Whist Lab

Laboratoire commun de l'Institut Télécom et de Orange Labs

Dosimétrie Stochastique ou le défi de la variabilité,

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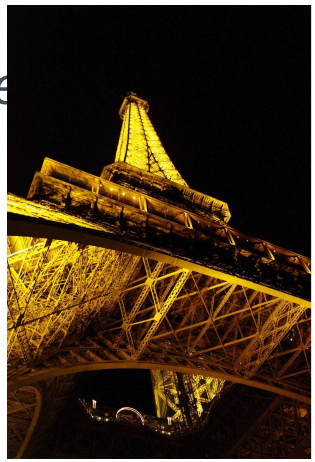

URSI France JS 2012 Parsi

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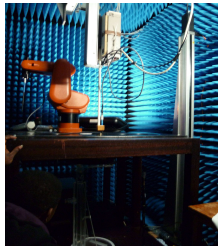
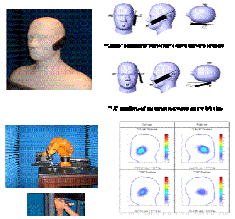
orange

From compliance to exposure assessement

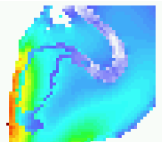
- Since 20 years large effort dedicated to
  - Compliance and Standards: *Over-estimation, worst case*…

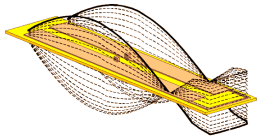


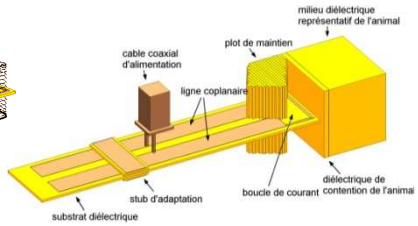


- Mobile standards (EN50360 & EN50361, IEC 62209-1, -2..) Worst case (SAM, Liquid)
- Base station: Putting base stations on the market (EN50383, EN50384 & EN50385), Putting base stations into service (EN50400, EN50401) In situ measurement EN50492. overestimation(extrapolation, summation..)

  - Exposure set up: *deterministic approach*
    - Animal exposure







- What is the “real” exposure?

