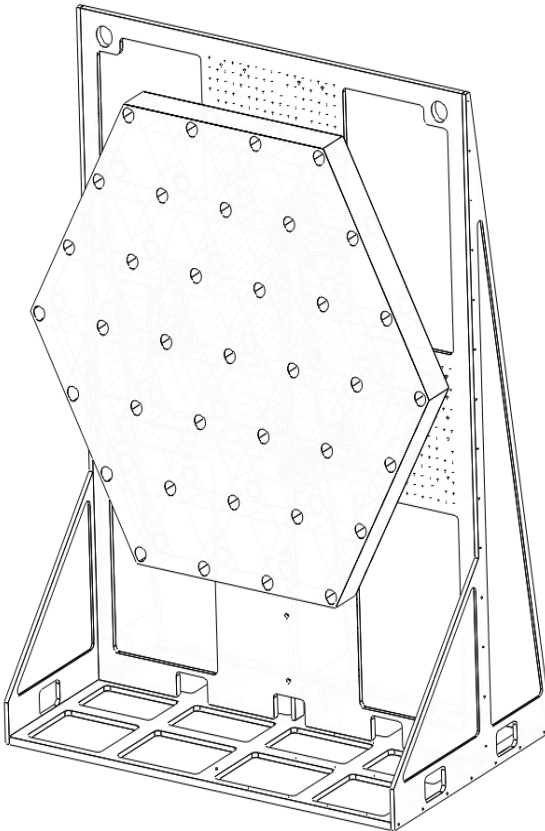
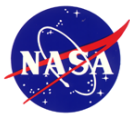


AMSD reaction structure *cryo deformation test*

Technology Days at NASA/MSFC May 22-23, 2002



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Outline



AMSD reaction structures

Test objective

Definitions

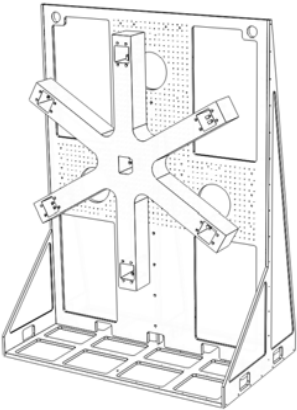
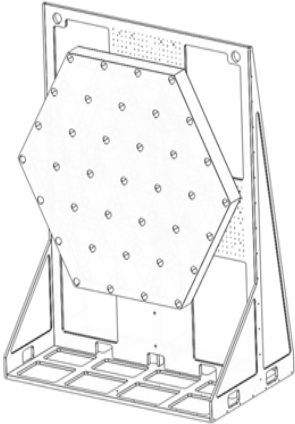
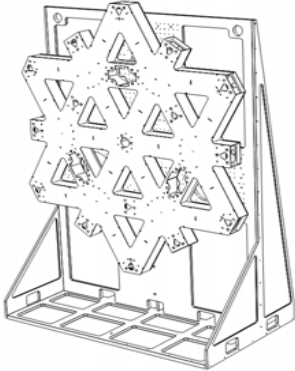
Test methods

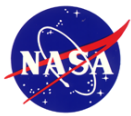
Test plan

Photos

Test results

Conclusions

	Ball	Goodrich	Kodak
Spec: Out-of-plane deformation for entire temp range	< +/- 100 microns	< 50 microns rms	< +/- 25 microns
Number of actuators total travel	4 10 micron fine 25 mm coarse	37 13 old, 87 microns 24 new, 100 microns	16 +/- 1.25mm
Manufacturer	COI	ATK	COI
Material	Gr/Ep (M55J)	Gr/Ep (M55J)	Gr/Ep (M55J)
			



Test objective



Measure out-of-plane and in-plane deformation from 290 to 25 and back to 290 deg. Kelvin.

Verify requirements and finite element model.

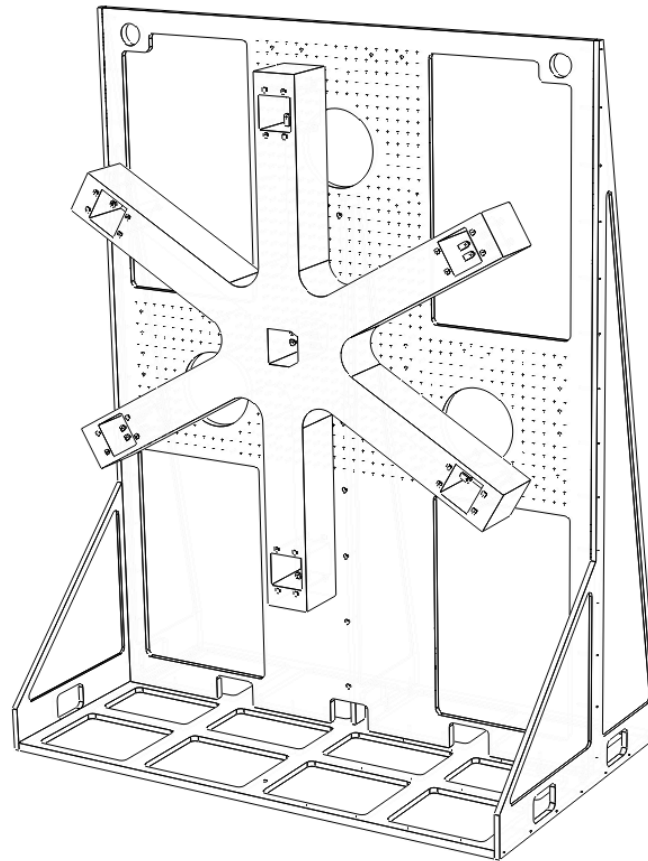
Unexpected reaction structure deformation could lead to lack of figure correctability (actuator stroke exceeded), actuator failure (side load exceeded), excessive stress in mirror, etc.

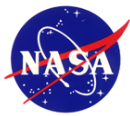
Reduce likelihood of surprises during AMSD cryo test.

Provide useful data to aid in separating mirror deformations from actuator, reaction structure, and test stand deformations.

Gain confidence in mission success.

- **Out-of-plane distortion:** reaction structure facesheet deforms with motion normal to optical axis; causing astigmatic distortion, using up actuator travel, and limiting ROC and figure corrections by the actuators.
- **In-plane distortion:** arms of the RS twisted or deformed laterally; inducing side load to actuators.

