

The inversion layer at the tropopause of the Venus atmosphere:

New insights from the Radio Science Experiment
(VeRa) onboard Venus Express

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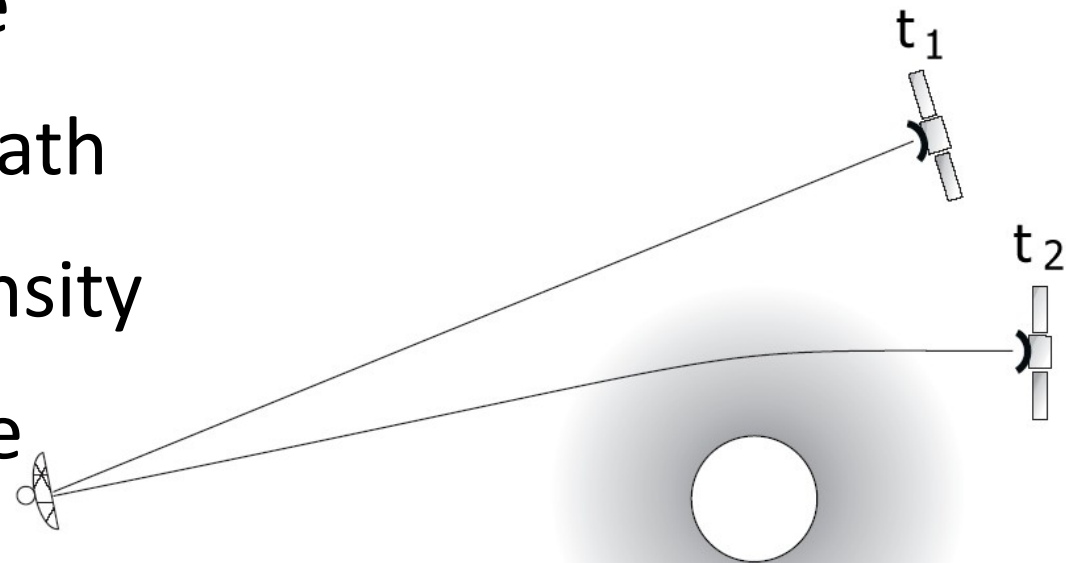
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About Venus Radio Science (VeRa)

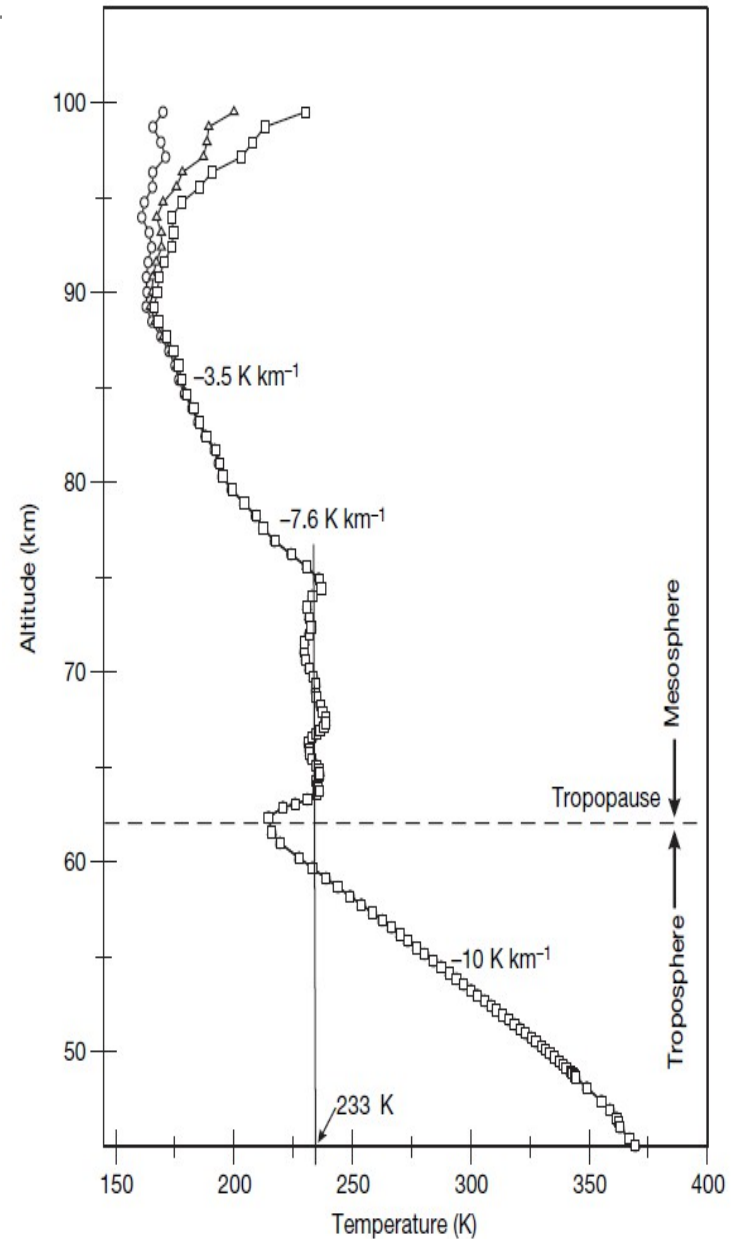
- Venus Express had an ultrastable oscillator on board
- one-way signal from spacecraft to Earth passed through the atmosphere
- Refraction of radio ray path gives information on density
=>temperature, pressure



Schaa 2005

The Inversion Layer

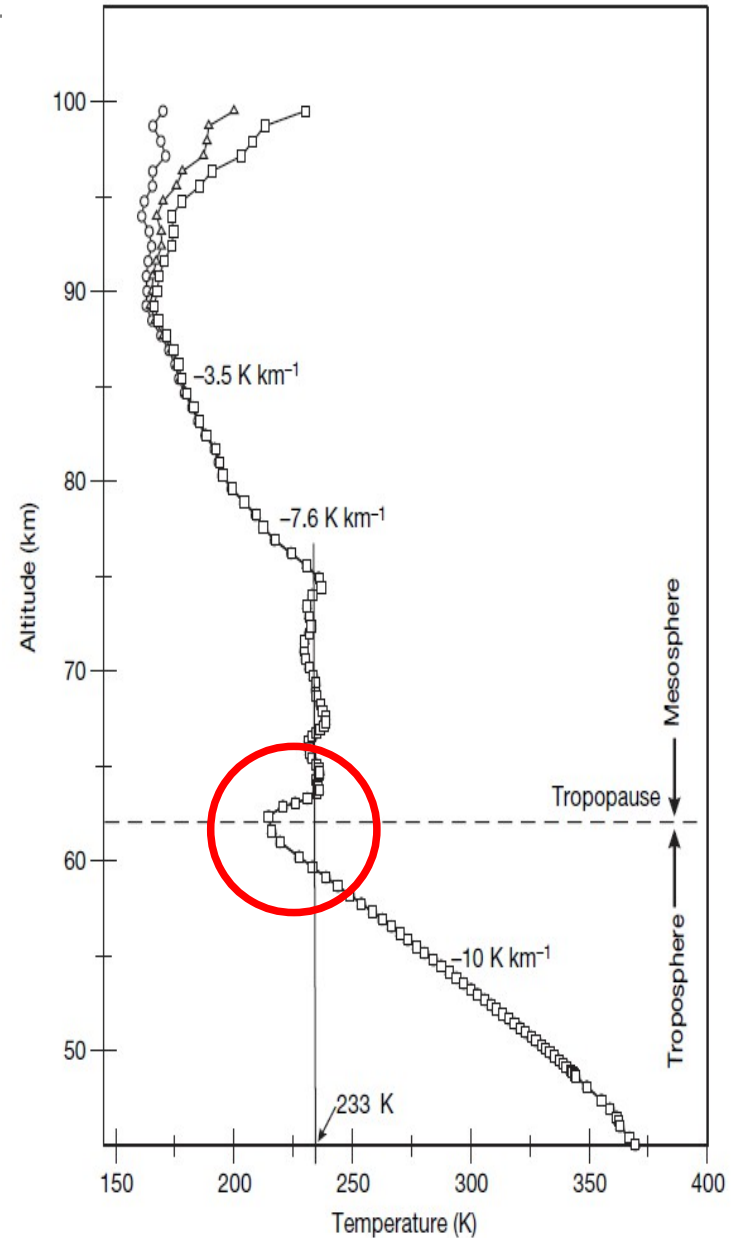
- Venus' atmosphere has an extraordinary temperature inversion layer at the tropopause @~ 60km
- The atmosphere is highly variable above the tropopause



