Mid-Scale Drift Chamber Prototype: Design and Construction

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on behalf of

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DUNE Pavia: *D. Calabro, G.L. Raselli, M. Rossella*

Dune Italia Meeting
10-12 November - LNF

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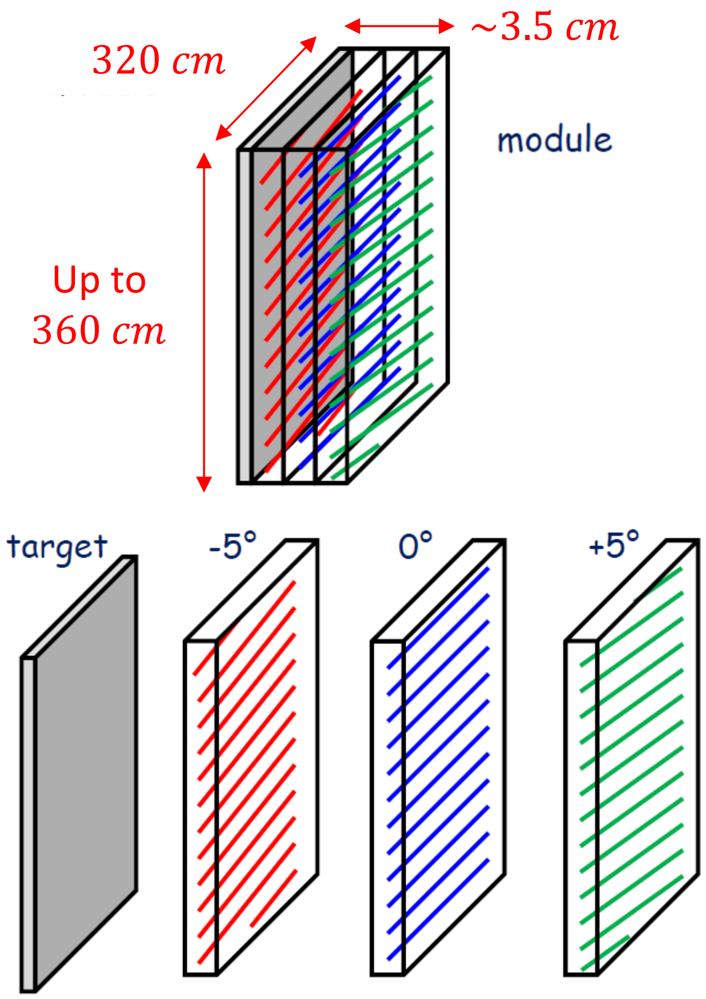
The Drift Chamber Concept



- Backup solution for the SAND tracker
- **Same target configuration** as for the STT
- **Reduces the number of channels** (and the complexity), ensuring the **same performances**
- **2 prototypes** have been successfully built and operated in Bologna

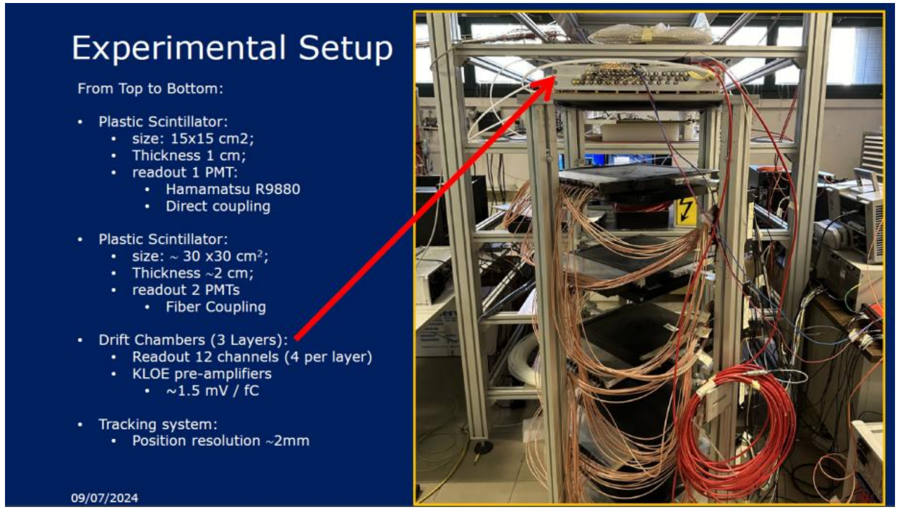
Module layout:

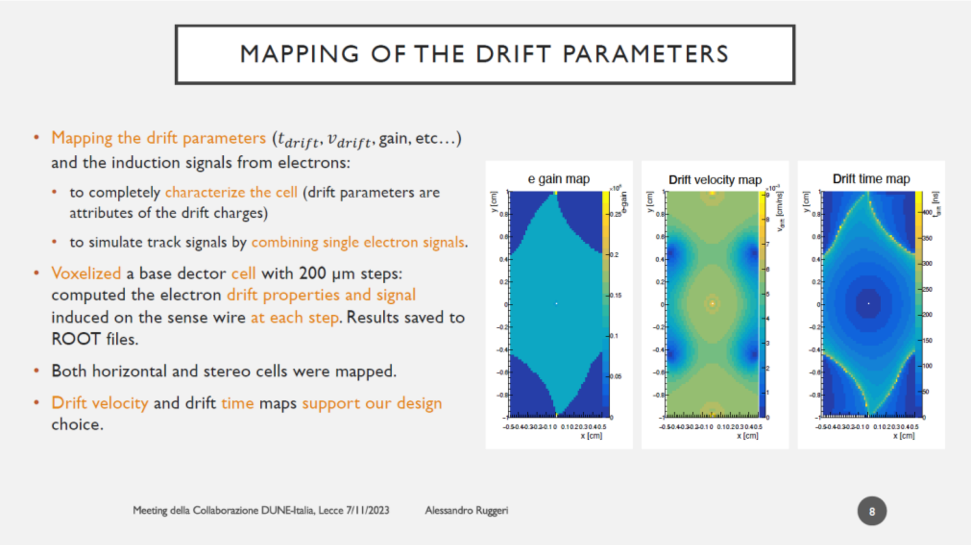
- Target layer of CH_2 or C
- **3 multiwire planes** with **stereo view**

The Road So Far…

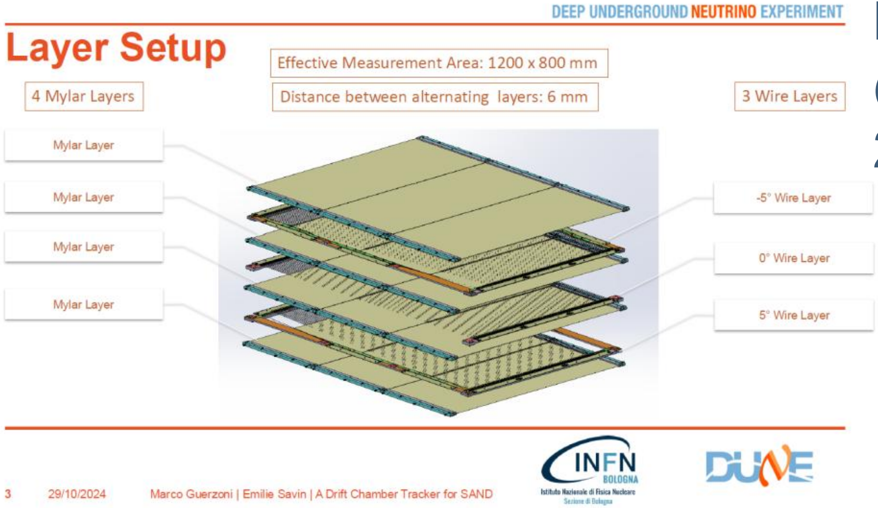
- Drift cell simulations with Garfield
- Mid-scale prototype mechanical design
- Test of the small-scale prototype

M. Pozzato
@ CSN1 Review
2024





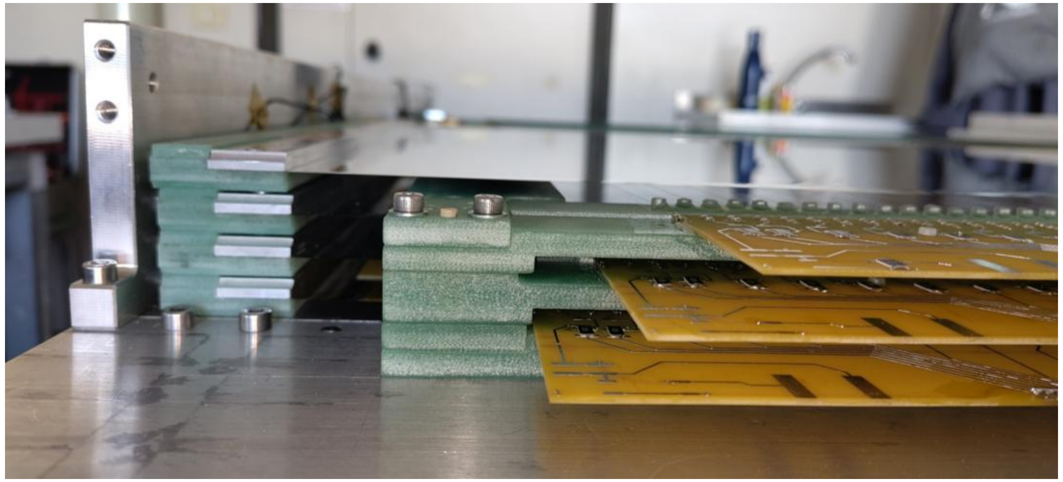
A. Ruggeri @ DUNE Italia 2023

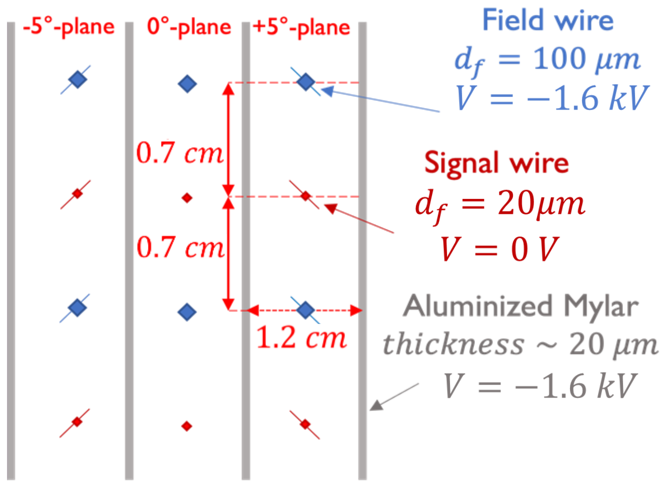


E. Savin
@ DUNE Italia
2024

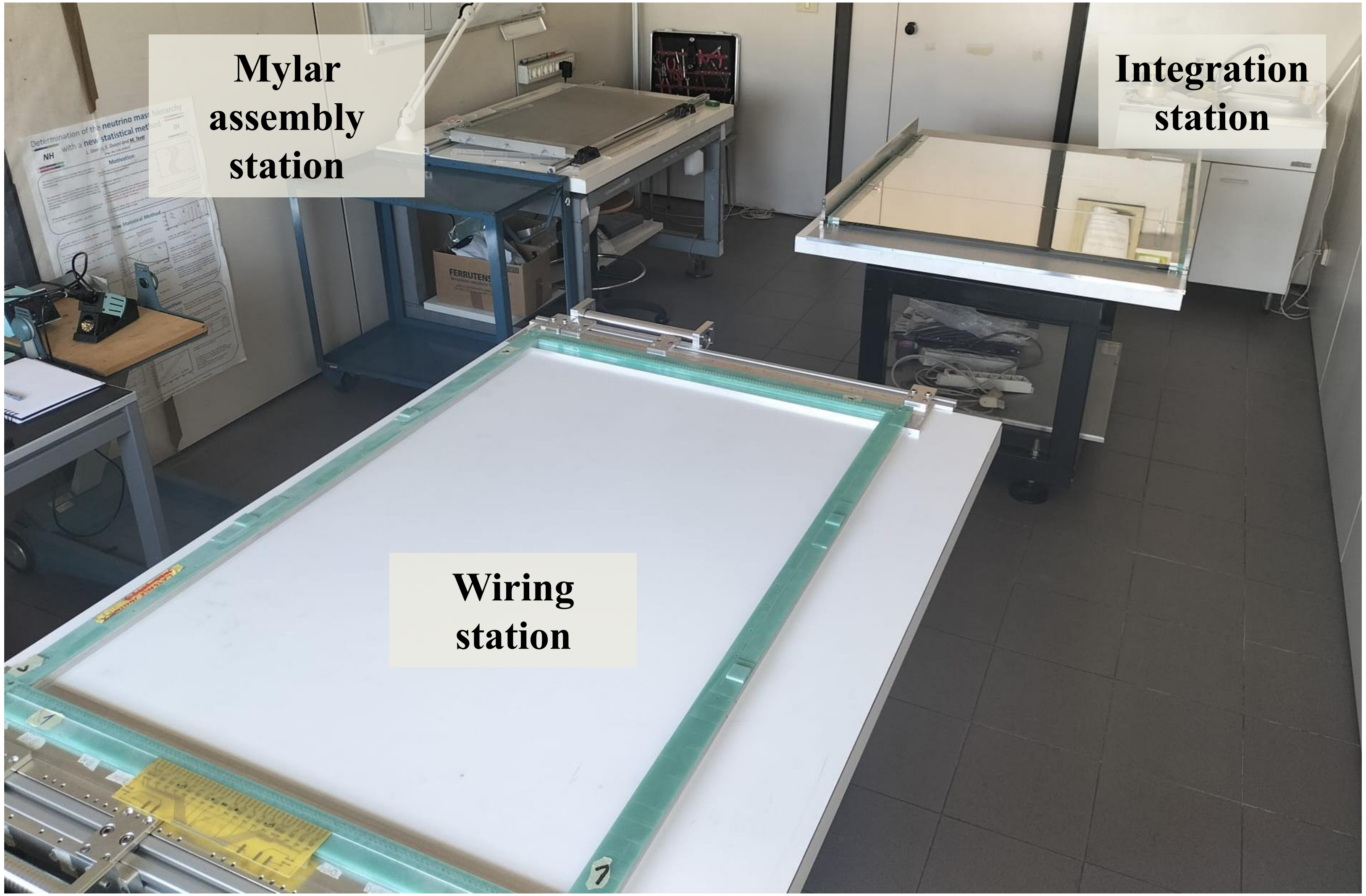
The New Prototype

- **120×80 cm²** active area
- **wire planes** with stereo angles (-5°, 0°, +5°)
- **4 segmented mylar planes** (20 μm thick)
- Gold-plated tungsten **sense** wire (20 μm)
- Copper-beryllium **field** wire (100 μm)
- **168** readout channels
- Gas mixture **Ar-CO_2 85/15**



