



## SUV-150B UV-Visible Spectroradiometer

**Biospherical Instruments Inc. SUV-150B** UV-Visible Scanning Spectroradiometer delivers continuous, high spectral resolution measurements of solar irradiance in the ultraviolet and visible. This all-new system design is based on more than 15 years experience building and operating similar instruments for the National Science Foundation's (NSF) UV Monitoring Network in the extreme climates of Antarctica and the Arctic.

The SUV-150B provides measurements of global spectral irradiance between 280 and 600 nm with a 0.63 nm bandwidth. These spectral measurements support a wide range of UV research programs and are used by numerous investigators to study the effects of ozone depletion, the transfer of radiation through the atmosphere, biological effects, and to validate satellite observations.

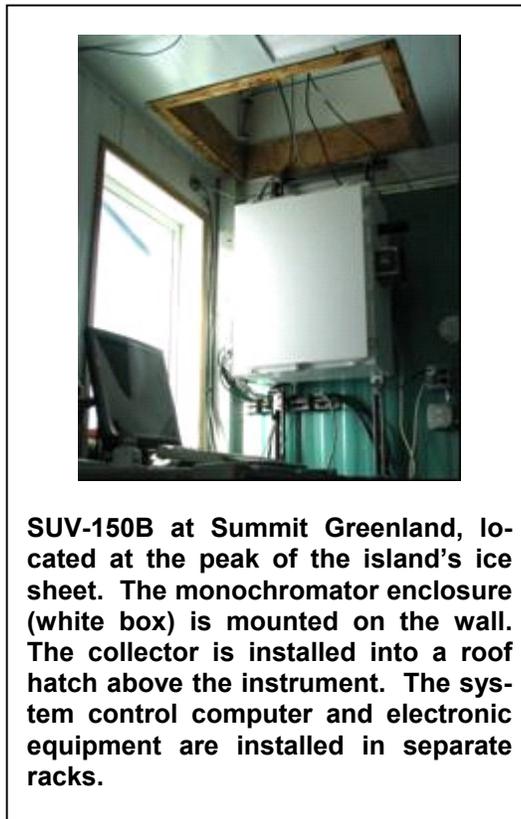
Each SUV system can be optimized to meet the specific needs of the customer and the site where the system will be installed. A typical system includes three subsystems: 1) An irradiance collector consisting of a PTFE-diffuser covering the entrance port of a baffled integrating sphere. This unit is fully weatherproof, heated to minimize ice and snow buildup, and coupled to a monochromator via an optical fiber bundle. 2) A monochromator, detector, and integral mercury and tungsten-halogen calibration assembly housed in a separate temperature-stabilized enclosure. 3) The system's control electronics, which may be located up to 5 meters away from the monochromator enclosure. This operator's station features a personal computer with custom software to acquire data from the SUV-150B and optional ancillary sensors such as a GPS receiver for time synchronization, pyranometers, and meteorological sensors. The system can be configured to be operated remotely via the Internet.



**SUV-150B System at Summit, Greenland. The collector is installed on a hatch on the roof. Auxilliary sensors**

At the heart of this system is a 150 mm, f/4.4 Czerny-Turner double monochromator, designed in-house and optimized for recording UV-B and visible solar irradiance. The monochromator uses two gratings, which are independently positioned by two micro-stepping motors. The drive mechanism uses high-resolution optical encoders, which provide real-time active-feedback position control. The monochromator's exit port is coupled to a bi-alkali photomultiplier detector. All parts of the instrument are temperature stabilized to within  $\pm 1^\circ\text{C}$  by a thermoelectric heater/cooler.

The system's design emphasizes the importance of automated calibration for quality control and ease-of-use. Internal wavelength and intensity sources are automatically scanned at user-defined intervals. NIST-traceable 200-Watt Standards of Spectral Irradiance are used to perform absolute calibrations and periodic evaluations of internal calibration sources. These are applied with a specially designed calibration fixture mounted over the collector.



**SUV-150B at Summit Greenland, located at the peak of the island's ice sheet. The monochromator enclosure (white box) is mounted on the wall. The collector is installed into a roof hatch above the instrument. The system control computer and electronic equipment are installed in separate racks.**

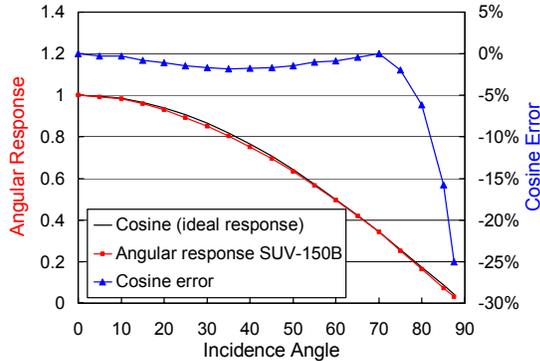
# Specifications

## Collector

**Design:** Integrating sphere with baffle; the entrance port is covered by a shaped PTFE diffuser; the exit port is coupled to the monochromator's entrance optics by a quartz optical fiber bundle.

