Meeting RD51 - 08/10/2020

Study by simulation of the influence of surface condition and grid shape on performances of Micromegas detectors

Théo Bossis

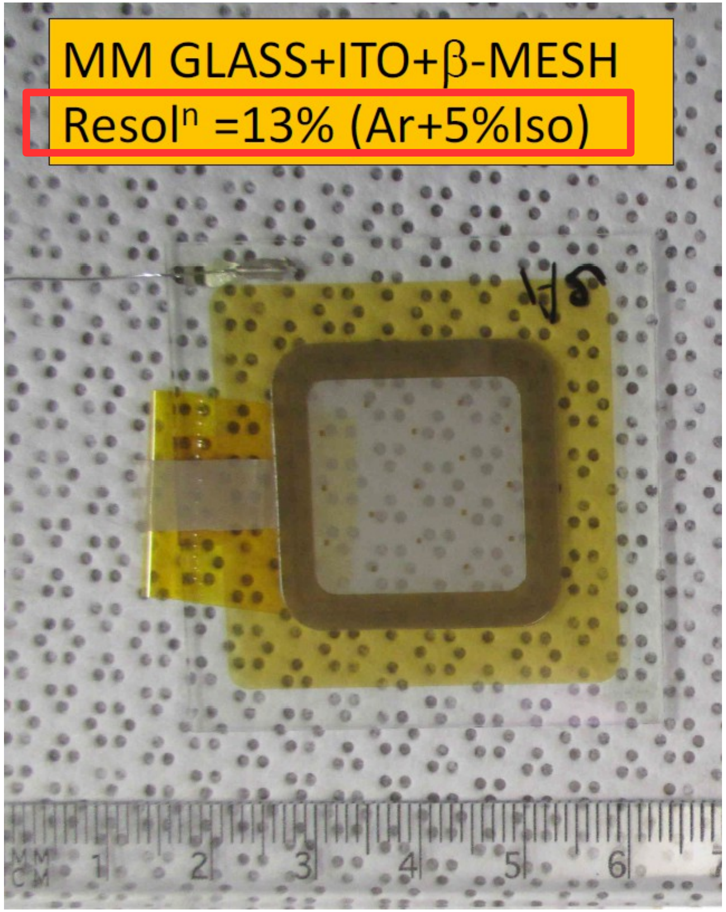
Outline

1) Influence of surface condition
2) Influence of mesh shape
3) Conclusion

Introduction

Micromegas with anode on a glass substrate have shown better energy resolution (13% @ 5.9 keV) :

→ Is it because of its smoother surface condition ?



E. Pollacco

Introduction

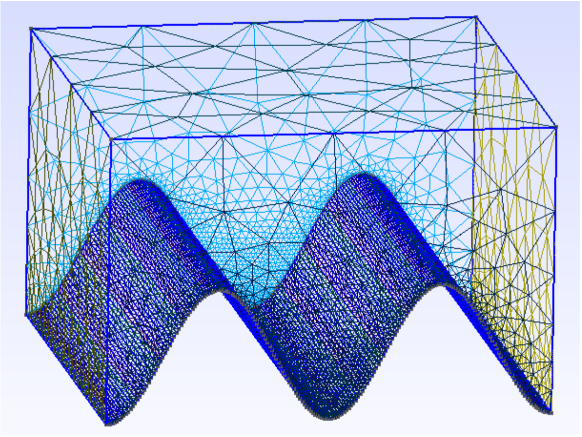
Conclusions drawn from this study :

Conclusions/Recommendations

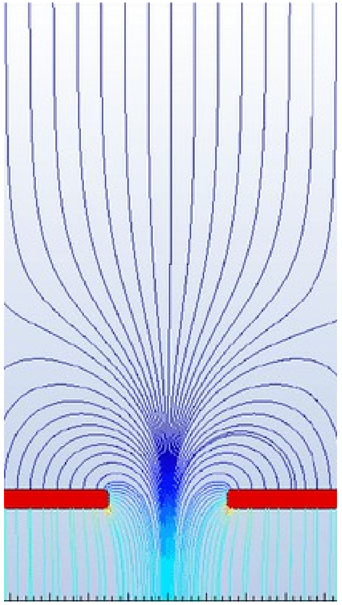
- Tests in progress should tell us where/when we should stop.
- Results to date show the obvious that with a surface roughness and planarity compatible within λ – the results can be improved.
- As with our advance in using clean rooms etc have improved the performance – these results suggest that by having the right definition and monitoring hardware we should be able to make significant progress.
- Add other physics/applications
- The results provide a leading edge of B-MM with respect to other assemblies.

E. Pollacco

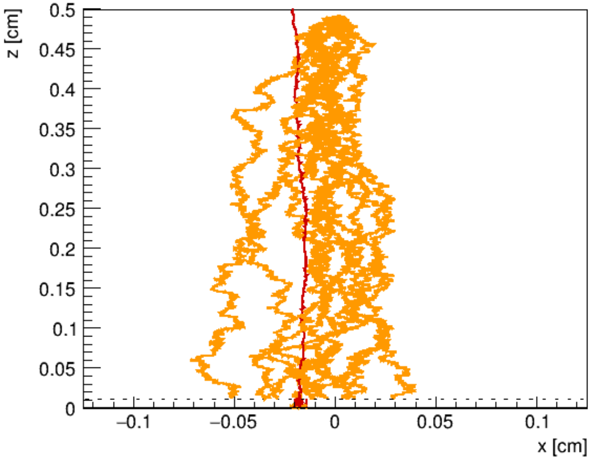
Simulation chain



1) GMSH : 3D modelisation and meshing software



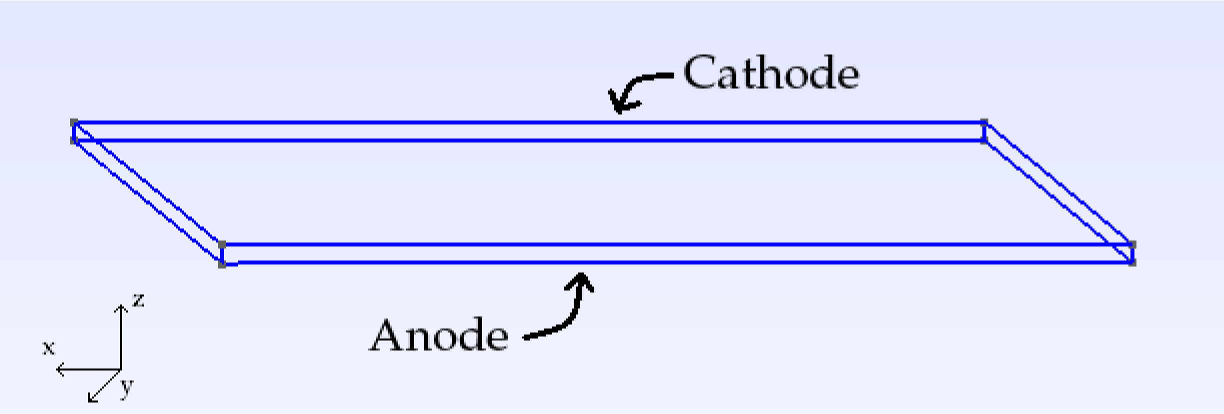
2) ElmerFEM : Electric field computation software by Finite Elements method



