Preliminary Measurement of the Temperature of a Blackbody using Filter Radiometers

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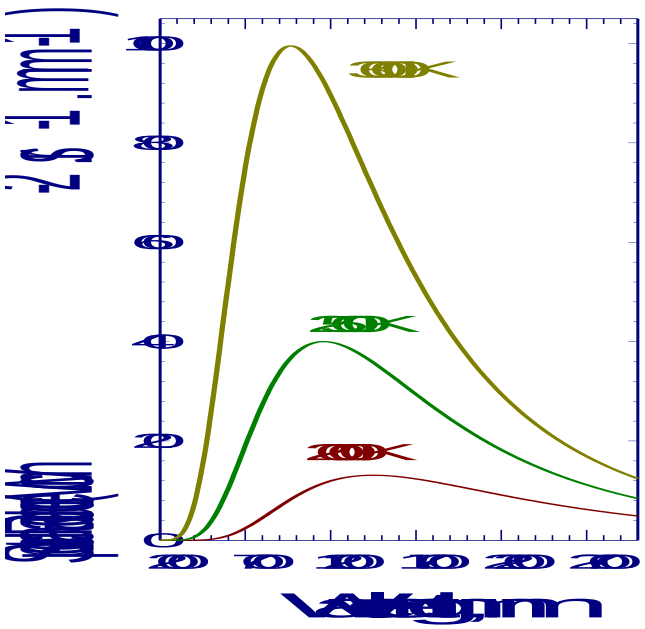
Charles Bamber, L.P. Boivin, A. Gaertner, F. Gauthier, R. Gerson, D.Woods
Institute for National Measurement Standards
National Research Council Canada

Lecture Topics

- Blackbodies as sources
- Filter radiometer design
- Aperture fabrication
- Filter radiometer performance
- Temperature measurements using filter radiometers
- Experimental setup
- Results
- Uncertainty budget
- Conclusion/ Future Work

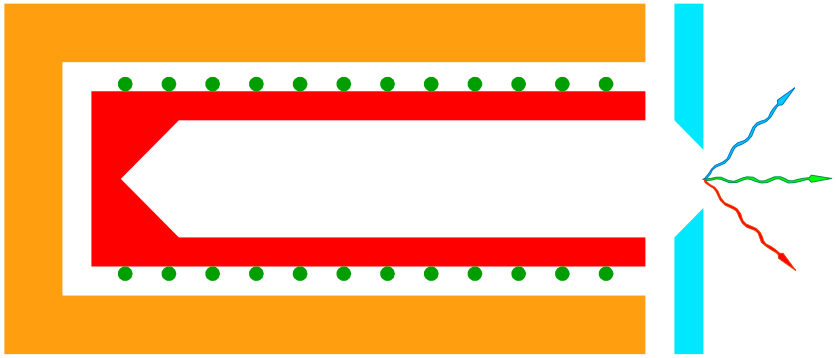
The spectral radiance from a black body is given by Planck's radiation equation

$$B_\lambda(T) = \frac{2hc^2}{\lambda^5\left[\exp\left(\frac{hc}{\lambda kT}\right)-1\right]}$$

