Evaluating the Validity of LPM Lamp Radiant Flux Measurement Methods

Michael Grather
LightLab International Allentown, LLC
mike@LightLabAllentown.com

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LPM Lamp Measurement Working Group

Working Group of the UV Subcommittee of the IES Testing Procedures Committee

IES LM-94-XX *Approved Method: Optical and Electrical Measurements of Low-Pressure Mercury Discharge Lamps*

- WG Chair: Andy Jackson
- WG members: E. Bretschneider, J. Lockner , Y. Zong, M. Grather, R. Bergman, C. Bloomfield, K.C. Fletcher, C. Miller, D. Spicer
- Currently in “pre-Ballot” Review by the IES TPC

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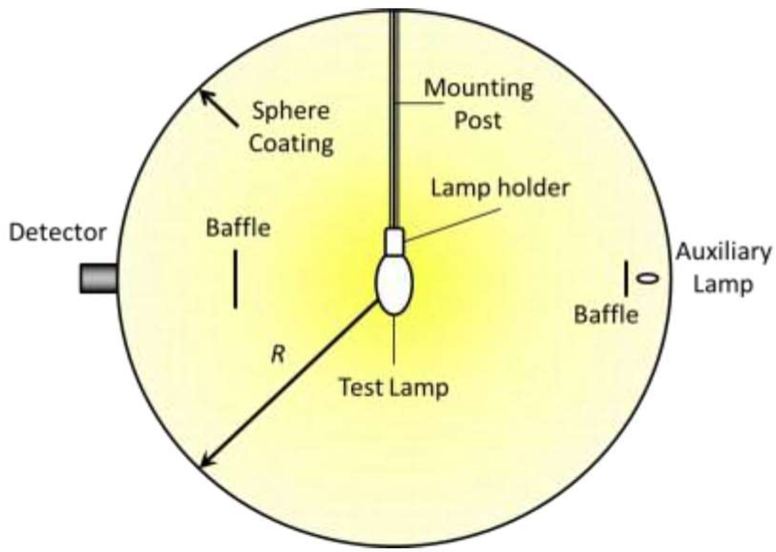
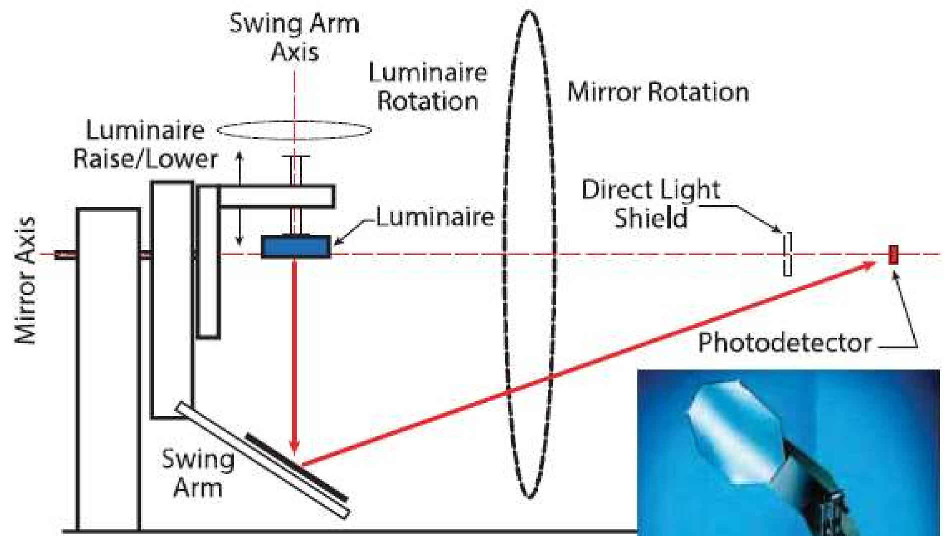
Radiant Flux Measurement Methods