RF exposure is facing variability

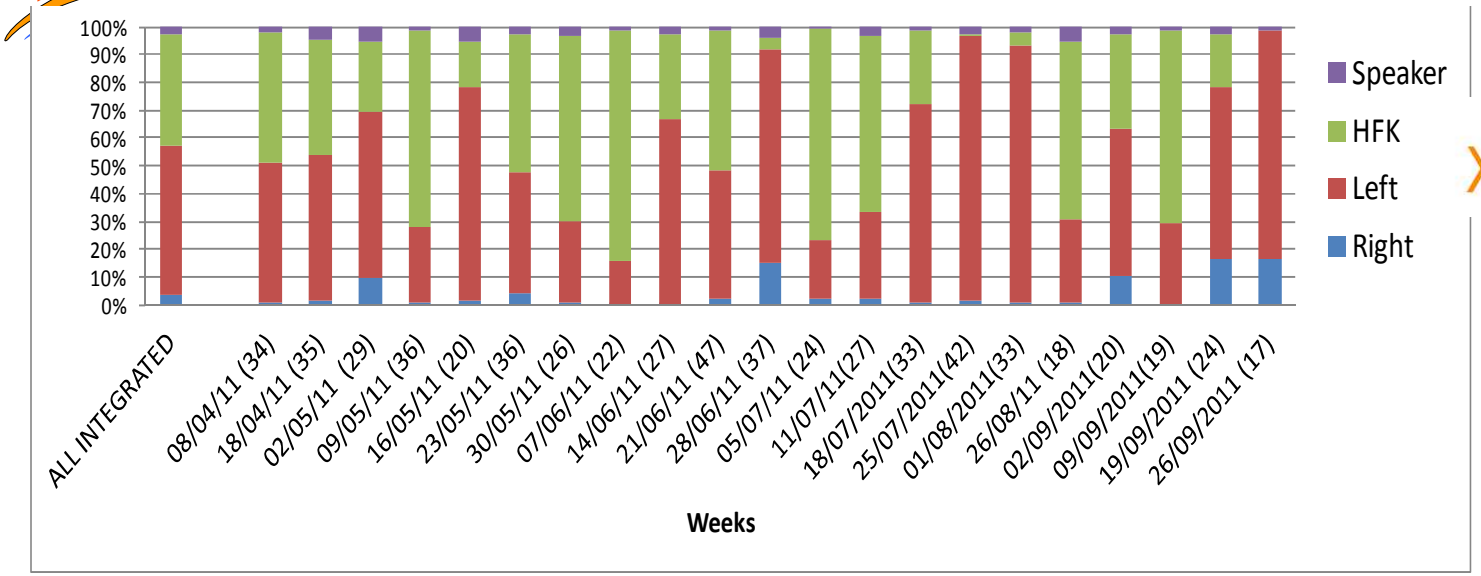
recherche & développe

What is the “real” exposure

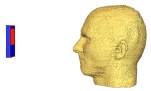
- Exposure depends on
  - Morphology
  - Frequency
  - Usage
  - Tecnologies
  - ….

