

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

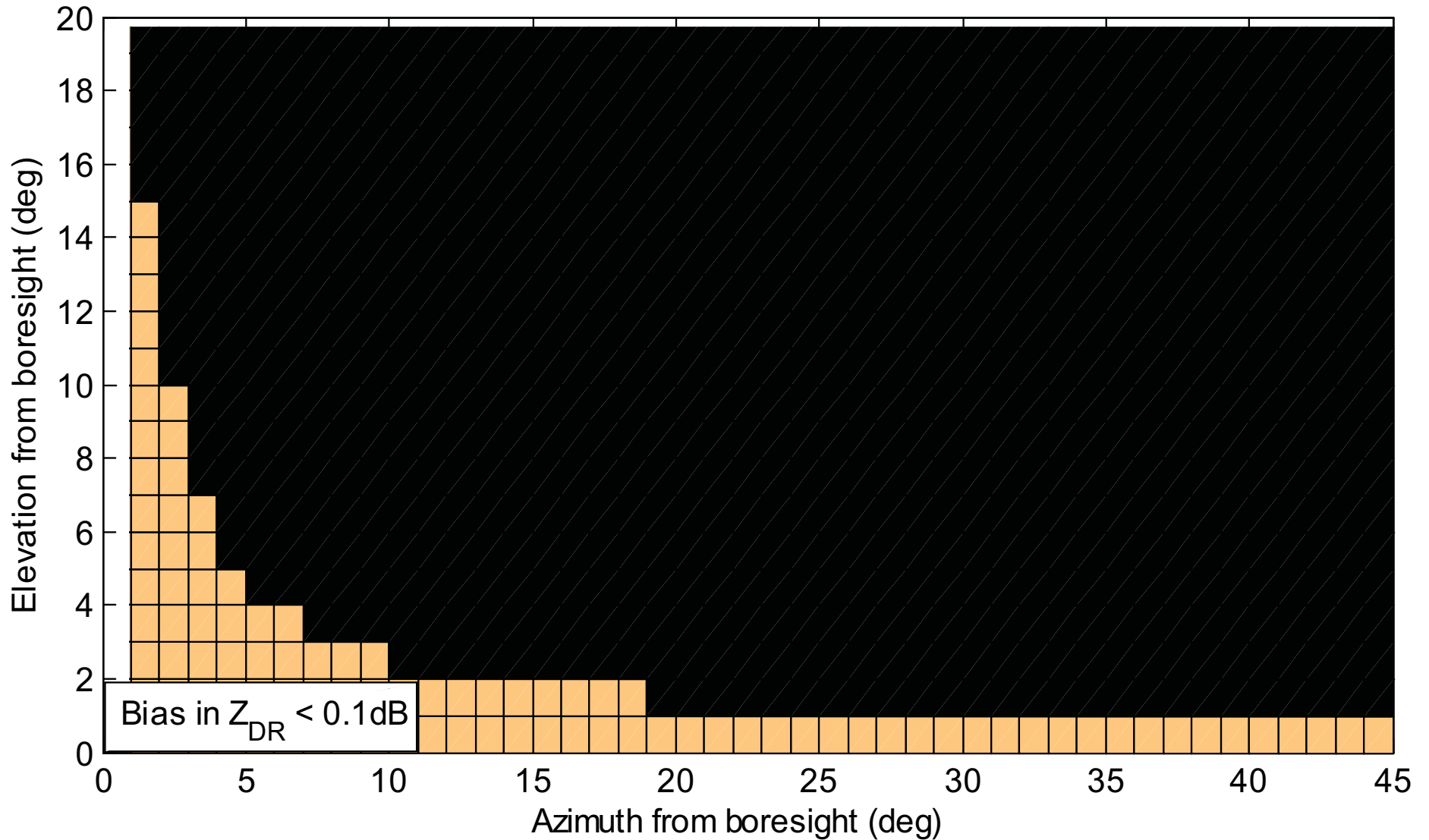
{COUPLING – Planar Array} Simultaneous (SHV) Mode

