Status of the DHCAL Simulation

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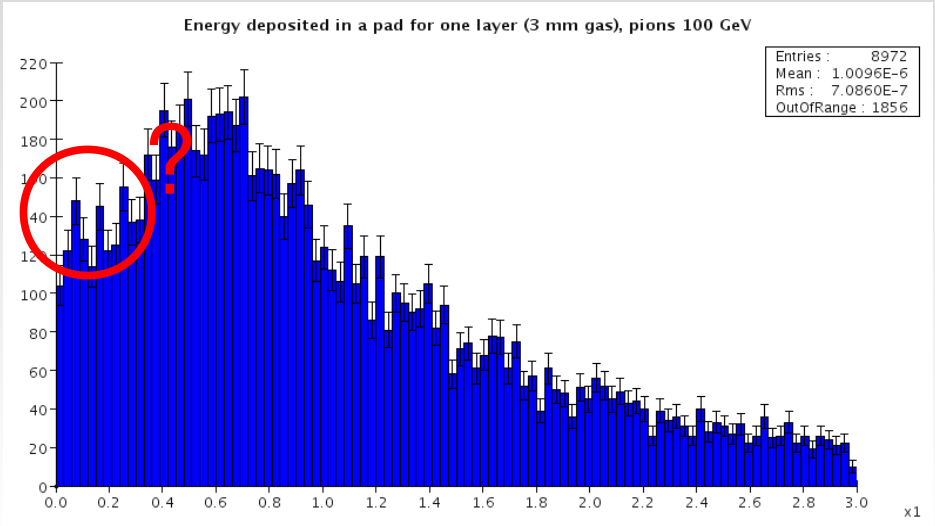
CALICE Analysis Meeting
LAPP, 9 February 2009

3 mm gas, 100 GeV pions

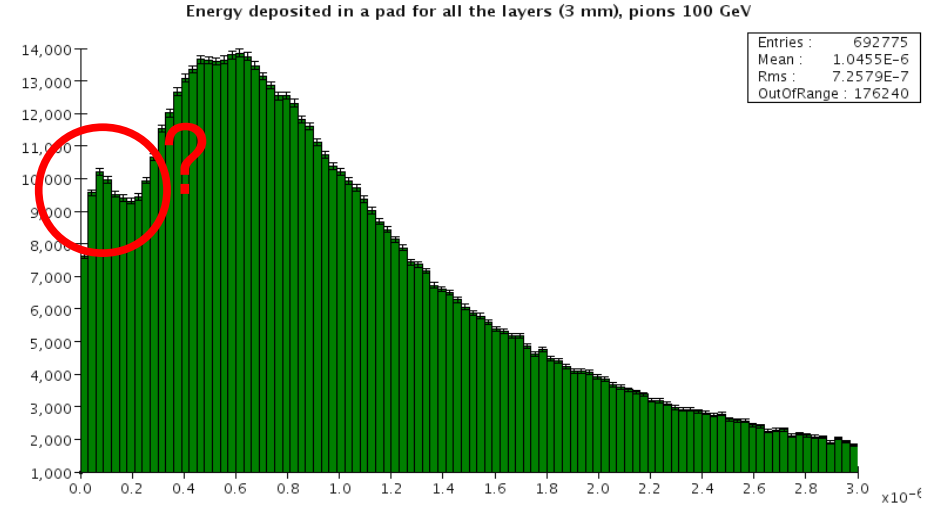
Energy deposited per pad for one layer



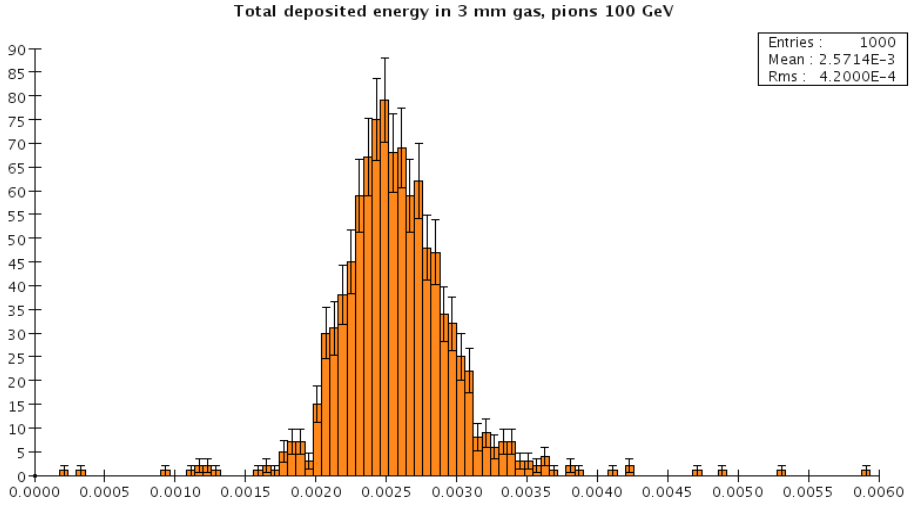
Slic simulation toolkit was used
Calorimeter configuration:
- 40 or 80 planes (~ 4.5 λ or ~ 9 λ)
- 1.9 cm steel absorber between planes
- μMegas like detector
  - 1 x 1 cm2 readout pads
  - 3 mm gas volume
    (95 % Argon + 5 % Isobutane)

A strange peak in the MIP spectrum was found.

Energy deposited per pad for all layers



Total deposited energy



Test with muons

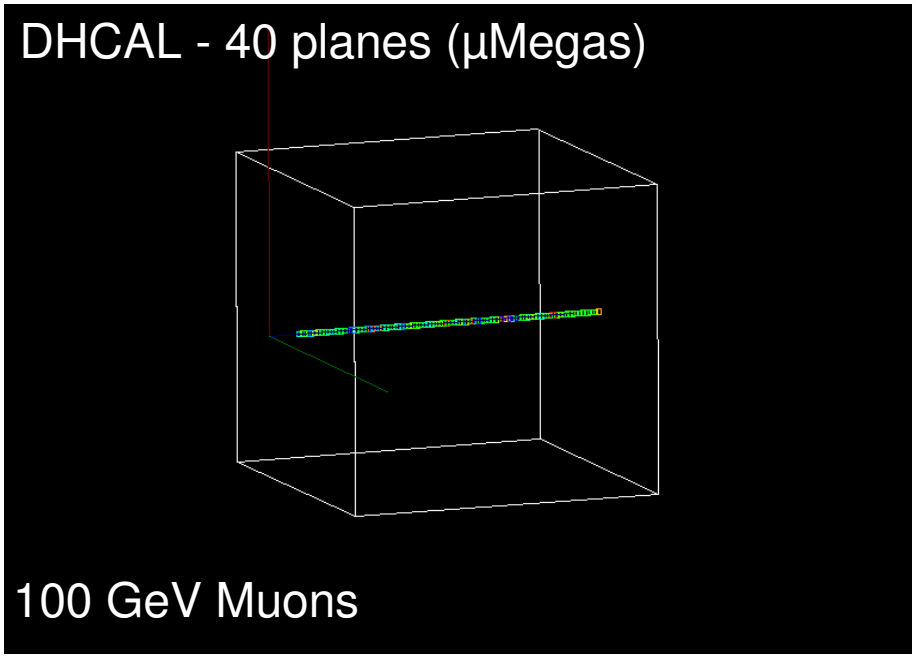
In order to find the origin of the strange peak in MIP spectrum we perform a detailed study with muons.

