



PERÚ

Ministerio  
del Ambiente

Instituto  
Geofísico del Perú - IGP

Dirección  
Científica

Radio Observatorio  
de Jicamarca

# Experiment design at Jicamarca Radio Observatory

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# Jicamarca antenna



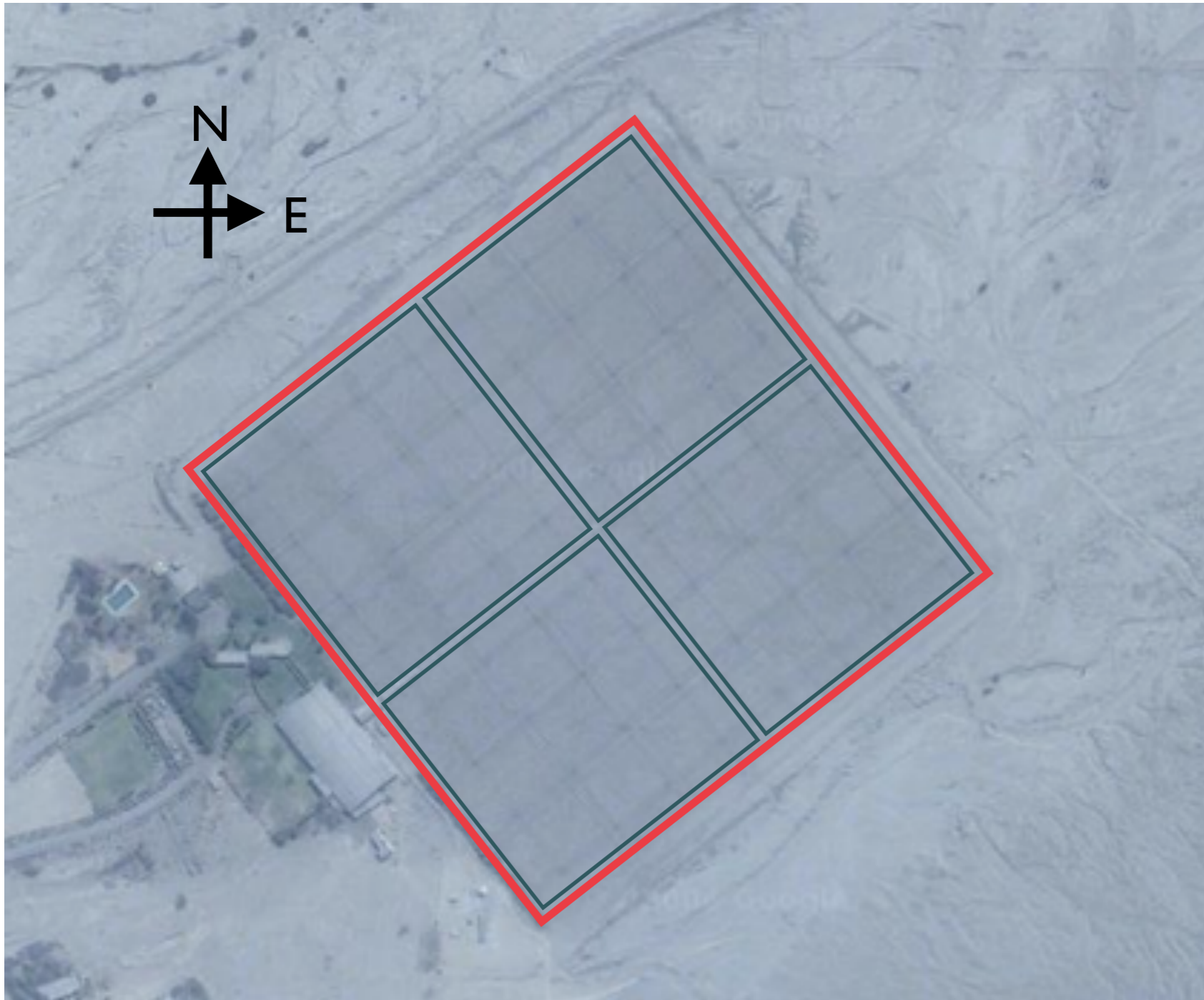
18432 dipole elements

Area approximate 85000 m<sup>2</sup>

2 polarizations



# Jicamarca antenna



Phase array antenna

Each polarization is divided in quarters



# How do we change the beam direction?

North Quarter				East Quarter			
4/2	4/2	5/3	5/3	2/2	5/2	3/3	A 2/3
4/2	5/3	5/3	2/4	3/5	2/5	B 4/2	C 3/2
5/3	5/3	2/4	2/4	D 4/3	3/3	5/4	4/4
5/3	2/4	2/4	3/5	5/2	4/2	2/3	5/3

West Quarter				South Quarter			
2/4	5/4	3/5	2/5	5/3	5/3	*E 2/4	2/4
3/3	2/3	4/4	3/4	5/3	2/4	2/4	3/5
4/5	3/5	5/2	4/2	2/4	2/4	3/5	3/5
F 5/4	4/4	G 2/5	5/5	2/4	3/5	3/5	4/2

**H** Hysell Module

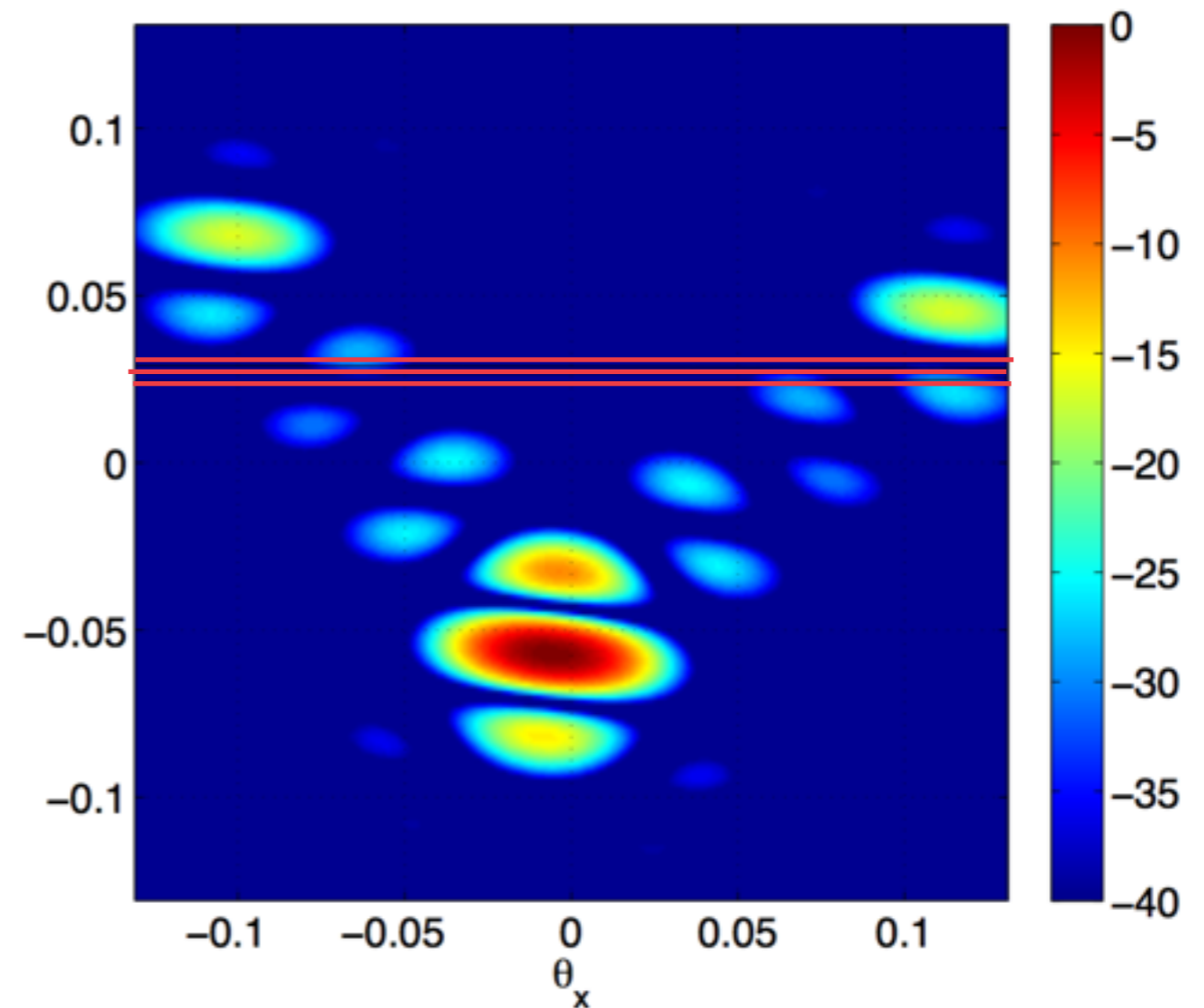
- We change the direction by changing the phase of each antenna module
- Typical beamwidth -  $1^\circ$
- Maximum beam steering -  $3^\circ$  in all directions

