



Clutter Environment Analysis using Adaptive Processing: The **CLEAN-AP** Filter

(Informational Briefing)

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What is the CLEAN-AP filter?



CLEAN-AP is a novel **real-time, automatic, integrated** approach for ground clutter **detection** and **filtering** that produces data with the **best possible quality** while meeting NEXRAD technical requirements



Outline



- Motivation
- Current approach
 - Maps/CMD + GMAP
- Proposed alternative
 - The CLEAN-AP filter
- Summary and recommendations
- Stay tuned: Performance analyses and comparisons with current approach



WSR-88D Strategic Directions

Snow et al. (2003)



- “Produce the best quality data possible from the WSR-88D throughout the remainder of its service life.”
 - “...these applications require that quality control/assurance be applied automatically.”
 - “Signal processing could be improved to almost completely mitigate ground clutter...”

Possible Strategic Directions For the WSR-88D Doppler Weather Surveillance Radar

John T Snow

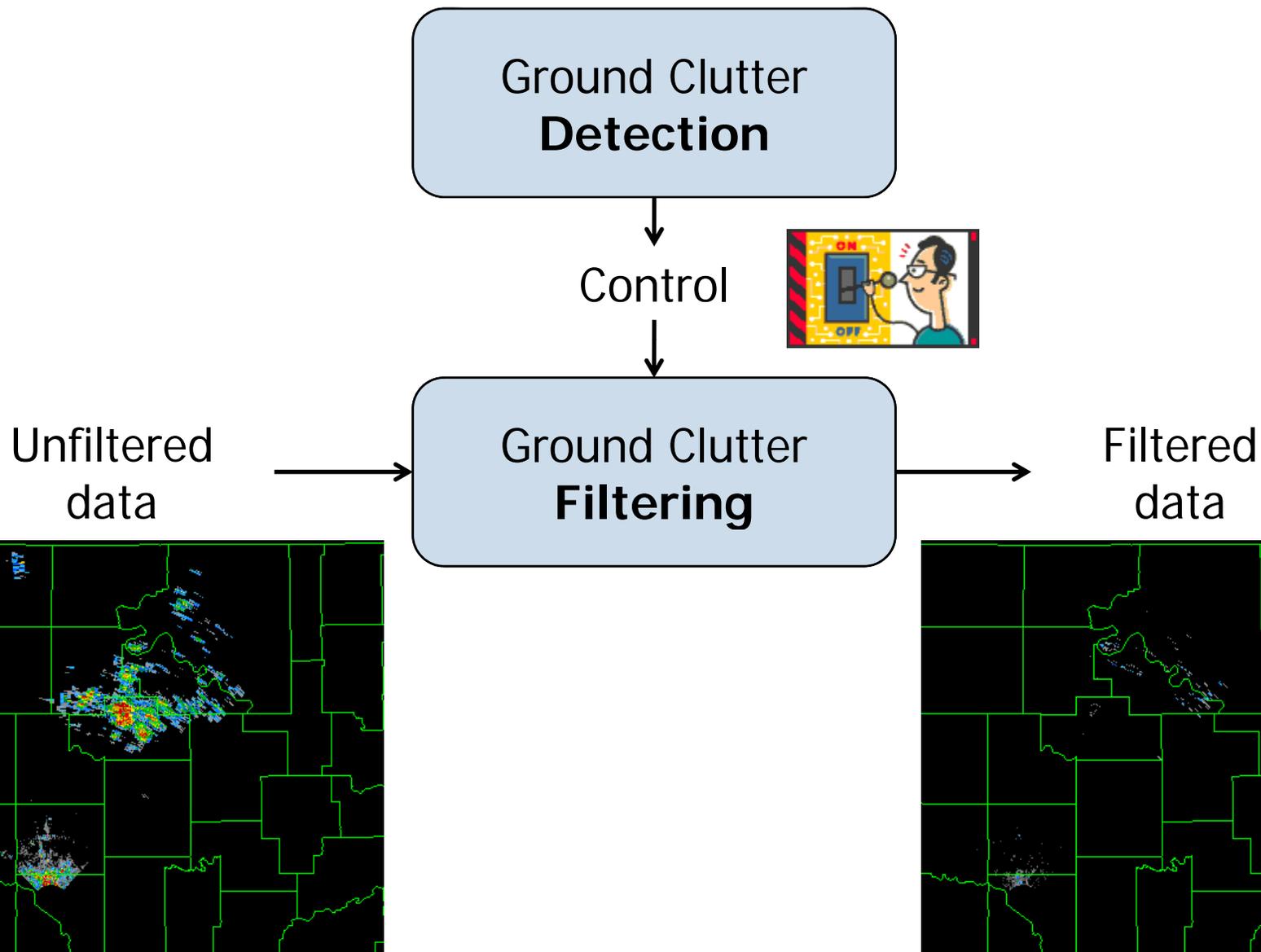
Chair, NEXRAD Technical Advisory Committee Chair
College of Geosciences, The University of Oklahoma

