Simulation on Electron Transparency in Micromegas

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on behalf of the
SINP KOLKATA GROUP

MPGD Laboratory at SINP, Kolkata

RD51 Activities

Simulation

- Development of neBEM
- Interface with Garfield
- Upgrade and maintenance
- Simulation of MPGDs

Experiment

- Test bench setup
- Characterization of MPGDs
- Upgrade for new measurements
- Explore other applications

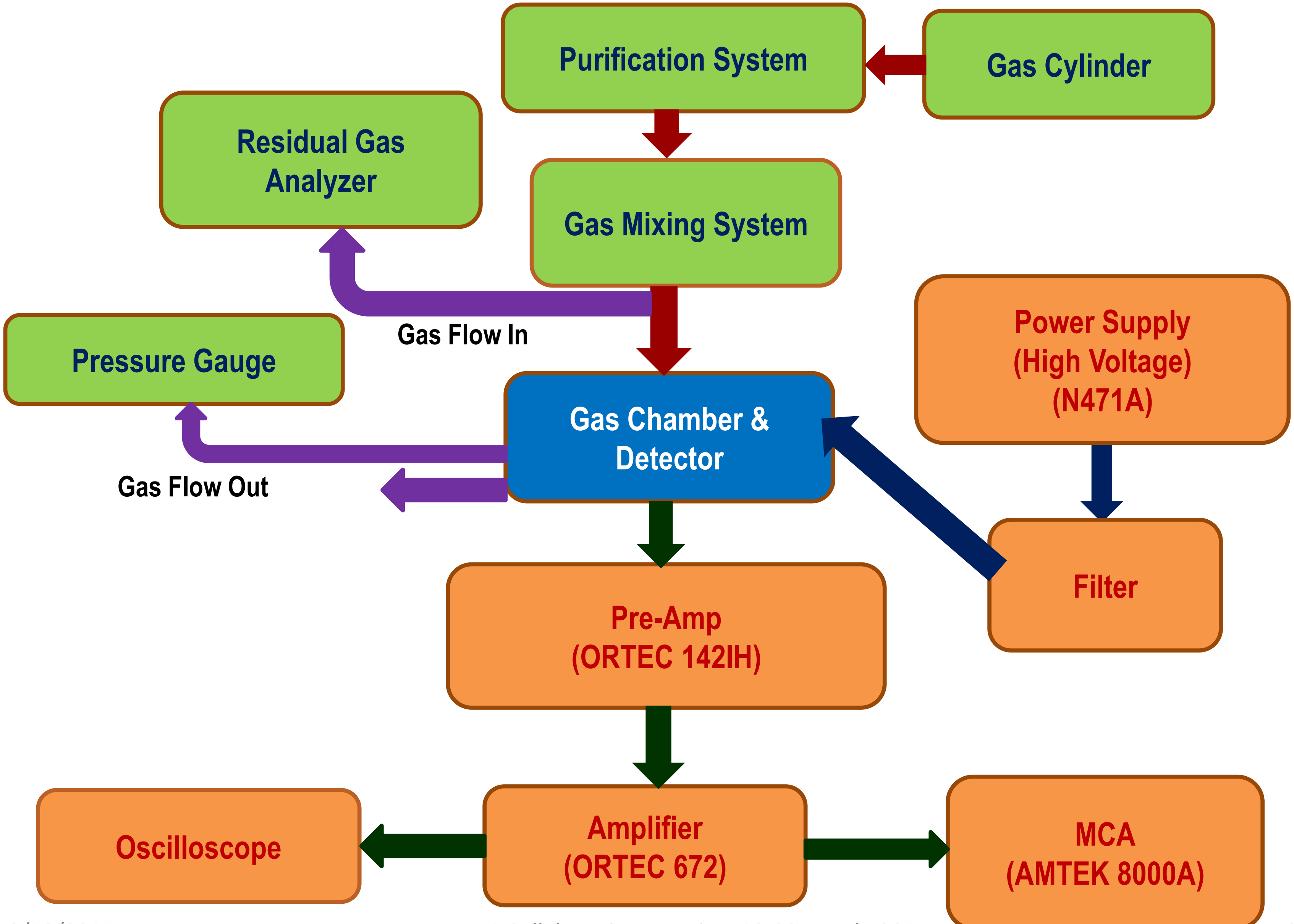
Bulk Micromegas, GEM, MHSP, microbulk Micromegas

Electron transparency
Electron gain
Energy resolution
Ion back-flow

Experiment

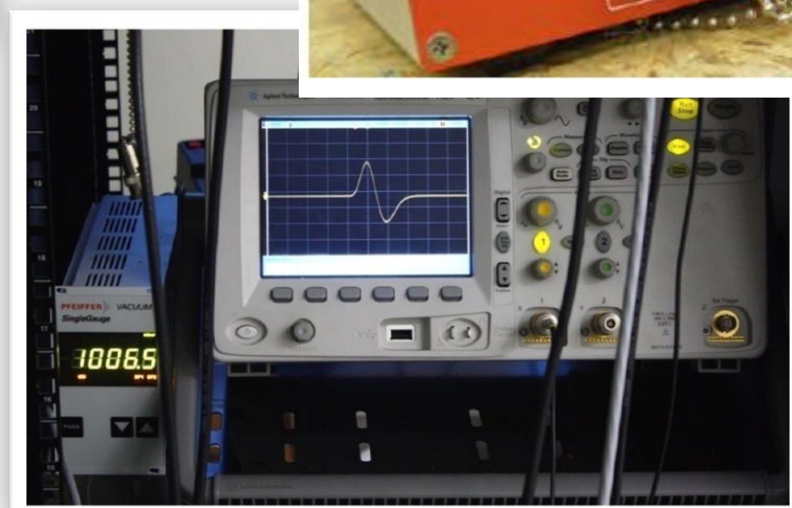
Simulation

Experimental Setup

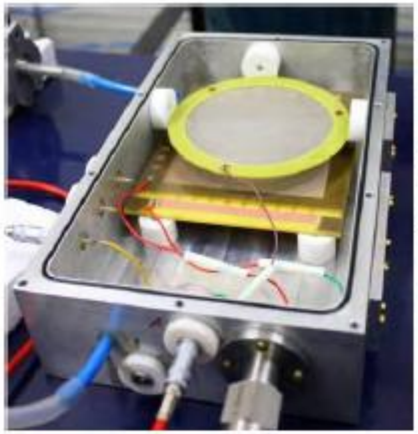


Test Bench Setup

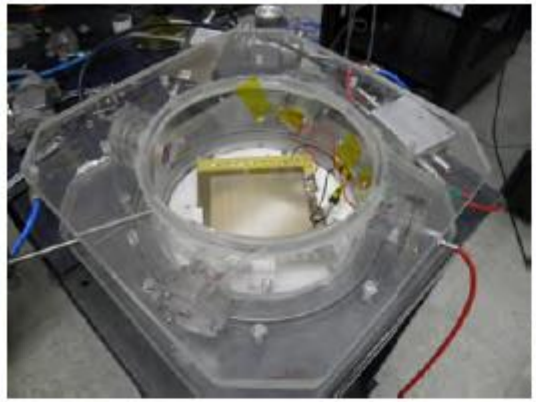
- Test boxes and small TPCs
- Gas distribution system with 4-channel mixing-unit
- Electronics with single-parameter data acquisition system
- Fe55 source



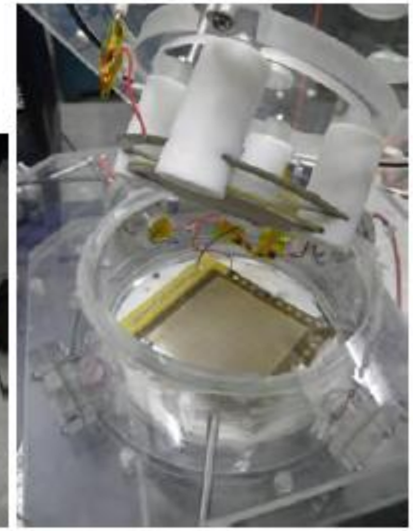
Bulk Micromegas and GEM Test Boxes

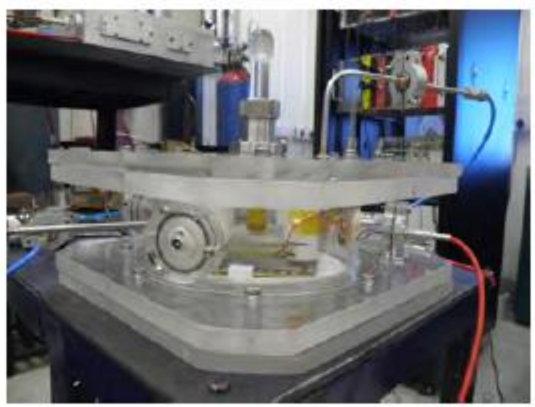


(a)

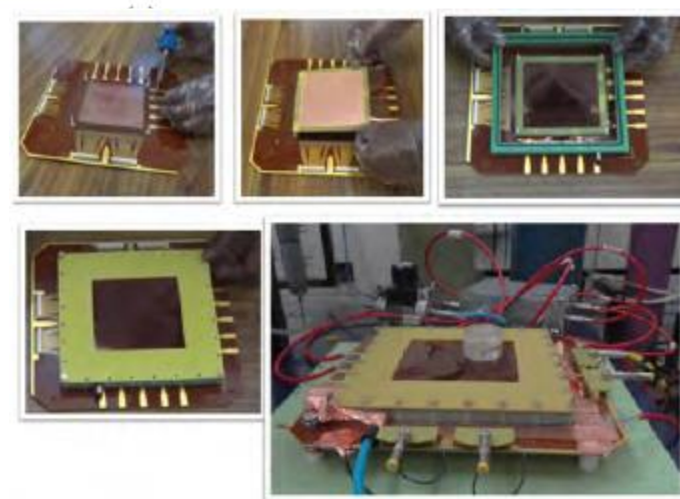


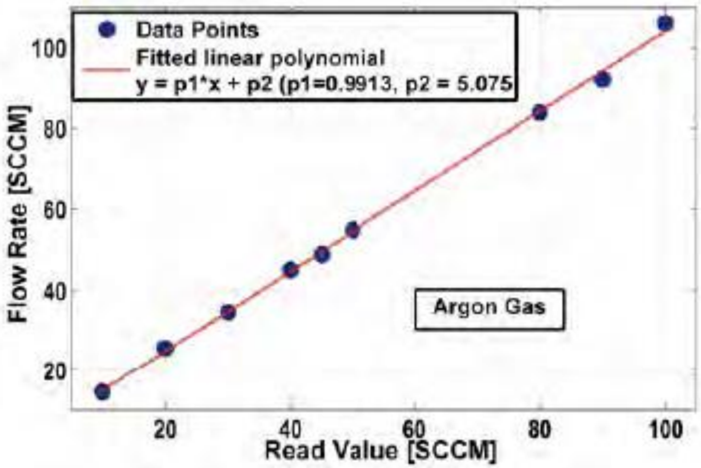
(b)

