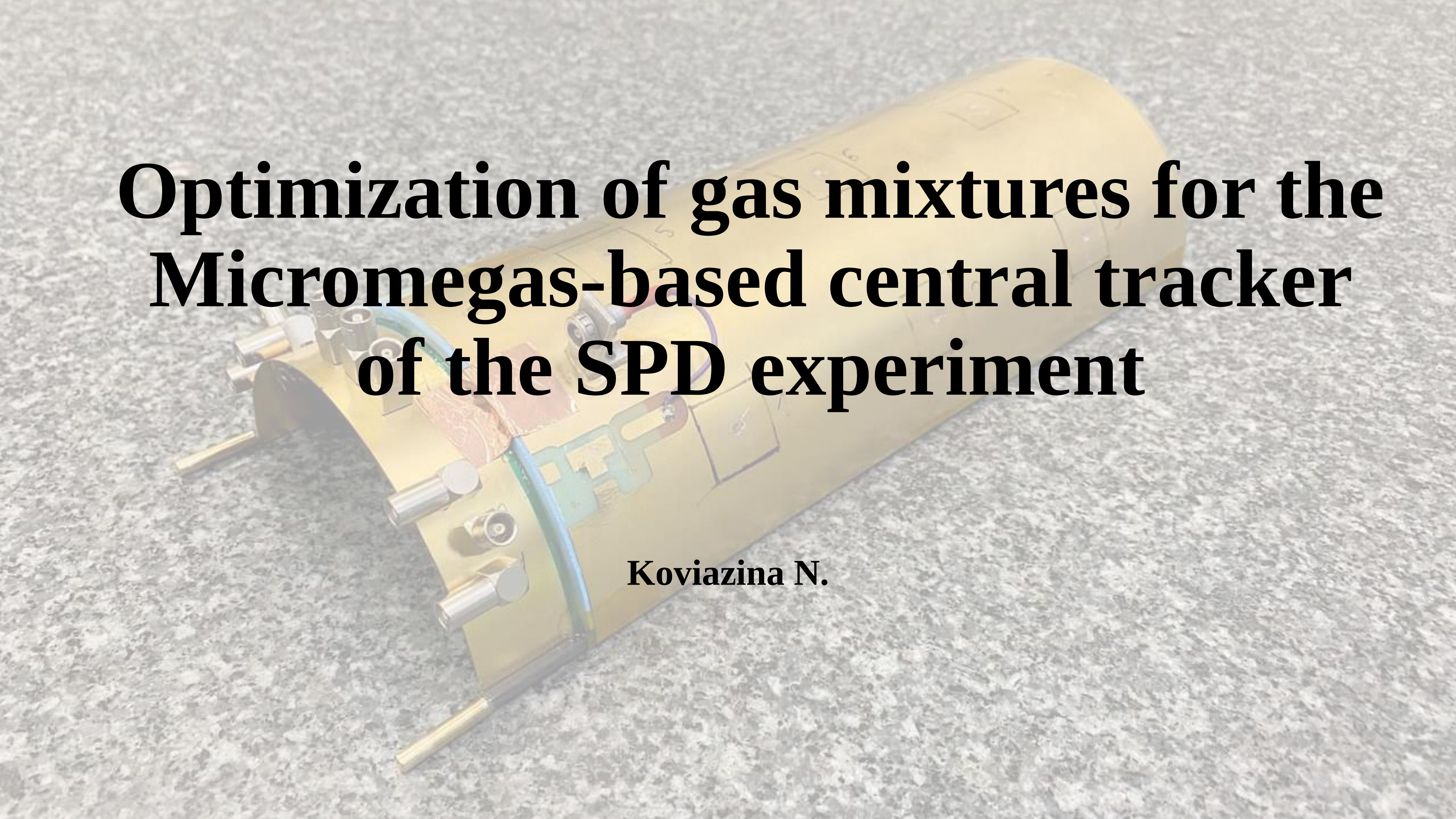
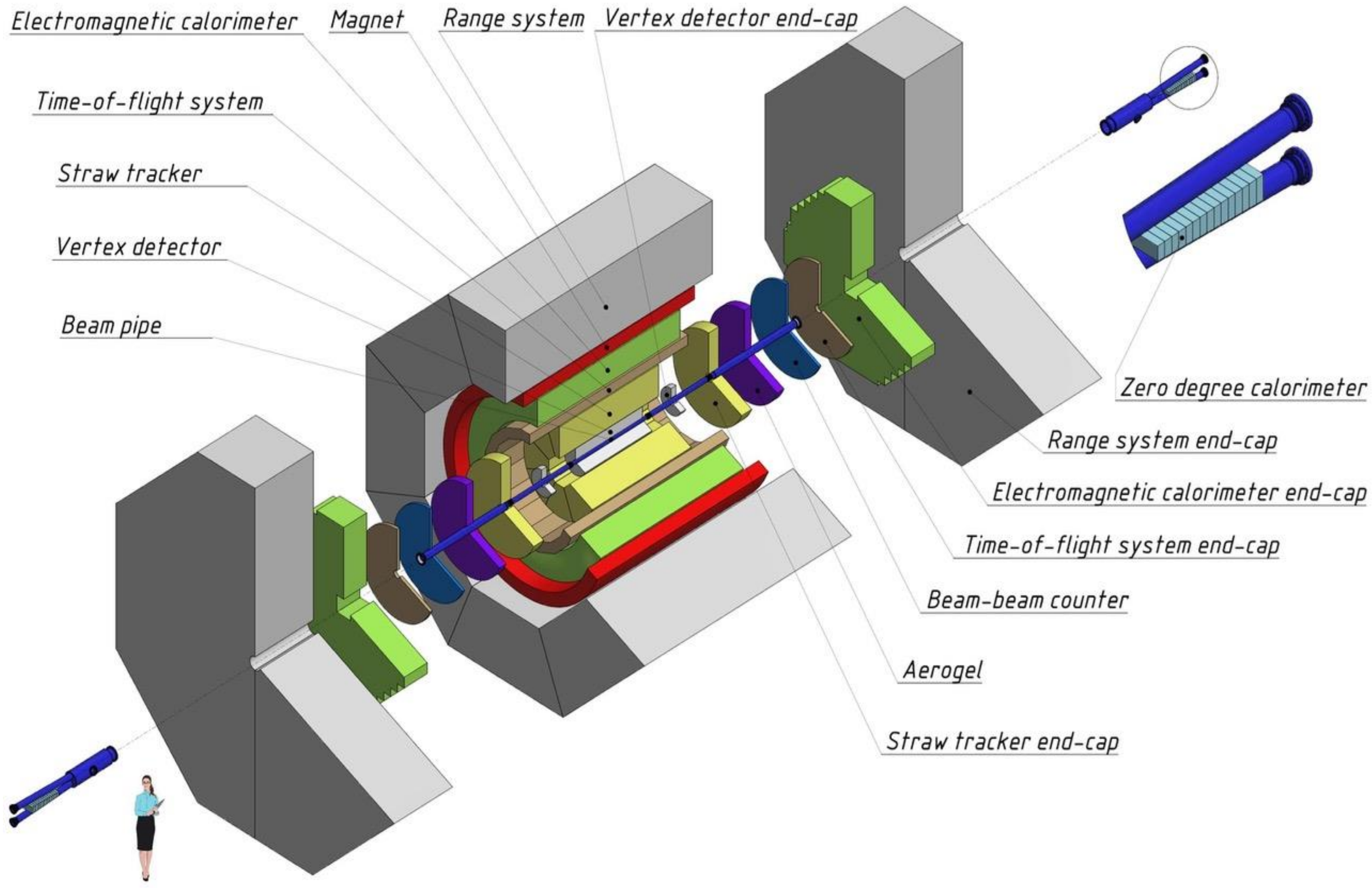