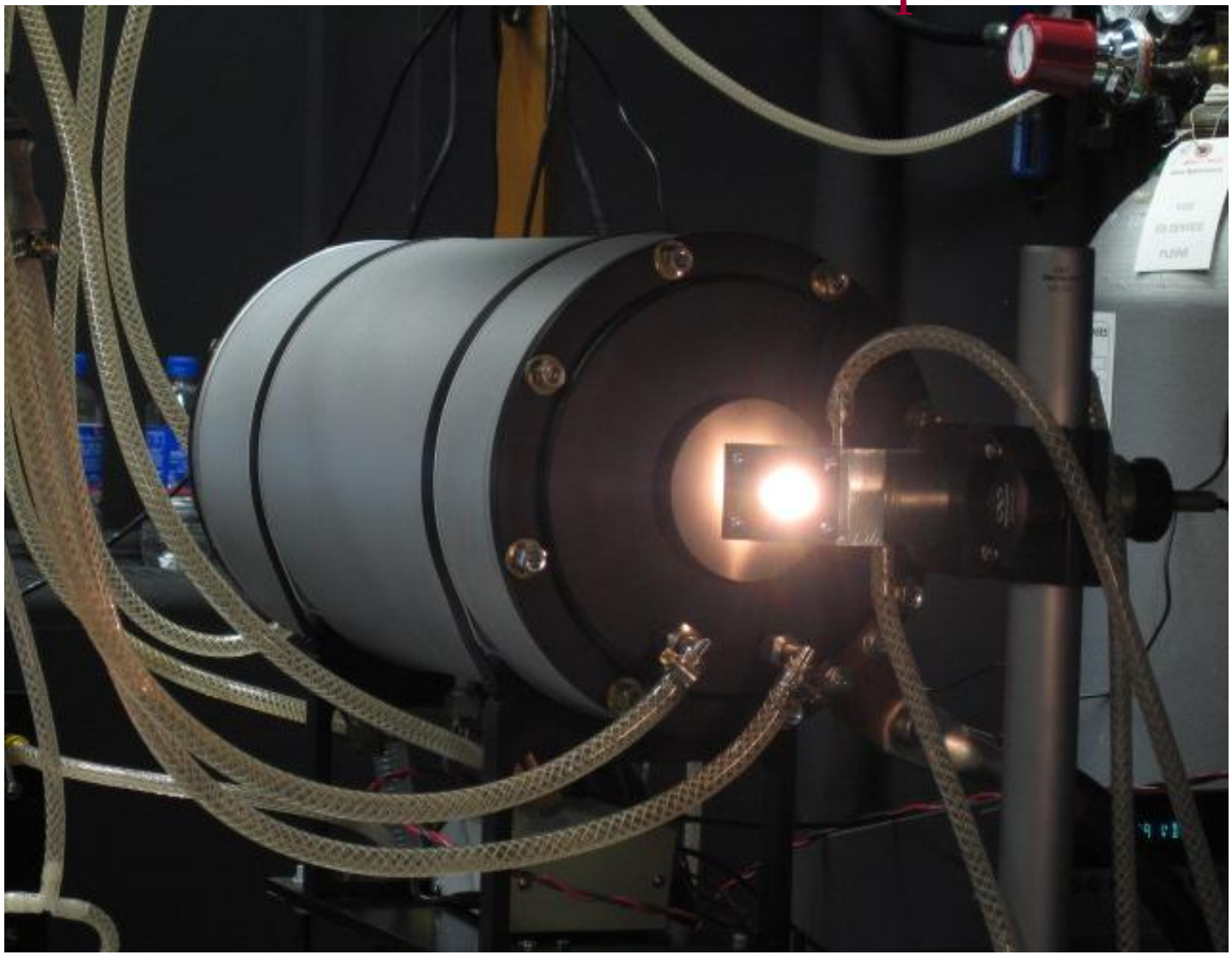


The spectral radiance is in units of W/cm^2/sr/μm

Radiance is a function of temperature T only.

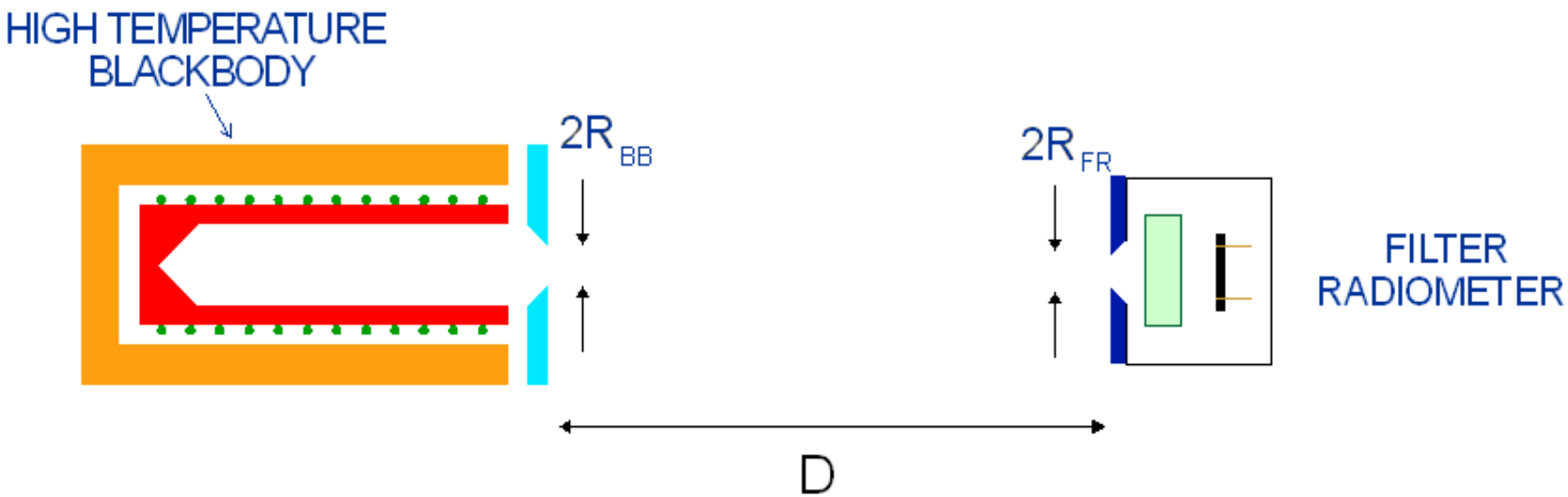


NRC has acquired a high-temperature blackbody and intends to use it to realize a new spectral irradiance scale



Vega
BB3500M

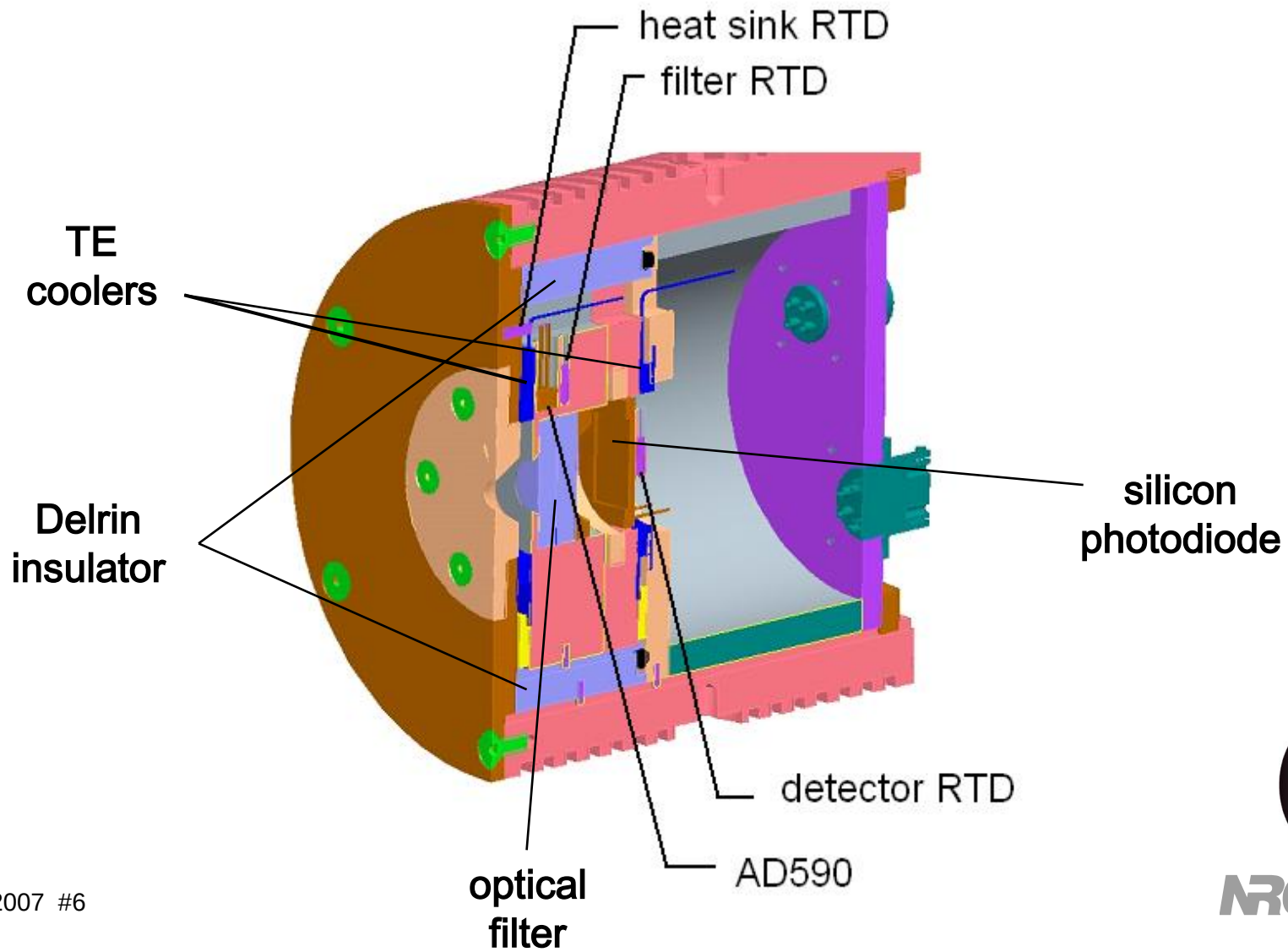
The temperature of the blackbody can be determined by measuring the response of a filter radiometer to the blackbody radiation



