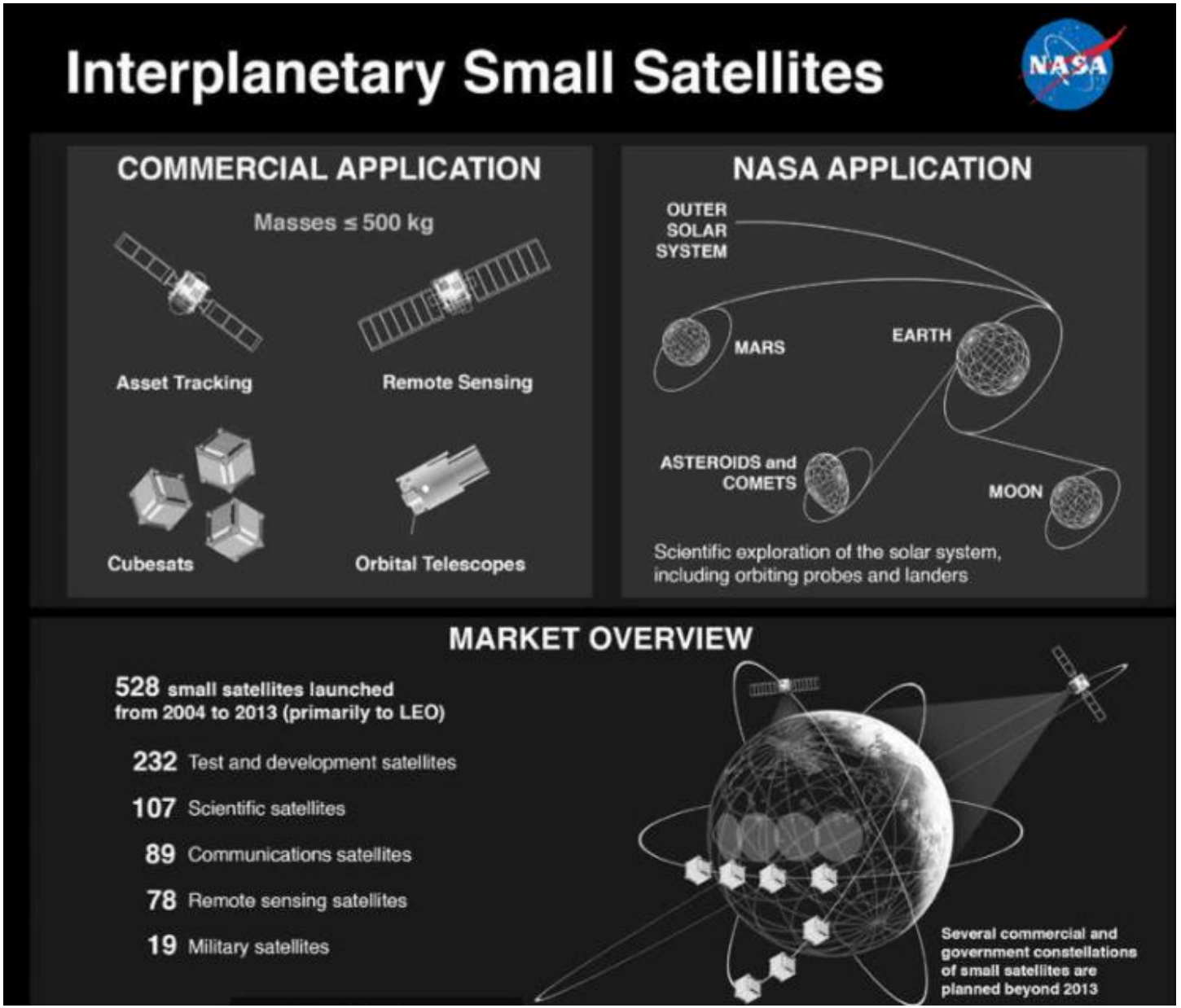
High Spectral Resolution Spectrometry in Compact Sizes

in Future Interplanetary Missions Using Spatial Heterodyne Spectrometer

Sona Hosseini, Ph.D.
Jet Propulsion Laboratory
California Institute of Technology

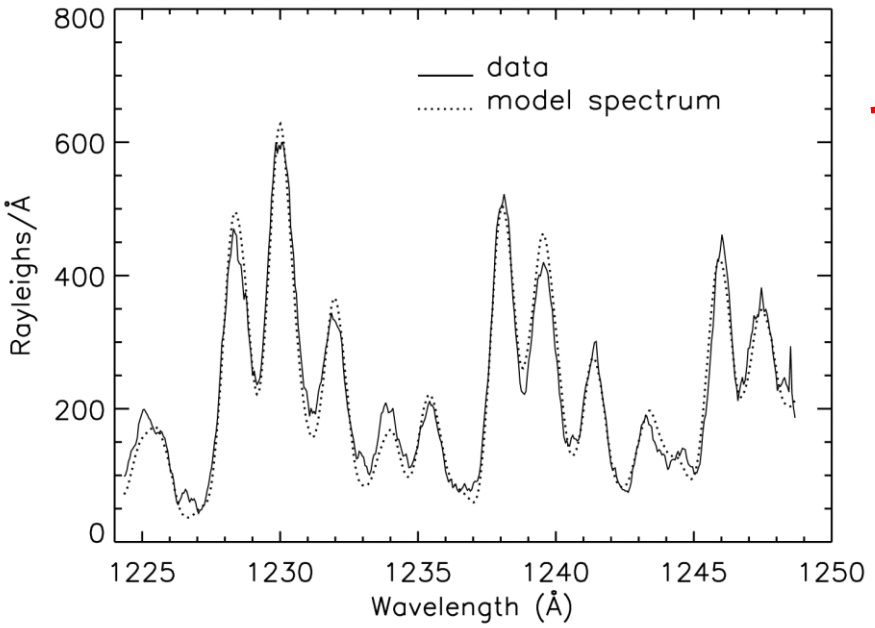


Public-Private Partnership for Space Capability Development, April 2014

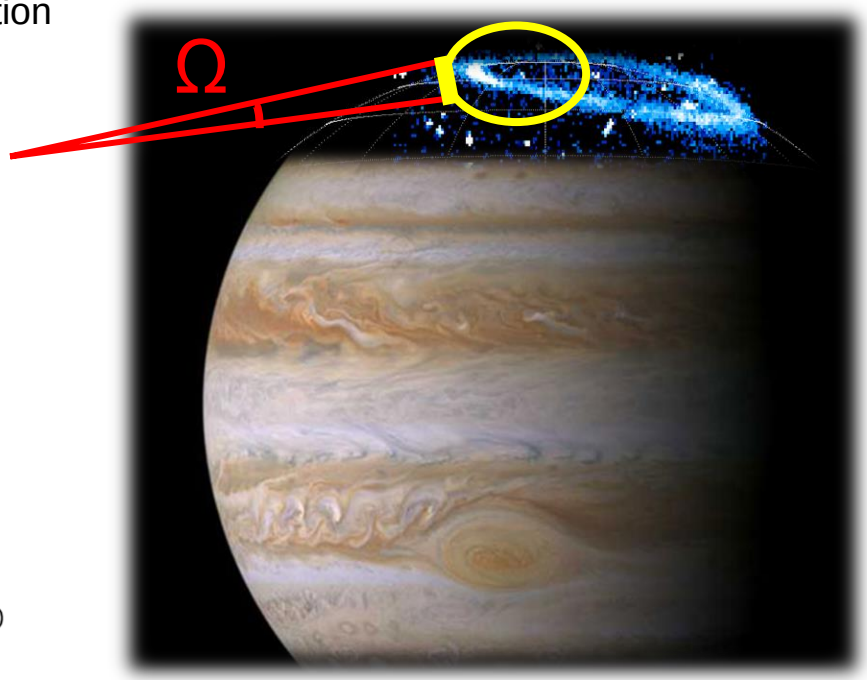
High Spectral Resolution Spectroscopy

High spectral resolution is needed for fine relative motions, multiple sources, isotope ratios, temperature, turbulence, currents, and etc.

