The Challenges of Low-Cost Instruments for Space Missions

Compact high resolution spectrometers

meters For

bservation Of

Extended Sources

Temporal high spectral resolution observations

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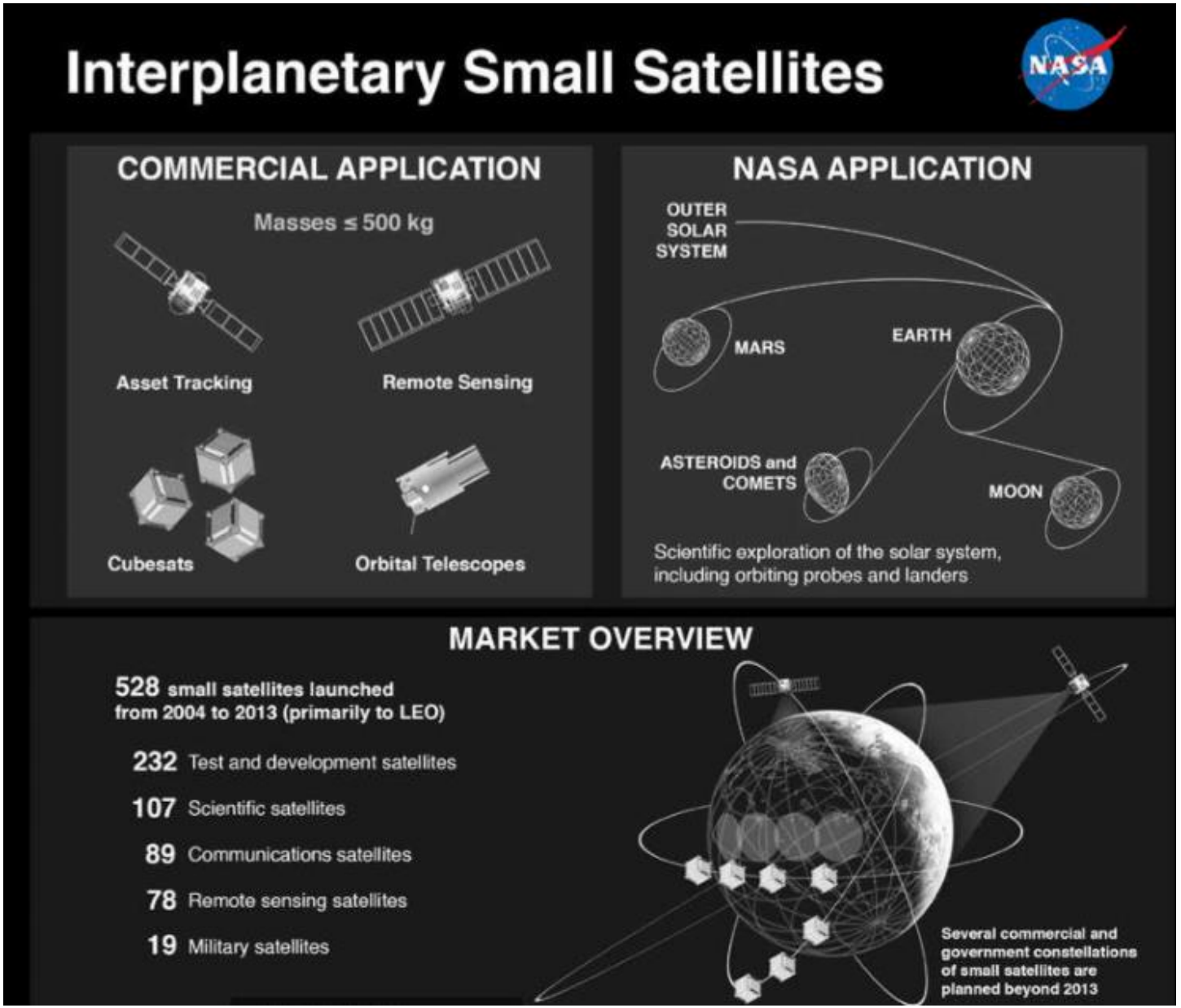
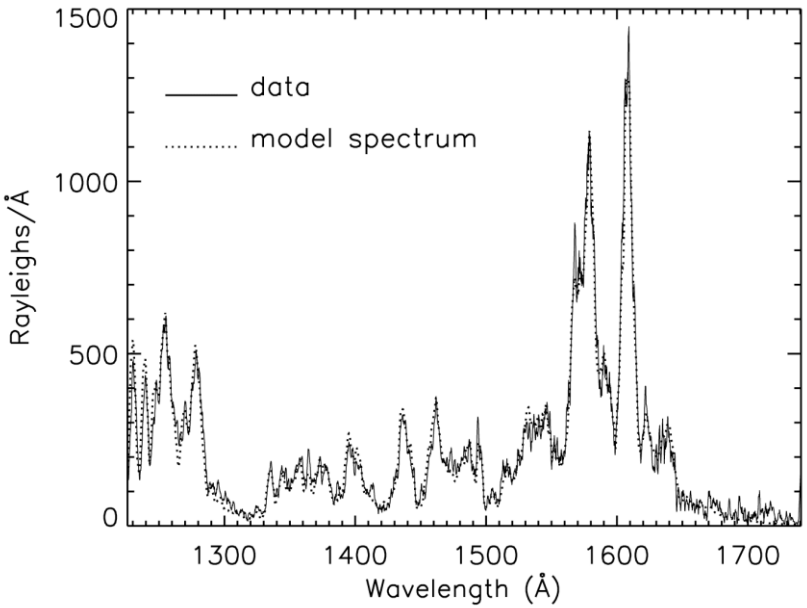
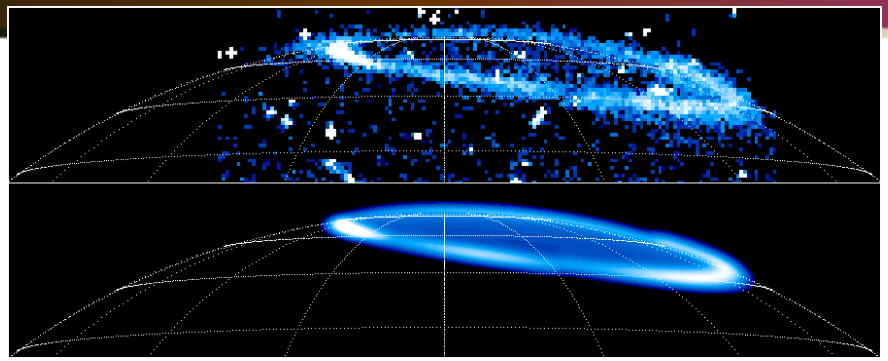
How to get high spectral resolution at wide FOV!?

