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Radiation Thermometry Research Activities at NRC

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National Research
Council Canada

Conseil national
de recherches Canada

Canada

International Temperature Scale of 1990 (ITS-90)

- for temperatures above approximately 1000 °C, the melting temperature of one the fixed points of Ag (961.78 °C), Au (1064.18 °C), or Cu (1084.62 °C) is used
- Planck's Law is then used to extrapolate to higher temperatures

$$\frac{L(T_{90})}{L[T_{90}(X)]} = \frac{\exp\left[\frac{c_2}{\lambda T_{90}(X)}\right] - 1}{\exp\left[\frac{c_2}{\lambda T_{90}}\right] - 1}$$

Where: $T_{90}(X)$ is the freezing temperature of Ag, Au or Cu;

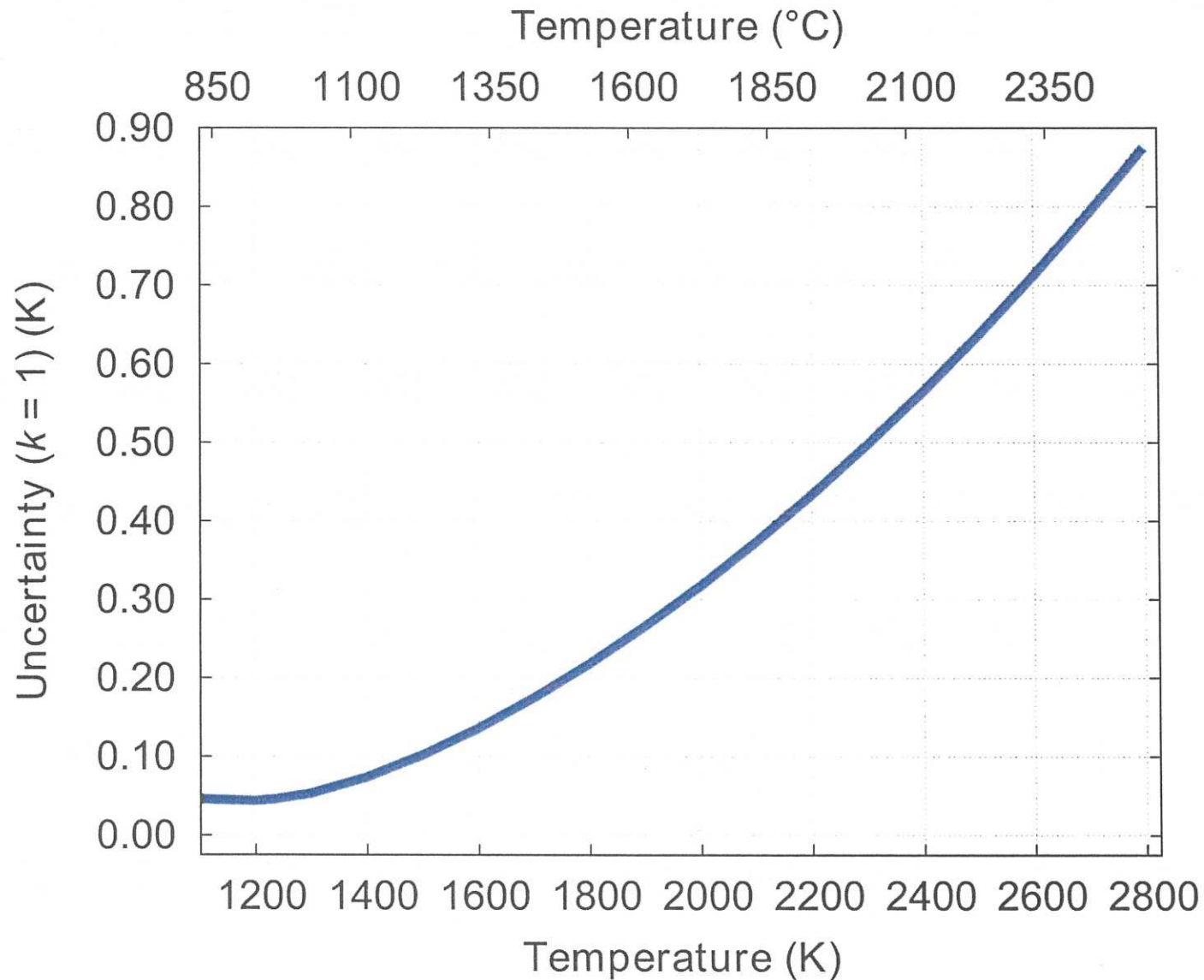
$L(T_{90})$ is the radiance at T_{90} ;

$L[T_{90}(X)]$ is the radiance at $T_{90}(X)$;

λ is the wavelength (in vacuum) and;

$c_2 = 0.014388$ m K.

Uncertainties for Radiation Thermometry

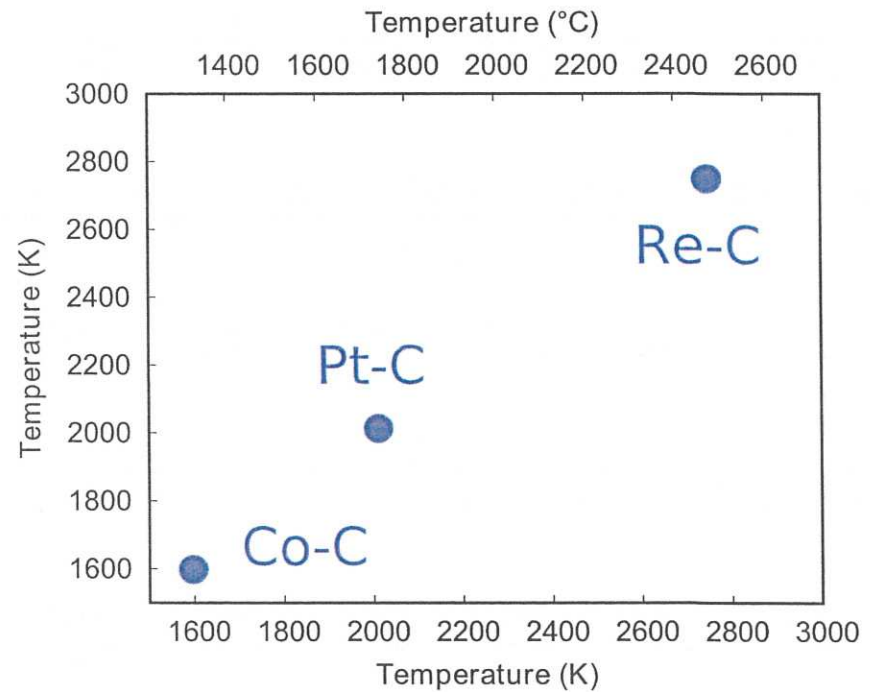
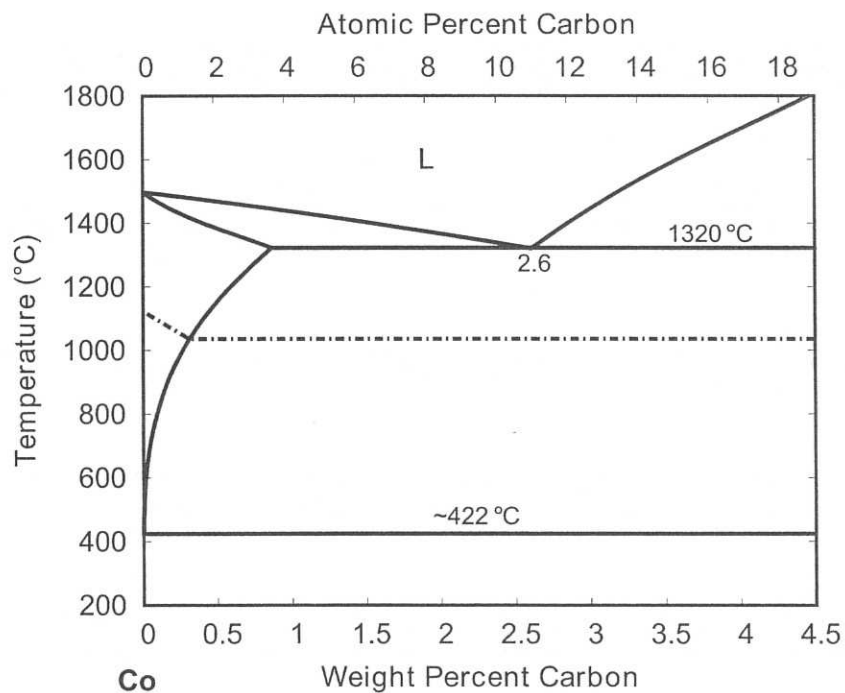


