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# Impact of EMF limits on 5G network roll-out

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

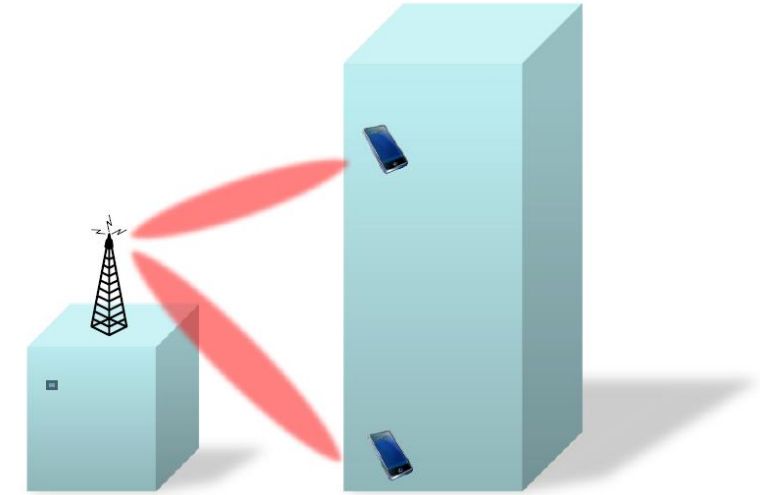
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Ericsson Research, Stockholm

# EMF challenges for 5G



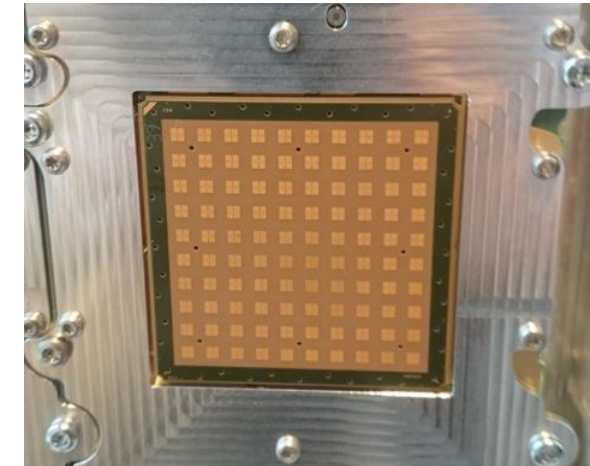
## › Massive MIMO and beamforming

- 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

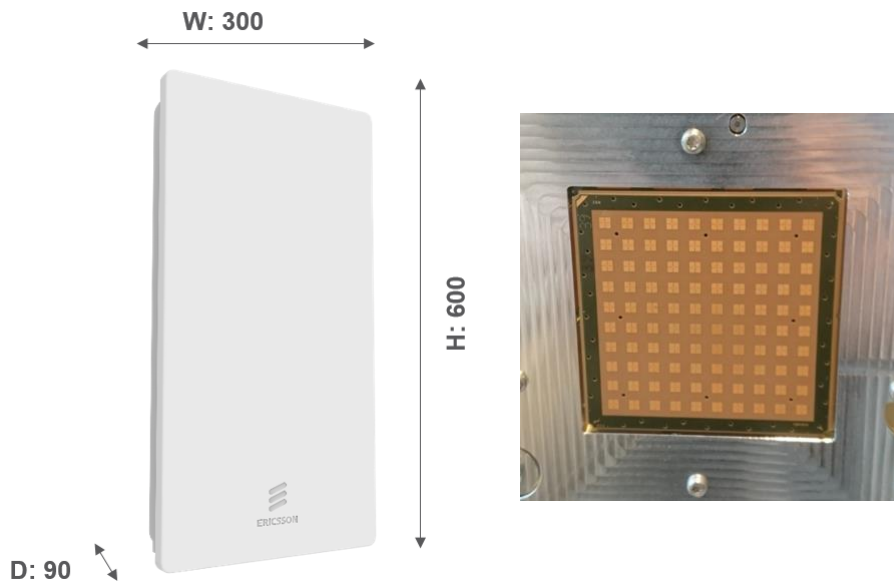
- EMF assessment methodology and standards available but need to be further refined
- International EMF limits more conservative in the nearfield which may lead to larger compliance distances for small cell base stations



