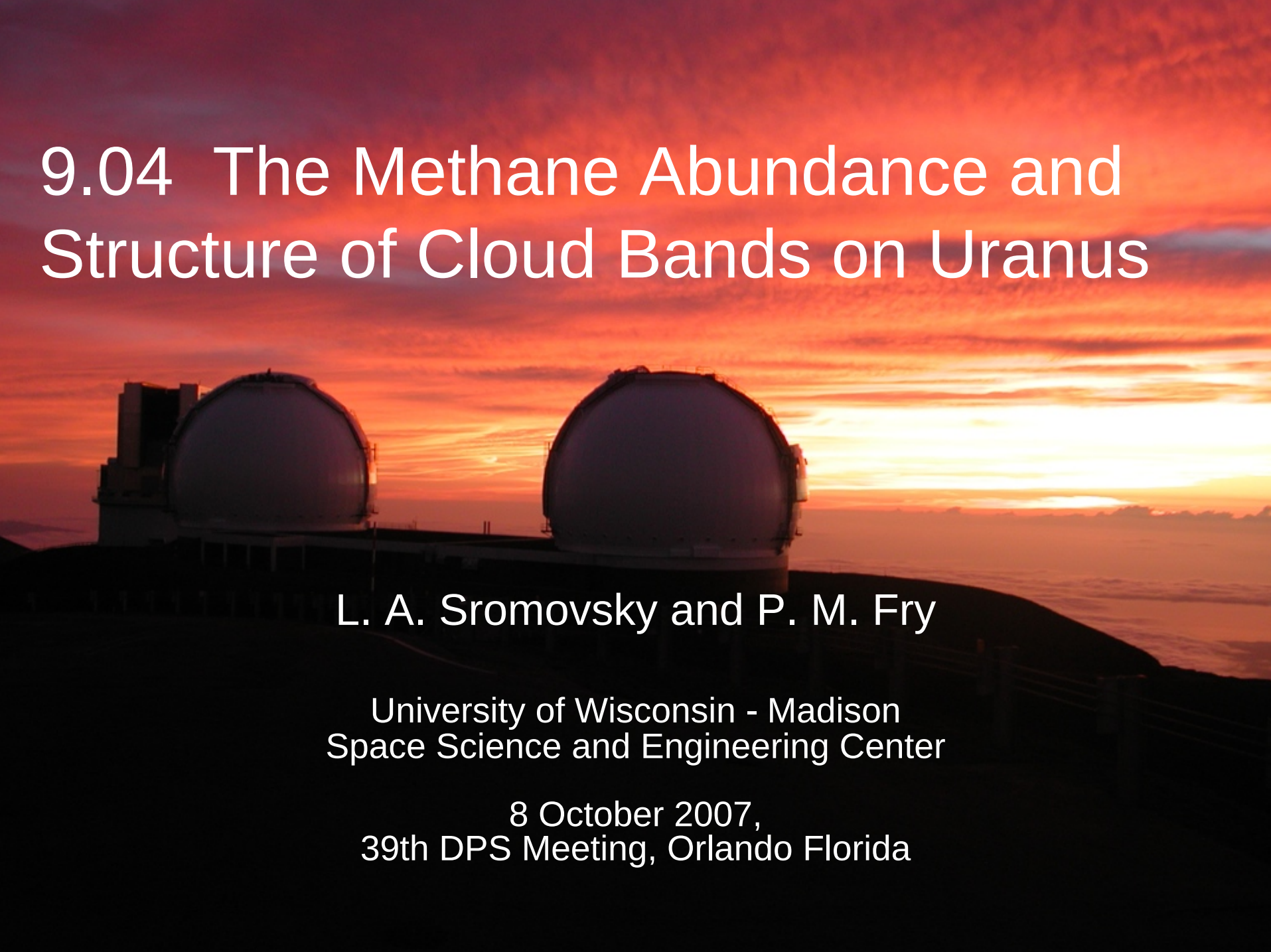

9.04 The Methane Abundance and Structure of Cloud Bands on Uranus

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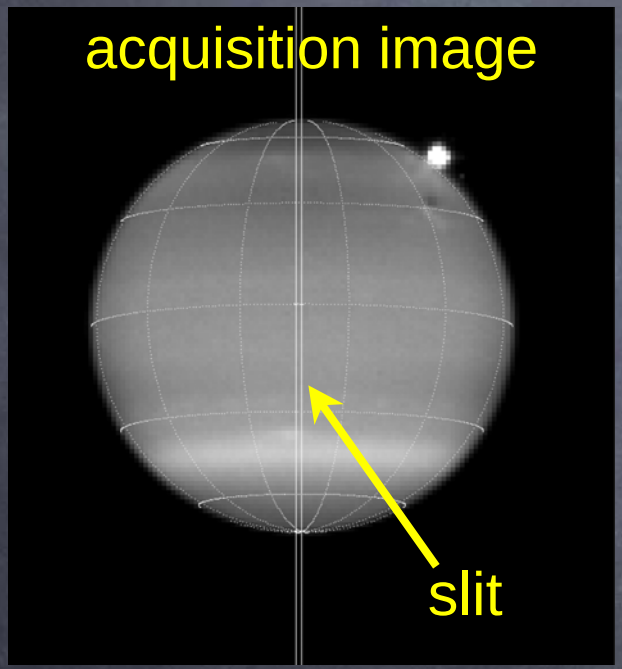
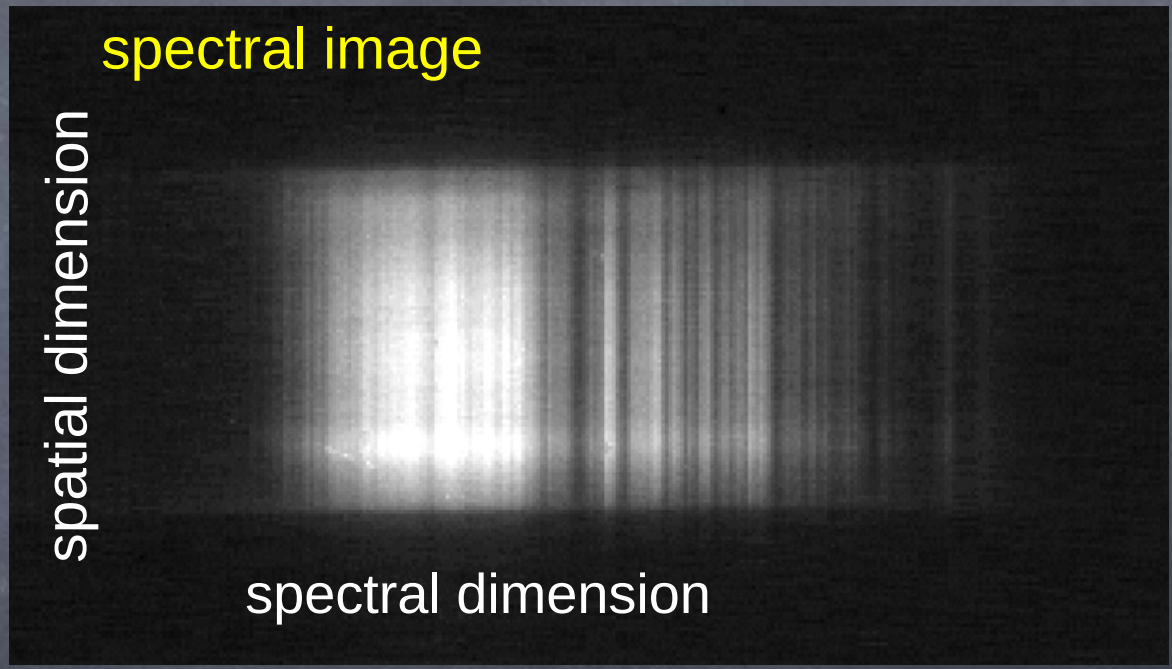
University of Wisconsin - Madison
Space Science and Engineering Center

