



# Radiation Thermometry Research Activities at NRC

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# 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;

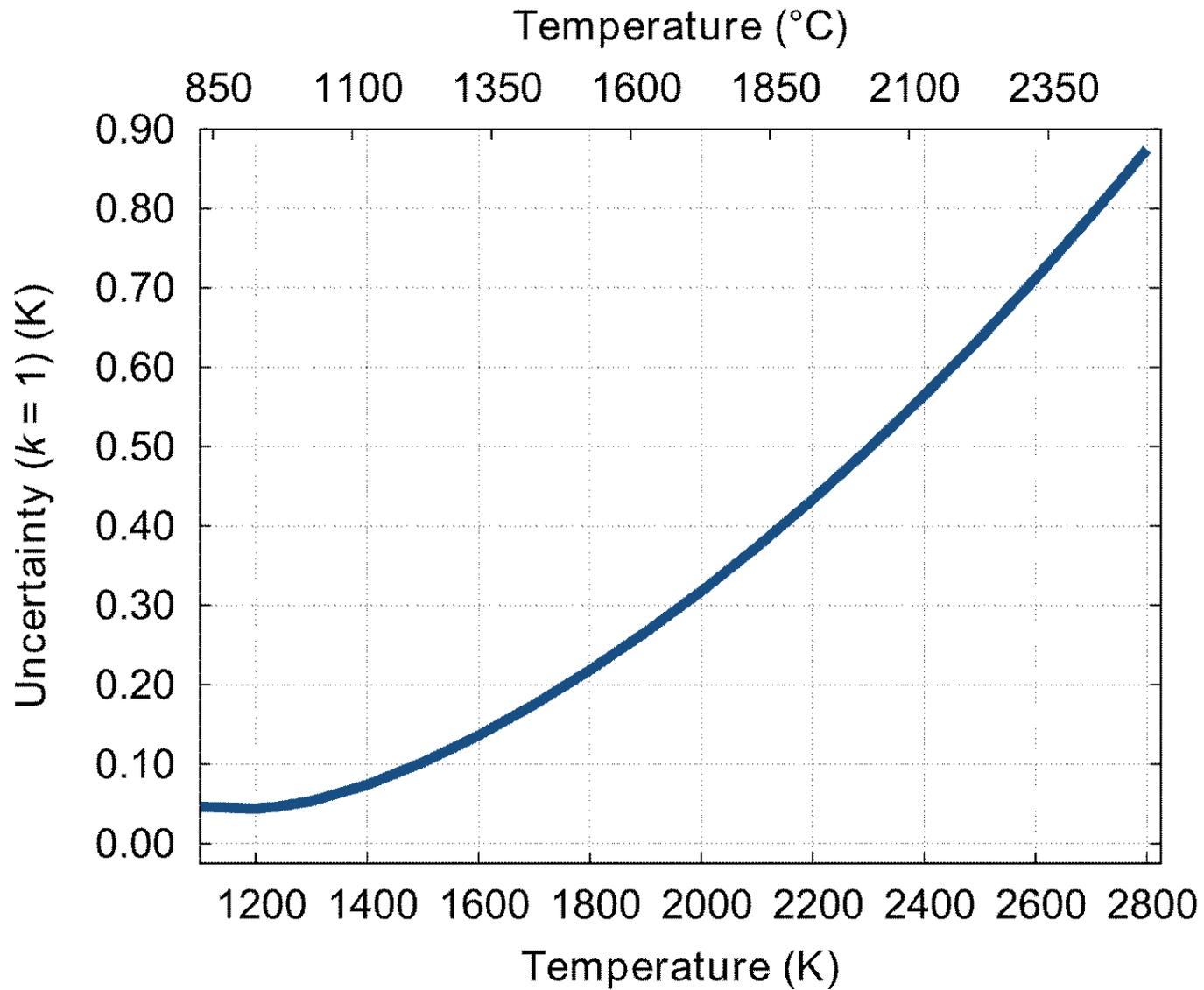
$L(T_{90})$  is the radiance at  $T_{90}$ ;

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

$\lambda$  is the wavelength (in vacuum) and;

$c_2 = 0.014388$  m K.

# Uncertainties for Radiation Thermometry

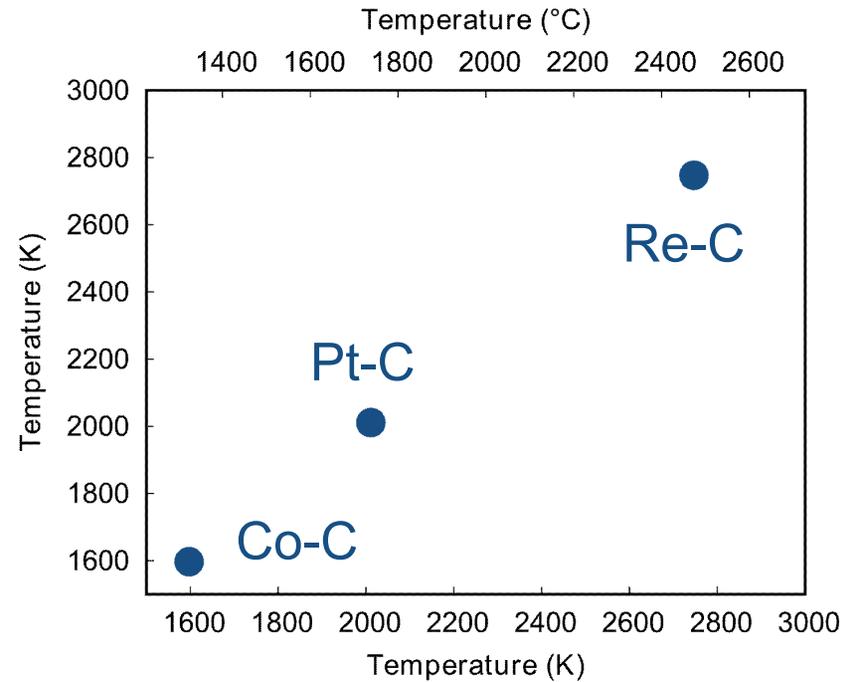
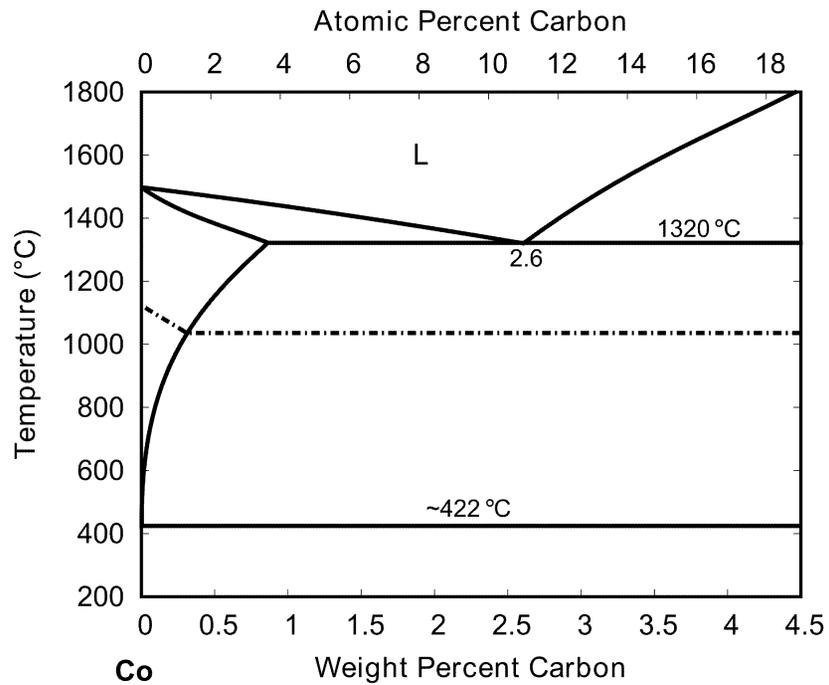


