HECAL: A cryostat for calibration of hot wires.

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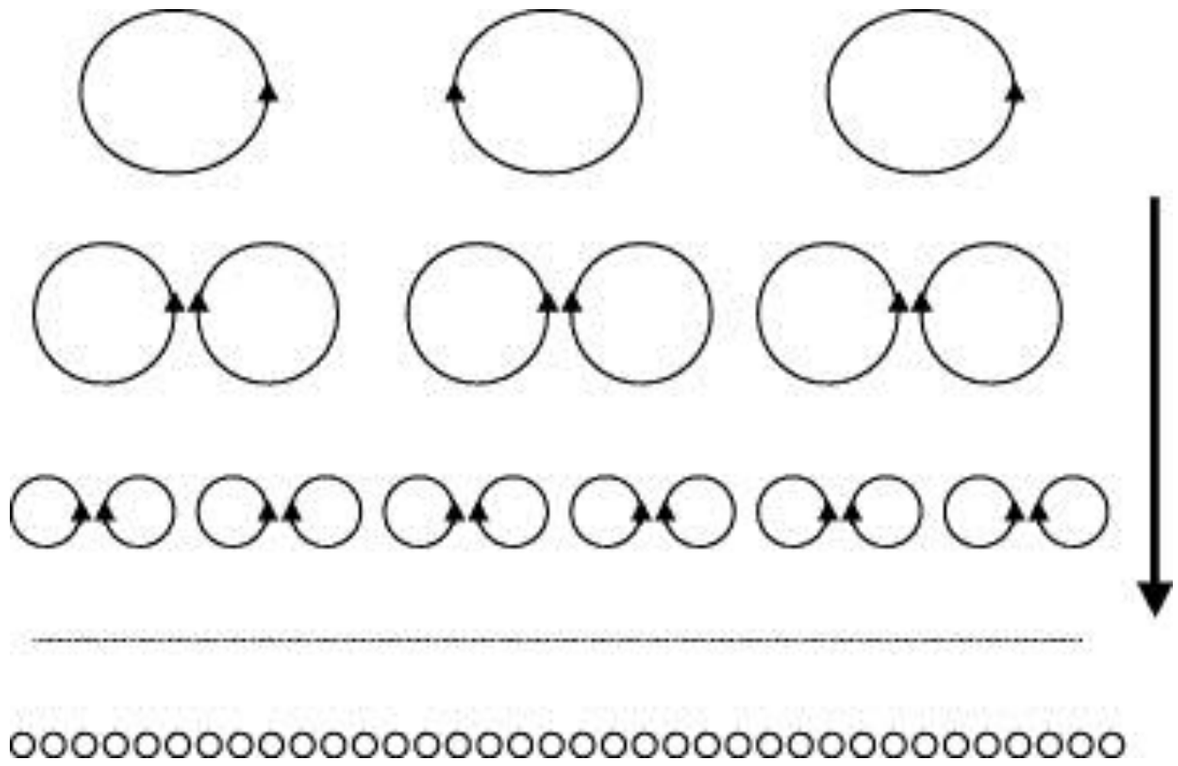
OUTLINE

