SDHCAL software status

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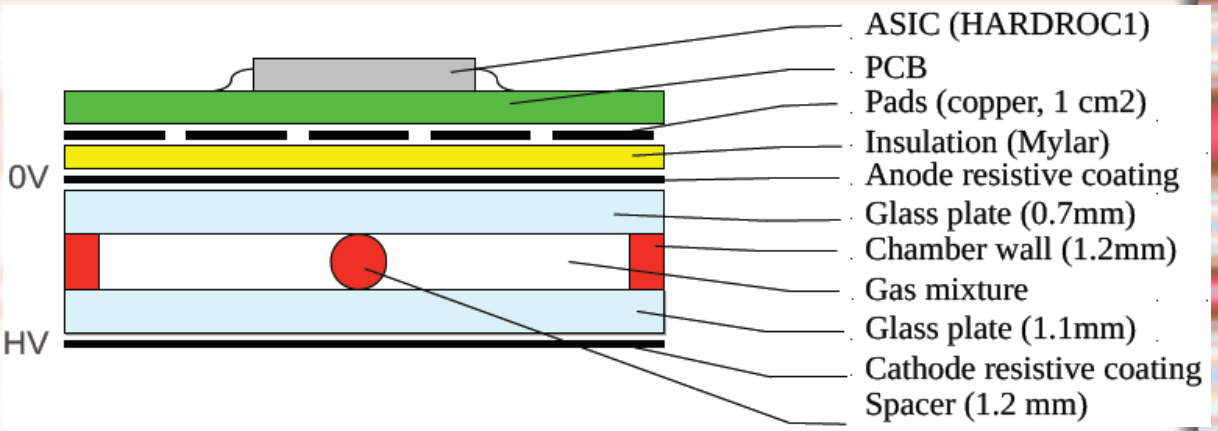
Mokka simulation

Available in ilcsoft v01-11 :

- **GRPC with detailed implementation**



Tracking of a Geantino through the RPC

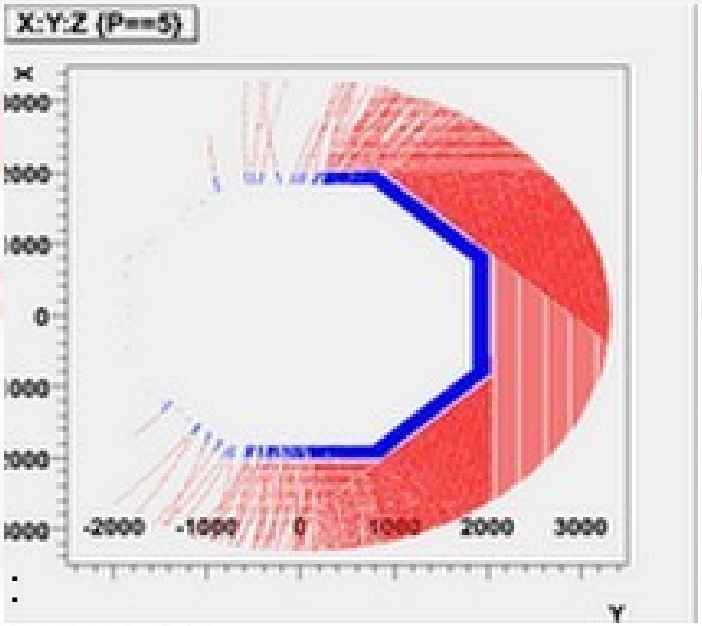
1	-844	-1.9e+03	365	4e+04	0	2.11e+03	2.11e+03	BarrelHcalModule	Transportation
2	-853	-1.92e+03	369	4e+04	0	21.8	2.13e+03	physiRPCFree	Transportation
3	-853	-1.92e+03	369	4e+04	0	0.402	2.13e+03	physiRPCmylarCathode	Transportation
4	-853	-1.92e+03	369	4e+04	0	0.196	2.13e+03	physiRPCGraphiteCathode	Transportation
5	-853	-1.92e+03	369	4e+04	0	0.0544	2.13e+03	physiRPCThickGlass	Transportation
6	-854	-1.92e+03	369	4e+04	0	1.2	2.13e+03	physiRPCGap	Transportation
7	-854	-1.92e+03	370	4e+04	0	1.31	2.14e+03	physiRPCThinGlass	Transportation
8	-855	-1.92e+03	370	4e+04	0	0.761	2.14e+03	physiRPCGraphiteAnode	Transportation
9	-855	-1.92e+03	370	4e+04	0	0.0544	2.14e+03	physiRPCmylar	Transportation
10	-855	-1.92e+03	370	4e+04	0	0.0544	2.14e+03	physiRPCPCB	Transportation
11	-855	-1.92e+03	370	4e+04	0	1.31	2.14e+03	physiRPCElectronics	Transportation
12	-856	-1.93e+03	370	4e+04	0	1.74	2.14e+03	BarrelHcalModule	Transportation

