Status of MAPS ECAL clustering

CALICE-UK meeting

27th March, 2007

at Imperial College, London

Yoshinari Mikami

University of Birmingham

On behalf of MAPS ECAL group

Outlines:

- **Feasibility studies before clustering**
- **MAPS ECAL primary electron clustering algorithm**
- **Energy resolution after clustering**
- **Summary and next steps**

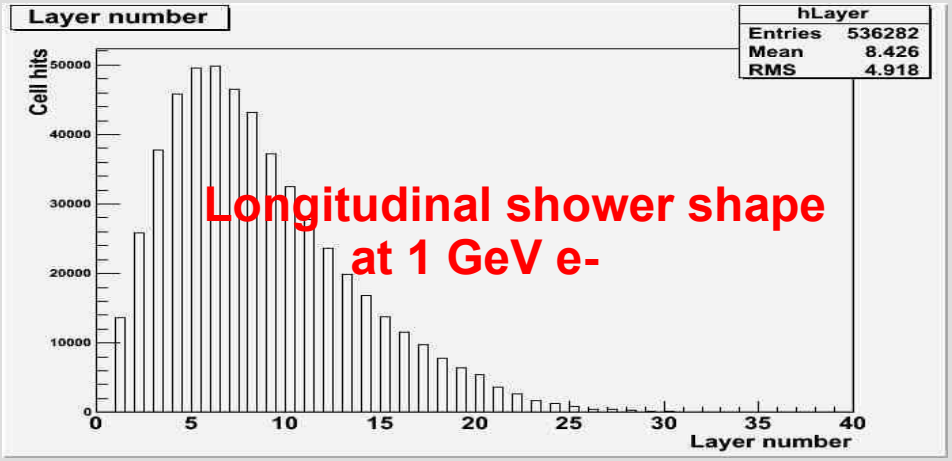
Introduction

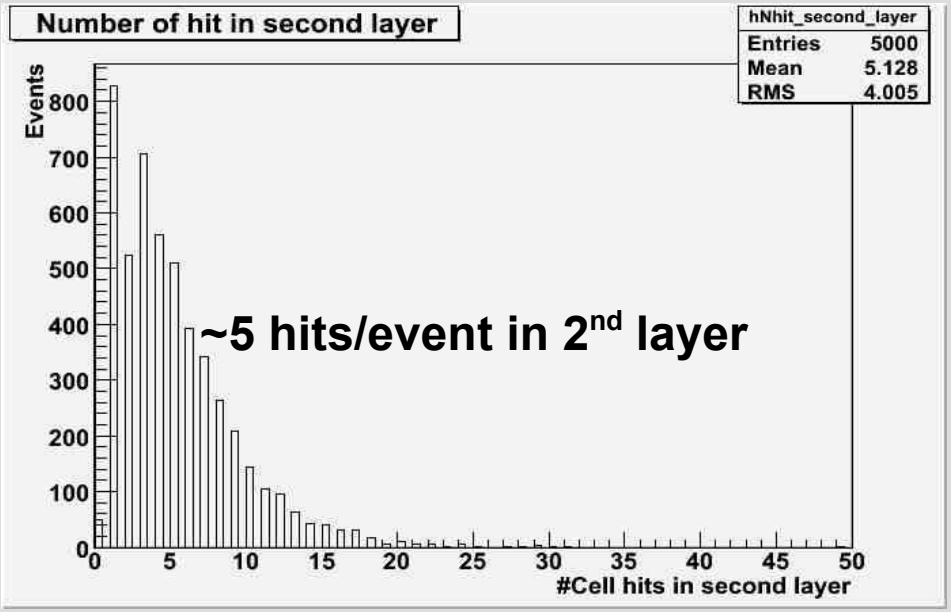
1. Clustering algorithm development of primary electron for MAPS ECAL which has many cell hits in each event. -> **Roughly 100 hits per GeV of electron shower with 50umX50um cell size case**

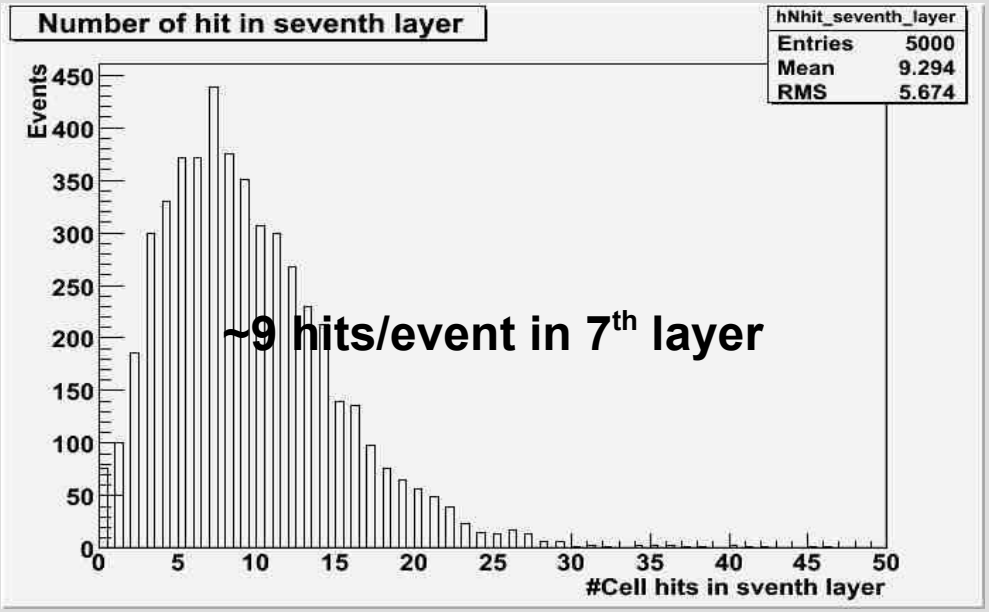
2. First trial of MAPS clustering R&D (all shown here are very preliminary studies)

