5G exposure

Joe Wiart

Telecom Paris
Institut Polytechnique de Paris
Institut Mines Telecom

https://chairec2m.wp.imt.fr

5G: State of knowledge and EMF exposure level
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Overview

- Introduction
- Dosimetry in a nutshell
- What is the present and actual exposure
- What are the specificity of 5G
- Conclusion

C2M Caractérisation - Modélisation - Maîtrise

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Introduction

Questions on 5G are rising

new frequency bands used

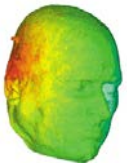
new smart antennas deployed

What about the Exposure ?

Exposure.
Dosimetry in a nutshell: Exposure metric

- **Specific Absorption Rate (SAR)**

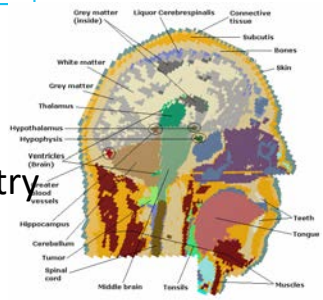
SAR definition:
Consider a volume V (e.g. the head), SAR is defined as the ratio of the RF power absorbed by the tissues inside the volume V and the mass of these tissues



$$SAR = \frac{W(v)}{M(v)}$$

SAR and E field in tissues:
Le power absorbed by tissues is linked to RF power deposition

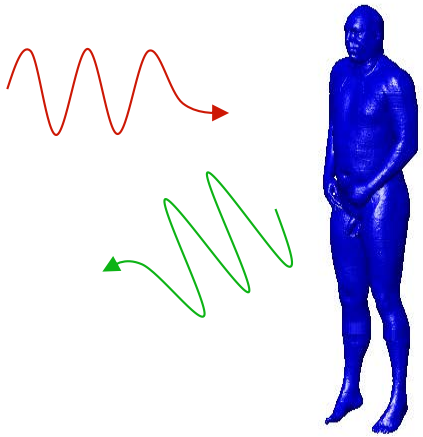
$$SAR = \frac{\sigma E^2}{2\rho}$$

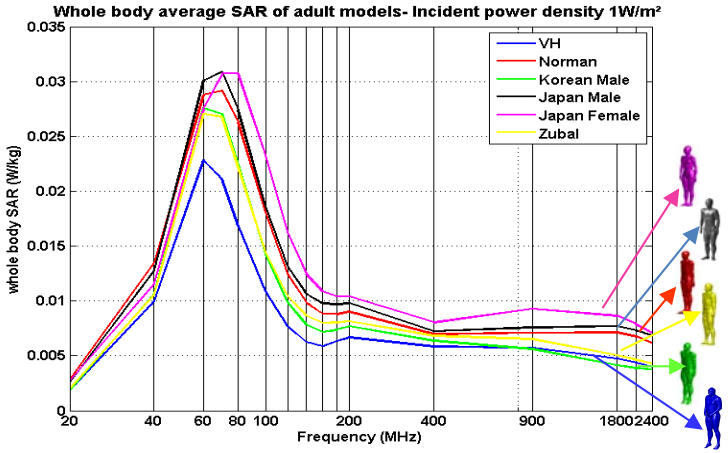


Thanks to Numerical dosimetry
And FDTD

- **Incident Electric field** as a « proxy »

The **whole boday SAR** assessment is **linked to the incident E field**





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Dosimetry in a nutshell: Measurement equipment

SAR measurement:

Devices : Standards exist (IEC 62209-1,-2 and -3) to measure maximum SAR induced by devices

Measurement in watt/Kg

Field measurement:

Base station: IEC output a measurement standard (62232) that has been endorsed by ANFr (Protocole de mesure *)

Measurement in watt/m²

* https://www.anfr.fr/fileadmin/mediatheque/documents/expace/2017-08-28__Protocole_de_mesure_V4.pdf