## **Value in having high temperatures fixed points (above 1000 °C)**

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

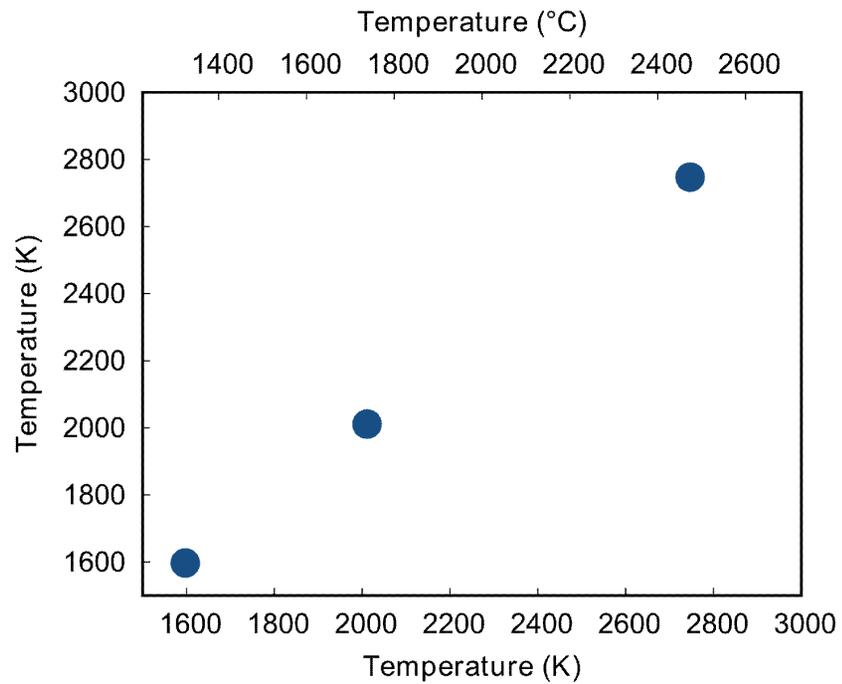
**why don't we have HTFPs already?**

# Solution: metal-carbon eutectic fixed points

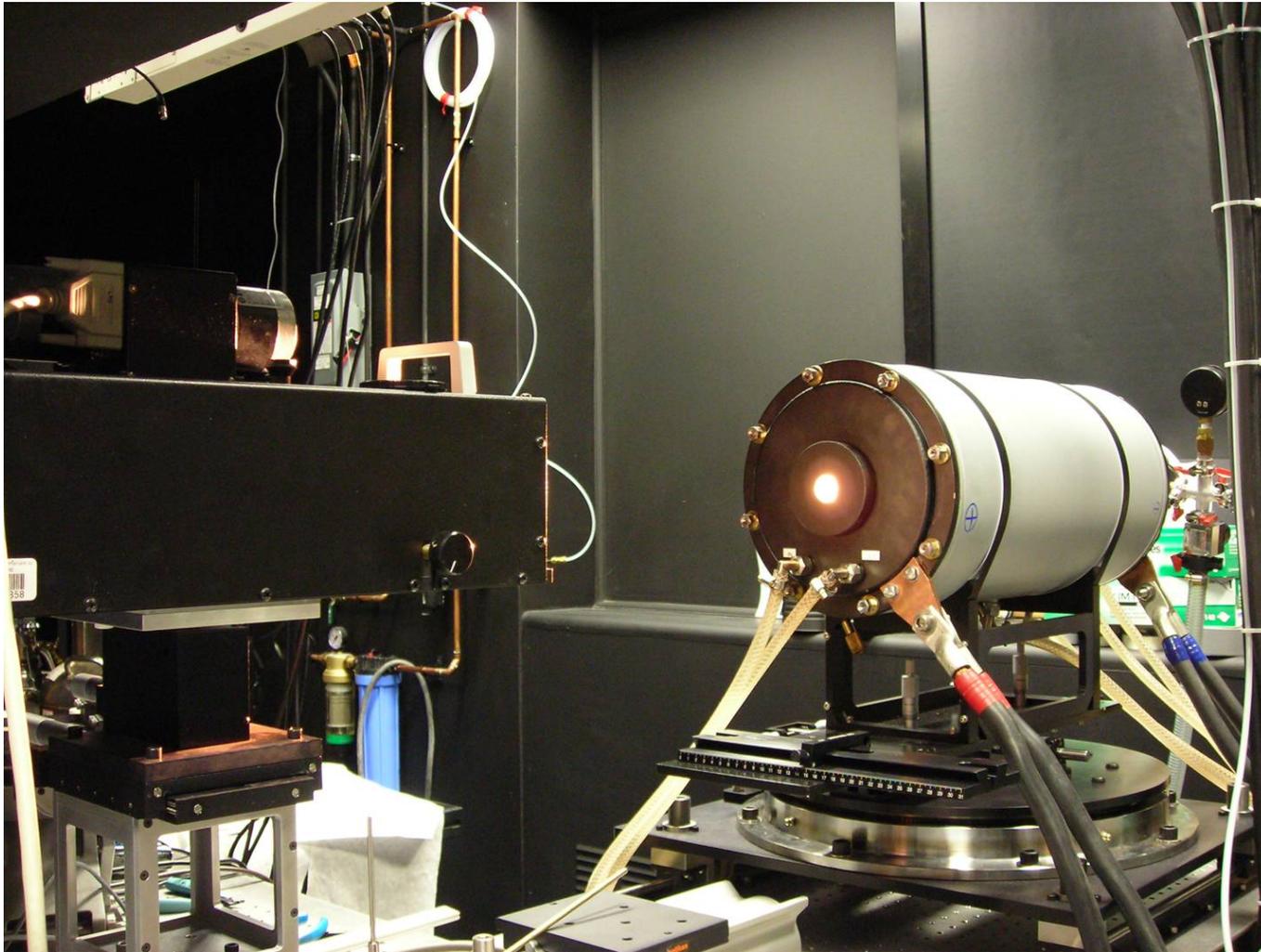


# How do we know (or assign) a melting temperature?

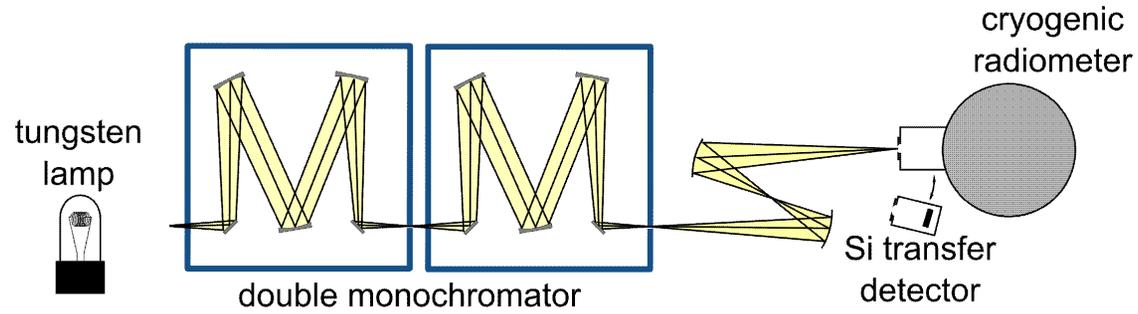