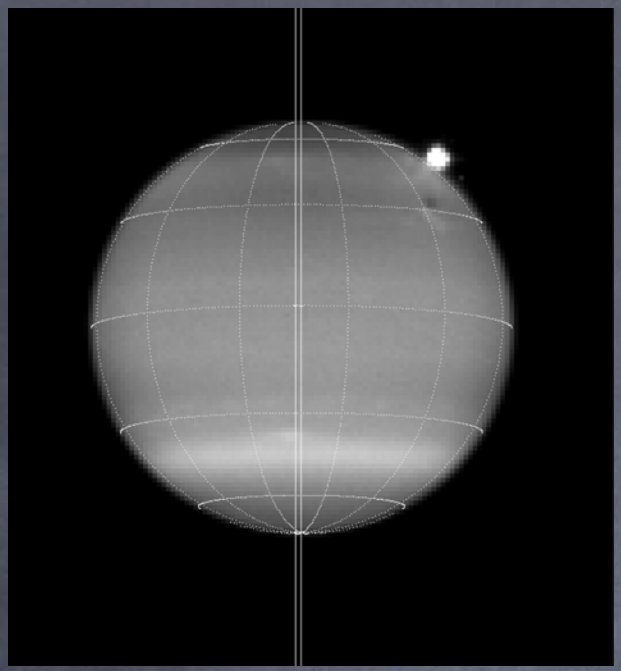
8 October 2007,
39th DPS Meeting, Orlando Florida

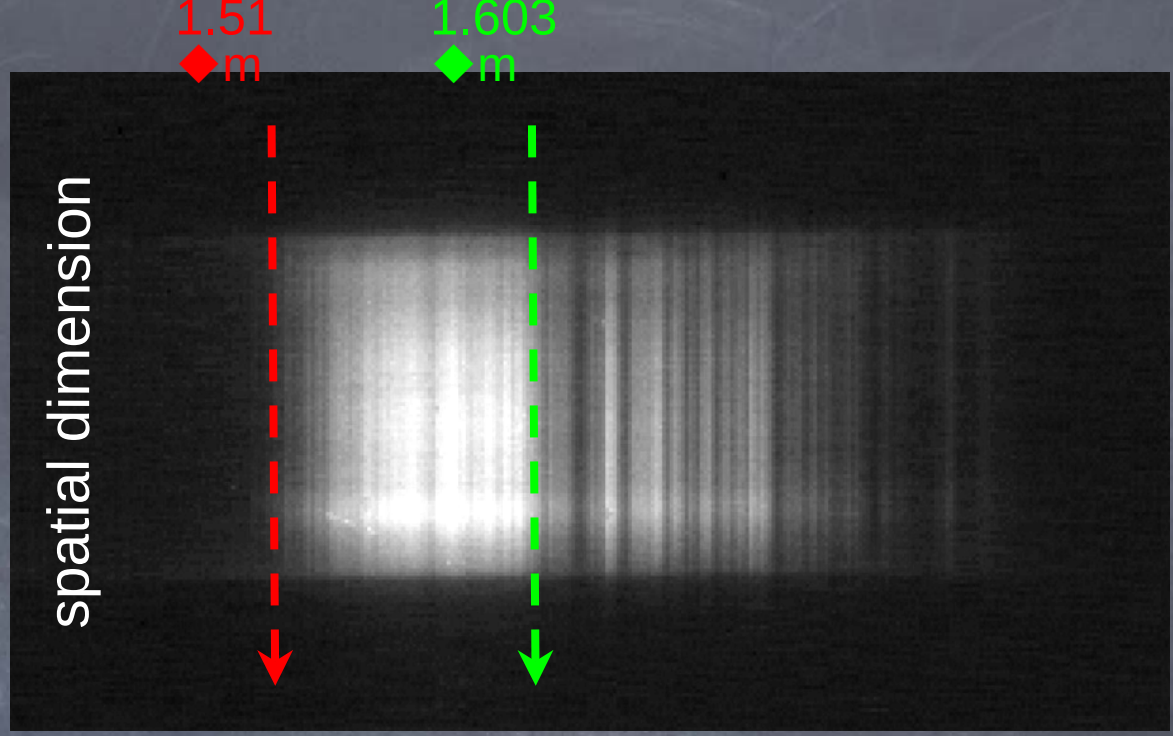
Date: October 2006
Telescope: Keck II with Adaptive Optics
Instrument: NIRC2, grism
Measurements: spatially resolved central-meridian spectra in J and H bands.