# Experimental Modes

## Antenna beam pattern

South Beam

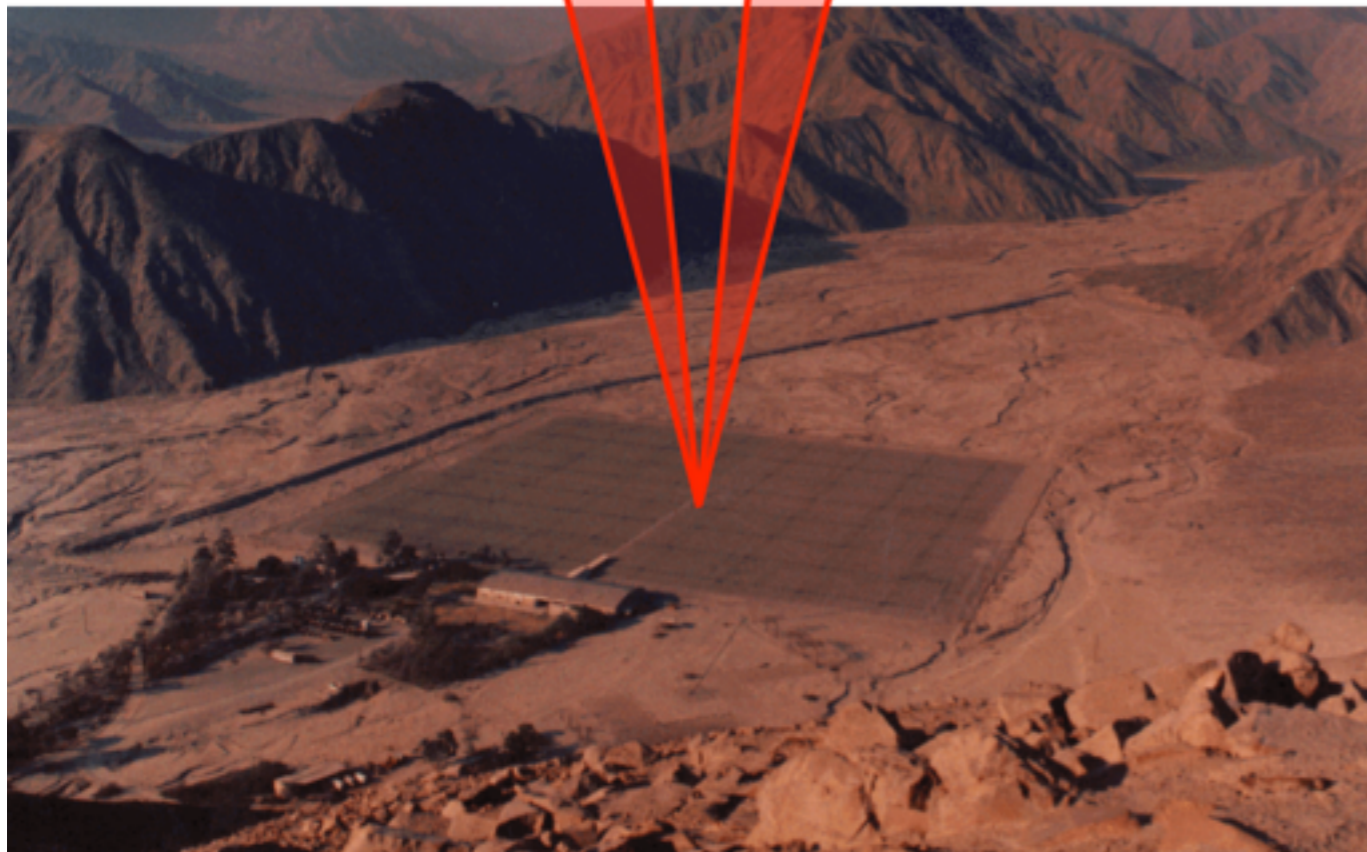
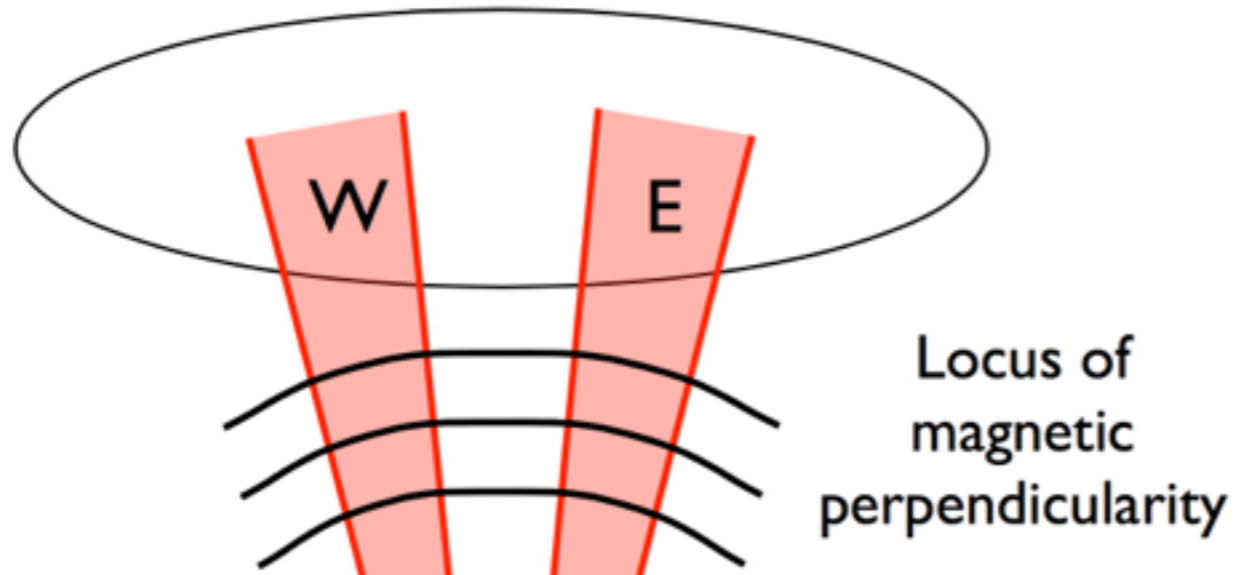
D2W = 79.7 dB – ABS = 6942



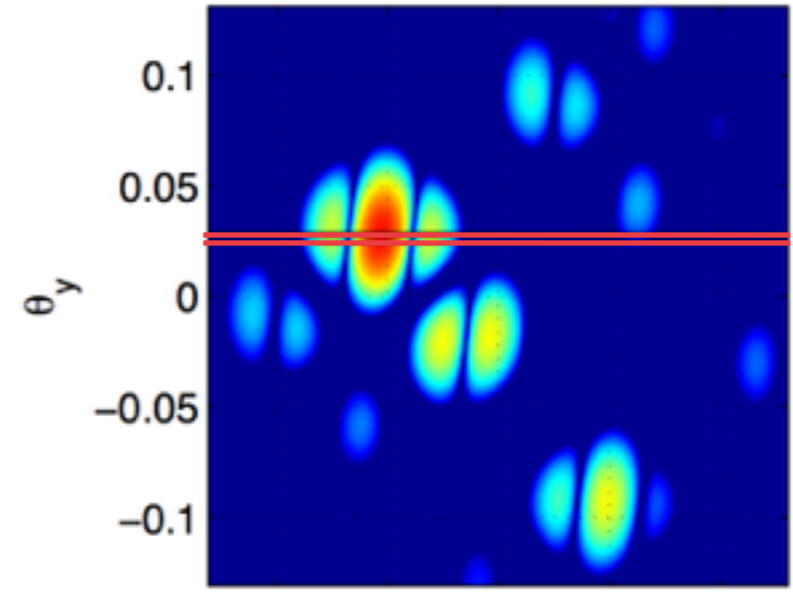
- EW - Drifts (perpendicular to the magnetic field)
- Faraday (off-perpendicular to the magnetic field)
- Imaging (to study coherent echoes!)

