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Impact of EMF limits on 5G network roll-out

ITU Workshop on
5G, EMF & Health
Warsaw, December 5 2017

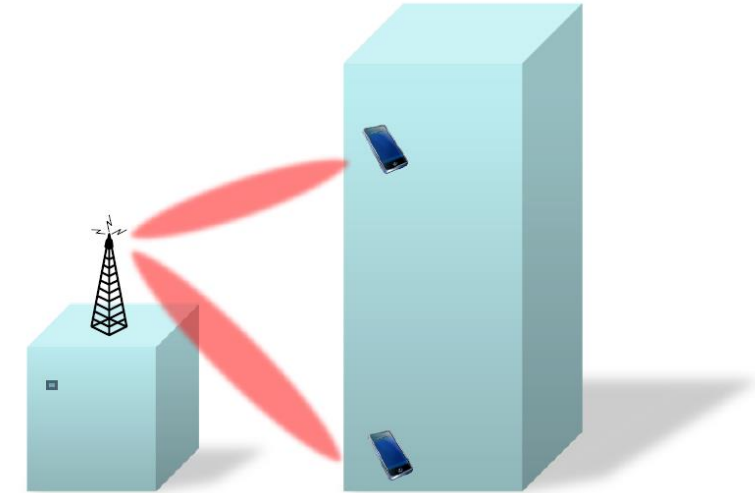
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EMF challenges for 5G



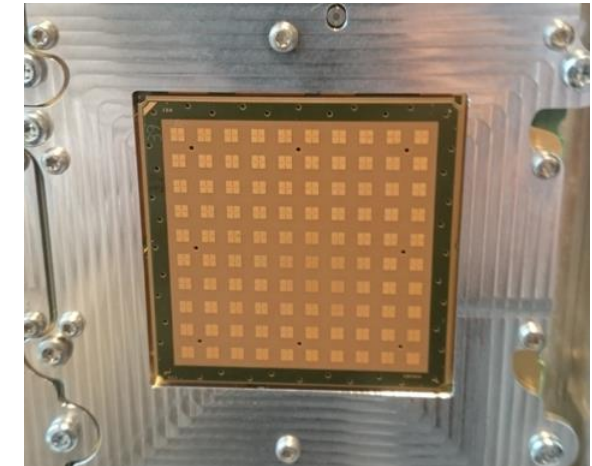
› Massive MIMO and beamforming

- More complex EMF compliance assessments
- Potentially higher EIRP and larger EMF compliance boundaries (exclusion zones) than for conventional antennas if theoretical maximum power is used for all beams
- Site design of increasing importance – especially in countries using limits lower than ICNIRP guidelines



› Frequency bands above 10 GHz

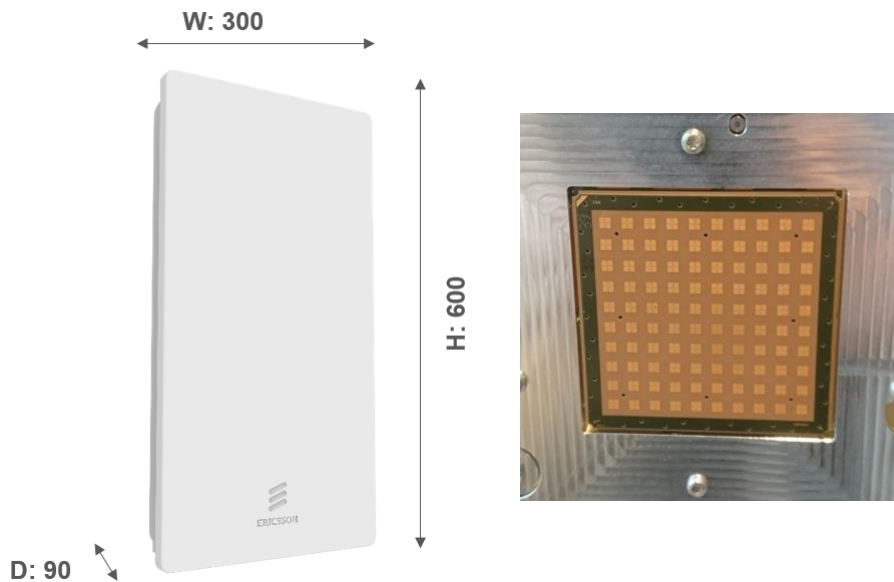
- EMF assessment methodology and standards available but need to be further refined
- International EMF limits more conservative in the nearfield which may lead to larger compliance distances for small cell base stations



