Status of the DLC machine

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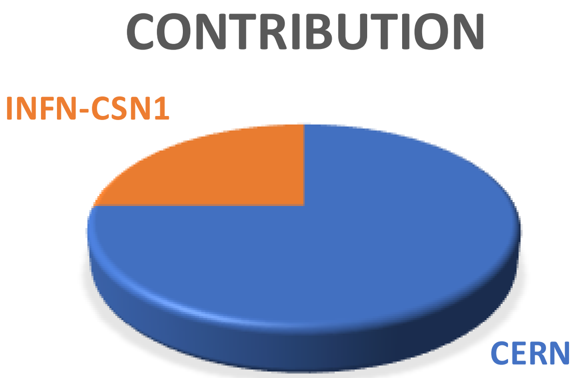
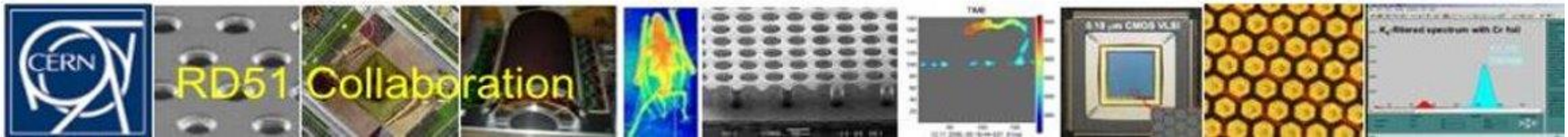
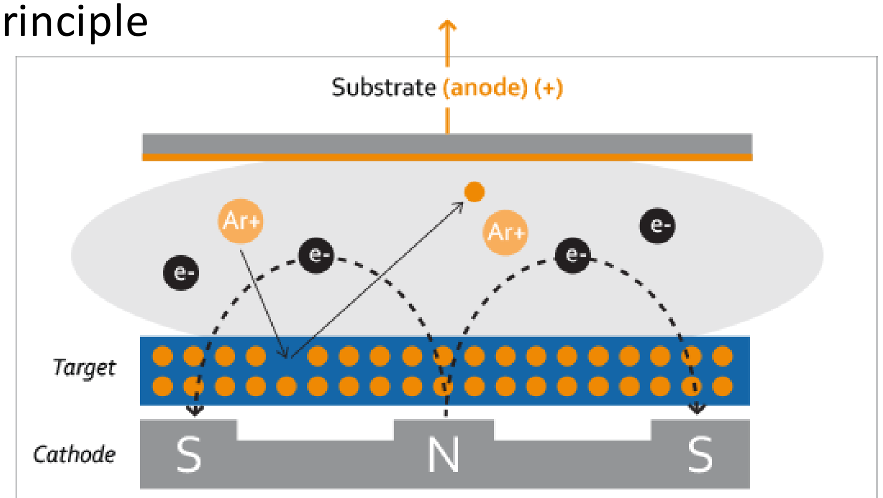


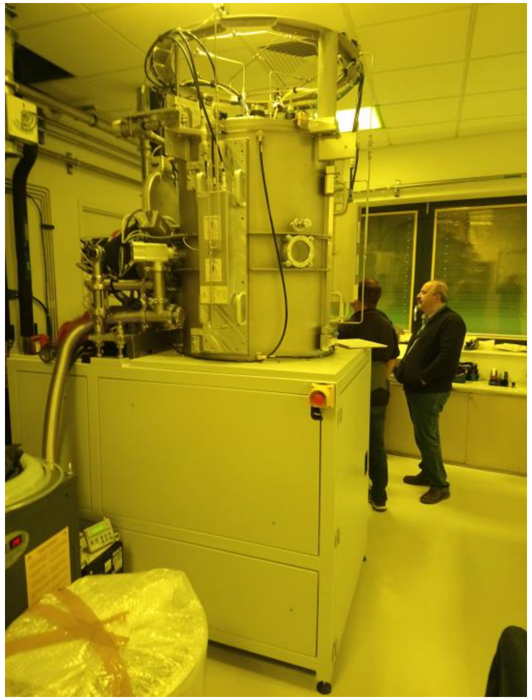


The magnetron sputtering machine

Working principle

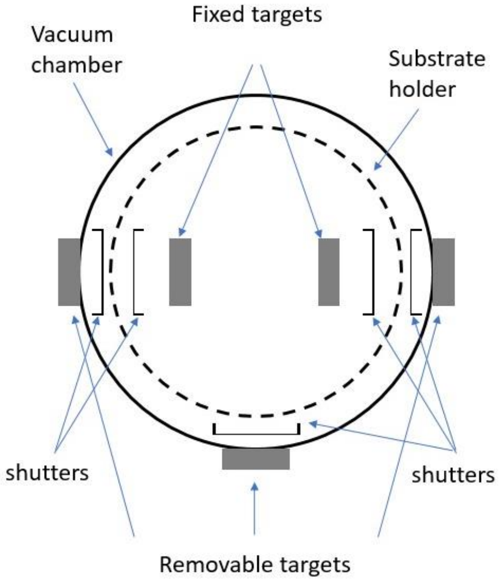


- The field creates ion-electron pairs in the plasma
- The electrons area accelerated and furtherly ionize the plasma generating new ions
- A magnetic field concentrate the ions in a peculiar region of the targer (speed track)
- The ions drift towards the target and by collision the material is extracted flying all over the vacuum chamber



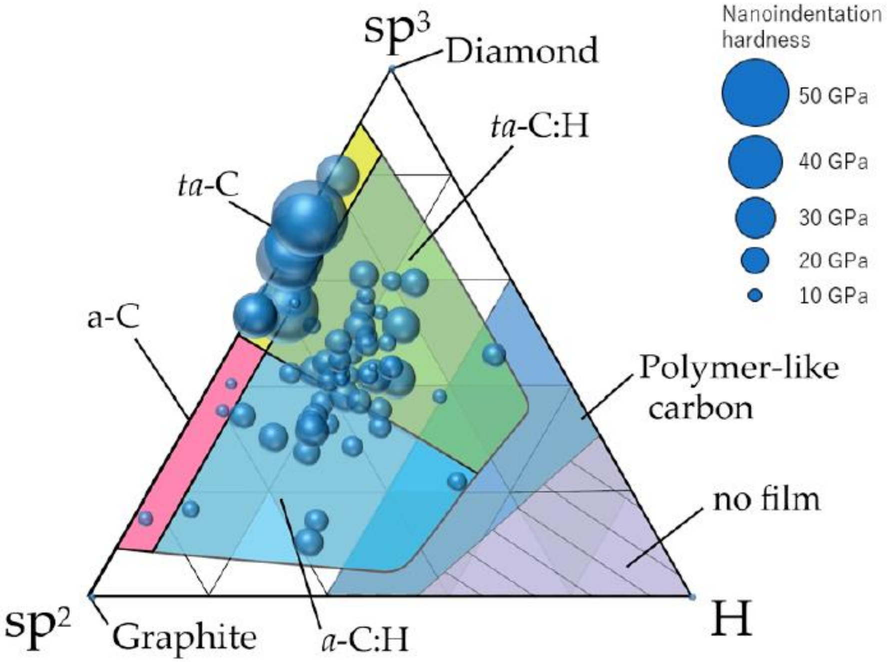
The graphite target

The three external cathodes



DLC tests

The machine phase-space is quite huge; thanks to Serge's experience the plan for the tests have been focused to few parameters.



