Multi-frequency and multi-volume radar studies of the equatorial 150-km region

J. L. Chau[1], M. A. Milla[2], and E. Kudeki[2]

[1]Radio Observatorio de Jicamarca, Instituto Geofísico del Perú, Lima

[2]Electrical and Computer Engineering, University of Illinois, Urbana-Champaign, IL, USA

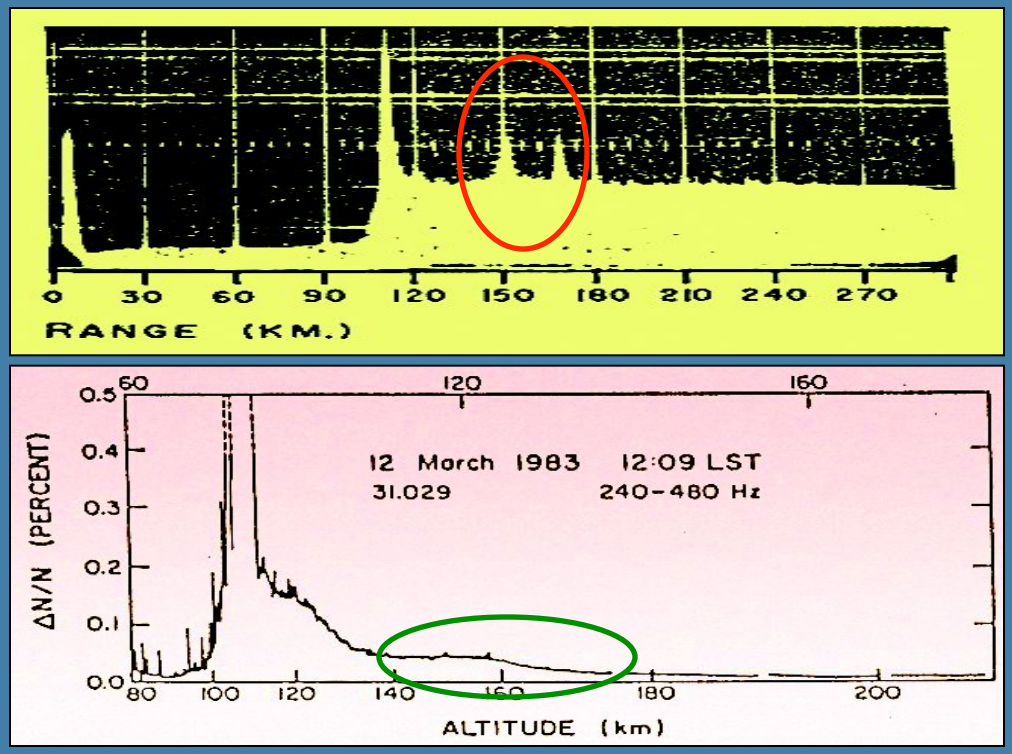
MST12, London, Canada – May 23, 2009

Outline

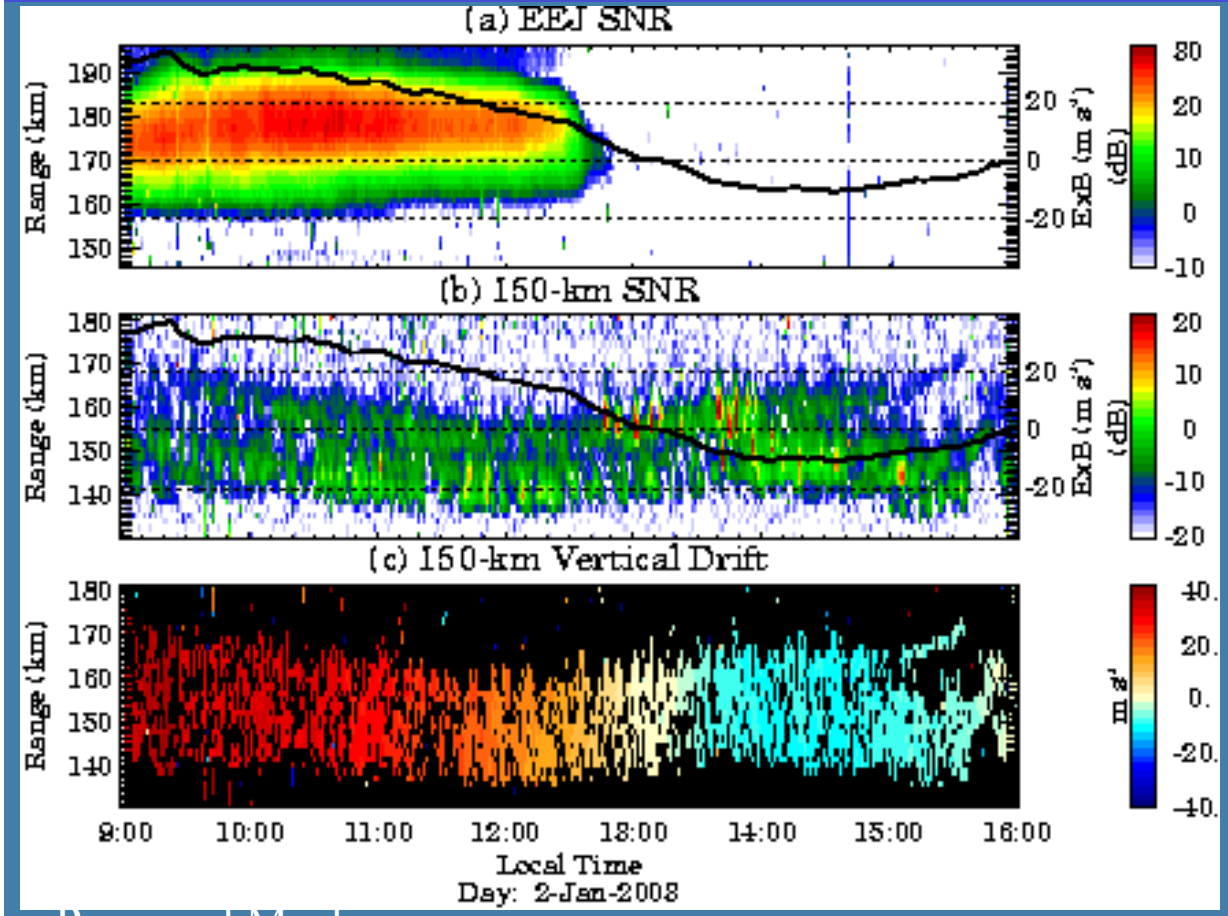
- Introduction: A “radar” puzzle?
- What do we know from previous Jicamarca measurements?
  - Perpendicular observations
  - Off-perpendicular observations
- New observations
  - Density profiles from Faraday experiments
  - Multi-frequency results

First detection

- Jicamarca Observations
  - Balsley [1964]
- Rocket Observations
  - Thumba, India [*Prakash et al.,* 1969]
  - Punta Lobos, Peru [*Smith and Royrvik*, 1985]
- A radar puzzle?



Perpendicular to B main features



Main features

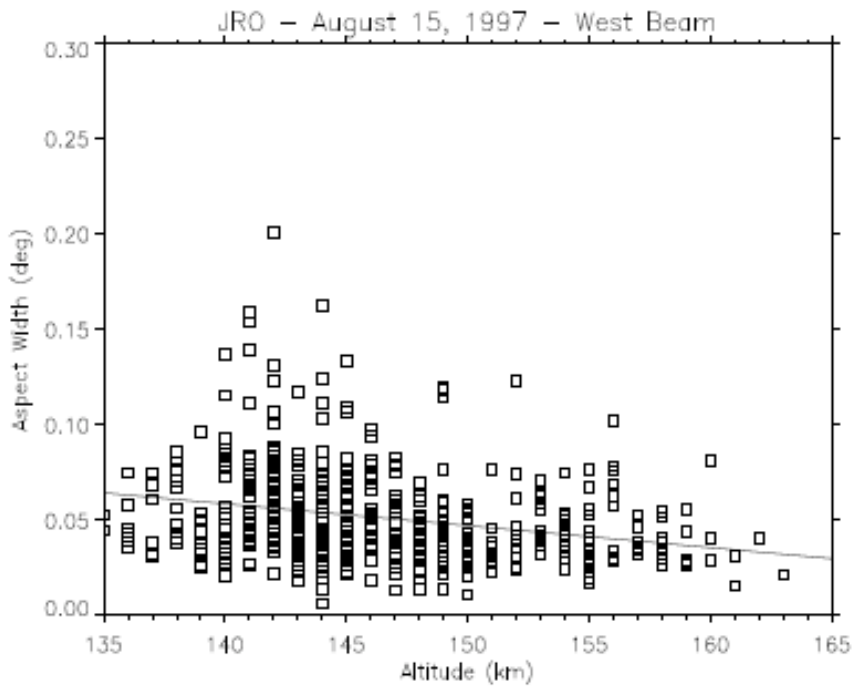
- Daytime phenomena
- Occur between 130-180 km
- Necklace shape
- Come from field-aligned irregularities (?)
- Observed at different longitudes and within "few" degrees away Mag. Equator
- At Jicamarca they are observed all seasons
- Vz ~ vertical F-region ExB.

