Measuring LED Lamps Used for Applications in Horticulture

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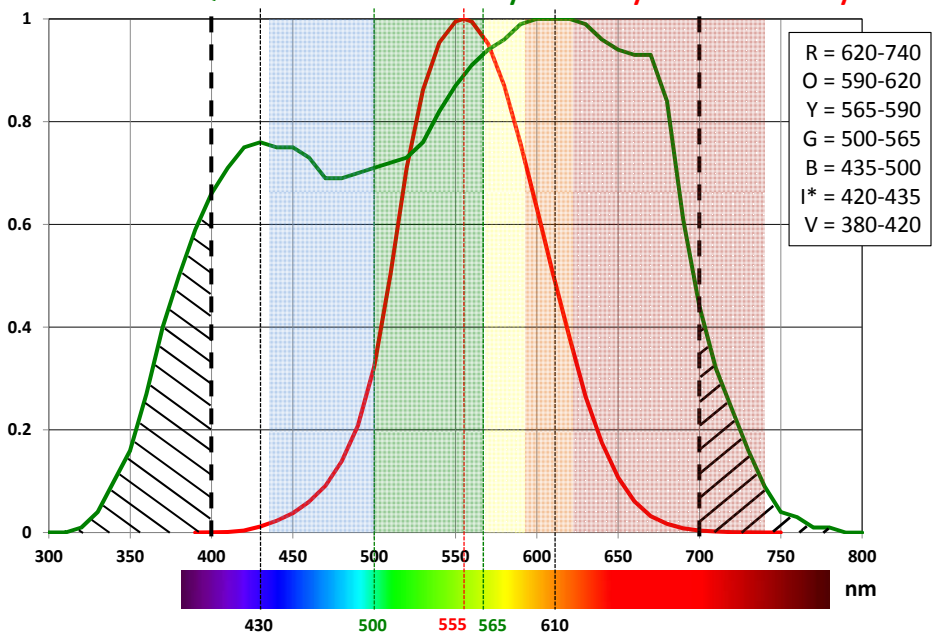
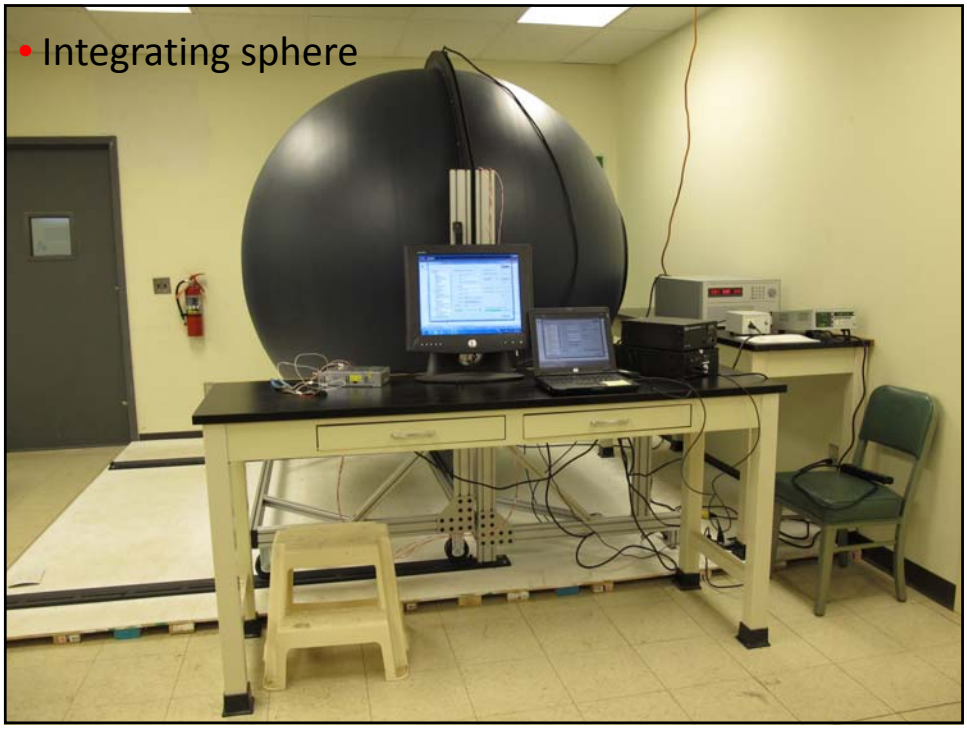
Relative Quantum Efficiency and Eye Sensitivity