QUICK GLOSSARY

Pressure limit: *the pressure of the vacuum at which the run starts. Typically 2.E-5 mbar*

Pressure process: *the pressure of the plasma during the sputtering phase*

Power: *the maximum power limit output from the DC PS on the cathode*

Time deposition: *the duration of the sputtering process*

- Ar-N_2 plasma tests
  - Scan in nitrogen percentage at a given pressure process
  - Scan in pressure process at a given nitrogen percentage
  - Tests with different time deposition

- Ar-C_2H_2 plasma tests
  - Scan in acetylene percentage at a given pressure process and power
  - Scan in time deposition at a given pressure process, acetylene percentage and power
  - Uniformity tests

DLC tests: modus operandi

SAMPLES

- APICAL foil dried in the oven (at least 16h at 100°C)
- Three rectangular samples, 15 x 10 cm2 (machine operating in oscillation mode), to check the uniformity of the deposition along z
- A small 1.5 x 1.5 cm2 glass next to each sample for thickness measurement

RUN

- Pure Ar-based plasma surface treatment (plasma etching)
- Pure Ar-based pre-sputtering process
- Sputtering process

POST RUN

- Resistivity measurements
- Baking of one sample from each run (2h at 220°C) to simulate the thermal shock during detector manufacturing
- Monitoring of the resistivity during the following days (stability check)

Repetitivity and stability with N2

First tests with N2 answered to two urgent questions:

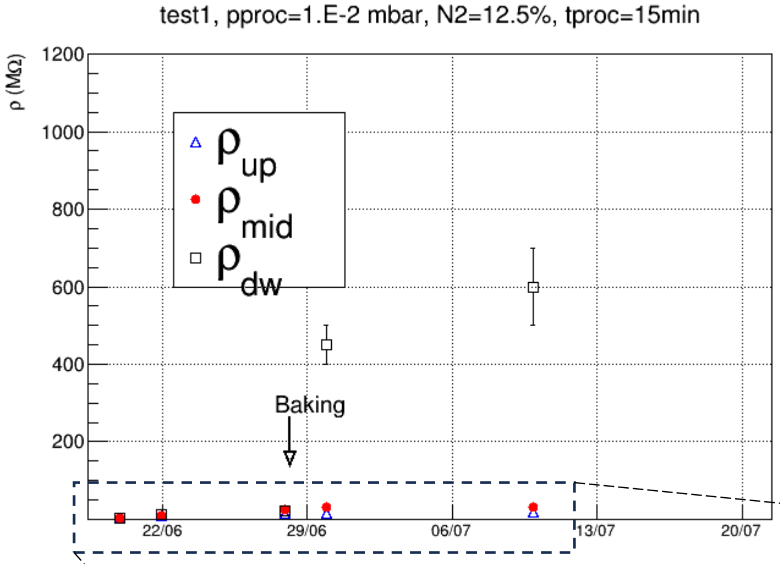
1) Standing the same deposition parameters, will the resisitivity be the same or will it change?
2) How does the resistivity change along the time?

1)

Test			20/06	22/06
1	P_{proc}=1.E-2 N_2 = 12.5% T_{proc} = 15min	ρ_{bot} ρ_{mid} ρ_{up}	2.7 2.5 2	
2	P_{proc}=1.E-2 N_2 = 12.5% T_{proc} = 15min	ρ_{bot} ρ_{mid} ρ_{up}	2.5 3 2	
3	P_{proc}=1.E-2 N_2 = 12.5% T_{proc} = 15min	ρ_{bot} ρ_{mid} ρ_{up}		3 3 4

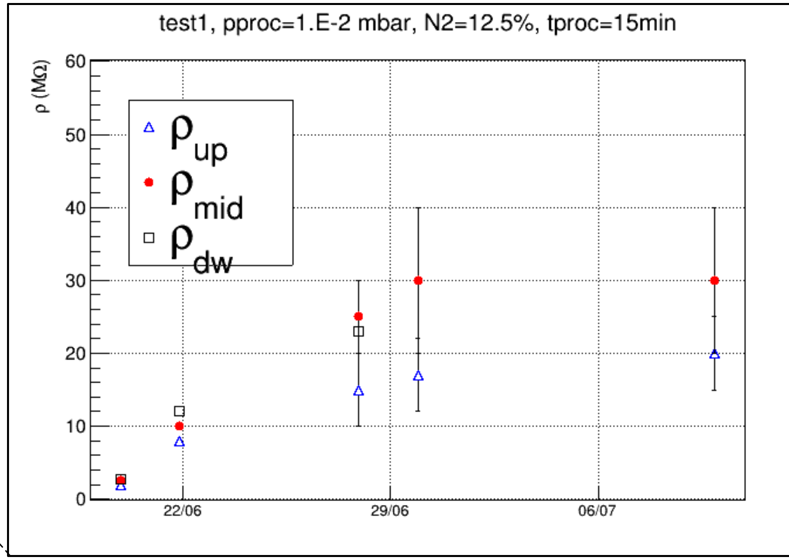
Measurements in Mohm/sq.
Quite satisfactory repetition capability
Further confirmations for other dep. conditions

2)