Scattering from the F-region

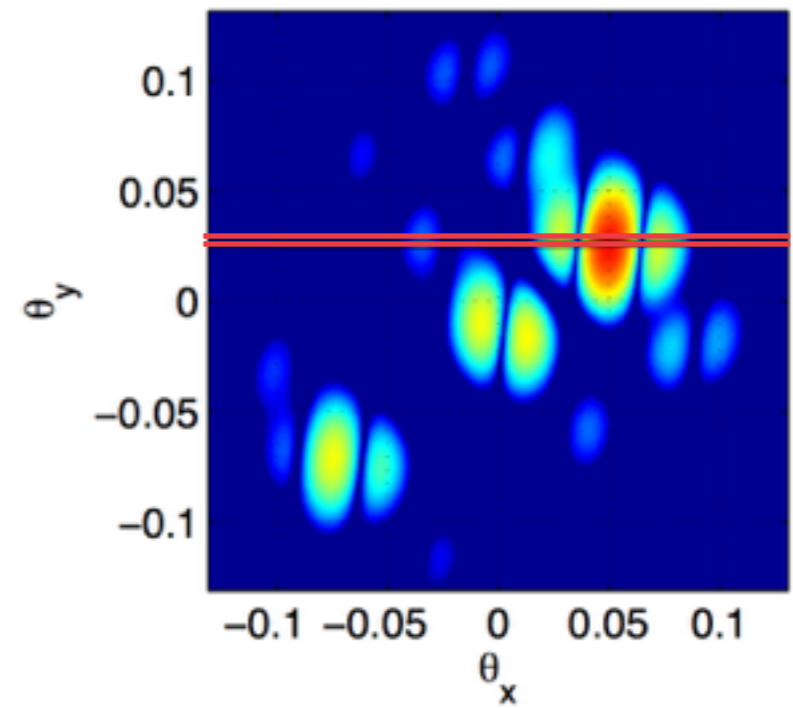
# EW-Drifts



West Beam 1 (Up)  
 D2W = 73.91 dB  
 ABS = 2833.6 - COH = 0.52

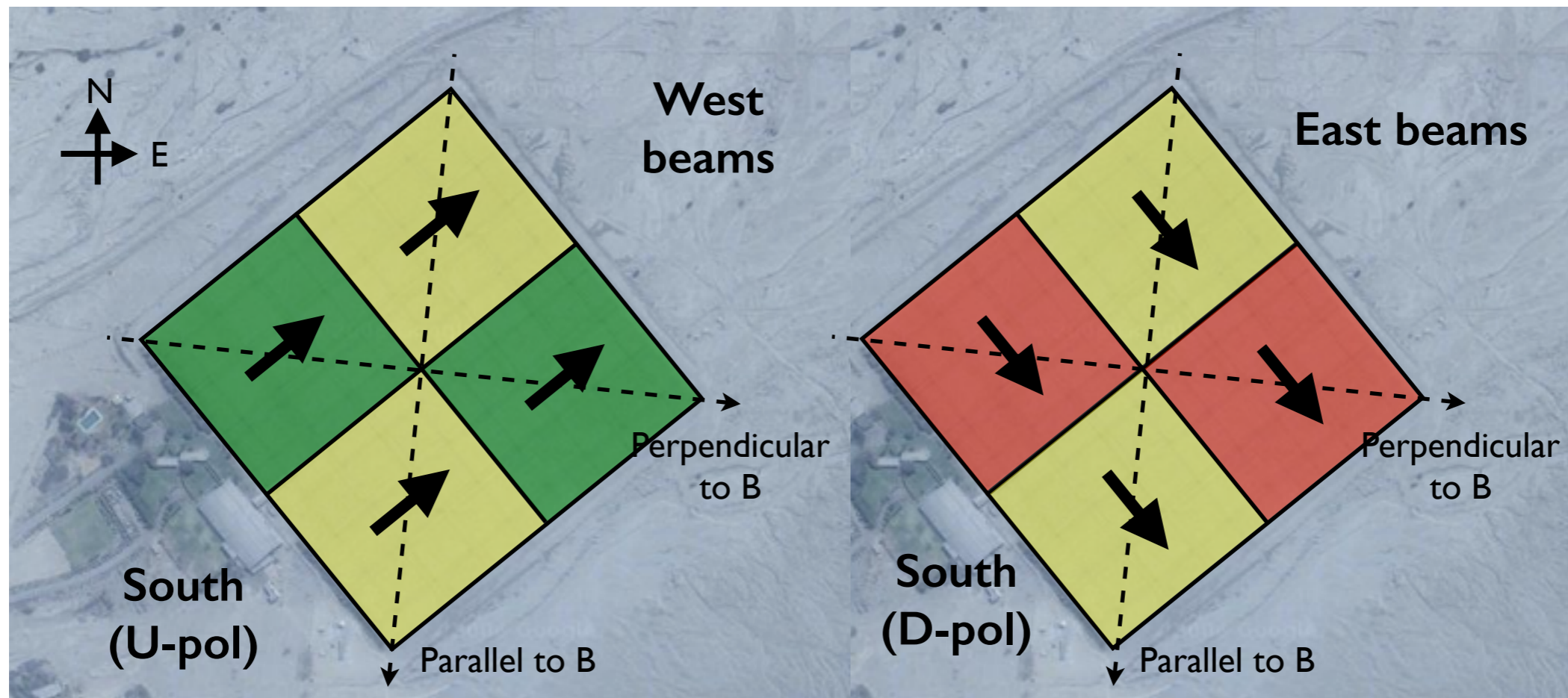


East Beam 1 (Dn)  
 D2W = 73.84 dB  
 ABS = 2830.4 - COH = 0.52

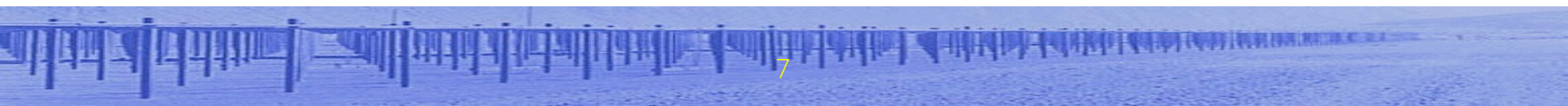


# EW-Drifts perp-to-B

U-pol excites and detects the West beams



D-pol is used for East beams



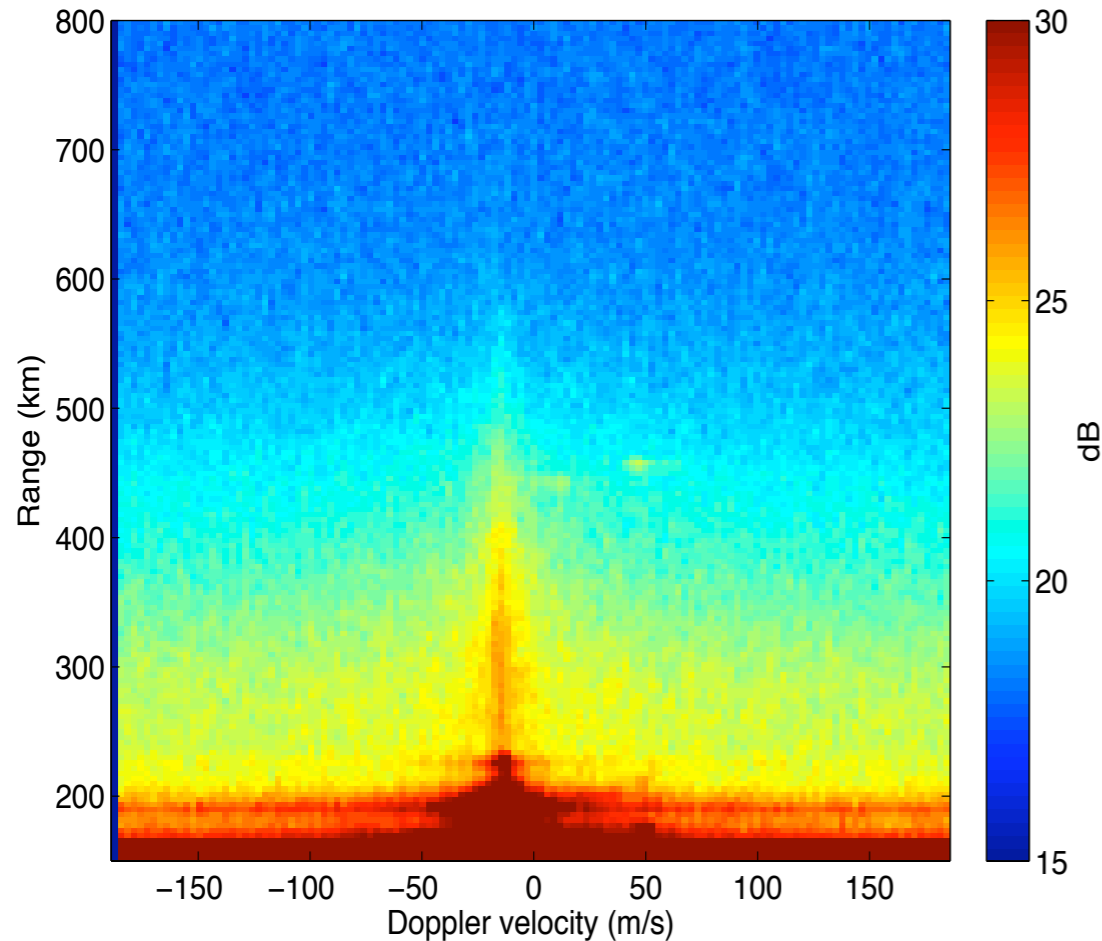
# EW-Drifts experiment: configuration parameters

Parameter	Value
IPP	1000 km
Tx A	45 km
Code	Barker 3 FLIP (110 - 001)
h0 (initial height)	0 km
sample spacing	5 km
Number of samples	200



