Status of the DHCAL Simulation

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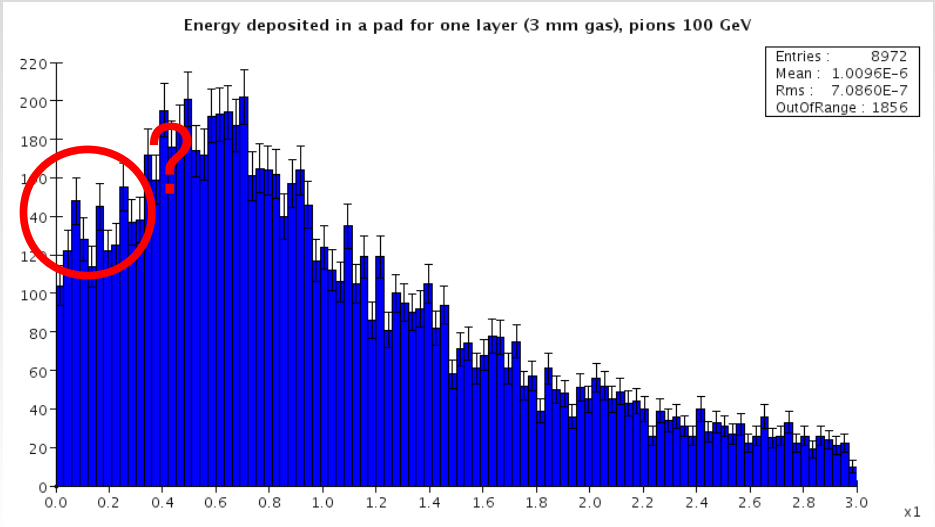
3 mm gas, 100 GeV pions

Energy deposited per pad for one layer

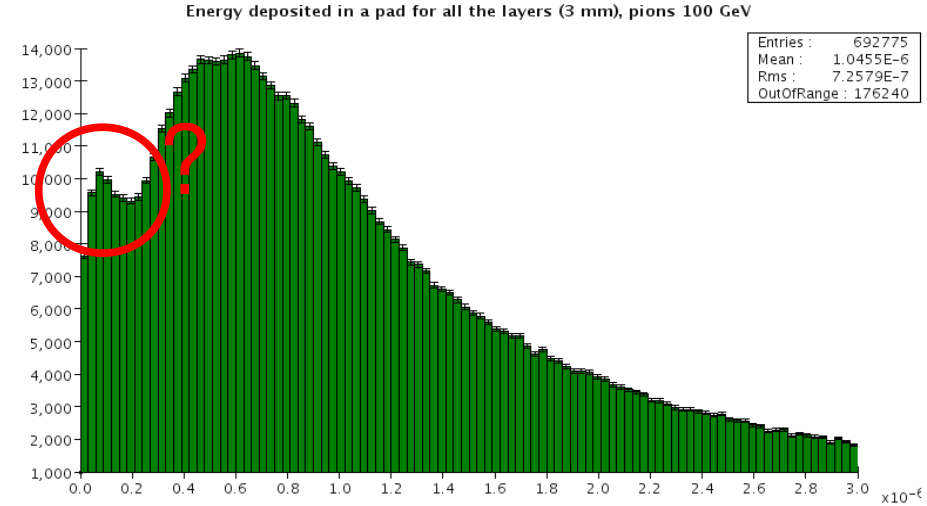


E (GeV)

Slic simulation toolkit was used
Calorimeter configuration:
- 80 planes (~ 9 λ)
- 1.9 cm steel absorber between planes
- μMegas like detector
  - 1 x 1 cm2 readout pads
  - 3 mm gas volume
    (95 % Argon + 5 % Isobutane)

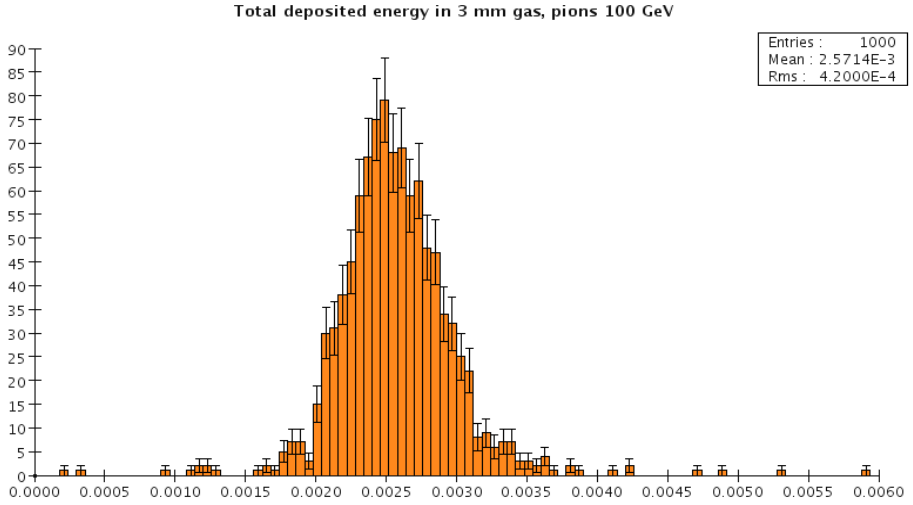
A strange peak in the MIP spectrum was found.

