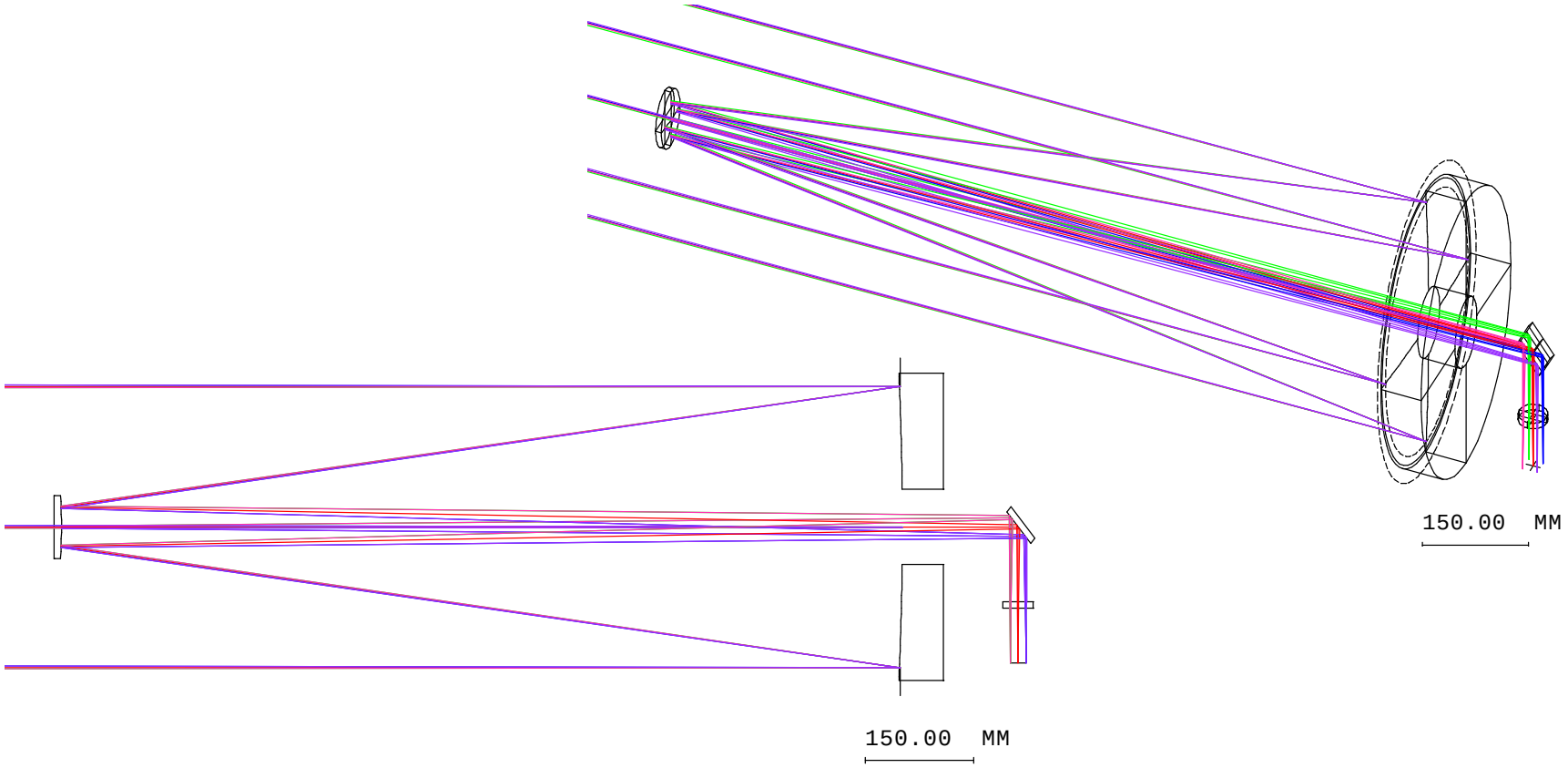
Opto-Mechanical Sub-System
HRI Telescope Optics

