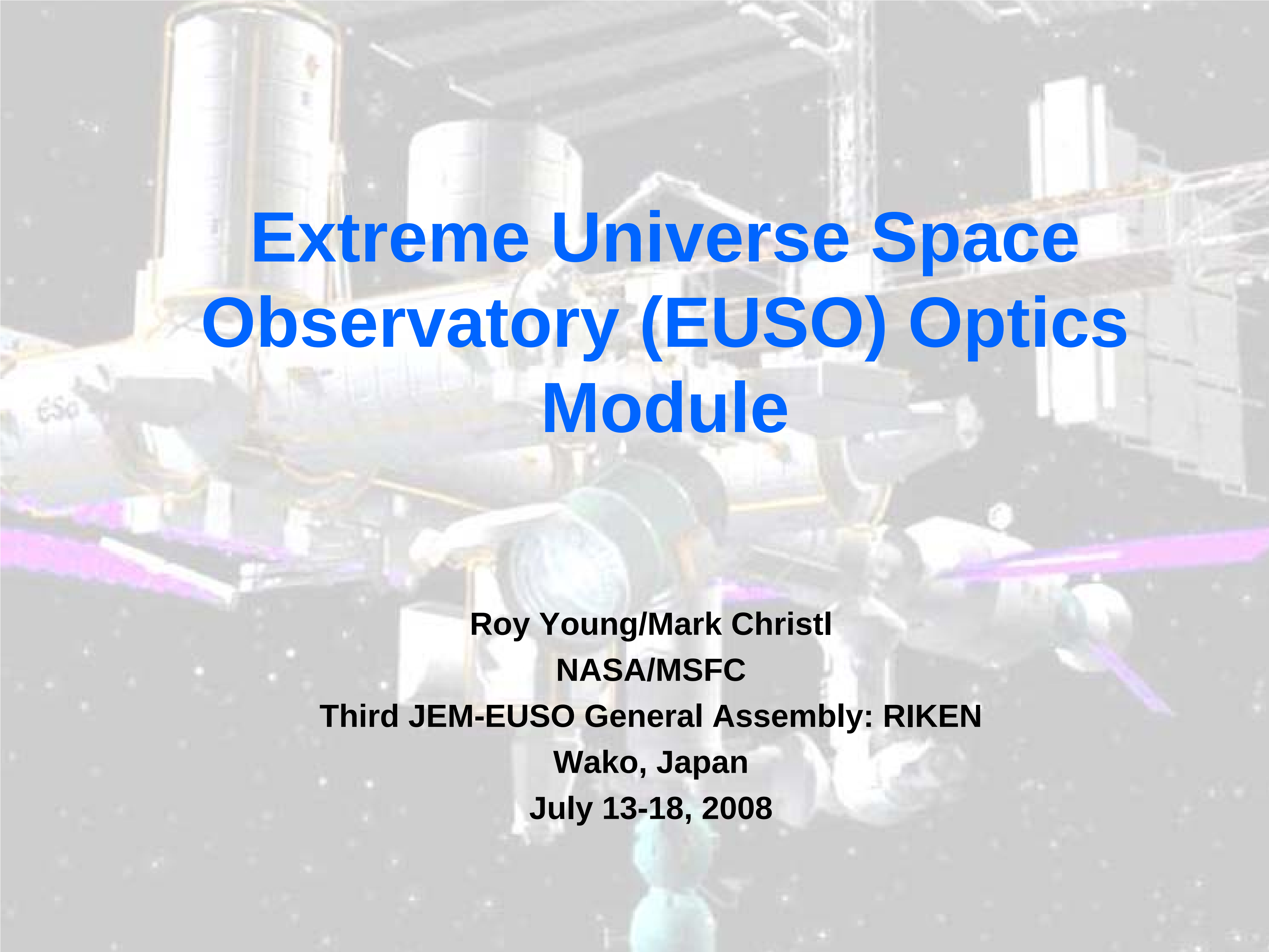

Extreme Universe Space Observatory (EUSO) Optics Module

Roy Young/Mark Christl

NASA/MSFC

Third JEM-EUSO General Assembly: RIKEN

Wako, Japan

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US Collaboration Roles

Institution		Optic Sub-System Roles
MSFC/NASA		Analysis, Simulation, Testing, Structure and Environmental
Univ. of Alabama in Huntsville		Design, Analysis and Testing
Univ. of Arizona		Integration, Focusing Algorithm
		Other Roles
MSFC/NASA		Management, Simulations, GLS, Data Analysis
U of Alabama in Huntsville		Theory, Simulations, Data Analysis
Vanderbilt		Theory, Simulations, Data Analysis
UCLA		Simulations, Atmosphere, Theory, Data Analysis
UCB		Simulations, EP/O, Data Analysis