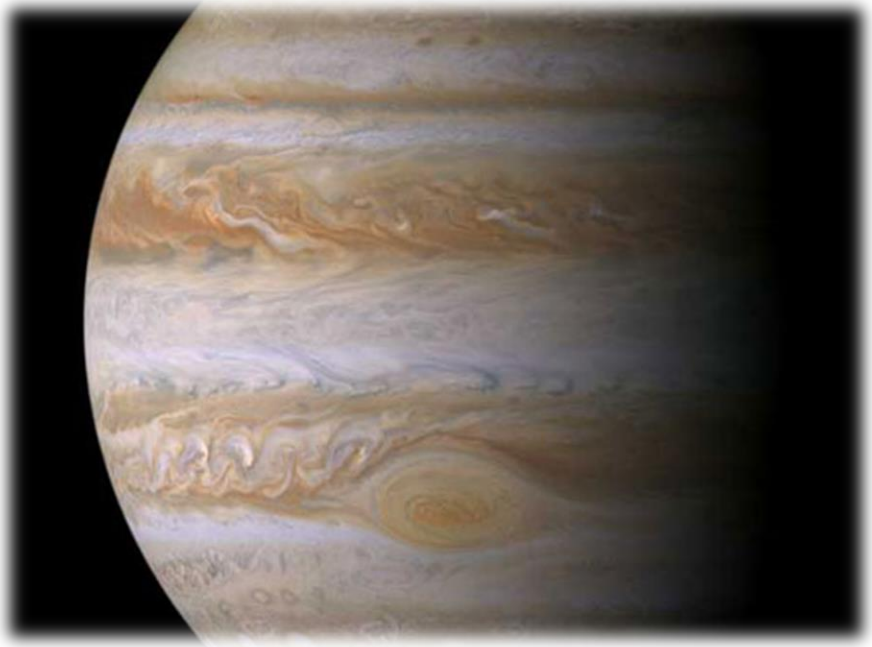


Public-Private Partnership for Space Capability Development, April 2014

The joy of finding things out!