Pätzold et al 2007

The Inversion Layer

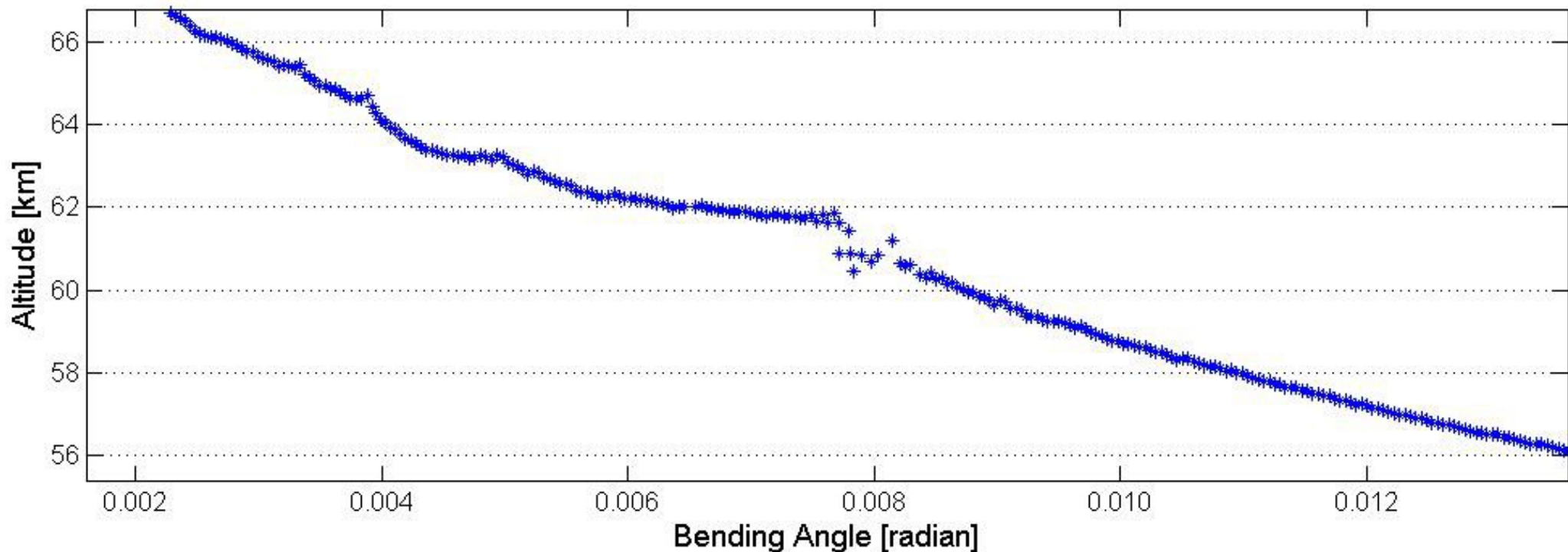
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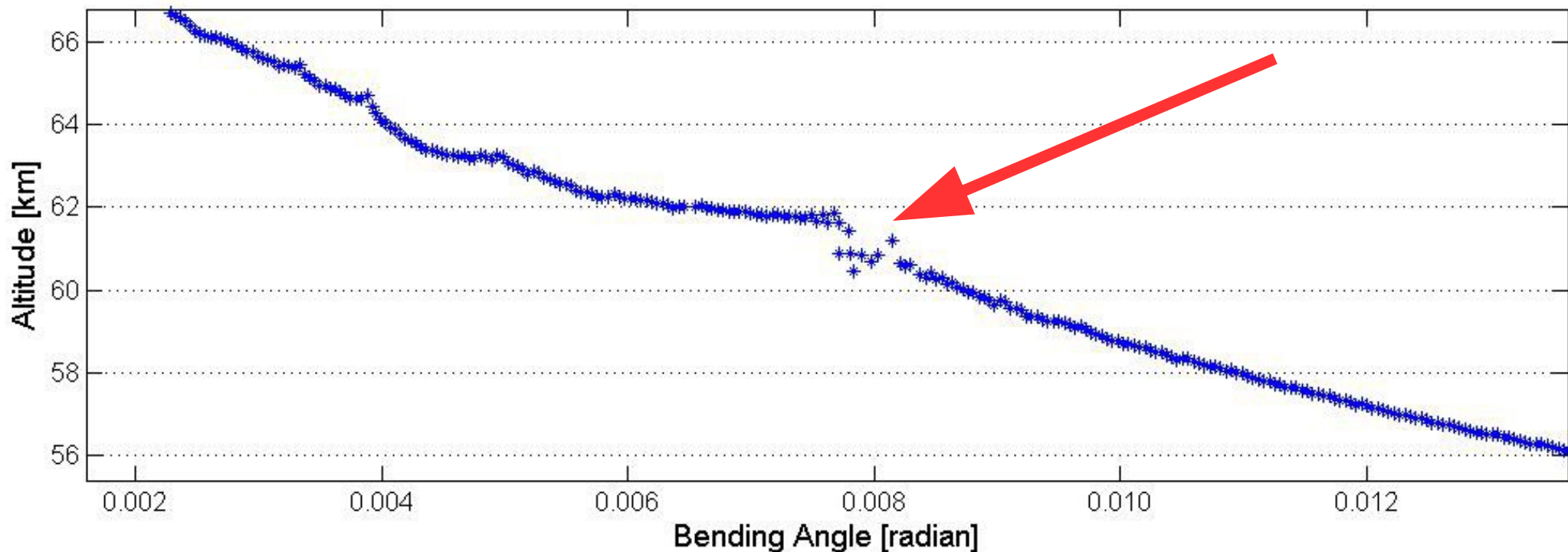
Discontinuities

- The bending angle shows discontinuities at the tropopause caused by a multipath effect



