Title: The Multi Aperture Spectroscopic Telescope: Status and potential as an intensity interferometry facility

Speakers: Sagi Ben Ami

Collection/Series: Future Prospects of Intensity Interferometry

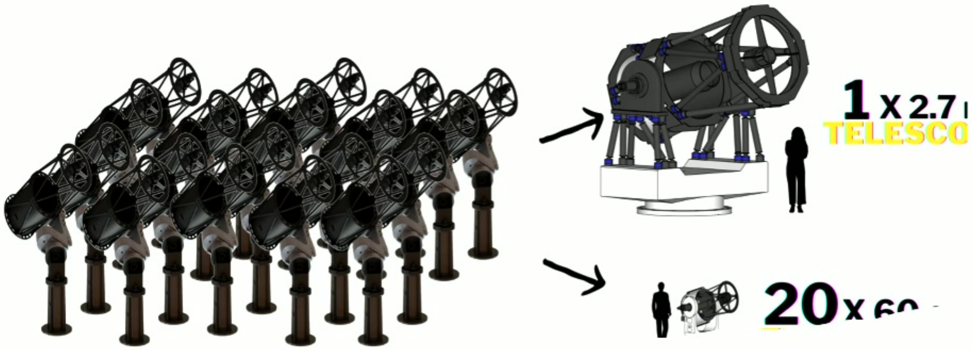
Subject: Cosmology

Date: October 30, 2024 - 1:00 PM

URL: https://pirsa.org/24100096

Abstract:

The Multi-Aperture Spectroscopic Telescope is an array of 20x60cm prime-focus telescopes with single F/3 parabolic mirrors. The telescope array is being commissioned in the Negev Desert, with 10 telescopes expected to see first light by the end of the year. In the following talk, I will present the array, its various properties, including unique fiber coupling and imaging units, and its potential as an intensity interferometry facility.



The Multi Aperture Spectroscopic Telescope as an SII facility

Sagi Ben-Ami

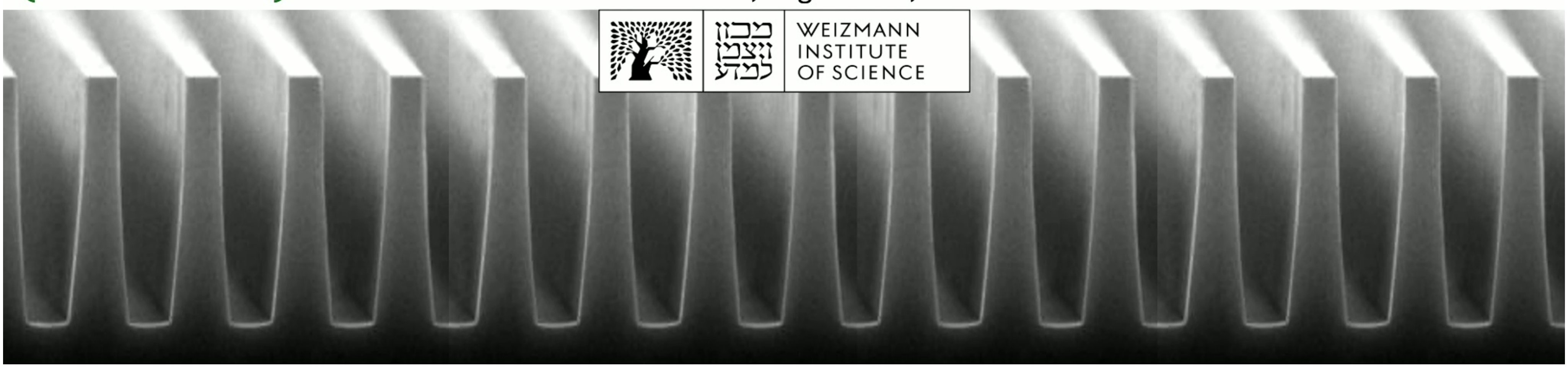
Eran Ofek, Ofer Yaron, Arie Blumzweig

Yahel Sofer Rimalt, Regev Klein, Oren Ironi

Joachim Von Zanthier
Sebastian Karl
Verena Leopold

Nick Konidaris

מכון ויצמן למדע
WEIZMANN INSTITUTE OF SCIENCE



The Grasp

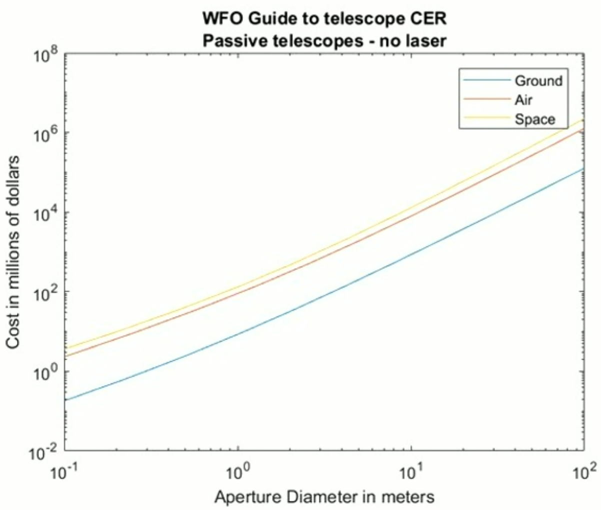
The volume of space a telescope can probe per unit time

