Development of transfer and working standard radiometers

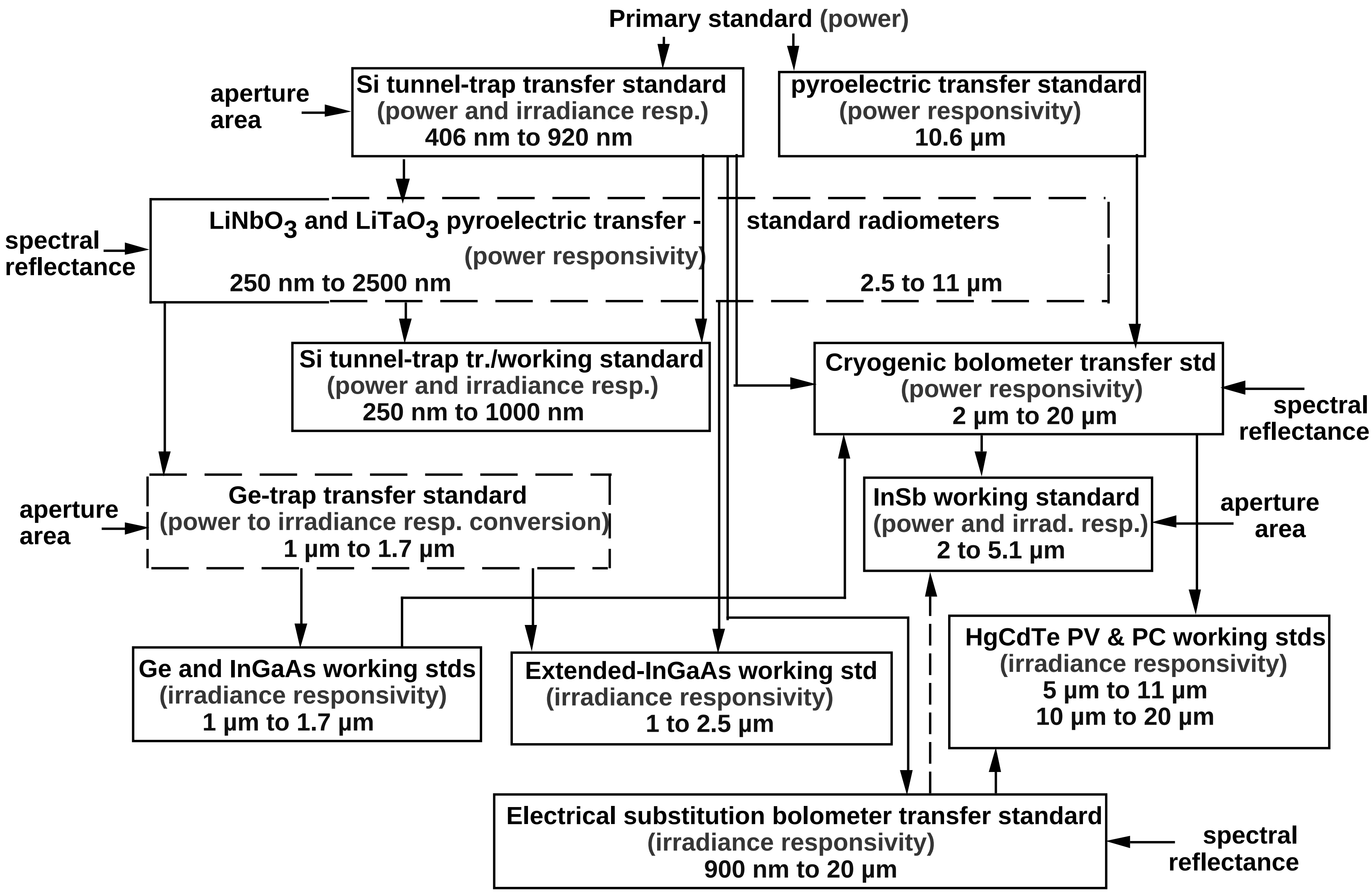
George P Eppeldauer

NIST
National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce

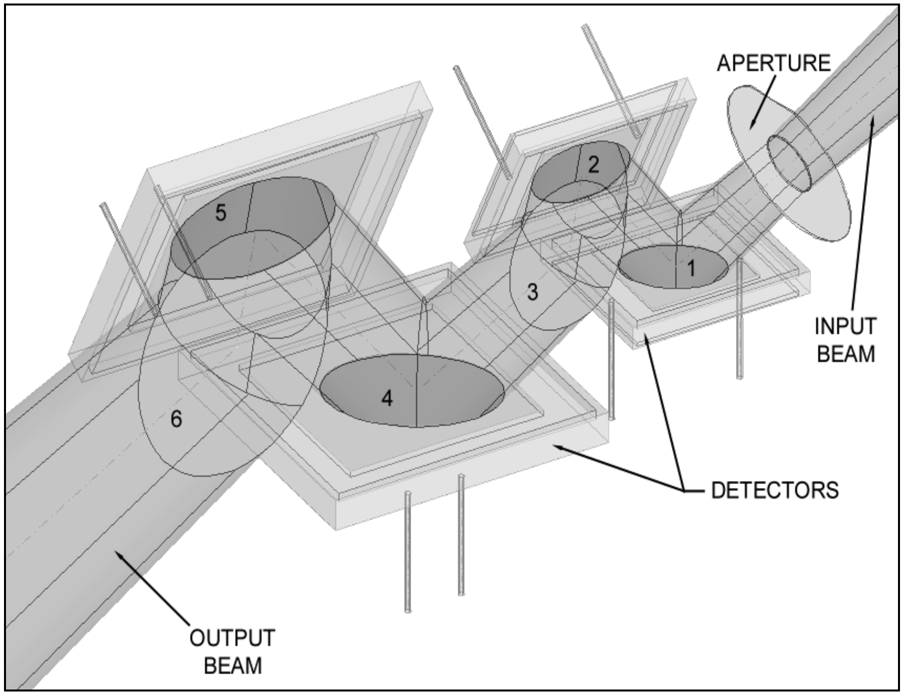
New generation transfer and working standard radiometers are developed to realize, maintain, and propagate high accuracy detector based scales

- **Scheme of the transfer and working standard radiometers for the detector-based power and irradiance responsivity scale realizations**
- **Radiometers to extend the spectral power responsivity measurements up to 20 µm (on the Ambient IR SCF)**
- **Accuracy improvement of responsivity scales on the SIRCUS**
- **Extension of spectral power responsivity to spectral irradiance responsivity**
- **Extension of spectral irradiance responsivity to spectral radiance responsivity**
- **12 detector-based NIST scales developed from 1991**

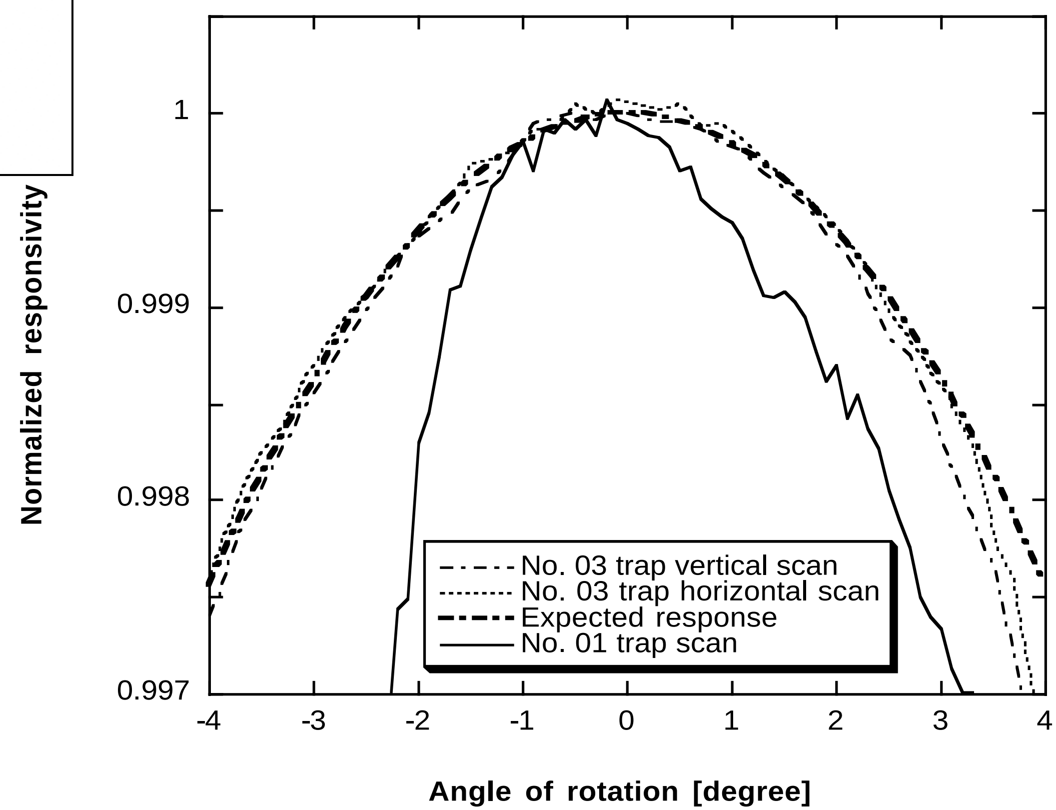
Power and irradiance responsivity scale maintenance with transfer and working standard radiometers

