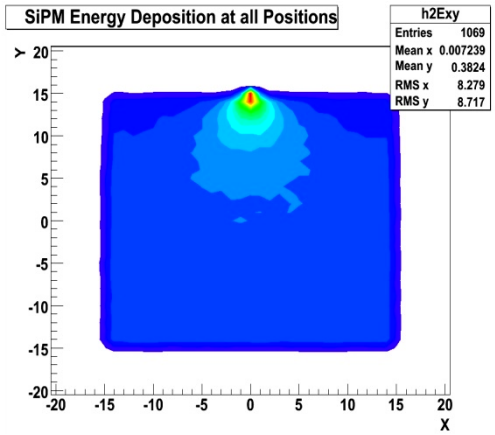
2.26%

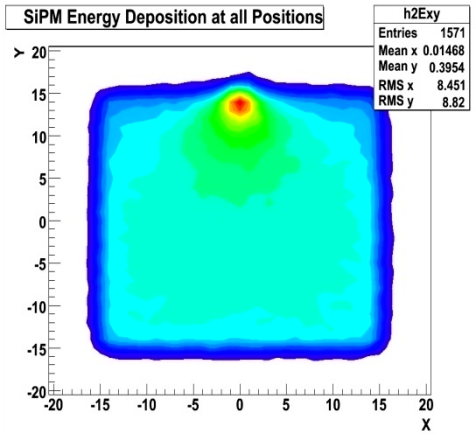
0.87%

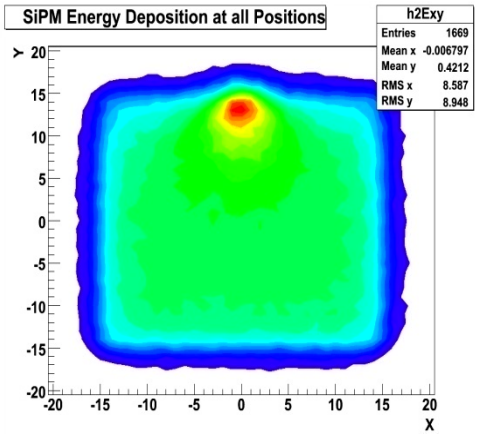
0.62%

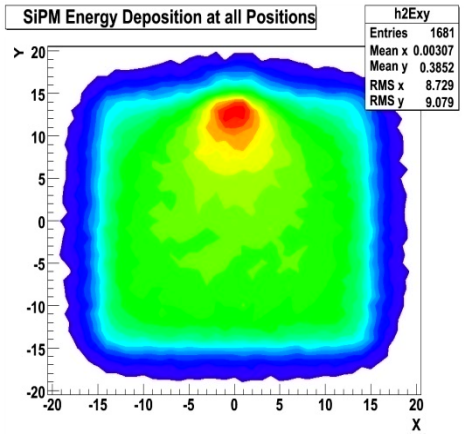
vs Beam Spread

(lateral beam standard deviation for 1 mm unit longitudinal length)