- 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
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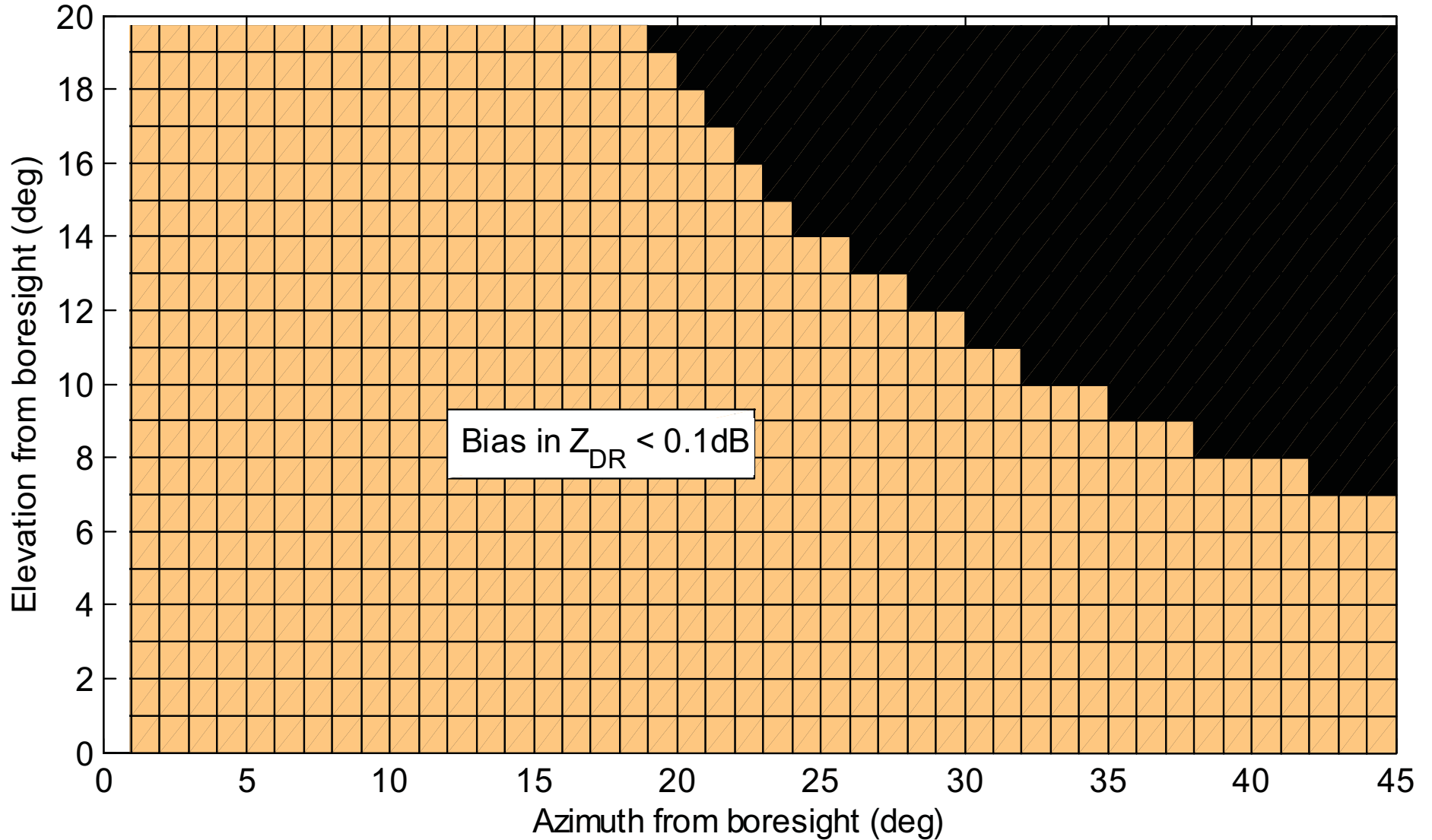
Field of View SHV mode

