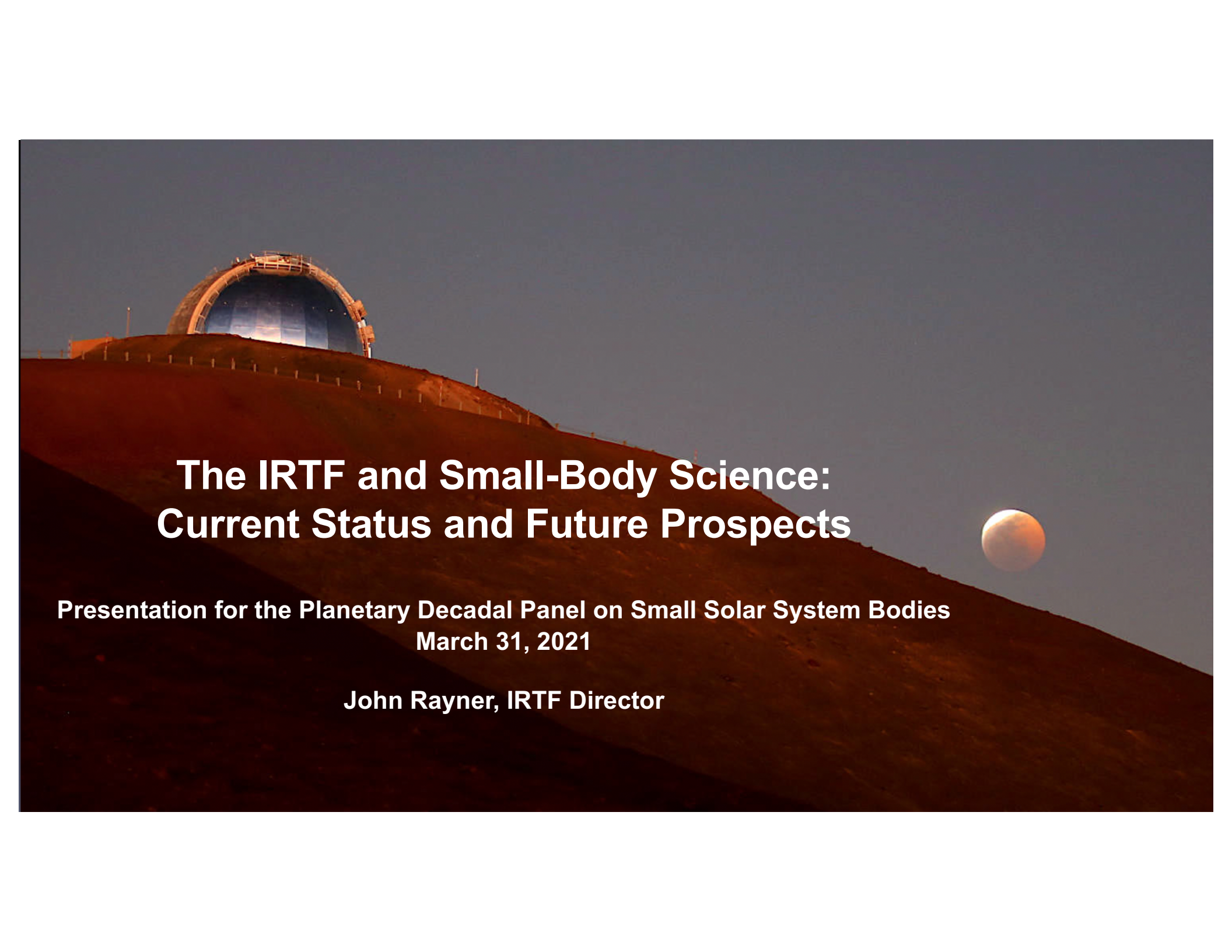


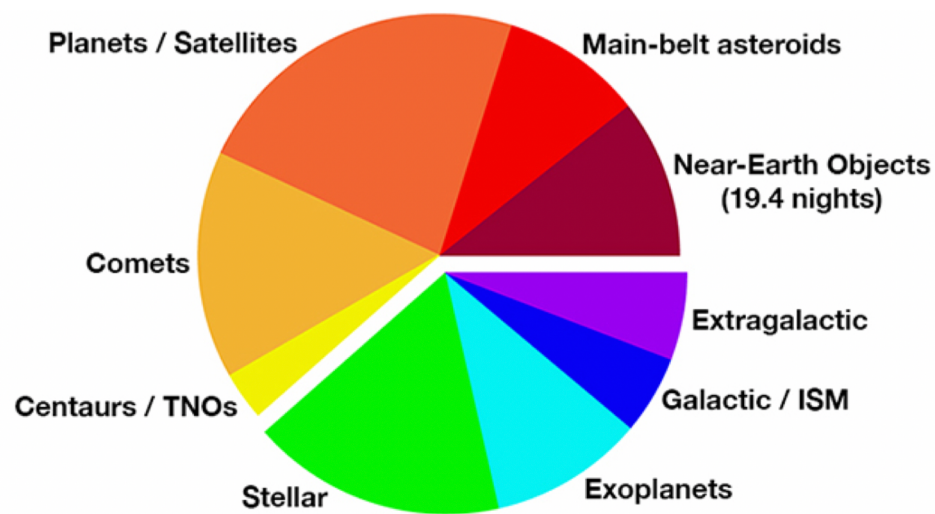


The IRTF and Small-Body Science: Current Status and Future Prospects

**Presentation for the Planetary Decadal Panel on Small Solar System Bodies
March 31, 2021**

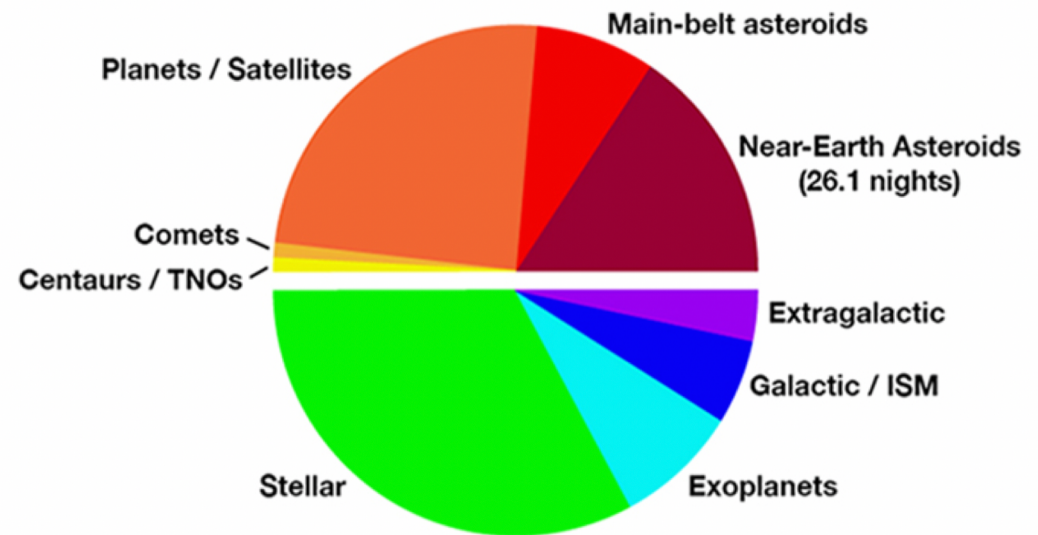
John Rayner, IRTF Director

Distribution of Awarded Observing Time



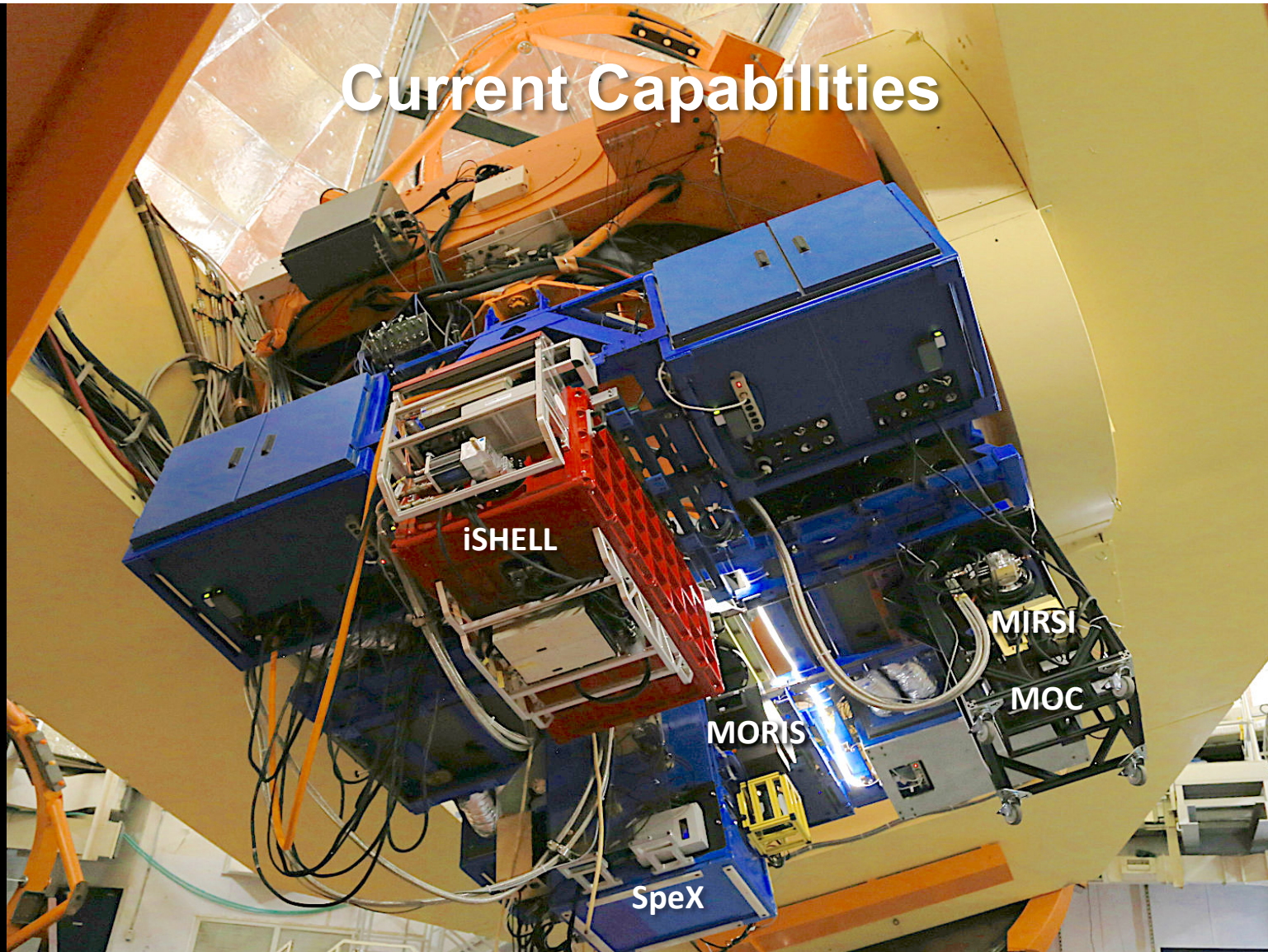