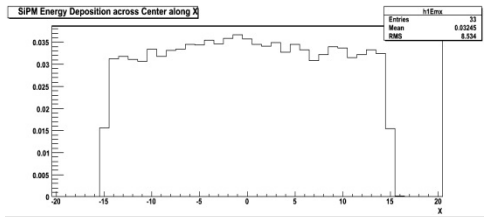


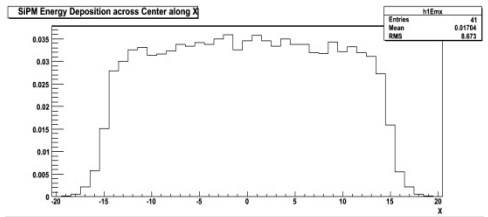


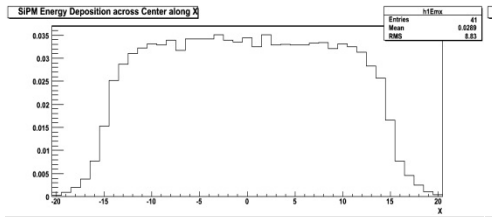
Projections

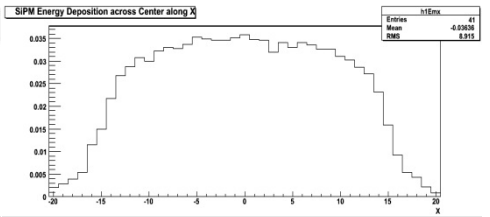
0.1 mm | 0.4 mm | 0.6 mm ★ | 0.8 mm

X

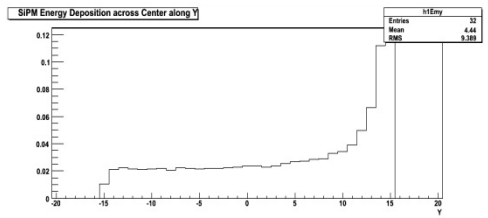


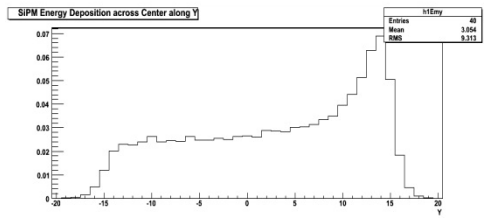


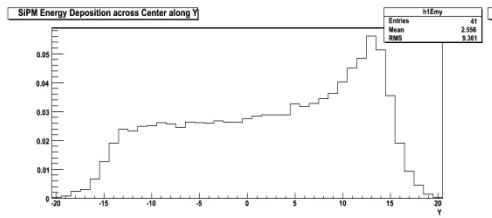


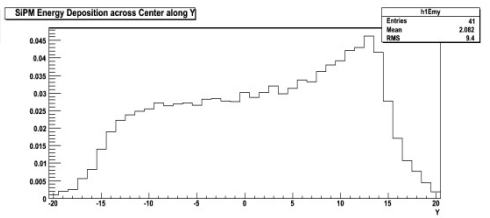


Y







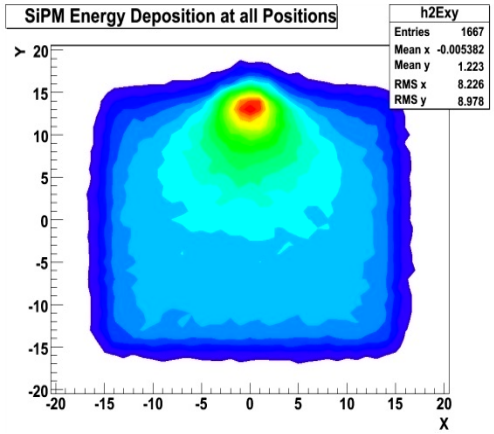


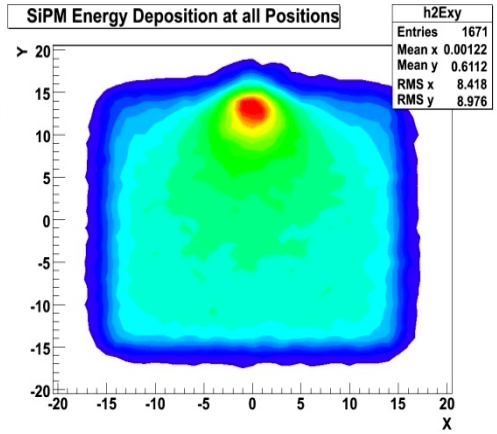
0.55% | 0.62% | 0.62% | 0.62%

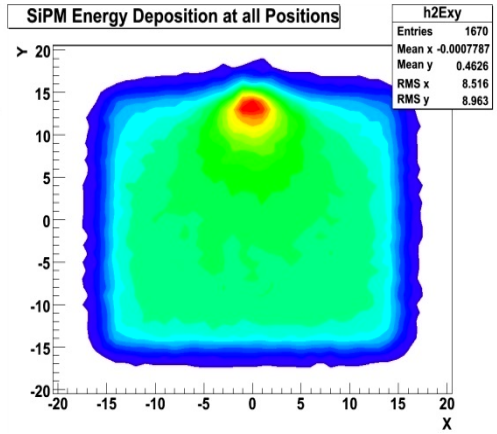
vs Attenuation Length

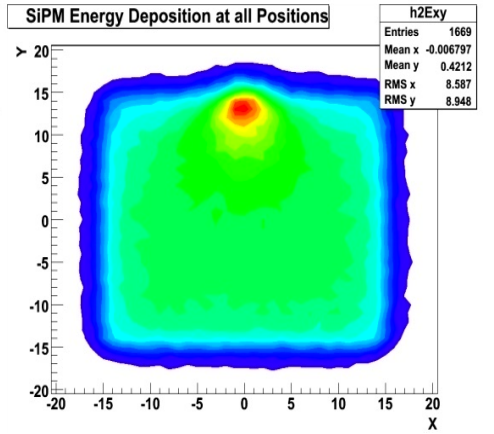
Scan

Note: attenuation length is constant in this set





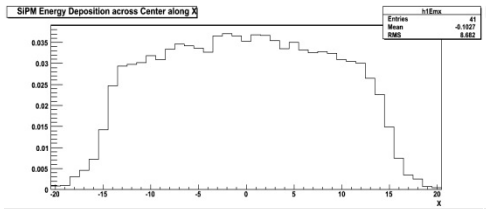


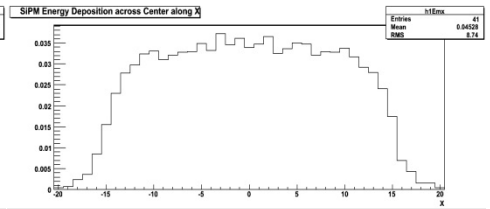


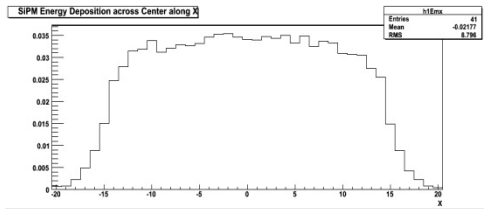
Projections

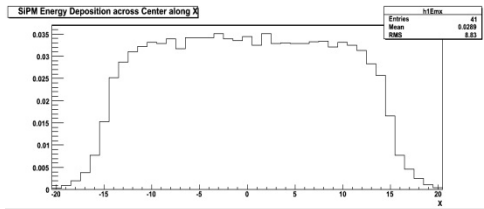
200 mm 300 mm 400 mm 500mm

X

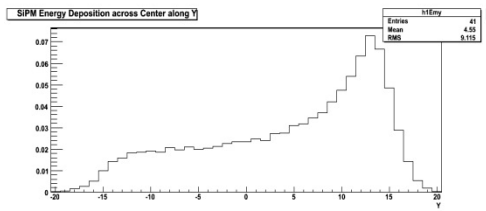


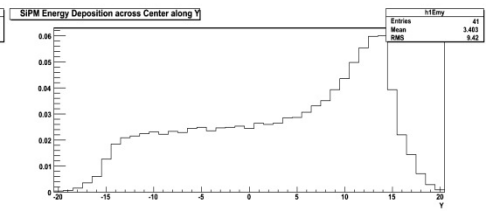


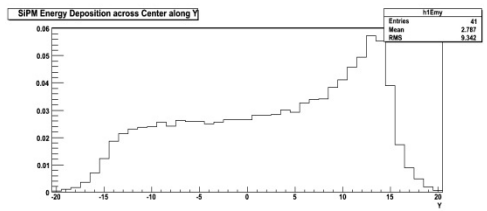


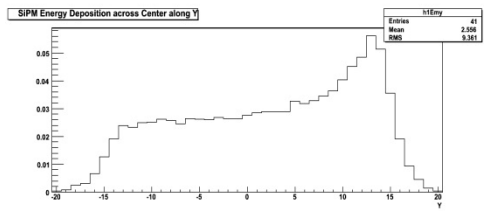


Y





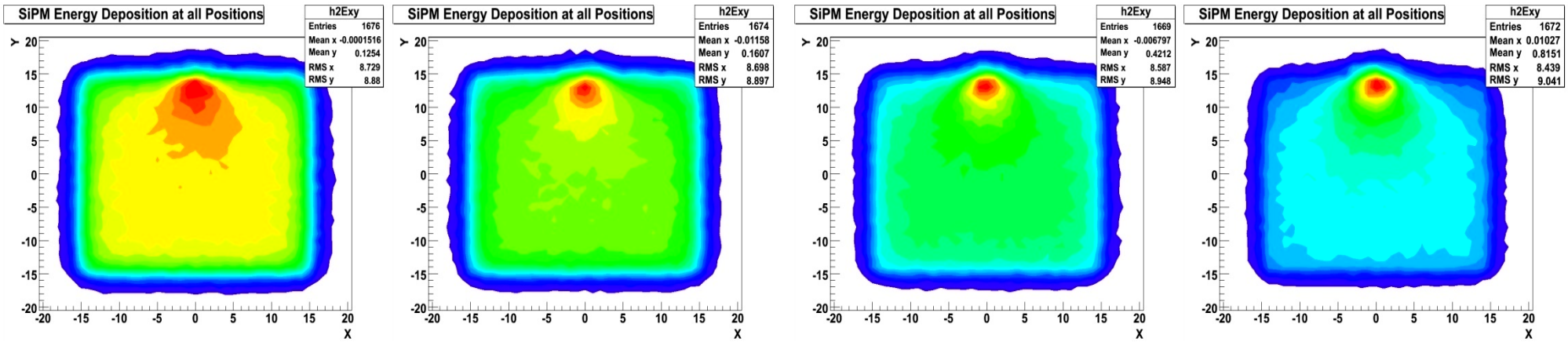




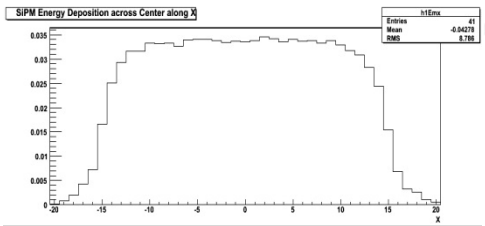
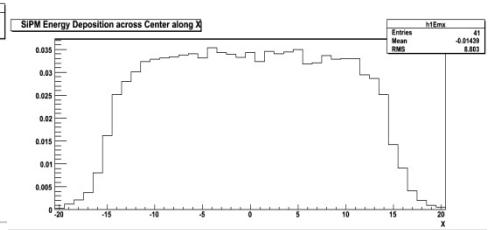
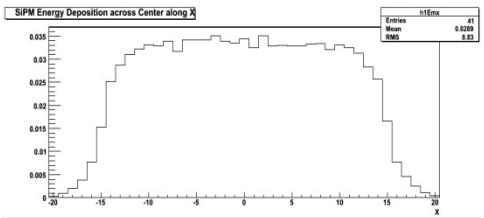
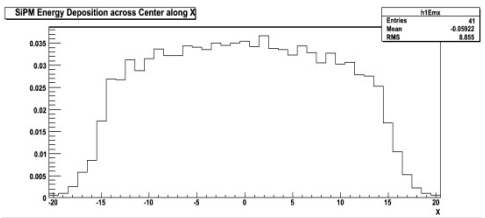
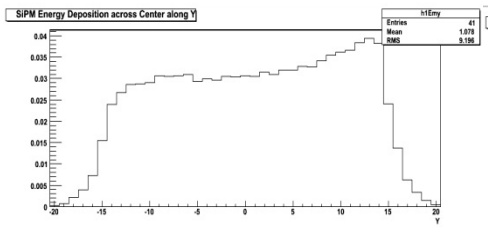
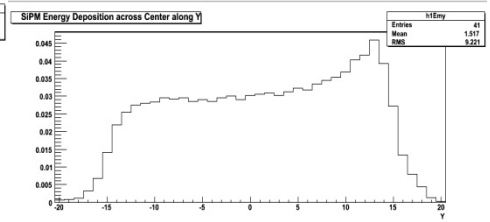
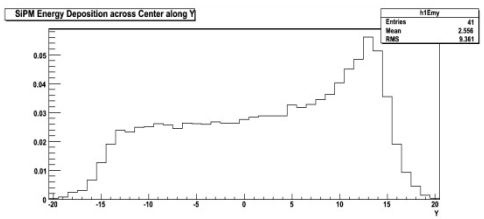
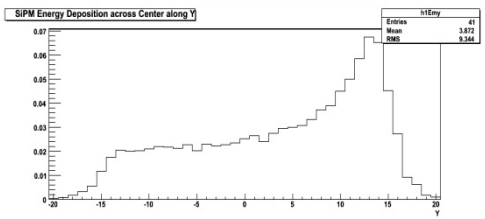
0.31% 0.42% 0.53% 0.62%