Feasibility study: Number of hits in each layer at 1 GeV electron

1. **Objective is enough high efficiency at 1 GeV electron.**





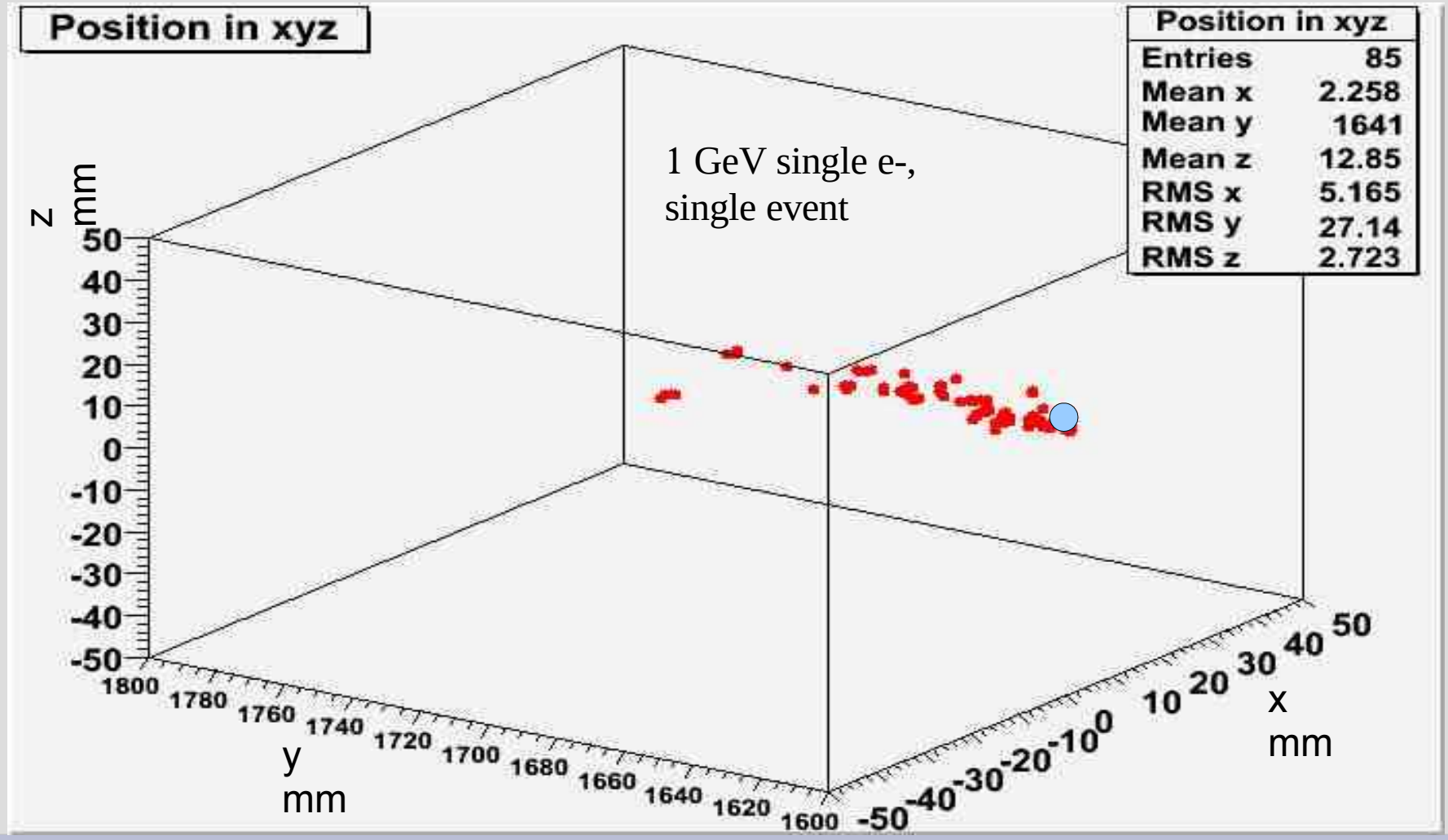


Base line of clustering algorithm

1. **Finding initial group of hits within one of inner layers.**
   - **Requiring several hits are within circle of mm order radius.**
2. **Deciding direction of cluster : Searching hits in outer layers which has located within hemisphere from initial hit. -> From the centre of gravity in the initial grouping within inner layer to the centre of gravity in the hemisphere.**
3. **Adding all hits in 30 layers within cylinder of Moliere radius order.**

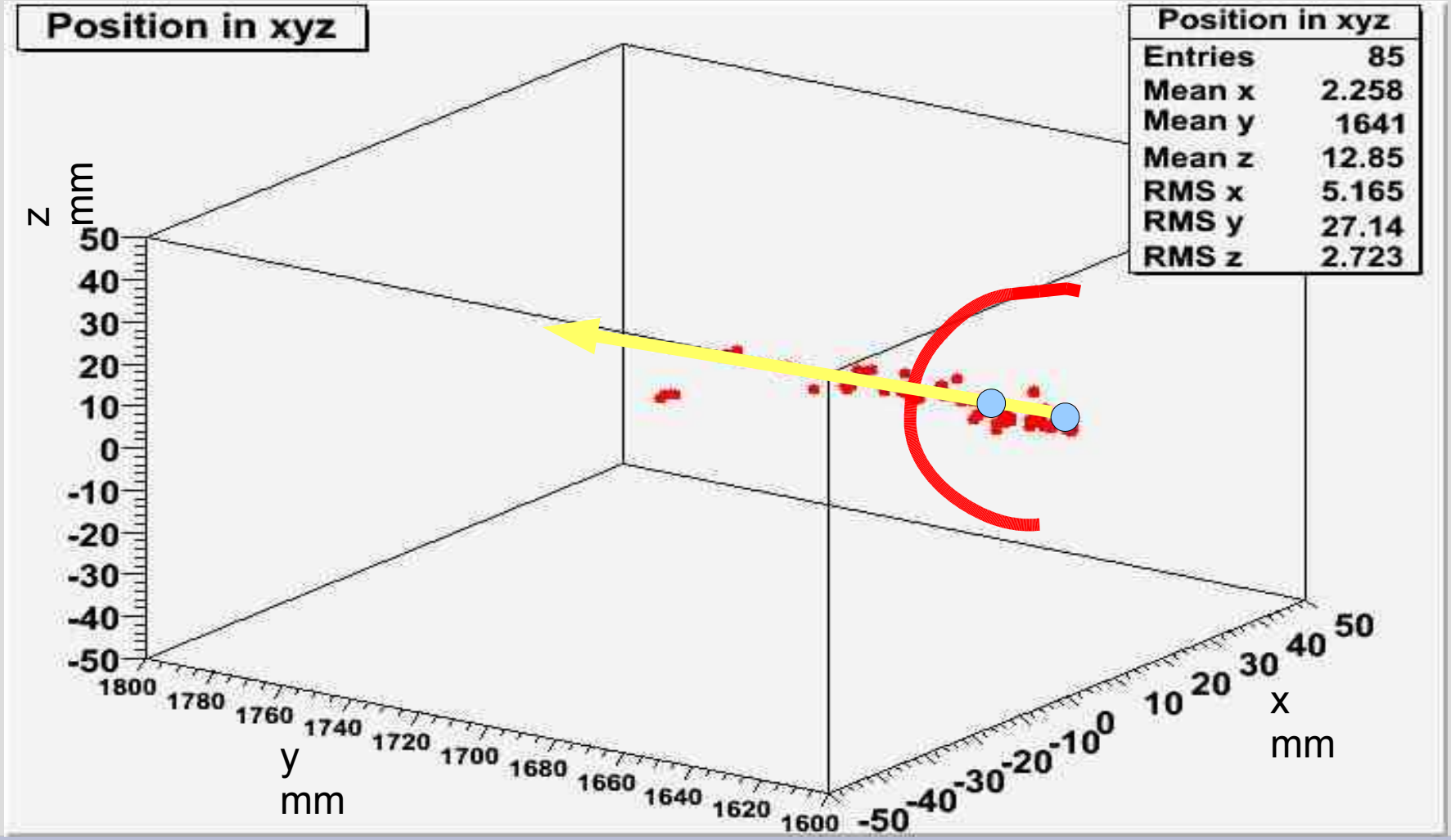
Clustering algorithm (1.1)

1. **Finding initial group of hits within one of inner layers.**
   - → **Requiring several hits are within circle of mm order radius.**



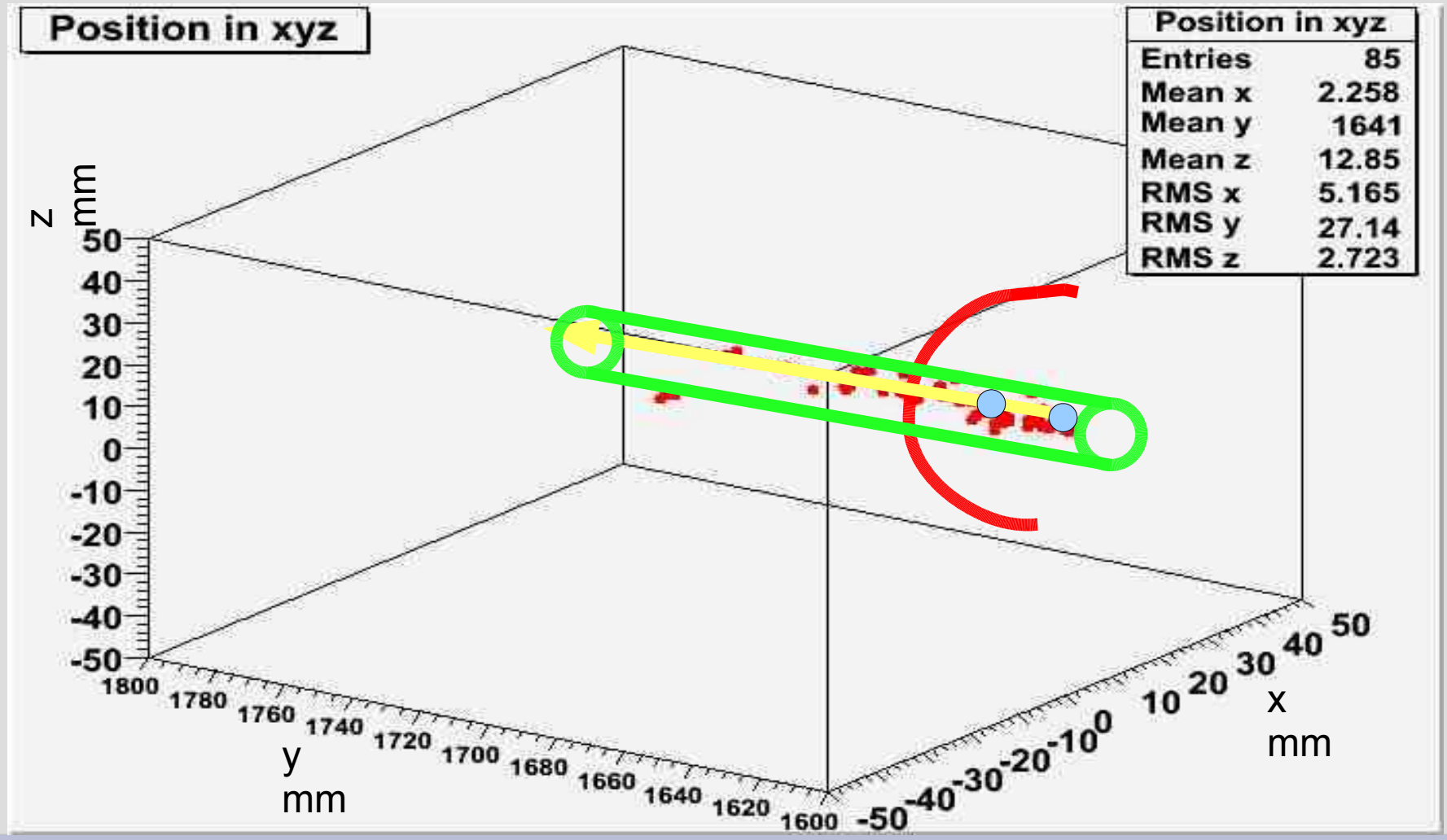
Clustering algorithm (1.2)

