SCF-TEST OF MOONLIGHT/LLRRA21,

THE LUNAR LASER RANGING RETROREFLECTOR

FOR THE 21ST CENTURY

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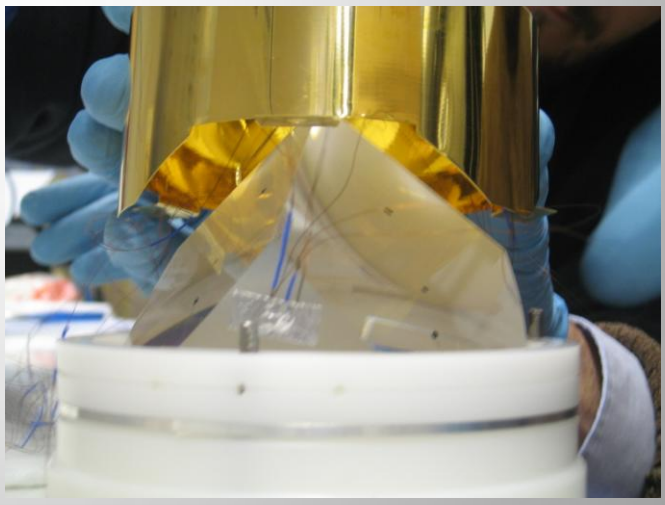
Outline

1. Issues on thermometry
2. Thermometer “environment” on solid CCR
3. SCF preliminary test of Moonlight CCR
4. Next step
5. Conclusions

HW and Instrumentation



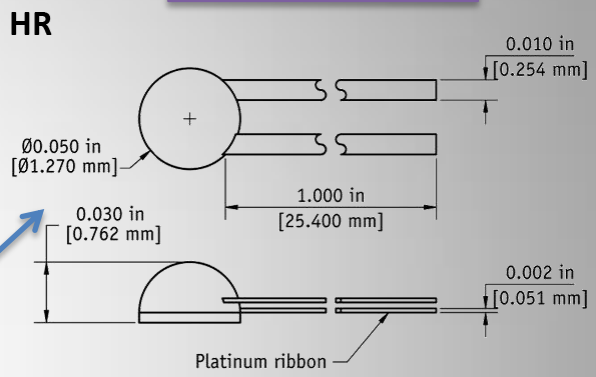
Some critical issues

1. The T distribution in the volume of a Solid CCR determines its optical performance.
2. Thermal and optical analysis must be tuned with thermal (optical) balance tests in order to correlate models and prototypes (extremely important for a big CCR on the Moon)
3. When measuring the T of an object we must be carefull to not measure “just” the T of the thermometer (radiation from environment, insufficient thermal contact contact etc.)

Thermometers environment

1. Nominal heat flux absorbed by the thermometer due to TIR loss is ≅ 1.5 x 10^{-3} W (Al or Ag coating spot?)
2. Nominal heat flux radiated by the thermometer due to TIR loss is ≅ 0.7 x 10^{-4} W (360 K vs. 300 K); coating of the dome could be advantageous and cheap (TIR loss)
3. 4W Manganine 36 AWG
4. Thermal interface conductance≅ 0.1 W/K (Hp: Stycast thickness =0.001 mm - contact factor 0.1)

