S2 Simulation with Garfield++

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Workflow

Gmsh: 3D mesh generator and geometry defination

Elmer: Imports the mesh, allows to define the boundary conditions/potentials and solves the electric field map

Magboltz: calculates the transport properties for e for 60 different gases and their mixtures, includes excitation and ionization levels for all these gases

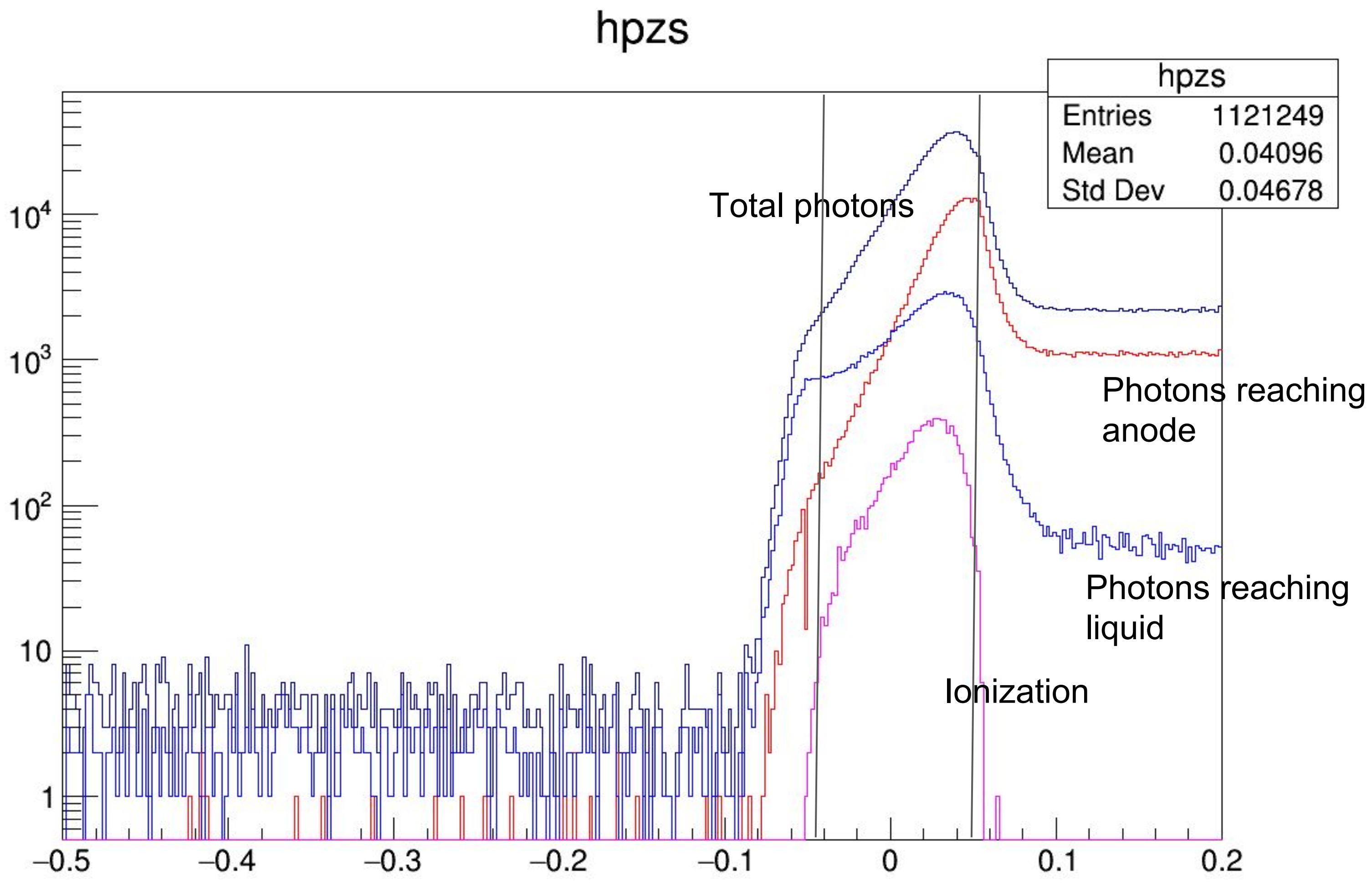
Garfield++: C++ framework with several classes to import the Elmer field maps and to do a microscopic MC transport of the e; allows to get back the position of any excitation or ionization

