

Strobe Waveform for Rapid Scanning Polarimetric Weather Radars

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Special thanks to:
John Meyer and Bob Palmer (OU ARRC)

The instrument development effort was
funded by NSF grant ATM-0821231 to
the University of Oklahoma.



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Rapid Scanning Weather Radars

The Rapid-DOW (from www.ucar.edu)



OU AIR

The Navy-CIRPAS MWR-05XP



NSSL MPAR

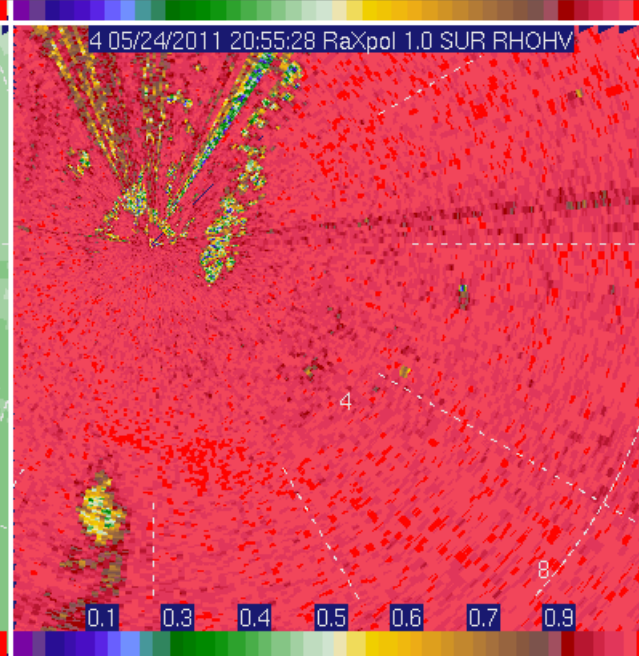
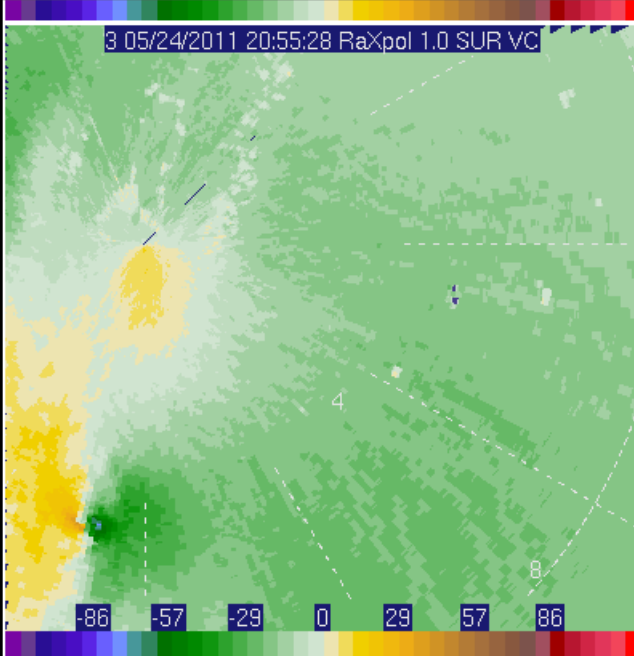
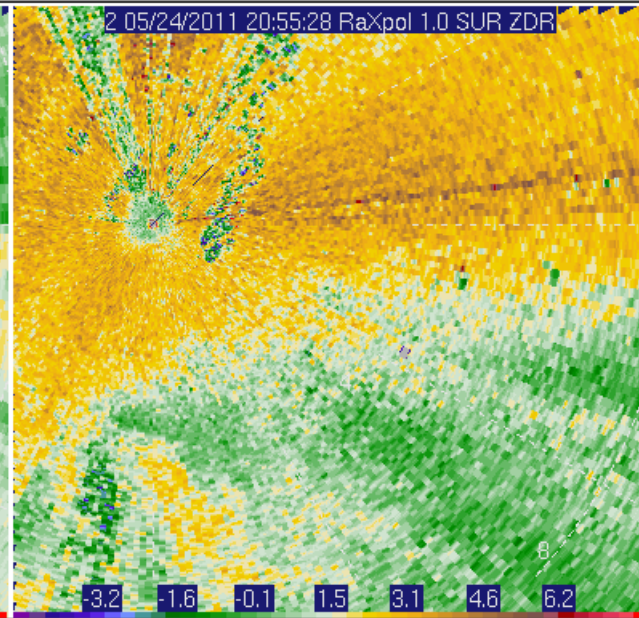
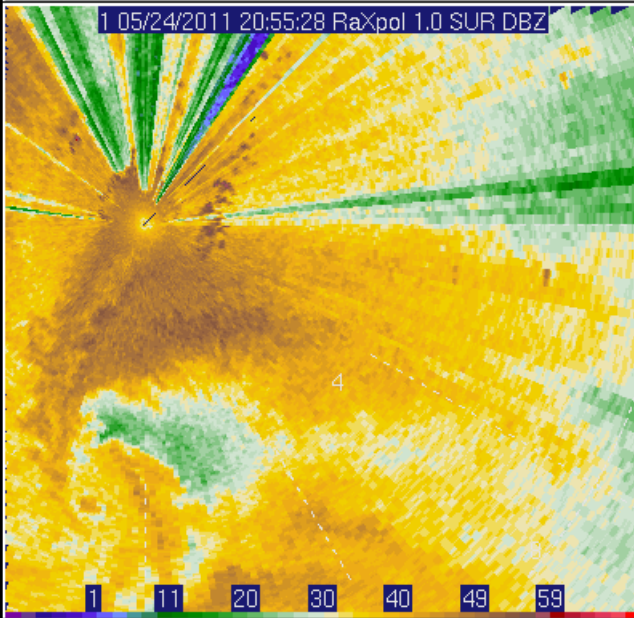


ProSensing/OU RaXpol Radar

- ❑ High Speed (180 deg/sec) Pedestal
- ❑ 1° Beamwidth Dual-Pol Antenna
- ❑ 20 kW, 1% Duty X-band TWTA