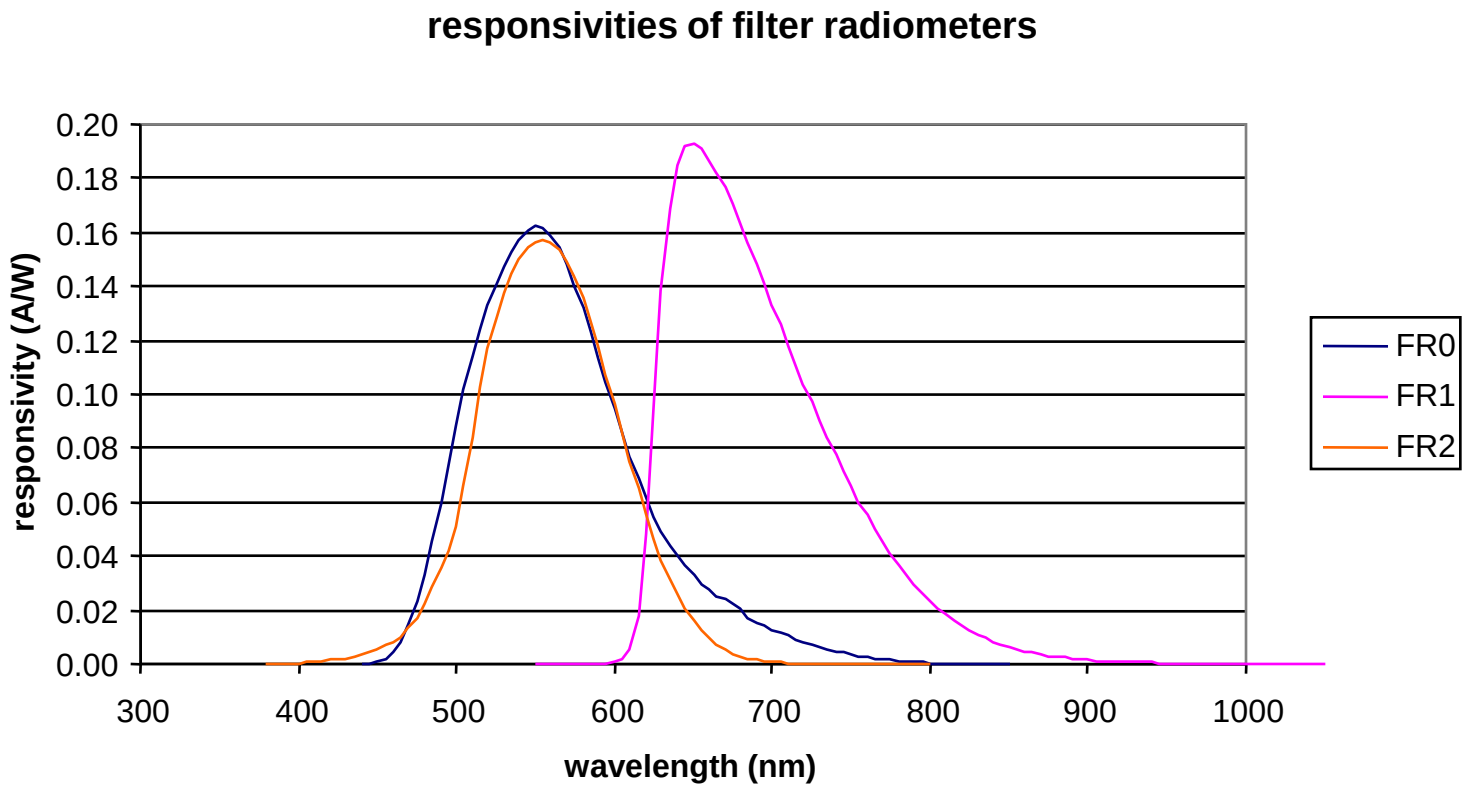
$$S_{total} = \frac{\pi^2 R_{BB}^2 R_{FR}^2}{D^2 + R_{BB}^2 + R_{FR}^2} \Delta\lambda \sum_{\lambda} \frac{2hc^2 S(\lambda)}{\lambda^5 \left(e^{\frac{hc}{\lambda k T}} - 1 \right)}$$

where S_{total} and $S(\lambda)$ are the total response and spectral responsivity of the filter radiometer

Design of the NRC filter radiometers : mechanical internal components temperature controlled to 0.1C

