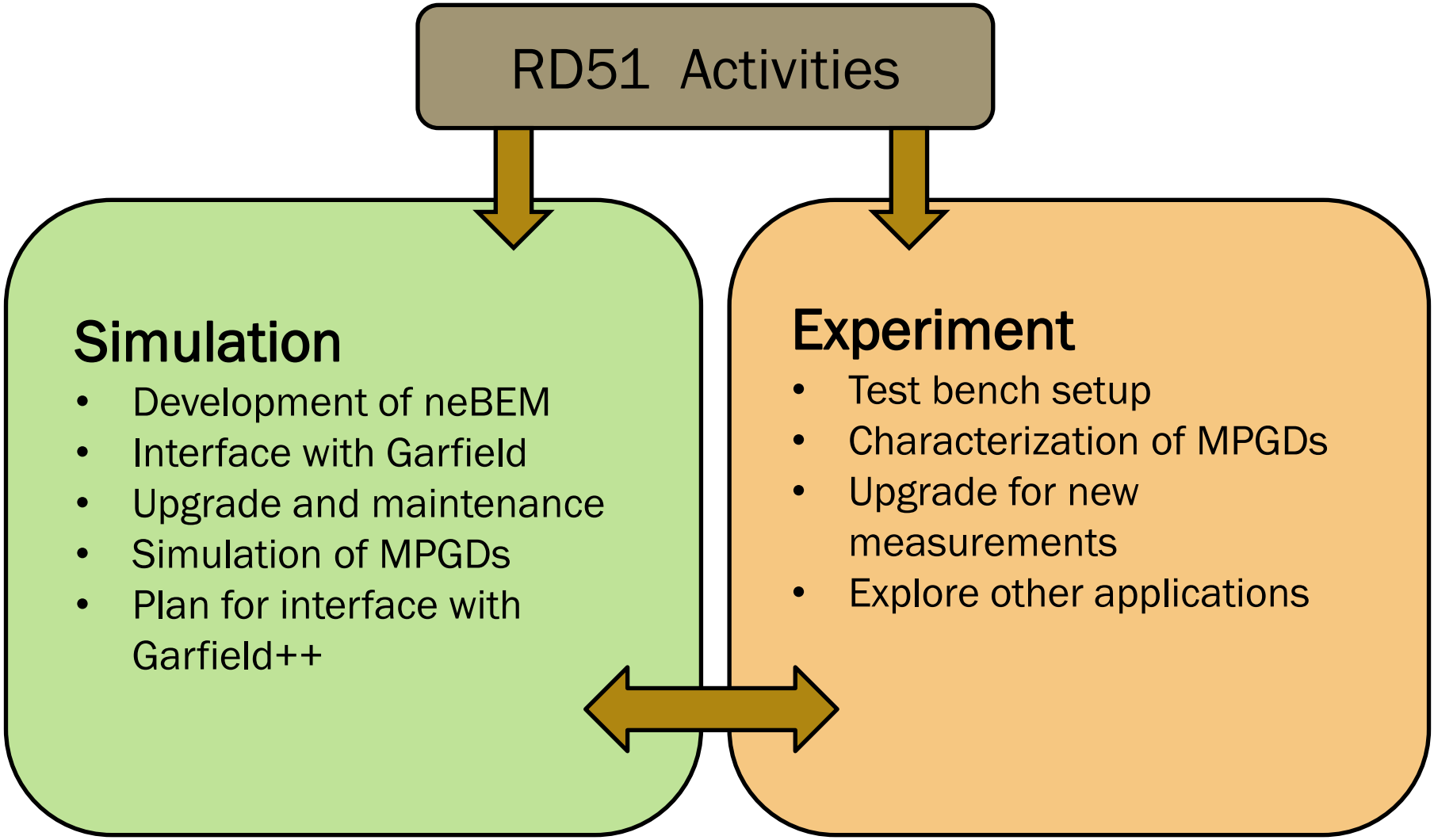
A Brief Report on

Characteristic Studies of Micromegas

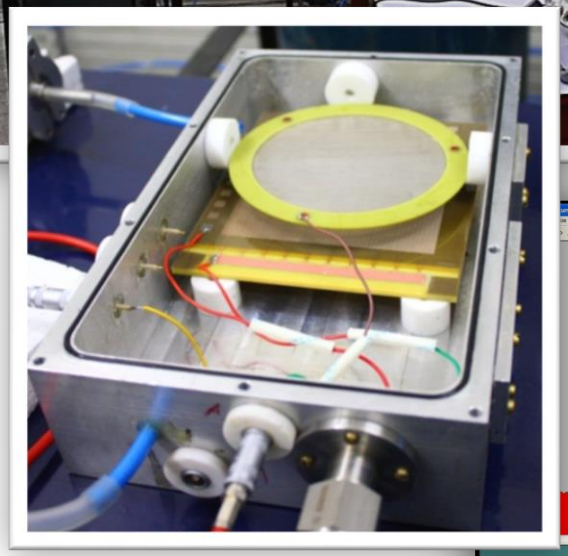
Applied Nuclear Physics Division
Saha Institute of Nuclear Physics, Kolkata, India

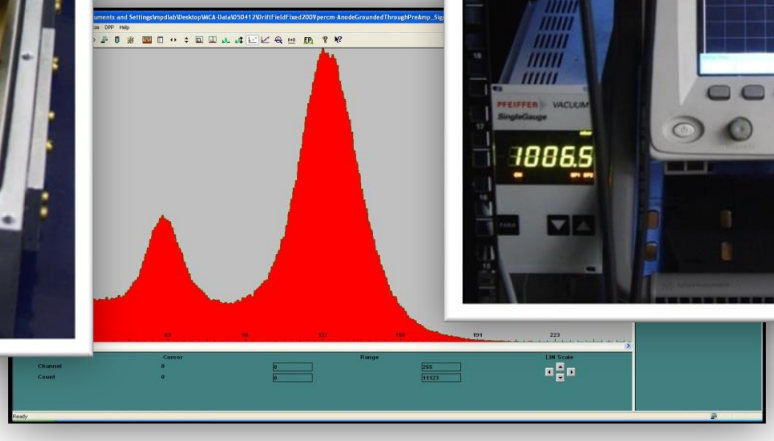
RD51 Collaboration Meeting
CERN, 14-17 October, 2013

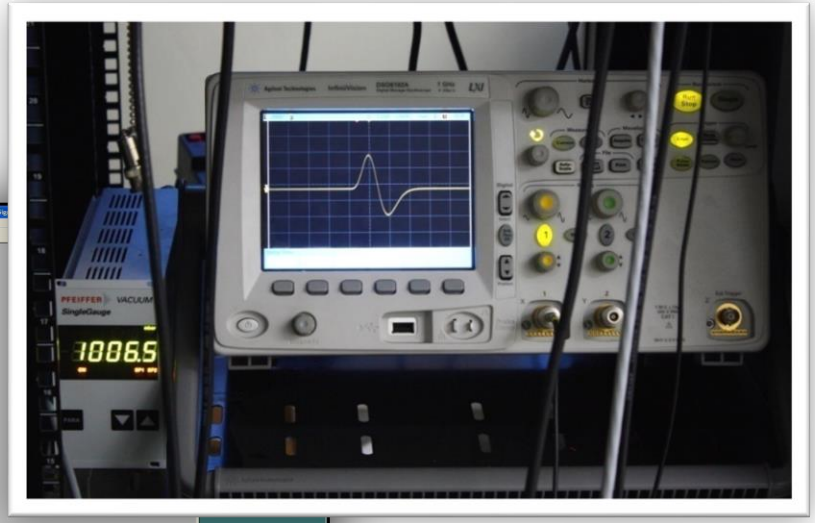
MPGD Laboratory at SINP, Kolkata



Test Bench Setup

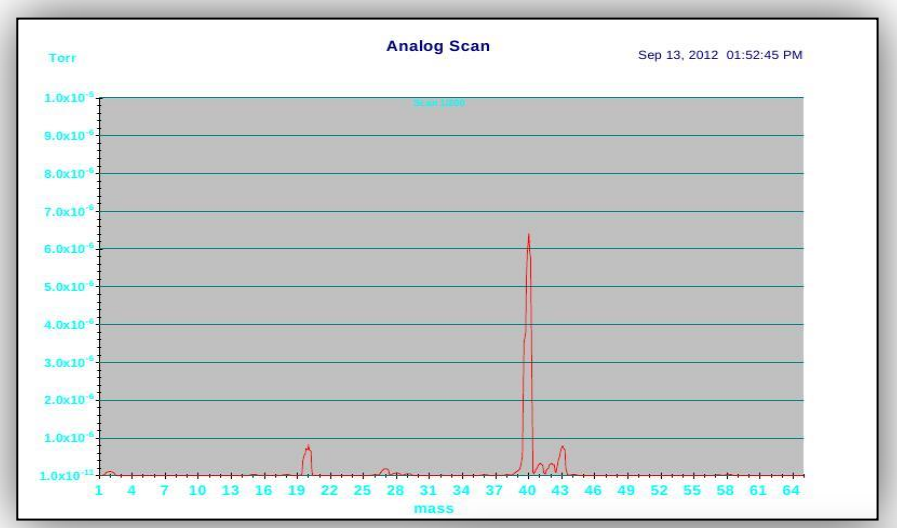




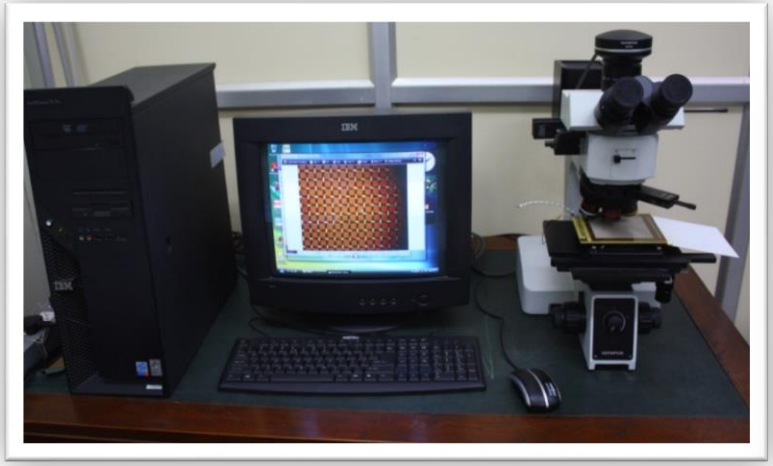


- Stainless steel test box
- Gas distribution system with 4-channel mixing-unit
- Electronics with single-parameter data acquisition system
- Fe55 source