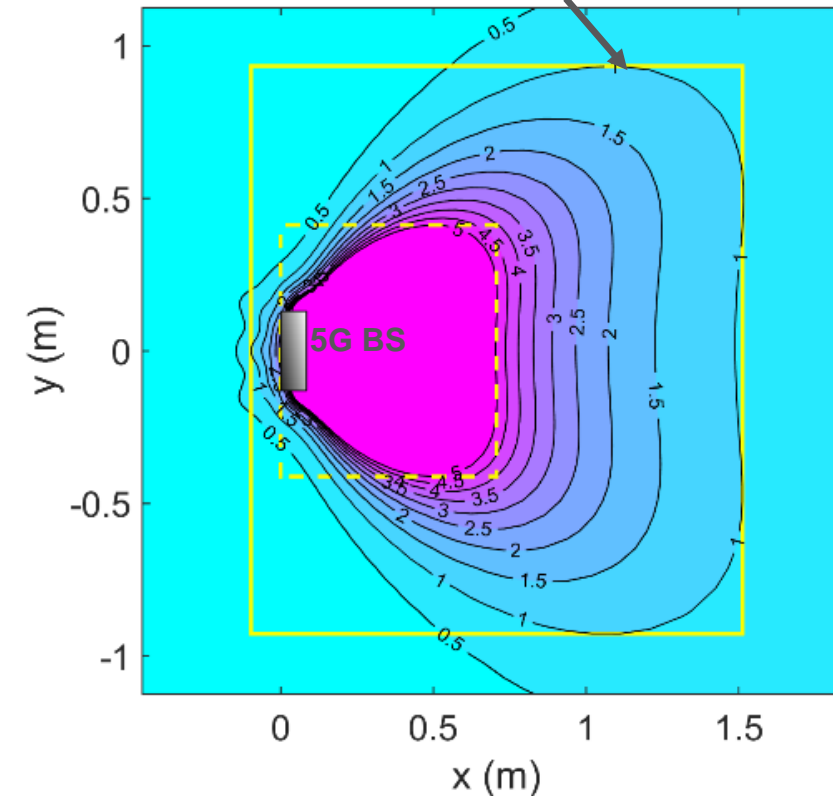
# 28 GHz 5G massive MIMO small cell



**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,  $10 \text{ W/m}^2$   
(ICNIRP power density limit for the general public)



