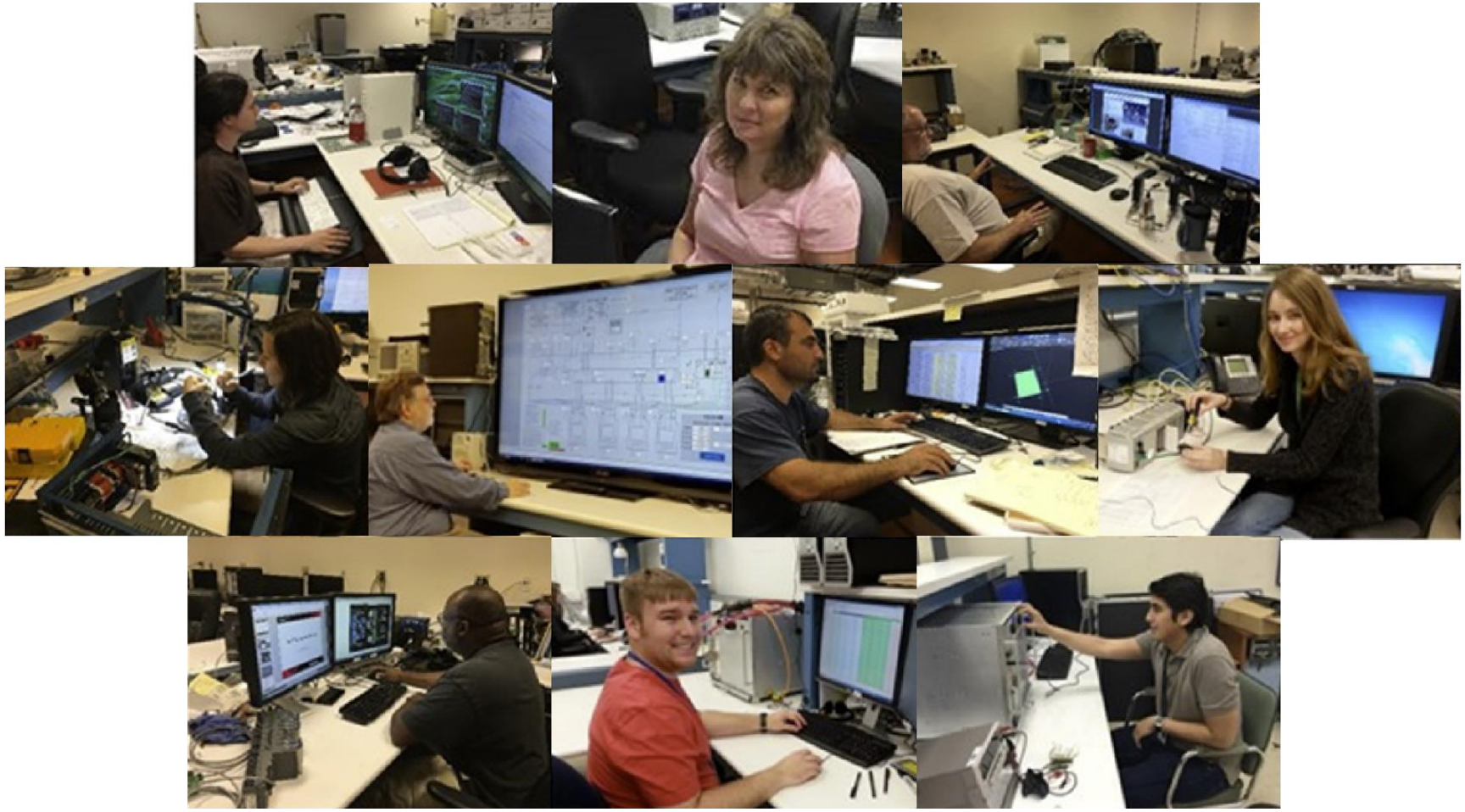
RICH Status Update

Tyler Lemon

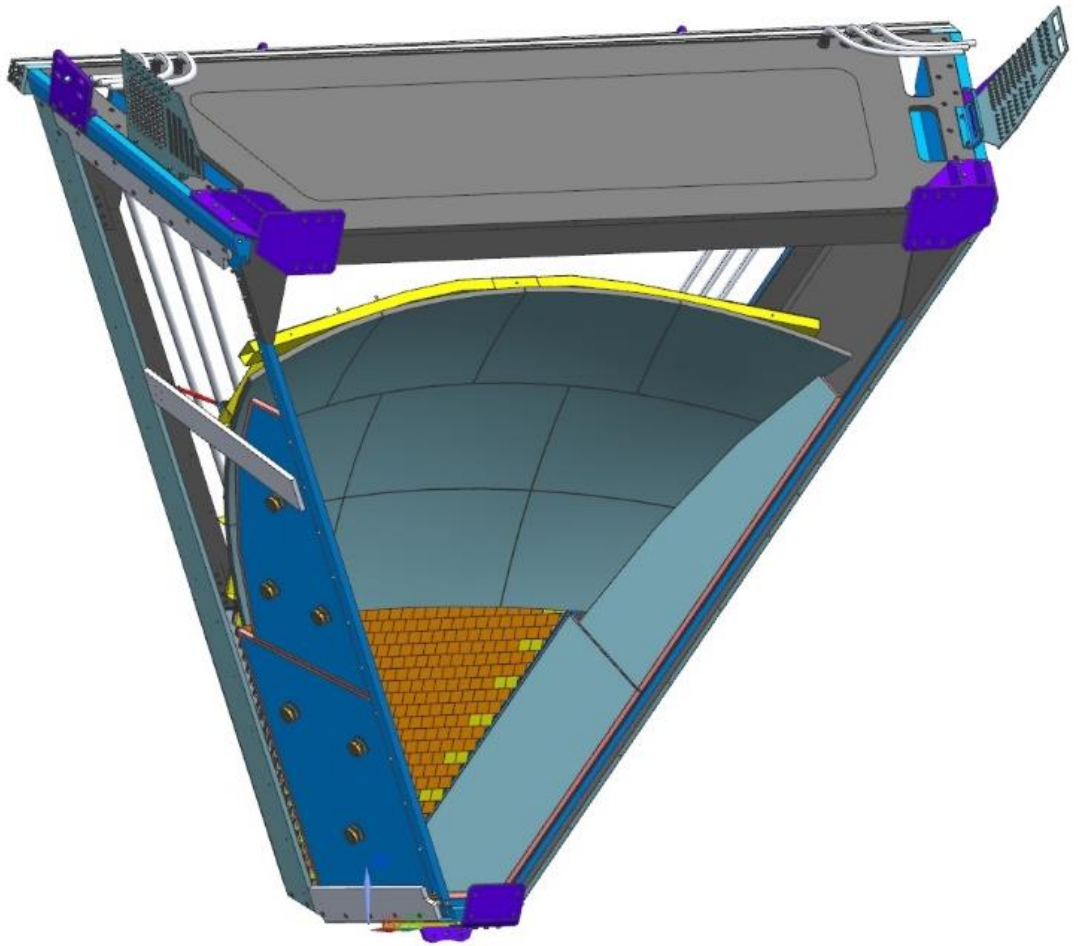
Detector Support Group

DSG Staff

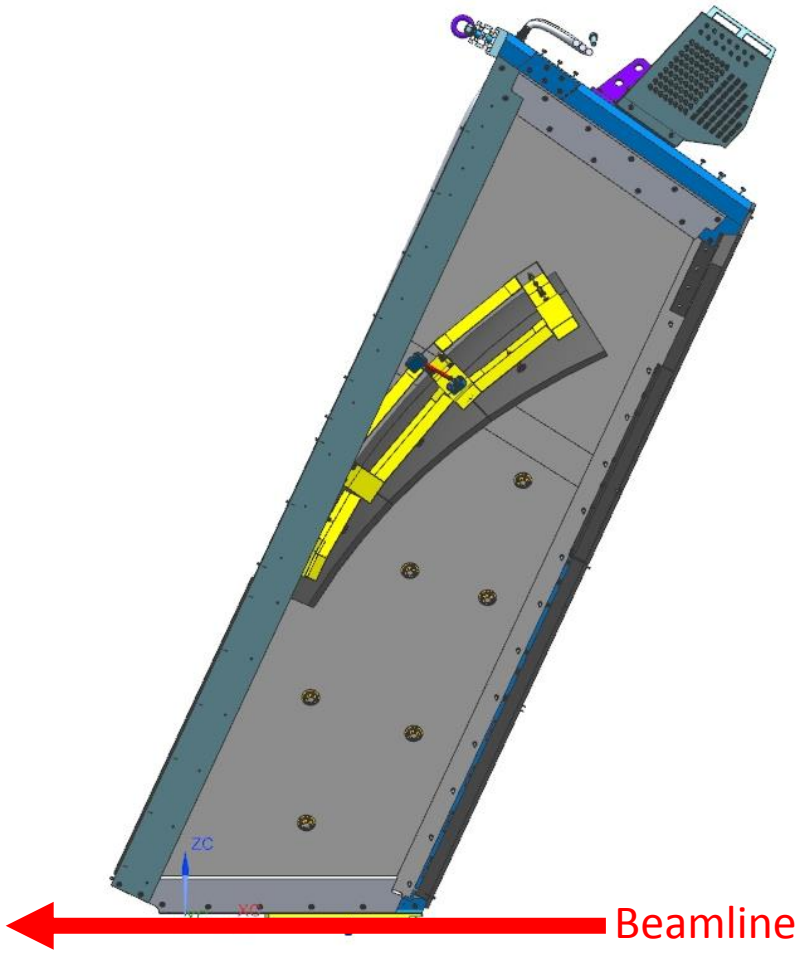


Contents

- Detector overview
- Spherical Mirrors
  - CMM analysis
  - Spot tests
- Gas System
  - Valve Panel
  - Interface Chassis
- Interlock System
- Upcoming Tasks



Ring-Imaging Cherenkov Detector



RICH Detector

- Electronics view Cherenkov light radiated by particles passing through aerogel.
- Small angle paths ($\theta < 12°$)
  - Light travels straight into electronics.
- Large angle paths ($12° < \theta < 35°$)
  - Light reflected off of spherical and planar mirrors and then into electronics

Spherical Mirrors

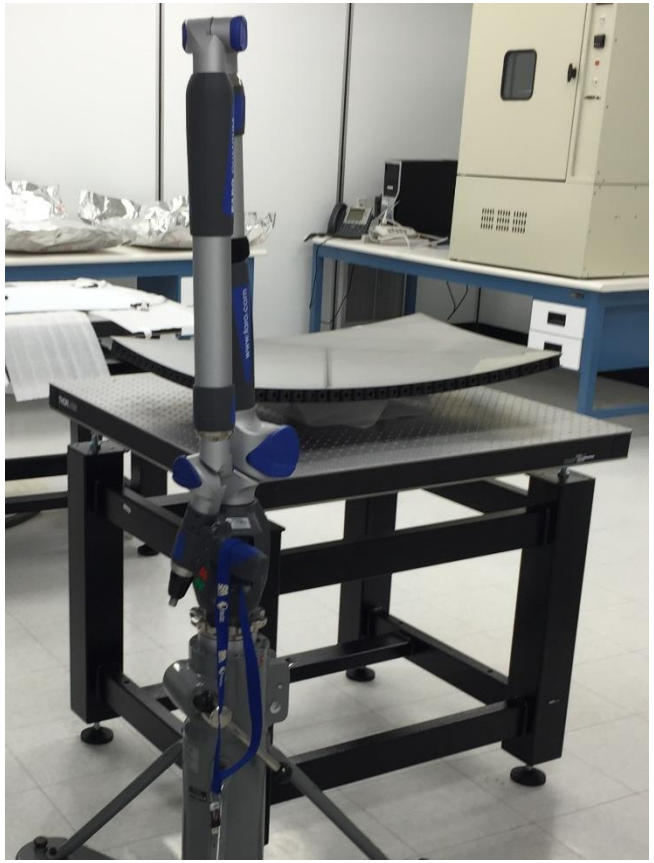
- Ten spherical mirrors
  - Carbon-fiber-reinforced-polymer
- Stored in small clean room (EEL 121)
- Measured via CMM
- Radius of curvature approximated with spot test

Mirrors 3 and 4 stored in protective bags on table in small clean room.

CMM Measurement

- Measured with portable CMM by Survey Group.
- CMM data points analyzed in AutoCAD, Python, and NX 9.0
- Measured:
  - Linear lengths
  - Arc lengths
  - Radius of curvature

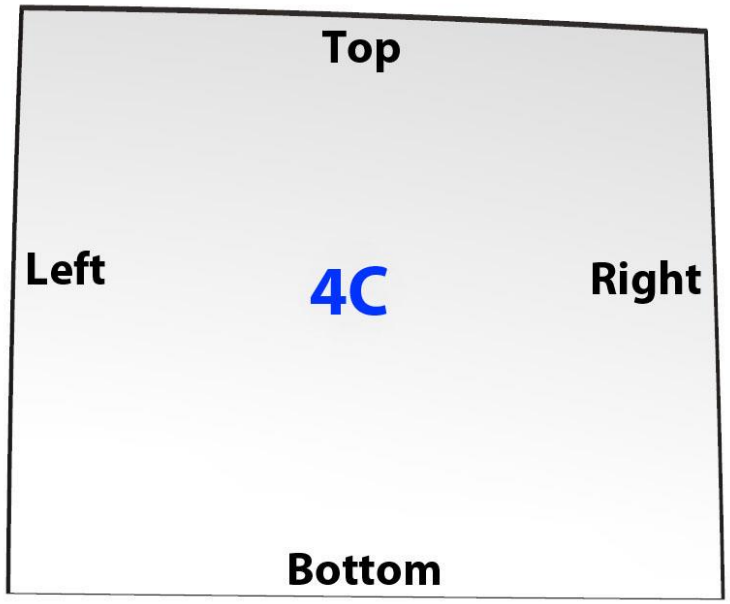
- **Results for Back Surface at end of presentation**



Portable CMM in small clean room with mirror prepped on optical table for measurement

Linear Lengths

- Indicator of how the mirrors will fit inside the detector frame.
- Measured by Mary Ann in AutoCAD using CMM measured corner points.



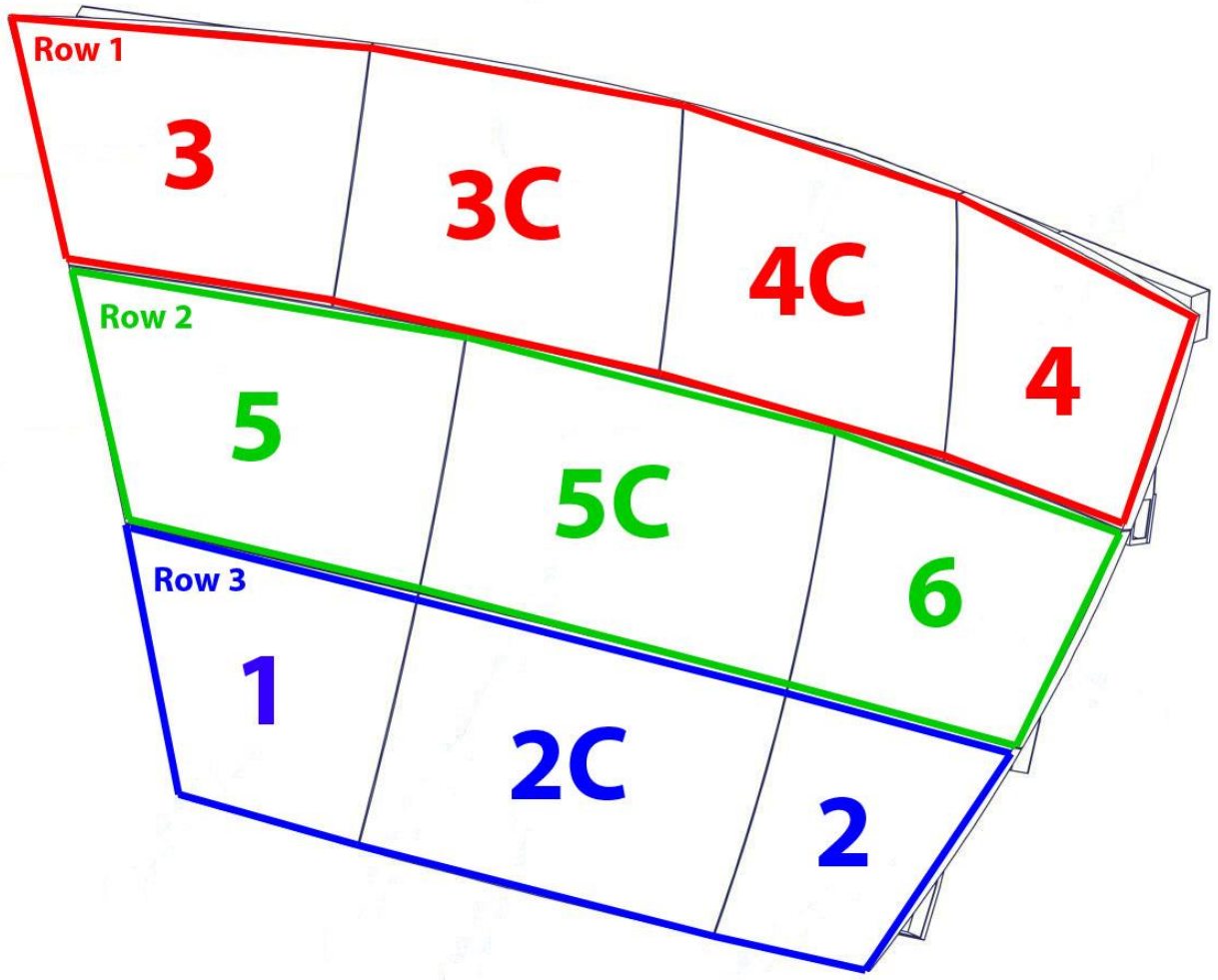
Individual Mirror Linear Lengths- Mirror Surface

■ = Ideal
■ = AutoCAD

Linear Lengths- Mirror Surface [mm]

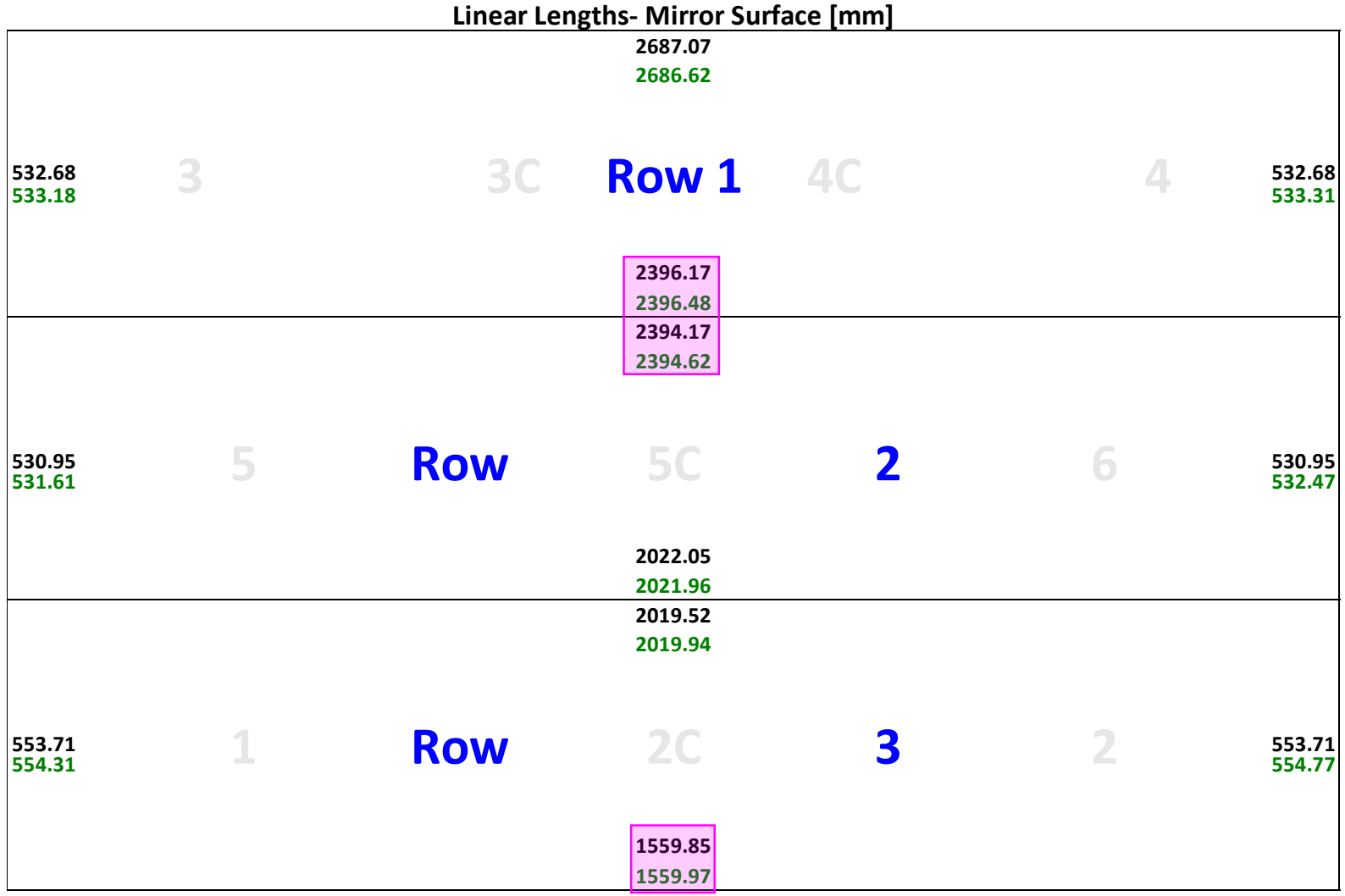
	728.81 729.14			668.99 668.72			668.99 668.96			728.81 728.74	
532.68 533.18	**3**	556.74 557.34	556.91 557.99	**3C**	574.68 575.24	574.68 570.85	**4C**	556.91 557.74	556.74 557.09	**4**	532.68 533.31
	535.56 536.56			698.46 698.51			698.46 699.21			535.56 535.92	
	813.59 814.48			837.68 837.84			813.59 812.99				
530.95 531.61	**5**	531.39 531.86	531.48 532.15	**5C**	531.48 531.88	531.39 531.32	**6**	530.95 532.47			
	611.43 612.11			837.68 837.60			611.43 611.46				
	610.12 610.91			837.59 837.07			610.12 610.55				
553.71 554.31	**1**	521.79 522.59	521.88 522.98	**2C**	521.88 523.74	521.79 522.44	**2**	553.71 554.77			
	383.51 384.22			805.71 806.40			383.51 383.55				

