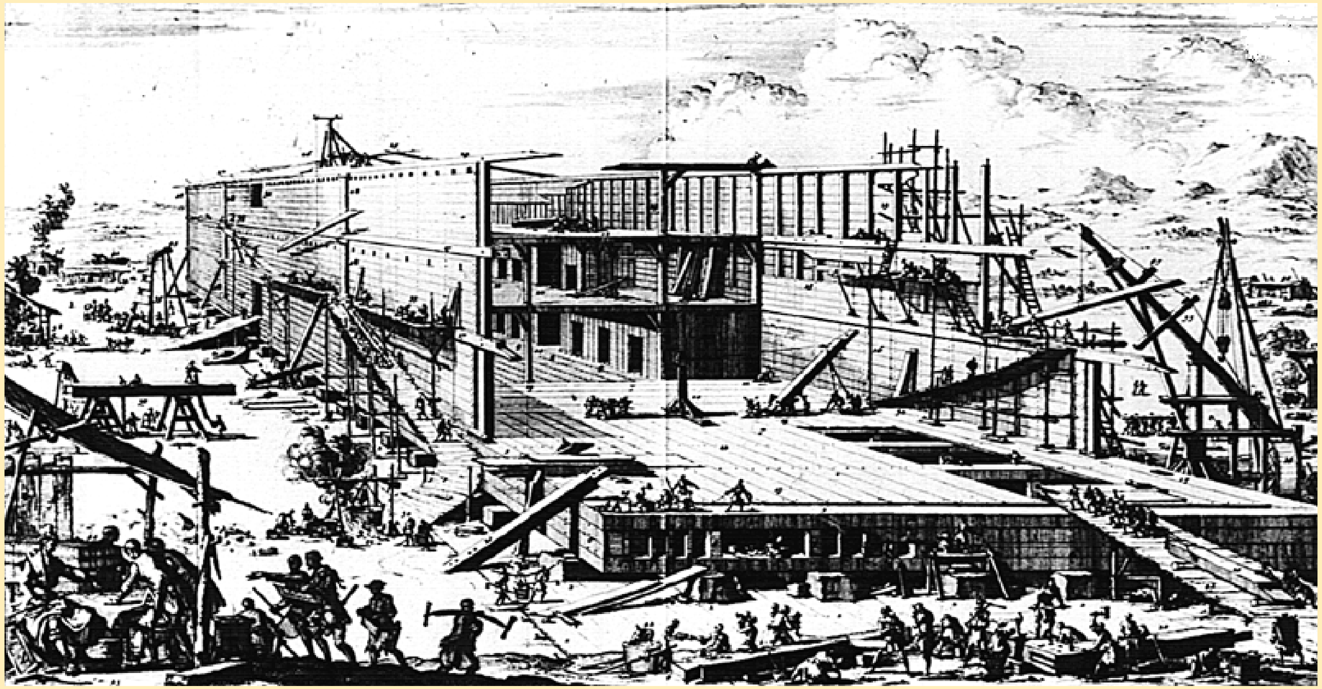
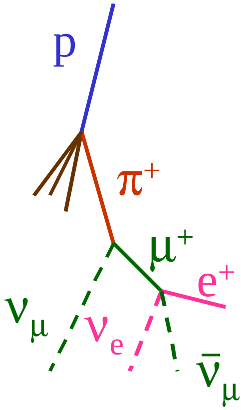
A STATUS REPORT ON THE ICARUS T600 DETECTOR SLOW CONTROL SYSTEM



JAVIER RICO   ETH-ZÜRICH

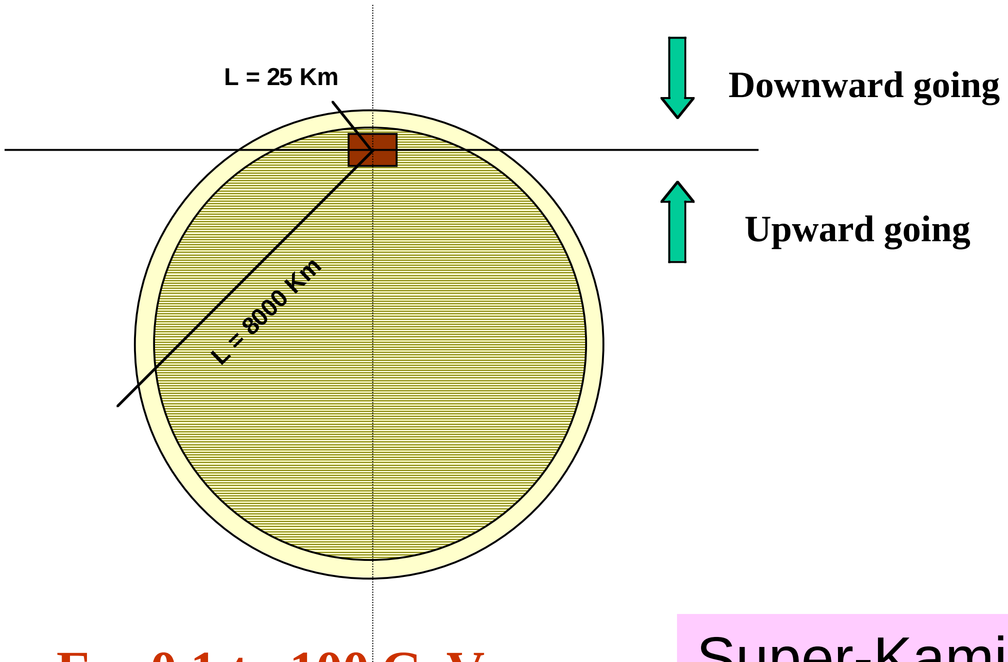
Doktorandenseminar, 3-5 October 2000

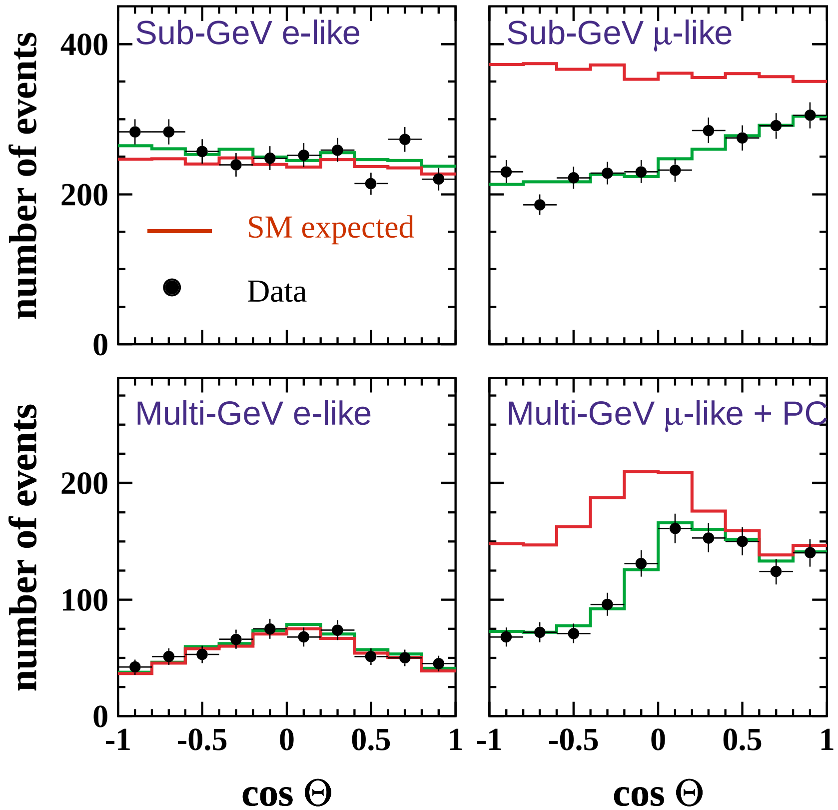
Atmospheric neutrinos



The interaction of cosmic rays with the atmosphere produces neutrinos

$$\frac{\nu_\mu + \bar{\nu}_\mu}{\nu_e + \bar{\nu}_e} \approx 2$$





E_ν : 0.1 to 100 GeV

~100 event/kton/year

Super-Kamiokande shows clear evidence for the disappearance of upward going muon neutrinos

Neutrino oscillations

Most plausible interpretation of atmospheric neutrino deficit is neutrino oscillation ⇒ mass eigenstates are related to weak eigenstates by means of a unitary matrix

$$\begin{pmatrix} \nu_e \\ \nu_\mu \\ \nu_\tau \end{pmatrix} = \begin{pmatrix} U_{e1} & U_{e2} & U_{e3} \\ U_{\mu 1} & U_{\mu 2} & U_{\mu 3} \\ U_{\tau 1} & U_{\tau 2} & U_{\tau 3} \end{pmatrix} \begin{pmatrix} \nu_1 \\ \nu_2 \\ \nu_3 \end{pmatrix}$$

Two family mixing approximation disappearance probability

$$P(\nu_\mu \to \nu_{x \neq \mu}) = \sin^2 2\theta \sin^2 (1.27 \Delta m^2 \frac{L}{E})$$

Δm^2 the difference of squares of masses in eV^2

L the length between neutrino production and detection in km

E the energy of neutrino in GeV

Neutrino oscillations ⟹ **massive** neutrinos

A new detection technique

- **"Traditional" techniques in neutrino detection provided first evidence for neutrino oscillations**
  - **Water Cerenkov**
  - **Iron Calorimeter**

- **Current experimental challenges on neutrino physics require *innovative detection techniques*:**

Liquid Argon detector

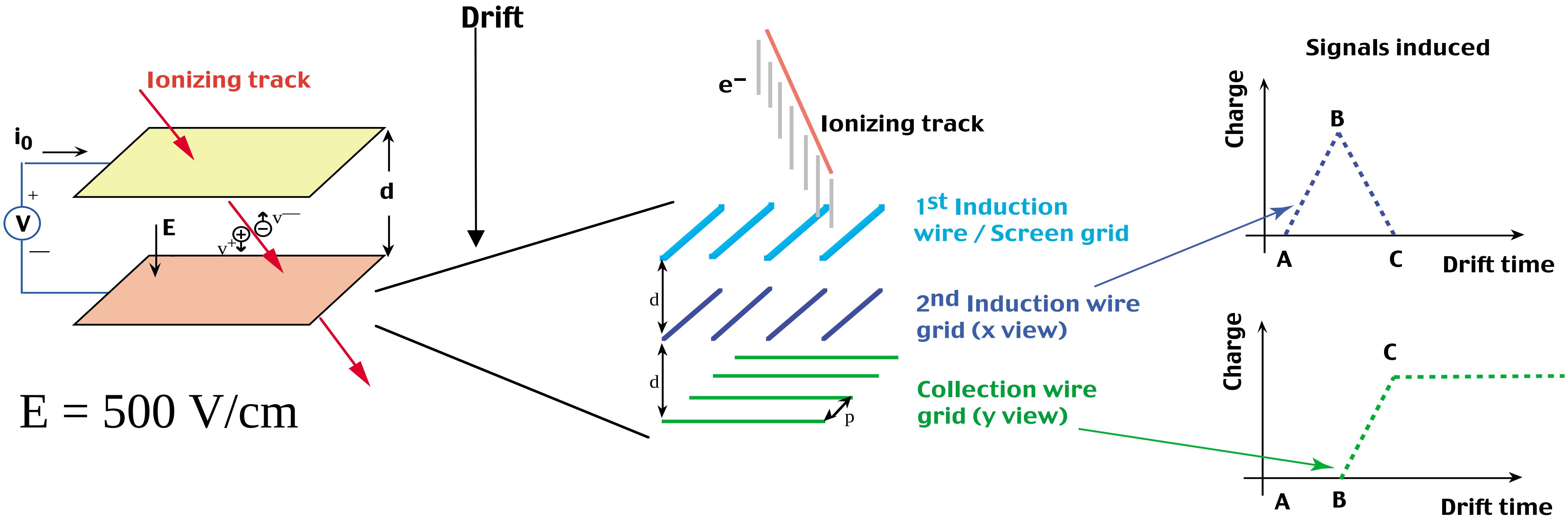
Improvements w.r.t. previous techniques

Atmospheric neutrino detection

- ✧ **Measurement down to production thresholds**
- ✧ **Complete event final state reconstruction**
- ✧ **Identification all neutrino flavors**
- ✧ **Identification of neutral currents**
- ✧ **Better momentum and energy resolution**

