TRIPLE GEM SIMULATION

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On behalf of the
RD51 group @ SINP

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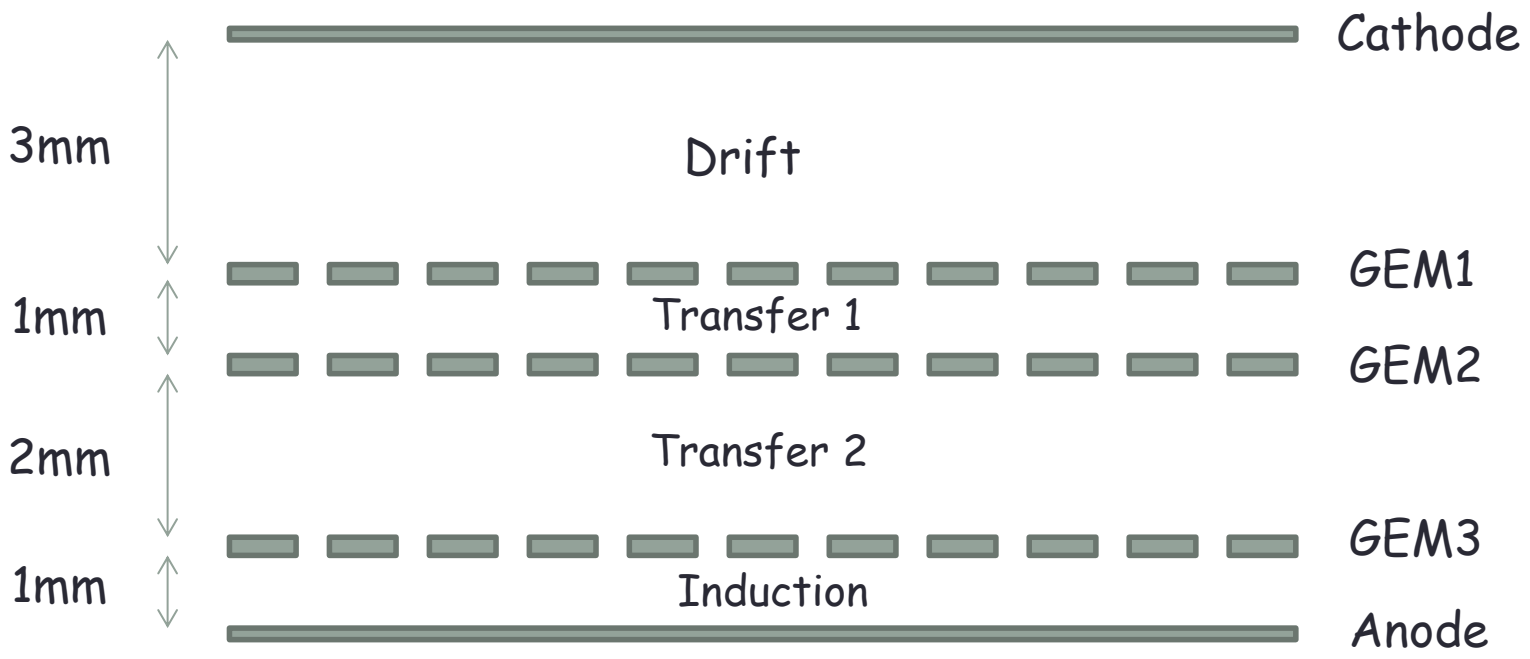
CERN

Triple-GEM



- Triple-GEM assembled in 3:1:2:1 configuration

Effective gain of single and triple GEMs

For a single GEM, effective gain, G_{eff} and electron transparency, T, is defined as: $G_{eff} = G_{intr} \cdot T = G_{intr} \cdot \epsilon^{coll} \cdot f^{extr}$

where

collection efficiency (ϵ^{coll}):

$$\epsilon^{coll} = \frac{electrons\ collected\ in\ the\ holes}{electrons\ produced\ above\ the\ holes}$$

