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Breakout Session 2: Spectro-radiometry

NREL
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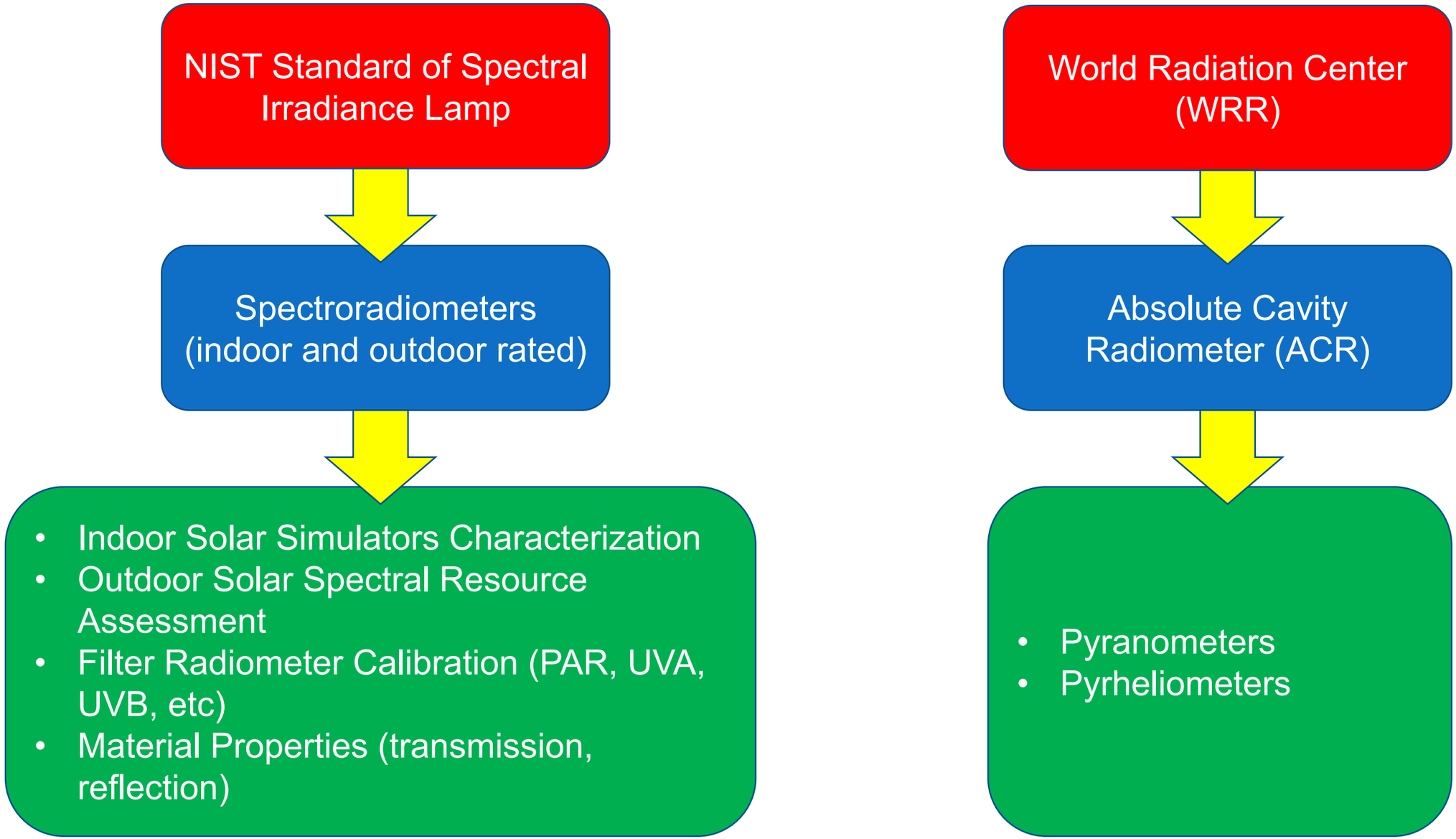
U.S. DEPARTMENT OF ENERGY

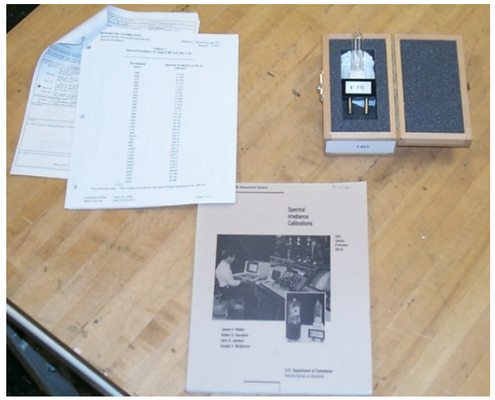
- NREL has been performing spectral calibrations and measurements since the 1980s.
- We became ISO17025 accredited for spectroradiometer calibrations in 2014.