use absolute radiometry



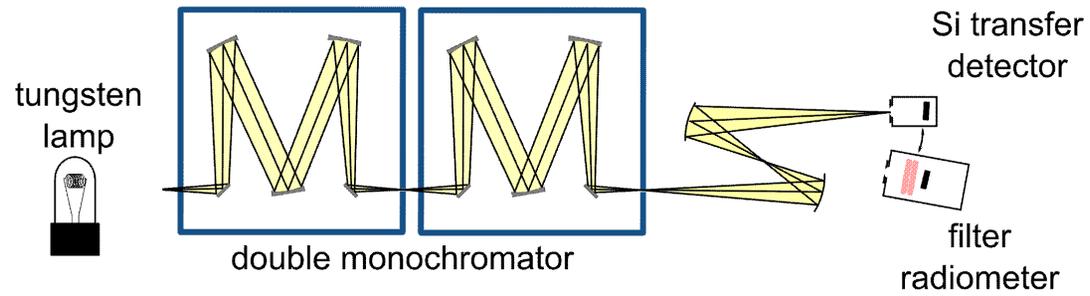
# Furnace to Realize HTFPs at NRC



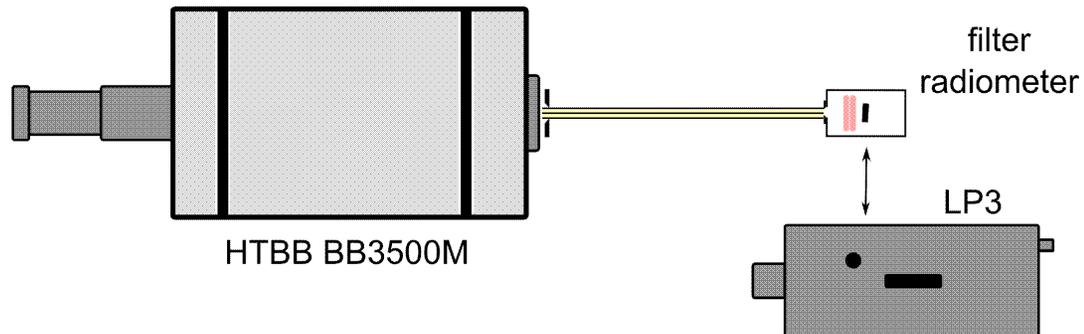
1. Calibrate transfer radiometer against the cryogenic radiometer



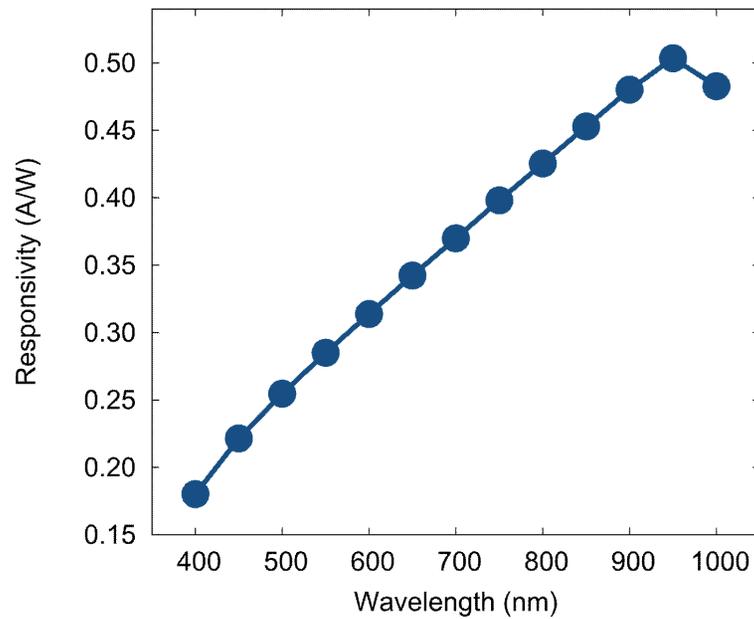
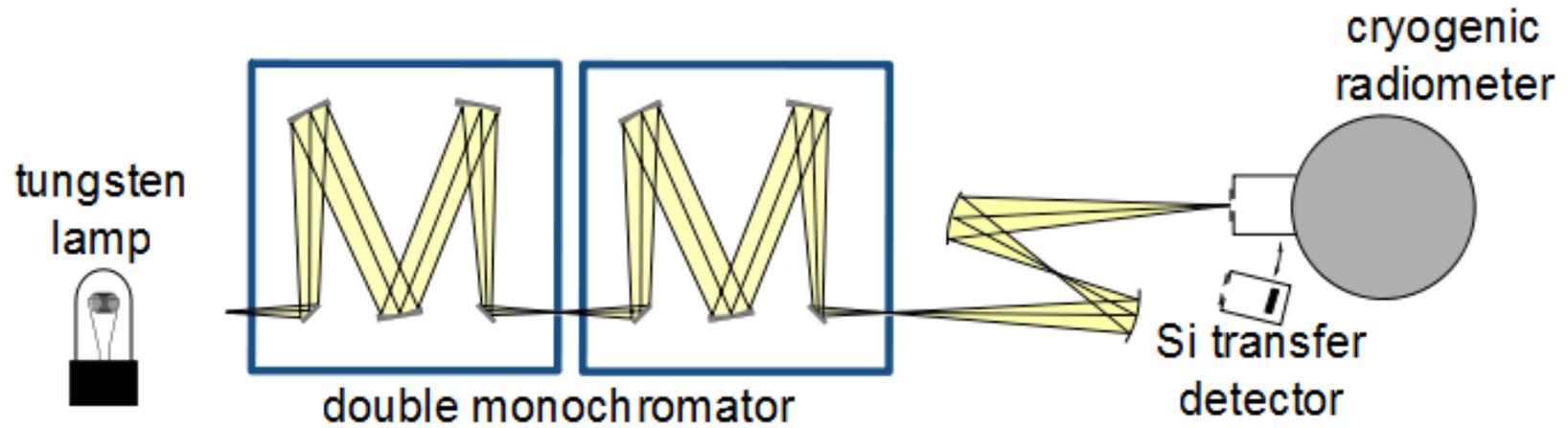
2. Calibrate the filter radiometer against the transfer radiometer