Optimization of gas mixtures for the Micromegas-based central tracker of the SPD experiment

Koviazina N.

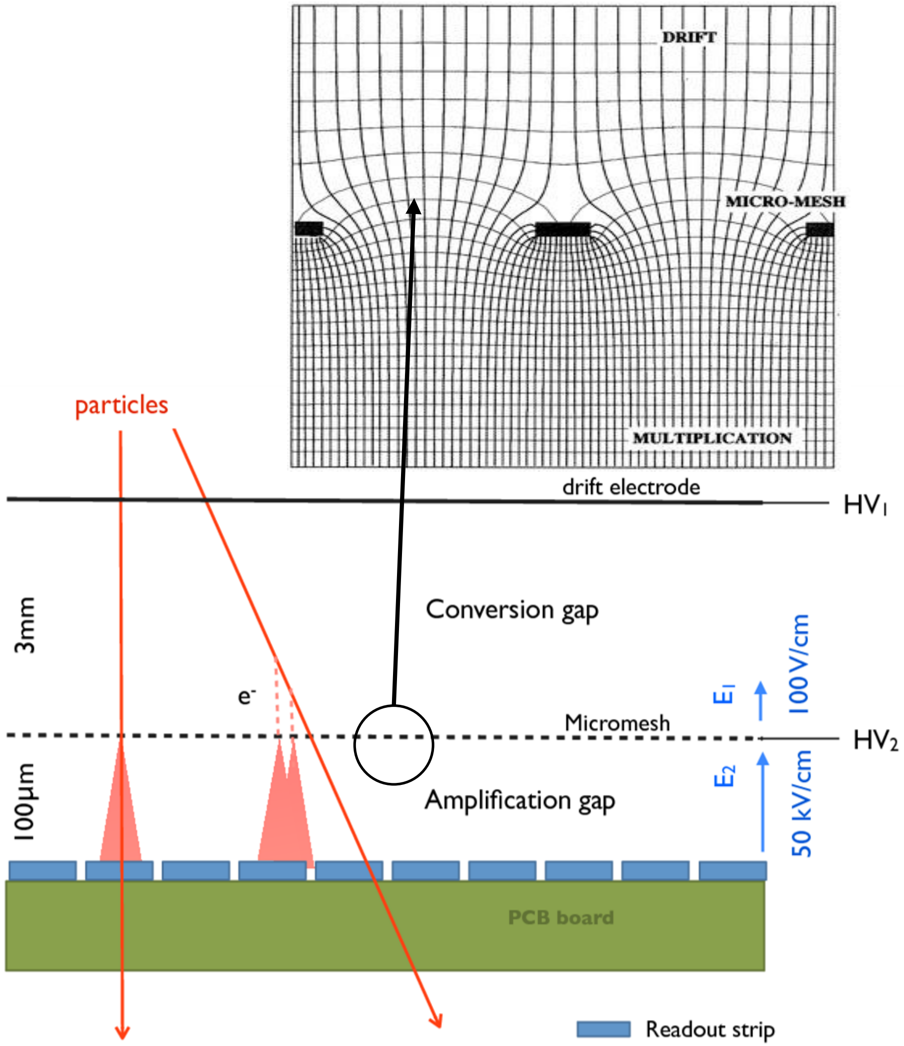
Spin Physics Detector (SPD)



