Aluminum Extrusion as an Option for LCLS Undulator Vacuum Chamber

Advantages:

1. It is cheap;
2. It is simple;
3. It is doable;
4. This chamber will have minimal residual outgassing;
5. We have hands-on experience how to fabricate similar chambers.

Disadvantages:

It is challenging to achieve 100 nm (RMS) surface roughness!

What we have made

- **40 ID Vacuum Chambers for the "APS"- 32 installed (four different extrusion cross sections, seven different design types).**
- **16 ID Vacuum Chambers for the "BESSY - II" (two different extrusion cross sections, four different design types).**
- **4 ID Vacuum Chambers for the "SLS " (two different extrusion cross sections, two different design types).**
- **2 ID Vacuum Chambers for the "CLS " (two different extrusion cross sections, two different design types).**
- **13 ID Vacuum Chambers for the "TTF " (one extrusion cross sections, two different design types).**
- **1 ID Vacuum Chambers for the "ESRF "**

TOTAL 76 CHAMBERS!

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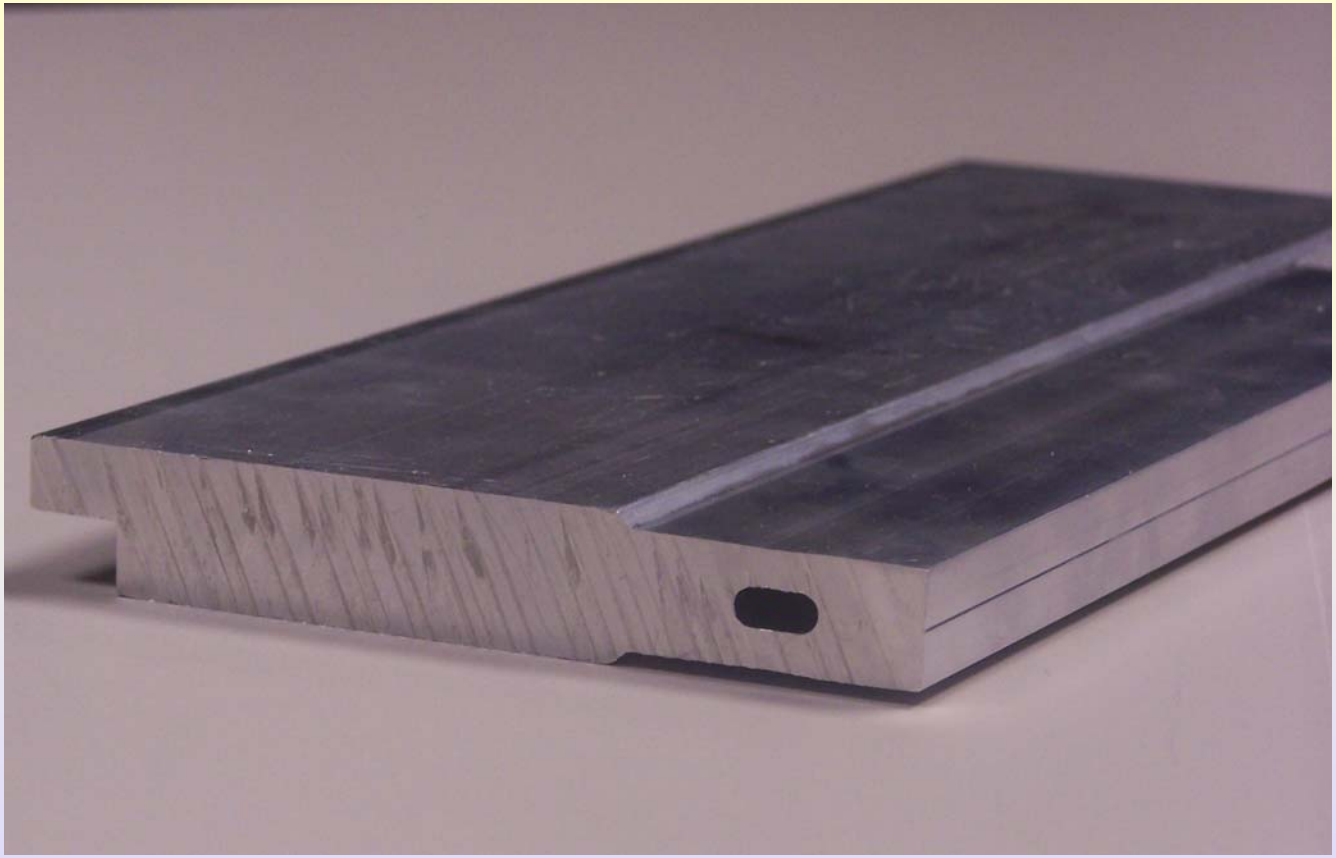
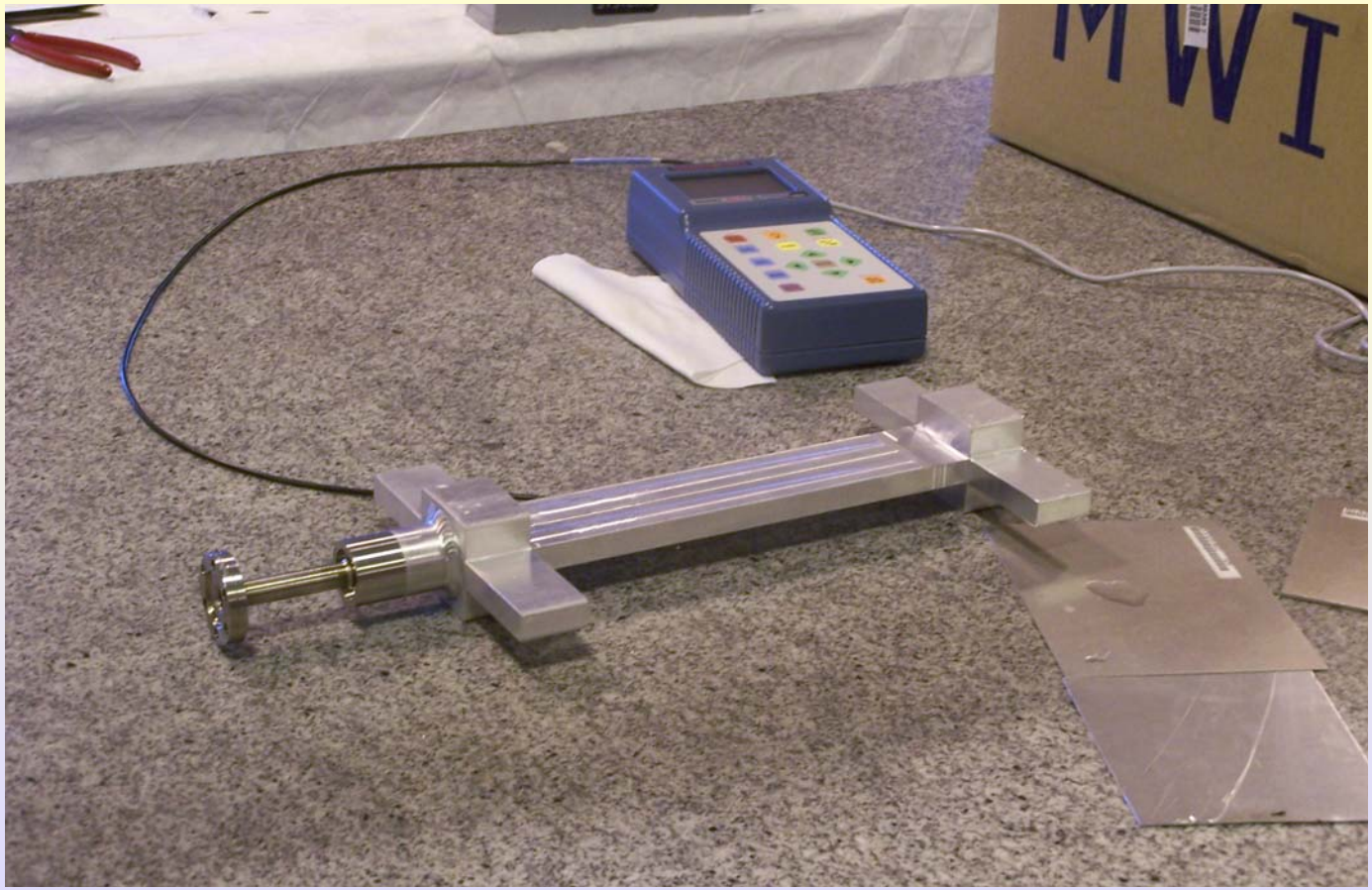