1. Introduction: helium for fundamental turbulence
A few experiments at CEA/SBT
SHREK
HEJET

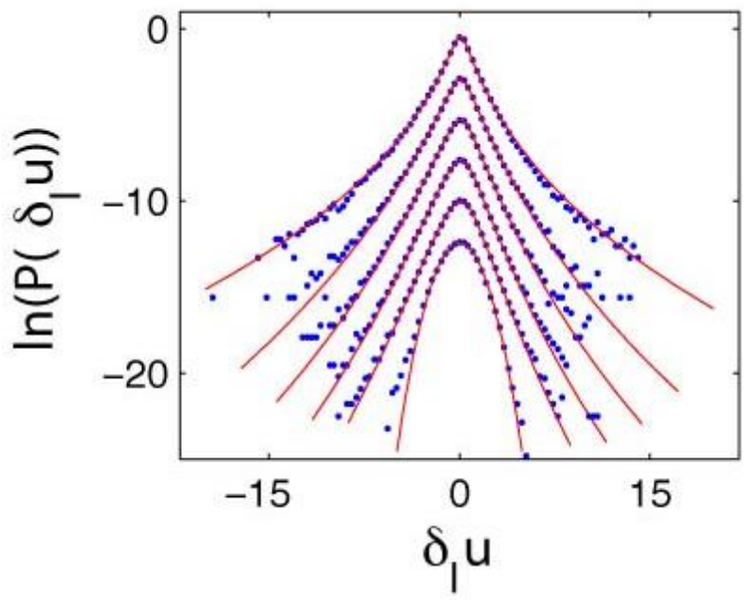
2. Hot wire anemometry

3. HECAL, measurements

Introduction: research on turbulence

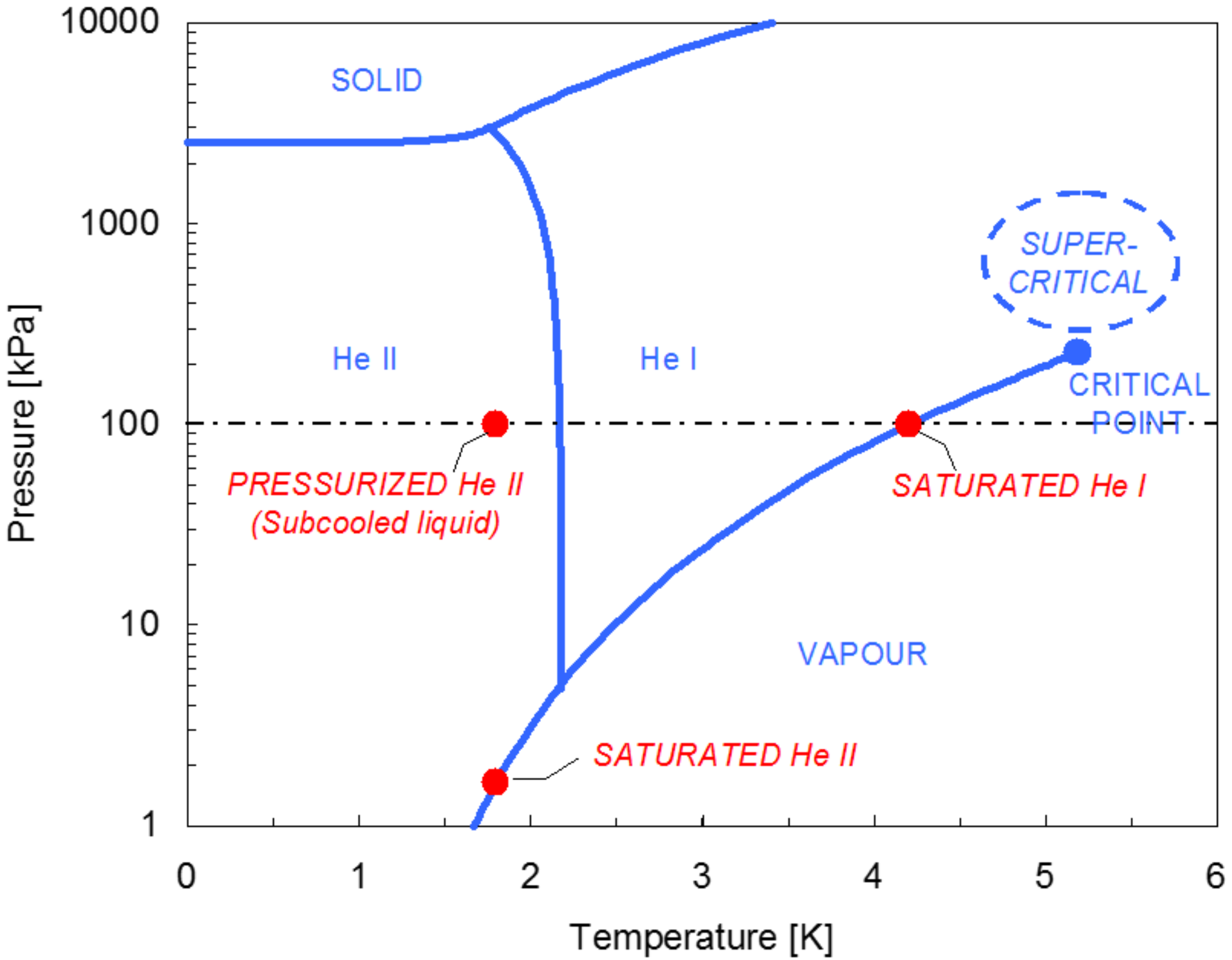


Description of the cascade process still under discussion :
intermittency (at small scales) not yet understood.

