

# Recent development in dosimetry to handle variability



**J. Wiart et col**

Whist lab.

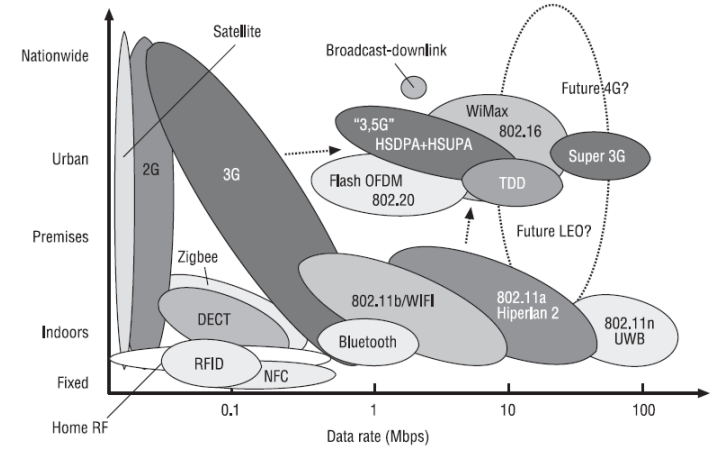
<http://whist.institut-telecom.fr/>

Telecom ParisTech, Telecom Bretagne & Orange Labs

# Wireless Ubiquitous World



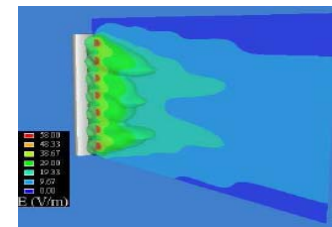
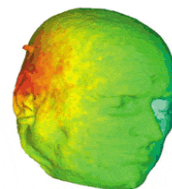
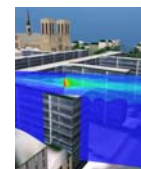
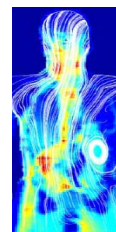
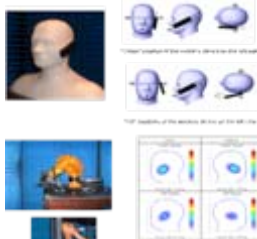
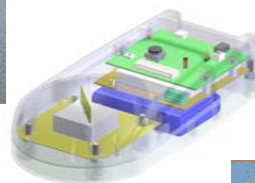
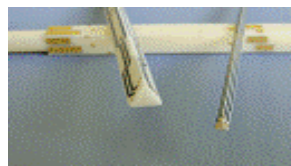
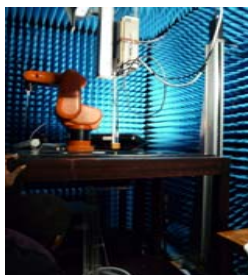
Wireless Technology Overview



Versatile use, versatile technologies...



# RF exposure assessment methods have been improved



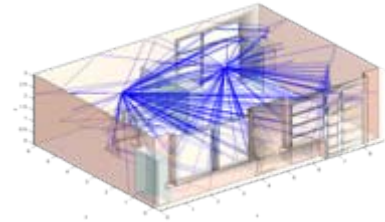
*Methods based on deterministic approaches ...*

# RF exposure assessment is facing variability



sources

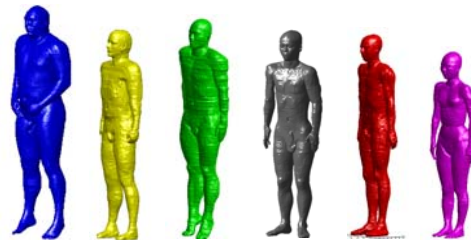
Environnement



Morphology



Posture

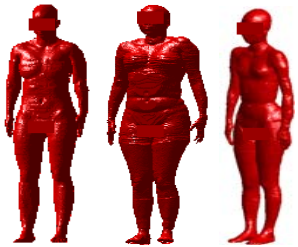


**A FDTD simulation is only a case within a lot**

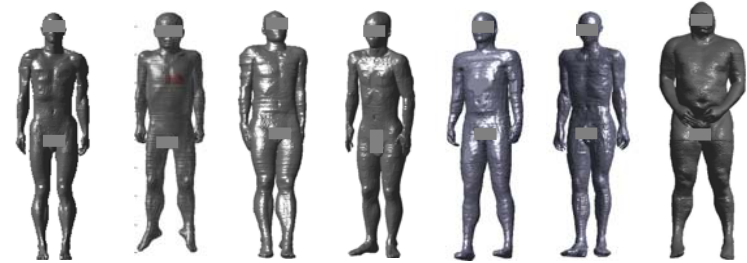
# Variable morphologies



International effort to develop models

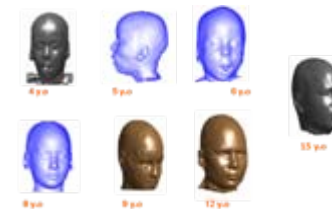
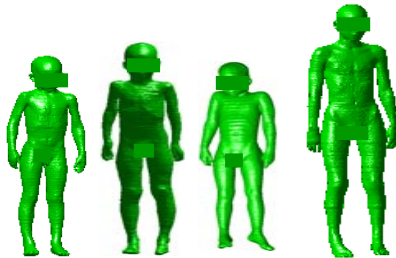