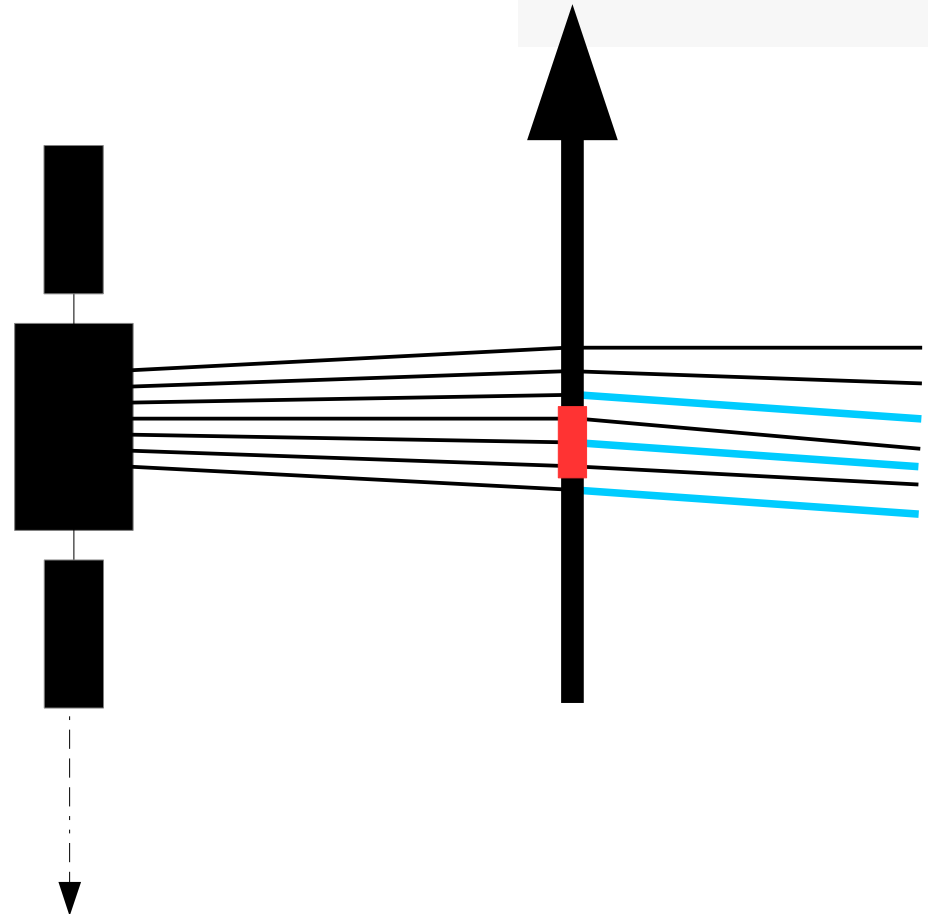
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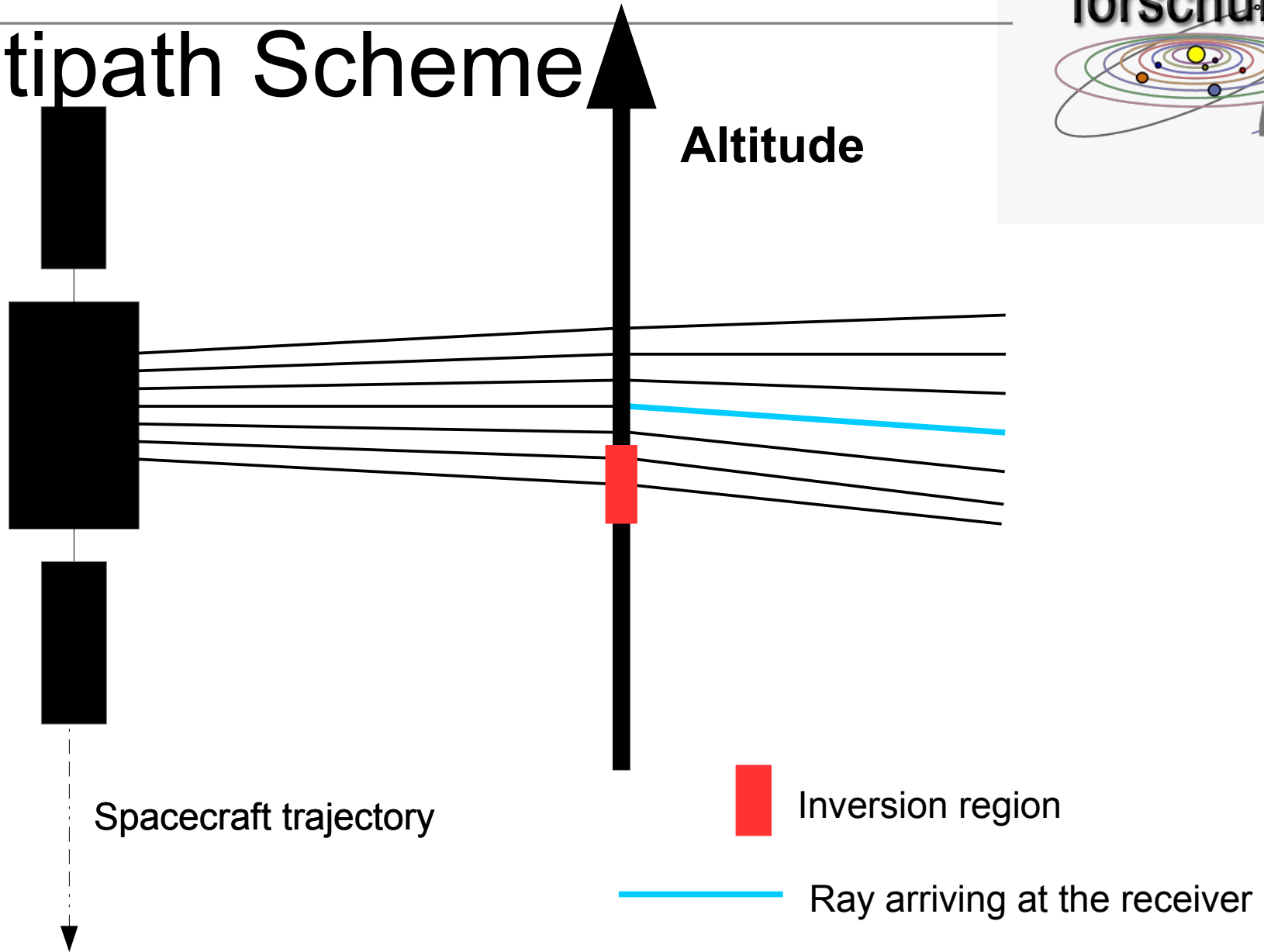


