



Solar System Science with the SMA

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SMA - Well-suited to Solar System Studies

- Spatial scales from ~ 1 arcminute to $\ll 1$ arcsecond
- Physical temperatures range from ~ 30 K (KBOs) to > 500 K (Mercury)
- 'spectral dynamic range' -- Wide, pressure-broadened lineshapes (up to 10's of GHz) down to narrow Doppler-broadened lineshapes -- sometimes in the same line

Large primary beam; multiple configurations including subcompact and very extended

Large bandwidth and dual receiver (sensitivity); mm/submm operation which samples strong molecular transitions

2 GHz bandwidth, with 10 GHz separation, coupled with flexible correlator capable of very high spectral resolution



Solar System Science 2005-2007

- Resolving the Pluto/Charon Binary
 - HCN from Comet SW3
 - Mapping Uranus
 - Evolution of HCN on Jupiter from Comet SL9
-
- Imaging Io's Volcanic Atmosphere
 - High-resolution Imaging of Titan's Atmosphere
 - "Deep Impact" Co-ordinated Campaign
 - Broad-band Spectrum of Neptune*
 - Millimeter/Submillimeter Line Survey of Titan*
 - Rotation Curves of the Galilean Satellites*

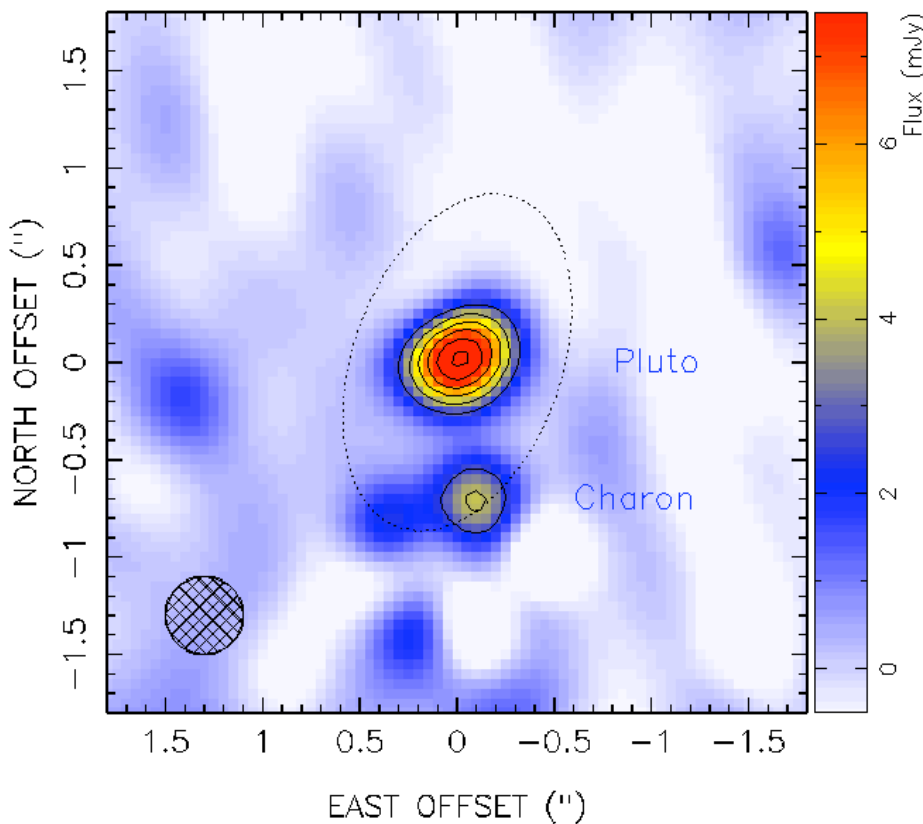
*primarily archive-based



Pluto & Charon - Cold Binary Dwarves

(Gurwell & Butler 2005) - SMA produces first ever image separating Pluto and Charon at a true thermal wavelength

PLUTO/CHARON @ 220 GHz [SMA: May 21 2005]

