# Observation of Plasma Density Structures in the Polar Cap Using the McMurdo SuperDARN Radar

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# Summary

- Development of plasma density estimate using SuperDARN ACF phase data.
  - Requires dual frequency radar operation
  - Requires new analysis algorithm
  - Technique is applicable to the full SuperDARN network
- Demonstrated on McMurdo
  - Observed spatially resolve density patch structures
  - Density structuring compares well with available satellite derived TEC

# Motivation

Doppler velocity should depend on index of refraction

$$\omega_{Doppler} = 4\pi F_t \frac{V_{los}}{C} n_s$$

but SuperDARN fitted data products typically assume:

$$n_s = 1$$

taking a simple model for index of refraction:

$$n_s = \sqrt{1 - F_c^2 / F_t^2}$$

the velocity estimate becomes:

$$\omega_{Doppler} = 4\pi F_t \frac{V_{los}}{C} \sqrt{1 - F_c^2 / F_t^2}$$

# Bayesian Analysis

A model function appropriate for SuperDARN ACF:

$$M(V_{los}, F_c, t_{lag}, F_t, \alpha) = Z(\alpha, t_{lag})[A\,\mathrm{e}^{i\omega t_{lag}} + i B\,\mathrm{e}^{i\omega t_{lag}}]$$

$$\omega = 4\pi F_t \frac{V_{los}}{C}\sqrt{1 - F_c^2/F_t^2}$$

Probability distribution for model parameters becomes:

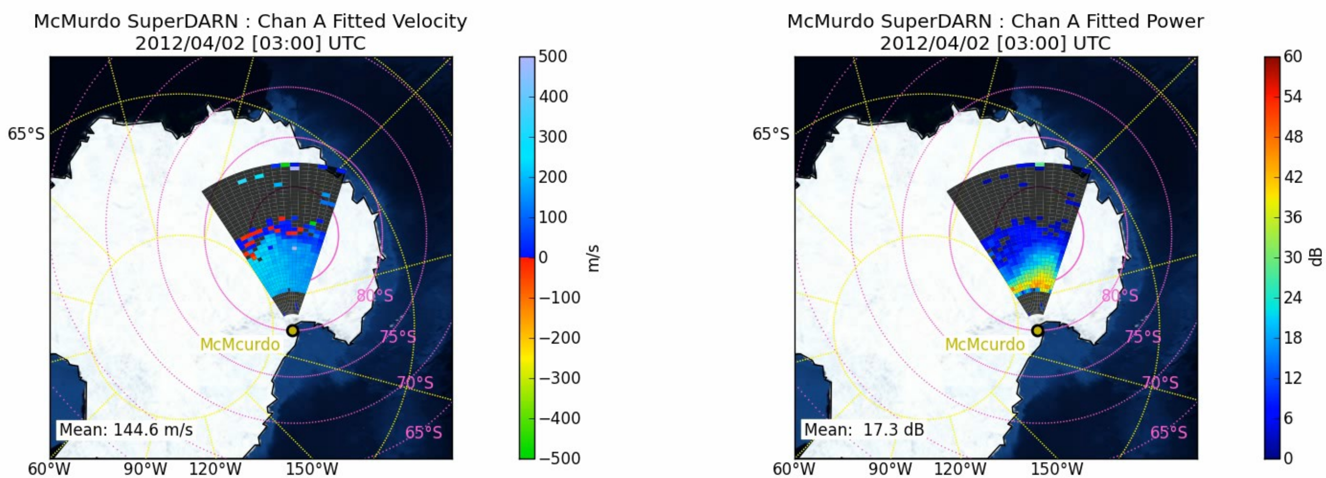
$$P(V_{Los} F_c A B \alpha | D I) \propto \int d\sigma\, \sigma^{N+1} \mathrm{e}^{\sum_i -(d_i - M_i)^2/\sigma^2}$$

Expected values for all model parameters are just moment integrals over the probability function, Example:

