Comparison of BULK Micromegas with Different Amplification Gaps

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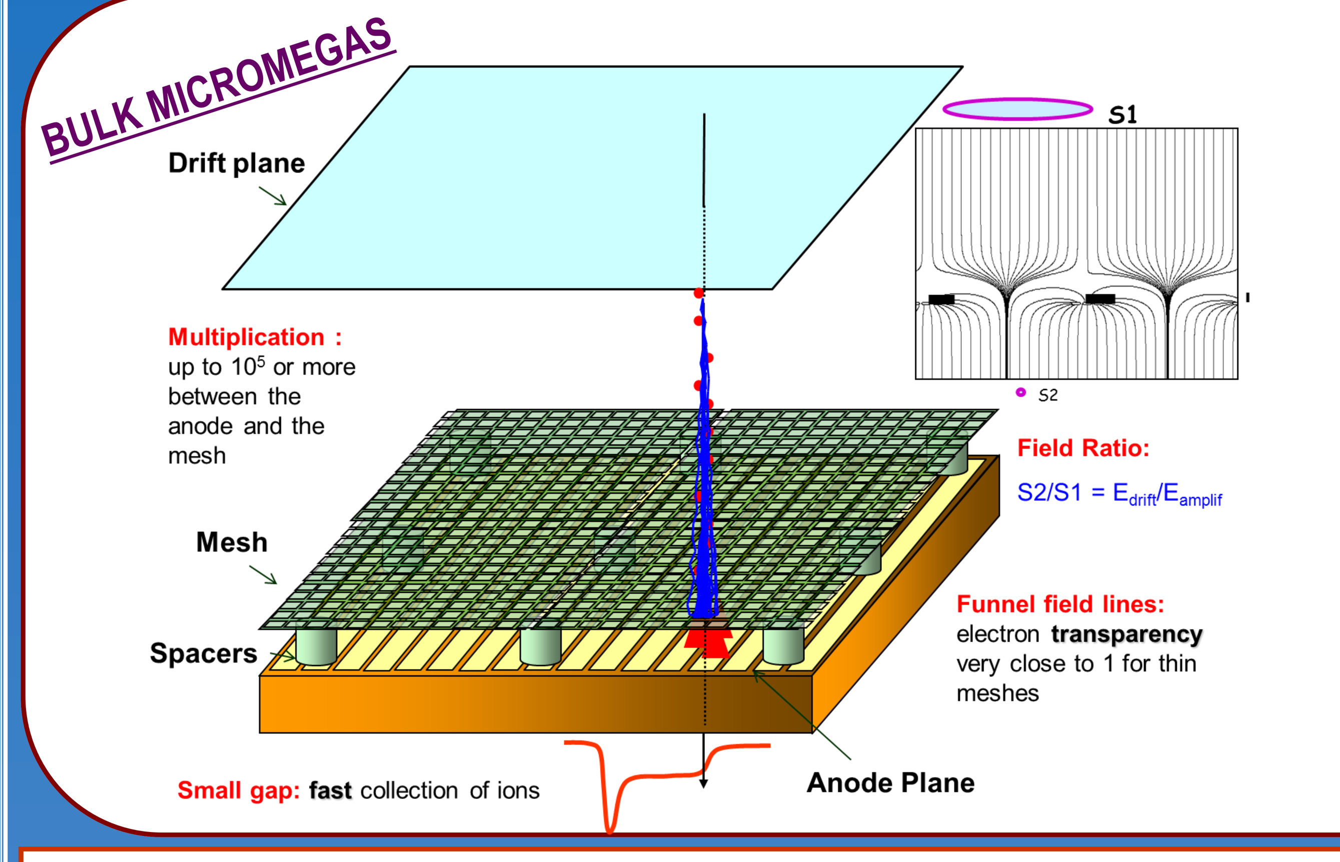
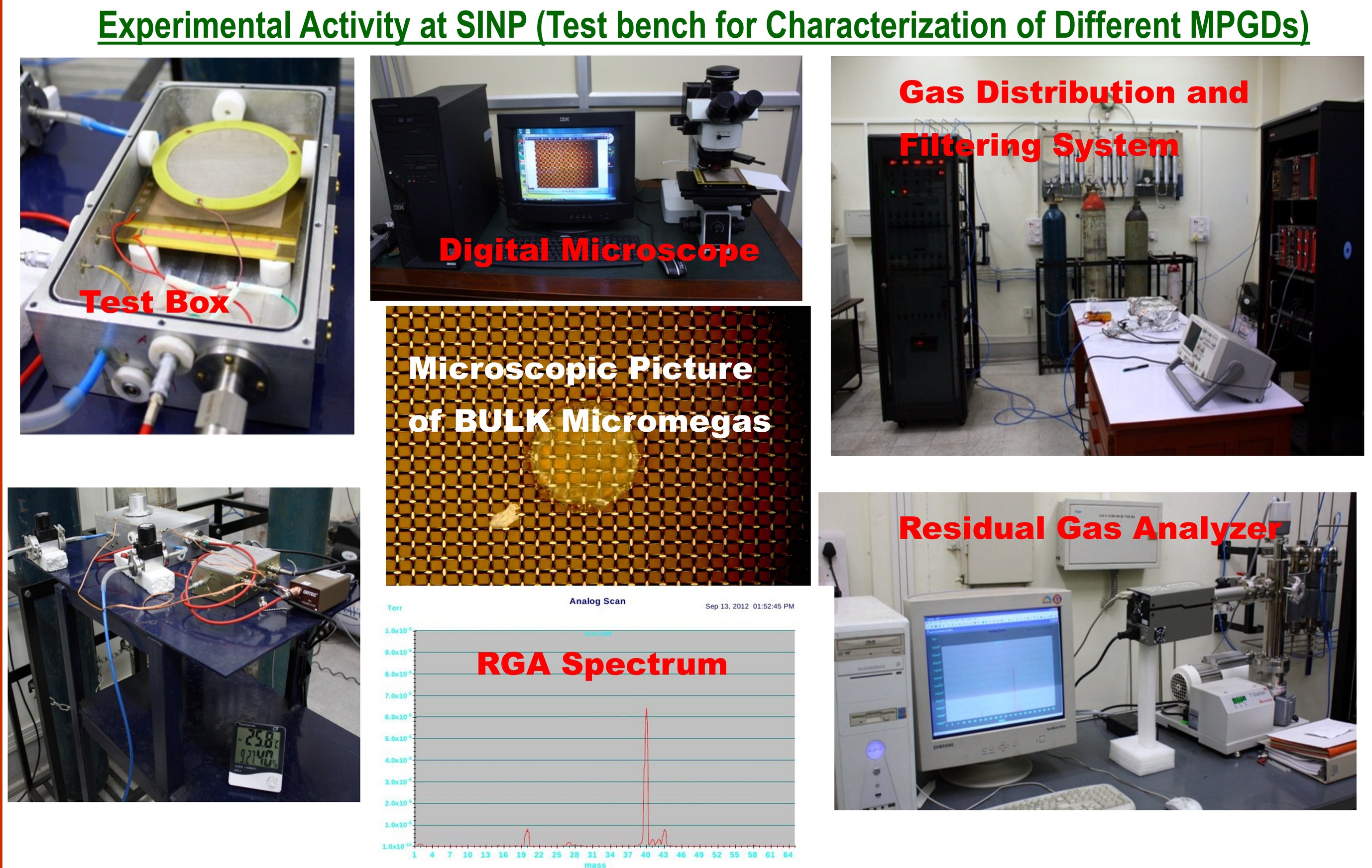


