

# The Large Array Survey telescope



**Nora Linn Strotjohann**  
on behalf of the LAST team

Ready, Set, Go!  
GW workshop Berlin  
2023-05-09

<http://www.weizmann.ac.il/wao/>



# The Large Array Survey telescope



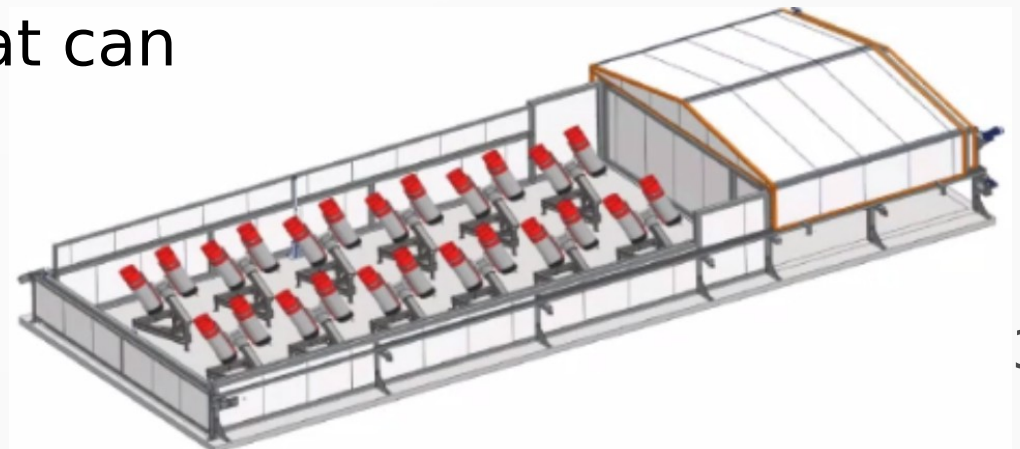
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# Idea

- optimize for survey speed (Ofek & Ben-Ami 2020) → shallow and wide
- many small, off-the-shelf telescopes instead of building a single large one is  $\sim 30$  times cheaper
- aperture  $> 20\text{cm}$  to be limited by seeing instead of diffraction
- short focal length (F/2.2) for a wide field of view
- need camera with small (4 micron) pixels to sample the PSF
- system feasible since a few years due to low-noise CMOS cameras with small pixels and computers that can process large amounts of data





# Site of the Weizmann Astrophysical Observatory

- Kibbutz Neot Smadar in the South of Israel
- excellent seeing, usually clear sky and low humidity
- Dusty, skybrightness degraded to 20.6 mag/arcsec<sup>2</sup>
- building start: February 2022