3) Garfield++ : Avalanche computation in gaseous detectors

Flat anode model

- amplification gap of 100 μm
- cathode high voltage from 200 to 350 V
- no grid because we only study influence of anode roughness on the electron avalanche



Avalanche computing with Garfield++

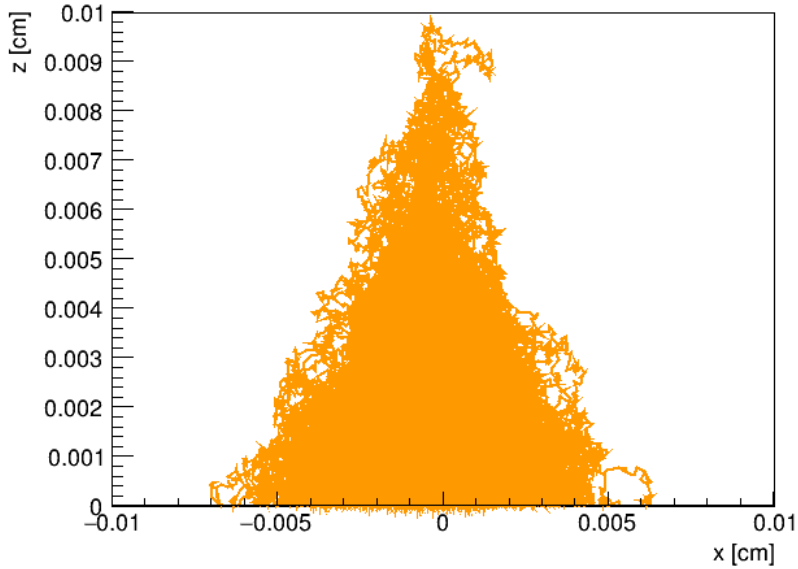
Computing time optimization :

1) Simulation of a catalog of 3000 Single Electron Responses

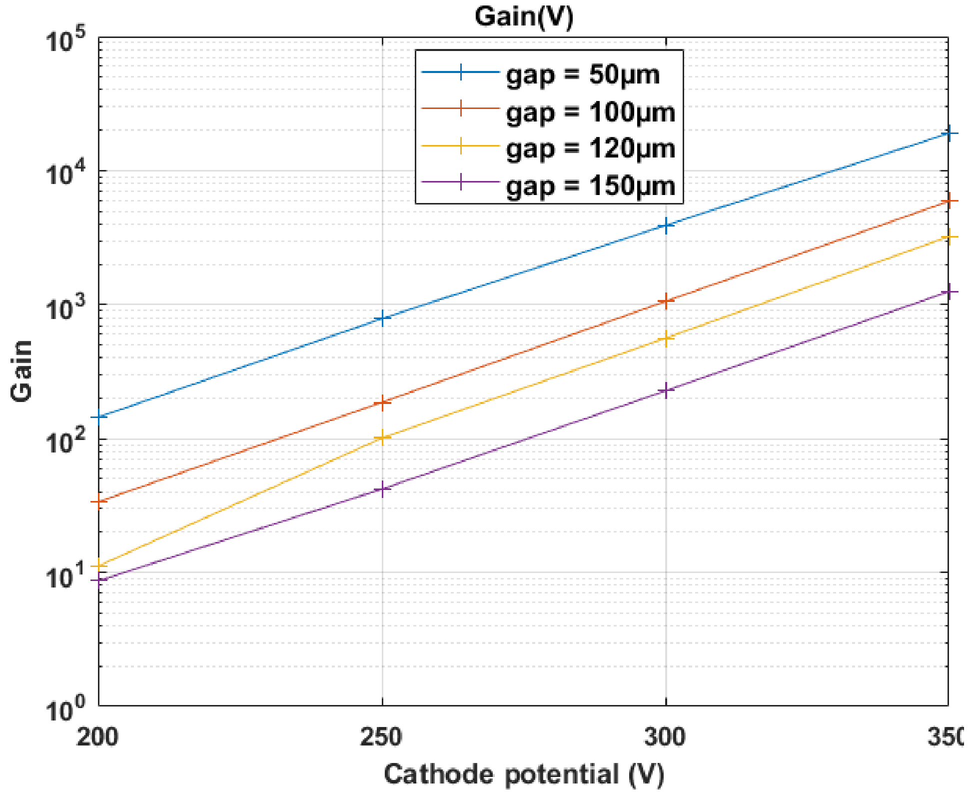
2) Event construction by randomly selecting 230 gain values in the catalog

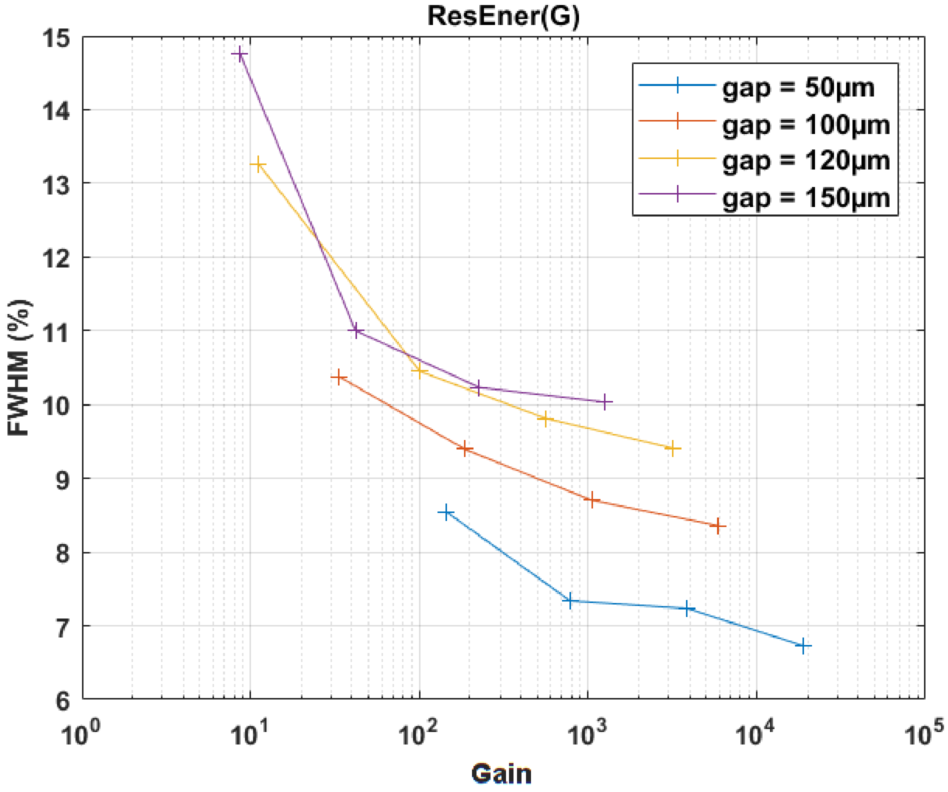
$n_e = E_{Fe\text{-}55} / W_{Ar} = 5.9\text{keV} / 26\text{eV} \approx 230\ e^-$

-> Computing time divided by ~ 50.



