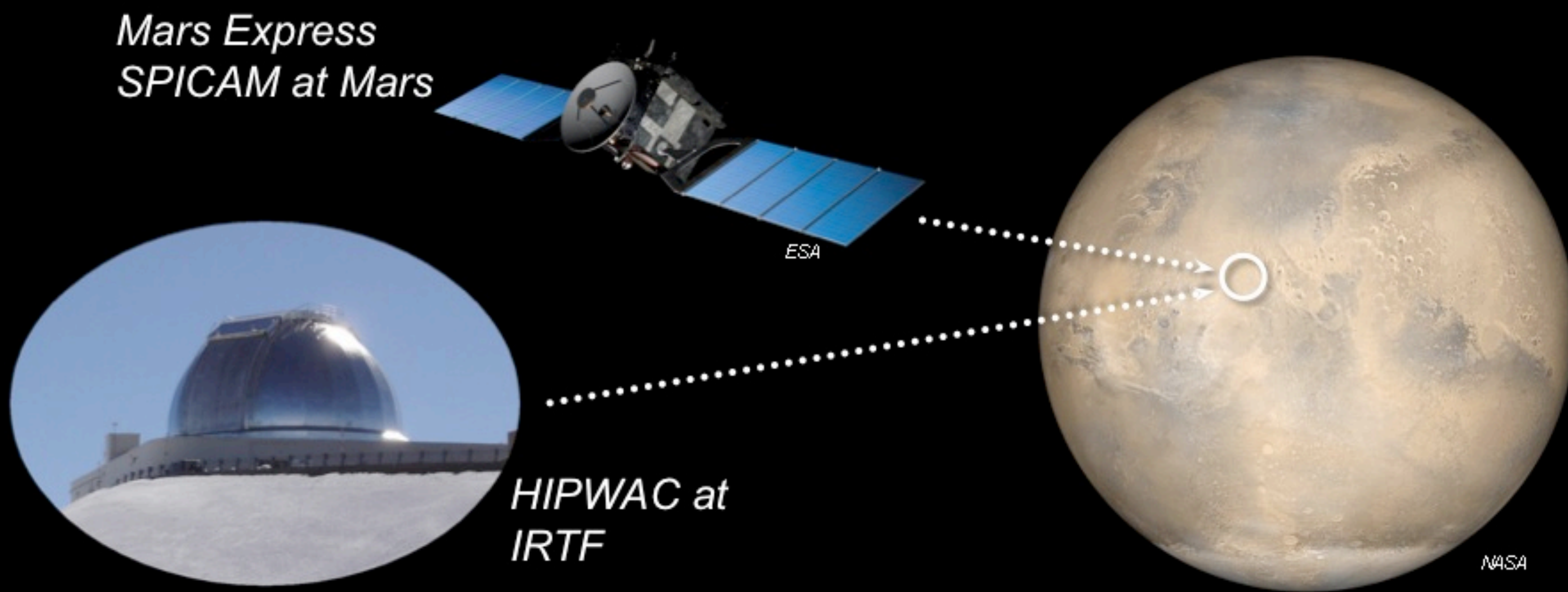
Coordinated observations of ozone on Mars by HIPWAC and Mars Express SPICAM



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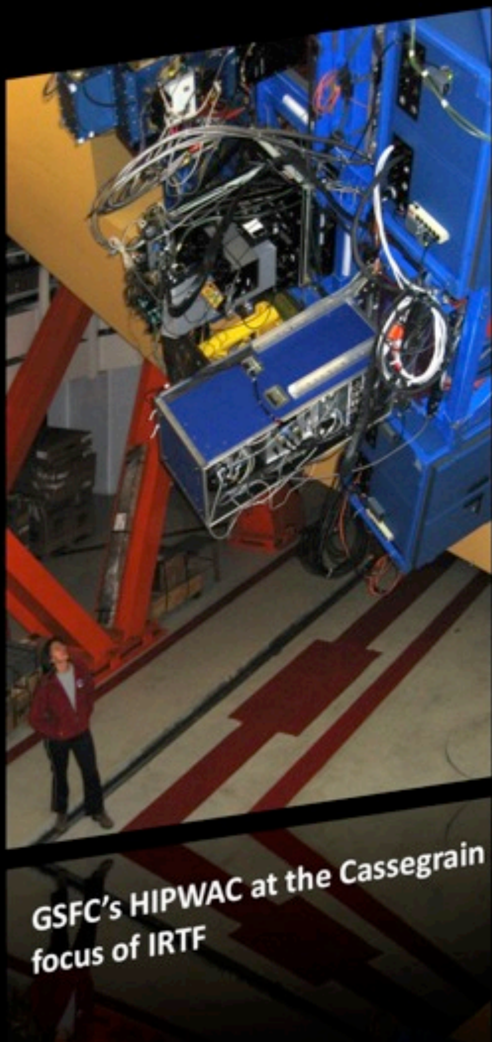
Comparison of HIPWAC and Mars Express SPICAM observations of ozone on Mars 2006-2008 and variation from 1993 IRHS observations