2. Deciding direction of cluster : Searching hits in outer layers which has located within hemisphere from initial hit. -> From the centre of gravity in the initial grouping within inner layer to the centre of gravity in the hemisphere.



Clustering algorithm (1.3)

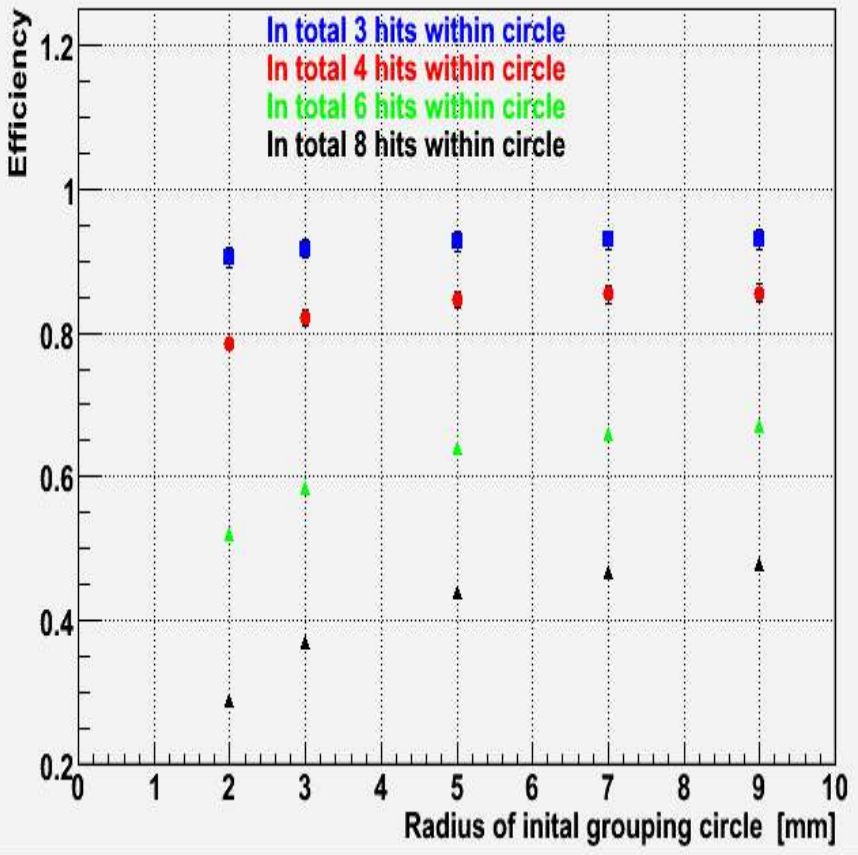
3. **Adding all hits in 30 layers within cylinder of Moliere radius order.**



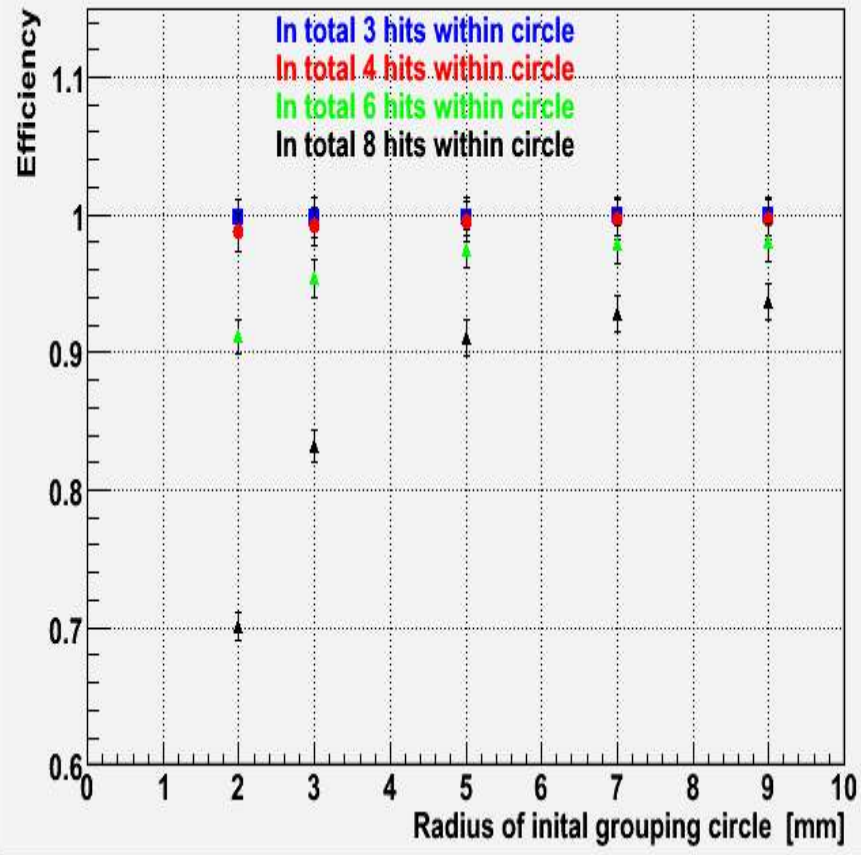
Efficiency of clustering (1);
(With initial grouping radius dependence and with #hits dependence)

Efficiency = #Event which have hits grouping within one of inner layers / #Events of all generated single e-
(Grouping was done within the same layer. No threshold and no noise are applied.)

