

Perpendicular-to-B incoherent scatter radar observations with AMISR14 at Jicamarca

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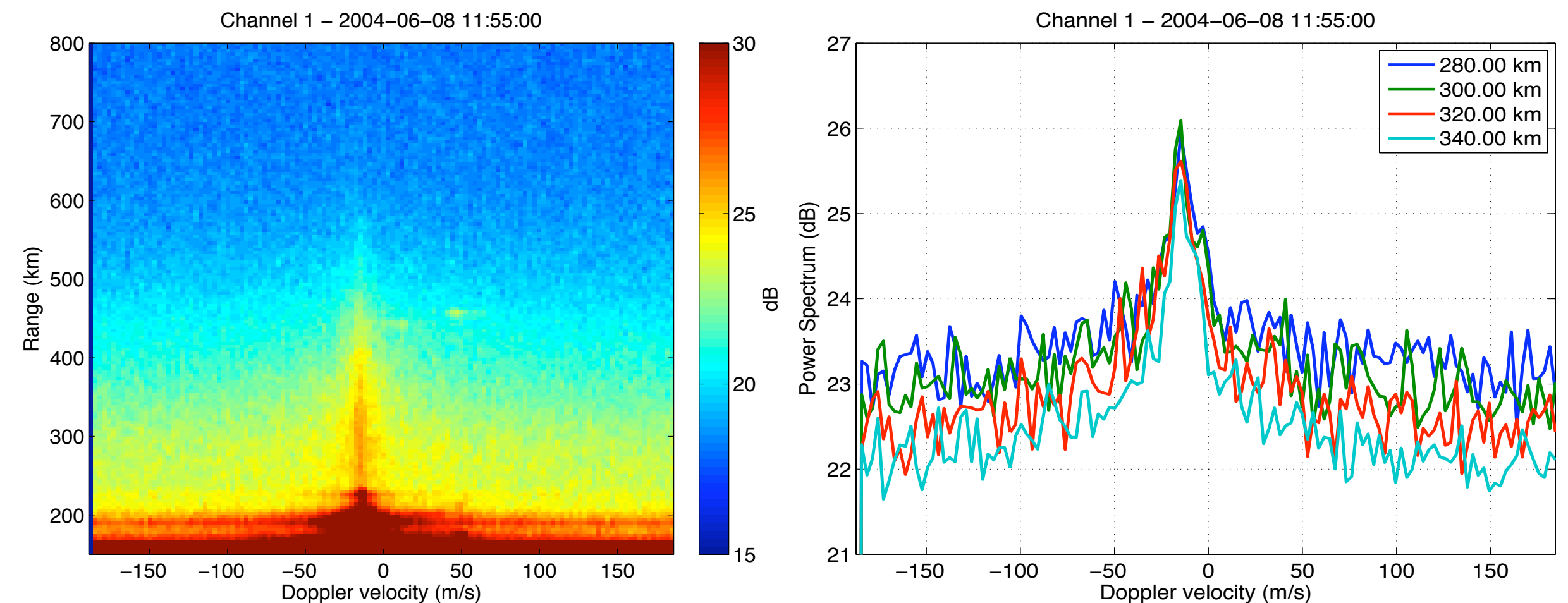
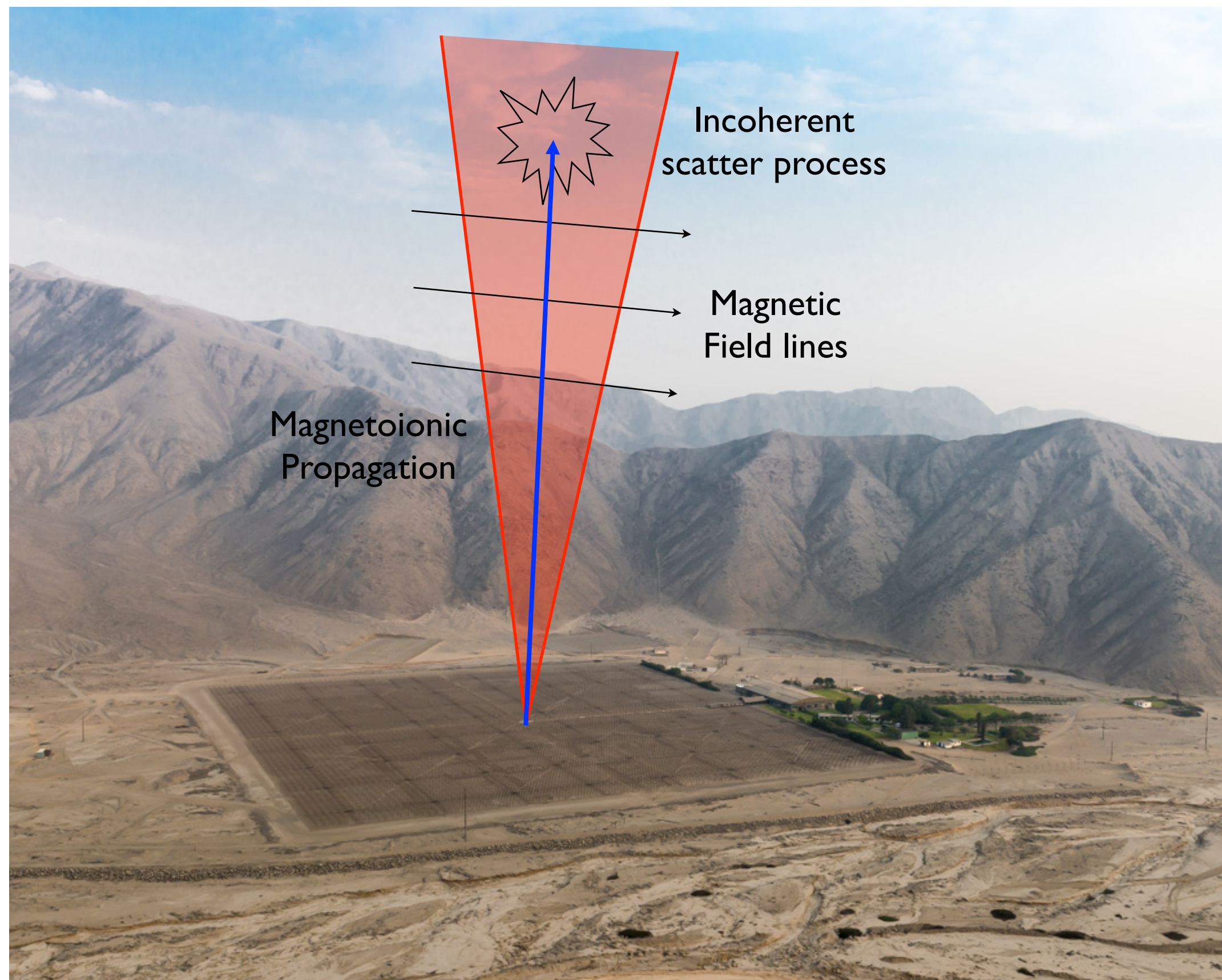
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Introduction

Typical perp-to-B spectrum with Jicamarca ISR



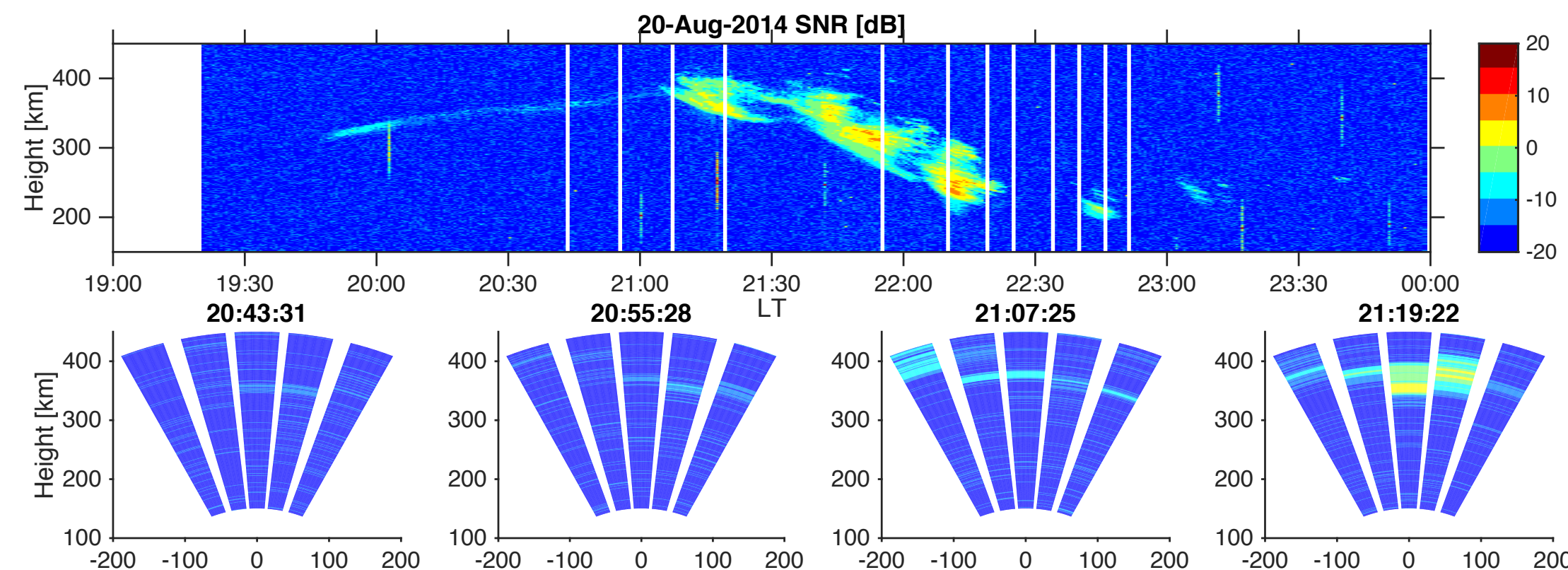
The 50 MHz incoherent scatter radar at Jicamarca can measure very narrow pulse-to-pulse spectra when pointing perpendicular to B at F-region heights.