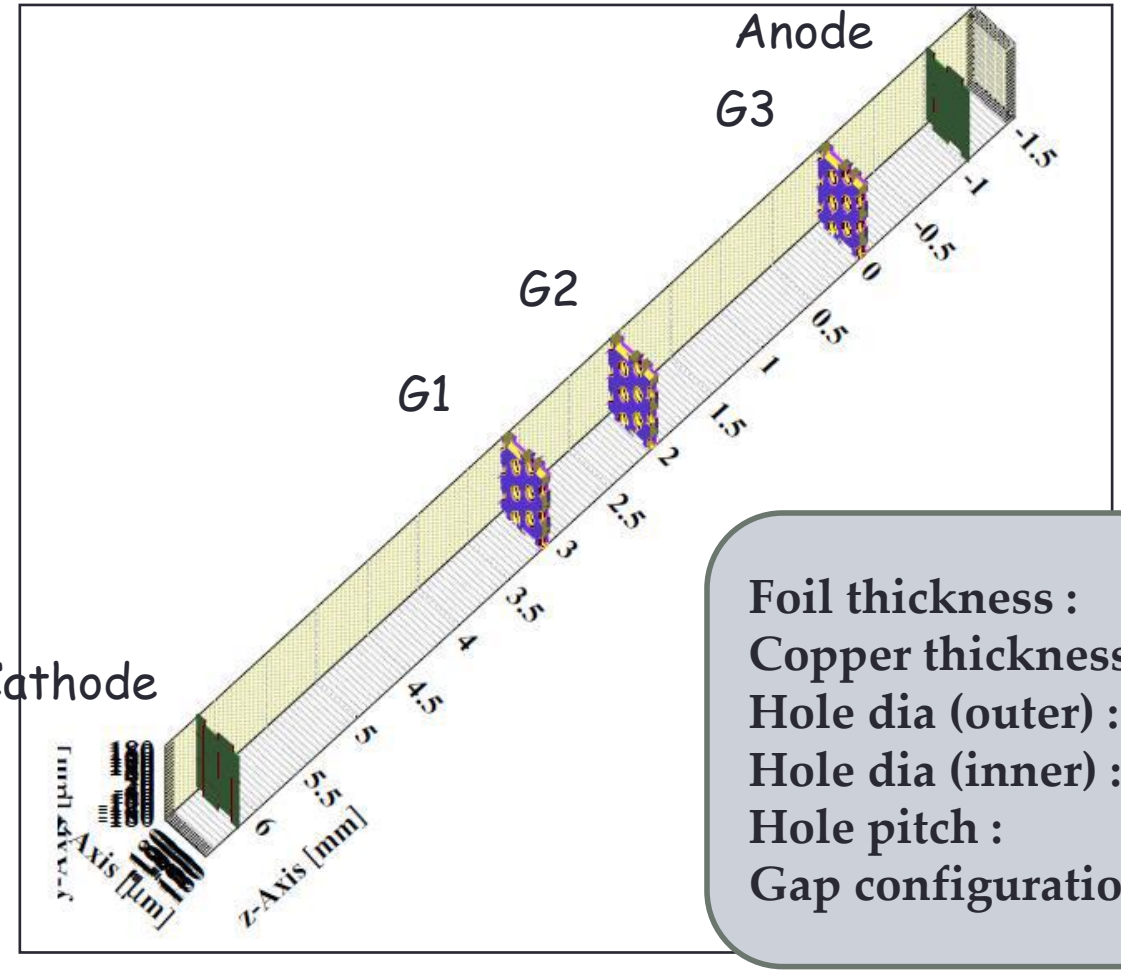
extraction fraction (f^{extr}):

$$f^{extr} = \frac{electrons\ extracted\ from\ the\ holes}{electrons\ produced\ in\ the\ holes}$$

For a triple GEM, effective gain, G_{eff} and total electron transparency, T_{tot} is defined as:

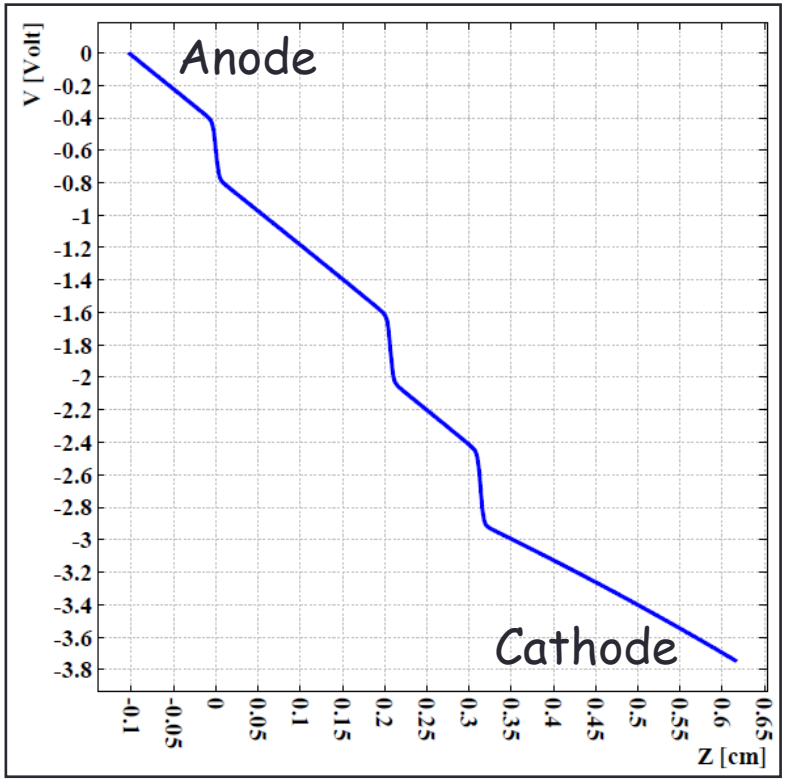
$$G_{eff} = G_{intr} \cdot T_{tot} = \prod_{k=1}^{3} e^{<\alpha>_k \cdot V_{GEMk}} \cdot T_k = e^{<\alpha>^{tot} \cdot V_{GEM}^{tot}} \cdot \prod_{k=1}^{3} \epsilon_k^{coll} \cdot f_k^{extr}$$