sulfur and oxygen line shapes for ion precipitation



Trafton *et al.*, 1998



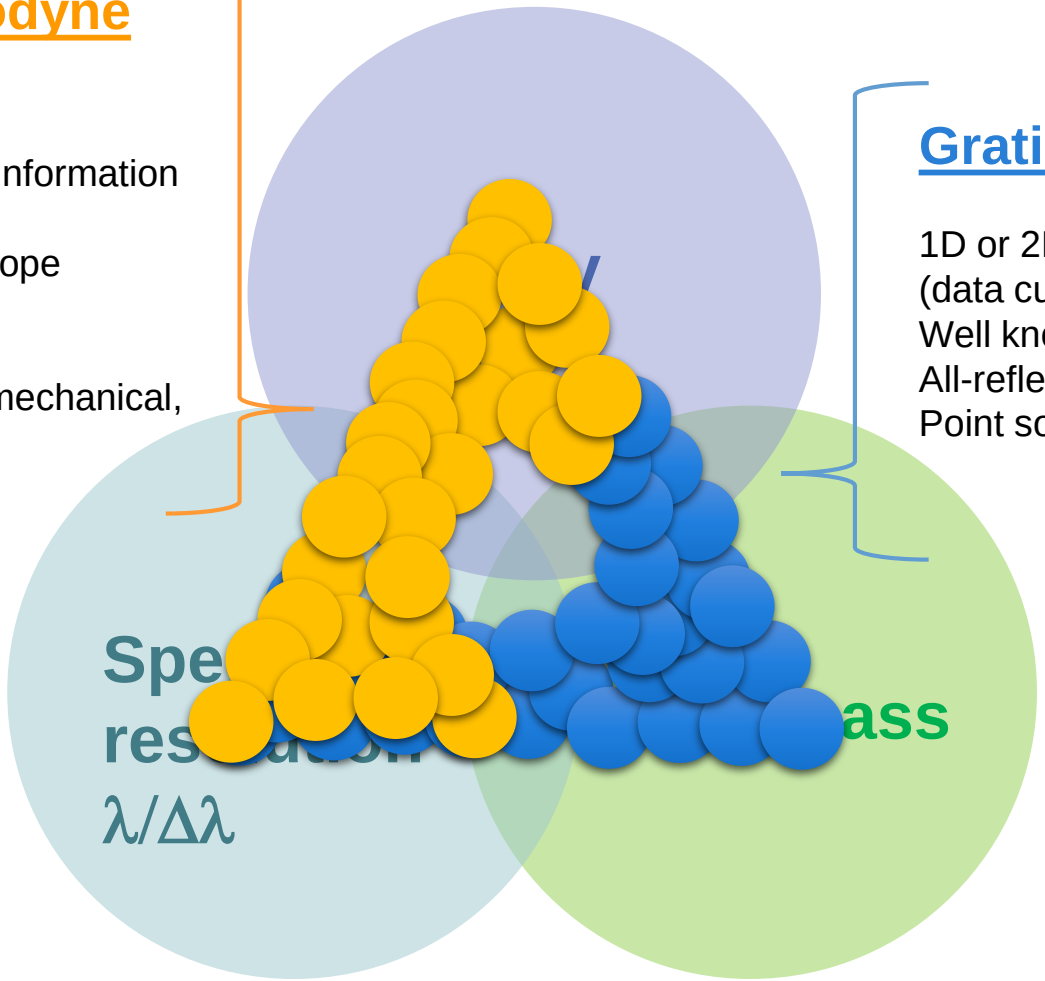
Jupiter's northern aurora, *(~1 Å) from Hubble-STIS*

Upper panel: image of the FUV Jovian northern aurora observed with WFPC2

High Spectral Resolution Spectrometry

Spatial Heterodyne Spectromter

No, 1D or 2D spatial information
Compact/miniature
Small aperture telescope
Low data volume
All-reflective design
High tolerance (optomechanical, temperature)

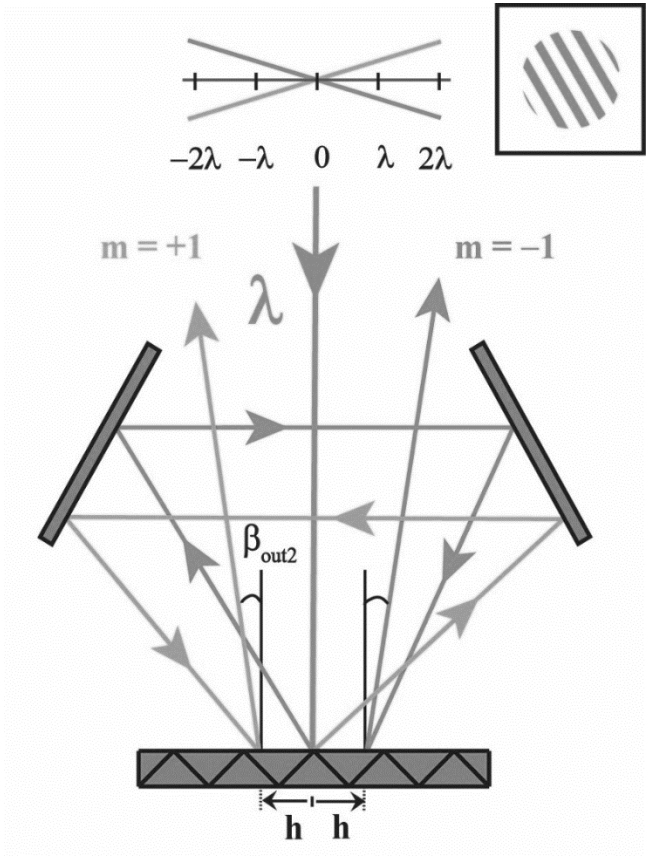


Grating spectrometer

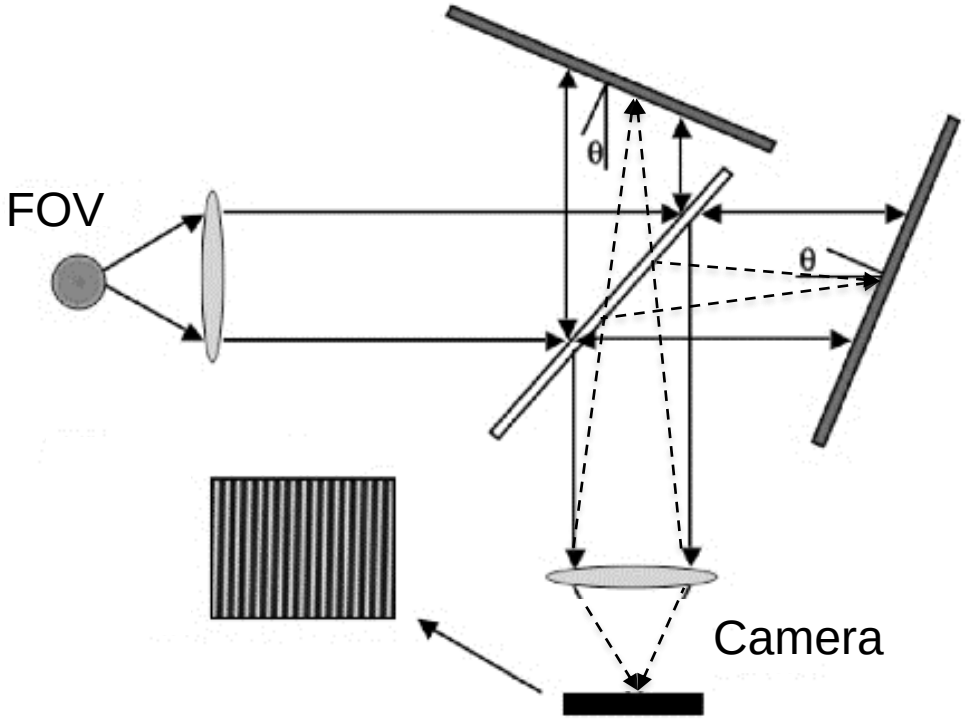
1D or 2D spatial information (data cube capability)
Well known concept/heritage
All-reflective design
Point sources

