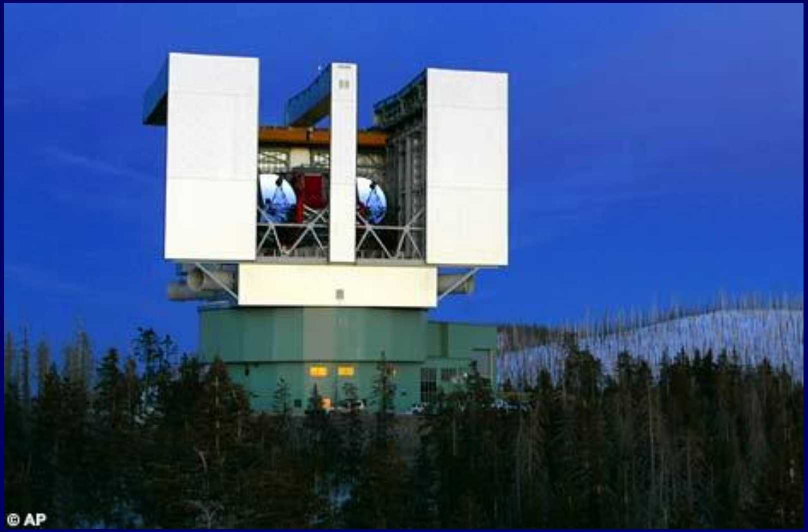
AO Imaging and Polarimetry in the Infrared with the Large Binocular Telescope and MMT



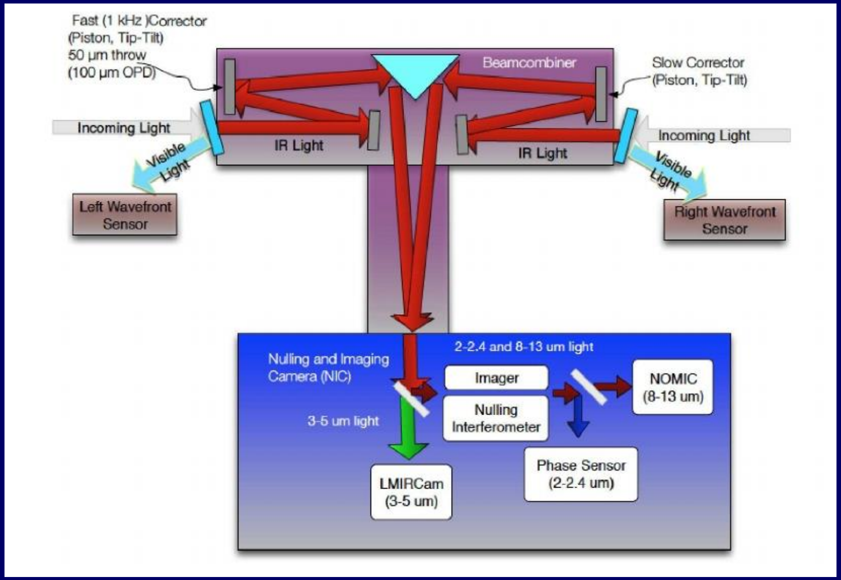
Two 8.4 m mirrors

6.5 m primary

Roberta Humphreys
University of Minnesota

LMIRCam 2 -- 5 μm Camera (Skrutski et al. 2010)

