Experimental and Numerical studies on Bulk Micromegas

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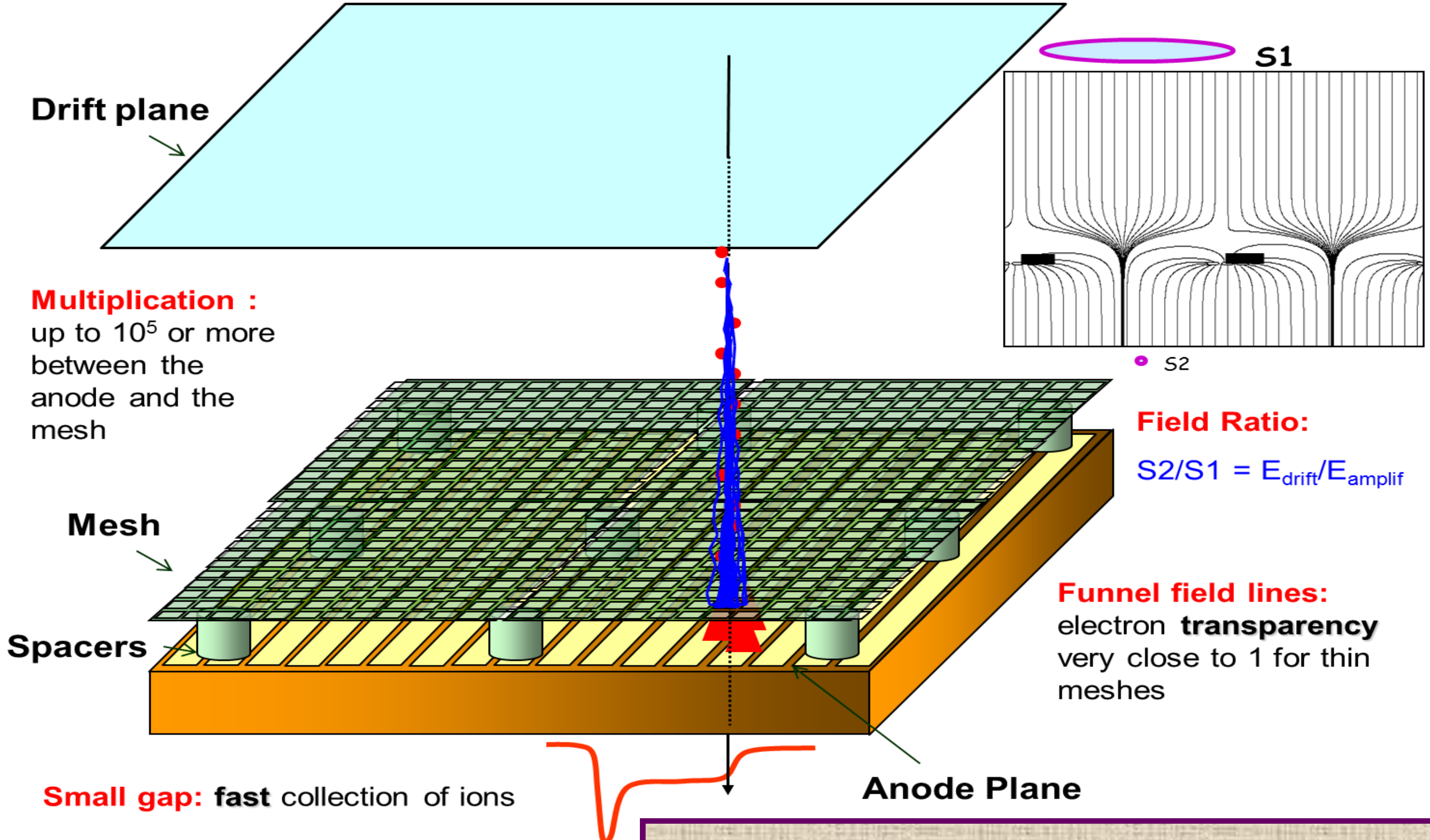
BULK MICROMEGAS



Details of BULK Micromegas used:

.10x10 cm^2 active area

.Amplification gap: 192 μm and 128 μm

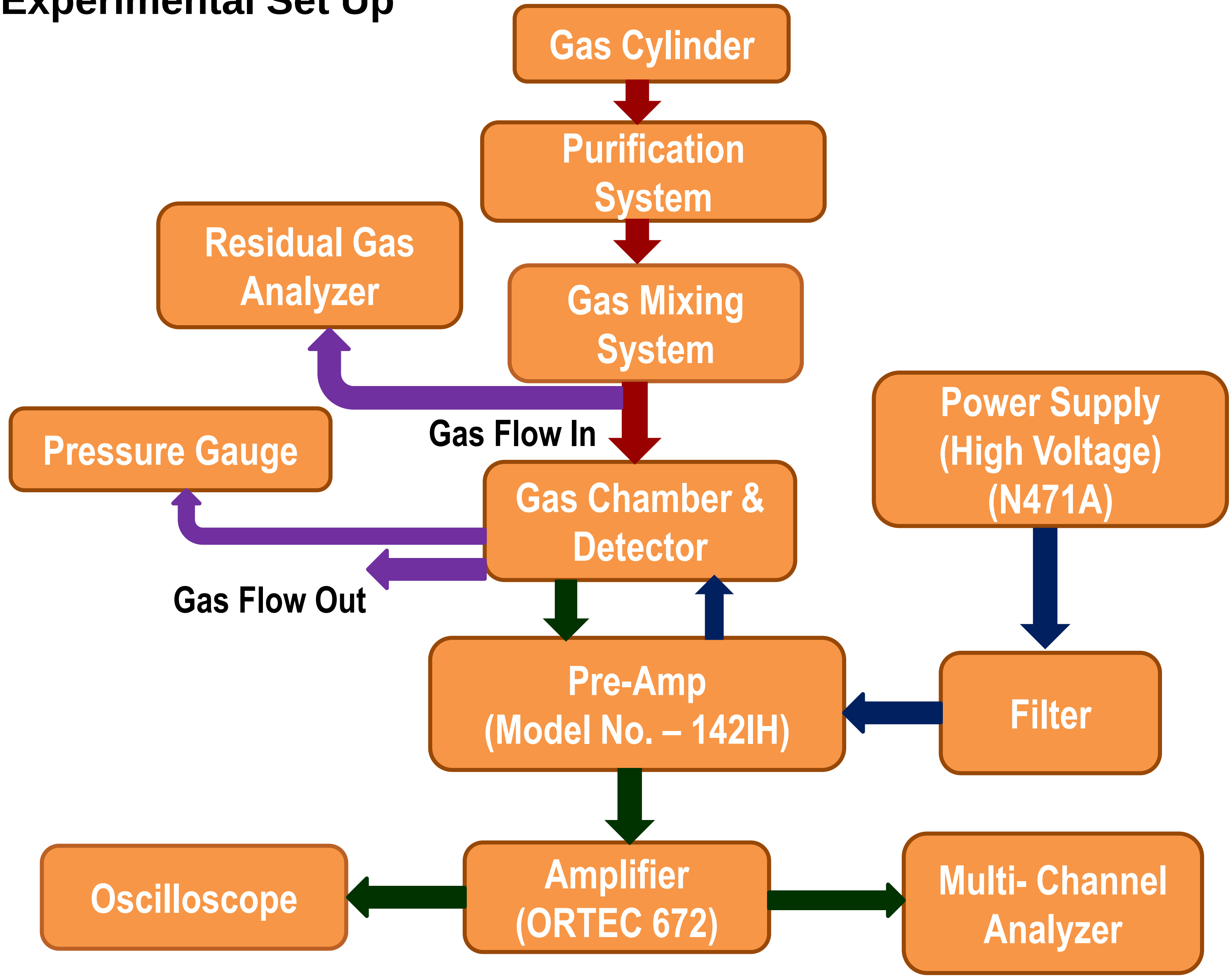
.Stainless steel mesh, wire diameter 18 μm, pitch 63 μm

.Dielectric Spacer, diameter 400 μm, pitch 2 mm

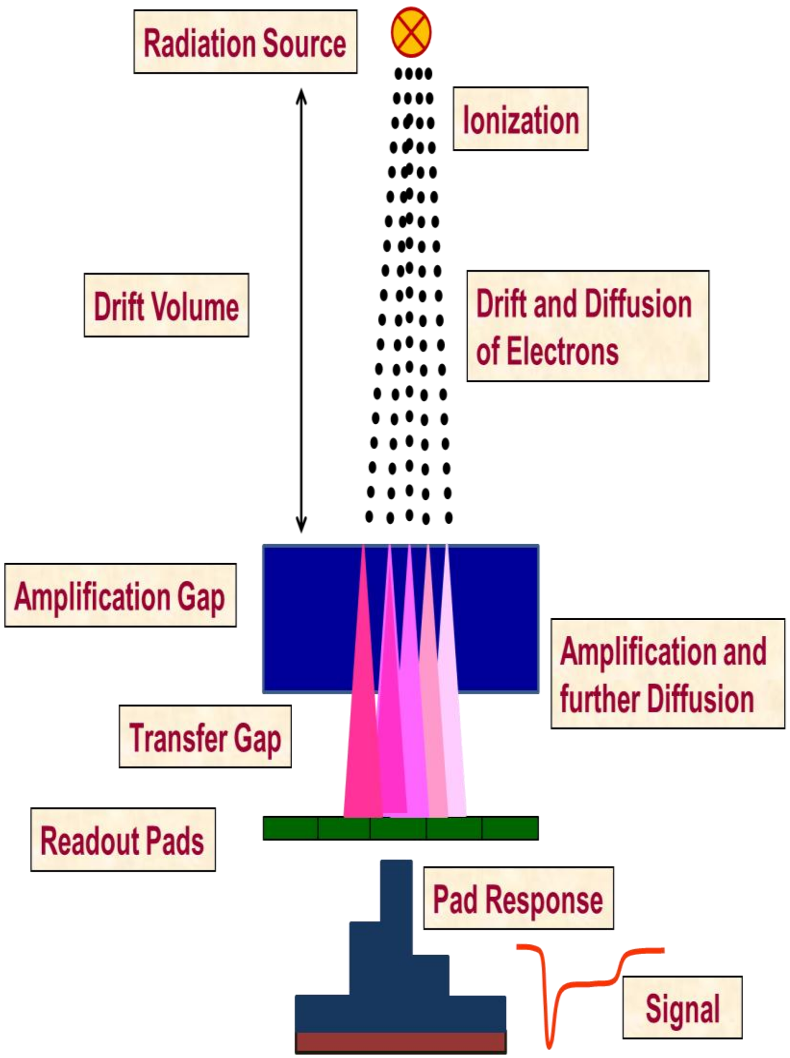
Motivation

- ***BULK Micromegas with 128 μm amplification gap – promising candidate for building TPCs***
- ***Recent interest – characterization of larger gap BULK Micromegas***
- ***Comparison of standard BULK with a BULK having larger amplification gap of 192 μm - measurement of detector gain, energy resolution, transparency etc in argon based gas mixtures***
- ***Comparison of measured detector characteristics to numerical simulations using Garfield framework***
- ***A numerical study to determine the effect of dielectric spacers***