Adult female body models



Adult male body models

Child body models



Child head models



# Exposure assessment in complex configuration

Partners

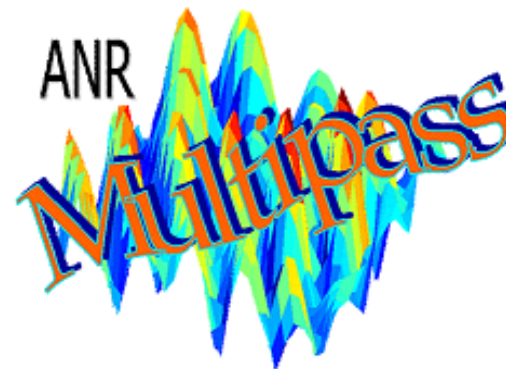
Orange Labs

Telecom Bretagne

Supelec

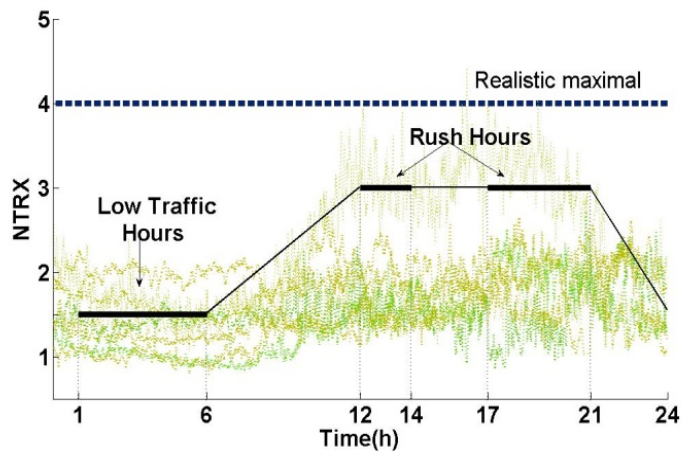
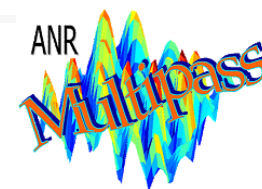
Xlim

Satimo

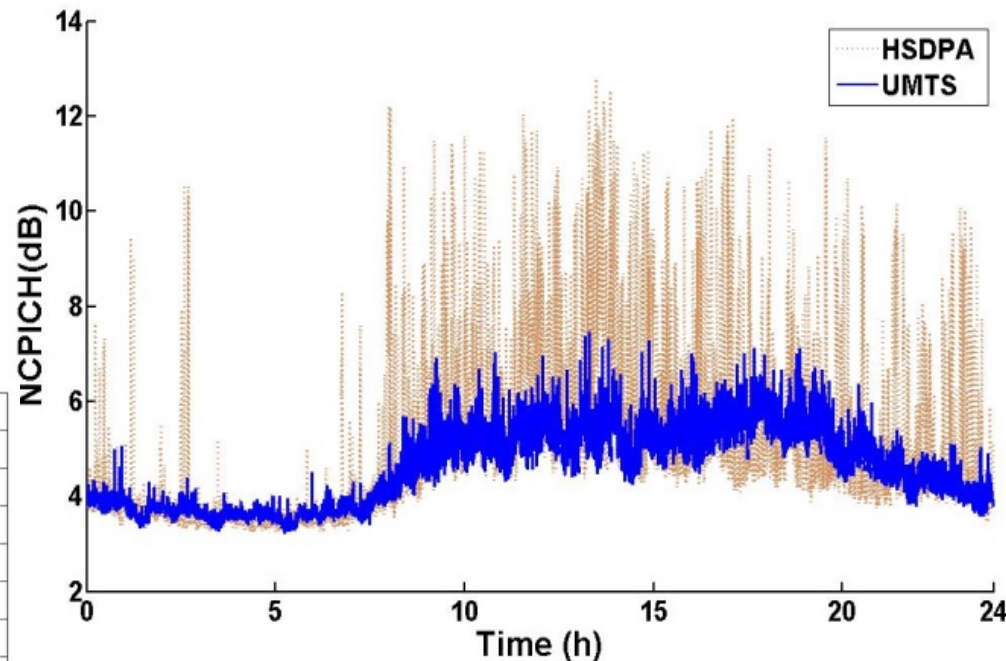
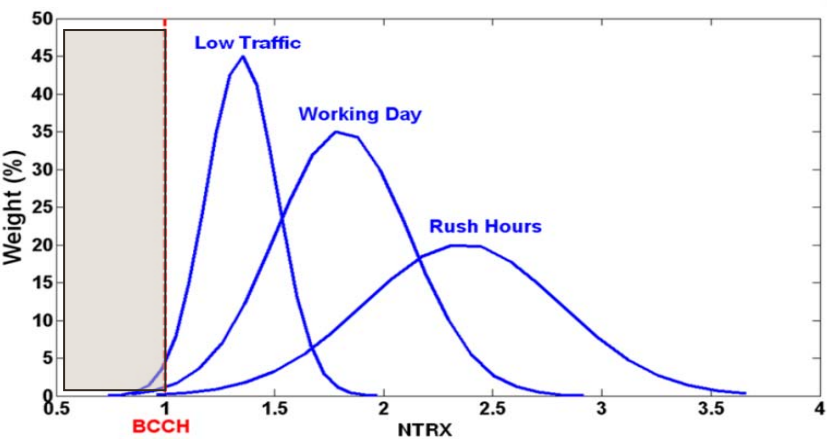