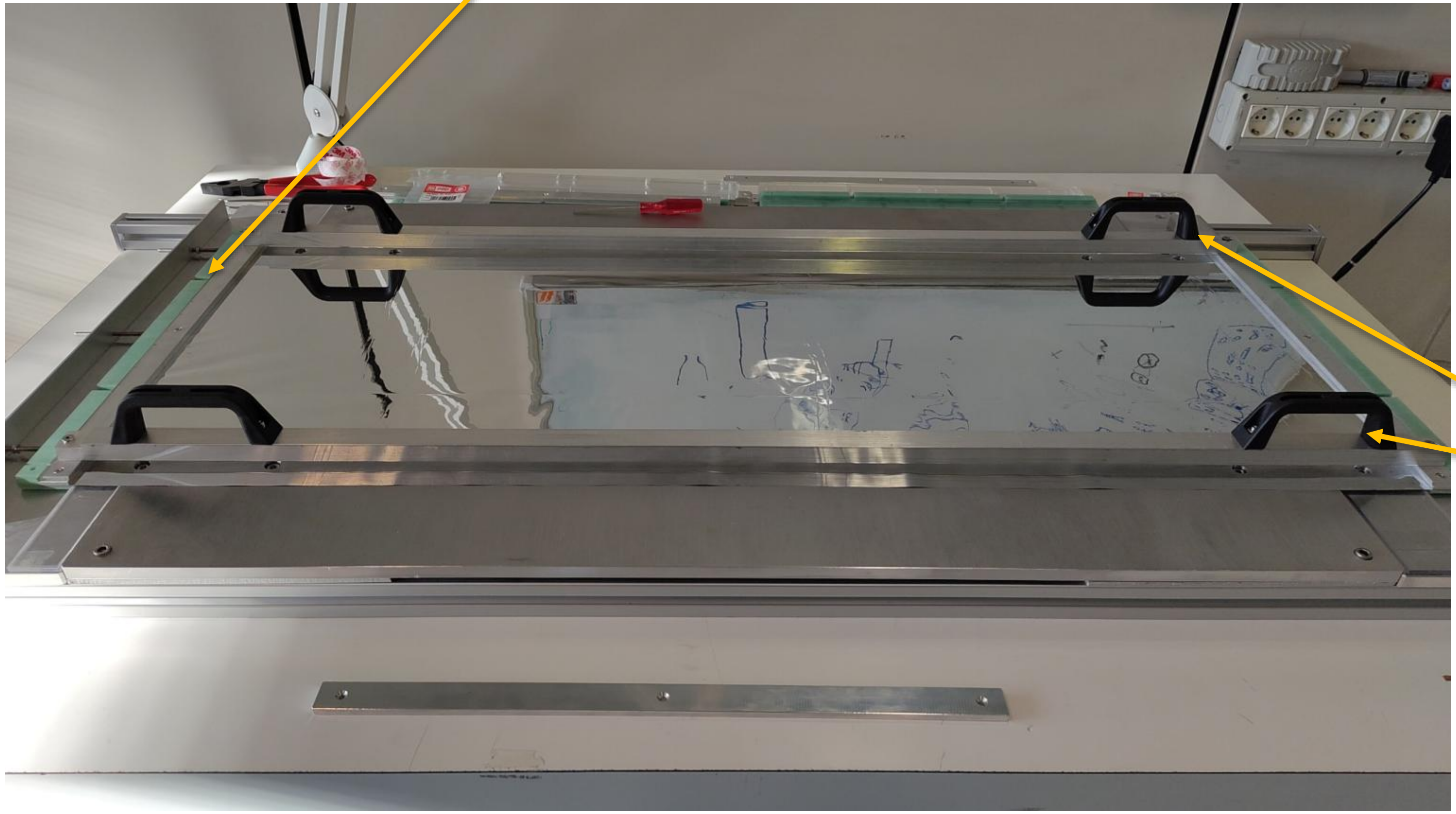


The Assembly Setup in Bologna



Mylar Layer – Assembly

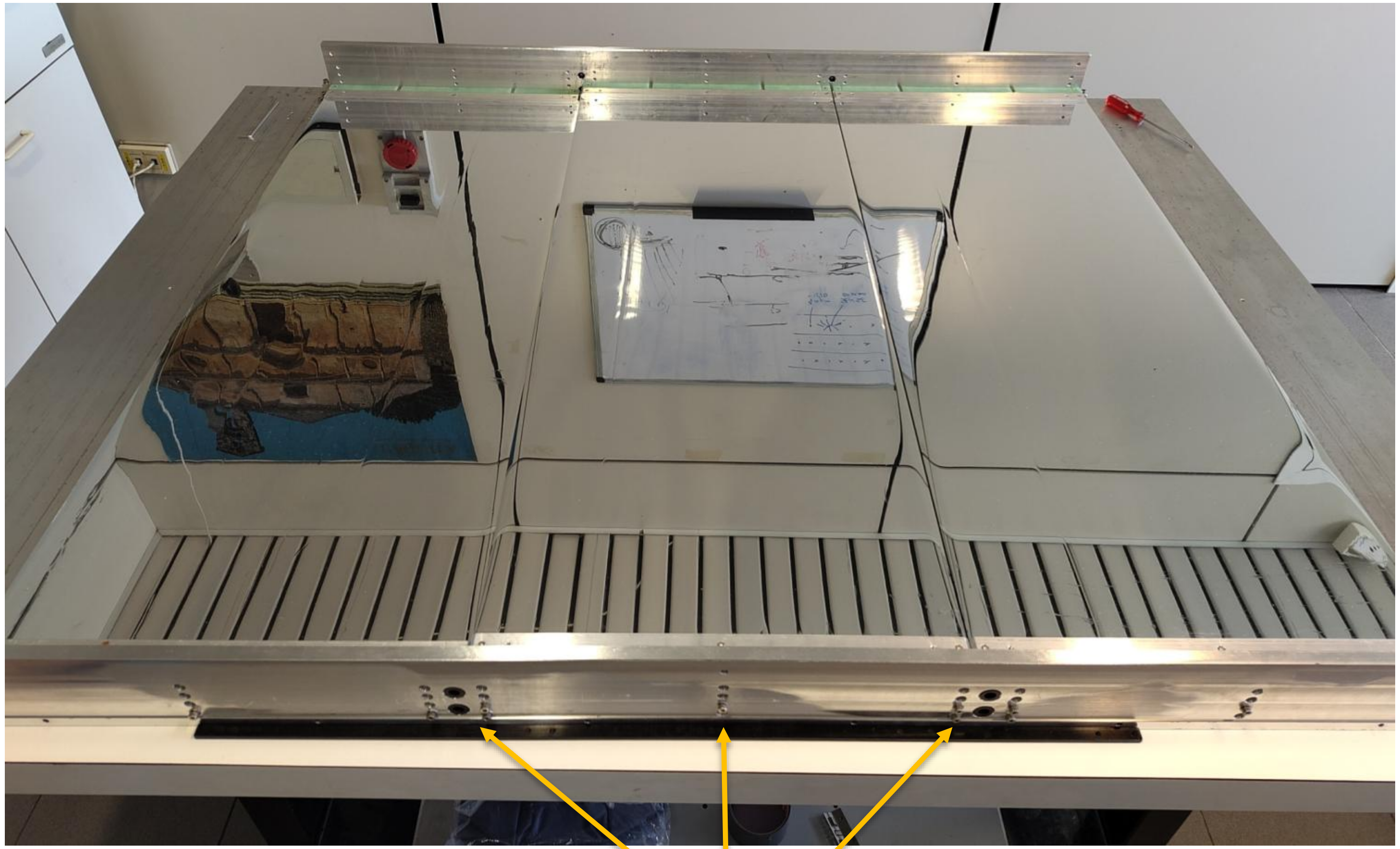
The Mylar sheet is laid on a flat plane to **avoid uneven tensions** and glued on two Stesalite bars with double-sided adhesive tape.



Tools to transfer Mylar sheets

Mylar Layer – Integration

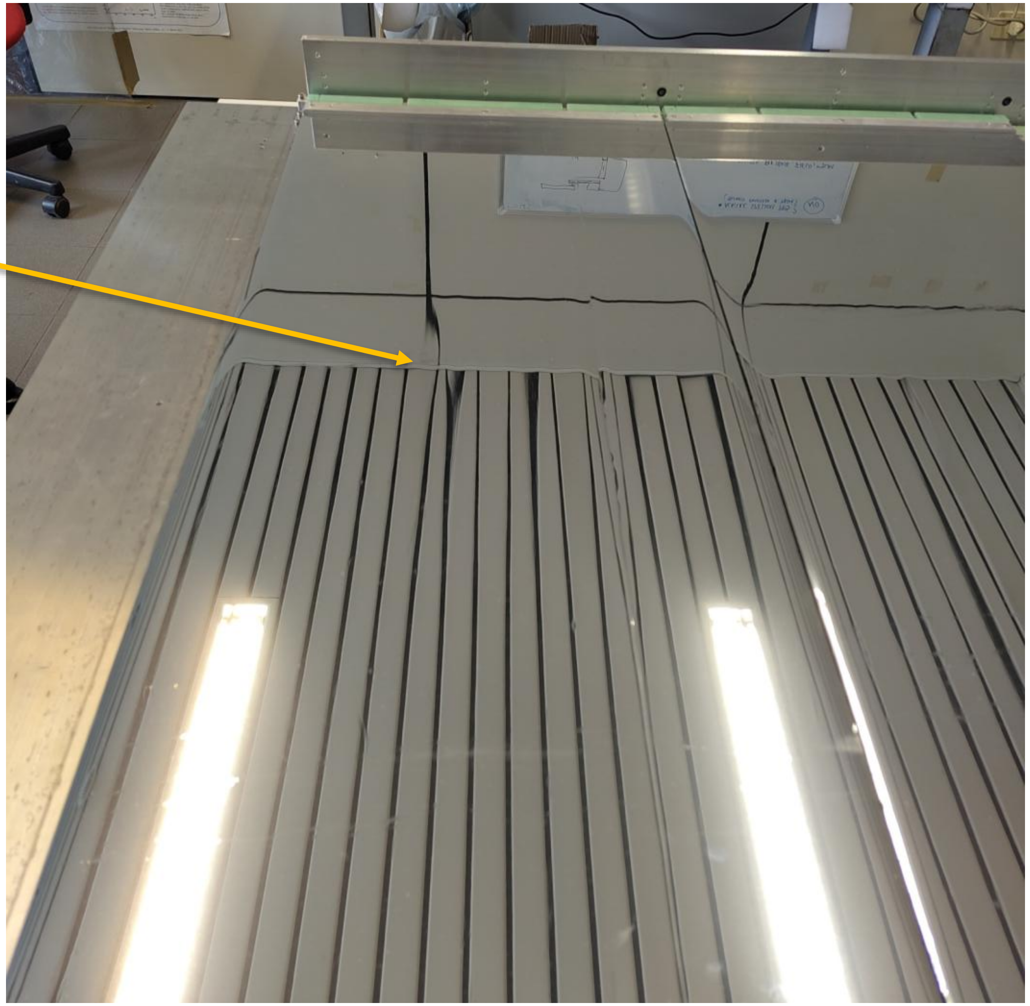
Three mylar sheets form a cathode plane



Every sheet is tensioned using 3 screws per side

Mylar Layer - Tensioning

- Few **creases** appeared in the middle of the sheet during the first tests.
- Fixed:
  I. using a **stronger adhesive** tape
  II. by tuning the tension of Stesalite bars.



