First Results from WIDE – Wideband Ionospheric Distortion Experiment

Paul Cannon[1], Keith Groves[2], David Fraser[1], Neil Rogers[1]

With grateful acknowledgements to:
William J. Donnelly[3], Kathleen Perrier[4]

[1]QinetiQ, Malvern, UK
[2]Air Force Research Laboratory, Hanscom AFB, USA
[3]MIT Lincoln Laboratory, Reagan Test Site, Kwajalein Atoll
[4]MIT Lincoln Laboratory, Lexington, USA

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The requirement

- Need to understand the signal delays, and the spreads in that delay, for a trans-ionospheric path
  - Coherency bandwidth
- Need to understand the frequency variations (Doppler) imposed on those same signals by the environment
  - Coherency time

- Need a wideband signal to examine the problem
  - Wideband signals also reflect system operation

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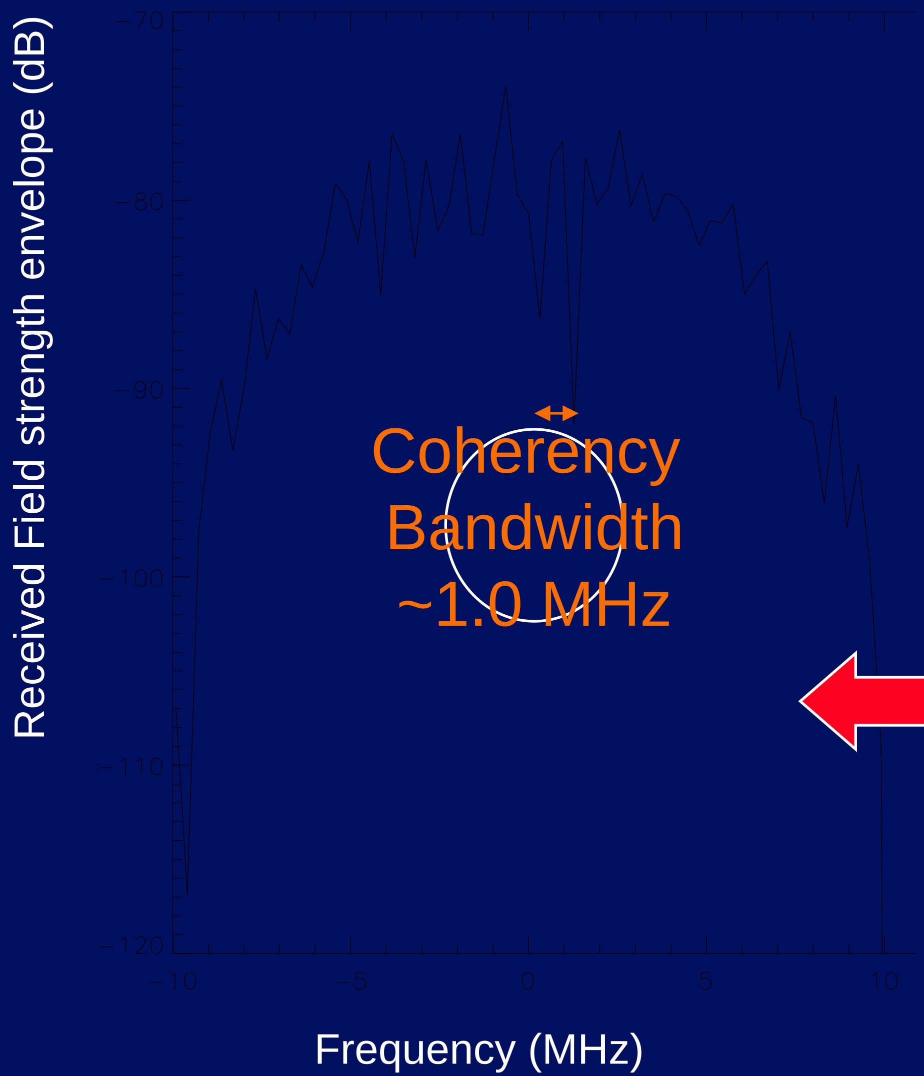
Wideband Coherency Bandwidth



- Phase screen calculation
- Carrier 500 MHz
- Transmitted 20MHz band-limited waveform
- Propagated through a strongly scintillating ionosphere, $S_4 = 1$
- Received signal

But is this a good estimate of the real world?

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Measuring Small Scale Ionospheric Effects Pertinent To Wideband Radio Systems

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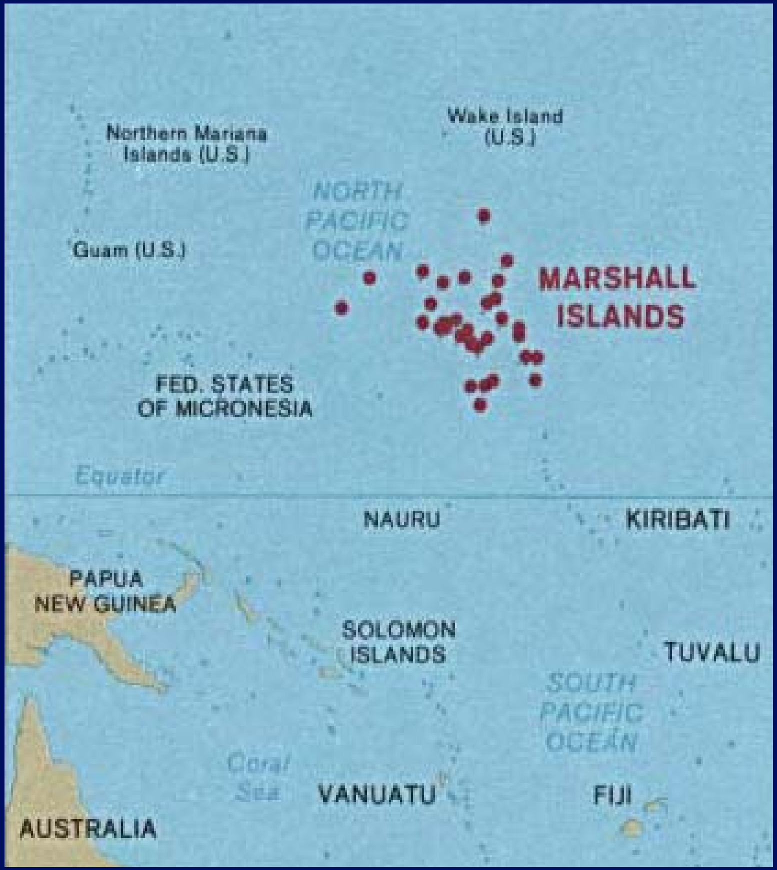
Measurement Instrument



