Détecteurs pour le spectromètre Lise

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Journées 2023 de l'atelier détecteurs gazeux

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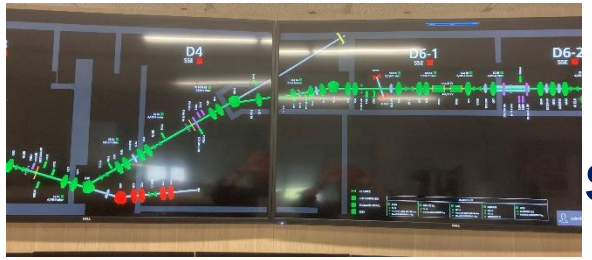
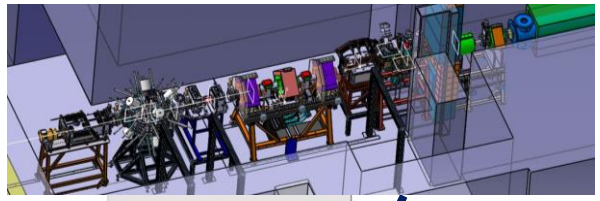
Institut de Physique des 2 Infinis de Lyon

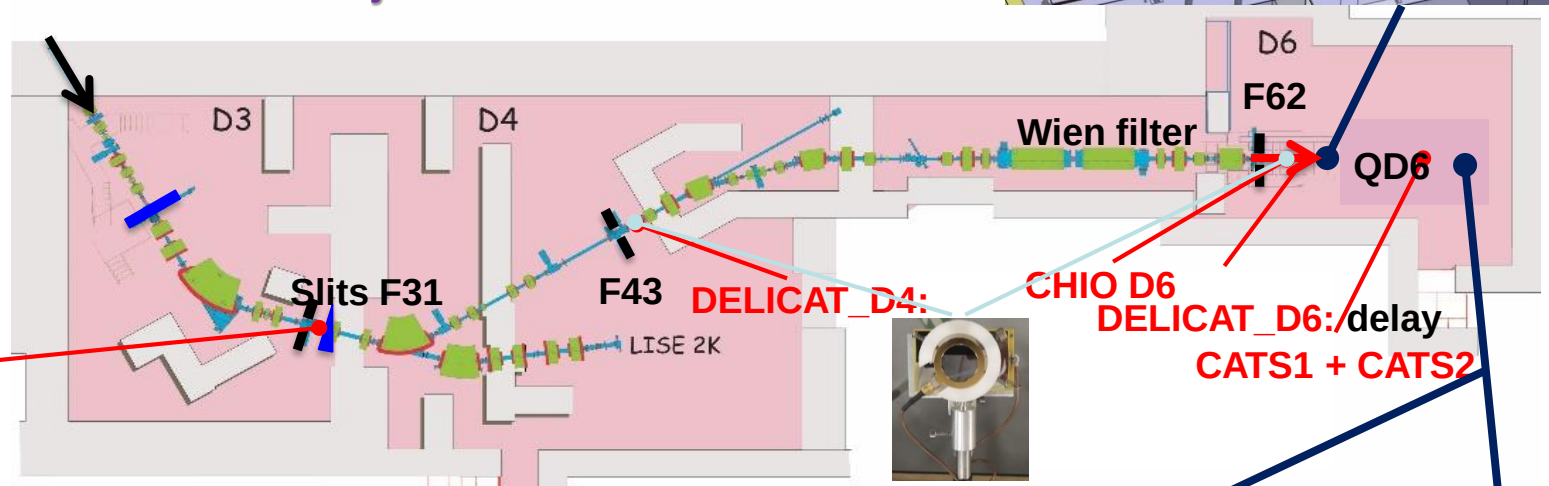
LISE spectromètre



LISE 2023
Campagne MUGAST
Test: 17-19 mars
Manip:-17-19 avril & 29mai-2juin

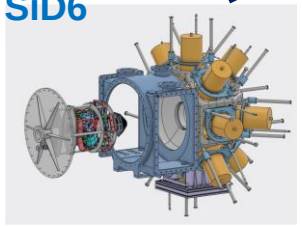
Setup MUGAST+EXO+ZDD

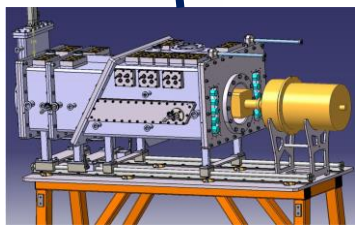




Gas detectors: isobutene at 6 to 300 mbar
EXOGAM*13 -> LN_2

CAVIAR CATS/CFA CHIO





MUGAST + EXOGAM2 + ZDD (DC + IC)