$Z_{DR}=0$ dB, $\rho_{hv}=1$; $\beta=0$ deg, $\Phi_{DP}=180$ deg



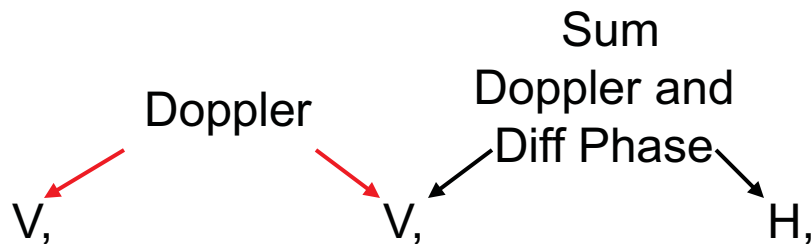
Field of View AHV mode

$Z_{DR} = 0 \text{ dB}, \rho_{hv} = 1; \beta = 0 \text{ deg}$



Decoupling Doppler from Differential Phase (AHV - mode)

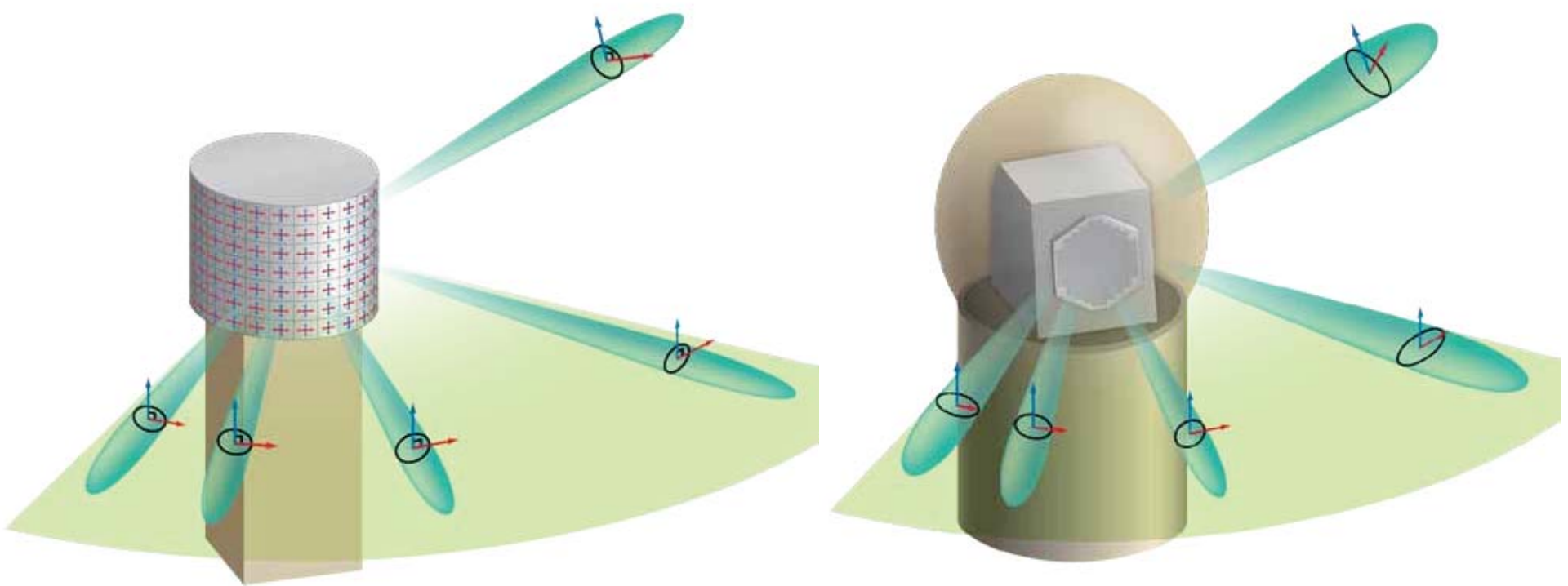
- Scanning strategy and transmission sequence should be designed to optimize overall performance. This is a **System Design Problem**
- The following Transmitted Sequence Triplet decouples Doppler from Diff Phase



