GOBIERNO DE ESPAÑA
MINISTERIO DE INDUSTRIA, ENERGÍA Y TURISMO

CCT/14-41

NOTED

# The EMRP project NOTED

## Novel Techniques for traceable temperature dissemination

CEM CENTRO ESPAÑOL DE METROLOGÍA

NOTED

## What is NOTED?

It is a multi-institute project with a practical focus on the temperature range from -218 ºC up to 1000 ºC.

## Why NOTED?

To solve some of the ITS-90 weaknesses

To develop and improve new interpolating instruments
To develop practical primary thermometers

**New ways for disseminating the kelvin**

GOBIERNO DE ESPAÑA
MINISTERIO DE INDUSTRIA, ENERGÍA Y TURISMO

## THE PARTNERS:

GOBIERNO DE ESPAÑA · MINISTERIO DE INDUSTRIA, ENERGÍA Y TURISMO · CEM CENTRO ESPAÑOL DE METROLOGÍA
CMI
LNE — Le progrès, une passion à partager
INRiM — Istituto Nazionale di Ricerca Metrologica
MKEH
Service Metrologie Metrologische Dienst
TÜBİTAK UME
LMK
VSL Dutch Metrology Institute
UC Universidad de Cantabria
Instituto Português da Qualidade
le cnam
NPL National Physical Laboratory
PTB

## COLLABORATORS:

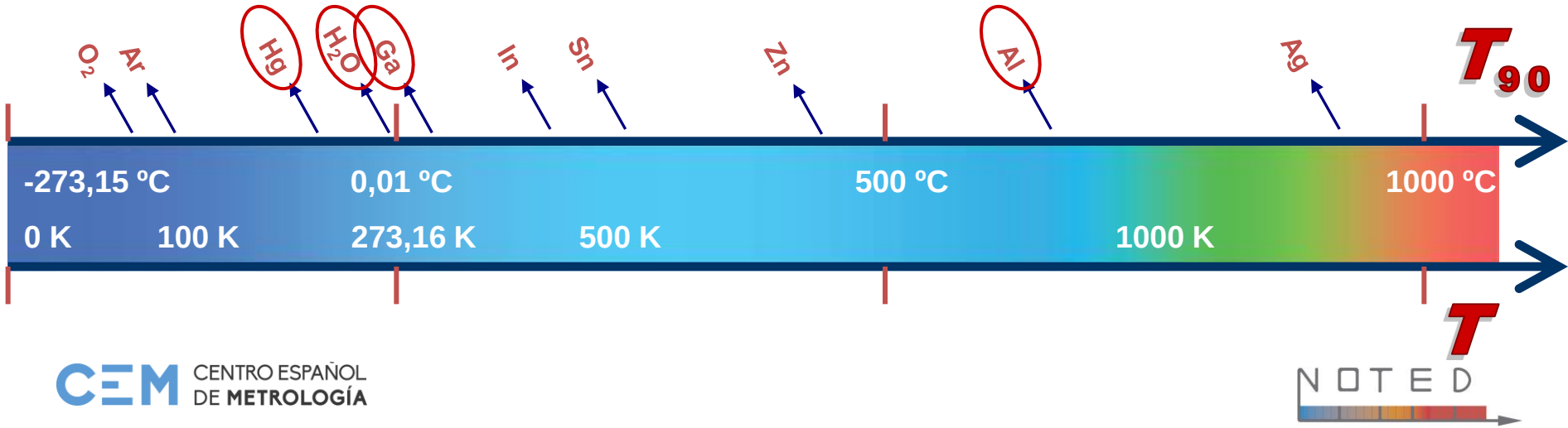
GUM Główny Urząd Miar
INTiBS PAN Wrocław
ZAVOD ZA METROLOGIJU
NIST
BOSNIA AND HERZEGOVINA
INM
NIS
ISOTECH

CEM CENTRO ESPAÑOL DE METROLOGÍA

NOTED

# Improving the present realization of the ITS-90

- **Impurities in the FP: doping experiments**
- Thermal effects in the FP: development of models + experimental validation
- Optimization of SPRTs and CSPRTs calibration procedures
- New FP for an improved scale: reducing the gaps
- Au/Pt thermocouple to replace the HT-SPRT



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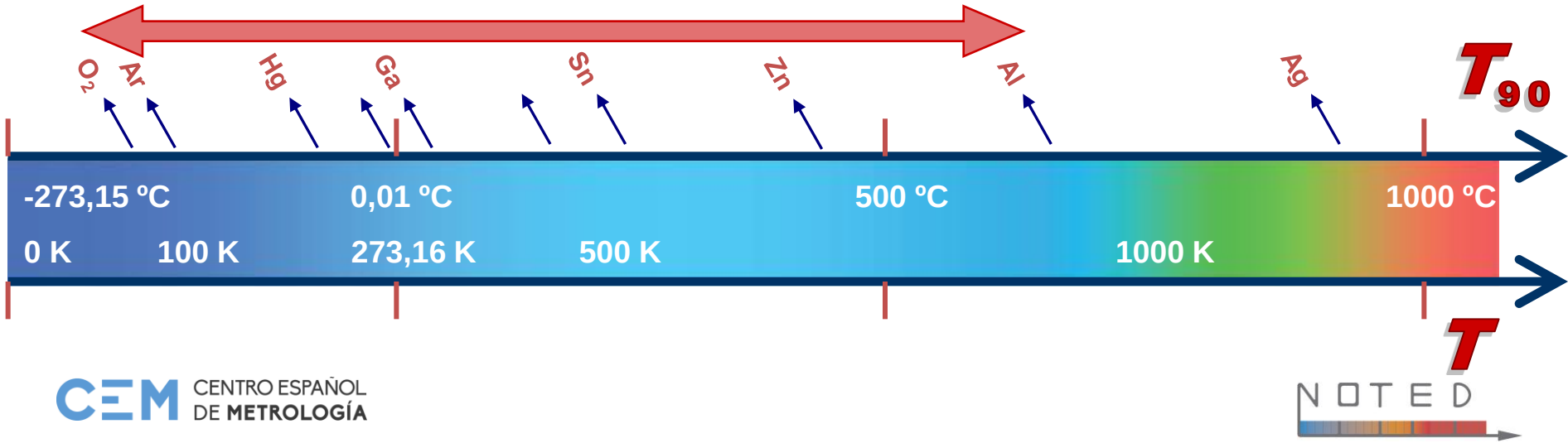