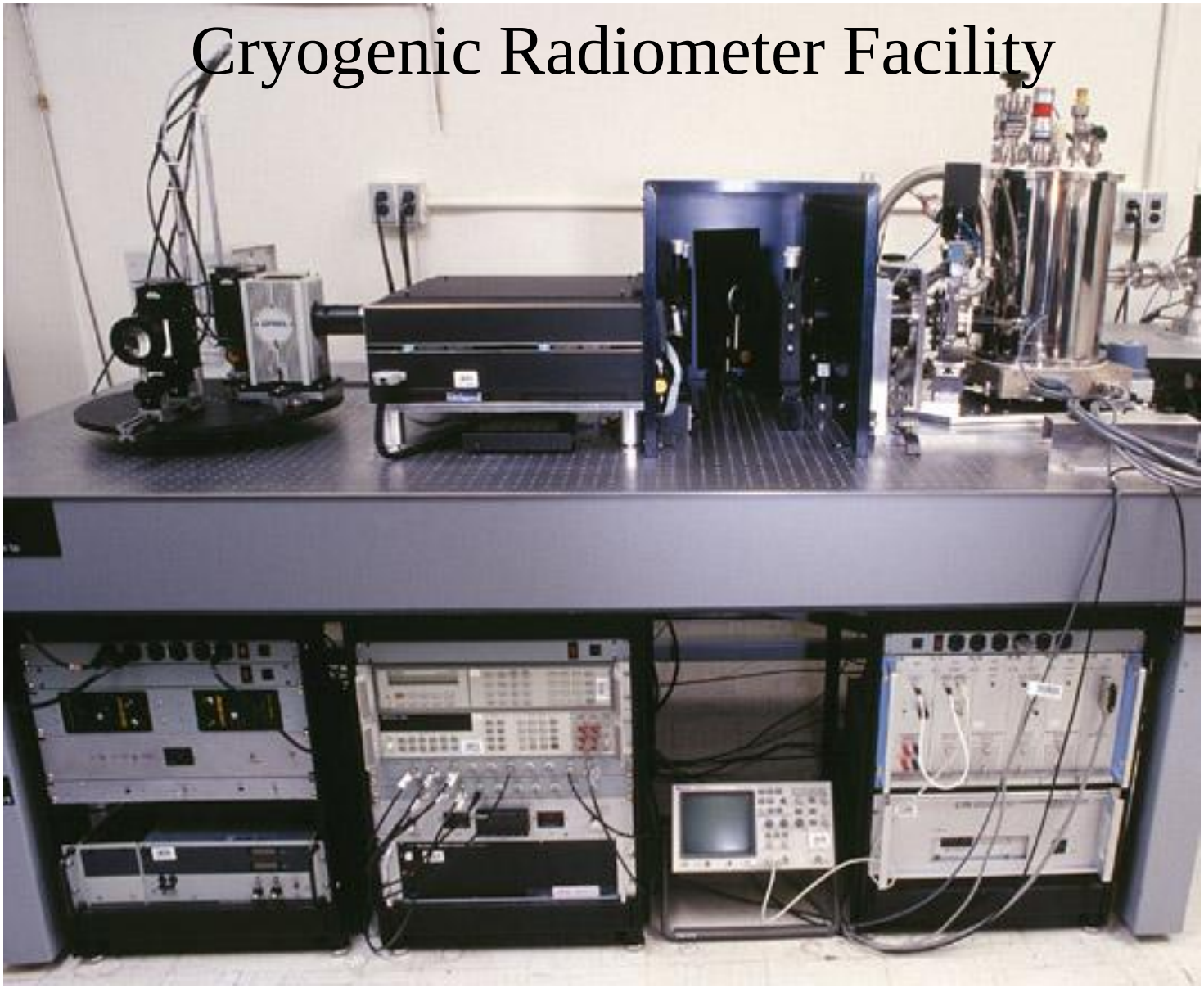


Design of the NRC filter radiometers : optical

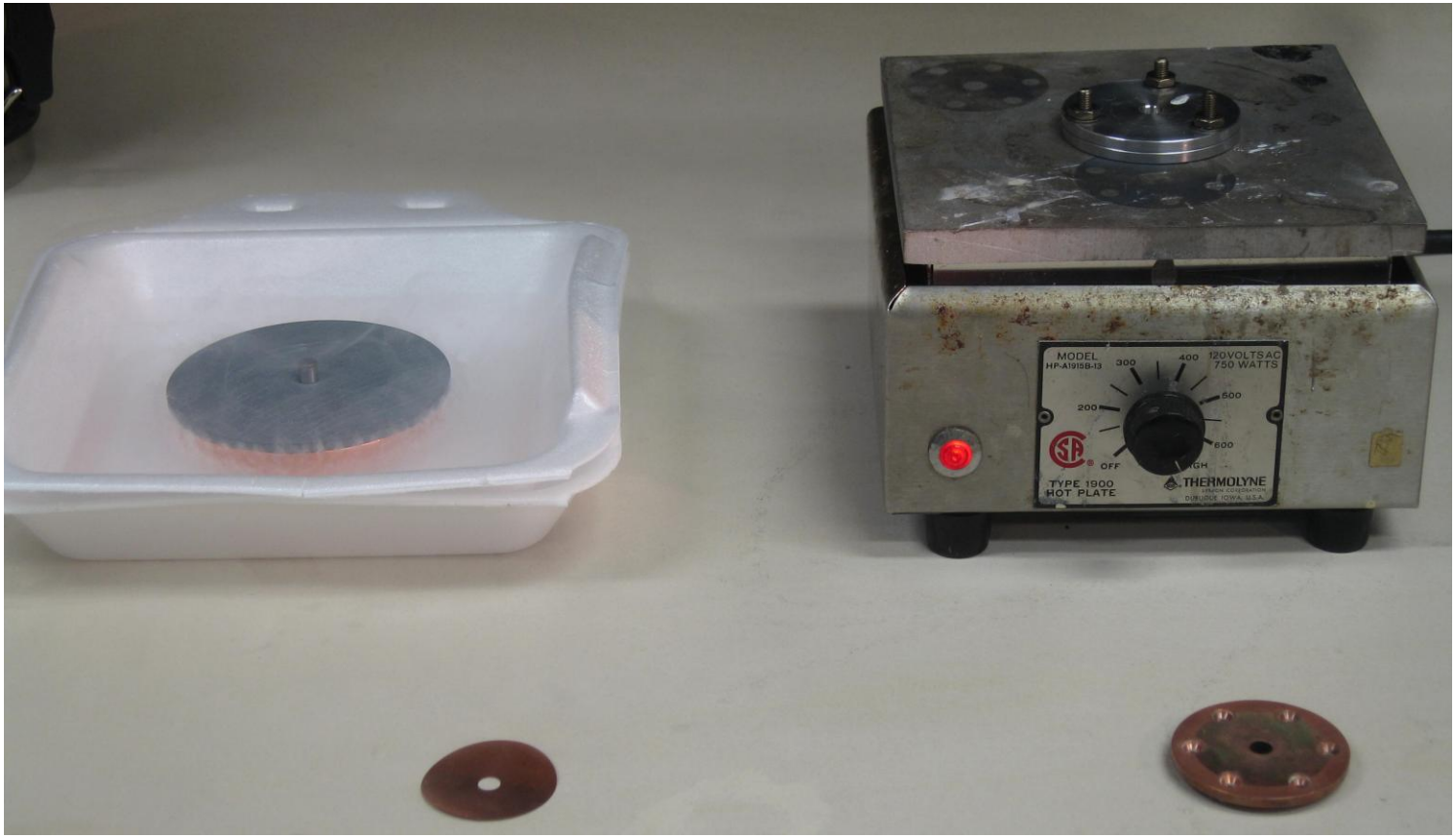


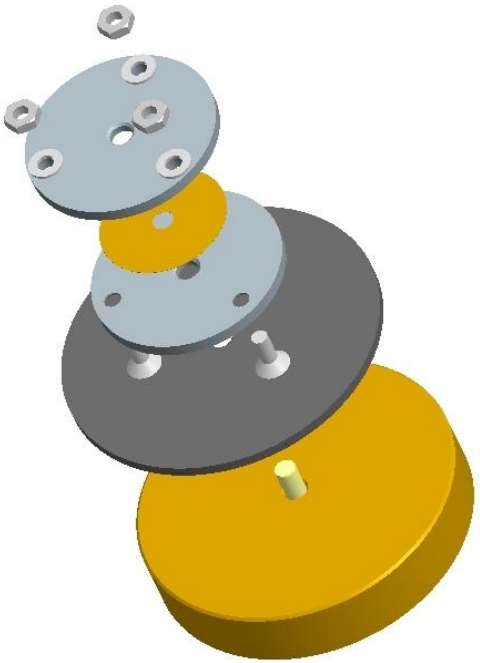
- the filter radiometers are calibrated using working standards & monochromator-based apparatus.
- the working standards are traceable to the cryogenic radiometer.

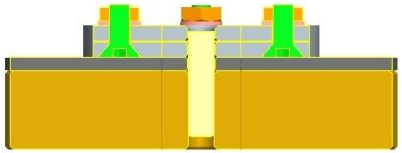
The filter radiometers are traceable to NRC's Cryogenic Radiometer Facility