Spatial Heterodyne Spectrometer

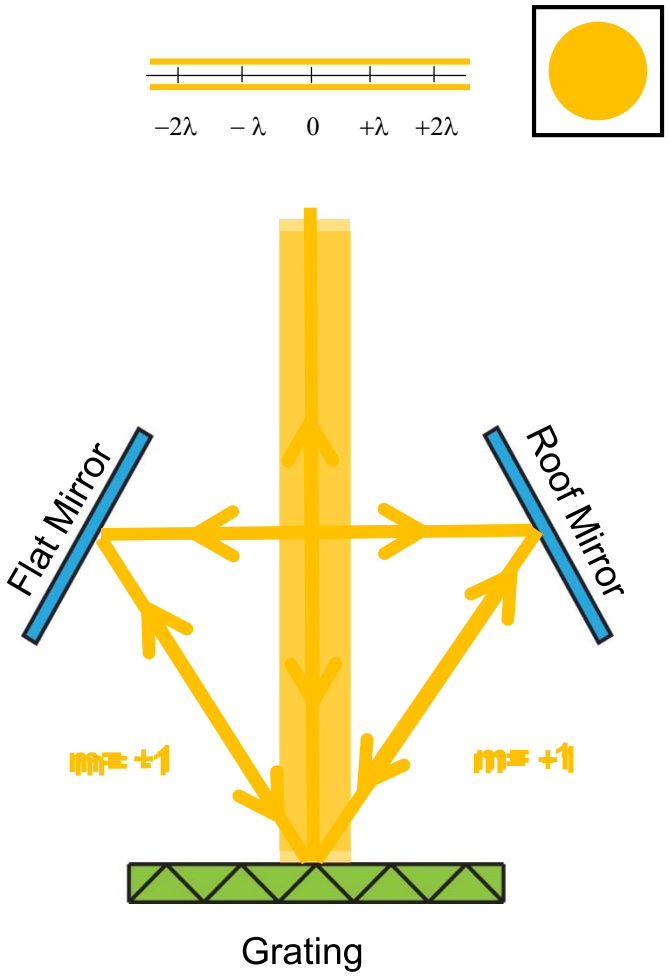
Reflective SHS



Michelson design SHS

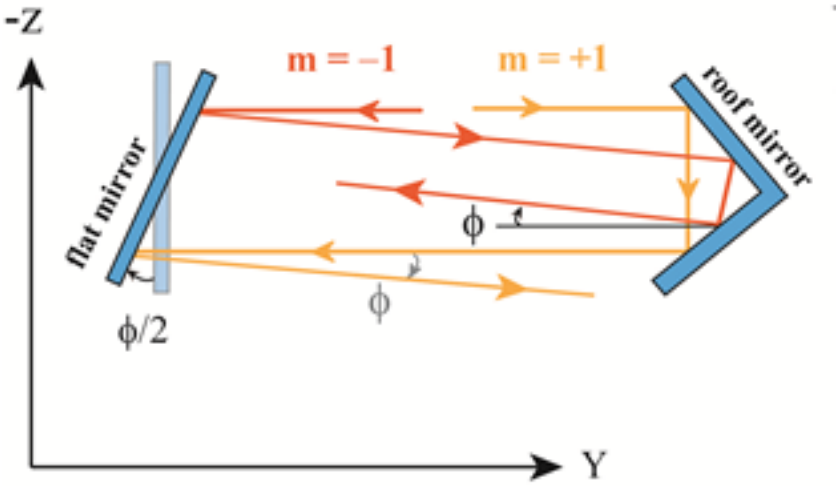


SHS is a cyclical interferometer

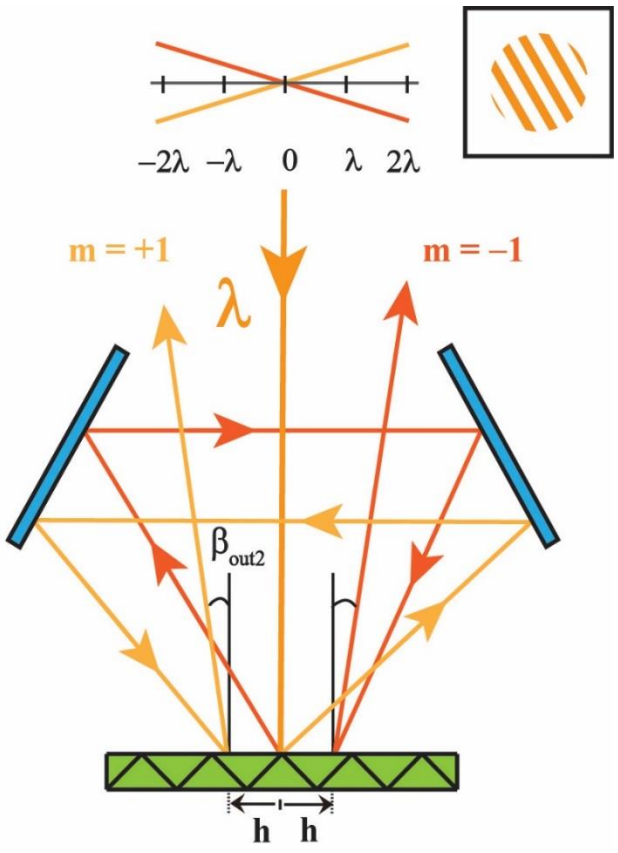