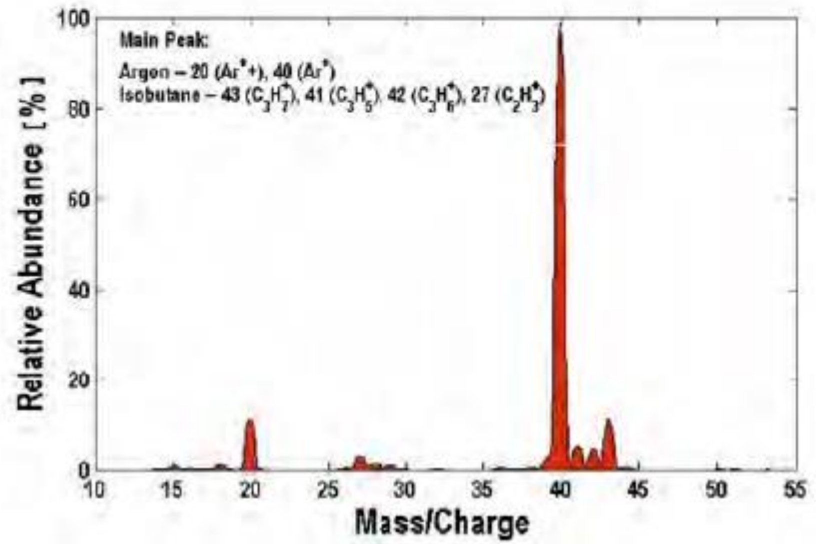


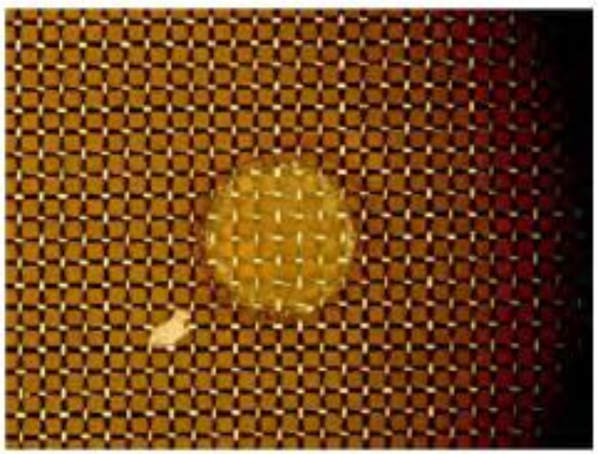


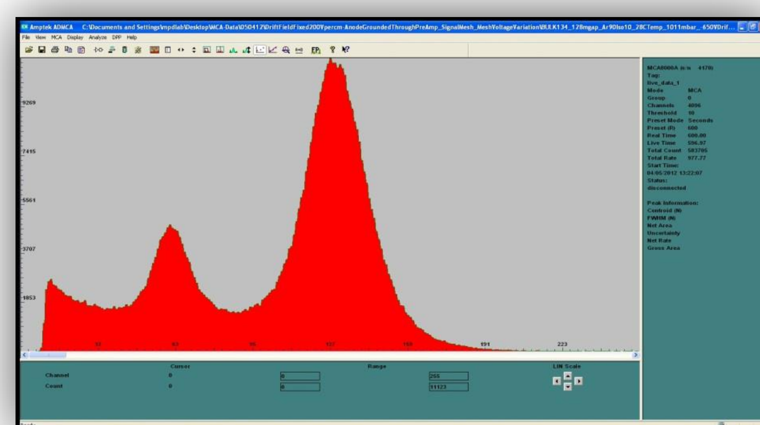
(d)



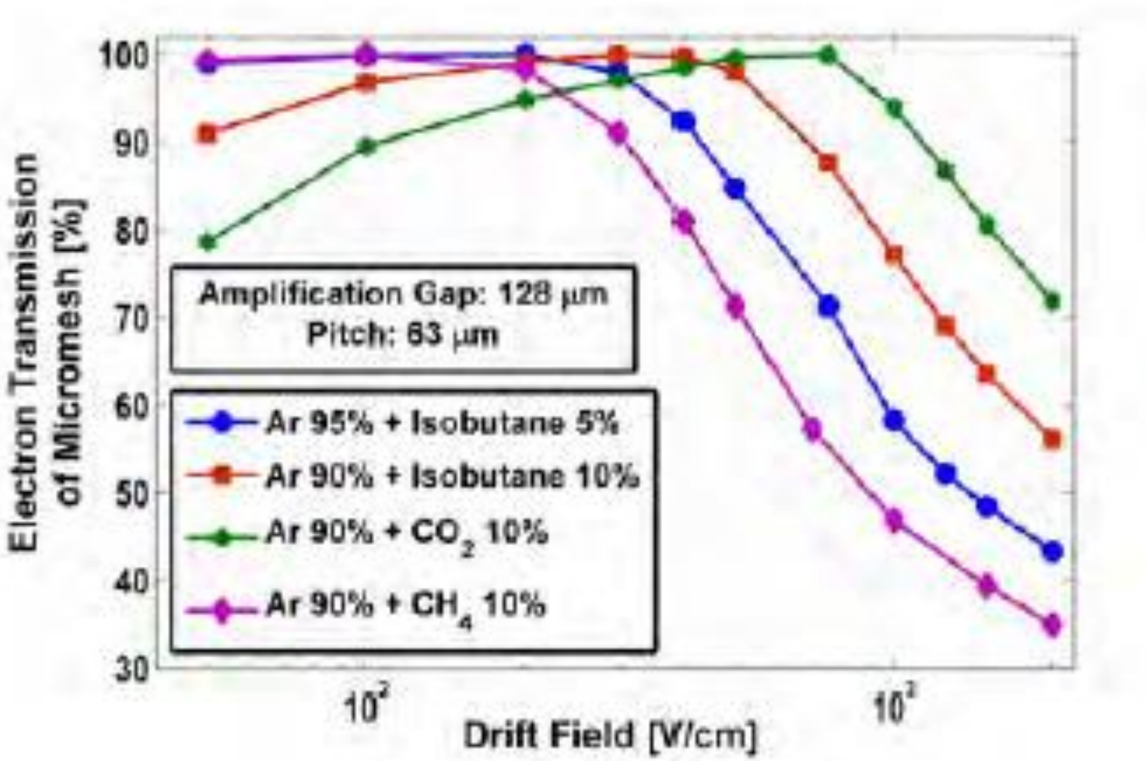

Data Points
Fitted linear polynomial
y = p1*x + p2 (p1=0.9913, p2 = 5.075
Argon Gas
Flow Rate [SCCM]
Read Value [SCCM]
20
40
60
80
100


Main Peak:
Argon – 20 (Ar^{+}+), 40 (Ar^{+})
Isobutane – 43 ($C_3H_7^+$), 41 ($C_3H_5^+$), 42 ($C_3H_6^+$), 27 ($C_2H_3^+$)
Relative Abundance [%]
Mass/Charge
0
20
40
60
80
100
10
15
20
25
30
35
40
45
50
55



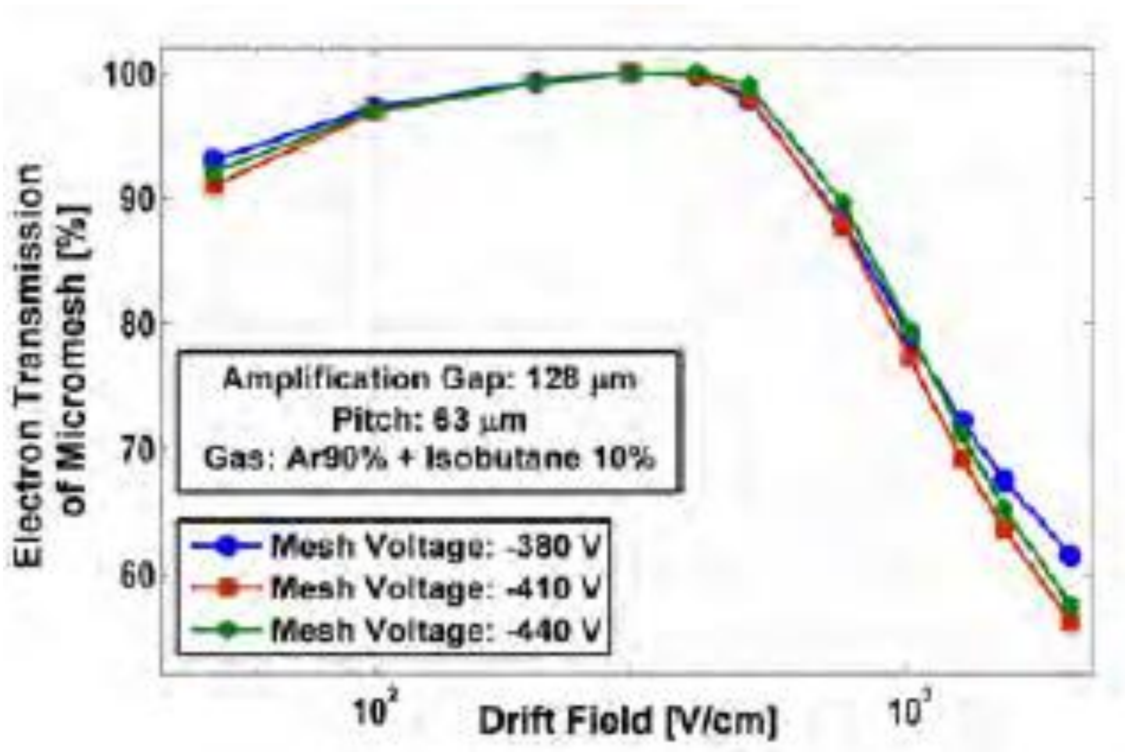


Electron transmission in bulk Micromegas



Variation of electron transmission with drift field for different Argon-based gas mixtures. Mesh Voltage = -350 V (Argon-Isobutane 95 : 5), -410 V (Argon-Isobutane 90 : 10), -500 V (Ar-CH4 90 : 10), -510 V (Ar-CO2 90 : 10).