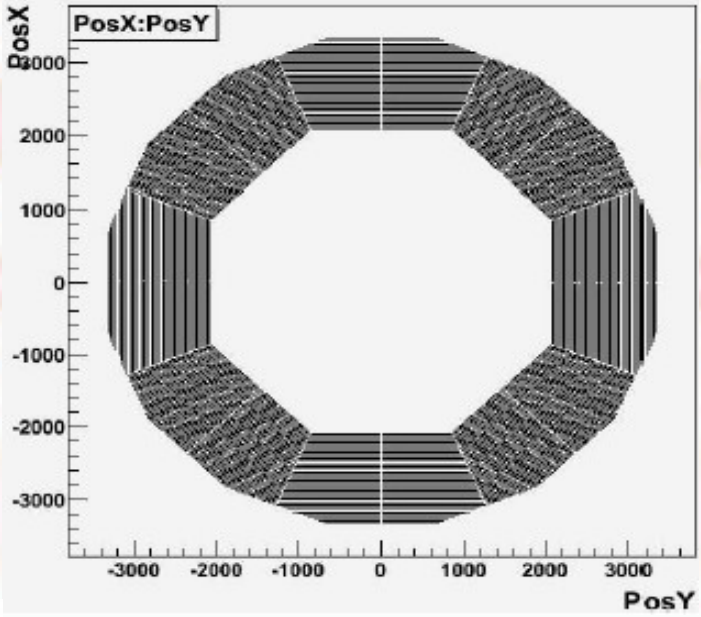
Mokka simulation

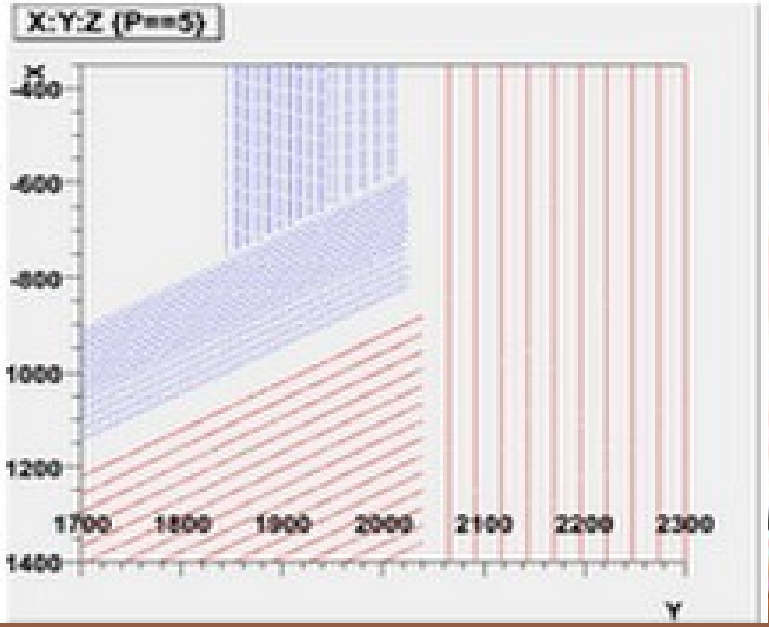
Available in ilcsoft v01-11 :

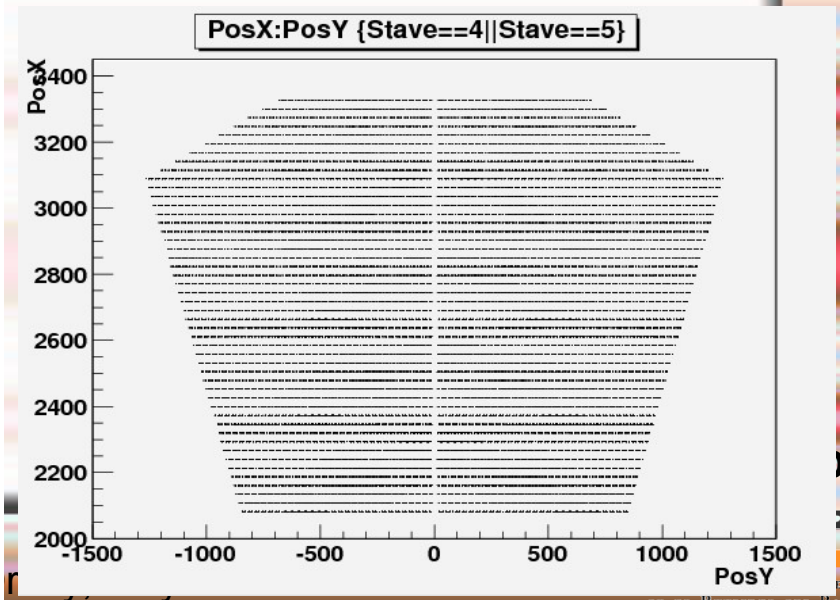
- GRPC with detailed implementation
- **GRPC sensitive detector with Videau barrel geometry or TESLA barrel geometry**

Hit position withsingle muon :









Mokka simulation

Available in ilcsoft v01-11 :

- GRPC with detailed implementation
- GRPC sensitive detector with Videau geometry or TESLA geometry
- **Easy to choose between geometries and options**

In the steering file for Mokka :

```
/Mokka/init/detectorModel ILD_01pre00
/Mokka/init/EditGeometry/rmSubDetector ShcalSc03
#TESLA GEOMETRY
/Mokka/init/EditGeometry/addSubDetector SHcalRpc02 110
#VIDEAU GEOMETRY
#/Mokka/init/EditGeometry/addSubDetector SHcalRpc01 110

#For TESLA GEOMETRY, CAN CHOOSE BETWEEN DETECTORS
#/Mokka/init/globalModelParameter Hcal_sensitive_model scintillator
/Mokka/init/globalModelParameter Hcal_sensitive_model  SDRPC
/Mokka/init/globalModelParameter Hcal_cells_size 10
```

Mokka simulation

Available in ilcsoft v01-11 :

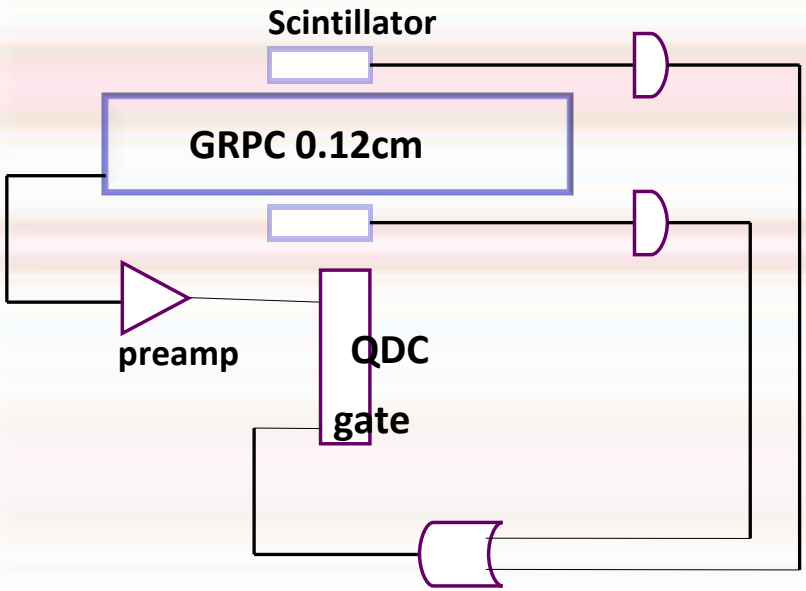
- GRPC with detailed implementation
- GRPC sensitive detector with Videau barrel geometry or TESLA barrel geometry
- Easy to choose between geometries ans options

Missing item :

- Endcaps and Endcap Rings still with scintillators in all cases.
  - Work started to put GRPC there too.
  - Code written locally
  - Not yet debugged
- No cables nor services in simulation (not a big effect for Videau geometry).