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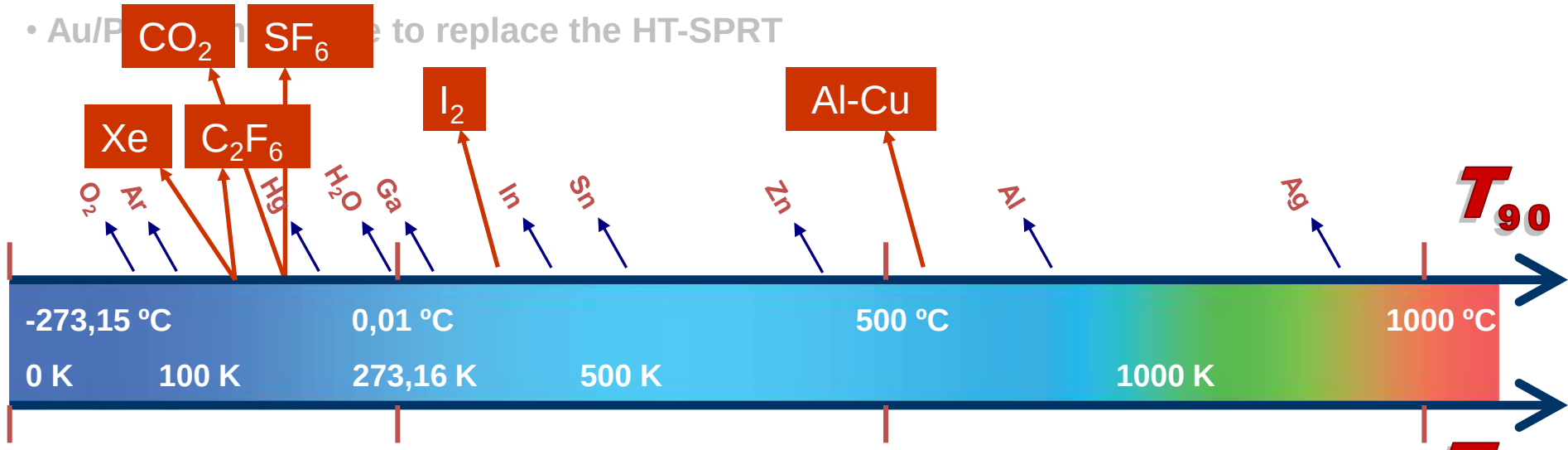

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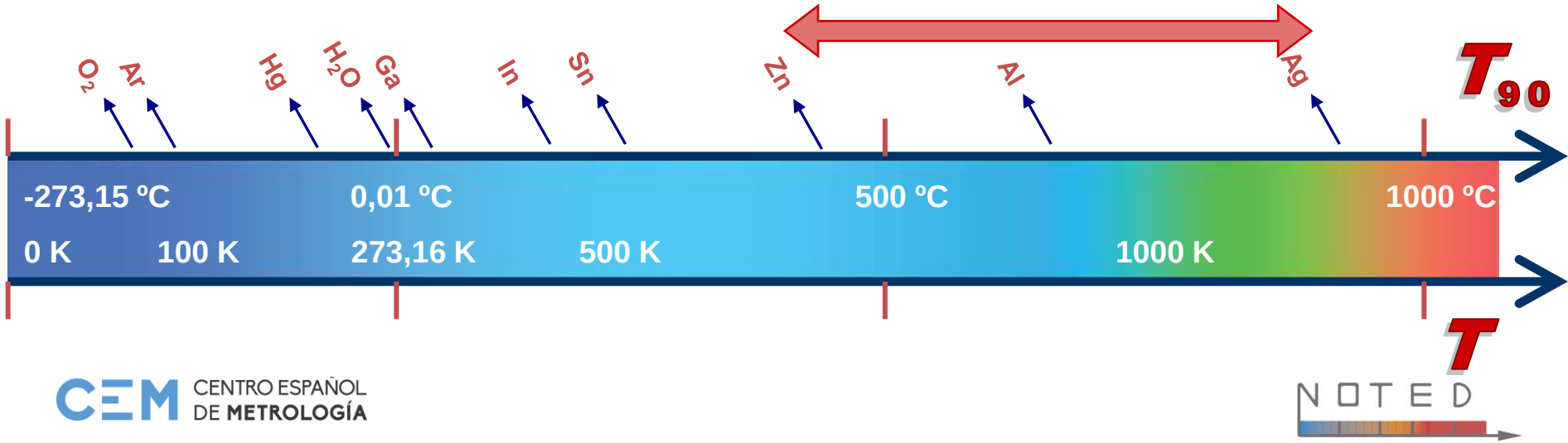
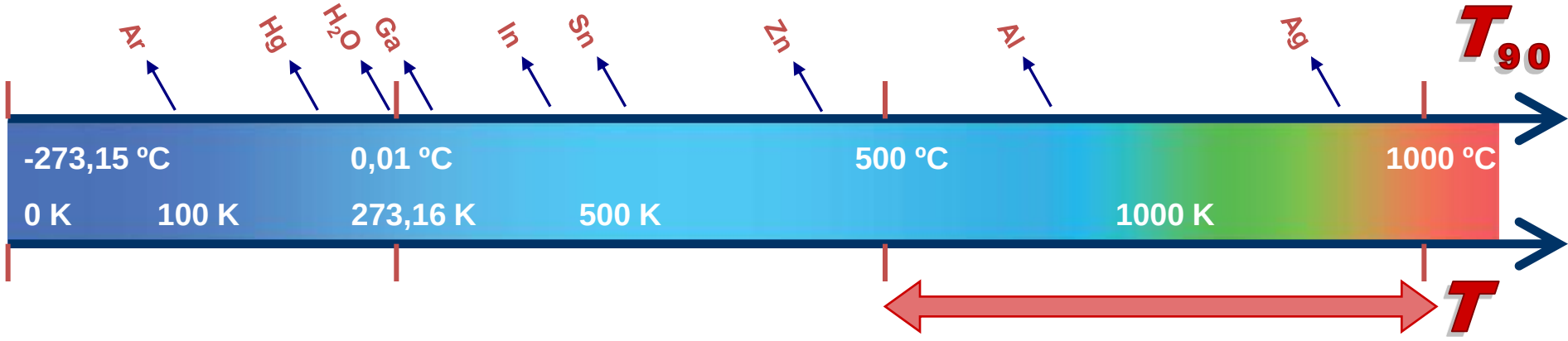