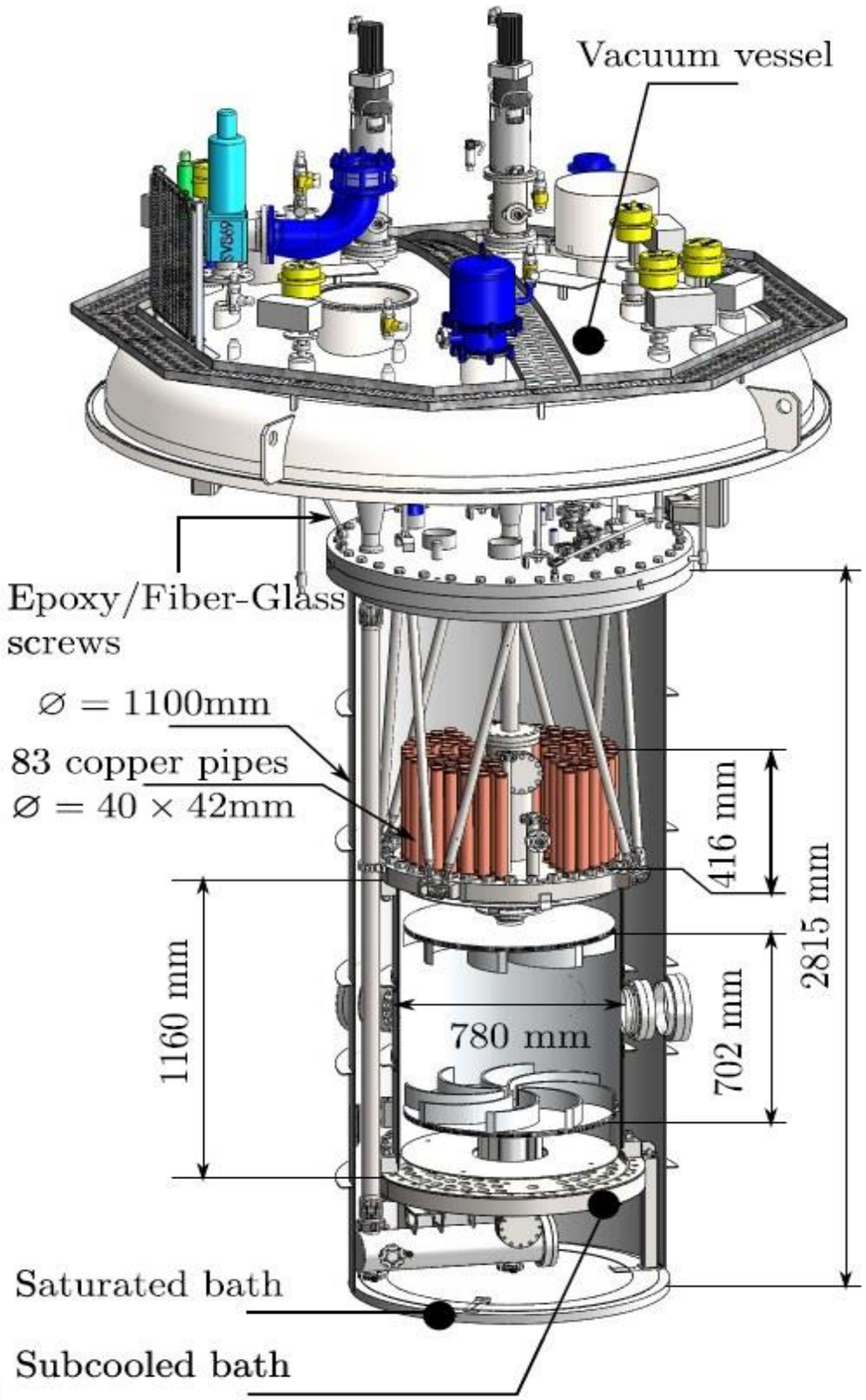


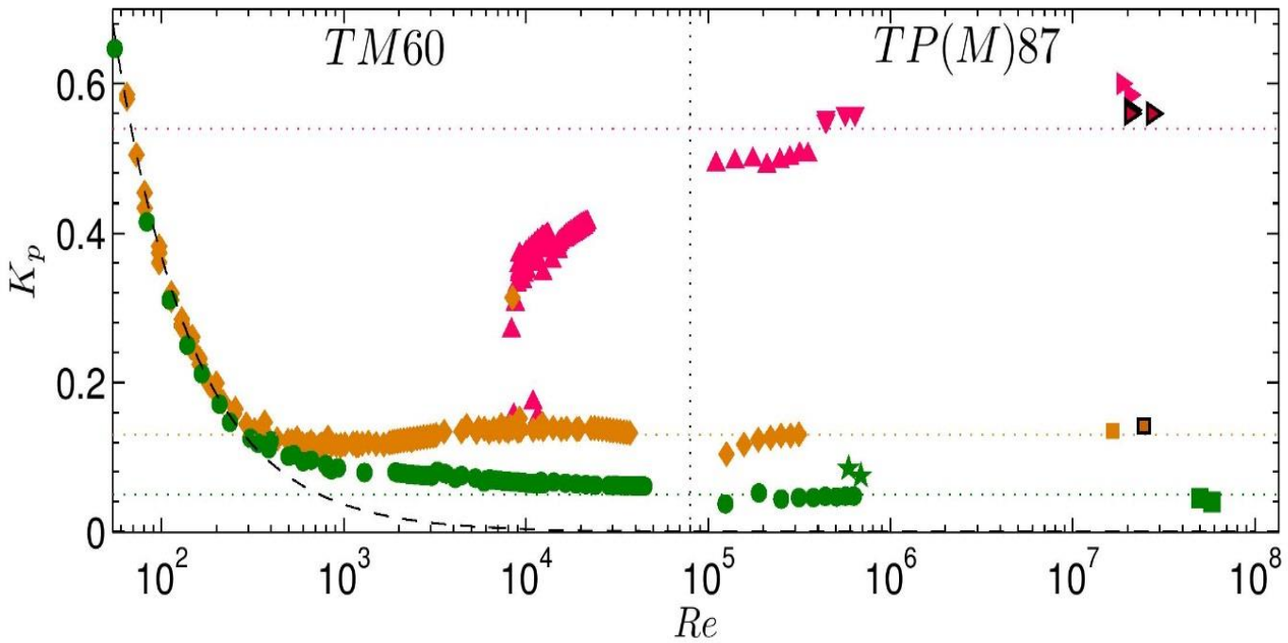
Models assume **infinite Reynolds**
=> interest of HELIUM

