EURECOM
Sophia Antipolis

OPEN AIR INTERFACE

Radio Engineering Lab Session 2

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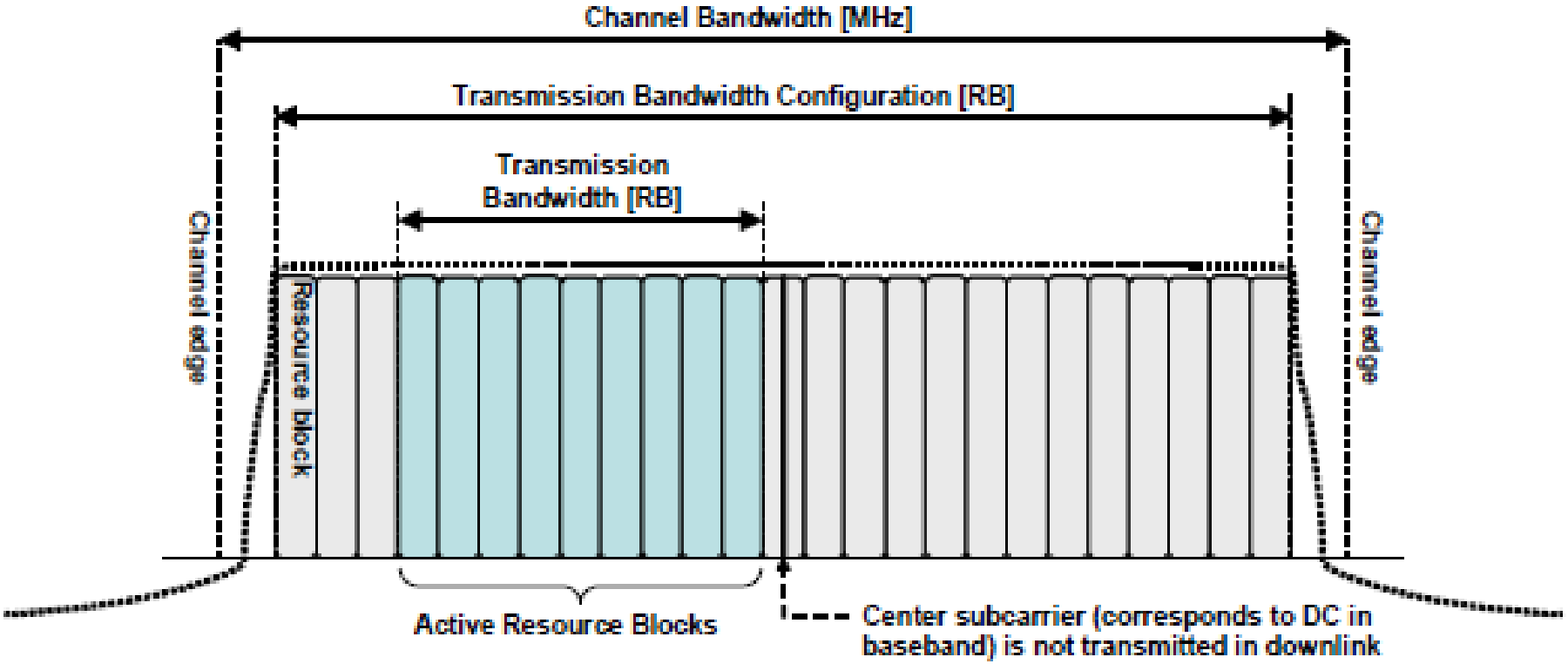
Outline

- **3GPP LTE Physical Layer Overview**
- **Measurements Overview**
- **Tasks**

Framing

- **LTE is specified for any bandwidth between 1.08 MHz and 19.8 MHz which is a multiple of 180 kHz**
- **The “common” sizes will be**
  - 1.08 MHz transmission bandwidth with 1.25 MHz spacing
  - 2.7 MHz transmission bandwidth with 3 MHz spacing
  - 4.5 MHz transmission bandwidth with 5 MHz spacing
  - 9 MHz transmission bandwidth 10 MHz spacing
  - 13.5 MHz transmission bandwidth with 15 MHz spacing
  - 18 MHz transmission bandwidth with 20 MHz channel spacing

