RV Ambiguity Mitigation for the Enhanced TDWR

John Cho

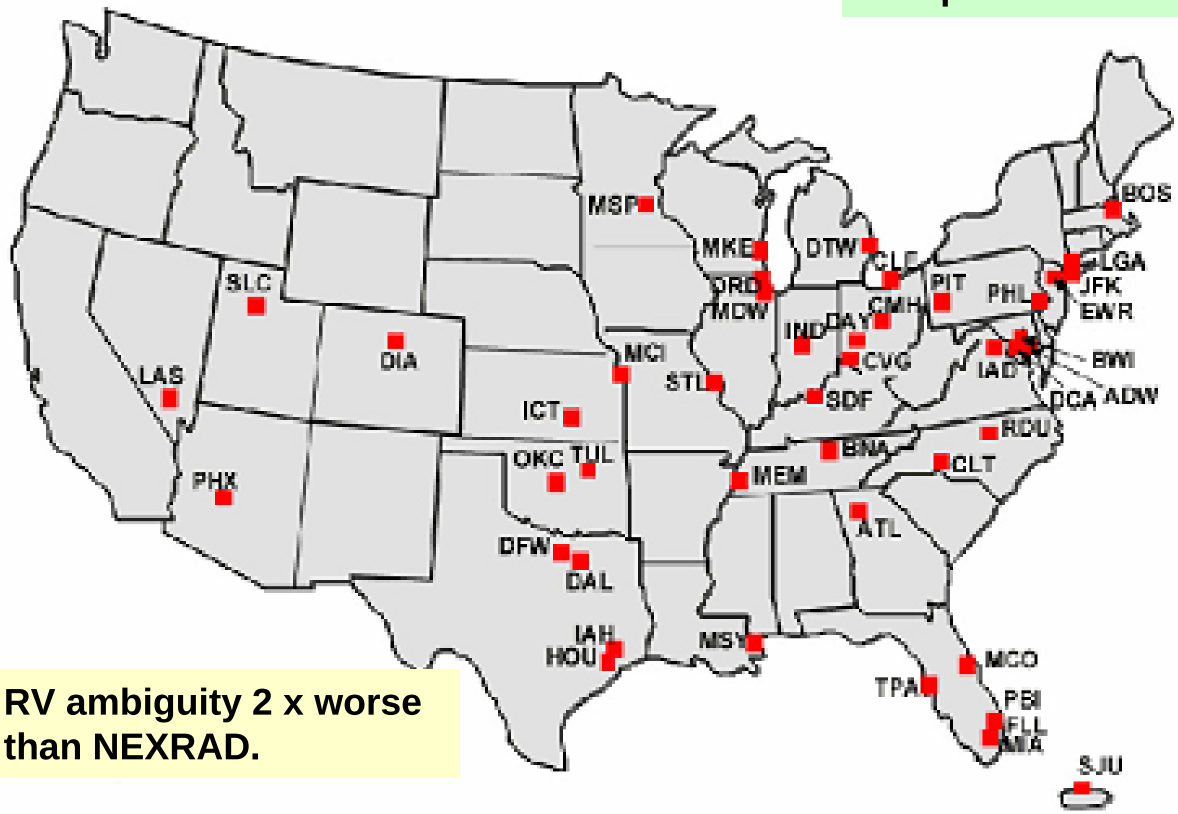
30 March 2004

Terminal Doppler Weather Radar (TDWR)

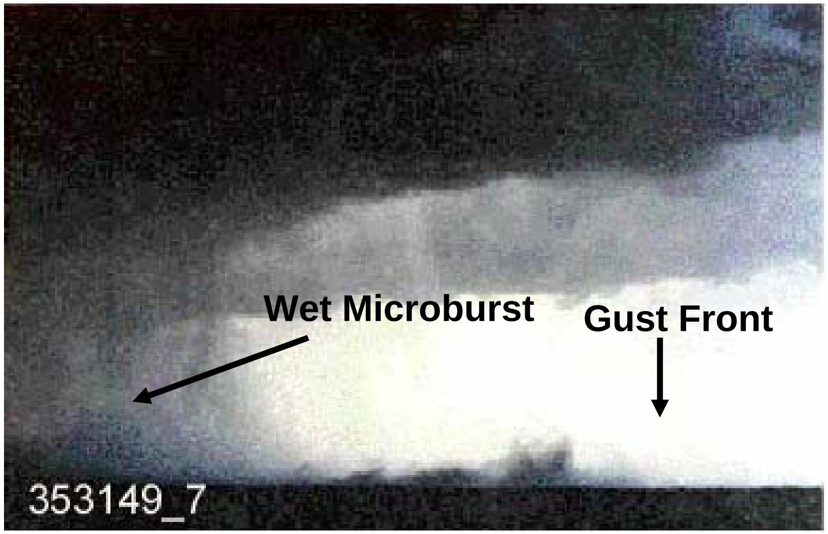
λ	=	5 cm
Beam width	=	0.5°
Scan rate	=	22°/s
P_T	=	250 kW
Δr	=	150 m

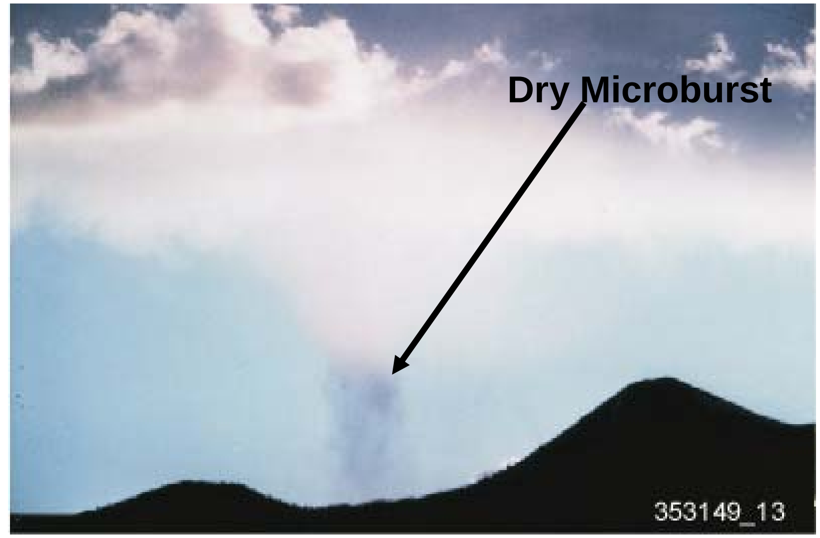
RV ambiguity 2 x worse than NEXRAD.