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CELESTRON  
ROWE-ACKERMANN  
F12.2 SCHMIDT ASTROGRAPH

LAST

LAST 1.8.2

LAST 1.6.3

LAST 1.6.3

LAST 1.6.2

LAST

LAST 1.6.1

LAST 1.6.0

1.6 West



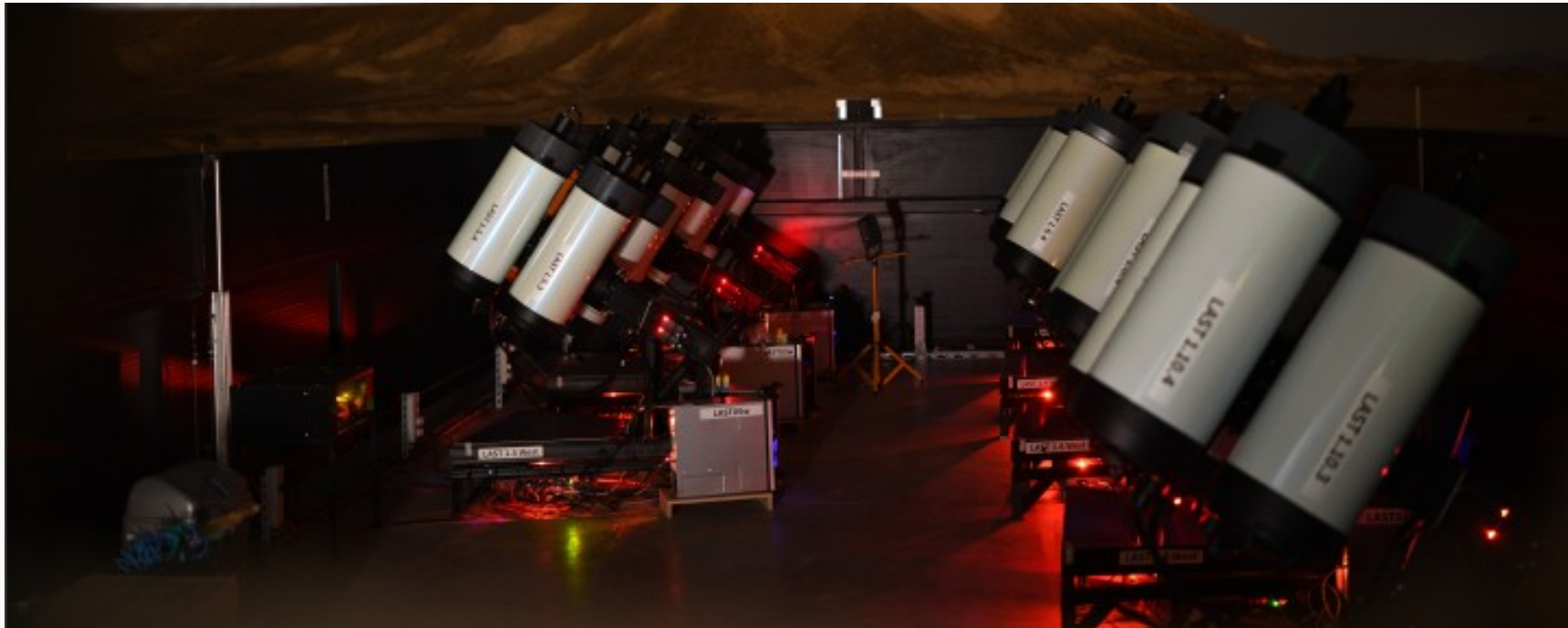
# LAST Design

- 12 units with 48 telescopes
- 28-cm diameter mirror Celestron with F/2.2
- Parallel: 1.9m telescope with 7.4 sqdeg or in open mode 28cm telescope with 355 sqdeg FoV
- Default visit: 20 20s exposures
- Limiting mags: 19.6 in 20s, 21 in 20x20s
- Unfiltered for maximal light, closest to the Gaia B-band
- Strategy: high- and low-cadence survey, ToOs



# LAST data rate

- Raw data: 8000 imgs/hour or 0.9 TB/hour → comparable to LSST
- Processed data: 2.3 TB/hour  
→ will keep only coadds, catalogs, maybe cutouts; delete individual images and raw images after 2 months





# LAST pipeline

- Image processing done in real time on computers that control unit
- 2 cameras per computer
- Images cut into 24 subimages (1700x1700 pixels): more precise astrometry & calibration, small data products