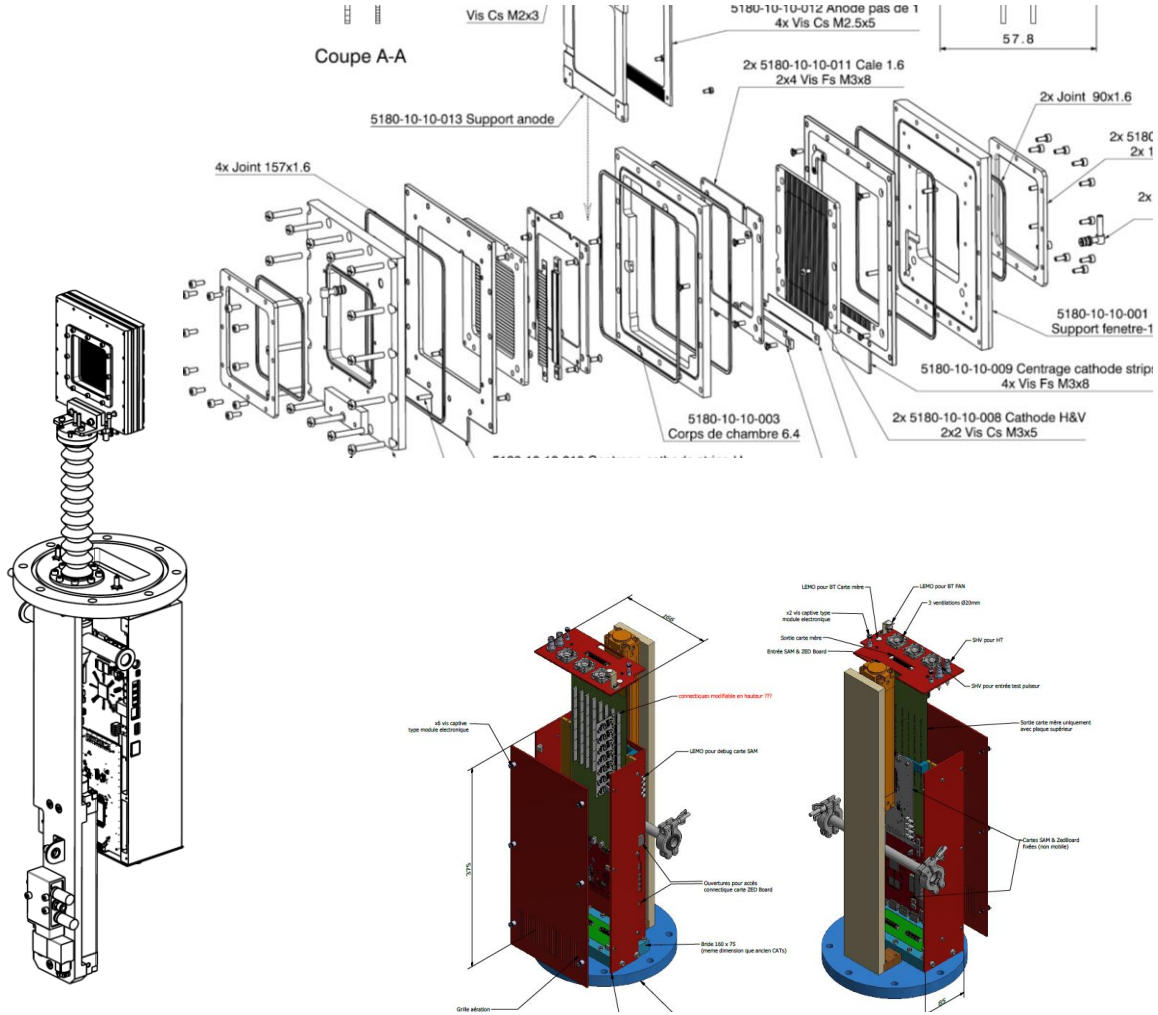
Existing trackers

Two type of tracker operated at low gas pressure for measurements of time and position - CATS and CAVIAR.

The difference - signal readout method for position.

Detector CATS has signal readout from stripped cathodes

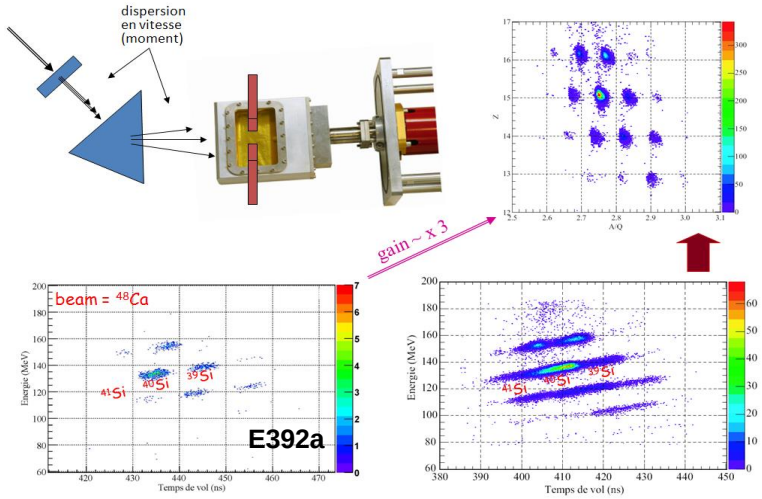
Detector CAVIAR has output signals from anode wires

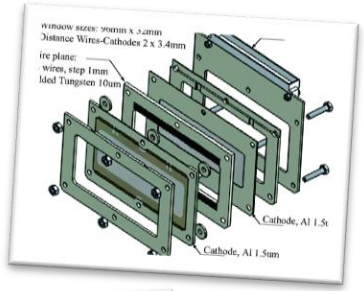


Upgraded version CATS tracker witn new FrontEnd electronic and mechanic

CAVIAR detector

- Provide magnetic rigidity (Bρ) measurement
- Improve A/Q identification
- Gain in counting rate of particles of interest





Sensitive area : multiwire proportional chamber

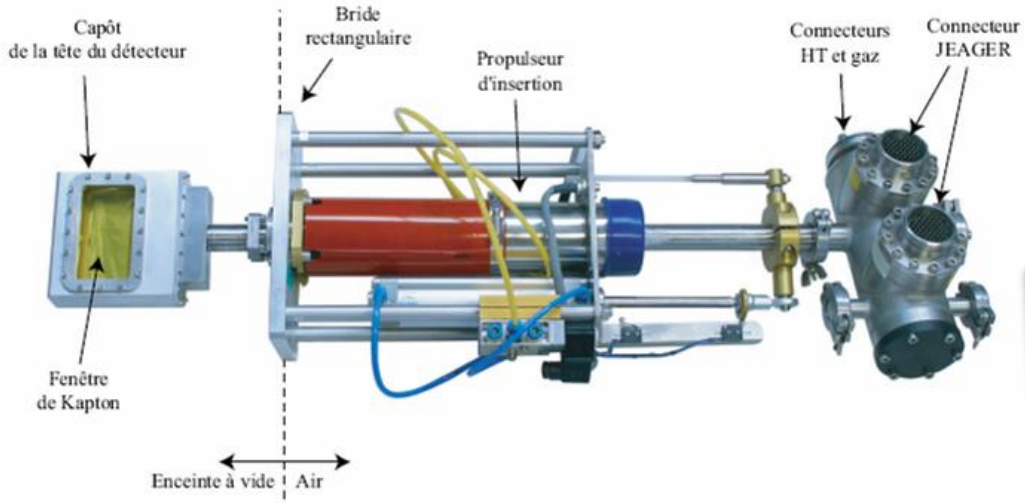
- 96 wires
- step = 1mm

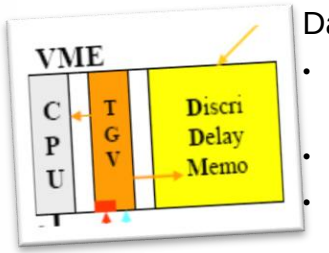
Gas unit

- gas : C4H10
- pressure : 10mBar

Electronic Front End

- charge preamplifier adapted
- max rate per wire : 10kHz



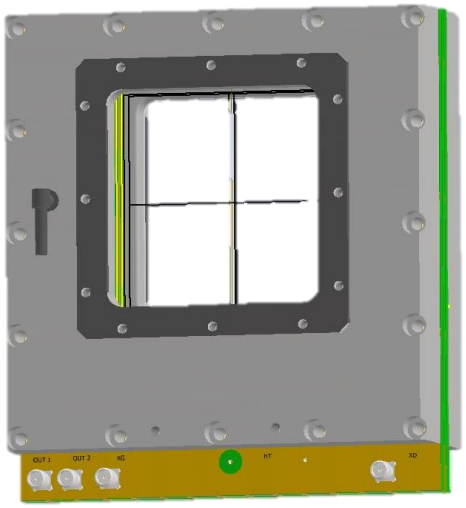


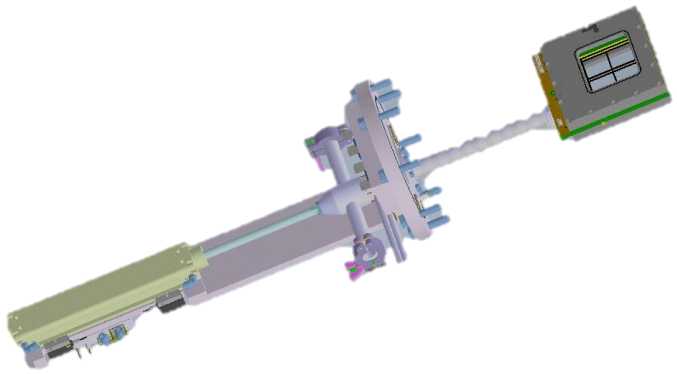
Data acquisition system

- 16 channels discriminator : -1mV to -256mV, step : 1mV
- delay : 200ns to 25,8µs, step : 25ns
- GANIL : development of a specific module : DDM16