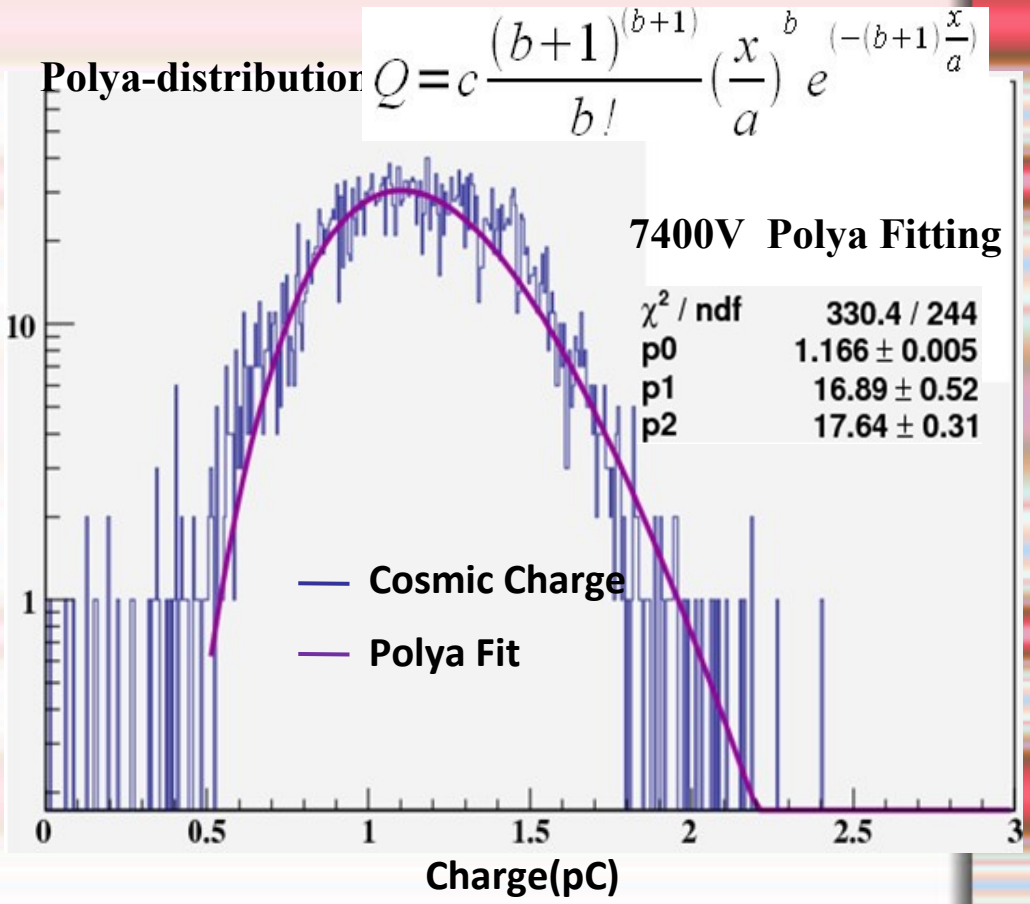
Digitisation

- Transform GEANT4 deposited energy to induced charge.
  - Measure GRPC Analog signal with cosmic muon



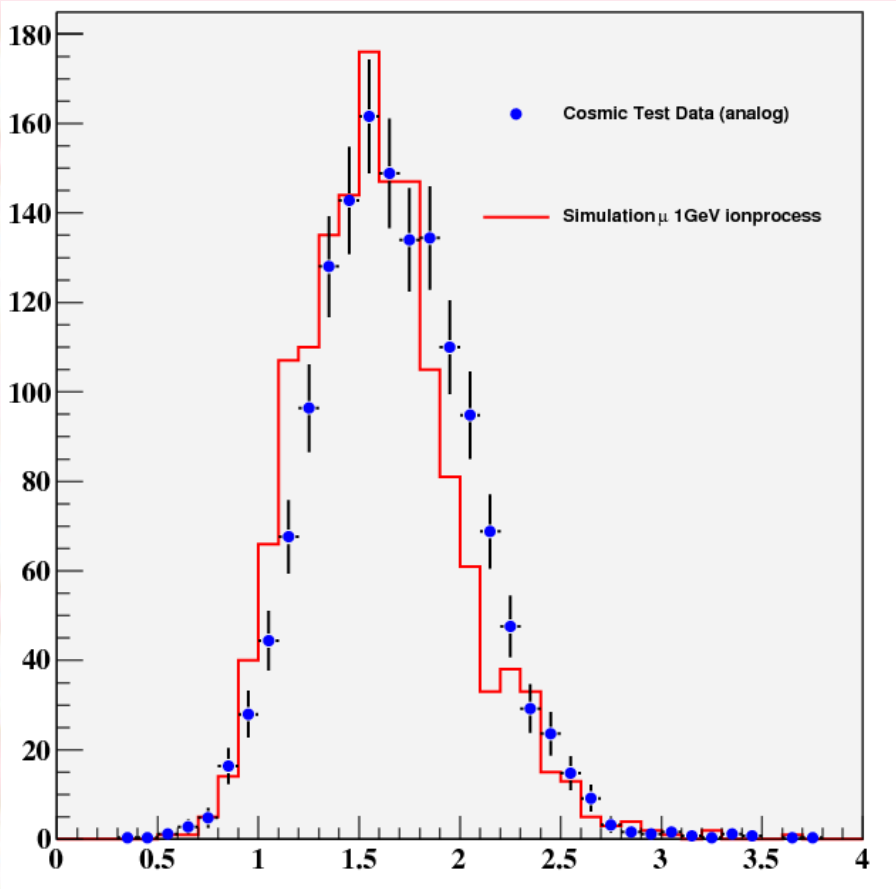
Charge Spectrum Cosmic Test Set Up
64 Channels, trigger area < Channel area
Analog readout

$$Q = c\frac{(b+1)^{(b+1)}}{b!}\left(\frac{x}{a}\right)^{b} e^{(-(b+1)\frac{x}{a})}$$