Integrating Sphere and Full Goniometer Scan





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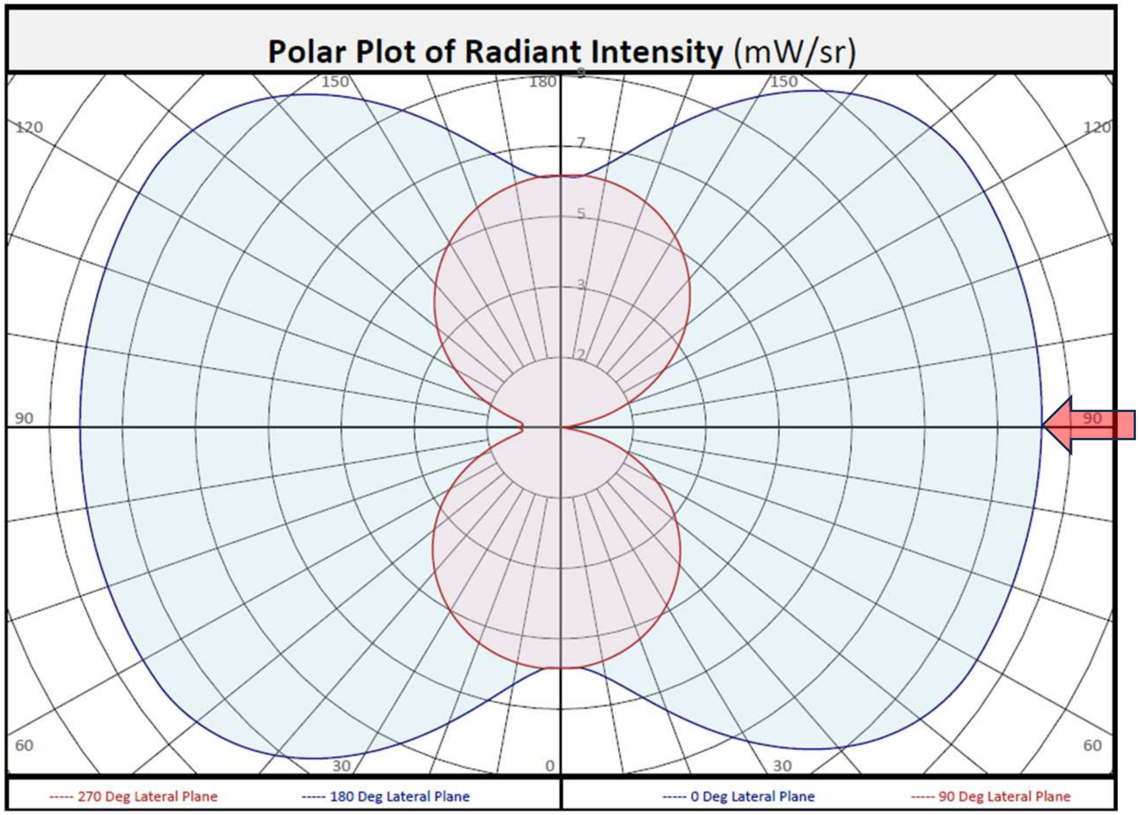
Twin-Tube LPM Lamp Radiant Flux Measurement
RCP Method (Discussion)

RCP (Rated CandlePower) Method
- Uses Full Intensity Scan
- Relationship between Intensity (red arrow) and Integrated Flux
- Reference vector needs to be clearly recorded



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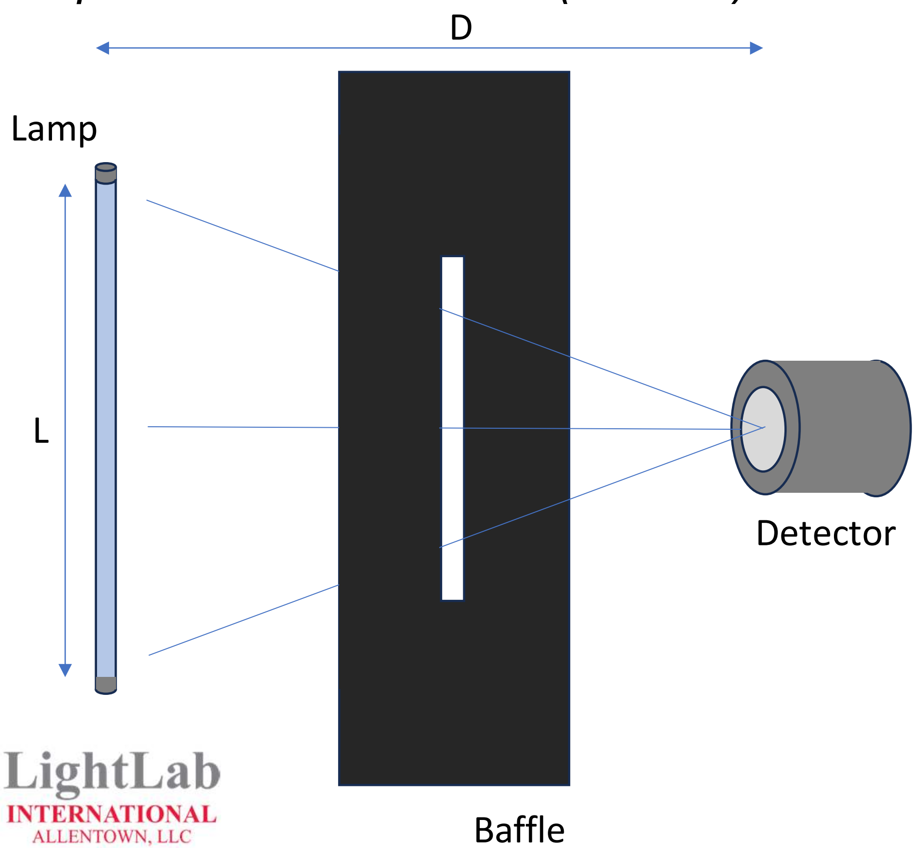
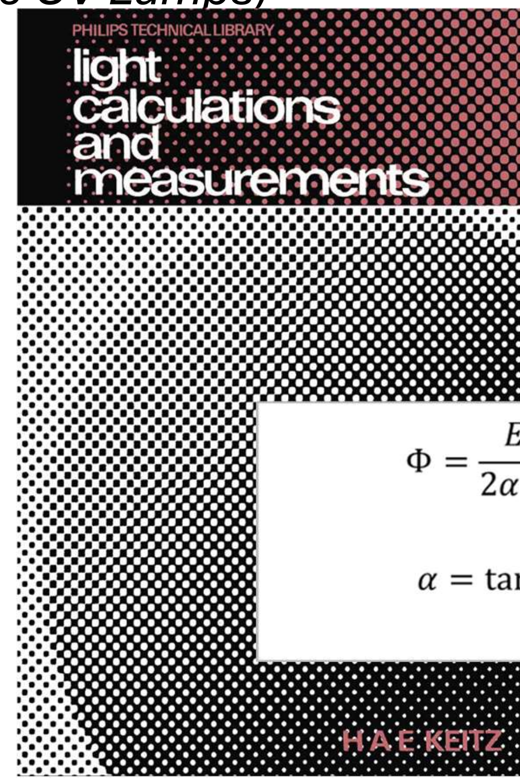
LPM Lamp Radiant Flux Measurement Methods