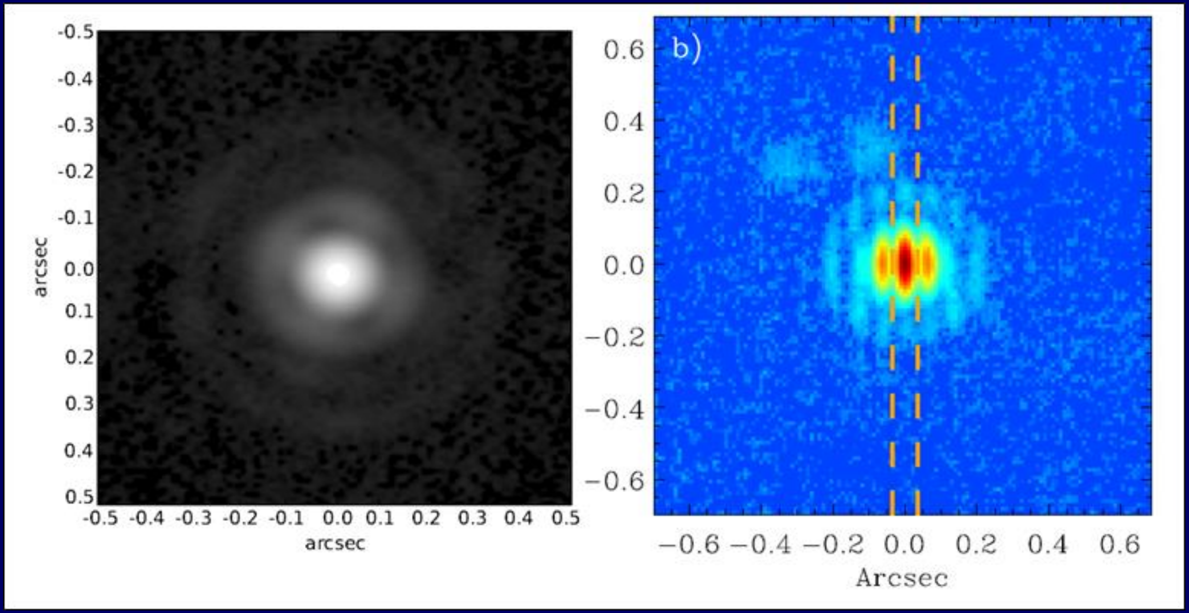
Operates at the combined focus of the LBT Interferometer. LBTI uses a cryogenically cooled beam combiner. With only 3 ambient temperature mirrors in the system, this significantly improves performance



Also NOMIC (8 – 13 μm) at LBTI focus

LMIRCam

FOV 11 x 11 arcsec,
scale 0”.011 per pixel,
PSF FWHM 0”.12



3.8μm, single mirror

4.8μm, in Fizeau interferometry mode

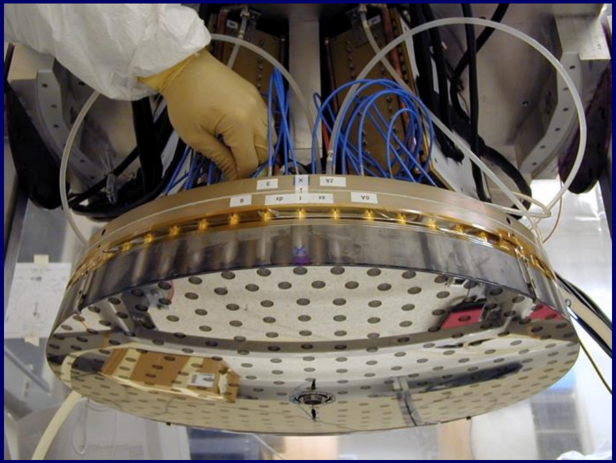
IO volcanoes – 49 mas

Performance Characteristics:

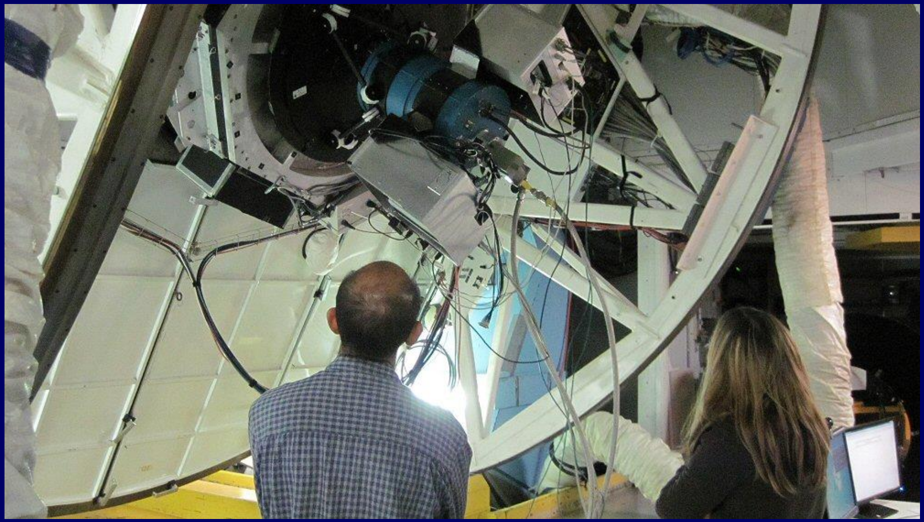
Wavelength Sensitivity	3.8μm	4.8μm
	5σ in 1 hr	5σ in 1 hr
point	18.0 mag	13.8 mag
extended	16.4m/arcsec^2	15.6m/arcsec ^{2}

