

Angular Response Measurements of a Bentham DMc150 Spectroradiometer

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Spectroradiometers & Radiometers



Calibration

◆ Correct for errors

- Human: Poor calibration procedures, improper maintenance, stray light from poor technique, inaccurate lamp orientation
- Equipment: Non-linearity, aging, directional response, temperature

◆ Evaluate remaining uncertainty

Spectroradiometer Response

◆ Depends on:

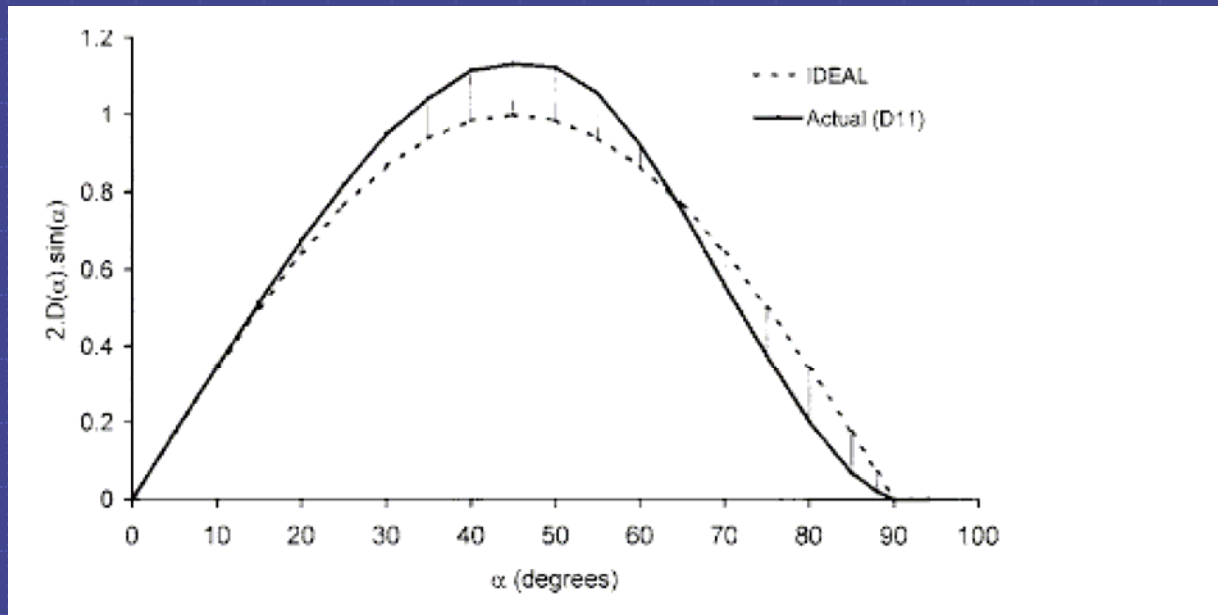
- Direction of incident radiation
- Temperature of Photomultiplier Tube
- Uniformity of irradiation

◆ Spectroradiometer used for a range of different source geometries

◆ Ideal Cosine response

Angular Response

f_2 error: quantifies the quality of the spectroradiometers directional evaluation of the incident radiation



Pye, S.D. and Martin, C.J.: A study of the directional response of ultraviolet radiometers.

f_2

$$f_2(\varepsilon, \varphi) = \frac{R_{reading}(\varepsilon, \varphi)}{R_{reading}(\varepsilon = 0) \cos \varepsilon} - 1$$

$$f_2(\%) = \int_{\varepsilon=0}^{1.309} |f_2(\varepsilon)| \sin 2\varepsilon d\varepsilon$$