These measurements are typically used to estimate F-region plasma drifts with high accuracy.

AMISR14 at Jicamarca

AMISR14 at Jicamarca

- 14 AMISR panels deployed at JRO in August 2014.
- Radar frequency: 430 - 450 MHz.
- 448 AEUs, nominal peak power 224 kWatts.
- Phase coding, 1 usec minimum baud length.
- Beam switching capabilities from pulse to pulse.
- Suitable for plasma irregularity observations (EEJ and Spread-F) and for meteor and space-debris detection.

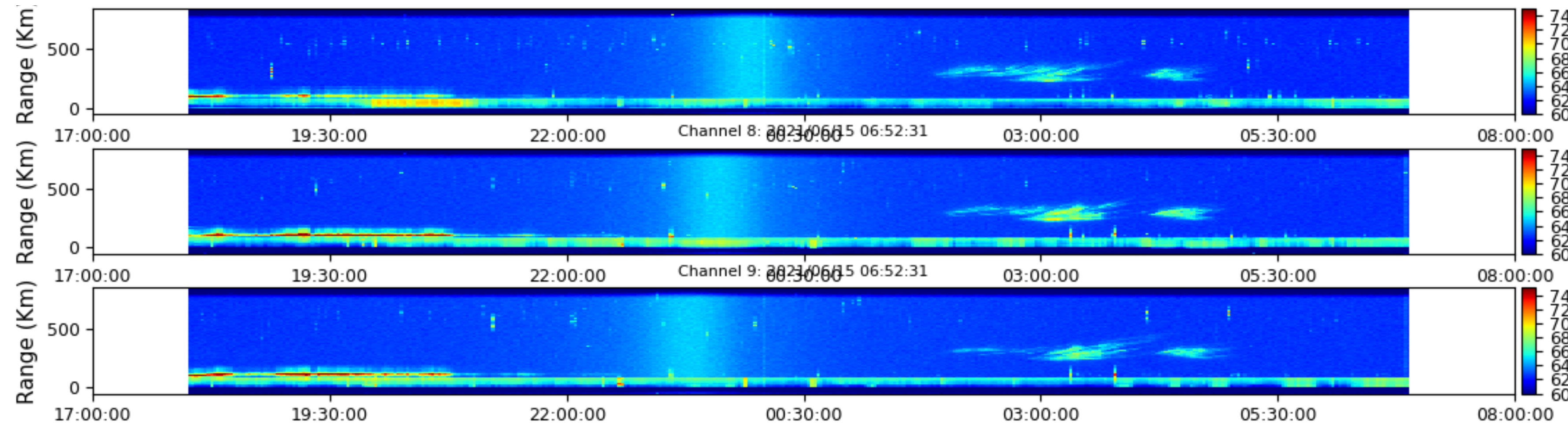
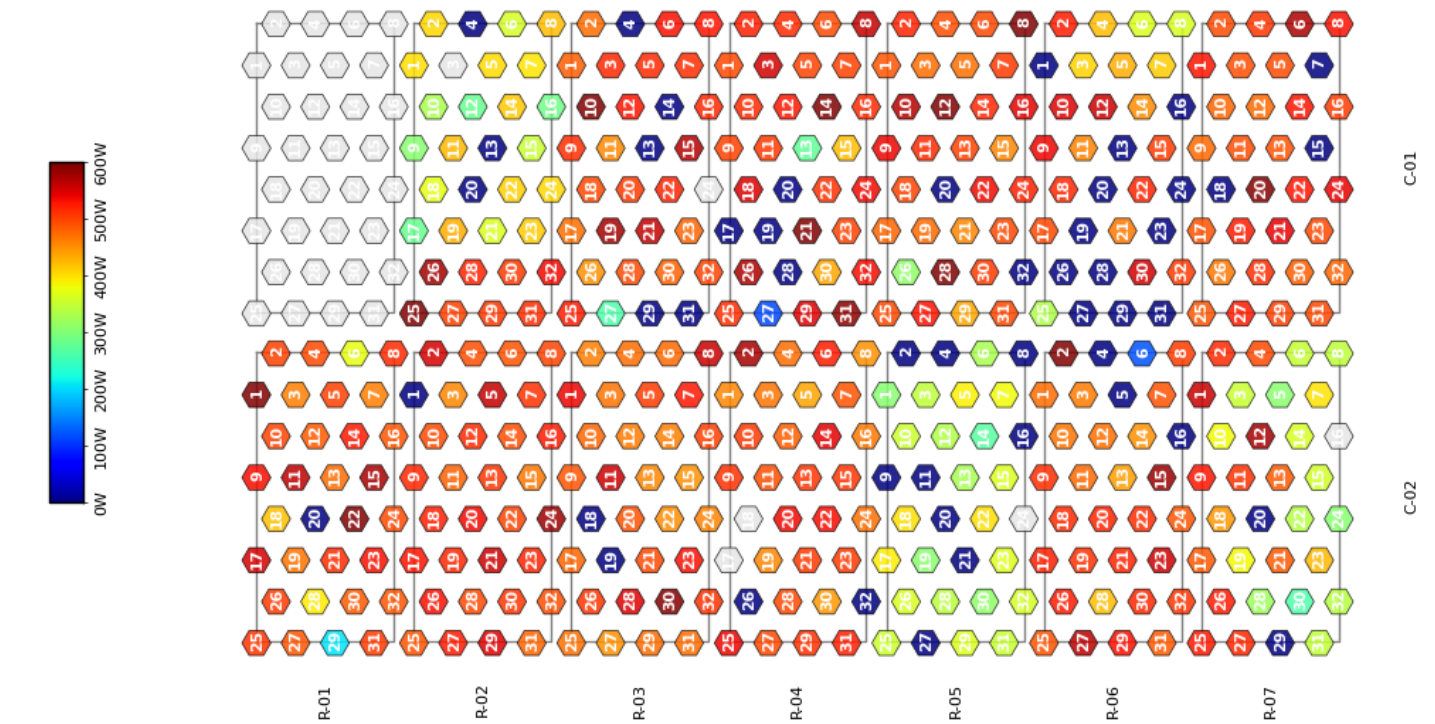


Can we detect incoherent scatter radar echoes with this system?

Different system failures prevented us from testing this idea until recently.