m = 23 mg

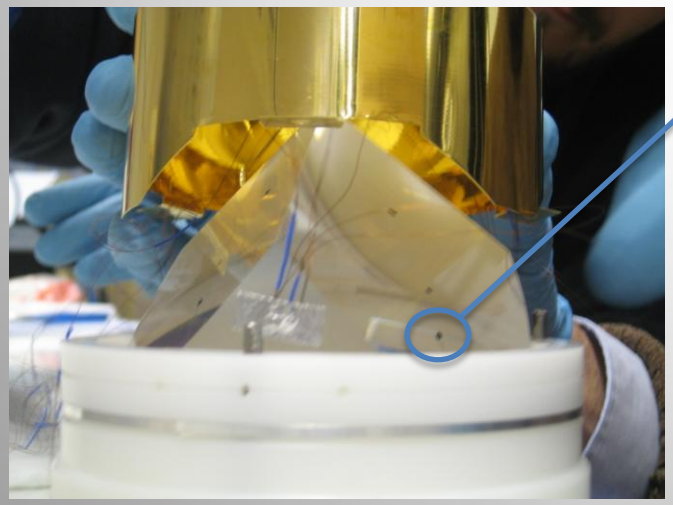


General tolerance of ±0.005 in [±0.127 mm] unless otherwise noted

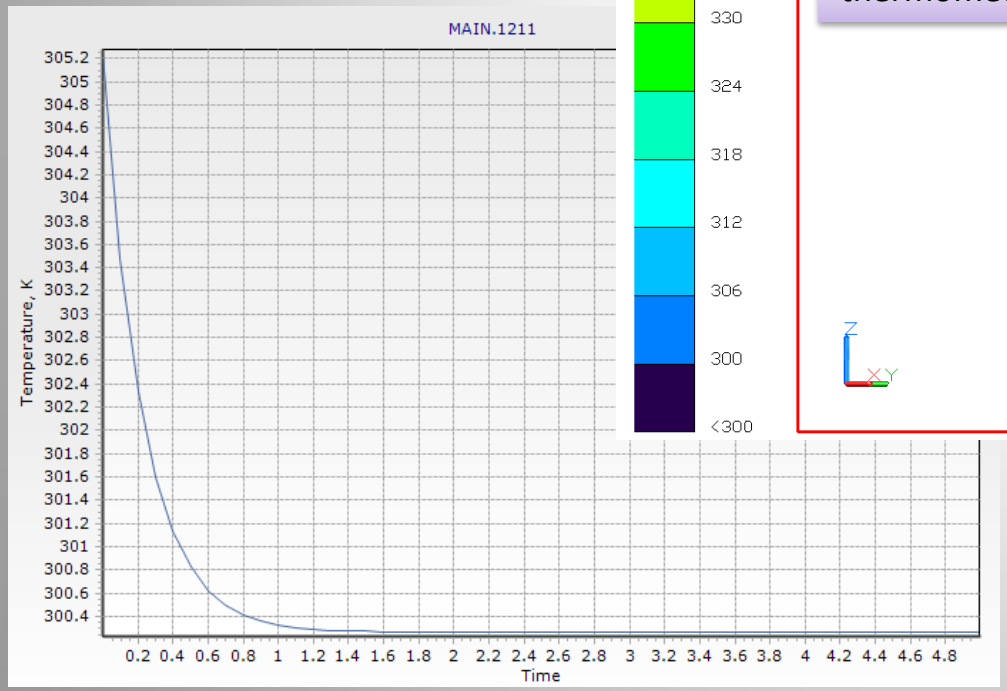
Calibrated Accuracy

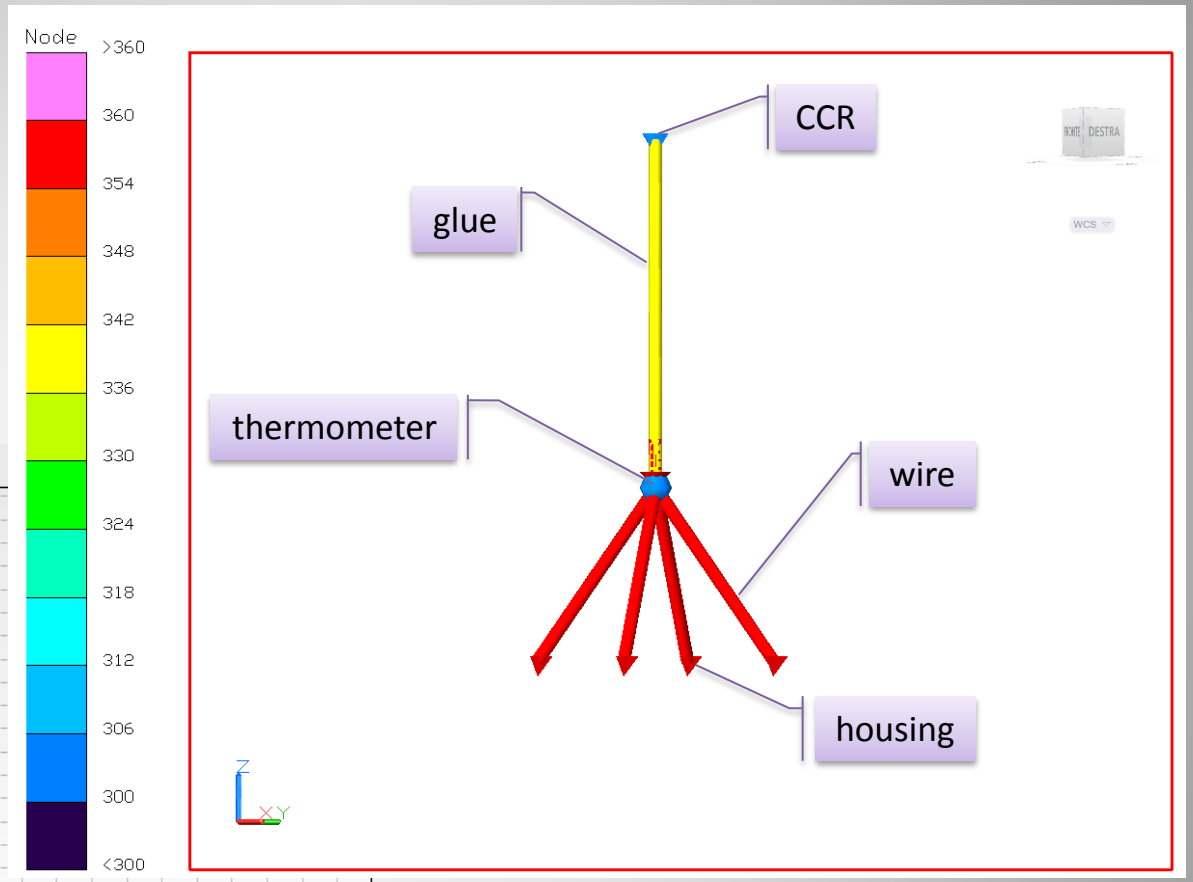
	Typical sensor accuracy[2]
1.4 K	±12 mK
4.2 K	±12 mK
10 K	±12 mK
77 K	±22 mK
300 K	±32 mK
500 K	±50 mK