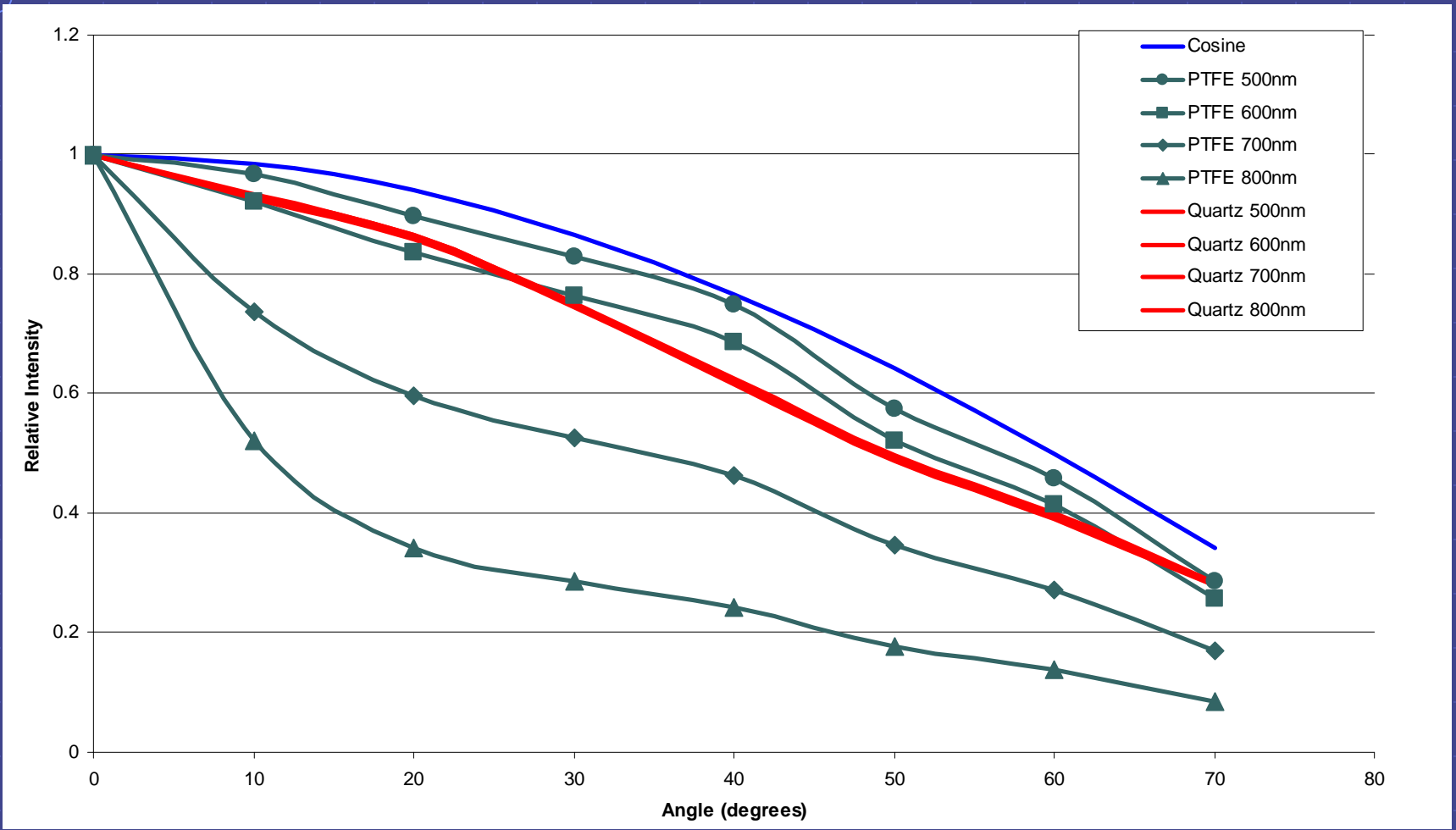
Background

- ◆ Yearly calibration of our Bentham DMc150 spectroradiometer
- ◆ Two calibrated lamps
 - Bentham CL3 30W deuterium lamp
 - Bentham CL2 100W quartz halogen lamp
- ◆ Two diffusers
 - PTFE diffuser
 - Quartz diffuser

UV Radiometer Calibration

Lamp \ Diffuser	PTFE	Quartz
Deuterium Lamp	$200 < \lambda < 325$	-
Quartz Halogen Lamp	$325 < \lambda < 600$	$600 < \lambda < 800$