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

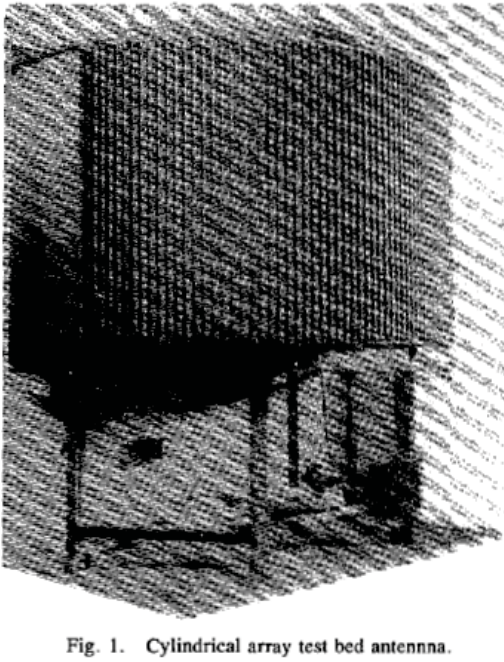
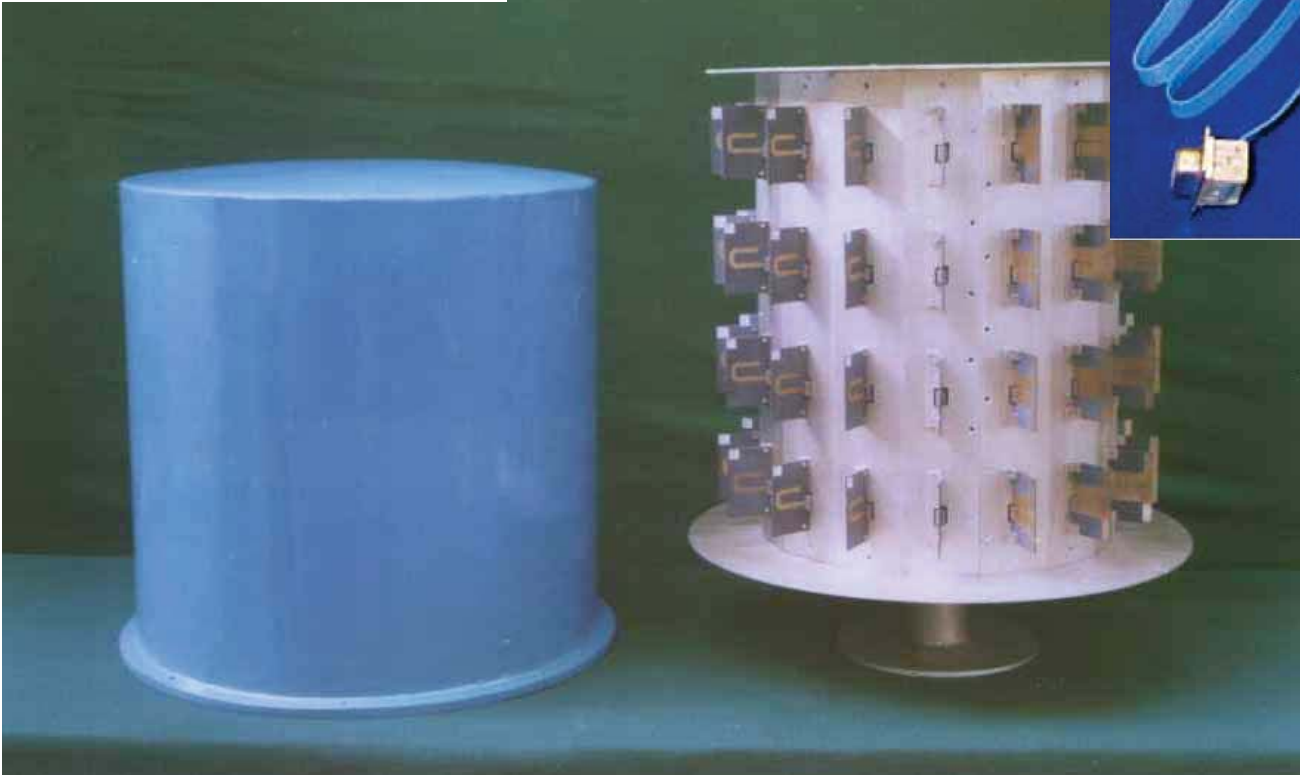


Fig. 1. Cylindrical array test bed antenna.



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.