Extrusion sample (second run) produced by "Cardinal Aluminum Co" Louisville, KY

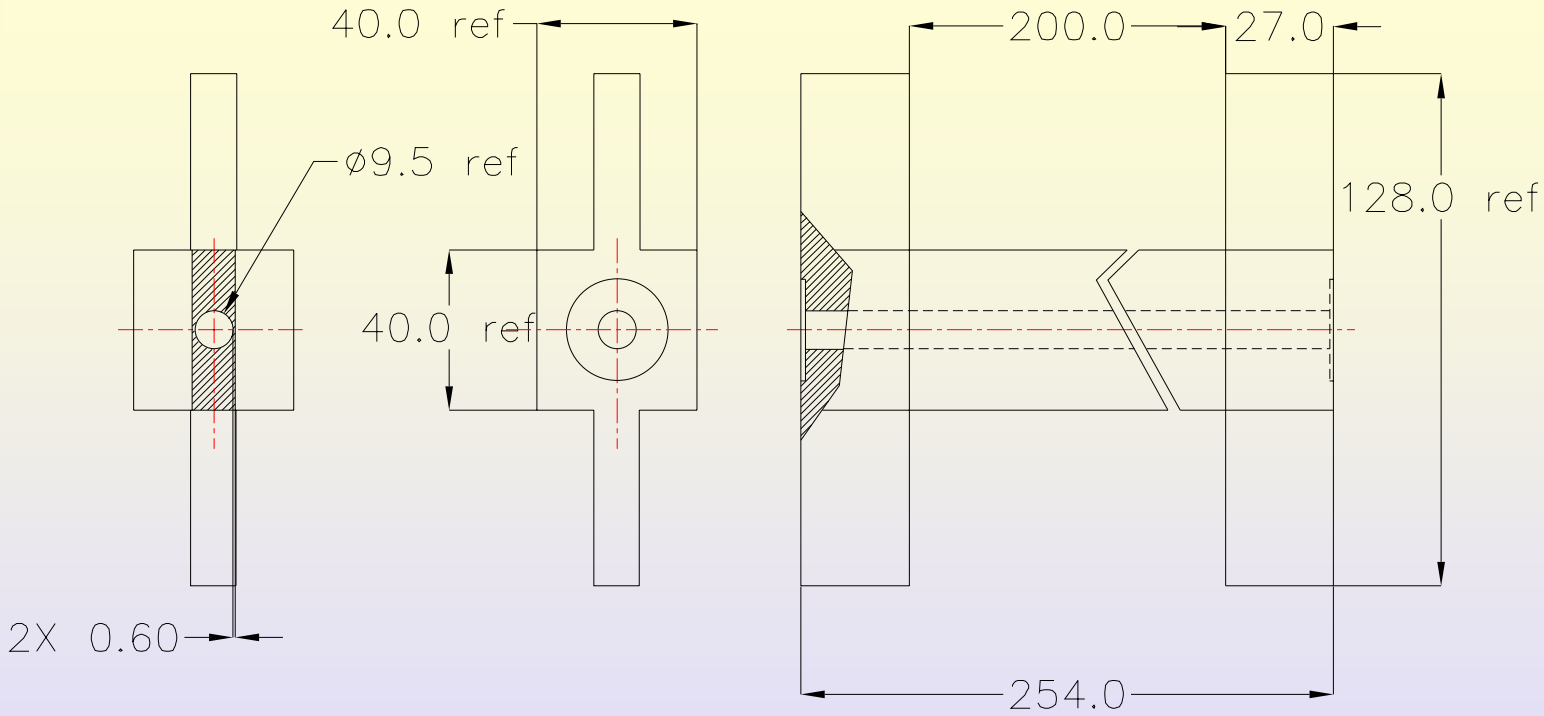
Vacuum integrity of the thin wall

- It was one of the first questions which should be answered;
- DESY extrusion was used for the tests;
- LCLS extrusion is being prepared for tests.

Test set up for the thin-wall measurements



DESY VC extrusion for the thin wall test



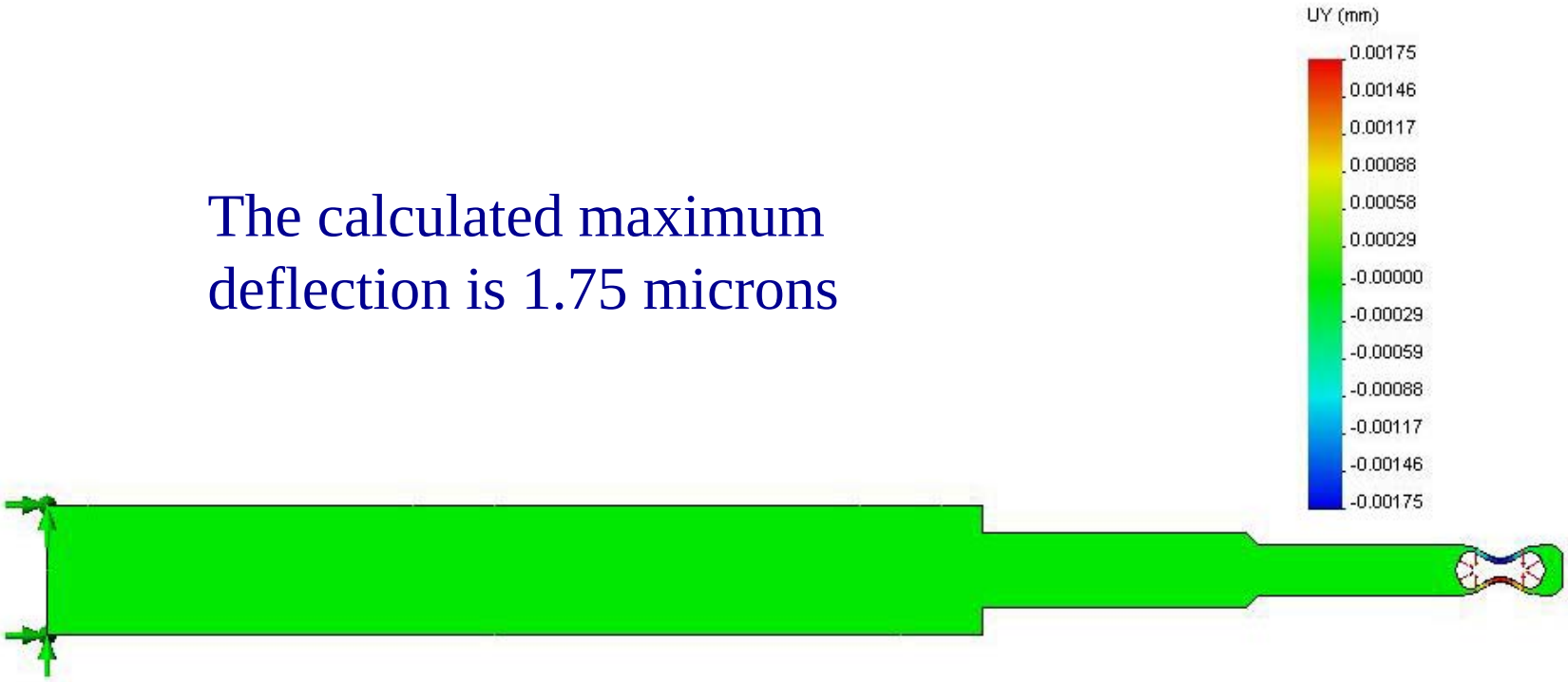
The wall thickness was successfully decreased to 0.5 and 0.4 mm

Final leak test results

Wall thickness	0.45mm – 0.38mm;
Deflection	none detected;
Vacuum inside the sample:	a/ 5.6•10-5 Torr;
	b/ 2.7•10-5 Torr;
Leak checker type	Alcatel-ASM 180.