Multipath Effects

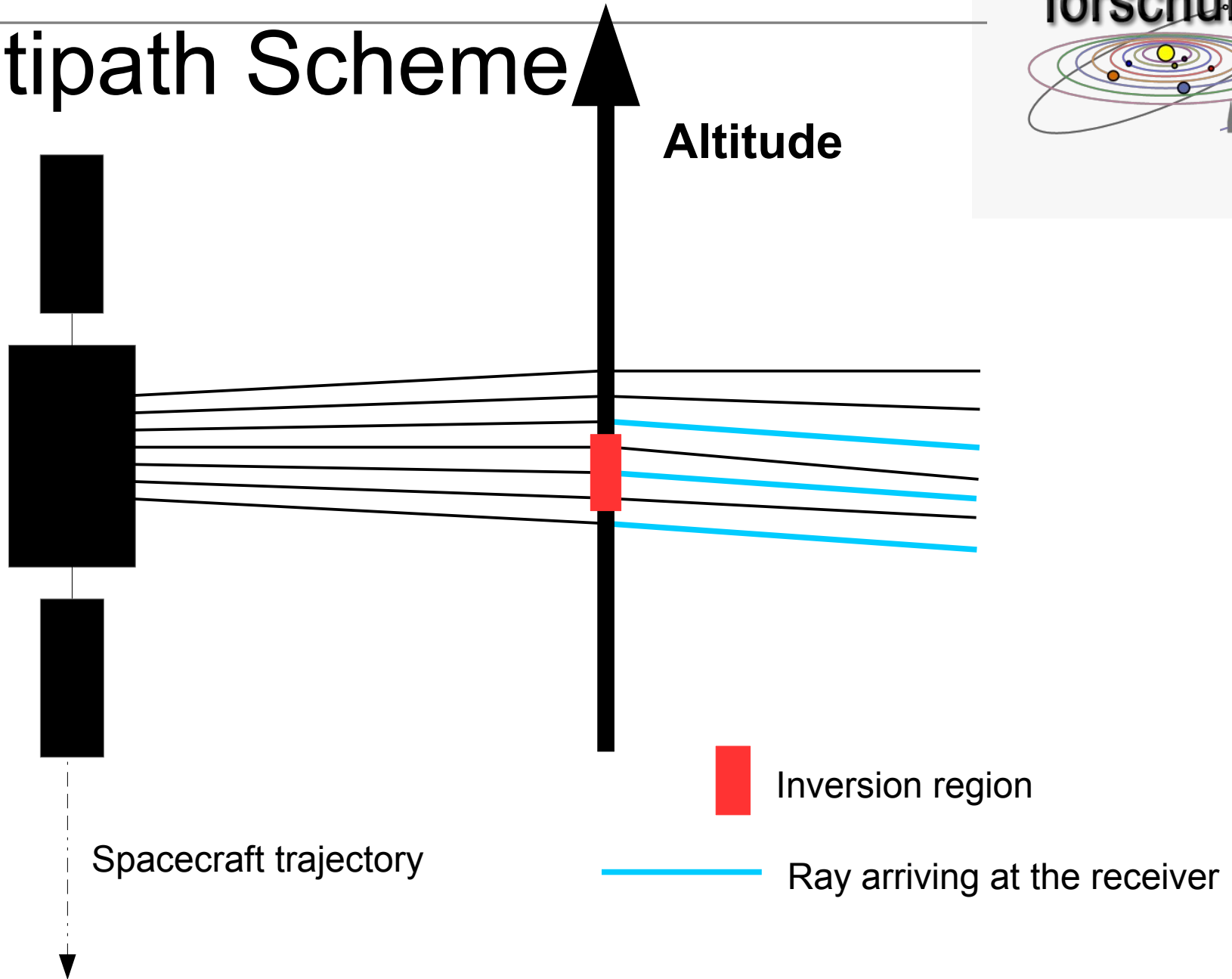
- Caused by a strong variation in the refractive index of the atmosphere
- Three rays sent at different angles by the spacecraft arrive at the groundstation at the same time