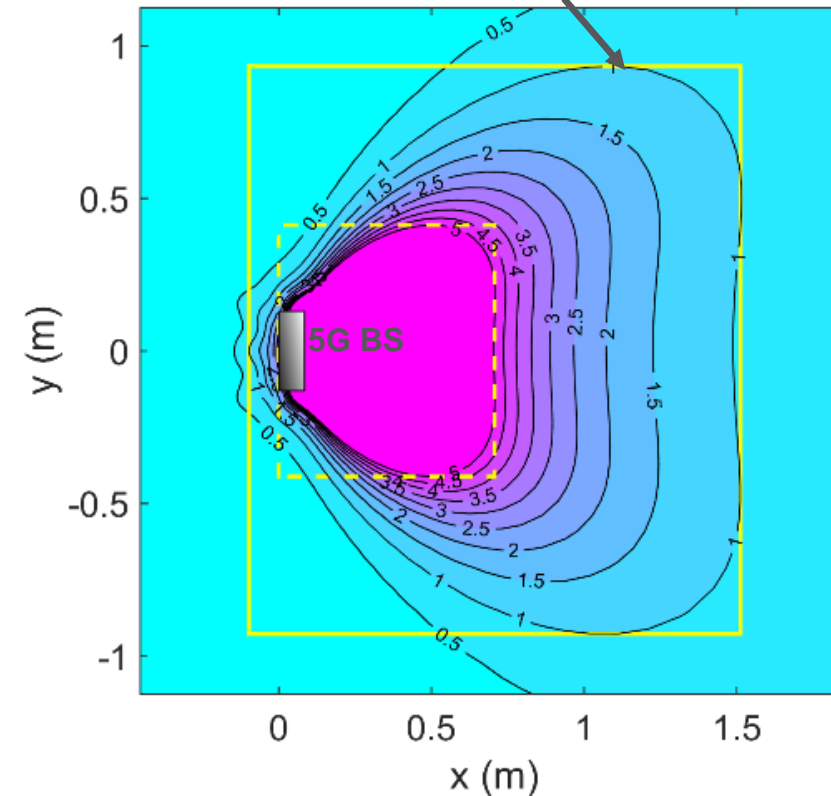
28 GHz 5G massive MIMO small cell



Ericsson AIR 5121
28 GHz
512 antenna elements
8 beams
< 1 W total output power
24 dBi antenna gain
Beam steering: $\pm 60^\circ$ (h), $\pm 15^\circ$ (v)



Exclusion zone, 10 W/m^2
(ICNIRP power density limit for the general public)



