Status of MAPS ECAL Simulation

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at Rutherford Appleton Laboratory

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Contents: following up last year's issues
- Minimum range cut effect in small cell cases
- Weighted mean for number of cell hits
- Linearity up to 400 GeV single electron
- B fields effect
- Energy resolution without charge diffusion
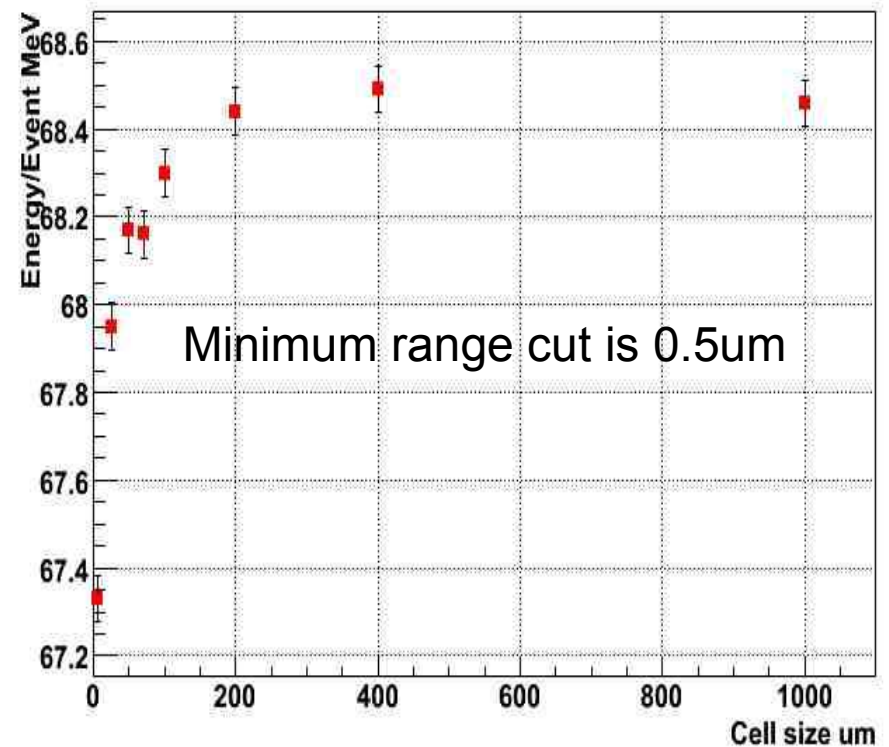- 36&48 contiguous cell hit patterns
- Next steps

Minimum range cut effect

In the steering file:

```
#/Mokka/init/rangeCut 0.005 mm
/Mokka/init/rangeCut 0.0005 mm
#  specifies the production Geant4 range cut
#  [default is 0.005 mm ]
```


Total Energy per event with cell size dependence

Minimum range cut is 5um
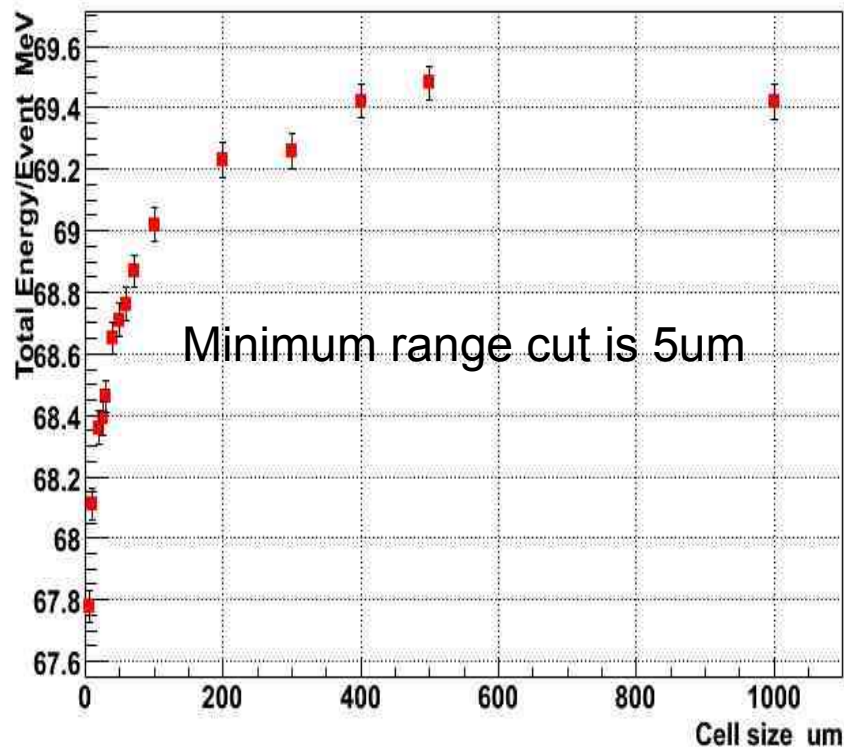
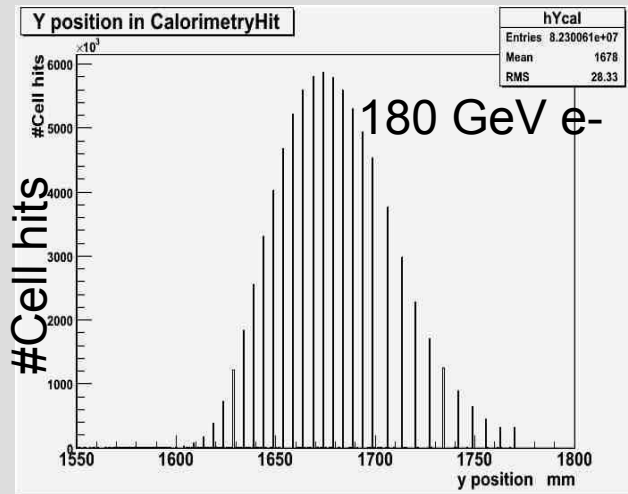Energy/Event with cell size dependence