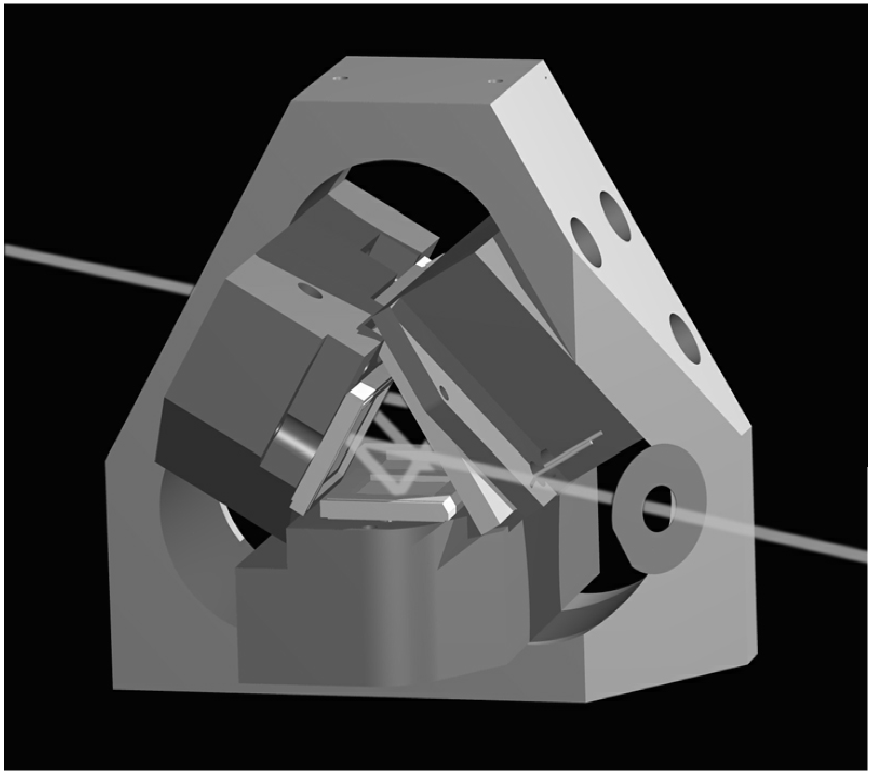


The highest level power/irradiance measuring transfer standard radiometer



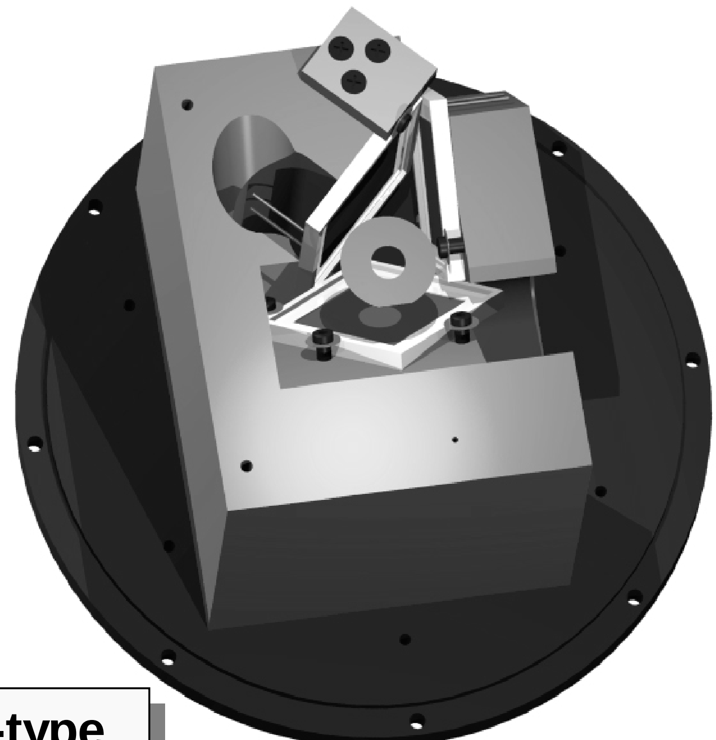
A tunnel-trap detector built with Si photodiodes of two different sizes