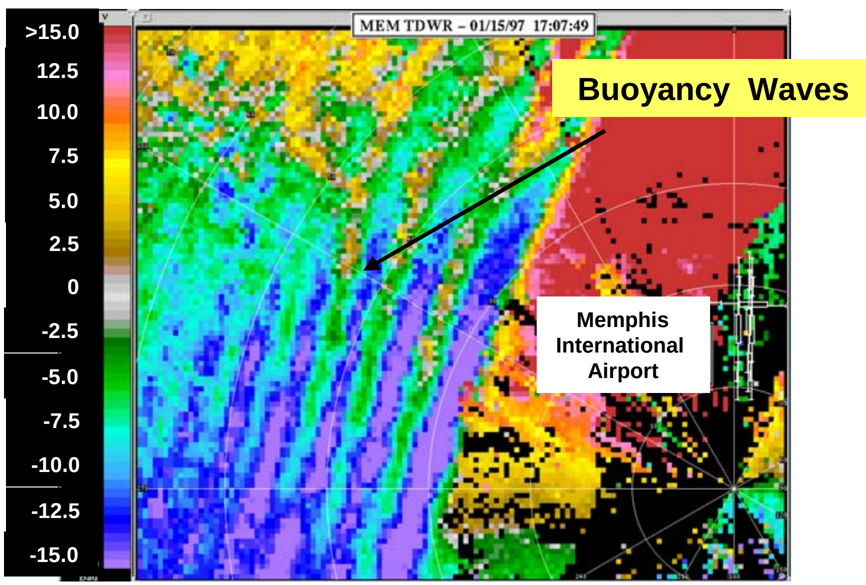
45 operational sites



TDWR Operational Mission

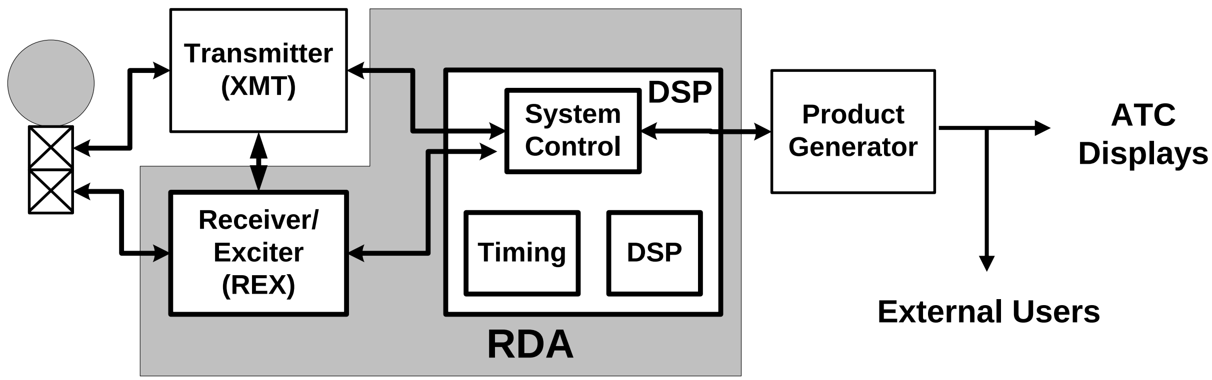






- Wind shear detection around airport and approach/departure paths
- Targets primarily low altitude, near range
- Key data quality issues
  - First-trip protection from range folding
  - Velocity dealiasing
  - Clutter filtering (esp. moving clutter)
  - Low SNR velocity estimation

TDWR Radar Data Acquisition (RDA) Replacement Project



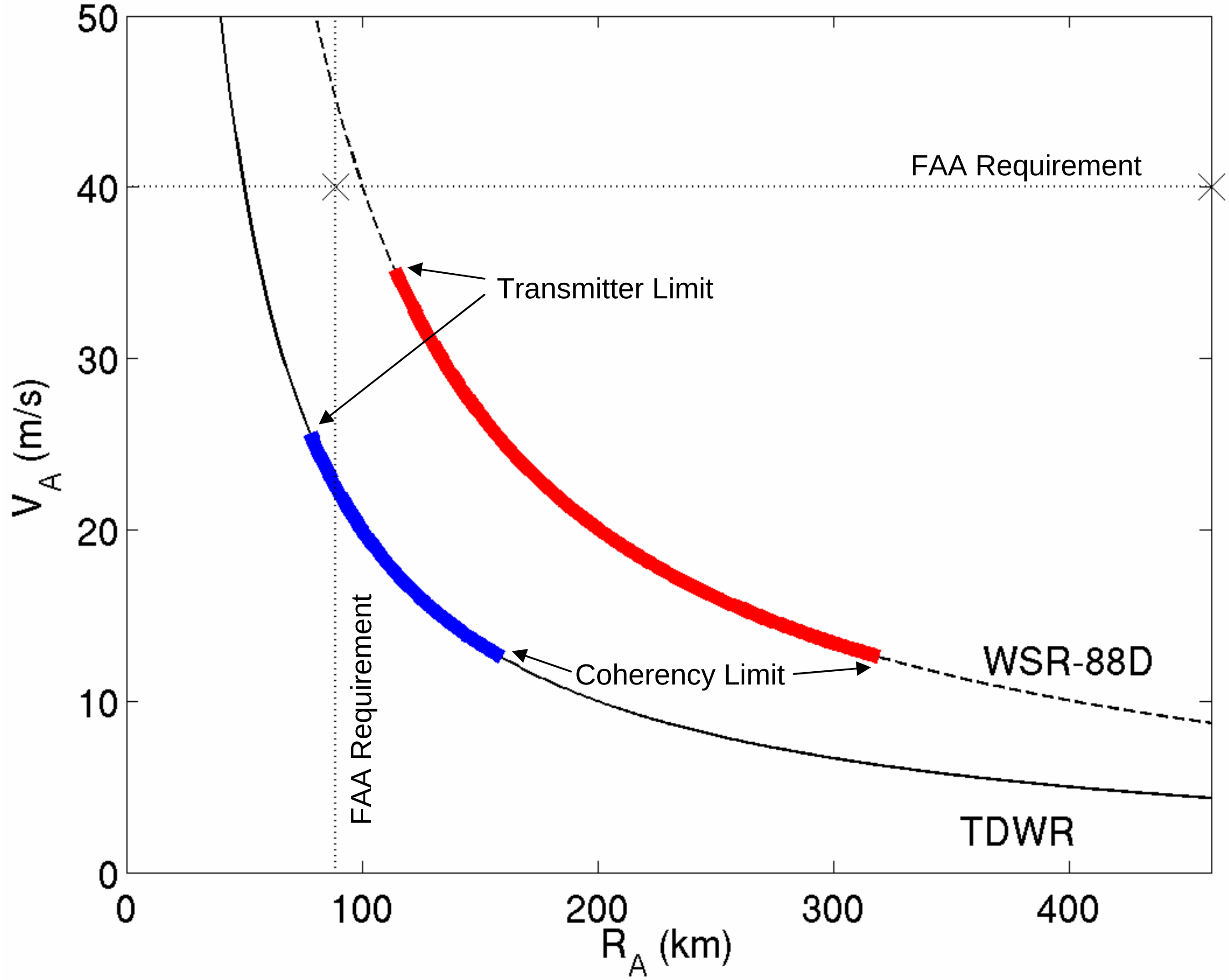
Engineering Prototype

Goals

- Enhance supportability
- Improve base data quality

- Incorporates Sigmet RVP8 PCI cards
- I/Q data processed by LL algorithms on separate DSP compute server(s)