Value in having high temperatures fixed points (above 1000 °C)

- have an interpolated scale
- have a robust artefact for inter-comparisons

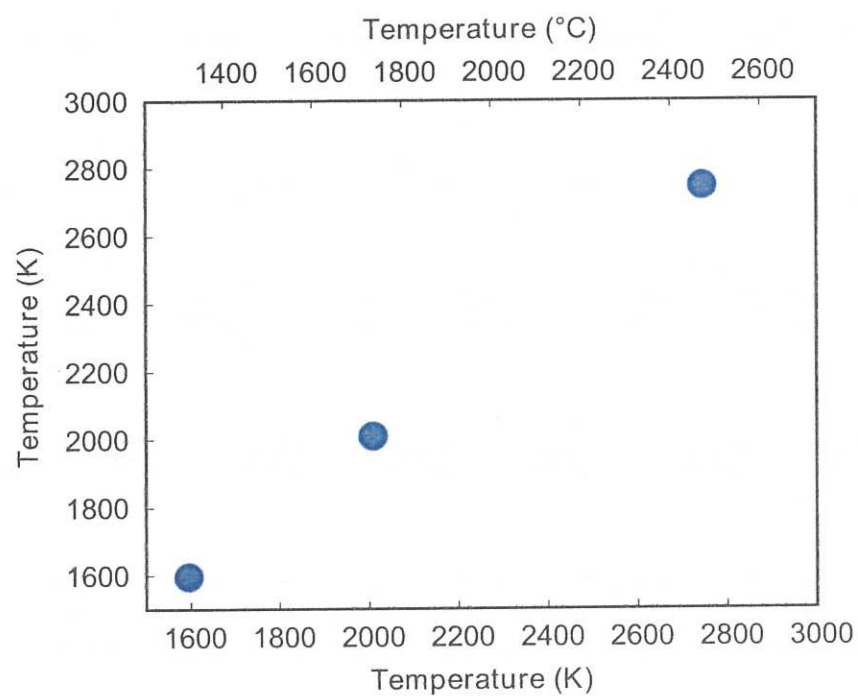
why don't we have HTFPs already?

Solution: metal-carbon eutectic fixed points

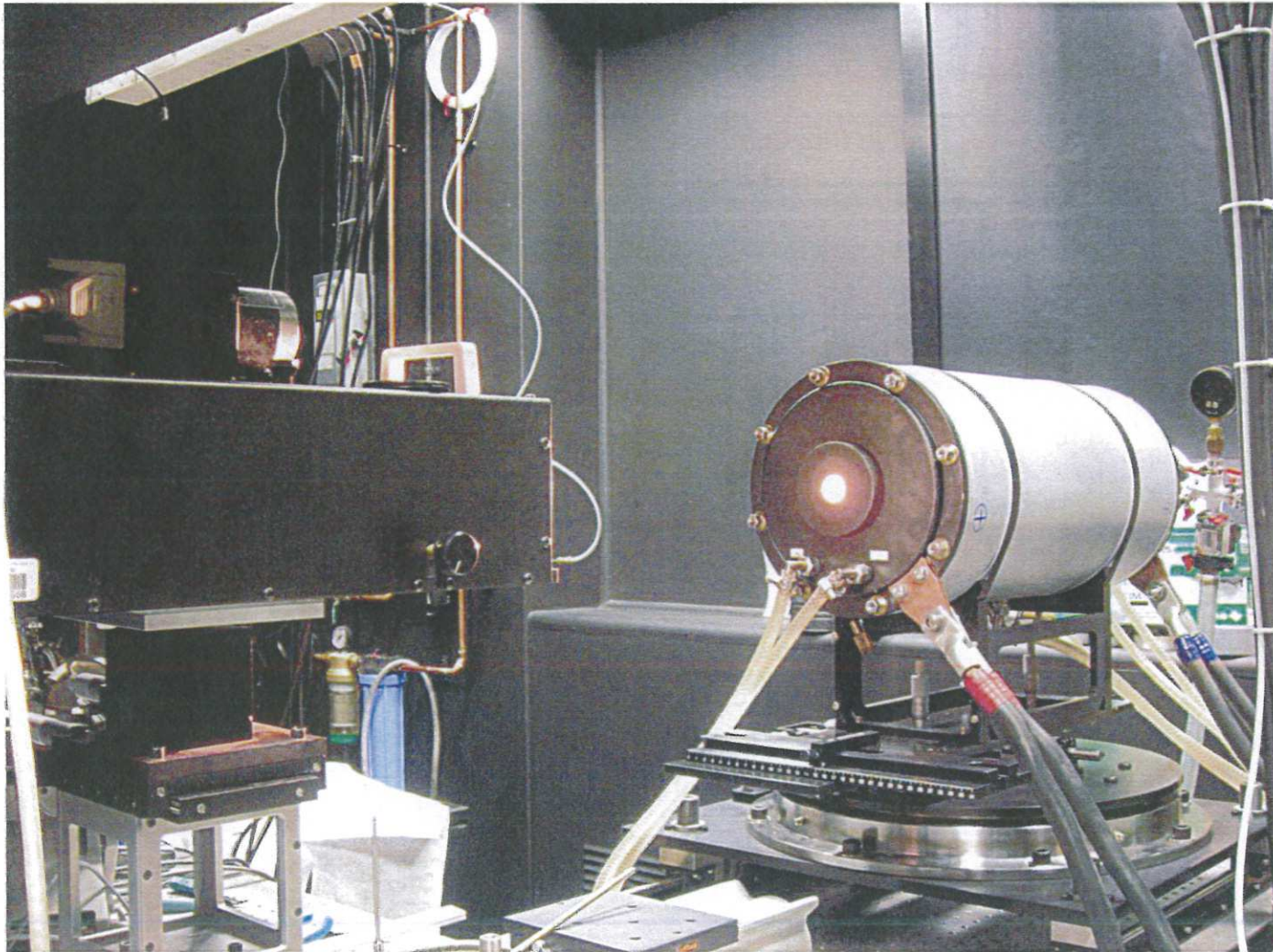


How do we know (or assign) a melting temperature?

