Optimization of gas mixtures for the Micromegas-based central tracker of the SPD experiment

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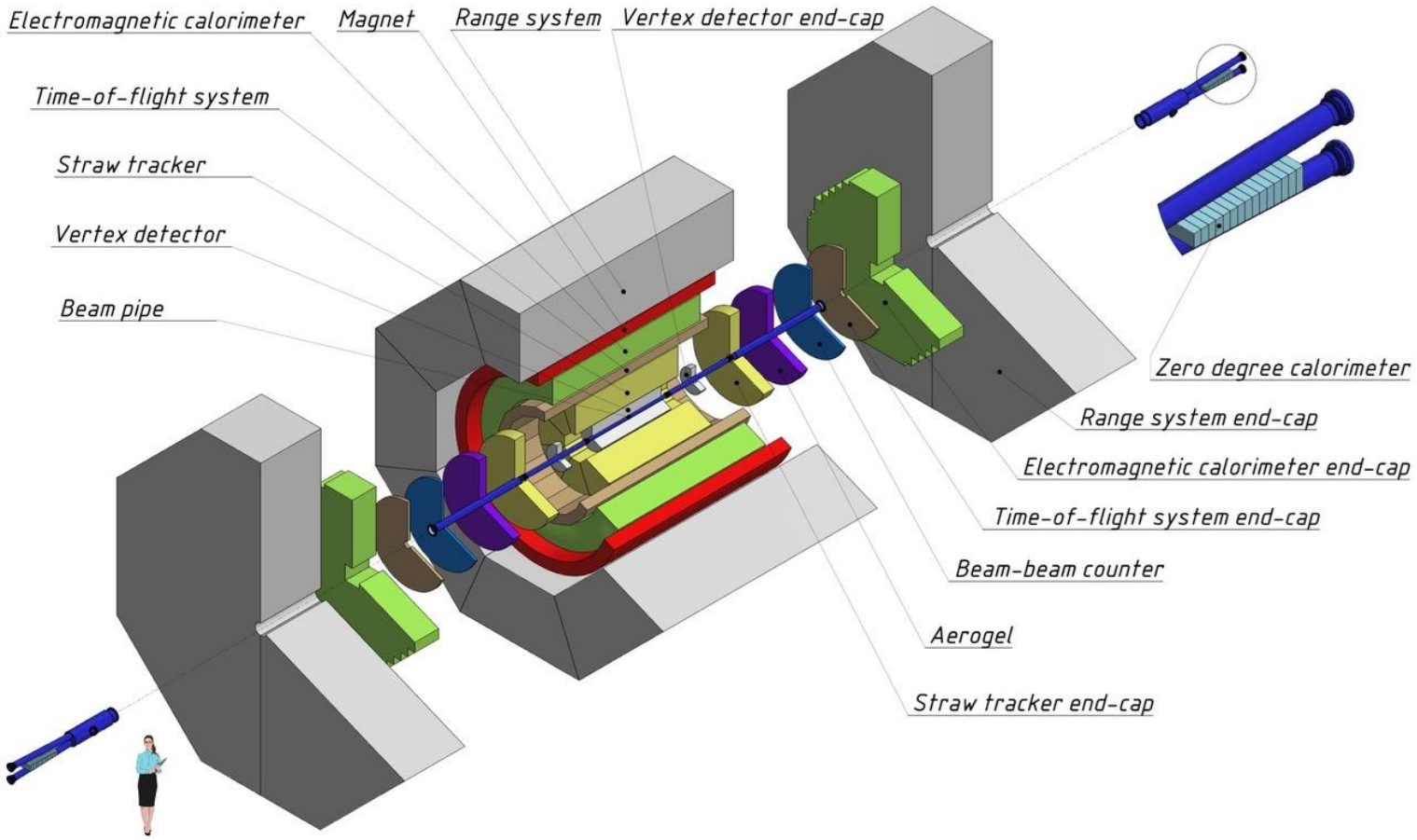
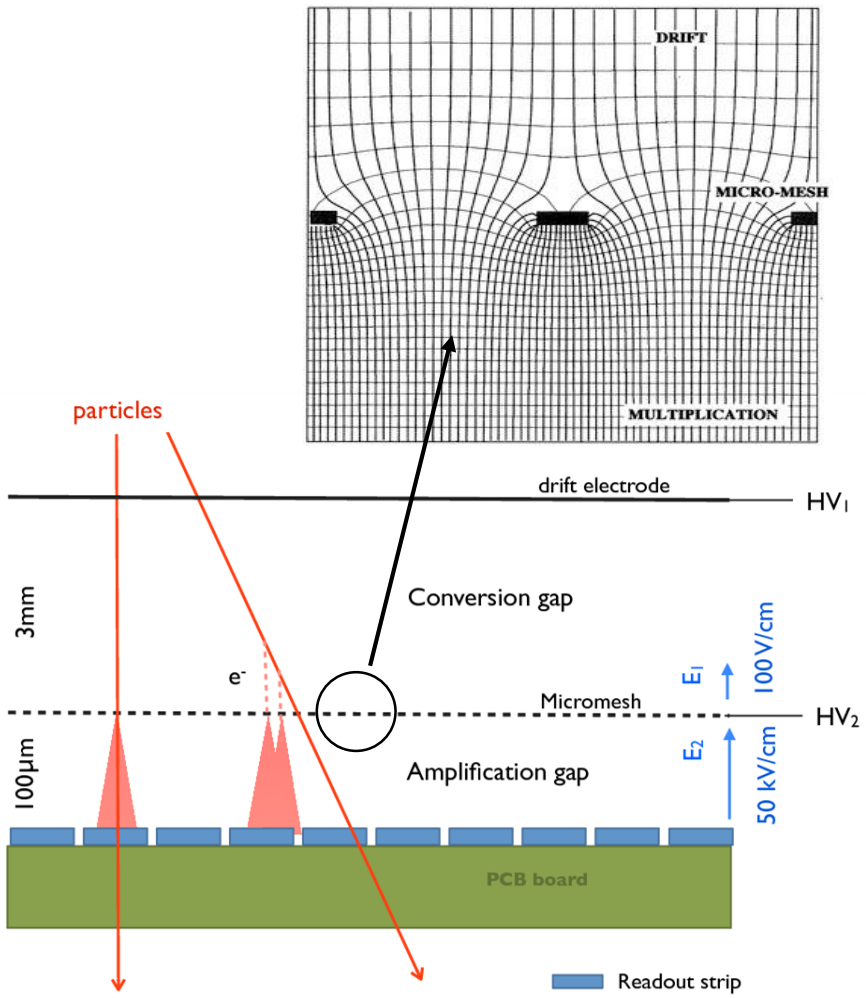
Spin Physics Detector(SPD)



