

Source: Ericsson  
Agenda Item: 8.1.7  
Document for: Discussion



# ON THE USE OF CHANNEL RECIPROCALITY FOR NR

# PREREQUISITES FOR MASSIVE MIMO PRECODING



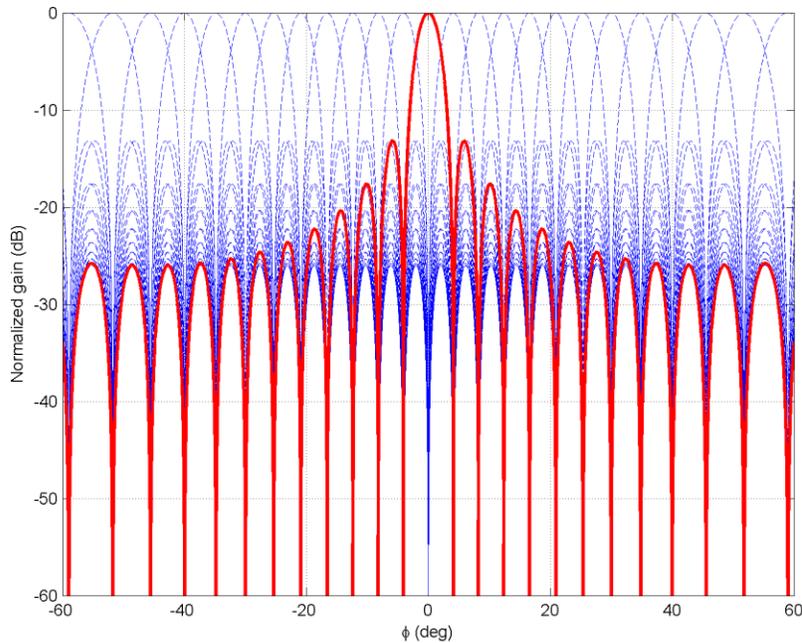
- › Desired conditions for best-performing multi-antenna schemes:
  - **Large eNB array** having many degrees of freedom
  - **Digital eNB implementation** allowing for baseband processing
  - **Explicit eNB knowledge** of instantaneous forward channel matrices
  
- › Precoding design principles:
  - **Flexible** (non-codebook based) “**beamforming**”, achieving full array gain even in high angular spread channels
  - **Coherent processing**, adapting to multipath propagation, to focus energy in spatial “points” rather than in directions
  - **Interference-nulling**, increasing mux possibilities for MU-MIMO