Experimental Set Up



Numerical Simulation



Simulation tools

Garfield framework: to model and simulate two and three dimensional drift chambers

◊**Ionization:** energy loss through ionization of a particle crossing the gas and production of clusters – **HEED**

◊**Drift and Diffusion:** electron drift velocity and the longitudinal and transverse diffusion coefficients – **MAGBOLTZ**

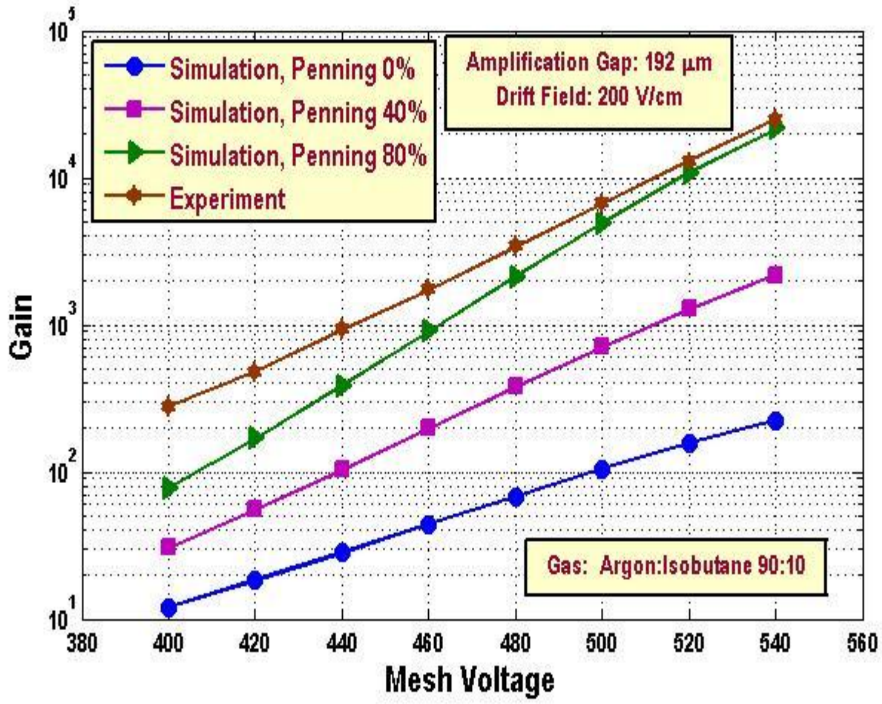
◊**Amplification:** Townsend and Attachment Coefficient –**MAGBOLTZ**

◊**Field:** Electric Potential and Field – **neBEM (nearly exact Boundary Element Method)**