Resource blocks



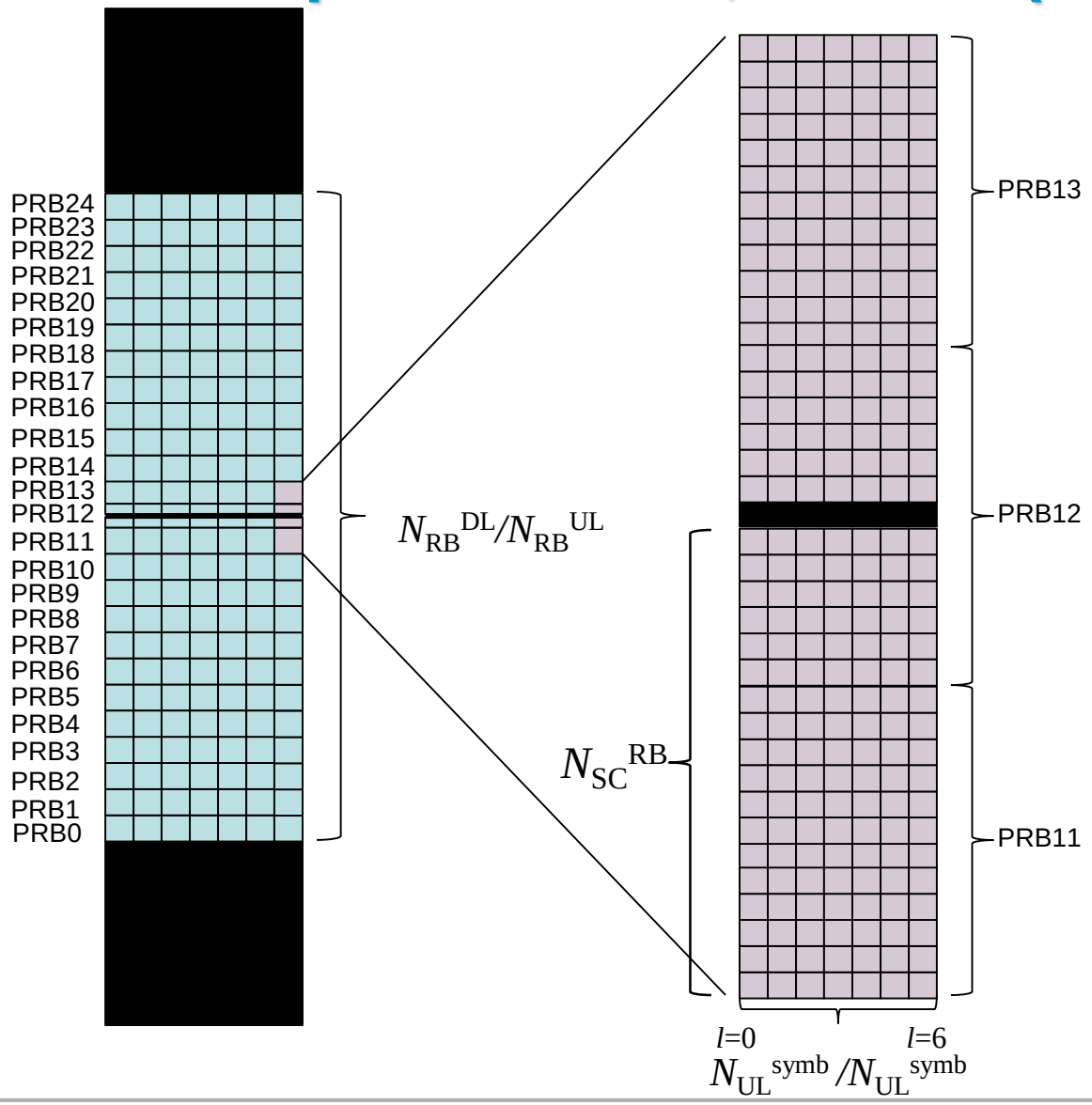
- **LTE defines the notion of a resource block which represents the minimal scheduling resource for both uplink and downlink transmissions**
- **A physical resource block(PRB) corresponds to 180 kHz of spectrum**

Common PRB Formats

Channel Bandwidth (MHz)	N_{RB}^{DL}/N_{RB}^{UL}	Typical IDFT size	Number of Non-Zero Sub-carriers (REs)
1.25	6	128	72
5	25	512	300
10	50	1024	600
15	75	1024 or 2048	900
20	100	2048	1200

- **PRBs are mapped onto contiguous OFDMA/SC-FDMA symbols in the time-domain (6 or 7)**
- **Each PRB is chosen to be equivalent to 12 (15 kHz spacing) sub-carriers of an OFDMA symbol in the frequency-domain**
  - A 7.5kHz spacing version exists with 24 carriers per sub
- **Because of a common PRB size over different channel bandwidths, the system scales naturally over different bandwidths**
  - UEs with different bandwidth constraints can still be served by an eNb with a wider channel bandwidth

