

SMS uScan Reflectivity measurements of M1 before and after CO2 cleaning of 16 March 2015  
 Data from 9 March taken day before a failed CO2 cleaning attempt (blockage)  
 Measurements in pairs to check 0.05% repeatability. Omit anomalous data (red) from statistics  
 Result of cleaning: Reflectivity from before calima has been recovered but water washing needed  
 Cleaning actions, measurements, statistics and report by Neil O'Mahony

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

Reference mirror check

34	5.04E-03	2.37E-03	0.943		49.2	13:05:51	03/09/2015
35	5.04E-03	2.38E-03	0.941		49.3	13:05:58	03/09/2015

Measurements on WHT M1 11 days after partial cleaning

datum #	Scattering at angles $\Theta, \Phi$			Reflectivity	user comment	Roughness RMS(Å)	TIME	DATE
	$\Theta$ s->		$\Phi$ s->					
		0	50					
		0	180					
36	pos 1	8.99E-03	3.05E-03	0.834		72	13:24:54	03/09/2015
37		8.99E-03	3.05E-03	0.833		72	13:24:59	03/09/2015
38	2	1.03E-02	6.34E-03	0.814		74.7	13:25:07	03/09/2015
39		1.02E-02	6.29E-03	0.814		74.7	13:25:11	03/09/2015
40	3	1.03E-02	6.30E-03	0.81	skip	74.9	13:25:18	03/09/2015
41		1.20E-02	3.83E-03	0.825		84.1	13:25:33	03/09/2015
42		1.20E-02	3.82E-03	0.825		84.1	13:25:38	03/09/2015
43	4	1.16E-02	4.13E-03	0.825		81.9	13:26:26	03/09/2015
44		1.16E-02	4.13E-03	0.827		81.8	13:26:31	03/09/2015
45	5	8.72E-03	2.64E-03	0.839		71.8	13:26:42	03/09/2015
46		8.74E-03	2.65E-03	0.839		71.9	13:26:47	03/09/2015
47	6	1.46E-02	6.59E-03	0.805		91	13:26:55	03/09/2015
48		1.46E-02	6.58E-03	0.809		90.8	13:27:02	03/09/2015
49		1.61E-02	7.95E-03	0.806	confirms	94.9	13:27:11	03/09/2015
50	7	1.38E-02	4.91E-03	0.821		89.4	13:27:20	03/09/2015
51		1.38E-02	4.91E-03	0.822		89.3	13:27:25	03/09/2015
52	8	1.83E-02	8.93E-03	0.796	stain	101.8	13:28:19	03/09/2015
53		1.83E-02	8.93E-03	0.796		101.8	13:28:23	03/09/2015
54	9	1.17E-02	3.94E-03	0.825		82.7	13:28:32	03/09/2015
55		1.17E-02	3.94E-03	0.823		82.8	13:28:37	03/09/2015
56	10	9.41E-03	3.10E-03	0.834		73.9	13:28:45	03/09/2015
57		9.40E-03	3.09E-03	0.834		73.9	13:28:51	03/09/2015
58	11	1.11E-02	4.15E-03	0.828		79.5	13:29:00	03/09/2015
59		1.11E-02	4.15E-03	0.826		79.6	13:29:05	03/09/2015
60	12	2.14E-02	1.52E-02	0.755	stain	111.9	13:30:16	03/09/2015
61		2.14E-02	1.51E-02	0.755		111.9	13:30:21	03/09/2015
62	13	8.81E-03	2.32E-03	0.842	max.	73.8	13:30:28	03/09/2015
63		8.84E-03	2.33E-03	0.841		73.9	13:30:34	03/09/2015
64	14	1.14E-02	4.80E-03	0.825		79.7	13:30:41	03/09/2015

65		1.14E-02	4.81E-03	0.823		79.8	13:30:46	03/09/2015
66	15	1.37E-02	5.96E-03	0.81		88	13:30:54	03/09/2015
average of selected		<b>1.10E-02</b>	<b>4.15E-03</b>	<b>0.826</b>		<b>79.5</b>		
average top only				0.822				
maximum				0.842				
std.dev		1.90E-03	1.33E-03	0.010				
std.error		<b>5.55E-04</b>	<b>2.77E-04</b>	<b>0.003</b>				

Reference mirror check

67		2.69E-03	2.22E-03	0.937		35.6	13:35:14	03/09/2015
68		2.70E-03	2.24E-03	0.938		35.6	13:35:19	03/09/2015
69		3.76E-03	2.78E-03	0.947		41.8	13:35:27	03/09/2015
70		3.76E-03	2.78E-03	0.948		41.8	13:35:33	03/09/2015
71		9.50E-03	2.76E-03	0.939		71.3	13:35:41	03/09/2015