CDR Optical Presentation Summary

- **HRI**
  - **Optical Layouts**
  - **Optical Requirements**
  - **Optical Performance**
  - **Opto-Mechanical Sensitivities**

High Resolution Instrument Telescope

- **No significant design changes since review**
  - **Mirrors are unchanged**
  - **Filters are thicker, normal to the beam**

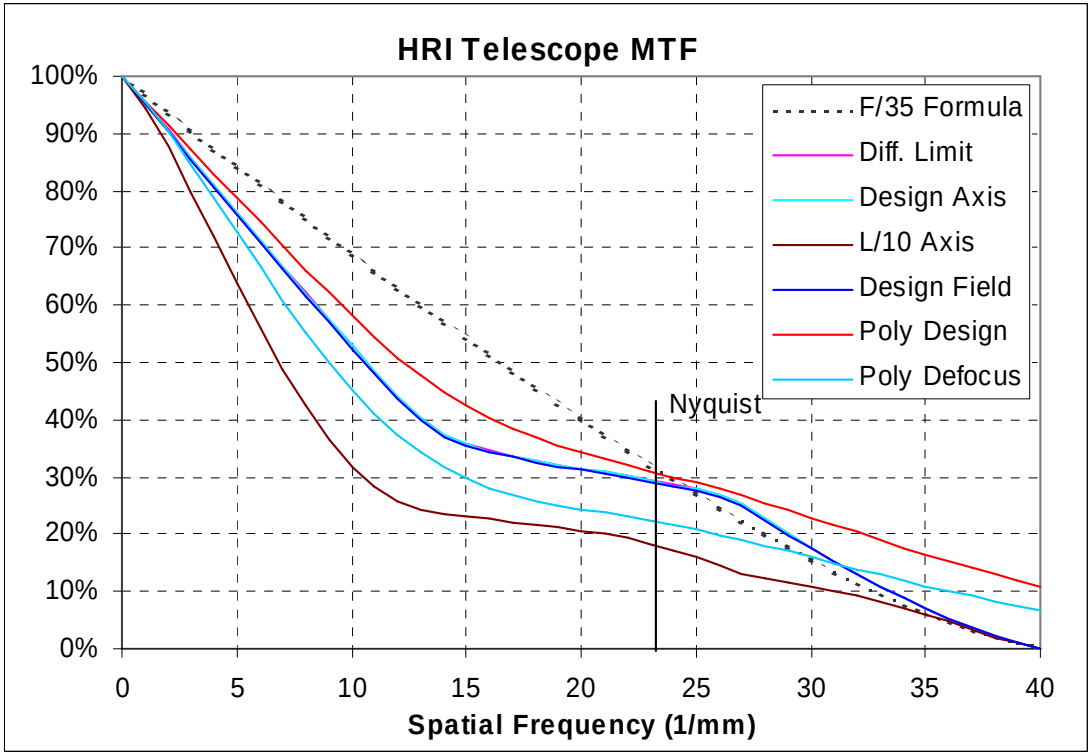


HRI Optical Requirements: Visible

Parameter	Value	Source / Performance
IFOV	2.0 ± 0.25 microradians (~0.4 arc-seconds)	B-Spec Requirement Predicted 2.0 ± 0.02 μR
Visible CCD Pixel Size	0.021 mm x 0.021 mm	System Implementation
Focal Length	10,500 mm	Derived To be verified in testing
Array size	1024 x 1024	By Design
FOV	0.059^0 to the Edges of Array 0.083^0 to the Corners of	Derived from IFOV & array
Collecting Area	550 square centimeters)	Sensitivity Requirement Predicted 613 sqcm
Baffling	No direct illumination of the focal plane, two bounces	B-Spec, good practice
Central Obscuration Linear	35.7% 12.7%	Acceptable
Entrance Pupil Diameter	300 mm	Yields sufficient collecting area
Primary to secondary mirror spacing	1161.7 mm	Limited by envelope, Driven by EFL, axial mag. , field curvature
Primary mirror vertex to image distance (BFL)	300 mm	Set to share focal plane with SIM Will be set in integration
Primary mirror F/#	F/4.5	Derived
Secondary mirror magnification	7.8x	Driven by EFL, BFL, axial mag., field curvature
Axial Magnification	60.5x	Derived, Large but acceptable
Wavefront Error Limit	λ/10 at 700 nm	B-Spec interpretation of MSRR req't spot size limit <2.25 pixels