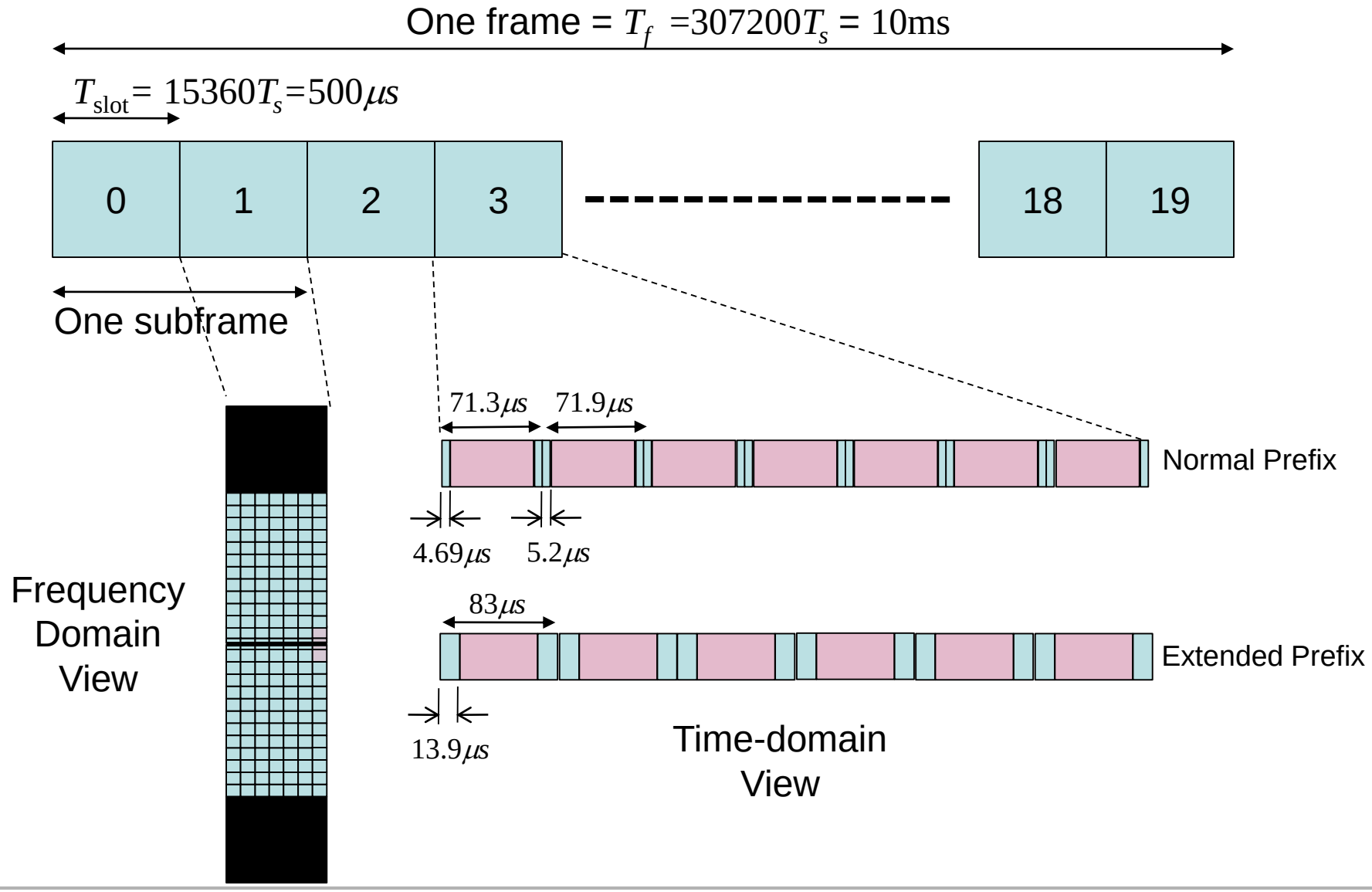
Example: 300 REs, 25 RBs (5 MHz channel)