SHS is a cyclical interferometer

$$E_{01} . E_{02} \cos((k_1 - k_2).r + \varepsilon_1 - \varepsilon_2) \neq 0$$

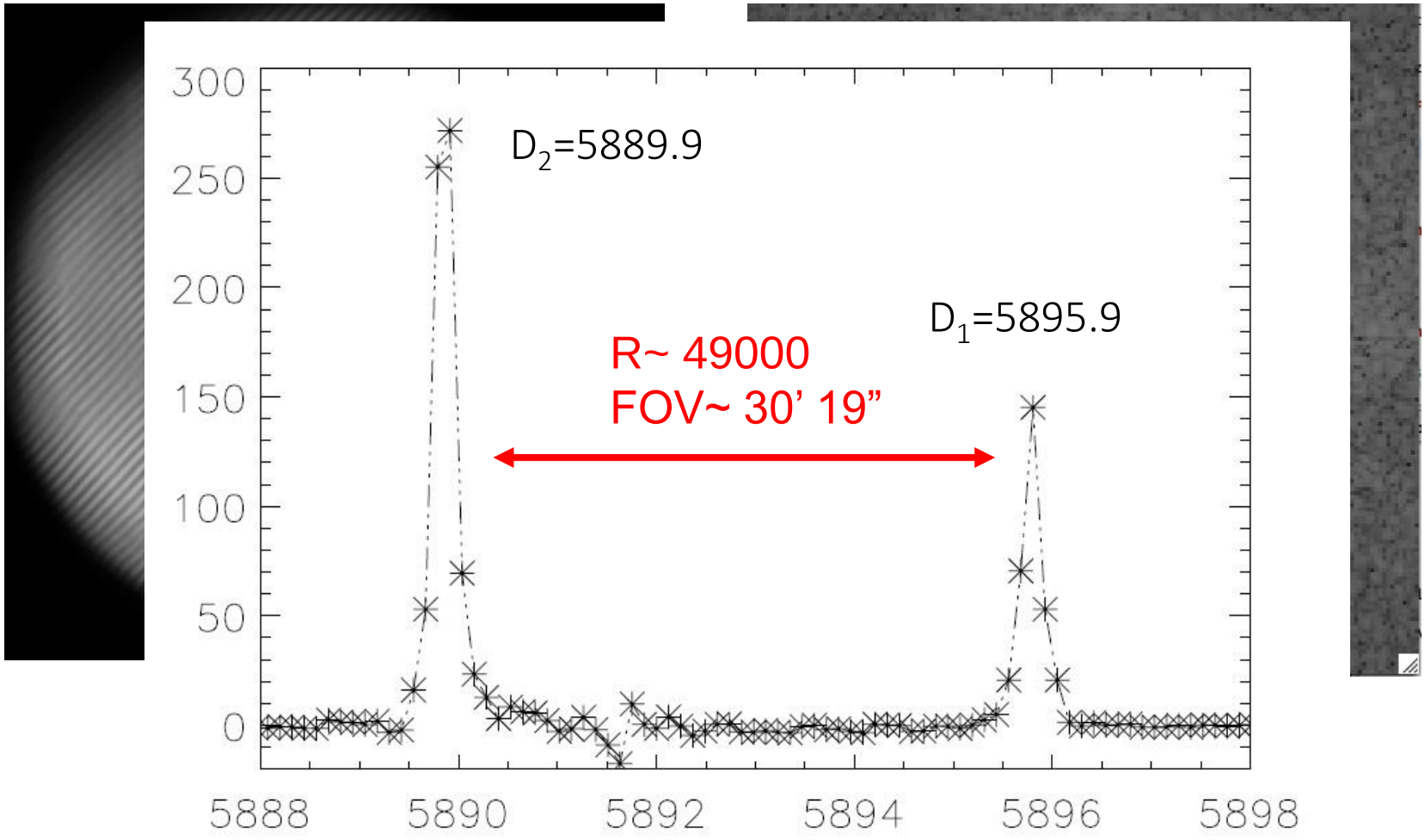


Side view

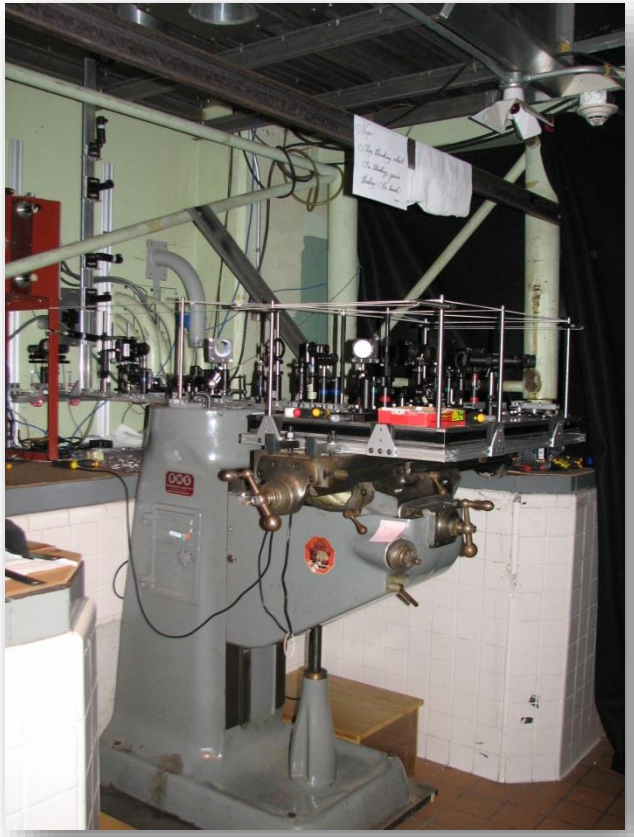