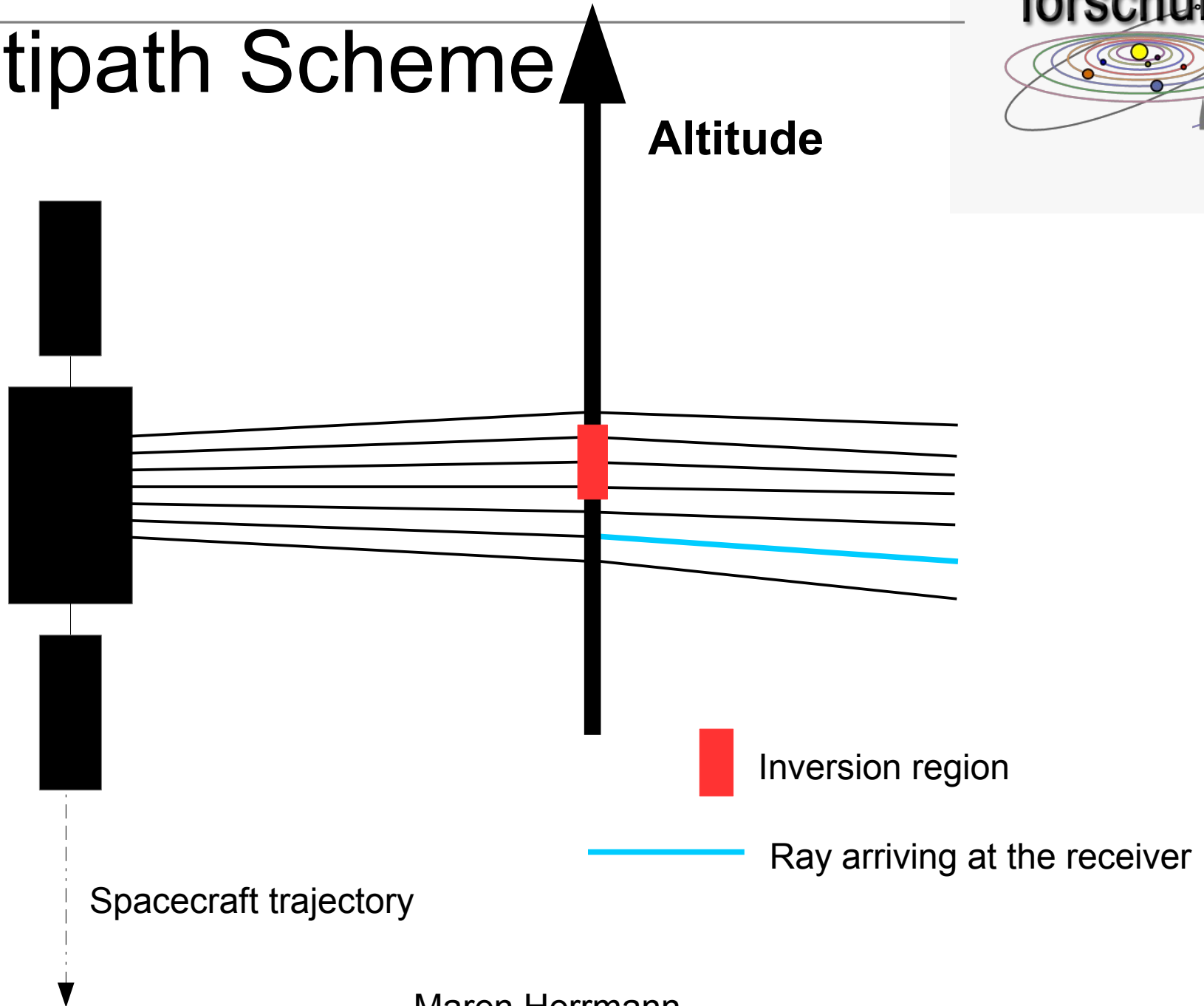
Multipath Scheme



Multipath Scheme

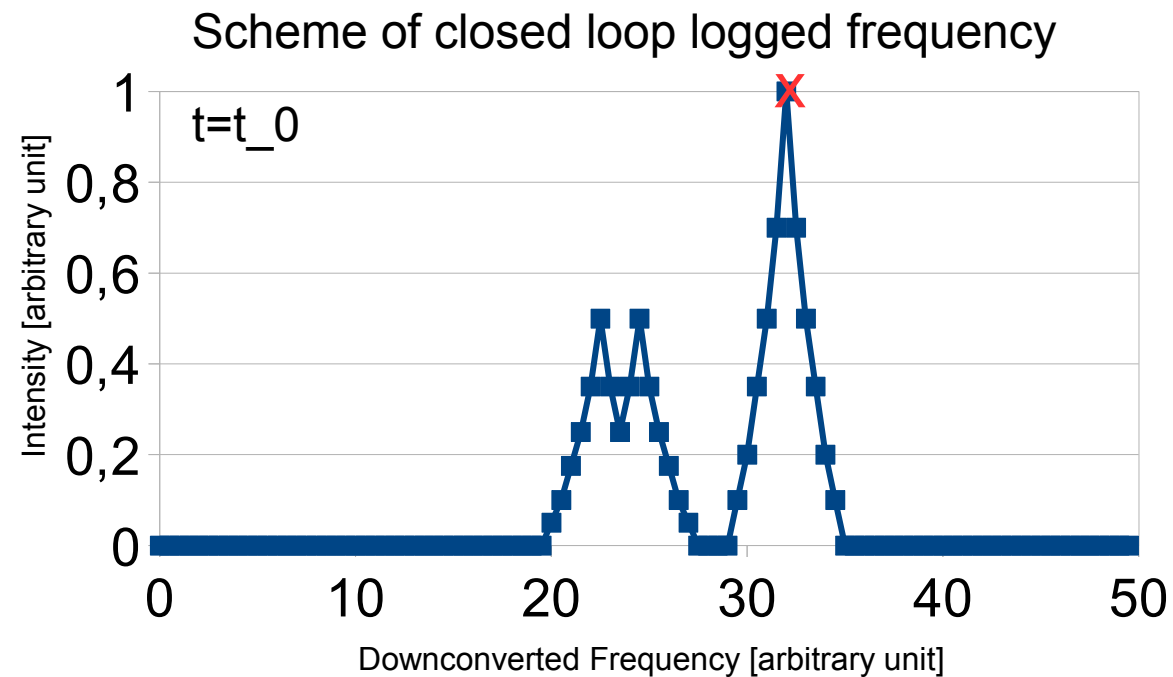


Multipath Scheme



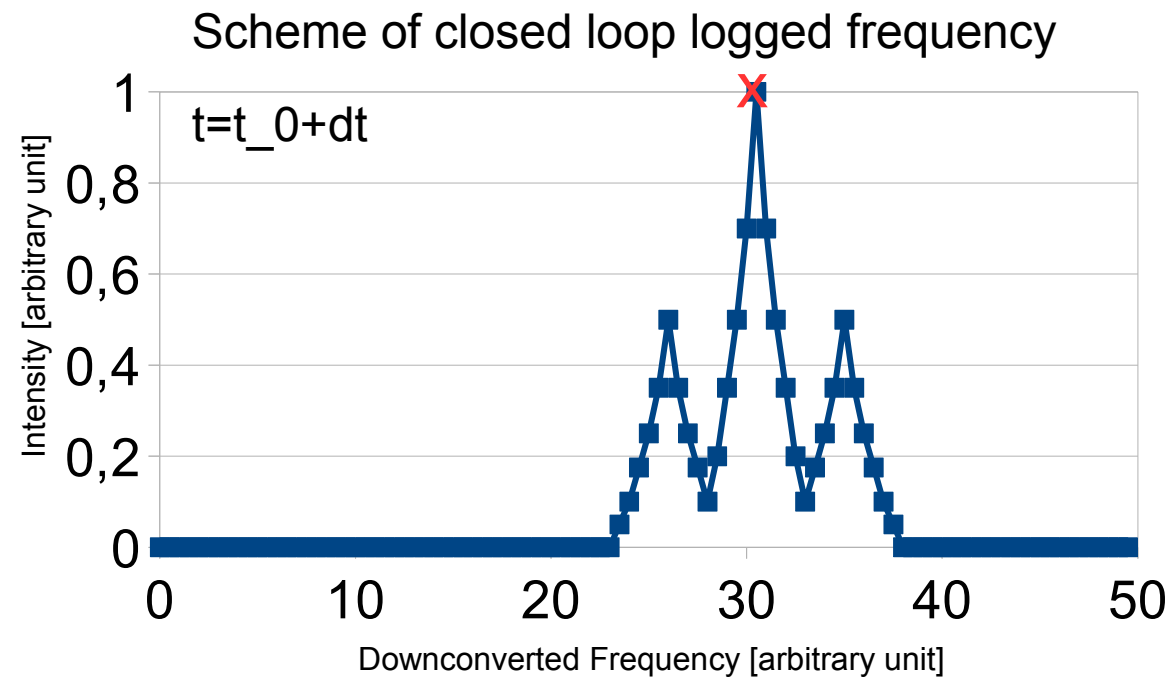
Multipath effect: a challenge

- Closed loop receiver logs at the frequency of the strongest received frequency
- Within the integration time it jumps through frequencies