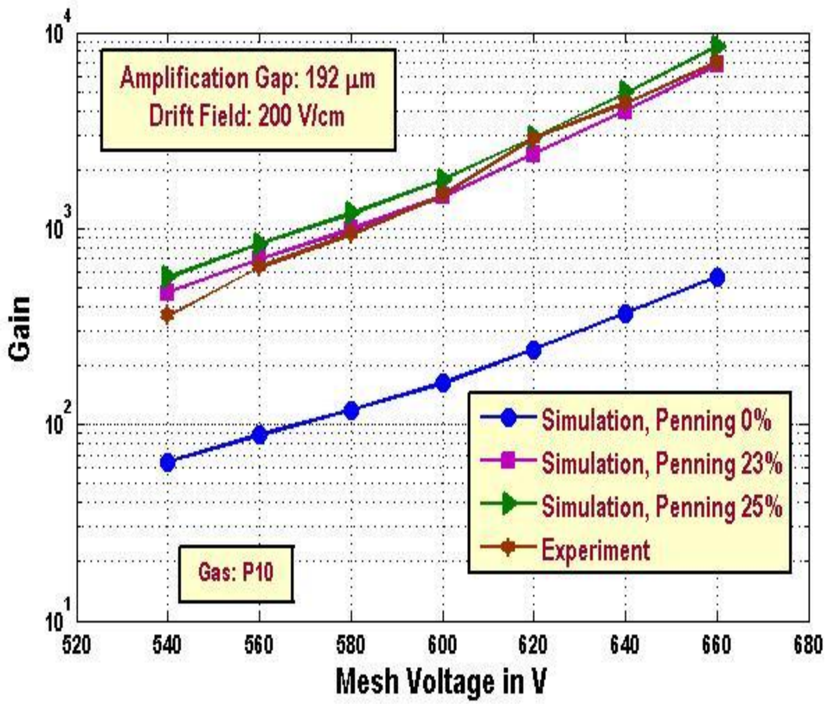
Garfield + neBEM + Magboltz + Heed

Measured Gain Vs. Simulated Estimate

Amplification Gap: 192 μm



a) Gas: Argon 90% Isobutane 10%



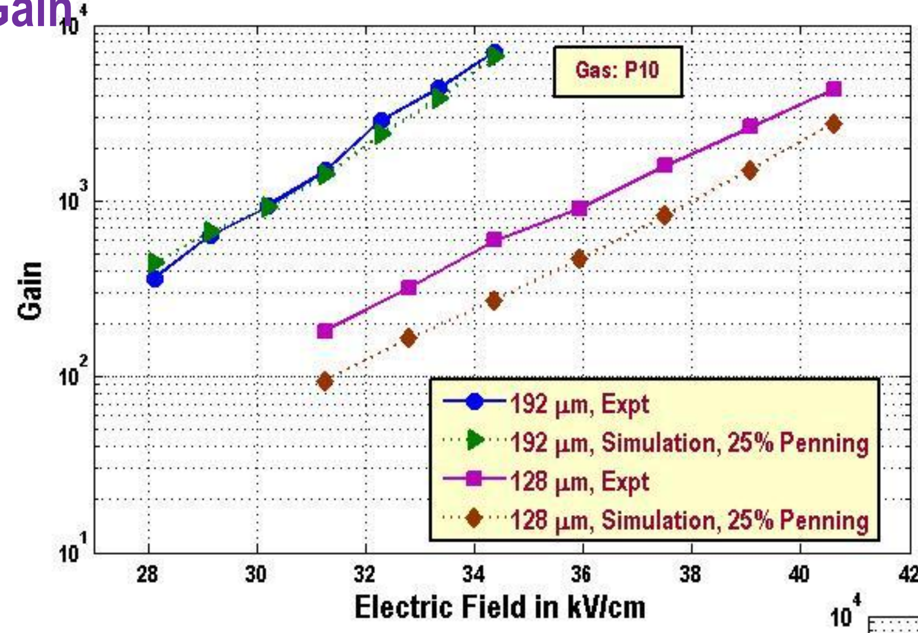
b) Gas: Argon 90% Methane 10%

* Without penning effect, simulated gain is considerably lower
* In Argon:Isobutane 90:10, we have chosen the penning transfer rate to be 80%, which is much higher than that used in ref [1]
* In P10, the chosen penning rate, 25%, agrees well with ref [1]