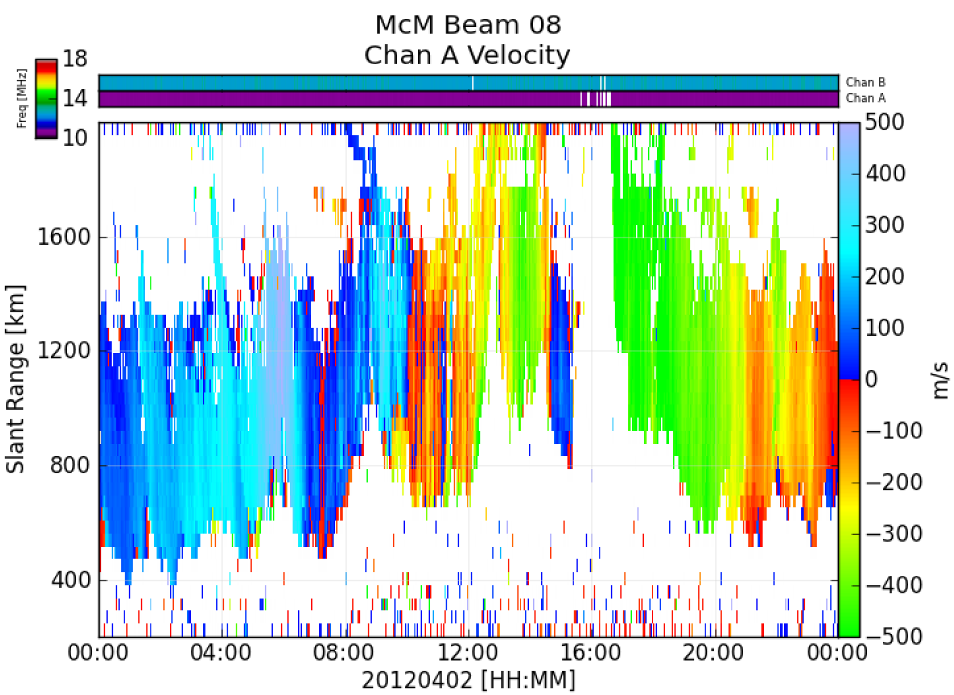
$$\langle F_c \rangle \propto \int dF_c F_c \int dA \int dB \int dV_{LOS} \int d\alpha \int d\sigma\, \sigma^{N+1} \mathrm{e}^{\sum_i -(d_i - M_i)^2/\sigma^2}$$

# The McM Radar

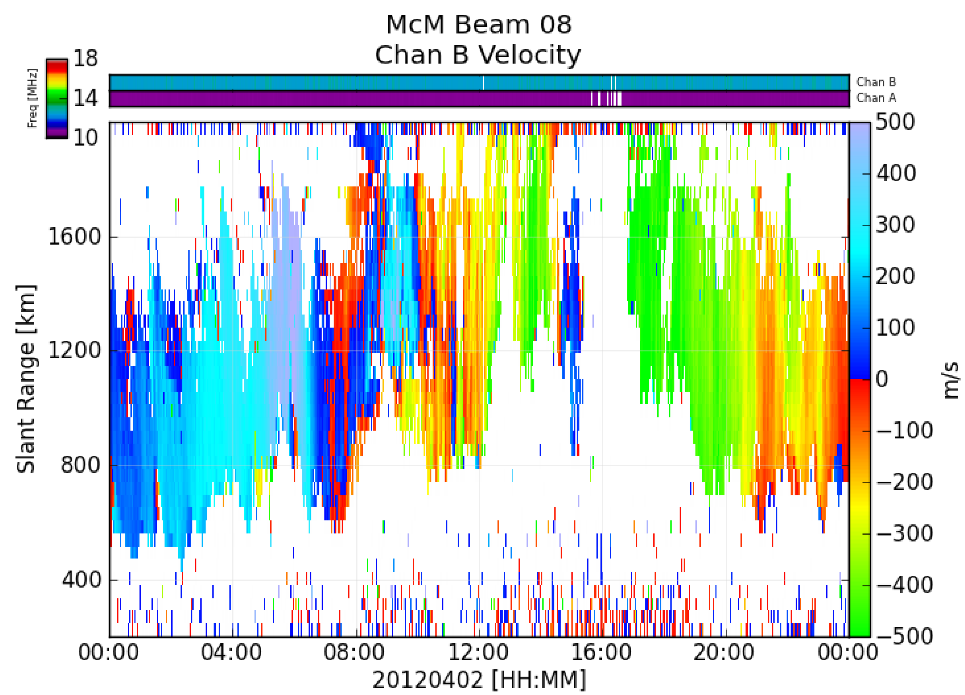
- Radar operational as of Feb. 2010
- Commonly experiences a wide region of persistent ionospheric scatter across the full field of view
- Persistent scatter poleward of 80 S geomagnetic latitude
- **Dual channel capable as of Jan 2012**