Angular Response of PTFE and Quartz Diffusers



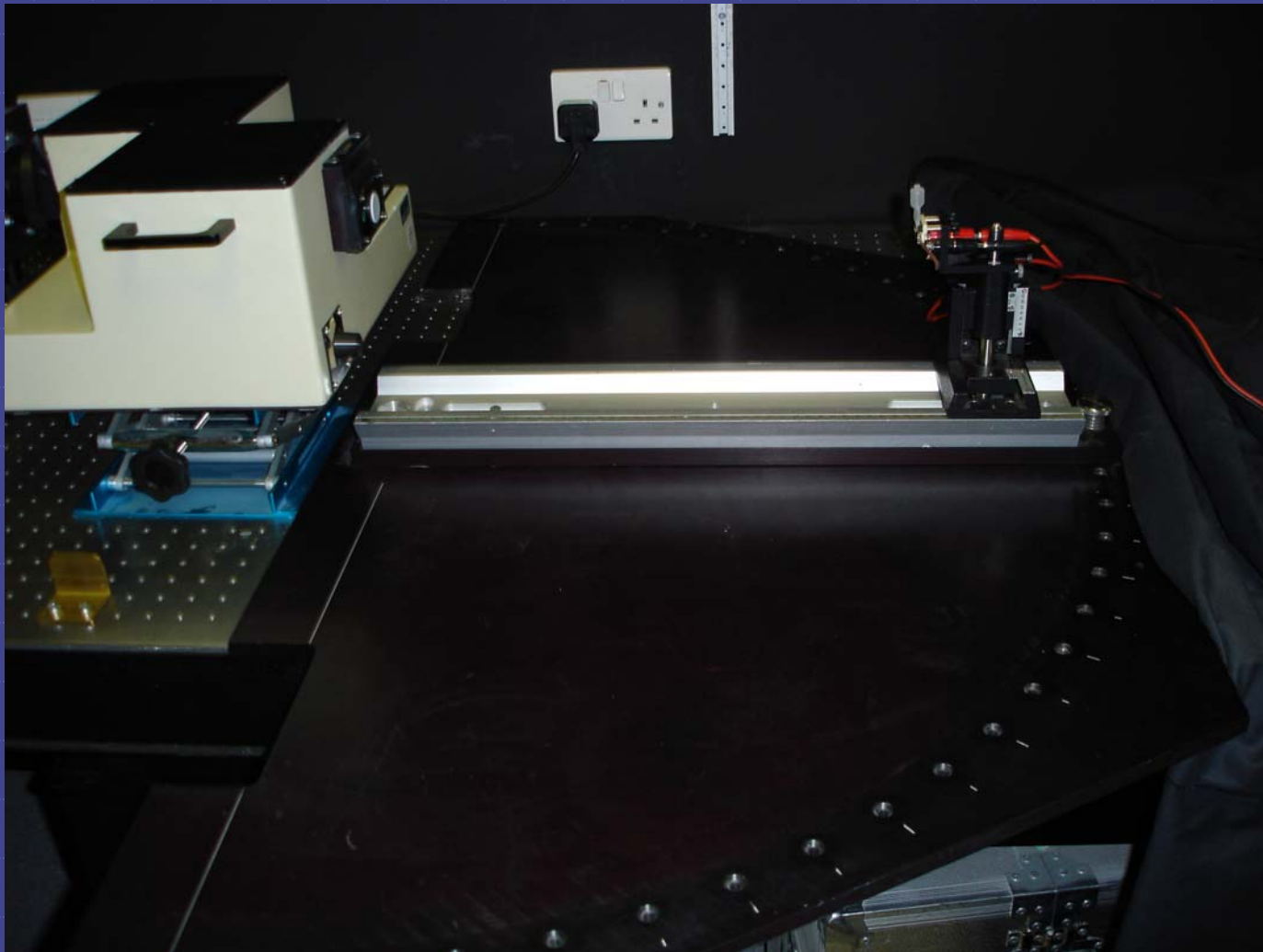
Angular Response Measurements

- ◆ Bentham DMc150 Spectroradiometer
- ◆ PTFE/Quartz diffuser
- ◆ Quartz Halogen Lamp
- ◆ Angular "Jig"
 - ◆ Distance = 50cm
 - ◆ Vertical Alignment
 - ◆ Horizontal
 - $\pm 0^\circ - 75^\circ$
 - ◆ Vertical
 - $\pm 0^\circ - 70^\circ$