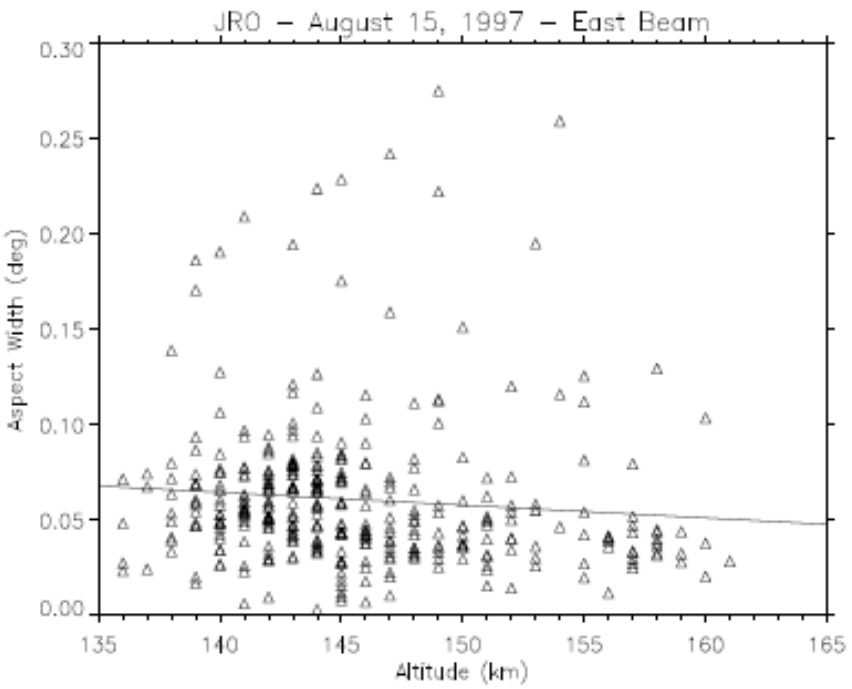
Proposed Mechanisms

- Gravity wave wind driven interchange instability [*Kudeki and Fawcett*, 1993
- Low-latitude Es layer instability providing free energy for the growth of interchange instability at equatorial 150-km [*Tsunoda and Ecklund*, 2004]

[from *Kudeki and Fawcett*., 1993 and *Fawcett*, 1999]

150-km Aspect Sensitivity

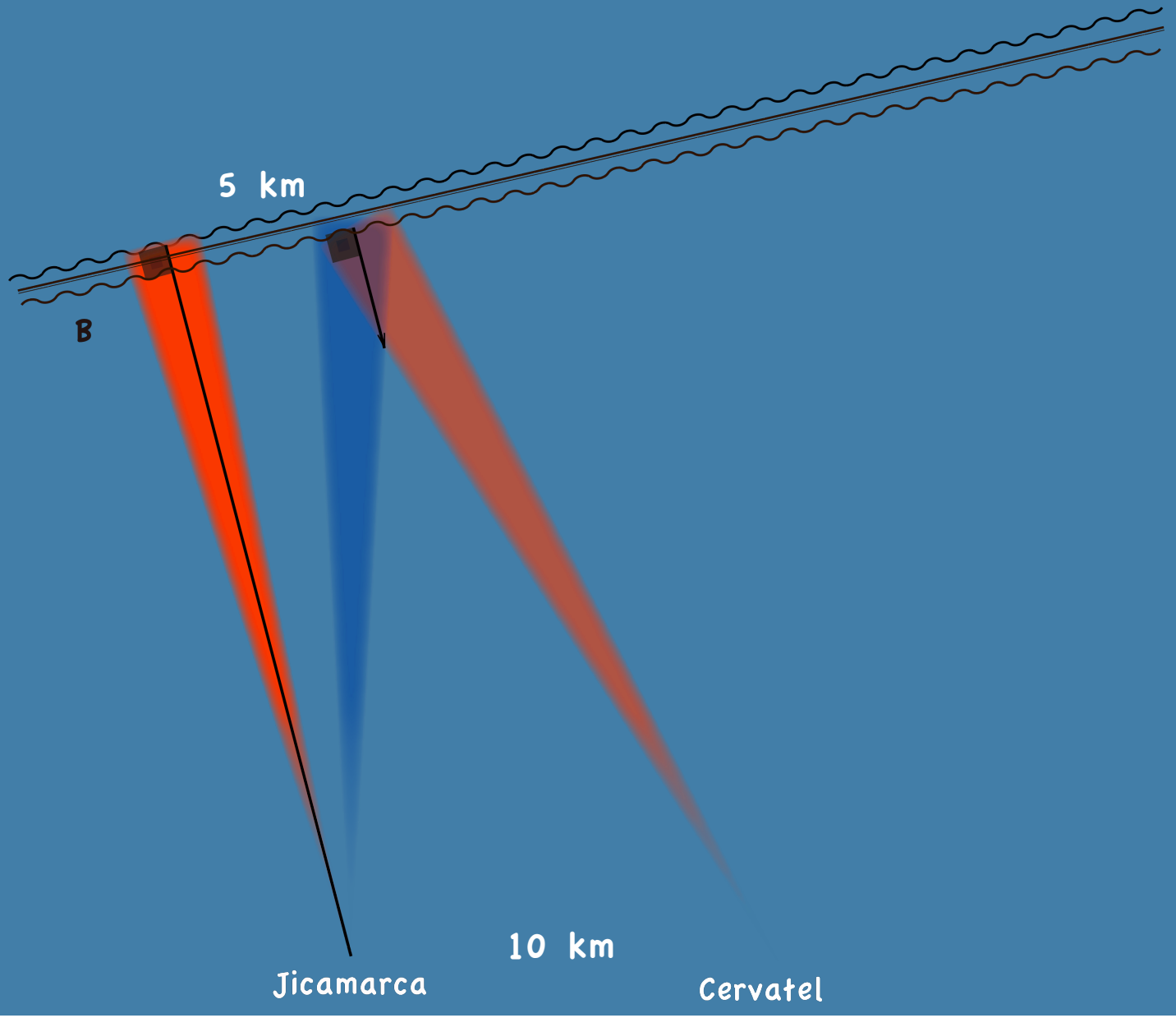




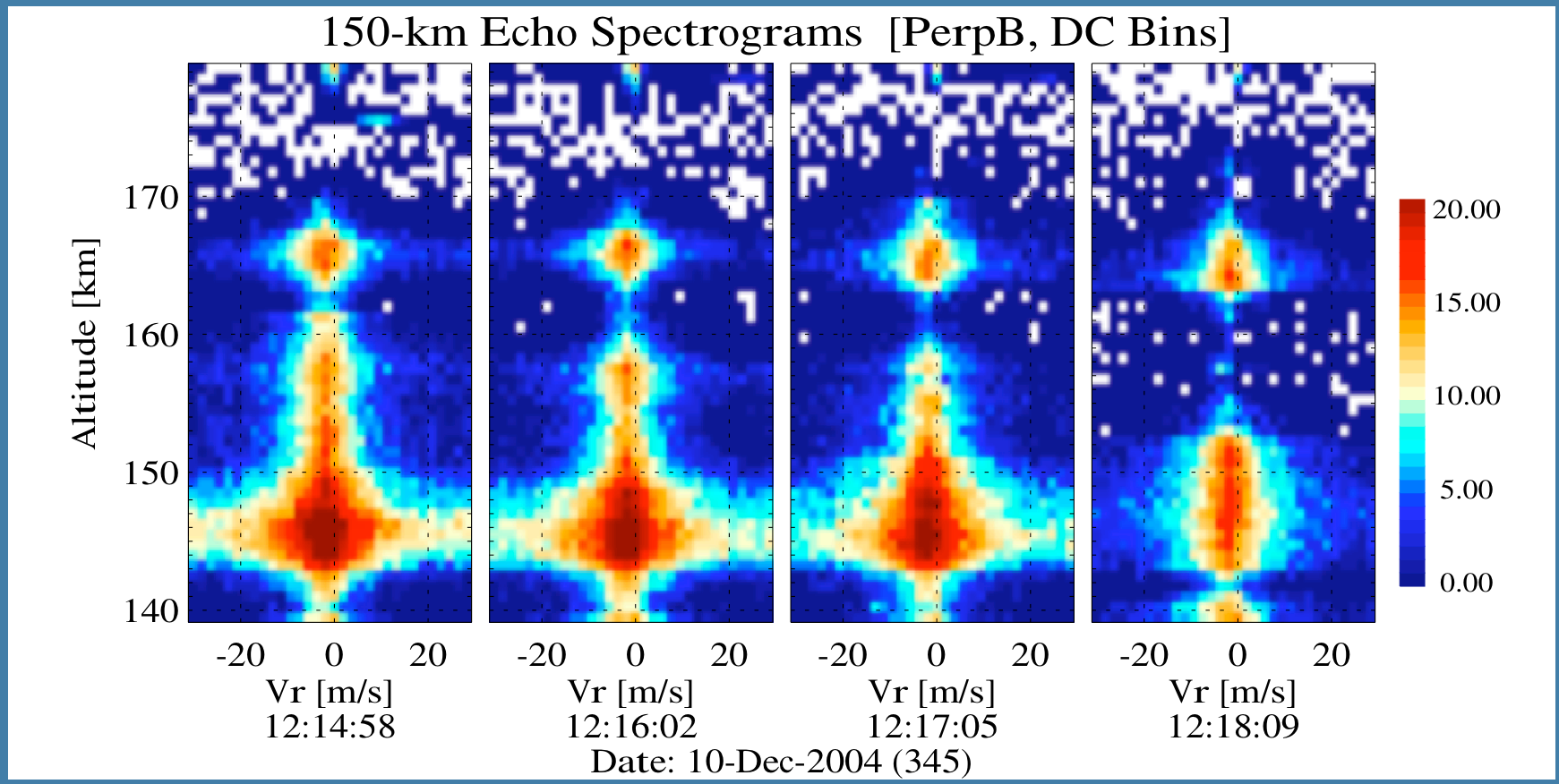
"We conclude that aspect widths of the 150-km echoes are smaller than those of the electrojet and that the central tendency of 0.05° presented above can be considered an upper bound of the aspect width of the 150-km echoes."