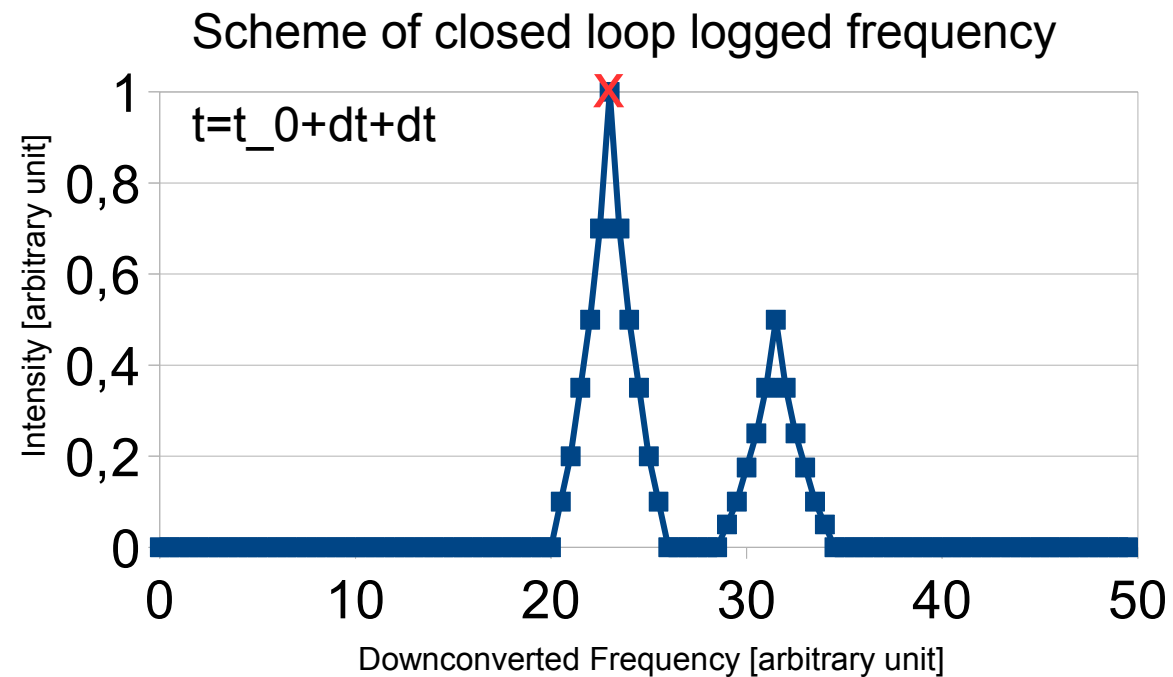
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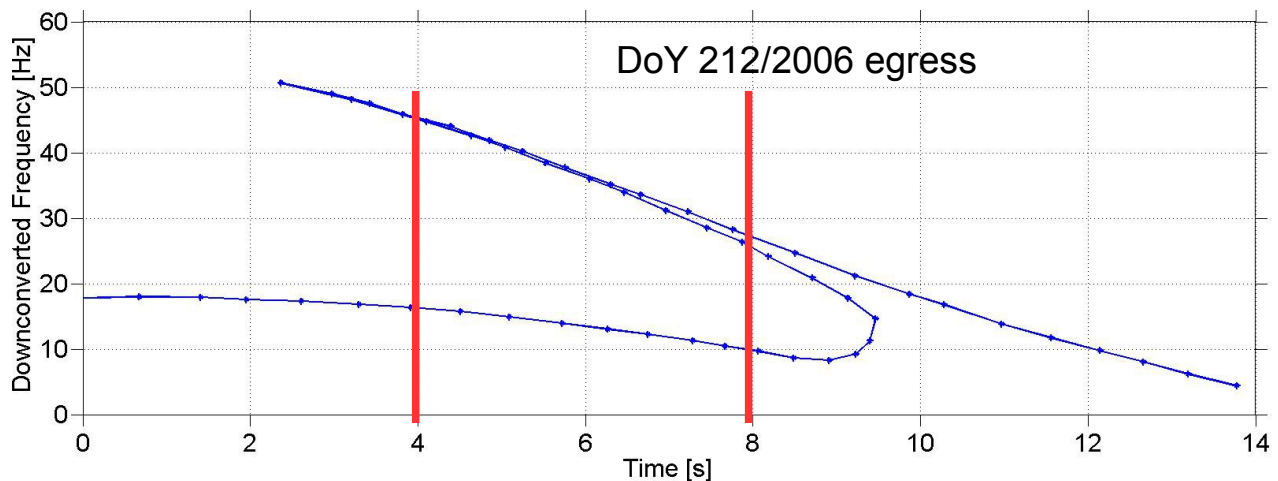
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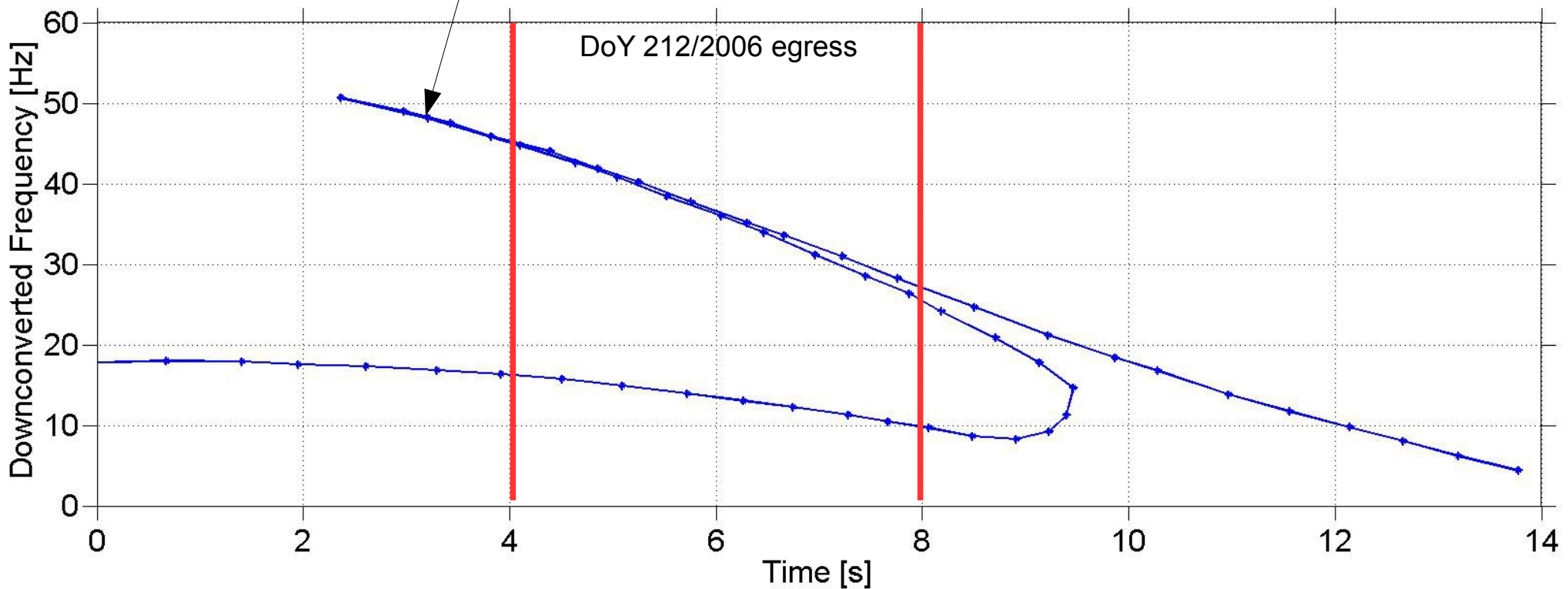
Solution: Open loop data recording

- Data were recorded and A/D converted
- Sample rate 100kHz
- All received frequencies are preserved
- Need a lot more processing steps



Solution: Open loop data recording

Two frequencies close to each other

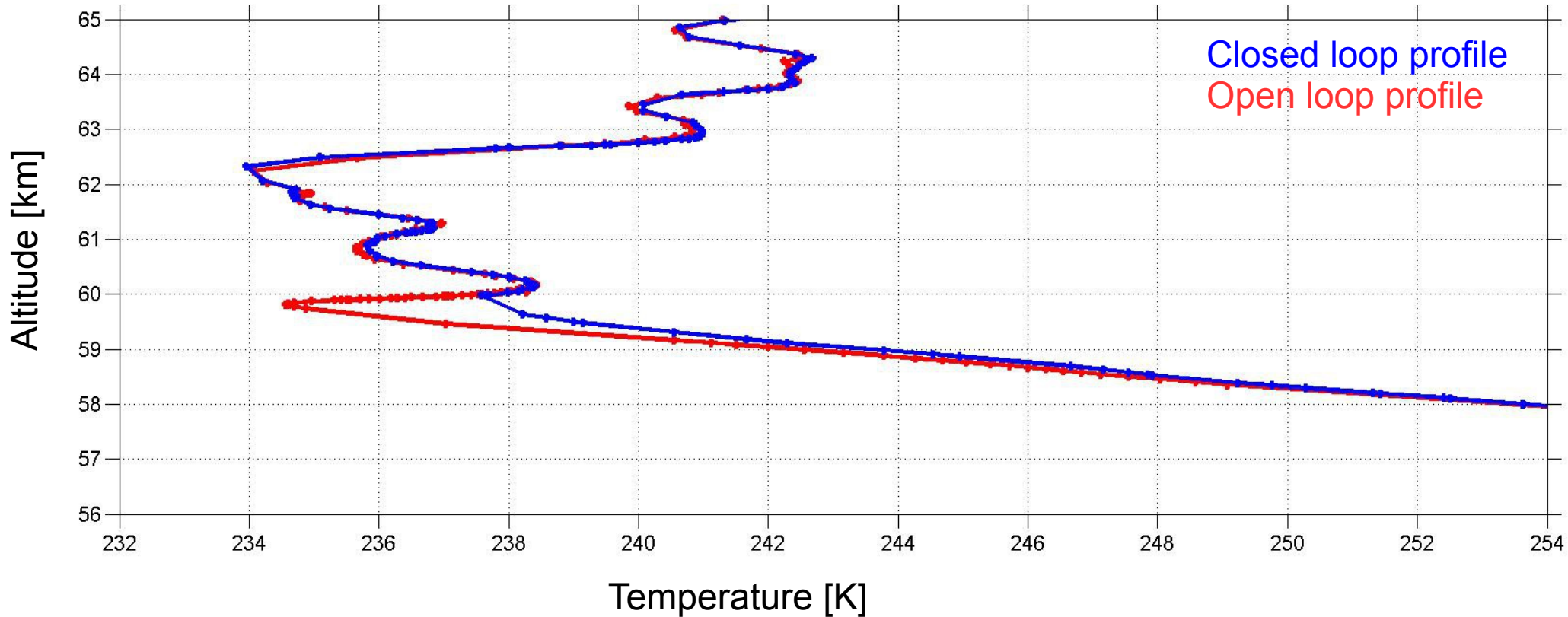


When and where does multipath occur?

