Dual Polarization the Challenge

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Two Dual Polarization Modes

Simultaneous SHV (it is not fully polarimetric)

H and V are transmitted simultaneously, both copolar components are received

H H H H H H H H

_|___|___|___|___|___|___|___|

H receiver

V V V V V V V V

_|___|___|___|___|___|___|___|

V receiver

Alternate AHV (it is fully polarimetric)

H and V are transmitted alternatively

H V H V H V H V

_|___|___|___|___|___|___|___|

Challenge: DualPol-PAR to have Same Data Quality as DualPol-WSR-88D

Polarimetric Data Quality Achieved on Conventional Radars:

- High cross-correlation coefficient ρ_{hv}, small bias in differential reflectivity Z_{DR}, and low linear depolarization ratio L_{DR}, characterize a well designed polarimetric radar
  - EEC recent Polarimetric Radars (Sigmet Processor, Gamic Processor): $\rho_{hv} \approx 0.996$ to 0.998
  - KOUN (WSR-88D, NSSL design) $\rho_{hv} \approx 0.998$, $L_{DR} < -33$ dB
  - Z_{DR} bias should be < 0.15 dB

ISSUES
affecting dual polarization data

- COUPLING between the horizontal and vertical components (inherent to Planar PAR for measurements away from the two principal planes)

- CROSS-POLAR PATTERN (present in PAR and Conventional Radar)

- MATCHING OF BEAMS at vertical and horizontal polarizations (present in PAR and Conventional Radar)

Transmitted Linearly Polarized Waves from a

- Parabolic Dish are orthogonal throughout the whole field of view
- Planar Phased Array are not orthogonal through most of the field of view

{COUPLING - Planar Array}
Alternate (AHV) Mode

- Tested extensively on parabolic antennas
- Planar Phased Array
  - Performs well if corrected over the field of view
  - Correction to mimic conventional radar can be done over most of the field of view
  - Correction is multiplicative and is a function of pointing direction

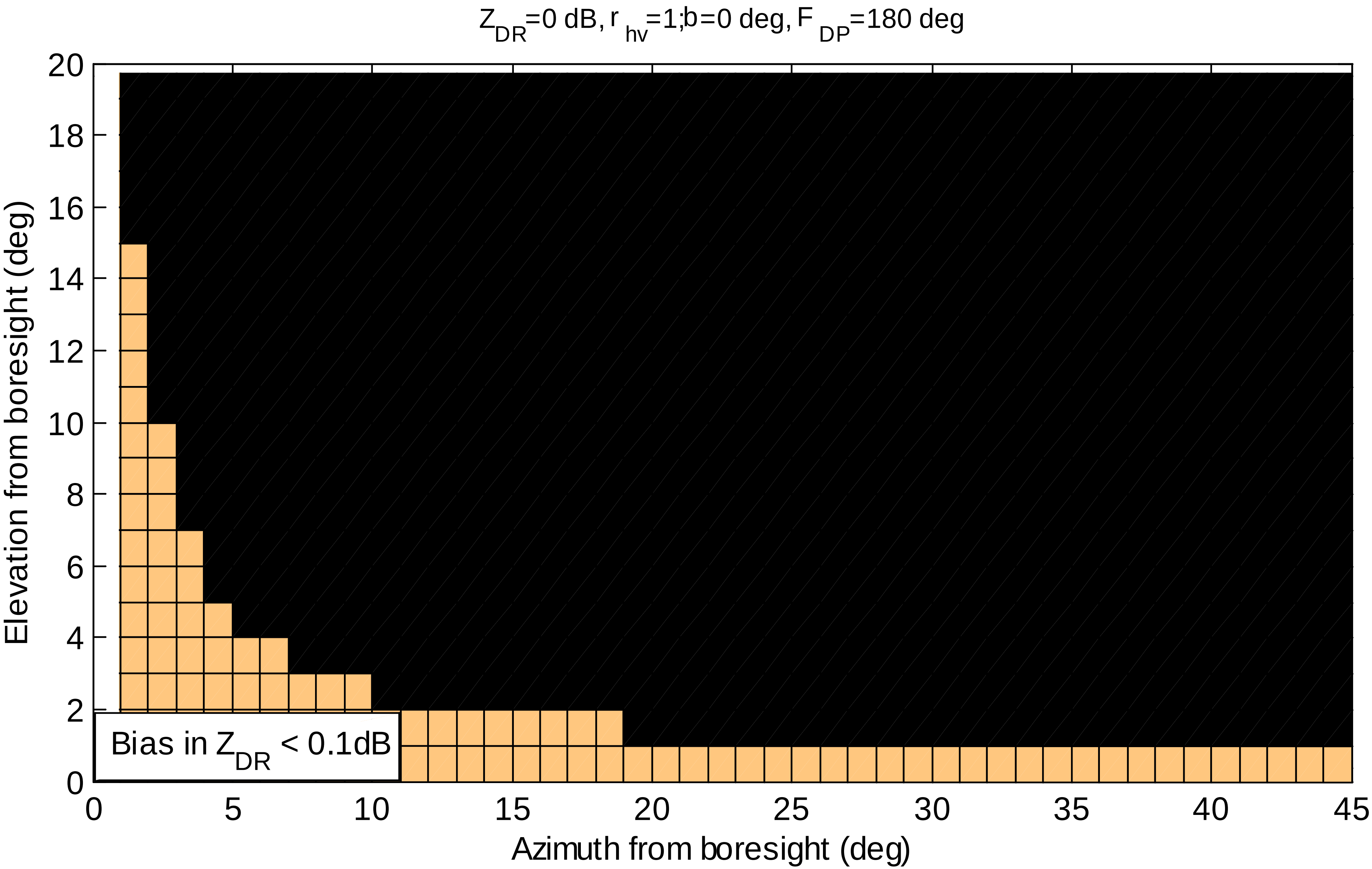
COUPLING, Ref: Guifu et al 2009
IEEE Tr., GRS-47