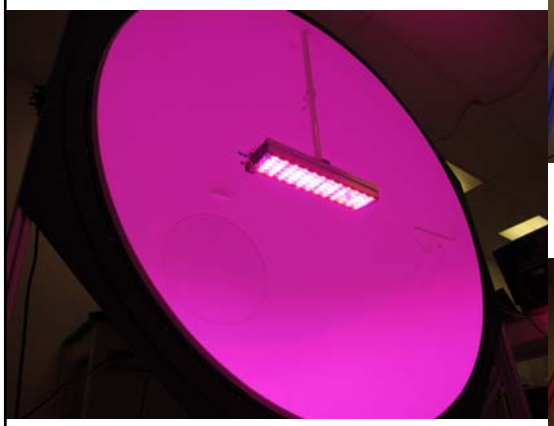


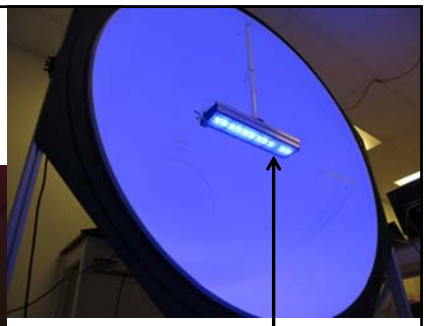
*Disputed (CRC Handbook of Fundamental Spectroscopic Correlation Charts. CRC Press, 2005)

- Instrumentation used
  - Integrating sphere (LabSphere, model Illumia 2100)
    - with spectroradiometer (model CDS 2100)
  - Power conditioner (Chroma, model 6415)
  - Power meter (Chroma, model 66202)
  - Spectroradiometer (StellarNet, model PS-300)
  - Datalogger (Campbell Scientific, model CR1000)
  - Darkroom with an adjustable mounting platform and a circular measurement area with a diameter of 2.4 m

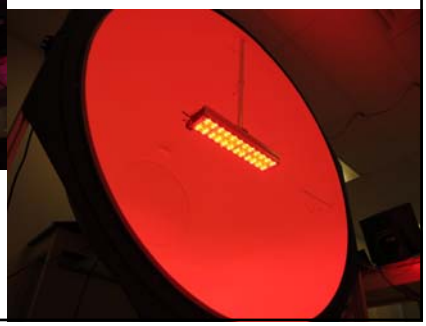


• Different color output

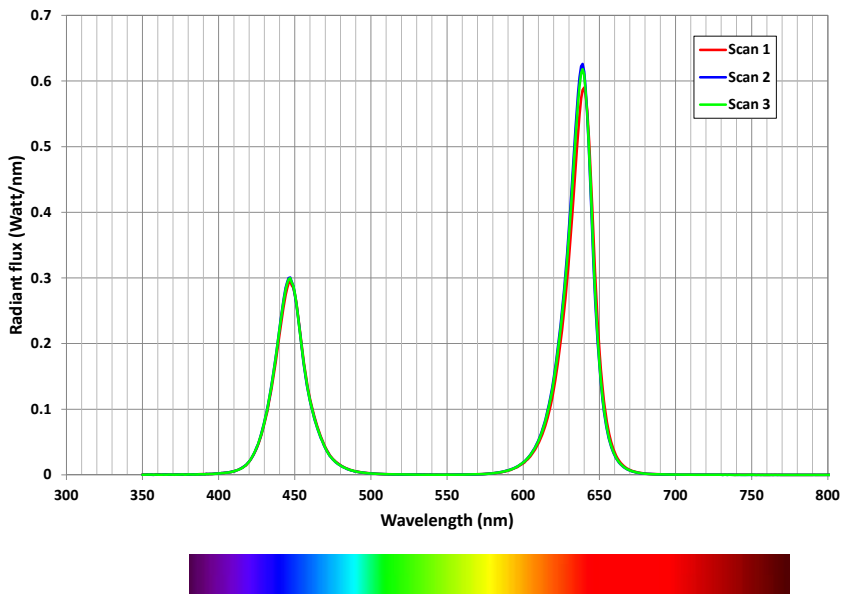




One blue LED off



- Spectral output (Lamp 2)