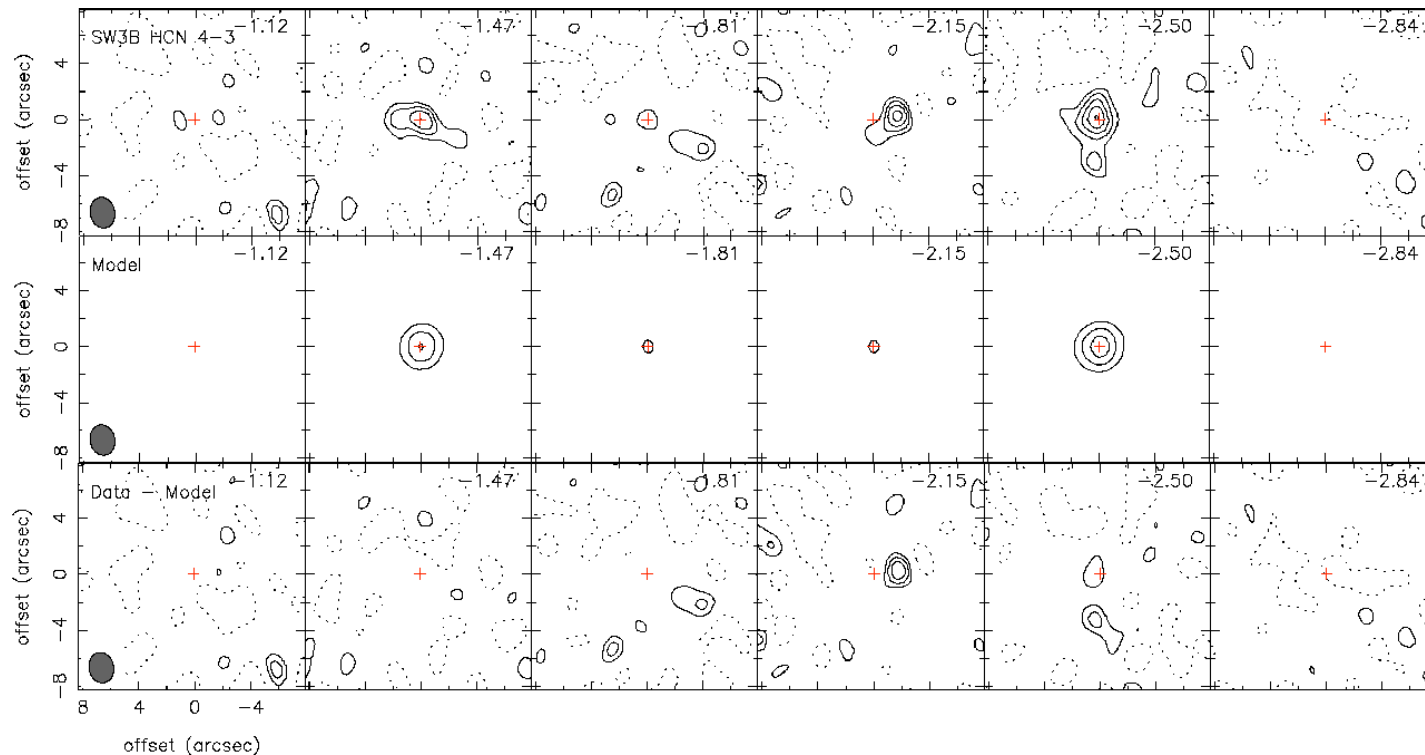


Results	Pluto	Charon
Flux Density	10.8±1.0 mJy	3.6±1.0 mJy
Mean T_B	39±3 K	48±12 K
Surface Temp.	43±4 K	54±14 K

Pluto is colder than required for radiative equilibrium - surface temperature buffered by N₂ atmosphere



