Cryogenic Refractive Index and Coefficient of Thermal Expansion for the S-TIH1 Glass

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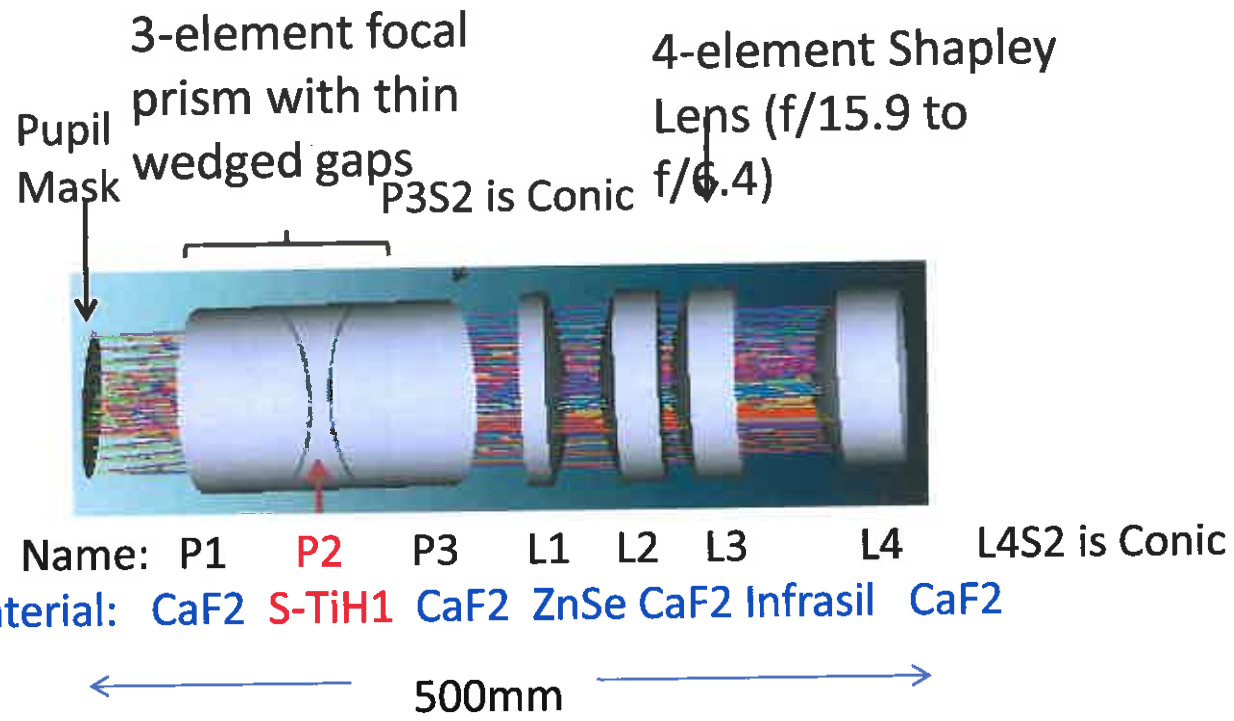
Outline

- Background on S-TIH1 Glass and its use on WFIRST
- Experimental Details
  - CTE
  - Spectral
  - CHARMS
- CTE and Spectral Results
- CHARMS Refractive Index Results
  - Comparison CHARMS vs. Ohara
  - Sellmeier Fits
- Conclusions

Background on WFIRST

SpC detail: 14 surfaces, 12 spheres, 2 conic



Detail of spectroscopy channel, showing the prism and Shapley lens groups.

S-TIH1 space qualification

S-TIH1 Ohara glass, high index, high dispersion Used in IDRM1 as dispersing material in BAO and SN prisms