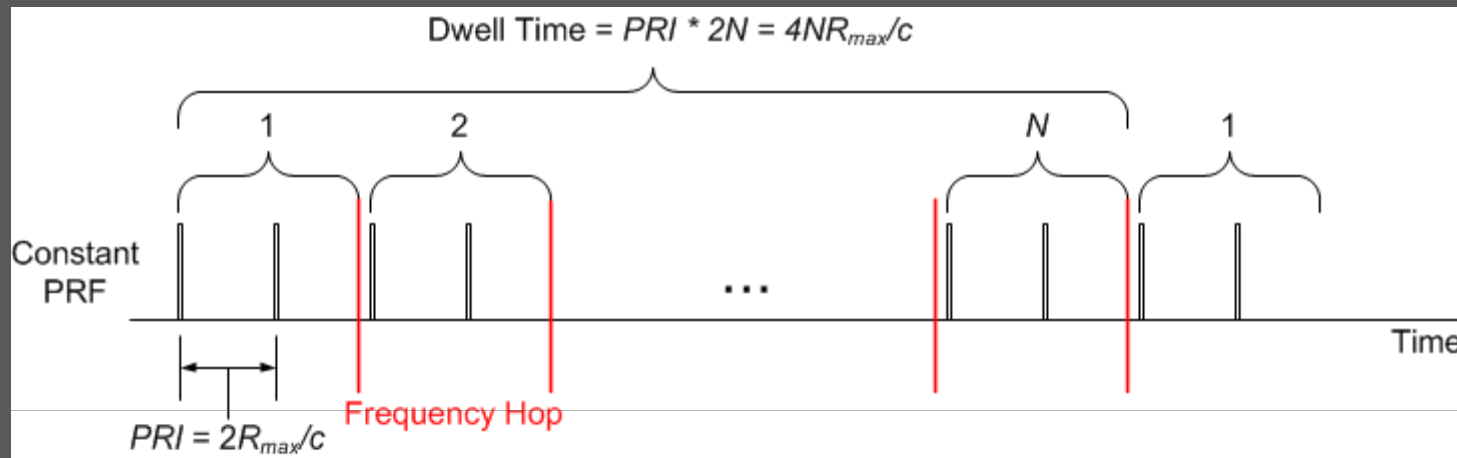


File Zoom Center Config Help



Conventional Pulsing

Frequency Hopping to Force Sample Independence



- $PRI = 2R_{max}/c$

- **Dwell Time = $4NR_{max}/c$**

R_{max} = maximum unambiguous Range

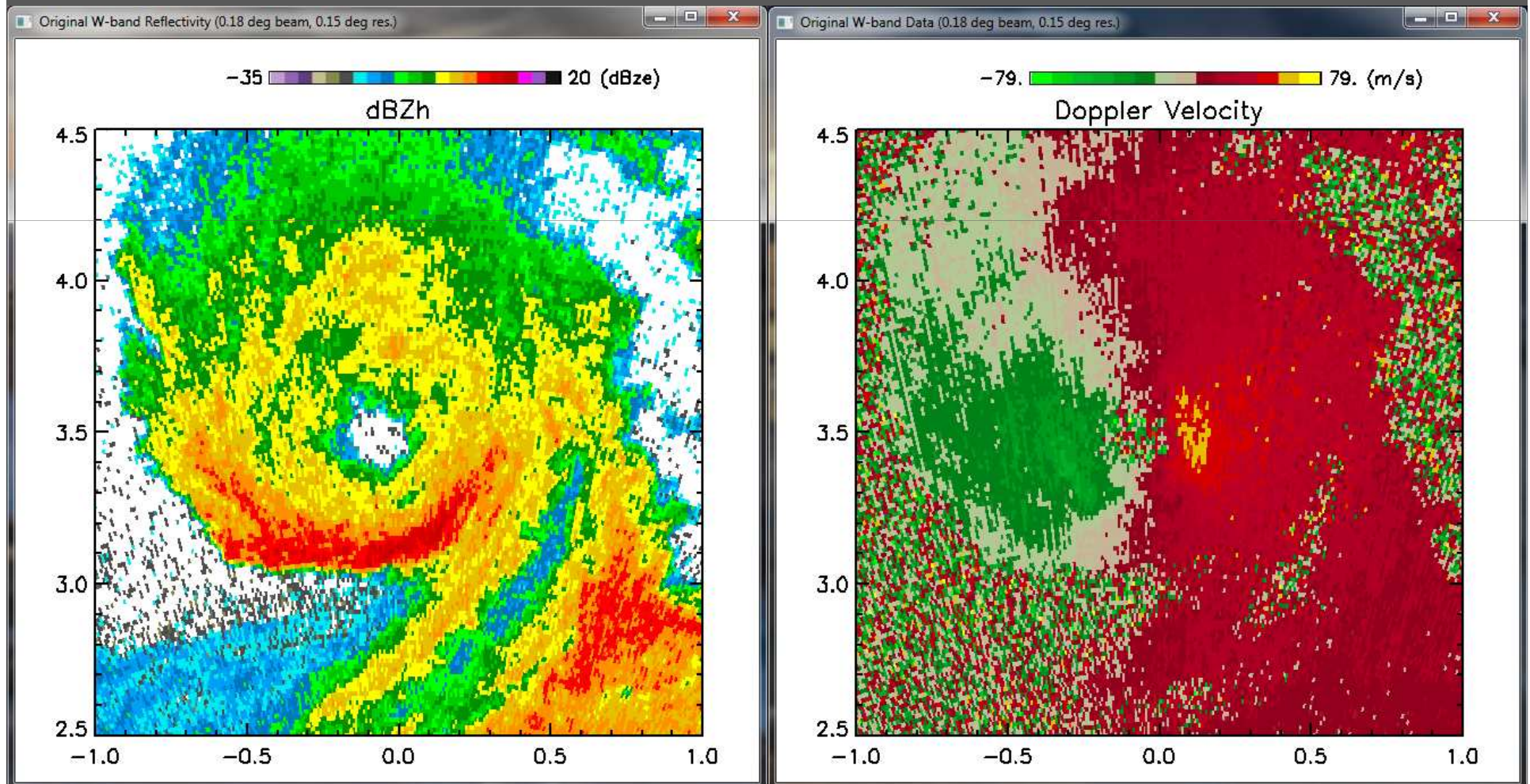
N = Number of independent samples

c = speed of light

- **Beam Smearing = Dwell Time x Scan Speed**

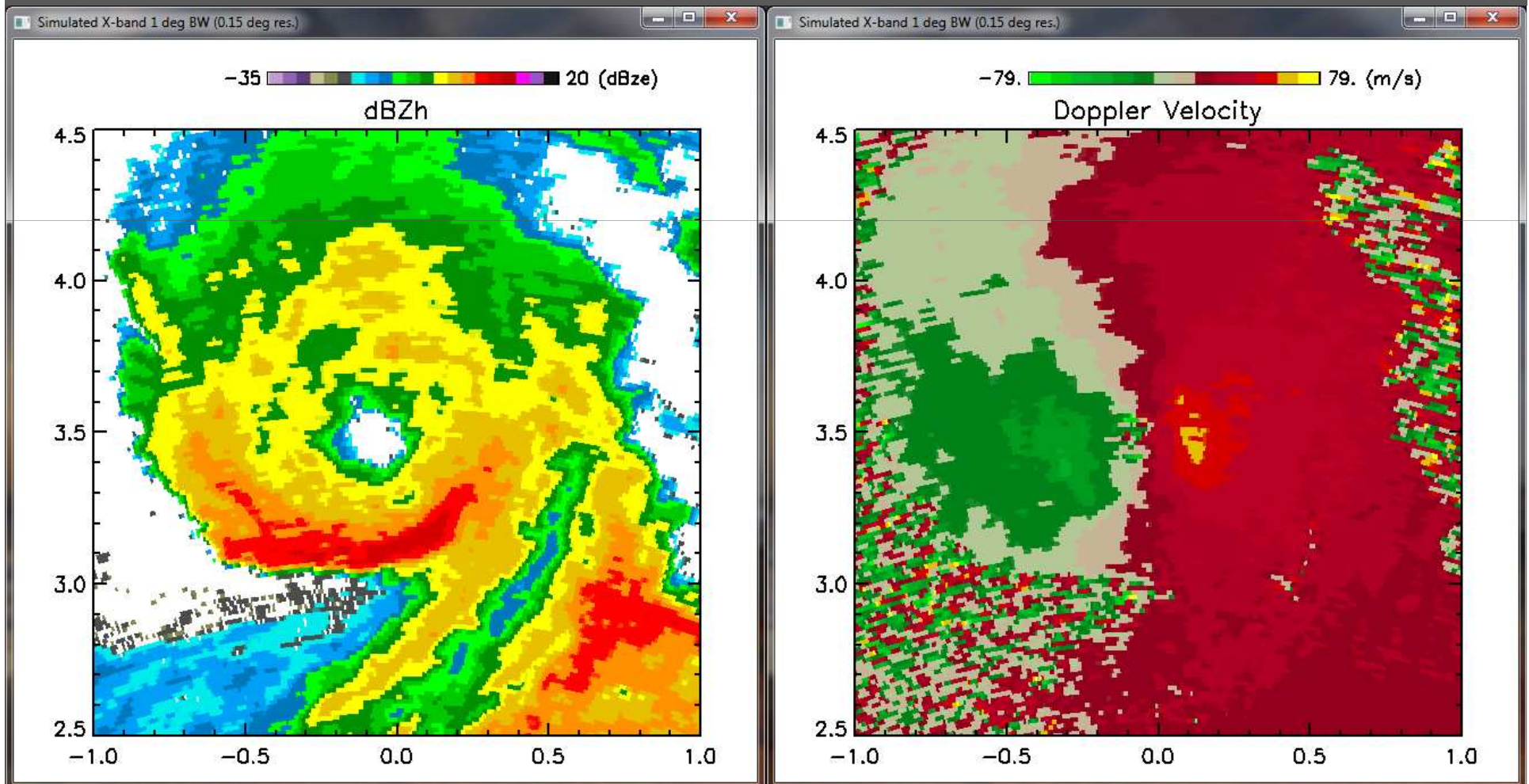
May 3, 1999, Tornado W-band Radar Data 0.18 deg Antenna Beam Width; 0.15 deg Sampling