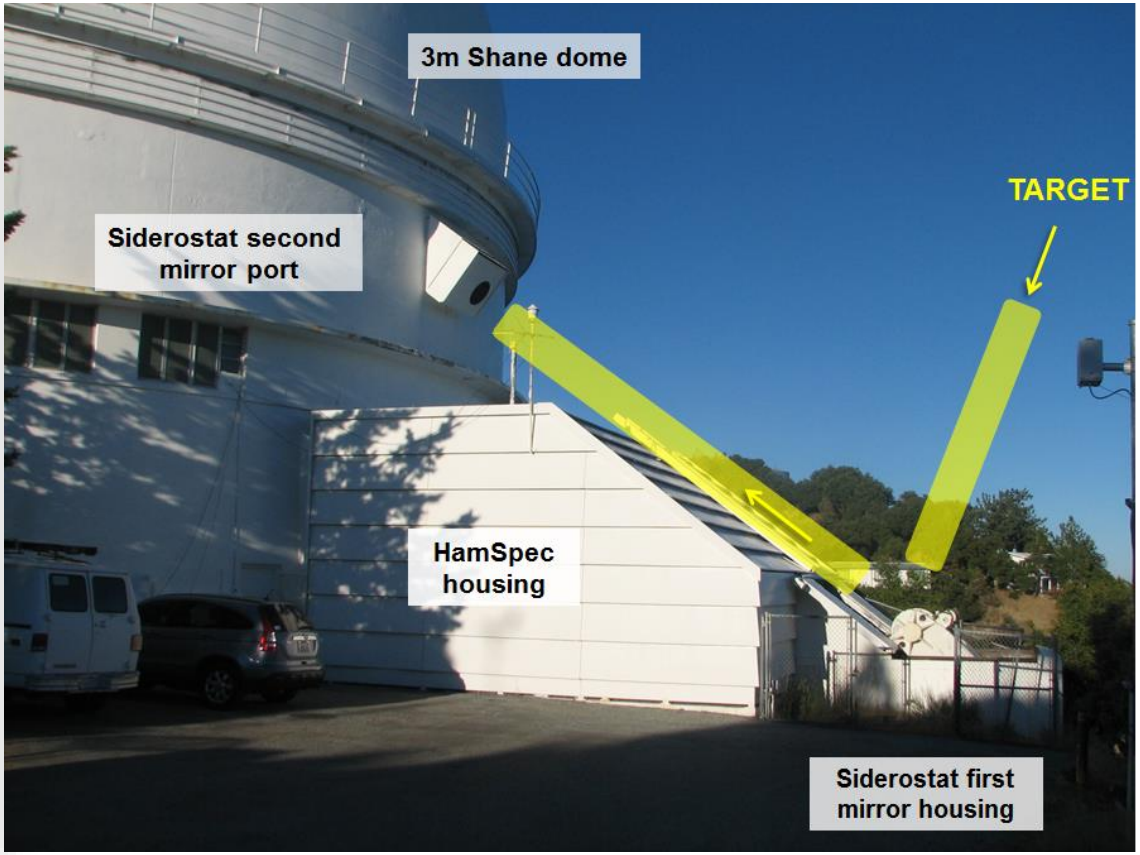
Top view

Na Lamp D lines

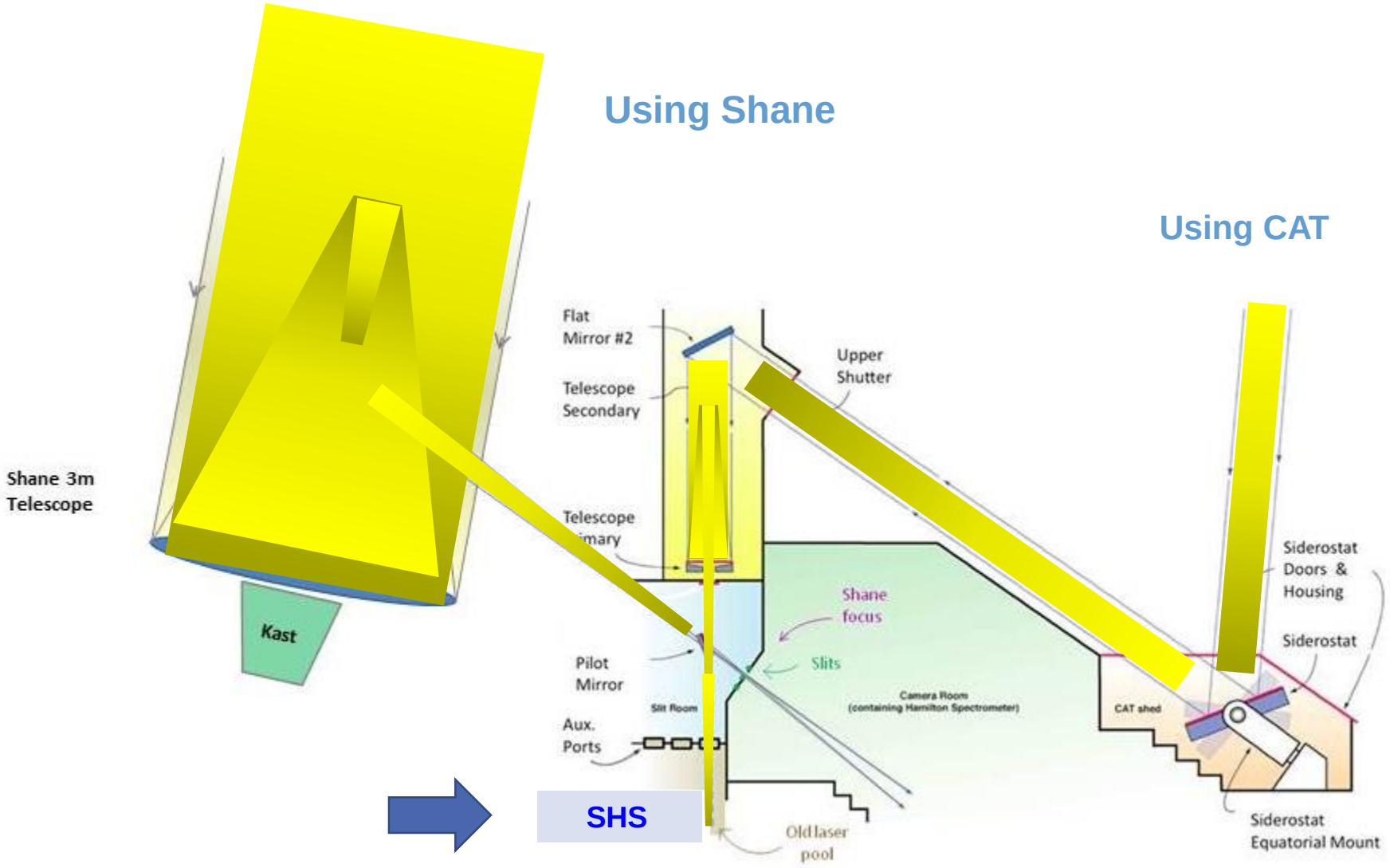


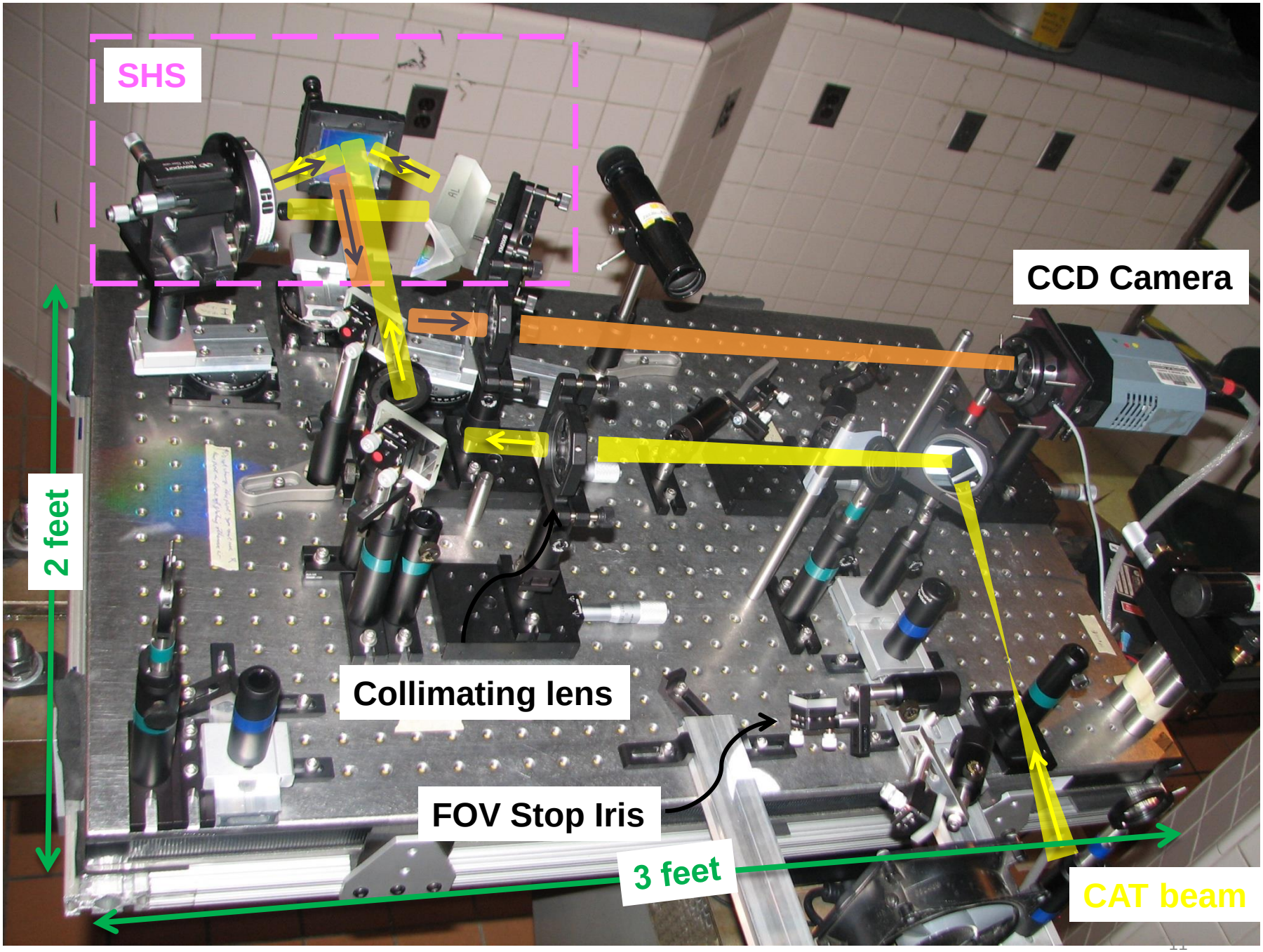
Khayyam: the first facility-class SHS constructed