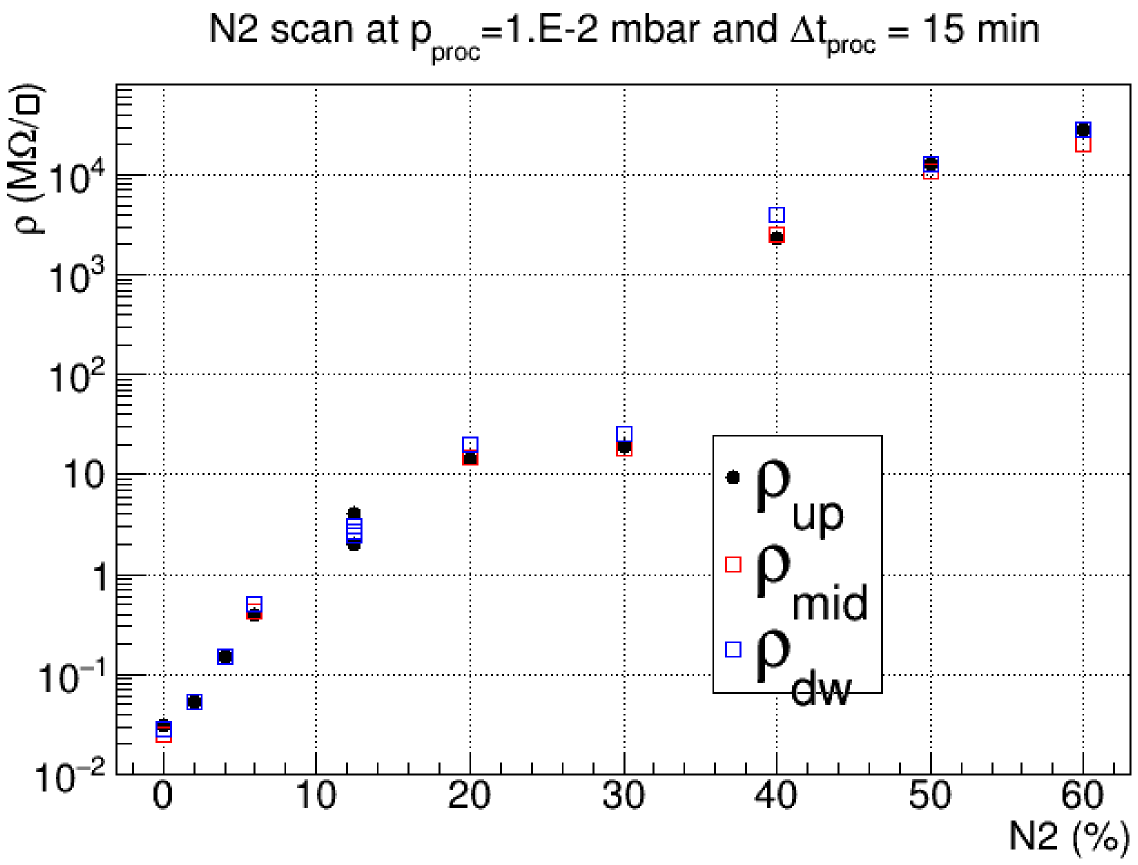
We baked one of the three sample and the resistivity jumped up of a factor 200

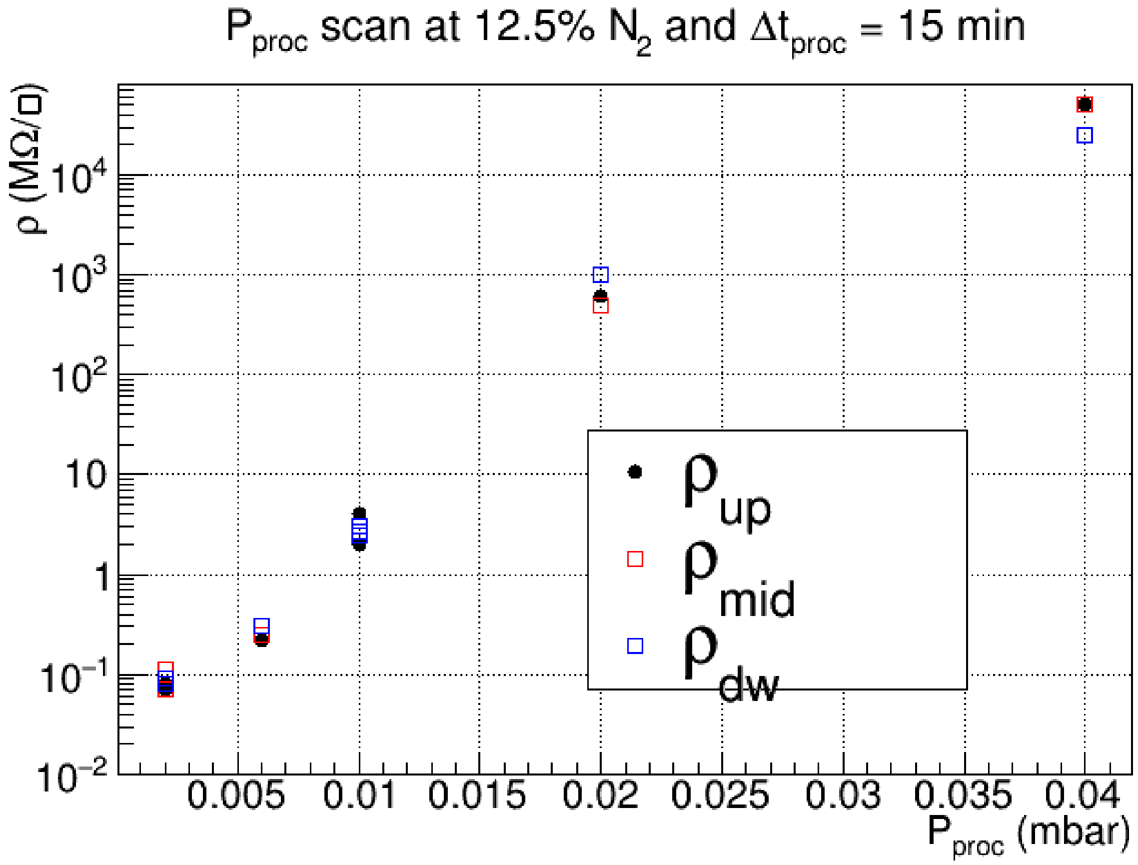
Anyway a drift towards upper values of resistivities is observed after few days
WE NEED STABLE VALUES



Summary of the test with N_2 (June 2023)

Nevertheless these tests have been helpful to understand the dependance of the resisivity on the quantity of the second component of the plasma and on the pressure process