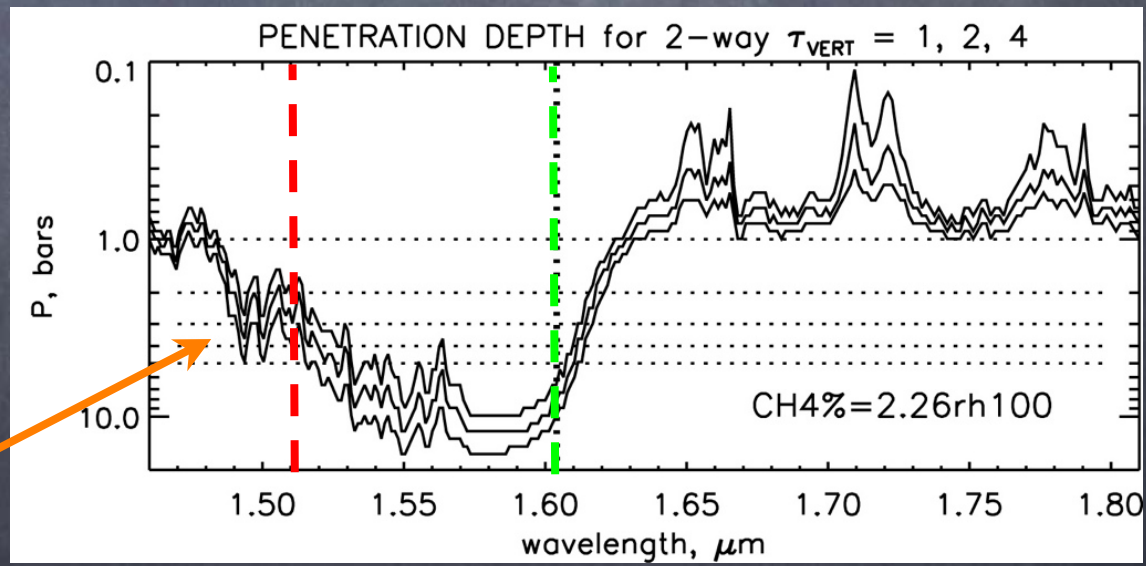
OBJECTIVES: Constrain the CH4 mixing ratio.
Locate the Uranus cloud layers in pressure.
Determine composition of cloud layers.





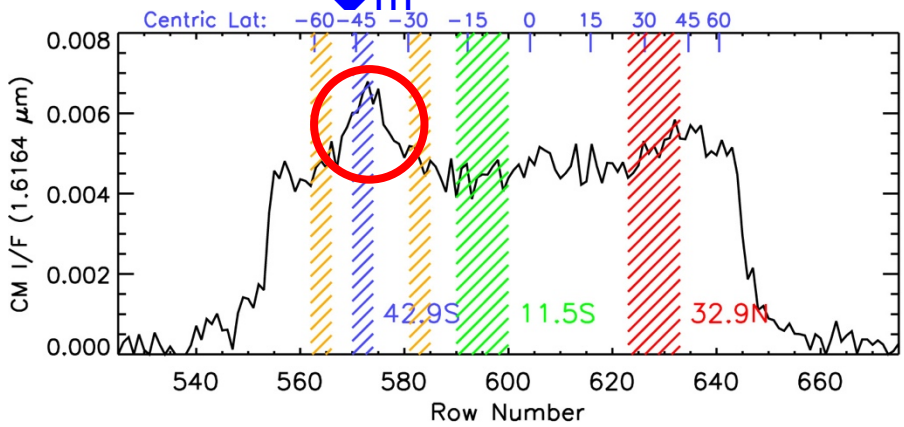
spatial scans at different wavelengths sample different atmospheric levels

Pressures at which a=0 to a=1 change in surface produces I/F change of 1/e, 1/e^2, 1/e^4 or 0.36, 0.13, 0.02.