Wire Planes

Procedure:

1. The wire is first soldered at one end
2. A weight is applied at opposite end
3. The second wire end is soldered

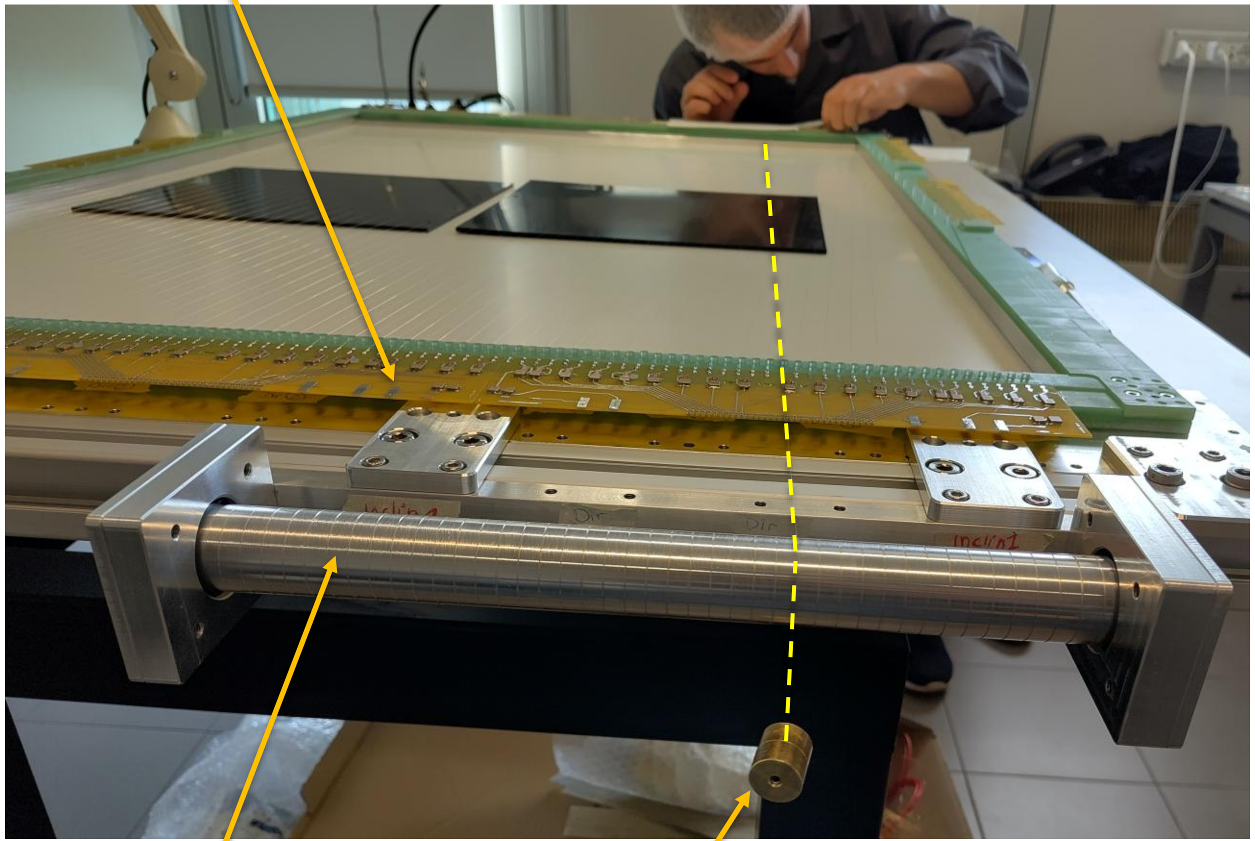
Goal: obtain the same *sagitta* when the DC is put in vertical position

Preliminary tests done with wires tensioned with:

- **50 g** for sense wires (20 um gold-plated tungsten)
- **250 g** for field wires (100 um copper-beryllium)

Wire board:
HV + Readout

Thanks to D. Calabro for its suggestions

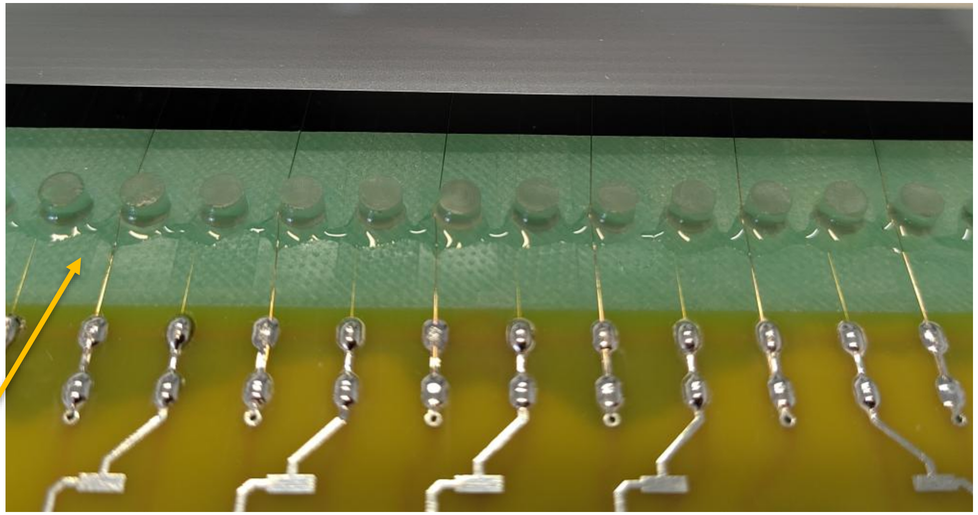


Grooved cylinder

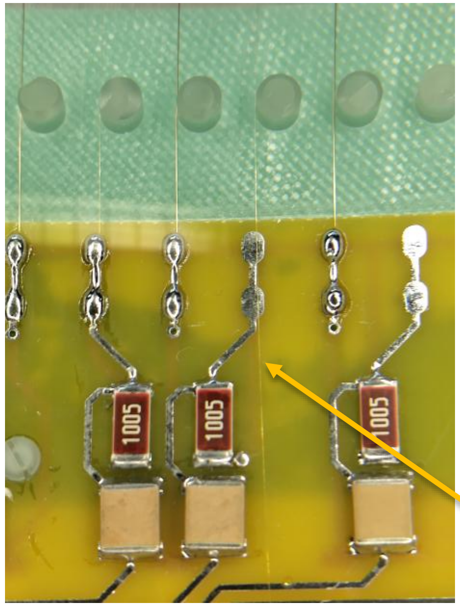
weight

Wire Planes

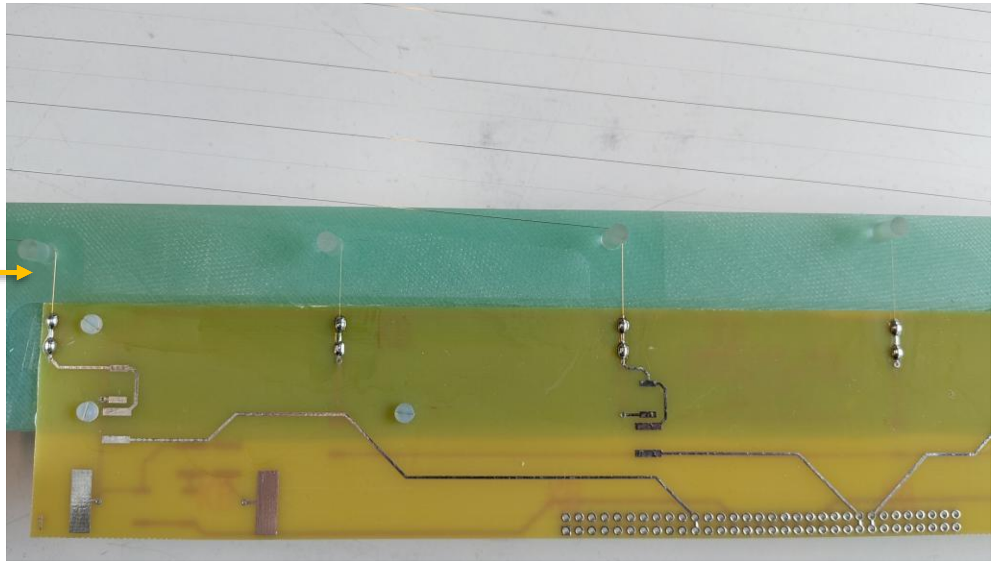
- **Plexiglass cylinders** provide a **precise positioning** for the wires
- Two solder points at both ends of each wire
- Wires and pins **glued with epoxy** (Araldite2011)



Epoxy glue

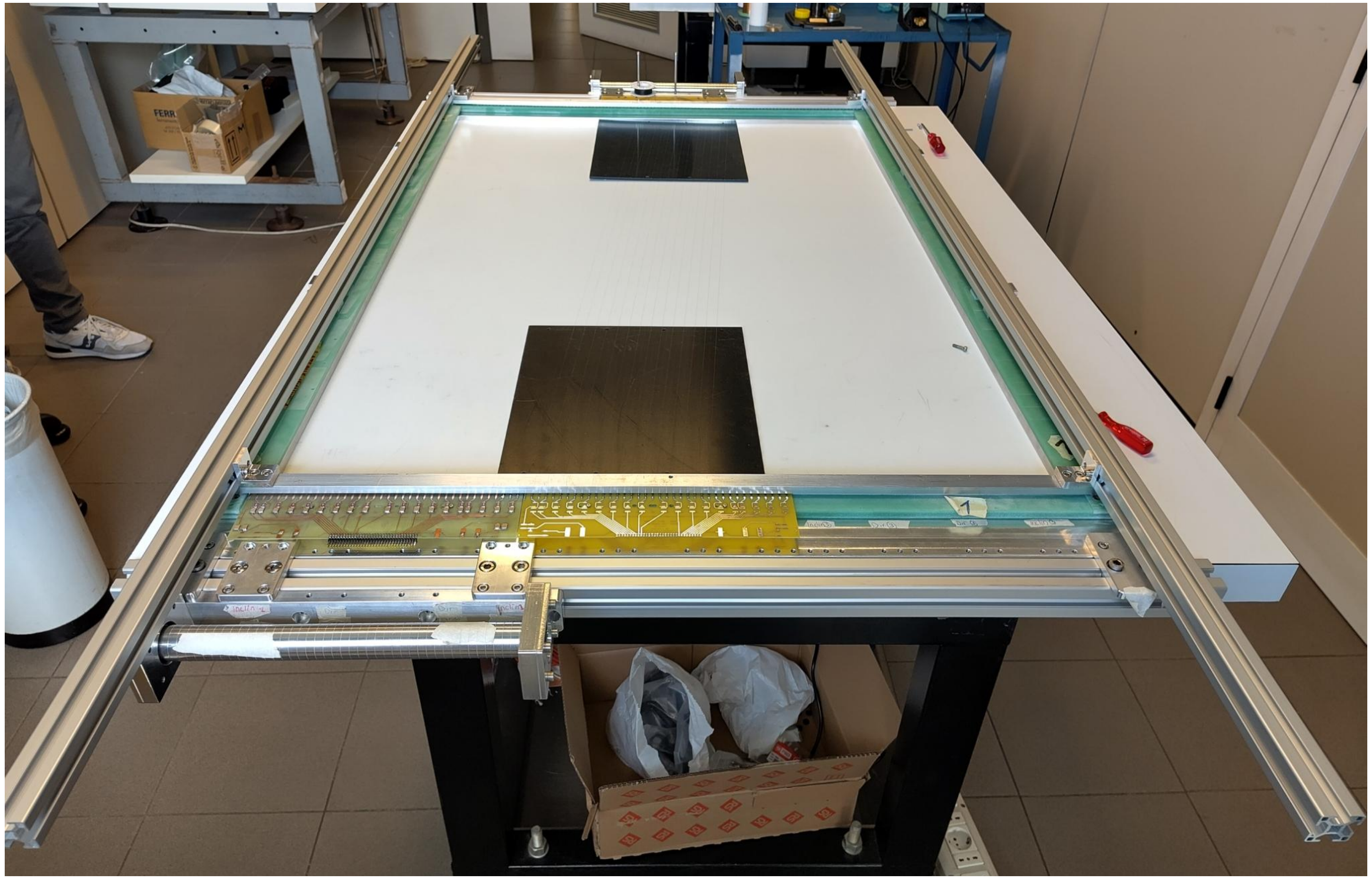


Inclined wires ending on the lateral bars



Wire ready to be welded

Wire Frame Transfer

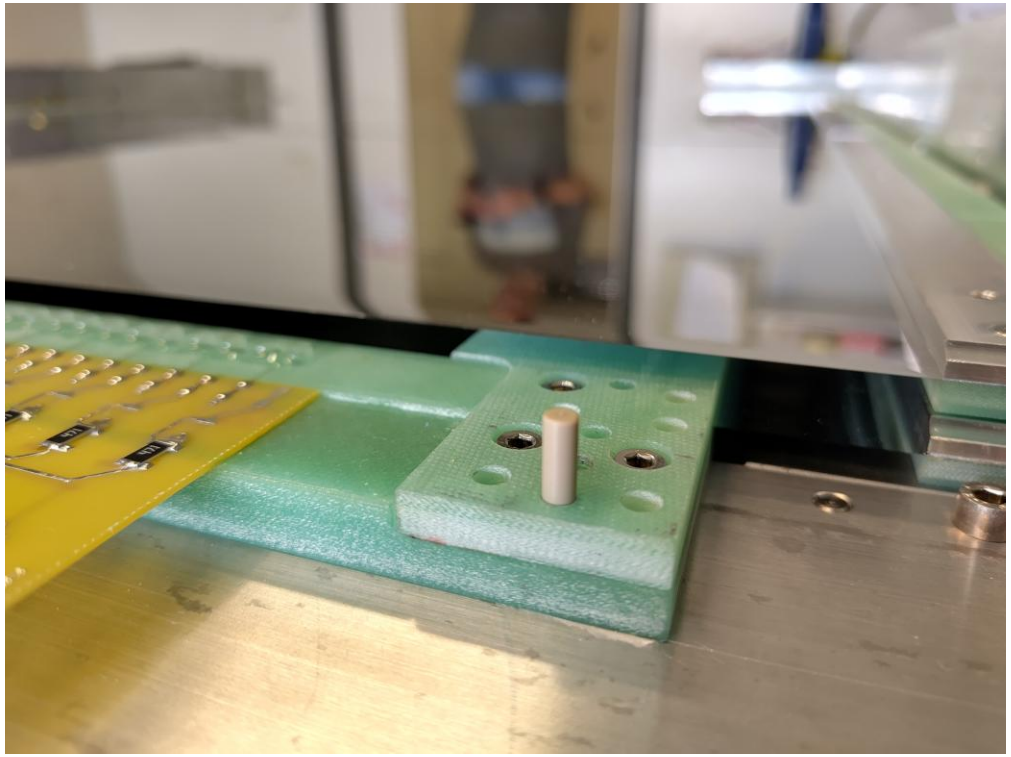


- This structure allows to **transfer a wire plane** (once completed) to **the integration table**.

- Tests performed to ensure **no dangerous deformations** are applied to the wire frame during the transfer.