Variation of mesh voltage



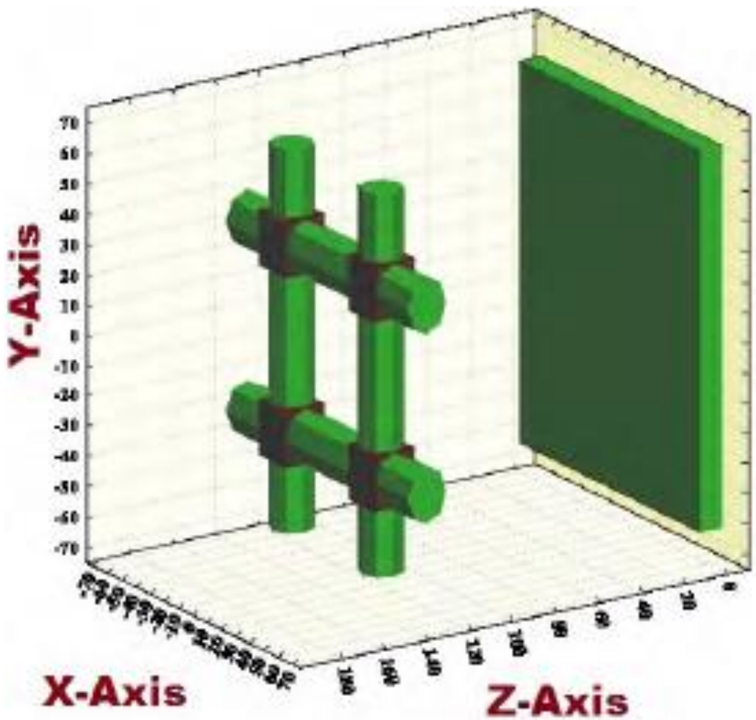
Experimentally observed variation of transmission with drift field for different amplification fields.

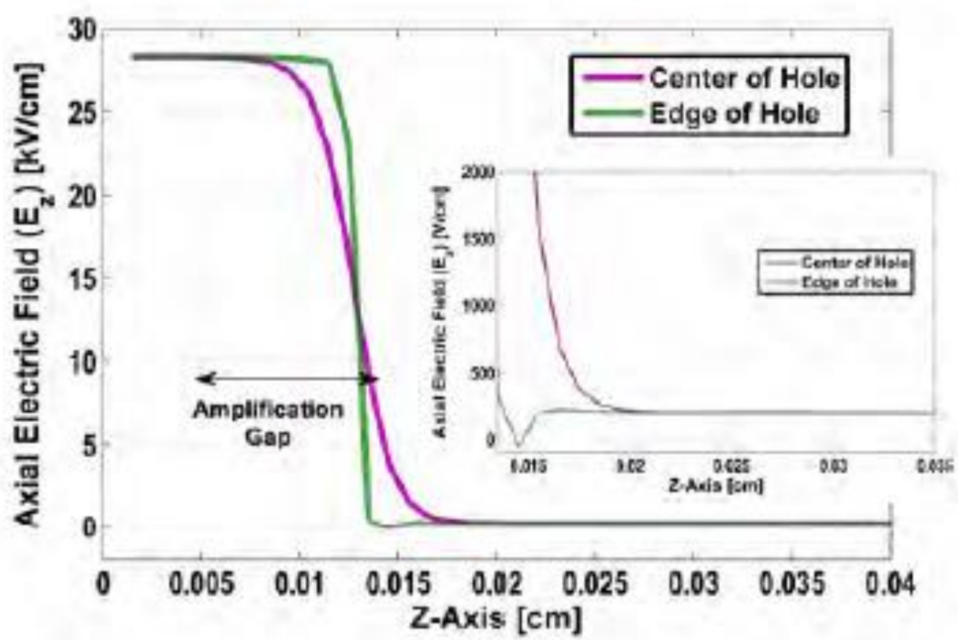
Simulation

Framework: Garfield + neBEM + Magboltz + Heed

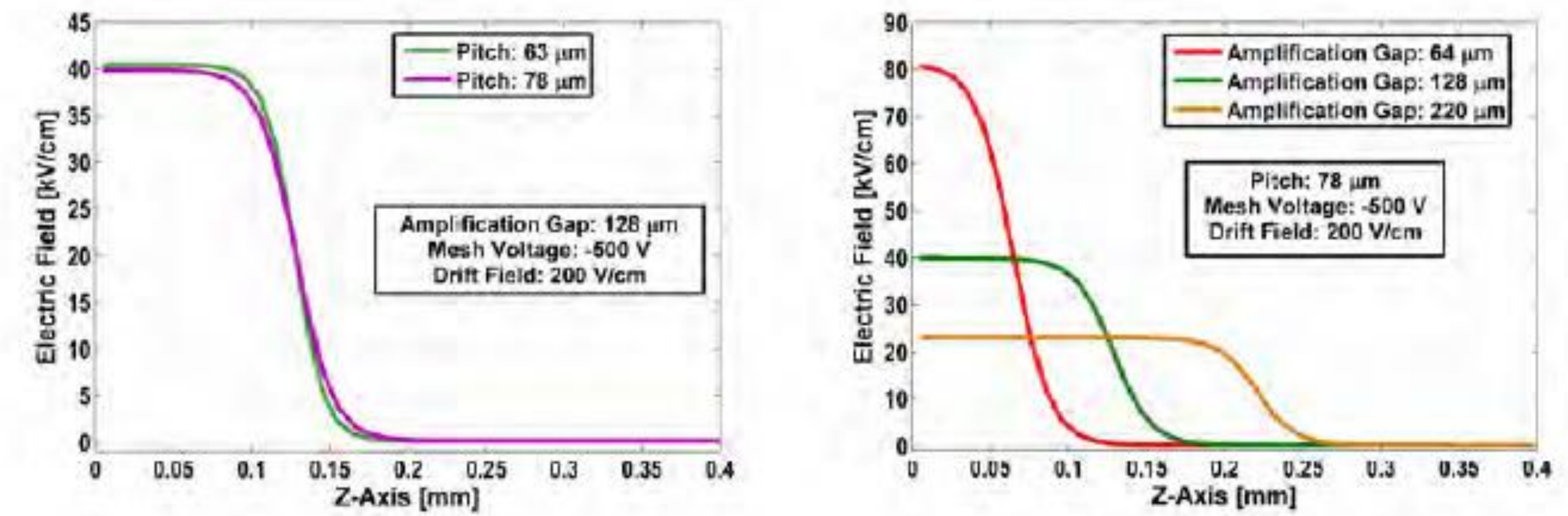
Routine	Description	Application
Drift_Microscopic_Electron	Using Monte Carlo technique, performs electron tracking at the molecular level. A typical drift path proceeds through millions of collisions. Each collision is classified as either elastic, inelastic, attachment, ionization according to the relative cross-sections of these processes	To calculate the transmission

Numerical Model and Field



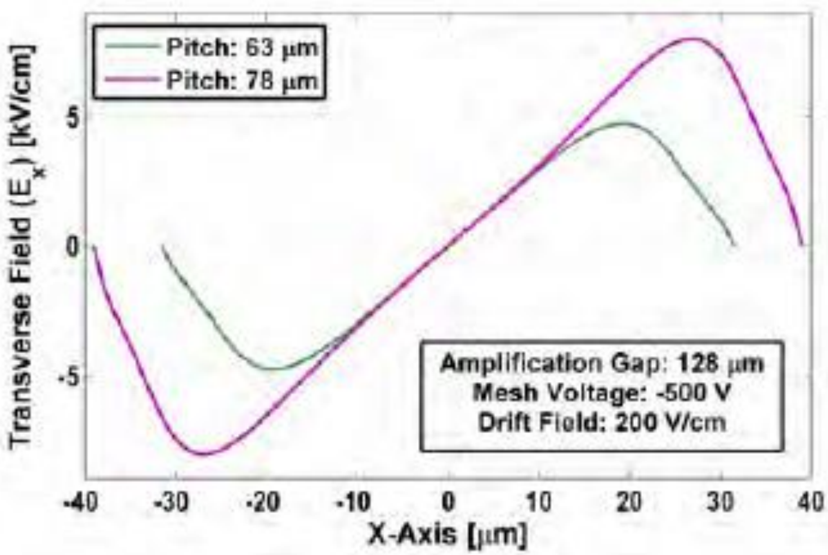


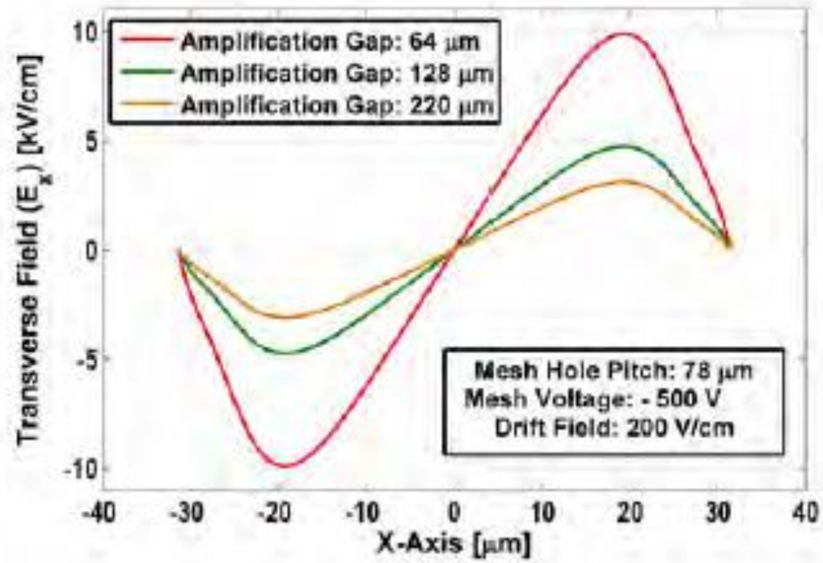
Geometry on Axial Field



Axial electric field for (a) different mesh hole pitches having the same amplification gap of 128 mu, (b) different amplification gaps having the same mesh hole pitch of 78 mu. In each of these cases, mesh voltage = -500 V, drift field = 200 V/cm.