<http://whist.institut-telecom.fr/collaboratif.html>

# Power emitted by base stations



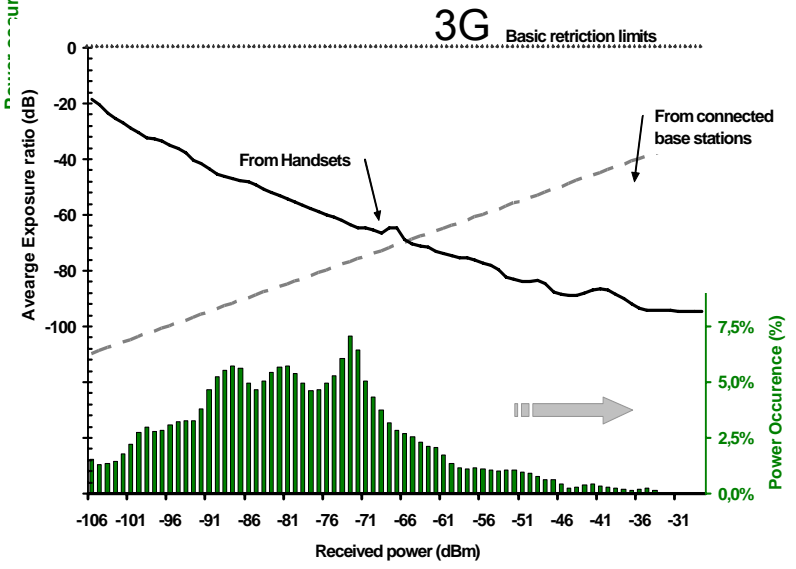
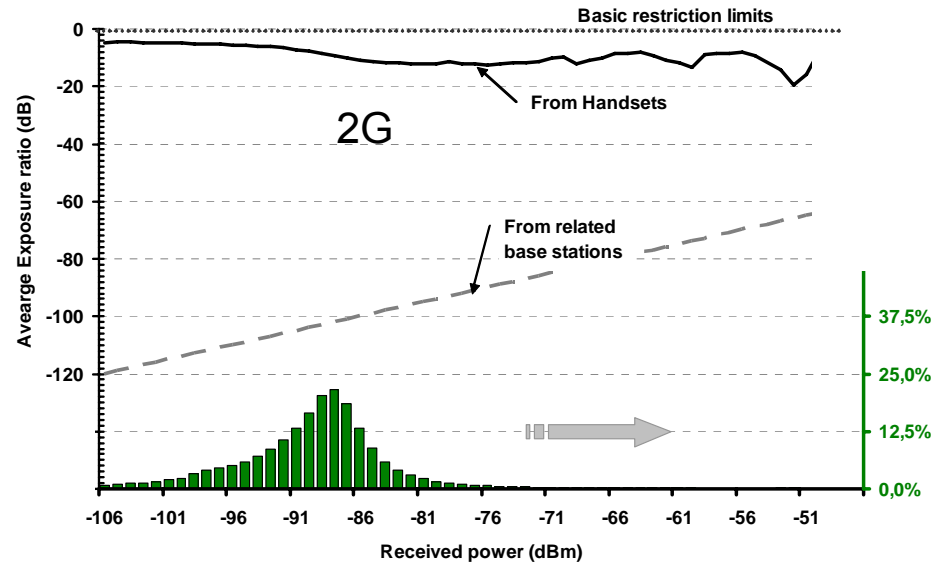
GSM 900 MHz