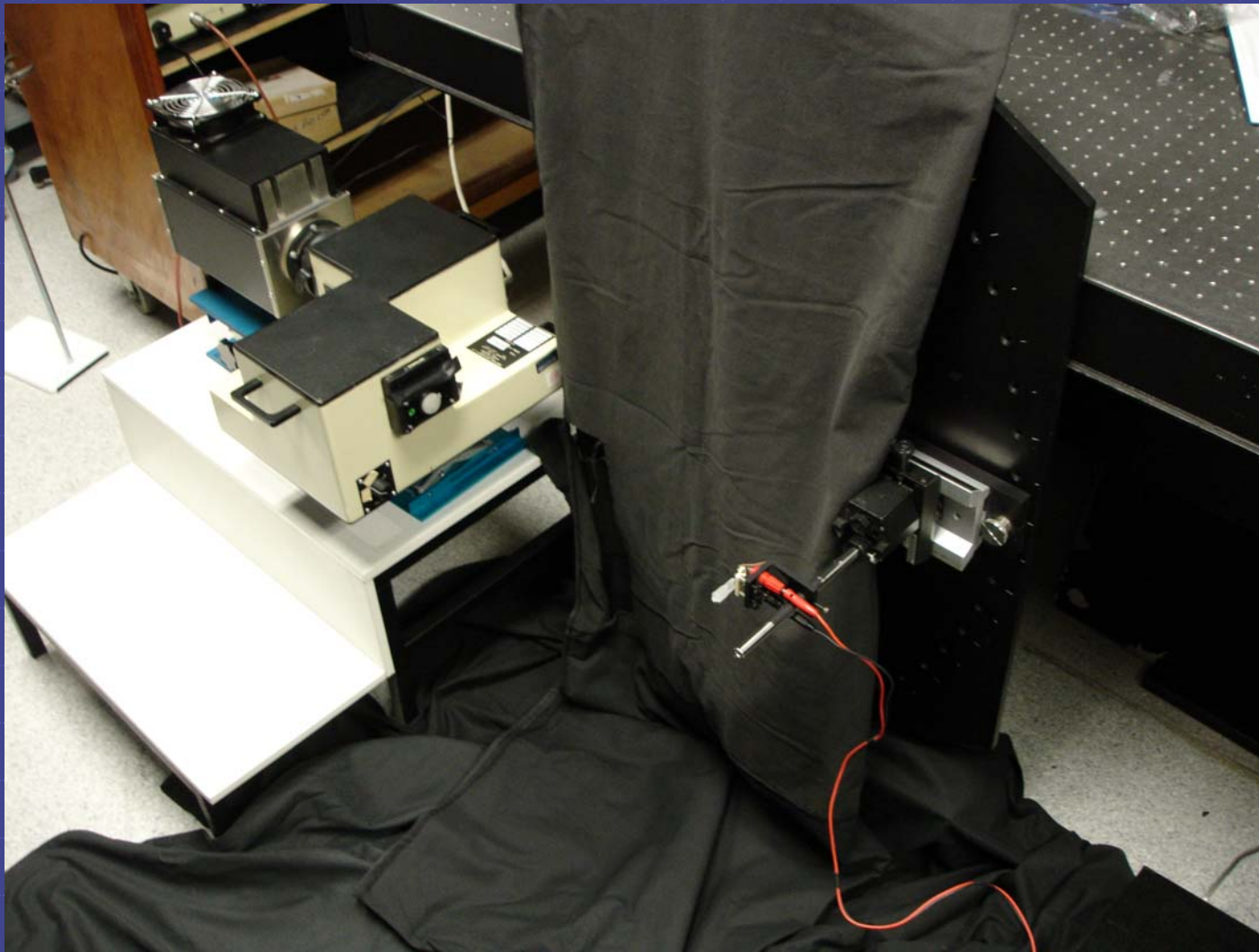
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Horizontal Measurements