2018B

~30% of observing time to
small-body science



2020B

Current Capabilities



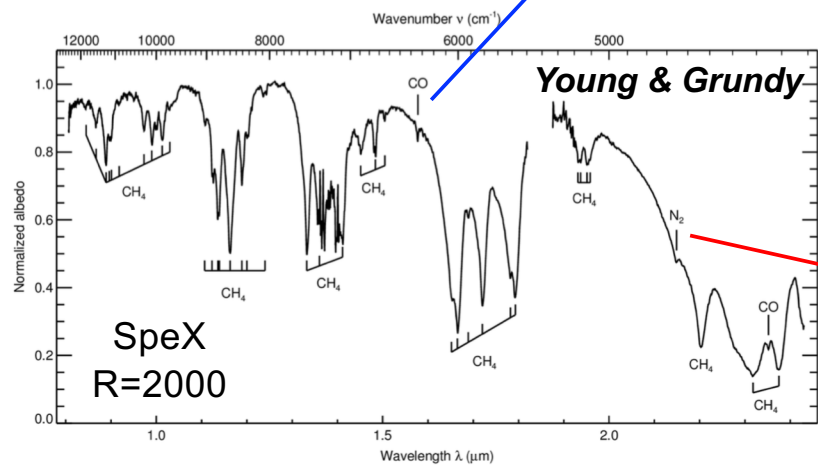
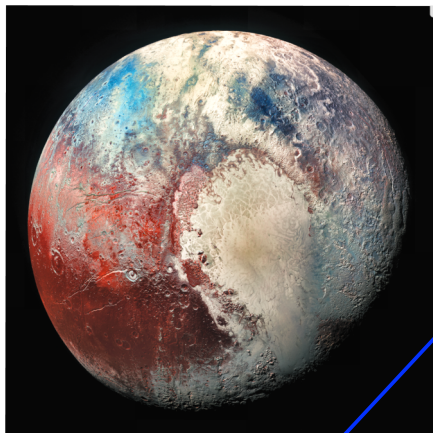
Telescope Operations

- National facility with observing time open to all through peer review of proposals
- 50% of observing time dedicated to solar system observations and mission support
- Flexible scheduling (multiple programs per night), 90% of observing is now remote