- VHF and UHF ALTAIR radar
- Allows measurements of equatorial ionosphere

9.395° N, 167.469° E
12.87° N, 237.16° E CGM

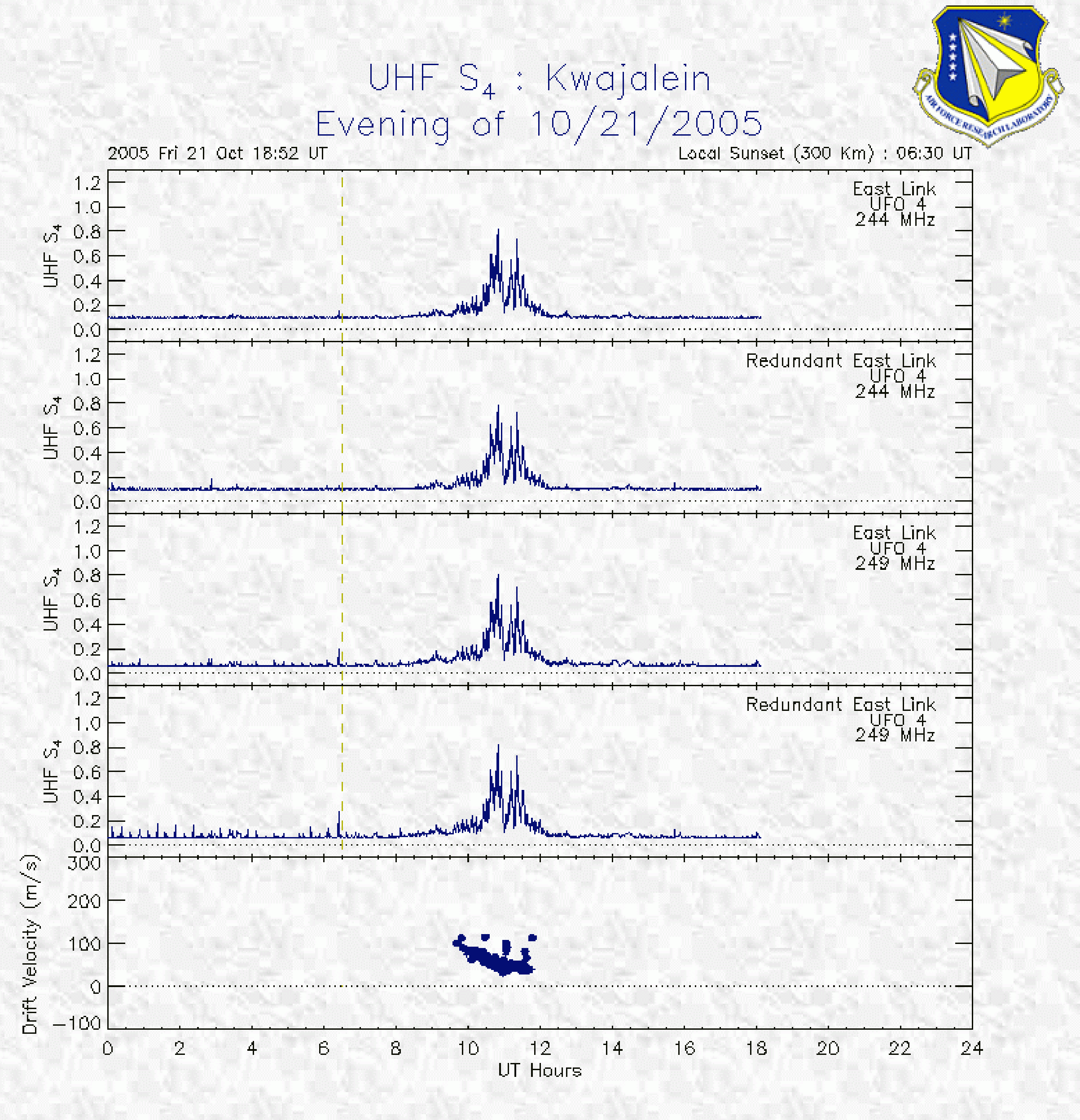
Relevant Radar Specification

5 MW into 42 m dish

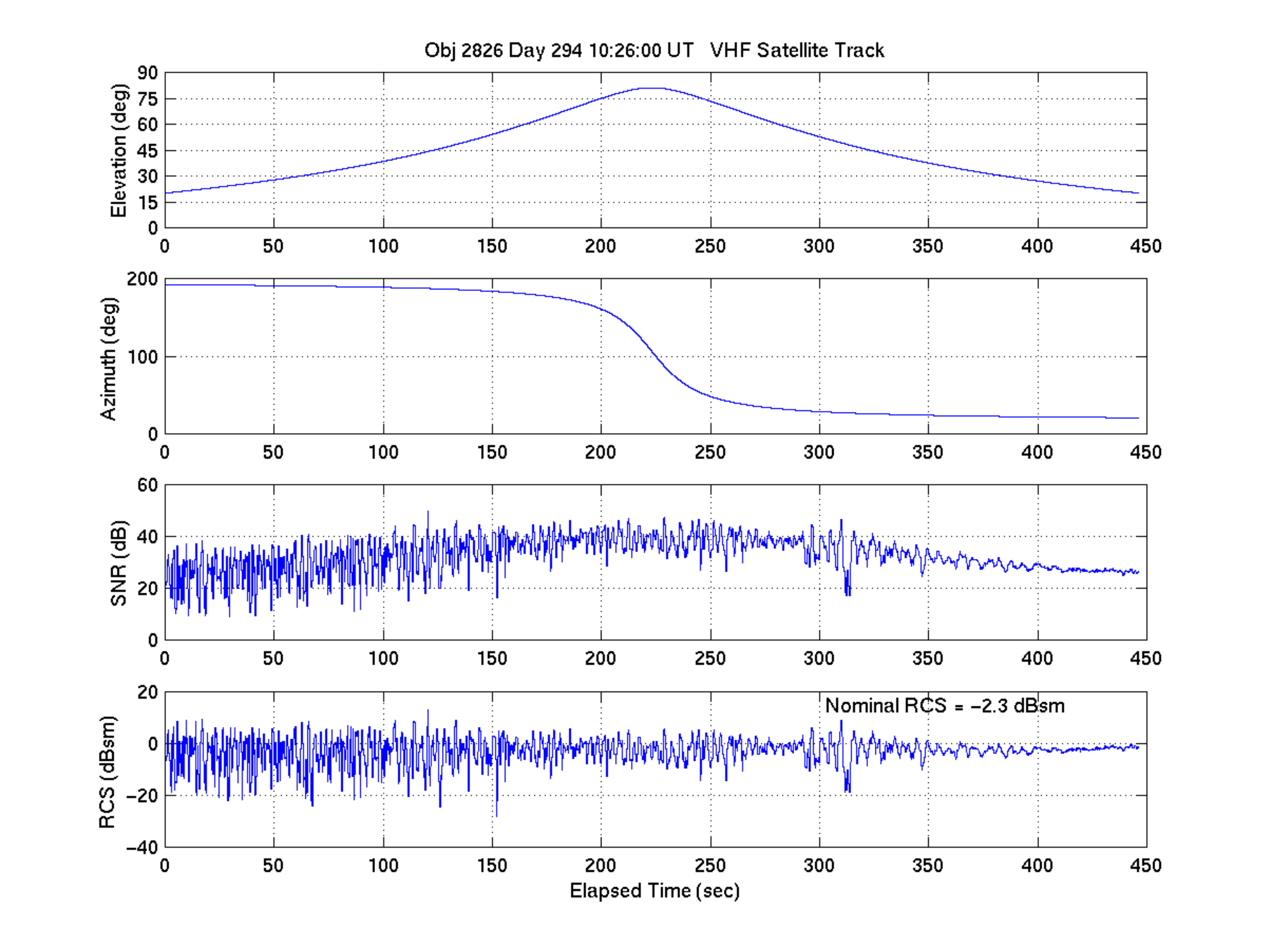
- VHF
  - 158MHz
  - Max bandwidth 7MHz
  - Pulse width 40μs
  - Range resolution 32 m (-6dB)
  - Sample spacing 15 m
- UHF
  - 422 MHz
  - Max bandwidth 18 MHz
  - Pulse width 150μs
  - Range resolution 15 m (-6dB)
  - Sample spacing 7.5 m