Digitisation

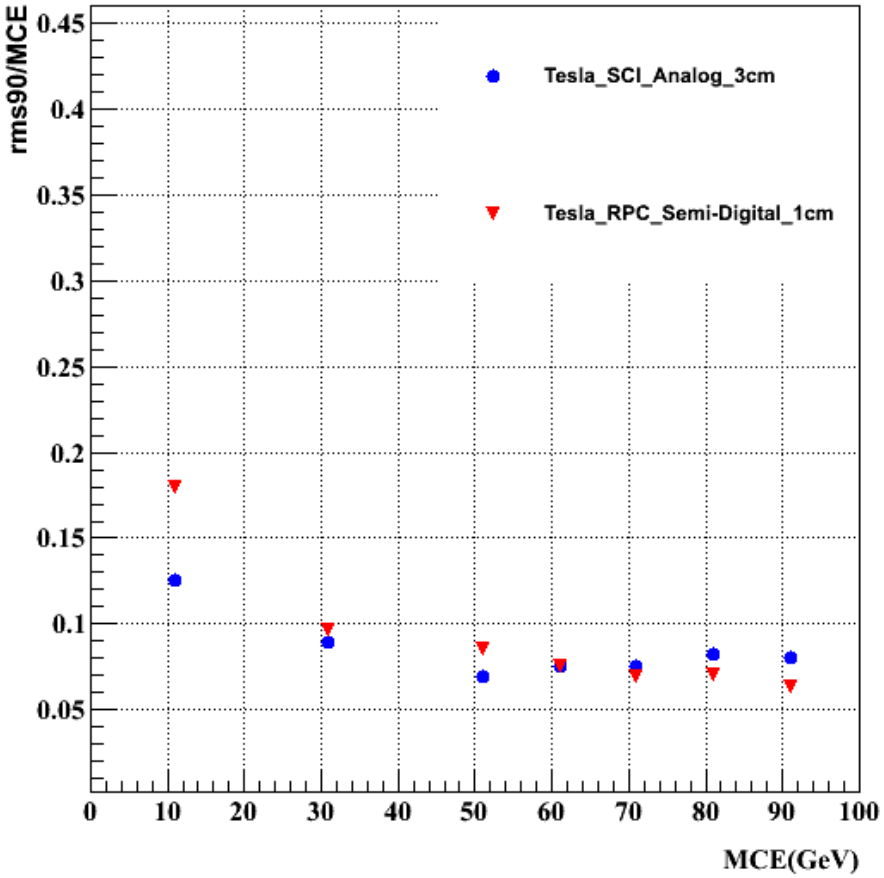
- Transform GEANT4 deposited energy to induced charge.
  - Measure GRPC Analog signal with cosmic muon
  - **Simulate it in Marlin Processor and compare with data**

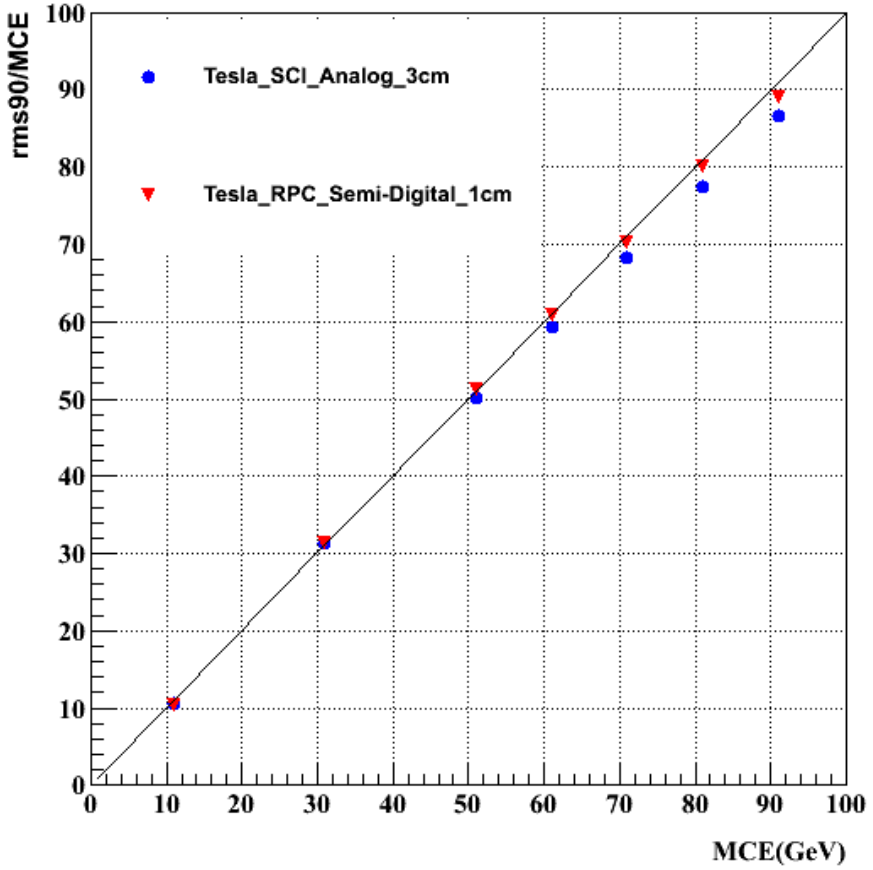


$$Q = c\frac{(b+1)^{(b+1)}}{b!}\left(\frac{x}{a}\right)^{b} e^{(-(b+1)\frac{x}{a})}$$

Digitisation

- Transform GEANT4 deposited energy to induced charge.
  - Measure GRPC Analog signal with cosmic muon
  - Simulate it in Marlin Processor and compare with data
  - **The Marlin Processor can also simulate the 3 thresholds.**
  - **Calibrate the 3 Thresholds with single K^0_L and Pandora.**
  - **Pandora made compatible with Videau geometry.**



