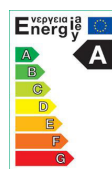
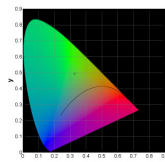
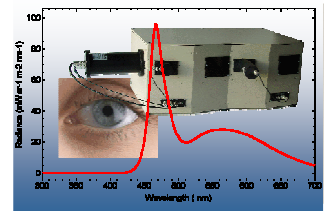
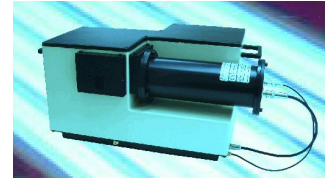




**The light measurement company**

# Lighting Industry Applications Update March 2010



[www.bentham.co.uk](http://www.bentham.co.uk)

*Over recent years, the landscape of the lighting industry has changed significantly with the convergence of a drive for energy efficiency, significant LED performance improvements (with an attendant increase in their market penetration), the banishment of some of those sources that we have all known and loved, and their interim replacement (?) by CFLs.*

*From a metrological perspective, has come a need for the evaluation of energy efficiency, for example through the EU energy related products directive and US energy star programs and a legal framework via IEC/EN62471, CE marking and the EU artificial optical radiation directive for the consideration of the photobiological safety of lamps and luminaires, comprising some potentially challenging measurements.*

*Celebrating this year our 35th anniversary of developing and supplying light measurement instrumentation (200nm to 50 $\mu$ m) to universities, research institutes and industry worldwide, Bentham is well placed to adapt to the ever-changing climate and respond to the needs of our customers.*

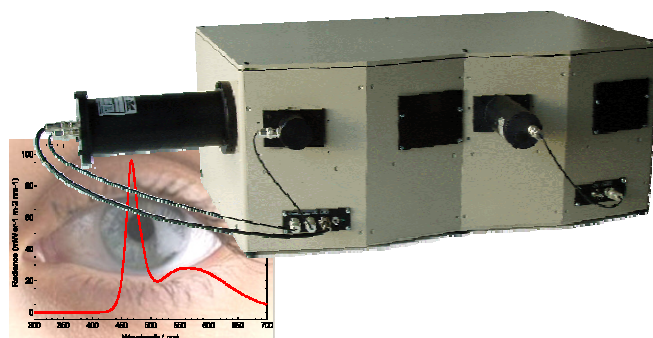
*Bentham Instruments Ltd.*

# Photobiological Safety of Lamps and Lamp Systems

The recent introduction of IEC62471:2006/EN62471:2008 concerned with the photobiological safety of non-laser sources represents a significant additional consideration in taking products to market.

Whilst standards vary between countries, they stem from the same source and show a high degree of commonality.

Therein are considered six potential hazards to the skin and eyes from electrically-powered sources emitting light in the spectral region 200-3000nm, evaluated by a complex set of measurements of spectral irradiance and radiance.



Skin or cornea hazard		
<b>Actinic UV skin &amp; eye</b>	$E_S$	200-400nm
<b>Eye UV-A</b>	$E_{UVA}$	315-400nm
<b>Blue light small source</b>	$E_B$	300-700nm
<b>Eye IR</b>	$E_{IR}$	780-3000nm
<b>Skin thermal</b>	$E_H$	380-3000nm

Retinal hazard		
<b>Blue light</b>	$L_B$	300-700nm
<b>Retinal thermal</b>	$L_R$	380-1400nm
<b>Retinal thermal (weak)</b>	$L_{IR}$	780-1400nm

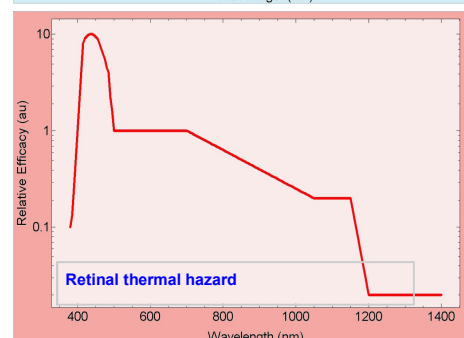
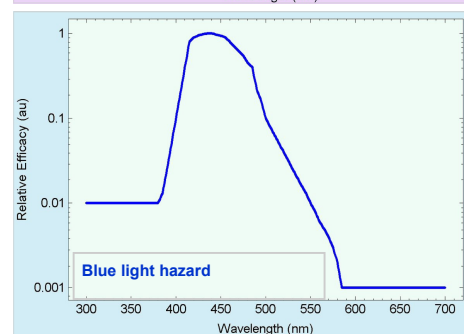
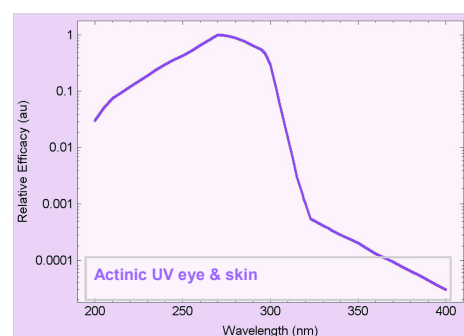
To perform these measurements with sufficient accuracy, IEC/EN62471 recommends the use of a double monochromator (to provide excellent stray light rejection and high spectral resolution wide spectral range) and recommends specific measurement bandwidths through the range of consideration.

Range (nm)	Wavelength Accuracy (nm)
20-300	0.2
300-325	0.1
325-600	0.2
600-1400	2

**IEC62471:2006 Recommended Wavelength Accuracy**

Range (nm)	Bandwidth (FWHM, nm)
200-400	<4
400-600	<8
600-1400	<20
>1400	No limitation

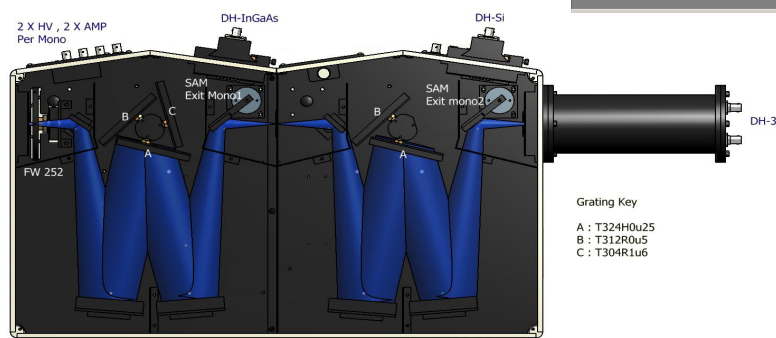
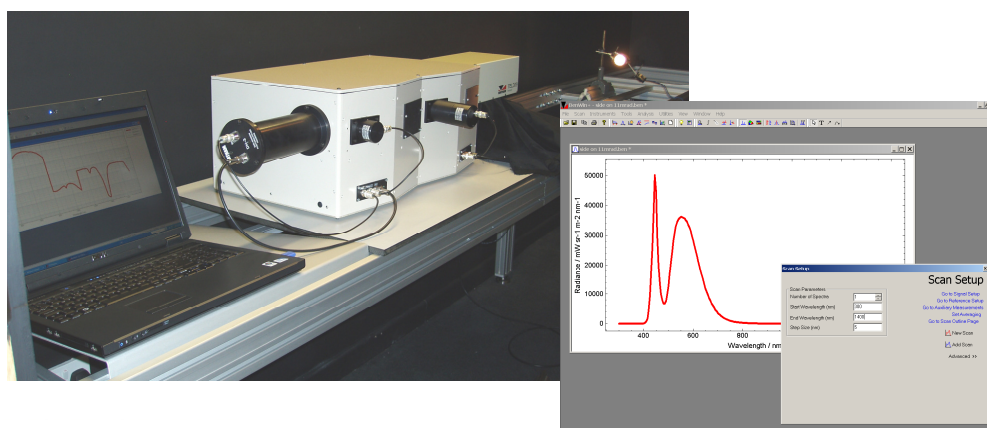
**IEC62471:2006 Recommended Bandwidths**