Motivation

- *Micromegas - promising candidate for TPCs including ILD main tracker*
- *Standard BULK with a spacing of 128 μm - good choice for its performance in terms of gas gain uniformity, energy and space point resolution, capability to efficiently pave large readout surfaces with minimized dead zone*
- *Comparison of bulks with 128 and 192 μm amplification gap for basic properties as detector gain, energy resolution, transparency etc under different argon based gas mixtures*
- *Comparison of measured detector characteristics to numerical simulations using Garfield*
- *A numerical study to determine the effect of dielectric spacers on different detector features*

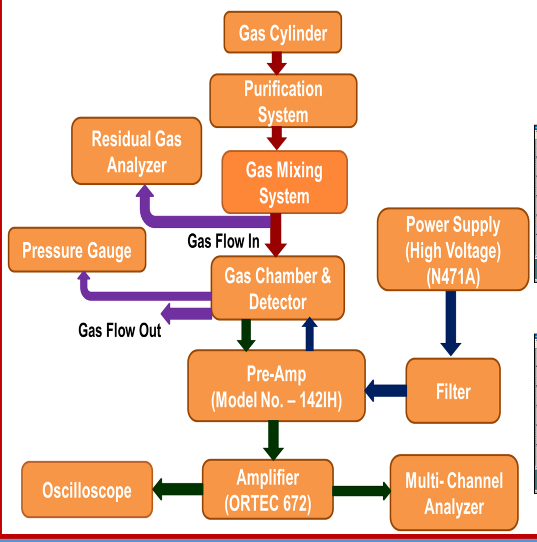
Experimental Activity at SINP (Test bench for Characterization of Different MPGDs)