**Accuracy of explicit CSI at transmitter** determines performance of massive MIMO precoding

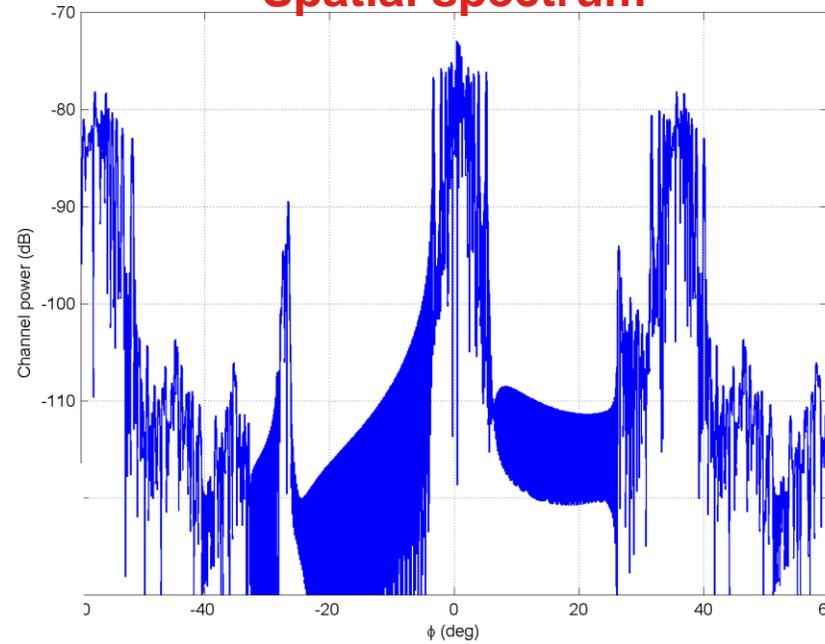


**CSIT unavailable /  
normal resolution CSI  
feedback:**

**Spatially oversampled grid of  
fixed beam codebook**



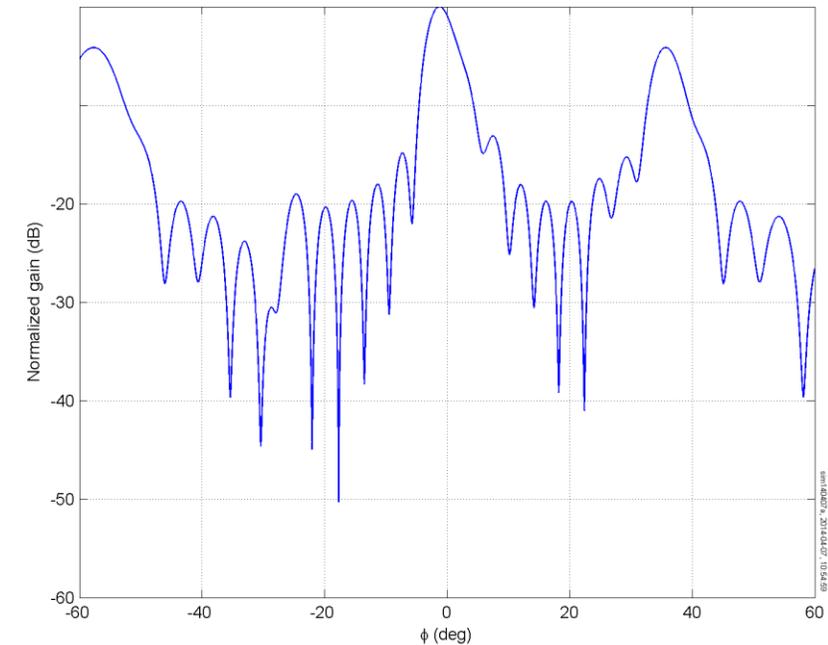
## Spatial spectrum



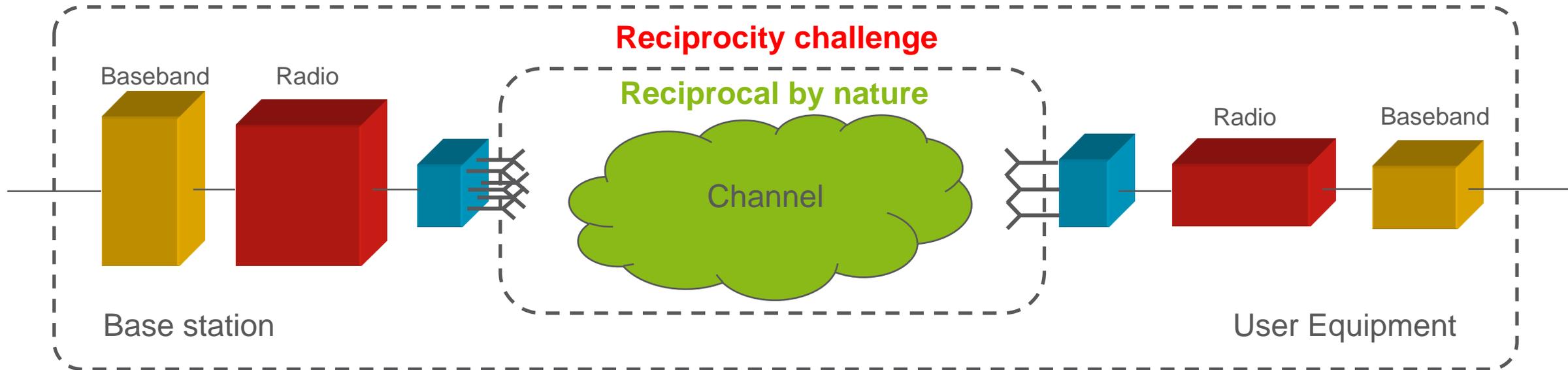
ULA, 20 elements, ITU UMa

**CSIT available / reciprocity  
or high resolution CSI  
feedback:**

**Conjugate beamforming**



# COHERENT RECIPROACITY



- › Reciprocity can have several forms (e.g. on AoA/D or channel statistics)
- › **”Coherent” reciprocity**: RX and TX channels are the same as seen from baseband within coherence interval
  - Most strict form of reciprocity, but with highest potential
  - Requirement for frequency-selective precoding and efficient nullforming
  - Imposes requirements on antenna TX and possibly even RX calibration and on SRS density