# Relationship between mobile and base station emitted power



ANR  
Multipass

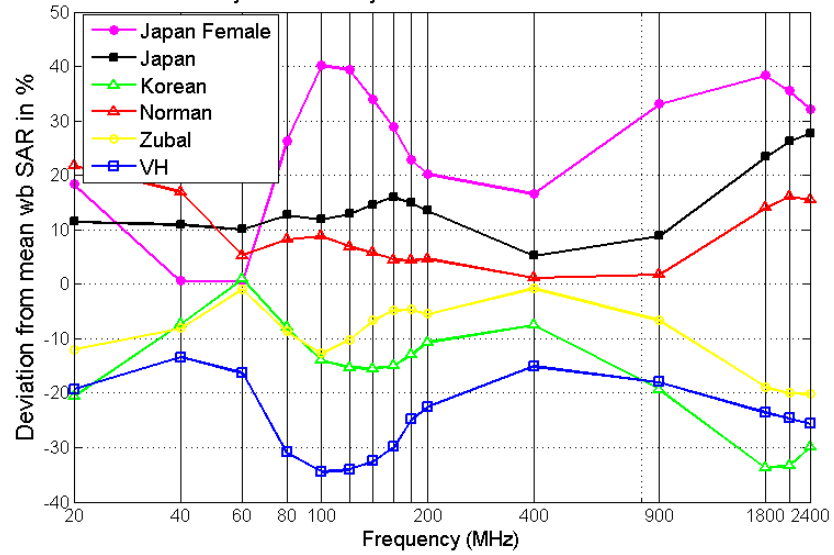




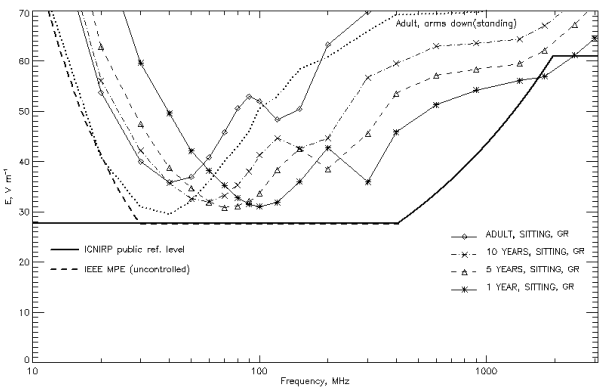
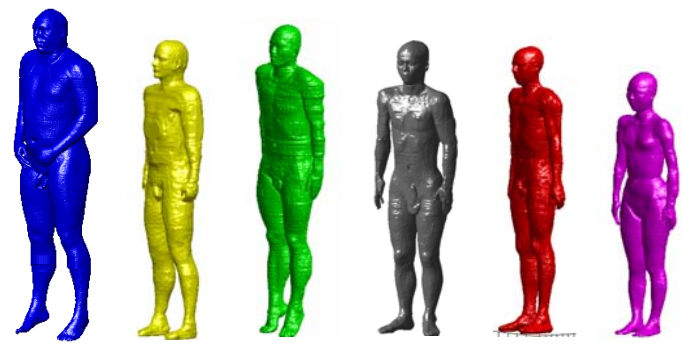
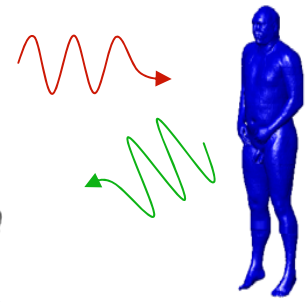
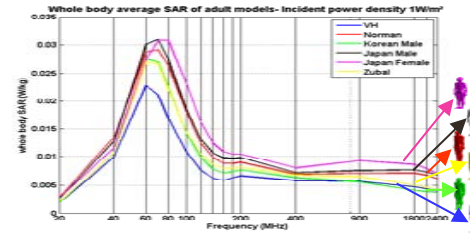


# Absorption depends on morphologies and posture

Variability of whole-body SAR - Deviation from mean WB SAR



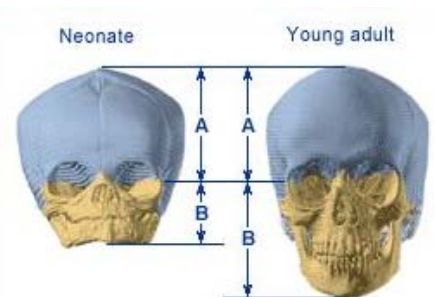
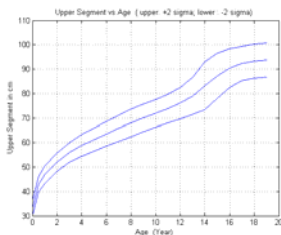
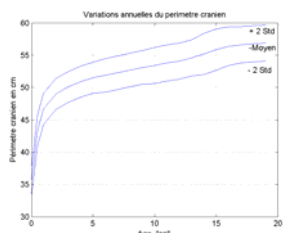
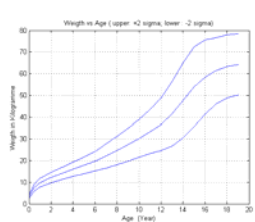
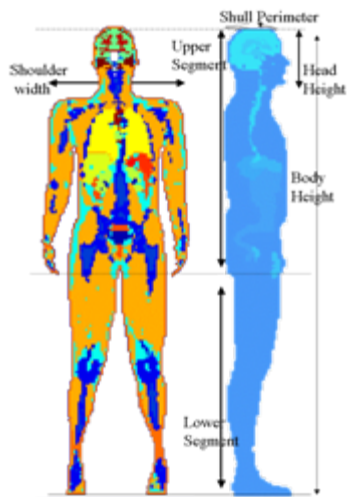
Conil & al Whist Lab – orange Labs



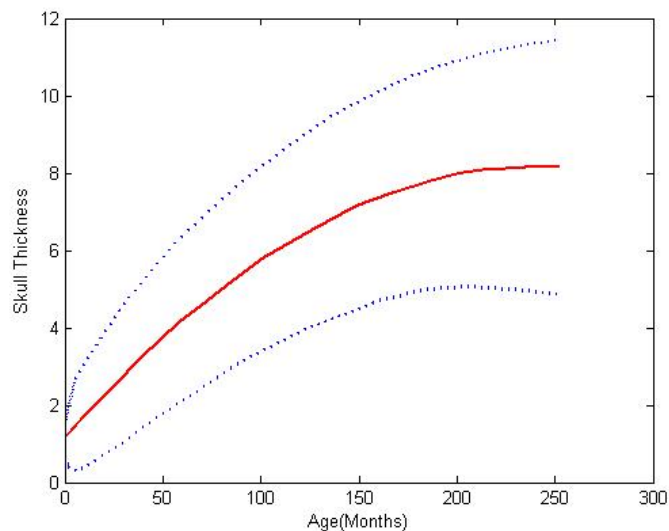
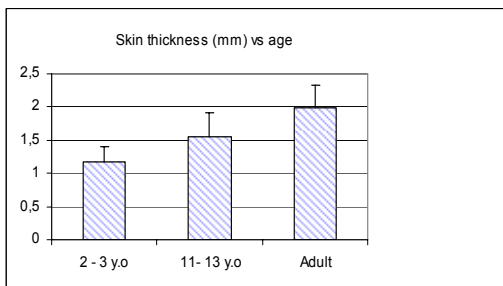
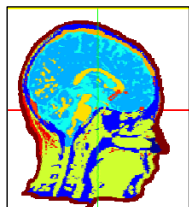
After Dr R P Findlay and Dr P J Dimbylow  
Health Protection Agency, UK.