Linear Lengths of Assembly Rows

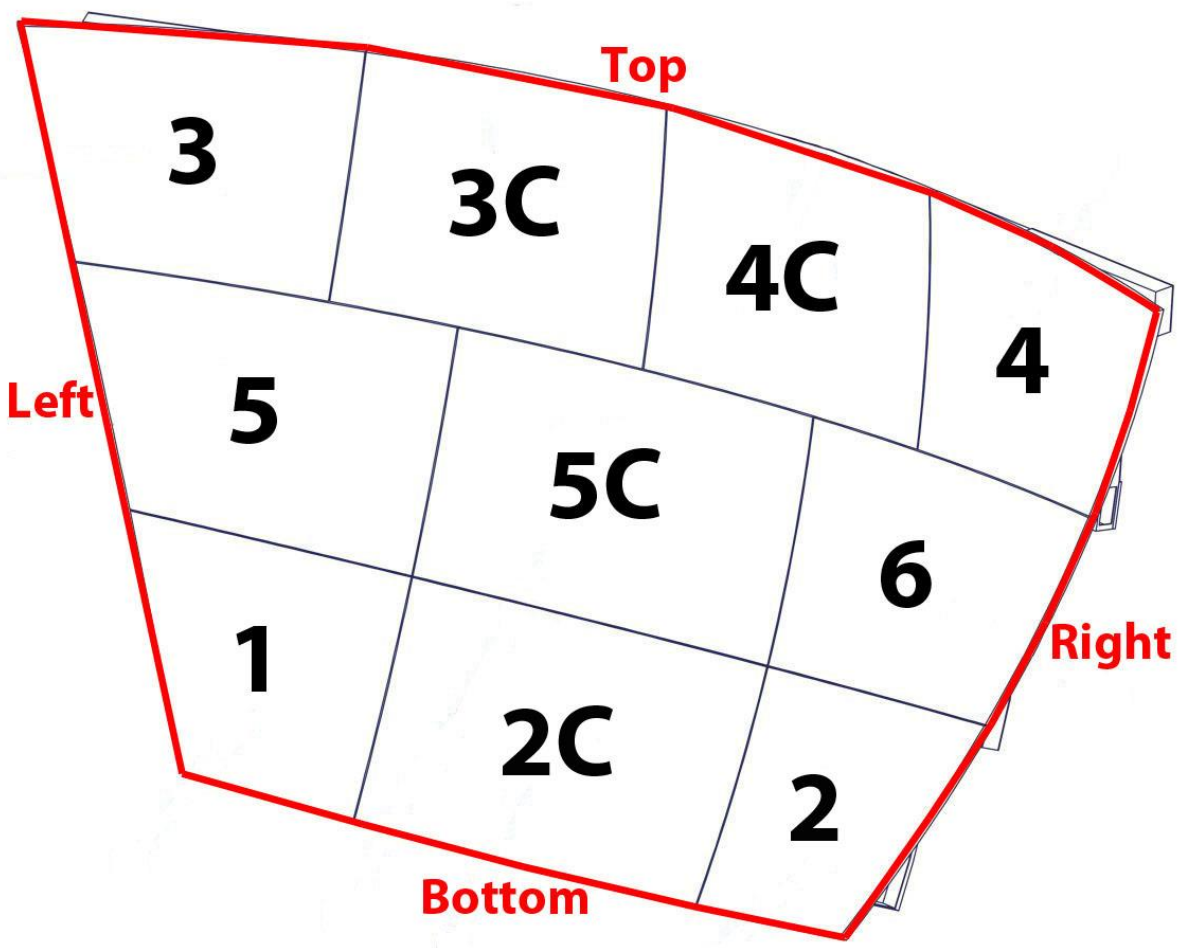


Assembly Row Linear Lengths- Mirror Surface

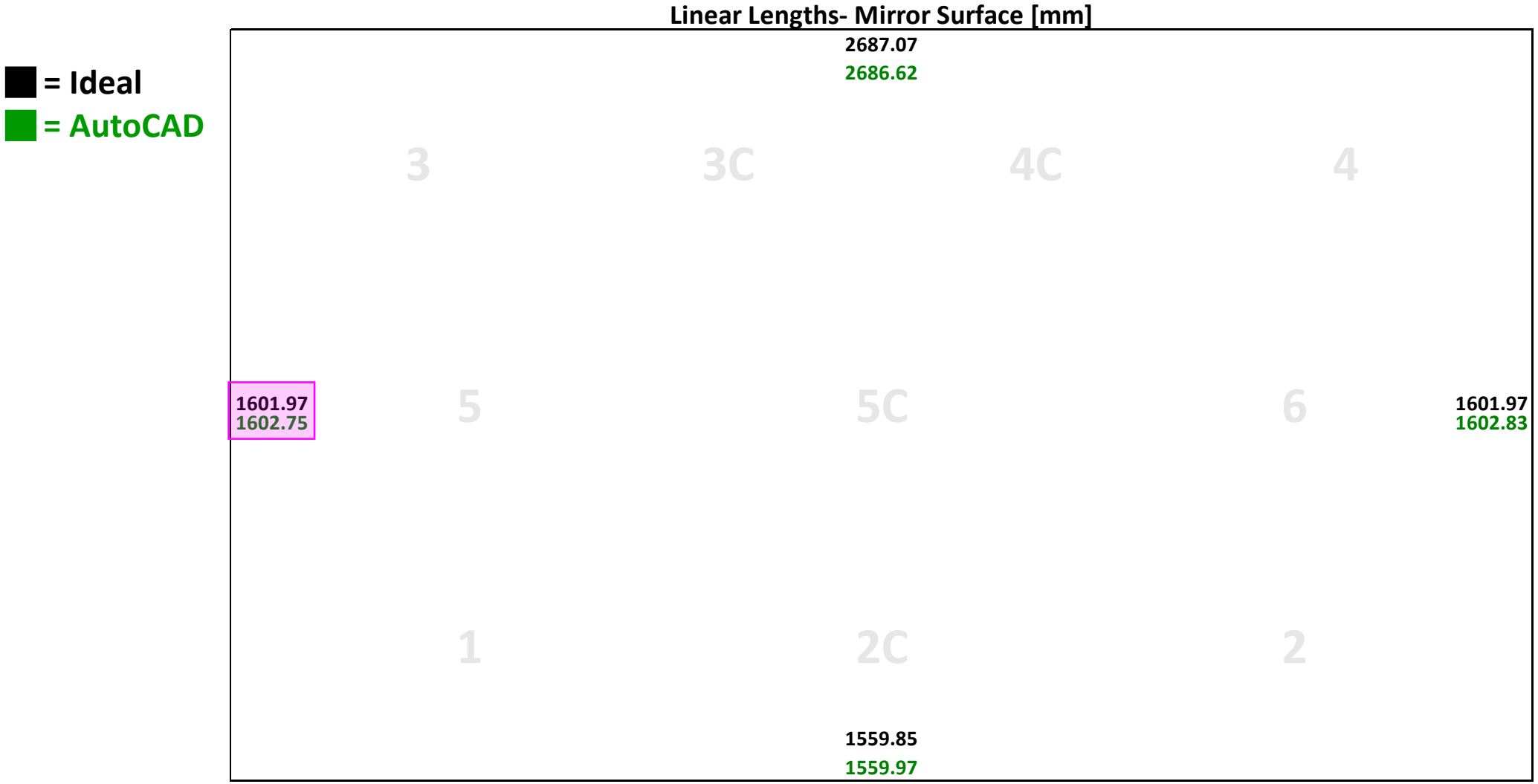
■ = Ideal
■ = AutoCAD



Linear Lengths of Sides of Assembly



Assembly Linear Lengths- Mirror Surface



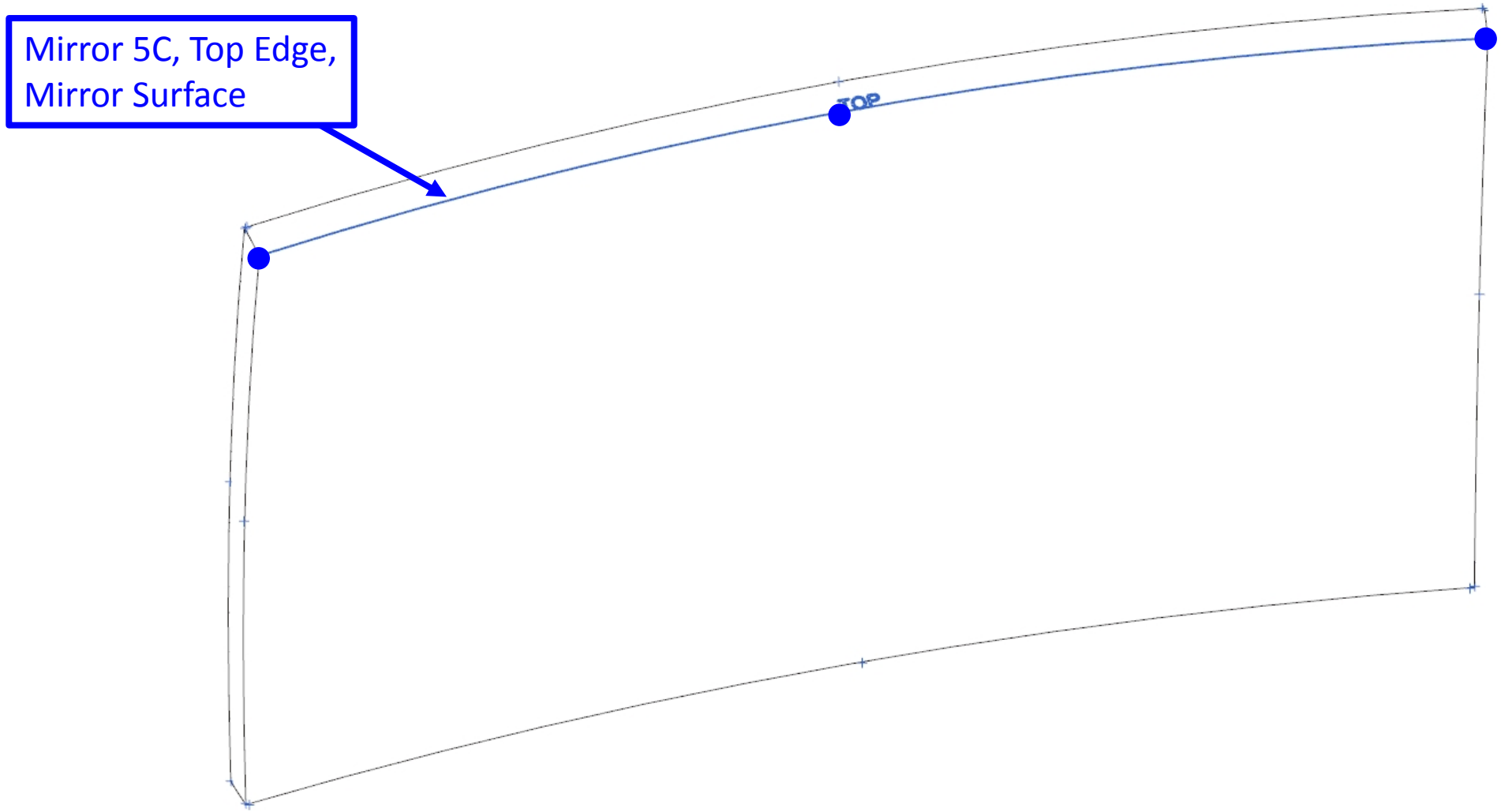
Linear Lengths

- For each mirror:
  - measured linear lengths ~± 1 mm from ideal model
- For assembly:
  - Mirrors will fit inside detector frame
- Linear distances for manufactured mirrors match ideal values
  - CMM measurements < 0.25% difference from ideal

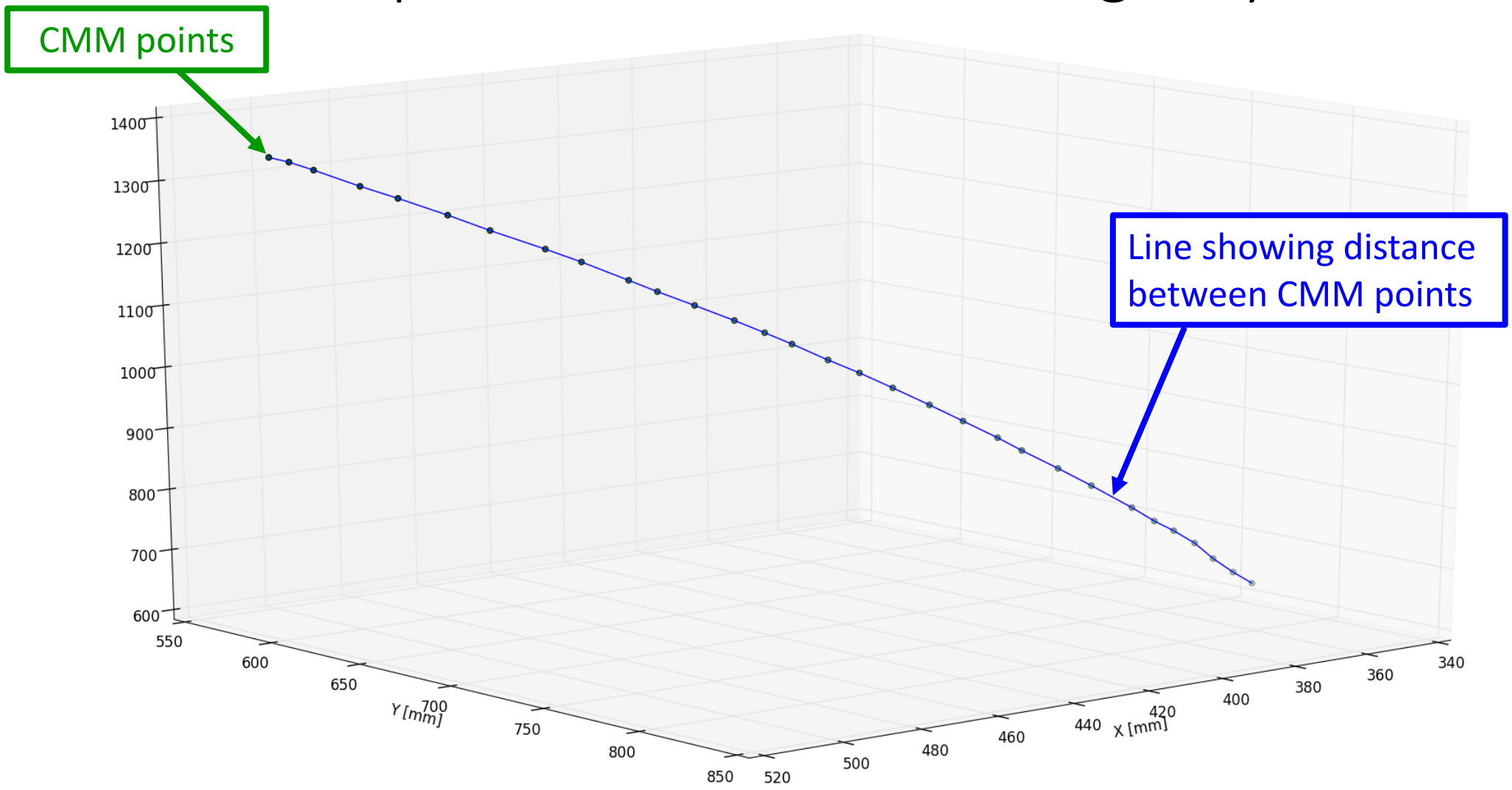
Arc Lengths

- With side radii, will show if assembled mirror is uniform from mirror to mirror.
- NX 9.0 by Mary Ann
  - fits arc to three CMM points on side, measured with built-in length tool
- Python by Amanda
  - Calculated distance between CMM points and added all distances for each side.

Fitting Arc to Individual Sides of Mirror in NX 9.0



Mirror 4, Top, Mirror Surface Arc Length Python Plot



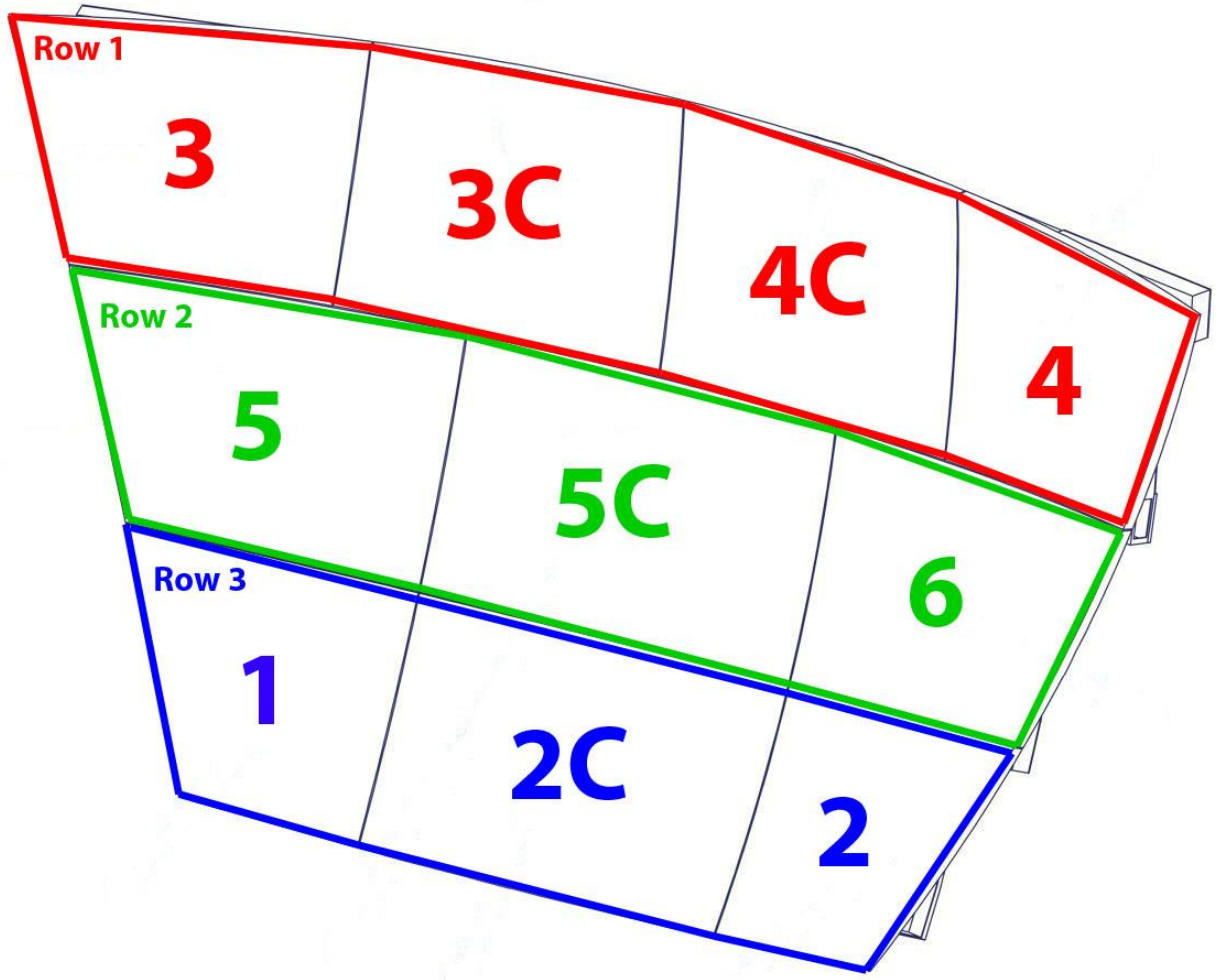
Individual Sides Arc Lengths- Mirror Surface

■ = Ideal
■ = Python
■ = NX 9.0

Arc Lengths- Mirror Surface [mm]

