

Reflectivity measurements for trial of "food grade" CO2 on Coude Flat and INT primary, 28-1-2016  
 Cleaning, measurements and report by Neil O'Mahony.  
 Note the Coude flat was Aluminised over 2 years ago, stored covered, diameter ~250 mm.

Conclusions: Both reflectometers show that the primary mirror registered only small improvements: 0.5% in reflectivity and marginal in scattering. The Coude mirror, in spite of excellent initial values, shows a more typical levels of improvement, probably because of scattering by paper fibres. However, CT7 is more pessimistic about improvement to Coude data than the SMS uScan.

The CT7 data (p3) shows that the INT primary mirror reflectivity had decreased by just 0.5% since water wash 2 months previously. The CO2 has recovered almost all of the reflectivity lost in that time. Thus the limited effectivity of the new CO2 is due to lack of loose dust on the primary.

p1: SMS Measurements usually in pairs at same location, to check 0.05% repeatability.  
 Those marked "Not rep" are omitted from statistics. Instrument clock is approx. 15 minutes ahead

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

Test of new CO2 on Coude Flat mirror

datum #	Scattering at angles $\Theta, \Phi$		Reflectivity	user comment	Roughness RMS(Å)	TIME	DATE
	$\Theta$ s->	$\Phi$ s->					
	0	50					
	0	180					

Reference mirror

1	location1	2.80E-03	1.88E-03	0.928		36.5	0.628322	01-28-2016
2		2.80E-03	1.88E-03	0.928	rep ok	36.5	0.62838	01-28-2016
3		6.44E-03	2.43E-03	0.928		57.1	0.628461	01-28-2016
4		1.24E-03	8.36E-04	0.934	>93%	24.2	0.628542	01-28-2016
5		1.97E-08	2.25E-08	0.001	null	3	0.628889	01-28-2016

Coude flat test before CO2

6	location1	6.10E-04	2.56E-04	0.842	Not rep	18.3	0.629016	01-28-2016
7		6.21E-04	2.60E-04	0.834		18.5	0.629074	01-28-2016
8		6.24E-04	2.59E-04	0.837	rep	18.5	0.629144	01-28-2016
9	location2	1.06E-03	8.90E-04	0.853		23.4	0.629282	01-28-2016
10		1.06E-03	8.91E-04	0.853		23.4	0.62934	01-28-2016
11	location3	6.52E-04	3.47E-04	0.851		18.5	0.629468	01-28-2016

Averages before 7.78E-04 4.84E-04 **0.847**

coude flat test after CO2

12	loc 1	4.47E-04	6.56E-05	0.862		19.6	15:13:18	01-28-2016
13		4.47E-04	6.42E-05	0.862		19.8	15:13:24	01-28-2016
14	loc 2	2.97E-04	3.52E-05	0.858		17.9	15:13:39	01-28-2016
15		2.97E-04	3.69E-05	0.855		17.5	15:13:46	01-28-2016
16	loc 3	3.74E-04	2.98E-04	0.861		13.8	15:13:55	01-28-2016
17		3.74E-04	2.97E-04	0.860		13.9	15:13:59	01-28-2016
18	loc 4	3.34E-04	9.16E-05	0.860		14.1	15:14:08	01-28-2016
19		3.32E-04	9.15E-05	0.862		14	15:14:13	01-28-2016

20 loc 5	2.74E-04	1.12E-04	0.865	12.1	15:14:22	01-28-2016
Averages after	3.53E-04	1.21E-04	<b>0.861</b>			

**Result of cleaning Coude mirror with new CO2:**

Increase in Reflectivity **1.4%**  
 Decrease in Scattering by factors of **2.2** and **4.0**

**INT Primary mirror before CO2**

22 loc 1	4.15E-03	2.25E-03	0.820 Not rep	47.6	15:16:55	01-28-2016
23	4.13E-03	2.25E-03	0.833	47	15:17:00	01-28-2016
24 loc 2	3.61E-03	1.16E-03	0.835	45.9	15:17:08	01-28-2016
25 loc 3	5.17E-03	1.97E-03	0.831	54	15:17:21	01-28-2016
26	5.20E-03	2.01E-03	0.831	54.1	15:17:26	01-28-2016
27 loc 4	2.88E-03	1.44E-03	0.828	39.5	15:17:37	01-28-2016
28	2.87E-03	1.45E-03	0.827	39.5	15:17:43	01-28-2016
29 loc 5	3.11E-03	9.48E-04	0.850	42.5	15:17:53	01-28-2016
Averages before	3.89E-03	1.68E-03	<b>0.832</b>			
std. dev.	9.3E-04	5.5E-04	0.01			