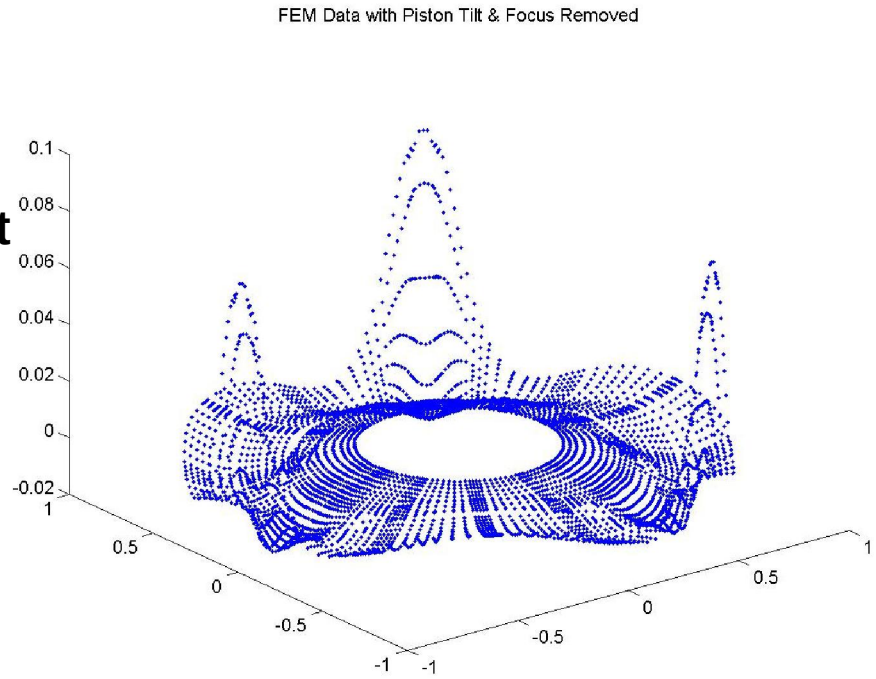
HRIT Will Provide Good Optical Performance: MTF Predictions

- **Close to field independent (≤ 0.085°)**
- **Shown "as designed" and with 0.10 λ RMS WFE @ 700 nm**
  - 700 nm is the wavelength specified in the B-spec
- **Also includes Polychromatic MTF as designed, w/ defocus**



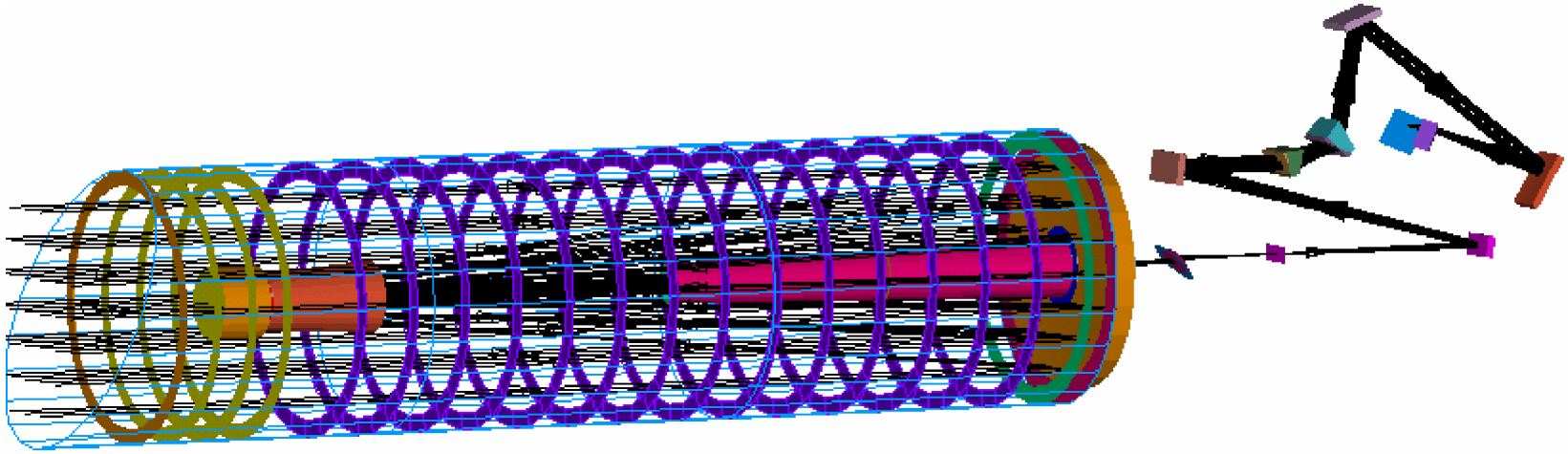
Structural Analysis for Mirrors supports Wavefront Error Budget

