

Source: Ericsson  
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Document for: Discussion and decision

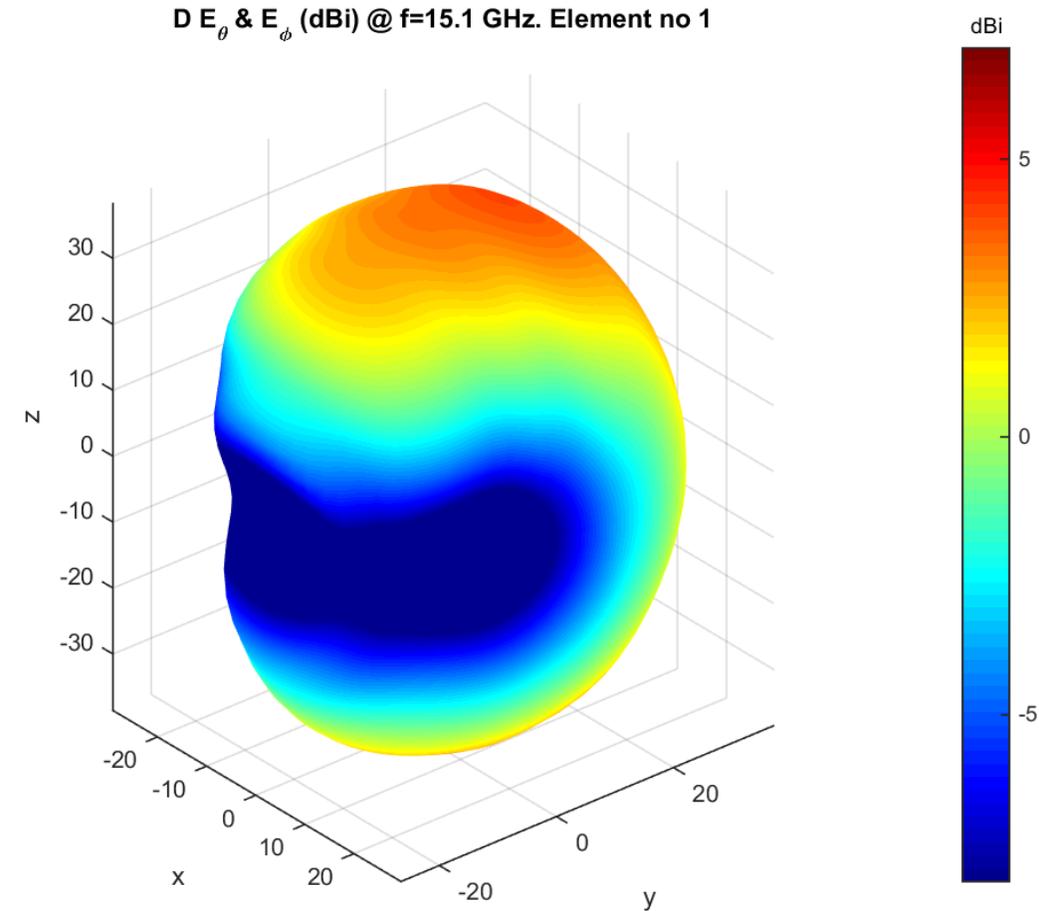


# ON UE SIDE BEAMFORMING IN NR

# IMPACT OF HIGH FREQUENCY



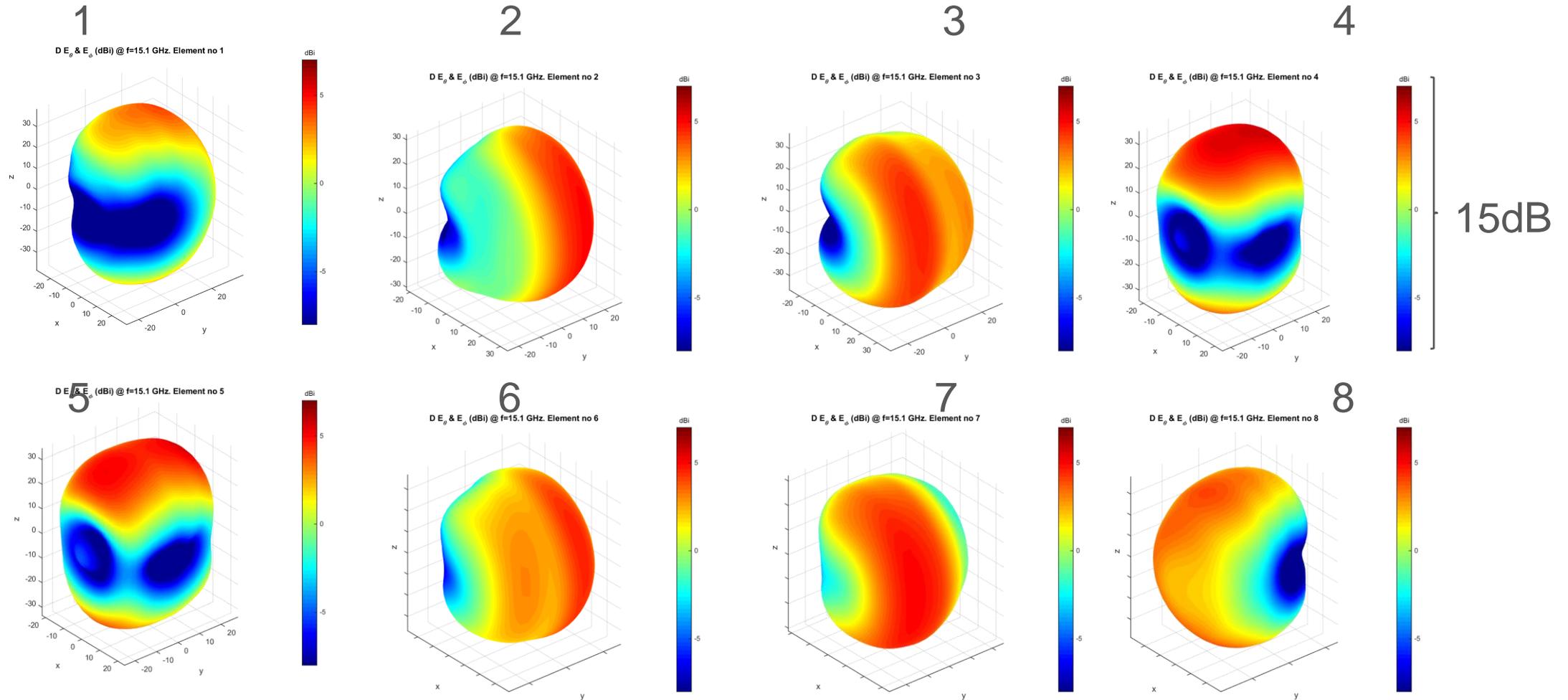
- › Angular coverage per antenna element reduced at higher frequencies compared to 2GHz
- › Poor link budget at high frequencies
- › Multiple elements to be considered at the UE side for RX as well as for TX
  - Improve the spatial coverage
    - › Elements with higher gain + beamforming gain
  - For DL reciprocity based operation



