

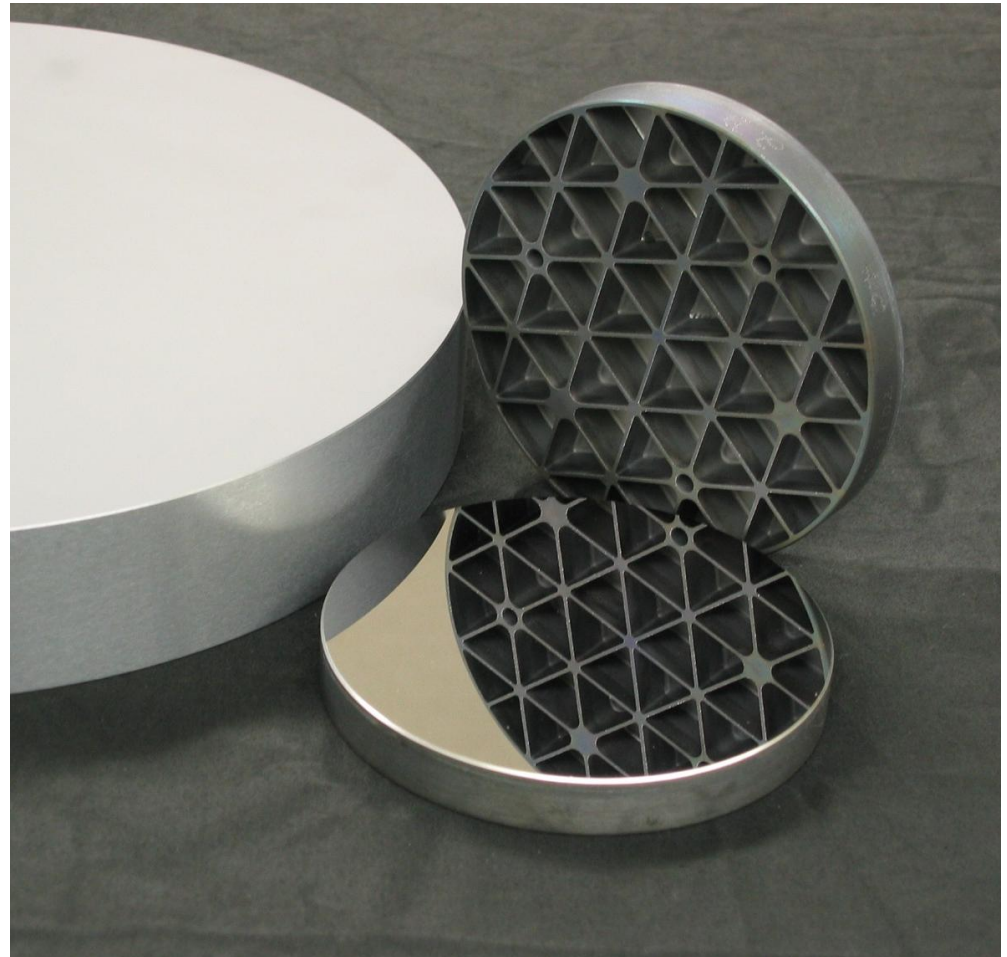
# Single Crystal Silicon Light Weight Mirrors



Vince Bly Goddard Space Flight Center NASA

## Topics:

- Brief review of current process & previously published results
- Results of cryogenic testing
- Results on 10" (25 cm) mirror
- An avenue to very light weight SCS mirrors

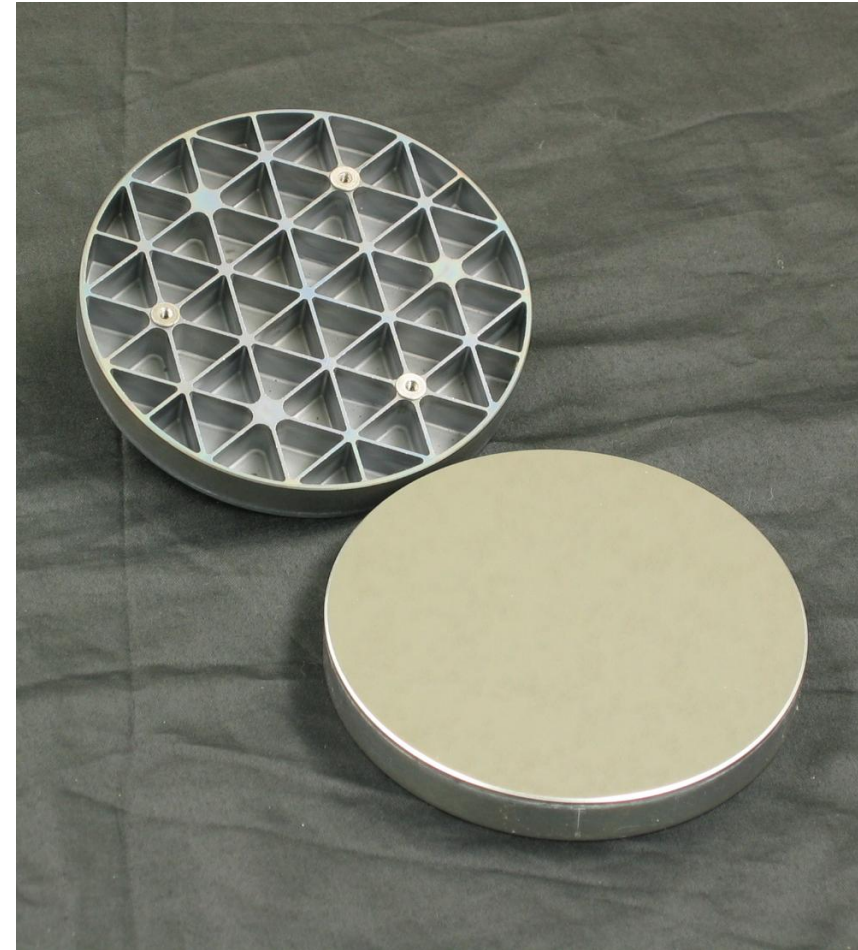




# Single Crystal Silicon Light Weight Mirrors



- Simple fabrication process
- Each mirror is a monolithic structure from a single crystal
- Excellent surface figure; typically better than  $\lambda/50$  RMS
- Excellent resistance to thermal distortion, especially at cryogenic temperatures