Flat anode - Results

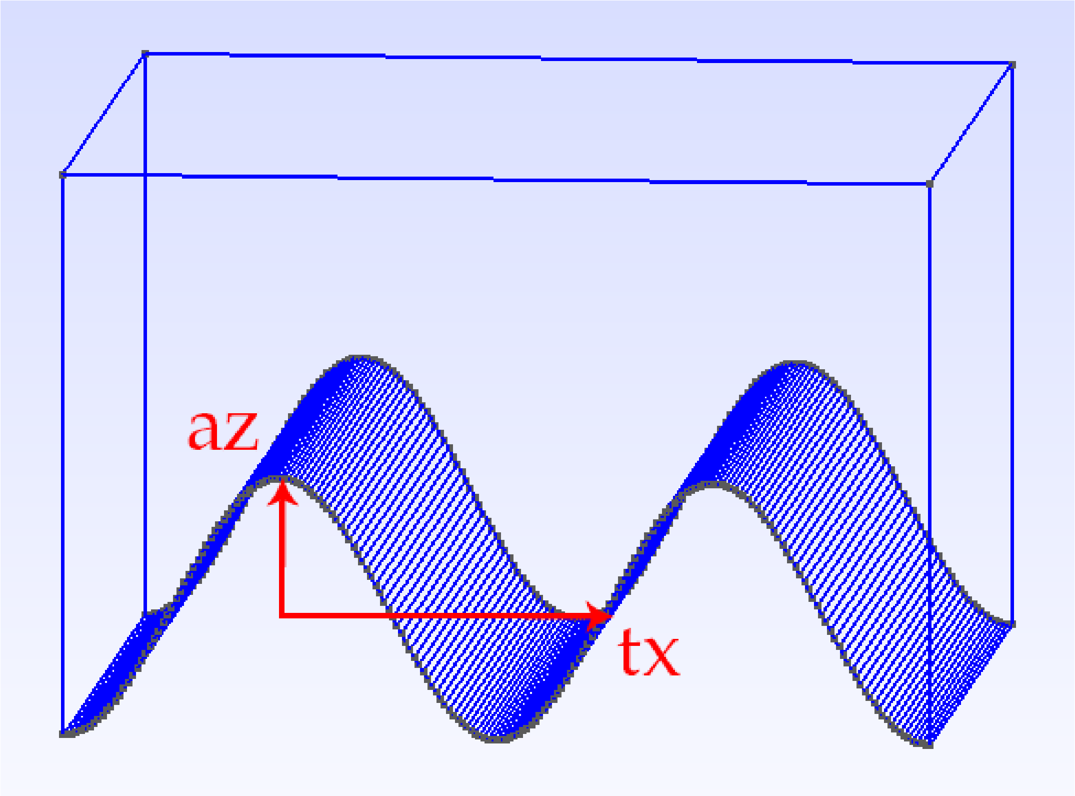




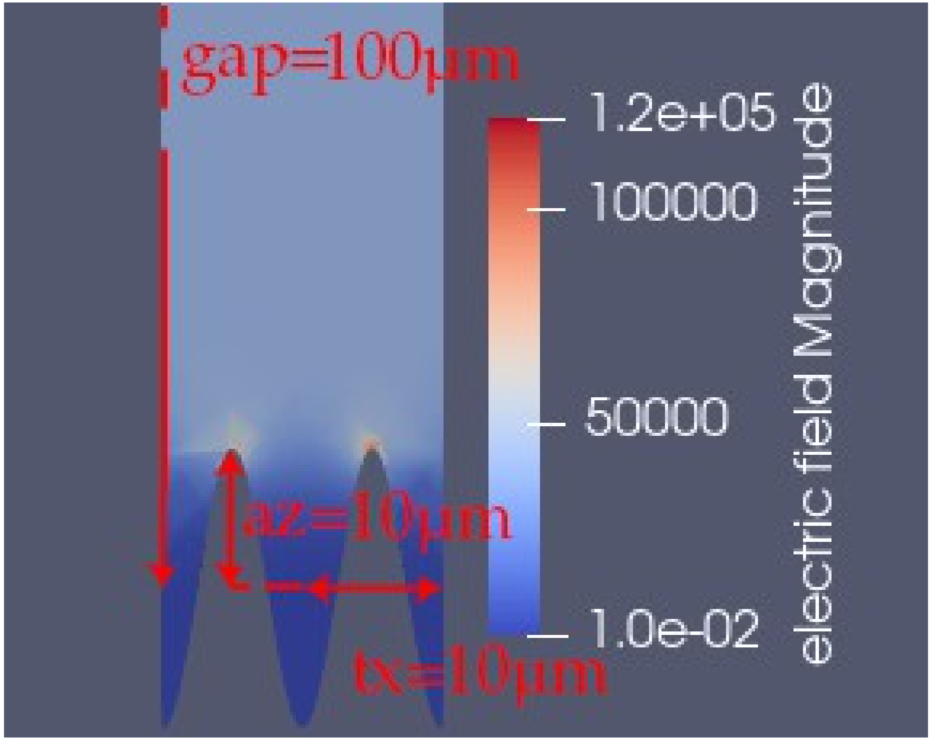
Roughness modelisation

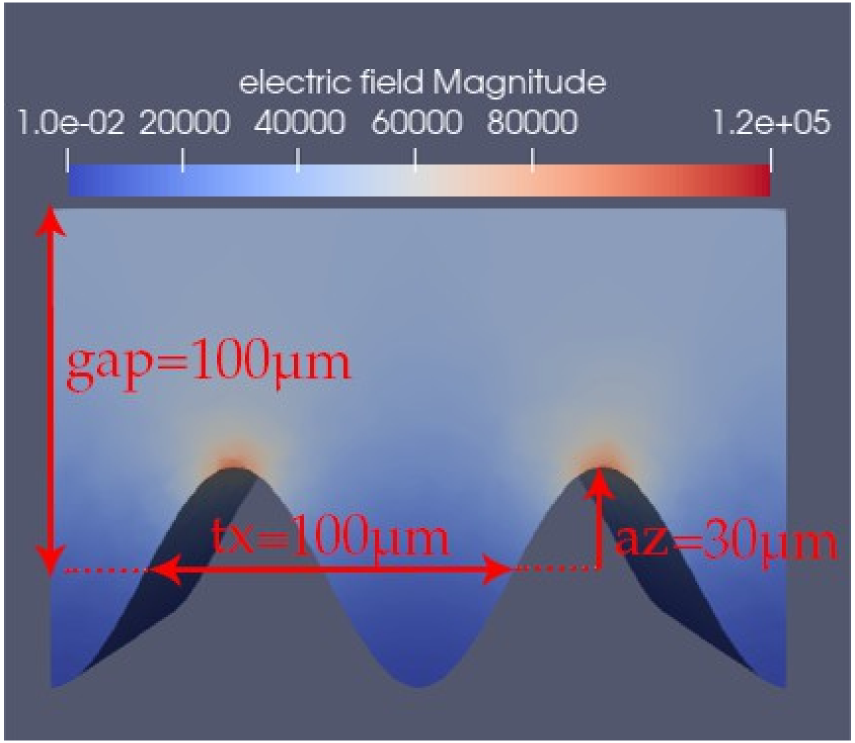
Anode roughness modelisation → 1D sinusoidal oscillations :