Vertical Measurements

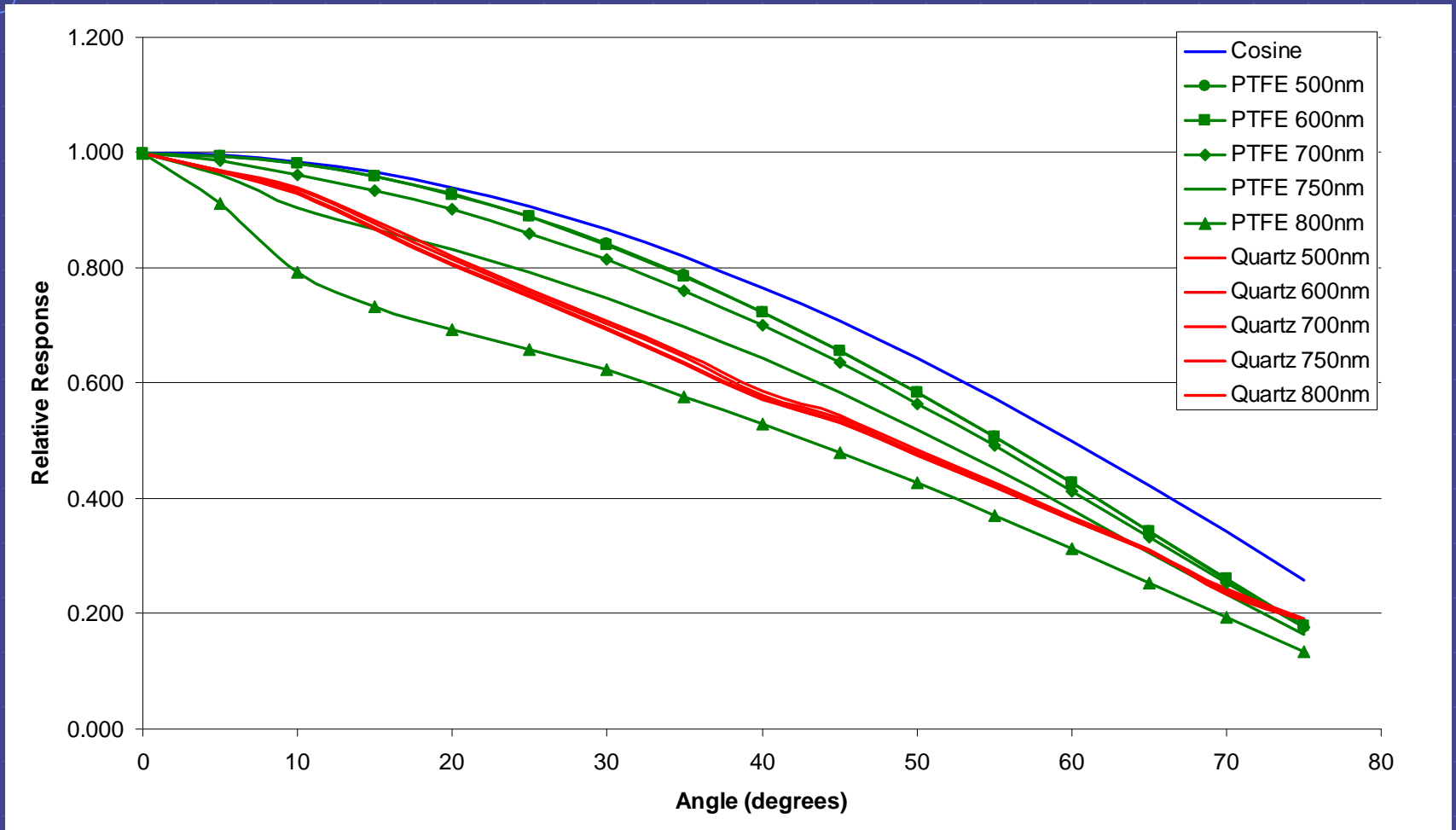


Results

- ◆ 4 readings for each angle
 - Horizontal $\pm \varepsilon$
 - Vertical $\pm \varepsilon$
- ◆ Average $R(\varepsilon)$
- ◆ Relative Response:

$$\frac{R(\varepsilon)}{R(\varepsilon = 0)}$$

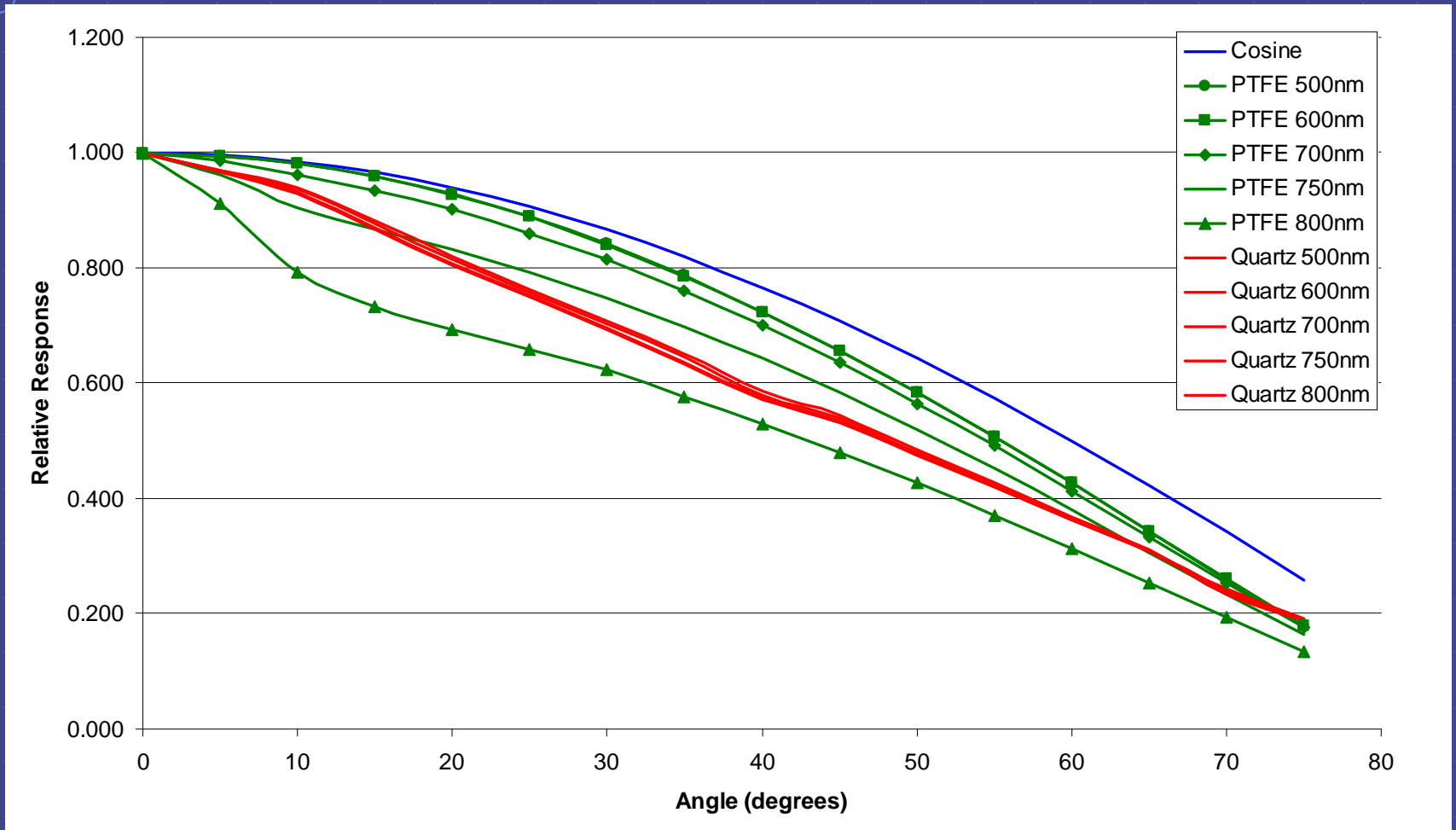
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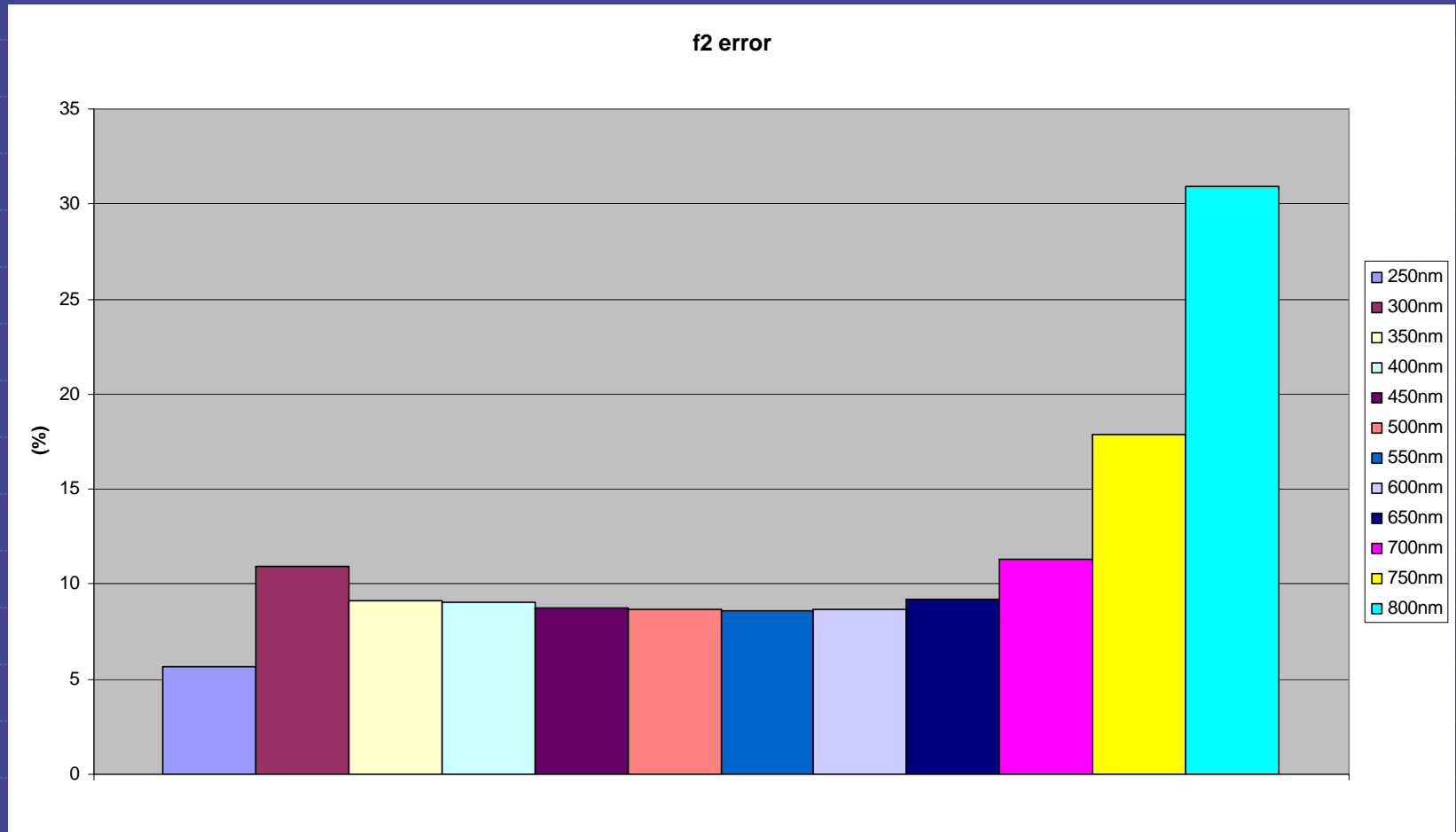
