Minimum Ionizing Particle (MIP) Studies

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Instrument Analysis Workshop II

SLAC

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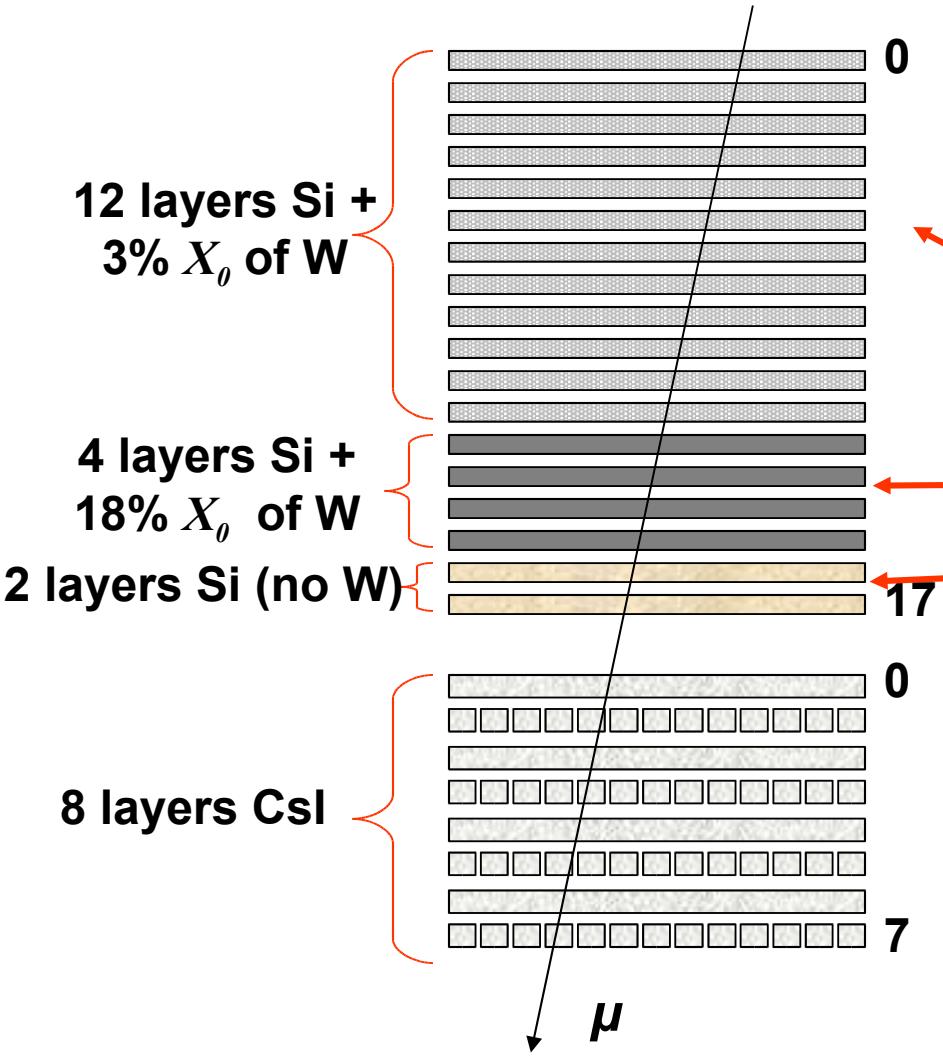
Introduction

- What is in this talk?
  - Summary of our experience working with the I&T group at SLAC during this summer.
- What we have learned :
  - Learned to use some data analysis tools (ROOT, HippoDraw, FRED, etc..)
  - Studied some of the ~ 300 variables available in the SVAC and MERIT files.
  - Investigated how to identify a MIP using a LAT tower

MIP Search

- Why search for a MIP?
  - It is a particle whose behavior is quite well understood in our detector (we need to start with something easy…)
- When will we need a MIP selection during I&T?
  - There will be a set of End to End tests to verify trigger and data flow
    - A MIP selection is needed to compare distributions when changing some of instruments setting.
  - Our project
    - Was to develop a series of cuts that could be used for the E2E test and verify them with MonteCarlo

First comes the geometry!



- Each TKR layer constists of 2 Si layers rotated by 90° (X,Y) which contains several thicknesses of W.
  - •Thin W
  - •Thick W
  - •Blank (no W)
- Each CAL layer consists of 12 crystals and each layer is rotated with respect with the next so that it can provide X and Y measurements

Variables Used

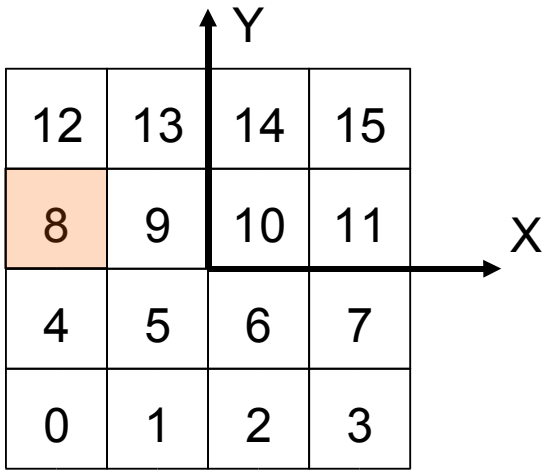
Description	Expected Value
Hits in Thin Region (Thin Tungsten)	~24
Hits in Thick Region (Thick Tungsten)	~8
Hits in Blank Region (Blank Tungsten)	~4
Clusters in Thin Region (Thin Tungsten)	24
Clusters in Thick Region (Thick Tungsten)	8
Clusters in Blank Region (Blank Tungsten)	4
Energy in Layer 0 of CAL (Top layer)	~11 MeV
Energy in Layer 1 of CAL	~11 MeV
Energy in Layer 2 of CAL	~11 MeV
Energy in Layer 3 of CAL	~11 MeV
Energy in Layer 4 of CAL	~11 MeV
Energy in Layer 5 of CAL	~11 MeV
Energy in Layer 6 of CAL	~11 MeV
Energy in Layer 7 of CAL (Bottom layer)	~11 MeV
Radiation length in TKR	1.5 X_0
Track length in TKR	550 - 664 mm
Radiation length in Cal Cristals	8.6 X_0
Sum of energy in the CAL	90 MeV
Sum of gaps between CAL layers	11 mm

Naively, our MIP should cross the entire tower producing hits in all Si layers and depositing about 11 MeV in each CAL layer.

Selected one tower only

- To simplify the work we selected only one tower out of the 2 towers generated in MC sample.
  - GltWord = 4 (only tracker trigger)

We select only this tower
(GltTower = 8)



- We divided the work to study the MIP.
  - CAL variables (Dario)
  - TKR variables (Sara)

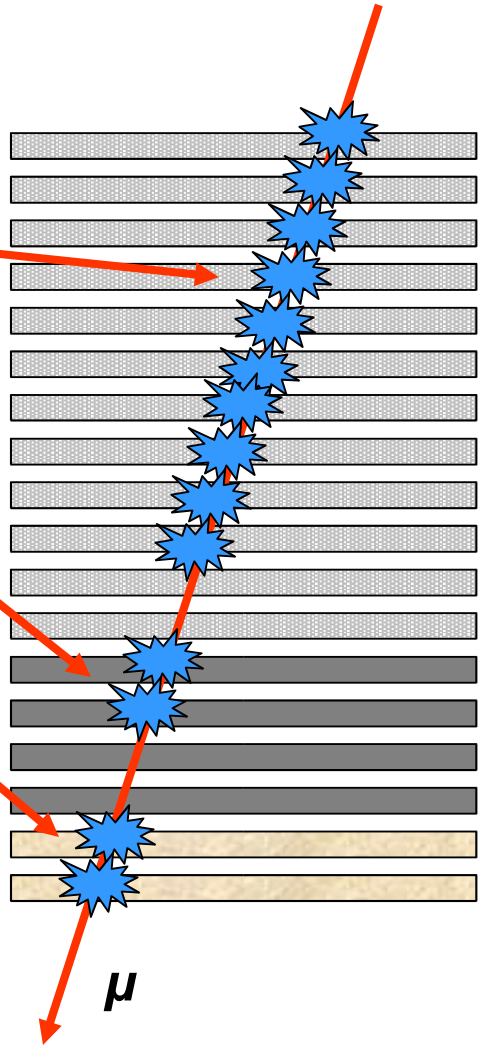
TKR selection

- We select the following topology for TKR events.