- Database: Occultation Season 1/2006:
34 occultations
- Multipath in 18 datasets
- Altitude range of the inversion layer from 58km up to 64km

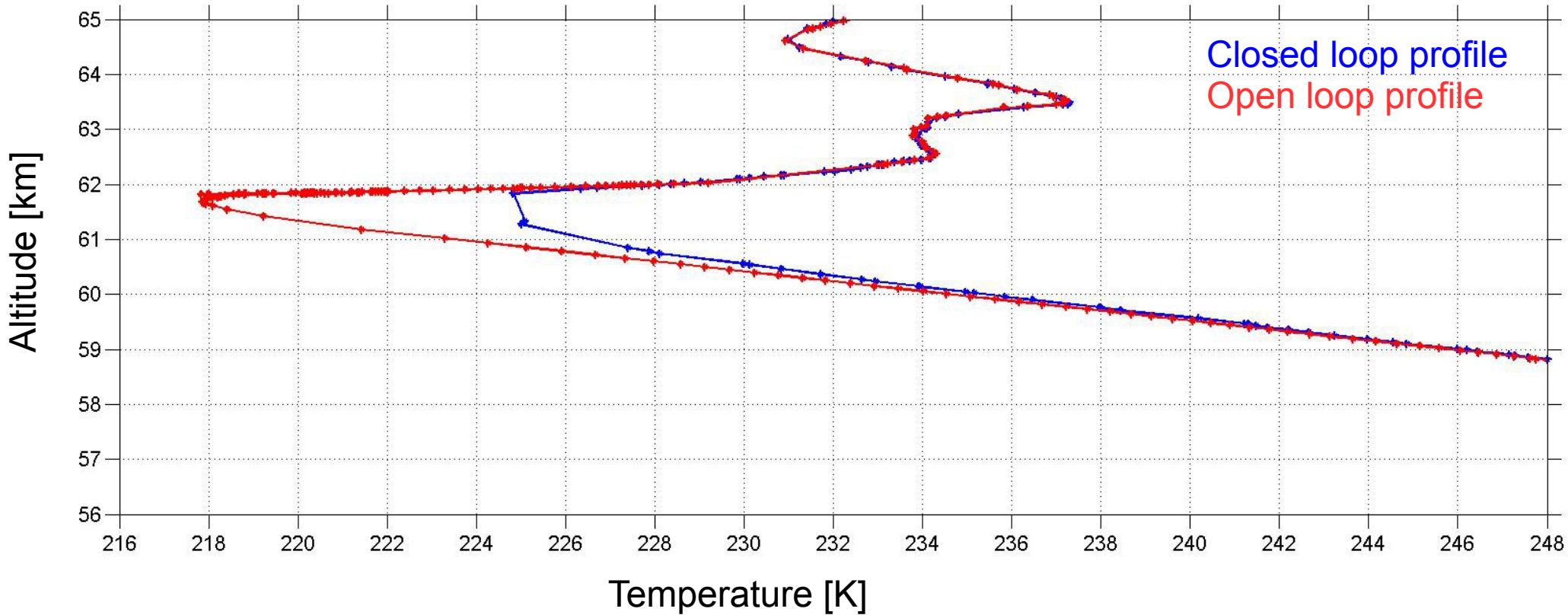
Comparison open loop to closed loop

DoY 218 2006 Ingress



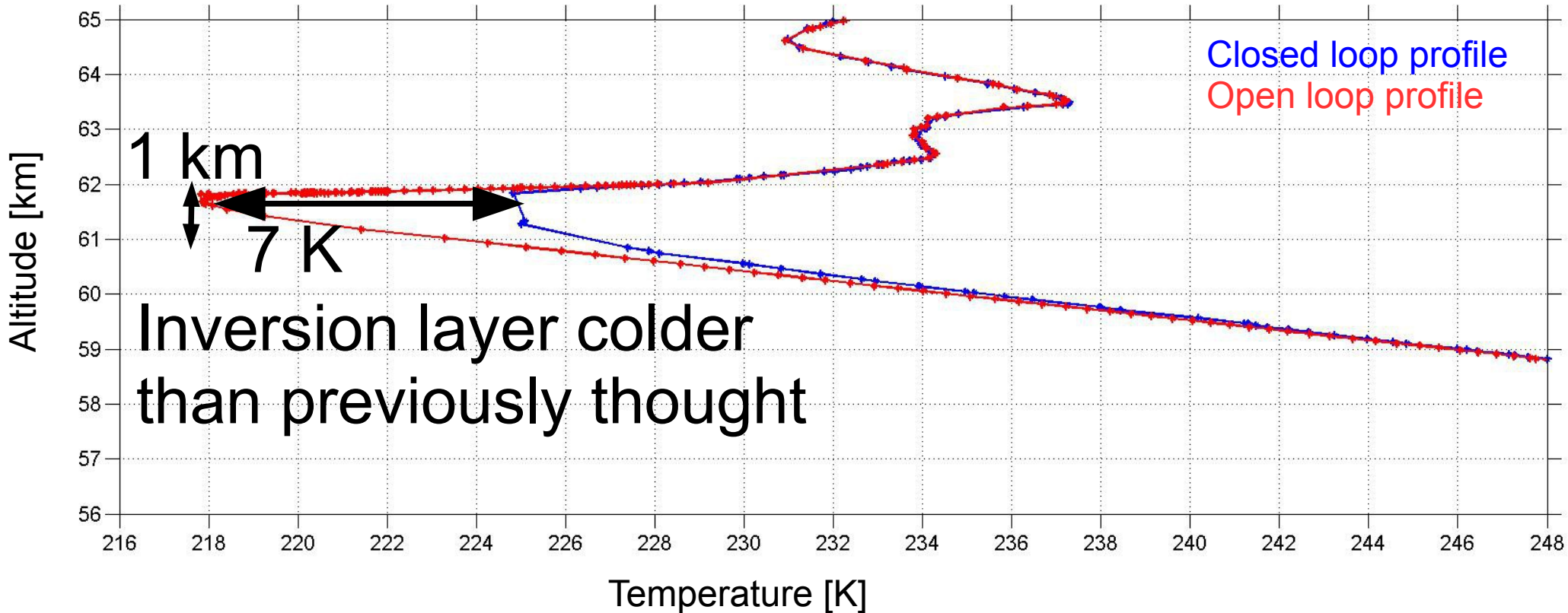
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DoY 212 2006 Ingress