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

The Micromegas Central Tracker (MCT) will be used at the first phase of experiment and will be replaced later by the Silicon Vertex Detector.

Micromegas



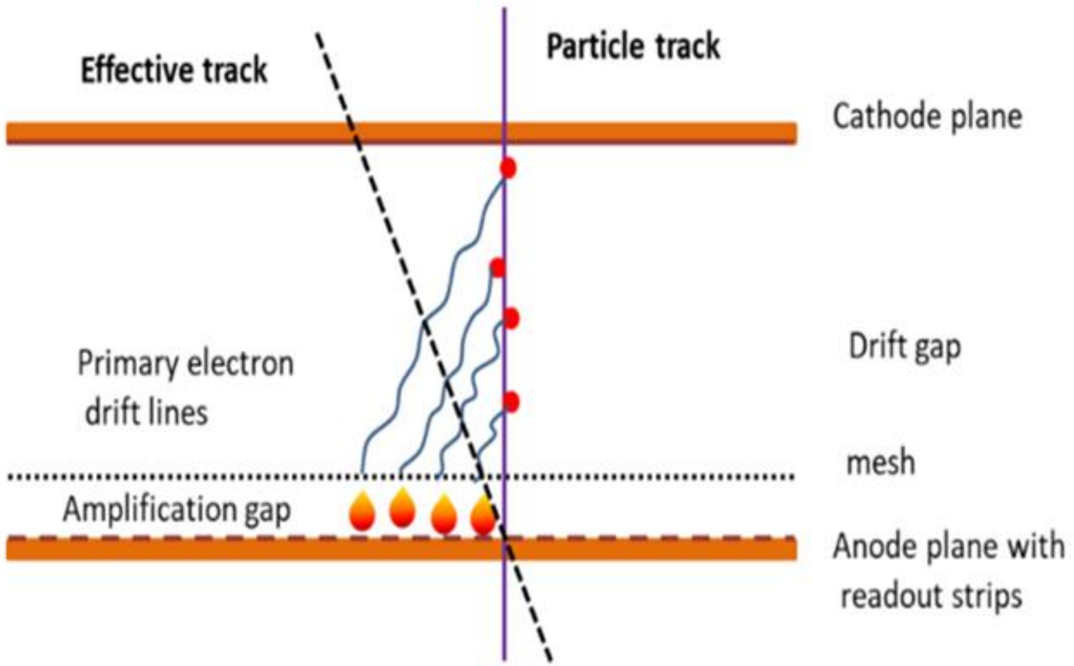
Micromegas (Micro Mesh Gaseous Structure) is a flat counter with ionization and amplification gaps separated by a fine mesh.

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

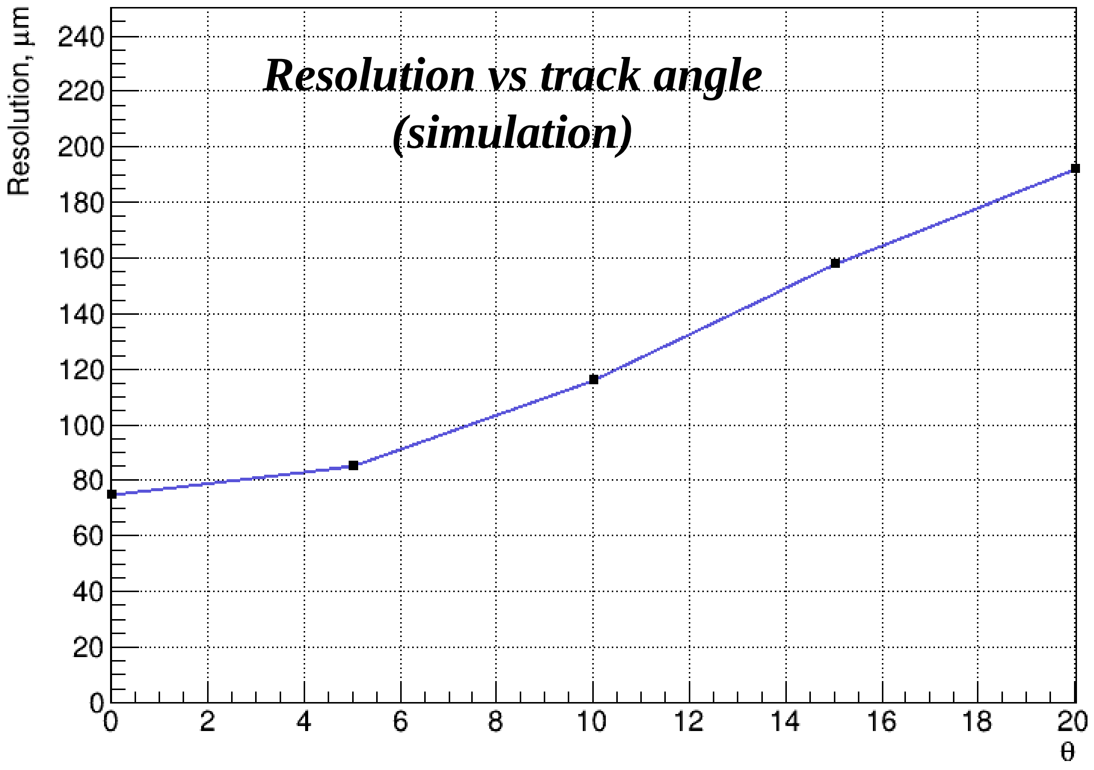
- Gas gain: ~10^4
- Mesh transparency for primary electrons: ~ 100% at optimum drift field
- Anode is segmented as a narrow strips