- tx : oscillation length
- az : oscillation amplitude



Roughness influence on electric field



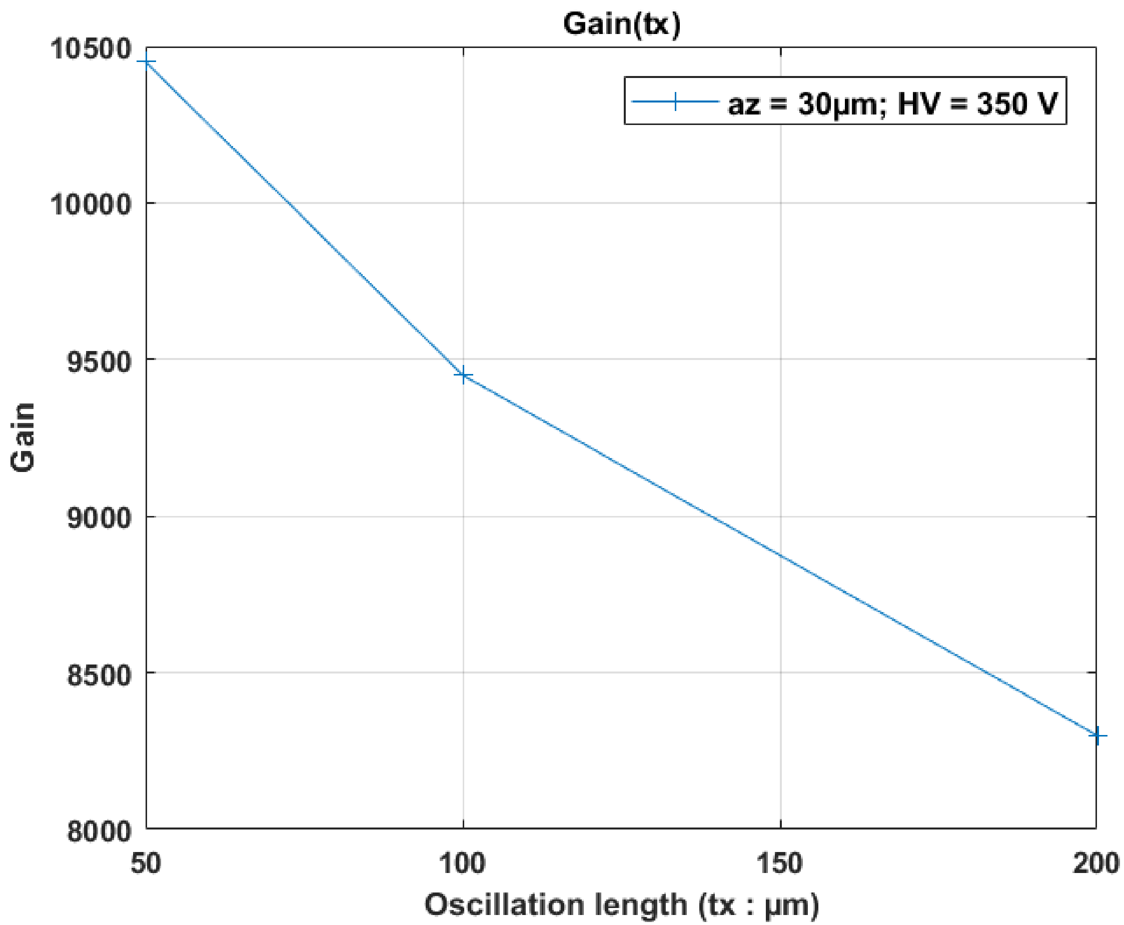


tx=10 µm ; az=10 µm – tx=100 µm ; az=30 µm

gap=100 µm

Influence of tx on gain

For a given az, the gain is a function of tx

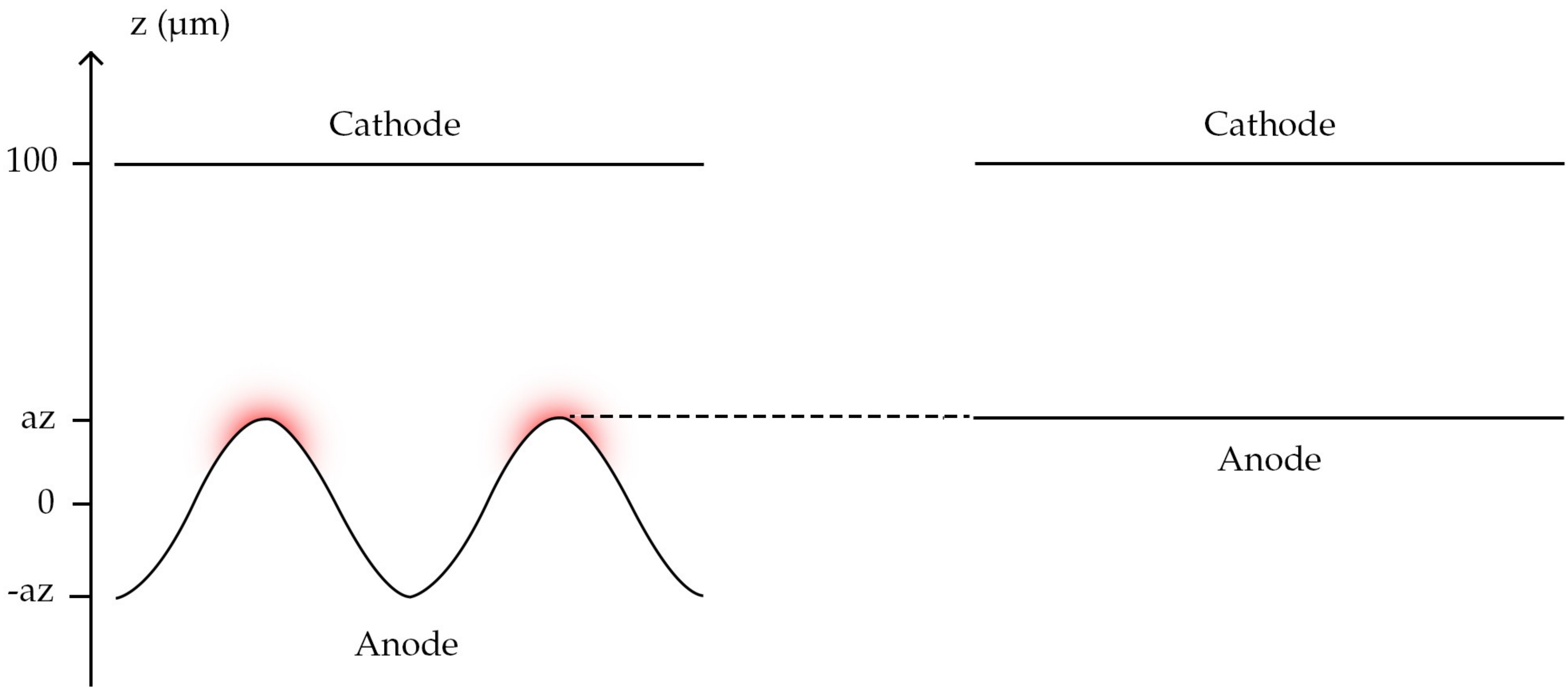


Peak effects

az/tx < 1 : low peakness → low peak effect
az/tx > 1 : high peakness → high peak effect