TDWR vs. WSR-88D RV Ambiguity

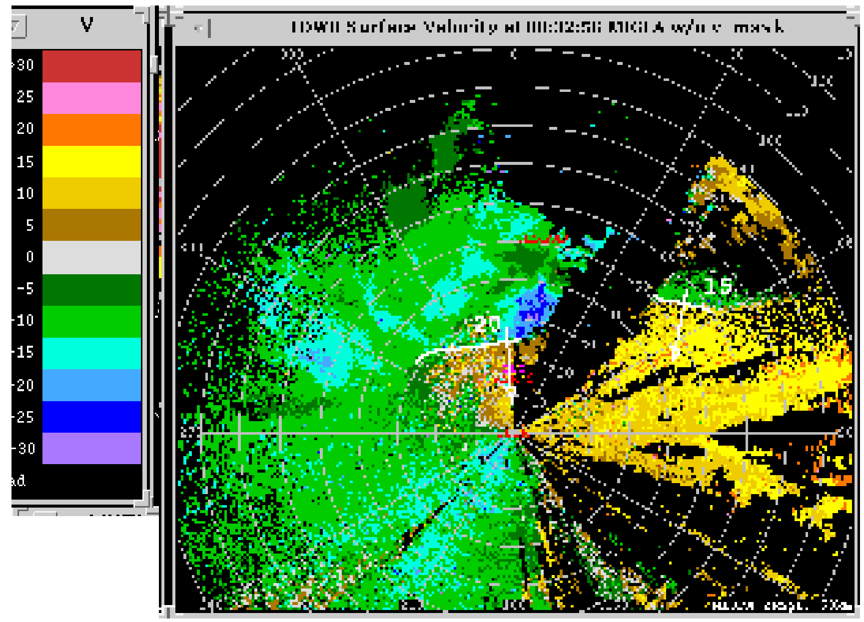


Current Procedure for Lowest Tilt Velocity Estimation

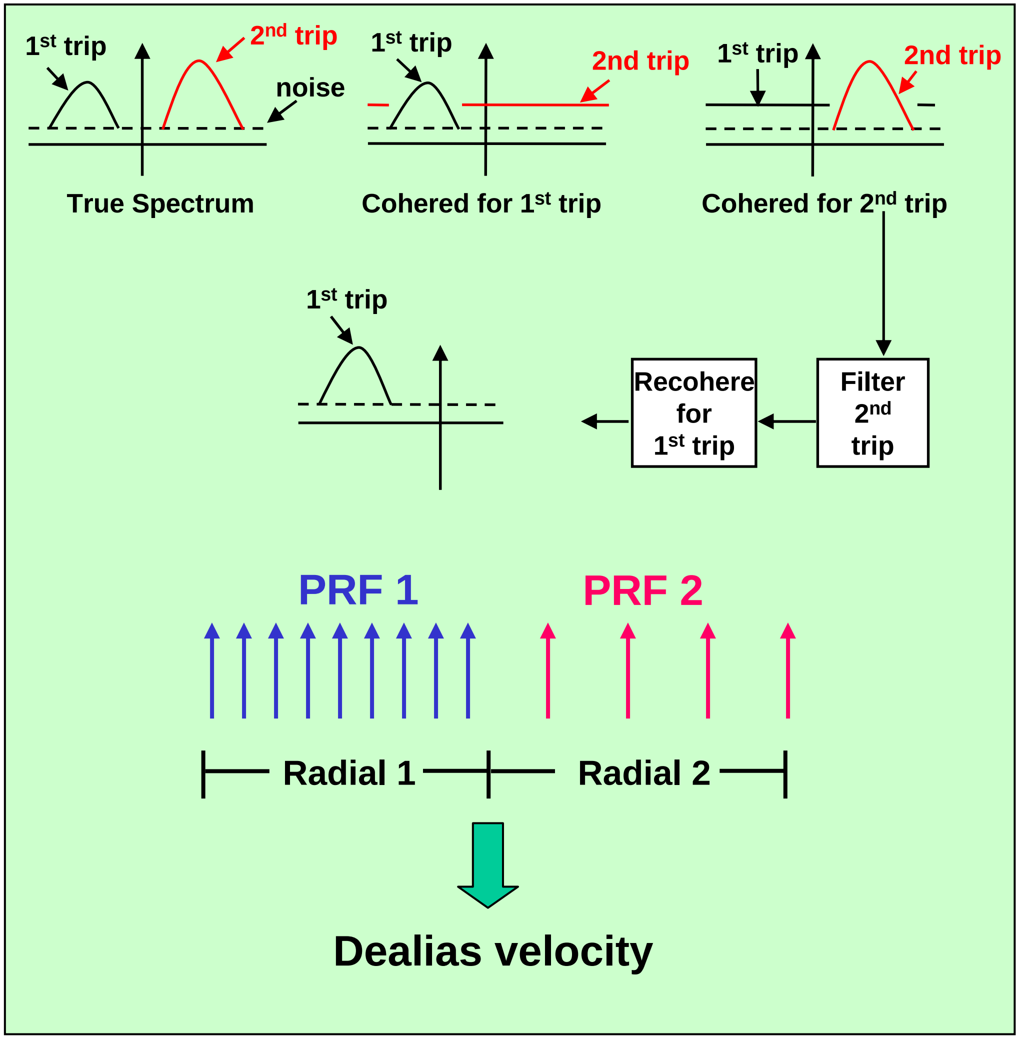
- 1st scan
  - Low PRF: Reflectivity to 460 km
- 2nd scan
  - Pick PRF to minimize obscuration of desired area
- 3rd scan
  - Pick another PRF to optimize velocity dealiasing
- Edit contaminated range cells

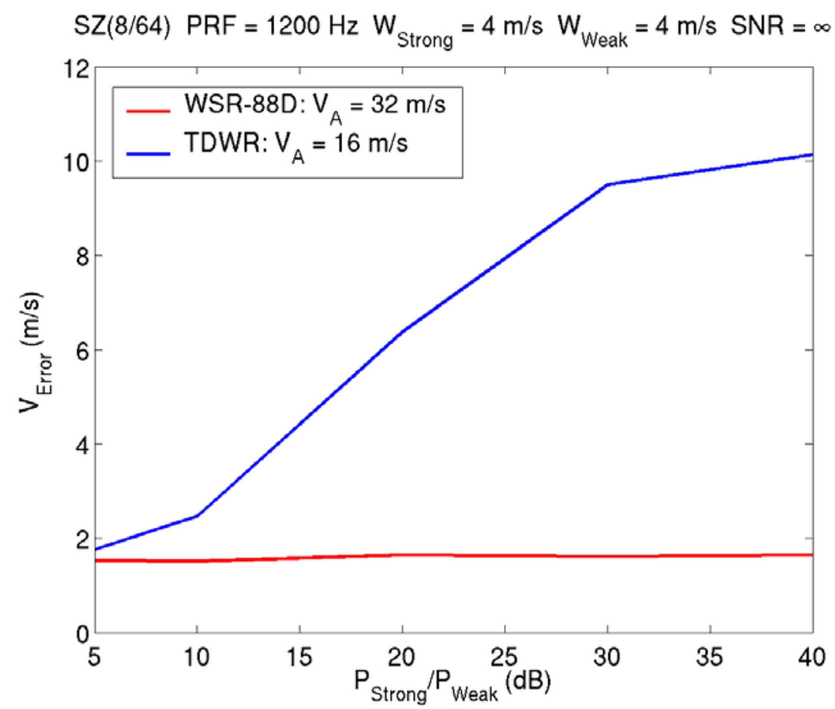
- Drawbacks
  - Limited 1st trip protection
  - 3 scans use up valuable time