**INT Primary mirror after CO2**

30	1.97E-08	2.25E-08	0.001 omit	3	15:30:02	01-28-2016
31	3.53E-03	9.65E-04	0.804 omit	47.4	15:30:16	01-28-2016
32	3.53E-03	9.63E-04	0.846 omit	46.3	15:30:21	01-28-2016
33	3.54E-03	9.63E-04	0.828 omit	46.8	15:30:27	01-28-2016
34 loc 1	3.52E-03	9.59E-04	0.853	46	15:30:32	01-28-2016
35	3.53E-03	9.56E-04	0.851	46.2	15:30:39	01-28-2016
36 loc 2	2.65E-03	7.98E-04	0.846	39.4	15:30:47	01-28-2016
37	2.63E-03	7.98E-04	0.846	39.2	15:30:53	01-28-2016
38 loc 3	2.91E-03	9.69E-04	0.835	41.1	15:31:09	01-28-2016
39	2.91E-03	9.68E-04	0.834	41.1	15:31:14	01-28-2016
40 loc 4	3.81E-03	1.26E-03	0.830 solo	47.1	15:31:21	01-28-2016
41 loc 5	3.72E-03	1.09E-03	0.834	47.3	15:31:29	01-28-2016
42	3.72E-03	1.09E-03	0.833	47.3	15:31:35	01-28-2016
43 loc 6	3.15E-03	9.53E-04	0.837	43.2	15:31:46	01-28-2016
44	3.15E-03	9.52E-04	0.833	43.4	15:31:51	01-28-2016
45 loc 7	4.36E-03	1.54E-03	0.832	50	15:32:02	01-28-2016
46	4.35E-03	1.54E-03	0.833	49.9	15:32:07	01-28-2016
47 loc 8	1.87E-03	3.52E-04	0.833	37.2	15:32:21	01-28-2016
Averages after	3.31E-03	1.02E-03	<b>0.838</b>			
Std.dev	7.8E-04	3.4E-04	<b>0.008</b>			

**Result of cleaning INT primary mirror with new CO2:**

Increase in Reflectivity **0.6%**  
 Decrease in Scattering by factors of **1.176** and **1.66**

**Reference mirror - final**

48	2.30E-03	1.53E-03	0.925	33.2	15:38:39	01-28-2016
49	2.31E-03	1.54E-03	0.926 rep - ok	33.2	15:38:45	01-28-2016

50	5.90E-03	1.61E-03	0.921	57.3	15:38:52	01-28-2016
51	4.38E-03	2.15E-03	0.931 > 93%	46	15:38:59	01-28-2016

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No evidence of contamination of the head - measurements can be trusted.



CT7 Measurements of reflectivity

% Reflectivity per waveband of measurement (nm)

				365	404	464	522	624	760	970
Coude Flat before CO2				T/°C	% Reflectivity					
598	28/01/2016 14:32	0 Normal	22.1	92.2	90.6	90.2	90.4	89.4	86.7	92.7
599	28/01/2016 14:34	0 Normal	22.1	92.1	90.5	90.1	90.4	89.3	86.8	92.6
600	28/01/2016 14:35	0 Normal	22.3	92.6	90.9	90.4	90.5	89.9	86.9	93
601	28/01/2016 14:36	0 Normal	22.4	92.6	90.9	90.4	90.7	89.7	87	92.9
averages				92.4	90.7	90.3	90.5	89.6	86.9	92.8

Coude Flat after CO2

602	28/01/2016 14:43	0 Normal	21.5	92.8	91.2	90.7	91	90.1	87.4	93.3
603	28/01/2016 14:44	0 Normal	21.4	93	91.3	90.8	91	90.2	87.4	93.2
604	28/01/2016 14:45	0 Normal	21.4	92.8	91.2	90.8	91	90.1	87.4	93.2
averages				92.9	91.2	90.8	91.0	90.1	87.4	93.2