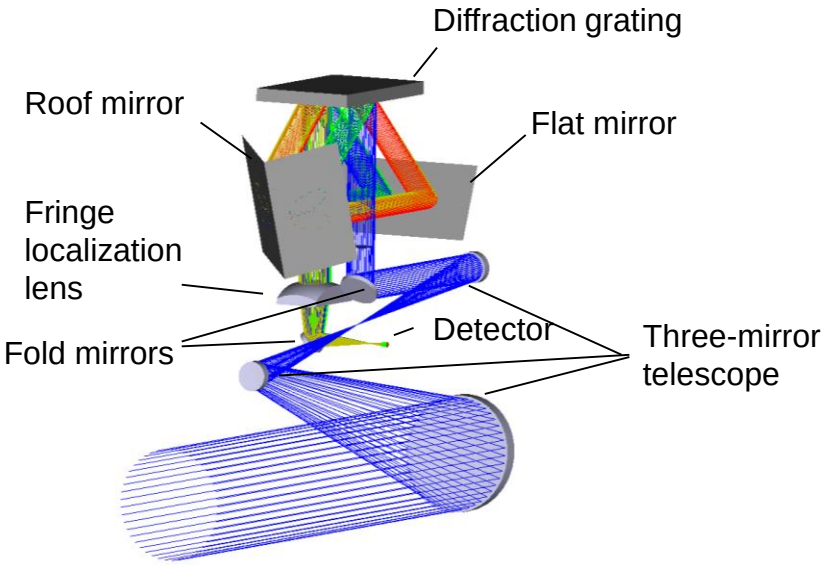


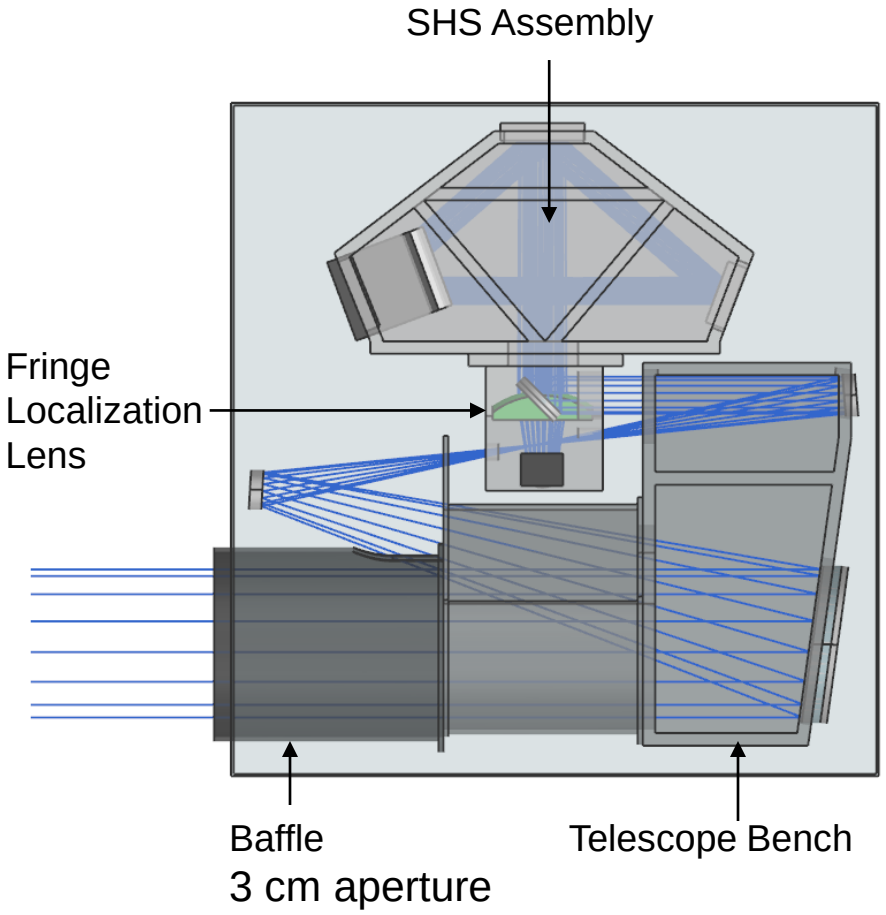
Coupling SHS to the Coudé Auxiliary Telescope (CAT)




SHS
CCD Camera
2 feet
Collimating lens
FOV Stop Iris
3 feet
CAT beam

SHS for Small Platforms





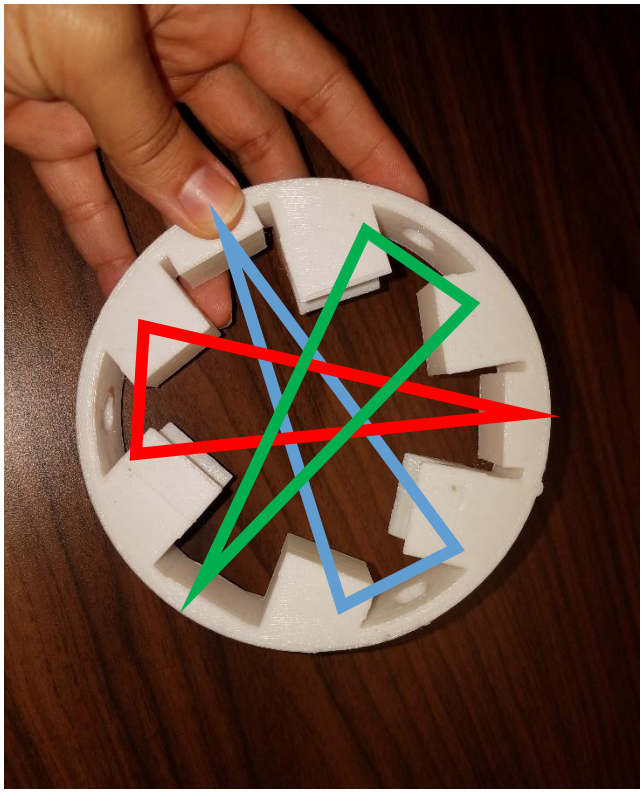
In comparison with similar spectral resolution instruments

R ~ 500 – 3000
Wide bandpass
Low throughput

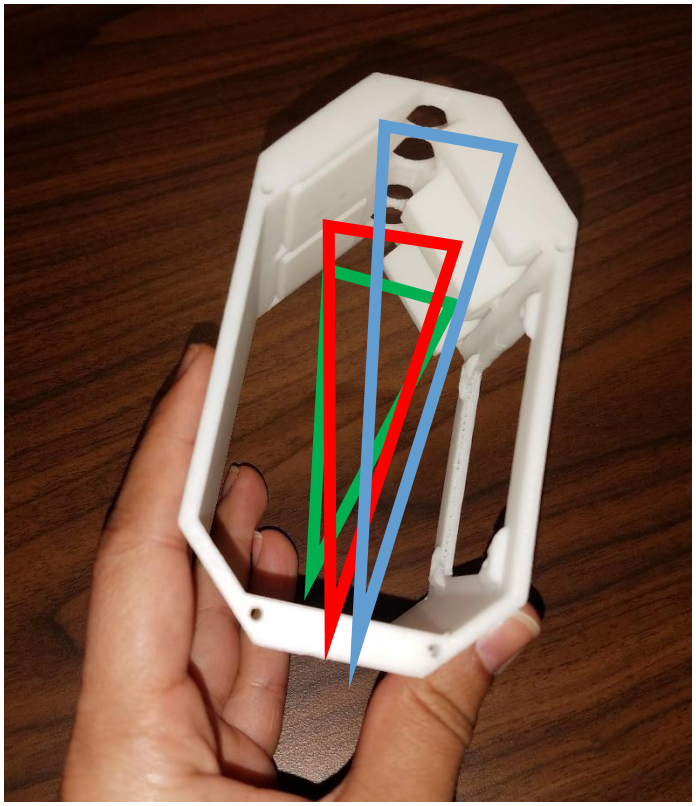
R ~ 30,000 – 100,000
Narrow bandpass
High throughput