GSFC's HIPWAC at the Cassegrain focus of IRTF

- Ozone (O_3) is an important observable tracer of Martian atmospheric chemistry that is used to test and validate photochemical models, such as those seeking to explain the abundance and fast destruction of methane.
- Only infrared heterodyne spectroscopy provides sufficient spectral resolving power ($\lambda/\Delta\lambda > 10^6$) to allow ozone features on Mars to be observable from the surface of the Earth when Doppler shifted away from telluric counterparts.
- The NASA Infrared Telescope Facility has hosted such measurements made with Goddard's Heterodyne Instrument for Planetary Wind and Composition (HIPWAC) and Infrared Heterodyne Spectrometer (IRHS), dating back to 1988. Such measurements provided important input to photochemical models during the long gap between missions targeting ozone (Mariner 9 and Mars Express, Mars Reconnaissance Orbiter), and complement current missions.

Fast, K. E., T. Kostiuk, F. Lefèvre, T. Hewagama, T. A. Livengood, J. D. Delgado, J. Annen and G. Sonnabend 2009. Comparison of HIPWAC and Mars Express SPICAM observations of ozone on Mars 2006-2008 and variation from 1993 IRHS observations, *Icarus*, 203, 20-27, doi:10.1016/j.icarus.2009.05.005.

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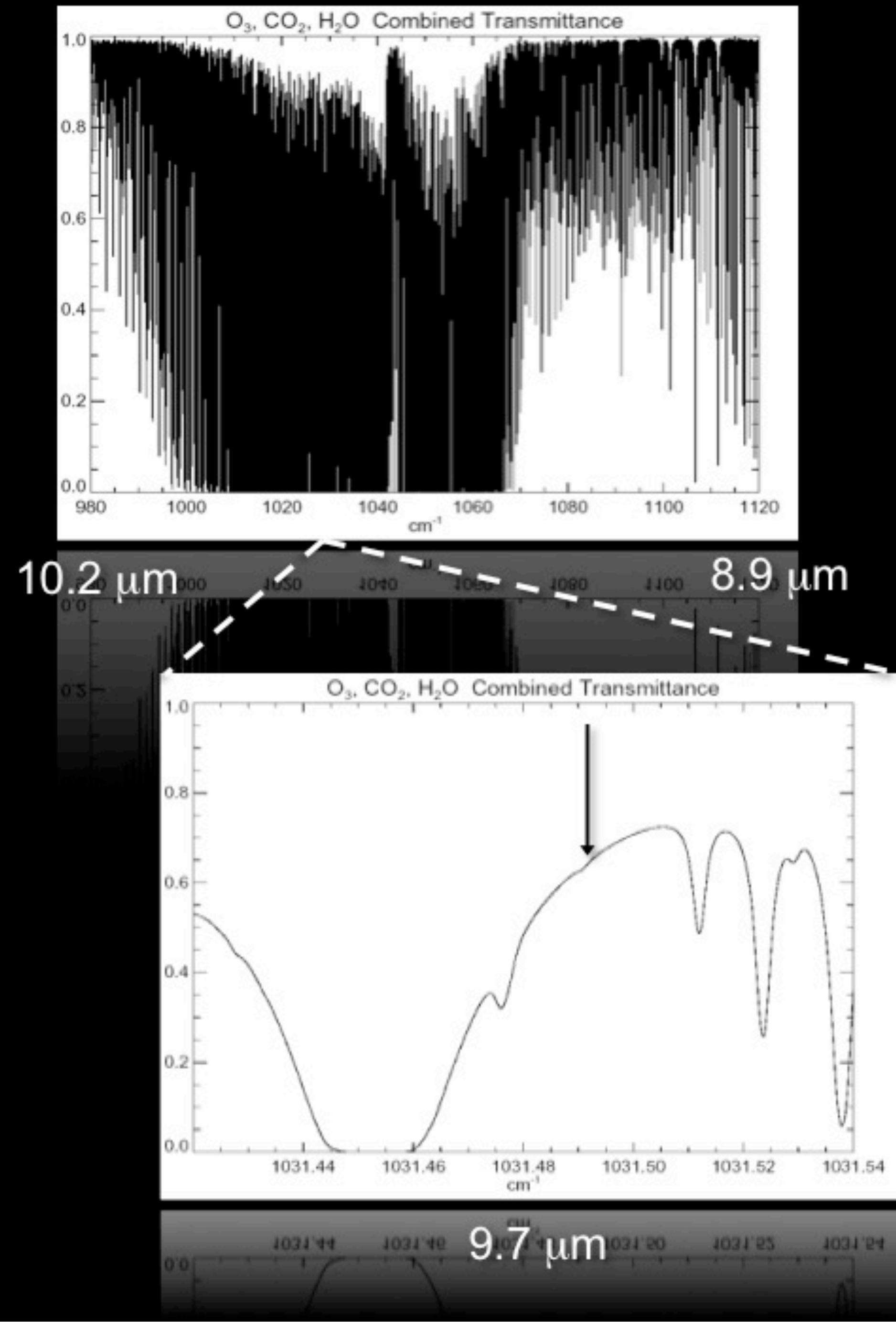
Looking through the Earth's

"Picket Fence"

Infrared Heterodyne Spectroscopy

- Spectral resolving power $\lambda/\Delta\lambda > 10^6$
- Only <u>direct</u> ground-based access to Mars ozone absorption features when Doppler shifted to regions of higher atmospheric transmittance (arrow).