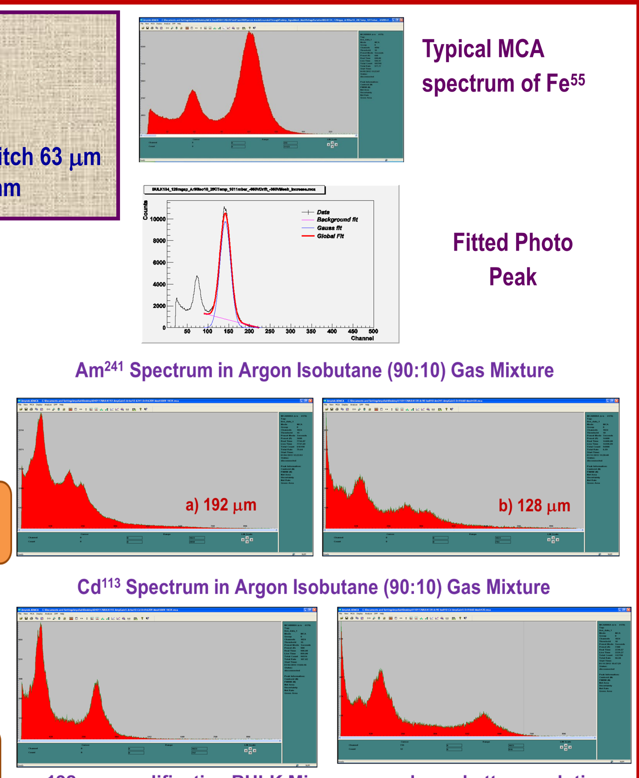


Details of BULK Micromegas:

1. 10x10 cm^2 active area
2. Amplification gap: 192 μm and 128 μm
3. Stainless steel mesh, wire diameter 18 μm, pitch 63 μm
4. Dielectric Spacer, diameter 400 μm, pitch 2 mm

