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Radius-Matched, Lightweight Spherical Mirrors for the AFRL Test Bed

Design and Fabrication Overview

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AFRL Mirror Program Overview

- Eastman Kodak fabricated and mounted three radius-matched lightweight ULE[®] mirrors for an Air Force Research Laboratory deployment test-bed



Key Requirements

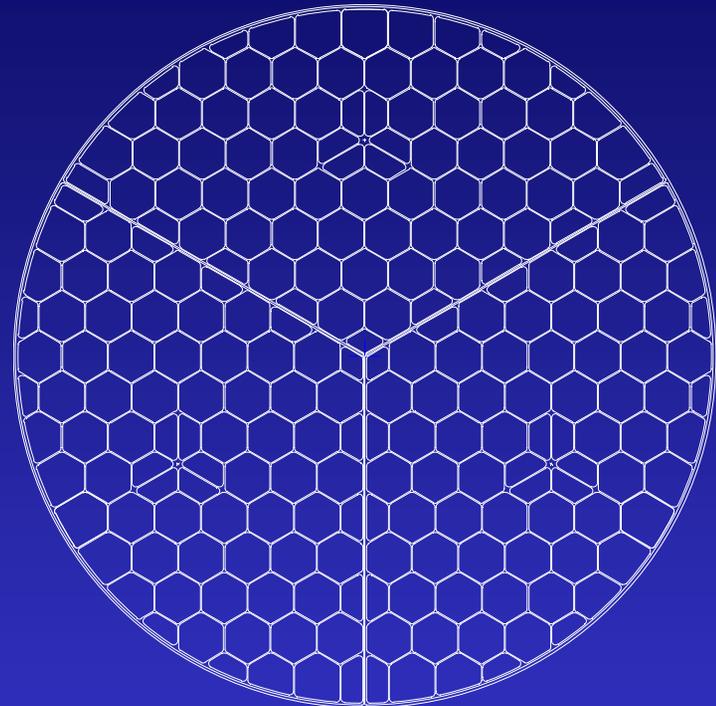
Description	Units	Specification
Diameter	mm	600
Surface Figure	nm rms	≤ 15
Optical Prescription	-	Sphere
ROC	mm	5000 +/- 10
ROC Match (3 mirrors)	microns	≤ 40
Areal Density (mounts included)	kg/m ²	≤ 15
First Mode (mounted)	Hz	≥ 80



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Mirror Design

- **Design and fabrication based on processes developed for Kodak's AMSD mirror.**
- **All ULE[®] Glass**
- **Sandwich Construction**
 - Lightweight core sandwiched between a front & back plate
- **Abrasive Water Jet (AWJ) Cut Honeycomb Core**
 - Reinforced mount locations
 - Three core segments minimize AWJ risk
- **Low Temperature Fused (LTF)**
 - Plates & core are fused into a plano mirror blank
 - Plano parts are fast & inexpensive to fabricate
- **Low Temperature Slumped (LTS)**
 - Blank is heat formed over a mandrel (sphere or asphere)
 - LTS efficiently creates near net shape mirror blanks having uniform thickness faceplates



Parameter	Value (mm)
Diameter	600
FP Thickness	1.9
BP Thickness	1.65
Core Depth	38
Core Rib Thickness	0.76



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Process Flow

Grind and polish 1.5" thick solids for core segments

Cut out core segments w/ abrasive water jet

Prep front and back plates

Low Temperature Fusion

Shape & grind assembled blank

Low Temperature Slumping

Grind and polish front plate

Ion finish mirrors

for figure and radius matching

Coat mirrors

Final test

Mount on AFRL test bed.





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Core and Plate Prep



Waterjet core cutting



Completed cores
ready for LTF



Completed faceplate
ready for LTF



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Low Temperature Fusion



The first two core segments assembled and positioned on the bottom plate and furnace base