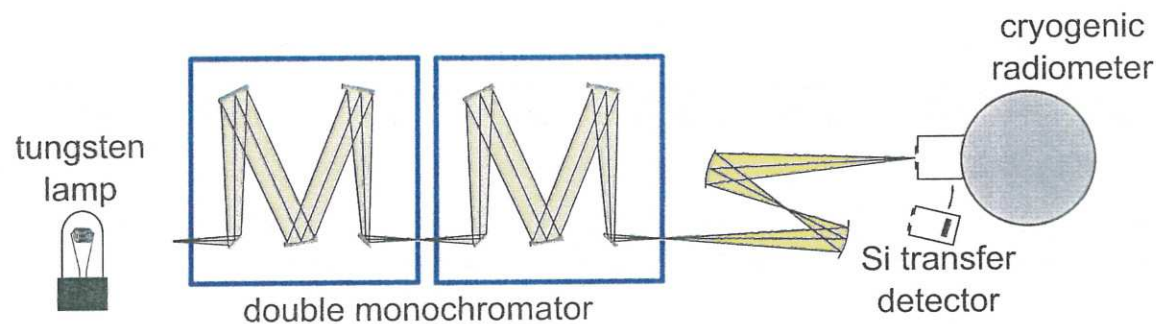
use absolute radiometry



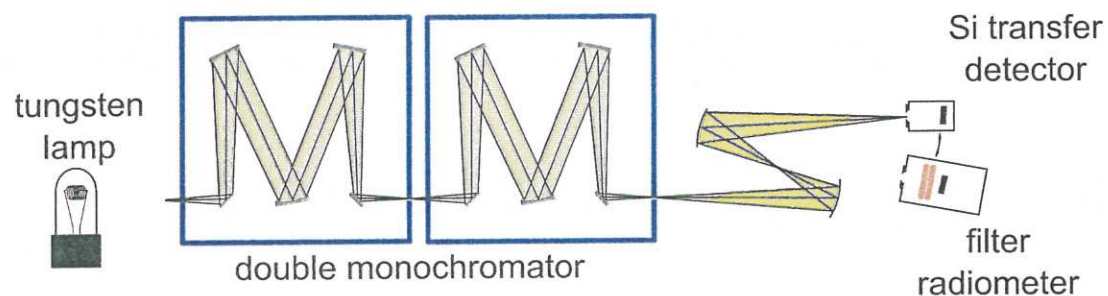
Furnace to Realize HTFPs at NRC



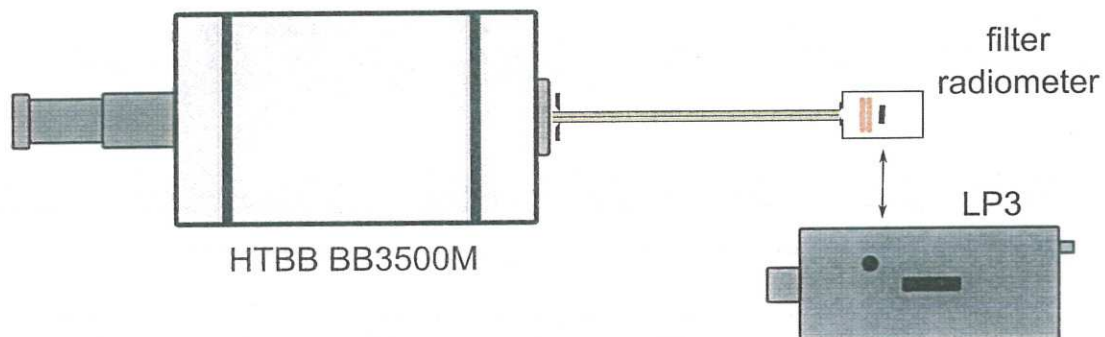
1. Calibrate transfer radiometer against the cryogenic radiometer



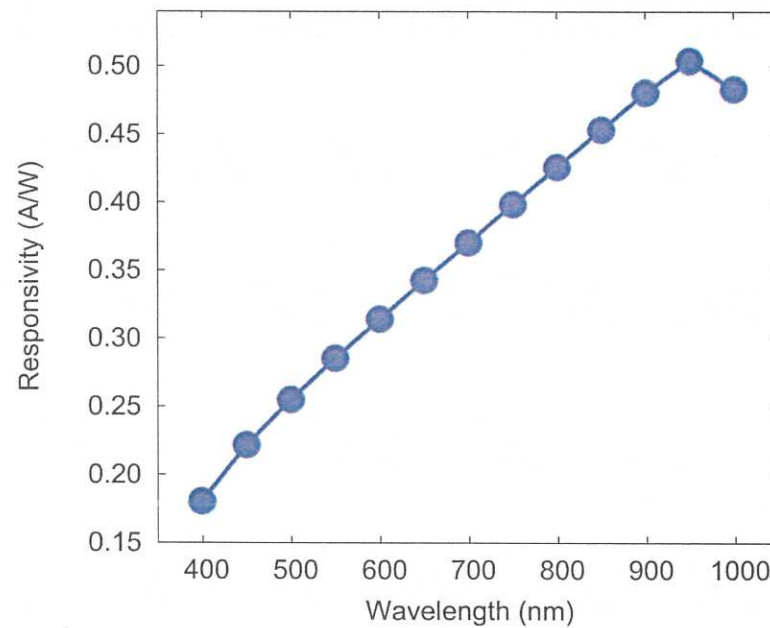
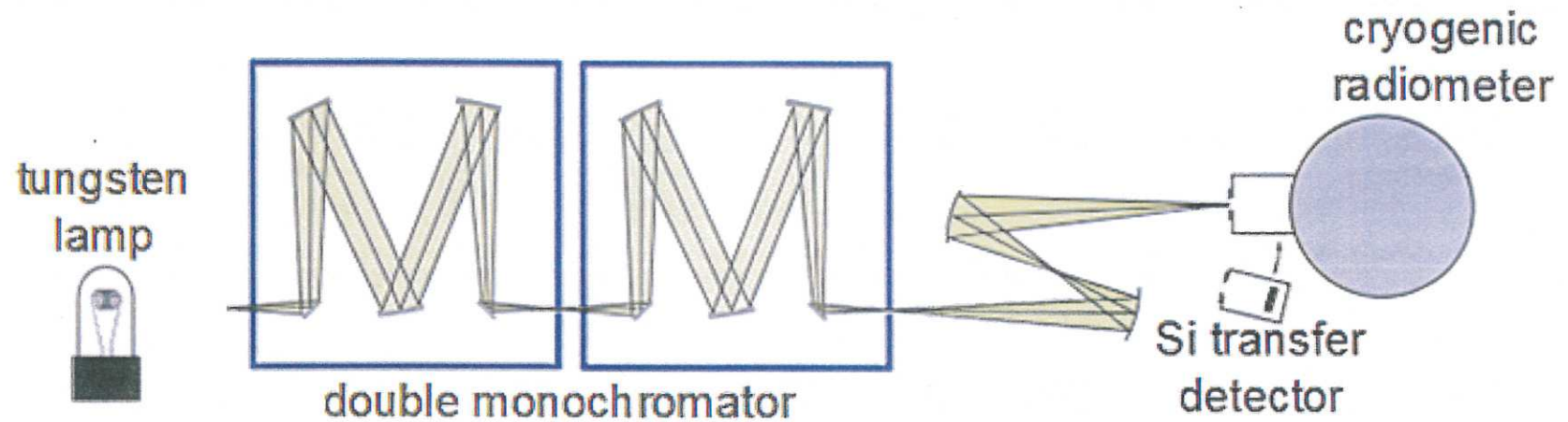
2. Calibrate the filter radiometer against the transfer radiometer