- Target-of-opportunity (ToO) programs
- Director Discretionary Time and NASA programmatic requests
- Daytime observing as necessary
- Dedicated time available for observing campaigns (comets, mission events)

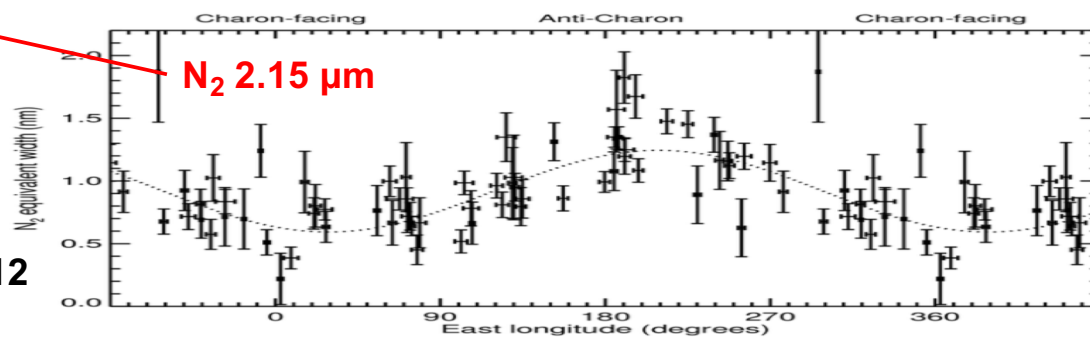
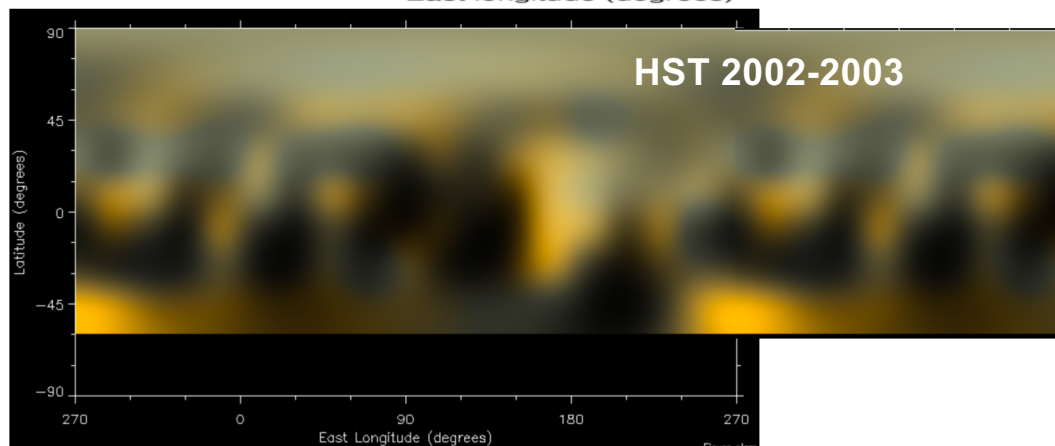
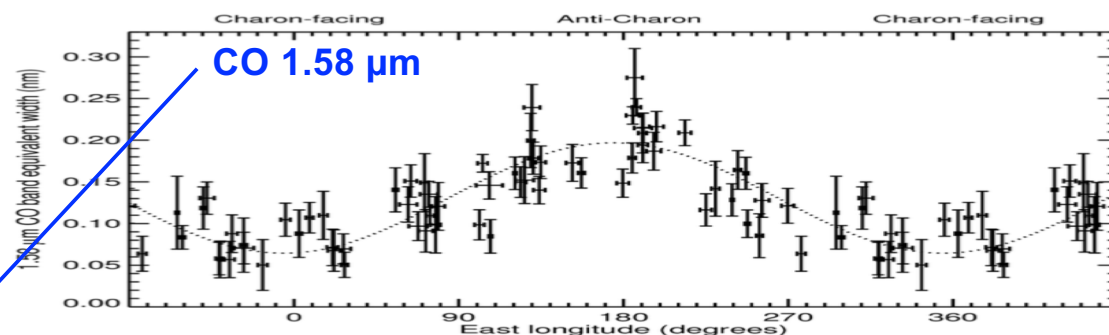
Small-Body Mission Support