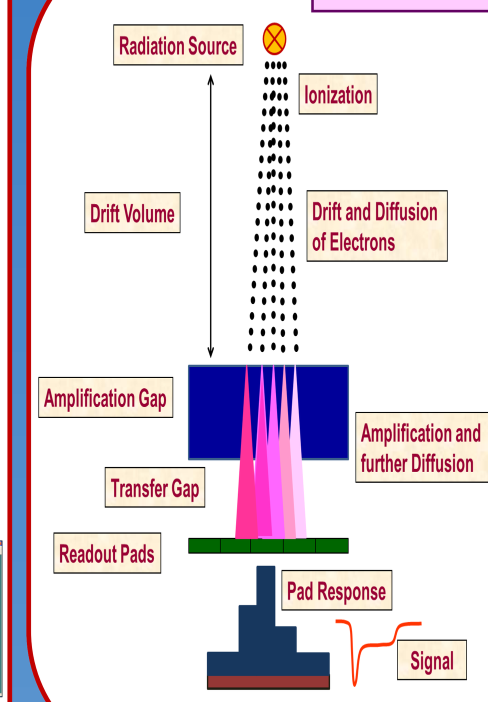
Experimental Set Up





192 μm amplification BULK Micromegas shows better resolution

Numerical Simulation



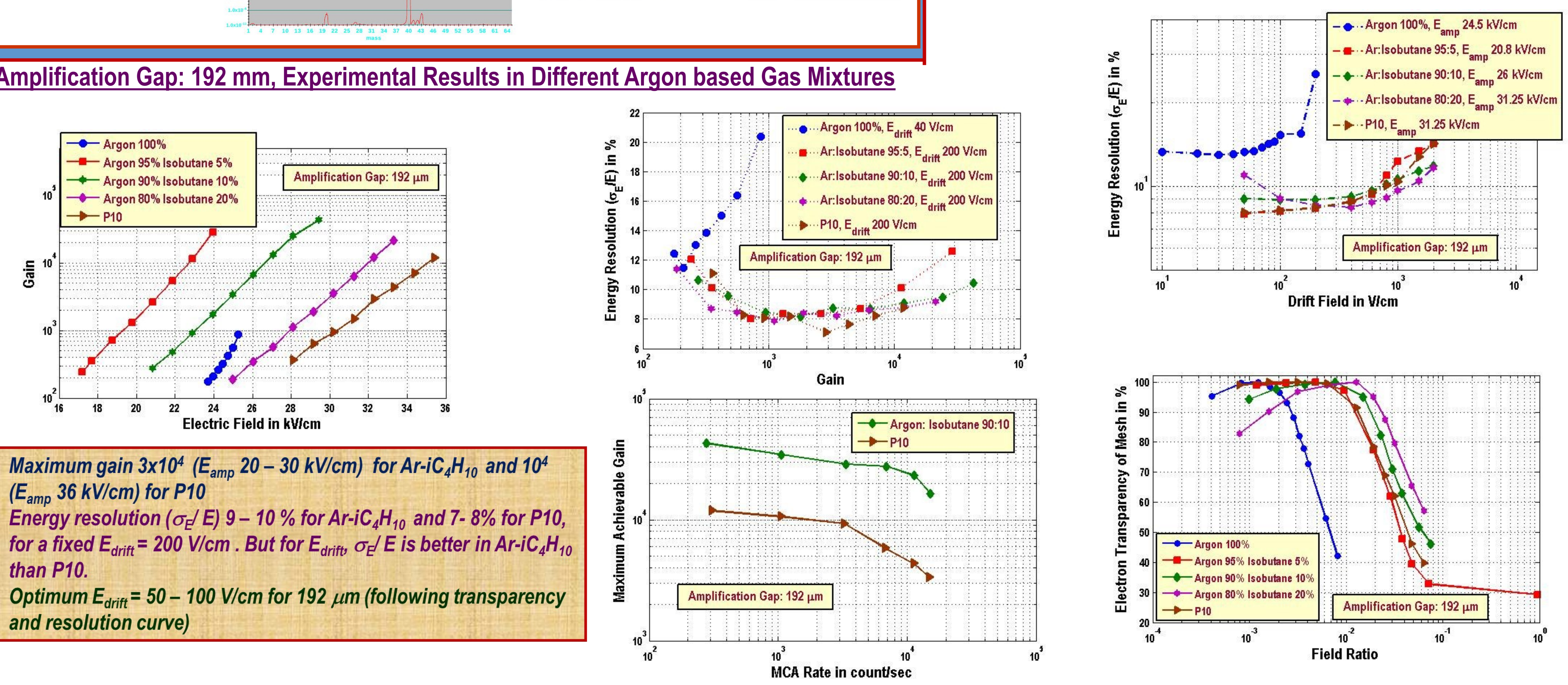
Simulation tools

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 Solver:** Potential and Field— neBEM (nearly exact Boundary Element Method)

Garfield + neBEM + Magboltz + Heed

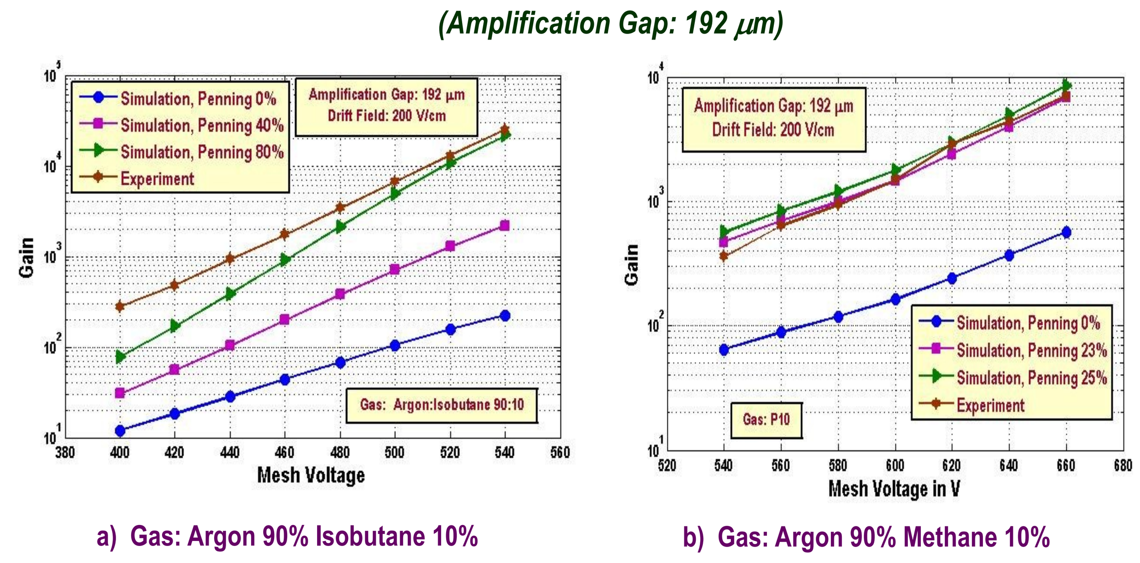
Amplification Gap: 192 mm, Experimental Results in Different Argon based Gas Mixtures