1 GeV single e- using inner three layers



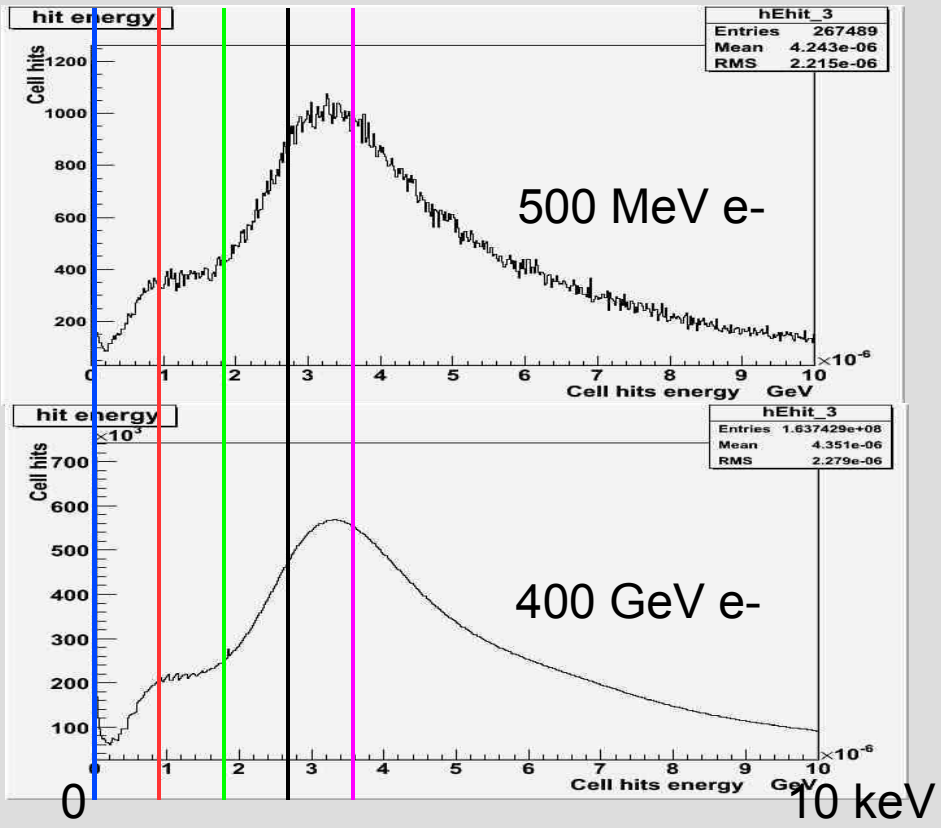
1 GeV single e- using inner seven layers

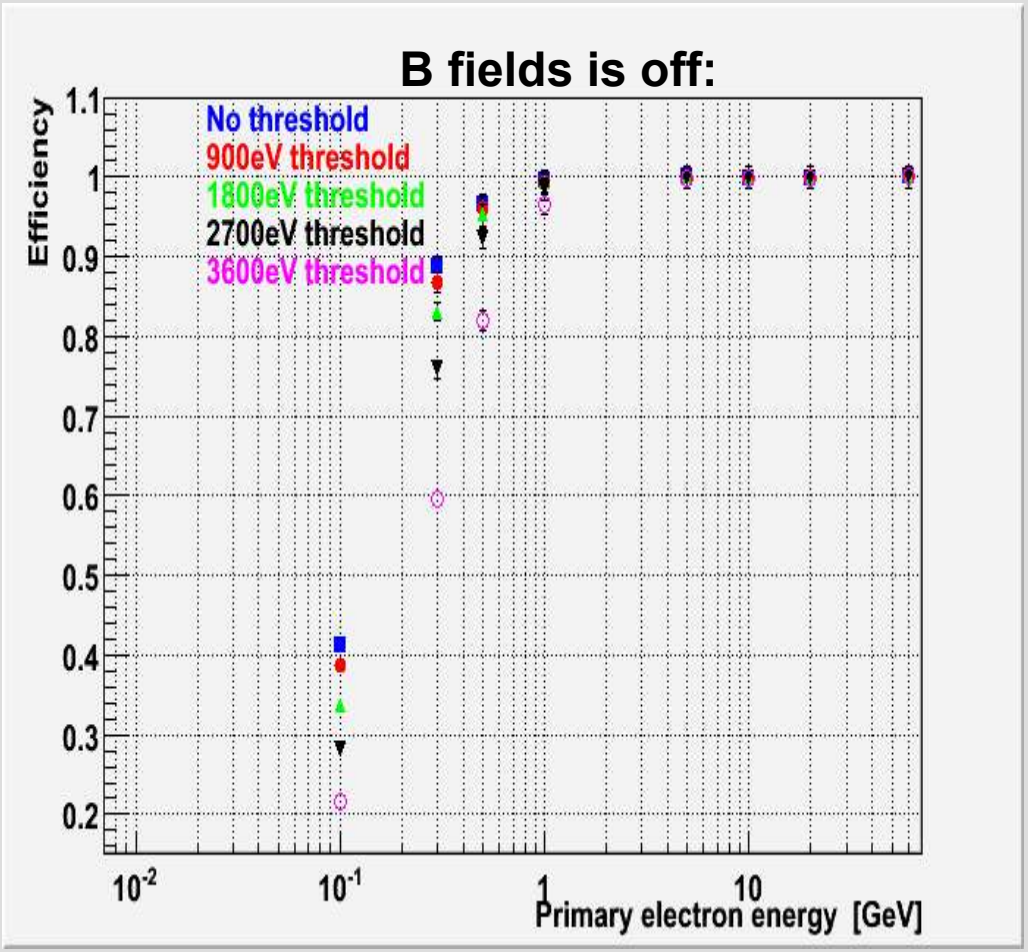


Efficiency of clustering (2);

(With cell hits energy threshold dependence and with primary electron's energy dependence)

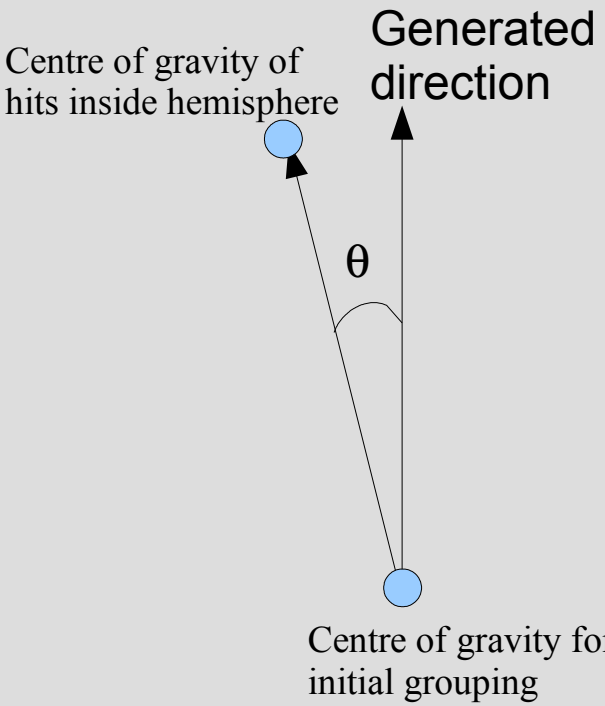
1. **Finding initial grouping of hits within one of inner 7 layers.**
   - **More than total 4 hits are within circle of 5.0 mm radius.**
   - **Applying threshold for all 4 hits**

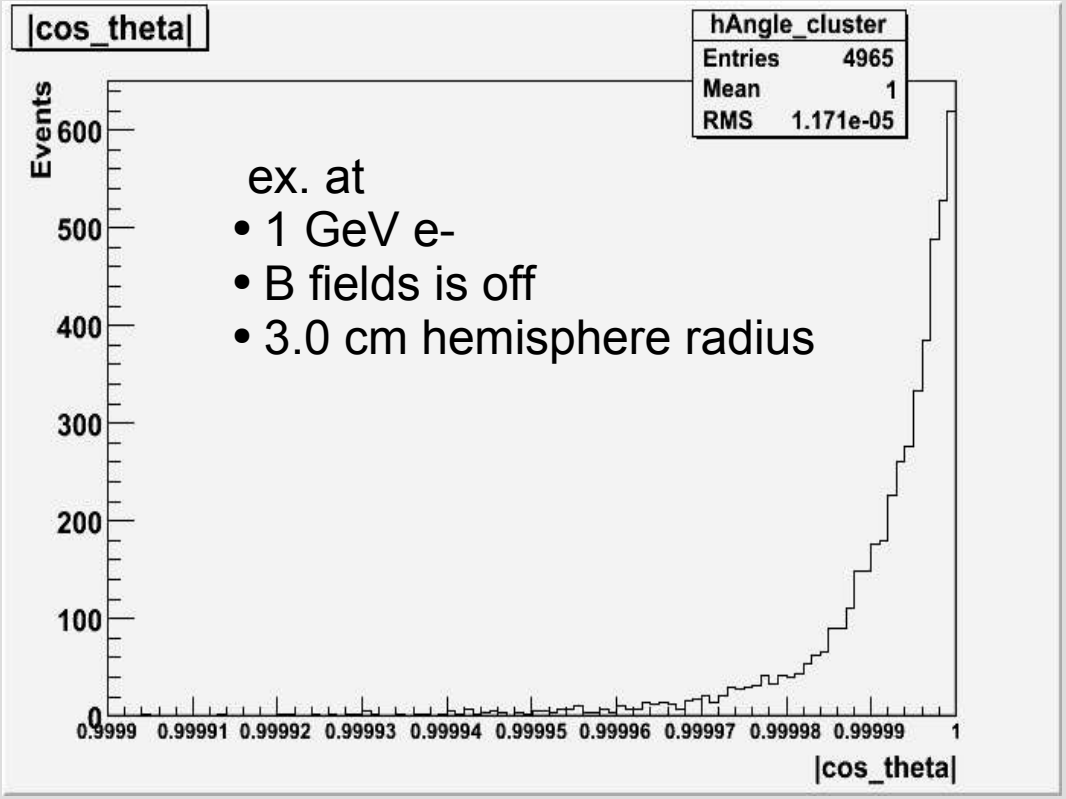




Cluster direction

2. Deciding direction of cluster : -> From the centre of gravity in the initial grouping within inner layer to the centre of gravity in the hemisphere.