FoV, Area, Seeing, Exp. Time, Dead Time, Background

$$\mathcal{G} \propto \Omega \left(\frac{S}{N}\right)^{-3/2} A_{\rm eff}^{3/4} B^{-3/4} \sigma^{-3/2} \frac{t_{\rm E}^{3/4}}{t_{\rm E} + t_{\rm D}}$$

$$\left(\frac{\rm S}{\rm N}\right) = \sqrt{\int_0^\infty 2\pi r dr \frac{F^2 A_{\rm eff}^2 t_{\rm E}^2}{B A_{\rm eff} t_{\rm E}} \frac{e^{-r^2/(\sigma^2)}}{4\pi^2 \sigma^4}} = \frac{F A_{\rm eff} t_{\rm E}}{\sqrt{4\pi\sigma^2 B A_{\rm eff} t_{\rm E}}}.$$

Ofek & Ben-Ami (2020)



$A_{eff}^{3/4}$ is the main factor influencing cost, assuming you can obtain small enough pixels....

Cost$\propto D^{2.45}$ (Belle et al. 2021)

Cost$\propto D^{1.96}$ (ATW)

$\rightarrow \mathcal{g} \propto D^3$

The Large Array Survey Telescope (LAST)

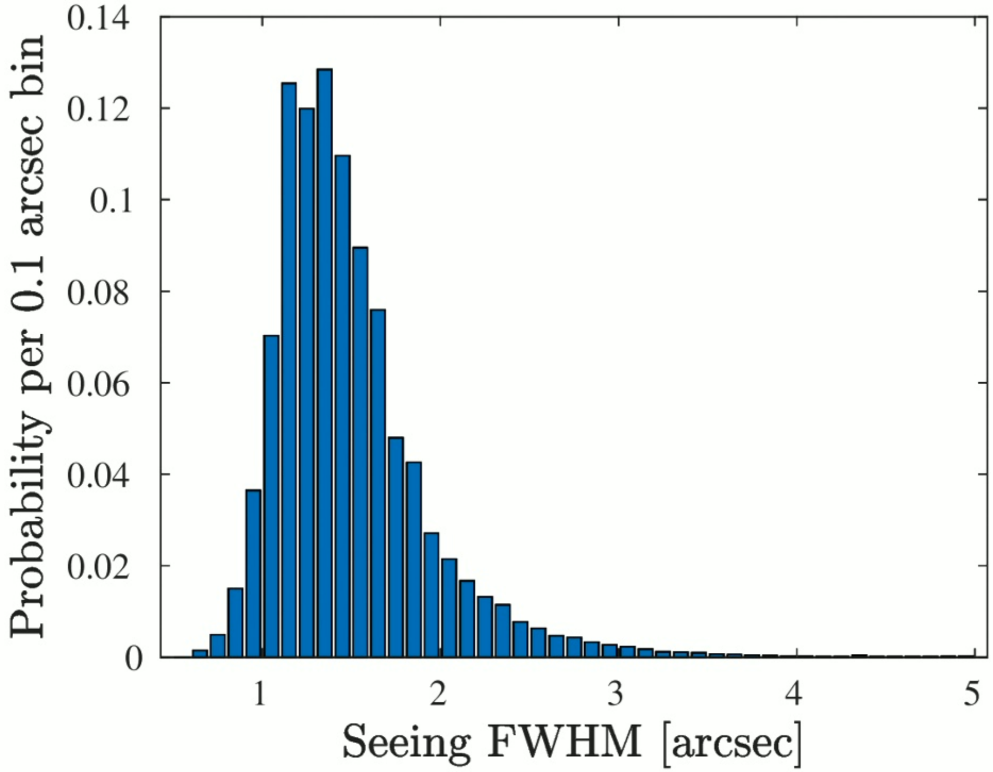
- PIs: Ofek + Ben-Ami
- A node: 48 × 28 cm F/2.2 telescopes from Celestron.
- Each telescope w/BSI CMOS, 1.2”/pix, 7.4 deg^2
- Equivalent to:
  - 1.9 m telescope w/7.4 deg^2 (narrow mode)
  - 28 cm telescope w/355 deg^2 (high grasp, wide mode)

- Ofek, E.O, Ben-Ami, S., et al. (2023)
- Ben-Ami, S., Ofek, E.O., et al. (2023)