vs Threshold

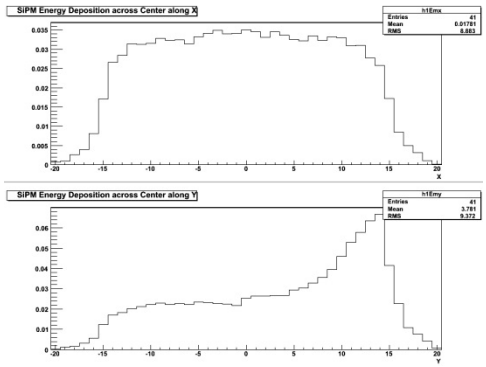
Scan



Projections

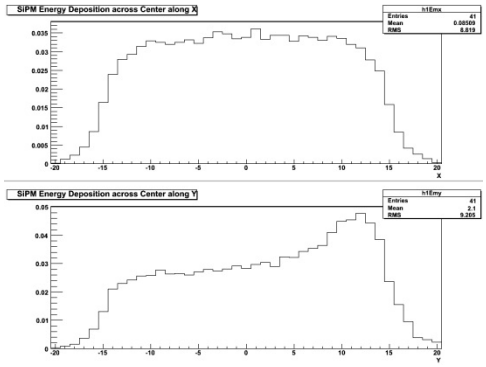
	0.1 eV	1.0 eV	2.0 eV ★	2.5 eV
X				
Y				
	1.53%	1.11%	0.62%	0.38%