Detection principle

- Detect electrons produced by ionizing tracks crossing the LAr



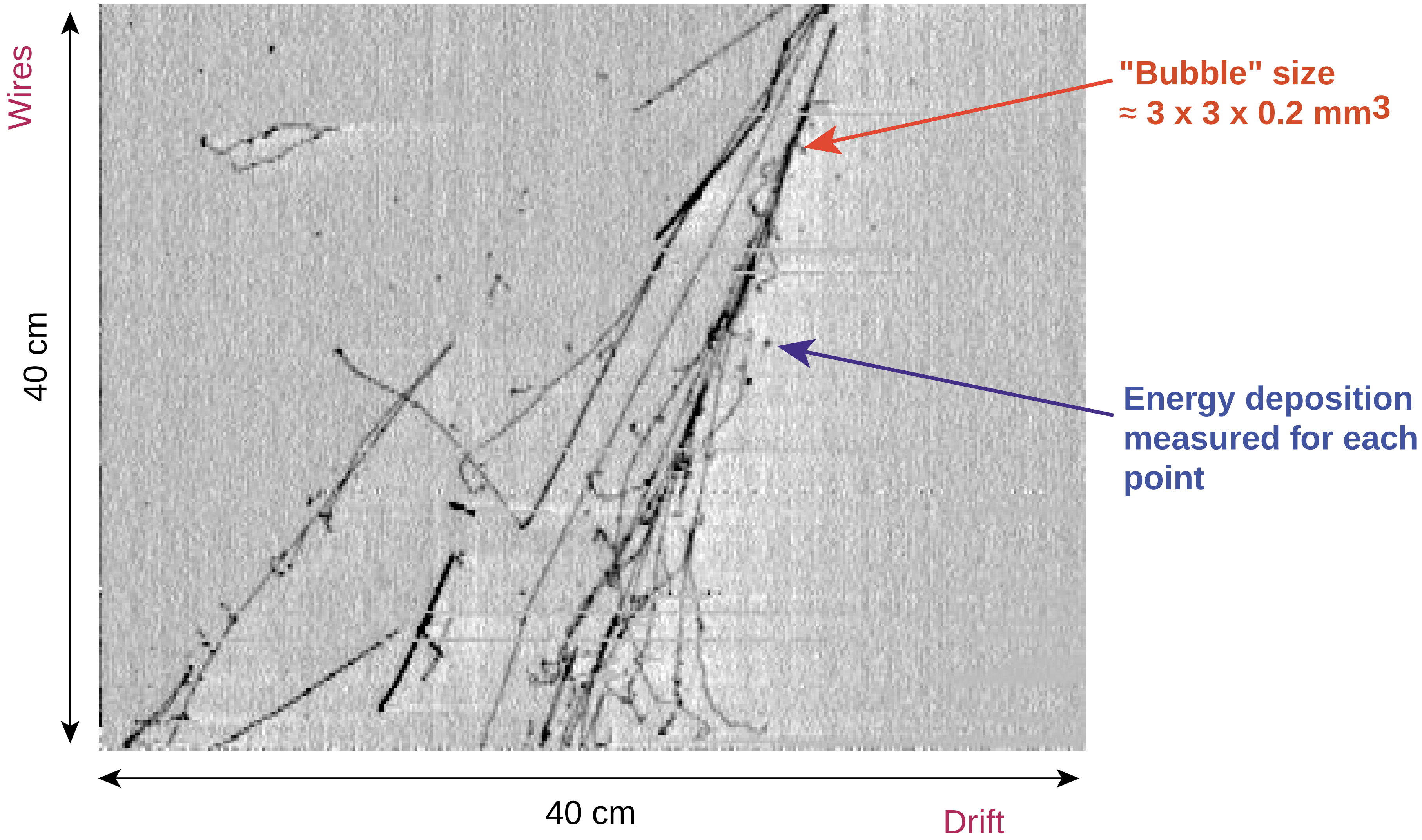
Electron-ion pairs are produced
Electrons give the main contribution to the induced current due to the much larger mobility

$$I_0 = e(v^+ + v^-)/d$$

A set of wires at the end of the drift give a sampling of the track
No charge multiplication occurs near the wires ➨ electrons can be used to induce signals on subsequent wires planes with different orientations ➨ ➨ 3D imaging

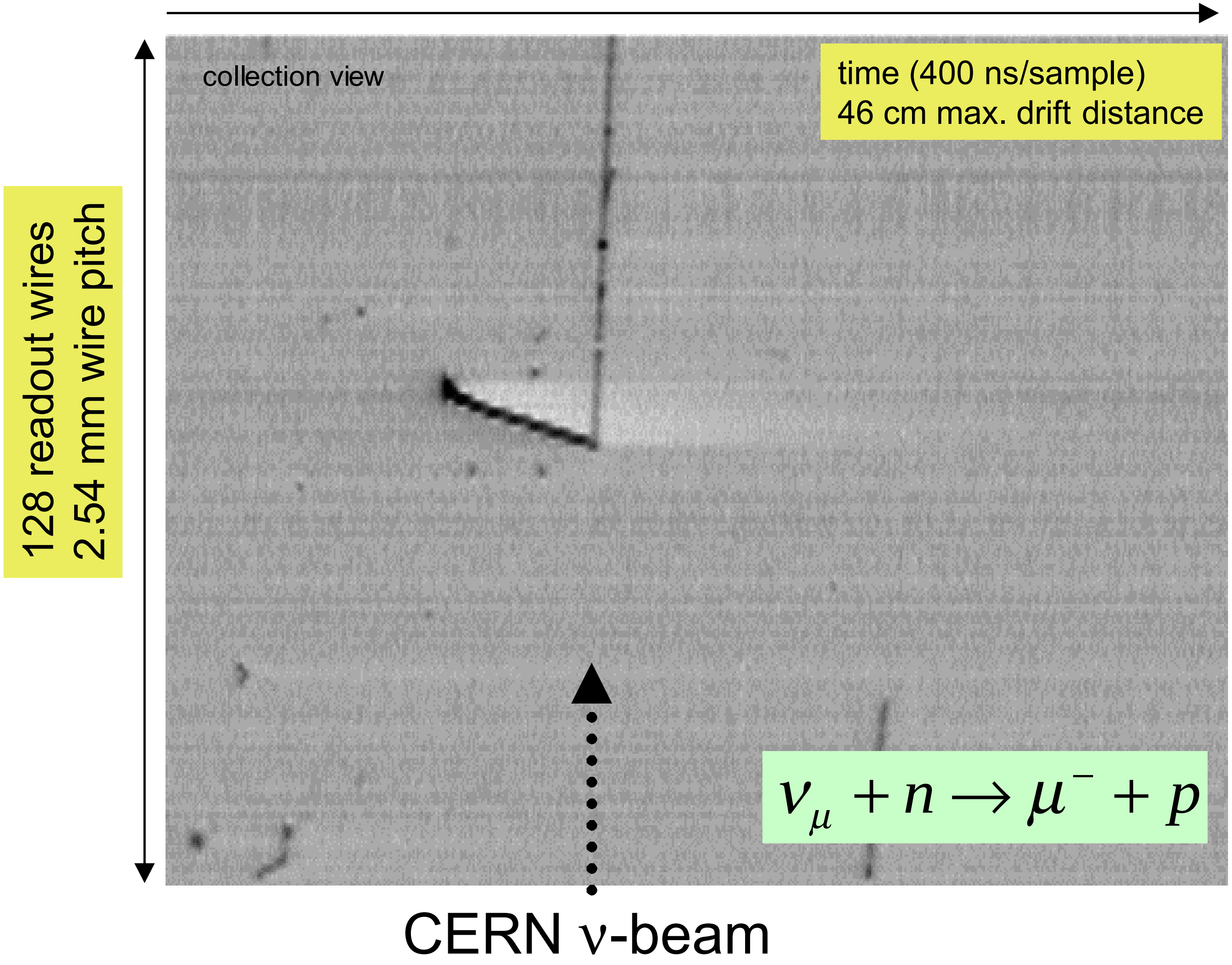
The liquid argon TPC

massive "electronic bubble chamber" with superb 3-D imaging



Neutrino event in 50 liter LAr TPC (1998)

ICARUS-CERN-Milano



(Chamber located in front of NOMAD detector)

ICARUS: a graded strategy

- The partnership of specialized industry already at the level of conceptual design has been crucial to the development of larger detector masses.

Lab activities:

Small-scale prototypes → **"15 ton"** → **2 x "300 ton"** → **"1400 ton"** → **?**

(2 x "300 ton": ≈2 m max. drift; 4 x 4 m^2 cross section)

("1400 ton": ≈4 m max. drift; 8 x 8 m^2 cross section)

Full test expected before end of 2000 (2 x "300 ton")

Cooperation with specialized industries:

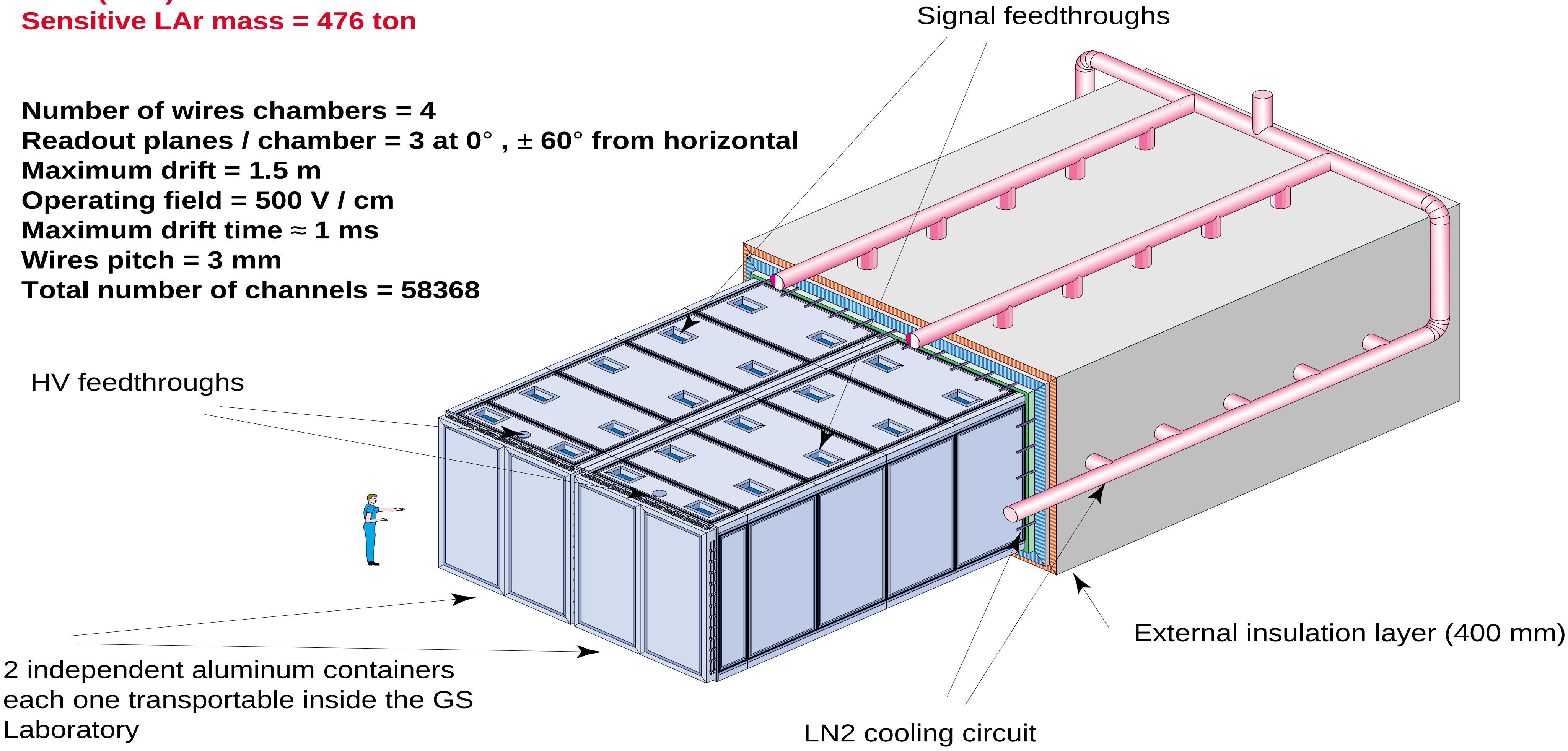
- **Air Liquide** for Cryostat and Argon purification
- BREME Tecnica for internal detector mechanics
- CAEN for readout electronics