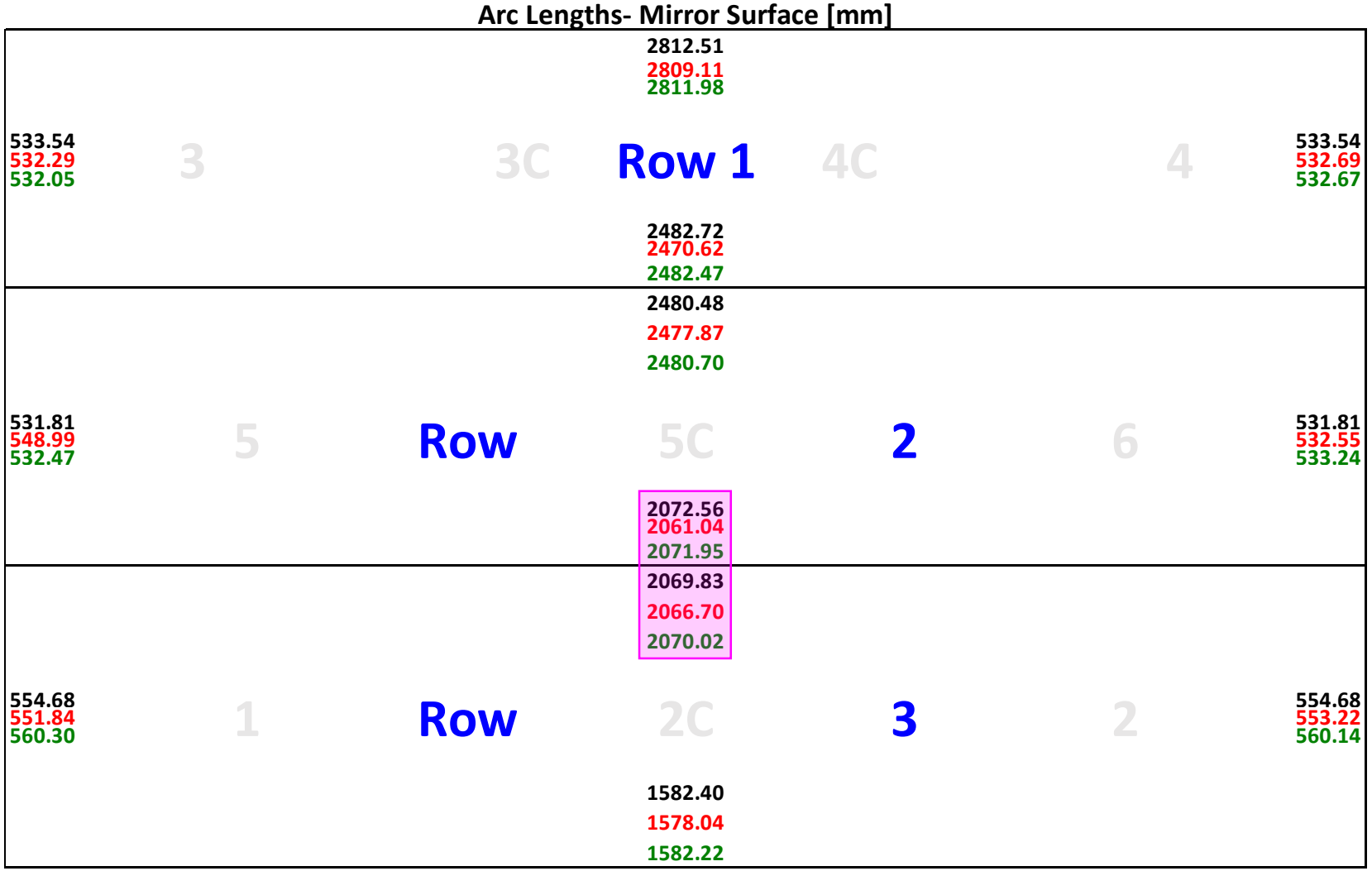
	731.04 728.07 727.92			670.71 669.21 669.14			670.71 654.55 654.50			731.04 728.57 728.51	
533.54 532.29 532.05	**3**	557.73 556.18 556.17	557.90 554.83 554.83	**3C**	575.77 571.71 571.68	575.77 571.53 571.48	**4C**	557.90 555.01 555.00	557.73 556.32 556.26	**4**	533.54 532.69 532.67
	536.44 534.44 534.42			700.42 700.60 700.45			700.42 698.48 698.46			536.44 534.76 534.69	
	816.70 813.68 817.41			841.08 839.28 839.15						816.70 811.82 816.03	
531.81 548.99 532.47	**5**	532.25 529.05 532.58	532.34 530.27 530.25	**5C**	532.34 528.41 528.40	532.25 526.88 532.19	**6**				531.81 532.55 533.24
	612.74 610.26 613.35			841.08 835.82 835.74						612.74 611.08 612.72	
	611.42 609.44 617.58			840.98 834.86 834.83						611.43 606.82 616.88	
554.68 551.84 560.30	**1**	522.61 519.50 527.45	522.70 520.57 520.55	**2C**	522.70 520.73 519.81	522.61 519.48 527.73	**2**				554.68 553.22 560.14
	383.83 380.49 387.99			808.73 804.34 804.29						383.83 378.54 386.82	

Arc Lengths of Assembly Rows

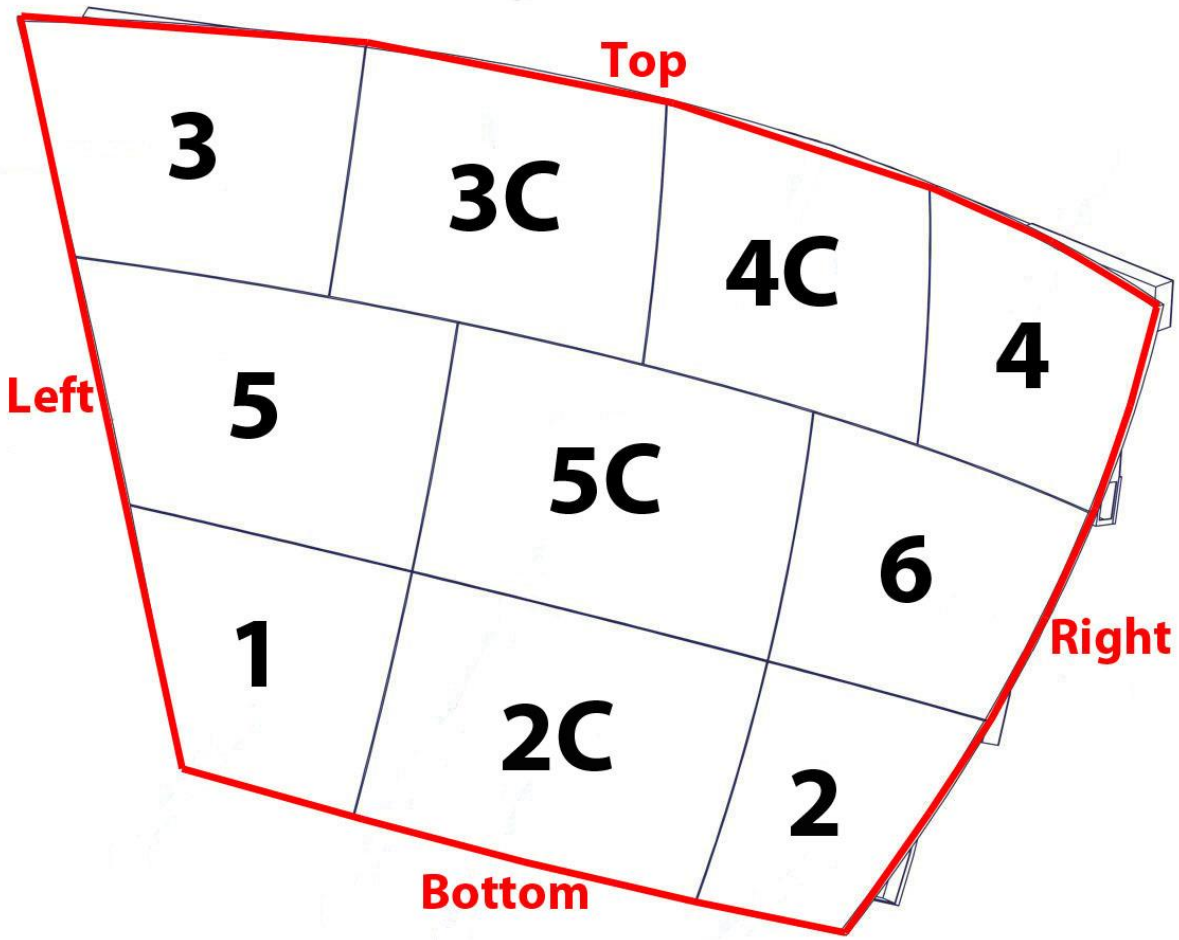


Arc Lengths of Assembly Rows- Mirror Surface

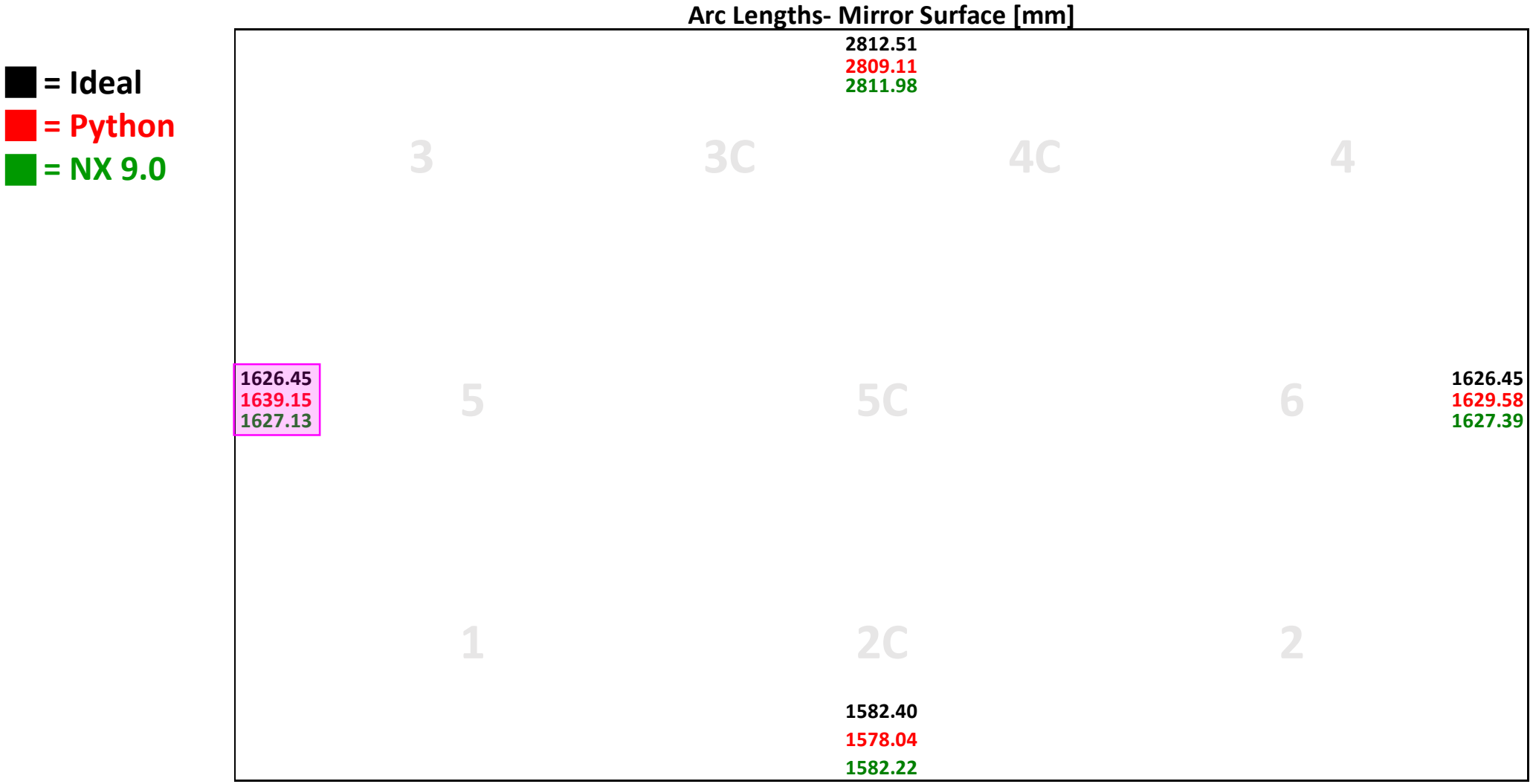
■ = Ideal
■ = Python
■ = NX 9.0



Arc Lengths of Sides of Assembly



Arc Lengths of Entire Assembly- Mirror Surface



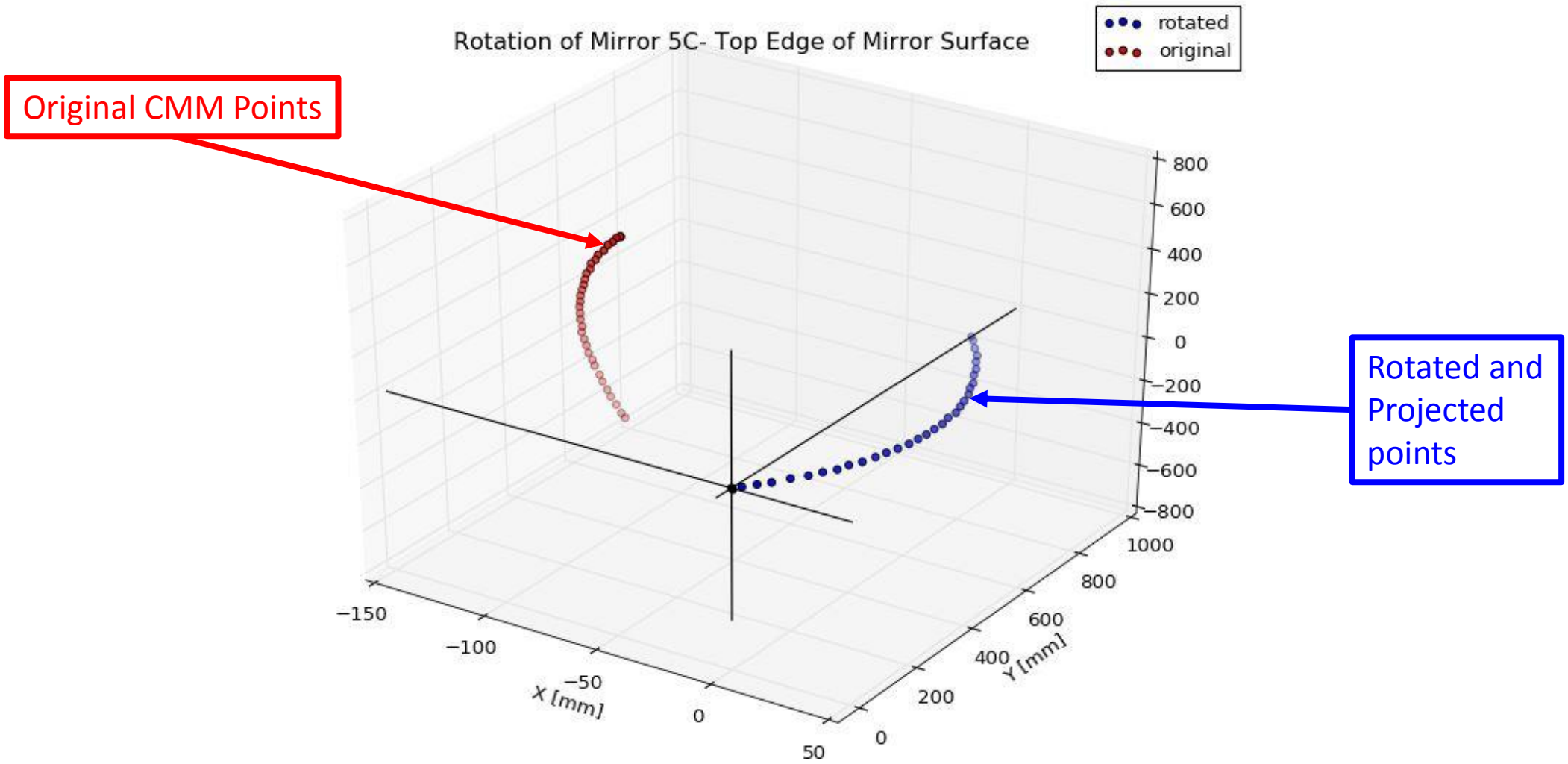
Arc Lengths

- Arc lengths measured from CMM points close to ideal arc lengths.
- Shows that the mirrors are the same size and will match up form a uniform surface.
- Corresponding sides of mirrors have similar arc lengths

Radius of Curvature

- With arc lengths, will show if assembled mirror surface is uniform from mirror to mirror.
- NX 9.0 by Mary Ann
  - When fitting arc to measure arc length, radius also given
- Python by Amanda and Tyler
  - projects CMM points to ideal plane, rotates the points and plane to x-y plane, fits points with a circle

Radius of Individual Sides of Mirrors



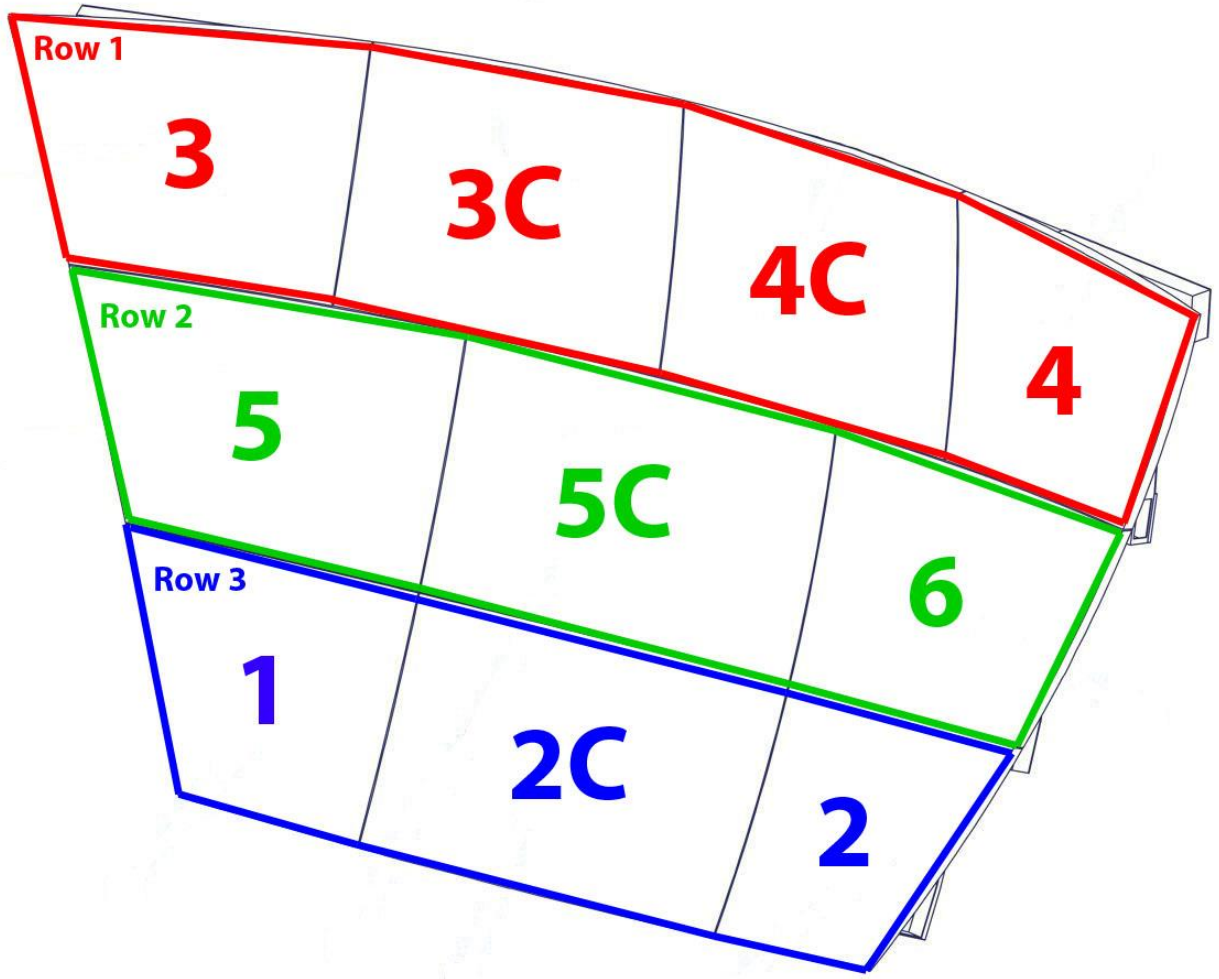
Radius of Individual Sides of Mirrors- Mirror Surface

= Python
= NX 9.0

Radius- Mirror Surface [mm]