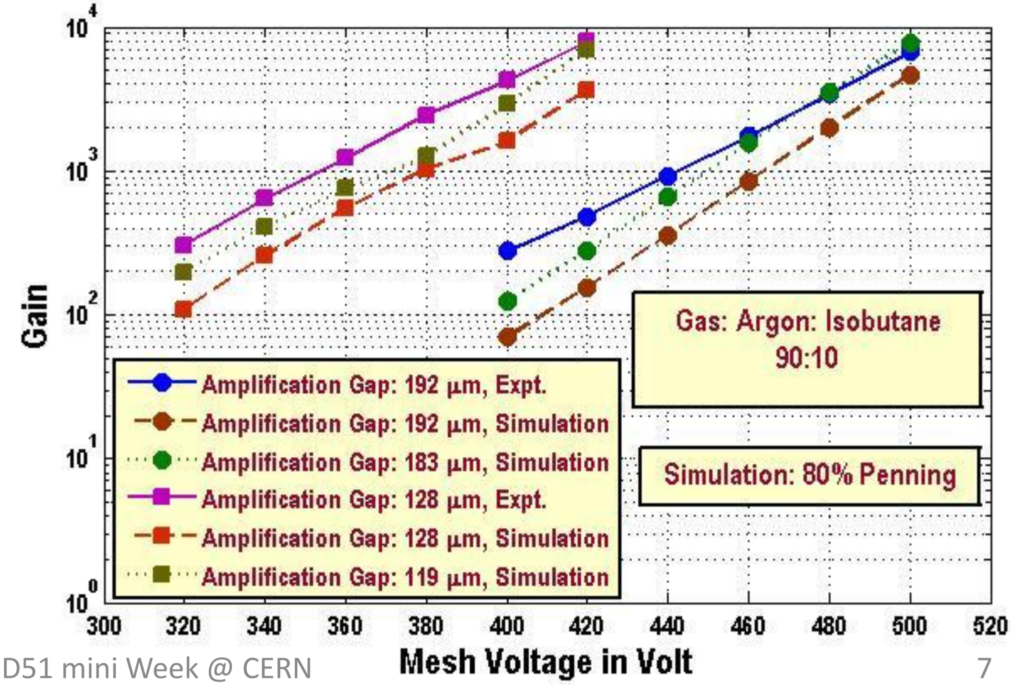
[1] ÖSahin et al 2010 JINST 5 P05002

192 μm vs 128 μm *(Experiment and Simulation)*

Gain

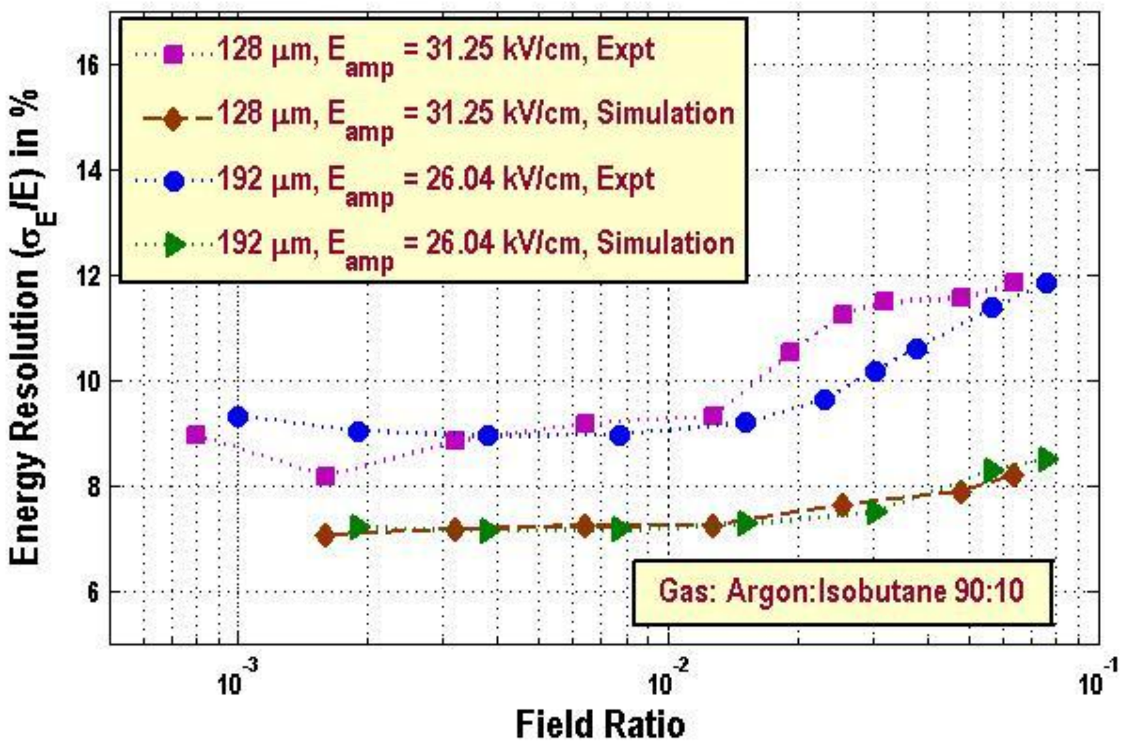


- *Penning rate 25%, for 192 μm, numerical value of gain agrees well with experimental one*
- *At this penning rate, for 128 μm, numerical value is lower than experimental data (preliminary)*

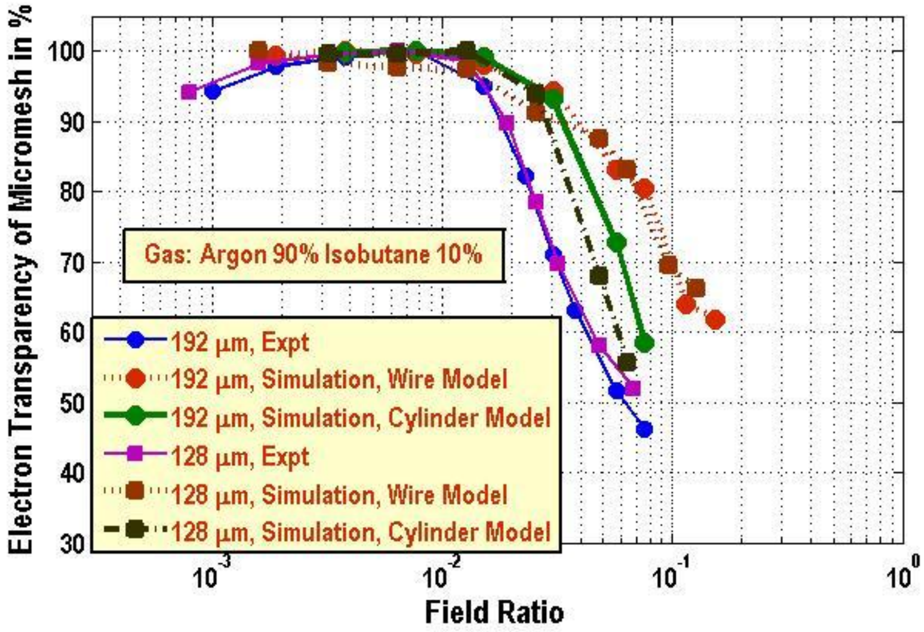


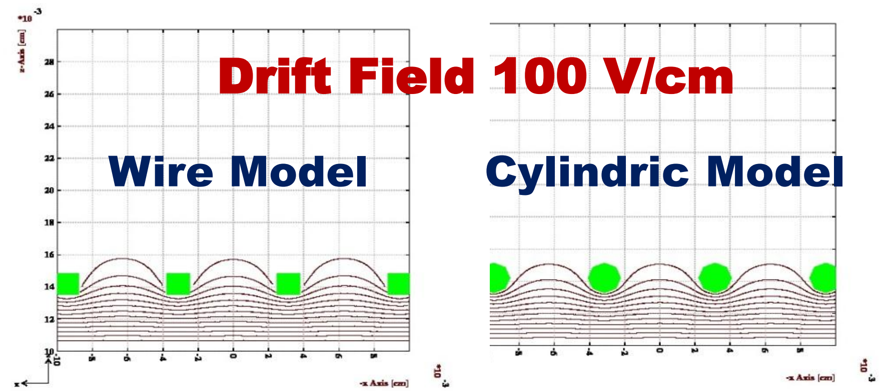
- *Penning rate 80% for both detectors, numerical value of gain is lower than that of experimental data*
- *A small change in amplification gap, changes simulated detector gain considerably. This effect is more prominent in 128 μm*