We consider only cleanest events:

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

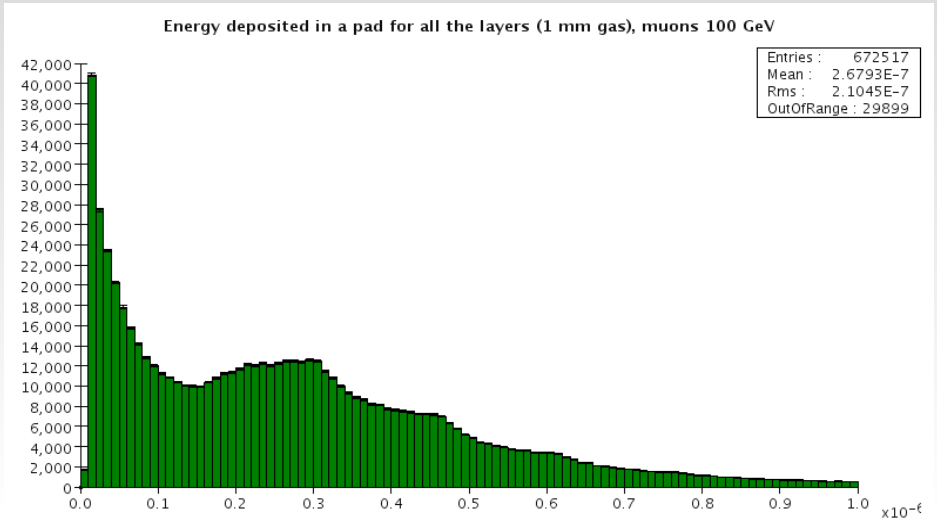
We change the thickness of gas:

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



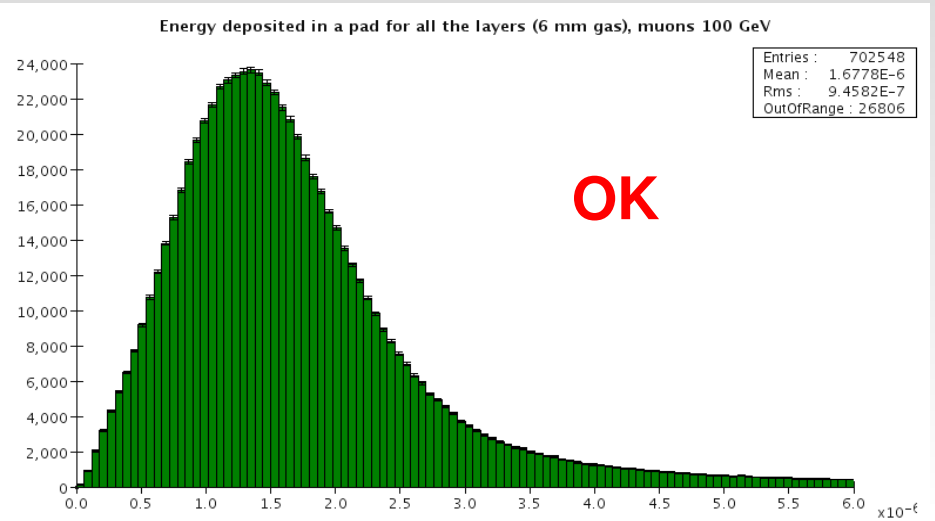
100 GeV muons

Energy deposited in 1 mm gas



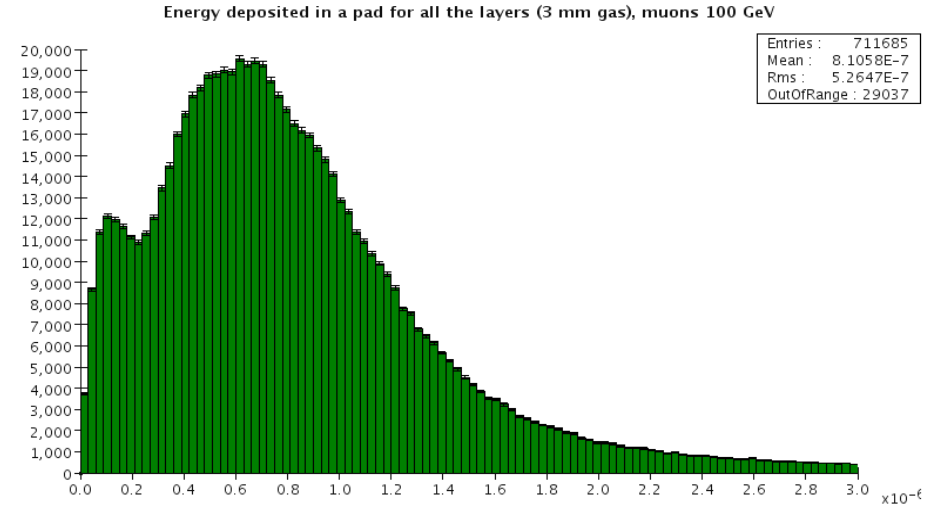
E (GeV)

Energy deposited in 6 mm gas



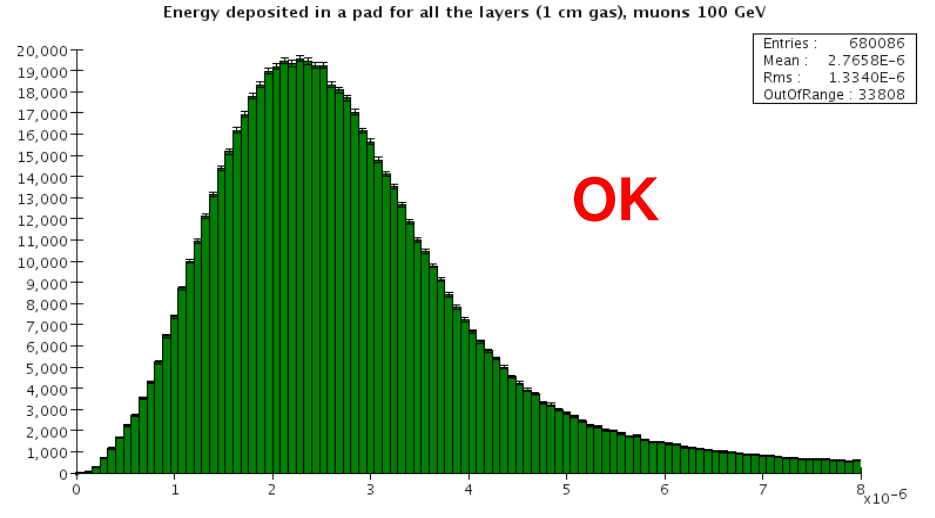
E (GeV)