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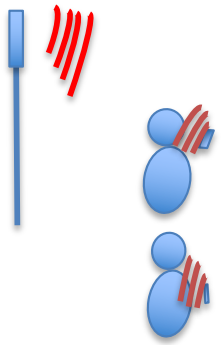
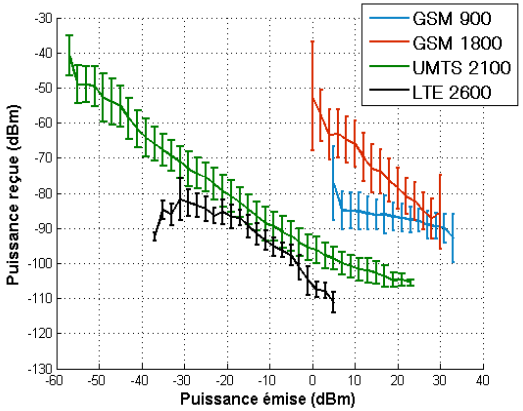
Exposure from Mobile AND Base Station





The actual exposure is the sum of the exposure from BSA and the exposure from Mobile

Power emitted and received are correlated

- The downlink exposure depends on the network and the traffic over the area
- The uplink exposure depends on the network and usage

Actual downlink RF Exposure in France

Typical present exposure : 0.38v/m
Indoor is about 50% of the outdoor