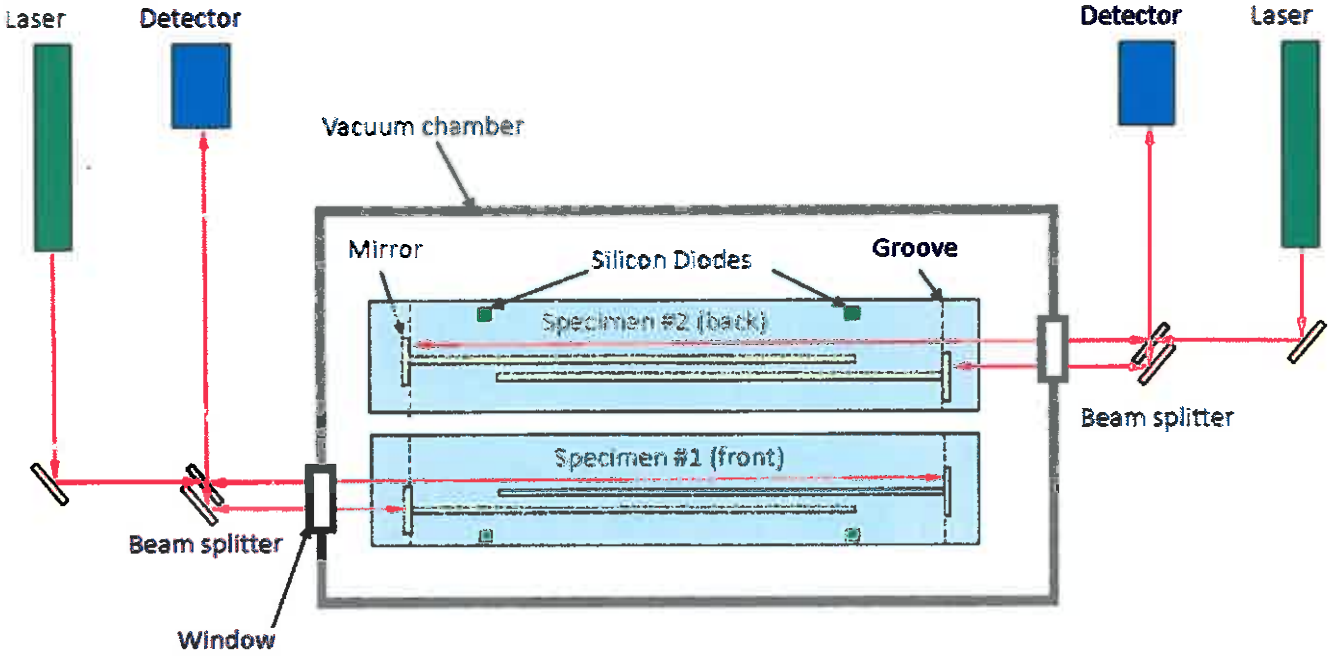
Not space qualified

Outline of test plan:

- Verify high transmission in NIR
- Cryo CTE
- Test cryo index [CHARMS]
- Test transmission loss after radiation exposure [rad hard] ~6.7% loss at 0.6um, 2.2% at 1.0um, ~1% >= 1.1um

Lab setup used in 541 for cte measurements

Laser Interferometer



- Thermal expansion $\Delta L/L_o$ is measured and normalized at 293.15K (20°C)
- The $\Delta L/L_o$ data is best-fit with a polynomial equation
- The instantaneous CTE is calculated from the derivative of the polynomial equation of thermal expansion

Spectral Measurements

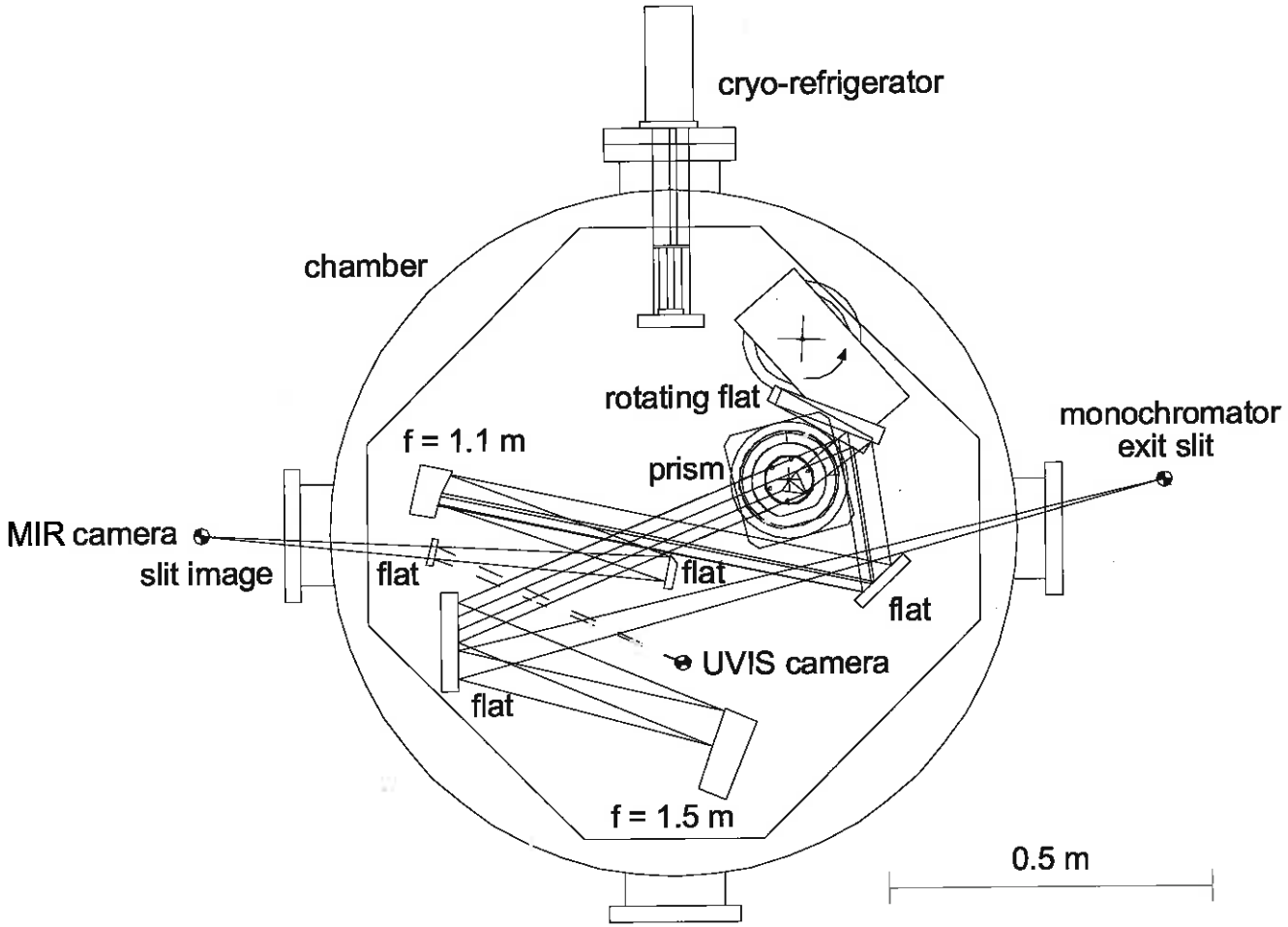
Instruments used: Perkin-Elmer (Lambda 950) with URA accessory