# Age dependant human Morphology

Head and Body shapes are age dependant



Internal anatomy evolves with age



# Children exposure

ANR Kidpocket project

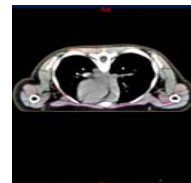


## Partners

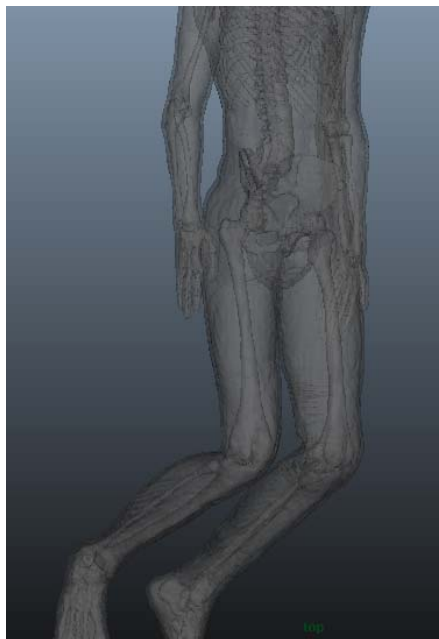
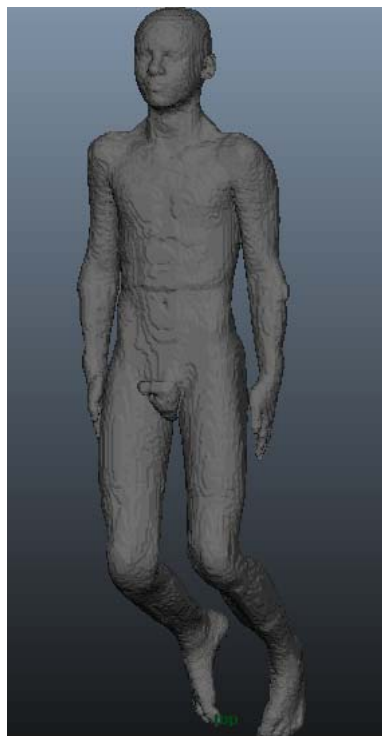
Orange labs  
Telecom ParisTech  
Telecom Bretagne  
IGR  
Phimeca  
INRIA  
PRES MLV  
UPMC



- Create children models
- Deform the models
- Analyse the exposure



# Deformation tools



<http://whist.institut-telecom.fr/en/collaboratif.html>

# Fetus exposure analysis

*Recommended by WHO*

*Funded by*

*ANR in France*

*JST in Japan*



France:

Orange  
Telecom ParisTech  
Telecom Bretagne  
Phimeca

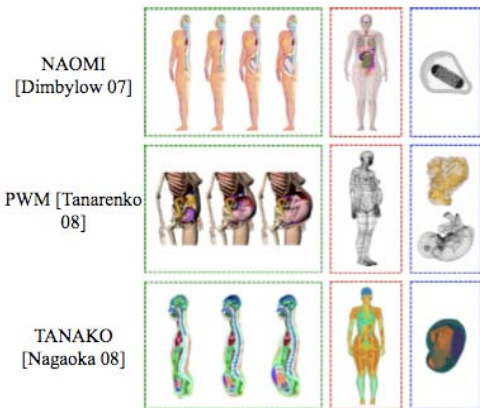
Japan

NICT  
CHIBA  
NITECH  
KCMC

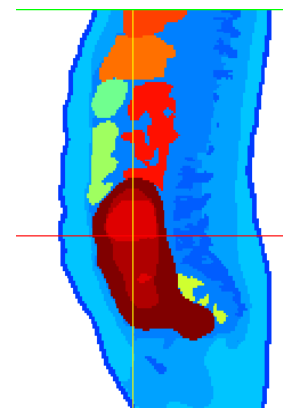
# Foetus models



## Existing models



## MRI based model



## Models developed Projet FEMONUM,



13 WA (US)



23 WA (MRI)



31 WA (MRI)



Representativeness?