[2] *[(Calibration uncertainty)² + (reproducibility)²]^0.5*

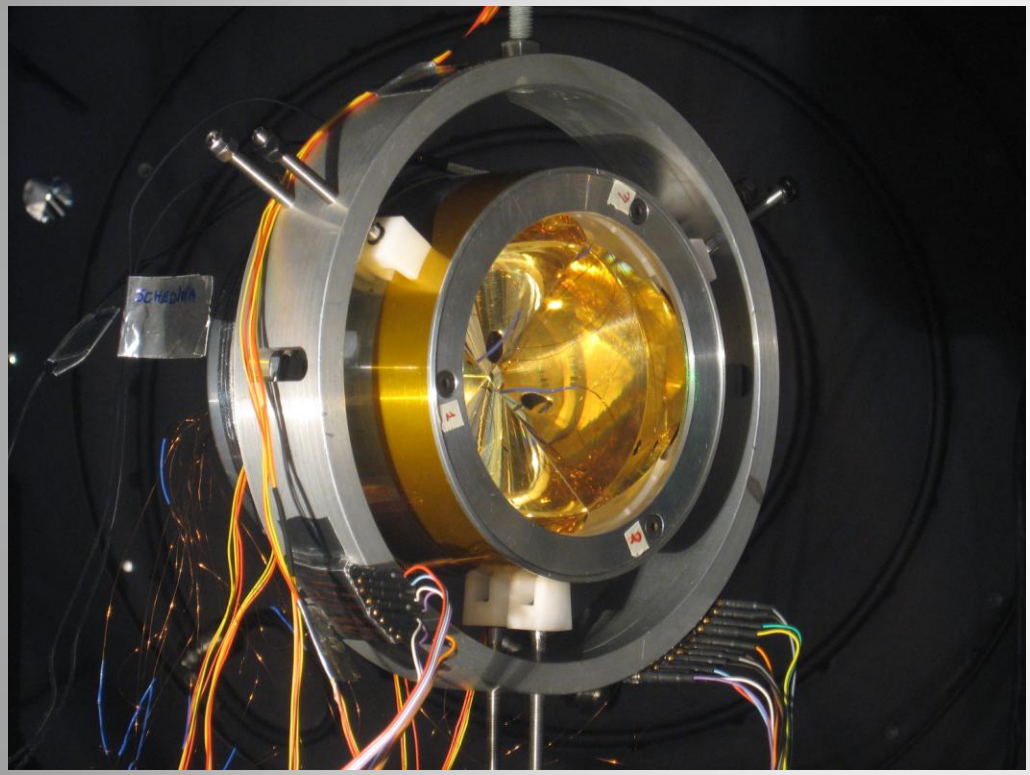


Thermometer “thermalization” on CCR

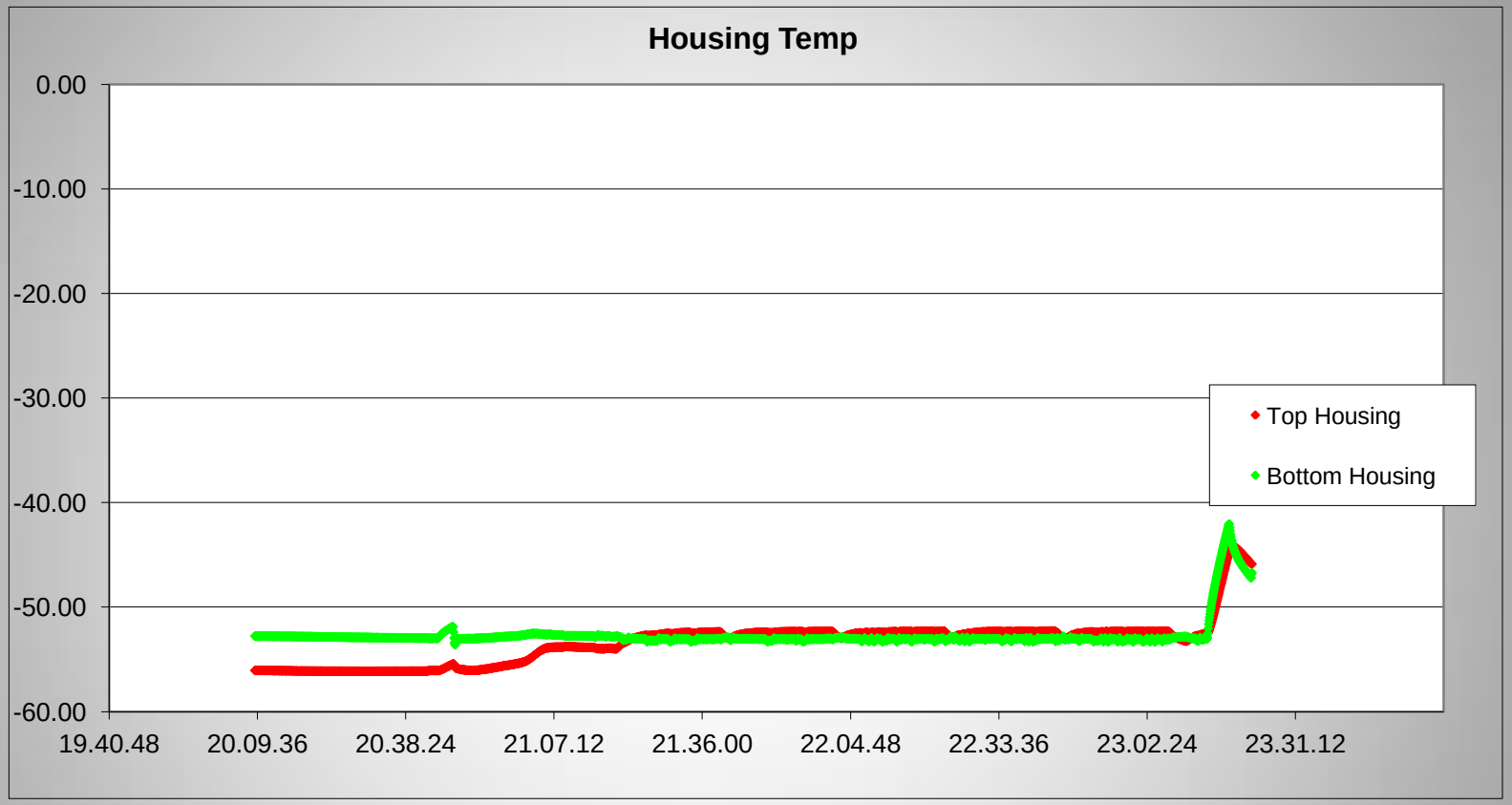