New generation power and irradiance measuring Si trap detectors

Si triangular Tunnel-trap detector

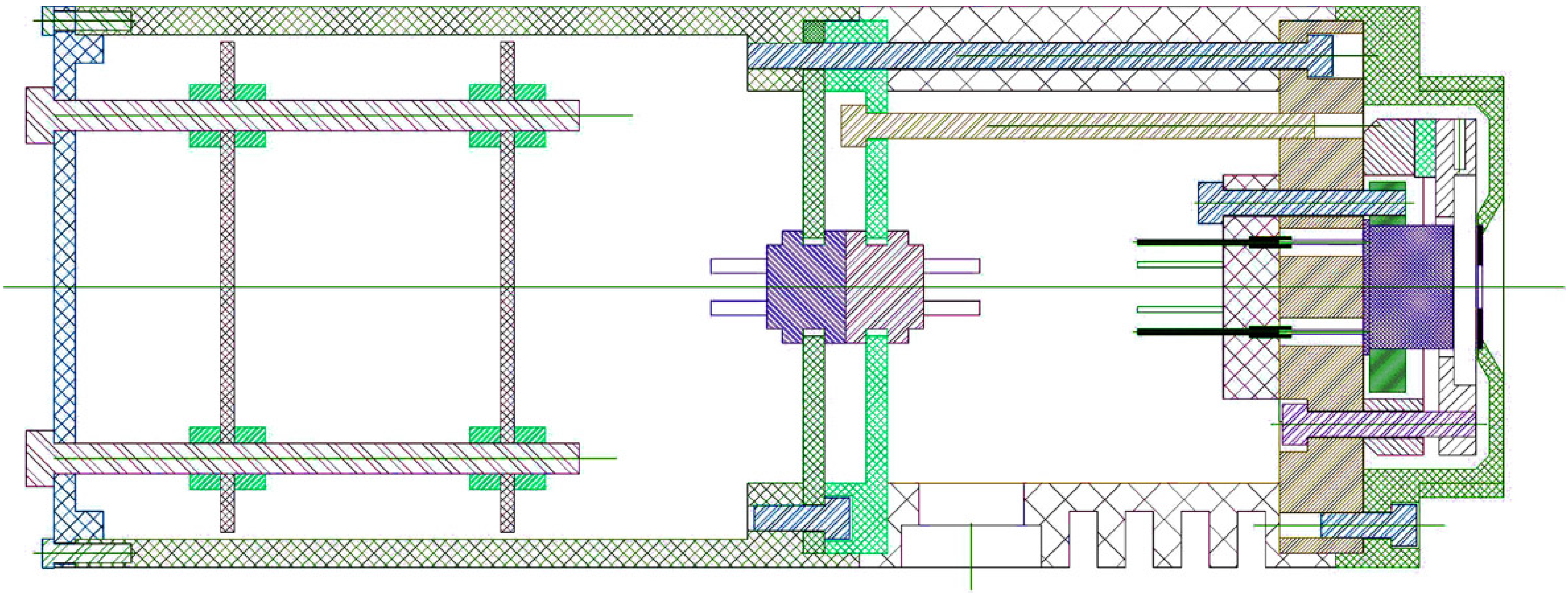


Reflectance-type Si trap detector

NEW GENERATION MODULAR RADIOMETER

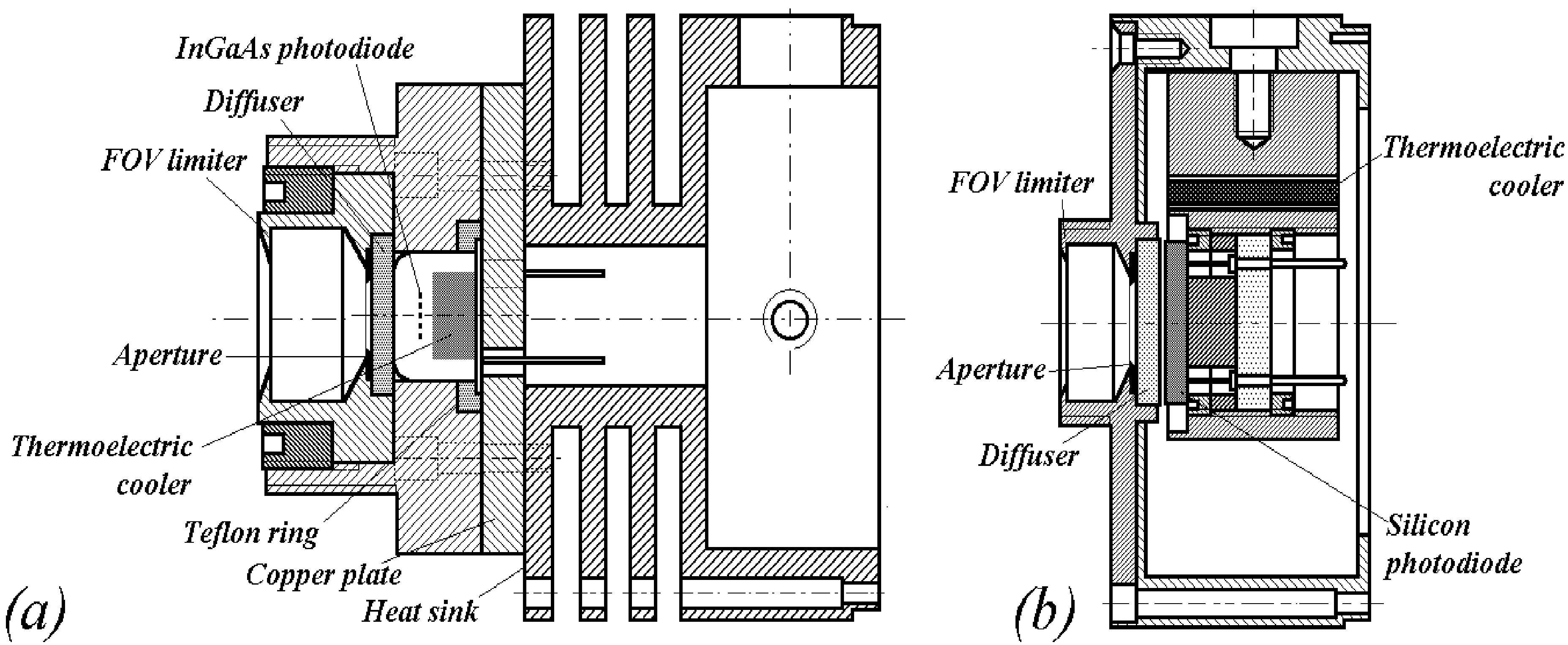
Radiometer with two temperature controlled components

(one is the photodiode and another one is the filter holder at the front)