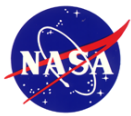




Test methods



	Kaman gages	Theodolite	Absolute distance meter (ADM)	Distance measurement interferometer (DMI)
Description	Cryo compatible Eddy current sensors	e.g. T2	Absolute distance; 1.5 to 50 meters	Relative distance
Accuracy	0.1 micron	0.5 arc sec	+/- 25 microns	10 nm resolution, 5 nm possible
Special requirements	A low CTE reference, 1.3 m zerodur to mount sensors for out of plane measurements	Targets mounted to RS for in plane measurements	Corner cubes mounted to the RS for out of plane measurements	Cryo interferometers and corner cubes, house laser head inside a can
PRO	Cryo compatible, sub micron accuracy	Low cost	Minimal cost	nm accuracy
CON	1.3 m zerodur bar to mount sensors, \$50000, 14 weeks	Limited illumination inside the chamber	New instrument	Retrofit off-the-shelf items for cryo; \$50000 + retrofit cost



Test Plan

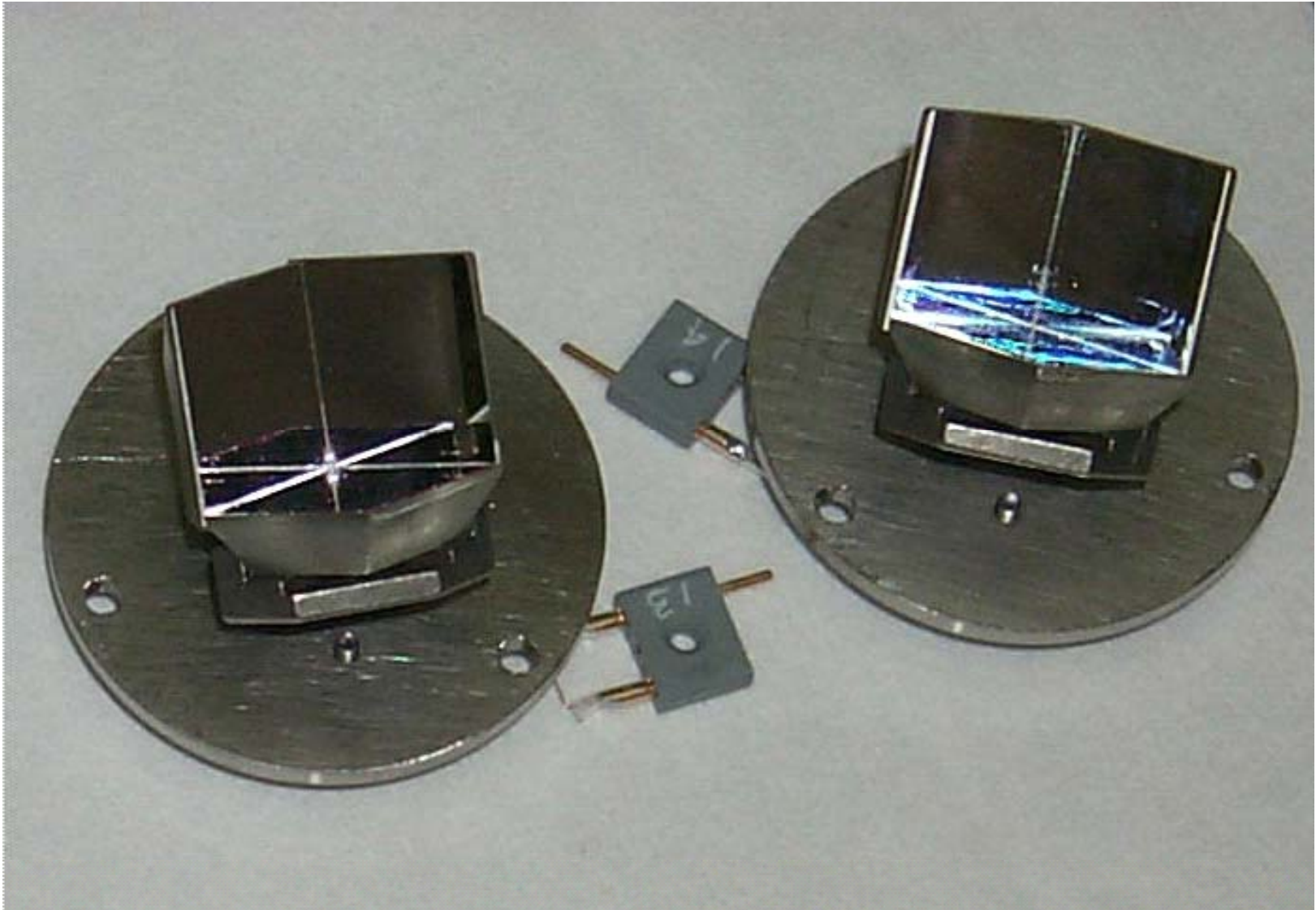


- **Measure out-of-plane deformation with ADM.**
- **Measure in-plane deformation with theodolite.**
- **Cryo compatible corner cubes.**
- **Attach 10 corner cubes onto reaction structure.**
- **Attach temperature diode next to corner cube.**
- **Mount reaction structure onto test stand.**
- **Mount ADM and theodolite onto hexapod.**
- **Hexapod: 6 DOF stage with 1 micron resolution for x,y; 0.5 for z; 1 arc sec for angular, 2x for repeatability.**

Goodrich reaction structure (front)



Corner cube and temperature diode mounted onto invar disc (10 total)