AMISR14 restarted operations in 2021

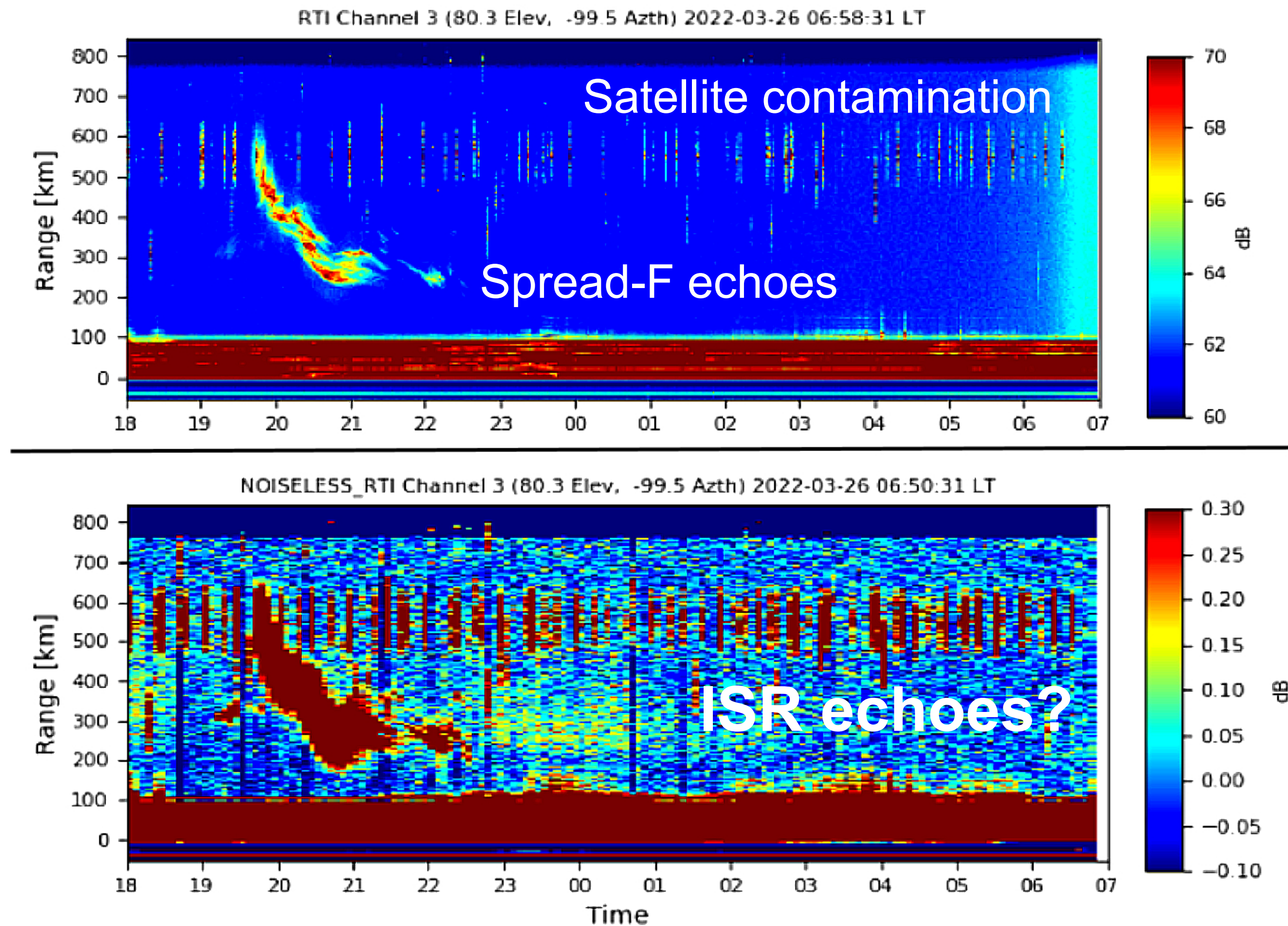
- AEU's modules were upgraded and repaired (with SRI support).
- Power-supply and system operational issues were fixed.
- Operations in parallel with JULIA restarted in June 2021.
- Maintenance and repairs are conducted in a regular basis to keep the system running.



In collaboration with UT Dallas (USA), UAGM (Puerto Rico).

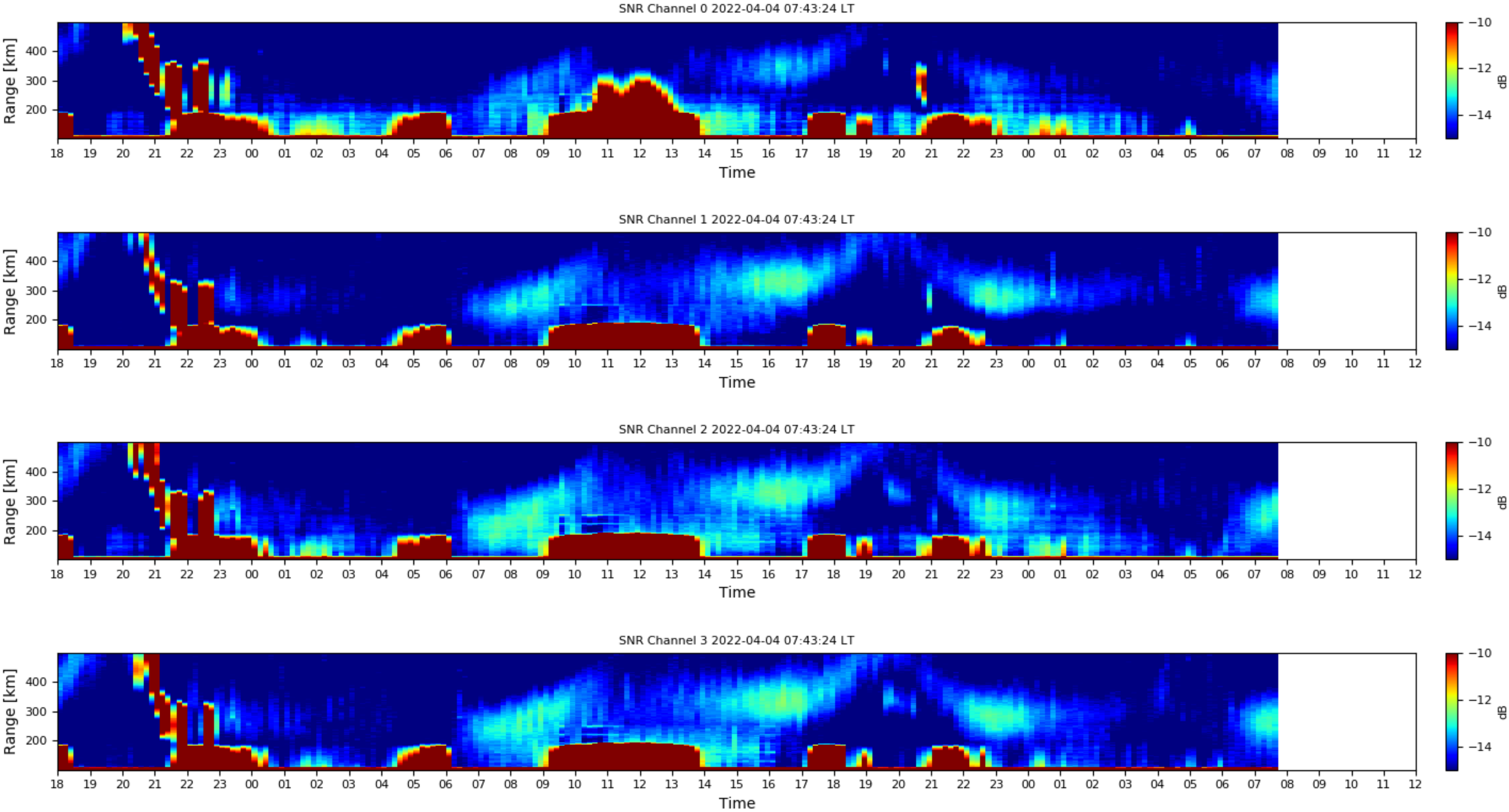
Incoherent scatter radar observations with AMISR14

AMISR14 mode for Equatorial Spread-F



- Nighttime mode (6 PM - 7 AM) for Spread-F observations.
- IPP: 937.5 km
- Pulse: 84 km, code: 28-bauds
- 10 different pointing directions in the east-west plane (all of them are perpendicular to B).
- Weak signals around Spread-F echoes were detected.

AMISR14 F-region observations - April 2022

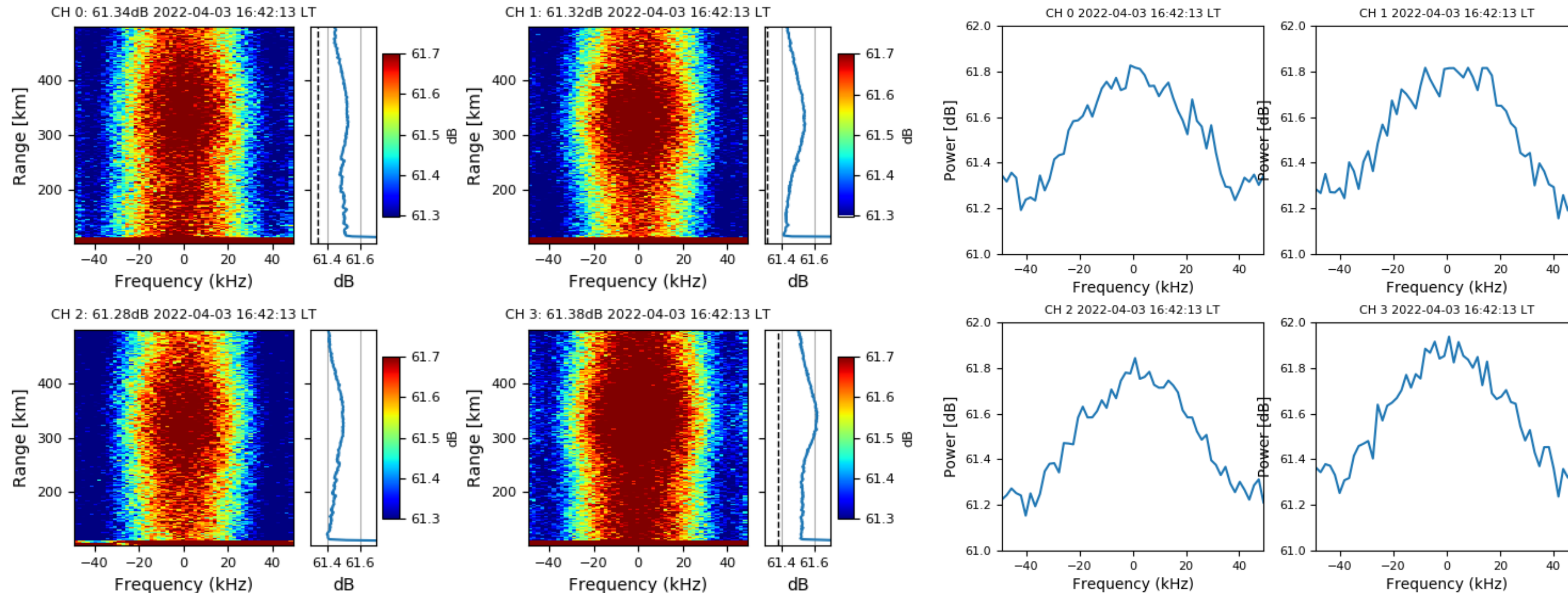


Parameter	Values
IPP	937.5 km
Tx	84 km
Sampling	1.5 km
Freq	445 Mhz
Code	Binary 28
Beams	10

Backscatter radar signals at F-region altitudes were detected during daytime and nighttime.