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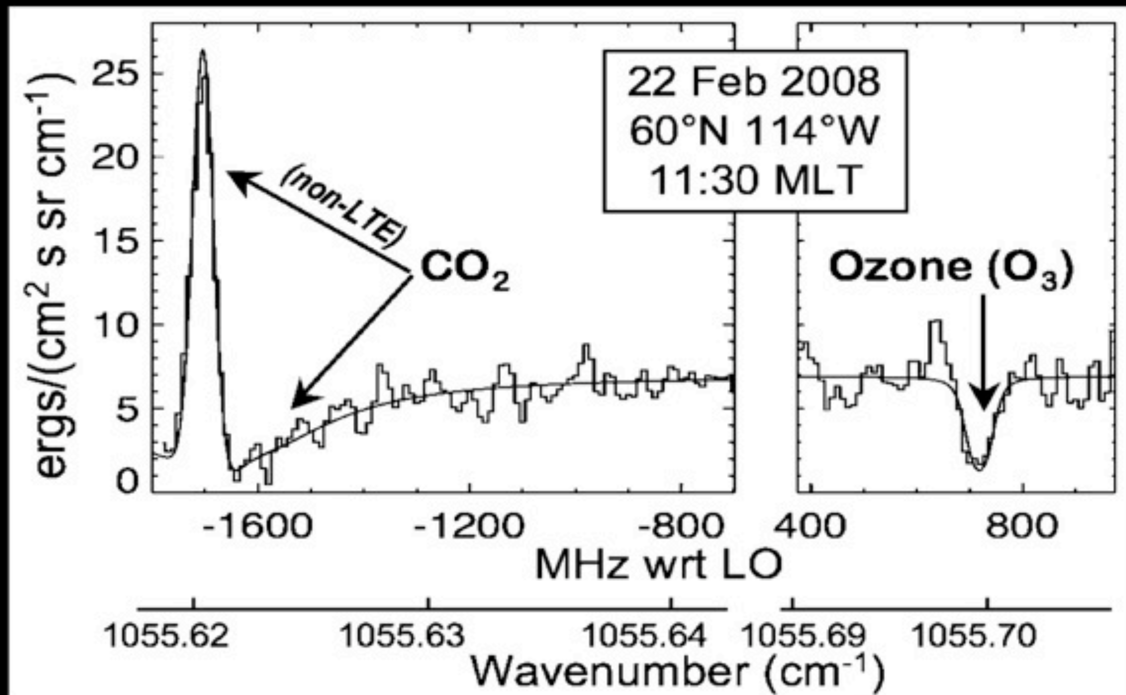

- Example HIPWAC spectrum of Mars (histogram) and model (solid).
- Telluric contribution has been modeled and removed. Original 1 MHz-resolution spectrum has been smoothed to 10 MHz for clarity and shown as single-sideband.
- Spectrum includes fully-resolved ozone and a CO_2 absorption features, as well as a high-altitude non-LTE emission feature.

