# Triton's atmosphere in 1989: new lab data, new profiles

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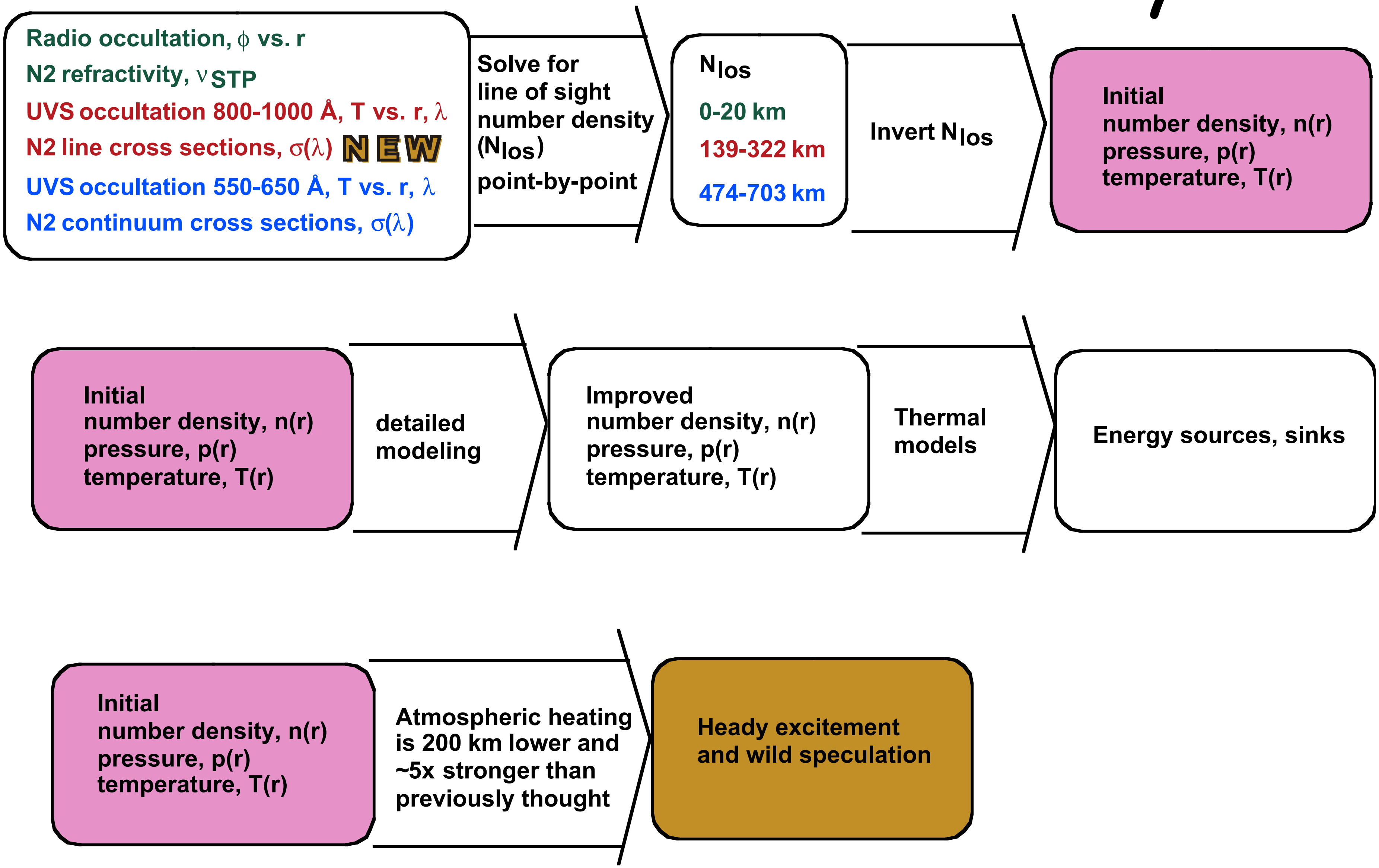
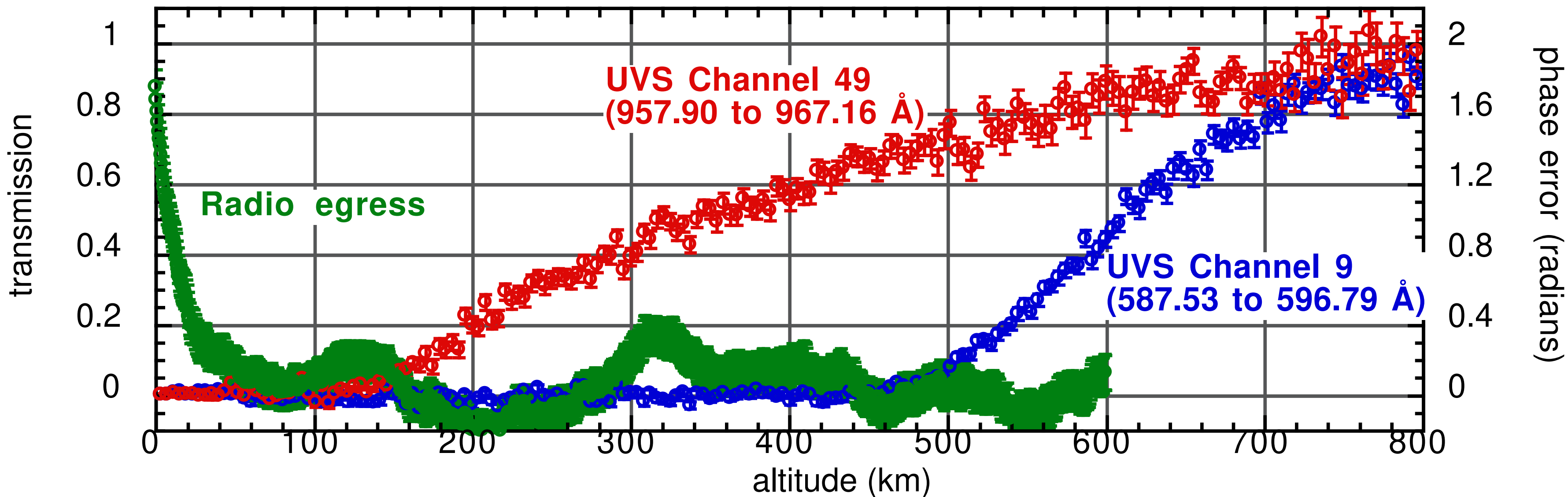
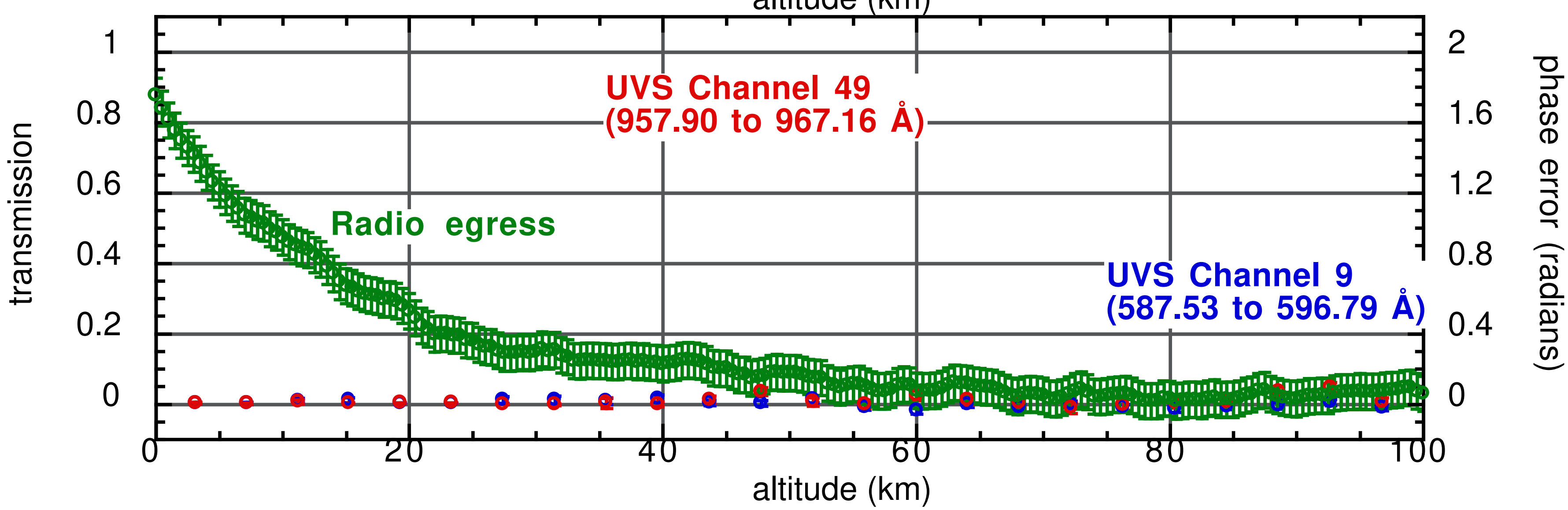
# Start with the Summary