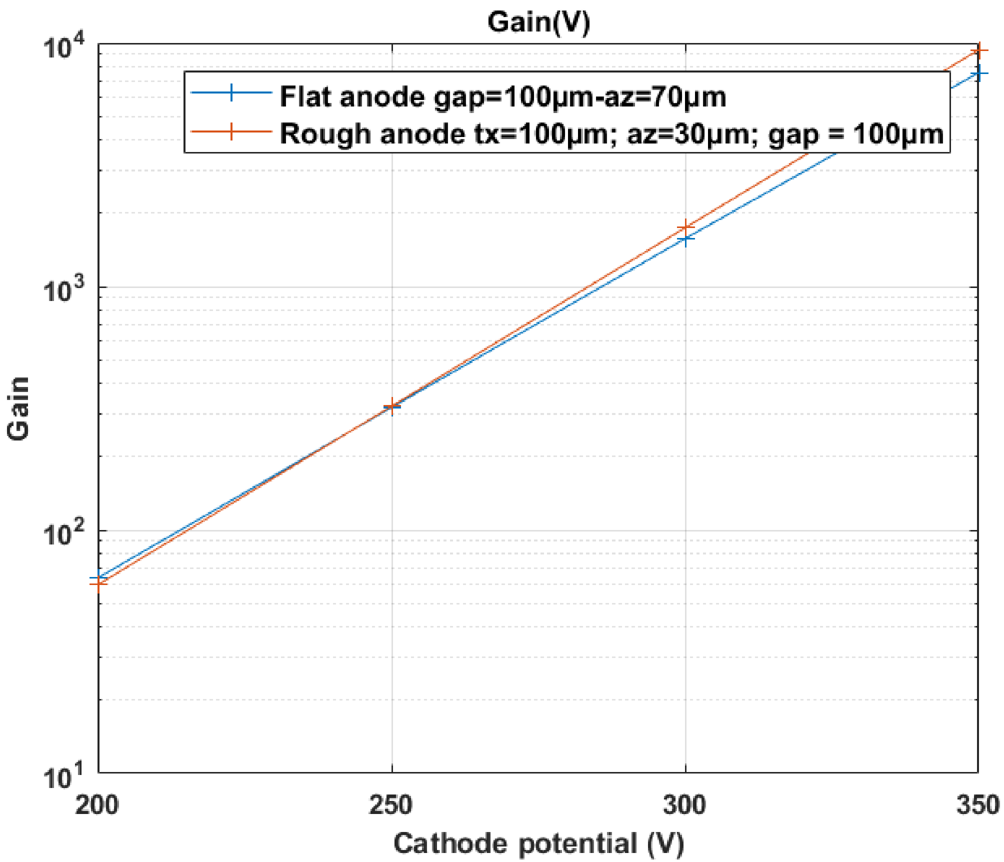
High peak effect → higher electric field near oscillation maximums

