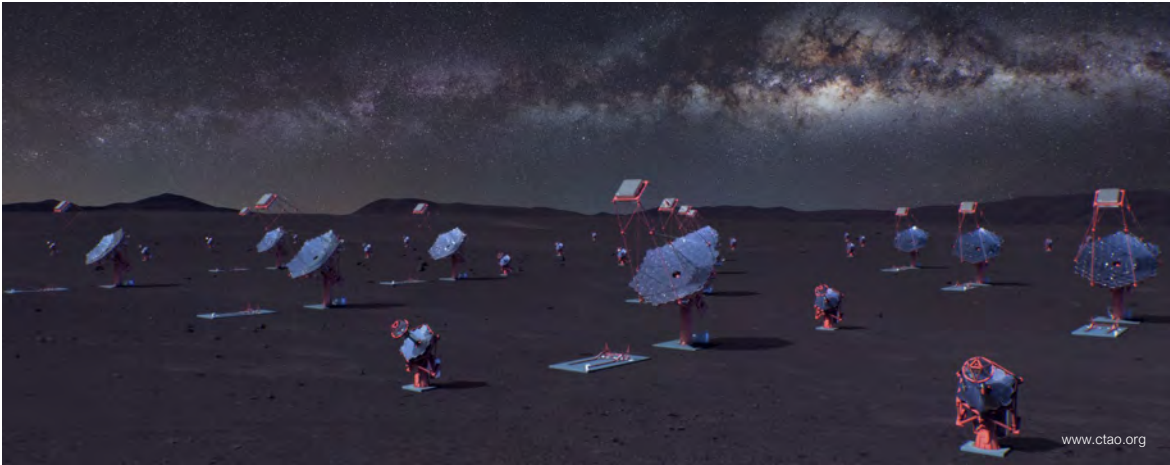


Emergent capabilities for Stellar diameter and asteroid shape measurements using the CTAO-S SST array



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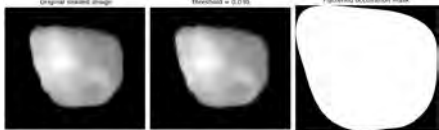


Abstract

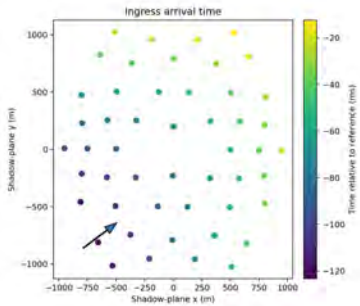
The 4-telescope VERITAS array has previously used the asteroid occultation technique to measure the angular diameters of stars as faint as 13th magnitude. Unlike Stellar Intensity Interferometry, the asteroid occultation technique has been demonstrated to measure stellar diameters on cooler classes of stars, extending the measurements of stellar radii to F and G stars. In this presentation, I will explore the possibility of using the 50 Small Size Telescopes (SSTs) in the CTAO-S array as a new type of optical astrophysical observatory, capable of measuring the angular diameters of stars to below 10 microarcseconds and reconstructing surface features and silhouettes of asteroids in the Kuiper belt. These emergent capabilities can substantially expand our knowledge of stellar evolution and structure, as well as our understanding of the origin and evolution of our solar system's asteroid population

Simulation of Asteroid Shadow passing over CTAO-S SST Array

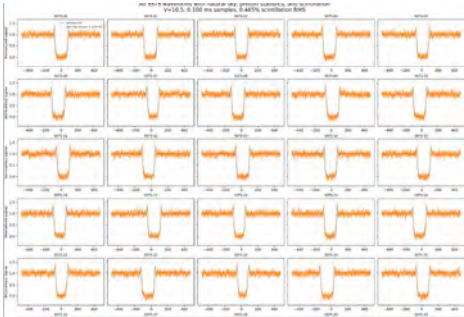
- 50 SST telescopes (4.3 m diameter) in CTAO-S array layout
- Egeria asteroid shadow shape
- 20 km/sec asteroid shadow velocity
- Occulted star located at zenith
- Photon statistics $m_v = +10.5$ 6000K blackbody
- q.e. = Hamamatsu Super-Bialkai
- Standard Dark Site Night Sky background
- Atmospheric scintillation @ Paranal (SST optics)
- 100 μ -arcsec stellar diameter
- 1 msec waveform sampling



Scaled Egeria Asteroid Shadow



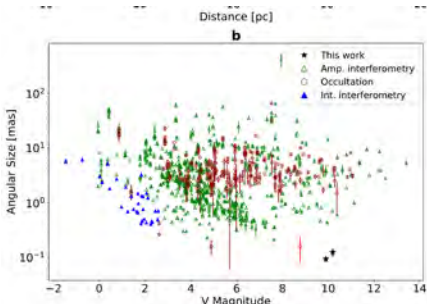
Timing of Egeria shadow across SST array