[from *Fawcett*, 1999, Ph.D. Thesis]

150-km Experiments: Oblique vs. Perpendicular

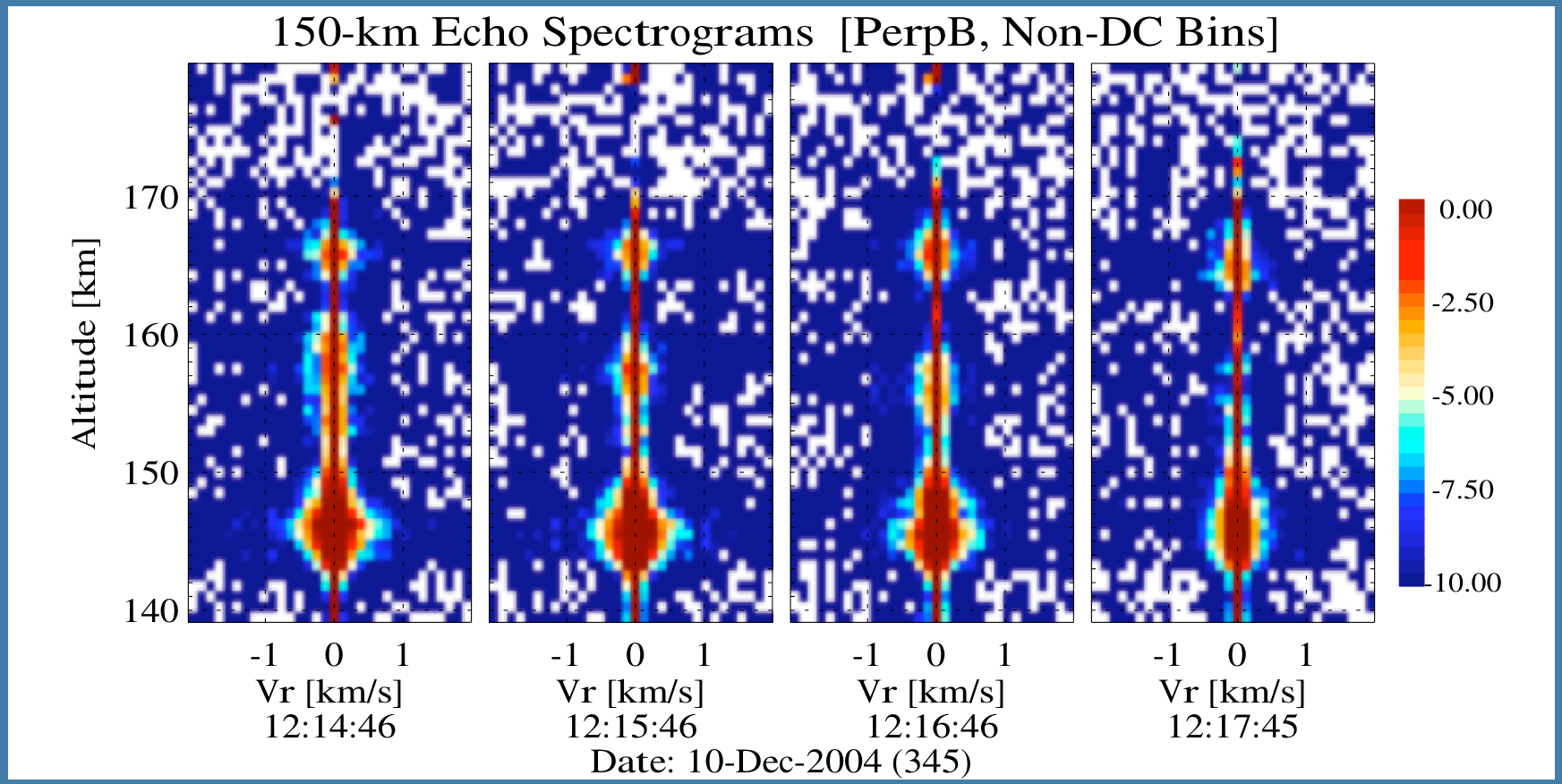


Perpendicular Spectrograms after coherent integrations



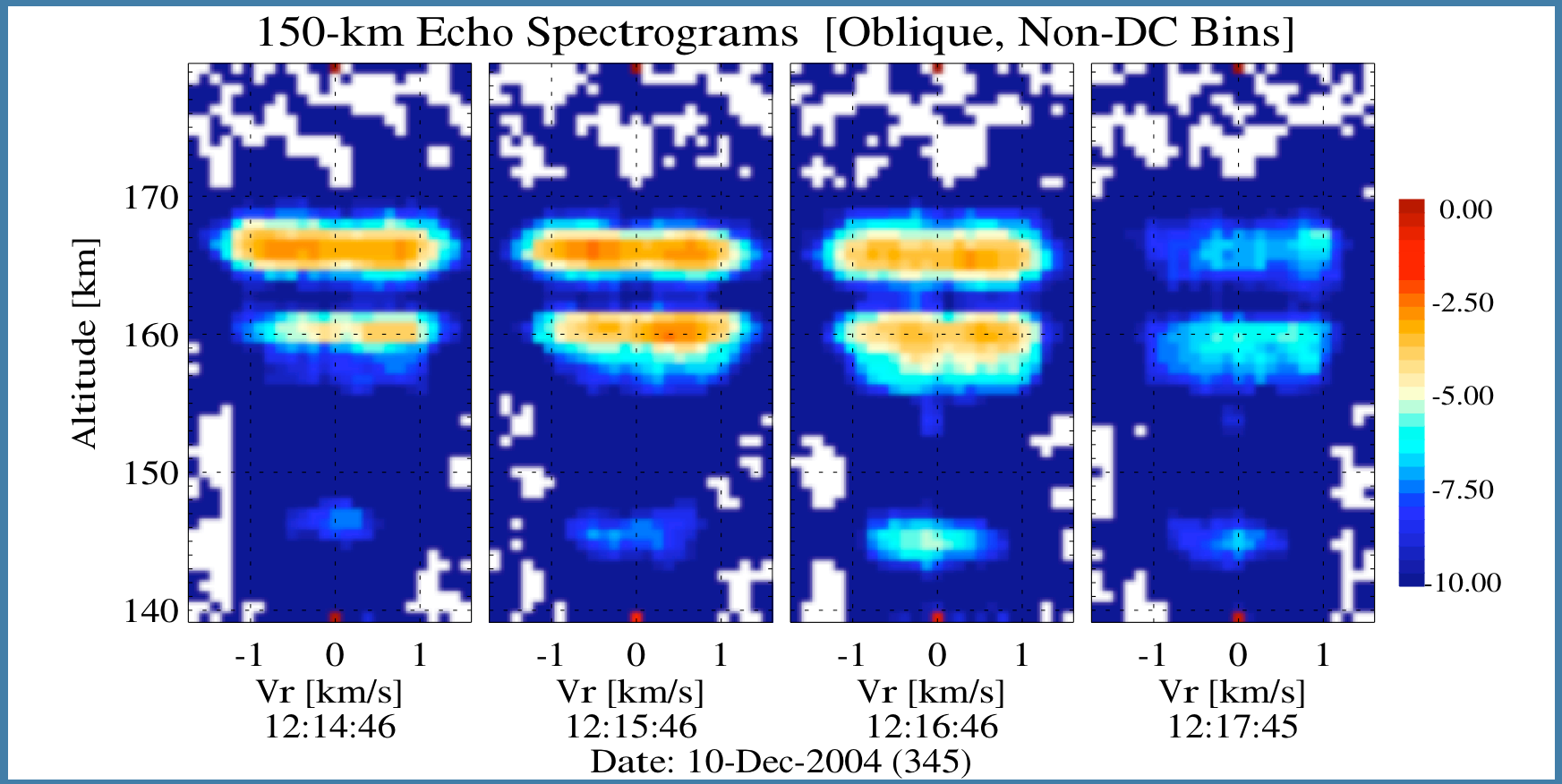
[from *Chau et al.*, 2009]

Perpendicular Spectrograms without coherent integrations



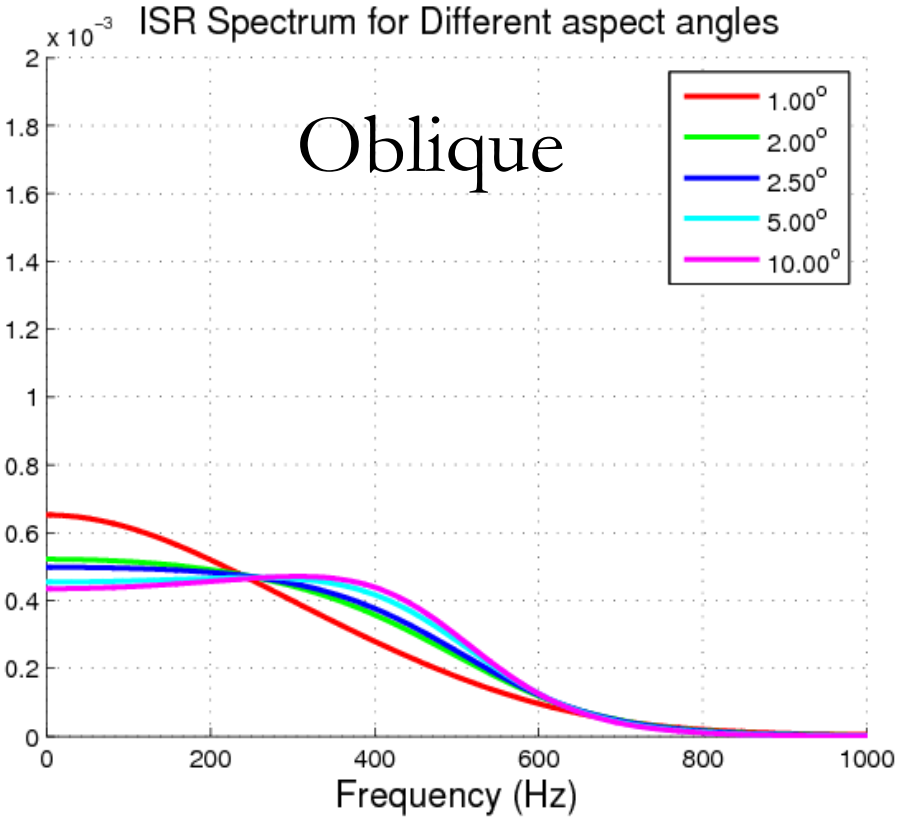
[from *Chau et al.*, 2009]

