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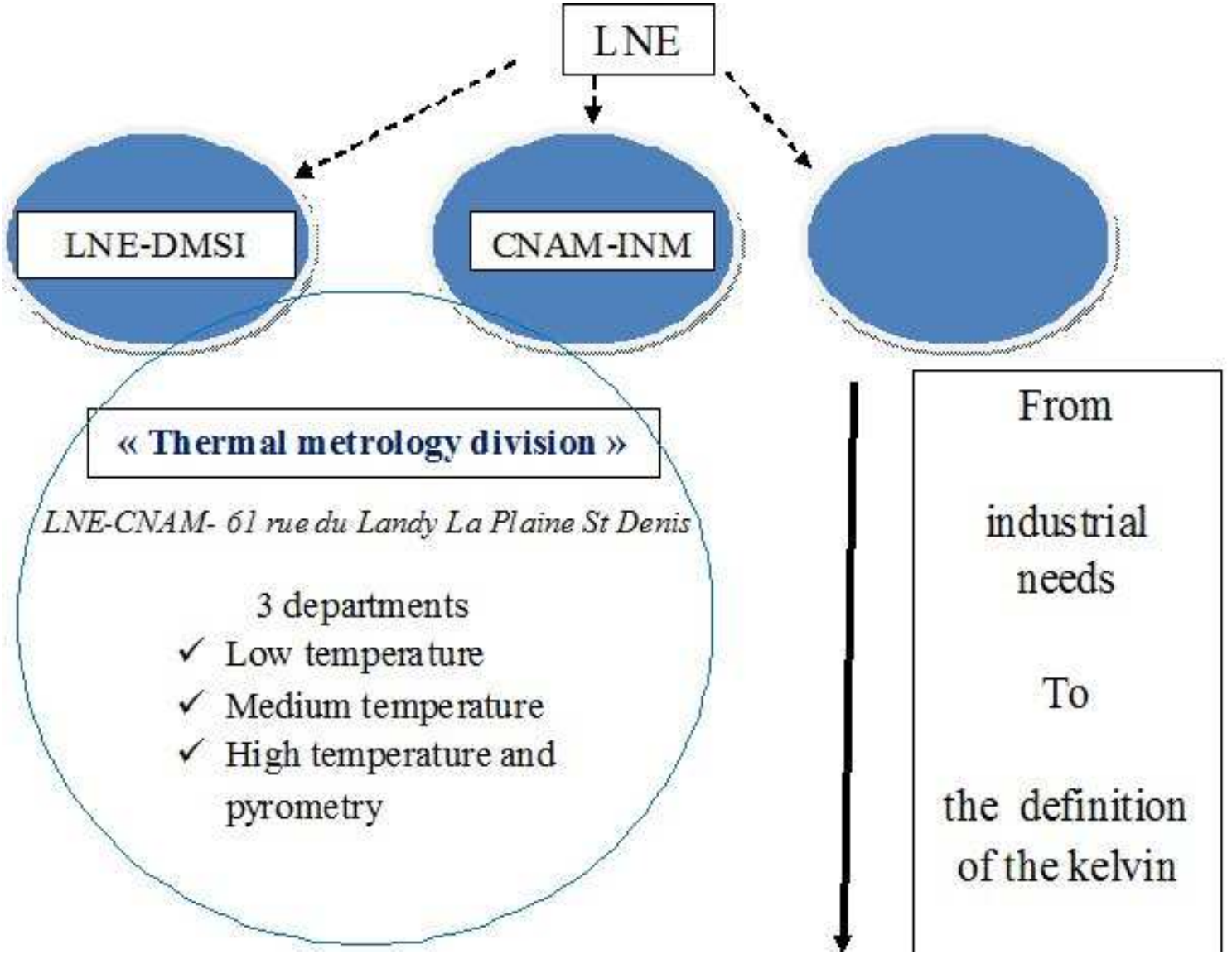
Responsable du pôle « Métrologie Thermique »

Société Française de Thermique

Groupe thématique « Hautes températures »

Le 29 juin 2010

Organisation



The benefits

A new structure to build a stronger bridge
between the research activities and the user (and not only industrial) needs

Research and Development activity:
To prepare the calibration benches for “tomorrow”
To answer specific requests in the frame of national or international programs.