Moonlight In the SCF

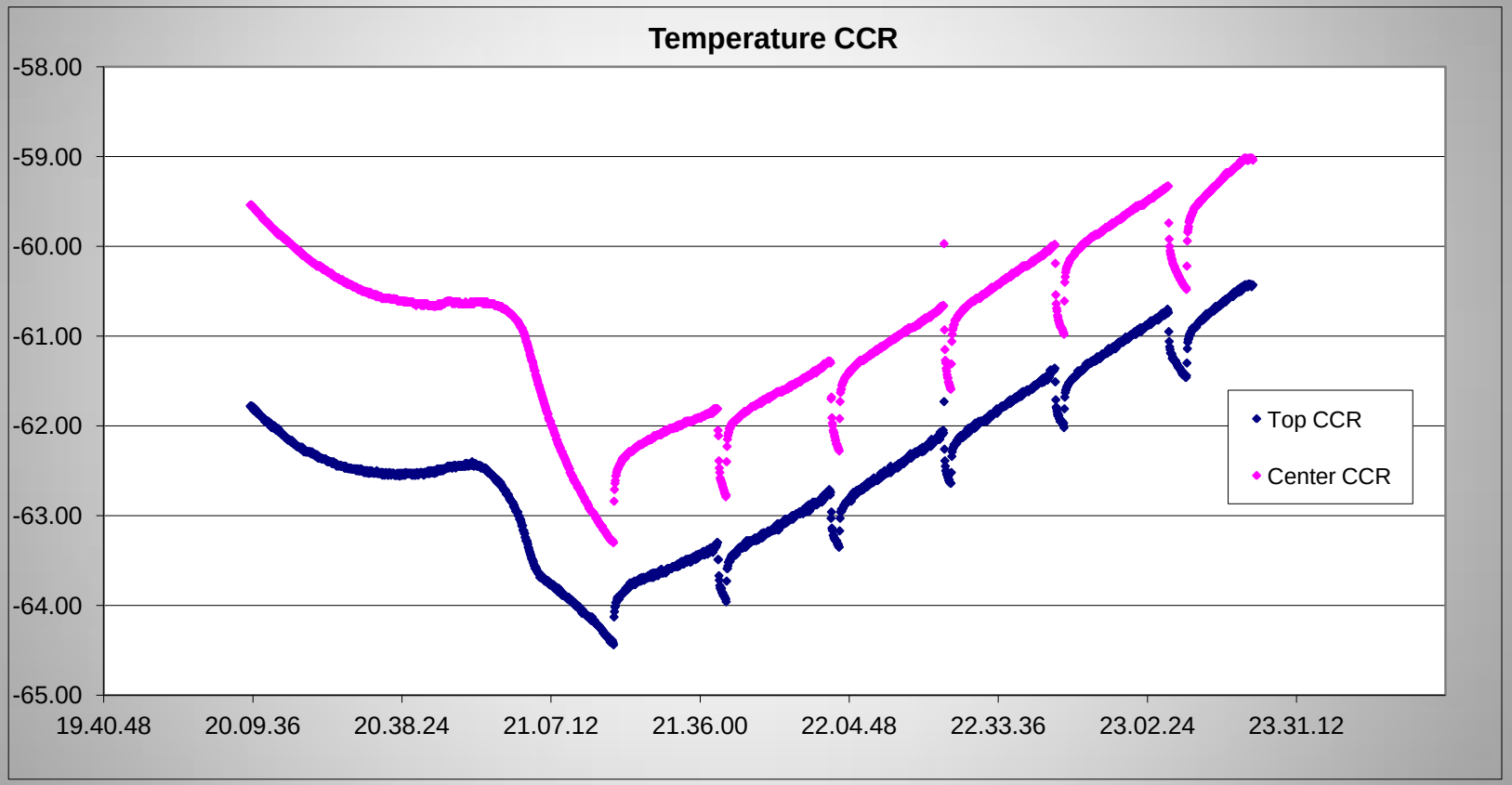


SCF Thermo-optical test



SCF Thermo-optical test

Run from cold to hot case SS expected to last 2 weeks!!