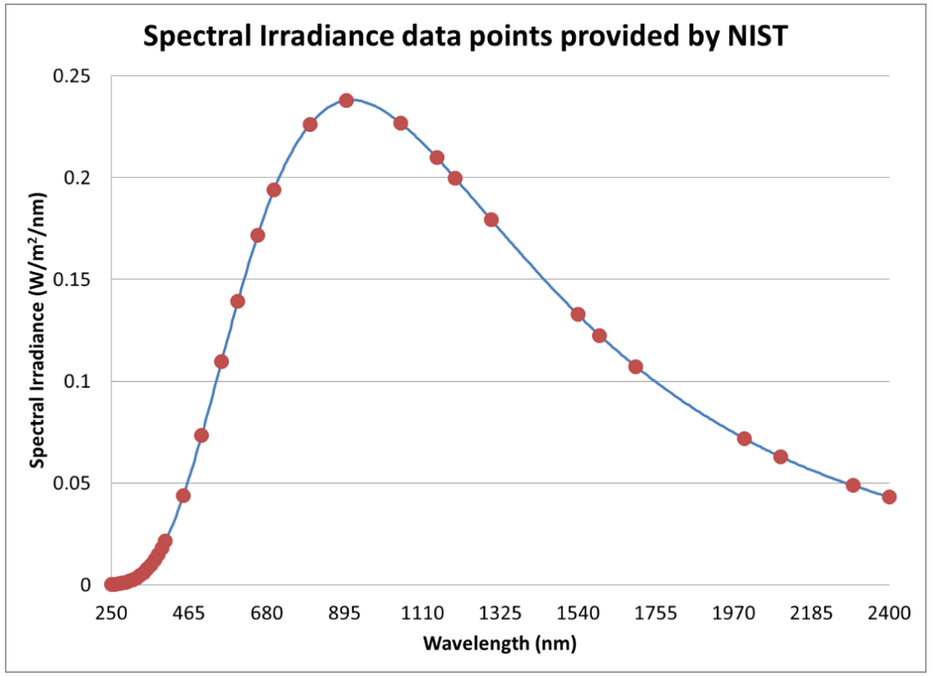
NREL Traceability Trees (Spectral & broadband)



NIST* Standard of Spectral Irradiance

- 1000-watt quartz halogen lamp, type FEL
- $20,000 USD, Calibrated Life = 50 hrs
- 35 data points, 250-2400nm