Calibrations:
From the highest level (MRA- Mutual Recognition Arrangement), to different levels of uncertainty (COFRAC accreditation)
On a wide range of temperature, from a few millikelvins above the absolute zéro up to 3000℃ (contact thermometry and pyrometry).

Training and expertise:
For technical needs
For organization needs (Quality systems)

Some new needs ??

✓research purposes at low temperatures (below 1K) considering the fact that CNRS (French national centre for research) is now sensitive to the metrological aspects,

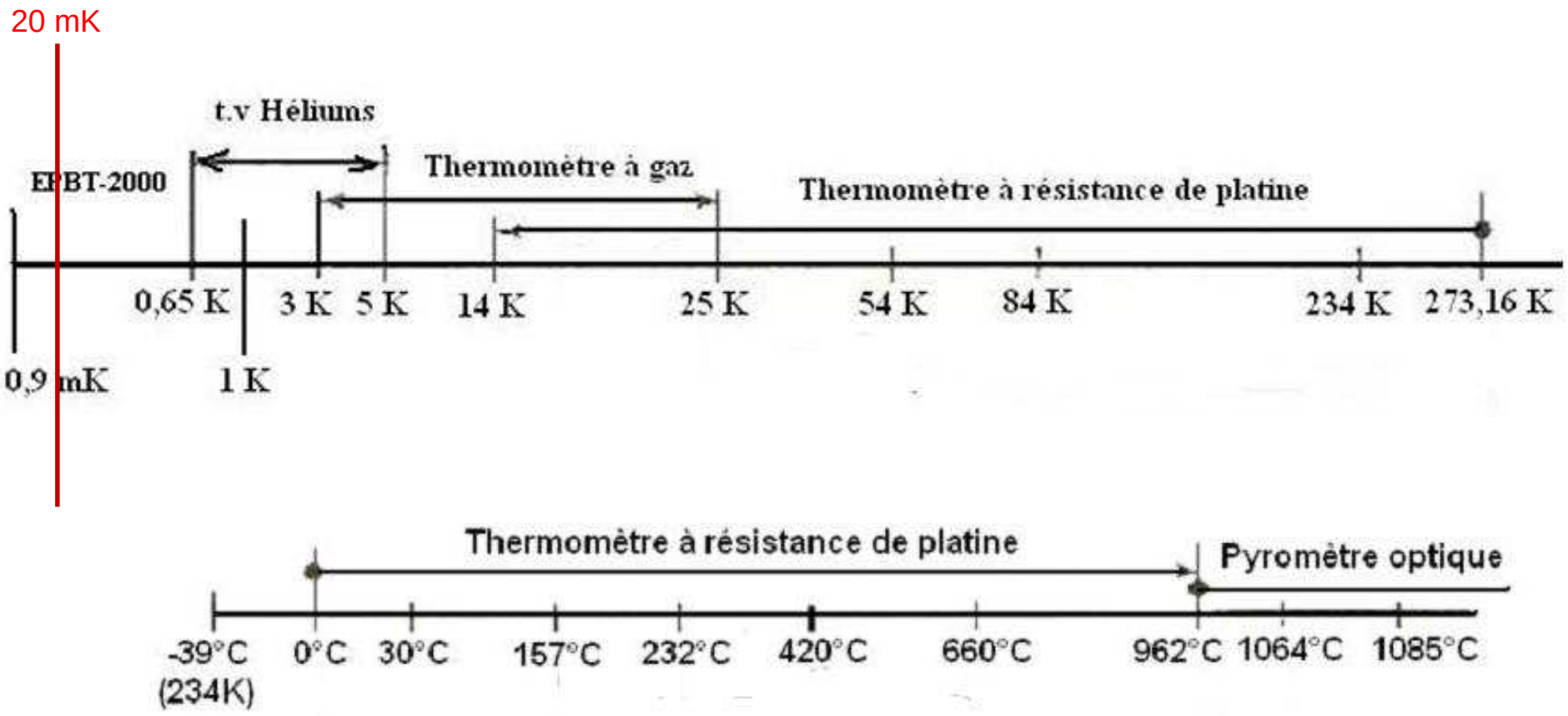
✓characterized and calibrated sensors below 10 K for space and superconductive magnets applications,