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
```

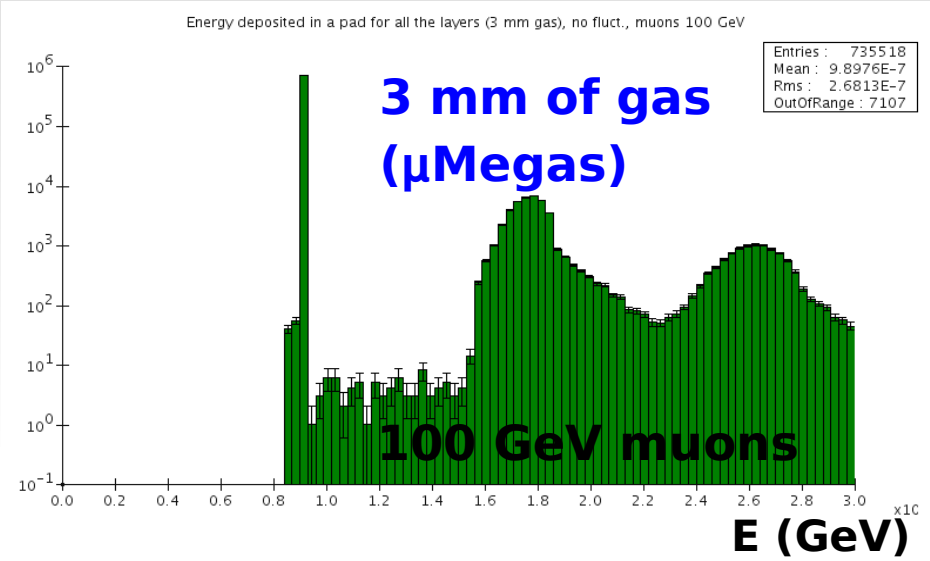
We can switch off the fluctuations interactively:

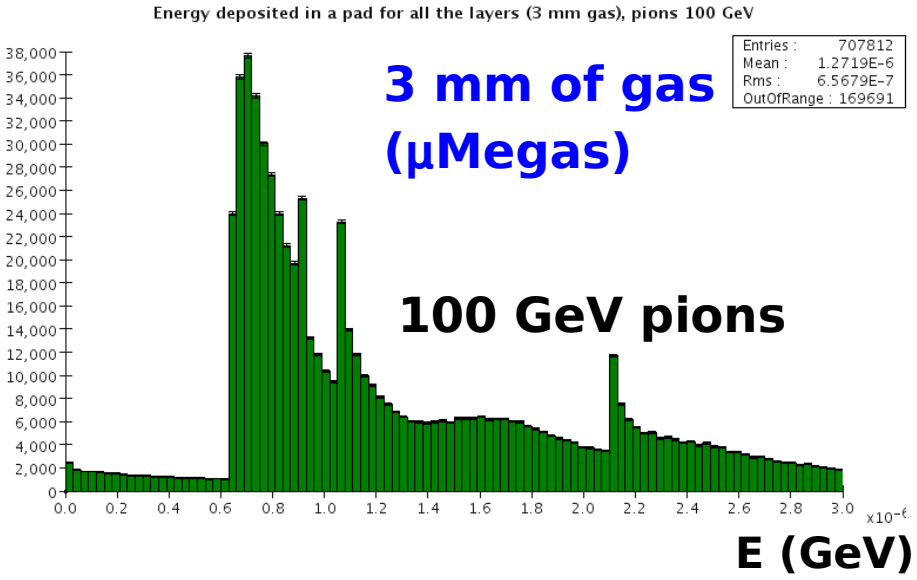
```
/process/eLoss/fluct        false
```

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

Optimization must be done for thin gas volume

Deposited energy in all planes without fluctuations of energy loss





Optimization

The fluctuation model in Gean4 works well for typical sampling calorimeters with solid or liquid materials (sampling fraction about few %), but it doesn't work well for a calorimeter with thin gas volumes (such as MicroMegas, ...)

In case of gaseous detector 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:

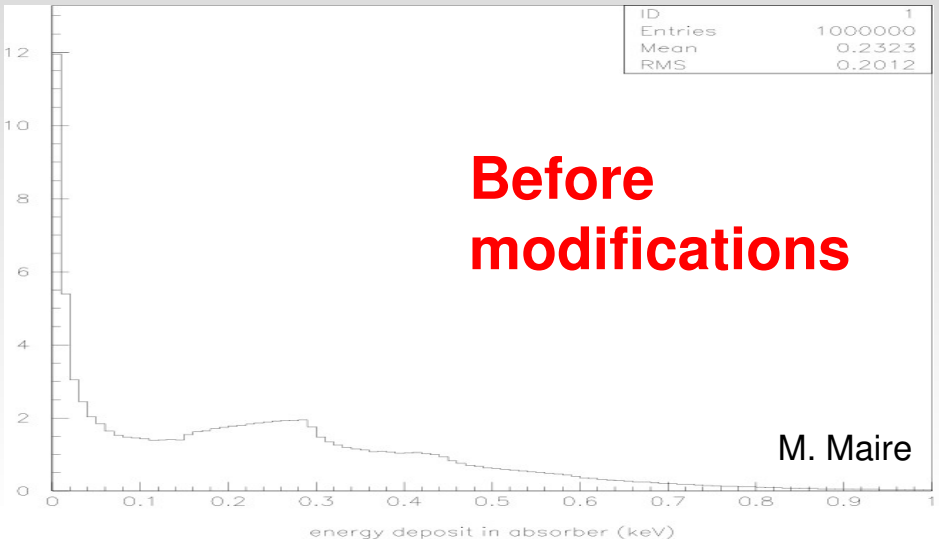
```
G4ProductionCutsTable::GetProductionCutsTable()
  ->SetEnergyRange(1.*eV,100*GeV);
```

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
```