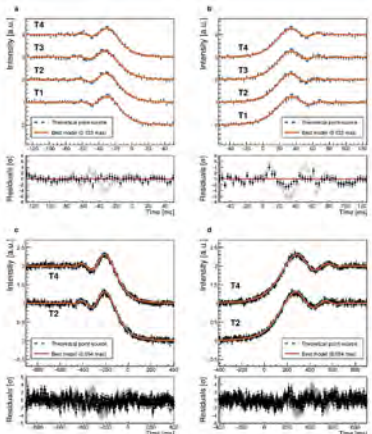
Occultations observed at different SST telescopes

VERITAS Measurement of Stellar Angular Diameters using Asteroid occultations

4 x 10 m IACT telescopes
Angular diameters $< 100 \mu$ arcsec
Stellar magnitudes $m_v \sim 10-13$



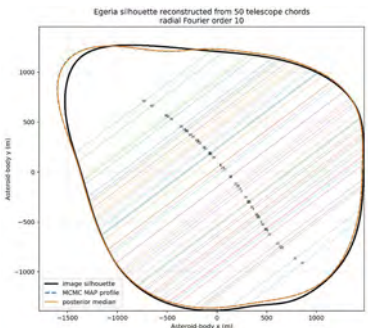
[W. Benbow et al., 2019, Nature Astronomy 3, 51]



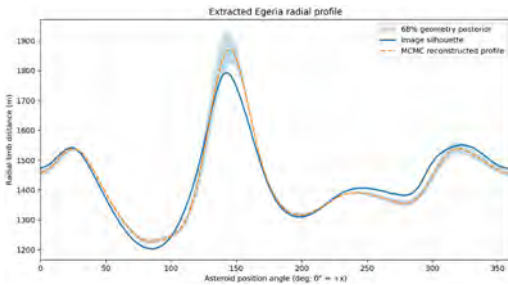
Occultation fringes and angular diameter fits

Sub - 100 μ arcsec stellar diameters $m_v > 10$

Asteroid Shape reconstruction

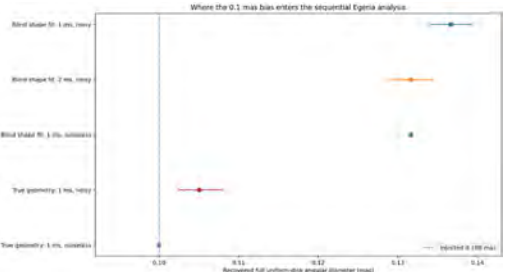


Egeria Shape determination from occultation edge timing
Reconstructed Shadow velocity = 20.0009 km/sec
RMS error of (fitted- true) shape normal = 9.78°



Reconstructed Egeria shape compared to input
Radial profile RMS error = 28.52 m

Stellar Angular Diameter Reconstruction

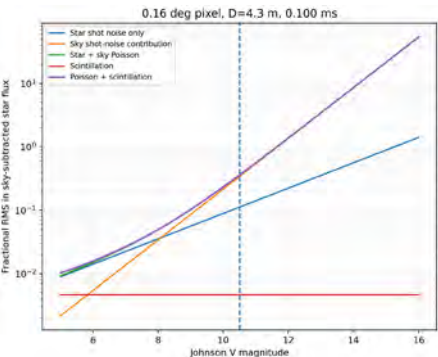


- Reconstructed stellar diameter compared to input
- Stellar angular Diameter bias Is dominated by error in Egeria Reconstructed shape normal (RMS ~ 9.78°)
- Angular diameter RMS error ~2%

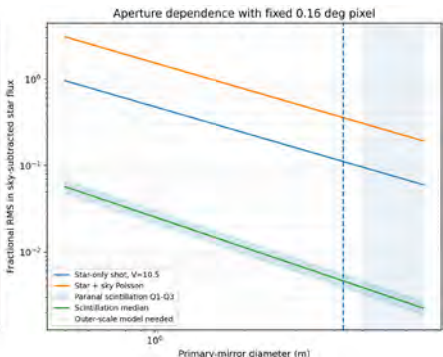
Summary

- 50 Telescope SST array allows 100 measurements of asteroid occultation
- Direct Reconstruction of small (< 1 km diameter) asteroid shapes – high fidelity
- Excellent reconstruction of dim ($m_v \sim 10-11$) ~ 50 -500 μ arcsec diameter stars,

We gratefully acknowledge support from the US National Science Foundation.



Noise contributions to SST pixels



Scintillation Noise at Paranal for 4.3 m SST