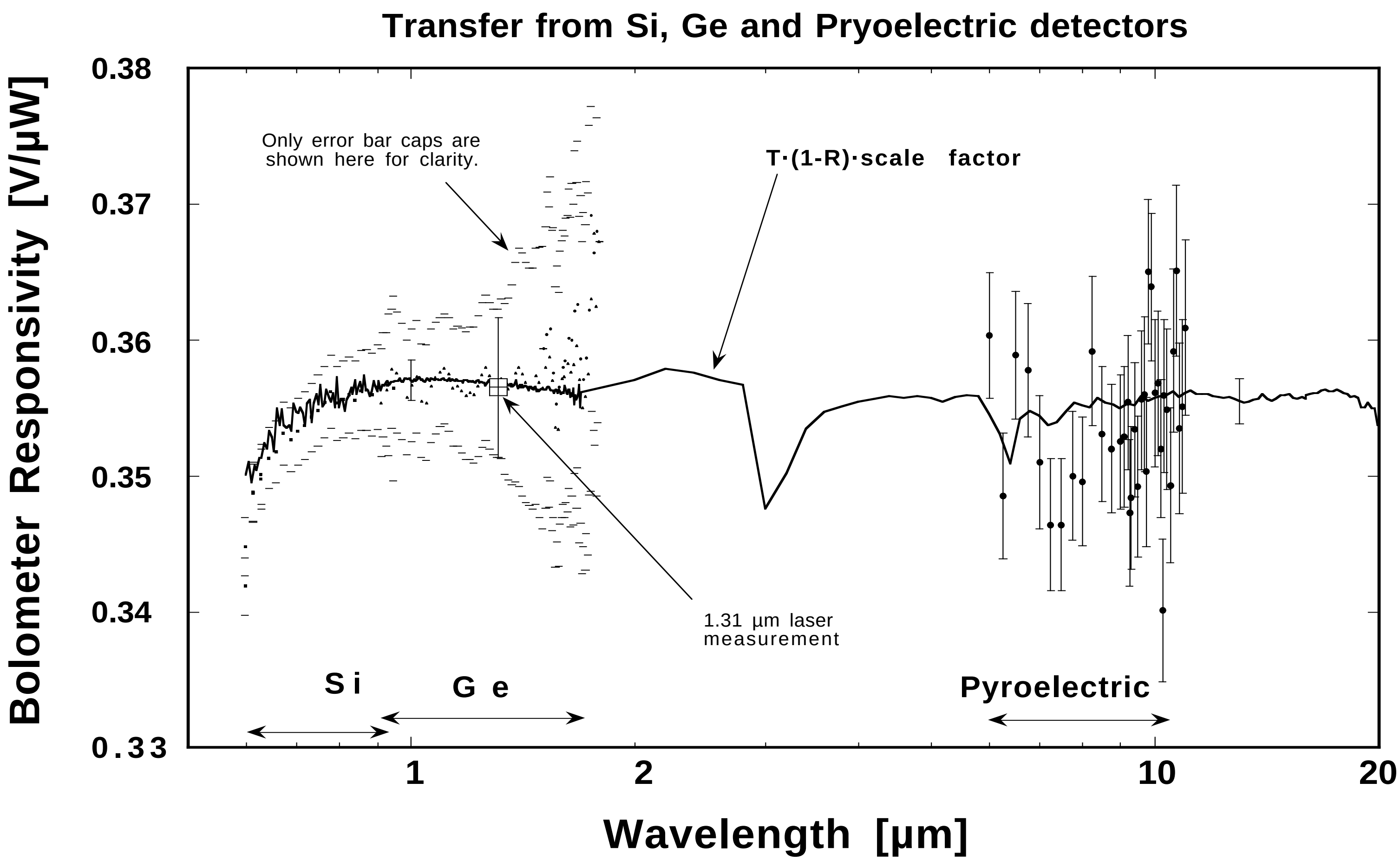


Near-IR irradiance measuring working standard radiometers

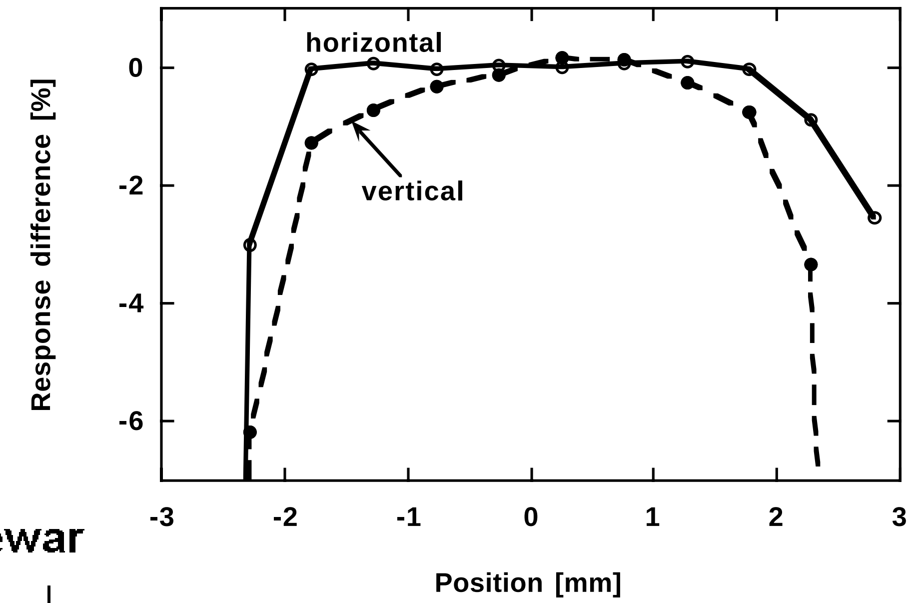
InGaAs (*a*) and Si (*b*) power/irradiance meters

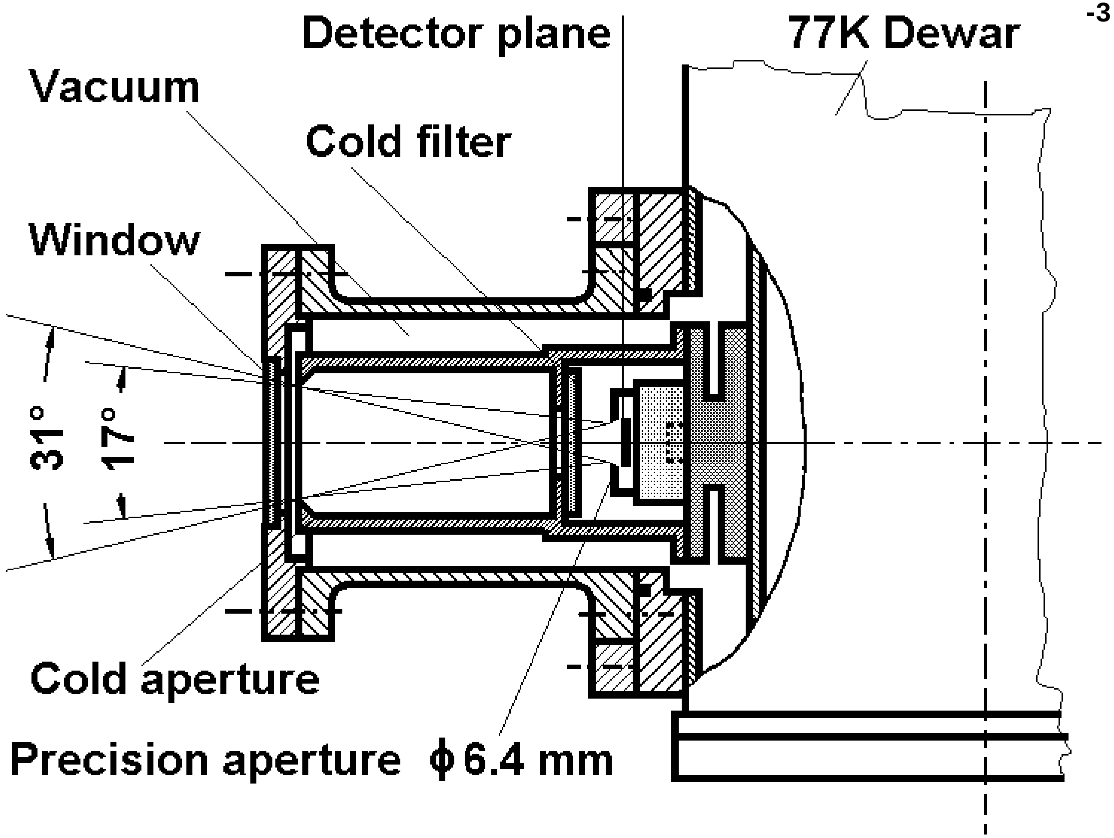


Spectral radiant power responsivity scale realization on a cryogenic bolometer from 2 µm to 20 µm