Years	2014	2015	2016	2017	2018	2019
Median (all)	0.38 v/m	0.36 v/m	0.38v/m	0.36v/m	0.40v/m	0.38v/m
Indoor (median)	0.31v/m	0.36v/m	0.36 v/m	0.31v/m	0.33v/m	0.38v/m
Outdoor (median)	0.53 v/m	0.56v/m	0.56v/m	0.52v/m	0.62v/m	0.56v/m
90% <	1.6 v/m	1.5v/m	1.4v/m	1.6v/m	1.8v/m	1.8v/m

Median over 3000 measurements per year (more than 16000 measurement) reported by ANFr

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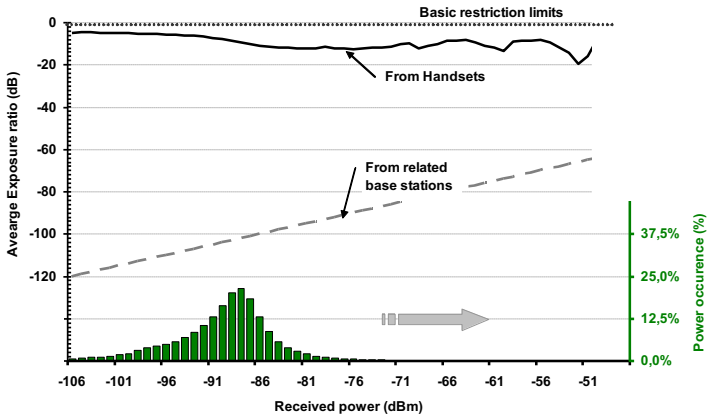
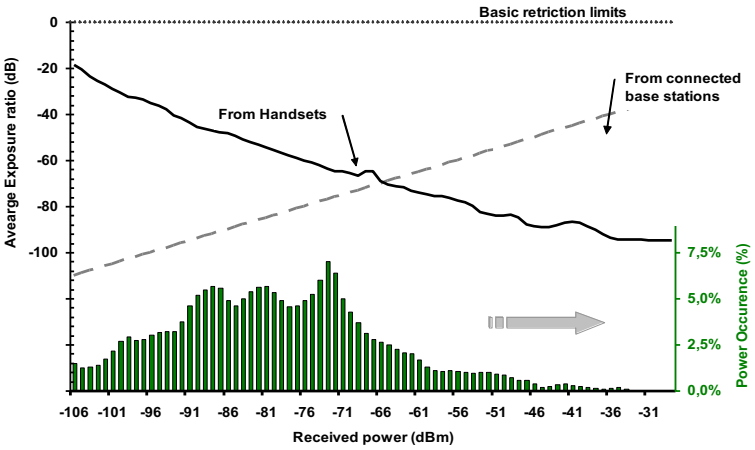
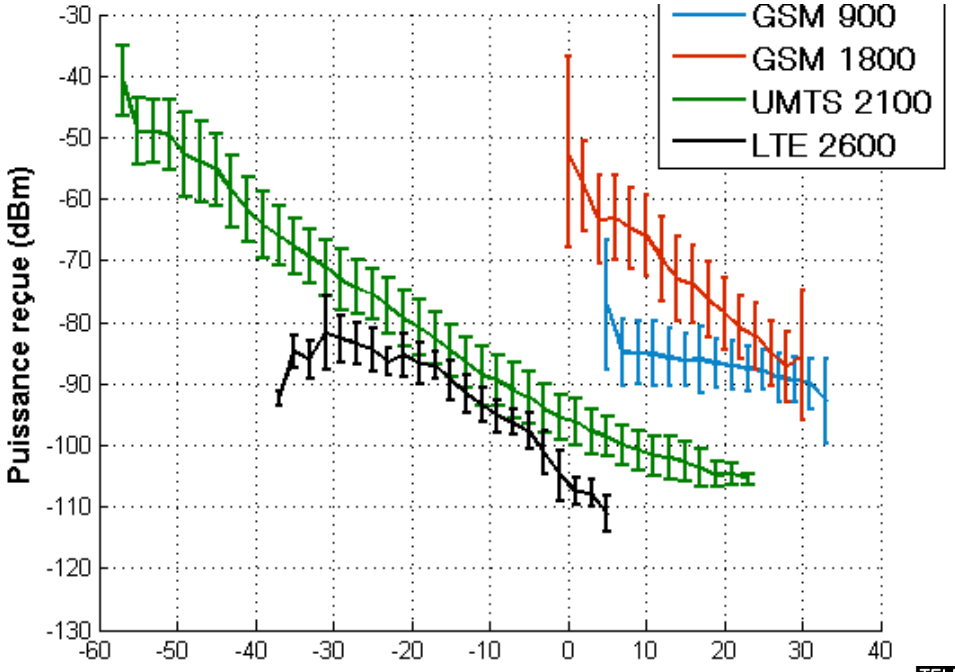
Actual Exposure from mobiles phones