Deflection of the 0.5-mm-thick wall

The calculated maximum deflection is 1.75 microns

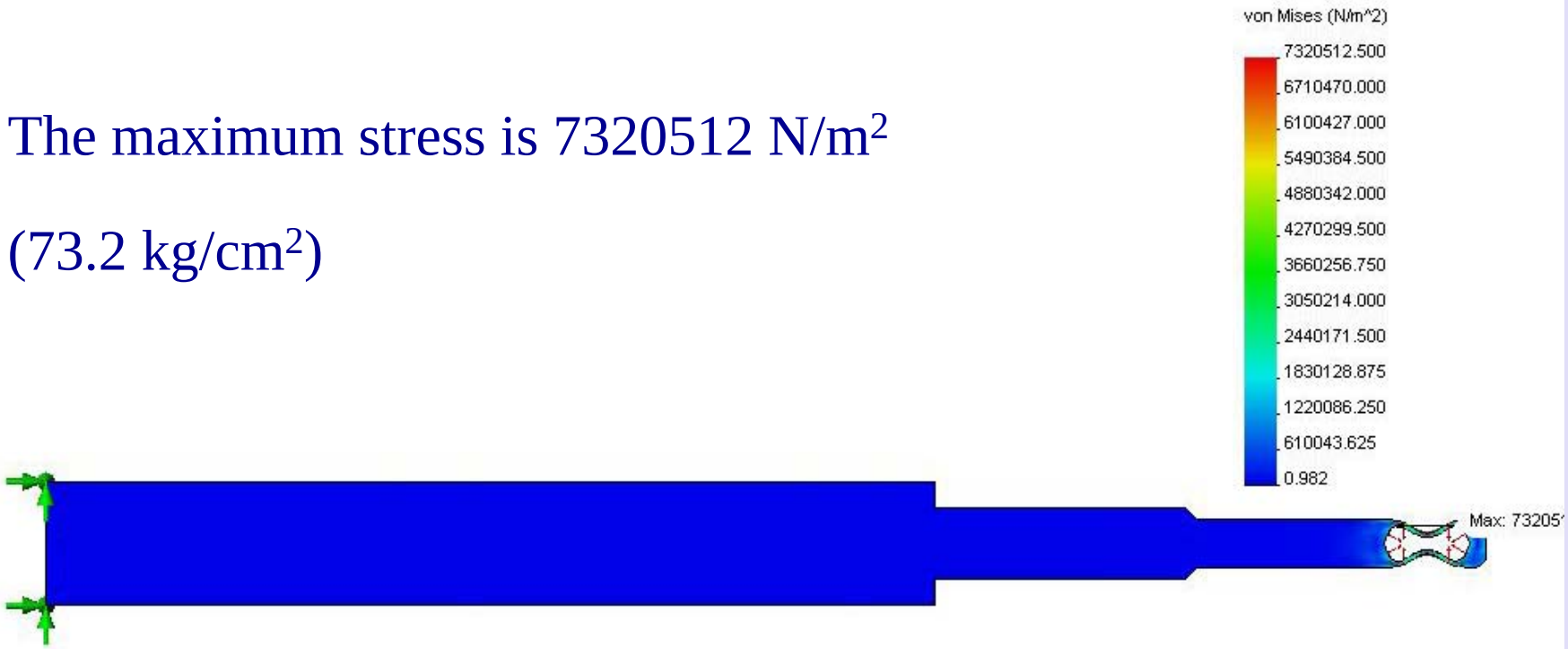


Courtesy of Bran Brajuskovic

Stresses in the 0.5-m-thick wall

The maximum stress is 7320512 N/m^2

(73.2 kg/cm^2)