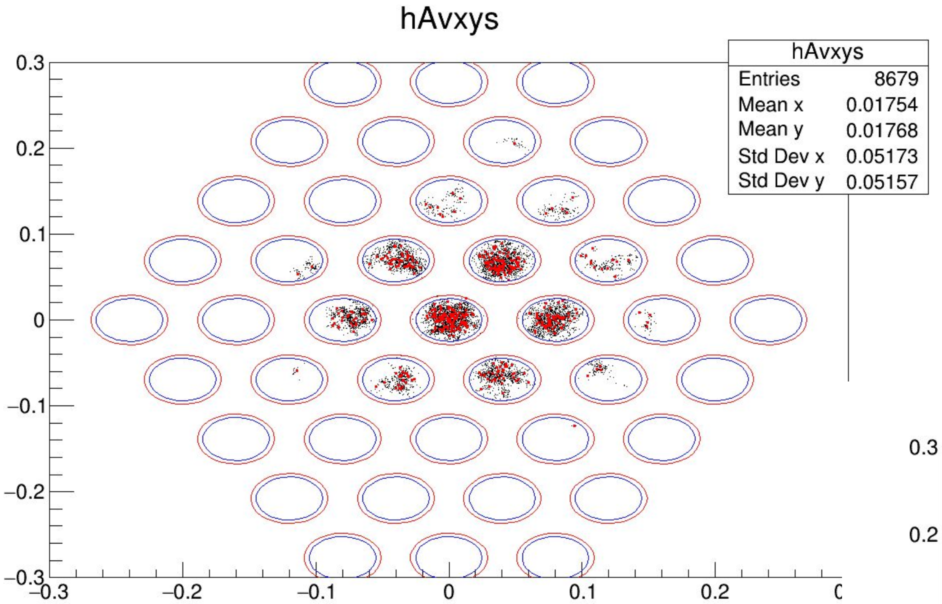
Geometry, Fields and Analysis Strategy

Geometry: LEM thickness 1 mm, hole radius 250 um, hole pitch 800 um, rim 40 um, copper thickness 35 um, induction gap 2 mm, extraction gap 5 mm

Fields/voltages: extraction field 3 kV/cm, induction field 5 kV/cm, LEM voltage varied but for the moment 3500 V

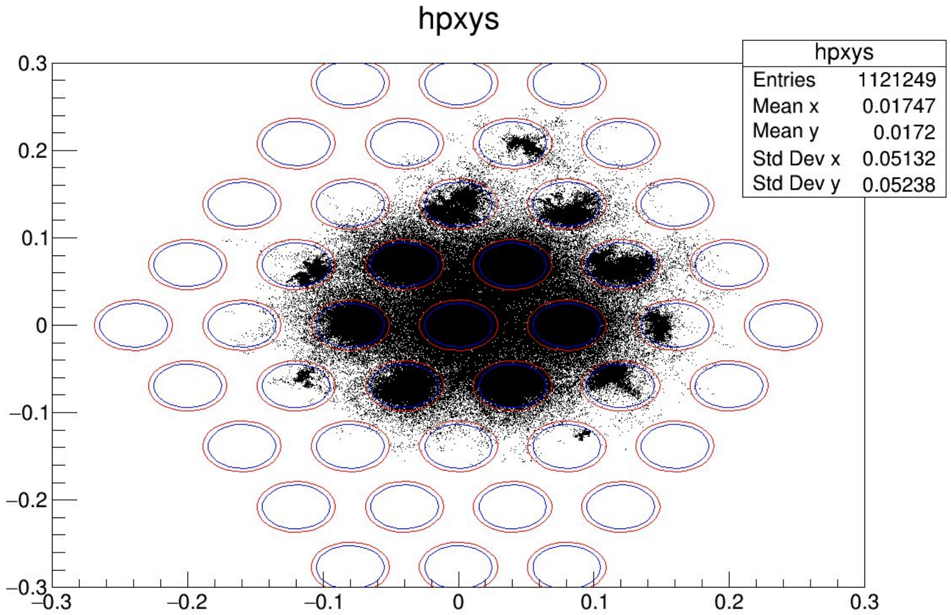
Strategy: get the position for each excitation, assume that 128 nm photon is emitted (copied from other study), produce photons isotropically, check if photons reach liquid