✓characterized and calibrated thermocouples up to 2000℃, especially for nuclear power plants applications,

✓characterized and calibrated radiation sources for pyrometers up to 3000℃.

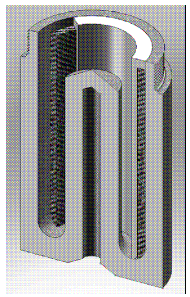
And some of these needs are at this time condensing through "European Program Calls" as recently through the "Energy", "industry" and ""environment" Calls.

LNE works on the whole temperature range (almost !!!)

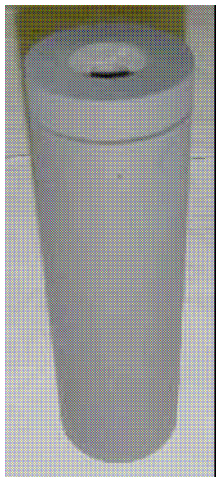


The answers from LNE – at high temperatures

At high temperatures, calibration possibilities using eutectics fixed points



for pyrometry



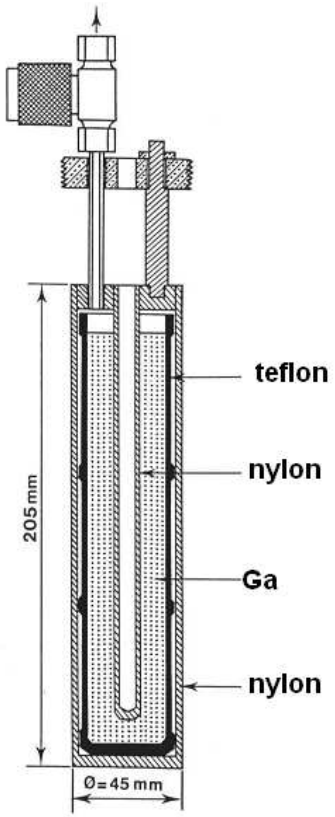
and for contact thermometry

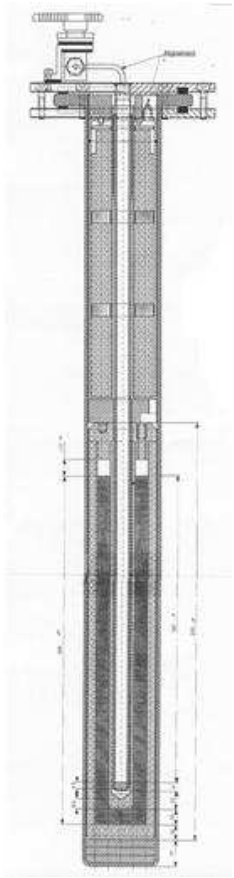
Au (1064.18)
Cu (1084.62)
Fe-C (1153)
Co-C (1324)
Pd-C (1492)
Rh-C (1657)
Pt-C (1738)
Cr7C3-Cr3C2 (1742)
Cr3C2-C (1826)
Ru-C (1953)
Re-C (2474 °C)
WC-C (2748 °C)

In blue the eutectics chosen by LNE to be developed.