- **Observations for mission planning and support (imaging and spectroscopy)**
 - Characterization and support observation of mission targets
 - Eros (NEAR)
 - Vesta and Ceres (Dawn)
 - Jupiter Trojans (Lucy)
 - Psyche (Psyche)
 - Itokawa (Hayabusa)
 - Ryugu (Hayabusa 2)
 - Bennu (OSIRIS-REX)
 - Phaethon / Geminid meteor shower (DESTINY⁺)
 - Didymos (DART)
 - possible PHO mission targets
 - Stellar occultations by dwarf planets (context for New Horizons)
 - Seasonal changes on Pluto (New Horizons)
- **Mission events**
 - Deep Impact: impact on comet 9P/Tempel 1
 - LCROSS: search for volatiles released on lunar impact

New Horizons
2015 July 14 1100 UT

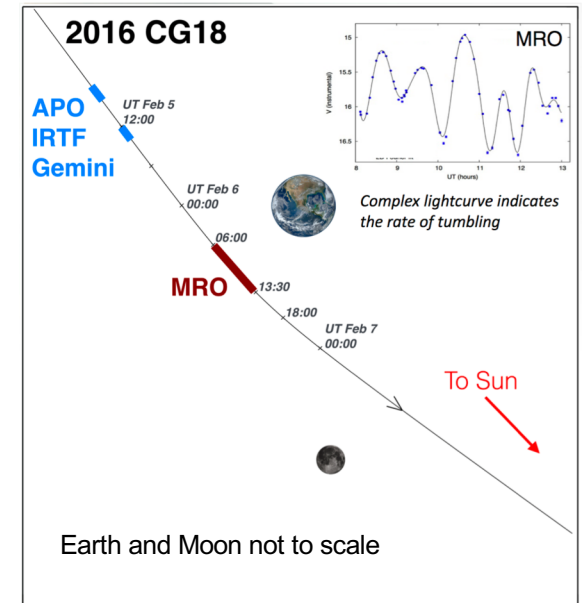


Grand average IRTF Pluto spectrum 2001-2012

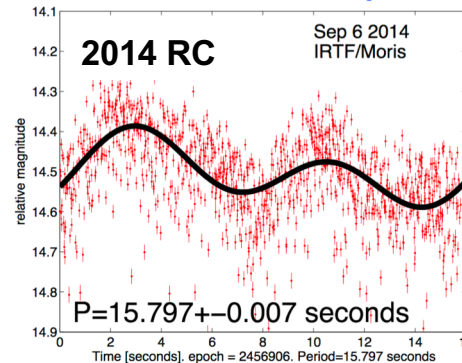


Critical capabilities for NEO characterization

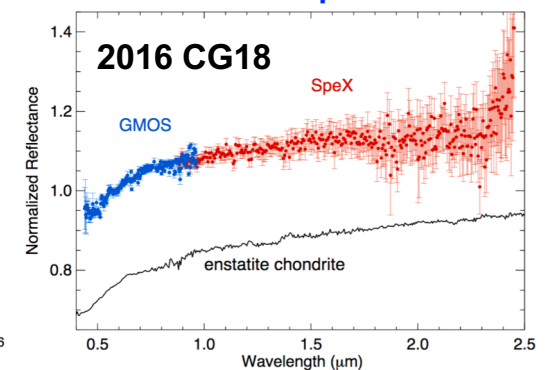
- ToO rapid response for newly discovered targets
- Accurate non-sidereal tracking at rates up to 60"/sec (1°/min)
- Multi-instrument characterization (SpeX + MORIS + MIRS + ...)
- Adding wide-field finder to improve acquisition and tracking