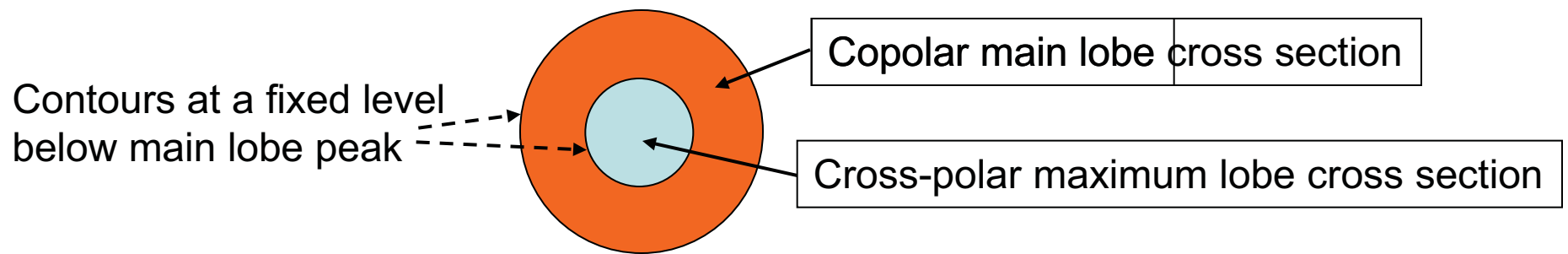
CROSS-POLAR PATTERN

- 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

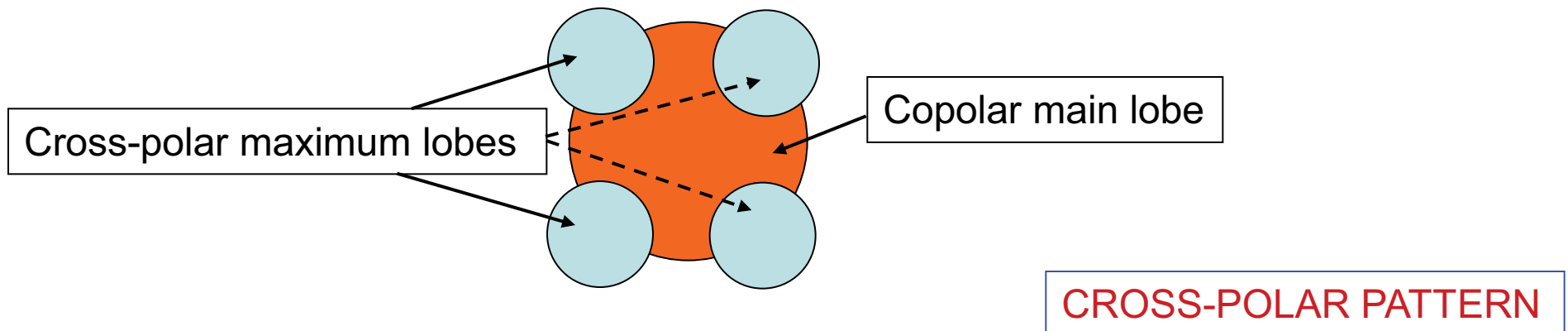
Two Antenna Types

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** :



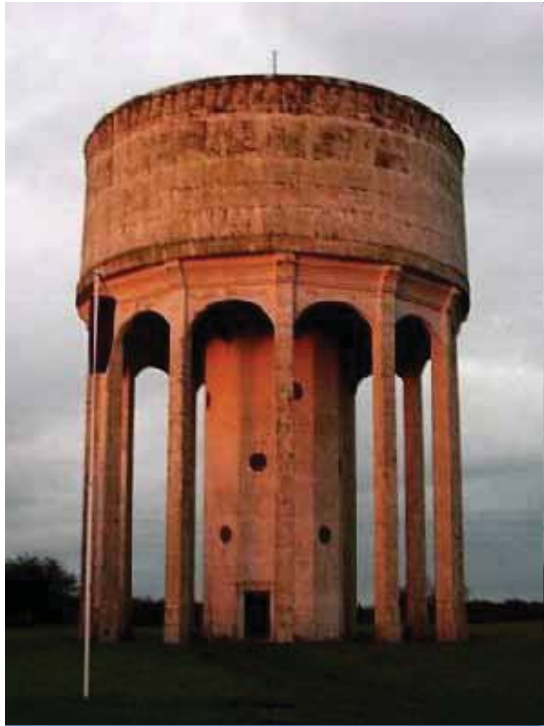
Comparison

- 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 than the value for multiple lobe (type II) pattern.