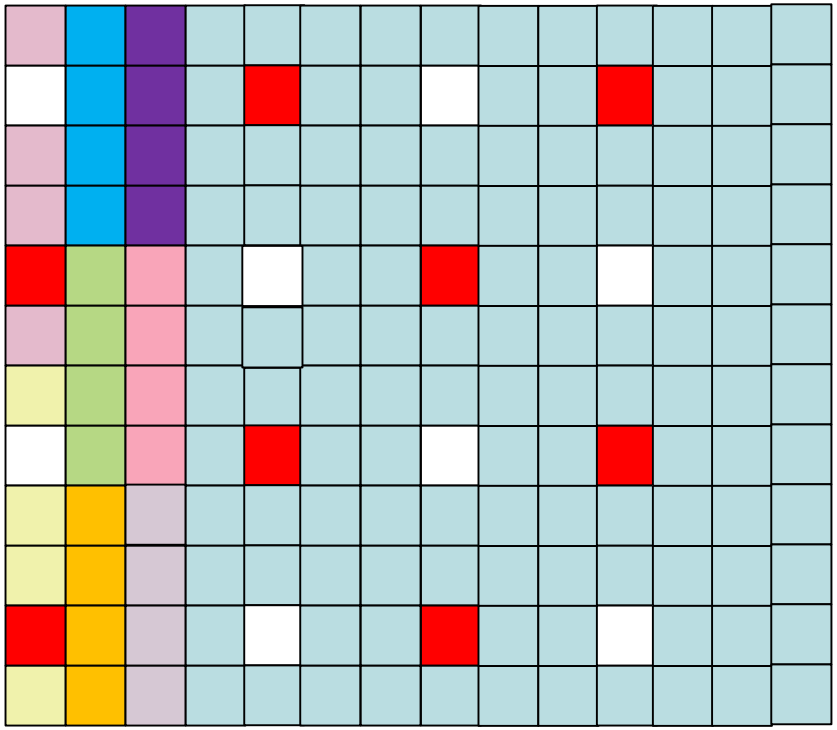
"Normal" Cyclic Prefix Mode (7 symbols)

"Extended" Cyclic Prefix Mode (6 symbols)

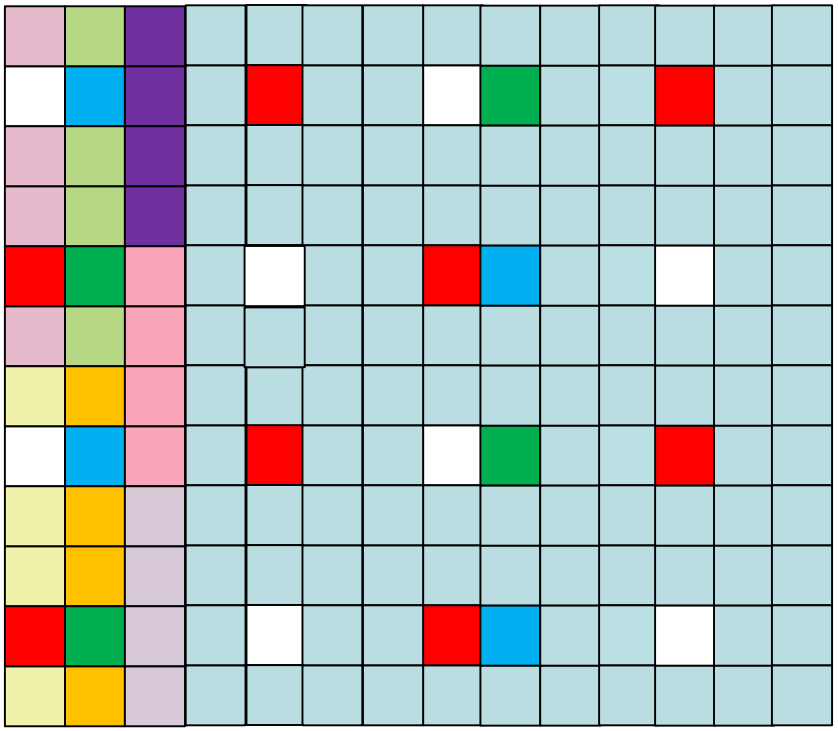
Sub-frame and Frame



Cell-Specific Reference Signals



$p=\{0\}, p=\{0,1\}$



$p=\{0,1,2,3\}$

p=0

p=1 (if active)