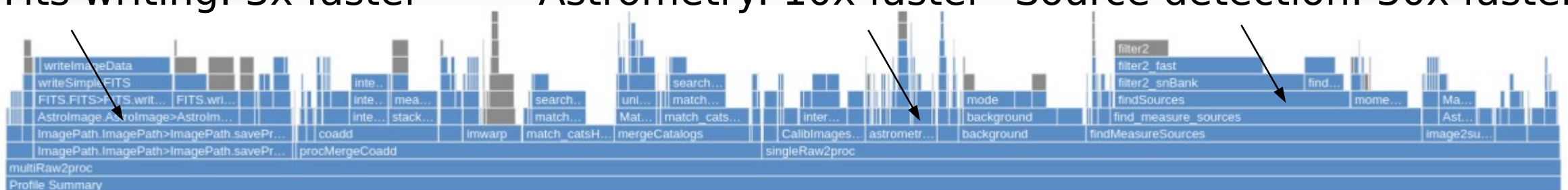


**Single visit (20x20s) processed in <5min for extragalactic fields**

Fits writing: 3x faster

Astrometry: 10x faster

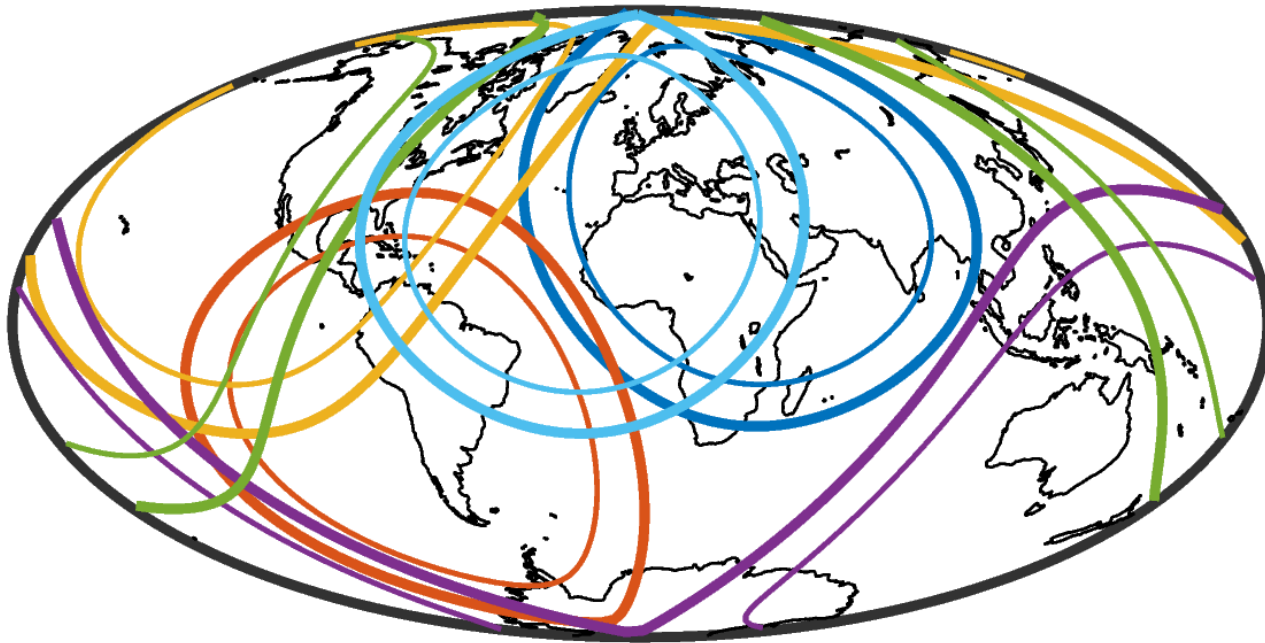
Source detection: 30x faster



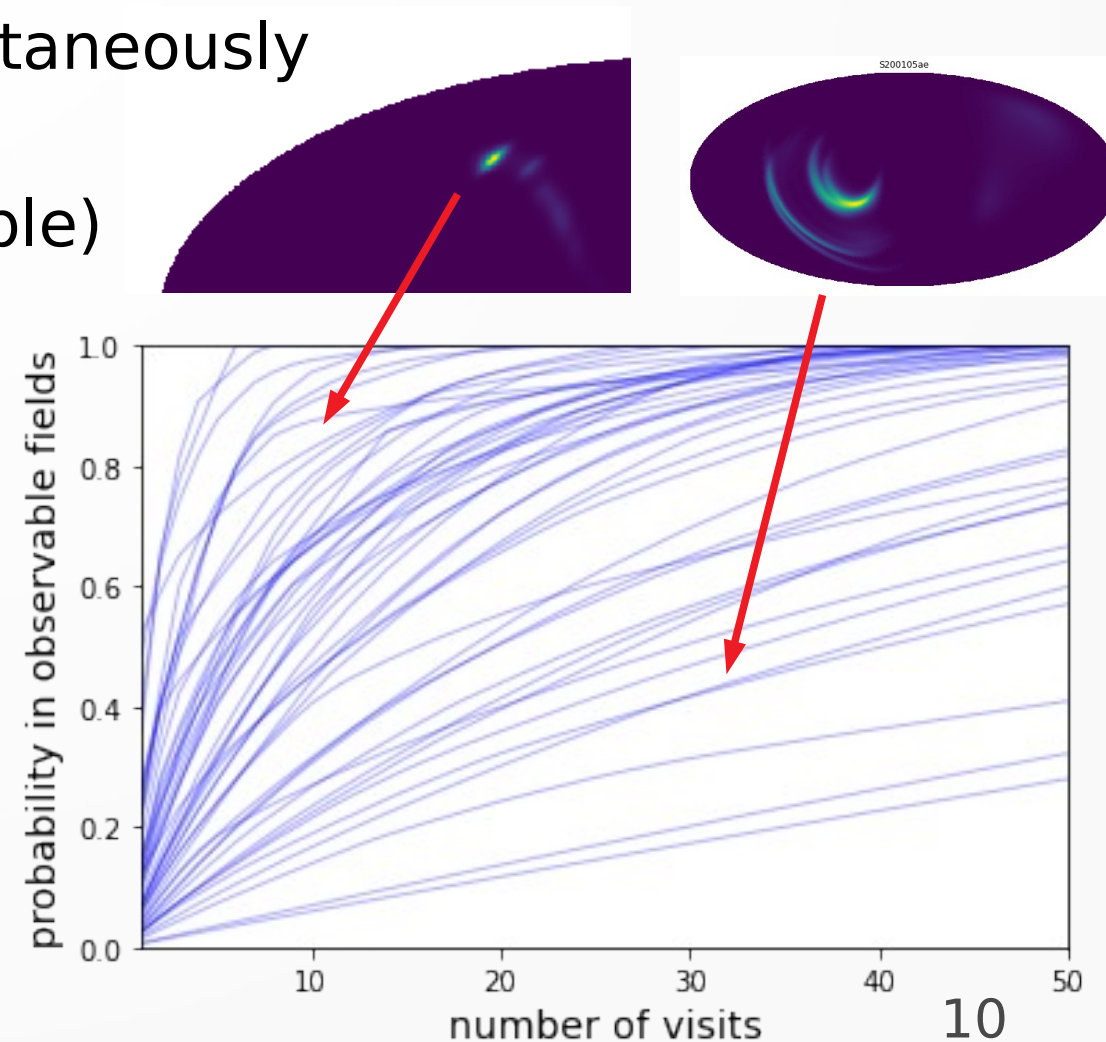


# Gravitational-wave follow-up with the Large Array Survey Telescope

- LAST fills in the Asiatic gap
- 12 units can cover 350 sqdeg instantaneously