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

Micromegas in SPD



Micromegas operation in the magnetic field

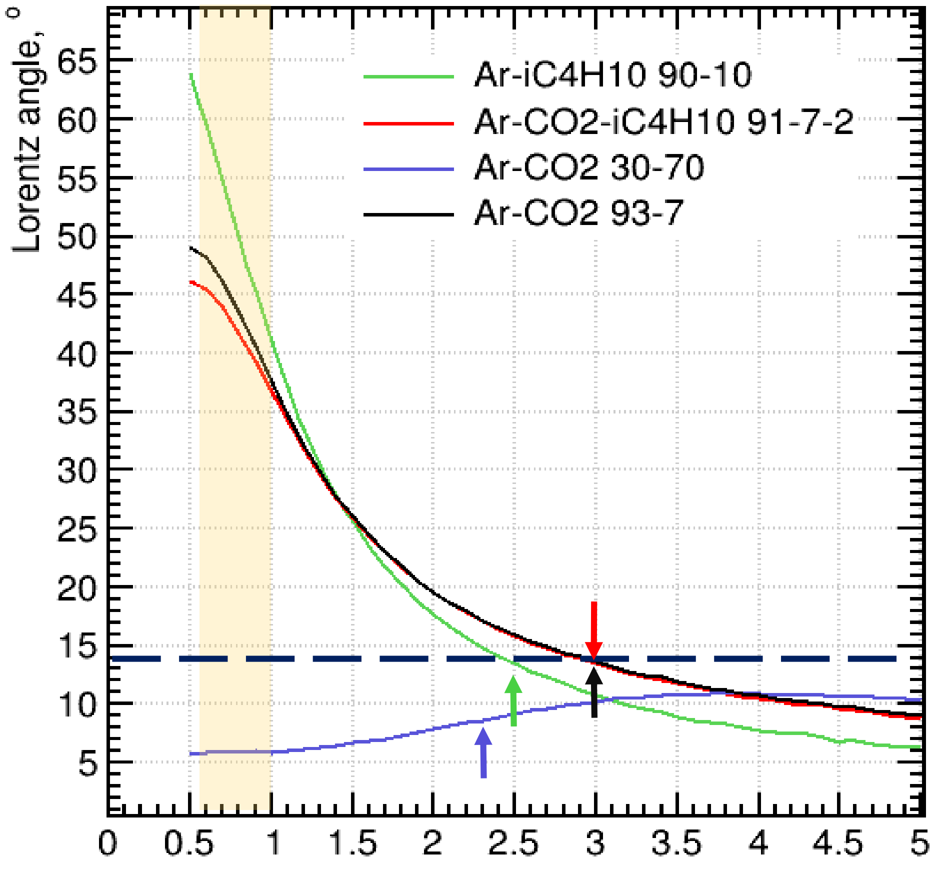


- In a magnetic field, electrons drift at an angle to the direction of the electric field strength.
- In terms of detector response, the track is “effectively inclined”.