- Measured lamp characteristics (red and blue)

ORBITEC Tower Lamp	Lamp 1 (n = 1)	Lamp 2 (St. dev., n = 3)
Supply voltage (V)	120.01	119.98
Current draw (A)	1.79	1.83
Power (W*)	118.38	123.68
Power factor (-)	0.55	0.56
Radiant flux (350-1050 nm, W)	20.59	21.72 (0.30)
Luminous flux (lm)	2346	2395.7 (78.6)
Chromaticity x coordinate (-)	0.40	0.38
Chromaticity y coordinate (-)	0.14	0.13
Peak red wavelength (nm)	639	639
Peak blue wavelength (nm)	446	447
Correlated Color Temperature (K)	1155	1204.7 (13.6)
Efficacy (lm/W)	19.82	19.37
Efficiency (µmol/J)	0.829	0.832

* The lamps were powered by two external power supplies (48 and 5 Volt) that also powered the lamps' fans during testing. The power draw by the fan of the 48V power supply was excluded (i.e., the measurements were collected when that fan was not operating).

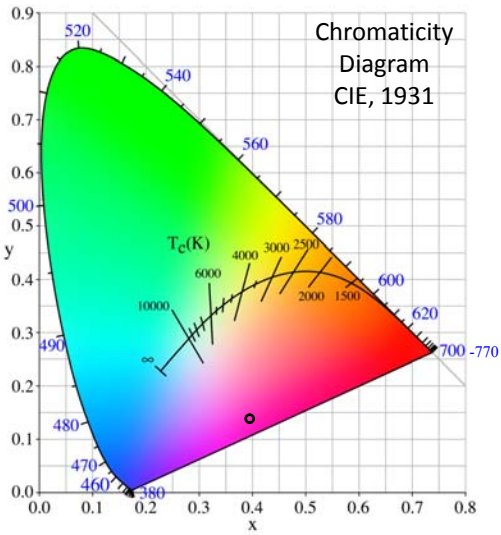
- Comparing efficiencies

Lamp type	Efficiency (µmol/J)
Ceramic MH, 315 W (n = 2)	1.38 - 1.46
HPS, 1000 W electronic ballast (n = 4)	1.30 - 1.70
HPS, 1000 W magnetic ballast (n = 2)	1.02 - 1.16
FL, 400 W induction (n = 1)	0.95
HPS, 400 W magnetic ballast (n = 1)	0.94
LED, combinations of red, white and blue (n = 10)	0.89 - 1.70
FL T8, 60 W (n = 1)	0.84
ORBITEC Tower Lamp (n = 2)	0.83

Source: Nelson, J.A. and B. Bugbee. 2014. Economic analysis of greenhouse lighting: Light emitting diodes vs. high intensity discharge fixtures. PLoS ONE 9(6):e99010.