Third segment and top plate added





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Low Temperature Fusion



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Mirror

Moving in the
load body

The completed
stack, ready
for LTF

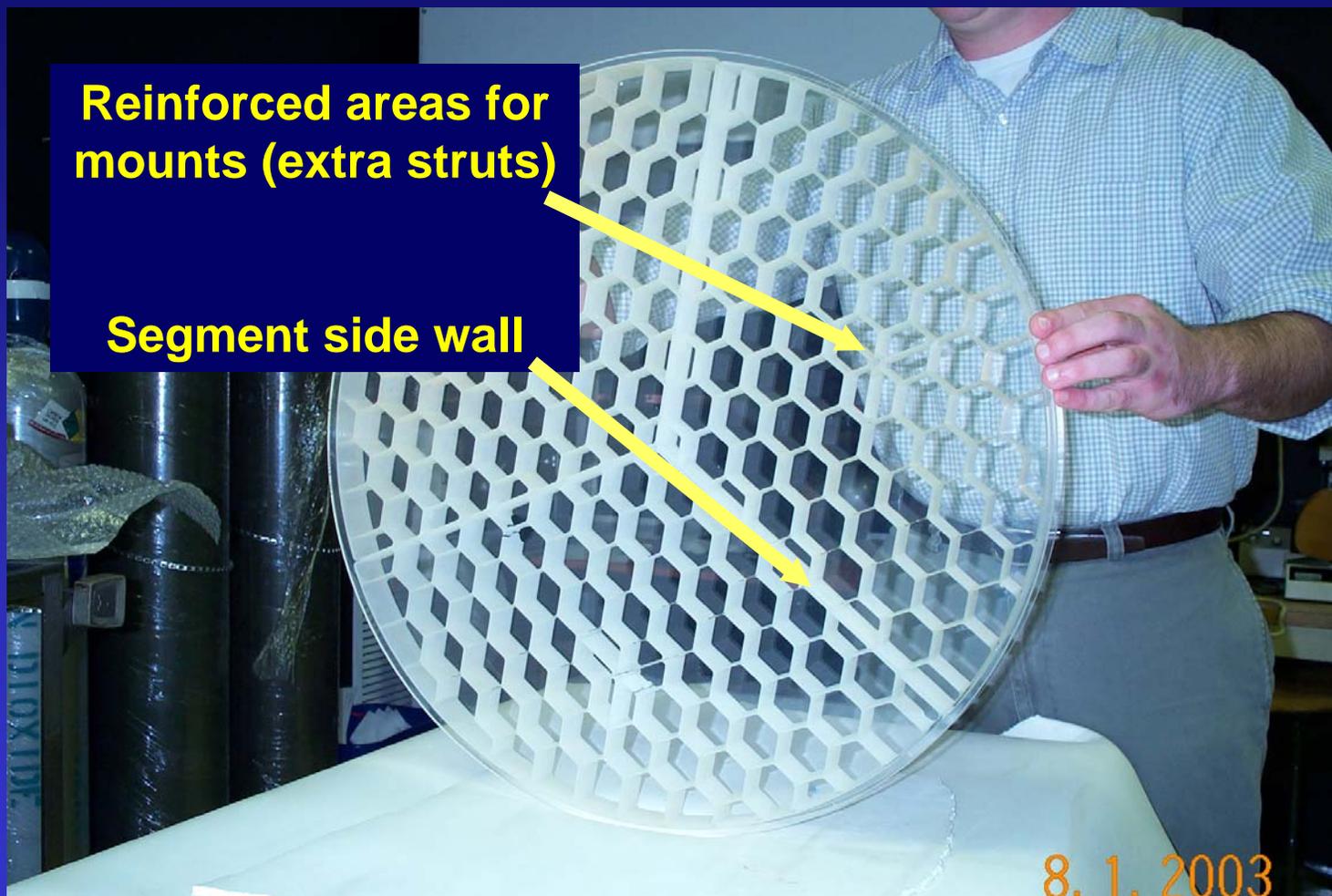


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Low Temperature Fusion



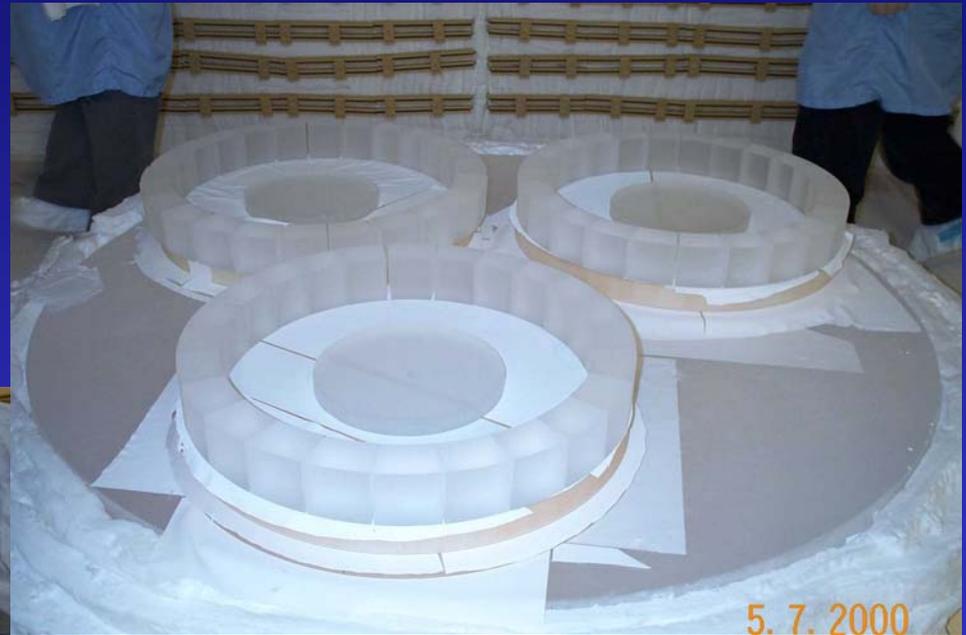
Completed mirror blank after LTF



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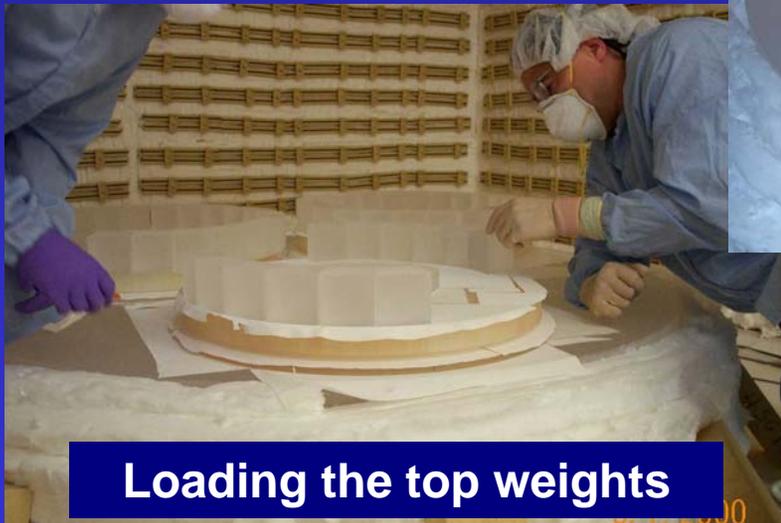
Low Temperature Slumping