The SPD facility is designed as a versatile 4π-detector including tracking, calorimeter, muon and particle identification systems.

The Micromegas Central Tracker (MCT) will be used for the first years of data collection and will be replaced by the Silicon Vertex Detector.

Micromegas



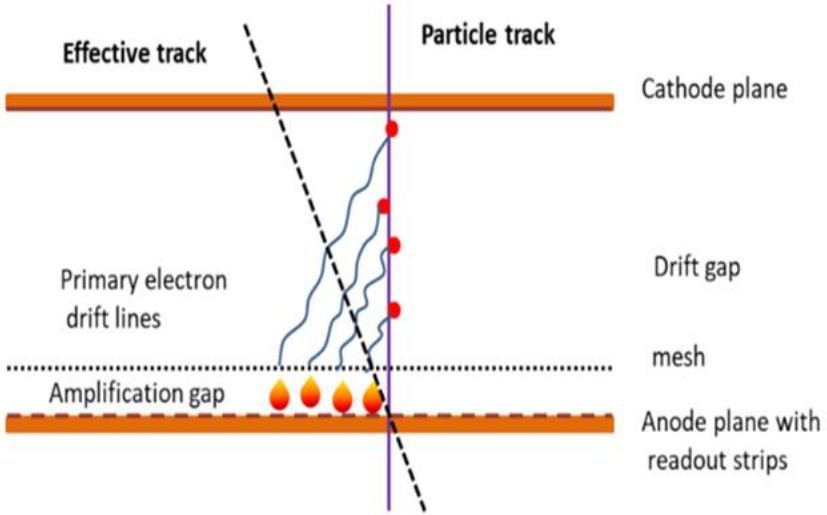
Micromegas (Micro Mesh Gaseous Structure) is a flat counter with ionization and amplification gaps separated by a thin grid.