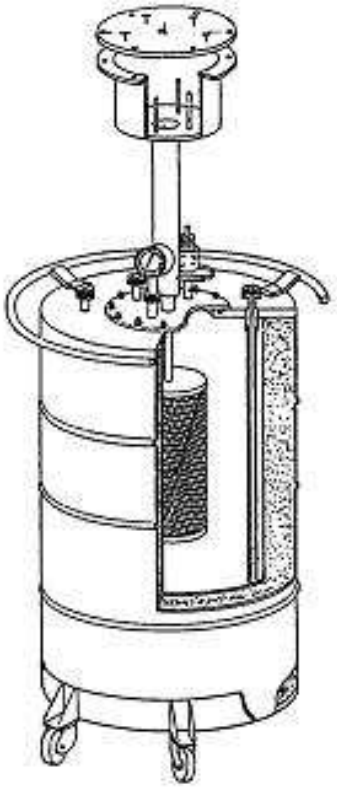
The answers from LNE – in the “medium temperature range”

Construction of all the fixed point cells (INM type) from argon up to silver point (except water)



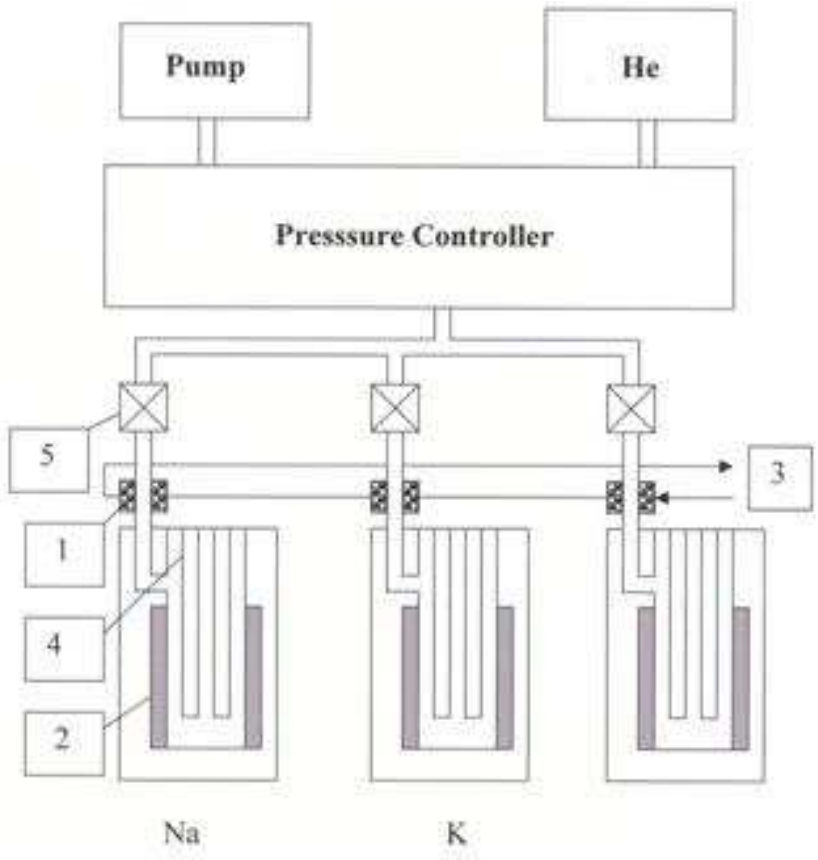


And in most cases the associated calorimeter



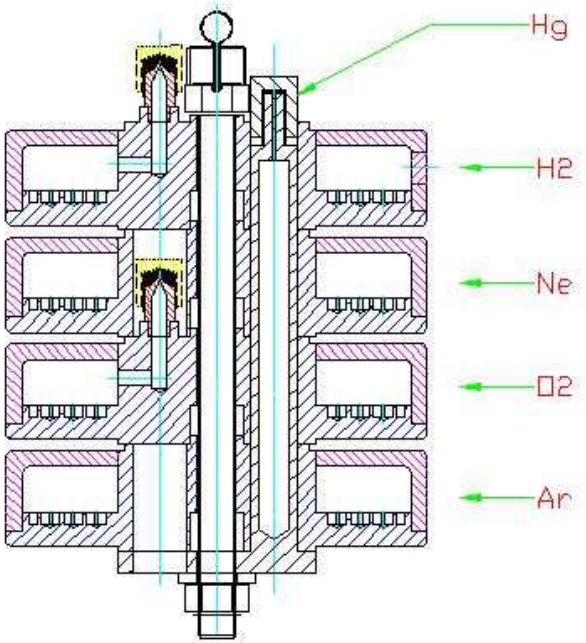
The answers from LNE – in the “medium temperature range”