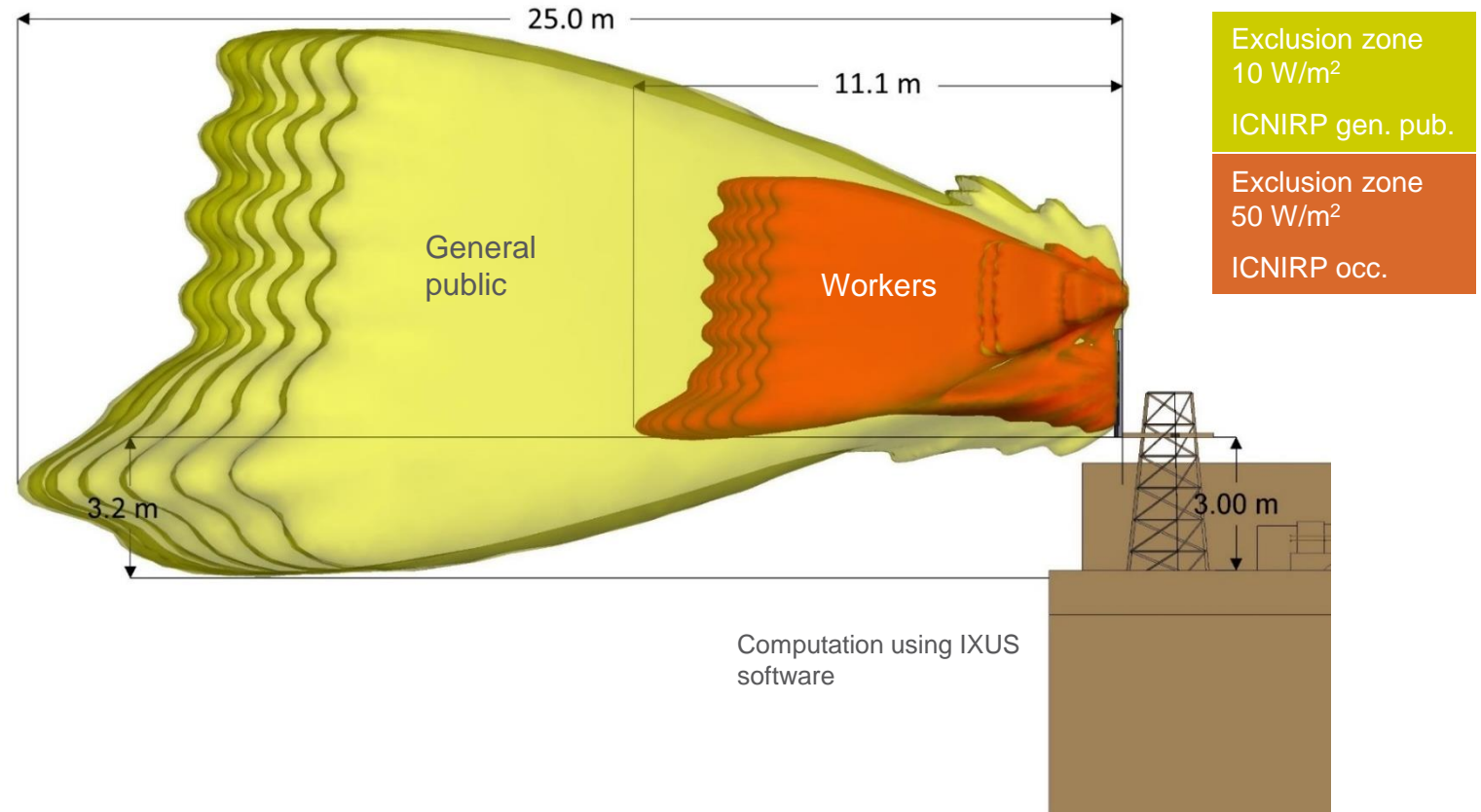
Computation assuming maximum power in all beam directions, TDD taken into account