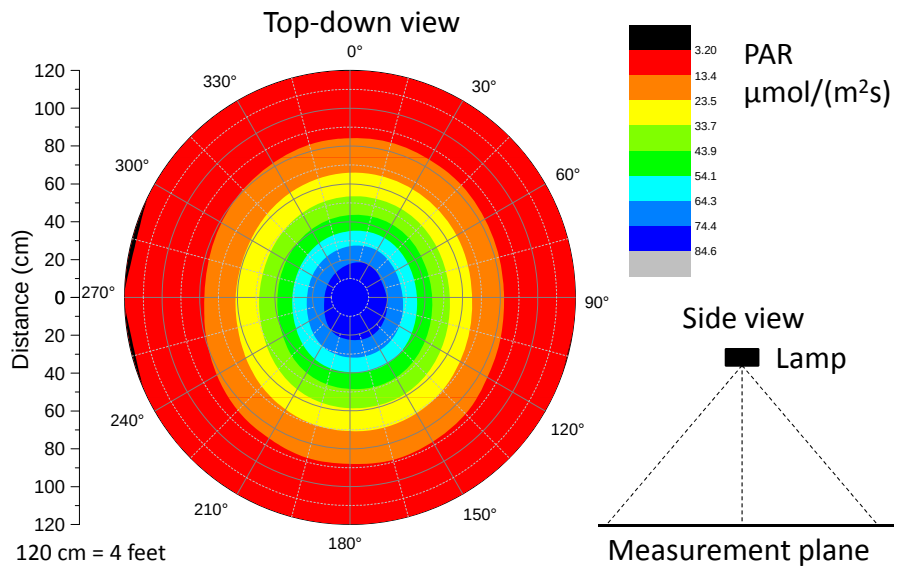
- Light colors

- Hues of colors are represented by x and y coordinates
- Color temperature: temperature of a black body that radiates a comparable hue
- 2,500-3,000K: warm
  4,000K: intermediate
  5,000-∞K: cool



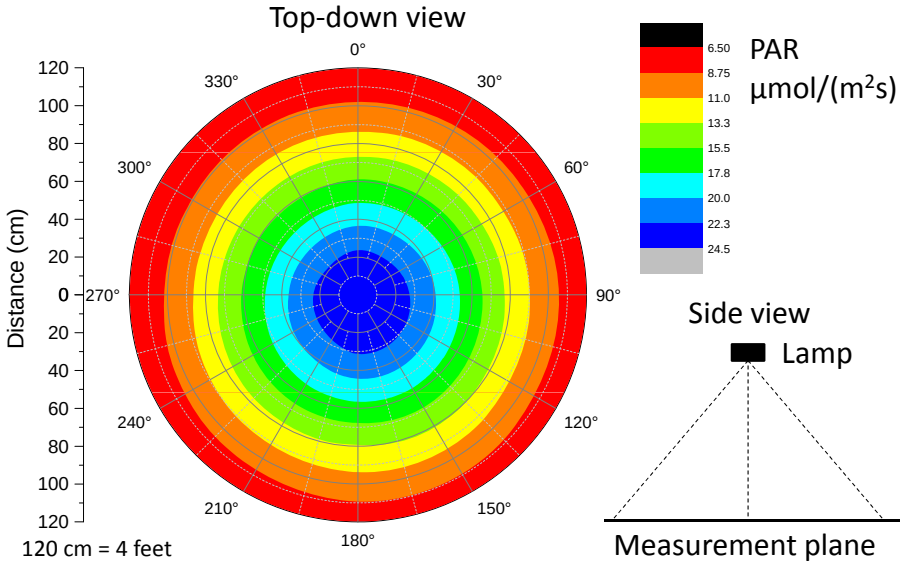
http://en.wikipedia.org

- Light distribution (at 2 feet mounting height)