Helium properties make it the ideal fluid for fundamental studies

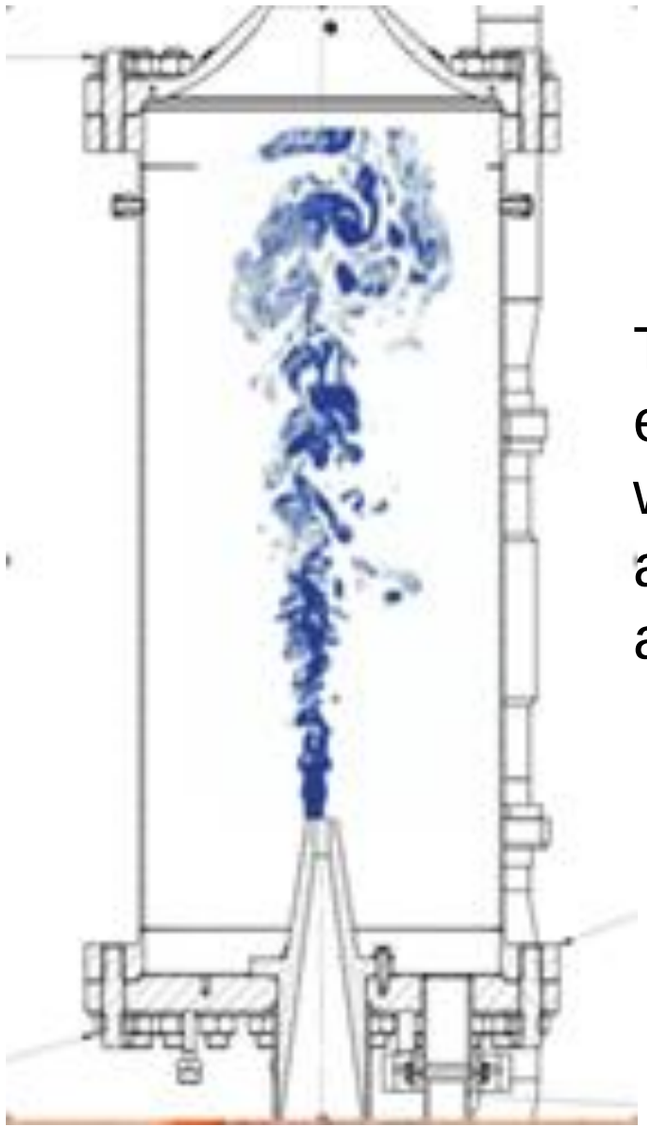


Examples : (1) the SHREK experiment





Examples (2) the Hejet experiment



The jet is generated by the expansion of the liquid helium which is set in movement by a rotating pump, and cooled via a copper heat exchanger

Measuring velocity fluctuations: Hot Wire Anemometry

$$\frac{L}{\eta} \propto Re^{3/4}$$ => Need for very small sensors ($\eta \sim$ few µm)

Hot wires are the most widespread (and efficient) sensors for measuring the turbulent fluctuations of the velocity,

Principle: convective flux cools the wire & changes its resistance

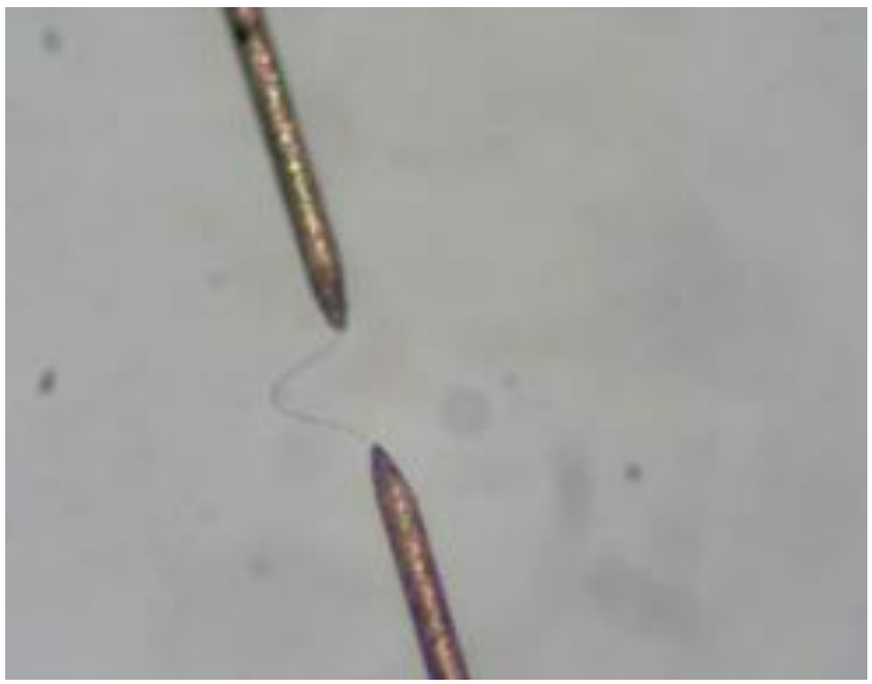
But : small hot wires are not available commercially