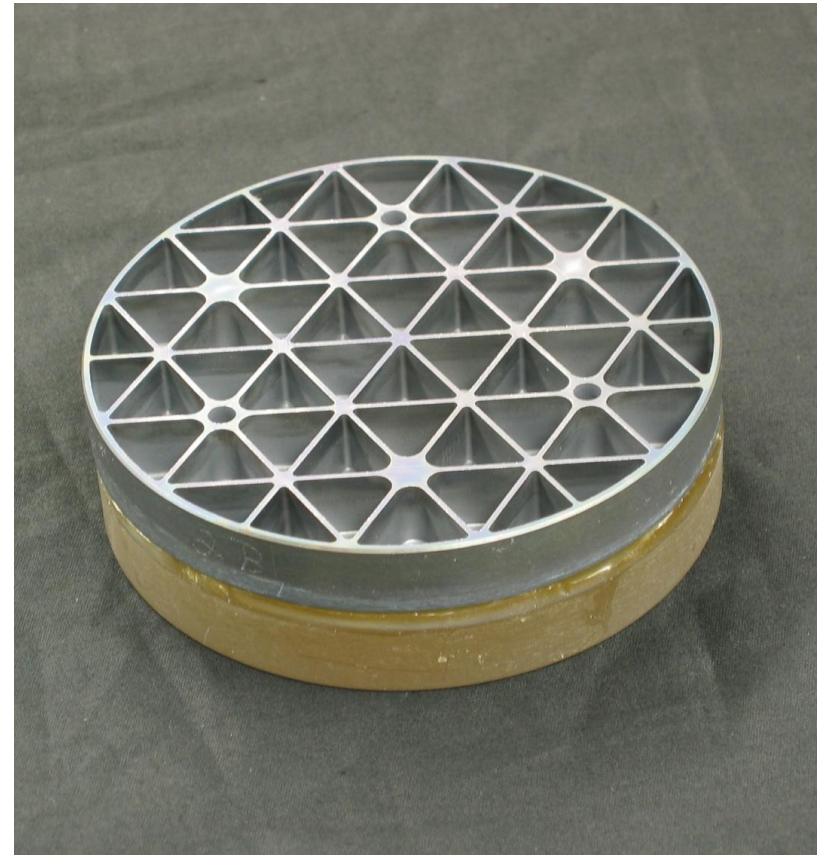


# Single Crystal Silicon Light Weight Mirrors



## **Fabrication Process:**

- Cut blank from single crystal silicon boule
- Heat treat
- Grind & polish solid blank using conventional techniques
- Attach Pyrex protector
- Lightweight using ultrasonic machining
- Remove protector & heat treat





# Single Crystal Silicon Light Weight Mirrors



## Lightweighting Process

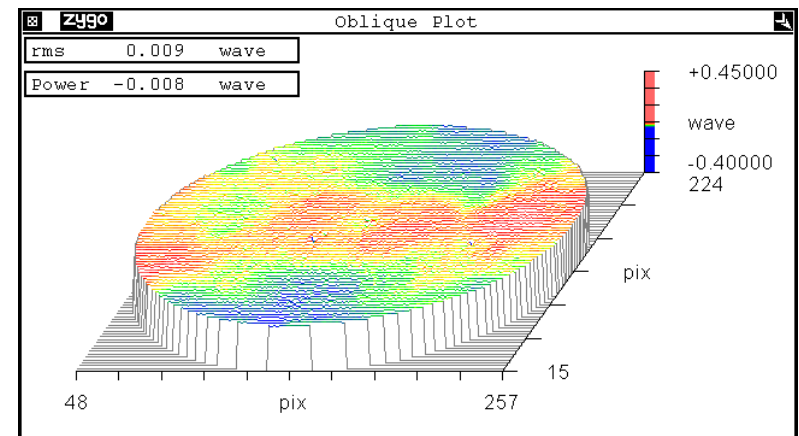
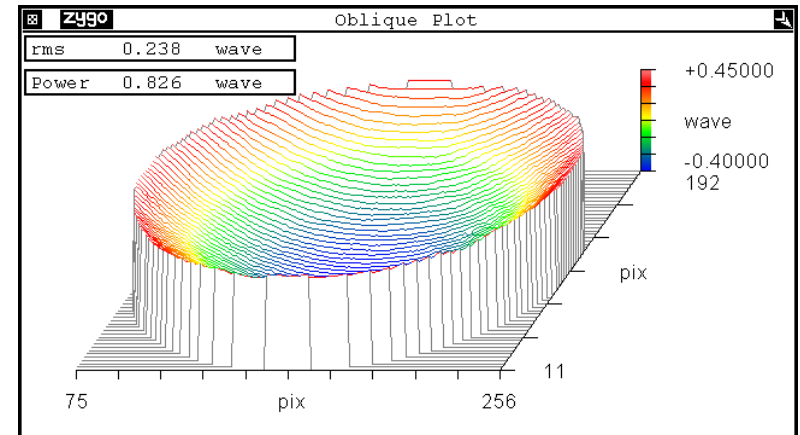
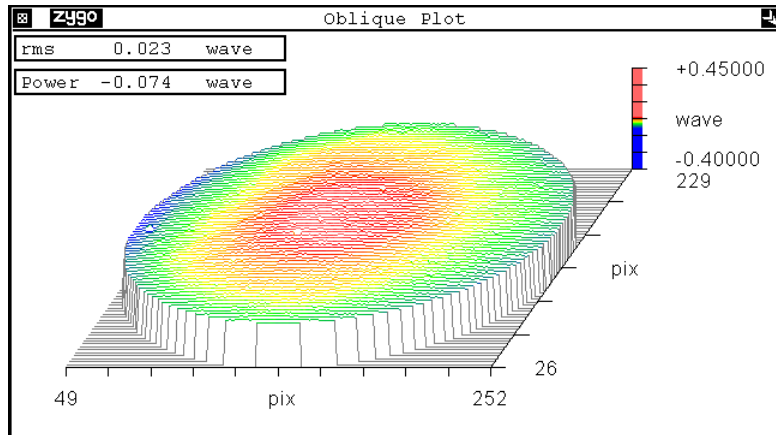