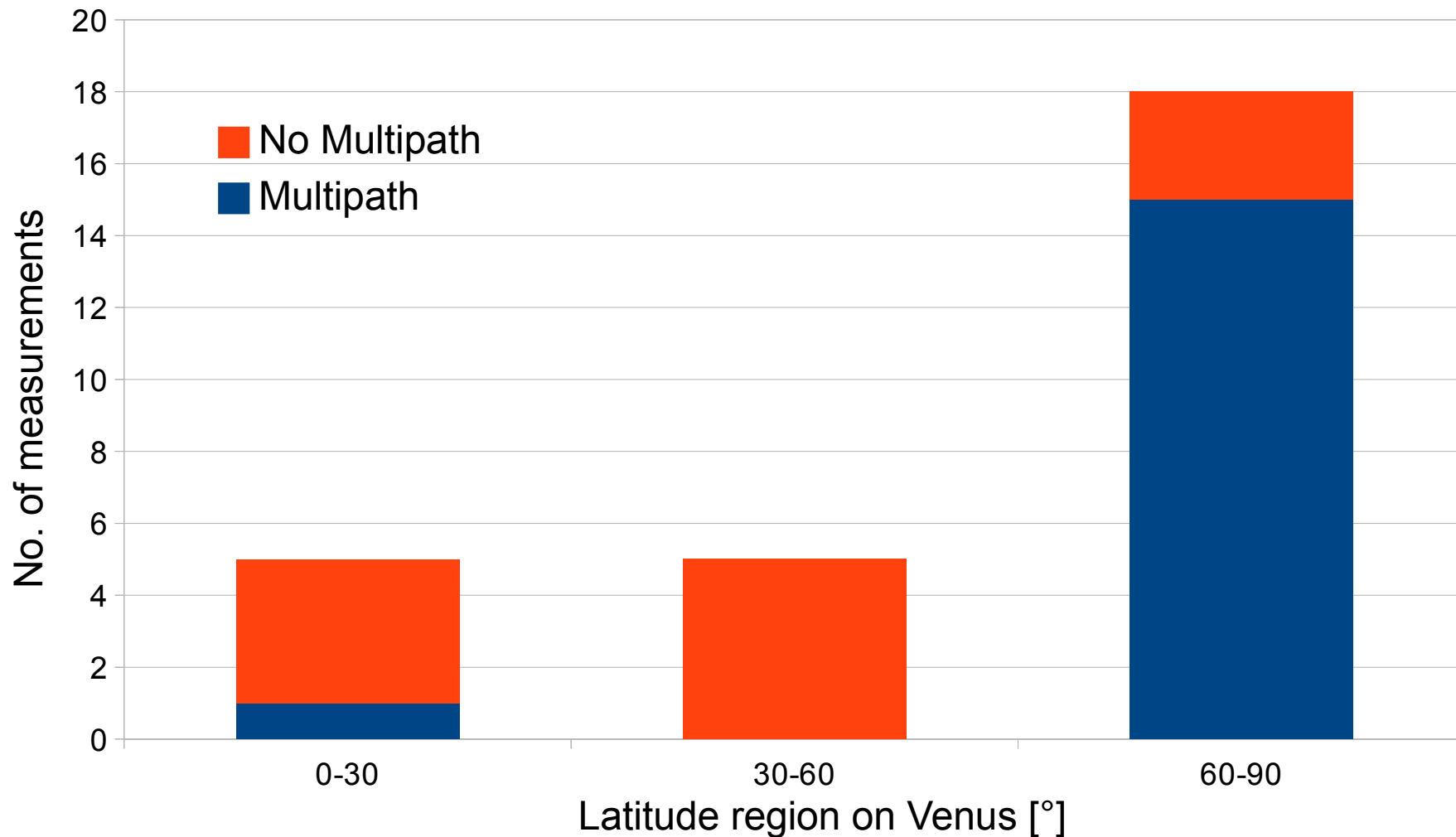


Comparison open loop to closed loop

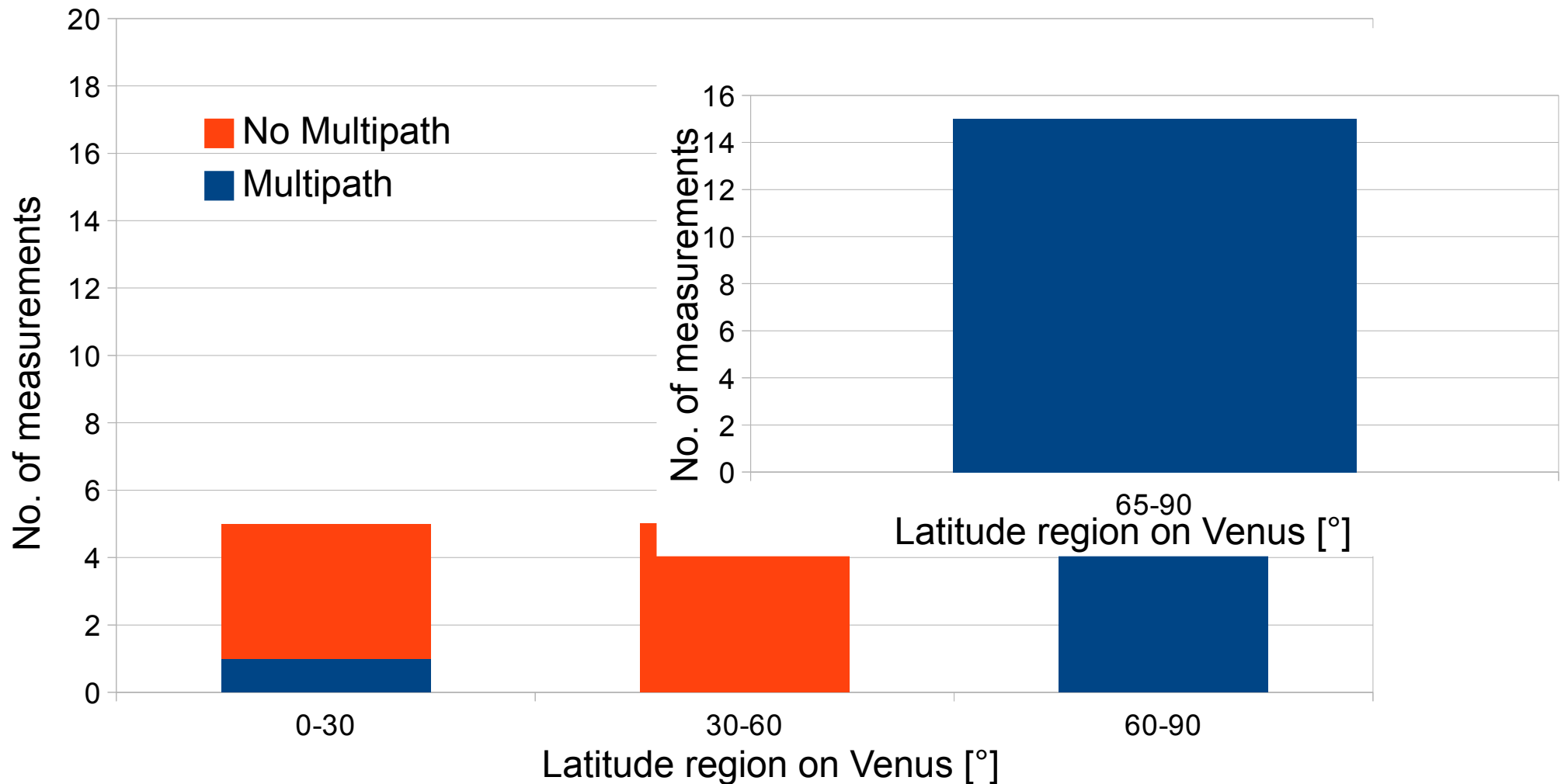
DoY 212 2006 Ingress



Local distribution of Multipath Effects



Local distribution of Multipath Effects



Conclusion

- Multipath effects are a very common phenomena in Venus' atmosphere above 65°
- leads to an underestimation of the inversion layer of about ten Kelvin

Outlook

- Open loop data will be analysed for more occultation seasons
- Interpretation of the meaning for the wave structures ongoing
- Small scale resolution in this altitude only possible with radio science observations

Thank you!