⇒Developments at CEA Grenoble for:

- Small (micron size) sensors
- Reliable sensors.

⇒ technique of **Wollastone** hot wires

⇒ Calibration ?



A few equations…

Energy balance :

$$m\,C\,\frac{dT_w}{dt} = R_w\,I^2 - \,\pi\,l\,k_f\,(T_w - T_a)\,Nu$$

King's law: $Nu = a + \,b\,Re_w^n$; $n=0.5$

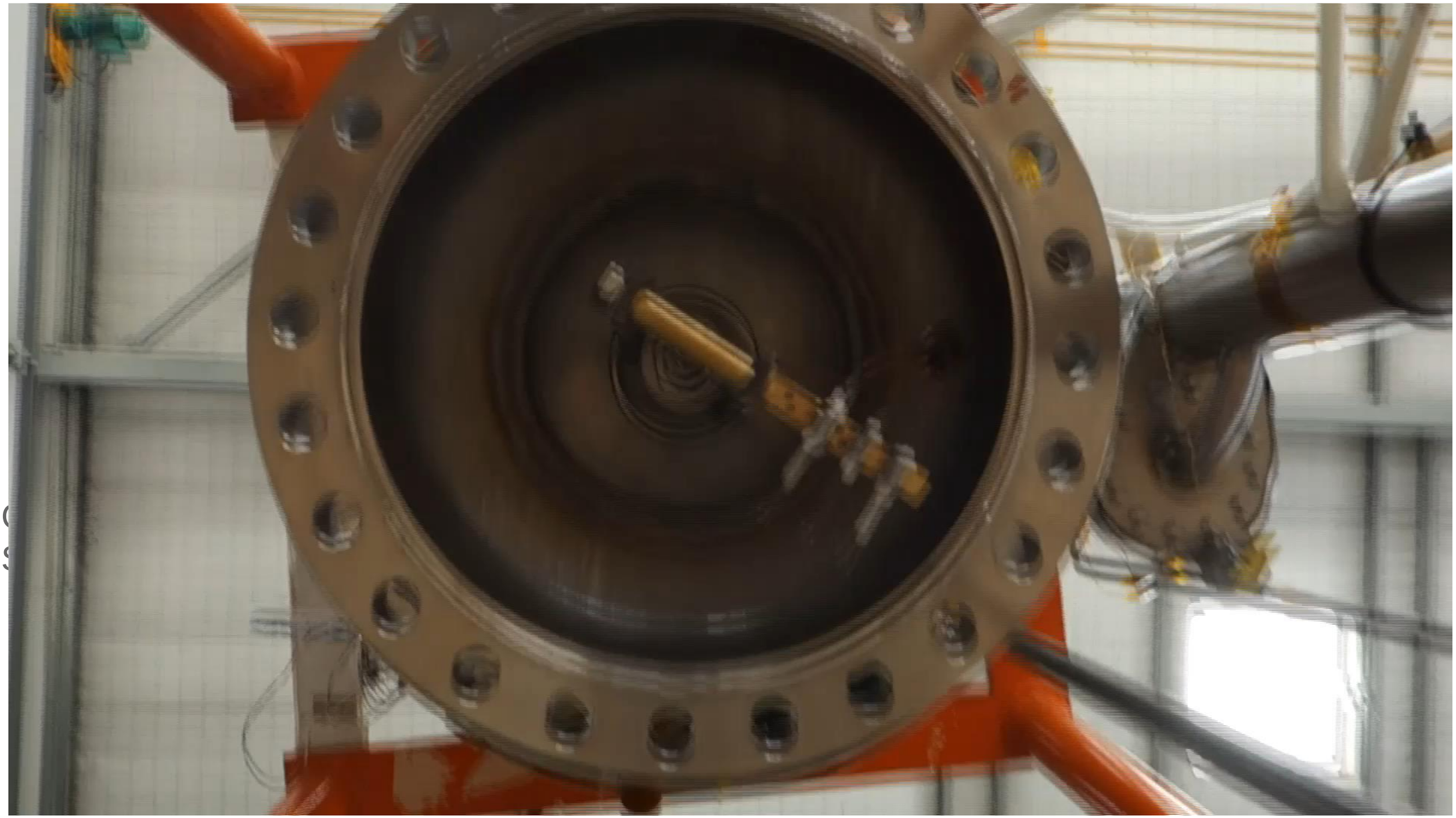
dependence of Resistance with Temperature

$$\frac{m\,C}{\alpha R_0\,(A - I^2 + BU^n)}\,\frac{dR_w}{dt} + \,R_w = \frac{A + BU^n}{(A - I^2 + BU^n)}\,R_0$$