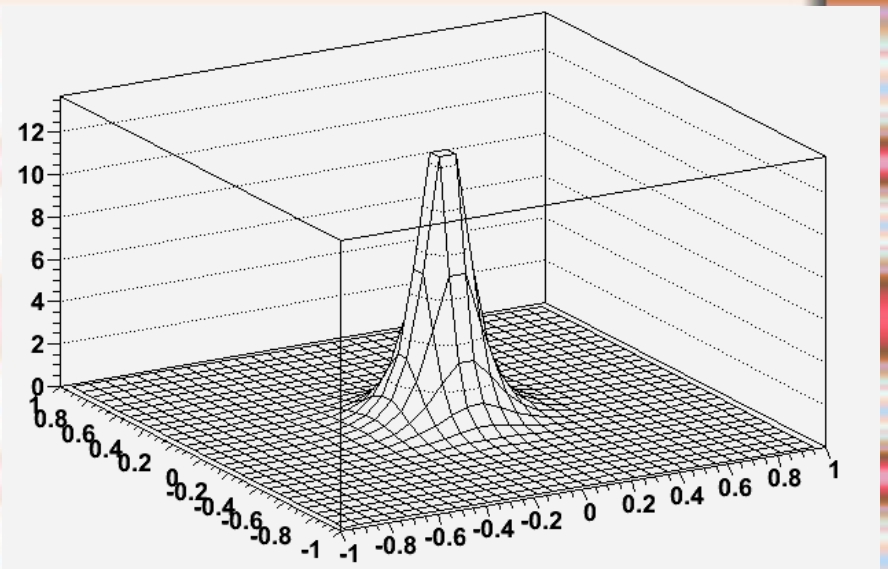


Multiplicity

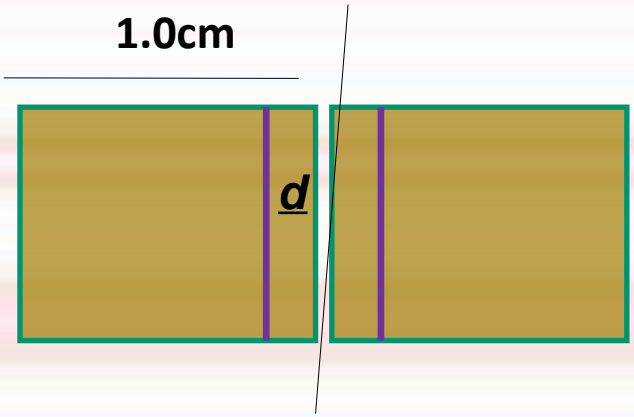
- **Spread of the induced charge**

KIRK T. MCDONALD's lecture

$$\sigma(x,y) = c\frac{-q}{2a}\frac{1}{\cosh\left(\pi\frac{\sqrt{(x-x_0)^2+(y-y_0)^2}}{a}\right)}$$



At low order, equivalent to a 2D gaussian with width $\frac{\sqrt{2}\,a}{\pi}$

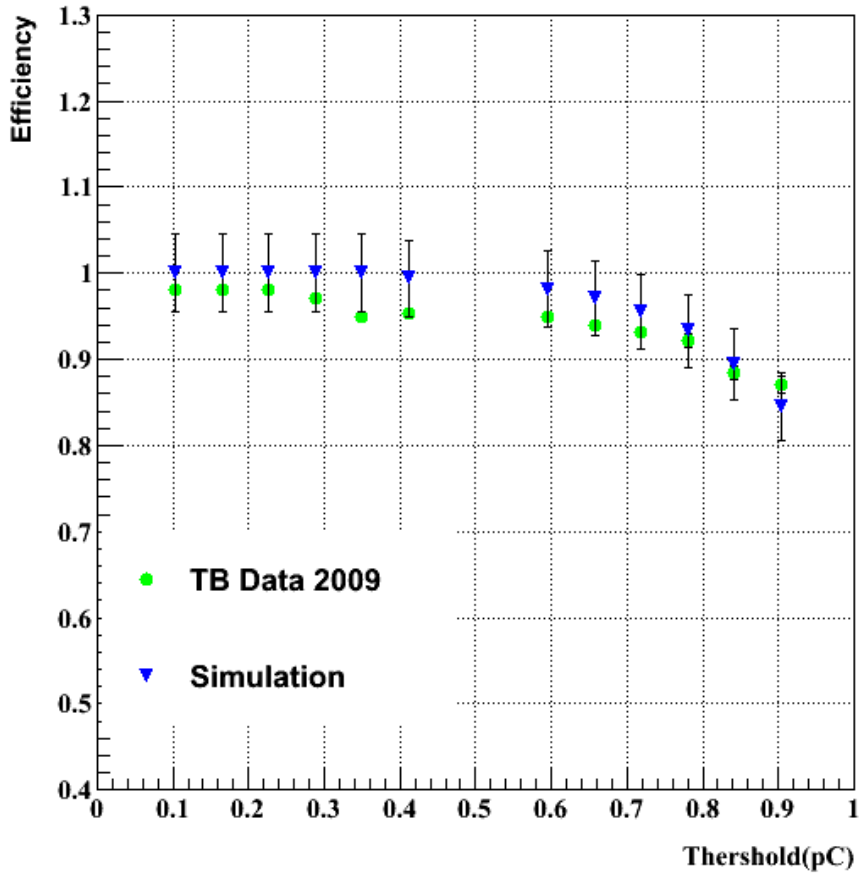


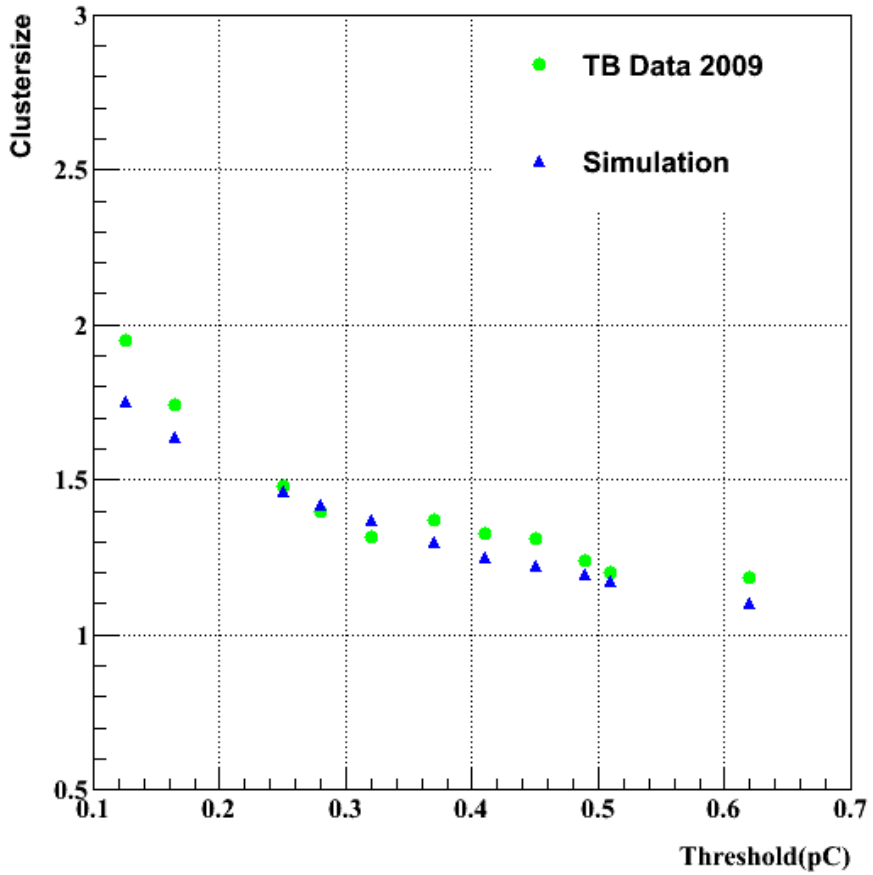
Dispatching induced charge on more than one cell for tracks on the cell border.
Parameter a tuned to data