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



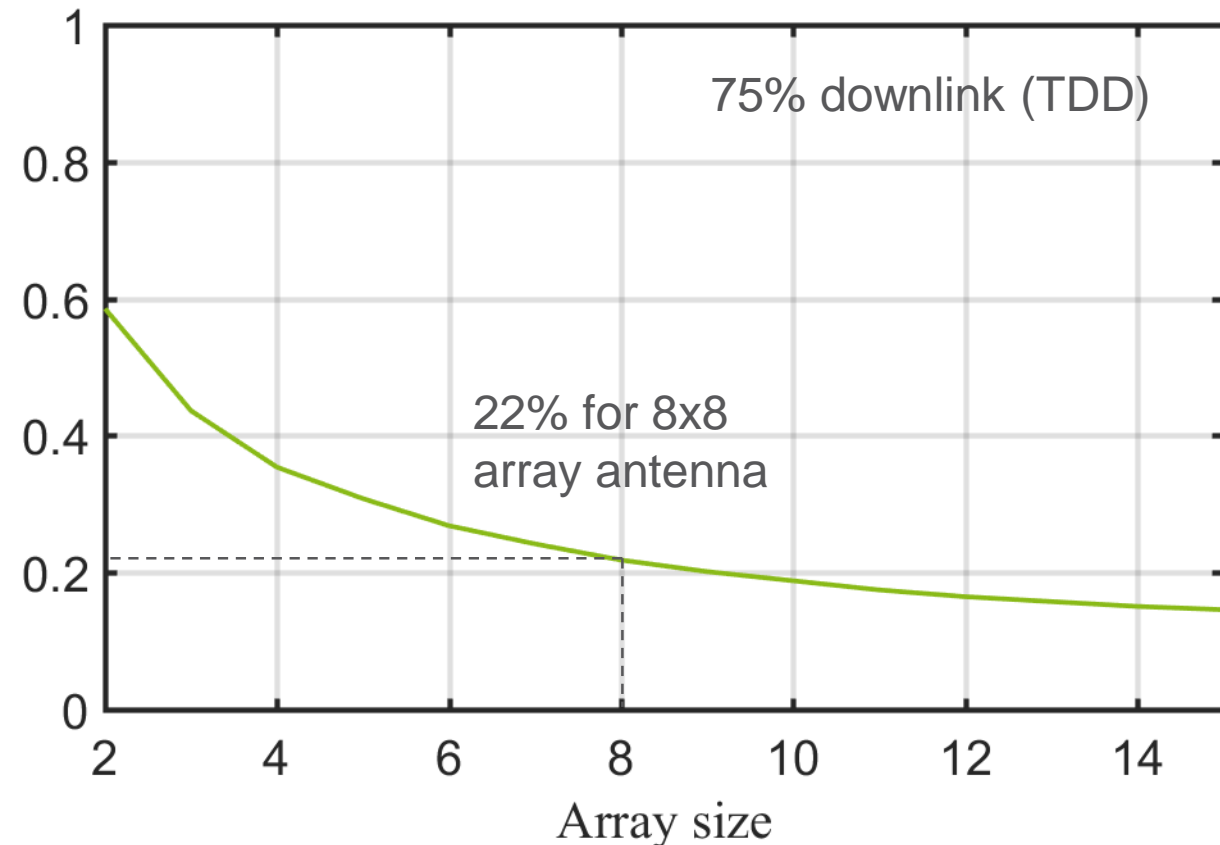
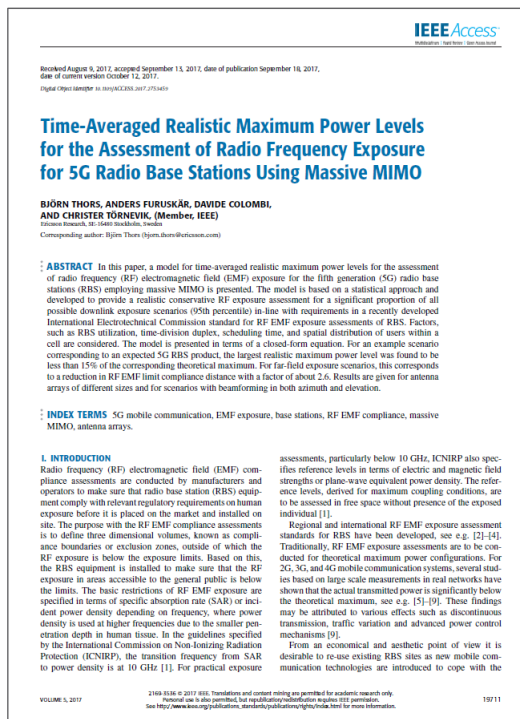
Very large exclusion zone due to unrealistic power - may lead to substantial 5G deployment challenges  
IEC 62232 (2017) and ITU-T K.100 standards open up for use of actual maximum output power (95<sup>th</sup> percentile)

