3μm帯同時分光で探る
原始惑星系円盤、及び系外惑星大気

寺田 宏

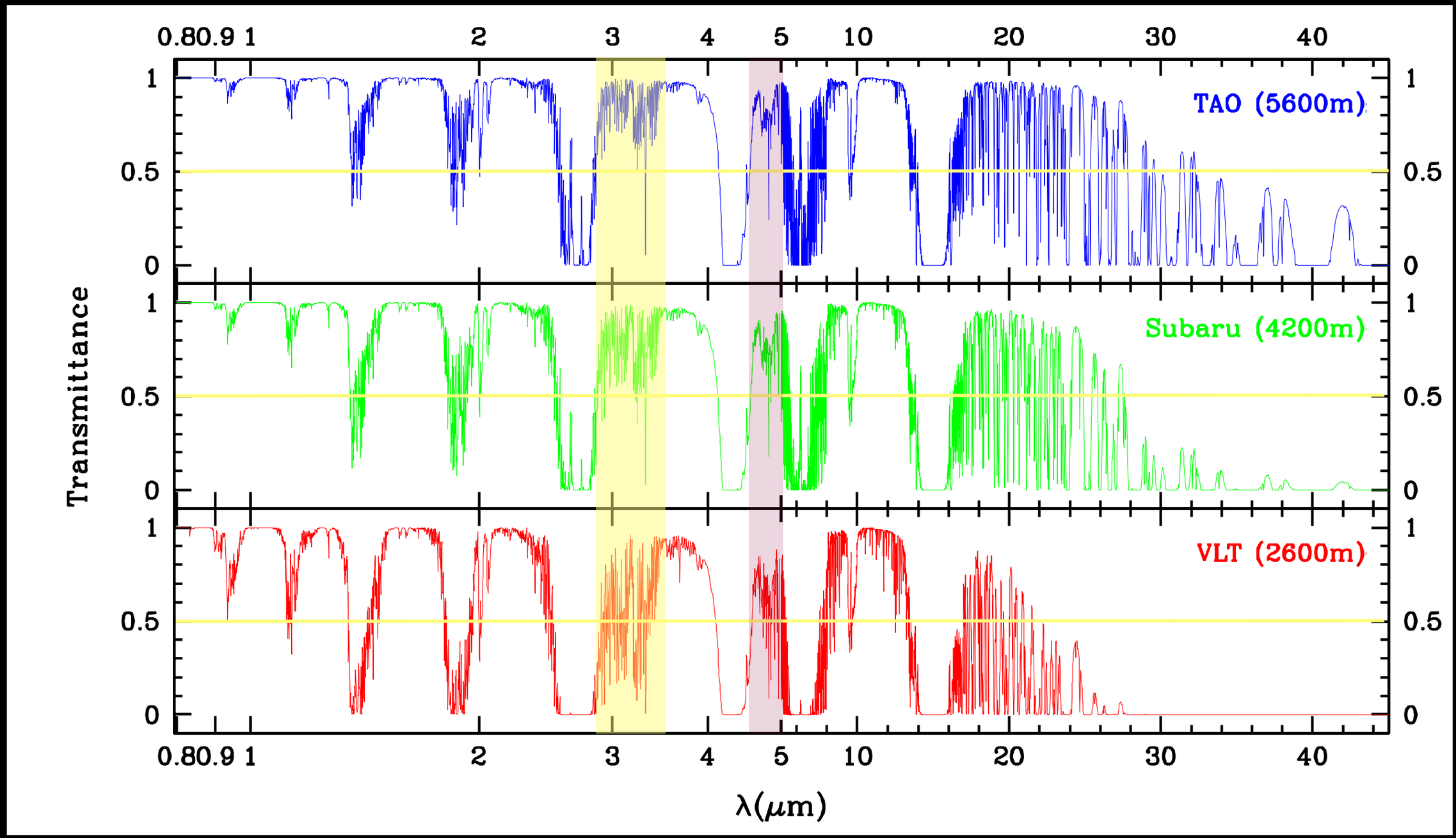
(国立天文台ハワイ観測所)

(I) Organic Molecules and Ices in Protoplanetary Disks
(II) Exo-Planetary Atmosphere in Transiting Systems

Advantage of MIMIZUKU

"Great Site" & "Simultaneity"

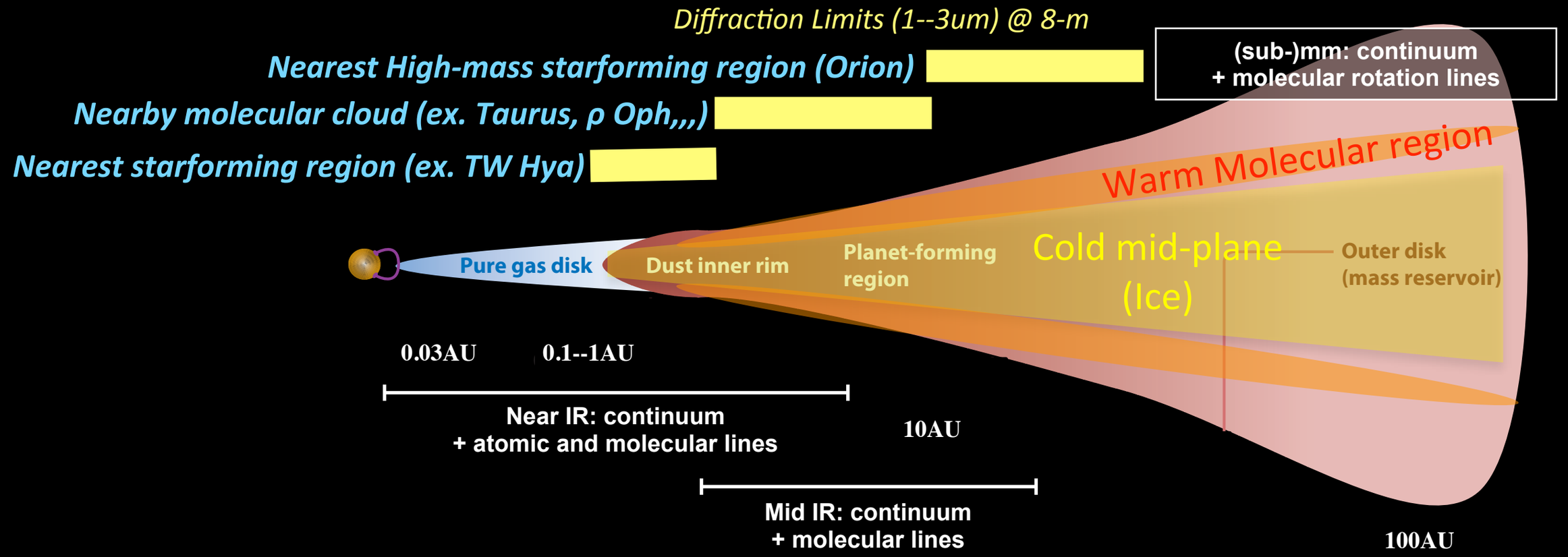
Atmospheric Calibration for Less Transmittance IR-Region



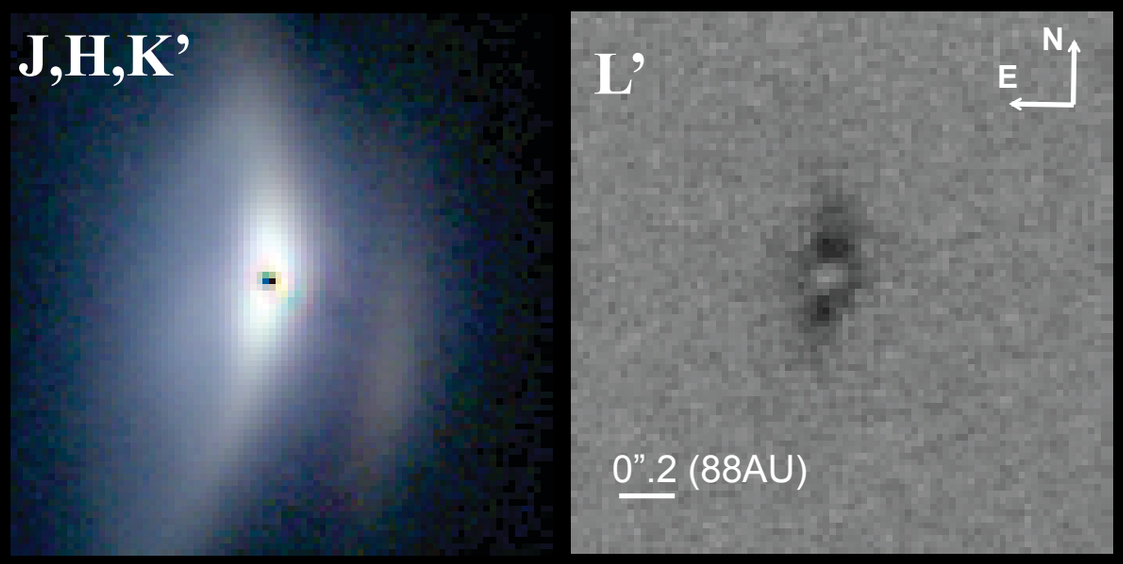
Hiroshi TERADA (Subaru Telescope)

(I) Organic Molecules and Ices in Protoplanetary Disks

Observational View of Protoplanetary Disks



IRCS + AO188 [NGS] @ Orion



Terada+ 2012

Ground-based AO works well in NIR region.

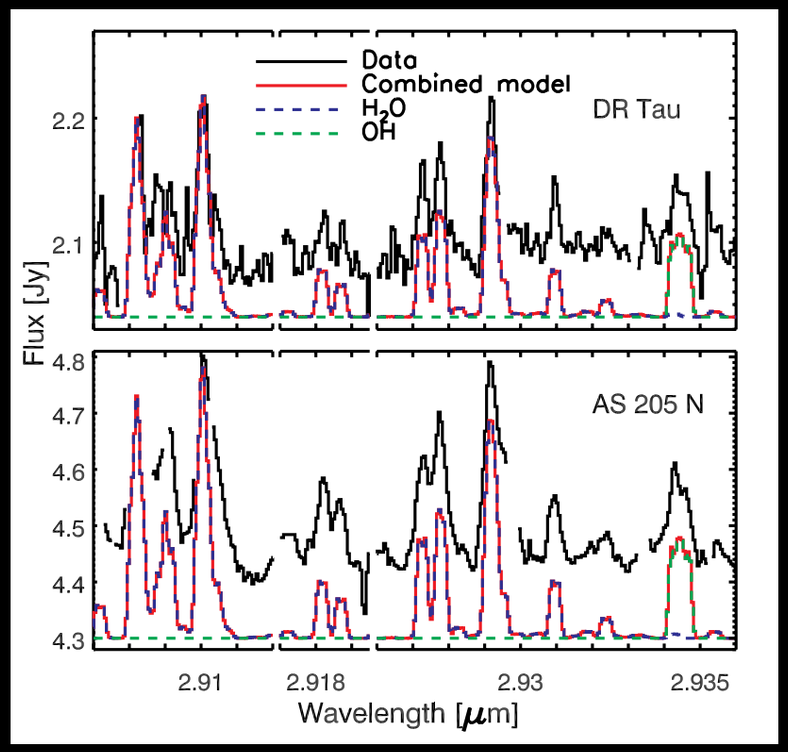
=> Spectro-Astrometry w/ AO is a hope to probe the inner region..

