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NIST

National Institute of Standards and Technology

Non-regulatory agency (Department of Commerce)

Congressional mandate:

Assist US industry; Improve health, safety, and environment; Conduct fundamental research in science and engineering

1989 Trade Bill added responsibility for extramural programs, especially in the areas of "competitiveness".

Radiometric Physics Division

National standards in radiation thermometry, spectroradiometry, photometry, and spectrophotometry;

Dissemination of these standards by providing measurement services to customers requiring calibrations of the highest accuracy;

Conduct fundamental and applied research to develop the scientific basis for future measurement services.

NIST SRM's
Standard Reference Materials
SP-260 and Appendix
(301) 975-6776

EXAMPLES

SRM 740 and 741. Defining fixed point for freezing zinc (419.58 °C) and tin (231.9681 °C) for calibrating thermometers and thermocouples.

SRM 1967. High purity platinum wire for thermocouple construction.

SRM 1920 (0.74-2.0 μm). Reflectance standard for establishing the accuracy of the wavelength scale of a reflectance spectrophotometer.

SRM 2021 (0.28-2.5 μm). Directional-hemispherical reflectance (black porcelain enamel)

NIST Calibration Services
SP 250 and Appendix
(301) 975-2002

EXAMPLES

Contact Thermometry: Calibration of thermometers, thermocouples, and platinum, germanium, and rhodium-iron resistance thermometers

Radiation Thermometry: Calibration at 650 nm of optical pyrometers or ribbon filament lamps, 800 °C to 4200 °C

Optical Radiation Measurements:

- Spectral transmittance and reflectance, 0.25 to 2.5 μm;
- Spectral radiance ribbon filament lamps, 0.225 to 2.4 μm;
- Spectral irradiance lamps 0.25 to 2.4 μm;
- Photodiode (silicon) spectral response rental package, 0.2 to 1.1 μm;
- Special tests of radiometric detectors, 0.2 to 1.8 μm, 10 μW and greater power levels;

Selected R/D Programs

Ambient Environment

TASK	λ	WHO	DATE
Ambient IR Facility for radiance temperature, minimum resolvable temperature, and imaging studies	3-14	Navy	1987
Calibration of commercial blackbody, 10 °C to 80 °C	8-14	Navy	1989
Characterization of commercial IR spectroradiometer	8-14	Navy	92-94
Calibrate 10-cm aperture water-bath blackbody (10 °C to 80 °C)	3-14	Navy	92-94
Build and characterize tin-point standard blackbody (231.928 °C)		Air Force	92-93
Calibrate blackbody source for radiance temperature and uniformity		SDIO	1992
Detector comparator facility for absolute calibration; develop IR detector standards	1.5-25	Air Force	91-94
Extend photodetector transfer standards to IR; calibrate with the HACR (High Accuracy Cryogenic Radiometer)	to 10.6	Air Force	91-93

Selected NIST R/D Programs

Cryogenic Environment

TASK	λ	WHO	DATE
Cryogenic facility for calibration of blackbodies from total power measurements (LBIR)	0.3-30	SDC Army	1989
Calibration of blackbody sources from 150 K to 1000 K			1989
Add spectral capability to LBIR	2-30	SDIO SDC	1992
Spectral calibration of cryogenic sources, detectors, and filters			1993
Extend noise floor of LBIR detector from 20 nW to 70 pW		SDIO	1992

Selected NIST R/D Programs

Spectrophotometric Measurements

TASK	λ	WHO	DATE
Calibration facility for bidirectional reflectance distribution function	0.33-10.6	Air Force	90-93
Develop IR diffuse reflectance standards	2-20	Navy	91-93
Optical heterodyne densitometry (12 decades; cryogenic operation by 1992)	0.633 & 10.6		1990

Relevance to EOS/TIR Calibration
Current Capabilities

AMBIENT (minimum 1 meter path length)

Calibrate customer blackbody sources

Calibrate unknown blackbody for radiance using a well-characterized NIST blackbody source by matching the radiant fluxes with an IR radiometer (Barnes): absolute uncertainty 0.11 °C at 10 °C; 0.25 °C at 45 °C; capable of precision of 1 mK;

Measure uniformity of unknown blackbody source with a minimum resolvable temperature difference of 50 mK at 33 °C (Barnes)