**Azimuthal Asymmetry and Spectral Effects:** < 1%.

**Temperature Stabilized:** User selectable; typically  $30 \pm 1$  °C



**Cosine Error:**  $\leq \pm 2\%$  for all angles < 75°, -6% at 80°,  $\leq \pm 1.5\%$  for isotropic radiance (figure above).

## Entrance Optics

**Purpose:** To bring radiation to the monochromator's entrance from the collector (optical fiber-bundle coupling), the internal mercury lamp, and the internal tungsten-halogen calibration lamp.

**Features:** Shutter (Uniblitz Model VS25S2T1K) to block radiation from the collector during internal calibration lamp scans; relay optics from all sources to match monochromator's f-number.

## Monochromator

**Type:** Double Czerny-Turner, additive.

**Focal Length:** 150 mm

**f-number:** 4.4

**Gratings:** plane ruled, 240 nm blaze, 2400 grooves/mm

**Spectral Range:** 200 – 700 nm (typically 280 – 600 nm)

**Control:** dual, independent, micro-stepping motors (one for each grating turret), computer controlled via RS-232.

Real-time positioning via feedback from 24-bit optical encoders. Spectral resolution limit :0.003 nm.

**Bandwidth:** 0.63 nm full-width at half-maximum (FWHM) at 325 nm, 1.8 nm full-width at 0.1% of maximum, see Figure 2.

**Wavelength Accuracy:**  $\pm 0.03$  nm ( $\pm 2\sigma$ )

**Wavelength Precision:**  $\pm 0.015$  nm ( $\pm 2\sigma$ )

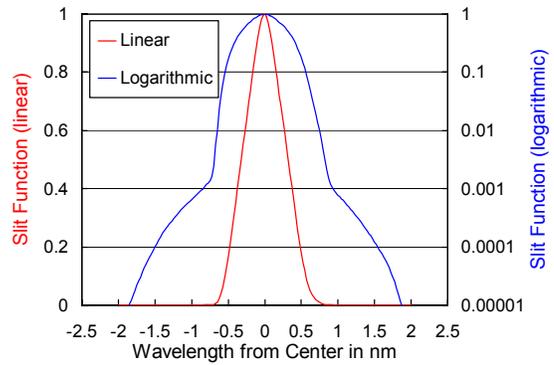
**Out-of-band Rejection:**  $> 5 \times 10^{-8}$ , see Figure 3.

Stray light of terrestrial solar spectra is not detectable.

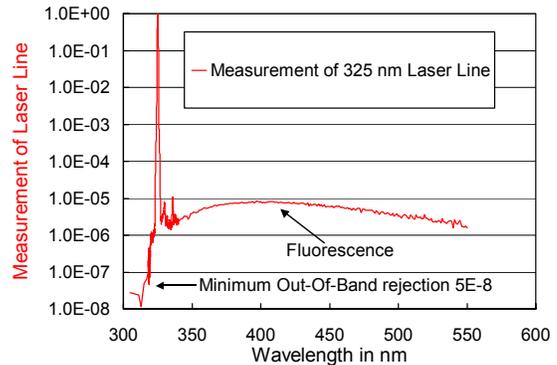
**Sampling Step Interval:** User definable. Typically 0.2 nm (for 280 - 405 nm), 0.5 nm (for 406 - 600 nm).

**Scan Time:** User definable. Typically 9 min. for 280 - 400 nm; 14 min. for 280 - 600 nm.

**Temperature Stabilization:** Peltier cooled, resistively heated. Temperature set-point user selectable, typically  $25 \pm 1$  °C



Slit function of SUV-150B



**Measurement of 325 nm Laser Line to determine out-of-band rejection.** Out-of-band rejection is likely larger than  $5 \times 10^{-8}$  but the measurement is limited by the instrument's dynamic range of approximately 8 orders of magnitude. Fluorescence is less than  $1 \times 10^{-5}$  and therefore does not affect solar measurements.

## Detector and Detection Limits

**Photomultiplier Tube (PMT):** Hamamatsu Model R2371P; selected for low noise; 9 stage dynodes; mounted in electrically and magnetically shielded housing with integral high-voltage power supply; 16-bit high-voltage control resolution.