Hiroshi TERADA (Subaru Telescope)

(a) Organic Molecules in Protoplanetary Disks

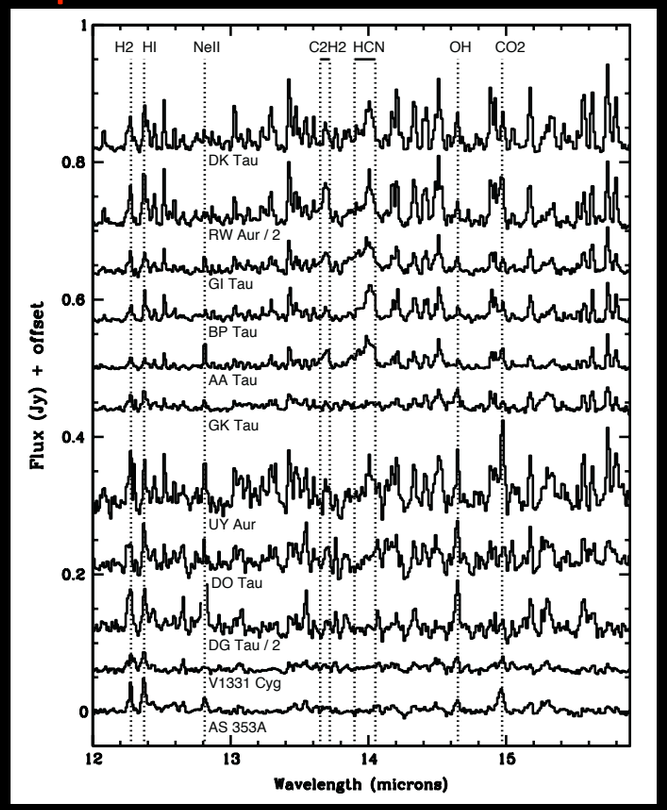
Previous Detections

Keck NIRSCPEC



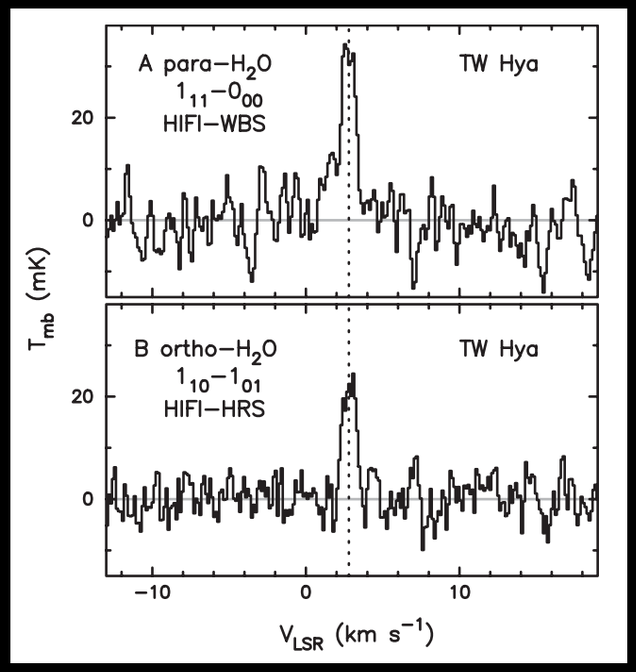
Salyk+ 2008

Spitzer C2H2 HCN OH CO2

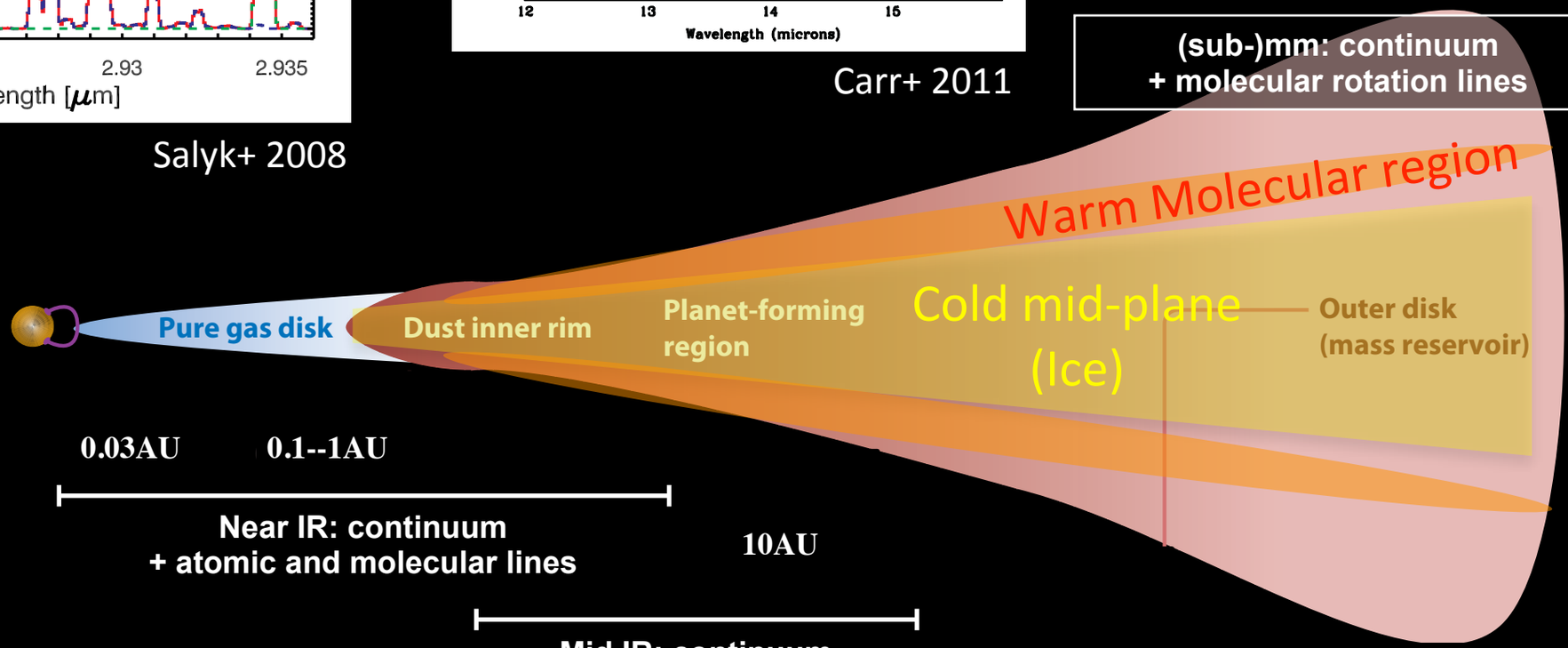


Carr+ 2011

Herschel



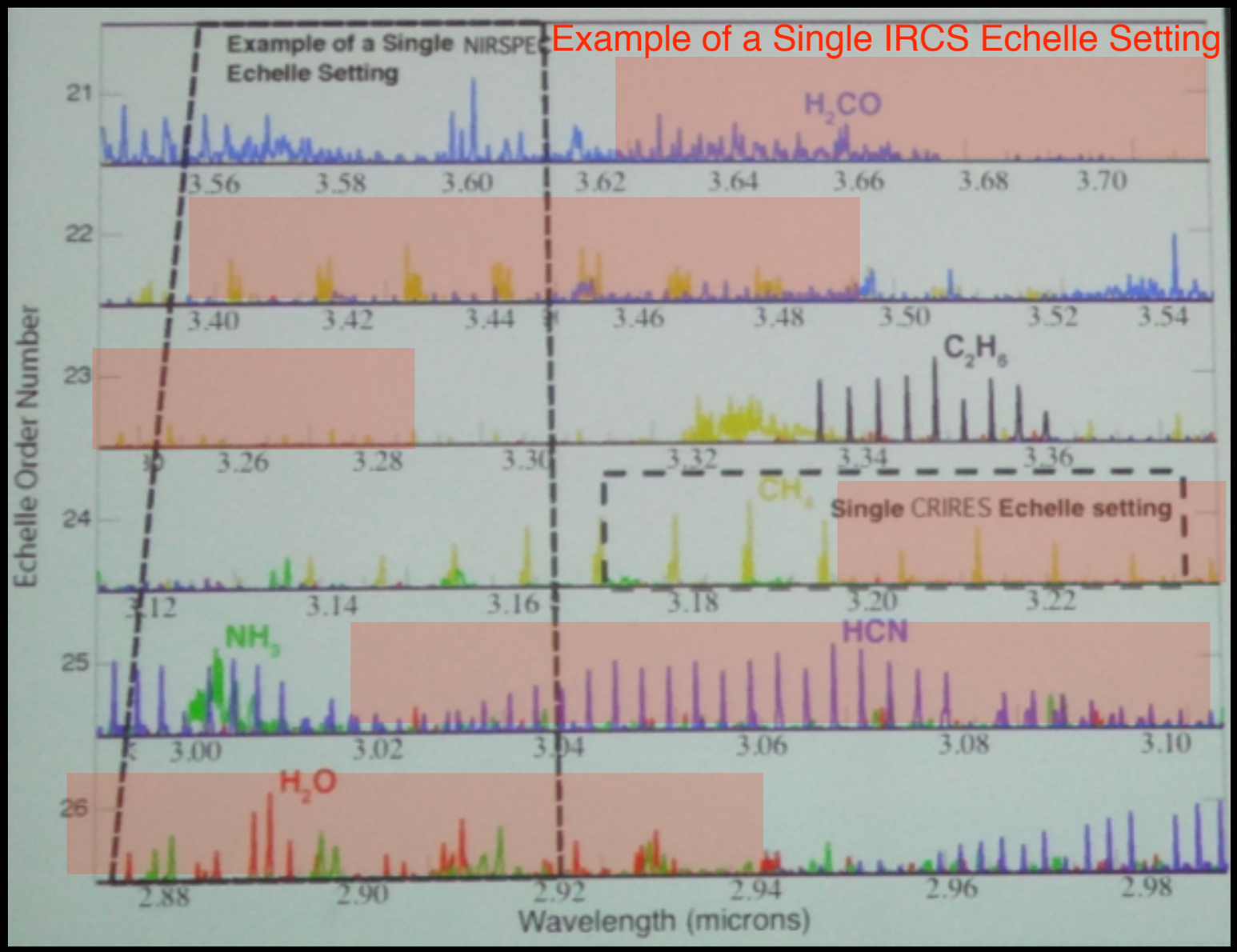
Hogerheijde+ 2011



Hiroshi TERADA (Subaru Telescope)