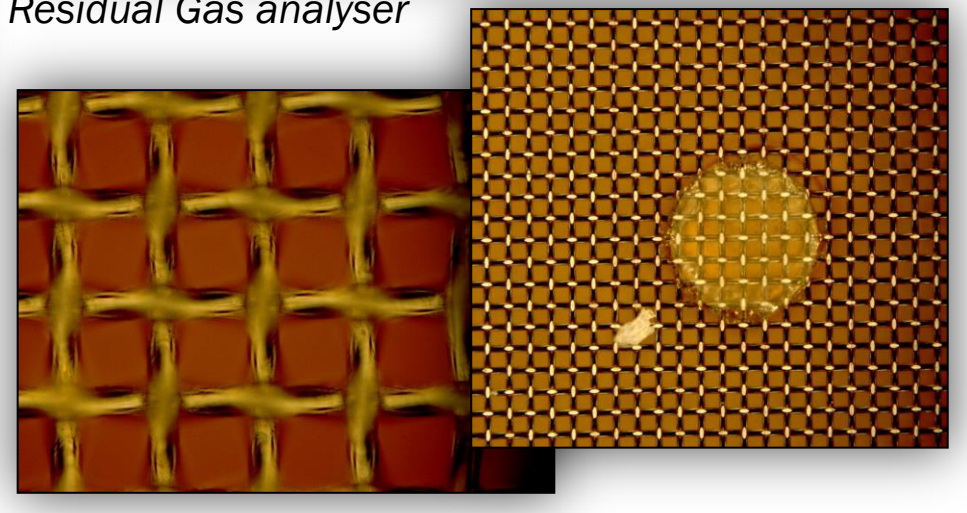
Supplementary Facilities



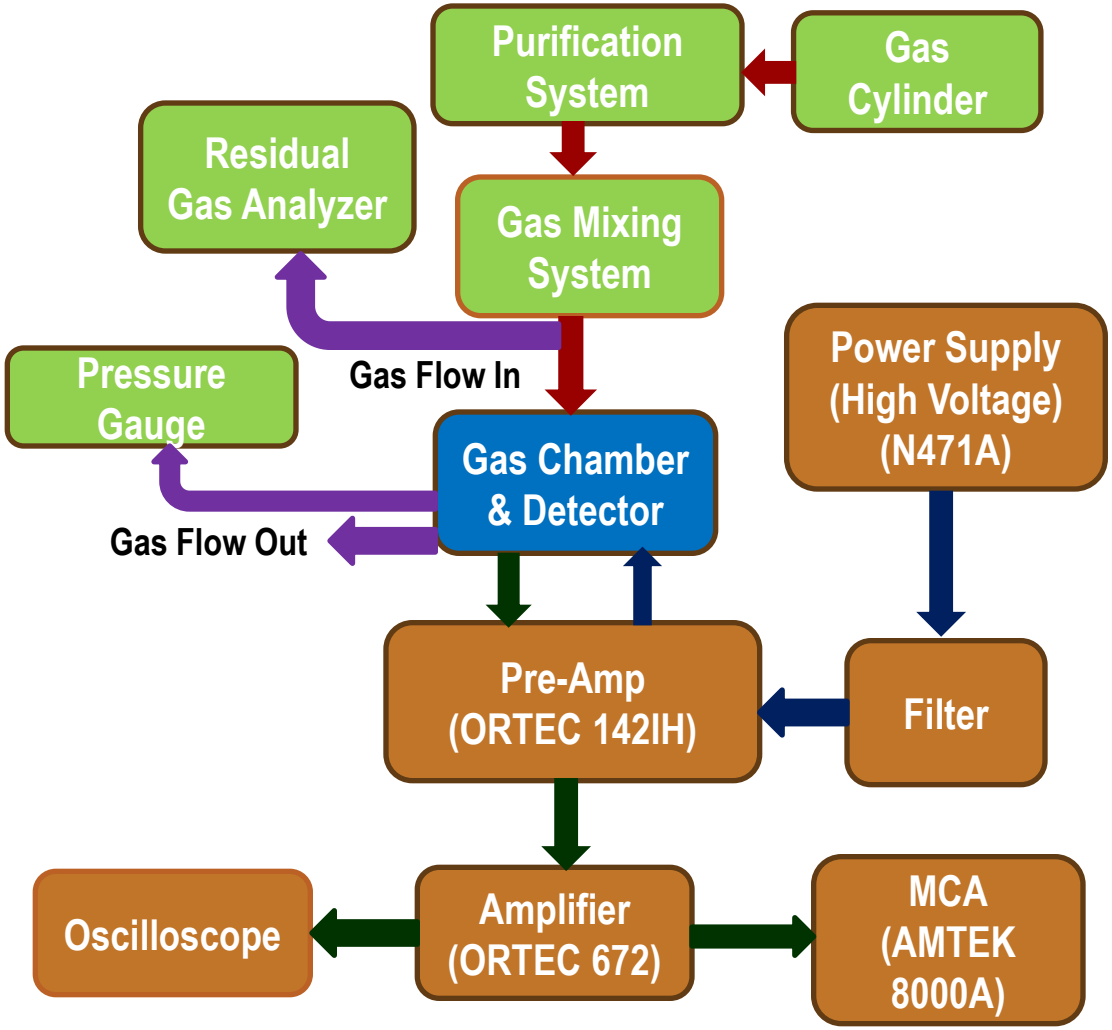
Residual Gas analyser



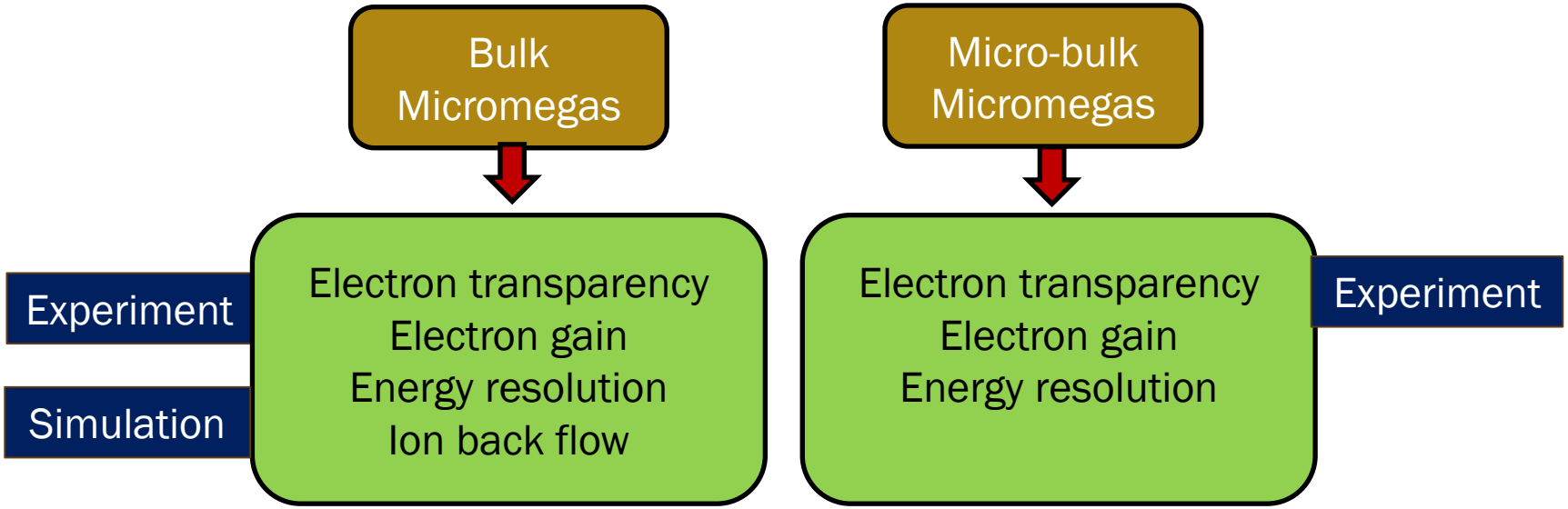
Digital microscope



Schematic Setup

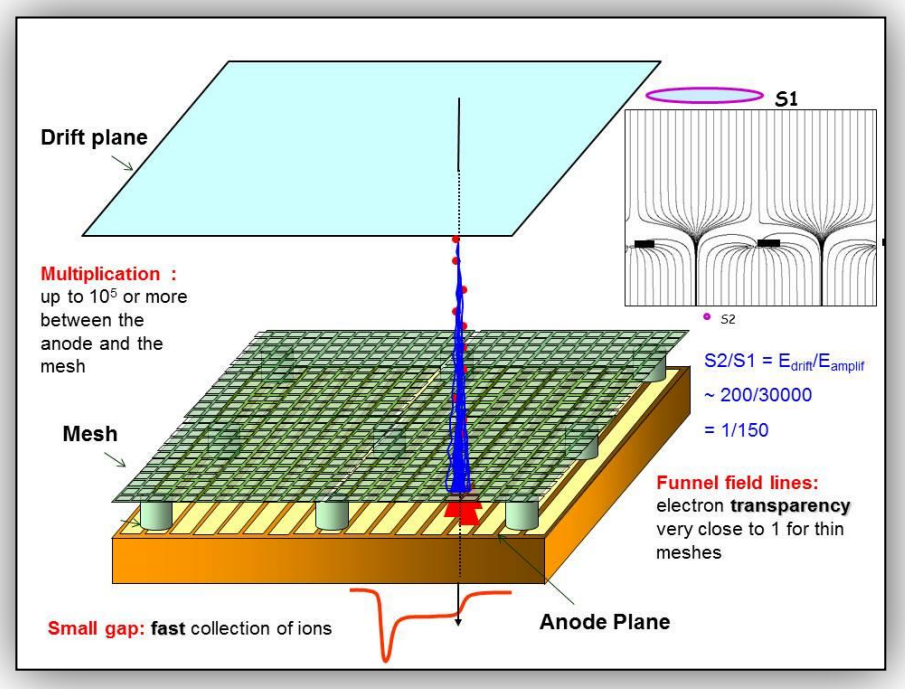


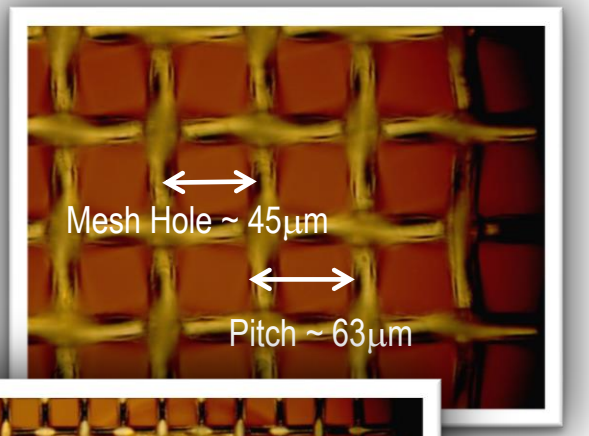
Characterization Studies

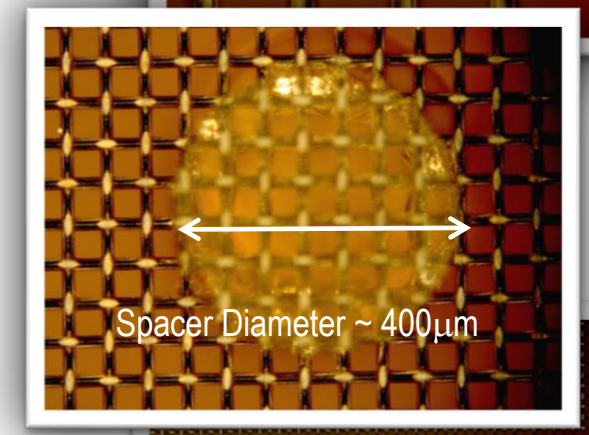


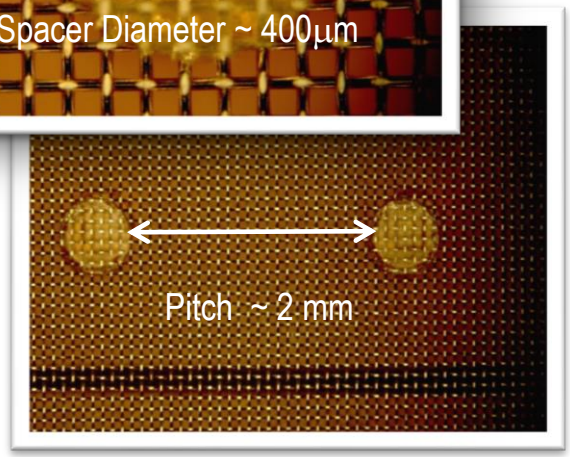
Experimental studies on GEM and triple-GEM have been initiated !!

Bulk Micromegas









Specifications

- Active area: 15x15 cm^2
- Amplification gap: 64 /128 / 192 / 220 μm
- SS wire diameter: 18 μm, pitch 63 / 78 μm
- Spacer diameter: 400 μm, pitch 2 mm

Estimate of Electron Transparency

Experiment:

Electron transparency at a given drift field value (d):

$$\varepsilon_d = S_d / S_{max}$$

where S_d : signal amplitude at the given drift field (d)

S_{max} : maximum signal amplitude

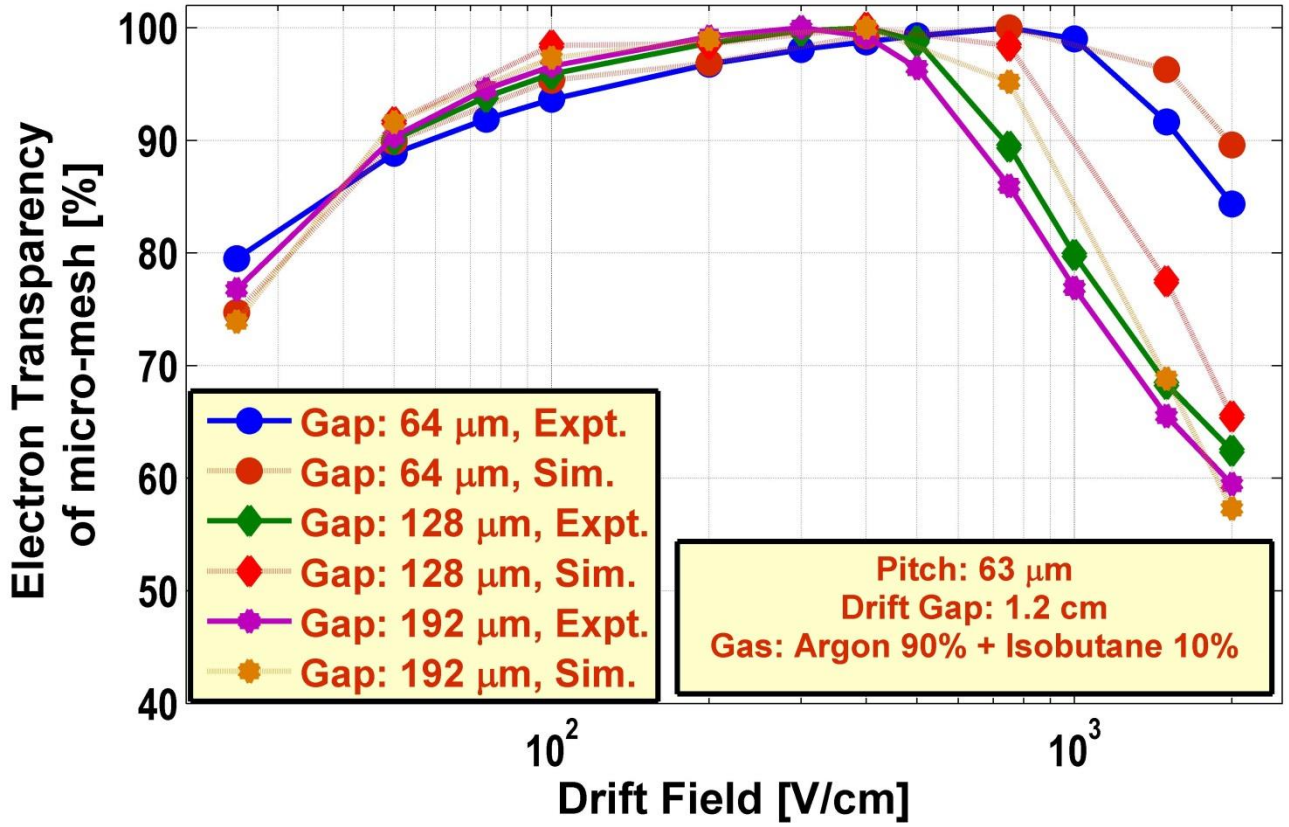
(keeping amplification field constant)

Simulation:

Drift of electron from randomly distributed points in drift region using microscopic tracking method

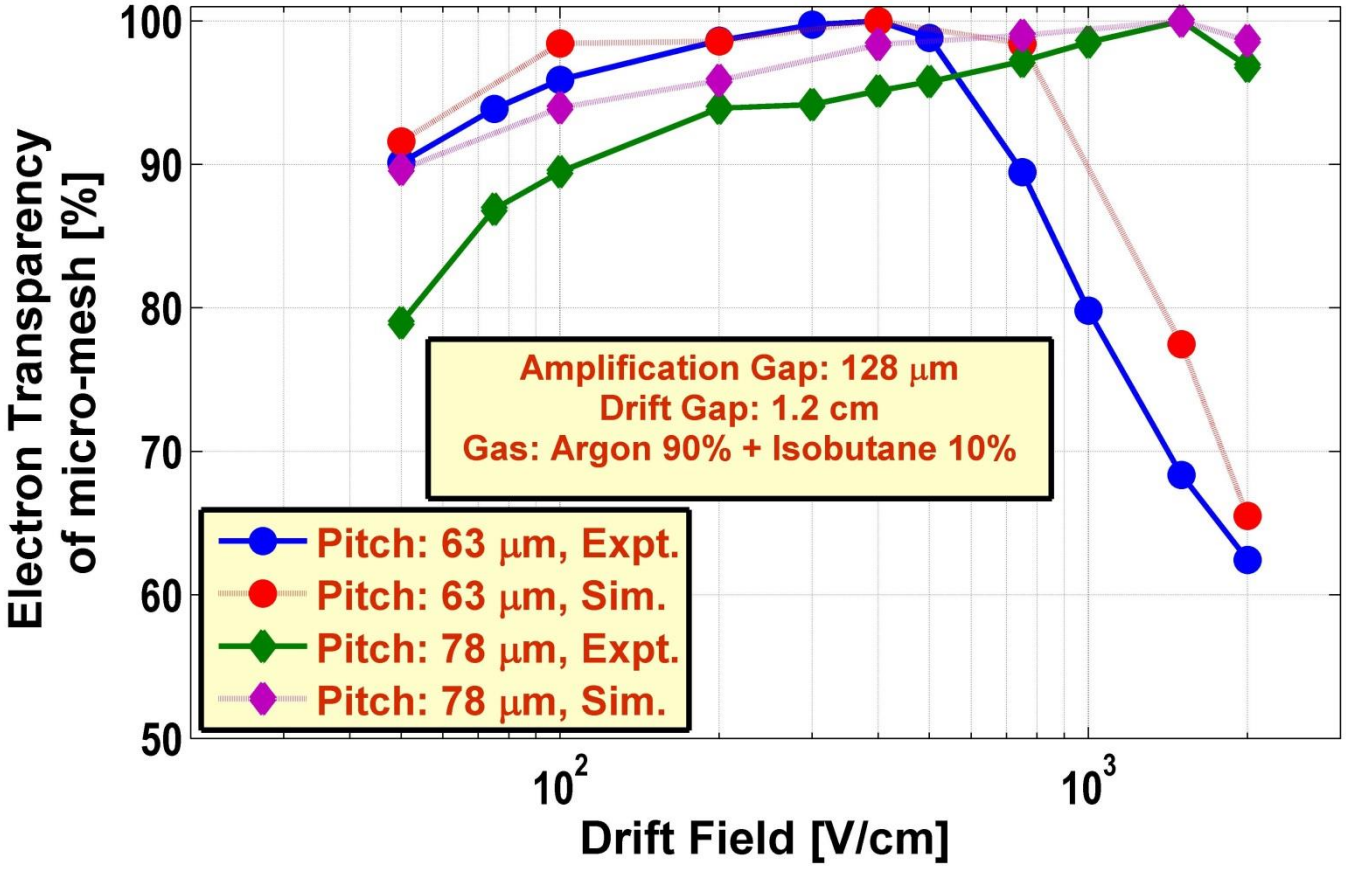
Estimate the fraction of electron arriving in amplification region

Electron Transparency for Different Gaps



Better transparency can be obtained with larger gaps at lower drift field although it worsens with increase in drift field. However, smaller gap shows better transparency at higher drift field !!