# New alternatives for disseminating the kelvin




- **A new NIR RT + facilities for the absolute calibration of NIR RT**
- Vapor pressure scales: Hg Gas-Controlled Heat Pipe+ Clausius-Clapeyron equation
- A new sapphire-based WGM thermometer
- Procedures for primary calibration of SPRTs and CSPRTs
- Practical (acoustic) primary thermometers (for calibrating long stem SPRTs)

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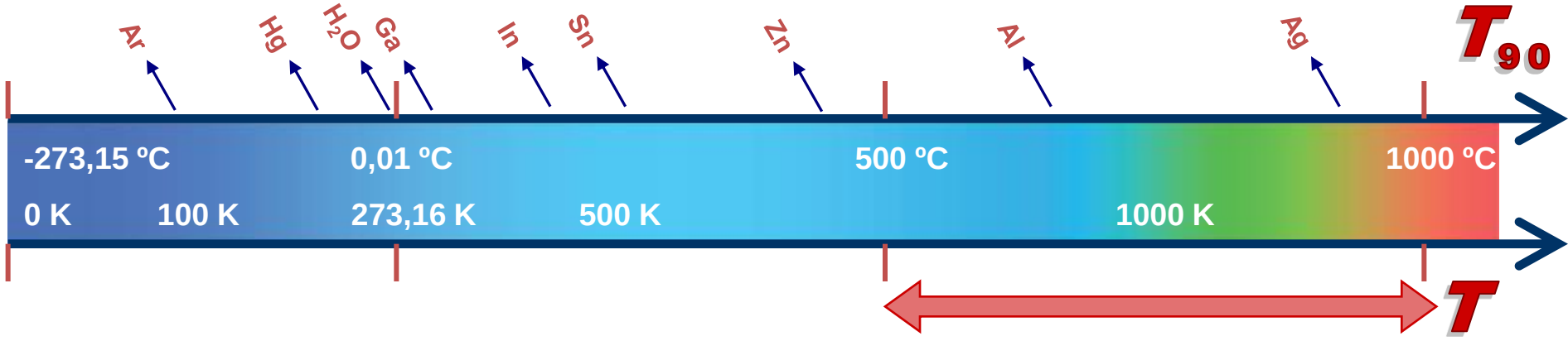


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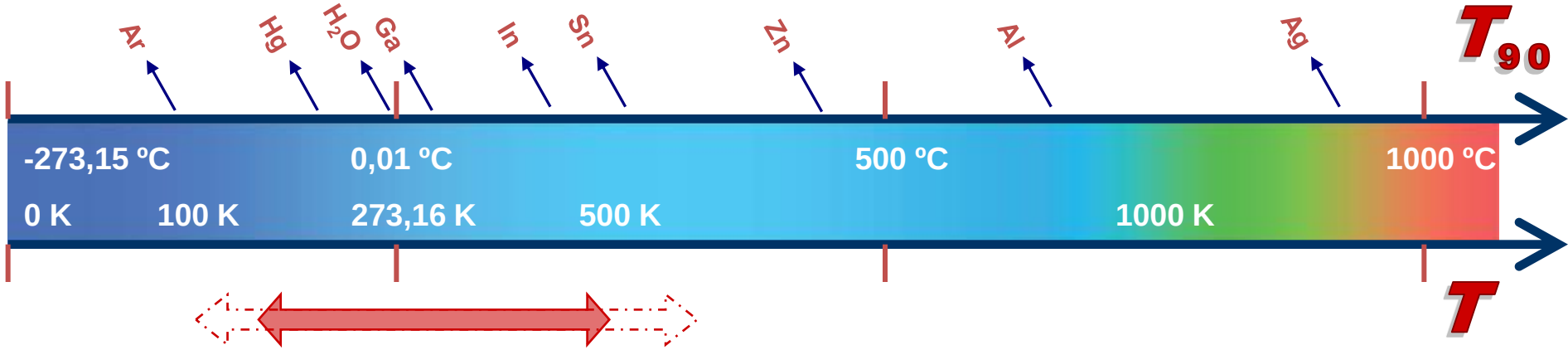


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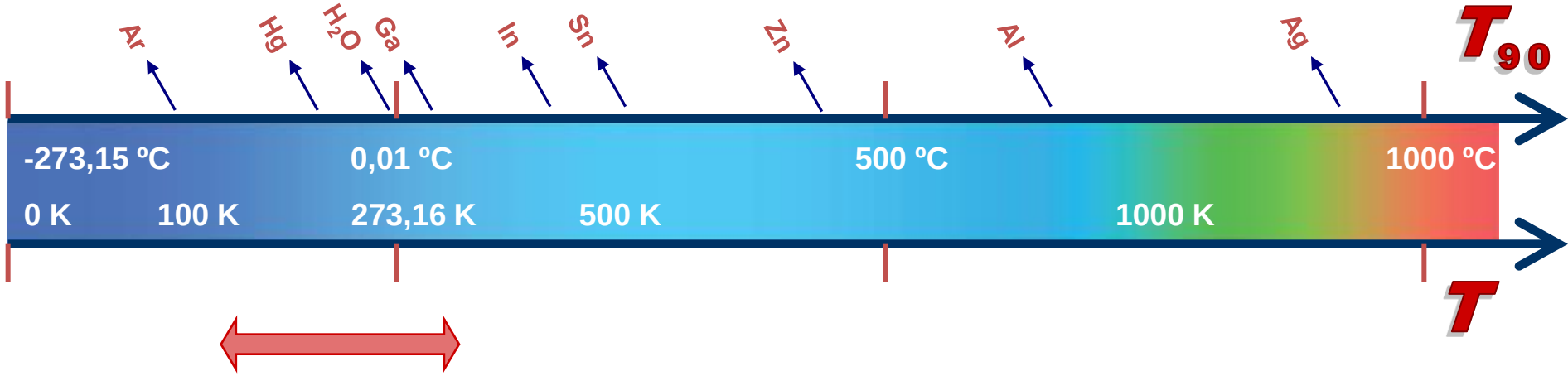