Multiplicity

- Spread of the induced charge
  - **Dispatching of induced charge in more than one cell**

Comparison between standalone GEANT4 program (not Mokka) and data : it works





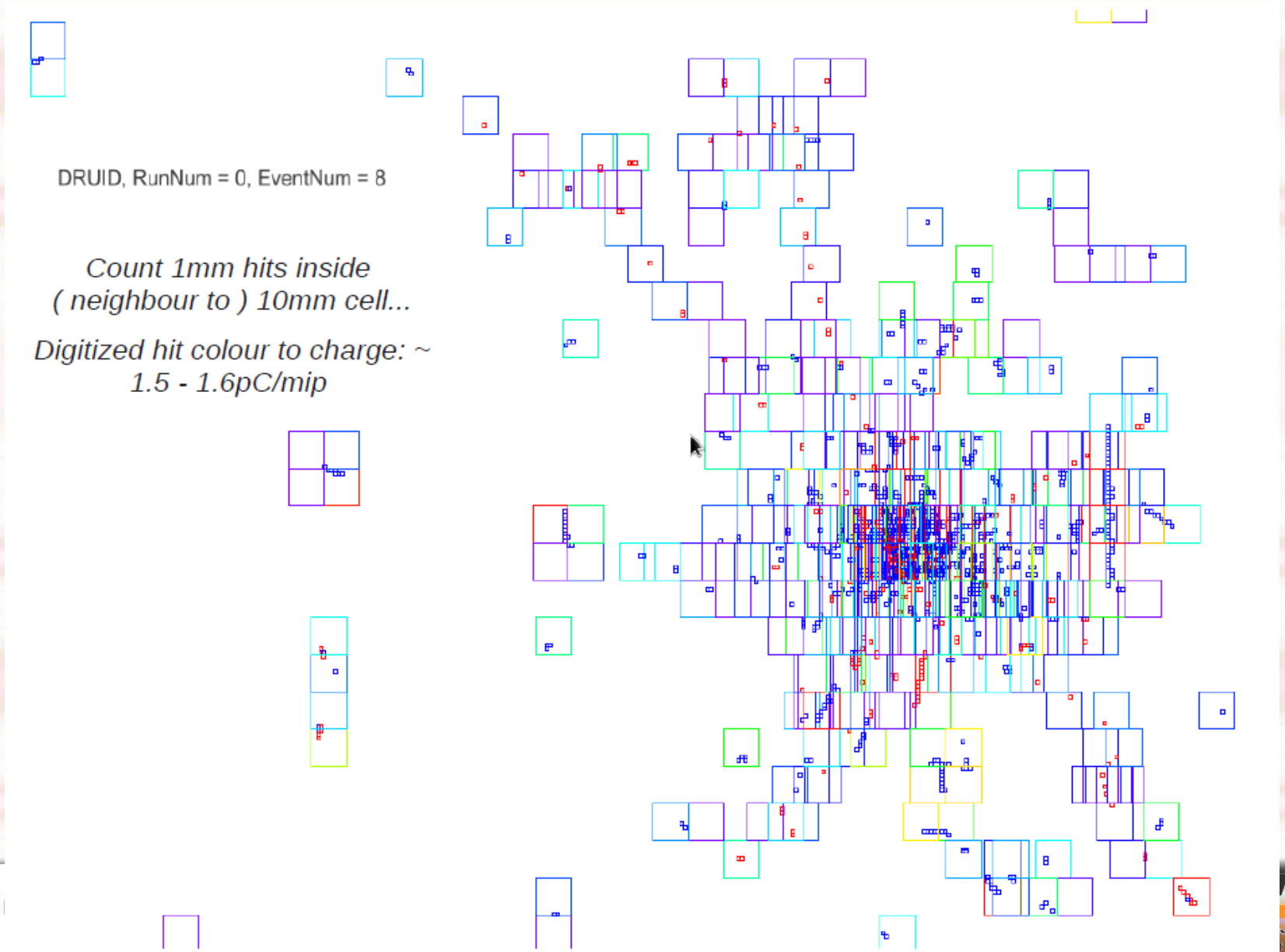
(note : standalone GEANT4 protoype simulation produces LCIO files)

Multiplicity

- Spread of the induced charge
  - Dispatching of induced charge in more than one cell
  - **Implementation in Marlin, need track position inside the cell :**
    - wait for LCIO v2
    - Randomly draw track position inside the Cell (Marlin Processor written)
    - Mokka simulation with $1mm^2$ cells and rebuild $1cm^2$ cells in Marlin (Marlin processor written)

Multiplicity

- Dispatching of induced charge in more than one cell
  - **Implementation in Marlin, need track position inside the cell :**
    - **Mokka simulation with 1mm^2 cells and rebuild 1cm^2 cells in Marlin (Marlin processor written)**



Multiplicity

- Dispatching of induced charge in more than one cell for tracks on the cell border

Options		pros	cons
Marlin processor	Wait for LCIO v2	•Flexible, •Realistic, •Tested against data.	•Not written •Size of Mokka output (detailed shower+position)
	Random draw of track position	•Marlin processor exists	•Not exactly right. •Not yet tested against data •Size of Mokka output (detailed shower)
	$1mm^2$ simulation	•Marlin processor exists •Size of Mokka output kept low •Tuned to reproduce mean data multiplicity and mean hit efficiency. •Can be used for GEM,μMEGAS,...	•Not yet fully tested against data. •Change of geometry while running Marlin (GEAR?)
Mokka	Perform it in simulation	•Tested against data for many thresholds. •Size of Mokka output low •Can simulate with the right cell size	•Energy to induced charge should also be put there. •No flexibility to retune parameters. •Code not yet ported to Mokka.