ICARUS T600 module

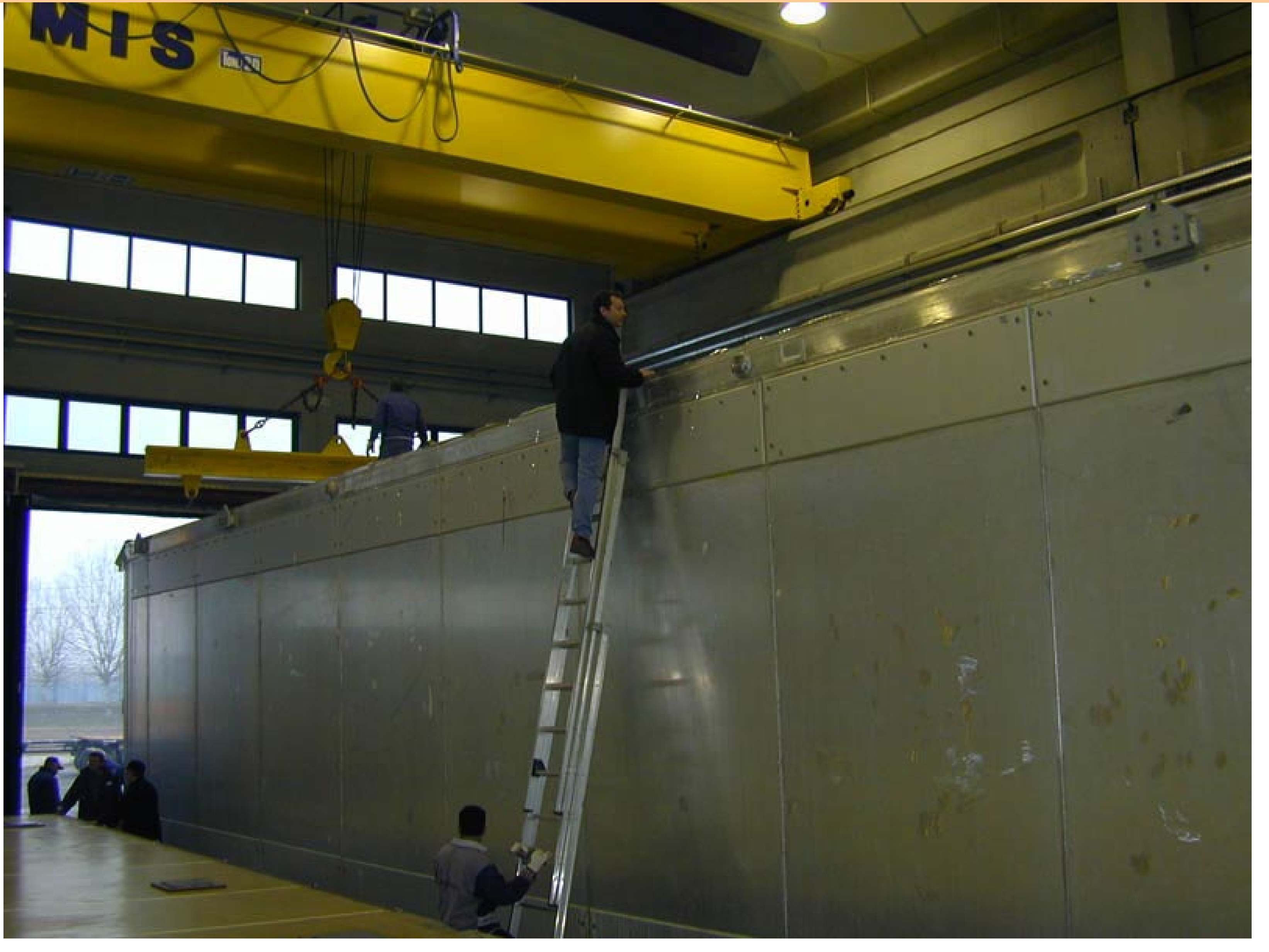
Under construction

Number of independent containers = 2
Single container Internal Dimensions: Length = 19.6 m , Width = 3.9 m , Height = 4.2 m
Total (cold) Internal Volume = 534 m^3
Sensitive LAr mass = 476 ton

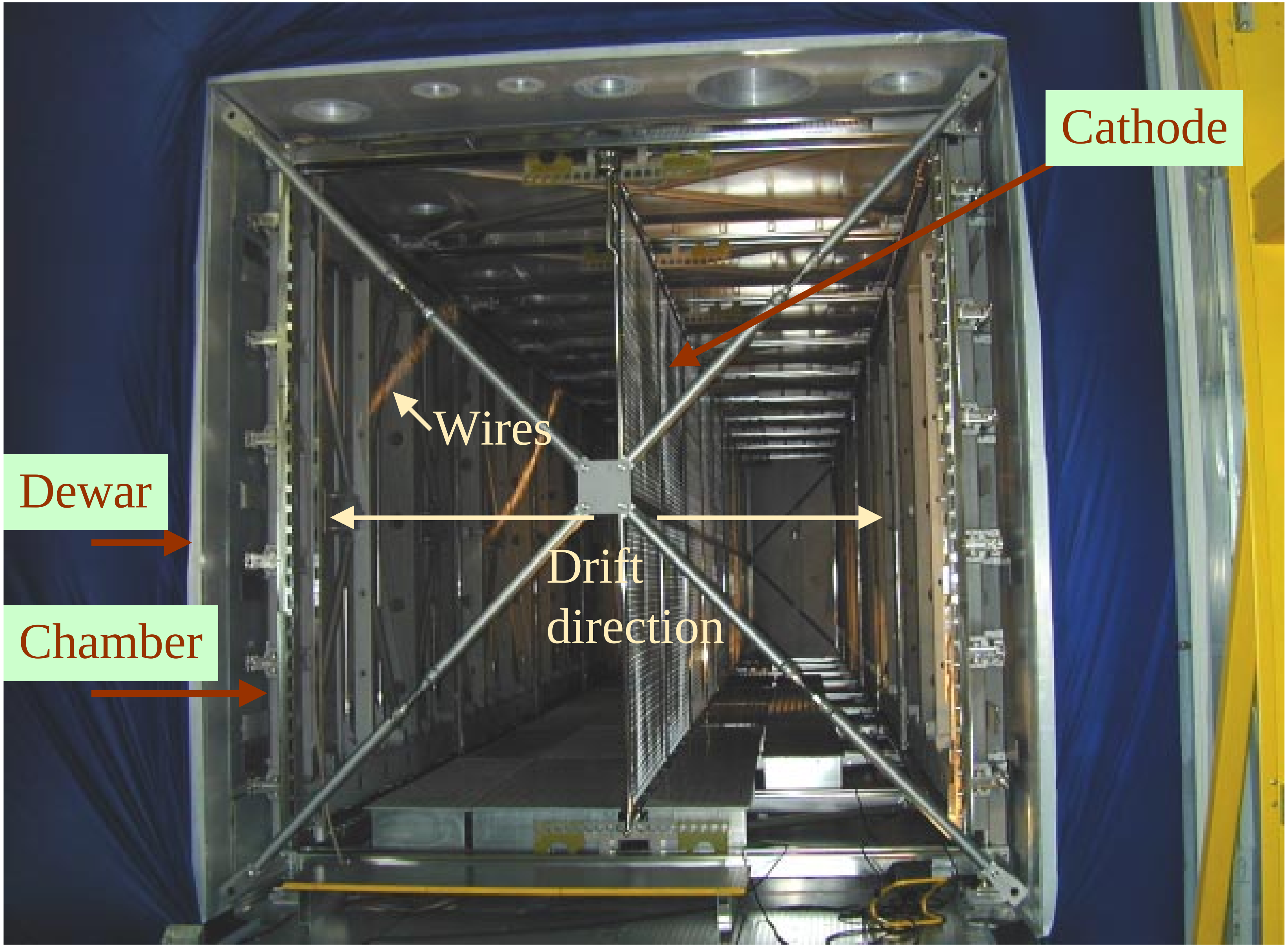
Number of wires chambers = 4
Readout planes / chamber = 3 at 0° , ± 60° from horizontal
Maximum drift = 1.5 m
Operating field = 500 V / cm
Maximum drift time ≈ 1 ms
Wires pitch = 3 mm
Total number of channels = 58368