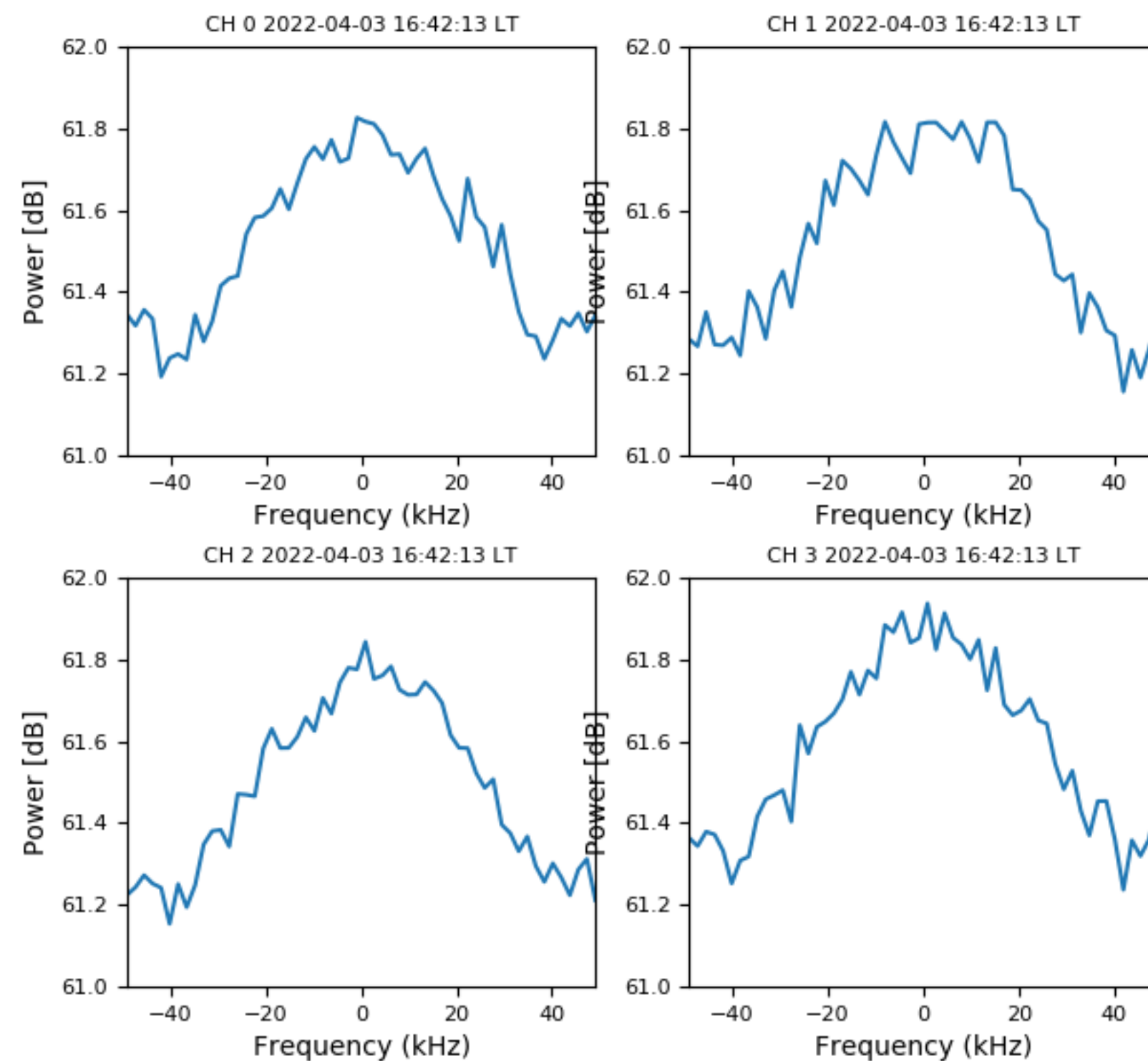
SNR is very weak less than 0dB but detectable after a few minutes of integration.

AMISR14 F-region observations - April 2022



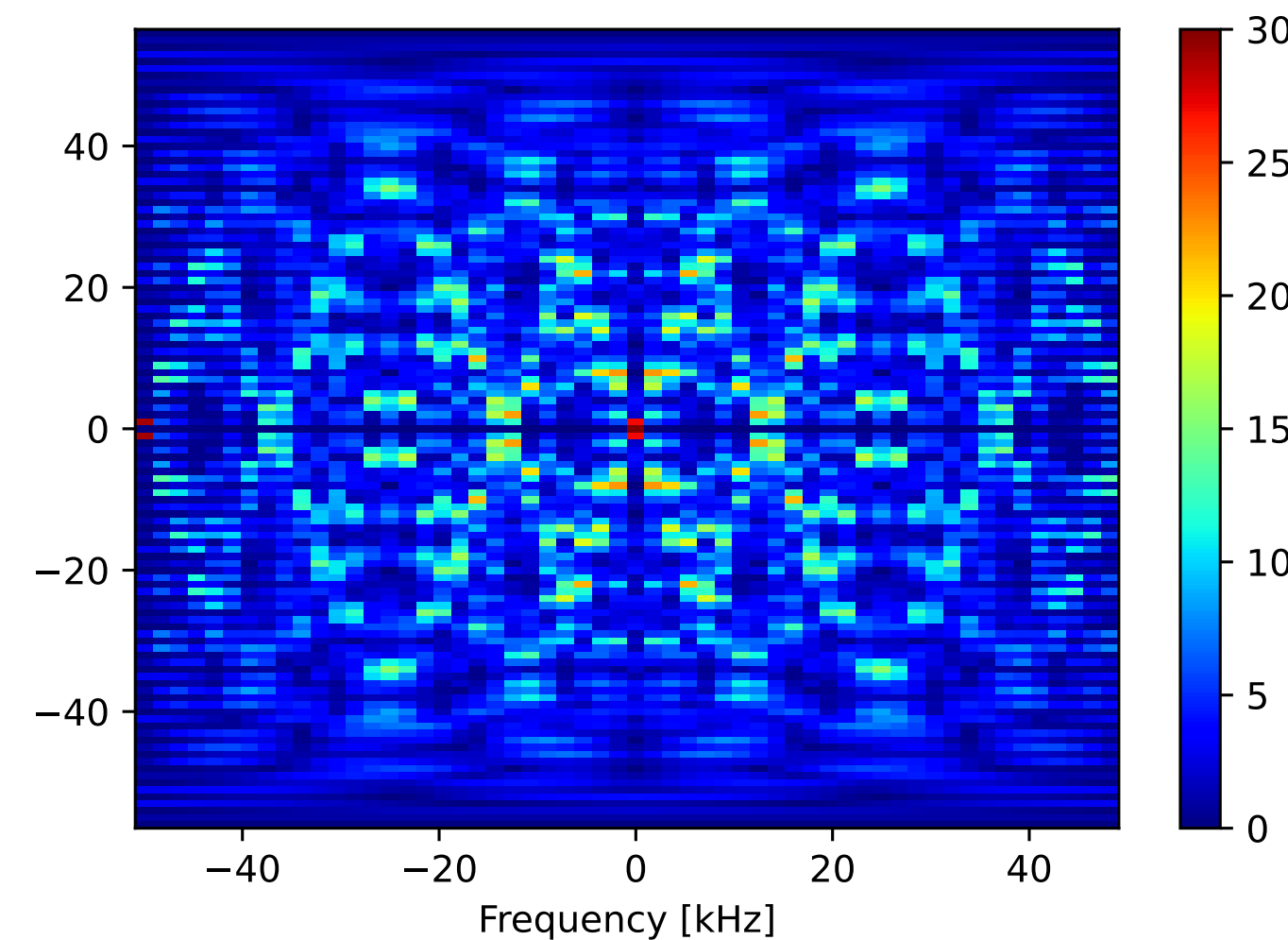
The estimated within-the-pulse spectrum was as wide as the receiver bandwidth.
This does not look like an ISR spectrum.