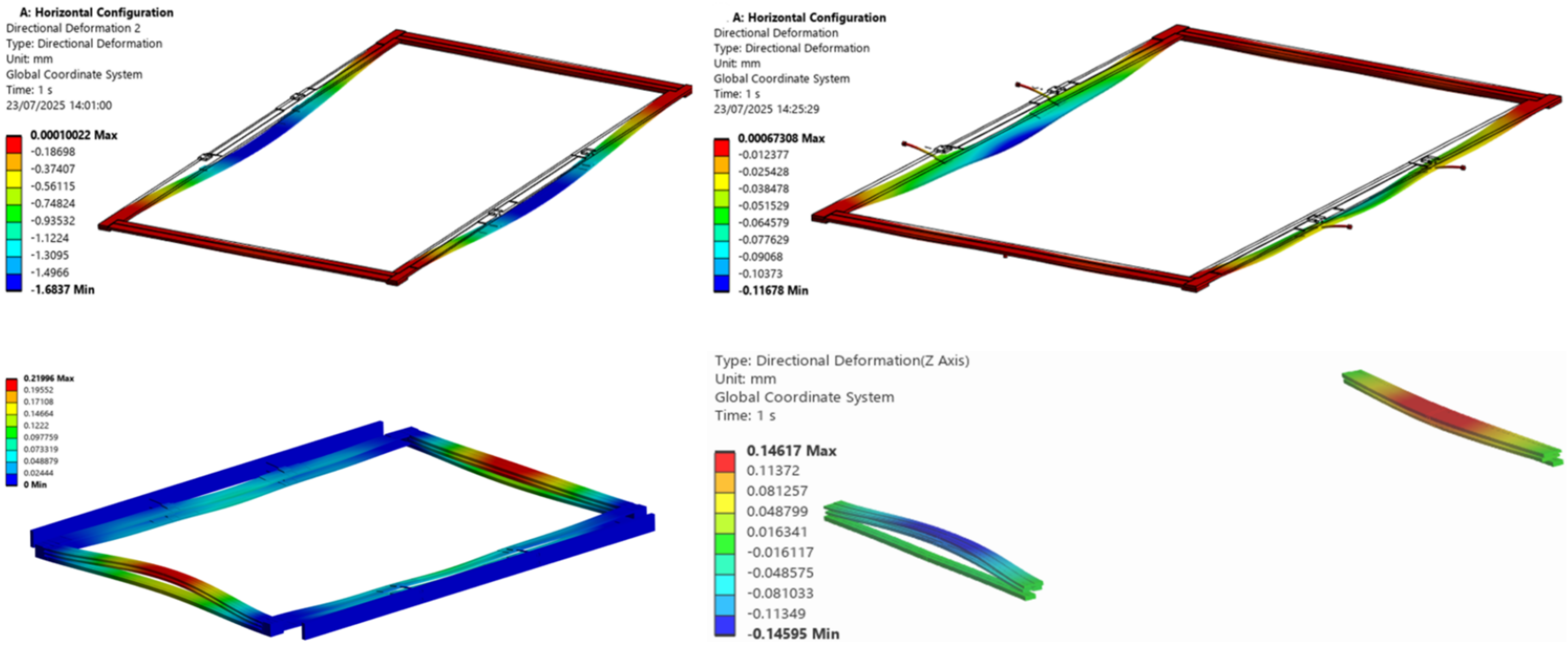
Wire Planes - Installation

- Installation of the second wire plane
- **Pins made of peek** are used to obtain a **precise positioning**



Wire Frame Deformations

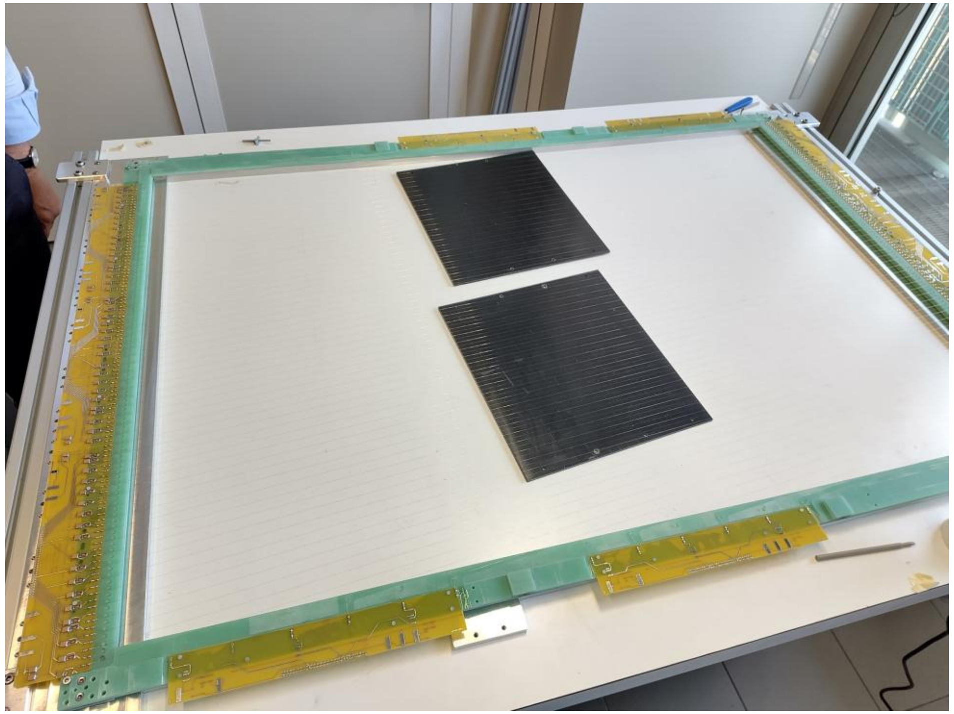
- Additional **peek pins** of 4 mm diameter are inserted in the middle of short the bars to reduce deformations due to wires tension **from 200 to 150 µm**
- Vertical deformations can be reduced **from 1.4 to 0.2 mm** by adding four **long screws** (two per side)

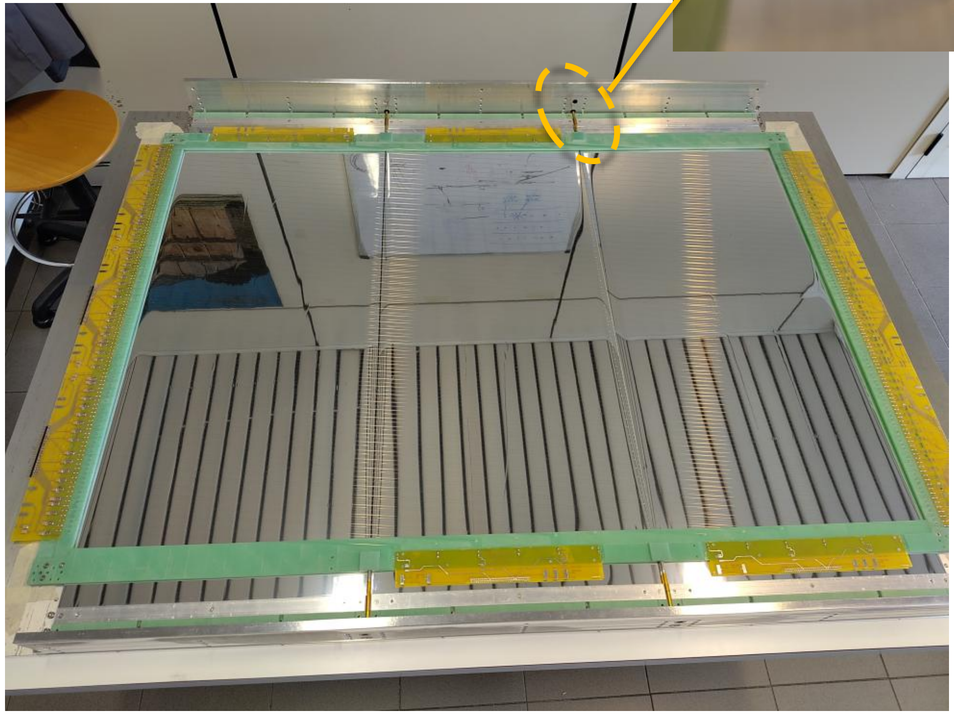


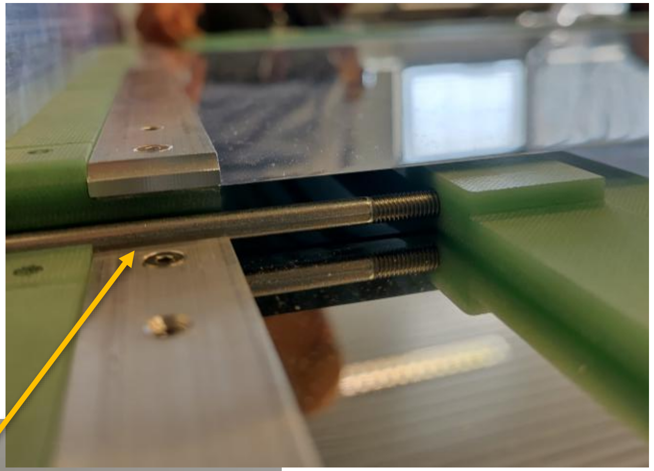
Wire Planes - Installation

- 3rd wire plane just transferred to the assembly station

Long screws provide lateral support to the wire frame







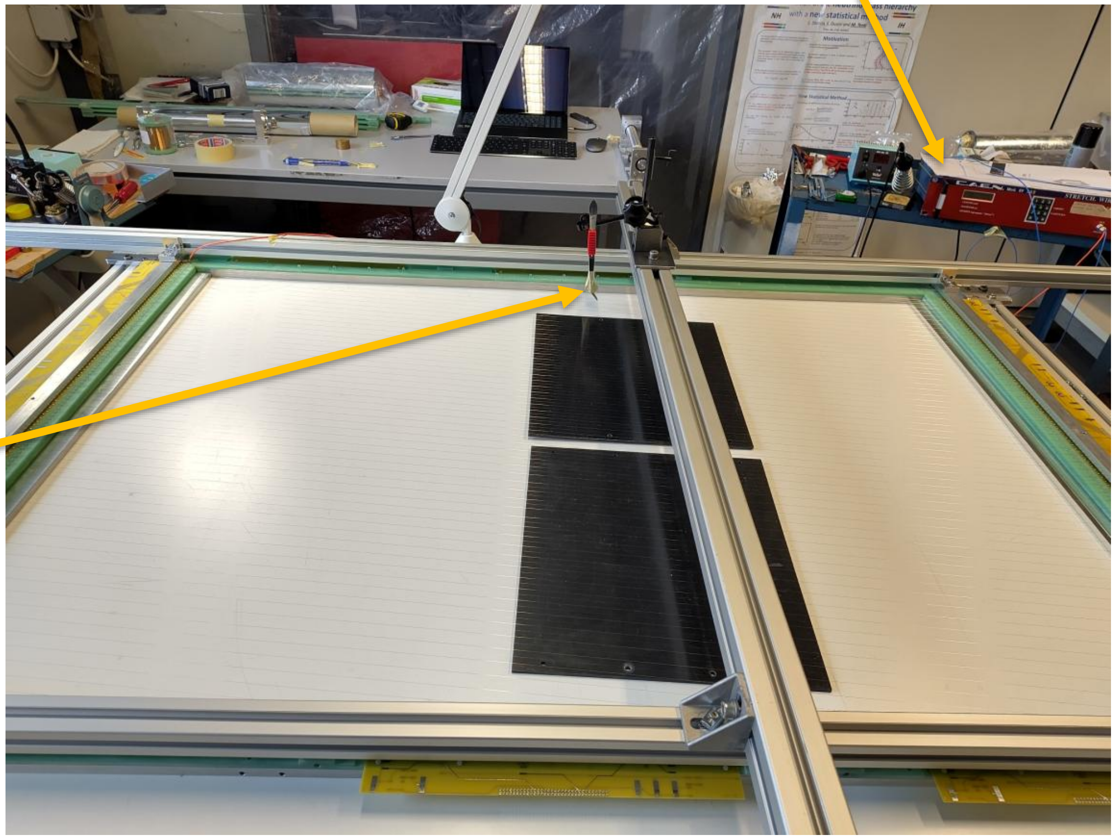
Wire Tension Measurement

*Thanks to the DUNE Pavia group

CAEN wire* stretch meter

Mechanical tension measured for sense and field wires using the resonance frequency method:

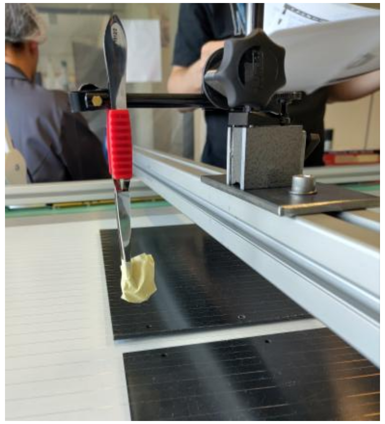
- One probe is connected at each end of the wire
- A magnet is hung at the centre of a wire
- AC current is generated by the instrument
- The frequency of the current is varied until it matches the resonance