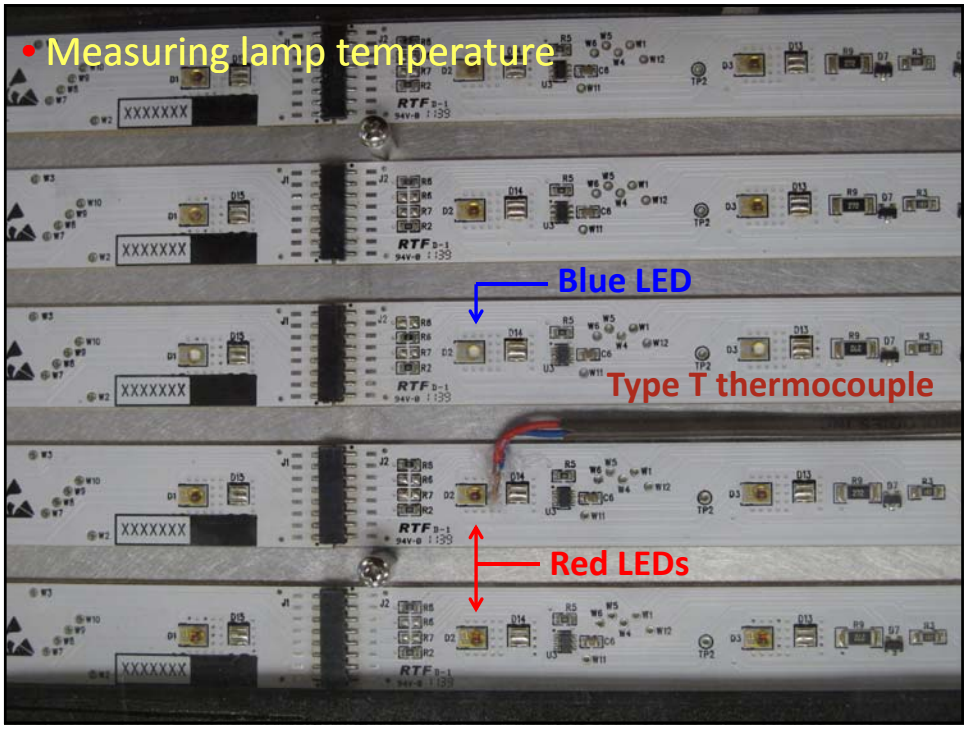


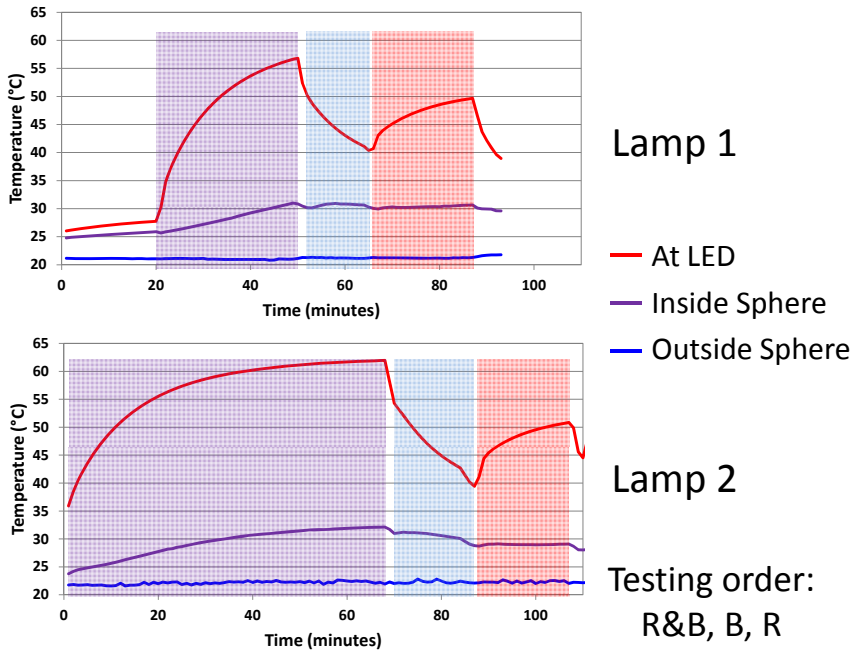
n = 97

- Light distribution (at 4 feet mounting height)



n = 97


Measuring lamp temperature
Blue LED
Type T thermocouple
Red LEDs


Temperature (°C)
Time (minutes)
Lamp 1
At LED
Inside Sphere
Outside Sphere
Lamp 2
Testing order:
R&B, B, R

- Additional observations
  - The ORBITEC Tower Lamp is equipped with a protective transparent cover that was left in place during our measurements
  - Our measurements included power consumption by the lamp fan and two external power supplies
  - Our integrating sphere is not temperature controlled. This could impact light output and prevents us from conducting L_{70} testing

- Conclusions
  - The (small) differences in luminous flux (lm), efficacy (lm/W) and efficiency (µmol/J) measured were likely due to the fact that Lamp 1 had one less operating blue LED
  - The measured efficacy and efficiency values are low compared to other LED and HID lamps
  - The light distribution from the rectangular lamp design (5 by 24 inches) produced regular cylindrical patterns at mounting heights of 2 and 4 feet
  - The temperature on the LED matrix rose to 62°C after the lamps were turned on for 60 minutes

Thank You!!!

Questions?

Specialty Crop Research Initiative LED Team:

with support from:

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National Institute of Food and Agriculture

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