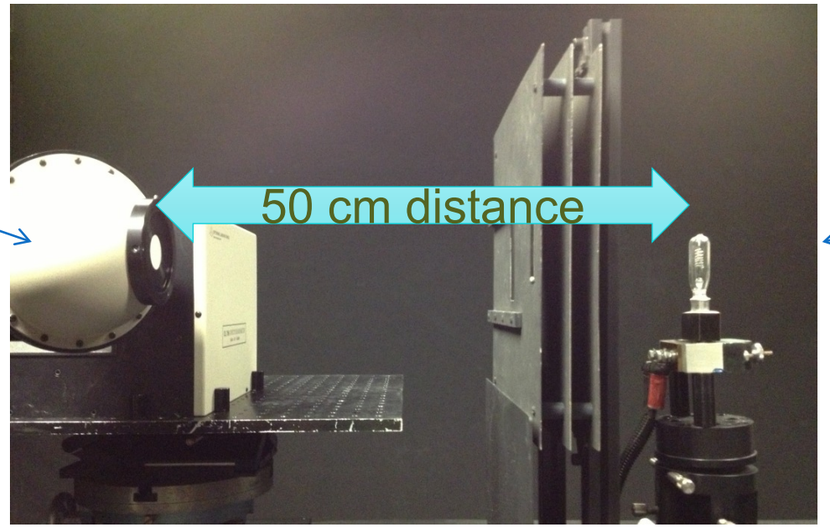


*NIST - National Institute of Standards and Technology

NREL Spectral Calibration Setup

Baffle, tunnel, laser curtains (flat black) to minimize reflections/stray light

Spectroradiometer under calibration



Lamp Standard

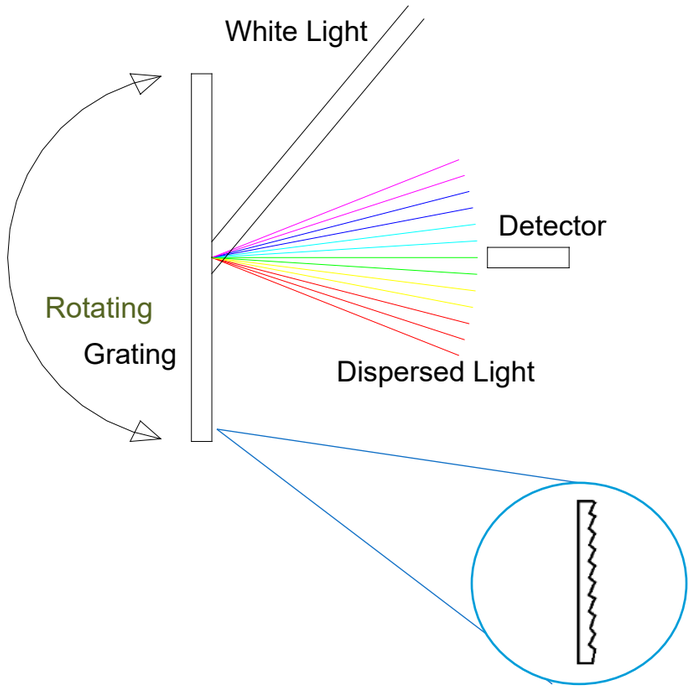
Computer controlled constant current power supply set at 8.00 Amps.

Also, important to monitor voltage at lamp terminals, deviations from NIST can indicate changes in lamp filament resistance.

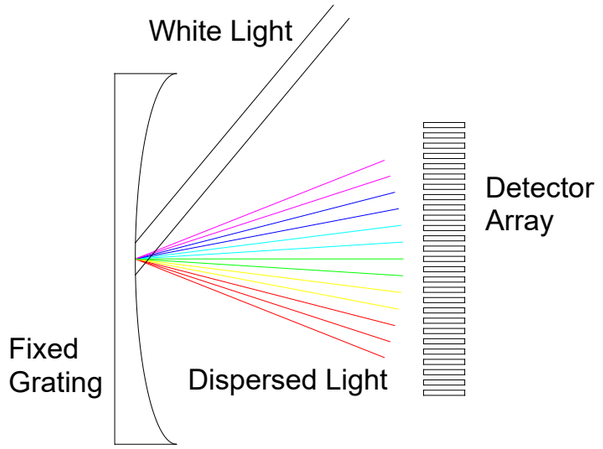
Monitor current by measuring voltage drop across standard resistor in series with lamp

Type of Spectroradiometer Systems

- **Scanning Monochromator:** Measure irradiance at one wavelength at a time.
- **Diode Array:** Measure irradiance at all wavelengths.



Scanning Monochromator



Diode Array

NREL Primary Indoor Spectroradiometers

- Optronic Labs OL750 (280-2400nm) – monochromator
- Optronic Labs OL756 (250-800nm) – double monochromator
- NREL Developed Pulse Analysis Spectroradiometer System (PASS) – monochromator (280-1720nm) - measure spectrum at any location in a pulse
- SOMA S-9011 and S-9001 (300-2200nm) – diode array - pulse measurement capability

- All indoor systems outfitted with integration sphere to eliminate cosine issues (can also be used outdoors during good weather).

NREL Primary Outdoor Spectroradiometers

- EKO WISER (Models MS711 & MS712) – 300-1650nm diode array. Can be used for global, direct, or diffuse.
- Prede PGS-100 – 350-1050nm – diode array (direct normal only)

NREL's first continuous outdoor spectral measurements

- LICOR LI-1800 (300-1100nm) monochromator – Installed January 2001 (Global 40-South Tilt)
  - Later moved to Global Horizontal
  - Then decommissioned in May 2015
  - This particular unit was owned by ARM.
- NREL also has several NIST FEL Lamps purchased by ARM in 1994.

