INTRODUCTION

G-CLEF is a precision radial velocity spectrograph chosen as the first-light instrument for the Giant Magellan Telescope (GMT). The instrument is designed to detect Earth-like exoplanets in the habitable zones of sun-like stars.

![Fig. 1 G-CLEF Mounted in Vacuum Vessel on GMT Azimuth Platform](image1)

PRV Precision Goal: 40 cm/s (10 cm/s for Multiple Observations)

PRV precision to achieve science requirements imposes challenging stability requirements on instrument structures. Analysis of image motions under operational environments led to the choice of carbon fiber cyanate composite as the primary material for the optical bench structure.

![Fig. 2 G-CLEF Optical Assemblies](image2)

METHODS

PRV error budgets for operational environments were developed by G-CLEF systems engineering. Allowable image motions at the CCD detectors were calculated from cm/s PRV budgets for thermal, pressure, inertial and moisture environments.

![Fig. 4 G-CLEF PRV Error Budget](image3)

A finite element model of the instrument was created to simulate response to thermal, inertial, and pressure environments.

![Fig. 5 G-CLEF System Level Finite Element Model](image4)

FEA translational and rotational displacements were input into SAO-developed Bisense software to determine resultant image motions at the detectors.

![Fig. 6 Longitudinal Displacement under Lateral 0.001 K Gradient](image5)

RESULTS

![Fig. 7 Bench CTE vs. Image Motion for 0.001K Lateral Temp Gradient](image6)

![Fig. 8 Image Motion Sensitivity to Instrument Accelerations](image7)

![Fig. 9 10mbar Pressure Change, IMAD vs. Flexure Orientation](image8)

![Fig. 10 Composite Shrinkage during Dry-Out from Saturated at 50% RH](image9)

CONCLUSIONS

- Near-zero CTE structure required for PRV - carbon fiber/cyanate optical bench: -0.15 < CTE < +0.20
- Instrument sensitive to micro-radian tip/tilts smaller than GMT azimuth axis alignment tolerance to gravity - self-leveling mechanisms built into supports
- Instrument sensitive to 10 mbar pressure change - Optimization of vacuum vessel and supporting structure - adjustable mounting flexures to tune red/blue IMAD/ΔP
- Minimal CME effects due to dry-out of composite bench, PRV precision within hours or days within vacuum

REFERENCES


AMERICAN INSTITUTE OF PHYSICS