The site: WAO @ Neot Semadar



The site: WAO @ Neot Semadar

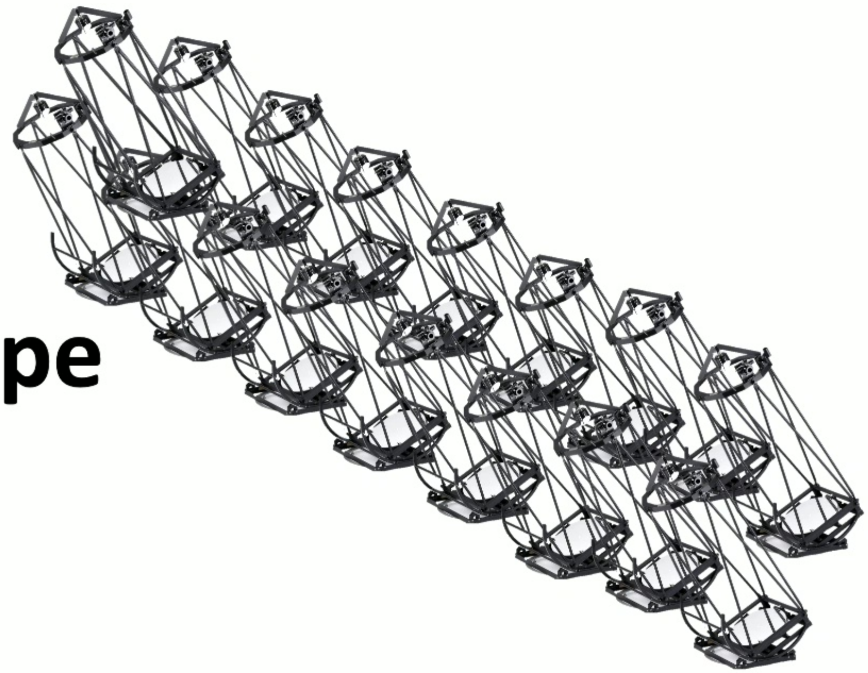


MAST
The Multi Aperture Spectroscopic Telescope

- We need a dedicated spectroscopic facility.
- Spectroscopy requires large, expensive telescopes that takes years to develop and build.

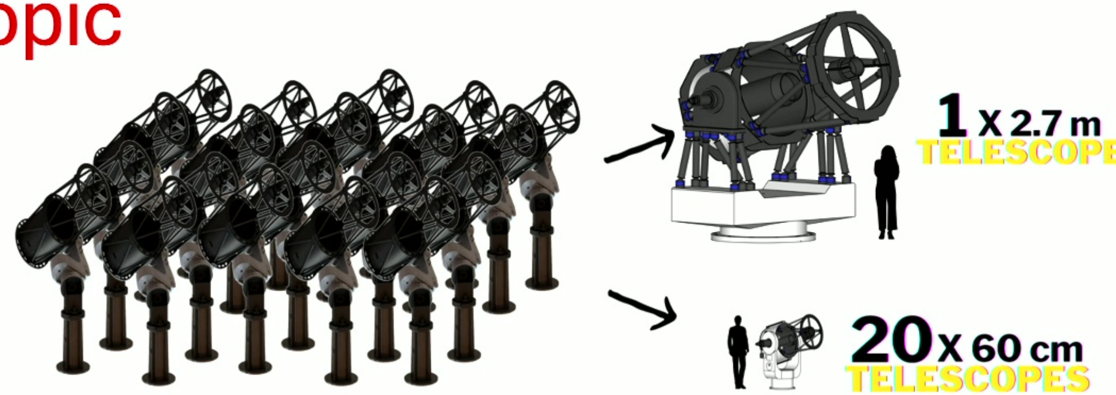
MAST

The Multi Aperture Spectroscopic Telescope

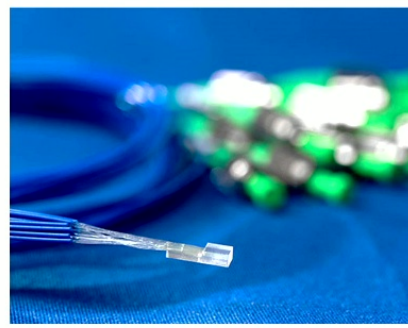


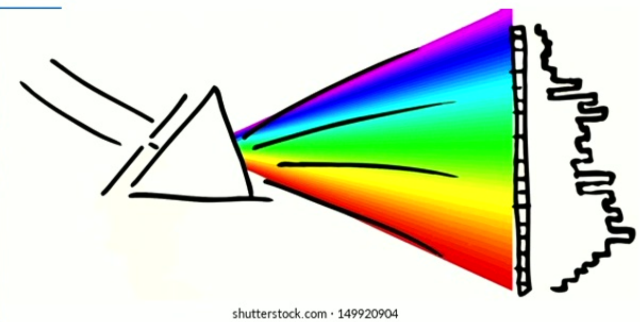
- We need a dedicated spectroscopic facility.
- Spectroscopy requires large, expensive telescopes that takes years to develop and build.
- We can manufacture small telescopes fast and efficiently.
- We adopt the LAST approach and combine the beam from multiple telescopes.
- $20 \times 60 cm\ telescopes$: **Equivalent to one 2.7 m telescope for 10% of the cost**.
- Develop a suit of instruments that will allow us to study various science cases.

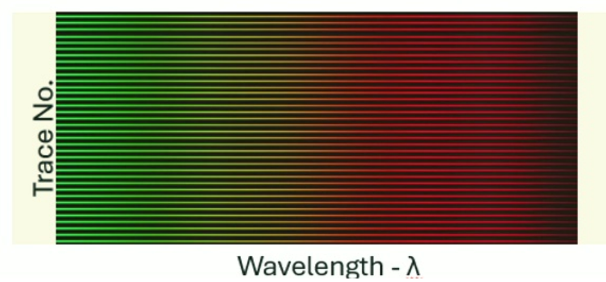
Multi Aperture Spectroscopic Telescope



- Array of $20 \times 24\ inch$ telescopes
- Collecting power of a $2.7m$ telescope.
- Order of magnitude reduced cost.