Half module external view



T600 - Detector Internal View



T600 module slow control system

Vacuum

Dewar walls acquire concavity

Cooling

Distance between dewar walls and chamber is reduced

Wires length reduced in a 3‰

LAr filling

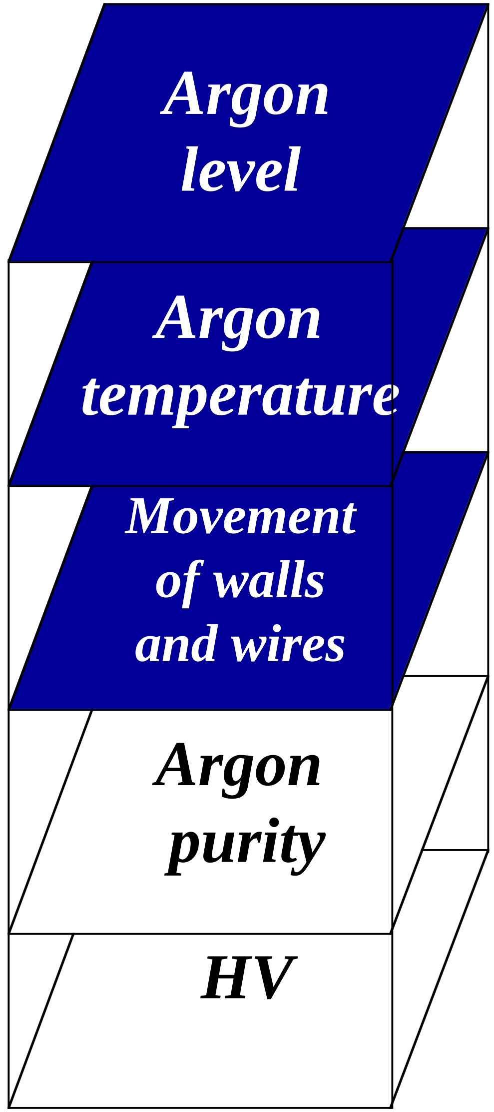
Dewar walls acquire convexity

Running mode

Argon gets impurities

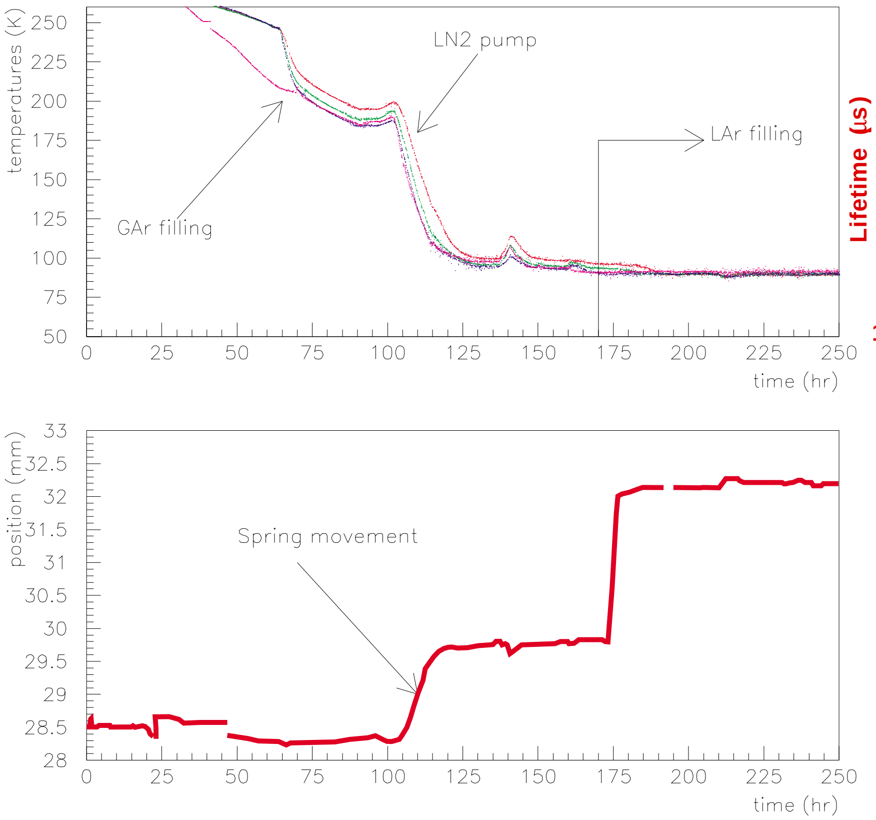
E Field has to be kept stable

Control:

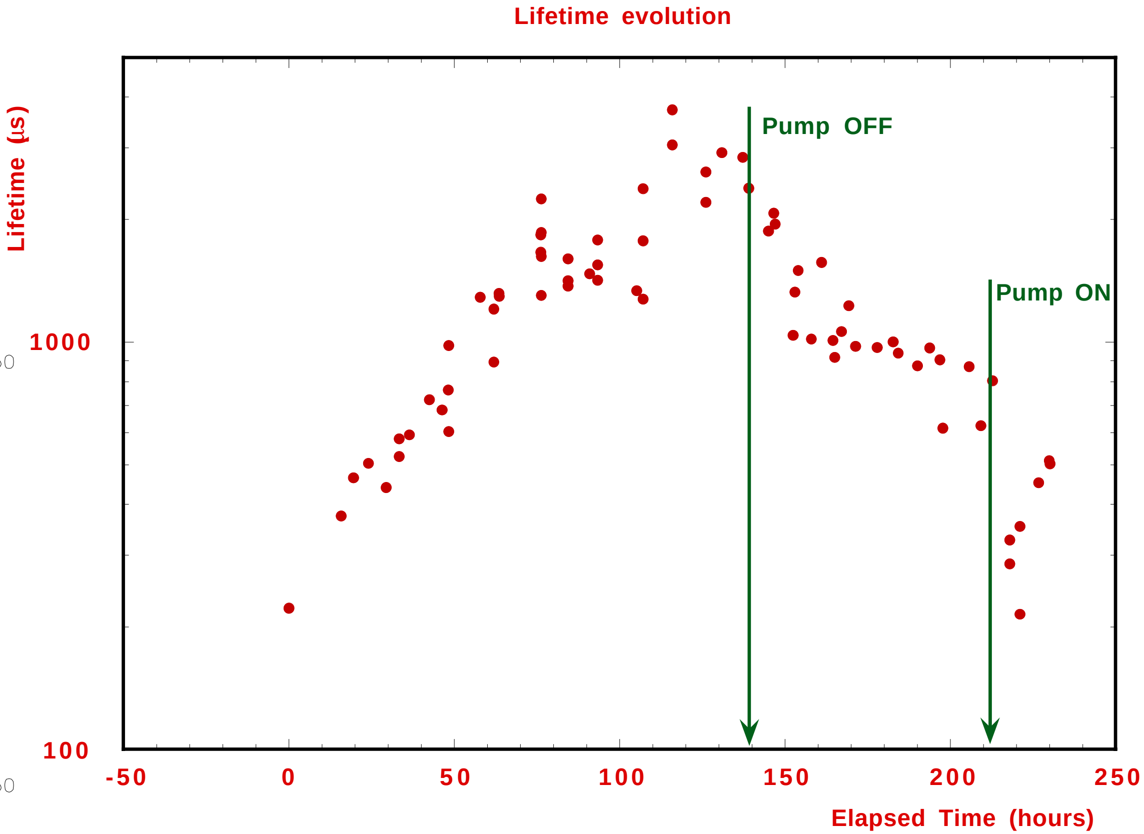


Cooling 15 ton prototype March ‘99

Temperature / Spring movement



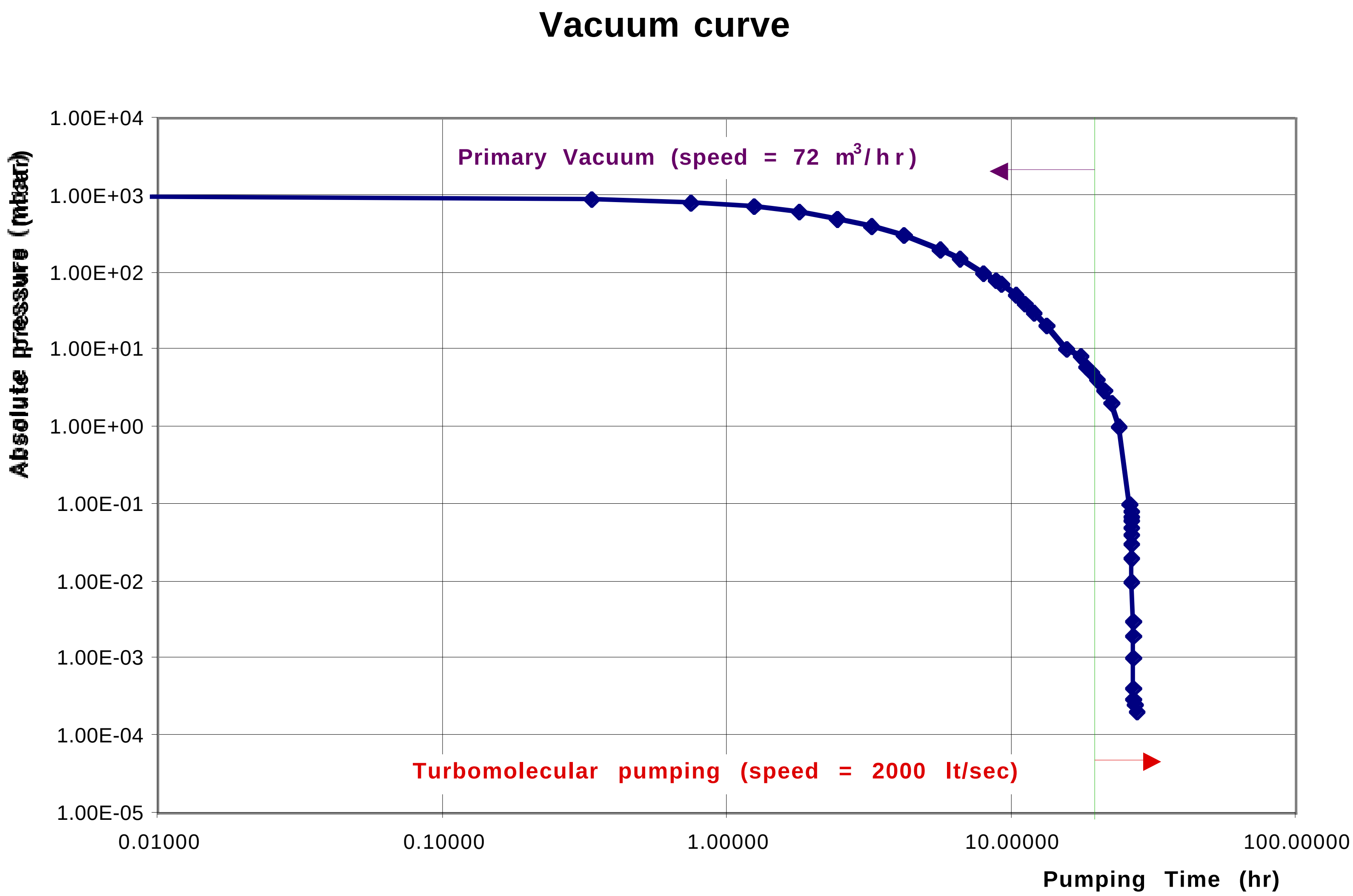
LAr purity



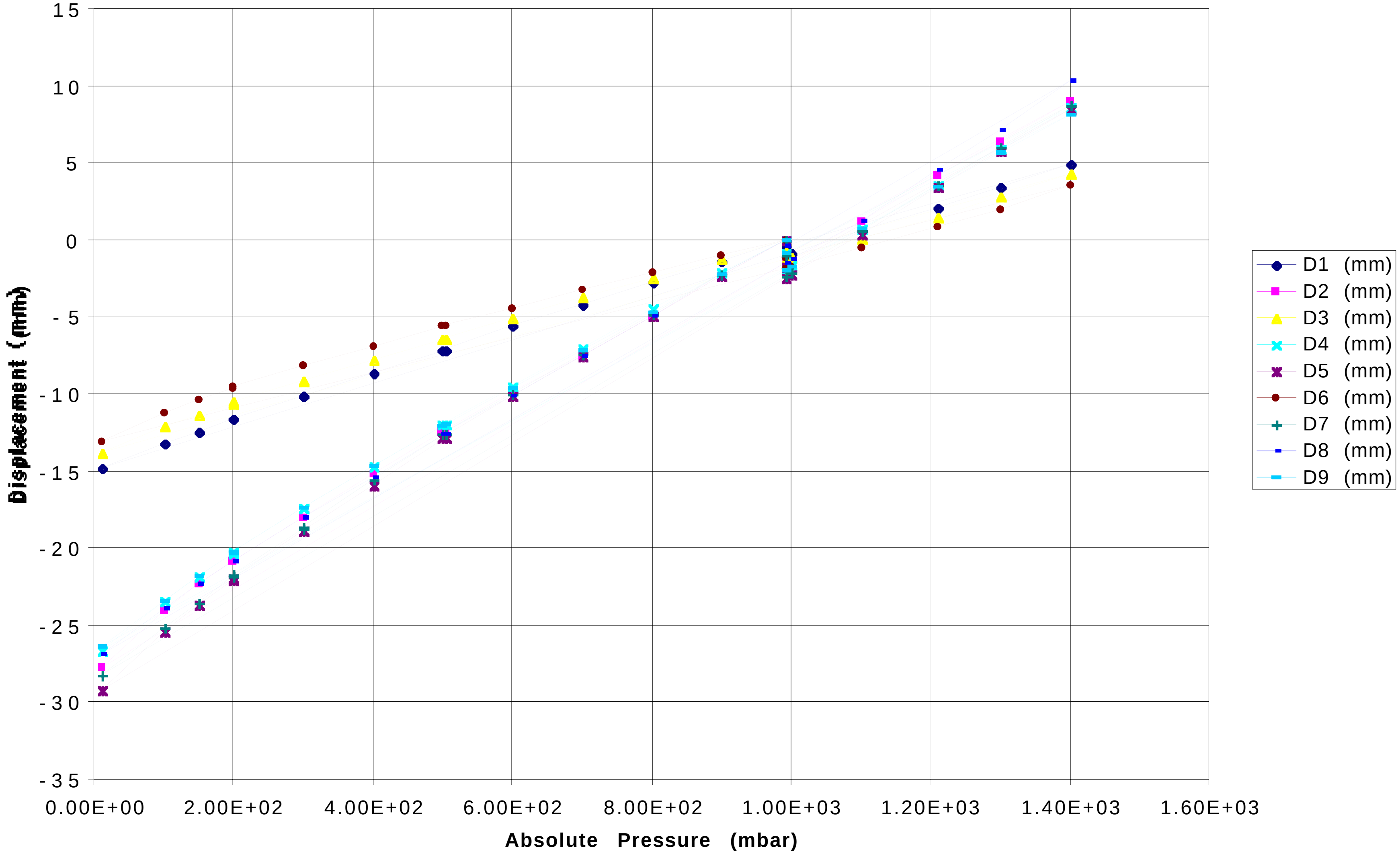
✖ Confirmation of the functionality of the *variable geometry* mechanics