Energy Resolution

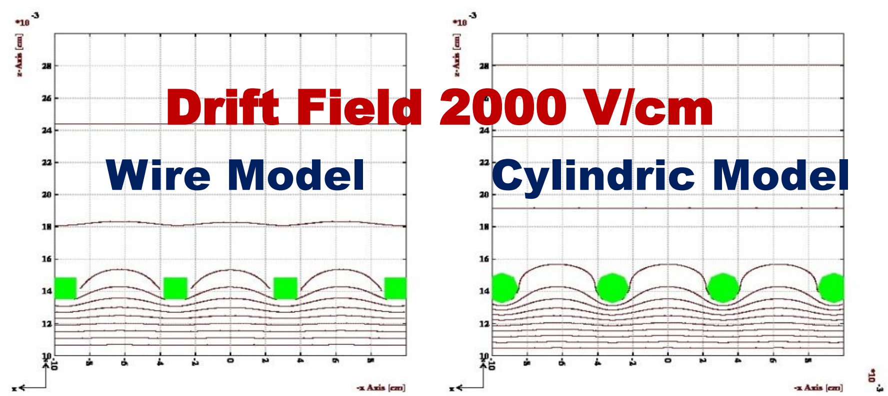


- At higher field ratio, 192 μm shows better resolution than 128 μm
- Simulations follow the experimental trend, though the estimated value is lower
- Higher estimation of electron transparency using wire model, affects the simulated value
- The calculation of variation of gain needs further investigation
- The energy resolution in P10 also shows the same trend





Electron Transparency with field ratio

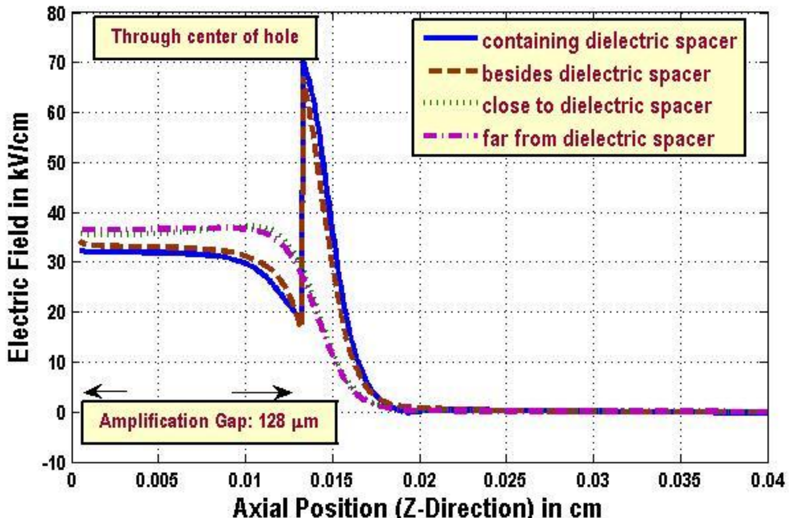


- At higher field ratio, the simulation results using wire elements are much higher than the experimental data
- The simulation results using solid cylindric elements agree quite well with experimental value

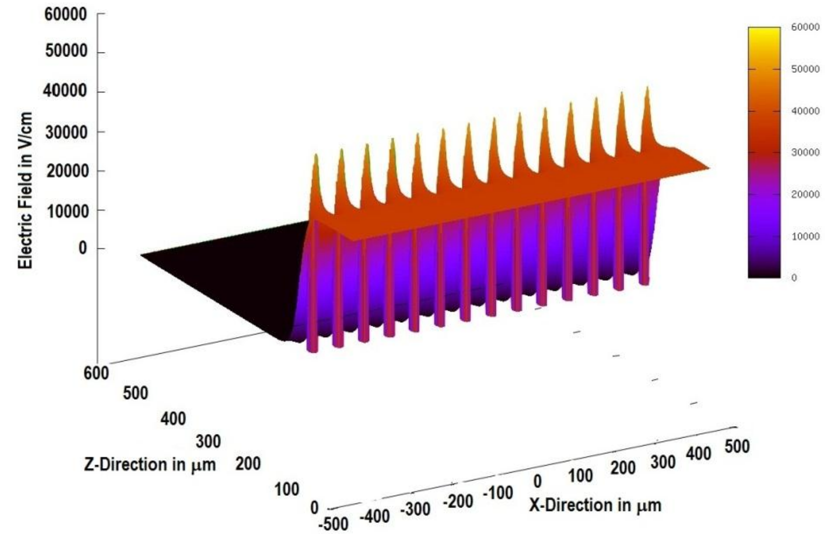
Equipotentials in the mid-plane of a mesh hole, in the thin-wire approximation of the mesh (left hand side) and using octagonal approximations of solid cylinders (right hand side).

Effect of Spacer (Diameter 400 μm, Pitch 2 mm, Amplification Gap 128 μm)