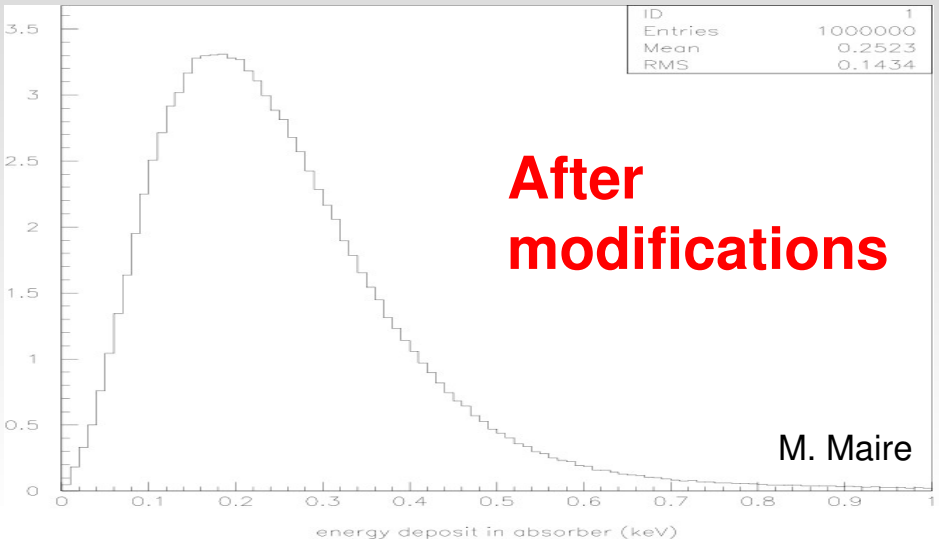
Test with Geant4, 100 GeV muons

Energy deposited in 1 mm gas



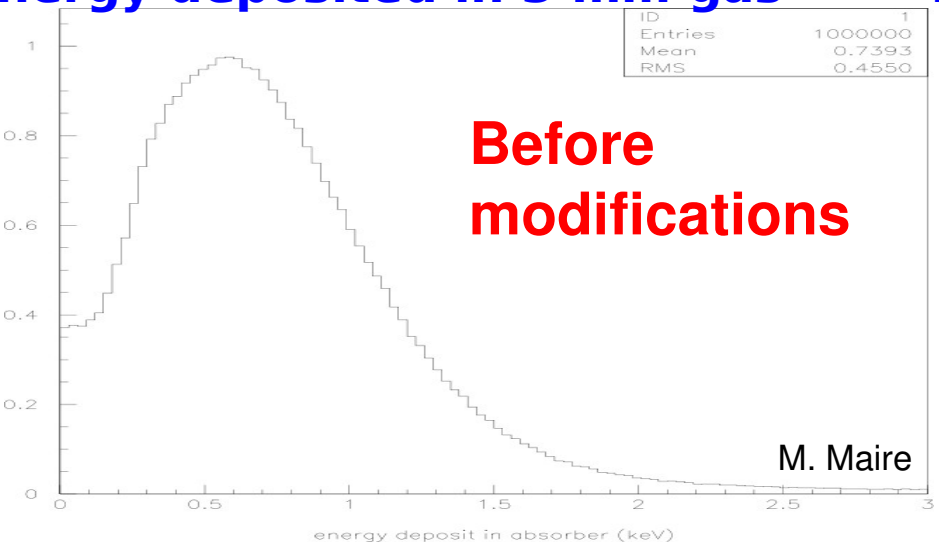
E (keV)

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 in SLIC 1/2

1. Energy range should be changed in PhysicsListManager.cc

N. B. Modification is applied on any physics list (LCPhys, LHEP, ...) that will be used

2. In the Slic framework, default settings are given in a lcdd file, which describes the geometry of the detector , e. g.:

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

N. B. If values defined by user are not set in the xml file, default values are added to the lcdd file by the GeomConvertor.

Modification in SLIC 2/2

The default values of the cut and threshold are not optimal for our detector. WRT the simulation precision and CPU time, we have set different values for gas and absorber. This can be done in the xml file, e. g.:

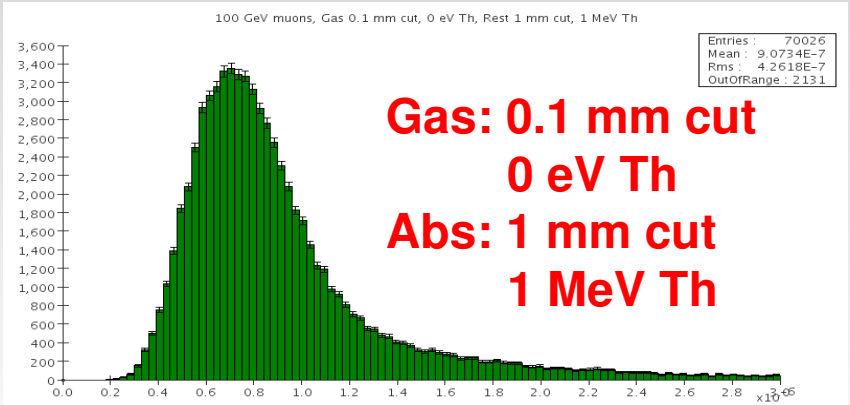
```
<regions>
  <region name="GasRegion" store_secondaries="true" cut="0.1"
    lunit="mm" threshold="0.0" eunit="MeV" />
</regions>

<detectors>
 <detector id="1" name="Cubmeter" type="TestBeamCalorimeter"
    readout="HcalEndcapHits" insideTrackingVolume="true">
       <layer repeat="80">
       <slice material="Steel235" thickness="1.5*cm" />
       <slice material="MmegasGas" thickness="0.30*cm"
         sensitive="yes" limits="cal_limits" region="GasRegion" />
    </layer> </detector>
 </detectors>
```

And they can be also changed by using a Geant4 command:

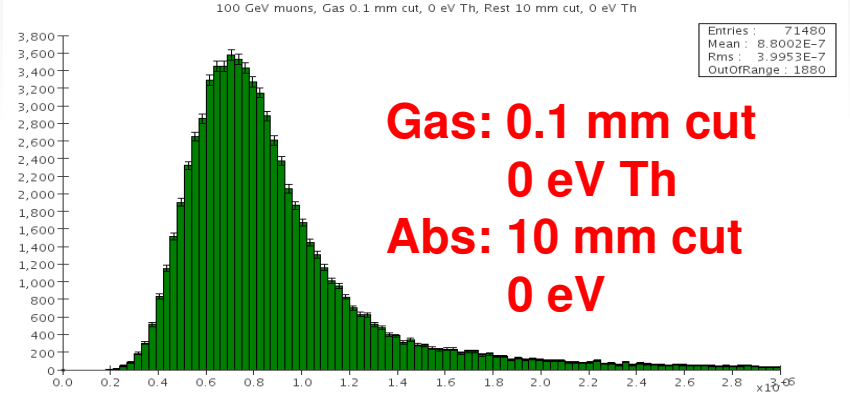
```
/run/setCutForRegion GasRegion 0.1 mm
```

Deposited energy in 3 mm gas

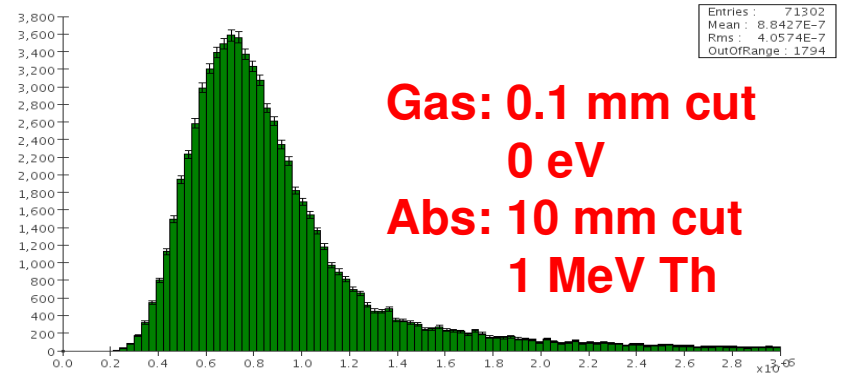
100 GeV muons



Gas: 0.1 mm cut
0 eV Th
Abs: 1 mm cut
1 MeV Th



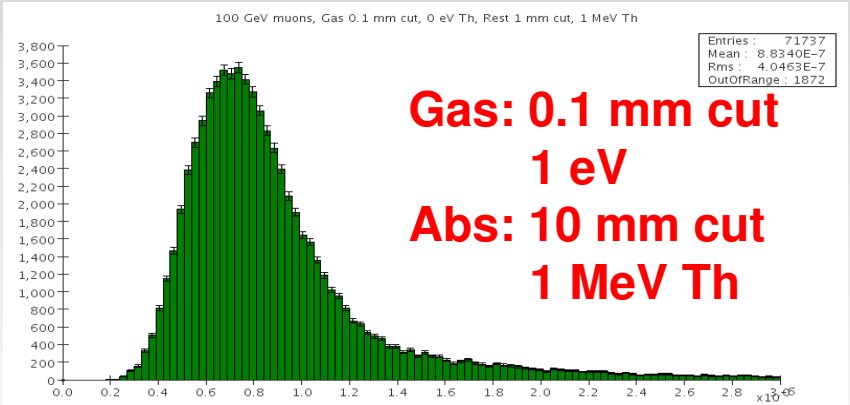
Gas: 0.1 mm cut
0 eV Th
Abs: 10 mm cut
0 eV