- Ionization gap: 3-5 mm
- Amplification gap: ~120 micron

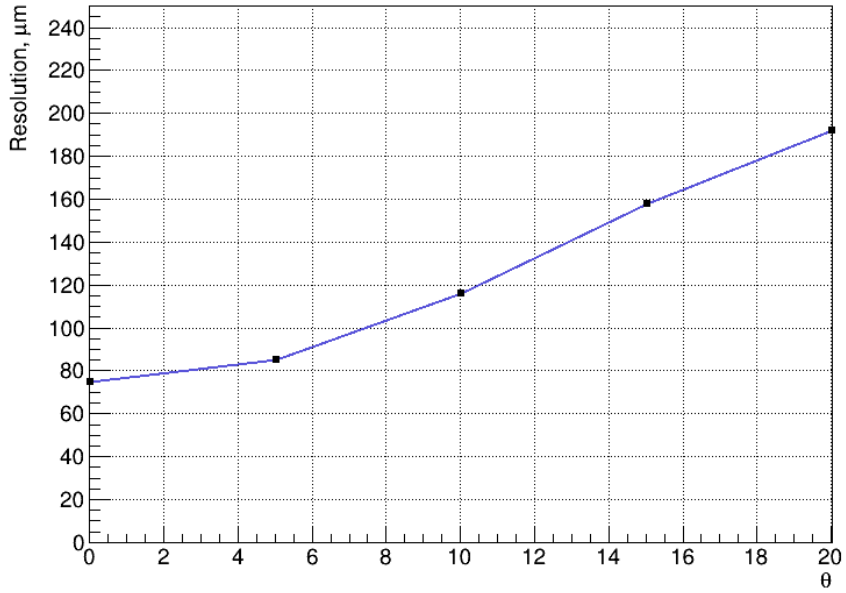
- Gas gain: ~10^4
- Mesh transparency for primary electrons: ~ 100% at optimum drift field
- Segmented anode as a narrow strip

- Coordinate reconstruction: $x_c = \frac{\sum x_i q_i}{\sum q_i}$
- Resolution is ~100 micron

Micromegas in SPD



- In a magnetic field, electrons drift at an angle to the direction of the electric field strength.
- In terms of detector response, the track is “effectively inclined”.
- In the field B = 1T, the Lorentz angle for standard mixtures at the optimum drift voltage exceeds 40^{o} .