"Keitz" Method – O. Lawal, et al. (2008), IUVA *(Method for the Measurement of the Output of Monochromatic (254 nm) Low-Pressure UV Lamps)*





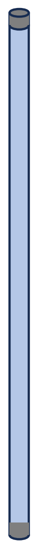
$$\Phi = \frac{E2\pi^2 DL}{2\alpha + sin2\alpha}$$

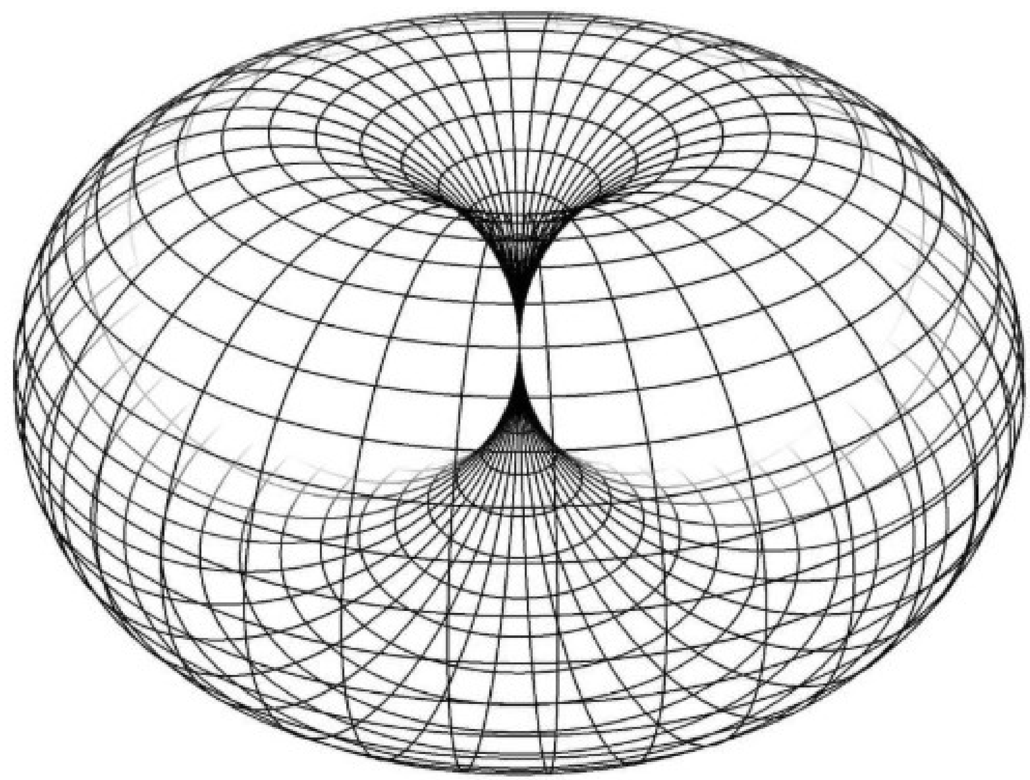
$$\alpha = \tan^{-1}\left(\frac{L}{2D}\right)$$

H. A. E. Keitz, 1971

LPM Lamp Radiant Flux Measurement Methods

“Keitz” Method





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LPM Lamp Radiant Flux Measurement Methods

“Keitz” Method

Advantages:

- Fast measurement time
- Able to accurately measure lamp during warm-up period
- Mitigates uncertainty by modeling nearfield effects (allowing closer measurements for larger lamps).

Potential limits to applicability including:

- assumptions of cosine intensity distribution
- cosine response of detector
- Only for rotationally symmetric linear lamps

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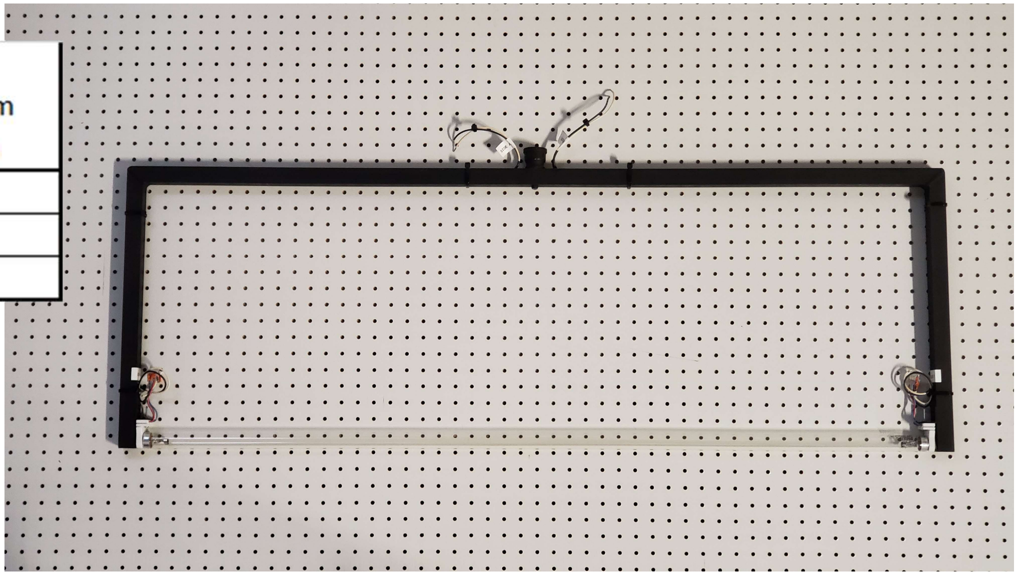
LPM Lamp Radiant Flux Measurement Methods
Linear LPM Lamp Measurement (Keitz Method)