- for 20x20s visit: single unit covers 250 sqdeg/hour (shorter visits possible)



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# Current status

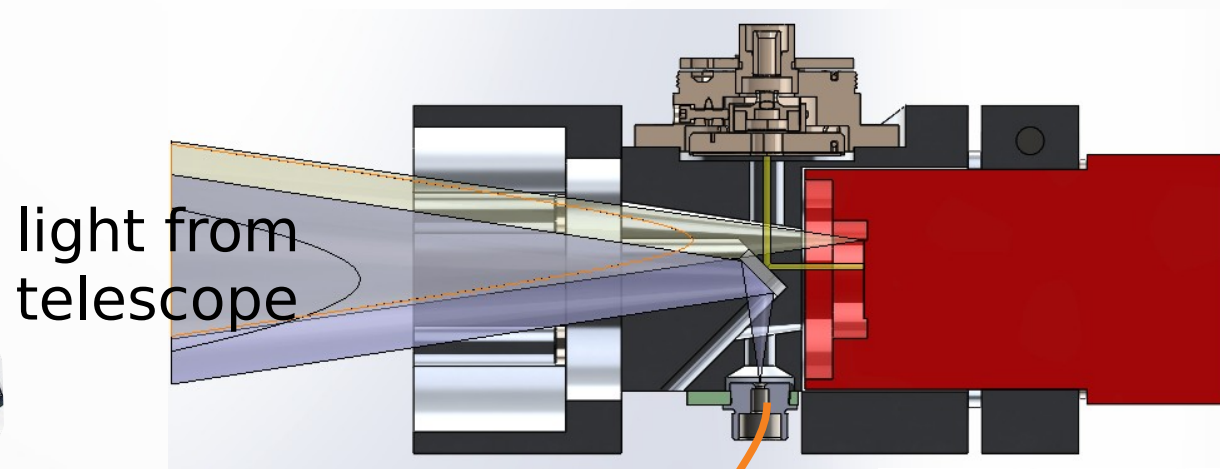
- Under commissioning, 32 telescopes deployed
- Individual mounts operate largely autonomously
- photometric pipeline and forced photometry working
- Still missing:
  - remote operation (roof!)
  - communication between units
  - image subtraction