Reflectometer reads repeatably and > 94% - has not been contaminated

Before CO2 cleaning on 16 March

datum #	Scattering at angles $\Theta, \Phi$			Reflectivity	user comment	Roughness RMS(Å)	TIME	DATE
	$\Theta_s \rightarrow$	0	50					
143	top 1		1.21E-02	4.36E-03	0.823	83.3	11:15:40	03-16-2015
144			1.21E-02	4.37E-03	0.824	83.4	11:15:45	03-16-2015
145	2		1.04E-02	4.77E-03	0.821	75.7	11:15:53	03-16-2015
146			1.04E-02	4.80E-03	0.821	75.9	11:15:58	03-16-2015
147	3		1.39E-02	5.77E-03	0.803	89.3	11:16:07	03-16-2015
148			1.39E-02	5.73E-03	0.805	89.3	11:16:12	03-16-2015
149	4		1.41E-02	5.44E-03	0.817	89.7	11:16:20	03-16-2015
150			1.41E-02	5.45E-03	0.814	89.9	11:16:25	03-16-2015
151			1.41E-02	5.36E-03	0.83	89.2	11:17:12	03-16-2015
152			1.41E-02	5.34E-03	0.827	89.5	11:17:17	03-16-2015
153	bottom 1		9.37E-03	3.15E-03	0.828	73.8	11:17:26	03-16-2015
154			9.38E-03	3.16E-03	0.828	73.8	11:17:30	03-16-2015
155	bottom 2		1.34E-02	4.20E-03	0.819	89.5	11:17:39	03-16-2015
156			1.34E-02	4.21E-03	0.817	89.7	11:17:44	03-16-2015
average this sample			1.25E-02	4.72E-03	0.820	84.4		
average all pre-CO2			1.16E-02	4.40E-03	0.824			
best reading			8.72E-03	2.32E-03	0.842 pre-CO2	71.8		

Reference mirror check.

157 2.11E-03 1.54E-03 0.94 31.5 11:38:30 03-16-2015

After CO2

158	top 1		1.46E-02	5.71E-03	0.816	91.3	15:00:41	03-16-2015
159			1.46E-02	5.70E-03	0.815	91.4	15:00:47	03-16-2015
160	2		1.30E-02	4.28E-03	0.822	87.6	15:00:56	03-16-2015
161			1.31E-02	4.28E-03	0.824	87.7	15:01:02	03-16-2015
162	3		1.08E-02	2.74E-03	0.832	82.7	15:01:11	03-16-2015
163			1.08E-02	2.74E-03	0.831	82.8	15:01:17	03-16-2015

164	4	6.42E-03	1.69E-03	0.842		63	15:01:29	03-16-2015
165		6.43E-03	1.69E-03	0.84		63.1	15:01:34	03-16-2015
166	bottom 1	6.84E-03	1.53E-03	0.844		67.2	15:02:26	03-16-2015
167		6.85E-03	1.53E-03	0.848		67.2	15:02:31	03-16-2015
168	2	1.37E-02	4.26E-03	0.818		90.7	15:02:43	03-16-2015
169		1.37E-02	4.25E-03	0.822		90.4	15:02:49	03-16-2015
170	3	1.05E-02	2.87E-03	0.831		80.6	15:02:57	03-16-2015
171		1.06E-02	2.87E-03	0.831		80.8	15:03:03	03-16-2015
172	left 1	4.73E-03	9.89E-04	0.849	max.	56.7	15:03:19	03-16-2015
173		4.74E-03	9.88E-04	0.848		56.9	15:03:24	03-16-2015
174	2	8.76E-03	2.47E-03	0.835		73	15:04:18	03-16-2015
175		8.77E-03	2.46E-03	0.835		73	15:04:23	03-16-2015
176	3	1.05E-02	3.29E-03	0.829		79	15:04:32	03-16-2015
177		1.05E-02	3.29E-03	0.828		79.1	15:04:37	03-16-2015
178	left 4	1.07E-02	3.82E-03	0.831		78.3	15:04:46	03-16-2015
179		1.07E-02	3.79E-03	0.828		78.5	15:04:52	03-16-2015
180	right 1	1.05E-02	2.88E-03	0.832		80.6	15:06:06	03-16-2015
181		1.05E-02	2.88E-03	0.83		80.6	15:06:11	03-16-2015
182	2	6.13E-03	1.39E-03	0.844		63.4	15:06:20	03-16-2015
183		6.15E-03	1.40E-03	0.843		63.5	15:06:25	03-16-2015
184	3	6.26E-03	1.35E-03	0.834		65.4	15:06:34	03-16-2015
185		6.35E-03	1.40E-03	0.856	skip	64.6	15:06:38	03-16-2015
186	3 rep	6.31E-03	1.40E-03	0.836		65	15:06:45	03-16-2015
average all		<b>9.54E-03</b>	<b>2.80E-03</b>	<b>0.833</b>		<b>75.7</b>		
average top only				0.828				
maximum				0.849				
std.dev		3.03E-03	1.34E-03	0.010				
std.error		8.32E-04	3.61E-04	<b>0.003</b>				
best		<b>4.73E-03</b>	<b>9.88E-04</b>	<b>0.849</b>		<b>56.7</b>		
difference between best								