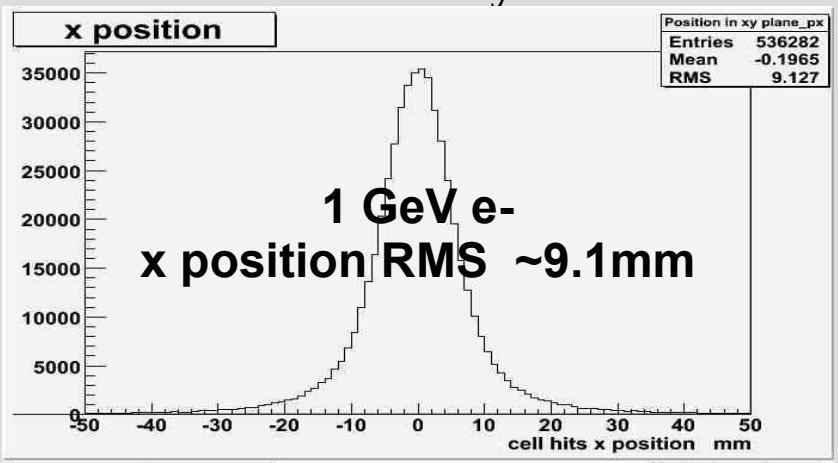
- **Hemisphere radius have to be optimized with physics events. (In order to avoid merging two neighbour clusters)**
- **Direction is affected significantly by B fields effect for low energy case.**

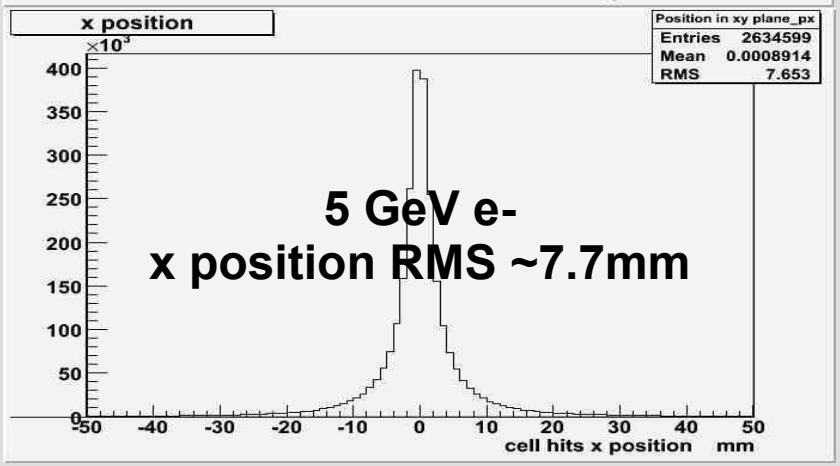
-> Temporarily clustering hemisphere radius is using 3.0 cm.

Shower spread & Efficiency of cell hits with clustering

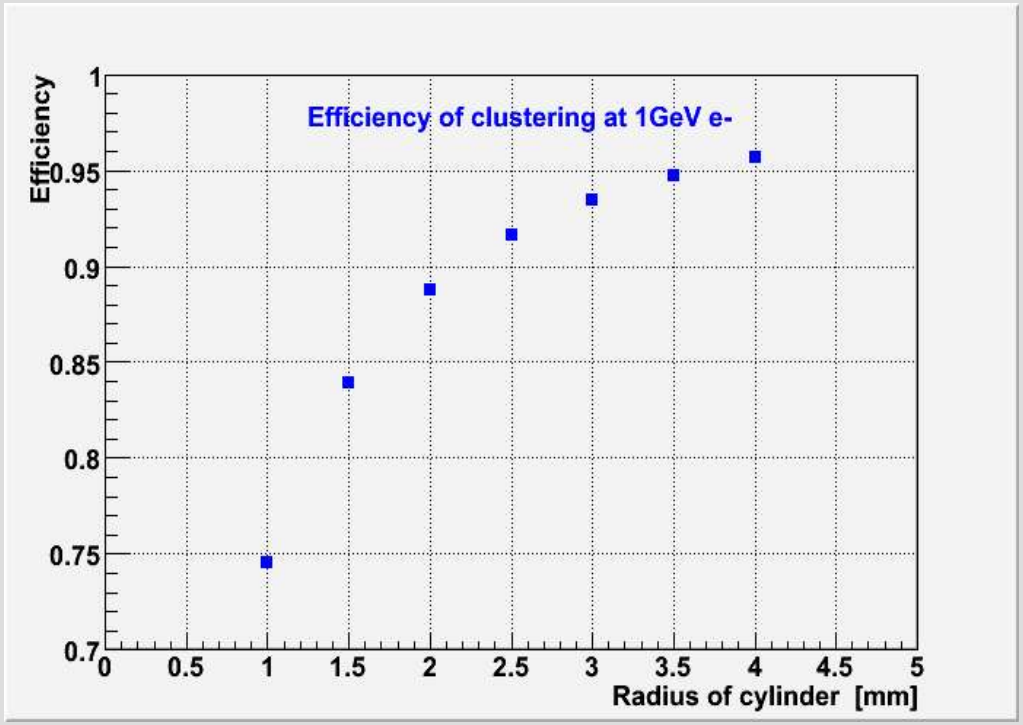
Sower spread distributions:

- B fields is off
- Electron is injected from IP to zenith
- All cell hits without any criteria





Efficiency = #Cell hits inside cylinder / All #cell hits in event (With 1800eV energy threshold for both case.)



- Cylinder radius have to be optimized with physics events. (In order to avoid merging two neighbour clusters)
  -> Temporarily clustering cylinder radius is 2.0 cm.

Tentative clustering criteria

Tentative clustering criteria (red variables need be optimized):

0. Applying 1800 eV (half of MIP peak) threshold for all cell hits energy

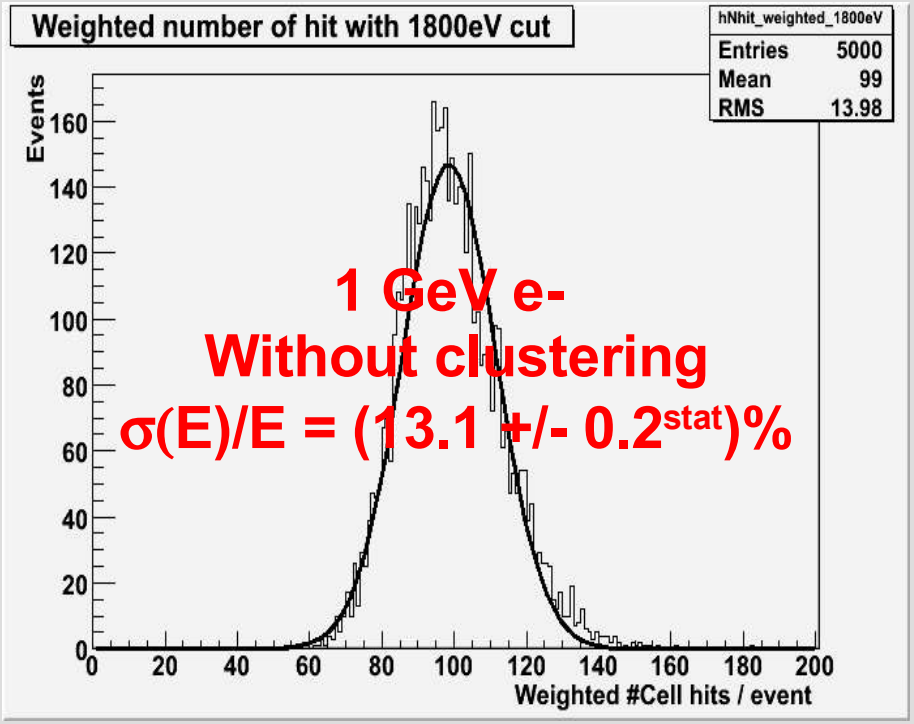
1. Finding initial group of hits within one of inner 7 layers.