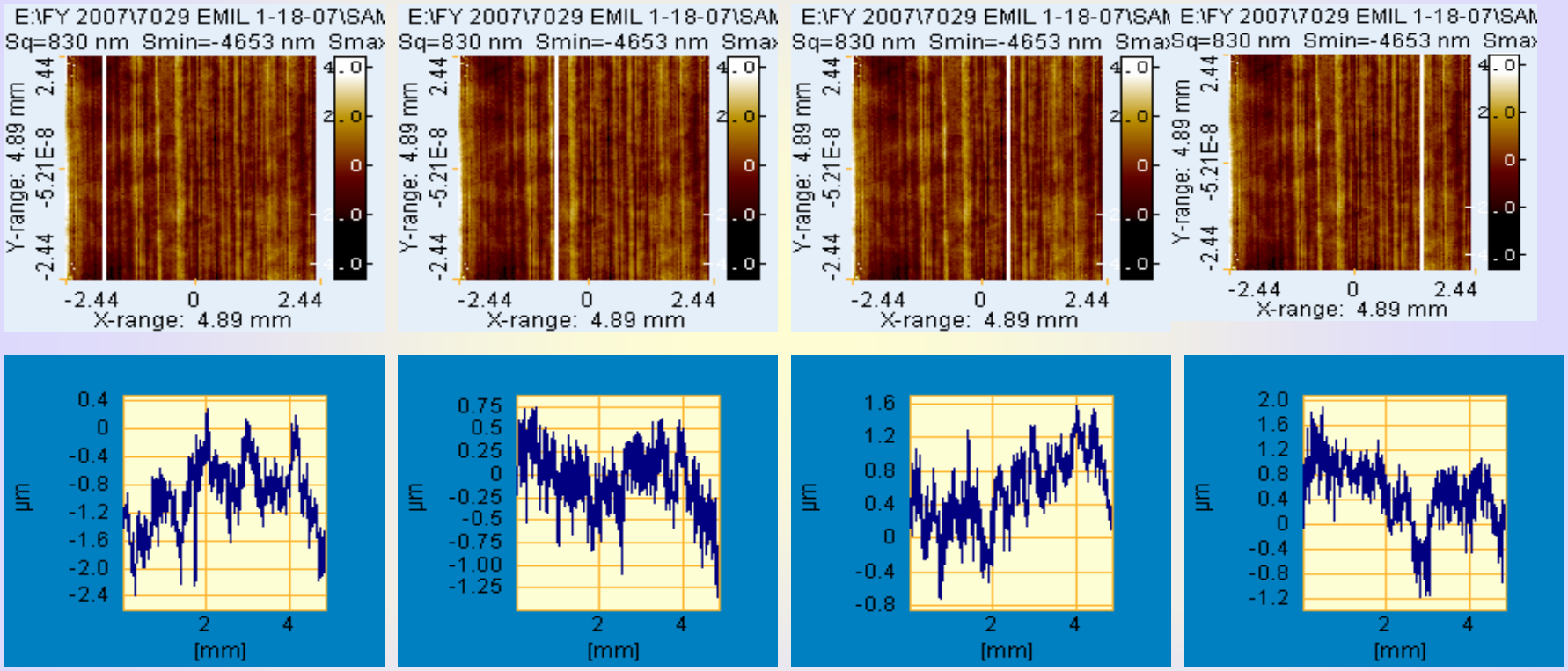


Courtesy of Bran Brajuskovic

Extrusion sample for the surface roughness measurements

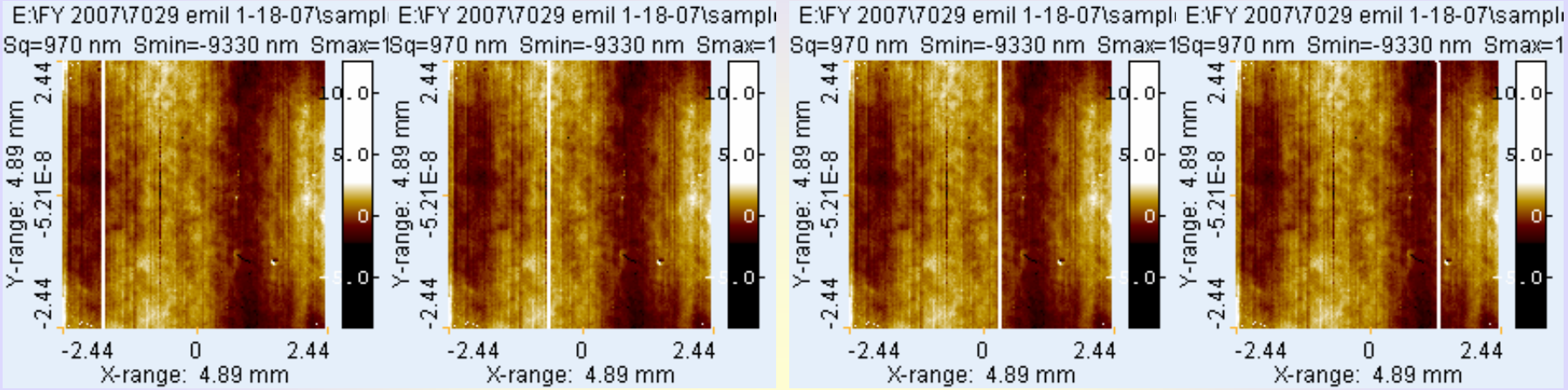
This sample was cut from first run extrusion

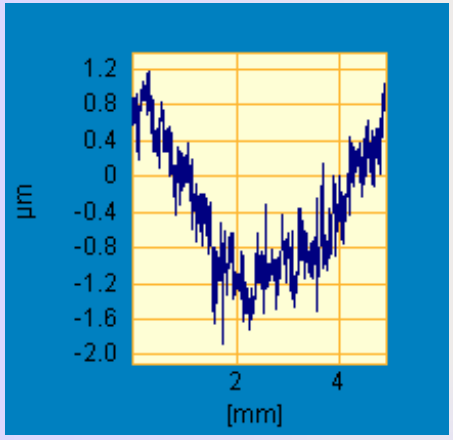
Extrusion sample 1 (first run) – surface finish as is



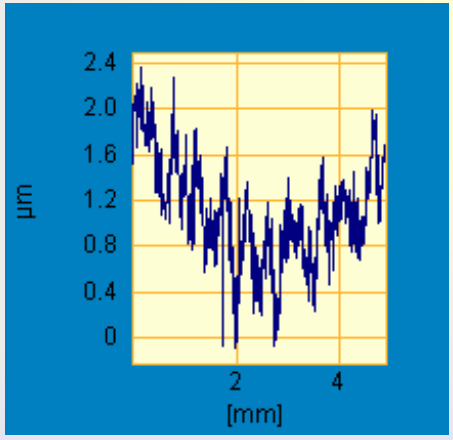
RMS 494 nm	RMS 342 nm	RMS 435 nm	RMS 507 nm
PV 2645 nm	PV 2102 nm	PV 2287 nm	PV 3052 nm