Rhonda B. Scott, Capt, USAF
Radar Operations Center

Members, NEXRAD Technical Advisory Committee

WSR-88D Clutter Mitigation

at the signal processing level (ORDA)



Ground Clutter Detection

Current Approach



- ORDA Build 10 **& 12**
 - Static ground clutter maps (BYPASS map)
 - Operator-defined Clutter Censor Zones (CCZ)
- ORDA Build 11
 - Lower tilts (split cuts)
 - Clutter Mitigation Decision (CMD)
 - Upper tilts
 - Static ground clutter maps (BYPASS map)
 - Operator-defined Clutter Censor Zones (CCZ)

CMD is good!

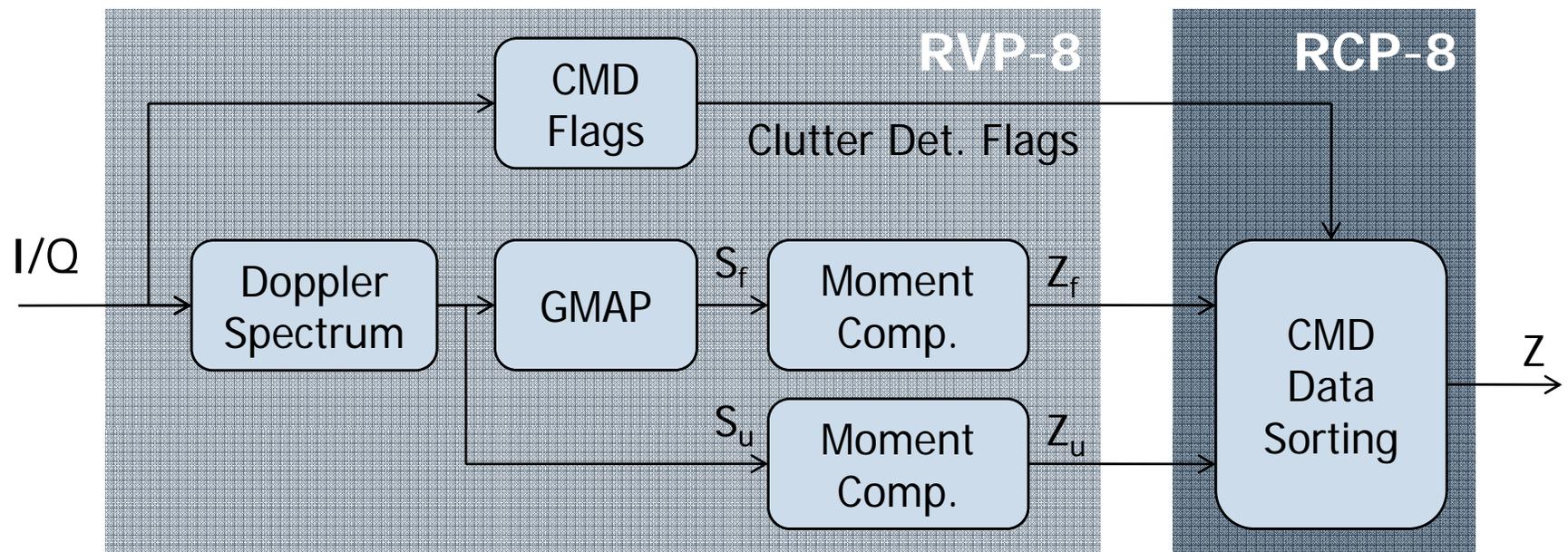


Ground Clutter Detection

Clutter Mitigation Decision (CMD)