2781.23 ± 1.63 2687.27 2603.14 ± 0.14 2564.17 **3** 2702.55 ± 0.18 2665.72 2506.43 ± 0.59 2695.05	2796.71 ± 1.36 2693.82 2675.51 ± 0.06 2685.45 **3C** 2725.34 ± 0.39 2756.68 2755.41 ± 0.23 2722.70	2921.69 ± 0.95 2712.32 2687.51 ± 0.22 2710.45 **4C** 2673.44 ± 0.18 2706.75 2729.83 ± 1.46 2678.37	2736.98 ± 0.41 2700.99 2731.25 ± 0.21 2688.76 **4** 2650.13 ± 0.07 2640.79 2641.92 ± 0.82 2623.80
2703.74 ± 0.39 2783.18 2643.26 ± 0.14 2767.91 **5** 2706.41 ± 0.18 3005.56 2625.38 ± 0.53 2663.77	2707.67 ± 0.27 2682.85 2730.41 ± 0.13 2727.91 **5C** 2792.1 ± 0.15 2672.32 2694.88 ± 0.15 2713.23	2695.78 ± 0.37 2925.00 2696.93 ± 0.11 2628.09 **6** 2684.61 ± 0.53 2687.75 2692.62 ± 0.44 2867.41	
2730.51 ± 0.5 2793.04 2685.46 ± 0.27 2984.24 **1** 2714.05 ± 0.15 3073.59 2390.74 ± 0.39 3786.05	2709.1 ± 0.22 2701.47 2706.31 ± 0.11 2700.06 **2C** 2708.97 ± 0.16 2669.77 2665.9 ± 0.25 2647.24	2675.93 ± 0.21 3069.95 2670.75 ± 0.43 2846.03 **2** 2701.65 ± 0.16 3408.22 2625.86 ± 0.37 3483.69	

Radius of Assembly Rows



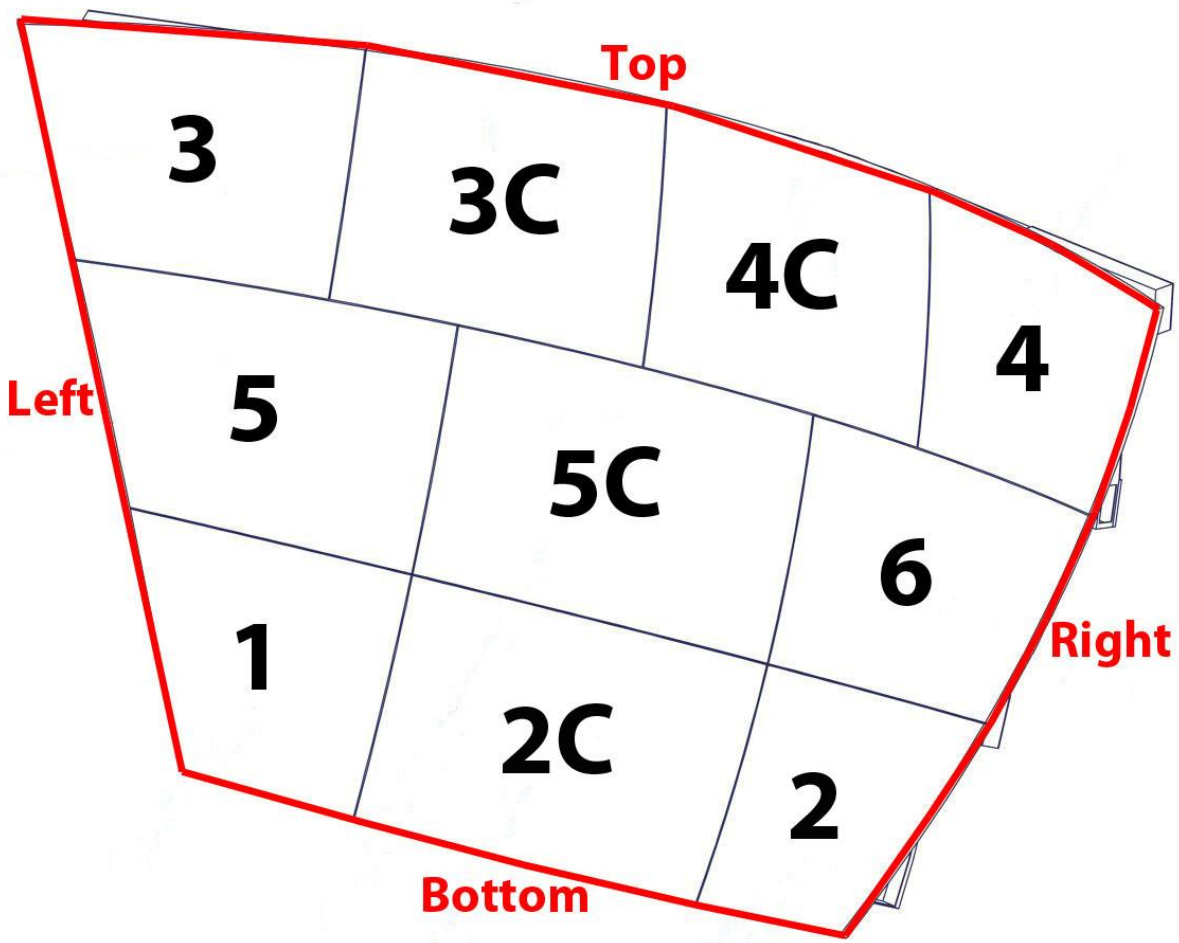
Radius of Assembly Row Sides – Mirror Surface

= Python
= NX 9.0

Radius- Mirror Surface [mm]

		2708.55 ± 10.67 2693.52				
2603.14 ± 0.14 2564.17	3	3C	**Row 1**	4C	4	2650.13 ± 0.07 2640.79
		2697.57 ± 3.24 2692.05				
		2702.56 ± 2.09 2714.18				
2643.26 ± 0.14 2767.91	5	**Row**	5C	**2**	6	2684.61 ± 0.53 2687.75
		2904.28 ± 13.95 2704.03				
		2714.5 ± 2.98 2709.88				
2685.46 ± 0.27 2984.24	1	**Row**	2C	**3**	2	2701.65 ± 0.16 3408.22
		3040.78 ± 10.17 2717.86				

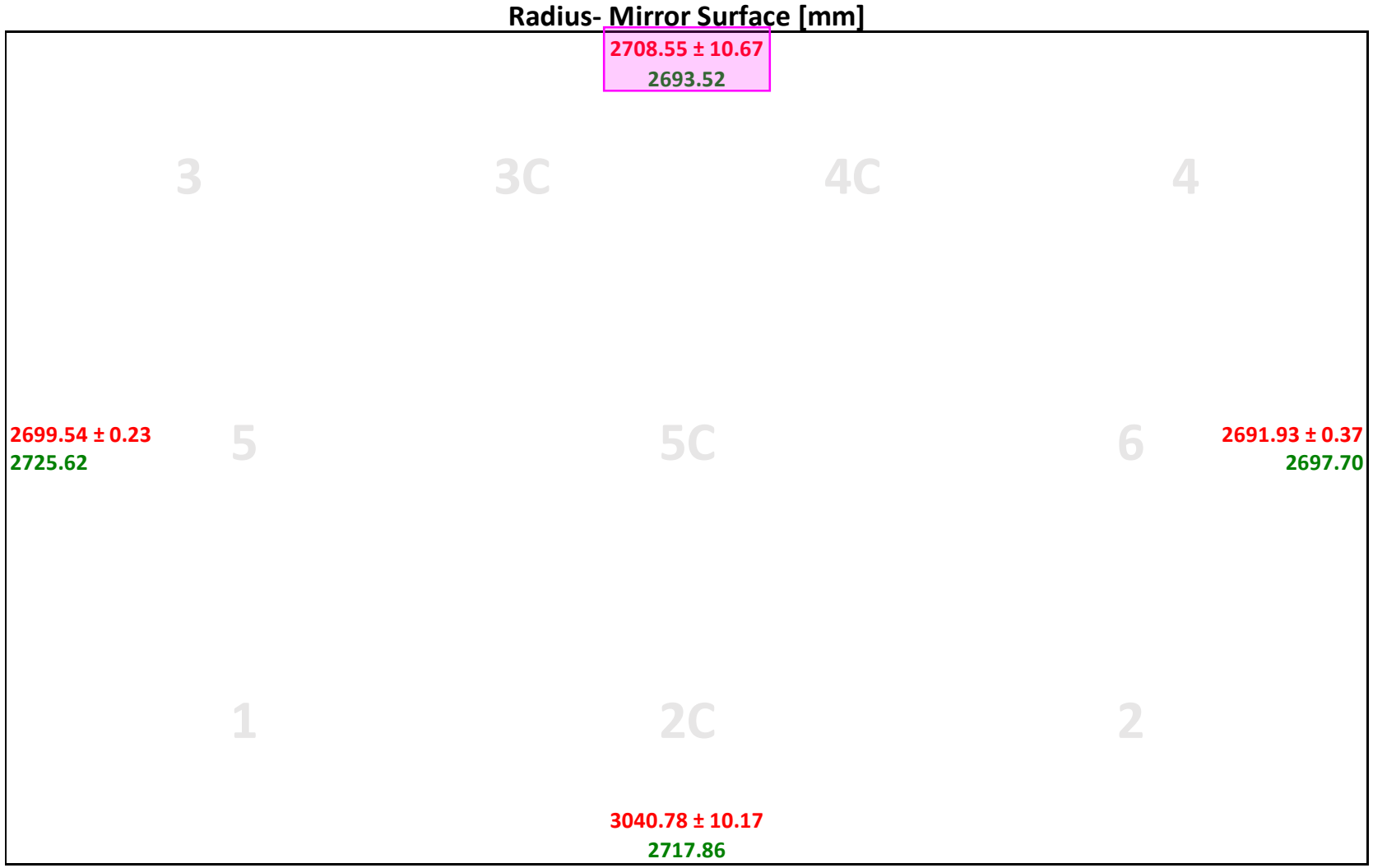
Radius of Sides of Assembly



Radius of Entire Assembly Sides- Mirror Surface

= Python

= NX 9.0

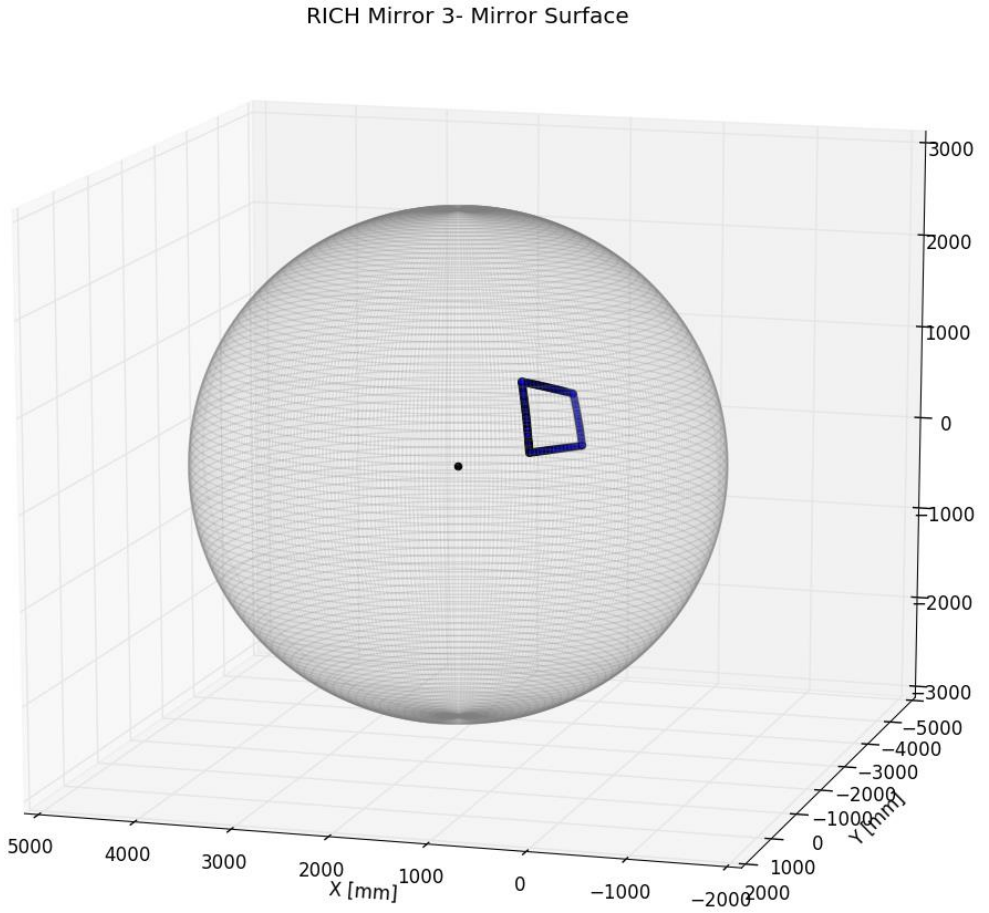


Radius of Mirror Sides

- NX 9.0 measurements closer to ideal radius than Python calculation.
- With arc length results, shows how uniform the assembled mirror surface will be from mirror to mirror.
- All mirrors have uniform radius of curvatures.
- Corresponding mirrors have uniform radius of curvatures.

Sphere Radius of Individual Mirrors

- Calculated in Python using Brian's algorithm
- Spec
  - Mirror: 2673 mm < R < 2727 mm
  - Back: 2698 mm < R < 2752 mm



Sphere Radius of Individual Mirrors

Mirror Surface

Mirror	Radius [mm]	RMS [mm]
3	2711.33	0.27
3C	2712.79	0.23
4C	2691.04	0.21
4	2702.59	0.23
5	2699.56	0.26
5C	2705.98	0.20
6	2713.12	0.37
1	2673.43	0.27
2C	2709.24	0.24
2	2687.19	0.21

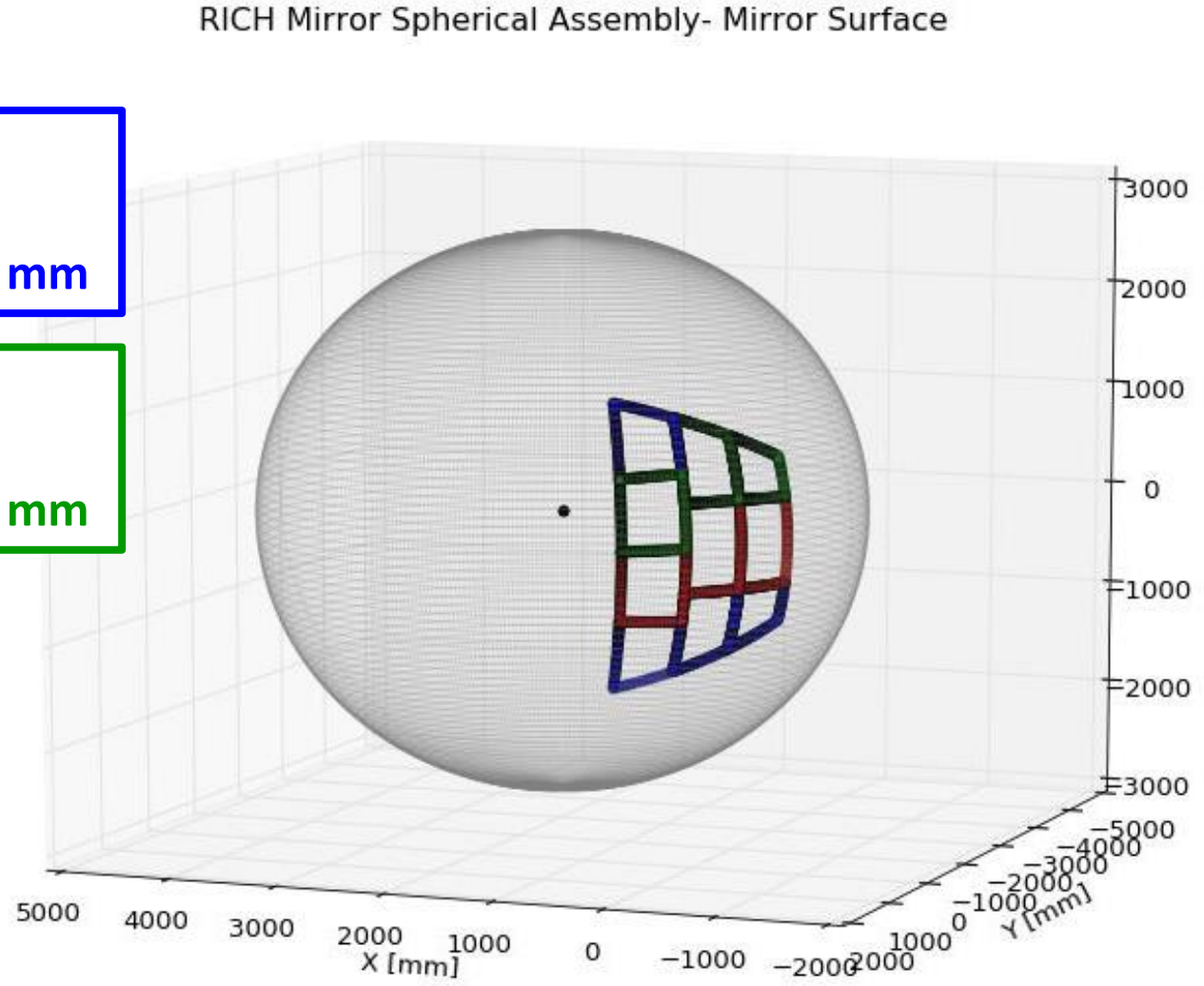
Back Surface

Mirror	Radius [mm]	RMS [mm]
3	2695.10	0.29
3C	2717.60	0.20
4C	2706.39	0.18
4	2713.43	0.17
5	2712.42	0.22
5C	2712.91	0.14
6	2725.07	0.19
1	2746.00	0.28
2C	2708.35	0.15
2	2742.77	0.28

Sphere Radius of Entire Assembly

Mirror Surface
Ideal R = 2700 mm
R = 2701.29 ± 0.28 mm

Back Surface
Ideal R = 2725 mm
R = 2725.50 ± 0.27 mm



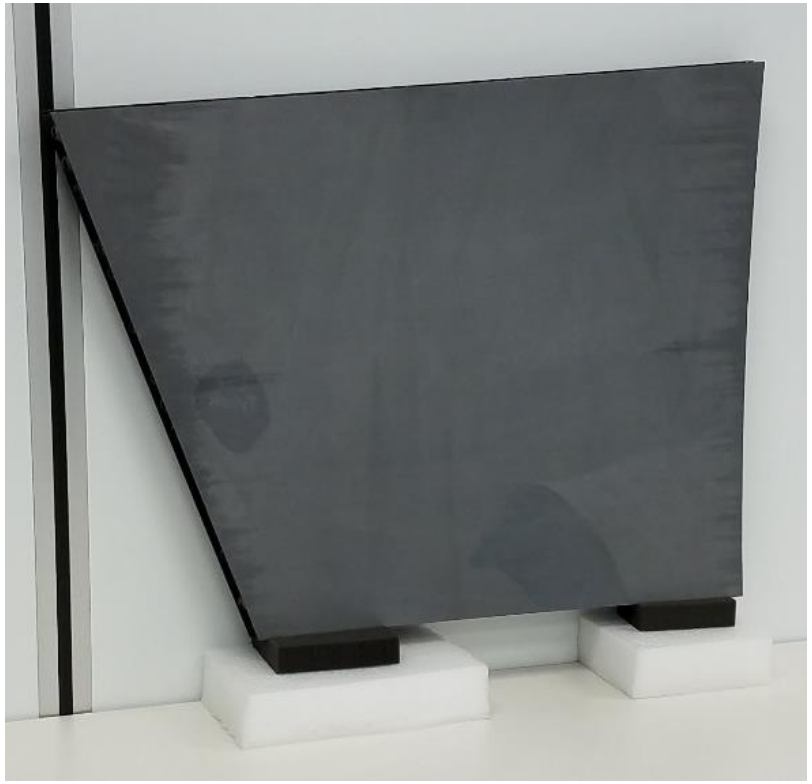
Sphere Radius

- Mirror surface of all mirrors is in acceptable range.
  - Acceptable range = 2673 mm < R < 2727 mm
- Both mirror and back surface of all mirrors together are very close to ideal spec
  - Mirror Surface < 0.05% from spec
  - Back Surface < 0.02% from spec

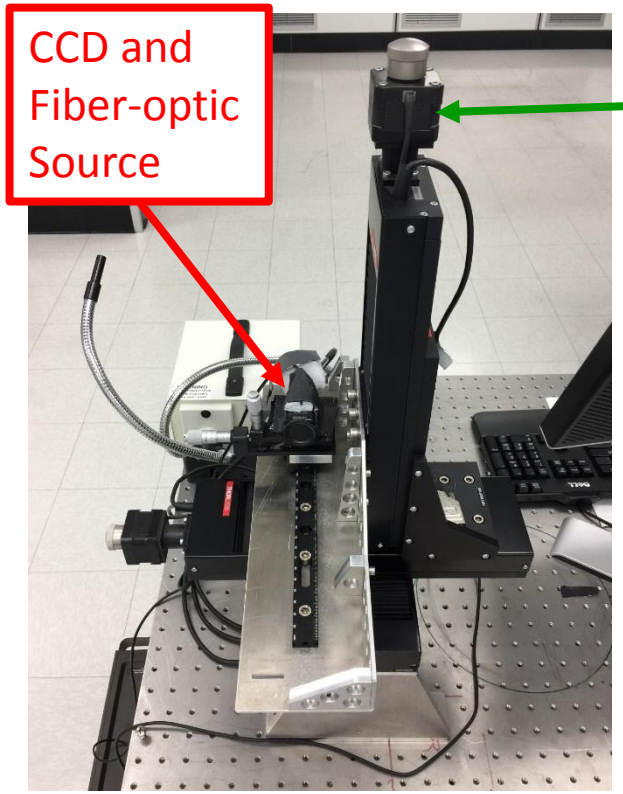
Spot Test

- Approximates radius of curvature of mirrors
- *d0* value is indicator of surface uniformity
  - Spec: *d0* < 2.5 mm
- Completed for all mirrors