Relevance to EOS/TIR Calibration
Current Capabilities

CRYOGENIC (20 K shield; 4 K ESR detector)

Calibrate customer blackbodies

Total radiant flux measurements; size of BB aperture and temperature are constrained by the detector;

Calibrate thermometers of source with respect to radiance temperature as a function of BB aperture size;

Absolute radiometric uncertainty at the 95% level is about 1%, corresponds to about 1.2% uncertainty in radiance temperature;

No uniformity studies are possible and strict vacuum requirements apply ($<1.33 \times 10^{-6}$ Pa total pressure and $<1.33 \times 10^{-8}$ Pa hydrocarbons before cooling with the 15 K helium gas).

Next LBIR workshop is scheduled for Tuesday morning, September 15, in conjunction with the 3rd annual SDL/USU Symposium on Cryogenic IR Radiometric Sensor Calibration and the EOS/TIR Peer Review Workshop.

EOS TIR Instruments

Overall Spectral Coverage (μm)

AIRS	3.4 - 15.4 0.4 - 1.7
ASTER	8 - 12, 1.6 - 2.5, 0.5 - 0.9
CERES	0.3 - 50, 8 - 12, 0.3 - 5
HIRDLS	6 - 12
MODIS-N	0.415 - 14.24
MOPITT	2.3 - 4.7
SAFIRE	62.5 - 125, 25.6 - 32.3, 6.4 - 15.9
TES	2.3 - 16.7

EOS/TIR Lab Source Verification
TIR Round Robin

Definition TIR Round Robin to VERIFY the calibration of the sources that are used for the absolute radiometric calibration of the individual EOS sensors

Requirements (preliminary)