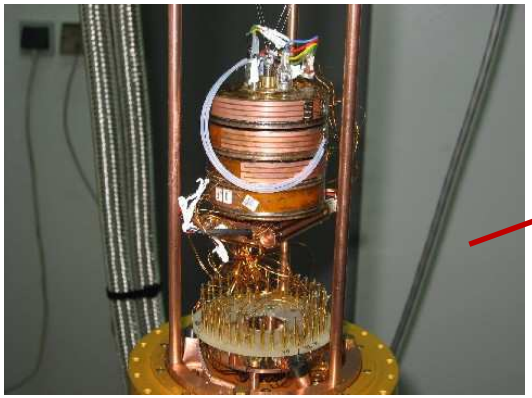
Construction of a “temperature amplifier”



The answers from LNE – in the “cryogenic range down to 14K”

“The multicells” and the calorimeter using a cryogenerator

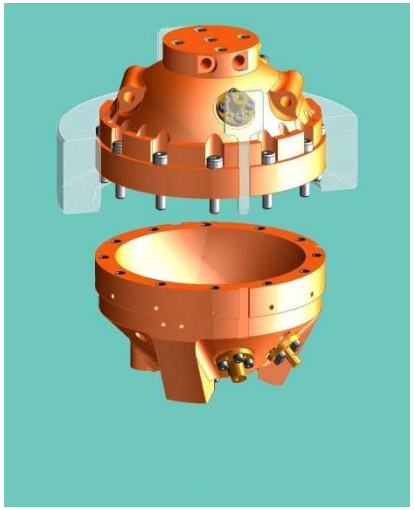


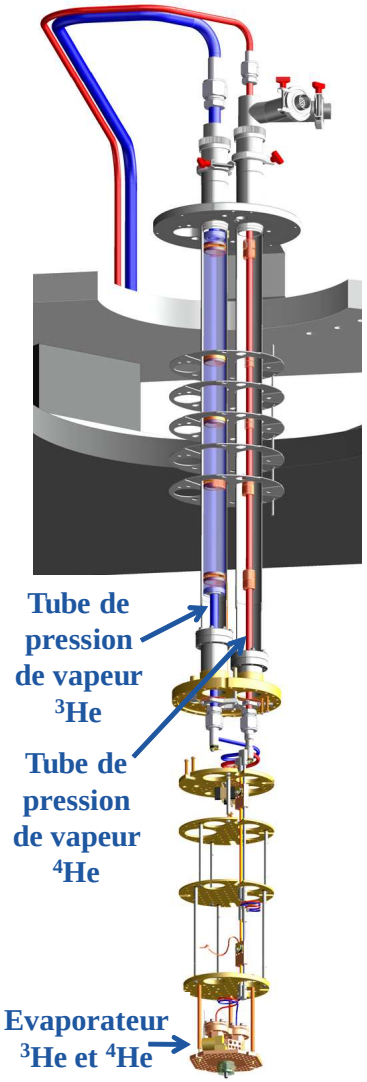


The answers from LNE – in the 0,65K – 14K temperature range

The acoustic thermometer