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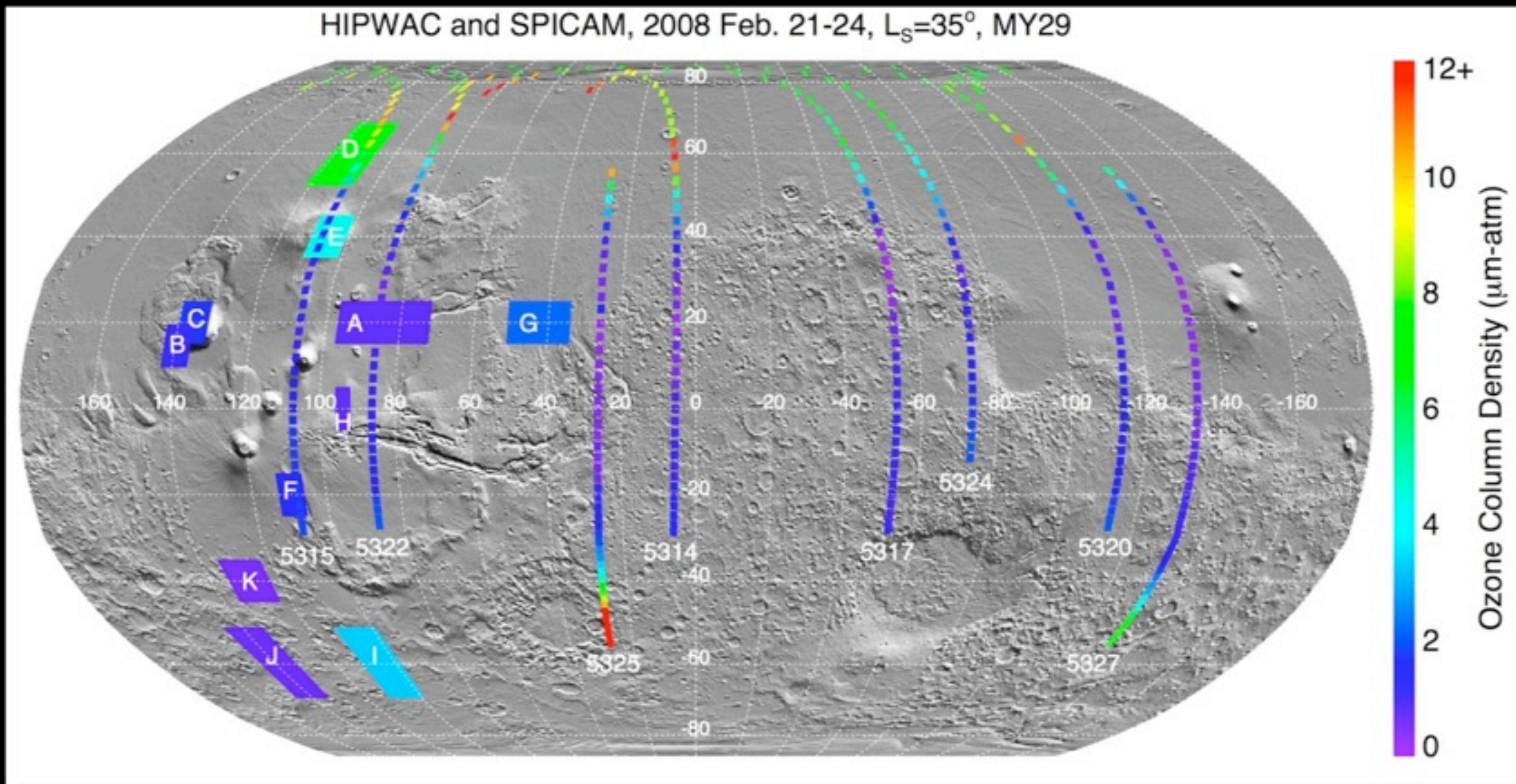

HIPWAC measurements from IRTF (solid) coordinated with Mars Express SPICAM measurements from Mars orbit (tracks) in 2008 resulted in generally consistent ozone abundance retrievals, providing mutual validation and supporting the combined use of retrievals from these IR and UV instruments for testing photochemical models.

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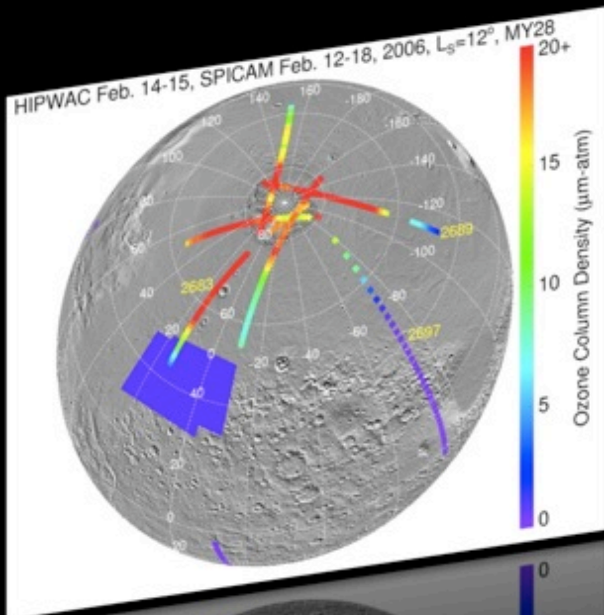