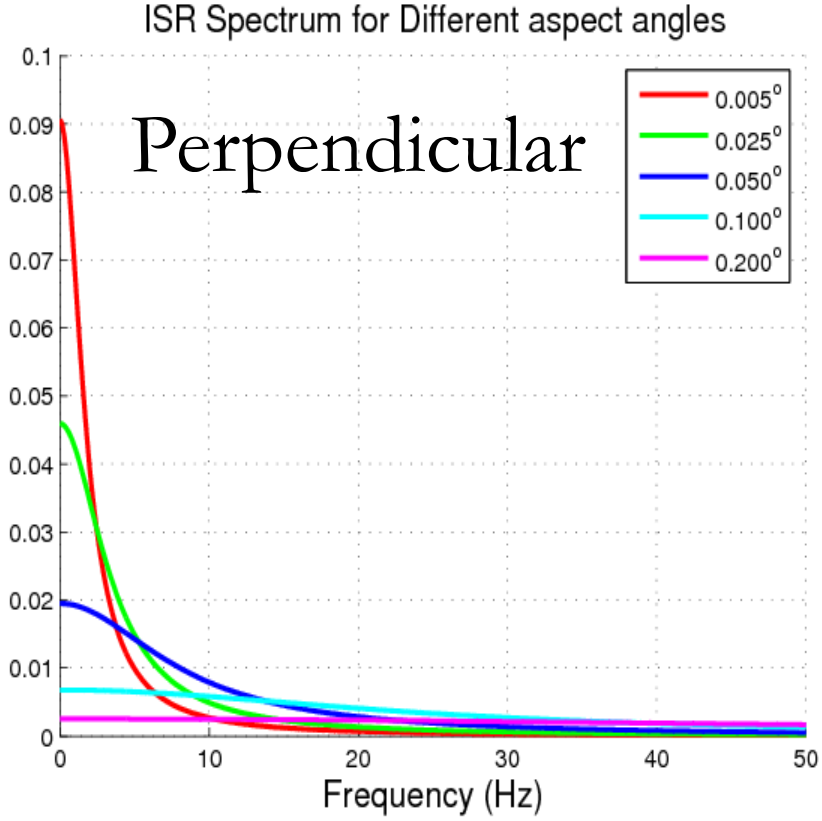
Oblique spectrogram



[from *Chau et al.*, 2009]

Incoherent Scatter Spectra

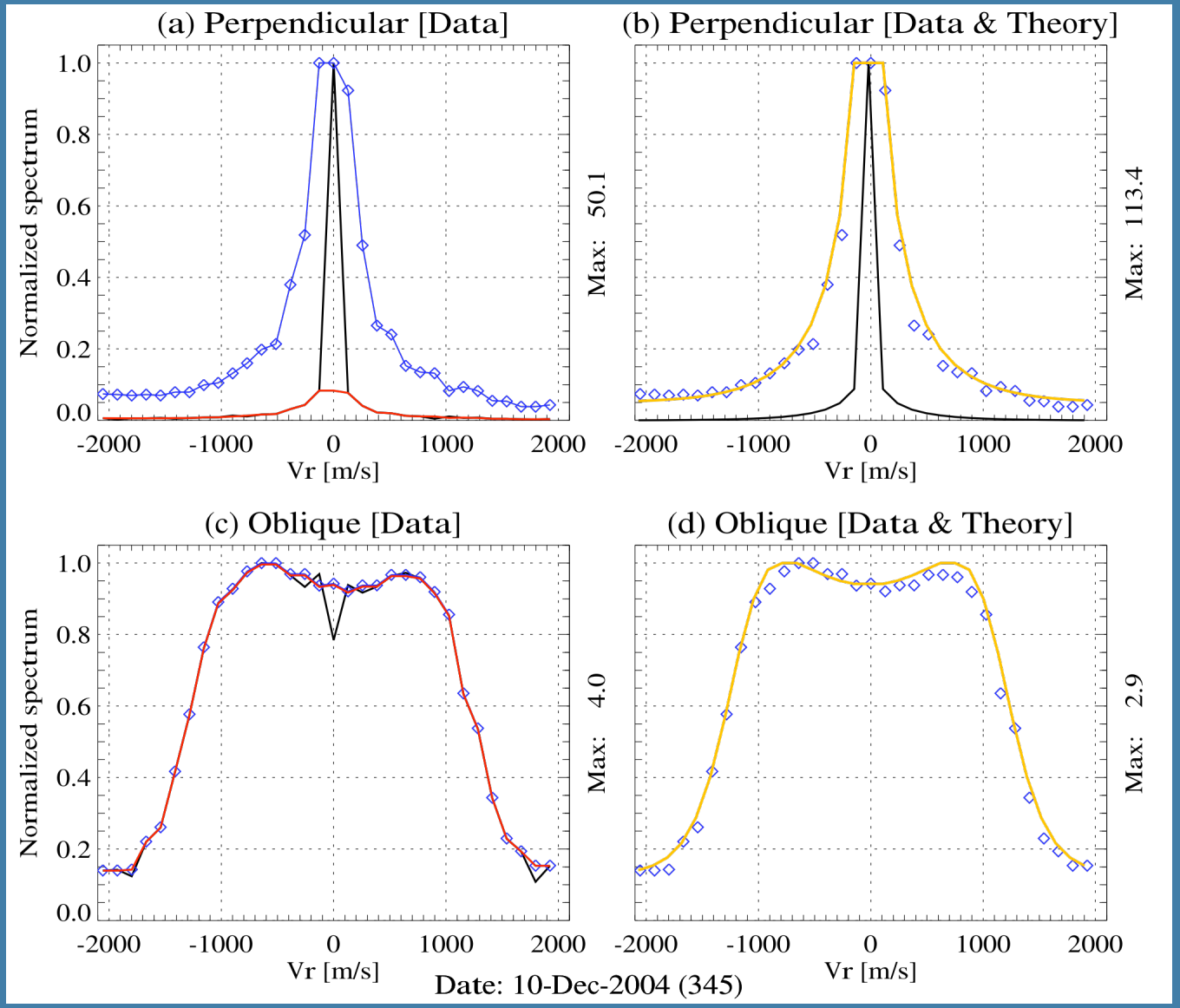




- Spectra are wide (>1000 m/s or 300 Hz at 50 MHz) and independent of α within typical antenna beam widths.

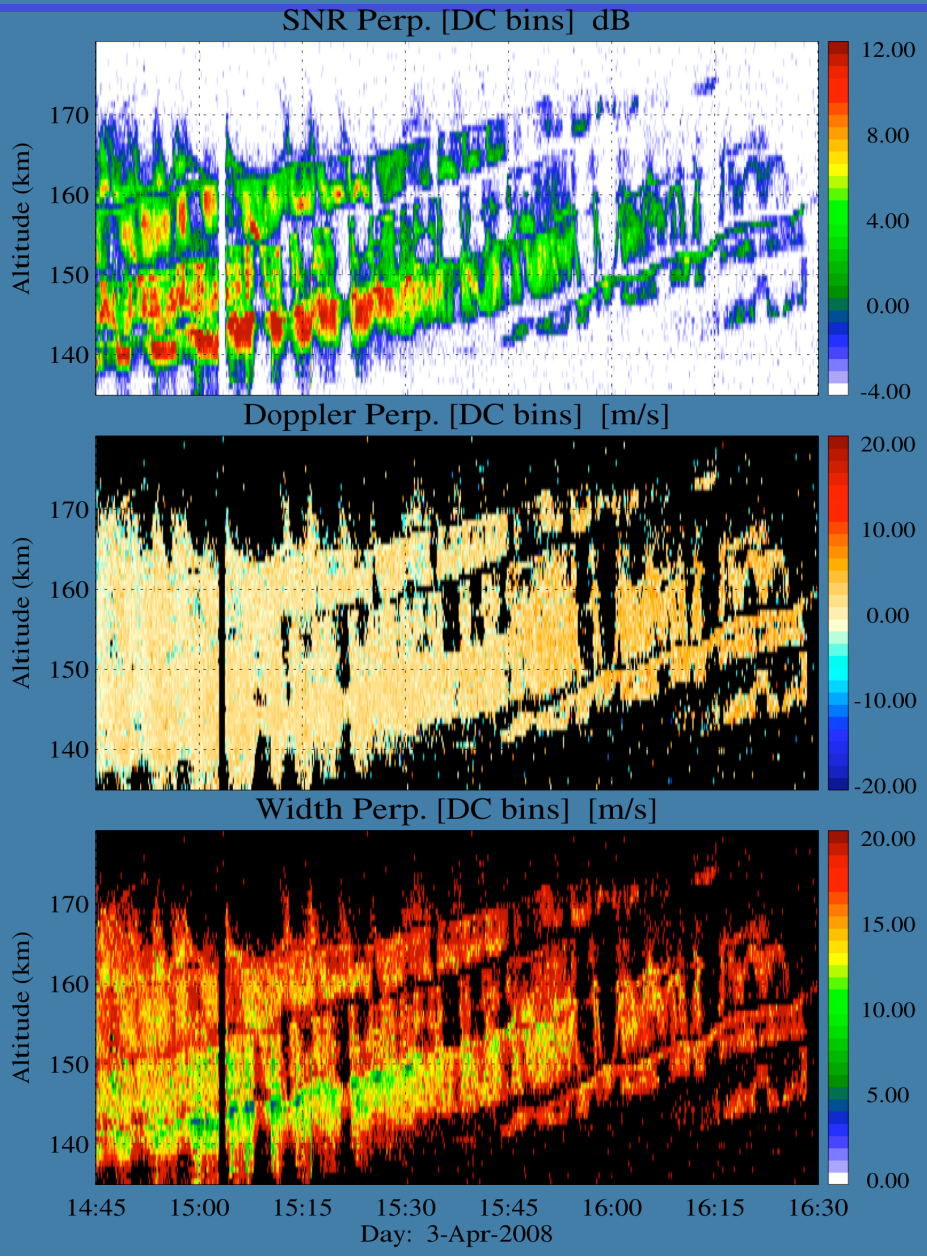
- Spectra get narrower (less than 150 m/s) for smaller α and change very quickly.
- Measured spectra results from a convolution of spectra with different widths due to finite antenna beam width.