Typical prf - 300 Hz

244 MHz Narrowband measurements



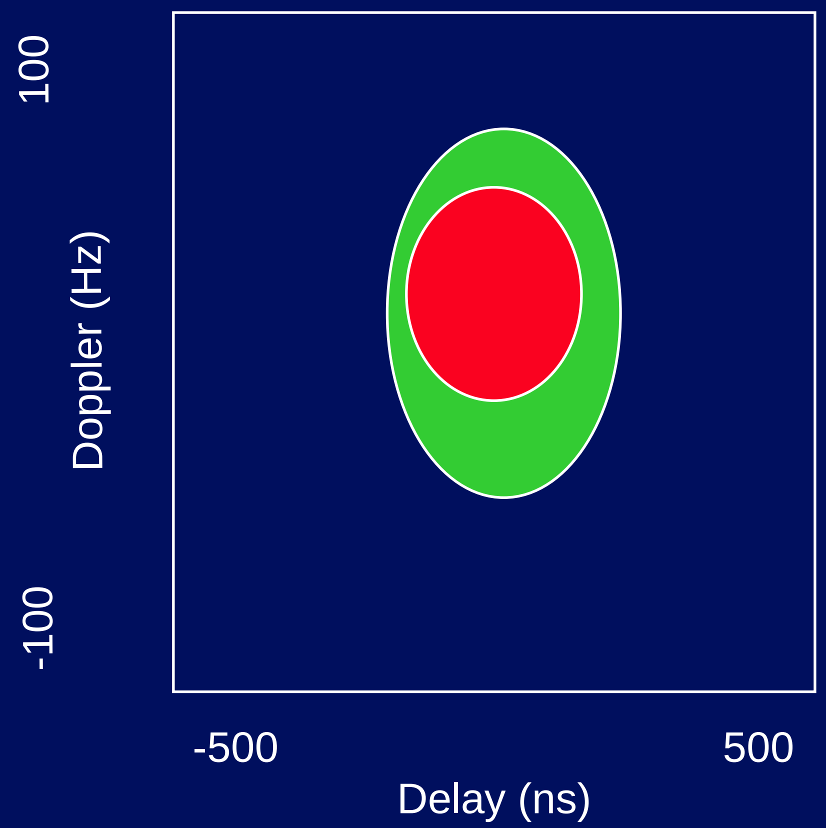
Day 294, 21 October 2005 VHF



Measurement Concept

- Transmit a pulse compression sounding (chirped) signal
- Bounce signals from aspect angle independent targets (calspheres ~ one square metre) in LEO
- Cross correlate reflected signal at the receiver to give the complex impulse response (CIR) (also known as transfer function).
  - low(ish) SNR
- Average over a number of CIRs to give the scattering function
  - higher SNR
  - Provides simultaneous range spread and frequency spread information