Detector DELICAT

(DElay LIne CATs)

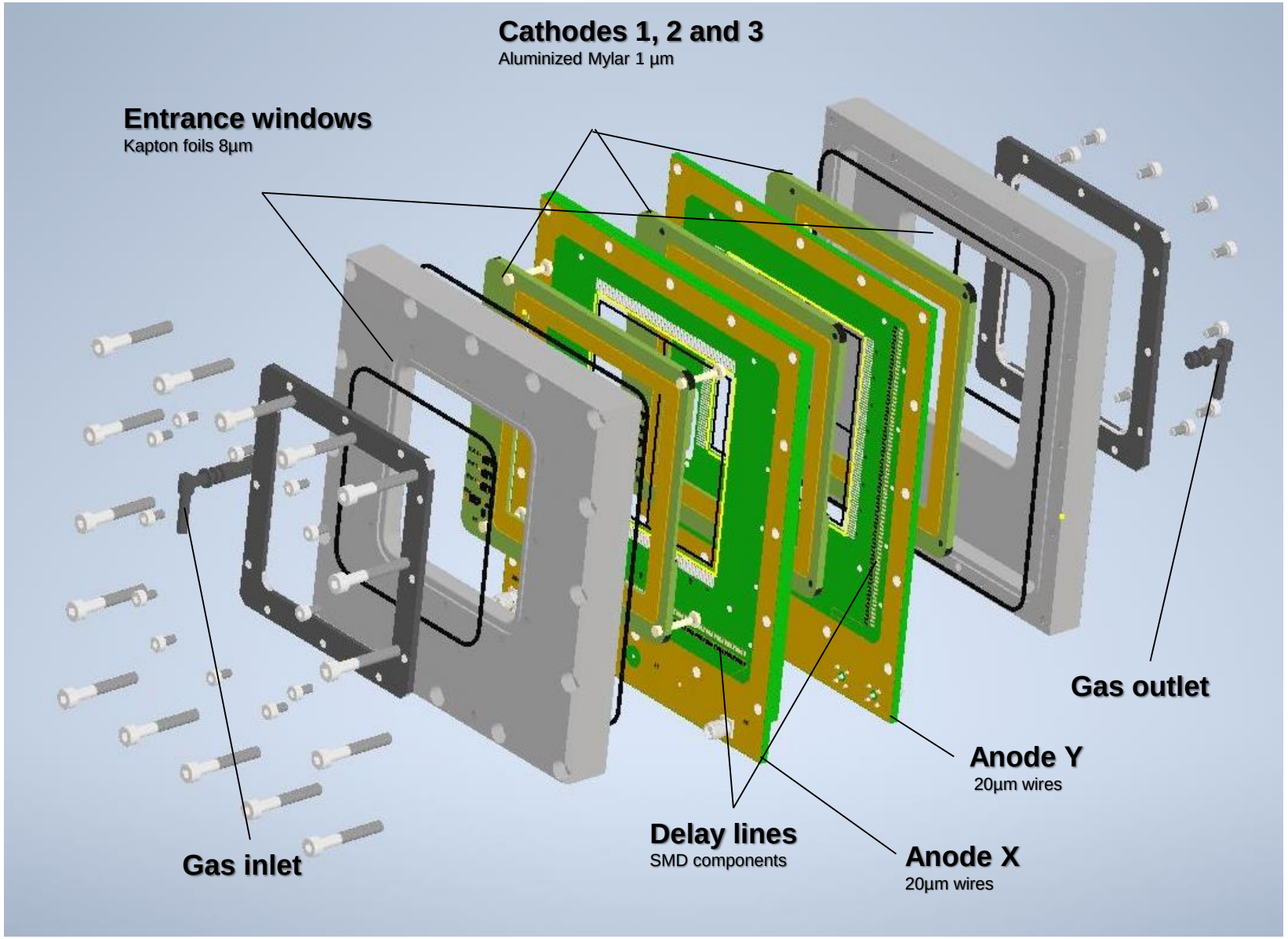




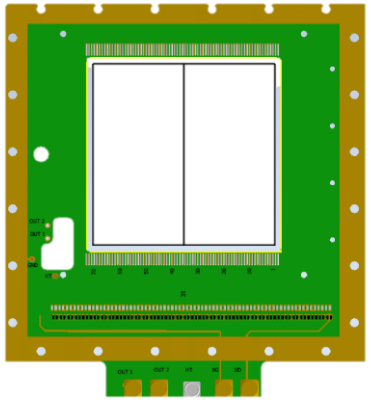
Tracker requirements

- ✓ ***Measurements of X position in D4 (F43) and Y position in D6 (F62), but preferably both, especially in D6***
- ✓ ***Entrance windows for detector in Kapton or Mylar with thickness ≤ 8 µm***
- ✓ ***Active size 70mm × 70mm***
- ✓ ***Working points similar to CATS or CAVIAR, about 10 mbar of pure isobutene***
- ✓ ***FrontEnd and ACQ: Fast signal on AR8 / FTA820 plus CFD for timing going to a TAC and to NUMEXO2, Fast signal also from wires on AR8 / FTA820 plus CFD going through delay lines to a TAC and NUMEXO2***
- ✓ ***2 to 3 similar detectors to build, 1 in D4, 1 in D6***

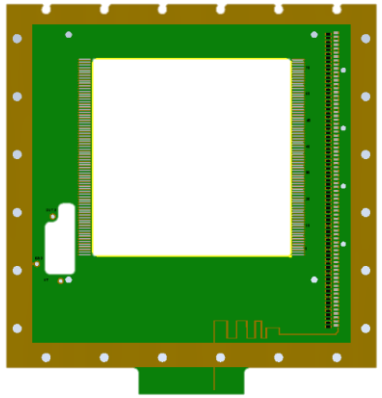
Conception of detector



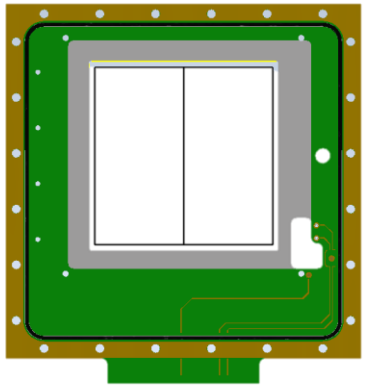
Anode X
(front view)