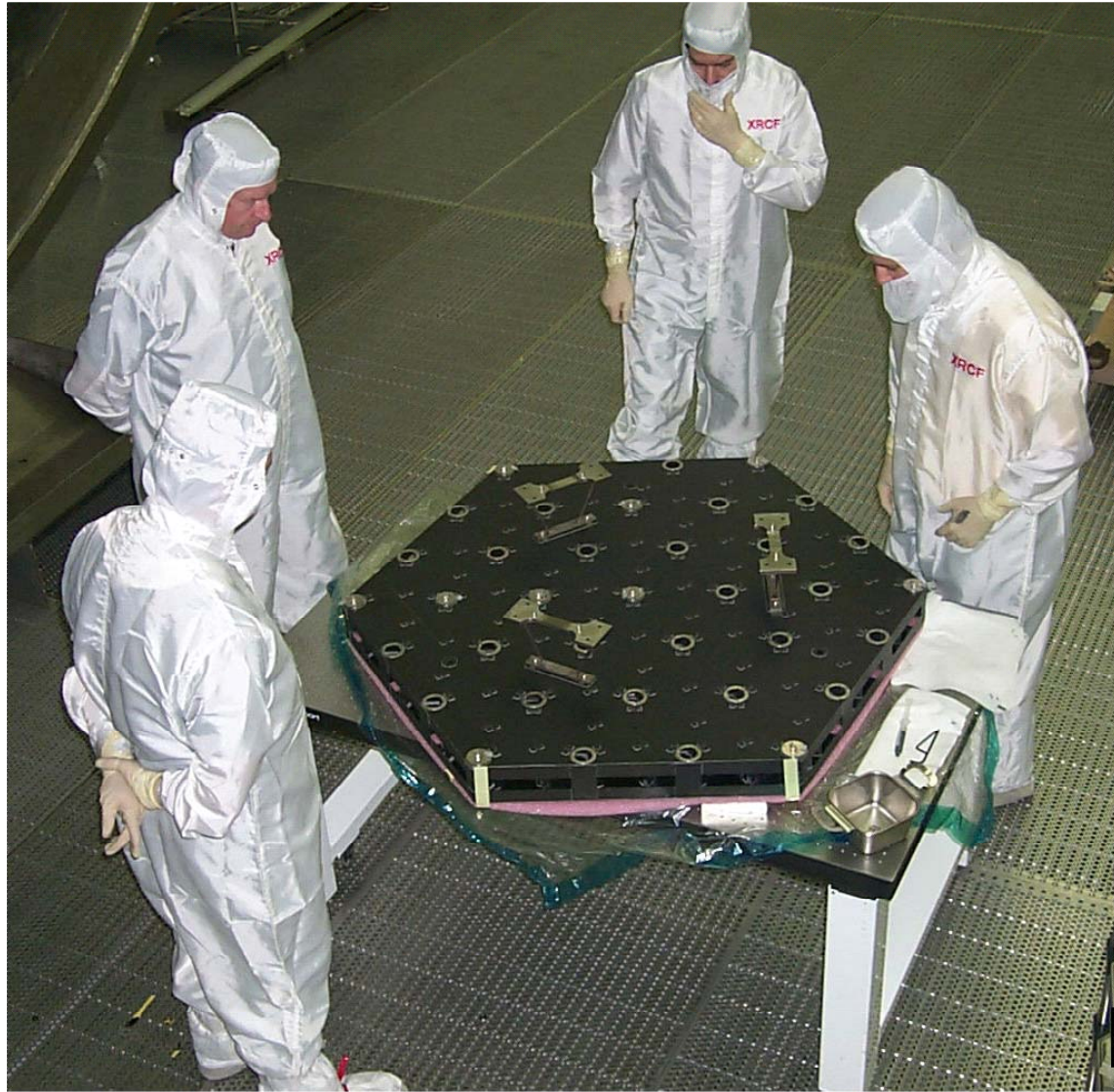


Corner cube installation





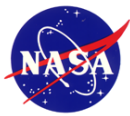
Will it fit onto test stand, and will it survive 25 deg K.?



everything fits!







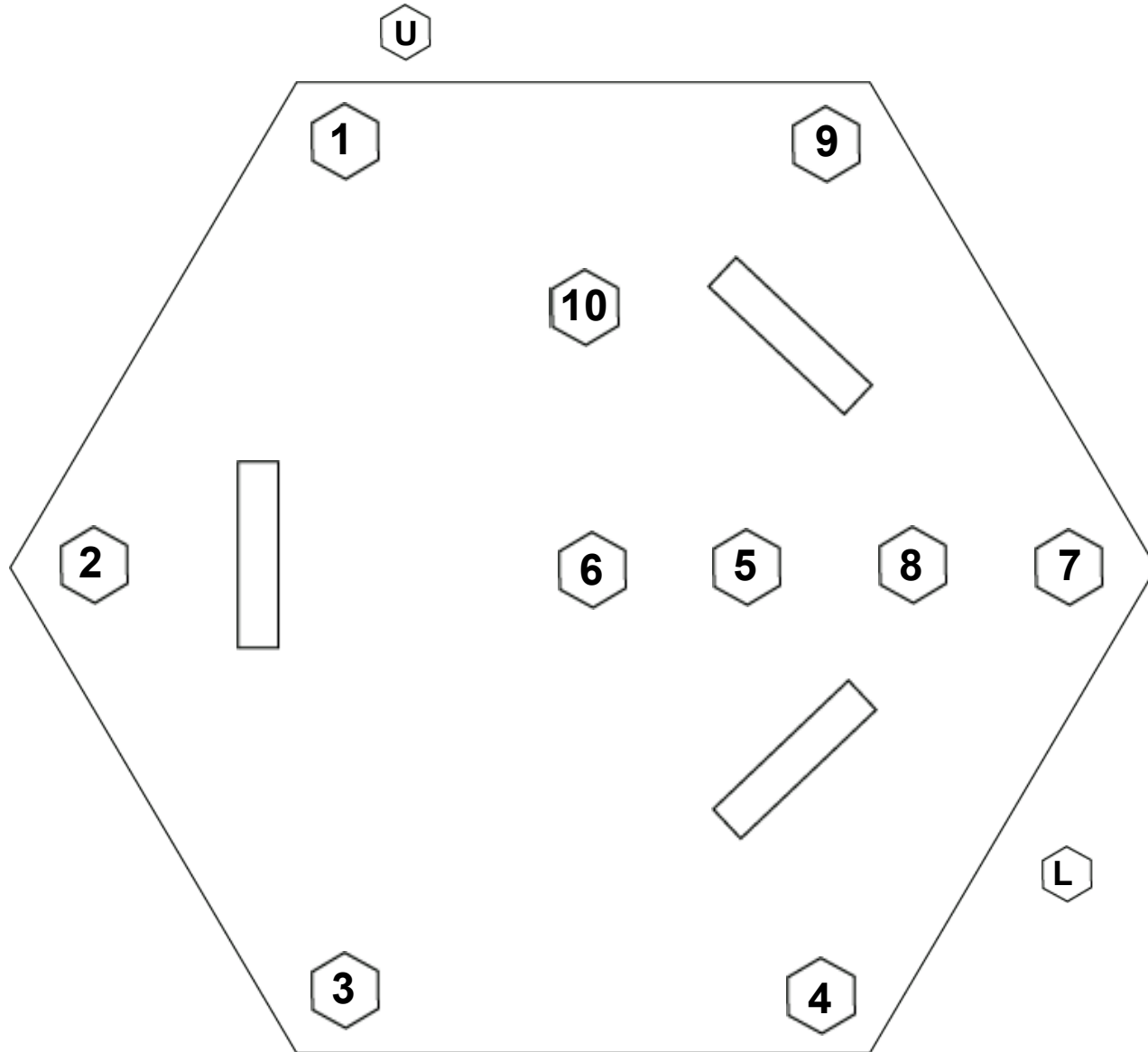
Goodrich AMSD reaction structure cryo deformation test

