

SMS Reflectometer meas., before & after CO2 cleaning of WHT Primary mirror on 18 May 2015.

Cleaning followed Calima, with dust in suspension of ~30 ug/m3 (TNG web) constant 11-16 May.

Results summarised end p3. CT7 Report follows on page 4-5, with its own conclusions at end.

CO2 without filter. 2 cleaning passes with 15 minute gap, first rapid flow and second gentler.

Measured again, with both SMS and CT7, on the day after cleaning.

Measured twice at each location to check 0.05% repeatability, omitting unconfirmed values.

SMS head was contaminated during measurement of dusty mirror. Eventually cleared.

Report by Neil O'Mahony 22/05/15.

Lambda	0.67 micron	
Incident Angle	25 deg	<--SMS Summary characteristics
BW Limits	1 0.01	

Measurements before cleaning (and before end of calima).

datum #	Scattering at angles Θ, Φ			Reflectivity	user comment	Roughness RMS(Å)	TIME	DATE
	$\Theta_s \rightarrow$	$\Phi_s \rightarrow$						
1	location 1	0	50	0.787		88.1	15:26:20	05-14-2015
2		0	180	0.782		88.7	15:26:25	05-14-2015
3	2	0		0.81		80	15:27:07	05-14-2015
4		0		0.813		79.8	15:27:12	05-14-2015
5	3	0		0.816		74.9	15:27:23	05-14-2015
6		0		0.813		74.8	15:27:27	05-14-2015
7		0		0.001	omit	3	15:29:37	05-14-2015
8	4	0		0.823		74.8	15:29:43	05-14-2015
9		0		0.823		74.8	15:29:48	05-14-2015
10	5	0		0.807		79	15:30:02	05-14-2015
11		0		0.792	omit	79.7	15:30:07	05-14-2015
12		0		0.805		78.9	15:30:15	05-14-2015
13	6	0		0.827		65	15:30:27	05-14-2015
14		0		0.825		65	15:30:31	05-14-2015
15	7	0		0.796	omit	91.6	15:30:41	05-14-2015
16		0		0.806	omit	91.2	15:30:45	05-14-2015
17	8	0		0.808		87.8	15:35:33	05-14-2015
18		0		0.809		87.7	15:35:39	05-14-2015
19	9	0		0.801		90.6	15:35:52	05-14-2015
20		0		0.8		90.8	15:35:58	05-14-2015
21	10	0		0.822		75.6	15:36:10	05-14-2015
22		0		0.821		75.6	15:36:16	05-14-2015
23	11	0		0.796		90.6	15:37:08	05-14-2015
24		0		0.795		90.7	15:37:13	05-14-2015
25	12	0		0.819		73.6	15:37:25	05-14-2015
26		0		0.82		73.6	15:37:30	05-14-2015
27	13	0		0.809		88.8	15:37:45	05-14-2015
28	14	0		0.806		91.4	15:41:10	05-14-2015
Averages		1.18E-02	5.30E-03	0.810		81.6		
std deviations		0.0024	0.0016	0.012		8.3		
std error				0.003				

Reference mirror checks, taken immediately afterwards, were typically 2-3% lower than usual, suggesting contamination of laser or sensor window during above measurements of dusty mirror. It also suggests some of the above measurements, before cleaning, may be 2-3% underestimated, although no step down is apparent in sequence of measurements. Contamination has been seen previously and was usually easily removed by blowing off with rubber bulb blower.

However it was not easily removed this time, as following sequence shows.