$$\frac{T}{273K} \equiv \lim_{p \to 0} \frac{U^2(T,p)}{U^2(T_W,p)}$$





…and the helium-vapour thermometers

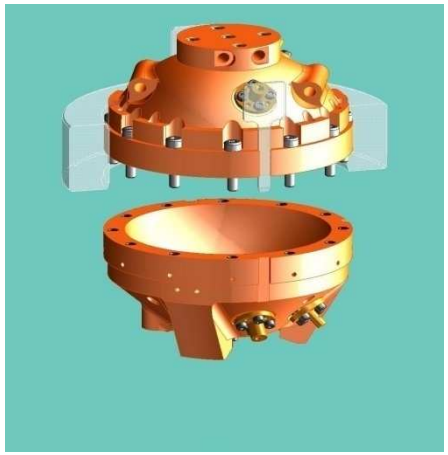
The answers from LNE – below 1K

The (helium-3) melting curve thermometer realizing the PLTS-2000

And the SS (second-sound) thermometer as a transfer standard

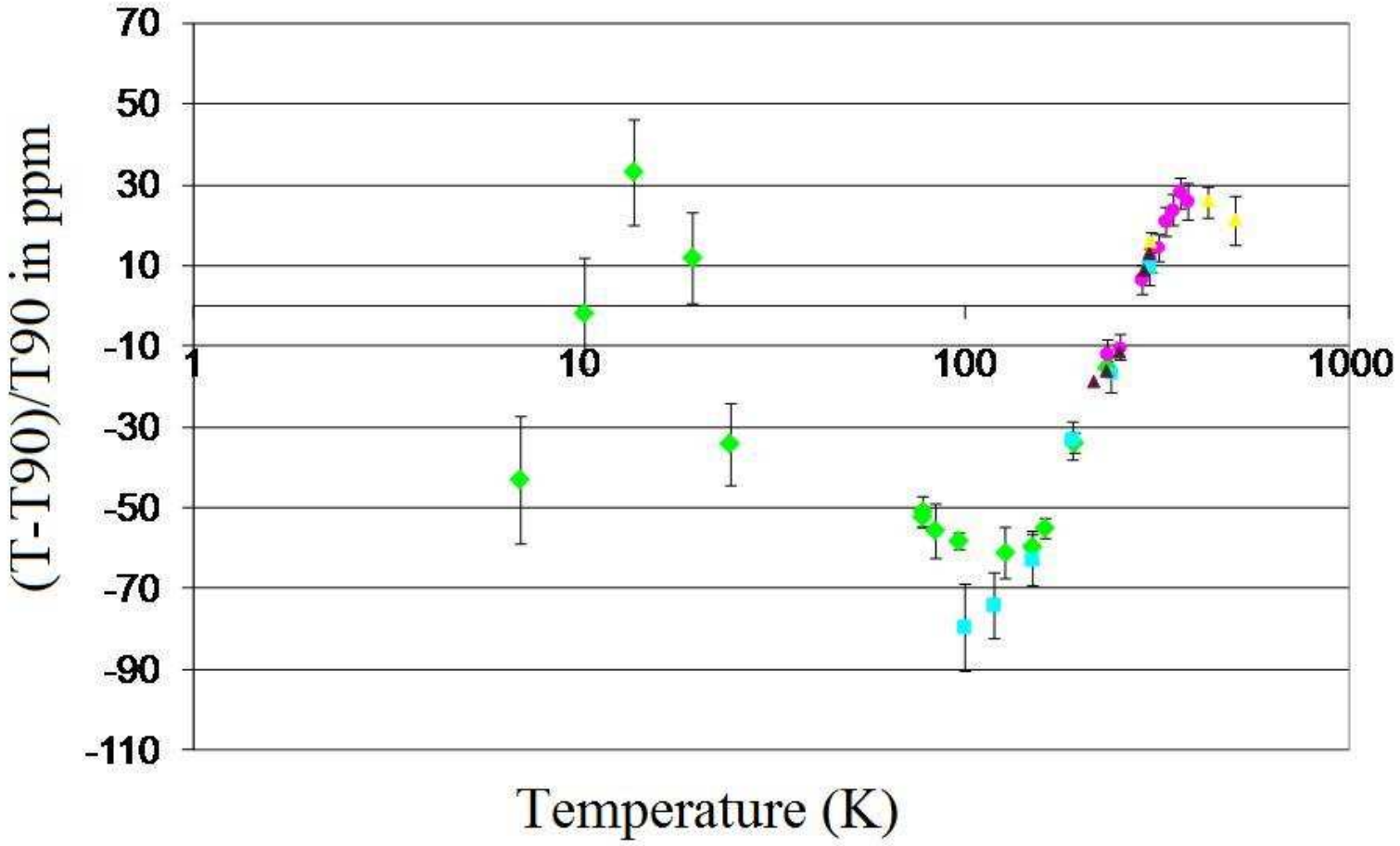
Is T90 wrong ?