Fastest known rotation periods



Unusual Compositions



Data courtesy Nick Moskovitz

NEO Science

Compositional Distributions and Evolutionary Processes for the Near-Earth Object Population: Results from the MIT-Hawaii Near-Earth Object Spectroscopic Survey (MITHNEOS)

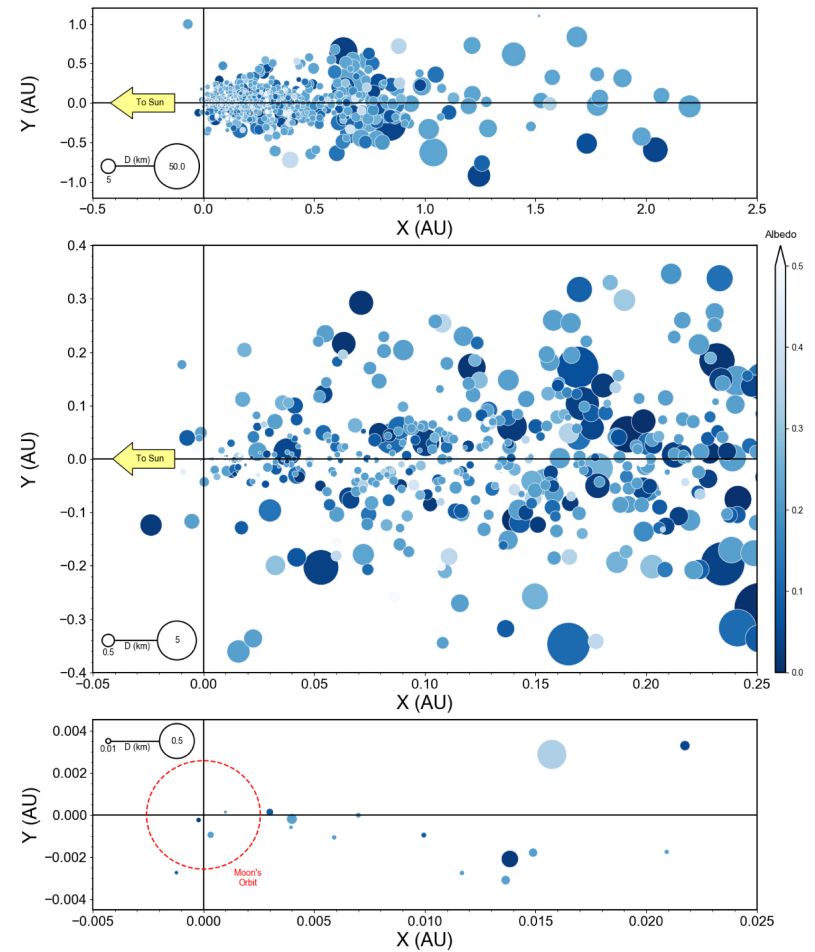
R. P. Binzel + 20 co-authors (*Icarus* 2019)

Study includes:

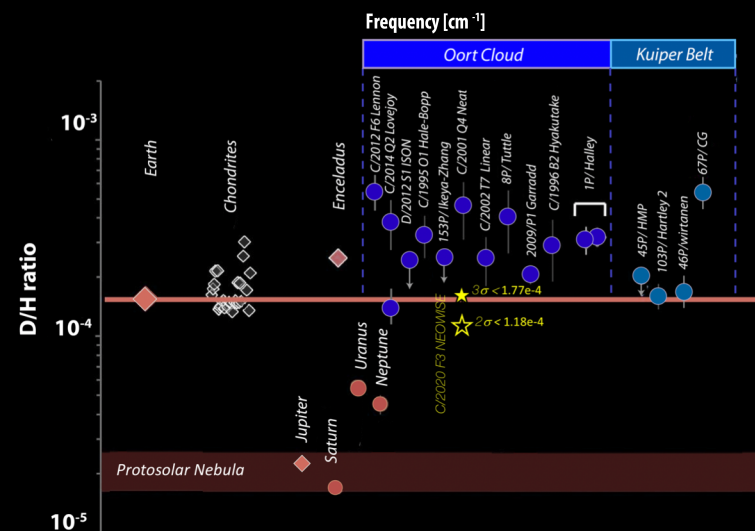
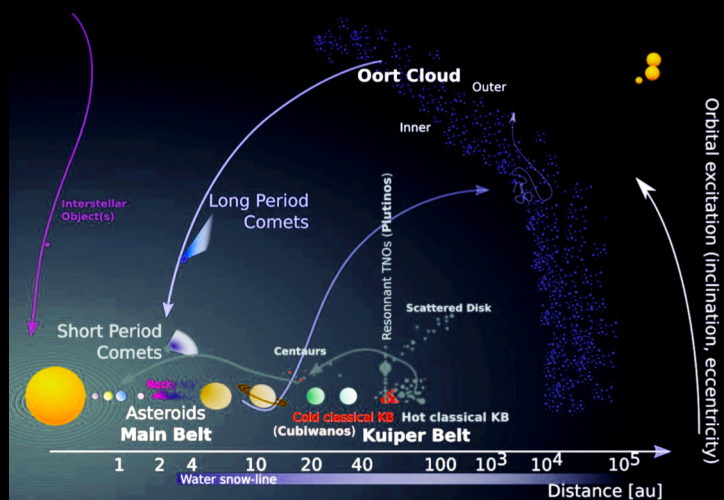
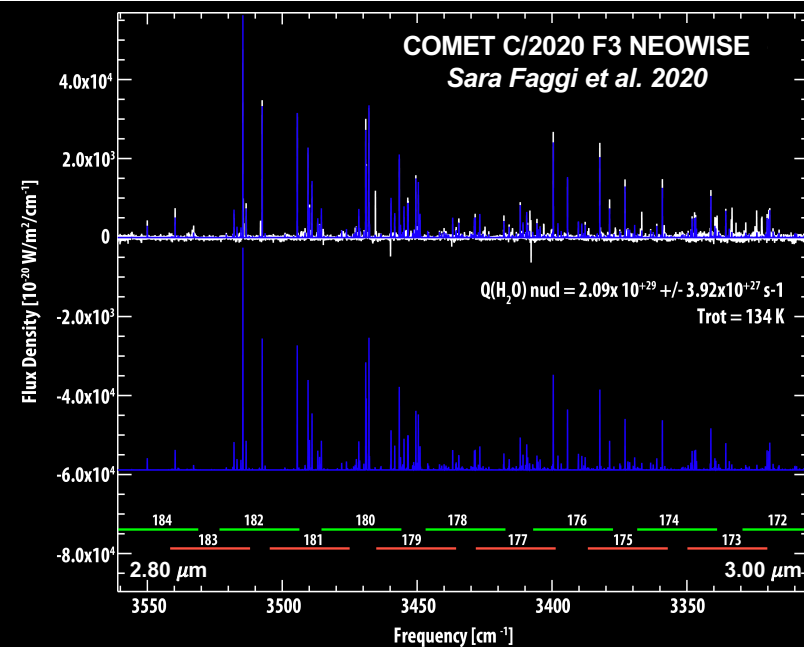
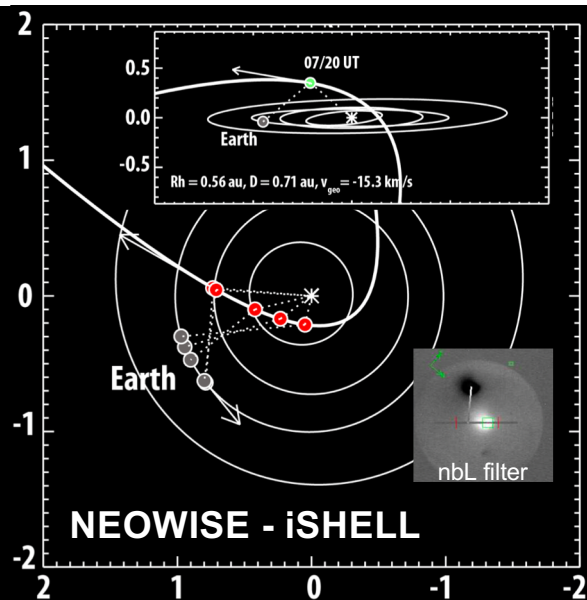
- ~1000 NEOs, [database http://smass.mit.edu/smass.html](http://smass.mit.edu/smass.html)
- ~350 Mars-crossing asteroids
- Large portion of the data were obtained with SpeX (prism mode, 0.8 – 2.5 μm , taken 2000 – present)