- Uses temporal and spatial features in a fuzzy-logic system to automatically detect ground clutter contamination in real time
 - Detections are “filled-in” using spatial filter
 - Requires filtered and unfiltered data
 - Functionality split between RVP-8 and RCP-8

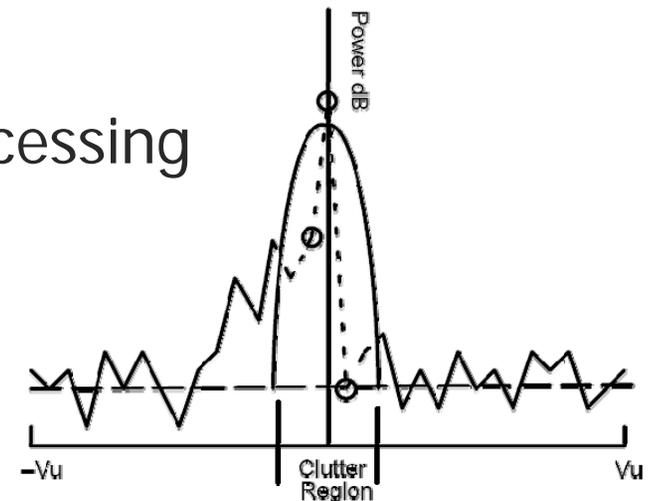


Ground Clutter Filtering

Gaussian Model Adaptive Processing (GMAP)



- Uses Gaussian model for clutter to determine notch width
 - Suppression is limited by maximum notch width
- Needs Blackman window to achieve required suppression
 - Does not produce data with best possible quality
- Uses iterative process to reduce reflectivity bias
 - Computationally intensive
- Needs at least 16 samples to achieve required suppression
 - Imposes limit on faster updates
- Not conducive to more spectral processing
 - Phase is lost from filtered signal
 - Affected by circular convolution biases
- Algorithm is under Vaisala control



Source: Siggia and Passarelli (2004)

The CLEAN-AP Filter (I)



- CLEAN-AP is **automatic**
 - No need for user intervention
 - Real-time detection
 - No need for clutter maps
- CLEAN-AP produces data with the **best possible quality**
 - Adaptive data windowing finds the best compromise between clutter suppression and data quality
- CLEAN-AP meets NEXRAD **requirements**
 - Improved suppression (not limited by max. notch width)
 - Requirements (Z) met with as little as 8 samples
- CLEAN-AP is **integrated**
 - One algorithm for ground clutter detection and filtering
 - Gate-by-gate operation

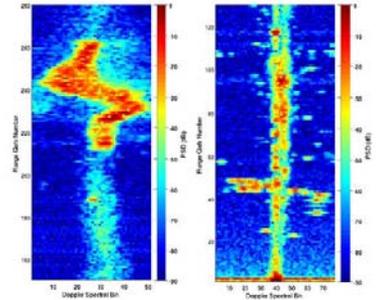


The CLEAN-AP Filter (II)



- CLEAN-AP “sets the stage” for further **spectral processing**

- Phase information is not lost
- Immune to biases from circular convolution



- CLEAN-AP is **operational on the NWRT PAR**

- Running in real-time since Sep 2008
- Performance informally evaluated by meteorologists and forecasters (PARISE experiments)



- CLEAN-AP consideration as an alternative clutter mitigation solution **makes sense now**

