OPTIMIZATION OF GAS MIXTURES FOR THE MICROMEGAS-BASED CENTRAL TRACKER OF THE SPD EXPERIMENT

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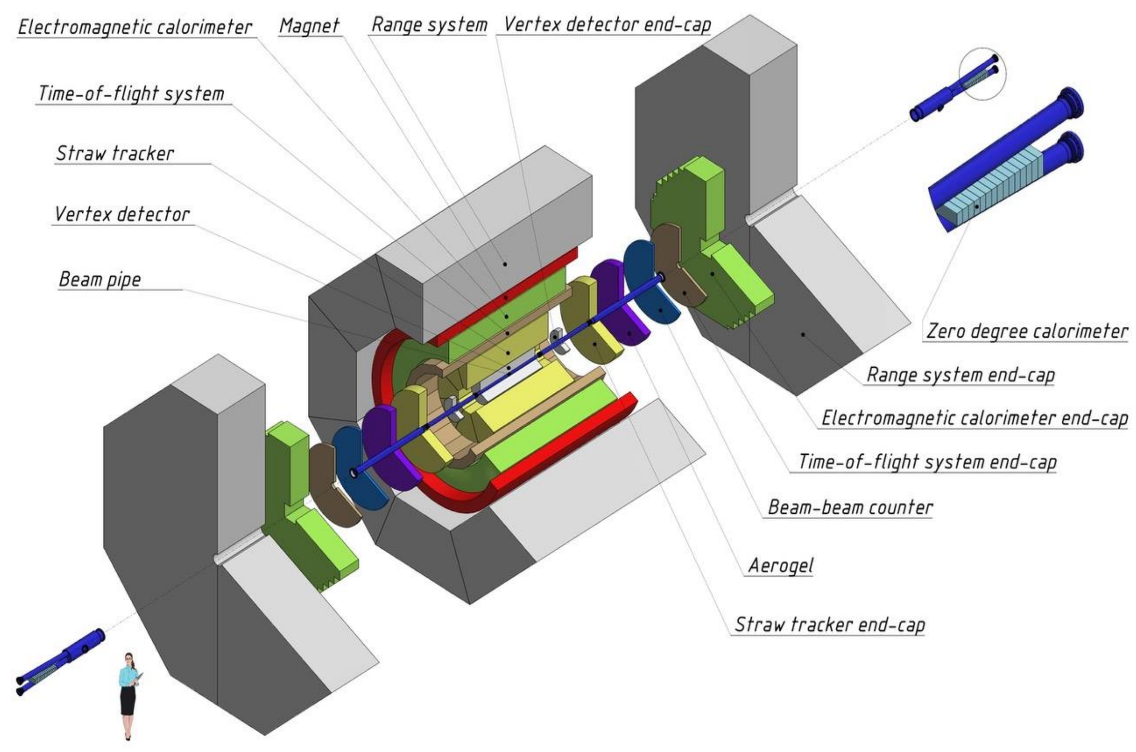
Introduction

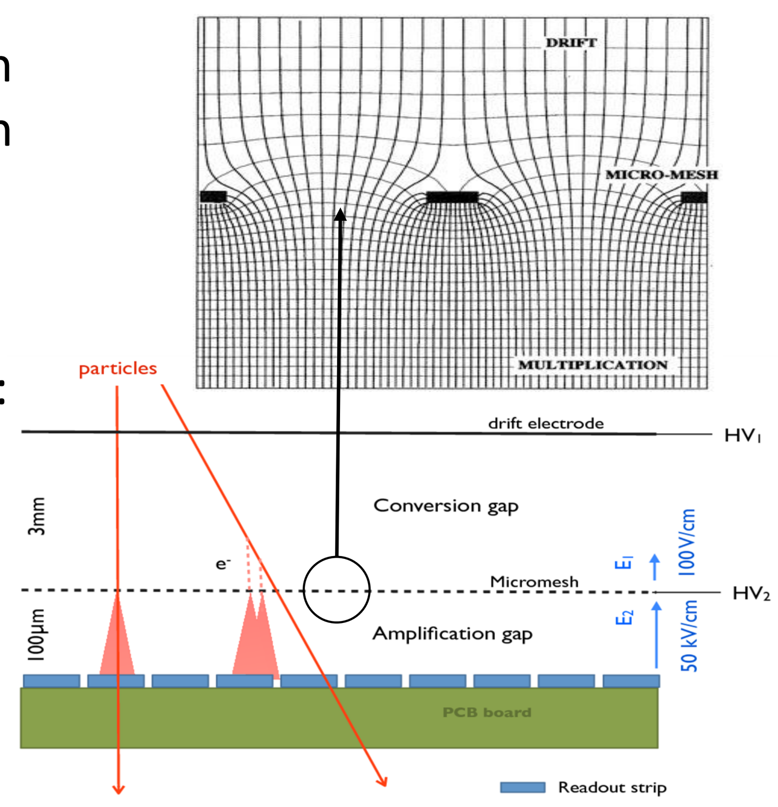
The Spin Physics Detector is a classical 4-pi experimental setup that will be installed at the second collision point of the NICA collider under construction. The tracking system of SPD includes a straw tube main tracker and a silicon vertex detector. In first phase of the experiment, the vertex detector will not be installed, which will result in significant degradation of tracking performance. To minimize these effect, it was proposed to complement the straw tracker with a relatively simple detector based on Micromegas technology.