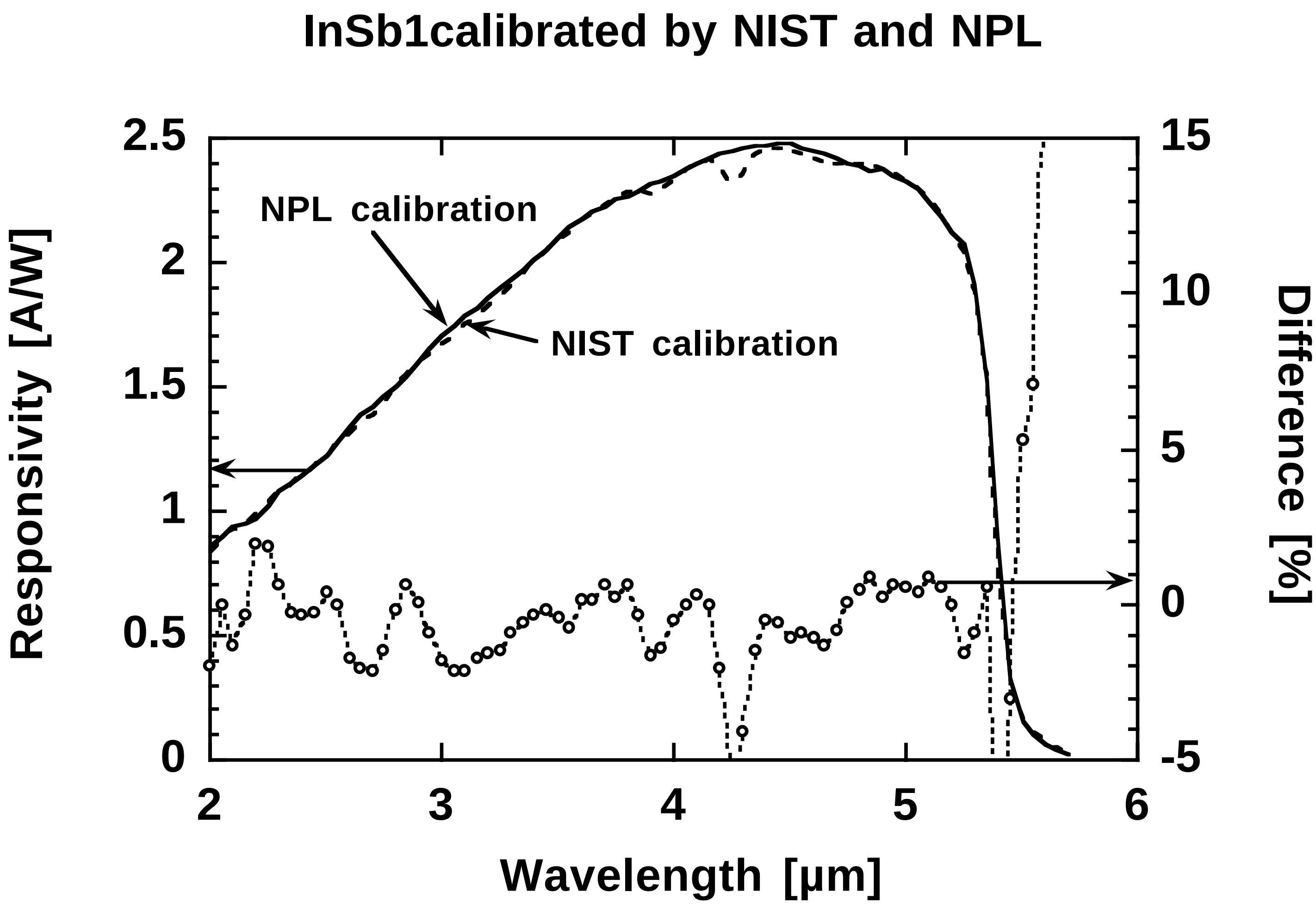


InSb working standard for 2 µm to 5.2 µm





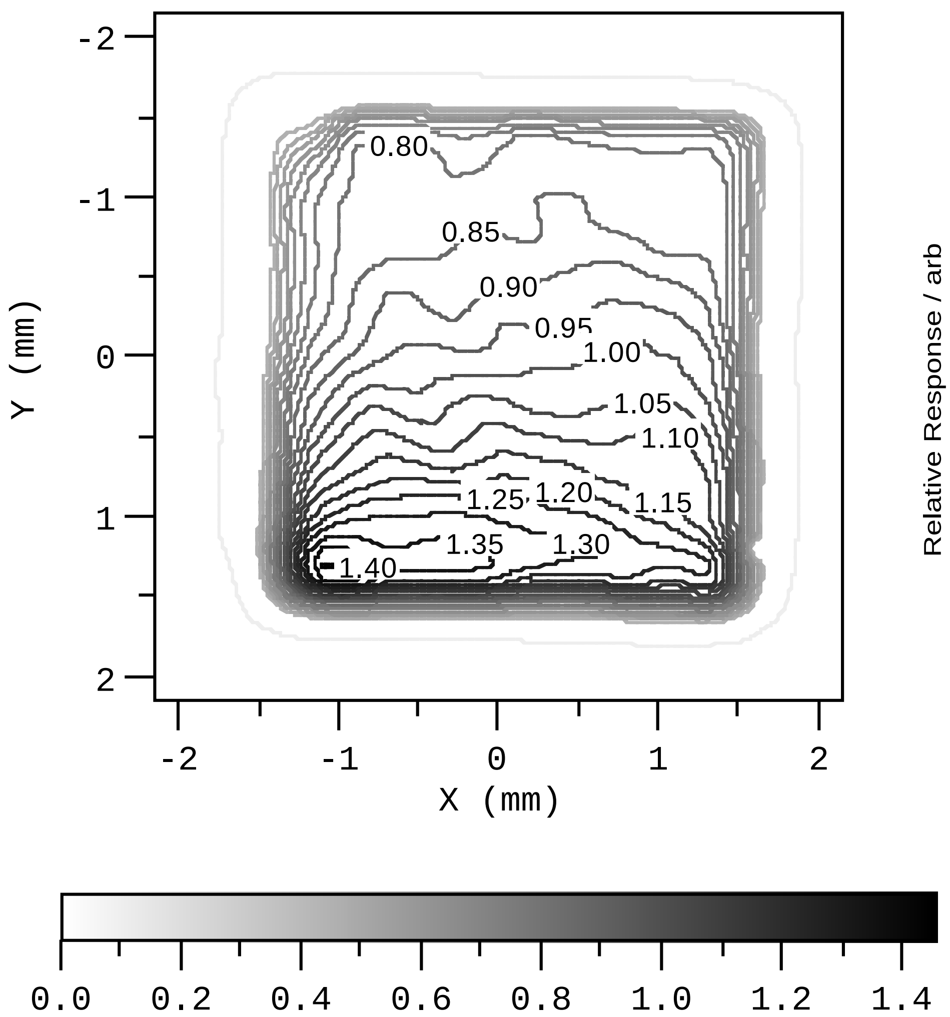
Comparison of the NIST and NPL (UK) IR spectral responsivity scales:

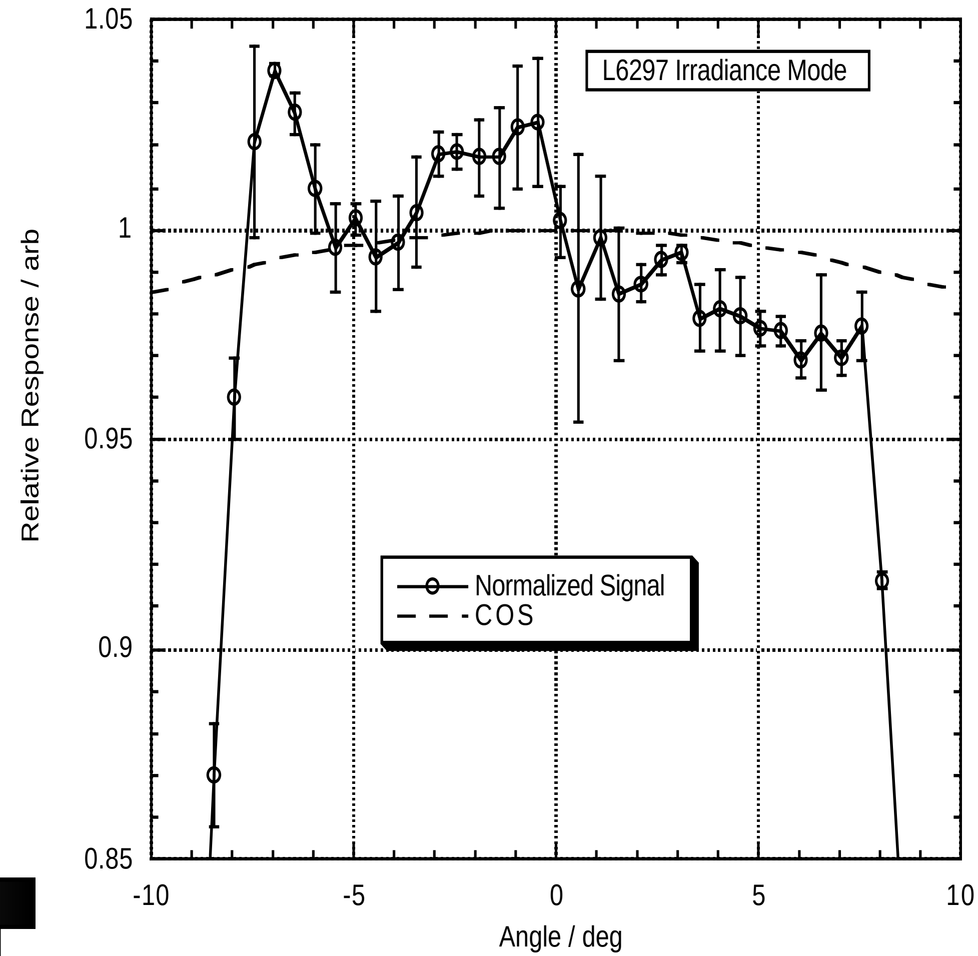


LWIR (HgCdTe) irradiance measuring working standard

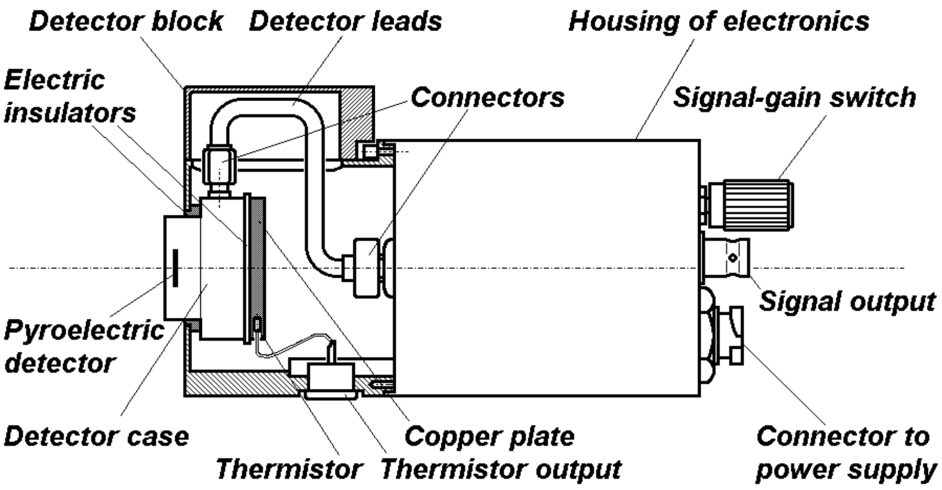
50 % spatial response non-uniformity in power measurement mode ;