Energy deposited per pad for all layers



E (GeV)

Total deposited energy



E (GeV)

Test with muons

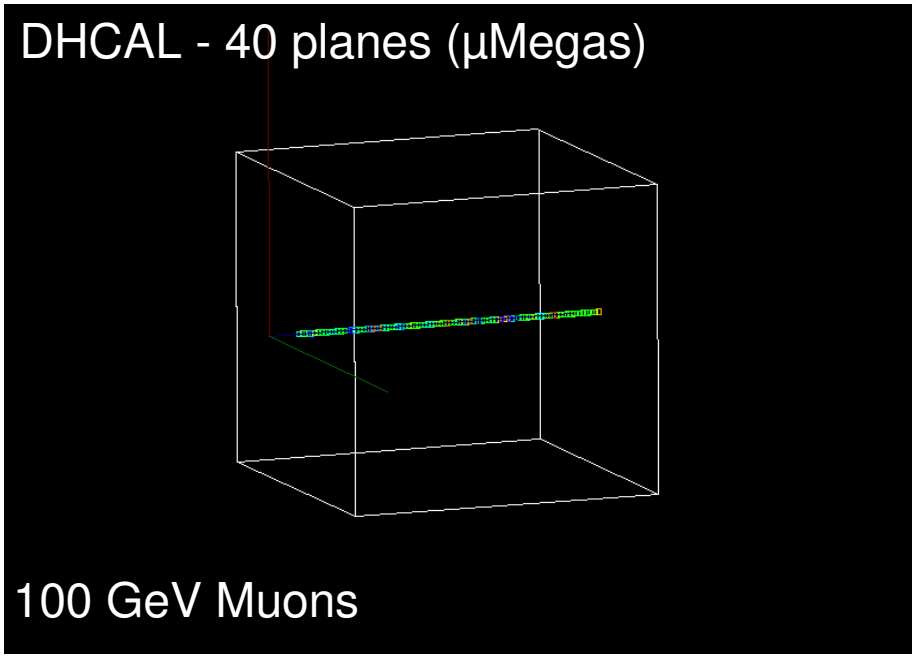
In order to find the origin of the strange peak in MIP spectrum we perform a detailed study with muons.

We consider only cleanest events:

- **one hit per pad per layer**
- **hit are far from pad boundary**

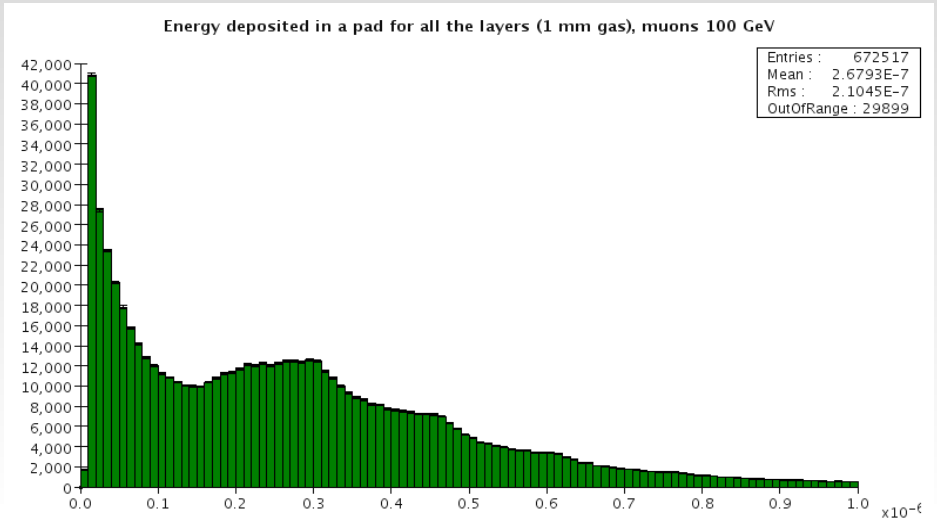
We change the thickness of gas:

- **1 mm**
- **3 mm (µMegas standard gas thickness)**
- **6 mm**
- **1 cm**



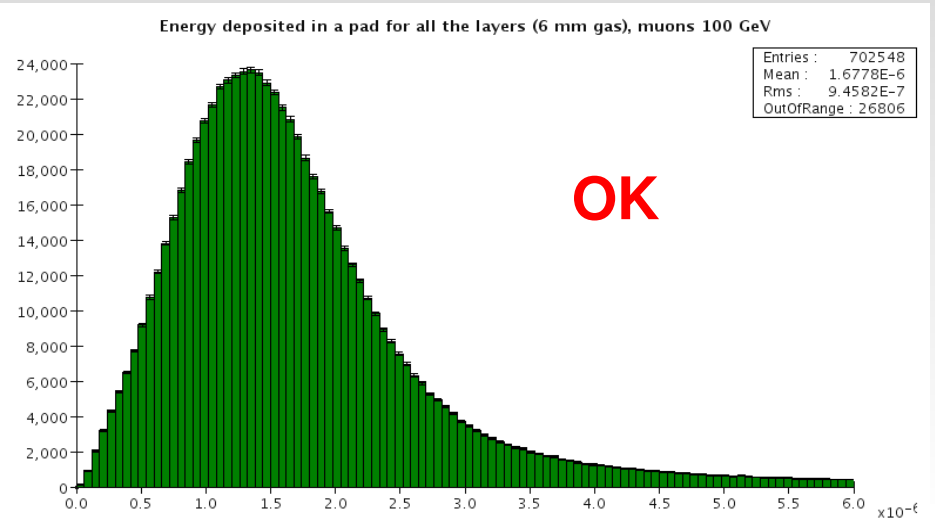
100 GeV muons

Energy deposited in 1 mm gas



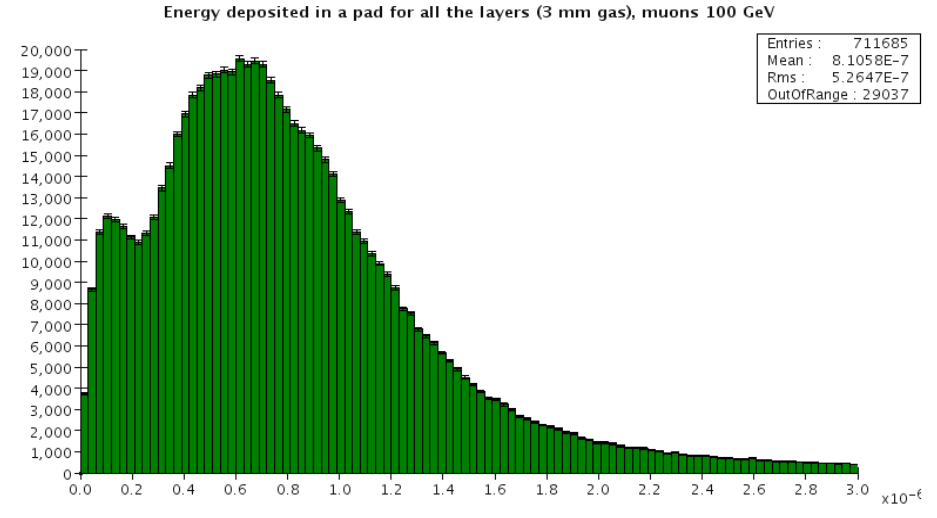
E (GeV)

Energy deposited in 6 mm gas



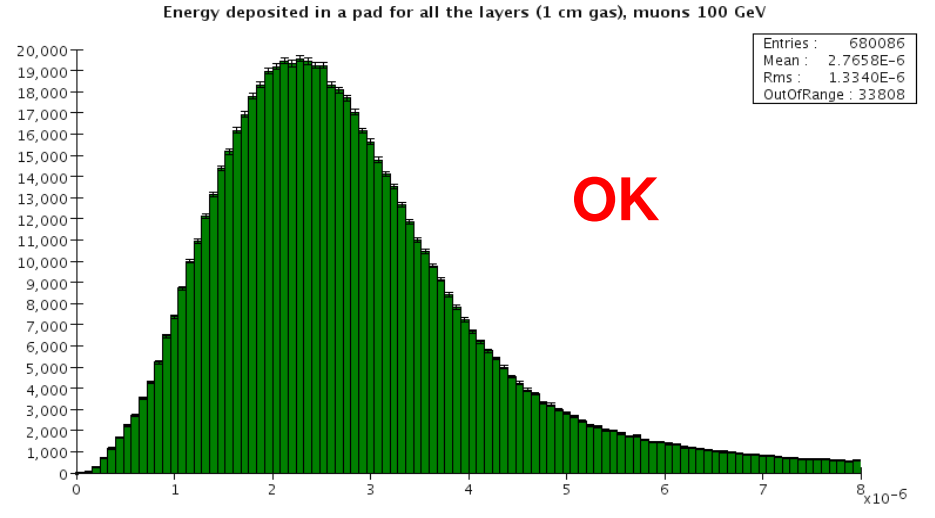
E (GeV)

Energy deposited in 3 mm gas



E (GeV)

Energy deposited in 1 cm gas



E (GeV)

Energy loss in Geant4

Energy loss in Gean4:

```
dE = <dE> + fluct
```

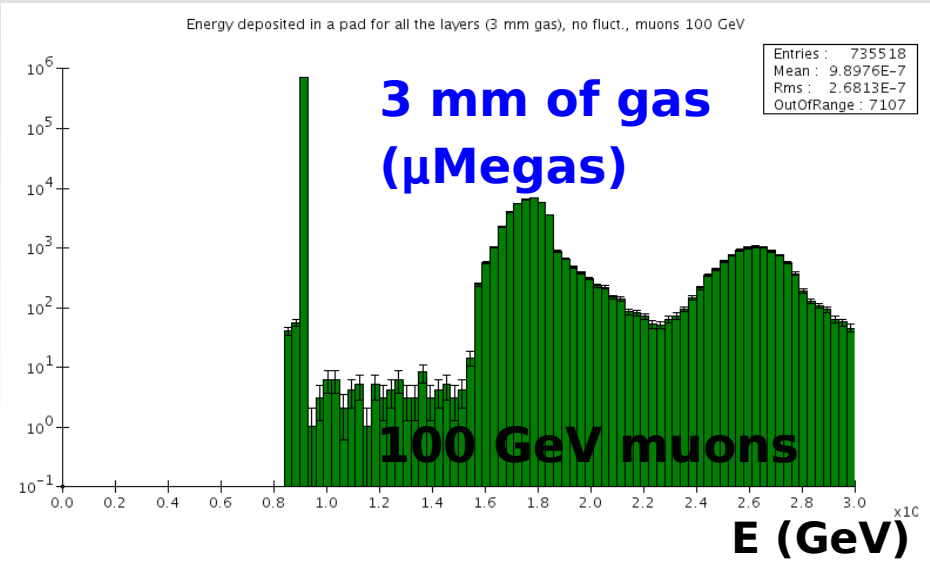
We can switch off the fluctuations interactively:

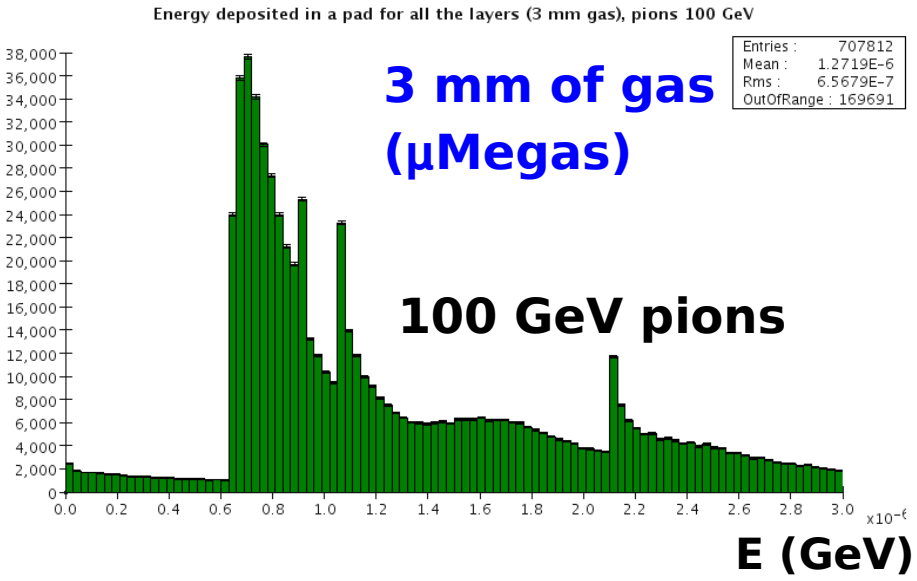
```
/process/eLoss/fluct        false
```

Mean energy loss <dE> is computed correctly, the problem is link to the computation of the fluctuations of energy loss

Correction must be done for thin gas volume

Deposited energy in all planes without fluctuations of energy loss





Proposed solution

The fluctuation model in Gean4 works well for typical sampling calorimeters with solid or liquid materials (sampling fraction about few %)

In case of gas we need to change some Geant4 parameters:

1. Default low limit of e- and gamma productions threshold from 1 keV to 1 eV. This can be done by modifying Physics List by adding the following line in the beginning of the SetCuts method:

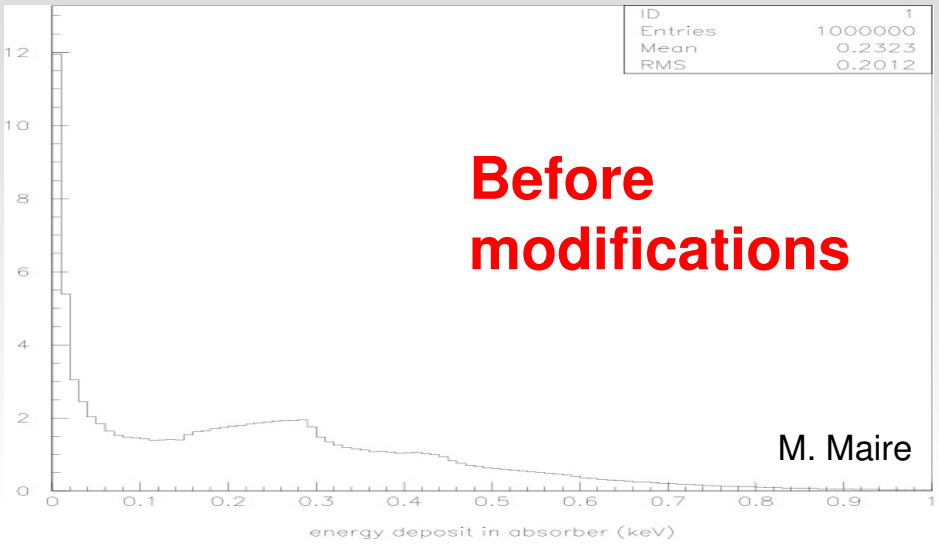
```
G4ProductionCutsTable::GetProductionCutsTable()
  ->SetEnergyRange(1.*eV,100*GeV);
```

2. Low value of cut in range
Solid/liquid: cut = 1/3*thickness
Solid/gas: cut = 1/30*thickness

```
/run/particle/setCut 0.1 mm
```