{COUPLING – Planar Array} Simultaneous (SHV) Mode

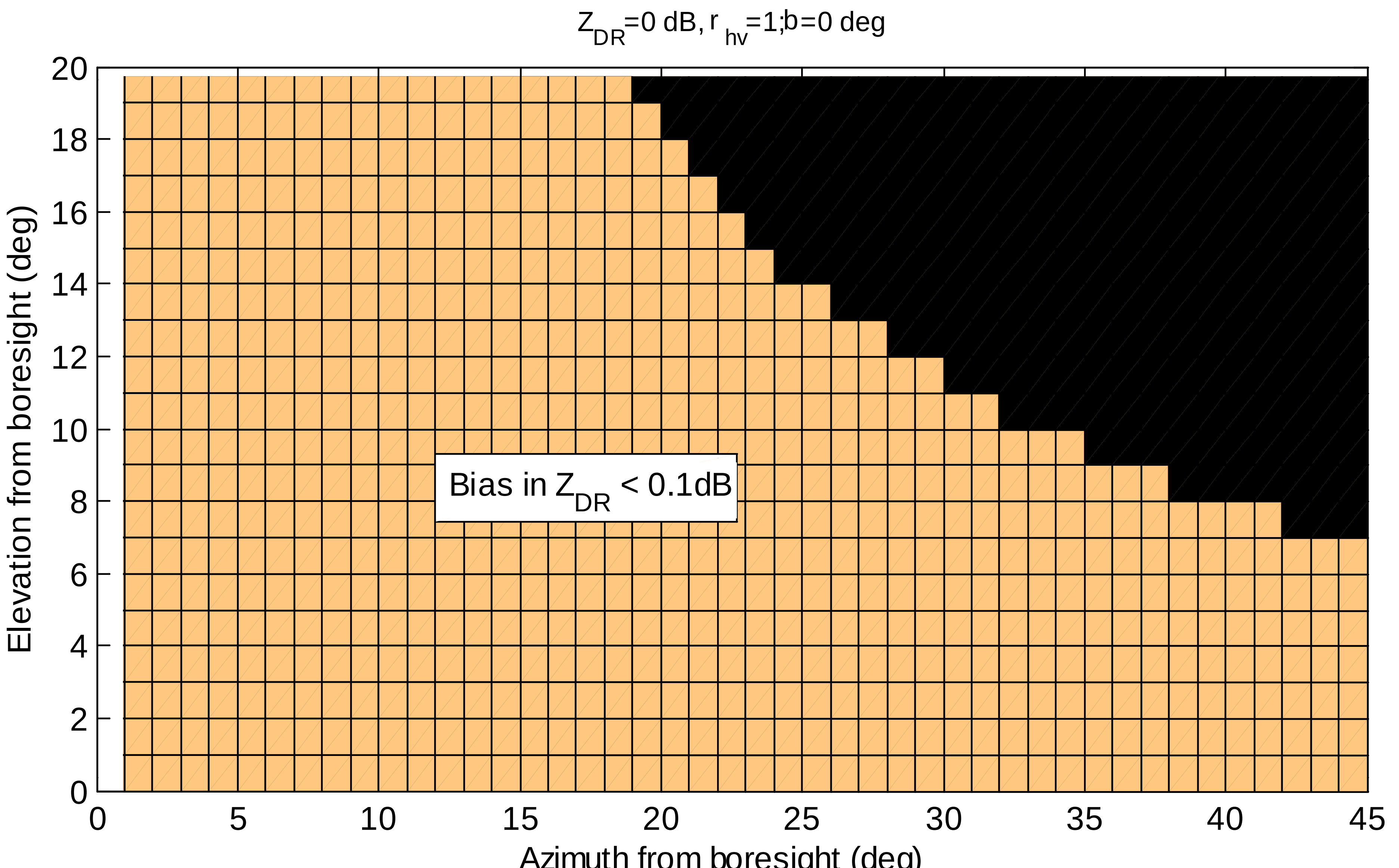
- Accepted for the WSR-88D
- Planar Phased Array
  - Performs – with multiplicative correction only over a limited field of view
  - Corrections* over the remaining field of view are not practical
  - Therefore alternatives are needed for most of the field of view:
    - Orthogonal coding
    - Alternate HV
    - Other?