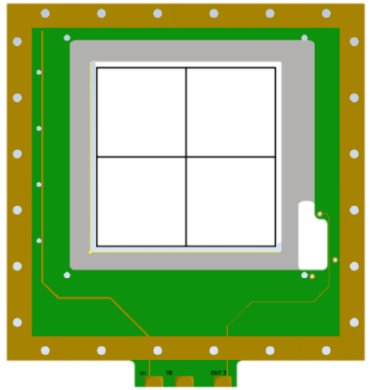
Anode Y
(front view)



Anode X
(back view)

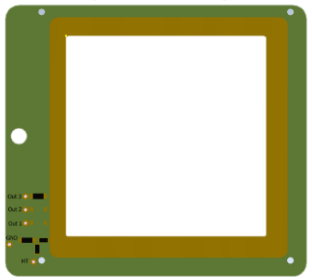


Anode Y
(back view)



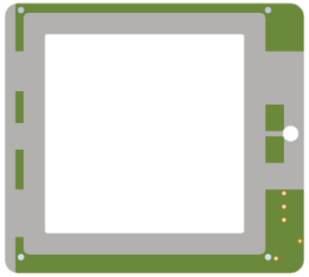
- Central opening (active area) is 75 mm × 75 mm
- Total 75 tungsten wires of 20µm diameter with distance 1mm (for X and Y planes)
- Delay line is realized on PCB using CMS components (capacitance and induction) in standard 0603 (1,6mm × 0,8mm × 0,8mm)
- PCB has 3,2 mm of thikness
- PCB has SMA connectors at the bottom for signal output for position and time signals from cathodes

Cathode
(front view)



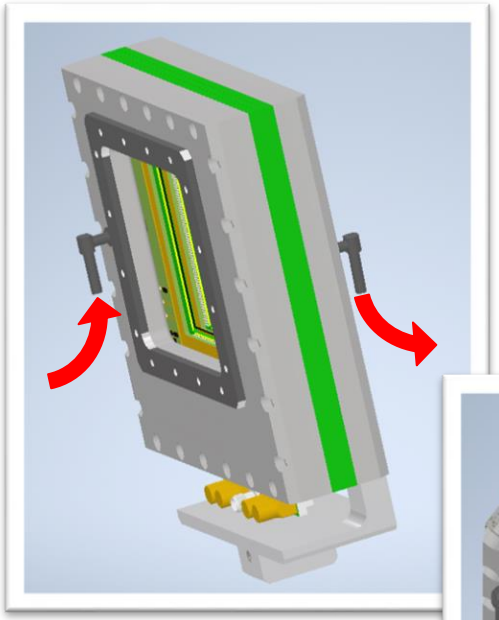
- Each cathode has fast signal output for time measurements
- HV filter is realised on a PCB with SMD components
- Mylar or Al foil is directly glued on PCB (golden pad)

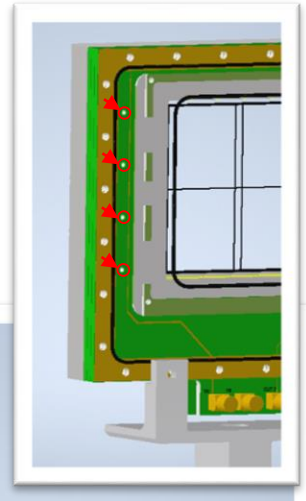
Cathode
(back view)

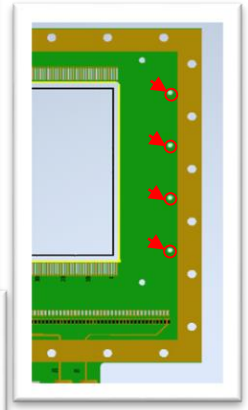


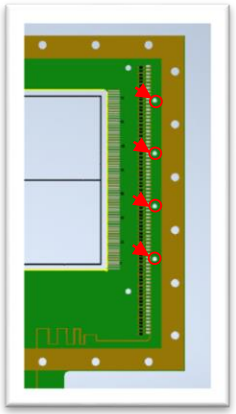
- Clearance on the opposite face around the central opening for soldered X and Y anode wires.
- Opening at one side of PCB are used for gas circulation

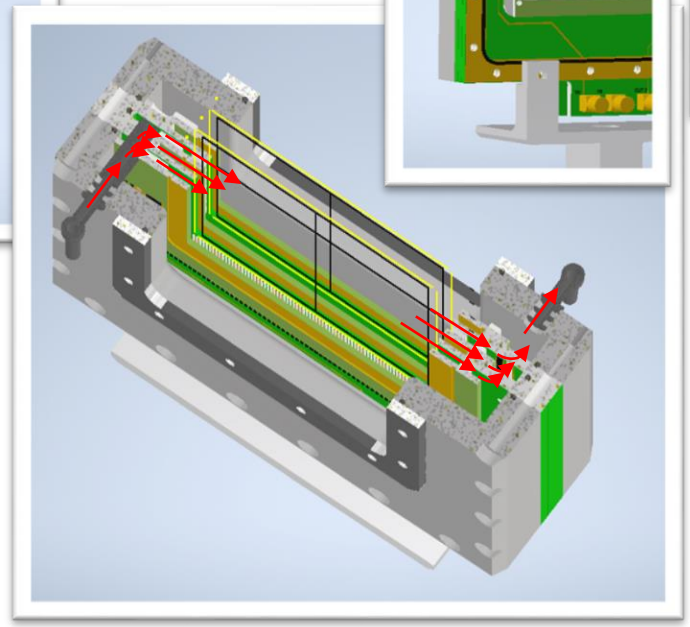
Gas circulation through Anodes / Cathodes stack