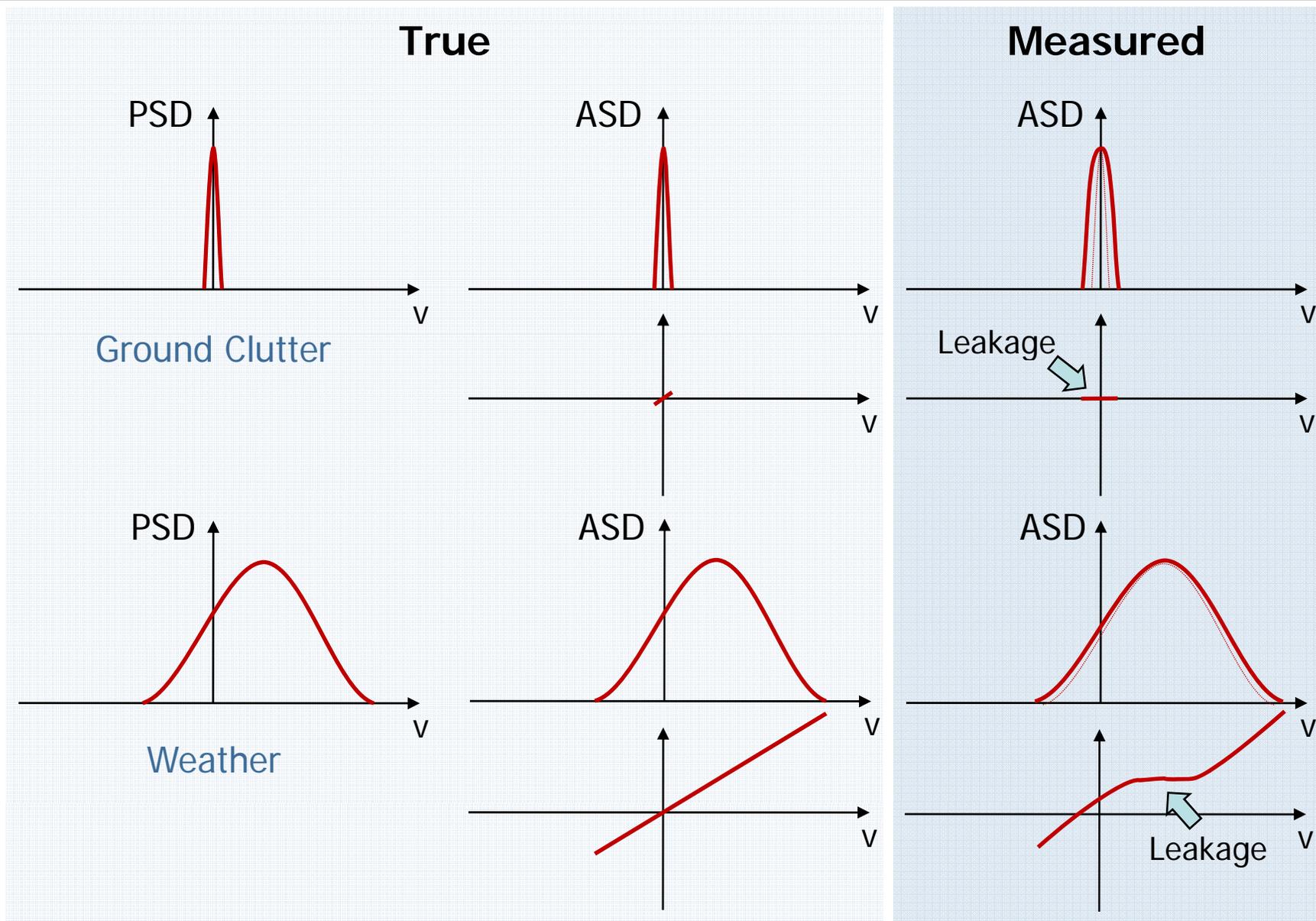
- Re-implementation of an automatic ground clutter detection scheme will be needed after ORDA B12
- In principle, compatible with dual pol., SZ-2, and SPRT