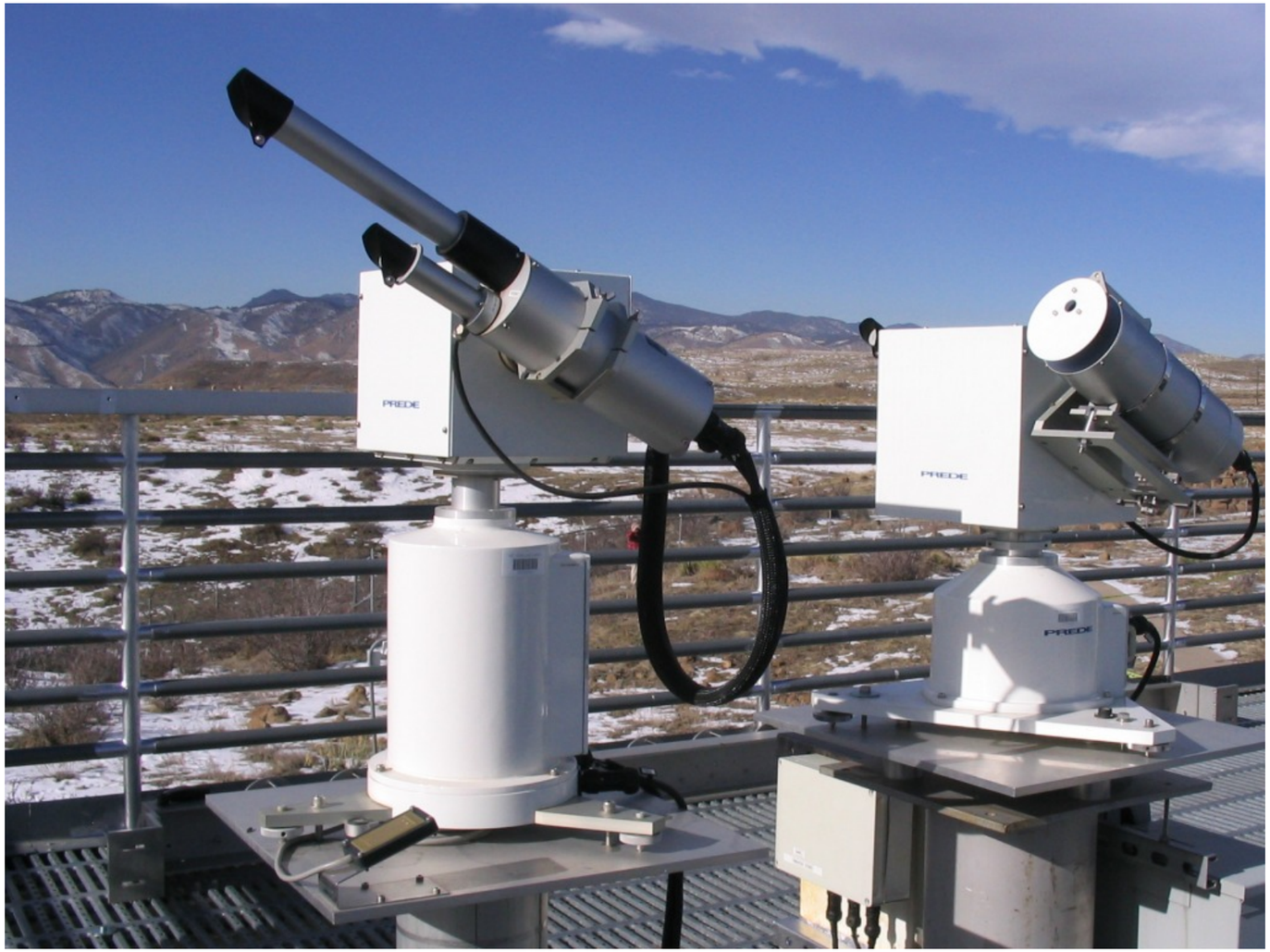
NREL's current continuous outdoor spectral measurements

Global Horizontal WISER – Installed March 2014

NREL's current continuous outdoor spectral measurements

2 and 1-axis tracking WISER – Installed Jan 2020 & Oct 2017

NREL's current continuous outdoor spectral measurements



Direct Normal PGS-100 (right) – Installed August 2008

Short term direct and diffuse test with WISER

NREL Spectral Intercomparisons

Interlaboratory comparisons is a valuable tool to allow laboratories to assess their performance with respect to calibration, methods, and measurement equipment. In addition, it is a requirement for ISO accredited laboratories.

Previous methods used by NREL:

- Ship lamps to various laboratories so that each lab can measure with their calibrated spectroradiometer.
- One lab hosts event where multiple labs bring their spectroradiometer to measure a source (lamp or outdoor solar spectrum).
- A lab purchases new (of-the-shelf) spectroradiometer and calibrates it in-house and compare to factory calibration

NREL Spectral Intercomparisons

Date	Organizer	Description
Pre-2010	Atlas Germany	Atlas shipped 4 FEL-type lamps, multiple labs participating. (prior to NREL's ISO accreditation)
2013	NREL	Spectroradiometers, indoor and outdoor measurements conducted at NREL, multiple labs participating at NREL.
2015	Atlas	Atlas shipped 6 FEL-type lamps and 2 Xenon-Arc lamps, multiple labs participating.
2017	NREL	Calibration of new EKO spectroradiometer at NREL
2019	NREL	Calibration of 2 new EKO spectroradiometers at NREL
2021	NREL	Calibration of new spectroradiometer(s) at NREL (planned)

NREL Spectral Intercomparisons

2022 or 2023, organize an intercomparison with ARM?