Micromegas

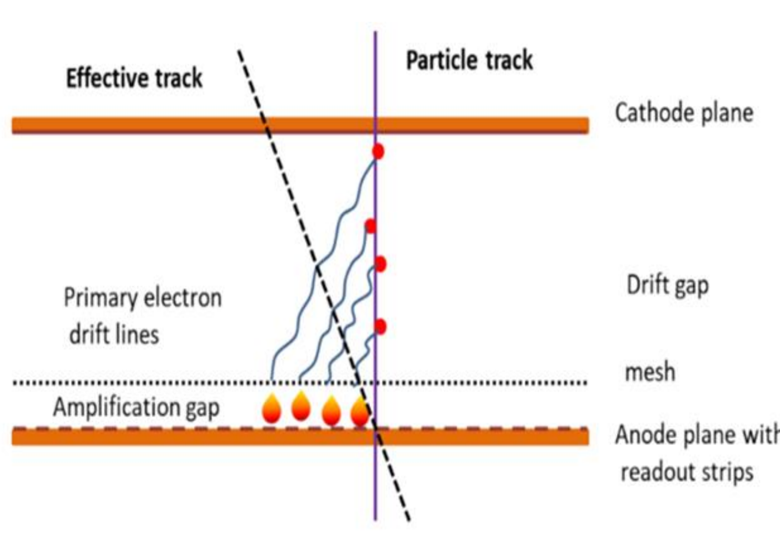
Micromegas is a flat counter with ionization and amplification gaps separated by a thin grid.

- 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

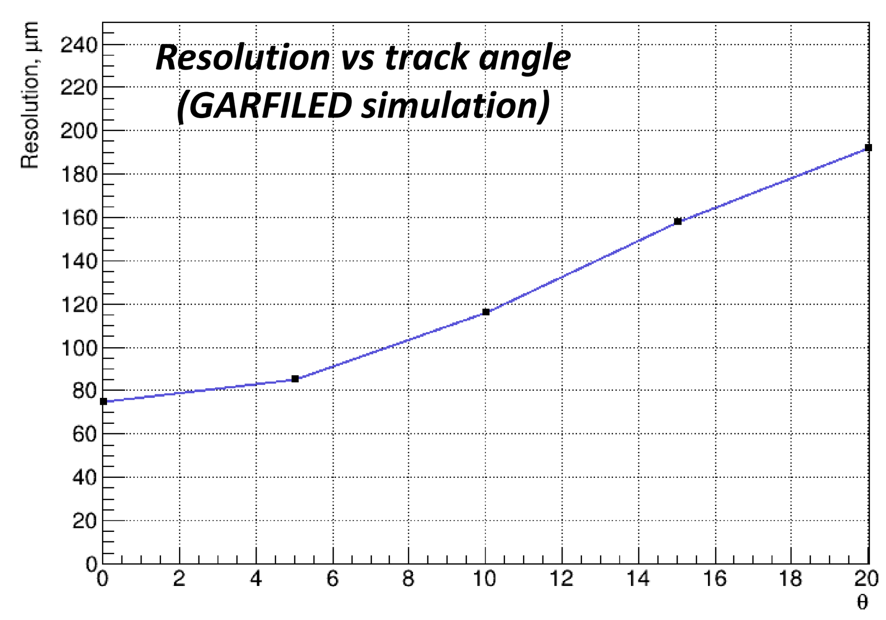


Micromegas in SPD

- 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".