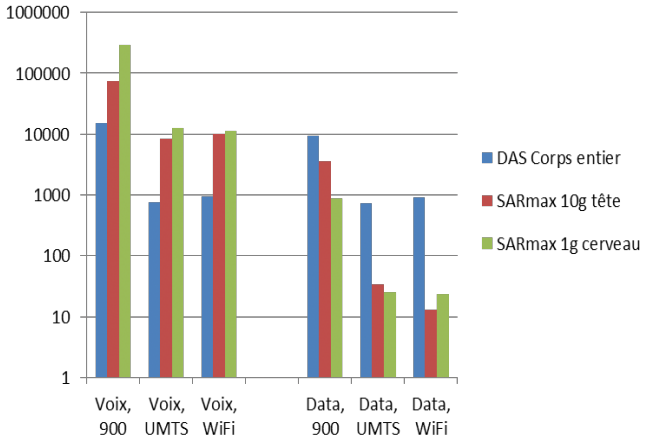


The **powers emitted by mobile devices are varying depending on the usage and location.**

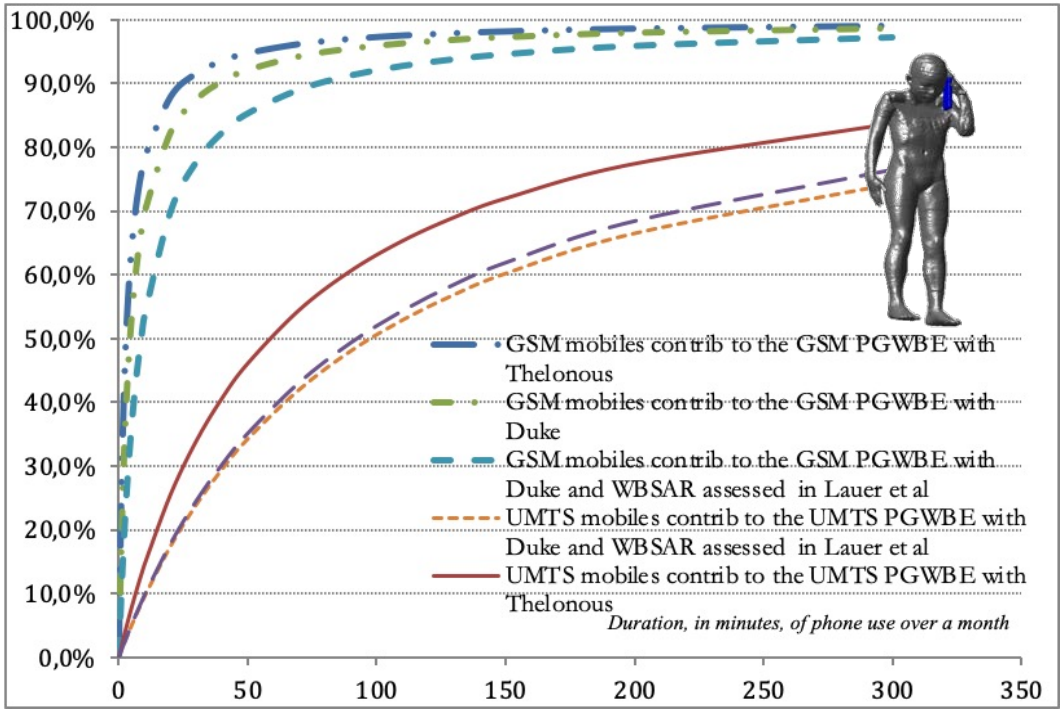
For instance, far from the base station, powers received by devices are small but powers emitted are large.



Total Exposure



Ratio of mean exposure induced by mobiles and base station (after LEXNET)



Contribution of mobile phone to the total exposure vs duration of use

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5G from the engineering point of view

- **Modulation :**
  - **OFDMA** (orthogonal frequency-division multiple access) as 4G
- **TDD instead of FDD**
  - Uplink and downlink are using the same frequency bands (Eg. 75% Down with DDDDDDDSUU)
- **Frequency bands**
  - New frequency bands : ***3.5 GH***z (3,4 - 3,8 GHz) and **26 GHz** (24,25 - 27,5 GHz)
  - Reuse of other used band
- **Antenna technologies**
  - Reuse of existing architecture (macro, micro
  - Use of ***massive MiMo*** smart antennas

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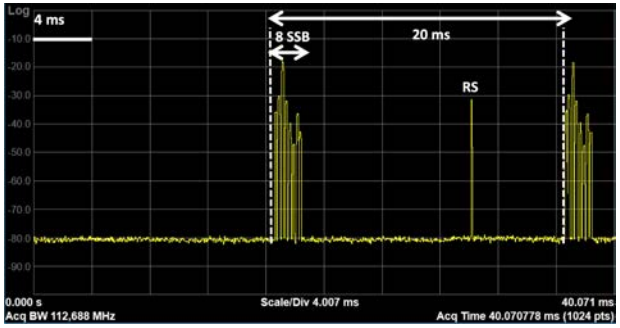
Millimeter waves

- In France the frequency band that will be used first is 26 GHz (24,25 - 27,5 GHz)