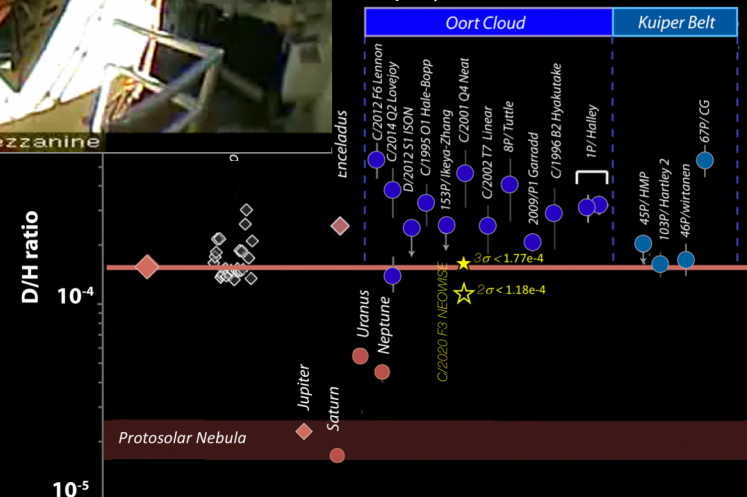
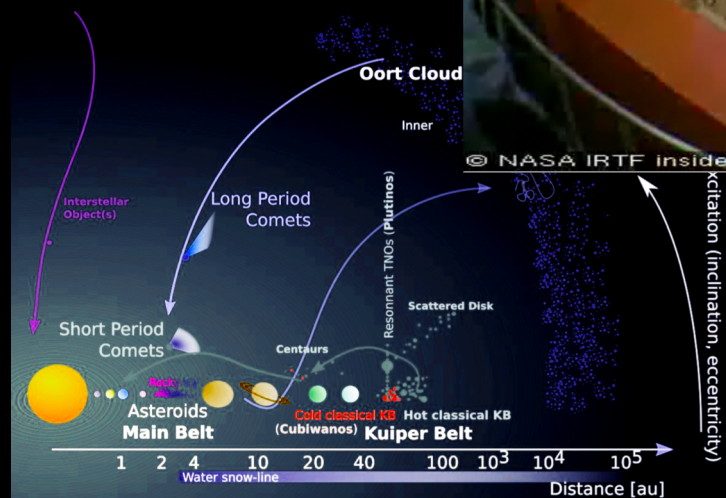
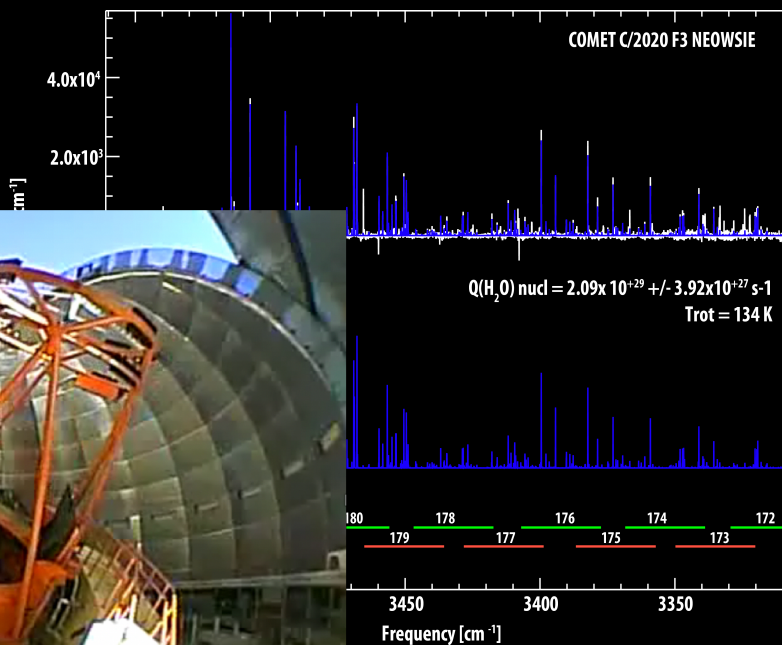
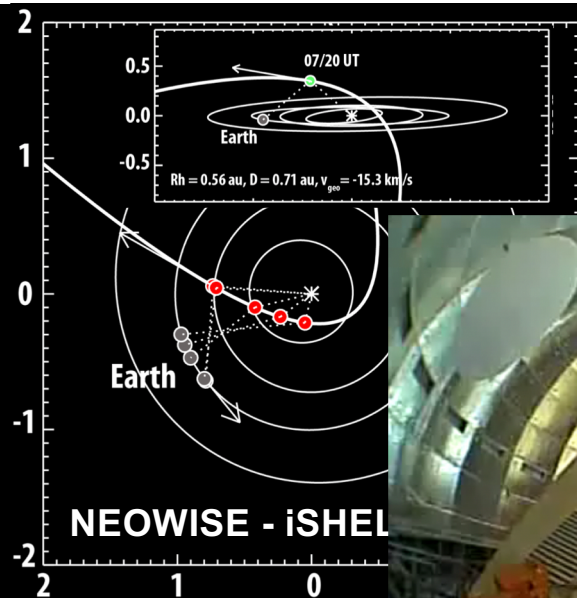
Topics addressed in analysis:

- Phase reddening
- Taxonomic distributions
- Space weathering trends
- Shock darkening trends
- Ordinary chondrite mineralogy
- NEO / meteorite source regions



Distribution of targets included in MITHNEOS study. The three panels depict different distance scales with markers representing target diameters (marker size), albedo (color), and geocentric position at the time of observation.





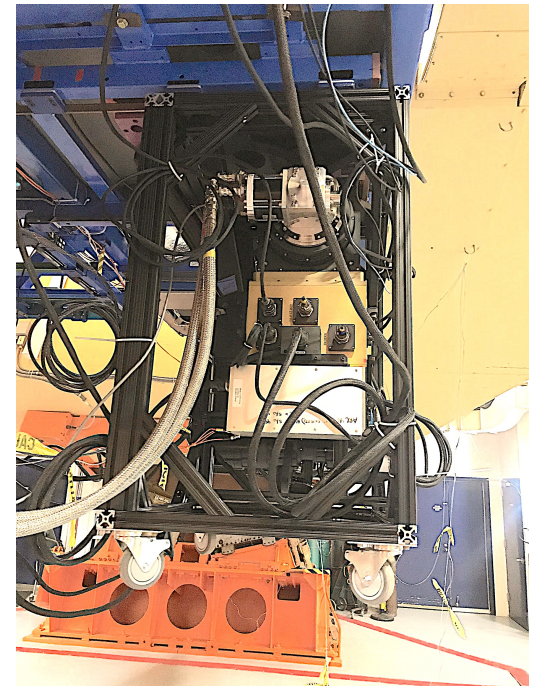
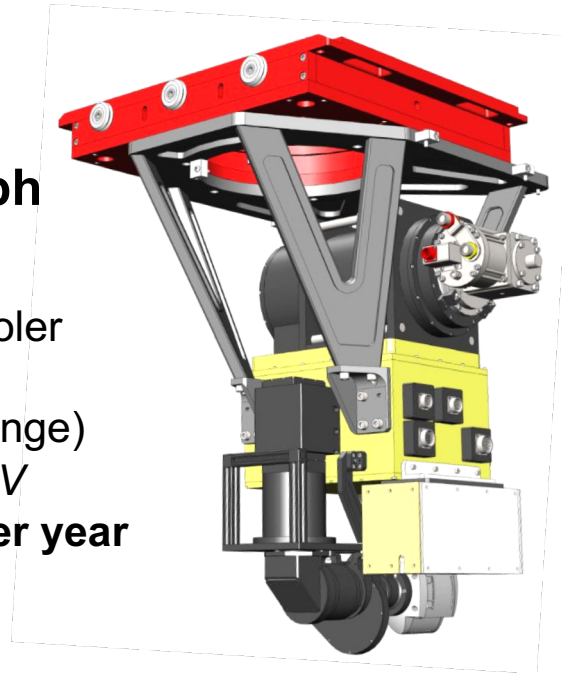
Planned Future Capabilities for Small-Body Science (2023-2032)