# IDR300-PSL System

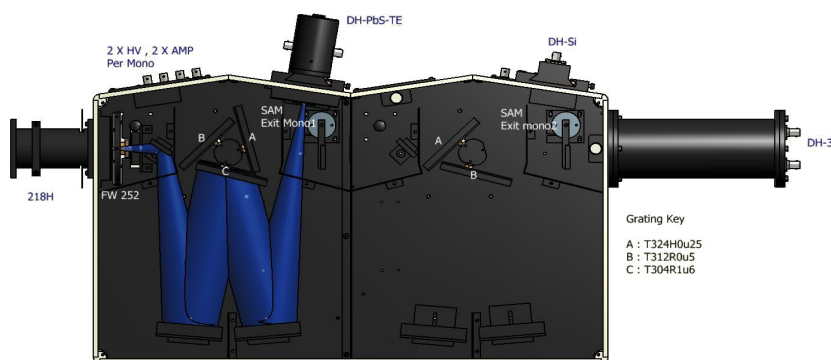
In response to IEC/EN62471, Bentham has configured the IDR300-PSL measurement system to provide a turnkey solution to such measurements. Operating as two single monochromators in tandem, the IDR300-PSL offers:-

- Double monochromator configuration for excellent stray light performance (200-1100nm)
- Can be used in single monochromator configuration (1100-3000nm) for high throughput
- Three detector ports; two in double and one in single configuration
- Wide spectral range of operation (200-3000nm)
- High spectral resolution
- Motorised slits to vary instrument bandwidth
- Integrated DC detection electronics
- Irradiance and radiance input optics adapted to requirements of standard
- Fully automated spectroradiometer with USB interface
- NPL traceable calibration standards
- Benwin+ Windows spectroradiometer software
- PSL wizard guides user through measurements, performs calculations, classifications and provides labelling information



## IDR300 200-1700nm

System configured for all hazards except eye IR and skin thermal

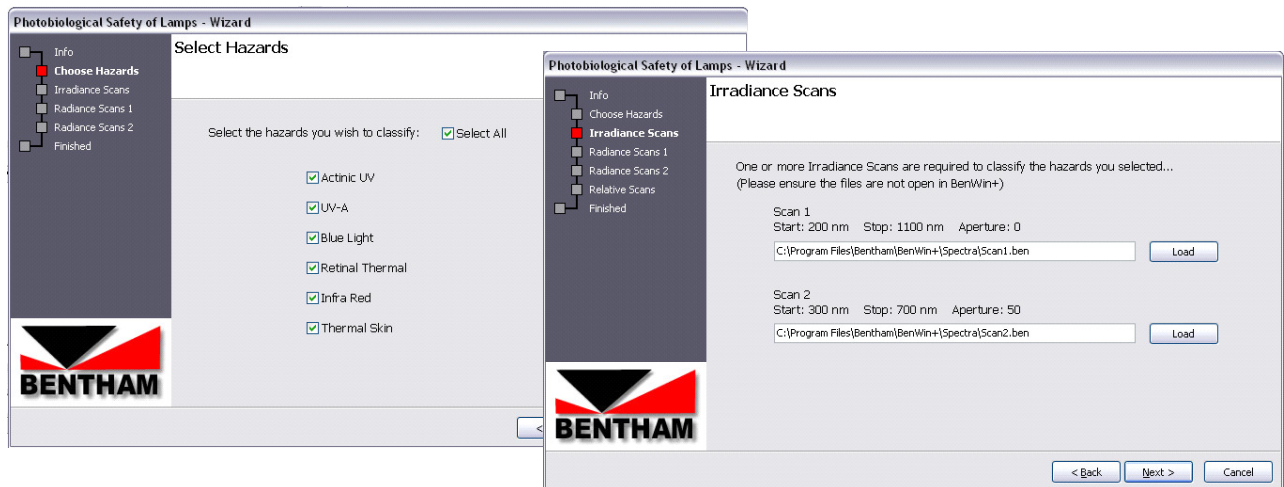


## IDR300 200-3000nm

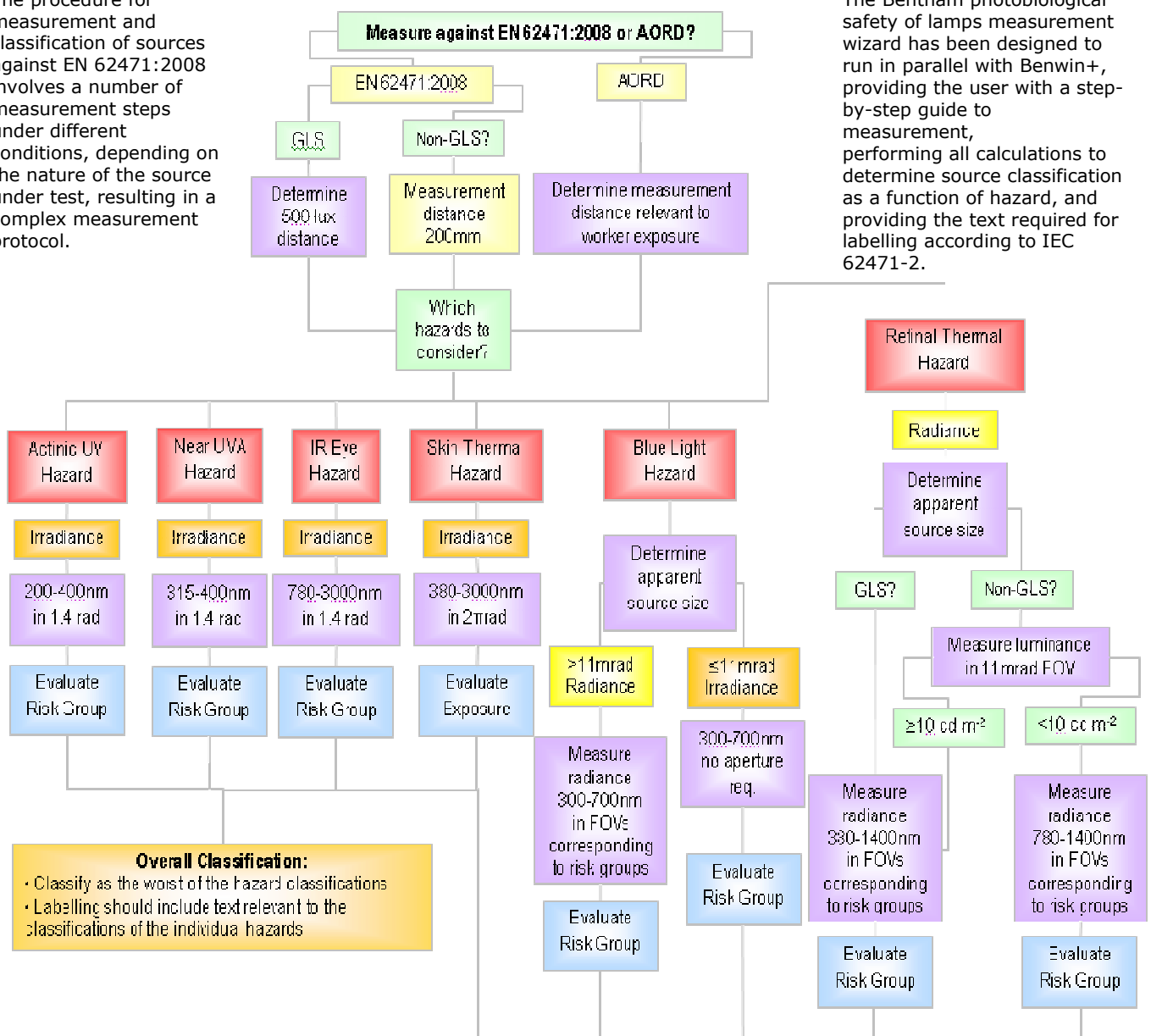
When configured for use to 3000nm, the IDR300 is used in conjunction with 495 lock-in and 218 optical chopper



# Photobiological Safety of Lamps Measurement Wizard



The procedure for measurement and classification of sources against EN 62471:2008 involves a number of measurement steps under different conditions, depending on the nature of the source under test, resulting in a complex measurement protocol.



The Bentham photobiological safety of lamps measurement wizard has been designed to run in parallel with Benwin+, providing the user with a step-by-step guide to measurement, performing all calculations to determine source classification as a function of hazard, and providing the text required for labelling according to IEC 62471-2.