Lab Measurements:

Keitz Formula Calculations for Radiant Power at distance

4’ T8 LPM Linear Lamp (1.127m Luminous Length)

Distance (m)	Measured Irradiance (W/m2 UV-C)	Keitz Flux (W)	Percent of 3m Calculation
1.00	1.403	16.59	-1.4%
3.00	0.1850	16.82	0.0%
5.00	0.06904	17.18	2.1%



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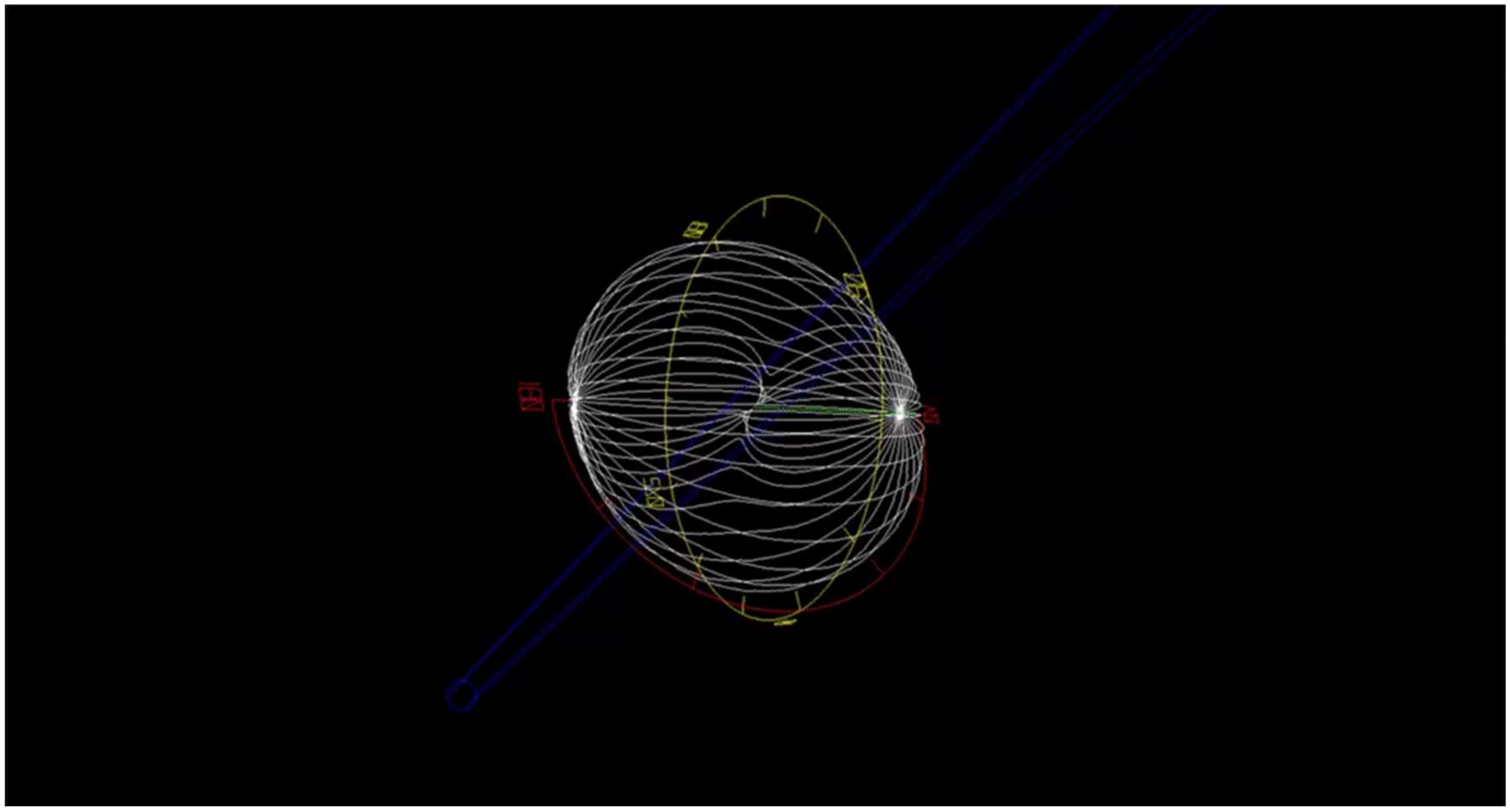
LPM Lamp Radiant Flux Measurement Methods
Linear LPM Lamp Measurement (Full Gonio Scan)

Integrated Gonio Measurements for Radiant Power (9.5m test distance)

4’ T8 LPM Linear Lamp (1.127m Luminous Length)

10 degree lateral inc., 0.5 degree vertical inc., two hemispheres.