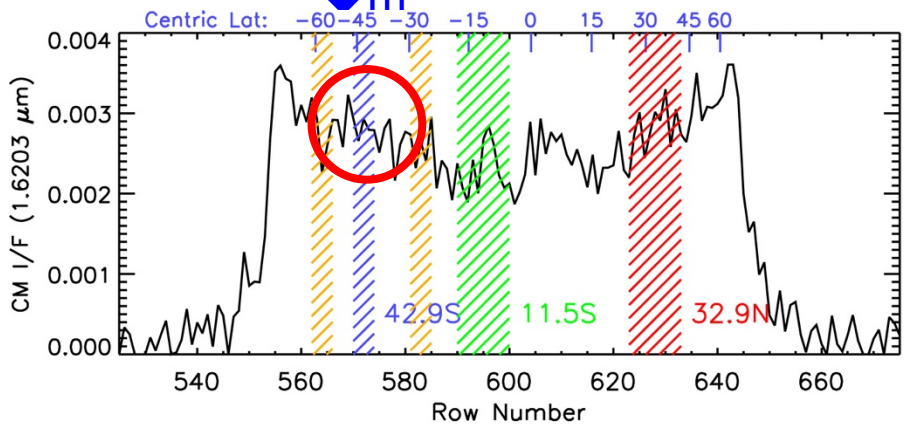


2.5-4 bars 7-10 bars

1.6164 ◆m



1.6203 ◆m

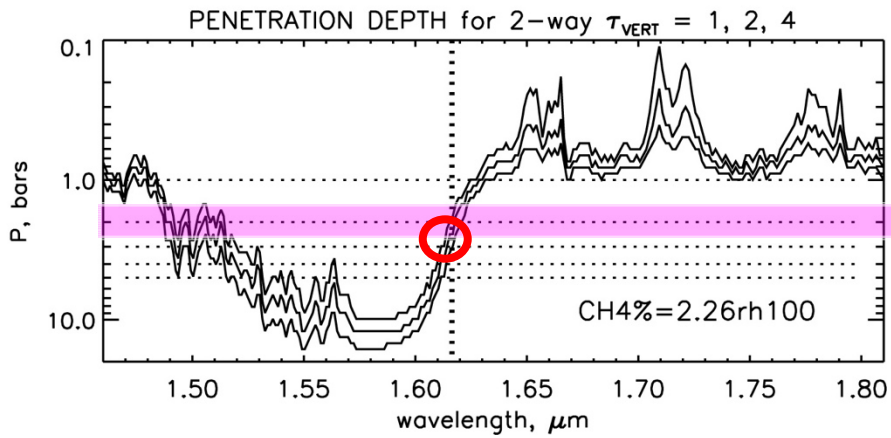


the bright band is seen above the 2-3 bar level

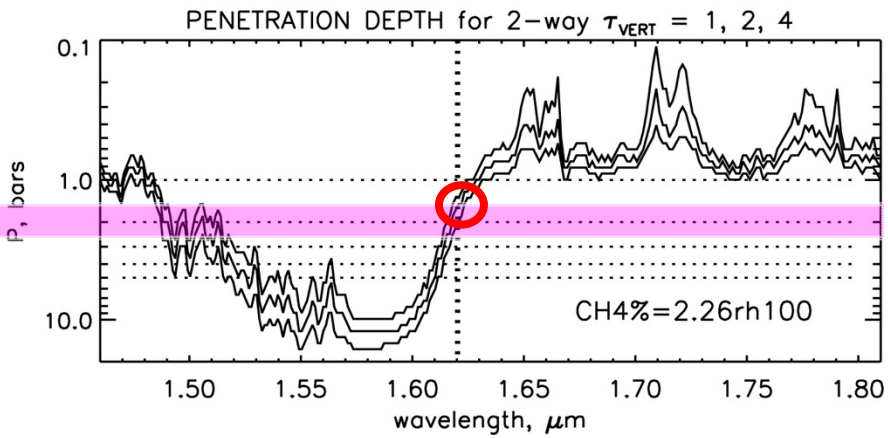
the bright band is not seen above the 1.5-bar level