3 Mandrels on large base



3 stacks, ready for slumping

Loading the top weights





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Grind and Polish



Conventional Polish

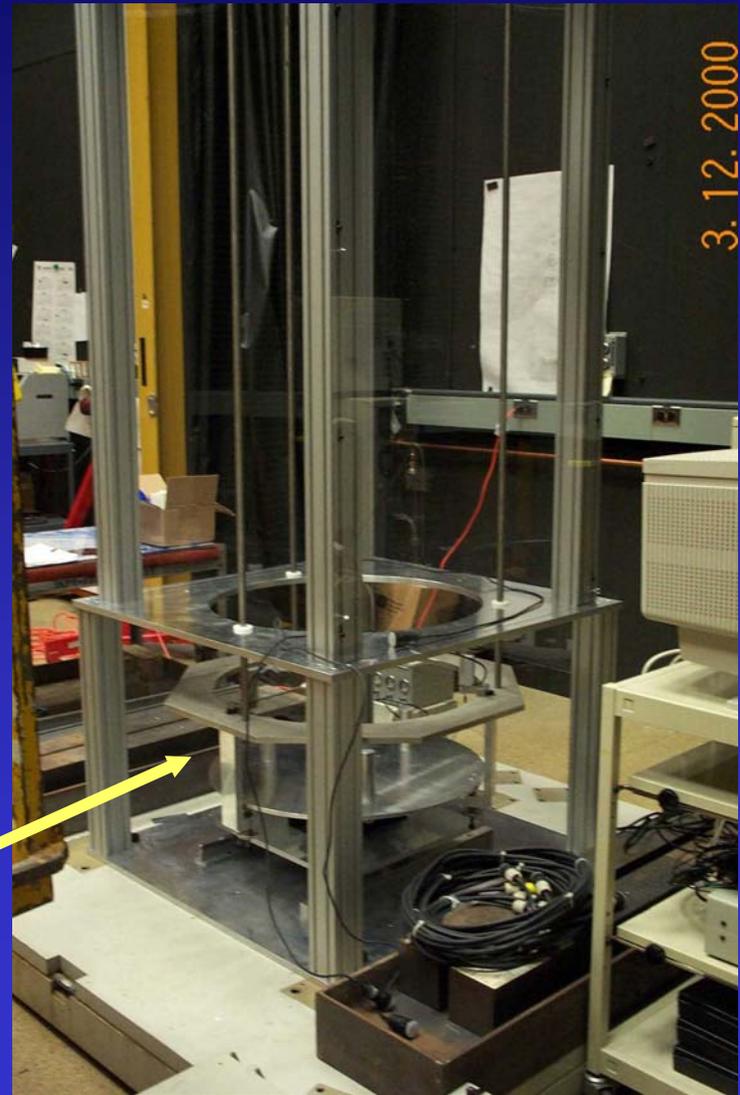


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Optical Test Set



Interferometer location



Mirror mounting area

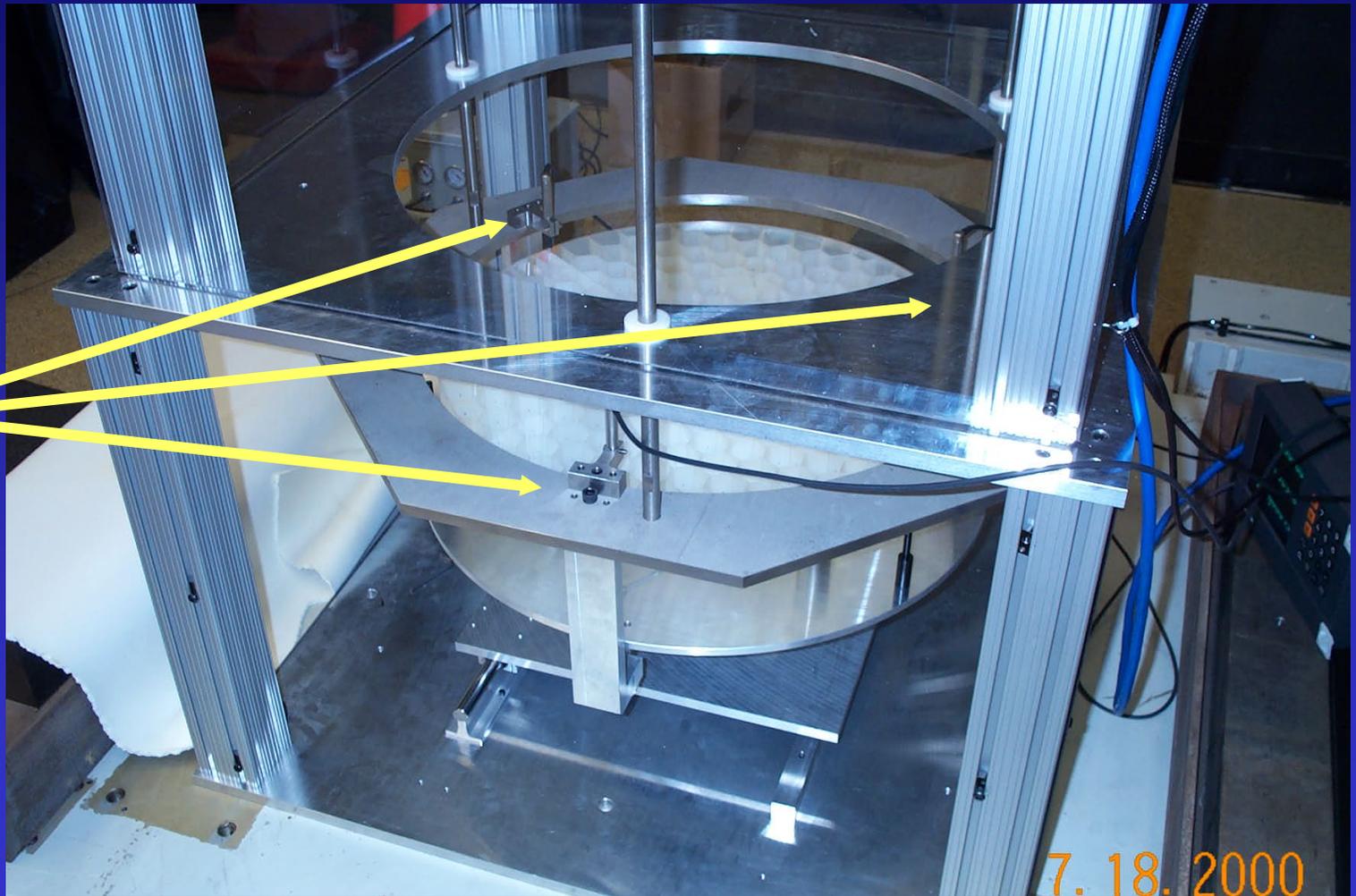
AFRL-DOT



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Optical Test Set – Radius Comparison