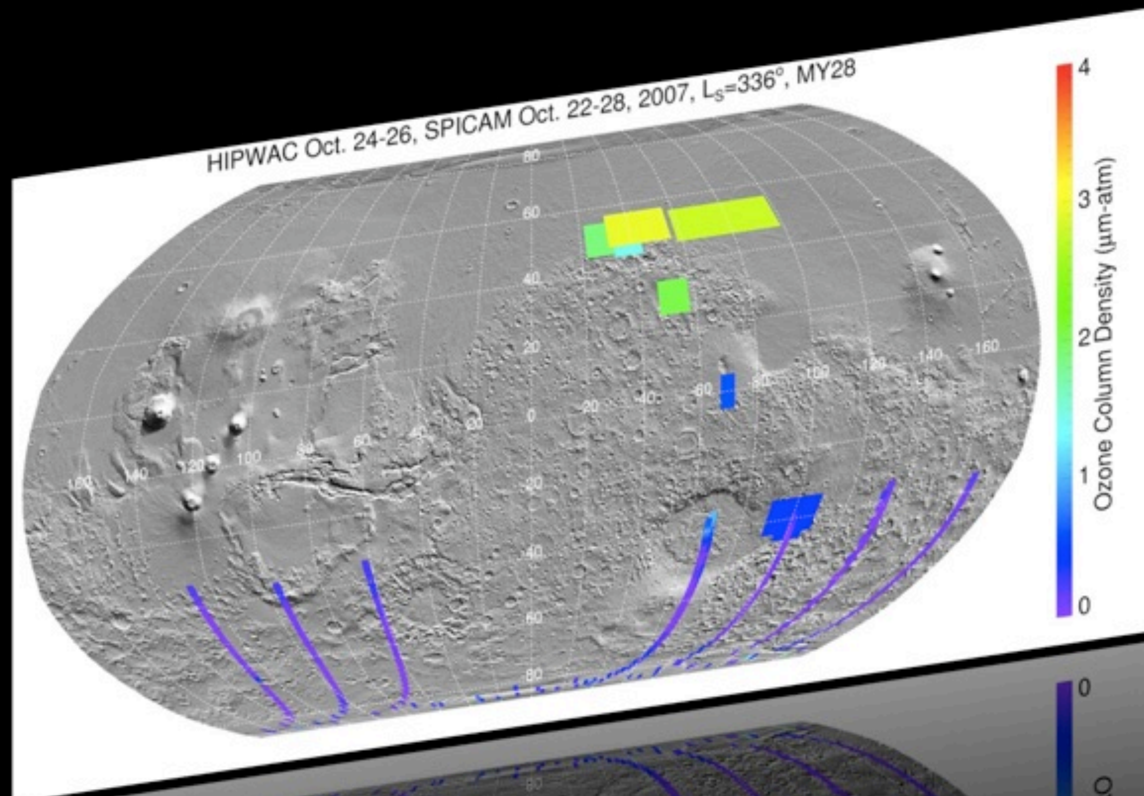

- HIPWAC measurements from IRTF in 2006 and 2007 (solid) and those from Mars Express SPICAM (tracks) consistently measure low ozone at their low latitude overlap points.
- SPICAM's polar measurements are complemented by HIPWAC's sampling of other latitudes, expanding spatial coverage during these seasonal periods.

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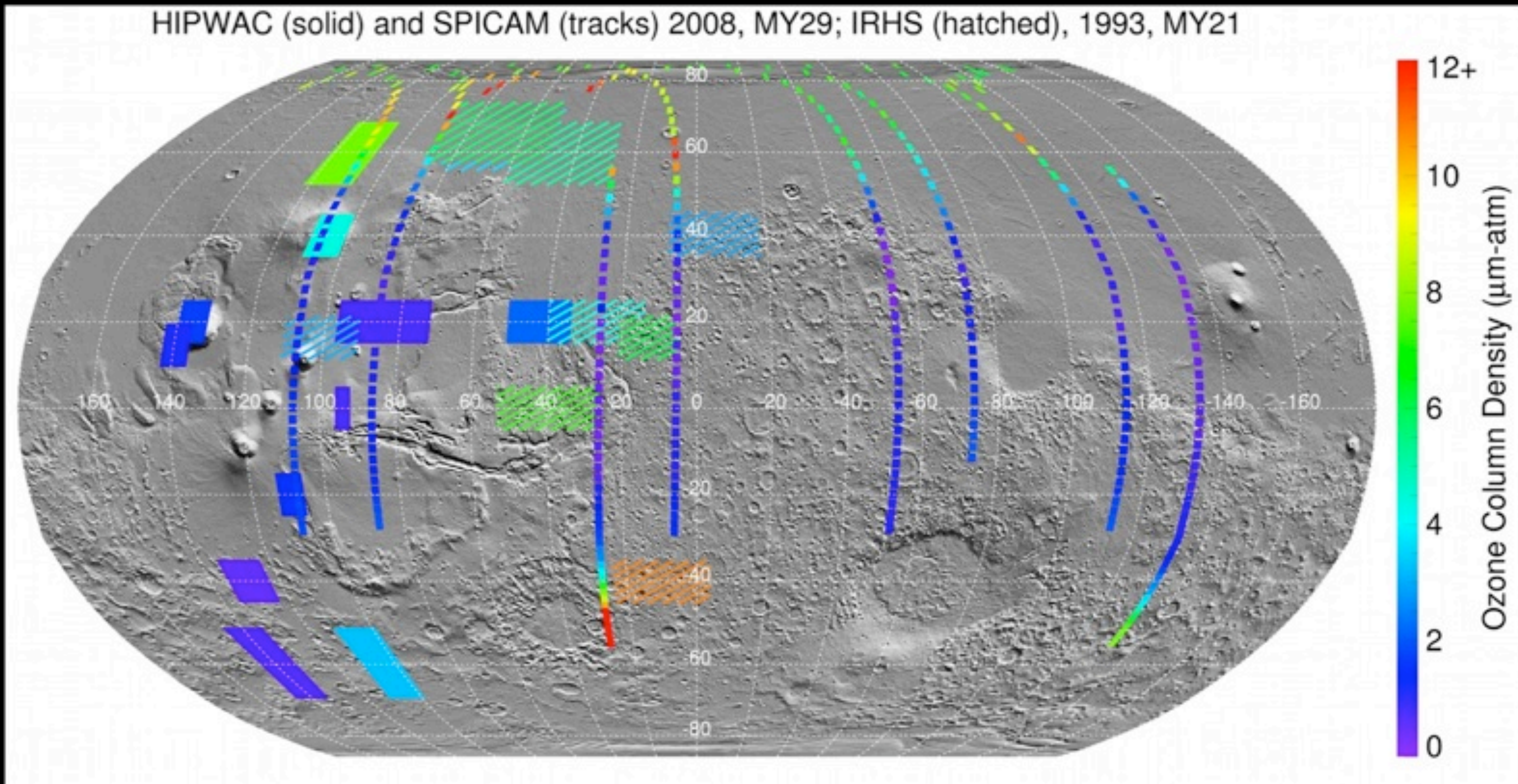