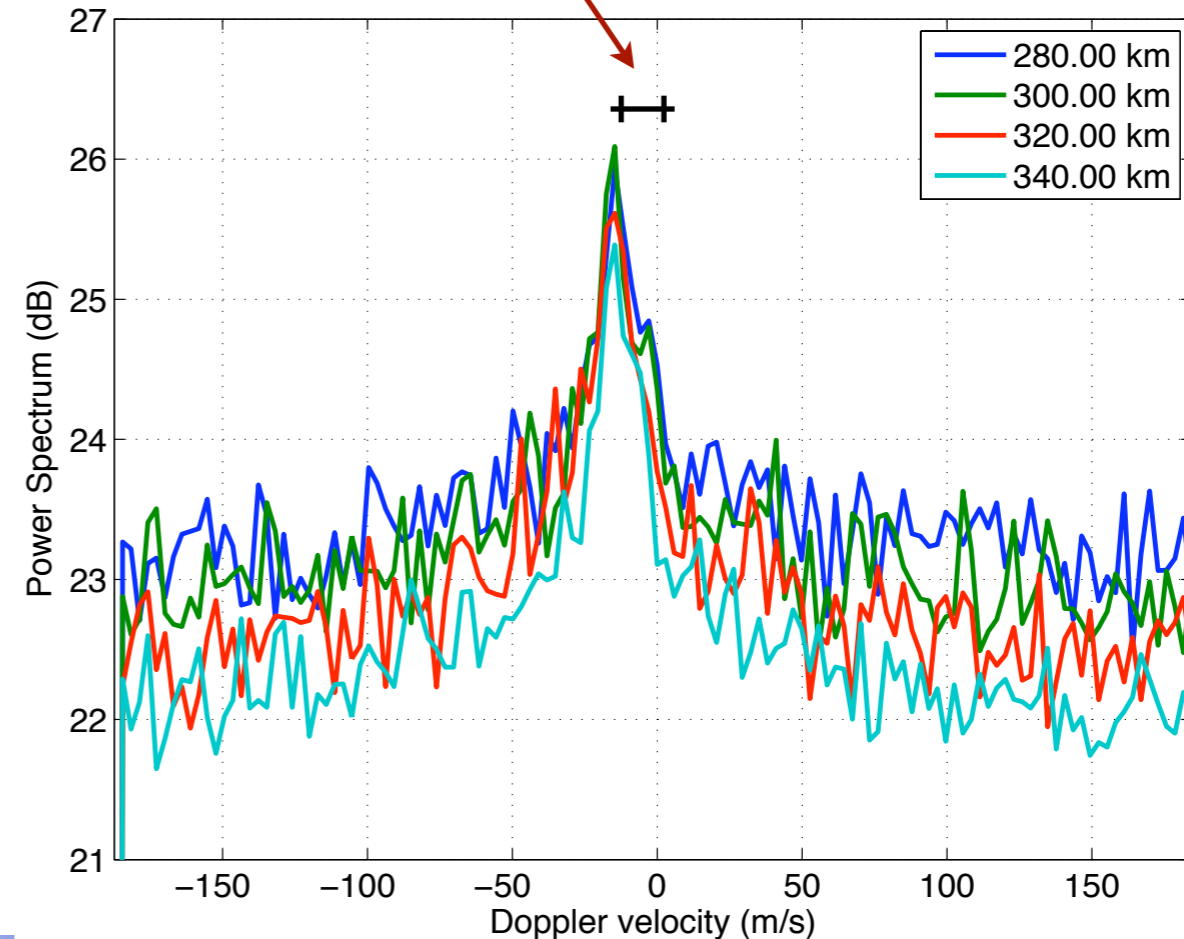
# EW-Drifts mode: Perp-to-B ISR

Channel 1 – 2004-06-08 11:55:00



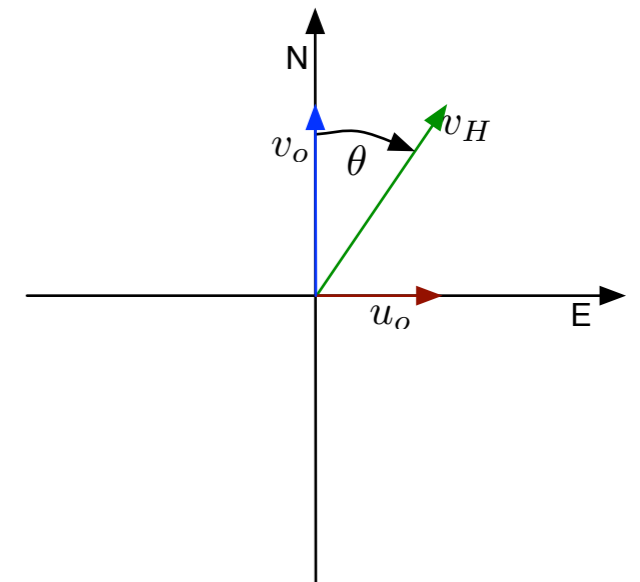
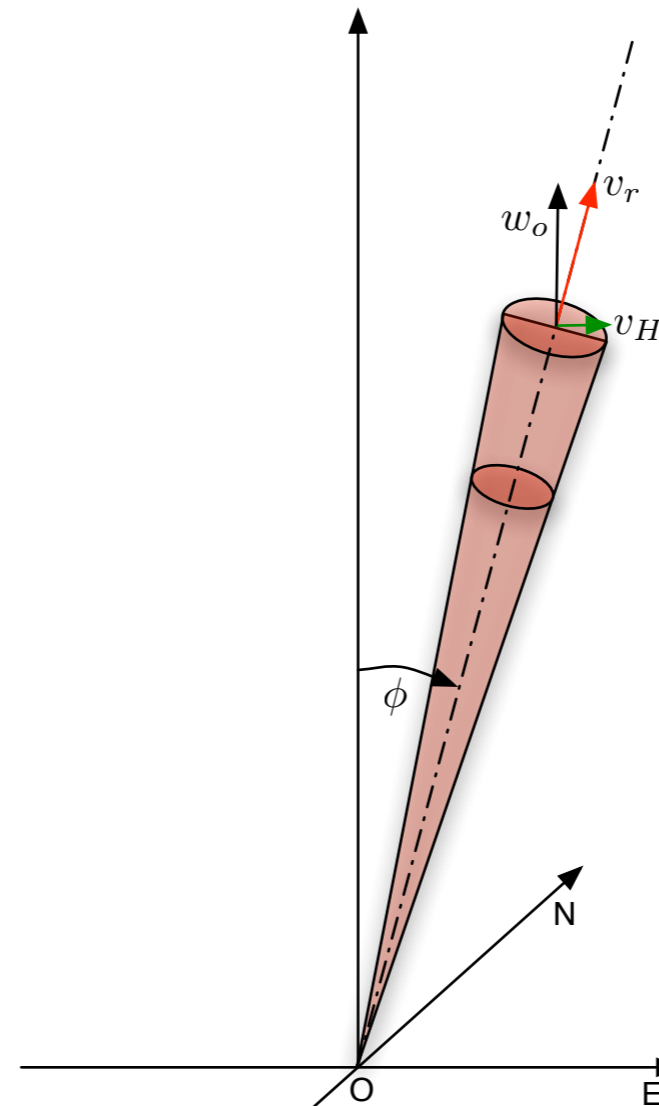
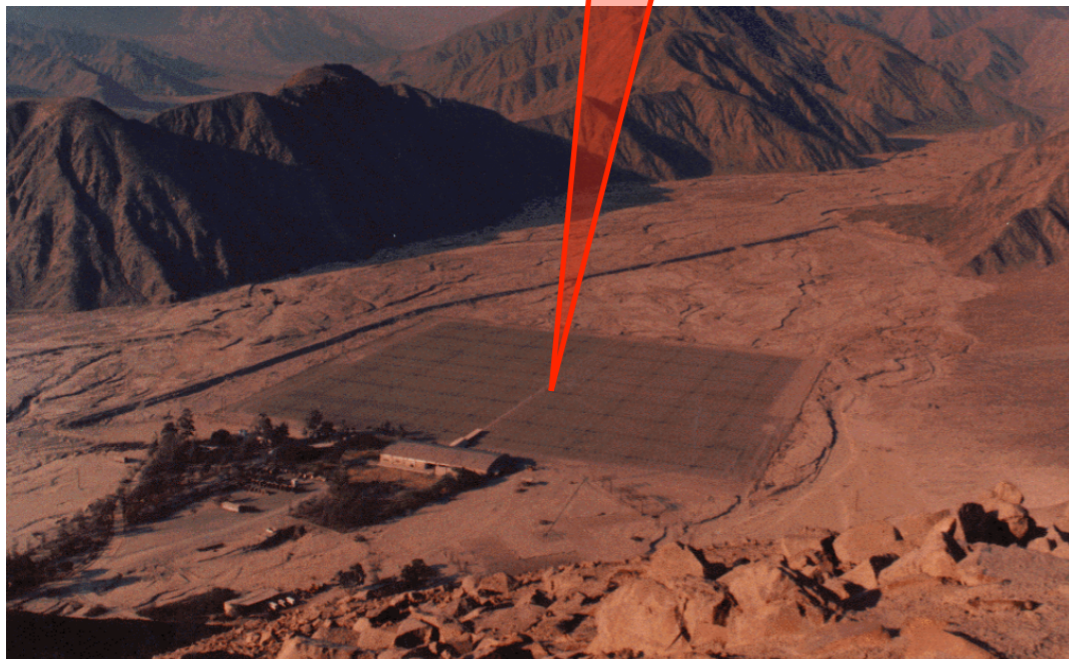
Doppler shift of the spectrum is directly proportional to the drift.