✖ **The electrons lifetime, after about 4 days of circulation, was between 2 ms to 3 ms.**

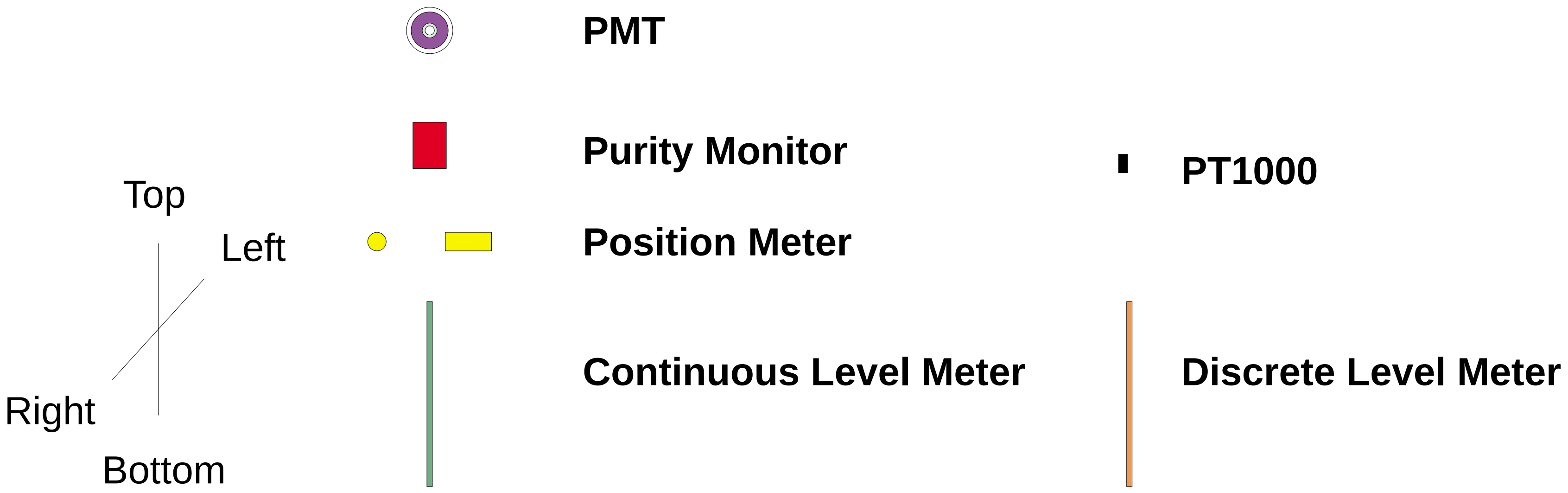
Vacuum Tests

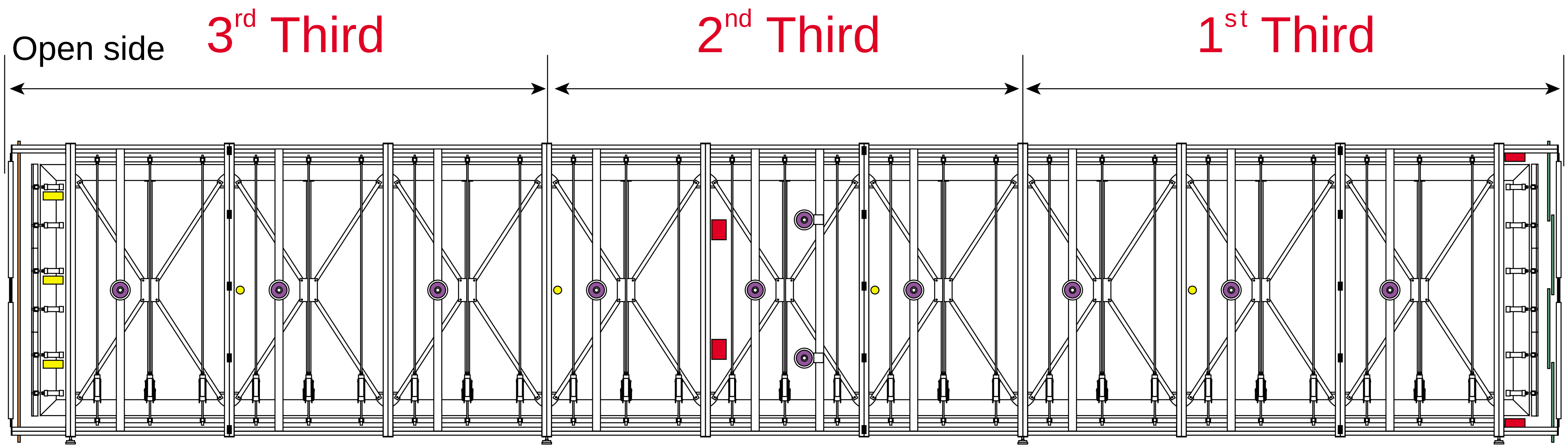


Walls displacements



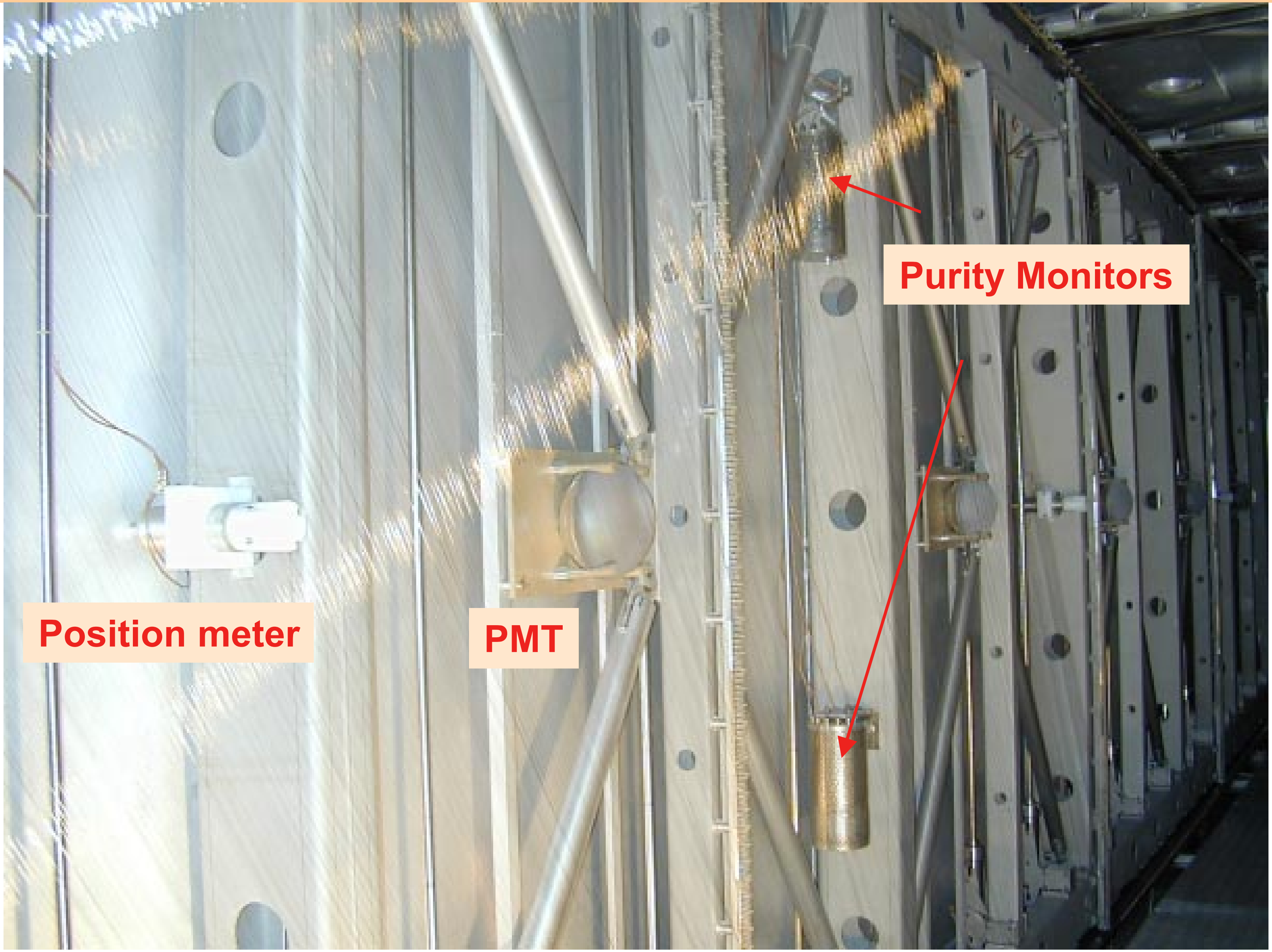
Instrumentation



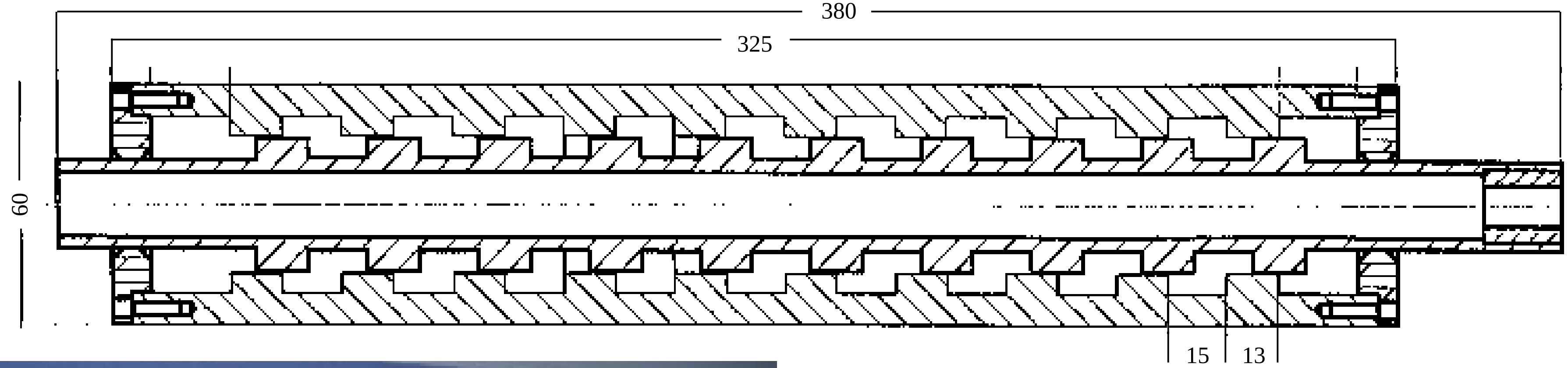


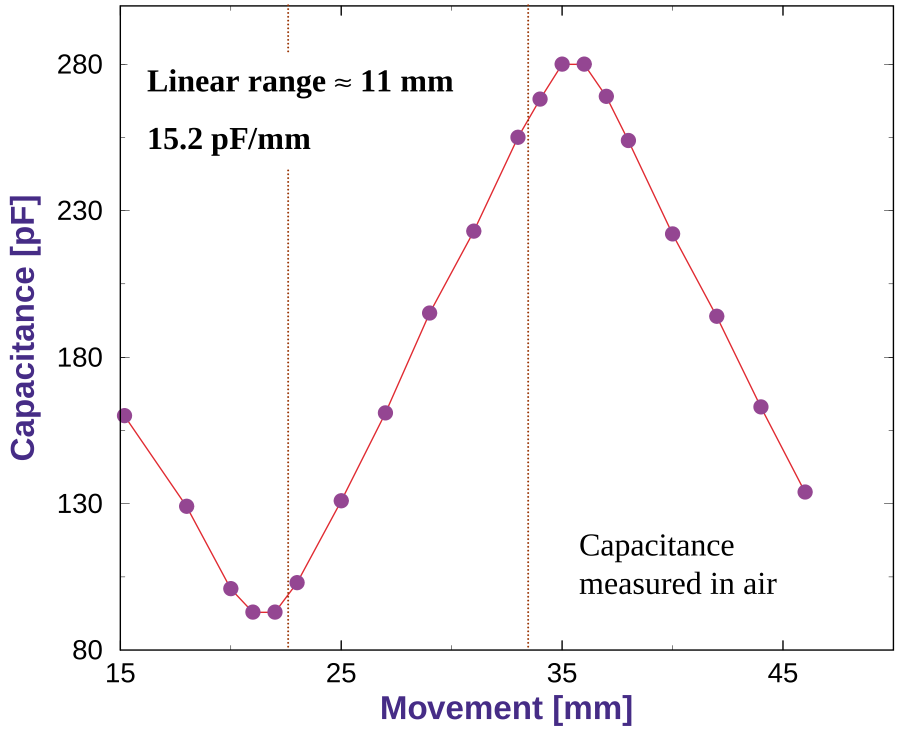
Mounting inside T600 detector (clean room)