AMISR14 F-region observations - April 2022

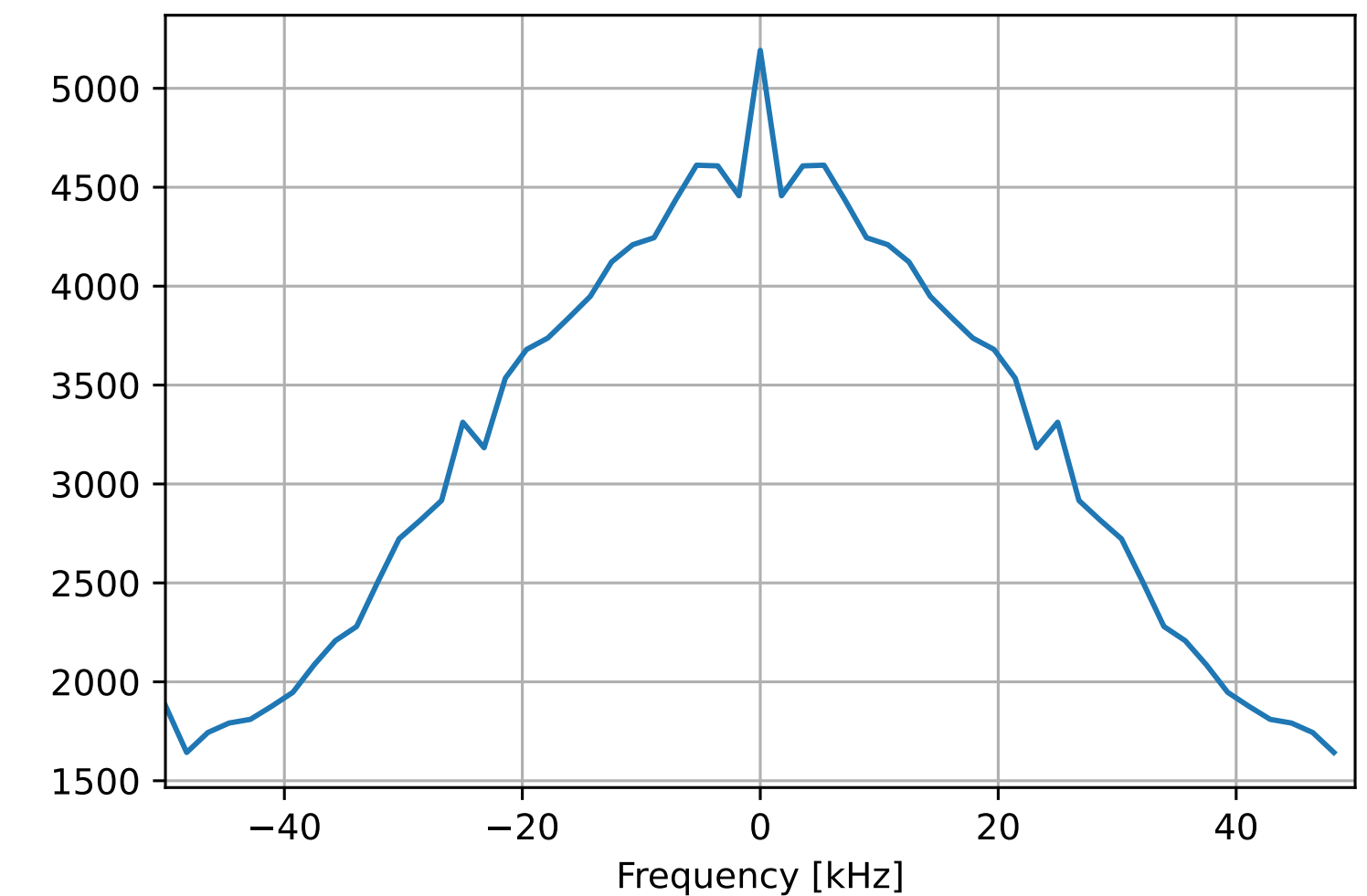


AMISR spectra at 300 km altitude
(28 baud code).

Radar Ambiguity function



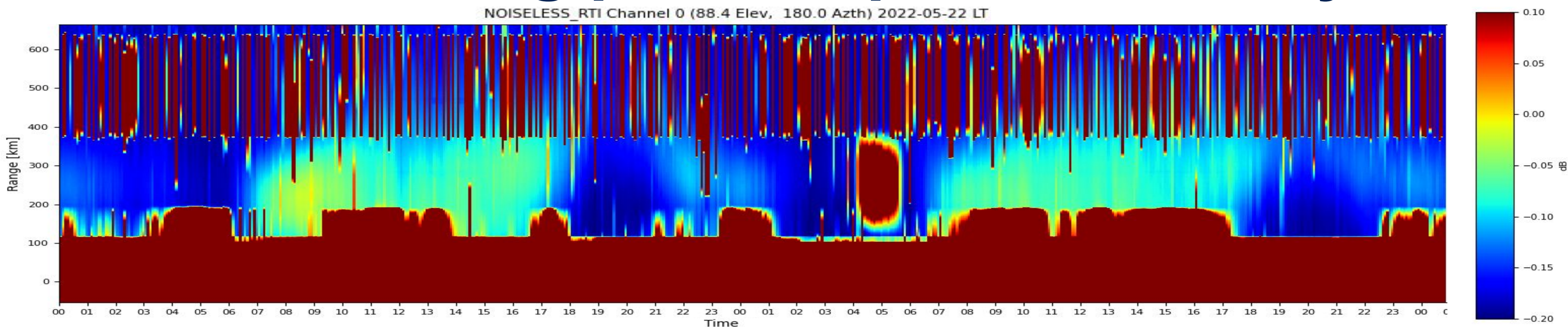
Integrated ambiguity function



The within-the-pulse spectrum looks like the ambiguity function integrated over range. The spectrum of the backscattered signal is smeared over frequency becoming difficult to deconvolve it from the measurements.

How can we adjust the experiment to measure the backscatter spectra?

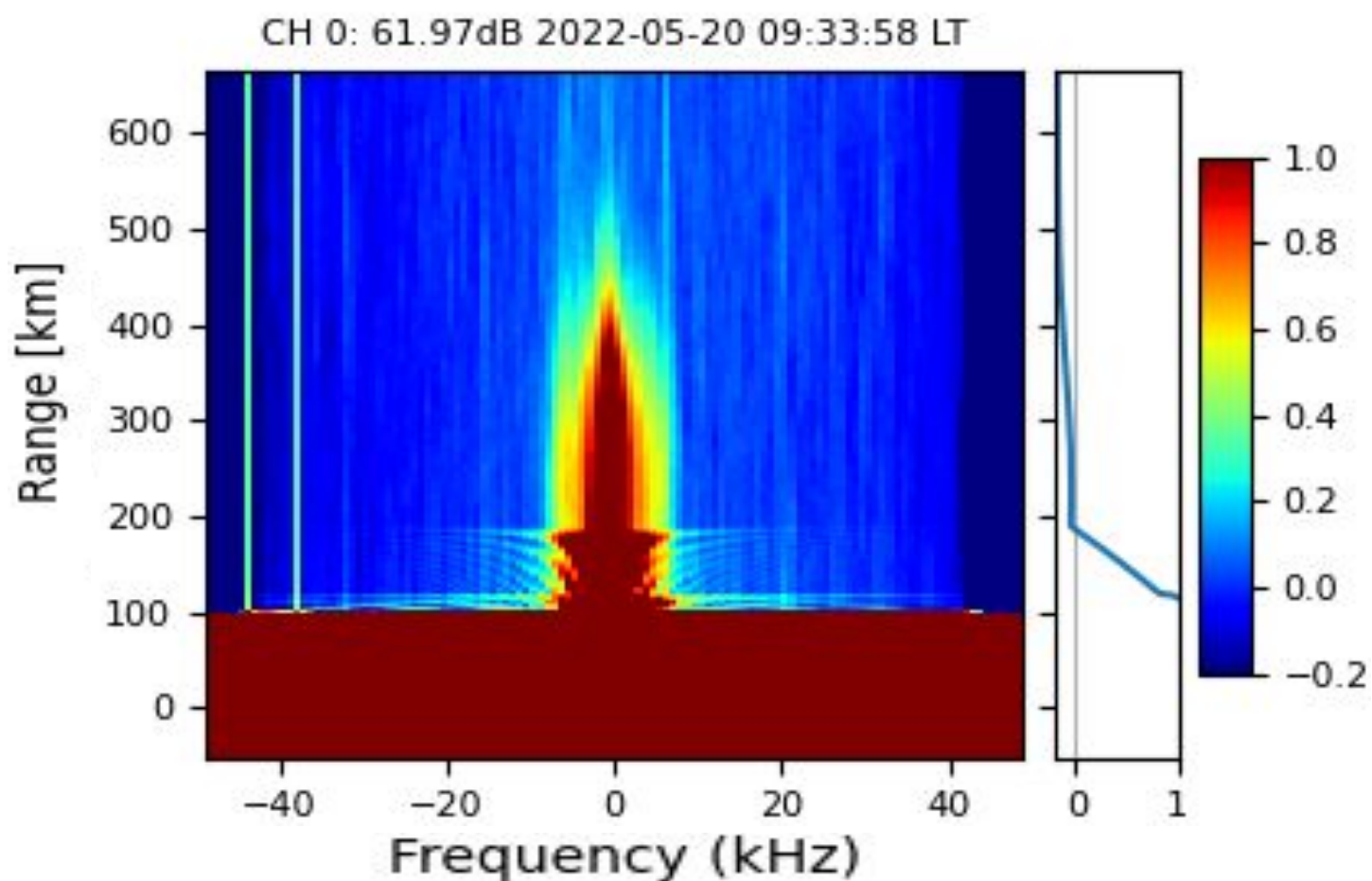
AMISR14 - Long pulse experiment - May 2022



A simple long pulse (no coding) experiment was used to collect backscattered radar signals.