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LPM Lamp Radiant Flux Measurement Methods

Linear LPM Lamp Measurement (Full Gonio vs Keitz Comparison)

Distance (m)	Measured Irradiance (W/m2 UV-C)	Keitz Flux (W)	Percent of 3m Calculation
1.00	1.403	16.59	-1.4%
3.00	0.1850	16.82	0.0%
5.00	0.06904	17.18	2.1%

Integrated Gonio Measurements	16.47W	-2.1%

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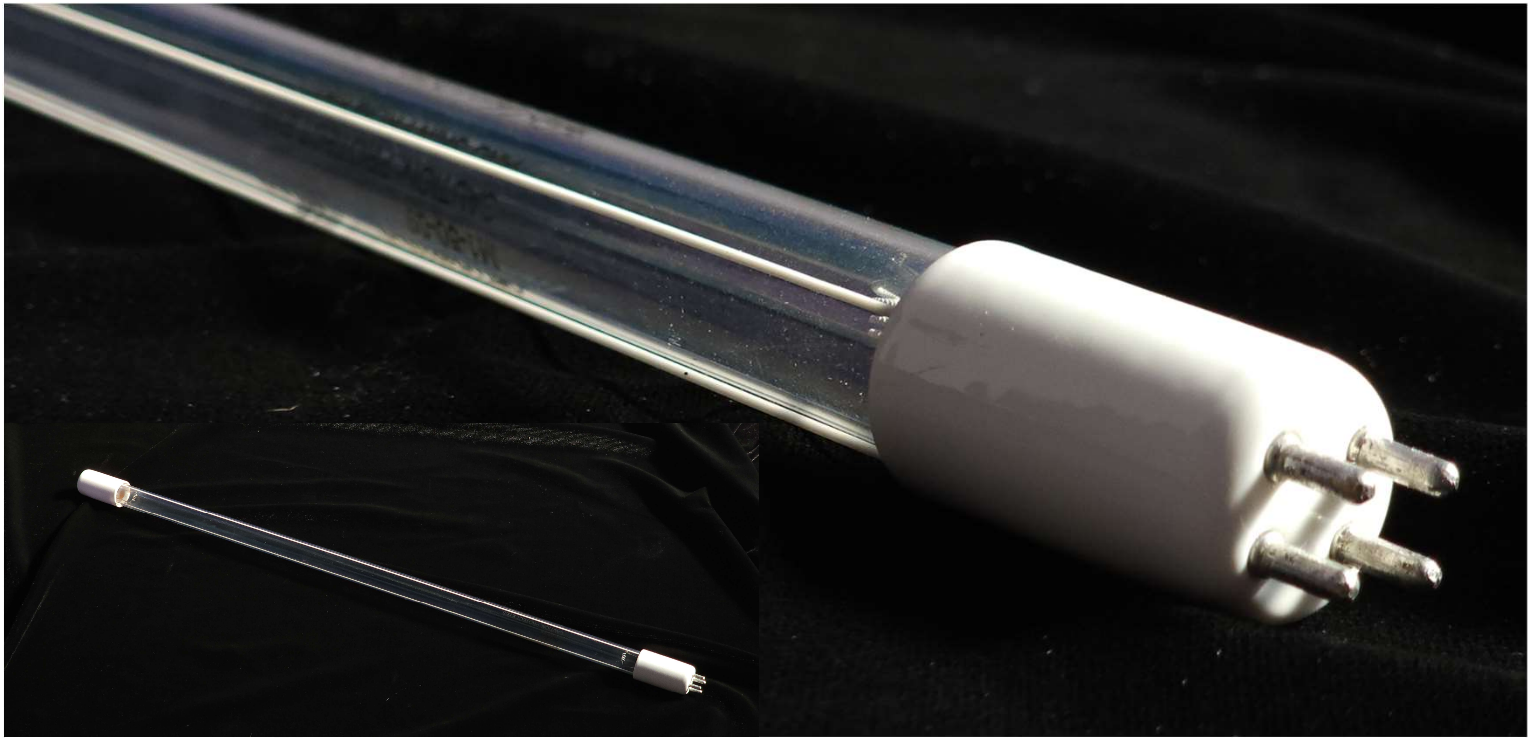
Single-Ended Linear LPM Lamp Radiant Flux Measurement