Provides absolute data over UV/VIS/NIR

Spectral range: 200-2500nm (2 nm resolution)

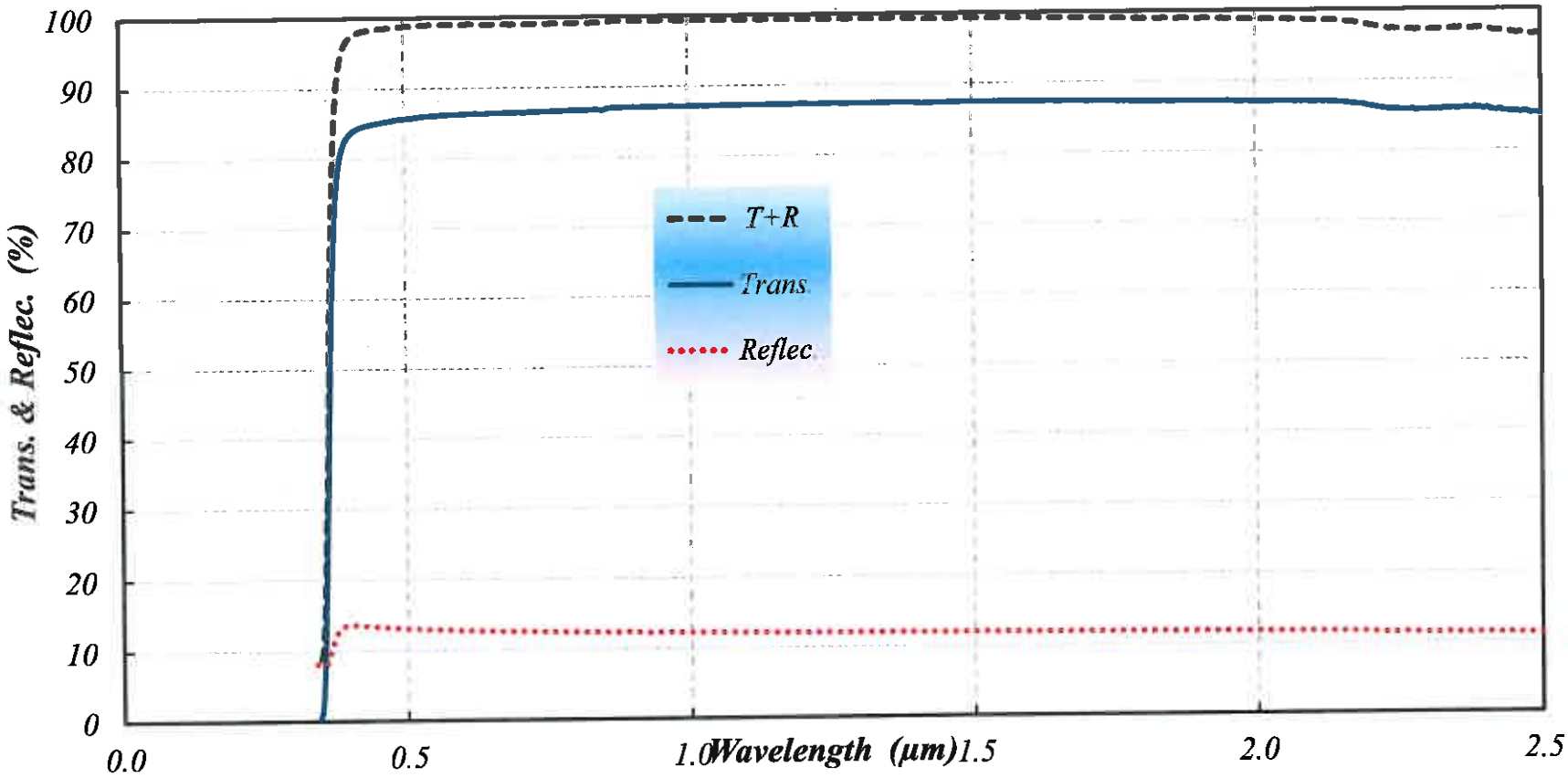
CHARMS: Cryogenic High Accuracy Refraction Measurement System