Spot Test

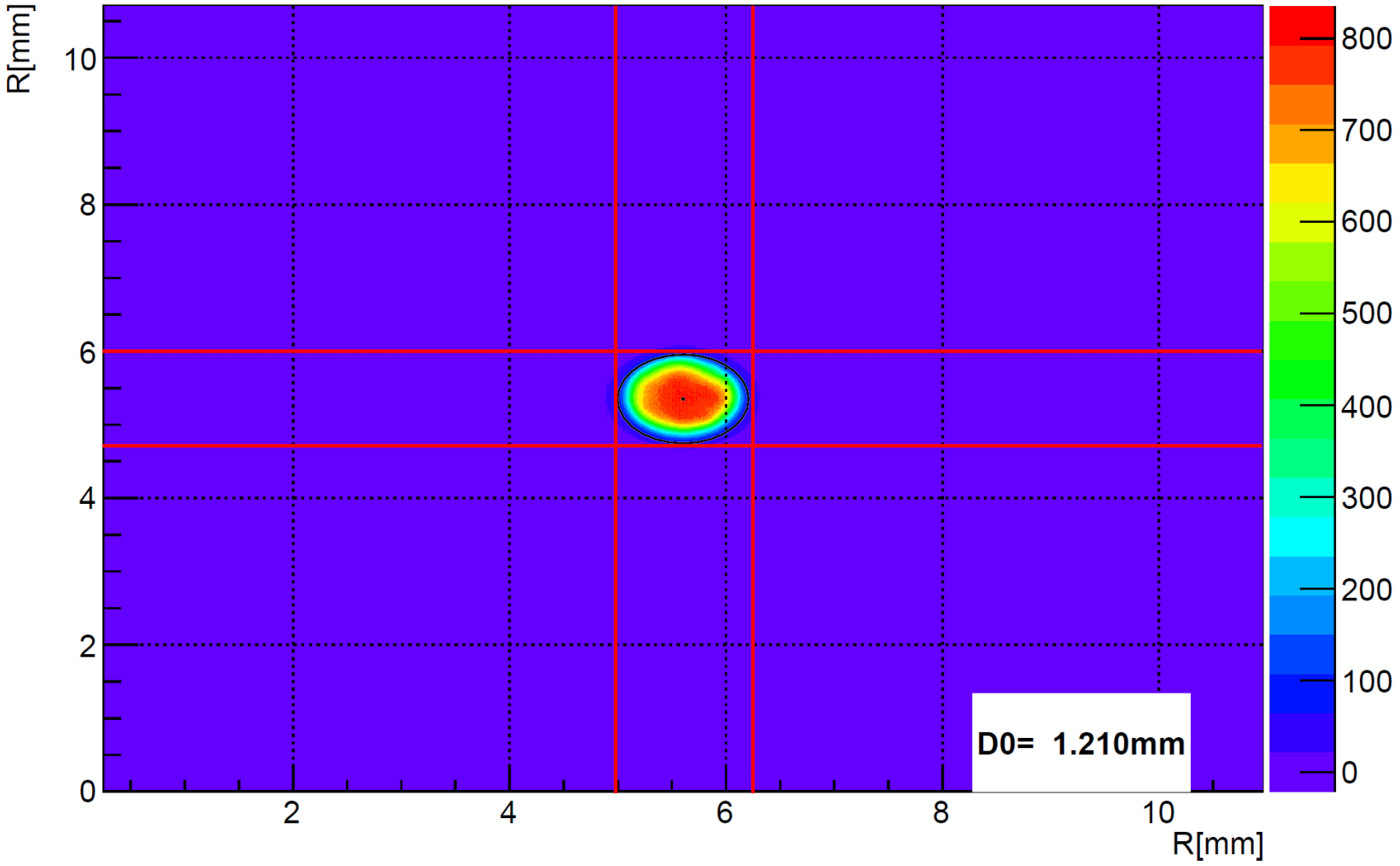


Mirror 3 placed on table in small clean room for spot test

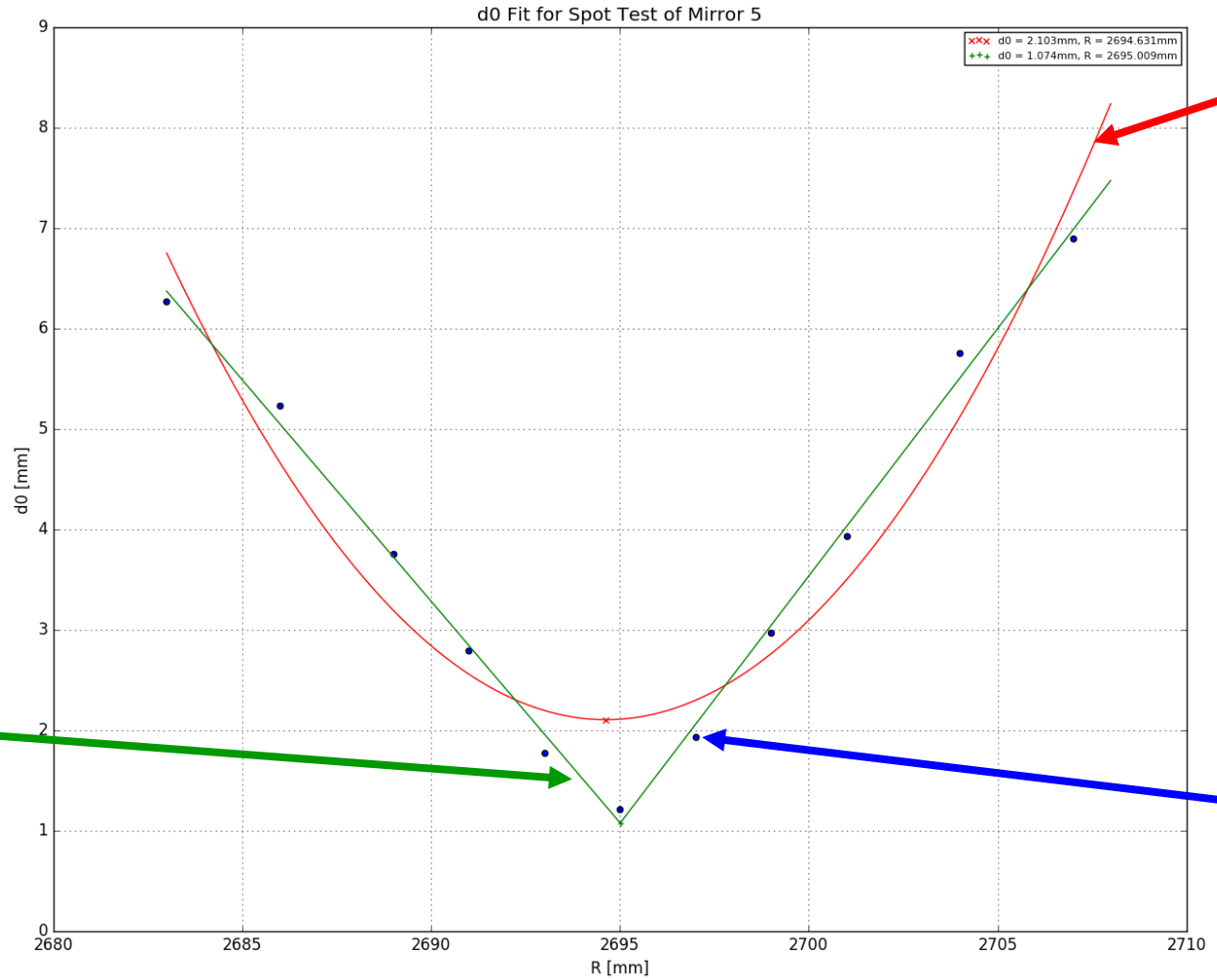


CCD stand for spot test.

Spot Test Image for Mirror 5



Mirror 5 Spot Test d0 Fit



Initial Parabolic *d0* fit
d0 = 2.103 mm
R = 2694.63 mm

Improved Linear *d0* fit
d0 = 1.074 mm
R = 2695.01 mm

Observed data points
d0 = 1.210 mm
R = 2695 mm

Observed *d0* Values

Mirror	d0 [mm]
3	1.471
3C	1.171
4C	1.390
4	1.569
5	1.210
5C	1.071
6	1.151
1	1.549
2C	1.069
2	1.370

Spot Test Results

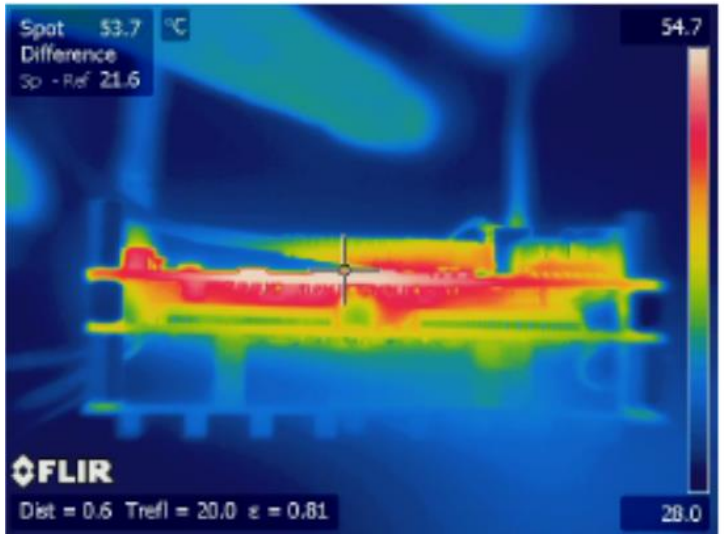
	Observed		Parabolic Fit		Linear Fit	
Mirror	d0 [mm]	Radius [mm]	d0 [mm]	Radius [mm]	d0 [mm]	Radius [mm]
3	1.471	2702.000	1.500	2702.186	1.467	2702.455
4	1.569	2709.000	1.636	2708.577	1.194	2708.258
5	1.210	2965.000	2.103	2694.631	1.074	2695.009
6	1.151	2695.000	2.975	2695.002	1.927	2694.997
1	1.549	2700.000	1.891	2700.796	1.484	2699.775
2	1.370	2700.000	1.715	2699.969	1.219	2700.363

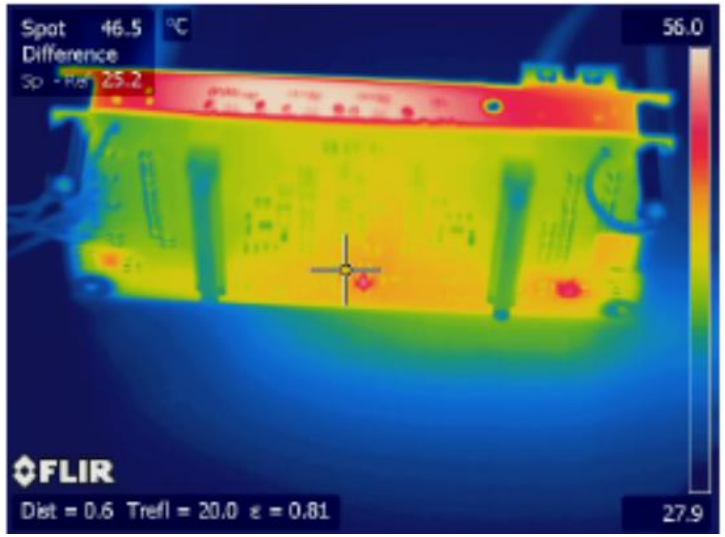
Did not get data for radius and d0 fit for Mirrors 2C, 3C, 4C, and 5C

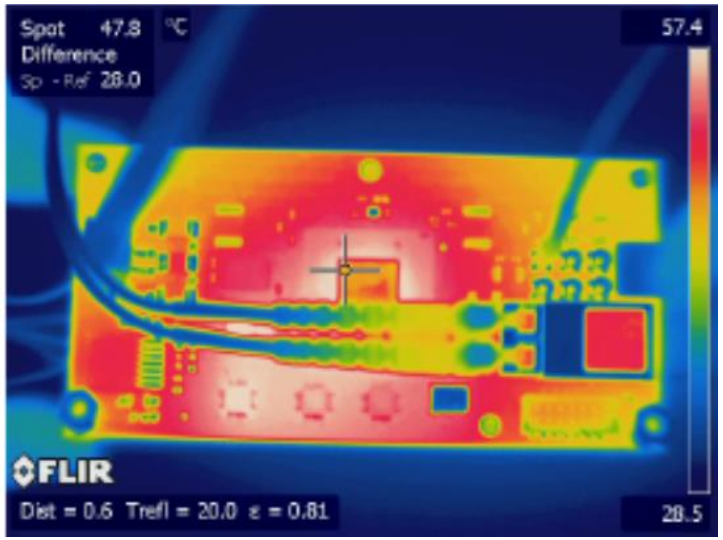
Spot Test

- All mirrors have observed *d0* < 2.5 mm
- Fit program needs to be adjusted
- Spot tests will be repeated with mirror stand
  - SVT repairs needed the optical tables
  - Will be able to use optical tables for spot test at end of November 2016

Gas System







Heat imaging for a RICH electronics boards. Hottest part of boards is ~130° F.

Gas System Status

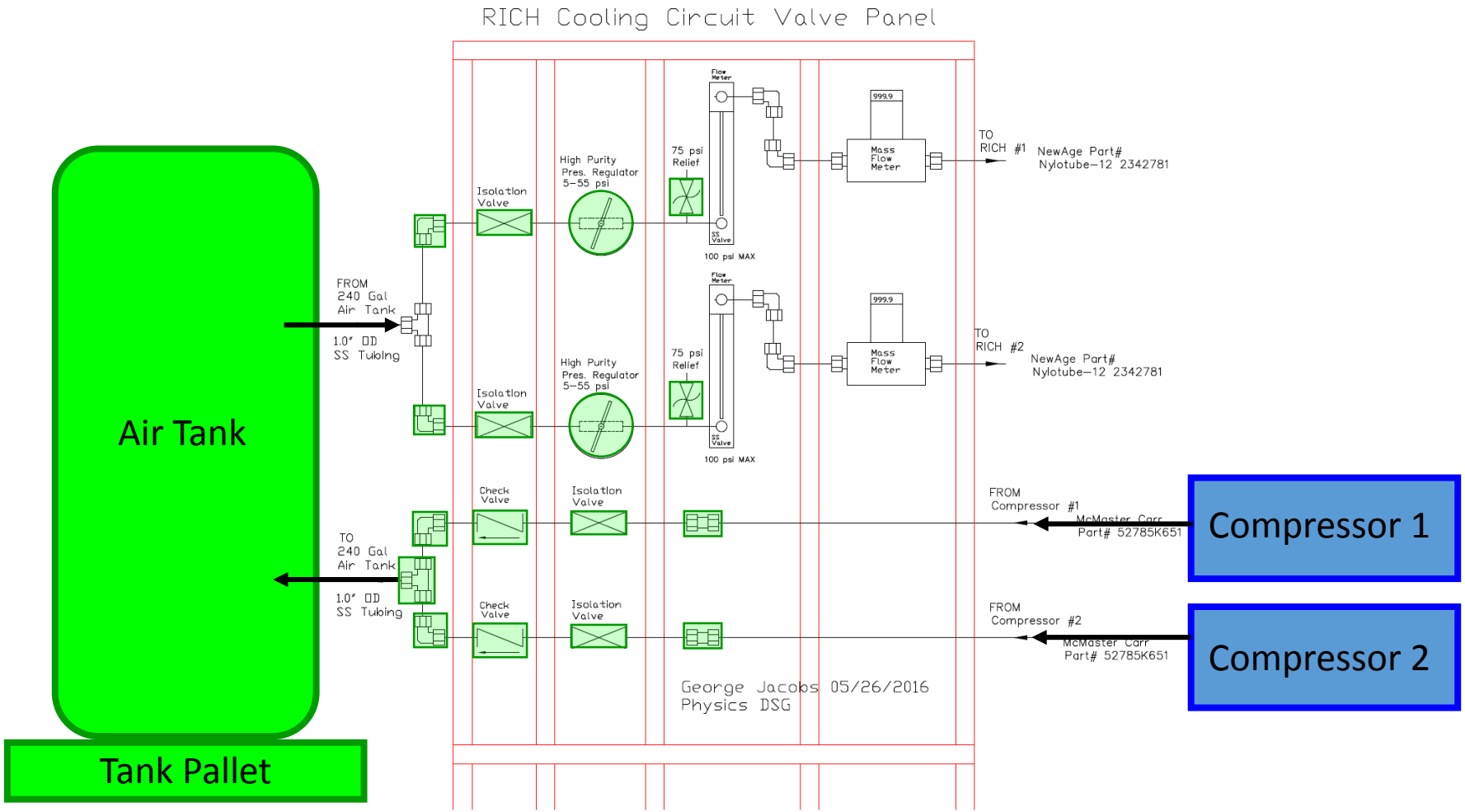
- Air Cooling System
  - Air compressors as cooling flow source
  - Electronics generate enough heat to damage FTOF behind RICH.
  - Electronics must be cooled below 100° F.
  - All components ordered, yet to receive all

- Nitrogen Purge System
  - Aerogel degrades if it absorbs moisture
  - Flow nitrogen over aerogel to prevent degrading
  - All components ordered, yet to receive all

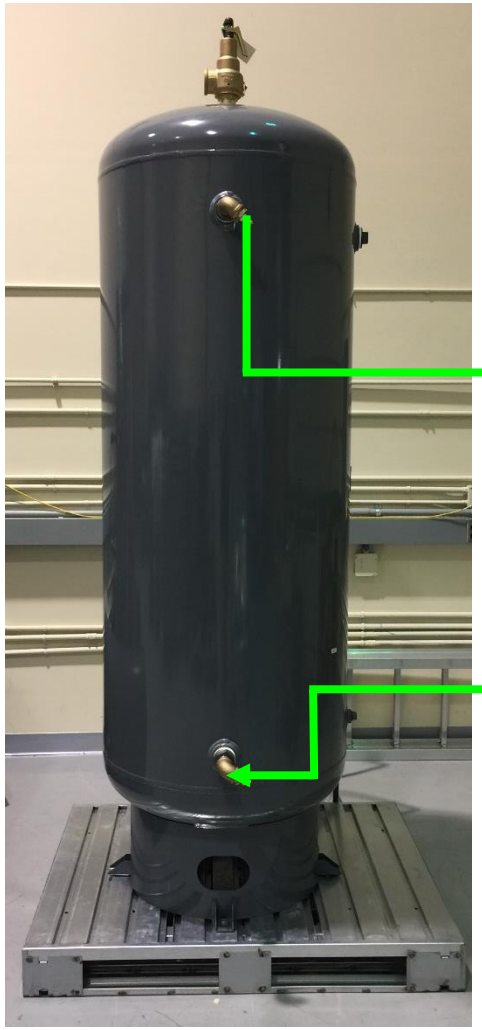
Gas System Valve Panel

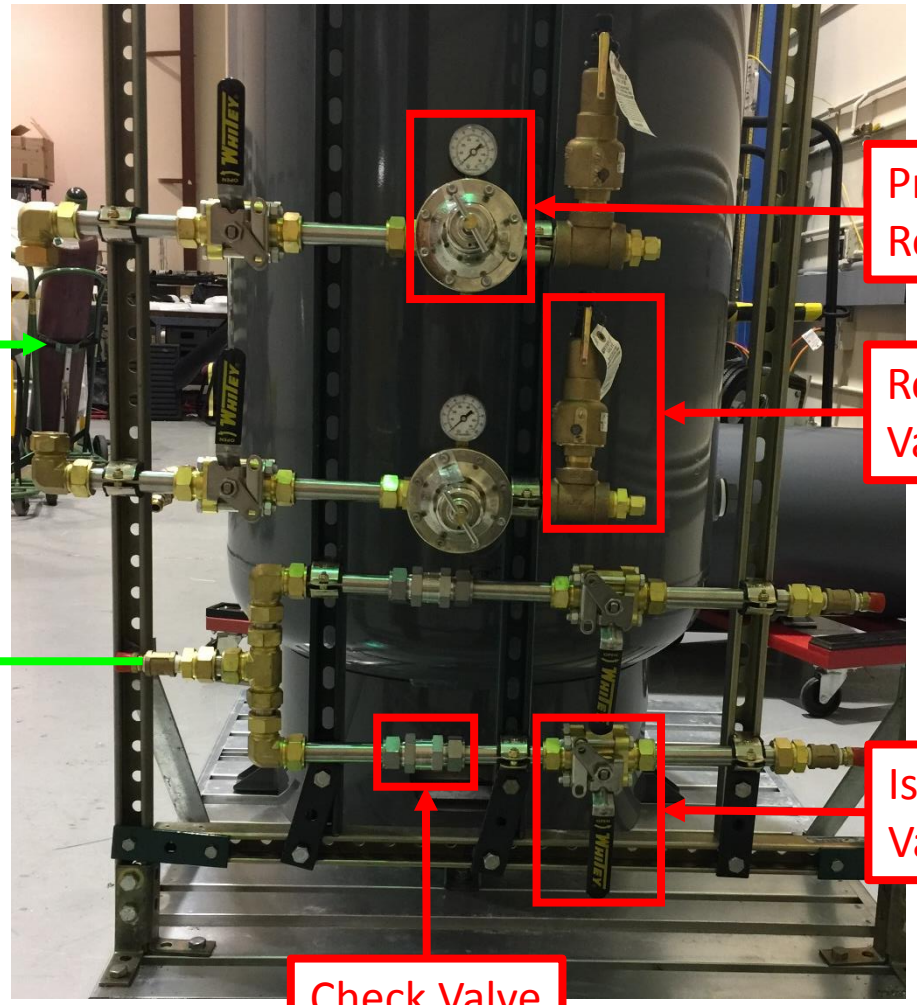
- 65% done
  - Waiting for components
  - Components expected second week of October 2016
- Designed by George
- Assembled by Sahin