tension

$$F = \frac{L^2 d\rho\pi}{gT^2}$$

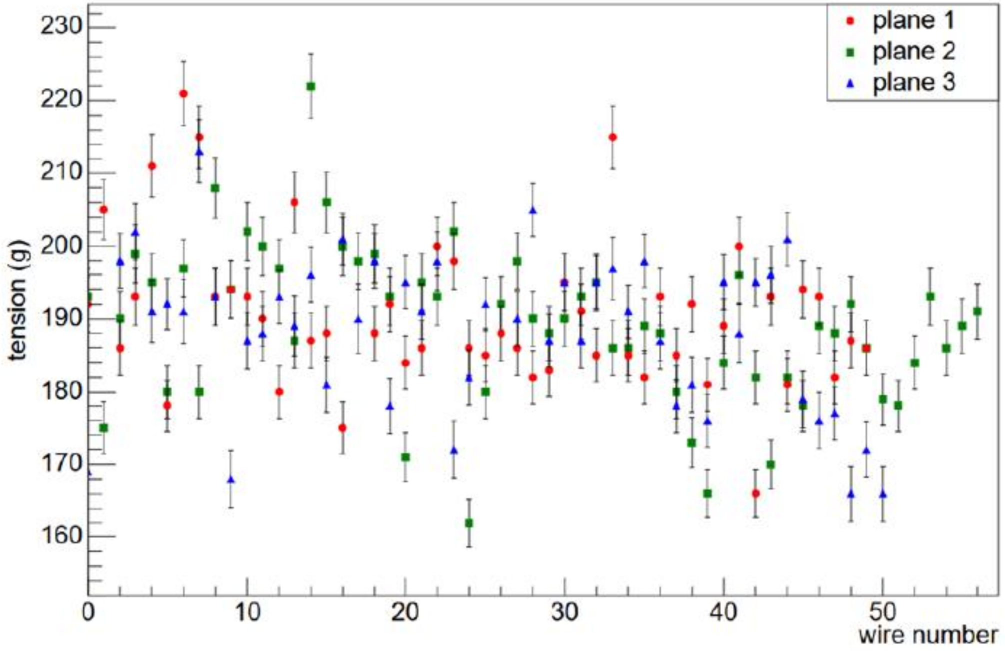
Oscillation period

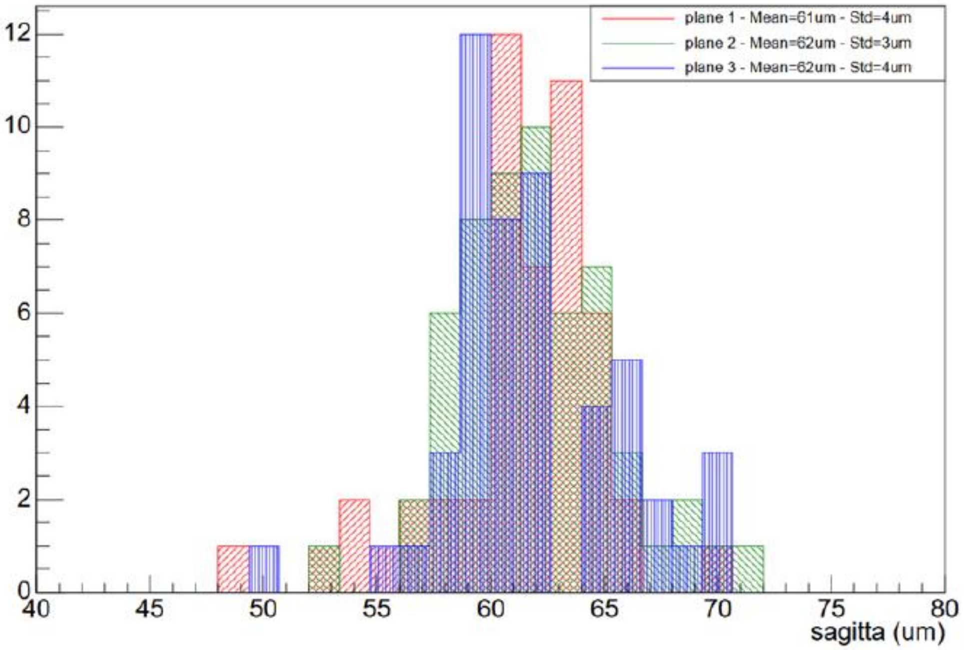


Magnet

Wire Tension Measurement

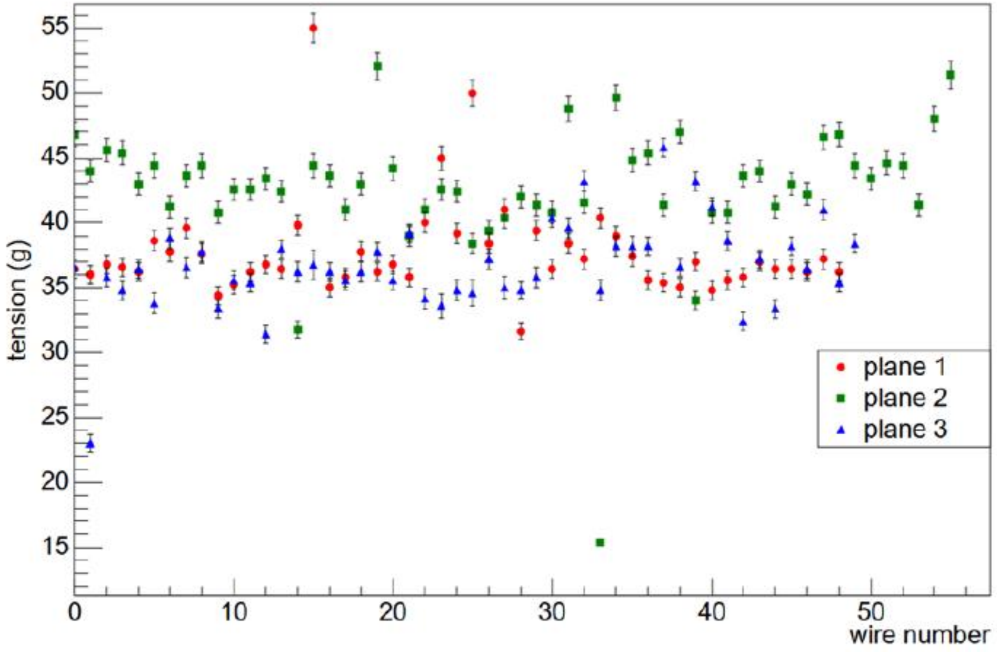
- **100 um** field wires
- Average tension is **190 g** , 250 g expected

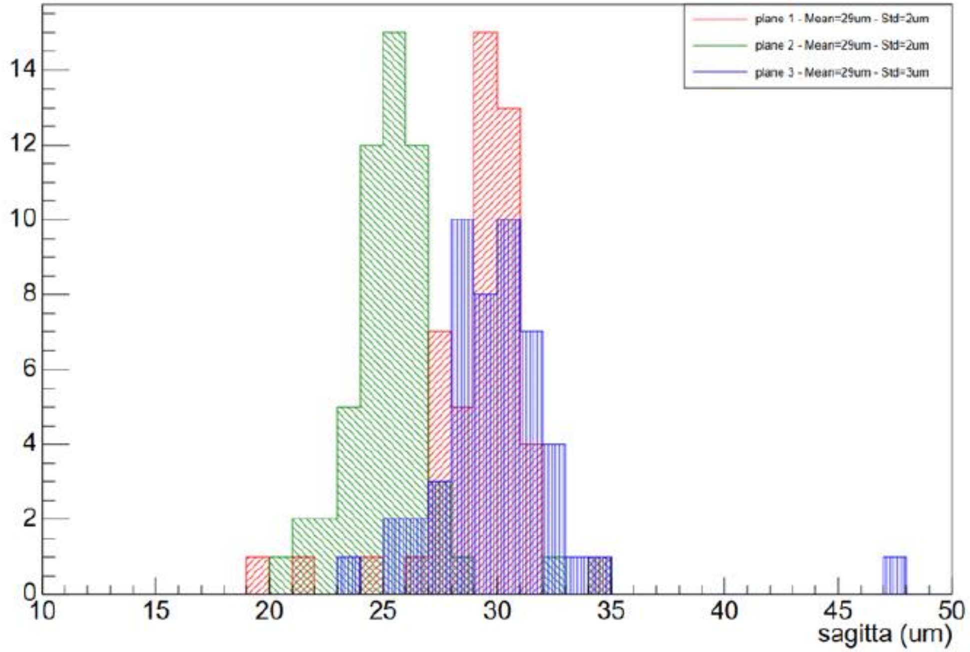




Wire Tension Measurement

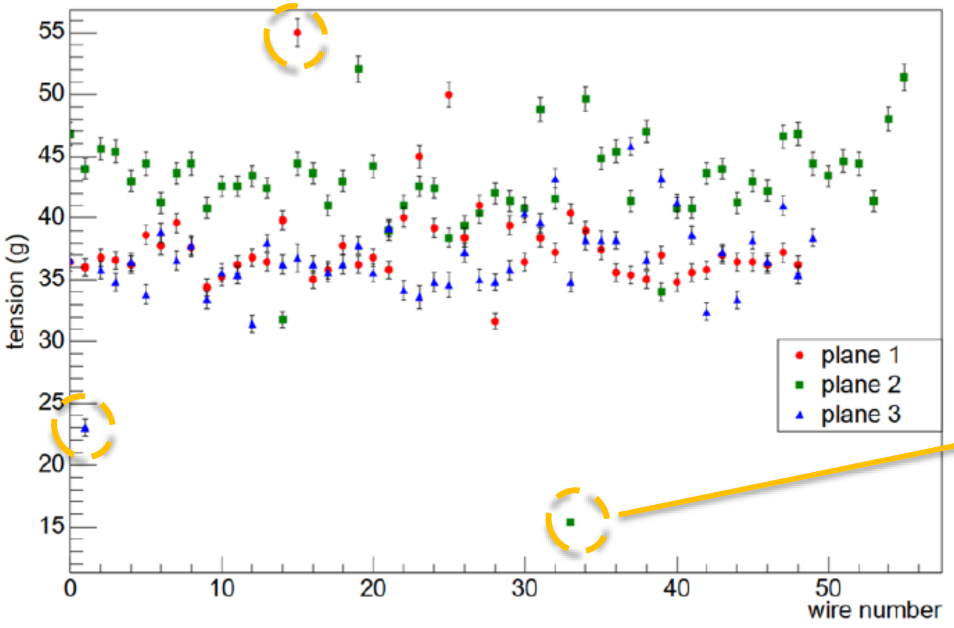
- **20 um** field wires
- Average tension is **40 g** , 50 g expected



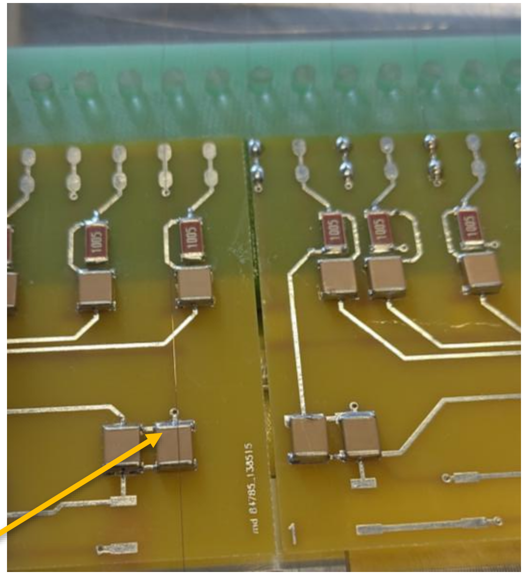


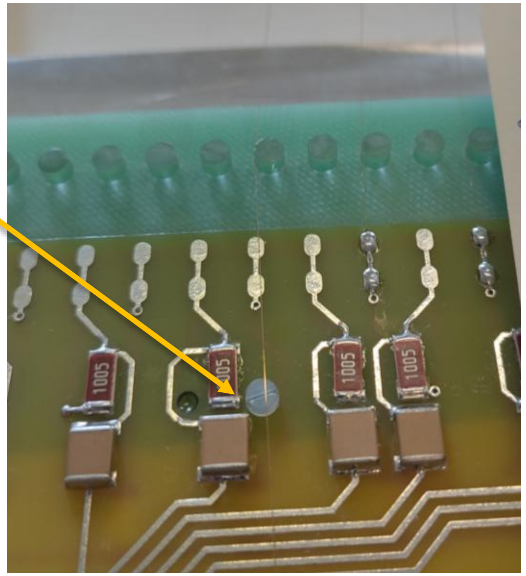
Wire Tension Measurement

- The reduced effective mechanical tension is due to the **friction of the wire with the grooved cylinder** used during the spinning.



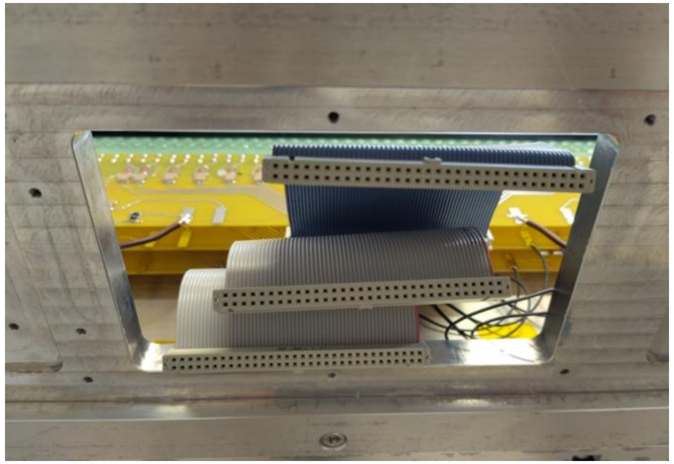
In few cases the **tensioning procedure** is **hindered** by the presence of one of the **small Teflon screws** or **components** on the PCB board



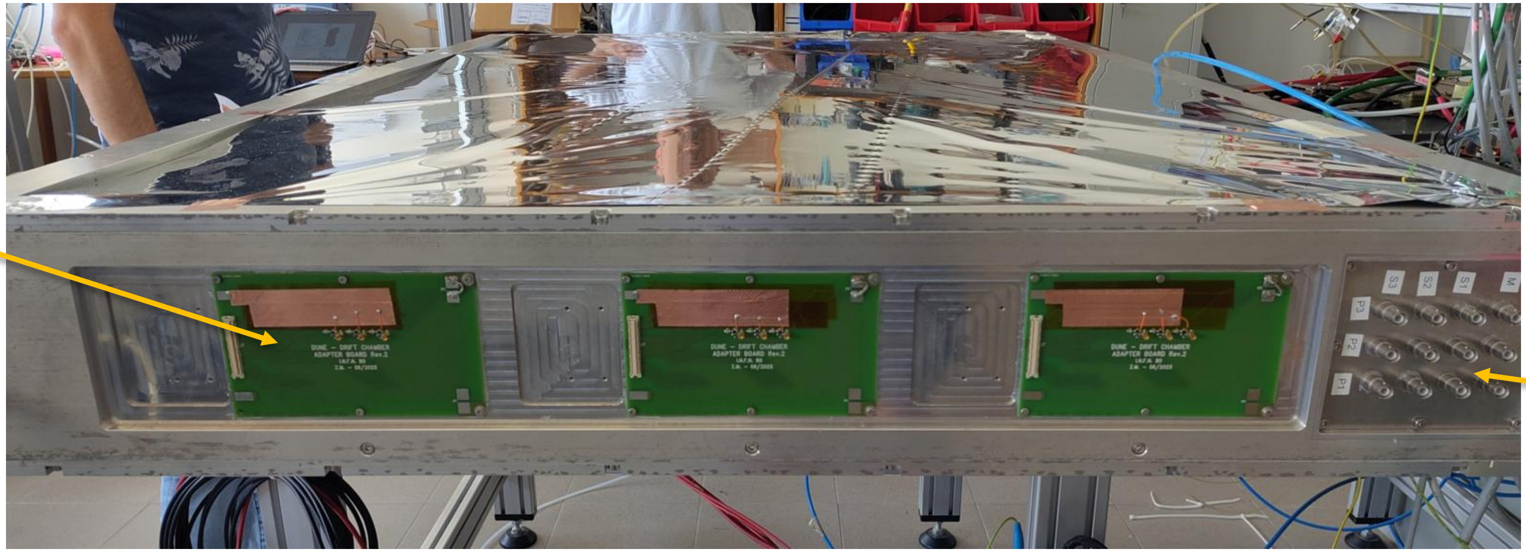


Detector Front-End

- For the DCH, an **interface card** routes **57** channels to a readout connector
- Every interface card reads **18 channels from each wire plane**
- **3** interface cards are necessary to read all DCH channels