- *Maximum gain 3x10^4 (E_{amp} 20 – 30 kV/cm) for Ar-iC4H10 and 10^4 (E_{amp} 36 kV/cm) for P10*
- *Energy resolution (σ_E/ E) 9 – 10 % for Ar-iC4H10 and 7- 8% for P10, for a fixed E_{drift} = 200 V/cm . But for E_{drift}, σ_E/ E is better in Ar-iC4H10 than P10.*
- *Optimum E_{drift} = 50 – 100 V/cm for 192 μm (following transparency and resolution curve)*

Measured Gain vs. Simulated Estimate

(Amplification Gap: 192 μm)



a) Gas: Argon 90% Isobutane 10%

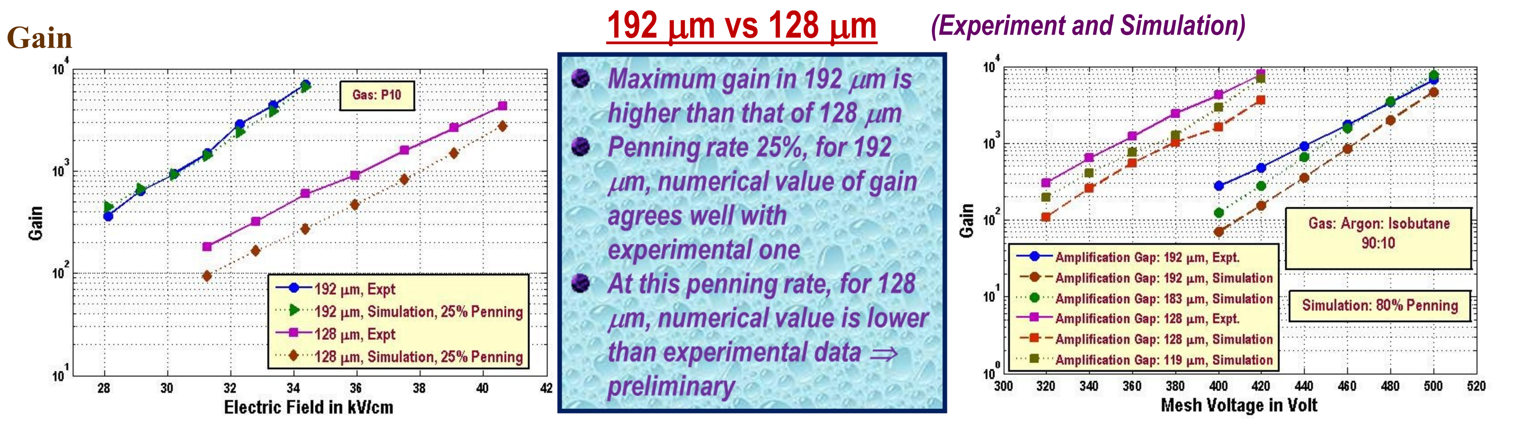
b) Gas: Argon 90% Methane 10%

- 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

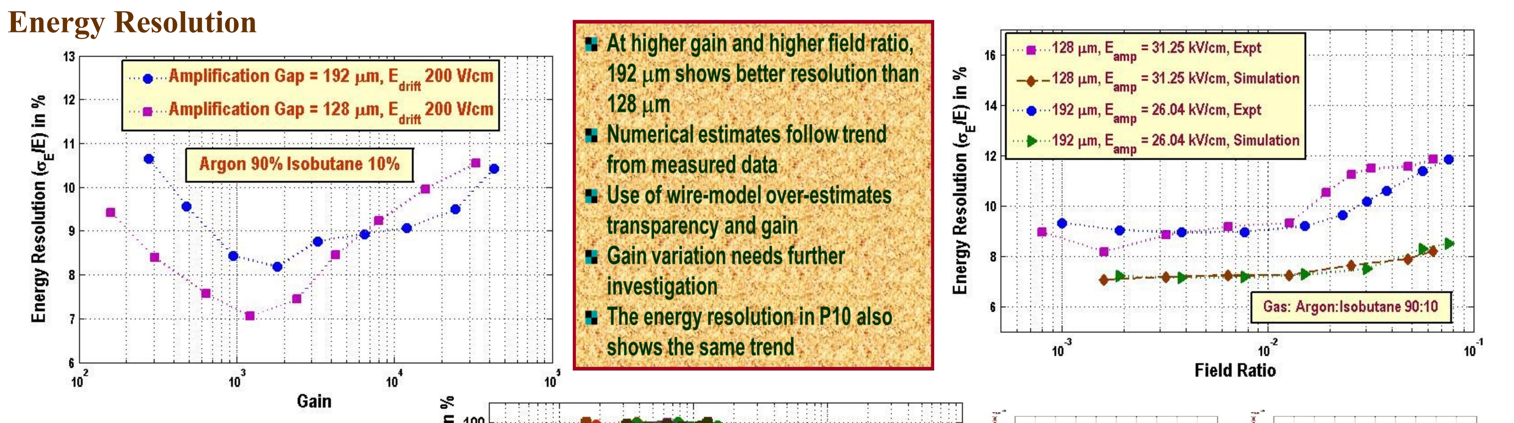
192 μm vs 128 μm *(Experiment and Simulation)*

Gain