Minimum range cut is 0.5um
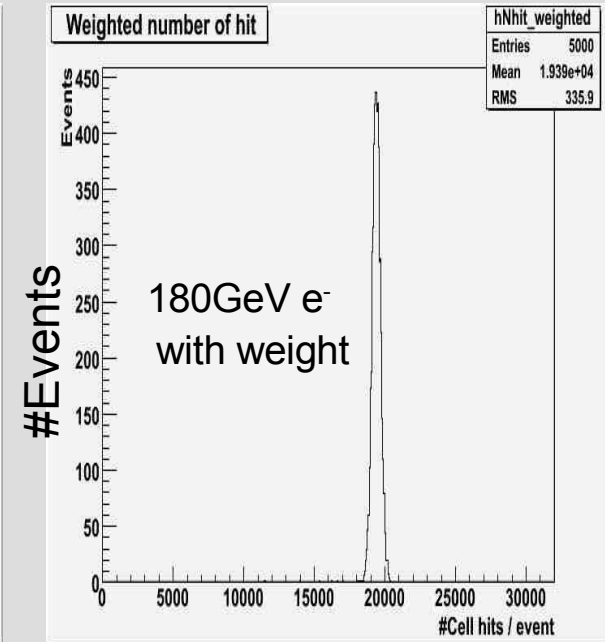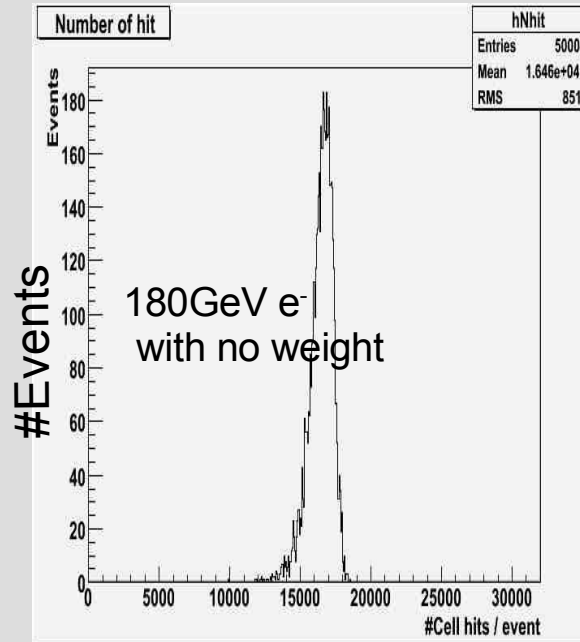
Not yet understood.
Geant4 cell boundary effect ??

Weighted #Cell hits

W thickness: 2.1mm for first 20 layers
4.2mm for last 10 layers

Longitudinal shower shape in 30layers:

$$N_{weight} = \sum_{layer\# =1}^{20} N^{hit} + 2 \sum_{layer\# =21}^{30} N^{hit}$$

180 GeV e-

180GeV e⁻
with no weight

#Cell hits / event

180GeV e⁻
with weight
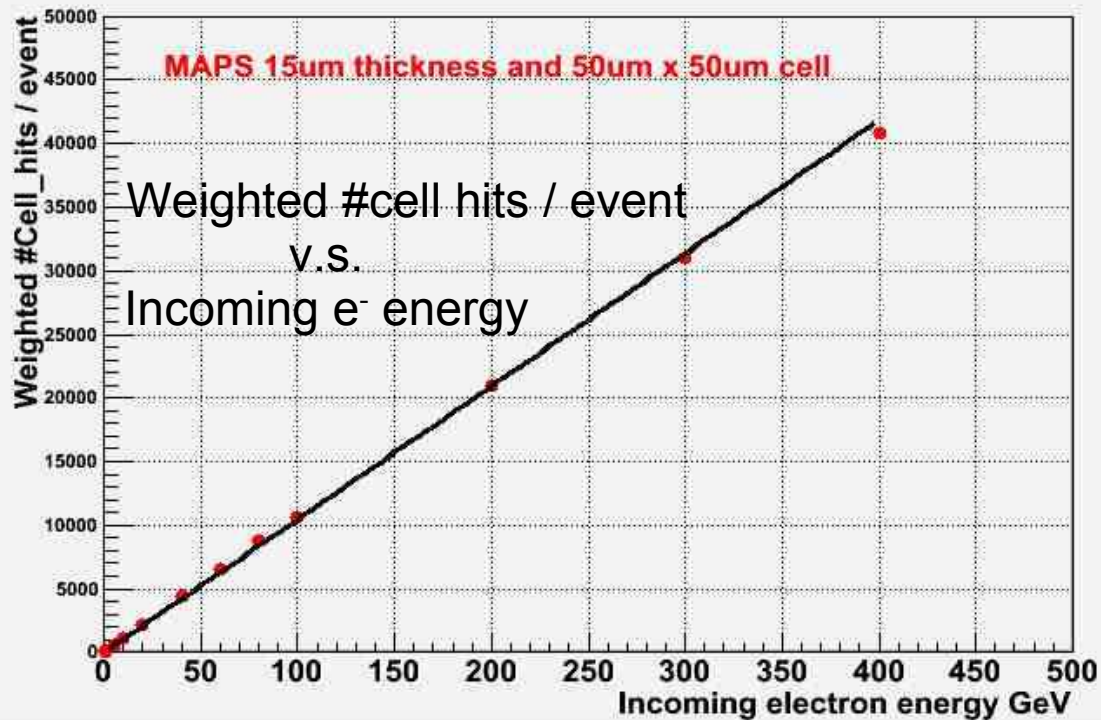
#Cell hits / event

Linearity for #cell hits

- 50μm X 50μm cell size
- B fields is off
- Charge diffusion is not yet added.

MAPS 15um thickness and 50um x 50um cell

Weighted #cell hits / event
v.s.
Incoming e⁻ energy

Linearity for #cell hits

- 50μm X 50μm cell size
- B fields is off
- Charge diffusion is not yet added.