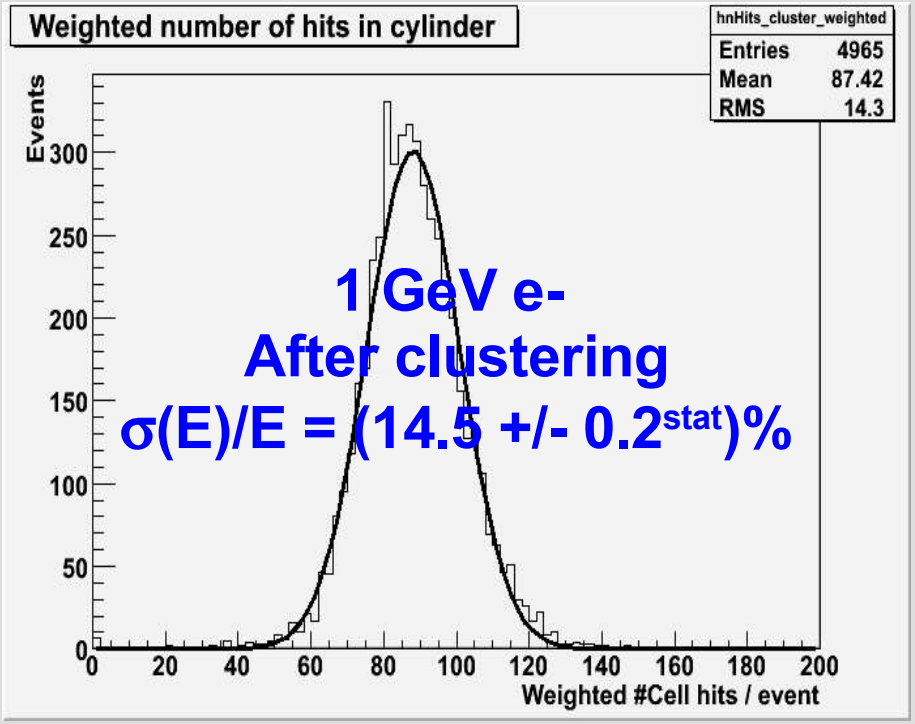
- **Requiring more than total 4 hits are within circle of 5.0 mm radius.**