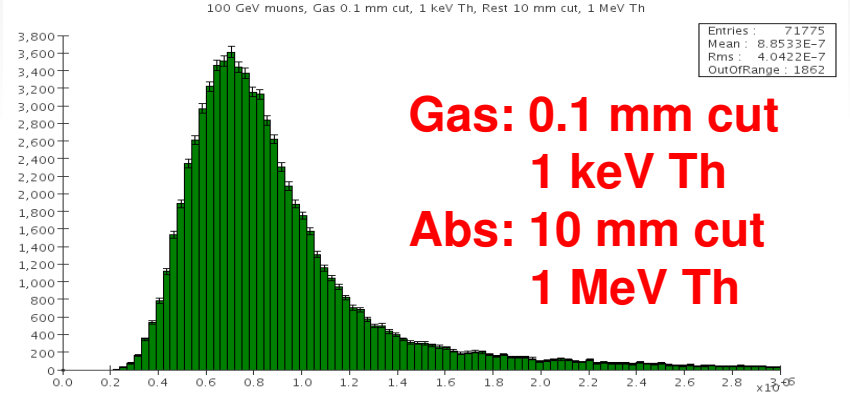
Gas: 0.1 mm cut
0 eV
Abs: 10 mm cut
1 MeV Th

E (GeV)

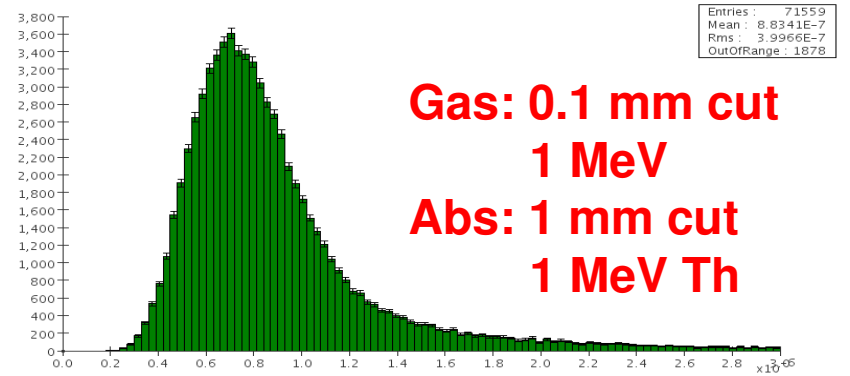
100 GeV muons



Gas: 0.1 mm cut
1 eV
Abs: 10 mm cut
1 MeV Th



Gas: 0.1 mm cut
1 keV Th
Abs: 10 mm cut
1 MeV Th

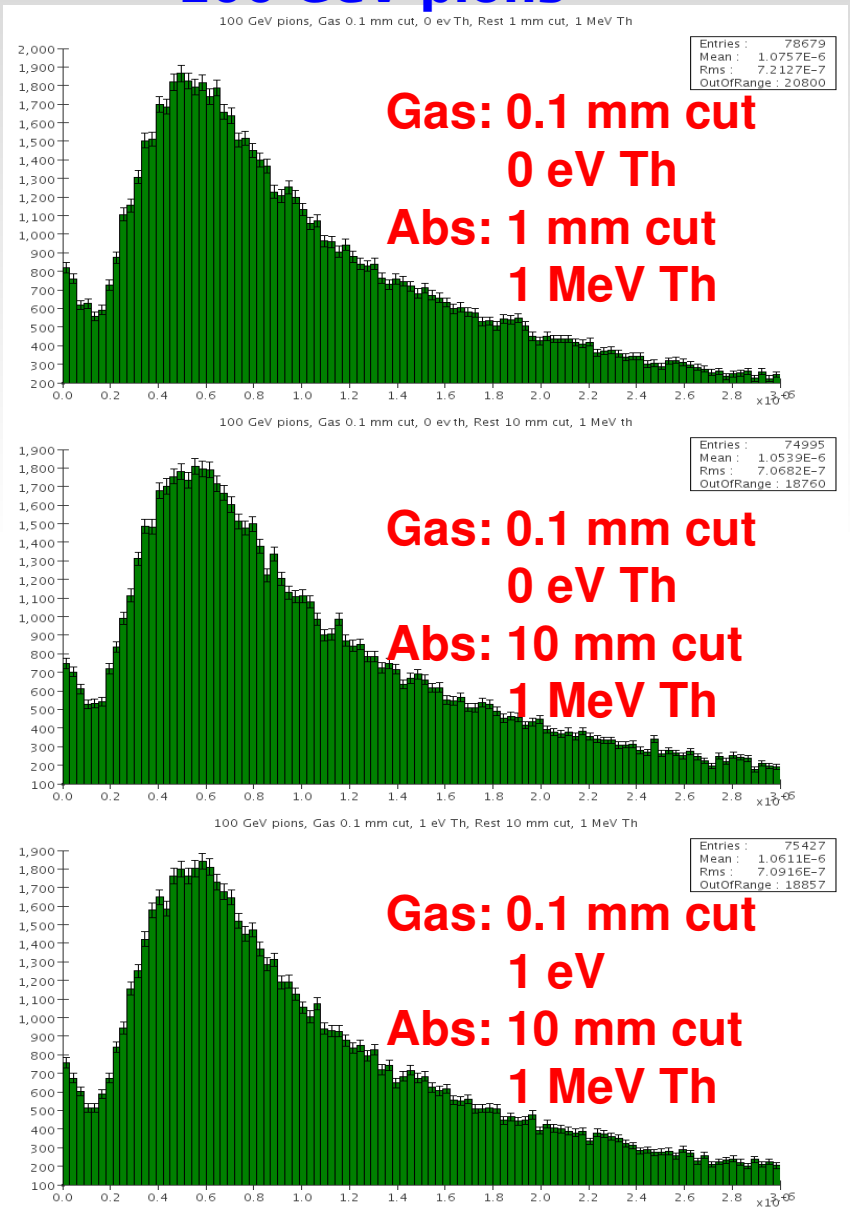


Gas: 0.1 mm cut
1 MeV
Abs: 1 mm cut
1 MeV Th

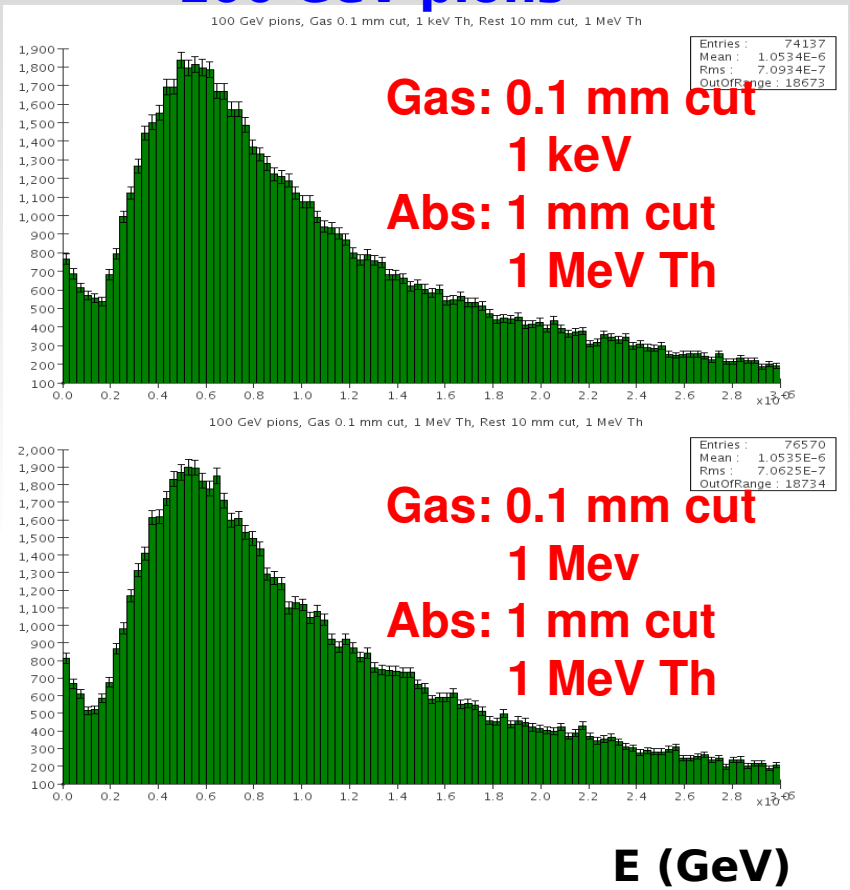
E (GeV)