# Photobiological Safety of Lamps Measurement Accessories



**D6/D7 Diffuser**

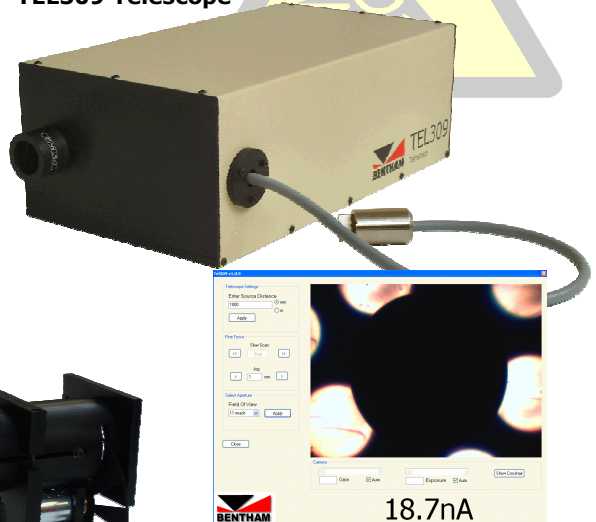
## Input Optics

The D7 diffuser is calibrated to have near perfect match to the cosine response ( $f2 < 1\%$ ) and high throughput, and is coupled to the entrance slit of the IDR300-PSL by quartz fibre bundle (typically 1-2m long).

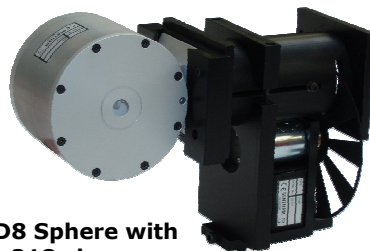
The TEL309 is a computer-controlled direct-view telescope, with stepping-motor driven focusing and aperture selection, permitting the measurement of radiance, over defined fields of view relevant to these standards (11 and 1.7mrad), for measurement distances from 200mm to 50m.

A USB camera-based viewer shows the user the measurement scene; the area of measurement is coupled to the IDR300-PSL via a quartz fibre bundle.

**TEL309 Telescope**



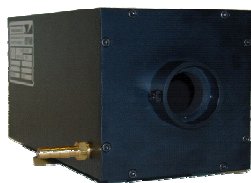
**495 lock-in with  
218 controller**



**D8 Sphere with  
218 chopper**

For measurements in the IR region beyond approximately 2000nm, it is necessary to use a lock-in amplifier based detection system. This is due to the detector technologies available and the need to eliminate the effects of background IR emissions. Bentham's 495 phase-insensitive Lock-in Amplifier and 218 Optical Chopper are readily integrated with the IDR300 system.

## Calibration Standards – supplied with calibrations traceable to NPL, UK



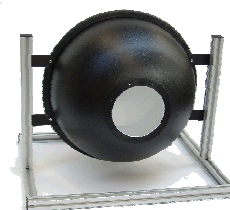
**CL7-H Standard  
(Spectral Irradiance)**

- 30W Deuterium lamp
- Enclosed housing
- Supplied with diffuser adaptor
- Operated by 705 power



**CL6-H Standard  
(Spectral Irradiance)**

- 50W quartz halogen lamp
- Enclosed housing
- Supplied with diffuser adaptor
- Operated by 605 constant



**SRS12 Standard  
(Spectral Radiance)**

- Baffled 100W quartz halogen lamp
- $\text{Ba}_2\text{SO}_4$  coated sphere
- Uniform illumination over 100mm port
- 12" sphere diameter
- Operated by 605 constant

# Example Applications of IDR300 Integrated Double Spectroradiometer

IEC62471:2006/EN62471:2008	Photobiological Safety of Lamps and Lamp Systems
EU Directive 2006/25/EC	Artificial Optical Radiation Directive
IEC60335-2-27:2007	Household and similar electrical appliances safety- particular requirements for appliances for skin exposure to ultraviolet and infrared radiation (sun tanning and collagen skin rejuvenation appliances)
IEC61228	Fluorescent ultraviolet lamps used for tanning. Measurement and specification method
Commission regulation (EC) No 244/2009	Energy Using Products Directive
IEC60335-2-59:2006	Household and similar electrical appliances safety- particular requirements for insect killers
EN 60598-1:2004, Luminaires	General requirements and tests, Annex P
UL 61010-1 annex DVC	Standard for Safety Electrical Equipment For Measurement, Control, and Laboratory Use; Part 1: General Requirements
CIE 13.3:1995	Method of measuring and specifying colour rendering properties of light sources
CIE 15:2004	Colorimetry
CIE 18.2:1983	The basis of physical photometry
CIE 84:1989	The Measurement of Luminous Flux
IES LM-79-08	UNECE vehicle regulations

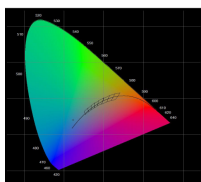
## Energy Efficiency of Lamps

As part of the drive across all industries to reduce CO<sub>2</sub> emissions, in a bid to slow down global warming, the lighting industry must adapt to produce energy efficient sources without compromising lighting performance.

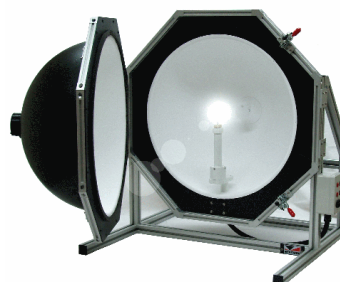
In Europe, the impetus is provided by the requirement of the consideration of energy efficiency as part of CE marking via regulations 244/2009 (amended 18/09/09) and 245/2009. In the US, the Department of Energy are bringing forward the Energy Star program to lighting.

The evaluation of sources from an optical radiation perspective includes a number of parameters:-

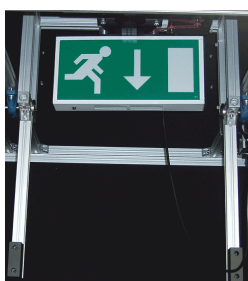
- total luminous flux (and electrical power measurement)
- angular output characteristics
- colour parameters
- colour rendering
- UV output



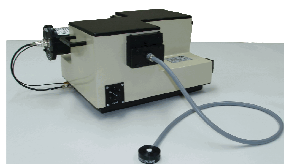
Bentham spectroradiometers provide high accuracy chromaticity data, CRIs and colour temperature



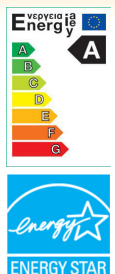
Bentham manufactures integrating spheres from 50mm (2 inch) to 1.8m (71 inches) diameter for the total luminous flux measurement of almost all lamp types.



Various size goniometer systems, for large luminaires to single LEDs



DMc150 Compact Double Monochromator based spectroradiometers for high accuracy UV measurements. Excellent scattered light rejection avoids unnecessary failure of lamps.



# Lamp Total Spectral/ Luminous Flux



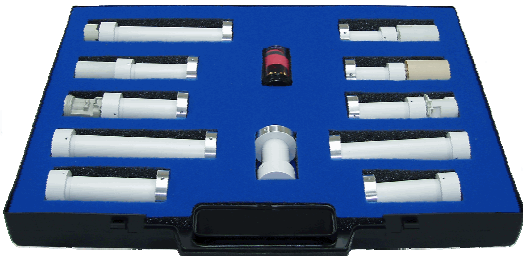
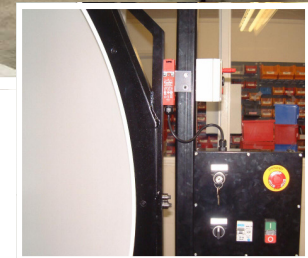
For the measurement of total spectral/ luminous flux, Bentham offers integrating spheres from 50mm (IS200) to 1.8m (IS1800) diameter. The size of the source in consideration determines the diameter of integrating sphere to be used ; CIE 84 recommends a diameter at least ten times the source size for compact lamps and two times for tubular lamps.

Whilst single LEDs may be measured in an IS200 sphere, the IS1800 tends to be used for measurements of tubular fluorescent lamps (EN60081) and high power lamps such as SOX and SUN.

Bentham spheres are also suitable for use with some reflector based lamps and small luminaires.

All spheres are available with many options and accessories including:

- spectroradiometer/ photometer/ colorimeter
- wide range of standard lamp holders
- adjustable lamp holders
- rotating lamp holders (0-360°)
- temperature monitors
- safety interlocks
- wiring options (internal/external control gear, HF operation etc)
- calibrated standard lamps and power supply



Bentham's standard range of integrating spheres for total spectral and luminous flux includes 50mm, 100mm, 200mm, 250mm, 300mm, 500mm, 1000mm and 1800mm diameters.



