On the improvement of simultaneous full field-of-view operations

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Outline

1. Motivation
2. Wide transmission beam design
3. Observed artifacts
4. Artifact correction

Radio Science

Research Article | Full Access

Application of Wide-Beam Transmission for Advanced Operations of SuperDARN Borealis Radars in Monostatic and Multistatic Modes

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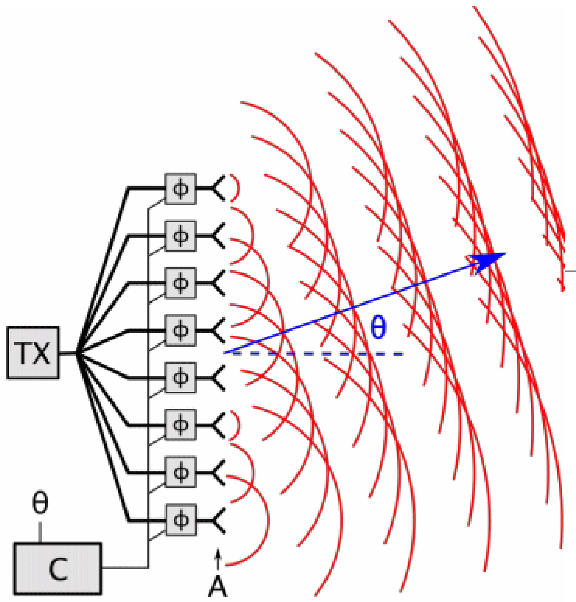
R.A. Rohel MSc. Thesis (2025): Improving Temporal Resolution and Spatial Coverage of SuperDARN Radars using Wide Transmission Beams and Multistatic Operation. https://hdl.handle.net/10388/16891

Motivation

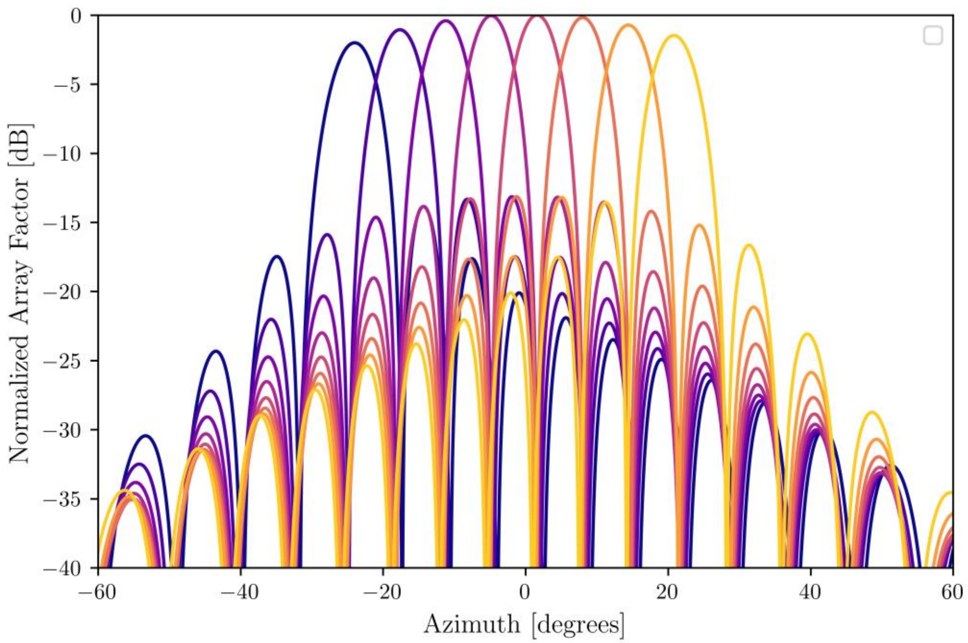
- Spread the transmitted power over the entire field-of-view
- Receive using 16 beams simultaneously, in conventional directions
- Pros:
  - 16x better temporal resolution
  - Measurements from different beams taken at same time
- Cons:
  - Less power in any given direction
  - Side lobe suppression much worse

