Garfield++ simulation of the Micromegas detector

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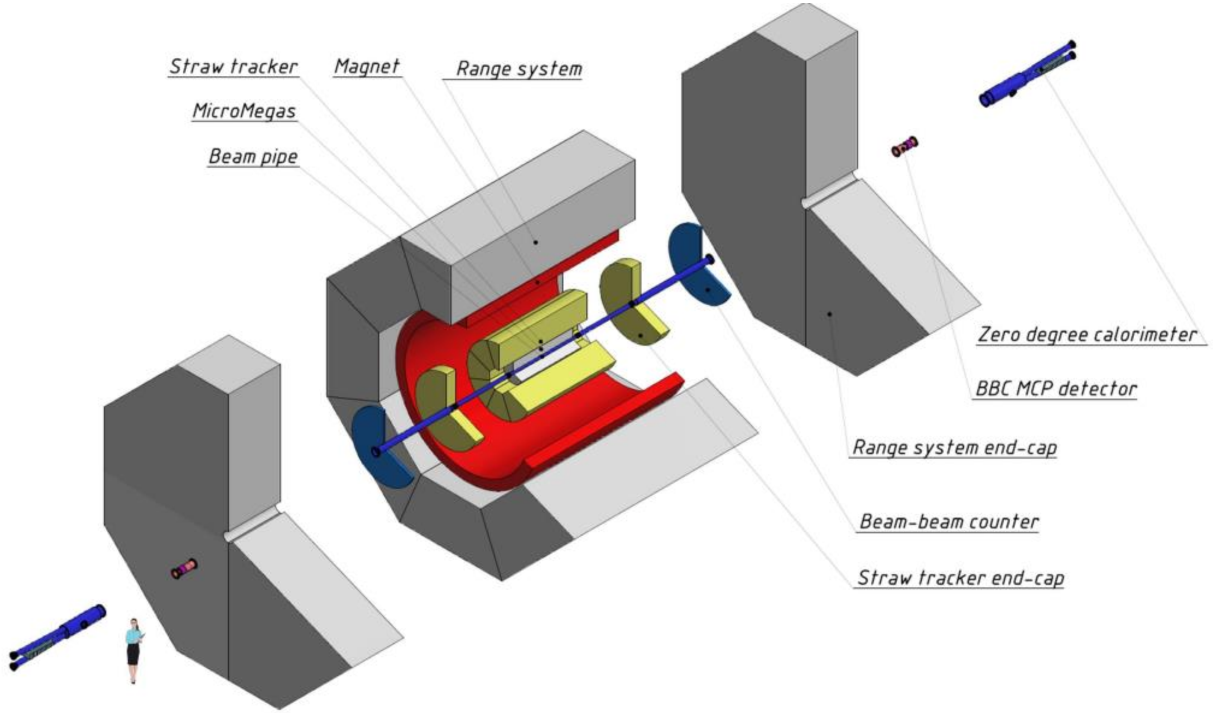
Spin Physics Detector (SPD)

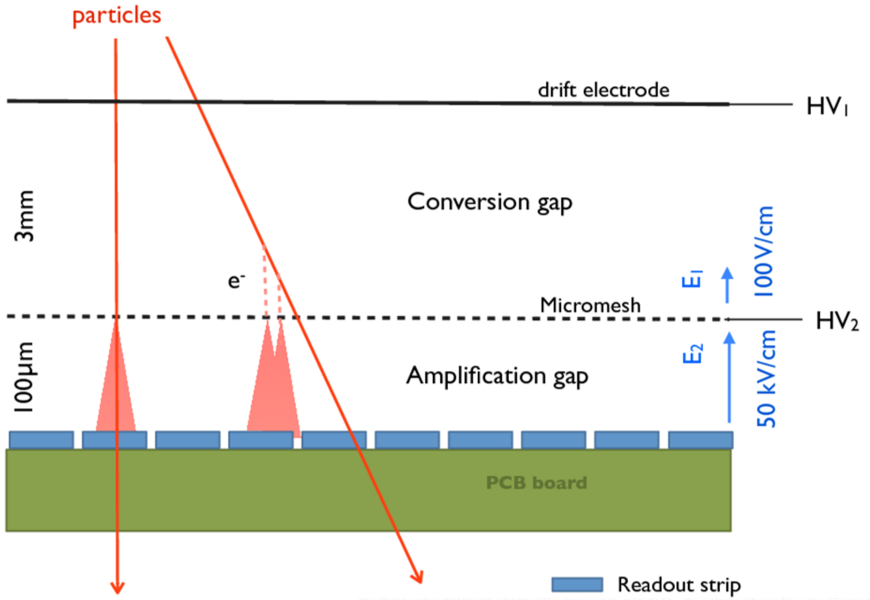
The SPD facility is designed as a versatile 4π-detector including tracking, calorimeter, muon and particle identification systems.