# Actual maximum power of 5G massive MIMO antennas

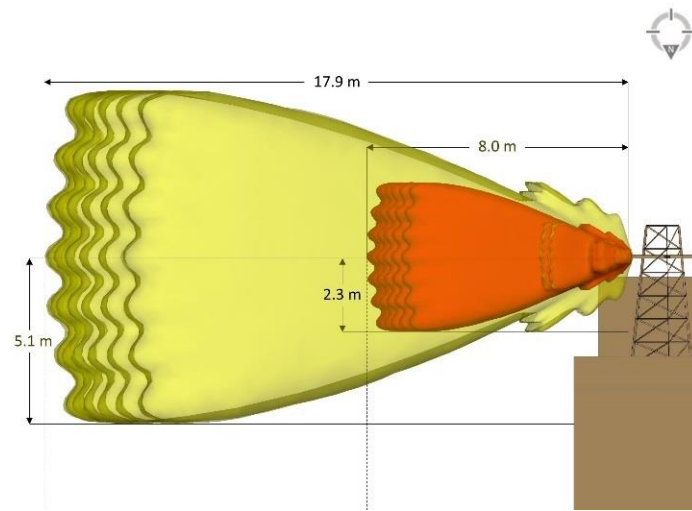


Statistical model developed that takes into account base station utilization, scheduling time, distribution of user equipment, and time-division duplexing to determine actual power

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

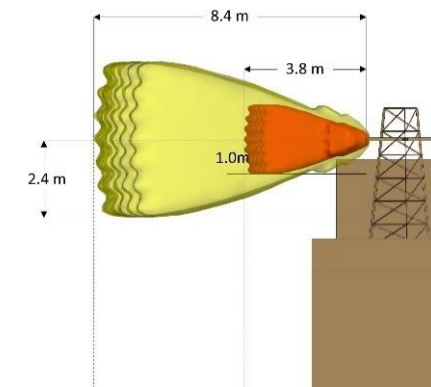


# Rationale for actual maximum power use



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

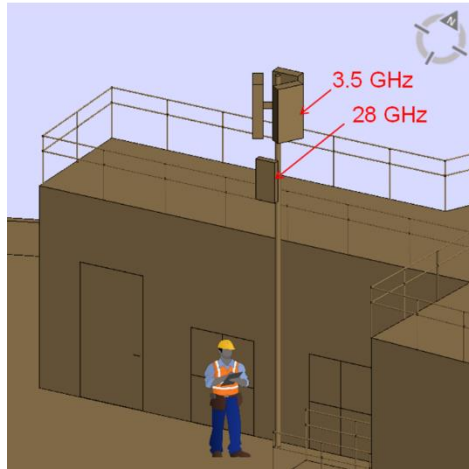
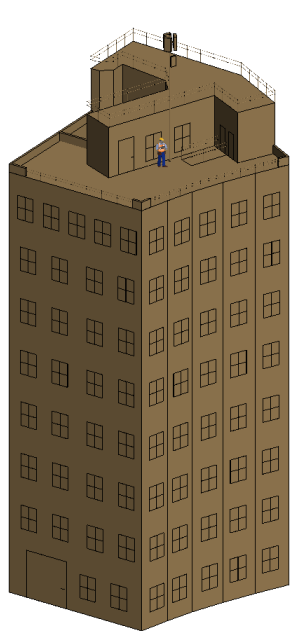
- Not all power will be focused in the same direction for several minutes
- 100% utilization is very unlikely
- TDD will limit transmit time



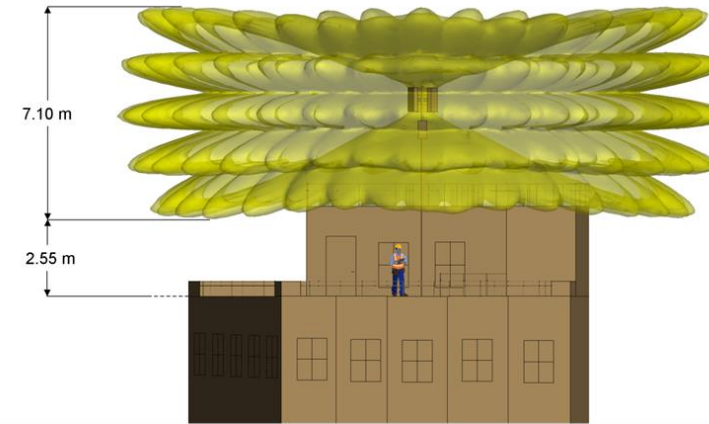
3.5 GHz 5G base station compliance boundary determined using **actual maximum** transmitted power (44 W)