How does CLEAN-AP work? (I)

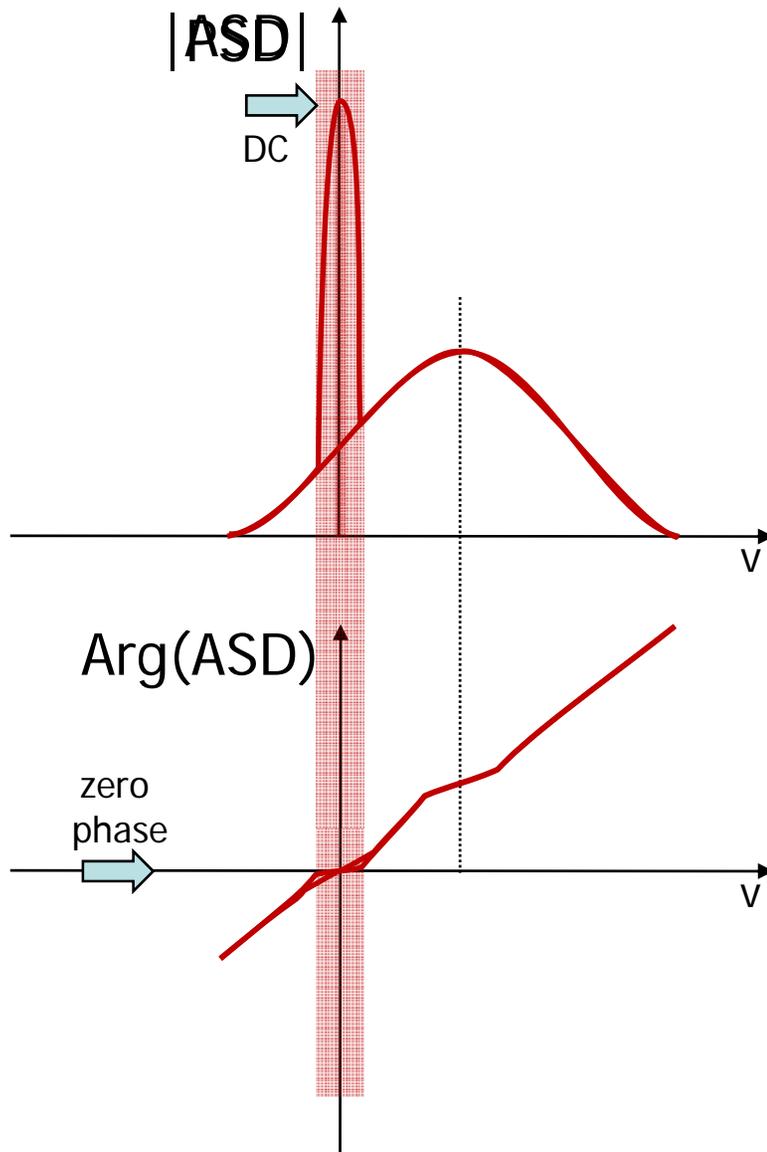


The "lag-1 autocorrelation spectral density" (ASD)



How does CLEAN-AP work? (II)