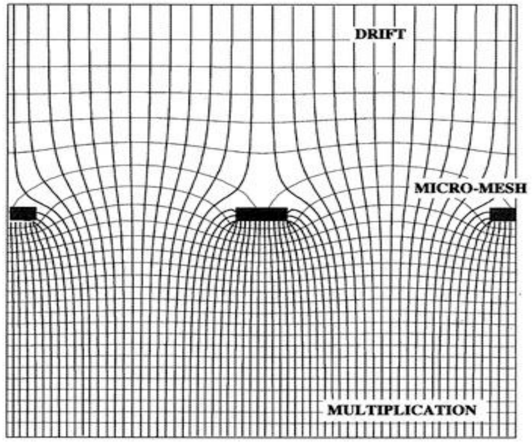
The Micromegas Central Tracker (MCT) is planned to be used for the first few years of data collection and will be replaced later by Silicon Vertex Detector.



The general scheme of the SPD installation at the first stage

Micromegas (Micro Mesh Gaseous Structure)





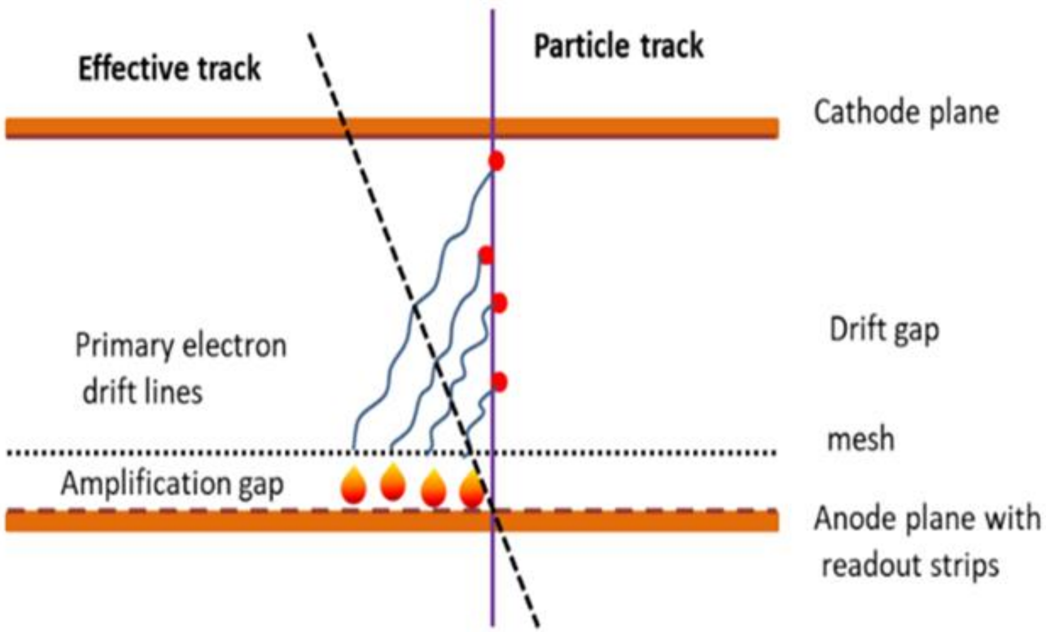
Micromegas is a flat counter with ionization and amplification gaps separated by a thin grid.