Rough anode vs. Flat anode

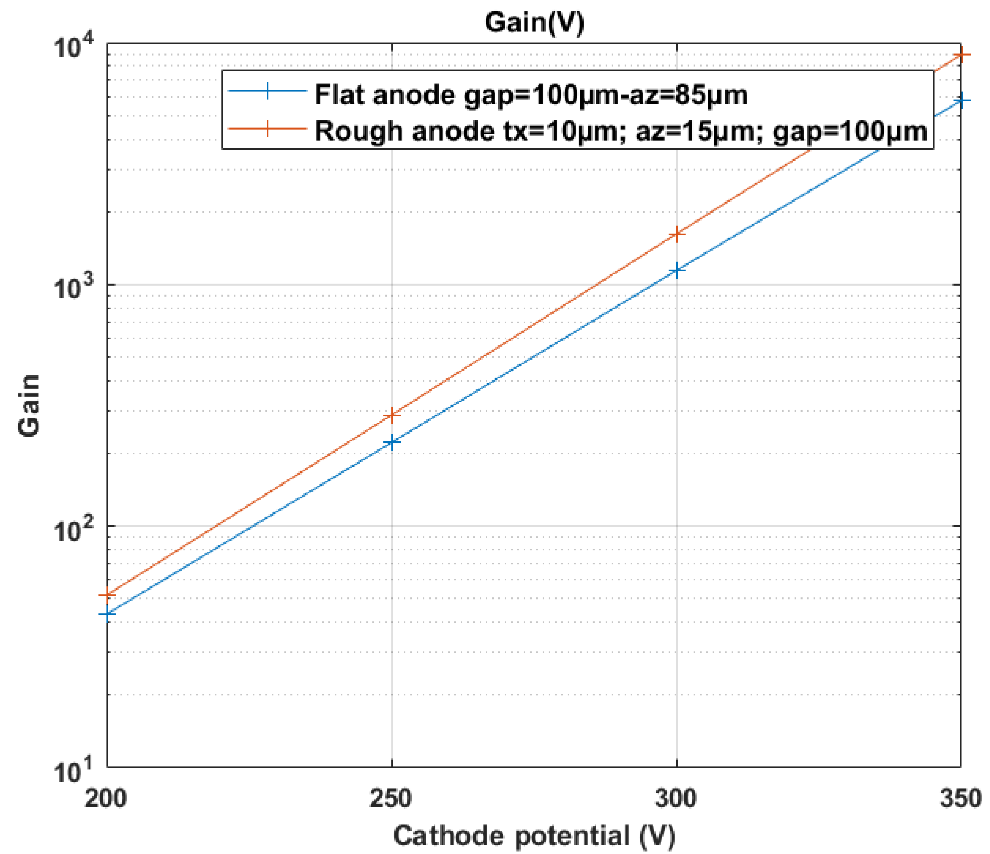


Performance comparison between a rough and a flat anode

Rough anode vs. Flat anode

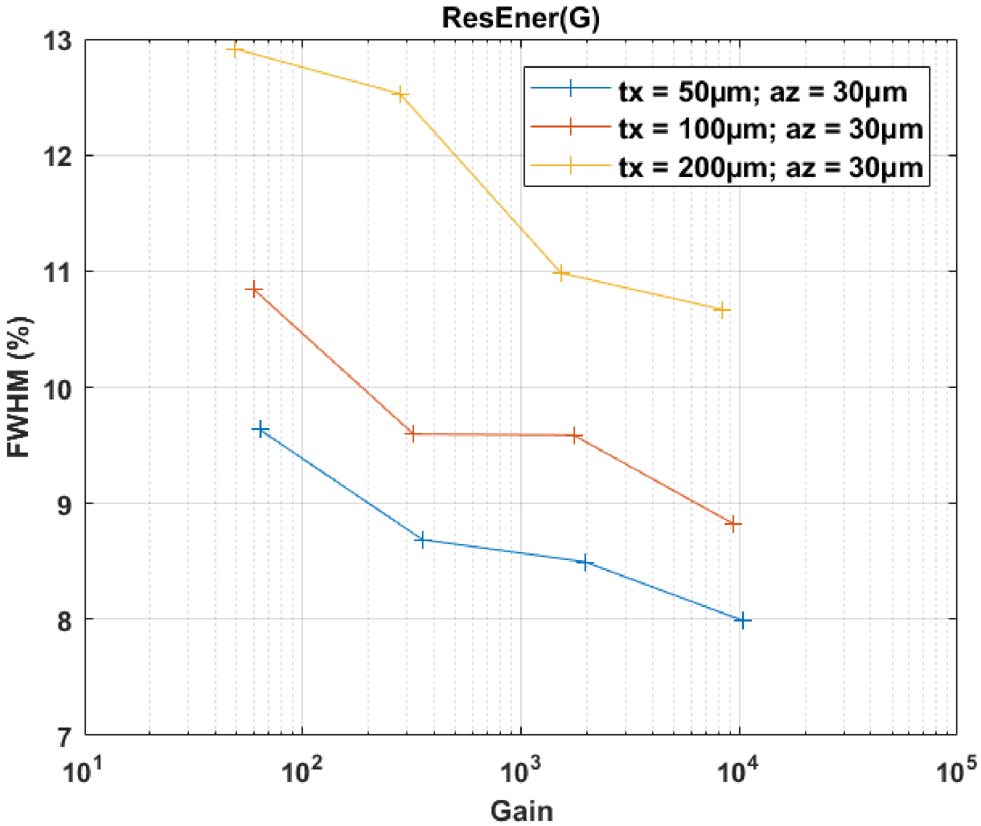


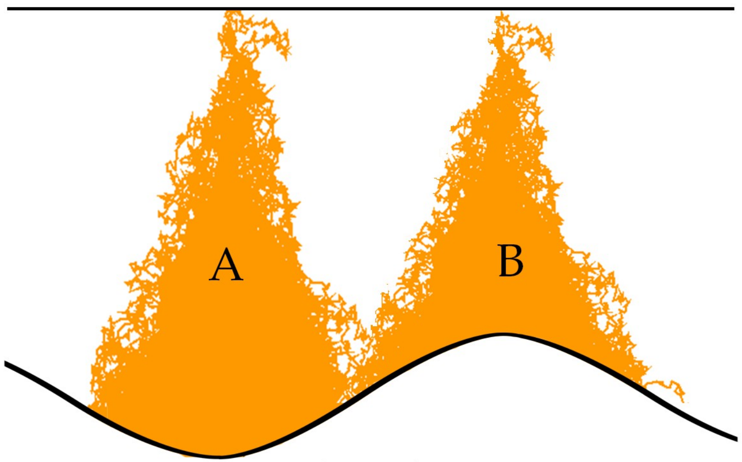
az/tx=0.3, low peak effect influence



az/tx=1.5, peak effects increase the gain by a 1.4 factor

Influence of tx on energy resolution





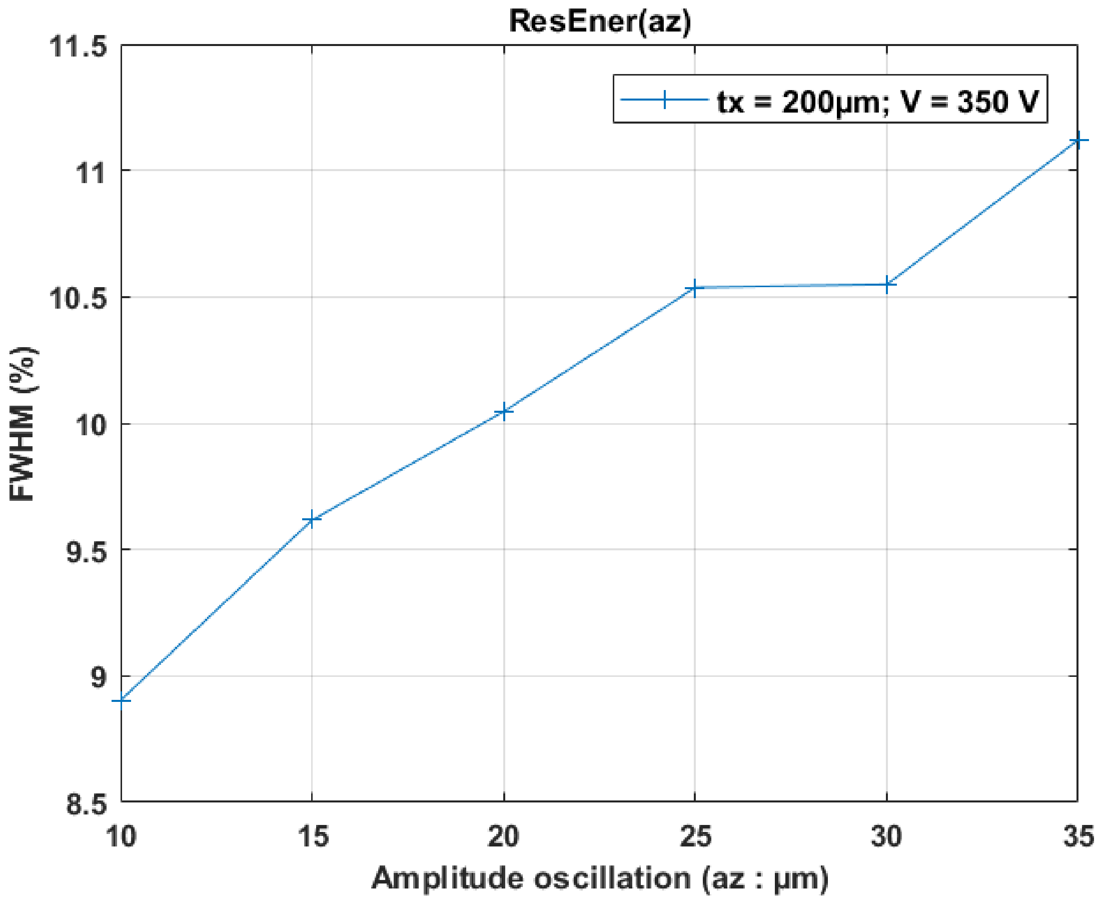
$Gain_B > Gain_A$

tx >= avalanche width → Bad energy resolution

Influence of az parameter

For a given voltage and tx, energy resolution is a function of az :

- Electrons travel a gap which length ∈ [100–az ; 100+az] µm
→ as oscillations are on x axis, gain depends of x

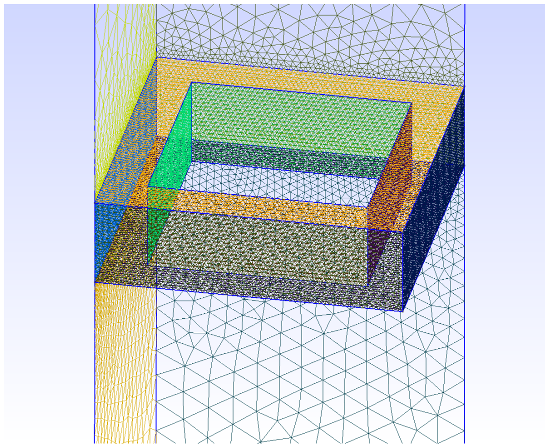


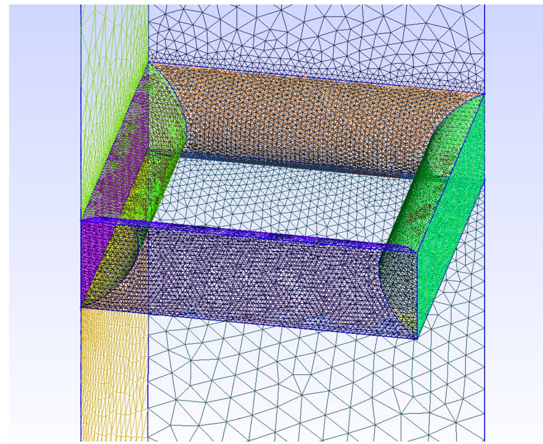
Influence of grid shape

Which grid shape has the best energy resolution ?