- 1993 IRHS measurements (hatched) reveal higher ozone abundance at low latitudes than seasonally similar measurements in 2008 by HIPWAC (solid) and SPICAM (tracks).
- The different low latitude abundances may indicate possible changes in northern spring cloud activity and subsequent heterogeneous chemistry not seen on the shorter timescale of the Mars Express mission.

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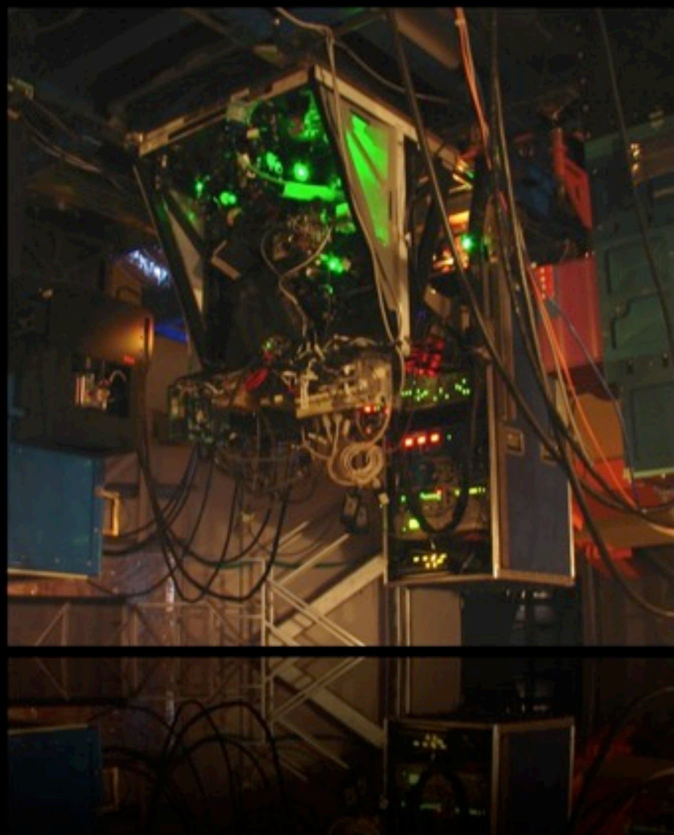

IRHS and HIPWAC are fundamentally the same instrument, linking quantitatively the larger timescale measurements made at IRTF with current spacecraft missions and revealing long-term photochemical behavior of the atmosphere of Mars.