Slow control sensors

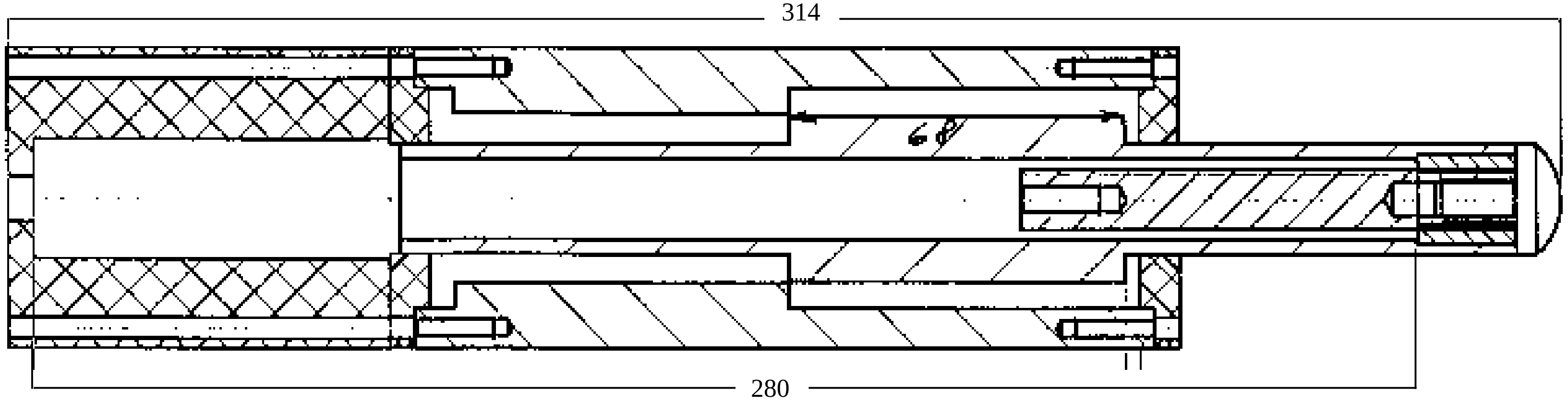


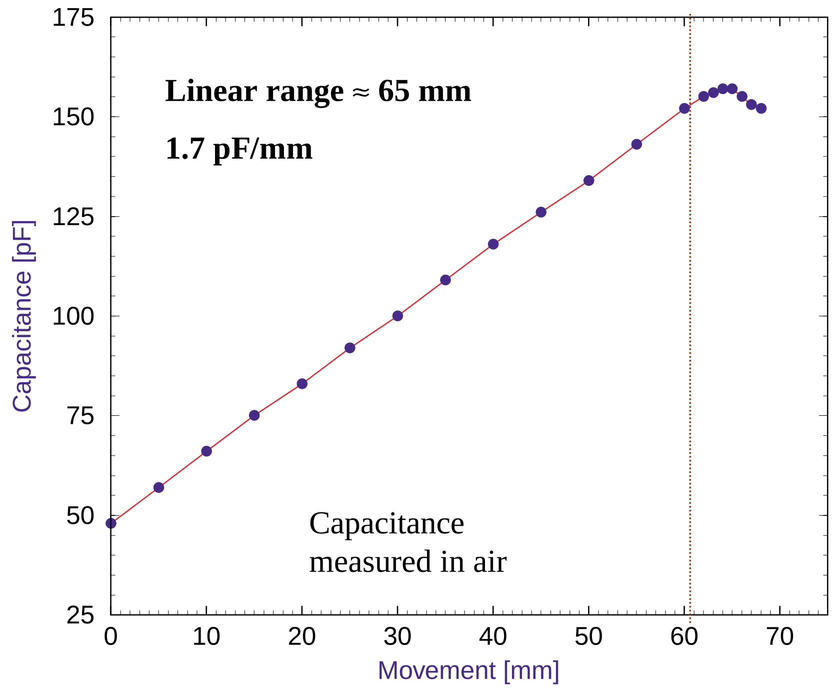
Wires position meters



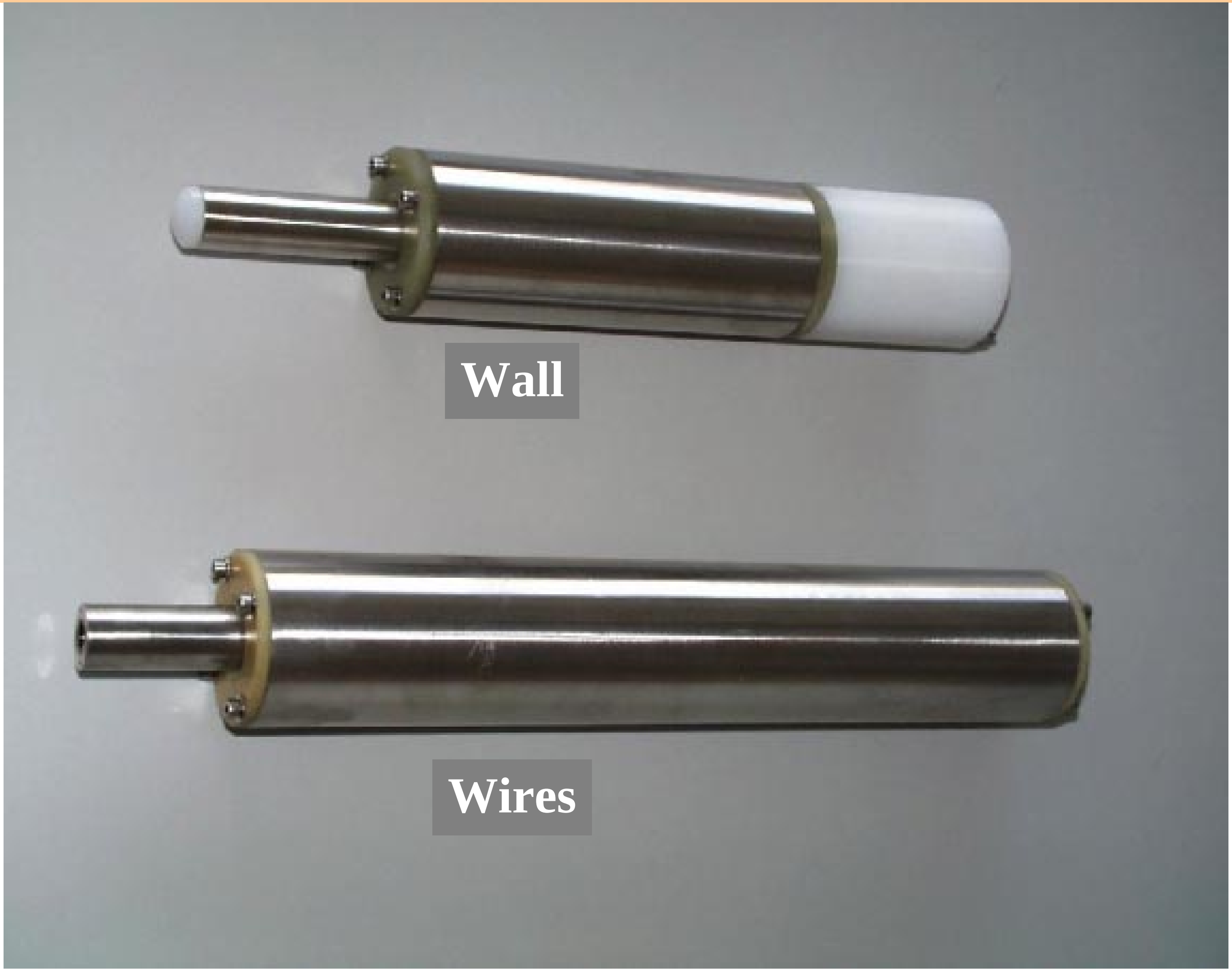


Wall position meters

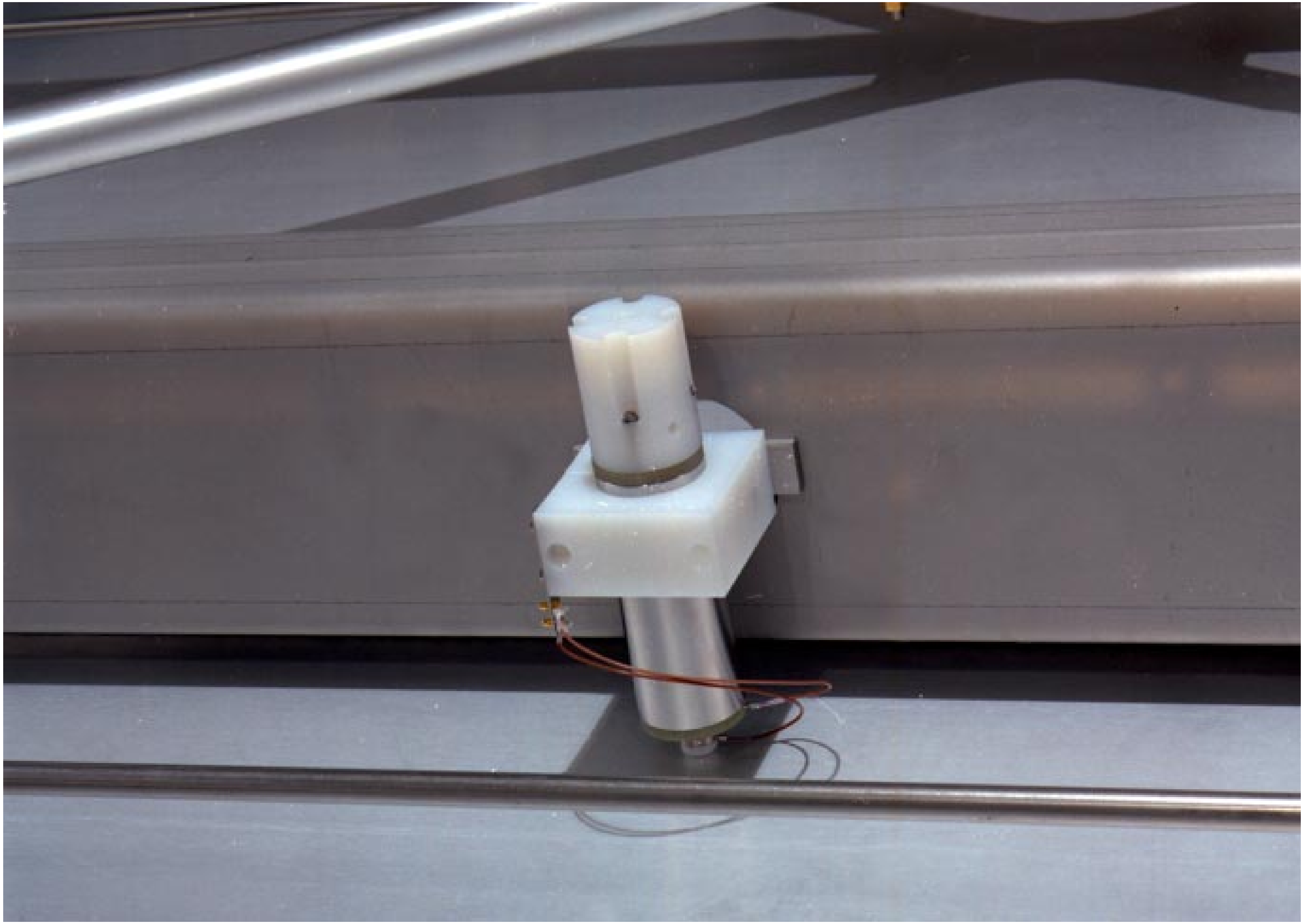




Mounted position meters



Wall position meters



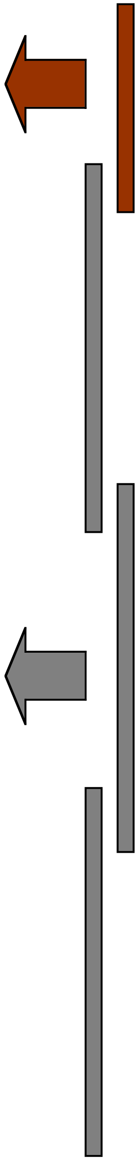
Level meters

1 level meter for precise measurement in running mode

- 50 cm long
- Zero capacitance: 750 pF
- Sensitivity ≈ 7 pF/cm
- Precision ≈ 1 mm

3 commercial level meters for level control during filling

- 130 cm long
- Zero capacitance: 240 pF