Deposited energy in 3 mm gas

100 GeV pions



100 GeV pions

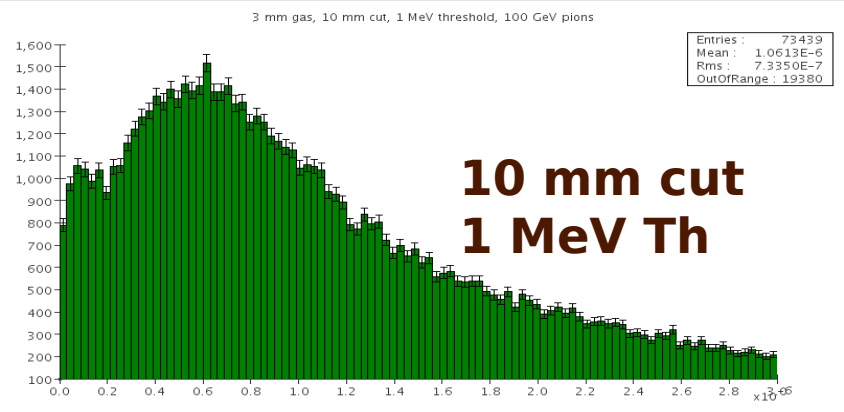


CPU time for different cuts and thresholds

100 GeV muons, 1000 events					100 GeV pions, 100 events				
cutGas	thGas	cutAbs	thAbs	CPU time	cutGas	thGas	cutAbs	thAbs	CPU time
10 mm	1 MeV	10 mm	1 MeV	00.02.85	10 mm	1 MeV	10 mm	1 MeV	01.25.40
0.1 mm	1 MeV	10 mm	1 MeV	00.04.99	0.1 mm	1 MeV	10 mm	1 MeV	01.16.29
0.1 mm	1 keV	10 mm	1 MeV	00.01.44	0.1 mm	1 keV	10 mm	1 MeV	01.13.38
0.1 mm	1 eV	10 mm	1 MeV	00.13.46	0.1 mm	1 eV	10 mm	1 MeV	2.20.18
0.1 mm	0 eV	10 mm	1 MeV	00.02.29	0.1 mm	0 eV	10 mm	1 MeV	01.28.33
0.1 mm	0 eV	1 mm	1 MeV	00.02.37	0.1 mm	0 eV	1 mm	1 MeV	01.27.20
0.1 mm	0 eV	1 mm	1 keV	01.59.28	0.1 mm	0 eV	1 mm	1 keV	28.15.57
0.1 mm	0 eV	10 mm	0 MeV	03.12.27	0.1 mm	0 eV	10 mm	0 MeV	22.32.32

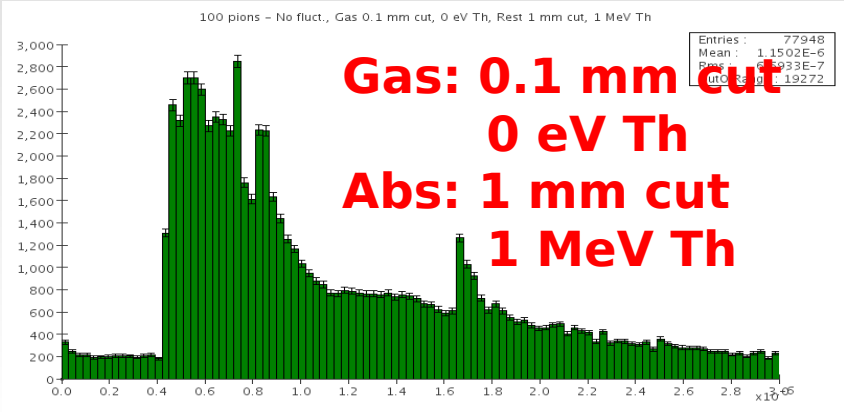
100 pions, 3 mm gas

First plot showing problem



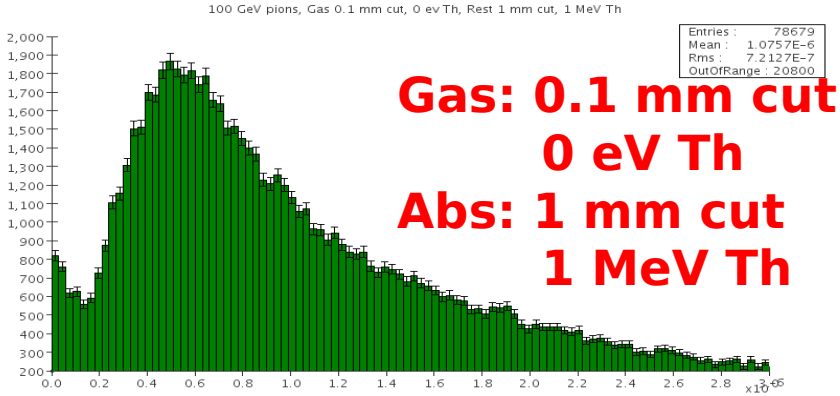
E (GeV)

No fluctuations



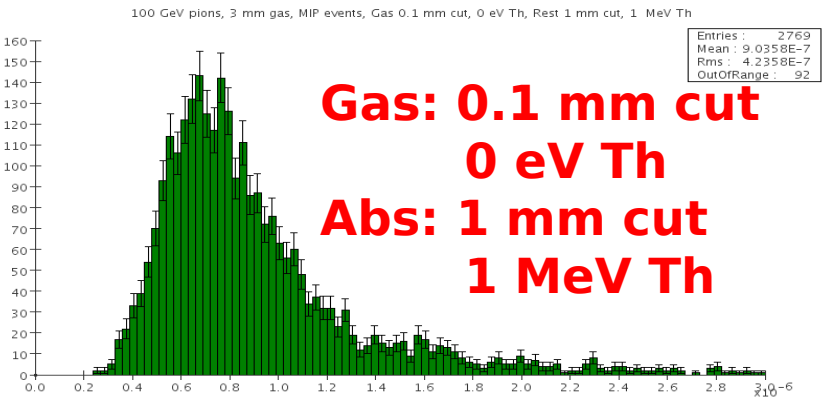
E (GeV)