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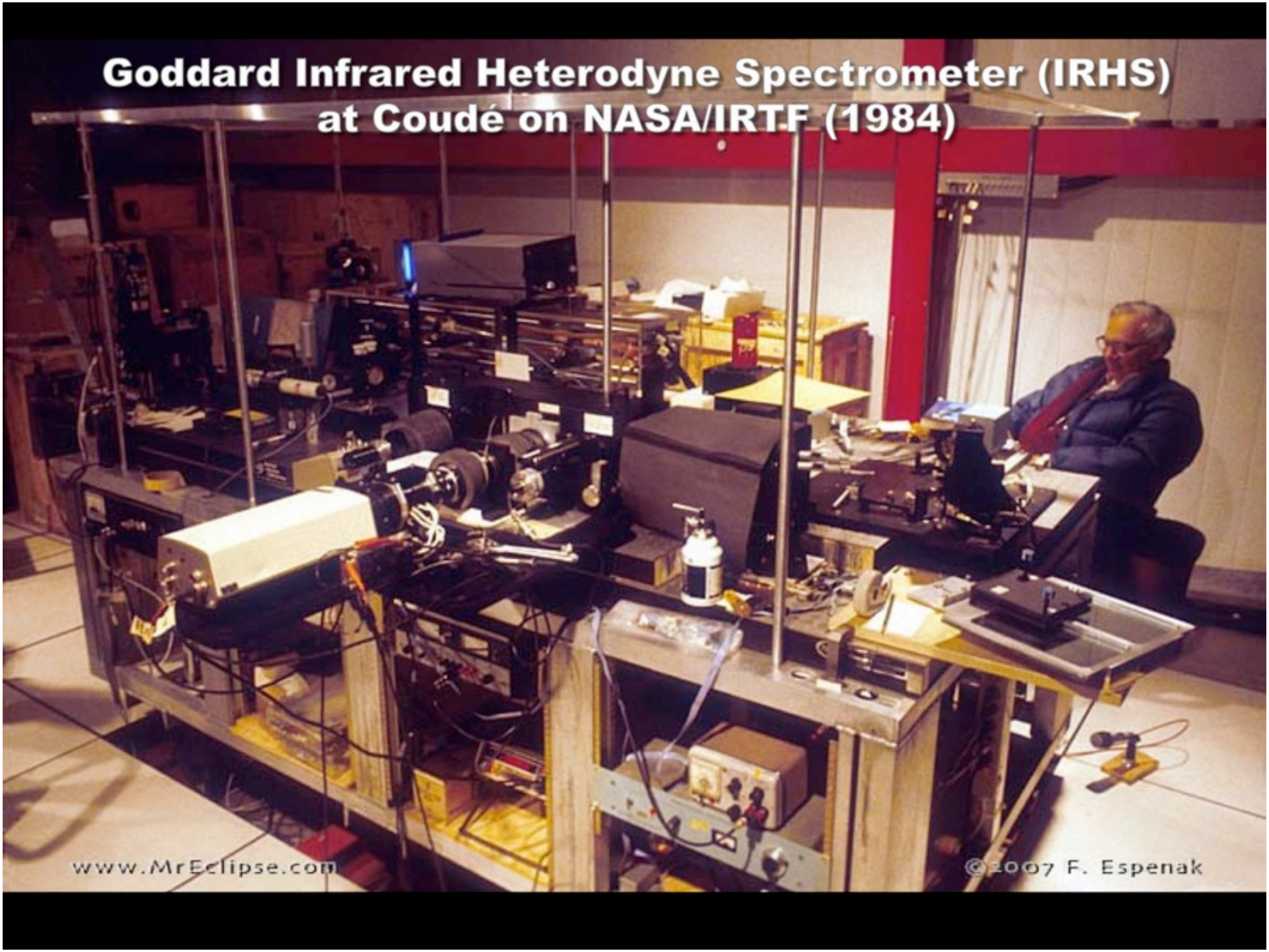
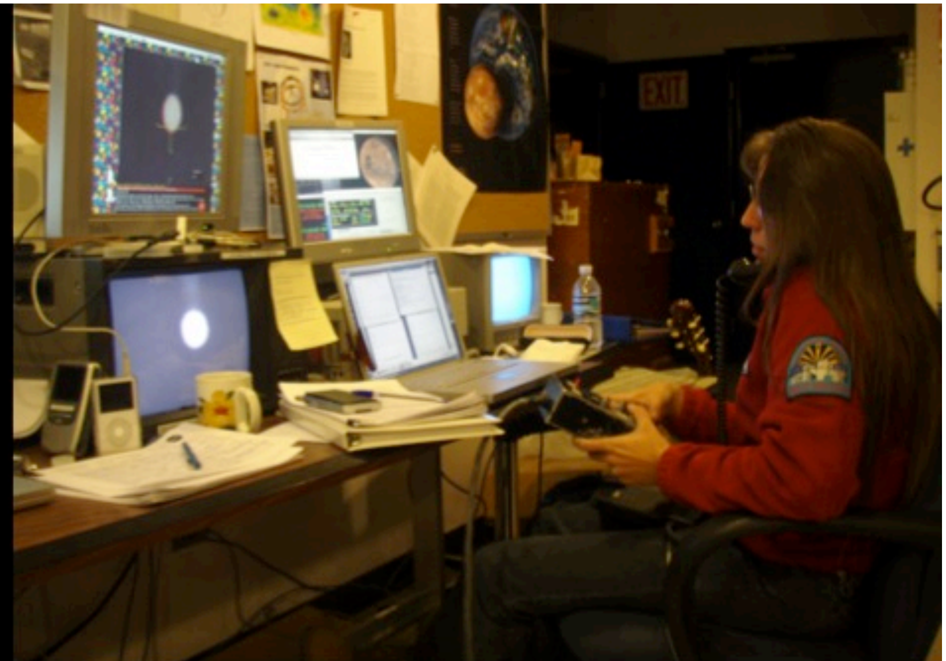

Goddard Infrared Heterodyne Spectrometer (IRHS)
at Coudé on NASA/IRTF (1984)
www.MrEclipse.com
©2007 F. Espenak

Freezing at Coudé operating IRHS in 1996...