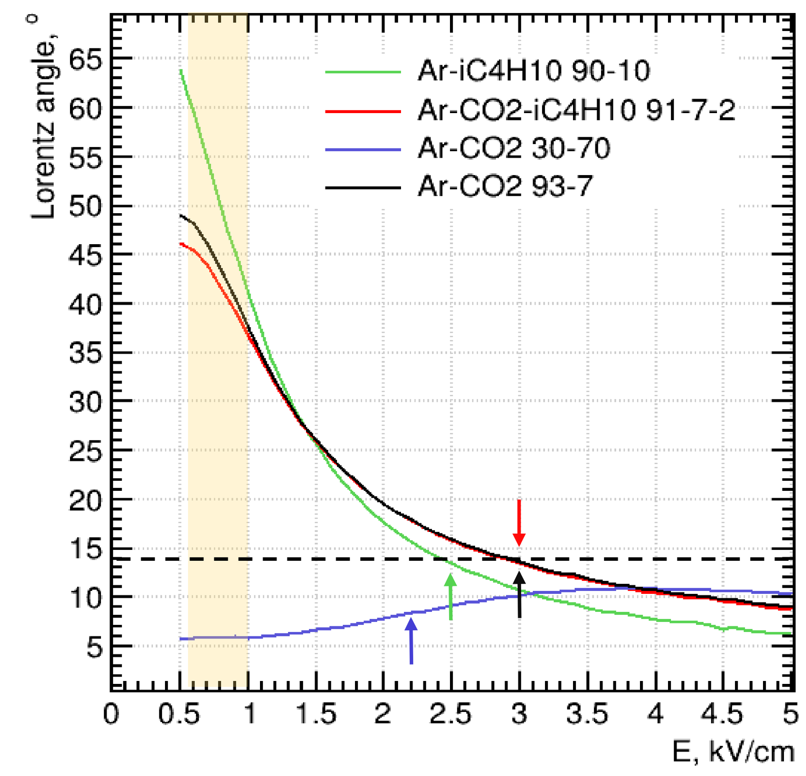


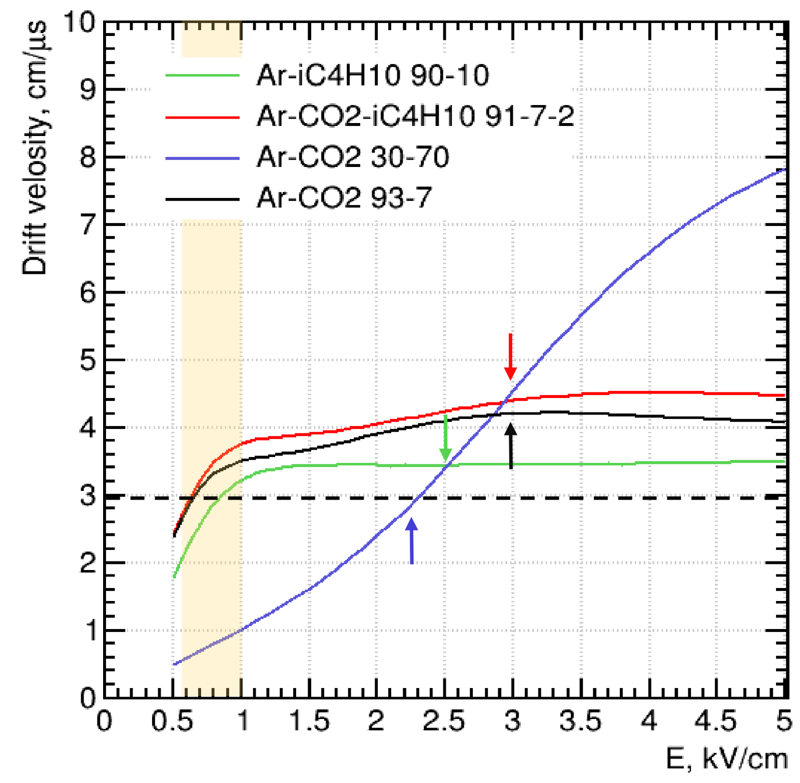
Micromegas operation in the magnetic field