At least 1 hit in at least 10 of 12 Thin layers

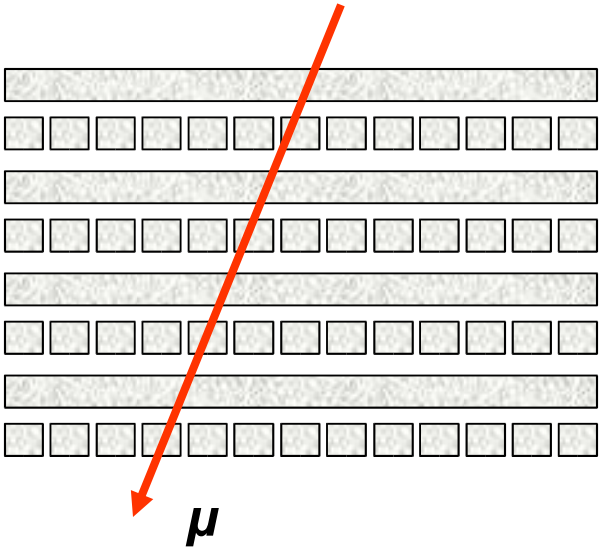
At least 1 hit in at least 2 of 4 Thick layers

At least 1 hit in at least 2 of 2 Blank layers



- These imply that a straight track goes through the TKR (not very efficient, but clean enough for us to study it)
- In addition we required:
  - TkrNumTrack = 1 (One track only)

CAL Selection

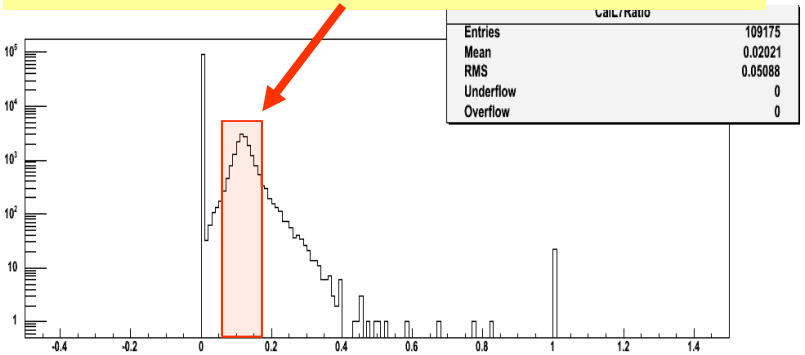


$$\frac{\text{Energy in layer 0}}{\text{Energy in all CsI Crystals}} = \text{CalLyr0Ratio}$$

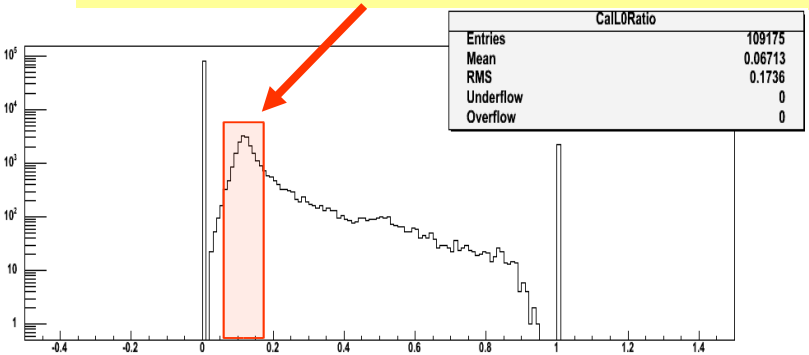
$$\frac{\text{Energy in layer 7}}{\text{Energy in all CsI Crystals}} = \text{CalLyr7Ratio}$$

- We used to cut the variables CalLyr0Ratio e CalLyr7Ratio
  - Expected value for ratio : 11 Mev / 90 MeV = 12 %

6 % < CalLyr0Ratio < 18 %



6 % < CalLyr7Ratio < 18 %



Summary of all Cuts

For reference only

- GltWord = 4
- GltTower = 8
- At least 1 hit in at least 10 on 12 Thin layers
- At least 1 hit in at least 2 on 4 Thick layers
- At least 1 hit in at least 2 on 2 Blank layers
- 6 % < CalLyr0Ratio < 18 %
- 6 % < CalLyr7Ratio < 18 %