3. Calibrate the LP3 with the FR at the temperatures of interest using the HTBB

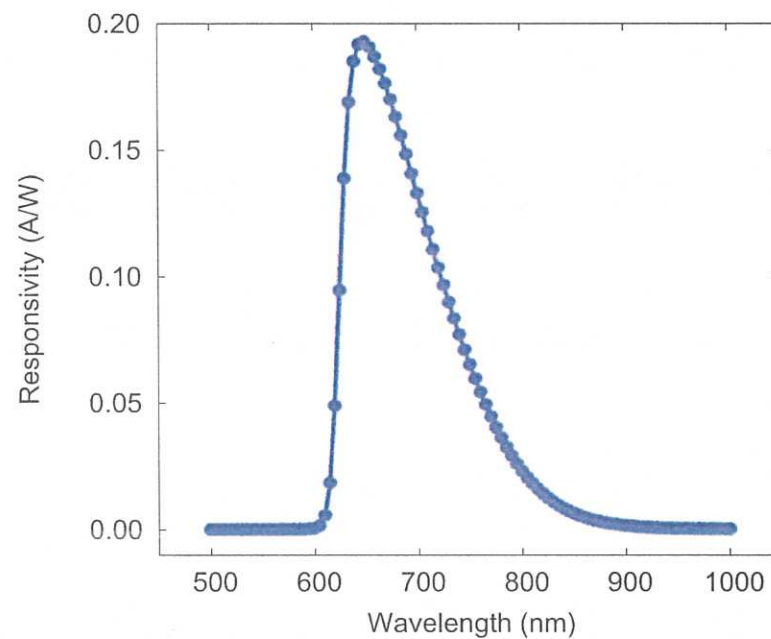
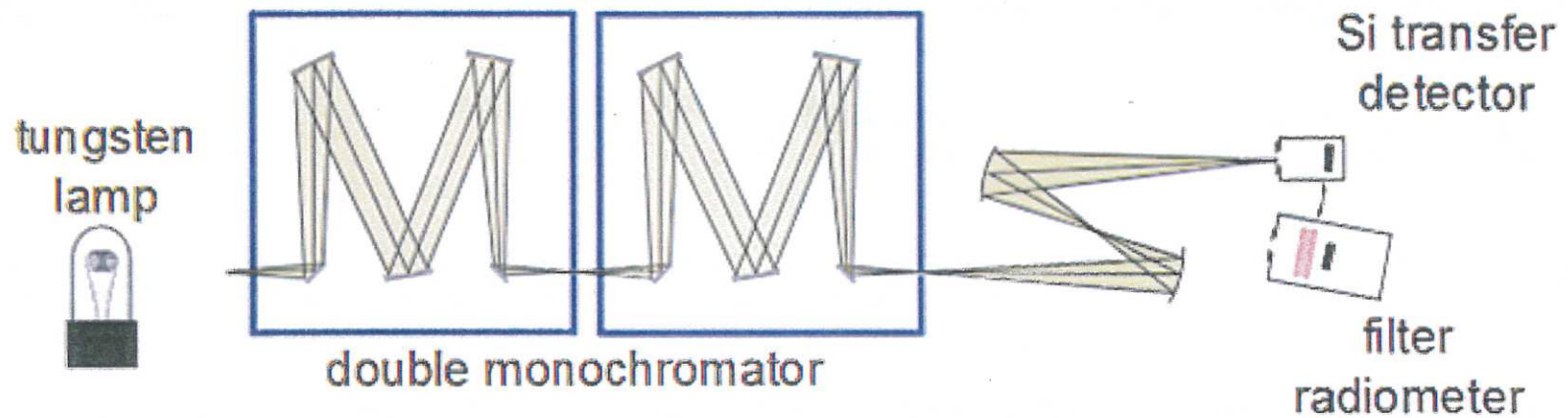