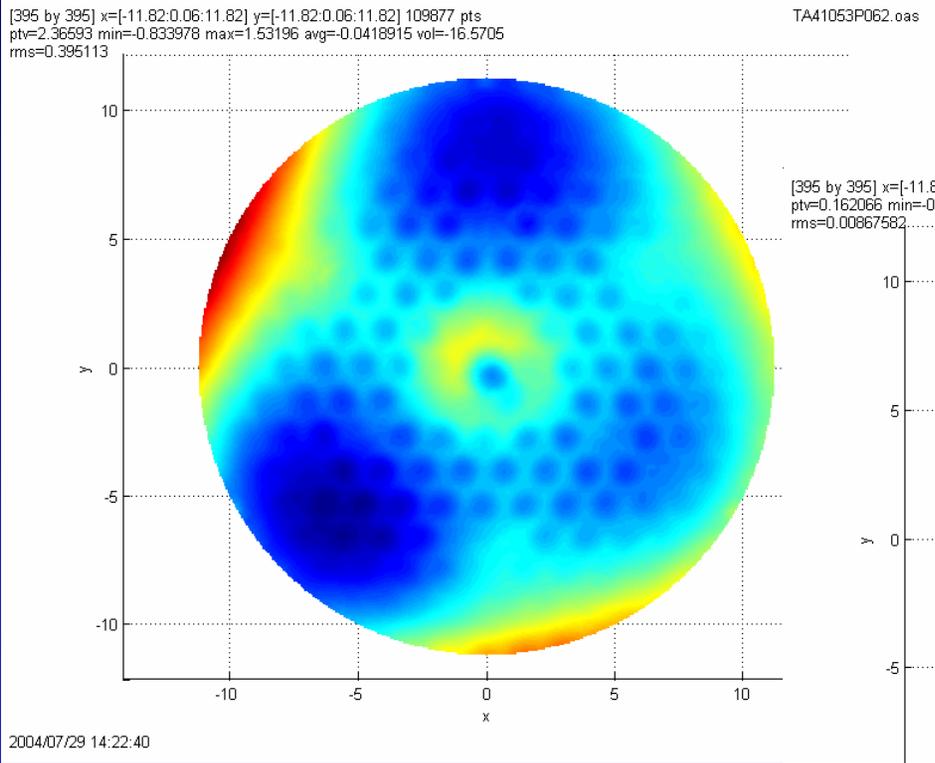
3
LVDTs



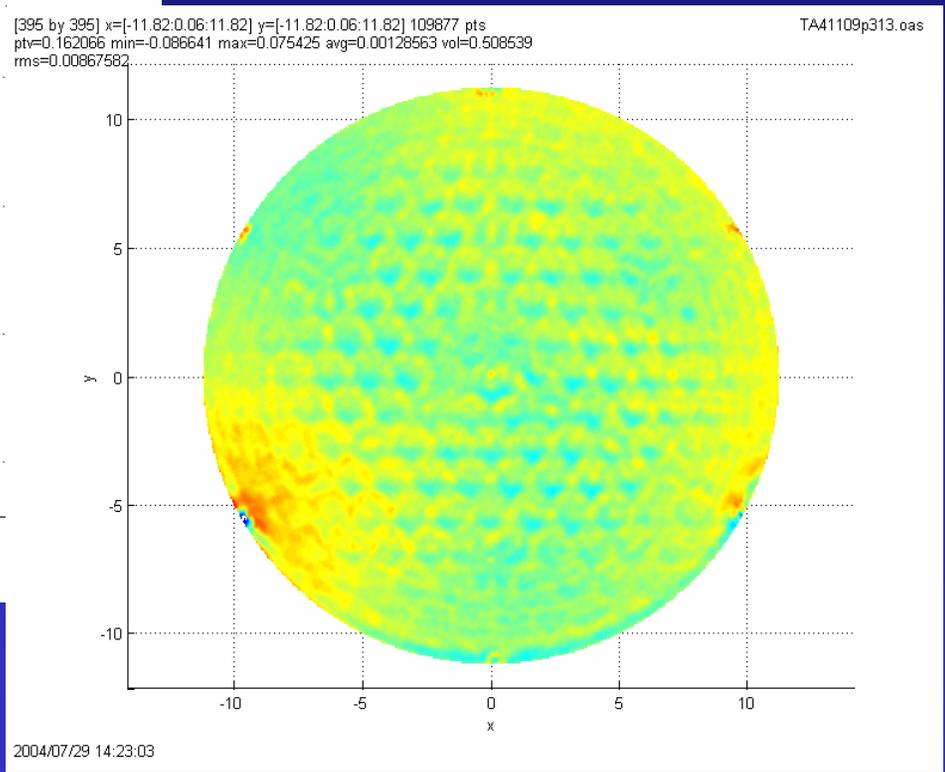


Ion Finishing

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Pre – ion finishing



Post ion, independent of scale

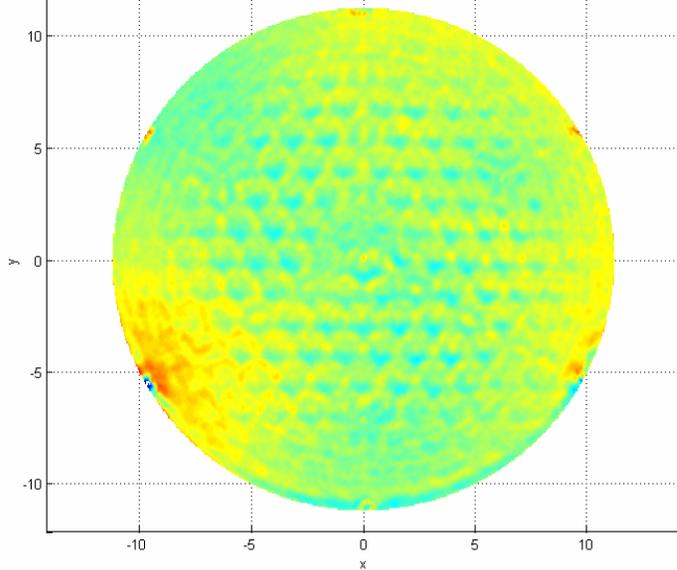