TKR variables after all cuts

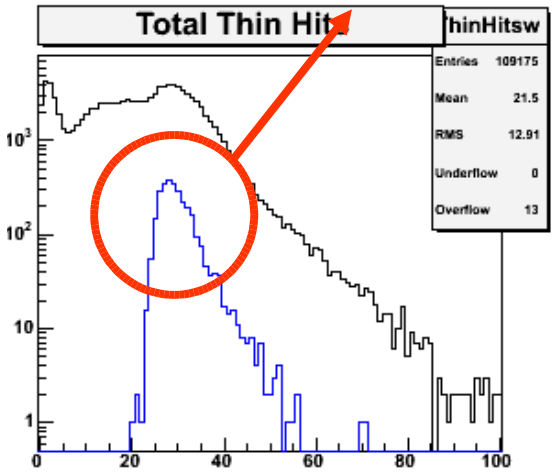
Black without cuts

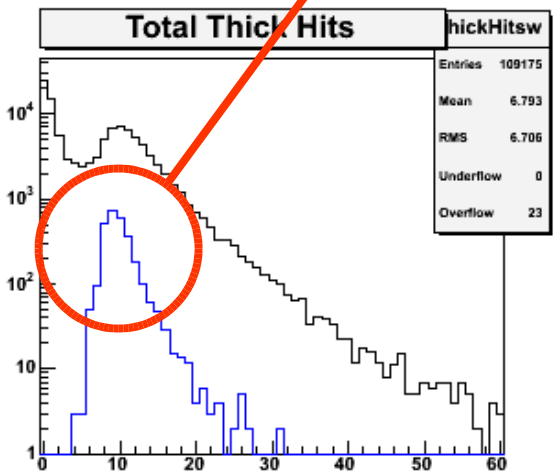
About 24 hits

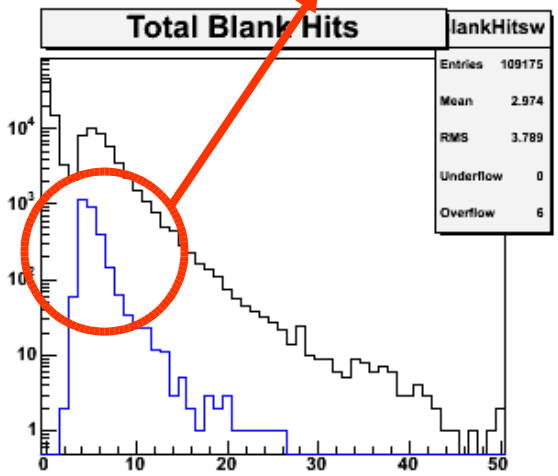
Blue with cuts

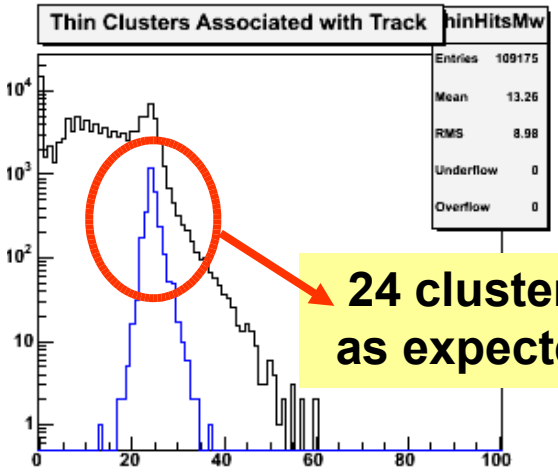
About 8 hits

About 4 hits

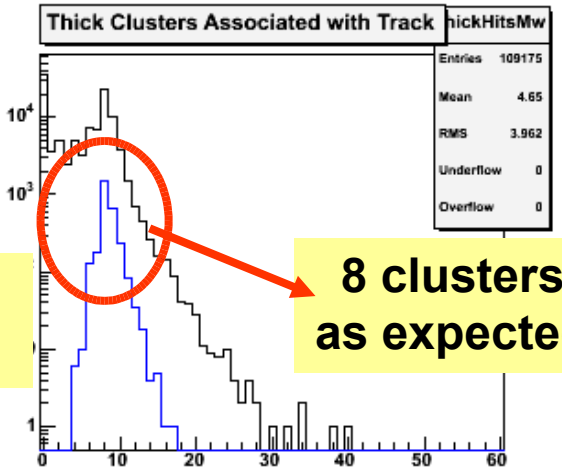




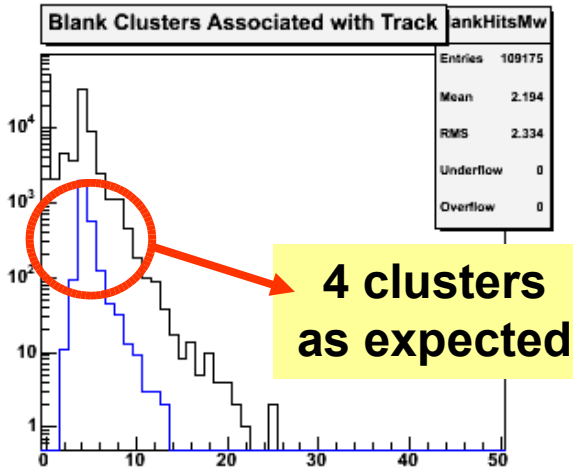




24 clusters as expected

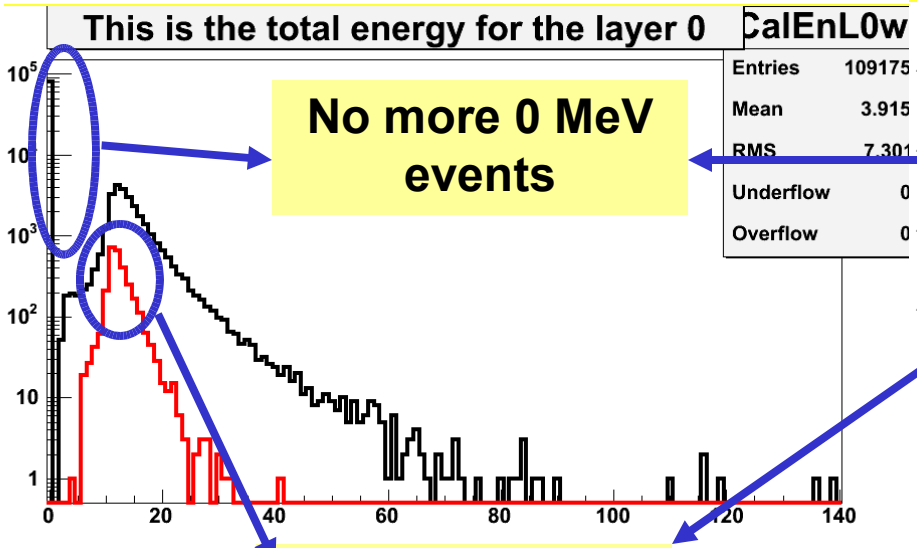


8 clusters as expected



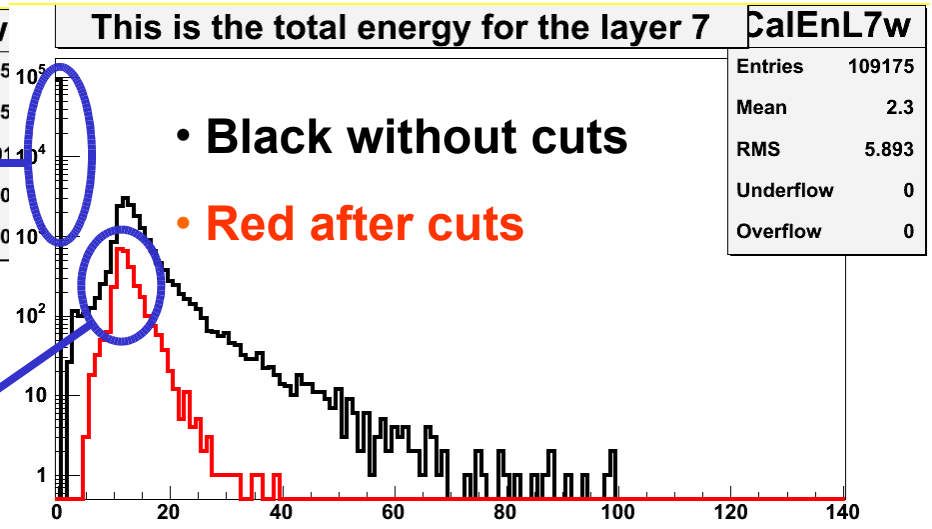
4 clusters as expected