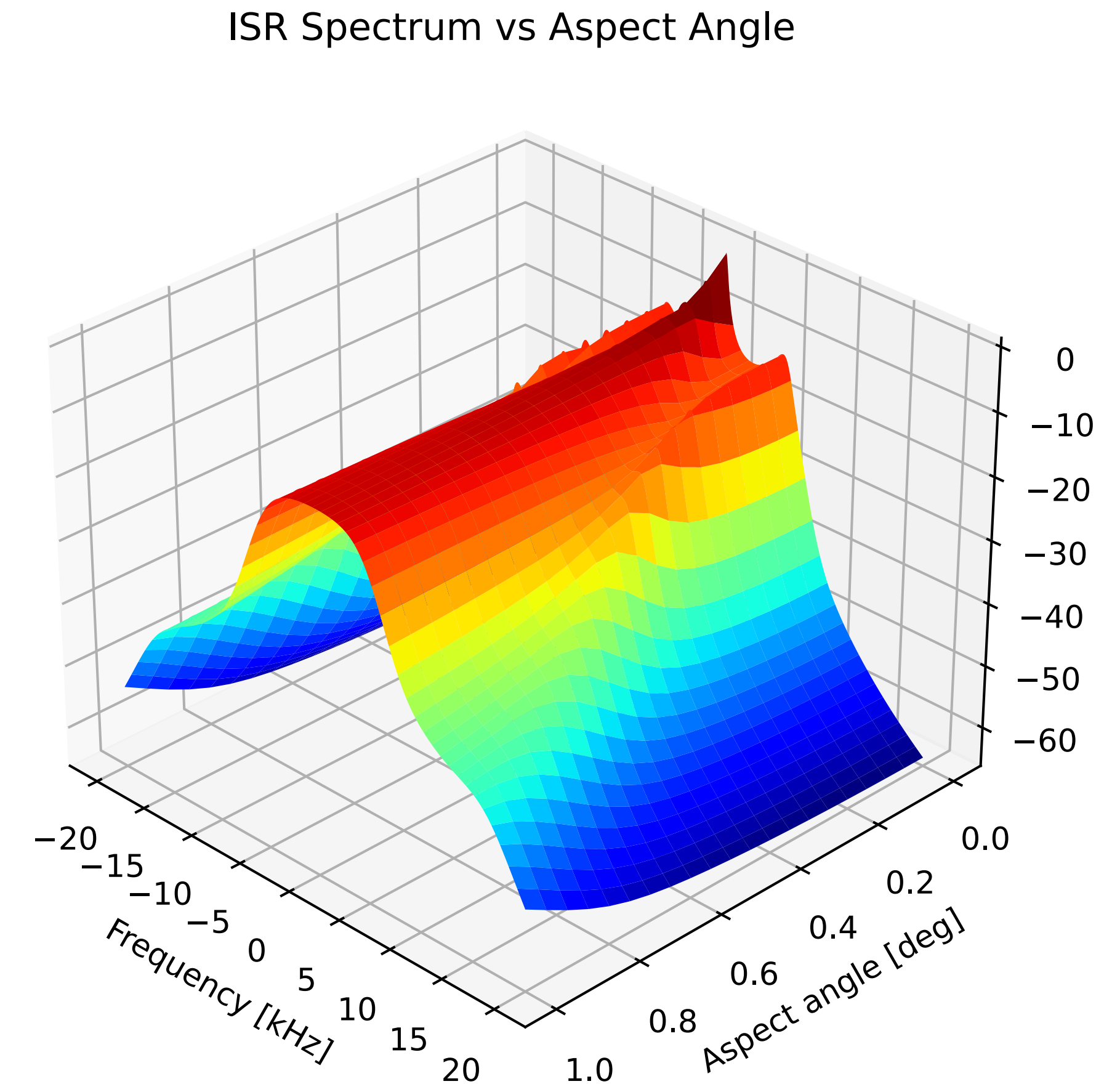
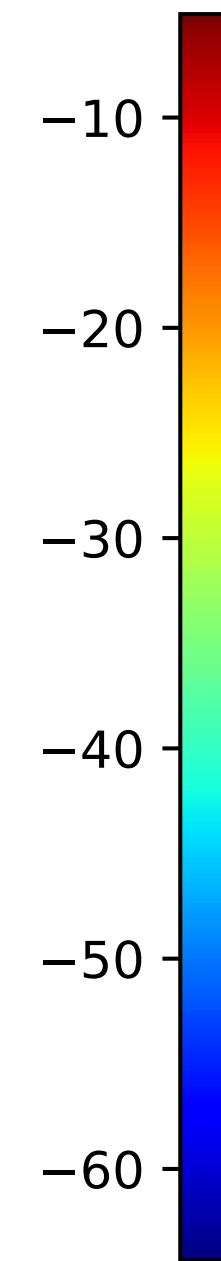
Narrow within-the-pulse spectra were observed as expected for ISR perp-to-B observations.

