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# Improved Diagnostic Systems for the Laser Beam Transfer Optics at Gemini South Observatory

Valentina Oyarzún<sup>\*1,2,3</sup>

<sup>1</sup>Cristian Moreno – Chile

<sup>2</sup>Ryan Ketterer – Chile

<sup>3</sup>Vincent Garrel – Chile

## Abstract

GeMS, the Gemini South telescope MCAO facility located on Cerro Pachon Chile, uses five Laser Guide Star (LGS) beams to correct the atmospheric turbulent wavefront. The Beam Transfer Optics (BTO) system relays the output of a Toptica SodiumStar 22 W laser along the telescope truss to a center launch telescope behind the secondary mirror. The system was designed to split the laser into five beams, equal in power and polarization state, before propagating them on-sky in an X-shaped constellation.

The BTO system's strategies for polarization control, however, have not produced the intended results for the Toptica SodiumStar laser (in use since 2017). Measurements taken with the telescope at zenith and horizon show a power imbalance and varied polarization states among the five beams after the splitting optics of the BTO.

The paper presents a characterization of the BTO system, including the state of polarization and power distribution, obtained from improved and newly developed diagnostic systems that allow for measurements at different telescope elevations. It discusses system upgrades that optimize the polarization state and power output of the five beams, aiming to improve the photon flux return at the wavefront sensors of the AO system.

**Keywords:** Polarization, GeMs, Multi, Conjugate Adaptive Optics, Laser Guide Star, sodium photon return

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<sup>\*</sup>Speaker