p=0

p=1

p=0

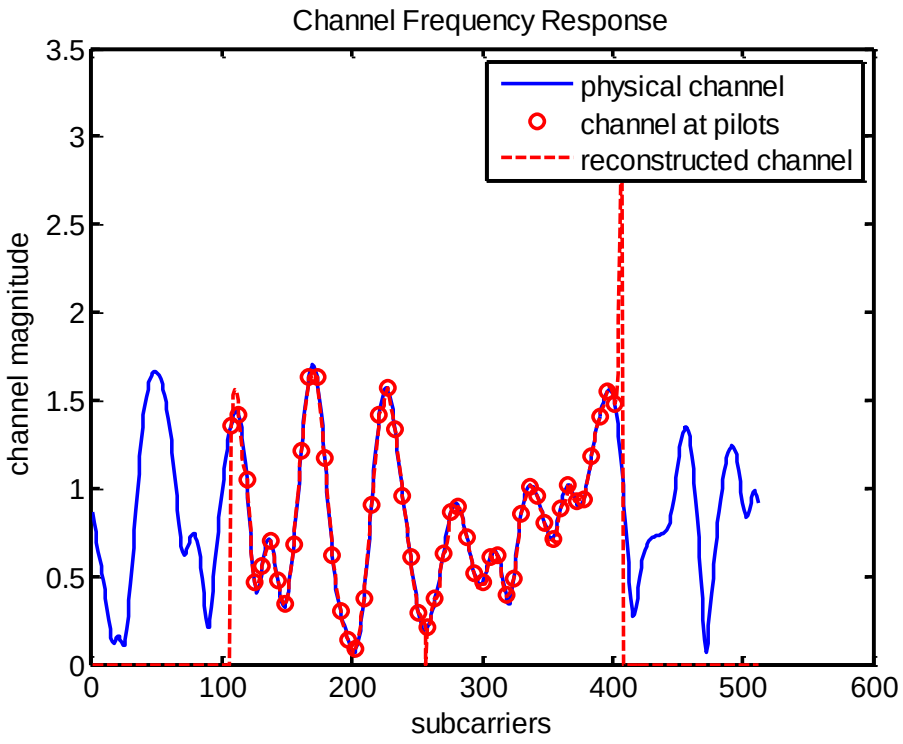
p=1 (if active)

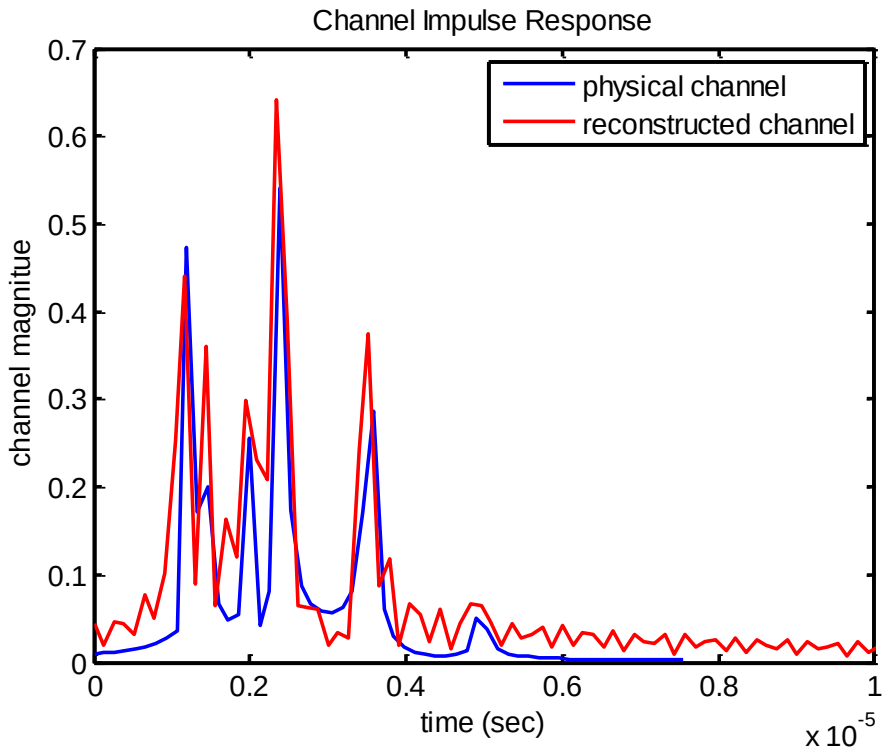
Cell-Specific Reference Signals

- **Pseudo-random QPSK OFDM symbols**
  - Based on generic LTE Gold sequence
  - Different sequence for different cell IDs
  - Different in each symbol of sub-frame
  - Different in each sub-frame, but periodic across frames (10ms)
- **Evenly spaced in subframe to allow for simple and efficient least-squares interpolation-based receivers**
  - Between REs in frequency-domain
  - Across symbols in time-domain

Channel sounding with LTE waveform

The channel impulse response can be reconstructed from the frequency domain LTE channel estimate by interpolation and application of the IFFT