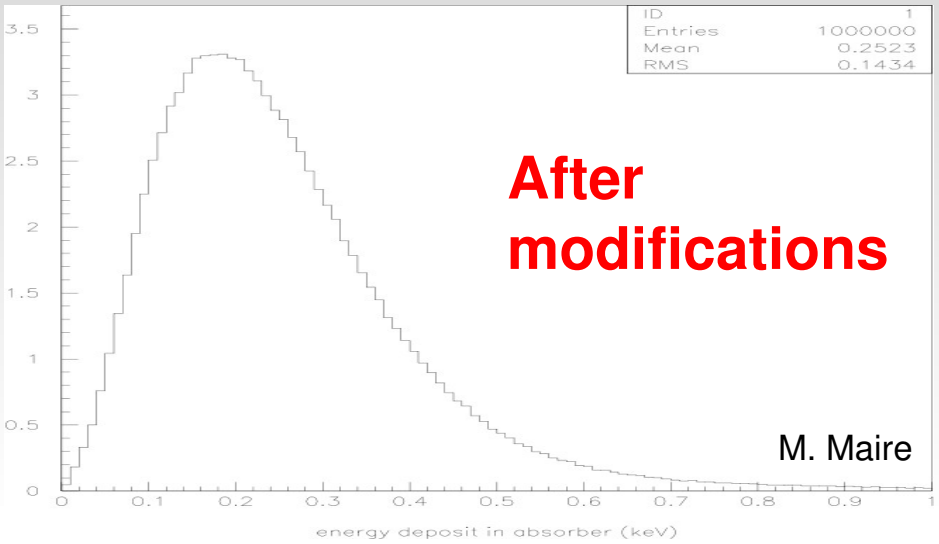
Test with Geant4, 100 GeV muons

Energy deposited in 1 mm gas



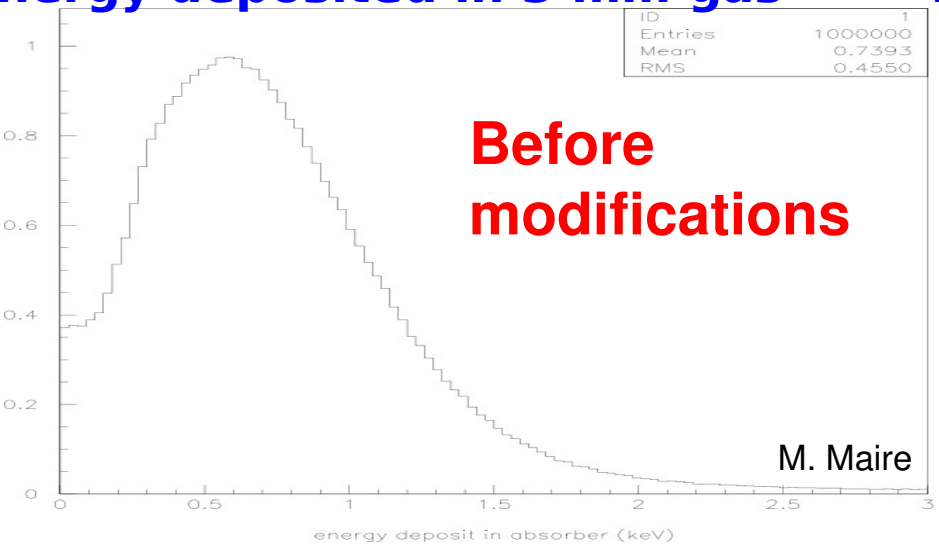
E (keV)

Energy deposited in 1 mm gas



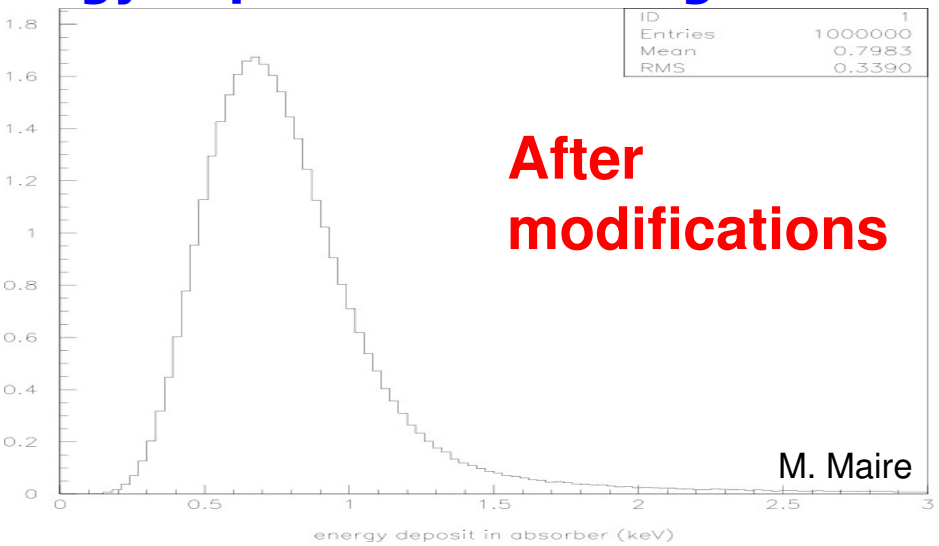
E (keV)

Energy deposited in 3 mm gas



E (keV)

Energy deposited in 3 mm gas



E (keV)