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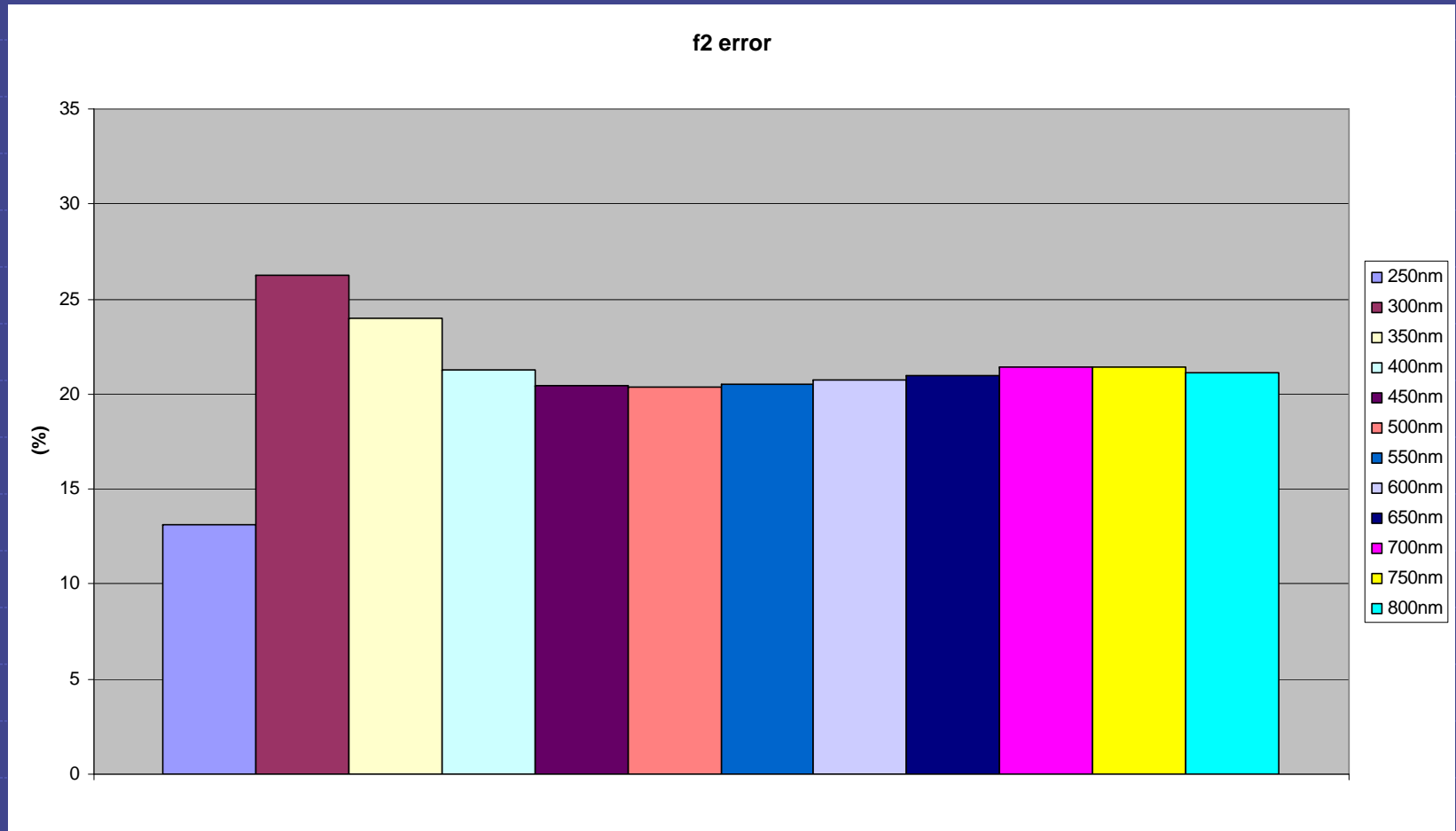
Angular Response of PTFE and Quartz Diffusers



