

SMS and CT7 measurements of WHT M1 following calima and overnight rain 14/7/2015  
 Repeat measurements 6 days later, immediately after cleaning with CO2 on 20th. Humidity 35%  
 CO2 without filter. 2 cleaning passes with 5 minute gap, first rapid flow and second gentler.  
 SMS measures twice at each location to check 0.05% repeatability, omitting unconfirmed values.  
 1% improvement in reflectivity measured with CT7, scattering reduced by factor 2 (SMS).  
 Result of cleaning is visibly non-uniform. Minimum R=80% at one out of 14 sampled locations

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

Reference mirror and M1 measurements at several porthole locations before cleaning:

datum #	Scattering at angles $\Theta, \Phi$			Reflectivity	user comment	Roughness RMS( $\text{\AA}$ )	TIME	DATE (mm-dd)
	$\Theta$ s->	0	50					
1	Ref	3.11E-03	1.65E-03	0.934		38.6	13:25:41	07-14-2015
2	location 1	1.26E-02	5.48E-03	0.823		83.7	13:35:16	07-14-2015
3		1.26E-02	5.49E-03	0.821		84	13:35:22	07-14-2015
4	2	1.59E-02	6.62E-03	0.803		95.4	13:35:31	07-14-2015
5		1.59E-02	6.62E-03	0.804		95.4	13:35:37	07-14-2015
6	3	1.16E-02	3.97E-03	0.839	close to 2	81.4	13:35:43	07-14-2015
7	4	1.12E-02	4.24E-03	0.83		79.7	13:36:32	07-14-2015
8		1.13E-02	4.23E-03	0.83		79.8	13:36:39	07-14-2015
9	5	1.14E-02	5.28E-03	0.832		79	13:37:52	07-14-2015
10		1.14E-02	5.29E-03	0.834		78.8	13:37:57	07-14-2015
11	6	1.18E-02	6.10E-03	0.824		80.1	13:38:05	07-14-2015
12		1.18E-02	6.09E-03	0.826		80	13:38:11	07-14-2015
13	7	1.39E-02	6.10E-03	0.818		88.3	13:39:16	07-14-2015
14		1.39E-02	6.10E-03	0.819		88.2	13:39:21	07-14-2015
15	8	1.04E-02	4.61E-03	0.835		75.5	13:39:30	07-14-2015
16		1.04E-02	4.58E-03	0.841		75.2	13:39:35	07-14-2015

**Averages**                    **1.24E-02**   **5.39E-03**      **0.825**                    **83.0**  
**Average omitting low reading at loc.2**                    **0.830**  
**Standard Deviation**        **1.7E-03**   **8.9E-04**      **0.011**                    **6.3**  
**Standard Error**            **6.2E-04**   **3.1E-04**      **0.004**                    **2.2**

Check of Reference mirror immediately following Primary Mirror measurements

17	Ref	3.18E-03	1.98E-03	0.927		39	13:49:27	07-14-2015
18	Ref	3.19E-03	1.98E-03	0.927		39	13:49:38	07-14-2015
19	Ref	1.84E-02	4.89E-03	0.923		101.8	13:49:44	07-14-2015
20	Ref	1.81E-02	7.05E-03	0.921		95.8	13:49:52	07-14-2015
21	Ref	1.56E-02	9.25E-03	0.917		87	13:49:58	07-14-2015

readings repeatable and above 92%

After CO2 on Monday 20th July

datum #	Scattering at angles $\Theta, \Phi$			Reflectivity	user comment	Roughness RMS( $\text{\AA}$ )	TIME	DATE (mm-dd)
	$\Theta$ s->	0	50					
22	Ref	1.74E-03	1.06E-03	0.929		28.8	11:39:46	07-20-2015