Our targeted environments are challenging using current high resolution technologies

Diffuse and extended

- arc-minutes to degrees in extent
- Typical low surface brightness

Needs → Wide FOV, High Étendue

Faint and low-energy environment

- Velocities of order 0.1-10 km/sec
- Temperatures of order 100-1000 K

Needs → High Étendue, High spectral R

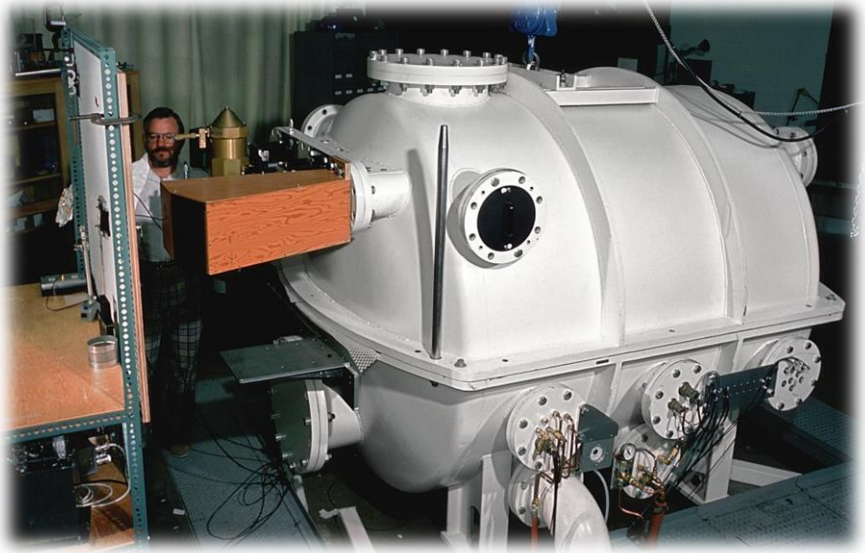
Temporally variable

- Heterogeneity
- Outbursts, diurnal variations
- Seasonal changes (long time scale)

Needs → High temporal coverage, Wide FOV

Current state of the art doesn't combine high spectral resolution with wide FOV and is not suited for temporal observations

Large Telescopes
Grating Spectrometers



Small Telescopes
Interferometers

Spatial Homodyne Spectrometer (SHS)