Status of Optic System Work

- Testing
  - Measurement of the spectral refractive index on PMMA prism (UAH, Geary)
  - Measure homogeneity of CYTOP plate (UAH, Geary)
- Test Facility
  - Evaluate the AMOR facility and make a preliminary measurement of the spectral reflectivity of the AMOR in the deep blue (UAH, Reardon)
- Manufacturing
  - Diamond turned copper mold for subscale model for manufacturing Fresnel Lens (UAH, Blackwell)
- Mechanical Structure
  - Focusing mechanism and algorithm (MSFC/UA)
- Anti-reflective Coating
  - SBIR contract to test and demonstrate new technique for achieving antireflective coatings that will adhere to PMMA with good performance in the UV

Plans for Optic System

- Complete ongoing tasks with remaining funds

- Support testing to raise TRL level

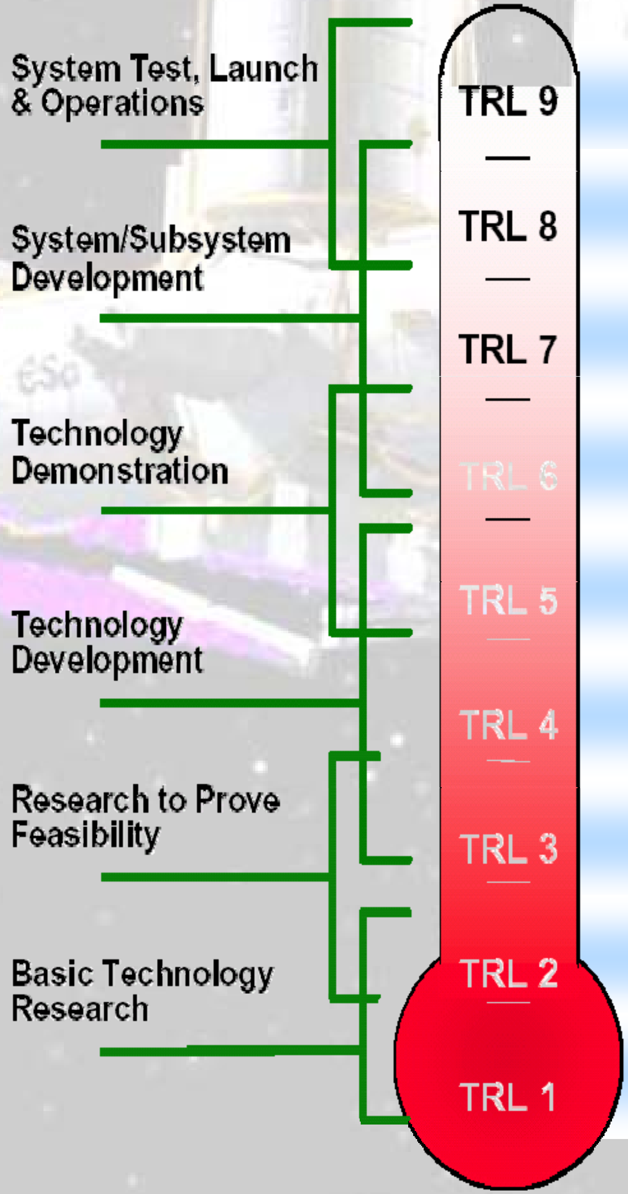
Test subscale model of complete central optic (Riken)

  – Full aperture optical test with focal plane detector (TBD)

Evaluate manufacturing precision

  – Annulus includes a 2.5m diameter that are representative of the Fresnel facets and micro-grating structure
  – For both annulus and subscale optic:
    - Verify grove placement and repeatability
    - Facet figure
    - Surface roughness

Technology Readiness Level (TRL)