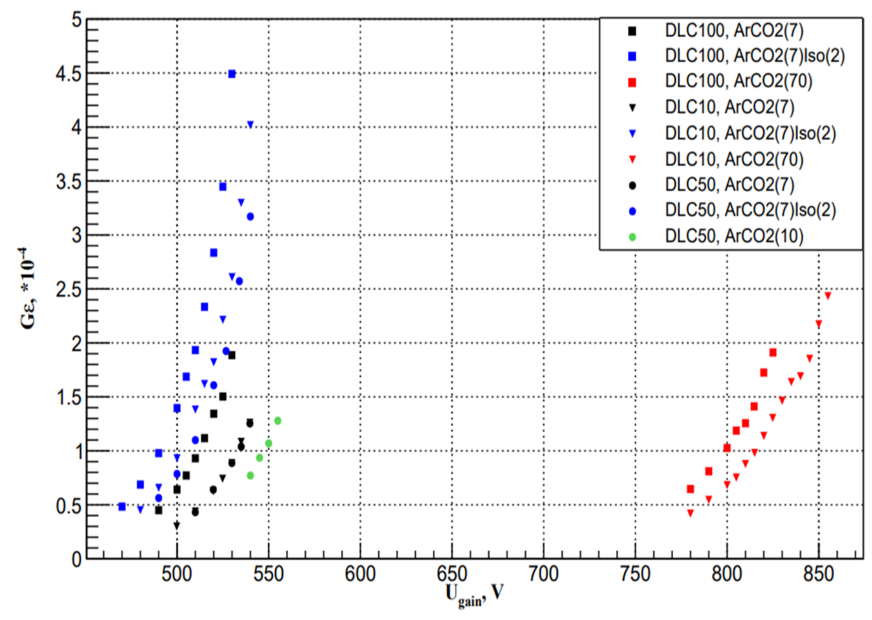
Detector requirements	Gas mixture requirements
Trigger less data acquisition system => high threshold is required	Stable operation with a sufficiently high gain, and high primary ionization, minimum Lorentz angle
Coordinate accuracy 150 μm	Lorentz angle below 14^0
Maximum drift time less than 100 ns	Electron drift velocity not less than 3 cm/μs

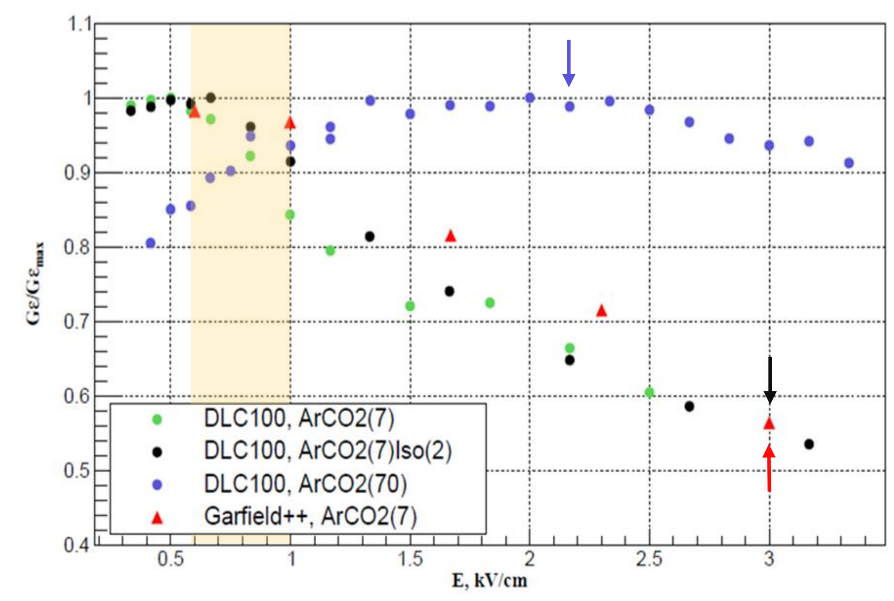
Gas mixture parameters (simulation)