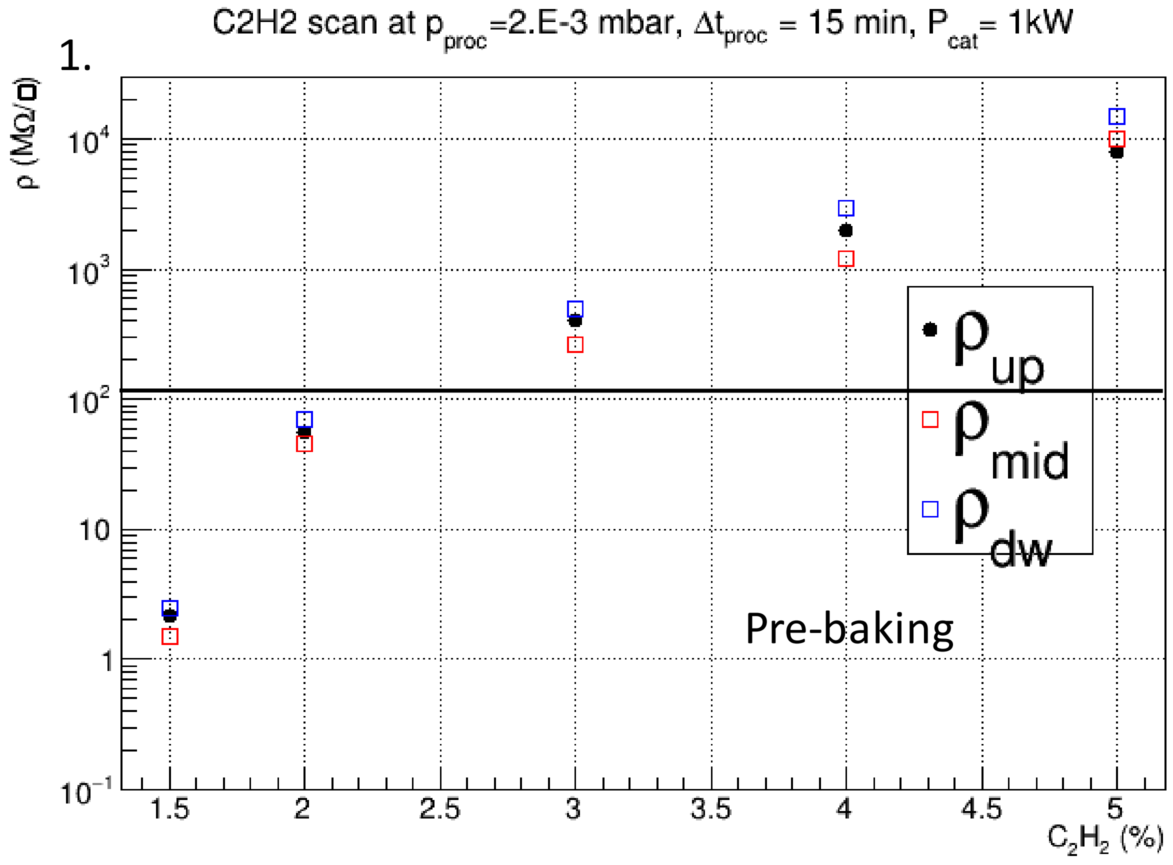


Very large amount of nitrogen to reach the target resistivity (50 – 200 Mohm/sq.)

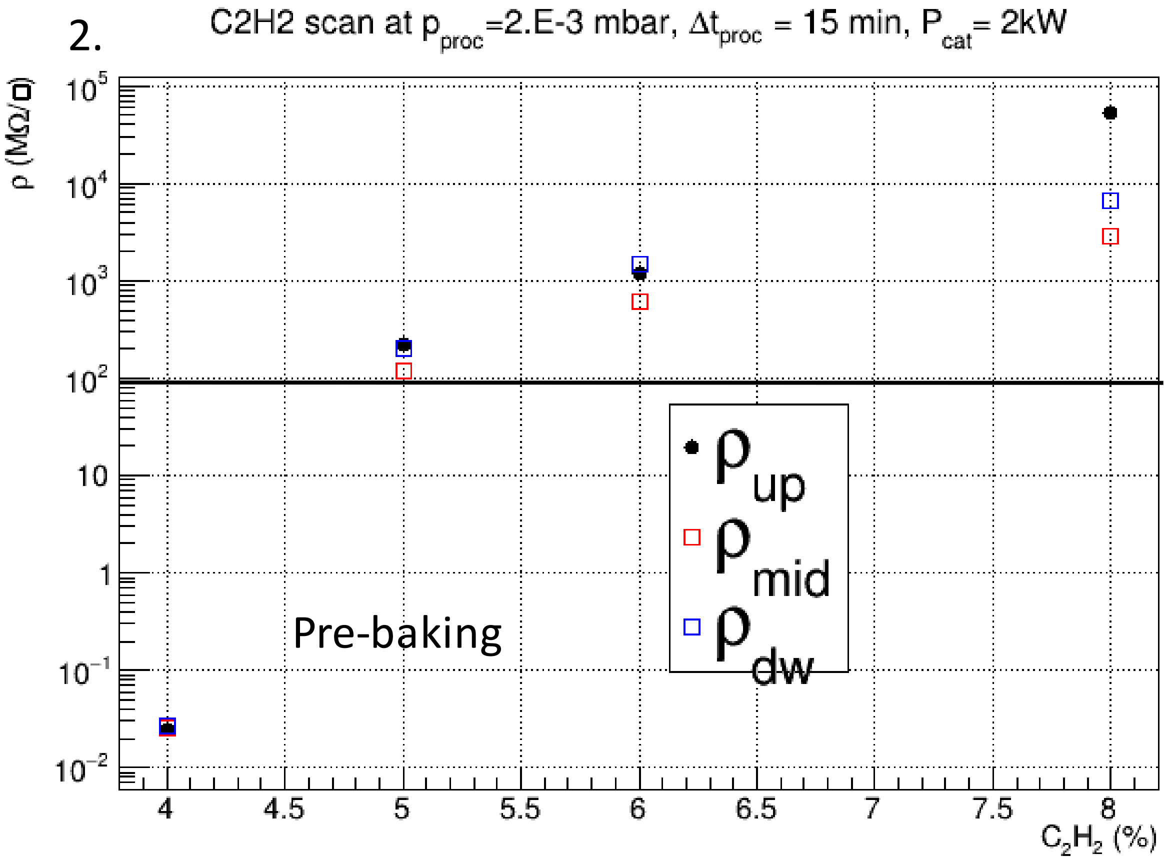
Summary of the test with C_2H_2 (Sept. 2023)

1. Scans in acetylene percentage (1.5% - 5%) at p_proc = 2.E-3 mbar, t_dep = 15 m and P_cat = 1 kW
2. Scans in acetylene percentage (4% - 8%) at p_proc = 2.E-3 mbar, t_dep = 15 m and P_cat = 2 kW
3. Test at different deposition time (15 m – 240 m) with 4% of C2H2 at p_proc 8.E-3 and P_cat = 1 kW
4. Repetitivity tests (C2H2 3%, p_proc = 2.E-3, P_cat = 1kW, t_dep = 22.5 m)
5. Uniformity tests