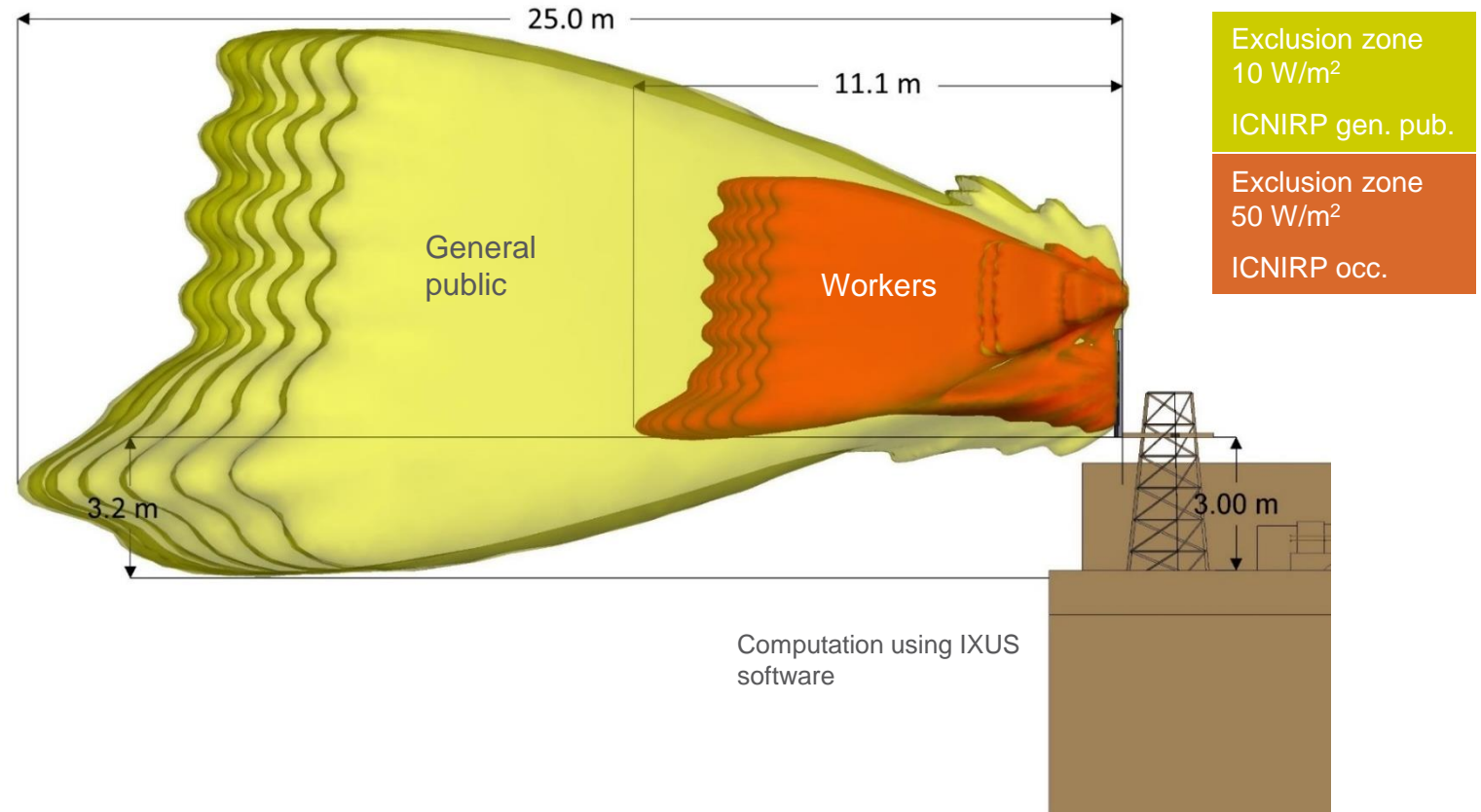
Computation assuming maximum power in all beam directions, TDD taken into account

ICNIRP limit compliance not an issue for normal installations – although larger exclusion zone than for 3G/4G
10x larger exclusion zone with 1/100 of ICNIRP – installations may be challenging

3.5 GHz 5G site with massive MIMO



- 3.5 GHz, 200 W
- Massive MIMO (64 elements)
- EIRP of 72 dBm
- Installation on existing site with 2G, 3G and 4G antennas
- Theoretical maximum power (100% simultaneous utilization) assumed for all antennas