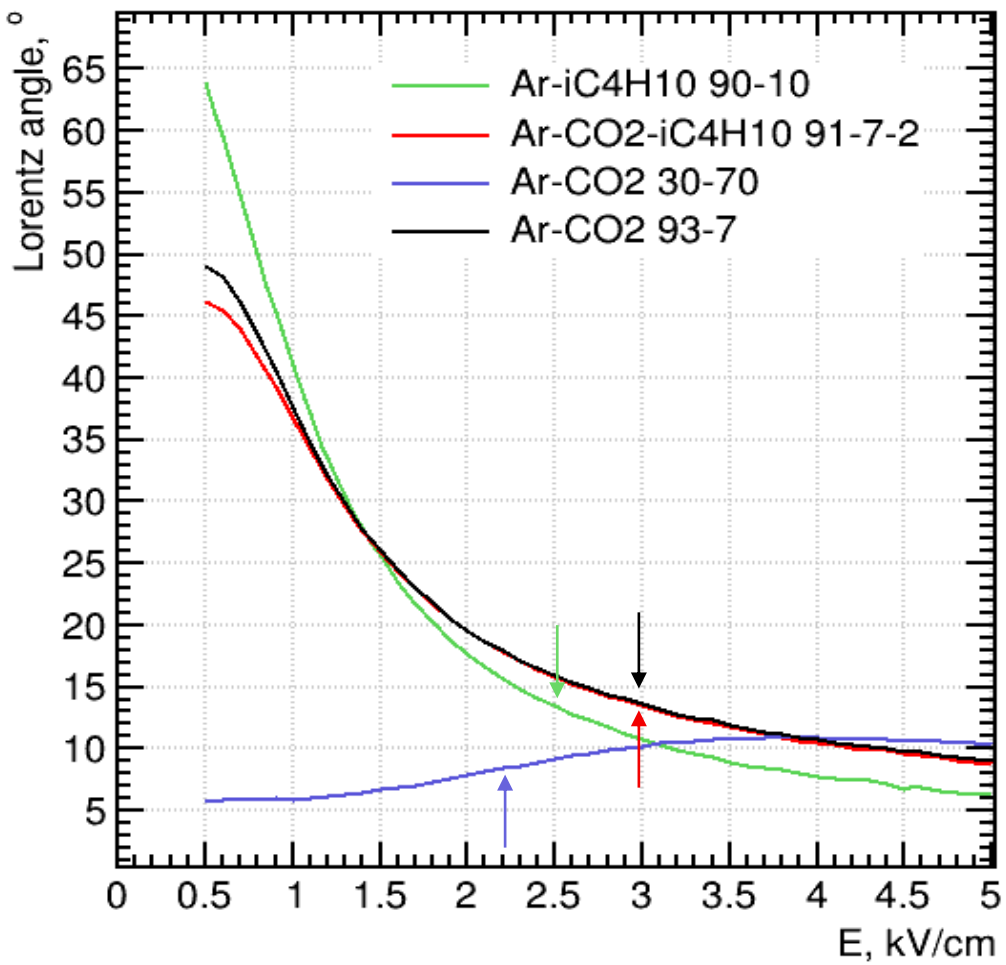


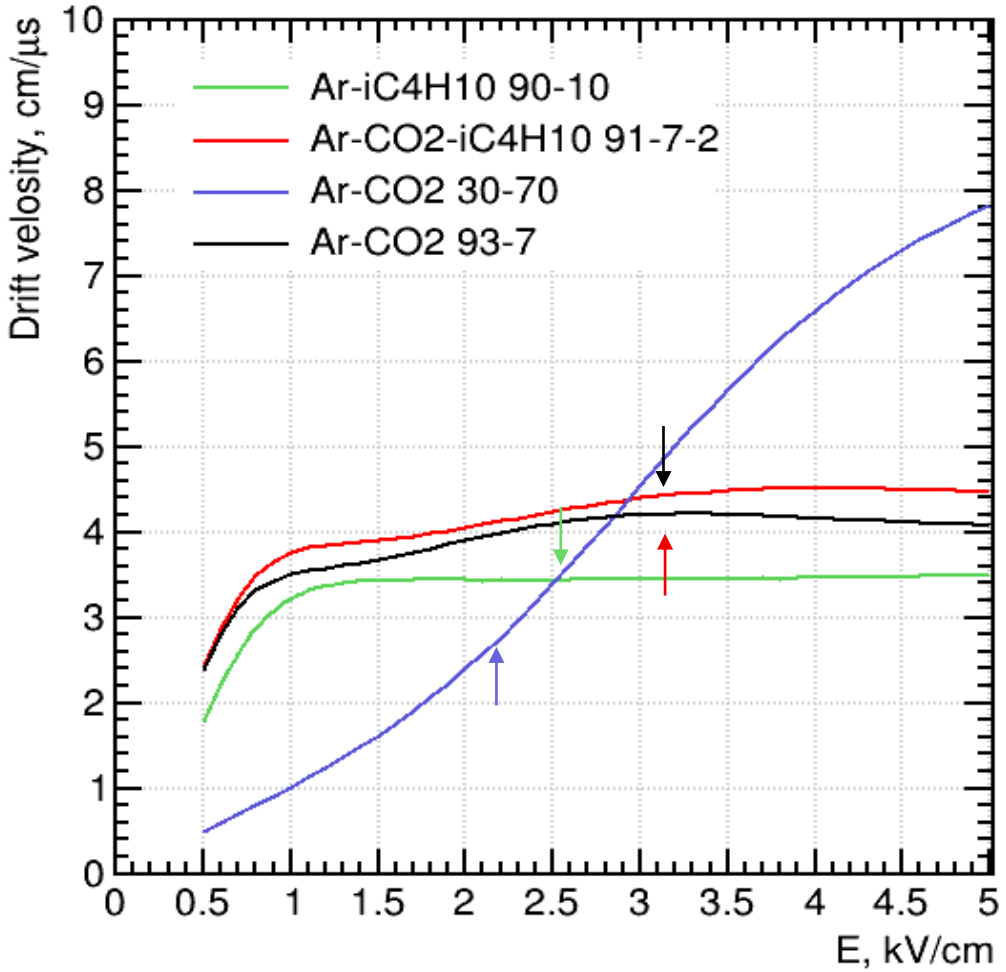
As the angle increases, our accuracy decreases. So choose a combination of working gas and drift field with a sufficiently small Lorentz angle.