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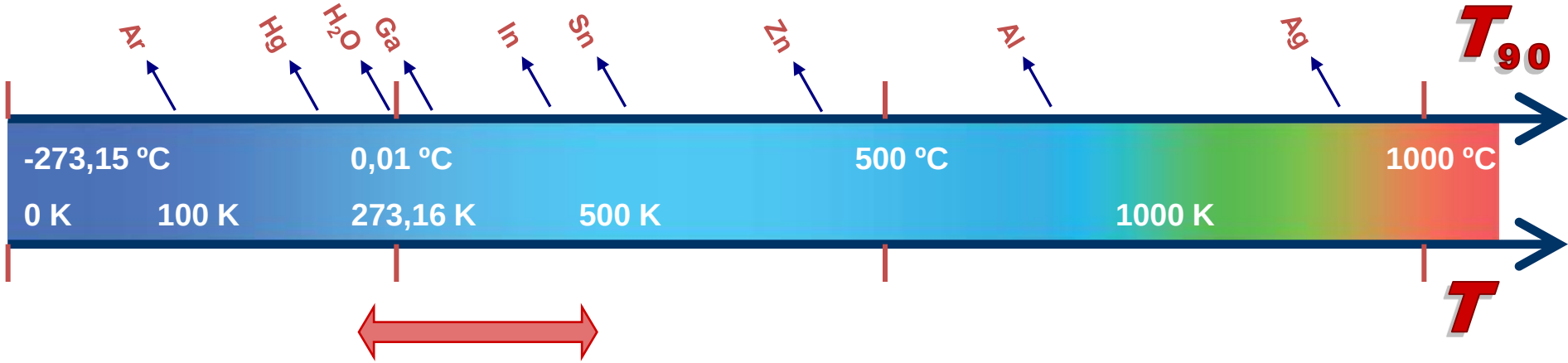


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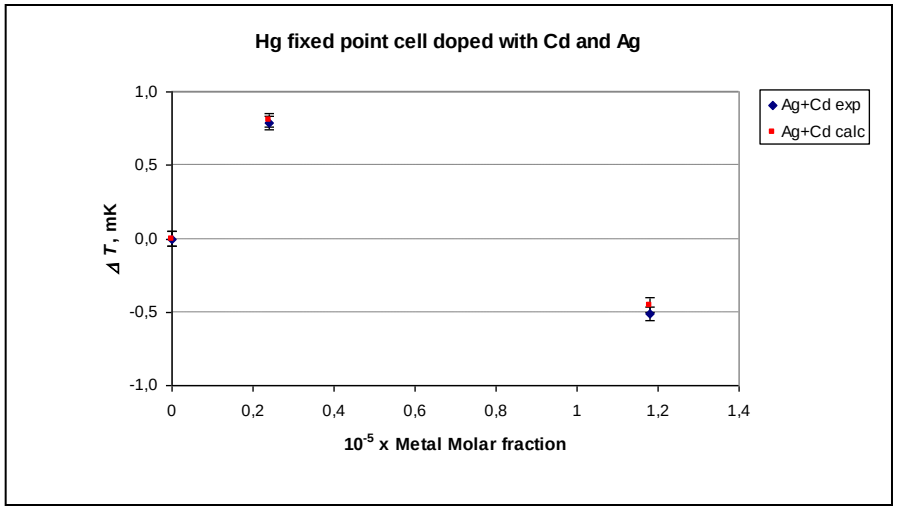
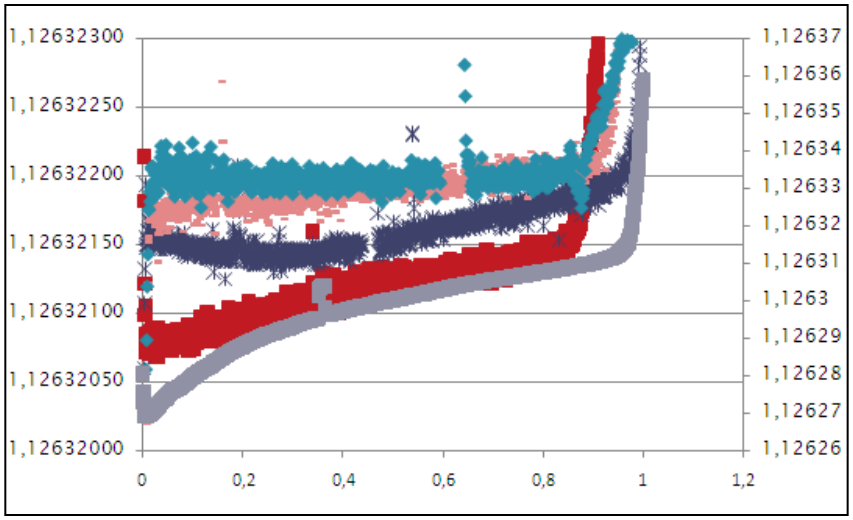
# What has been done so far?

## Impurities in the FP: doping experiments

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**Binary doping experiments Cd+Ag in the TP of Mercury**

**Doping Ga with Pb and Ni**

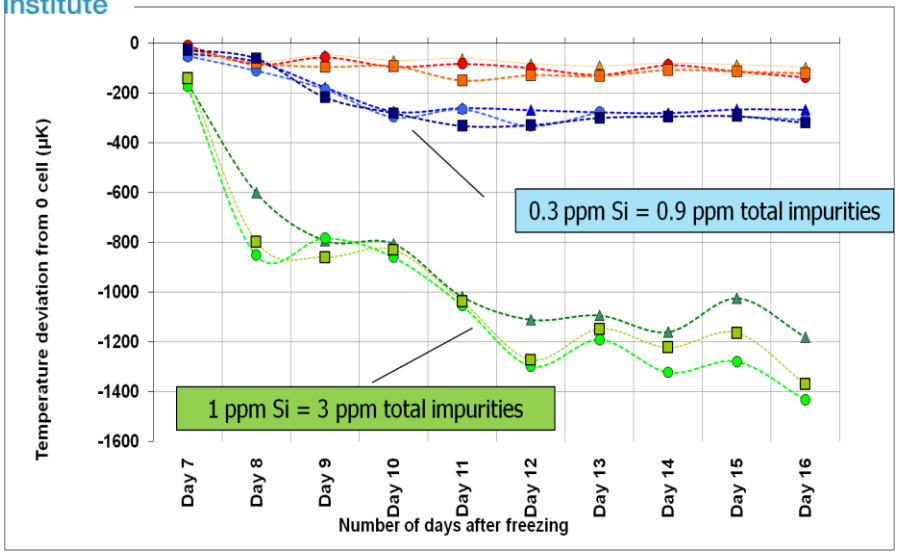
# Impurities in the FP: doping experiments