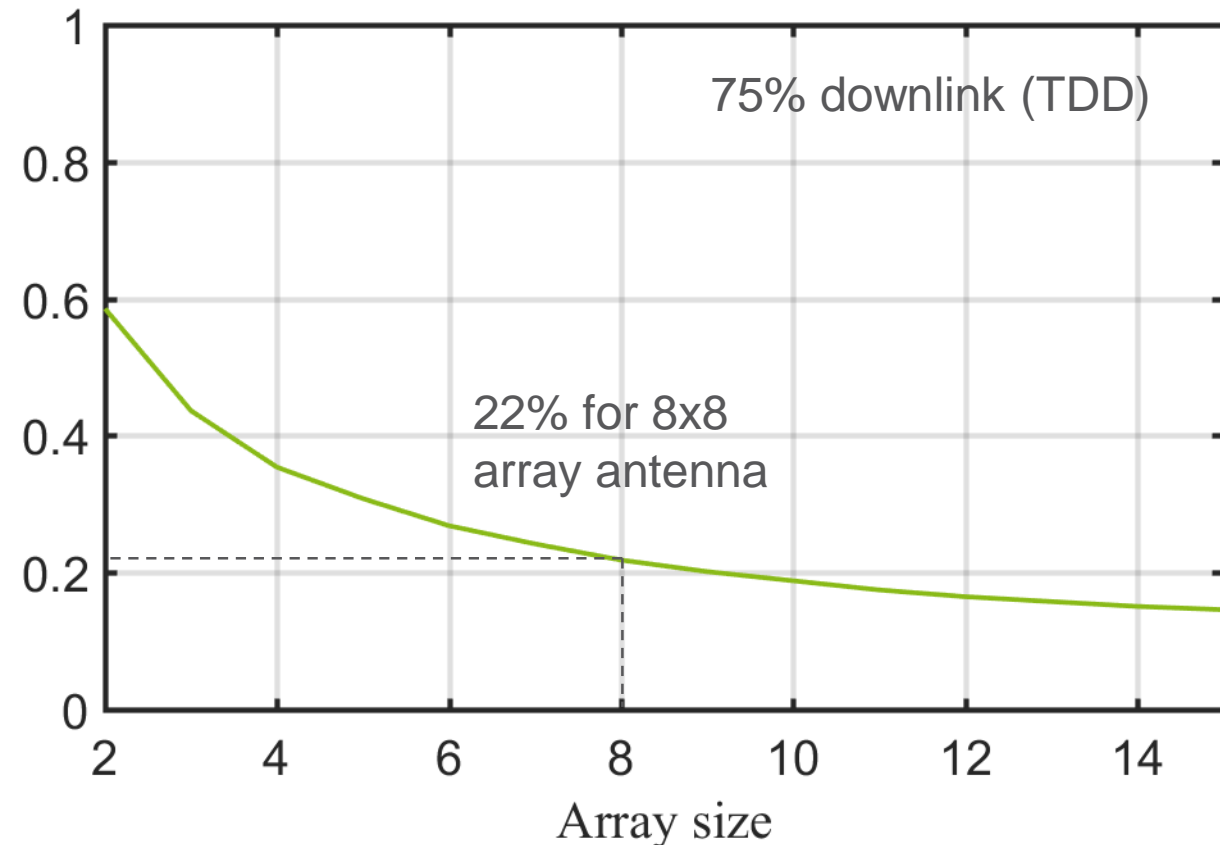
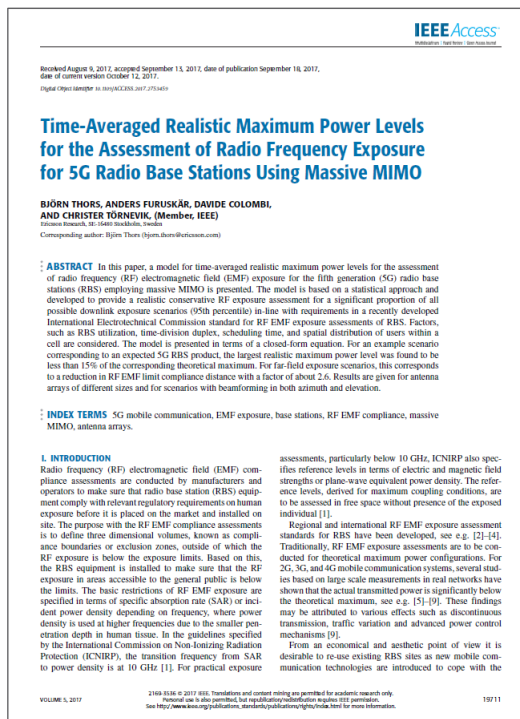
Very large exclusion zone due to unrealistic power - may lead to substantial 5G deployment challenges
IEC 62232 (2017) and ITU-T K.100 standards open up for use of actual maximum output power (95th percentile)