(a) Organic Molecule Signatures

Near IR (~3um) Wavelengths



Background figure from Mandell 2012

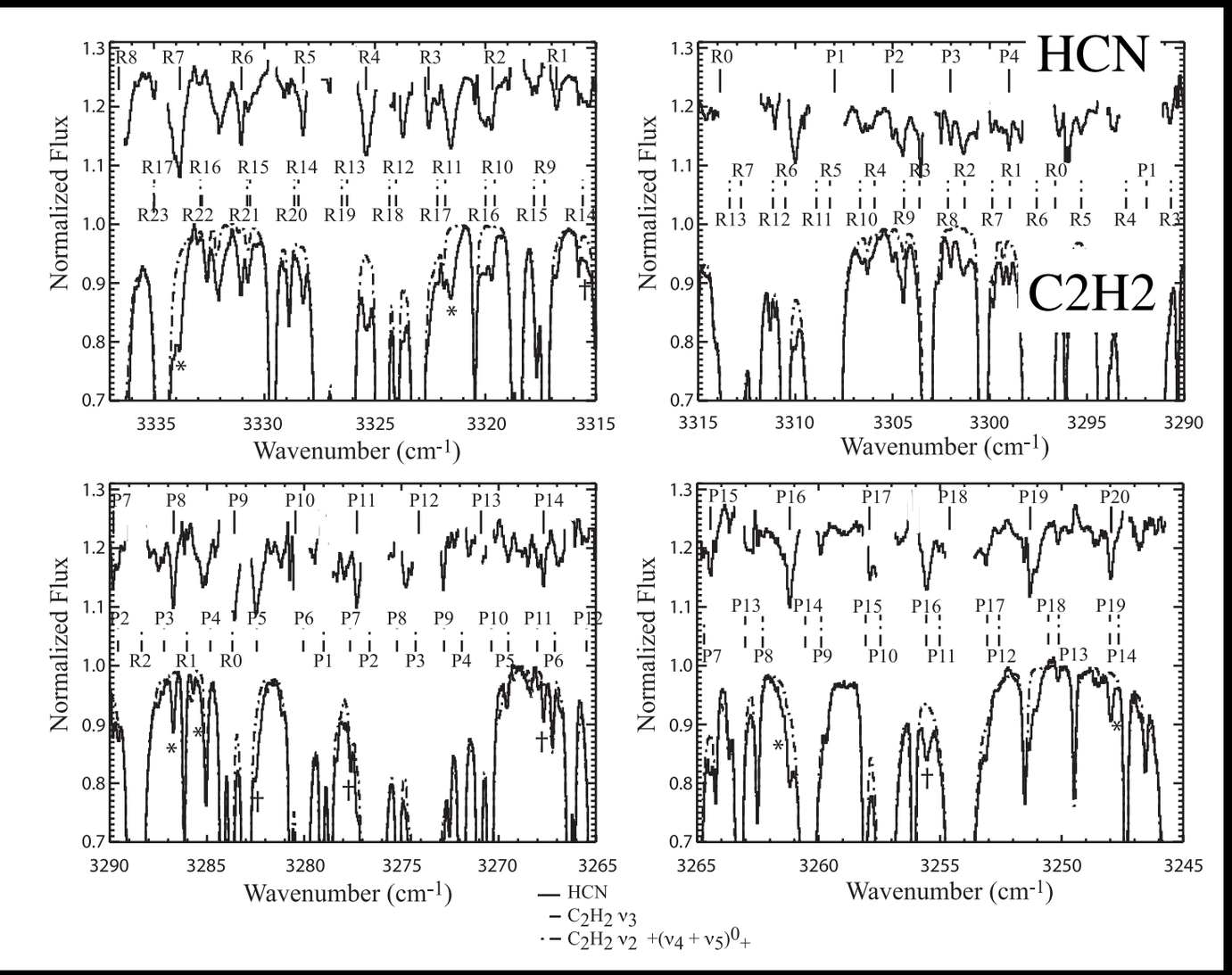
Suitable for tracing warm molecular volatile gases.

Sensitive for temperature (100--1000K) ==> <5AU molecule

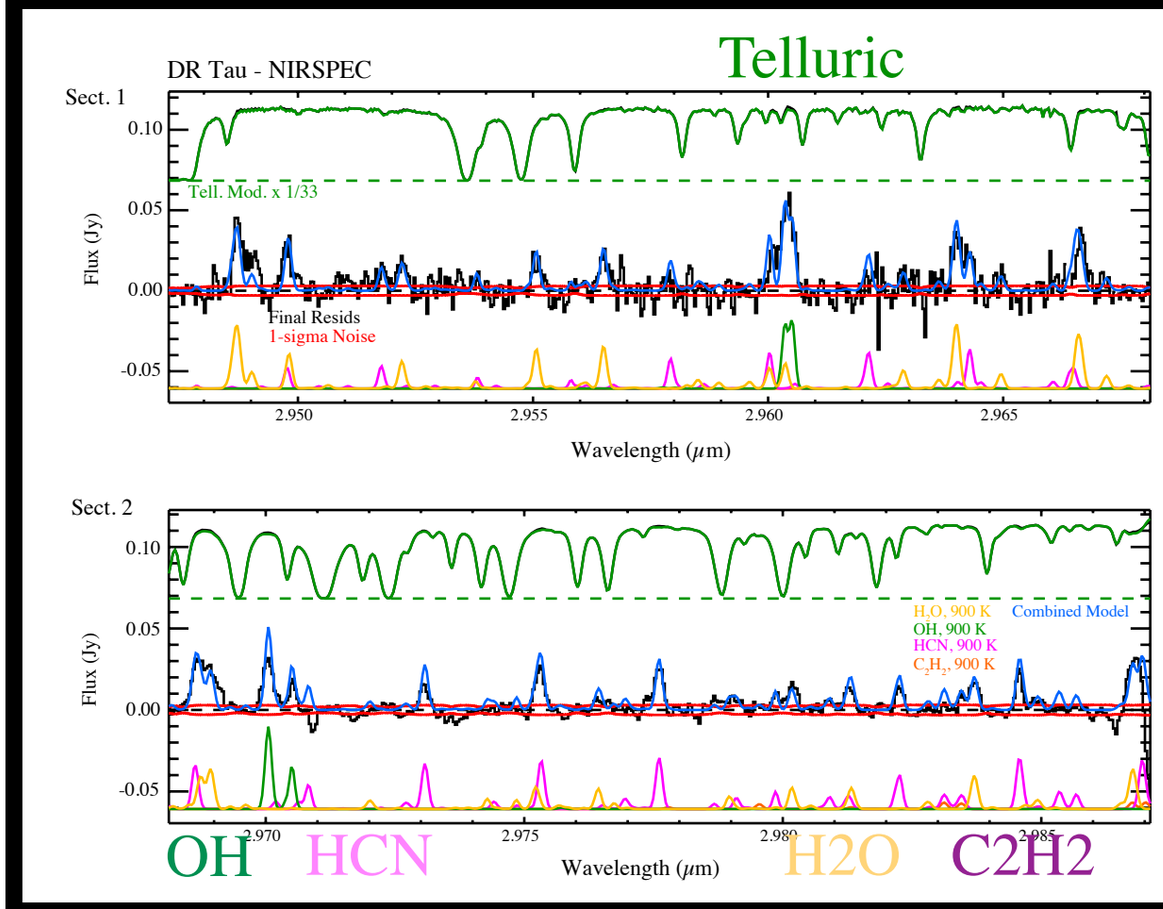
Limitation: Atmospheric correction

(a) Organic Molecules in Protoplanetary Disks:

Difficulties in Detection



Gibb+ 2007



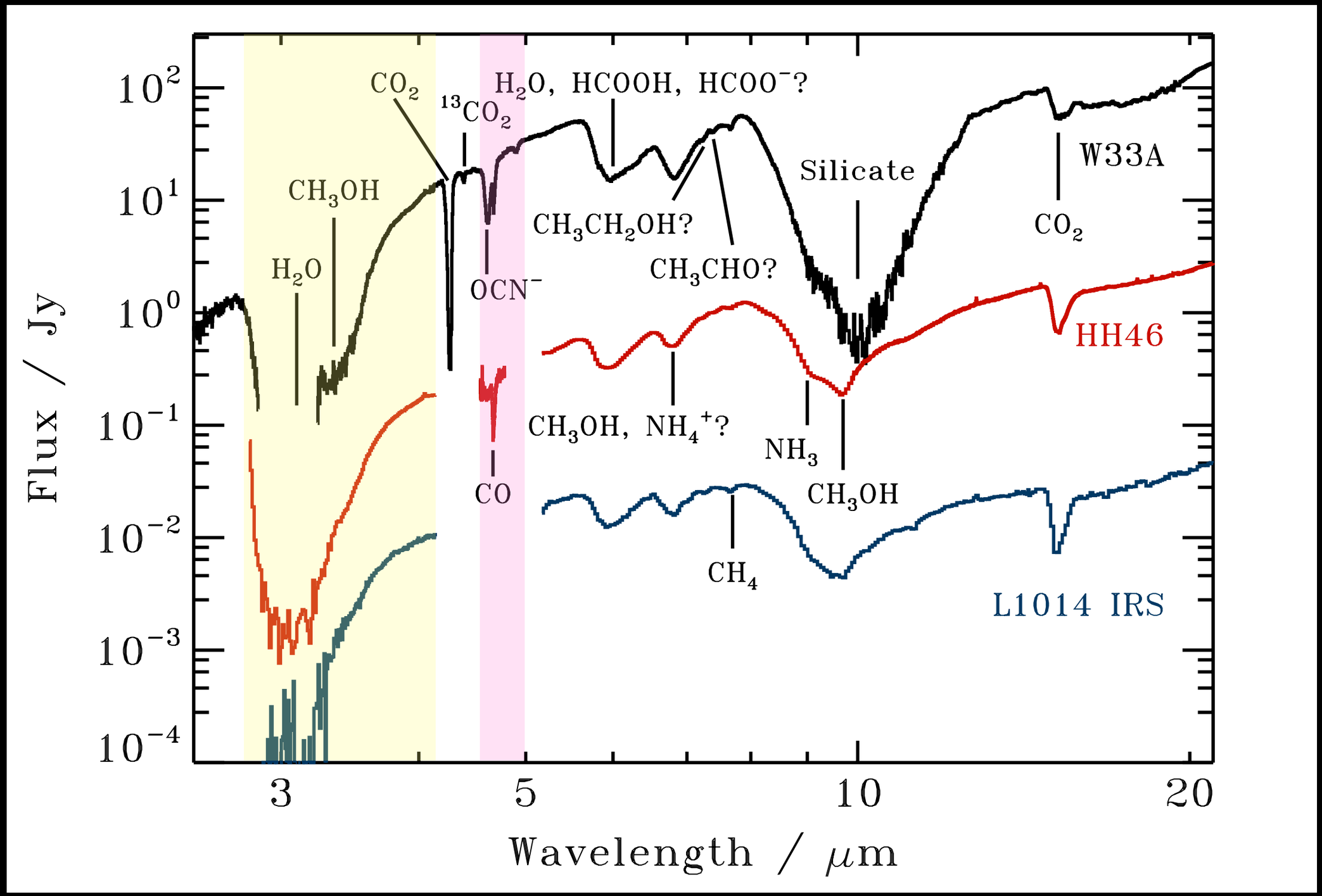
Mandell+ 2012

=> Higher resolution is definitely better

(b) Ices Signatures

Towards Protostars

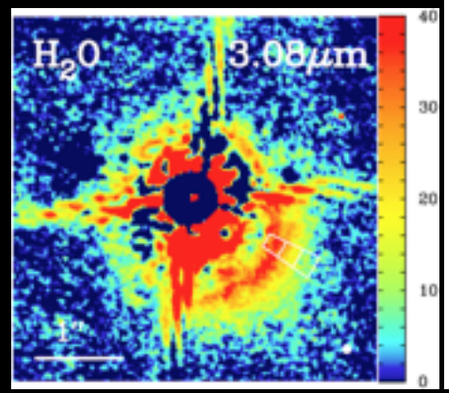
Oberg+ 2011

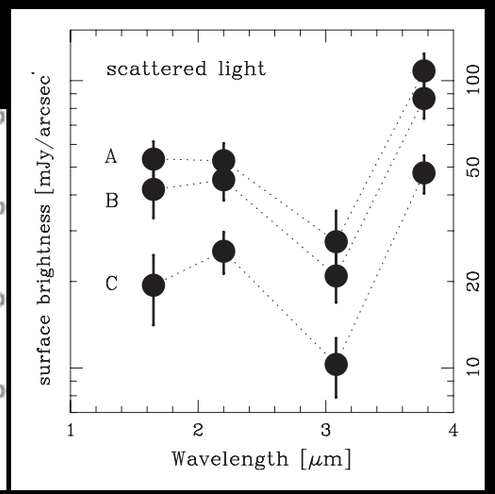


(b) Ices in Protoplanetary Disks

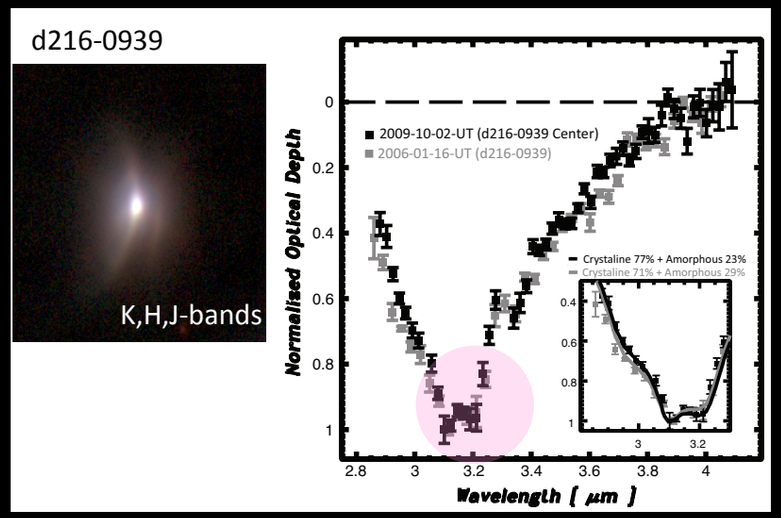
Previous Detections

Honda+ 2009

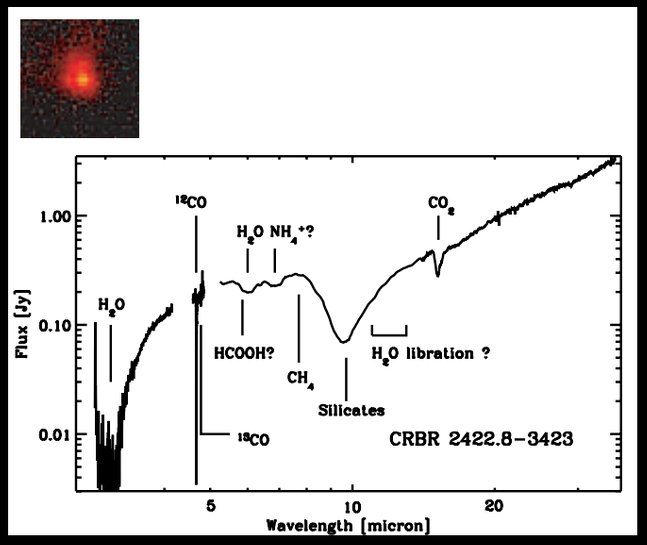




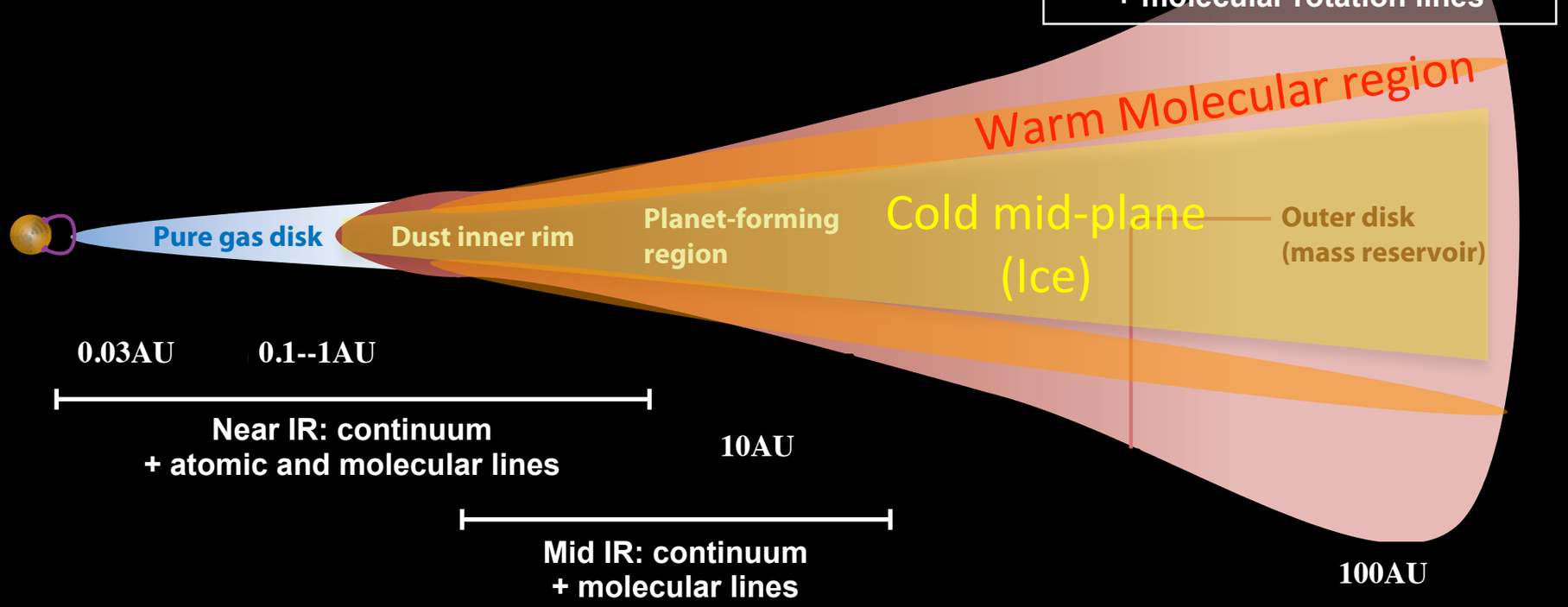
Terada+ 2012

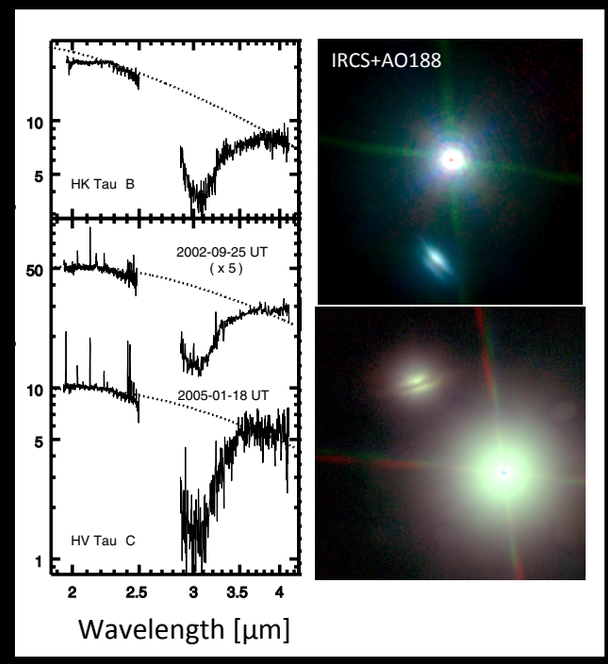


Pontoppidan+ 2005



(sub-)mm: continuum
+ molecular rotation lines



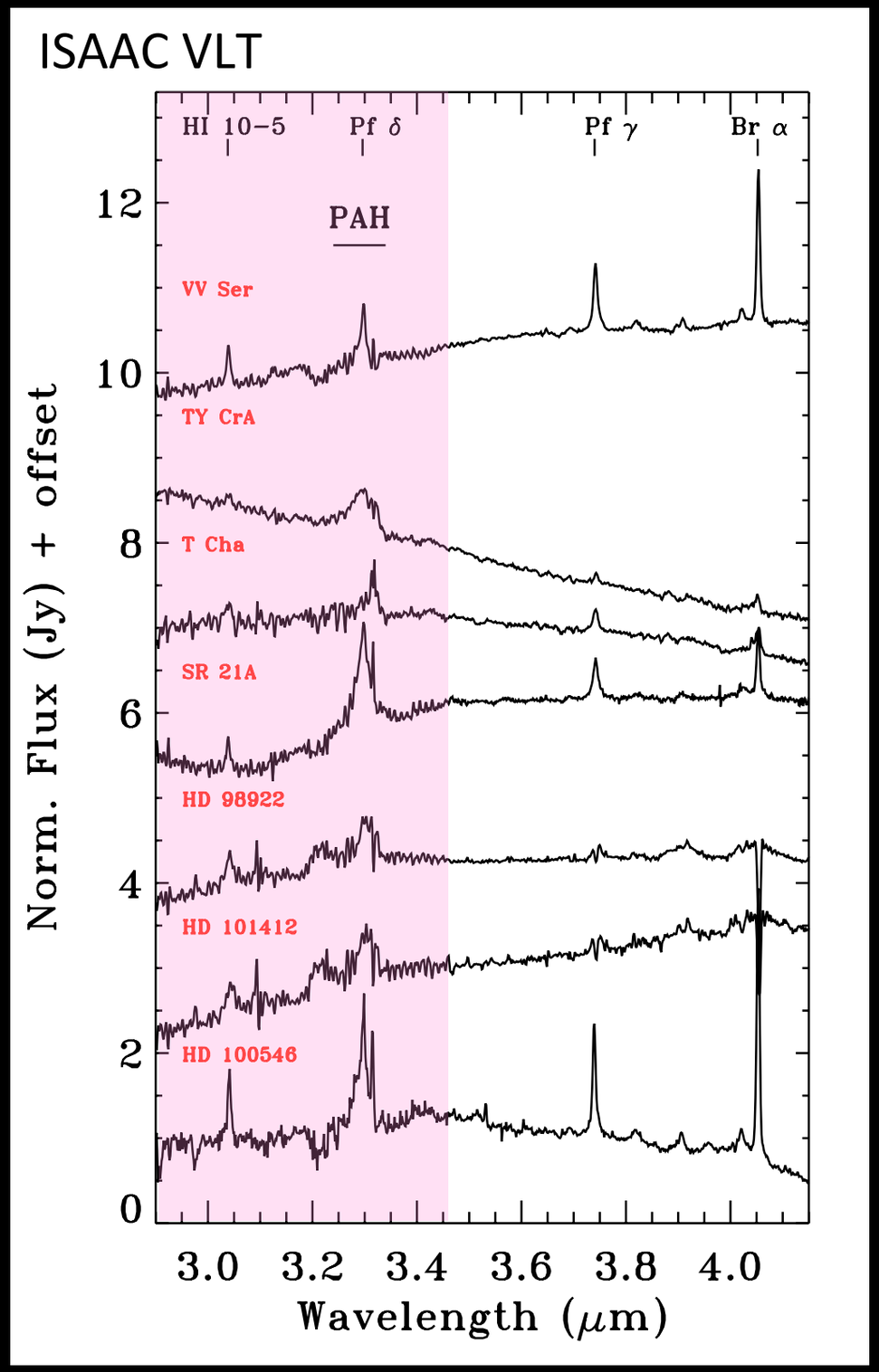


Terada+ 2007

Hiroshi TERADA (Subaru Telescope)

(b) Ices Signatures

Difficulties in Detection



Geers+ 2007

@ VLT site

Worse quality in < 3.5μm region even for such bright objects (L~5)

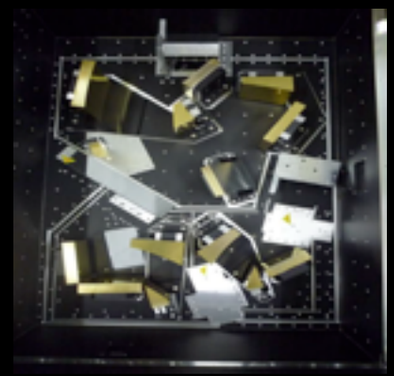
Very difficult for its profile discussion...