Gas gain and charge collection efficiency





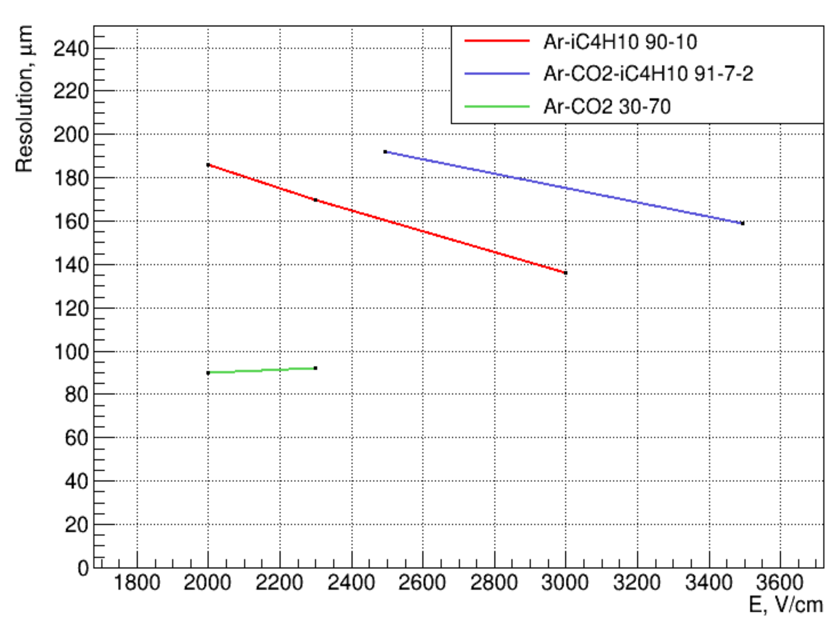
Gas mixture	Max. gain, $x10^4$	E_{drift}, kV/cm	Charge collection efficiency, Garfield++	N_{cl}	Lorentz angle
Ar-CO_2 (93-7)	1,5	3	0,57	7,71	13
Ar-CO_2 (30-70)	1,6	2,2	0,95	9,6	8
Ar-CO_2-iC_4H_{10} (91-7-2)	3,5	3	0,63	8,1	13
Ar-iC_4H_{10} (90-10)	3	2,5	0,8	9,45	13

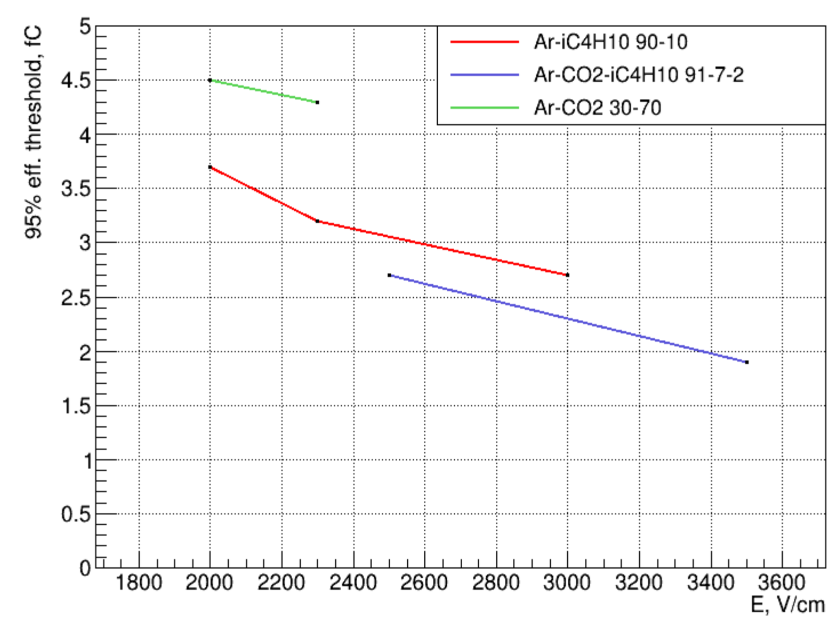
Detector performance

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

- 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

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