Single-Ended Linear LPM Lamp



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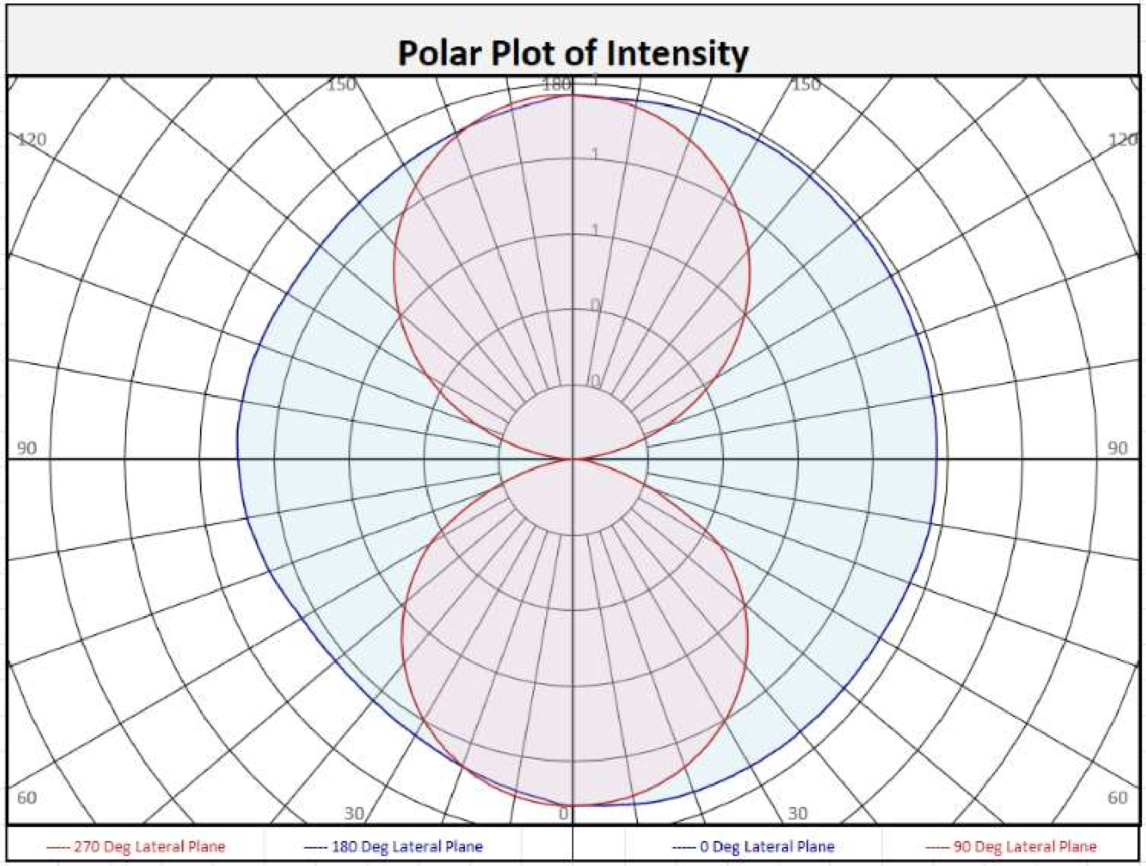
Single-Ended Linear LPM Lamp Radiant Flux Measurement