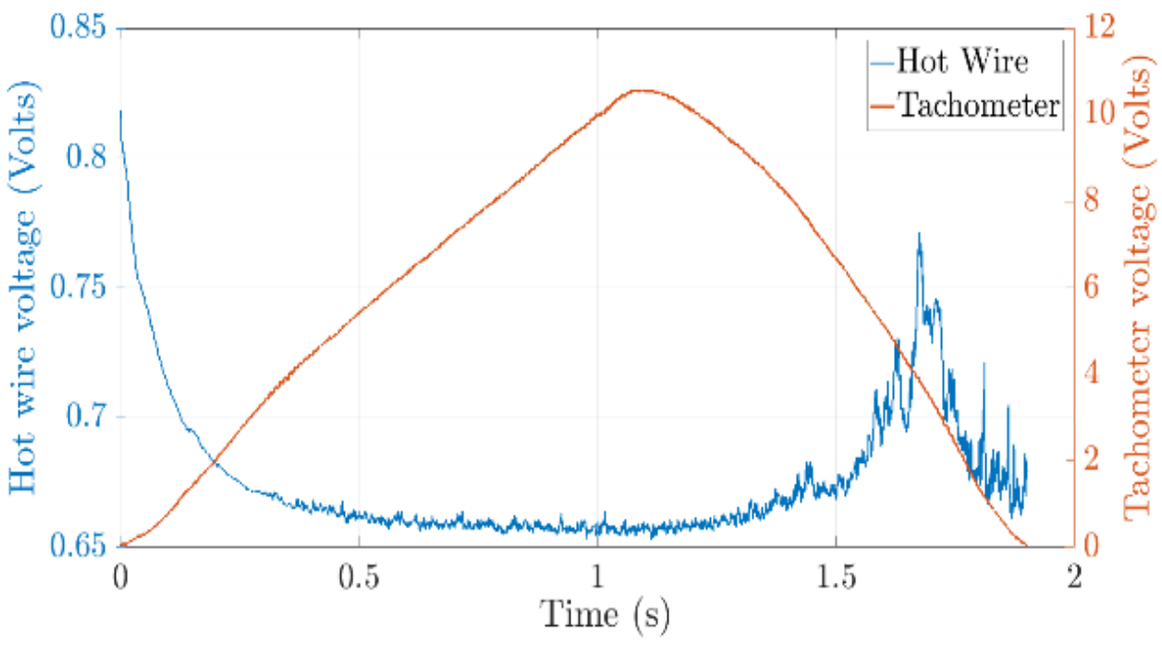
⇒Need for calibration

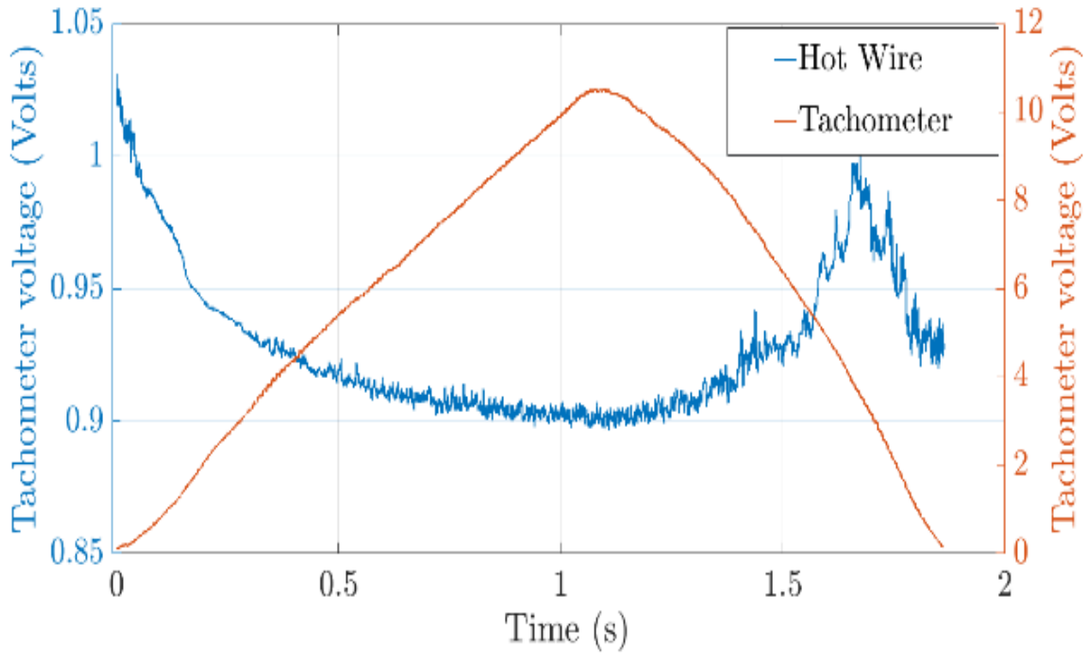
⇒Determination of the time constant : $\tau = \dfrac{m\,C}{\alpha R_0\,(A - I^2 + BU^n)}$