Example Out-of-trip Velocity Editing

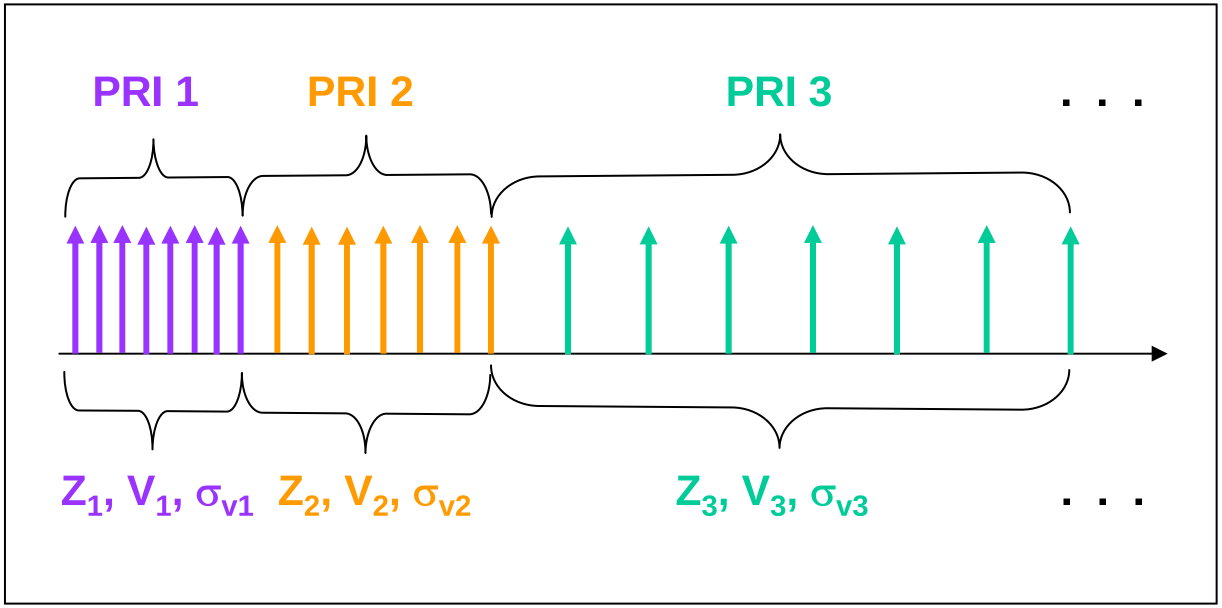


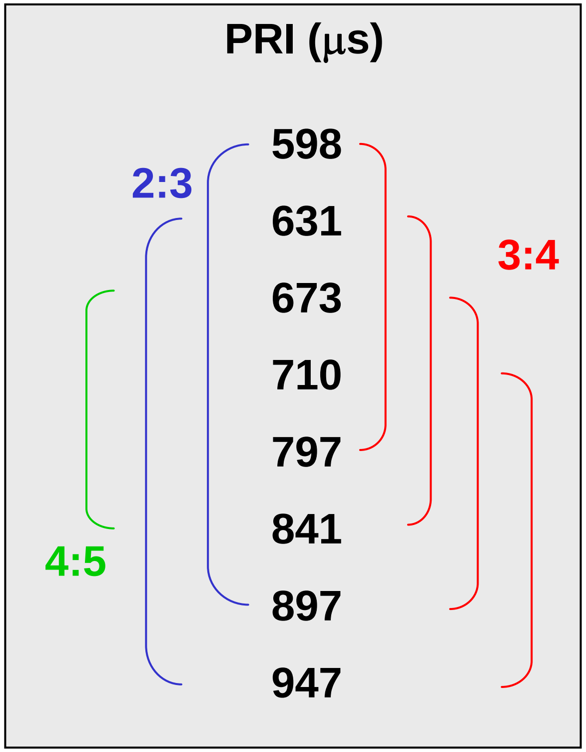
Phase Code Processing + Dual PRF





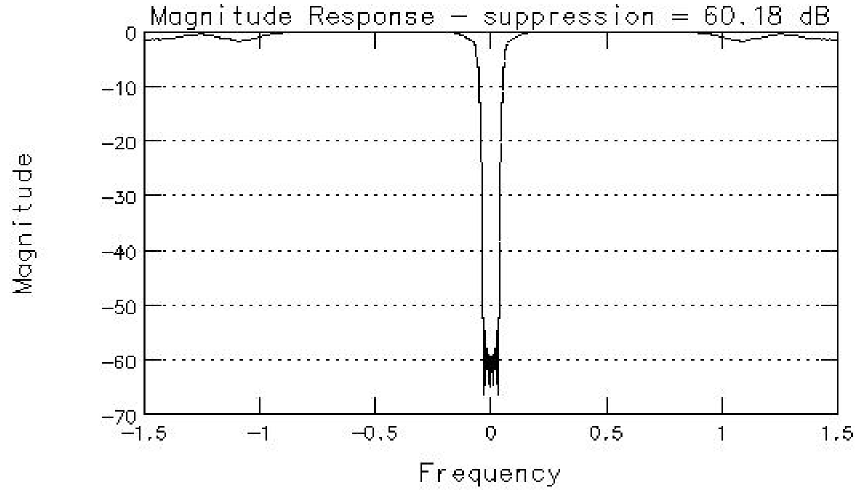
Multi-PRI Processing Within Each Radial

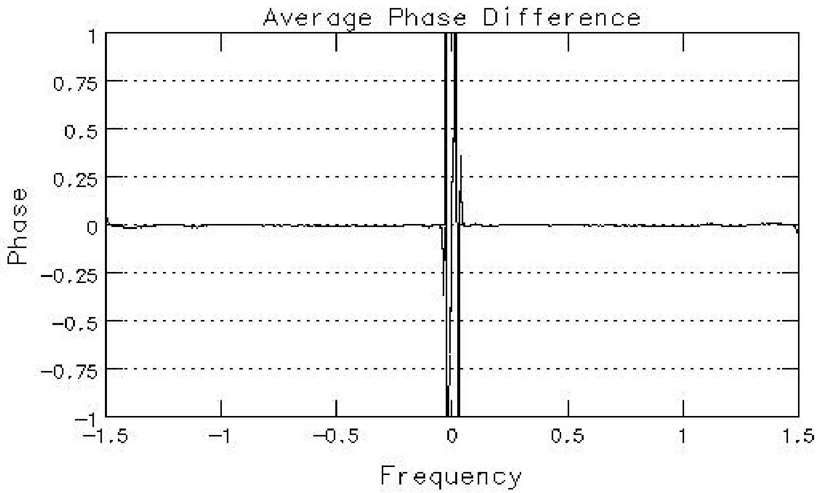




- Only use PRIs that are not contaminated by out-of-trip signals
- Multiple PRI provides velocity dealiasing

Multi-PRI Clutter Filter



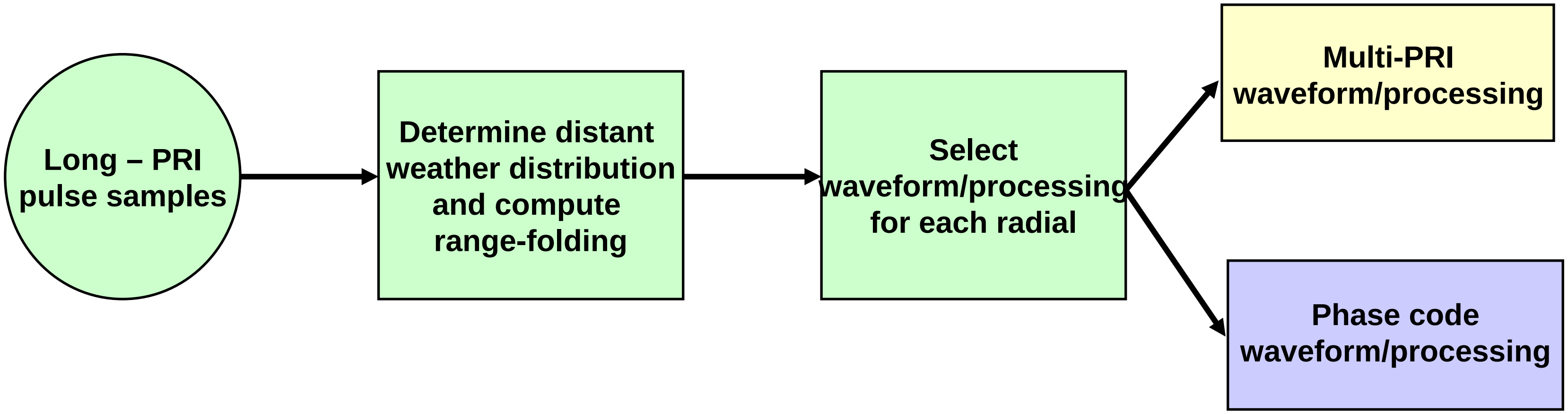


- MSE design algorithm for FIR filter [Chornoboy, 1993]
- Works well for block staggered pulse trains
- Operational clutter filter used in ASR-9 WSP signal processing