Extrusion sample 2 (first run) –surface finish as is

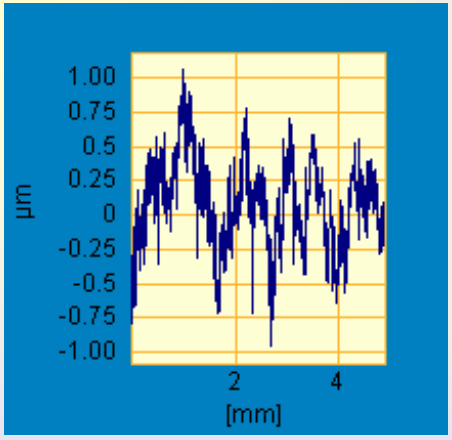




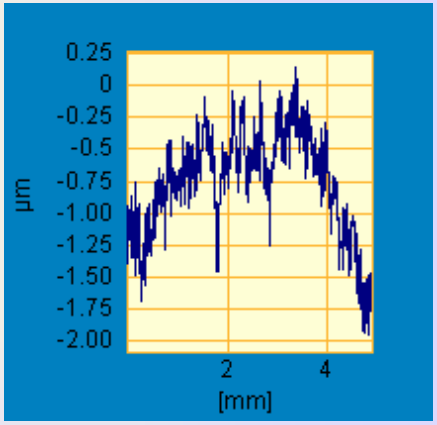
RMS 562 nm
PV 3016 nm



RMS 447 nm
PV 2455 nm

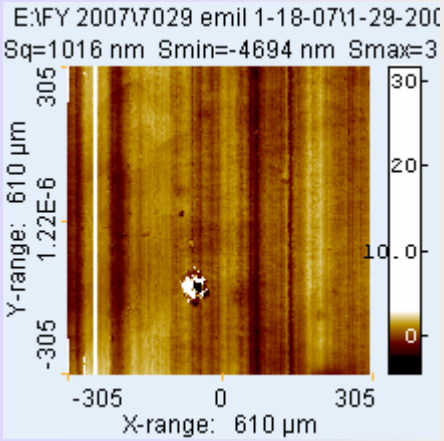


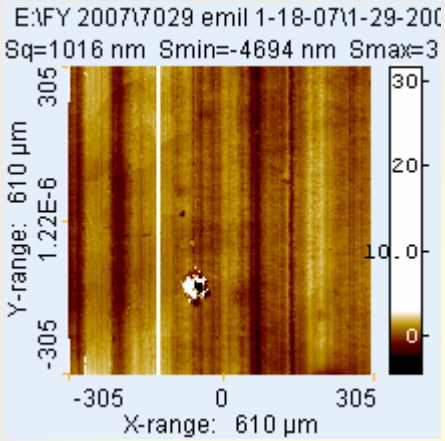
RMS 321 nm
PV 2007 nm

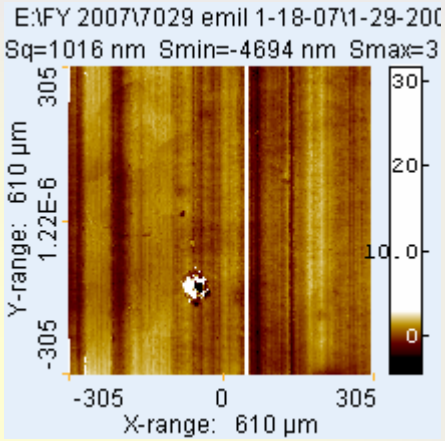


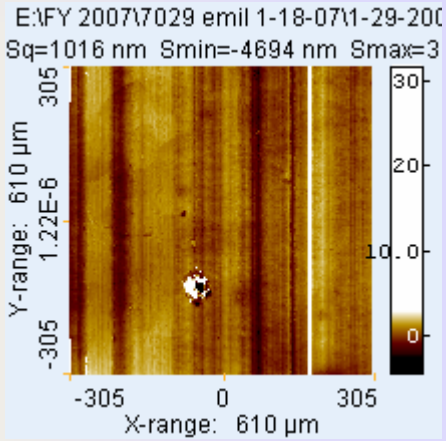
RMS 480 nm
PV 2143 nm

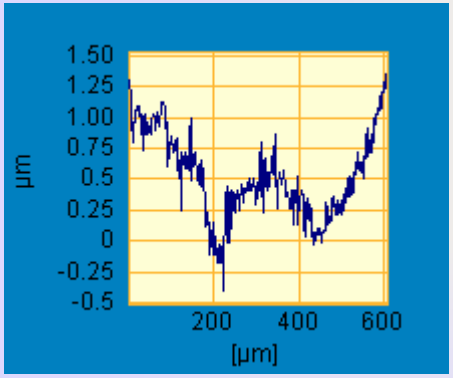
Extrusion sample (first run) - surface roughness after electrochemical polishing