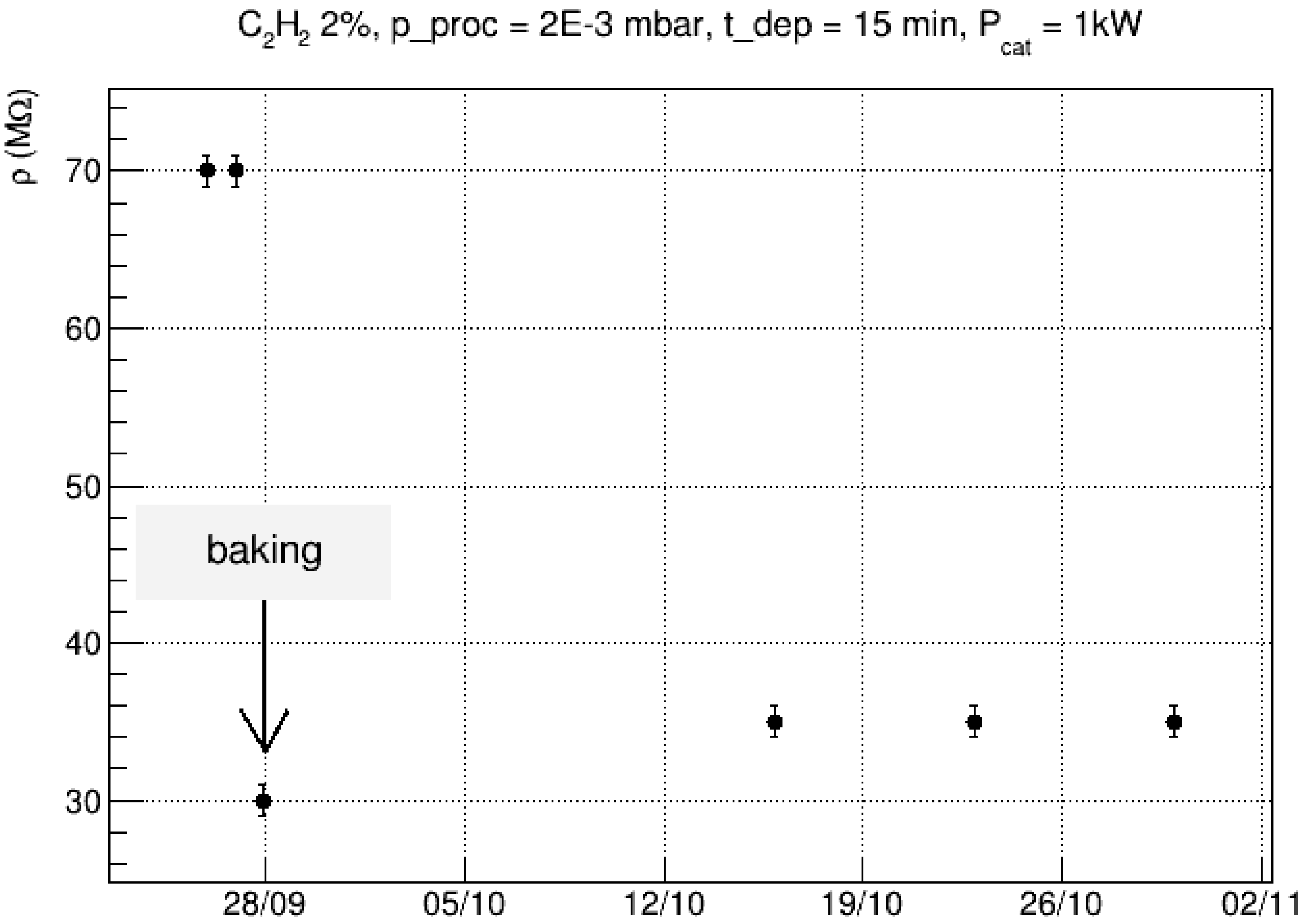
1.



2.

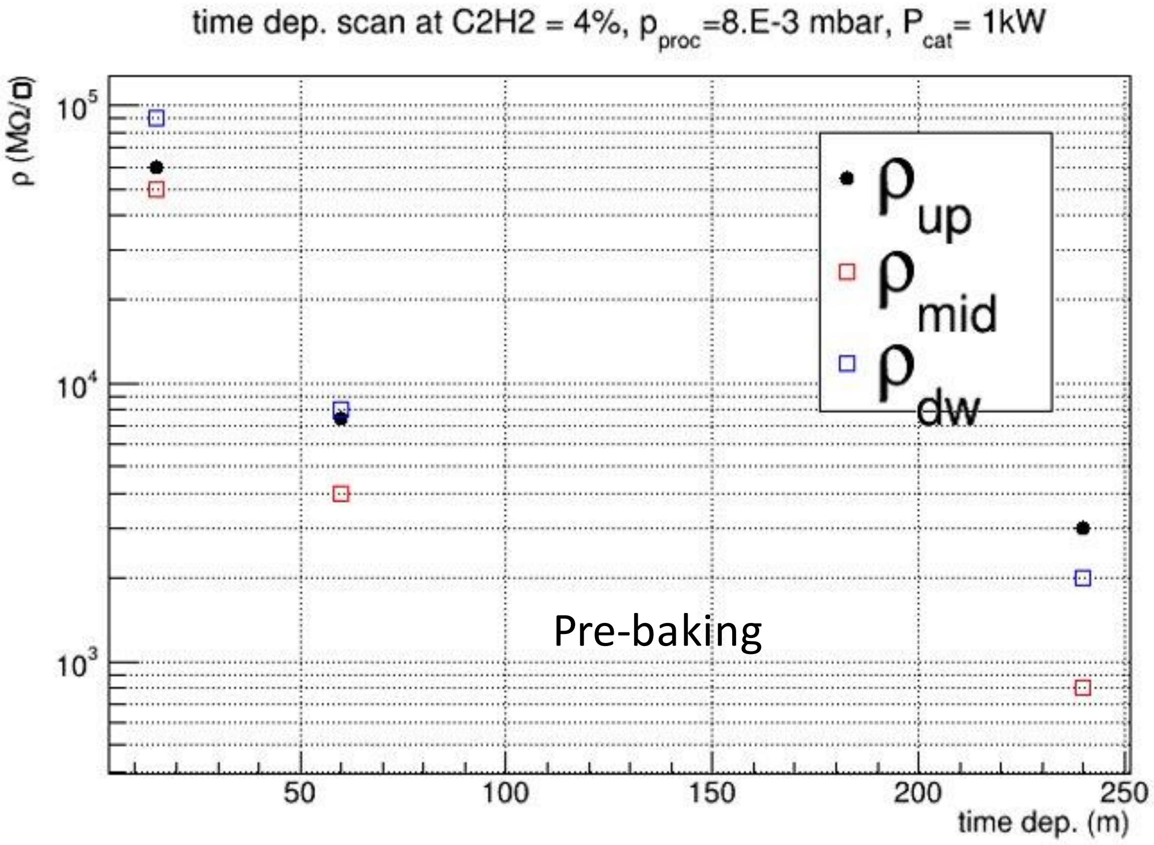


Stability with C_2H_2 (Sept. - Oct. 2023)