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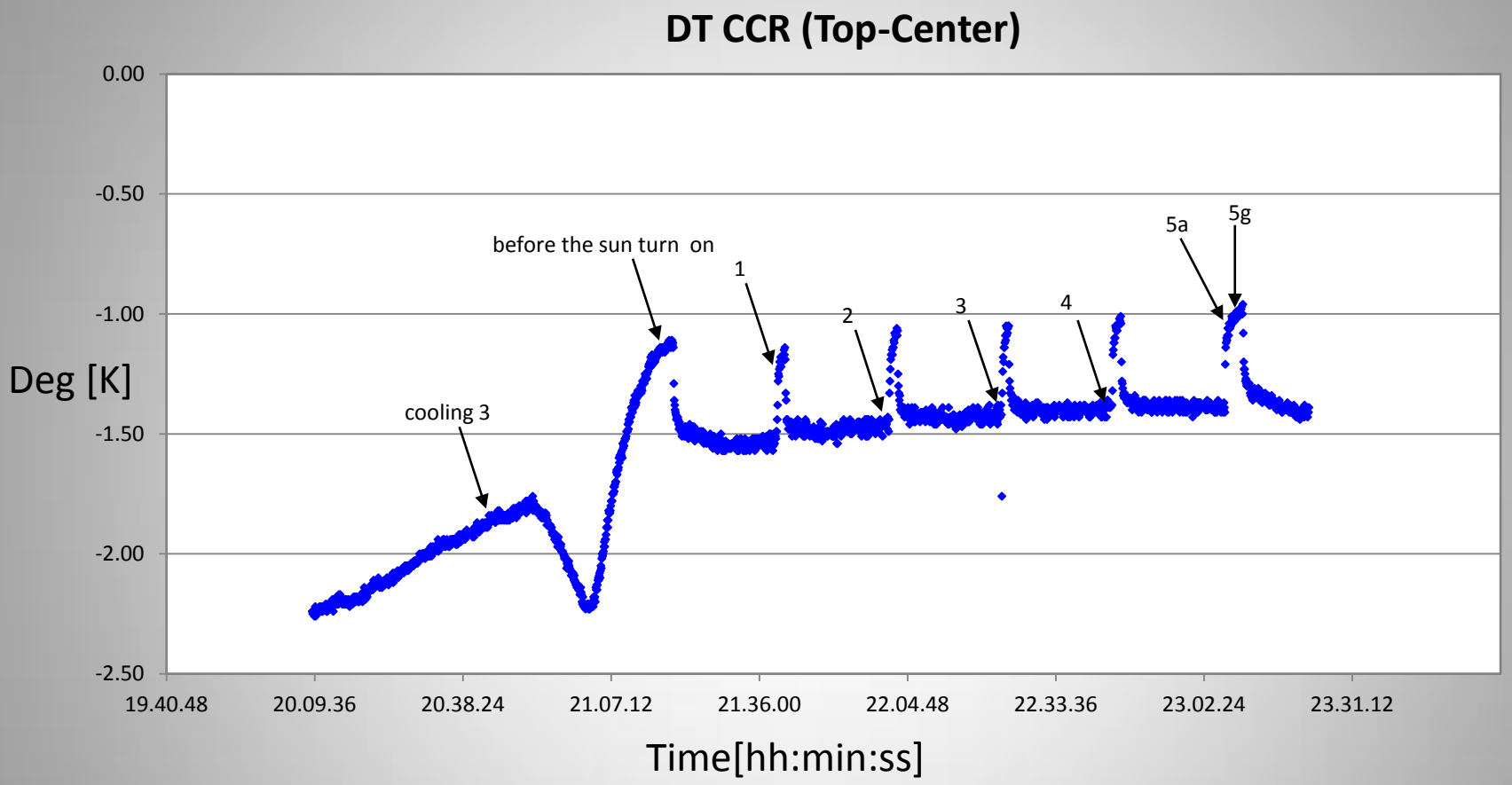
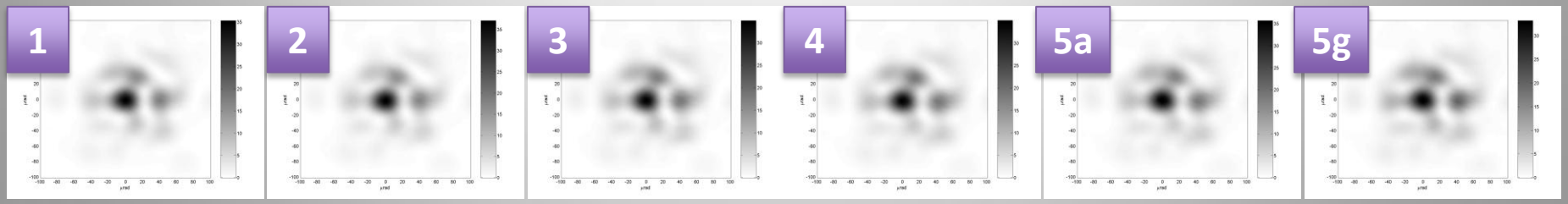
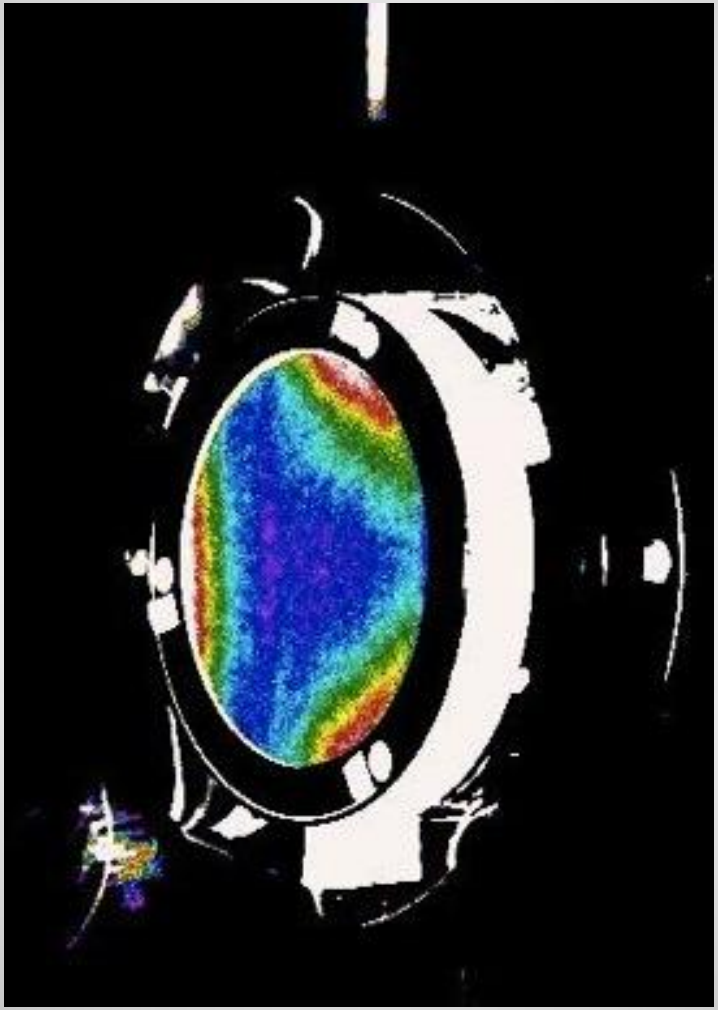