<b>Difference in Coude flat from CO2</b>				<b>0.5</b>	<b>0.5</b>	<b>0.5</b>	<b>0.5</b>	<b>0.6</b>	<b>0.6</b>	<b>0.4</b>
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INT Primary mirror before CO2

605	28/01/2016 14:55	0 Normal	19.8	90.4	89.2	89	89.3	88.5	85.9	91.8
606	28/01/2016 14:56	0 Normal	19.6	90.2	89.1	88.8	89.3	88.5	86	92
607	28/01/2016 14:57	0 Normal	19.6	89.3	88	87.9	88.5	88	85.4	91.6
608	28/01/2016 14:58	0 Normal	19.6	89.4	88.4	88.3	88.7	88	85.4	91.3
Averages				89.8	88.7	88.5	89.0	88.3	85.7	91.7

Average following wash 26/11/2015				90.3	89.2	89.0	89.3	88.9	86.2	92.0
Loss in reflectivity since washing				0.5	0.5	0.5	0.4	0.6	0.5	0.3

INT Primary mirror after CO2

609	28/01/2016 15:06	0 Normal	18.7	90.2	89	88.8	89.3	88.5	86	92.1
610	28/01/2016 15:07	0 Normal	18.6	90	88.8	88.6	89.1	88.6	85.8	92.1
611	28/01/2016 15:08	0 Normal	18.7	89.3	88.1	88.4	88.6	88.2	85.5	91.6
Averages				89.83	88.63	88.60	89.00	88.43	85.77	91.93

INT Primary mirror next day

612	29/01/2016 12:33	2 %R only	18.5	90.2	88.9	89	89.2	88.7	86.1	92.1
613	29/01/2016 12:33	2 %R only	18.6	90.7	89.2	88.9	89.3	88.7	85.9	92.2
614	29/01/2016 12:34	2 %R only	18.7	89.9	88.8	88.7	89.4	88.5	86.1	92.1
615	29/01/2016 12:35	2 %R only	18.7	90.2	88.9	88.9	89.3	88.8	86.2	92.4
616	29/01/2016 12:35	2 %R only	18.9	90.5	89.2	89.1	89.6	88.8	86.3	92.3
617	29/01/2016 12:36	2 %R only	18.9	89.8	88.5	88.4	88.9	88.1	85.7	91.7
				90.2	88.9	88.8	89.3	88.6	86.1	92.1

Difference in %R resulting from CO2

<b>0.4</b>	<b>0.2</b>	<b>0.3</b>	<b>0.3</b>	<b>0.4</b>	<b>0.4</b>	<b>0.5</b>
365	404	464	522	624	760	970

waveband of measurement (nm)

**Conclusion: A small increase in reflectivity is detected, recovering almost all of reflectivity lost since water wash 2 months previously, though less effective in 404, 464 nm abnds**

Corresponding measurements of Dust Index follow

coude before	2.4	2.2	1.8	1.4	1.3	1.5	1.3
	2.9	2.7	2.3	2.1	2	1.6	2.1
	2.6	1.8	1.4	1.2	1.1	1.1	1.1
	1.7	1.5	1.3	1	1.1	0.9	1
	2.4	2.1	1.7	1.4	1.4	1.3	1.4
Coude afer	1.5	1.3	1.1	0.8	0.6	0.5	0.6
	1.1	1	0.8	0.7	0.6	0.5	0.7
	1.4	1.4	1.1	0.8	0.6	0.6	0.8
	1.3	1.2	1.0	0.8	0.6	0.5	0.7
change in Coude	1.1	0.8	0.7	0.7	0.8	0.7	0.7

INT Primary before	4.1	3.7	3.6	2.9	3.2	2.7	3.1
	4.6	4.3	4.3	3.1	3.6	2.8	2.8
	6.6	6.5	6.4	4.2	4.5	3.6	3.3
	6.3	5.6	9.2	4	4.5	4.2	3.6
	5.4	5.0	5.9	3.6	4.0	3.3	3.2
INT Primary after	5.4	4.7	4.3	3.3	3.5	2.8	2.9
	5.1	4.7	4.7	3.4	3.3	3.1	2.7
	6.4	5.8	4.9	4	4.3	3.2	3.3
	5.6	5.1	4.6	3.6	3.7	3.0	3.0

Difference in Dust index in Primary mirror is negligible.