- **Used to estimate surface deformation from perturbations**
  - **Isothermal drop to operational temperature**
  - **Differential expansion of mounting pads (shown in figure)**
    - **.02 λ RMS Δ WFE: acceptable**
  - **Differential expansion of decontamination heaters**
    - **.013 λ RMS Δ WFE: acceptable**
  - **Shimming of flexures**
    - **insignificant Δ WFE**
- **Zernike decompositions used to separate changes like position shift which have different impacts**
- **All deformations included in tolerance analysis**
- **Secondary Mirror also analyzed**
  - **.014 λ RMS focus, no added WFE**



Telescope Design Incorporates Stray Light Suppression

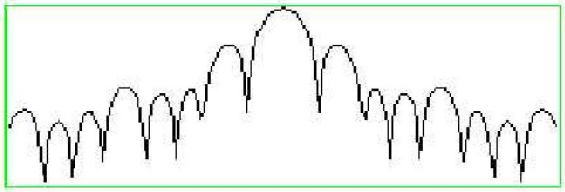
- Telescope is fully baffled against direct illumination of the detector
- Flat, absorptive masks around Primary & Secondary mirrors
- Vanes in Telescope structure trap most out of field light
- Vanes incorporated inside primary conical baffle, one outside
- Secondary cone modified to redirect specular out of field light
- Many surfaces left unpainted with approval of stray light analyst
- Several specific cases modeled



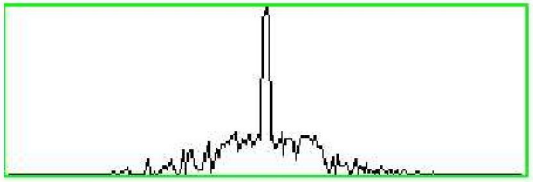
Components Evaluated for Stray Light Contributions

- Filter Ghosts will be acceptable
- Beamsplitter roughness was most significant risk
  - 30 Å RMS was as good as the substrate vendor would promise
  - Previous coatings of similar nature have doubled or tripled roughness
  - Stray Light Analysis done for 75Å RMS Surface
    - Even 75Å RMS Surface would not degrade images
    - Surface will be better than that but not meet specified 25 Å RMS
  - Monochromatic analysis shown in plots, effect less for polychromatic

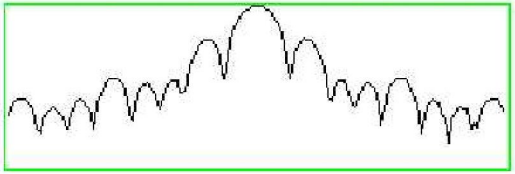
Imaged Light (log scale)



B/S Scattered Light (same scale)