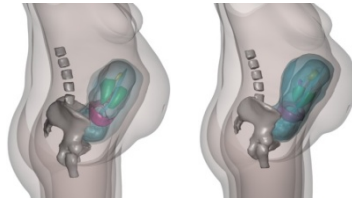
# Synthetic deformable pregnant woman



**GROWTH  
PROCESS**

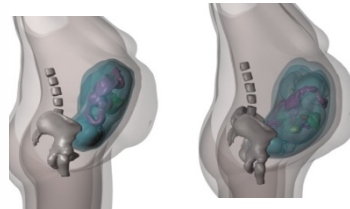


**RESULTS**

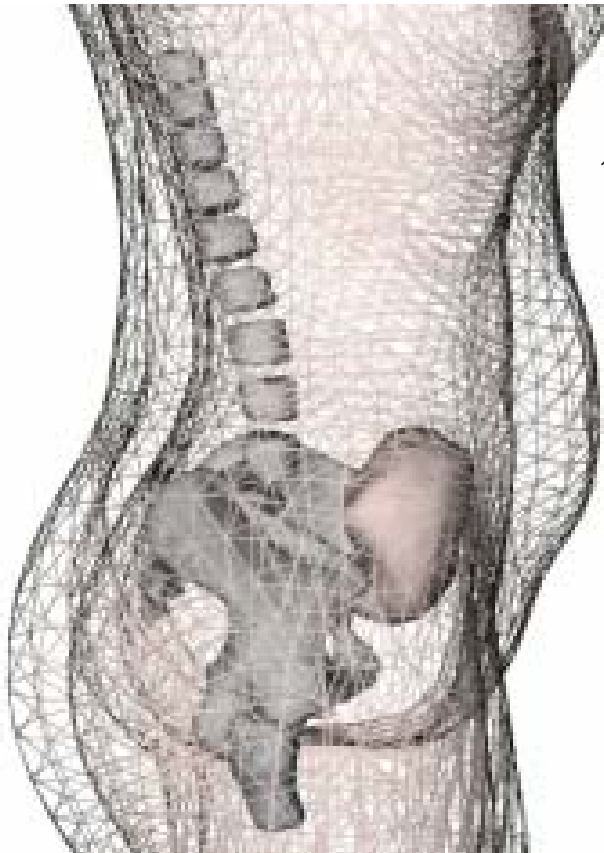
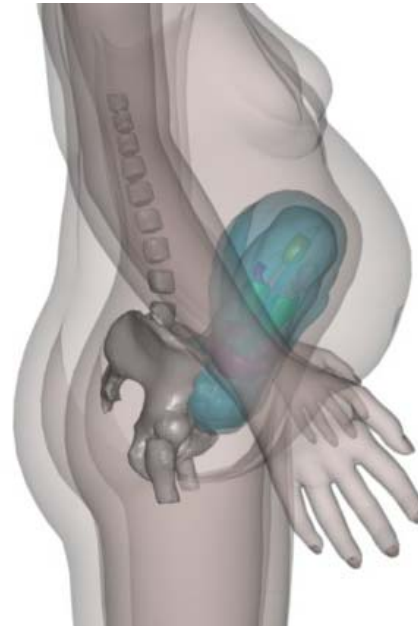


30 W.A.

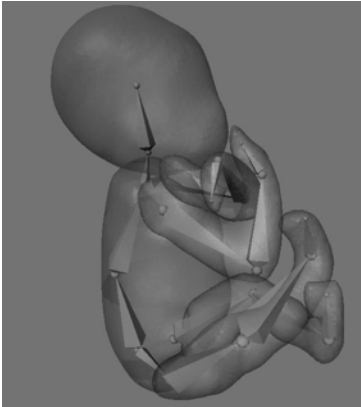
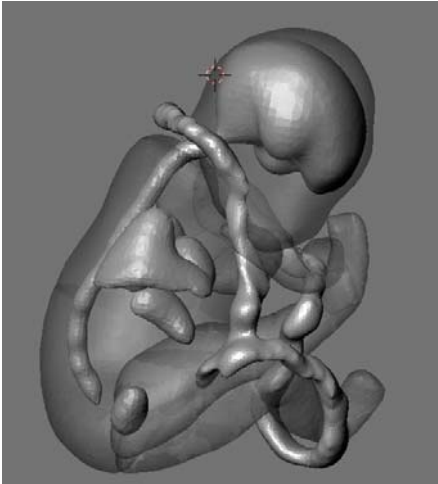
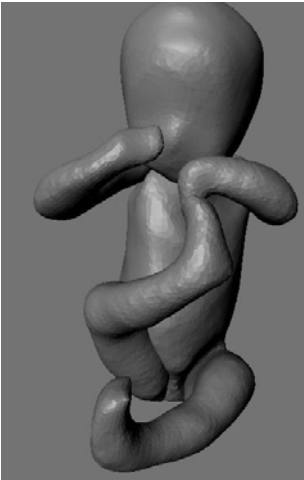
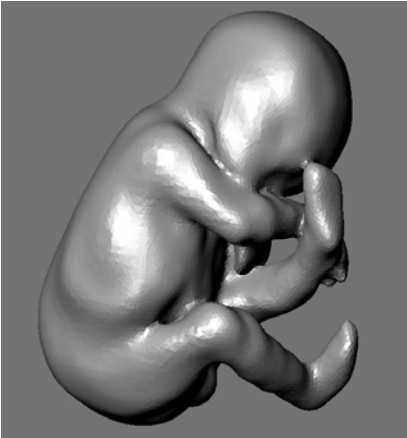
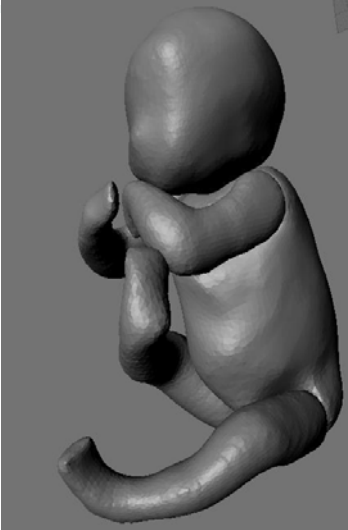
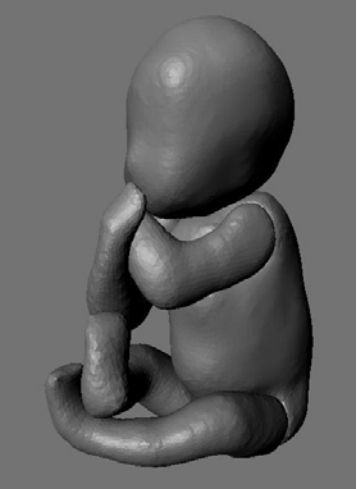
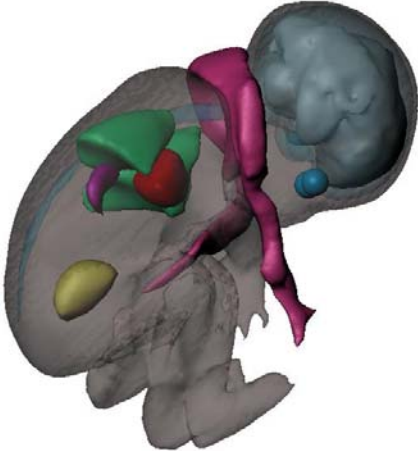
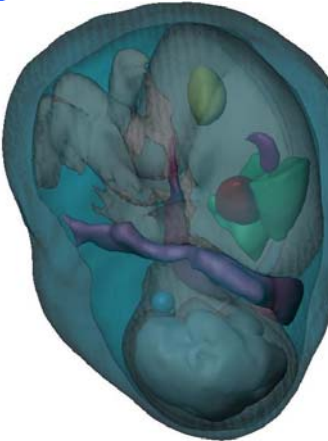
32 W.A.