Figure before lightweighting

Figure after lightweighting,  
before heat treating

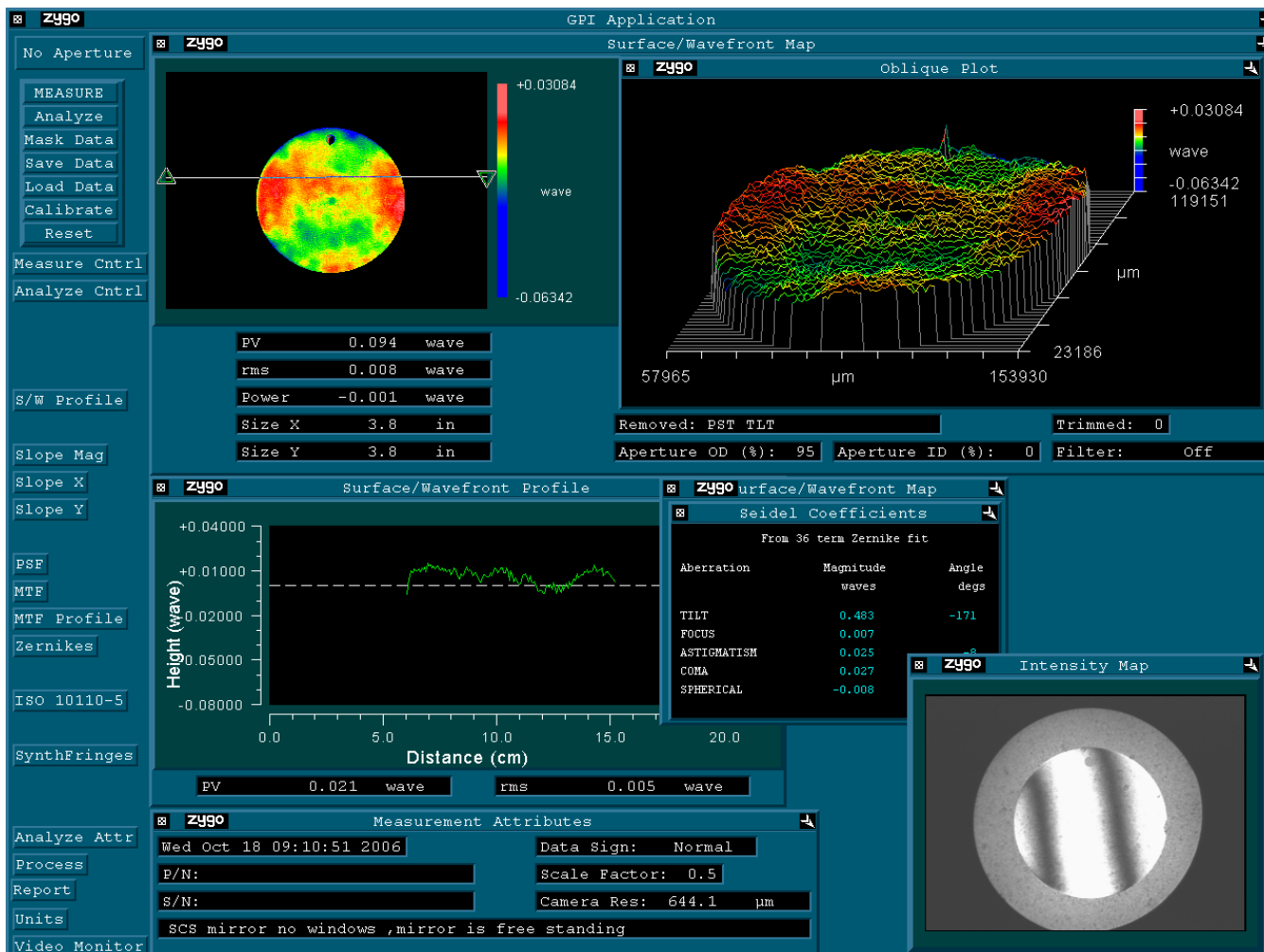
Figure after heat treating



# Single Crystal Silicon Light Weight Mirrors



## Interferogram of 10cm (4") SCS Flat #2C





# Single Crystal Silicon Light Weight Mirrors



For more detailed information, see:

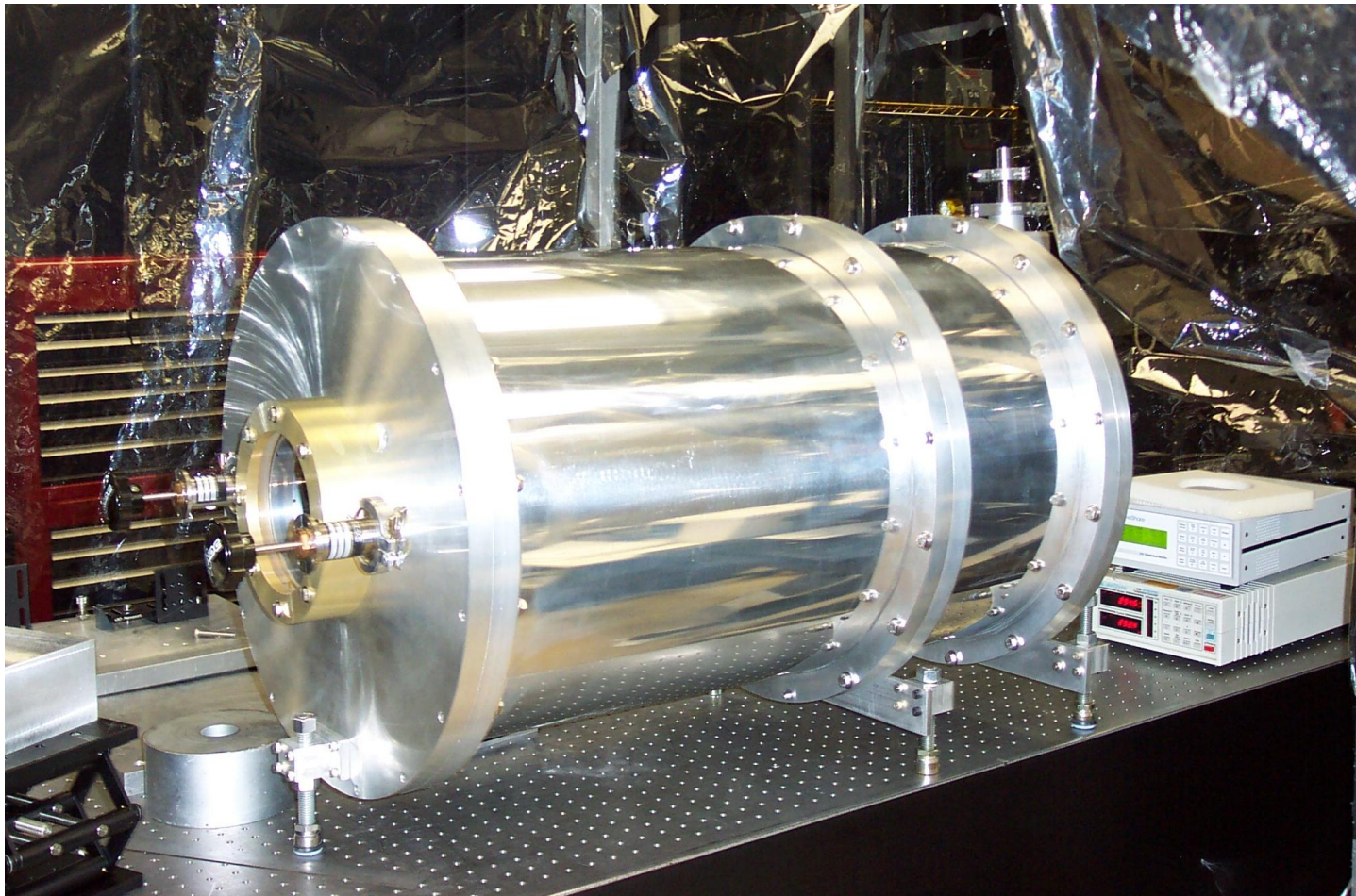
*Lightweight instrument mirrors from single crystal silicon*, V. T. Bly et al., Space Telescopes and Instrumentation I: Optical, Infrared, and Millimeter, May 2006, SPIE Vol. 6265 Part One