**Maximum Source (Saturation) Irradiance:**  $> 2 \times 10^{-4}$  Watts/(cm<sup>2</sup> · nm)

**Noise Equivalent Irradiance at 300 nm:**  $6 \times 10^{-10}$  Watts/(cm<sup>2</sup> · nm)

## Data Acquisition

**PMT Signal:** Keithley Model 6514 Electrometer

**Ancillary Sensors:** Agilent Model 34970A Data Acquisition Unit and BSI Q2100-Series Multi-Tag.

**Lamp Current:** Agilent Model34401A Digital Multimeter with an ISA-PLAN Precision Shunt type RUGZ-R010-0.1 (Zeranin).

**System Control Computer:** Intel Pentium® personal computer running the Microsoft® XP Professional operating system. Includes BSI-developed SUV-150B System Control Software that provides system control, data acquisition and recording. The computer can be controlled over the Internet; data can be retrieved remotely.

**Data File Formats:** ASCII and Microsoft® Access

## Auxiliary Sensors

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**Internal Temperature:** at several locations on the system including the collector, PMT, monochromator, and its enclosure.

**Room Temperature:** also serves as internal intensity calibration source temperature monitor.

**Humidity:** inside monochromator enclosure.

**Total Scene Irradiance:** filtered-photodiode integral to the entrance optics, for broad-band UV monitoring of radiation entering the monochromator.

**DC Power Supply and AC Voltages:** system's supplies and AC voltage to them is monitored.

**Thermoelectric Cooler:** load-current is monitored.

**System Status:** monochromator control, PMT high-voltage, electrometer, digital multimeter, lamp power supply, data acquisition unit and collector sensors; with indicating software-LED "bar."

**User-settable Alarms:** user-definable for a variety of sensors.

## Dimensions

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**Collector:** 20 cm diameter x 27 cm L. Collector interface tilt-plate 45 cm diameter.

**Entrance Optics/Monochromator Enclosure:** 71 cm W x 36 cm D x 82 cm H can be mounted in 2 orientations vertically, or horizontally.

**Control Console:** a welded-frame rack cabinet (NIM), 58W x 61D x 198cm is standard. See Options for alternatives.

## Calibration

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**Internal Wavelength (Mercury) and Intensity (Tungsten-Halogen) Lamps** for automatic calibrations at user-programmable intervals. For absolute reference of the internal intensity calibration lamp, a specifically designed fixture that utilizes a NIST-traceable 200-Watt Standard of Spectral Irradiance is periodically mounted above the irradiance collector and manual calibrations are performed. Tungsten-Halogen (T-H) lamps are driven by the system-integral Agilent Model 6654A Power Supply. T-H lamp current is feedback-controlled with a calibrated high-accuracy, high thermal stability, 10m $\Omega$  shunt (Isabellenhutte) and an Agilent Model 34401A Digital Multimeter.

**Characterizations Performed:** systems are characterized for angular response, sensitivity, band-pass/band-shape, and stray-light rejection prior to shipment. This data is provided to the customer.

## Options

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**Power Selection:** a no-cost option, the SUV-150B spectroradiometer system can be configured for either 115VAC/60Hz or 220VAC/50Hz.

**Ancillary Collector Sensors:** Four filtered photodiodes at user selectable wavelengths (typically 313, 340, 380, and 490 nm); two level sensors (x and y direction).

**Pyranometer(s):** total solar irradiance and solar IR models available.

**GPS Receiver:** can be added for timekeeping accuracy.

**Uninterruptible Power Supply (UPS):** dependent on local power capacity, one or more UPS can be integrated with the system. Also available is remote power switching via SNMP, which allows the user to power-cycle system components. We use American Power Conversion products.

**GUV System Integration:** for acquisition at increased temporal frequency for specific UV wavelengths (or Photosynthetically Active Radiation), the SUV control software can simultaneously acquire GUV-2511 system data and incorporate it into the SUV data set.

**Outdoor Temperature:** meteorological-grade; other met sensors are available.

**Additional Sensors:** available upon request, including custom-designed for research objectives.

**Roof Penetration:** configured to customer specifications, including both fixed position and easily serviced roof-hatch implementations.

**System Electronic's Portable Enclosures:** Several options are available for system electronics packaging and configuration, including Hardigg transportable instrument racks.

**Customized Shipping Containers:** customer specifies packaging and shipment; custom-fitted Hardigg cases are available.

**Support Services:** Biospherical Instruments provides a wide range of services for SUV owners on a contract basis, including site preparation, system installation, factory training, protocol development, data processing, and annual maintenance and calibration.

## References

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SUV instruments have seen more than a decade of continuous service in the National Science Foundation's Polar UV Monitoring Network. The reliability and accuracy of the SUV has also been shown in numerous national and international intercomparisons with other UV measuring devices from around the world. References are available from:

[www.biospherical.com/nsf/references.asp](http://www.biospherical.com/nsf/references.asp)



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