Electron Transparency for Different Pitches



Smaller pitch shows better transparency at lower drift field whereas it is larger pitch which helps at larger values !!

Estimate of Electron Gain

Experiment:

Electron gain at a certain field configuration :

$$G = \frac{N_t}{N_p} = kP/N_p$$

where N_t : total number of electrons

N_p : primary electrons

k : constant dependent on electronics

P : peak position

Simulation:

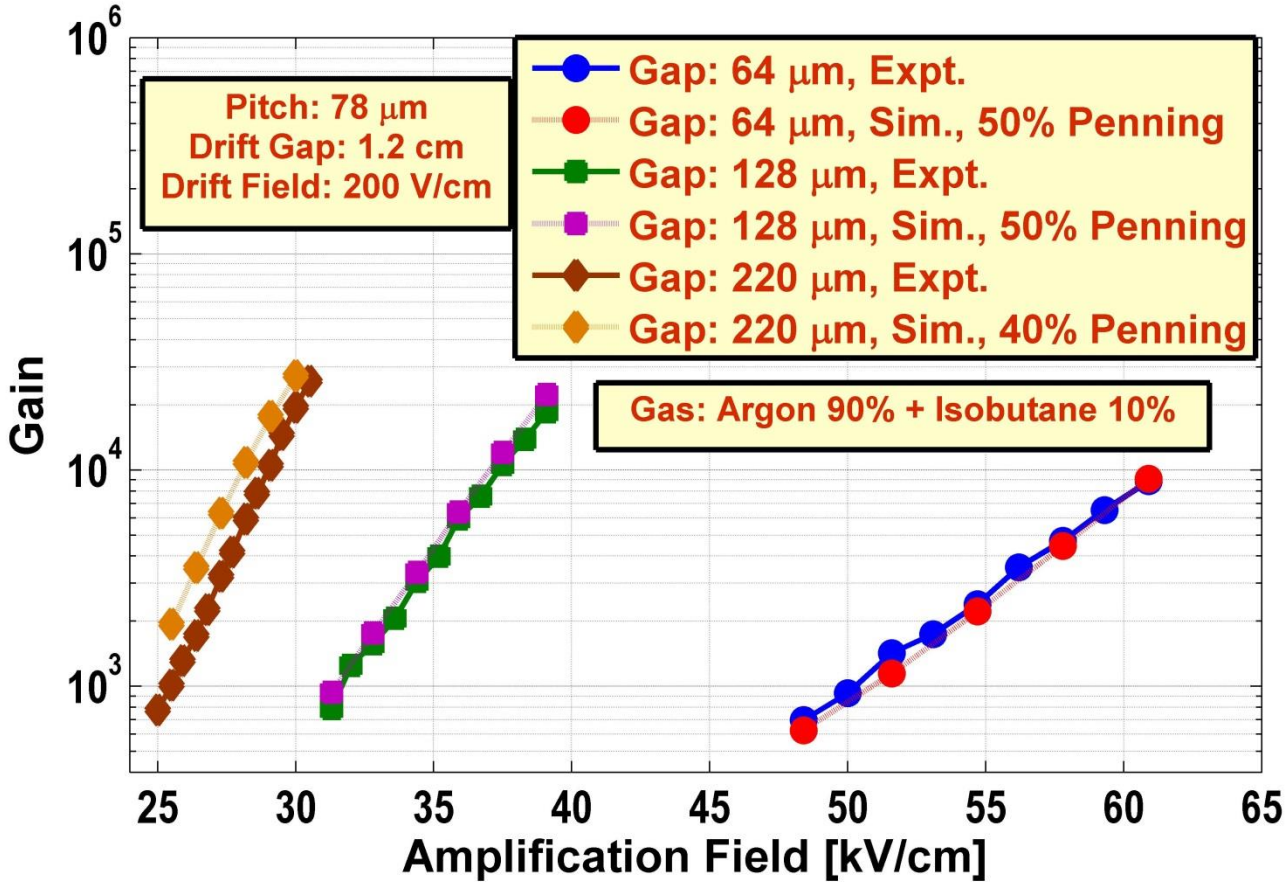
Effective electron gain :

$$G_{eff} = \eta \times G_{mult}$$

where η : electron transparency

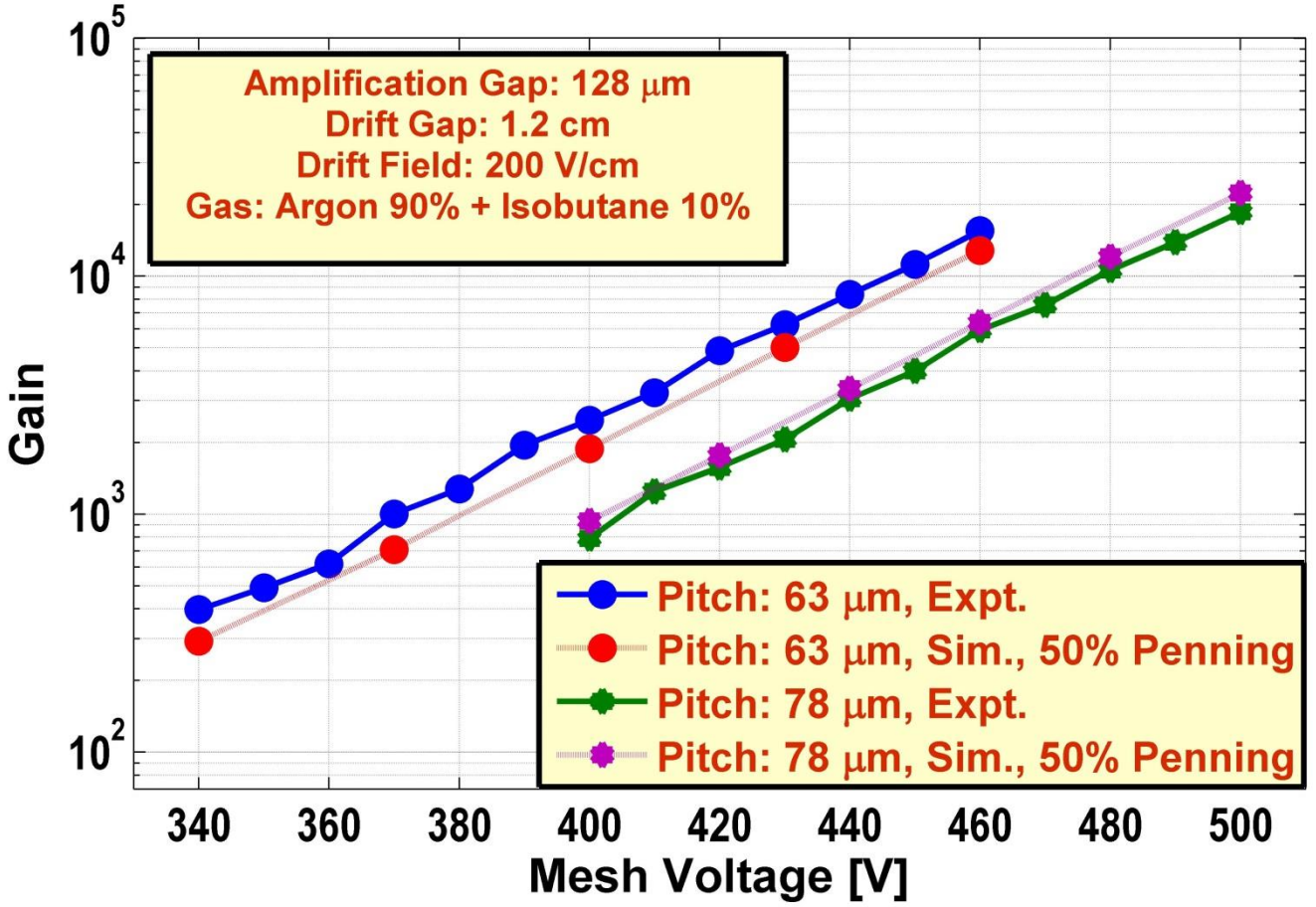
G_{mult} : multiplication factor of electrons in their trajectories

Electron Gain for Different Amplification Gaps



Higher gain can be achieved with larger amplification gap at safer operating regime. Slightly higher transfer rate is required to make the simulation agree with experiment which needs further verification !!

Electron Gain for Different Mesh Pitches



Higher voltage is required for larger pitch to obtain same gain as of smaller pitch !!

Estimate of Energy Resolution

Experiment:

Energy resolution at a certain field configuration :

$$\mathrm{R} = \sigma_P / \mathrm{P}$$

where σ_P : r.m.s of the pulse height distribution

P : peak position

Simulation:

Energy resolution :