Channel 1 – 2004-06-08 11:55:00



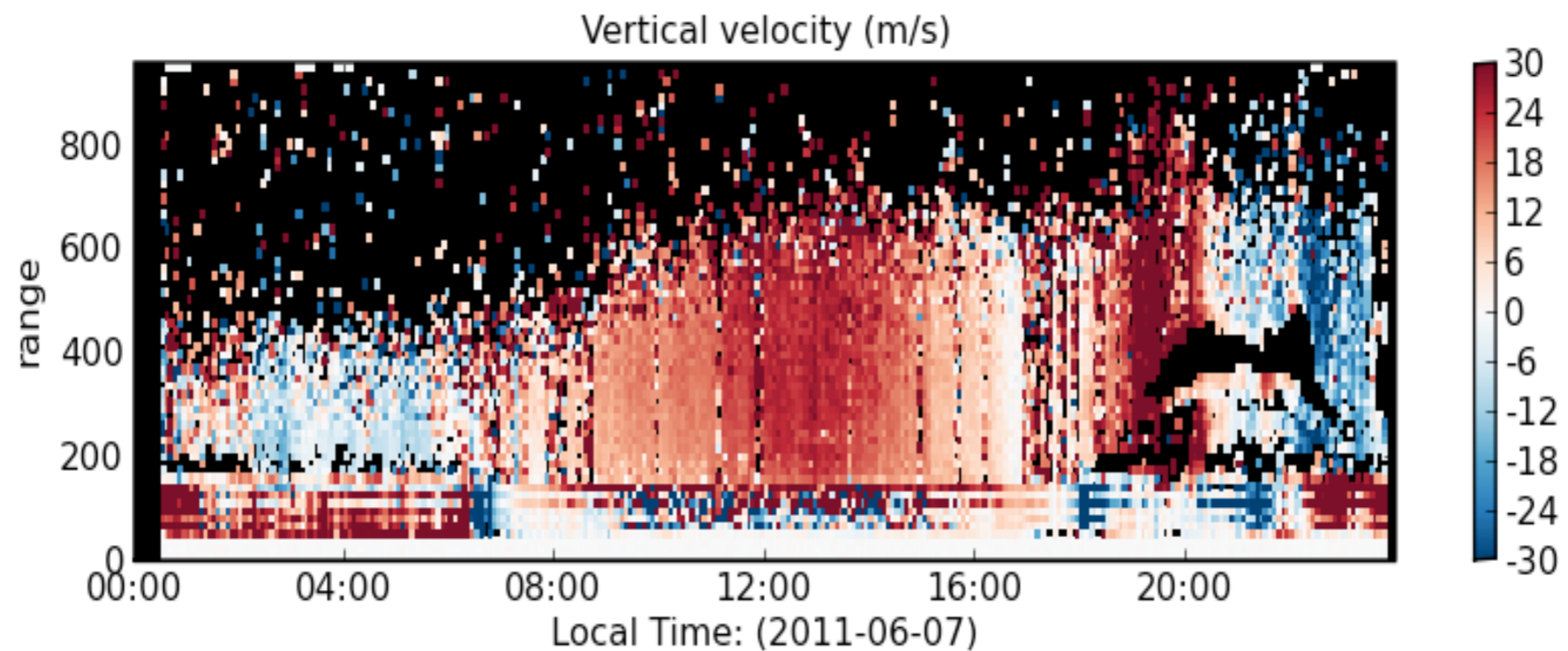
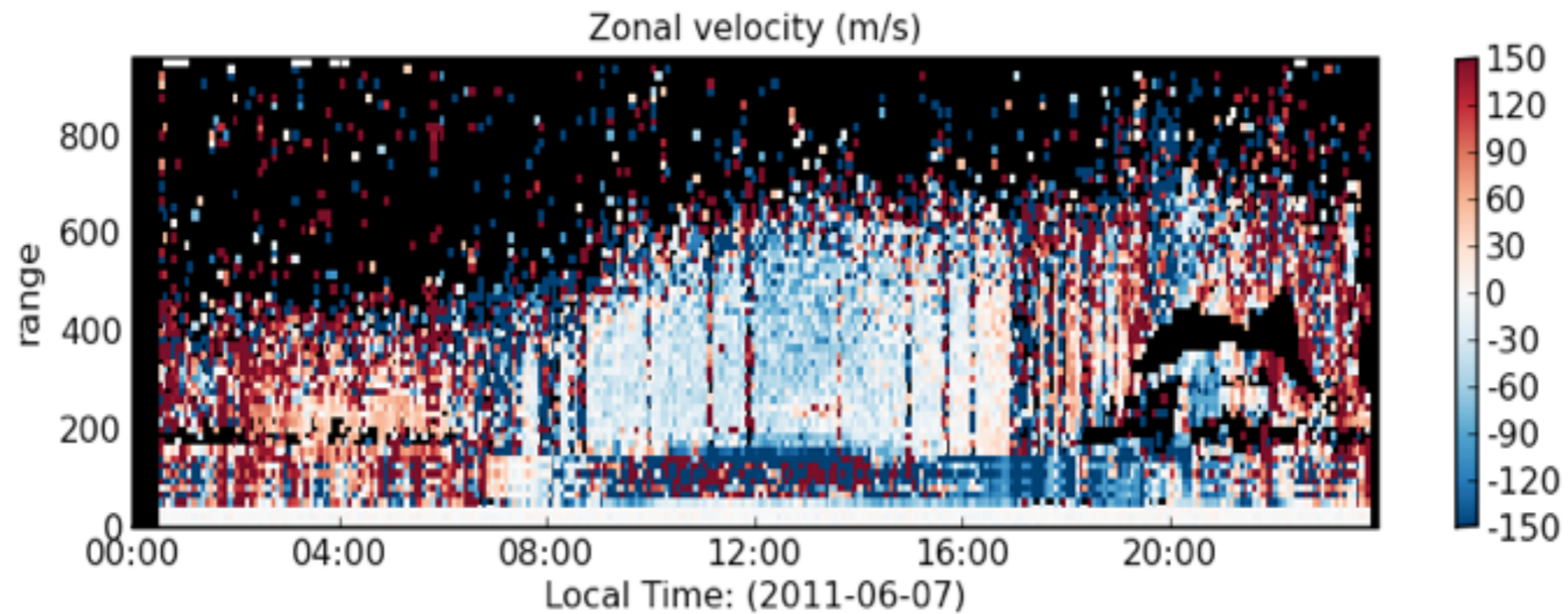
Typical perpendicular-  
to-B spectra  
(very narrow)

# Doppler beam swinging (DBS)



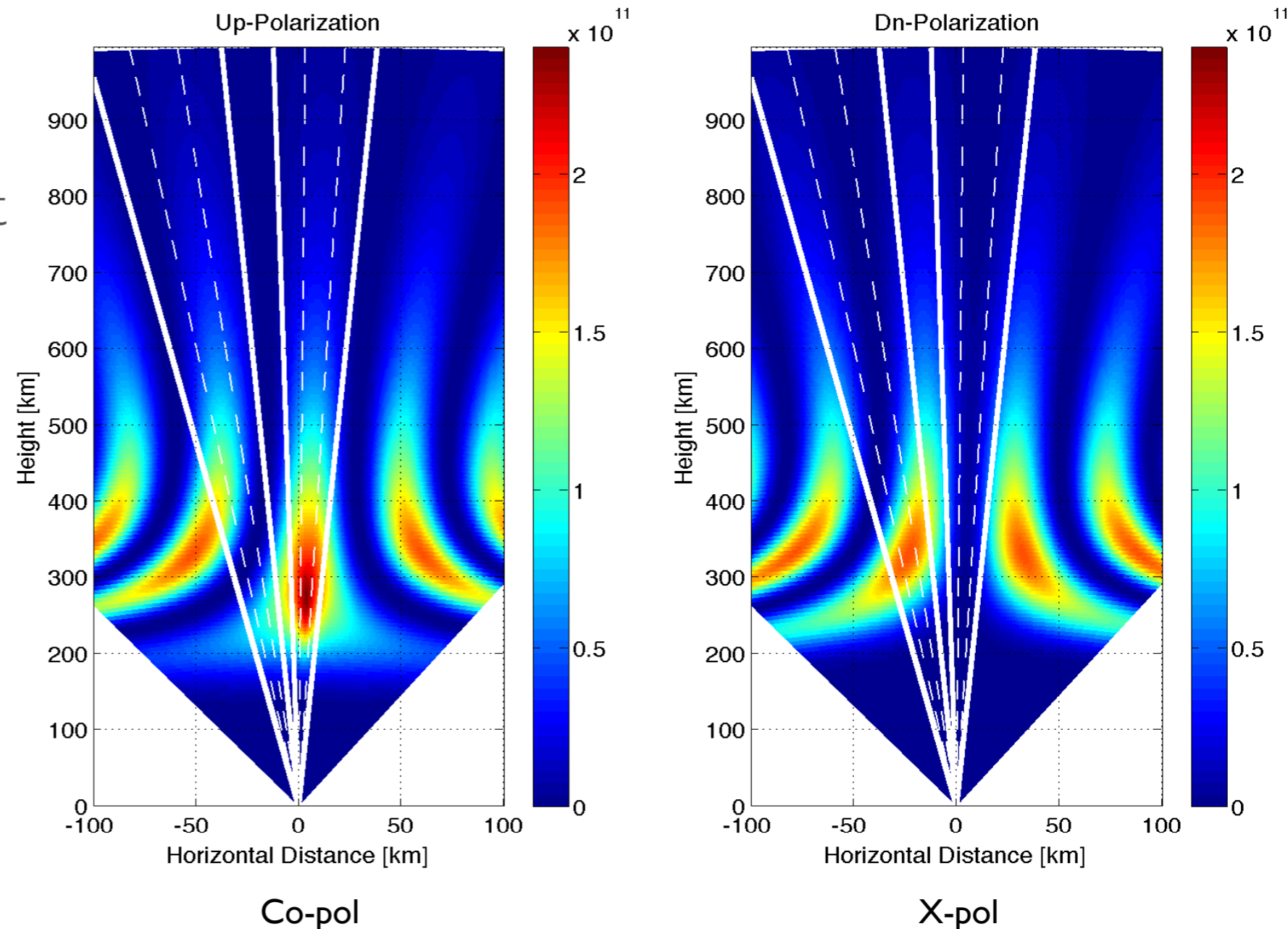
$$v_r(\theta, \phi) = u \sin \theta \sin \phi + v \cos \theta \sin \phi + w \cos \phi$$