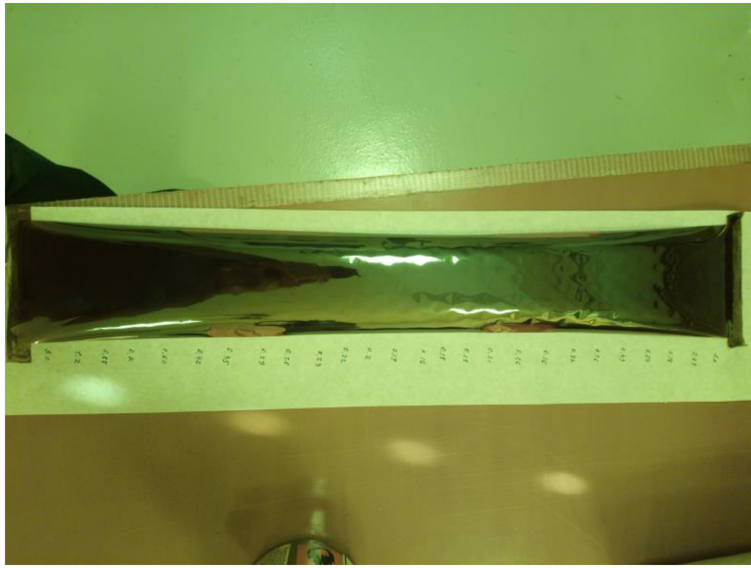


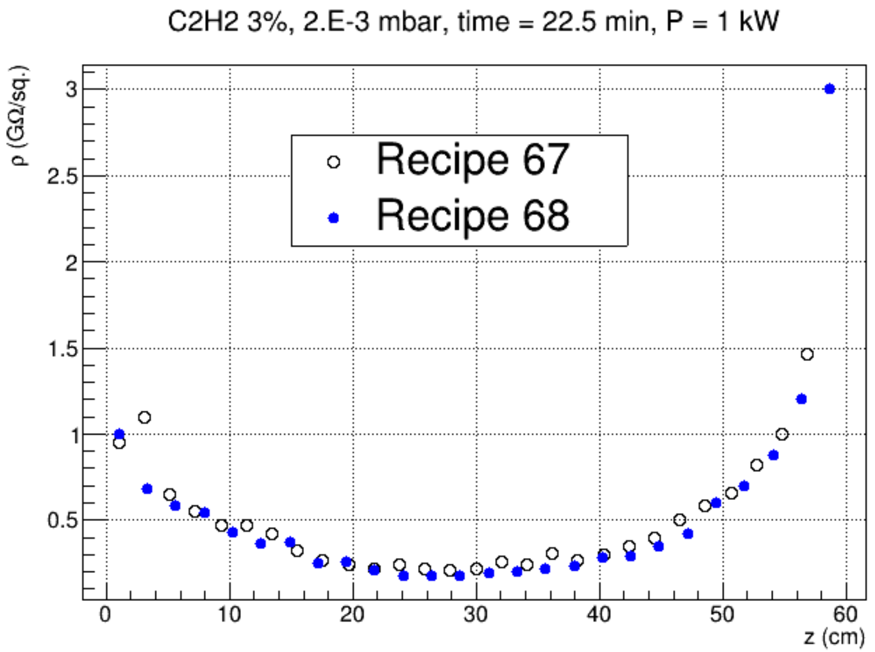
A drop after the baking and a small drift, but then very stable values

Deposition time and repetitivity test



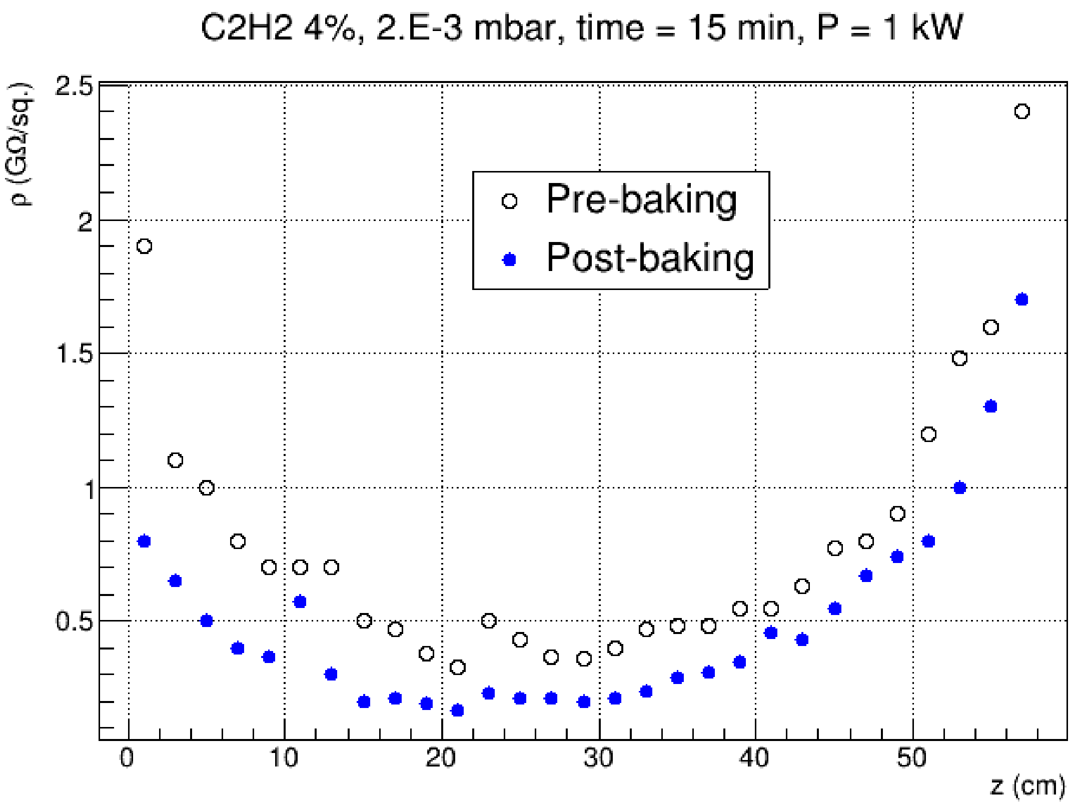
From now on, we use a single APICAL sample 60 x 10 cm2
We measure the resistivity along the longitudinal axis