MMT-POL a 1 – 4 μm imaging polarimeter (Packham et al. 2012)

AO compensation is done at the secondary, thus MMT-POL has very low instrumental polarization – 0.0% +/- 0.03% at 2.2μm

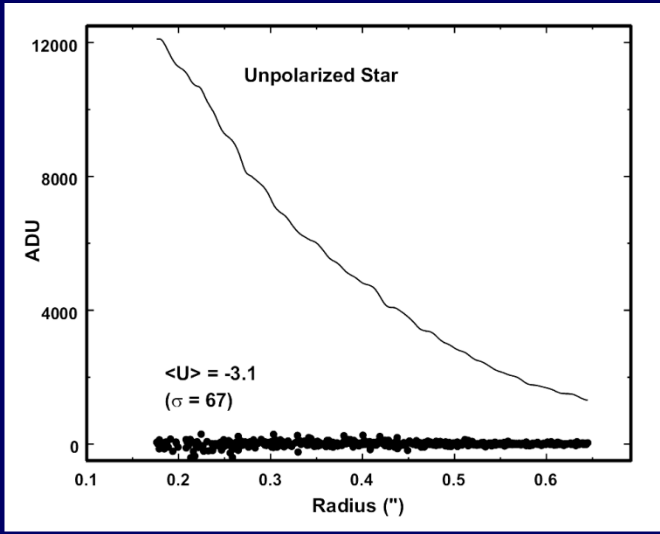


MMT Adaptive Optics Secondary Mirror



MMTPOL

Imaging in polarized intensity – the light from the star can be greatly suppressed for detection of discrete structures in CS ejecta.