Actual maximum power of 5G massive MIMO antennas

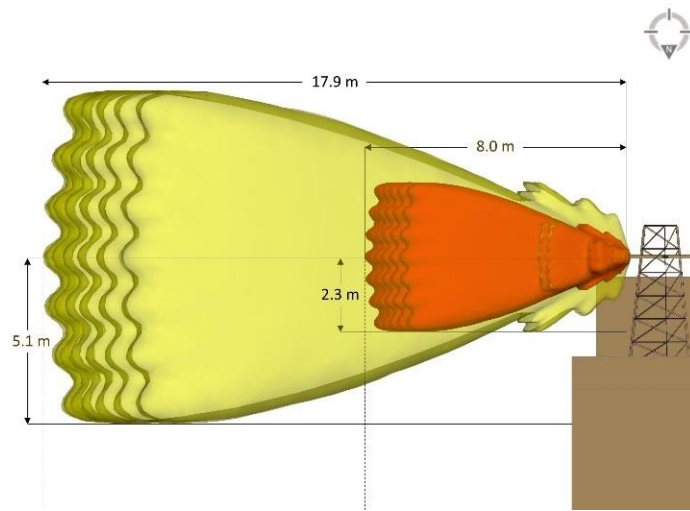


Statistical model developed that takes into account base station utilization, scheduling time, distribution of user equipment, and time-division duplexing to determine actual power

Fraction of total power contributing to the EMF exposure as function of antenna array size (95th percentile)

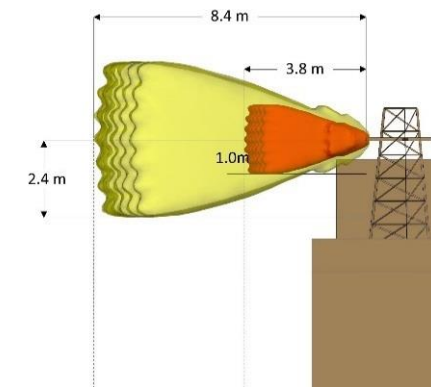


Rationale for actual maximum power use



3.5 GHz 5G base station compliance boundary determined using **theoretical maximum** transmitted power (200 W)

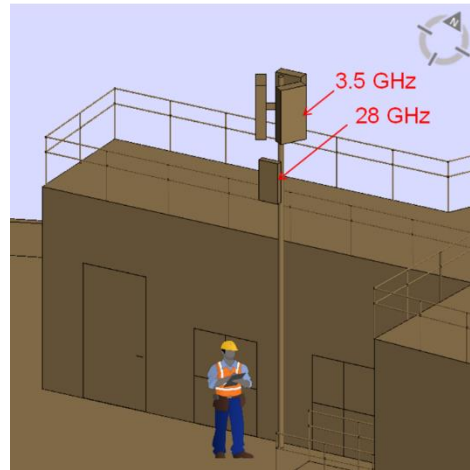
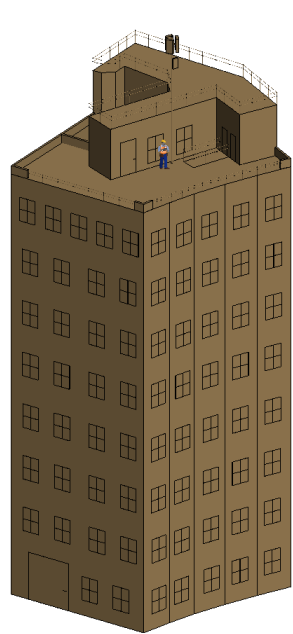
- Not all power will be focused in the same direction for several minutes
- 100% utilization is very unlikely
- TDD will limit transmit time



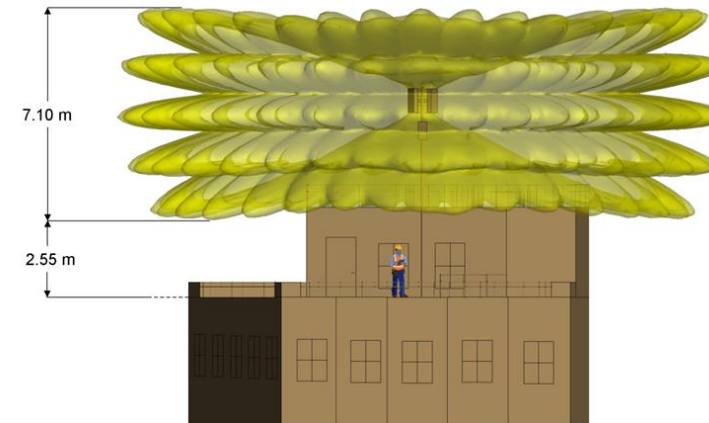
3.5 GHz 5G base station compliance boundary determined using **actual maximum** transmitted power (44 W)