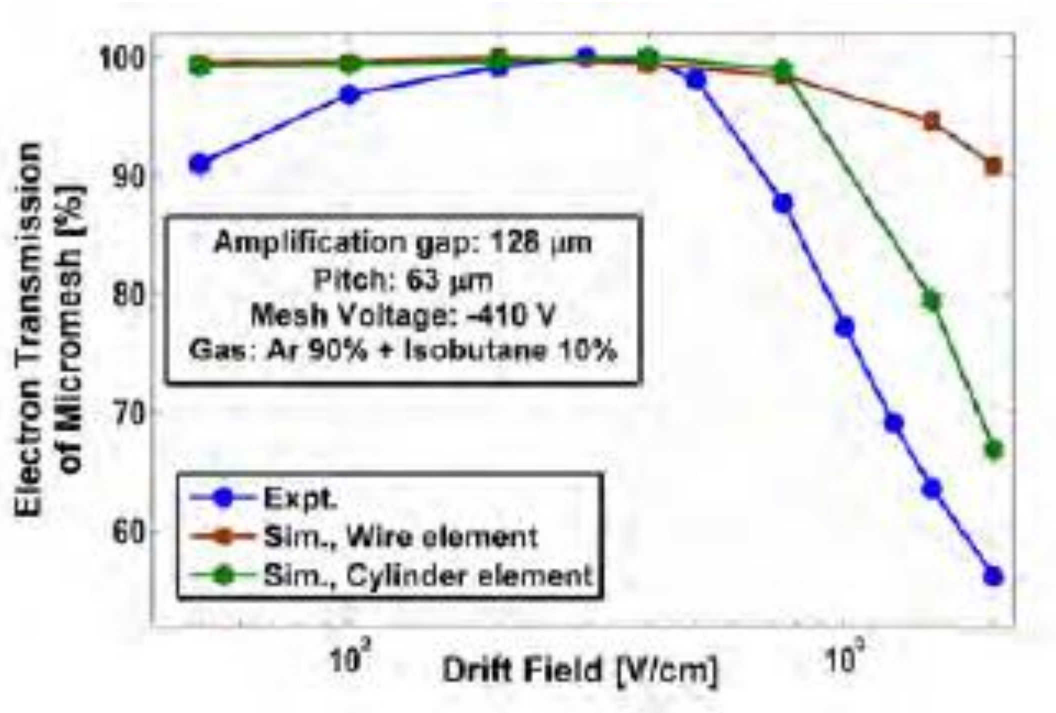
Geometry on Transverse Field





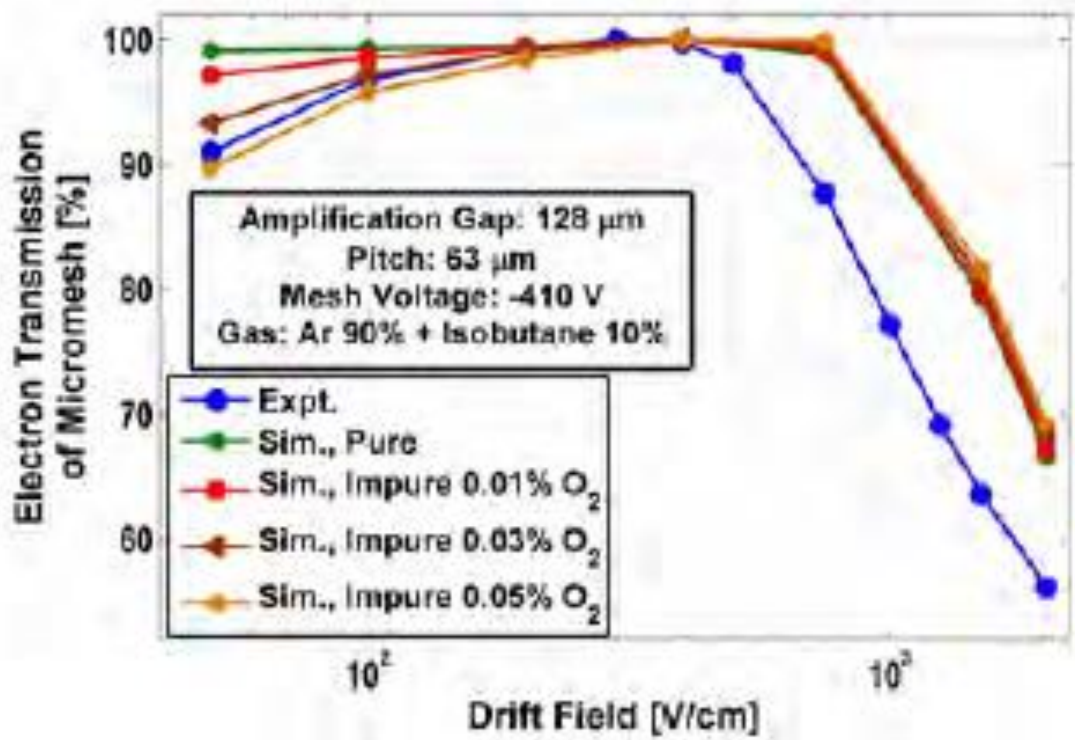
Transverse electric field close to the hole entrance (1 mu above the micromesh) for (a) different mesh hole pitches having the same amplification gap of 128 mu, (b) different amplification gaps having the same mesh hole pitch of 78 mu. In each of these cases, mesh voltage = -500 V, drift field = 200 V/cm.

Estimation of transmission



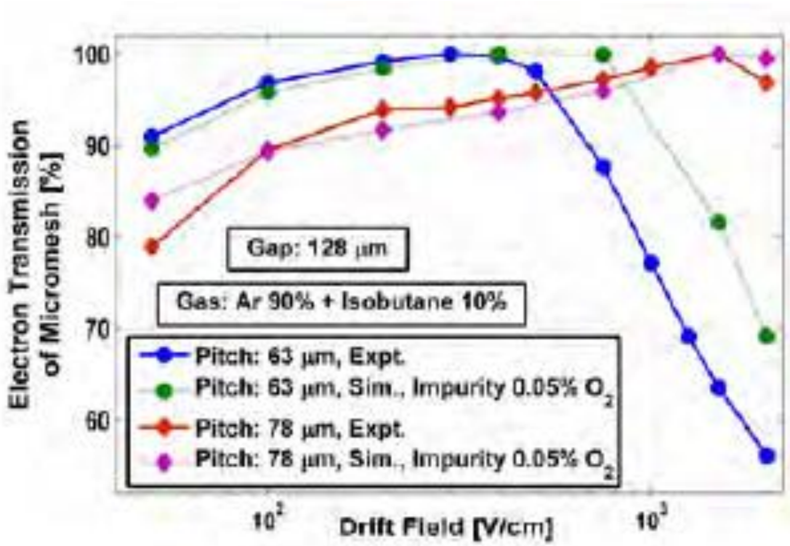
Comparison of electron transmission between experimental and simulated transmissions using two different schemes of mesh representation in Argon-Isobutane (90 : 10) gas mixture.

Effects of impurity

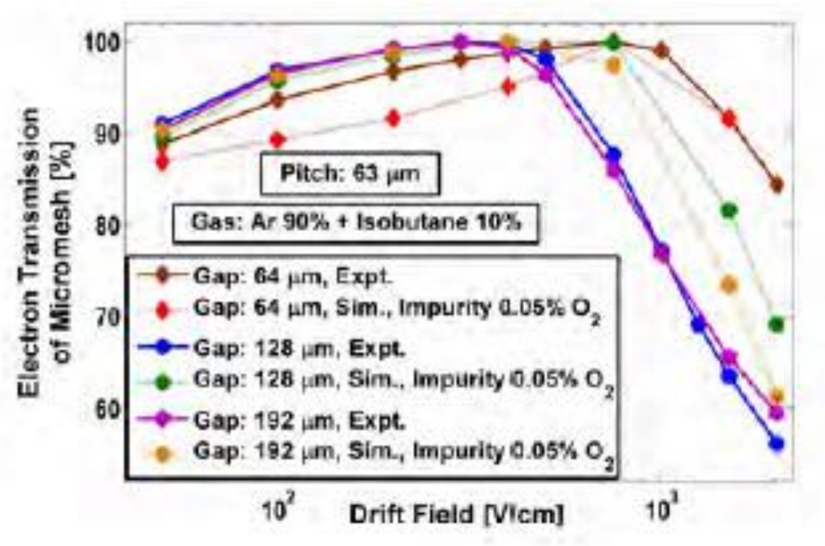


Comparison of electron transmission between experimental and simulated transmissions using different levels of Oxygen impurity in Argon-Isobutane (90 : 10) gas mixture.

Geometry on transmission



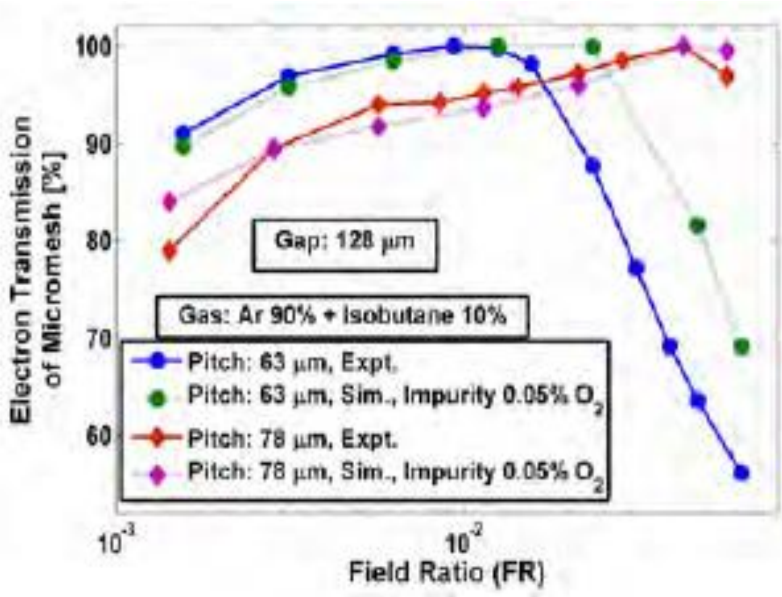
(a)



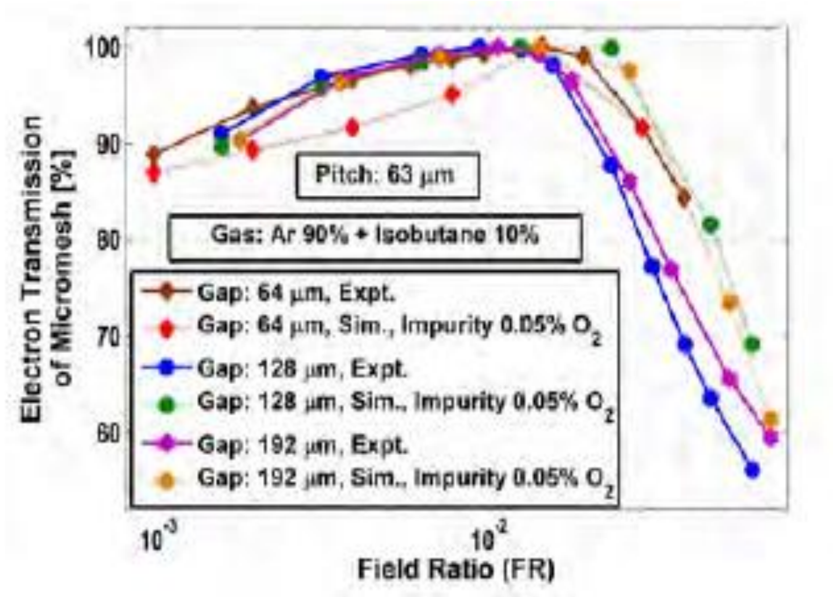
(b)

Variation of the electron transmission of the micromesh with the drift field in Argon-Isobutane (90 : 10) mixture for (a) two different mesh hole pitches [pitch = 63 mu, mesh voltage = -410 V, gain 3200; pitch = 78 mu, mesh voltage = -450 V, gain 4000] having the same amplification gap of 128 mu; (b) three different amplification gaps [gap = 64 mu, mesh voltage = -330 V, gain 3000; gap = 128 mu, mesh voltage = -410 V, gain 3200; gap = 192 mu, mesh voltage = -540 V, gain 3600] having the same mesh hole pitch of 63 mu.