Modification is SLIC

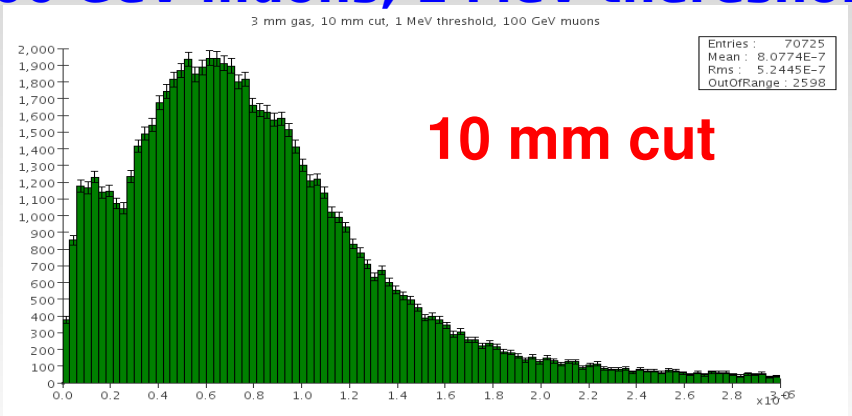
In the Slic framework, so far we use the default settings in lcdd file:

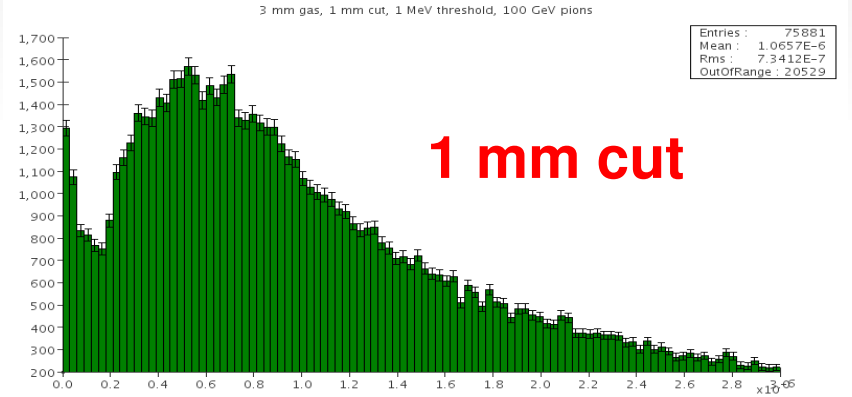
```
<regions>
  <region name="TrackingRegion" store_secondaries="true"
        cut="10" lunit="mm" threshold="1.0" eunit="MeV" />
</regions>
```

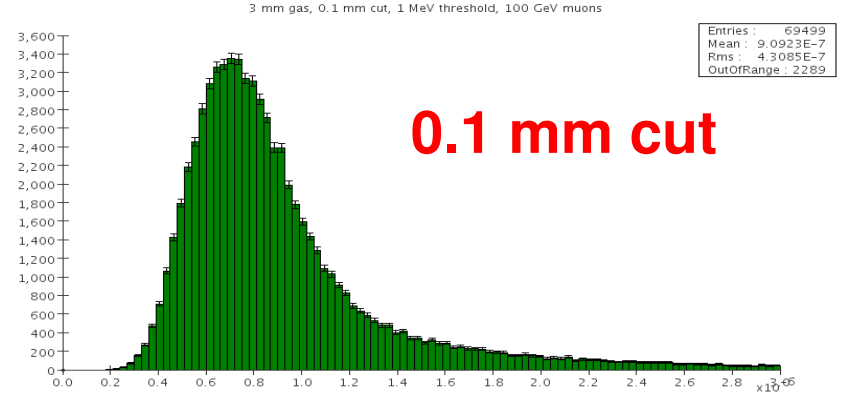
The values of the cut and threshold are not optimal for our detector. So we have tried to find out the best values with respect to the simulation precision and CPU time.