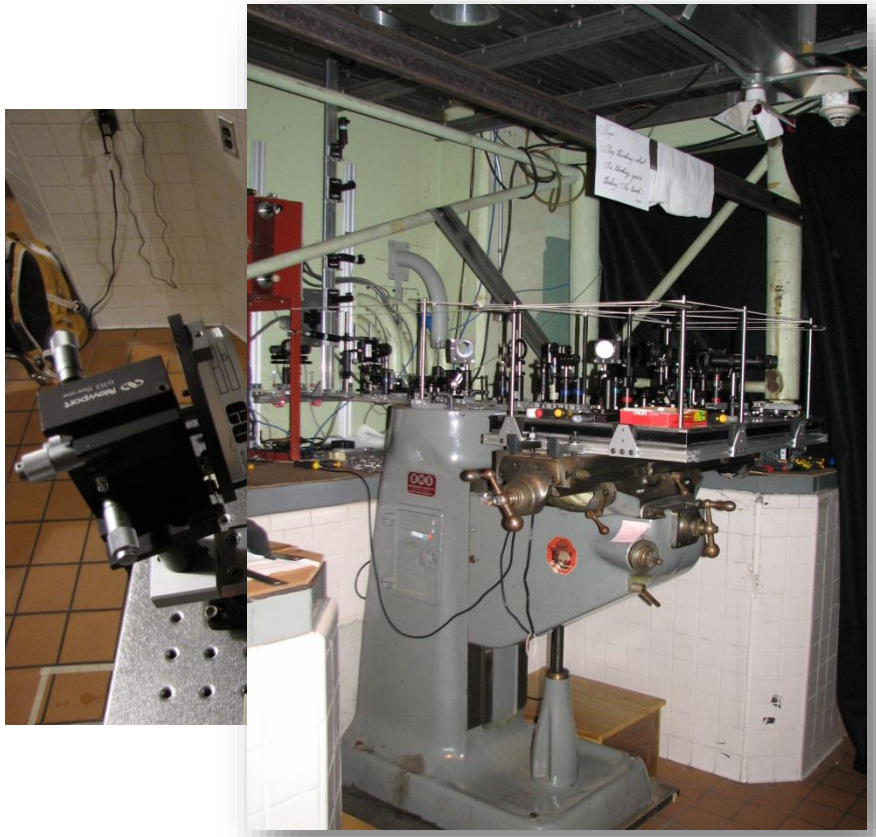
SHS can observe

at IR, Optical and UV wavelengths

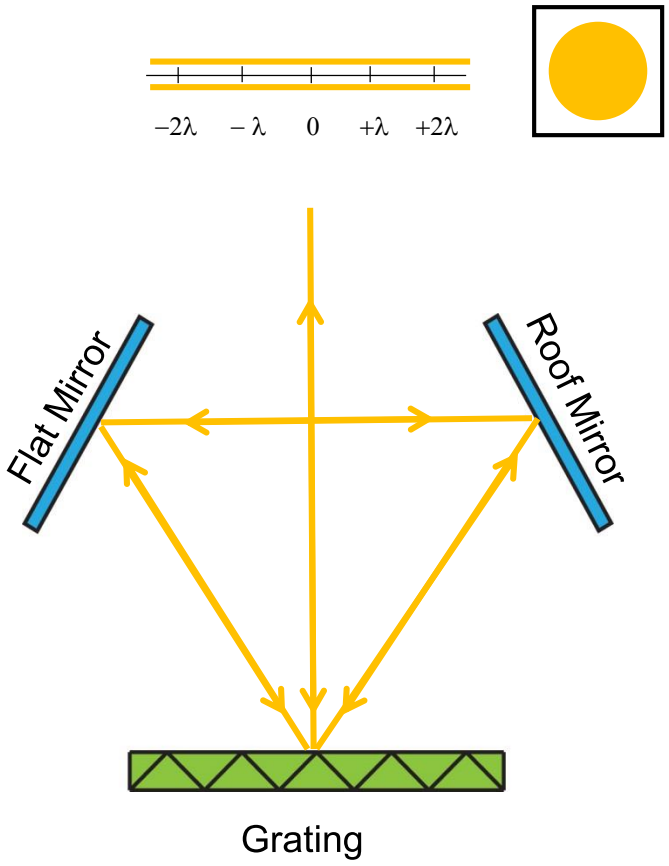
extended faint sources

at high Resolving Powers

in a compact format!



Spatial Homodyne Spectrometer achieves high spectral resolution at wide FOV in compact format