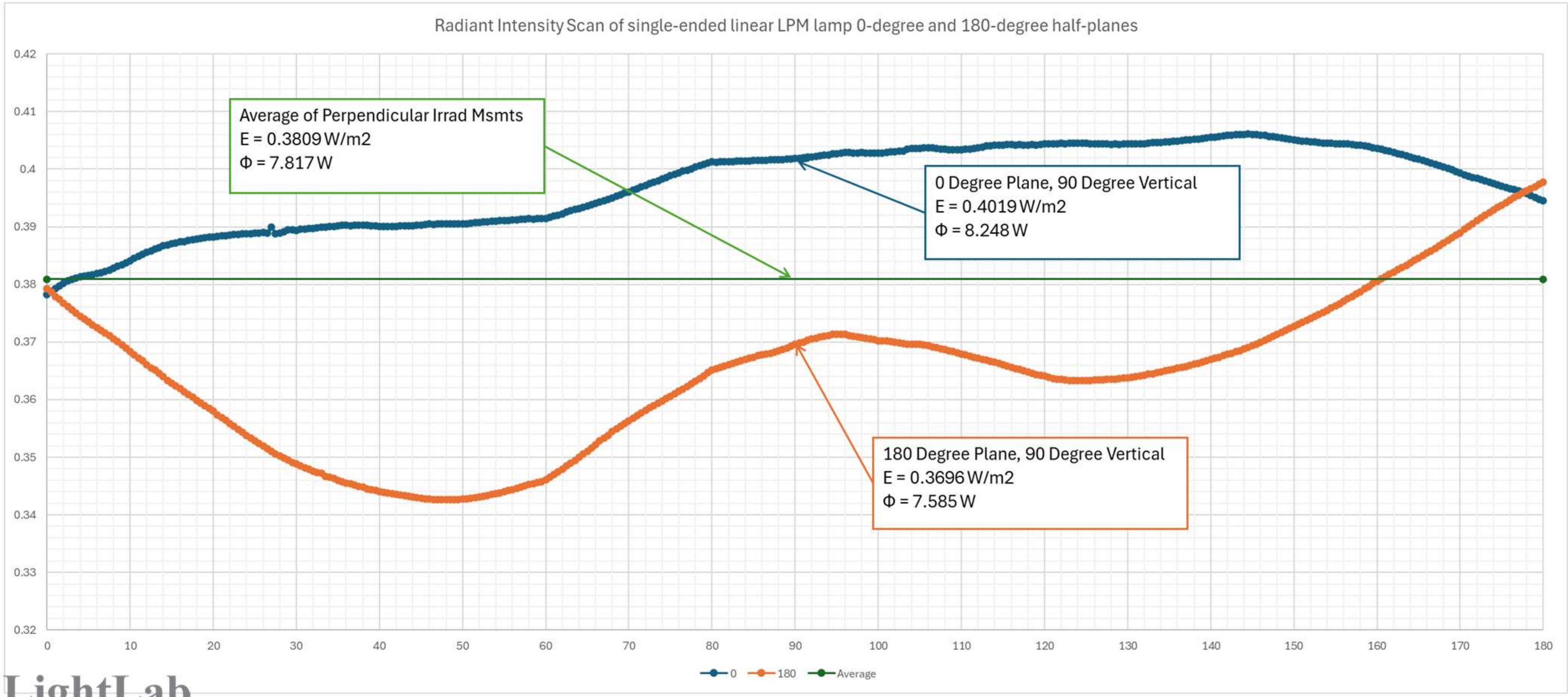
Full Goniometer Scan

Full Intensity Scan
10 degree Lateral Inc.,
0.5 degree Vertical Inc.



Single-Ended Linear LPM Lamp Radiant Flux Measurement

Two Half-Planes (0 deg and 180 deg) From Full Intensity Scan



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Single-Ended Linear LPM Lamp Radiant Flux Measurement
Full Gonio vs Keitz Comparison

	Irradiance (W/m2)	Radiant Flux (W)	Radiant Efficiency	Percent from Full Scan Method	Percent from 0L, 90V Keitz Method
Full Intensity Integration	n/a	7.693	33.3%	0.0%	-6.7%
0 deg Plane, 90 deg Vertical	0.4019	8.248	35.7%	6.7%	0.0%
180 deg Plane, 90 deg Vertical	0.3696	7.585	32.9%	-1.4%	-8.0%
Average of 0-180 deg plane measurements	0.3809	7.817	33.9%	1.6%	-5.2%

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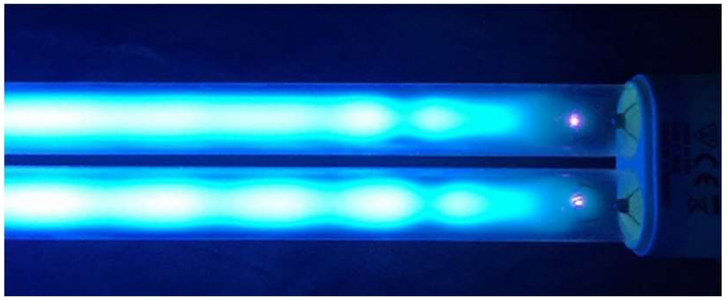
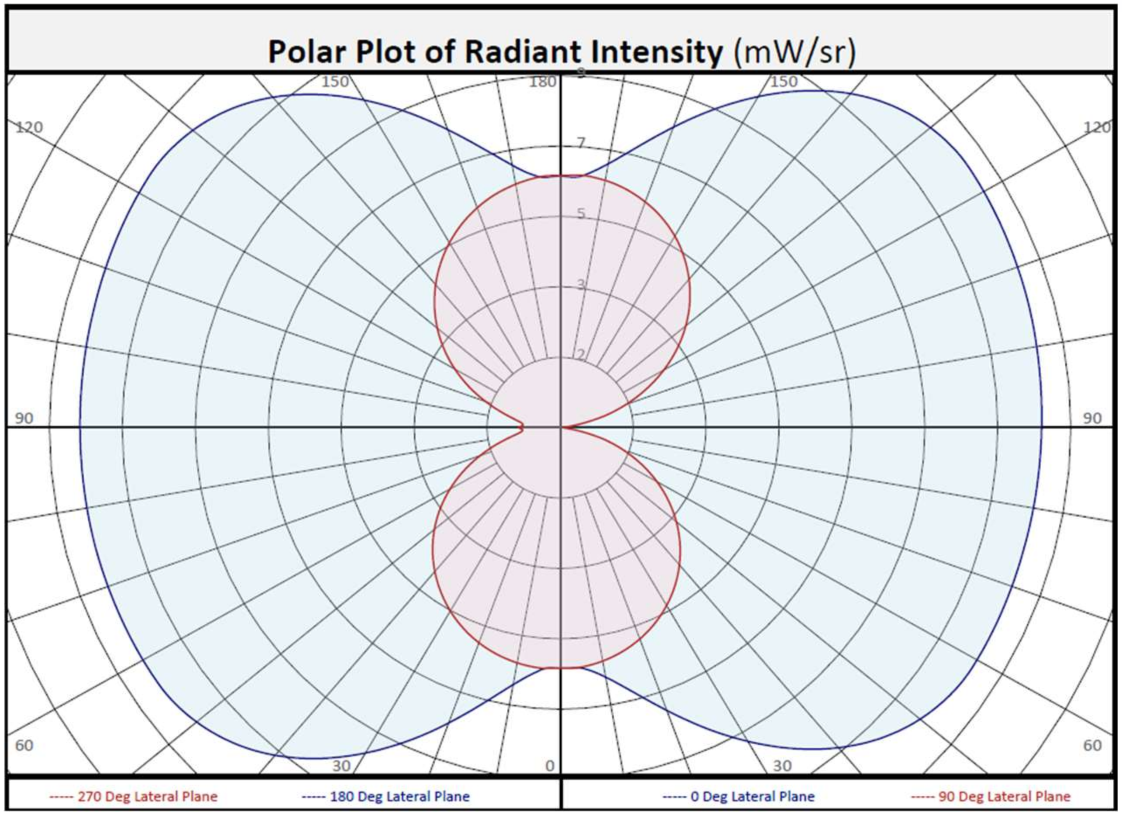
Twin-Tube LPM Lamp Radiant Flux Measurement
Full Goniometer Scan



Full Intensity Scan
10 degree Lateral Inc.,
0.5 degree Vertical Inc.