part of the bright band is between 1.7 bars and 2.5 bars

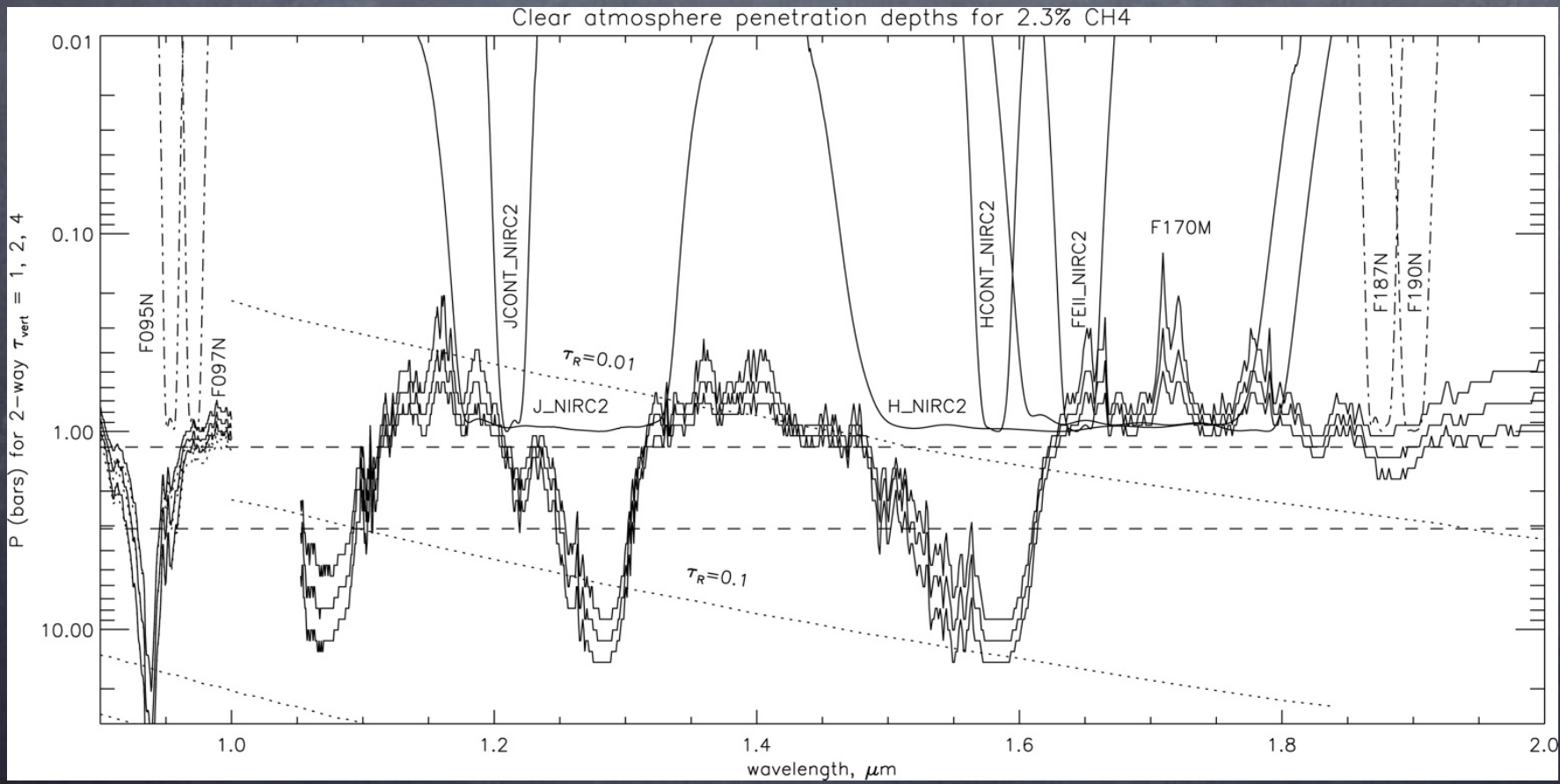
2-3 bars

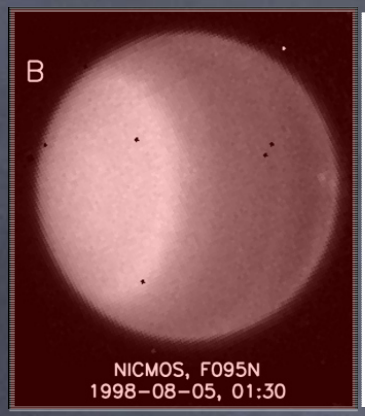


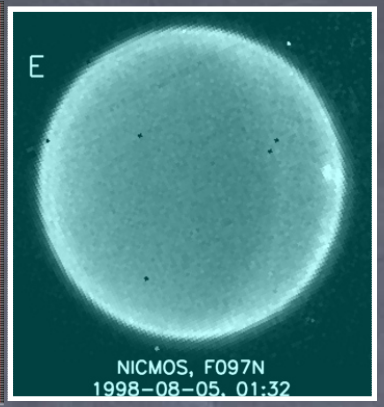
1.3-2 bars



the bright band location is verified by bandpass filter imaging




B
NICMOS, F095N
1998-08-05, 01:30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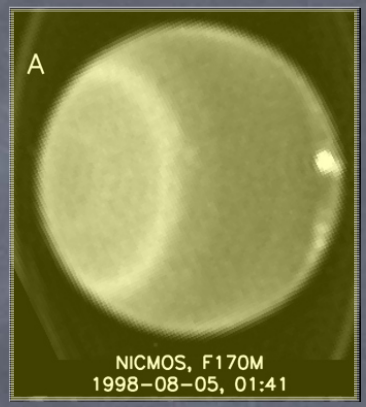
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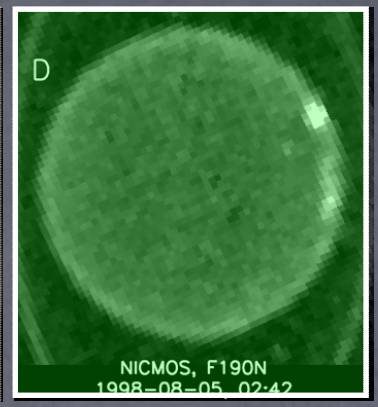
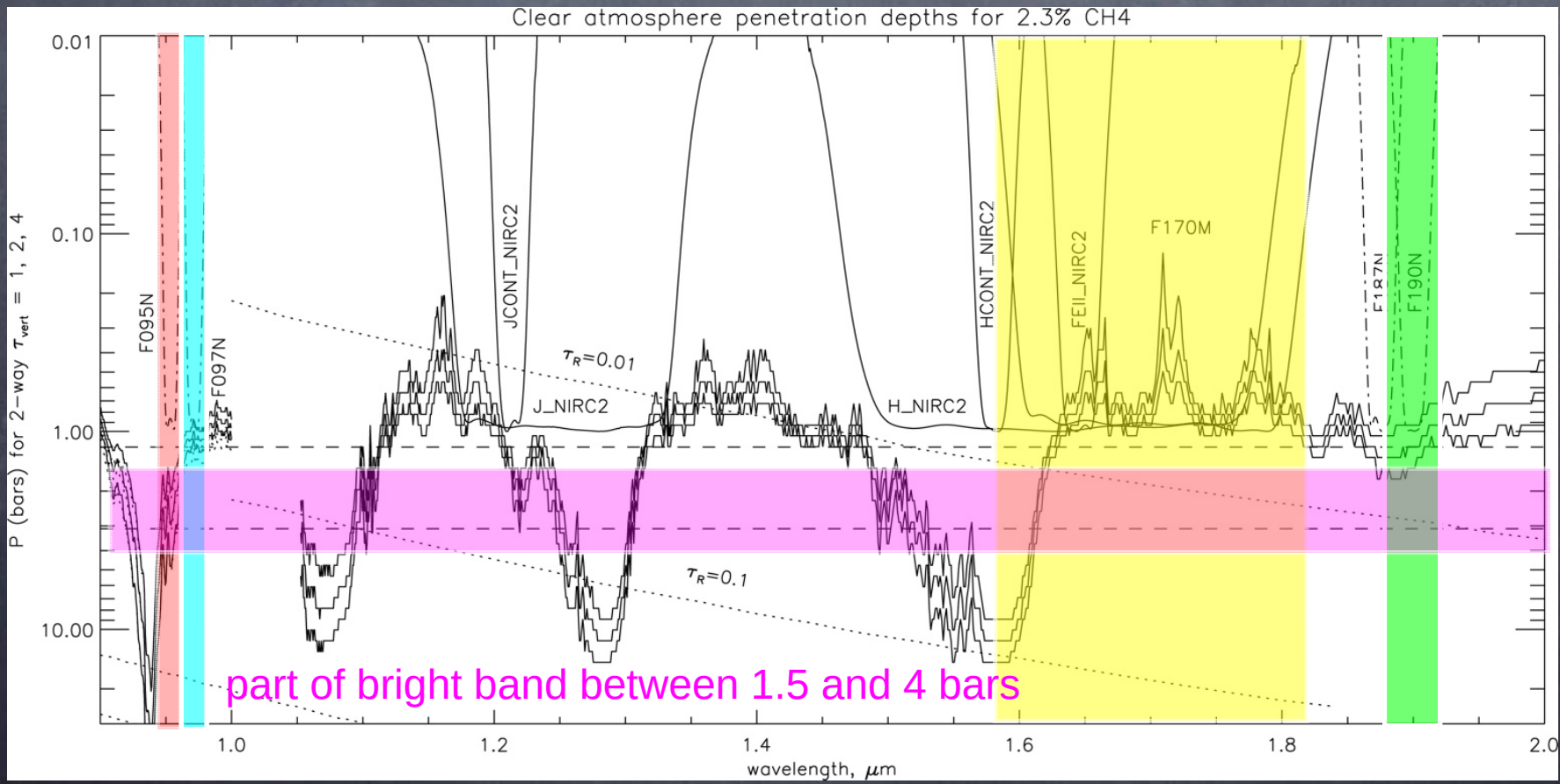