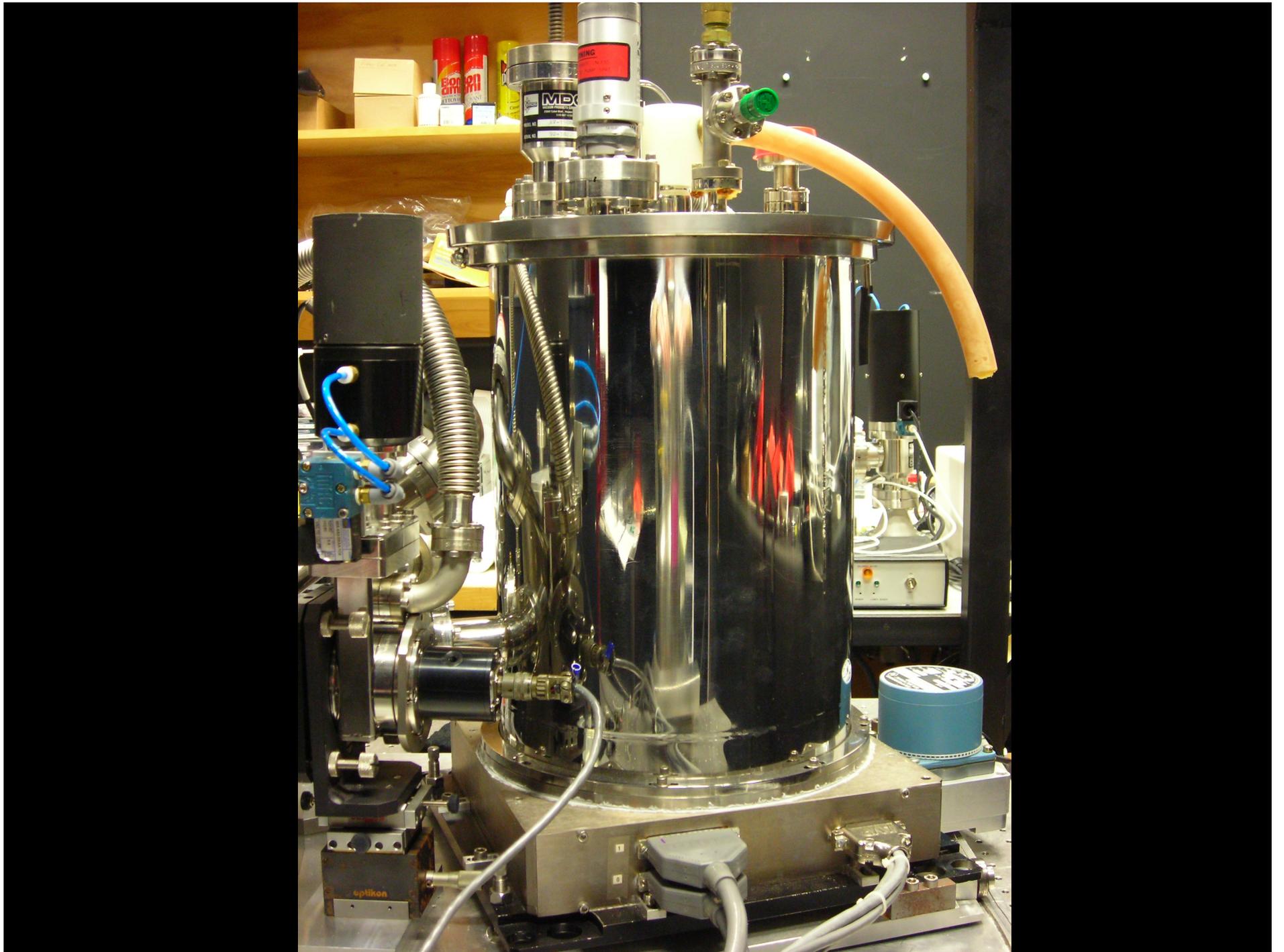


3. Calibrate the LP3 with the FR at the temperatures of interest using the HTBB

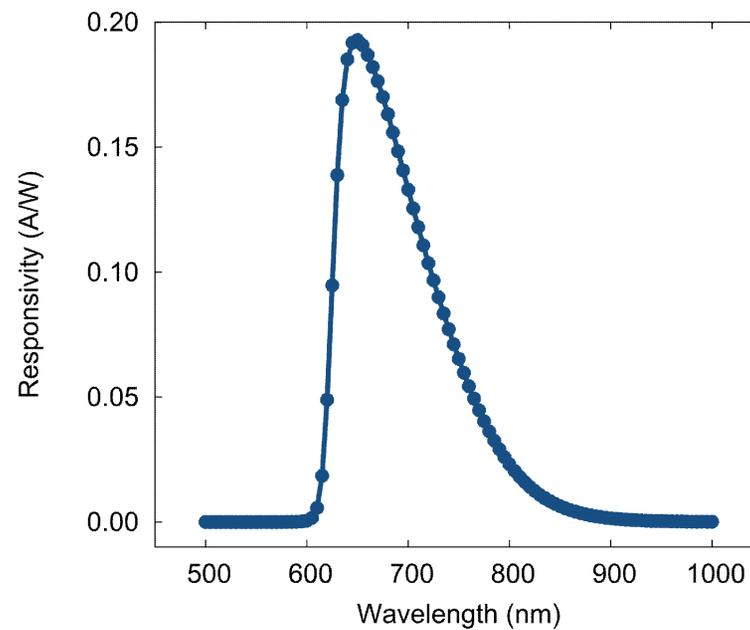
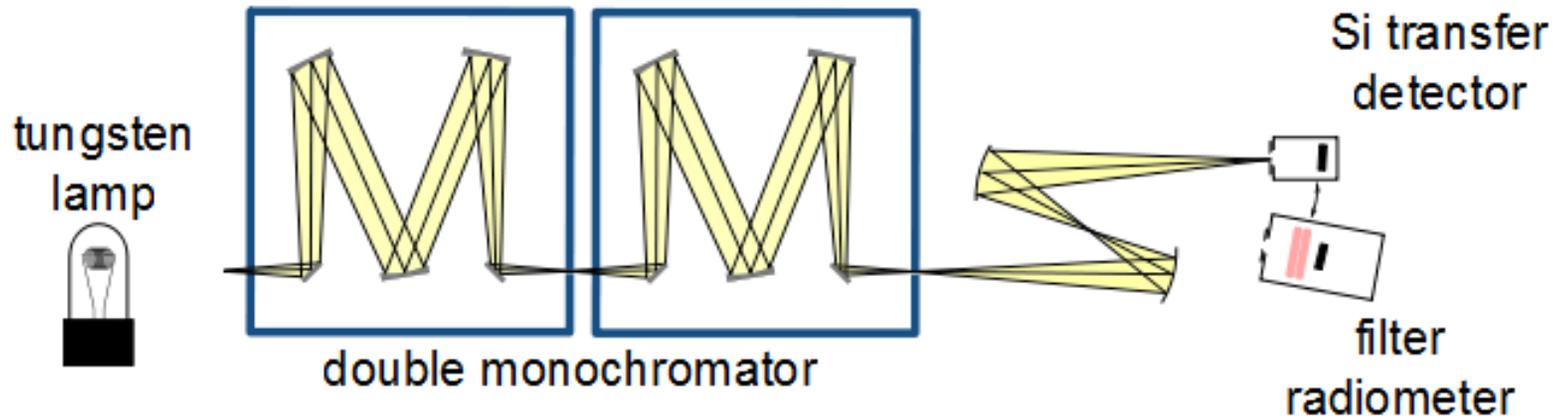