150-km Spectra: Oblique vs. Perpendicular



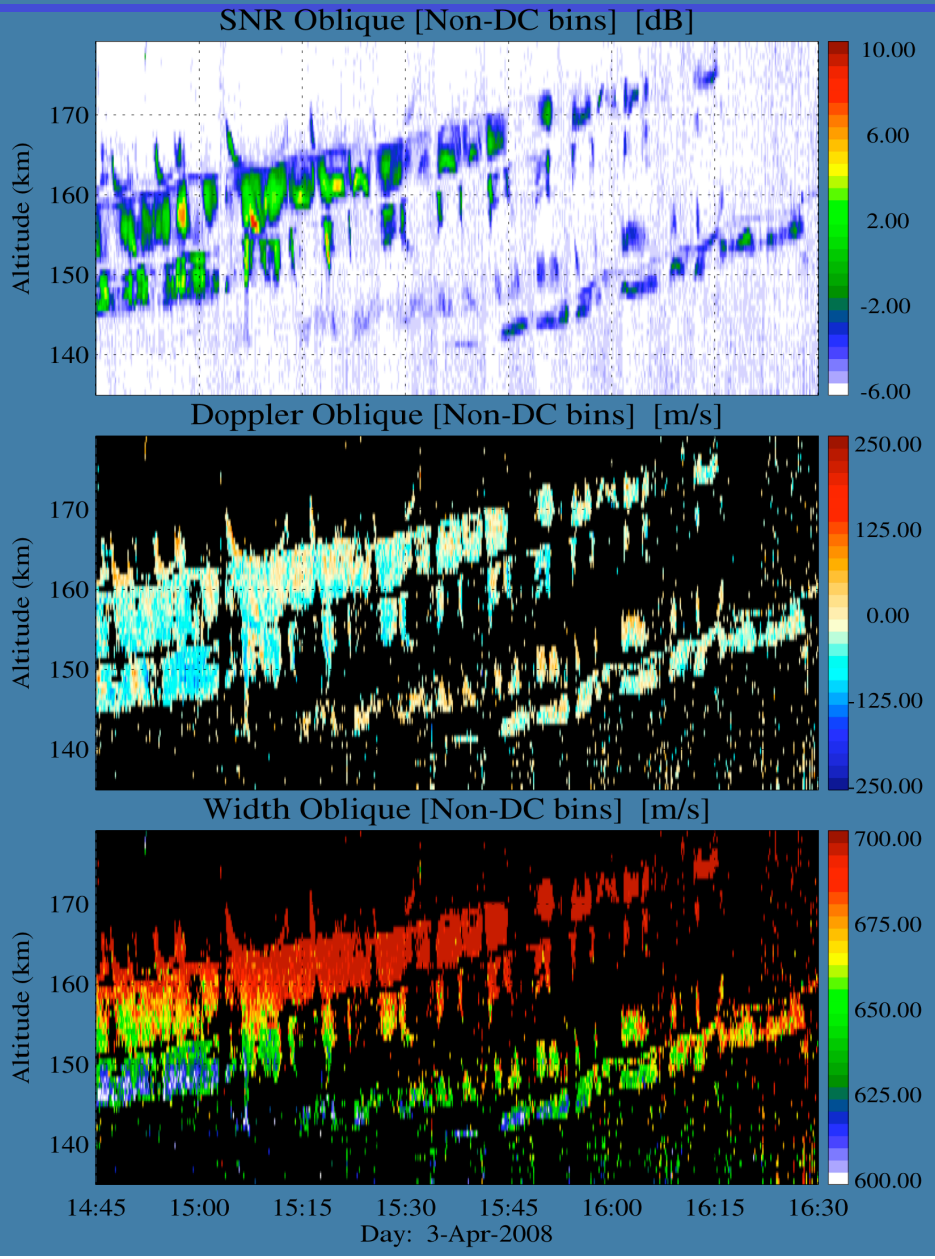
[from *Chau et al.*, 2009]

150-km Perpendicular Parameters



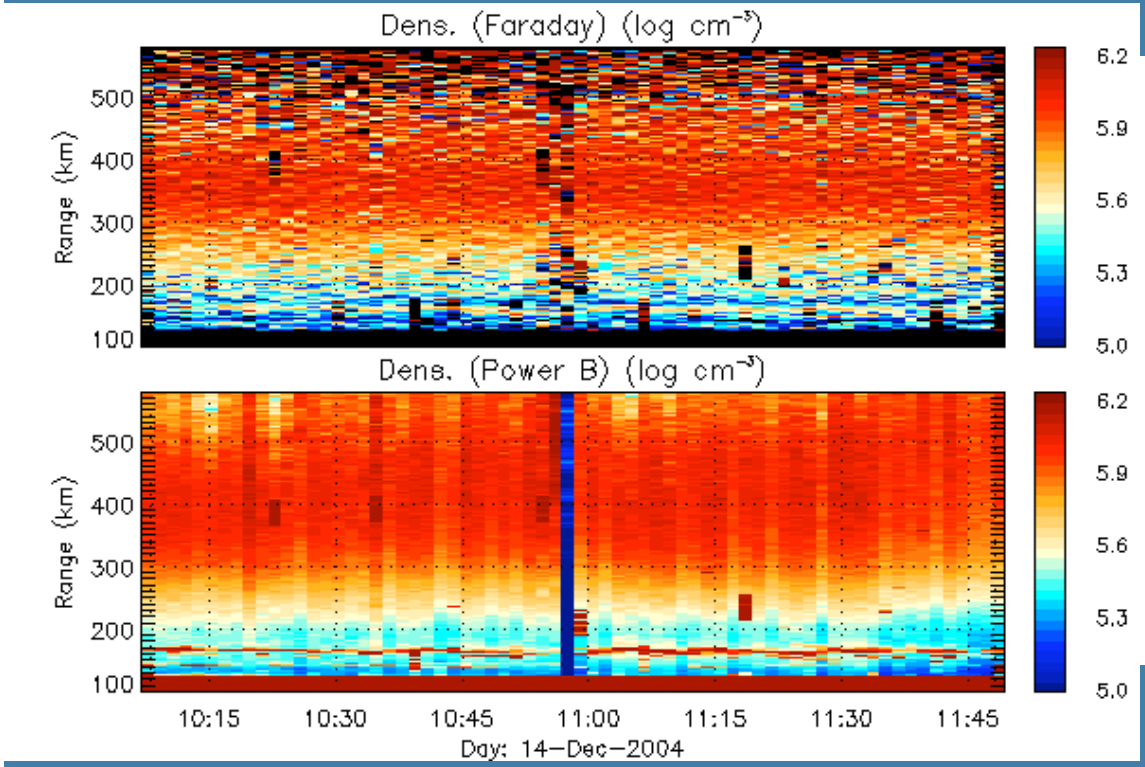
[from *Chau et al.*, 2009]

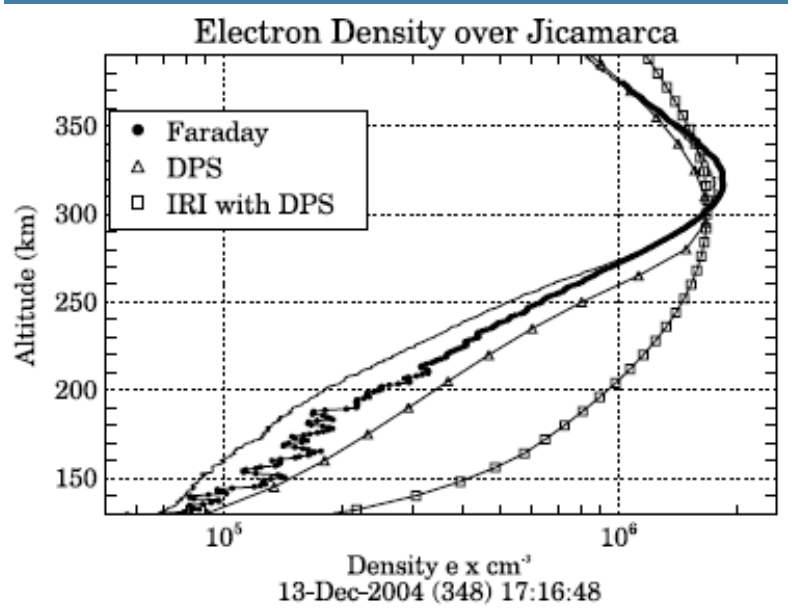
150-km Oblique Parameters



[from *Chau et al.*, 2009]

Faraday Density Experiments (1)