Comets - 73P/SW3

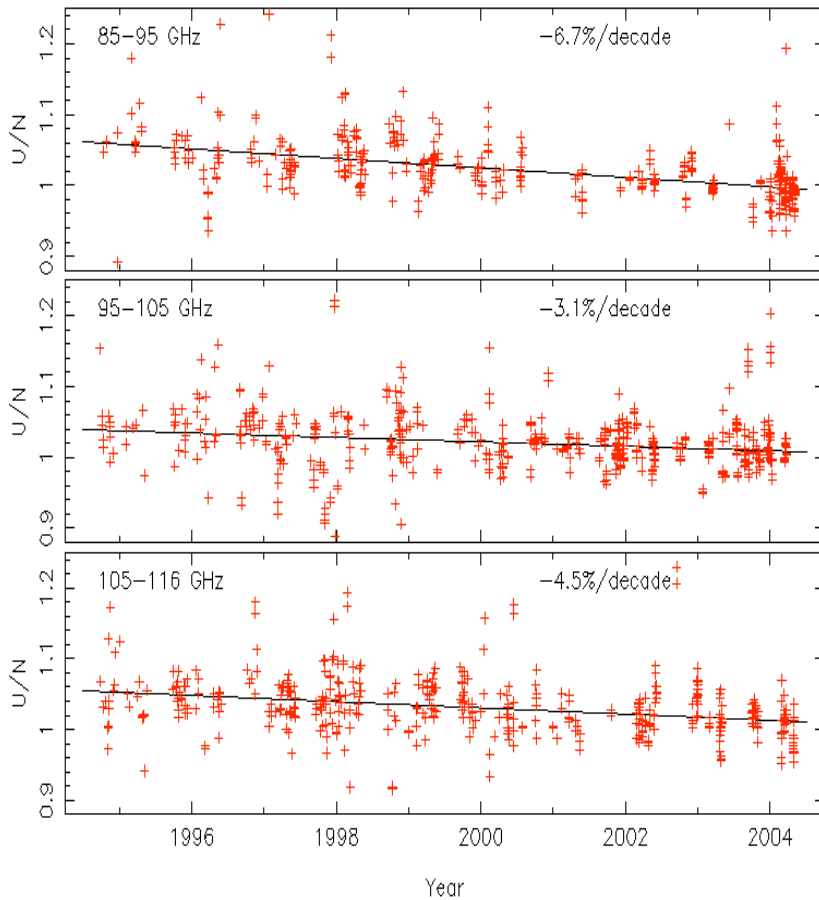


(Qi et al, in prep) Comet 73P/Schwassmann-Wachmann 3 broke into 3 fragments during 1995-1996 apparition. At closest approach (just 0.08 AU from Earth on May 13th 2006), SMA detected HCN $J=4-3$ from inner coma of fragment B (beam of $2.2 \times 1.8''$ where $1'' \approx 50$ km in linear scale). HCN shows apparent jet from nucleus.

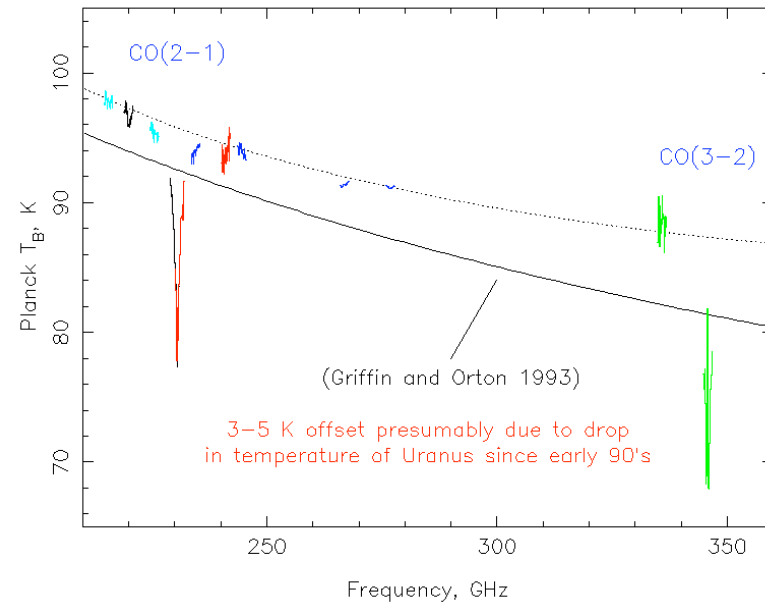


The Temperature of Uranus

OVRO Derived Uranus to Neptune Intensity Ratio (Average Slope: $-4.5\%/decade$)



Neptune Calibrated by Uranus (2004 SMA Observations)



Uranus appears cooler than in late 1980's



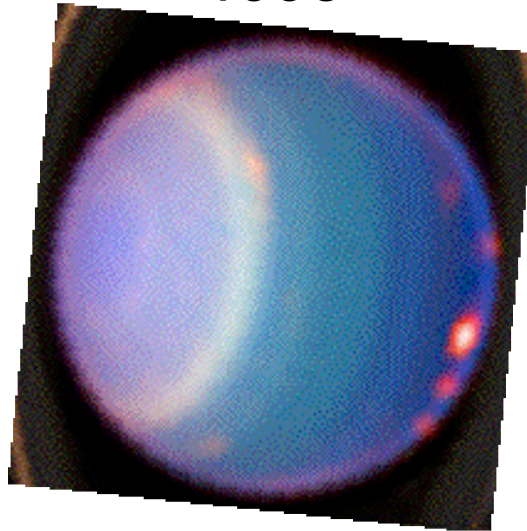
Why?