Deposited energy in 3 mm

100 GeV muons, 1 MeV thereshold

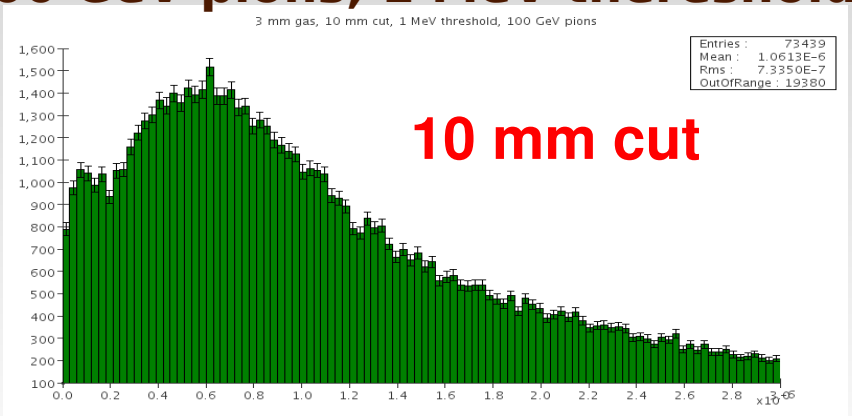


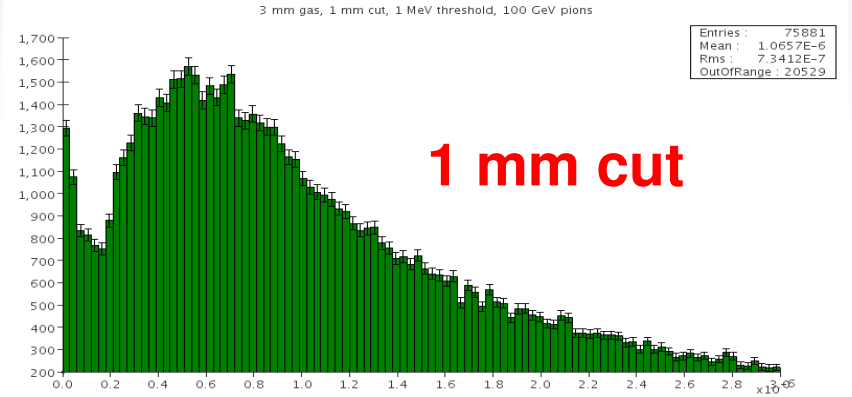


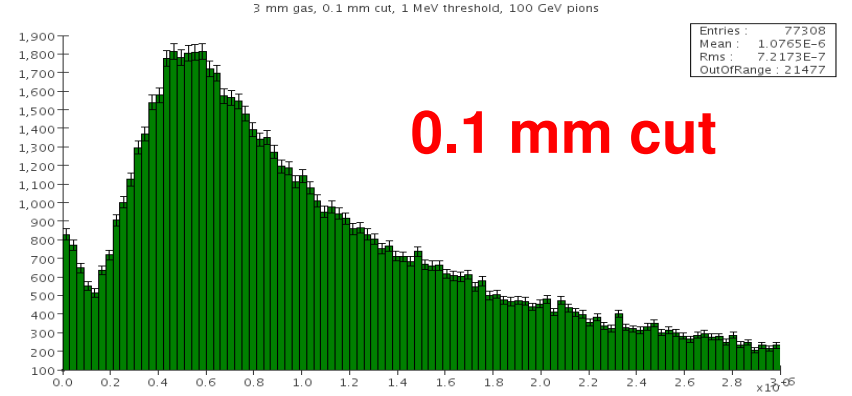


E (GeV)