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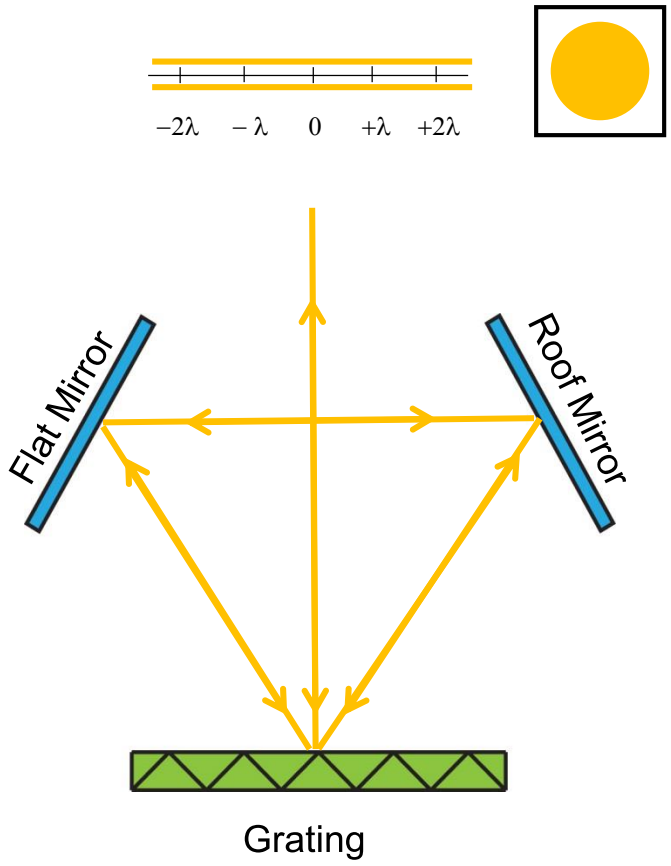