29		1.68E-03	1.64E-03	0.9	28.7		15:50:40	05-14-2015
30		1.67E-03	1.63E-03	0.899	28.7		15:50:45	05-14-2015
31		1.30E-03	8.56E-04	0.914	25		15:50:52	05-14-2015
32		4.69E-03	1.74E-03	0.905	49.4		15:50:59	05-14-2015
33		4.45E-03	1.50E-03	0.911	48.5		15:51:06	05-14-2015
34		2.10E-03	1.30E-03	0.927	31.6		16:06:41	05-14-2015
35		2.11E-03	1.30E-03	0.927	31.7		16:06:47	05-14-2015
36		3.22E-03	1.57E-03	0.907	40		16:06:53	05-14-2015
37		7.60E-03	2.11E-03	0.906	65.4		16:07:01	05-14-2015
38		4.32E-03	1.80E-03	0.905	46.9		16:07:23	05-14-2015
39		4.32E-03	1.80E-03	0.904	46.9		16:07:28	05-14-2015
40		6.52E-03	1.88E-03	0.904	60.3		16:07:48	05-14-2015
41		5.04E-03	2.12E-03	0.893	51		16:07:55	05-14-2015
42		3.95E-03	1.35E-03	0.905	45.7		16:08:16	05-14-2015
43		1.72E-03	1.44E-03	0.911	28.8		16:08:22	05-14-2015
44		4.52E-03	1.89E-03	0.909	47.8		16:08:28	05-14-2015
45		6.21E-03	3.48E-03	0.898	55.5		16:08:47	05-14-2015
46		1.78E-03	1.49E-03	0.899	29.5		16:08:54	05-14-2015
47		3.63E-03	2.53E-03	0.914	41.8		16:09:24	05-14-2015
48		7.06E-03	2.90E-03	0.912	59.8		16:09:31	05-14-2015
49		7.59E-03	2.81E-03	0.906	62.8		16:09:38	05-14-2015
50		2.21E-02	5.85E-03	0.9	112.9		16:09:44	05-14-2015
51		2.10E-02	6.15E-03	0.911	107.5		16:09:53	05-14-2015
52		2.12E-02	6.09E-03	0.919	107.8		16:10:00	05-14-2015
53		3.17E-03	1.97E-03	0.928	38.9		16:10:16	05-14-2015
54		5.47E-03	2.04E-03	0.909	53.2		16:10:23	05-14-2015
Averages		6.09E-03	2.36E-03	0.909	51.8	0.67		

Readings highlighted in green are close to required values but are followed by low measurements.

Further cleaning attempts including ethanol spray were also unsuccessful.

1		4.34E-03	2.13E-03	0.912		46.3	09:36:20	05-19-2015
2		1.85E-03	1.21E-03	0.911		29.9	09:36:27	05-19-2015
3		2.33E-03	1.66E-03	0.907		33.6	09:36:33	05-19-2015
4		2.39E-03	1.28E-03	0.915		34.2	09:37:18	05-19-2015
5		2.92E-03	1.89E-03	0.91		37.7	09:37:24	05-19-2015
6		6.37E-03	2.05E-03	0.875		59.5	09:38:02	05-19-2015
7		1.98E-03	1.30E-03	0.906		31.1	09:38:17	05-19-2015
8		2.73E-03	1.63E-03	0.909		36.5	10:08:32	05-19-2015
9		4.95E-03	2.15E-03	0.907		50	10:08:41	05-19-2015
10		4.97E-03	2.36E-03	0.898		50	10:16:11	05-19-2015
11		3.49E-03	1.71E-03	0.9		41.8	10:16:19	05-19-2015
12		3.28E-03	1.44E-03	0.911		40.6	10:16:27	05-19-2015
13		2.01E-03	1.39E-03	0.903		31.3	10:16:35	05-19-2015

14		4.20E-03	1.15E-03	0.906		48.7	10:18:15	05-19-2015
15		2.17E-03	1.08E-03	0.949	normal/ high	32.1	10:27:09	05-19-2015

The final measurement shows contamination was cleared, by blowing with dry air supply at 2.5 bar.

A repeated measurement was not recorded - a known SMS bug.

Measurements of WHT Primary, 1 day after CO2 cleaning, through port holes.

Repeatability was worse than usual, which may suggest contamination is still present.

Less weight may be given to lower measurements.