# Single Crystal Silicon Light Weight Mirrors



## Cryogenic Test Facility

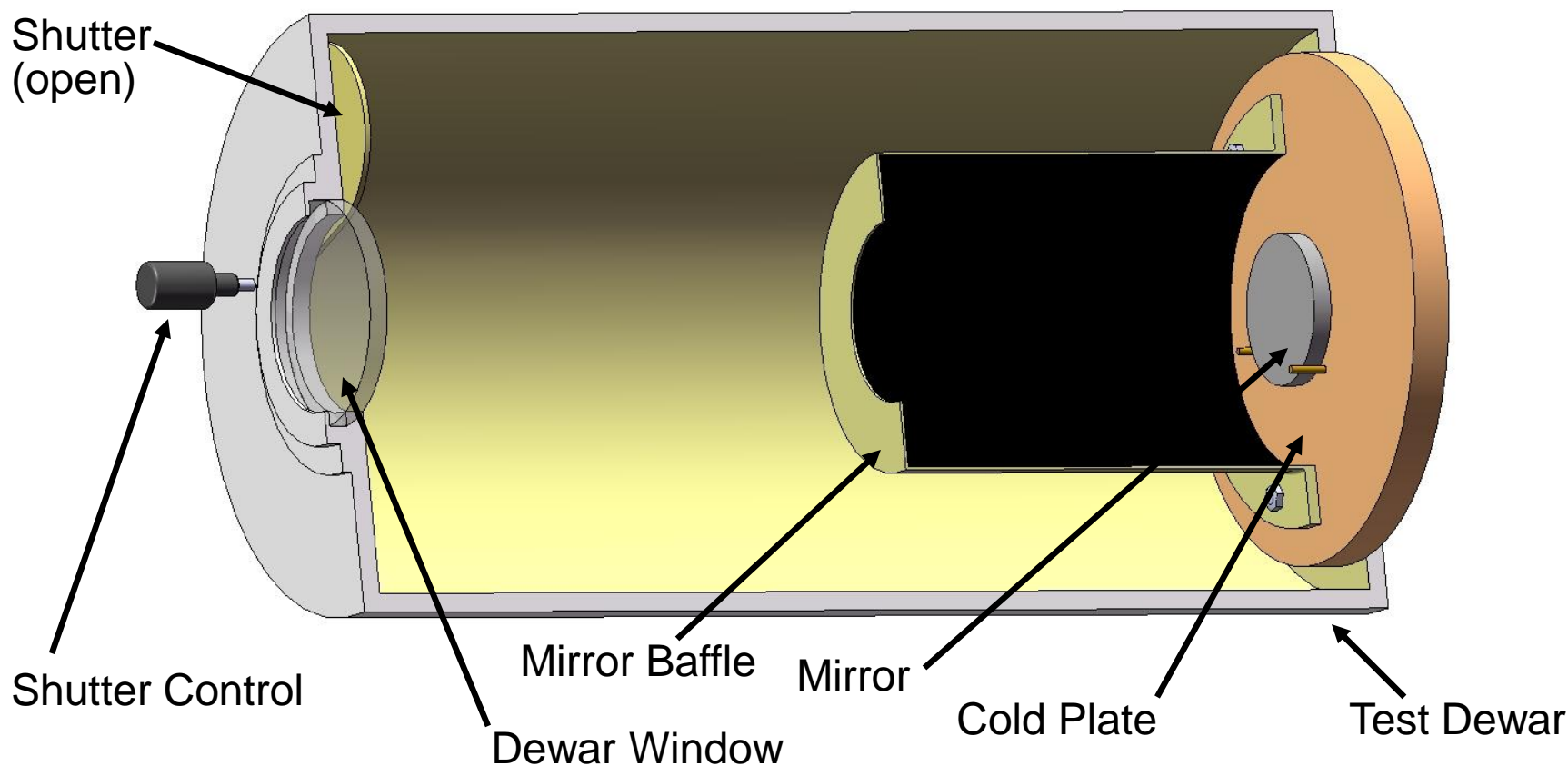




# Single Crystal Silicon Light Weight Mirrors



## Cryogenic Test Facility – Component Layout

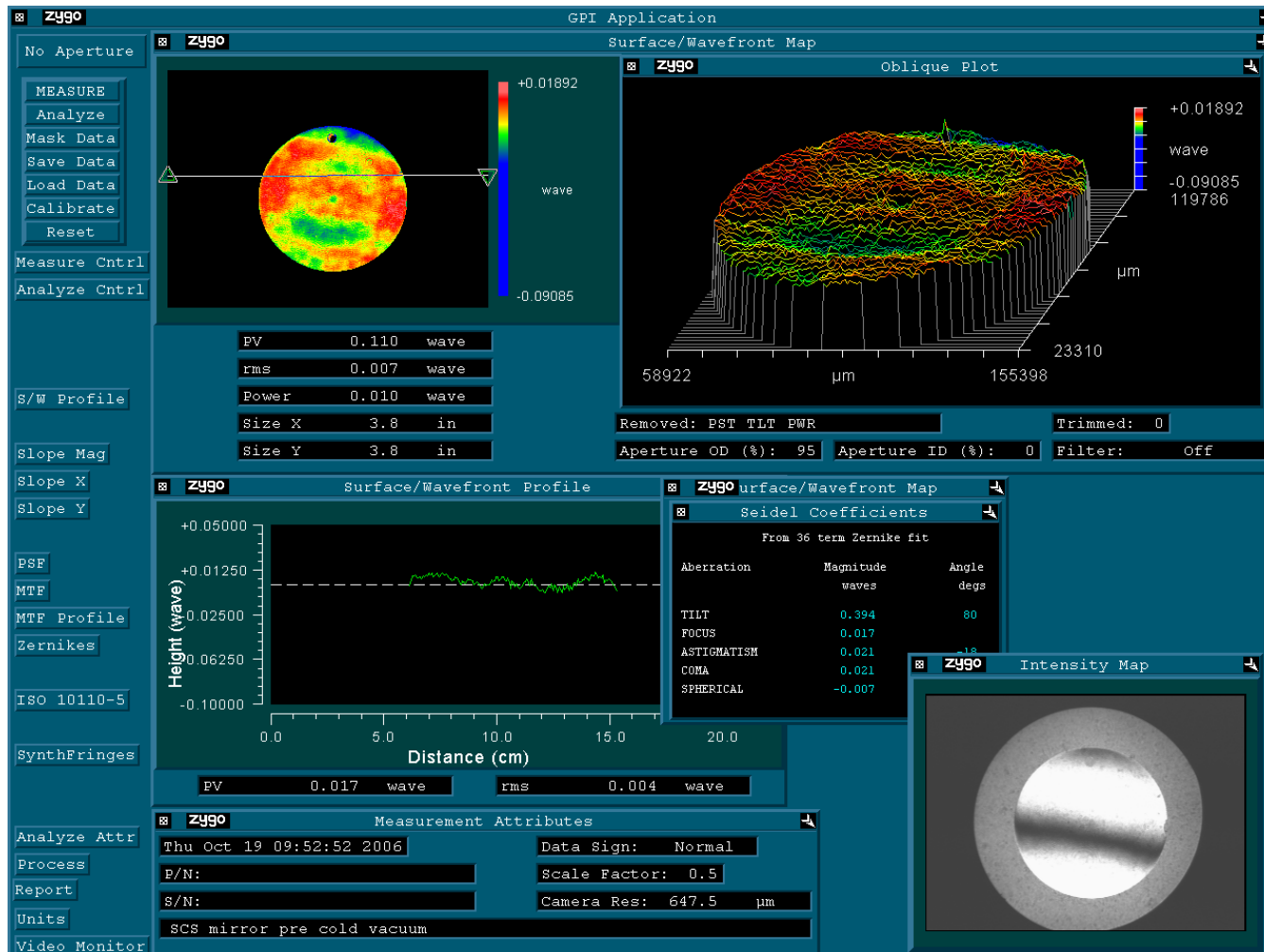




# Single Crystal Silicon Light Weight Mirrors



## SCS Mirror 2C In Dewar at Ambient Temperature

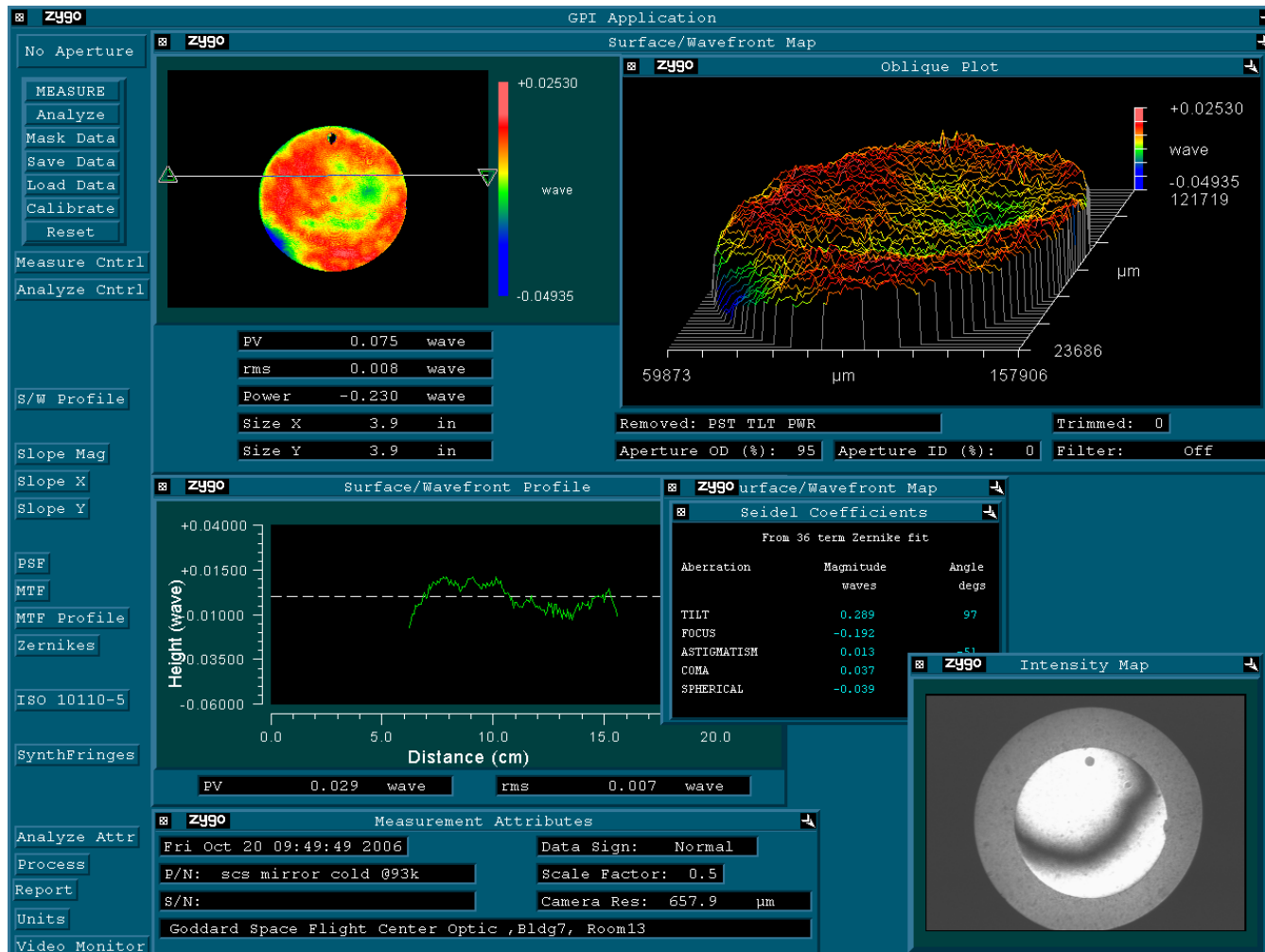