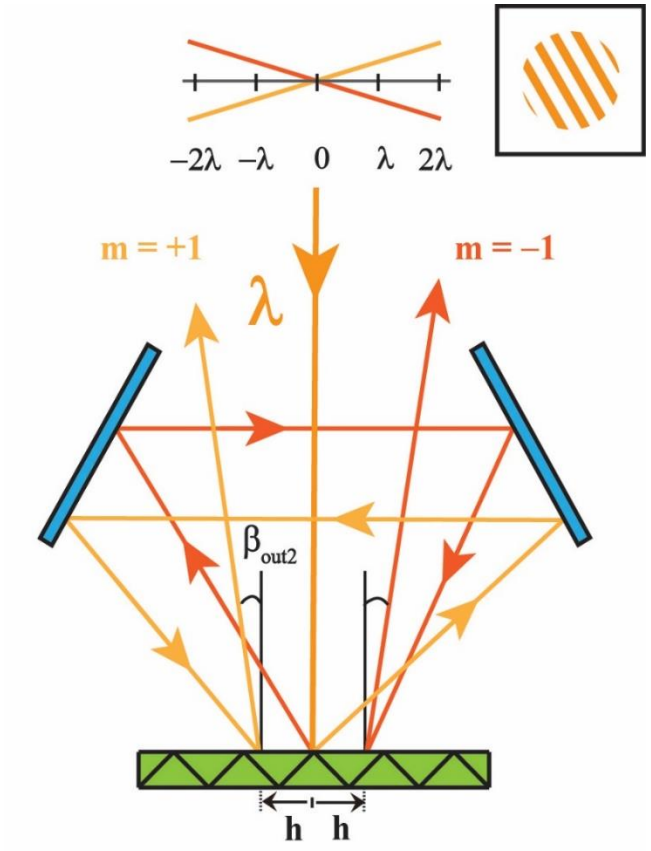
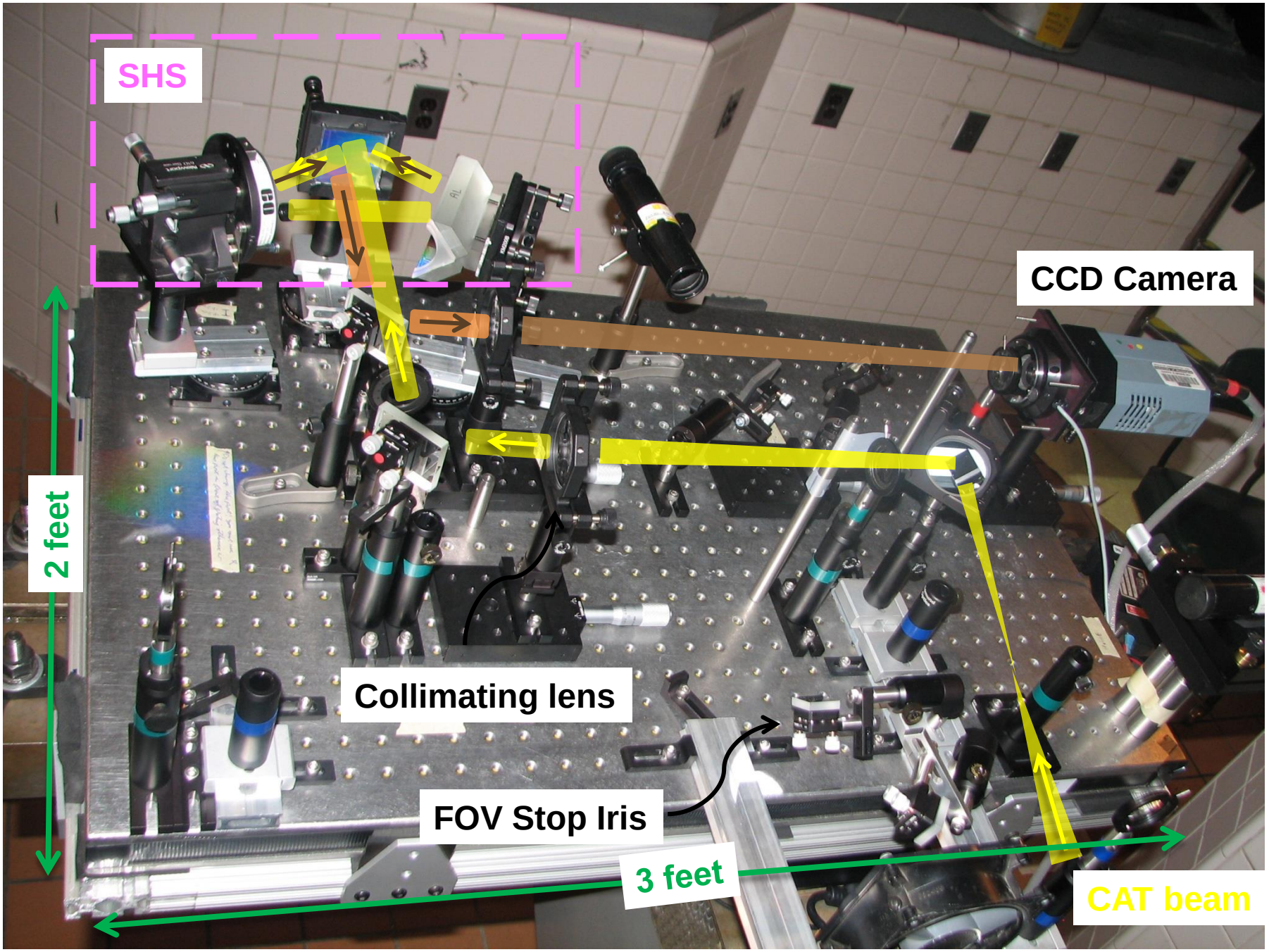
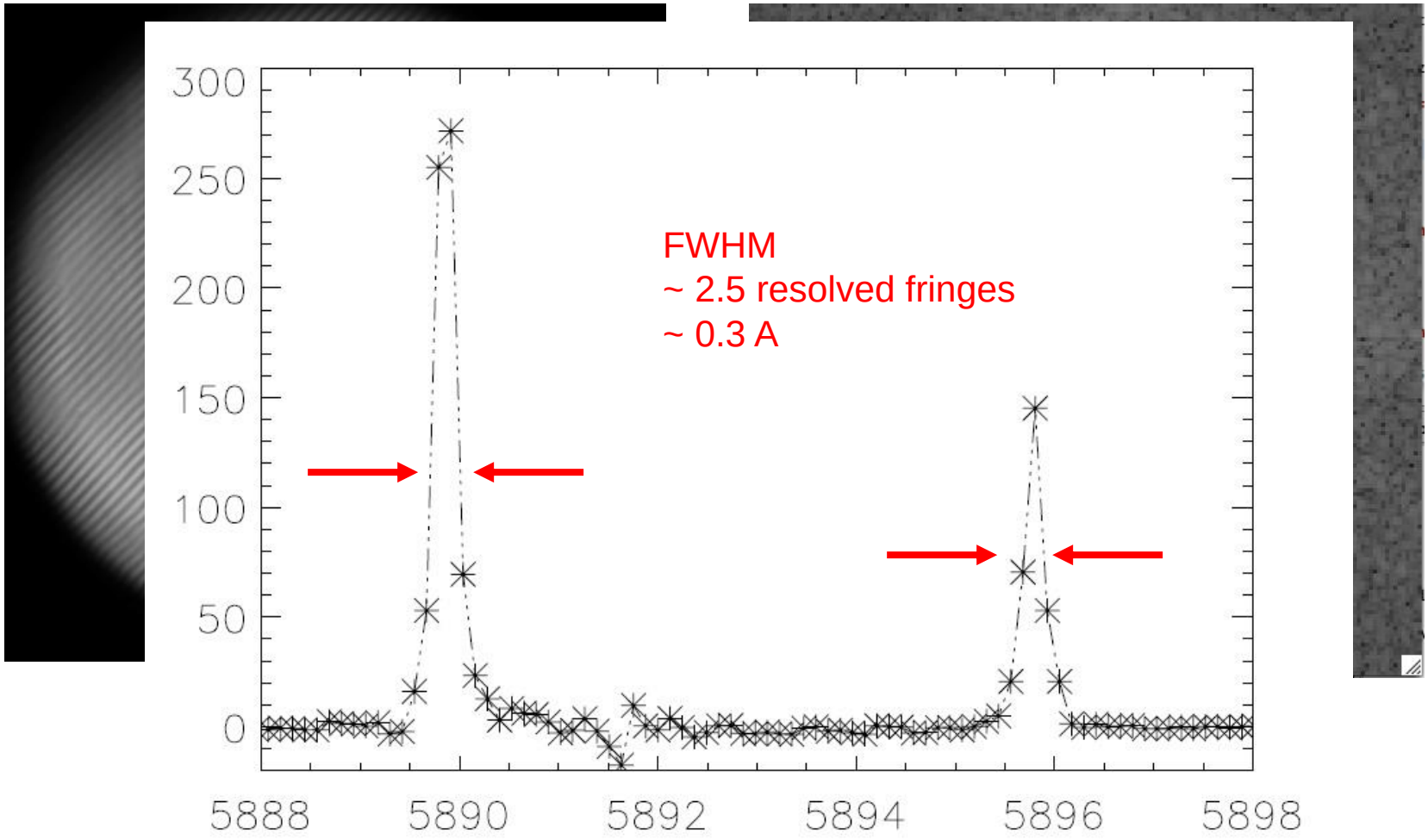