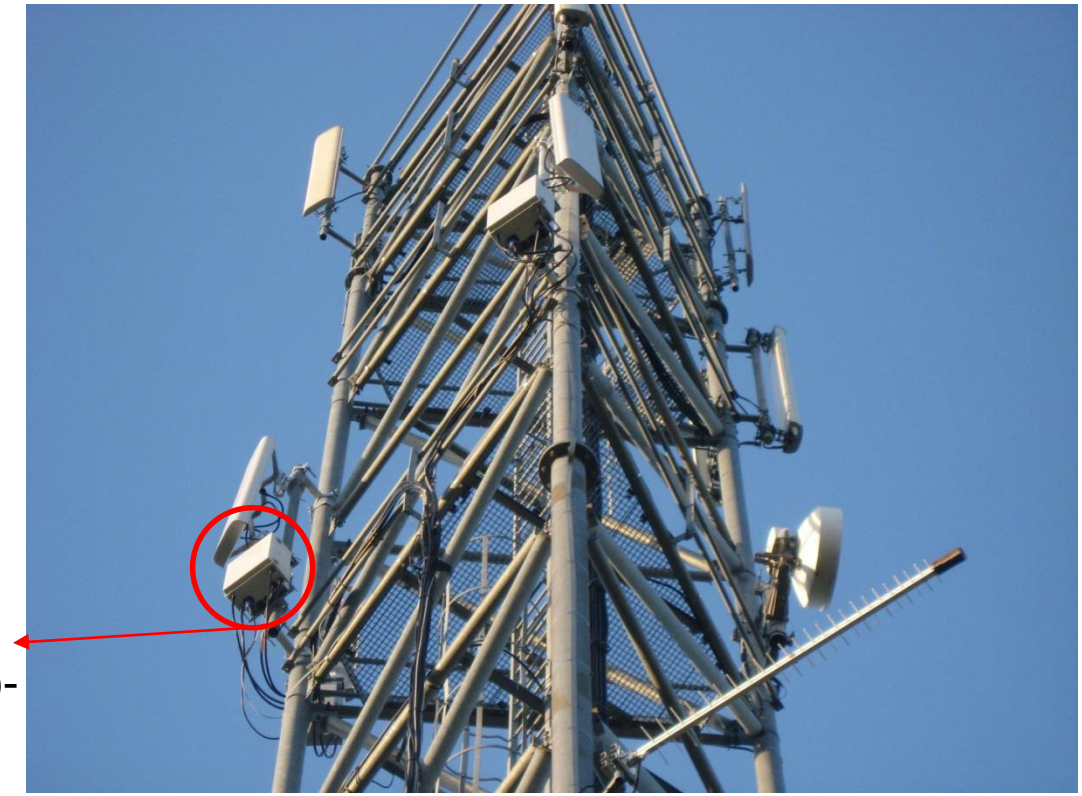
LTE Measurement Configuration

- **5 MHz Bandwidth TDD**
  - 25 Resource Blocks
  - UL/DL Frame Configuration 3 (6 DL subframes, 3 UL subframes, 1 S subframe)
  - S subframe configuration 0 (longest guard interval)
  - 859.5 MHz carrier frequency
  - Extended prefix
  - 3 symbols for PDCCH
  - SRS transmitted in each UL subframe, configured over entire bandwidth
  - PUSCH aperiodic wideband feedback only (i.e. no PUCCH), not a limitation