The apertures were fabricated by cold forming







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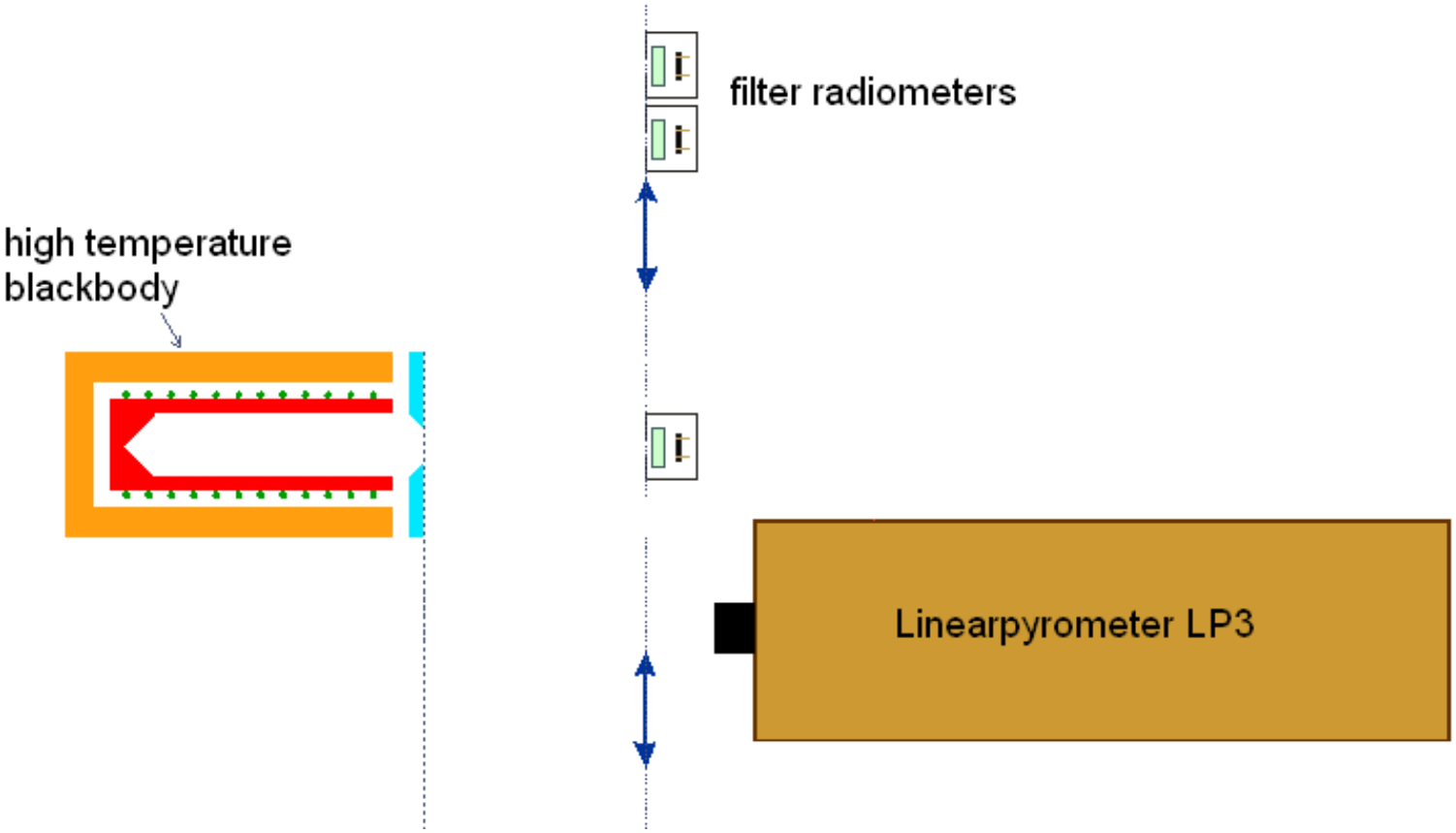