SHS
CCD Camera
2 feet
Collimating lens
FOV Stop Iris
3 feet
CAT beam

Na Lamp D lines



SHS vs. Other High Throughput Instruments

Telescope	Diameter (m)	Instrument	FOV (L"xW ")	Resolving Power	Étendue (m^2 $arcsec^2$)
Lick Obs./ CAT	0.6	SHS	48 × 48	72000	**650**
Lick Obs./ Shane	3.0	SHS	9.5 × 9.5	72000	**650**
Keck	10	HIRES	8 × 0.7	47000	**440**
McDonald Observatory	2.7	Coudé Spectrograph	8 x 1.2	60000	**55**
Apache Point Observatory	3.5	ARCES	1.3 x 0.8	27000	**10**
Nordic Optical Telescope	2.5	SOFIN Echelle	0.4 × 3.8	70000	**8**
Kueyen	8	UVES	0.45 × 8	80000	**180**

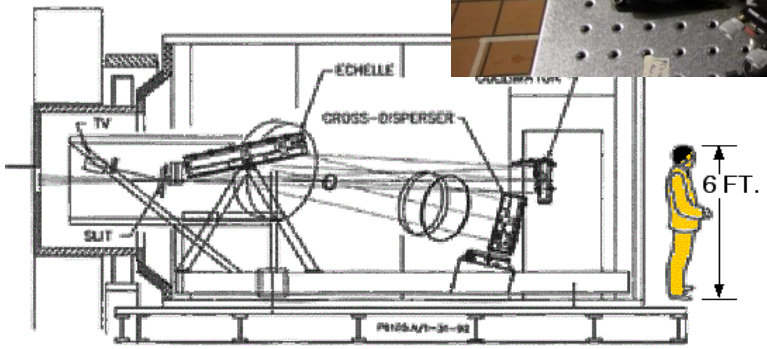
SHS could reveal incredible detail in a cometary coma/tail