**IS1000: typically used for CFL and CMH lamp types**

**IS500: typically used for automotive and decorative lamp types**

**IS4/6/8 spheres: typically used for individual LEDs and small clusters**



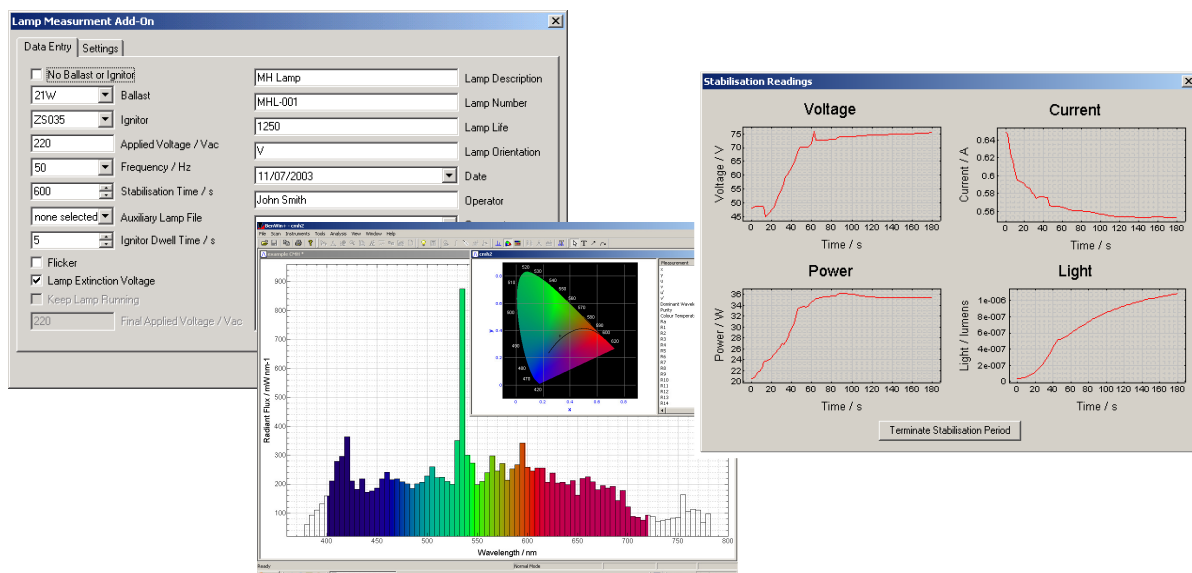


# Fully Automated Spectroradiometer (Ceramic Metal Halide 15W-1kW)

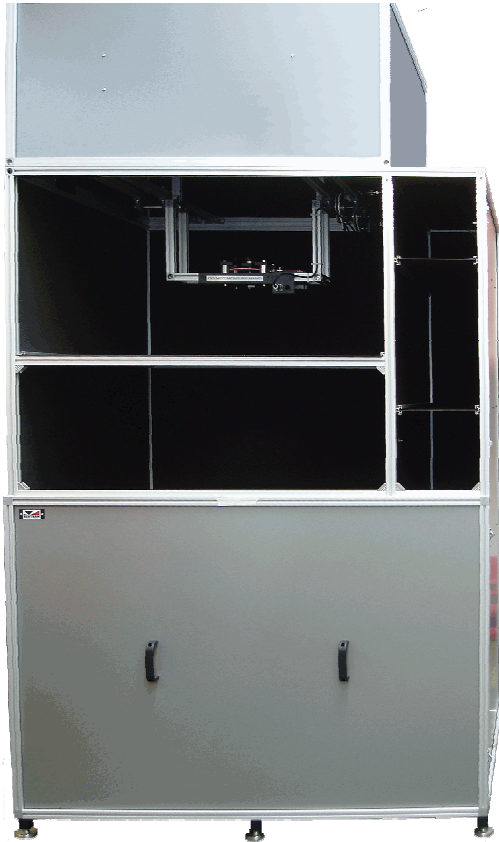


Combining optical radiation measurement and electronic control provides a fully integrated and automated lamp measurement facility for testing and characterising ceramic metal halide lamps ranging in power from 15W to 1kW. An integrating sphere based spectroradiometer is combined with software selected control gear (power supply, ballasts and ignitors) and electrical measurement instrumentation to allow complete lamp characterisation. The lamps are mounted on a turntable allowing lamp orientation to be rotated in 5 degree intervals, 0-360 degrees. A simple Windows form instigates a full measurement procedure under complete software control including:

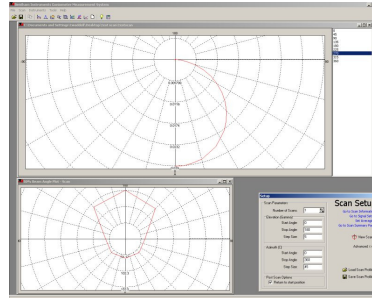
- Reference ballast selection (15W to 1000W)
- Ignitor selection (or electronic)
- Applied voltage and frequency selection
- Lamp stabilisation time and monitoring
- Spectral power distribution (spectral flux, 250-1700nm)
- Colour temperature
- Colour rendering indices
- Chromaticity co-ordinates
- Emission peak wavelengths
- Total lumens
- Lamp flicker (%)
- Lamp extinction voltage
- Sphere/ambient temperature
- Electrical parameters:  
 $V_{min}$ ,  $V_{pk}$ ,  $V_{rms}$ ,  $A$ ,  $W$  and  $PF$  etc



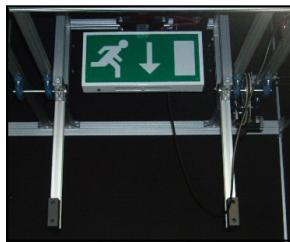
# Goniometer Systems



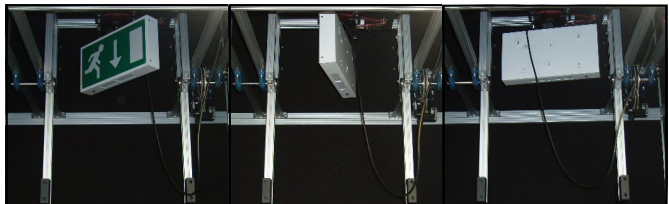
Bentham manufactures a range of manual and motorised goniometer systems for many applications ranging from single LED and luminaire polar distributions, to transmission and reflection measurements of complex shapes.



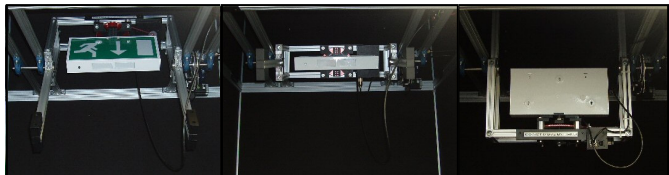
Motorised goniometers provide the convenience of full automation, more accurate results by enabling the measurement of a large number of C-planes and data points, and software control, luminaire data is provided in the format of choice (EULUMDAT, IES etc.) for use in lighting design packages, and information relevant to the destined use, for example zonal flux.



**Vertical Rotation**



**Horizontal Rotation**

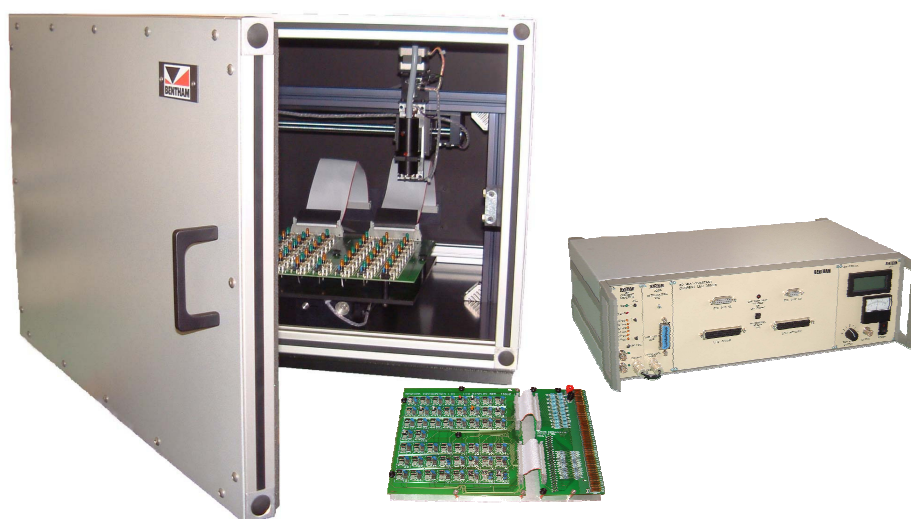


Bentham's benchtop **LED goniophotometer system** provides automated spatial measurements of single LEDs, clusters, and lamp modules.