Detector and gas mixture requirements

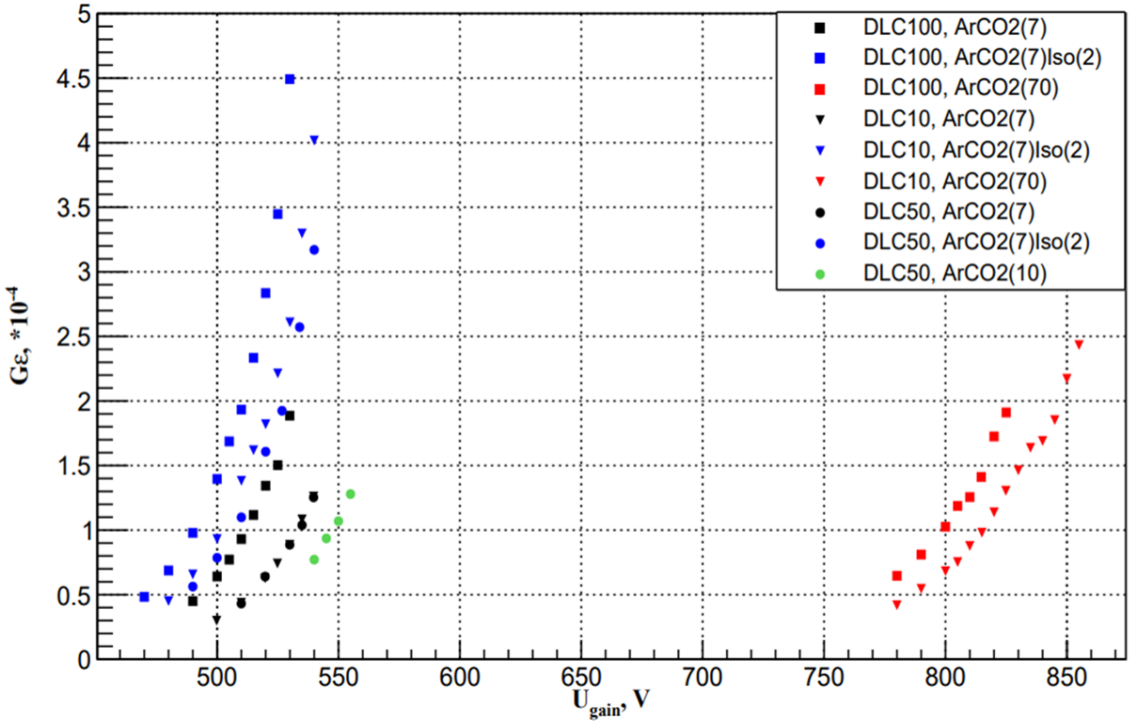
1. Trigger less data acquisition system => high threshold is required	Stable operation with a sufficiently high gain, and high primary ionization, minimum Lorentz angle
2. Coordinate accuracy 150 µm	Lorentz angle not more than 10-15 degrees
3. Maximum drift time less than 100 ns	Electron drift velocity not less than 3 cm/µs