final Ref check

datum #	Scattering at angles $\Theta, \Phi$			Reflect-ivity	user comm-ent	Rough-ness RMS(Å)	TIME	DATE
	$\Theta_s \rightarrow$	0	50					
187	$\Phi_s \rightarrow$	0	180	0.939		35.9	15:24:47	03-16-2015
188		2.75E-03	2.20E-03	0.939		35.9	15:24:53	03-16-2015
189		2.74E-03	2.19E-03	0.941		35.7	15:25:01	03-16-2015
190		2.72E-03	2.18E-03	0.942		35.5	15:25:12	03-16-2015

Reflectometer reads repeatably and > 94% - has not been contaminated

**Conclusion: uScan registers an increase in reflectivity of  $1.30\% \pm 0.3\%$  and decrease in scattering by factors of  $1.31$  (0 deg.) and  $1.68 \pm 10\%$**

Measurements from CT7 immediately before and after CO2 cleaning  
 Increase in reflectivity in agreement with uScan, but is somewhat smaller in blue bands  
 Top of the mirror appears less reflective than bottom (trend not easily seen with uScan)

%R measurements before CO2 cleaning

					365	404	464	522	624	760	970
411	16/03/2015	10:04	0 top 1	15.8	86.7	85.3	85.0	85.2	84.6	81.8	87.5
412	16/03/2015	10:05	0 top 2	15.6	85.3	85.0	84.4	85.6	83.2	81.7	88.4
413	16/03/2015	10:06	0 top 3	15.6	82.7	82.3	83.1	83.6	82.7	80.4	85.3
414	16/03/2015	10:07	0 bottm1	15.6	87.8	86.4	86.2	86.4	85.8	83.0	88.8
415	16/03/2015	10:08	0 bottm 2	15.5	88.3	87.1	87.0	87.1	86.5	83.7	89.3
416	16/03/2015	10:09	0 bottm 3	15.5	86.7	85.2	84.8	85.5	84.4	81.7	87.5
417	16/03/2015	10:10	0 left 1	15.5	87.1	85.8	85.8	85.3	85.6	82.6	87.9
418	16/03/2015	10:11	0 left 2	15.6	86.9	86.2	86.5	86.2	85.3	83.2	87.4
			averages		87.0	85.9	85.7	85.9	85.1	82.5	88.1
			maxima		88.3	87.1	87.0	87.1	86.5	83.7	89.3

%R measurements after cleaning

420	16/03/2015	13:51	0 top 1	10.8	86.6	85.5	85.4	86.1	85.1	82.9	88.8
421	16/03/2015	13:52	0 top 2	10.9	87.1	85.9	85.7	86.3	85.1	82.9	88.5
422	16/03/2015	13:53	0 top3	11.1	86.0	84.8	84.6	85.2	84.5	81.6	87.5
424	16/03/2015	13:56	0 bottm 1	11.7	89.3	88.2	88.3	88.6	87.8	85.3	90.9
425	16/03/2015	13:57	0 bottm 2	11.9	88.3	87.0	86.8	87.3	86.6	84.0	89.8
426	16/03/2015	13:58	0 bottm 3	12.1	88.2	86.8	86.8	86.7	86.5	83.3	89.1
427	16/03/2015	13:59	0 left 1	12.4	89.4	88.1	88.0	88.3	87.7	84.8	90.7
428	16/03/2015	14:00	0 left 2	12.7	88.3	87.1	87.2	86.8	86.5	83.7	88.5
429	16/03/2015	14:01	0 left 3	13	89.9	88.7	88.3	88.9	87.9	85.3	91.2
			average		88.1	86.9	86.8	87.1	86.4	83.8	89.4
			average difference following cleaning		1.2	1.0	1.1	1.2	1.4	1.2	1.3
			maxima		89.9	88.7	88.3	88.9	87.9	85.3	91.2
			difference between maxima		1.6	1.6	1.3	1.8	1.4	1.6	1.9