# LED Lifetime Measurement System



Bentham manufactures a system for batch testing LEDs. Each carrier board accommodates up to 50 devices. A universal mounting socket has been developed to suit nearly all LED device packages currently supplied. A single keystroke enables full optical and electrical characterisation of each device with seamless integration with database and analysis software. The modular drive electronics are most commonly supplied with programmable forward current,  $I_f$ , and reverse voltage,  $V_r$  power supply. The system records for each device:

- Full spectral distribution
- Averaged intensity,  $I_{LED B}$
- Peak wavelength and bandwidth
- Dominant wavelength
- Chromaticity co-ordinates
- Colour purity and CRIs
- Forward voltage,  $V_f$
- Reverse current,  $I_r$

## Measurement of LEDs in accordance with CIE127

Bentham manufactures a range of equipment to facilitate the measurement of LEDs in accordance with CIE127 recommendations. The CIE defines a quantity 'Averaged LED intensity' and is specified for two geometries, CIE Standard Condition A and Condition B. These requirements specify a detector with circular entrance aperture of  $100\text{mm}^2$  area and measurement distances of 316mm for Condition A and 100mm for Condition B, which are fulfilled with our LED intensity tube that incorporates a small integrating sphere.

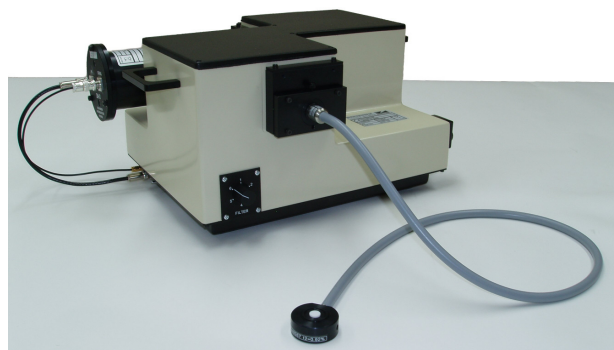
The intensity tube can be used in conjunction with our spectral measurement systems or filter based photometer/radiometer products.

An integrating sphere is used for total flux measurements and incorporates the necessary auxiliary and calibration lamps. Both the intensity tube and total flux spheres can be used in conjunction with our spectral measurement systems or filter based photometer/radiometer products.



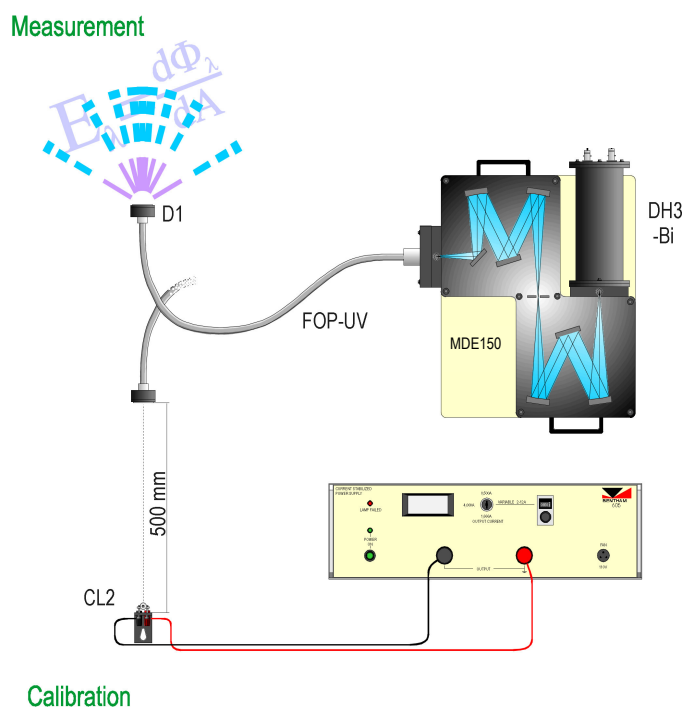
# UV Spectroradiometer

The ultimate accuracy of most spectroradiometric measurements is limited by the scattered light inside the instrumentation used. This is particularly so for many UV measurements especially health and safety related work. Bentham's family of double monochromator based systems are used in national measurement institutes, industry, hospitals, and universities, across the world for accurate UV spectral measurements.

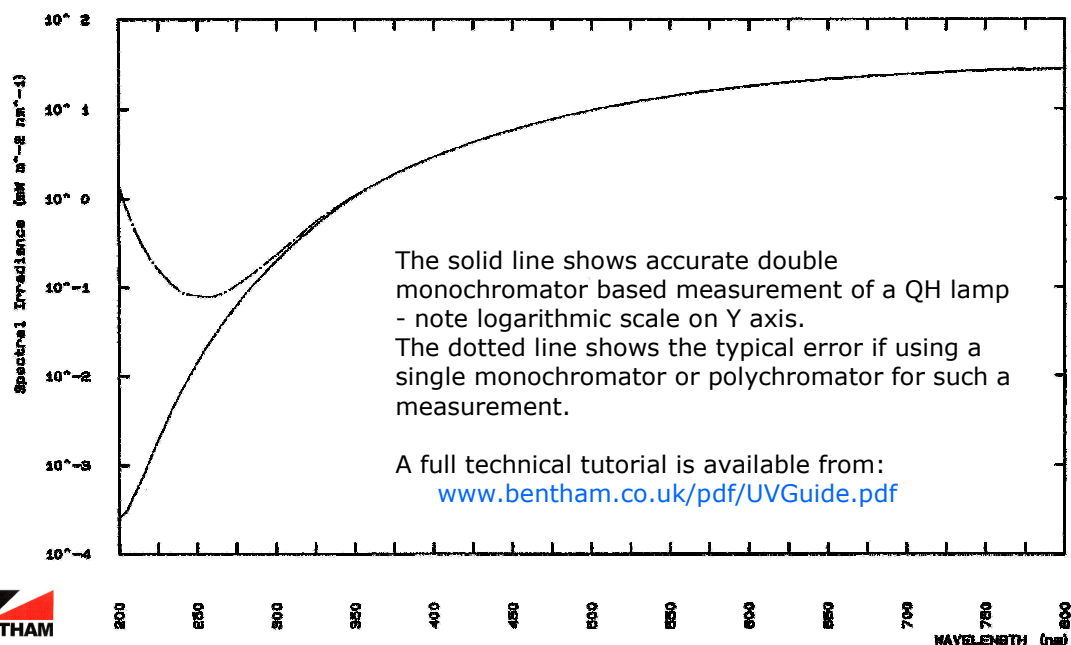


Typical applications include measurement of light sources employed in following:

- Type testing of sunbeds in accordance with EN60335-2-27
- Measurement of fluorescent tubes in accordance with EN61228
- Photostability of pharmaceutical products (ICH guidelines)
- Sun protection factor testing of sun cream (COLIPA SPF test method)
- Phototherapy light sources (PUVA and UV-B)
- Solar simulators
- Germicidal UV lamps
- UV curing and drying systems



Calibration



# Solar Irradiance



Since the Antarctic ozone hole was announced in 1985 (Farman et al.), Bentham has been a driving force in spectroradiometer developments for the measurement of solar irradiance.

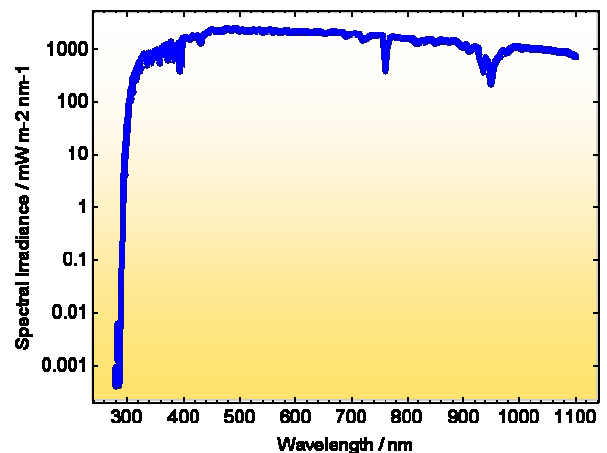
over the years, the solar measurement community have proven to be the most demanding in terms of system performance; the response of the community to Bentham's offering can be clearly seen in the number of Bentham systems deployed for the measurement of solar irradiance, from the Arctic Circle to the Antarctic.

Using either a compact DMc150 or a 600mm focal length DTMc300 double monochromator, with a fibre coupled cosine response input optic, the system can be run in unattended mode to record global solar irradiance spectra.