# 1. Calibrate transfer radiometer against the cryogenic radiometer

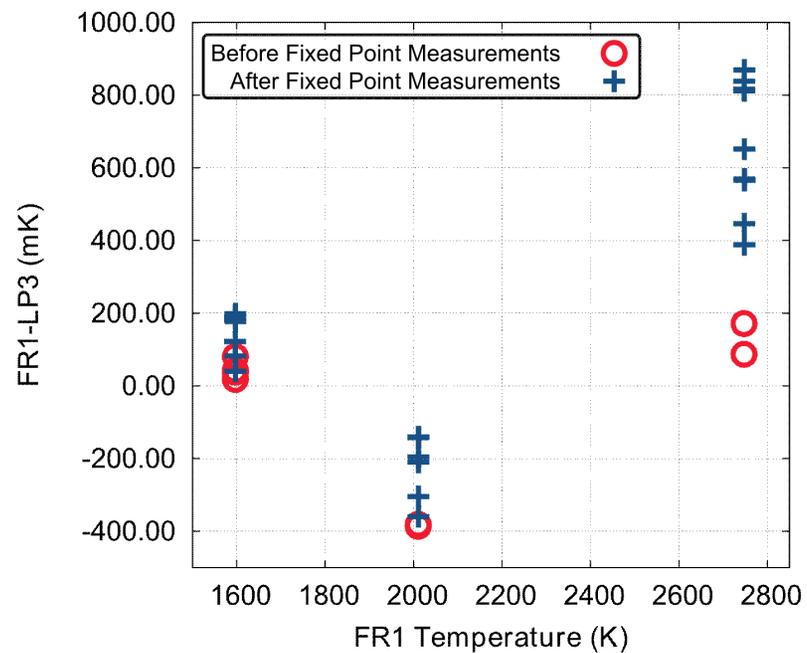
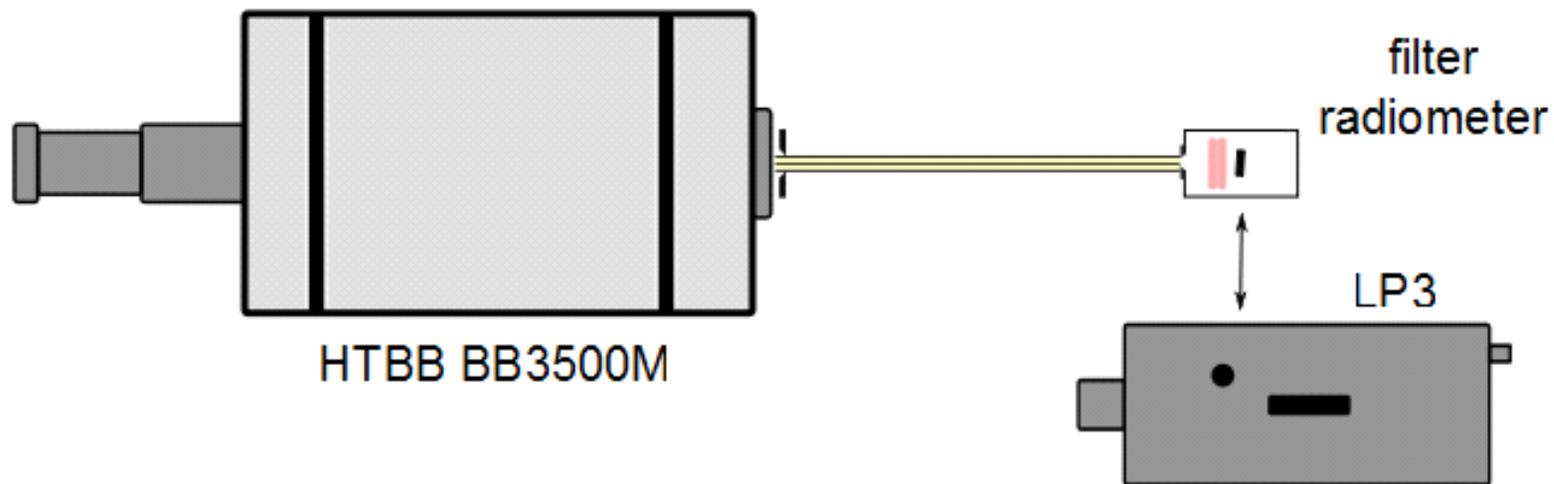