Gas System Valve Panel

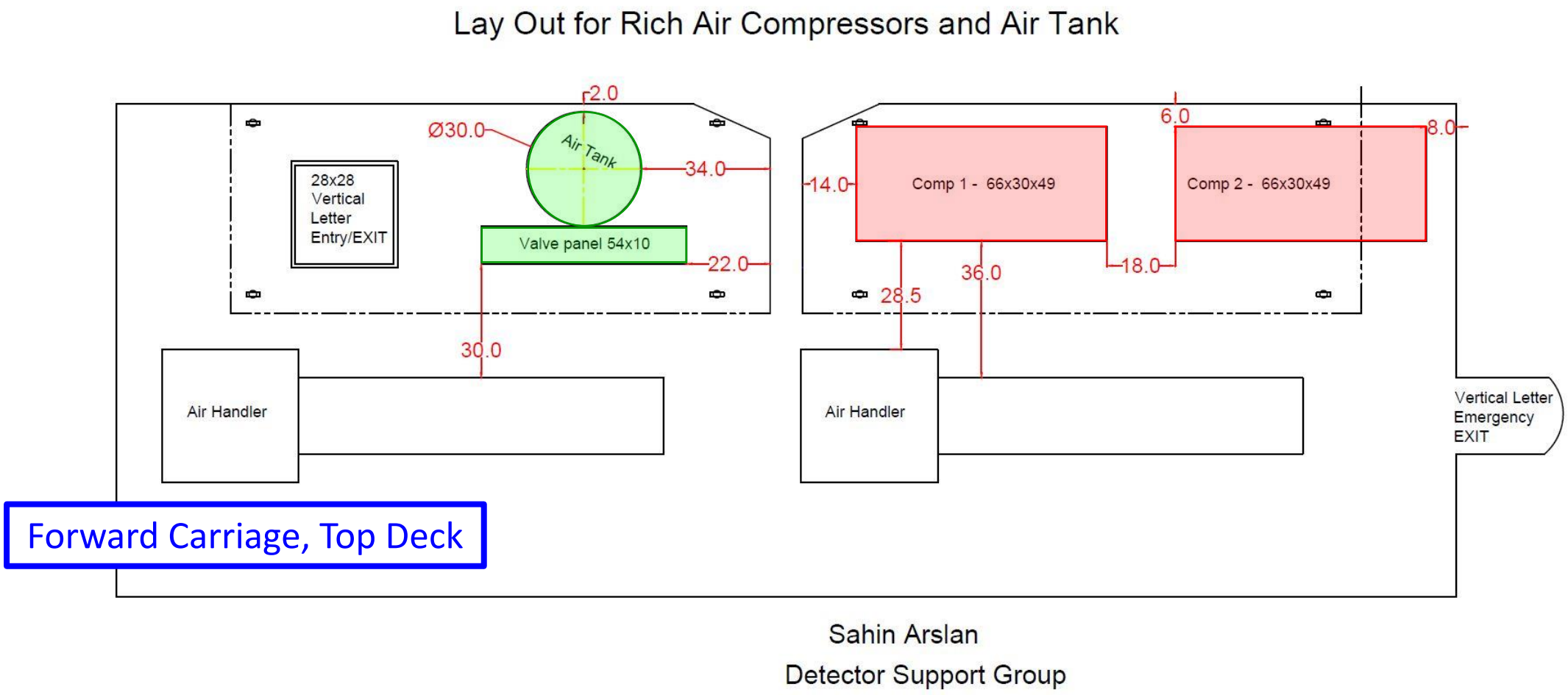


Gas System Valve Panel





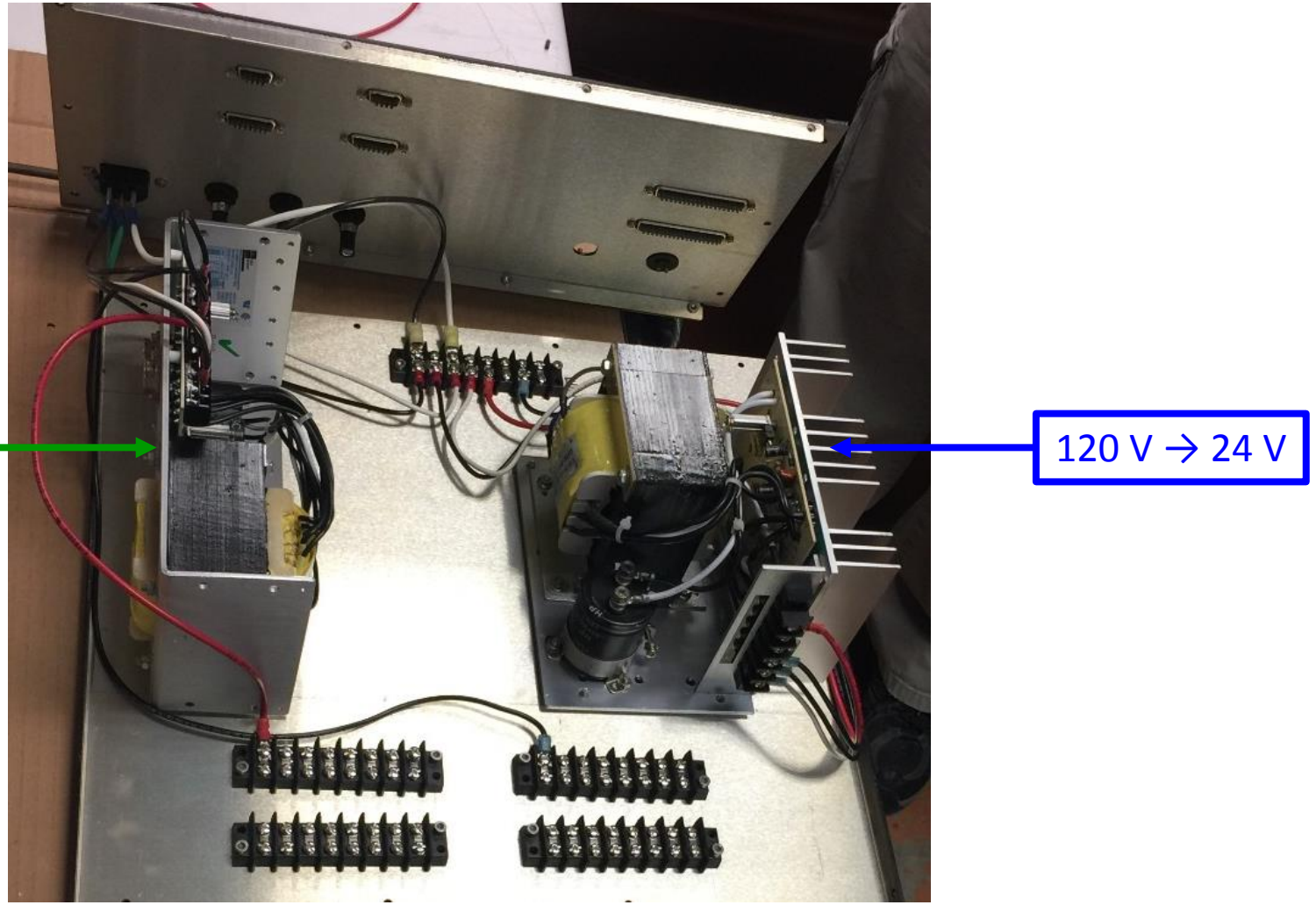
Valve Panel Location in Hall B



Gas System Interface Chassis

- Provides power to sensors
- Acts as patch panel for signal cables
- All components received
- Power supplies mounted and power distribution wired.
- Fabricated by Marc

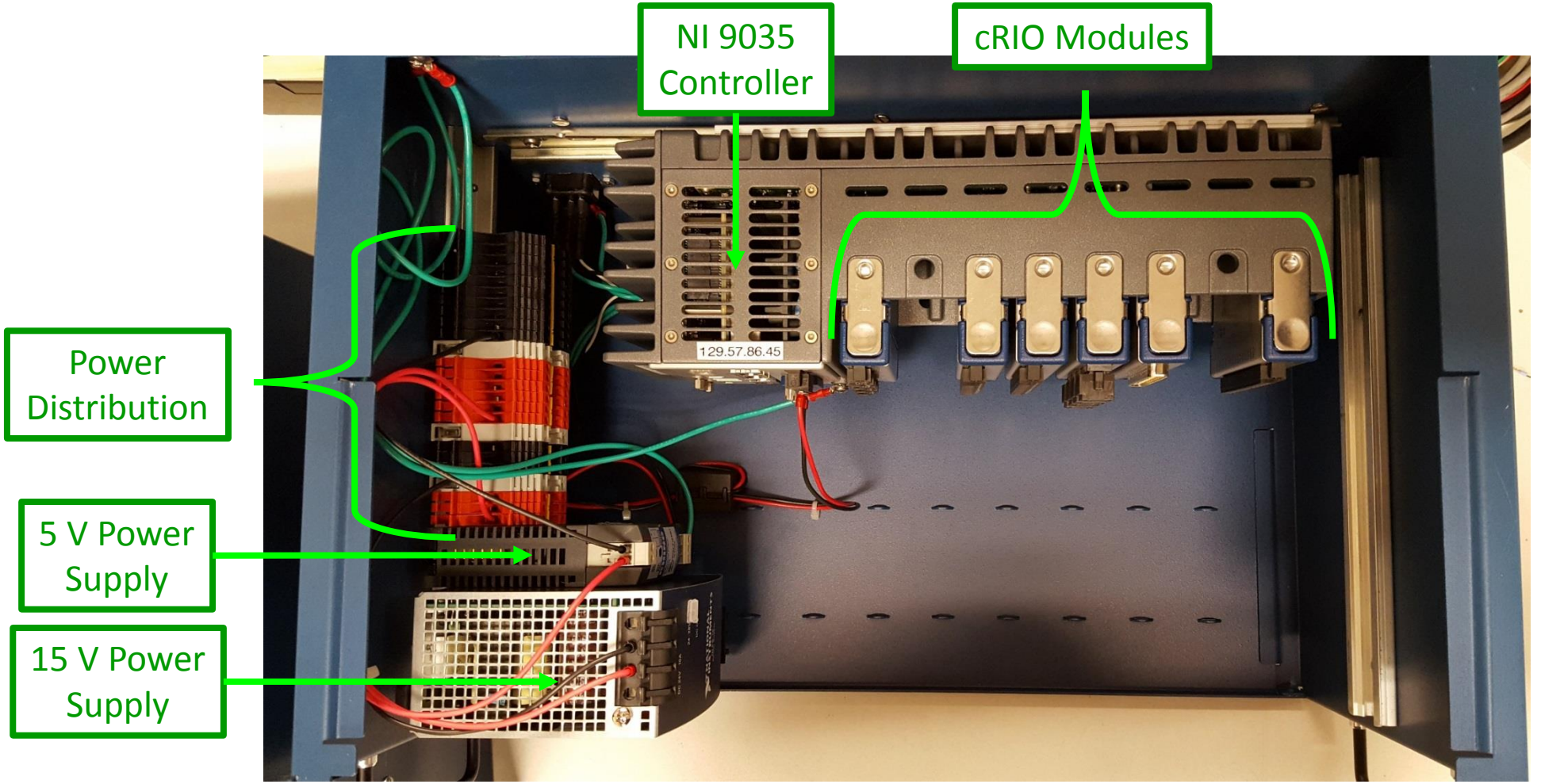
Gas System Interface Chassis



Interlock System Status

- Monitor internal temperature and cooling air flow
  - Turn off voltage to detector if temperature or air flow is out of bounds
  - Prevent detector from turning on if no cooling air flow
- All components received
  - Faulty 5 V power supply returned and replaced
- cRIO chassis assembled and interlock cables fabricated by Mindy
- Operating system installed and cRIO tested by Peter

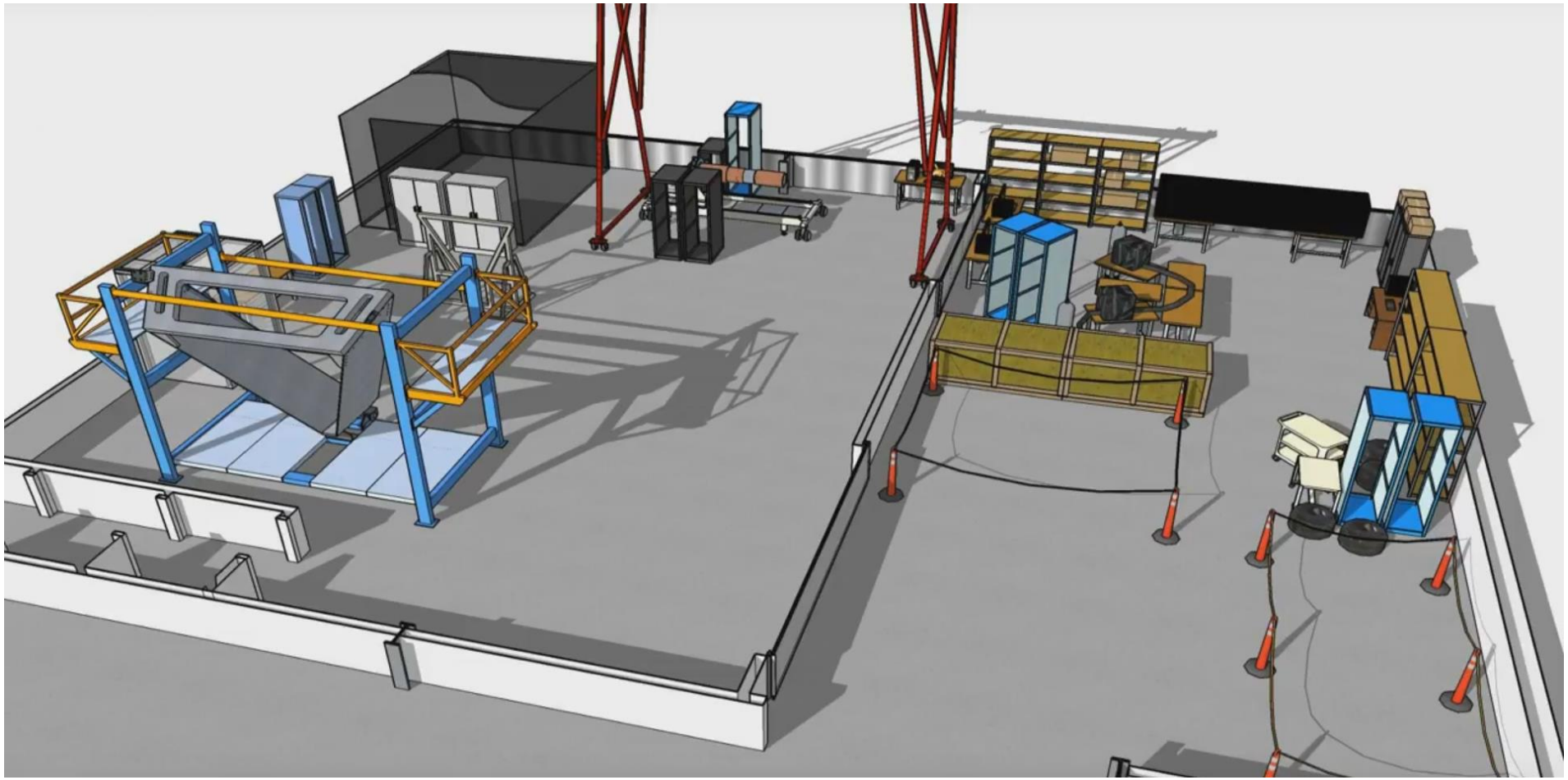
Interlock cRIO Chassis



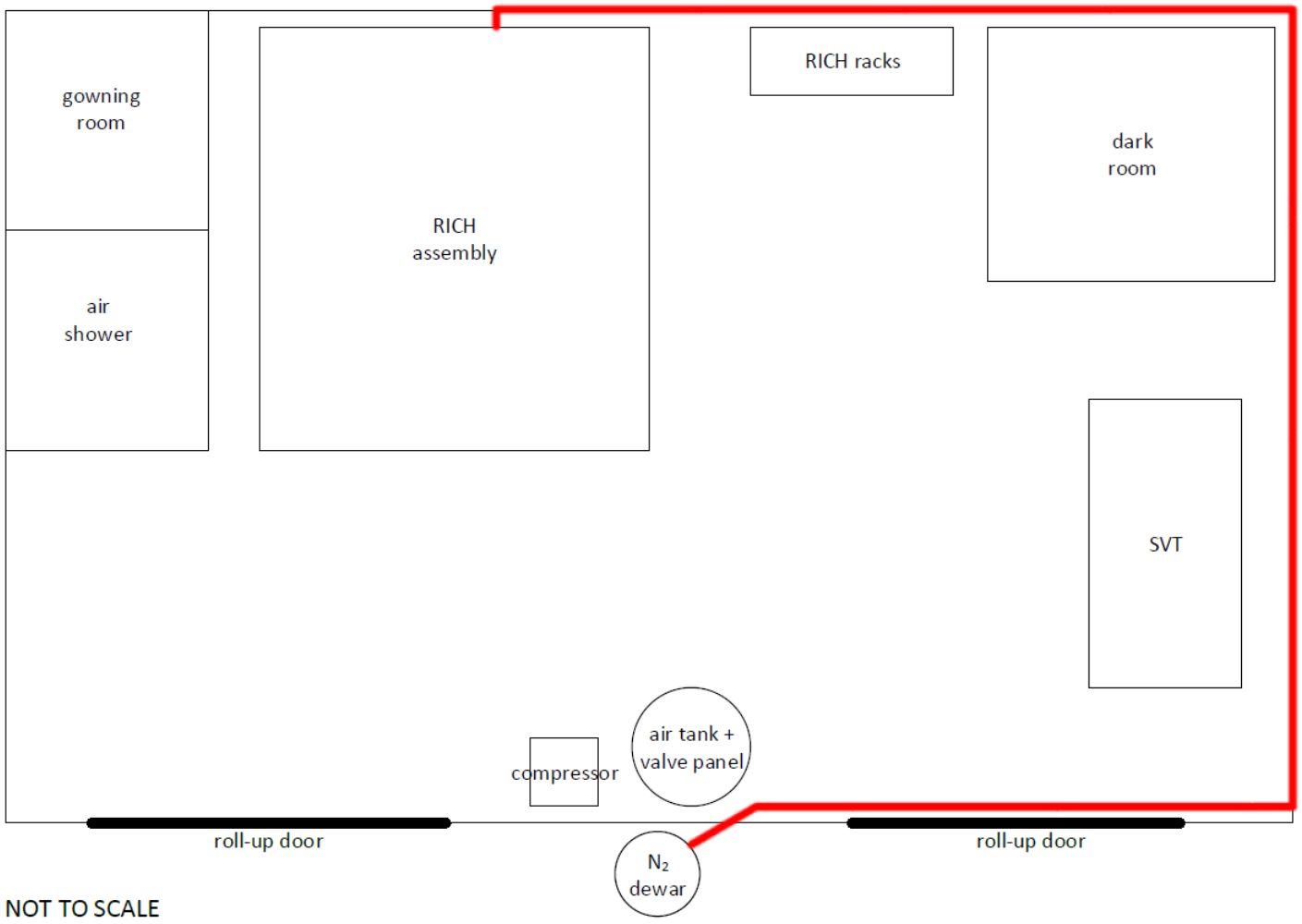
Assembly Components Status

- Big clean room (EEL 124) arranged according plan
- Assembly test at INFN facility in Italy complete
  - Detector frame and assembly structure to arrive at JLab in October 2016
- R3 DCs leave clean room → preparations start for RICH assembly

EEL 124 Layout



EEL 124 Layout Diagram



Upcoming and Ongoing Tasks

- Ship mirrors for mounting and final coating
- Assembly of Gas System Valve Panel
- Fabrication of Gas System Interface Chassis
- Development of Interlock System
- Electronic panel assembly
- Detector assembly

Outstanding Tasks

- Prepare big clean room for assembly
  - Determine bolt size needed for anchoring assembly structure
  - Drill holes in clean room floor for anchoring
- Repeat mirror spot test
  - Two optical tables available end of November 2016
  - Waiting to receive mirror stand

Conclusion

- Contributions by *all* DSG members
- Spherical mirrors
  - Fully analyzed
  - Accepted
- Gas System
  - Components starting to arrive
  - Assembly and fabrication started
- Interlock System
  - Components received
  - Assembly and fabrication of cRIO chassis complete
- Assembly components to be delivered in October 2016
- **Detector assembly expected to start in October 2016**