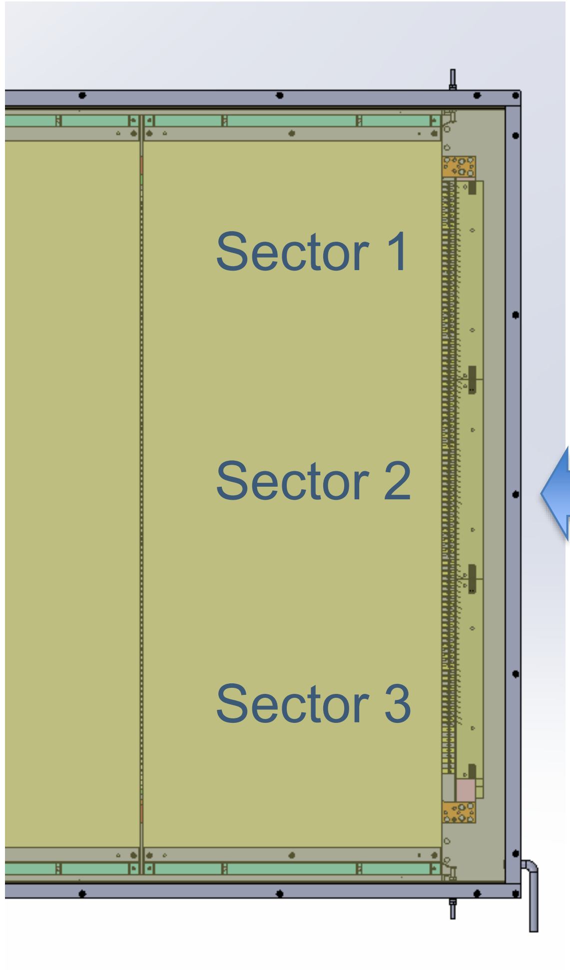


Interface card

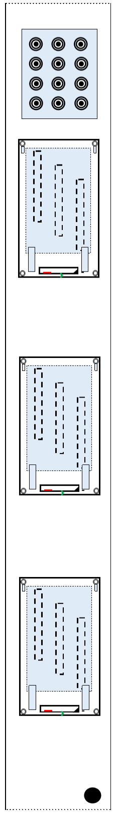


HV panel

Detector Front-End

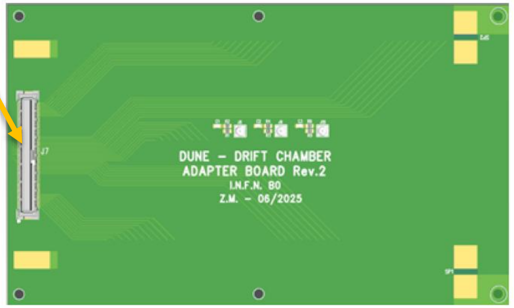


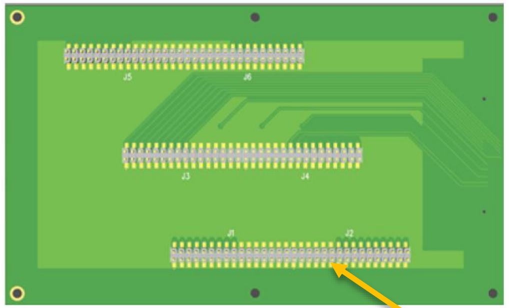
r/o connector



Interface card

front

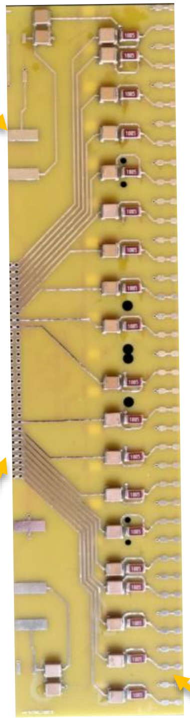




back

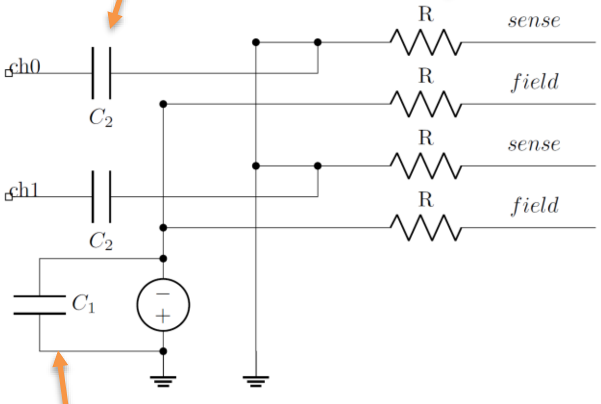
Wire board

HV



1pF decoupling capacitance

10MΩ dumping resistance



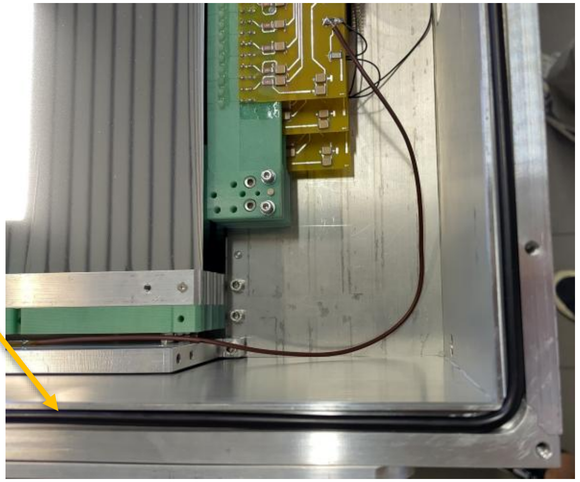
2pF

Flat cable connector

Soldering pads

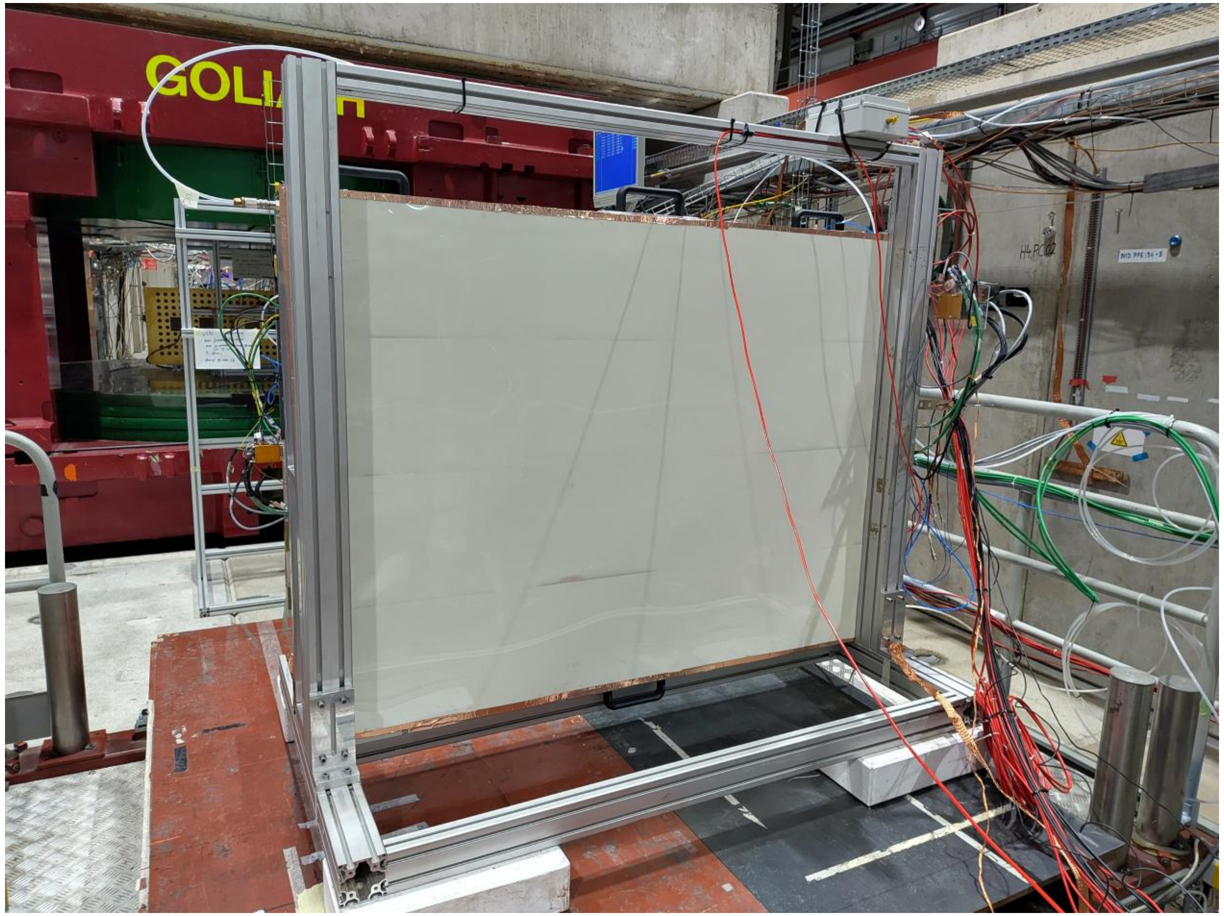
The Final Sealing

- Chamber closed with a **300 µm thick Mylar foil**
- Gas-tightness ensured by o-ring and silicone between metallic juctions



Conclusions

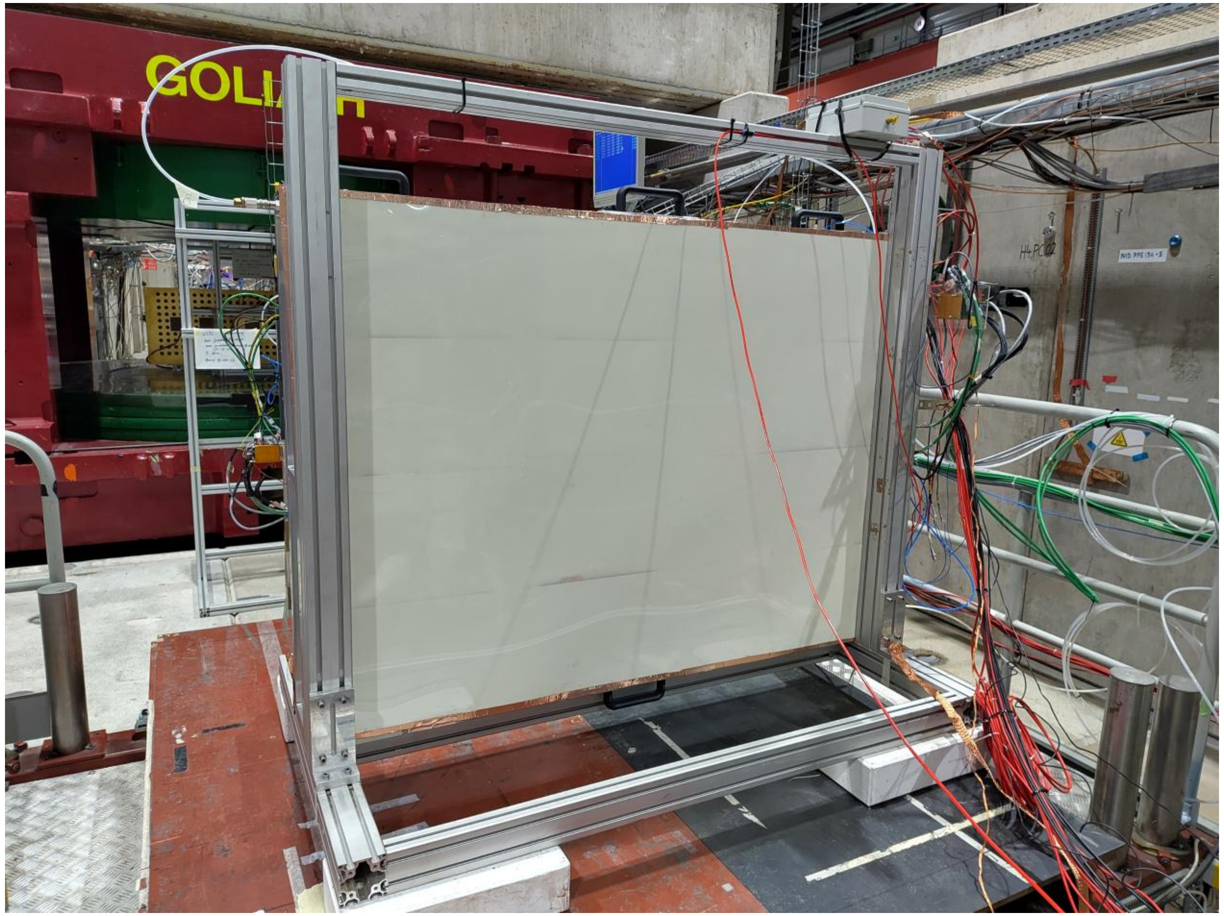
- Procurement was the most time-consuming task. The entire camera was effectively realized in 2 months.
- The wiring process **easily handled by three people** (~1.5 days / frame).
- The external box is **gas tight** but is just a temporary design.
- **Wire tension is uniform**, but the measure cannot be repeated after the sealing



Outlooks

After the validation of this prototype, next steps could be:

- The usage of **carbon-fiber frames** will be considered
- The **design of the wire boards** must be **improved**
- The choice for the best glue/adhesive tape for Mylar planes and requires **long-term validation tests**
- **Start to design the full-scale tracker**



Thank you

Backup

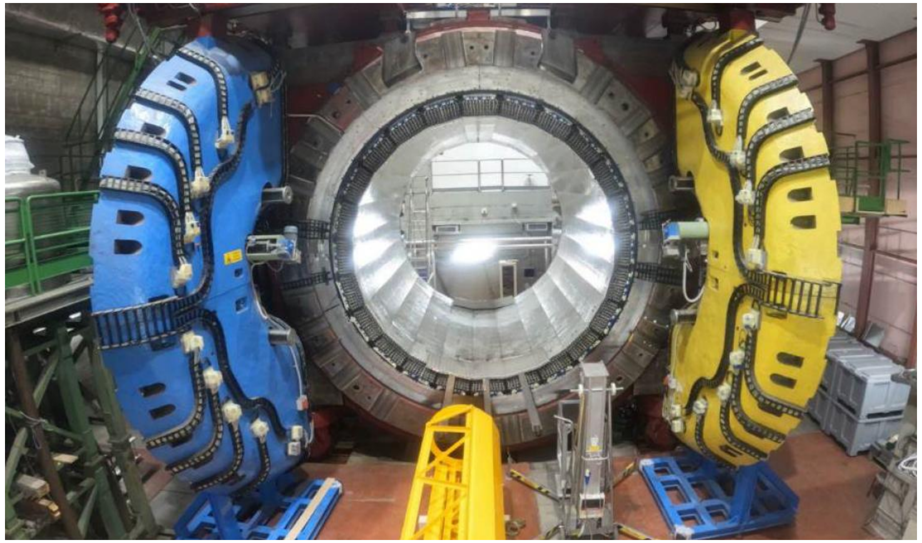
SAND

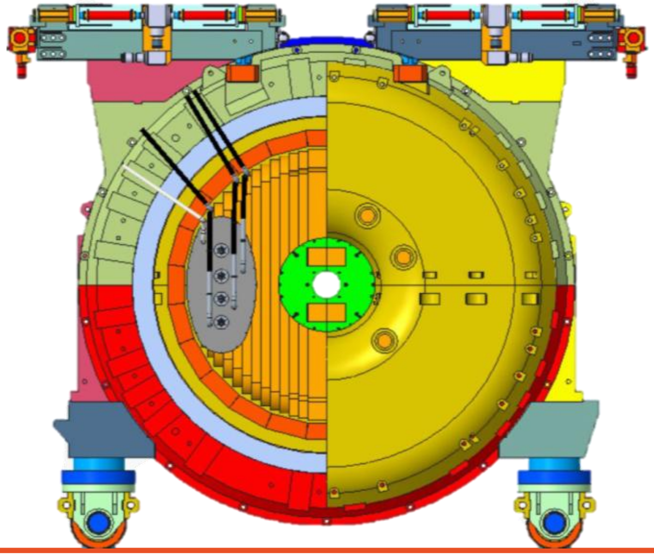
System for on-Axis Neutrino Detection

- Permanently on-axis
- **ECAL**: Pb + scintillating fibers

$$\sigma_E/E \cong 5\%/\sqrt{E(GeV)}$$
$$\sigma_t \cong 40ps/\sqrt{E(GeV)}$$

- **GRAIN** : 1t LAr active target
- **Inner Tracker**



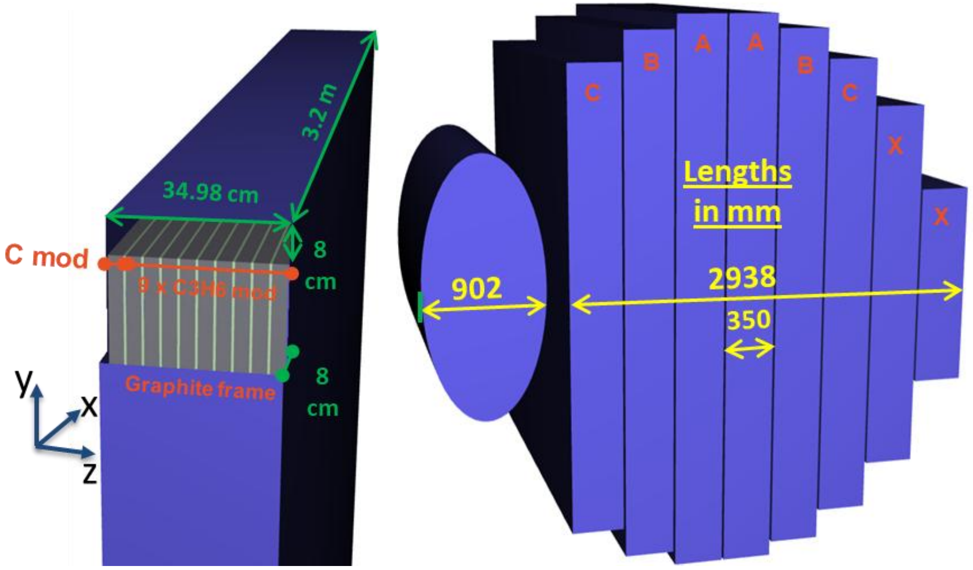


Objectives:

- Measurement of $\boldsymbol{\nu/\bar{\nu}}$ **flux** (absolute and relative)
- Measurement of ν **cross sections on Ar, CH_2, C ($\rightarrow$H)**
- **Calorimetry**
- **High precision tracking**

The Inner Tracker

- 4.7 t tracker composed of **8 super-modules**
- Each super-module contains 10 modules
  - 9 with **polypropylene** (C_3H_6) targets, used as C-H target
  - 1 with **graphite** target
- A single module is composed by
  - a drift chamber with **3 wire planes**
  - the **target** material

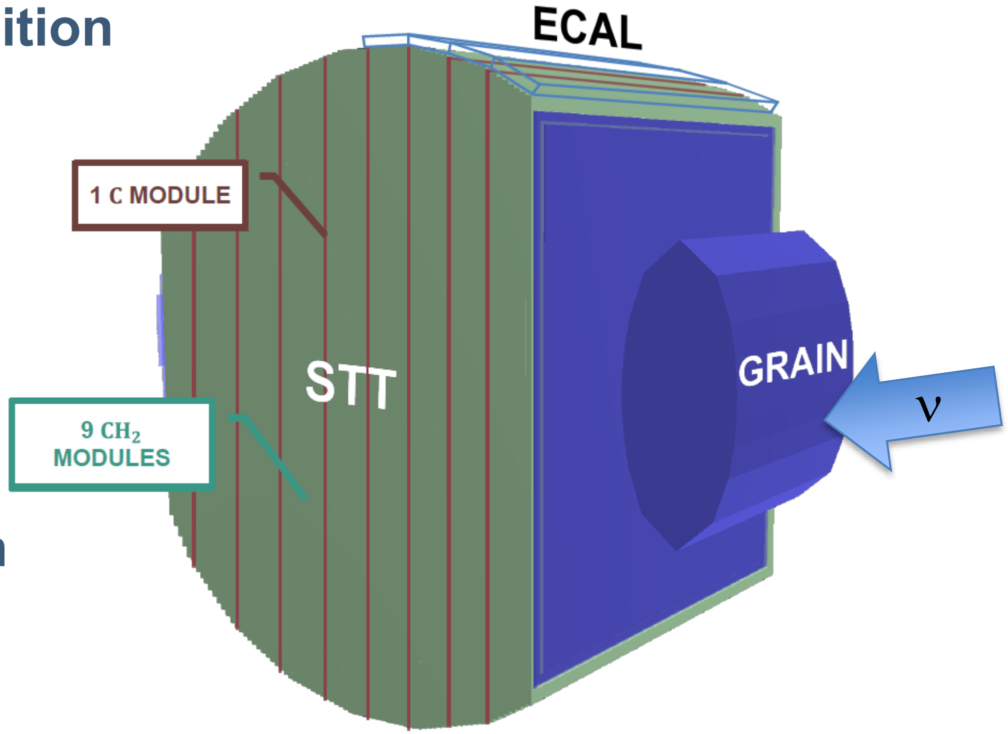


- Modules height varies **from 1.2 to 3.8 m**, for a fixed width of **3.2 m**
- **~220 drift planes**
- From $3.6 \cdot 10^4$ to $5.2 \cdot 10^4$ **readout channels,** depending on the cell geometry

The Inner Tracker

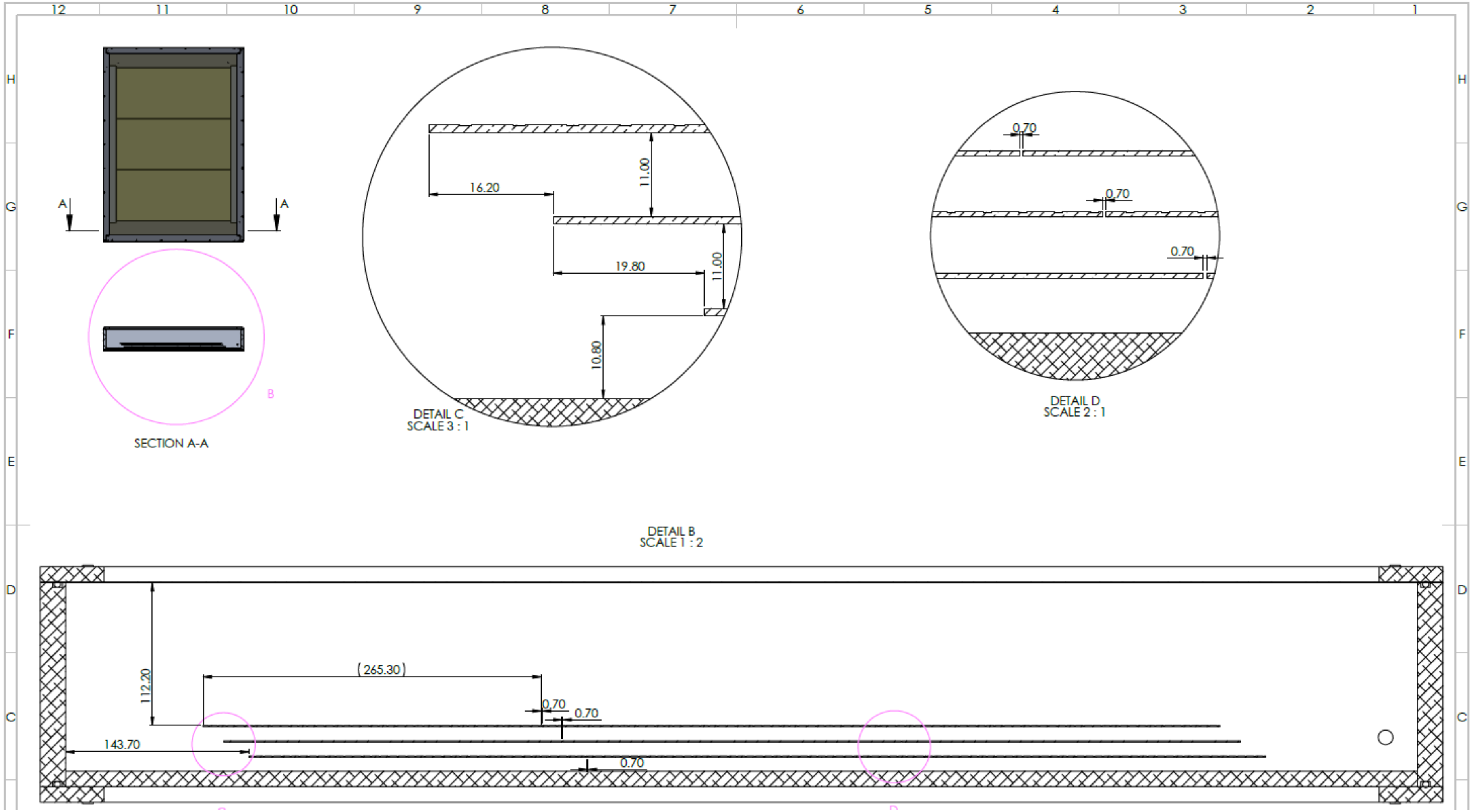
Objectives:

- Separate **neutrino and antineutrino events** (charge ID)
- Identify **beam flavor composition**
- Measure the **energy** of **charged** and **neutral particles*** (π_0, n)
- **Correct systematic errors** combining H and Ar cross sections
- Localize **neutrino interaction vertices** in the target material (precision < 5 cm)
- Timing resolution **< 10 ns**