35 W.A.



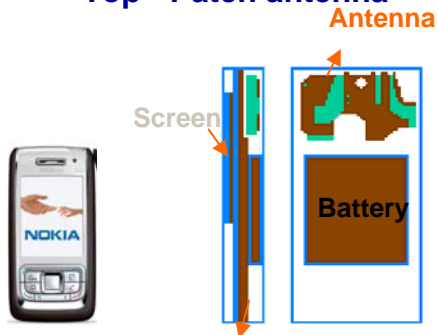
# Articulated fetus



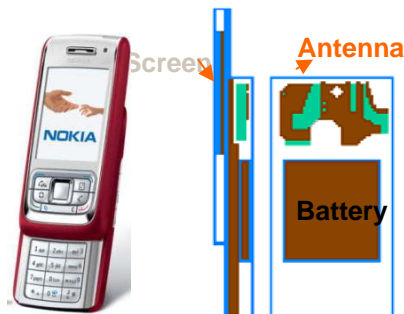


# Variable phones

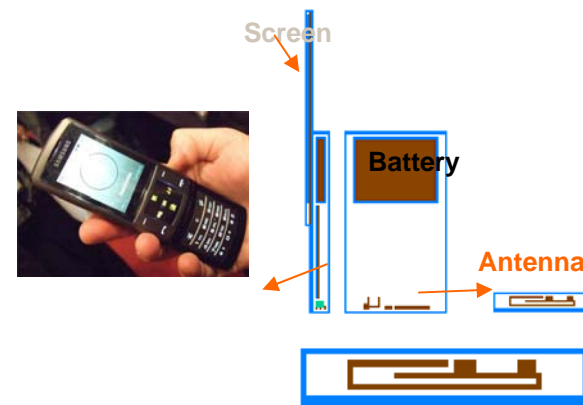
Top - Patch antenna



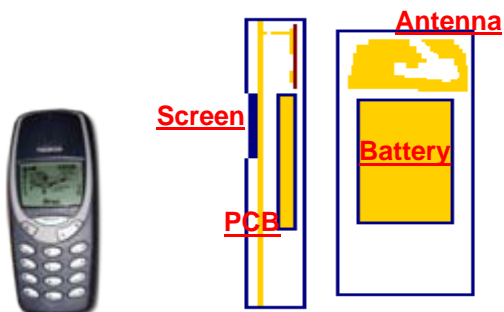
Centered - Patch antenna



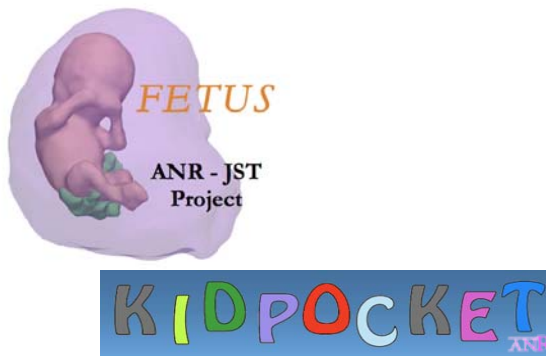
bottom - dipole antenna



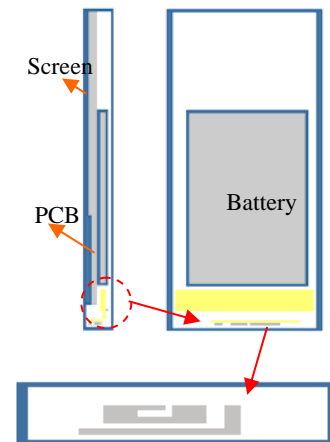
Top - Patch antenna



GSM -900MHz /1800MHz



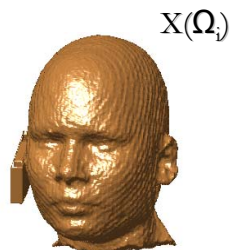
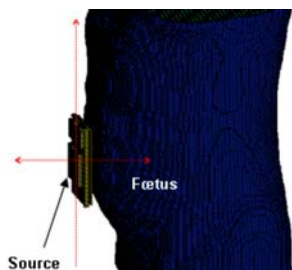
bottom antenna



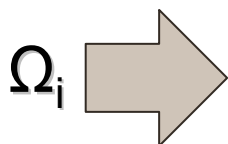
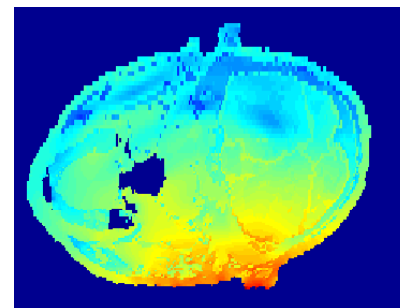
UMTS-1900MH/2100MHz



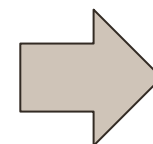
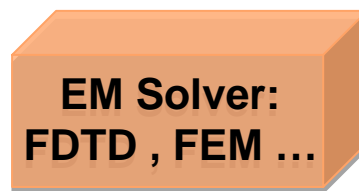
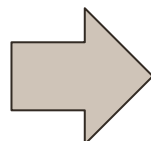
# Stochastic dosimetry...