23	location 1	7.71E-03	1.76E-03	0.847		70.9	11:49:19	07-20-2015
24		7.71E-03	1.76E-03	0.845		71	11:49:25	07-20-2015
25	2	1.78E-02	6.96E-03	0.802		101.8	11:49:33	07-20-2015
26	4	1.01E-02	2.54E-03	0.837		79.7	11:49:44	07-20-2015
27		1.01E-02	2.53E-03	0.837		79.7	11:49:50	07-20-2015
28	5	1.25E-02	3.19E-03	0.83		89.2	11:49:58	07-20-2015
29		1.25E-02	3.19E-03	0.827		89.4	11:50:03	07-20-2015
30	6	8.05E-03	1.95E-03	0.832		72.2	11:50:12	07-20-2015
31		8.03E-03	1.95E-03	0.825		72.3	11:50:17	07-20-2015
32		8.04E-03	1.95E-03	0.824		72.4	11:50:23	07-20-2015
33	7	9.83E-03	2.17E-03	0.819		82.2	11:50:33	07-20-2015
34	8	1.05E-02	3.05E-03	0.79	close to 7	81.9	11:50:41	07-20-2015
35	9	1.13E-02	3.39E-03	0.828	close to 8	82.5	11:50:53	07-20-2015
36	10	8.80E-03	2.06E-03	0.839		75.7	11:52:22	07-20-2015
37		8.80E-03	2.06E-03	0.84		75.7	11:52:27	07-20-2015
38	11	7.23E-03	1.78E-03	0.839		67.9	11:52:36	07-20-2015
39		7.22E-03	1.78E-03	0.843		67.7	11:52:41	07-20-2015
40		7.07E-03	1.53E-03	0.841		69.1	11:52:49	07-20-2015
41	12	9.89E-03	2.23E-03	0.84		80.9	11:53:59	07-20-2015
42		9.88E-03	2.23E-03	0.84		80.8	11:54:04	07-20-2015
43	13	6.75E-03	1.85E-03	0.848		63.8	11:54:12	07-20-2015
44		6.75E-03	1.85E-03	0.846		63.9	11:54:18	07-20-2015
45		7.84E-03	2.22E-03	0.841		68.7	11:54:26	07-20-2015
46	14	1.34E-02	3.57E-03	0.823		91.6	11:56:40	07-20-2015
47		1.34E-02	3.57E-03	0.823		91.6	11:56:45	07-20-2015
48	15	7.51E-03	2.03E-03	0.841		67.8	11:56:53	07-20-2015
49		7.51E-03	2.03E-03	0.841		67.8	11:56:58	07-20-2015
50	16	8.64E-03	2.30E-03	0.838		73.1	11:57:05	07-20-2015
51		8.64E-03	2.30E-03	0.836		73.1	11:57:10	07-20-2015
52		8.66E-03	2.31E-03	0.839		73.1	11:57:16	07-20-2015
53	17	1.26E-02	4.31E-03	0.827		85.6	11:57:24	07-20-2015

<b>Average</b>	<b>9.51E-03</b>	<b>2.53E-03</b>	<b>0.833</b>	<b>76.9</b>
<b>Average, omitting low values 7,8,9</b>			<b>0.838</b>	
<b>Standard Deviation</b>	<b>2.5E-03</b>	<b>1.1E-03</b>	<b>0.007</b>	<b>9.2</b>
<b>Standard Error</b>	<b>8.9E-04</b>	<b>3.7E-04</b>	<b>0.003</b>	<b>3.3</b>

Check of Reference mirror immediately following Primary Mirror measurements

54 Ref	7.16E-03	2.54E-03	0.933	60.4	12:06:08	07-20-2015
55 Ref	7.17E-03	2.54E-03	0.934	60.4	12:06:15	07-20-2015

reading repeatable and above 92%

**Reflectivity before cleaning: 82.5 % ± 0.4 %**  
**Reflectivity after cleaning: 83.3 % ± 0.3 %**  
**Increase in R%: 0.8%**  
**Avg decrease in Scattering: 31% at 0° and 113% at 180°**  
**Surface Roughness improvement is marginal (5%)**

**The measurable improvement in reflectivity is marginal but is good in wide-angle scattering  
Scattering remains almost twice as high as last year's values.  
Water stains remain and require a water wash to remove them.**