Multi-channel SHS

Each channel is 0.5 – 2nm bandpass and targets a specific spectra future at 20,000 to 70,000 resolving power.



orbital channels



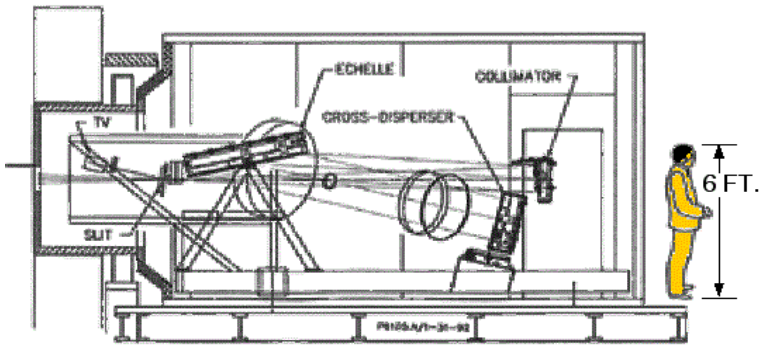
vertical channels

In comparison with similar spectral resolution instruments

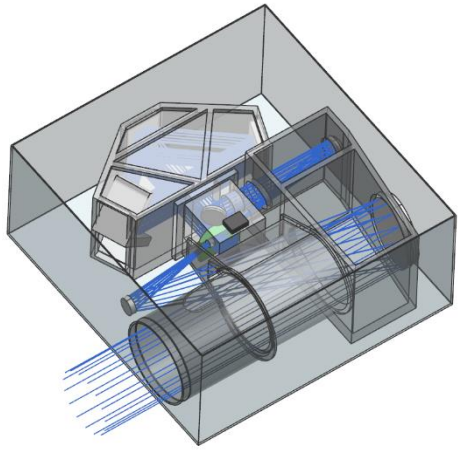
STIS - Hubble (2.4 m)

HamSpec – Lick (3 m)

Keck spectrometer (HIRES)
$4 million, 8 tons, 5 m length



HIRES - Keck (10 m)

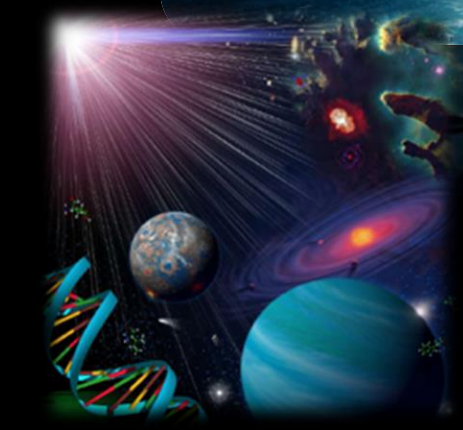


SHS (8 cm)
Volume: 13.5 x 13 x 6 cm

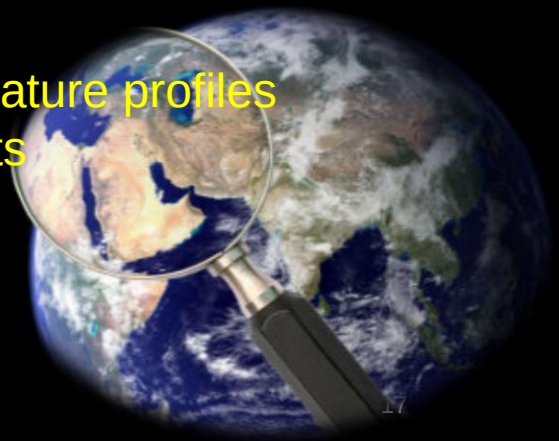
SHS will reveal incredible spectral detail in a cometary coma/tail

Sona Hosseini
sona.hosseini@jpl.nasa.gov

Planetary Science
Mars Methane
Cometary Coma
Io Plasma Torus
Venus night airglow
Lunar sodium tail



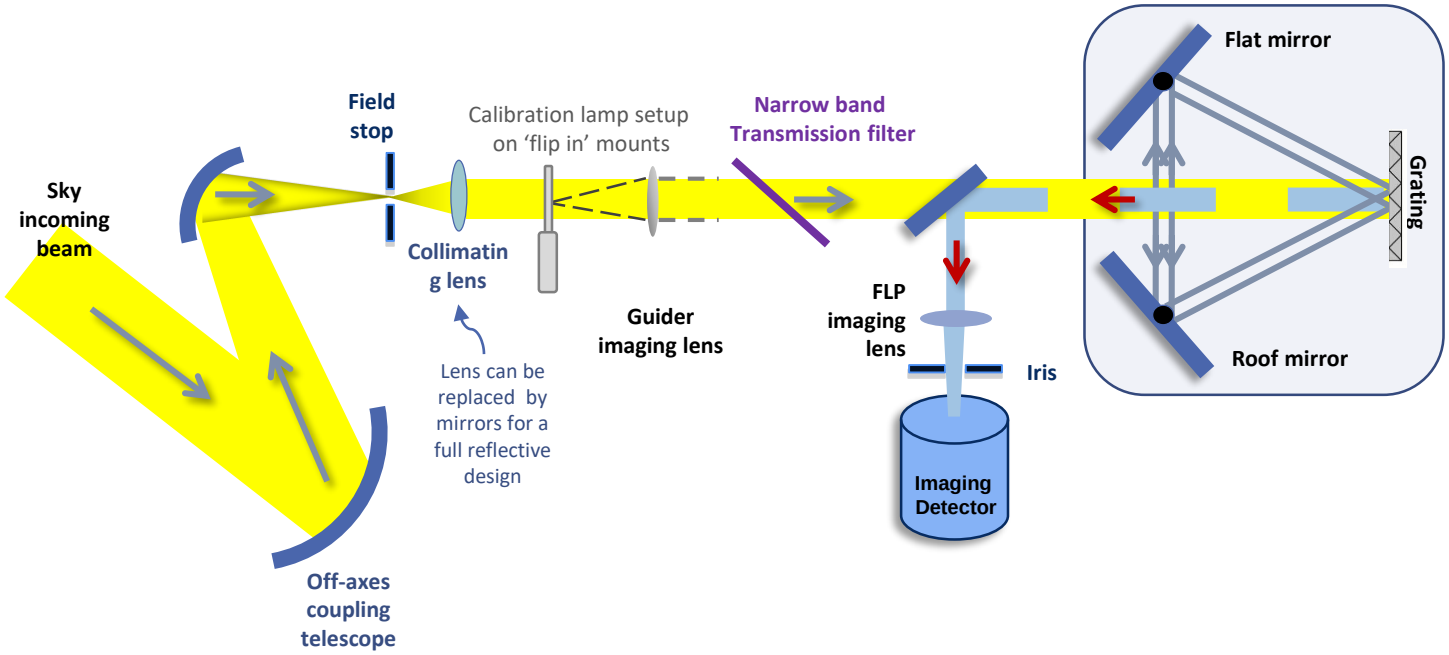
Earth Science
Wind and Temperature profiles
OH Measurements