2 % cosine response (dominant) error (within 12° FOV) in irradiance mode at 10.6 µm

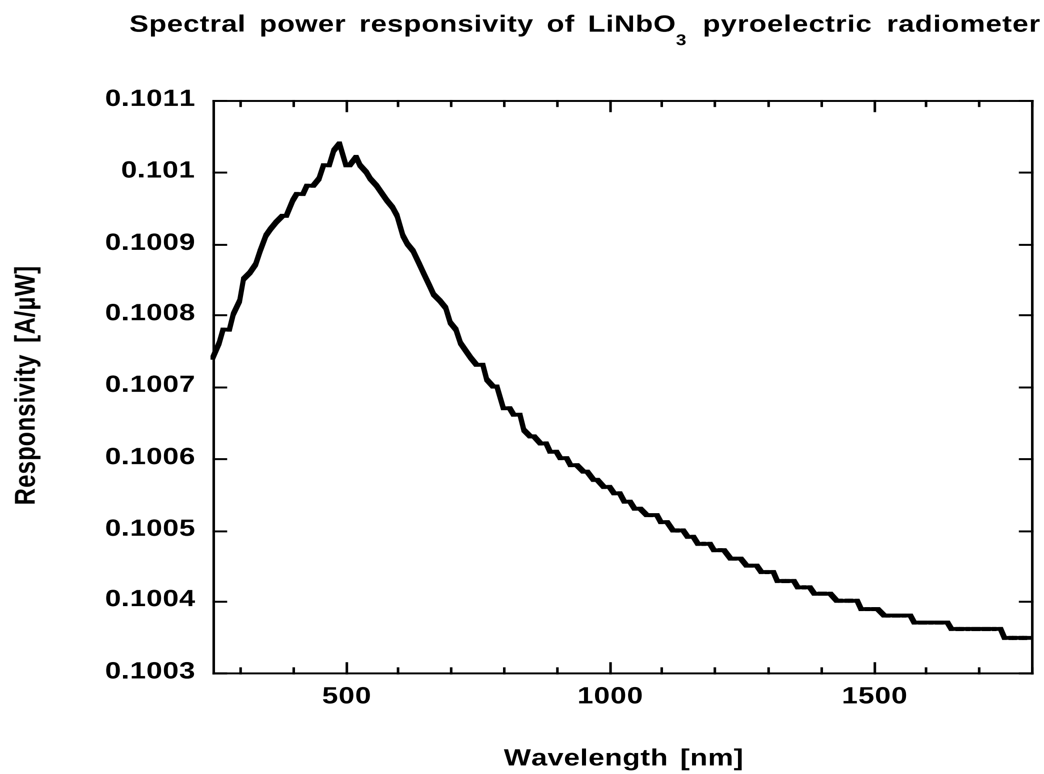




Power responsivity scale extension
with the $LiNbO_3$ pyroelectric radiometer



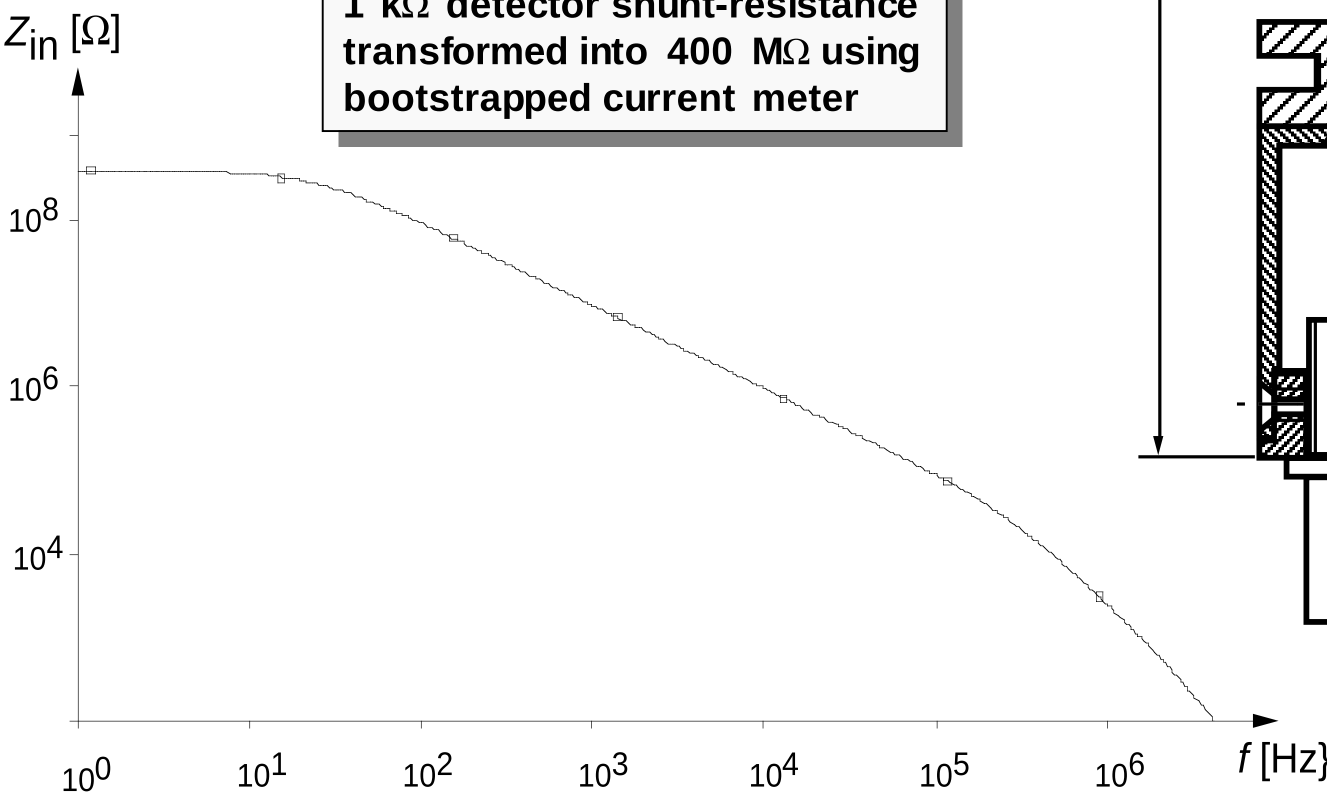
Less than 0.1 % uncertainty between 250 and 1600 nm