MAPS 15um thickness and 50um x 50um cell

Weighted #cell hits / event
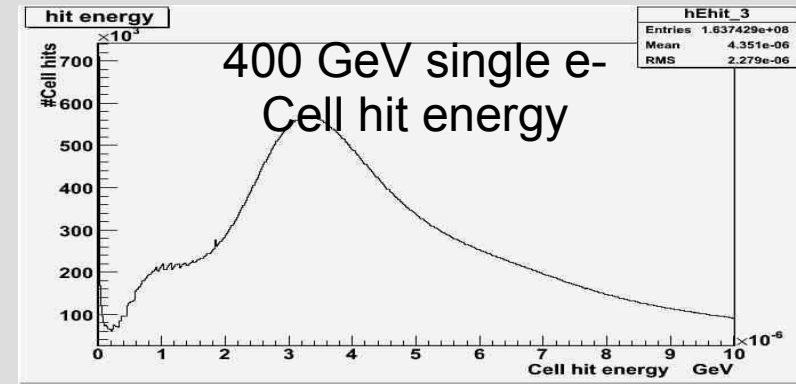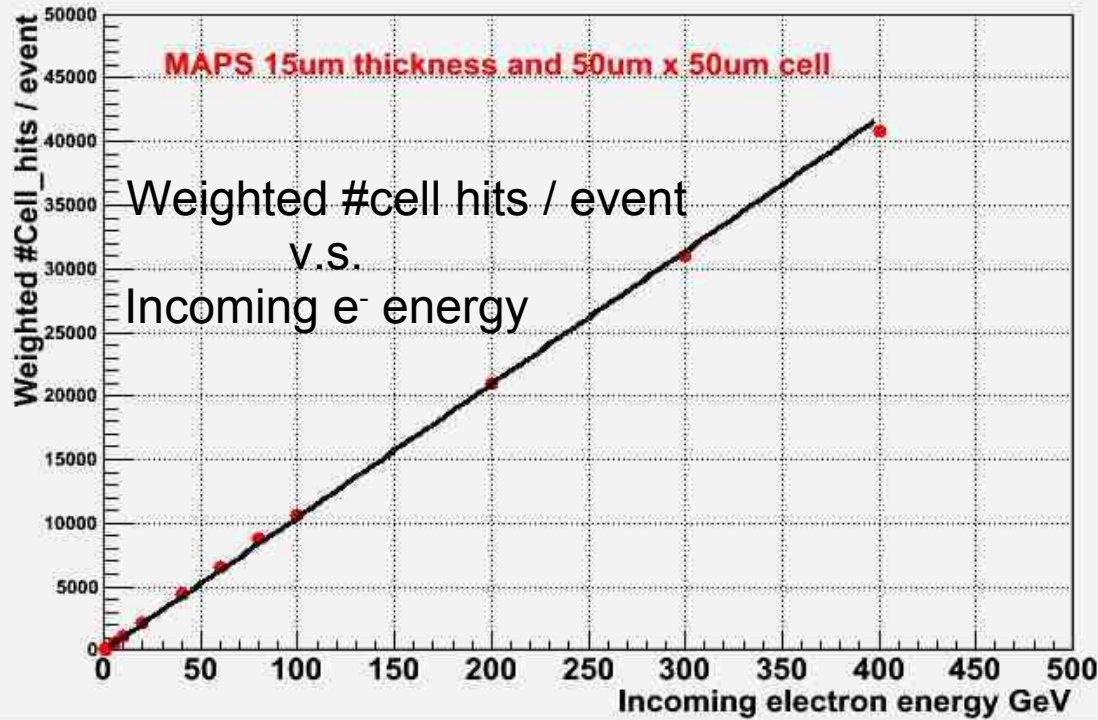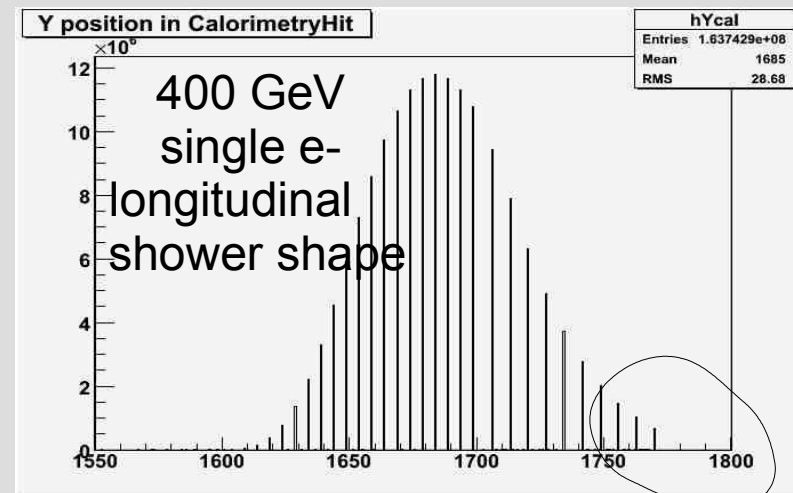v.s.
Incoming e⁻ energy

400 GeV single e-
Cell hit energy

Linearity for #cell hits

- 50μm X 50μm cell size
- B fields is off
- Charge diffusion is not yet added.