# Single Crystal Silicon Light Weight Mirrors



## SCS Mirror 2C In Dewar at 83 Kelvin



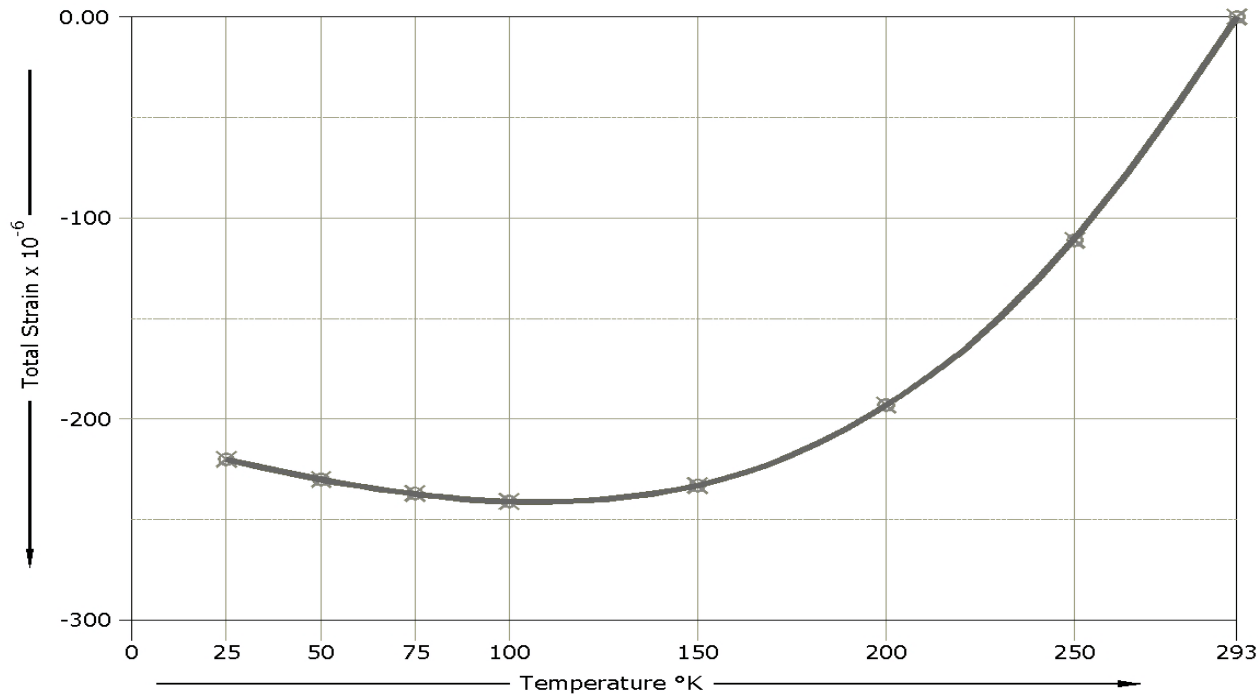


# Single Crystal Silicon Light Weight Mirrors



## SCS Mirror Cryogenic Distortion Test Summary

- Change with power removed =  $0.001 \lambda \pm 0.002 \lambda$
- Change in power corrected for dewar window =  $0.055 \lambda$