$V_{max} = 66 \text{ m/s}$



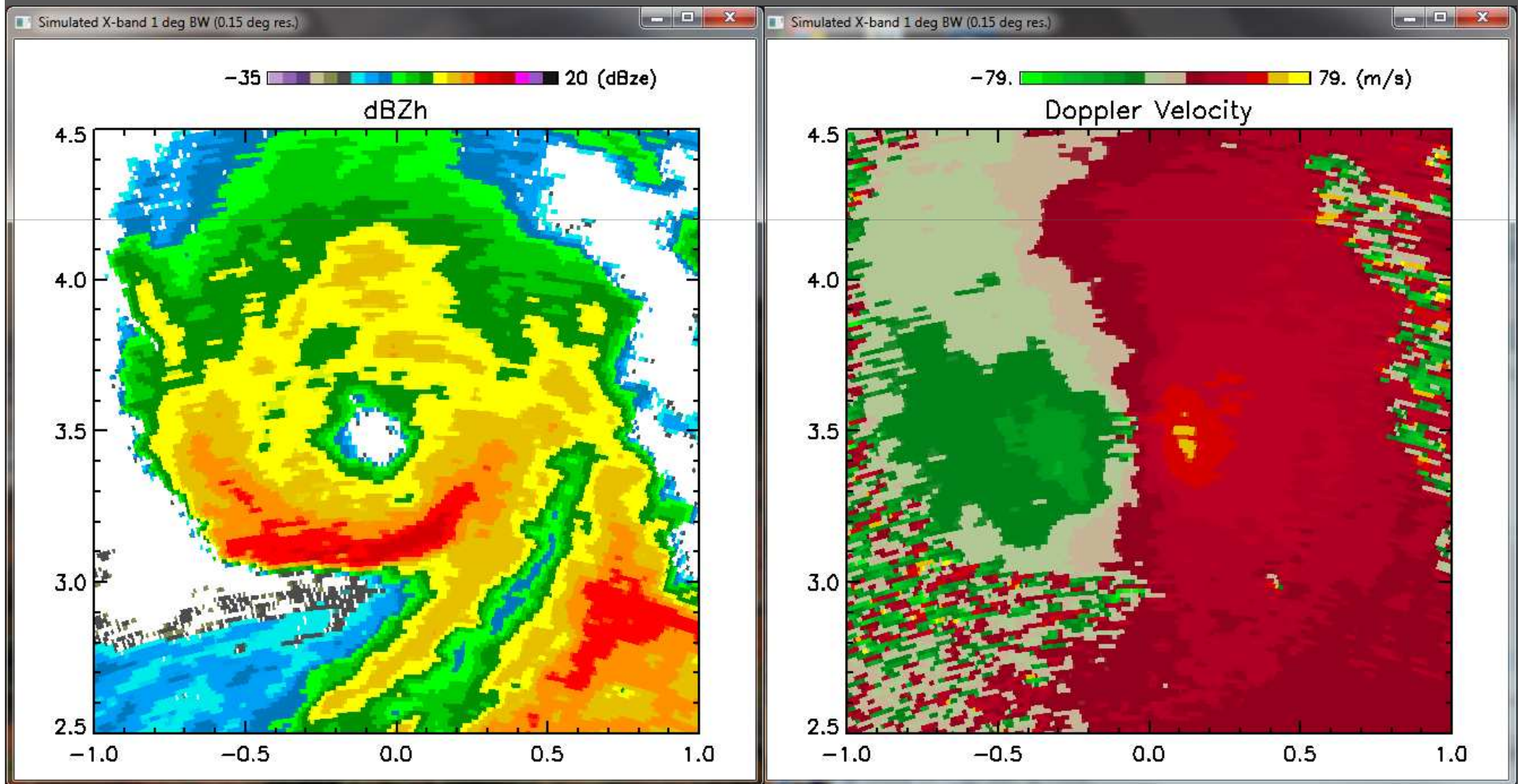
Convolved with a 1 deg BW Antenna Pattern

$V_{max} = 59 \text{ m/s}$



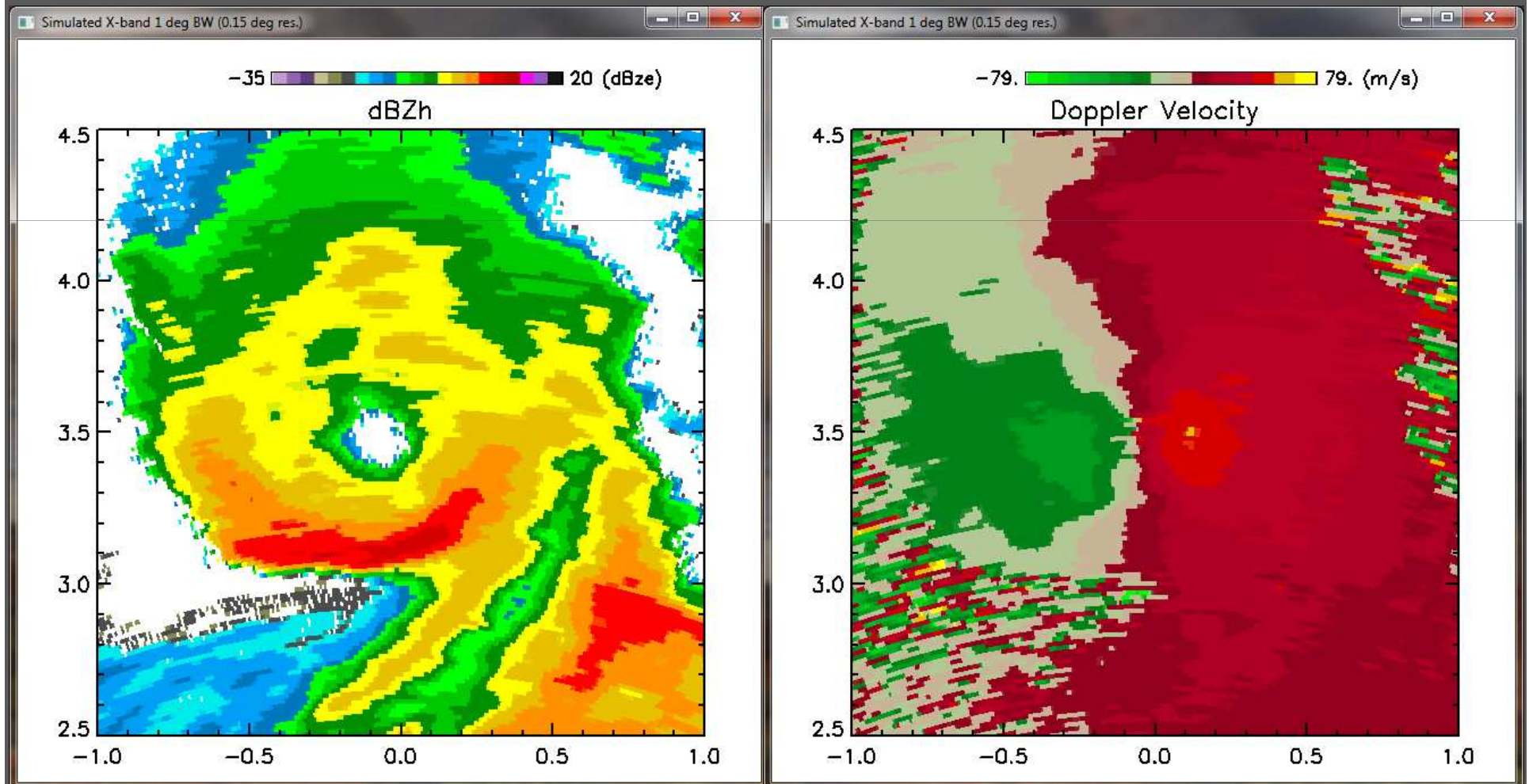
1 deg Averaging (1 BW Beam-Smearing)