The Envirobox is a rugged, temperature controlled environment in which to house the spectroradiometer, providing laboratory accuracy in the field.

## Core Features

- Direct determination of global solar irradiance *in situ*
- Double monochromator based spectroradiometer
- Temperature-controlled Envirobox
- Environmentally-sealed cosine diffuser
- CL6-H enclosed spectral irradiance standard



Typical solar spectrum

## Options

- DMc150 monochromator for narrow range measurements; 280-600, 300-1100nm
- DTMc300 for wide range measurements 280-2500nm
- Measurement of diffuse solar irradiance, using **rotating shadow band**
- Measurement of direct solar irradiance with direct solar accessory and **solar tracker**



Rotating Shadow Band



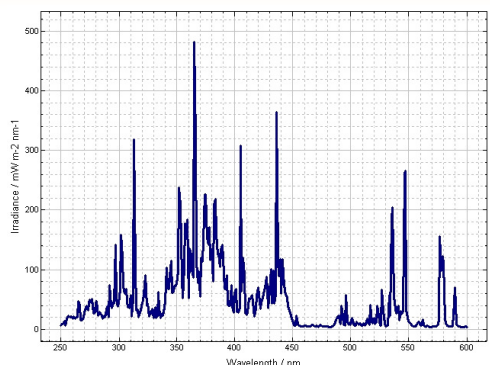
IS75-ODM

Solar Tracker



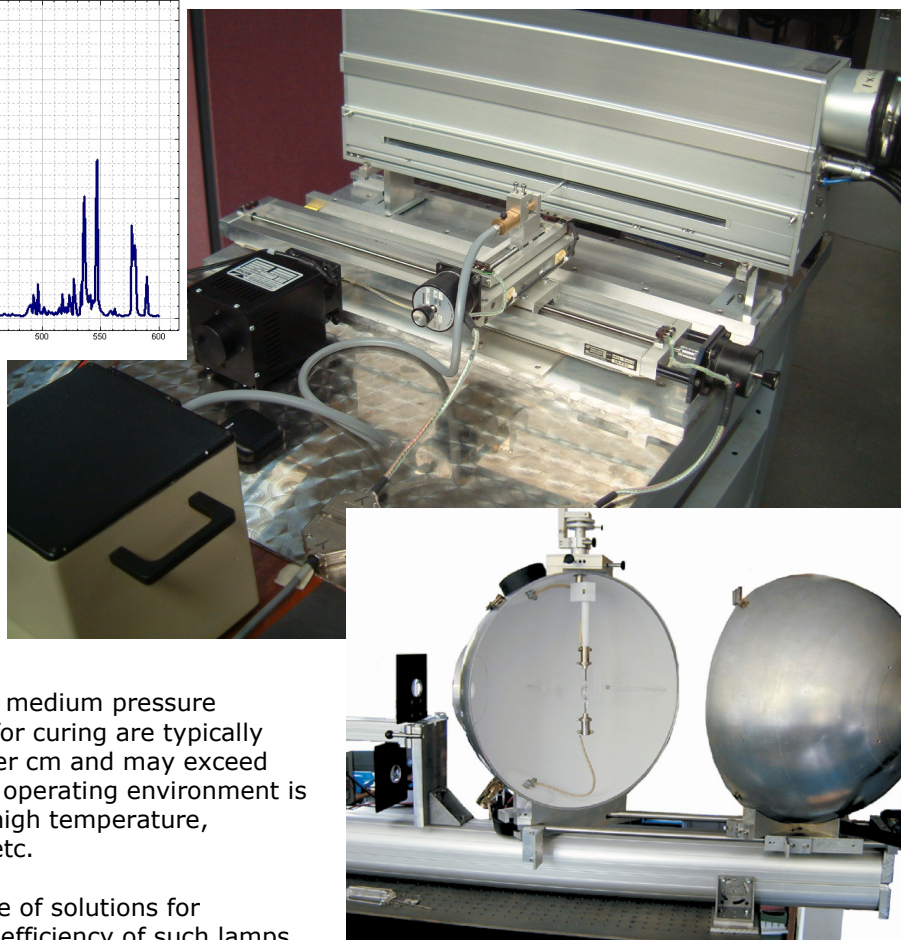


## High Intensity UV Systems



Accurate measurements of high intensity UV sources used in industrial processes such as UV curing/coating, reprographic equipment, water purification and air conditioning systems pose particular difficulties. For example, medium pressure mercury arc lamps used for curing are typically rated from 80 to 400W per cm and may exceed 2m in length. The lamps operating environment is usually very hostile e.g. high temperature, hazardous to operators, etc.

Bentham provides a range of solutions for measuring the functional efficiency of such lamps as well as accurately assessing health and safety issues. The pictures show a double monochromator based system with motorised x-y stage for mapping the UV irradiance of UV curing lamps and a system for measuring total flux of metal halide lamps.



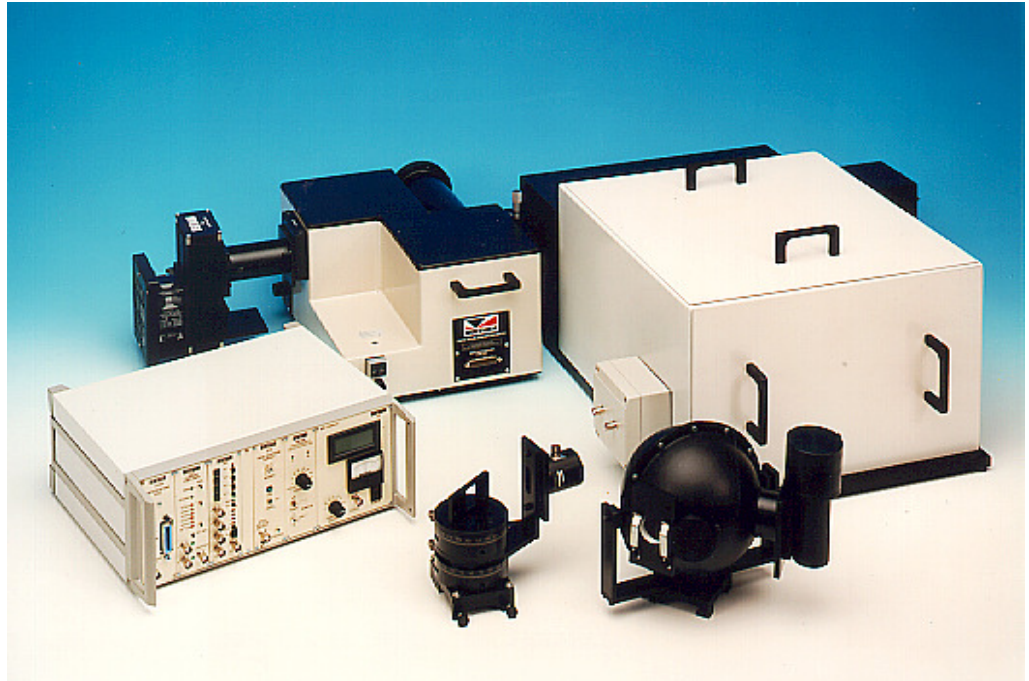
## Linear Tube Colour Uniformity Systems



The novel integrating sphere shown here determines the colour uniformity along the length of linear fluorescent tubes. Interchangeable 'jaws' accommodate T5 to T12 tube sizes. The measurement is performed with the CT3701 temperature-controlled 4-detector colorimeter.

Bentham also offers coating thickness gauges for fluorescent tubes.