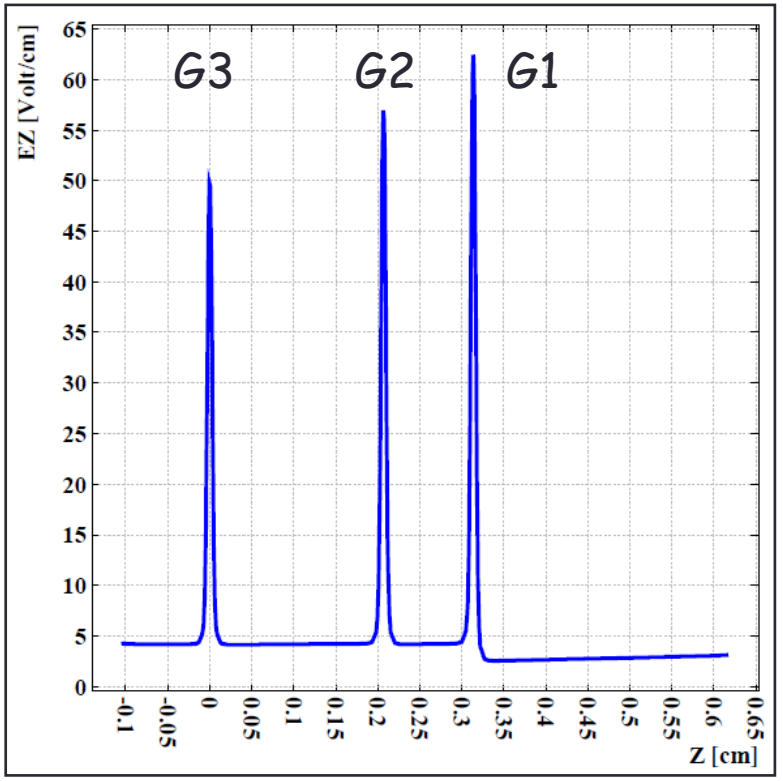
Triple GEM Geometry



Foil thickness :	**50 μm**
Copper thickness :	**9 μm**
Hole dia (outer) :	**70 μm**
Hole dia (inner) :	**50 μm**
Hole pitch :	**140 μm (staggered)**
Gap configuration :	**3:1:2:1 (mm)**

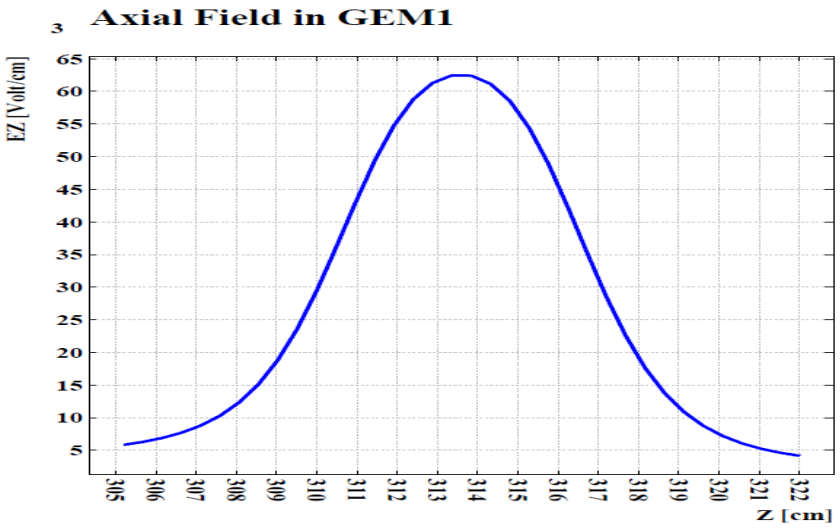
Axial Potential and Field Configuration using neBEM