$SAR_i$



Input  
 $X(\Omega_i)$



$Y_i = SAR_i$

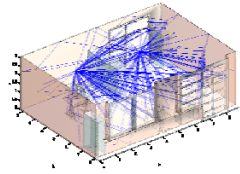
SAR statistical distribution ?



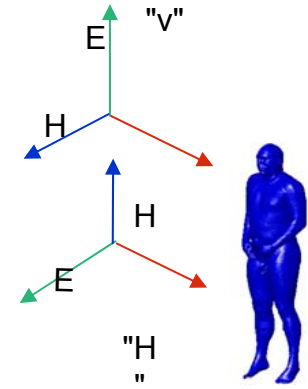
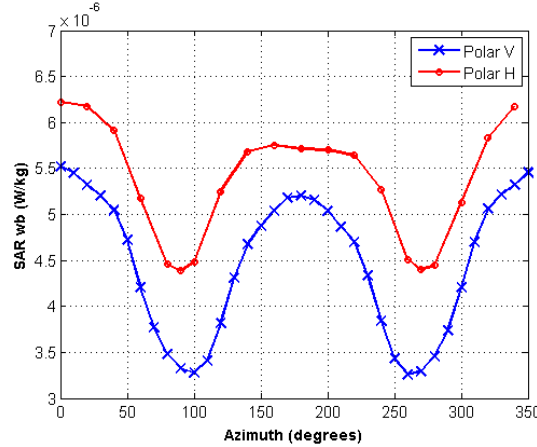
High performance calculation have been set up  
But Simulation time is not compatible with Monte Carlo



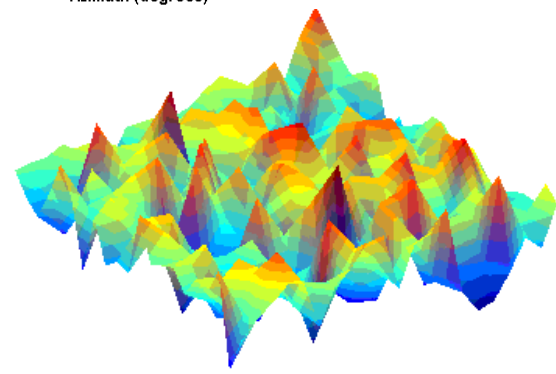
# How deal with multi coherent narrow band plane waves exposure



SAR vs incident field depends on angle, amplitude, morphology, polar...



In case of multiple coherent plane wave The combination is locally random amplitude, morphology, polar...



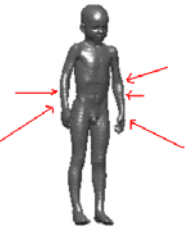


# Exposure to multiple random plane wave.

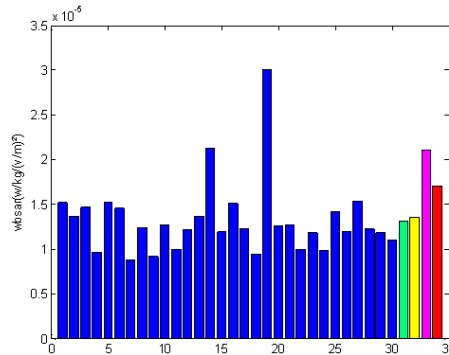
**15 random input data: 5 angles, 5 amplitudes, 5 phases**

First approach 30 FDTD simulations

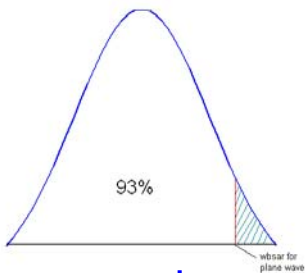
**Weak point: no real planning experiment**



→  
Amplitudes: Log-Normal distributed  
phases: Uniformly distributed  
Angles: Uniform distribution



**Exposure distribution of narrow band coherent signal transported by multiple plane waves**



In case of multiple non coherent signals ( ie multiple transmission channes)l the emission is close to mean value

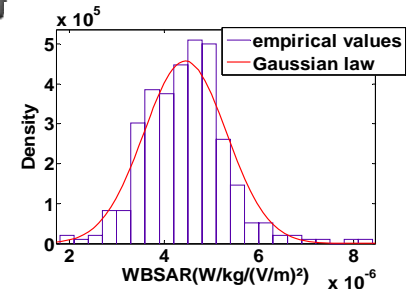
Second approach using an experiment plan

36 FDTD simulations performed each 10° (0:10:360)



**LHS design**

17 sets of 5 azimuth angles chosen between 36 are designed. 20 sets of 5 amplitudes having Log-Normal distribution and 5 phases having Uniform distribution are designed to obtain Y (WBSAR).





# As conclusion

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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*