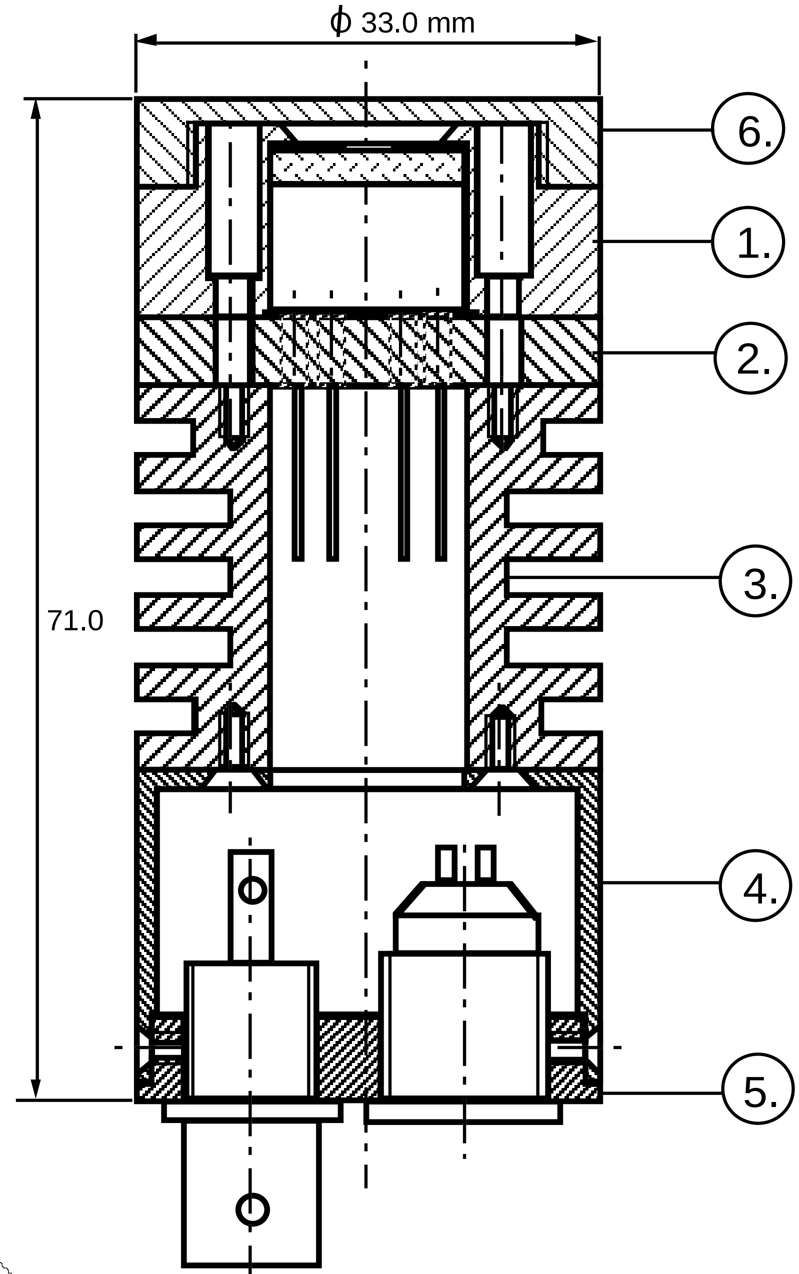


Extended InGaAs working standard irradiance meter for 1 µm to 2.5 µm

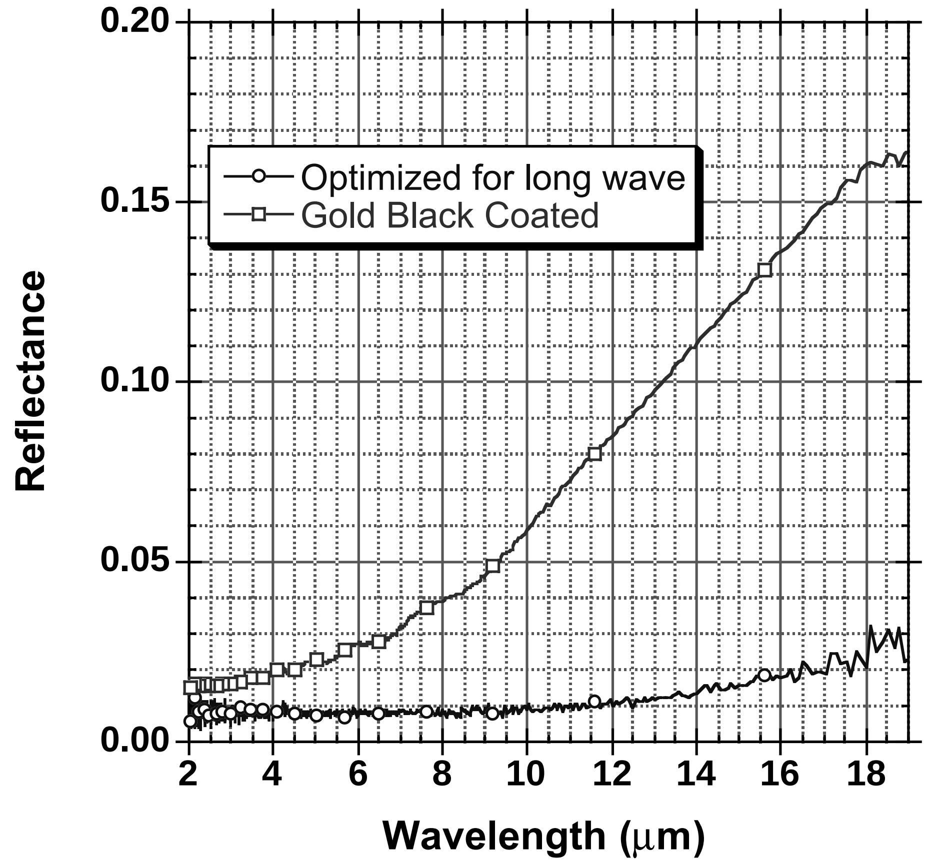
$$Z_{\mathrm{in}}(s)=(A(s)+1)Z_{\mathrm{d}}$$

1 kΩ detector shunt-resistance transformed into 400 MΩ using bootstrapped current meter