CT measurements of M1 taken at same time as SMS

Primary mirror reflectivities before CO2 cleaning				waveband template (nm)						
				365	404	464	522	624	760	970
488	14/07/2015 13:17	0 port 1	22.3	86.2	85.2	85.2	85.8	84.8	82.8	88.3
489	14/07/2015 13:17	0 port 1	22.4	86.6	85.3	85.3	85.5	84.8	82.4	87.8
490	14/07/2015 13:19	0 port 2	22.5	87.4	86.0	85.8	85.9	85.3	82.6	88.0
491	14/07/2015 13:20	0 port 3	22.7	87.0	85.5	85.5	85.5	85.0	82.2	87.6
492	14/07/2015 13:21	0 port 4	22.9	86.0	84.6	84.6	85.0	84.2	81.7	87.4
averages				86.6	85.3	85.3	85.5	84.8	82.3	87.8

**Primary Mirror reflectivities following CO2 cleaning**

495	20/07/2015 11:34	0 error	18.4	2.2	3.6	9.1	3.4	10.0	13.6	2.2
496	20/07/2015 11:36	0 Normal	18.4	88.3	86.4	86.0	86.0	86.3	82.6	89.7
497	20/07/2015 11:37	0 Normal	18.7	87.9	86.7	86.7	87.0	86.2	83.8	89.6
498	20/07/2015 11:38	0 Normal	18.9	88.9	87.6	87.0	87.9	87.0	84.2	90.6
499	20/07/2015 11:40	0 Normal	19.1	87.1	85.9	86.3	86.4	86.2	83.7	89.3
averages				88.1	86.7	86.5	86.8	86.4	83.6	89.8

<b>Change in Primary mirror R% due to CO2 cleaning</b>	<b>1.4</b>	<b>1.3</b>	<b>1.2</b>	<b>1.3</b>	<b>1.6</b>	<b>1.2</b>	<b>2.0</b>
Averages after CO2 cleaning 18 May	88.1	86.7	86.5	86.8	86.4	83.6	89.8
Change since 18 May	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Measurements on gauge mirror associated with above sets of M1 data

493	14/07/2015 13:49	0 Gauge	21.8	84.6	83.6	88.4	90.6	89.6	83.3	86.6
494	20/07/2015 11:21	0 Gauge	18.9	84.6	83.7	88.6	90.7	89.6	83.4	86.7

Previous and recent Gauge Mirror Measurements and statistics

15/05/2015 12:08	Gauge	22.0	84.5	83.5	88.4	90.6	89.5	83.2	86.4	
17/03/2015 15:08	Gauge	16.8	84.5	83.5	88.4	90.6	89.5	83.1	86.3	
475	19/05/2015 11:53	0 Gauge	20.2	84.7	83.7	88.5	90.7	89.6	83.2	86.4
475	19/05/2015 11:53	0 Gauge	20.2	84.7	83.7	88.5	90.7	89.6	83.2	86.4
<b>Averages</b>			84.6	83.6	88.5	90.7	89.6	83.2	86.4	
<b>Range</b>			0.2	0.2	0.1	0.1	0.1	0.1	0.1	
Change in Reference meas. since May			<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0.2</b>	<b>0.3</b>	

**Conclusion: CO2 cleaning has restored the reflectivity obtained in May. There are signs of drift in the reflectometer readings in the 2 red-most bands of up to 0.3%. Improvement in %R of >1% is more optimistic in CT7 than in SMS.**

**The CT7 has much smaller error margin (~0.2%) and the SMS is known to underestimate (<5%)**

Dust Indices from CT7 taken at same time as ab **waveband template (nm)**

	365	404	464	522	624	760	970
Primary mirror before CO2:	11.6	11.2	11.3	9	10.1	8.1	8.6
	11.7	11.4	11.5	9.7	10.8	9.3	9.5
	10.1	9.7	10.4	8.7	9.8	8.7	9.2
	11	10.5	11	9	10.3	9.2	9.5

11.1	11	11.7	9.4	11	9.7	9.6
2.5	3.2	2.8	1.6	1.3	1	1.1

Gauge mirror

2.4	3.0	2.5	1.5	1.1	0.8	1.0
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Primary mirror after CO2

29.8	38.7	46.7	30.5	26.5	22.1	22.3
10.2	10.6	11.2	9.6	9.2	9.6	7.3
10.7	10.3	10.5	8.4	9.3	7.9	7.6
9.0	8.7	10.6	7.1	8.0	7.9	5.7
10.9	10.2	10.1	8.1	8.5	7.4	7.4