Pictorial Representation of Scattering Function



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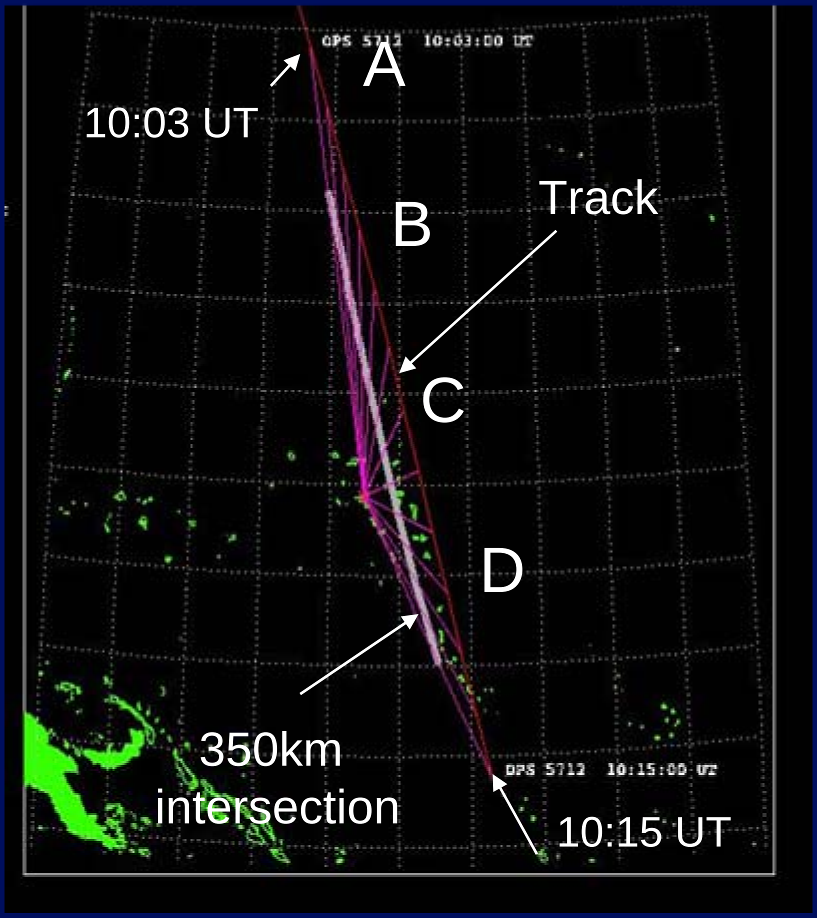
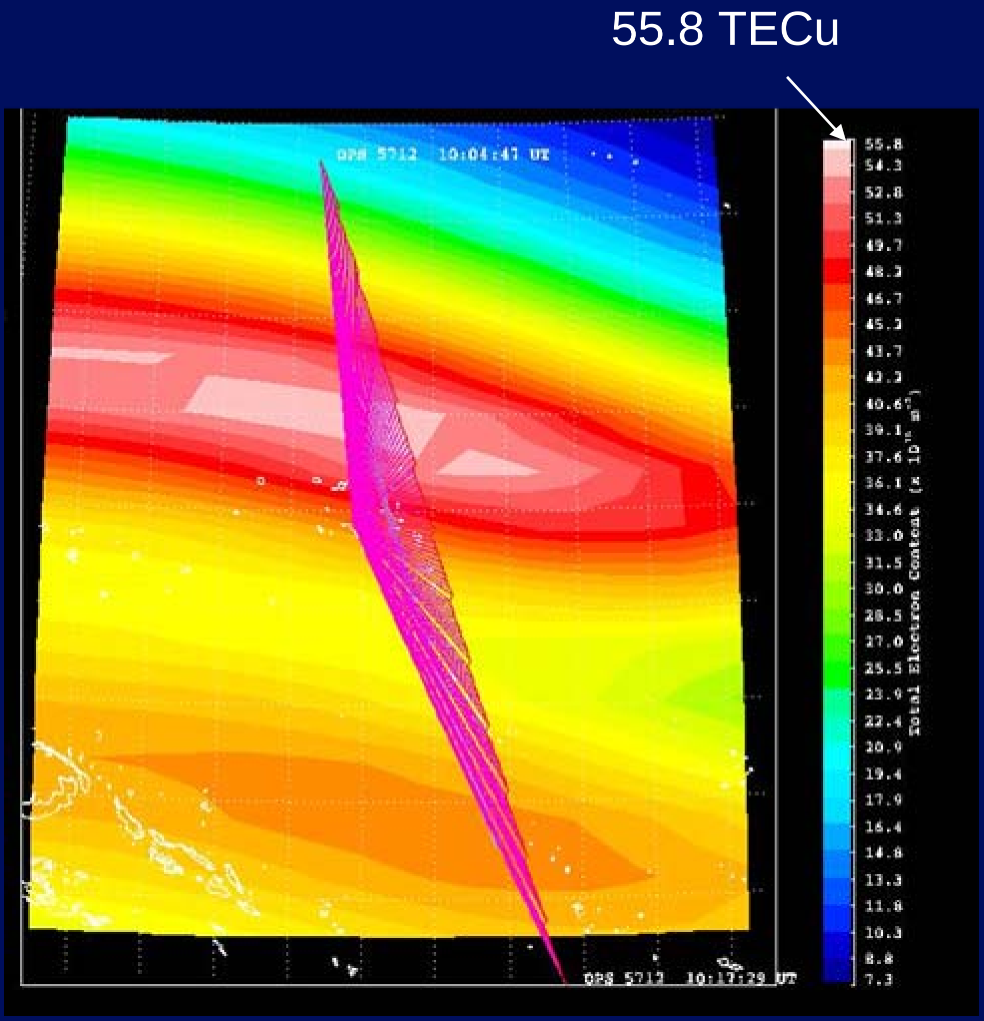
18th January 2005 measurements

18th January 2005, 10 UT (21 LT)