1986



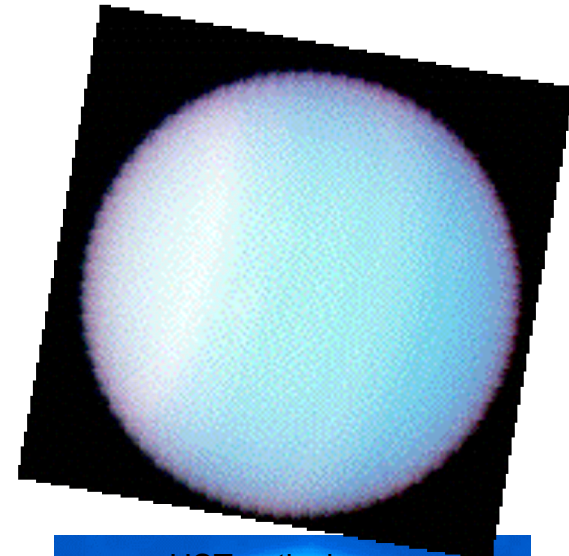
Voyager optical

1998



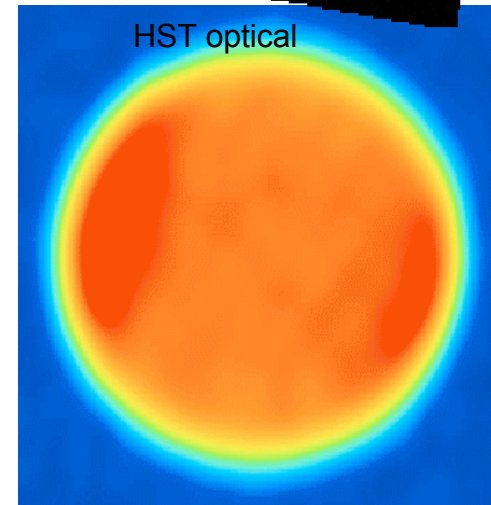
HST NIR

2005



HST optical

Changing Geometry Plays a Part

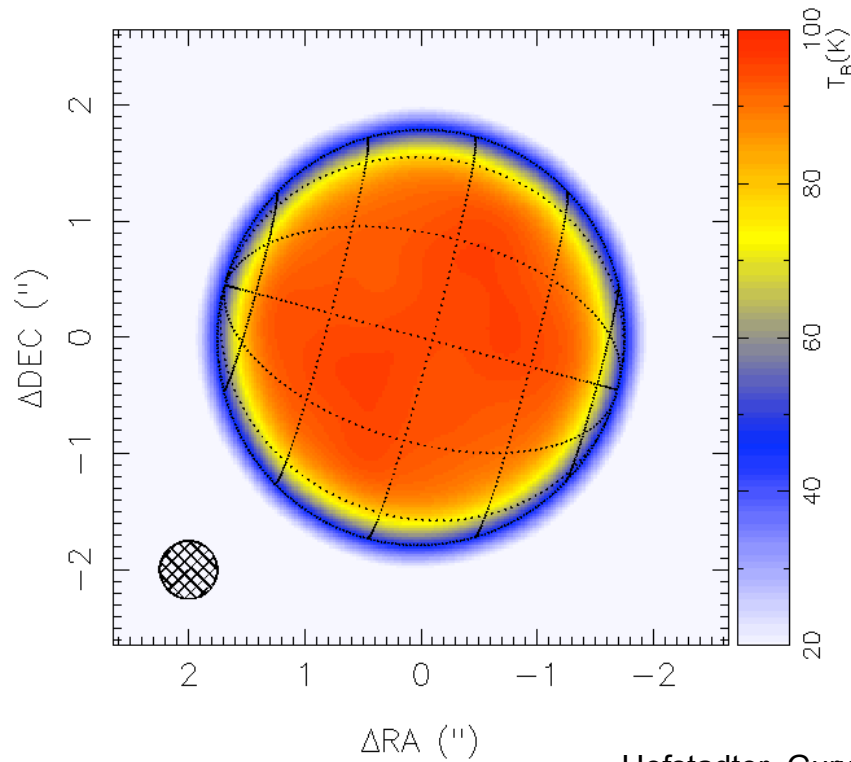


VLA 1.3 cm