Facilities for 3μm Simultaneous Spectroscopy

for BEST cancelation of telluric absorption

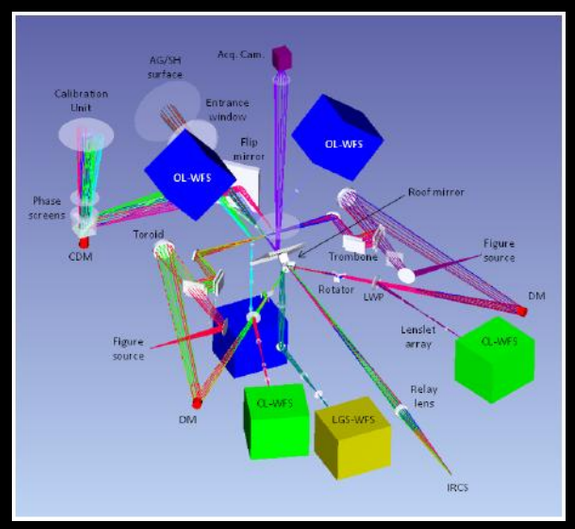
✦ *MIMIZUKU @ Subaru, TAO*

MIMIZUKU



✦ *RAVEN (+IRCS) @ Subaru [2014 Spring]*

RAVEN



"2" Science Path
MOAO system

UVic, HIA, Subaru, Tohoku-U

Complementarity for 3μm Simultaneous Spectroscopy

✦ *MIMIZUKU @ Subaru, TAO*

- *Patrol area: ~6', ~25'*
- *Fully optimized for thermal-IR bands*
- *Low resolution (R=180) only*

Ice

✦ *RAVEN (+IRCS) @ Subaru [2014 Spring]*

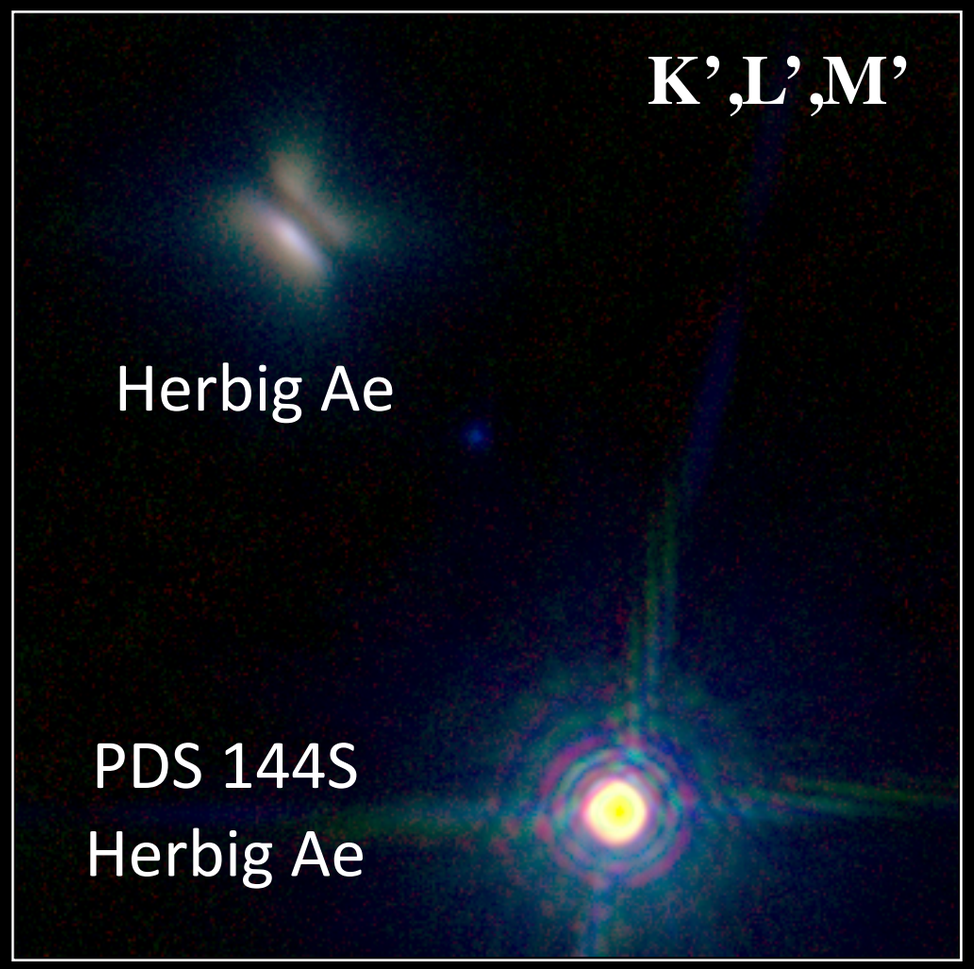
- *Diffraction limited image*
- *High resolution (R=20,000) is also available*
- *Slit PAs can be independent.*
- *Patrol area: 3'.5*
- *Not optimized for thermal-IR bands*
- *Need "2" NGS guide stars*

gas

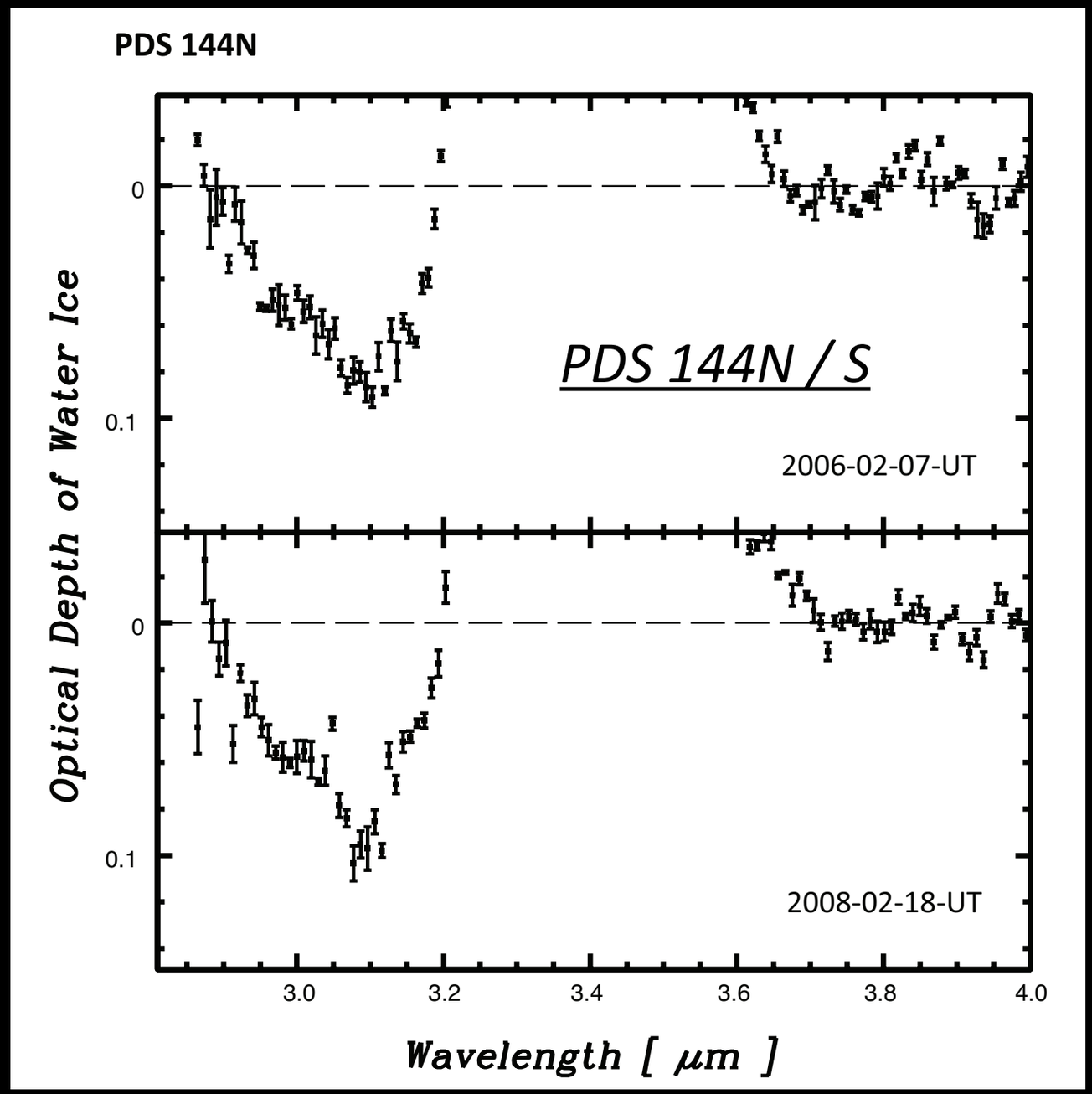
Benefit of Simultaneity

Example of IRCS Result for "Ice"

PDS 144N



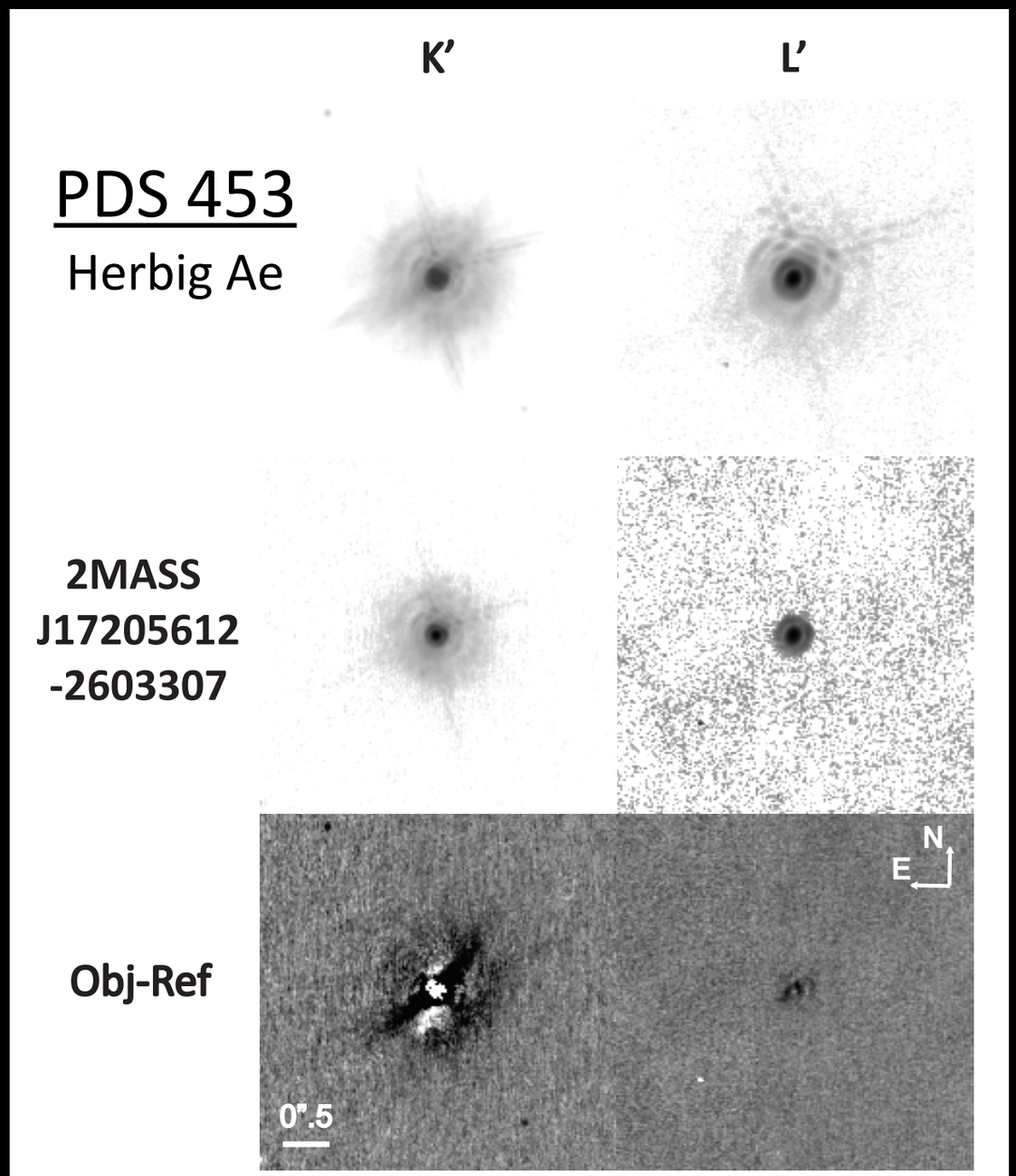
IRCS+AO188 [NGS]