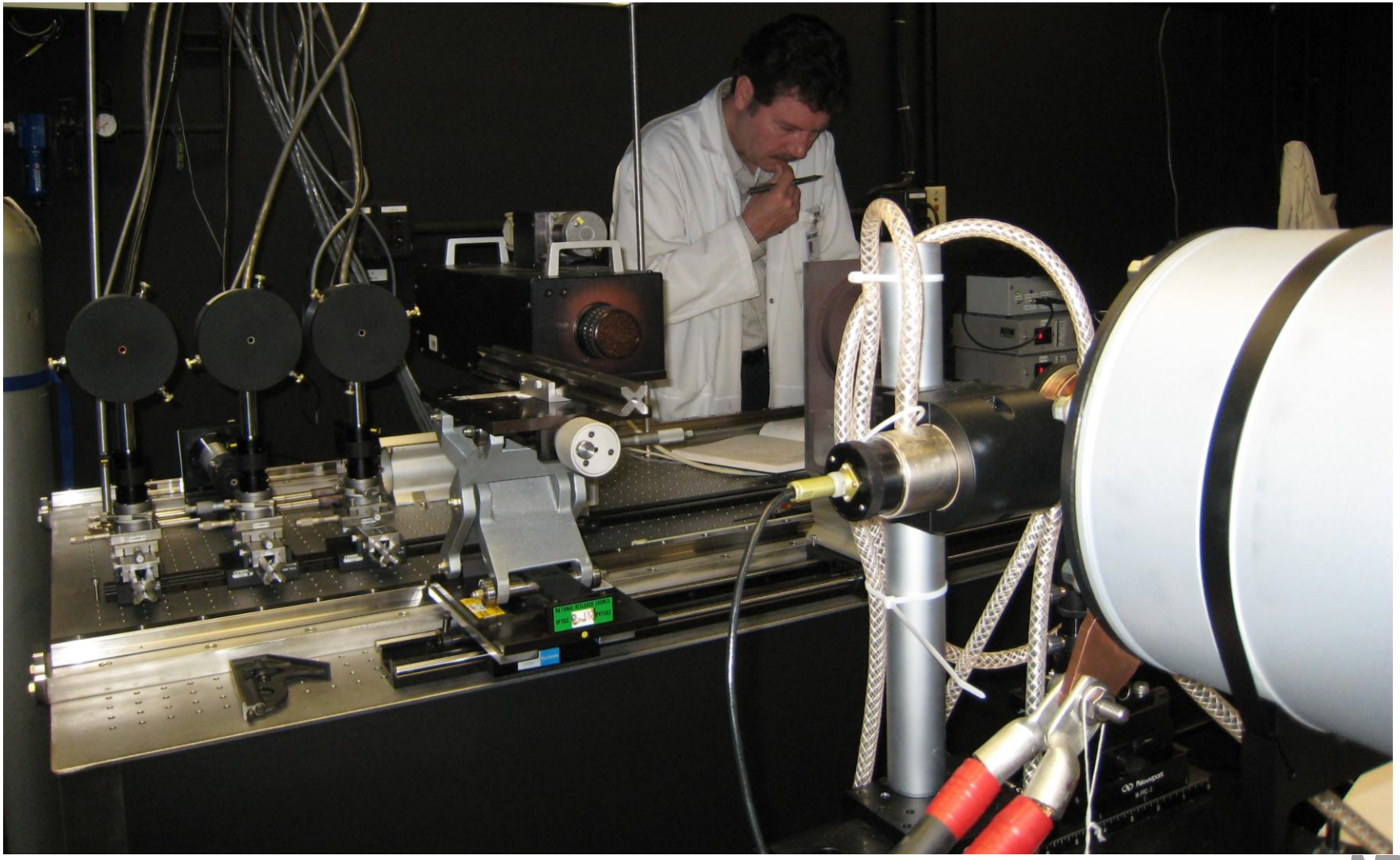
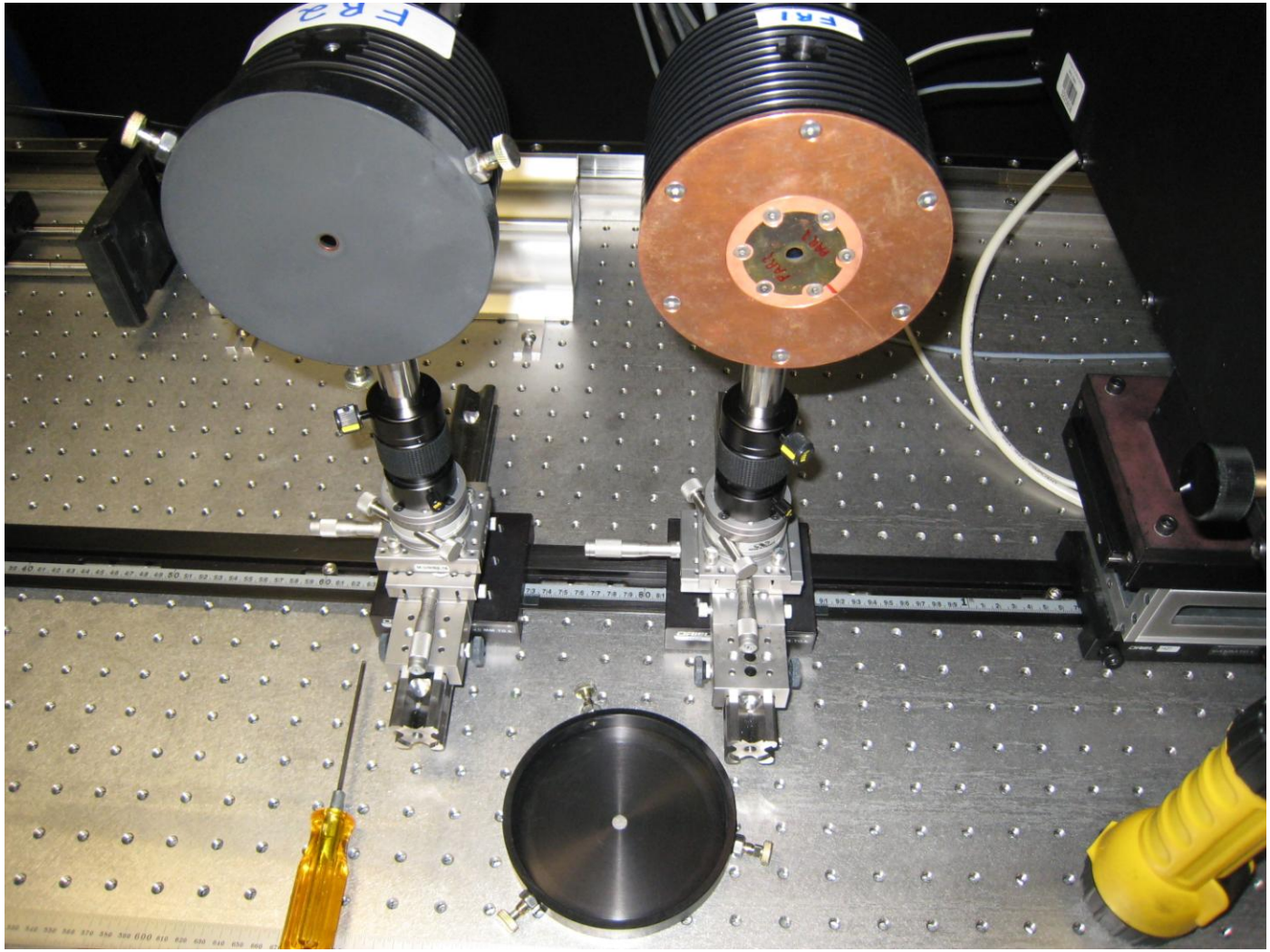
Experimental Setup: radiometers and pyrometer were pre-aligned on a rail