# Voyager (1989) occultation data

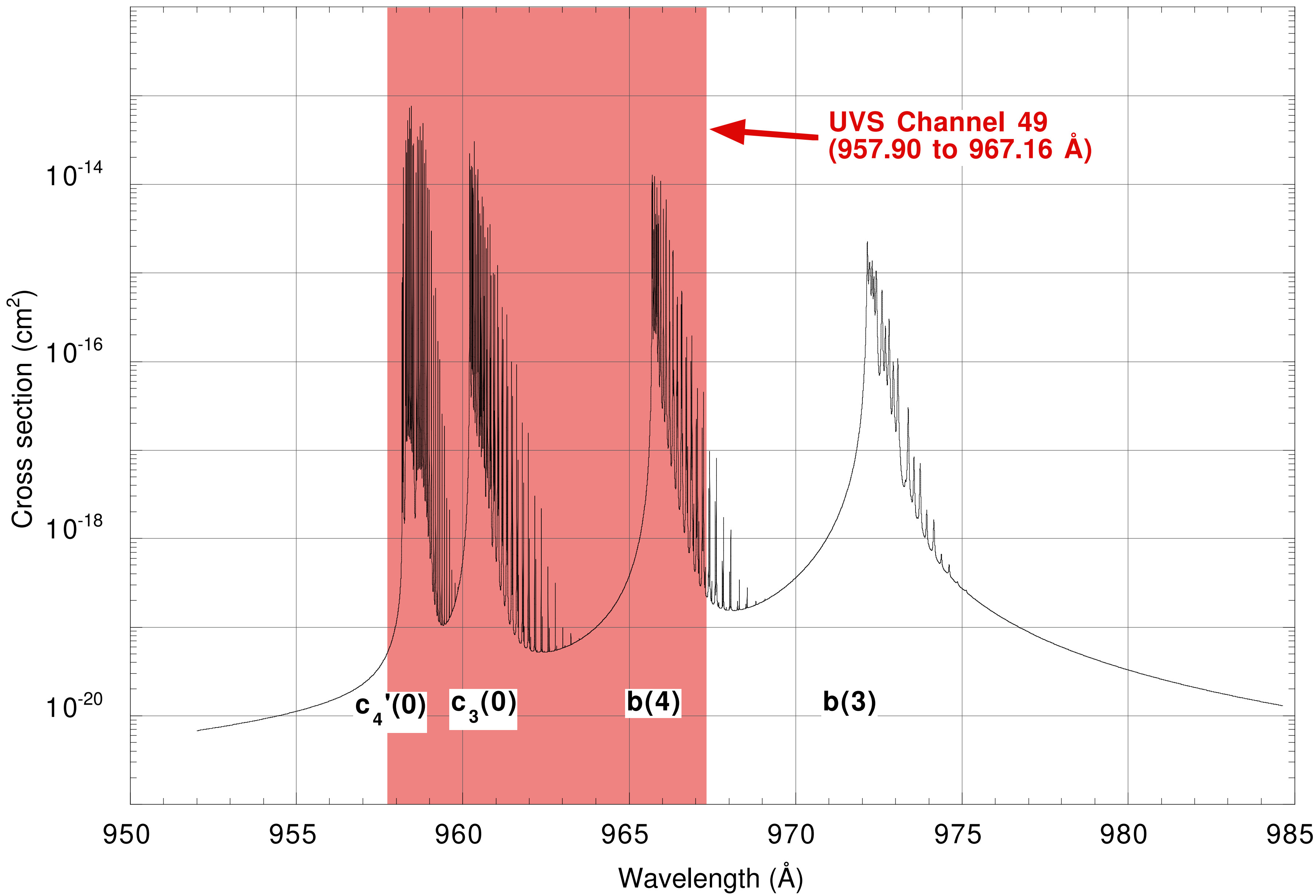


# Voyager data details

- UVS transmission vs. altitude and wavelength
  - Use Ron Vervack's most recent reduction (~1992)
  - Use only odd channels
  - Account for wavelength shifts with altitude by shifting the transmissions
  - Estimate errors by comparing ingress and egress transmissions at the same wavelength, altitude
- Radio phase delay vs. altitude
  - Using most recent reduction: Gurrola, E. M. 1995. *Interpretation of Radar Data from the Icy Galilean Satellites and Triton*. Ph.D. Thesis, Stanford University, Fig 6.2, as preserved in Planetary Data System
  - Gurrola estimates errors at 0.1 radian; however, errors are highly correlated
  - Use the background estimated by Gurrola, taking into account this correlation; this is the background in Gurrola Table 8.3.