Simulated pattern

UE antenna design by Sony

# EXAMPLE OF 8 ANTENNA UE

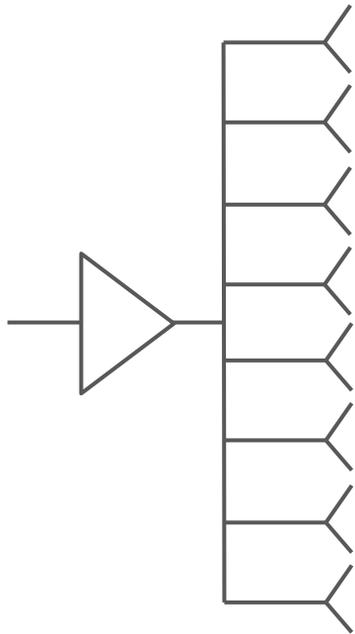


# PA IMPLEMENTATIONS



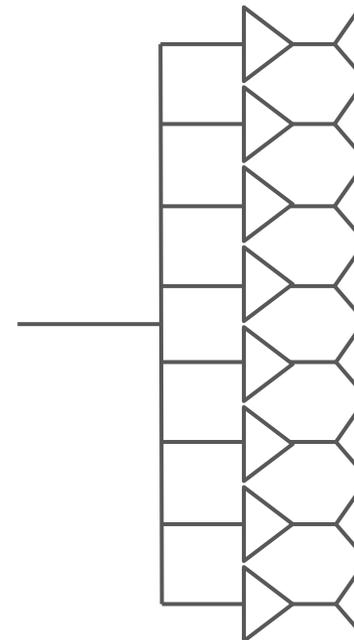
## > Common amplifier

- One common PA for all antennas

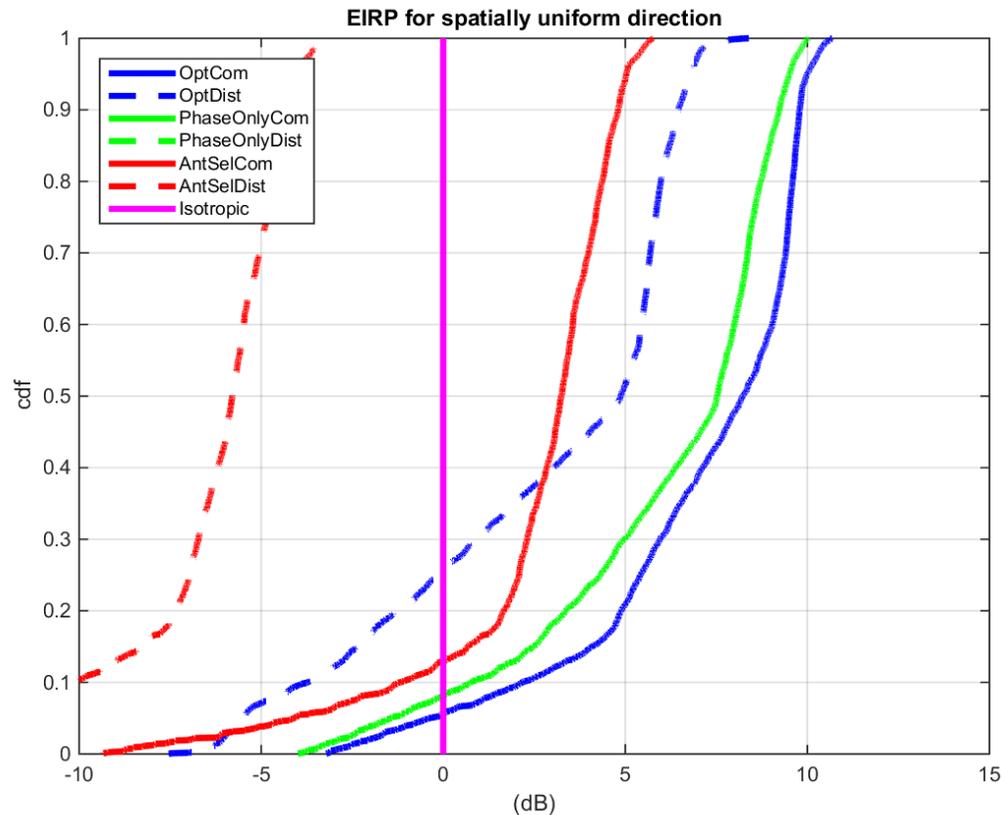


## > Distributed amplifier

- One PA per antenna



# RESULTING EIRP IN LOS



- › No fading channel involved (perfect LoS)
- › Evaluation of UE transmission techniques and PA implementations
  - Antenna selection (AntSel)
  - Phase only precoding (PhaseOnly)
  - Phase+amplitude (Opt)
  - Common amplifier (Com)
  - Distributed amplifier (Dist)
- › Large differences in EIRP between different combinations of precoder and PA configurations
  - **Antenna selection** and distributed PA a bad combination as expected
- › Significant gains compared to Isotropic for several combinations
  - **Optimal precoder** requires common PA not to suffer from amplitude variations in optimal precoder
  - **PhaseOnly precoder** promising