- Gas gain: ~10^4
- Mesh transparency for primary electrons: ~ 100% at optimum drift field

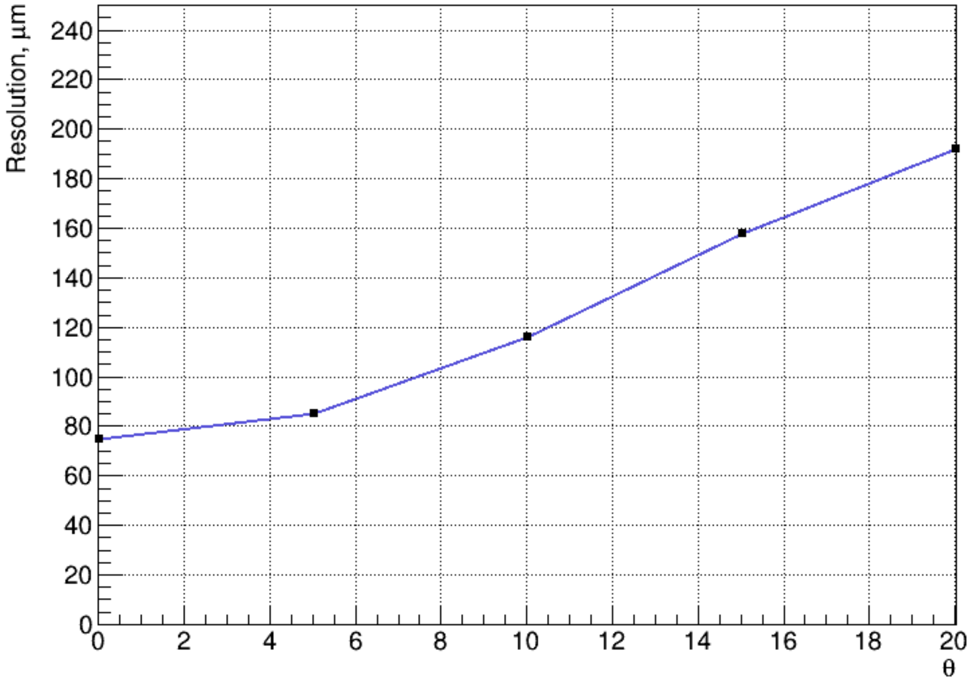
- Segmented anode
- Coordinate reconstruction: $x_c = \frac{\sum x_i q_i}{\sum q_i}$
- Resolution is ~100 micron

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”.



Micromegas operation in the magnetic field



Resolution vs track angle (GARFIELD simulation)