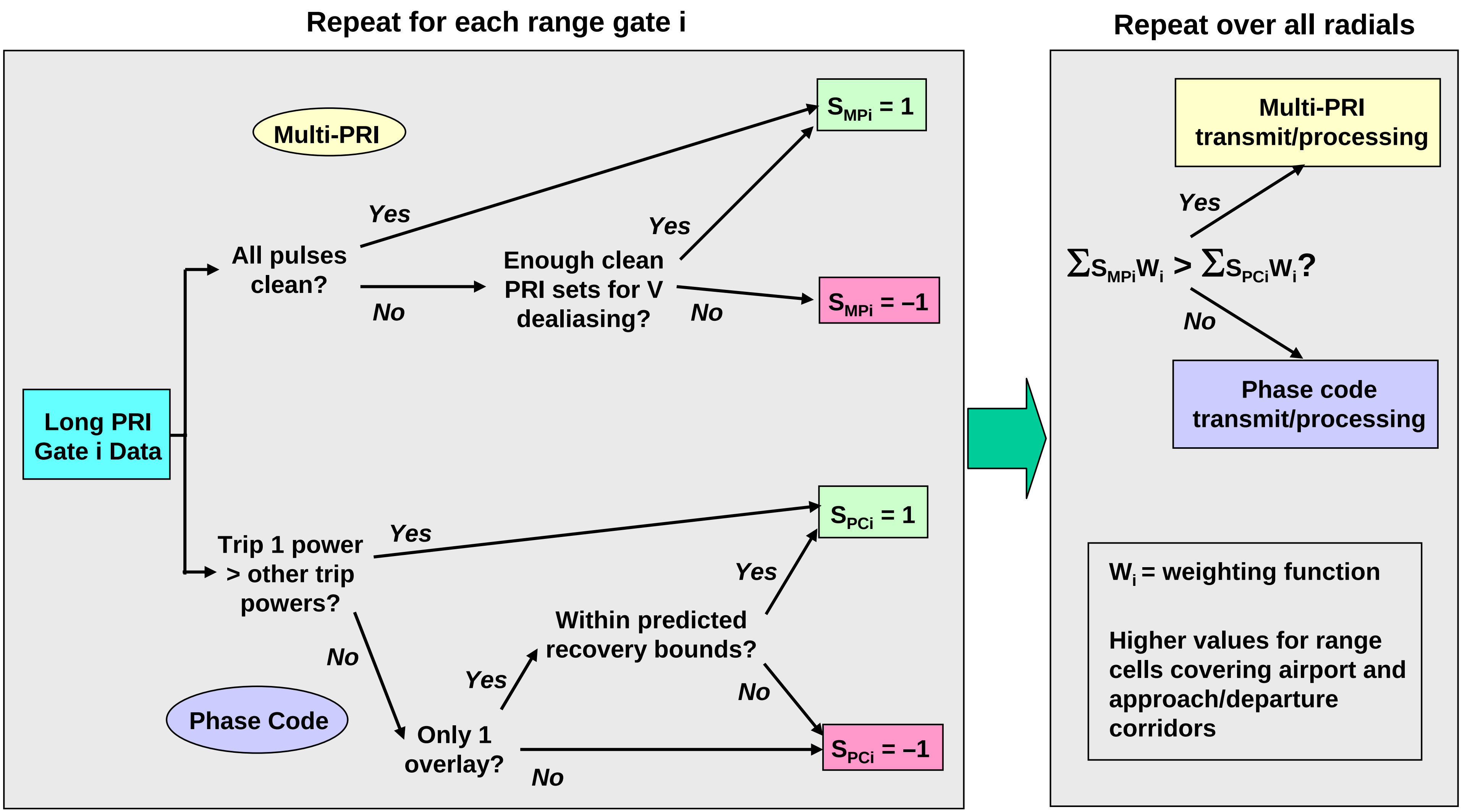
Adaptive Waveform Selection

1st Trip Protection Comparison Chart

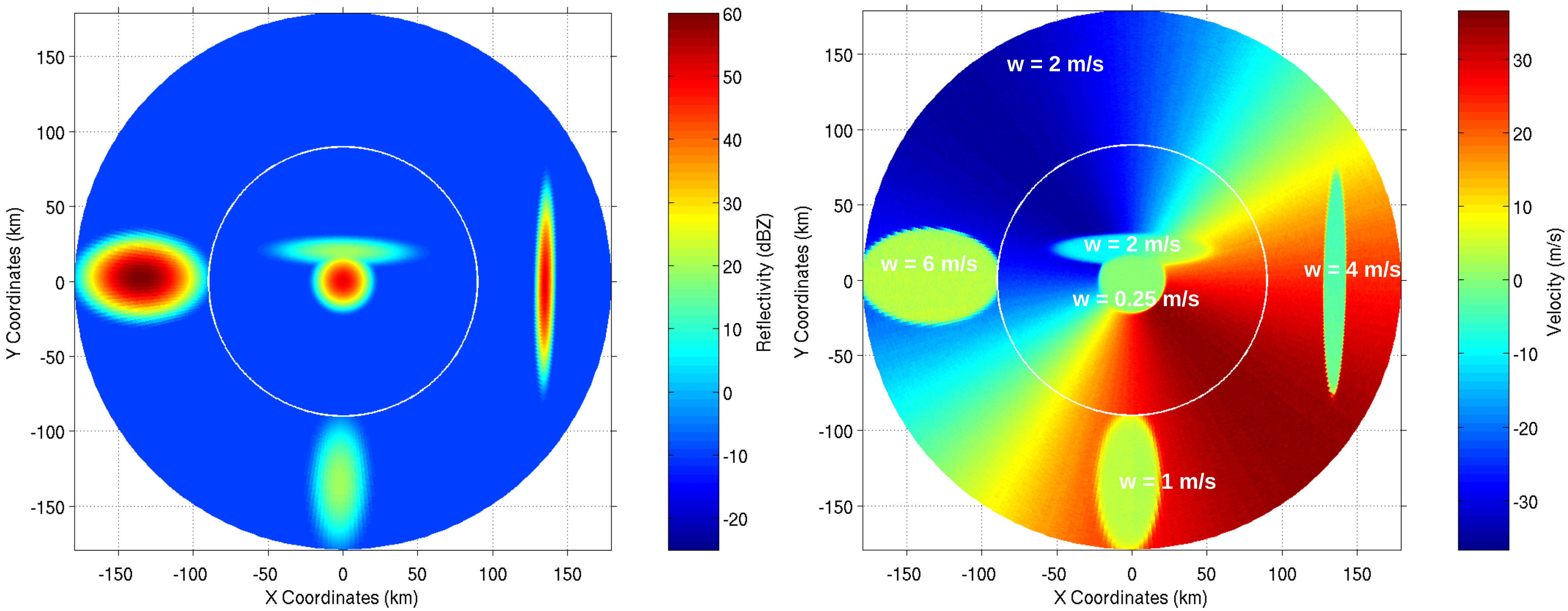
Technique \ Out-of-trip Signal Type	High Power or Wide Spectrum	Long Contiguous Range Extent
Multi-PRI Processing	Yes	No
Phase Code Processing	No	Yes