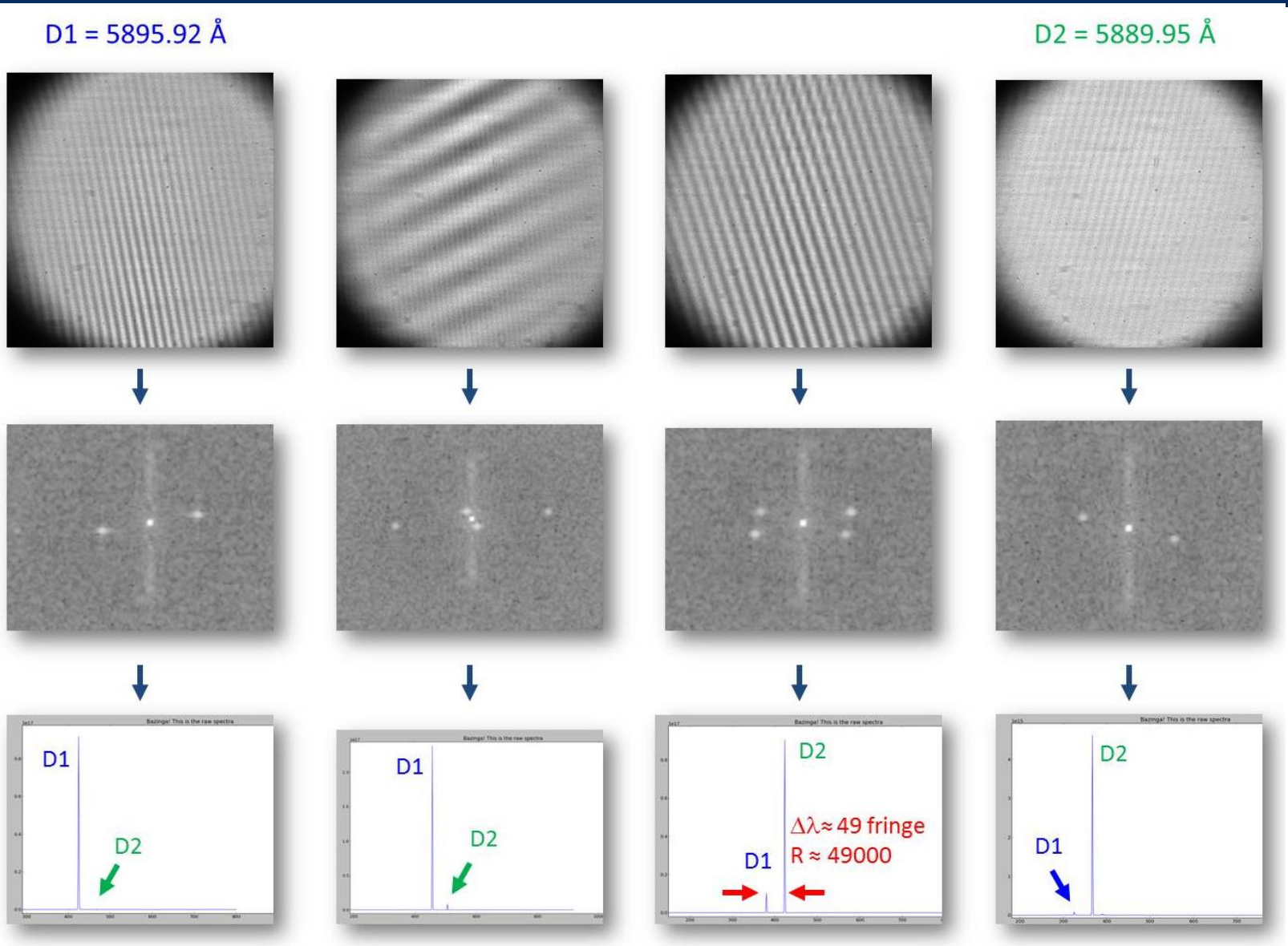
Astrophysics
Direct imaging of exoplanets
Interstellar Medium
H-alpha mapping of Nebula and Galaxies
Solar wind interface

Back Up

Optical layout



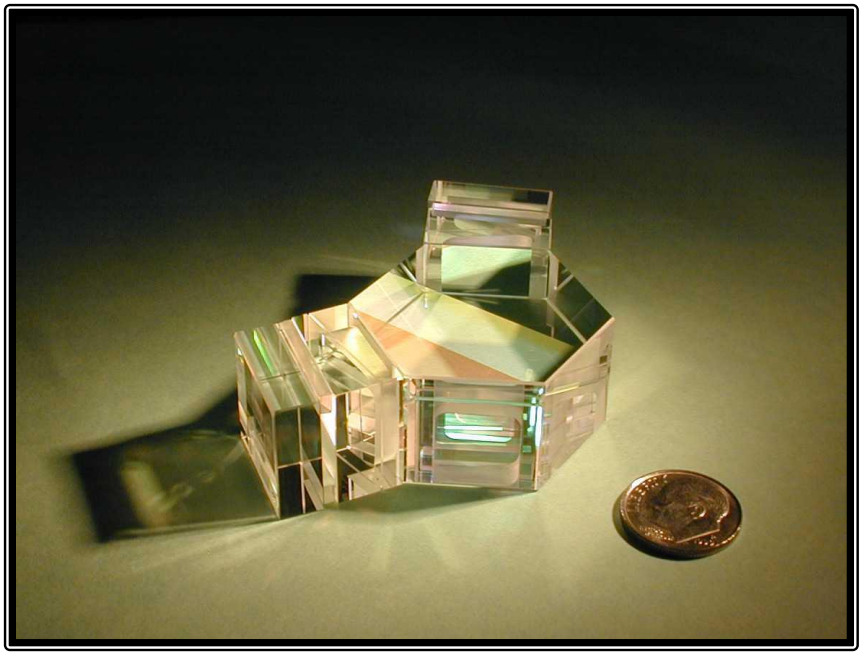
Tuning in Na D lines



SHIMMER on STPSat-1

Launched 2007, decommissioned after completing 2.5 years of successful on-orbit operation

Mesospheric hydroxyl (OH)



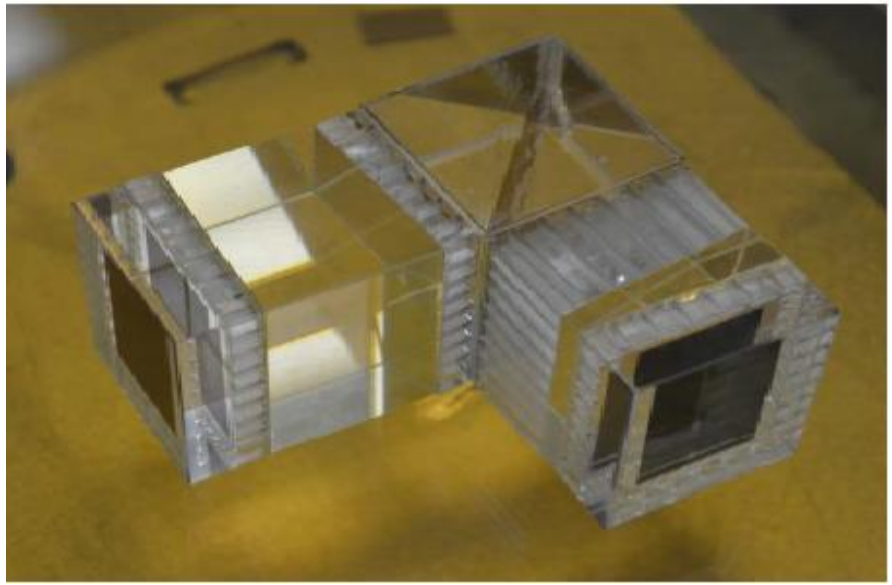
The STPSat-1 small satellite, built for the Department of Defense (DoD) Space Test Program (STP) and operated by the DoD STP for the first year then transitioned to NRL.

MIGHTI on ICON Heliophysics Explorer Mission will launch at 2017

$200 M ICON mission

(Tom Immel, UCB; Orbital Sciences)

Earth's thermospheric winds and temperatures at altitudes 90-300 km



Engineering model of the MIGHTI interferometer

MANIC: direct detection of nearby Jupiter-like exoplanets

Boston University, MA with input from Light Machinery Inc.