Parameter	Values
IPP	937.5 km
Tx	90 km
Δh	1.5 km
Freq	445 Mhz
Code	None
Beams	1

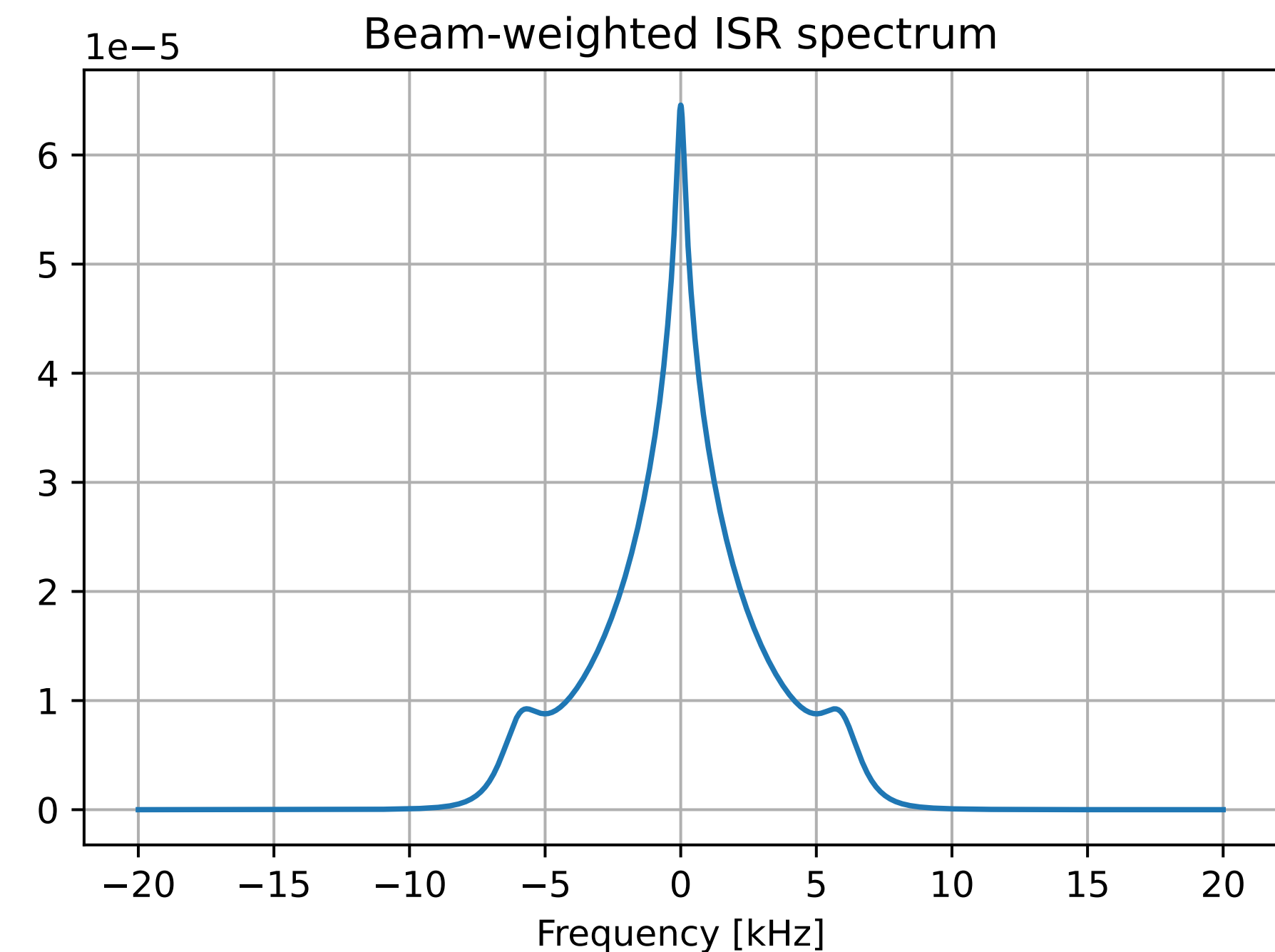
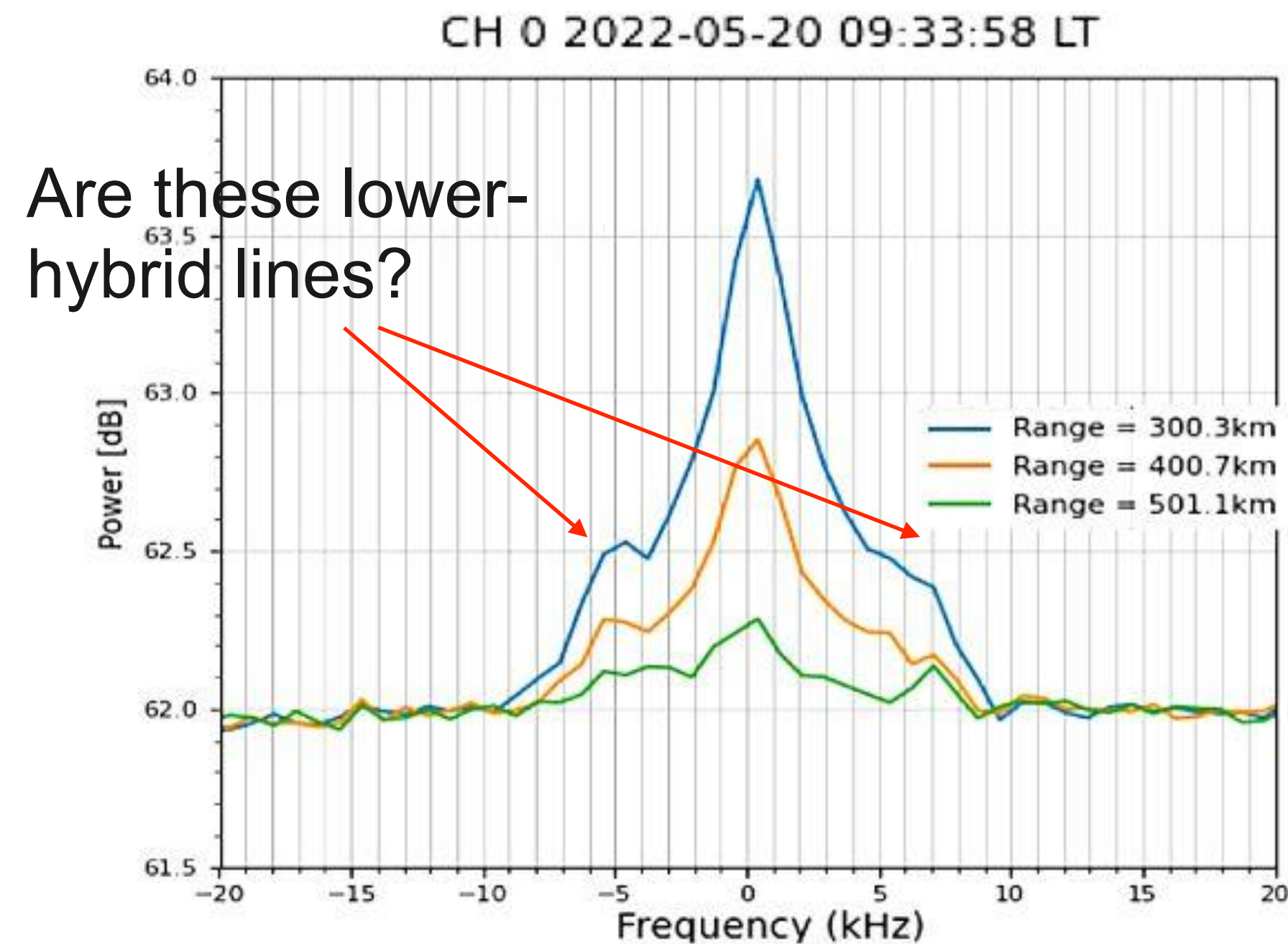


Modeling ISR spectrum at UHF frequencies

- The measured spectrum was modeled using the general framework for ISR theory [e.g., Kudeki & Milla, 2011].
- Coulomb collisions were considered as a Brownian motion process (constant friction and diffusion).
- ISR spectrum was computed as a function of magnetic aspect angle for an O⁺ plasma, $N_e = 10^{12} \text{ m}^{-3}$, $B = 22,000 \text{ nT}$, $T_e = T_i = 1000 \text{ K}$.
- The ISR spectrum becomes narrower as aspect angle decreases. Notice the narrow spectral lines around the main spectrum.



Comparing measured and modeled spectrum



ISR spectrum was integrated along aspect angle weighted by a gaussian beam shape.

Conclusions and future work

- UHF ISR perpendicular-to-B spectral measurements were successfully conducted with AMISR14 at the magnetic Equator.
- It seems the standard ISR theory can be used to model the spectral observations considering Coulomb collisions as a Brownian motion process. However, radar ambiguity function effects need to be considered.

Open questions:

- Are spectral features, even the “lower-hybrid” lines, fully modeled by the general framework of ISR theory?
- Can we estimate physical parameters from the measured spectrum?
- How these AMISR14 observations compared with Jicamarca perp-to-B spectra? Can we try to estimate collision rates from these measurements?