Integrated detection and filtering



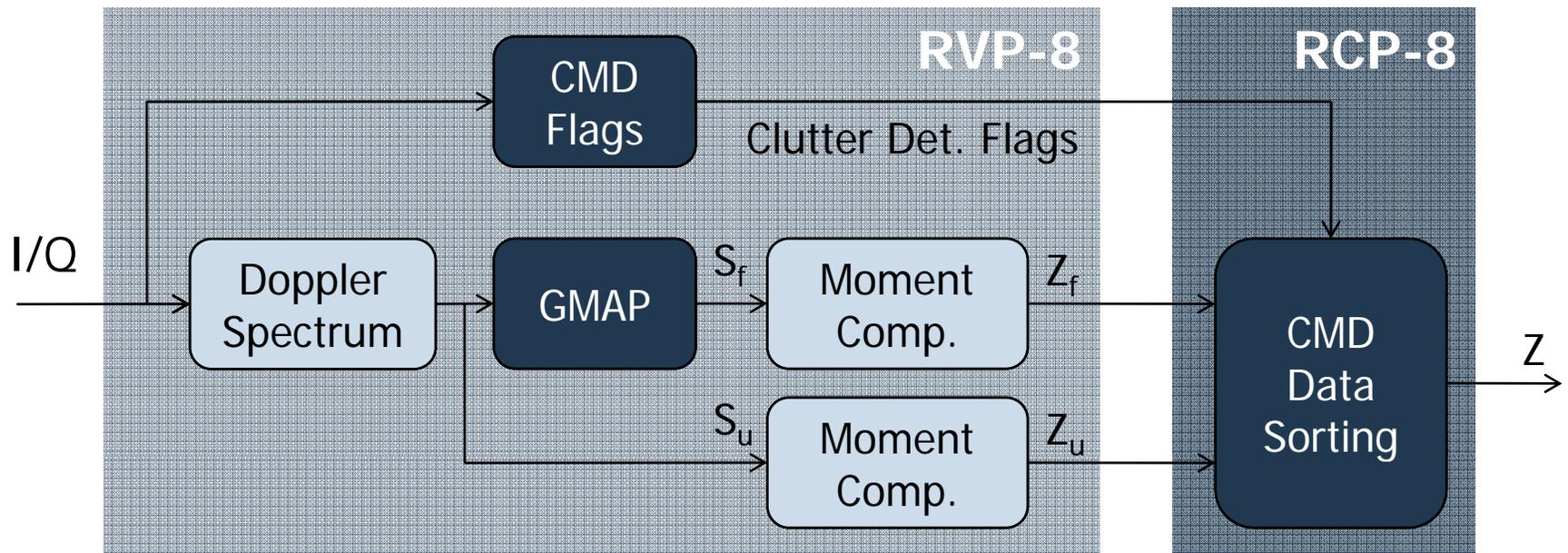
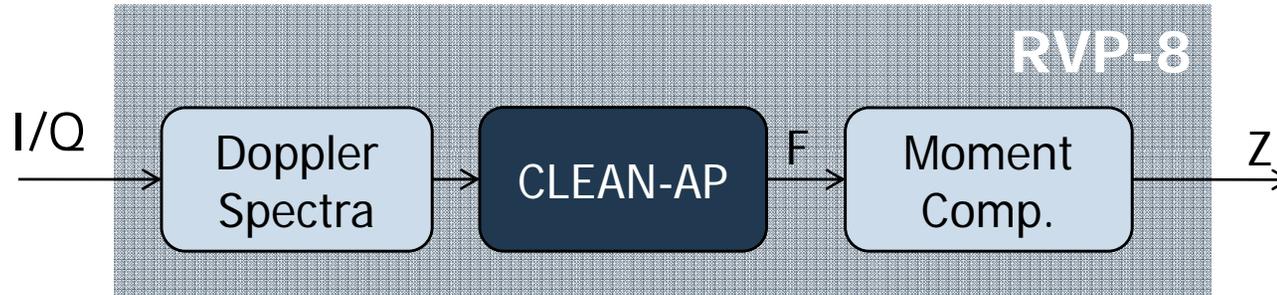
Detection

- Estimate CNR
- Select appropriate data window
- Compute ASD
- Identify components with clutter contamination
 - Phase of ASD is near zero due to leakage effect

Filtering

- Remove clutter
- Interpolate weather
- ASD is used to estimate spectral moments directly

CLEAN-AP vs. Current Approach



Summary and Recommendation



- CLEAN-AP is a **real-time, automatic, integrated** approach for ground clutter **detection** and **filtering** that produces data with the **best possible quality** while meeting NEXRAD technical **requirements**
 - Improved performance compared to current approach
- We recommend considering the CLEAN-AP filter as a ground clutter mitigation solution for the NEXRAD network
 - TAC endorsement is needed