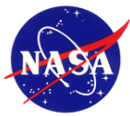


- 4/17 Install reaction structure onto chamber test stand.
- 4/19 Alignment and measurements in ambient condition. Chamber pumpdown starts. ADM measurements with chamber in partial vacuum.
- 4/20-21 Reaction structure in 290 degrees Kelvin / vacuum for Gr-Ep desorption.
- 4/22 290 deg. / vacuum ADM and theodolite measurements. Cooldown starts. 270 deg. ADM measurements.
- 4/23 162 and 127 deg. ADM measurements.
- 4/24 100 and 81 deg. ADM measurements.
- 4/25 44 deg. ADM measurements with 20 deg. gradient across reaction structure.
- 4/26 18 deg. ADM and theodolite measurements. Warmup to 290 deg. starts for 2nd cryo cycle.
- 4/27-28 Warmup to 290 deg.
- 4/29 ADM/theodolite measurement for 290 deg. Cooldown starts for 2nd cryo cycle. 270 deg. ADM measurements.
- 4/30 163 and 129 deg. ADM measurements.
- 5/1 67 and 46 deg. ADM measurements.
- 5/2 No measurements, 30 deg. with >12 deg. gradient across reaction structure.
- 5/3 25 deg. ADM/theodolite measurements. Warmup to 290 deg. starts. 40 deg. ADM measurements during warmup.
- 5/4-5/5 Warmup to 290 deg. Theodolite and ADM measurements. Backfill chamber.
- 5/6 Ambient temp/pressure ADM/theodolite measurements.



Location of corner cubes viewed from front of reaction structure





Preliminary data: deformation in microns (piston removed) Cryo cycle 1



	4/22am	4/22pm	4/23am	4/23pm	4/24am	4/24pm	4/25am	4/26am	4/29am
Temp (Kelvin)	290-part. vac.	270-290	162-290	127-290	99-290	81-290	44-290	18-290	290a-290
Pressure	10e-5	10e-5	10e-5	10e-5	10e-5	10e-5	10e-5	10e-5	10e-5
cc1	0	26	-96	-156	-172	-221	-243	-249	-33
2	-1	6	-21	32	2	-34	-19	-37	-51
3	-9	4	158	192	191	185	234	221	-22
4	-12	-1	212	248	237	252	294	308	-47
5	13	2	23	34	20	20	31	34	29
6	0	0	0	0	0	0	0	0	0
7	-5	42	102	110	103	106	123	139	98
8	6	15	54	66	60	57	66	77	53
9	-2	49	-67	-94	-2373	-141	-162	-152	42
10	2	30	-55	-84	-86	-119	-135	-132	14
U	0	123	-66	-155	-----	-----	- 483	-501	-54
L	0	0	47	-16	-73	-99	-112	-139	71



Preliminary data: deformation in microns (piston removed) Cryo cycle 2



	4/29am	4/29pm	4/30am	4/30pm	5/1am	5/1pm	5/3am	5/3am	5/5am	5/5am	5/6am
Temp (Kelvin)	290a	270- 290a	163- 290a	129- 290a	67- 290a	46- 290a	25- 290a	40- 290a	291- 290a	291a- 290a	291- 290a
Pressure	10e-5	10e-5	10e-5	10e-5	10e-5	10e-5	10e-5	10e-4	10e-6	10e-6	751
cc1	-	50	-160	-166	-183	-236	-233	-212	21	6	-13
2	-	48	-42	0	21	7	-10	13	37	26	-11
3	-	19	134	201	240	251	251	288	17	1	5
4	-	-10	204	254	269	281	310	333	-17	-31	20
5	-	-2	21	32	15	11	26	24	-12	-23	5
6	-	0	0	0	0	0	0	0	0	0	0
7	-	-17	81	84	68	50	86	93	-33	-43	19
8	-	-16	50	51	43	27	52	58	-24	-34	11
9	-	6	-90	-114	-147	-200	-175	-148	-22	-36	-3
10	-	31	-83	-83	-98	-151	-142	-102	4	-11	-6
U	-	133	-27	-127	-304	-452	-471	-450	-1	-6	0
L	-	-7	-7	-27	-98	-117	-146	-98	-36	-54	32



Preliminary data: deformation in microns for cryo cycle 1 & 2



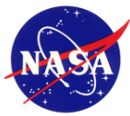
	4/22 am	4/22 pm	4/23 am	4/23 pm	4/24 am	4/24 pm	4/25 am	4/26 am	4/29 am	4/29 pm	4/30 am	4/30 pm	5/1 am	5/1 pm	5/3 am	5/3 am	5/5 am	5/5 am	5/6 am
Temp	290- p.vac	270- 290	162- 290	127- 290	99- 290	81- 290	44- 290	18- 290	290a- 290	270- 290a	163- 290a	129- 290a	67- 290a	46- 290a	25- 290a	40- 290a	291- 290a	291a- 290a	291- 290a
Pres	10e-5	10e-5	10e-5	10e-5	10e-5	10e-5	10e-5	10e-5	10e-5	10e-5	10e-5	10e-5	10e-5	10e-5	10e-5	10e-4	10e-6	10e-6	751 T
cc1	0	26	-96	-156	-172	-221	-243	-249	-133	50	-160	-166	-183	-236	-233	-212	21	6	-13
2	-1	6	-21	32	2	-34	-19	-37	-51	48	-42	0	21	7	-10	13	37	26	-11
3	-9	4	158	192	191	185	234	221	-22	19	134	201	240	251	251	288	17	1	5
4	-12	-1	212	248	237	252	294	308	47	-10	204	254	269	281	310	333	-17	-31	20
5	13	2	23	34	20	20	31	34	29	-2	21	32	15	11	26	24	-12	-23	5
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	-5	42	102	110	103	106	123	139	98	-17	81	84	68	50	86	93	-33	-43	19
8	6	15	54	66	60	57	66	77	53	-16	50	51	43	27	52	58	-24	-34	11
9	-2	49	-67	-94	-2373 error	-141	-162	-152	42	6	-90	-114	-147	-200	-175	-148	-22	-36	-3
10	2	30	-55	-84	-86	-119	-135	-132	14	31	-83	-83	-98	-151	-142	-102	4	-11	-6
U	0	123	-66	-155	-----	-----	- 483	-501	-54	133	-27	-127	-304	-452	-471	-450	-1	-6	0
L	0	0	47	-16	-73	-99	-112	-139	71	-7	-7	-27	-98	-117	-146	-98	-36	-54	32