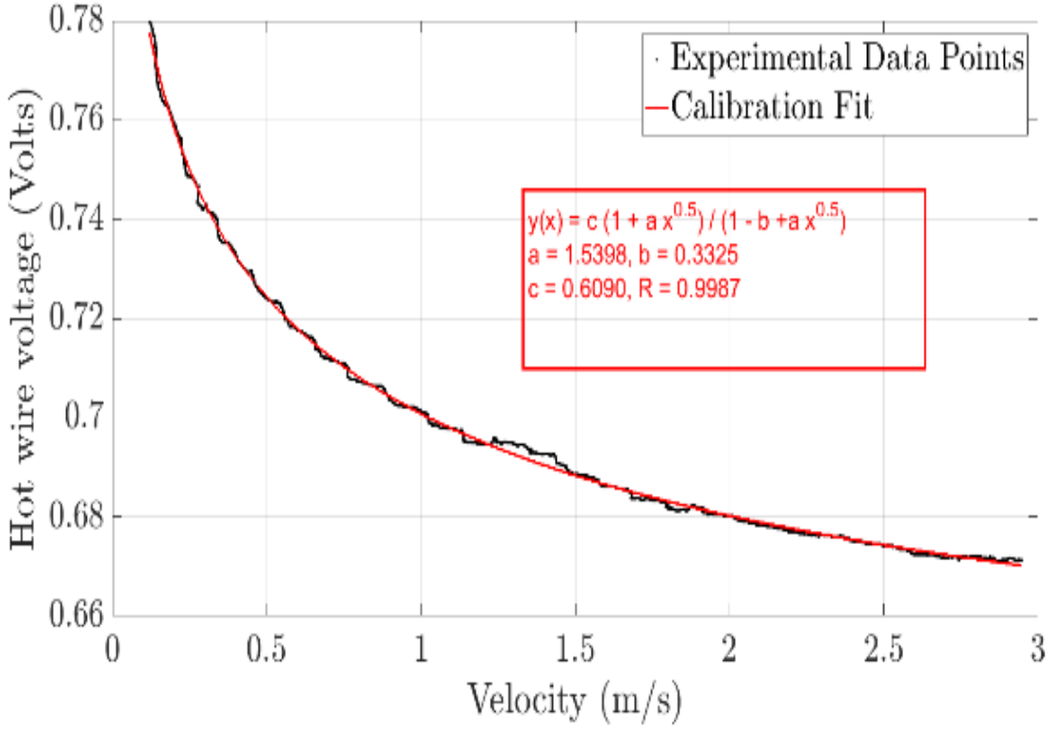
HECAL: Calibration of hot wires

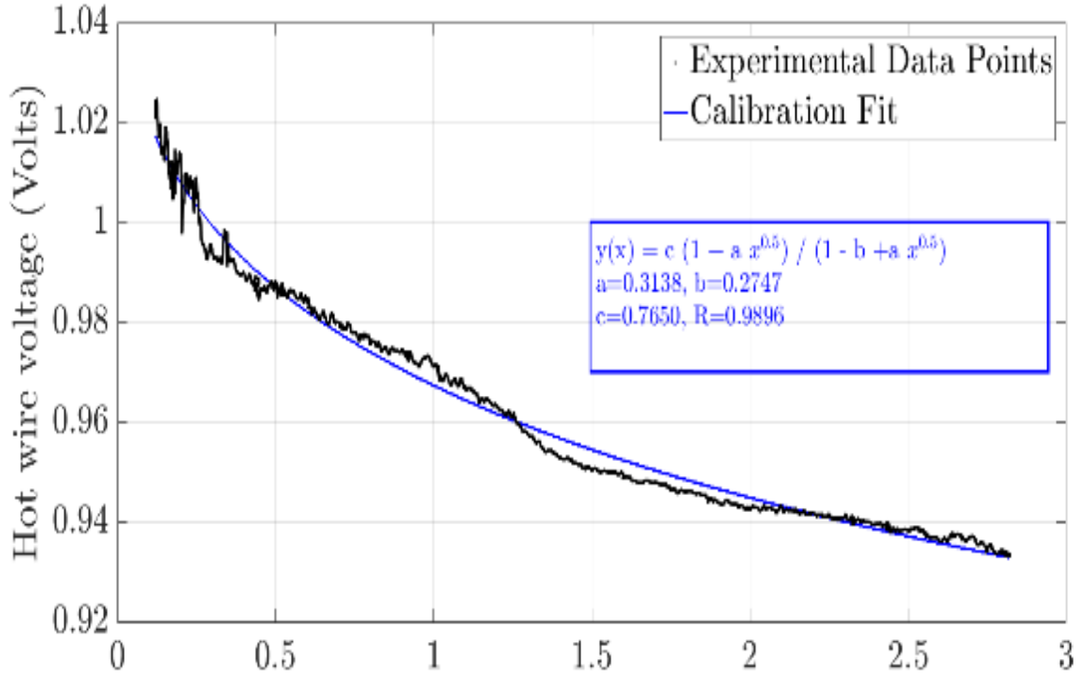


Calibration (continued)

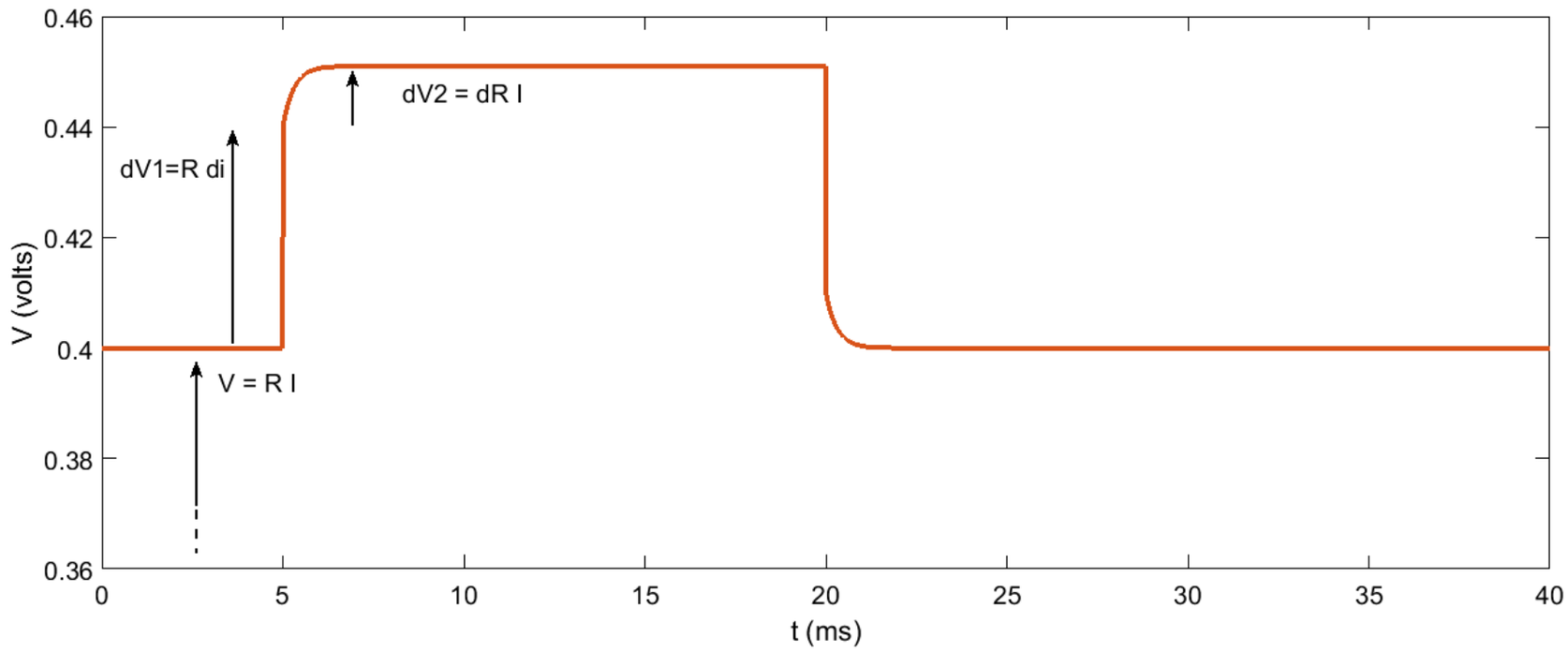








Time constant measurement (CCA operation)



Velocity (m/s)	Time constant (µs)
3.1	22.6
4.4	20.7
5.6	18.6

As expected, the time constant decreases as the velocity increases.

Conclusions, more work…

The Hecal provides a calibration tool to characterize hot wires used in Cryogenic facilities. It works in He-I as well as in He-II

Hot wires exhibit a different behavior in He-II

- Need for a higher current in He-II to get the same resistance
- Calibration curve does not fit King's law, but is sensitive to velocity
- However, time constant depends also on velocity in He-II

Heat transfer in He II is totally different from what happens in He-I
=> More experiments in HeCal for different He-II temperatures, with different heating currents and velocities.

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Thank you for your attention….