CAL Selection



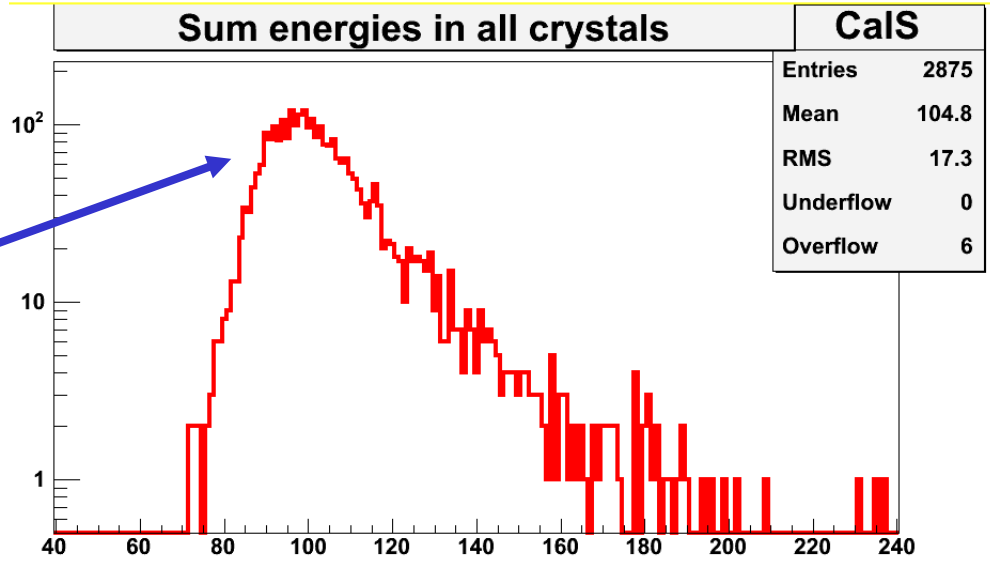
No more 0 MeV events

About 11 MeV as expected

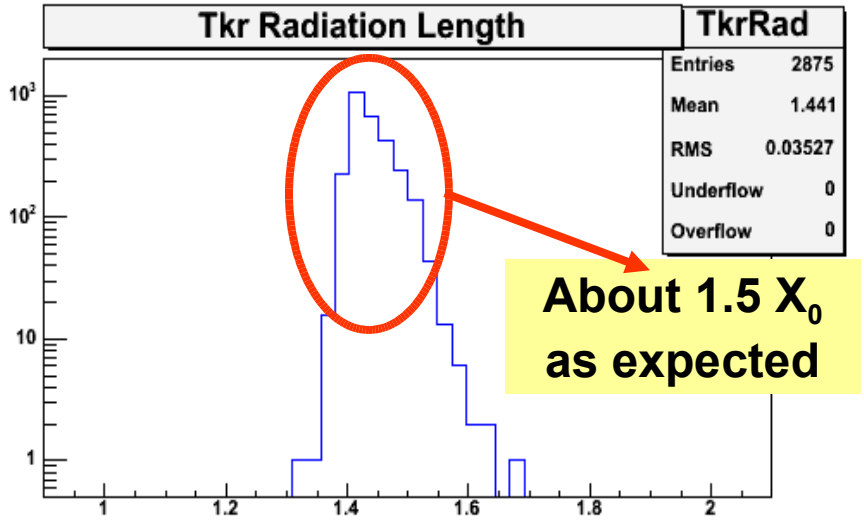


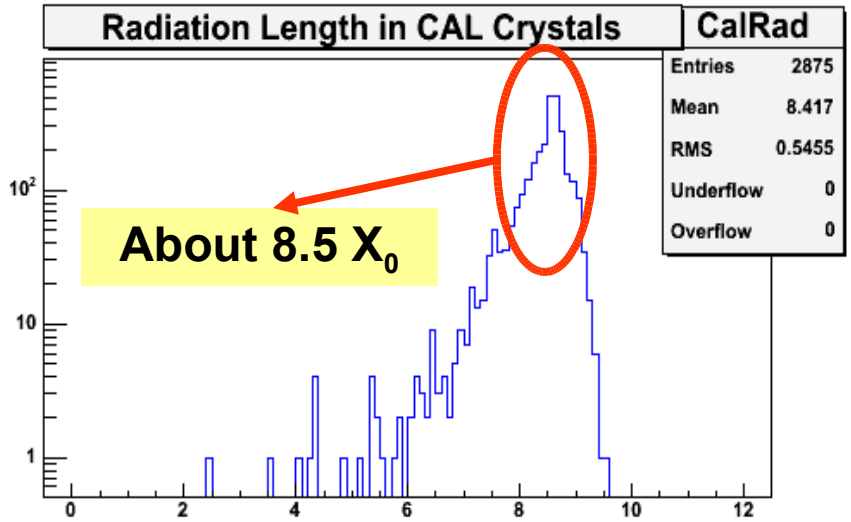
- Black without cuts
- Red after cuts

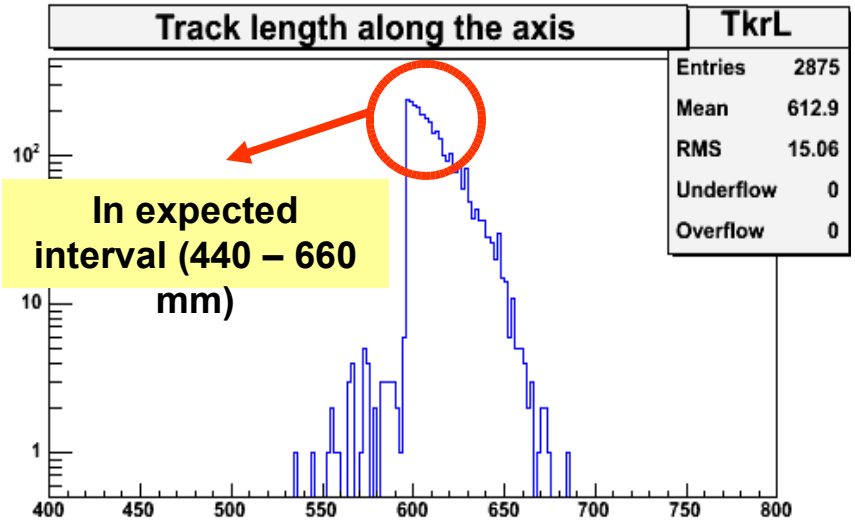
The sum of energies is like we expected it (about 90 MeV)



Control variables after cuts

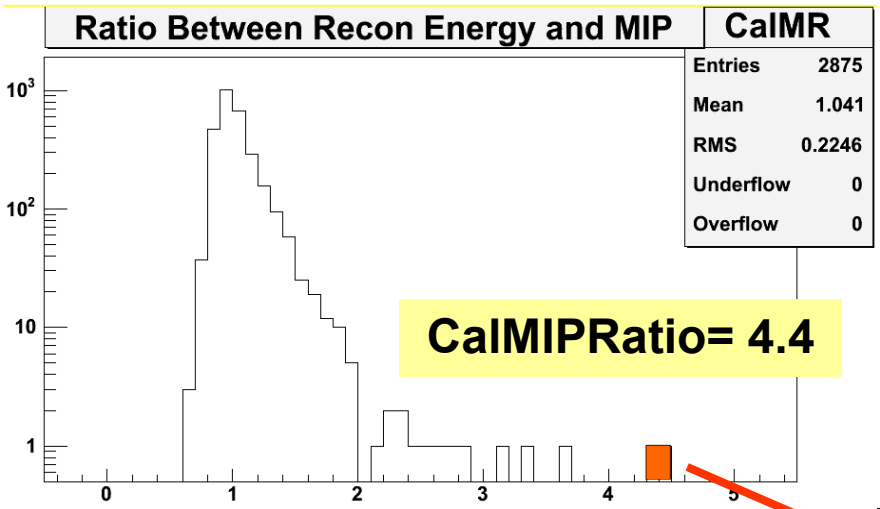




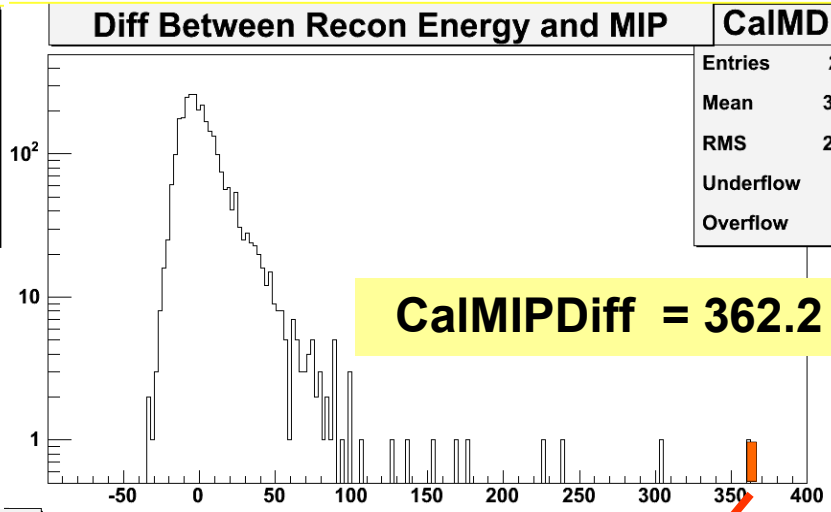


Now we will study tails of distributions with Event Display (FRED)