# $N_2$ cross sections

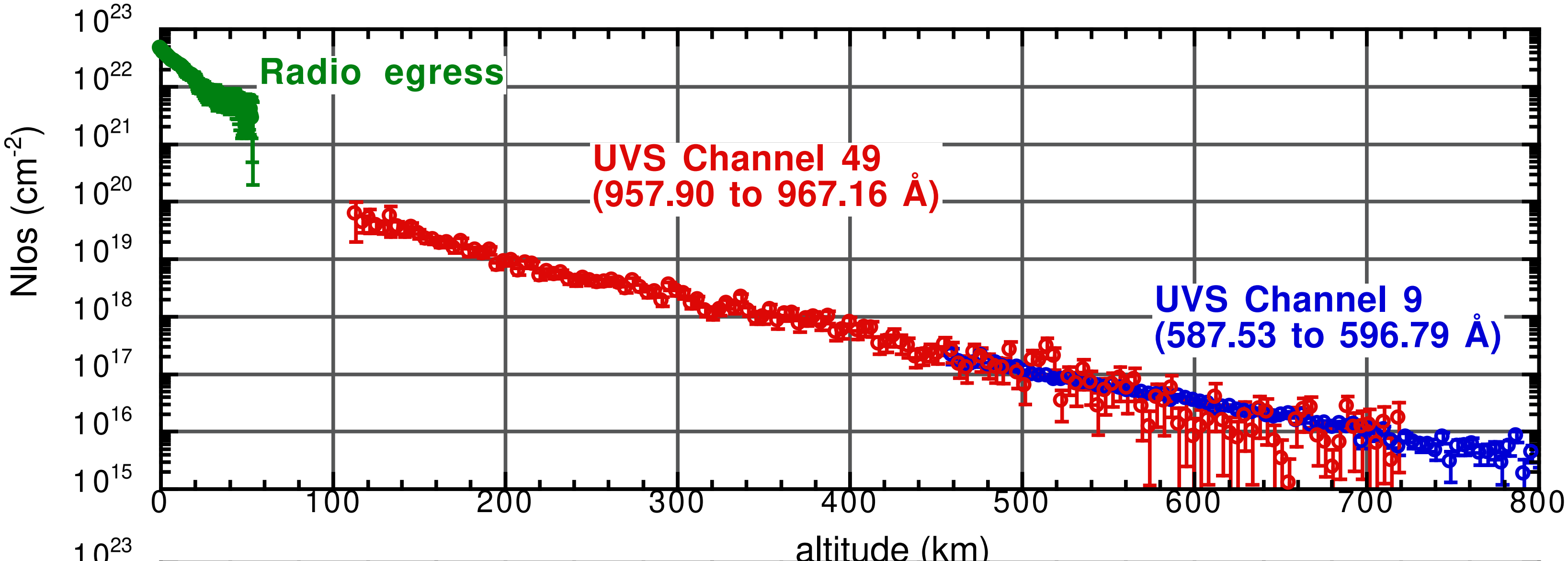


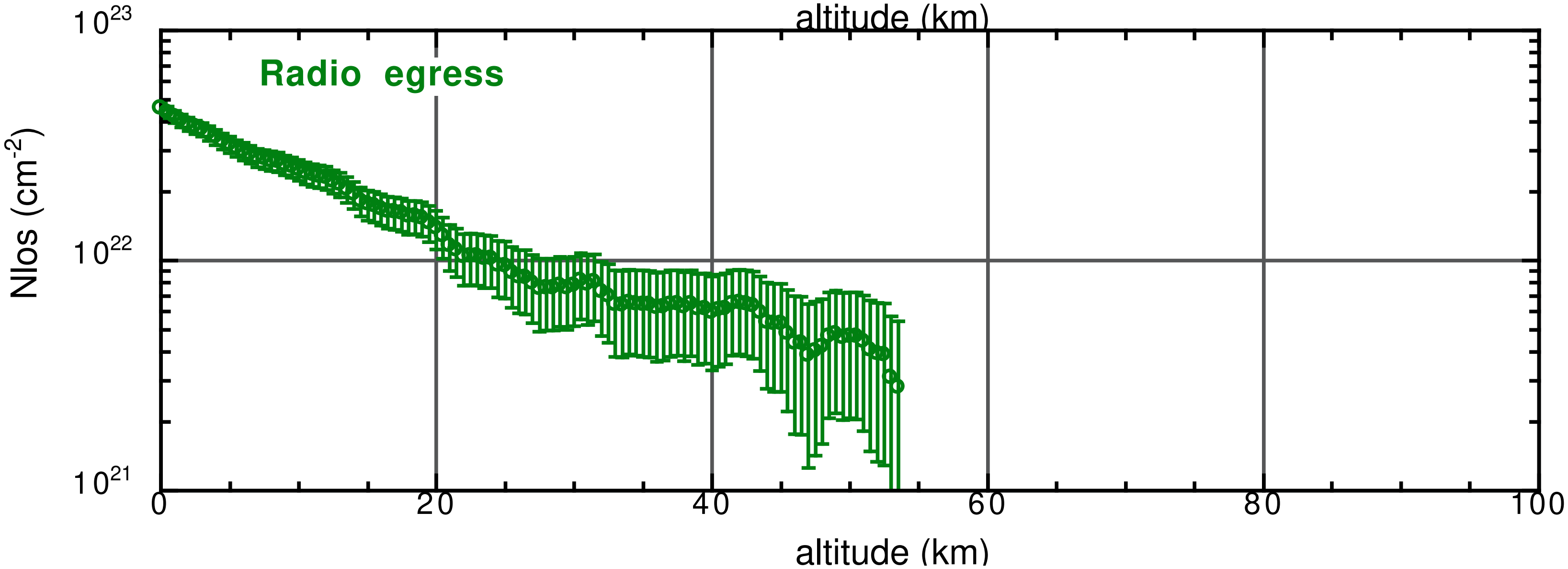
# $N_2$ cross section details

- Four bands used in this analysis ($c_4'(0)$, $c_3(0)$, b(4), b(3))
  - $N_2$ photoabsorption measured by Stark and others at the Photon Factory synchrotron radiation facility at the High Energy Accelerator Research Organization in Tsukuba, Japan, 1997, 1998, 1999
  - Predissociation widths from Stark's measurements, or from Ubachs (e.g., Ubachs, W. 1997. Predissociative decay of the $c_4'\ {}^1\Sigma_u^+$ v=0 state of $N_2$, *Chem. Phys. Lett.* **268**, 201.)
  - Use Hönl-London factors to derive individual line strengths, and use one predissociation width for each band.
  - Use cross sections for T=95 K

| Band | Integrated cross section (cm$^2$ Å) | Predissociation width (Å) |
|---|---|---|
| $c_4'(0)$ | $1.11 \times 10^{-15}$ | 0.0001 |
| $c_3(0)$ | $4.57 \times 10^{-16}$ | 0.00067 |
| b(4) | $5.03 \times 10^{-16}$ | 0.0029 |
| b(3) | $4.57 \times 10^{-15}$ | 0.03 |