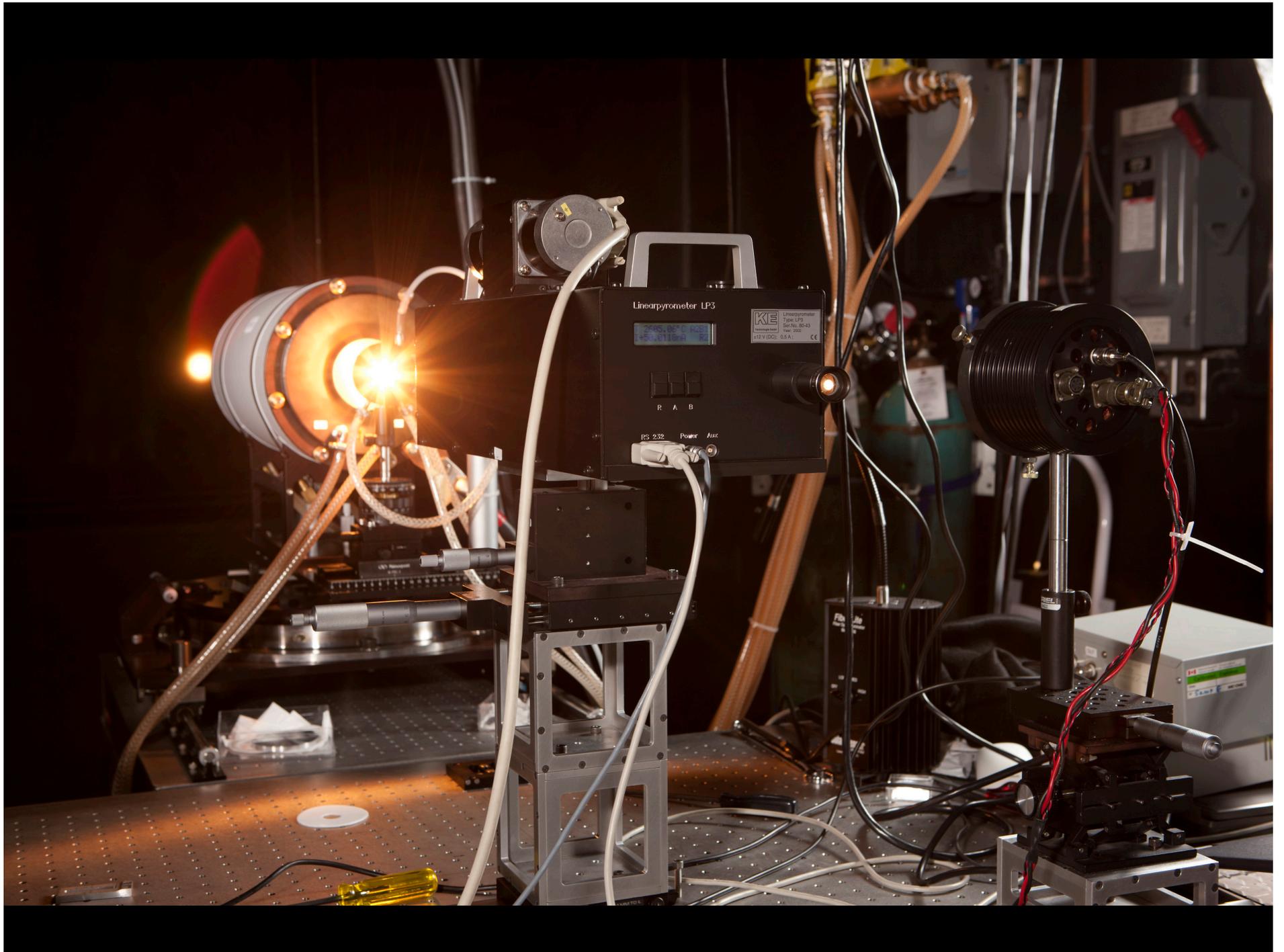


## 2. Calibrate the filter radiometer against the transfer radiometer



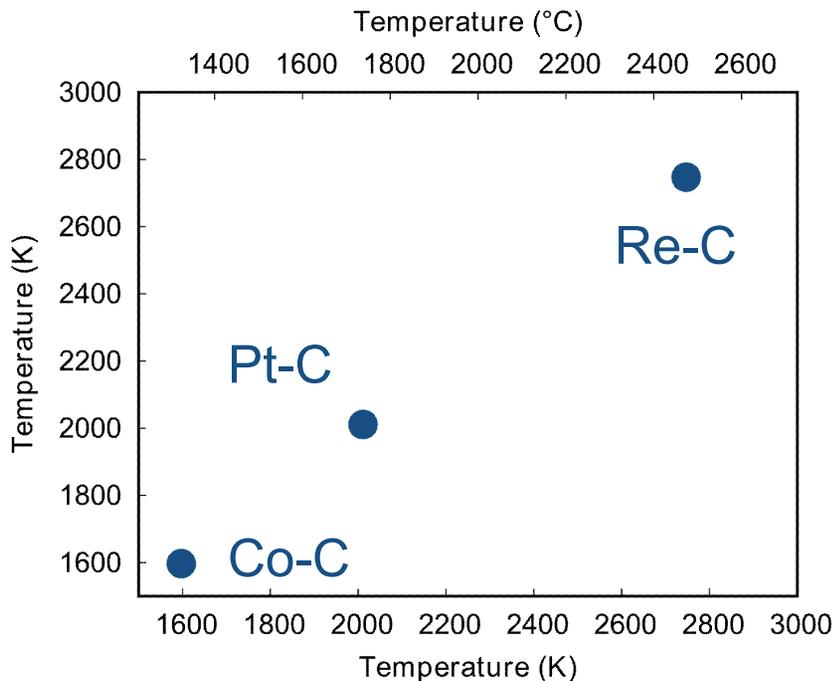
### 3. Calibrate the LP3 with the FR at the temperatures of interest using the HTBB





# 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

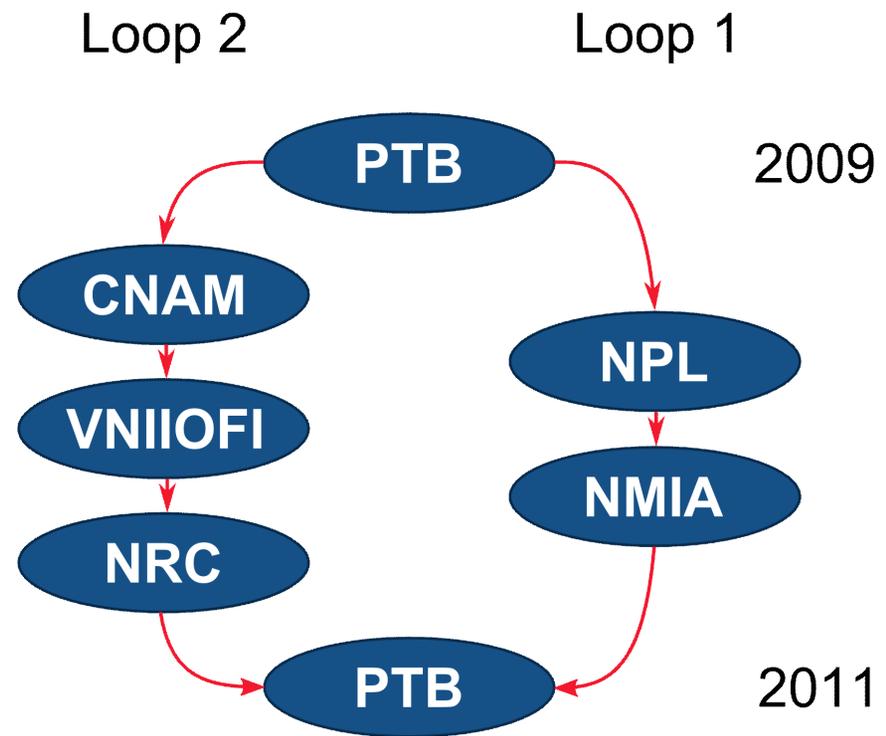
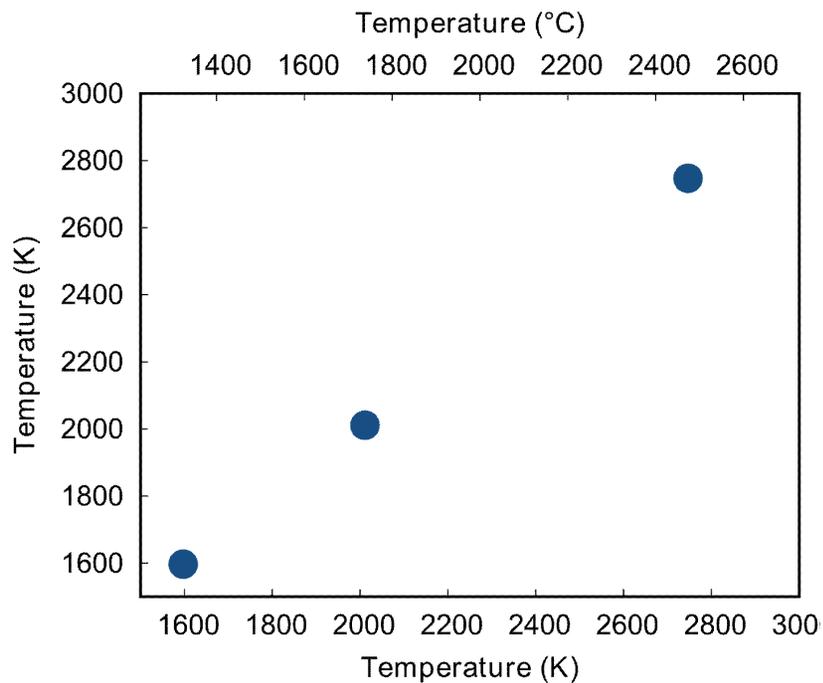
WP3: uncertainties and analysis