D
NICMOS, F190N

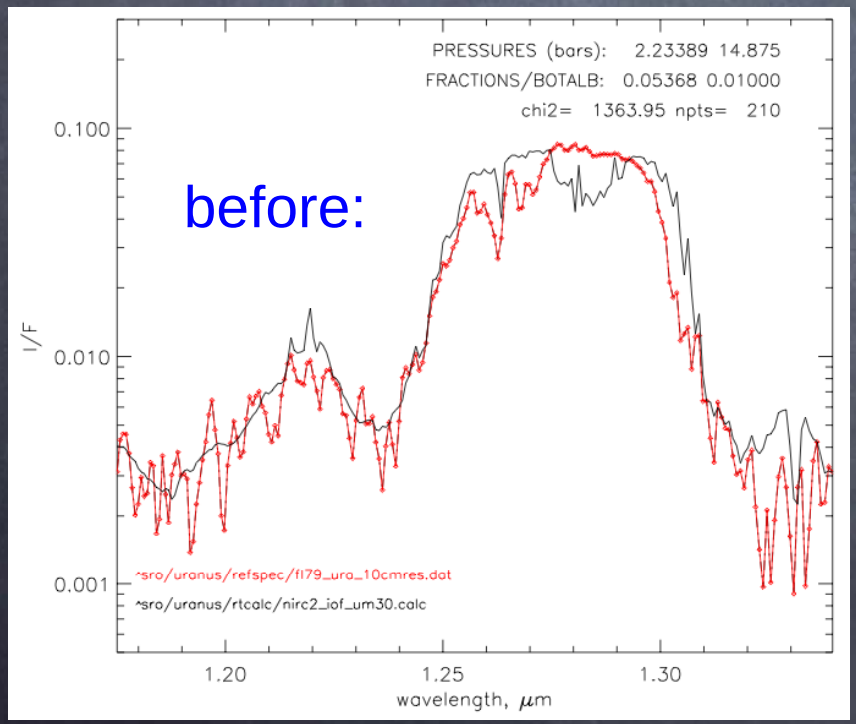

Clear atmosphere penetration depths for 2.3% CH4
P (bars) for 2-way τ_{vert} = 1, 2, 4
0.01
0.10
1.00
10.00
F095N
F097N
JCONT_NIRC2
HCONT_NIRC2
FEII_NIRC2
F170M
F187N
F190N
τ_R=0.01
J_NIRC2
H_NIRC2
τ_R=0.1
part of bright band between 1.5 and 4 bars
1.0
1.2
1.4
1.6
1.8
2.0
wavelength, μm

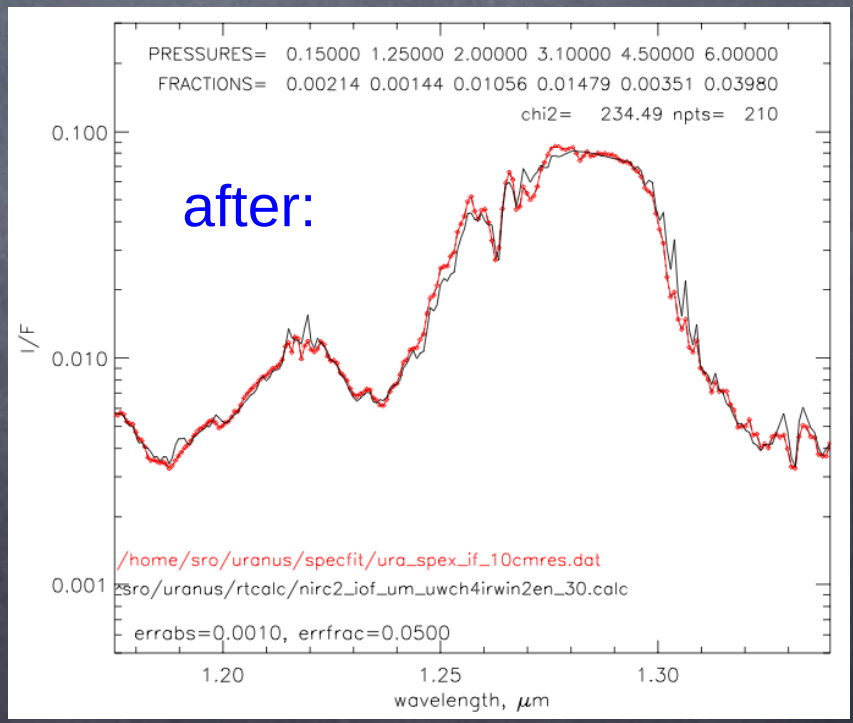
using spectral fits to constrain cloud structure models

Recent improvements in modeling methane absorption:

Sromovsky, L.A., Irwin, P.G.J., Fry, P.M. 2006 Near-IR methane absorption in outer planet atmospheres: Improved models of temperature dependence and implications for Uranus cloud structure. Icarus 182, 577-593.

Irwin, P.G.J., Sromovsky, L.A., Strong, E.K. Sihra, K. Bowles, N. Calcutt, S. B. Remidios J.J. 2006, Fry, P.M. Improved near-infrared methane band models and k-distribution parameters from 2000 to 9500 cm-1 and implications for interpretation of outer planet spectra. Icarus 181, 309-319.





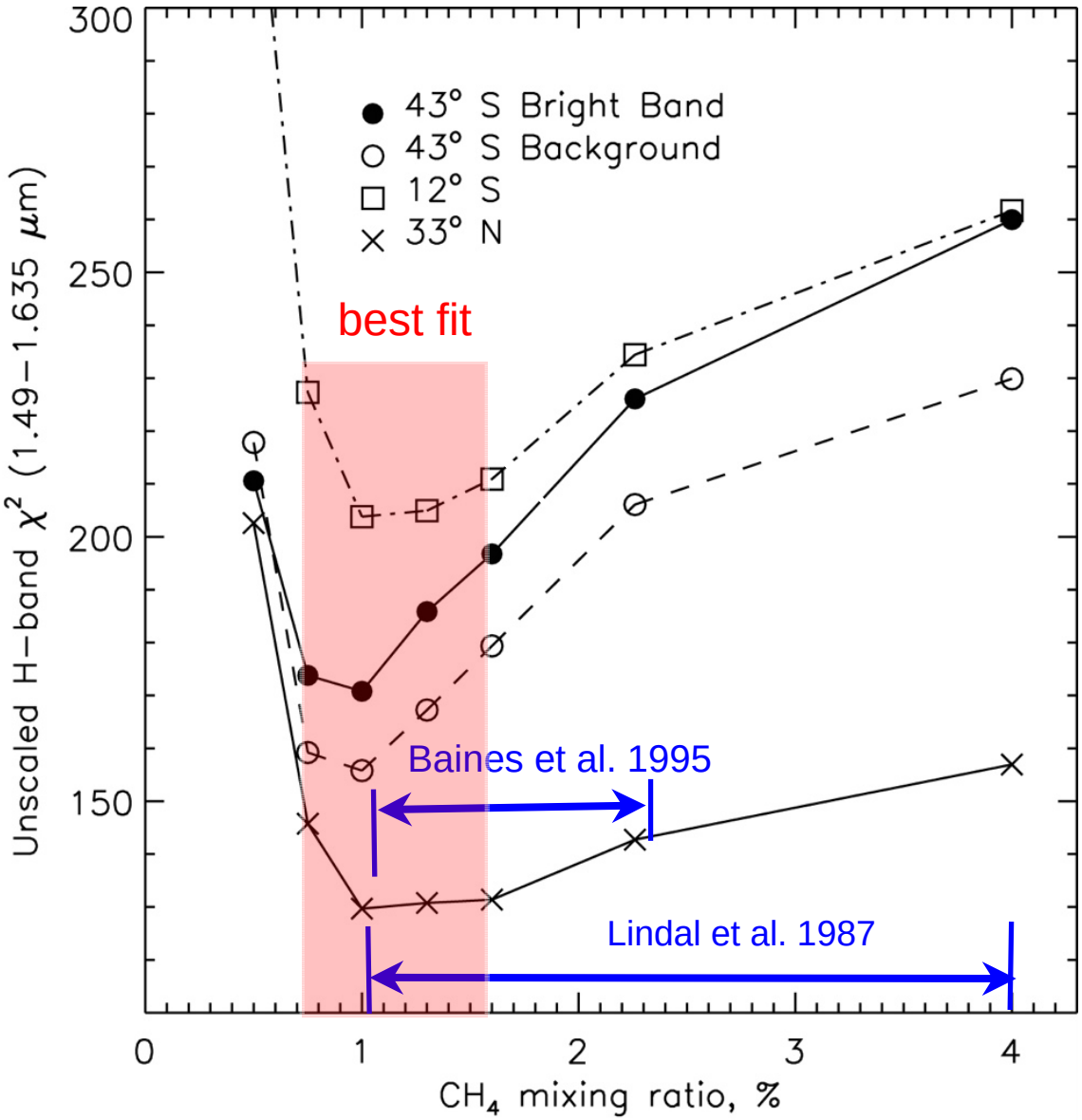
a simple reflecting layer model of cloud structure