# EW-Drifts mode: Perp-to-B ISR

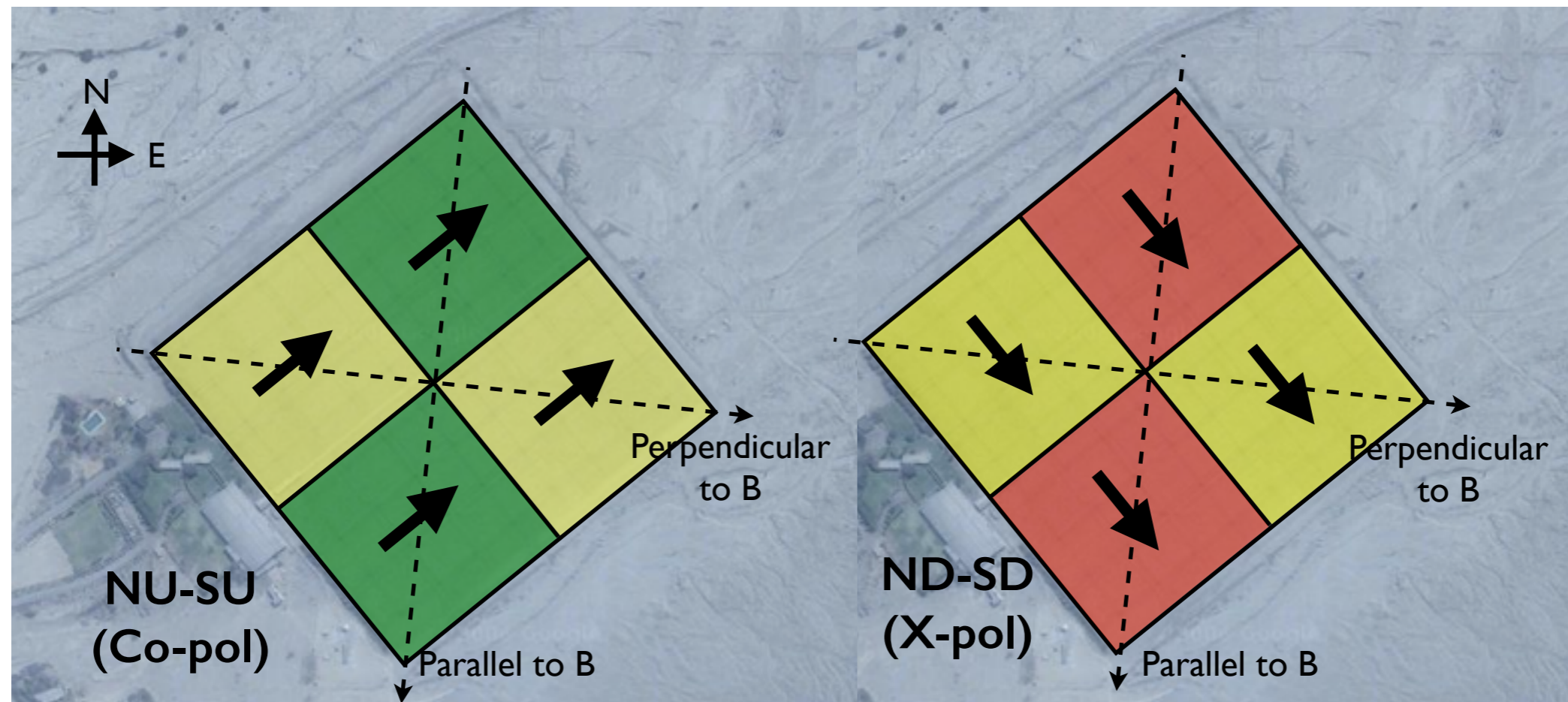


# Faraday mode: off-perp ISR

- At JRO (50 MHz)  
Magneto-Ionic propagation is important
- For propagations effects a few degrees from perp-to-B, Faraday effects take place (polarization rotates as the wave propagates)
- The effects are due plasma density ( $N_e$ ) and magnetic field ( $B$ )



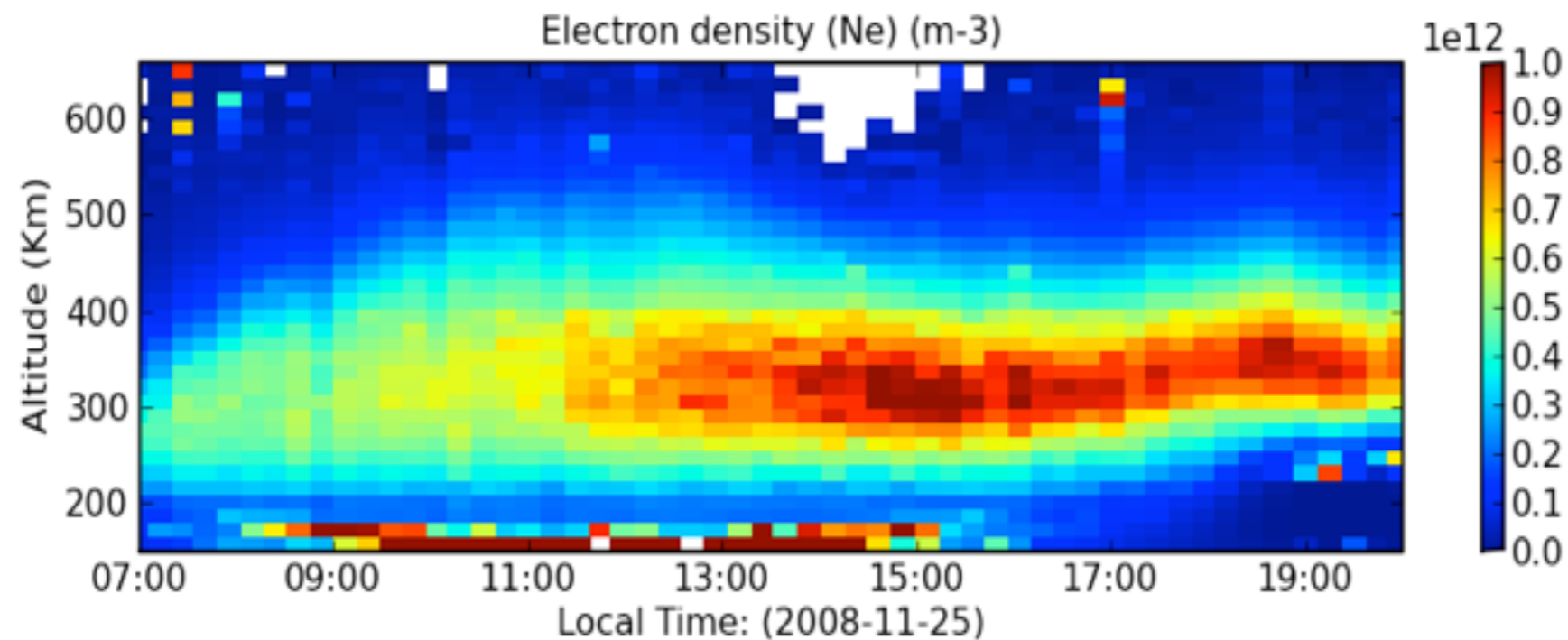
# Faraday mode: off-perp ISR



# Faraday experiment: configuration parameters

Parameter	Value
IPP	1000 km
Tx A	15 km
Tx B	15 km
Tx B (delays)	22 taus: 0, 0, 30, 30, 60, 60, 90, 90, 120, 120, 150, 150, 180, 180, 210, 210, 240, 240, 270, 270, 300, 300
Code TxB	FLIP (0, 1)
h0 (initial height)	0 km
sample spacing	5 km
Number of samples	198

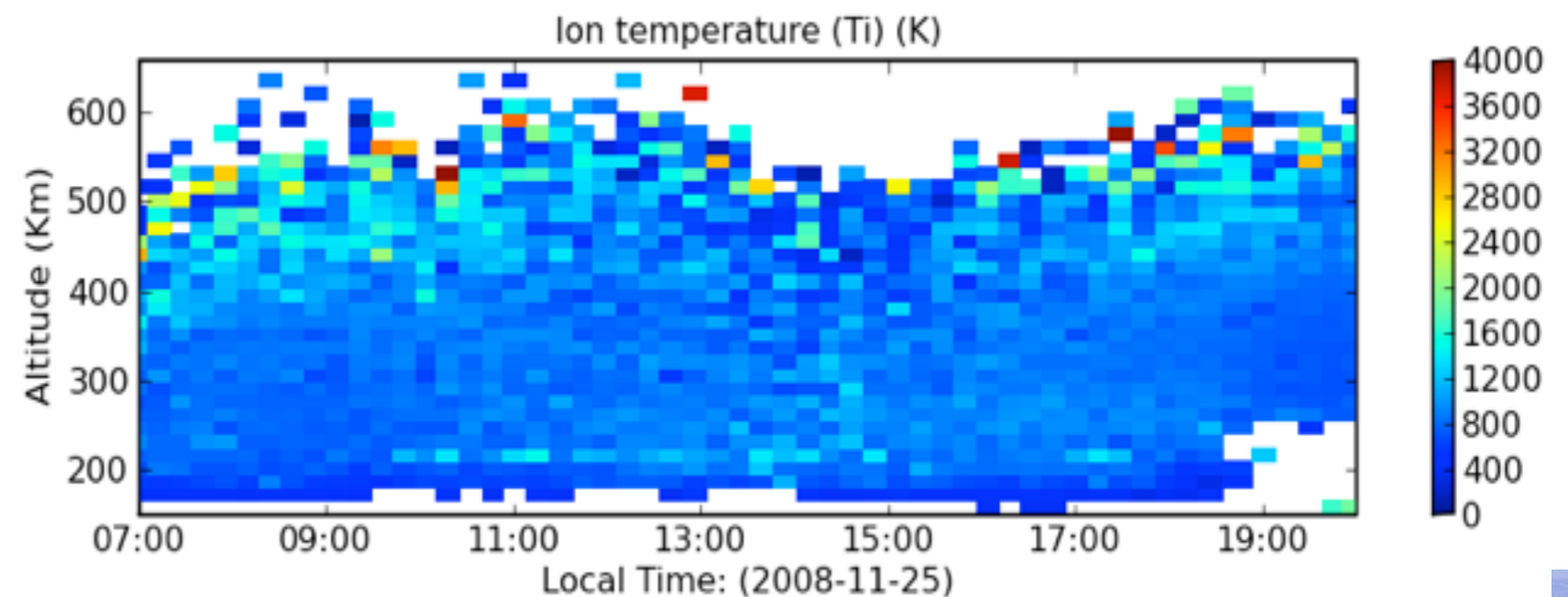
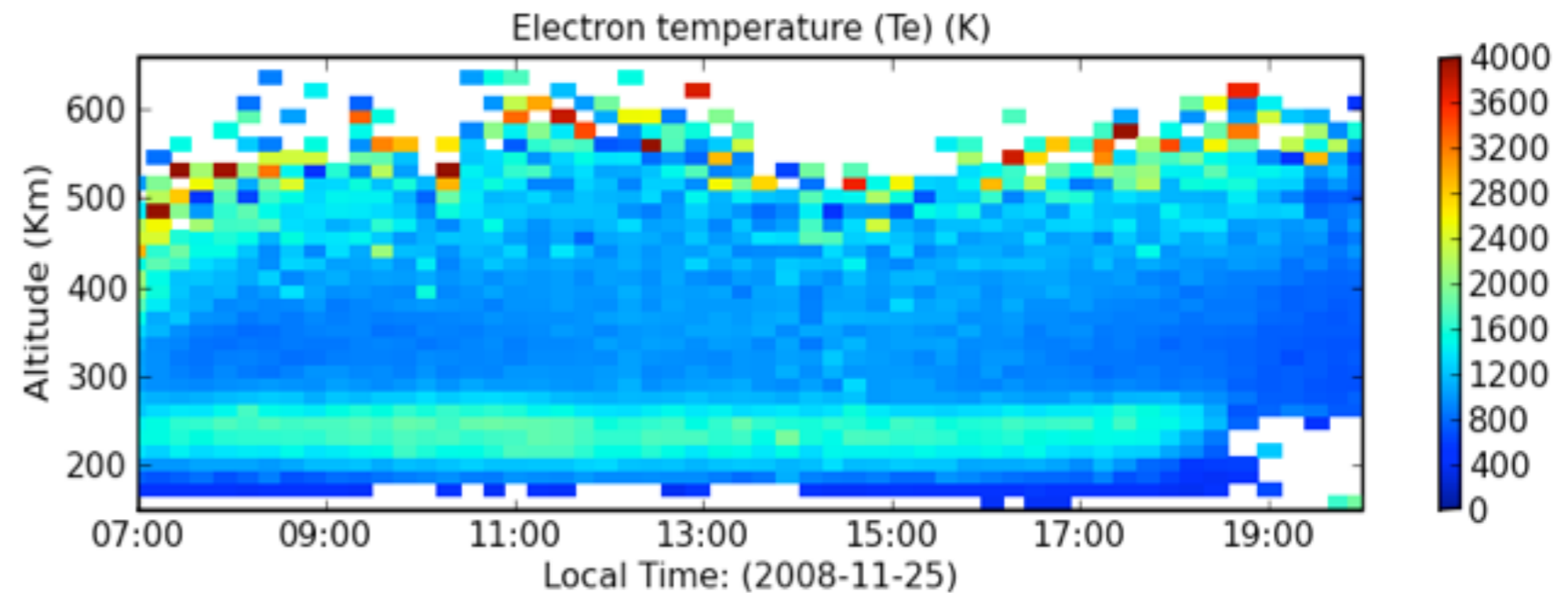
# Faraday mode: off-perp ISR