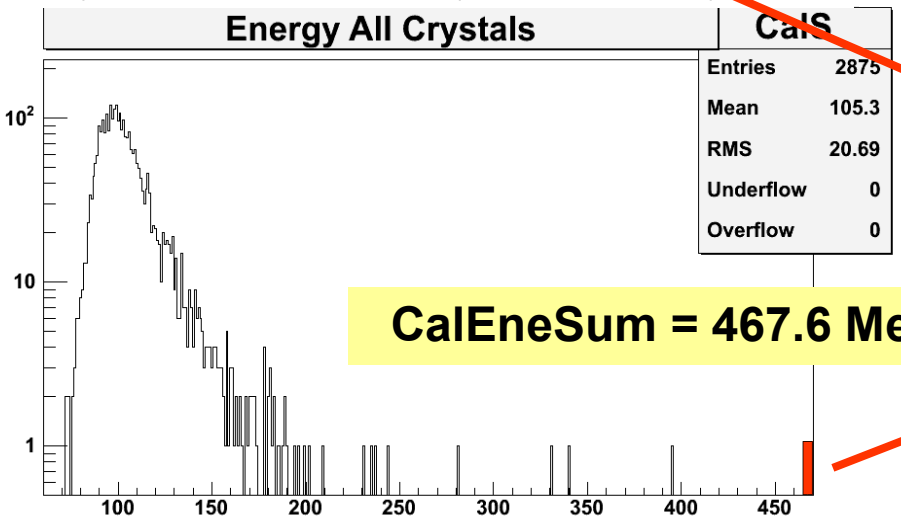
Tails of distributions



CalMIPRatio= 4.4



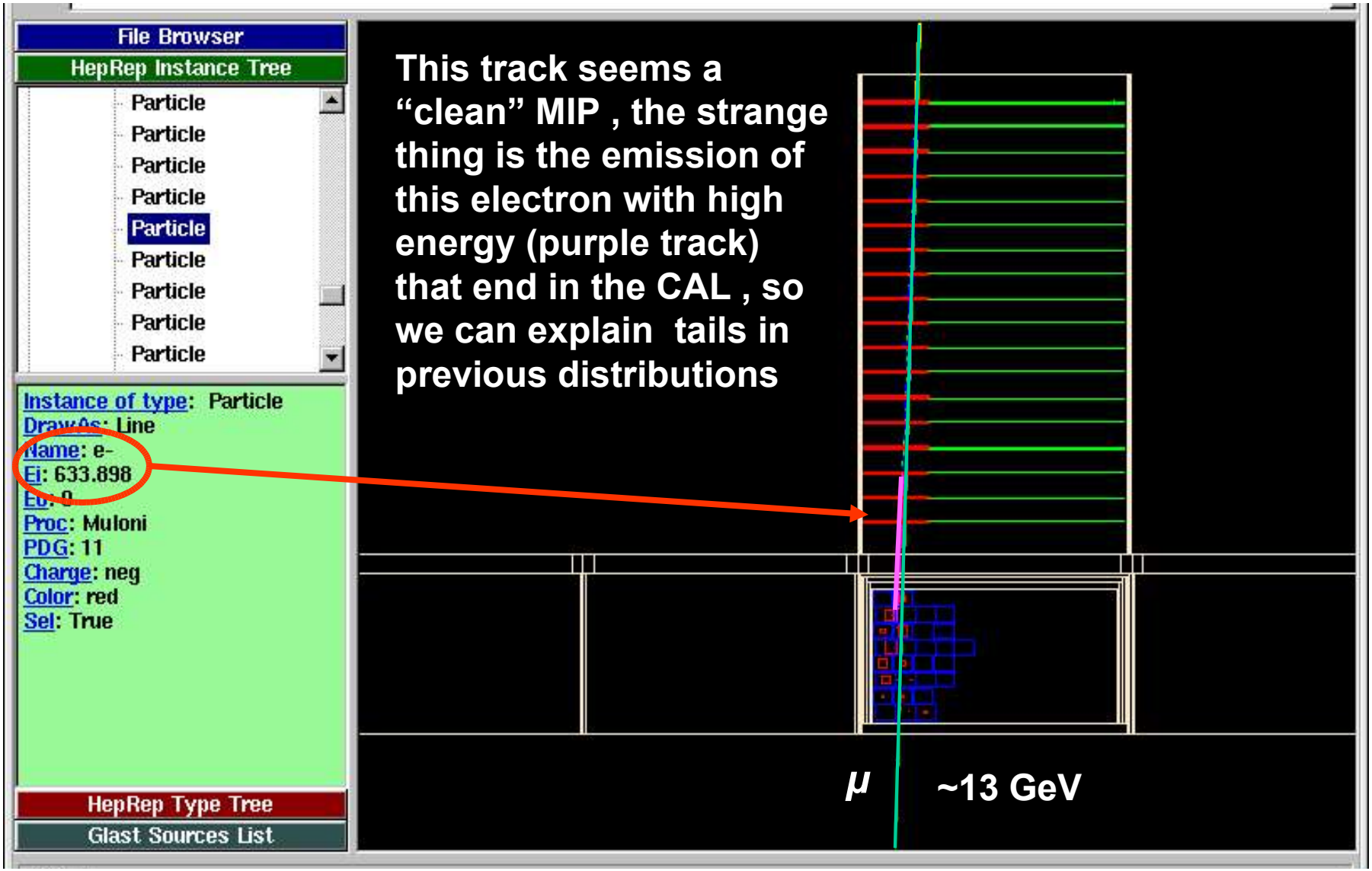
CalMIPDiff = 362.2 MeV



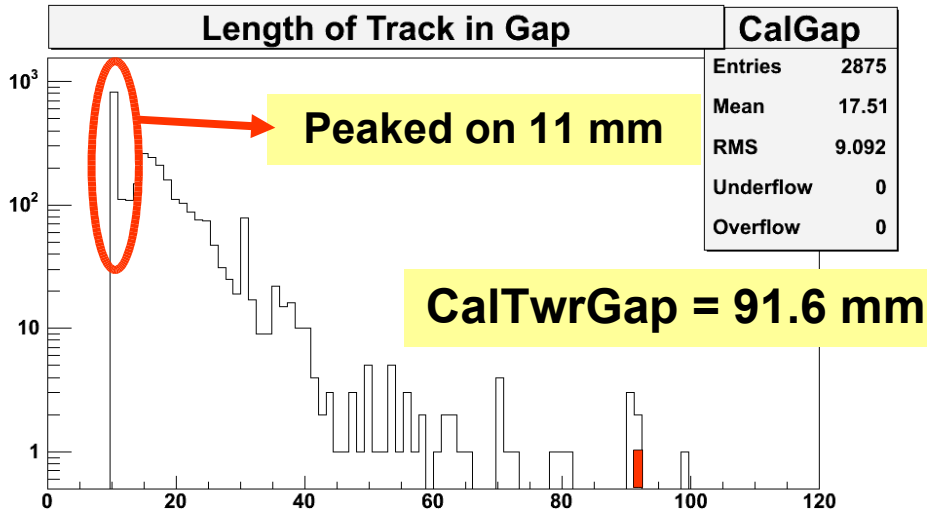
CalEneSum = 467.6 MeV

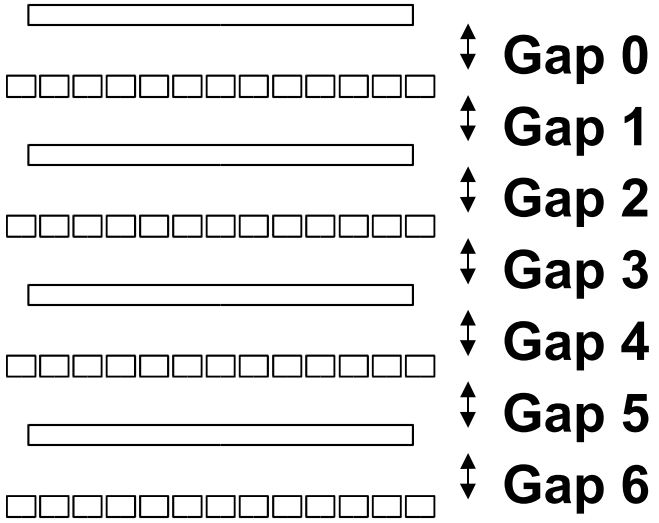
Let's look it with Event Display

"Strange" event



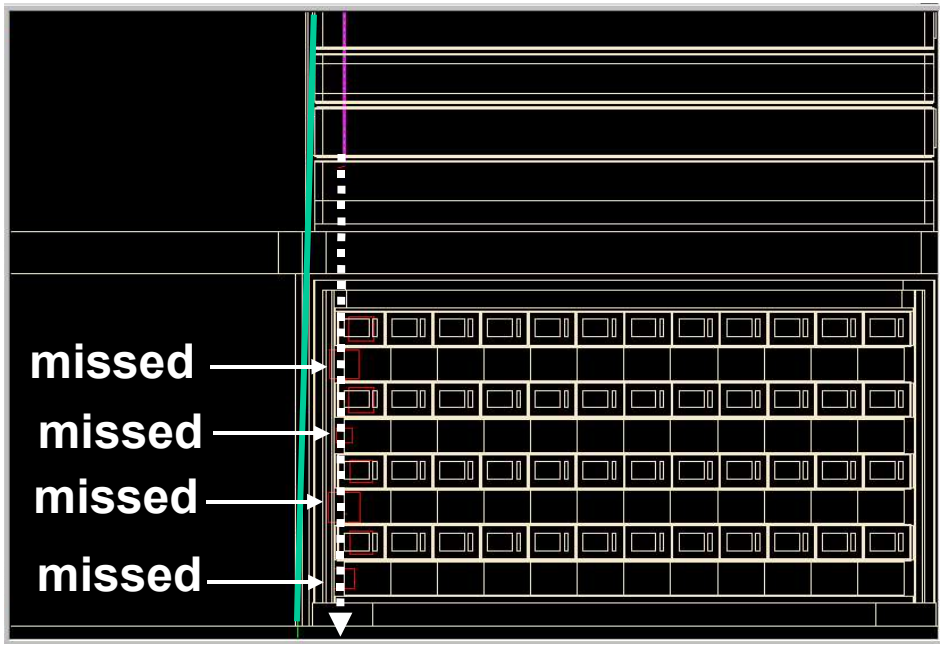
Tails in CalTowerGap



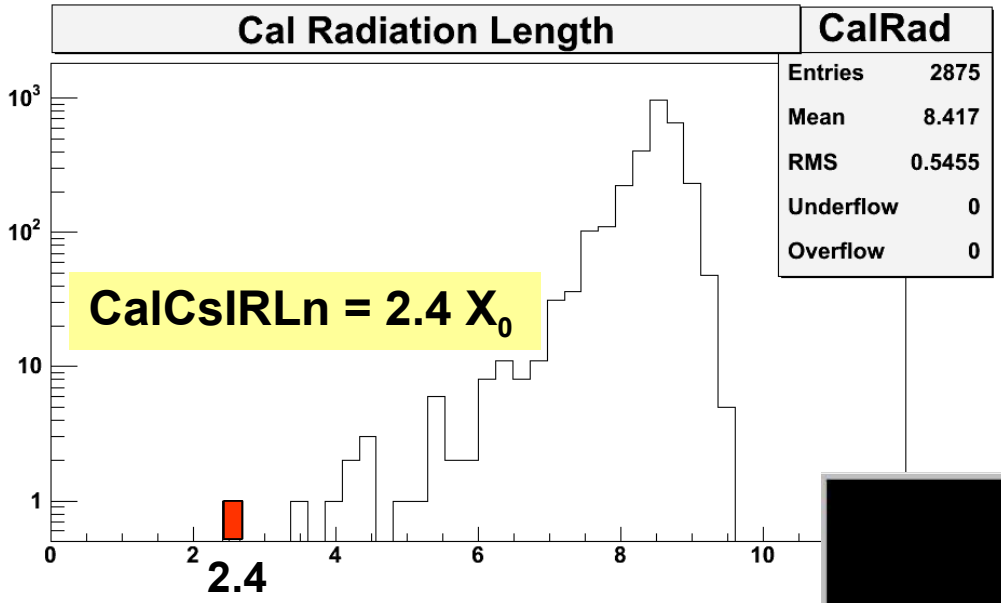


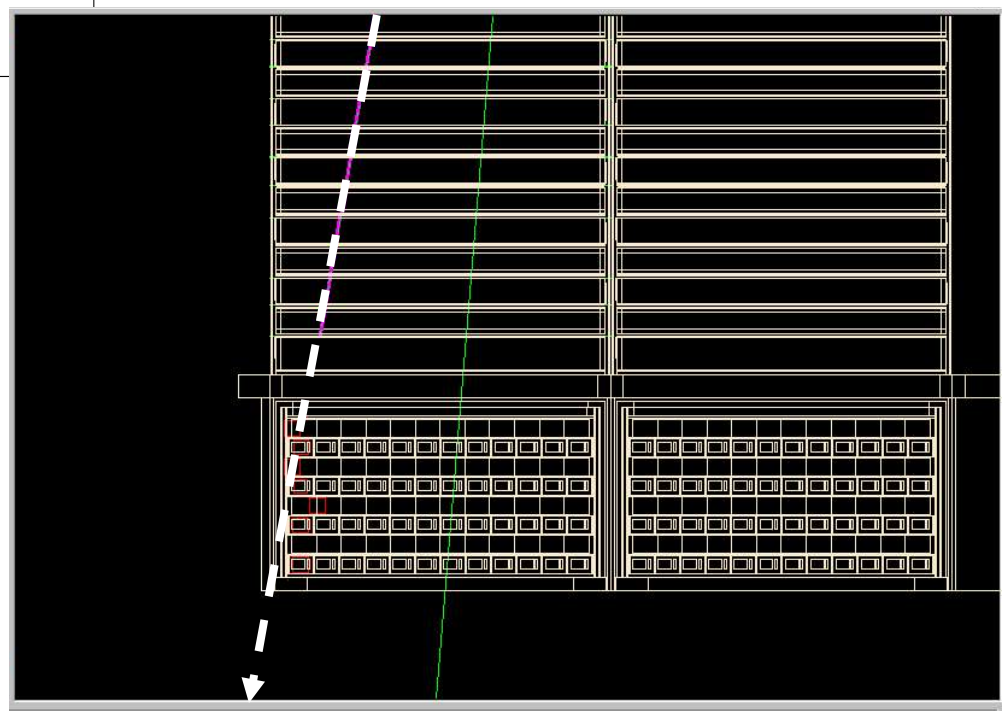