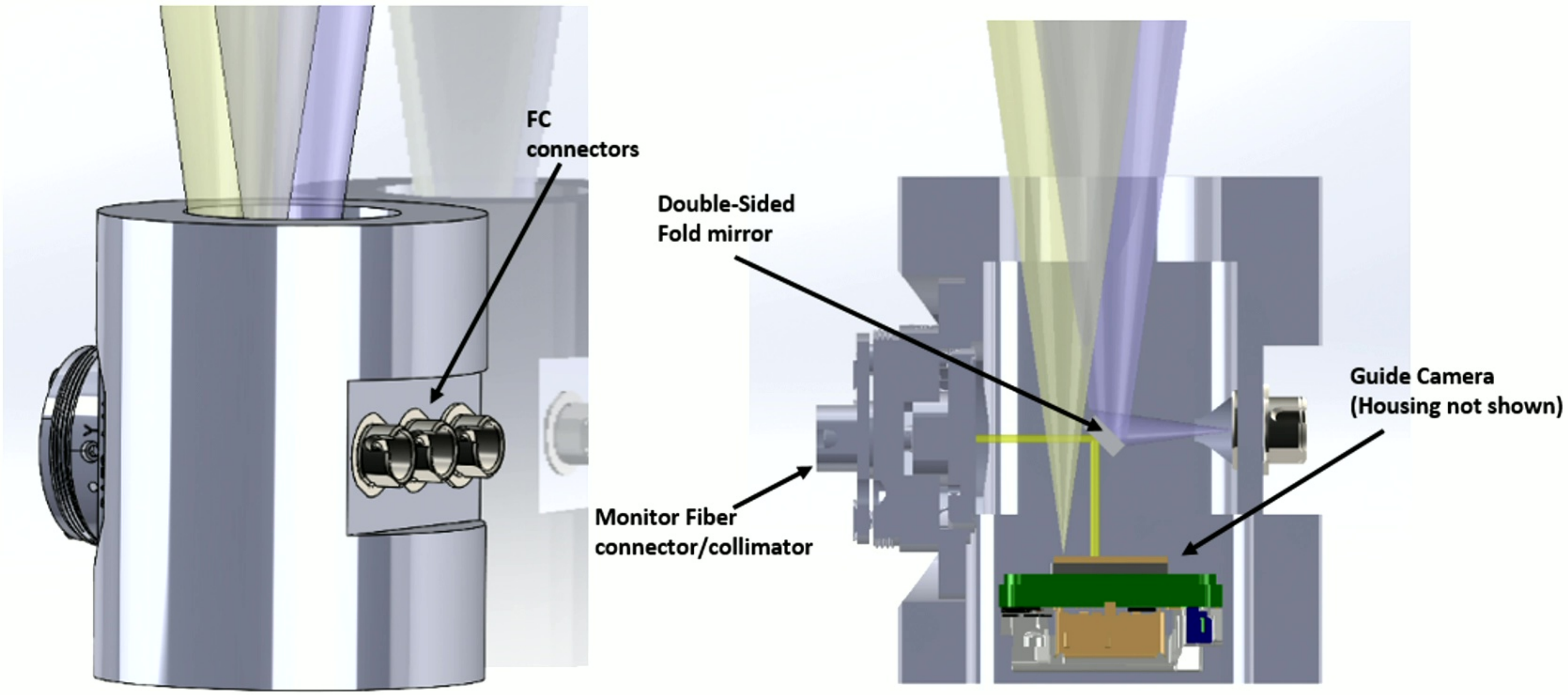


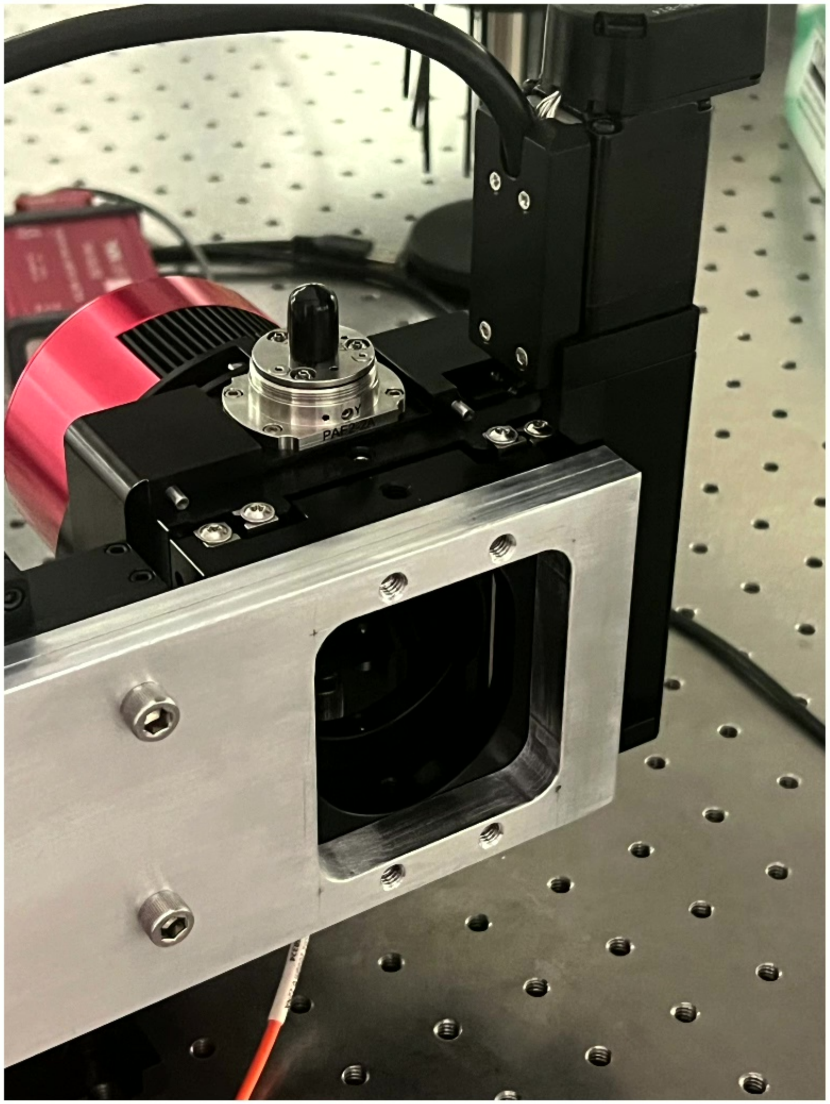


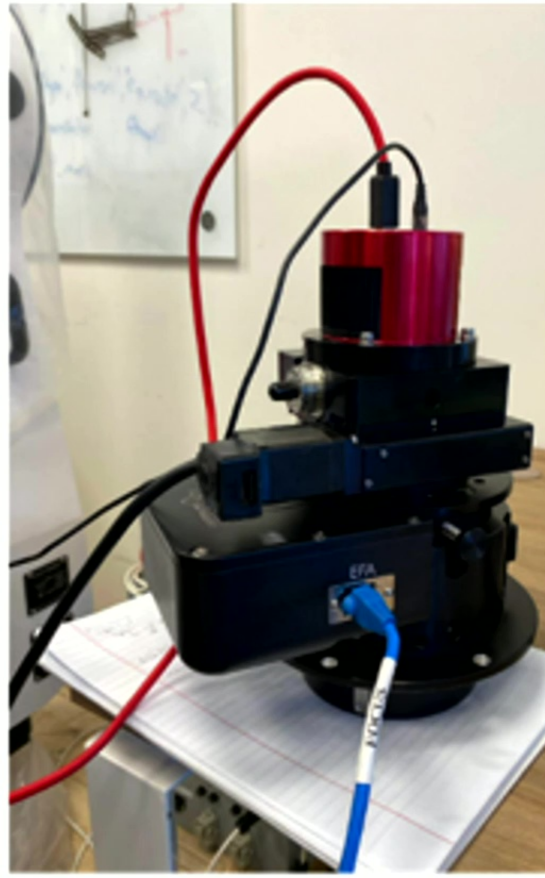
Telescopes

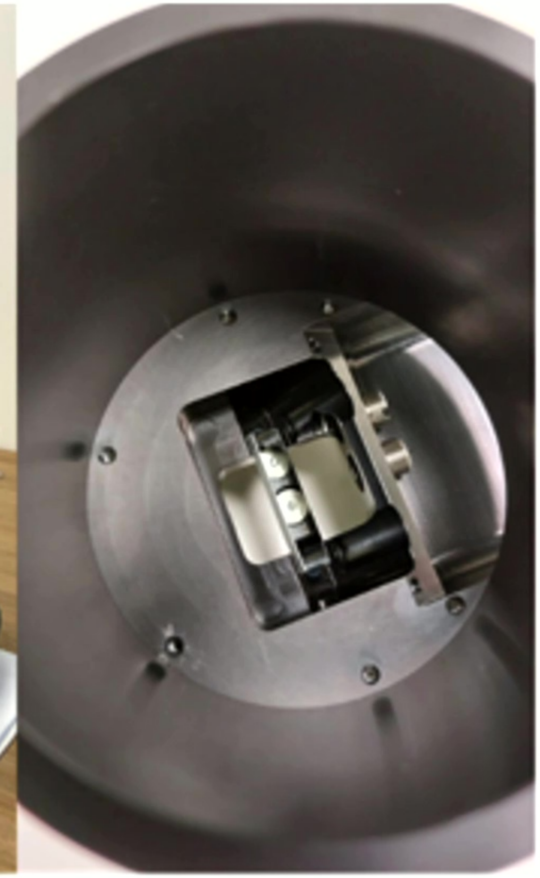
- The most simplistic telescope for maximum efficiency: A single parabolic mirror, prime focus telescope at F/3.
- The fast beam is optimal for FM/MM fiber feed with minimal focal ratio degradation.
- Simple robust telescope: Fused silica primary, L-550 direct drive mount, and a high duty Hendrik focuser in prime focus.
- First 10 telescopes completed, tested and approved for shipping.
- Additional 10 telescopes on order
- Full deployment – end of 2025.