Detector and gas mixture requirements

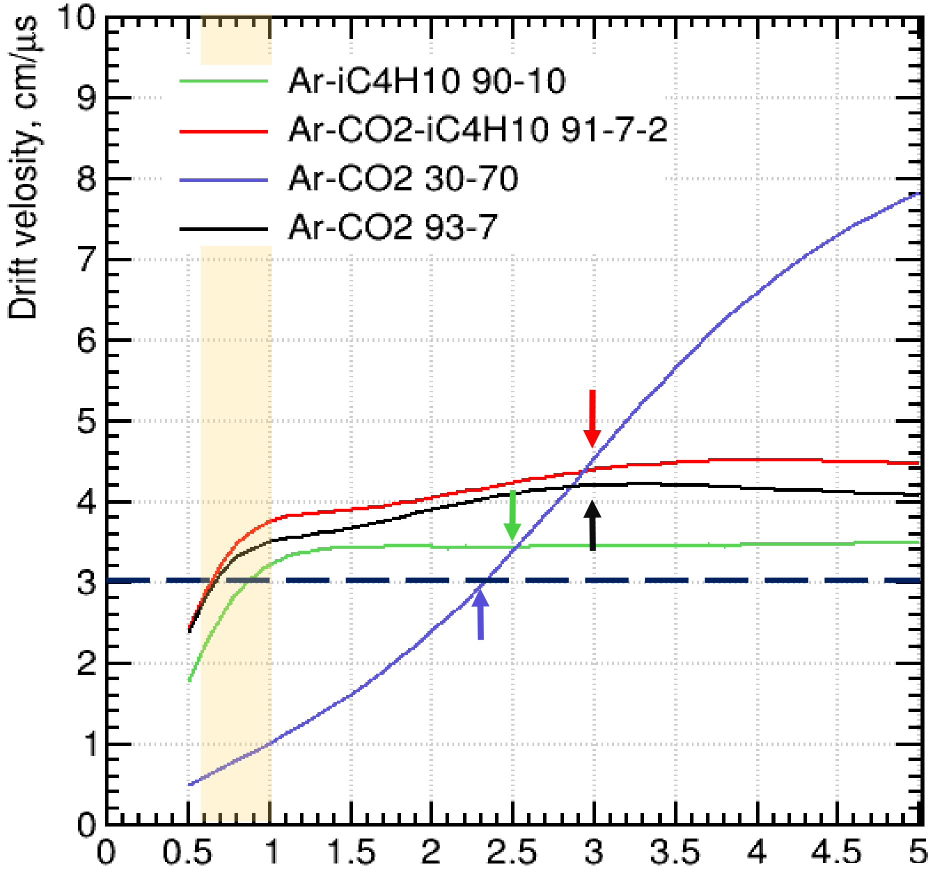
Trigger less data acquisition system => high threshold is required	Stable operation with a sufficiently high gain, and high primary ionization, minimum Lorentz angle
Coordinate accuracy 150 μm	Lorentz angle below 14^0
Maximum drift time less than 100 ns	Electron drift velocity not less than 3 cm/μs

Gas mixture parameters (simulation)



E_{drift}, kV/cm

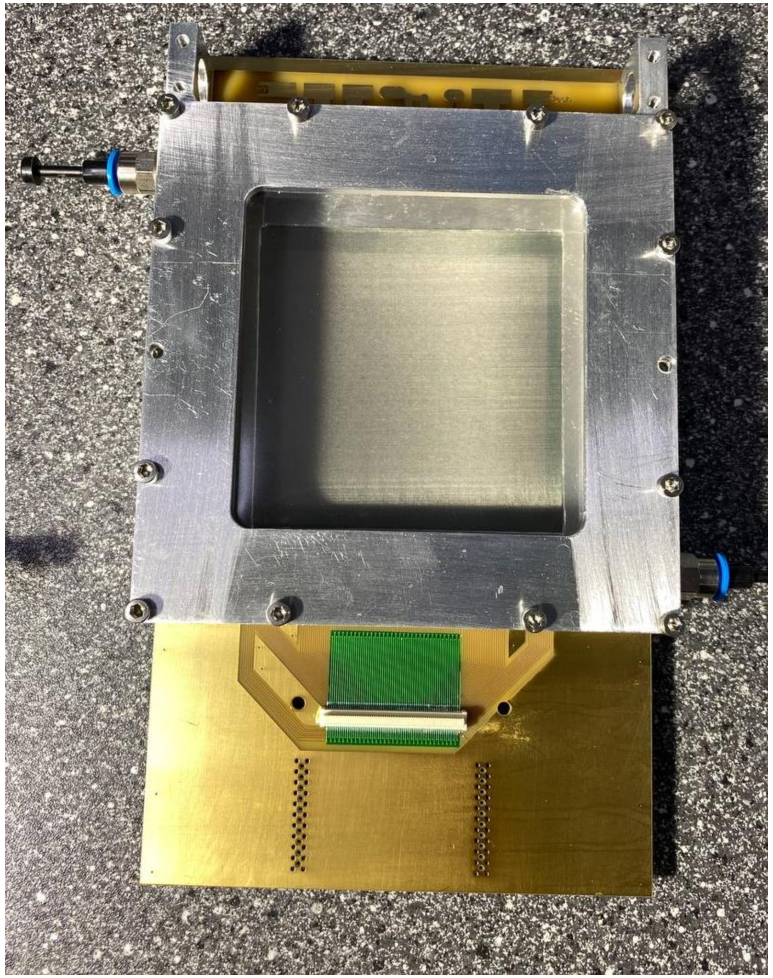
Lorentz angle vs electric field (simulation)



E_{drift}, kV/cm

Electron drift velocity vs the electric field (simulation)