Geometry on transmission



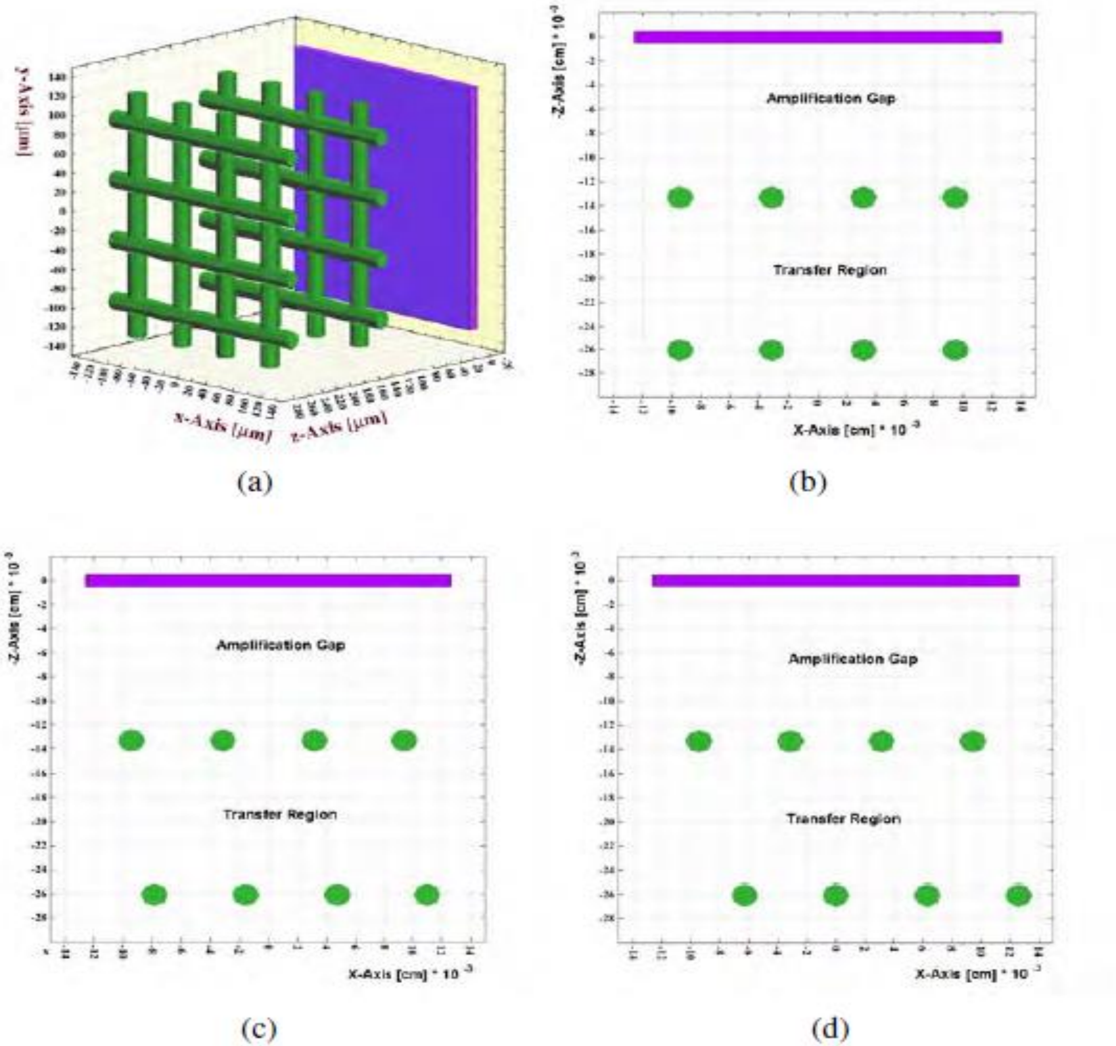
(c)



(d)

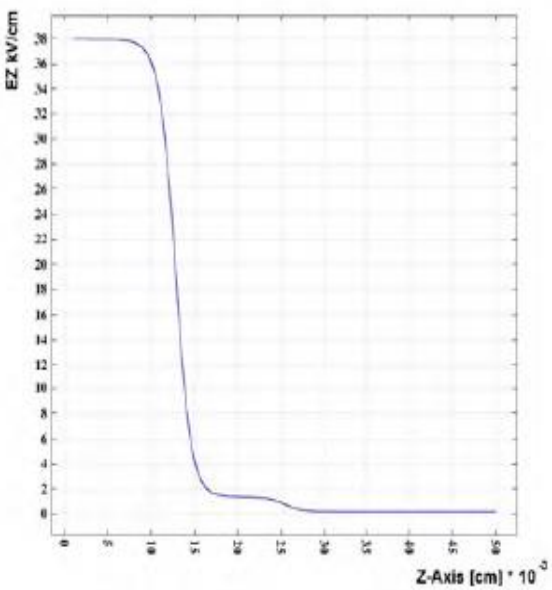
(c) and (d) represent the same variation but with the field ratio FR (E_{drift}/E_{amp})

Double Micromesh and Transmission

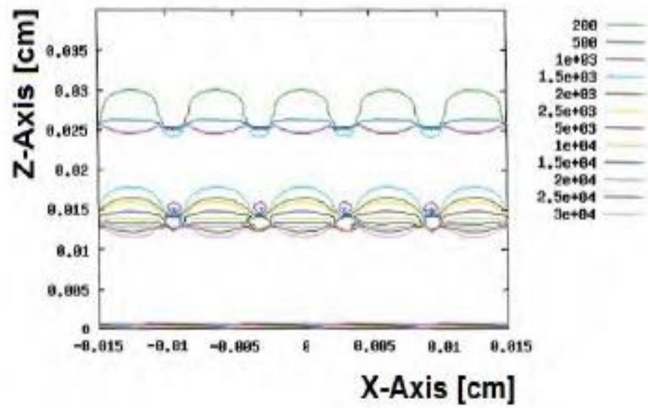


(a) The simulation model for double micromesh in 3D; The 2D view, when (b) the two meshes have been placed such that the holes are aligned perfectly and the second micromesh is shifted to (c) one quarter (15.75 mu) and (d) half the hole pitch (31.5 mu) with respect to the first one.

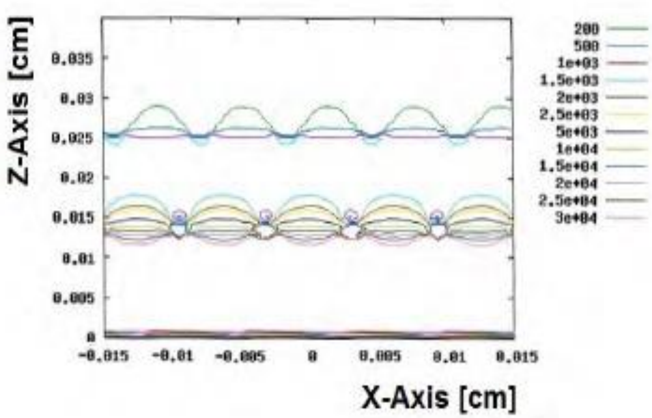
Axial electric field



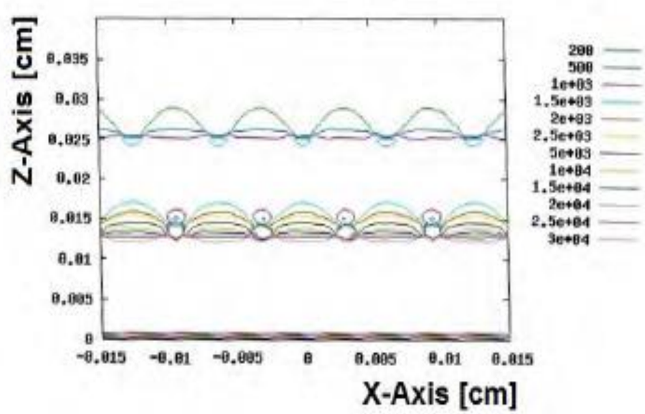
(a)



(b)



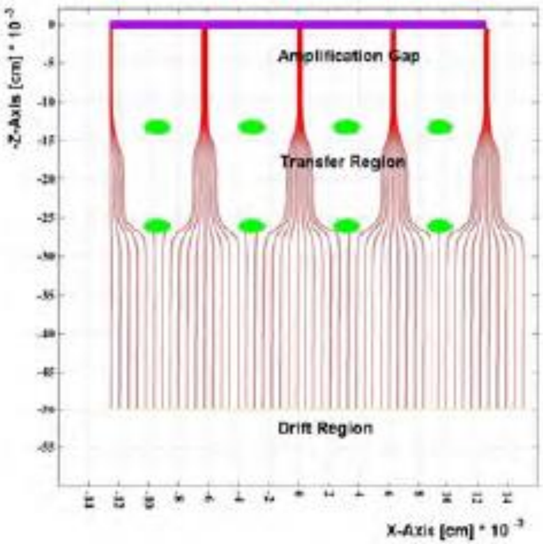
(c)



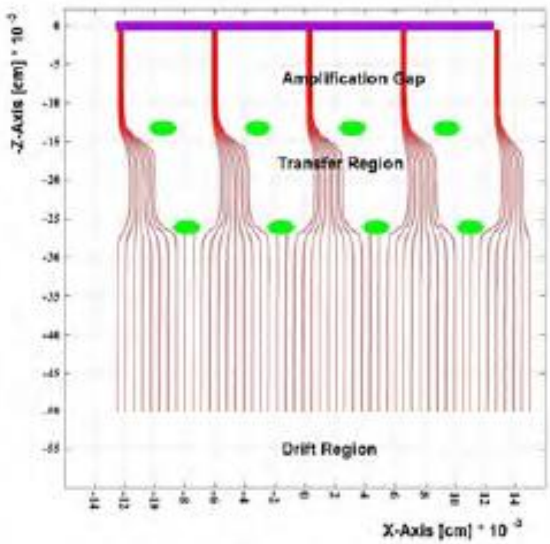
(d)

(a) The axial electric field through center of hole for double micromeshes; The field contour when the meshes are shifted (b) 0 mu, (c) 15.75 mu, (d) 31.5 mu with respect to one another.