Weighted #cell hits / event
v.s.
Incoming e⁻ energy

MAPS 15um thickness and 50um x 50um cell

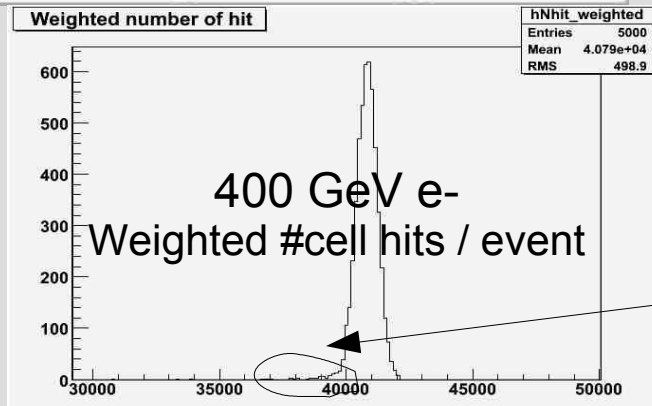400 GeV single e-
Cell hit energy

400 GeV single e- longitudinal shower shape
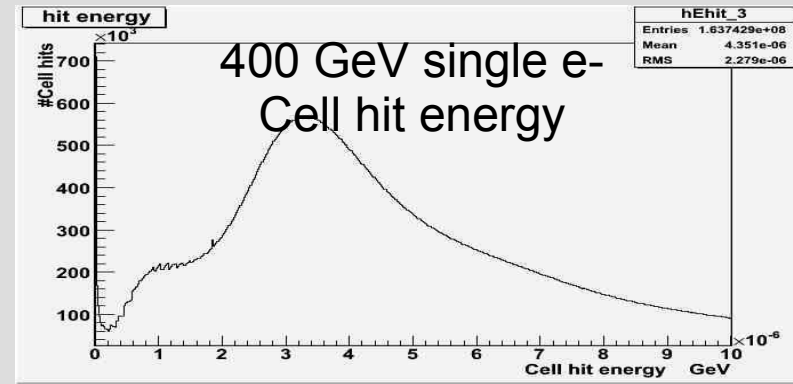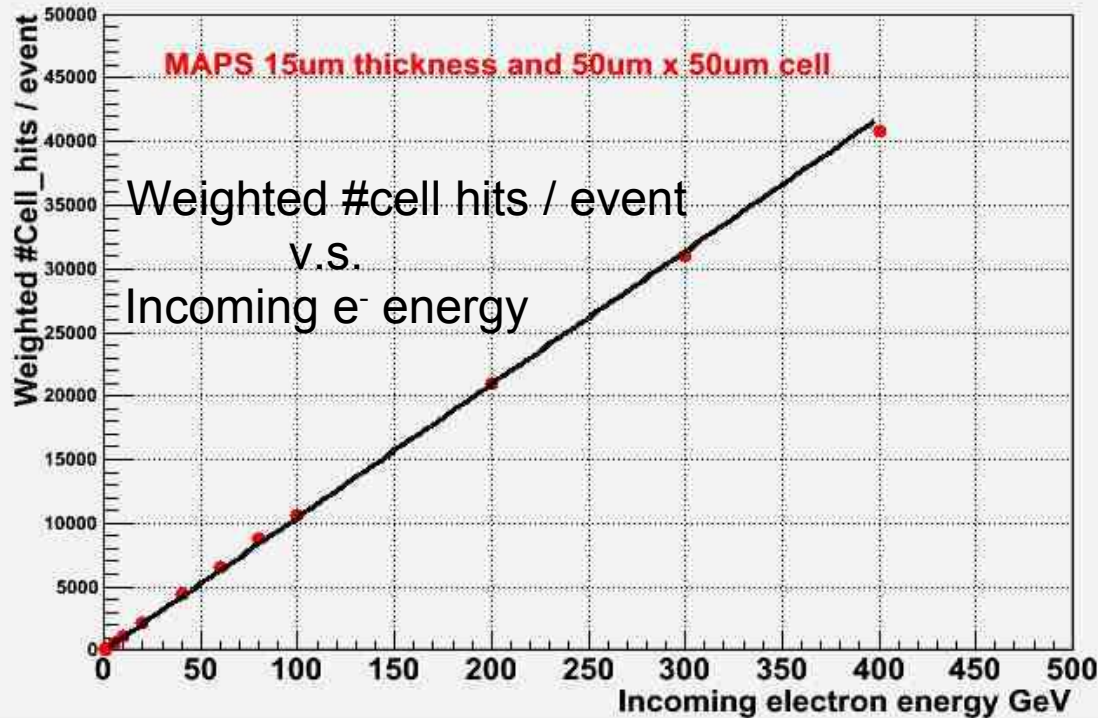
Energy leak

Linearity for #cell hits

- 50μm X 50μm cell size
- B fields is off
- Charge diffusion is not yet added.

MAPS 15um thickness and 50um x 50um cell

Weighted #cell hits / event
v.s.
Incoming e- energy

400 GeV single e-
Cell hit energy

400 GeV single e- longitudinal shower shape

100 GeV e-
Weighted #cell hits / event

400 GeV e-
Weighted #cell hits / event
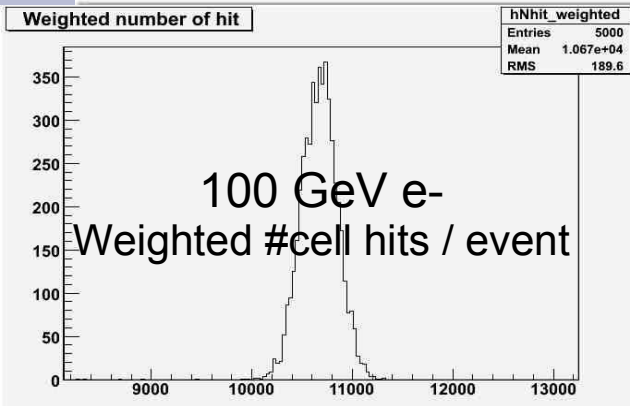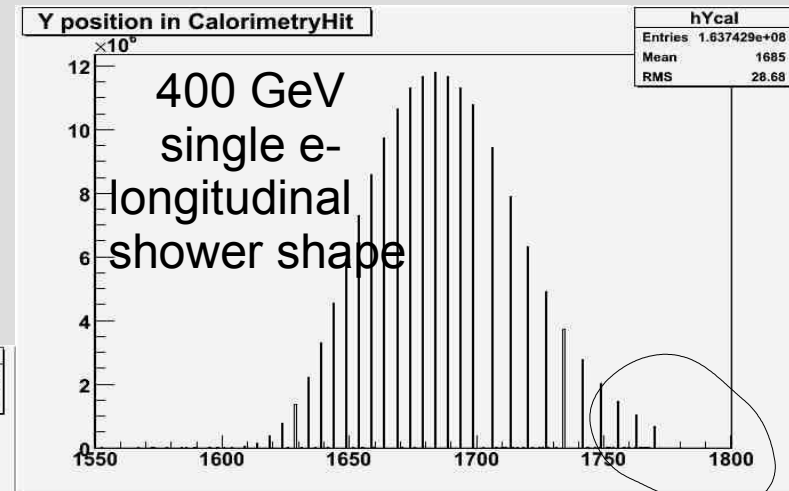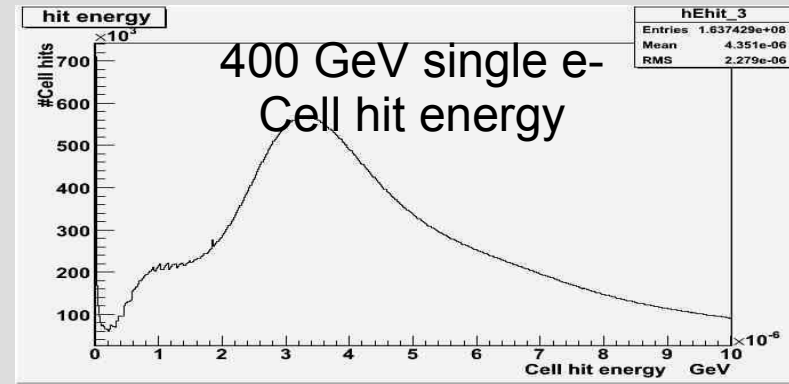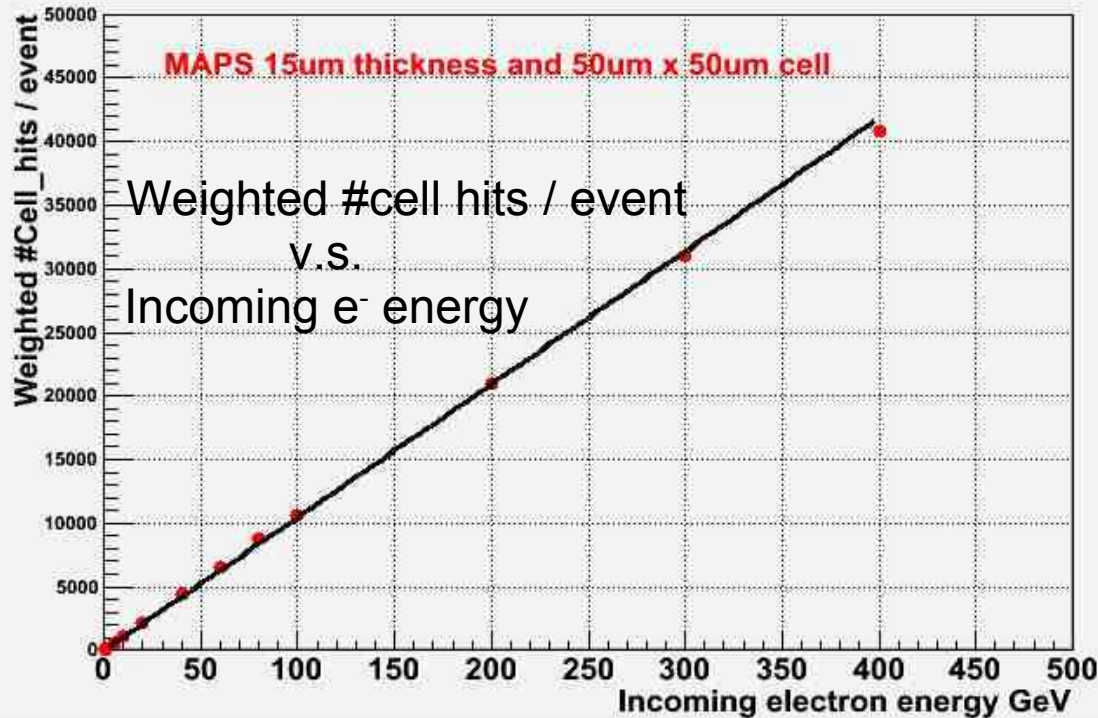
Energy leak