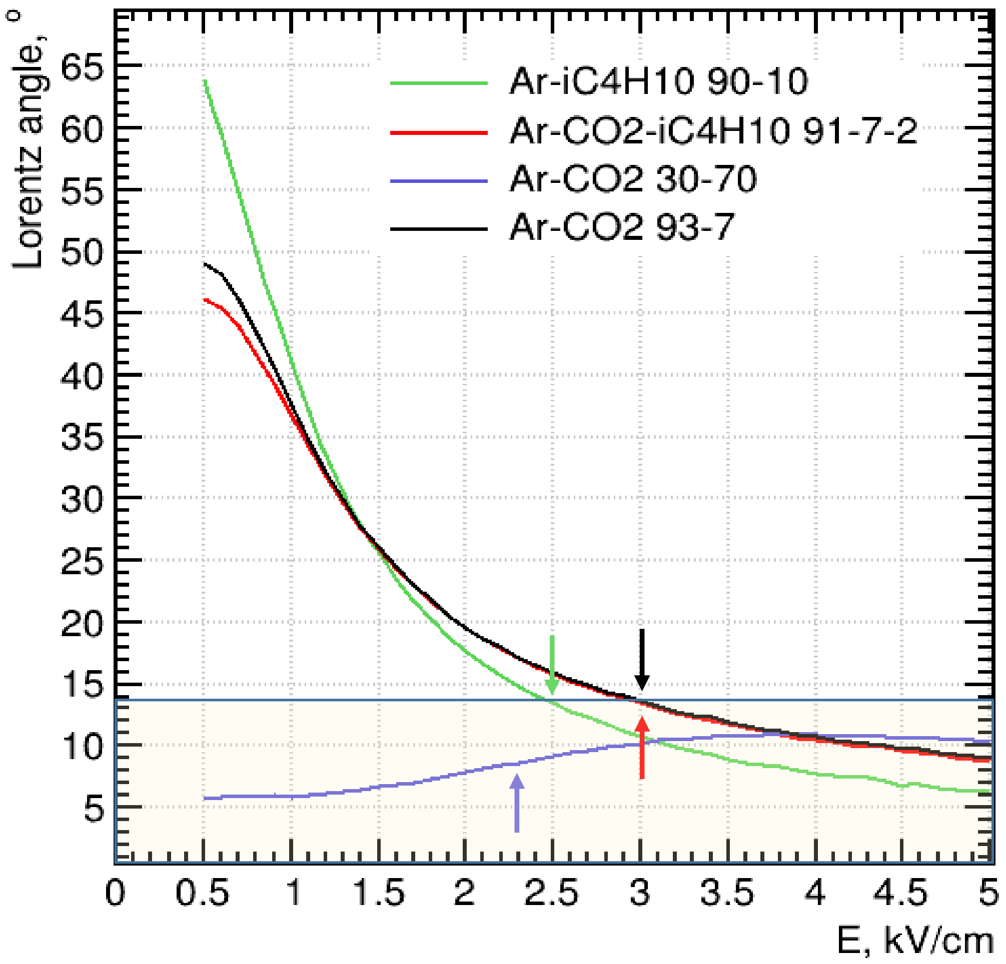
Detector and gas mixture requirements

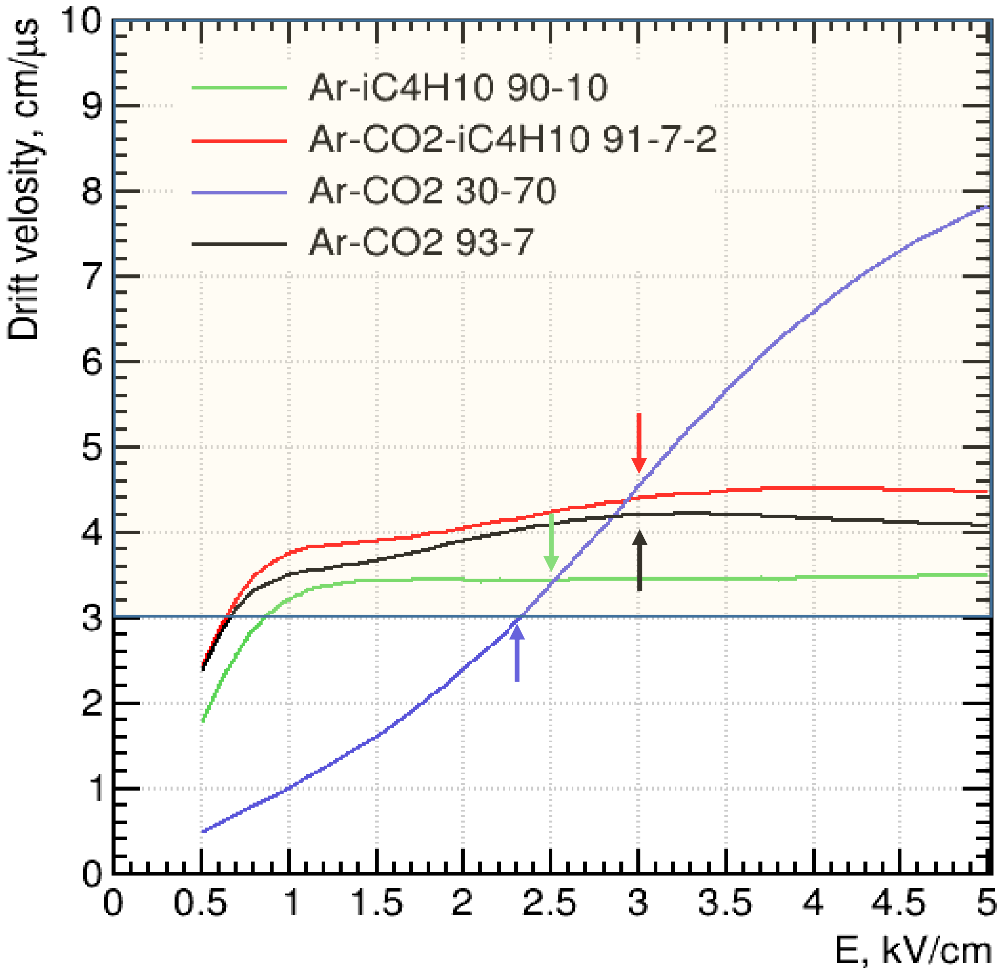
1. Trigger less data acquisition system => high threshold is required
   - Stable operation with sufficiently high gain, and high primary ionization, minimum Lorentz angle