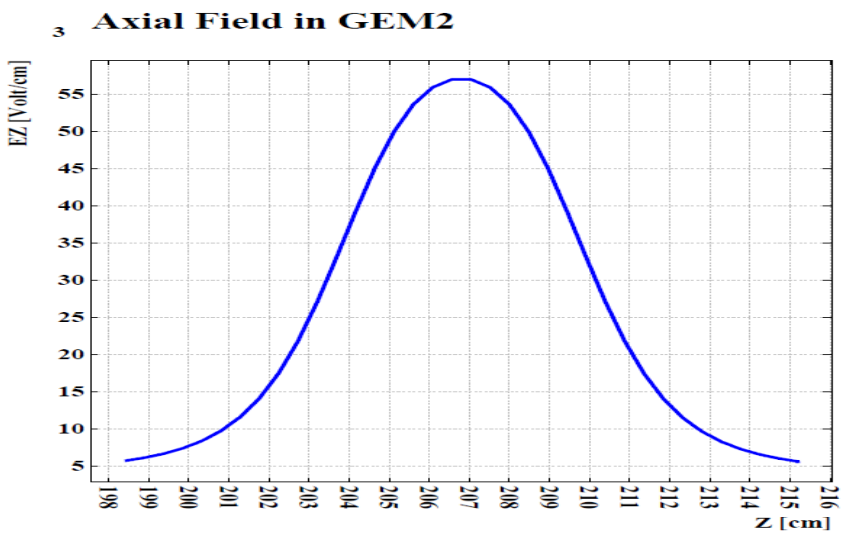


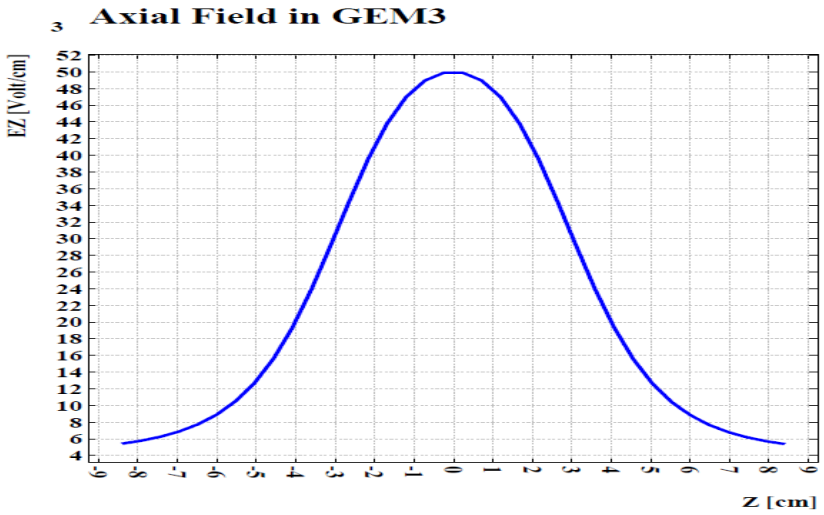


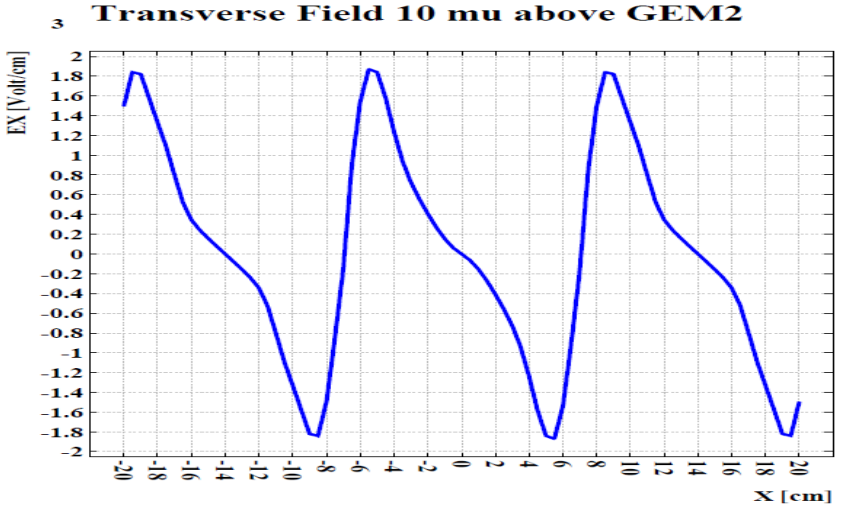
- Calculation at supply of 4.0 kV
- Voltage at drift: 3.75 kV