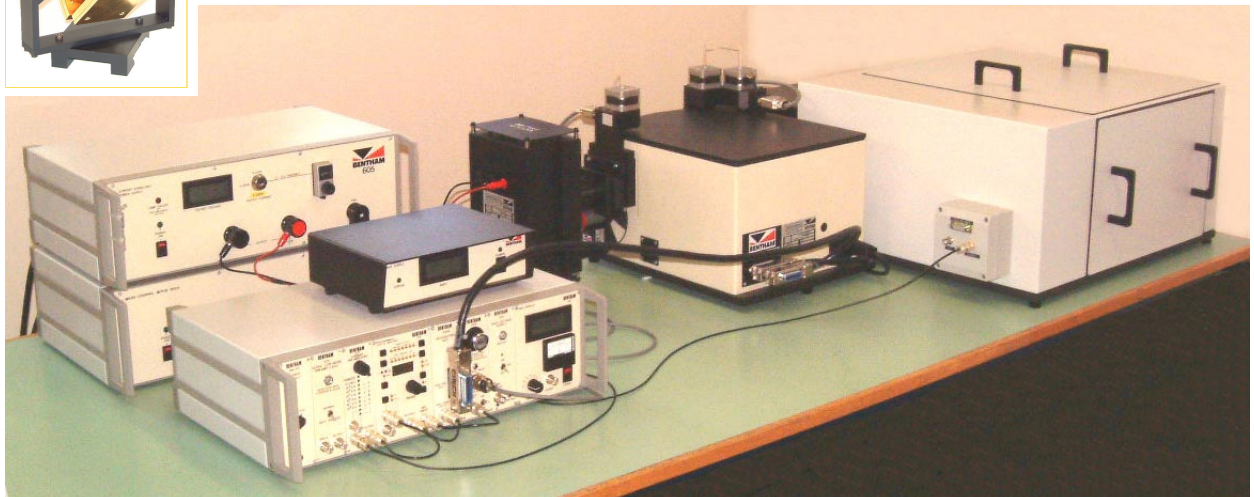
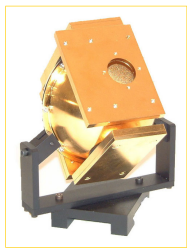
# Combined Spectroradiometer and Spectrophotometer System



Sometimes it can be beneficial to combine the requirements of a spectroradiometer and a spectrophotometer into a single system. This can be particularly true for specialist requirements such as UV or IR systems.

Above is shown a DMc150 double monochromator based system suitable for measurements over the wavelength range 180 - 1100nm. A fibre-coupled diffuser is employed for spectral irradiance measurements. Alternatively the UMS (universal measurement system) can be fitted with an integrating sphere for transmission measurements of scattering materials (i.e. lamp diffusers) or reflection of such samples. The UMS can also be fitted with a two axis goniometer for measuring specular reflectance at any angle (i.e. for reflector materials).

The fully automated, multiple grating TMc300 monochromator system shown below performs absolute and radiometric measurements over the wavelength range 1mm to 15mm. A gold-coated integrating sphere is used as the input optic for spectral irradiance measurements as well as inside the UMS for transmission/reflectance measurements. A lock-in amplifier based system is used in conjunction with a pyroelectric detector, peltier cooled PbS/PbSe detectors and liquid nitrogen cooled InSb and MCT offering a wide choice of wavelength range and sensitivities.

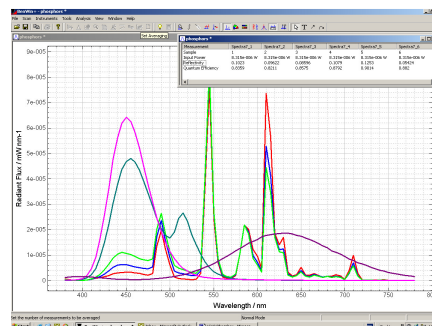




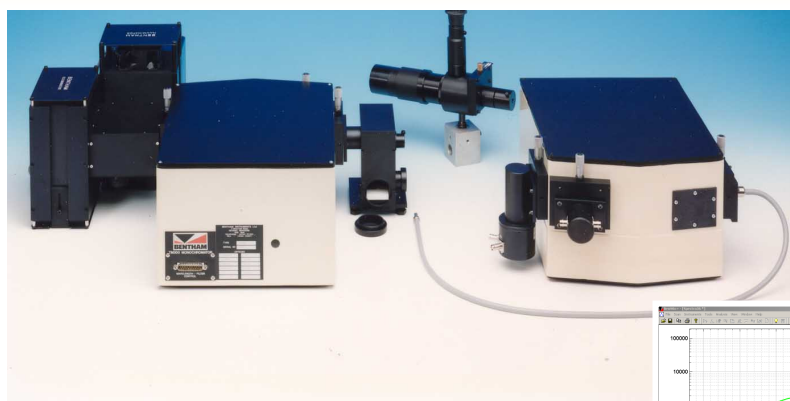
## Phosphor Quantum Efficiency System



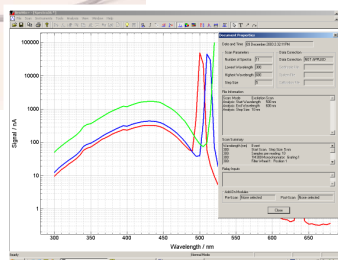
The above picture shows a system for determining the quantum efficiency of phosphor powder samples used in the lighting industry. Up to 6 samples can be loaded into the motorised carousel. A calibrated Hg source, with closed loop controller for necessary stability, is used to excite the phosphors. Significantly, the temperature of each sample can be heated to  $200^{\circ}\text{C} \pm 1^{\circ}\text{C}$  all under software control. A carefully designed integrating sphere is used to collect all of the emitted light which is measured by a spectroradiometer system. Besides quantum efficiency of the phosphors as a function of operating temperature the system also provides full spectral emission and chromaticity data.



## Phosphor Research System (excitation and emission analysis)



In order to fully characterise both excitation and emission spectra of phosphors, Bentham supplies a dual monochromator based system. Typically a dual excitation source comprising Xenon and quartz halogen lamps is fitted to the excitation monochromator and PMT, silicon and InGaAs detectors can be fitted to the emission monochromator, therefore both excitation and emission spectra can be measured from 200nm to beyond 1800nm.





## Filter-based Radiometer/Photometer Products

In addition to our extensive family of monochromator and polychromator based spectral measurement systems, we also offer a range of precision filter based radiometer products into our line of light measurement solutions.

The detector range includes:

- Precision photometric,  $f_1 < 3\%$
- General photometric,  $f_1 < 5\%$
- Scotopic,  $f_1 < 5\%$
- UV-A (320-400nm) radiometric
- UV-B (280-320nm) radiometric
- UV-C (254nm) radiometric
- UV-Erythema (250-400nm)
- Blue light hazard (400-520nm)

- Radiometric Visible
- Radiometric NIR

**DH-400-VL**

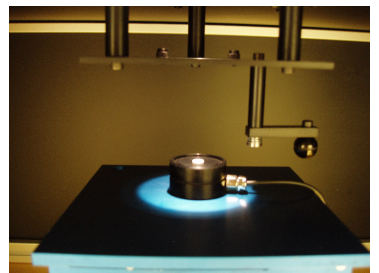


## Lux/Luminance Meter Calibrator



The calibration of illuminance and luminance meters requires appropriate sources of known, variable, optical output, and having a correlated colour temperature close to that of standard illuminant A, 2856K, as recommended by CIE 69.

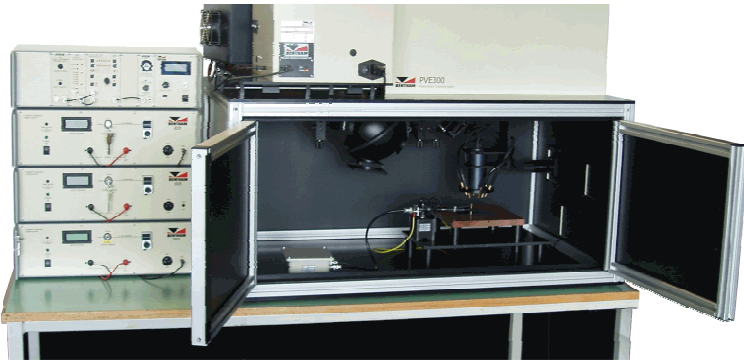
The illuminance/ luminance calibrator is a light-tight enclosure, housing standards of illuminance and luminance for the quick and accurate calibration of lux- and luminance-meters.



To the upper of the chamber is situated a quartz halogen based illuminance calibration source, using a combination of ND filters and measurement distance to achieve a calibration range of 20-20000lx.

To the side of the chamber is situated a quartz halogen integrating-sphere based standard of luminance, which, with a range of ND filters, provides a calibration range of 20-10000 cd m<sup>-2</sup>.

# PV Solar Cell Efficiency Testing



The PVE300 system is a monolithic, turnkey solution for both photovoltaic material and device research, and as part of a production-line quality process.

Flexible in use, and compatible with all types of photovoltaic devices, from silicon to 3rd generation devices, the PVE300 permits the quick and accurate determination of spectral response, EQE (IPCE) and IQE, over a range up to 200-2500nm.