COUPLING, Ref: Guifu et al 2009 IEEE Tr., GRS-47

Field of View SHV mode



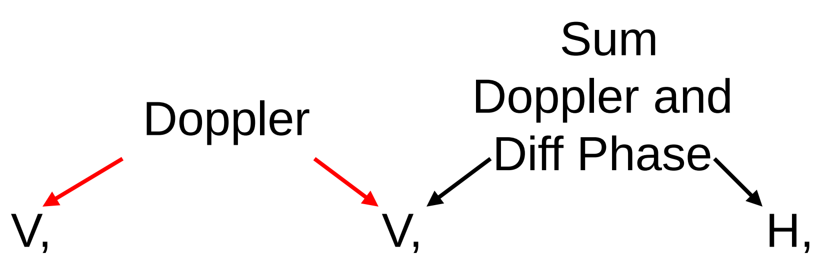
Field of View AHV mode



Decoupling Doppler from Differential Phase (AHV - mode)

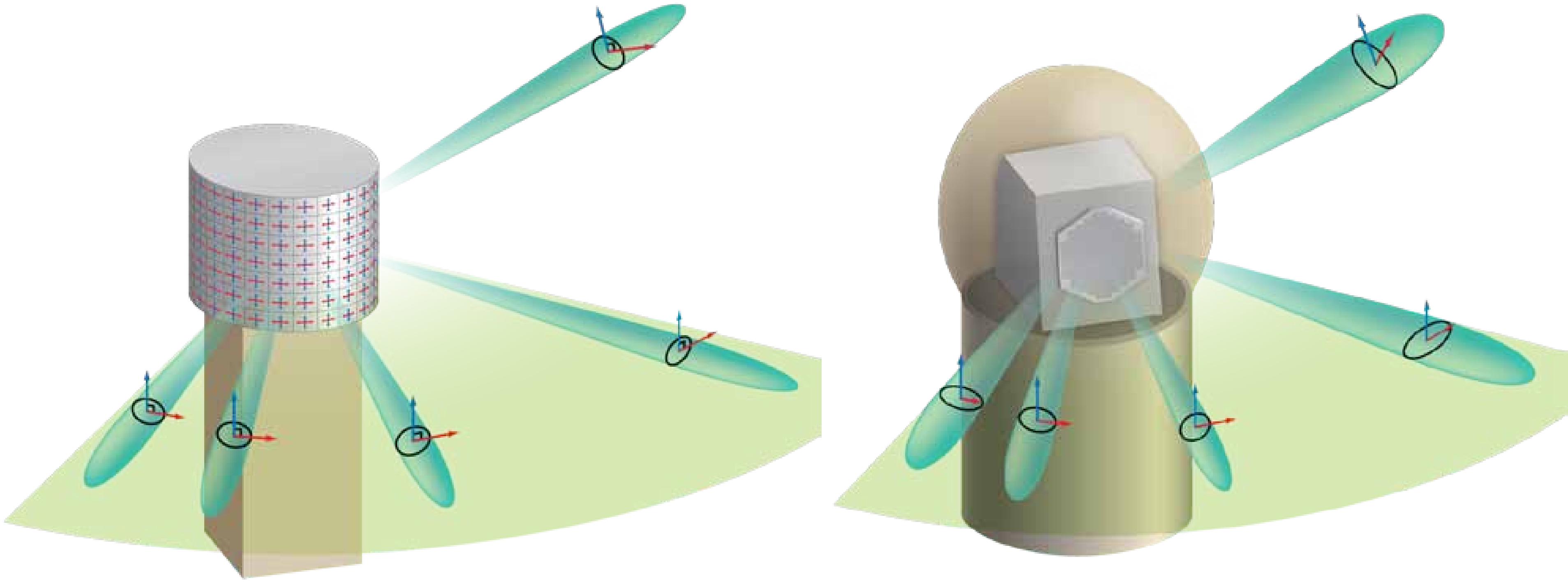
- Scanning strategy and transmission sequence should be designed to optimize overall performance. This is a System Design Problem

- The following Transmitted Sequence Triplet decouples Doppler from Diff Phase