Preliminary data: deformation in microns for cryo cycle 1 & 2 (piston + tilt removed)



	4/22 am	4/22 pm	4/23 am	4/23 pm	4/24 am	4/24 pm	4/25 am	4/26 am	4/29 am	4/29 pm	4/30 am	4/30 pm	5/1 am	5/1 pm	5/3 am	5/3 am	5/5 am	5/5 am	5/6 am
Temp	290- p.vac	270- 290	162- 290	127- 290	99- 290	81- 290	44- 290	18- 290	290a- 290	270- 290a	163- 290a	129- 290a	67- 290a	46- 290a	25- 290a	40- 290a	291- 290a	291a - 290a 10e- 6	291- 290a
Pres	10e-5	10e-5	10e-5	10e-5	10e-5	10e-5	10e-5	10e-5	10e-5	10e-5	10e-5	10e-5	10e5	10e-5	10e-5	10e-4	10e-6	10e-6	751 T
cc1	-4	9	60	33	22	8	19	21	-84	15	16	32	31	17	33	42	1	-12	4
2	3	13	28	73	45	29	44	44	25	12	19	42	42	28	39	51	0	-12	3
3	-1	29	51	44	40	19	35	32	5	18	19	45	48	20	33	71	0	-19	1
4	-8	16	56	59	43	23	32	38	-2	25	28	56	55	28	44	79	3	-13	3
5	12	-1	7	20	6	-1	10	7	4	10	1	18	8	4	10	11	0	-10	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	-9	35	53	69	60	43	60	58	22	19	20	42	47	29	37	55	4	-5	5
8	4	10	21	39	31	15	24	23	3	8	9	23	29	13	19	33	1	-9	2
9	-10	24	40	54	37	25	37	37	15	7	25	42	45	31	43	69	-5	-16	1
10	-2	16	33	28	29	13	19	21	22	20	14	35	37	10	19	55	3	-10	1
rms	7	19	40	47	36	22	32	33	30	15	18	37	38	20	31	53	2	12	3



Surface plot of reaction structure 270-290a 15 microns rms



Zernike

Pis 11.8630

Tilt 0.2957

Tilt -2.4788

Def 4.5709

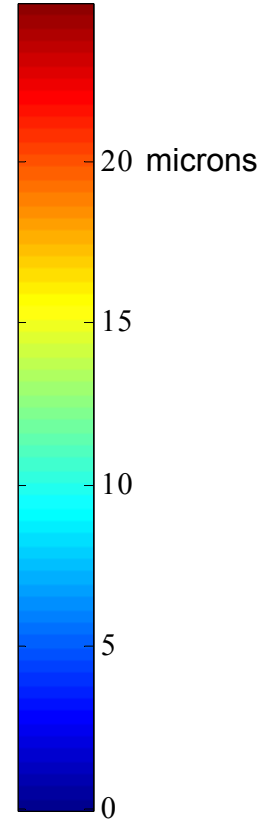
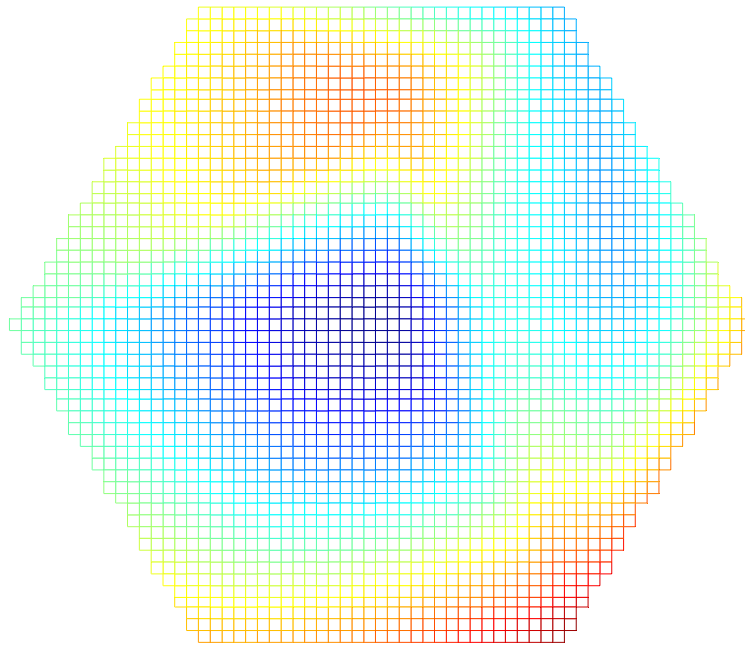
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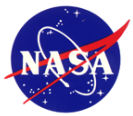
Ast -6.0317