1. Calibrate transfer radiometer against the cryogenic radiometer

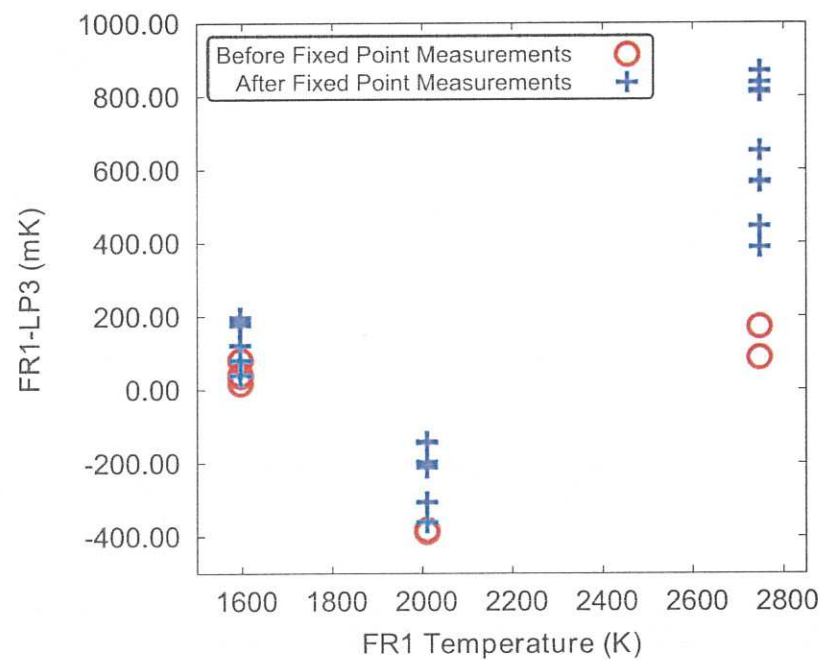
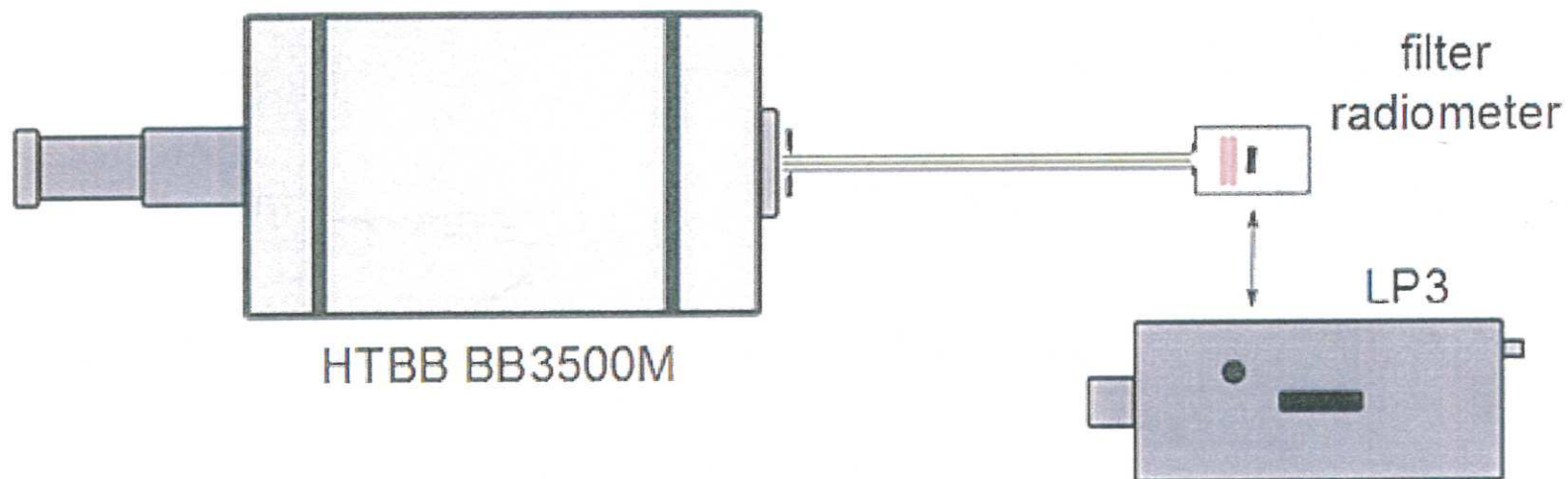