Phased Array Beamforming

- Superposition of waves emitted by each antenna in the far-field
- Antenna phases chosen for constructive interference in specific direction(s)
- Linear phase progression used for standard beams
  - Gives narrowest beam and highest gain



From superdarn.ca

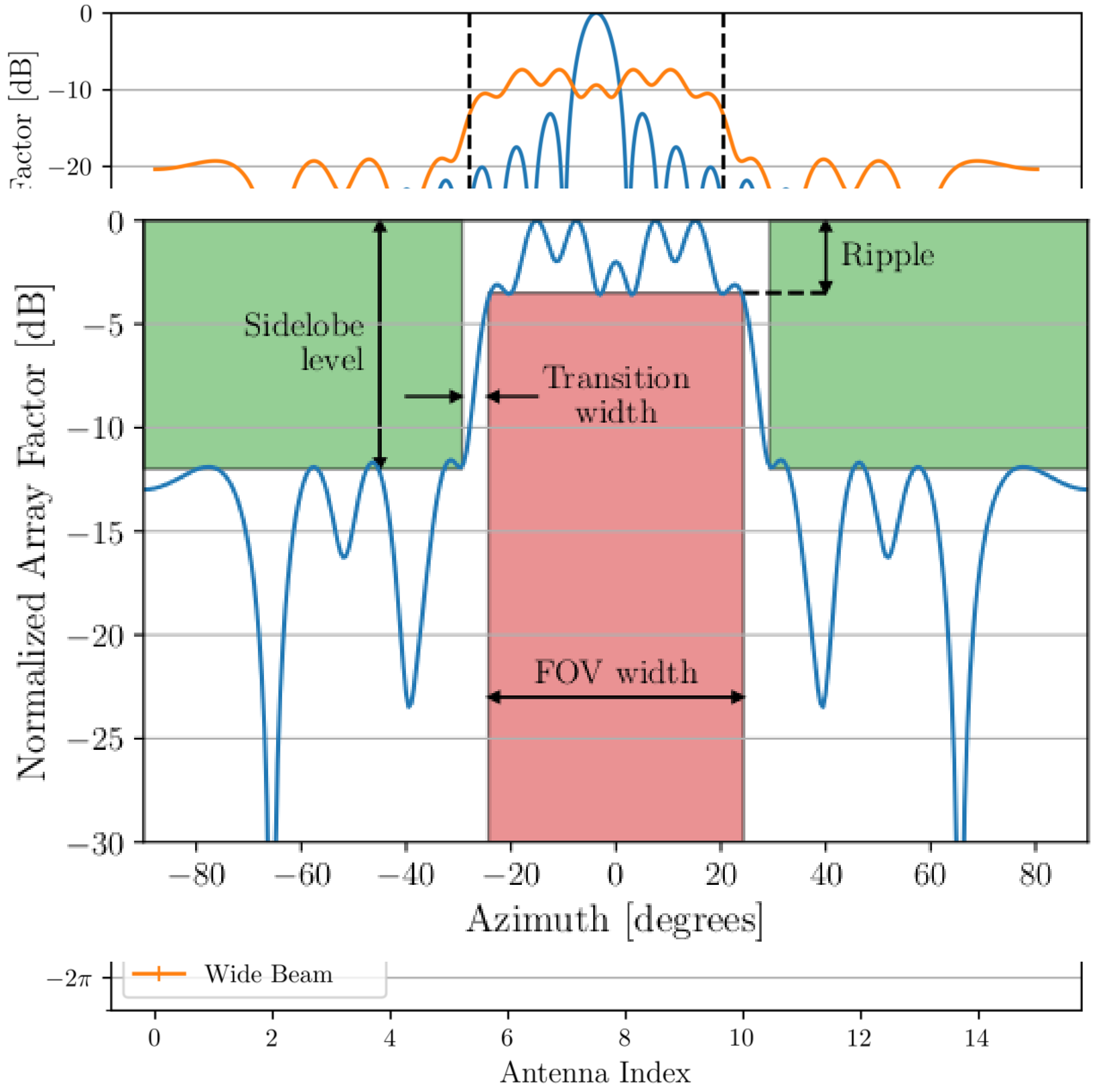


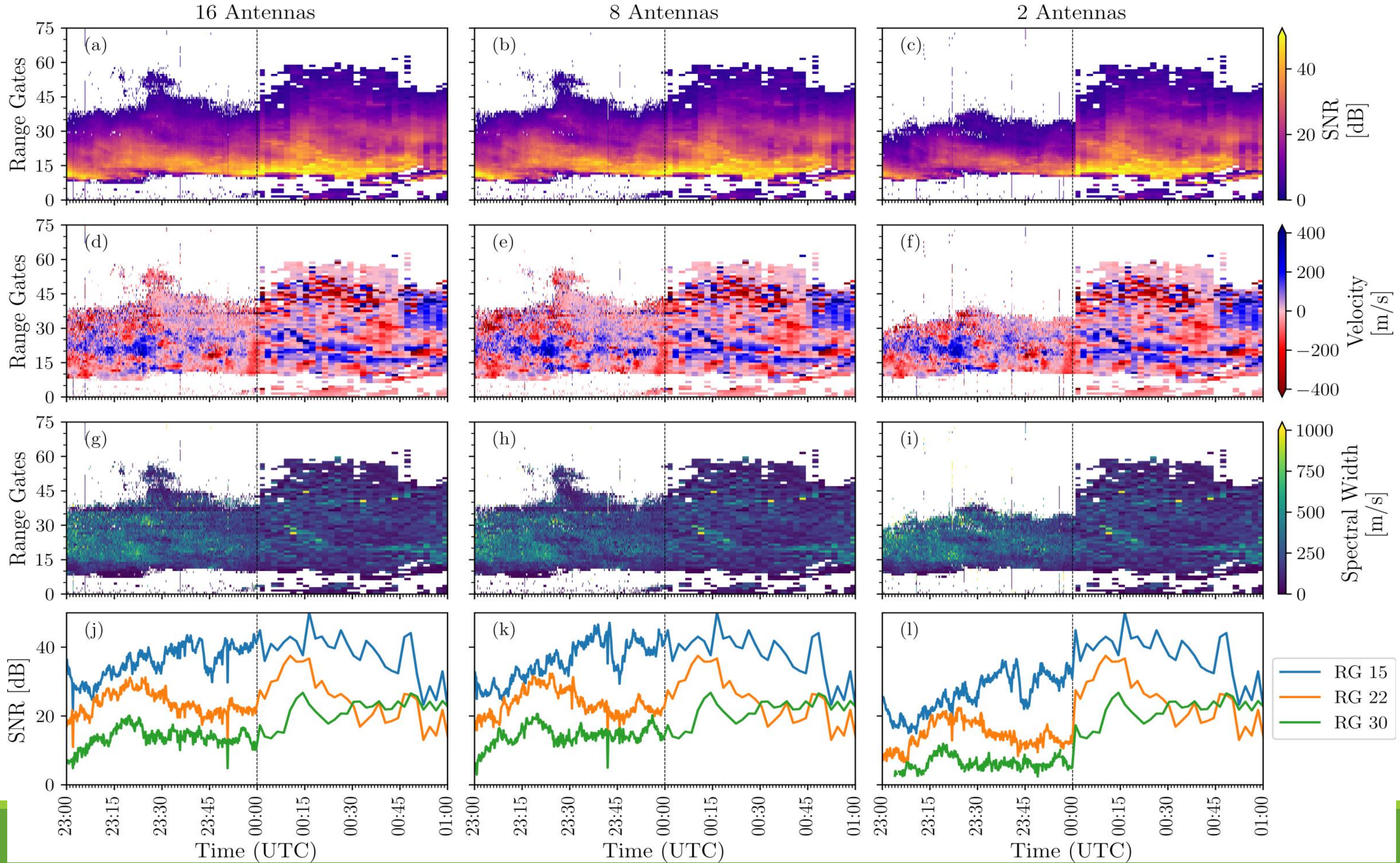
Beam Optimization

Beam objectives:

- as uniform as possible within FOV
- as little power as possible outside FOV

Fulfilled by using genetic algorithm (i.e. kindergarten AI) to find relative antenna phases




16 Antennas
8 Antennas
2 Antennas
(a)
(b)
(c)
(d)
(e)
(f)
(g)
(h)
(i)
(j)
(k)
(l)
Range Gates
SNR [dB]
Velocity [m/s]
Spectral Width [m/s]
SNR [dB]
RG 15
RG 22
RG 30
Time (UTC)
23:00
23:15
23:30
23:45
00:00
00:15
00:30
00:45
01:00

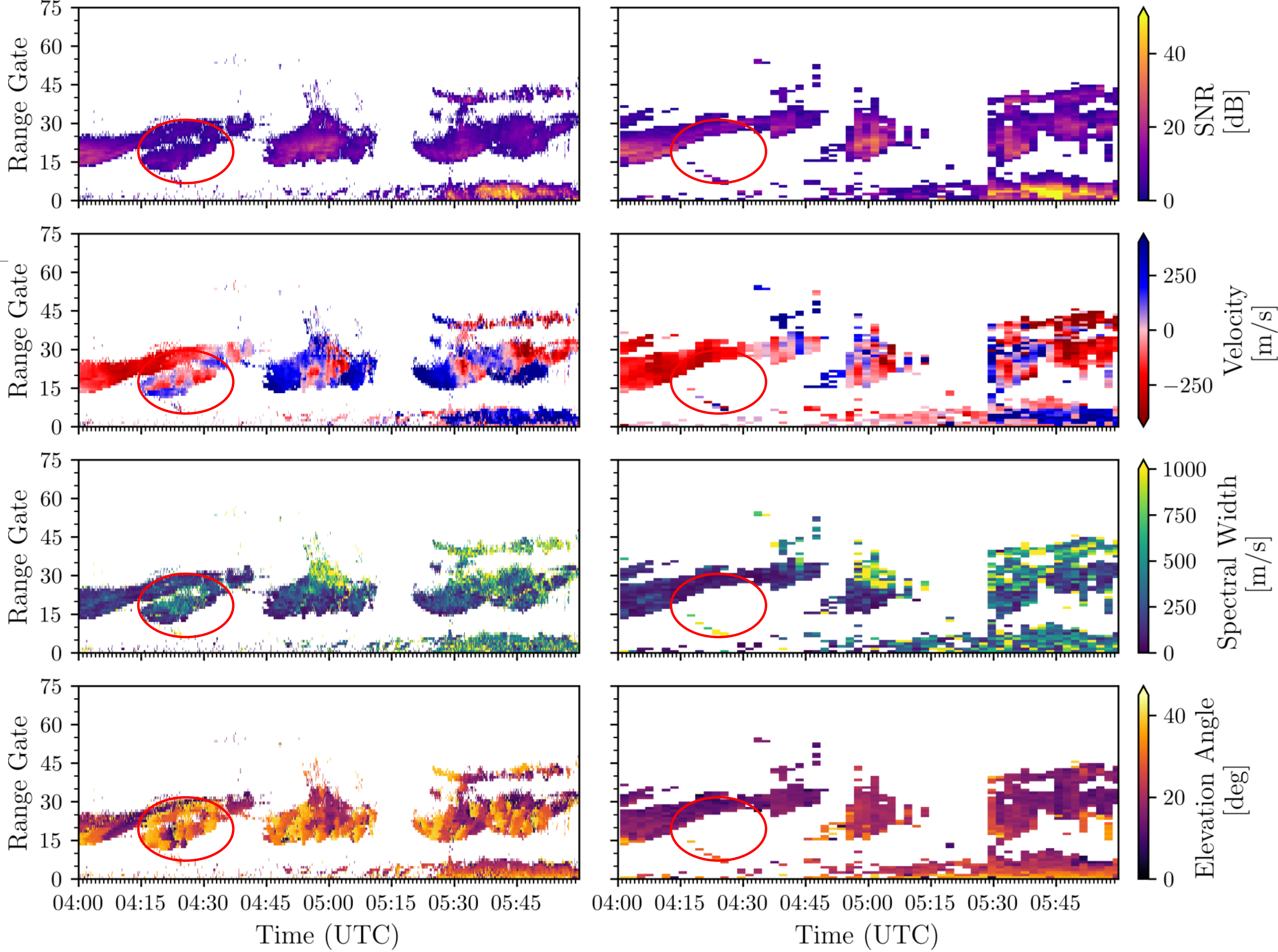
Artifacts

Wide beam on left

Narrow beam on right

RX beam 0 for both

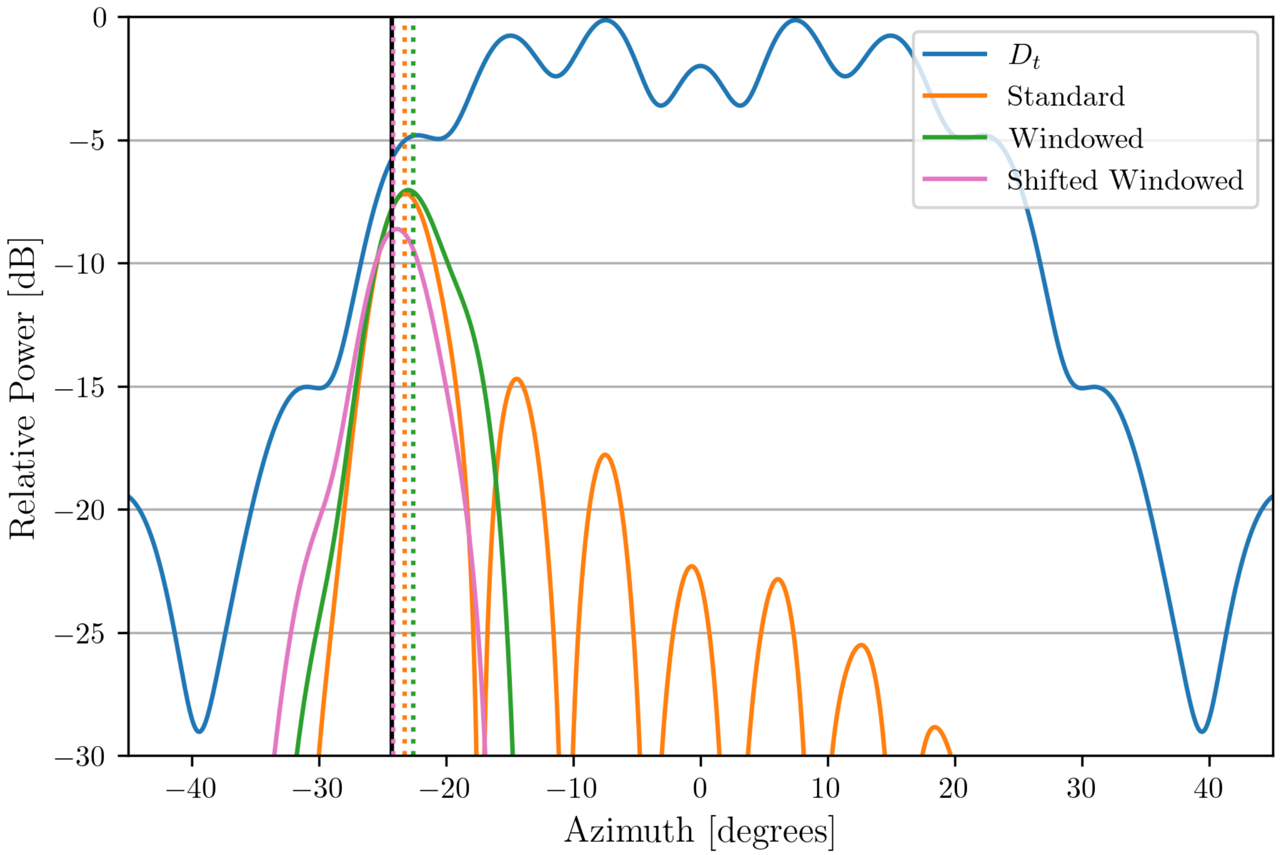