COUPLING

{SOLUTION to COUPLING} Cylindrical Phased Array (CPA)



- There is no inherent coupling so CPA is equivalent to a conventional radar (Ref: Guifu 2009 – *OU-NSSL Patent pending*)

- System Study is in Order – scanning strategy, multiple beams, frequencies, beamwidth, waveforms, ...

COUPLING

CPAs Single Pol

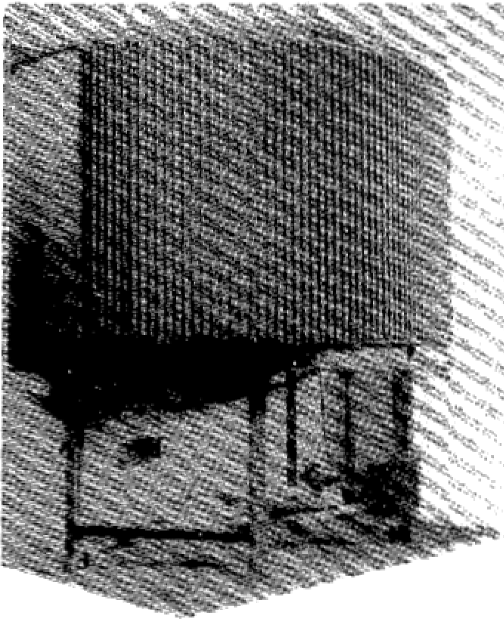
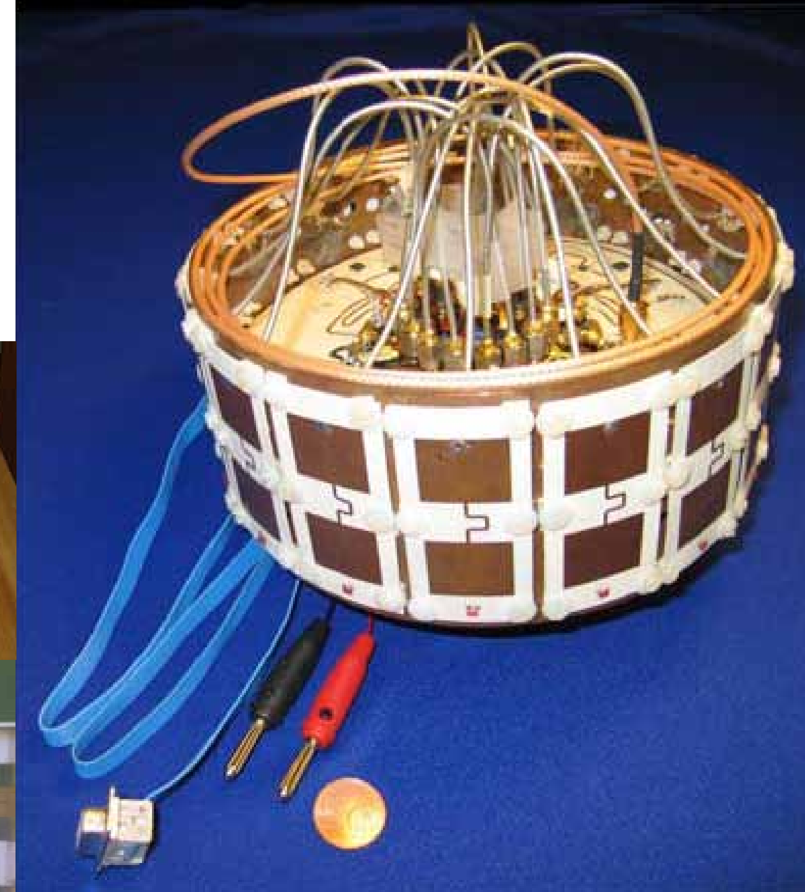