No event selection



E (GeV)

Pions MIP events



E (GeV)

Summary

If the thin gaseous detector is used, the modifications in Geant4/Slic have to be done

WRT the CPU time and precision, the modifications must be applied independently for gas and absorber

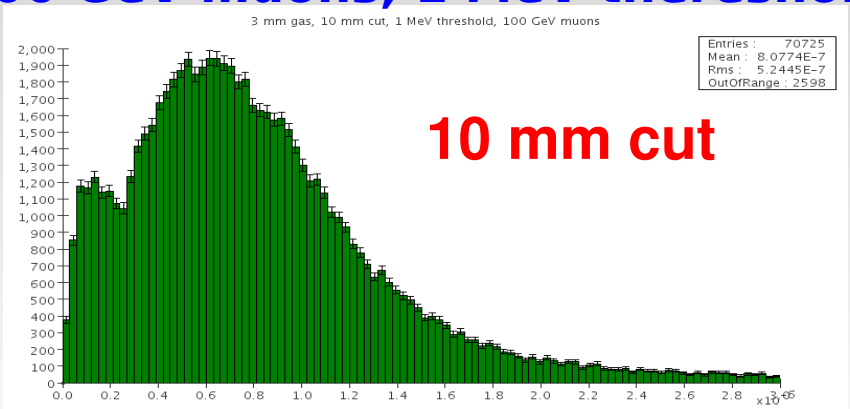
As the optimal parameters for a sampling calorimeter with a thin gaseous detector were found:

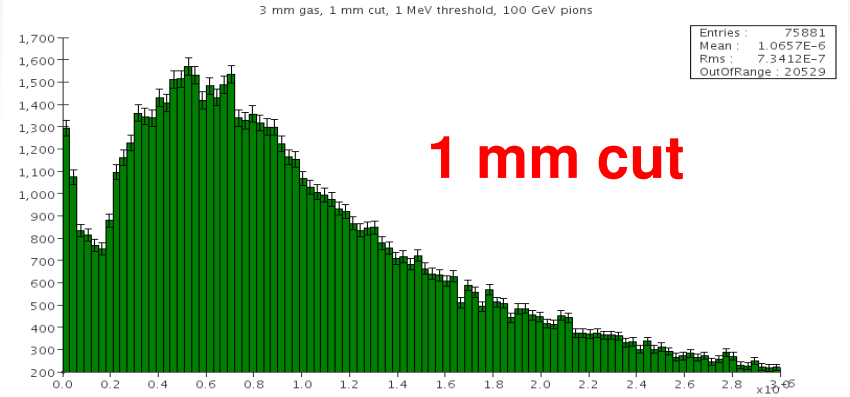
Gas: **Cut = 0.1 mm, threshold = 0 eV**
Absorber: **Cut = 1 mm, threshold = 10 MeV**