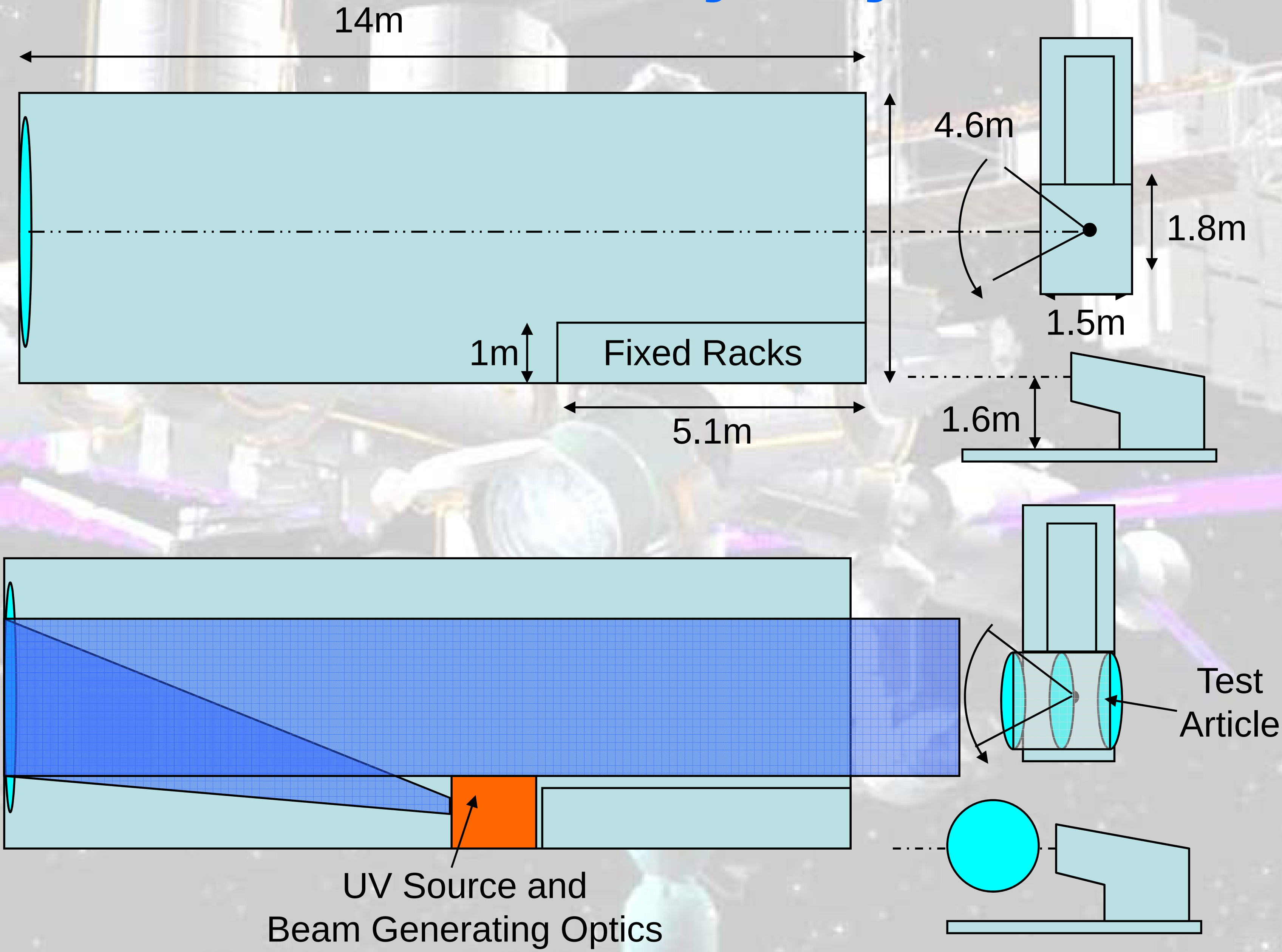


- **TRL 9:** Actual system "flight proven" through successful mission operations
- **TRL 8:** Actual system completed and "flight qualified" through test and demonstration (Ground or Flight)
- **TRL 7:** System prototype demonstration in a space environment
- **TRL 6:** System/subsystem model or prototype demonstration in a relevant environment (Ground or Space)
- **TRL 5:** Component and/or breadboard validation in relevant environment
- **TRL 4:** Component and/or breadboard validation in laboratory environment
- **TRL 3:** Analytical and experimental critical function and/or characteristic proof-of-concept
- **TRL 2:** Technology concept and/or application formulated
- **TRL 1:** Basic principles observed and reported