$$R^2 = \frac{1}{N} \times \left[\mathrm{F} - 1 + \frac{(b+1)}{\eta}\right]$$

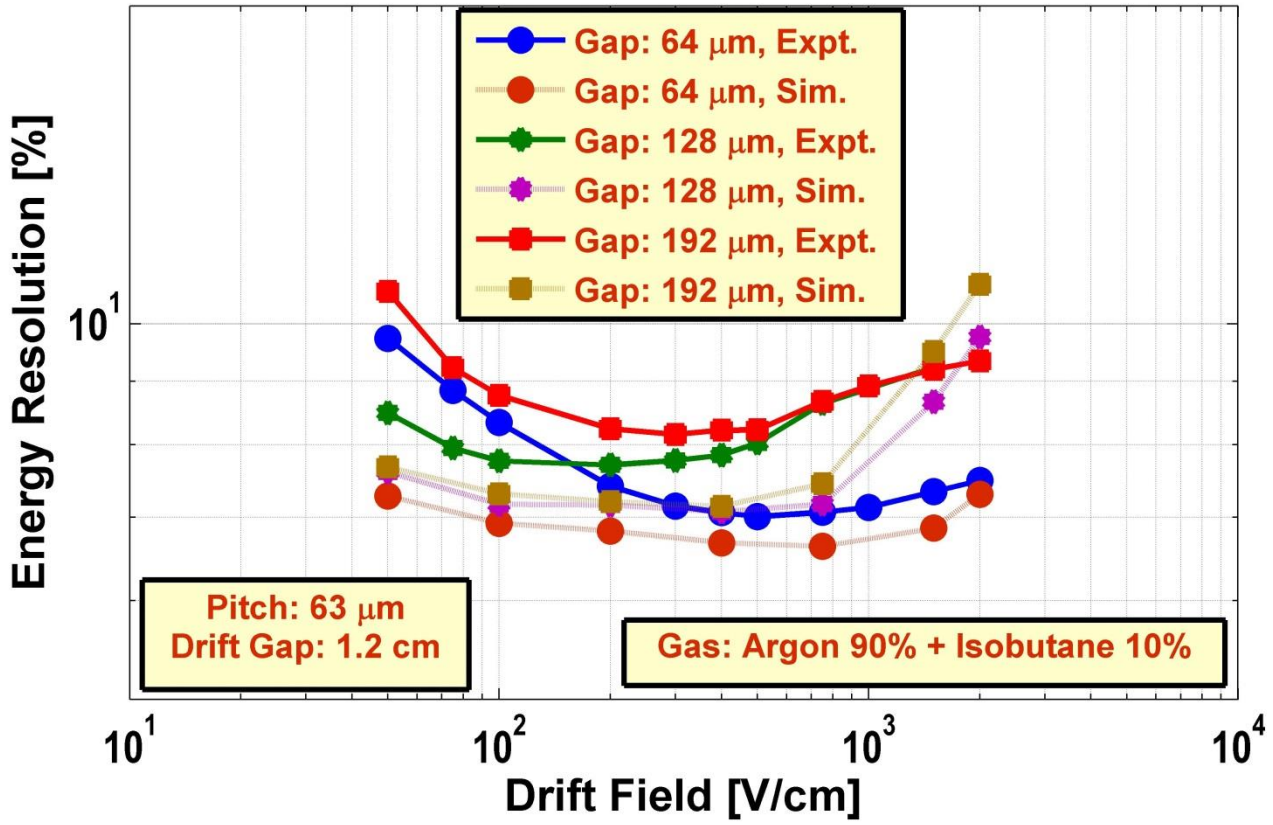
where F : fano factor

b : relative variance of gain distribution

η : transparency

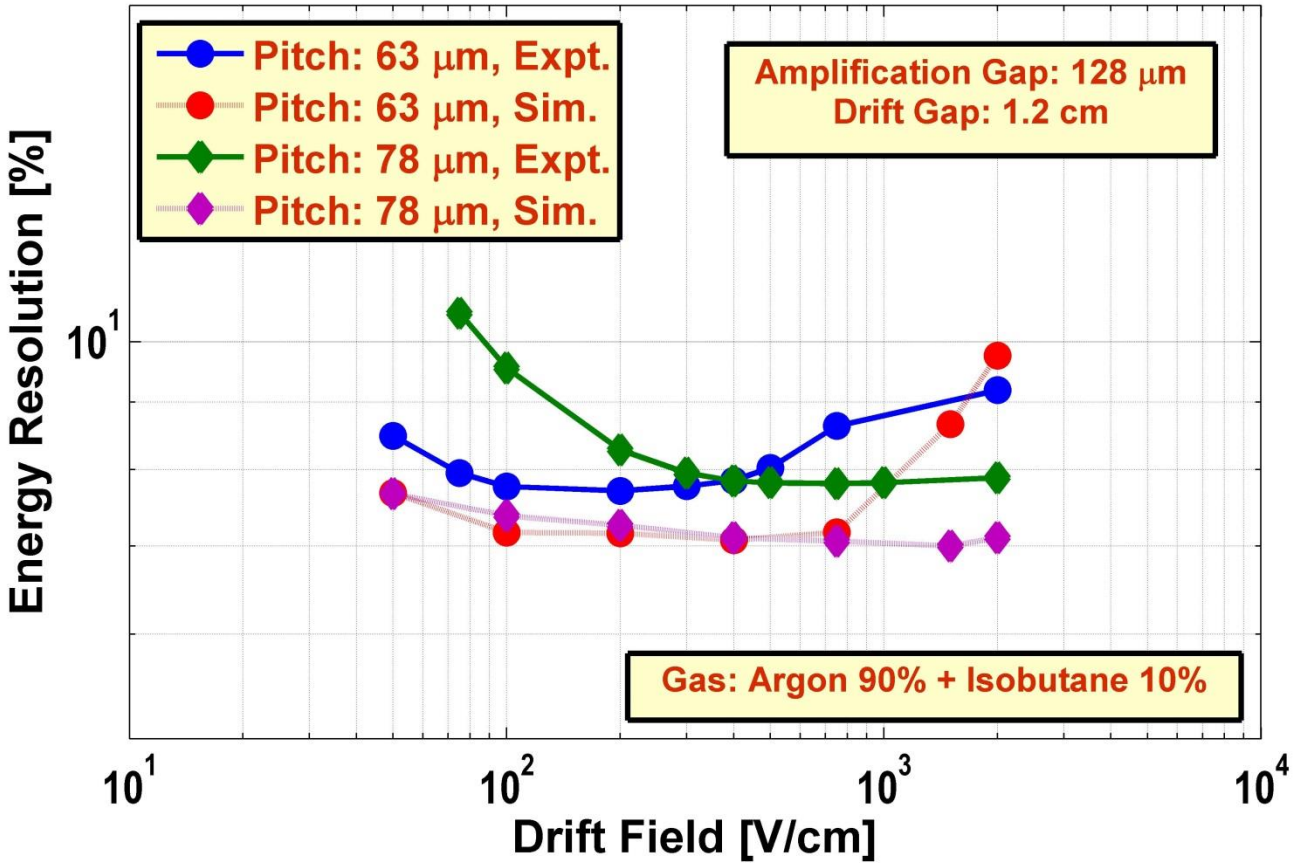
N : number of primary electrons

Energy Resolution for Different Gaps



Smaller gap shows better resolution at higher drift field. In all cases, the resolution seems to worsen at higher field beyond a limit of 1kV/cm !!

Energy Resolution for Different Pitches



Larger pitch shows better resolution at higher drift field. Simulation needs further investigation as there is still a substantial disagreement with experiment!!

Estimate of Ion Back Flow

Experiment:

Ion back flow : $\mathbf{BF} = \frac{N_b}{N_t} = \frac{(I_C - I_P)}{(I_M + I_C - I_P)}$

where N_b : number of backflowing ions

N_t : number of total ions produced in avalanche

I_C : current on drift cathode

I_P : primary current on drift cathode (referred to primary ionization)

I_M : current on micromesh

Simulation:

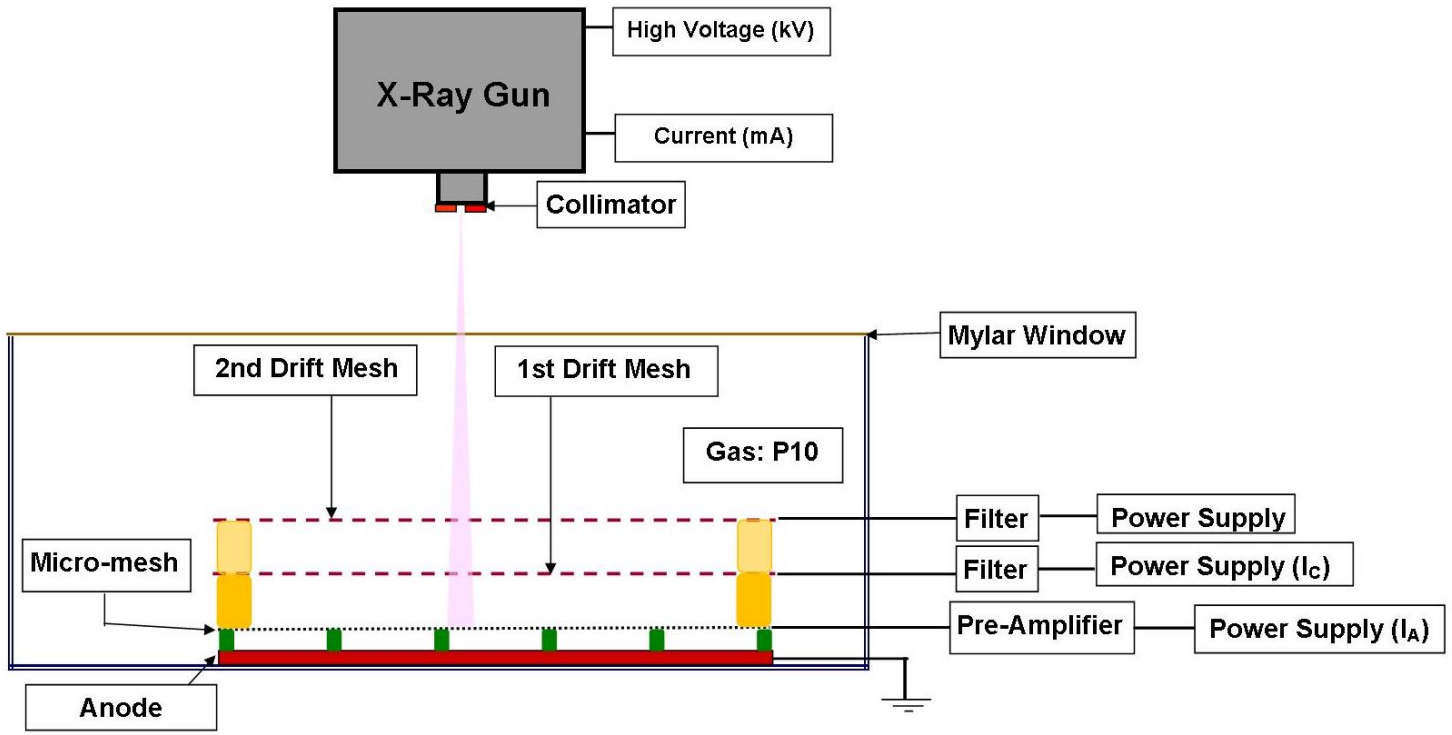
Ion back flow : $\mathbf{BF} \propto \frac{p^2}{(FR \times {\sigma_t}^2)}$

where p : mesh pitch

FR : field ratio (amplification field/drift field)

