Relation of the World Radiometric Reference to SI from Laboratory comparisons

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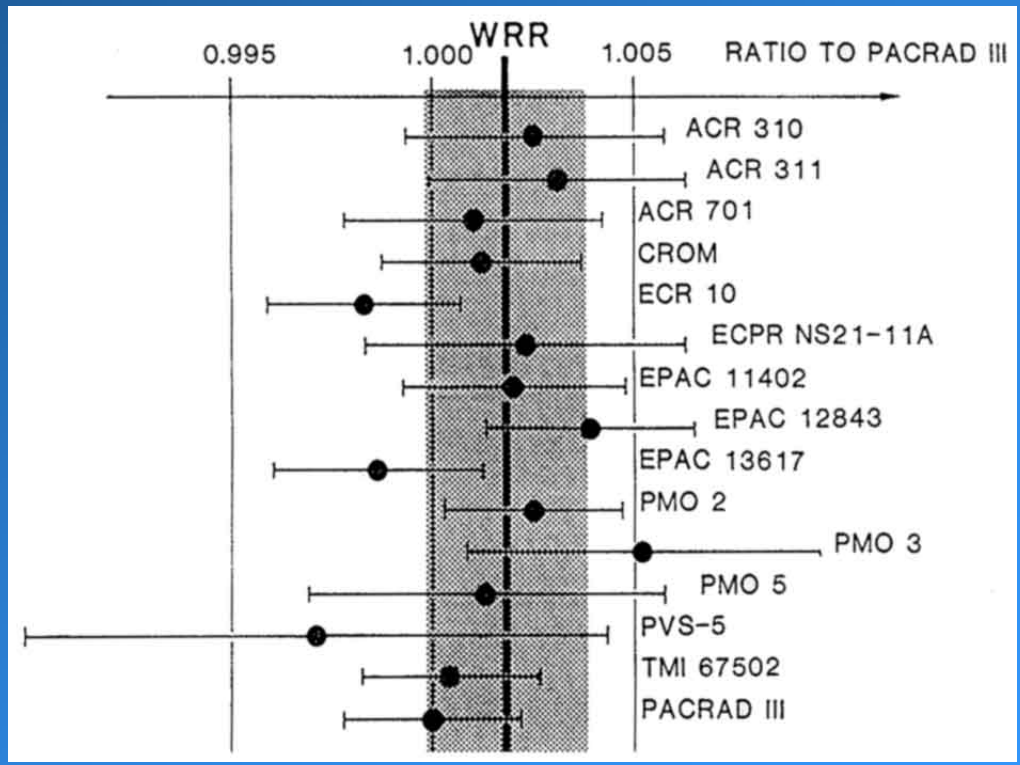
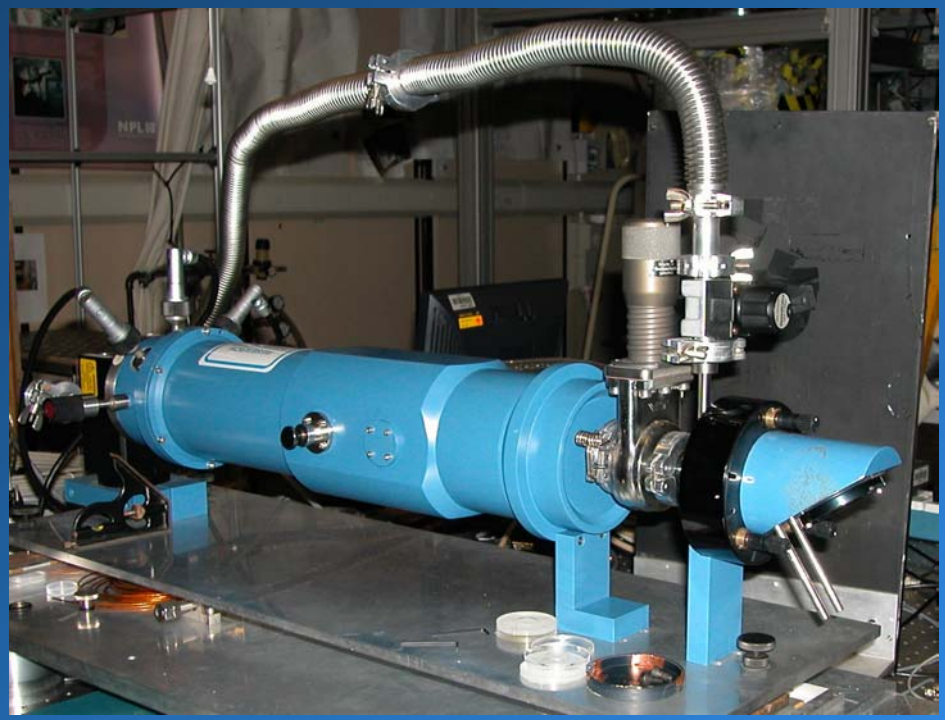
World Radiometric Reference and SI