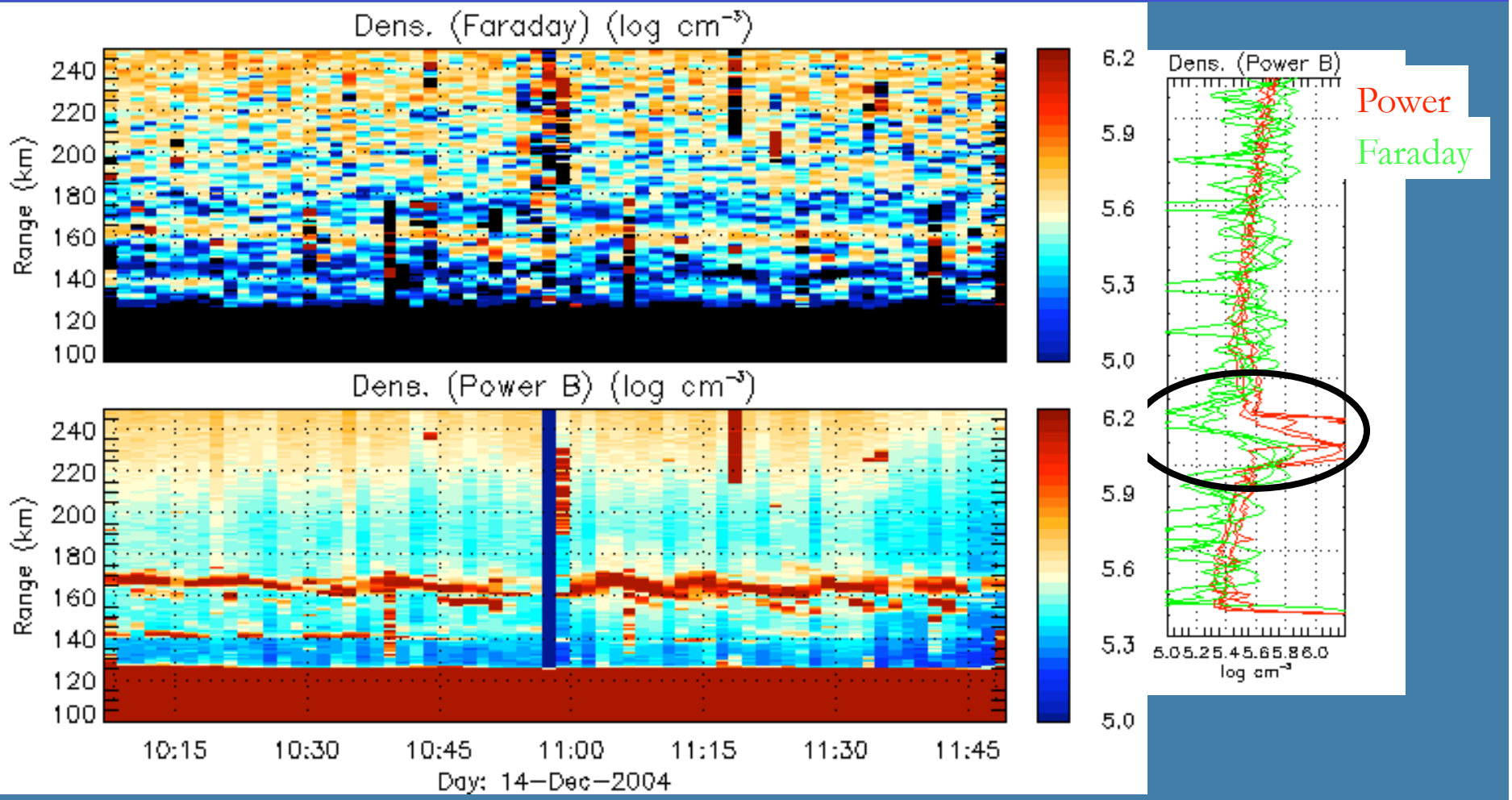




[from *Chau and Woodman.*, 2005]

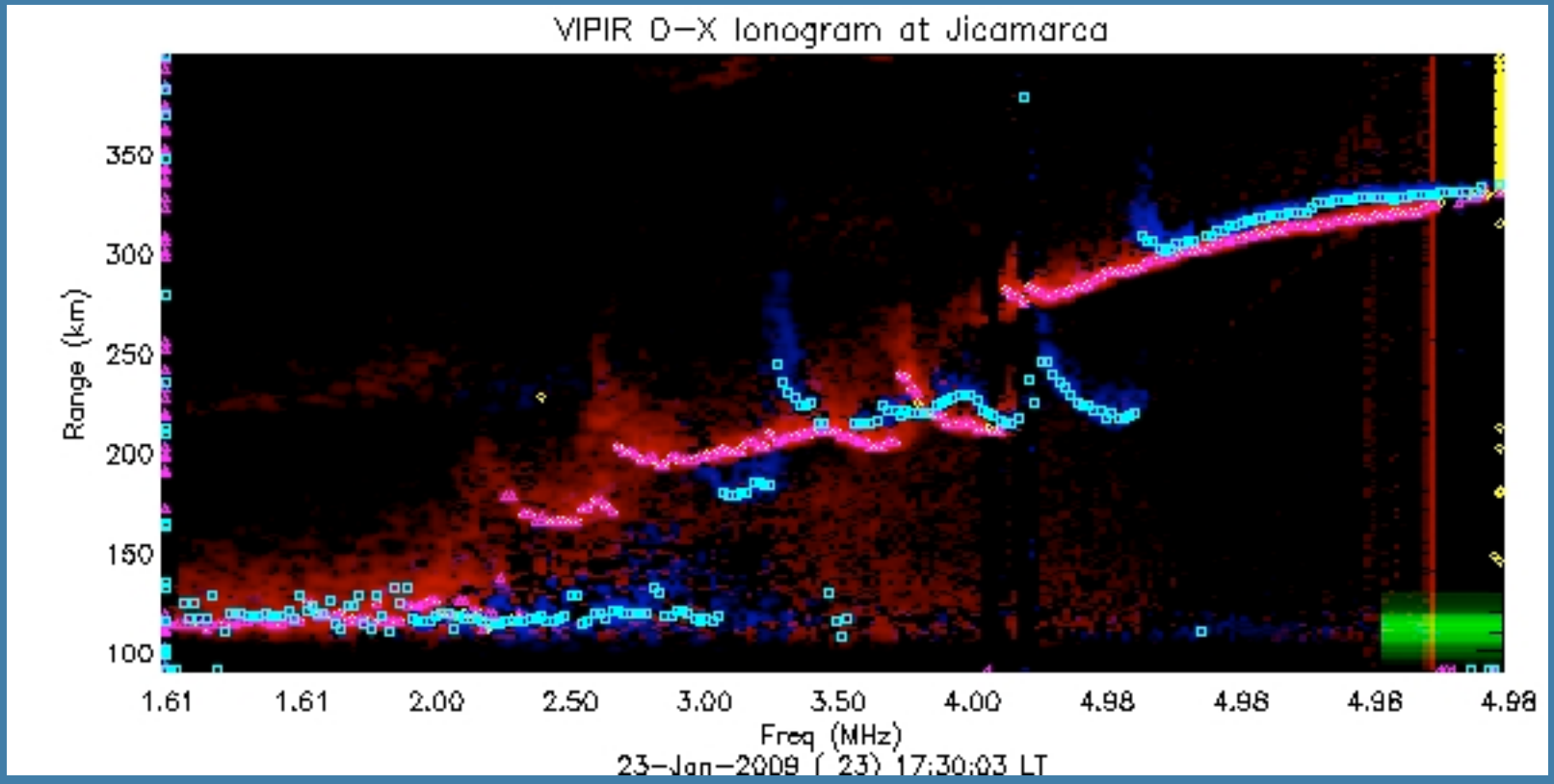
For Incoherent scatter, Power is proportional to N

Faraday density experiments (2)

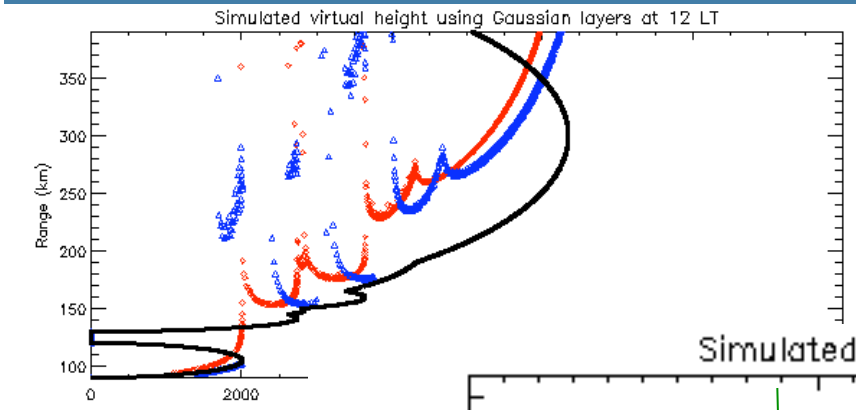


150-km echoes appear to correlate with density depletions/enhancements below or above.