Cassegrain operation with HIPWAC…from the much more hospitable control room!


IRTF in 1991
www.MrEclipse.com
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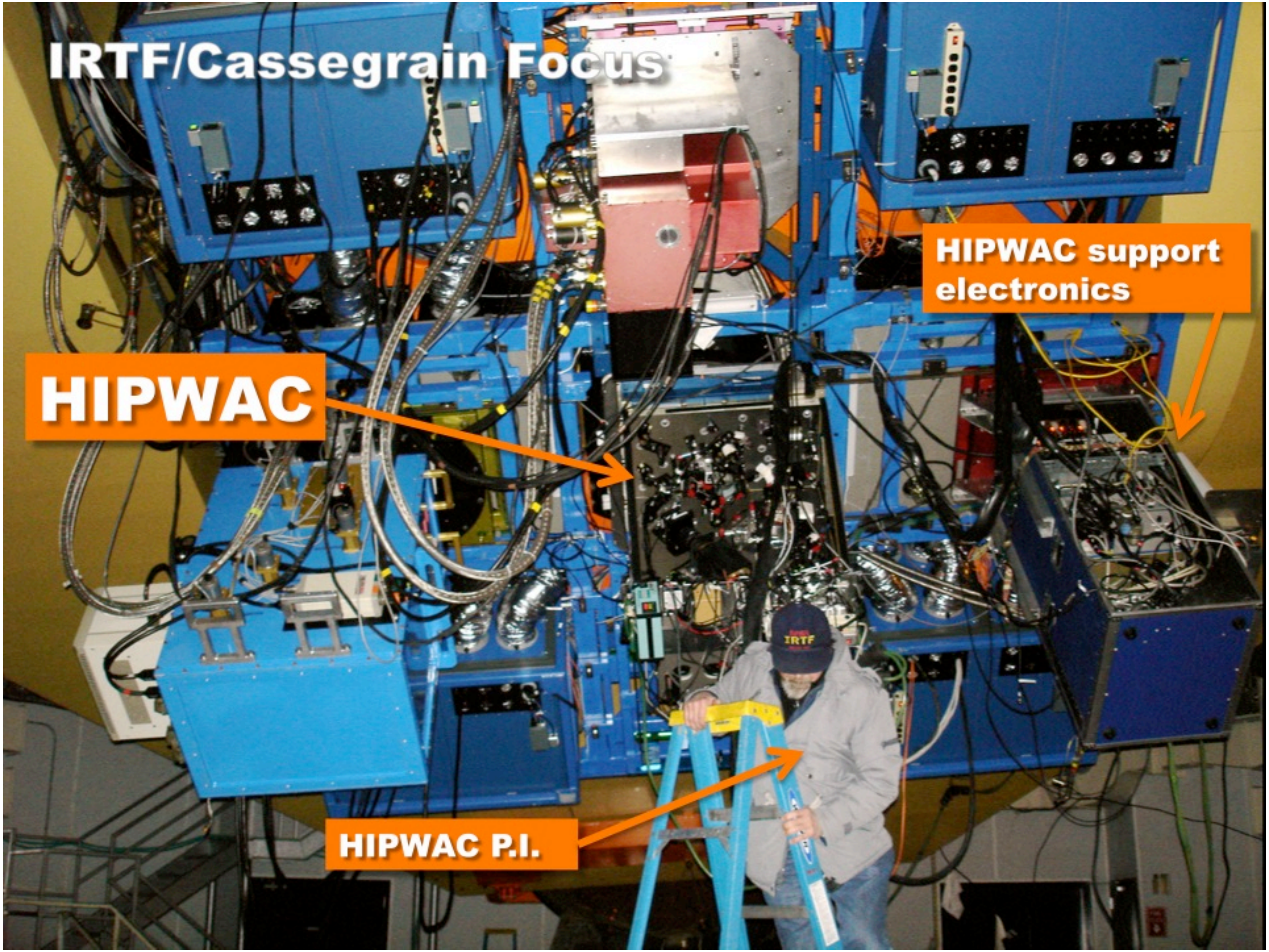
IRTF/Cassegrain Focus
HIPWAC support electronics
HIPWAC
HIPWAC P.I.
IRTF

Visitor instruments made available to the community on a collaborative basis enhance the wavelength coverage and resolving power obtainable at IRTF.

Instrument	Range	$\lambda/\Delta\lambda_{max}$
SpeX	0.8-5.4 μm	2500
CSHELL	1-5.5 μm	40,000
NSFCAM2	1-5.2 μm	
MIRSI2	2-28 μm	200
HIPWAC	9-12 μm	1,000,000
THIS	9-12 μm	1,000,000
BASS	3-14 μm	120
TEXES	8-26 μm	100,000
CELESTE	5-25 μm	40,000




Many thanks to the IRTF day crew, telescope operators, and staff for making visitor instrument programs possible.