# Line-of-sight number density

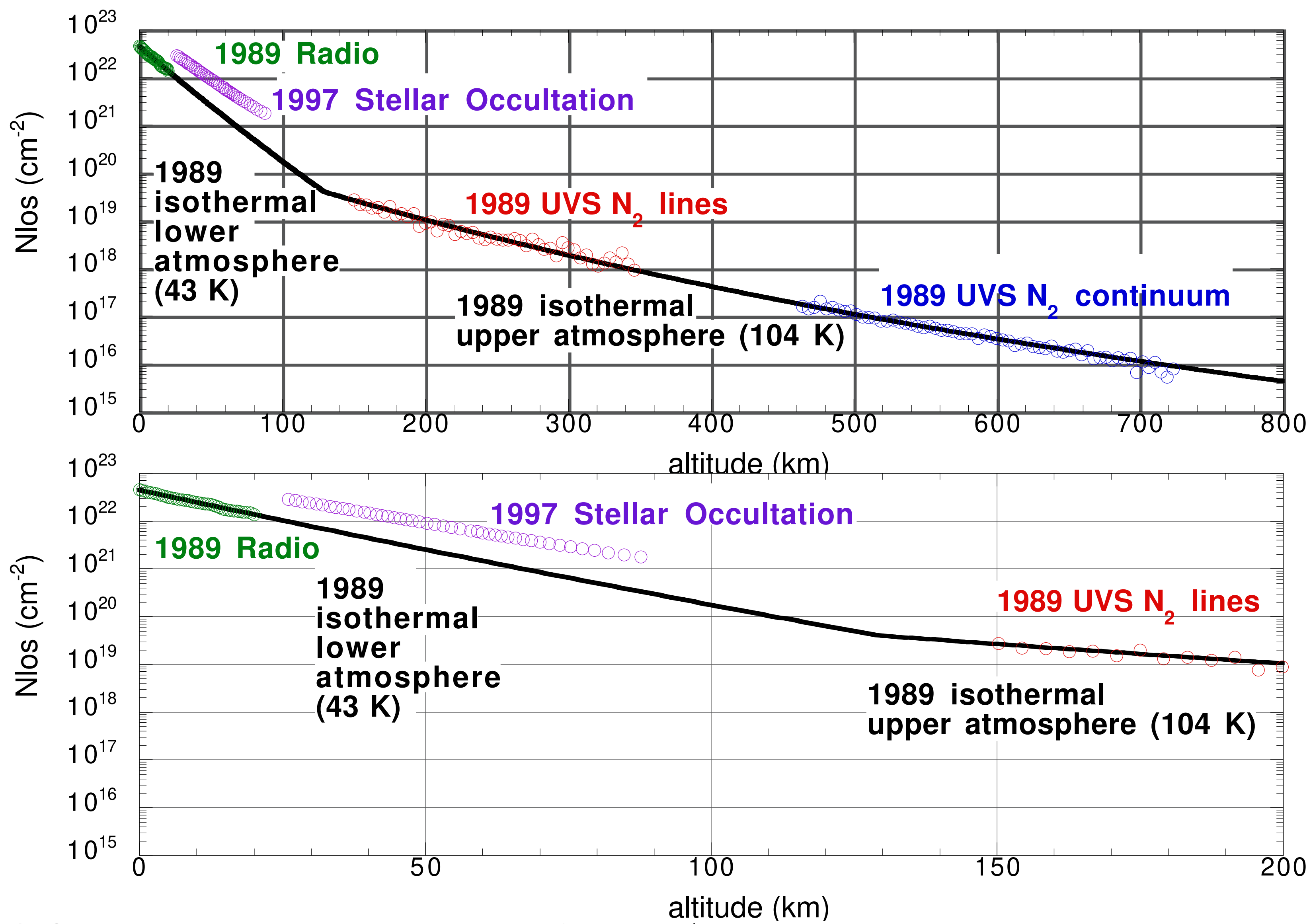


# Line-of-sight density details

- $N_{los}$ from $N_2$ continuum transmission
  - Simple Beer's law
  - $transmission = e^{-N_{los}\bar{\sigma}}$, where $\bar{\sigma} \approx \dfrac{\int_{\lambda_0}^{\lambda_0+\Delta\lambda} F_\odot \sigma_\lambda \, d\lambda}{\int_{\lambda_0}^{\lambda_0+\Delta\lambda} F_\odot \, d\lambda}$
- $N_{los}$ from $N_2$ line transmission
  - Explicit averaging over wavelength
  - Consistent with $N_{los}$ from $N_2$ continuum transmission
  - $transmission \approx \int_{\lambda_0}^{\lambda_0+\Delta\lambda} e^{-N_{los}\sigma_\lambda} \, d\lambda$
- $N_{los}$ from radio phase
  - $phase\ delay = \dfrac{4\pi\nu_{STP}}{\lambda N_L} N_{los}$