Satellite Track



IRI estimate of vTEC

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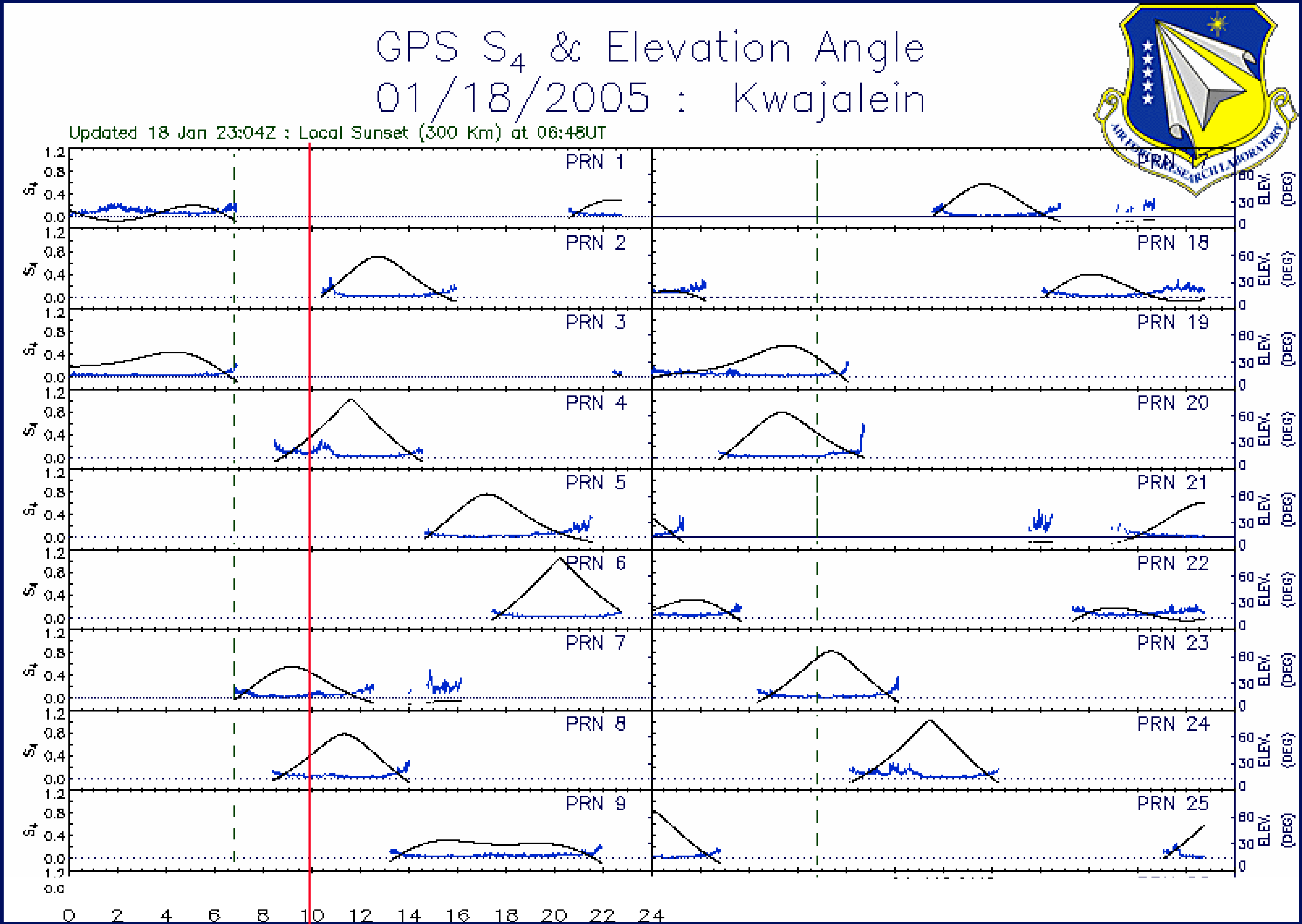
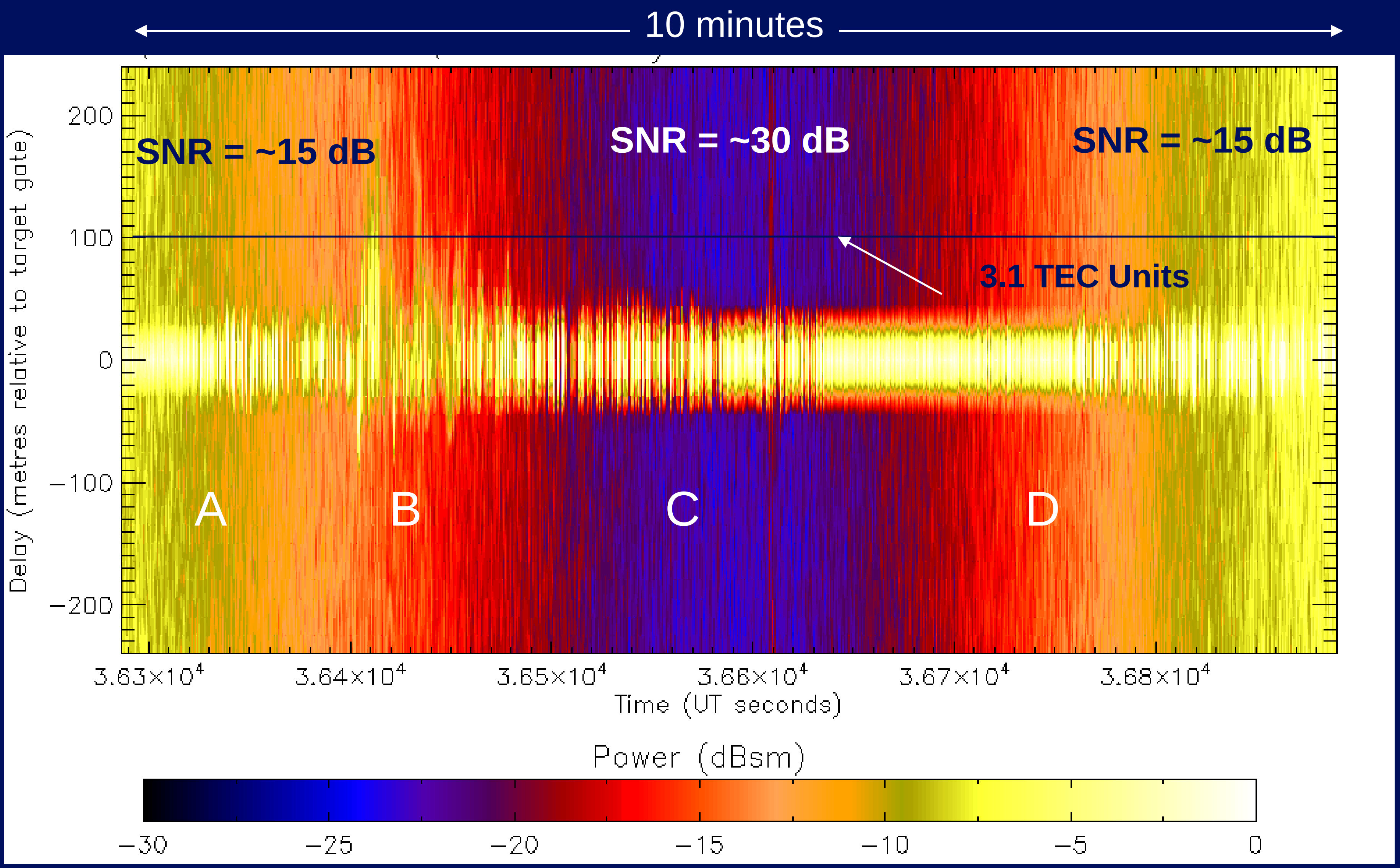
GPS Scintillation Data