PTFE f_2



Quartz f_2



Angular Correction Factor

$CF(\varepsilon)$

- ◆ True irradiance underestimated
- ◆ Apply a correction factor
- ◆ Depends on
 - Wavelength (PTFE)
 - ◆ Average between 250nm and 500nm
 - Range of angles
 - ◆ Source geometry

Angular Correction Factor

$CF(\varepsilon)$

Source	Range of Angles
Bank of 6 x 180cm lamps	$\pm 0^\circ$ to 70°
Single 180cm lamp	$\pm 0^\circ$ to 70°
Ninewells UVA1 Bank 8 x 60cm	$\pm 0^\circ$ to 35°
Dr Honle Column	$\pm 0^\circ$ to 60°
Single 60cm lamp	$\pm 0^\circ$ to 35°
Dr Honle Dermalight Ultra 1	$\pm 0^\circ$ to 20°
Deuterium Lamp	n/a
QHT lamp	n/a
Dr Honle lamp	n/a

Angular Correction Factor

CF(ε)

Source	CF(θ)
Bank of 6 x 180cm lamps	1.07
Single 180cm lamp	1.04
Ninewells UVA1 Bank 8 x 60cm	1.03
Dr Honle Column	1.03
Single 60cm lamp	1.02
Dr Honle Dermalight Ultra 1	1.01
Deuterium Lamp	n/a
QHT lamp	n/a
Dr Honle lamp	n/a

Conclusions

- ◆ 250nm to 750nm: PTFE diffuser better represents a cosine response
- ◆ Response with PTFE is wavelength dependent
- ◆ Angular correction factor, $CF(\varepsilon)$, included in UV radiometer calibrations
- ◆ Uncertainty in $CF(\varepsilon) = 0.4\%$

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References

1. Methods of characterizing the performance of radiometers and photometers. CIE N° 53. 1982
2. Methods of characterizing illuminance meters and luminance meters. Performance, characteristics and specifications. CIE N° 69. 1987
3. Pye, S. D. and Martin, C. J. A study of the directional response of ultraviolet radiometers: I. Practical evaluation and implications for ultraviolet measurement standards. *Phys. Med. Biol.* 2000
4. Martin, C. J. and Pye, S. D. A study of the directional response of ultraviolet radiometers: II. Implications for ultraviolet phototherapy derived from computer simulations. *Phys. Med. Biol.* 2000

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