- *Maximum gain in 192 μm is higher than that of 128 μm*
- *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*

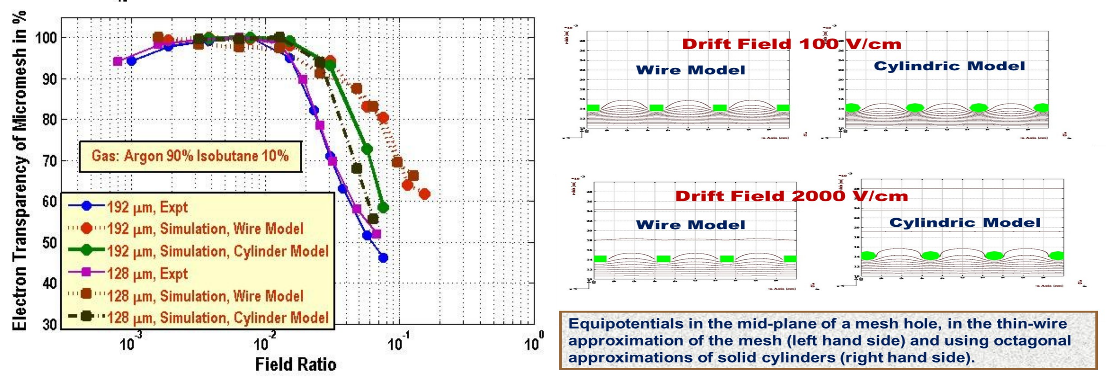
Energy Resolution



- At higher gain and higher field ratio, 192 μm shows better resolution than 128 μm
- Numerical estimates follow trend from measured data
- Use of wire-model over-estimates transparency and gain
- Gain variation needs further investigation
- The energy resolution in P10 also shows the same trend

Electron Transparency

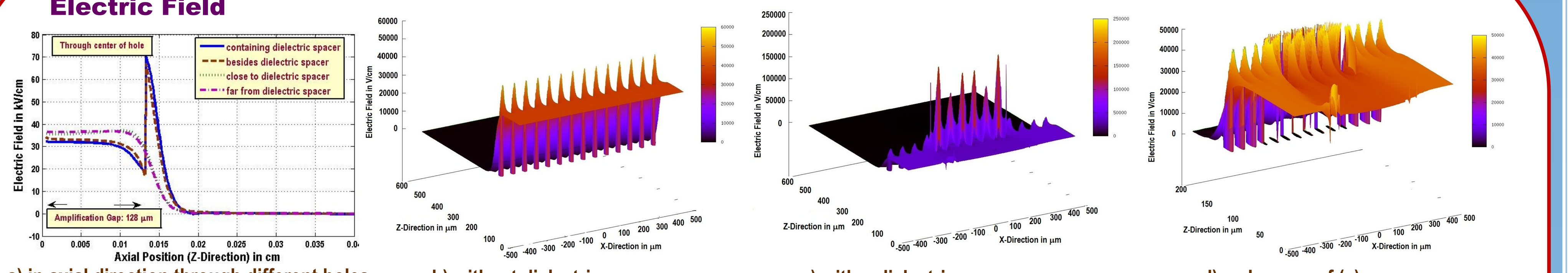
- At higher field ratio, the simulation results using wire elements are much higher than the experimental data
- Use of solid cylindrical elements allows better estimates of transparency