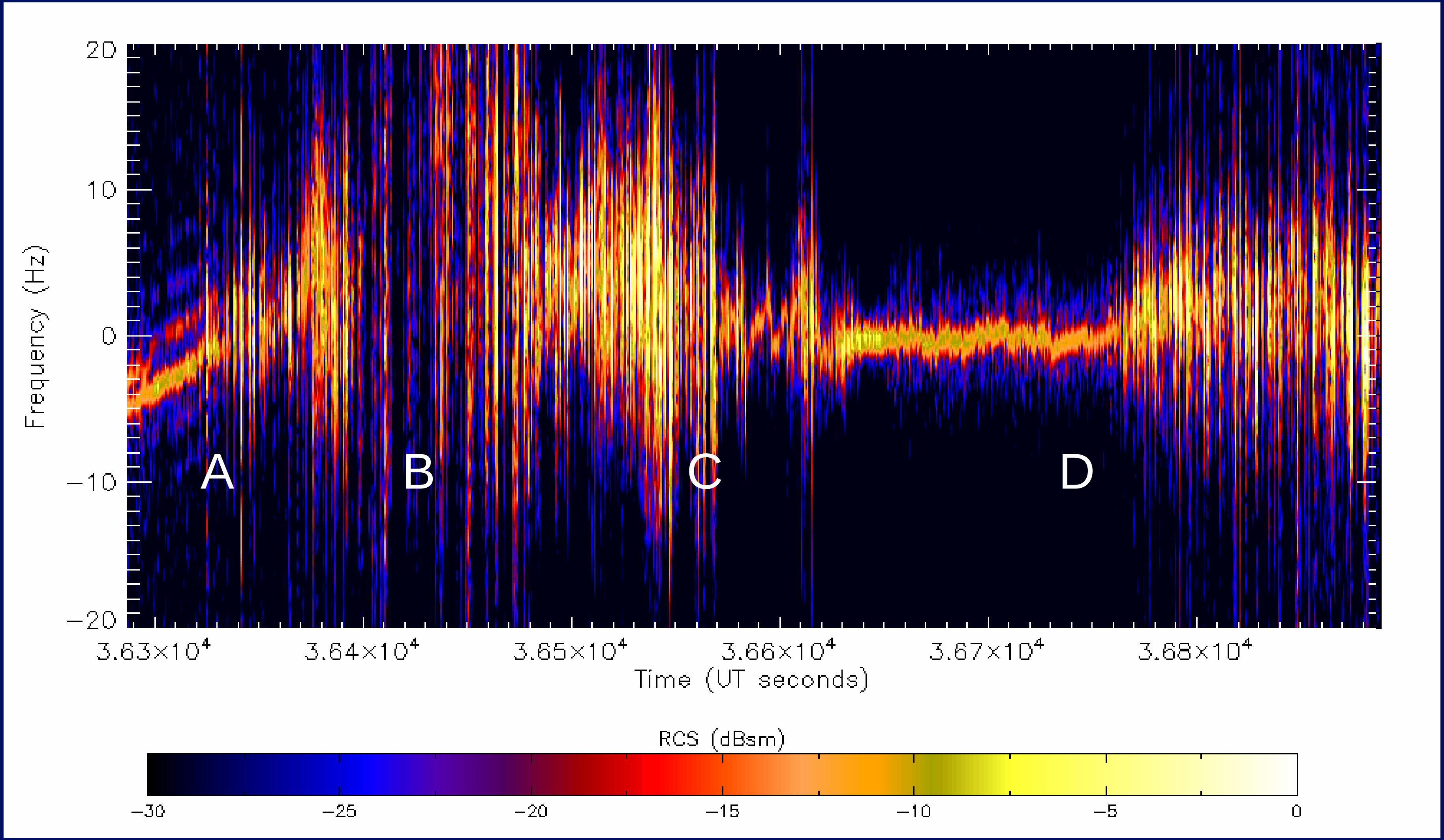


VHF Range Time Intensity, 18 Jan 05



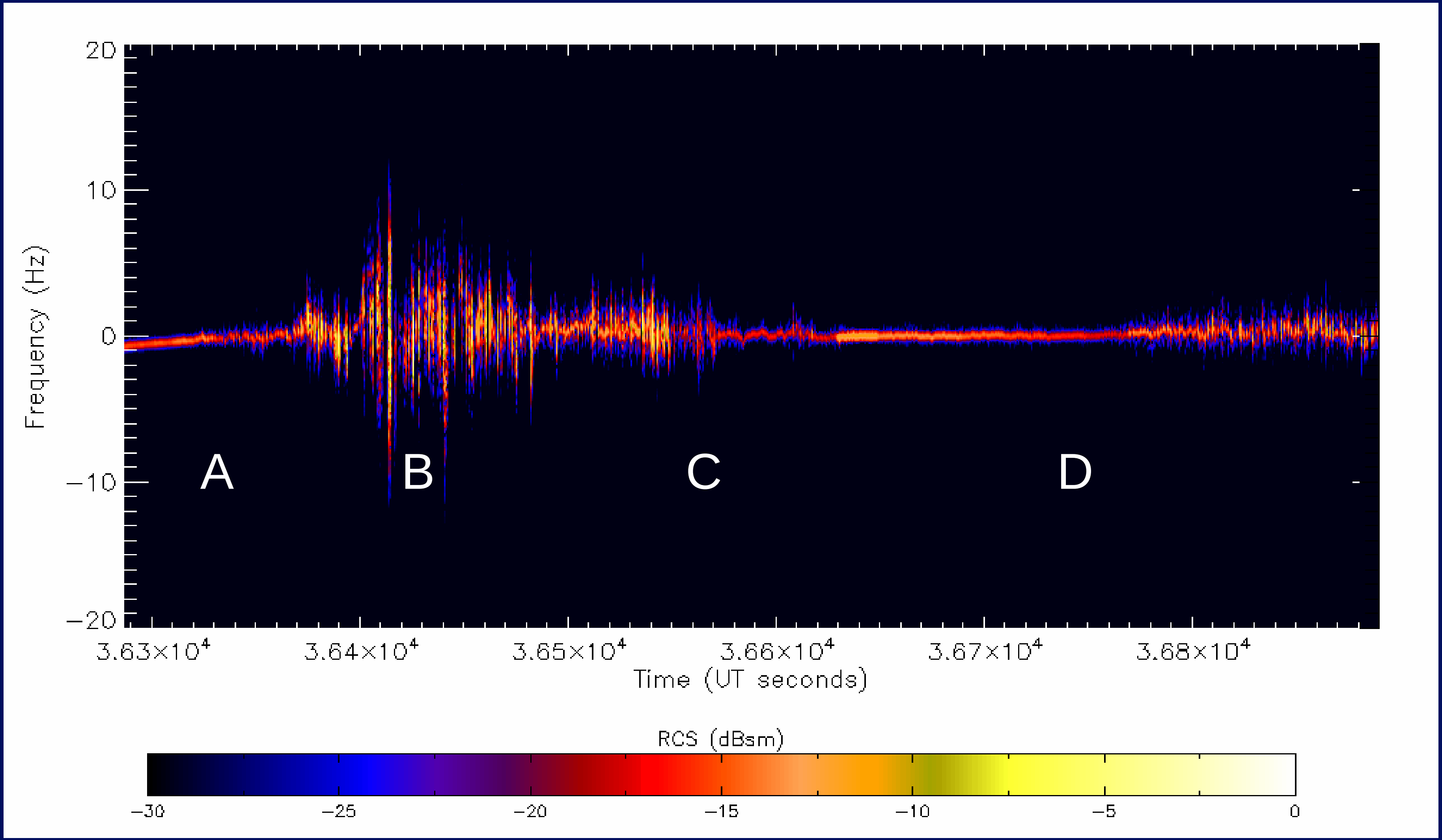
Based on 0.1s incoherent average

VHF Doppler Time Intensity, 18 Jan 05



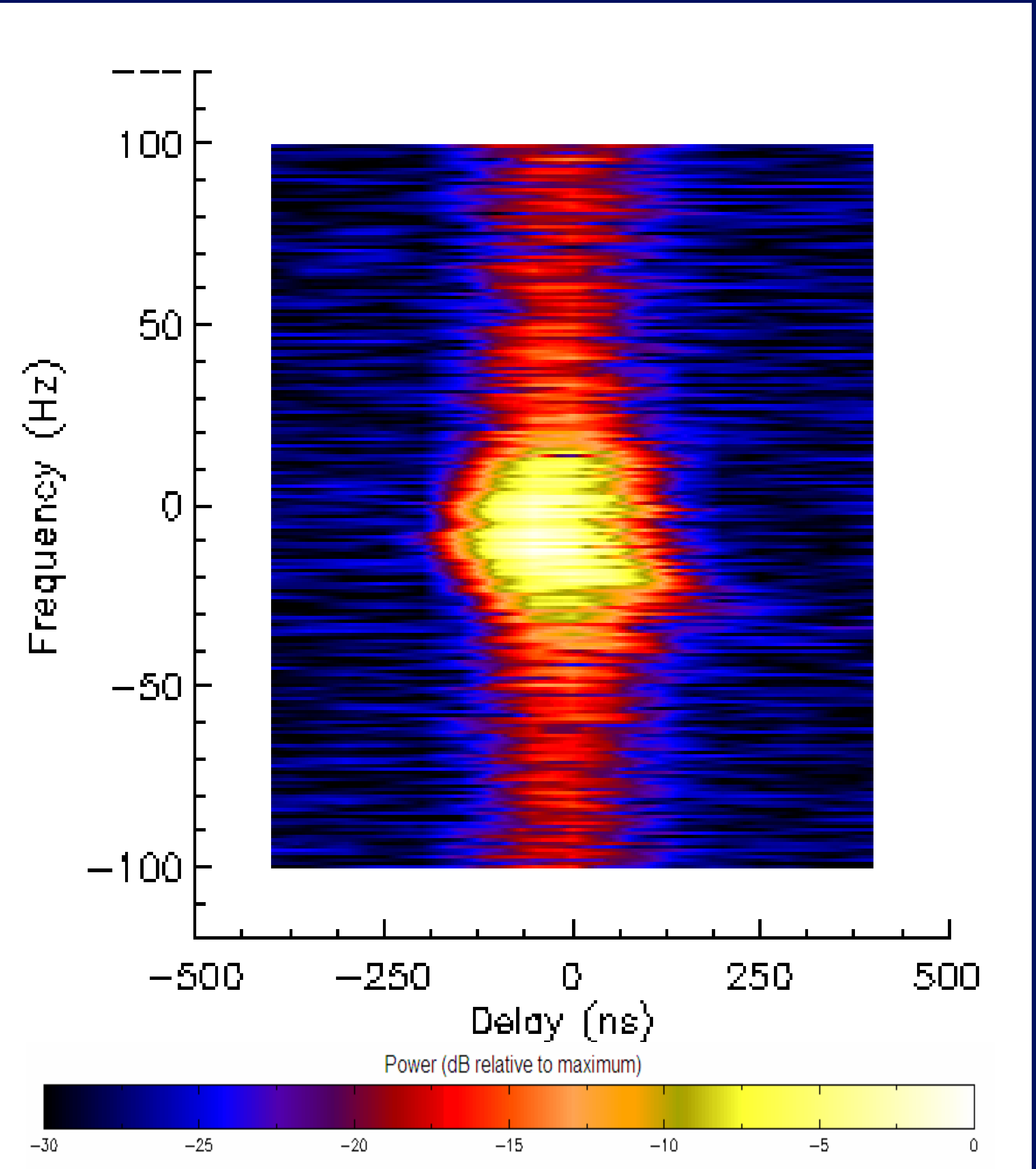
Centre gate, 1 Hz resolution

UHF Doppler Time Intensity, 18 Jan 05



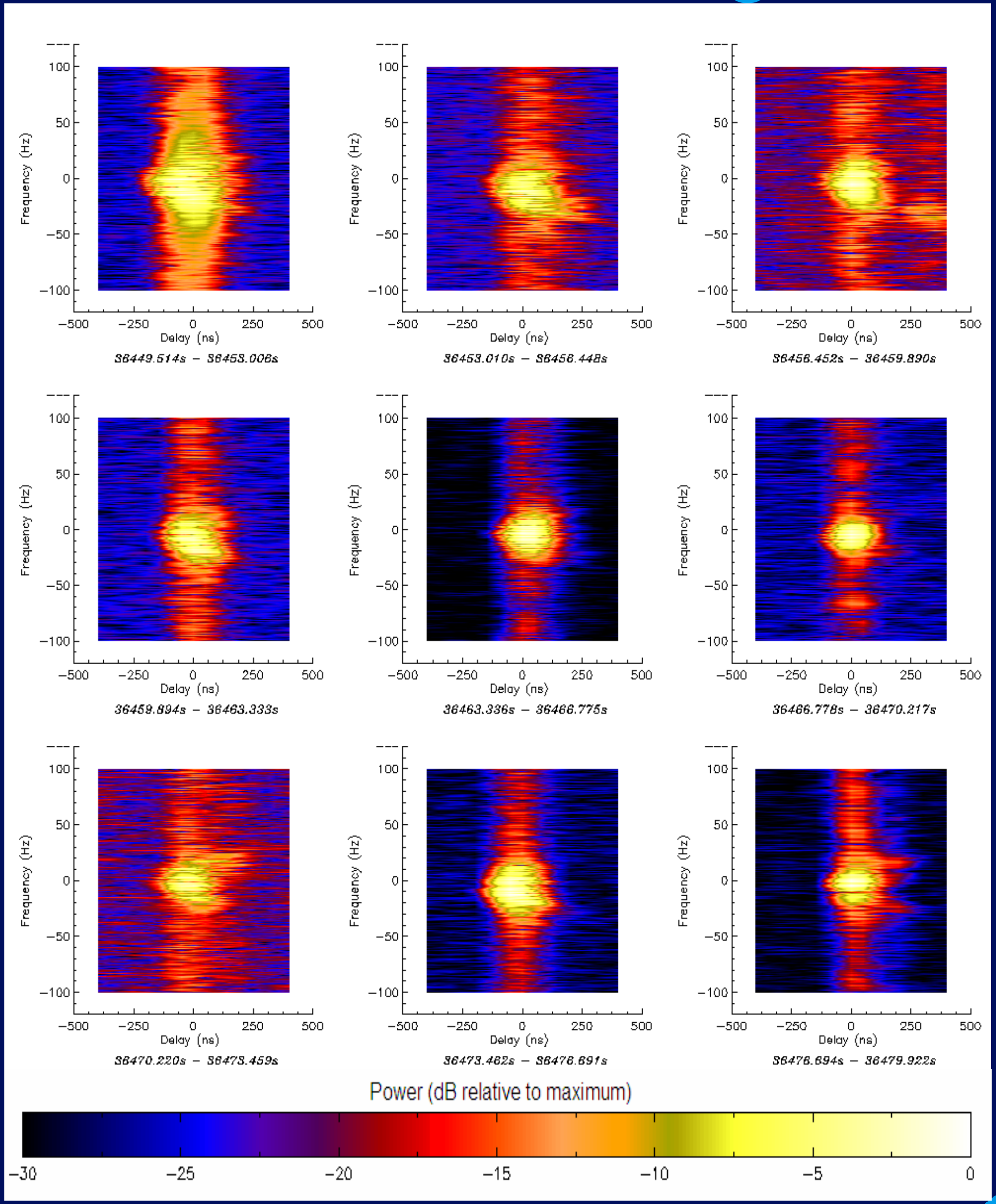
Centre gate, 1 Hz resolution

Single VHF Scattering Function



~4 s average

VHF Channel Scattering Functions



~4 s average

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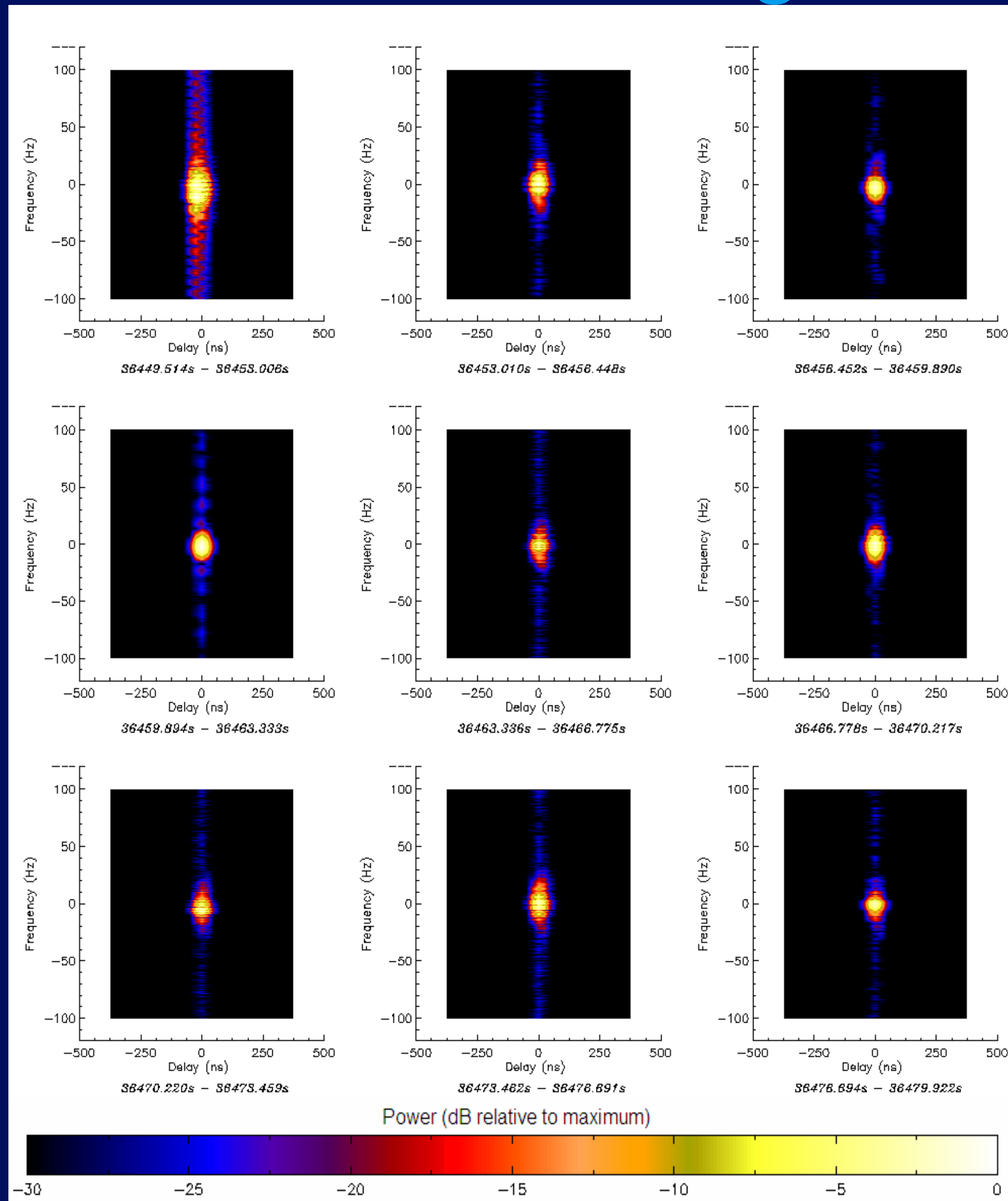