- $N_e$  profiles are obtained from the phase difference between circular propagation modes

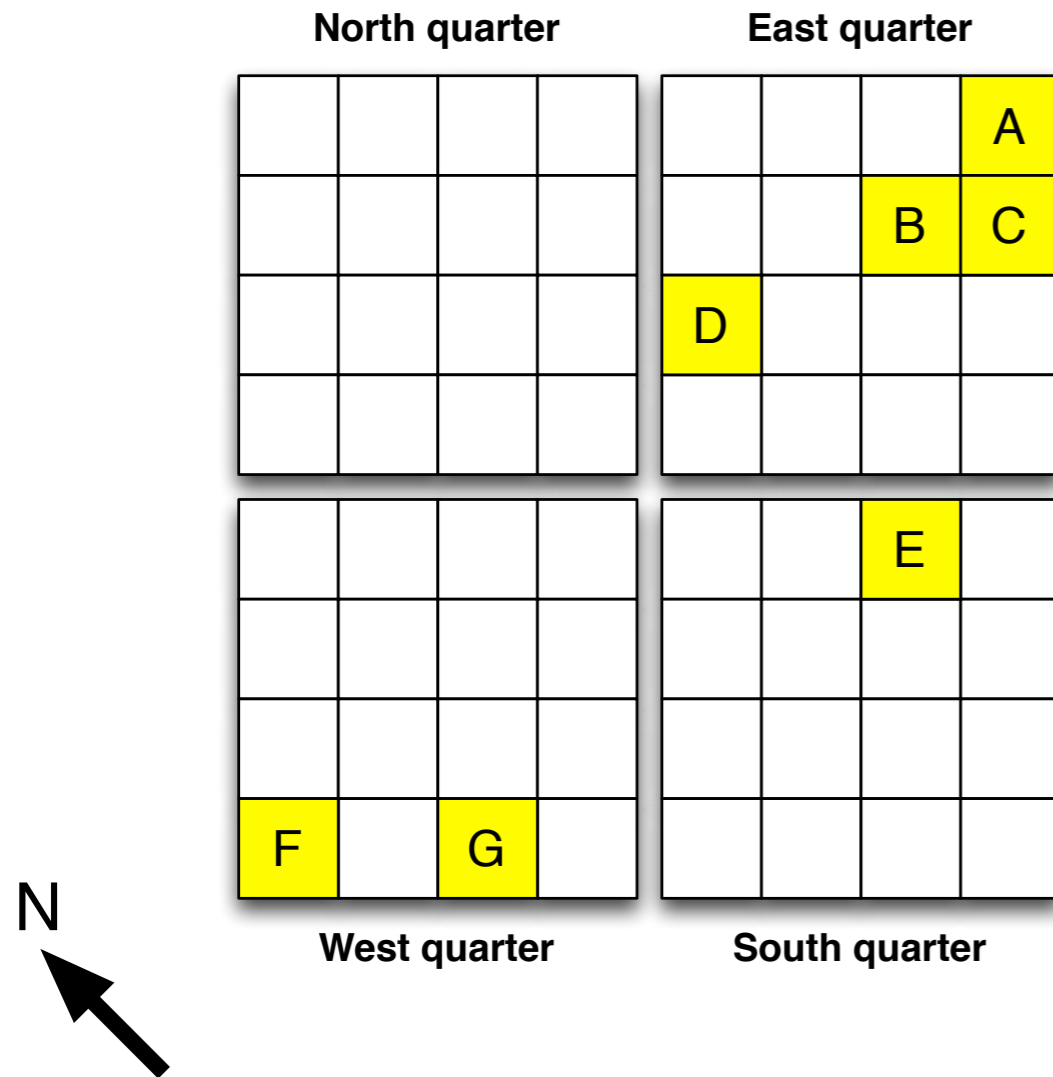
# Faraday mode: off-perp ISR

- $T_e$  and  $T_i$  are obtained from fits of measured ISR ACF



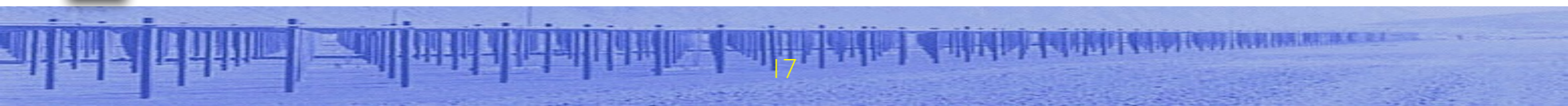


# Radar Imaging mode



- 8 receiving antenna modules aligned in EW direction.
- 60kW peak power on TX with one antenna module.