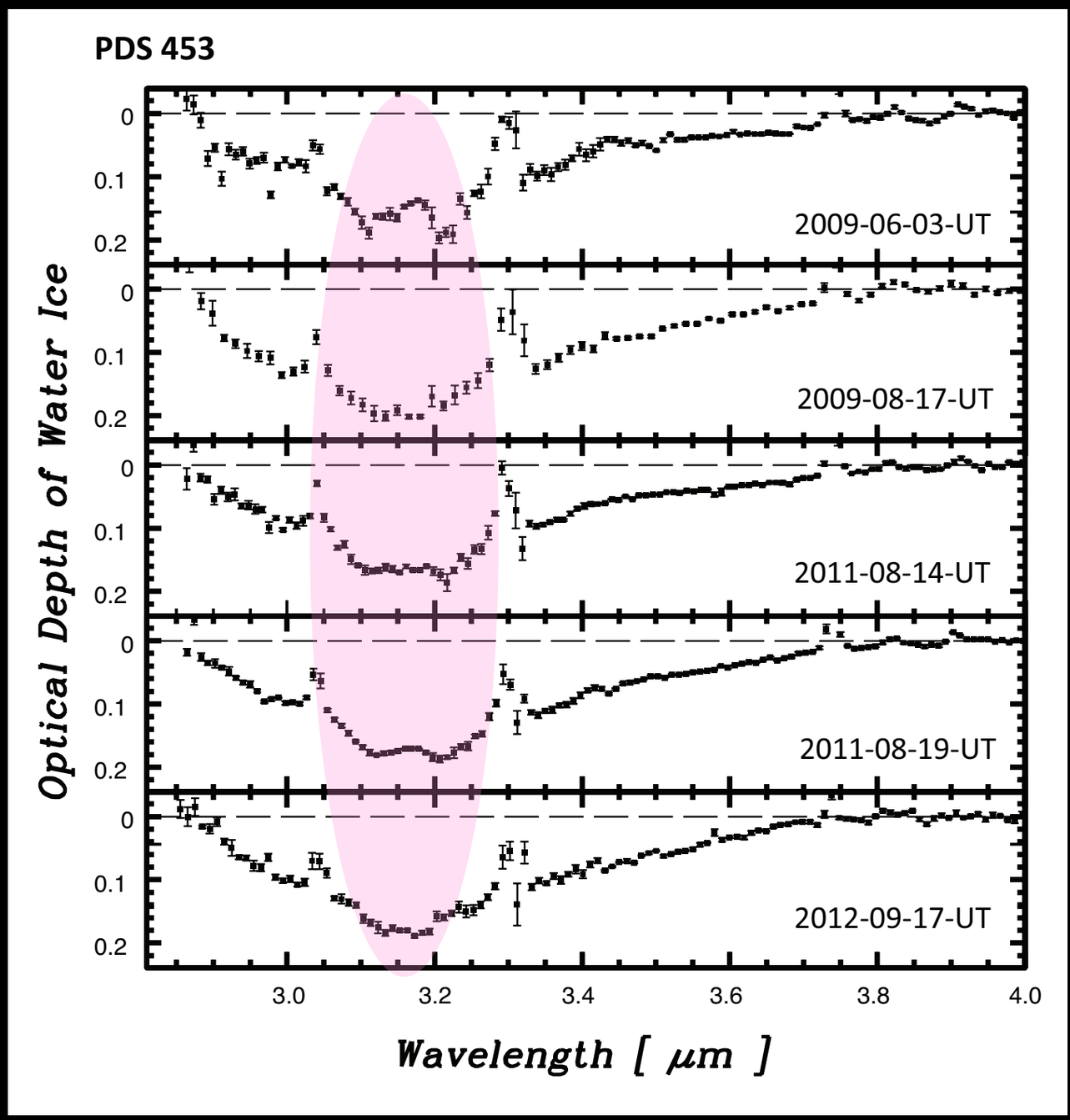


Terada+ in prep.

Possible Target for “Ice” w/ MIMIZUKU Monitoring

IRCS+AO188 [NGS]





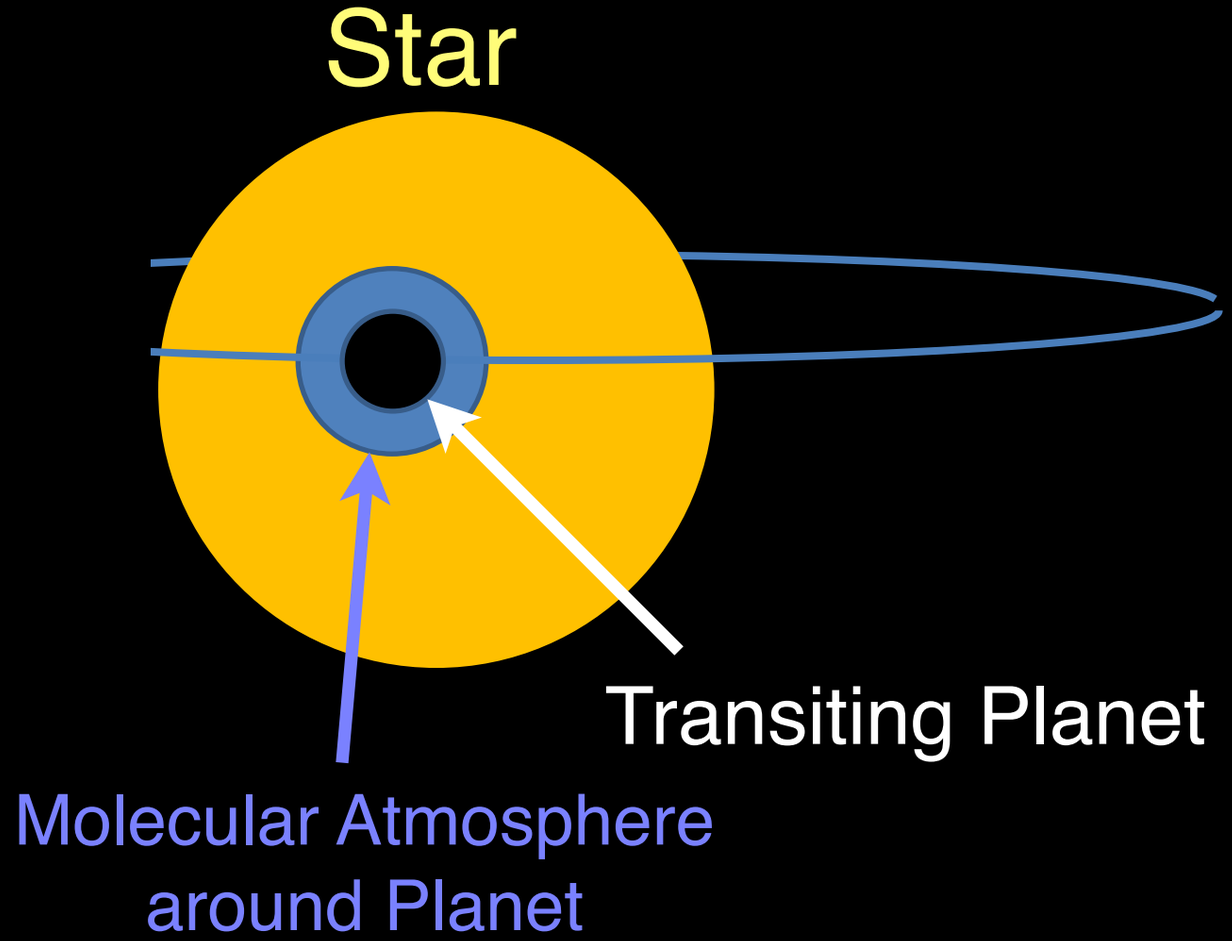
Terada+ in prep.

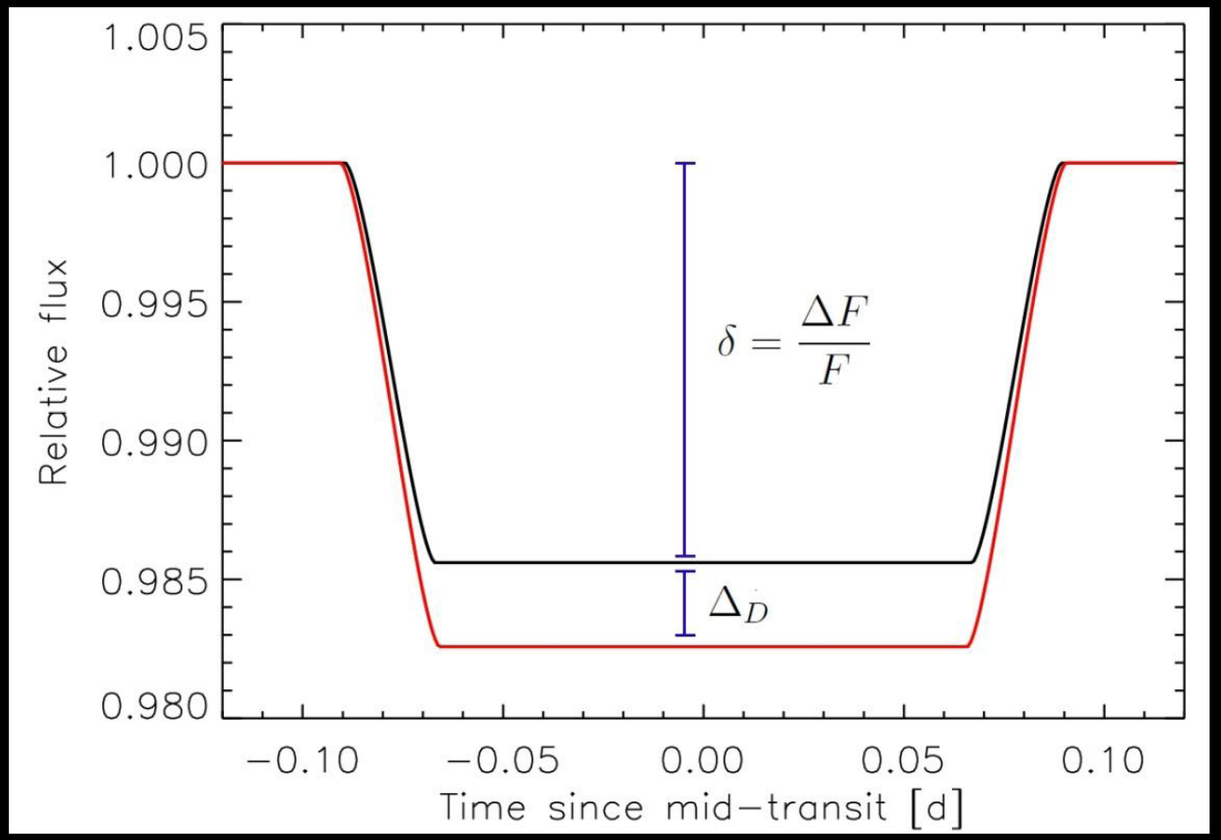
Hiroshi TERADA (Subaru Telescope)

