

# SDHCAL Preliminary Analysis Results on TB.

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# Outline

- Raw Event Format ,Event builder and selection.
- Very preliminary analysis results on TB@PS (November 2011).
- Simulation on influence of induced charge avalanche on pads.

## Part 0:

Raw Event Format ,Event builder and selection.

# Event Builder,

## Data format

- DAQ save all hits during one time window called "Trigger"
- The physical events are merged in this window. (the acquisition are stopped when the memory of one ASIC are full)

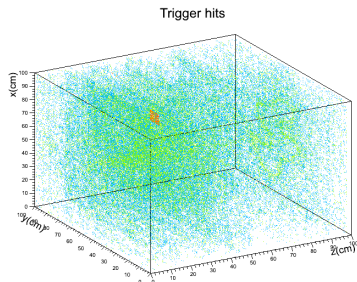


Figure 1: All hits saved on one trigger

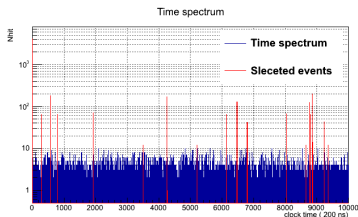


Figure 2: Time spectrum corresponding to one trigger

- In fact to select the physical events, a Marlin processor has been written called Trivent.
- Trivent selects the hits with same time corresponding to the peaks on the time spectrum.
- The selection follows 3 step :
  - ▶ Determine the peaks on time spectrum with  $N_{hit} \geq noise_{cut}$ .
  - ▶ Determine the time with opening time  $t_{peak} \pm Opening\ time$
  - ▶ Save all hits corresponding to this time slice as candidate event.

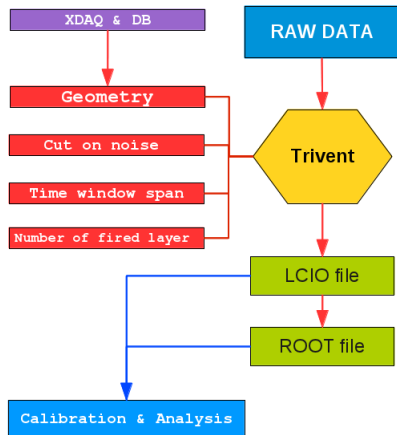
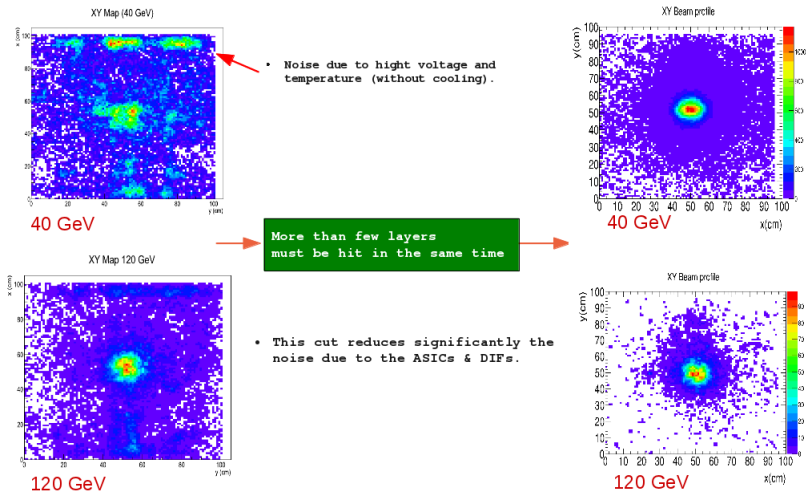


Figure 3: Trivent working diagram

- another cut is adding corresponding to the number of fired layer of candidate event. At list a certain number of layers must be hit.



- ( Beam profile on H8 beam line @ SPS (Sep-Oct 2011))

# Event Display.

- Druid is used to display the selected event<sup>1</sup>.