CHARMS Optical Layout



Spectral Results

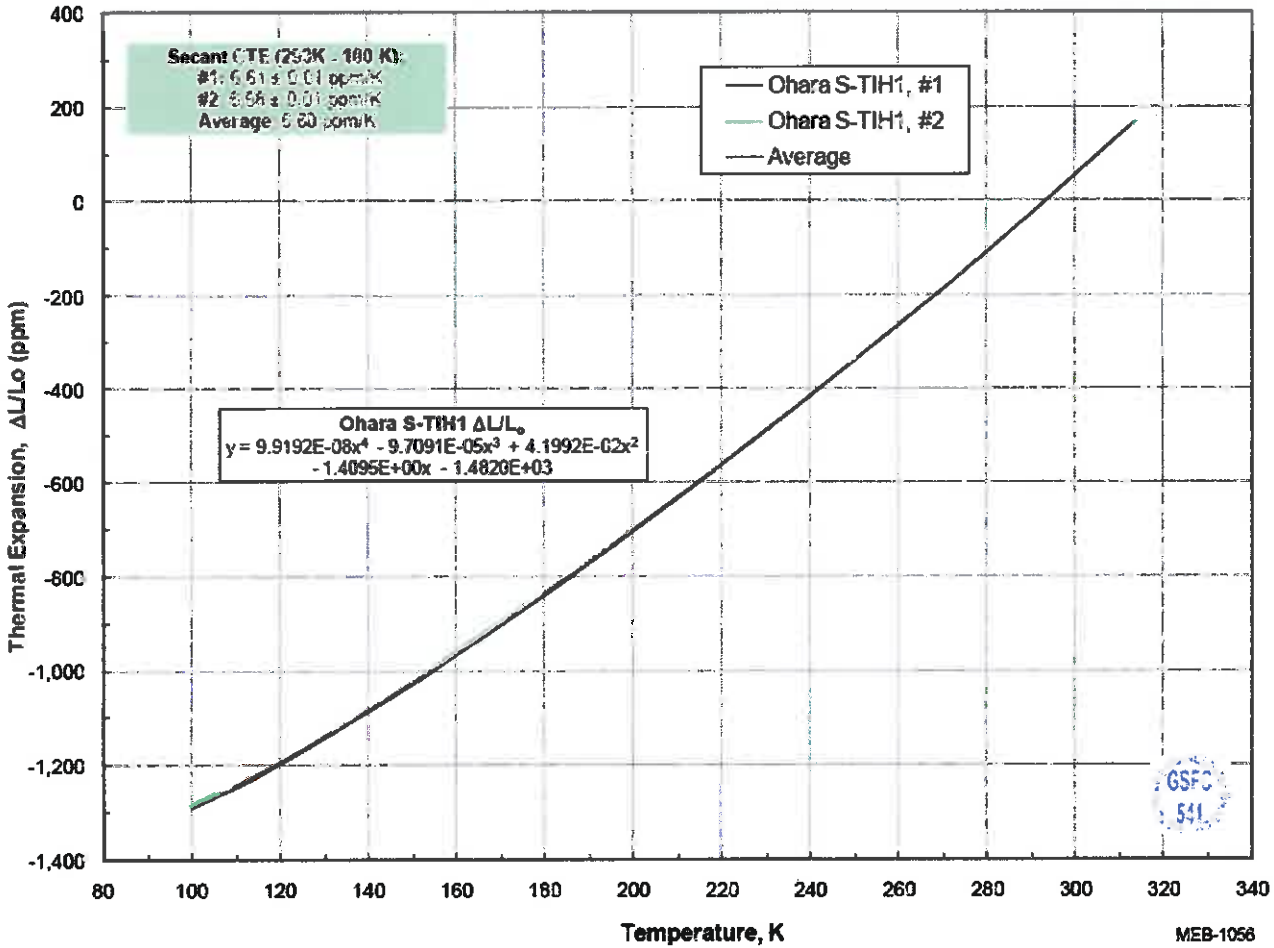
Transmission & reflection tested using PE Lambda900 spectrophotometer