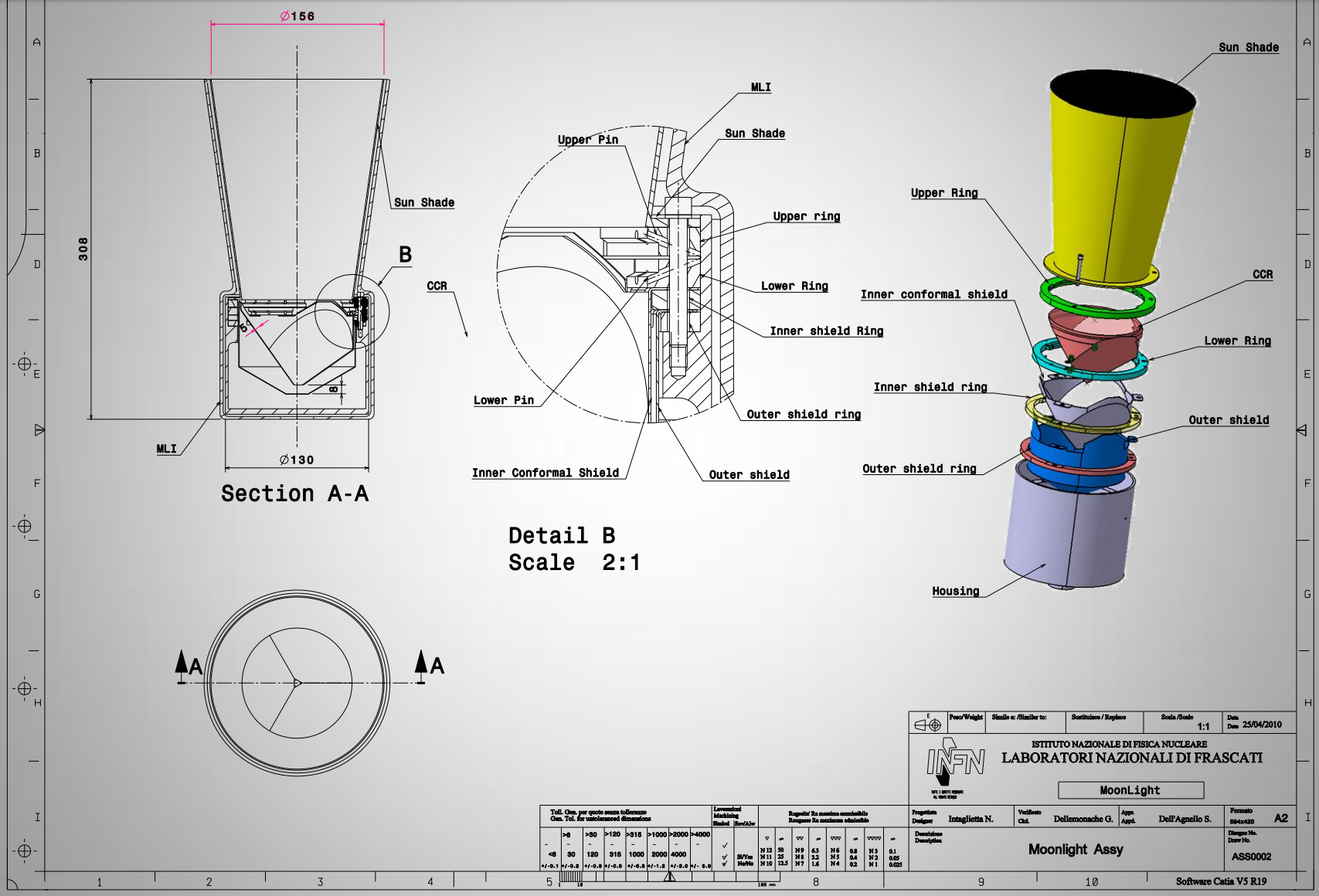
SCF Thermo-optical test

time	Top	Center	ΔT ()	DT(Fr-Tip)	FFDP name	FFDP Peak int (Tot)	FFDP Peak int (Hor)
n.a.	n.a.	n.a.	n.a.	0	STP*	0.2683	0.2241
18.52.02	-27.91	-23.82	-4.09	-6.87	cooling 1	0.1538	0.1181
19.22.02	-52.95	-49.39	-3.56	-5.92	cooling 2	0.1426	0.1184
20.45.02	-62.50	-60.66	-1.84	-2.83	cooling 3	0.3458	0.219
21.18.02	-64.36	-63.22	-1.14	-1.58	Before sun on	0.3434	0.2297
21.40.02	-63.83	-62.61	-1.22	-1.72	1	0.3527	0.2358
22.01.02	-62.72	-61.28	-1.44	-2.12	2	0.3706	0.2431
22.23.02	-62.08	-60.66	-1.42	-2.08	3	0.3487	0.2485
22.44.02	-61.38	-60.00	-1.38	-2.01	4	0.3498	0.2434
23.08.02	-61.30	-60.29	-1.01	-1.34	5a	0.3567	0.2475
23.08.22	-61.35	-60.32	-1.03	-1.38	5b	0.3509	0.2449
23.08.42	-61.36	-60.37	-0.99	-1.31	5c	0.3601	0.2622
23.09.02	-61.41	-60.40	-1.01	-1.34	5d	0.3684	0.2297
23.09.22	-61.41	-60.43	-0.98	-1.29	5e	0.344	0.2658
23.09.42	-61.43	-60.46	-0.97	-1.27	5f	0.3648	0.2492
23.09.57	-61.44	-60.48	-0.96	-1.26	5g	0.3312	0.2728