Fiber Coupling Unit

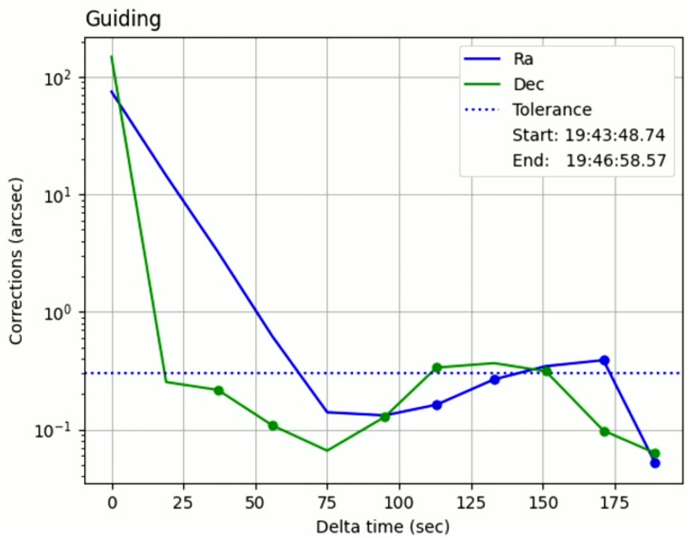


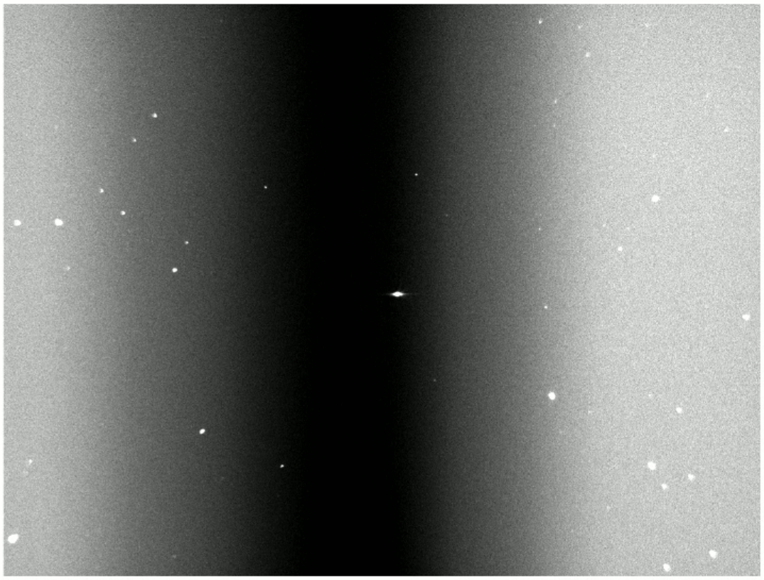


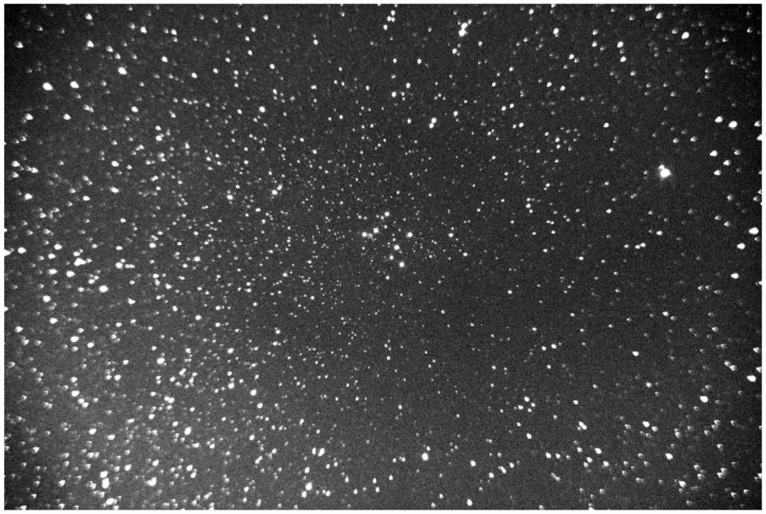




Telescope Guiding



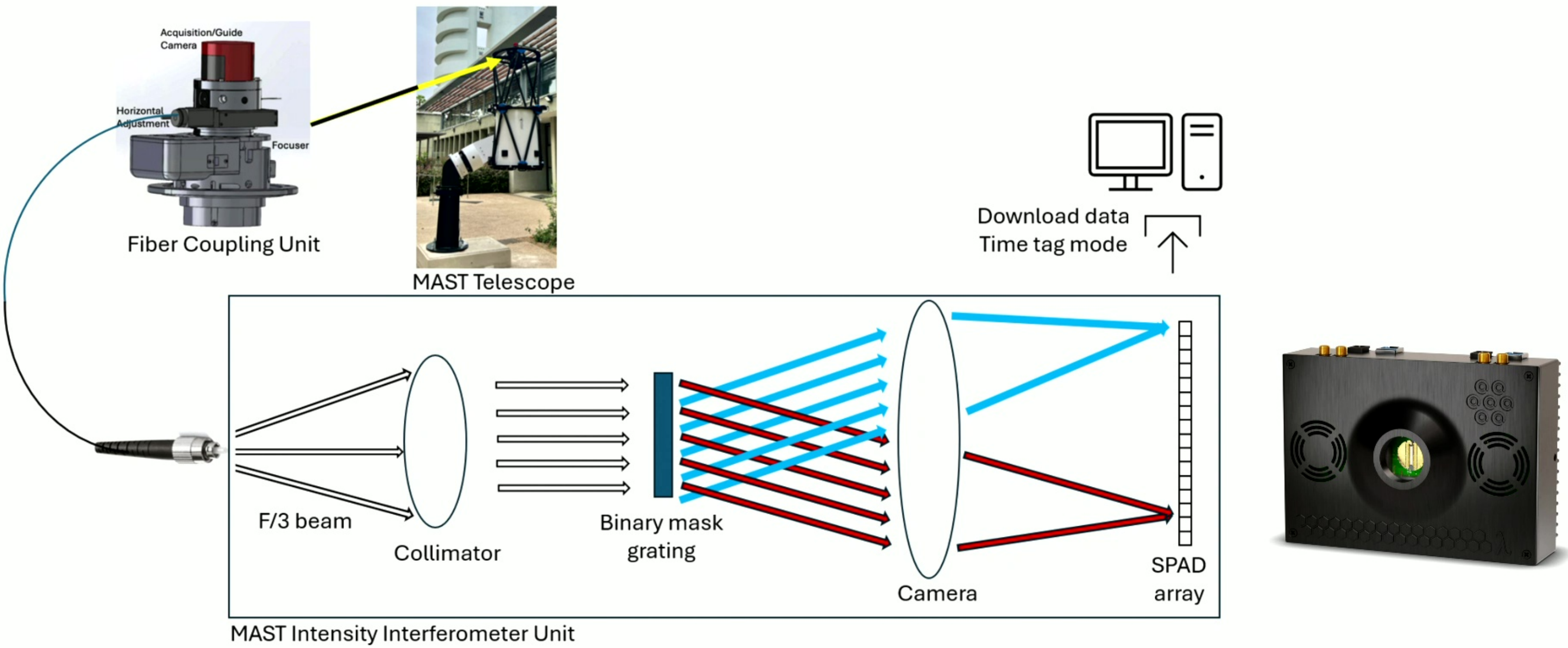




- Seeing during test: 3arcsec

Changing baselines

SII unit for MAST



SII with MAST

- Stellar Intensity Interferometer allows us to achieve high angular resolution, without the need to align instruments at a sub-wavelength precision.
- The S/N of a measurement is

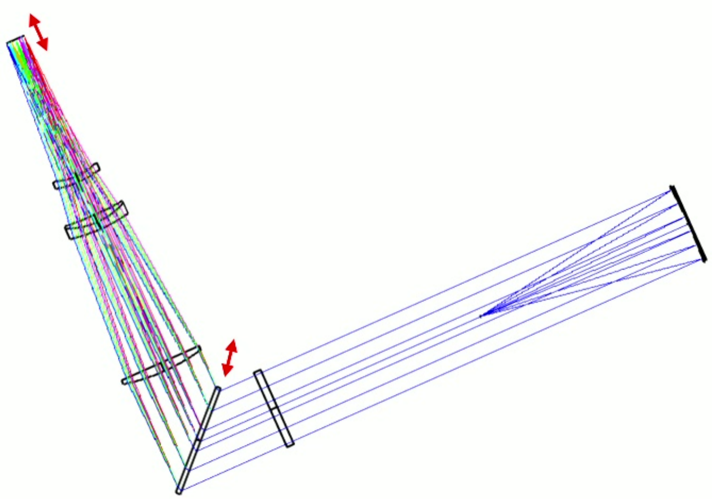
$$\left(\frac{\boldsymbol{S}}{\boldsymbol{N}}\right)_{tel} = \frac{\boldsymbol{g}^2(\boldsymbol{\tau} = 