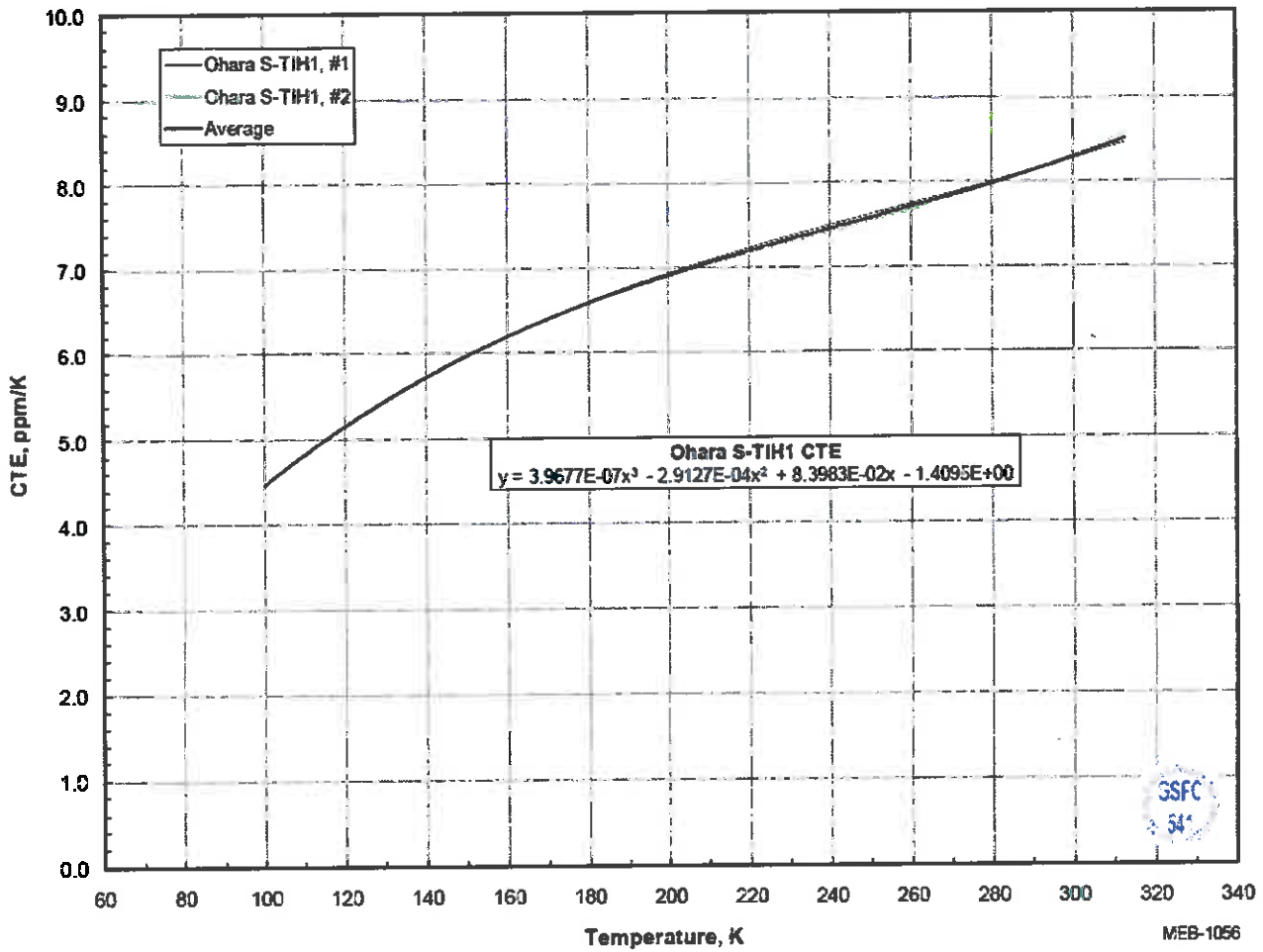
Cryo CTE

- Two Ohara S-TIH1 glass samples, 4"x2"x0.08"
- CTE between 313K (40°C) and 100K (-173°C) was measured using a Michelson laser interferometer measurement system (ASTM Standard E 289 - 95).
- Test conditions: 3 cycles, ramp rate 1°C/min, in vacuum