2. Coordinate accuracy 150 μm
   - Lorentz angle below 14 degrees

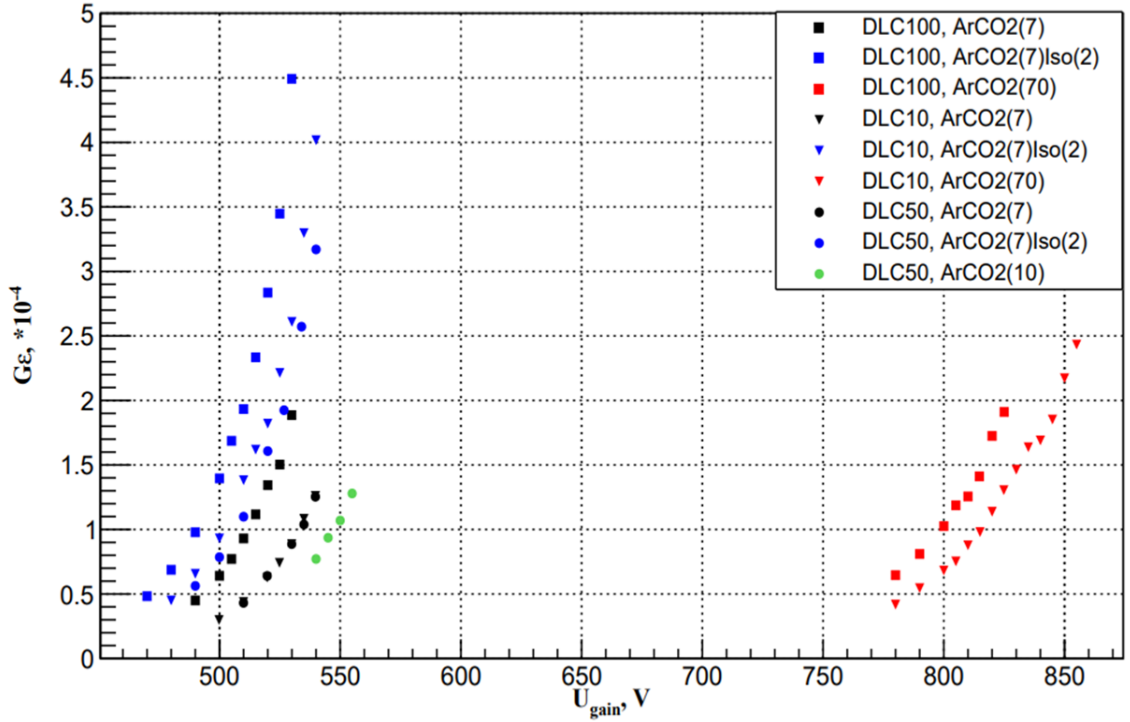
3. Maximum drift time less than 100 ns
   - Electron drift velocity not less than 3 cm/μs