Radial-by-Radial Waveform Selection Algorithm

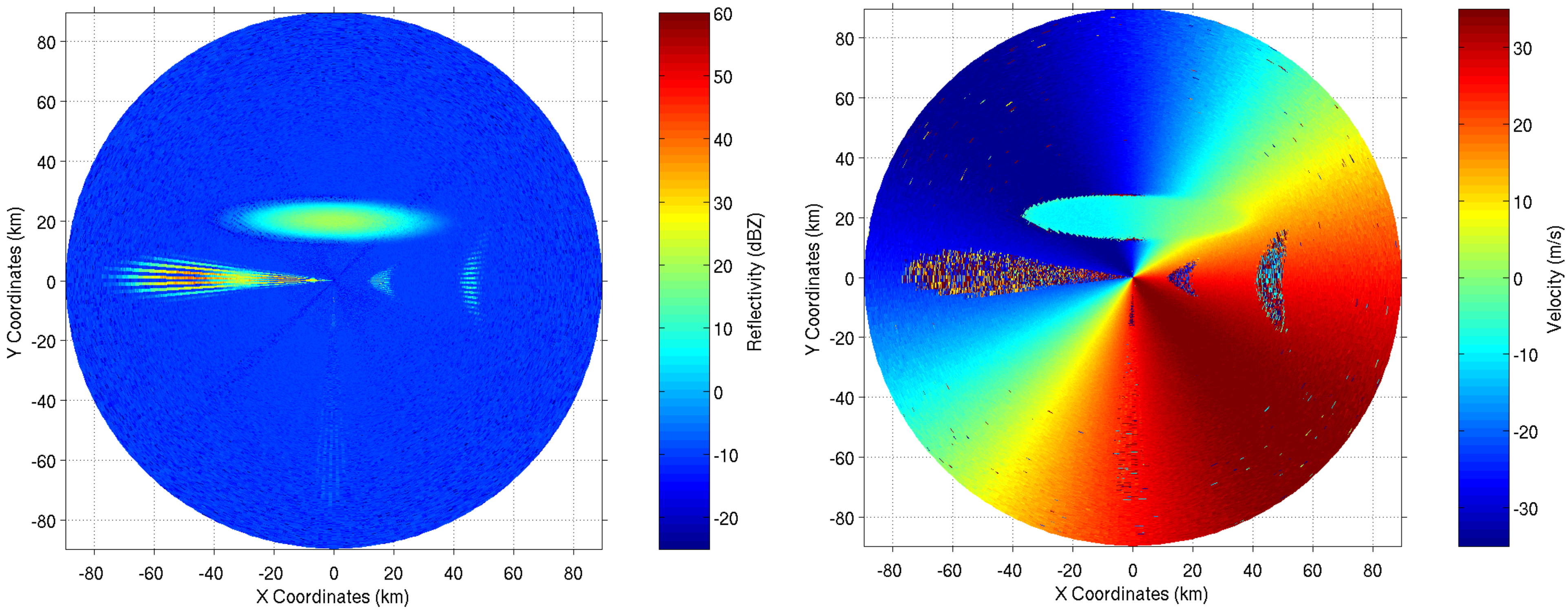


Simulation Input



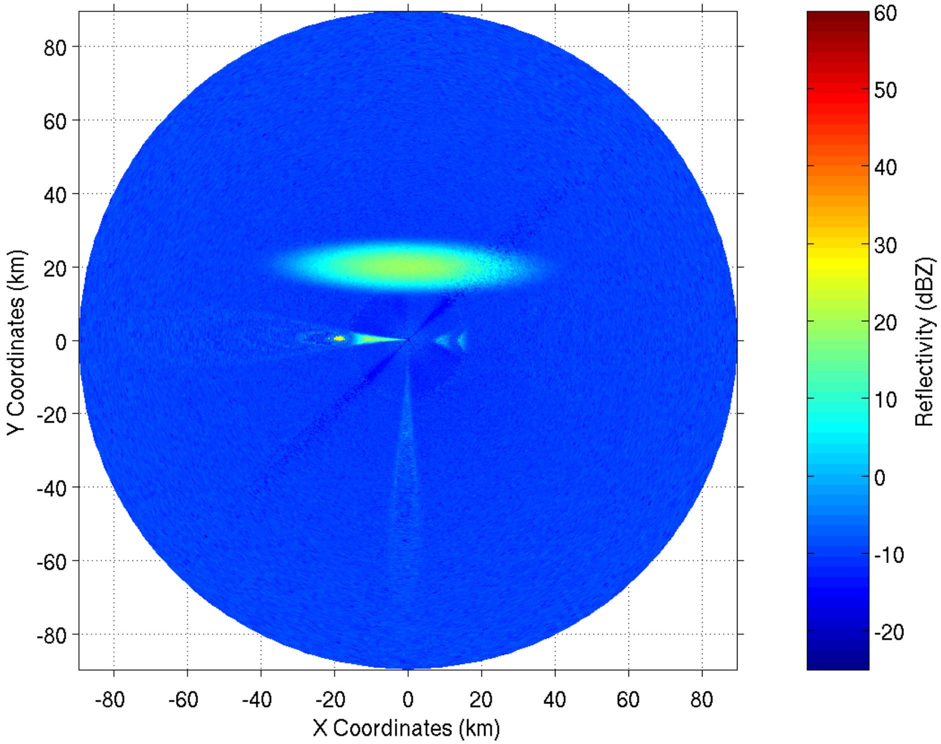
- Stratiform background: -10 dBZ, northwesterly @ 35 m/s (velocity dealiasing test)
- Central patch: Peak 50 dBZ, zero velocity (clutter filter test)
- 1st trip north patch: Peak 20 dBZ, northwesterly @ 10 m/s (shear test)
- 2nd trip east patch: Peak 50 dBZ (strong, but limited-range-spread overlay test)
- 2nd trip south patch: Peak 20 dBZ (weak, but range-extensive overlay test)
- 2nd trip west patch: Peak 60 dBZ (strong and range-extensive overlay test)