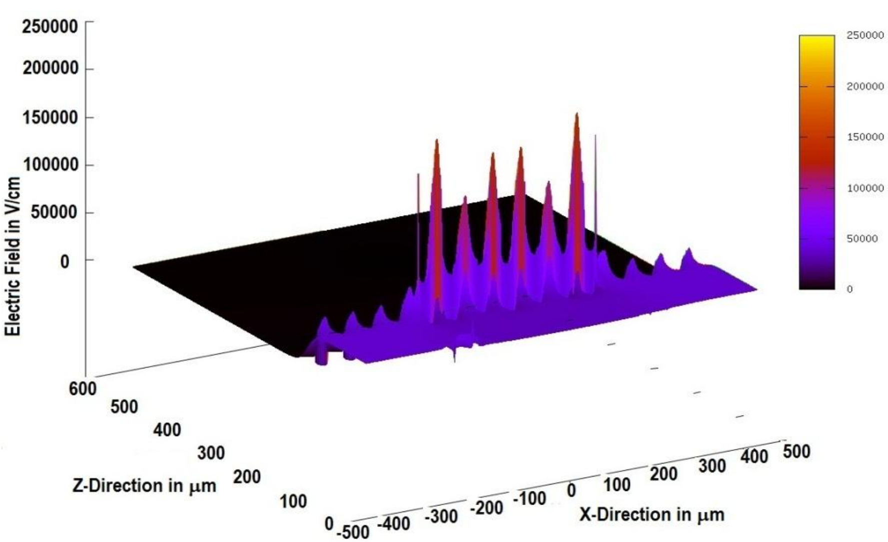
Electric Field



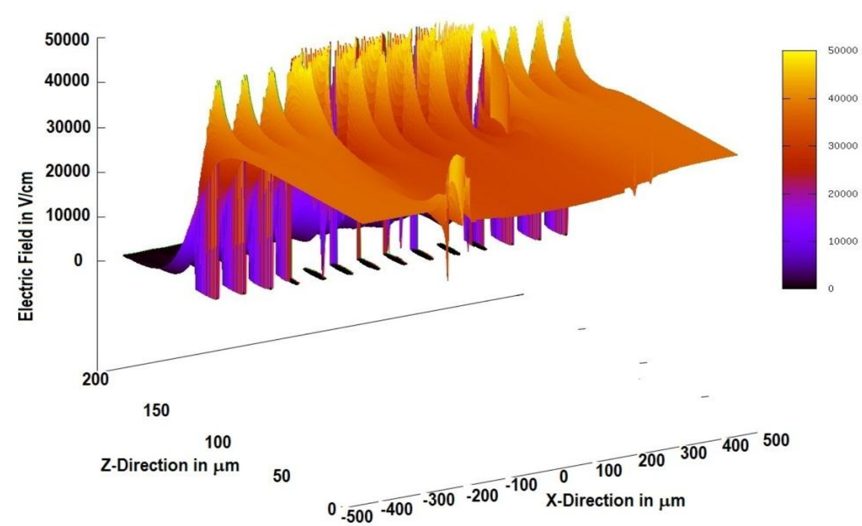
a) in axial direction through different holes



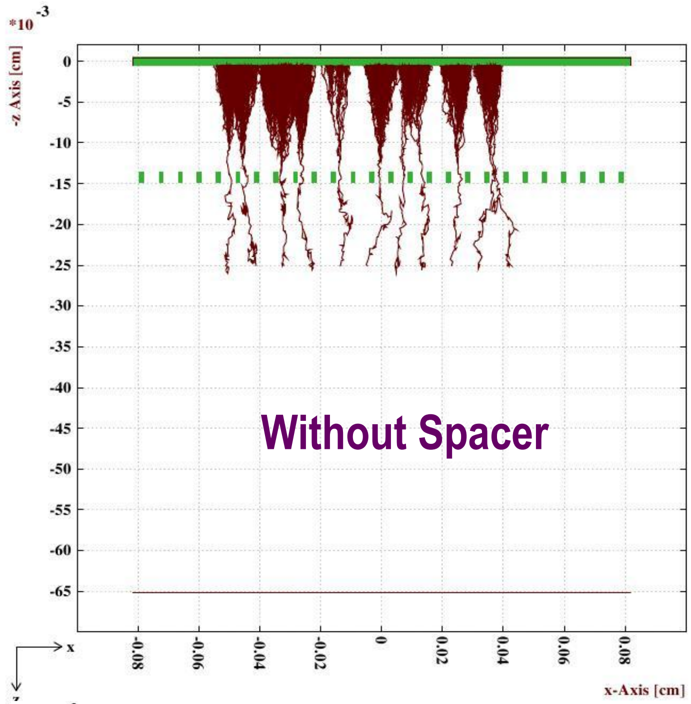
b) without dielectric spacer

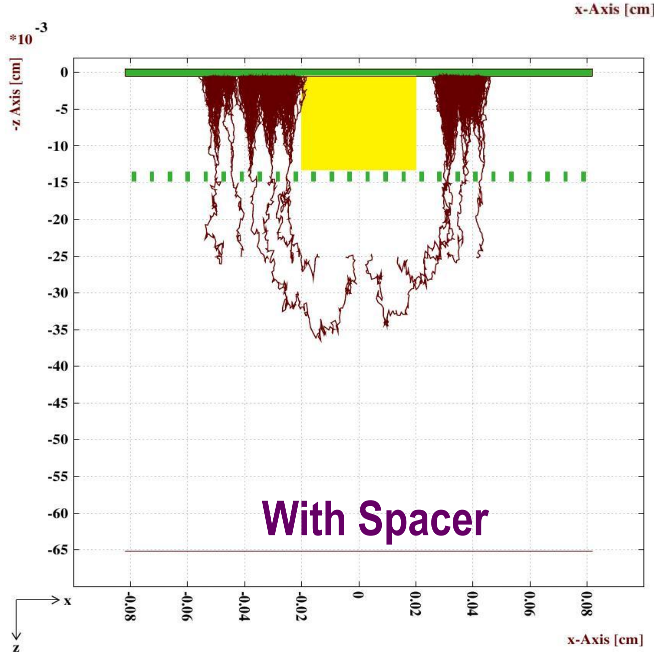


c) with a dielectric spacer



d) a close-up of (c)





Without Spacer

Track: 25 μm above mesh		
Primary Electrons		Gain
Cross the mesh	Reach middle of amplification area	
97.794	97.794	600

Track: 50 μm above mesh		
Primary Electrons		Gain
Cross the mesh	Reach middle of amplification area	
97.304	97.304	594