Field in GEM holes



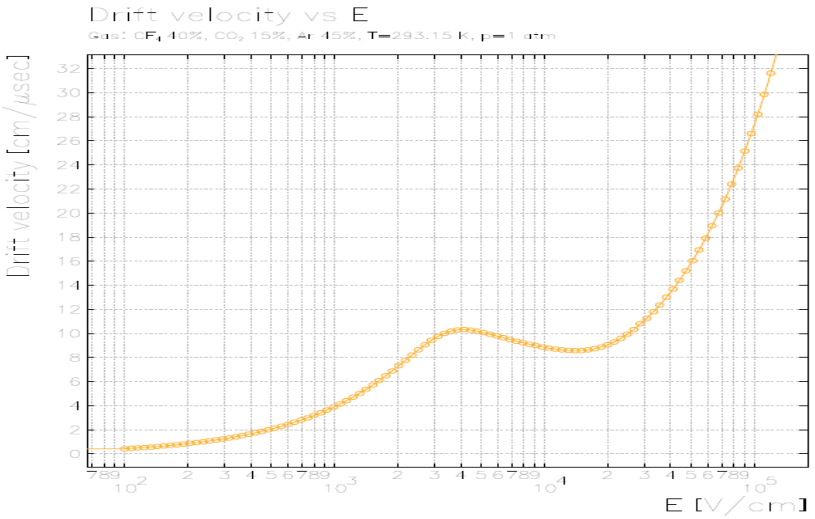


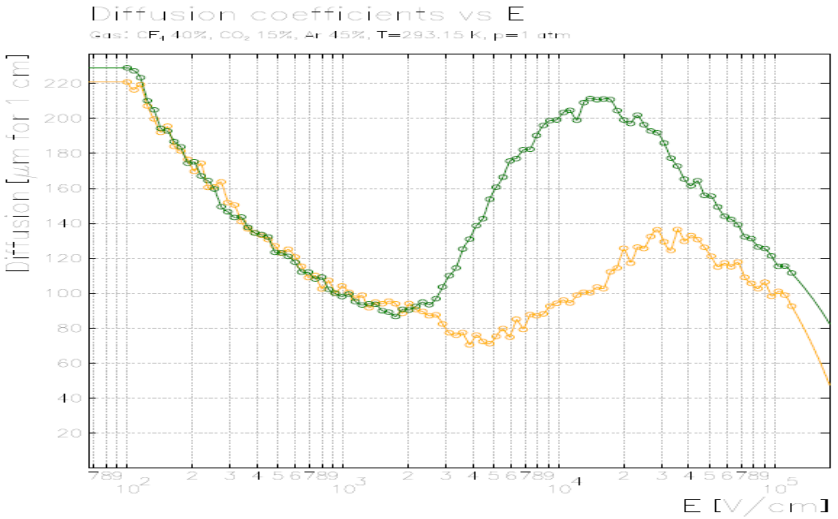


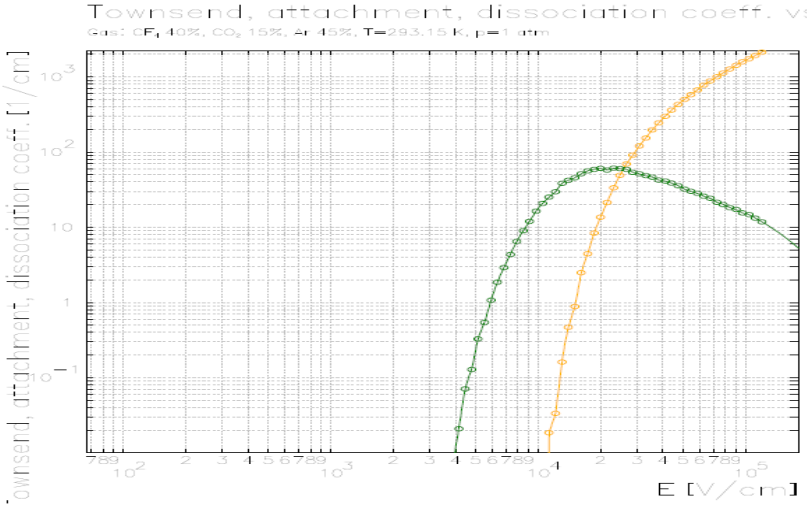


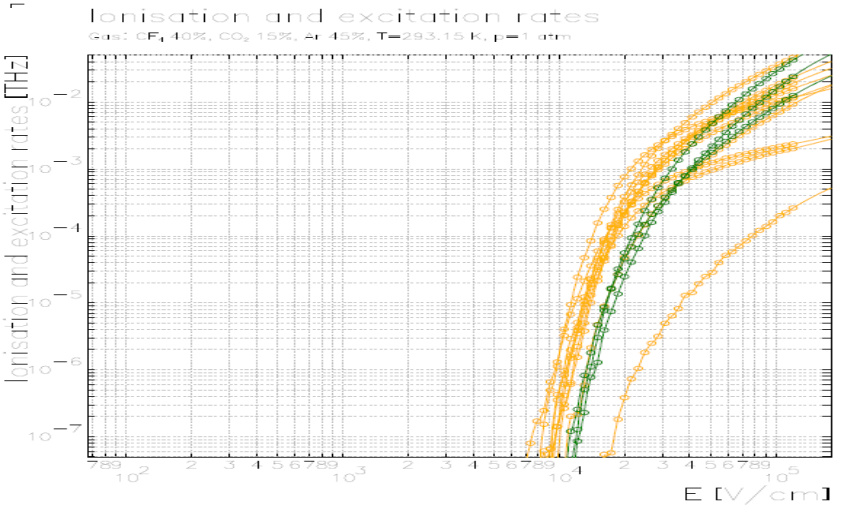
Transport properties

Ar+CO_2+CF_4 (45:15:40)