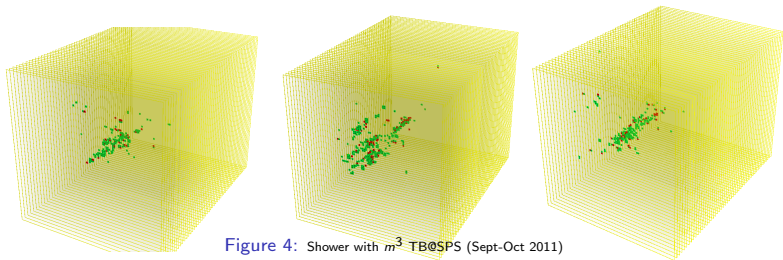


Figure 4: Shower with  $m^3$  TB@SPS (Sept-Oct 2011)

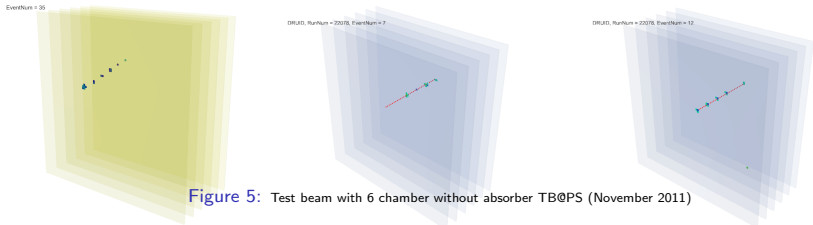


Figure 5: Test beam with 6 chamber without absorber TB@PS (November 2011)

<sup>1</sup>This tool is developed @ LLR by Manqi Ruan

## Part 1:

Very preliminary analysis results on TB@PS(November 2011).



- Setup of TB@PS is composed to 5 GRPC chambers without absorber (+Multi-gap GRPC).
- Pions with energy = 3-8 Gev are used.
- Track reconstruction follow this following steps :
  - ▶ Use Trivent to get the physical events.
  - ▶ the neighbor clustering is used. an additional cuts is added to remove the track whit a big cluster. impose  $N_{hit}(cluster) \leq 4$ .
  - ▶ do the linear fit to reconstruct the track by  $\chi^2$  minimization defined by,

$$\frac{\chi^2}{N_{hit}} = \sum_{i \neq j} \frac{(x - x_{cluster})^2}{\sigma_x} + \frac{(y - y_{cluster})^2}{\sigma_y}$$

the  $i$  index correspond to layer number.

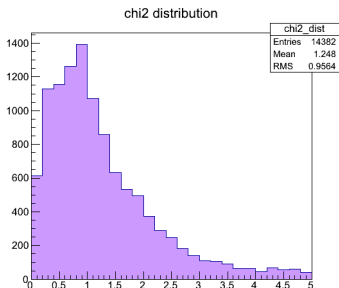


Figure 6: The  $\chi^2$  distribution

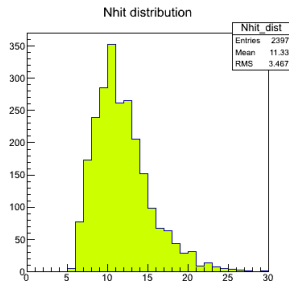


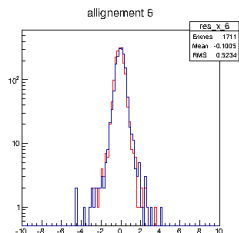
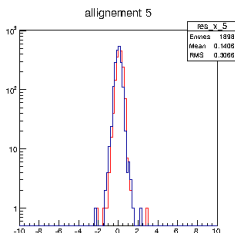
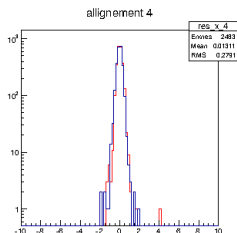
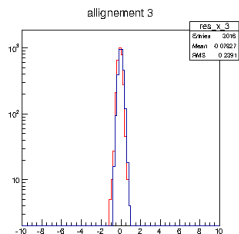
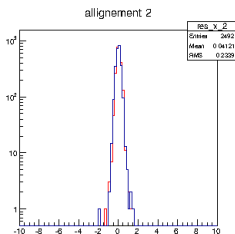
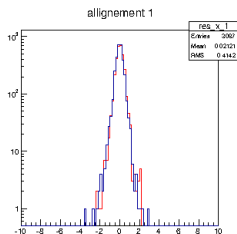
Figure 7: The  $N_{hit}$  distribution

# Alignment

- For each Layer  $i$  plot residual in x and y axis

$$R_x^i = x_{cluster}^i - x_{track}^i$$

$$R_y^i = y_{cluster}^i - y_{track}^i$$



## Efficiency & multiplicity

- The efficiency are determined using the reconstructed track, and looking in layer  $i$  around  $5\text{cm}$  to find hit. The efficiency can be formalized by

$$\epsilon_{\text{layer}} = \frac{\sum_{\text{tracks}} 1_{N_{\text{hit}} > 0} | \text{Layer}}{\text{Nbr tracks}}$$

- The multiplicity is just number of hit in given layer.