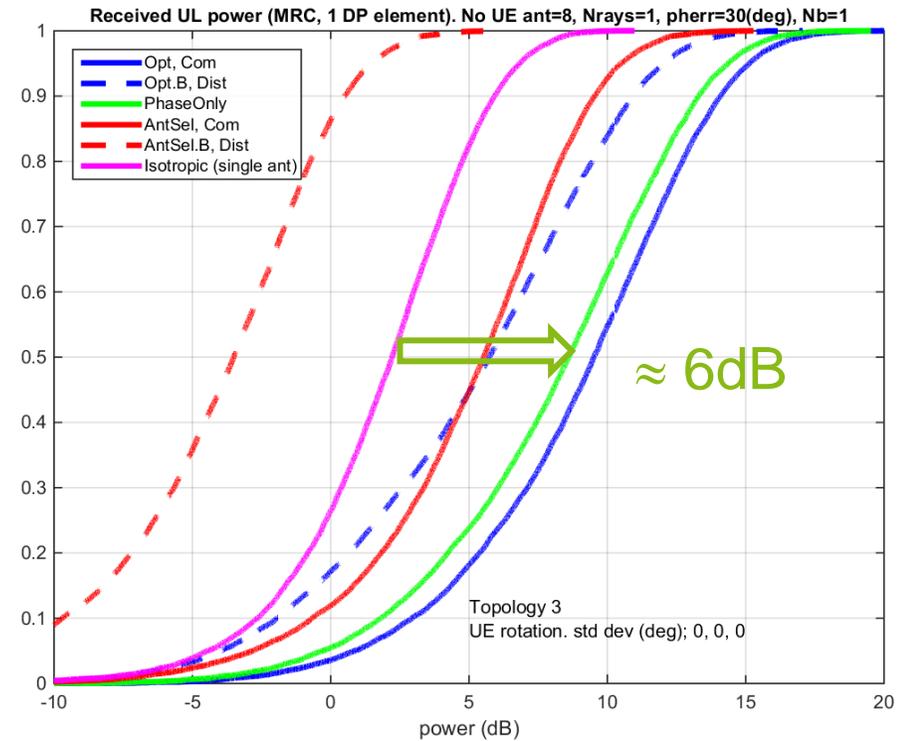
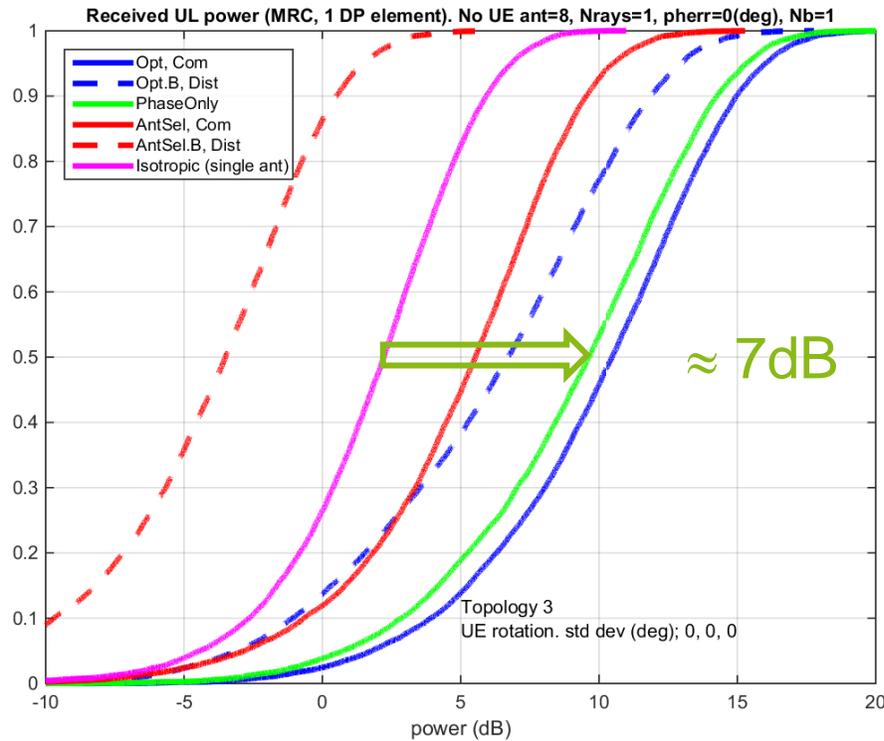
Phase only precoding a promising UE side transmission technique

# RECEIVED UL POWER IN SINGLE RAY CHANNEL



$\sigma_{\text{Phase error}} = 0(\text{deg})$

$\sigma_{\text{Phase error}} = 30(\text{deg})$



Significant gains!

Common PA outperforms distributed PA

Phase-only precoder performs well compared to OptCom. Loss for median about 1dB.

Only “small” loss from phase errors.