Combined Light



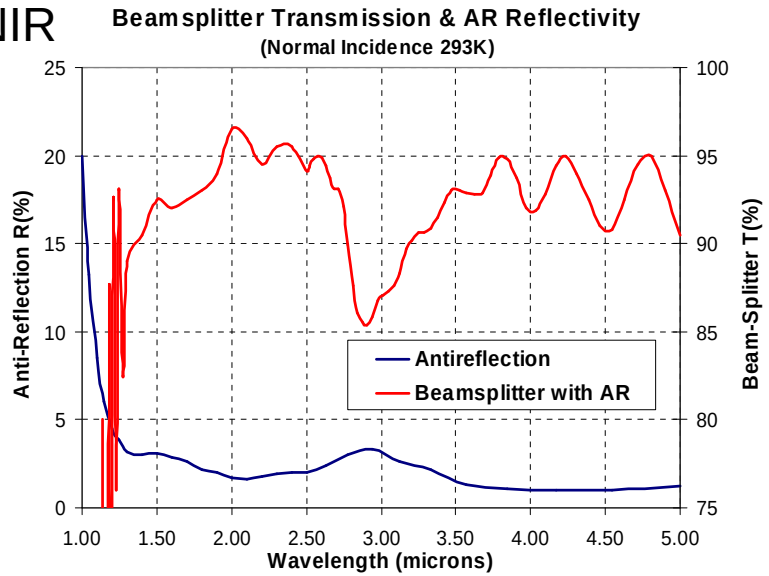
Filters Defined and in Production

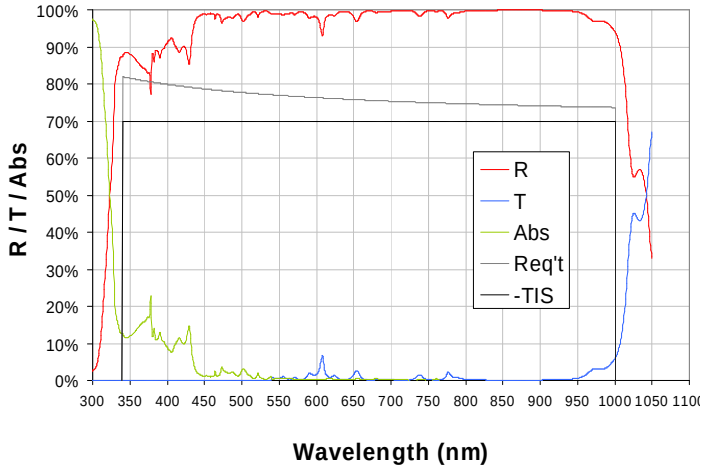
- **UV-Visible-NIR Filters for 9 position wheels in HRI & MRI**
  - **HRI uses broad bands plus long & short wave pass -007 to -013**
  - **Most are coated fused silica paired with colored glass**
  - **Most substrates at vendor, sized and edged**
  - **Multi-layer filters & colored glass will be measured at operating temperature**

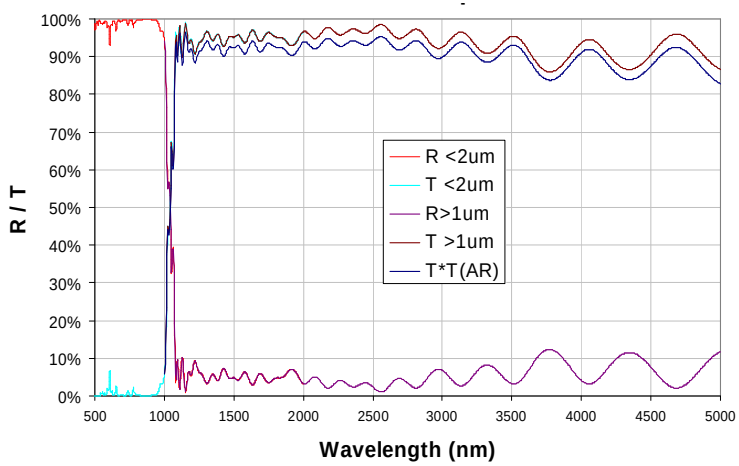
Filter #	Wavlength	Bandpass	Purpose	Wheel	Blocker	Avg Trans
-1	Clear	N/A	Parfocality	Both	N/A	>90%
-2	309.0 ±0.8	6.2 ± 0.7	OH	MRI	UG-11	>40%
-3	345.5 ±0.8	6.8 ± 0.8	UV Cont.	MRI	UG-11	>40%
-4	387.0 ±1.2	6.2 ± 0.7	CN	MRI	S-8612	>55%
-5	514.1 ±1.2	11.8 ± 1.2	C2	MRI	GG-475	>70%
-6	526.0 ± 0.7	5.6 ±0.7	Green Cont.	MRI	GG-495	>70%
-7	<400 ± 5.0	N/A	UV Short Pass	HRI	Coated FS	>50%
-8	450 ± 5.0	100± 5.0	Blue BP	HRI	S-8612	>70%
-9	550 ± 5.0	100± 5.0	Green BP	HRI	GG-475	>70%
-10	650 ± 5.0	100± 5.0	Orange BP	HRI	OG-570	>70%
-11	750 ± 5.0	100± 5.0	Red BP	Both	RG-645	>70%
-12	850 ± 5.0	100± 5.0	NIR BP	Both	RG-715	>70%
-13	>900.0 ± 5.0	N/A	IR LWP	HRI	RG-830	>70%