Analysis tools

- **Marlin processors written :**
  - **Use of PandoraPFANew**
    - Code have been updated to deal with Videau geometry
    - Some other minor stuff to implement (gap between modules)

Analysis tools

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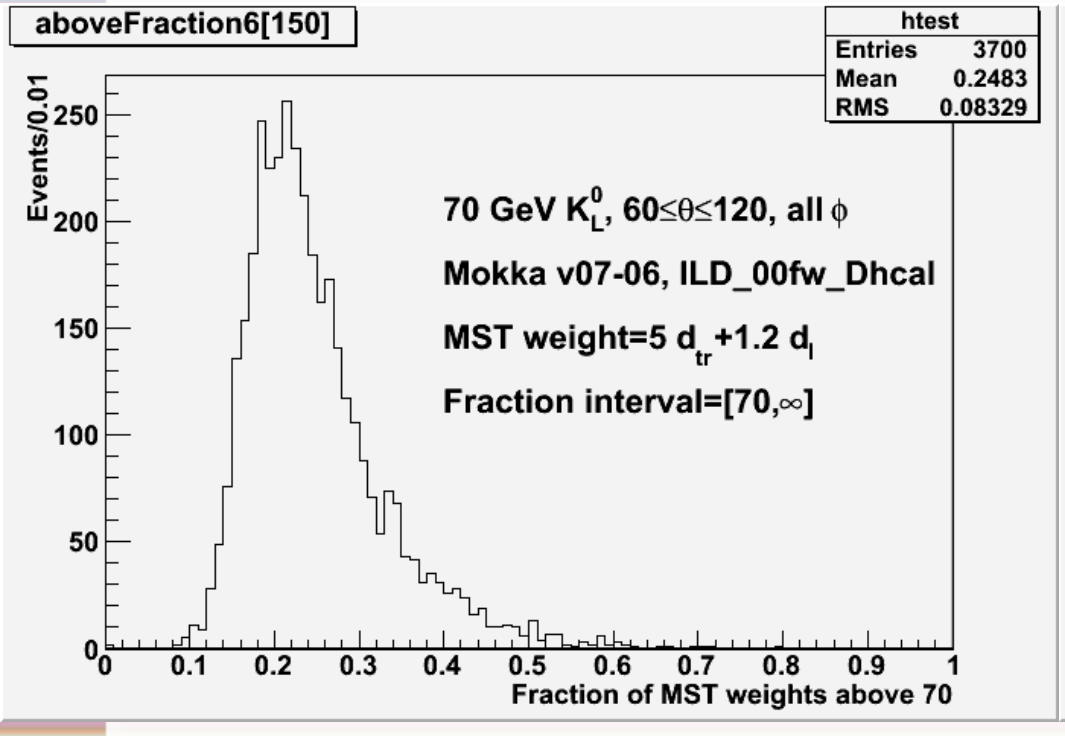
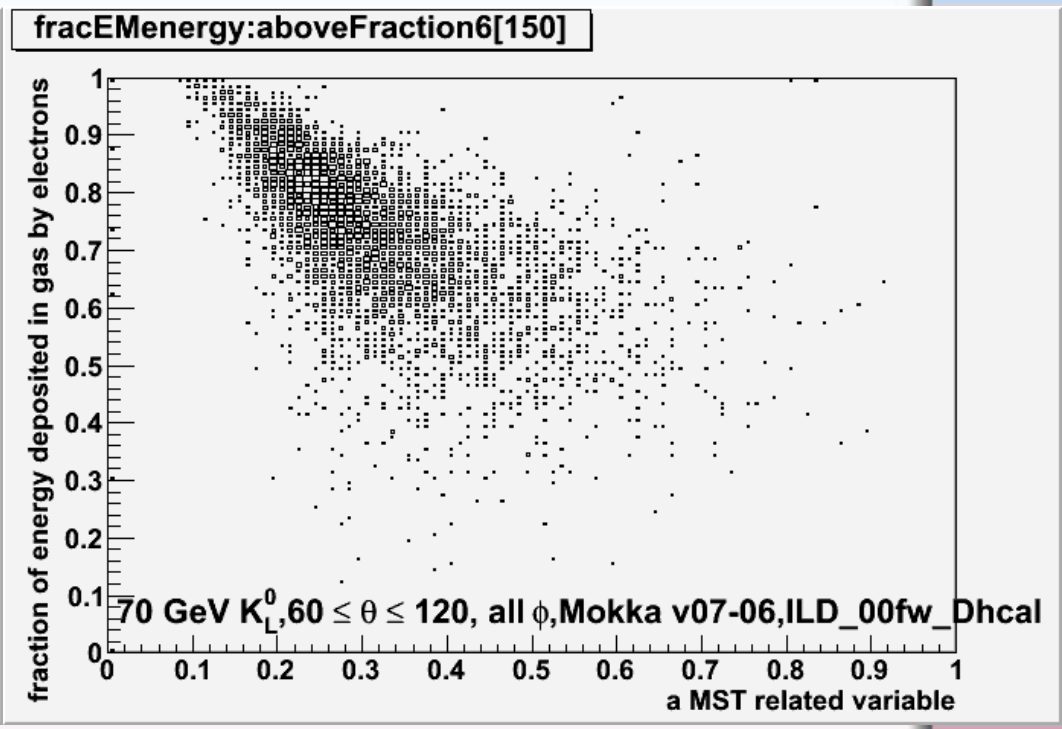
  - Use of PandoraPFANew
    - Code have been updated to deal with Videau geometry
    - Some other minor stuff to implement (gap between modules)
  - **Minimum Spanning Tree**