VSL Dutch Metrology Institute

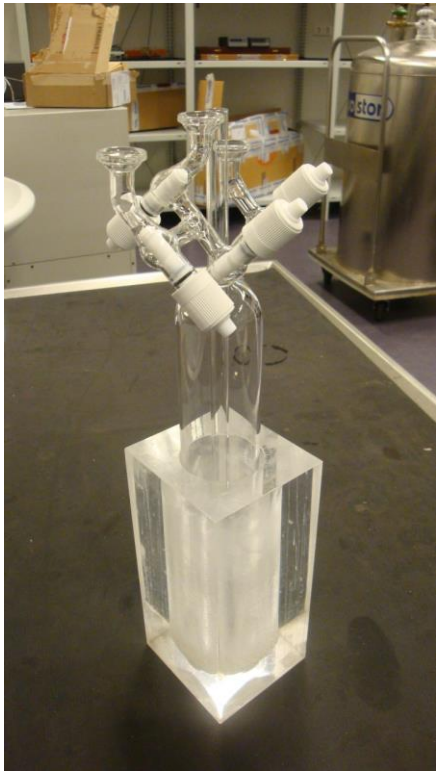
Service Metrologie Metrologische Dienst

TÜBİTAK UME

NIST

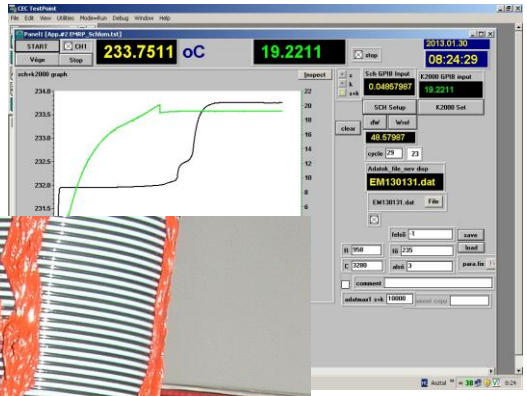


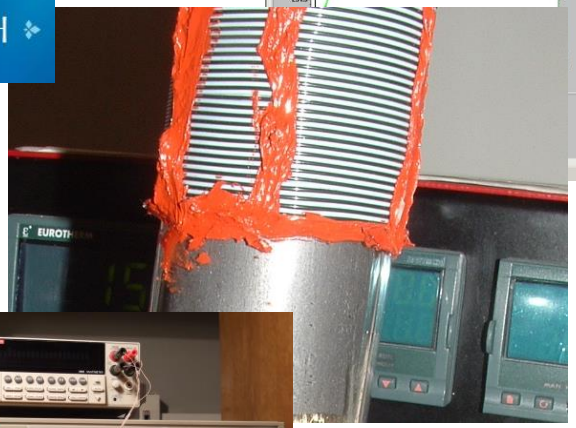

Si in the TPW

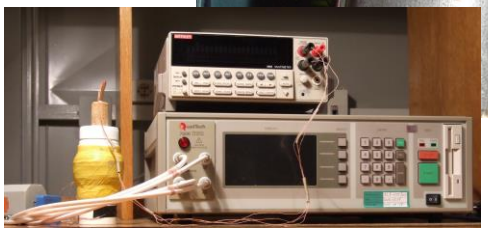


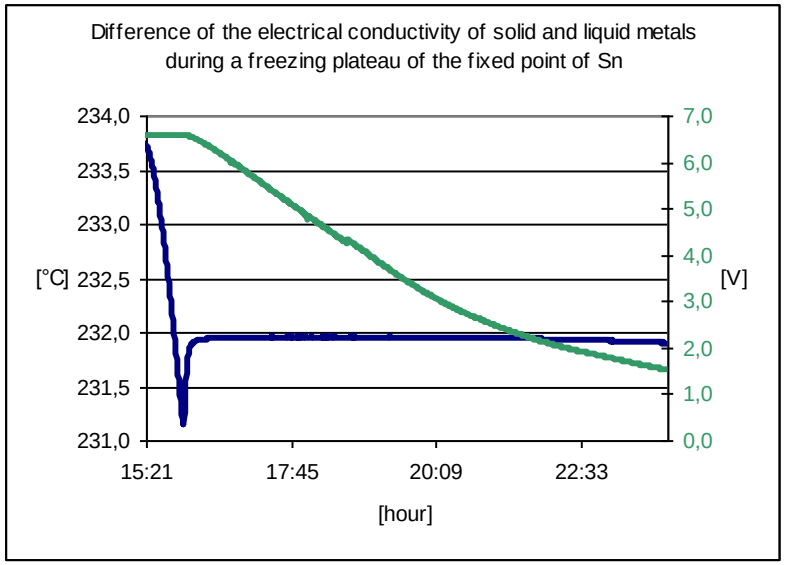
Re-seleable TPW

# Thermal effects in the FP: development of models + experimental validation

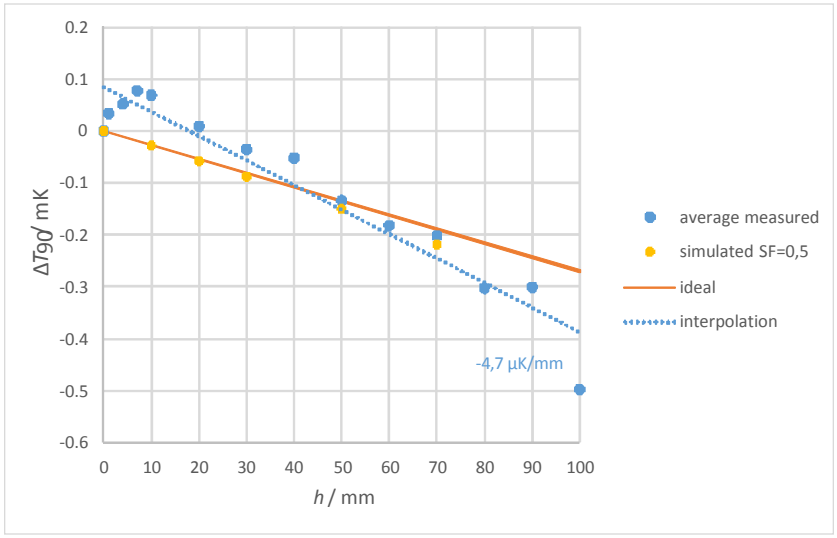




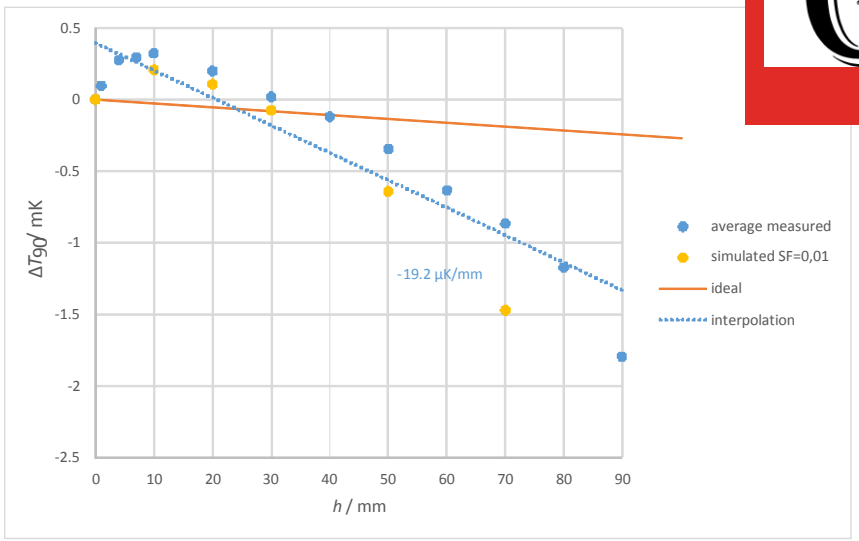

**The time evolution of the solid fraction and melt fraction along the phase transformation studied based on the difference of the electrical conductivity of solid and liquid metals**

## Thermal effects in the FP: development of models + experimental validation

**Estimation