27	location 1	8.00E-03	1.72E-03	0.844		73.5	14:51:36	05-19-2015
28		8.00E-03	1.72E-03	0.843		73.5	14:51:41	05-19-2015
29	2	8.27E-03	2.26E-03	0.843	solo	71	14:51:50	05-19-2015
30	3	9.73E-03	2.74E-03	0.836	non-rep	76.9	14:52:03	05-19-2015
31		9.74E-03	2.75E-03	0.845	rep	76.4	14:52:08	05-19-2015
32		9.73E-03	2.77E-03	0.848	rep	76.2	14:52:14	05-19-2015
33	4	1.39E-02	6.02E-03	0.805	low: omit	88.8	14:53:04	05-19-2015
34		1.39E-02	6.02E-03	0.803		89	14:53:08	05-19-2015
35	5	1.14E-02	4.37E-03	0.814	low	81	14:53:18	05-19-2015
36		9.81E-03	2.81E-03	0.839	non-rep	76.8	14:53:28	05-19-2015
37		1.15E-02	3.48E-03	0.821	rep	83.2	14:56:24	05-19-2015
38	6	5.51E-03	1.53E-03	0.838		57.9	14:56:36	05-19-2015
39		5.50E-03	1.53E-03	0.839		57.8	14:56:42	05-19-2015
40	7	7.91E-03	2.06E-03	0.828		70.6	14:56:52	05-19-2015
41		7.99E-03	2.45E-03	0.831		68.9	14:57:12	05-19-2015
42	8	8.01E-03	2.45E-03	0.84		68.6	14:57:17	05-19-2015
43		8.01E-03	2.45E-03	0.838		68.8	14:57:22	05-19-2015
44	9	8.08E-03	2.44E-03	0.829		69.5	14:58:09	05-19-2015
45		8.08E-03	2.44E-03	0.828		69.6	14:58:13	05-19-2015
46	10	1.07E-02	3.34E-03	0.821	solo: omit	79.9	14:58:23	05-19-2015
47	11	9.87E-03	3.13E-03	0.827		76.4	14:58:32	05-19-2015
48		9.86E-03	3.13E-03	0.831	rep	76.2	14:58:37	05-19-2015
49		1.29E-02	3.88E-03	0.833	solo	87.5	14:58:47	05-19-2015
Averages		9.08E-03	2.82E-03	0.836		74.7		
std deviations		0.0023	0.0013	0.008		8.2		
std error				0.003				

Final Check of Reference Mirror

50		2.82E-03	1.63E-03	0.932		36.7	15:04:26	05-19-2015
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Reflectometer sensitivity and repeatability is back to normal.

Reflectivity before cleaning: **81.0 % ± 0.3 %**

Reflectivity after cleaning: **83.6 % ± 0.3 %**

Avg increase in R%: **2.6%**

Avg decrease in Scattering: **23% at 0° and 47% at 180°**

Surface Roughness improvement is marginal (5%)

The improvement in reflectivity is good, but in scattering it's small.

The latter remains about twice the optimal value.

Water stains remain and require a water wash to remove them.

CT7 multiband reflectivity measurements from before and after CO2 cleaning.

First, checks of reference (gauge) mirror:

				waveband template (nm)						
				365	404	464	522	624	760	970
14 July 2014 gauge meas.				85.8	82.6	89.7	90.2	88.8	84.4	86.3
Reference mirror check following measurement on Wyffos Primary										
17/03/2015 15:08	Normal	16.8	84.5	83.5	88.4	90.6	89.5	83.1	86.3	
Difference now from 2014 (pre-service)				-1.3	0.9	-1.3	0.4	0.7	-1.3	0

Reference mirror check just before meas. of WHT M1 (Note date should say 15/05/2015)

21/10/2010 12:08	Normal	22	84.5	83.5	88.4	90.6	89.5	83.2	86.4	
Change in 2 months				0	0	0	0	0	0.1	0.1

Reference mirror check immediately after final measurement of cleaned mirror

475	19/05/2015 11:53	0	Normal	20.2	84.7	83.7	88.5	90.7	89.6	83.2	86.4
Change in 5 days				0.2	0.2	0.1	0.1	0.1	0	0	

Changes are very small and give estimate of error margins.