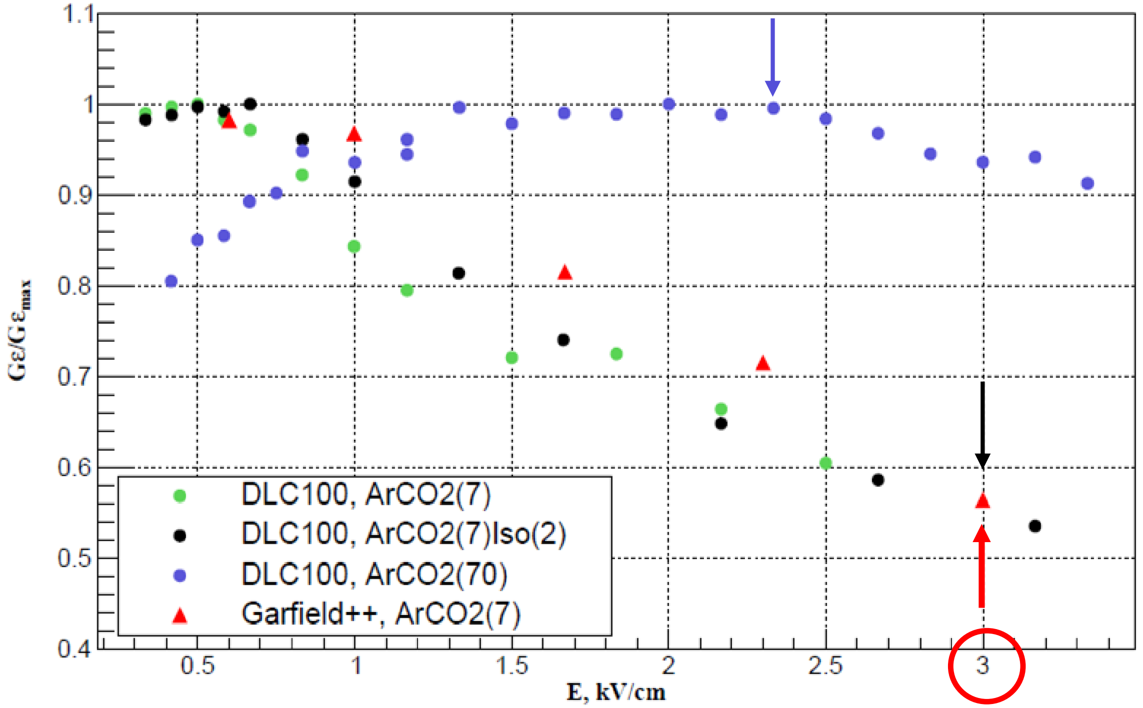
Gas mixture parameters (simulation)