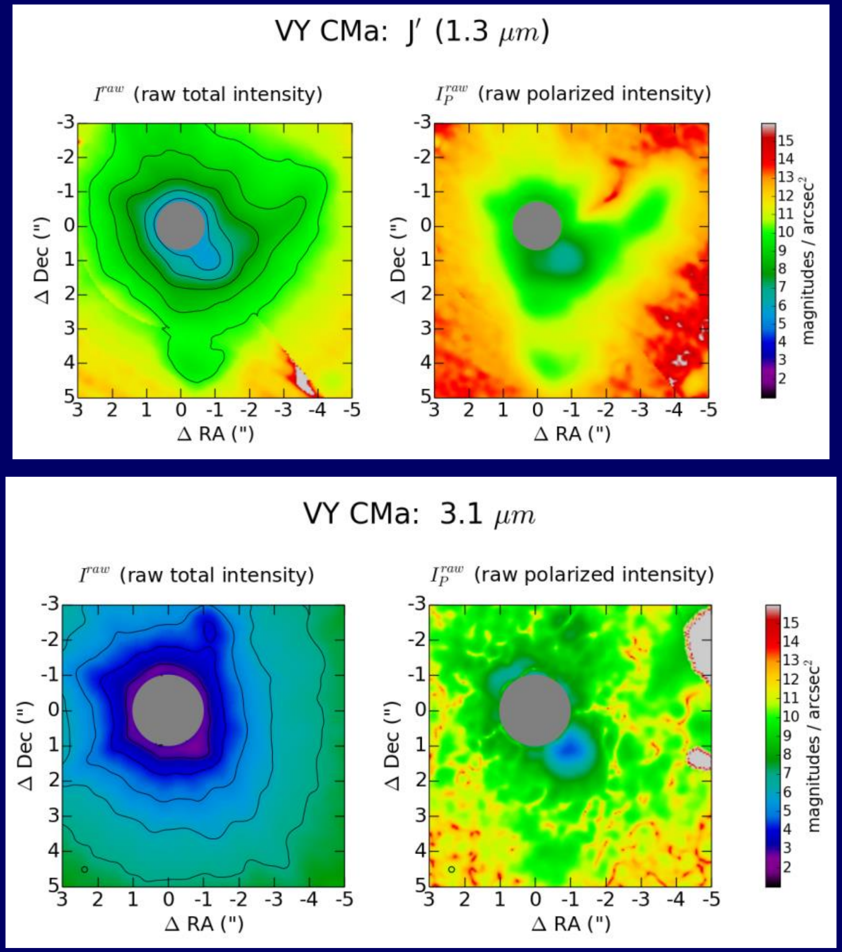


Comparison of the total intensity profile and Stokes U

MMT-POL Performance Characteristics:

Wavelength	2.2µm	3.1µm
point	14.7m, P=+/- 1% in 2hrs.	12.2mag, P +/- 1% in 2hrs.
extended	18.1m/arcsec^2, S/N 3 in 2 hrs.	15.9m/arcsec^2, S/N 3 in 2 hrs.

MMT-POL polarized intensity images -- VY CMa

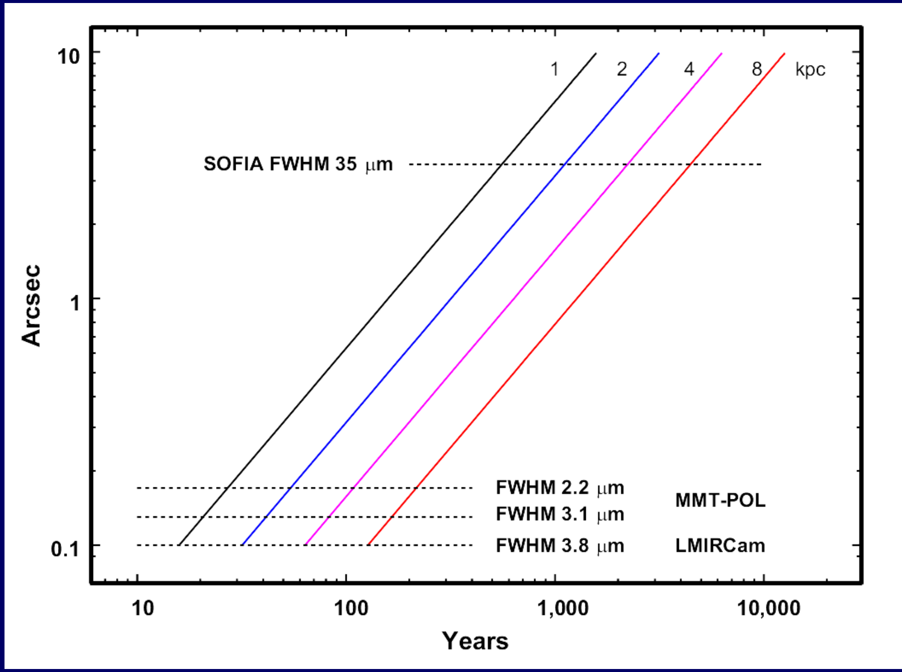


The PSF is sufficiently low at 1 arcsec from star that the fractional polarization of scattered light can be measured and we can also separate discrete features from surrounding nebulosity and dust.

We achieve the advantages of both AO imaging and imaging polarimetry

Observing strategy combines MMT-POL and LMIRCam (NOMIC)

Optical depth in scattering can be related to the ratio of the surface brightness in the ejecta to the total flux from the star in the LMIRCam images. With optical depth and distance we can estimate the dust mass and the mass loss rate. For example at 4 kpc with a 30 km/s wind, with the low instrumental polarization, we can detect mass loss rates of few x 10^{-6} M/yr at 1 arcsec, and determine mass loss histories over past 100’s to 1000 yrs. With SOFIA we can extend the timescale to 1000’s of years.



Relation between imaging resolution and travel time for dust in a 30 km/s wind.

Current and future developments

LBT – ARGOS – laser guide star system – commissioning
-- ALES -- 1.5 – 5.5μm AO Integral Field Spectrograph for LMIRCam
-- iLocator IR high precision spectrograph

MMT – MAPS – MMT AO exoplanet characterization system – including AO upgrades and infrared wavefront sensor

Many thanks to NASA and NSF