Measurements of mirror before CO2 cleaning (same day as SMS)

Minimum measurement marked in orange, maximum in green

					365	404	464	522	624	760	970
452	14/05/2015 15:15	0	Normal	22.2	88.2	86.9	86.9	86.9	86.0	83.7	89.3
453	14/05/2015 15:18	0	Normal	22.3	86.8	85.5	85.6	85.9	85.1	82.7	88.1
454	14/05/2015 15:19	0	Normal	22.4	86.2	84.8	85.0	85.0	84.3	81.8	87.1
455	14/05/2015 15:20	0	Normal	22.5	87.6	85.9	85.6	86.0	85.3	82.4	88.3
456	14/05/2015 15:20	0	Normal	22.6	87.5	86.2	86.0	86.3	85.5	83.0	88.4
457	14/05/2015 15:26	0	Normal	22.9	87.4	86.1	86.1	86.2	85.6	82.9	88.5
458	14/05/2015 15:28	0	Normal	23.1	85.4	84.1	84.0	84.2	84.0	81.3	86.6
459	14/05/2015 15:29	0	Normal	23.2	85.8	84.3	84.3	84.5	83.8	81.0	86.5

**Averages (omitting
2 lowest values)**

87.3 85.9 85.9 86.1 85.3 82.8 88.3

460	19/05/2015 09:28	0	Normal	23.0	90.1	88.8	88.7	89.1	88.4	85.7	91.9
461	19/05/2015 09:29	0	Normal	22.7	88.4	87.4	87.5	87.8	86.9	84.7	90.3
462	19/05/2015 09:31	0	Normal	22.5	89.6	88.2	88.2	88.8	88.1	85.5	91.7
463	19/05/2015 09:32	0	Normal	22.3	88.6	87.3	87.3	87.7	87.1	84.6	90.5
464	19/05/2015 09:33	0	Normal	22.0	88.3	86.9	87.1	87.0	86.5	83.7	89.2
465	19/05/2015 09:34	0	Normal	21.9	87.5	86.4	86.2	86.6	85.4	82.8	88.2
466	19/05/2015 09:36	0	Normal	21.8	85.7	84.5	84.9	85.6	84.9	82.5	88.1
467	19/05/2015 09:37	0	Normal	21.7	87.7	86.0	85.8	85.8	85.5	82.0	88.1

**Averages of the
best values**

88.8 87.5 87.5 87.8 87.1 84.5 90.3

Increase in averages

1.5 1.6 1.6 1.8 1.8 1.8 2.0

Average from last cleaning	86.8	87.4	87.5	87.3	n/a	84.4	90.1
Difference from last cleaning	2.0	0.1	0.0	0.5	n/a	0.1	0.3

Conclude: this cleaning produced very similar results to previous, but significantly better in UV

Result from Water Wash 2014	90.5	88.5	92.3	91.8	88.9	87.7	92.0
Current shortfall from Wash values	1.8	1.0	4.8	4.0	1.8	3.2	1.7

Note that in 2014 the CT7 gauge measurements were different (see first line of this section)

We add these corrections to the Current shortfall to estimate the room for improvement

Corrected shortfall	0.5	1.9	3.5	4.4	2.5	1.9	1.7
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These are the improvements in Reflectivity that can be expected from a Water Wash of WHT M1 waveband template (nm)

	365	404	464	522	624	760	970
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Finally a comparison with standard values shows agreement with improvement expected from Washing.

Aluminium %R from Literature	92.0	91.9	91.8	91.6	90.8	88.6	92.4
current shortfall	3.3	4.4	4.3	3.8	3.7	4.1	2.1

The above also corroborates result from April 2014 implying Washing was almost as good as Aluminising.

Gauge check after last measurement shows instrument response has been trustworthy

475	19/05/2015 11:53	0	Normal	20.2	84.7	83.7	88.5	90.7	89.6	83.2	86.4
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