PSD

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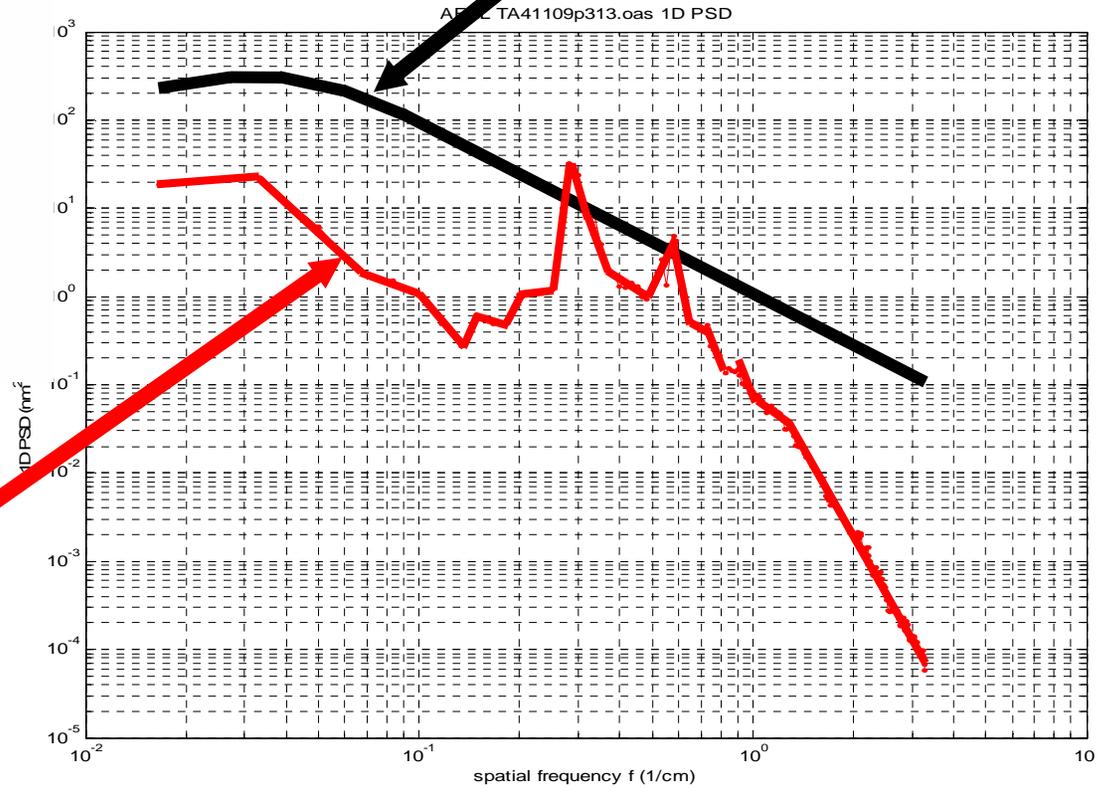
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ptv=0.162066 mm=-0.086641 max=0.075425 avg=0.00128563 vol=0.508539
rms=0.00867582