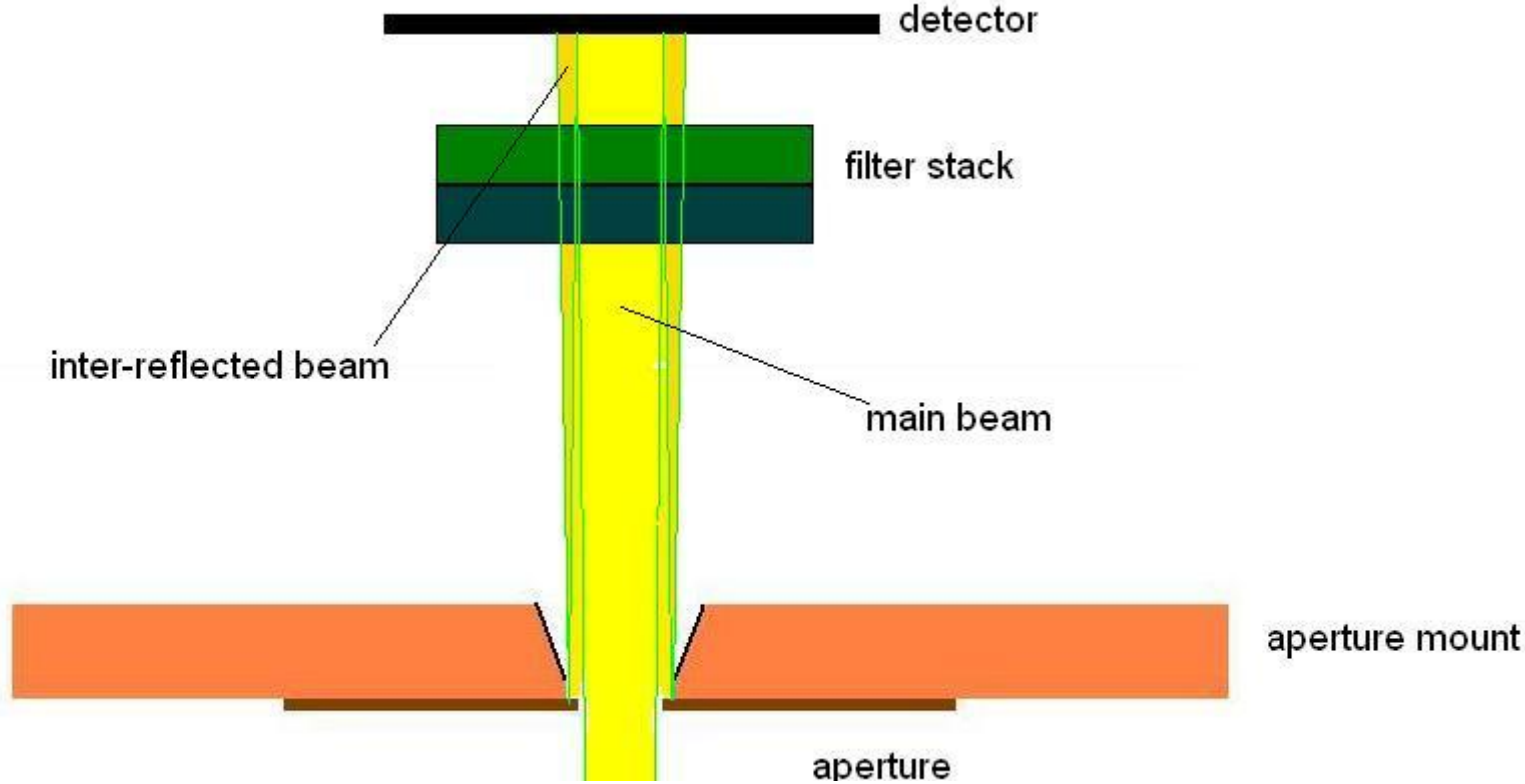
Filter radiometer measurements were compared to a KE Linearpyrometer LP3