$V_{max} = 58 \text{ m/s}$



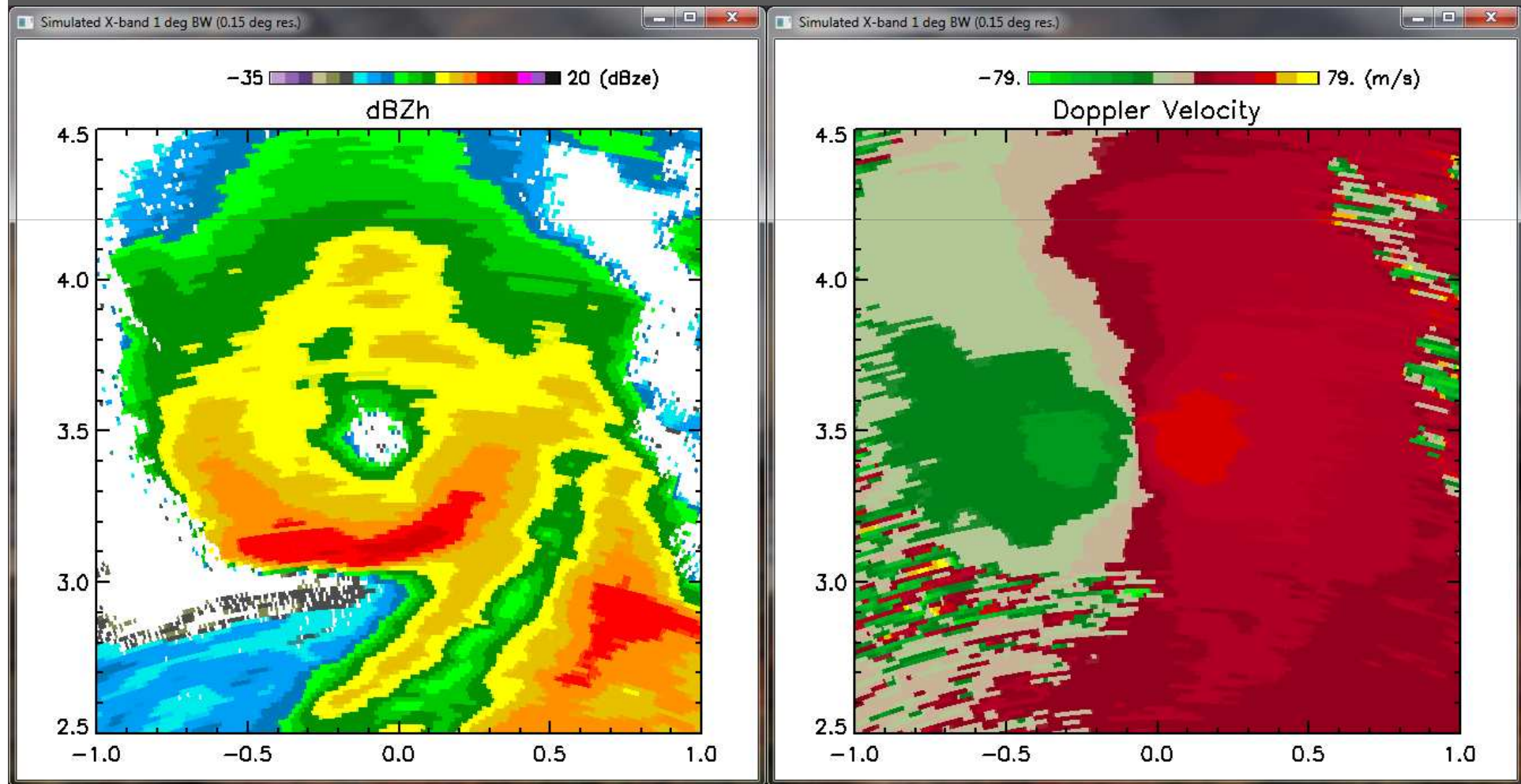
2 deg Averaging (2 BW Beam-Smearing)

$V_{max} = 56.5 \text{ m/s}$



3 deg Averaging (2 BW Beam-Smearing)

$V_{max} = 55 \text{ m/s}$



Scan Rate to Match Beam Smearing to Beam Width

□ Conventional Waveform:

- $PRF = c/2R_{max}$

- Max. Scan Rate = $PRF/2N$ (beams/sec)

Example #1 (X-band):

$$R_{max} = 40 \text{ km and } N = 11 \text{ (22 pulses)}$$

$$\text{Max. Scan Rate} = 170 \text{ beam/sec}$$

$$1 \text{ deg BW ant.: Max. Scan Rate} = \mathbf{170 \text{ deg/sec}}$$

$$\Rightarrow \mathbf{PPI \text{ Update Interval: } \sim 2 \text{ sec}}$$

Example #2 (Ka-band):