0)}{\sqrt{\boldsymbol{M}}} \propto \boldsymbol{A\alpha\eta}\sqrt{\frac{\boldsymbol{t}}{\boldsymbol{\Delta T}}}$$

- MAST has the potential to increase the S/N by two orders of magnitude due to high aperture multiplcity and by using spectral multiplexing.

$$\left(\frac{\boldsymbol{S}}{\boldsymbol{N}}\right)_{\substack{spectroscopic\\array}} \propto \sqrt{\boldsymbol{N_{tel}}(\boldsymbol{N_{tel}} - 1)\boldsymbol{N_{spec}}}\left(\frac{\boldsymbol{S}}{\boldsymbol{N}}\right)_{tel}$$

HighSpec:

A Novel High Spectral Resolution Spectrograph



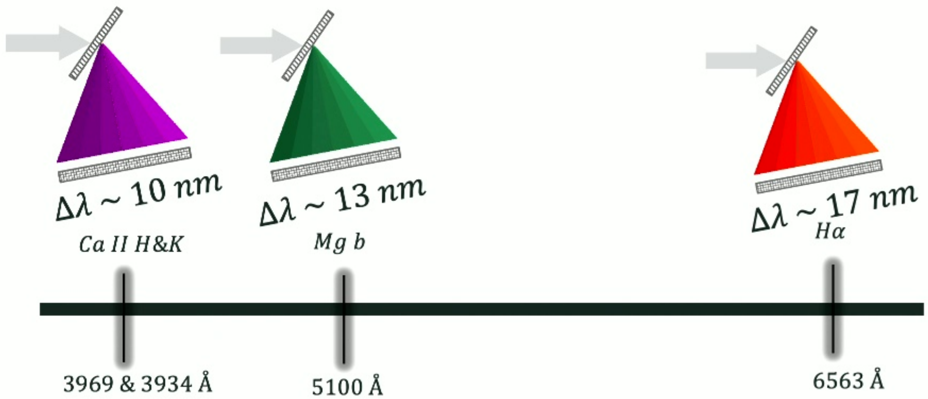
Sofer-Rimalt, Y., et al. (2024) Proceeding of the SPIE