CLY radar, Dec. 17 2023

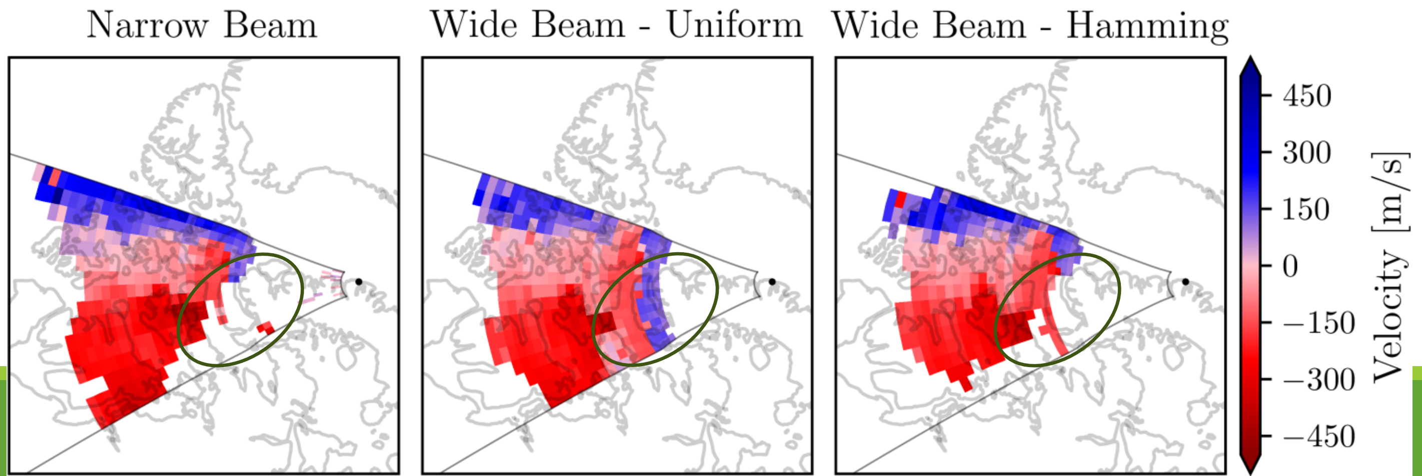


Beam Corrections

Two corrections taken:

1. Apply window function (e.g. Hamming) to reduce RX beam side lobes
   - from –13 dB to –30 dB
2. Direct RX beam to offset TX beam non-uniformity