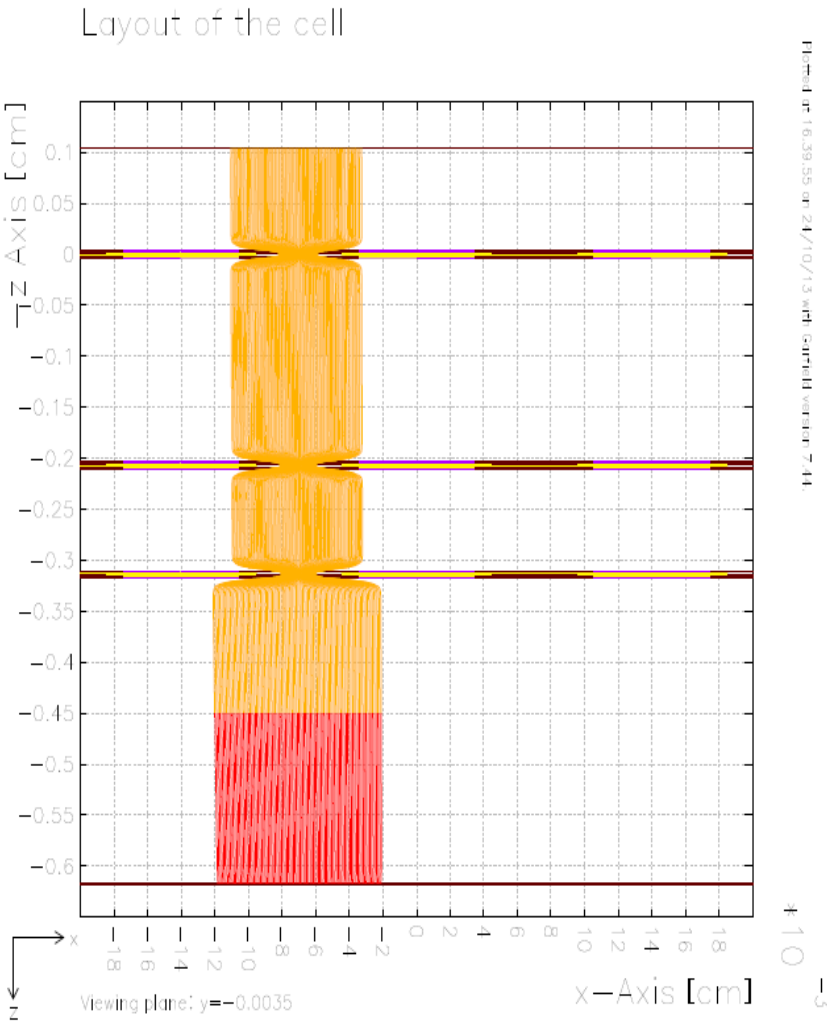


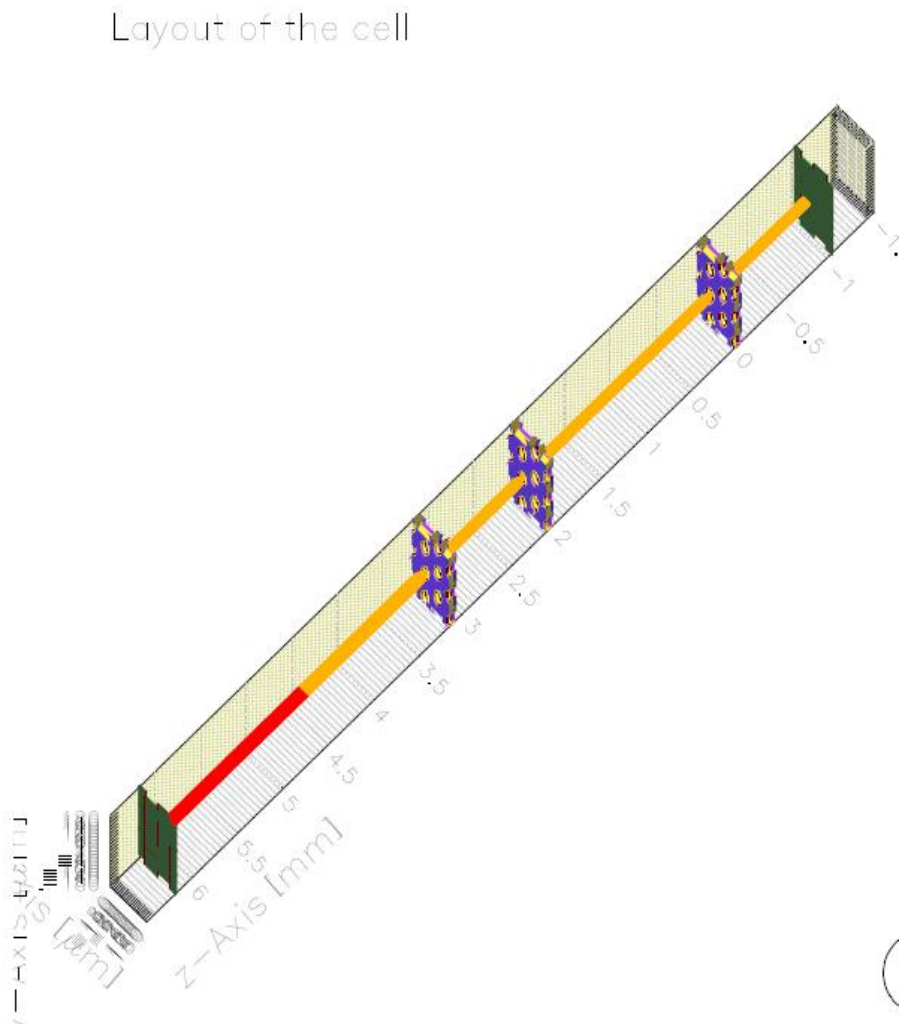




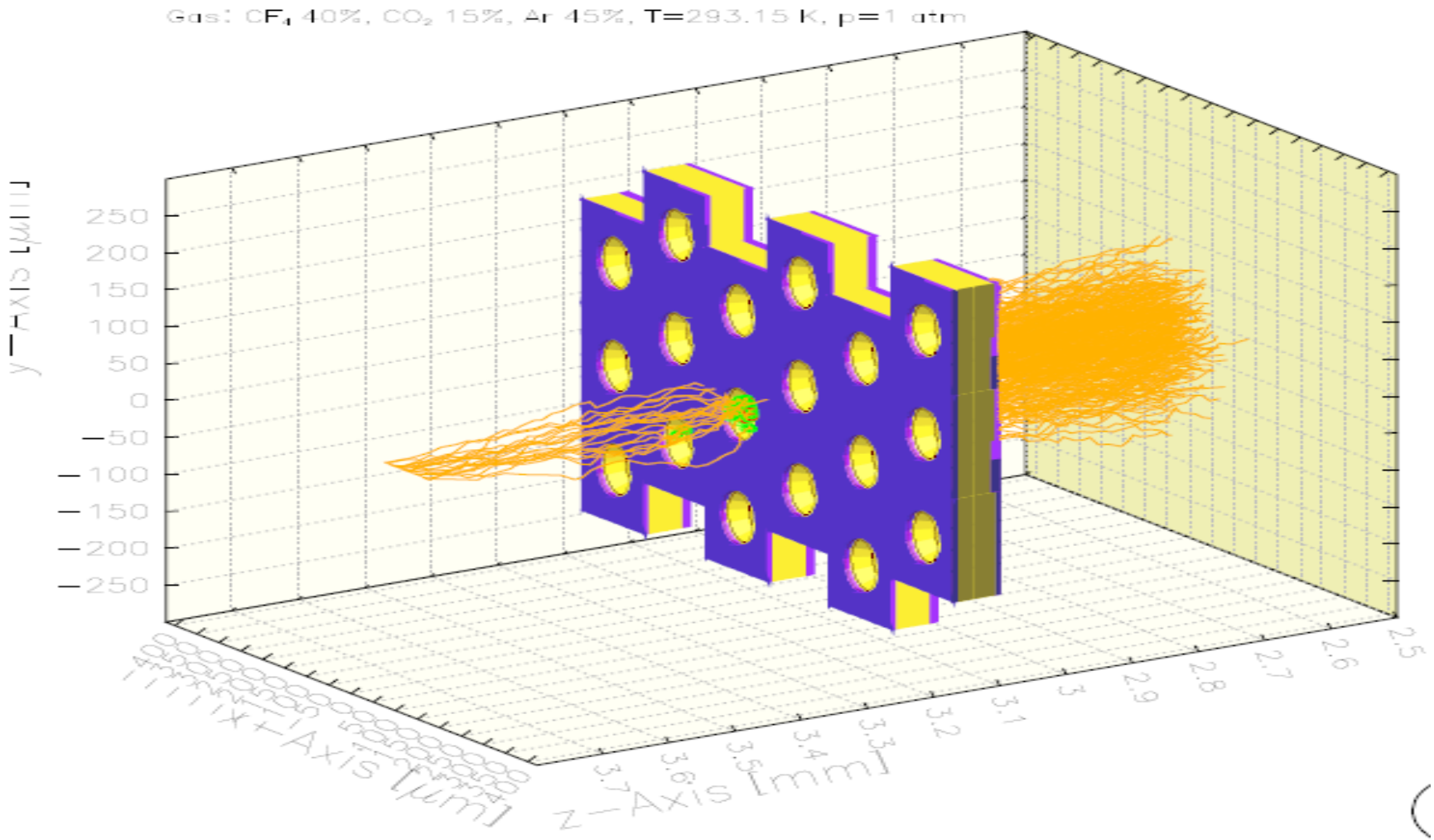


RKF drift: intrinsic gain of triple GEM

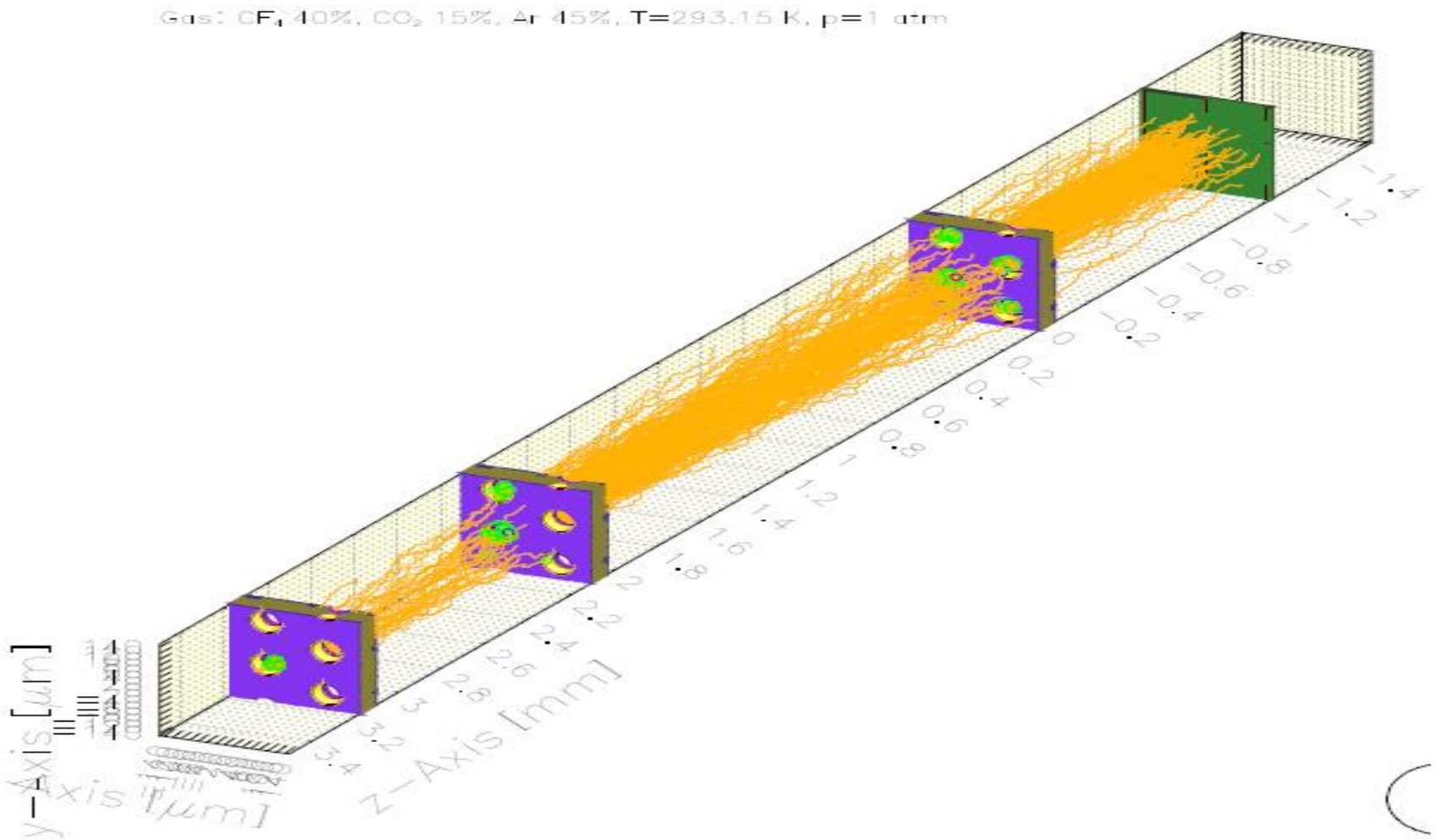