Stray light can introduce errors greater than 1 C



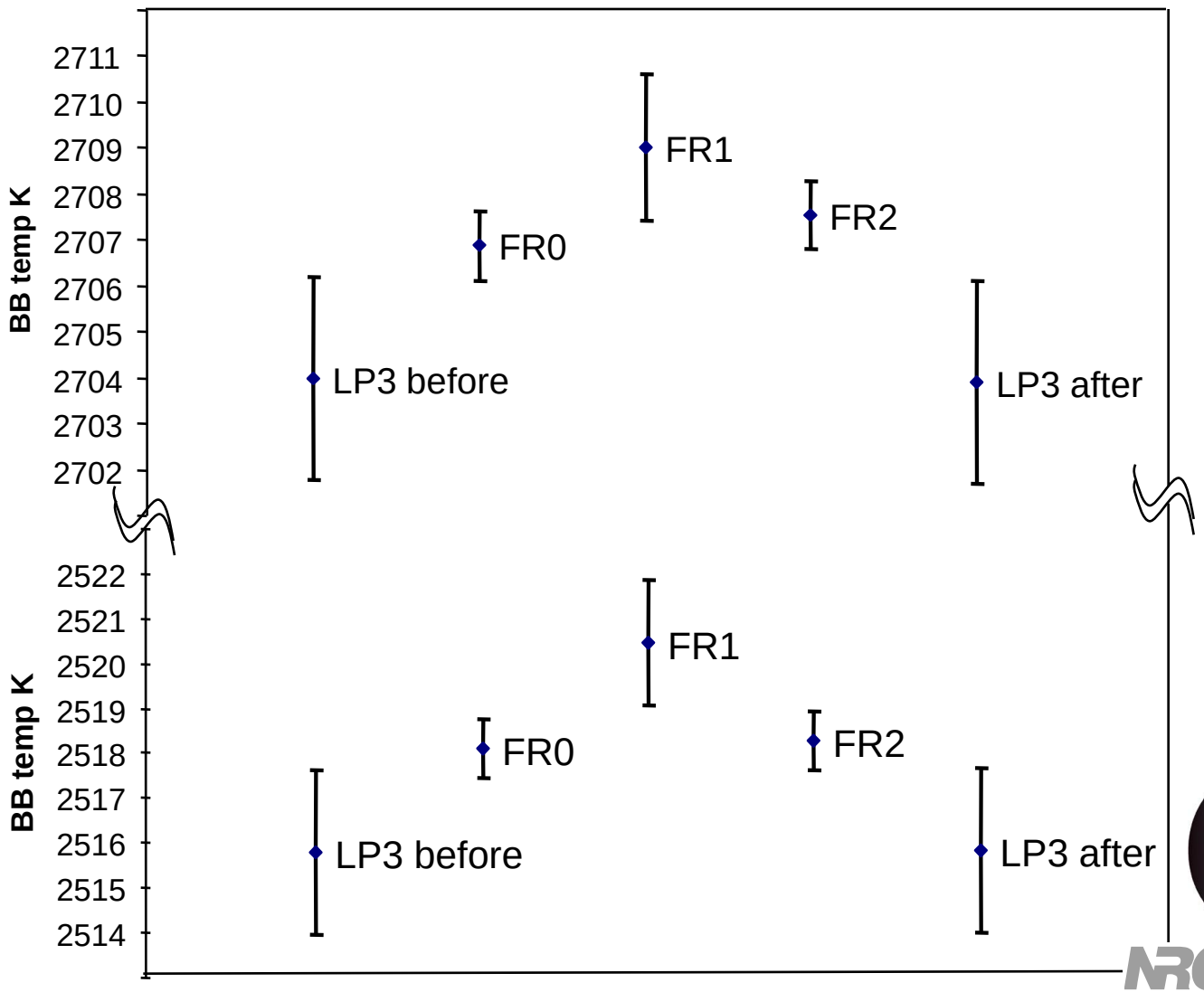
Inter-reflections within the radiometer give rise to a spuriously high signal



Uncertainty Budget for FR measurements of Blackbody k=2,T_{BB}=2700K

	relative uncertainty %	temperature uncertainty K)
Responsivity		
FR0	**0.43**	**1.3**
FR1	**0.88**	**3.1**
FR2	**0.42**	**1.3**
R_{BB}	**0.013**	**0.17**
R_{FR}	**0.016**	**0.22**
D	**0.001**	**0.01**
electrical	**0.040**	**0.14**
repeatability	**0.177**	**0.63**
overall		
FR0		**1.48**
FR1		**3.17**
FR2		**1.48**

Blackbody temperature measurements with uncertainties (k=1)



Conclusion

- agreement between NRC filter radiometers and pyrometer is reasonable

Future Work

- stray light suppression to be further studied and engineered
- improvement in aperture fabrication and measurement is planned
- 3 more filter radiometers are under construction
- future responsivity measurements of filter radiometers will reduce uncertainty
- engineered integration of filter radiometers into blackbody facility