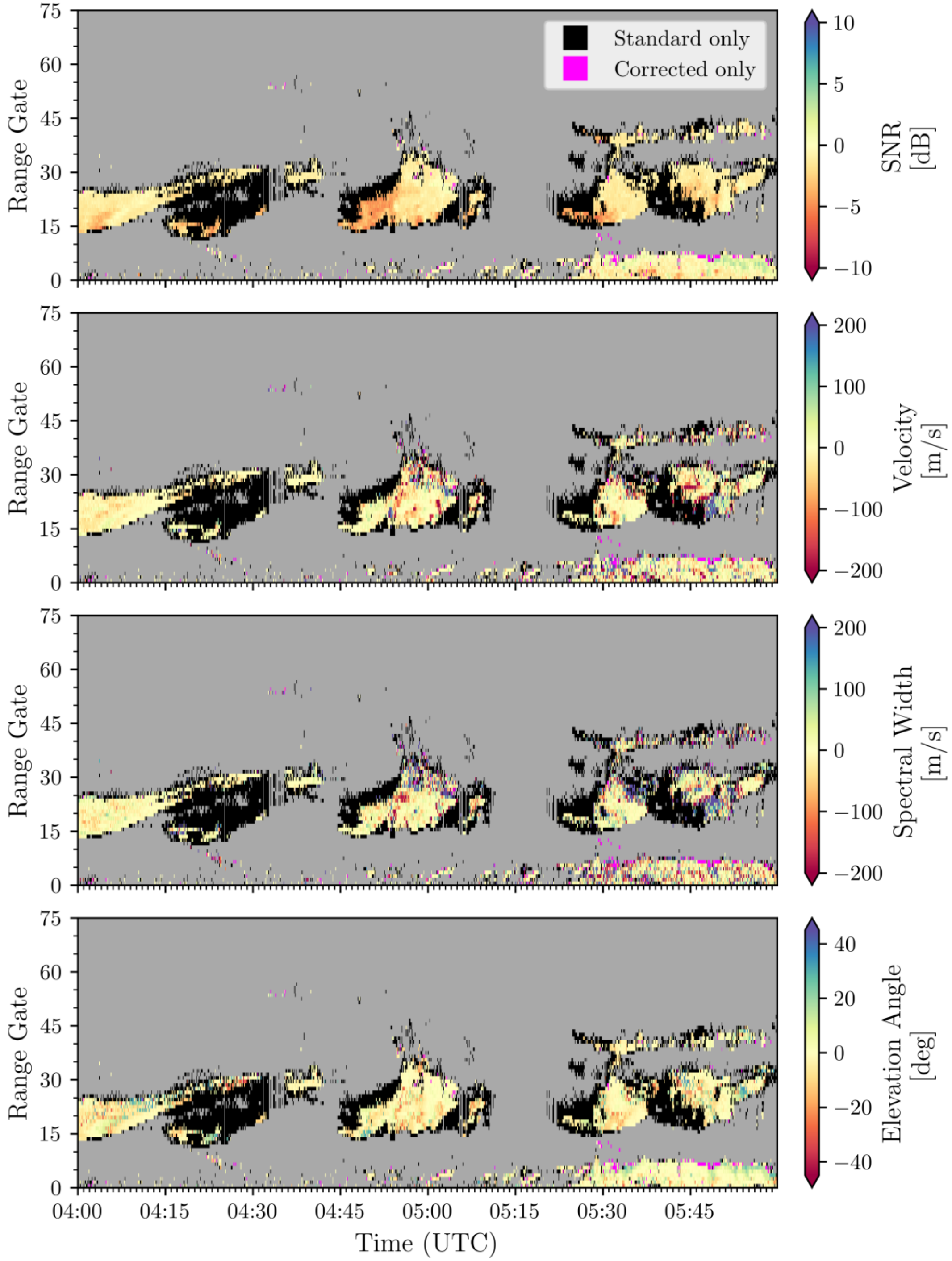
Correction Results

Plots shows differences in parameters (corrected minus no correction)

Windowed RX beam with adjusted direction removes artifacts

Black: data eliminated by windowing

Magenta: data added by windowing (not much)



Summary

Widebeam operation has a lot of positives:

- Conduct entire FOV scan in 1 integration time
- All beams measured at same time

Also some negatives:

- Loss in SNR, i.e. scatter at far ranges <-- not too bad
- Much more signal in from side lobes <-- can be remedied
- Makes A LOT of data <-- IQ files the same size, so could only process all beams when requested

SUPERDARN CANADA

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