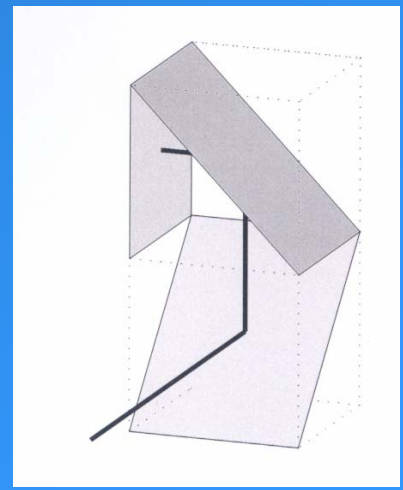
- From a thorough discussion of the results of comparison of many ECRs with the sun as source at PMOD/WRC the Word Radiometric Reference has been defined and adopted by WMO in 1975. A group of radiometers, the World Standard Group, have been identified to materialize it. The WWR is what is called in metrology a conventional reference as it has a much higher repeatability than its estimated SI uncertainty of 0.3%.



Transfer from a Cryogenic Radiometer to Trap Detector

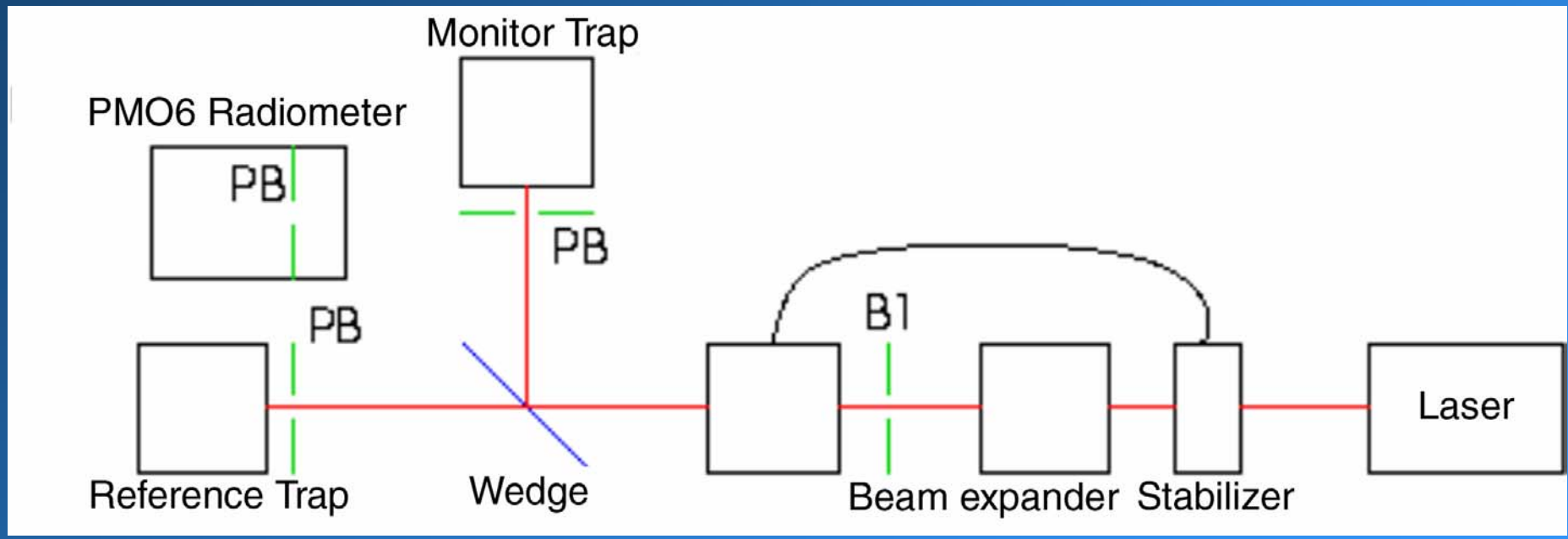
Trap detector

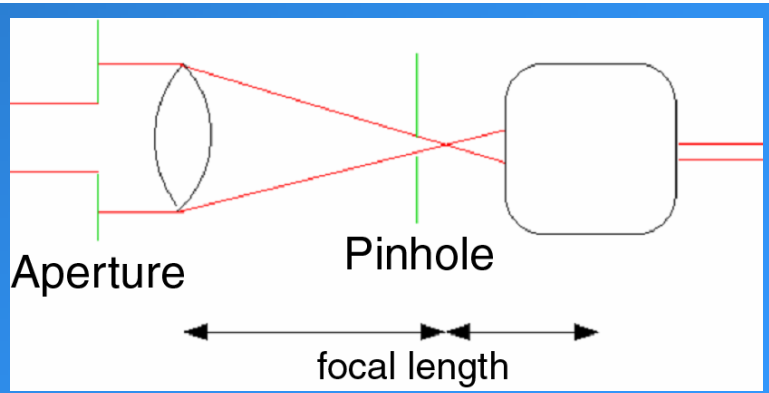




Cryogenic Radiometer

Optical Setup