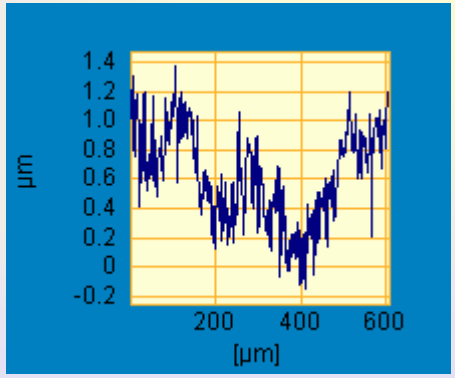




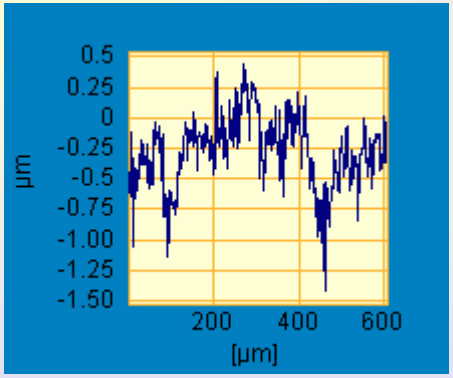




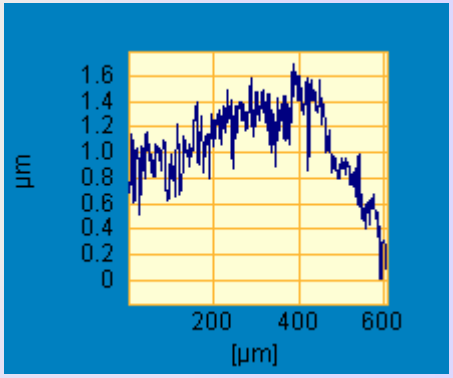
RMS 341 nm
PV 1831 nm



RMS 312 nm
PV 1516 nm

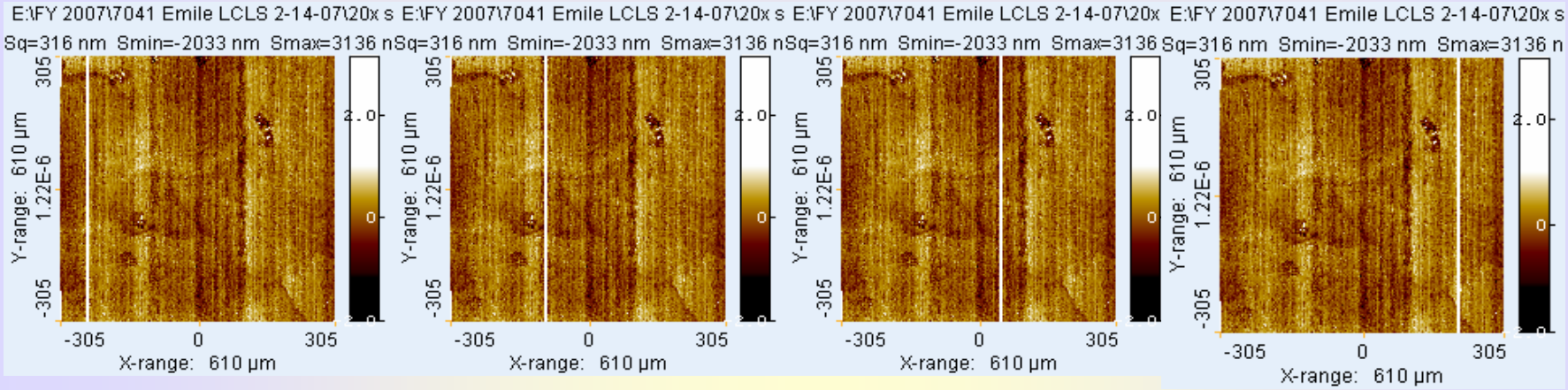


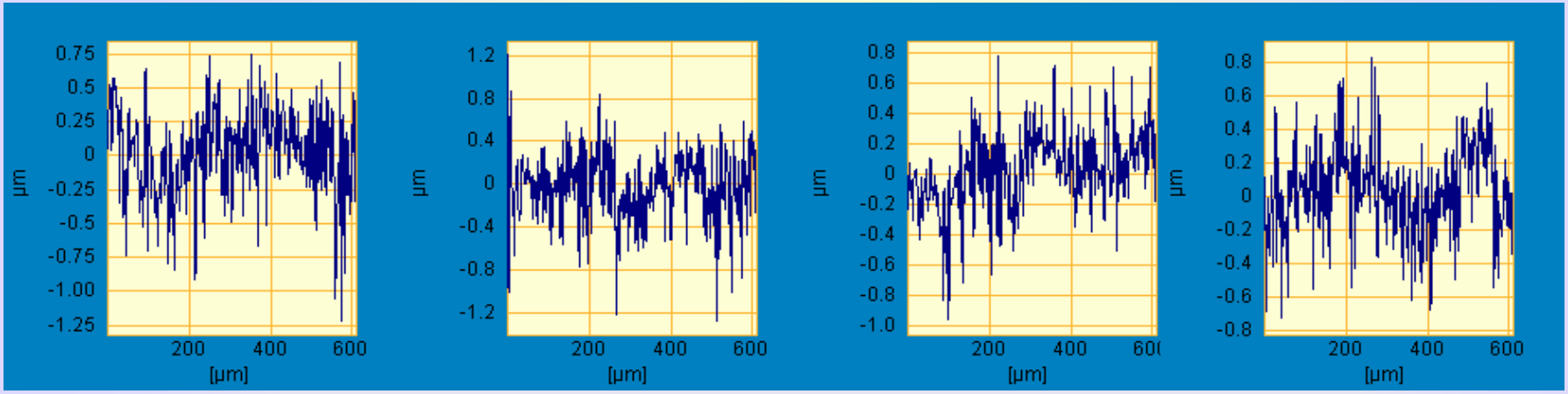
RMS 273 nm
PV 1852 nm



RMS 315 nm
PV 2767 nm

Extrusion sample (second run) - surface roughness as is after extrusion





RMS 291 nm	RMS 290 nm	RMS 230 nm	RMS 236 nm
PV 1955 nm	PV 2470 nm	PV 1731 nm	PV 1548 nm

Extrusion sample (second run) - surface roughness after electrochemical polishing (?)

Based on our previous experience we can expect surface roughness after an electrochemical polishing ~200 nm or slightly better (RMS)

Technology to achieve a better surface roughness

Extrude Hone is dedicated to innovating and providing advanced manufacturing processes to produce some of the highest quality engineered surfaces and edges on the planet. A menu of technologies and equipment for deburring, polishing, and producing controlled radii are available to our customers for improving the strength, performance, and overall reliability of the components they produce.