LNE develops « primary » (thermodynamic) instruments in order to measure T and T-T90



Is T90 wrong ? Some results

Deviation T-T90 measured with the acoustic thermometer

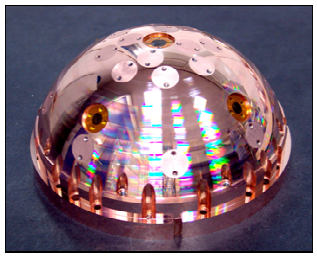


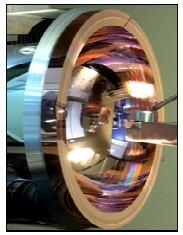
And for measuring T ? Temperature unit ?

Two experiments at LNE for a new determination of the Boltzmann constant with as a target a relative uncertainty below 1 ppm

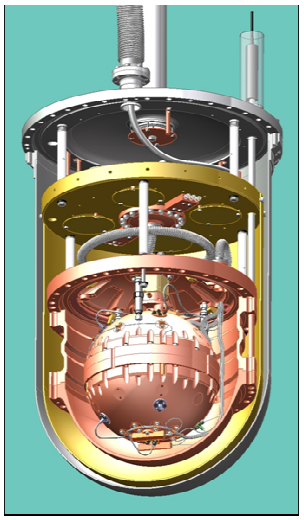
The acoustic way ….

SPHERE BCU4





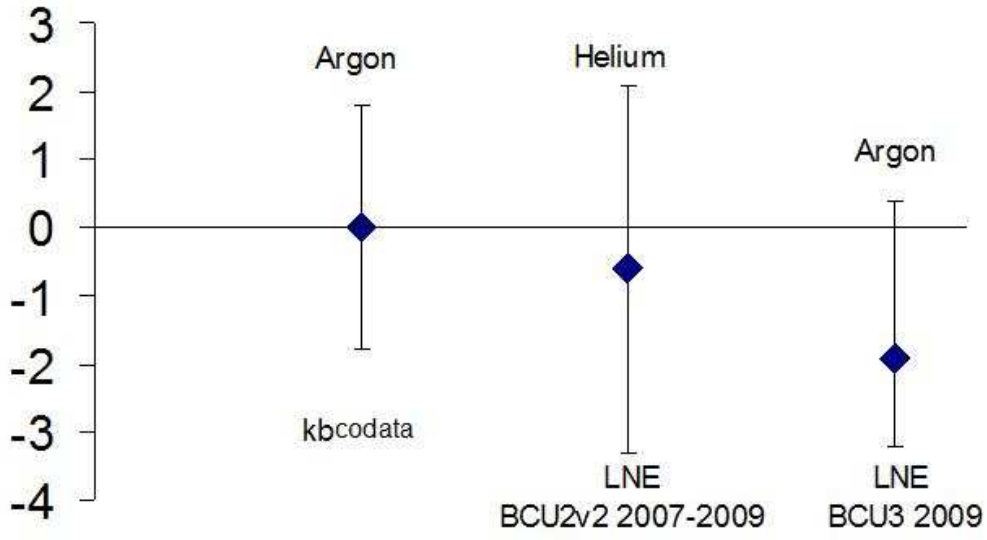
CONCEPTION DU CRYOSTAT



$$k = \left\langle \frac{3}{5}\frac{mc_0^2}{T_{tp,eau}}\left(\frac{Z_{nl}^{EM}}{Z_{nl}^{A}}\right)^2 \lim_{p\to 0}\left(\frac{< f_{nl}^{A} + \Delta f_{nl}^{A} >}{< f_{nl}^{EM} + \Delta f_{nl}^{EM} >}\right)^2 \right\rangle$$