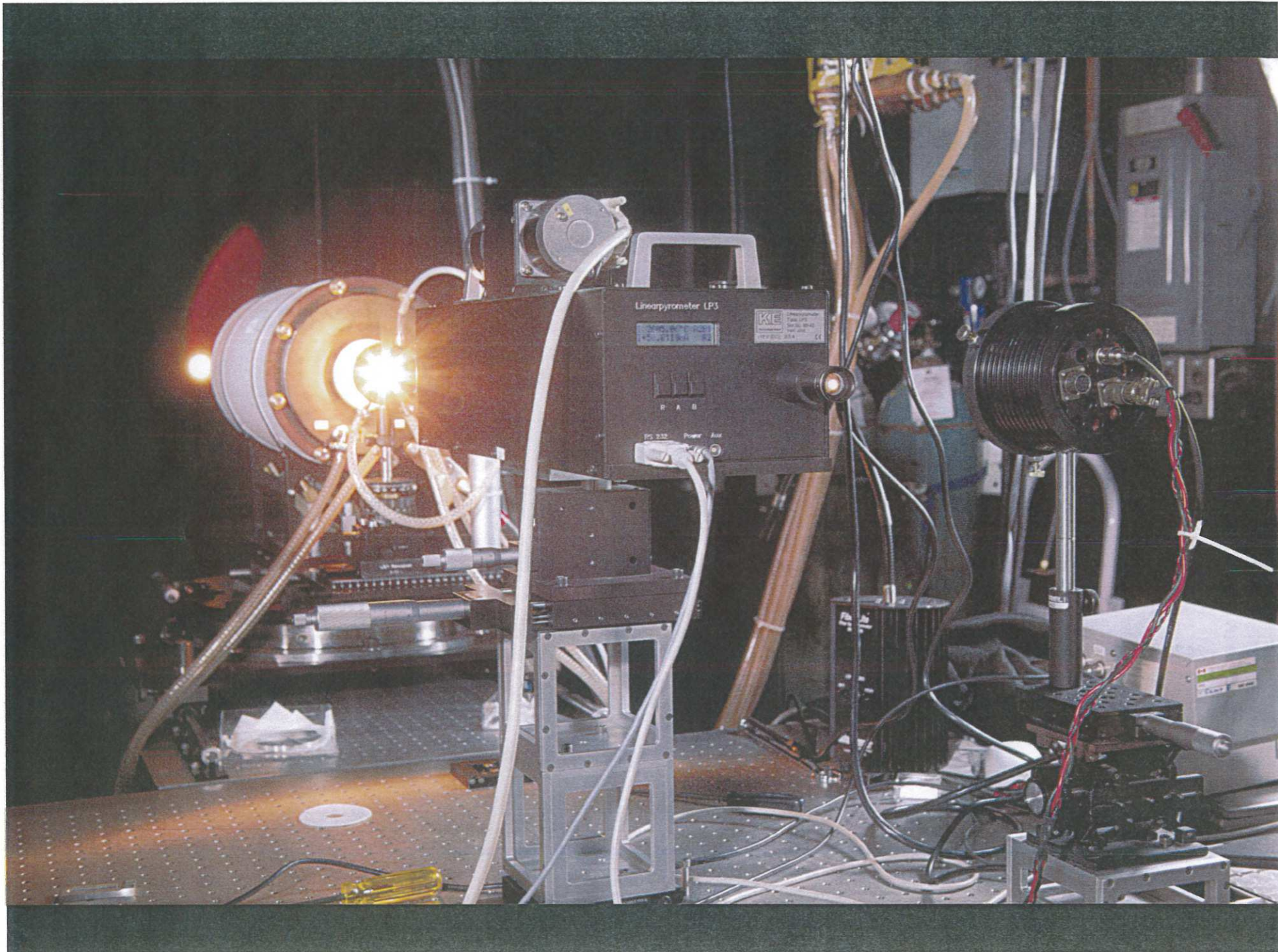


2. Calibrate the filter radiometer against the transfer radiometer



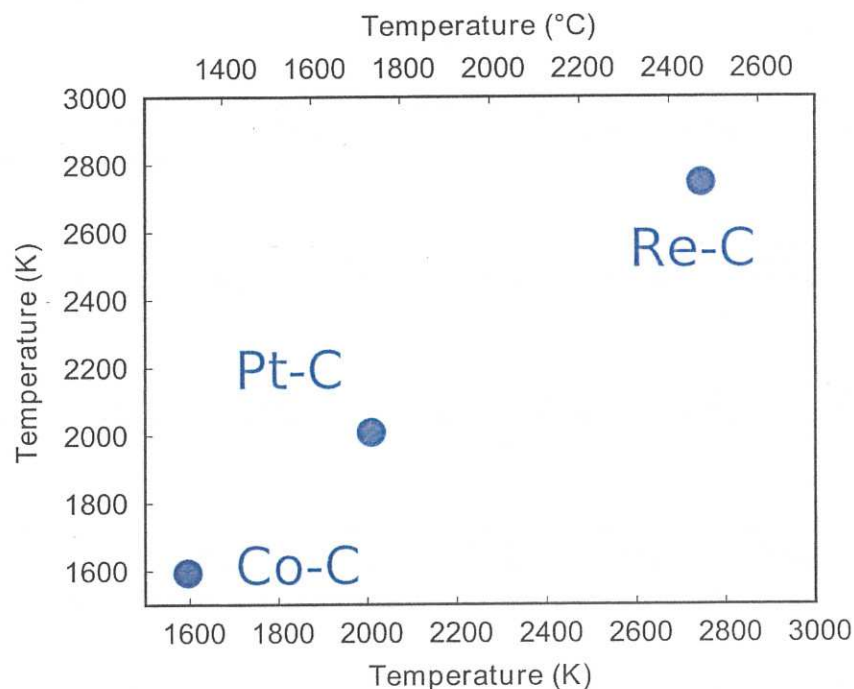
3. Calibrate the LP3 with the FR at the temperatures of interest using the HTBB





International effort to measure the melting temperatures of Co-C, Pt-C and Re-C

As part of working group 5 (radiation thermometry) of the Consultative Committee of Thermometry (CCT-WG5) there is a project to measure the absolute melting temperatures of HTFPs

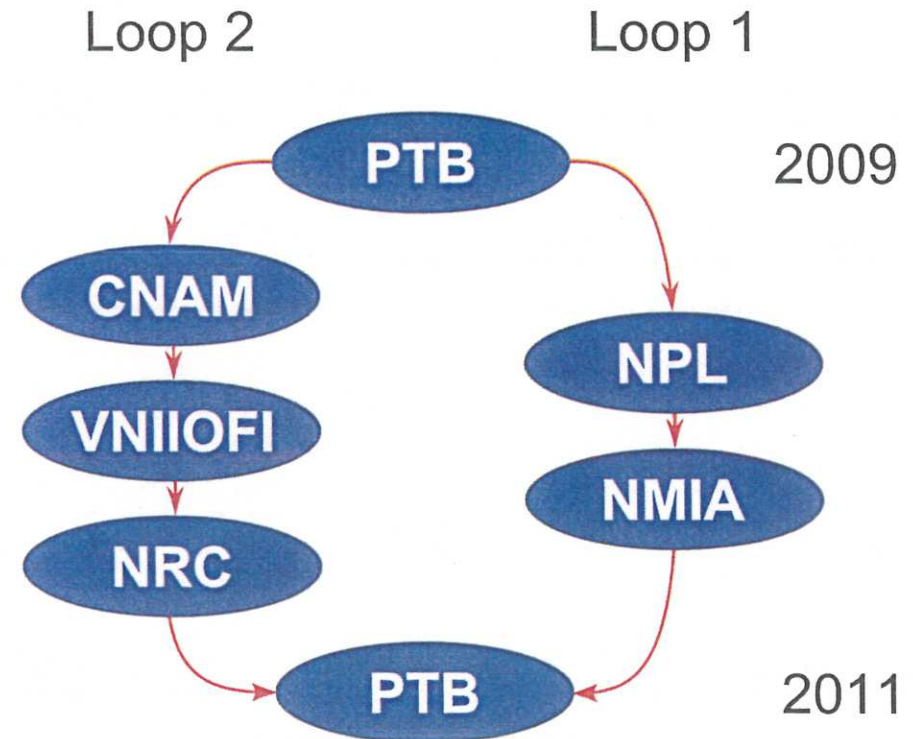
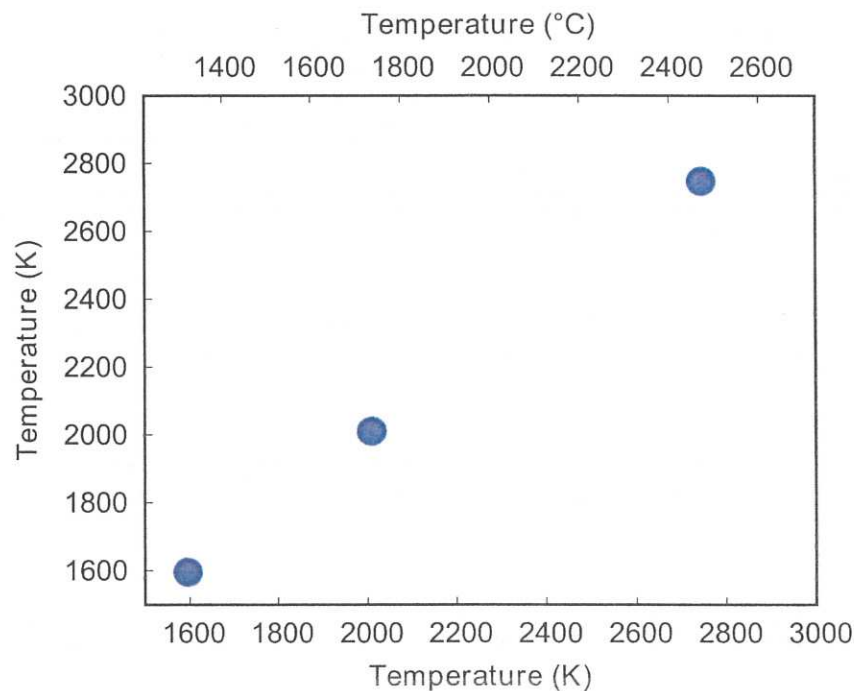


5 work packages:

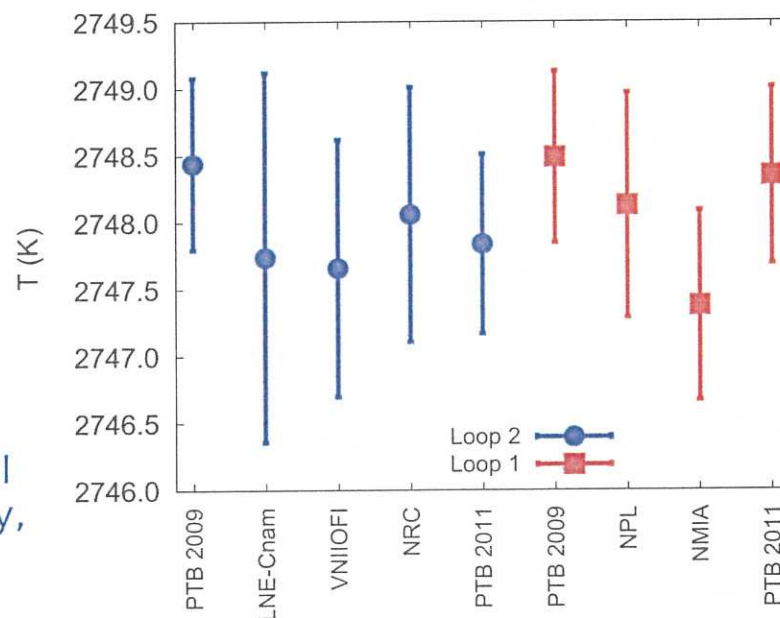
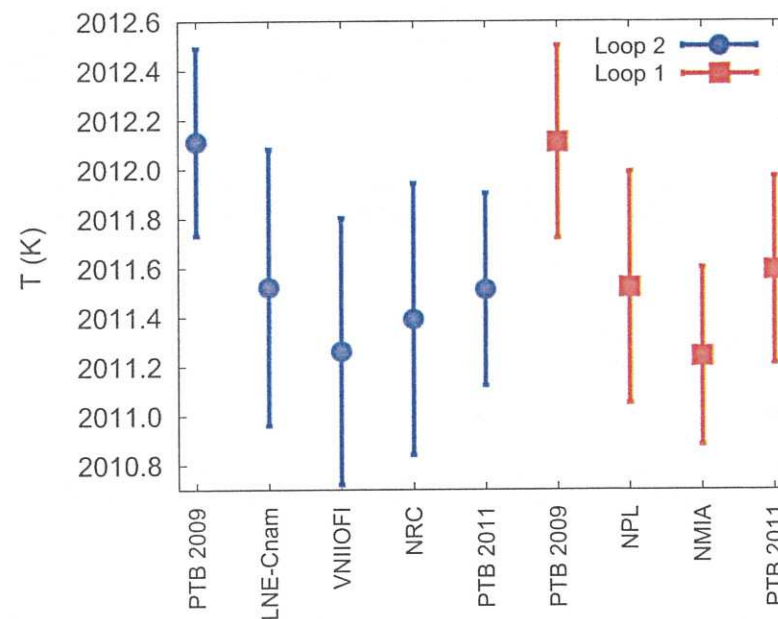
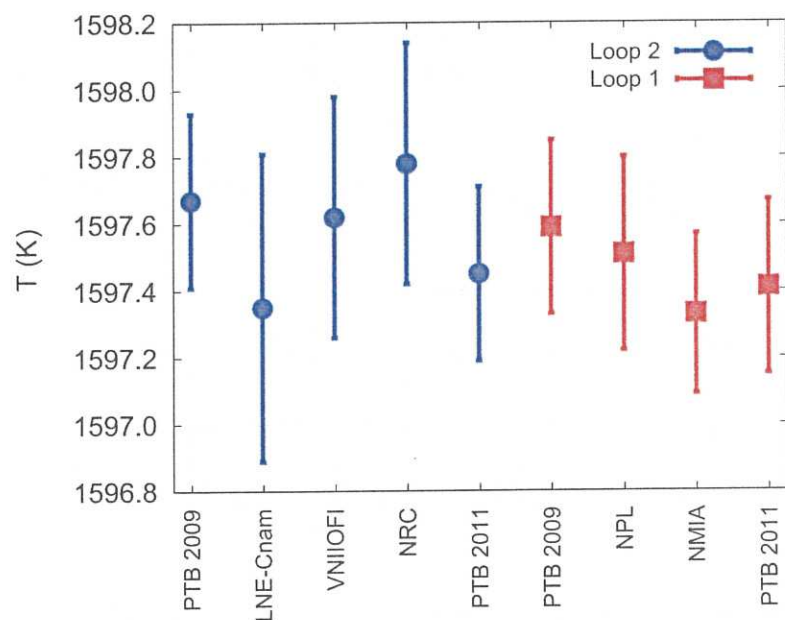
- WP1: long term stability
- WP2: HTFP construction methods
- WP3: uncertainties and analysis
- WP4: preliminary assessment
- WP5: assignment of temperature

Preliminary comparison (WP4)

Part of this project was a preliminary comparison of two sets of HTFPs to assess how well NMIs could measure