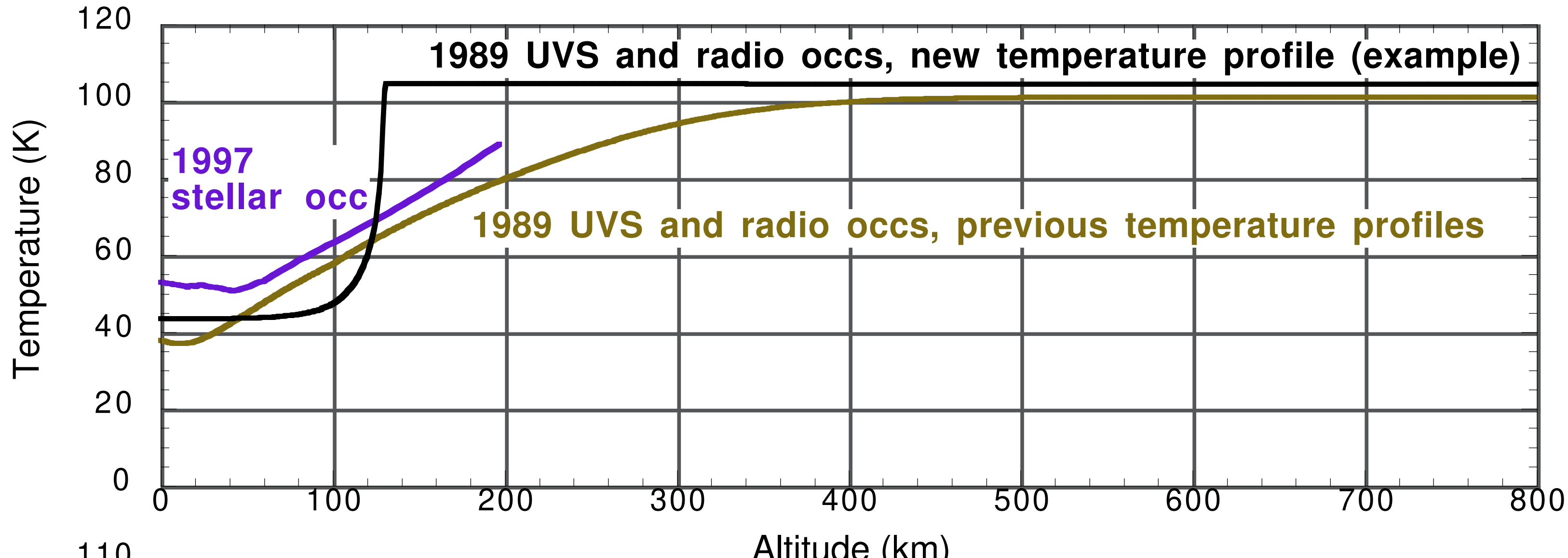
# $N_{los}$ interpretation

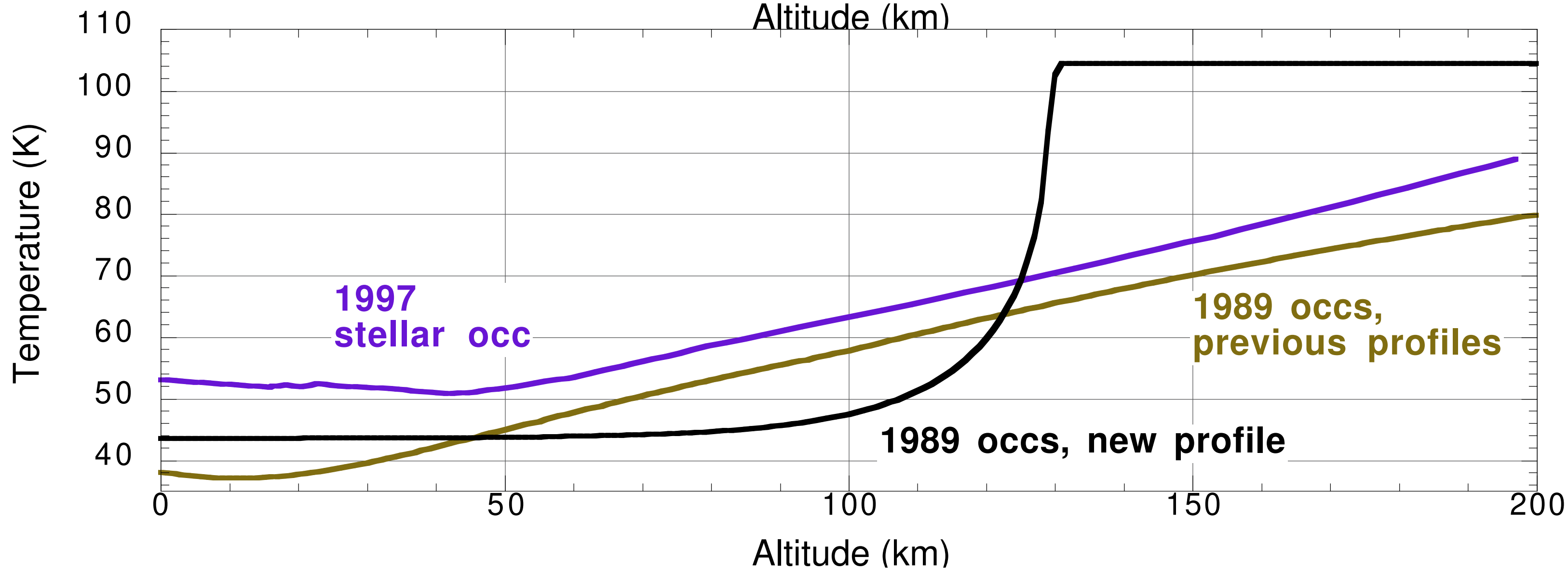


# $N_{los}$ interpretation details

- Fit UVS and radio with (small-planet) isothermal models
  - $$N_{los} = N_{los}(r_o)\left(\frac{r}{r_0}\right)^{3/2} \exp\left[\frac{r}{H} - \frac{r_0}{H_0}\right]\left[1 + \frac{9}{8}\left(\frac{H}{r} - \frac{H_0}{r_0}\right)\right]$$
- Upper atmosphere
  - All of the SNR>5 UVS $N_{los}$ can be fit with single temperature
  - T=104 K (c.f. Krasnopolsky et al. 1993; T=102±3 K)
- Lower atmosphere
  - All of the SNR>5 radio $N_{los}$ consistent with single temperature
  - T=44 K (c.f. Gurolla 1995; T=42±8 K)
- Comparison with 1997
  - Calculate $N_{los}$ from temperature profile (Elliot et al. 2000)
  - $N_{los}$ has increased between 1989 and 1997

# Temperature profiles



# Temperature profile details

- Invert the "spliced isothermal" $N_{los}$ profile from above
  - Use the "small planet" Abel transform
  - $n(r) = -\frac{1}{\pi r^2} \int_0^\infty \frac{dsN_{los}(s)}{ds} \frac{s\, ds}{\sqrt{s^2 - r^2}}$
- Implied heating differs from previous models
  - Stevens et al. 1992; Yelle et al. 1991
  - Main heating is below 150 km (c.f. Stevens et al 1992; 300-400 km)
  - Gradients may be as high as 1.4 K/km for fluxes as high as $8 \times 10^{-3}$ erg/cm$^2$/s
  - Heating by chemical recombination or energetic particle precipitation?
  - Thermal models may not split the atmosphere into "upper" and "lower"
- Lower atmosphere (<90 km): colder in 1989 than in 1997
  - As reported by Elliot et al. 2000
  - Higher conductive flux will affect thermal models of the 1997 occultation, which are currently unsatisfactory.