Achieving **coherent** reciprocity will enable best performing multi-antenna scheme in NR

# CSIT ACQUISITION VIA COHERENT RECIPROACITY



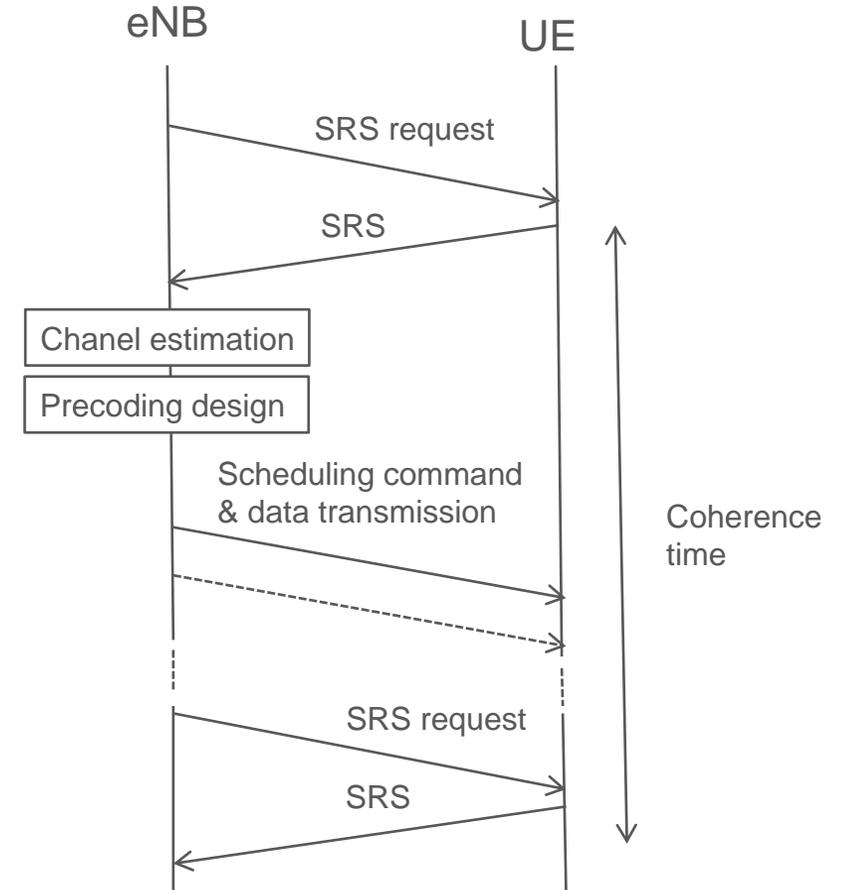
## CSIT refinement procedure

### > Principle:

- Uplink channel estimation
- Precoding design @eNB

### > Approach is attractive for large eNB arrays:

- # of SRS scales with total # of UE antennas
- Feedback can be limited to interference measurements
- Avoid standardizing (super large) antenna-specific codebooks



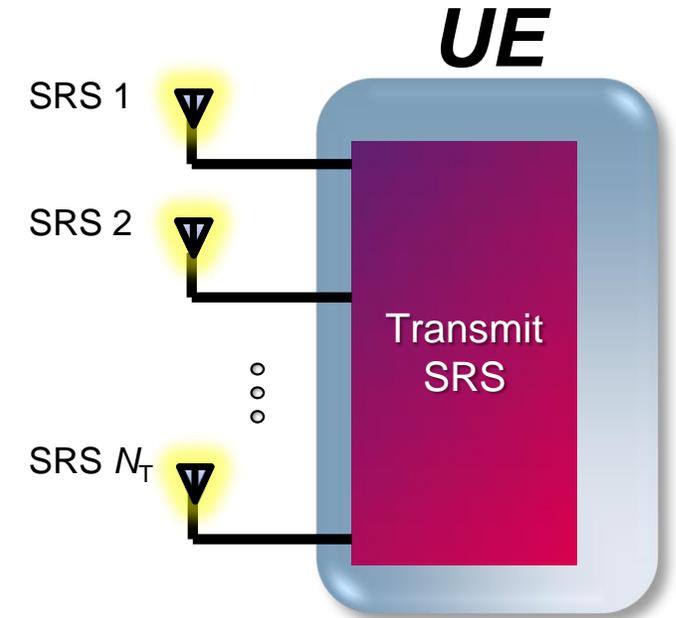
**Coherent reciprocity enables explicit CSIT acquisition for large arrays**