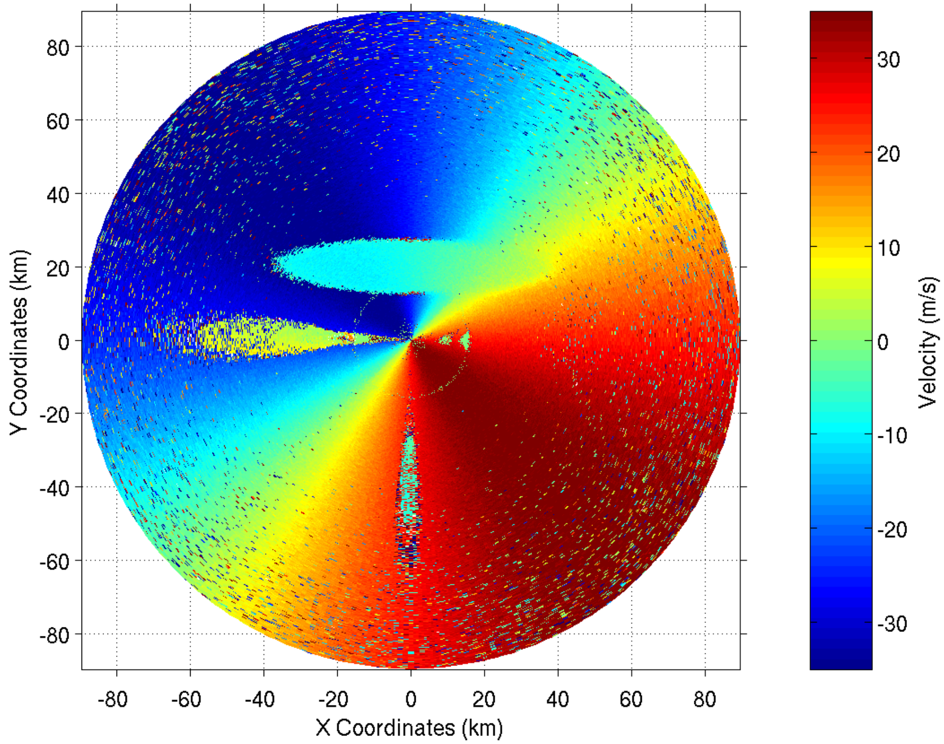
Alternating-Radial Dual PRF With Pseudorandom Phase Code Processing



- Adaptive clutter filter (GMAP-like) works well
- Velocity dealiasing works well even in high gradient area (north patch edge)
- 1st trip protection works well only for south patch because overlay is weak with narrow spectral width (but note failure where overlay overlaps clutter zone)
- East and west patches are too strong (and too spectrally wide) for 1st trip protection

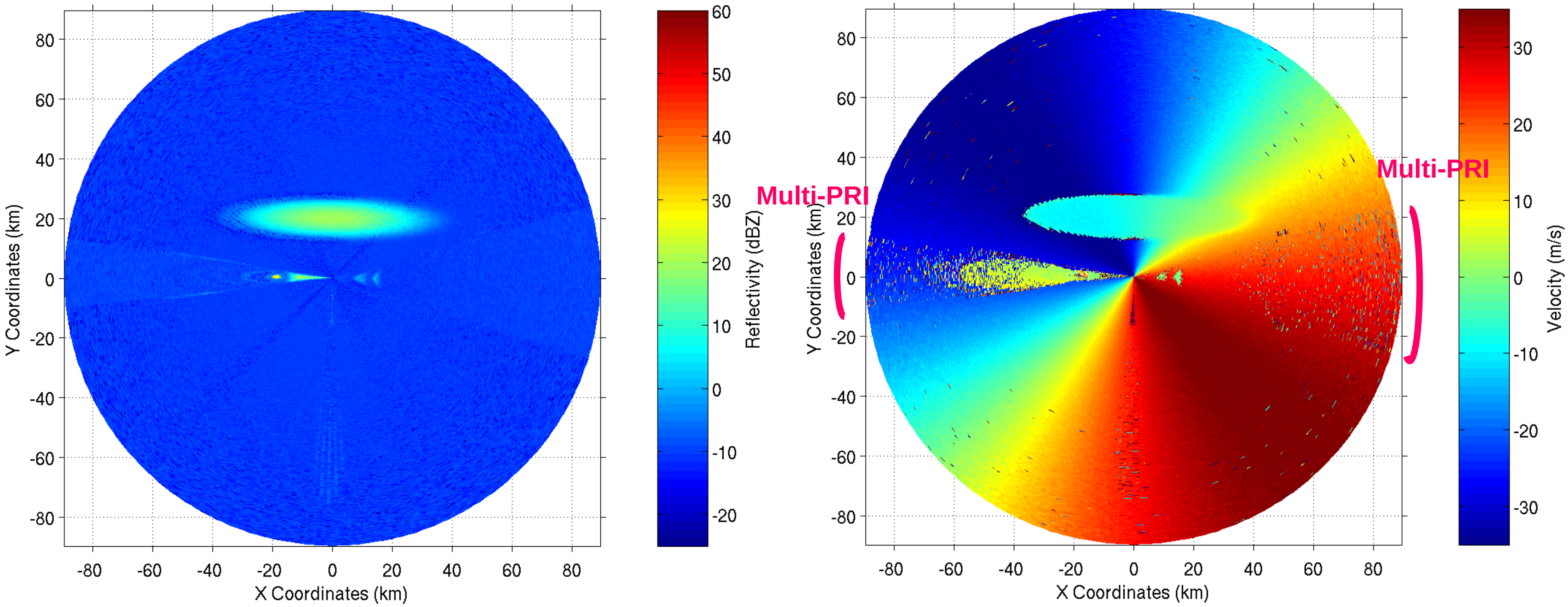
Multi (8) PRI Waveform and Processing





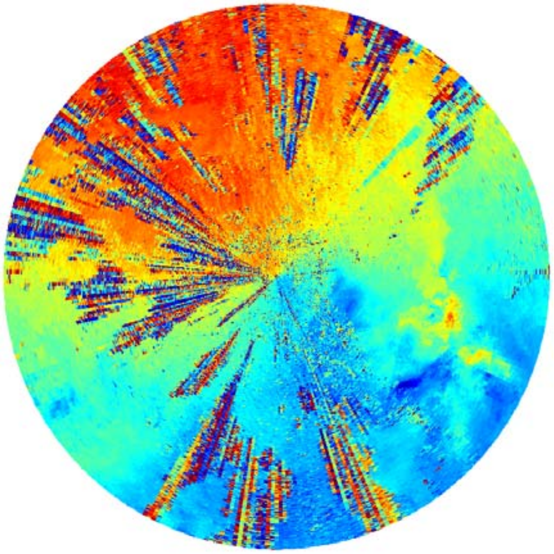
- **4-level (60 dB, 40 dB, 20 dB, all pass) clutter filter selected on the fly: Works well, not as well as adaptive spectral filter**
- **Velocity dealiasing works well; however, velocity estimate quality not as high as for constant PRF**
- **1st trip protection works almost completely for east patch (except for overlap area with clutter)**
- **South and west patches are too range-extensive to filter out for velocity estimates (reflectivity estimate is protected surprisingly well), although west patch is filtered better than with phase code processing**

Adaptive Radial-by-Radial Combination



- Algorithm used only long-PRI scan data, i.e., equivalent to real-time algorithm
- Algorithm selection did optimize first-trip protection of velocity
- The western patch overlay was too range-extensive and too strong for either waveform/processing type to eliminate from the velocity estimate
- 1st trip cannot be protected from out-of-trip overlay if there is significant clutter in the same cell

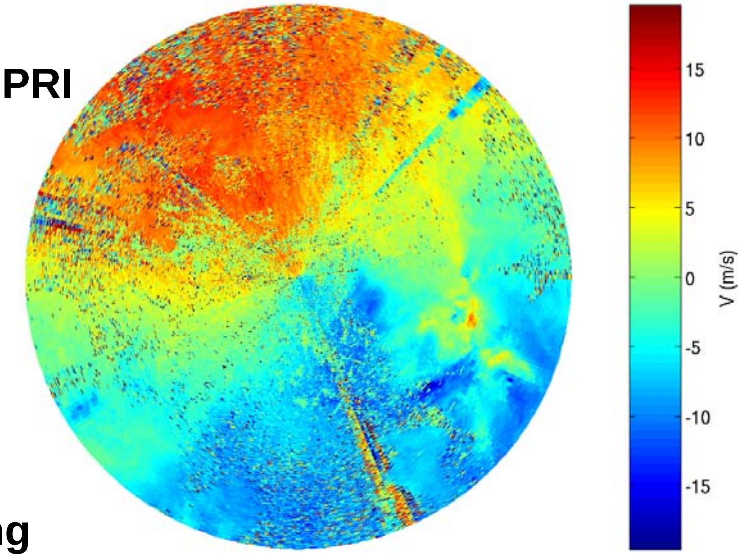
Real Data Example: 1st Trip Protection of Velocity