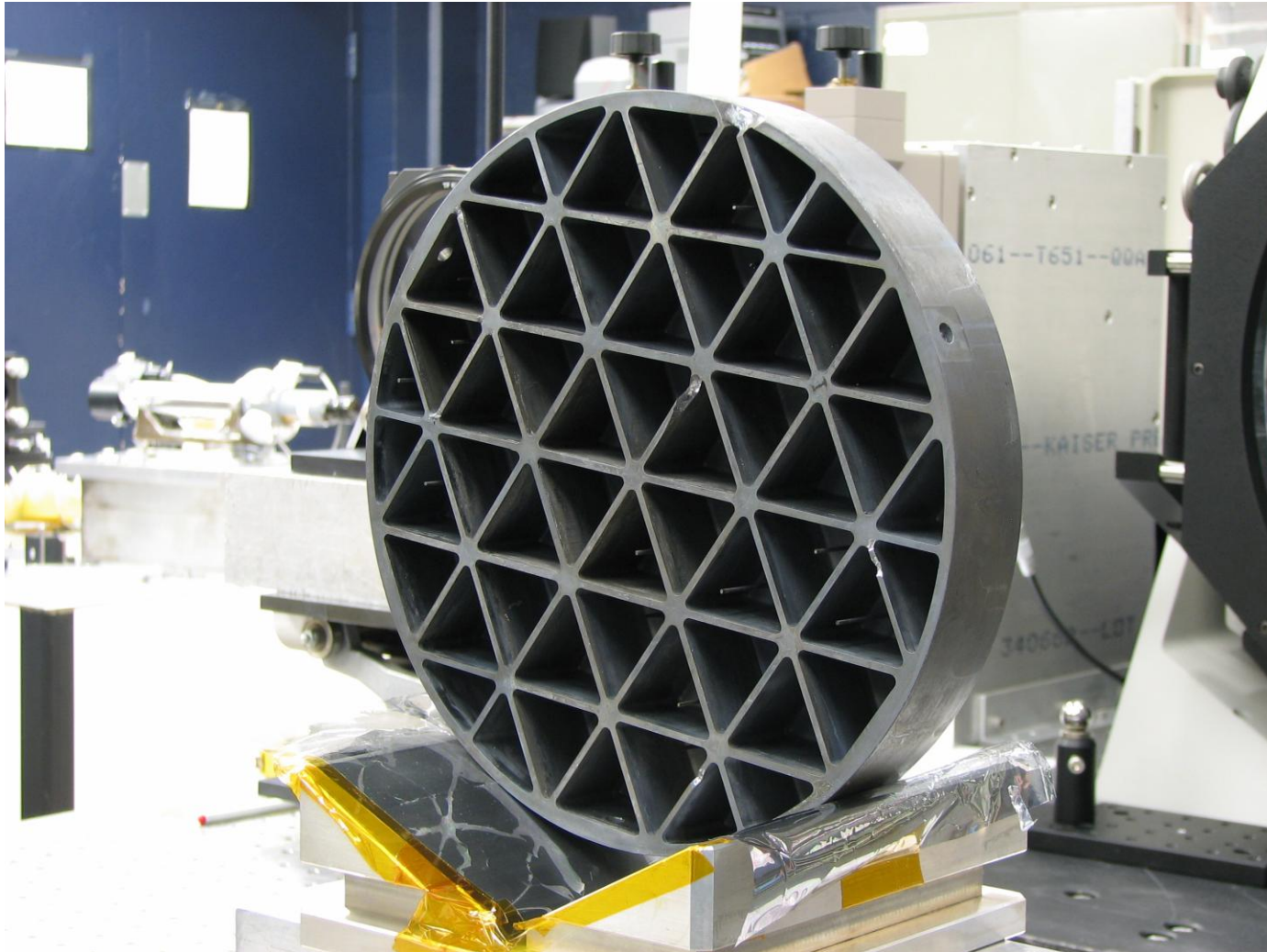




# Single Crystal Silicon Light Weight Mirrors



10" (24 cm) Diameter Single Crystal Silicon Mirror

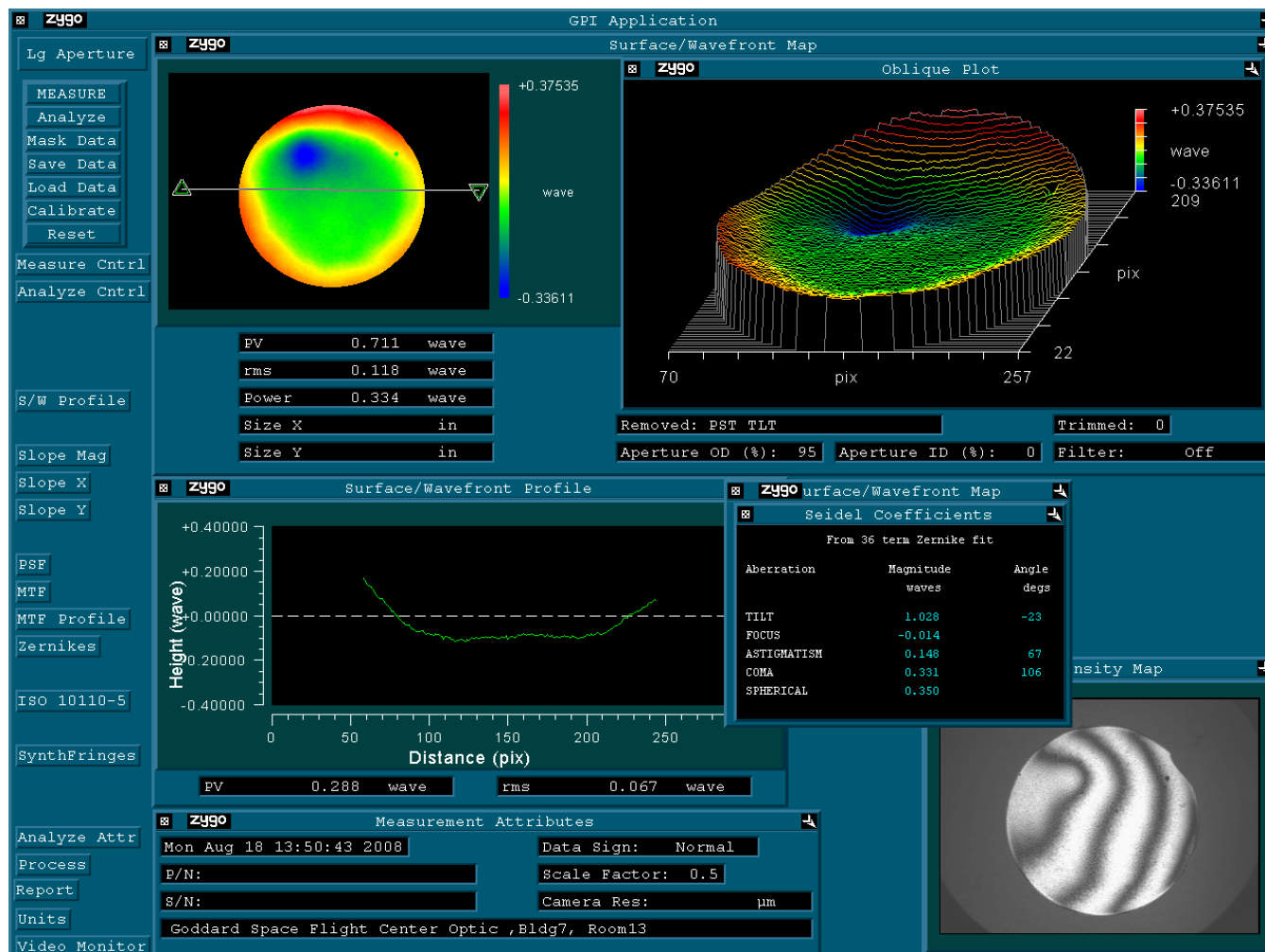




# Single Crystal Silicon Light Weight Mirrors



## 25 cm (10") Diameter Single Crystal Silicon Mirror





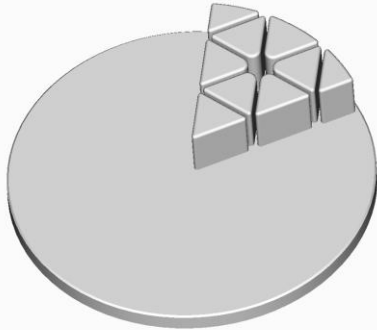
# Single Crystal Silicon Light Weight Mirrors



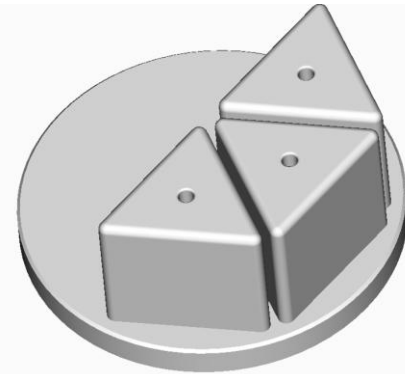
## 10" (24 cm) Diameter Single Crystal Silicon Mirror

The Primary Problem is how best to remove material from the light weighting pockets now that the volume is 15X larger.