# ACQUIRING CHANNEL ESTIMATES

## SRS



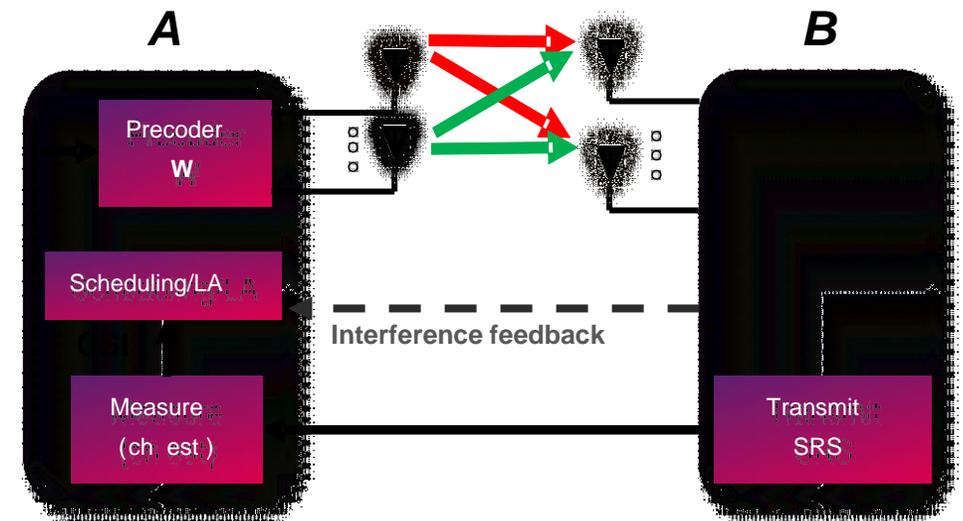
- › Sounding reference signals (SRSs) transmitted from UE to BS
- › Baseline assumption:
  - UE uses the same antennas for TX and RX
  - Antenna switching possible if limited TX chains
  - One SRS per TX antenna – ok if few antennas
- › SRS dynamically scheduled/triggered
  - Many UEs → persistent SRS scheduling mechanism may be useful
- › Design principles for SRS:
  - Create a large number of orthogonal sequences
    - › Avoid pilot contamination for large # of UEs and/or UE antennas
  - Do not precode SRS as baseline
    - › Obtain the entire MIMO channel for multi-antenna UEs
    - › Additional option to precode SRS should also be considered, e.g. when coverage limited
  - › Adapt SRS time density to channel conditions
    - › High mobility is the main limitation



# INTERFERENCE MEASUREMENTS



- › Unlike the channel, interference is not reciprocal
  - Interference knowledge required for scheduling and link & rank adaptation
- › Study the options for acquiring interference knowledge, for example
  - Each UE reports CQI based on CSI-RS (and/or CSI-IM)
  - Each UE reports CQI based on DMRS
  - Each UE reports interference, and SINR is derived in BS side



# SUMMARY



- › Efficient reciprocity-based transmission schemes need to be standardized as in some use cases they will **have significantly better performance** compared to normal resolution closed loop schemes (as has been specified for smaller arrays, e.g. LTE)
- › Coherent reciprocity allows for efficient acquisition of explicit channel knowledge even for very large arrays, thus enabling frequency-selective precoding and nullforming
- › Achieving coherent reciprocity imposes several additional requirements, e.g., on antenna calibration
  - Whether there is standard impact (RAN1 or RAN4) is FFS
- › RAN1 should study Sounding Reference Signal design and the necessary quality of the estimates
  - SRS sequences and density need to be designed for enabling high-quality channel estimates, to reduce the effects of channel aging and pilot contamination
- › RAN1 should also study Interference acquisition schemes
  - to complement the reciprocity-based channel acquisition for the purpose of scheduling and link adaptation



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