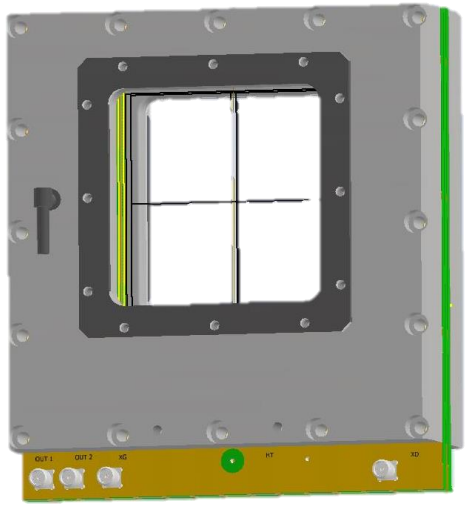




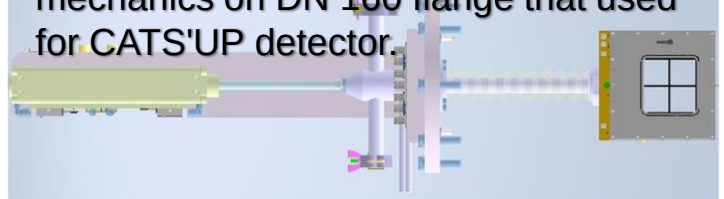


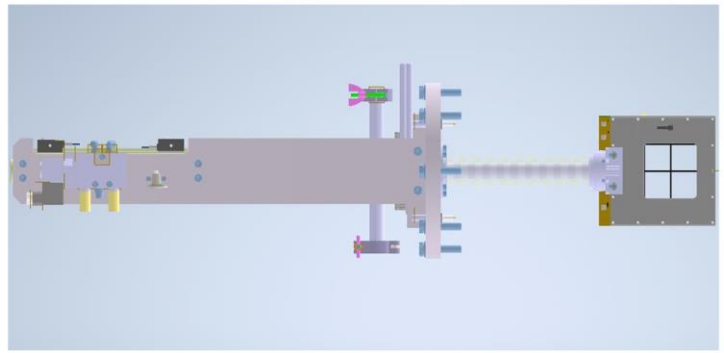




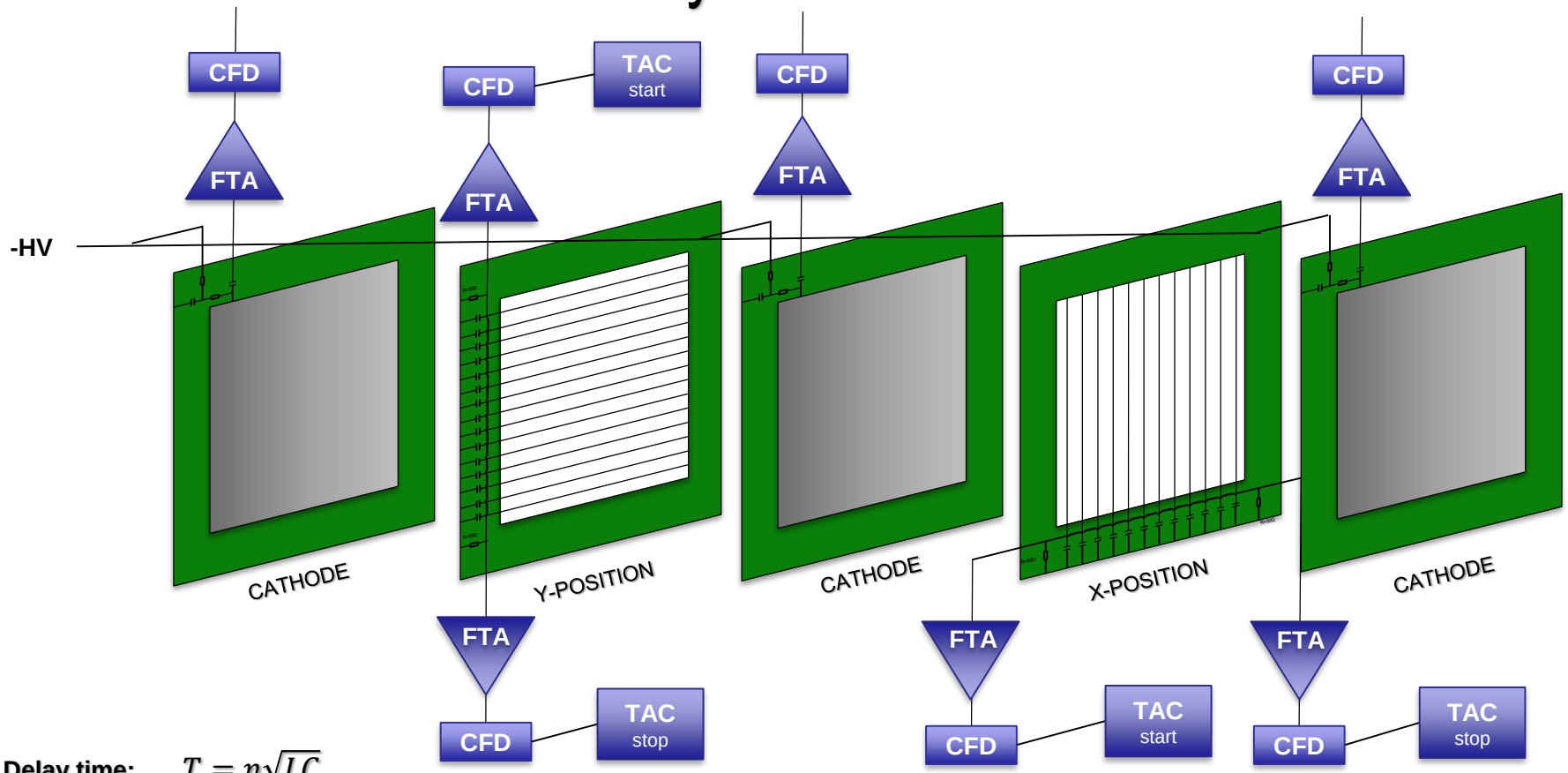


Detector has the same insertion mechanics on DN 160 flange that used for CATS'UP detector.





Delay line readout



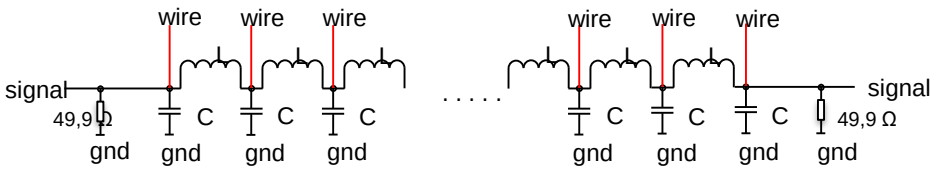
Delay time: $T = n\sqrt{LC}$

Characteristic impedance: $Z = \sqrt{L/C}$

For capacitance *C = 39 pF* and inductance *L = 95 nH*, *n = 75* wires

Characteristic impedance *Z = 49,35 Ohm*

Delay line cell is *1,925 ns* and total delay time *T = 144,4 ns*



Electronics

FTA adjustment
ORTEC 820

Using IT100 inverter for input signals from cathodes (positive polarity)

CFD adjustment
CAEN N605

Delay line = 2ns
Threshold = 13mV
Walk = ~ 0mV

TAC adjustment
ORTEC 566
(2 modules - X and Y)
Delay start-stop = 150ns
Range = 50ns