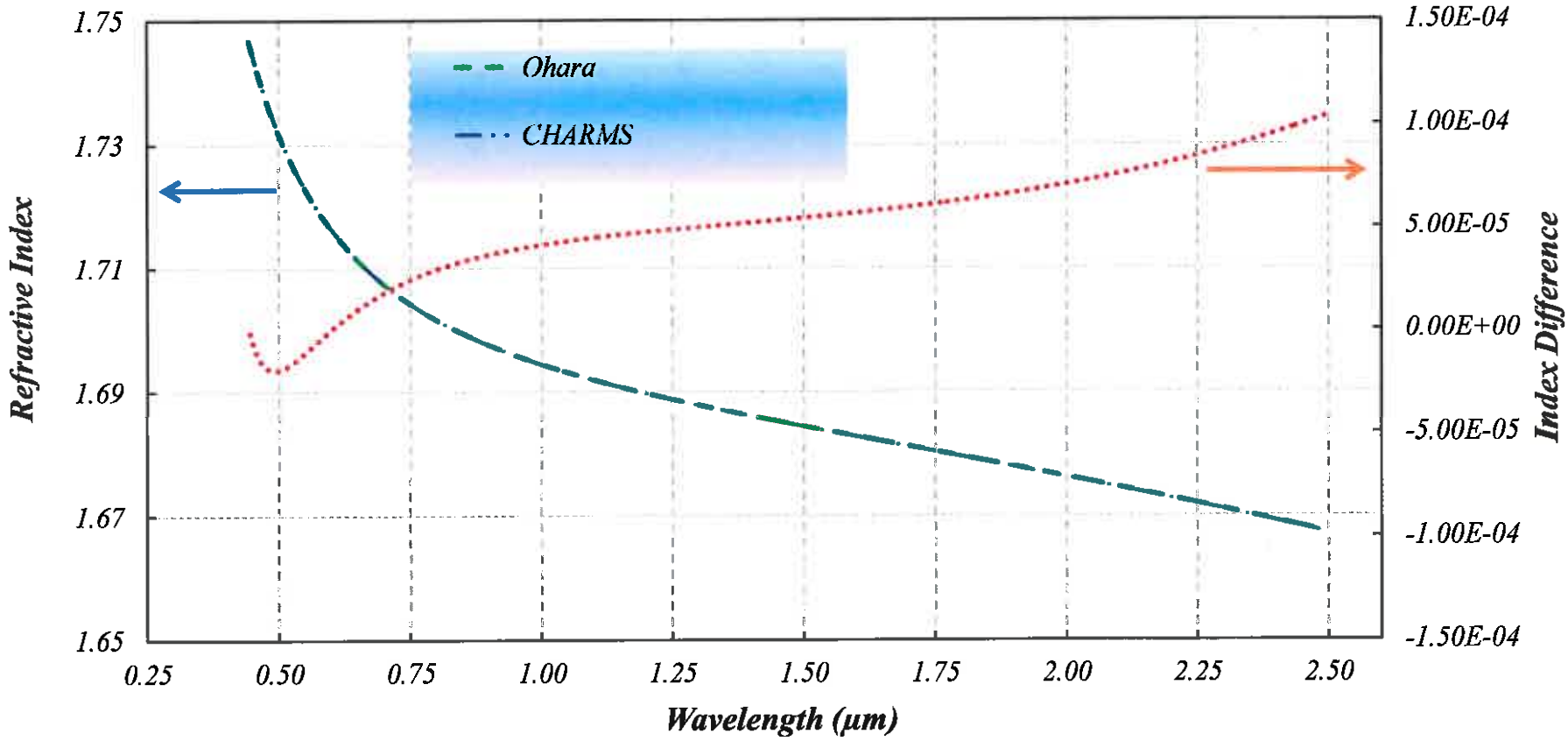
S-TIH1 Thermal Expansion



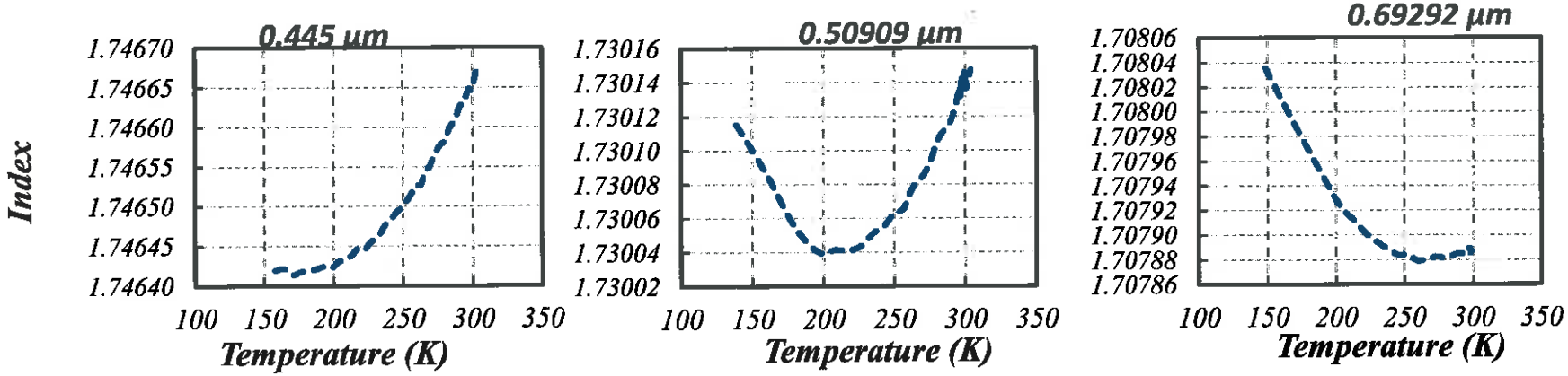
S-TIH1 CTE

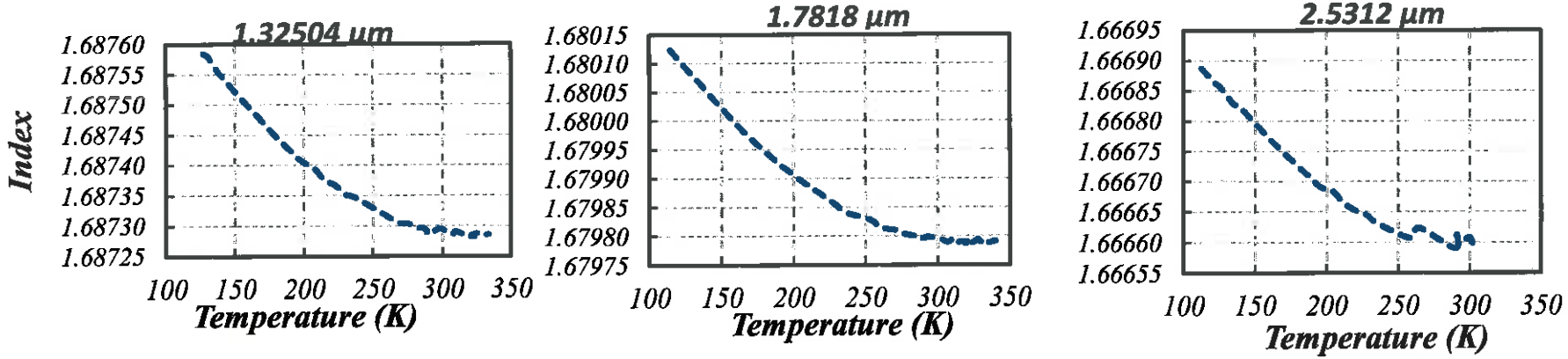

Ohara S-TIH1, #1
Ohara S-TIH1, #2
Average
Ohara S-TIH1 CTE
y = 3.9677E-07x³ - 2.9127E-04x² + 8.3983E-02x - 1.4095E+00
CTE, ppm/K
Temperature, K
MEB-1056
GSFC
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340