WP4: preliminary assessment

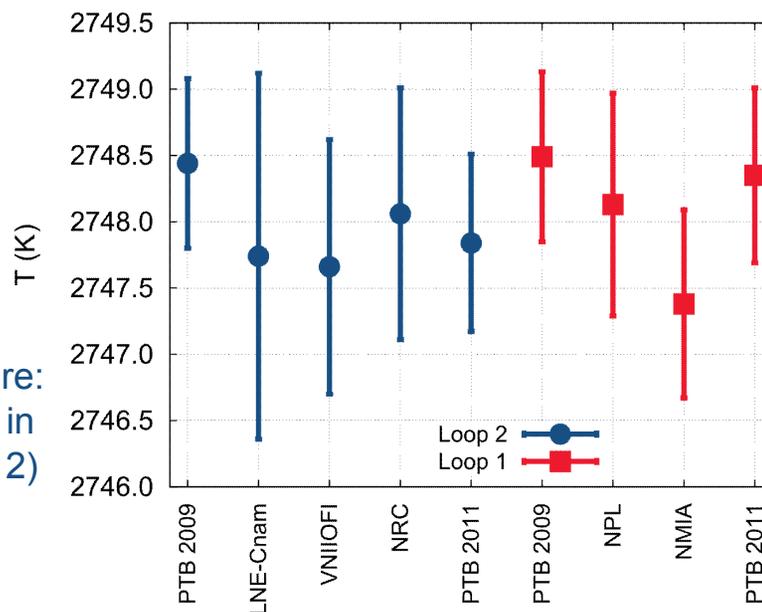
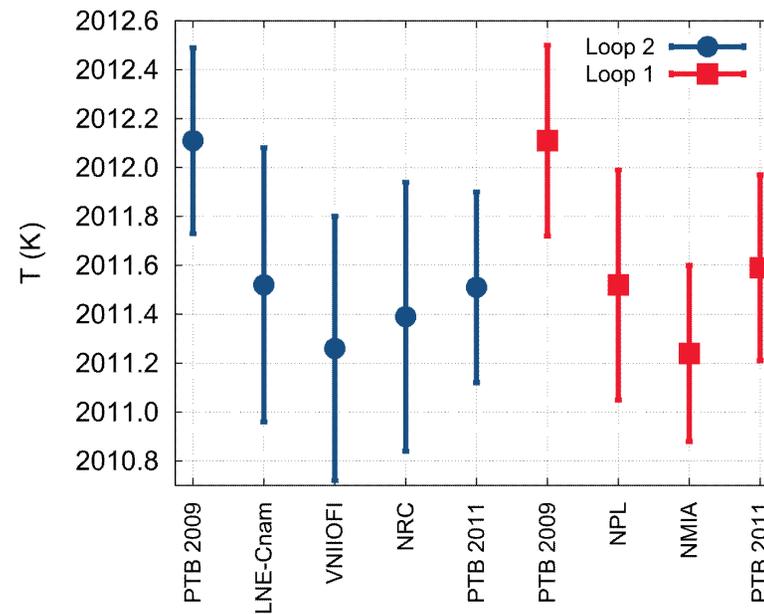
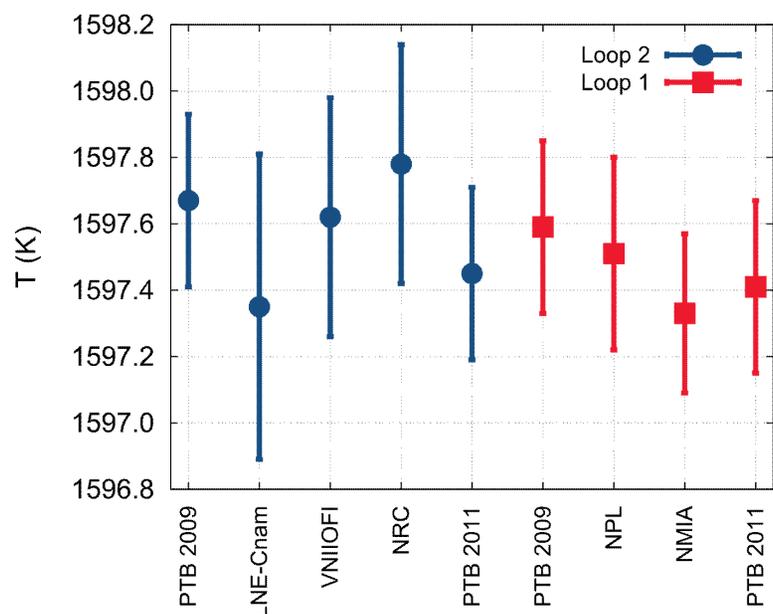
WP5: assignment of temperature