Energy resolution and B field effect (1)

- 50μm X 50μm cell size
- Charge diffusion is not yet added.
- No noise and no threshold

1 GeV electron energy resolutions:

(1) With no B field and starting the e⁻ from IP: σ/Mean = 14.6/109.6 = (13.3 ± 0.2)%

(2) With no B field and starting the e⁻ right in front of the ECAL: σ/Mean = 14.6/110.4 = (13.3 ± 0.2)%

#Events

Weighted number of hit

hNhit_weighted	
Entries	5000
Mean	109.6
RMS	15.43

(1) 1 GeV e⁻ starting from IP with no B field

σ/Mean = (13.3 ±0.2)%

#Cell hits / event

Weighted number of hit

hNhit_weighted	
Entries	5000
Mean	110.2
RMS	15.15

(2) 1 GeV e- starting in front of ECAL with no B fields

σ/Mean = (13.3 ±0.2)%

#Cell hits / event

#Cell hits

hit energy

hEhit_3	
Entries	536282
Mean	4.235e-06
RMS	2.206e-06

(1) 1 GeV e- starting from IP with no B field

Cell hits energy GeV

0   10keV

hit energy

hEhit_3	
Entries	539200
Mean	4.242e-06
RMS	2.21e-06

(2) 1 GeV e- starting in front of ECAL with no B fields

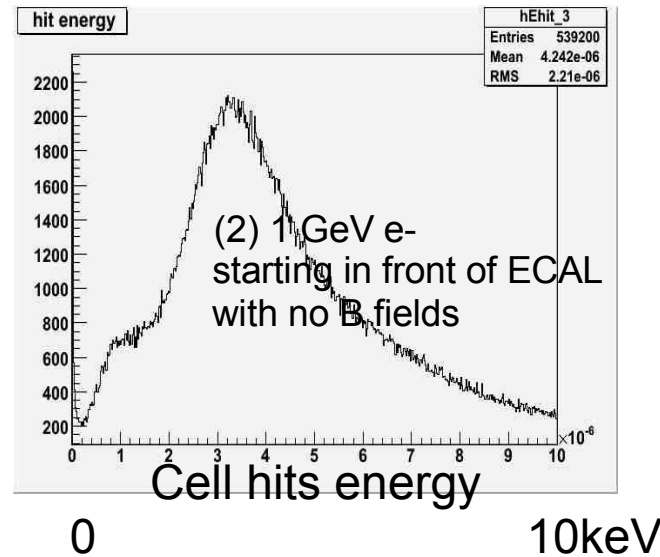Cell hits energy
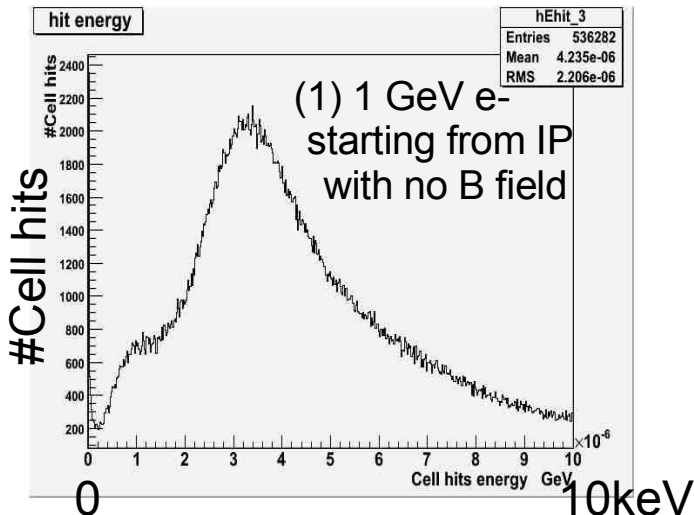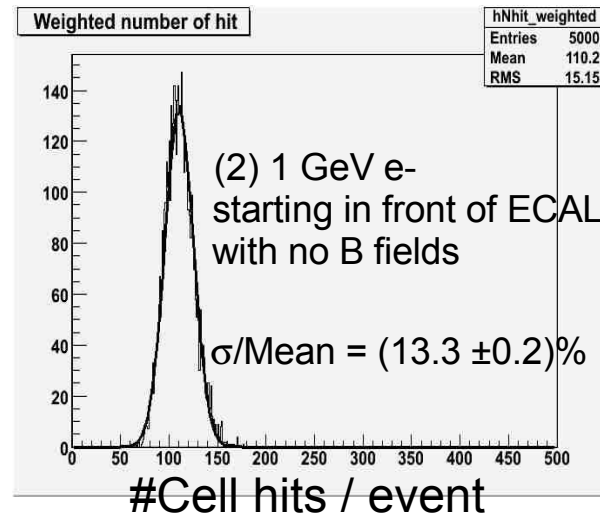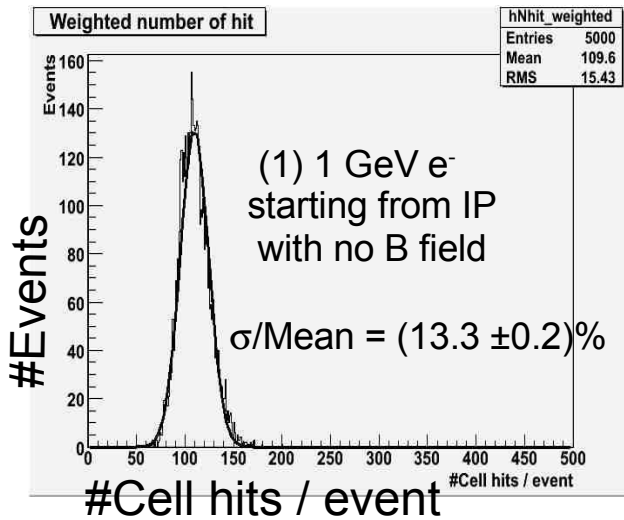
0   10keV