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

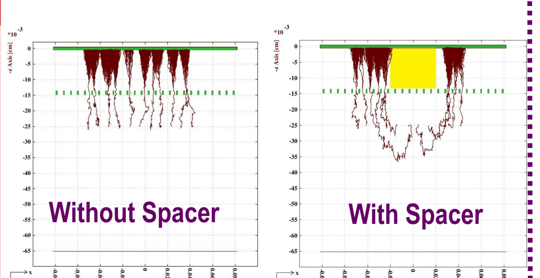
b) without dielectric spacer

c) with a dielectric spacer

d) a close-up of (c)

Spacers cause significant perturbation resulting in increased field values (100 kV/cm in comparison to 40 kV/cm in normal condition), particularly in the regions where cylinder touches the mesh.

Drift Lines and Avalanche

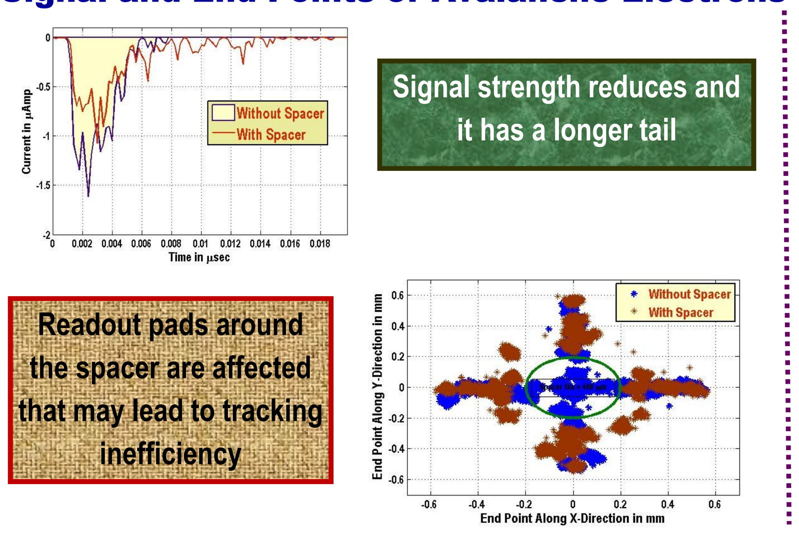


Without Spacer

With Spacer

Near to the dielectric spacer, electron drift lines get distorted.

Signal and End Points of Avalanche Electrons



Signal strength reduces and it has a longer tail

Readout pads around the spacer are affected that may lead to tracking inefficiency

Without Spacer

Track	Primary Electrons: Cross the mesh	Primary Electrons: Reach middle of amplification area	Gain
Track: 25 μm above mesh	97.794	97.794	600
Track: 50 μm above mesh	97.304	97.304	594
Track: 100 μm above mesh	97.549	97.549	596

With Spacer

Track	Primary Electrons: Cross the mesh	Primary Electrons: Reach middle of amplification area	Gain
Track: 25 μm above mesh	97.549	54.902	338
Track: 50 μm above mesh	95.343	92.892	570
Track: 100 μm above mesh	95.833	95.343	584

Electrons are lost on the spacer resulting in reduced gain

Outlook

- Experiments with Micromegas (amplification gaps 128 μm, 192 μm) in several gas mixtures.
- Estimation of important detector parameters such as gain, energy resolution, transparency etc.
- Maximum gain achieved with a larger gap found to be similar/ slightly more than that with a smaller gap.
- For higher gains and higher field ratios, larger gap found to yield better resolution.
- Significant increase in count rate observed for the larger gap Micromegas.
- 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.
- Significant change in the numerical estimation of transparency between thin-wire models and realistic cylindric models.
- 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.

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