Track: 100 μm above mesh		
Primary Electrons		Gain
Cross the mesh	Reach middle of amplification area	
97.549	97.549	596

With Spacer

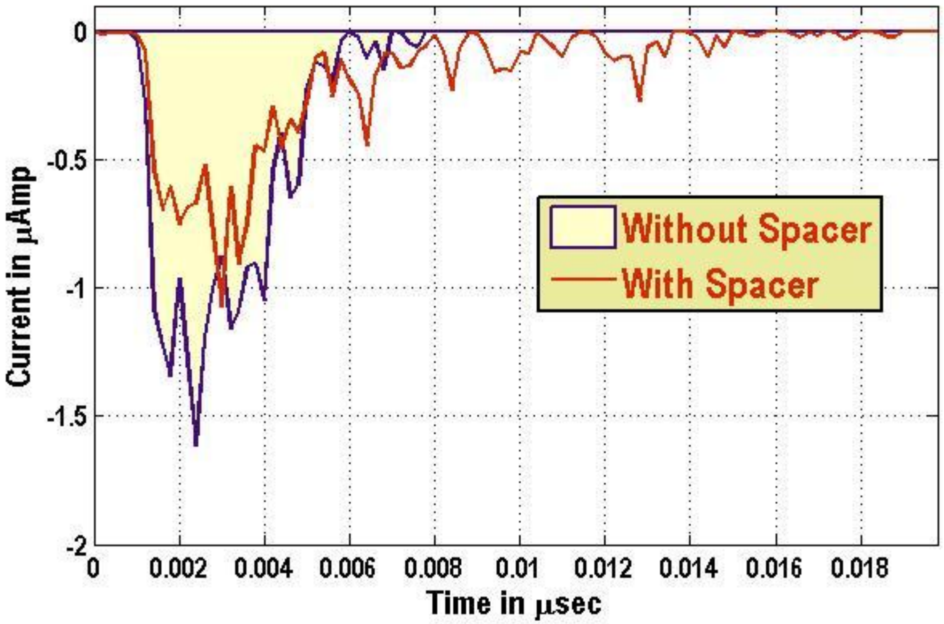
Track: 25 μm above mesh		
Primary Electrons		Gain
Cross the mesh	Reach middle of amplification area	
97.549	54.902	338

Track: 50 μm above mesh		
Primary Electrons		Gain
Cross the mesh	Reach middle of amplification area	
95.343	92.892	570

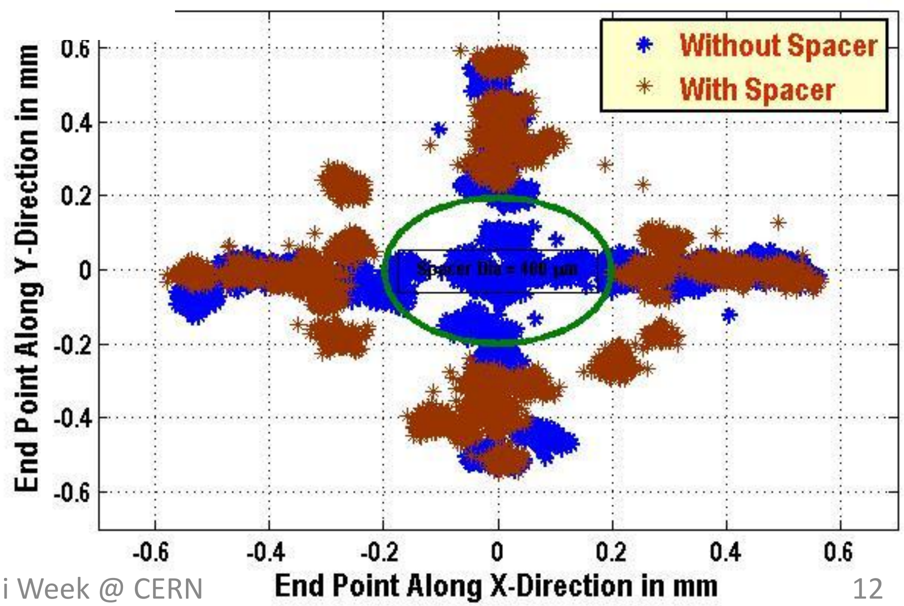
Track: 100 μm above mesh		
Primary Electrons		Gain
Cross the mesh	Reach middle of amplification area	
95.833	95.343	584

Near spacer, electron drift lines get distorted – affect detector gain

Signal and End Points of Avalanche Electrons



With spacer, the signal amplitude is lower and it has a long tail.



Readout pads around spacer are affected— likely to affect tracking efficiency

To be further investigated soon …

neBEM

- All the calculation presented here have been carried out with V1.8.12
  - One bug-fix
  - Increase in speed by 20-30% in the post-processing phase (evaluation of potential and field)
  - No compromise in accuracy
- Future versions will focus on
  - Error estimation
  - Even faster execution
  - Solid modeling capabilities

Summary

* Maximum gain achieved with a larger amplification gap found to be similar/ slightly more than that with a smaller gap.

* For higher gains and higher field ratios, larger gap yields better resolution.

*Successful comparisons with simulation indicate that the device physics is quite well understood. Exact value of Penning rate for certain gases remains an issue, though.

*Effects of spacers on gain, signal and distribution of electrons as they reach the anode, indicated significant changes occurring around the spacer.

* In future, further studies to be carried out using Micromegas having a wider range of amplification gaps. Additional gas mixtures to be used, as well.

* Other important features such as ion back flow to be studied.

*A new version of neBEM released. Further developments expected soon.