Energy resolution and B field effect (2)

- 50μm X 50μm cell size
- Charge diffusion is not yet added.
- No noise and no thresholds

1 GeV electron energy resolutions:

(1) With no B field and starting the e⁻ from IP: σ/Mean = 14.6/109.6 = (13.3 ± 0.2)%

(2) With no B field and starting the e⁻ right in front of the ECAL: σ/Mean = 14.6/110.4 = (13.3 ± 0.2)%

(3) With 4T B field and starting the e⁻ right in front of the ECAL: σ/Mean = 16.0/112.0 = (14.3 ± 0.2)%
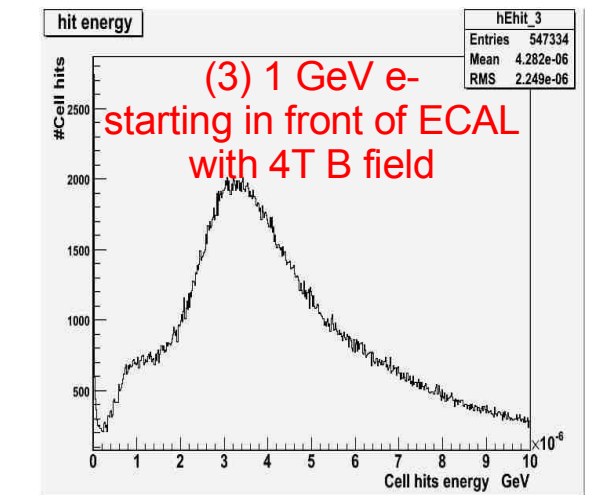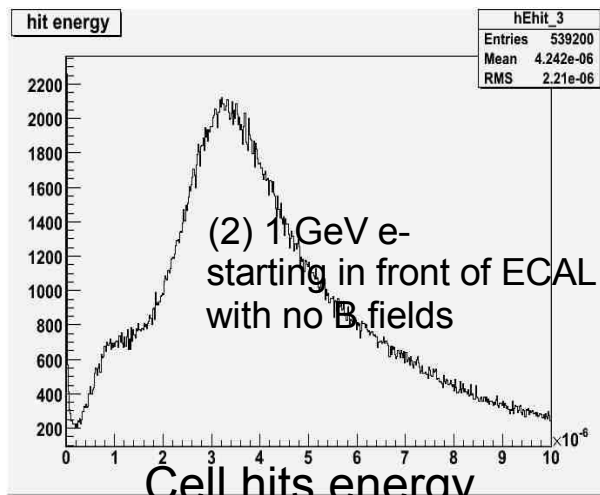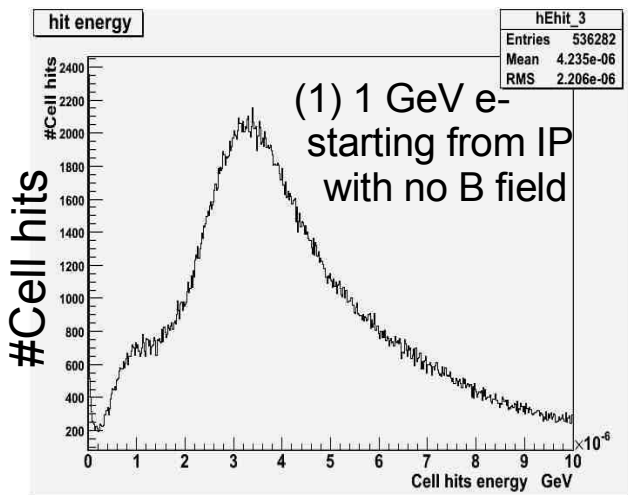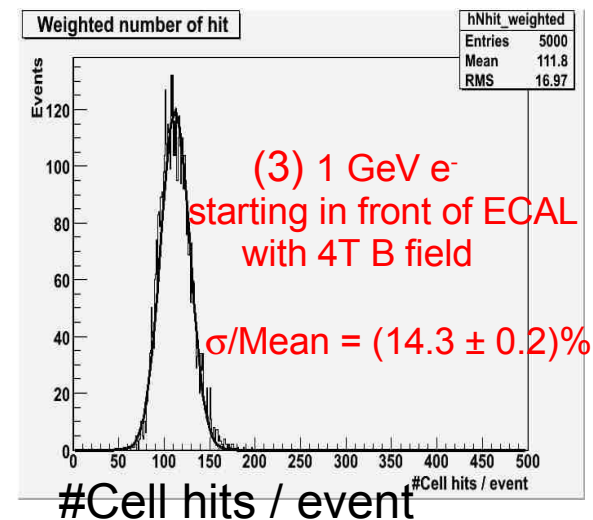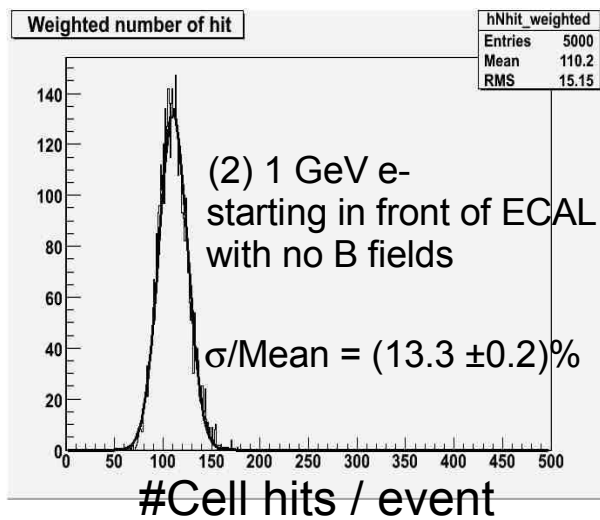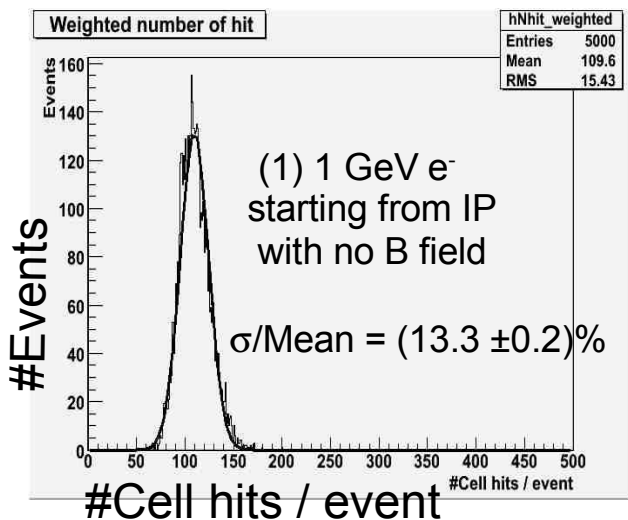
Very preliminary energy resolution