- MIRSI upgrade for simultaneous mid-IR and visible photometry - albedos and diameters (2021)
- Wide-angle telescope finder to acquire NEOs with large position uncertainties (2021)
- Low-order off-axis WFS to improve image quality (2022)
- Proposal for new facility instrument optimized for small-body science (SPECTRE)

MIRSI Upgrade

5-20 μm camera and spectrograph upgrade

- Replace LN2/LHe with closed-cycle cooler
- New low-noise array controller
- New hexapod chopper (no top-end change)
- Add CCD channel for simultaneous $N+V$
- **NEO albedos and diameters: ~200 per year with 10 hours observing per month**



Wide-angle Finder ('Opihi)

- **Capabilities**

- 0.43-m telescope
- 0.5 degree FOV (2k² Andor CCD)
- $V=19.5$ 60s-20 σ
- Filters g, r, i, z
- Boot-strap photometry for all instruments
- Extinction and cloud monitor
- Context camera

- **On-telescope for testing in fall 2021**



SPECTRE: 0.4-4 μm $R=150$ IFU SPECTROGRAPH

- Endorsed by IRTF community workshop (2018)

- **Technical features**

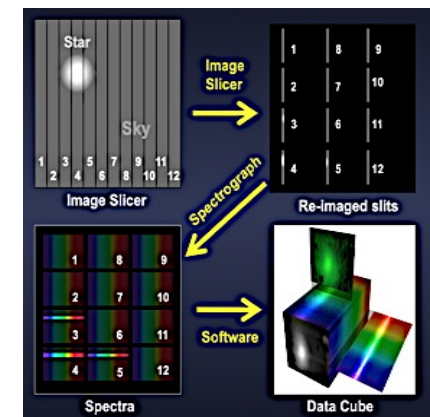
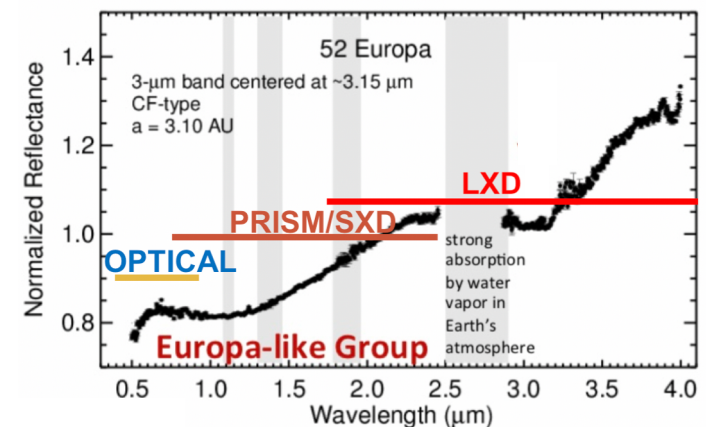
- Optical, NIR and MIR channels
- 7" x 7" IFU – absolute spectro-photometry on point sources
- High throughput (70%), no slit losses
- Compact and rigid spectrograph, no moving optics
- 3'x3' CCD camera for A&G (e.g. NEOs)

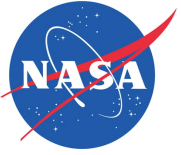
- **Optimized for small-body science**

- $R=150$ for solid-state features and SEDs
- One-shot 0.4-4 μm to remove degeneracy, time variability
- > 1 mag improvement in sensitivity, multiplex advantage
- Rapid response for newly discovered NEO targets
- Many more targets observable throughout Solar System

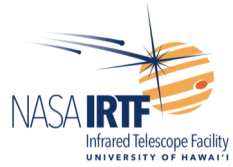
- **Seeking funding from NSF or NASA (\$3.5m)**

Data courtesy of Driss Takir





SPECTRE Mission Support for Lucy Trojan Asteroid Tour (2027-2033)



3548 Eurybates (flyby 8/27)

- 64 km diameter, rotation 9 hours
- 0.4-4 μm $R=100$ 50σ in 1 hour at opposition
- map at sub-hemispheric resolutions
- 50 Trojans brighter than Eurybates
- order of magnitude more objects observable 0.4-2.4 μm

Ground-truth Lucy observations can then be applied to a large population of Trojans