# Example: 5G site with massive MIMO

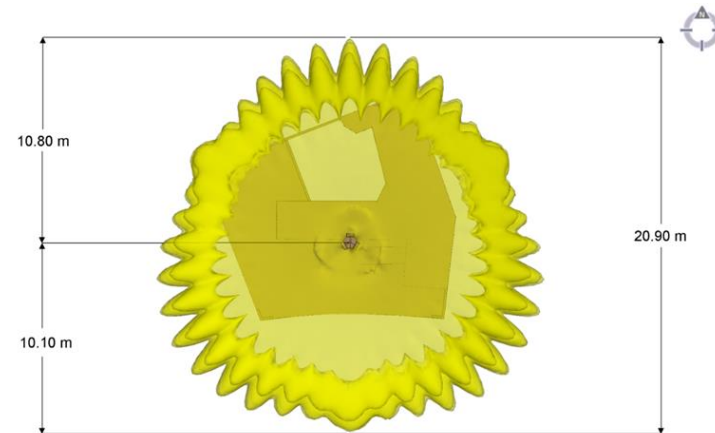
3.5 GHz and 28 GHz, actual maximum power



5G urban roof-top installation



Exclusion zone  
10 W/m<sup>2</sup>  
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

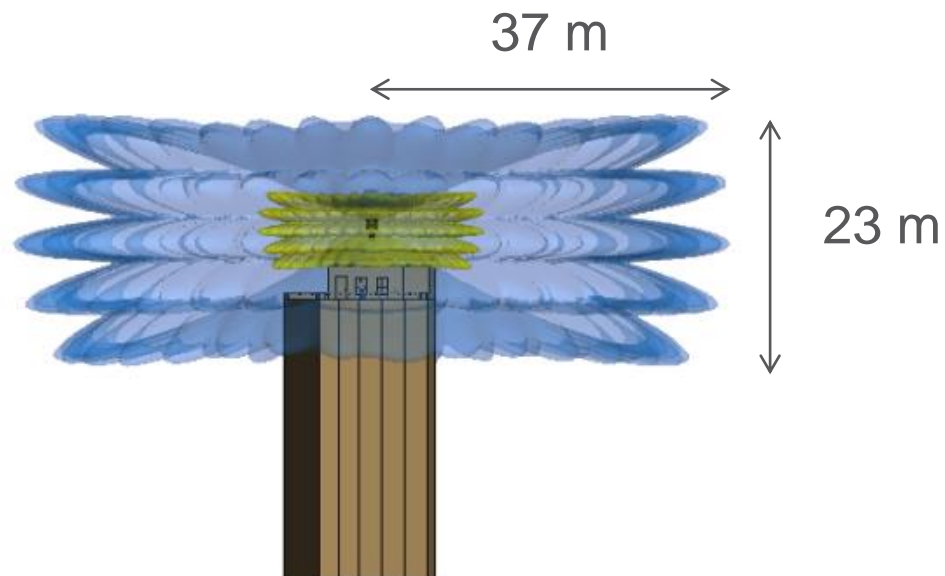
# Impact of lower national EMF limits

1/10 of ICNIRP limit



## 5G site

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



Exclusion zone  
10 W/m<sup>2</sup>

ICNIRP limit

Exclusion zone  
1 W/m<sup>2</sup>

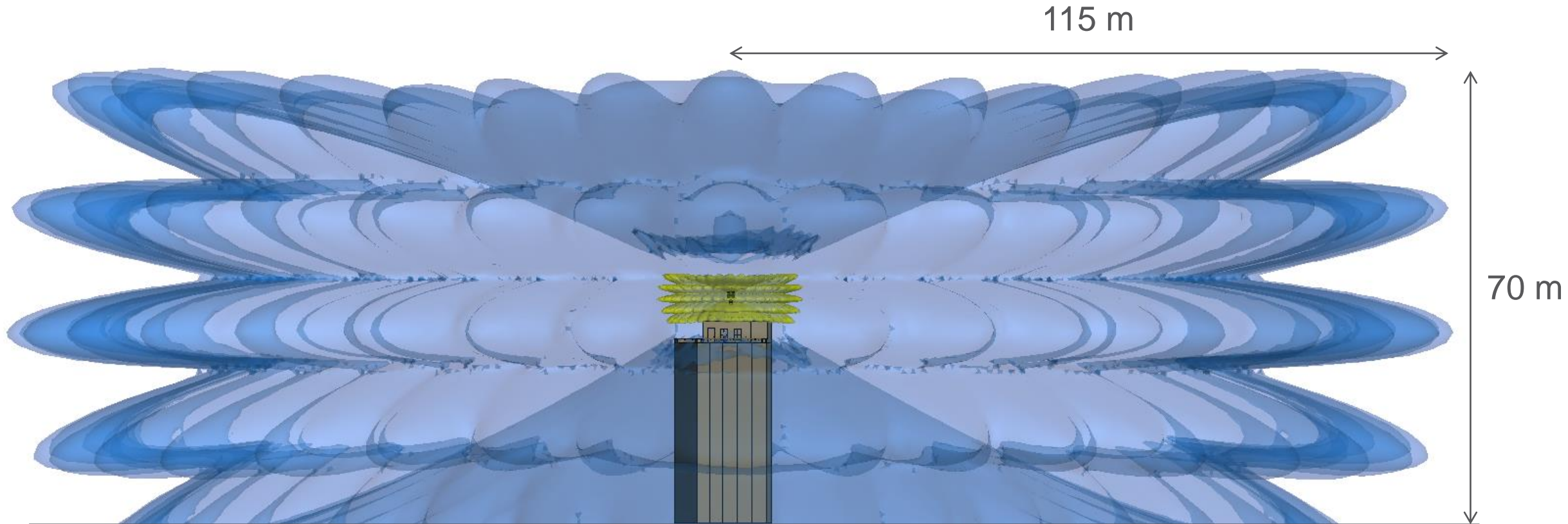
1/10 of ICNIRP limit

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 <sup>2</sup> ICNIRP limit
Exclusion zone 0.1 W/m <sup>2</sup> 1/100 of ICNIRP limit