- Single electron
- B field is off

⁃ Counting number of cell hits in earn event without clustering. (i.e. It includes hits of radiated photons.)
⁃ Weighted number of cell hits is used for different W thickness layers.
⁃ Charge diffusion is not yet added. (Adding charge diffusion is essential to confirm whether only one hit per cell after diffusion.)
⁃ No threshold is applied. (Almost the same cell hit energy distribution means almost the same efficiency for threshold applying -> The linearity could be represented again after threshold)
⁃ No noise is applied. (It will be small effect after threshold application.)
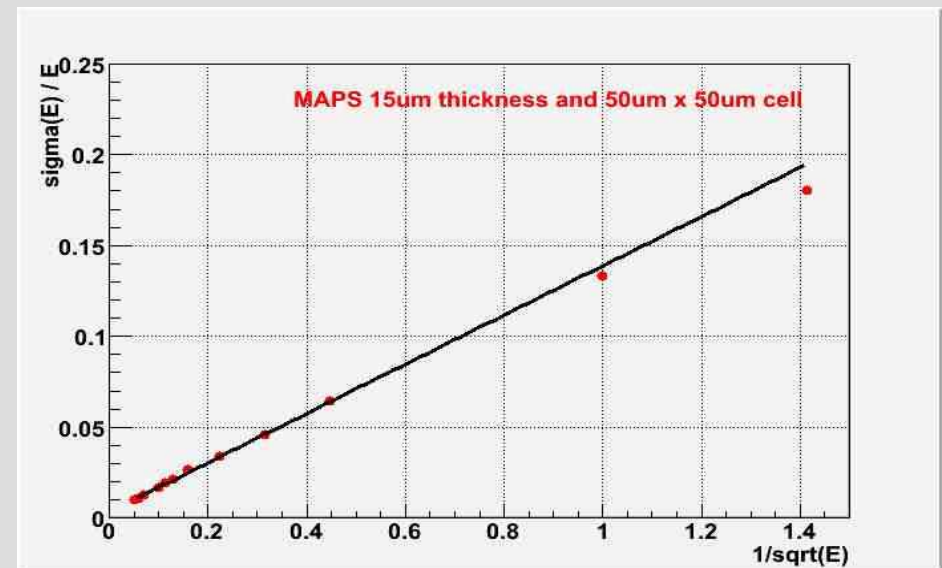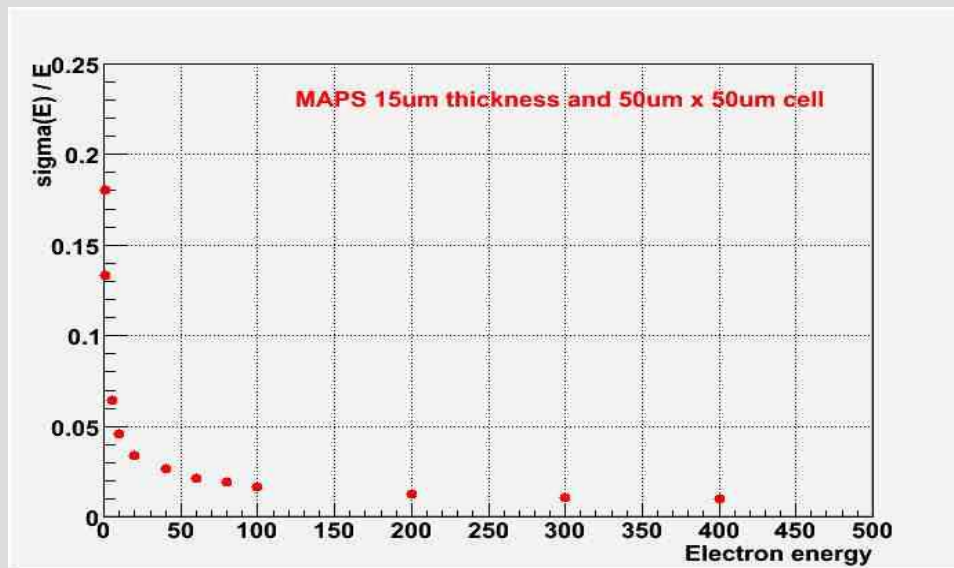
Fitting: $\sigma / E = (13.5\pm0.2)\% / \sqrt{E} + (0.35\pm0.02)\%$

E with Ge and using up to 400 GeV.

36 or 48 contiguous cell (in z direction) hit patterns

- 50μm X 50μm cell size
- B fields is off
- Charge diffusion is not yet added.

Number of hits in 36 contigous z cells

HNumber_36cells	
Entries	758
Mean	1.166
RMS	0.475

36 contiguous cells,
1 GeV e-
Average: (1.17 +/- 0.06) hits
Energy increase ~15%

Number of hits in 48 contigous z cells

HNumber_48cells	
Entries	758
Mean	1.166
RMS	0.4723

48 contiguous cells,
1 GeV e-
Average: (1.17 +/- 0.06) hits
Energy increase ~ 15%

36 or 48 contiguous cell (in z direction) hit patterns

- 50μm X 50μm cell size
- B fields is off
- Charge diffusion is not yet added.