eNB Configuration

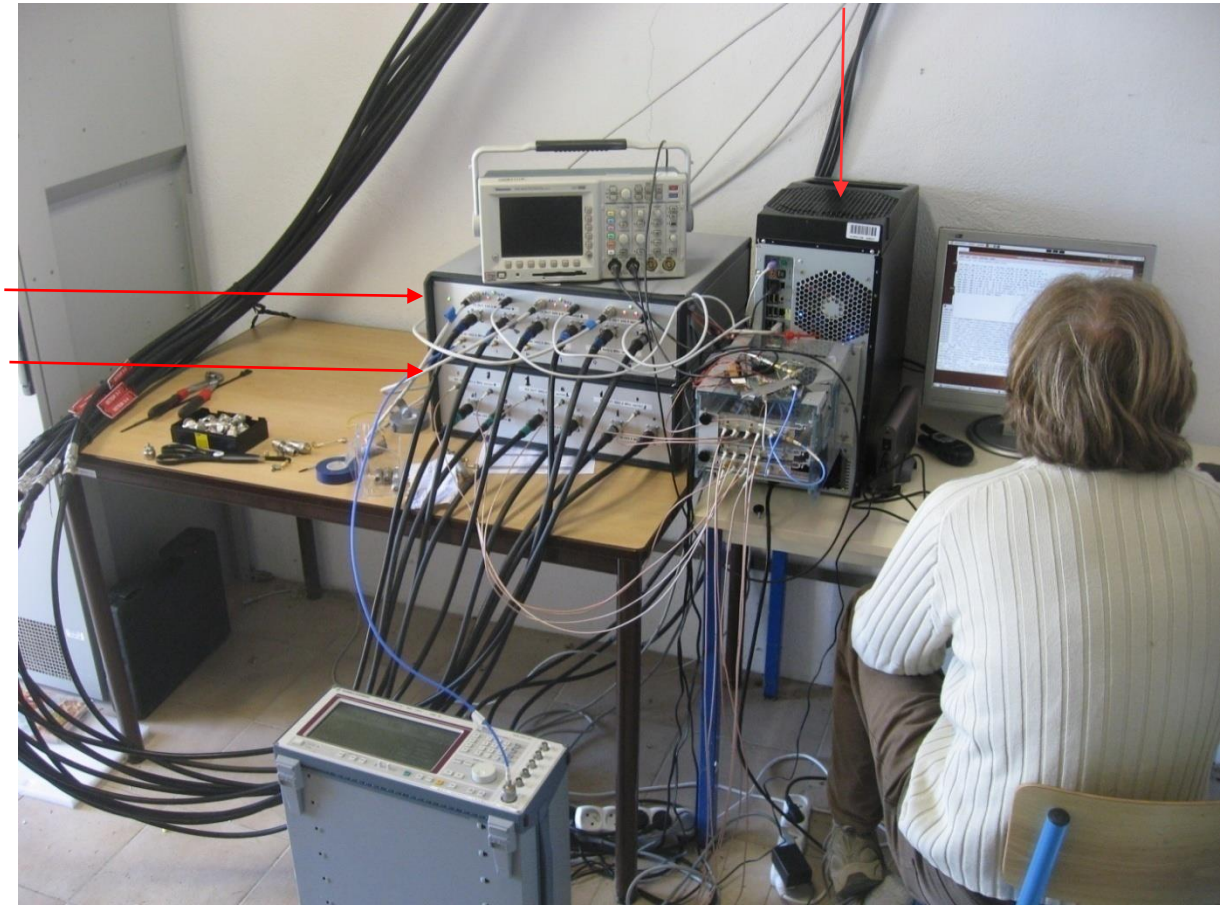
- 3 sectors, cross-polarized antenna
- Dual-polarization used for 2 antenna transmission modes (2,4,5,6)
- 43 dBm output power per sector (47.7 dBm total output), spectral mask compliant with 3GPP 36-104 and regulatory constraints
- 3-4 dB RX noise figure
- Power and RX amplifiers at co-located with antenna
- Baseband and up/down converters in control room

Cordes-sur-Ciel Installation



2 Antenna PA/LNA Module

eNB Control Room (Cordes-sur-Ciel)