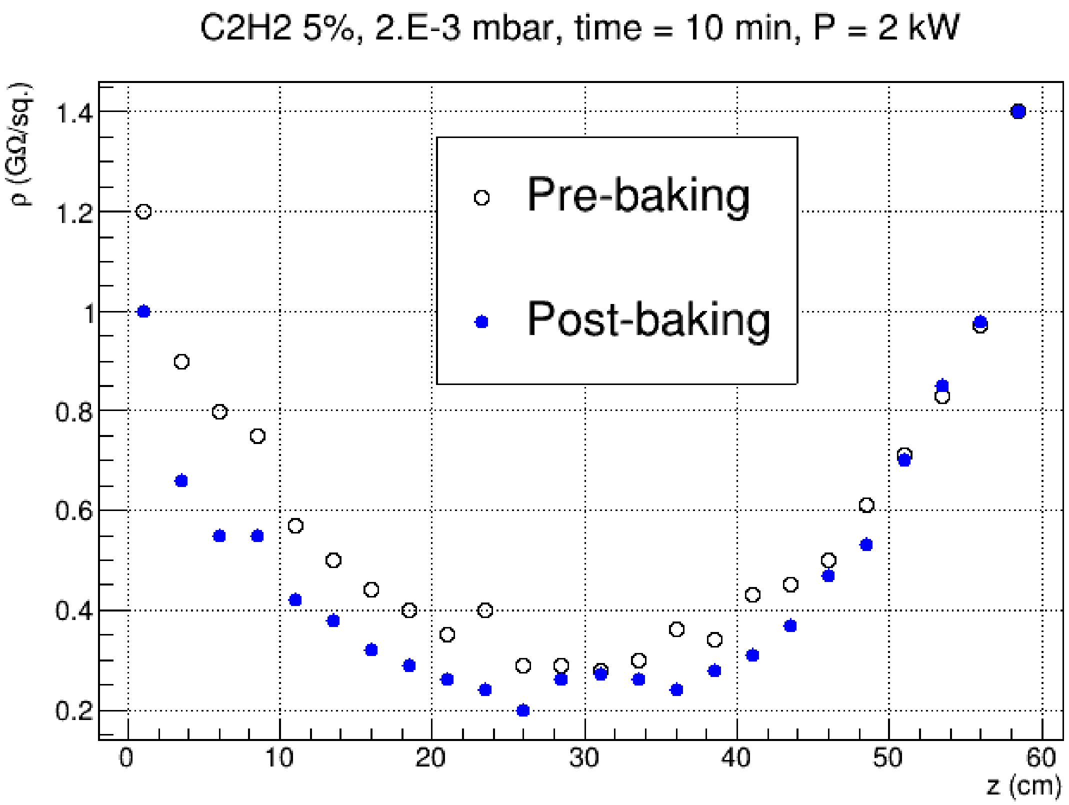




Confirmed the behaviour 1/t
Time can be an important parameter for the resistivity adjustment
WARNING = evidence of non-uniformity along z!

Uniformity test





The baking, as expected, doesn't change the thickness profile

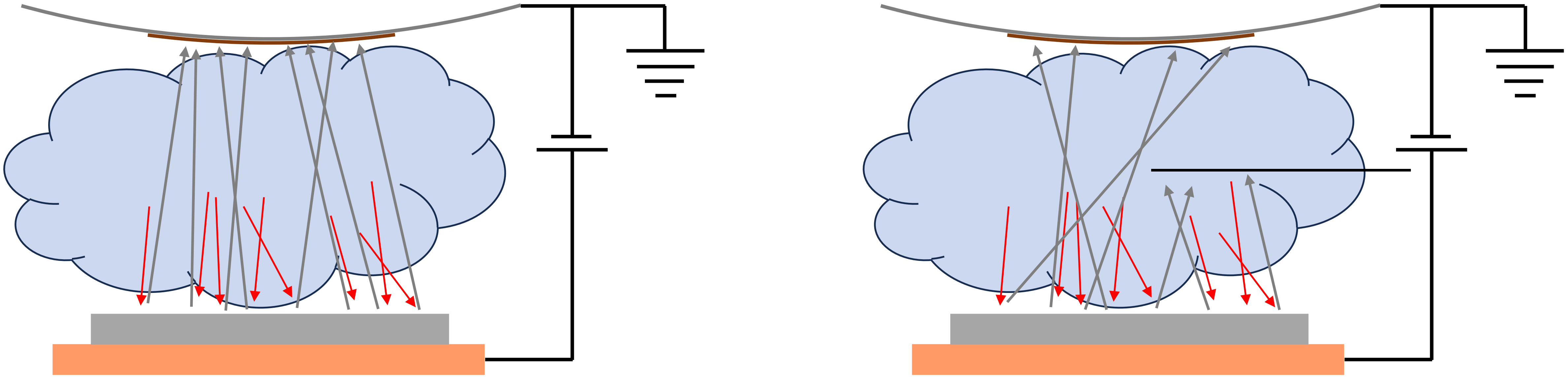
These tests pointed out that the deposition, along the axis, is uniform in a very narrow central region

We would like to have a uniformity ≤ 15%

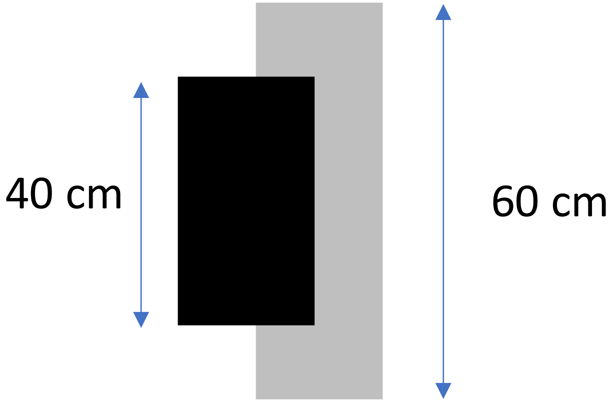
THIS REGION MUST BE EXTENDED

Summary of the test with C_2H_2 (Nov. 2023)