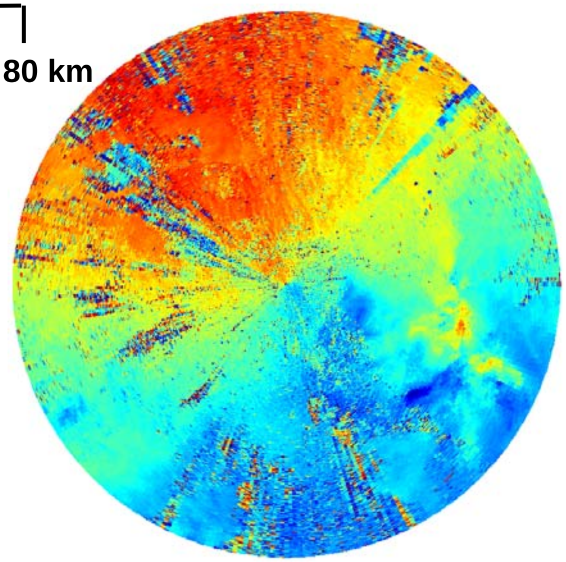
0 40 80 km

1 PRF, no phase-code processing

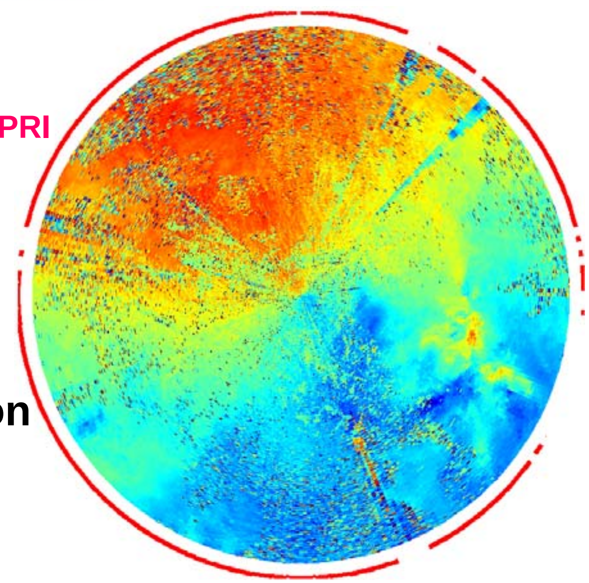
Multi-PRI



Phase code processing

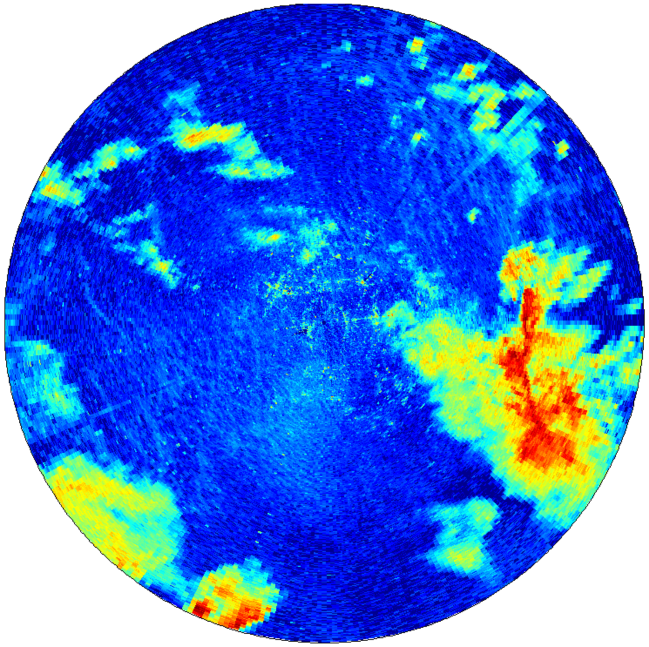


Multi-PRI



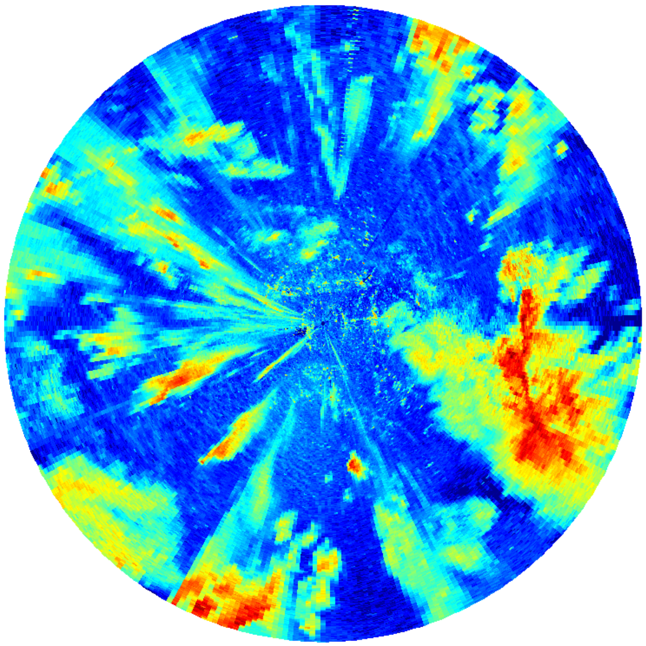
Combination using selection algorithm

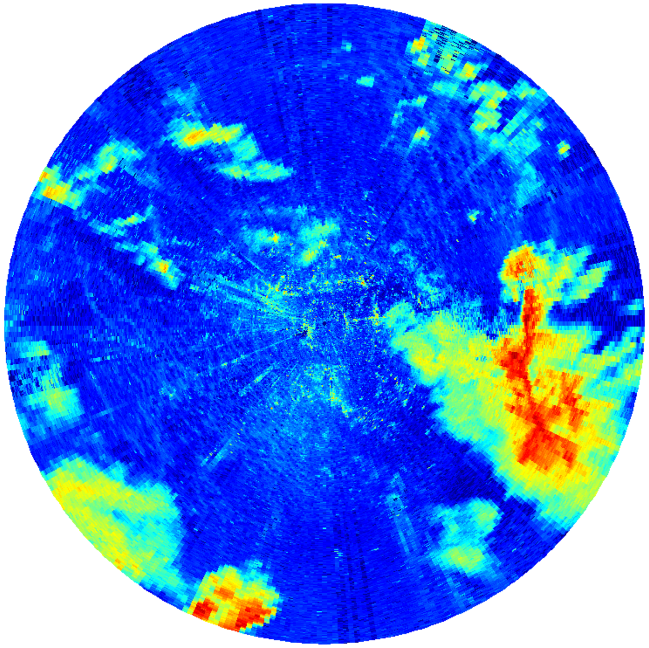
Real Data Example: Reflectivity vs. “Truth”



Low-PRF “Truth”

1 PRF, no phase code processing





Multi-PRI/phase code combination

Summary

- C-band TDWR has severe RV ambiguity
- LL-designed new RDA for the TDWR enables implementation of new algorithms to enhance base data quality
- Range-velocity ambiguity can be dramatically mitigated by combining multi-PRI and phase code processing techniques on an adaptive radial-by-radial basis
- Real-time implementation is next step