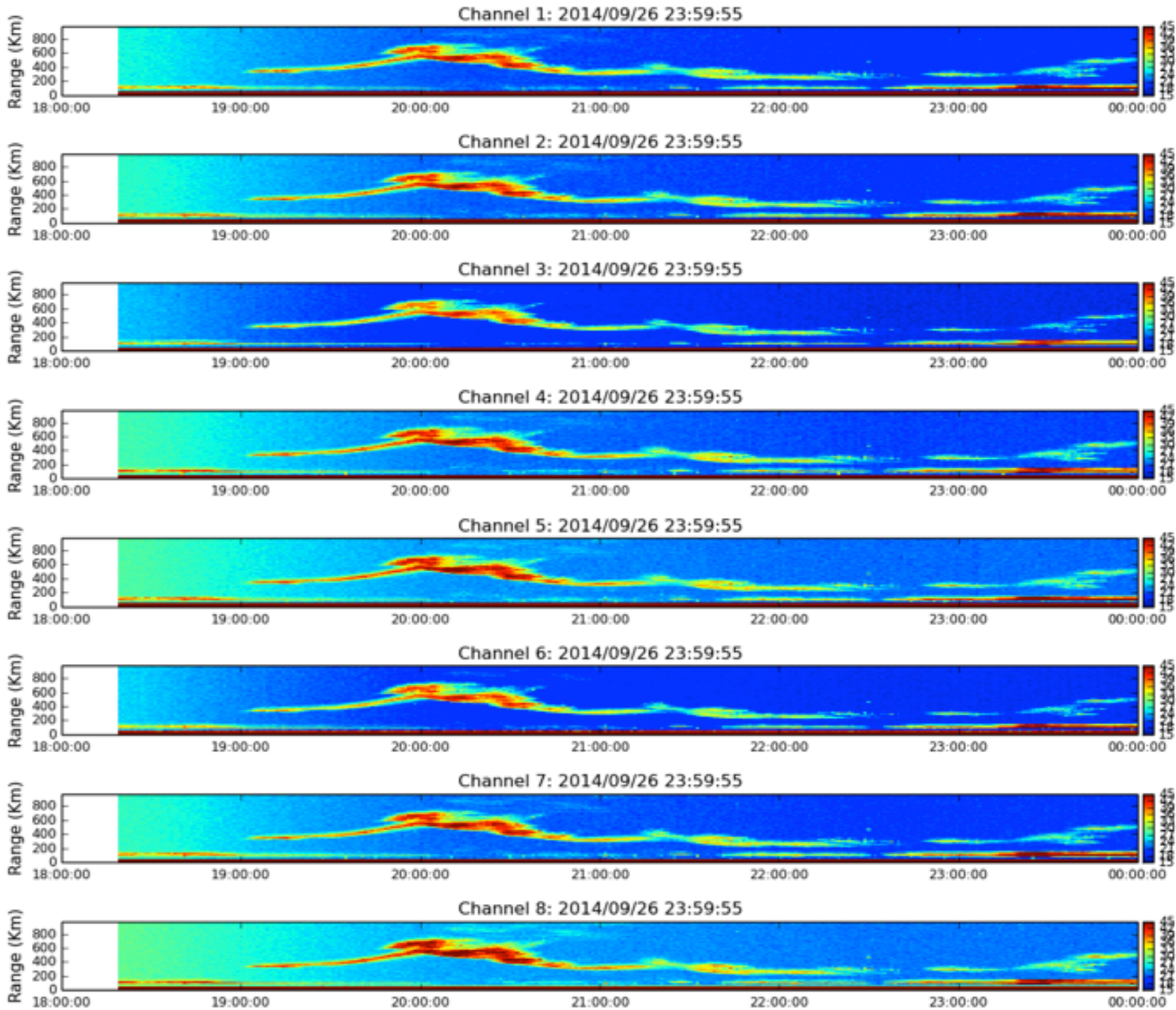
**H** Hysell module



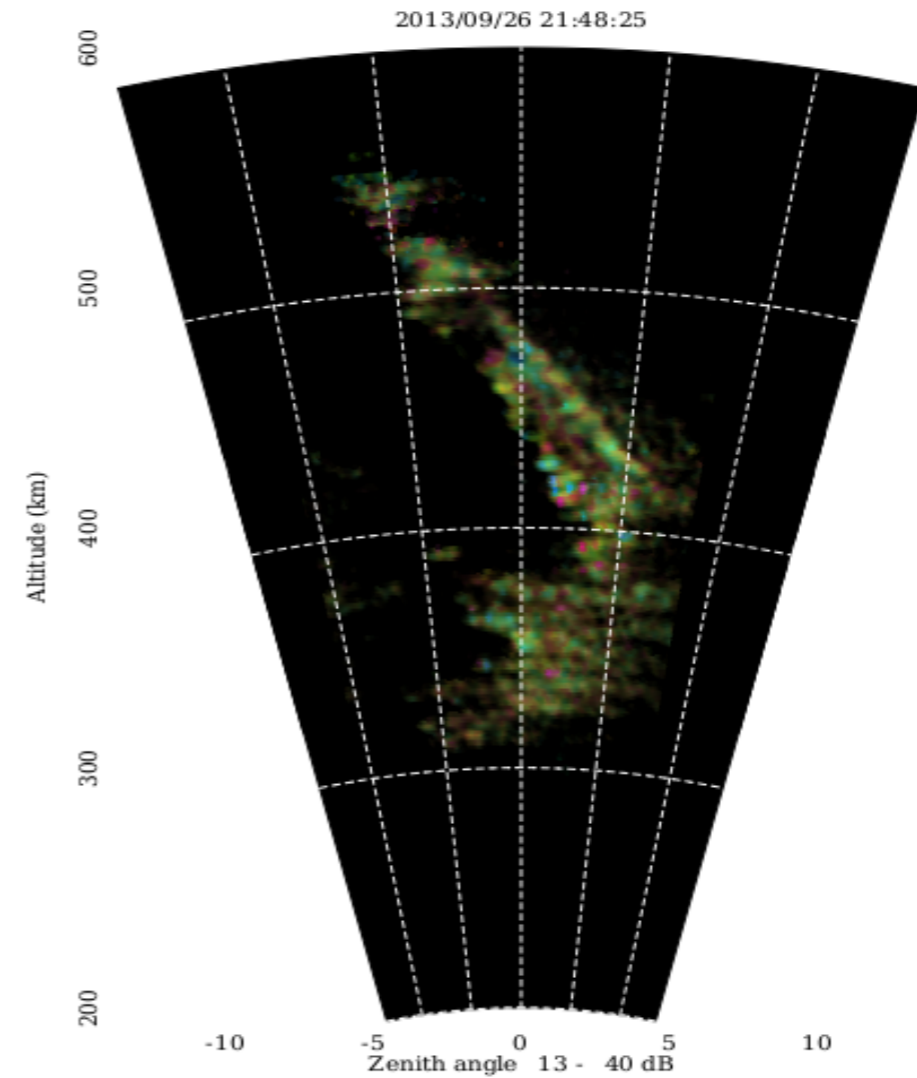
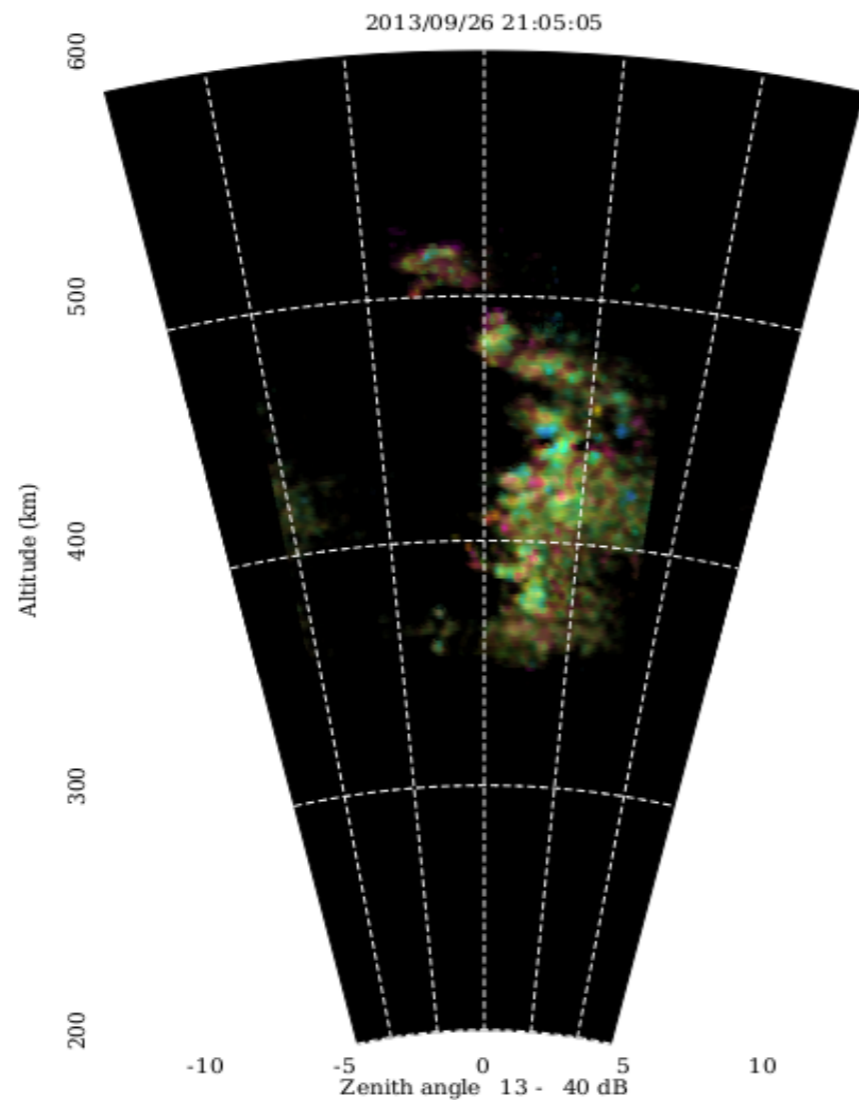
# Imaging experiment: configuration parameters

Parameter	Value
IPP	1000 km
TxA	48.75 km
Code TxA	Barker 13 Flip
h0 (initial height)	0 km
sample spacing	1.25 km
Number of samples	793

# 8 channel - Imaging



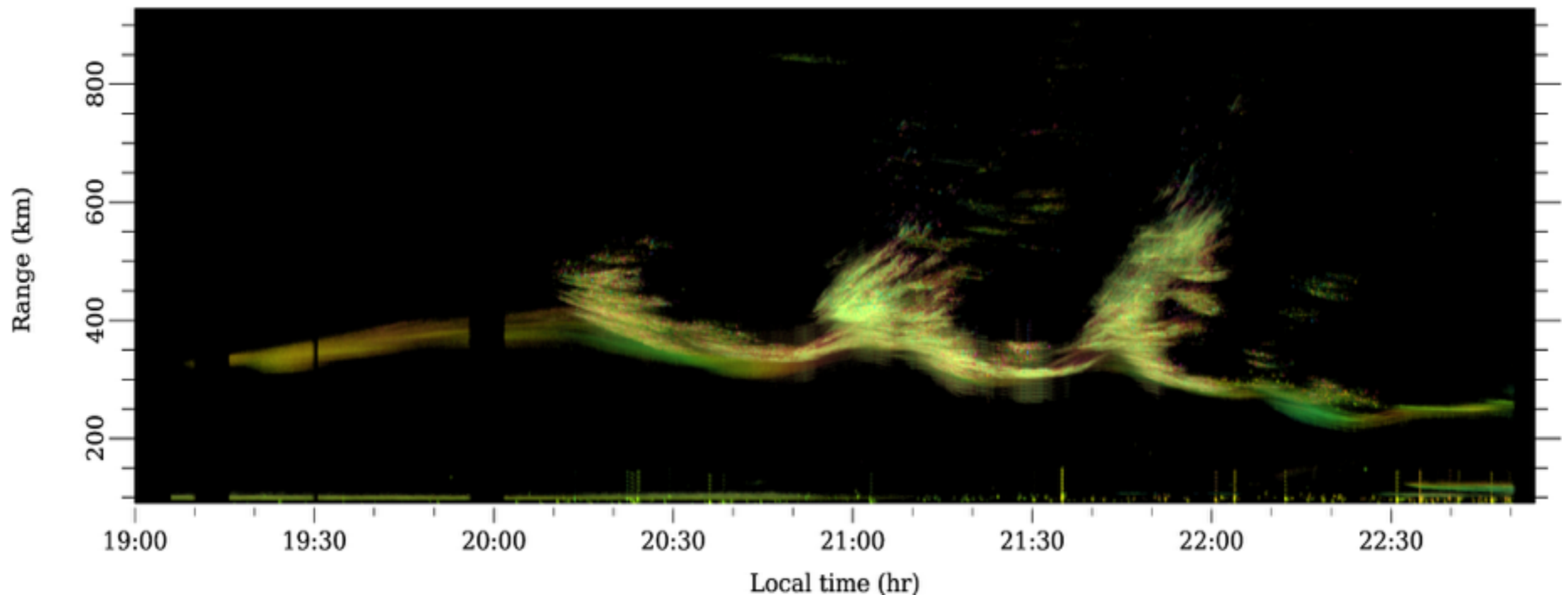
# Radar Imaging mode



- Maximum Entropy method to invert Spread-F images.

# RTDI (Range, Time, Doppler Intensity)

Thu Sep 26 19:06:07 2013



This set of data can be used to conduct simulation and forecasting studies of the equatorial ionosphere (e.g., Hysell et al [2014]).