- Sensitivity ≈ 0.8 pF/cm
- Precision ≈ 1 cm



One set of four level meters at all four corners

LAr level meters

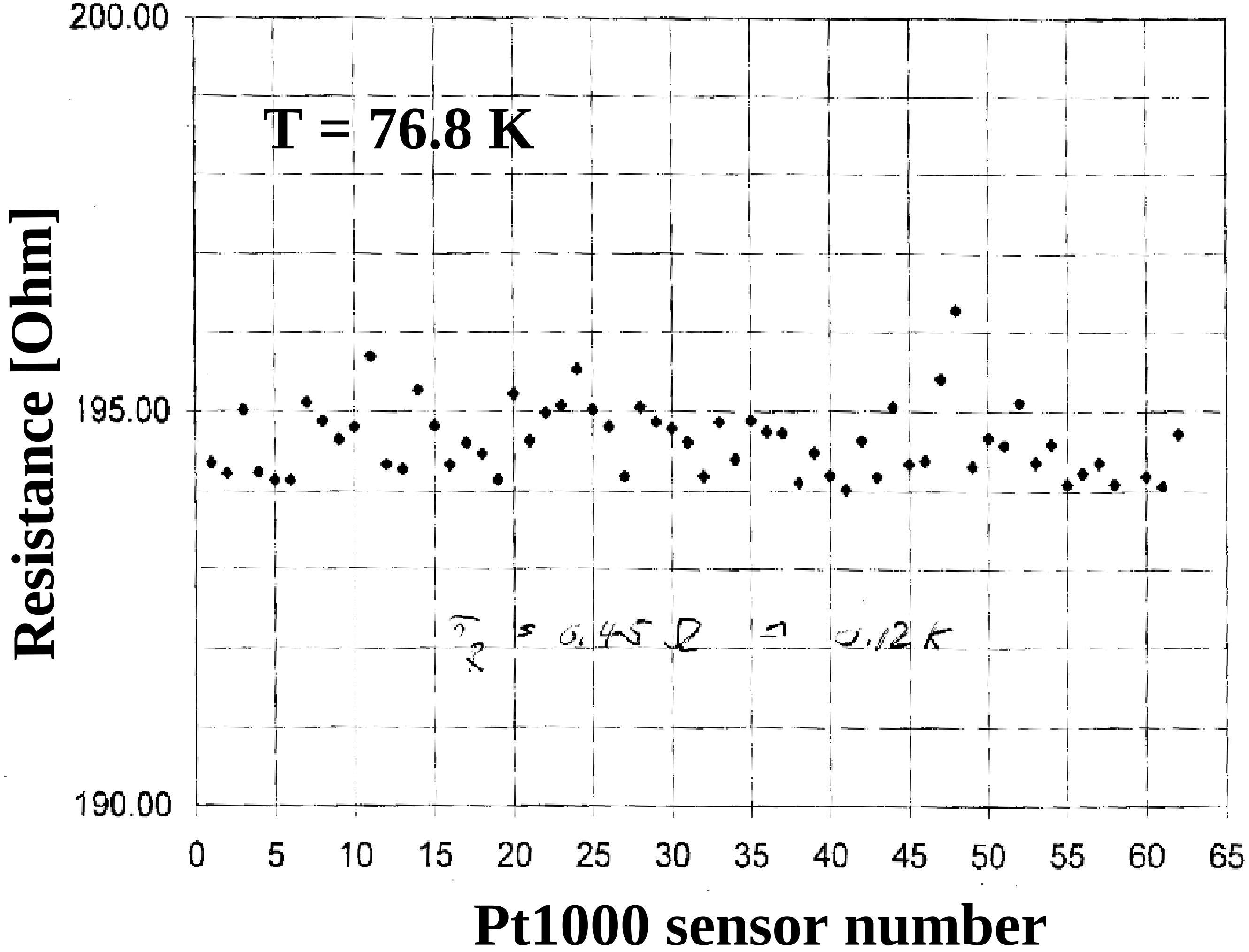
Temperature measurement

Dispersion of Pt's

Temperature is measured with Pt1000 sensors

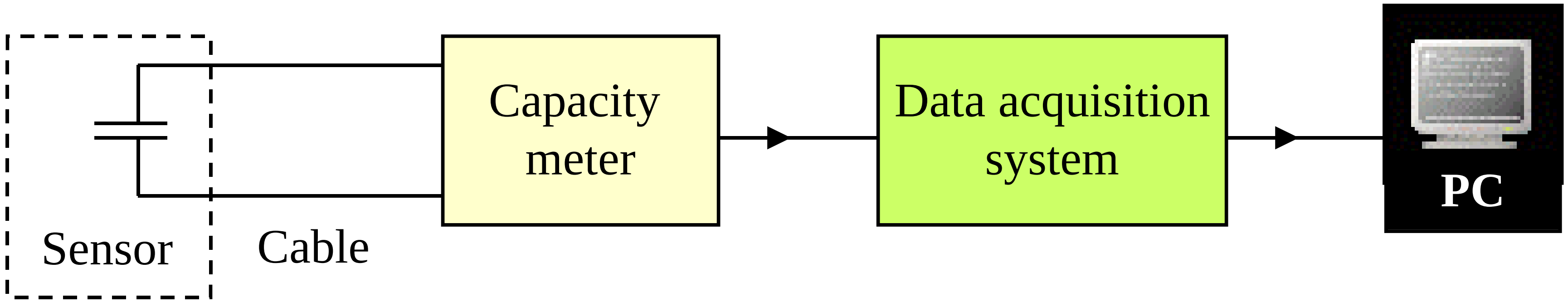
$$
\begin{aligned}
R(T) \;=\; & -145.61 + 4.6035 \cdot T \\
& -1.9713 \cdot 10^{-3} T^2 \\
& +1.7584 \cdot 10^{-6} T^3
\end{aligned}
$$

(with T in K)



Stability of the slow control readout system

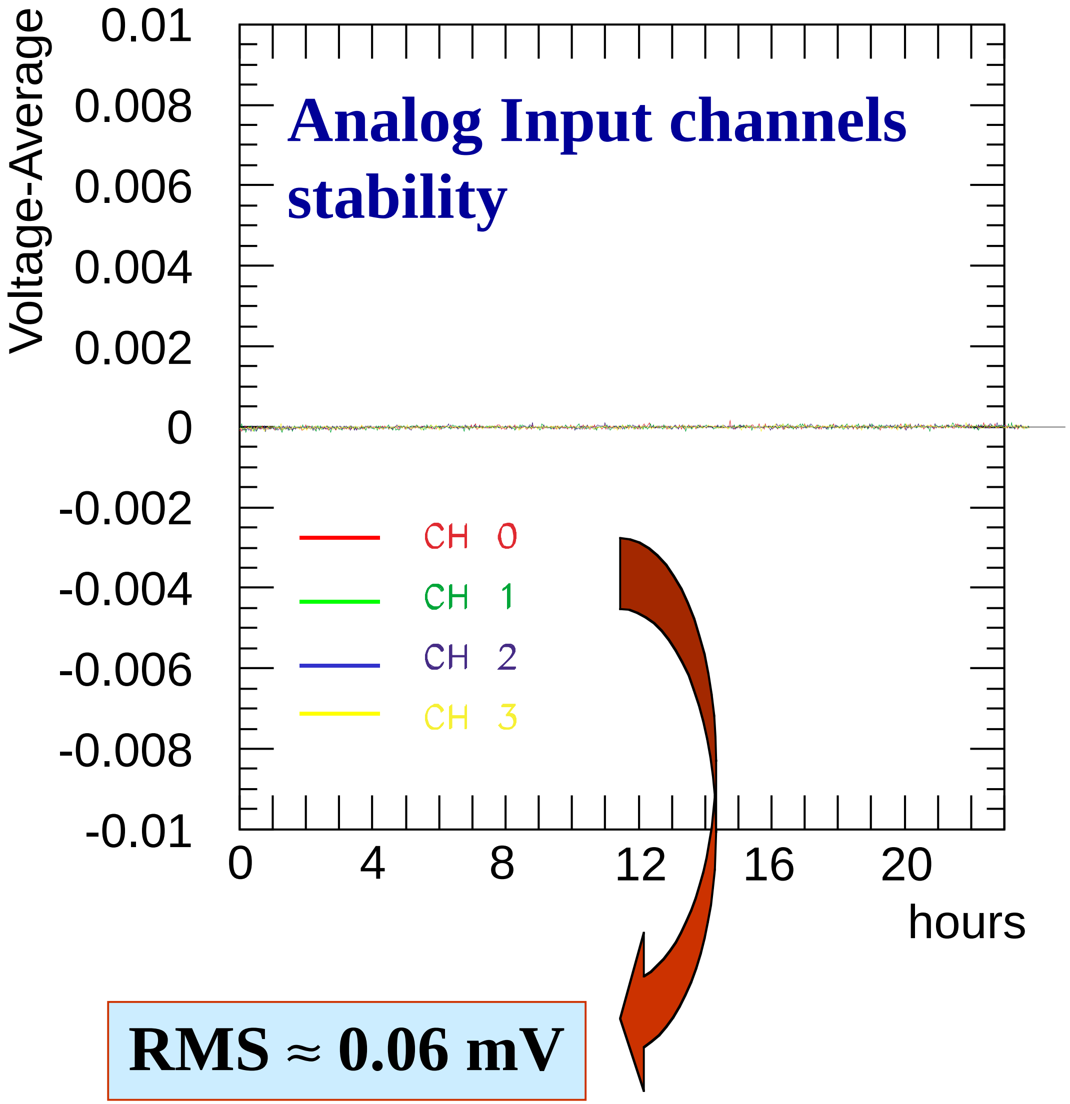
Measurement chain for level and position meters:



The stability of the whole measurement chain has to be checked

- ✓ **Noise**
- ✓ **Temperature effect**

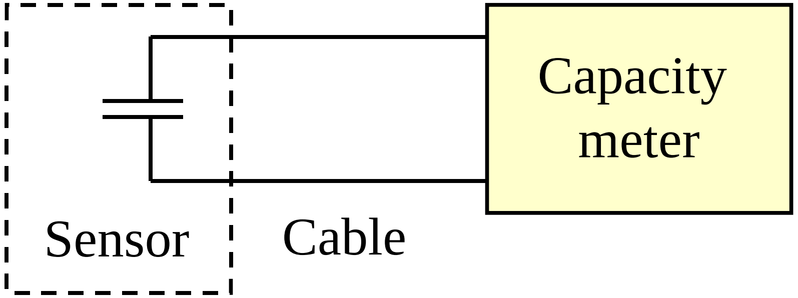
Stability of the data acquisition module (EDAS)



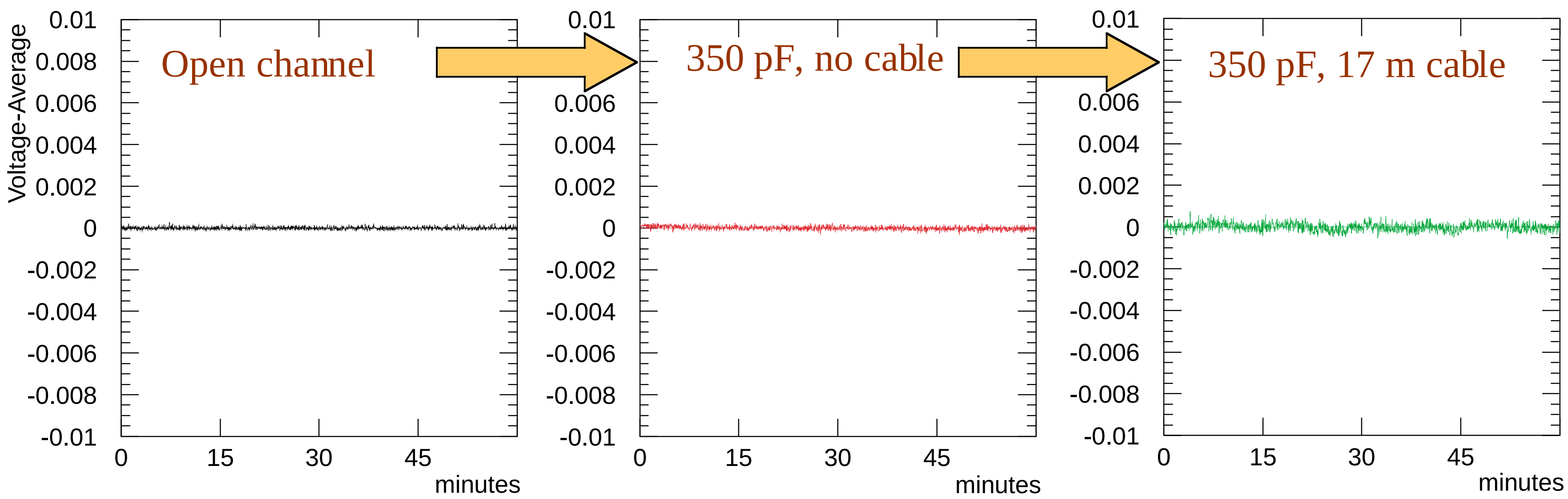
Analog input channels shorted in order to measure the stability of the EDAS device

RMS ≈ 0.06 mV

Stability of capacity meters



Checking noise introduced by this part of the experimental setup

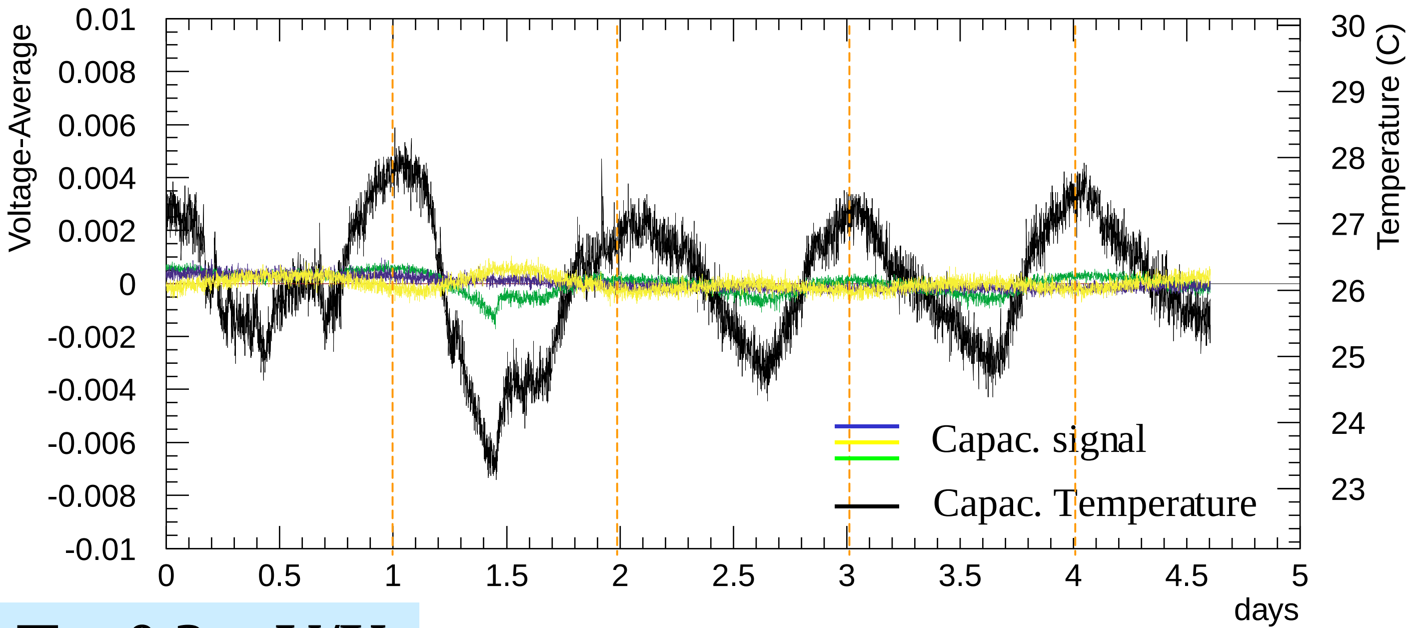


RMS ≈ 0.06 mV

RMS ≈ 0.09 mV

RMS ≈ 0.20 mV

Long term stability

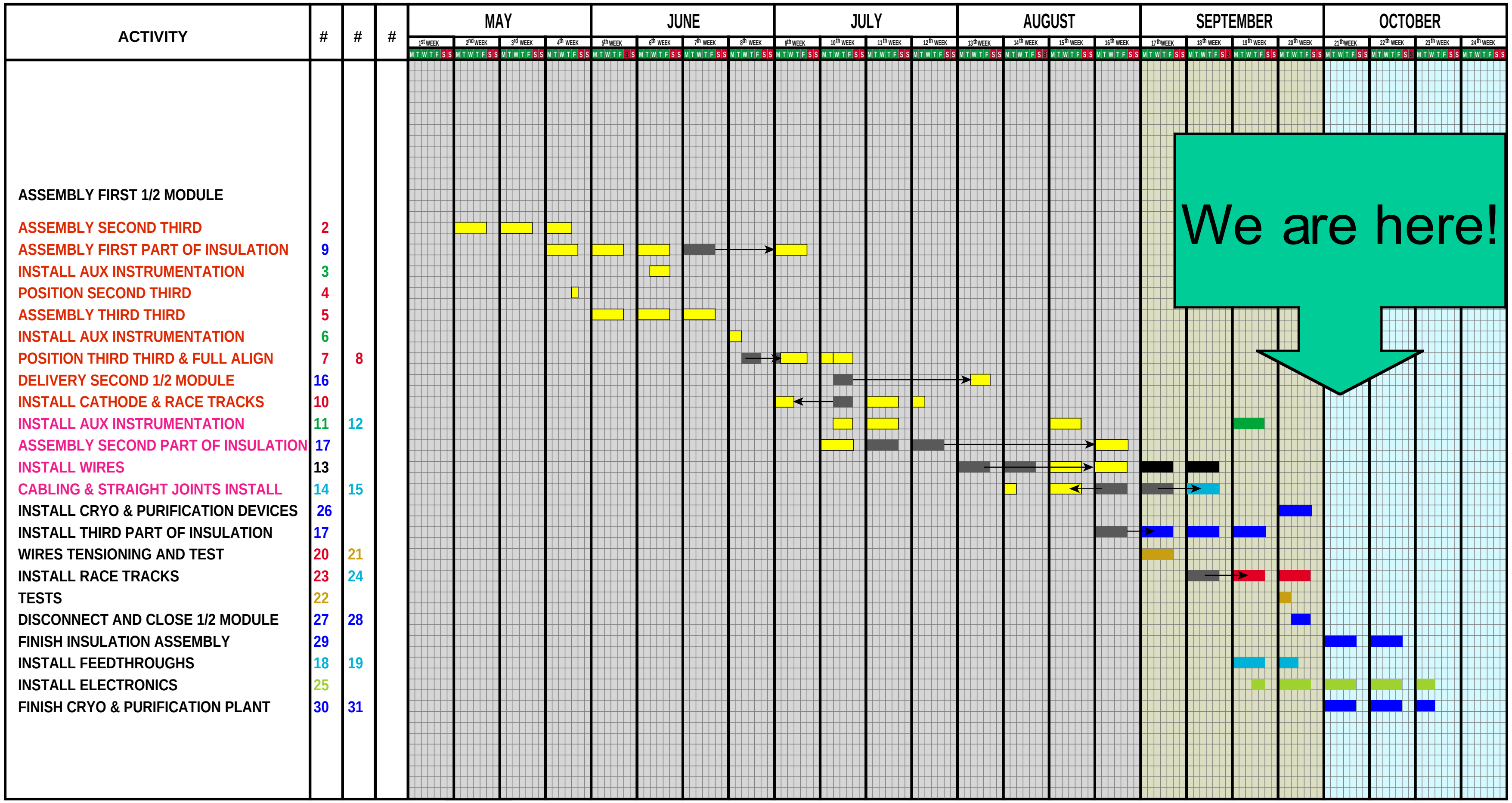


ΔV/ΔT ≈ 0.3 mV/K

After correction of these effects:

- 1.3m level meters: ±2 mm
- 0.5m level meters: ±1 mm
- Position wires: <0.1 mm
- Position walls: <0.3 mm

Planning for the assembly of the first half module



Color Scheme:

- Completed
- Moved
- Cryogenics & Purification
- Internal Detector Mechanics
- Electronics
- Auxiliary Instrumentation
- Wires Positioning
- Tests

Conclusion

⊙ Current experimental challenges on neutrino physics require innovating detection techniques

⊙ The ICARUS technology will help elucidate the atmospheric neutrino anomaly

⊙ ICARUS T600 module first semi-module is near finishing mounting phase

⊙ The slow control system sensors have been tested and their precision and stability checked. The required features have been achieved