Beamsplitter Performance Enhanced
Design Curves & First Data

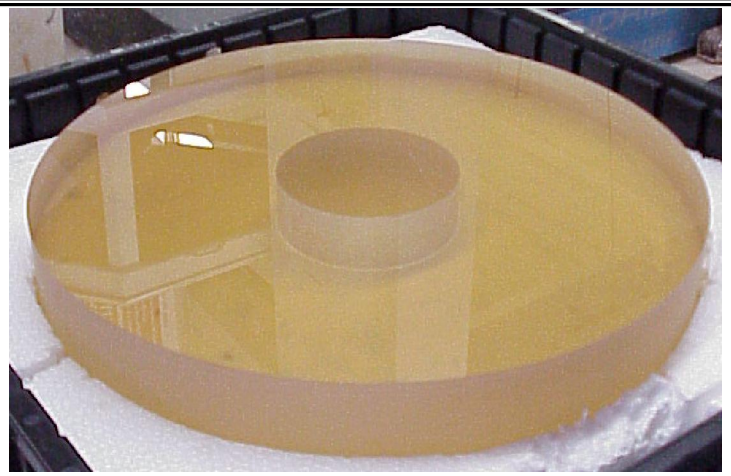
- 5-stack pushes visible farther into UV and NIR
  - Crossover now at ~1030nm
  - Reflectivity down past 340 nm
  - Filters type similar to series previously produced at Barr
- First run flight article coated
  - 50% R at ~330 nm, ~ 1010 nm,
  - temperature insensitive
  - AR R < ~3% 1.1 to 4.8 microns
  - Visual inspection of witness looks very smooth





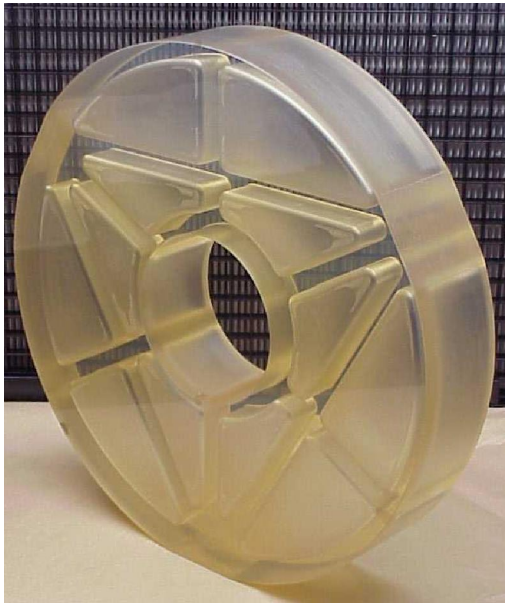


HRI Mirrors in Fab at LWO:
Fused Silica Proof and Zerodur Flight Mirrors



Zerodur Primary Blank

S/N 1 Primary Flight Mirror



Fused Silica Secondary Proof Article

Shaped Zerodur Primary Getting Fiducials