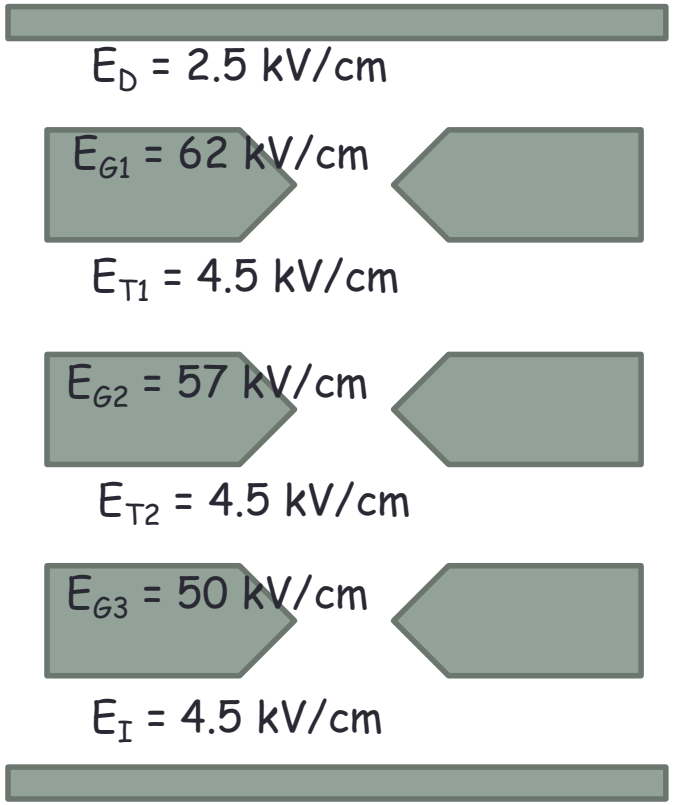
Micro-tracking: estimating efficiencies



Micro-tracking for the entire system



Results for a typical configuration



Experimental setup with $Ar+CO_2$ (70:30)