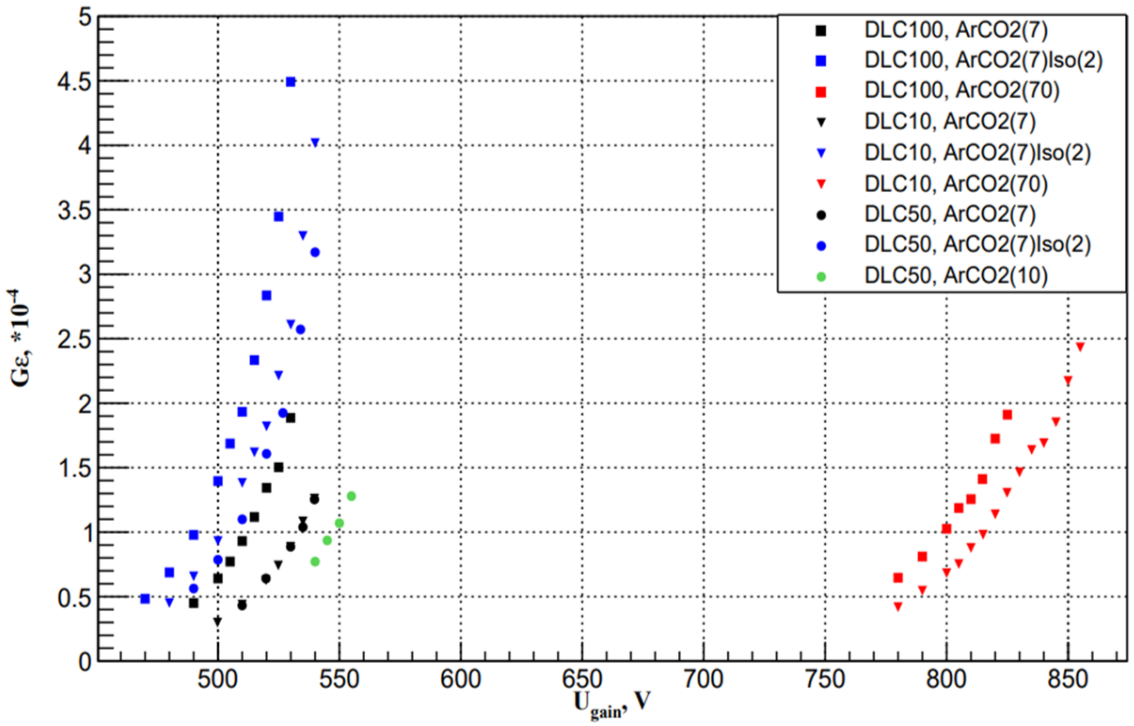
Test chamber for gas study



MM prototype with DLC resistive layer

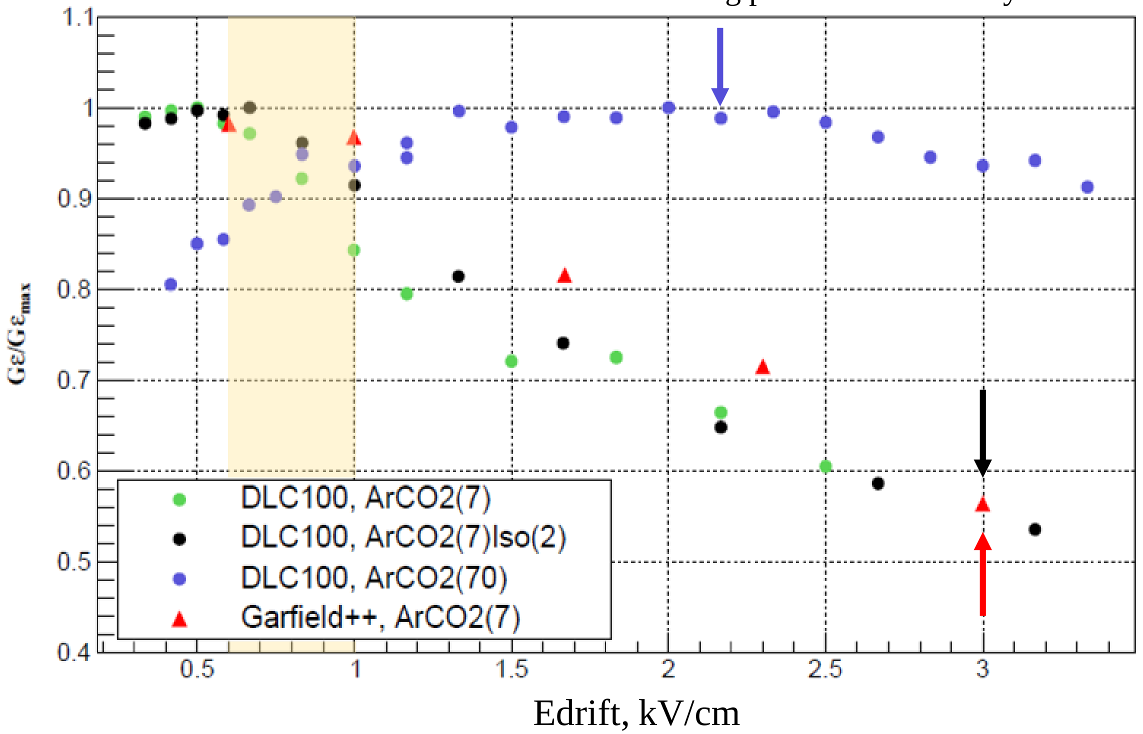
- 10x10 cm^2 active area
- 120 um amplification gap, 3 mm drift gap
- All strips connected to single charge amplifier