Beam-Splitter Ratio and Beam Power

$$STV = \frac{\overline{\frac{S_{RT} - \overline{S_{RT0}}}{G_{RT}}}}{\frac{S_{MT} - \overline{S_{MT0}}}{G_{MT}}}$$

STV	beam-splitter ratio
$S_{RT,MT}$	signal reference, monitor trap
$S_{RT0,MT0}$	dark reference, monitor trap
$G_{RT\ MT}$	gain reference, monitor trap
P_{RT}	power
P_{rad}	power measured by radiometer
C_{rad}	Correction factor
C_{WRR}	WRR factor

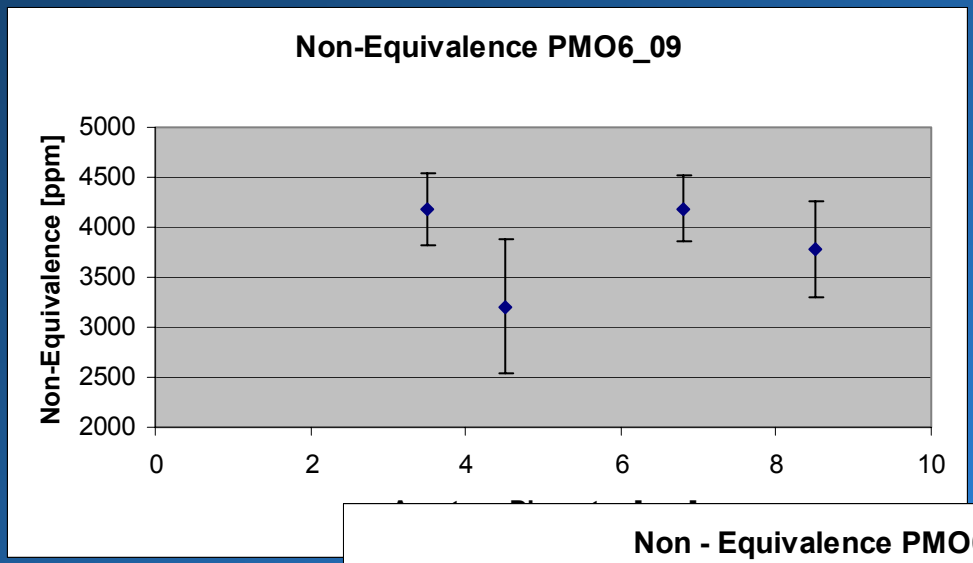
$$P_{RT} = \frac{\overline{S_{MT} - \overline{S_{MT0}} \cdot STV}}{R_{RT} \cdot G_{MT}}$$

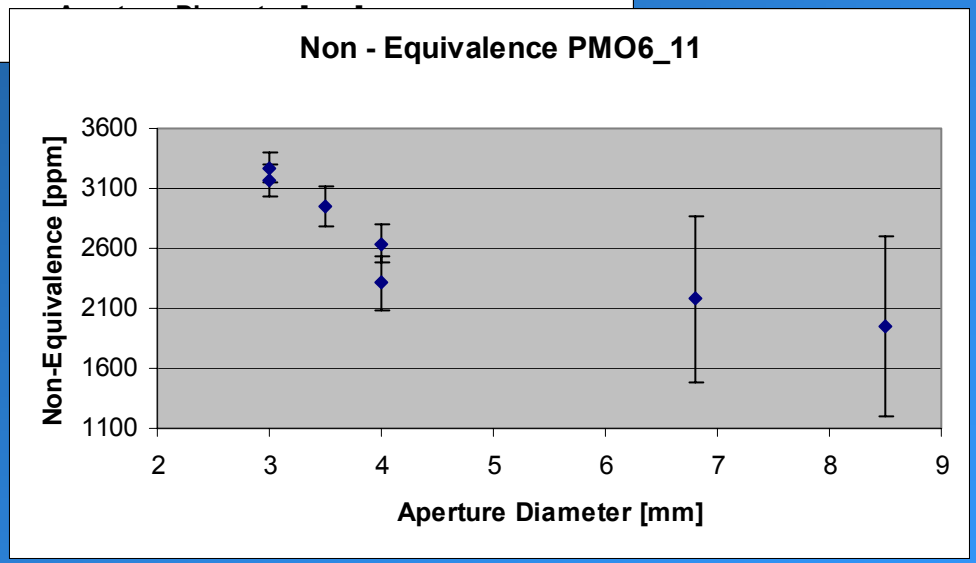
$$\frac{WRR}{SI} = \frac{P_{PMO6} \cdot C_R \cdot C_{WRR}}{P_{RT}}$$