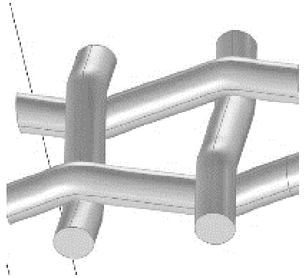


Gas gain and charge collection efficiency

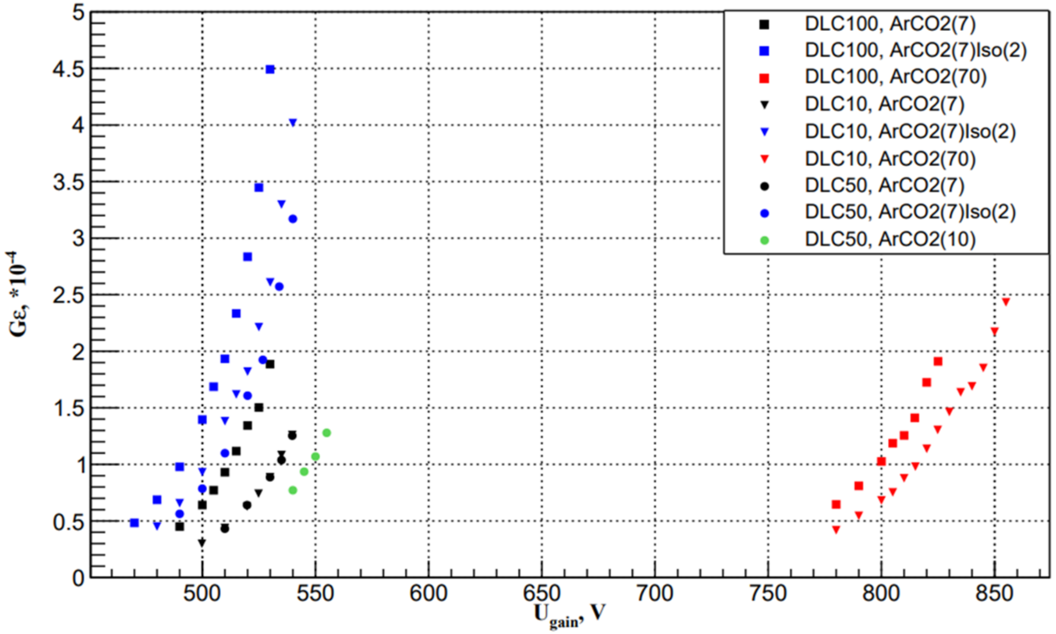


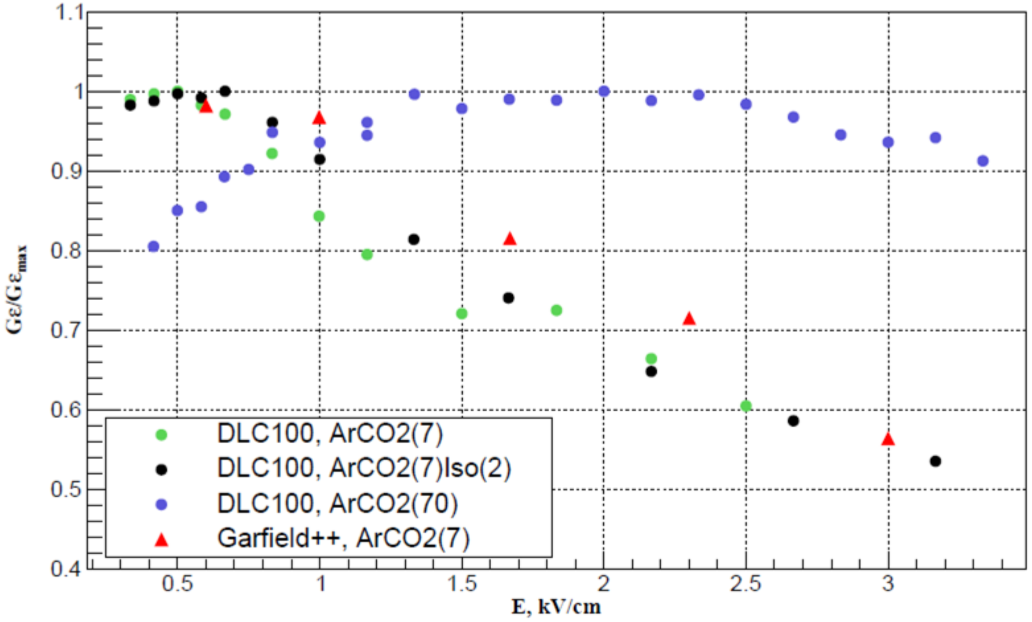


- Three prototype Micromegas with different resistance of DLC coating.
- When the voltage reaches 3 kV/cm, we lose almost 40% of the charges.
- The modelling was carried out with a realistic mesh.