Manufacture and test Prototype Sub-scale System

- **Central 1.0 to 1.5 meters of all three optical elements made from PMMA manufactured in Japan..**
- **Mounted to a metering structure the same way they are mounted for flight, but the metering structure will be fixed, not telescoping as the flight one.**
- **Optics prescription will be used in simulations to predict the performance of the optics in flight.**
- **The optics will be tested by illuminating the full aperture. The throughput and the spot size will be measured at a sampling of field angles from 0° to 30°.**
- **Results will be compared with the optical simulations in order to validate these models.**
- **The validated models can then be used to predict the performance of the full 2.5 meter diameter optical system.**

AMOR Facility Layout



Manufacture and test a full-scale single lens

- A demonstration part will be manufactured in Japan on one of the large Toshiba machines with a diameter of 2.5 meters. This will be a flat PMMA disk that is cut between 0.5 and 1.25 meters radius. The cut should demonstrate manufacturing the most difficult parts of the 2.5 meter Fresnel pattern and the blazed grating on the diffractive surface.

- Optical simulations, validated with the subscale prototype, will be used to determine the limits on manufacturing errors (tolerances) that will result in optics that meet EUSO's requirements. There will be limits on surface roughness (or errors at high spatial frequency); radial and azimuthal slope errors (at lower spatial frequencies) and plunge cut depth errors in the blazed grating.

- The demonstration part will be measured to determine whether it was made within the allowable tolerances.

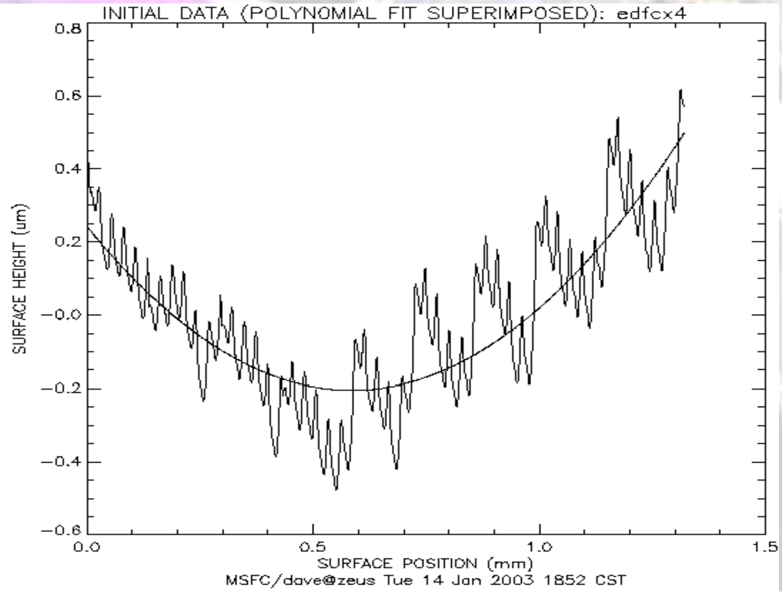
Metrology

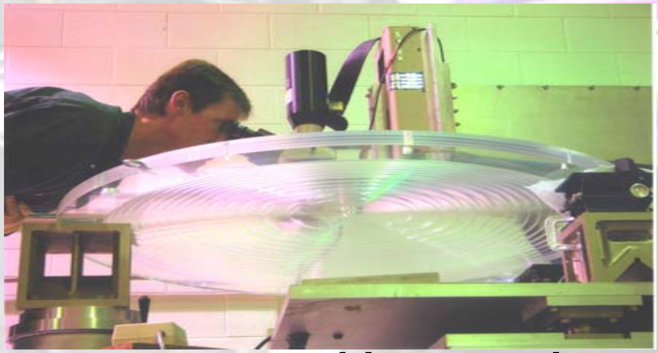
On the Fresnel surfaces we will measure:

- The surface roughness, which we expect to be in the 10 nm rms range.
- The local profiles of the Fresnel surfaces in the radial and azmuthal directions over distances of the order of the width of a Fresnel zone.
- The root and tip radii at the Fresnel backcuts.

On the Diffractive surface we will measure:

- The surface roughness, which we expect to be in the 10 nm rms range.
- The root and tip radii at the blazed grating backcuts.
- The local plunge depth irregularity at the blazed grating backcuts.





1m Double Fresnel

Zone	Radial	Tangential
Center	1210 (edfcx4)	624 (edfcx3)
Edge	416 (edfcx2)	114 (edfcx1)

(Units are Angstroms RMS)

Anti-Reflective Coating

- Small Business contract to test and demonstrate new technique
- AR coating based on nano-particle technology
- Small scale test articles have been demonstrated
- Tunable index of refraction and thickness of coating
- Suitable for near UV
- Adheres to PMMA