Enhancements to the LCO NEO Follow-up Network for rapid characterization

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The LCO NEO Follow-up Network is using the global robotic telescopes of Las Cumbres Observatory (LCO) to perform astrometric, photometric and spectroscopic characterization of Near Earth Objects (NEOs). The distribution of telescopes around the world and the combination of remote & robotic telescopes with flexible scheduling, allows for rapid response characterization of newly discovered NEOs. We describe recent development efforts at LCO which have resulted in the deployment of a new 4 channel simultaneous imager (MuSCAT3) and the upcoming deployments of four more 1-meter telescopes which will complete the Northern ring of telescopes.

The LCO Network

LCO has operated the two 2m FT's since 2005. Starting in March 2012, the following telescopes are now deployed and operating:
- 2m FTN & FTS low-resolution ($R\sim400$, $320-1000$ nm) FLOYDS spectrograph. FTS has 10'x10' FOV imager (+18 filters) & FTN has **new MuSCAT3 4 channel imager (see right).**
- Ten 1m telescopes have 26'x26' FOV CCD with 21 filters – **four more 1-m's coming; 2 to Tenerife in 2021, 2 to Ali (Tibet) in 2022**.
- Ten 0.4-m telescopes with CCD imagers deployed.
- LCO/NOAO Open Access time available – through regular NOAO TAC call.

2m FTN (home of MuSCAT3) on Maui (Hawai'i)

1m telescope at McDonald Observatory (Texas)

2m FTS at Siding Spring Observatory (Australia)

LAS CUMBRES OBSERVATORY GLOBAL TELESCOPE NETWORK
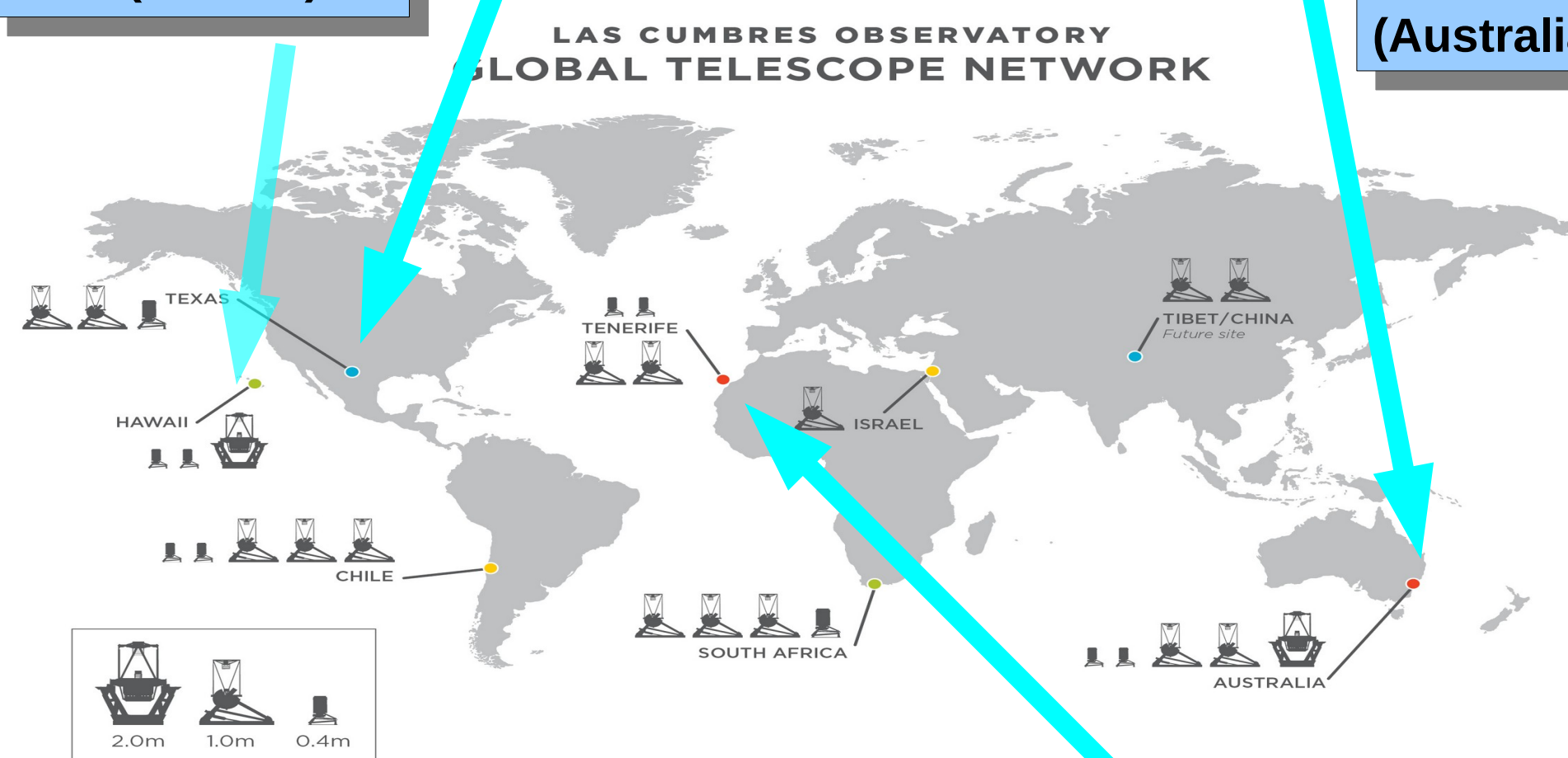
Network map of LCO facilities
The two 1-m's for the Tenerife site have been shipped (April 2021) and will be installed and commissioned in Summer 2021. PlaneWave 1-m class telescopes for the site at Ali in Tibet/China are undergoing testing for future deployment.