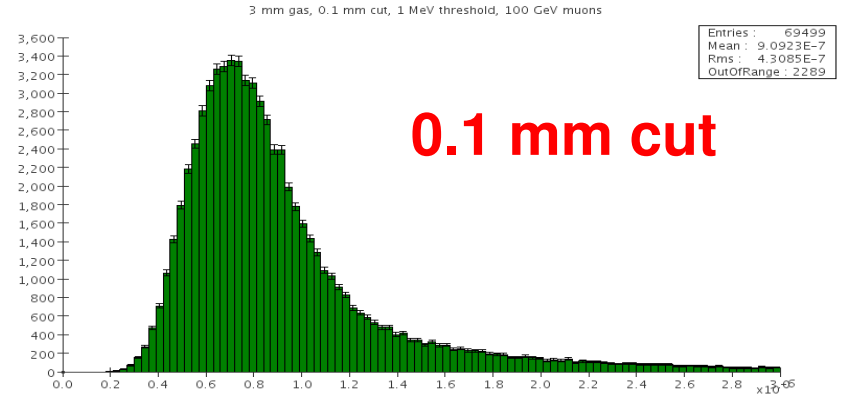
Back up slides

Deposited energy in 3 mm gas

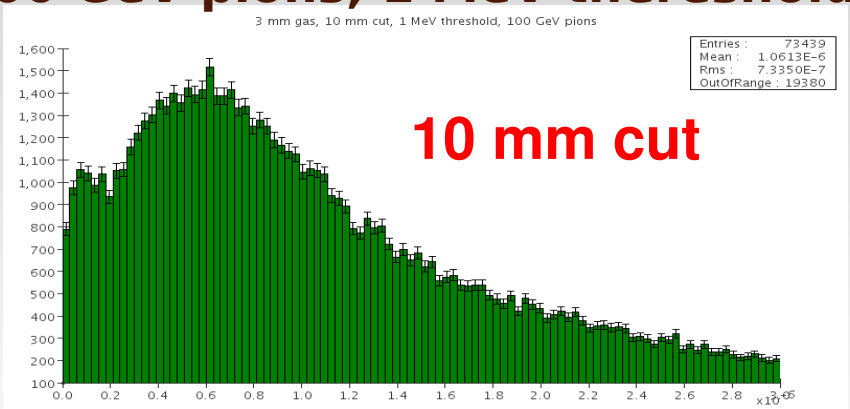
100 GeV muons, 1 MeV thereshold

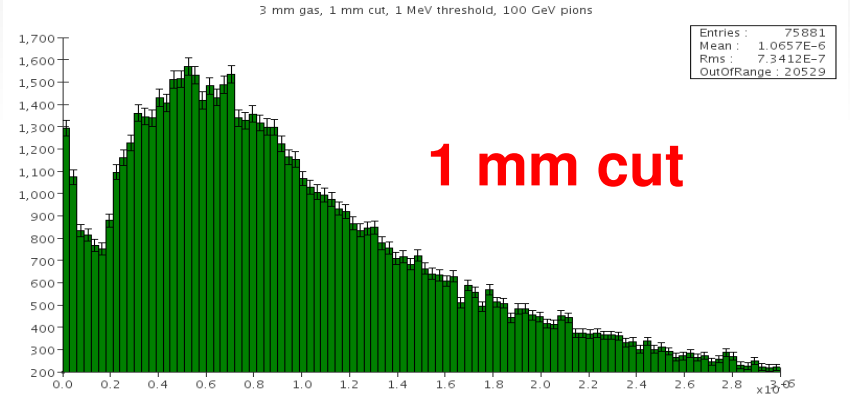


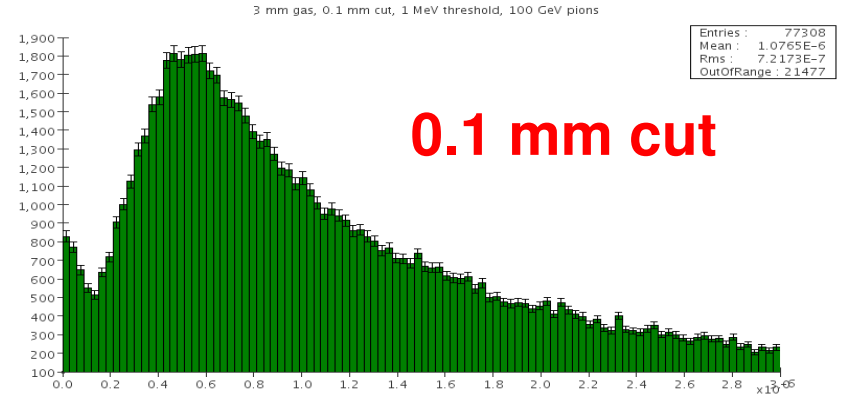




100 GeV pions, 1 MeV thereshold

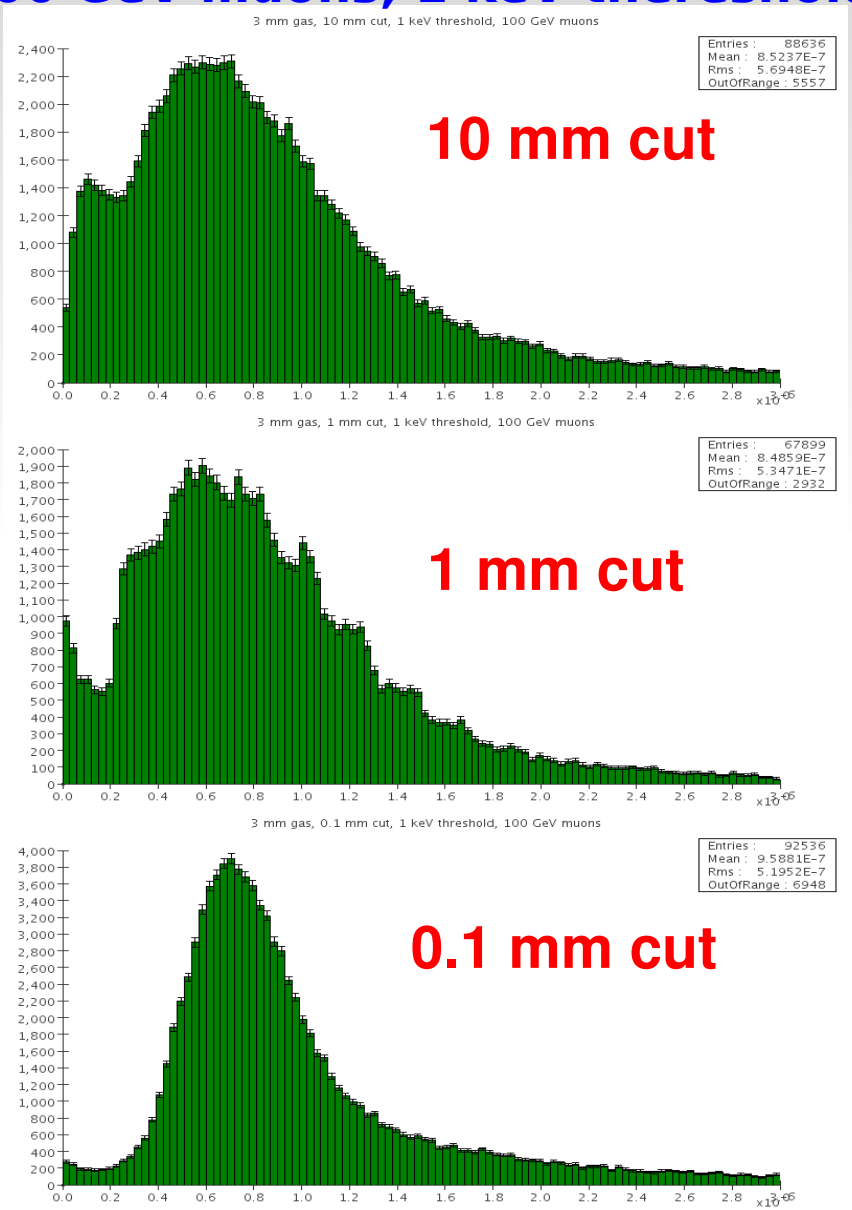




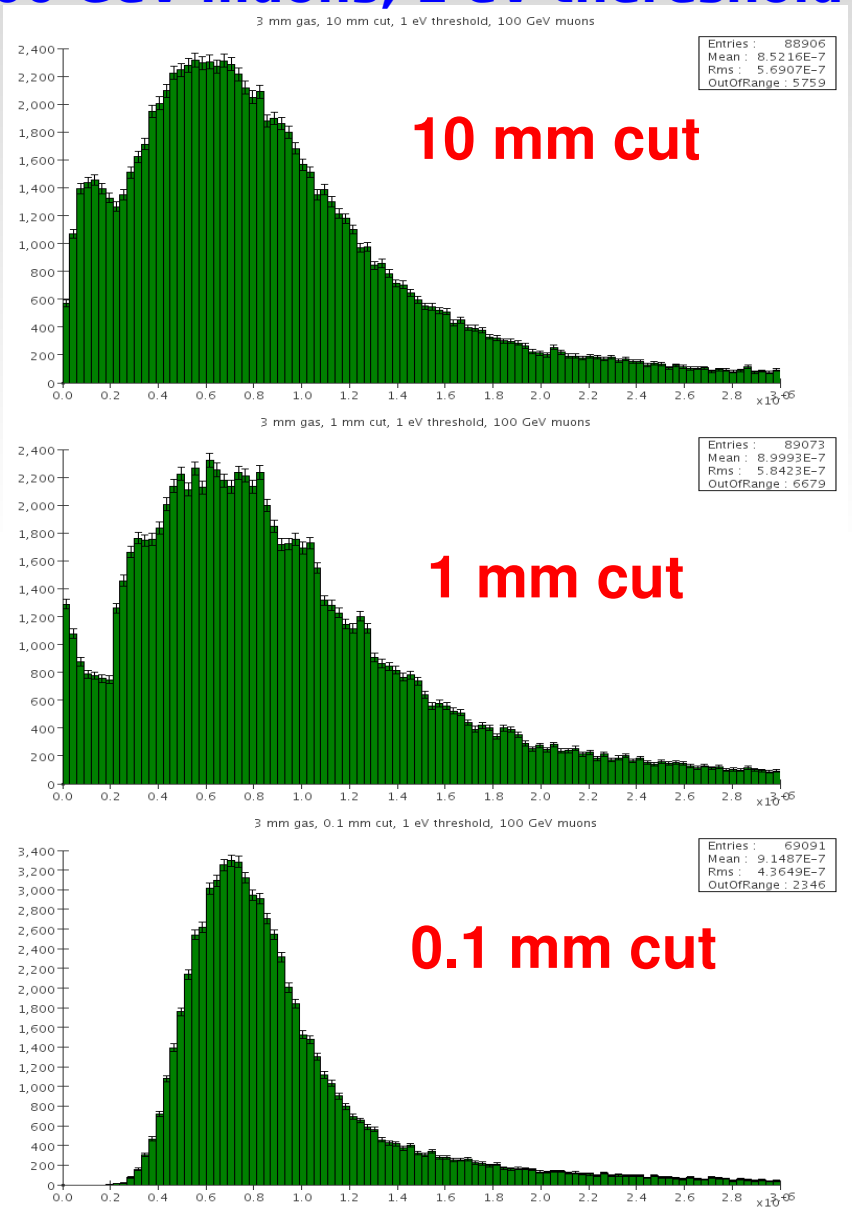


Deposited energy in 3 mm gas

100 GeV muons, 1 keV thereshold



100 GeV muons, 1 eV thereshold



CPU time for different cuts and thresholds

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	29:17:34
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	33:44:59
1 mm	1 eV	01:23:07	1 mm	1 eV	
0.1 mm	1 eV	4:37:16	0.1 mm	1 eV	