# 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

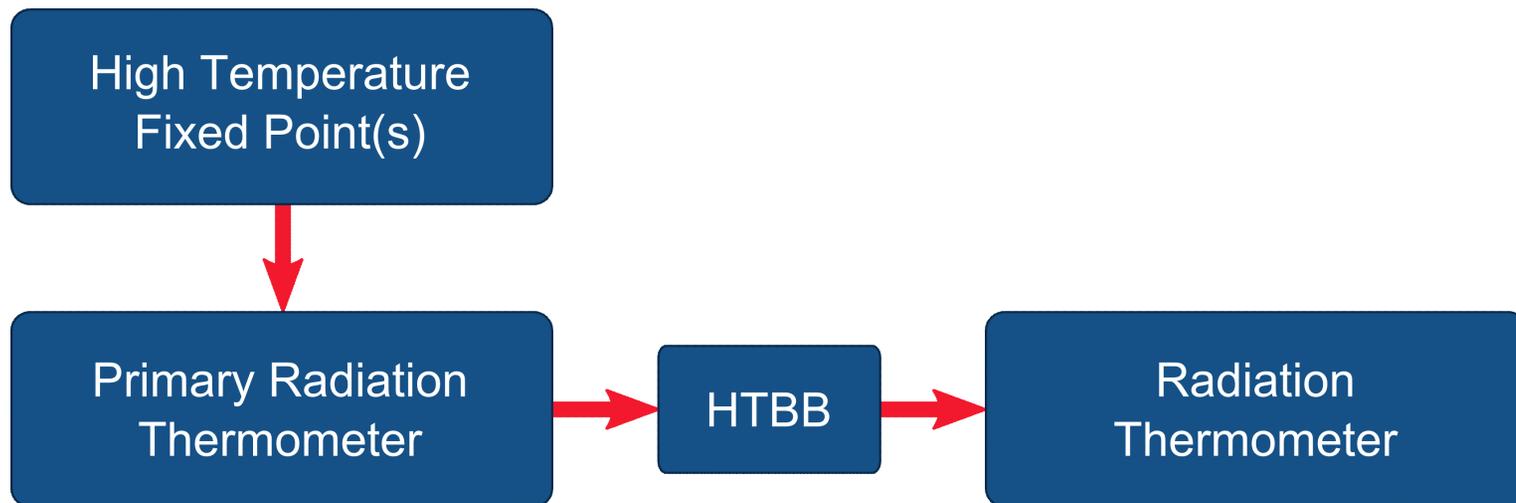


K. Anhalt *et al.* In: Temperature: Its measurement and control in science and technology, (2012) submitted

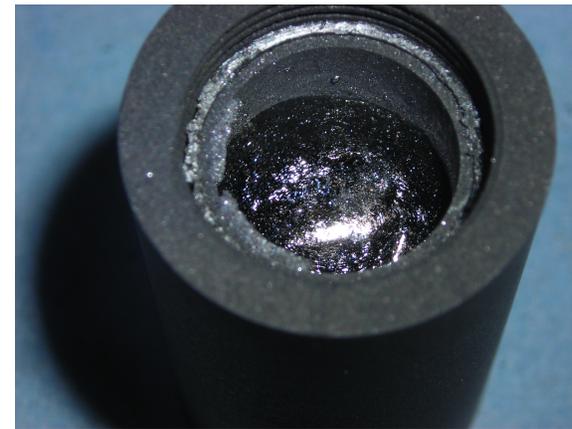
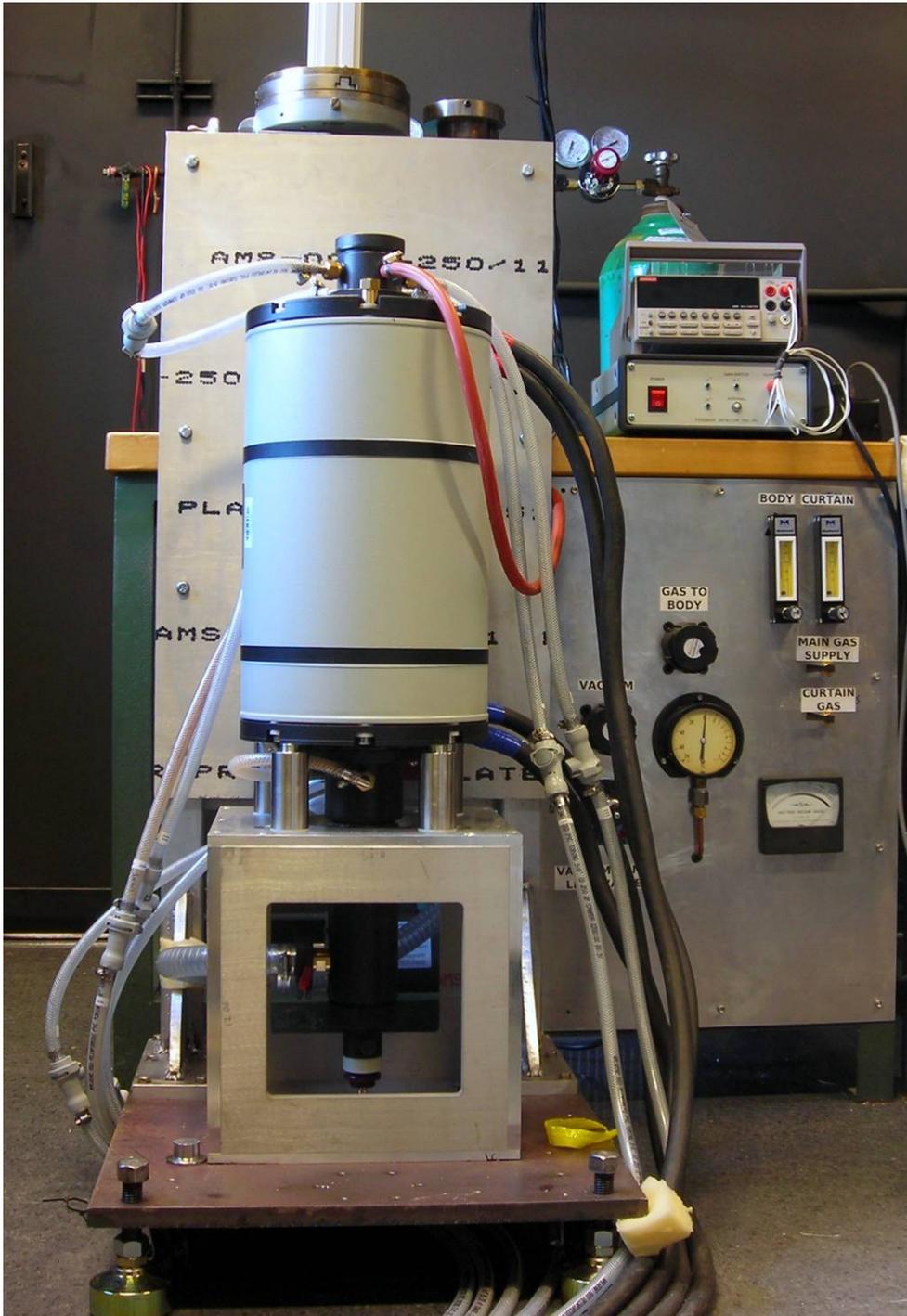
## Result (future)

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

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