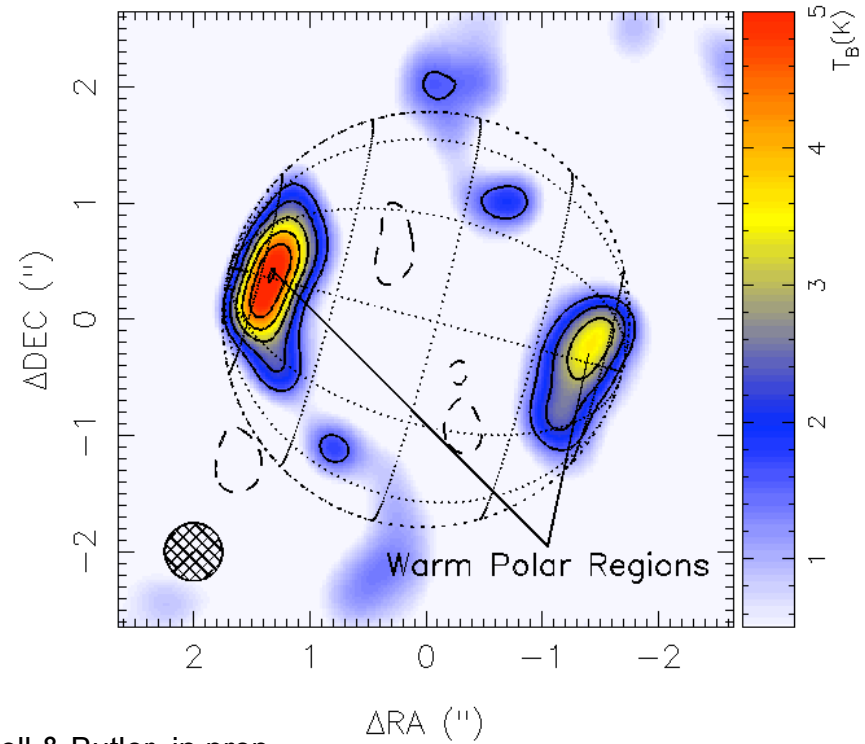
Imaging the Warm Poles of Uranus

URANUS @ 220.3 GHz [SMA: July 11, 2006]



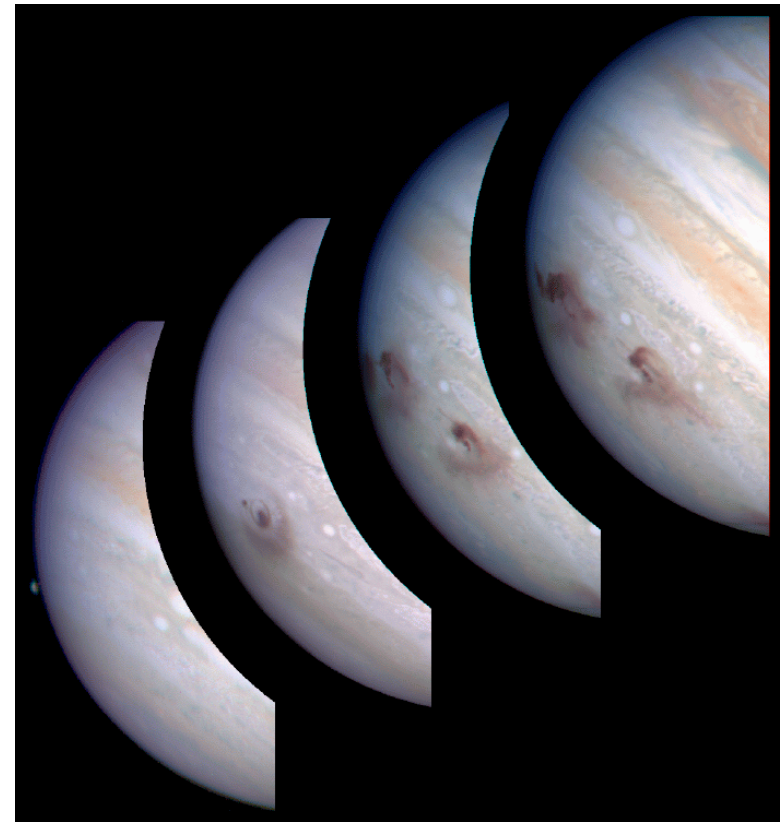
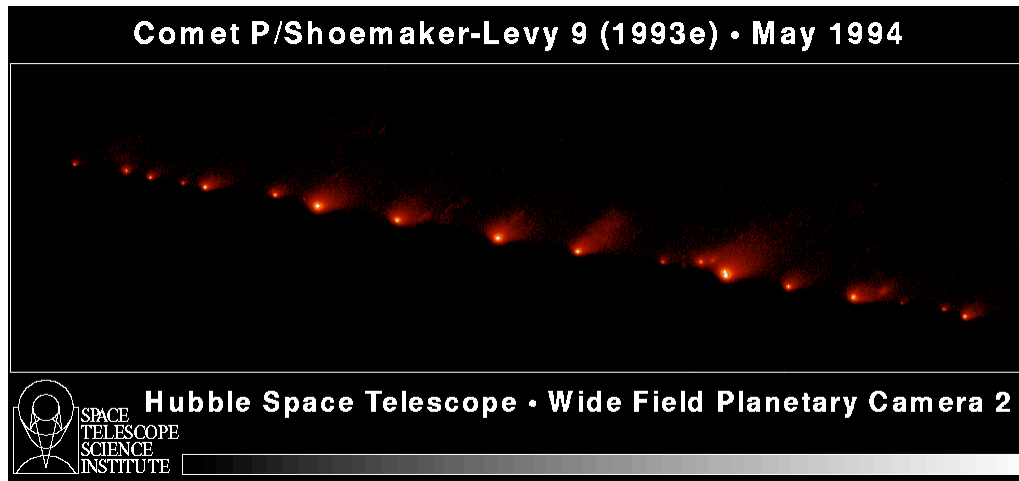
Hofstadter, Gurwell & Butler, in prep