Fig. 1. Cylindrical array test bed antennna.



COUPLING

Advantages of CPA

- No beamwidth increase if AZ scans are at constant Elevation. That is: Quality of measurements is isotropic in each conical scan.
- Effects of precipitation on the radome is expected to be smaller.
- Polarimetric issues are equivalent to the issues concerning the conventional radar.

CROSS-POLAR PATERN

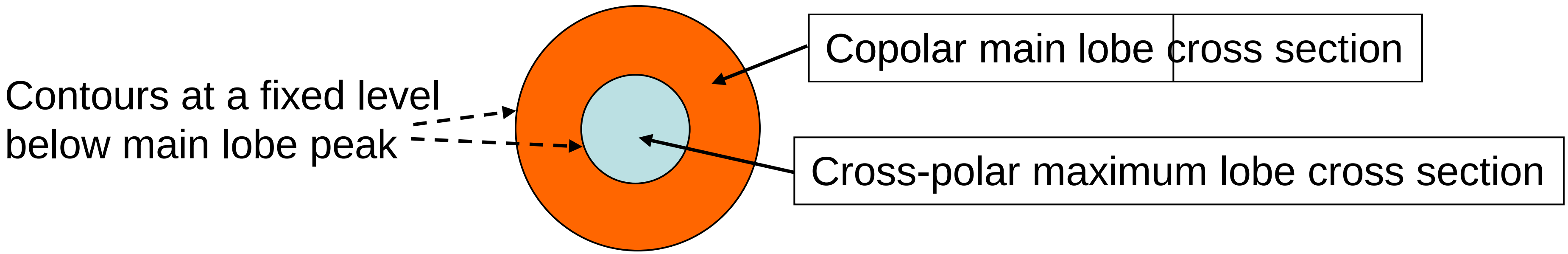
- This issue affects both the PAR and the Parabolic dish antenna

- Two types of cross polar pattern have profound effect on biases of the polarimetric variables