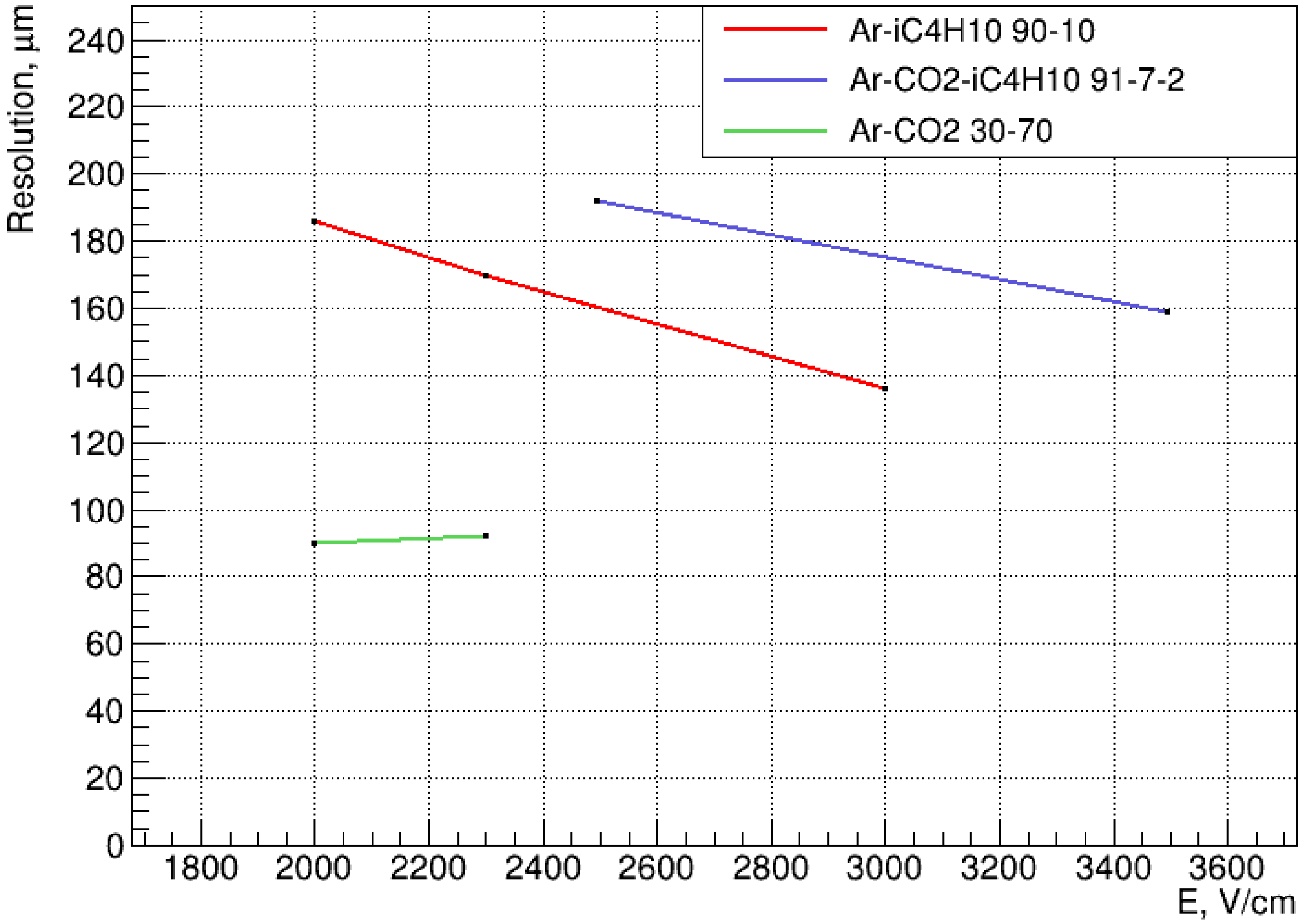
Gas gain and charge collection efficiency





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	2,3	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 3 mixtures:

- Ar-C_4H_{10}(10%),
- Ar-CO_2(7%)-iC4H10(2%),
- Ar-CO_2(70%).

Conclusion

- A realistic description of the detector in the GARFIELD package was created and a simulation of the detector response was carried out taking into account the experimental data

- We have selected 2 candidates that provide stable operation in the SPD environment:
  1. Ar-CO_2 (30-70) is a new gas mixture. According to the simulation results, it provides the best performance in the magnetic field
  2. Ar-iC_4H_{10} (90-10) is a well-tested backup solution used by the CLAS12 experiment

Thanks for your attention!