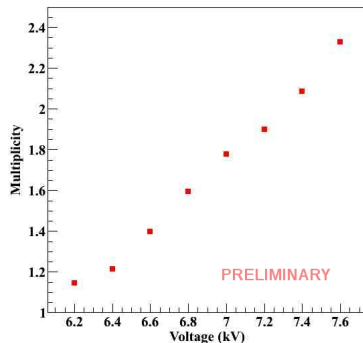
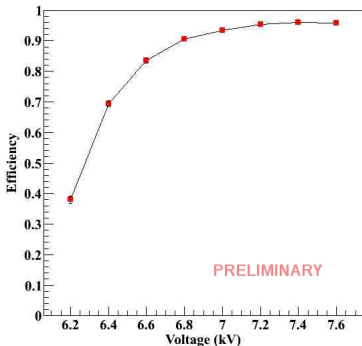


Figure 9: Efficiency scan on High voltage(TB@PS Nov2011).

Figure 10: Multiplicity scan on high voltage(TB@PS Nov2011).

# Efficiency & multiplicity

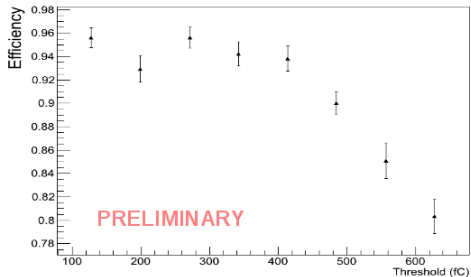
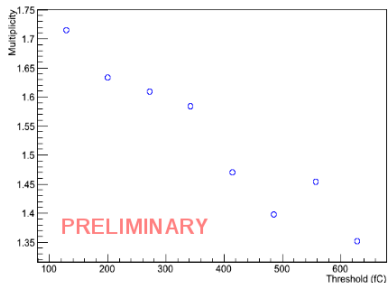


Figure 11: Efficiency & multiplicity scan on threshold(TB@PS).

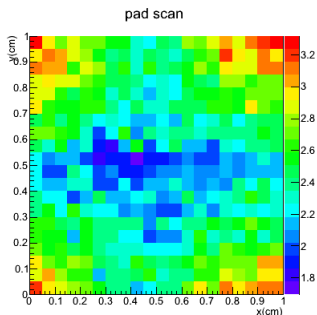
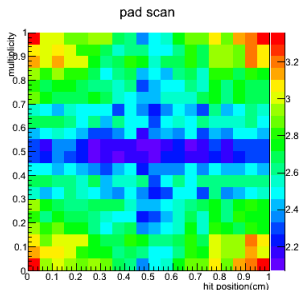
## Scan across pad

- The reconstructed track can be used to determine the space charge distribution on the pad. For that we can plot the flowing variables,

$$x = (x_{track} + 0.5) \bmod 1. \text{ if } x \geq 0, \quad x = x + 1. \text{ if } x \leq 0$$

$$y = (y_{track} + 0.5) \bmod 1. \text{ if } y \geq 0, \quad y = y + 1. \text{ if } y \leq 0$$

- the multiplicity distribution is obtained by normalization of number of entries in each position. the size of this distribution is correlated with avalanche size.



## Part 2:

Simulation on influence of induced charge avalanche on pads

# The idea

We want to measure the influence of avalanche size on multiplicity and efficiency for given Threshold. For that we get the uniform random position of MIP particle, each particle take one value of charge in "polya" distribution, calculate the induced charge in each pad, and for given threshold determine the efficiency and multiplicity.

- Get the uniform random position as shown on hatching zone in figure 12.
- Each point get a value of charge in polya distribution corresponding to total induced charge (figure 13).
- Assume that the spatial distribution of induced charge for one hit is Gaussian distribution.