vs MPPC Position



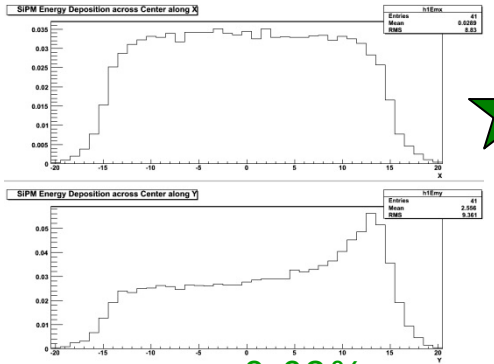
0.50%

Bottom edge



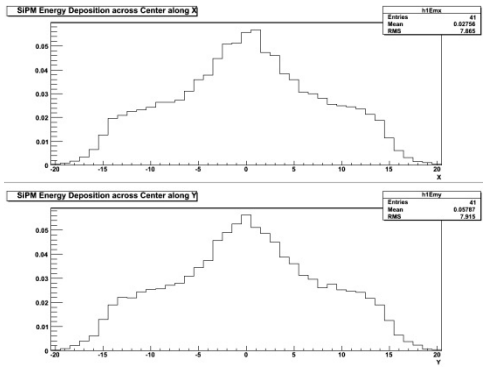
0.62%

Side low edge



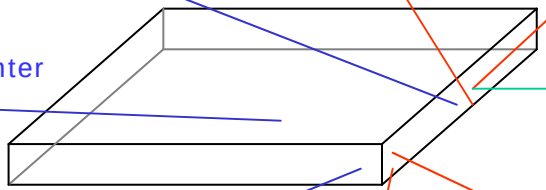
Side center

0.62%

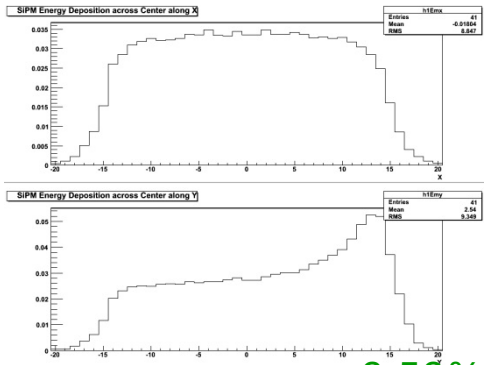


0.49%

Bottom center



MPPC 2x2

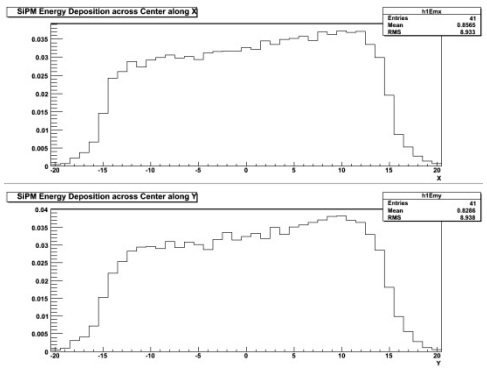


2.52%

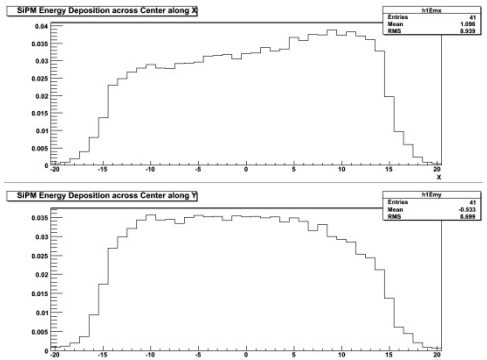
Bottom corner

Side edge

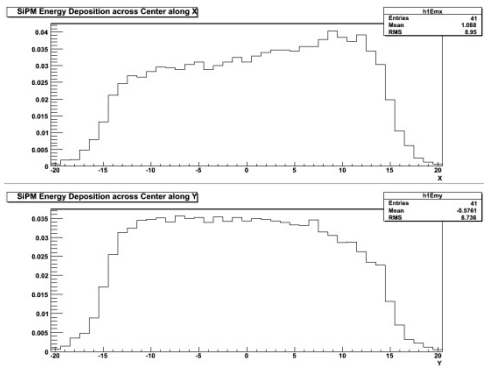
Side corner



0.51%

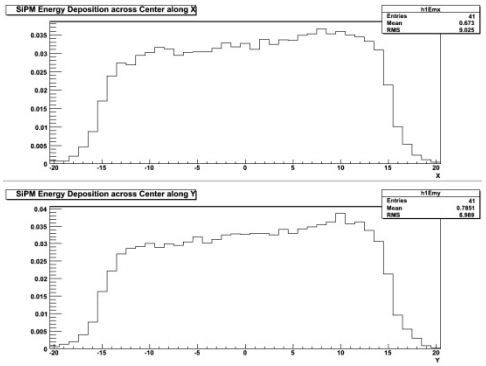


0.62%



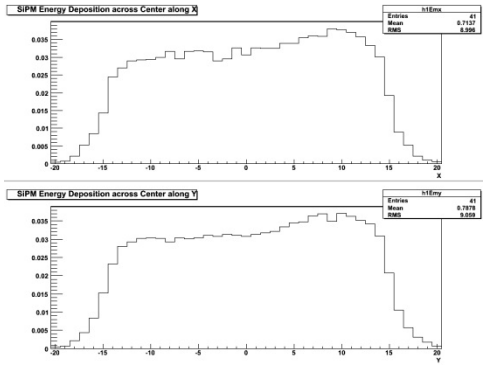
0.62%

vs Corner Variations



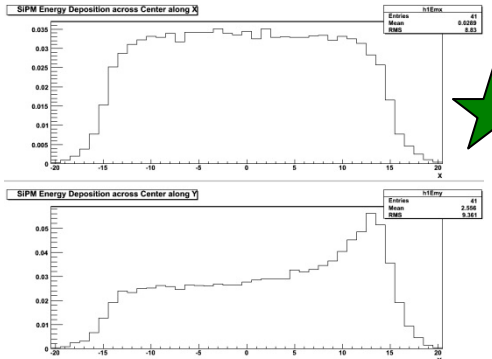
0.65%

Cut 5 mm



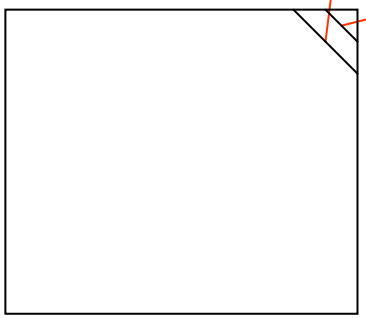
0.65%

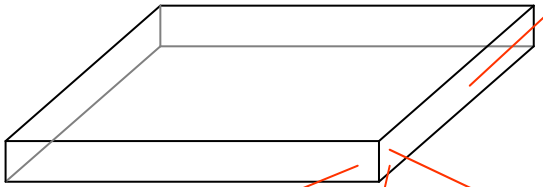
Cut 2 mm



Side center

0.62%

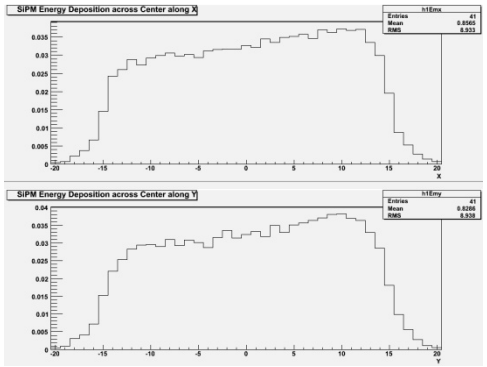




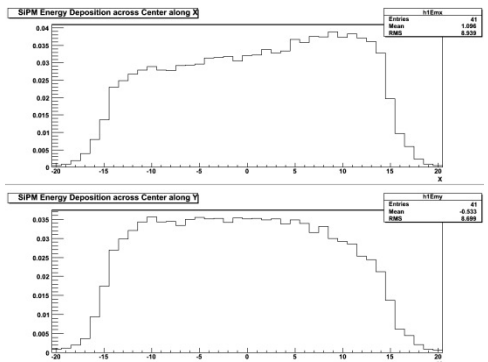
Bottom corner

Side corner

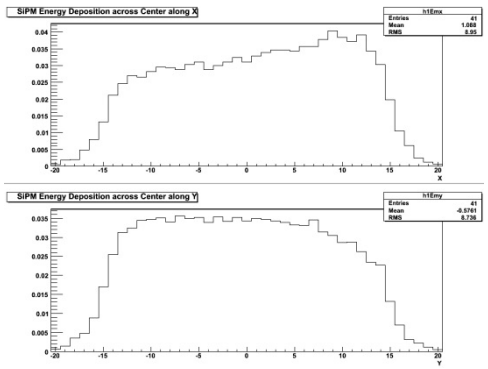
Side edge



0.51%



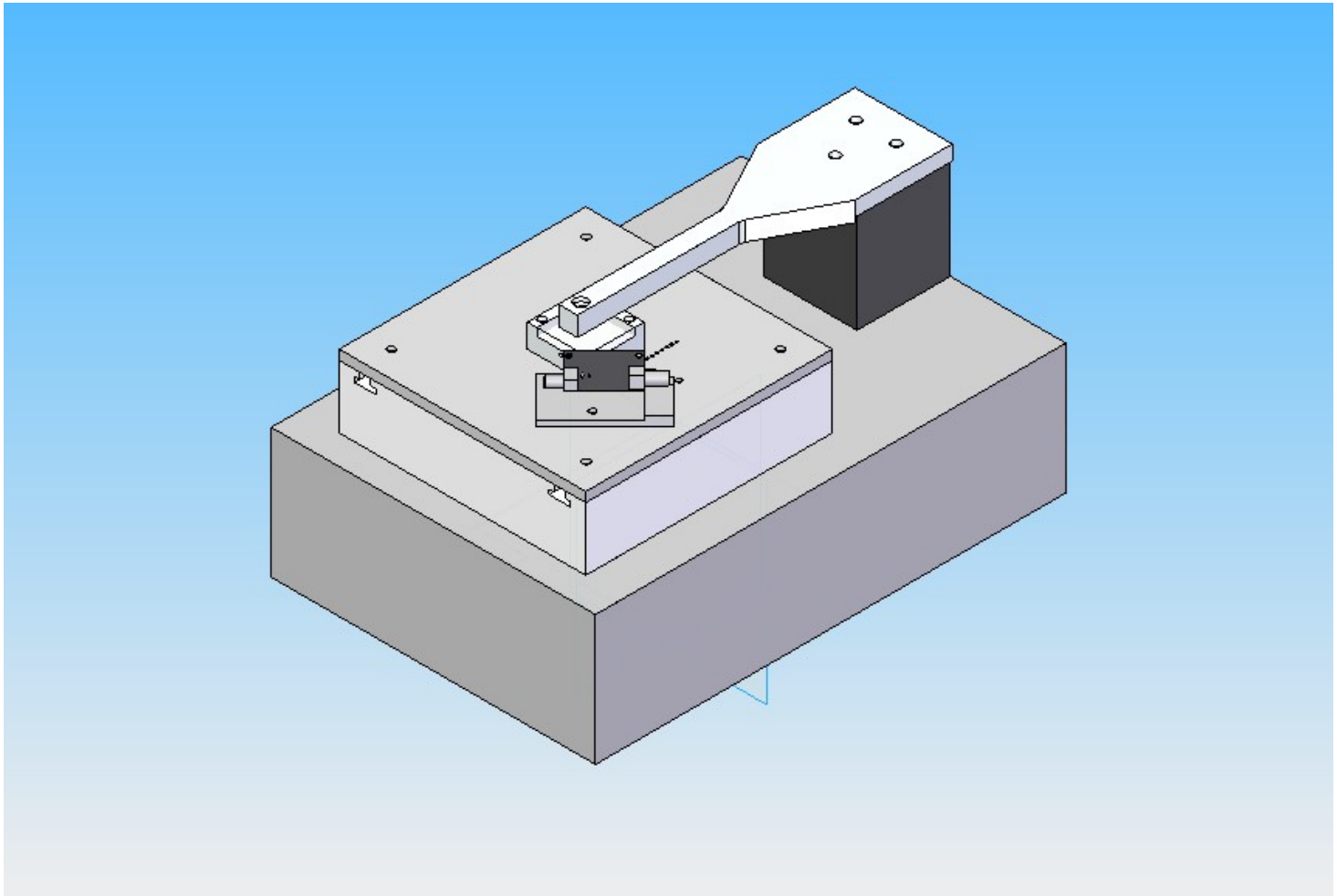
0.62%



0.62%

Measurements at Regina

M.Barbi and S.Schonhoffer (Univ. of Regina)



- Several types of MPPC available, variable tile geometries (e.g. cut): no result yet
- MPPC simulation newly available (from T2K)

Summary

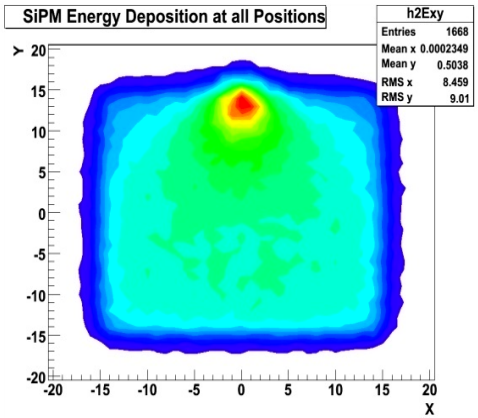
- First simulation results were obtained and several effects were studied
- The simulation reproduces the general features of the measurements
- Small discrepancies, edge effects and non-uniformity responses were observed – tuning!
  less critical for a digital/threshold calorimeter?
- No plan for the GEANT4 simulation
- New set of measurements initiated at Regina
- Feedback most welcome!