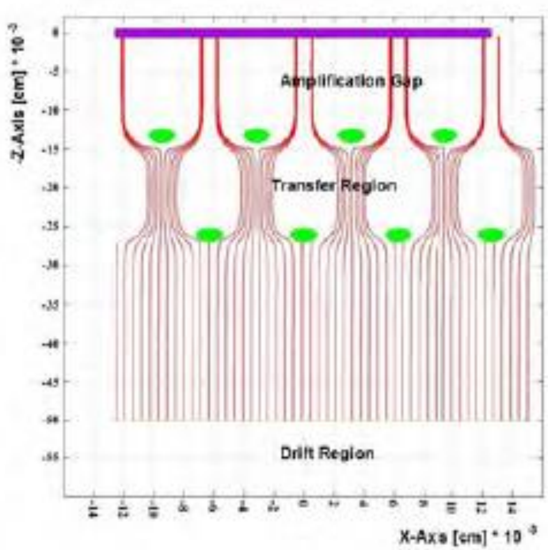
Drift lines



(a)



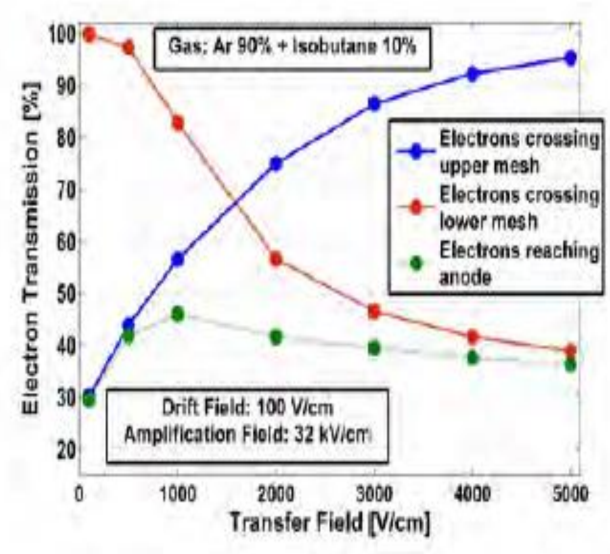
(b)



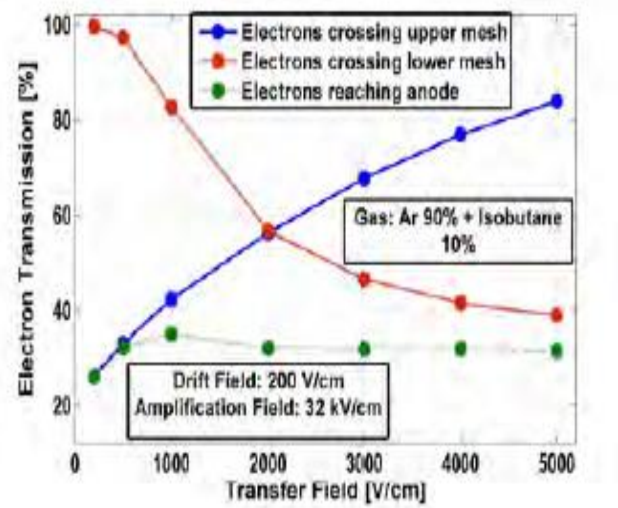
(c)

Drift lines for double micromesh configurations when the meshes are shifted (a) 0 mu, (b) 15.75 mu, (c) 31.5 mu with respect to one another.

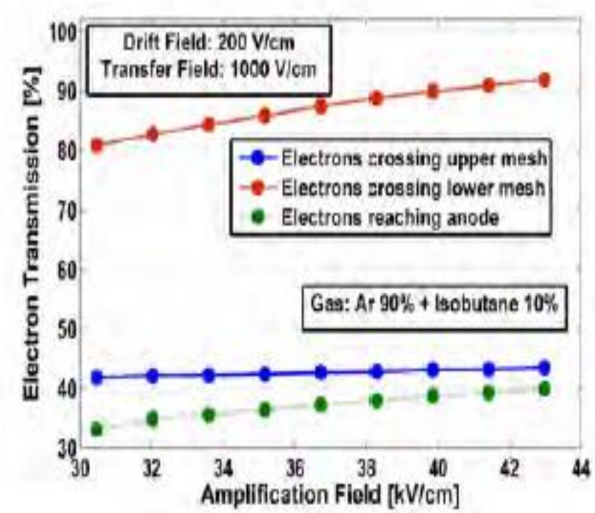
Electron Transmission



(a)



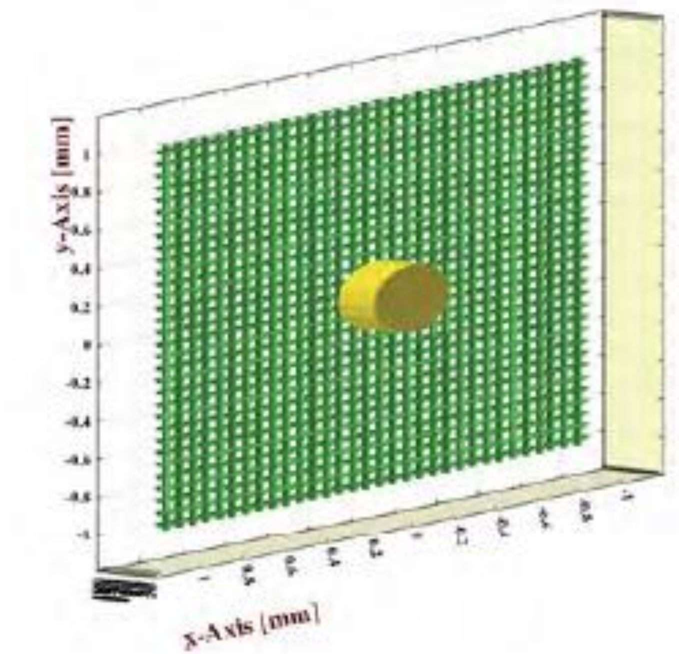
(b)

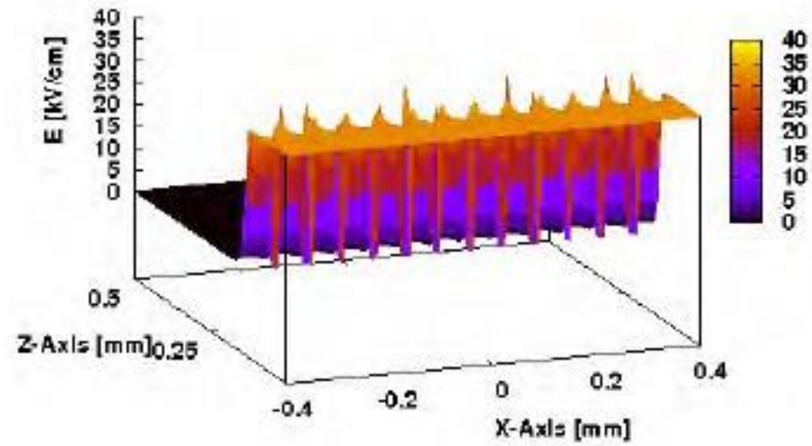


(c)

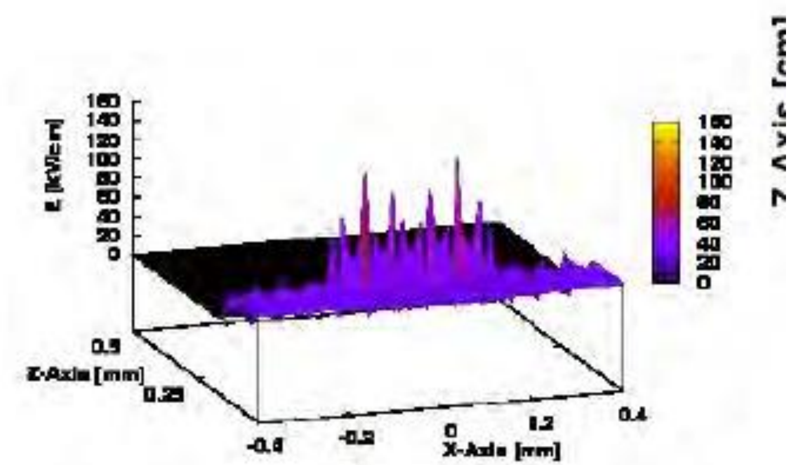
For double micromesh, in Argon-Isobutane (90 : 10), the variation of electron transmission with transfer field for drift field of (a) 100 V/cm, (b) 200 V/cm at a fixed mesh voltage of -410 V. (c) The same variation but with amplification field at a fixed drift field of 200 V/cm and transfer field of 1000 V/cm.

Spacers and Transmission





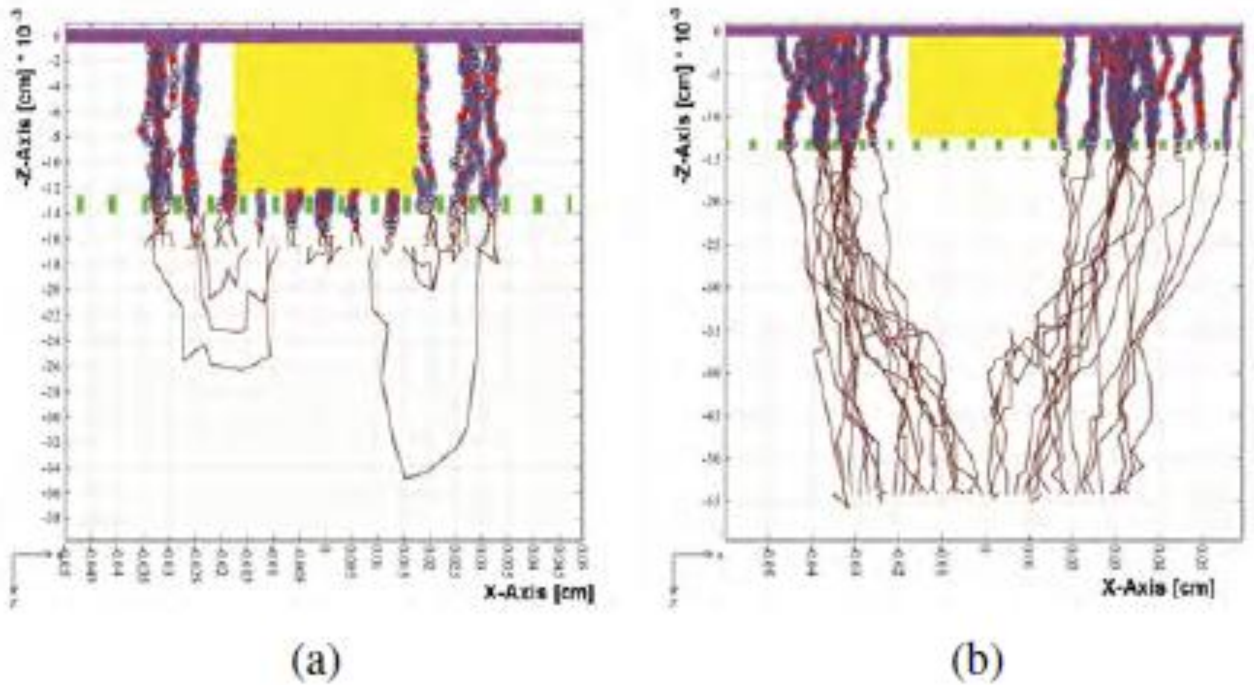
(a)