Electronic transparency ?

Square wires
t=18µm

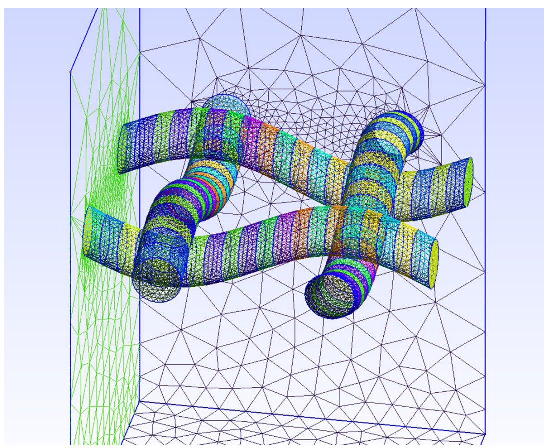


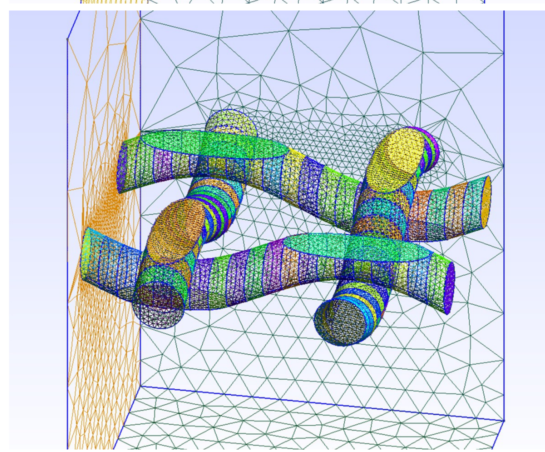


Cylindrical wires
t=18µm

Woven wires
t=36µm

Amplification
gap=100µm
Hole width=45µm

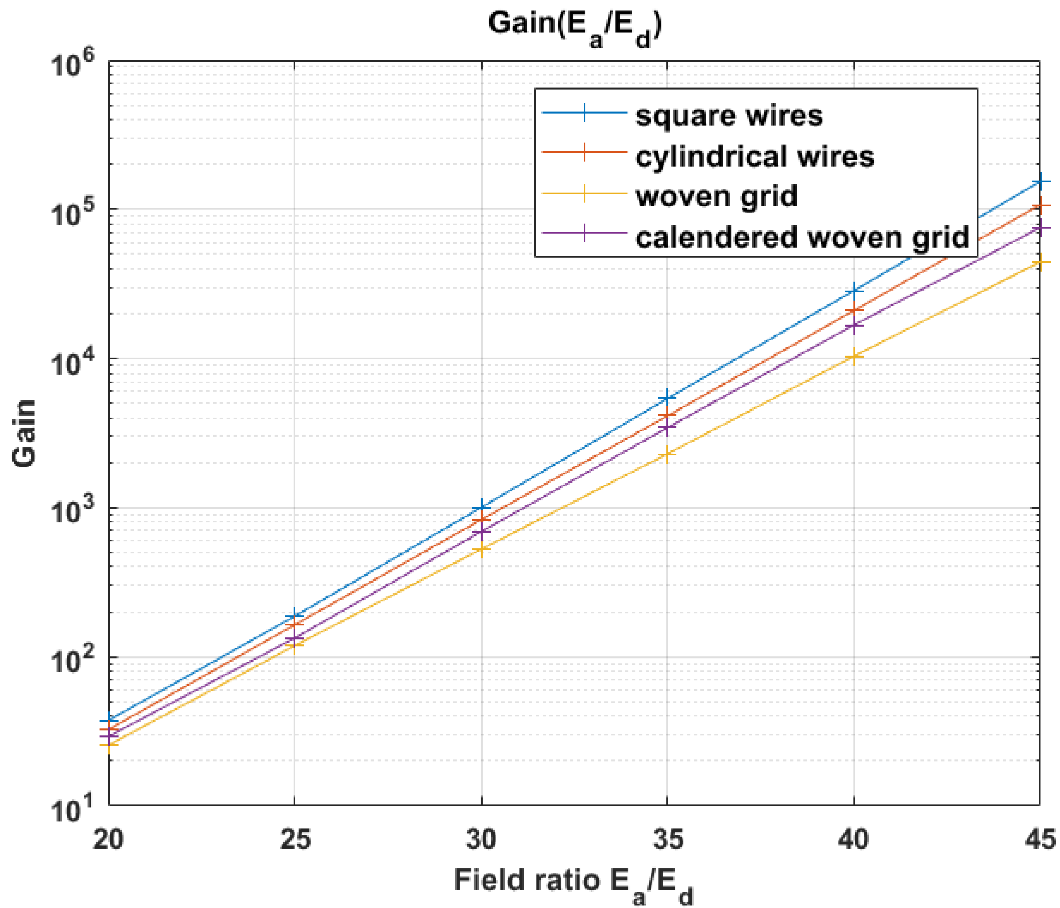




Woven and
calendered wires
t=26µm

Influence of mesh shape

Gain



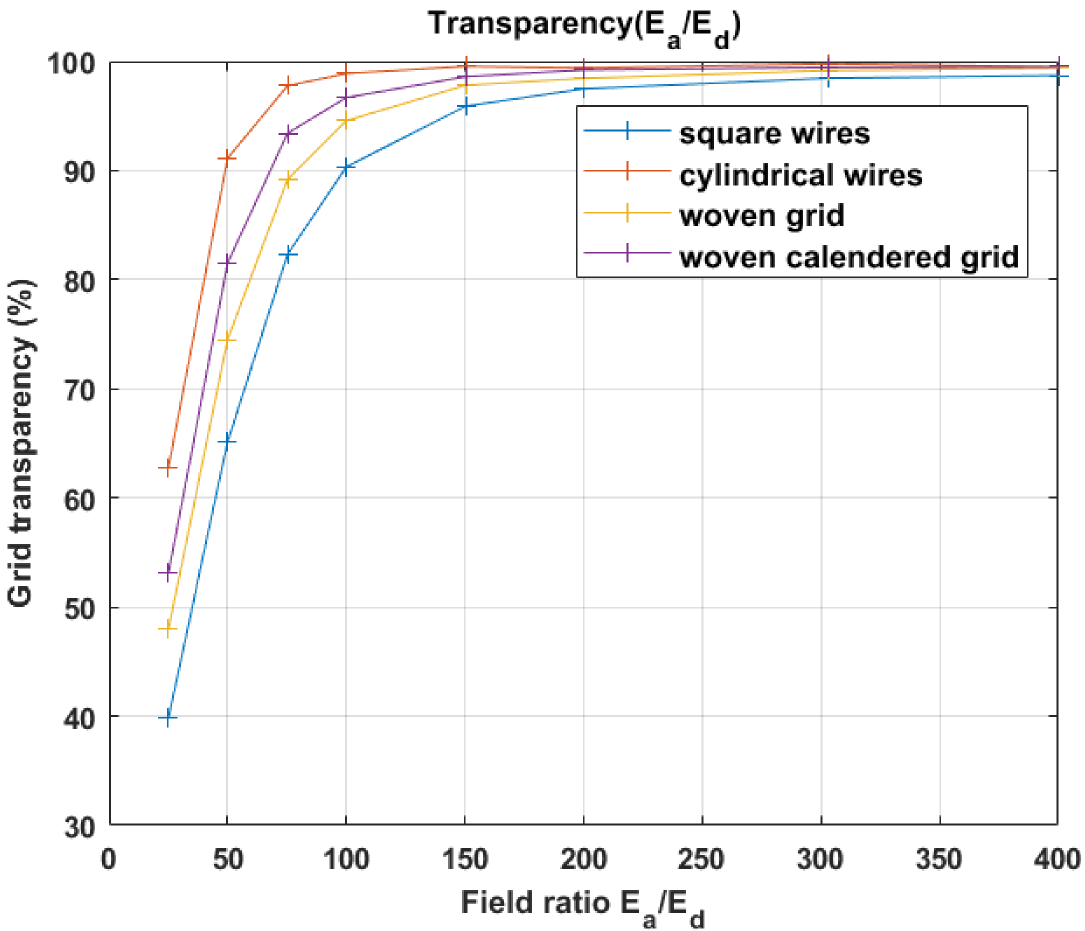
Mesh shape	Gain @ E_a/E_d=40 E_a=40 kV/cm
Woven (t=36µm)	10370
Woven & calendered (t=26µm)	16790
Cylindrical wires (t=18µm)	20980
Square wires (t=18µm)	28530