UHF Channel Scattering Functions



~4 s average

Coherency Time and Bandwidth

- The coherency time (*CT*) and coherency bandwidth (*CB*) are variously defined. For simplicity, we have chosen:

$$CT = \frac{1}{\Delta B}$$

$$CB = \frac{1}{2\pi \Delta T}$$

- where, ΔB is the Doppler induced bandwidth and ΔT is the multipath spread.
- Both are taken to include 68 % of the power (-2.2 dB for a normal distribution).

Summary

		Typical multipath and corresponding coherency bandwidth		
VHF		200 ns 0.8 MHz		
UHF		100 ns 1.6 MHz		

Summary

	Typical Doppler and corresponding coherency time	Typical multipath and corresponding coherency bandwidth		
VHF	50 Hz 20 ms	200 ns 0.8 MHz		
UHF	25 Hz 50 ms	100 ns 1.6 MHz		

Summary

	Typical Doppler and corresponding coherency time	Typical multipath and corresponding coherency bandwidth	Maximum Doppler and corresponding coherency time	Maximum multipath and corresponding coherency bandwidth
VHF	50 Hz 20 ms	200 ns 0.8 MHz	80 Hz 12.5 ms	300 ns 0.5 MHz
UHF	25 Hz 50 ms	100 ns 1.6 MHz	40 Hz 25 ms	125 ns 1.2 MHz