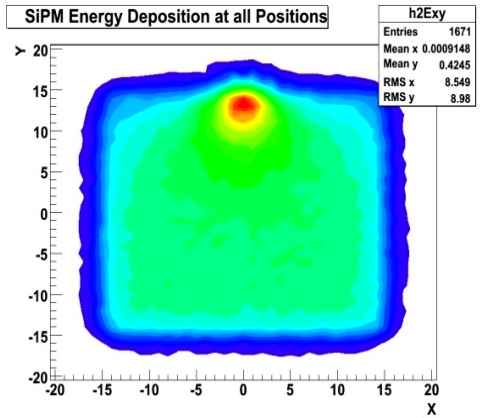
Backup Slides

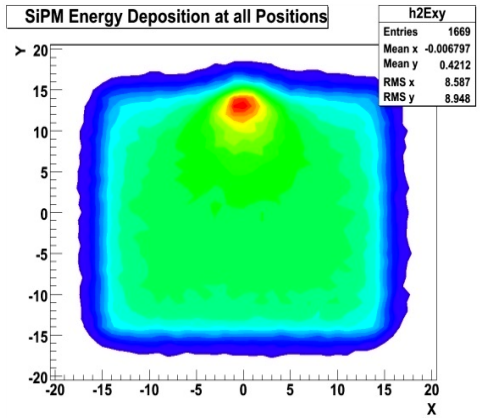
vs Minimum Reflectivity

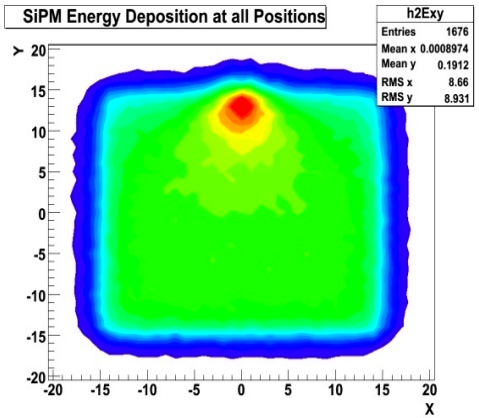
Scan

(reflection for small incident angles = how good is the paint/surface)