of the measurement uncertainty due to perturbing heat exchanges using home made FEM software (conductive and radiative heat transfer).**



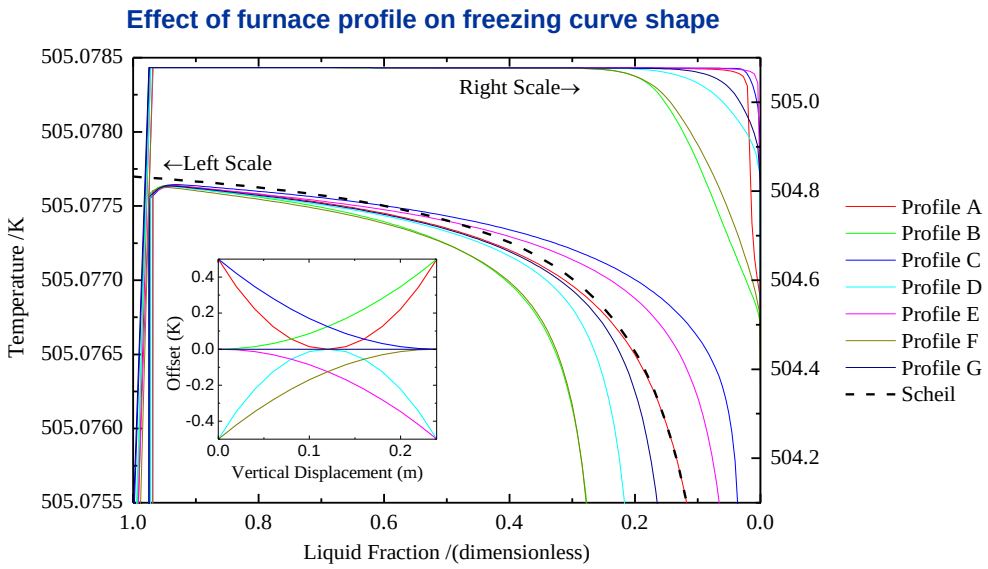

a)



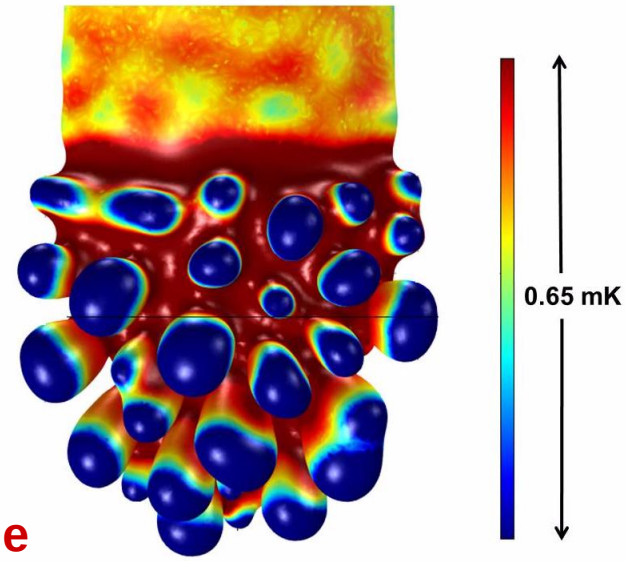

b)

**Comparison of measured and simulated immersion profiles for an open zinc cell with a) and without b) a sandblasted thermometer well**

# Thermal effects in the FP: development of models + experimental validation




NPL National Physical Laboratory




**A phase-field solidification model to understand the effect of experimental parameters like furnace uniformity**

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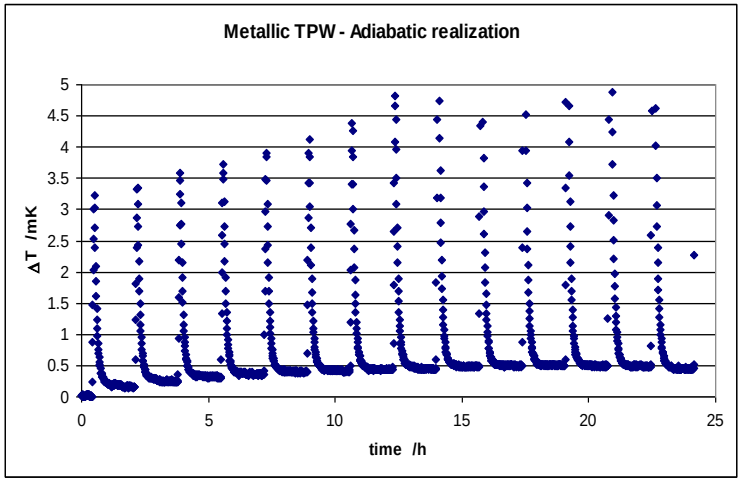
# Thermal effects in the FP: development of models + experimental validation