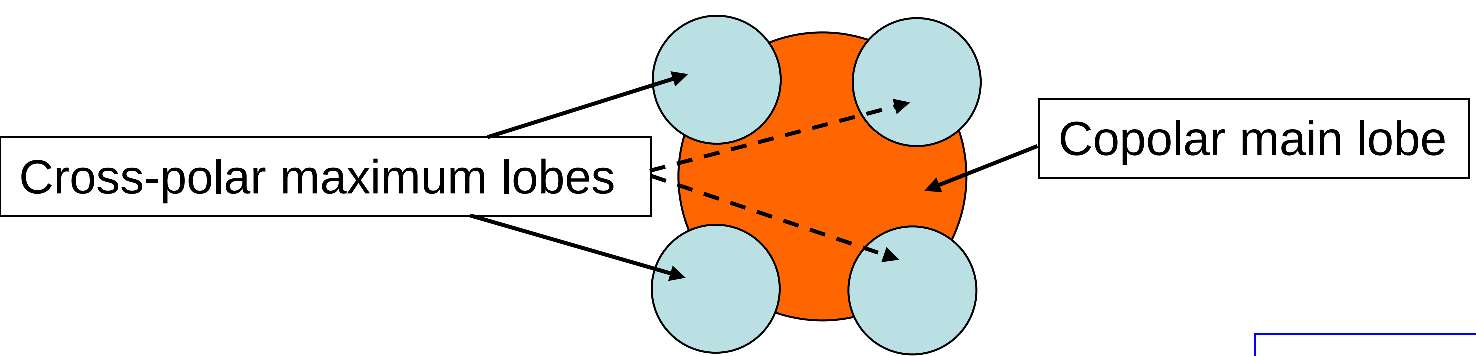
Two Antenna Types

1) SINGLE CROSS-POLAR MAIN LOBE:

Principal cross-polar LOBE centered on the copolar main lobe



(2) MULTIPLE CROSS-POLAR MAIN LOBES: symmetric with respect to beam axis and **IN PHASE OPOSITION TO EACH OTHER** :



CROSS-POLAR PATTERN

Comparison

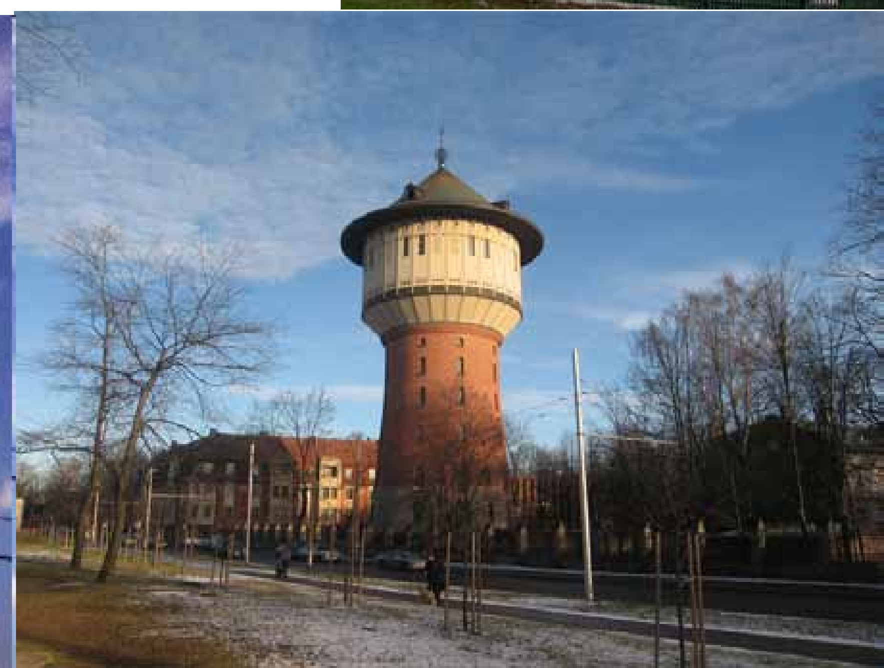
- Type I (single lobe) pattern is much more detrimental than type II.
- To achieve the same reduction of bias in polarimetric variables the integrated cross-polar single lobe pattern to integrated main lobe pattern must be 10 dB lower then the value for multiple lobe (type II) pattern.