# Conclusions



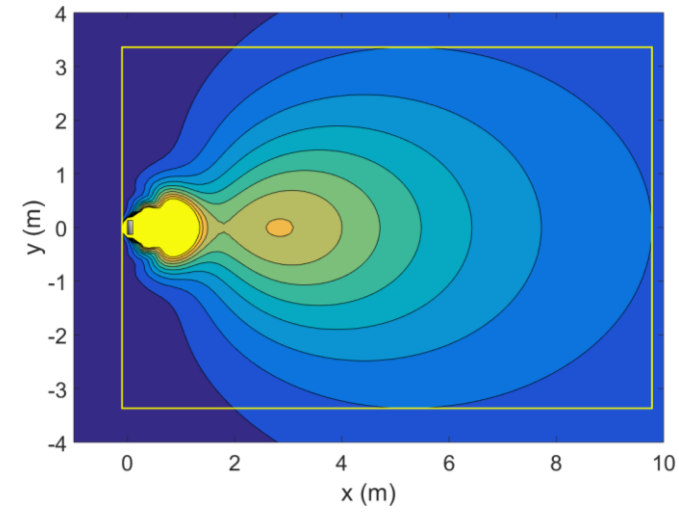
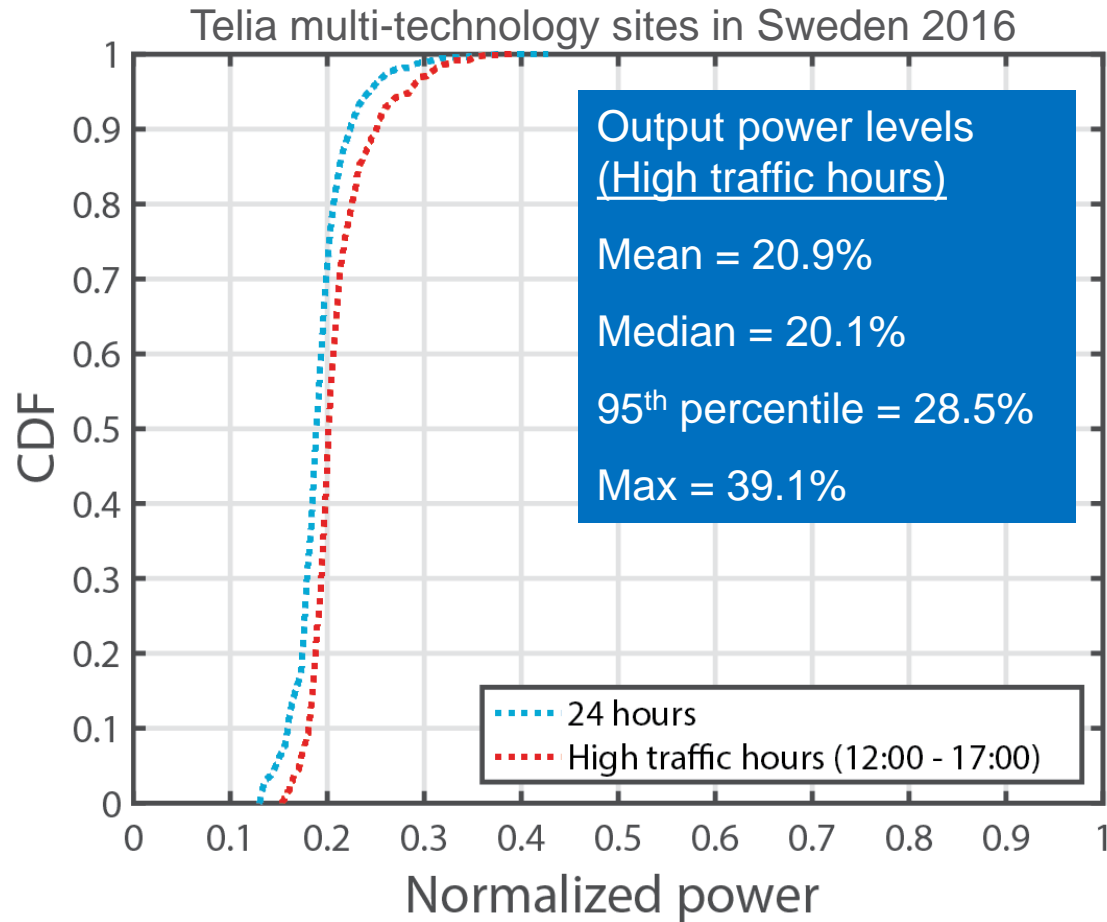
- › EMF compliance may be a challenge for 5G massive MIMO sites if assuming theoretical maximum power for all beams
- › International standards IEC 62232 and ITU-T K.100 open up for use of actual maximum power to perform realistic EMF compliance assessments