dust measurements before cleaning

	365	404	464	522	624	760	970
	10.2	10.5	11.9	9.4	11.2	10.4	10.5
	12.2	11.3	12.3	8.9	12.7	9.5	8.4
	12.2	11.9	12.2	10.5	12.9	11.8	13.0
	9.7	9.6	10.2	8.0	9.3	8.1	7.9
	8.5	8.3	8.6	6.9	7.7	6.8	6.8
	10.7	11.0	12.2	9.3	11.3	10.2	9.8
	10.9	10.7	11.0	9.6	9.8	9.0	9.0
	10.3	9.5	9.7	8.3	9.8	7.8	9.6
averages	10.4	10.1	10.8	8.6	10.3	8.8	8.9

dust measurements after cleaning

	11.4	11.0	11.5	8.5	10.6	8.5	8.4
	10.8	10.5	11.5	9.1	10.7	8.8	8.8
	12.1	12.0	13.0	9.9	11.7	10.6	10.0
	7.3	6.8	6.7	4.8	5.5	4.0	4.1

10.2	9.7	10.1	7.4	8.5	6.8	6.2
9.2	9.2	9.4	7.8	8.0	7.7	7.2
7.8	7.6	7.5	5.9	6.0	5.2	4.7
8.9	8.6	8.8	7.9	8.4	7.3	8.3
6.6	6.2	6.6	4.4	5.4	4.1	3.4
9.4	9.1	9.5	7.3	8.3	7.0	6.8
-1.0	-1.1	-1.4	-1.3	-1.9	-1.8	-2.1

averages

average change in dust index

Measurements on M1 immediately after calima event. Porthole locations labelled  
 624 nm band is too high due to typo error in factory calibration

				365	404	464	522	624	760	970	624 nm corrected
364	09/03/2015 11:54	1 top	21.1	85.4	86.1	86.7	86.6	94.6	84.3	90.4	85.81166
365	09/03/2015 11:56	1 top	20.8	86.5	86.9	86.7	86.7	94.1	83.8	89.6	85.35811
366	09/03/2015 11:57	1 top	20.6	84.0	84.7	84.5	84.9	92.1	82.1	88.2	83.54391
367	09/03/2015 11:58	1 bottom	20.1	85.9	86.4	86.4	86.4	93.5	83.5	89.0	84.81385
368	09/03/2015 11:59	0 bottom	20	86.8	87.1	87.2	86.8	94.7	84.1	89.8	85.90237
369	09/03/2015 12:00	0 bottom	19.9	85.4	86.0	86.0	85.9	93.2	83.1	88.5	84.54172
372	09/03/2015 12:03	1 left	19.5	86.7	87.2	87.2	86.9	94.5	83.8	89.3	85.72095
373	09/03/2015 12:04	1 left	19.4	86.3	86.5	86.3	86.2	93.6	82.9	88.6	84.90456
374	09/03/2015 12:05	1 right	19.1	84.6	85.6	85.6	85.8	92.3	82.9	87.9	83.72533
375	09/03/2015 12:06	1 right	19.1	84.5	85.0	85.0	84.8	92.2	81.9	87.2	83.63462
376	09/03/2015 12:07	1 right	19	84.8	85.6	85.5	85.4	92.4	82.6	87.3	83.81604
		averages		85.5	86.1	86.1	86.0	93.4	83.2	88.7	84.7
		minimum		84.0	84.7	84.5	84.8	92.1	81.9	87.2	83.5
		maximum		86.8	87.2	87.2	86.9	94.7	84.3	90.4	85.9
		std.dev.		1.0	0.8	0.9	0.7	1.0	0.8	1.0	

Gauge measurement following M1 measurement.

Change of Target for 624 has not changed Gauge measurement. New Calibration required

09/03/2015 13:42	Gauge	15.3	83.2	84.0	89.0	90.6	98.4	83.8	86.8
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Difference between averages estimates change since 27 Feb cleaning.

-1.2	-1.3	-1.4	-1.3	-1.4	-1.2	-1.3
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change between 9 and 16th March	1.4	-0.2	-0.4	-0.1	-8.3	-0.7	-0.6
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Note: a new calibration was recorded in the CT7 on 12/3,  
 so the above change reflects this (typo error in 624 nm band)