Example: 5G site with massive MIMO

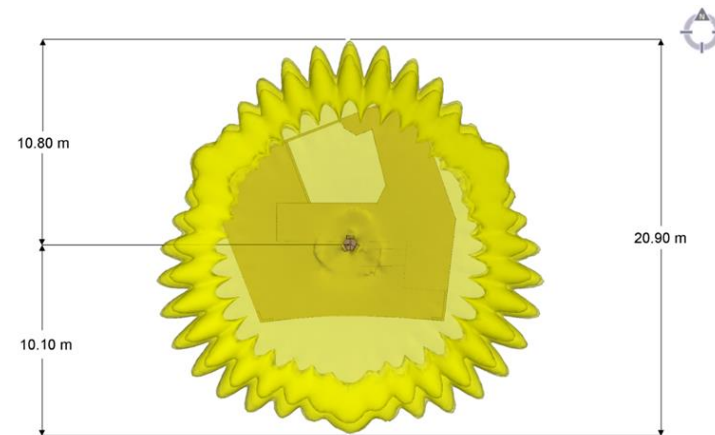
3.5 GHz and 28 GHz, actual maximum power



5G urban roof-top installation



Exclusion zone
10 W/m²
ICNIRP general
public limit



Actual maximum power = 25% of theoretical maximum
RF EMF exposure below ICNIRP limits in public areas
Case study to be included in IEC TR 62669 (2018) and
ITU-T Supplement on 5G EMF compliance