FTA
Fast Timing Amplifier

ORTEC 820

CFD
Constant Fraction Discriminator

CAEN N605

TAC
Time Amplitude Converter

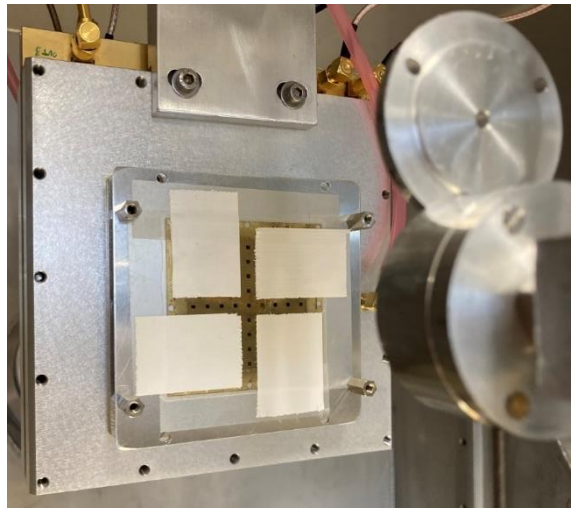
ORTEC 566

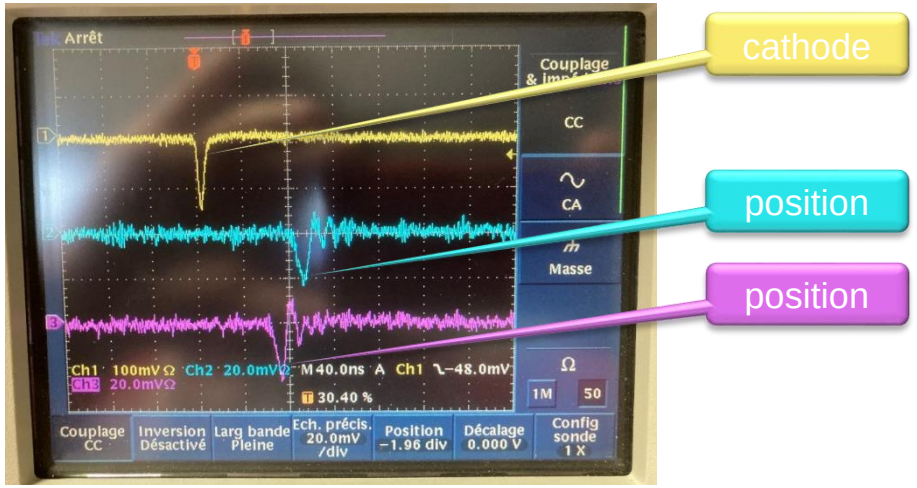
HV adjustment
MESYTEC MHV-4

Polarity - negative
Current limit -1nA
HVmax tested - 580 V

MESYTEC MHV-4

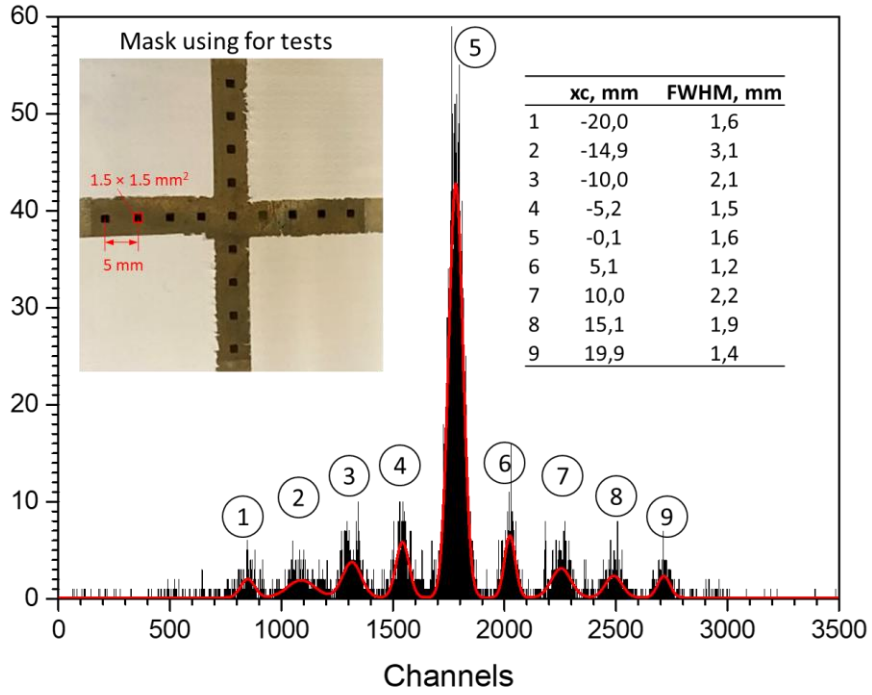
Test with α source for spatial resolution





Test with α-source at standard conditions:

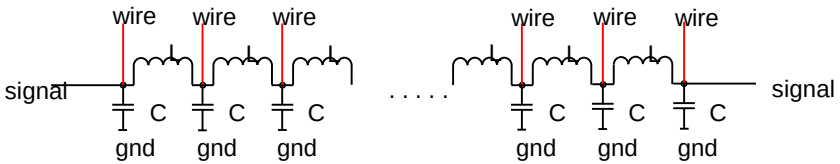
Gas – isobutane (iC4H10)
Presure – 6 mbar
Flowrate – 30 cm3/min
HV - 560 Volts (negative)

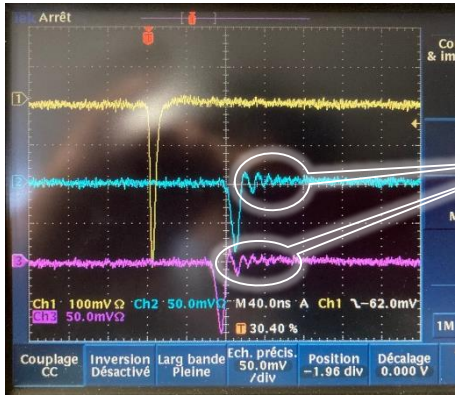


	xc, mm	FWHM, mm
1	-20,0	1,6
2	-14,9	3,1
3	-10,0	2,1
4	-5,2	1,5
5	-0,1	1,6
6	5,1	1,2
7	10,0	2,2
8	15,1	1,9
9	19,9	1,4

Attempt to modify schema to avoid the ringing in output signal (adding 500 kOhm resistance)

Plan X (standard)



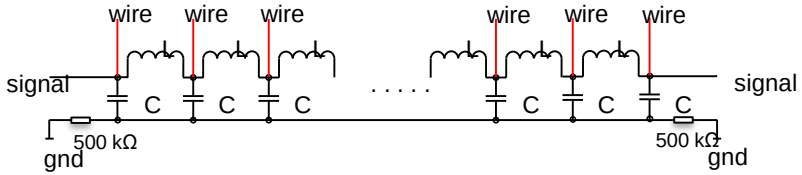


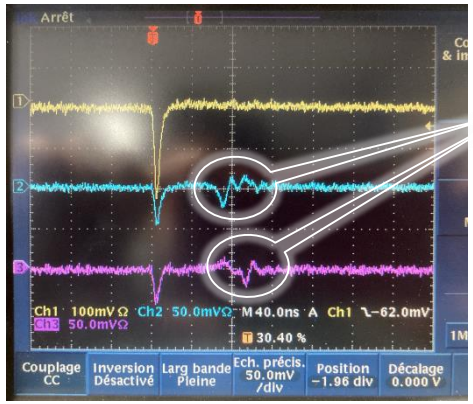
Ringing effect in pulses

Probably due to mismatch of impedance?