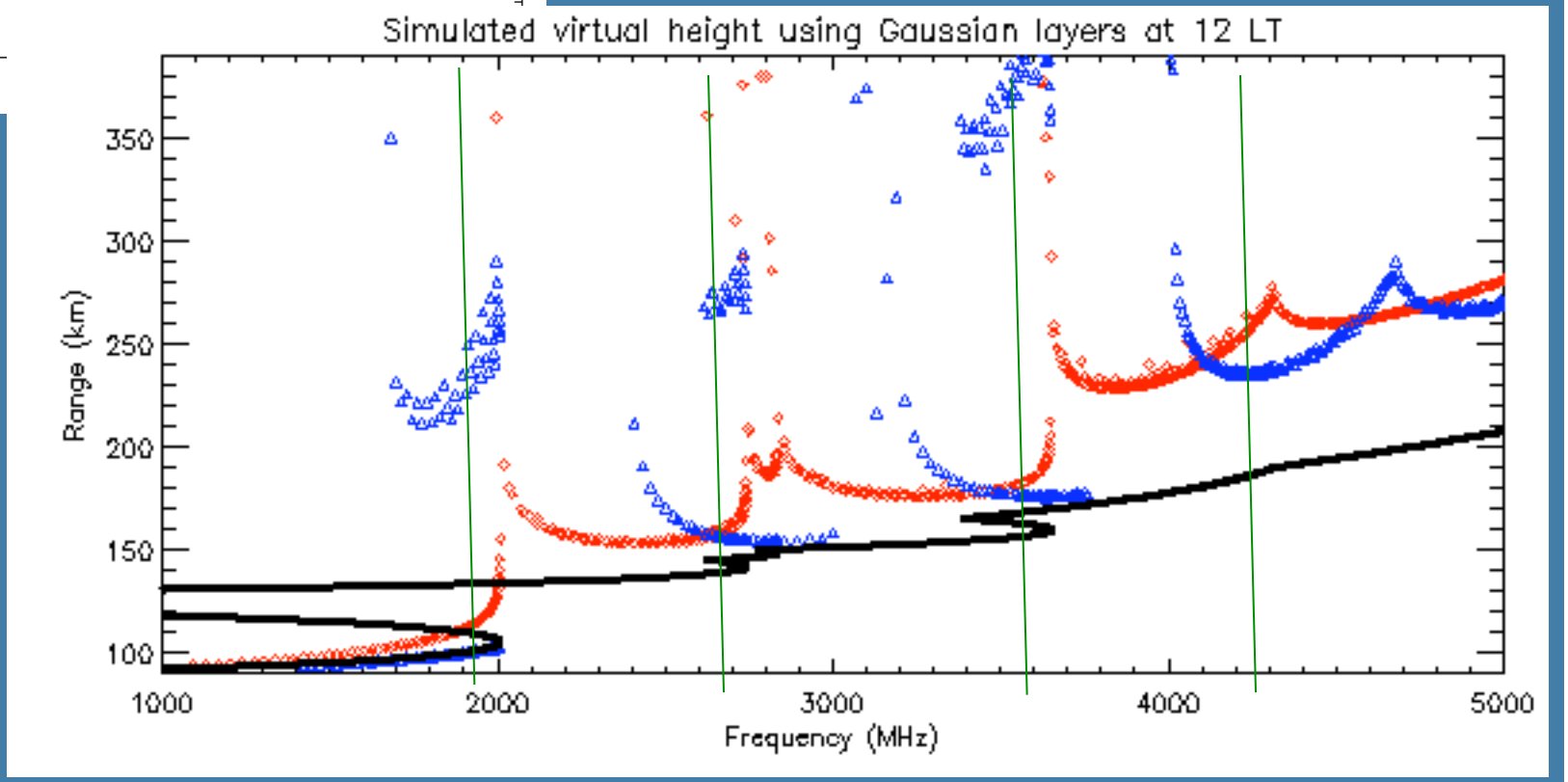
Digital Ionograms (VIPIR)