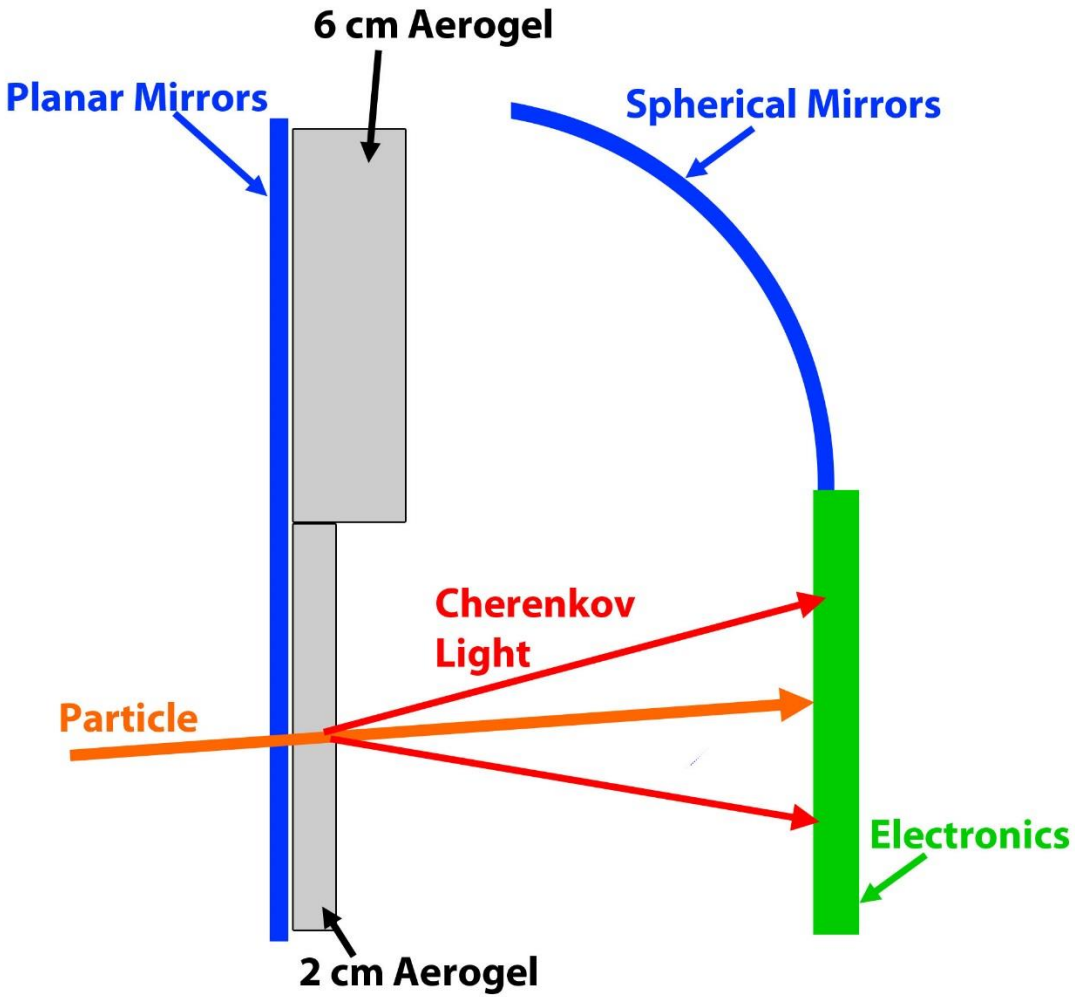
Acknowledgements

- Marco Contalbrigo
- Marco Mirazita
- Ilaria Balossino
- Giovanni Angelini
- Sandro Tomassini
- Dario Orecchini
- Luca Barion
- Dr. Patrizia Rossi

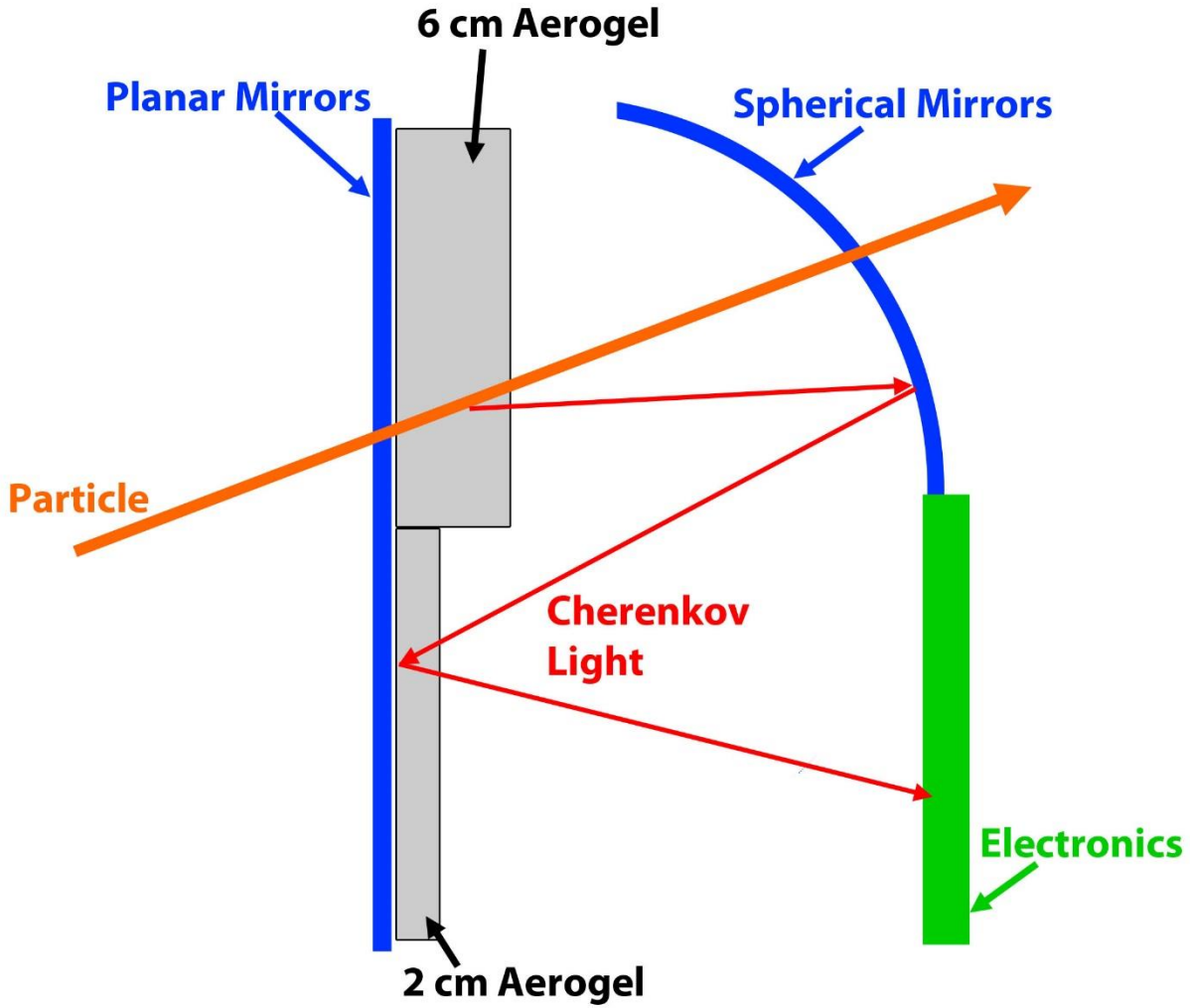
Thank You

Back Up

Small Angle Cherenkov Light Paths



Large Angle Cherenkov Light Path



Individual Mirror Linear Lengths- Back Surface

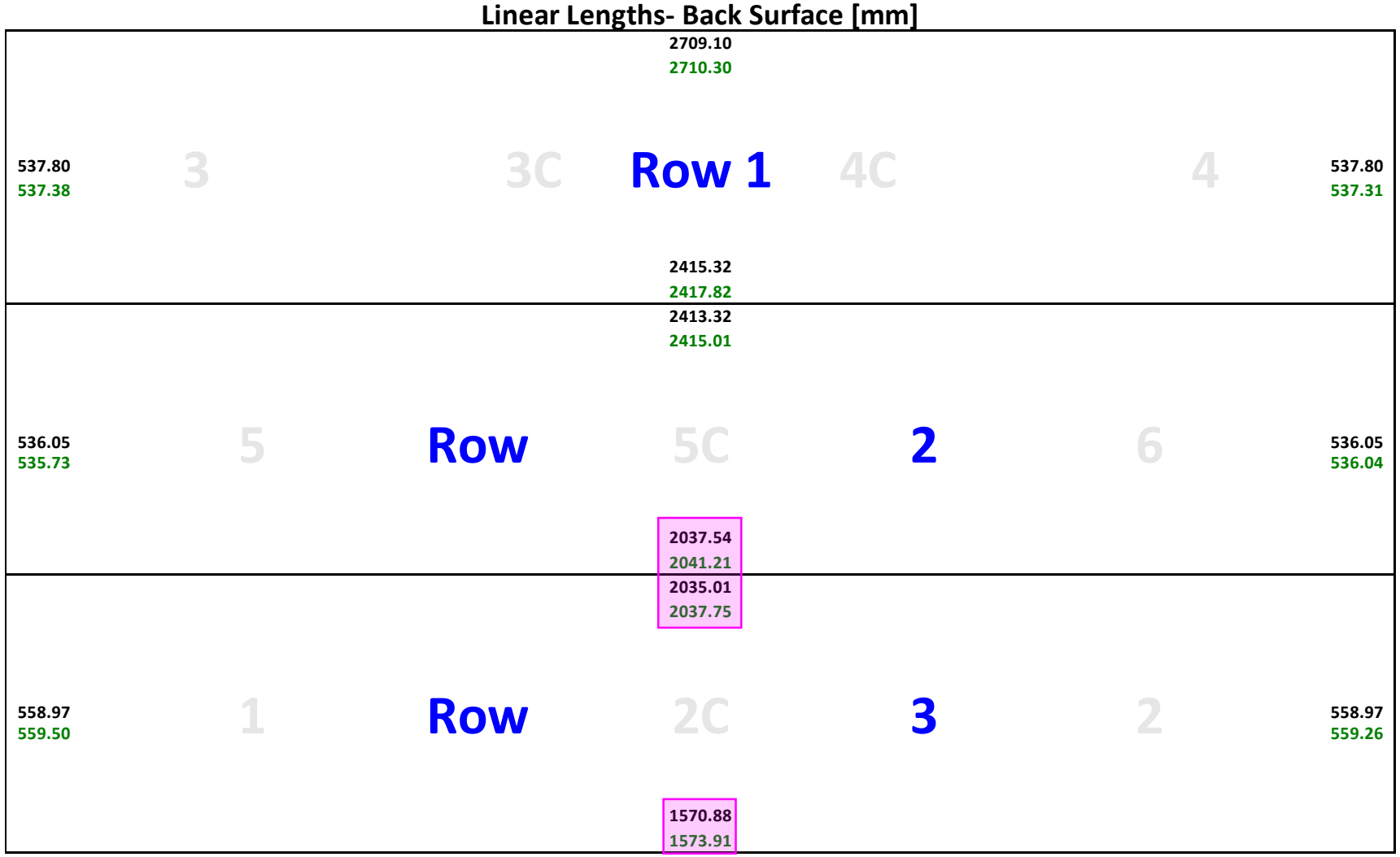
■ = Ideal
■ = AutoCAD

Linear Lengths- Back Surface [mm]

	733.94 734.85			675.21 674.28			675.21 674.69			733.94 734.14	
537.80 537.38	**3**	561.91 561.58	562.07 562.30	**3C**	580.01 579.72	580.01 580.09	**4C**	562.07 562.26	561.91 561.56	**4**	537.80 537.31
	538.84 541.06			704.95 704.78			704.95 704.42			538.84 540.21	
	819.47 820.53				845.46 844.26				819.48 819.59		
536.05 535.73	**5C**	536.34 536.20	536.43 536.35	**5C**	536.43 535.85	536.34 536.53	**6**	536.05 536.04			
	615.37 617.22			845.46 843.79			615.37 616.85				
	614.06 616.31			845.37 843.51			614.06 615.56				
558.97 559.50	**1**	526.64 526.71	526.73 526.61	**2C**	526.73 526.65	526.64 527.02	**2**	558.97 559.26			
	385.30 387.77			813.20 812.57			385.30 386.56				

Assembly Row Linear Lengths- Back Surface

■ = Ideal
■ = AutoCAD

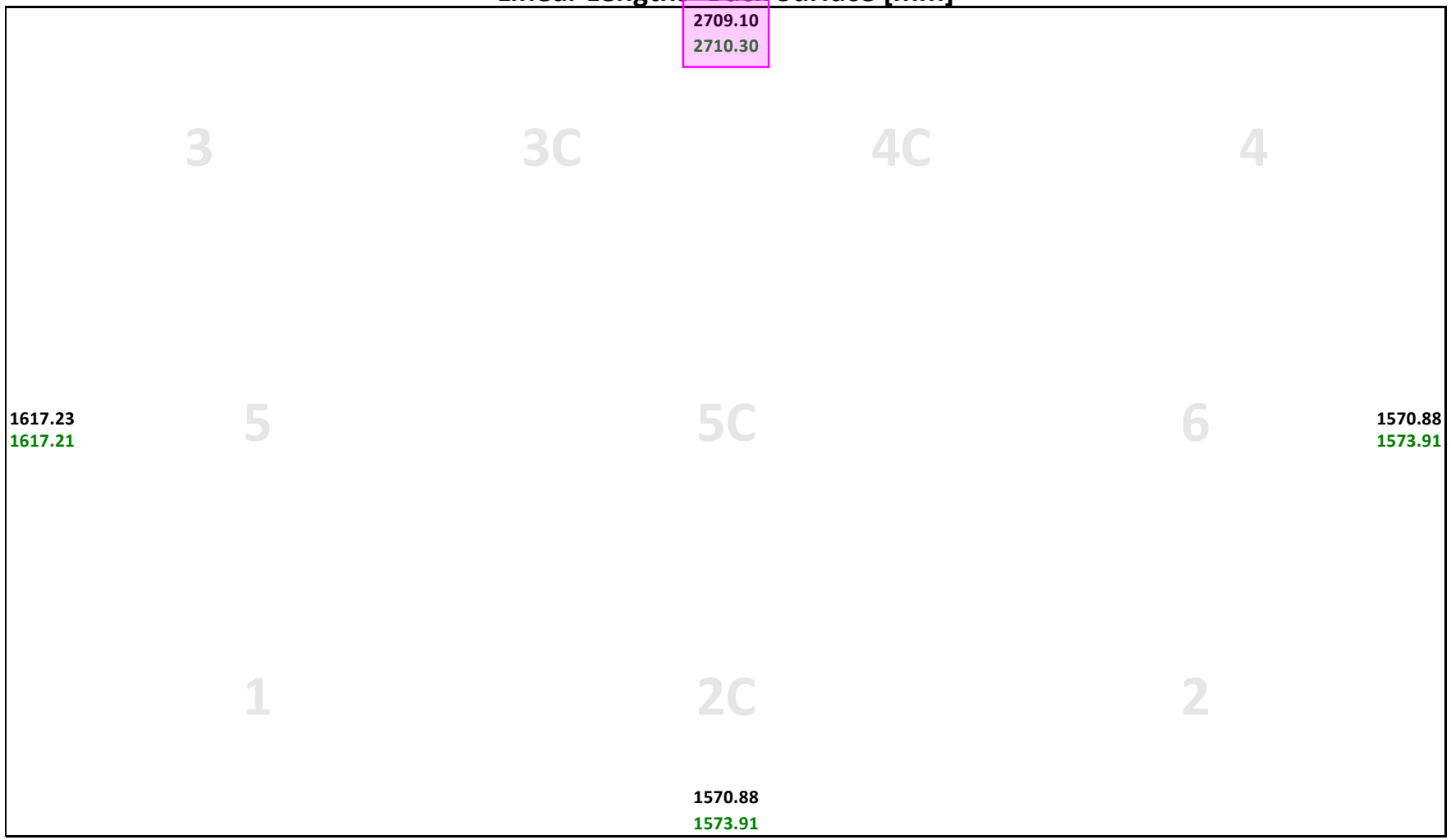


Assembly Linear Lengths- Back Surface

Linear Lengths- Back Surface [mm]

= Ideal

= AutoCAD



Individual Sides Arc Lengths- Back Surface

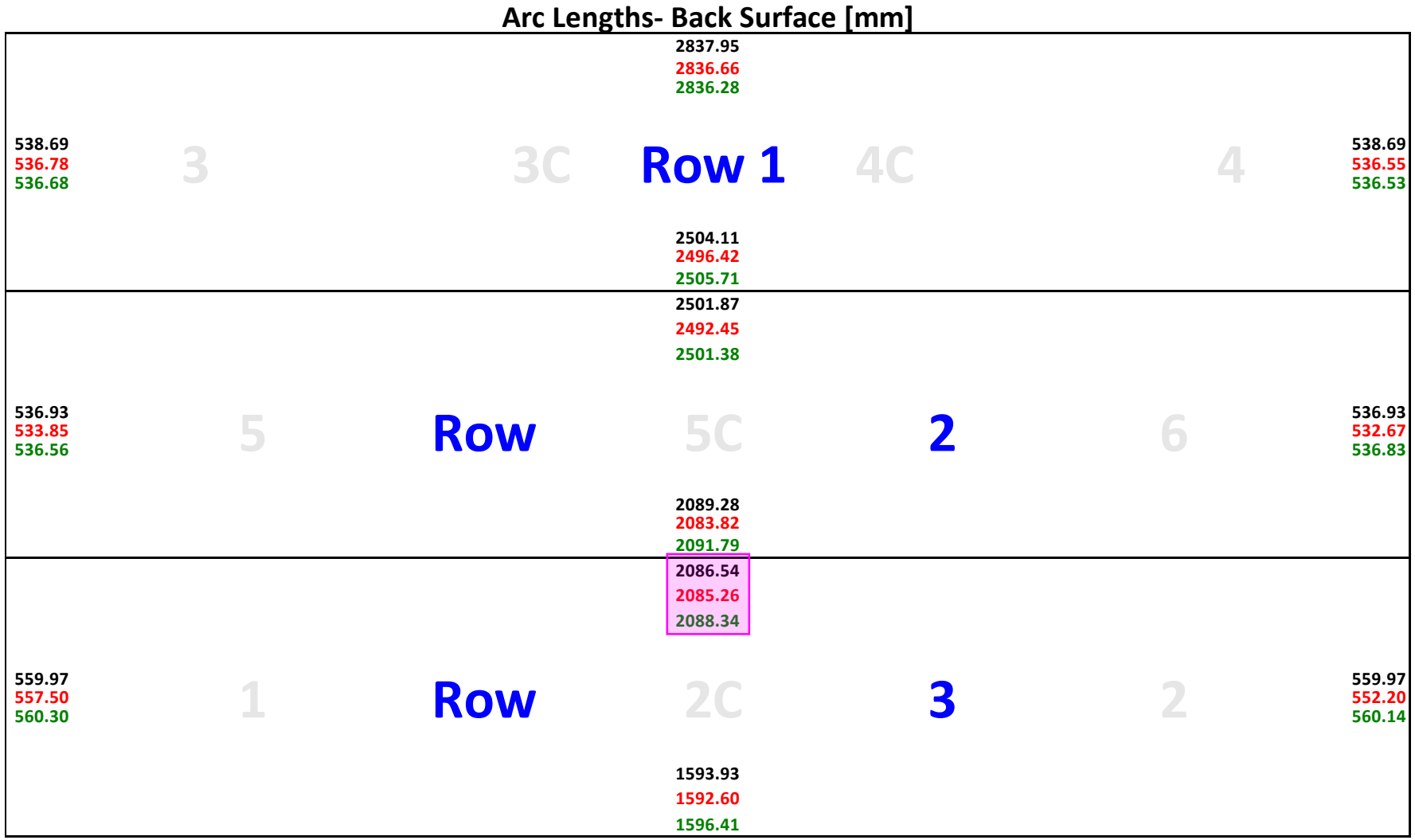
■ = Ideal
■ = Python
■ = NX 9.0

Arc Lengths- Back Surface [mm]

	736.22 734.76 734.69			676.98 673.84 673.80			676.98 673.25 673.25			736.22 736.53 735.52	
538.69 536.78 536.68	**3**	562.93 561.34 561.32	563.09 561.25 561.16	**3C**	581.13 579.34 579.34	581.13 579.02 578.94	**4C**	563.09 560.56 560.52	562.93 560.34 560.32	**4**	538.69 536.55 536.53
	539.74 543.28 539.37			706.97 705.25 705.24			706.97 703.70 703.67			539.74 537.97 537.98	
	822.65 819.20 823.58			848.96 845.66 845.65			822.65 813.32 822.60				
536.93 533.85 536.56	**5**	537.22 534.66 536.96	537.32 536.03 535.98	**5C**	537.32 534.53 534.75	537.22 534.01 537.31	**6**	536.93 532.67 536.83			
	616.71 616.60 618.44			848.96 845.48 847.05			616.71 613.88 618.06				
	615.39 613.97 617.58			848.86 844.67 844.63			615.39 613.14 616.88				
559.97 557.50 560.30	**1**	527.48 524.81 527.45	527.57 524.15 524.13	**2C**	527.57 523.82 523.75	527.48 523.28 527.73	**2**	559.97 552.20 560.14			
	385.62 384.43 387.99			816.30 813.02 812.96			385.62 384.53 386.82				