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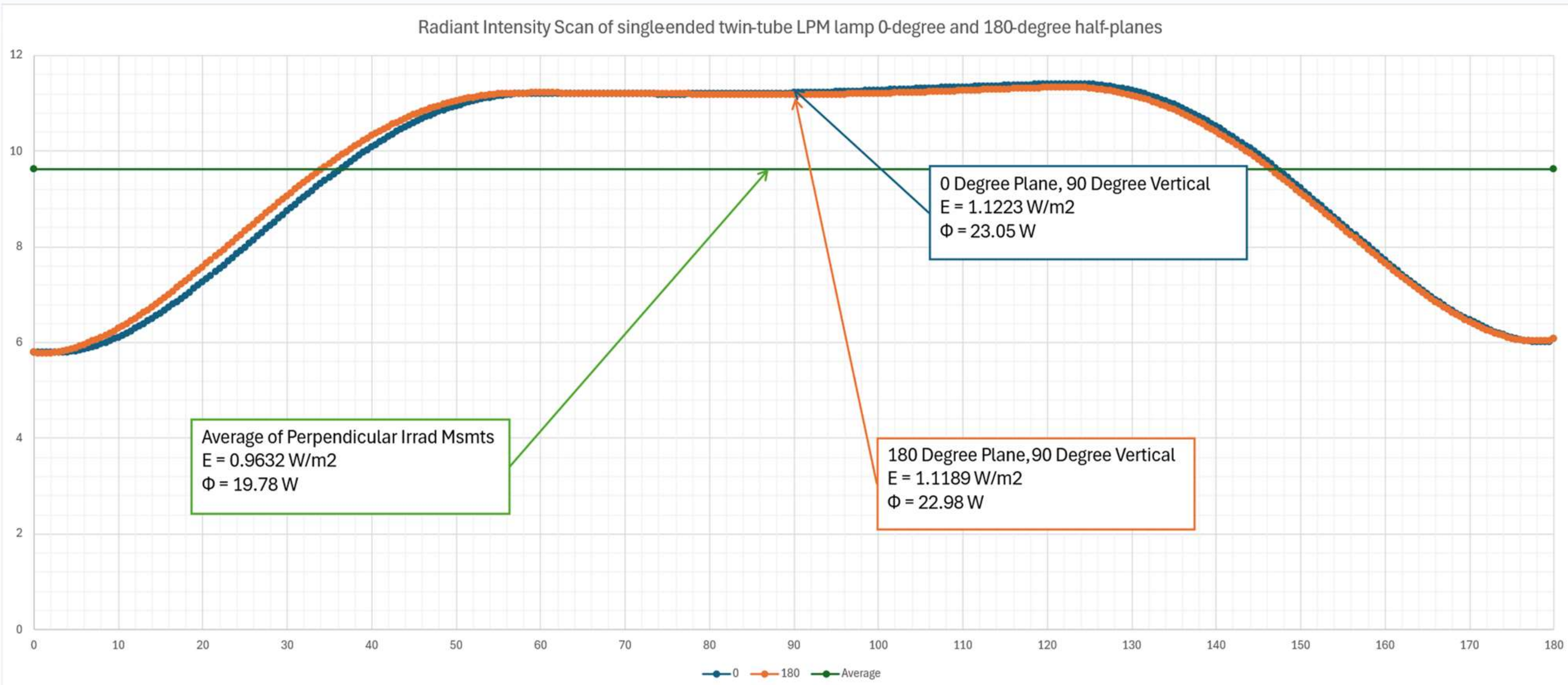
Twin-Tube LPM Lamp Radiant Flux Measurement

Keitz Method (Single point and averaged)



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Twin-Tube LPM Lamp Radiant Flux Measurement

Full Gonio vs Keitz Comparison

	Irradiance (W/m2)	Radiant Flux (W)	Radiant Efficiency	Percent from Full Scan Method	Percent from 0L, 90V Keitz Method
Full Intensity Integration	n/a	19.42	n/a	0.0%	-15.7%
0 deg Plane, 90 deg Vertical	1.1223	23.05	n/a	15.7%	0.0%
180 deg Plane, 90 deg Vertical	1.1189	22.98	n/a	15.5%	-0.3%
Average of 0-180 deg plane measurements	0.9632	19.78	n/a	1.8%	-14.2%

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Conclusions

Rotationally Symmetric Linear Lamps can be measured using:

- Full Gonioradiometric Scan
- Keitz Method (within appropriate distance)

Non-Rotationally Symmetric Linear Lamps can be measured using:

- Full Gonioradiometric Scan
- Rotationally Averaged Keitz Method
- RCP method

Non-Rotationally Symmetric Lamps can be measured using:

- Full Gonioradiometric Scan
- Rotationally Averaged Keitz Method
- RCP method

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Thank You!

Michael Grather
LightLab International Allentown, LLC
mike@LightLabAllentown.com

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