H emissions in Lyman α at 121 nm
Comet Hale-Bopp

In comparison with similar spectral resolution instruments

Spec

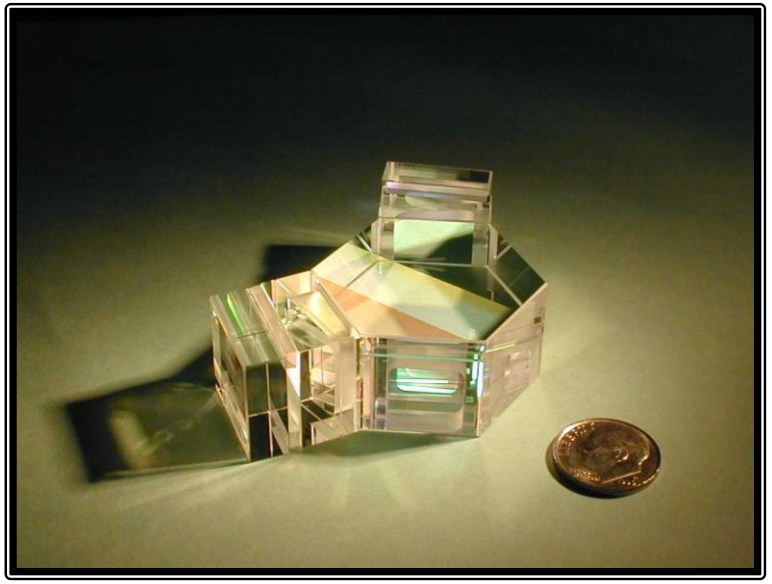
Keck spectrometer (HIRES)
$4 million, 8 tons, 5 m length



SHIMMER on STPSat-1 was decommissioned after completing 2.5 years of successful on-orbit operation

Launched 2007

- Make high resolution spectral measurements, using UV resonance fluorescence, of mesospheric hydroxyl (OH), an atmospheric trace constituent which is important for ozone chemistry
- Measures Earth's mesospheric OH radicals at 309 nm using solar resonance fluorescence - Diurnal variations measured



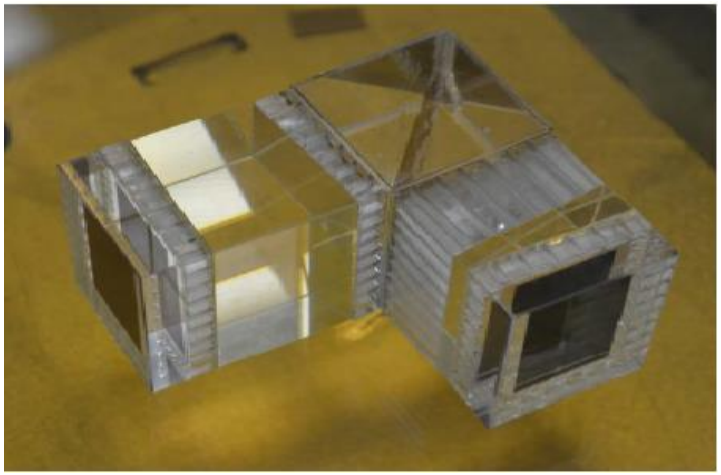
The STPSat-1 small satellite, built for the Department of Defense (DoD) Space Test Program (STP) and operated by the DoD STP for the first year then transitioned to NRL for the last 16 months.

MIGHTI on ICON Heliophysics Explorer Mission will launch at 2017

$200 M ICON mission

(Tom Immel, UCB; Orbital Sciences)

- Michelson interferometer for global high-resolution thermospheric imaging (MIGHTI)
- Will determine Earth's thermospheric winds and temperatures at altitudes 90-300 km
- Maps oxygen A-band at 630 nm
- Derivative of UARS WINDI instrument and SHIMMER on STPSat-1



Engineering model of the MIGHTI interferometer

MANIC's optic is designed to enable the direct detection of nearby Jupiter-like exoplanets, and maybe extended to enable Earth-like system detection

Monolithic achromatic nulling interference coronagraph: design and performance

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Hicks, Boston University, MA with input from Light Machinery Inc.

Compact design that greatly reduces star-exoplanet contrast

Astrophysics
Direct imaging of exoplanets
Interstellar Medium
H-a mapping of Nebula and Galaxies

Planetary Science
Mars Methane
Cometary Coma
Io Plasma Torus

Earth Science
Wind and Temperature profiles
OH Measurements