## Product Highlights

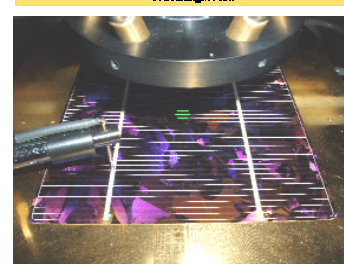
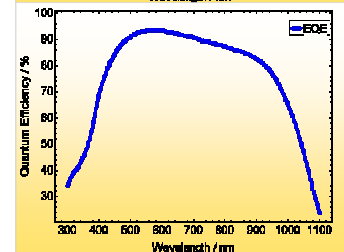
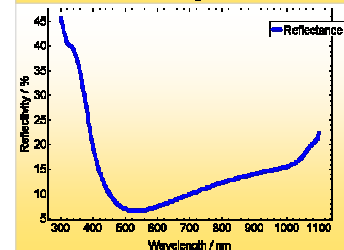
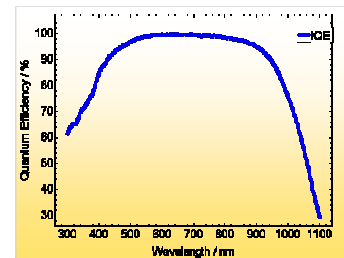
- Measure PV devices of all types– c:Si, mc:Si, a:Si,  $\mu$ :Si, CdTe, CIGS, CIS, Ge, dye-sensitised, organic, tandem, multi-junction, quantum well, quantum dots...
- Direct determination of spectral response (SR,  $A\ W^{-1}$ )
- Direct determination of external quantum efficiency EQE/IPCE, %)
- Integrating sphere-based determination of reflectance/ transmittance (R/T)
- Modify EQE by R/T to yield internal quantum efficiency (IQE, %)

## Core Features

- Chopped, monochromatic probe, 1-10mm diameter
- Wide range of operation 300-2500nm
- Purpose– built, light-tight measurement chamber
- 20x20cm temperature controlled vacuum mount
- Compatible with substrate, superstrate or packaged devices
- Transformer or Preamplifier & lock-in amplifier based detection
- Device operation in short circuit or voltage biased
- Modular design permitting facile future extension of capability
- Choice of single or multiple channel solar simulators
- Calibrated reference Si/Ge detectors





## Options

- Motorised x-y stage for device uniformity measurement/ photocurrent mapping
- Characterisation of fluorescent materials with addition of second monochromator



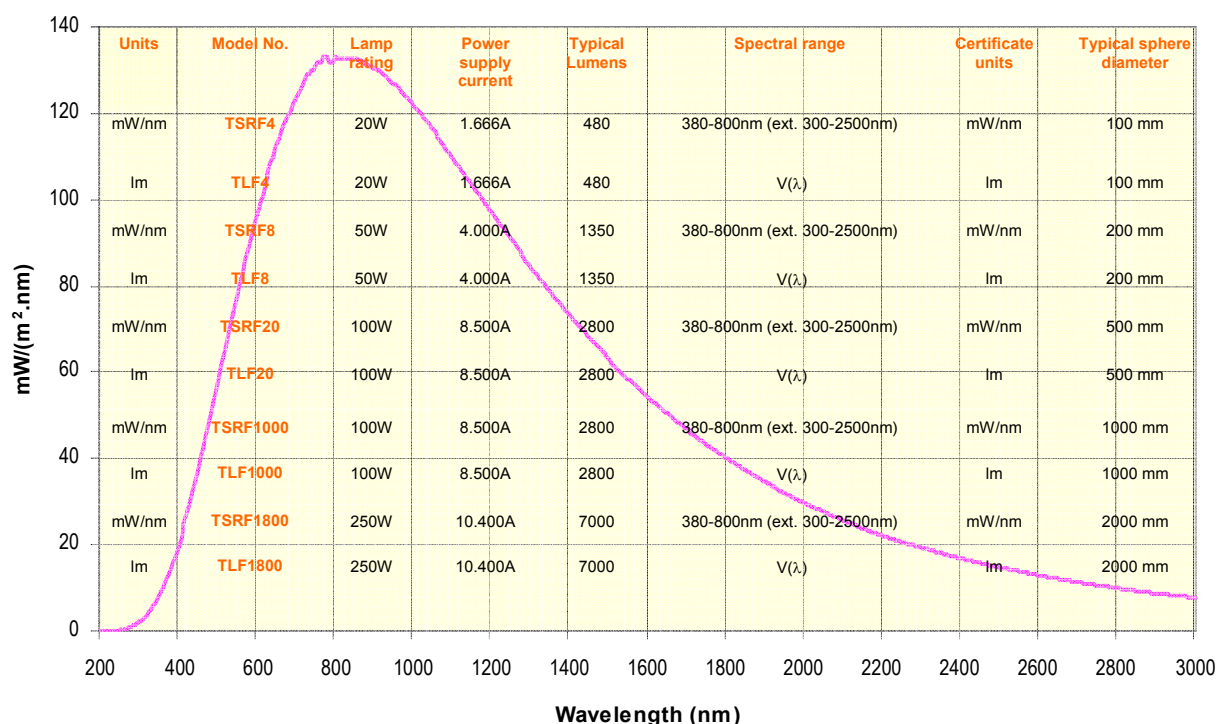
# Spectroradiometer Measurement Quantities

The optical quantity measured by a spectroradiometer system is determined by the input optic employed, as described in the table below. An appropriate calibration source is required in each case. Bentham manufactures spectroradiometers covering the spectral range 150nm to 30µm. All photometric, colorimetric, UV radiometric, etc. quantities are most accurately determined by performing spectroradiometric measurements and using software to integrate/weight values as defined by CIE etc. However, Bentham also supplies a range of filter based radiometers/photometers with close match spectral responses for simple integral type measurements.

Typical Input Optic	Measurement Quantity	Unit	Photometric Parameter	Photometric Unit
Diffuser 	Spectral irradiance	mW/(m <sup>2</sup> .nm)	Illuminance	lux
Telescope 	Spectral radiance	mW/(sr.m <sup>2</sup> .nm)	Luminance	cd/m <sup>2</sup>
Baffled tube 	Spectral radiant intensity	mW/(sr.nm)	Luminous intensity	cd
Integrating Sphere 	Spectral total radiant flux	mW/nm	Total luminous flux	lumens

## Calibration Standards

The accuracy of any spectroradiometric measurement can only be as good as that of the standard source used to calibrate the system. Bentham offers a range of standard lamps calibrated against an NPL calibrated version of the same product minimising measurement uncertainties. Alternatively, direct NPL, PTB, NIST etc. calibration can be supplied.



## Calibration Standards cont.

The **TSRFx series** of total spectral radiant flux standards are designed for use with integrating spheres with diameters ranging from 100mm to 2m. Standard calibration range is 380-800nm, but this can

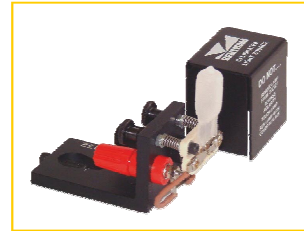


### **SRS8 Spectral Radiance/Luminance Standard, 380-800nm (ext. 300-2500nm)**



The SRS8 is a uniform source calibrated in spectral irradiance designed for routine calibration of spectroradiometers, telephotometers, luminance meters etc. It comprises a 200mm diameter integrating sphere with a 50mm diameter window (diffuser) and is easily mountable on all optical bench systems or flat surfaces.

### **CL2 Spectral Irradiance, 250-3000nm**



The CL2 is a universal spectral irradiance standard lamp for the calibration of spectro-radiometers, lux meters and radiometers. Its mounting bracket is compatible with all optical table and mounting

systems. Calibration distance is measured from a simple datum face plate.

### **CL3 UV Spectral Irradiance, 200-400nm**



The CL3 is a universal UV spectral irradiance standard lamp for the calibration of spectroradiometers and radiometers. It is housed in a metal enclosure with optical bench compatible mounting holes in the base. Calibration distance is set using a spacer bar supplied with the lamp.

The calibration is performed with respect to National Physical

### **CL6 Enclosed Spectral Irradiance, 200-3000nm**






The CL6 is a fully enclosed spectral irradiance standard lamp that greatly simplifies the calibration of spectroradiometers, lux meters and radiometers. It removes the need for a dark room, precision optical bench, and alignment tools associated with conventional calibration lamps.

Interchangeable adapters accommodate all Bentham's diffusers, photometric detectors and integrating spheres as well as many other devices. The system to be calibrated is simply 'plugged in' to a very reproducible location alleviating the need for any other positioning or alignment.

## Contact Us

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