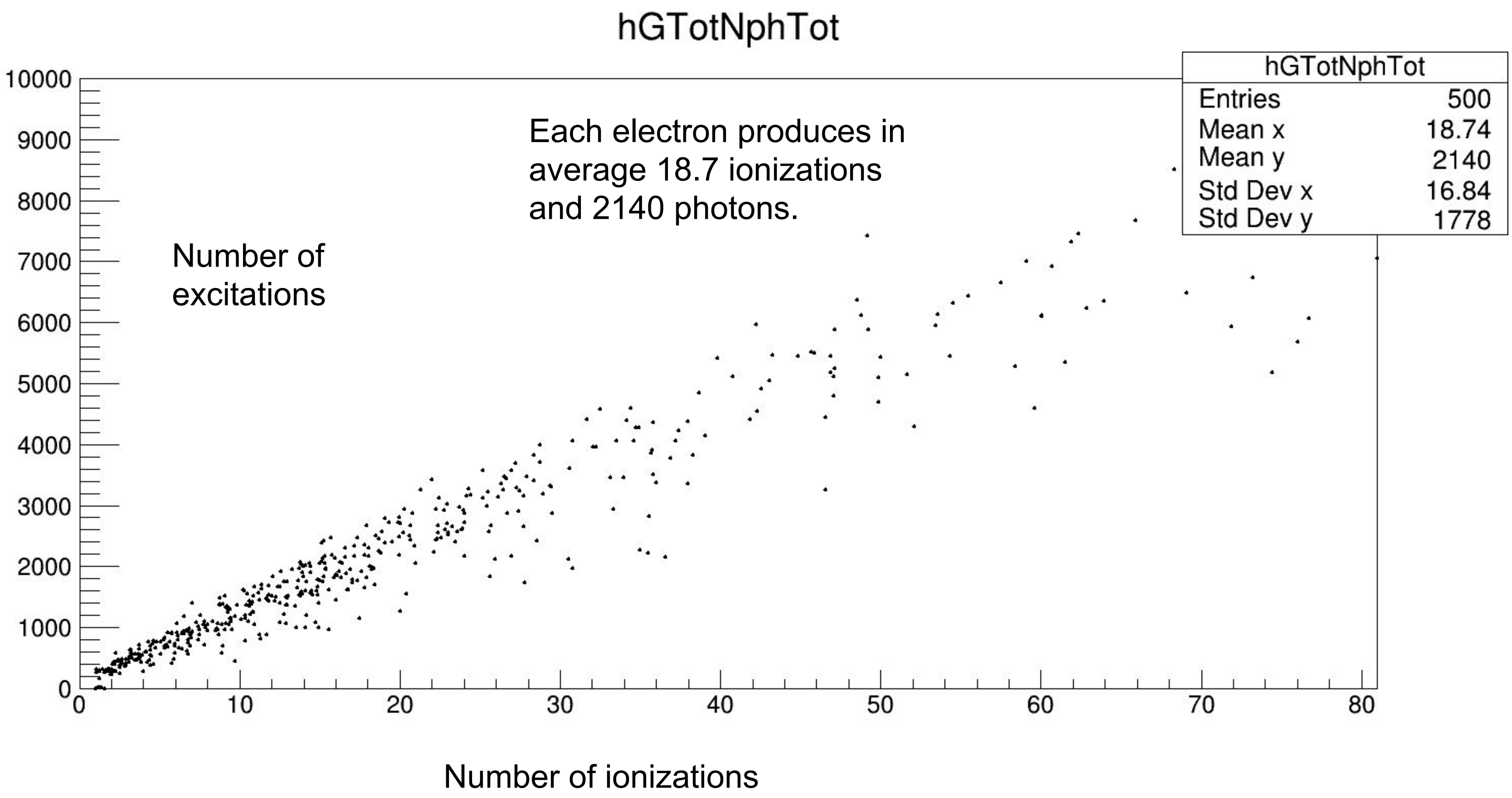

hpzs
hpzs
Entries 1121249
Mean 0.04096
Std Dev 0.04678
Total photons
Photons reaching anode
Photons reaching liquid
Ionization
10^4
10^3
10^2
10
1
−0.5
−0.4
−0.3
−0.2
−0.1
0
0.1
0.2