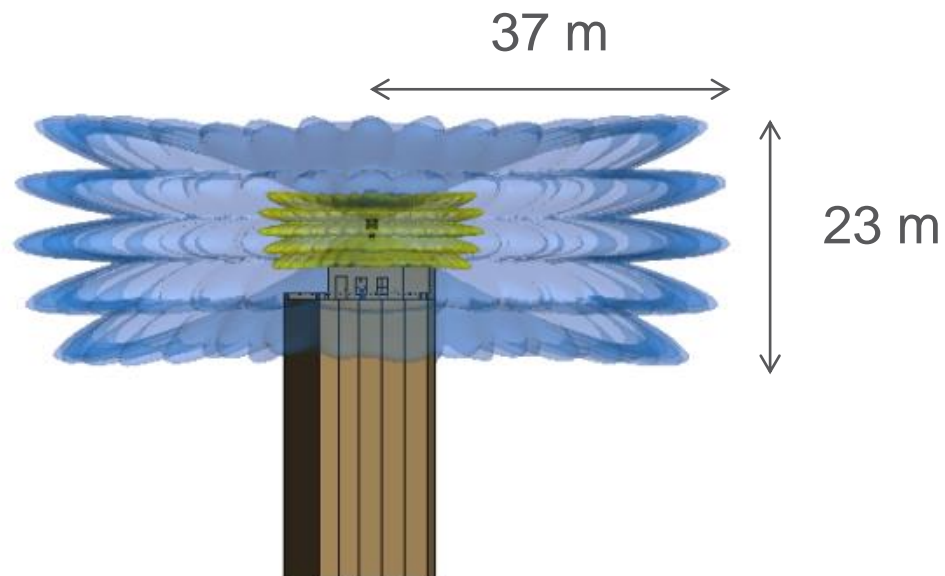
Impact of lower national EMF limits

1/10 of ICNIRP limit



5G site

3.5 GHz, three sectors
28 GHz, one sector
Actual maximum power



Exclusion zone
10 W/m²

ICNIRP limit

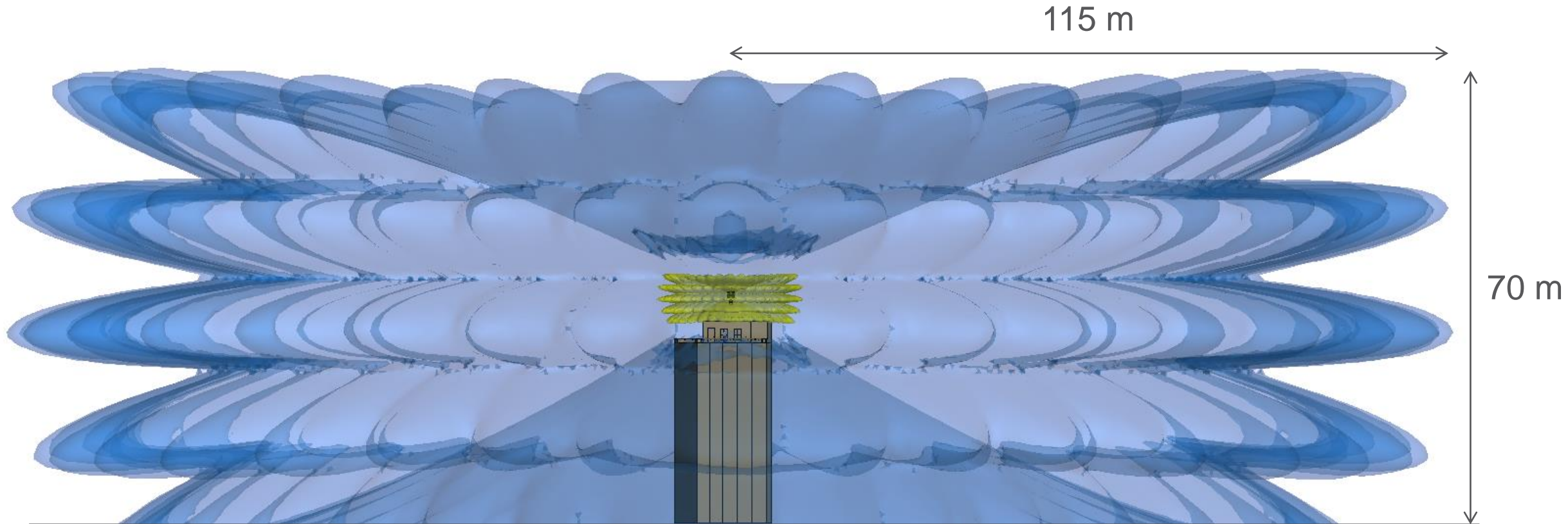
Exclusion zone
1 W/m²

1/10 of ICNIRP limit

Size of exclusion zone
makes 5G network roll-out
very challenging

Impact of lower national EMF limits

1/100 of ICNIRP limit



Size of exclusion zone makes 5G network roll-out a major problem or impossible

Exclusion zone 10 W/m ² ICNIRP limit
Exclusion zone 0.1 W/m ² 1/100 of ICNIRP limit