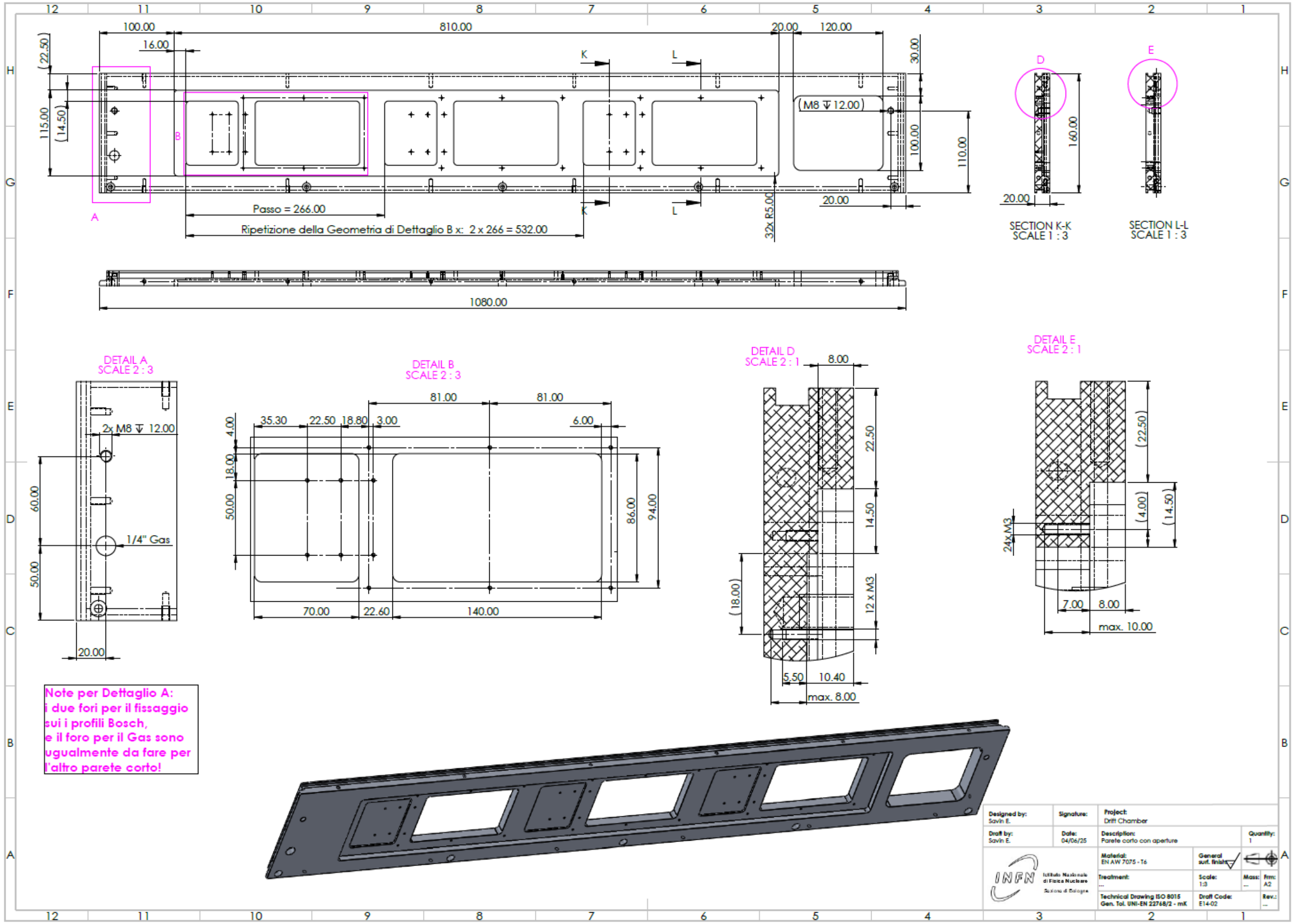


* with the help of the calorimeter

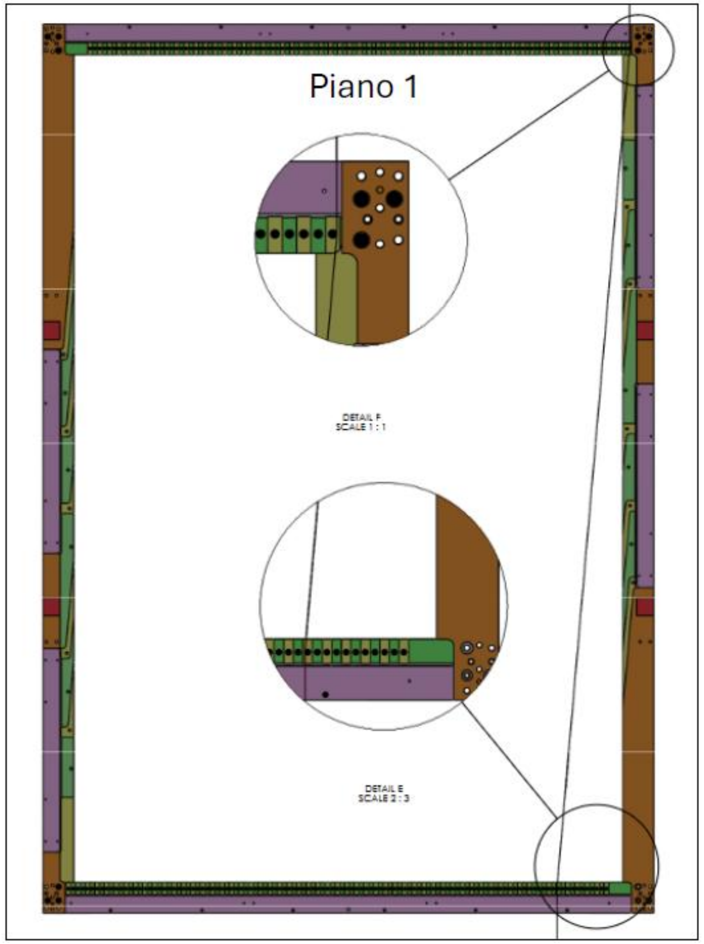
Prototype Design

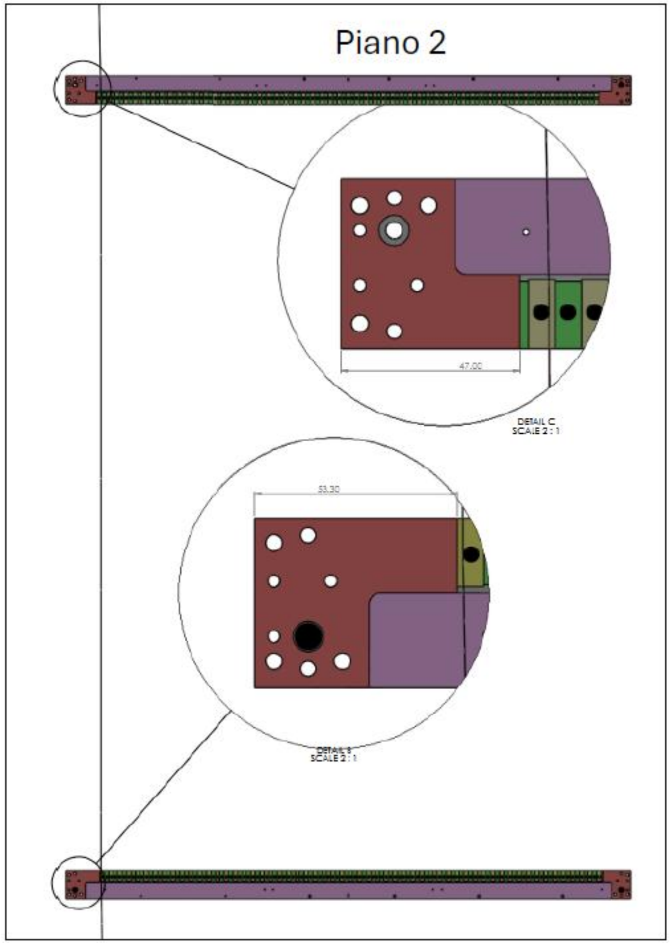


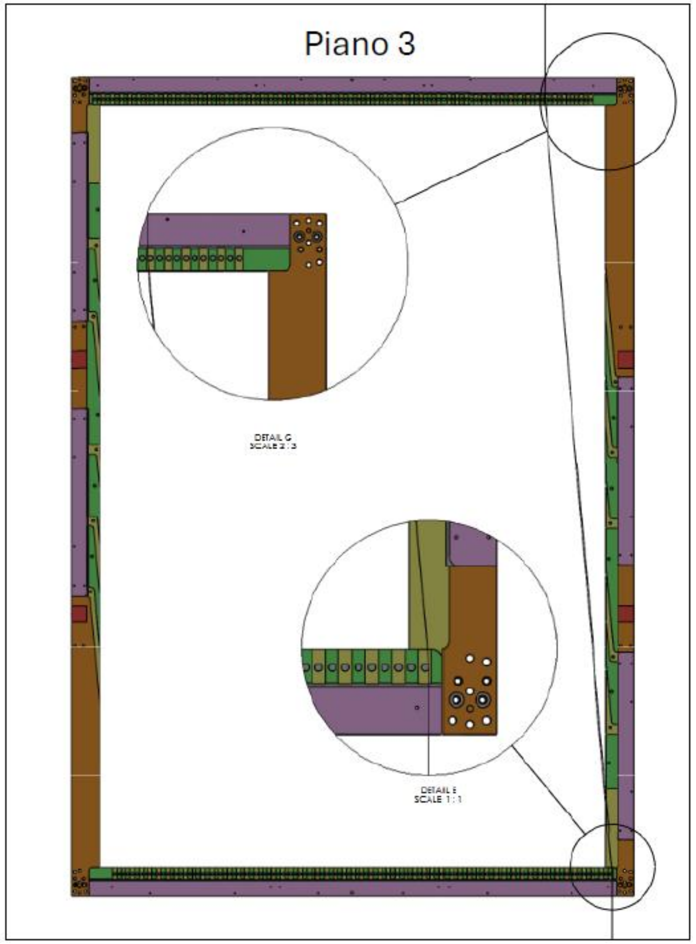
Prototype Design



Prototype Design





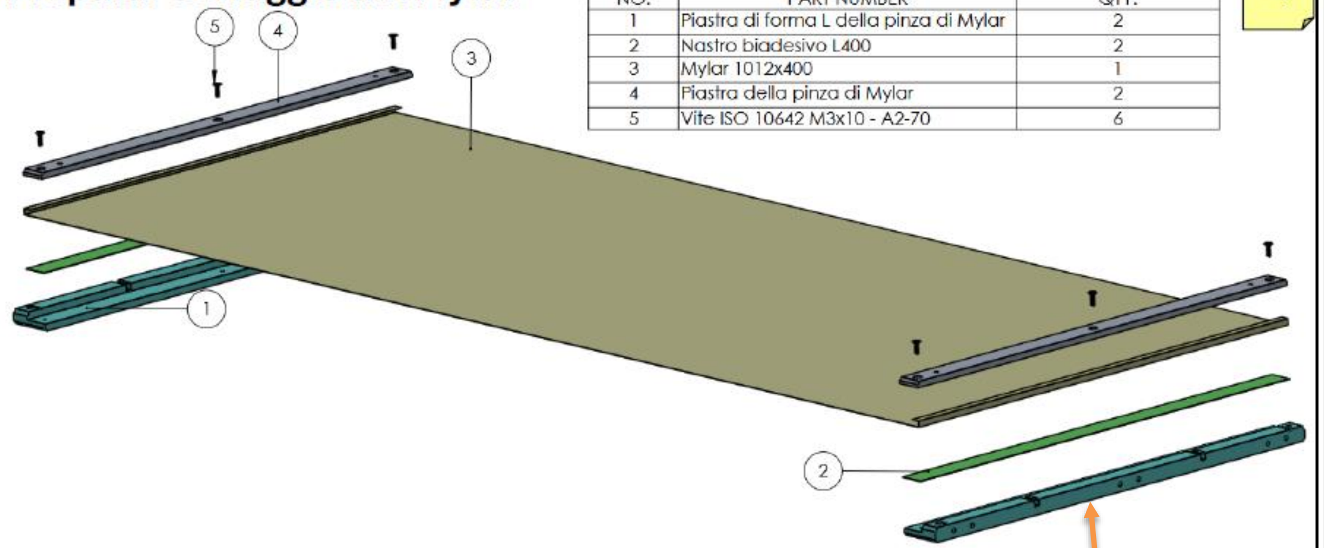


Prototype Design

Prepara: Serraggio del Mylar

4

NO.	PART NUMBER	QTY.
1	Piastra di forma L della pinza di Mylar	2
2	Nastro biadesivo L400	2
3	Mylar 1012x400	1
4	Piastra della pinza di Mylar	2
5	Vite ISO 10642 M3x10 - A2-70	6

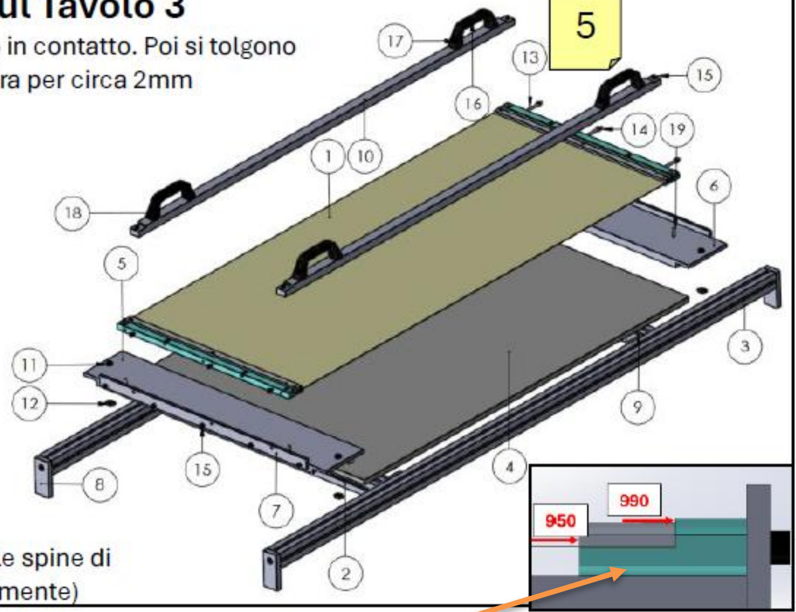


Montaggio del Mylar sul Tavolo 3

5

In modo rilassato No. 4,5, e 6 sono in contatto. Poi si tolgono le due spine (No. 19) da No.6 e si tira per circa 2mm

NO.	PART NUMBER	QTY.
1	Serraggio del Mylar	1
2	Bosch 30x30 L500	2
3	Bosch 30x30 L1300	2
4	Piastra di supporto sotto il mylar	1
5	Piastra di Montaggio del Mylar	1
6	Piastra di Montaggio del Mylar 2	1
7	Lastra Montaggio Mylar	2
8	Linguette Montaggio Mylar	4
9	Staffa angolare	4
10	Piastra del Trasporto di Mylar	2
11	Vite ISO 4762 - M6x16 - A2-70	16
12	2768170 (Dado 8)	12
13	Barra filettata M4 x 55	3
14	Dado ISO 4032 M4 - 10	3
15	Vite ISO 4762 - M4x16 - A2-70	12
16	456589 (Maniglie)	4
17	Vite ISO 4762 - M5x20 - A2-70	8
18	Dado ISO 4032 M5 - 9	8
19	Spina ISO 2338 - 4 h6x20	4



Per comodità si possono usare delle spine di h7 invece da m6 (per togliergli facilmente)