DATA – MODEL
0.75 K Contours, starting at 1.5 K





HCN on Jupiter...from Comet SL9



Shoemaker-Levy slams into
Jupiter, July 1994
Deposits material into
troposphere and stratosphere



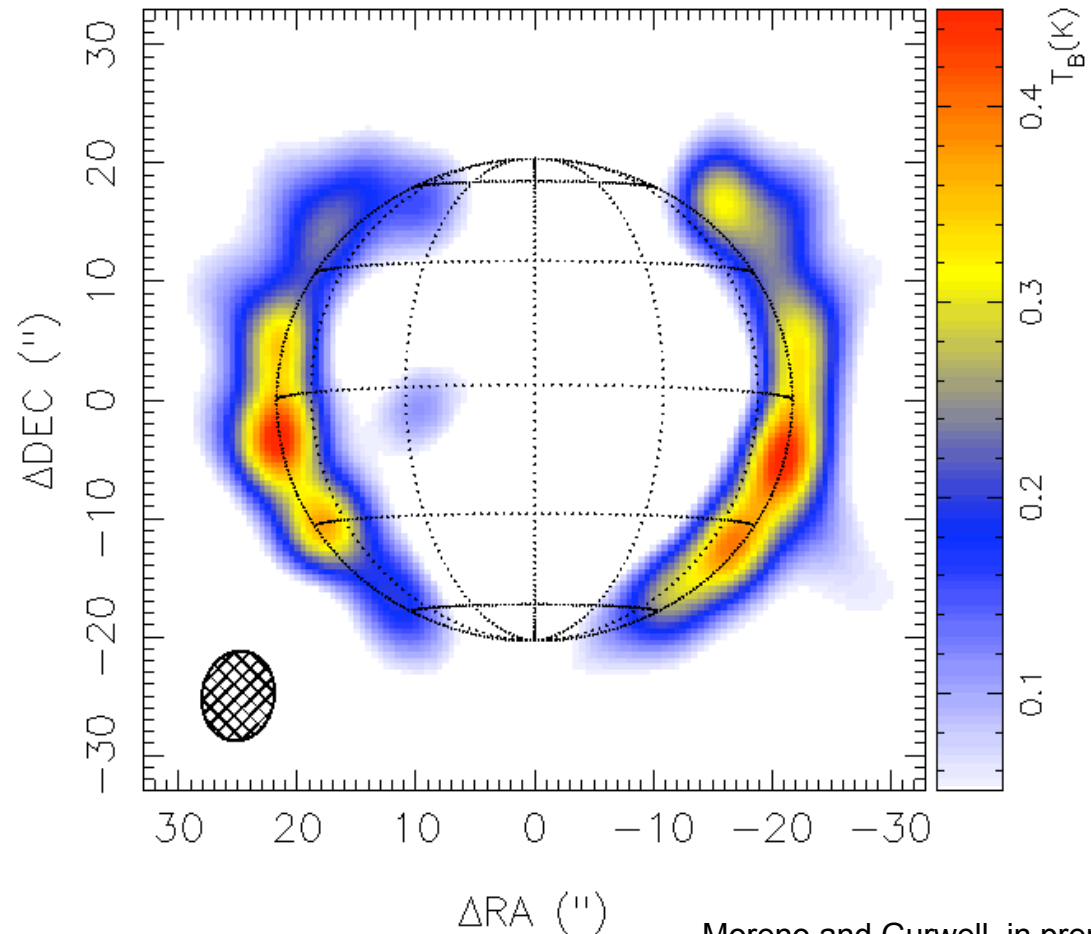
Loss of HCN due to Dynamics

er HCN(3-2) Integrated Emission [SMA: 28 April, 2007

HCN mass loss from 1998-2006
~factor of 8. No detections of daughter species (e.g. CH₃CN) implies mass loss rate primarily due to dynamics (transport) not photochemistry.

Hypothesized downward transport near poles, driving HCN to higher pressures and temperatures where it is destroyed in favor of methane and ammonia.