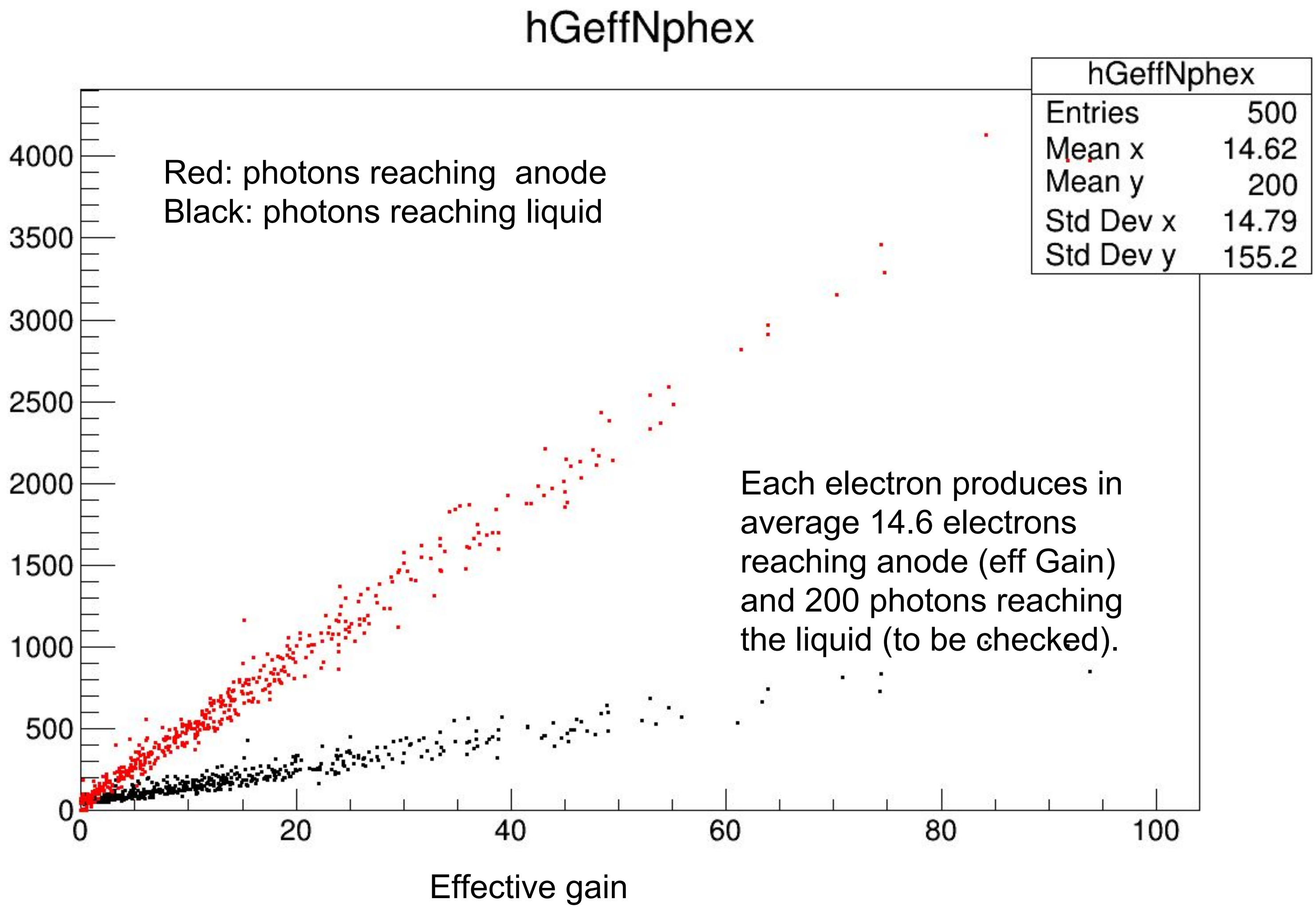


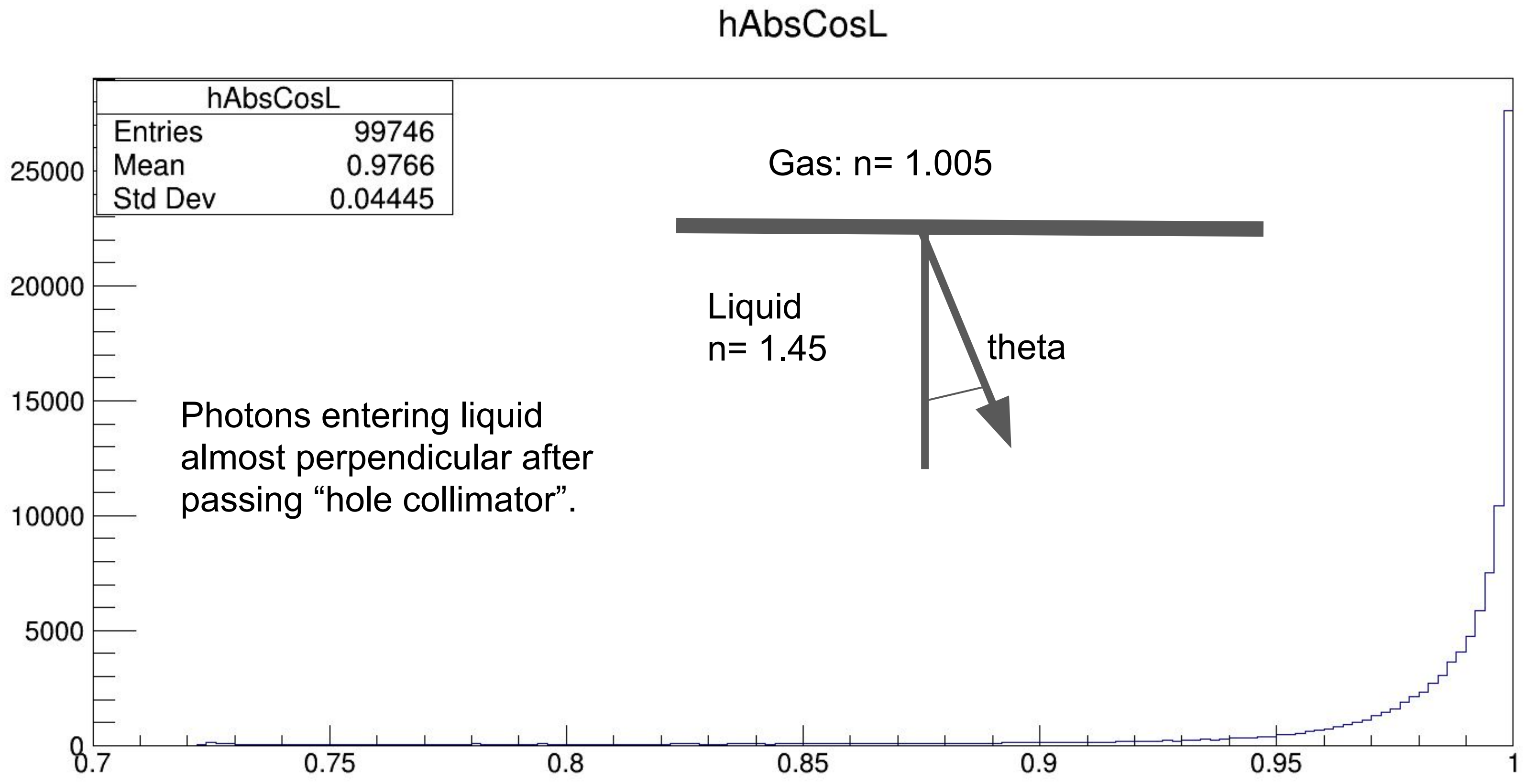
Ionization distribution (black single, red avalanche center)