# Synergy with future telescopes

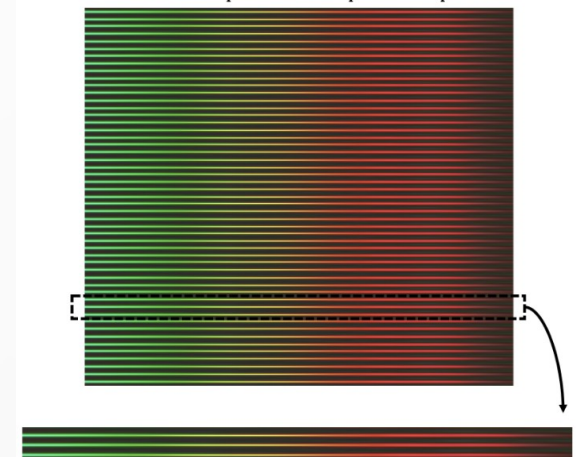
- Multi-Aperture Spectroscopic Telescope (MAST): optical fibers feed light from many 60cm telescopes into a single spectrograph



25 micron  
(2.4 arcsec)  
optical fiber

to spectrograph

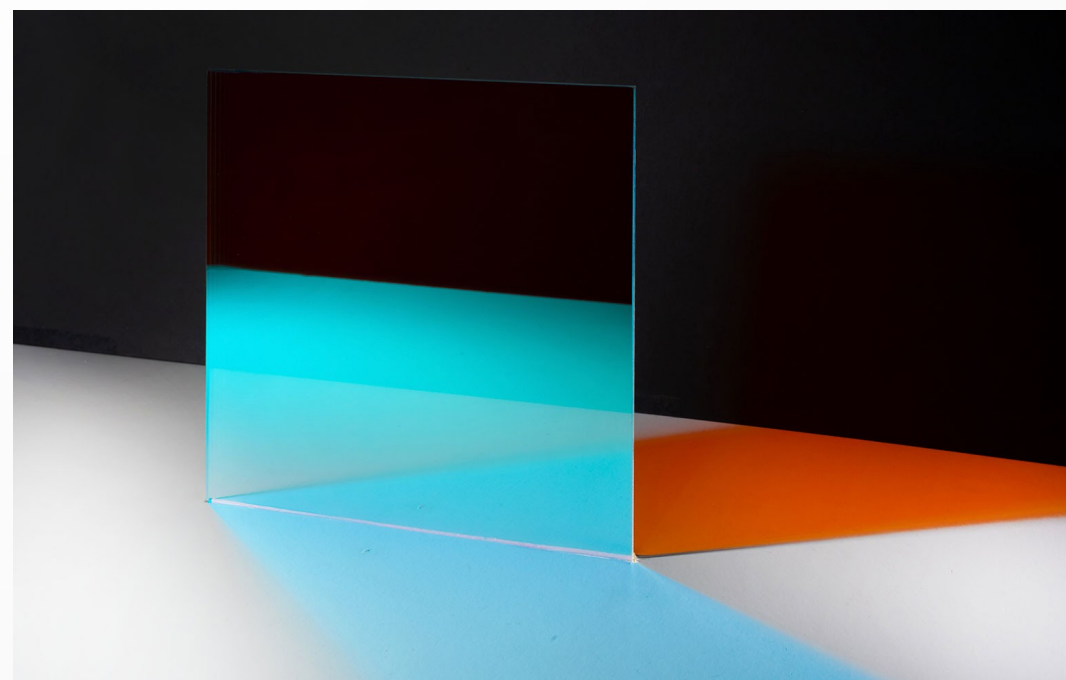
HighSpec Image Plane: 51 traces  
17 telescopes  $\times$  3 traces per telescope