Com -0.8254

Com -7.1376

Sph -3.3878





Surface plot of reaction structure 163-290a 18 microns rms



13.1898

0.3124

2.1166

9.4664

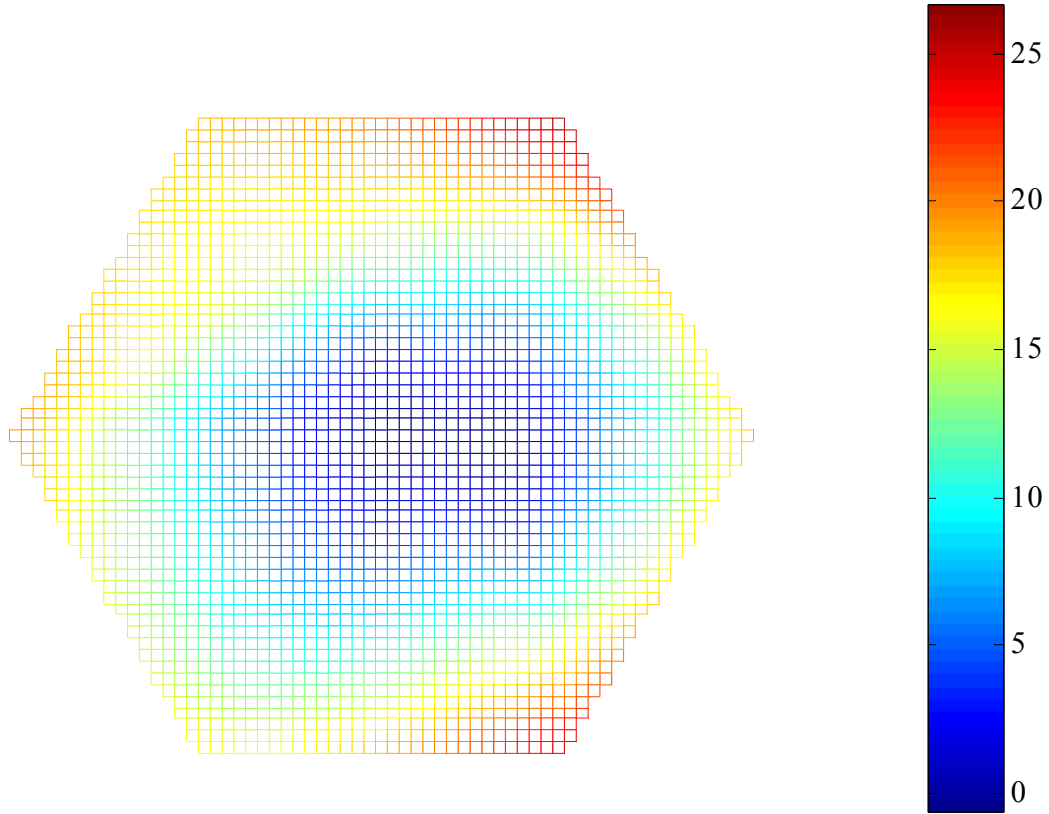
-3.2000

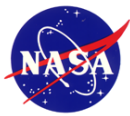
-1.2834

3.8757

-1.9241

-2.8344





Surface plot of reaction structure 129-290a 37 microns rms



29.6907

-0.5097

0.4728

15.7598

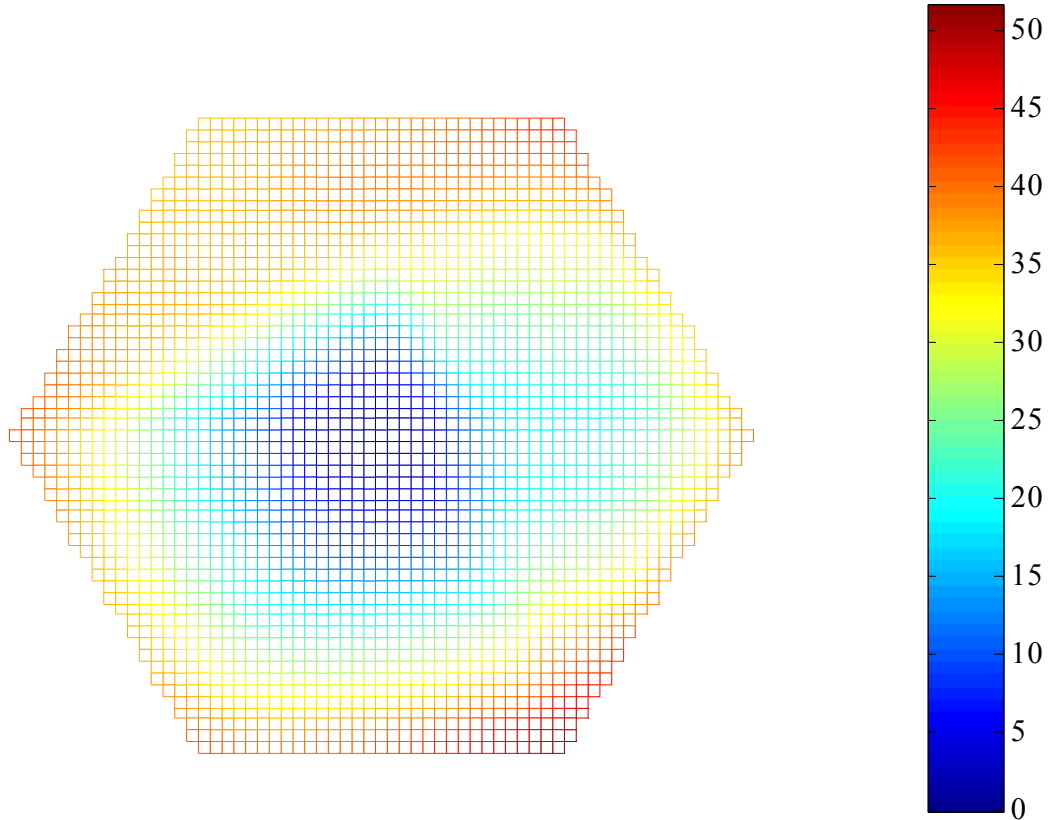
-4.8554

-3.3211

0.3145

-9.2745

-7.4900





Surface plot of reaction structure 67-290a 38 microns rms



30.3181

1.4927

0.8909

17.7579

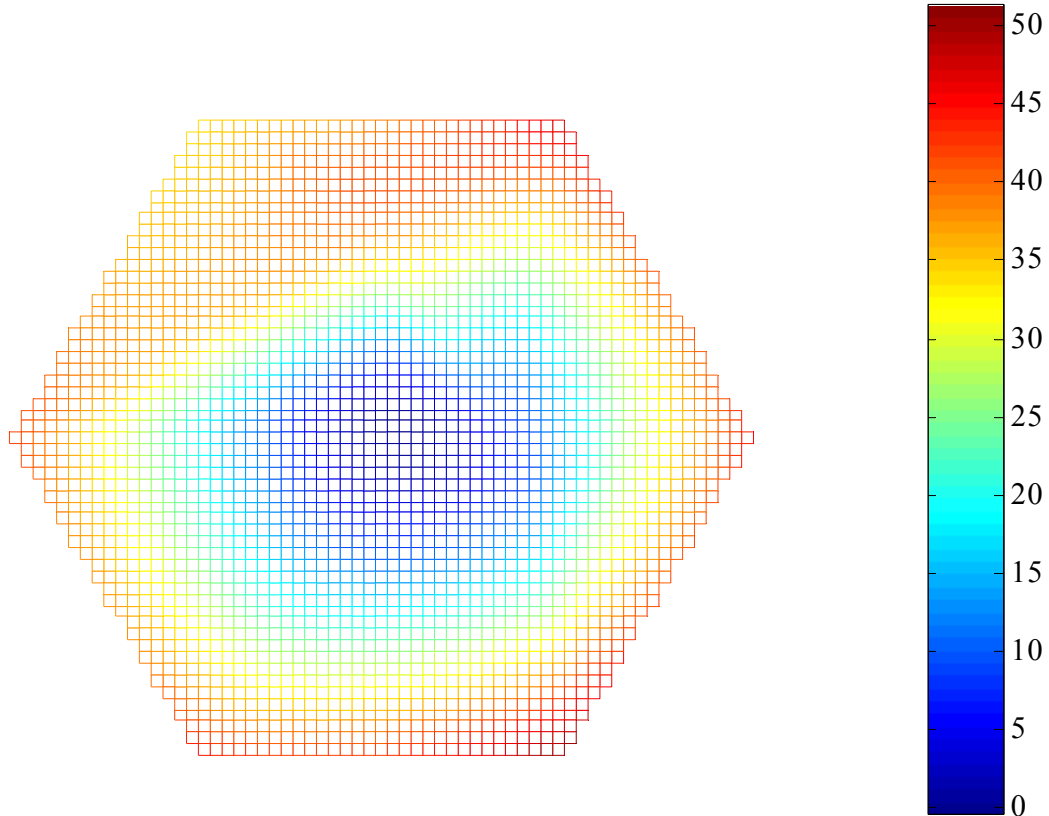
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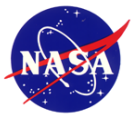
-1.5165