(c)

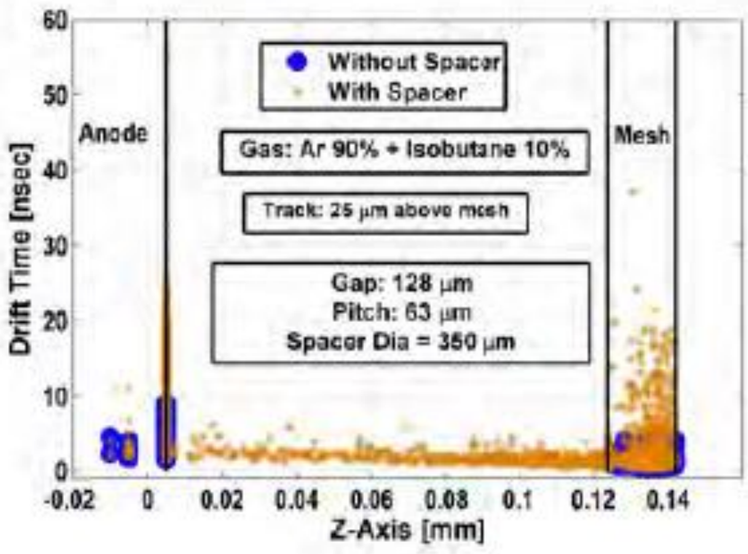
Model of a bulk Micromegas with a cylindrical spacer at the center; The effect of spacer on electric field in a bulk Micromegas detector having amplification gap of 128 mu and pitch of 63 mu. (a) The field without spacer, (c) with spacer

Drift lines from two tracks

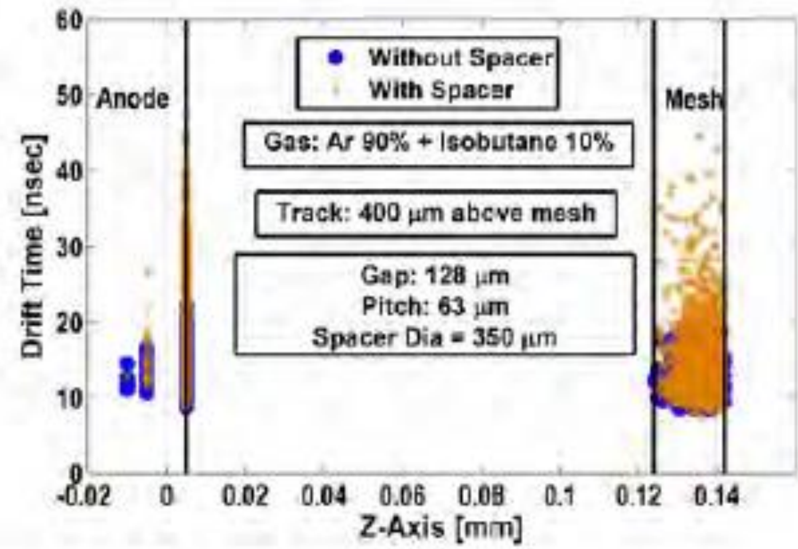


The electron drift lines in Argon-Isobutane (90 : 10) mixture from a track (a) 25 mu, (b) 400 mu above the micromesh. Amplification gap = 128 mu, pitch = 63 mu, mesh voltage = -430 V, drift field = 200 V/cm. Brown line: electron drift line, Blue circle: excitation, Red dot: ionization.

End-points from two tracks



(a)



(b)

The endpoint (Z-Axis) and drift time of electrons in Argon-Isobutane (90 : 10) mixture from pre-defined tracks (a) 25 mu, (b) 400 mu above the micromesh. Amplification gap = 128 mu, pitch = 63 mu, mesh voltage = -430 V, drift field = 200 V/cm.

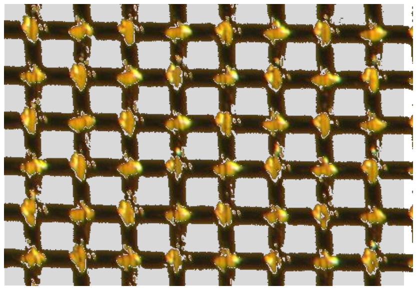
Spacers and transmission

	Track position above mesh (μm)	Fraction of primary electrons below mesh %	at anode %	Gain
Without Spacer	25	87.43	87.43	655
	50	86.72	86.72	647
	100	87.55	87.55	653
	200	86.92	86.92	648
	400	87.51	87.51	652
With Spacer	25	60.89	56.46	421
	50	82.55	80.51	594
	100	84.25	83.82	620
	200	84.14	83.79	618
	400	84.64	84.36	624

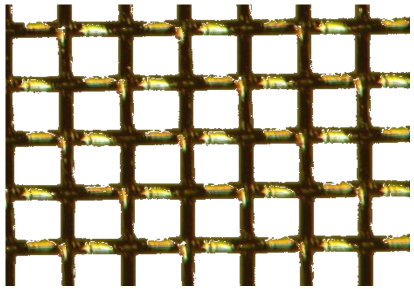
Electron transmission and gain (without and with Spacer) Argon-Isobutane (90 : 10) mixture. amplification gap = 128 mu, pitch = 63 mu, mesh voltage = -430V, drift field: 200 V/cm.

A variety of meshes!

45/18 – 50%

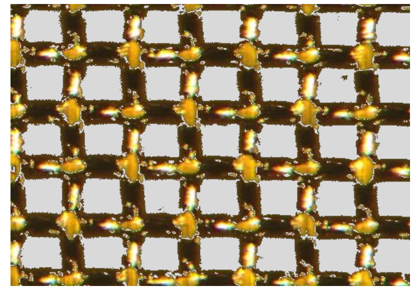


standard for small size MM chambers



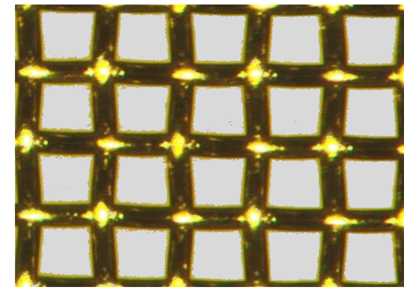
maximized open area with 18µm thin wires

50/30 – 39%



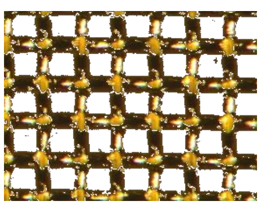
standard for large size MM prototypes at CERN (MMSW)

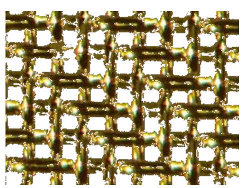
71/30 – 49%



alternative 30µm wire-mesh with larger openings

A variety of **mesh specification** details can be studied:

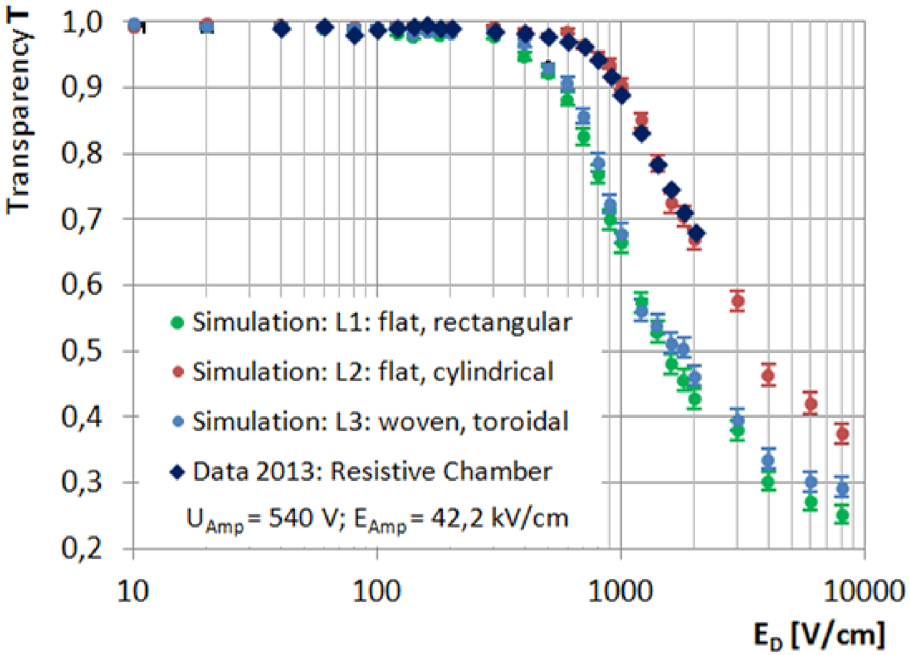


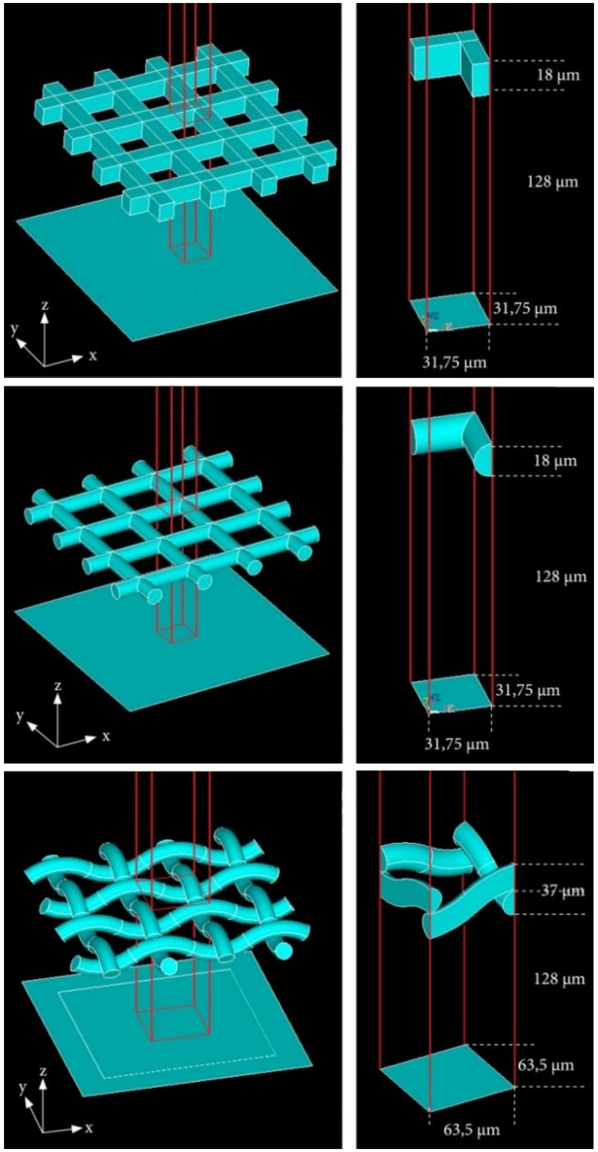


- different wire diameter
- different openings with same wires
- no/ soft / strong calendared meshes
- different types of weaving (plain vs. twill weave)
- alternative mesh material (metalized synthetics)