$$\text{CalTwrGap} = \sum_{i=0}^{6} Gap_i$$

•There is energy in each crystal layer and if we make extrapolation from recon track (white dashed) it seems not hit crystals of one orientation, in fact the two orientation have different length.



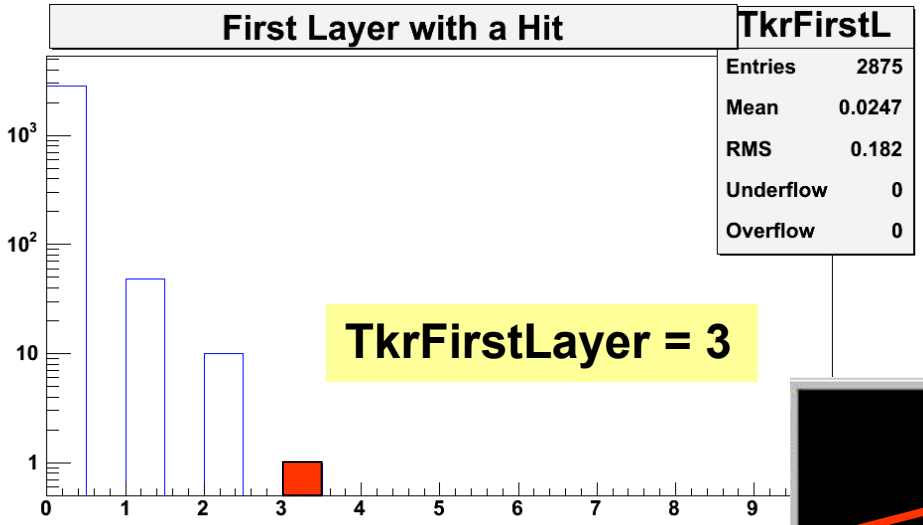
Tail in CsI radiation length





Also here there is energy in each crystal, but the recon track (white) goes out of CAL, so we have a radiation length lesser then expected