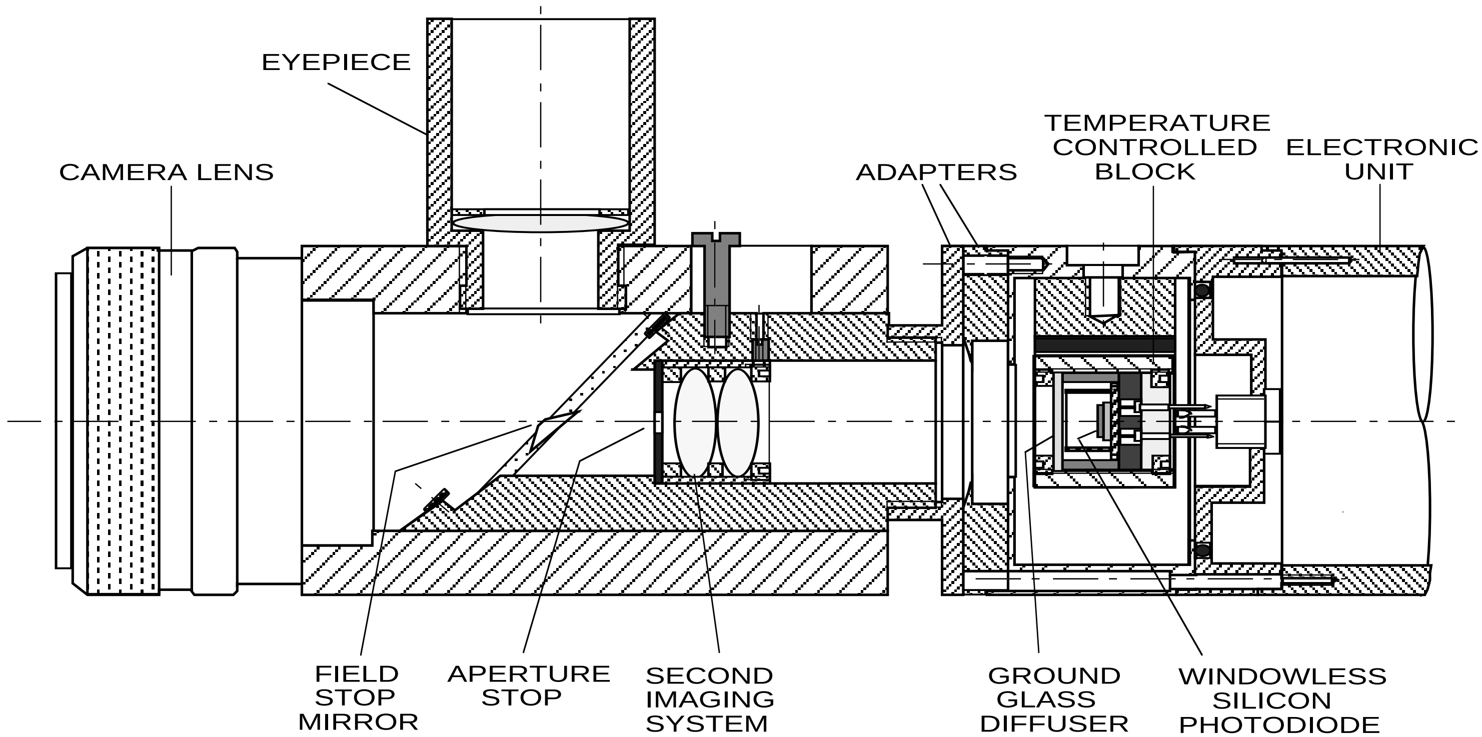


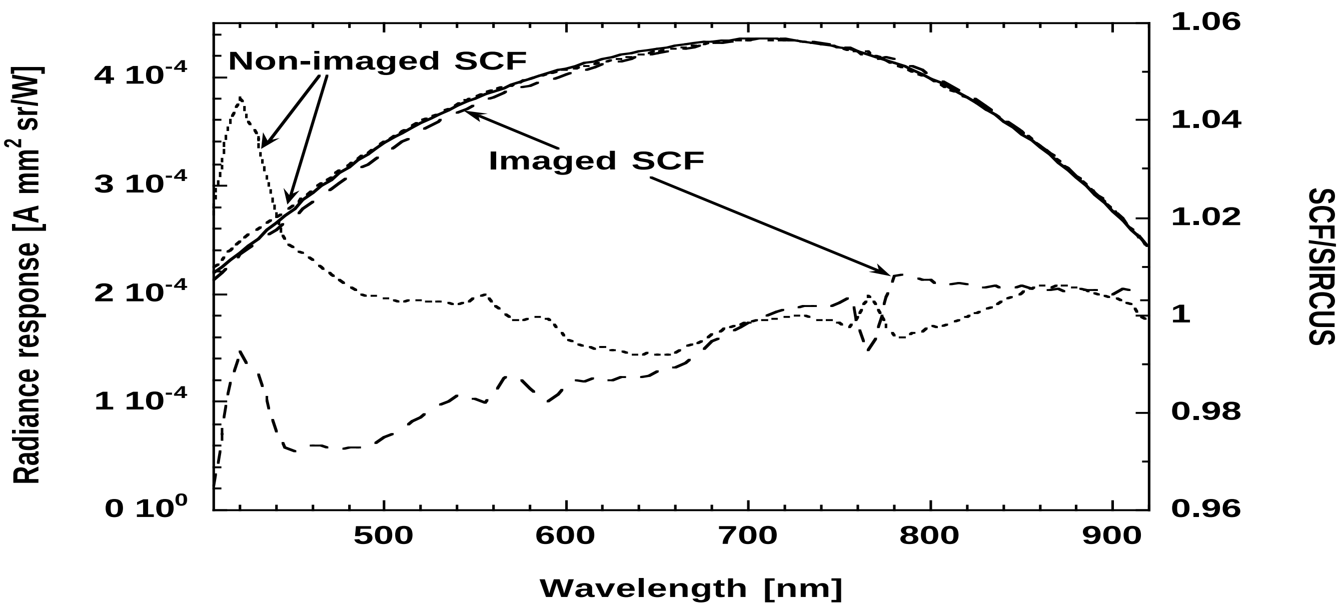
$LiTaO_3$ pyroelectric transfer standard radiometer for the IR



Si radiance meter working standard
that holds the spectral radiance responsivity scale

Design and radiance responsivity of the Si radiance-meter standard





Five-channel filtered trap-detector

Temperature-controlled filter combinations in front of trap

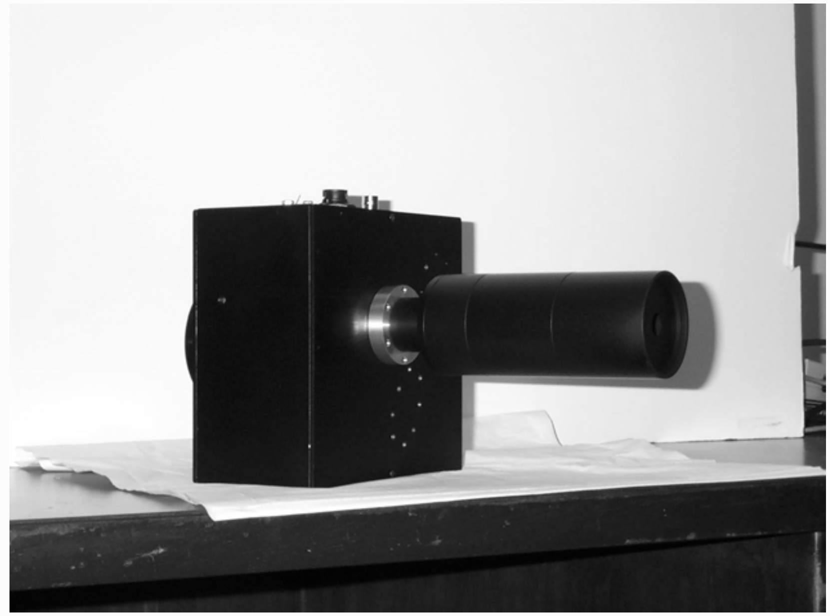
Uncertainty in spectral **power, irradiance and radiance** responsivity is less than 0.1 %

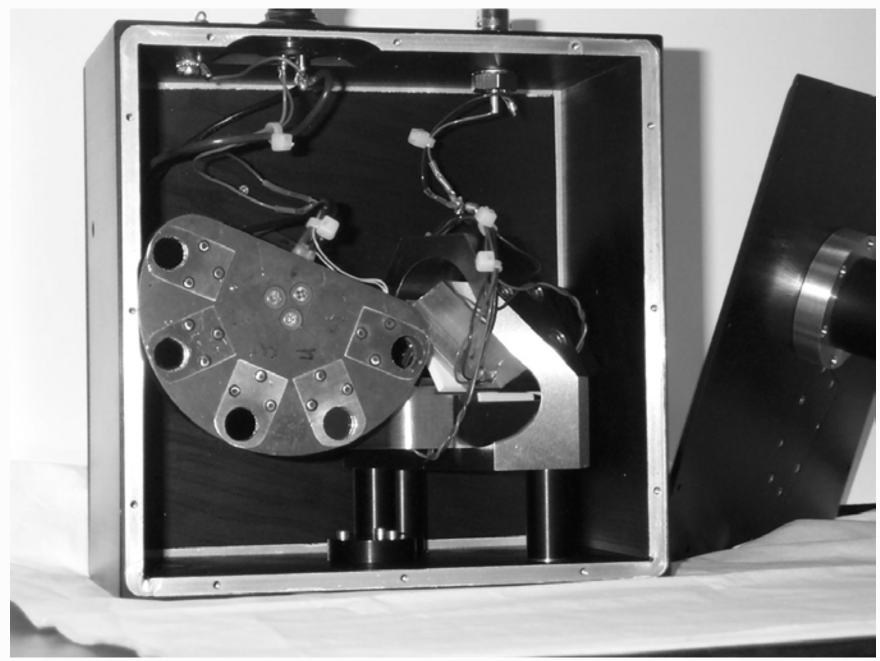
Applications

Equipped with UV filters
transfer standard detector currently being used to calibrate the EPIC satellite sensor

Equipped with CIE XYZ filters
reduce the uncertainty in photometric and color measurements

Equipped with 650 nm filter
Reference pyrometer for blackbody temperature measurement





CONCLUSION

The impact of new transfer/working standard radiometer developments:

- The spectral power responsivity calibrations of NIST have been extended to a wider wavelength range and irradiance and radiance responsivity calibrations were introduced to satisfy the need of field applications.
- The recently developed detector-based NIST scales have a high impact for the radiometric, photometric, and color measurements of the US military and industry: detector-based calibrations are increasing and source-based calibrations are shrinking.
- The NIST developed transfer and working standard radiometers and photometers are widely used inside and outside of NIST to realize and propagate the increased accuracy detector-based scales.
- The new reference platform for detector-based scale derivations is the very high accuracy spectral irradiance responsivity scale of the SIRCUS facility.
- The new high accuracy spectral irradiance responsivity scale can improve the NIST candela by about a factor of 3.