100 GeV pions, 1 MeV thereshold



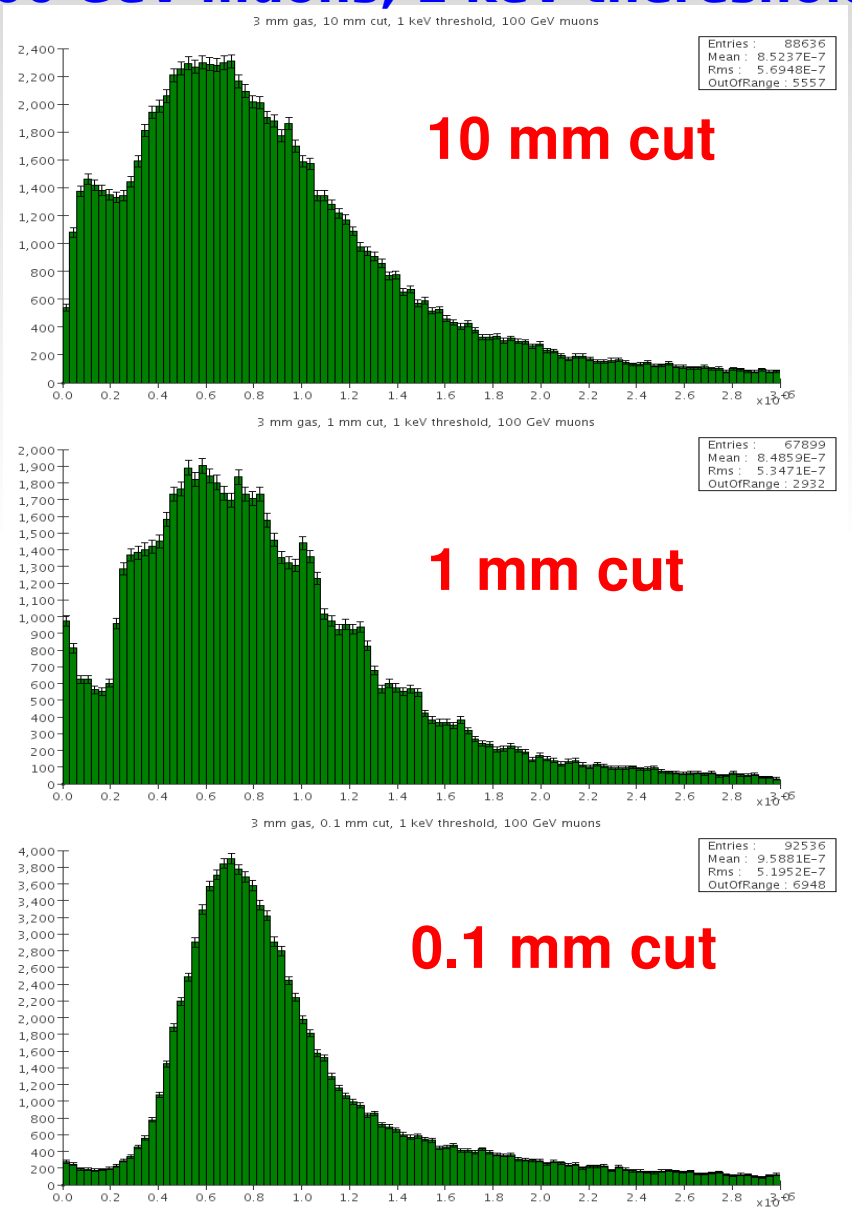




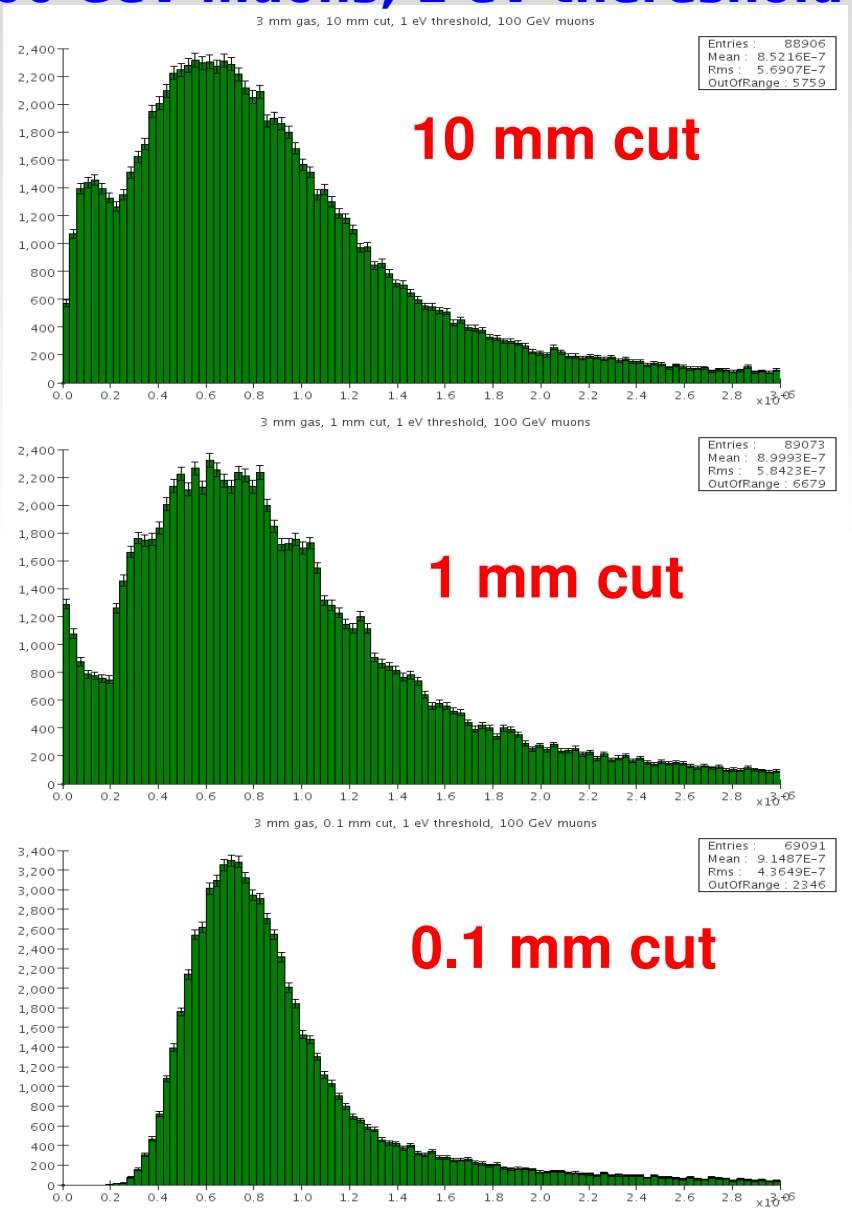
E (GeV)

Deposited energy in 3 mm

100 GeV muons, 1 keV thereshold



100 GeV muons, 1 eV thereshold



CPU time for different cut and threshold

100 GeV muons, 1000 events			100 GeV pions, 100 events		
Cut	threshold	CPU time	Cut	threshold	CPU time
10 mm	1 MeV	00:02:55	10 mm	1 MeV	01:25:40
1 mm	1 MeV	00:11:34	1 mm	1 MeV	02:12:07
0.1 mm	1 MeV	00:05:09	0.1 mm	1 MeV	01:38:25
10 mm	1 keV	01:20:33	10 mm	1 keV	
1 mm	1 keV	02:59:37	1 mm	1 keV	
0.1 mm	1 keV	01:32:01	0.1 mm	1 keV	
10 mm	1 eV	02:29:33	10 mm	1 eV	
1 mm	1 eV	01:23:07	1 mm	1 eV	
0.1 mm	1 eV	4:37:16	0.1 mm	1 eV	

Conclusion

If the gaseous detector with thin gas volume is used, some modifications in Geant4/Slic have to be done.

The modification works well if only Gean4 is used, but some difficulties were found when we tried to implement it into the Slic framework.

Gas volume need to be defined as an region for which we the modifications will be applied independently.