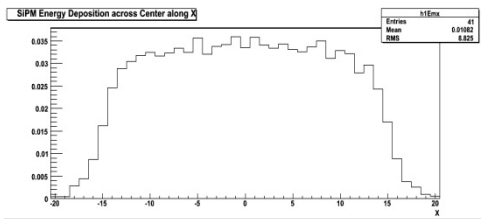


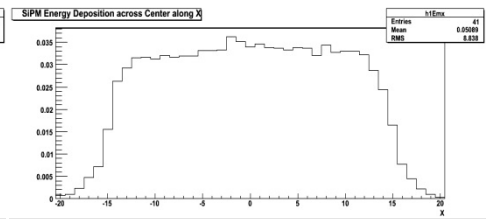


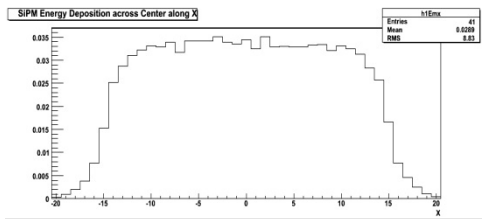
Projections

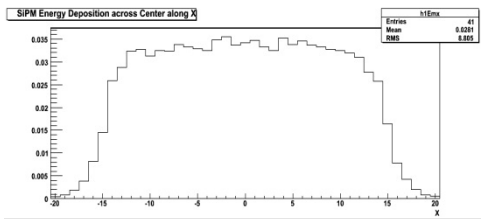
0.1 0.9 0.95 ★ 0.99

X

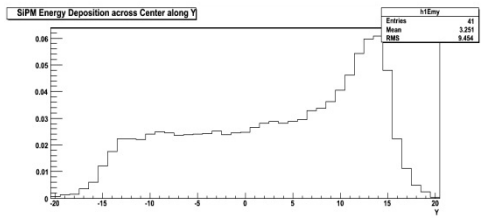


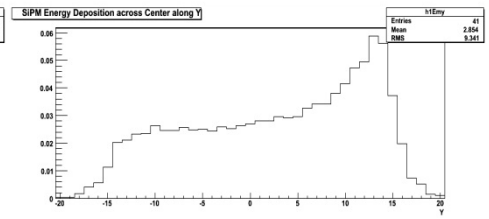


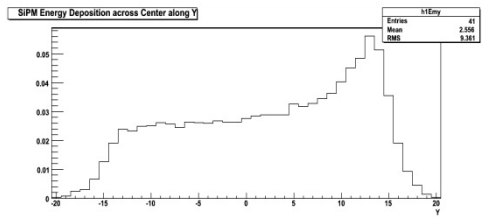


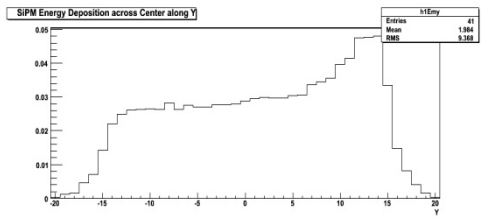


Y







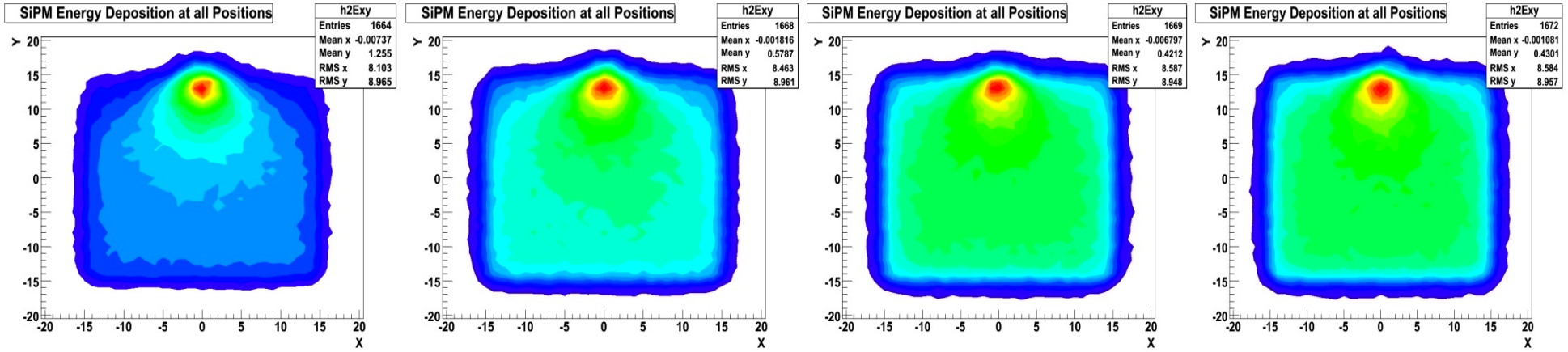


0.40% 0.54% 0.62% 0.78%

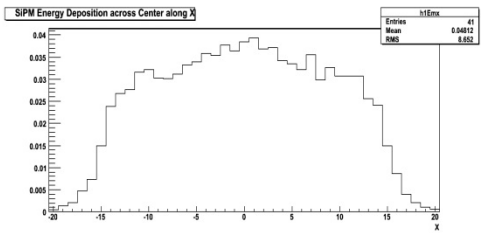
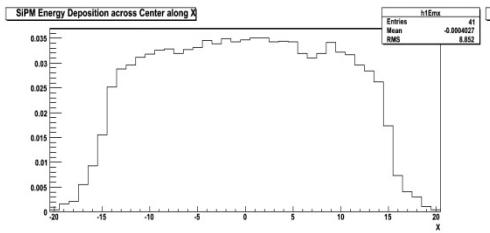
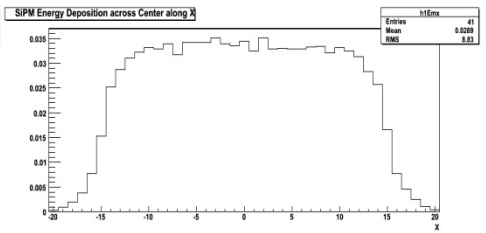
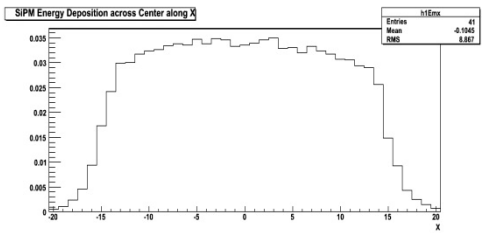
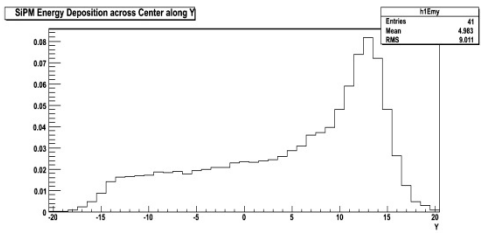
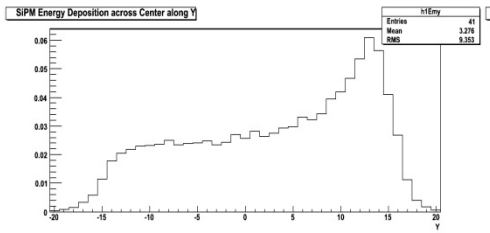
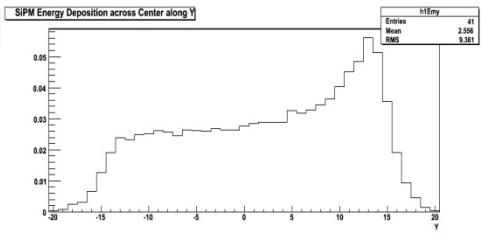
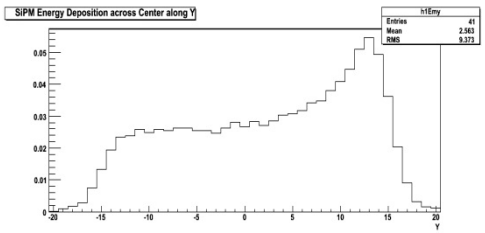
vs Maximum Reflectivity

Scan

(reflection for large incident angles = “total” (or almost) reflection)

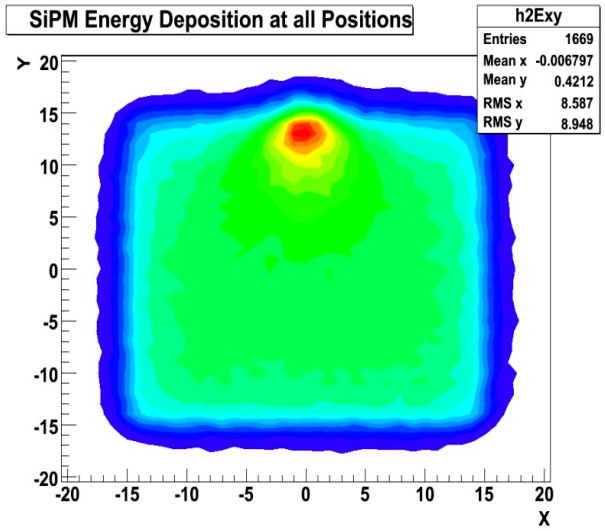


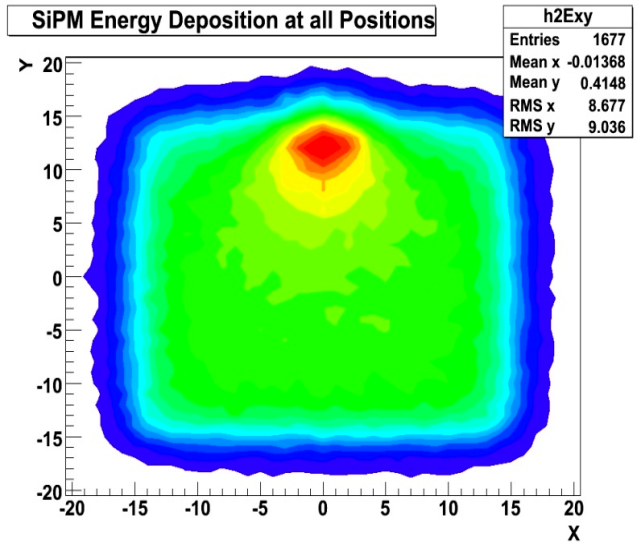
Projections

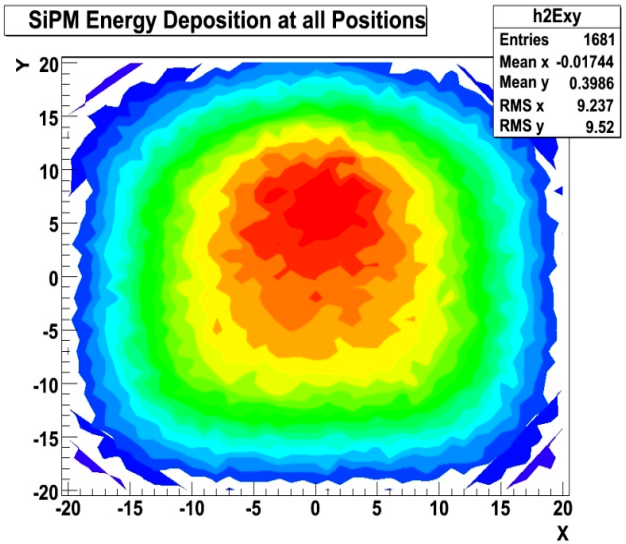
	0.95	0.99	0.9999 ★	1.0
X				
Y				
	0.26%	0.46%	0.62%	0.62%

vs Source Height

Scan



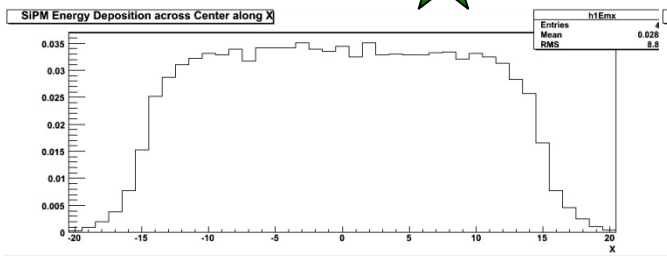


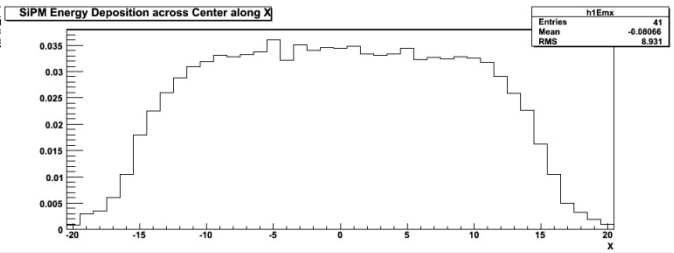


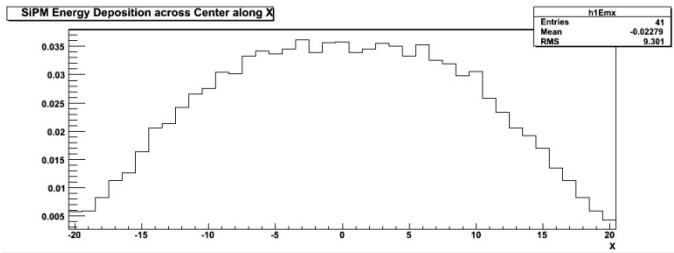
Projections

0.2 mm ★ 1.0 mm 5.0 mm

X







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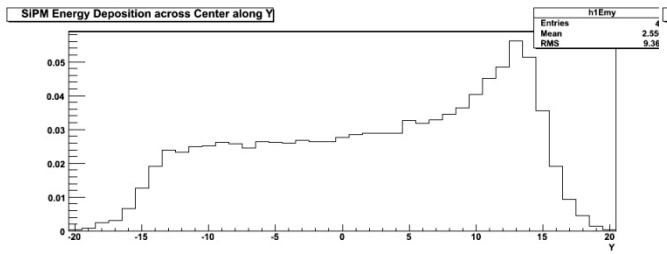
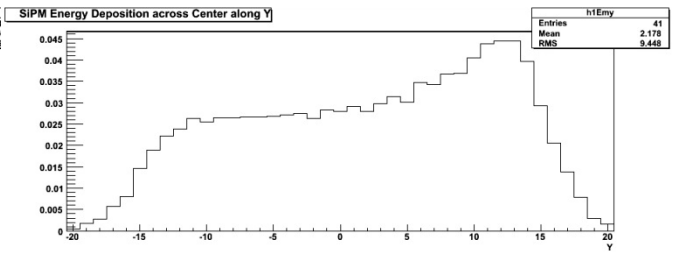
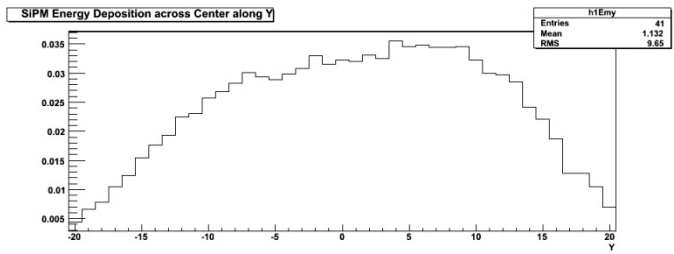