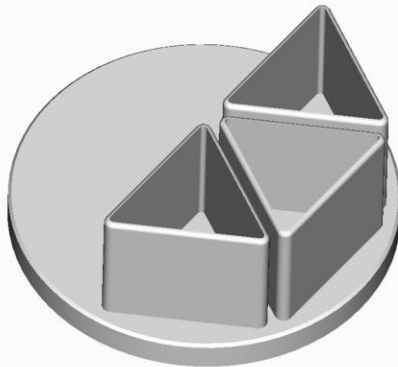
Small →  
Mirror Tool



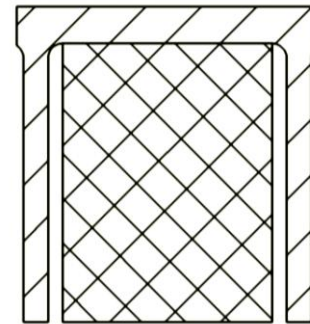
Original  
10" Mirror  
Tool →



Revised  
10" Mirror  
Tool 1 →



X-Section  
of 2-Step  
w/Revised  
Tool Set





# Single Crystal Silicon Light Weight Mirrors



## **Extreme Light Weight Designs (10 to 1 or greater)**

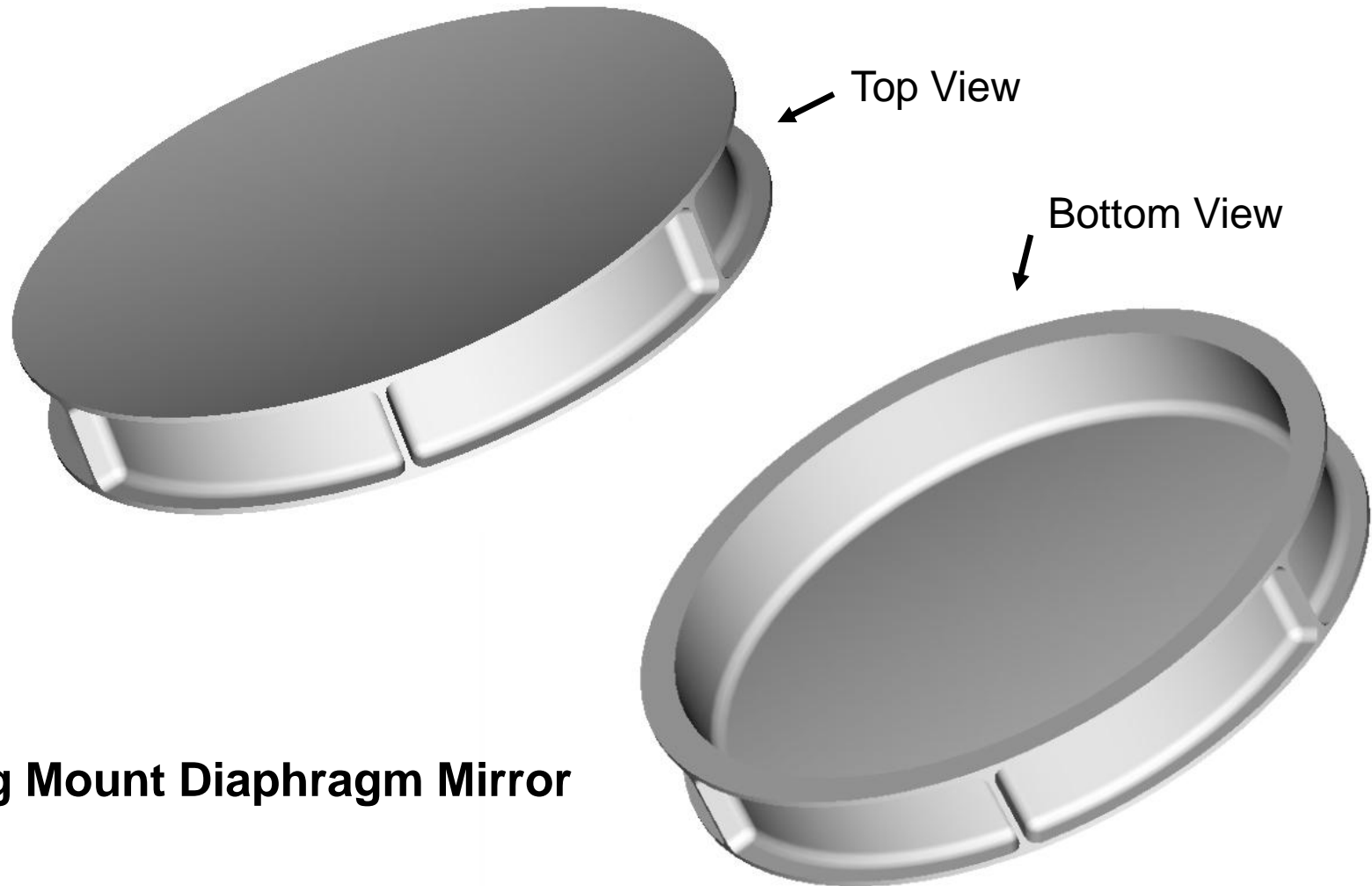
- The greatest mechanical stress that a mirror encounters is the grinding and polishing of the optical surface.
- Since SCS mirrors are light weighted afterward, the light weight structure does not need to withstand these forces.
- This open up a whole new avenue to light weight mirror structures that only need to resist self-weight distortion and the stresses induced by the mounting.



# Single Crystal Silicon Light Weight Mirrors



**Extreme Light Weight Designs (10 to 1 or greater)**



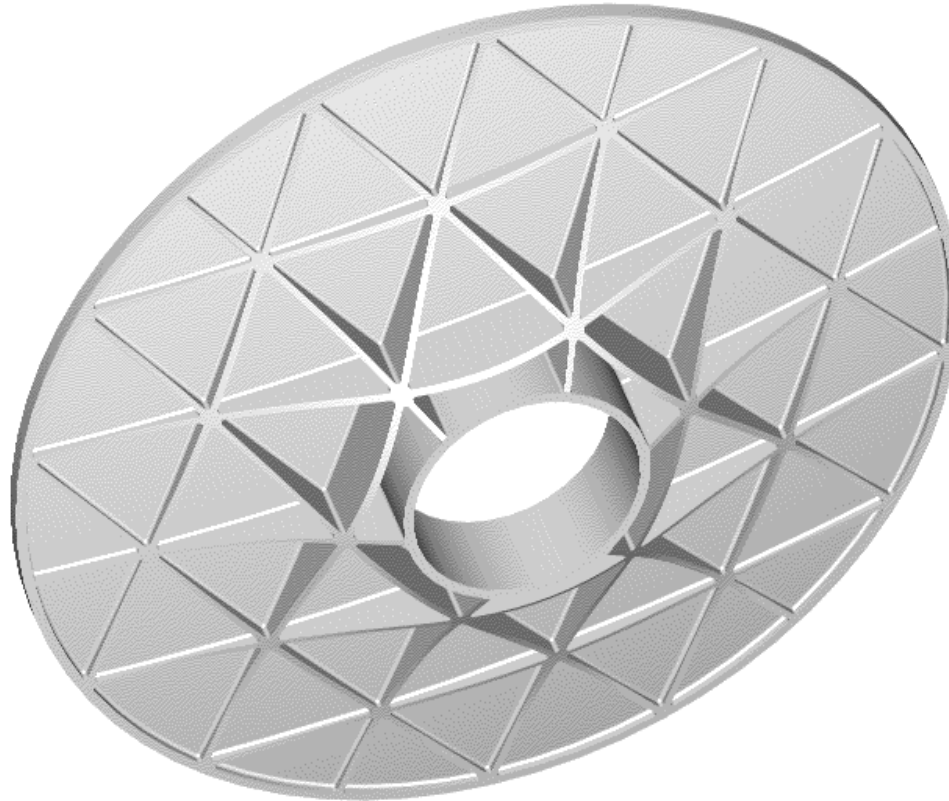
**Ring Mount Diaphragm Mirror**



# Single Crystal Silicon Light Weight Mirrors



**Extreme Light Weight Designs (10 to 1 or greater)**



**Light Weighted & Sculptured Back Perforated Primary**