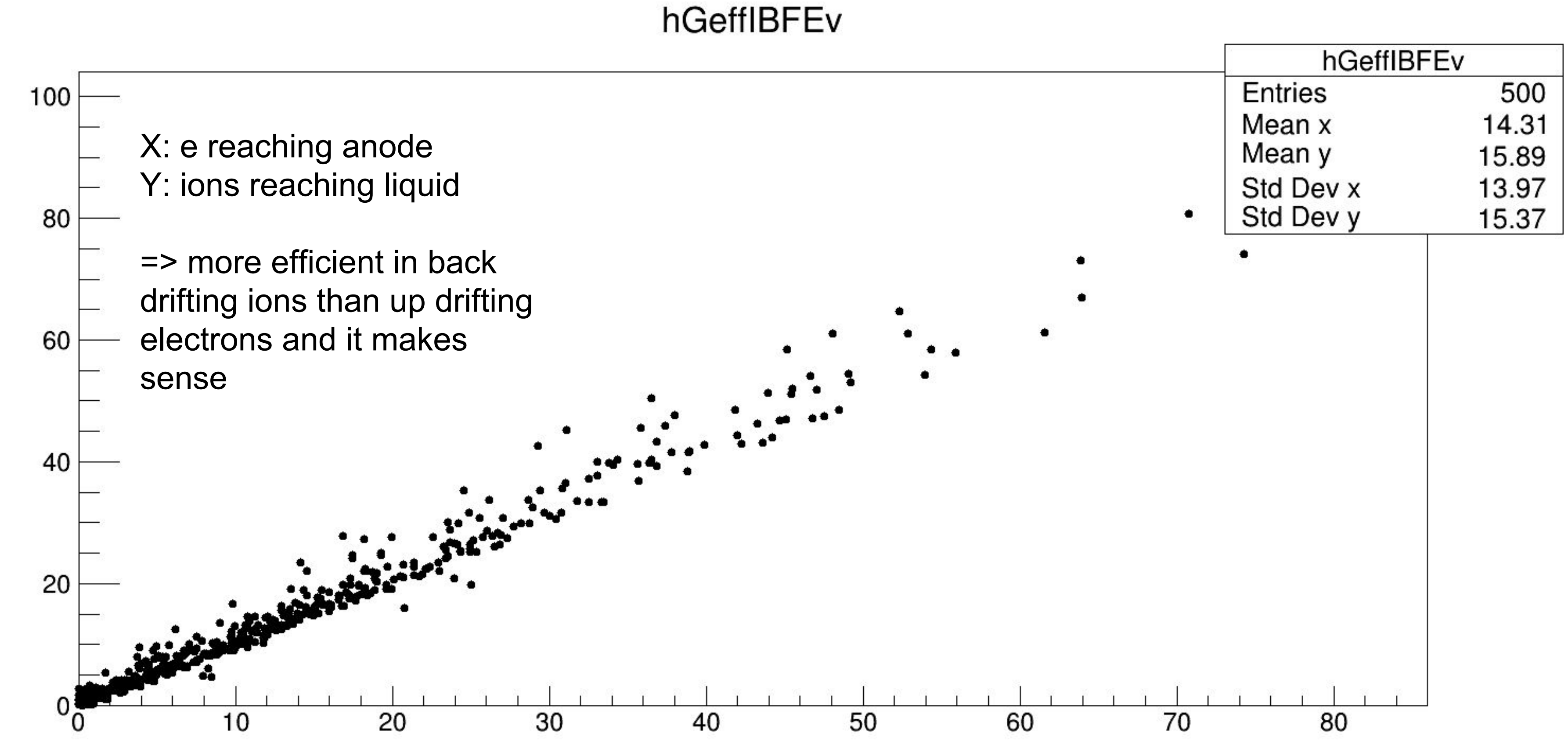
Photon production




hGTotNphTot
hGTotNphTot
Entries 500
Mean x 18.74
Mean y 2140
Std Dev x 16.84
Std Dev y 1778
Each electron produces in average 18.7 ionizations and 2140 photons.
Number of excitations
Number of ionizations
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
0
10
20
30
40
50
60
70
80


hGeffNphex
hGeffNphex
Entries 500
Mean x 14.62
Mean y 200
Std Dev x 14.79
Std Dev y 155.2
Red: photons reaching anode
Black: photons reaching liquid
Each electron produces in average 14.6 electrons reaching anode (eff Gain) and 200 photons reaching the liquid (to be checked).
0
500
1000
1500
2000
2500
3000
3500
4000
0
20
40
60
80
100
Effective gain

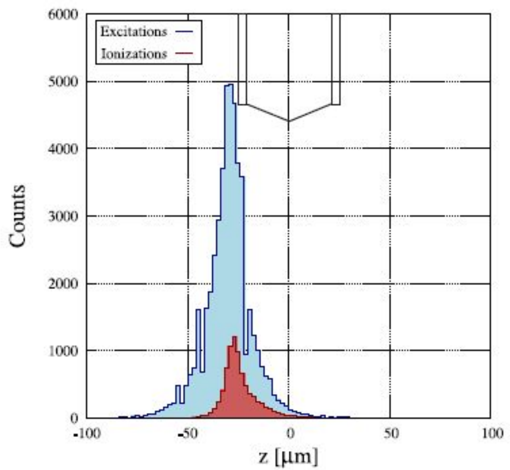

hAbsCosL
hAbsCosL
Entries 99746
Mean 0.9766
Std Dev 0.04445
Gas: n= 1.005
Liquid
n= 1.45
theta
Photons entering liquid almost perpendicular after passing “hole collimator”.
25000
20000
15000
10000
5000
0
0.7
0.75
0.8
0.85
0.9
0.95
1



hGeffIBFEv
hGeffIBFEv
Entries 500
Mean x 14.31
Mean y 15.89
Std Dev x 13.97
Std Dev y 15.37
X: e reaching anode
Y: ions reaching liquid
=> more efficient in back drifting ions than up drifting electrons and it makes sense
0
20
40
60
80
100
0
10
20
30
40
50
60
70
80

Summary

- First results of S2 simulation
- Results still preliminary but make sense in general
- Photons will enter the liquid almost perpendicular
- Current light gain in LArSoft far too low
- Discrepancy in effective gain: at 3500 V it should be almost 200 (ETH) but only around 15 in simulation => might mean much more light
- In fact reported gain cannot be explained by gas avalanche with 1st Townsend coefficient



(d) $V_{GEM} = 500$ V