SMA imaging from April 2007 strongly supports this view.



Moreno and Gurwell, in prep



A look back...and forward

From my 2005 Advisory Committee presentation...

Future

- Imaging Io's Volcanic Atmosphere ✓*
- Coordinated 'Deep Impact' Observations ✓
- Resolving the Pluto/Charon Binary ✓+
- Mapping the Uranus "Hot Polar Cap" ✓+
- Winds on Mars, Venus, and Titan -
- Asteroid Light Curves and Imaging -
- ToO Comets ✓+

11 April 2005 SMA Advisory Committee Meeting 17

use eSMA?

no detection

proposing



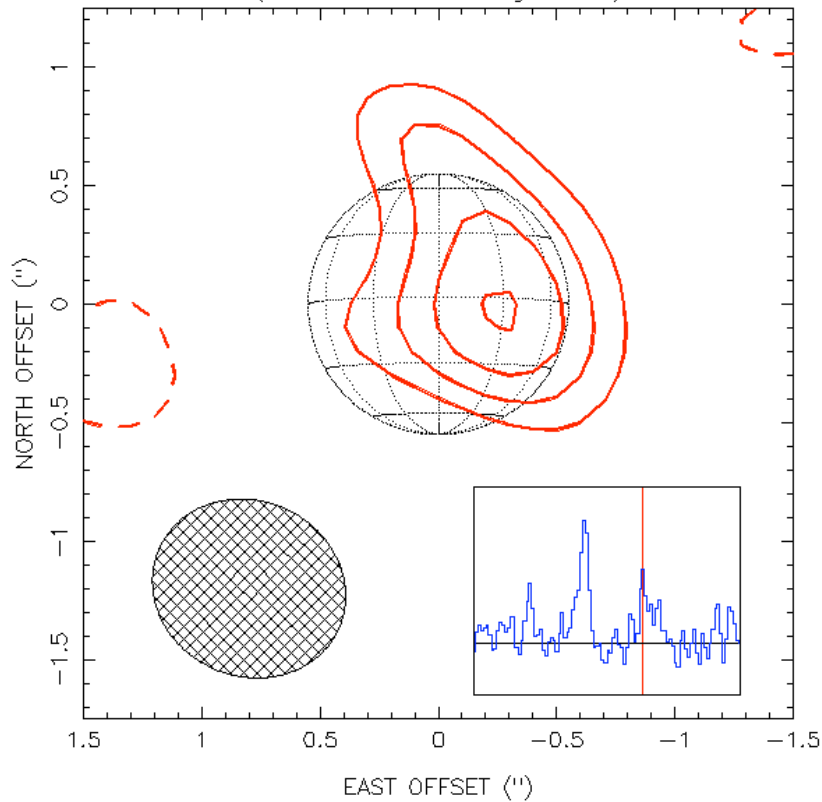
Summary

- SMA proficient at Solar System studies
- Diverse projects pursued
- More to come!