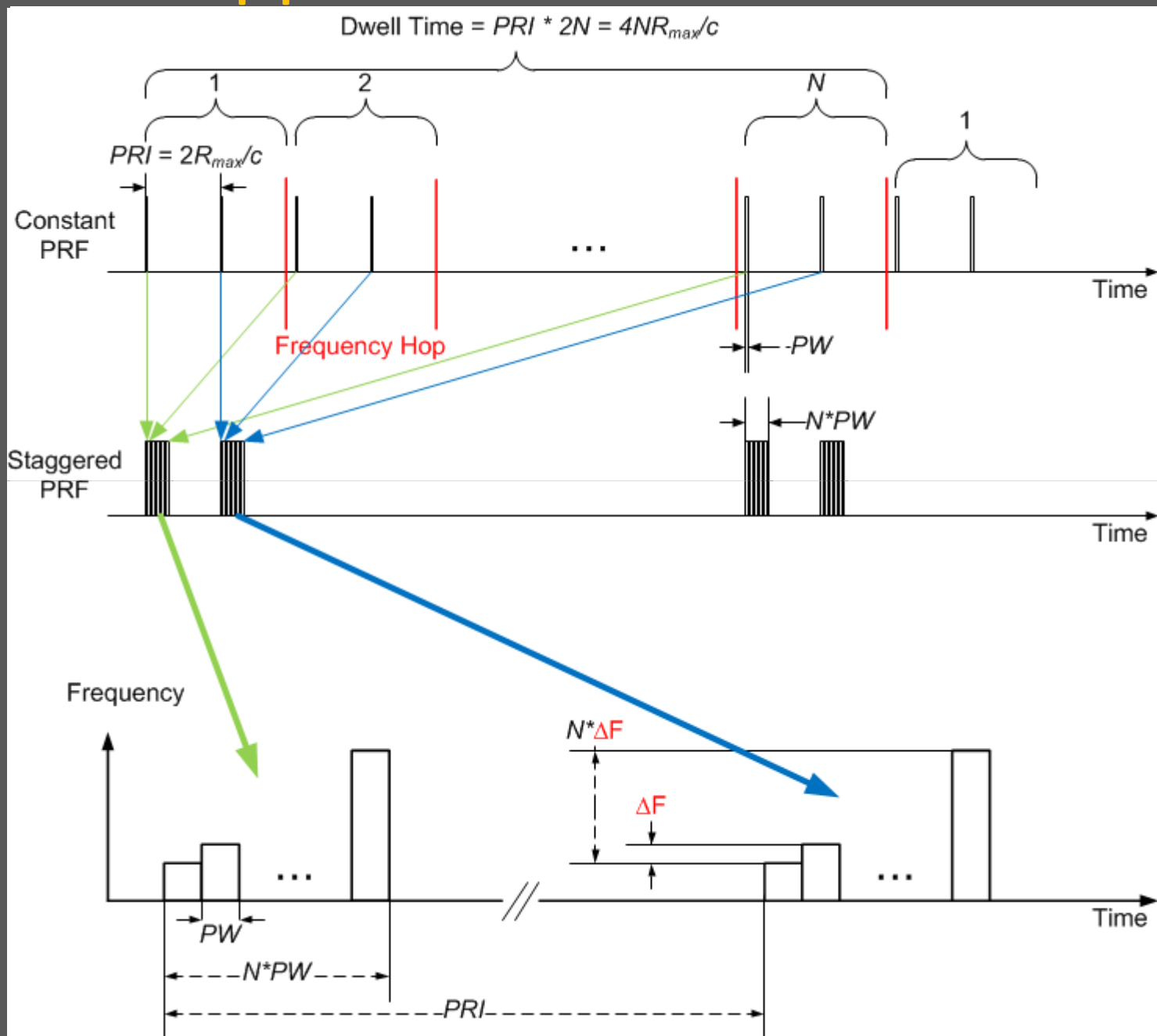
$$R_{max} = 30 \text{ km and } N = 11 \text{ (22 pulses)}$$

$$\text{Max. Scan Rate} = 208 \text{ beam/sec}$$

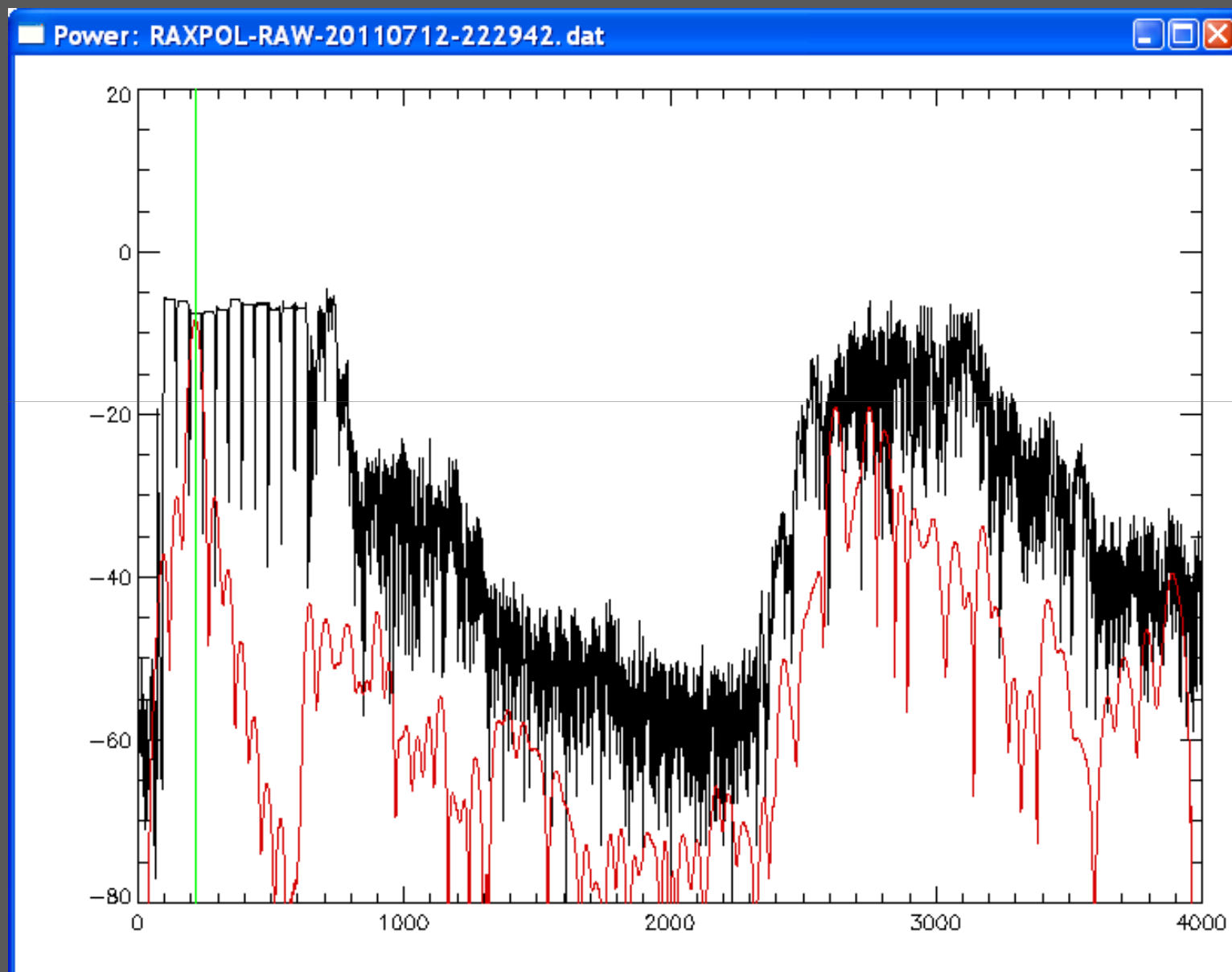
$$0.3 \text{ deg BW (Ka-band) ant.: Max. Scan Rate} = \mathbf{62.5 \text{ deg/sec}}$$