In a matter of minutes, the Orbital AFM process produces a surface finish that is twenty to thirty times better than the original. Average surface roughness can be reduced to 0.01 micron (0.4 micro inch) Ra or better. Not only does this process produce surface finishes previously unattainable by conventional polishing methods—including hand polishing—but, it does it in one-quarter of the time and cost.

Approximate cost (per chamber)

Extrusion	$500.00
Straightening before machining	$500.00
Machining of the chamber	$4,000.00
Bi-metallic flanges	$1,000.00
Weldment	$1,000.00
Inside surface polishing	$1,000.00 $2,000.00
Supporting parts	
Chamber assembly	$500.00
Subtotal per Chamber	$10,500.00

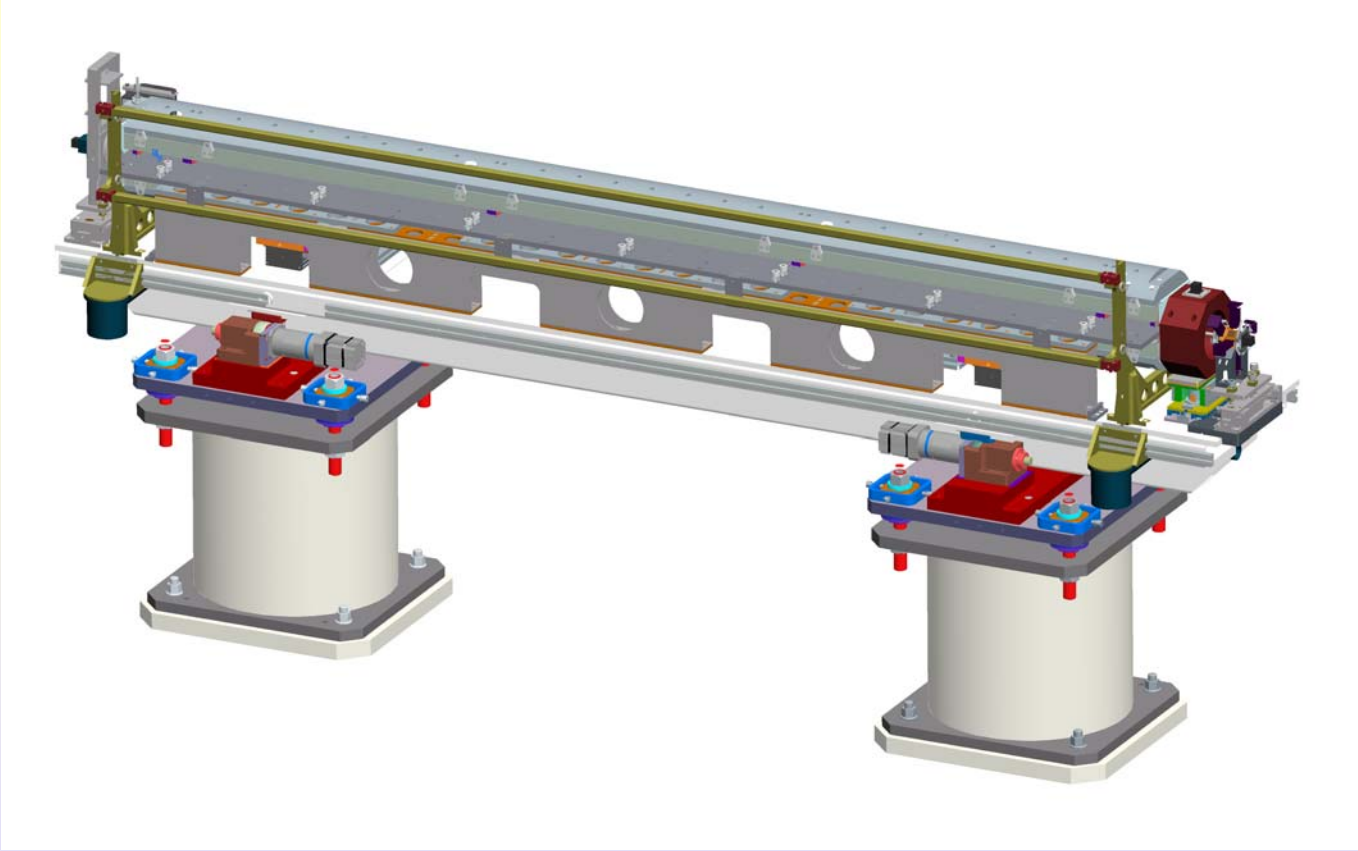
- Additional expenses for cleaning, baking and certification are the same amount as for any other type of chamber.

Probable Timescale – About One Year

• Extrusion	4 weeks
• Straightening before machining	4 weeks
• Machining of the chambers	30-40 weeks
• Bi-metallic flanges	12 weeks
• Weldment	4 weeks
• Surface finish enhancing	6 week
• Supporting parts	10 weeks
• Chamber assembly	2 weeks
• VC baking and certification	1 week per chamber

Note: Procurement of bi-metallic flanges and manufacturing of the supporting parts should be done in parallel.

CONCLUSION



The extruded vacuum chamber option appears to be viable for LCLS startup and commissioning, and could easily be pursued in parallel with small cost impact.

ACKNOWLEDGMENTS

A special “thank you” to:

Greg Wiemerslage, Tom Powers,

Kevin Knoerzer, Russel Otto,

Lassen Assoufid, Jun Qian,

Branislav Brajuskovic, Ruben Khatachuryan,

Frank Bock (“Cardinal aluminum.”),

Simon Sorsher (“Hi-Tech Mfg.”)