		adjustable parameters	fixed parameters
broken		fstrat	Pstrat
broken		Pmid, fmid	
opaque		Pbot, abot	

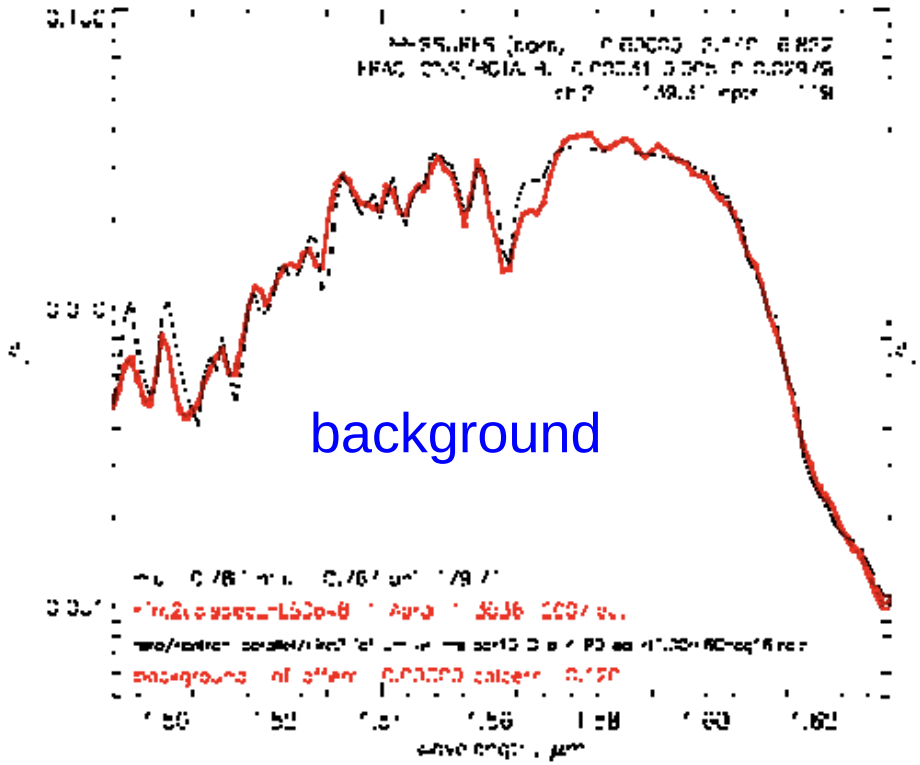
$$I(\lambda) = f_{\text{strat}} \times I_1(P_{\text{strat}}, \lambda) + f_{\text{mid}} \times I_1(P_{\text{mid}}, \lambda) + (1 - f_{\text{strat}} - f_{\text{mid}}) \times$$

$$[a_{\text{bot}} \times I_1(P_{\text{bot}}, \lambda) + (1 - a_{\text{bot}}) \times I_0(P_{\text{bot}}, \lambda)]$$