le cnam

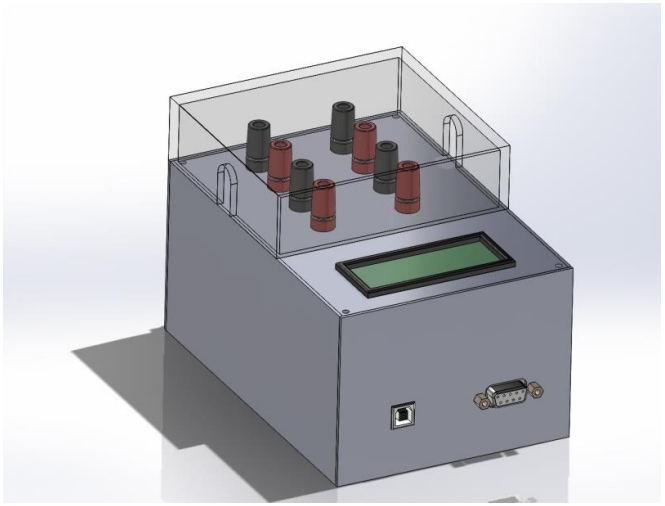
Experimental apparatus

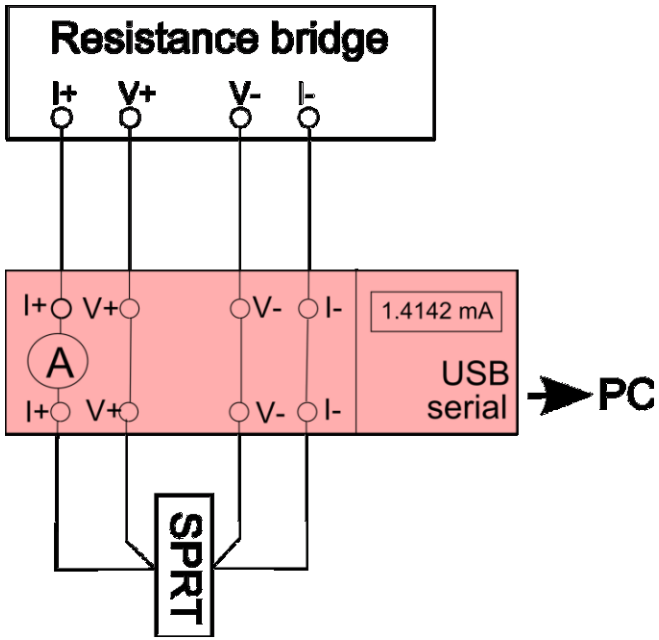



The metallic TPW cell

**Metallic TPW cell realized quasi-adiabatically**
**New calorimeter for SPRT calibration at the $O_2$ and Ar FP**

## Optimization of SPRTs and CSPRTs calibration procedures






**A dedicated measurement instrument for integrated and non-intrusive measurement of bridge measurement current:**

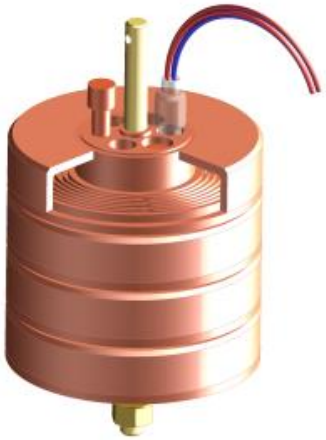
- **applicable to DC and AC bridges,**
- **absolute accuracy 0.1%, relative accuracy 0.01%,**
- **measurement range 0-4 mA and 0-20 mA**