Cathode (V)	G1 Top (V)	G1 Bot (V)	G2 Top (V)	G2 Bot (V)	G3 Top (V)	G3 Bot (V)	Gain
3920	3210	2840	2100	1767	1036	721	821

Simulation setup for $Ar+CO_2+CF_4$ (45:15:40)

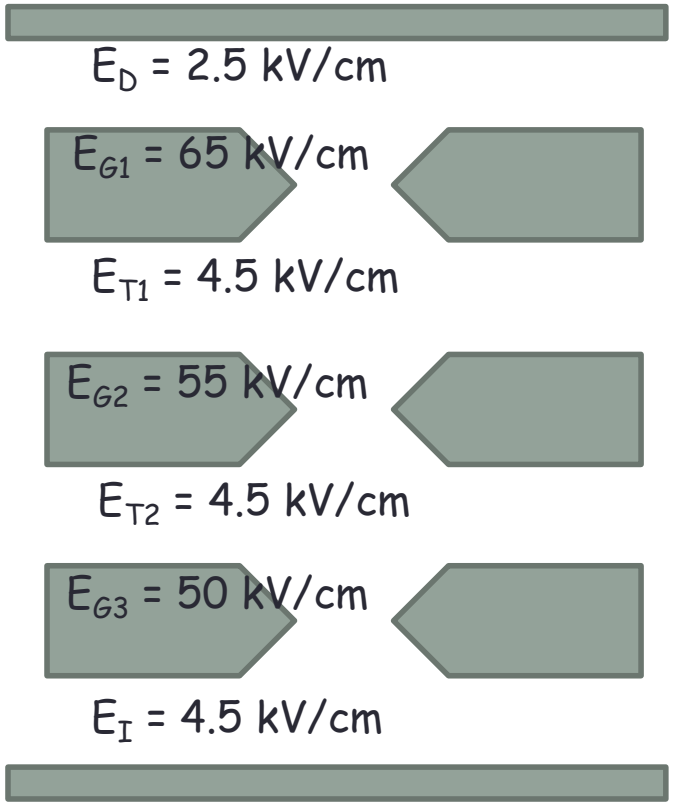
Cathode (V)	G1 Top (V)	G1 Bot (V)	G2 Top (V)	G2 Bot (V)	G3 Top (V)	G3 Bot (V)
3749	2914	2454	2036	1618	783	418

Experimental Voltage-Current Tabulation

HV (V)	I (μA)	Cathode (V)	G1 Top (V)	G1 Bot (V)	G2 Top (V)	G2 Bot (V)	G3 Top (V)	G3 Bot (V)
4750	820	4340	3550	3150	2330	1956	1141	800
4700	811	4290	3510	3110	2300	1933	1134	790
4650	803	4240	3470	3080	2270	1911	1121	781
….	….	….	….	….	….	….	….	….
….	….	….	….	….	….	….	….	….
4350	751	3965	3250	2880	2125	1787	1048	730
4300	742	3920	3210	2840	2100	1767	1036	721

- **Voltages measured at all planes for HV supply 4750-4300 V**
- **Current flow read from HV supply**

Results for a typical configuration



Numerical estimates of efficiencies and gains
Collection efficiency evaluated at Cu-gas interface
Without Penning transfer

ϵ^{coll}_1	f^{extr}_1	ϵ^{coll}_2	f^{extr}_2	ϵ^{coll}_3	f^{extr}_3	G_{intr}	G_{eff}
0.953	0.571	0.967	0.373	0.968	0.733	25000	3500

Numerical estimates of efficiencies and gains
Collection efficiency evaluated at Cu-Kapton interface
Without Penning transfer

ϵ^{coll}_1	f^{extr}_1	ϵ^{coll}_2	f^{extr}_2	ϵ^{coll}_3	f^{extr}_3	G_{intr}	G_{eff}
0.651	0.411	0.486	0.417	0.428	0.411	21000	200

Numerical estimates of efficiencies and gains
Collection efficiency evaluated at Cu-Kapton interface
With 50% Penning transfer

ϵ^{coll}_1	f^{extr}_1	ϵ^{coll}_2	f^{extr}_2	ϵ^{coll}_3	f^{extr}_3	G_{intr}	G_{eff}
0.651	0.411	0.486	0.417	0.428	0.411	53000	505

Remarks

- The triple-GEM configuration has been analyzed as an integrated system.
- A T7500 DELL workstation has been used. No parallelization has been attempted, although each of the steps can be parallelized very efficiently.
- Field computation within the fast volume (241800 points) takes around ten days.
- Estimation of intrinsic gain using RKF for 10,000 electrons takes a day. Time taken does not change if Penning is included.
- Collection and extraction efficiencies have been computed using Micro-tracking. Computations have been carried out in stages, as well as, in the integrated mode.
- Transparency has been estimated from the above efficiencies. It has also been computed in the integrated mode.
- Microscopic tracking for 10,000 events takes three days.

Remarks

- Results for different gas mixture, e.g., Ar+CO_2, can be easily estimated now for this geometry and voltage configuration.
- Field computations for other voltage configurations are close to completion for the same geometry. Voltages at drift considered are: 1875V, 2812V, 4687V.
- Field computations for other geometries are yet to begin.
- The approach is still being optimized. Lot of issues to be fine-tuned.

THANK YOU!