$$\Rightarrow \mathbf{PPI \text{ Update Interval: } \sim 6 \text{ sec}}$$

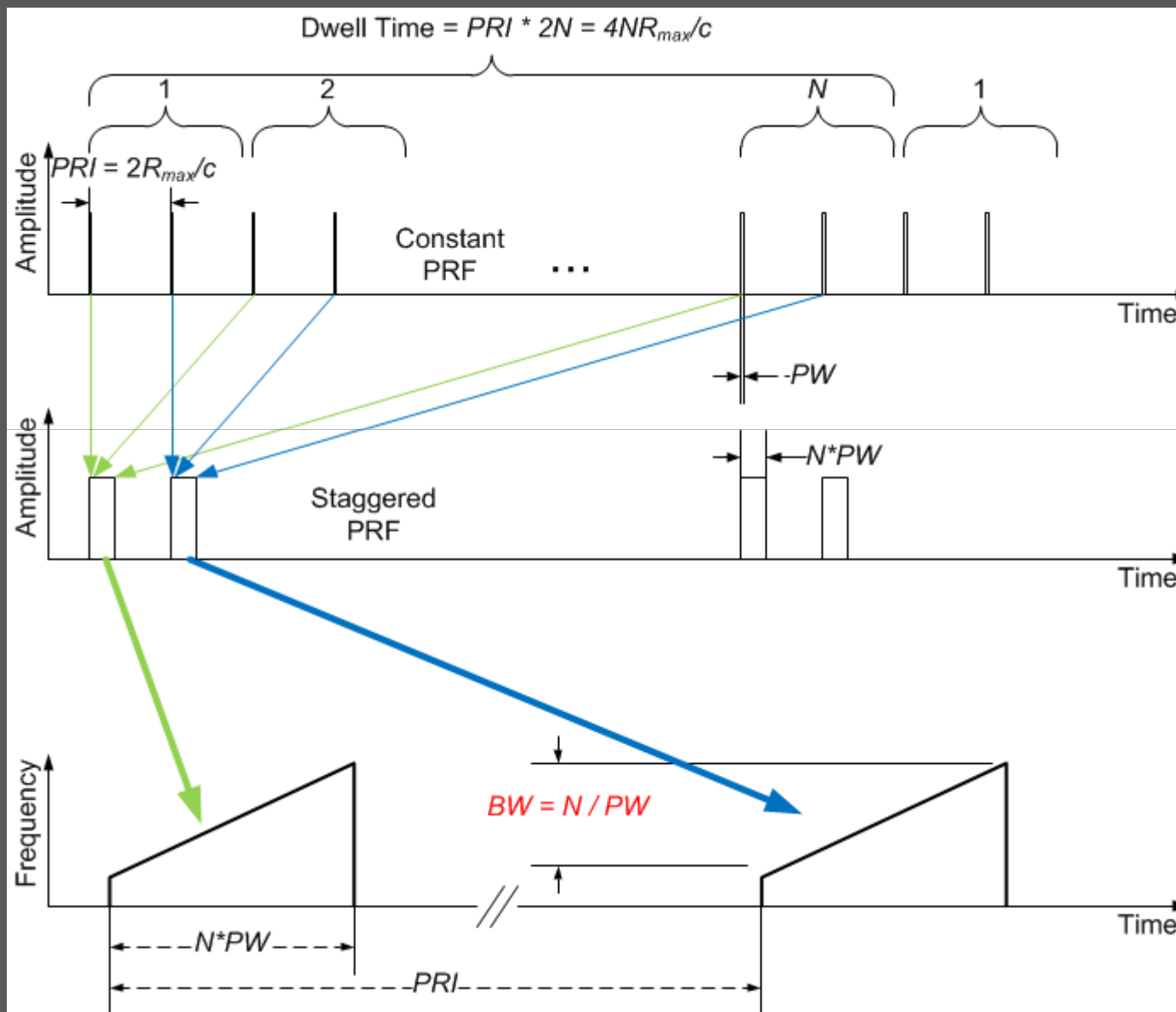
Stepped FM Strobe Mode



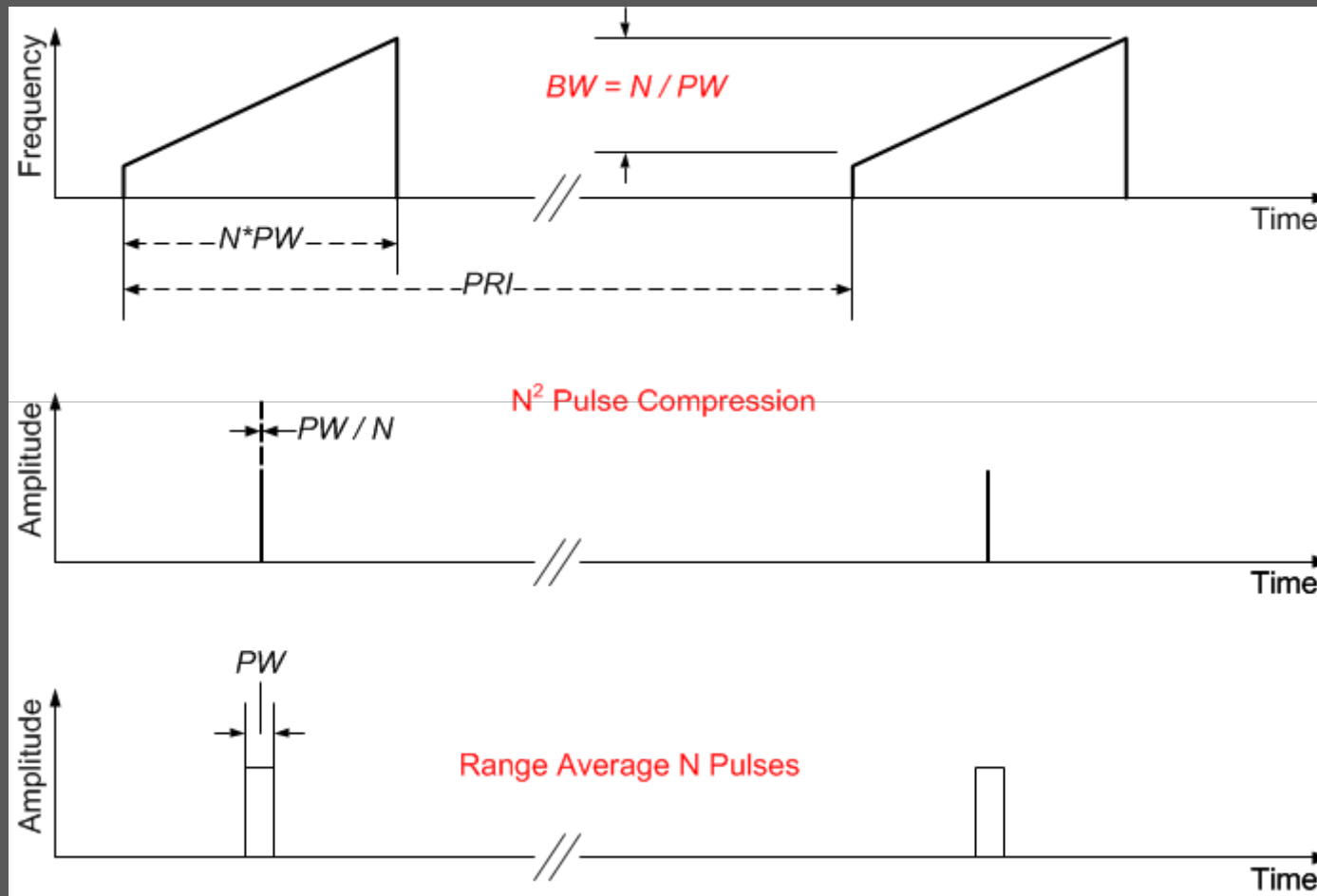
Strobe-Mode Waveform and Return



Range Averaging Strobe Mode



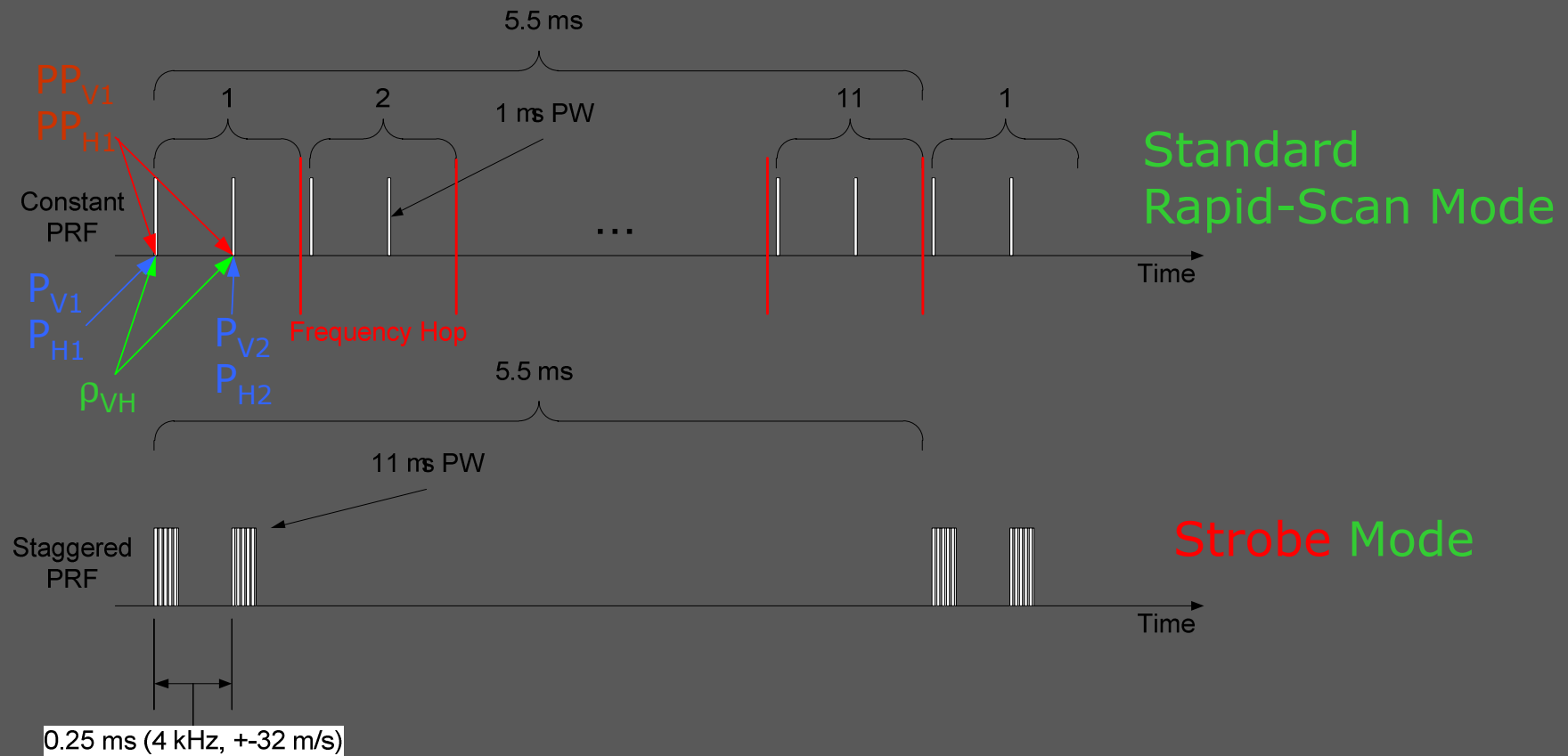
Range Averaging Strobe Mode (cont.)



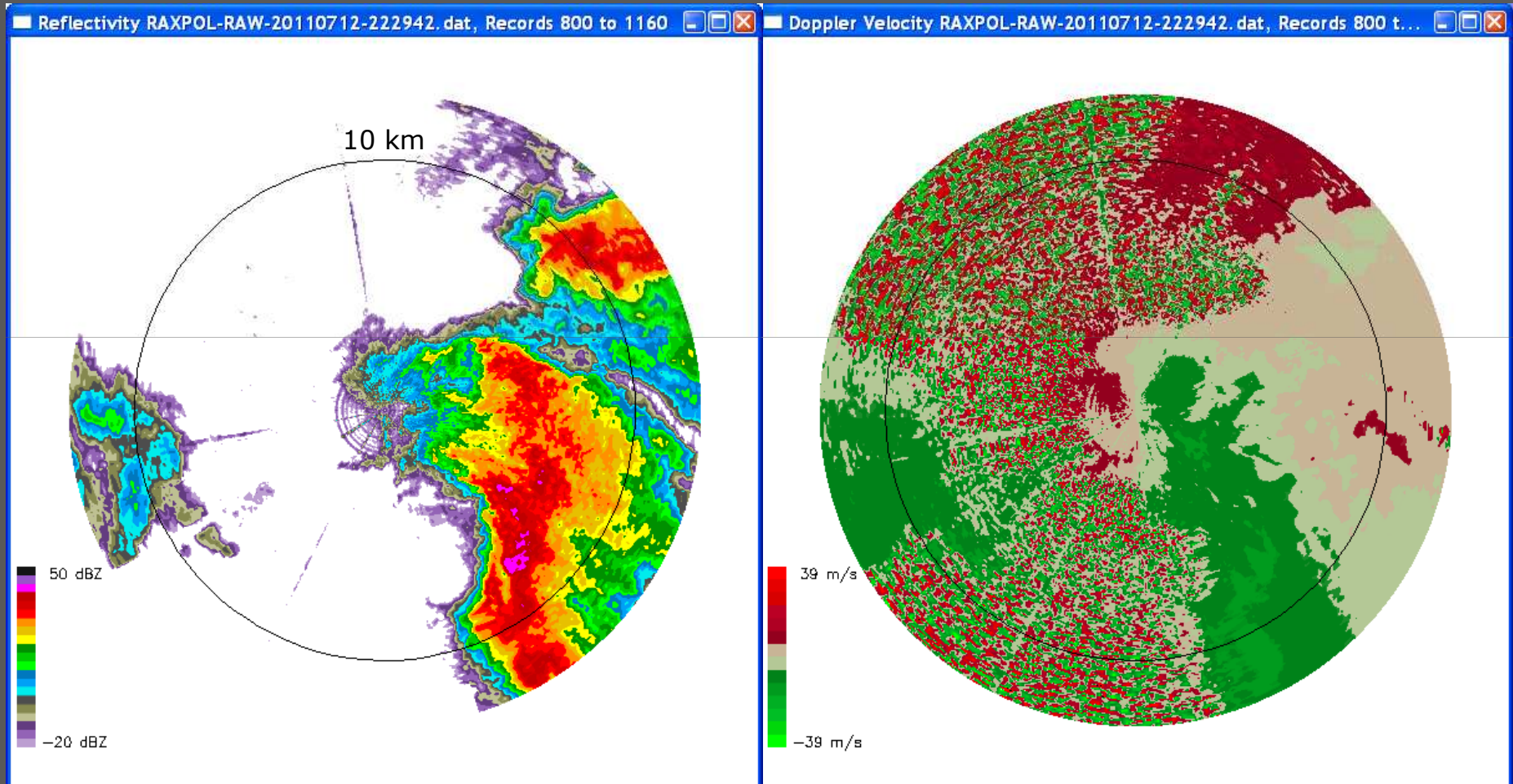
Stepped FM vs. Range Averaging

	Stepped Frequency FM	Range Averaging
<u>Receiver Bandwidth:</u>	$>3N/PW$	N/PW
<u>Sampling Rate:</u>	$>6N/PW$	$2N/PW$
<u>Convergence to Mean:</u>	ΔF can be increased to ensure independence.	Poor when reflectivity field has fine structure.
<u>Processing:</u>	Computationally Intensive	Relatively Easy
<u>Sensitivity:</u>	Same	\sqrt{N} Worse
<u>Range Resolution:</u>	~ Same	