Gas gain and charge collection efficiency



Gas gain vs voltage (experimental data)

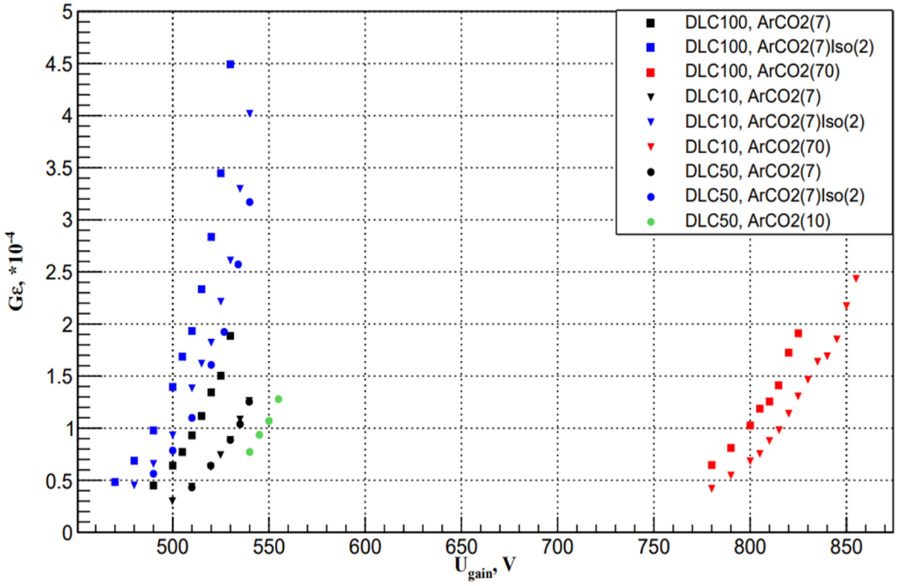
Working points are marked by arrows

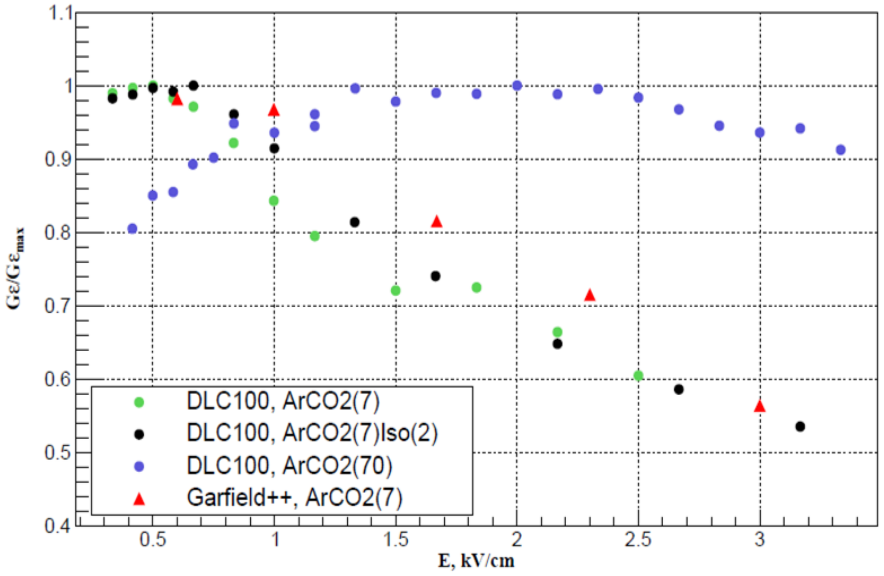


Charge collection efficiency vs drift field (experimental data + simulation)