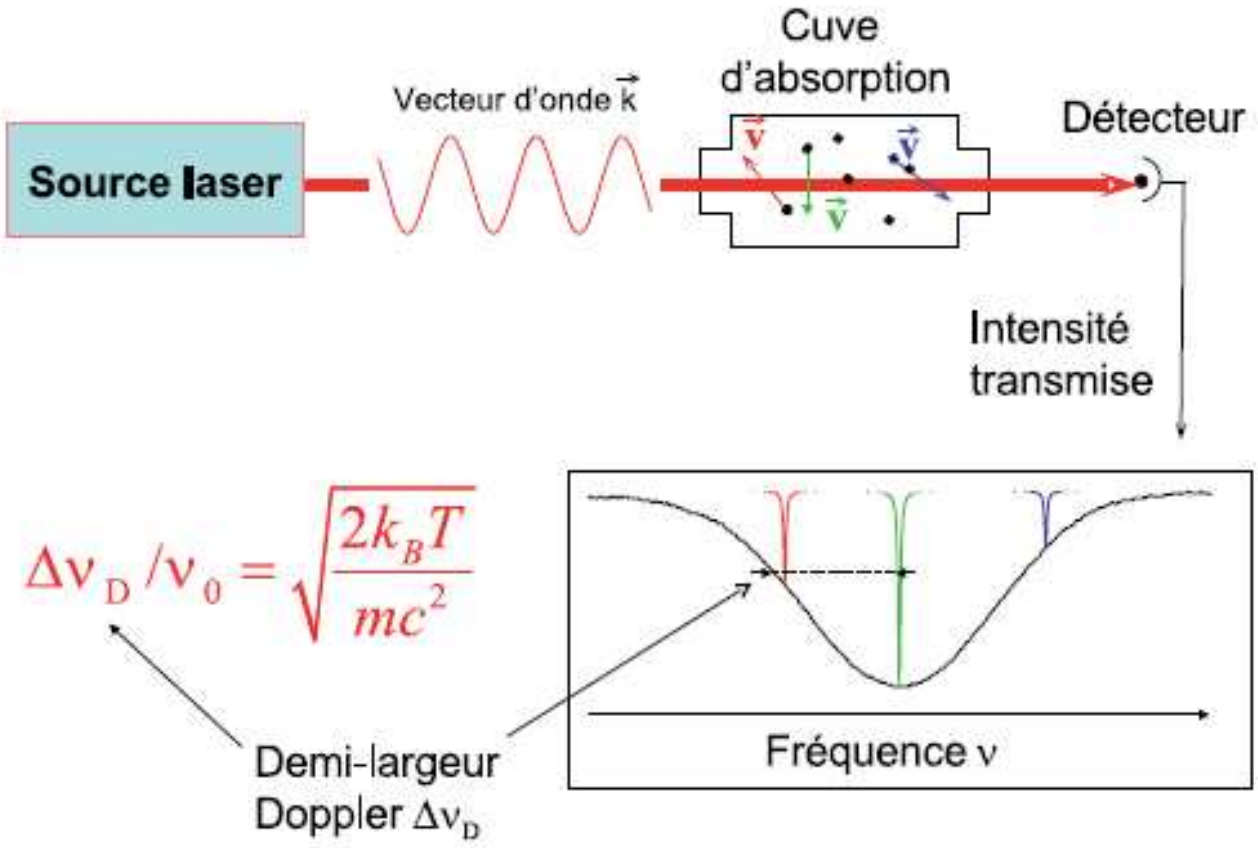
Near the WTP temperature

(k_B mes – k_B codata)/k_B codata ppm



And for measuring T ? Temperature unit ?

… and the spectroscopic way (in cooperation with Paris North university -galileo institute)



At the present time, a larger relative uncertainty (10 ppm) than for the acoustic way

Conclusion

The “thermal metrology division” of LNE is putting in place all the references at any level of uncertainty in order to fulfill the actual and future needs of all kind of users.