(II) Exo-Planetary Atmosphere in Transiting Systems

Exo-Planetary Atmosphere in Transiting System

Theory for Detection





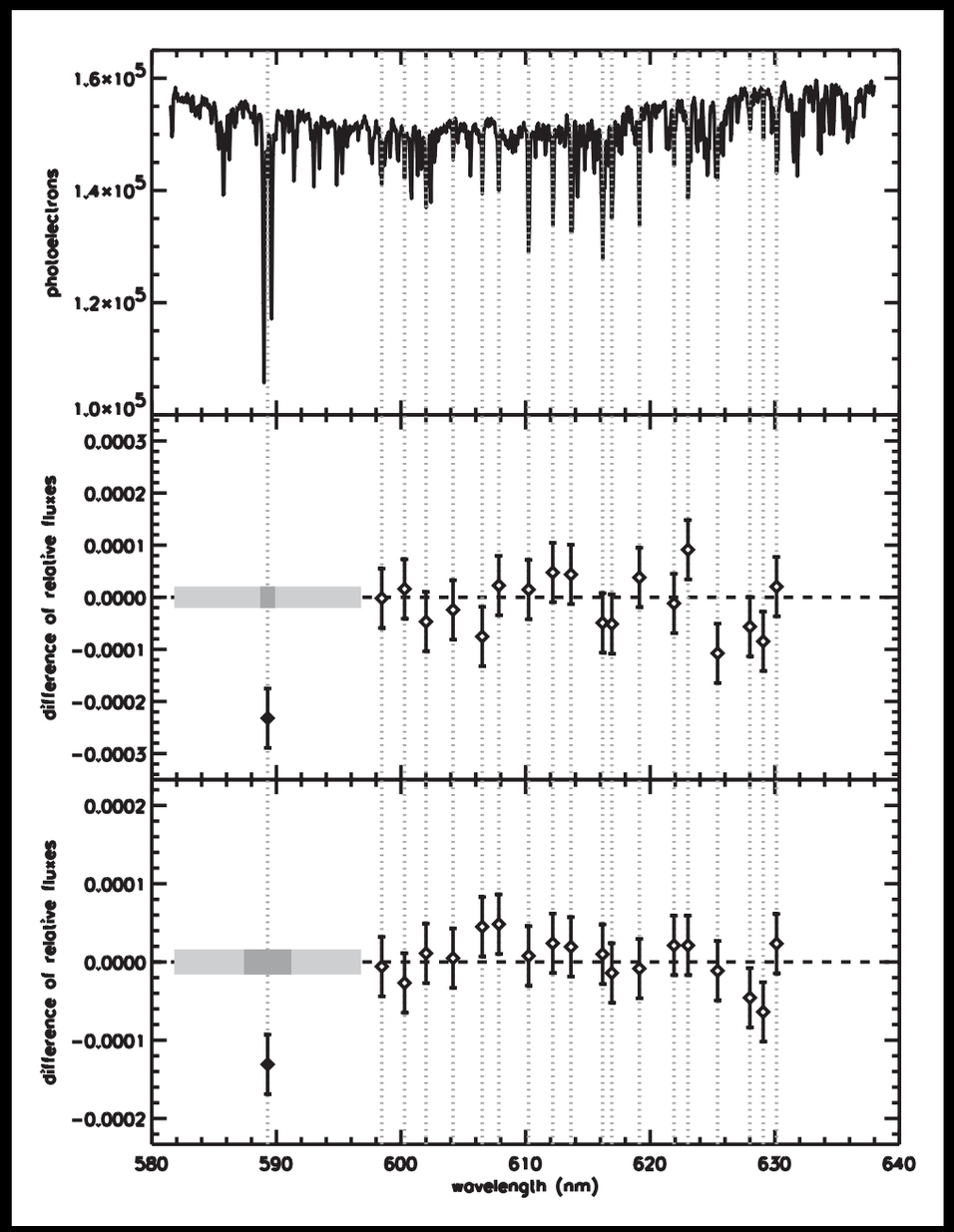
Required Precision ~ 10(-4)

Exo-Planetary Atmosphere in Transiting System:

Observational Achievements

First detection w/ HST STIS

NaD line: HD 209458

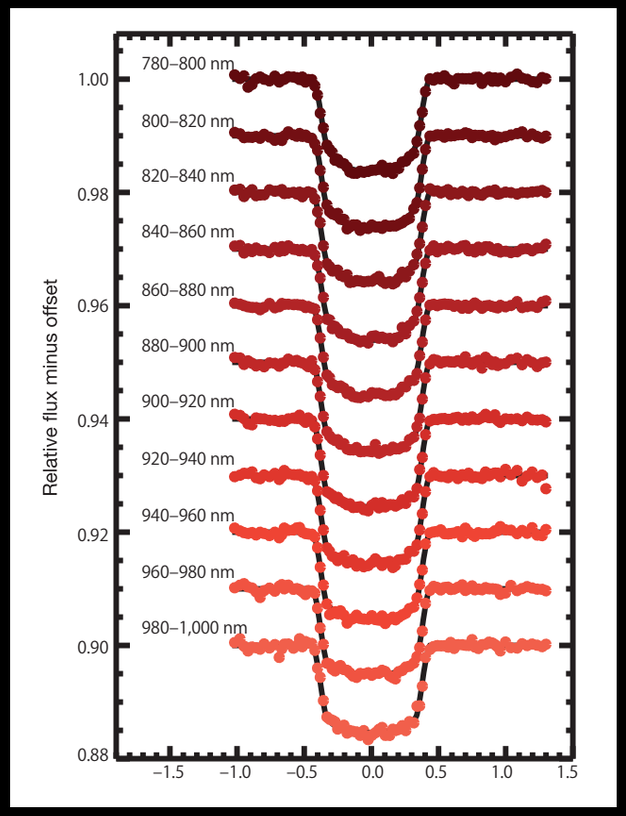


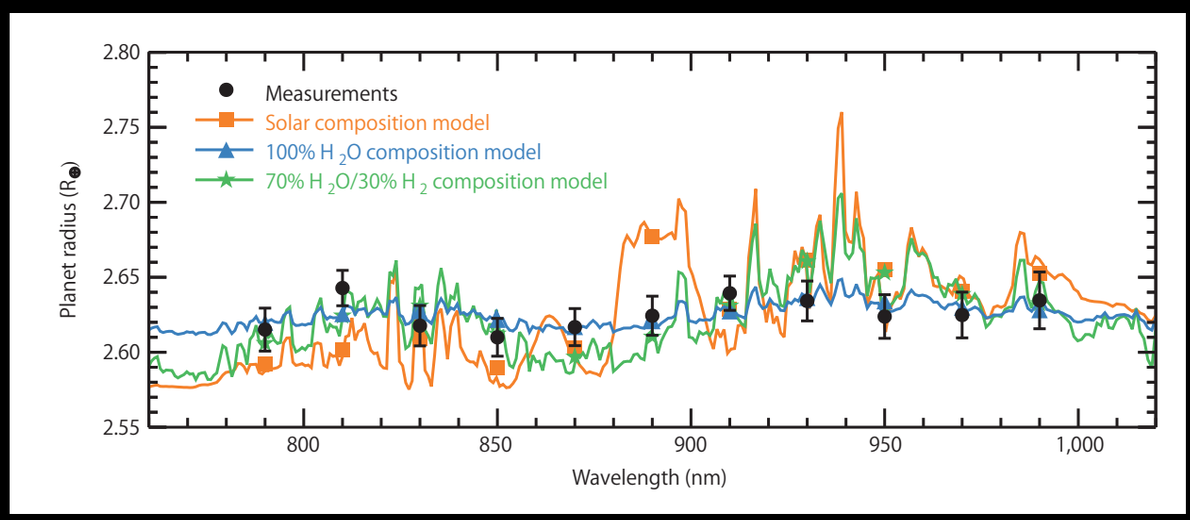
Charbonneau+ 2002

Ground-based detection w/ VLT FORS

Optical Spectroscopy

GJ 1214b





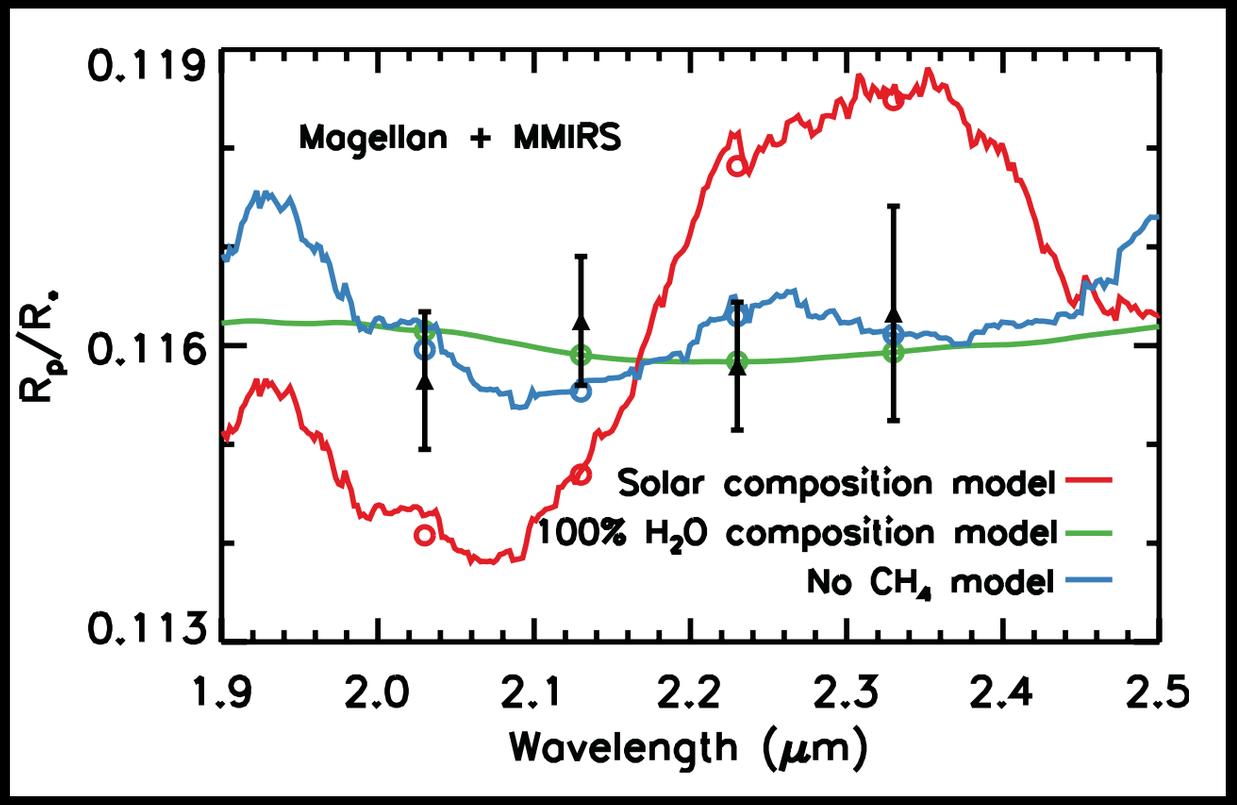
Bean+ 2010

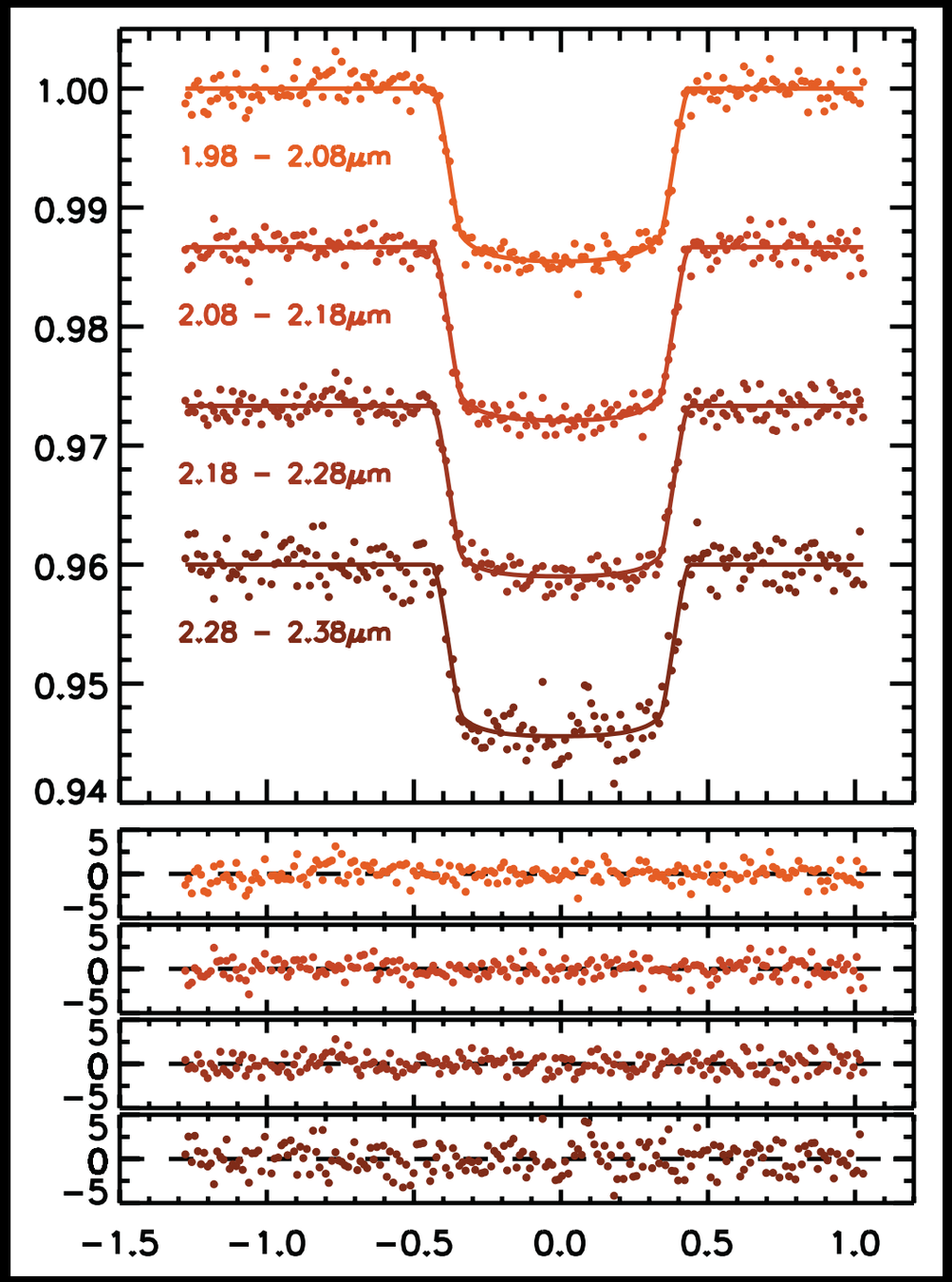
Exo-Planetary Atmosphere in Transiting System:

Ground-based Trial in IR

Ground-based IR detection
w/ Magellan + MMIRS

Infrared K-band Spectroscopy
GJ 1214b





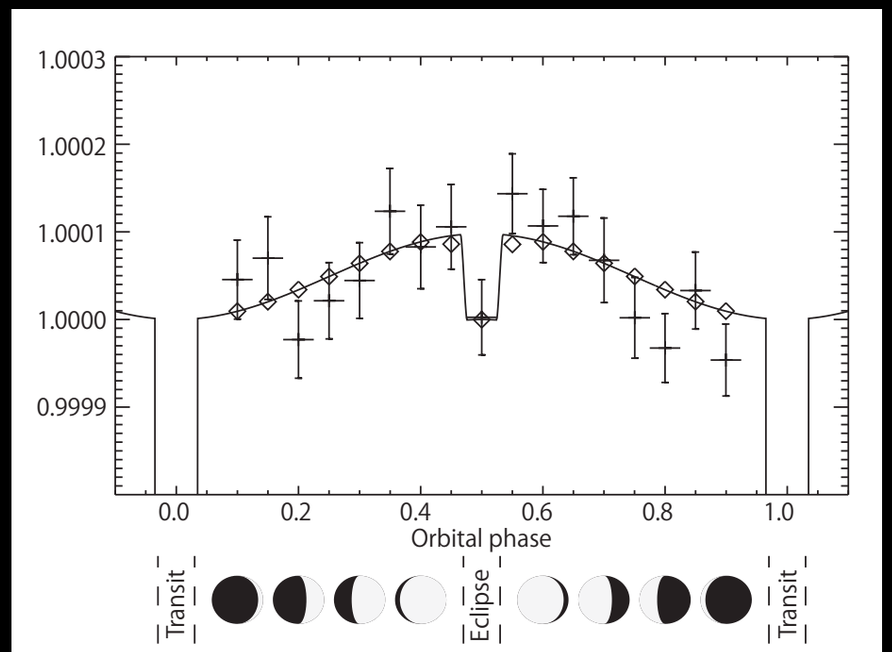
Bean+ 2011

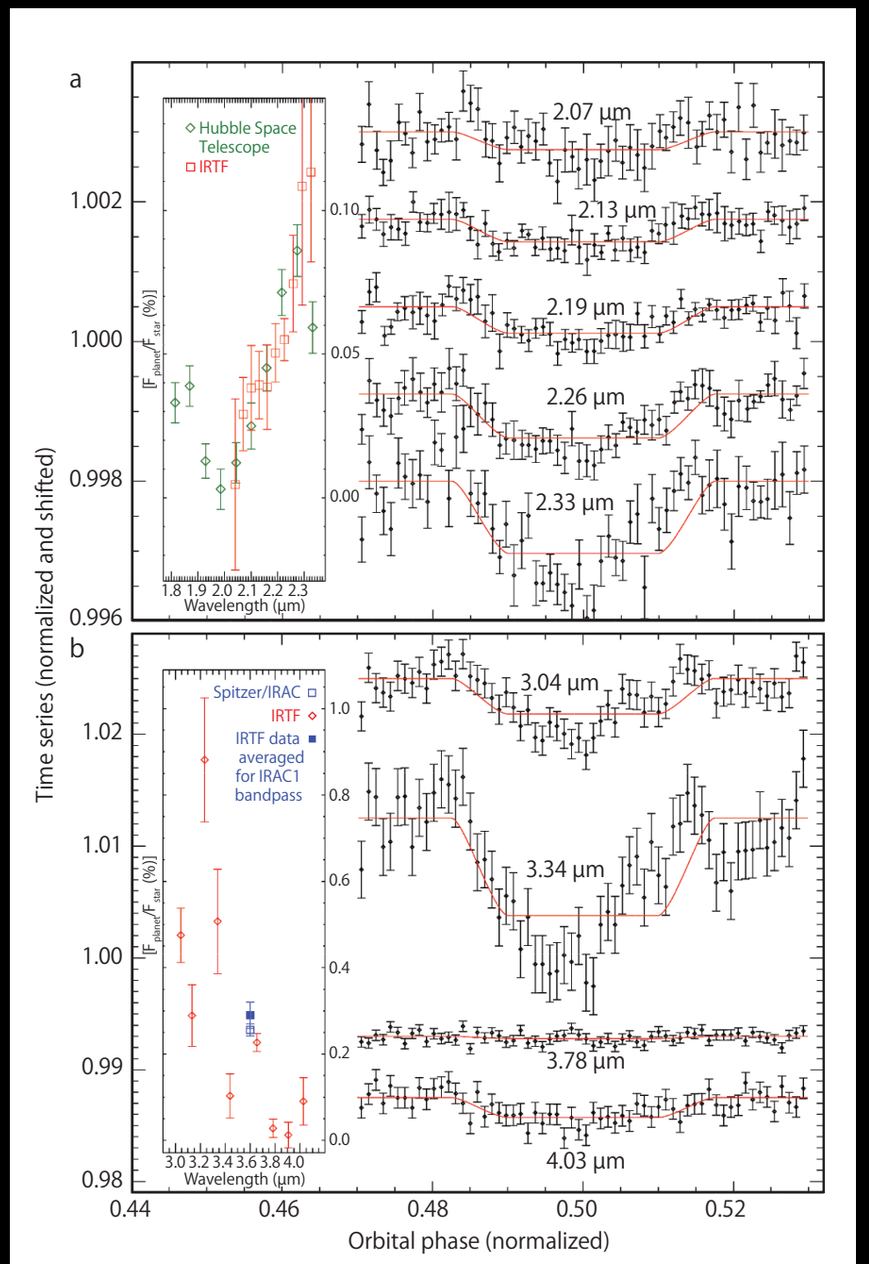
Hiroshi TERADA (Subaru Telescope)

Exo-Planetary Atmosphere in Transiting System:

Secondary Eclipse in 3μm

Secondary Eclipse

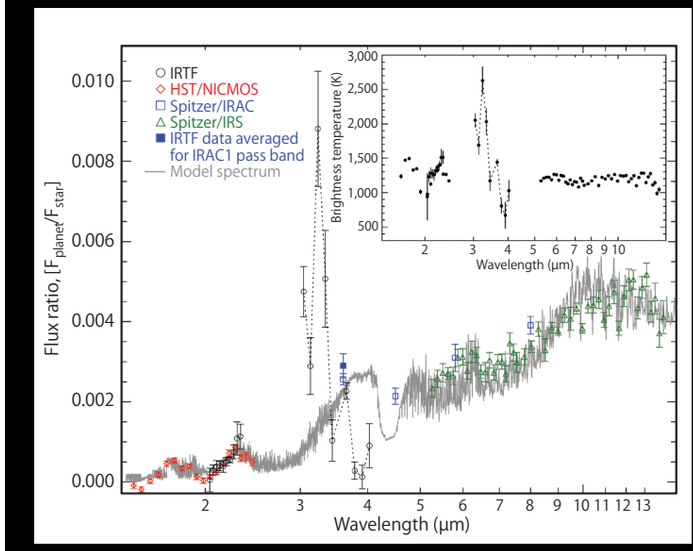




Ground-based 3um detection w/ IRTF + SpeX

K,L-band Spectroscopy

HD 189733



Swain+ 2009

Exo-Planetary Atmosphere in Transiting System:

Issues: Keys to Achieve "10(-4)"

Especially for IR, it's so difficult..

a. *Stick the target exactly at the same location of the detector.*

=> Uncertainty of "ununiform sensitivity" in the infrared detector has to be eliminated.

b. *Increase the S/N using over-sampling of the object.*

=> Usually defocused image is used.

c. *"Simultaneously" observe the reference.*

=> Eliminate variability of atmospheric absorption

Summary

- ✓ *Shorter wavelength region of L-band:*
  one of the most fruitful area at the Atacama site.
- ✓ *"Simultaneous spectroscopy" would be a key for detecting gas features and monitoring ice profiles in the protoplanetary disks.*
- ✓ *"Exo-Planetary Atmosphere" in the secondary eclipse may be able to be detected in 3μm. Stability of guiding should be an issue.*
- ✓ *MIMIZUKU would work for "simultaneous spectroscopy" at Subaru complementarily with RAVEN (+IRCS).*

 # RAVEN 2nd Science Meeting will be held on
 # July 25 and 26, 2013 at Waikoloa, Hawaii,
 # which is right after TMT forum. Your interest is welcome!