0.62% 0.62% 0.62%

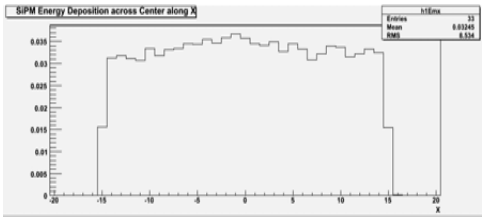
vs Beam Spread

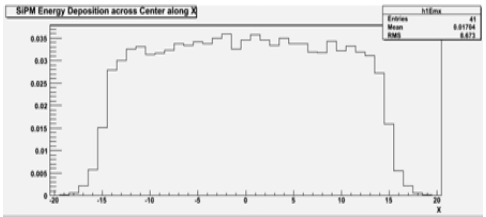
Projections

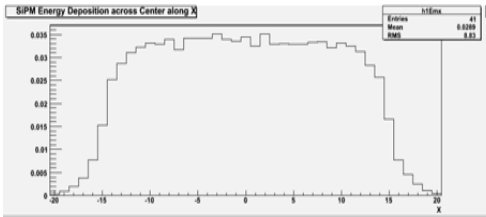
(lateral beam standard deviation for 1 mm unit longitudinal length)

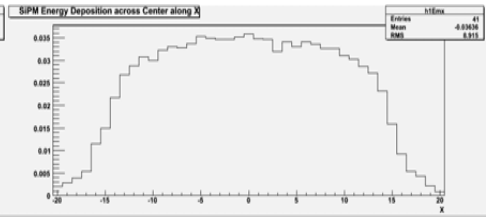
0.1 mm | 0.4 mm | 0.6 mm ★ | 0.8 mm

X









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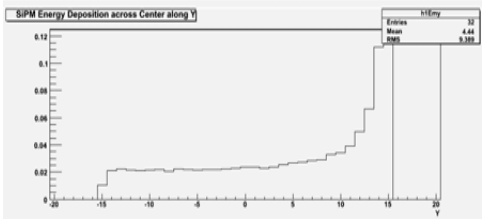
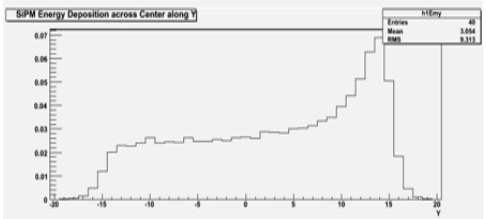
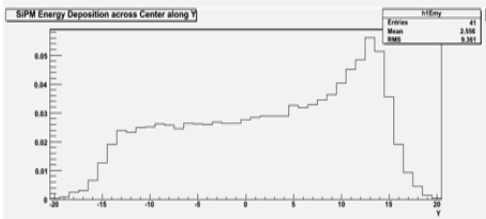
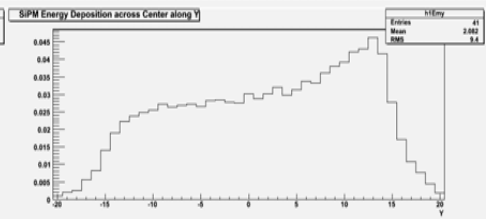


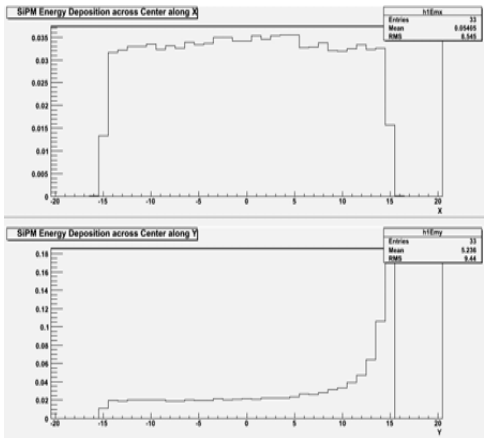






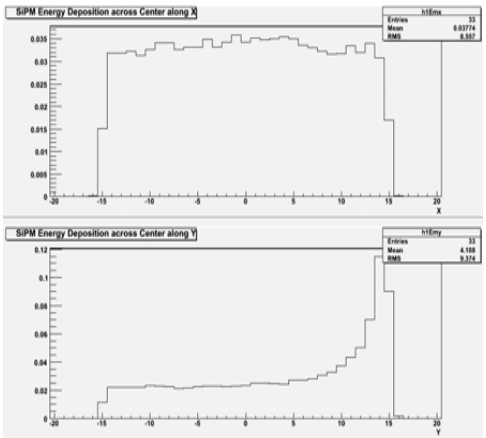
0.55% | 0.62% | 0.62% | 0.62%

0.1 mm (top)



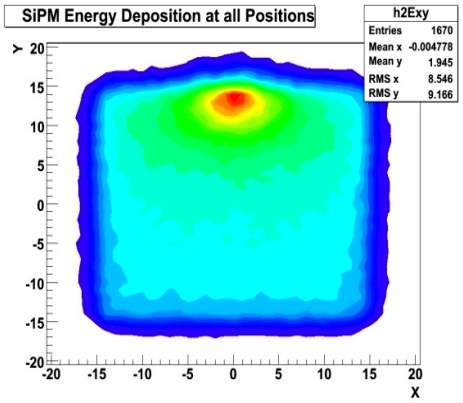
0.66%

0.1 mm (bottom)

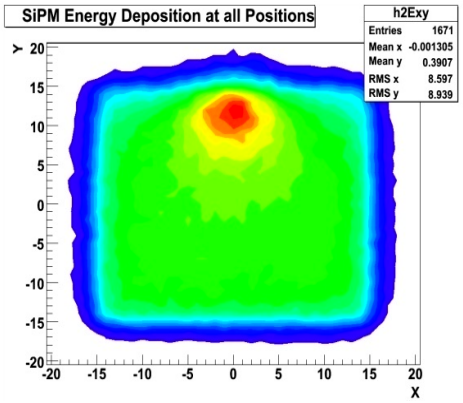


0.66%

vs MPPC Position



0.50%



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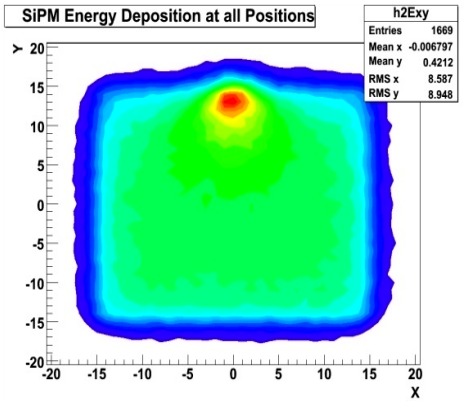