A Cyli every

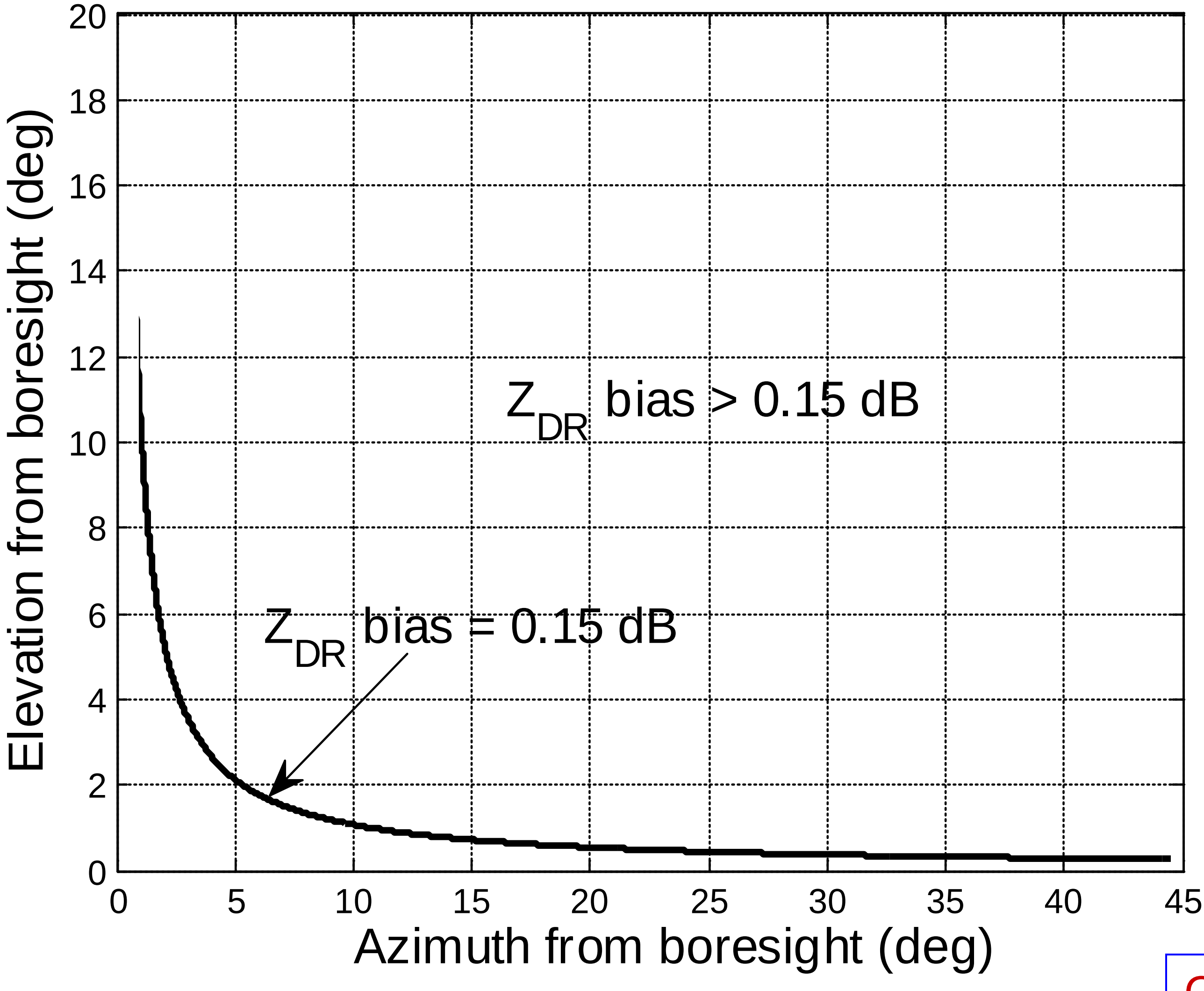


END





Envelope of Z_{DR} bias < 0.15 dB in the Az – El from boresight (SHV mode)



COUPLING

{COUPLING - Planar Array}
Alternate (AHV) Mode

- The differential phase and Doppler are coupled
- Tested extensively on parabolic antennas
- Planar Phased Array
  - Performs well if corrected over the field of view
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MATCHING BEAMWIDTHS

- At 20 dB below the peak the beam patterns for H and V polarizations should be within 1.85 dB of each other