UE Configuration

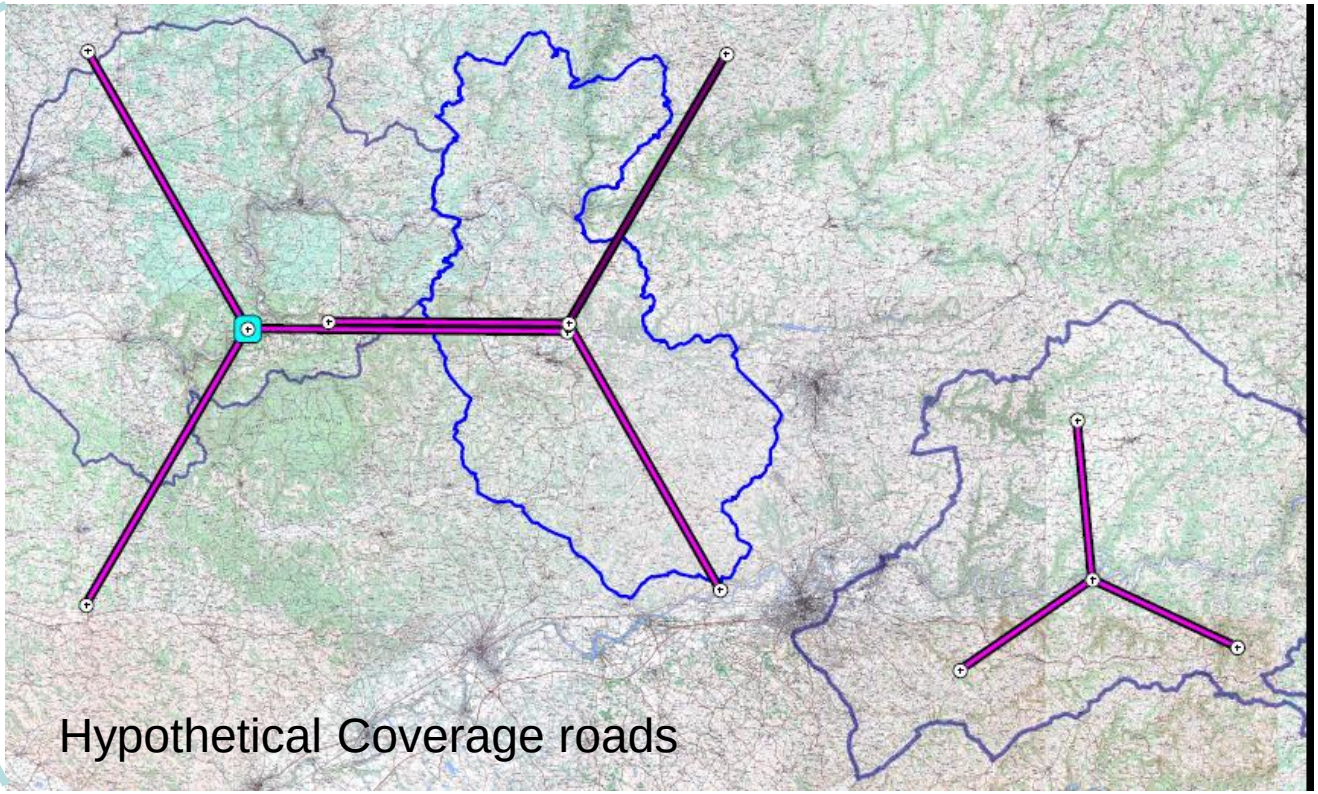
- **Dual isotropic antenna for RX**
  - Magnetic vehicular antennas for most measurements
  - PC-card type rabbit ears for “nomadic” measurements
- **23 dBm transmit power on single TX antenna**
- **6 dB noise figure at full RX gain**
- **Vehicle equipped with RF and baseband equipment**
- **Storage of 5 MHz MIMO channels twice per 10 ms, direct to disk**
  - Sufficient for extrapolation of channels up to 100km/h and CQI feedback
  - Channel estimates derived from all cell-specific (DL) and UE specific (UL) standard compliant reference signals (DL RS, UL SRS)

UE Equipment

Cell Site Locations

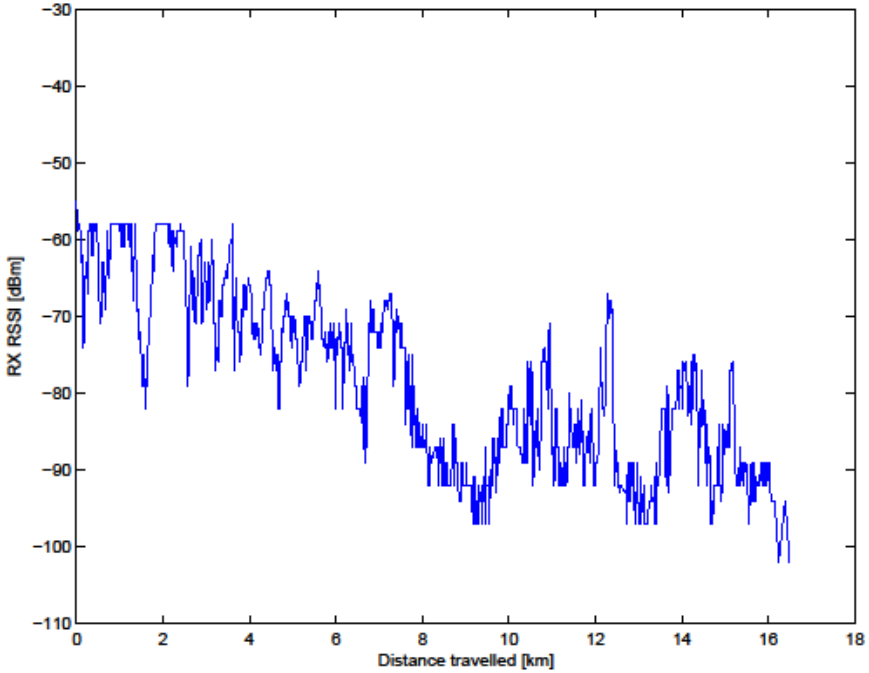
Cell-site locations in TARN department (81)
in south-west France

Penne Cordes-sur-Ciel Ambialet



Route: eNb to cell edge

- **RX RSSI vs distance travelled**



- **RX RSSI on map**