Conclusions



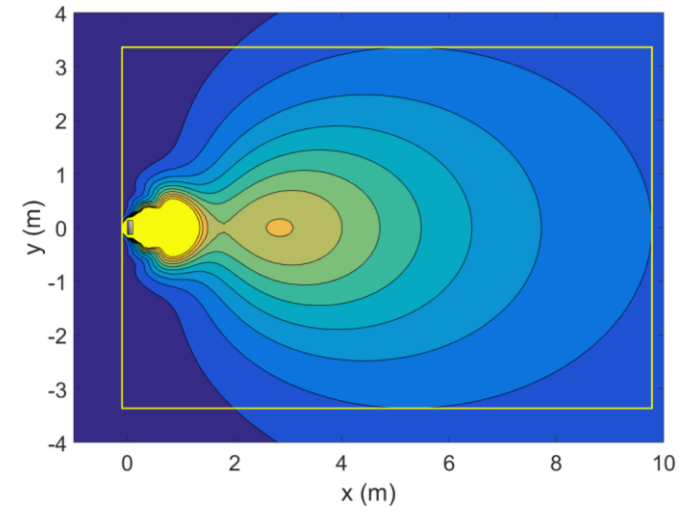
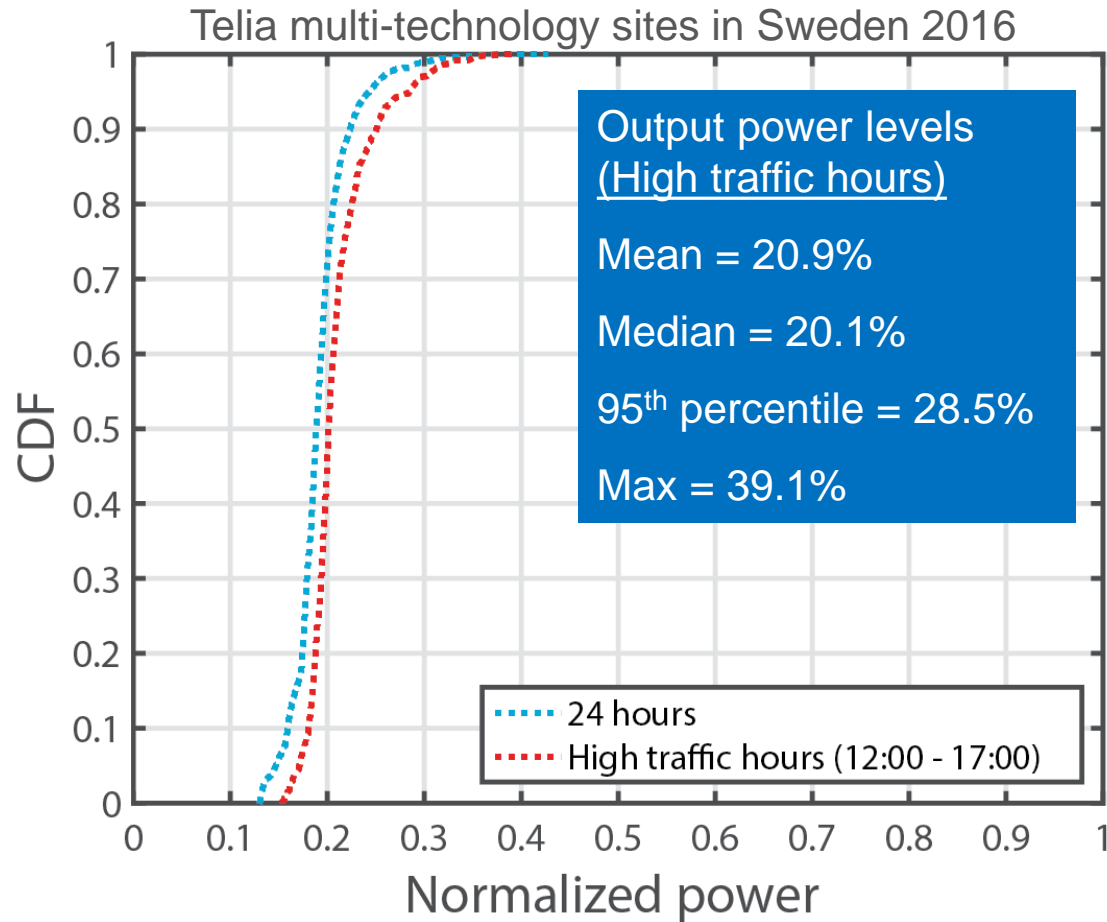
- › EMF compliance may be a challenge for 5G massive MIMO sites if assuming theoretical maximum power for all beams
- › International standards IEC 62232 and ITU-T K.100 open up for use of actual maximum power to perform realistic EMF compliance assessments
- › Statistical model to determine actual maximum power of 5G massive MIMO antennas has been developed: found to be around 25% of theoretical maximum power for 8x8 array antennas
- › In countries with EMF limits significantly below the international science-based ICNIRP limits the roll-out of 5G networks will be a major problem



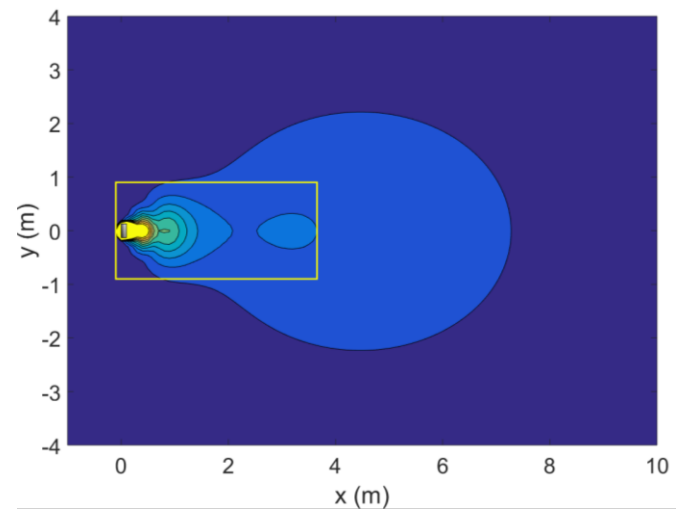
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Actual maximum power use example

Impact on exclusion zone – 2G/3G/4G multi-technology site



Theoretical maximum total output power applied



95th percentile of the combined output power values applied