2. Deciding direction with using hits which has located within 3.0 cm hemisphere from initial hits.

3. Adding all hits in 30 layers within cylinder of 2.0 cm radius.

Energy resolution after clustering at 1 GeV e-

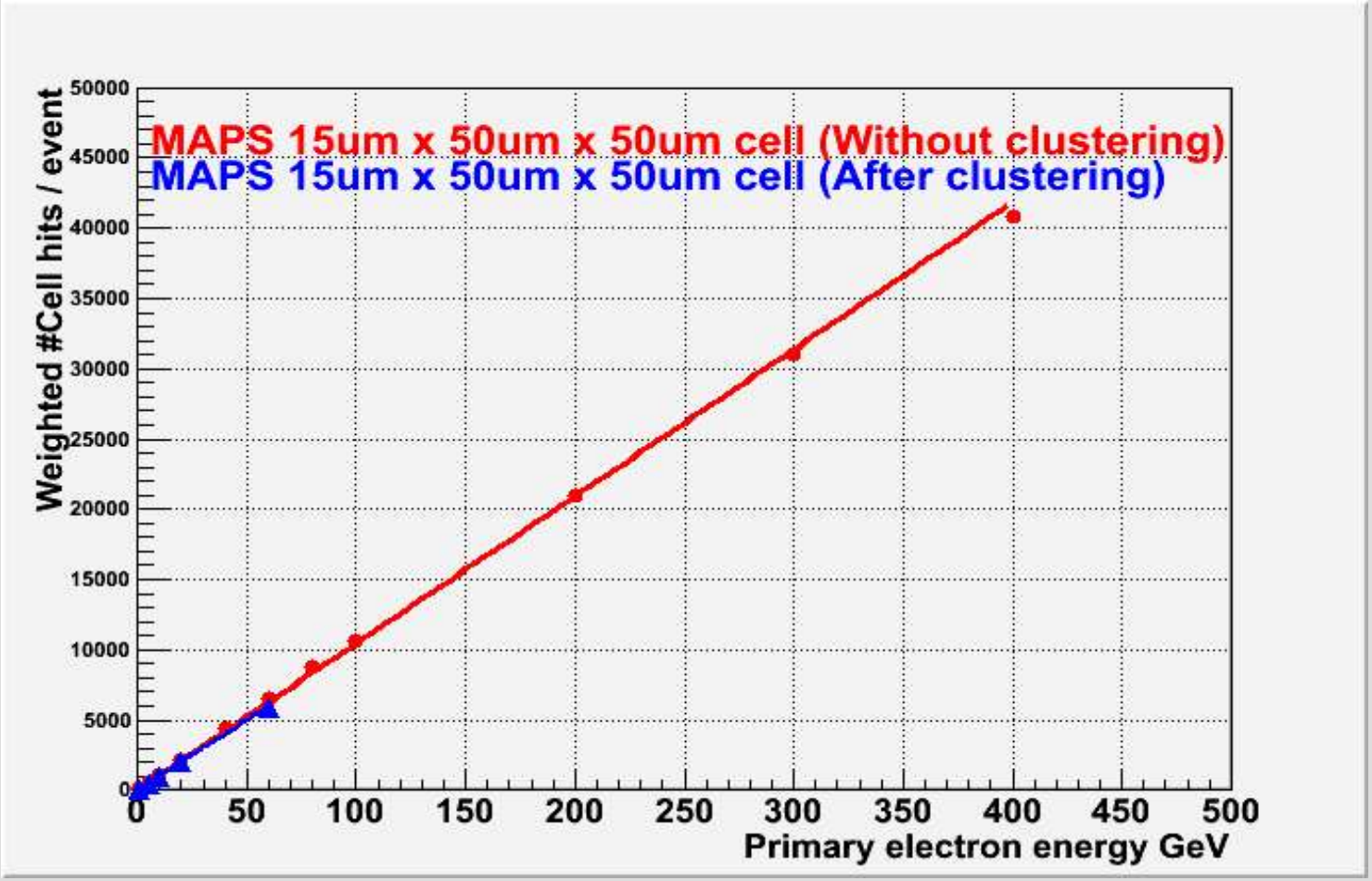




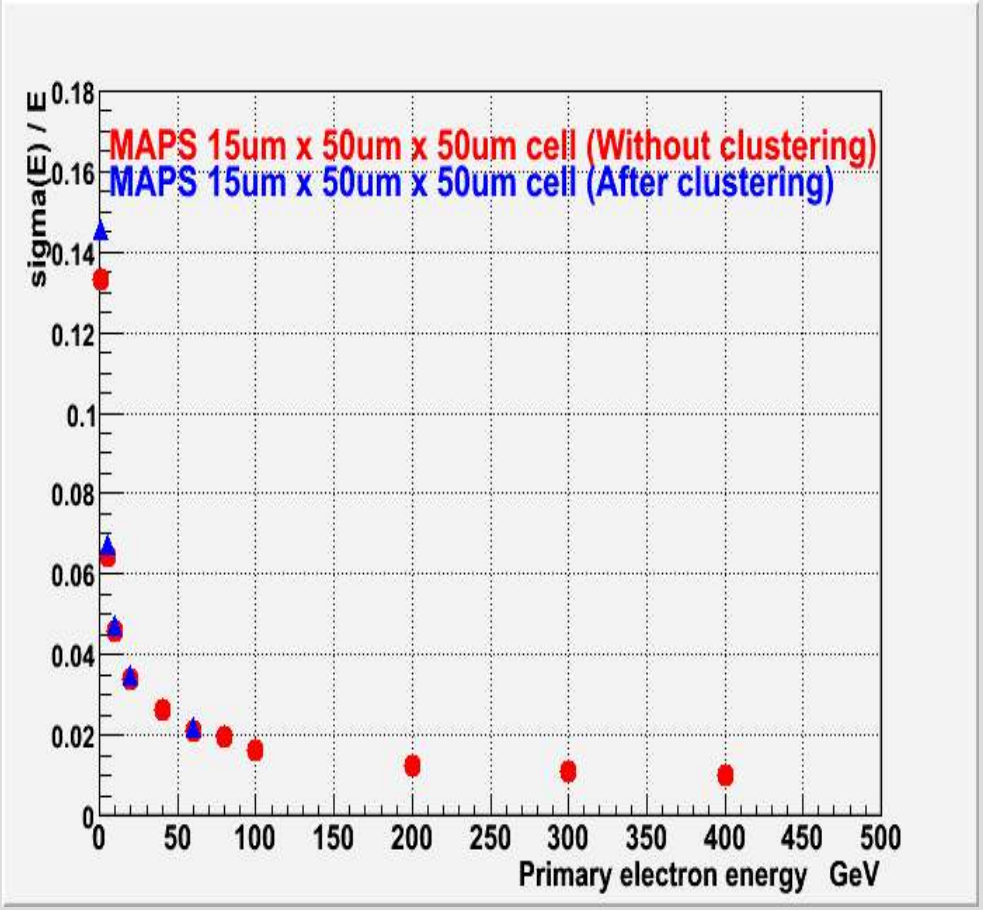
- B fields is off
- Using Gauss fitting
- Using Geant4 output which would be very roughly correspond to output after charge diffusion plus digitization.
- Double counts removing in clustering algorithm is not yet. (->Temporarily, one cluster per event is required.)
- Weighted number of cell hits is used for different W thickness layers.
- Applied 1800eV threshold for all cell hits

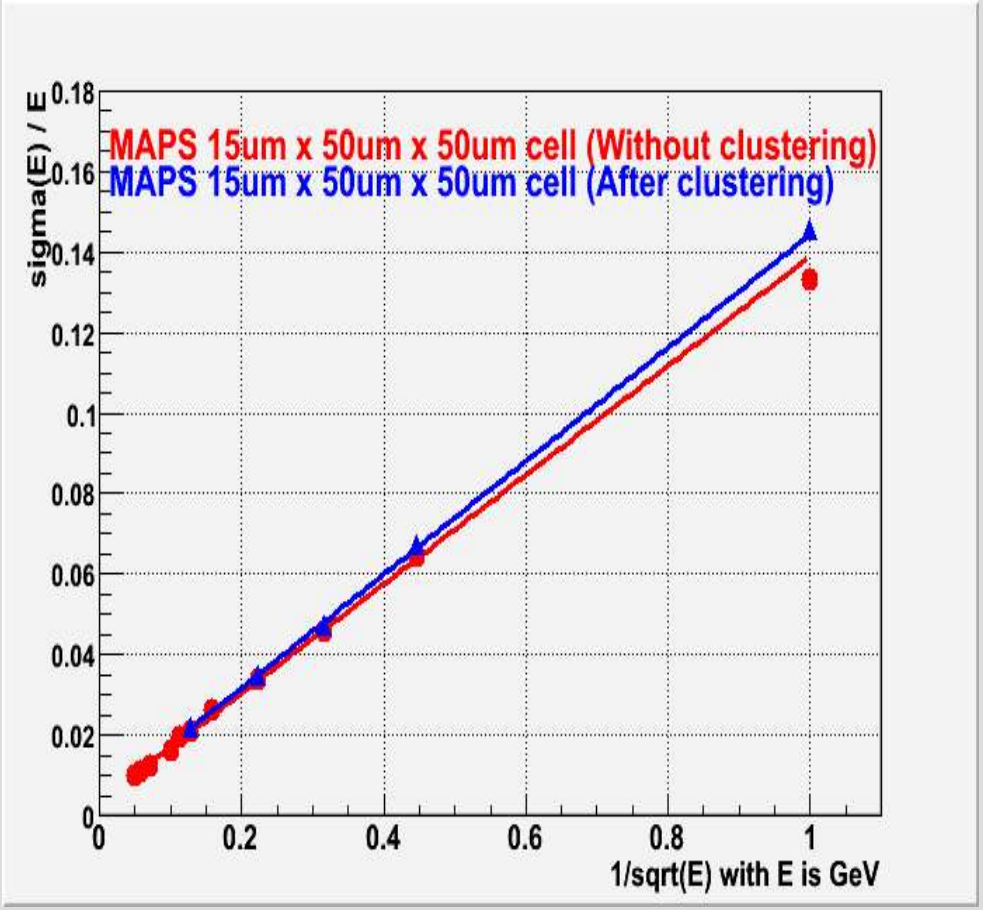
Roughly 10% effect at 1 GeV.