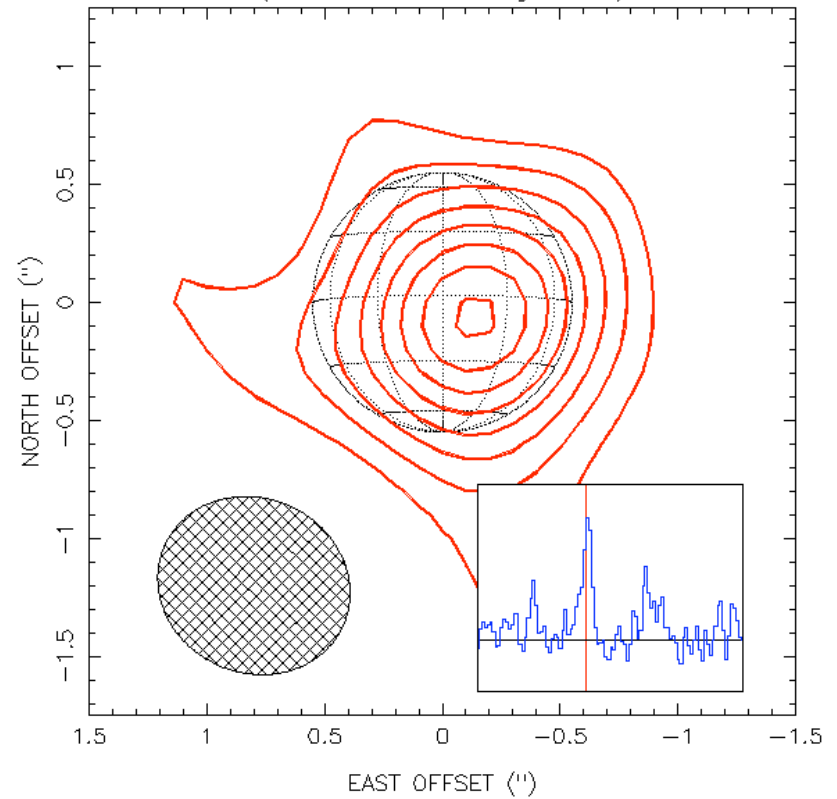


Extras: Imaging Io's Atmosphere

$\text{SO}(8_9-7_8) @ 346.528 \text{ GHz}$ [SMA: June 10, 2006]
(2 K Contours, starting at 4 K)



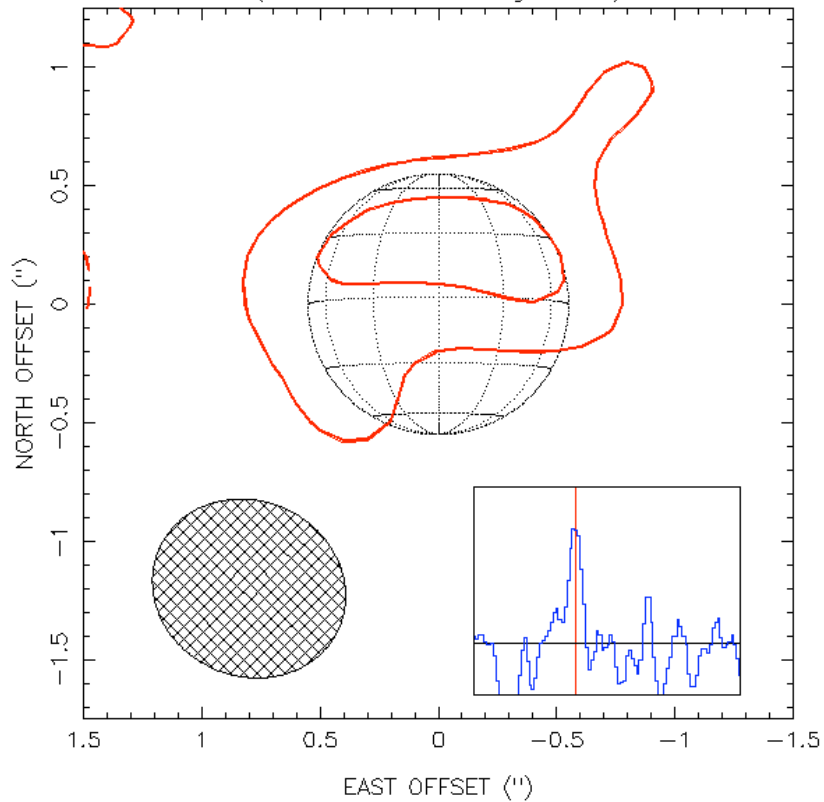
$\text{SO}_2(16_{4,12}-16_{3,13}) @ 346.524 \text{ GHz}$ [SMA: June 10, 2006]
(2 K Contours, starting at 4 K)





Extras: Imaging Io II

NaCl(26-25) @ 338.022 GHz [SMA: June 10, 2006]
(2 K Contours, starting at 4 K)



SO₂(19_{1,19}-18_{0,18}) @ 346.652 GHz [SMA: June 10, 2006]
(2 K Contours, starting at 4 K)