IR thermometry



Hardware design for next test



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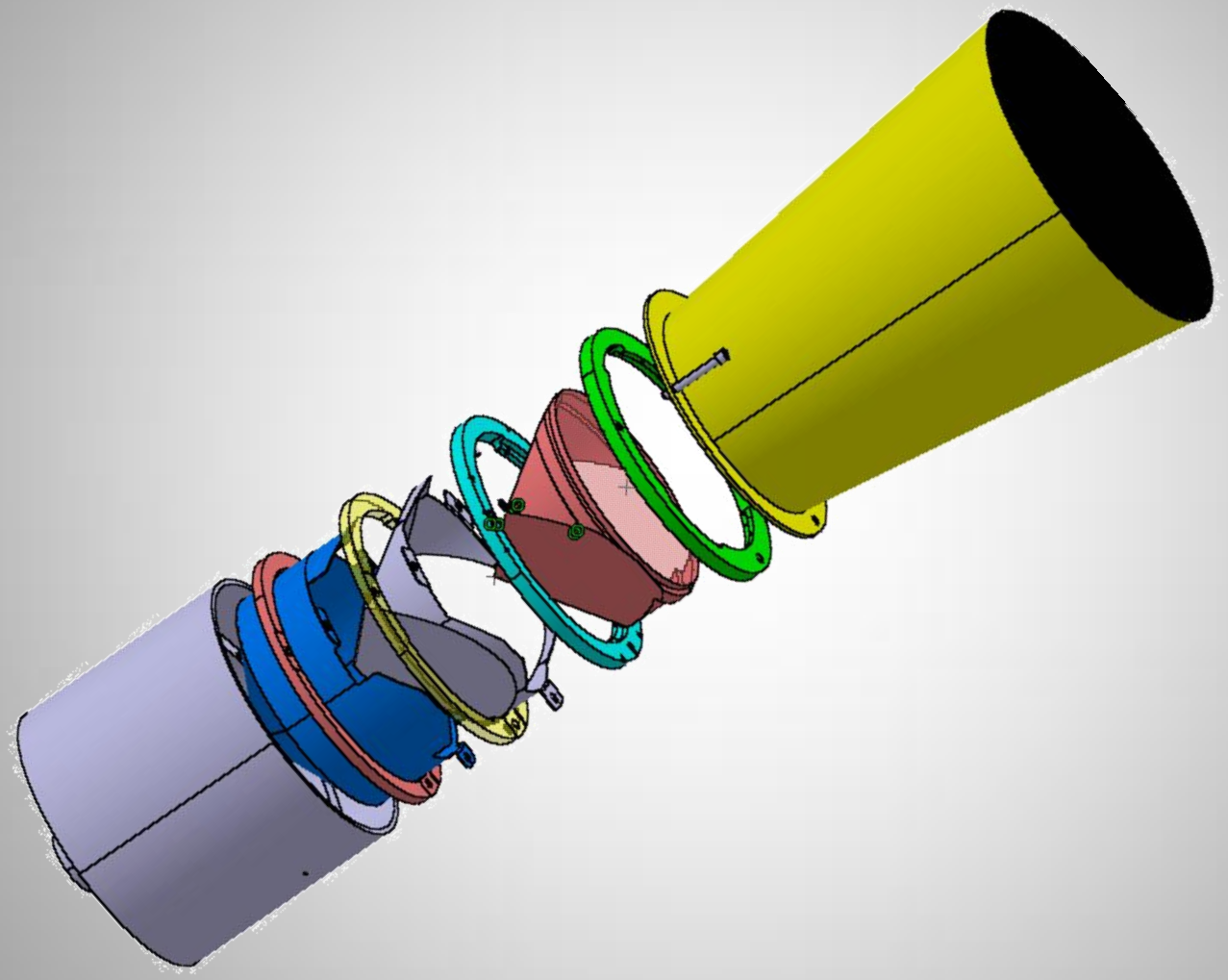