Two of LCO's 0.4-m telescopes inside their clamshell enclosure at the LCO Node on Tenerife in the Canary Islands.
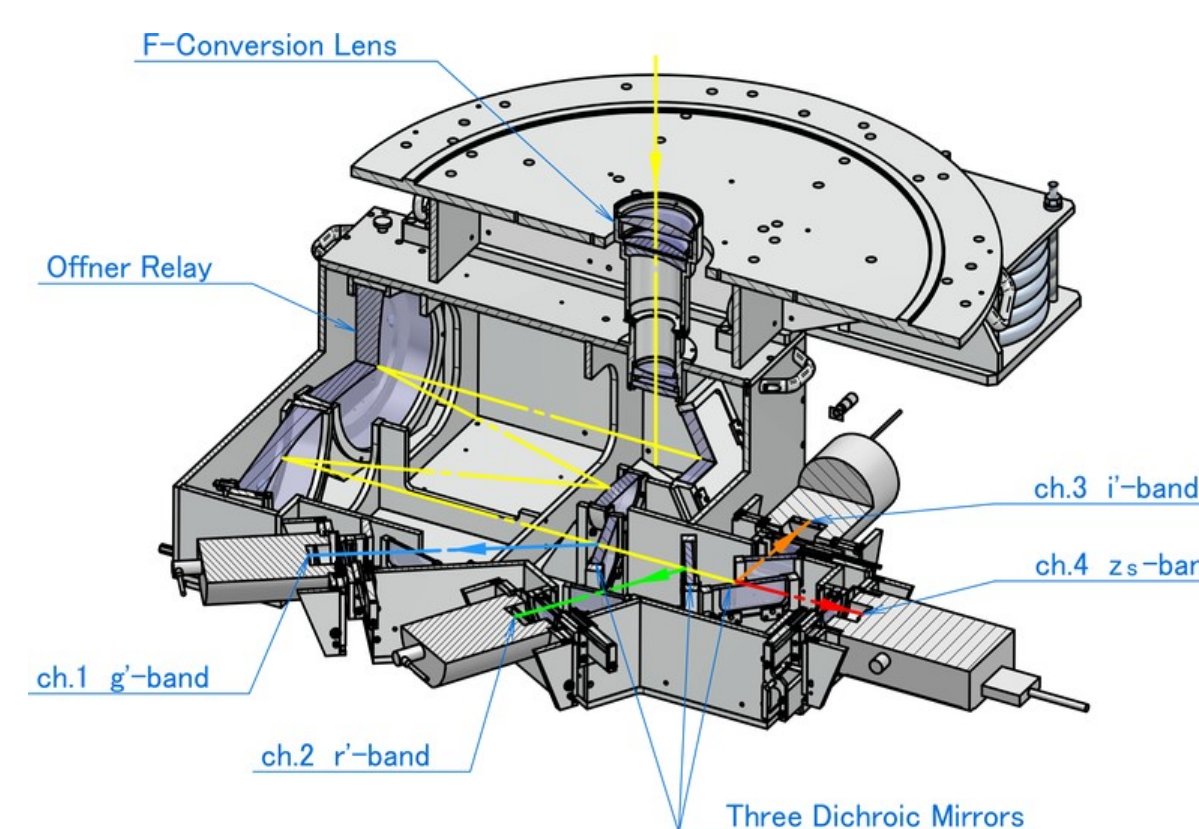
New Capabilities