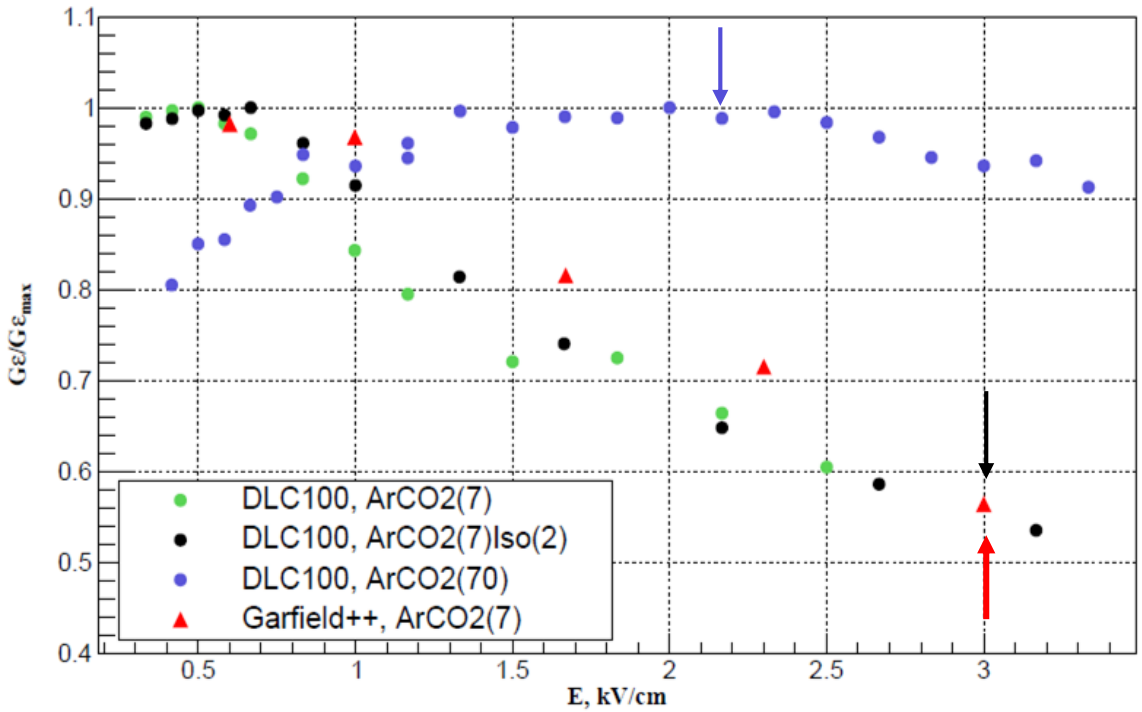
Gas mixture simulation





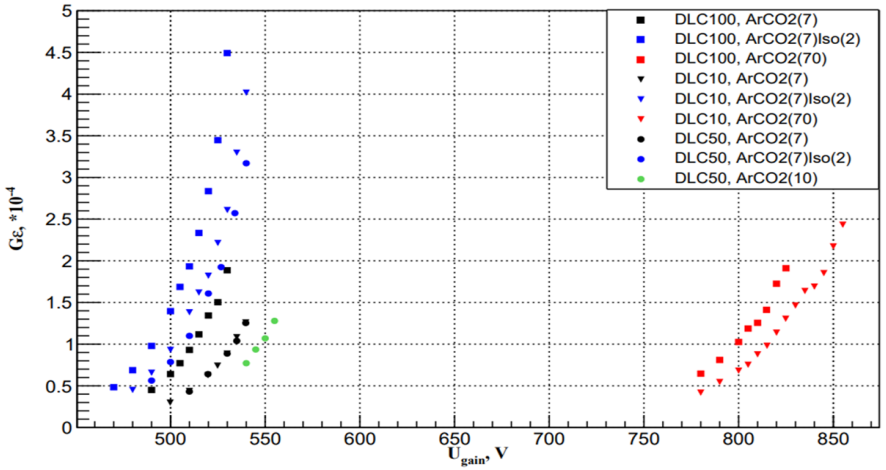
Gas gain and charge collection efficiency

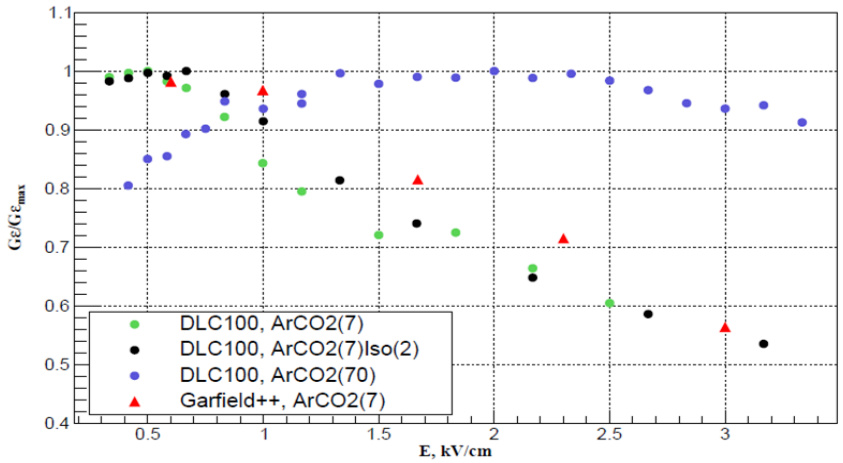




- Three prototype Micromegas with different DLC coating resistances
- When the voltage reaches 3 kV/cm, we lose almost 40% of the charges
- The modeling was done with a realistic mesh