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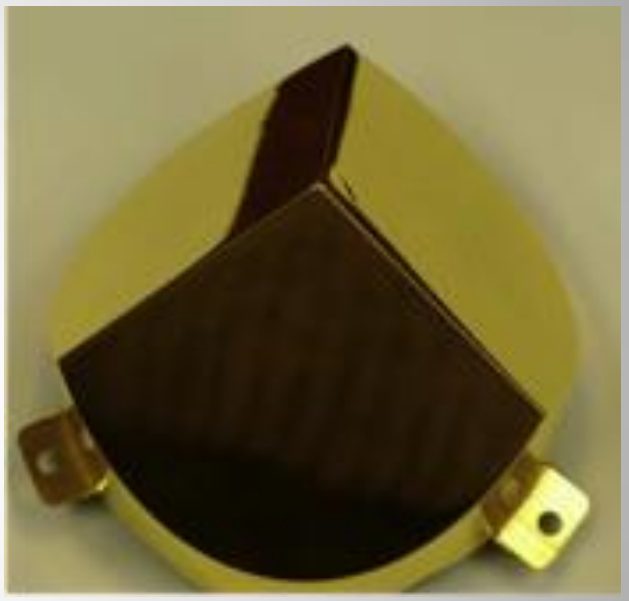
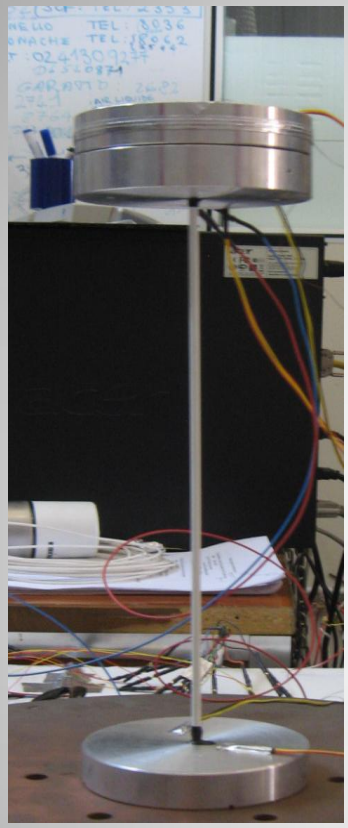
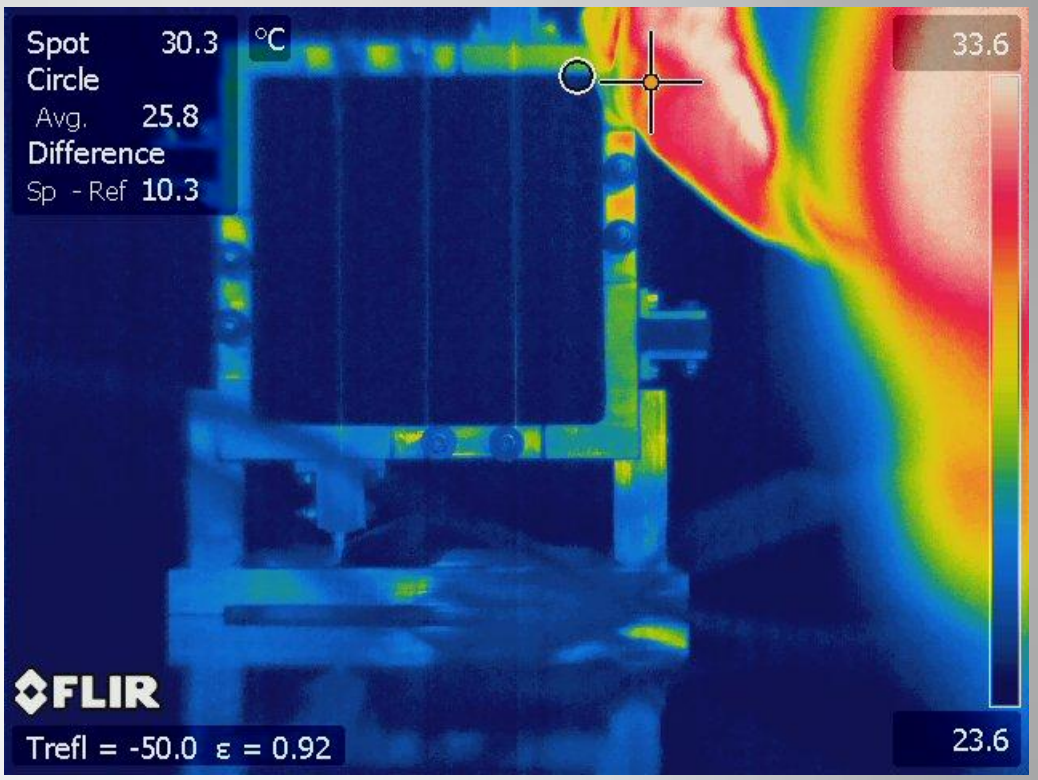


"Jigsaw" Sun shade: geometry and thermo optical properties optimized to reflect back to space as much Sun radiation as possible

Inner conformal shield: to limit green house thermal budget in the CCR cavity

Hardware design for next test





Breadbord for thermal interface study between CCR and mounting rings

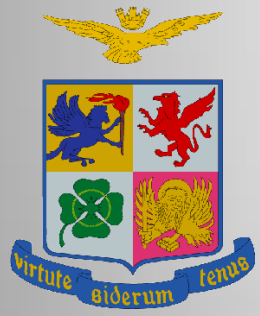
New concept of IR simulator for CCRs

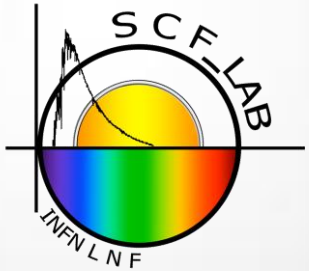
Conclusions

1. FFDPs measured in the preliminary test show encouraging performance of the CCR and the surrounding hardware
2. Silicon diode thermometers are good choice if we want to glue them on CCR reflecting faces
3. Simplified thermal model of thermometer assembly shows the thermometers do not introduce considerable sistematic error (no need for Al or Ag spot coating in gluing zones)
4. Anyway, glueing technique must be improved to limit direct heat flux absorption by the thermometers
5. Low emissivity/absorptivity coating of the thermometers dome represents substantial improvement toward Sun Simulator heating in break-through or non light tight conditions
6. A full run of the Moonlight CCR flight hardware is estimated to last 2 weeks in order for the CCR to reach steady states (Hot and Cold case)

Thanks for your attention!

Questions?





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