Number of hits in 36 contigous z cells

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Energy increase ~15%

Number of hits in 48 contigous z cells

HNumber_48cells	
Entries	758
Mean	1.166
RMS	0.4723

48 contiguous cells,
1 GeV e-
Average: (1.17 +/- 0.06) hits
Energy increase ~ 15%

Number of hits in 36 contigous z cells

HNumber_36cells	
Entries	59099
Mean	1.451
RMS	0.9378

36 contiguous cells,
100 GeV e-
Average: (1.45 +/- 0.01) hits
Energy increase ~ 45%

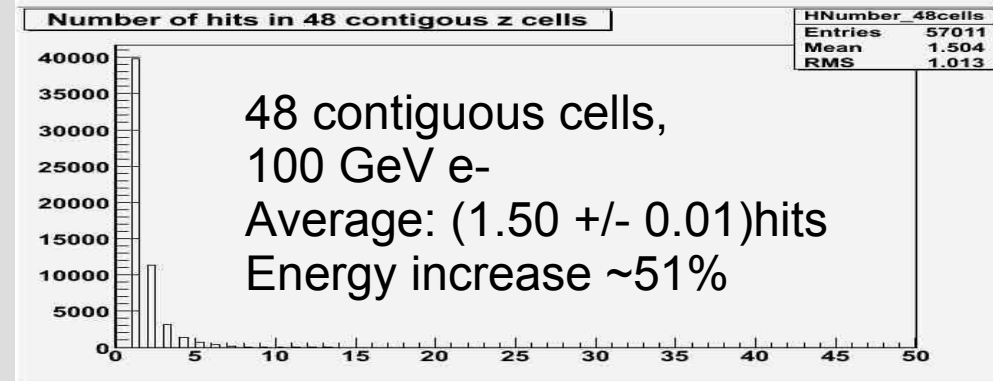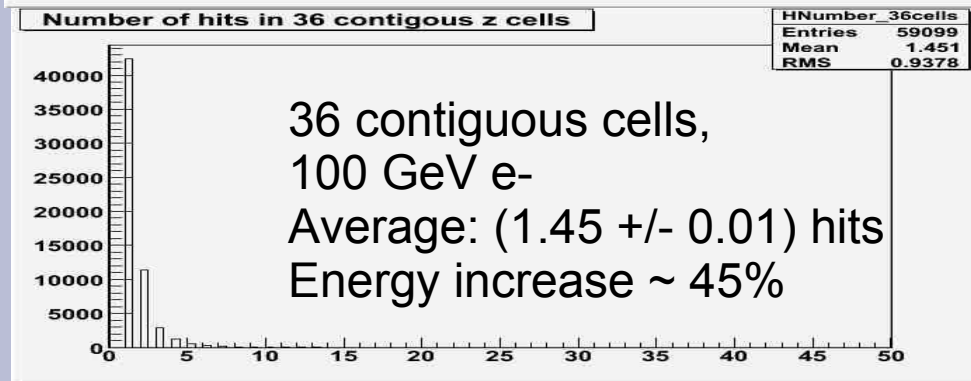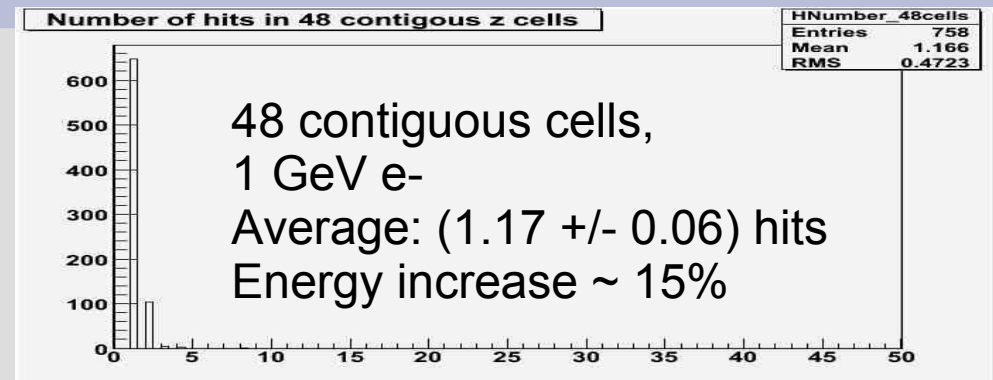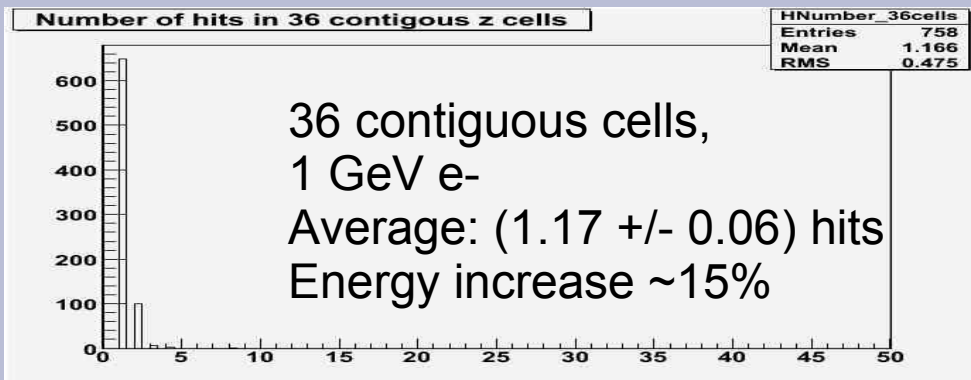**Number of hits in 48 contigous z cells**

HNumber_48cells	
Entries	57011
Mean	1.504
RMS	1.013

48 contiguous cells,
100 GeV e-
Average: (1.50 +/- 0.01)hits
Energy increase ~51%

Number of hits in 36 contigous z cells

HNumber_36cells	
Entries	162260
Mean	1.795
RMS	1.704

36 contiguous cells,
400 GeV e-
Average: (1.80 +/- 0.01) hits
Energy increase ~ 80%

Number of hits in 48 contigous z cells

HNumber_48cells	
Entries	152332
Mean	1.912
RMS	1.912

48 contiguous cells,
400 GeV e-
Average: (1.91 +/- 0.01) hits
Energy increase ~ 92%

- 36 and 48 has similar hit pattern -> Cell hits position will be close inside contiguous lines.
- Average hit and energy increase ratio is similar. -> It will not be charge sharing hits but will be normal hits.

Next steps

- Using dead area implementation
- Using Anne-Marie's codes for charge sharing compensation and charge diffusion compensation.
- Energy/Angle/Position resolutions
  - Comparison between analogue v.s. digital
  - Devoting on a clustering algorithm development
    - e.g. Requiring high density with cylinder based topology