We are able to obtain spectrum, stayed with standard schema

Plan Y (modified)



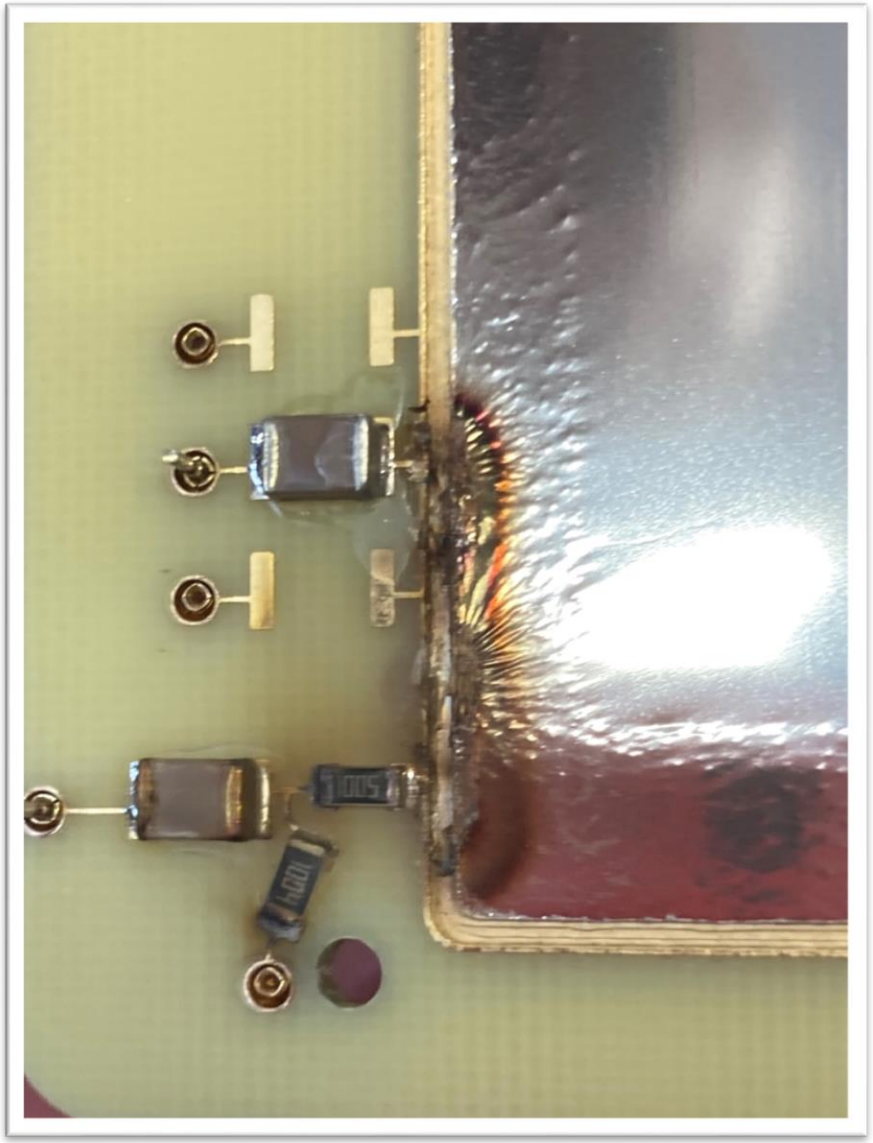


Amplitudes of pulses are less and appearance of secondary pulses

Secondary pulses trigger the CFD, as a result, information about the position is lost.

NOT WORKING

Result of multiply voltage breakdown at cathode

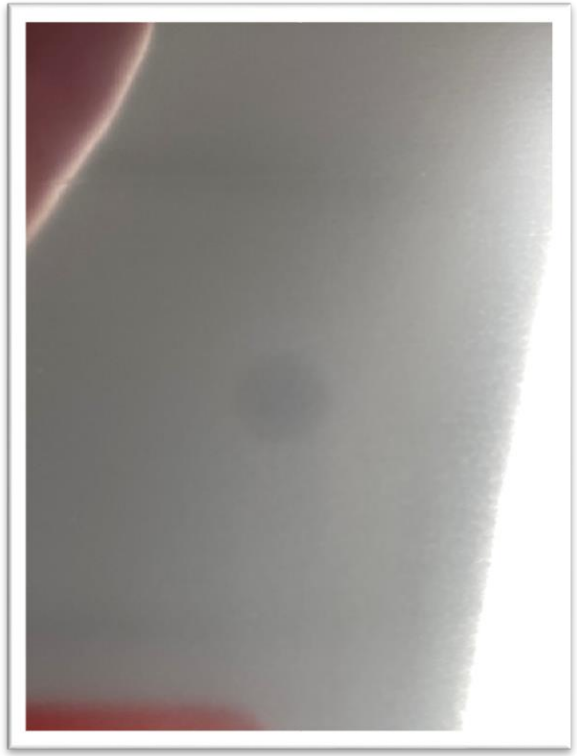


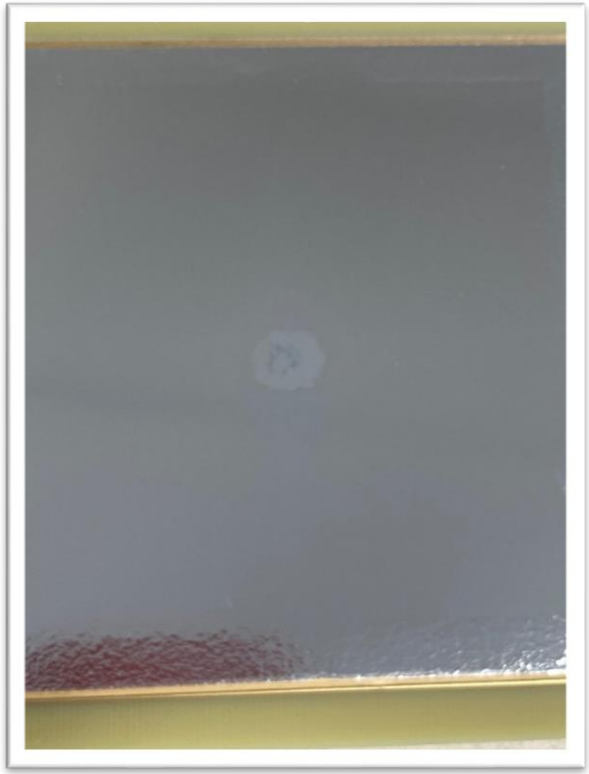
Detector was operated at 560 V during the night.
Multiply breakdowns are occurred during the data acquisition

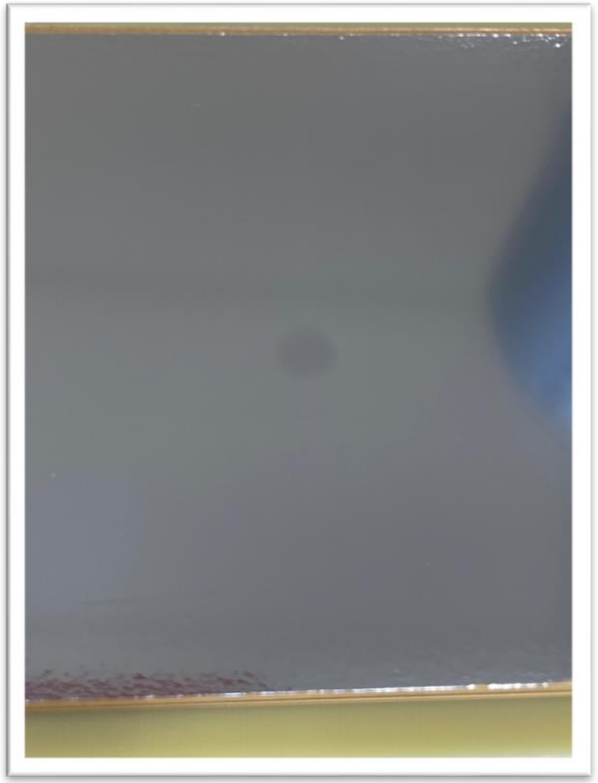
Traces of sparkling were localized in the places where conductive glue is applied
The conductive glue had a non-uniform structure, which could create irregularities on the surface. After dissolving with acetone, the glue became more liquid and was applied again.
A varnish was also applied to the high-voltage capacitor.