VIPIR Simulated profiles

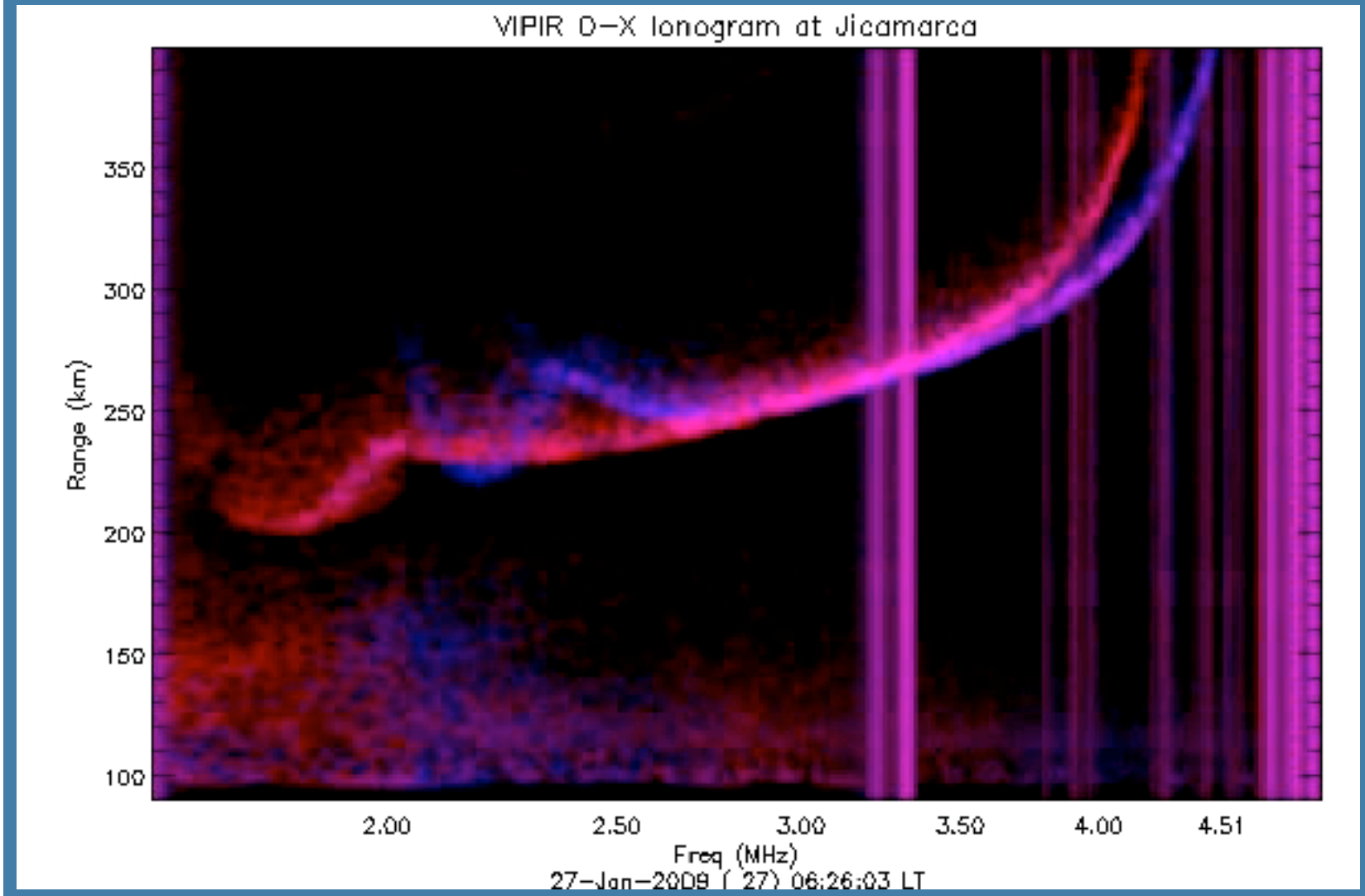


$$f \propto \sqrt{N}$$



140-170 km => virtual heights of 160-210 km

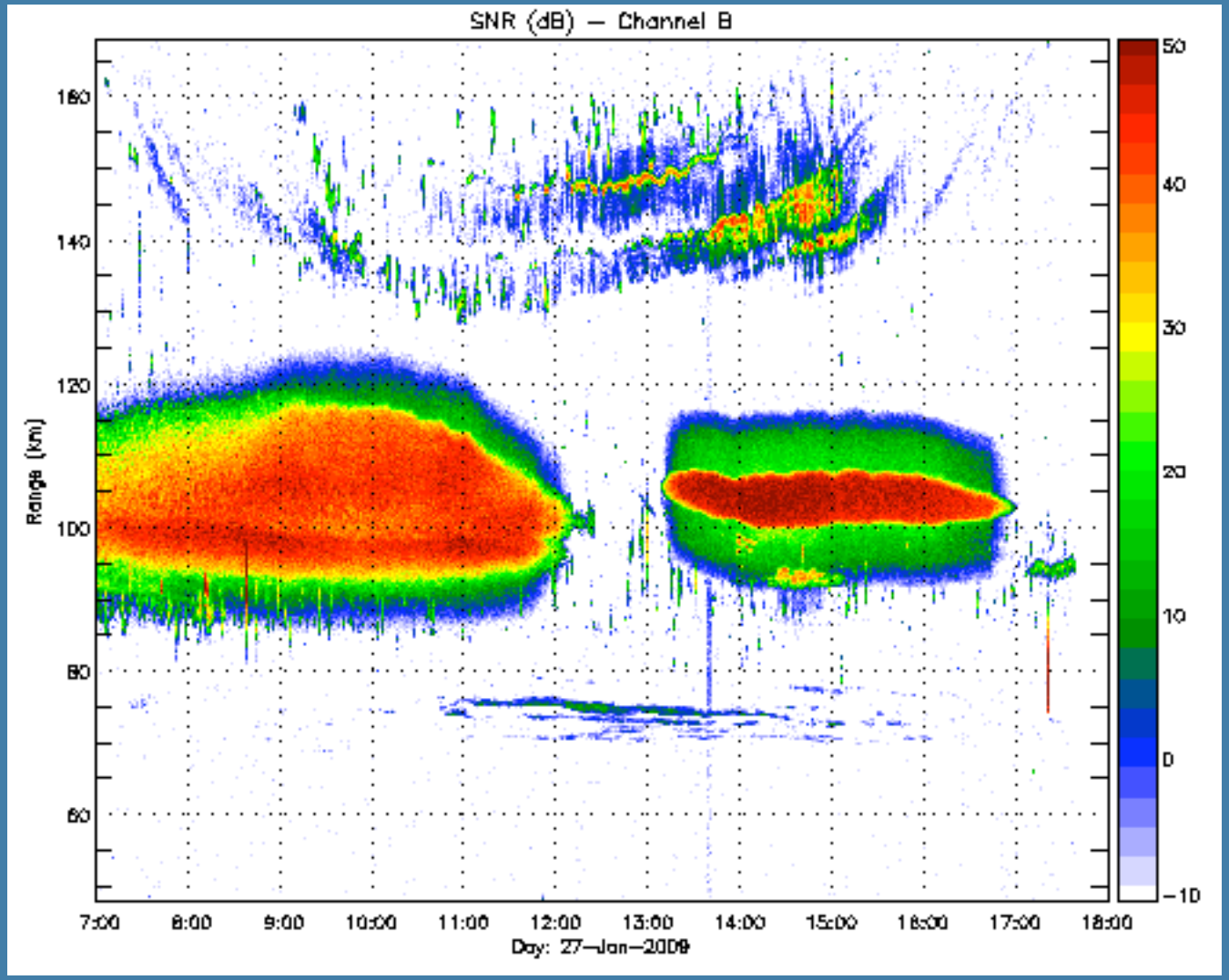
VIPIR Ionograms: Every 2 minutes



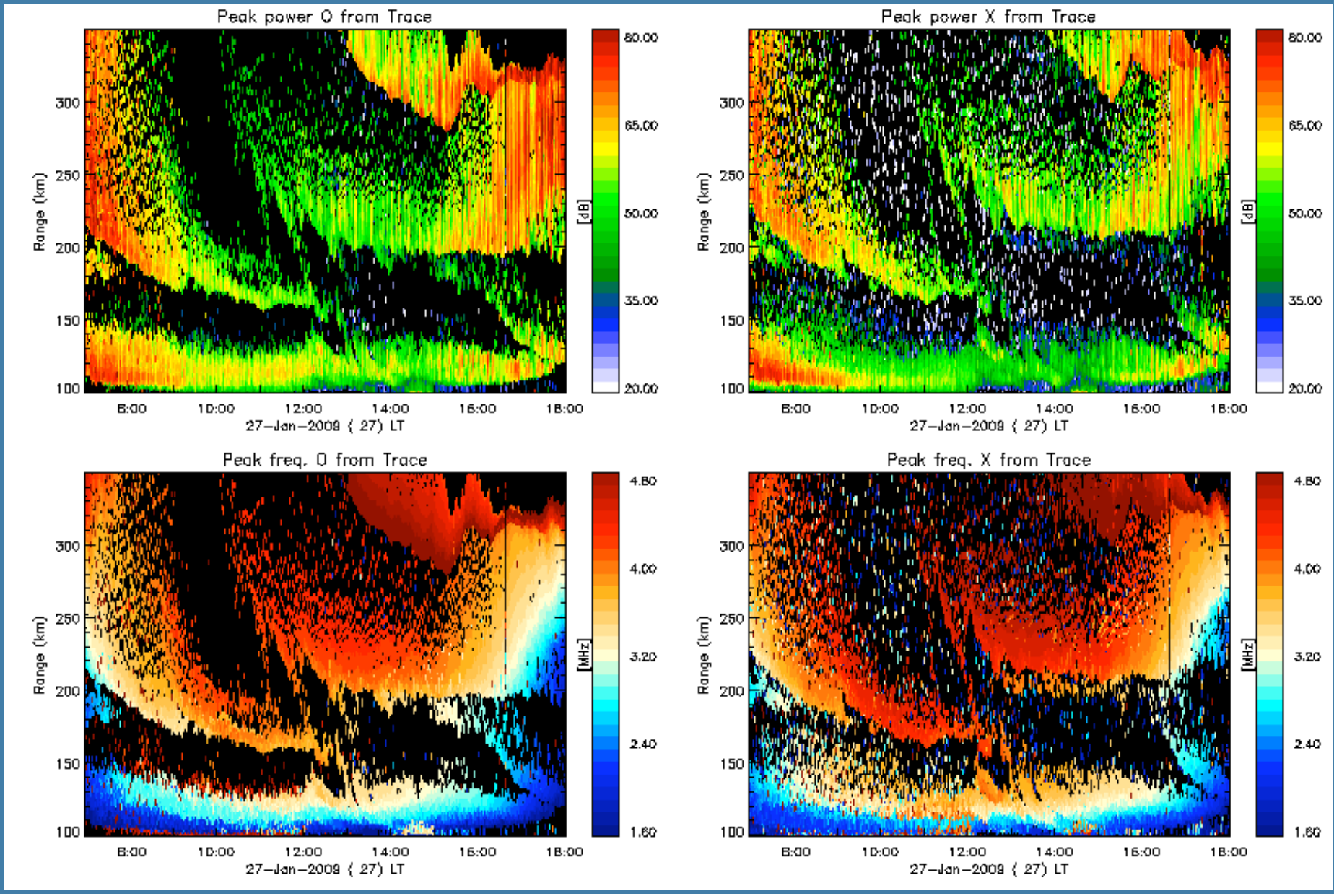
170 km

140 km

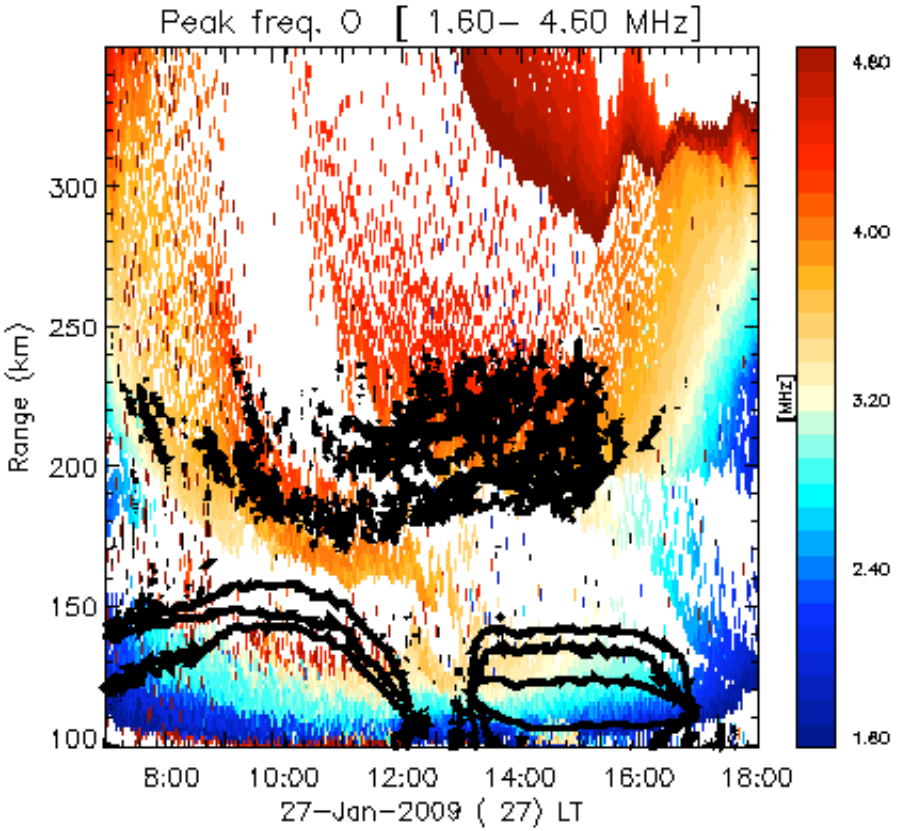
150-km observations at 50 MHz

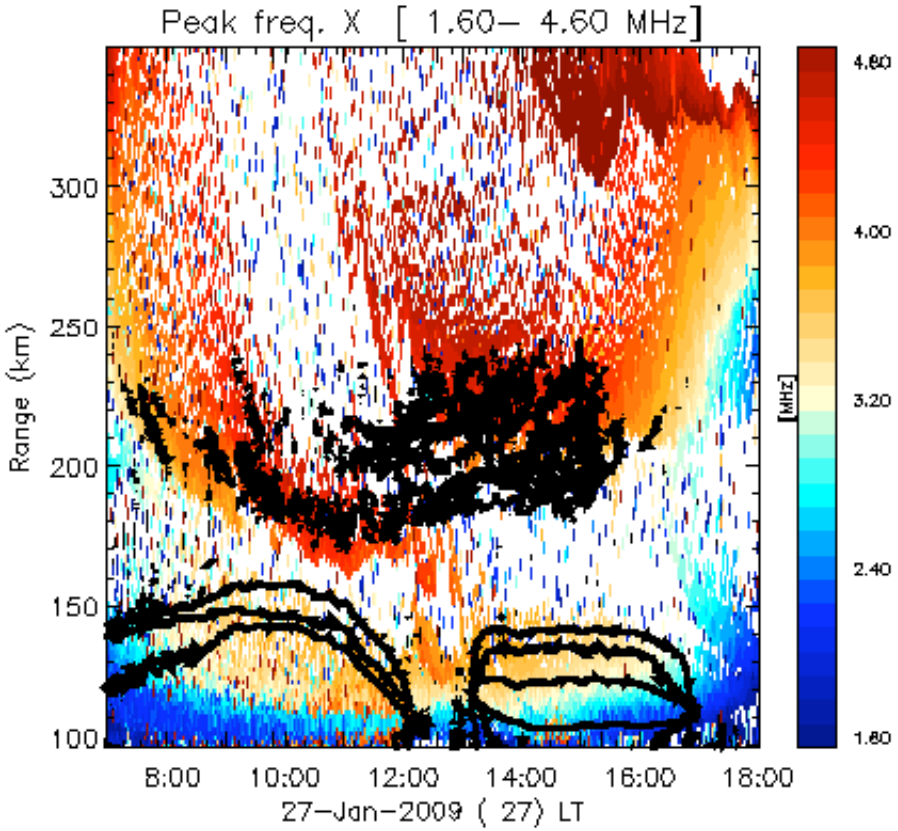


VIPIR "Range-time" parameters



Plasma Frequency vs. 150-km irregularities





Equatorial Daytime Valley Region

- In this region occurs the transition between the dominant molecular ions of lower altitudes and F-region dominant atomic oxygen ion.
- Collisions with neutrals start to be less important as the altitude increases.
- Magnetic field lines around 140–170 km are mapped to both the north and south E regions that are located outside the EEJ belt.
- Intermediate layers are known to occur at these altitudes but so far they have not been observed at equatorial regions during the day.
- Large electron to temperature ratios are expected and observed during the day.
- Maximum photoelectron production rate occurs around 150 km.
- Highly-structured electron density profiles (altitude, time, and horizontal?)