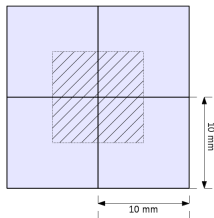


Figure 12: The pads configuration. the hatched area correspond  
shotted

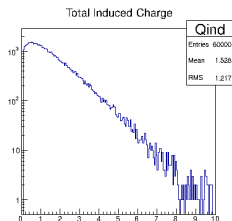


Figure 13: Induced charge distribution.

- The spatial charge distribution correspond to the avalanche, this distribution can be approximated by 2D Gaussian in position  $(x_0, y_0)$

$$G(x, y; x_0, y_0, \sigma) = \frac{1}{2\pi\sigma} e^{-\frac{(x-x_0)^2+(y-y_0)^2}{\sigma^2}}$$

- $\sigma$  characterize the size of avalanche and it depend to the geometry of chamber and high voltage.
- The induced charge of each pad is calculated by integration of the Gaussian distribution in area of each pad.

$$Q_{pad} = \int_{x_{min}}^{x_{max}} \int_{y_{min}}^{y_{max}} G(x, y; x_0, y_0, \sigma) dx dy$$

- Example: for the right top pad the charge induced in it for the hit position  $(x_0, y_0)$  is :

$$Q_{pad} = \int_0^{10} \int_0^{10} G(x, y; x_0, y_0, \sigma) dx dy$$



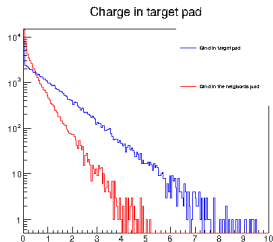


Figure 14: Induced charge in target & neighbors pads.

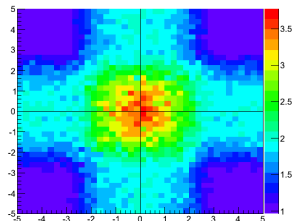


Figure 16: spatial multiplicity distribution.

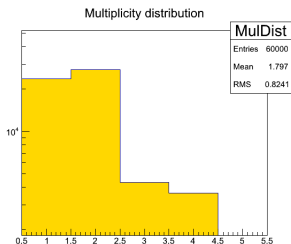


Figure 15: Multiplicity distribution

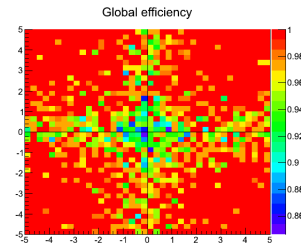


Figure 17: Multiplicity distribution  

- The right plots is the average multiplicity and efficiency in each position on the pads.
- The efficiency, by definition, is the probability the fired the pad on each position.

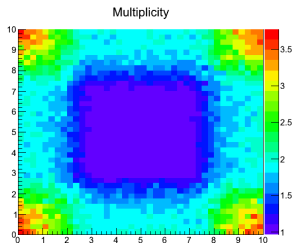


Figure 18: Multiplicity distribution on pad.

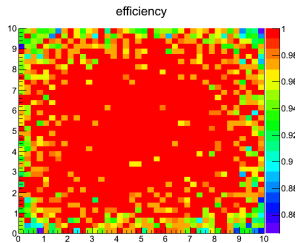


Figure 19: Efficiency distribution on pad.

- We want to represent the dependence of the avalanche size to the fitted multiplicity distribution
- To fit the multiplicity distribution we use two 1D Gaussian distributions as,

$$\mu(x, y) = \mu_0 + G(x; x_0, \sigma_x) + G(y; y_0, \sigma_y)$$

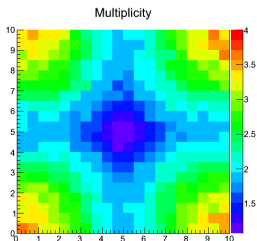


Figure 20: Multiplicity distribution on pad (simulated data)

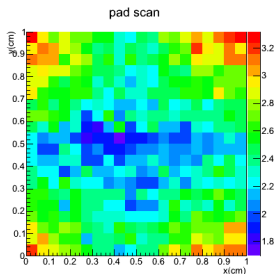


Figure 21: Multiplicity distribution on pad (real data)

- The size of the induced charge distribution is perfectly correlated of size of multiplicity distribution.
- evolution of mean multiplicity and  $Q_{ind}$  size are perfectly correlated too.