Gas gain and charge collection efficiency

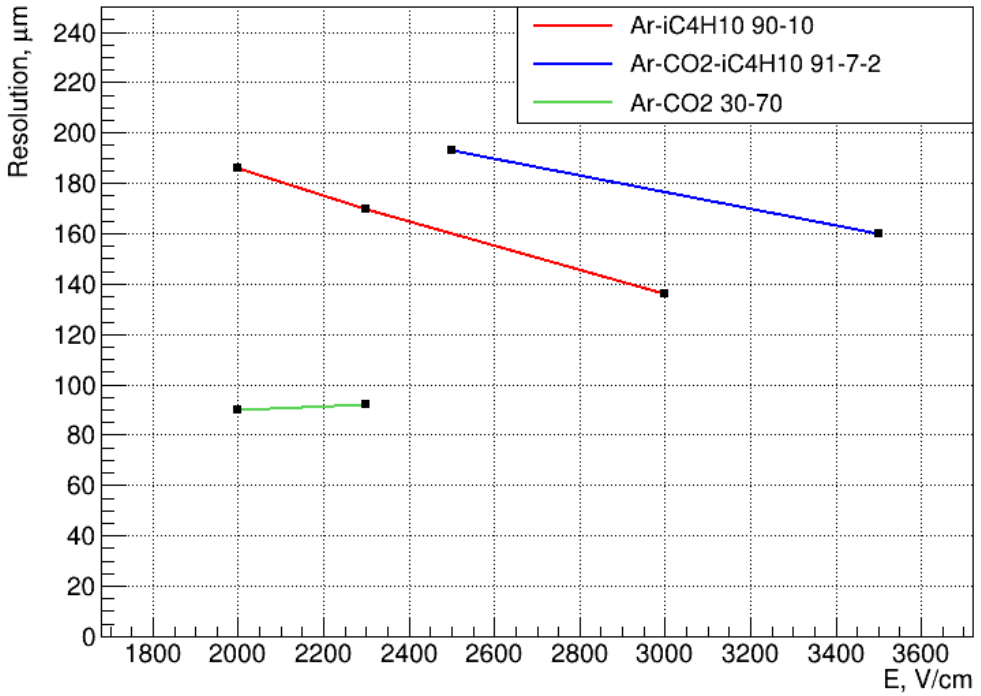


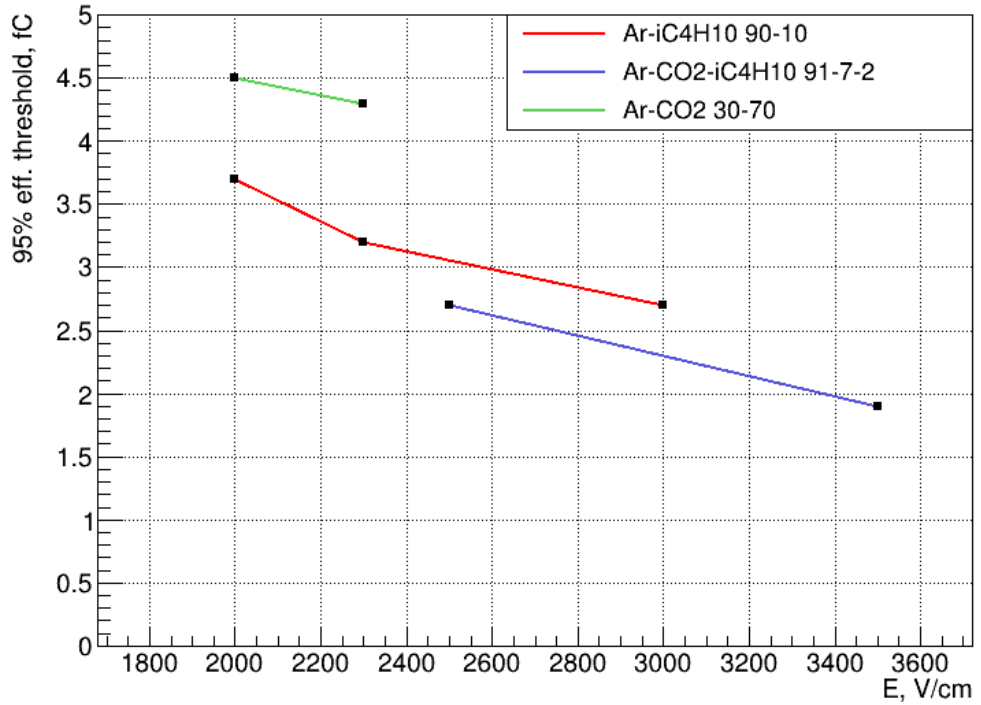


Gas mixture	Max. gain, $x10^4$	E_{drift}, kV/cm	Charge collection efficiency, Garfield++	N_{cl}	Lorentz angle
Ar-CO_2 (93-7)	1,5	3	0,57	7,71	13
Ar-CO_2 (30-70)	1,6	2,2	0,95	9,6	8
Ar-CO_2-iC_4H_{10} (91-7-2)	3,5	3	0,63	8,1	13
Ar-iC_4H_{10} (90-10)	3	2,5	0,8	9,45	13

Detector performance

- Full modelling was carried out for 4 mixtures: Ar-C4H10(10%), Ar-CO2(7%)-iC4H10(2%), Ar-CO2(70%), Ar-CO2(7%).
- Gas gain was normalized to real data with a coefficient of 0.5





Conclusion

1. Testing of gas mixtures for operation in a magnetic field.

2. A realistic model of the detector was created using the GARFIELD package. The performance of the detector was simulated, taking into account the experimental data.