5.7256

-9.4107

-8.6614





Surface plot of reaction structure 46-290a 20 microns rms



15.3262

0.8305

4.3903

11.6842

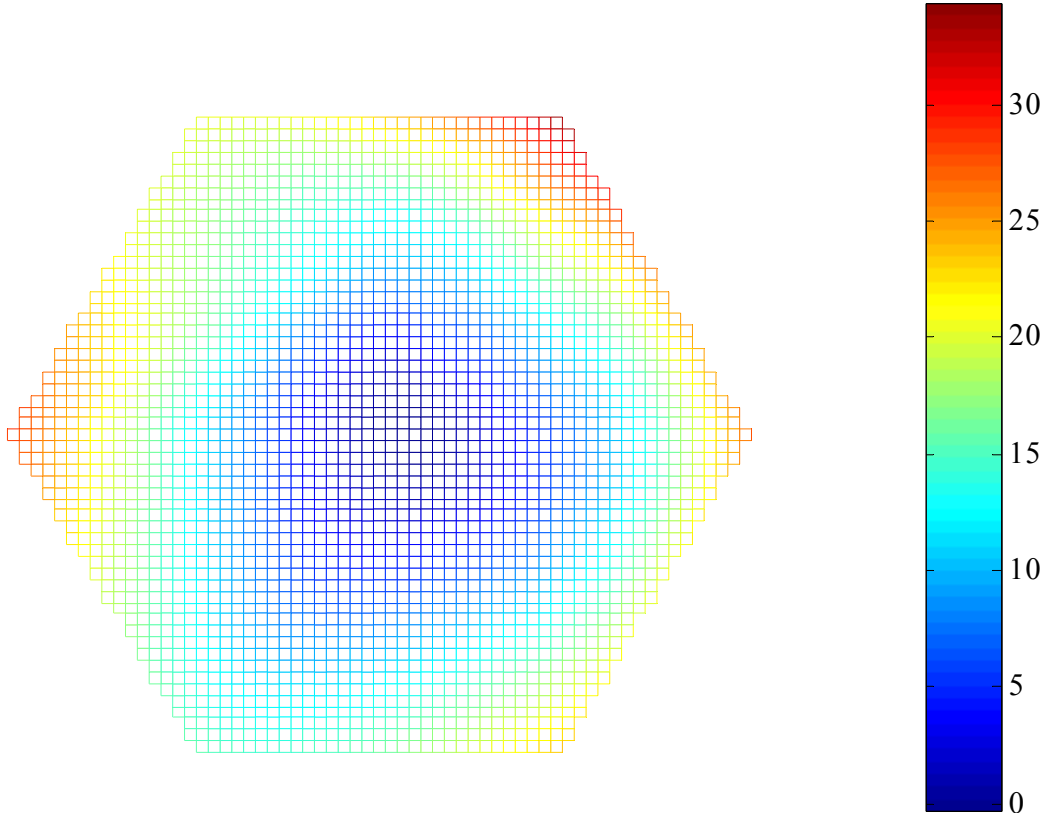
2.5578

0.7615

3.6275

-0.1711

-2.4007





Surface plot of reaction structure 25-290a 31 microns rms



23.8241

-0.0898

4.1008

16.5845

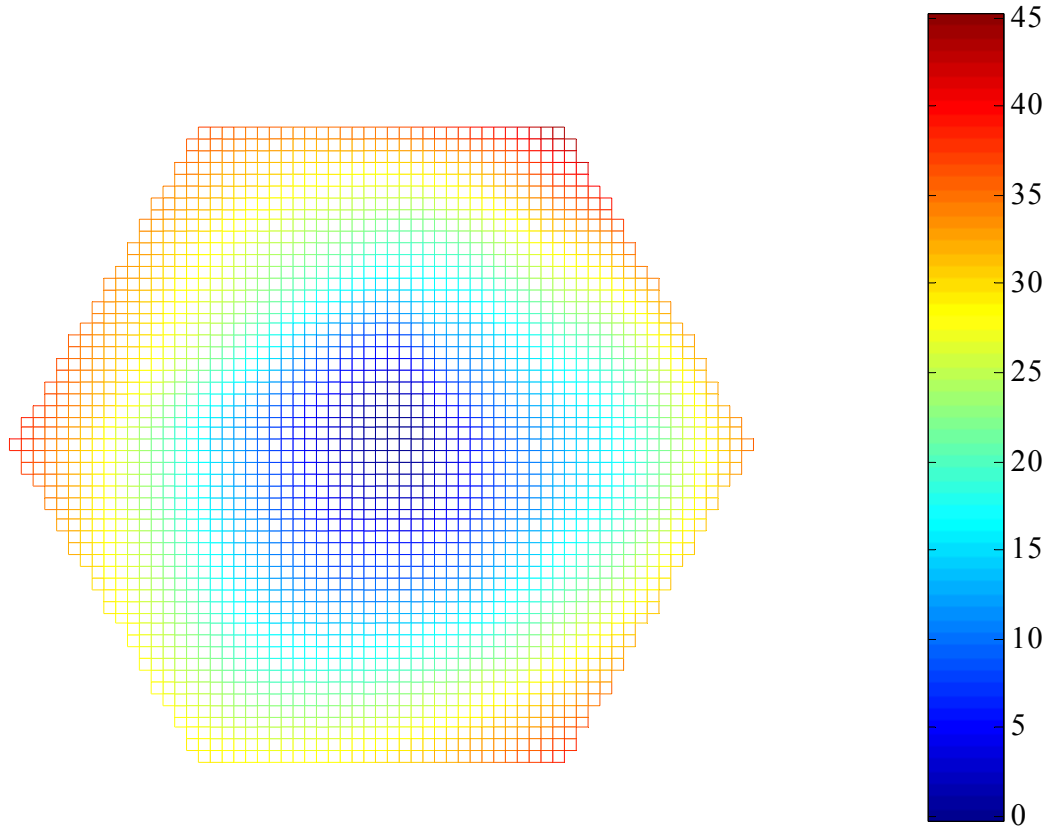
-0.6187

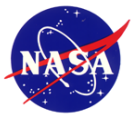
-1.3888

1.9498

-1.1512

-4.3076





Surface plot of reaction structure 291-290a 2 microns rms



0.5965

0.7487

-0.5998

-0.1825

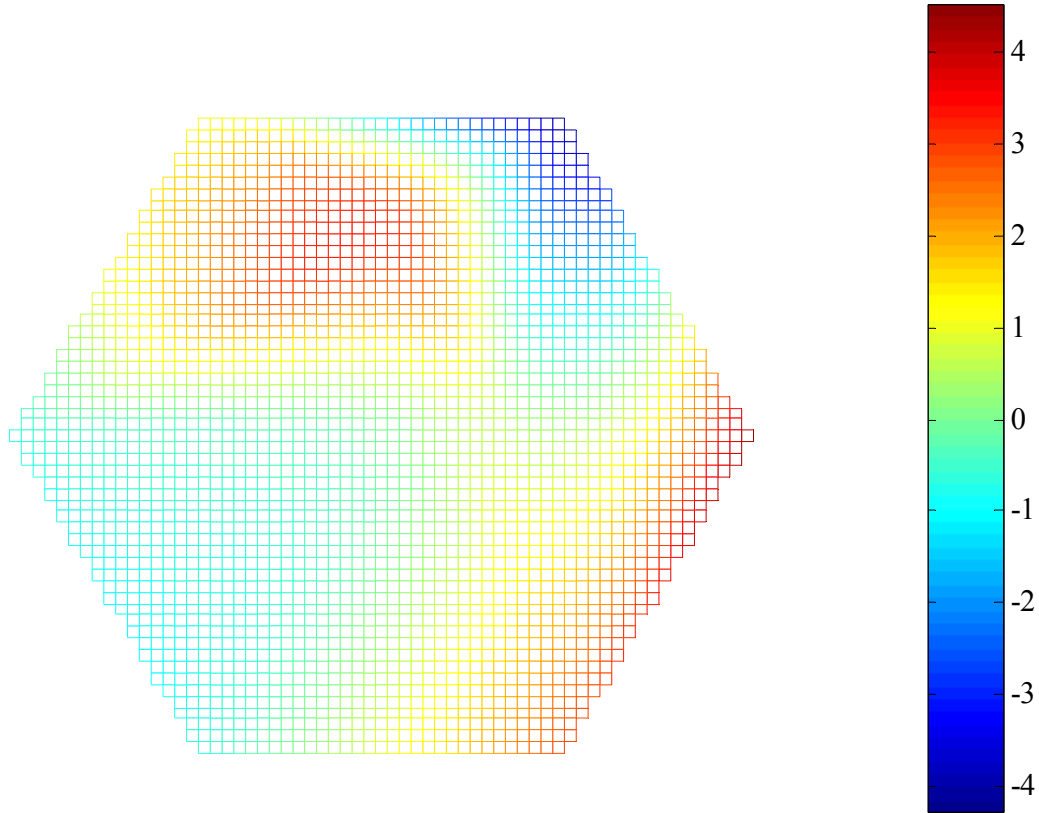
0.1399

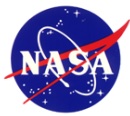
-3.0416

0.5114

-1.9193

-0.3606





Conclusions



Goodrich's AMSD reaction structure met out-of-plane deformation specification.

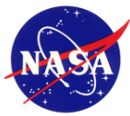
Vendor specification: out-of-plane deformation < 50 microns rms for entire temperature range.

Gr-Ep reaction structure desorption at ambient temperature and vacuum showed little deformation.

Reaction structure deformation seems repeatable for both cryo cycles.

10 corner cubes mounted to the reaction structure performed well in cryo. Before and after cryo cycles Zygo measurements of the corner cubes showed small permanent changes.

ADM measurements appear to be accurate and repeatable.



Acknowledgements



Mark Baker, Lisa Blackwell, Barry Hale, Harlan Haight, Jim Mankoski, Jeff McCracken, Harry Rutledge, Richard Siler, Martin Smithers, Gary Thornton, John Tucker, Ernie Wright.

Tom Alesi, Mark Furber, Enrique Garcia of Goodrich.