- When the voltage reaches 3 kV/cm, we lose almost 40% of the charges

Gas gain and charge collection efficiency

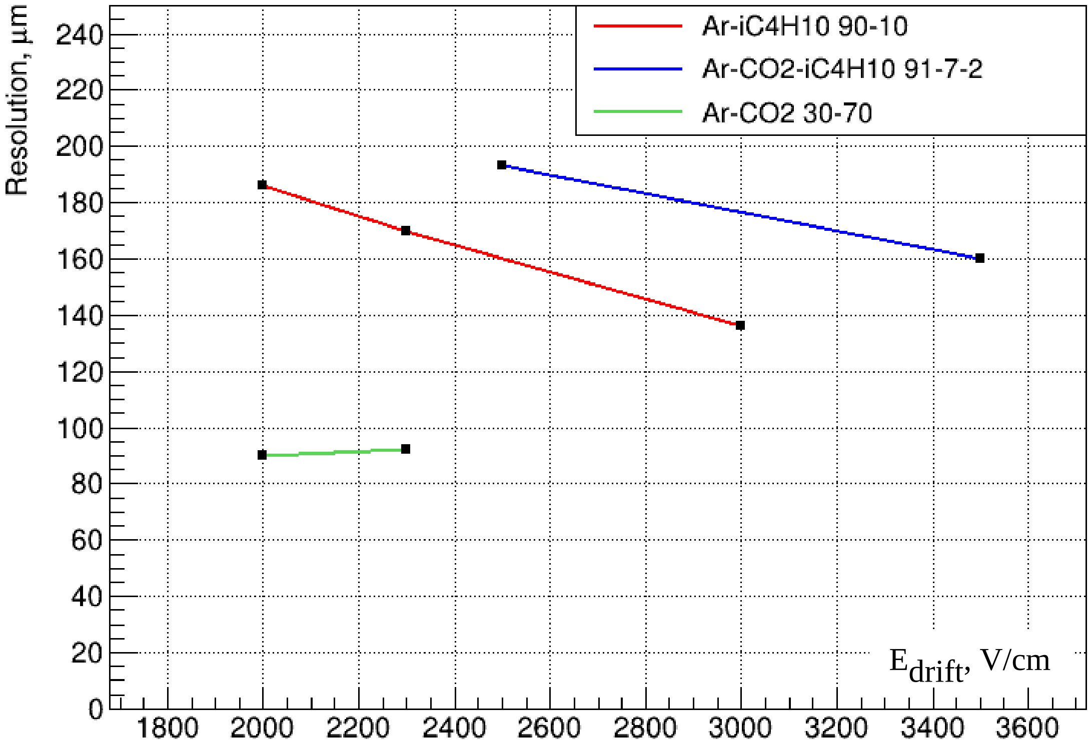




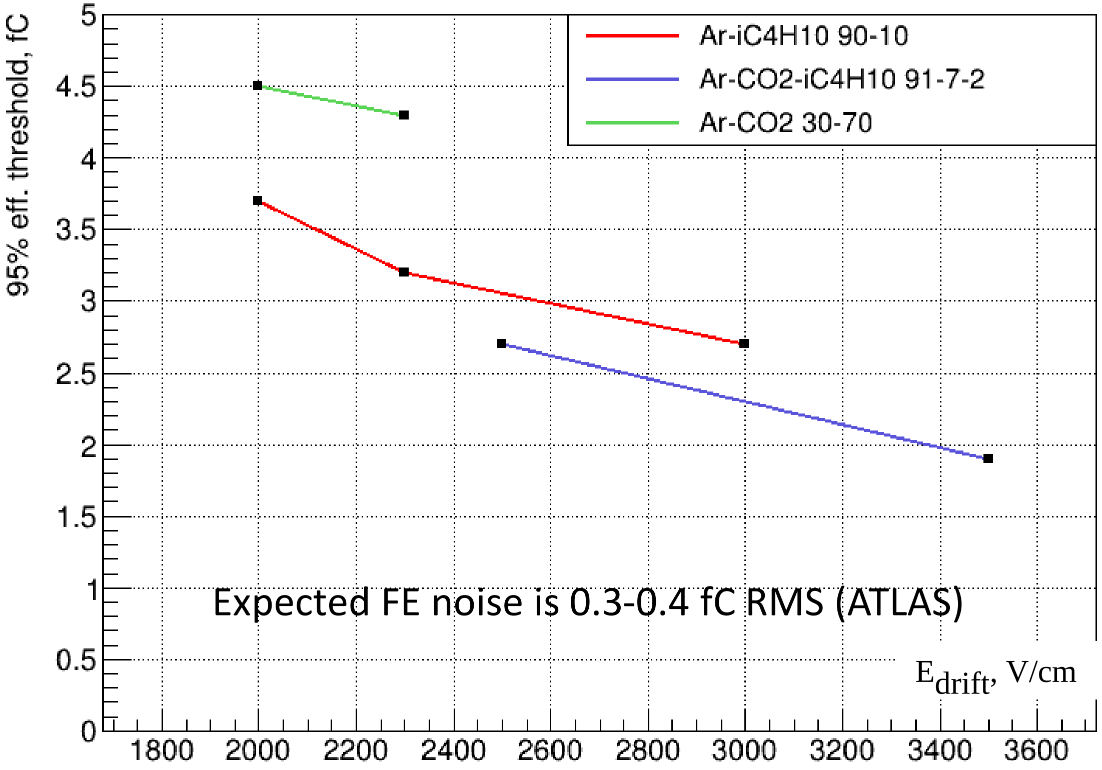
Gas mixture	Max. gain, $x10^4$	E_{drift}, kV/cm	Charge collection efficiency, Garfield++	N_{cl}	Lorentz angle
Ar-CO_2 (93-7)	1,5	3	0,57	7,71	13
Ar-CO_2 (30-70)	1,6	2,3	0,95	9,6	8
Ar-CO_2-iC_4H_{10} (91-7-2)	3,5	3	0,63	8,1	13
Ar-iC_4H_{10} (90-10)	3	2,5	0,8	9,45	13

Detector performance

- Full simulation (B=1 T) was carried out for 4 mixtures: Ar-iC_4H_{10}(10%), Ar-CO_2(7%)-iC_4H_{10}(2%), Ar-CO_2(70%), Ar-CO_2(7%).
- Gas gain was normalized to real data with a coefficient of 0.5



Resolution vs drift field (simulation)



Threshold for 95% efficiency vs drift field (simulation)

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