CROSS-POLAR PATTERN

A Cylindrical Water Tower

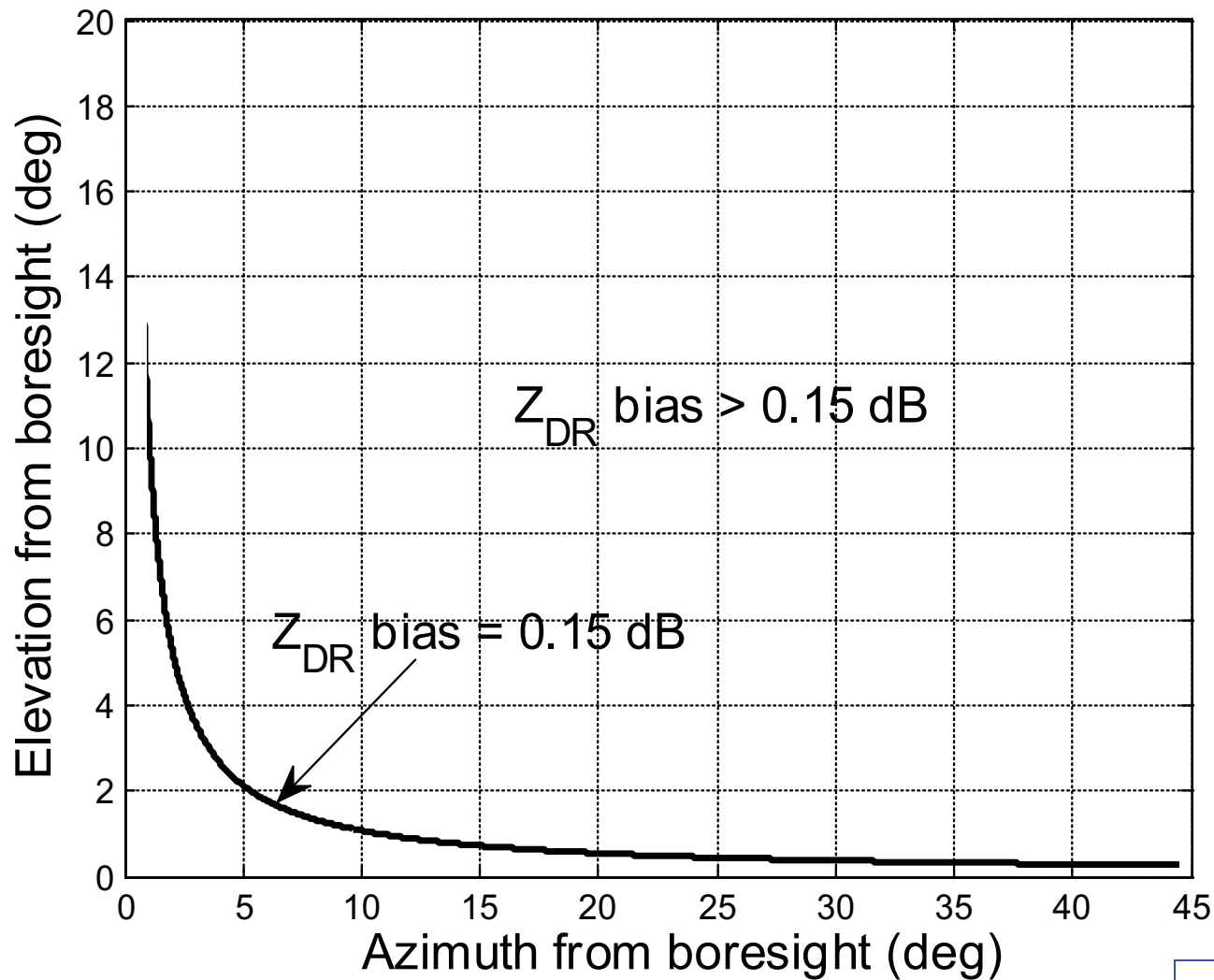




END



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



COUPLING

{COUPLING - Planar Array}

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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