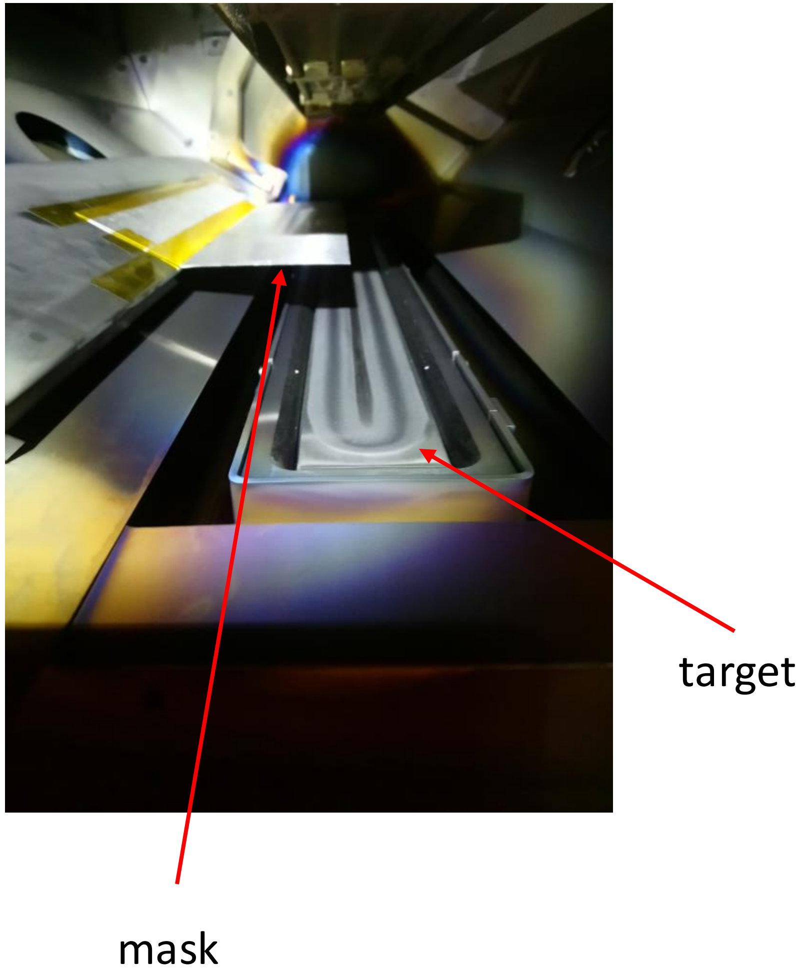
To improve the uniformity, Serge's idea is to install a mask stuck to the shutter to reduce the material extraction in the central part of the target

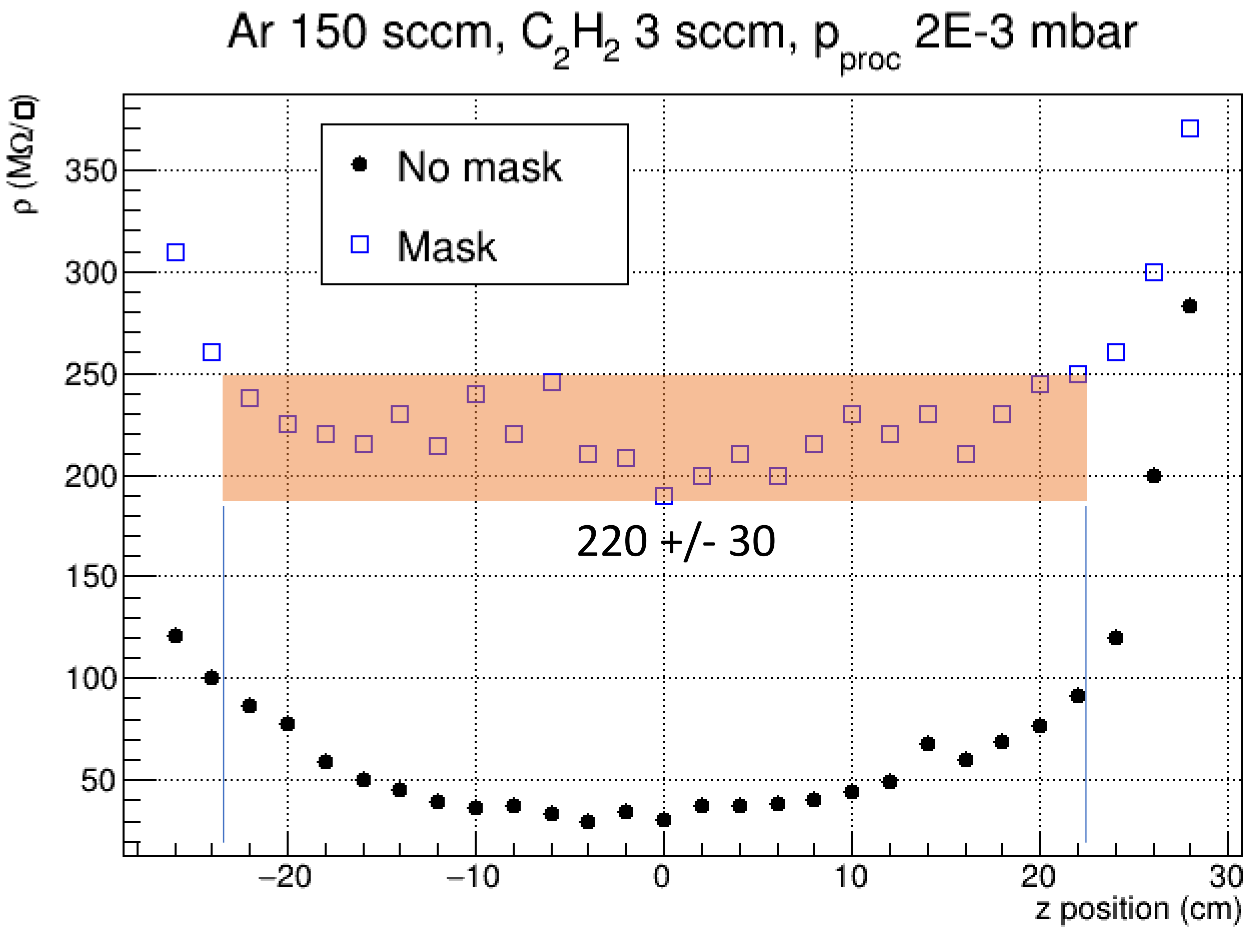


Lower extraction → thinner deposition → larger resistivity



Summary of the test with C_2H_2 (Nov. 2023)





The mask seems promising. The uniformity region has been extended to about 45 cm. Further improvements con be achieved with a different mask shape

Summary and plans

- Repetitivity of the results have been confirmed with different plasma composition
- The first tests with nitrogen have been very helpful to understand and confirm the dependence of the resistivity on the plasma composition and pressure
- Nitrogen does not help in stability
- Acetylene seems very promising as the wanted resisitivity can be obtained with different recipies
- The uniformity along the vertical axis have been remarkably improved with the insertion of an aluminum mask (to be optimized)
- Next tests (early 2024) dedicated to deposition on a large area APICAL foil (170 x 60 cm2)