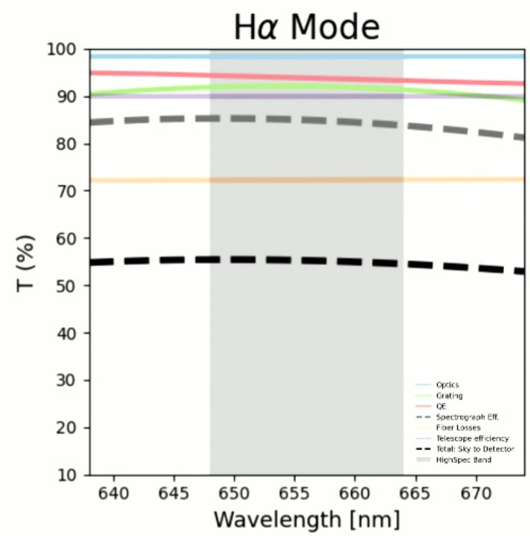
High resolution: $R = \frac{\lambda}{\Delta\lambda} \sim 21{,}000$

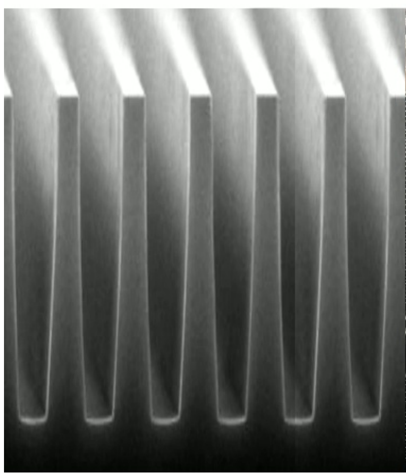
End-to-End efficiency: **>55%**

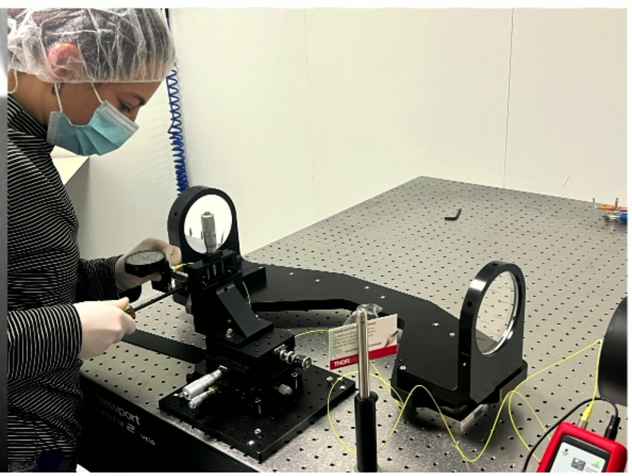
Tailor-made for high-impact Scientific studies

HighSpec:
High Resolution – High Efficiency







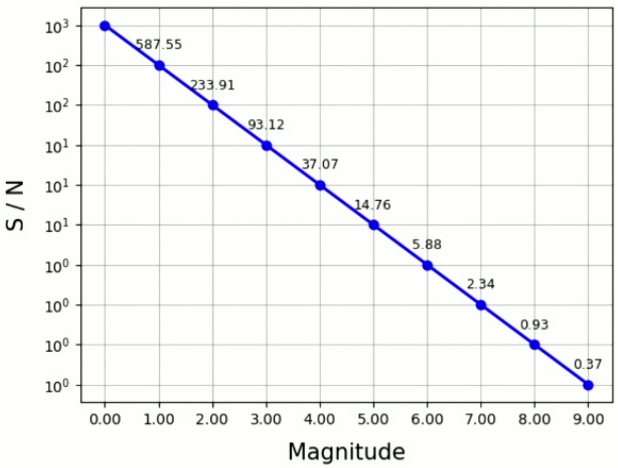


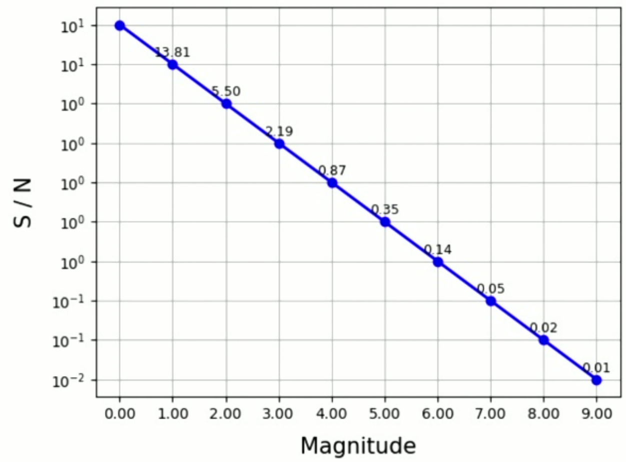
$30pm$ resolution element

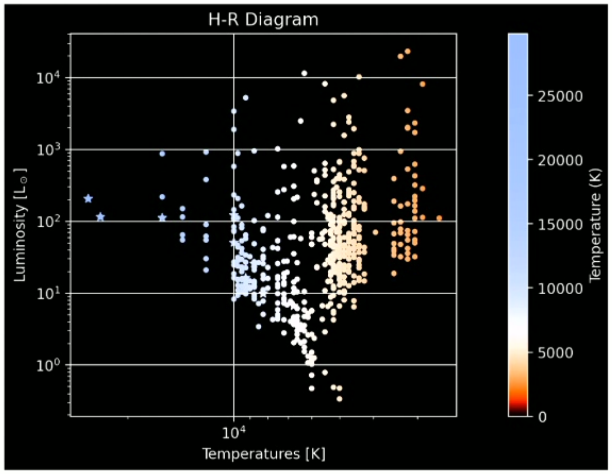
↓

High contrast in the correlation function

S/N – SII with MAST







So what do you think?

We welcome feedback/suggestions/ harsh criticism/comments!!!