- The skin will be the main tissue exposed

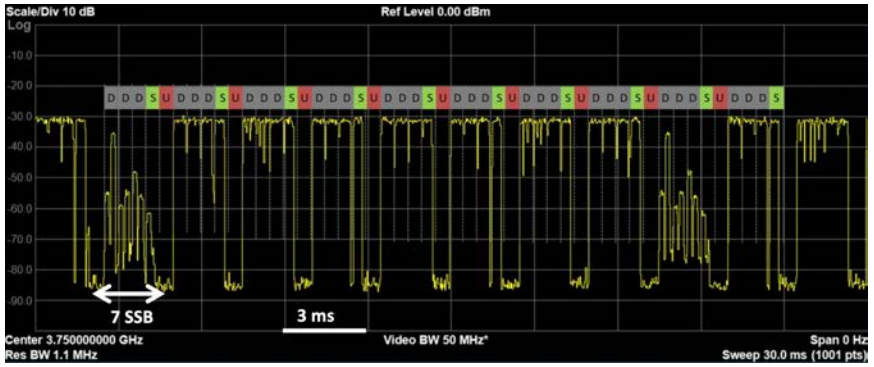
Time occupation of 5G signals



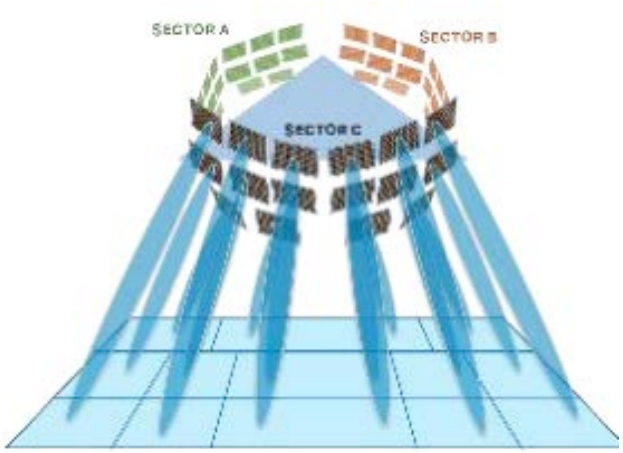
Trame 20ms (2*10)
5ms for SSB (synchronisation signal block)
15 ms for RB (

https://www.anfr.fr/fileadmin/mediatheque/documents/5G/20200410-ANFR-rapport-mesures-pilotes-5G.pdf

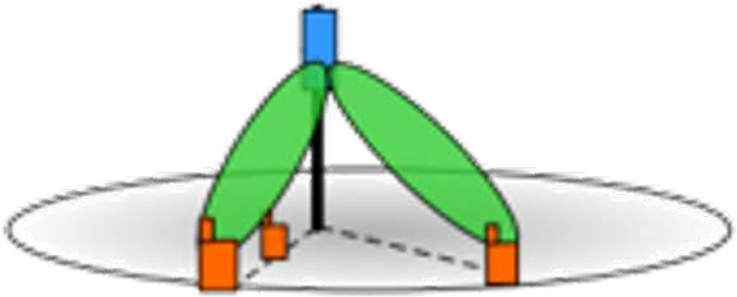
Measurement performed by ANFr

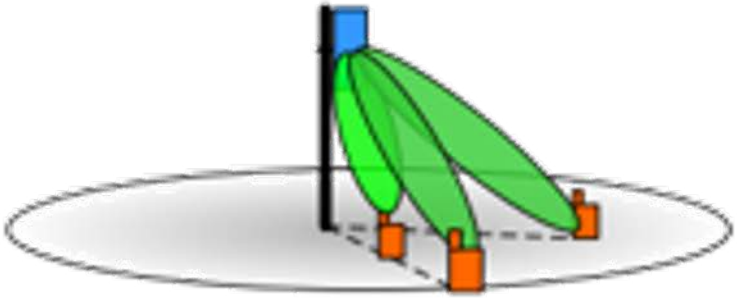


"massive MiMo" antenna

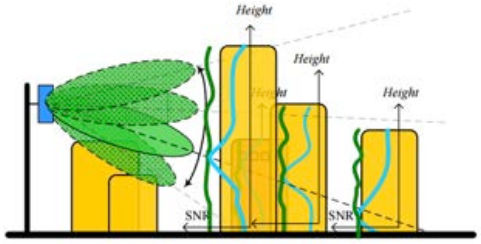


The antenna beam is oriented toward the user





Beamforming antenna



Beamforming will generate higher field in variable direction and during variable duration

Gain of Beamforming
Will reduce the power emitted by mobile phones

Gain in increasing, so instantaneous exposure too. Actual exposure must be averaged over a duration time

Higher is the throughput shorter is the duration of the emission

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Challenges for Exposure assessment

- *With 4G The exposure depends on the duration, throughput and amount of data transmitted*
- *With 5G, Uplink **and Downlink** exposure will depend on usage and networks performances*
- *Standards are presently developed under the umbrella of CENELEC and IEC to check the compliance of Base station antenna and mobile phone.*
- *Actual total exposure will be analyzed when the networks will operate*

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Dans la confusion trouver la simplicité
De la discorde faire jaillir l'harmonie
Au milieu de la difficulté se trouve l'opportunité

Albert Einstein,
Trois règles de travail

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