# Simultaneous Dual Channel Velocity Measurements

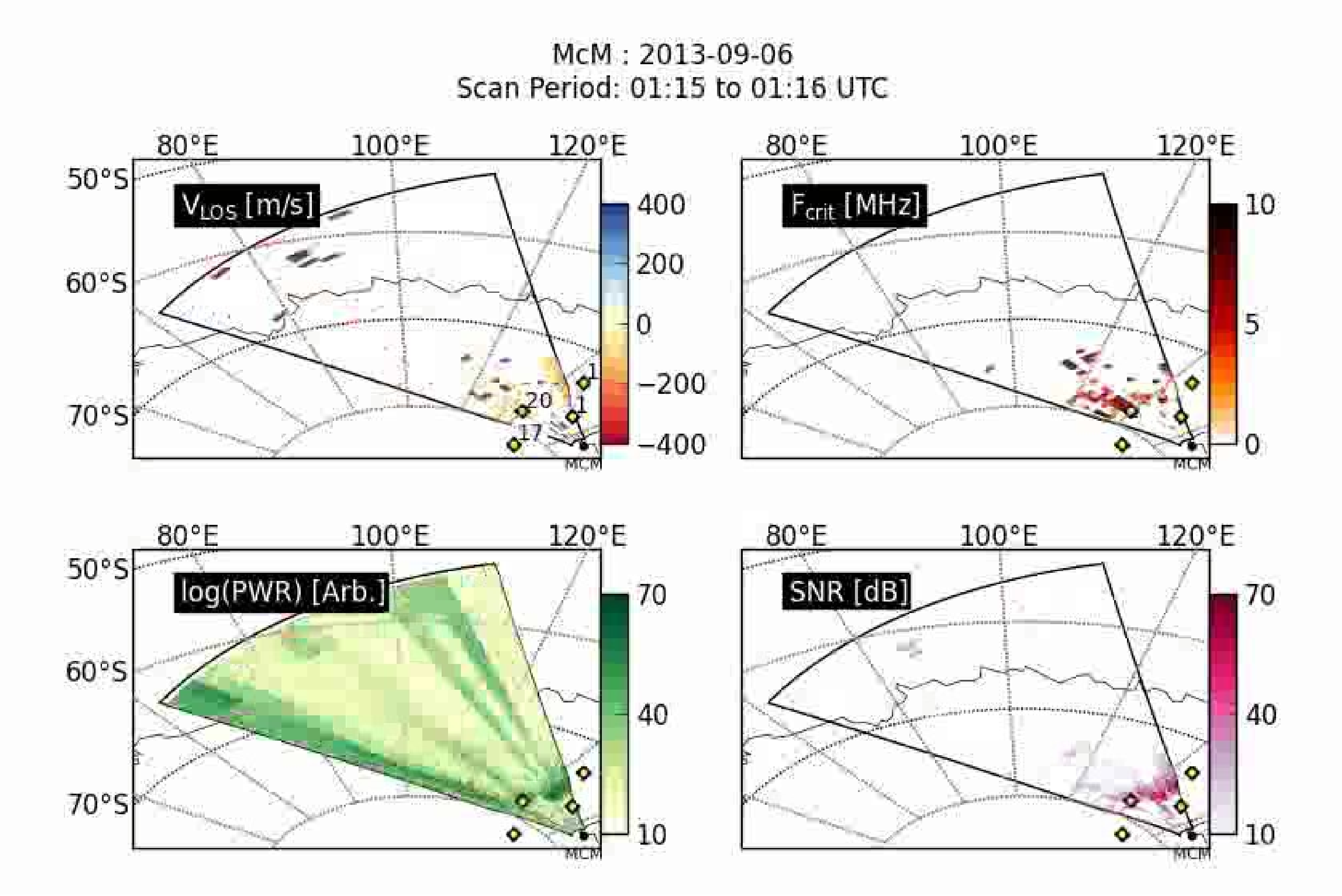



Channel A: Tfreq ~ 10 MHz

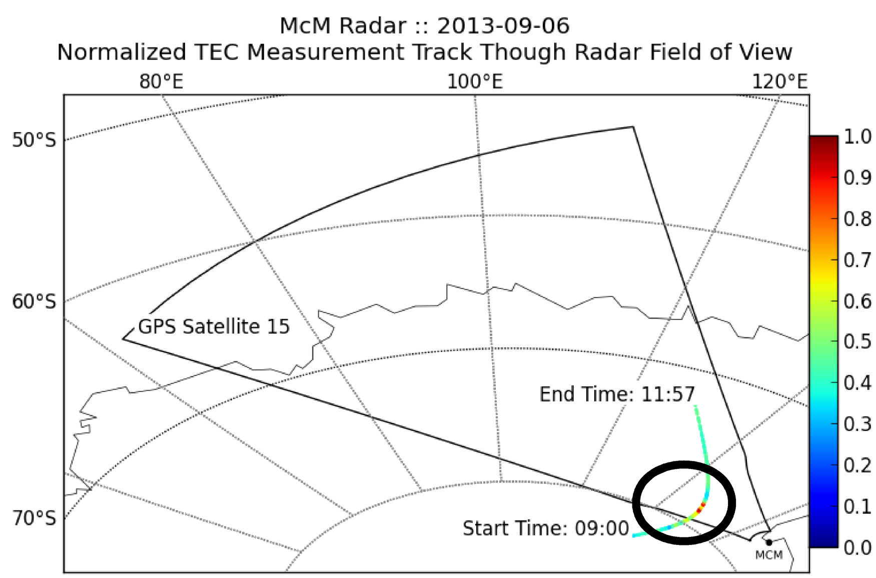


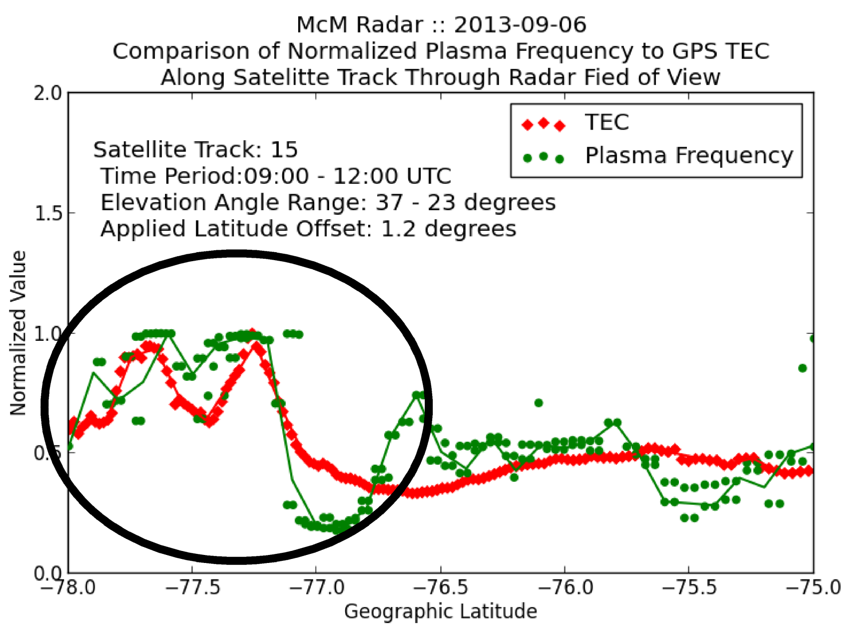

Channel B: Tfreq ~ 12 MHz

# Spatially Resolved Density Structures at McMurdo



# Comparison against TEC




Good agreement of observed density structuring
with TEC measurements at elevation angle > 30 degrees

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