The MuSCAT3 Instrument

- New 4-channel imager called MuSCAT3 (Narita et al. 2020) deployed to 2-m FTN on Maui, HI.
- Clone of the previous MuSCAT (Narita et al. 2015) and MuSCAT2 instruments (Narita et al. 2019)
- Performs simultaneous imaging in Sloan g', r', i', z_s filters.
- Commissioning completed in 2020 November.
- Upgrade of CCD camera in z_s to originally planned Princeton Instruments SOPHIA with better QE and lower readnoise completed in 2021 March.
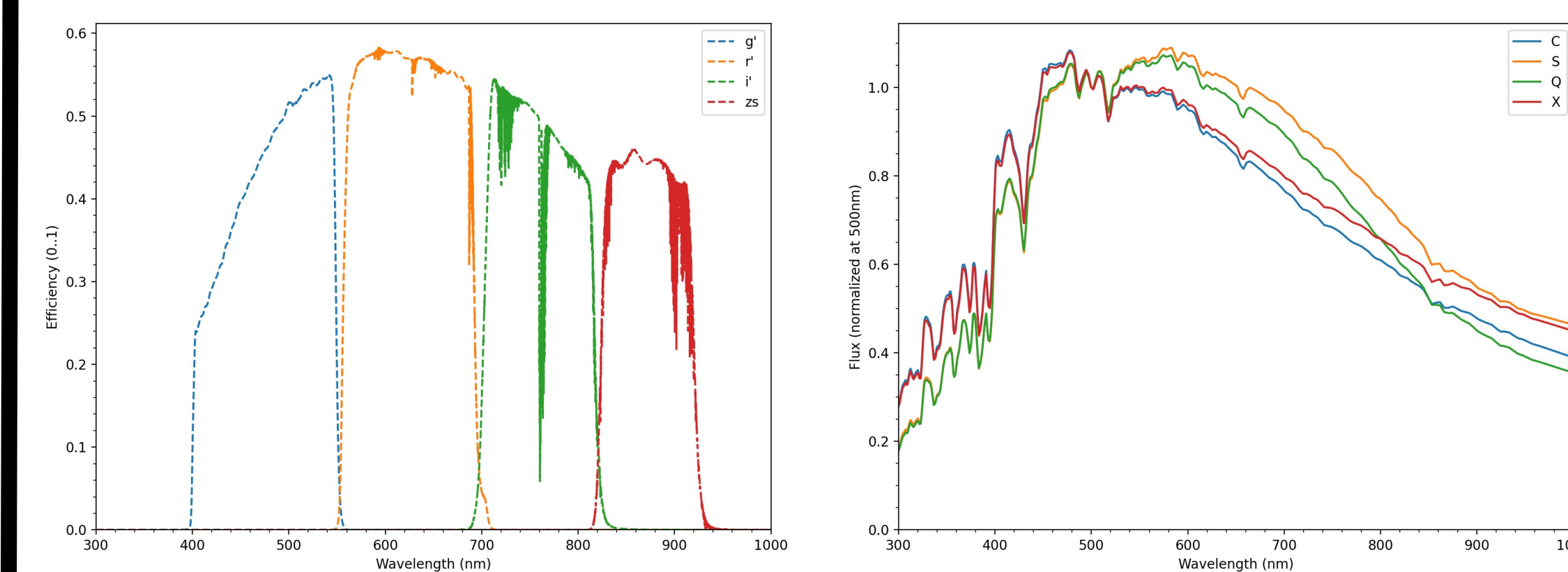

A rendering of the MuSCAT3 instrument with light entering from the top in the center of the mounting flange, passing through an Offner relay and through 3 dichroic beamsplitters into the 4 CCD camera channels.

The MuSCAT3 instrument installed on the Cassegrain port of the LCO 2m Faulkes Telescope North (FTN) in Maui, HI. The FLOYDS low resolution spectrograph is installed on the same telescope on a side port and can be quickly switched to in approximately 1 minute.

Use of MuSCAT3 for taxonomic classification

The combined throughput including airmass 1.2 atmosphere + telescope + instrument (optics, beamsplitters, filters, CCD) of the FTN 2m telescope & MuSCAT3 instrument is shown above (left).
We also plot C, S, Q, X asteroid taxonomic types, which are some of the most common types among NEOs, from the Bus-DeMeo taxonomy (DeMeo et al. 2009).
Observation of NEOs through the Sloan g', r', i', z_s filters of MuSCAT3 from the robotic and rapid response FTN (trigger→on-sky in <10 minutes) should allow separation of bulk taxonomic classes in g'-r' and i'-z_s color space. This will allow the rapid characterization of NEOs which are too faint for spectroscopy or have short windows of visibility. It will also allow short term rotational variability to be studied in 4 bands simultaneously.

Future Upgrade and Rapid Characterization

- LCO plans to seek funding for MuSCAT4 for FTS in Australia
- Would harmonize instrumentation, creating powerful follow-up facilities in both hemispheres.
- Observing in MuSCAT's 4 channels simultaneously dramatically improves the effective throughput of the telescope.
- Allows measuring color and albedo variations on rapidly rotating NEOs with truly simultaneous observations in multiple passbands, removing rotational or viewing angle uncertainties.
- Low resolution FLOYDS spectrographs allows rapid taxonomic typing and automated pipeline goes from observation→ interactive reflectance spectra in web browser.
- FLOYDS and MuSCAT on LCO 2m's plus the now global 1m network allows rapid observation and characterization of NEOs "any time".

References

1) Narita et al., 2020, SPIE Proceedings Volume 11447, Ground-based and Airborne Instrumentation for Astronomy VIII; 114475K
2) Narita et al., 2015, Journal of Astronomical Telescopes, Instruments, and Systems 1, 045001
3) Narita et al., 2019, Journal of Astronomical Telescopes, Instruments, and Systems 5, 015001
4) DeMeo et al. 2019, *An Extension of the Bus Asteroid Taxonomy into the Near-Infrared*, Icarus, 202, pp. 160-180.