- › Statistical model to determine actual maximum 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



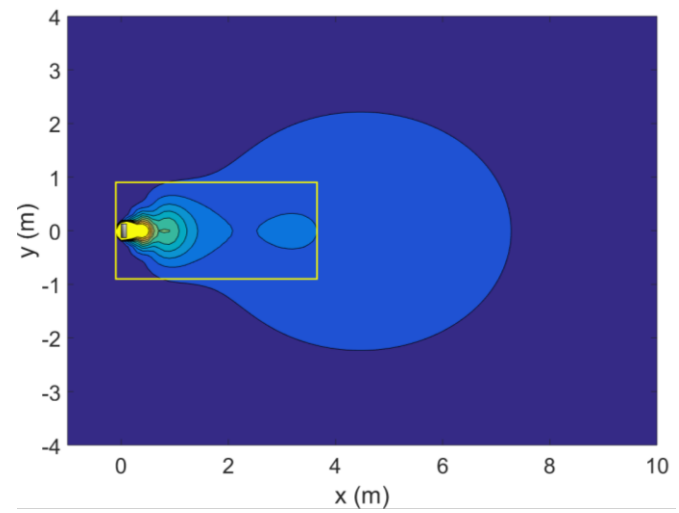
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# Actual maximum power use example

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



Theoretical maximum total output power applied



95<sup>th</sup> percentile of the combined output power values applied