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TDM's PSD Spec



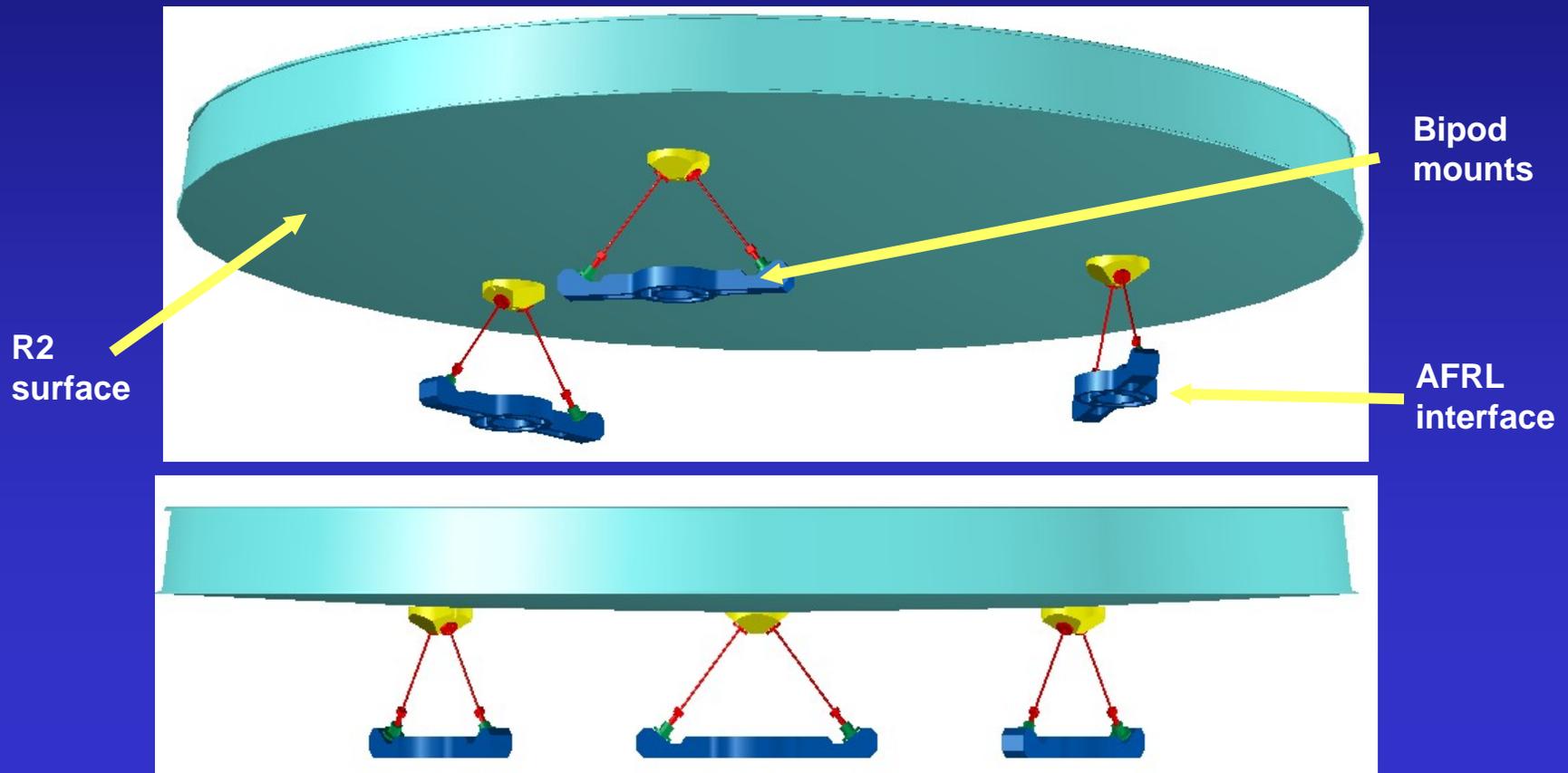
AFRL Mirror 1 actual PSD



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Mirror Mount Overview

- Each spherical mirror is supported by three bipod flexure mounts
 - Each bipod flexure mount is composed of two 0.050" diameter flexures
- Bipod mounts provide kinematic mirror interface





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Mirror Mount Overview



Bonded mounting pads
on S2 of the mirror
(shown upside down)