Tail in TKRFirstLayer



TkrFirstLayer = 3

We have hit on layer 0 while track enters detector in layer 3

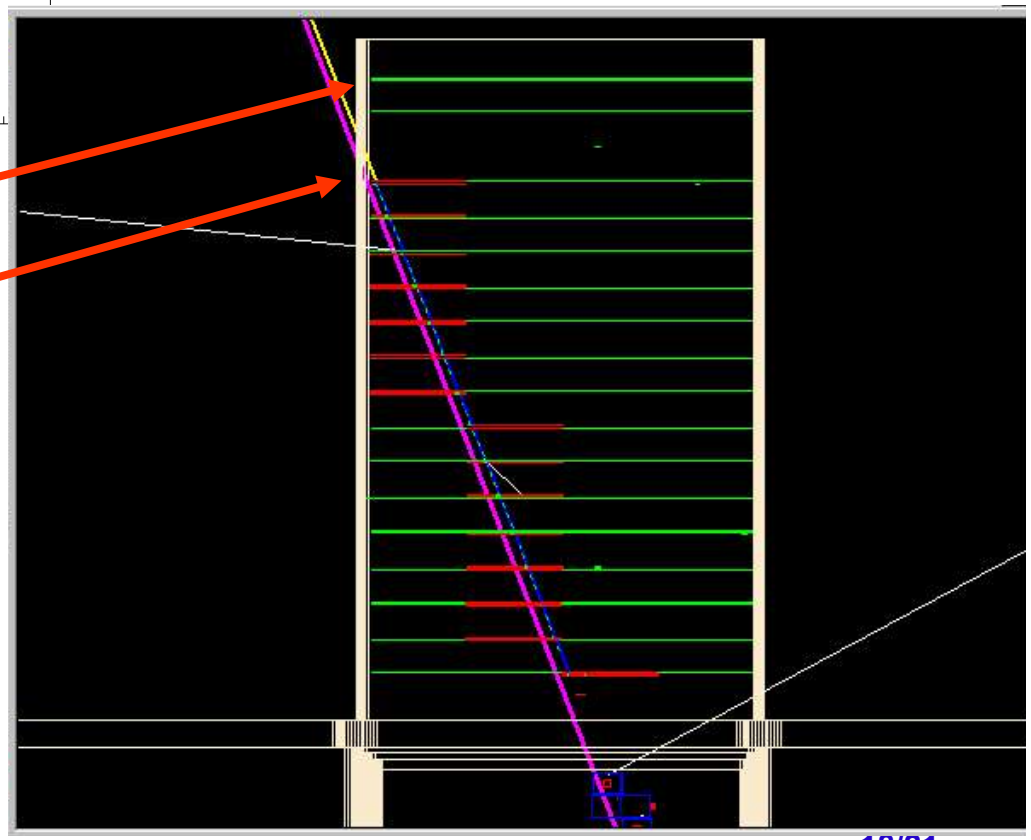
Probably that hit is made by noise

The simulated noise is

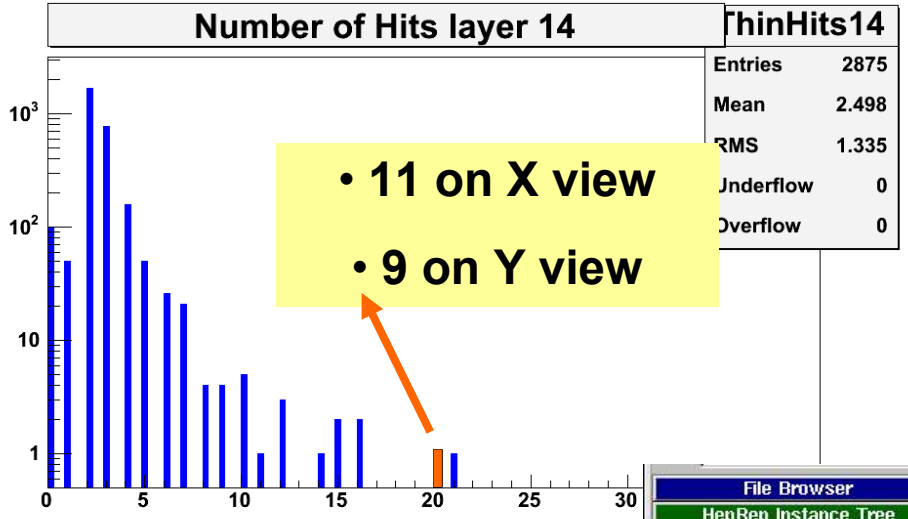
5×10^{-5} per strip

So for one tower we have:
$5 \times 10^{-5} \times 1536 \times 36 \sim 3$ strip

Strip per layer Layer per tower



Tails of hits multiplicity

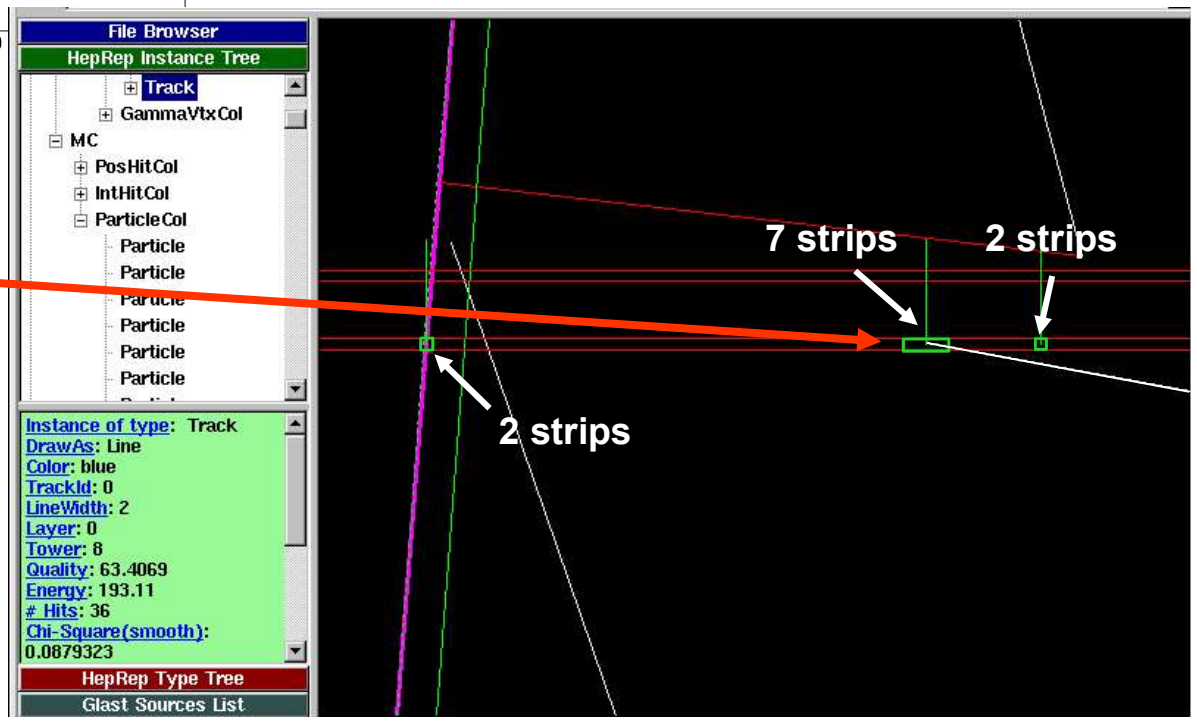


- 11 on X view
- 9 on Y view

We had looked for events that have more than 15 hit per layer. We consider layer 14, we can see with FRED this event with 20 hits

This is a electron Bremsstrahlung gamma of 2.2 MeV. Tha gamma maybe makes Compton scattering in the Si

(Thanks Tracy for suggest how to view this!)



Summary

- Helped to debug some of the data analysis tools
  - Use “friends” within ROOT, HippoDraw, FRED
- Helped to prepare the Instrument Data Analysis Primer
- Became more familiar with
  - data analysis variables and
  - LAT geometry
- Develop preliminary cuts to identify a MIP using a single LAT tower

- Future work
  - Bring experience back to Perugia
  - Get ready to apply all that with real data

Acknowledgements

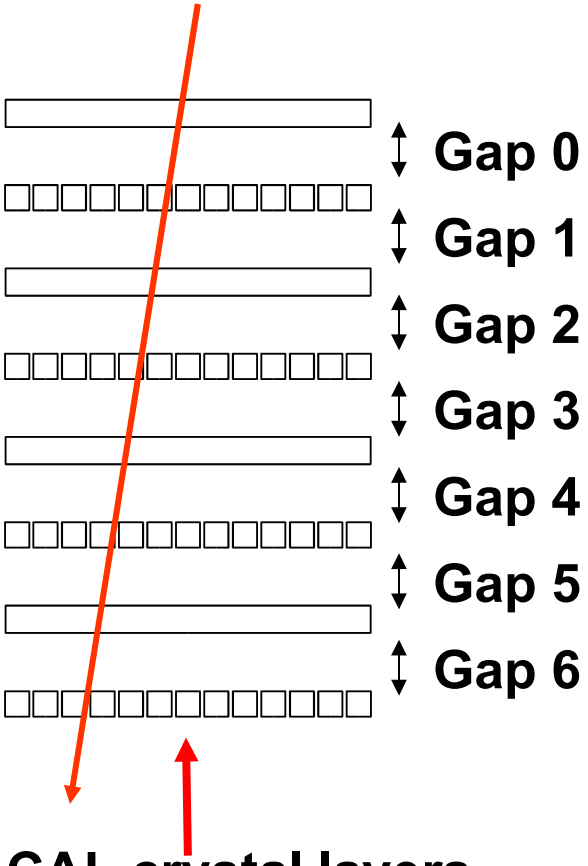
- **Eduardo** (Thanks, Thanks, Thanks)
- **Anders** (Thanks, Thanks)
- **Riccardo** (Thanks)
- **Paul** (Thanks)