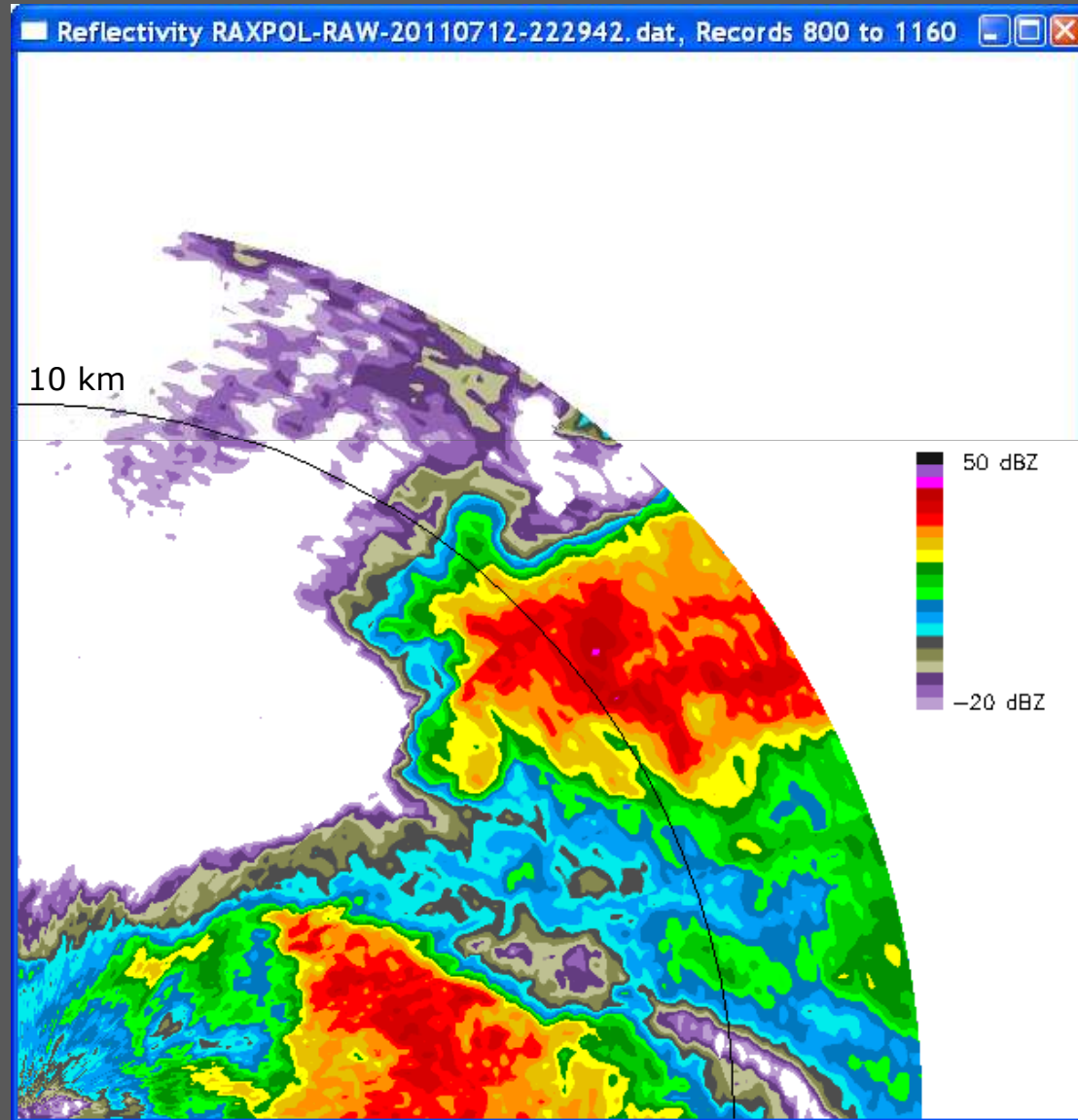
RaXPol Strobe Mode



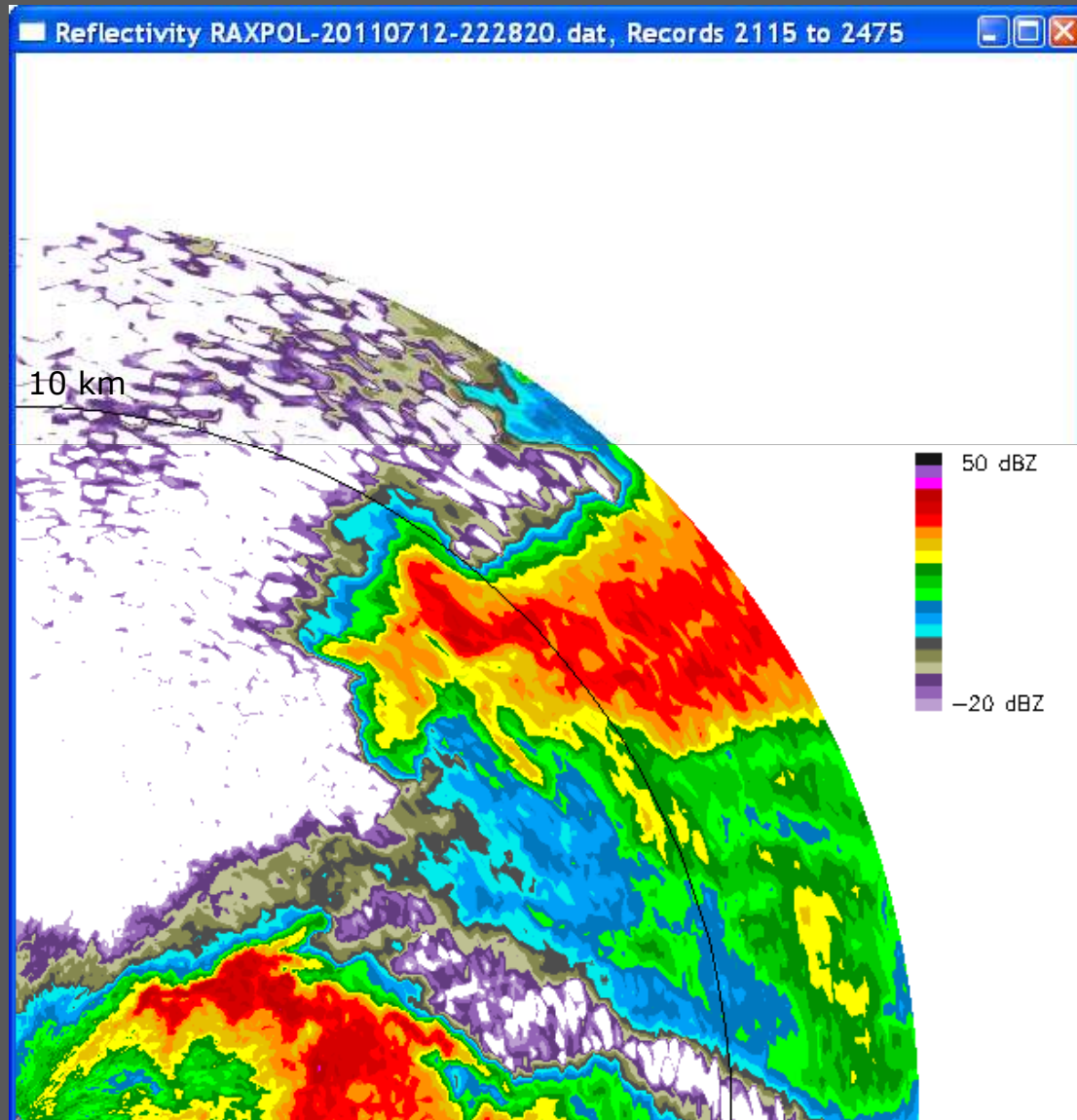
Strobe Mode



Strobe vs. Standard Mode



Strobe vs. Standard Mode



Conclusions

- Impact of beam smearing is increasingly significant when averaging more than 1 antenna beam-width.
- Stepped FM or Range Averaging Strobe pulsing mode can effectively eliminate beam smearing.
- Future narrow-beam MM-wave rapid scanning radars will require Strobe mode.