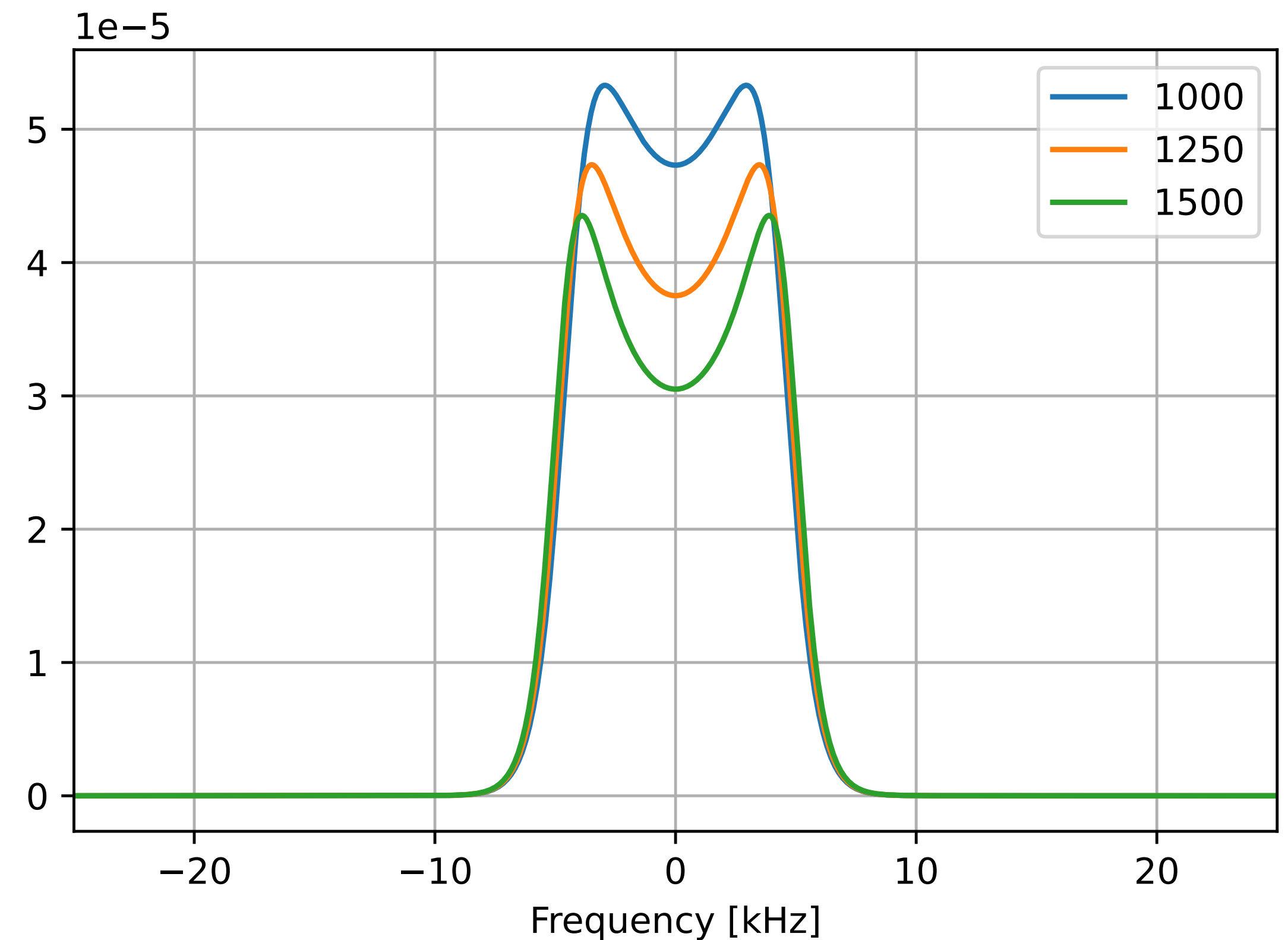
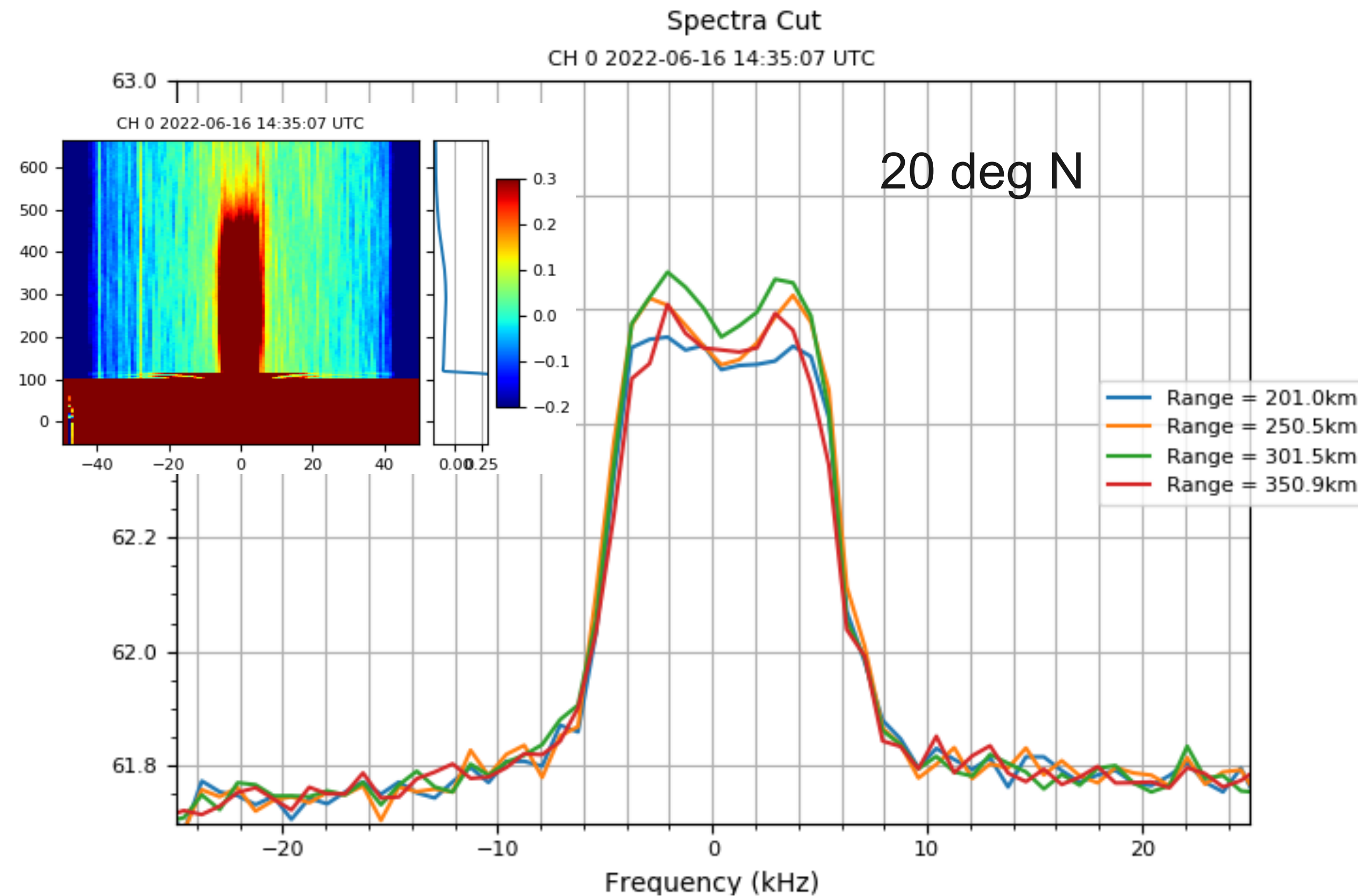
List of current and future experiments

- Off-perpendicular-to-B observations at different magnetic aspect angles.
- 150 km echoes and valley region radar experiments with coded pulses.
- Perpendicular and off-perpendicular radar campaigns in parallel with Jicamarca and other instruments.
- High-altitude coherent echoes experiment in parallel with Jicamarca.
- Plasma line experiment with a wide bandwidth receiver.

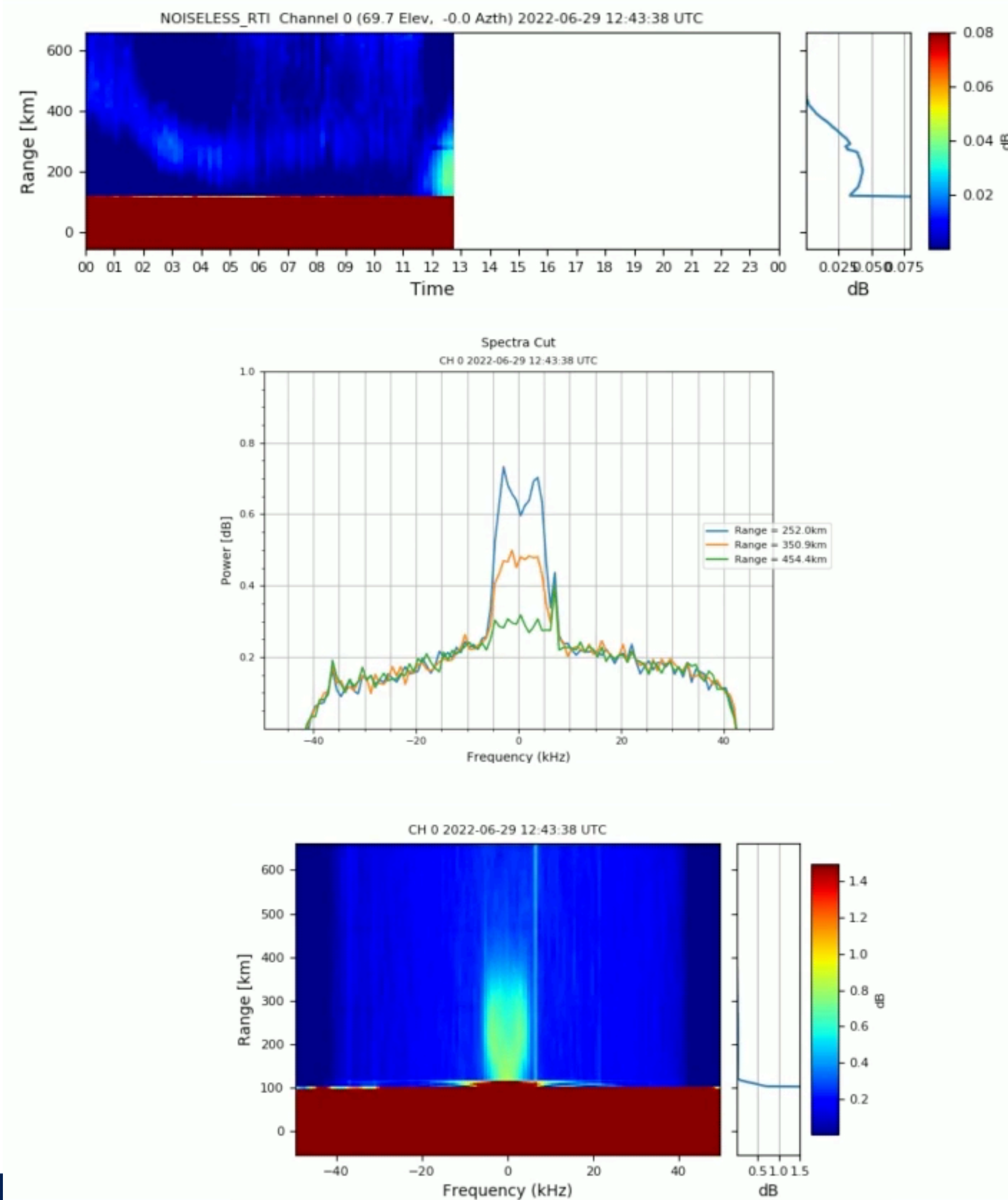
More ideas for experiments are welcome.

Thanks for your attention!

Off-perpendicular to B spectral measurements



Standard ISR model (including collisions) seems to represent very well the observations.



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