For PID and Energy Estimation

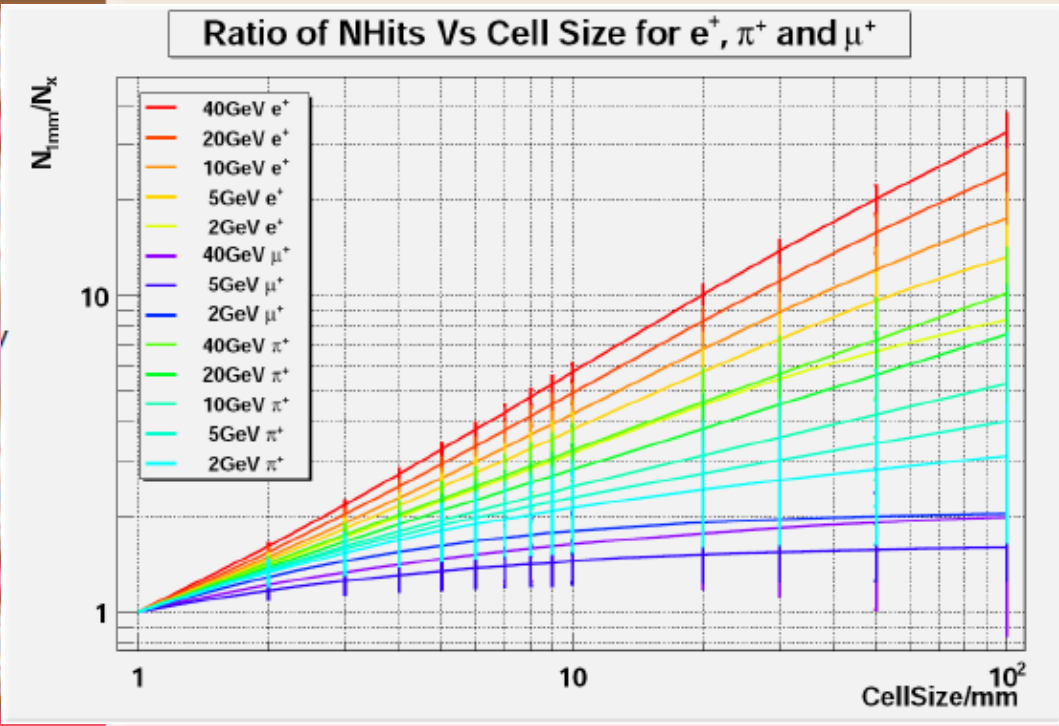


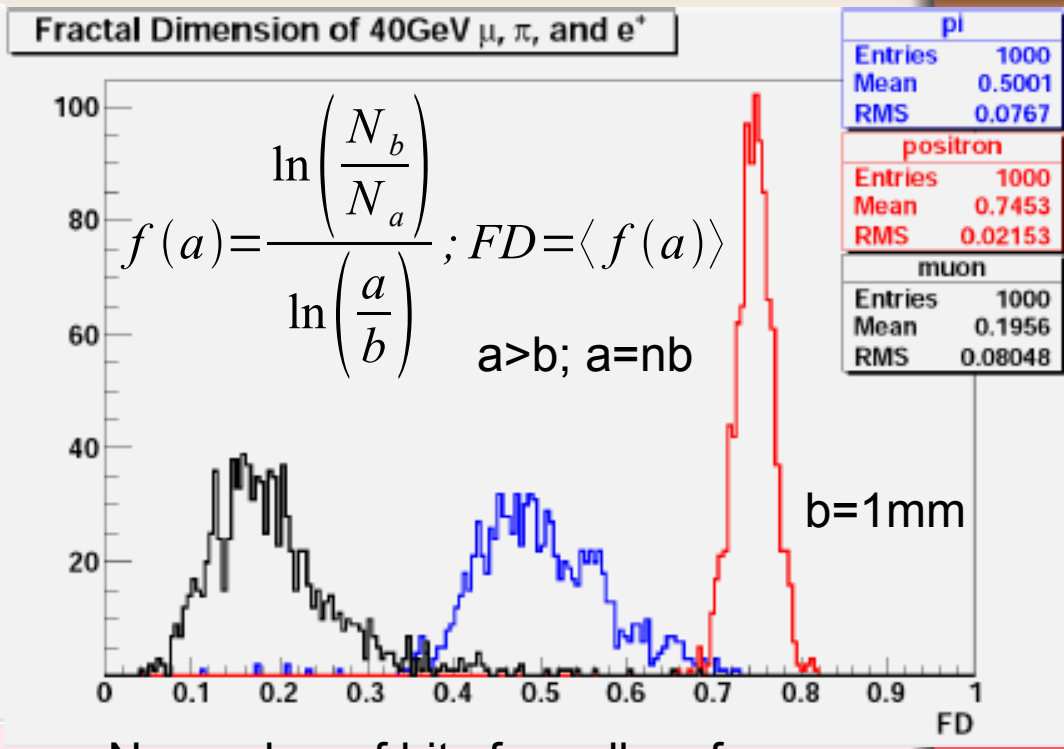


Analysis tools

- **Marlin processors written :**
  - Use of PandoraPFANew
    - Code have been updated to deal with Videau geometry
    - Some other minor stuff to implement (gap between modules)
  - Minimum Spanning Tree
  - **Fractal Dimension**

For PID and Energy Estimation





N_a number of hits for cell surface = a

PID performance :

b=1mm

1mm	e+	u	h
e+	998	0	2
u	1	994	5
h	15	14	971

b=10mm

10mm	e+	u	h
e+	1000	0	0
u	0	995	5
h	17	14	969

Conclusion

- Geometry simulation :
  - **Barrel simulation ready, in Mokka and debugged**
  - **Endcap simulation : debug GRPC as sensitive detector.**
- Simulation of induced charge and threshold effects :
  - **Ready**
  - **Debugged**
  - **Tested against data**
- Multiplicity simulation:
  - **Physics understood**
  - **Tested against data**
  - **Technical solution to choose.**
- Reconstruction :
  - **Update of Pandora started.**
  - **Some advanced tools using SDHCAL fine granularity already developped.**
- Testbeam data :
  - **Testbeam DAQ produces LCIO files.**

For more details, see CALICE meetings talks :

- https://indico.cern.ch/getFile.py/access?contribId=41&sessionId=6&resId=1&materialId=slides&confId=136864
- http://indico.cern.ch/getFile.py/access?contribId=19&sessionId=5&resId=0&materialId=slides&confId=136864
- http://indico.cern.ch/getFile.py/access?contribId=28&sessionId=5&resId=0&materialId=slides&confId=136864