effect of CH_4 mixing ratio on H-band fit quality

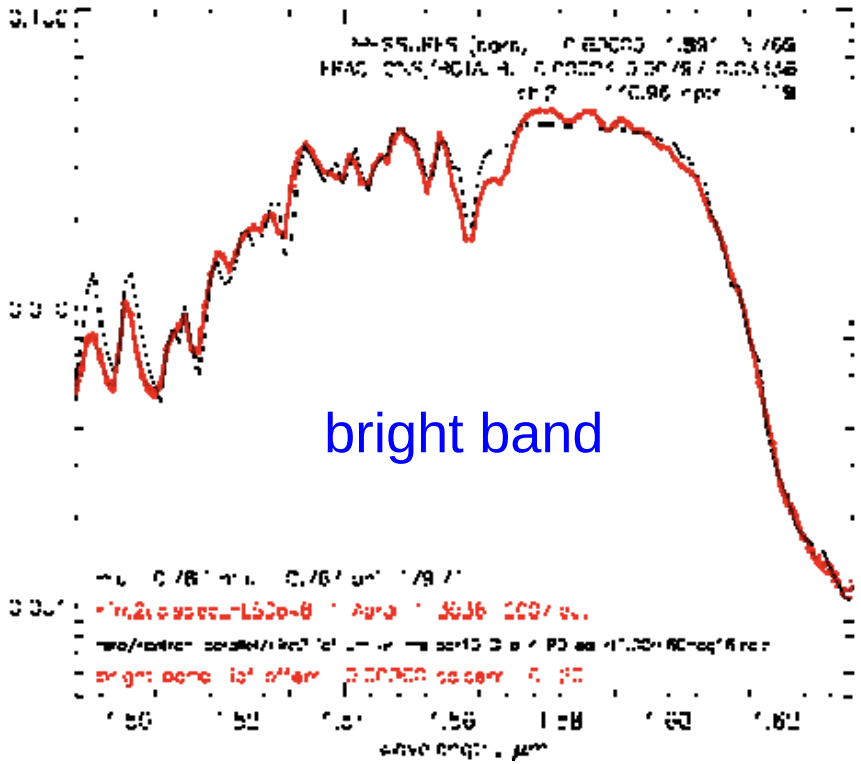


sample fits for 1% CH4



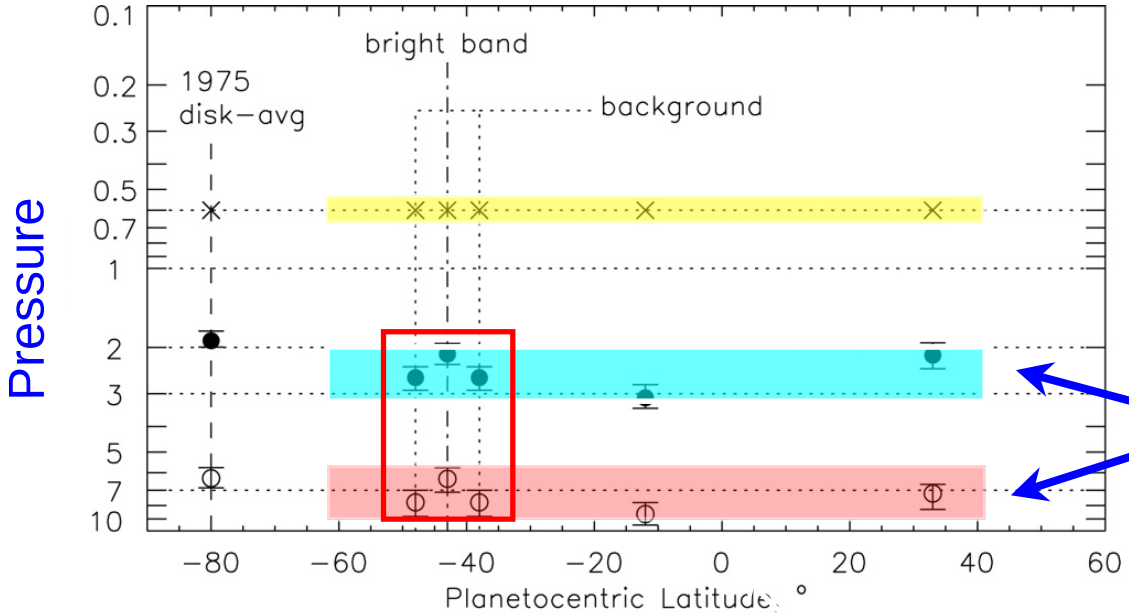
background

Pmid = 2.1 bars
Pbot = 6.8 bars
fmid = 0.006
abot = 0.030



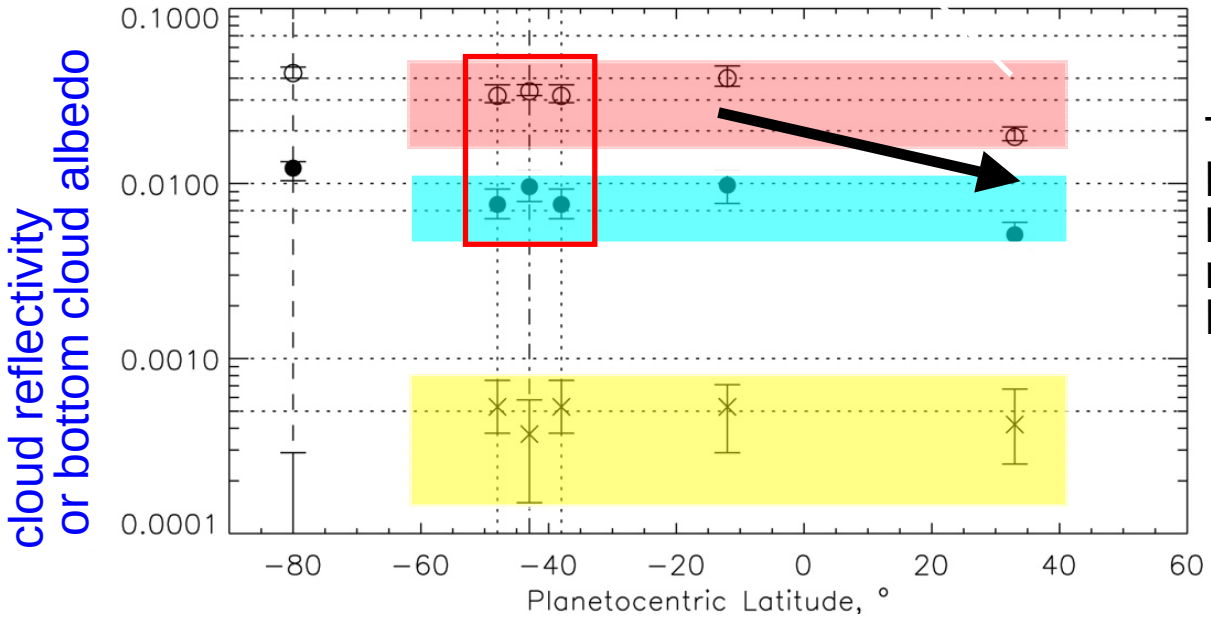
bright band

Pmid = 1.9 bars
Pbot = 5.8 bars
fmid = 0.008
abot = 0.033



In the bright band clouds are more reflective and at a lower pressure

Main clouds are near 2-3 bars and 7 bars at all lats.



The dark northern hemisphere is due to lower reflectivity of main clouds (50% lower at 35 N)

SUMMARY

- 1.0+/-0.3% CH4 provides best fits to H spectra at most latitudes (lower than prior estimates of 1.6% and 2.3%)
- There is no significant cloud contribution at the methane condensation level (near 1.2-1.3 bars), nor at the expected level of 3.8 bars from prior analyses.
- Bandpass filter images confirms lack of band structure at 1.2-bar methane condensation level.
- Instead we find the main clouds are near 2-3 bars and 7 bars, slightly lower at higher CH4 mixing ratios (similar pressures found from analysis of 0.6-0.83 micron STIS spectra; presented in Fry and Sromovsky poster 55.03).
- The darker northern hemisphere is due to lower reflectivity of the main clouds near 2 bars and 7 bars.
- The bright band is due to increased reflectivity and lower pressure of main clouds (both vary across bright band).