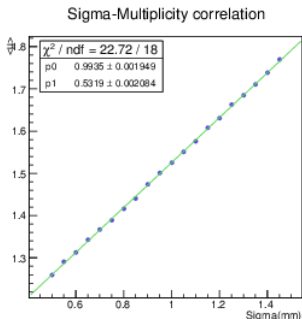


Figure 22: Linear evolution of multiplicity bay  $Q_{ind}$  size for given threshold ( $thr = 0.1\text{pC}$ )

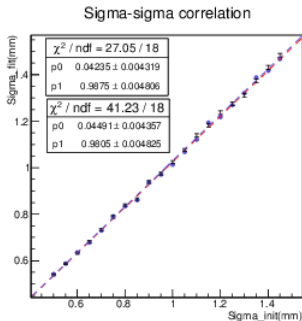
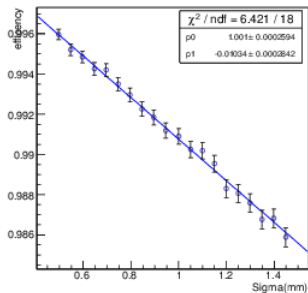
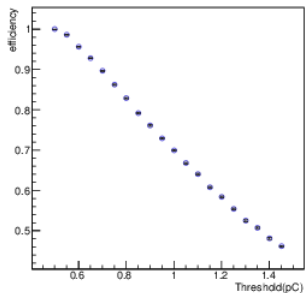


Figure 23: Correlation between the induced charge size an multiplicity distribution size for given threshold ( $thr = 0.1\text{pC}$ )

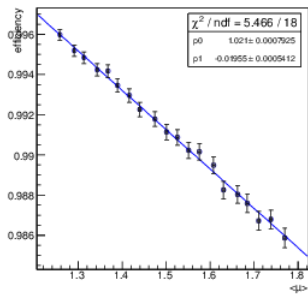
efficiency-sigma



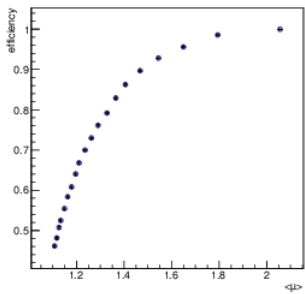
efficiency-thres



efficiency-multiplicity by sigma variation



efficiency-multiplicity by threshold variation



# Summary

- The data analysis has begun. and other results coming soon.
- Comparison with simulation are in preparation.
- A small simulation are presented on effect of charge distribution size on multiplicity and efficiency. Comparison with real data are in preparation.



BACKUP



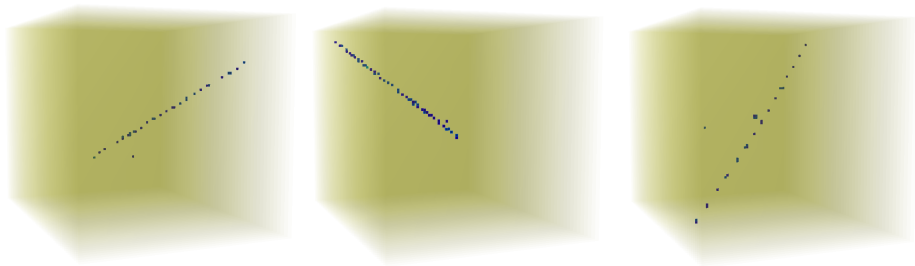


Figure 24: cosmic event with  $m^3$  prototype @ Lyon



DRUID, RunNum = 21509, EventNum = 5

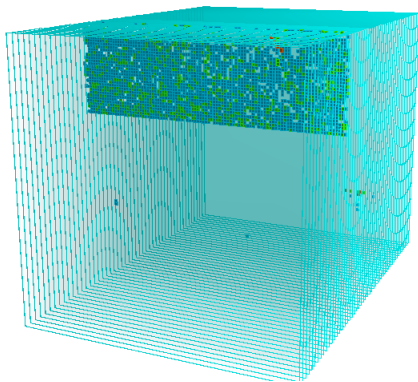


Figure 25: Noisy Dif on  $m^3$  prototype @ SPS (October 2011)