Ref: Fabian’s talk in 2014 Kolkata meeting

Mesh models

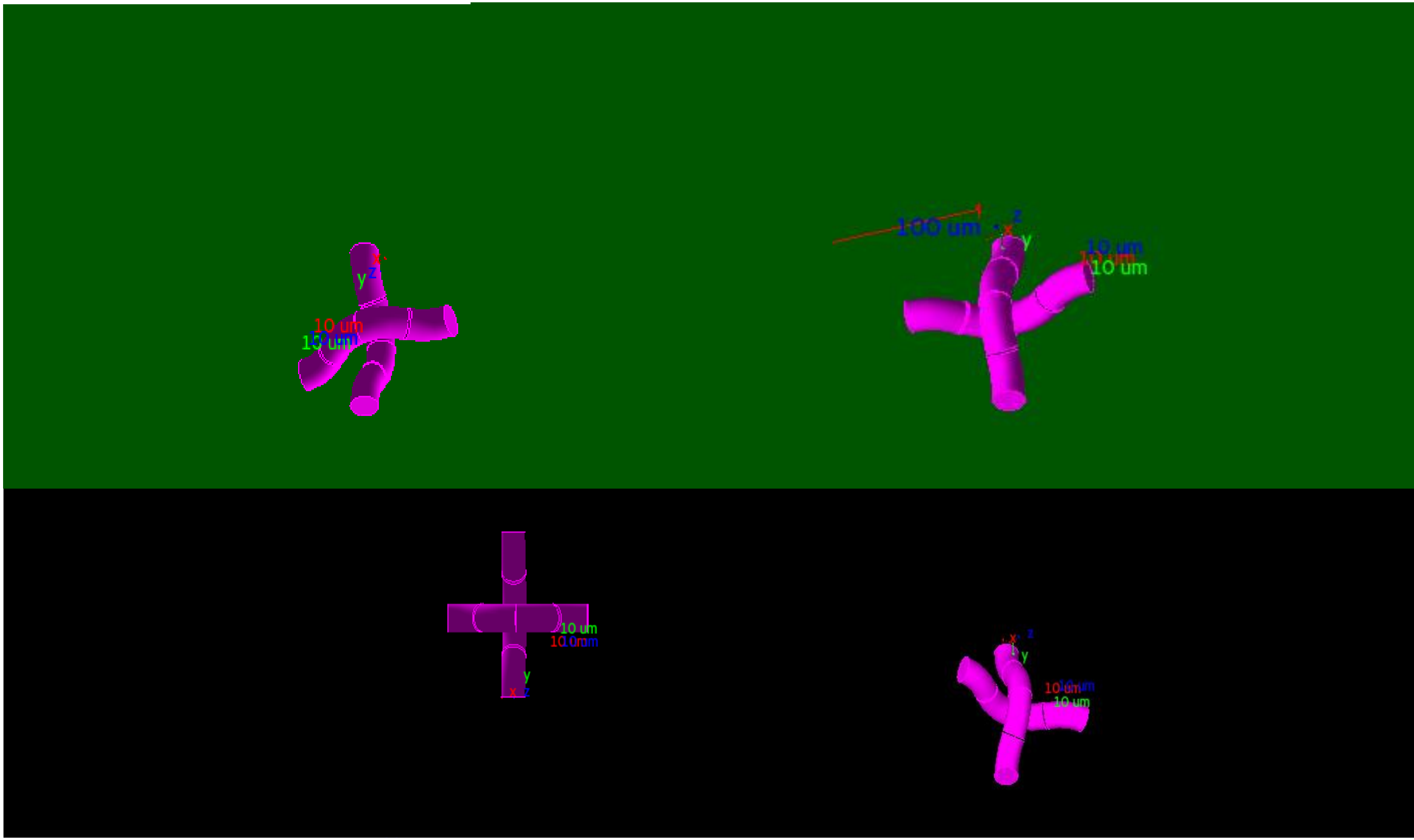




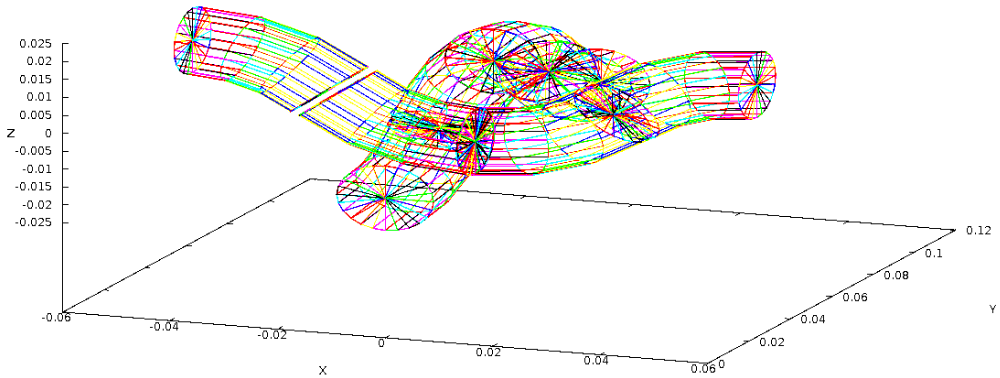
- Covering FEM models with different geometries, to test and understand previous results* where best agreements have been reached with flat, cylindrical wire mesh approximation.

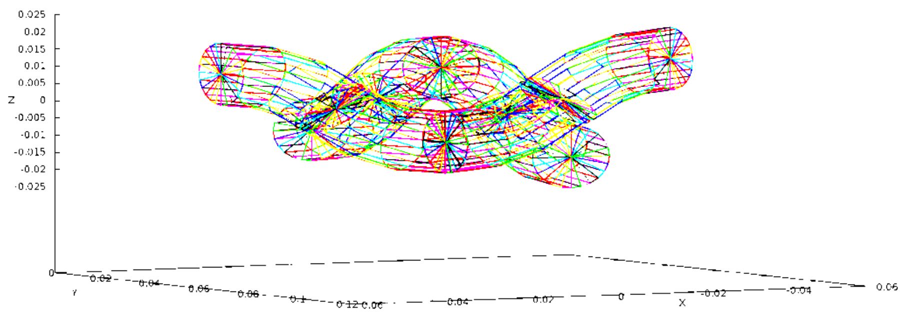
Ref: Fabian's talk in 2014 Kolkata meeting

What a mesh!



Meshy primitives for neBEM





Used Geant4!
Still a long way to go ...

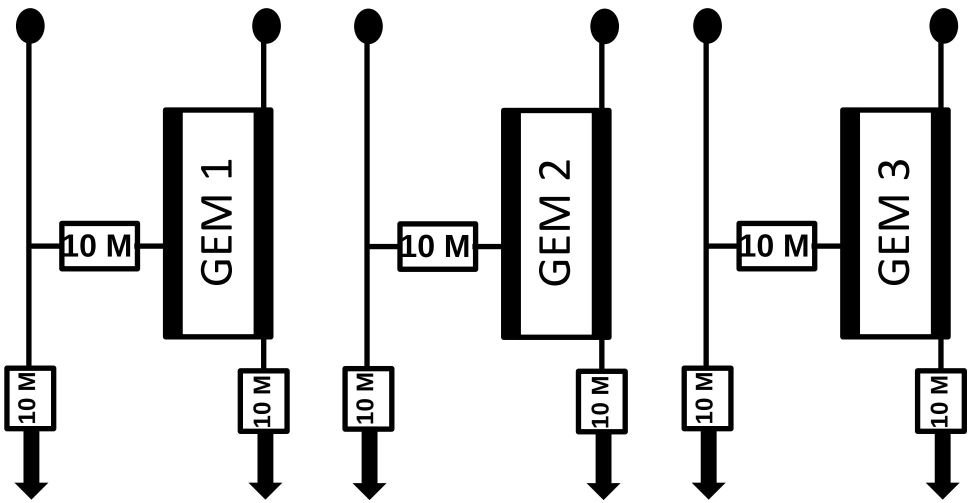
Status update

- New gases (Ar+isobutane+CF_4, Ar+CO_2+CF_4)
- New power supply (CAEN SY4527)
- Less fund!
- Less personnels!

- To continue with detailed studies on transmission, IBF and so on ... on GEM, Micromegas, Thick GEM and so on ...

Individual Voltage Supply on Different Electrodes

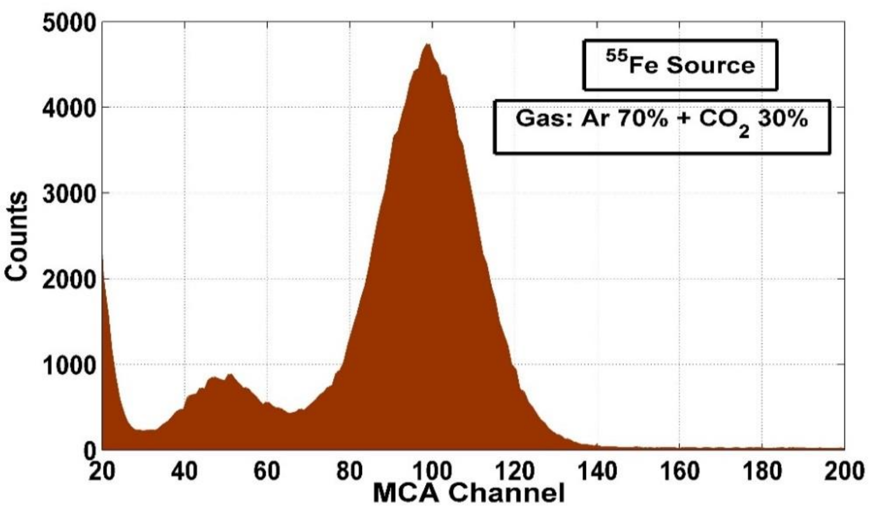
High Voltage Circuit for Individual Electrodes



Electrodes	Applied Voltage
Drift	3400
GEM 1 Top	2320
GEM 1 Bottom	1950
GEM 2 Top	1688
GEM 2 Bottom	1311
GEM 3 Top	781
GEM 3 Bottom	412

12 Channels Power Supply

Typical MCA Spectrum



Thanks a lot for your kind attention!