Linearity
after primary electron clustering



Energy resolution after primary electron clustering



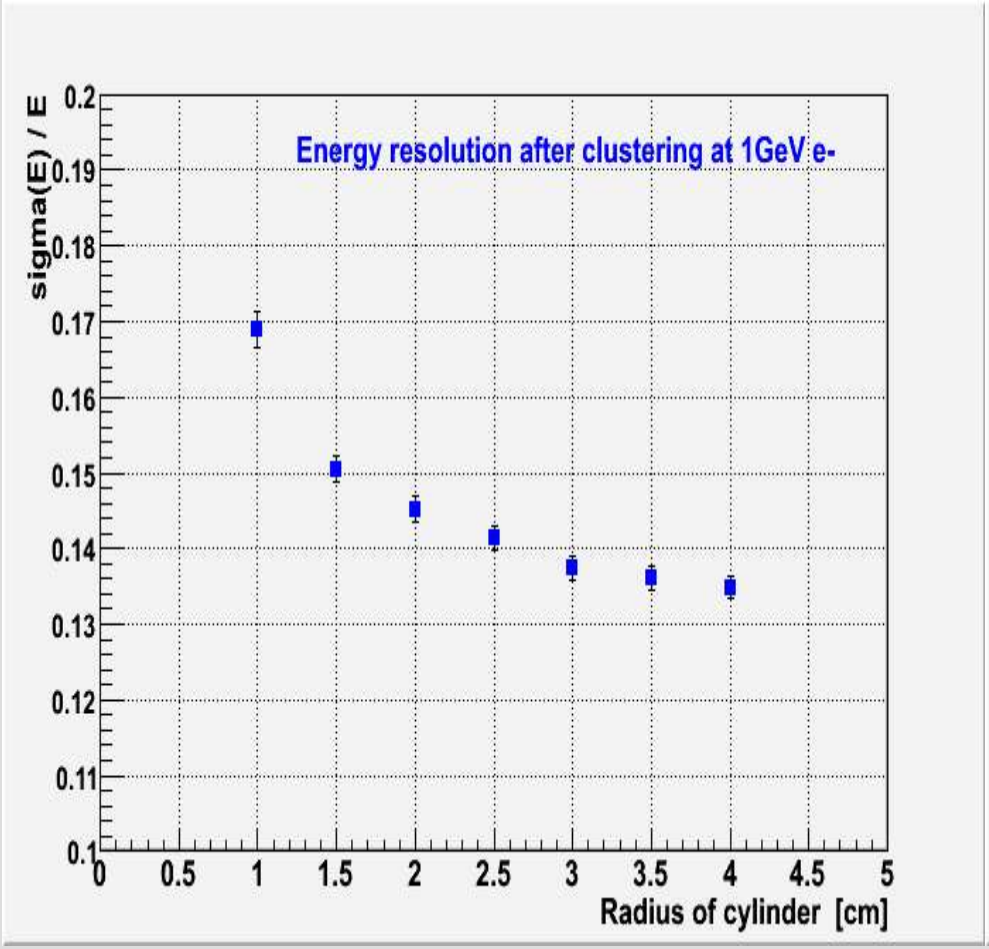


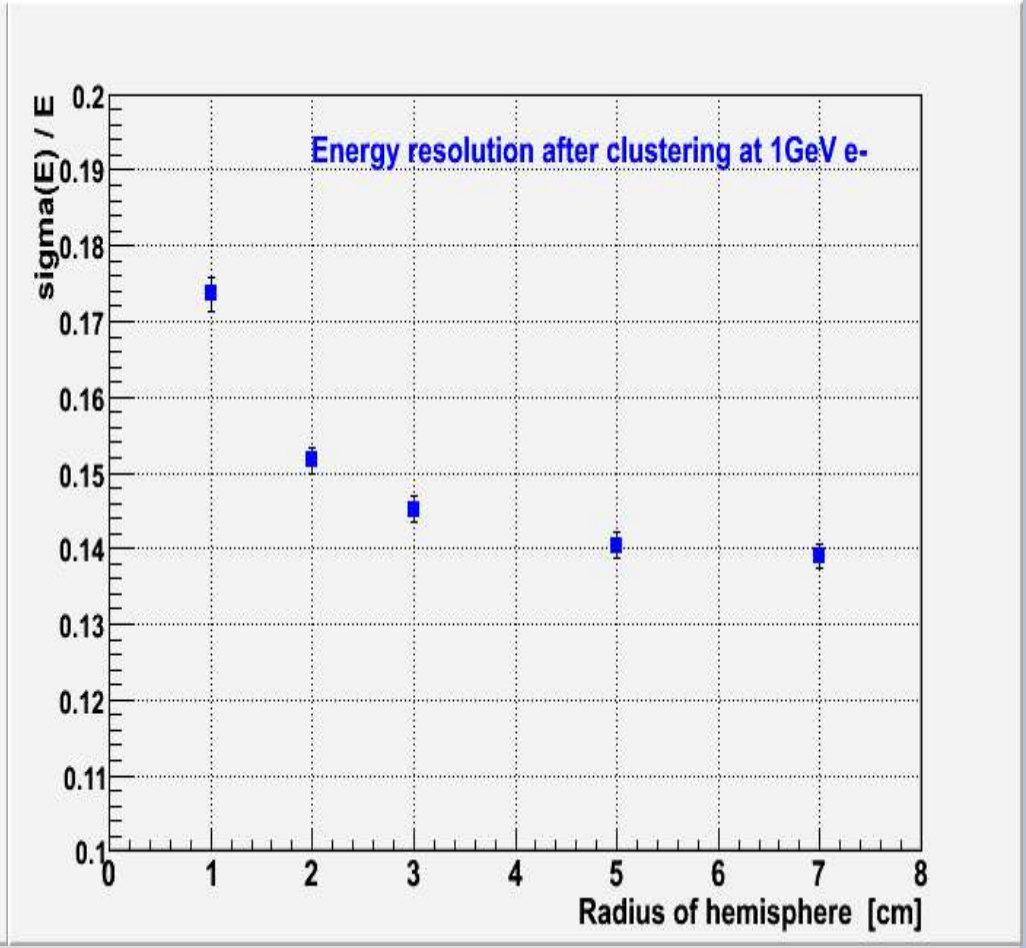
Without clustering: $\sigma(E) / E = (13.5 \pm 0.1^{stat})\% / \sqrt{E} + (0.35 \pm 0.02^{stat})\%$

After clustering: $\sigma(E) / E = (14.1 \pm 0.2^{stat})\% / \sqrt{E} + (0.38 \pm 0.04^{stat})\%$

Clustering effect is several percent. -> It looks reasonable.

Energy resolution with cylinder radius and hemisphere radius dependence





Have to be optimized with general physics event.
(In order to avoid merging two neighbour clusters)

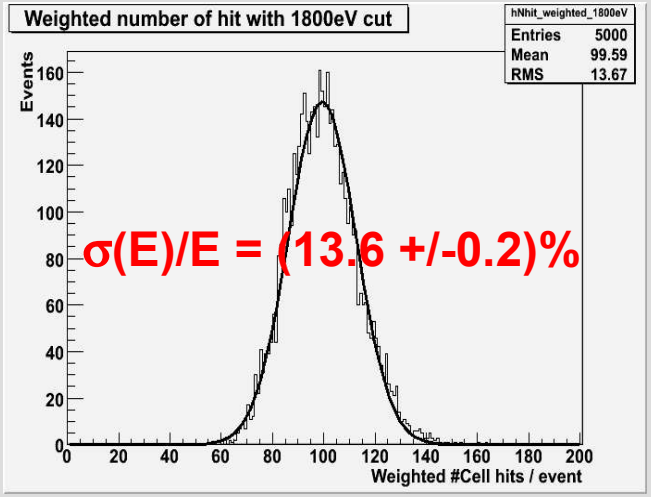
Magnetic effect for 1 GeV e-

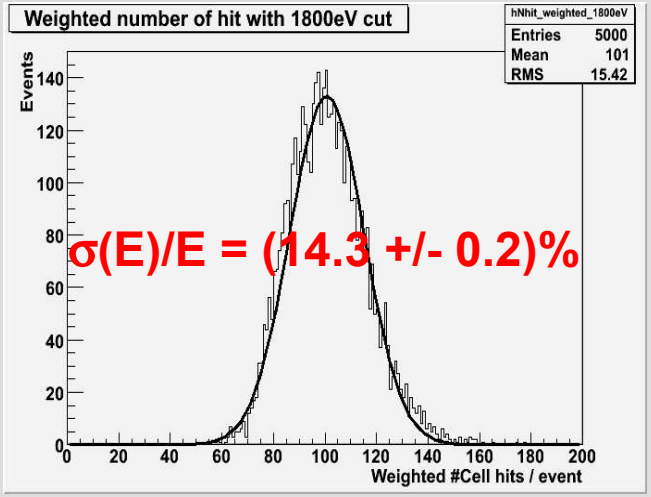
- **Electron is injected just in front of ECAL for all cases.**

B fields is off:

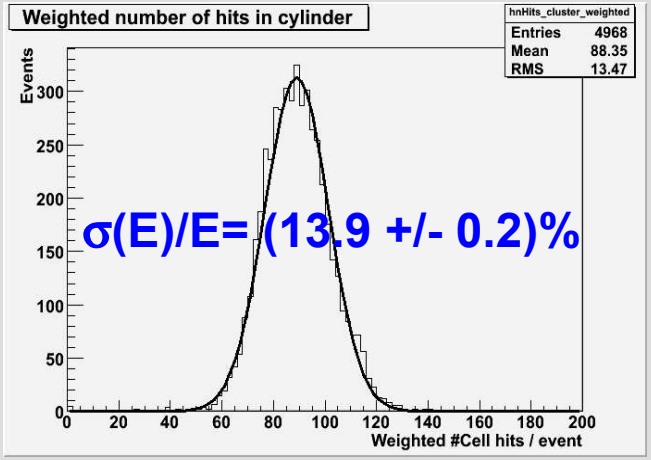
B fields is on:

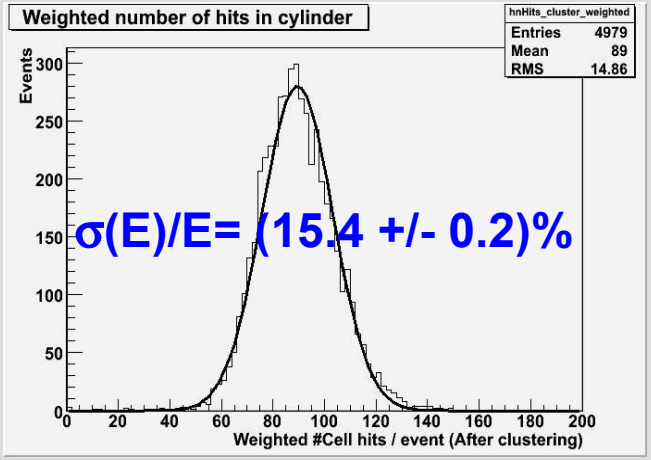
Without clustering:





After clustering:





-> Magnet effects is roughly several to 10 percent at 1 GeV.

Summary and next steps

Summary:

- **Base line of MAPS clustering algorithm looks working well.**

Next steps:

- **Algorithm of removing double counts for physics event case.**
- **Optimizing clustering criteria using 4T magnetic fields, charge diffusion, digitization, dead area and physics events.**
- **Study of energy resolution and spatial resolution with them.**
- **Angular dependence study**
- **Cleaning codes to save CPU time as possible as I can.**
- **Clustering code release as Marlin processor**

- **Physics event studies**