Results of the preliminary comparison

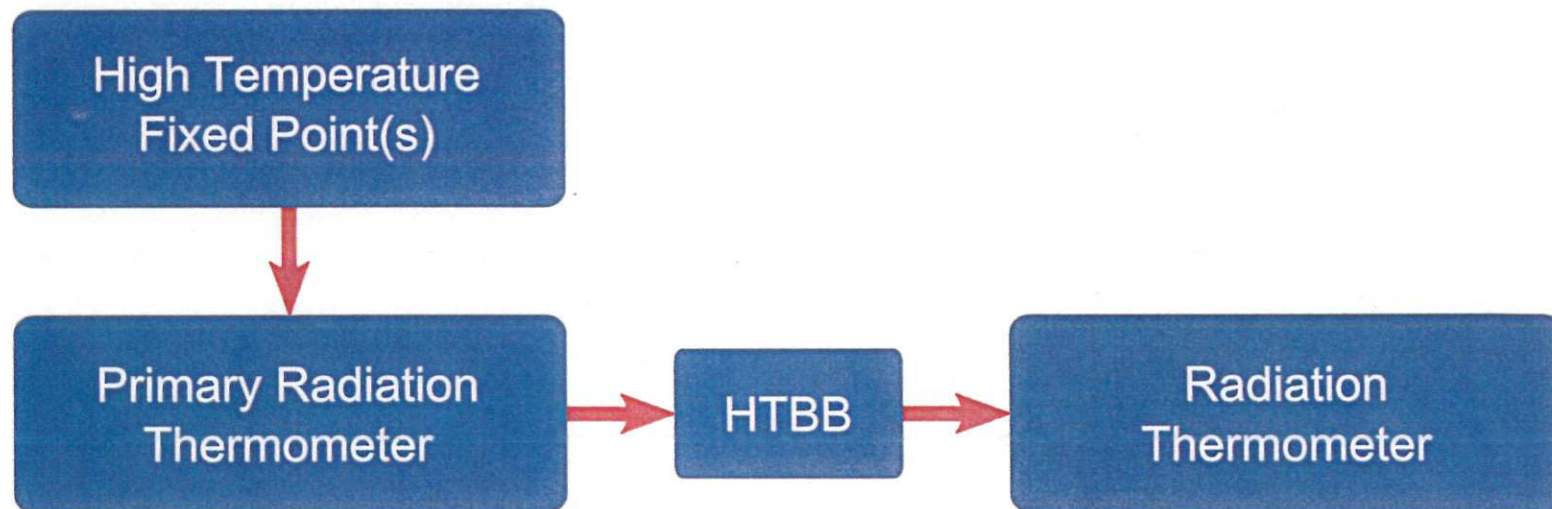


K. Anhalt *et al.* In:
Temperature: Its
measurement and control
in science and technology,
(2012) submitted

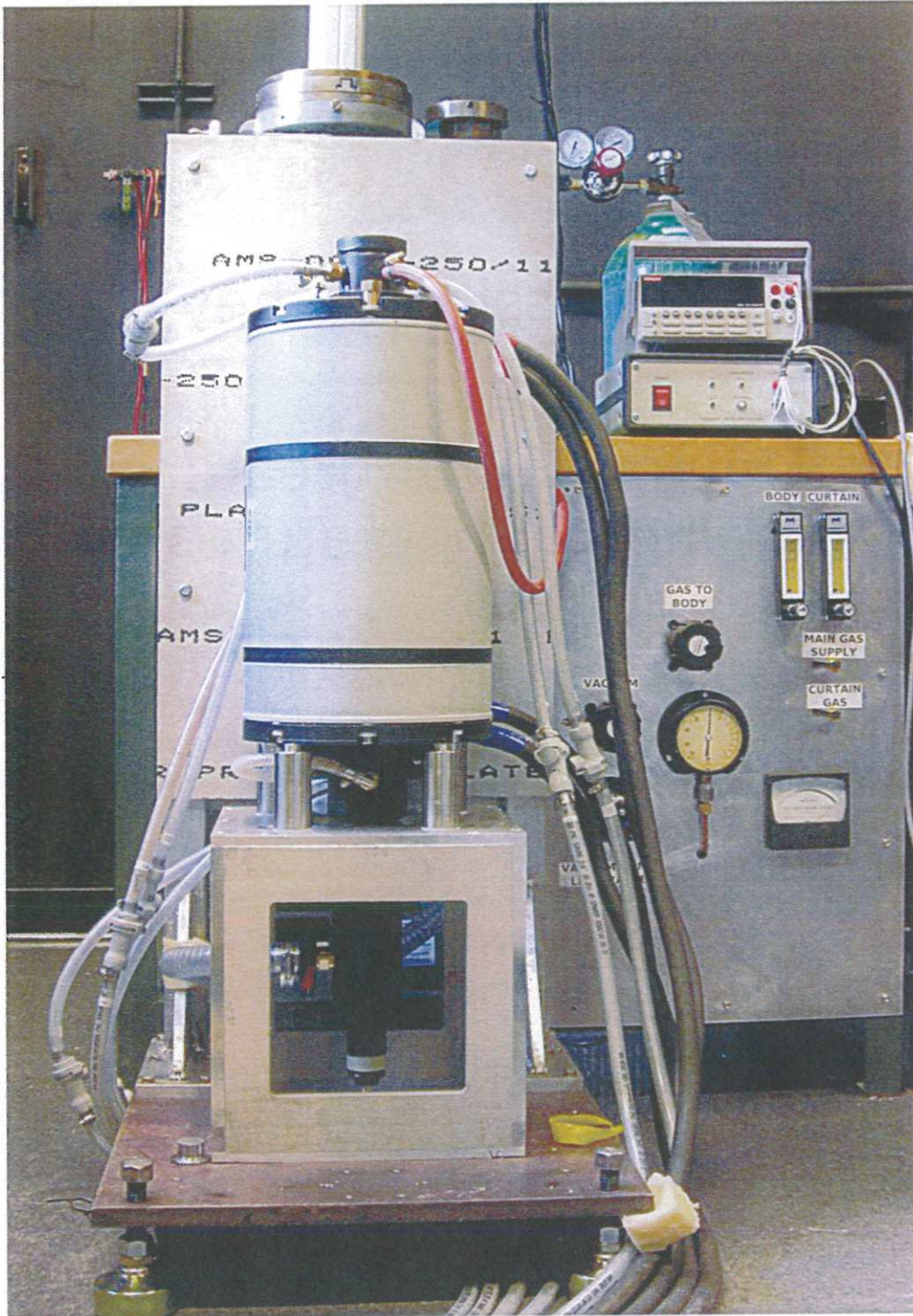
Result (future)

Once the HTFPs have temperatures assigned they can be used to:

- Reduce uncertainties (by a factor of 4 or greater at the highest temperatures) at high temperatures (radiation and contact thermometry)
- Enable artefacts for inter-comparisons



Casting Furnace at NRC



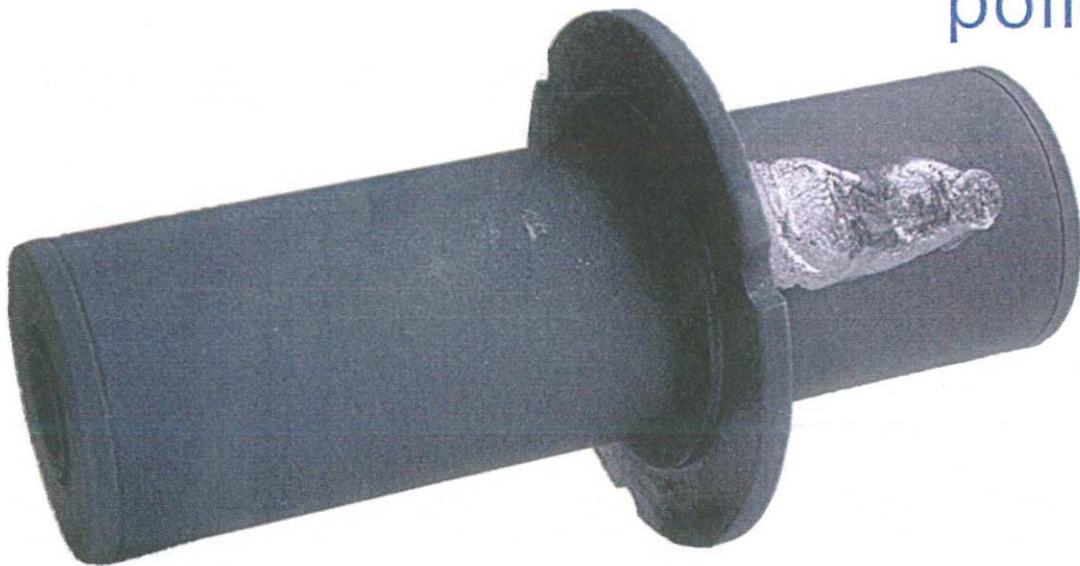
There are other HTFPs of interest to radiometry

WC-C melts ~ 3021 K

TiC-C melts ~ 3034 K

HfC-C melts ~ 3458 K

Large(r) aperture fixed points





Acknowledgements

Ken Hill
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