## New FP for an improved scale: reducing the gaps

TP of $CO_2$,

TP of $I_2$

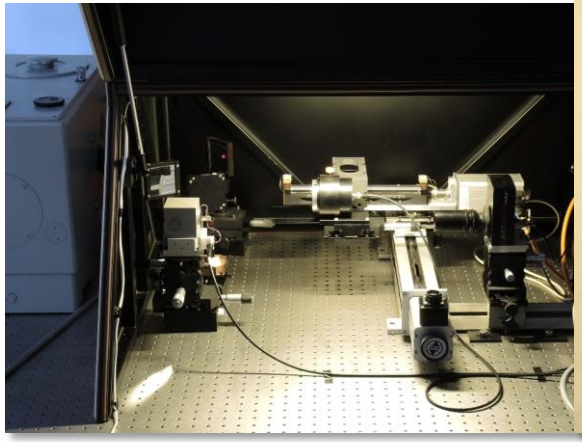
le cnam

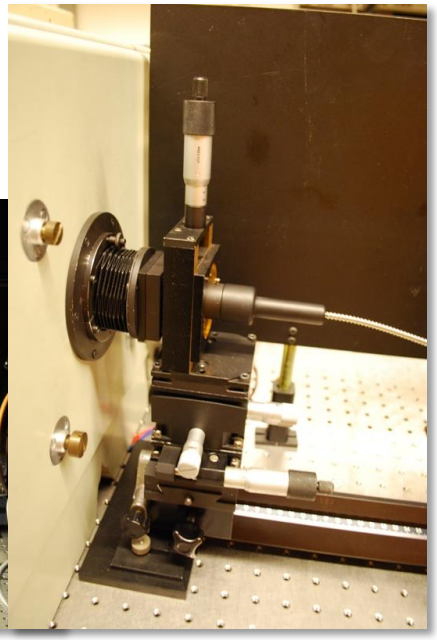


TPs of Xe, $C_2F_6$, $SF_6$

## Approximation of the kelvin in the range from 500 ° C to 1000 ° C

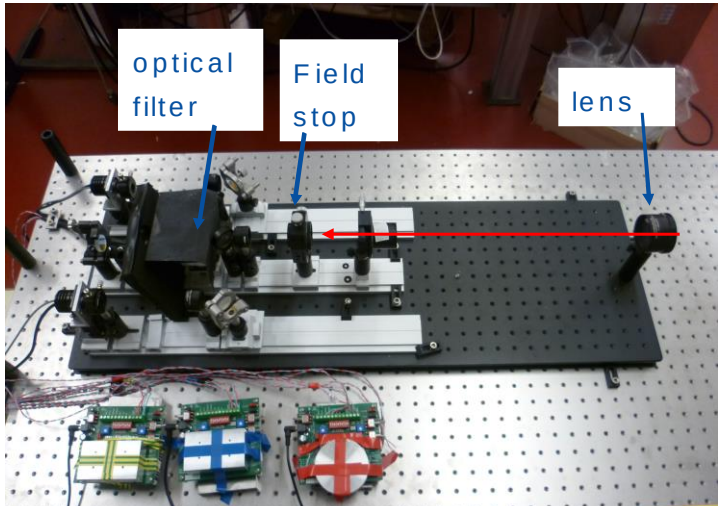
PTB





**Radiance calibration set up for absolute calibration NIR radiation themometers**

le cnam




**New tuneable NIR radiation thermometer.**
**IR (1.2 µm – 1.8 µm) prototype**

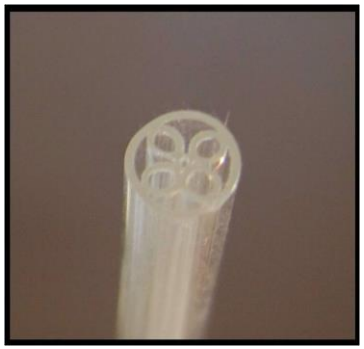
## Approximation of the kelvin in the range from 500 ° C to 1000 ° C

INRiM ISTITUTO NAZIONALE DI RICERCA METROLOGICA

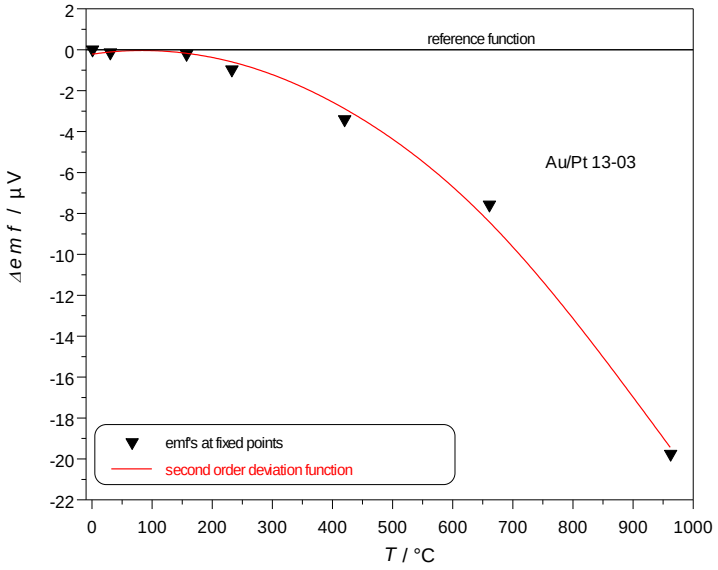
**New gas controlled heat pipes constructed and characterized:**

- **pressure control 1 ppm in the whole range**
- **corresponding temperature controlled:**
  - **1 mK at the low temperature GCHP**
  - **⇒ maximum of 3 mK in the high temp. HP**
- **temperature stability within fractions of mK**
- **uniformity of 1 mK in the first 15 cm of the wells**

# New methods to establish traceability to the kelvin



**New design of a Au/Pt thermocouple using quartz glass tubes**



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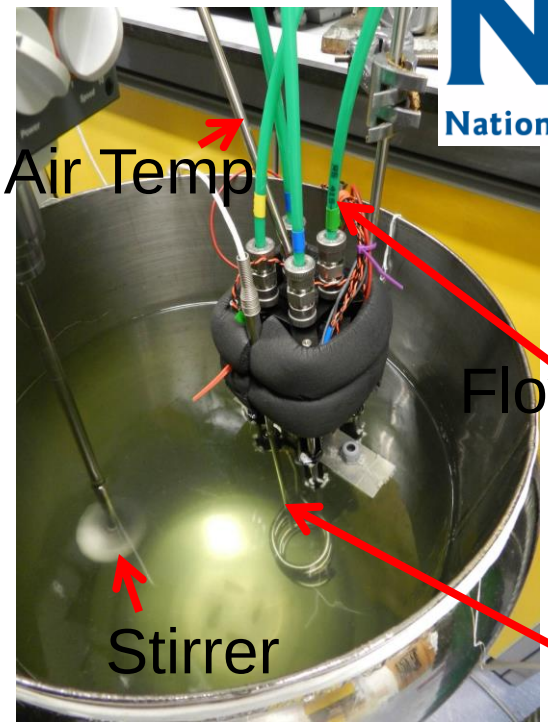
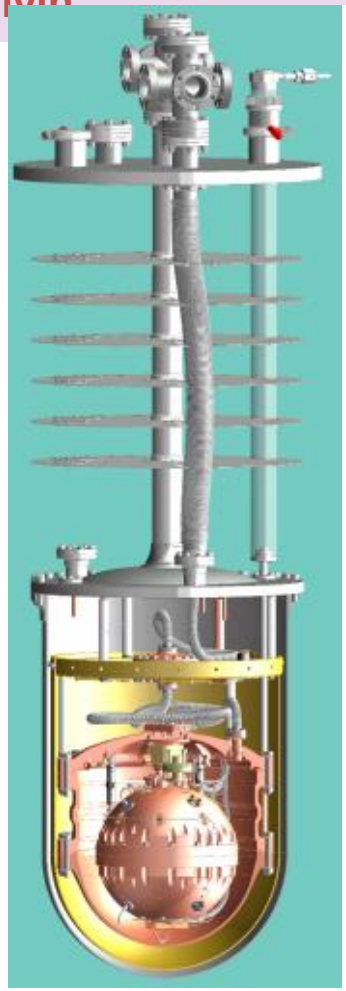
NPL National Physical Laboratory




**Prototype of an acoustic "block calibrator" constructed.**



LNE
Le progrès, une passion à partager

**An acoustic thermometer for the calibration of SPRTs.**

## Conclusion

**The main important outputs of NOTED (to date) have been presented**

**… but more results will be published soon, the CCT will be informed of the final outputs and conclusions of the project in its next meeting.**

**If you are interested in the project you can contact us and visit our web page [www.notedproject.com](http://www.notedproject.com)**

# Thanks for your attention!