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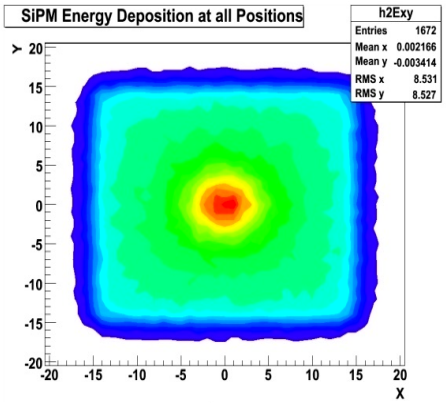
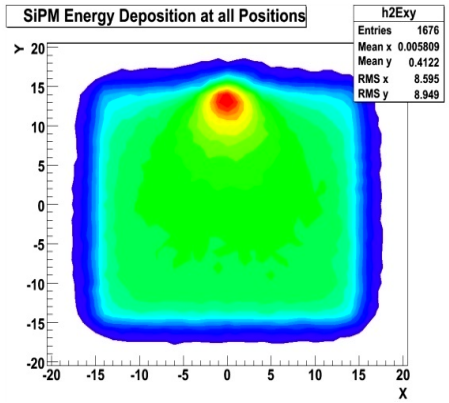
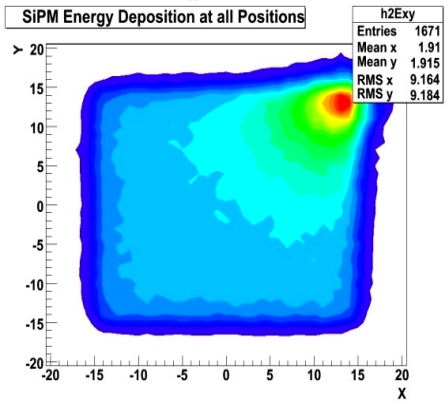


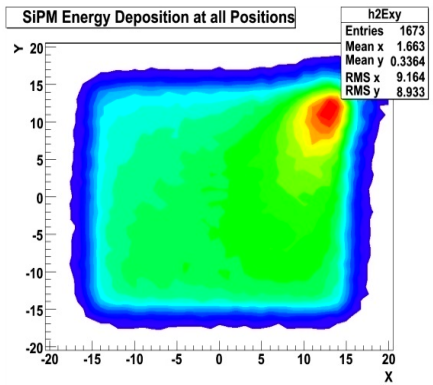
0.49%



2.52%



0.51%



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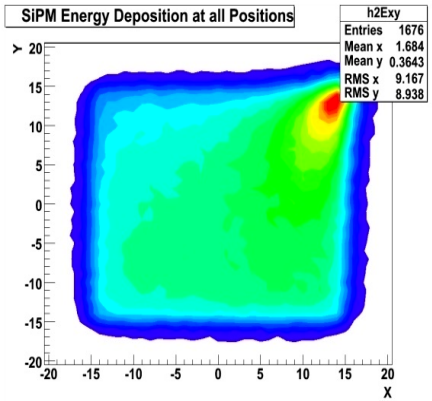

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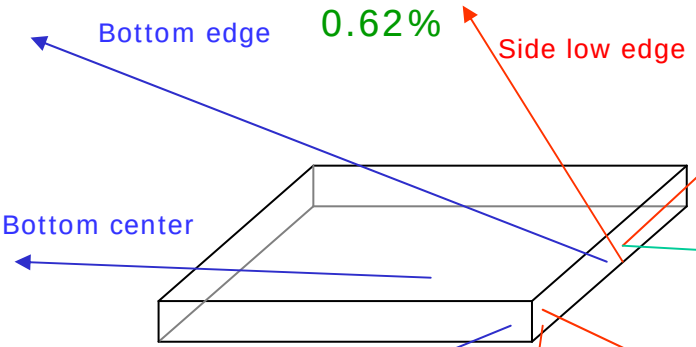
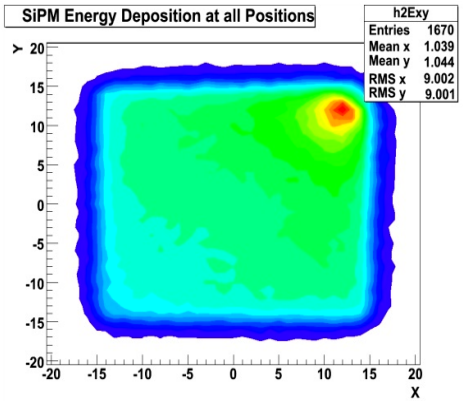
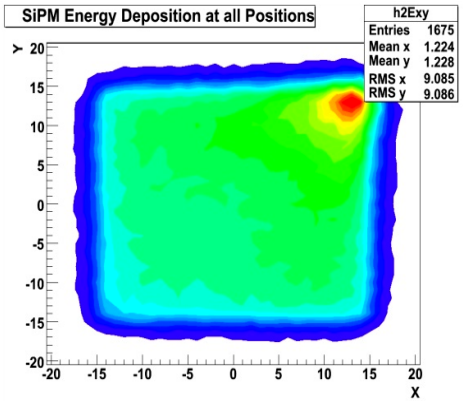


vs Corner Variations



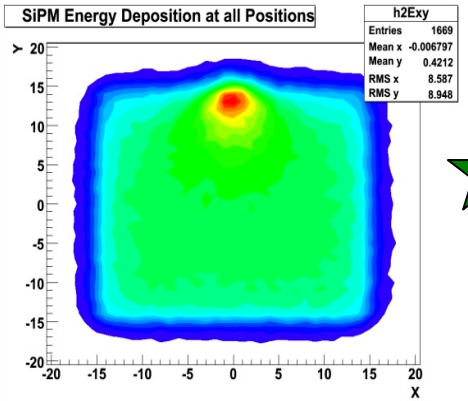
0.65%

Cut 5 mm



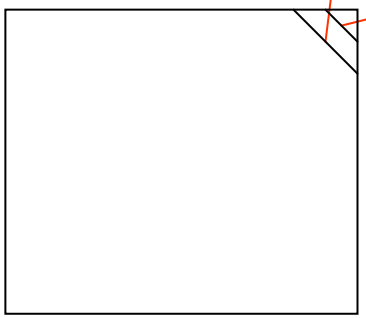
0.65%

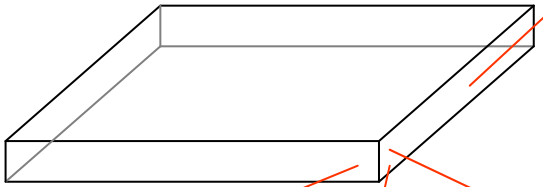
Cut 2 mm



0.62%

Side center

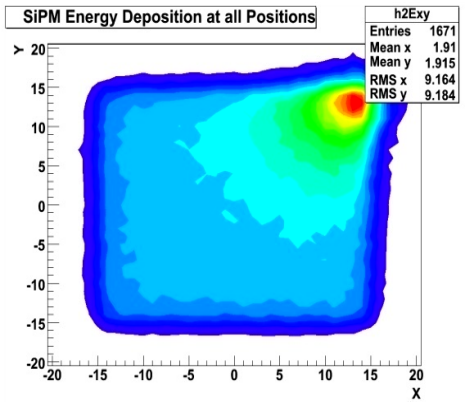




Side edge

Bottom corner

Side corner



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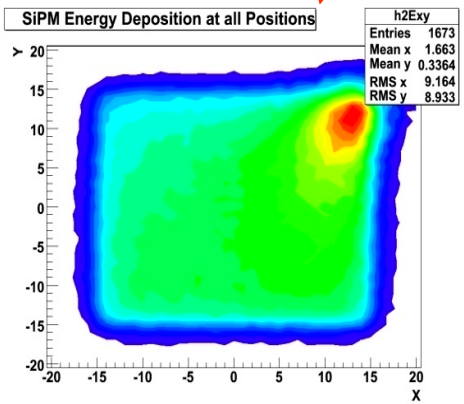

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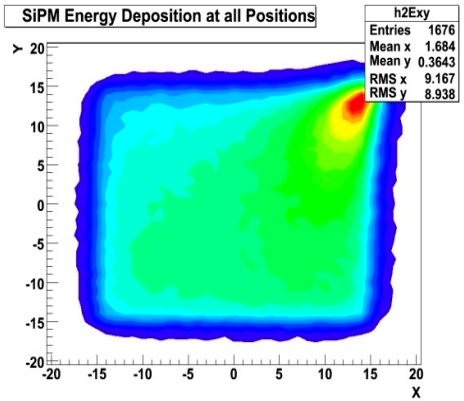

0.62%