After these manipulations, it was possible to achieve a stable HV 580V without any breakdowns. Voltage breakdowns start from 590-600 volts.

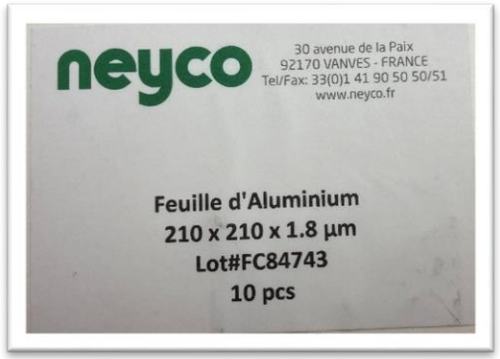
Results of cathodes exposition by beam during experiment







Cathodes – aluminized mylar 0,9 µm

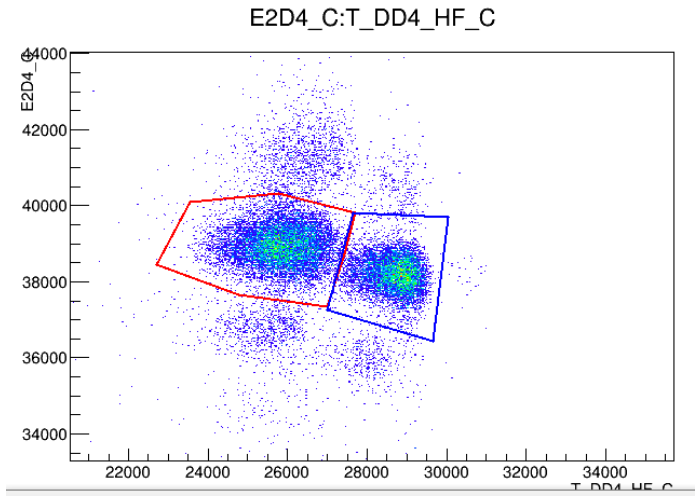


Mylar was remplaced by aluminium foil 2 µm

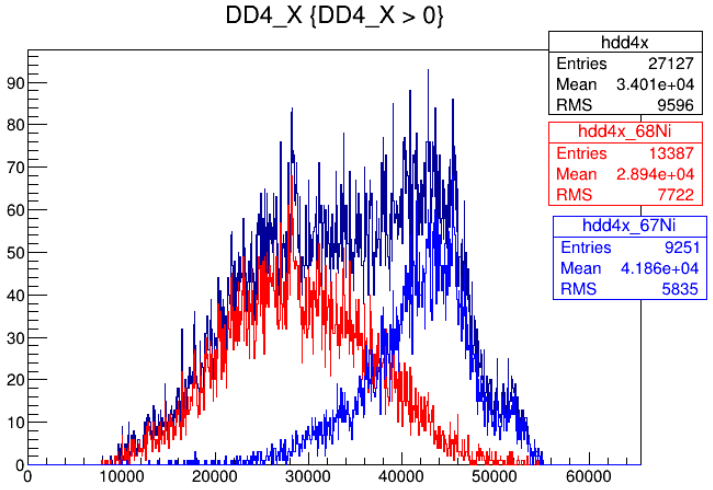
Feedback from experiment

CHIO_LISE

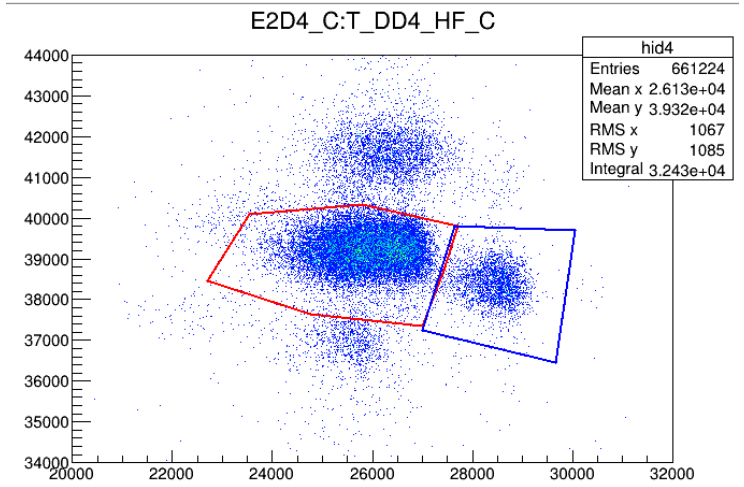
Run 441

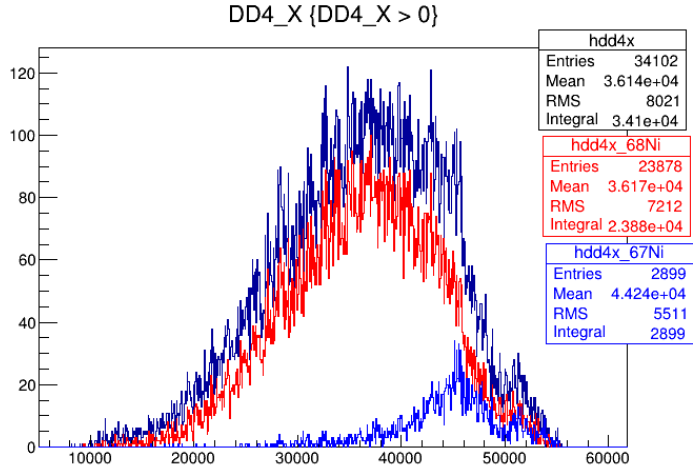


DELICAT_D4



Run 442





Outlook

- A new tracker has been developed for the LISE spectrometer to replace the existing CAVIAR detector. The new tracker was successfully used during the last physical campagna of 2023 at LISE spectrometer.
- Using the delay line readout reduces the number of electronic channels required. In addition, the new detector uses the same mechanical insertion flange as the CATS detector. These design choices make it possible to create a more cost-effective and standardized tracker with improved performance.

Issues, questions and propositions:

- The issues related to electrical breakdown have been successfully resolved
- The cathodes of aluminized Mylar have been replaced with aluminum foil
- Qualification tests are still needed to evaluate the registration efficiency in relation to applied HV and gas pressure
- There is potential to enhance the registration of light mass particles by increasing the gas pressure and/or using C3F8 gas

Thank you for your attention !