# Synergy with future telescopes

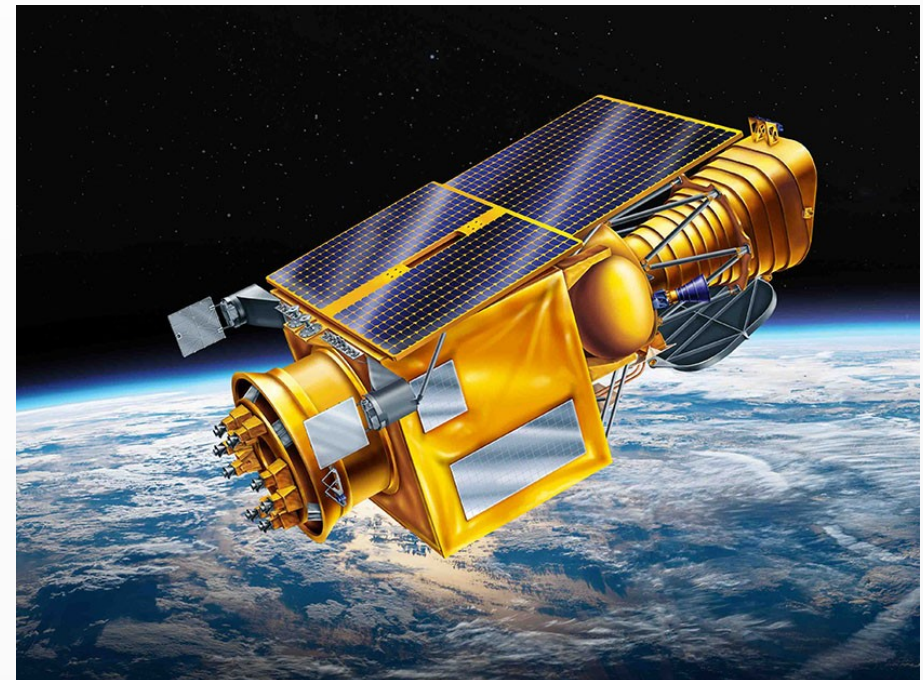
- Multi-Aperture Spectroscopic Telescope (MAST): optical fibers feed light from many 60cm telescopes into a single spectrograph
- Panchromatic Survey Telescope (PAST): more sensitive telescopes with dichroics and several cameras for photometric follow-up





# Synergy with future telescopes

- Multi-Aperture Spectroscopic Telescope (MAST): optical fibers feed light from many 60cm telescopes into a single spectrograph
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- ULTRASAT: UV telescope with 200 sqdeg field of view (launch in late 2026)





# Science projects during LAST commissioning

- Late-time monitoring of SNe Ic and FBOTs (Ping & Erez)
- Monitoring of white dwarfs: search for binaries or planets (Yarin)
- All-sky survey once a month: reference building and slow transients/variables (Nora)
- Near-Earth Astroids: measure rotation periods, elongation, etc. (David & Eran)
- Occultations: search for rings around asteroids or minor planets (David & Eran)
- Polarization survey: support for CTA (Bochum & Desy groups)
- Minute-scale blazar variability: constrain size of emission region (Simone)



# Submitted papers

- "The Large Array Survey Telescope - System Overview and Performances" <https://arxiv.org/pdf/2304.04796.pdf>
- "The Large Array Survey Telescope - Science Cases" <https://arxiv.org/pdf/2304.02719.pdf>
- "The Large Array Survey Telescope - Pipeline. I. Basic Image Reduction and Sub Visits Coaddition"
- "Observational characterization of the ejecta from the DART-Dimorphos impact"
- <http://www.weizmann.ac.il/wao/>