Correlation between gain and mesh thickness : High thickness → low gain

Larger gain on square wires → amplification on wire edges ?

Influence of mesh shape

Transparency

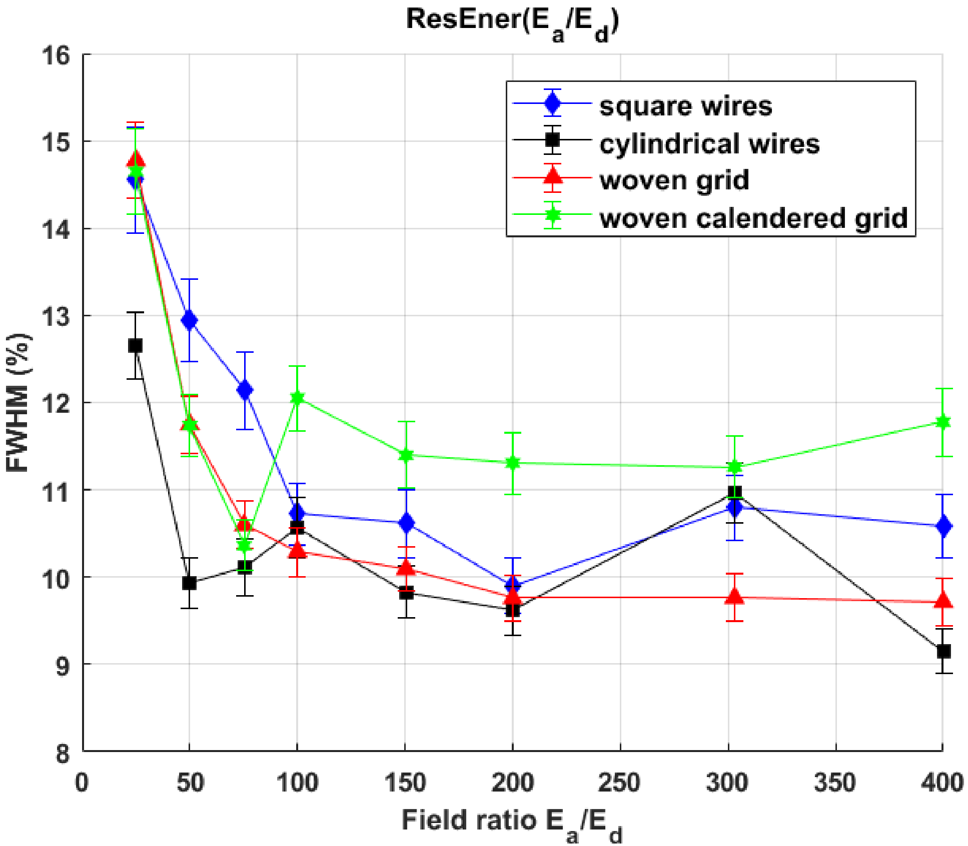


Mesh shape	Transparency @ E_a/E_d=100 E_a=40 kV/cm
Square wires (e=18µm)	90,5%
Woven (e=36µm)	95%
Woven & calendered (e=26µm)	97%
Cylindrical wires (e=18µm)	99%

Better transparency with thinner and smoother meshes

Influence of grid shape

Resolution



Mesh shape	Resolution @ Optimal point (FWHM)
Woven and calendered	11,5%
Square wires	10,2%
Cylindrical wires	9,8%
Woven	9,7%

Optimal point @ 200 for square and cylindrical meshes, @ 300 for woven meshes (E_a=40 kV/cm)

No strong dependency of mesh shape on energy resolution

Conclusion

- Anode **large scale oscillation** (tx > 100 µm & az > 10 µm) **impact badly the energy resolution**
- Defects with **high peakness** (az/tx > 1) **impact the gain** and therefore energy resolution
- **Mesh shape** has an **impact on amplification and e^- transparency**, but almost **no effect on energy resolution**

Perspective

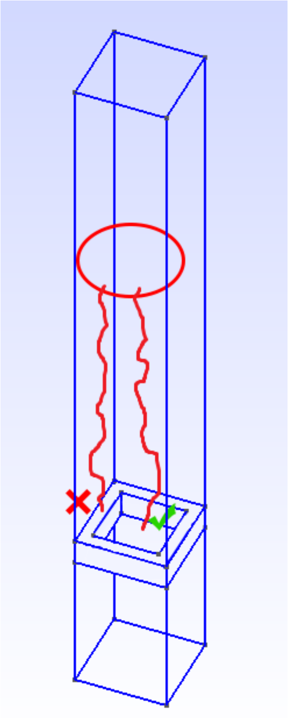
- Further studies needed to compare with real detector data
- More realistic anode modelisation ? (2D roughness, effects of readout strips, …)

backup

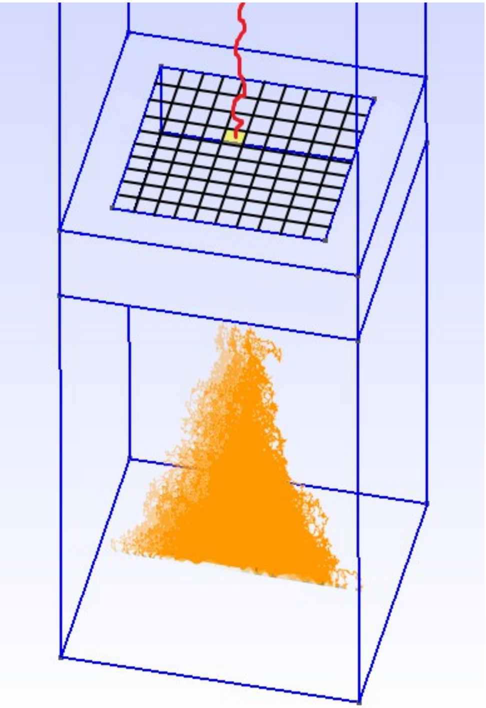
Influence of grid shape

Computing method

Nearly the same method as the one used for surface condition study
But with mesh transparency calculated by Garfield++



1) drift of the primary electrons



2) Segmentation of the hole and gain computing