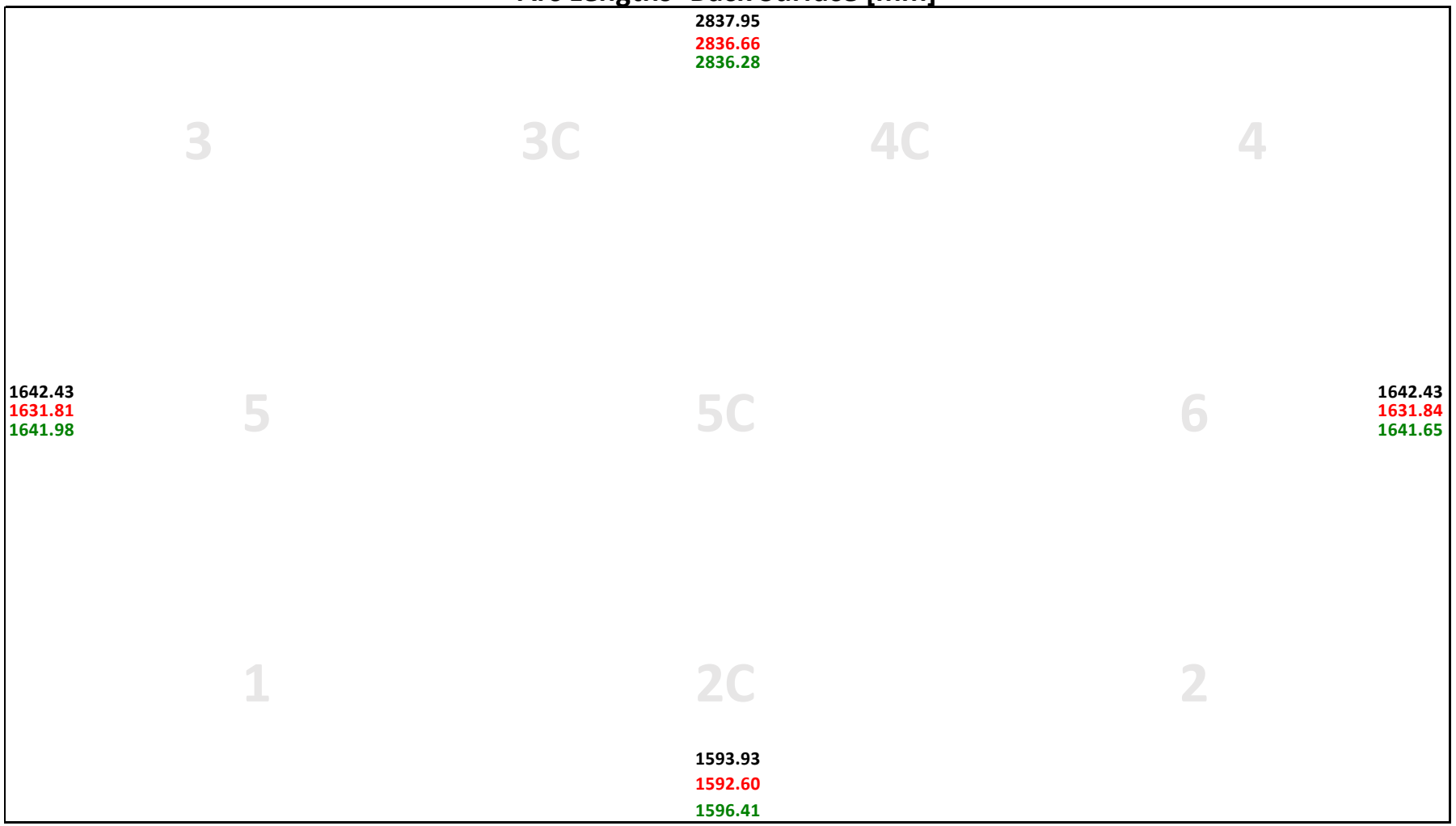
Arc Lengths of Assembly Rows- Back Surface

= Ideal
= Python
= NX 9.0



Arc Lengths of Entire Assembly- Back Surface

= Ideal
= Python
= NX 9.0



Radius of Individual Sides of Mirrors- Back Surface

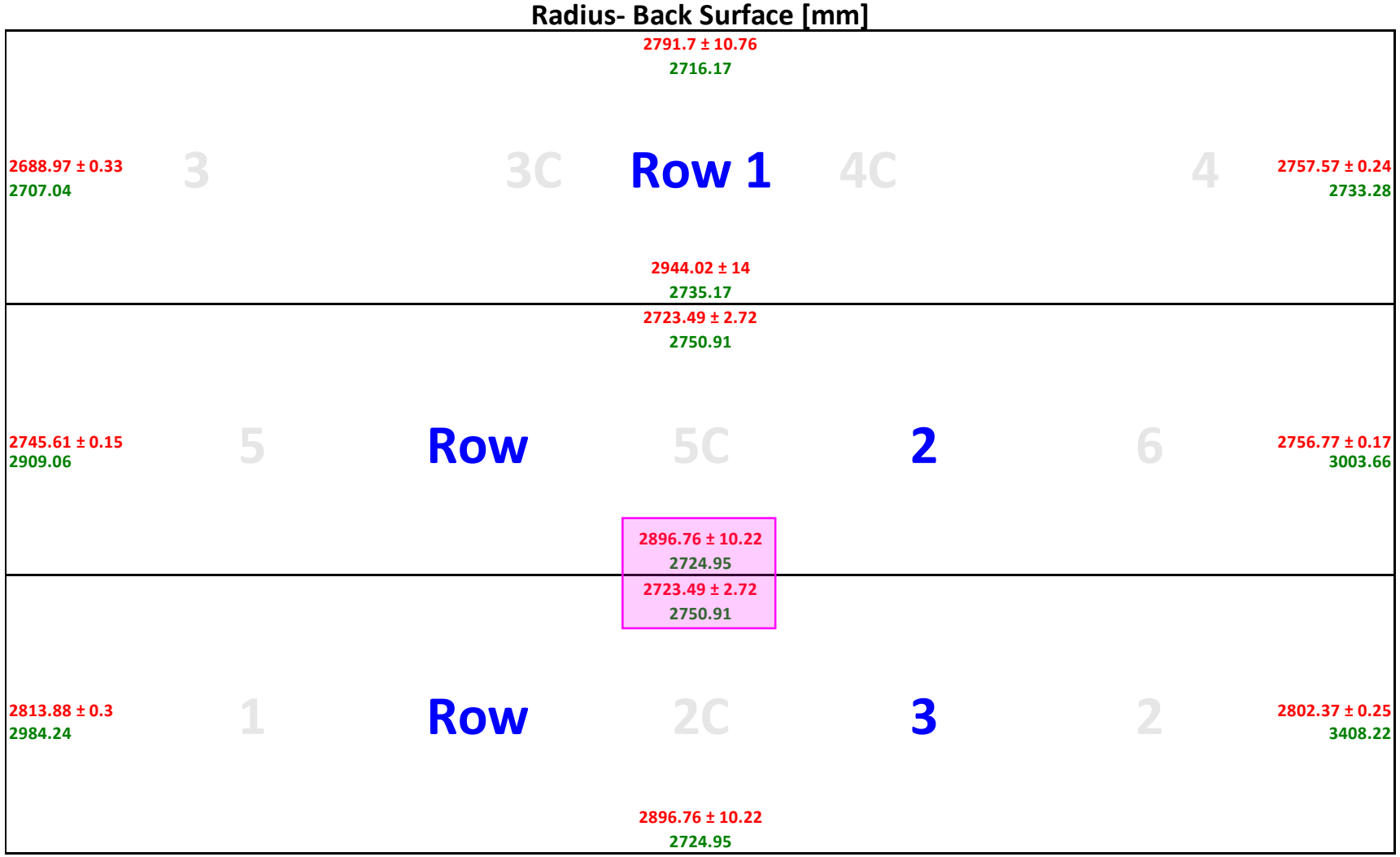
= Python
= NX 9.0

Radius- Back Surface [mm]

2695.49 ± 1.57 2682.11 2688.97 ± 0.33 2707.04 **3** 2732.34 ± 0.08 2735.55 2666.95 ± 0.72 2606.42	2657.27 ± 1.54 2700.32 2818.18 ± 0.19 2845.42 **3C** 2718.84 ± 0.12 2723.56 2707.6 ± 0.3 2722.75	2789.27 ± 0.56 2696.80 2769.52 ± 0.17 2795.40 **4C** 2712.06 ± 0.08 2737.97 2536.26 ± 1.85 2716.97	2695.18 ± 0.35 2719.74 2738.39 ± 0.09 2732.99 **4** 2757.57 ± 0.24 2733.28 2689.56 ± 0.84 2659.14
2729.01 ± 0.36 2740.09 2745.61 ± 0.15 2909.06 **5** 2721.63 ± 0.11 3028.08 2681.28 ± 0.69 2839.90	2731.83 ± 0.1 2725.51 2684.92 ± 0.16 2673.26 **5C** 2835.43 ± 0.07 2688.93 2716.12 ± 0.08 2700.93	2731.75 ± 0.25 2787.05 2734.78 ± 0.11 2807.32 **6** 2756.77 ± 0.17 3003.66 2754.89 ± 0.41 3006.96	
2684.04 ± 0.54 2793.04 2813.88 ± 0.3 2984.24 **1** 2835.14 ± 0.12 3073.59 2637.39 ± 0.18 3786.05	2715.19 ± 0.12 2708.71 2707.18 ± 0.1 2682.41 **2C** 2699.12 ± 0.14 2725.71 2719.58 ± 0.14 2725.44	2623.58 ± 0.55 2846.03 2762.58 ± 0.18 3069.95 **2** 2802.37 ± 0.25 3408.22 2781.24 ± 0.31 3483.69	

Radius of Assembly Row Sides – Back Surface

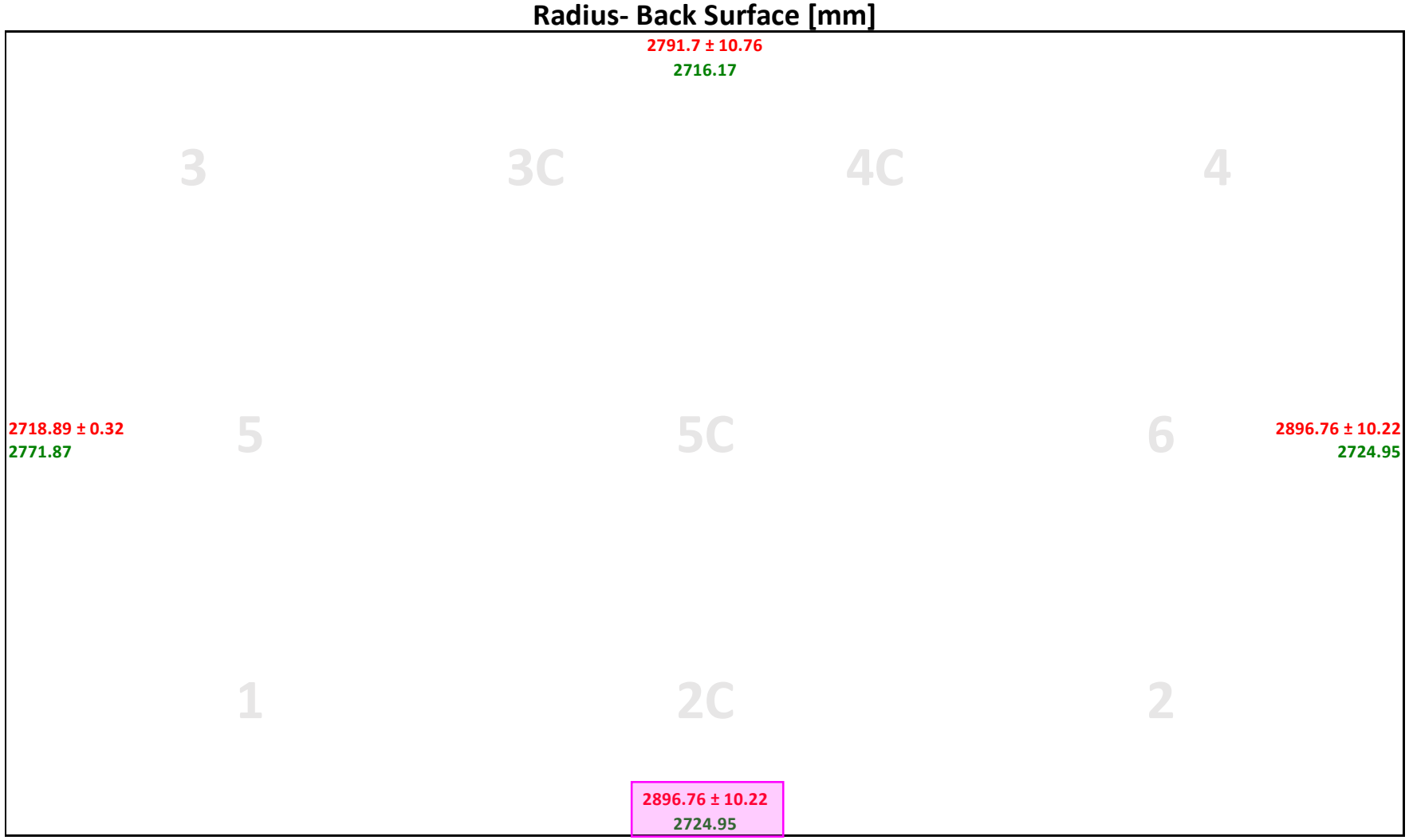
= Python
= NX 9.0



Radius of Entire Assembly Sides- Back Surface

= Python

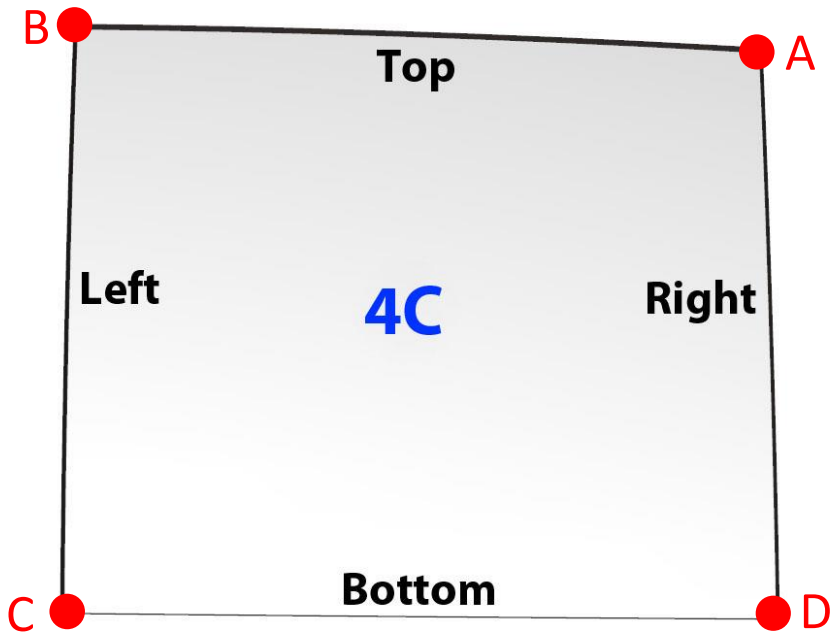
= NX 9.0



Linear Lengths- Individual Mirror Diagonals

Mirror Surface

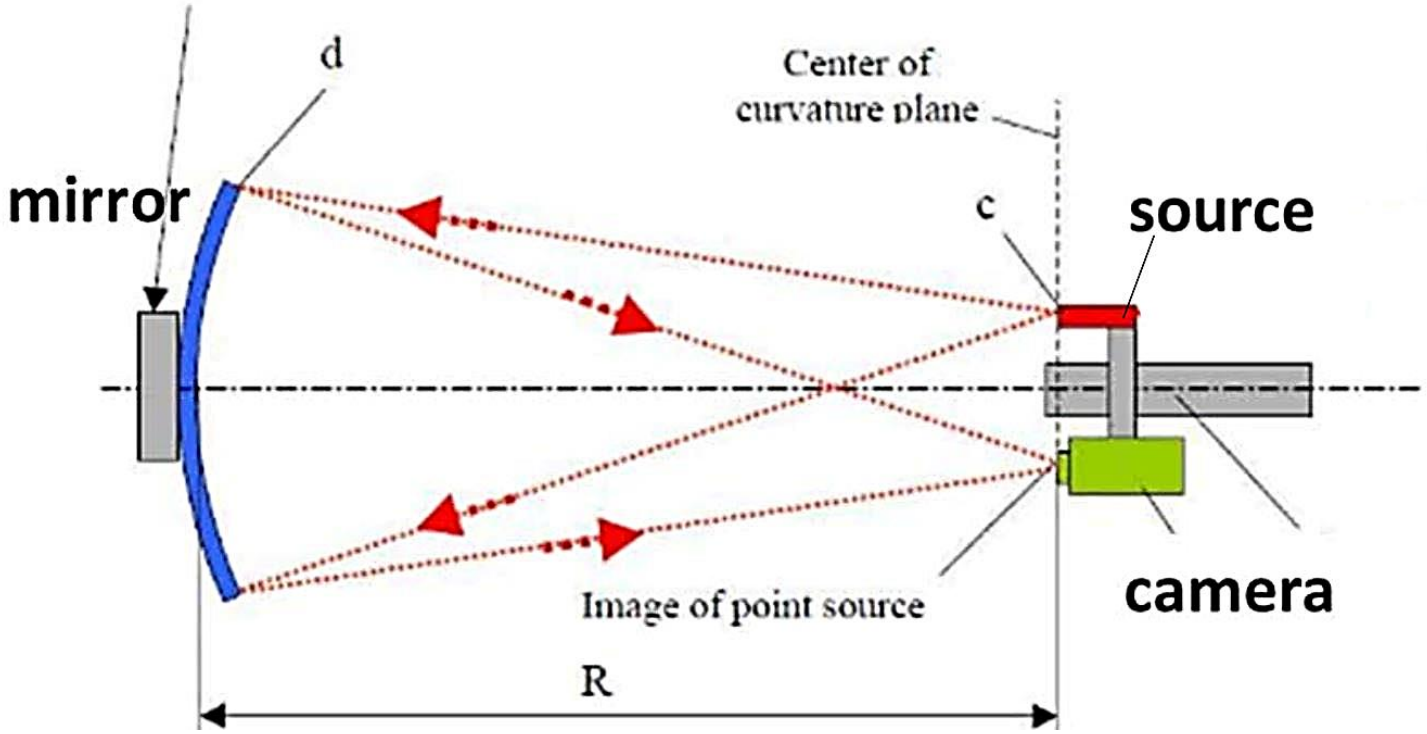
Mirror	Diagonal	Ideal	CMM AutoCAD
3	AC	778.41	778.89
	BD	875.11	876.37
3C	AC	898.30	899.22
	BD	876.14	876.09
4C	AC	876.14	874.40
	BD	898.30	898.70
4	AC	875.11	875.58
	BD	778.41	778.88
5	AC	799.27	800.21
	BD	958.14	959.13
5C	AC	992.06	992.75
	BD	992.06	992.02
6	AC	958.14	958.57
	BD	799.27	799.35
1	AC	631.19	632.10
	BD	804.58	805.69
2C	AC	973.25	974.52
	BD	973.25	973.73
2	AC	804.59	805.36
	BD	631.19	631.97



Back Surface

Mirror	Diagonal	Ideal	CMM AutoCAD
3	AC	784.47	785.22
	BD	881.99	883.26
3C	AC	906.65	906.41
	BD	884.28	883.61
4C	AC	884.28	884.02
	BD	906.65	906.26
4	AC	881.99	882.15
	BD	784.47	785.13
5	AC	805.42	806.90
	BD	965.67	966.44
5C	AC	1001.28	1000.08
	BD	1001.28	999.70
6	AC	965.67	966.27
	BD	805.42	806.43
1	AC	636.07	637.91
	BD	810.76	812.69
2C	AC	982.29	981.32
	BD	982.29	981.07
2	AC	810.76	811.96
	BD	636.07	637.25

Spot Size Ray Diagram



Air Compressor Specs

Model: SF 11-100 AFF Multi (Includes 3 x SF4 modules)

	100 psi	Unit
Inlet conditions		
1. Barometric pressure	14.5	psi(g)
2. Ambient air temperature	68	°F
3. Relative humidity	0	%
Performance		
1. Maximum discharge pressure[1]	112	psi(g)
2. Operating pressure[1]	100	
3. Capacity delivered[1]	43	cfm
4. Shaft power input - loaded	11.1	bhp
5. Shaft power cooling fan	2.0	bhp
6. Drive Arrangement	Belt Drive	
7. Dryer - FF only	.7	bhp
8. Package power input - Loaded	12	kW
9. Sound level[2]	60	dB(A)
10. Pressure dew-point	37	°F
11. Minimum ambient temperature	32	°F
12. Maximum allowable inlet temperature	104	°F
Cooling data		
1. Cooling air flow – Unit canopy total cfm with dryer included	1363	cfm
2. Cooling air flow – Dryer only	106	cfm
3. Discharge air temperature (Ambient +)	TBD	°F
Electrical data		
1. Motor	3 x 4 / 3 x 5	kW / Hp
2. Motor type	Induction	
3. Enclosure	TEFC	
4. Service Factor	1.15	
5. Efficiency	88.5	%
6. Speed	3505	rpm
7. Insulation	F w/B rise	
8. Bearing	Antifriction	
9. Starter type	Press Switch - Stop/Start	
Physical data		
1. Dimensions L x W x H		
- Floor Mount	66 x 30 x 48	inches
2. Weight		
- Floor Mount	1136	lbs
3. Air discharge	1/2	inch NPT
4. Condensate drain – manual / auto	1/8 / 1/4	Ø inches NPT