Spectral response: 2.3 - 15

3% total absolute uncertainty in radiance at the 3σ level

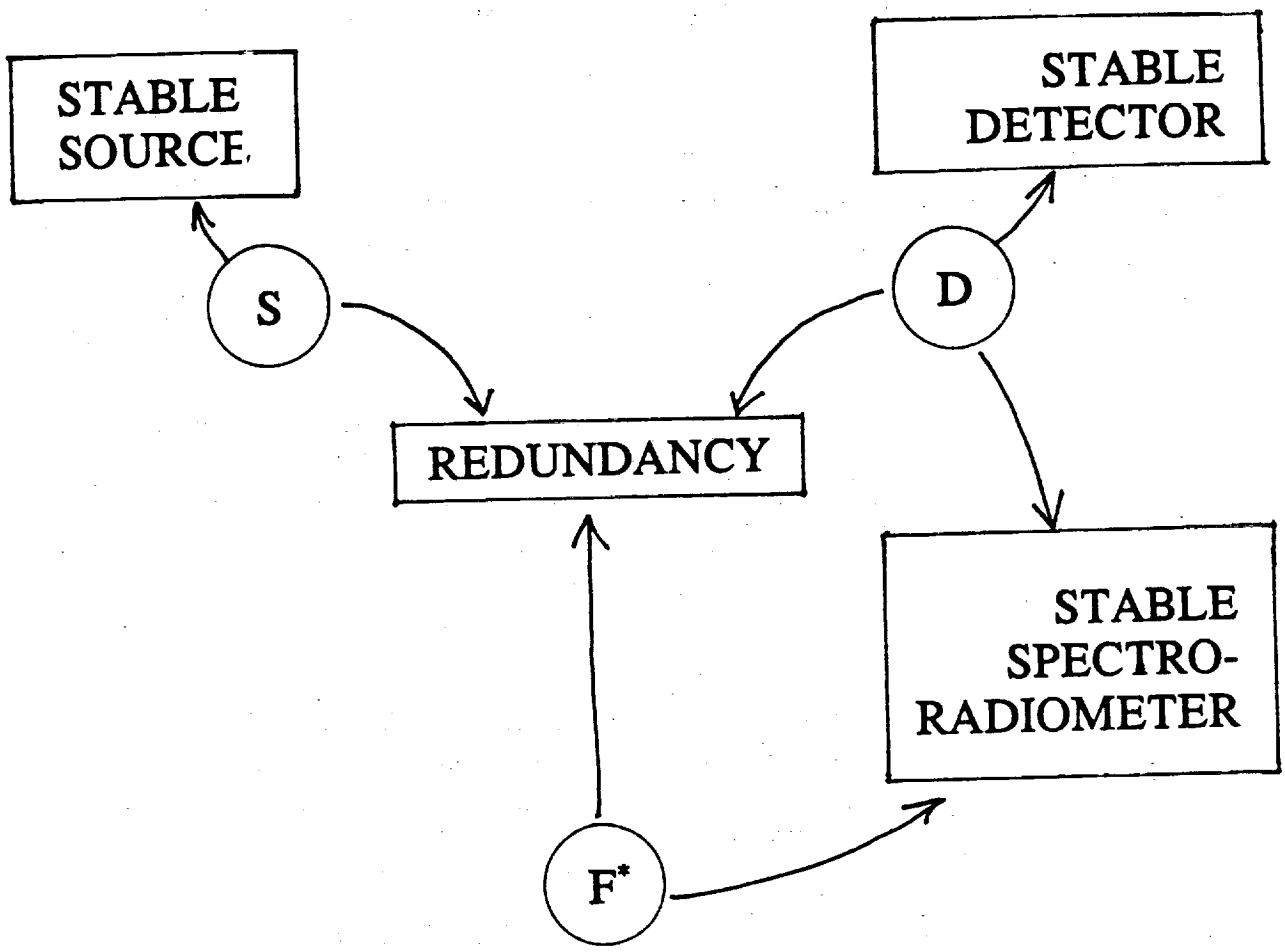
Long term stability

Proven vacuum compatibility

Meets EOS schedule

Calibration at NIST, or NASA-acceptable traceability

Philosophy of Lab Source Verification

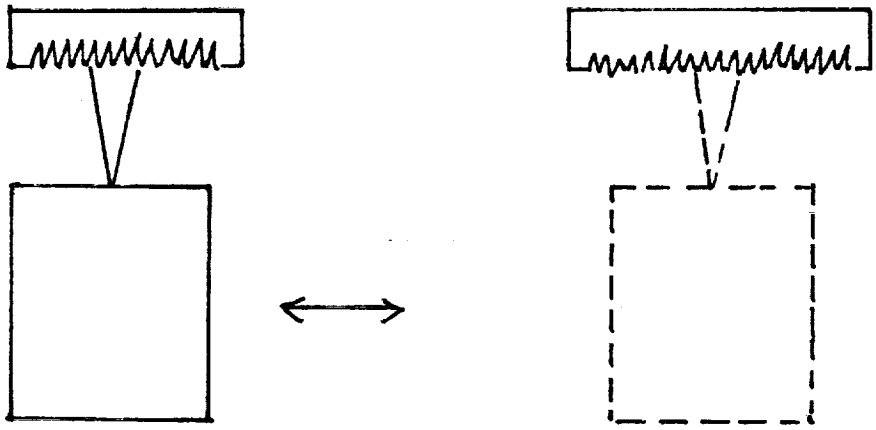


* Filter, monochromator, or interferometer

STABLE SOURCE

EOS LAB SOURCE

ROUND ROBIN SOURCE
(Blackbody)



EOS Instrument

PRT resistance vs T_λ of the RR source is NIST "traceable"

Problem Thermal radiation properties of the RR Source could change

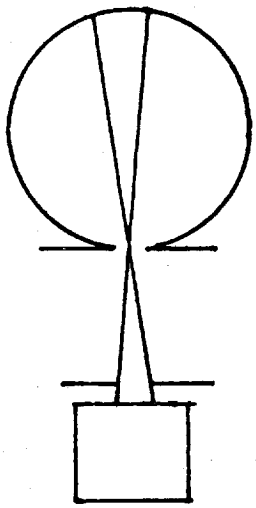
Return to NIST often?
Design way to monitor $\epsilon(\lambda)$?

Option Circulate a RR detector (not necessarily stable) to compare the sources

STABLE RADIOMETER

(broadband or spectral)
(irradiance or radiance mode)

EOS LAB SOURCE



ROUND ROBIN
RADIOMETER

Calibration constants determined or confirmed by NIST

Round robin source could be included for redundancy

DESIRED INFORMATION

INSTRUMENT SPECIFICATIONS

CALIBRATION METHODS (pre-flight and on-board)

ROUND ROBIN

- Overall Philosophy
- Laboratory Sources to be verified
- Environment for measurements
- Revised Requirements