S-TIH1 Absolute Refractive Index

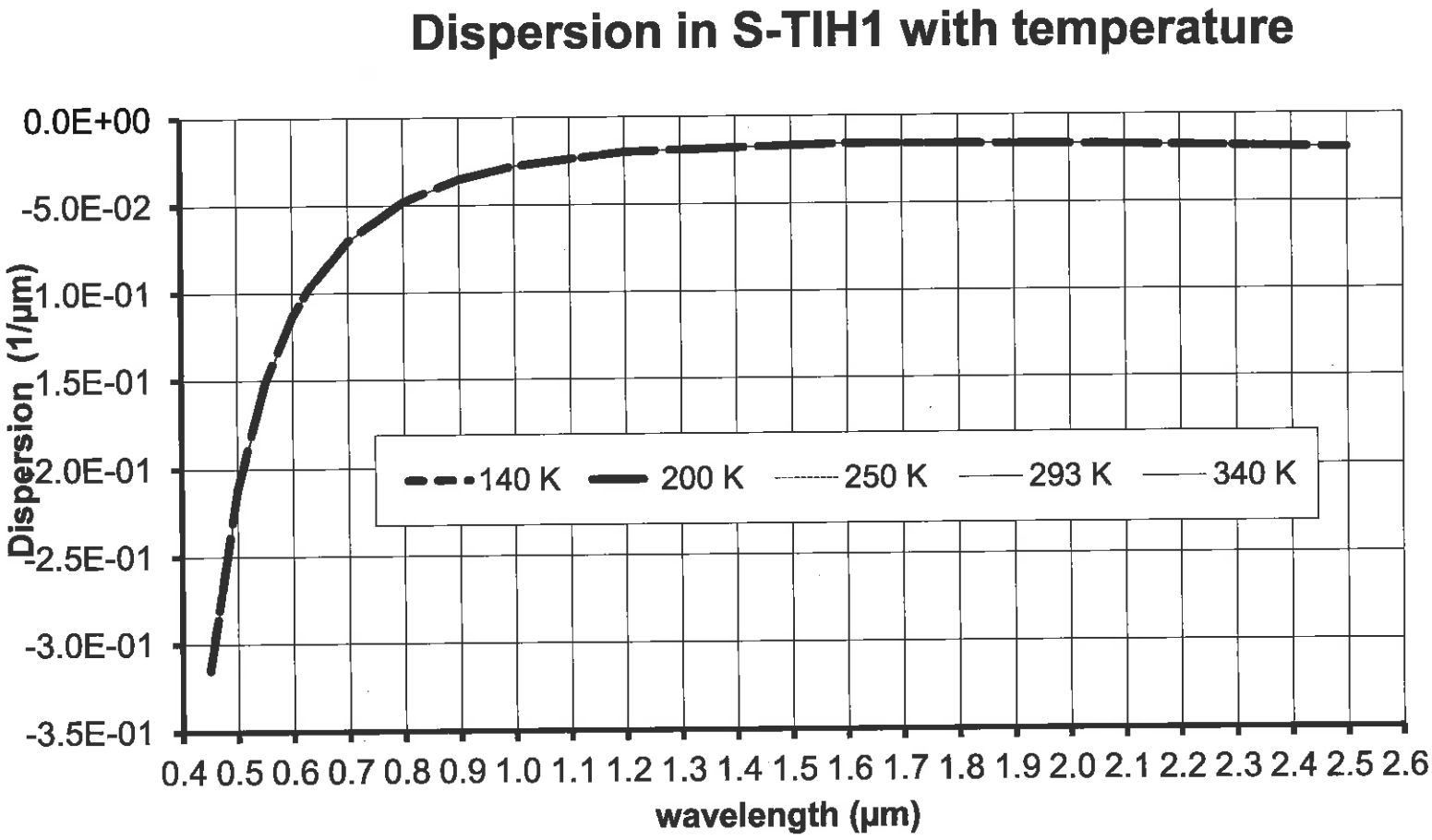


Index Temperature Dependence

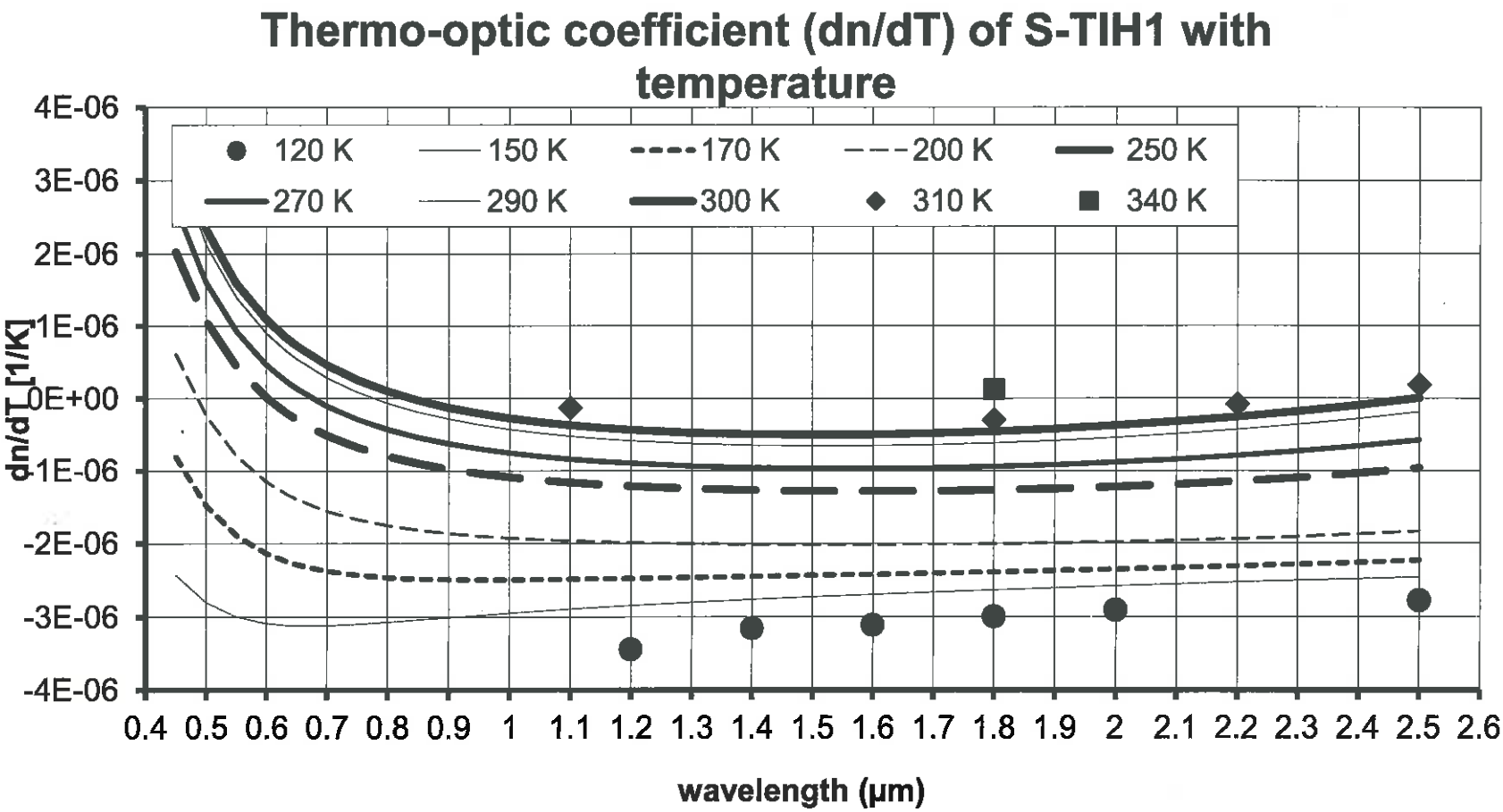




Sellmeier Fits: Dispersion



Sellmeier Fits: Thermo-Optic Coefficient



Conclusions

➢ Using the CHARMS facility at NASA GSFC, we have measured the cryogenic refractive index of the Ohara S-TIH1 glass from 0.40 to 2.53 μm and from 120 to 300K. We have also examined the spectral dispersion and thermo-optic coefficients (dn/dT). We also derived temperature-dependent Sellmeier models from which refractive index may be calculated for any wavelength and temperature within the stated ranges of each model. The S-TIH1 glass we tested exhibited unusual behavior in the thermo-optic coefficient. We found that for $\lambda < 0.5$ μm, the index of refraction decrease with a decrease in temperature (positive dn/dT). However, the situation was reversed for λ larger than 0.63 μm, where the index will increase with a decrease in temperature (negative dn/dT). We also measured the coefficient of thermal expansion (CTE) for the similar batch of S-TIH1 glass in order to understand its thermal properties. The CTE showed a monotonic change with a decrease in temperature.