No loss for AntSel and Isotropic

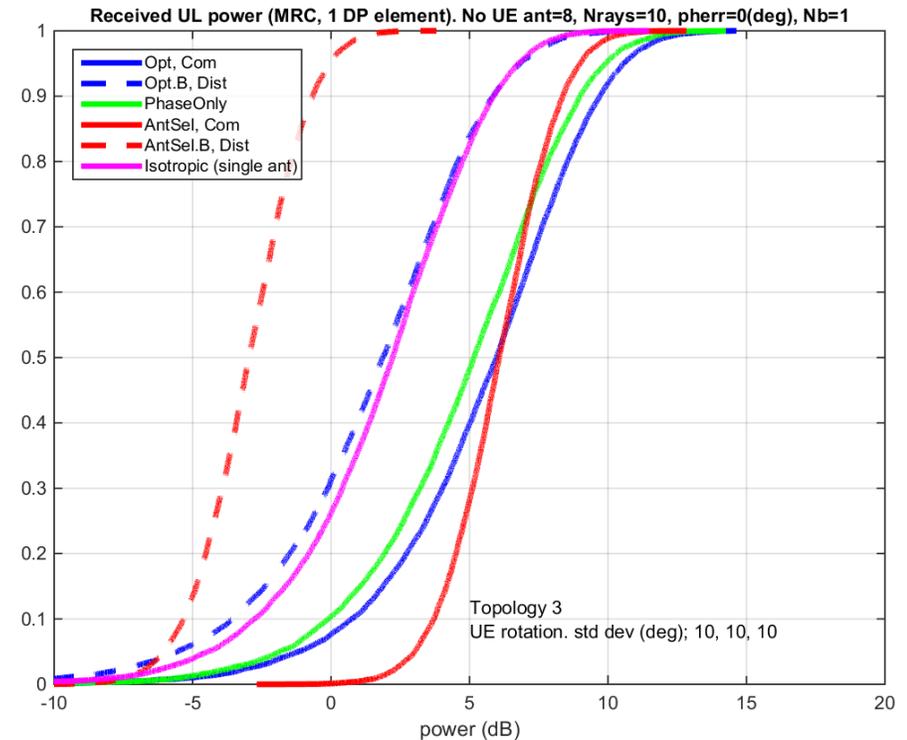
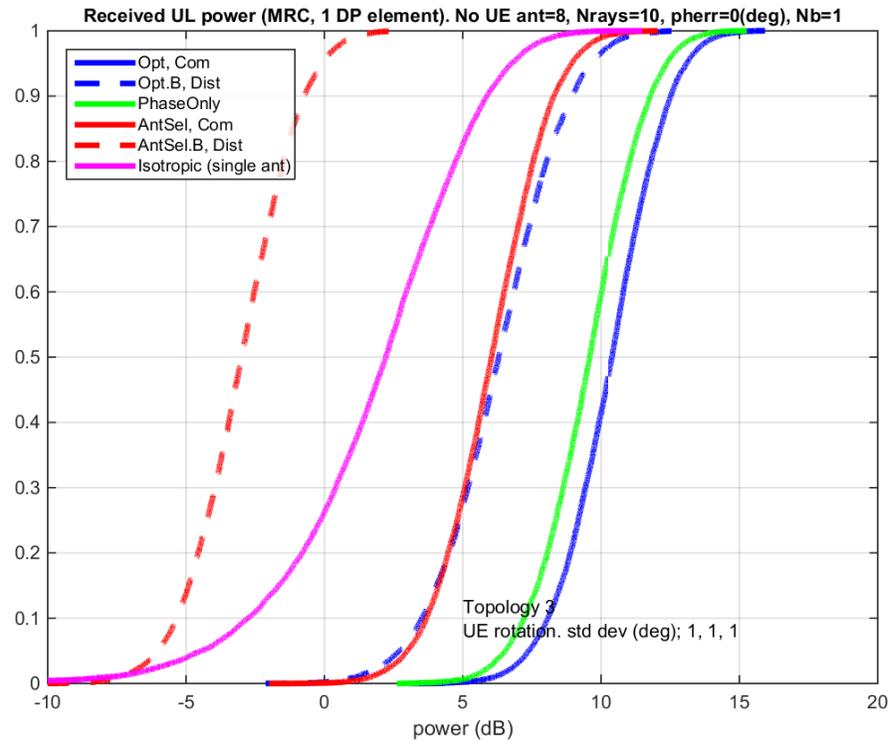
30 degree TX phase error seem acceptable in single ray channel

# UE ROTATION



0° (stddev) rotation

10° (stddev) rotation



Comparison between 0 and 10deg (stddev) rotation;

- Major impact from 10 deg rotation for all multi-antenna precoders
- Single antenna precoders insensitive to rotation

Gains sensitive to large UE rotations

# SUMMARY



- › **Observation 1**      UL beamforming has a great potential to improve link budget
  - Median gain in many cases between 6-7dB for phase only precoding over 8 antennas compared to isotropic antenna
  - Gains fairly insensitive to large phase errors, up to 30deg standard deviation
  - Gains sensitive to large UE rotations (10deg standard deviation per axis between Rx and TX transm.)
- › **Observation 2**      Reciprocity schemes outperforms feedback based.
- › **Observation 3**      PhaseOnly precoding performs fairly well, loss 1-2dB compared to optimal precoder. The PhaseOnly precoder is equal magnitude in contrast to the Optimal precoder and does not suffer from (equal) power per element restrictions.