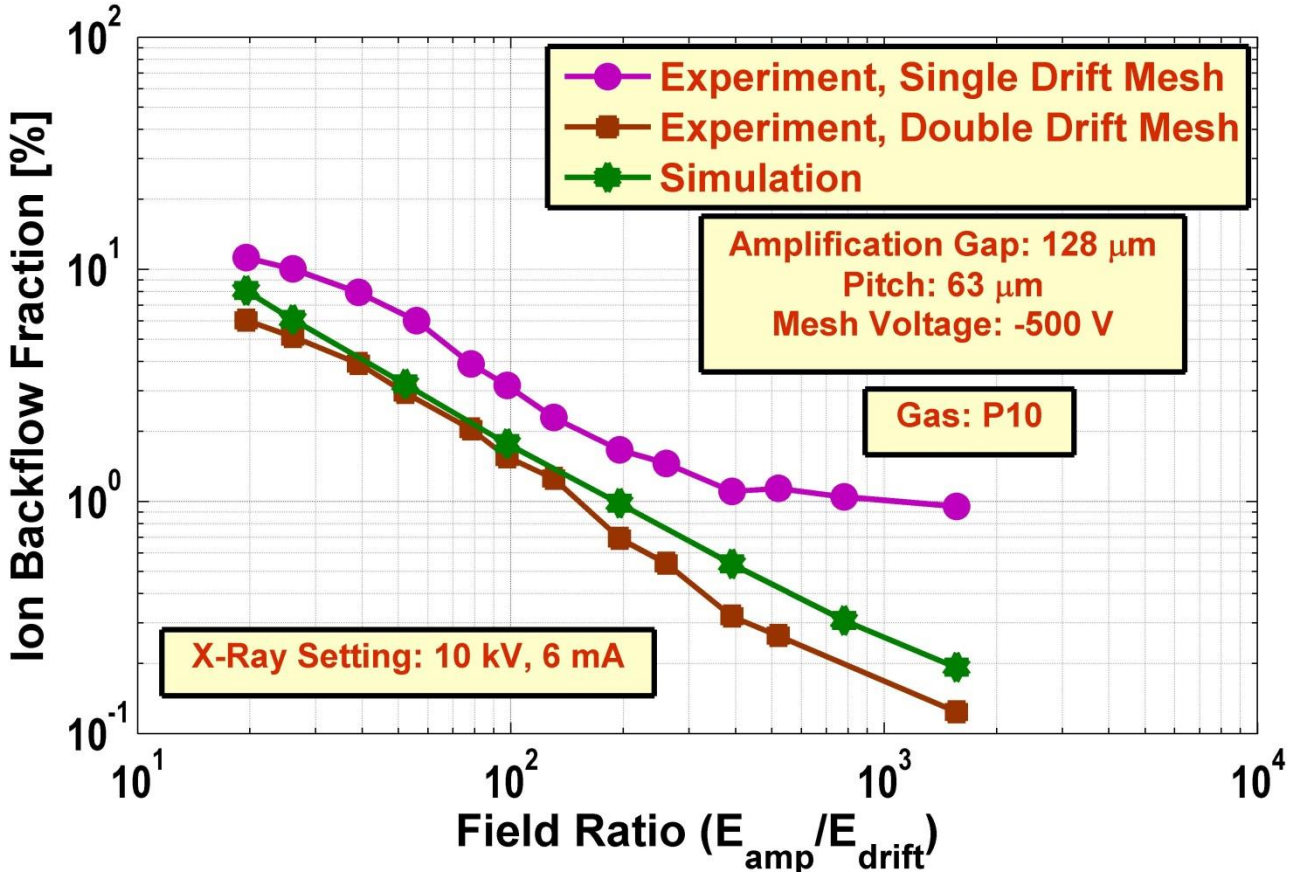
σ_t : transverse diffusion

Experimental Setup for IBF Measurement



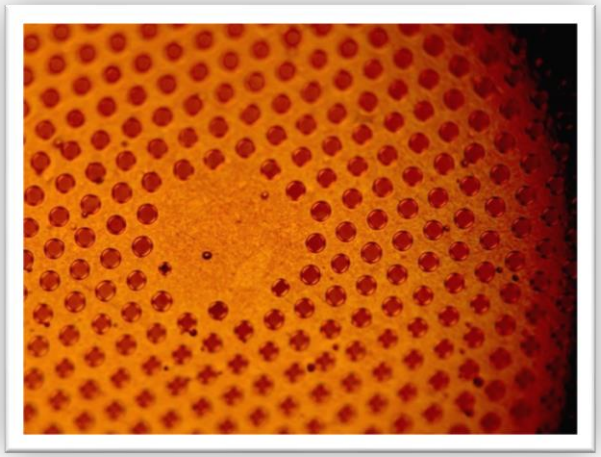
- X-ray tube (XRG 3000) for delivering photons with variable intensity
- Currents on drift and mesh planes measured from HV supply (CAEN N471A)
- Second drift placed 1 cm above the first at same voltage

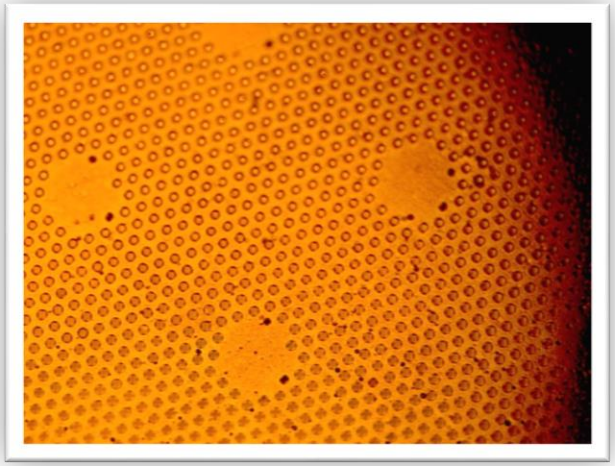
Comparison of Experiment & Simulation



Use of double drift improves the result !!

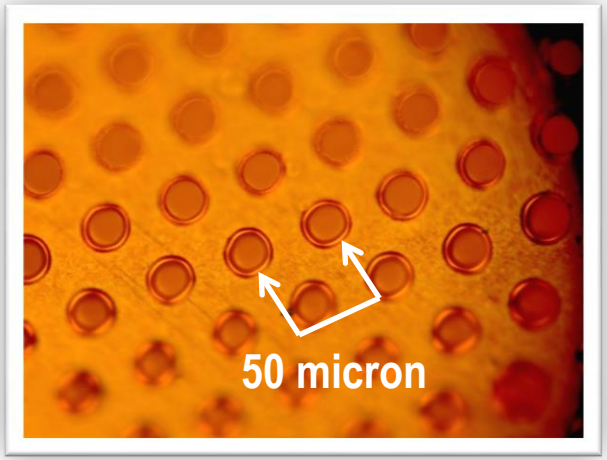
Micro-Bulk Micromegas

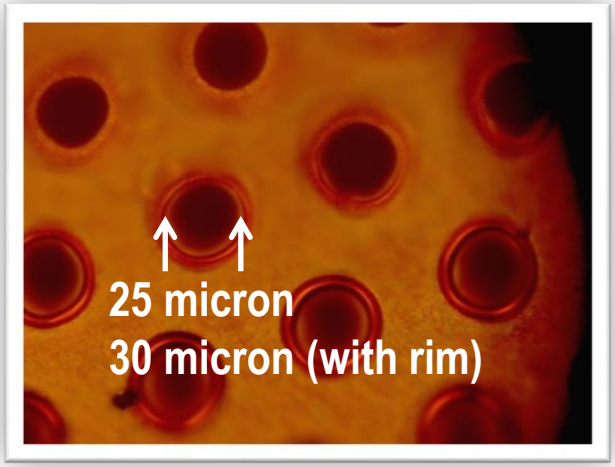




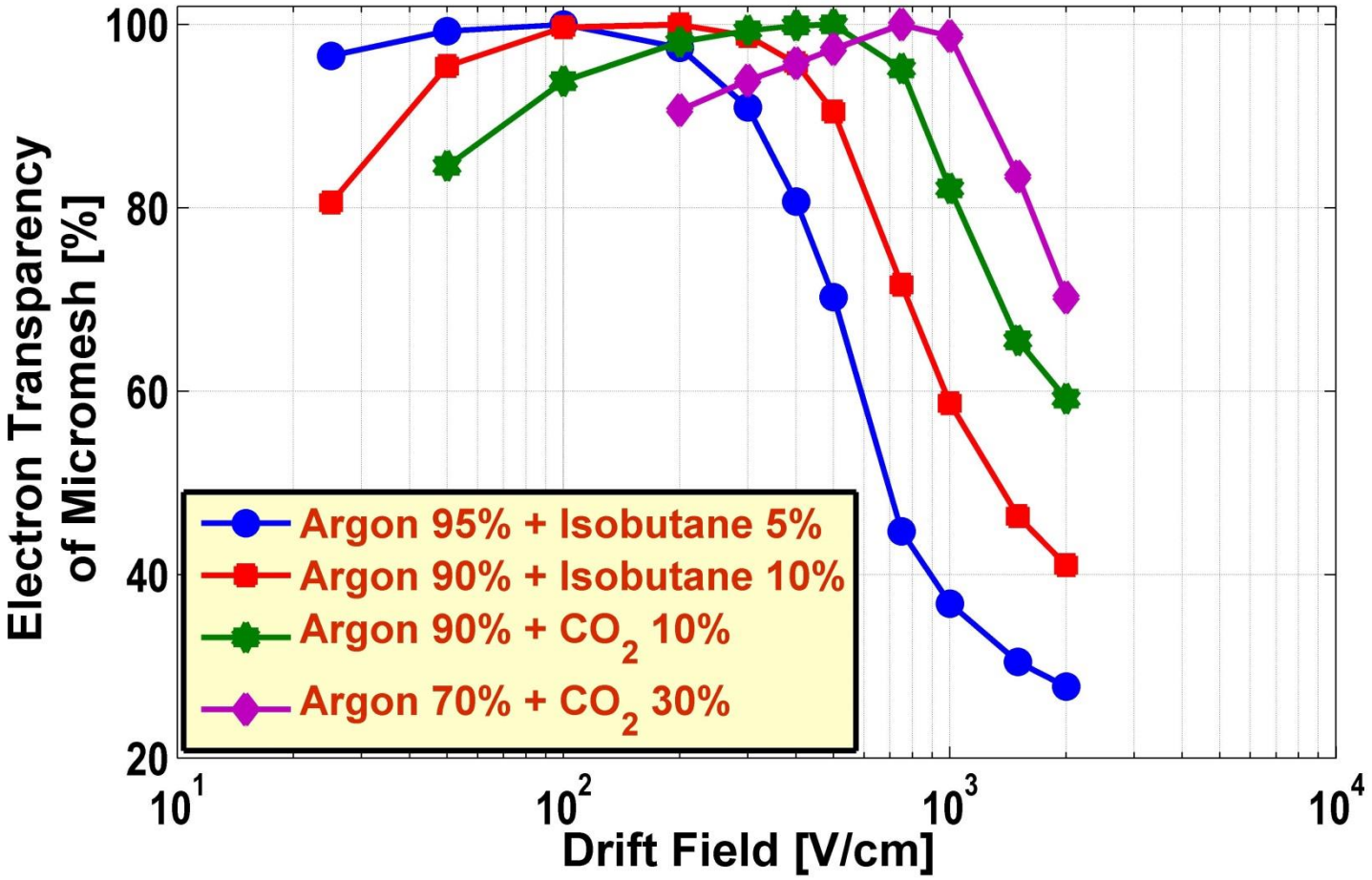
Specifications:

Amplification Gap:
50 micron

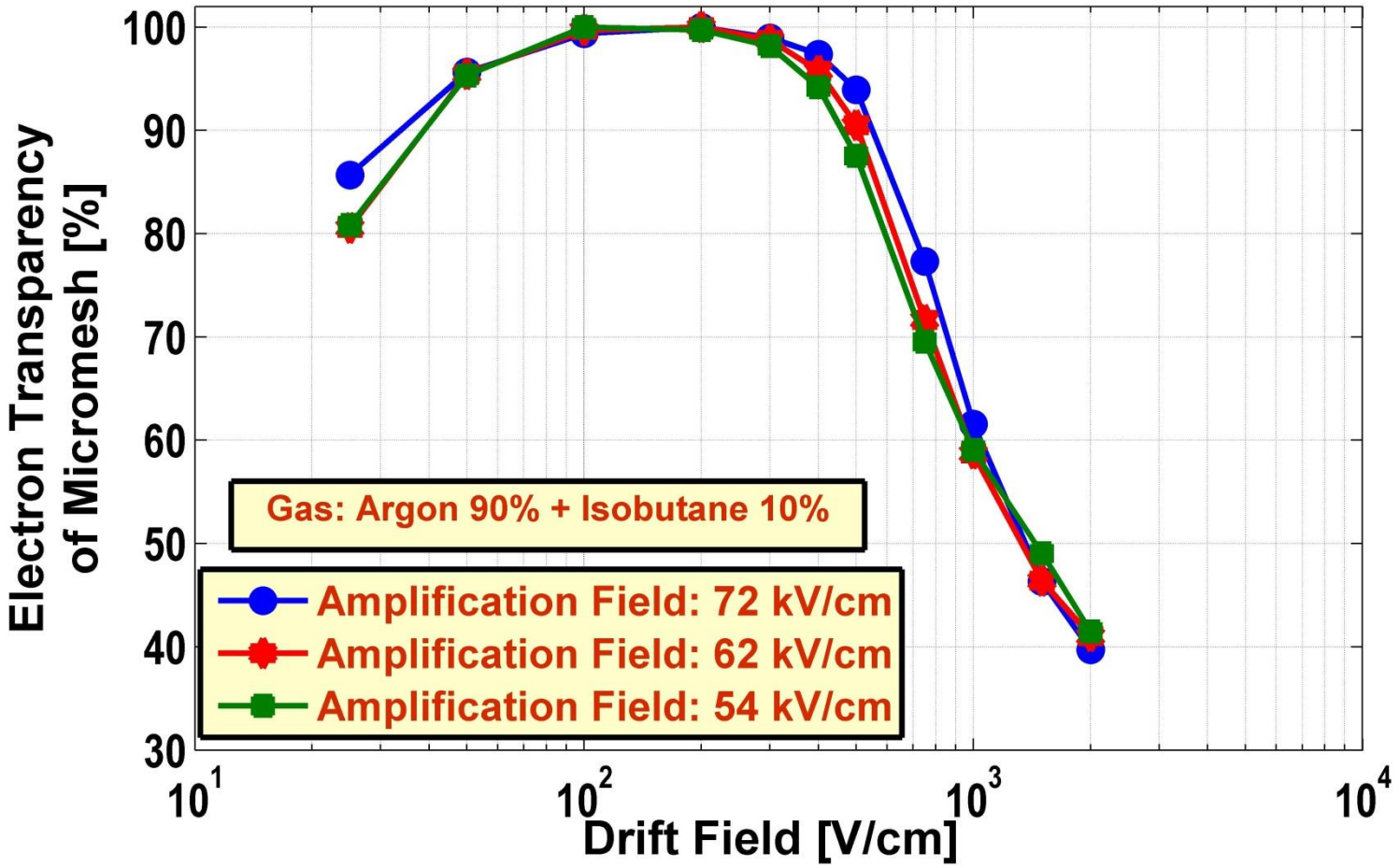




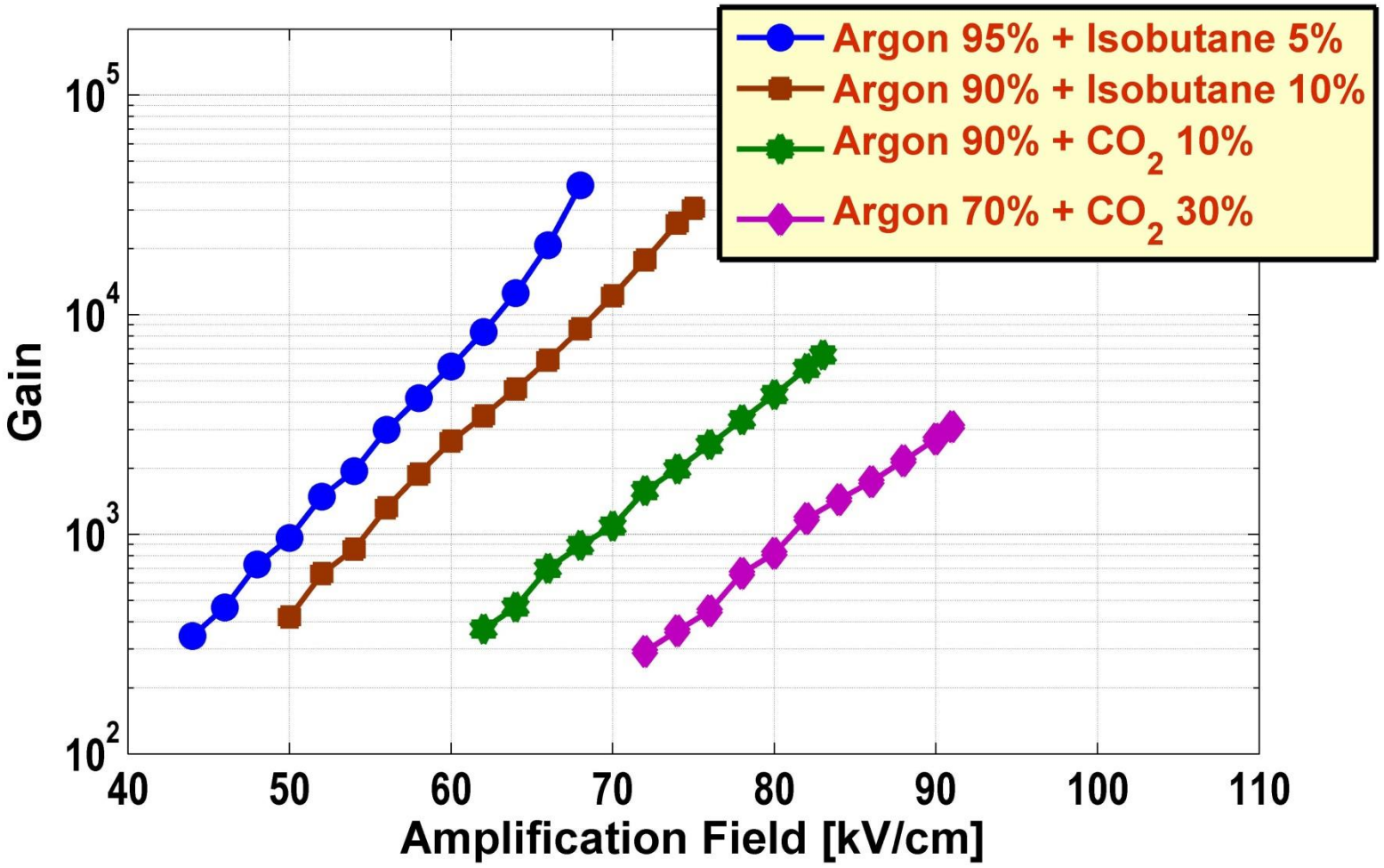
Electron Transparency



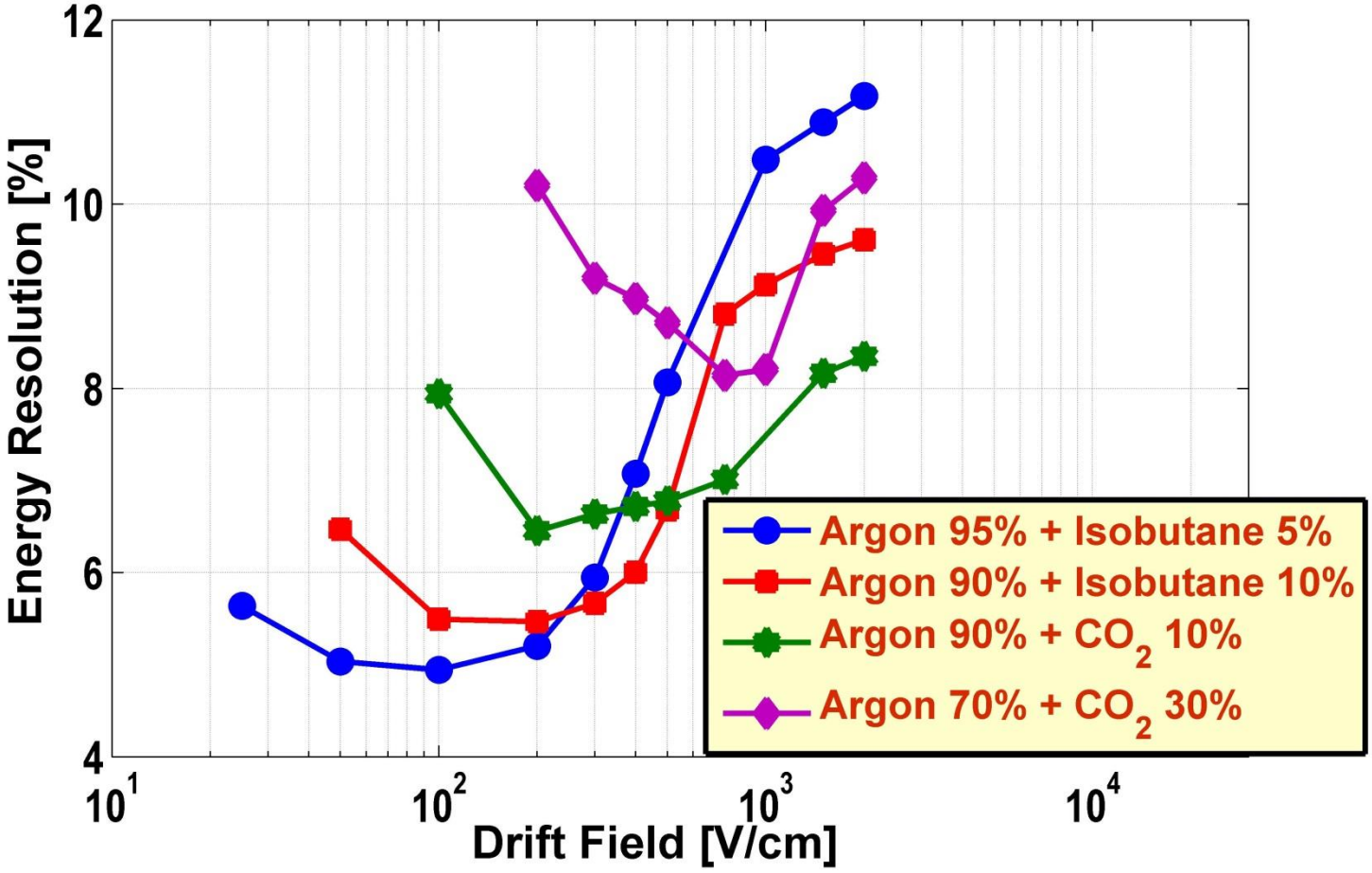
Electron Transparency



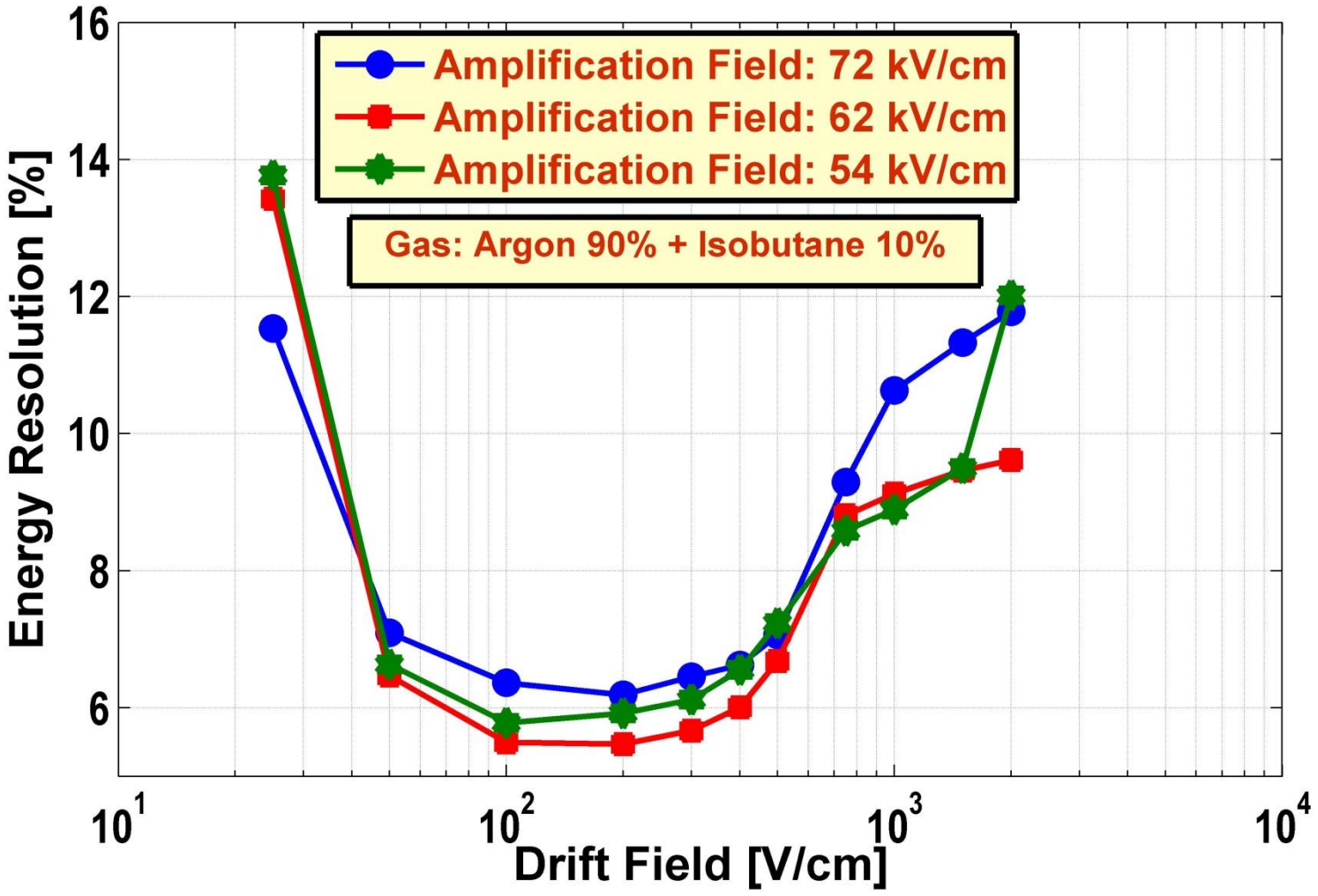
Electron Gain



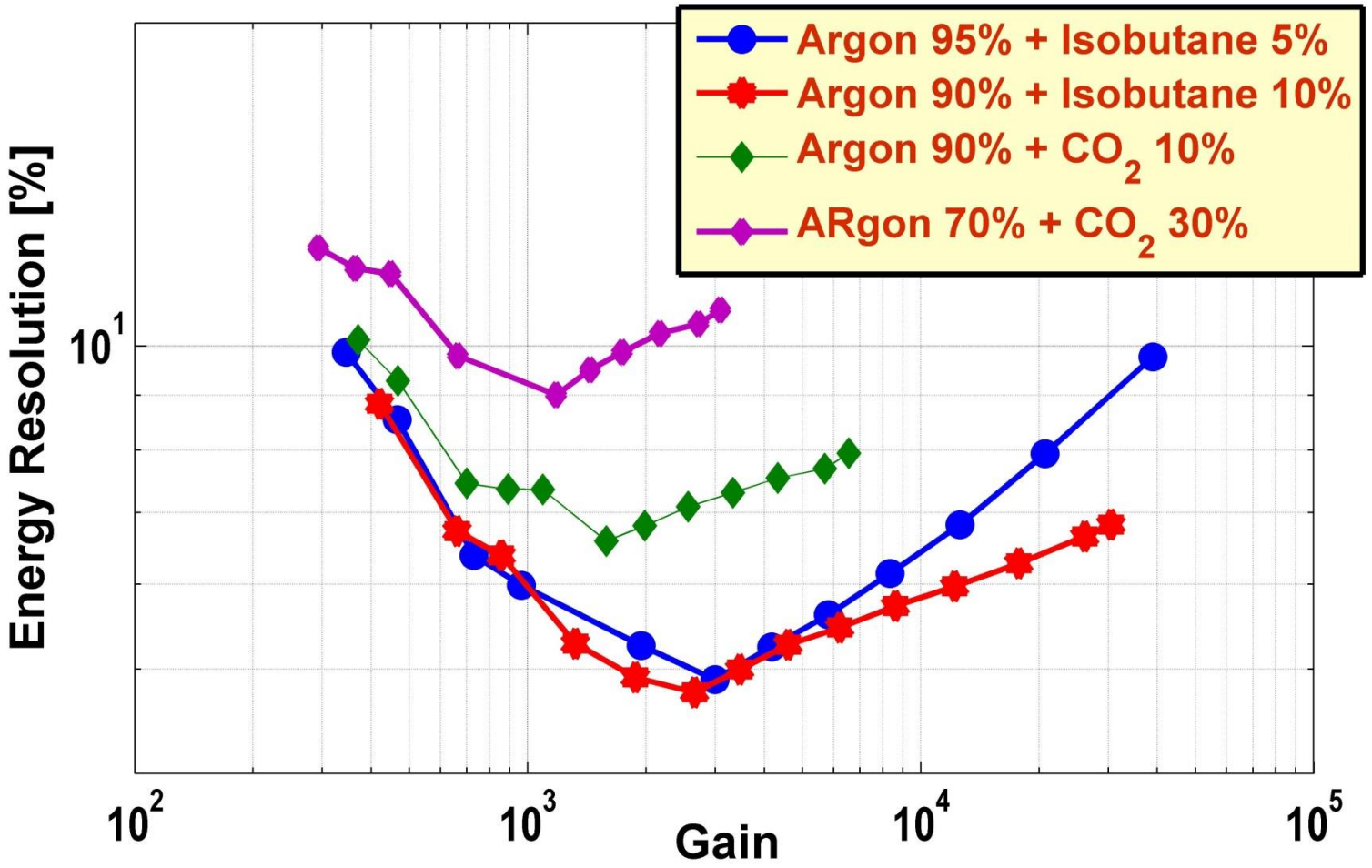
Energy Resolution



Energy Resolution



Energy Resolution



Future Plans

- **Upgrade of cosmic-ray bench for efficiency measurement**
- **Procurement of multi-parameter data acquisition system for measuring space resolution and time resolution**
- **Use of existing X-ray source for more detailed characterization studies including IBF and ageing**
- **Detailed setup for IBF measurement with precise pico-ammeter (already procured)**
- **Expecting microbulk detectors from CERN for a long time!**
- **Experimental measurement on triple-GEM characteristics**
- **Procurement of gases to initiate various gas compositions**

Group Members:
SINP: Purba Bhattacharya, Sudeb Bhattacharya, Nayana Majumdar, Supratik Mukhopadhyay
CEA-Saclay: Paul Colas, David Attie, Wenxin Wang

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