Radiometeric Constants to be used

Solar Measurements: C_I	SI Comparison: C_R
• Aperture area	•
• Reflectivity	• Reflectivity
• Diffraction	•
• Stray light	•
• Lead heating	• Lead heating
• NE over-filled	• NE under-filled

Non-Equivalence





The difference between the under-filled and over-filled aperture (8.5mm) is 0±820 ppm for 6-9 and 545 ±770 ppm for 6-11.

Radiometer Uncertainty

PMO6-9 Characterization for Flux @ 1000W/m2

Component	Value	u	c	(u*c)^2	
Area	n/a	7.0452E-10	5.00E+07		
Pclosed	40 mW	0.000004	5.00E+04	0.04	
Popen	20 mW	0.000002	5.00E+04	0.01	
CNE		1	5.00E-04	1.00E+03	0.25
CR		1	7.00E-05	1.00E+03	0.0049
CSt	n/a	1.00E-04	1.00E+03	0	
CLH		1	3.00E-05	1.00E+03	0.0009
CApH	n/a	5.00E-04	1.00E+03		
Cdiff	n/a	1.00E-04	1.00E+03	0	
				0.3058	
		Uncertainty abs		0.5530	W/m2
		Uncertainty rel		553.0	ppm
	Flux	95% Uncertainty		1106.0	ppm
	Irradiance	95% Uncertainty		1519.3	ppm

Uncertainty of the comparison at NPL

Variable	Messwert	u_i	c_i	$(u_i ci^2)$
P_{PMO6} [W]	$1.67 \cdot 10^{-2}$	$5.77 \cdot 10^{-6}$	59.92	$1.20 \cdot 10^{-7}$
$C_R \cdot C_{WRR}$	1.01	$8.01 \cdot 10^{-4}$	$9.94 \cdot 10^{-1}$	$6.45 \cdot 10^{-7}$
S_{MT} [V]	0.43	$7.51 \cdot 10^{-7}$	-2.30	$2.98 \cdot 10^{-12}$
$\overline{S_{MT0}}$ [V]	$-1.22 \cdot 10^{-4}$ V	$2.89 \cdot 10^{-7}$	2.30	$4.40 \cdot 10^{-13}$
$\overline{S_{MT0}}$ [V]	W	$1.66 \cdot 10^{-7}$ V	2.30	$1.46 \cdot 10^{-13}$
$S_{MT} - \overline{S_{MT0}}$ [V]	W	$2.10 \cdot 10^{-5}$	2.30	$2.32 \cdot 10^{-9}$
STV	20.07	$1.14 \cdot 10^{-3}$	$-4.98 \cdot 10^{-2}$	$3.24 \cdot 10^{-9}$
STV	W	$1.04 \cdot 10^{-3}$	$-4.98 \cdot 10^{-2}$	$2.70 \cdot 10^{-9}$
R_{RT} $[\frac{A}{W}]$	0.52	$6.00 \cdot 10^{-5}$	1.92	$1.33 \cdot 10^{-8}$
G_{MT} $[\frac{V}{A}]$	$1.00 \cdot 10^{2}$	$2.89 \cdot 10^{-2}$	$1.00 \cdot 10^{-3}$	$8.33 \cdot 10^{-7}$
95% Uncertainty: 0.178 %			u_c^2	$7.84 \cdot 10^{-7}$
			u_c	$8.86 \cdot 10^{-4}$

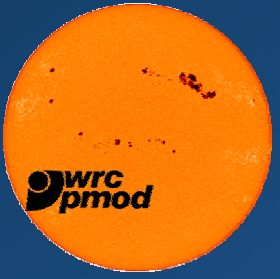
Results of WRR to SI Ratio

1991: 1.000557 ±0.001974
1996: 0.999757 ±0.000948
2005: 0.999828 ±0.000809

weighted average:
0.999937 ±0.000808

including aperture heating:
0.999832 ±0.000808

95% uncertainty: ± 0.001780



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