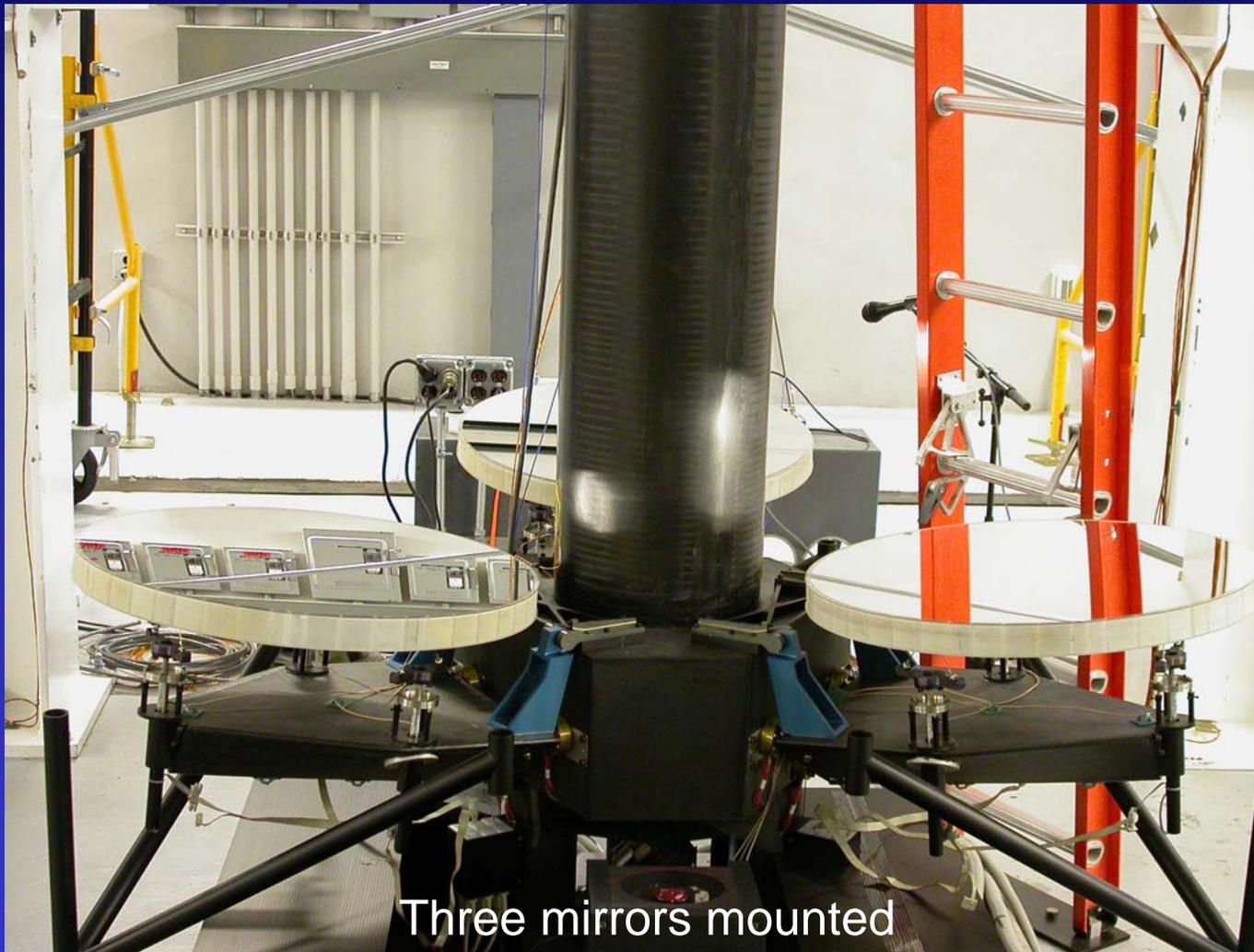


Mirror mounted in
the test set



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Installation on Test Bed

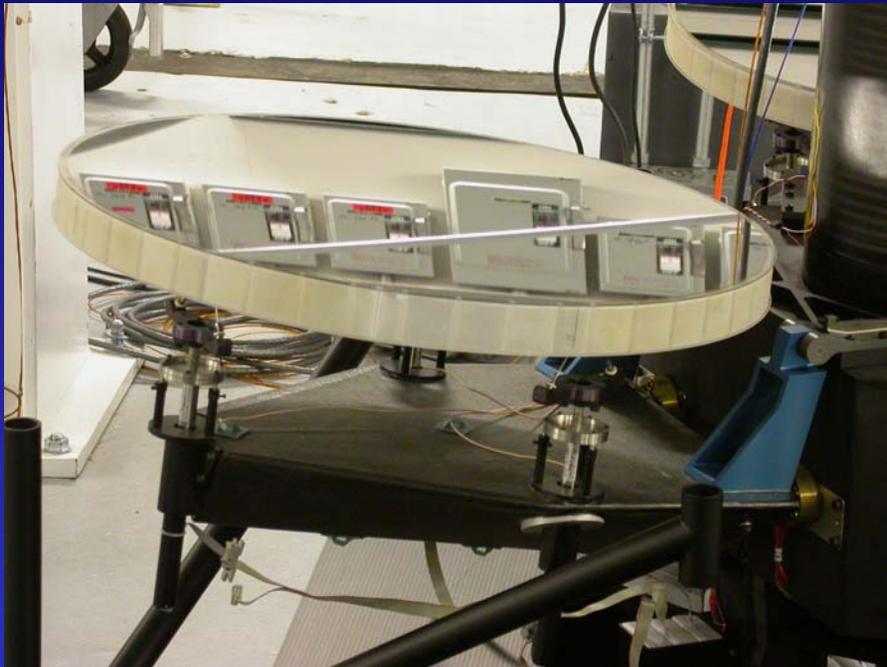


Three mirrors mounted
on the test bed



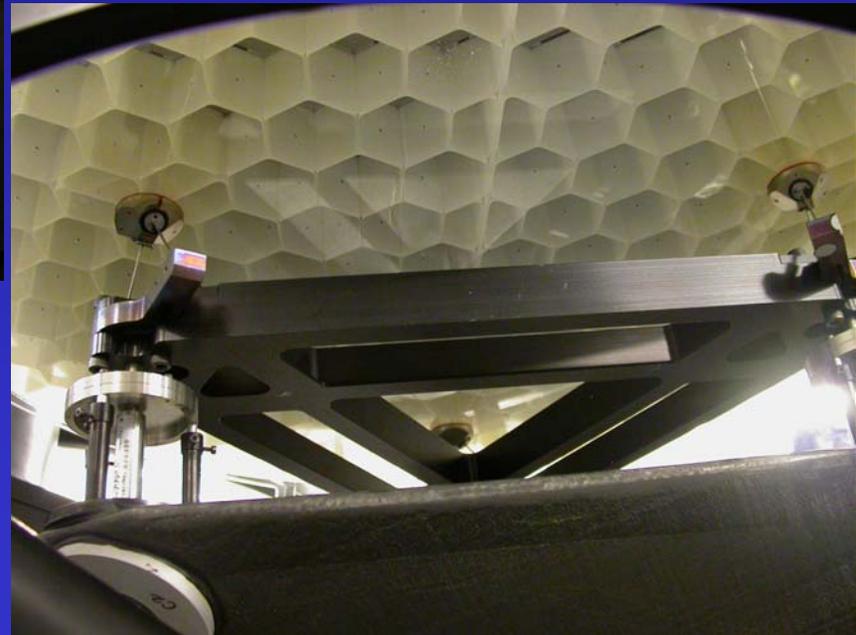
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Installation on Test Bed



Detail: One of the mirrors mounted on the test bed frame

Detail: Underside of a mirror, showing mounts





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Results and Summary

Key Performance Parameters			
Description	Units	Specification	Performance
Surface Figure	nm rms	≤ 15	Mirror 1 = 4.4 Mirror 2 = 5.0 Mirror 3 = 8.2
ROC Match (3 mirrors)	microns	≤ 40	10
Areal Density (mounts included)	kg/m ²	≤ 15	14.7
First Mode (mounted)	Hz	≥ 80	85 (530 mirror only)

■ Summary

- Eastman Kodak continues to develop and implement key technologies needed to efficiently fabricate and test high quality large aperture lightweight mirrors