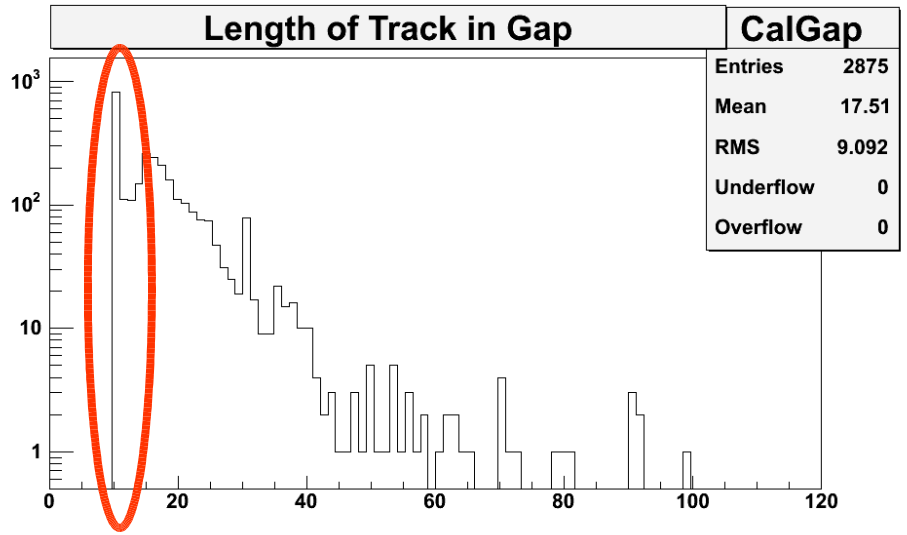
and all I&T group

Backup slides

Cal tower gap

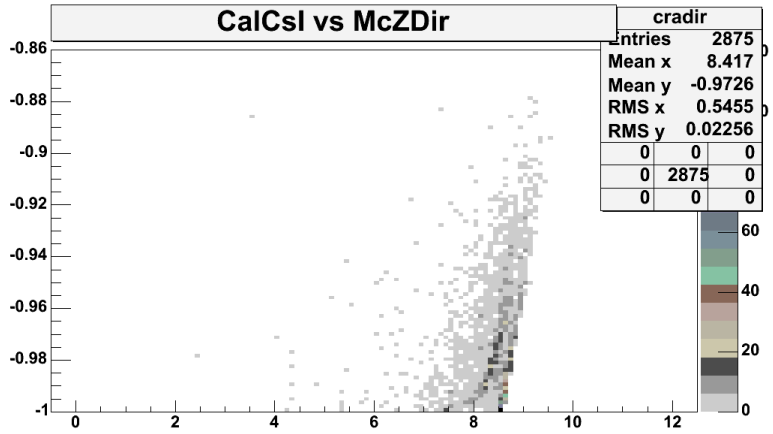
$$\text{CalTwrGap} = \sum_{i=0}^{6} Gap_i$$

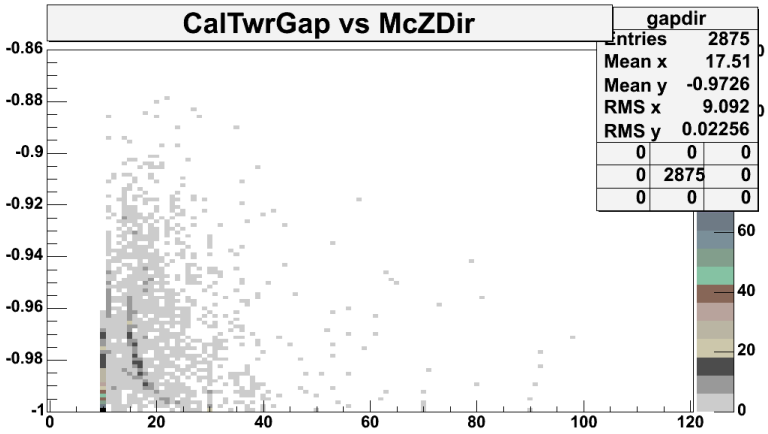


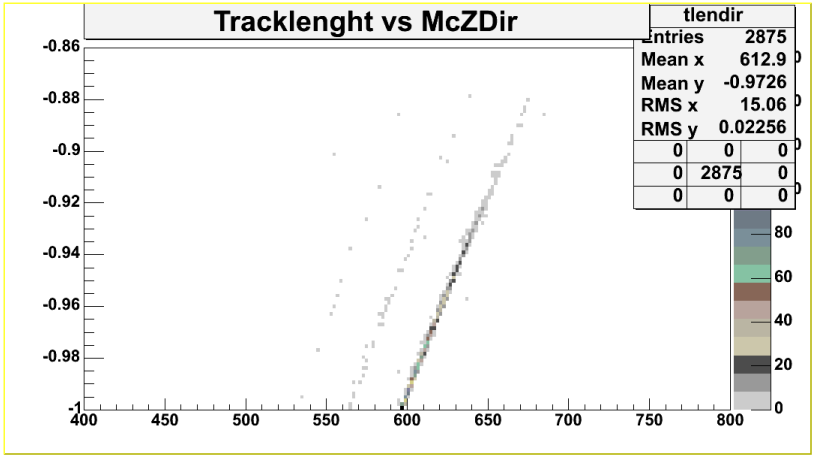


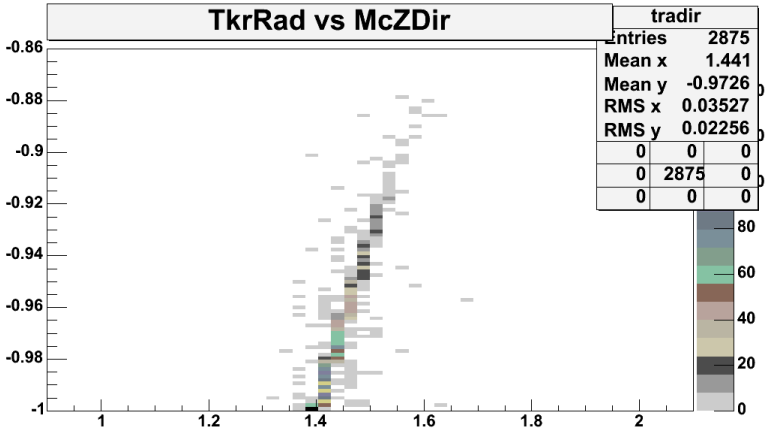
- Each gap is about 1.5 mm and we expect value of ~11 mm

Angular dependence

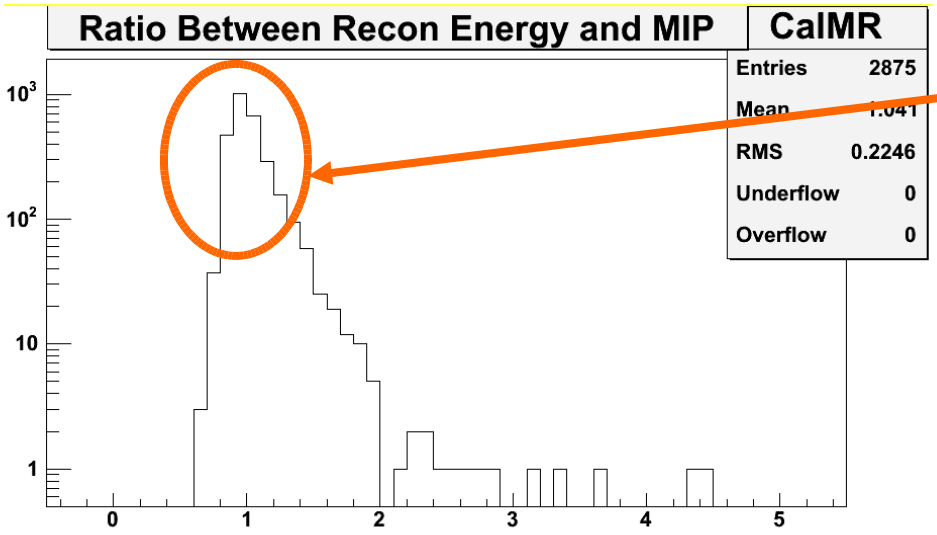








MIP variables



This is the ratio between measured energy and expected for a MIP, so we expected 1.

This is the difference between measured energy and expected for MIP and we have to have 0.