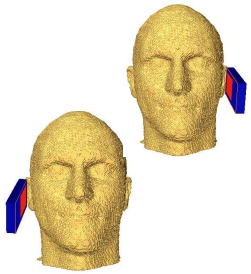
LTE
UMTS
GSM
DECT
WIFI
Bluetooth

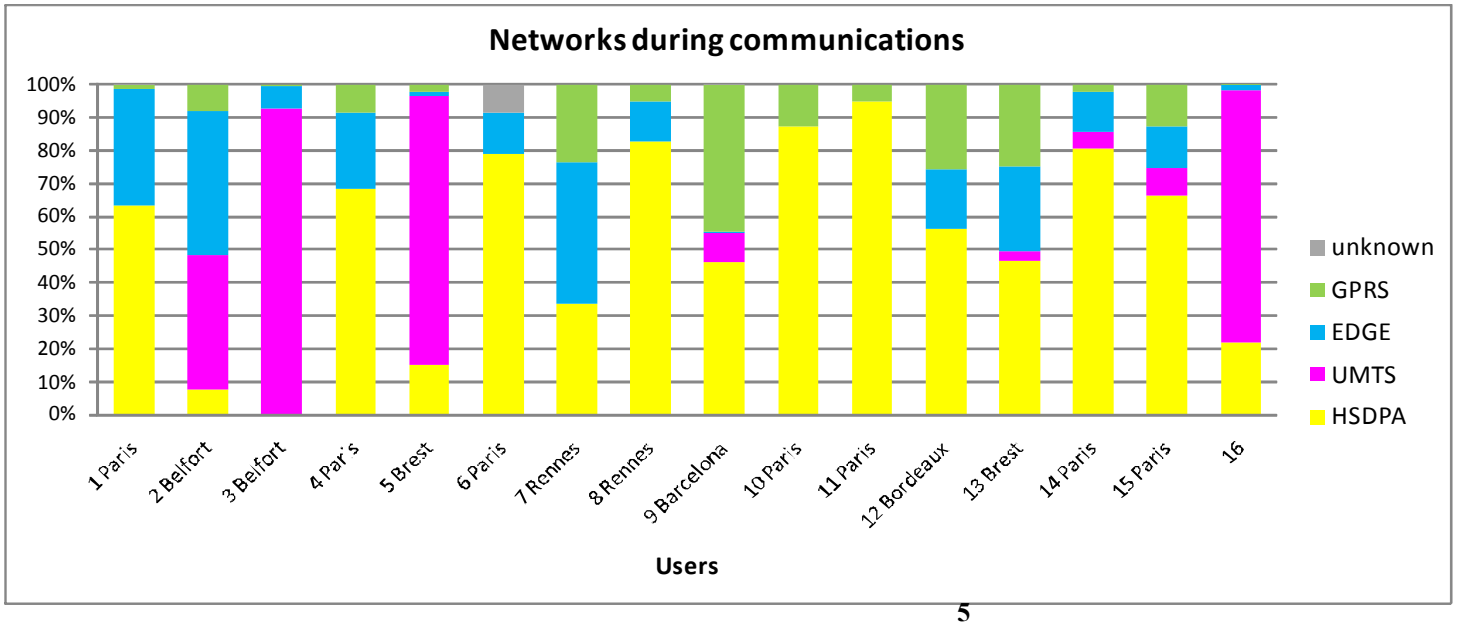
Usage and network are varying…



XMobiSense





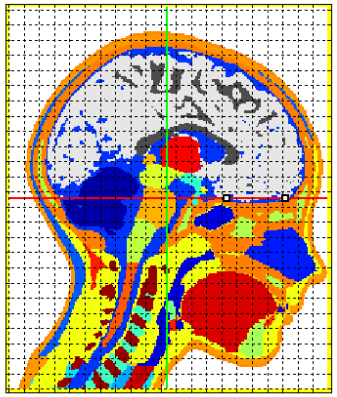


mobi-kids
Study on Communication Technology, Environment and Brain Tumours in Young People

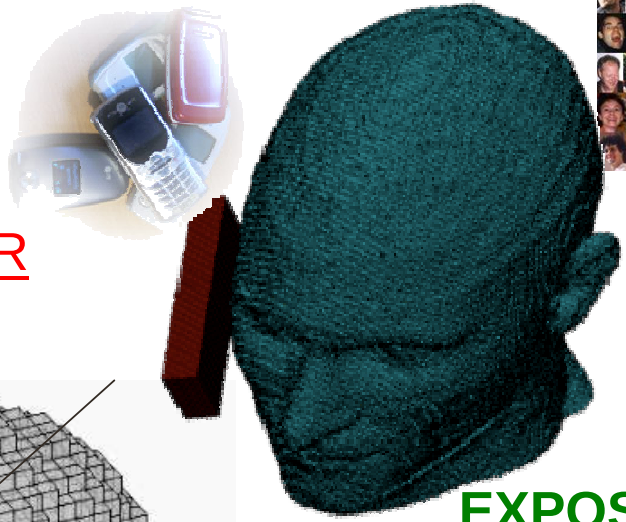
Groupe France Télécom

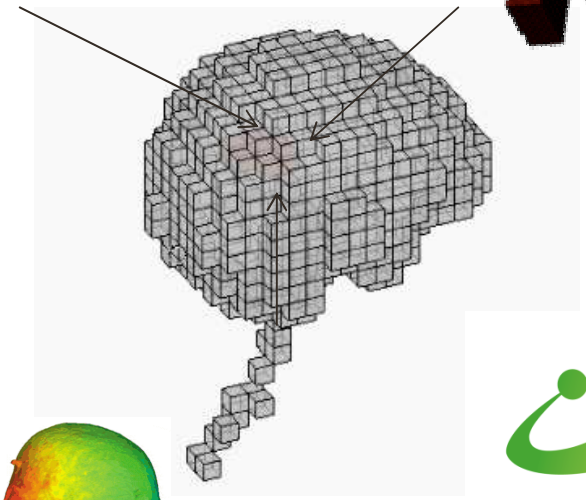
Brain exposure depend on the laterality

Tumor localisation



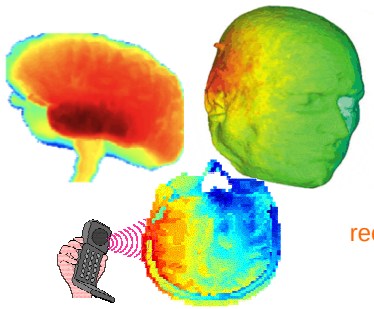
SAR





EXPOSURE

SAR distribution in brain :



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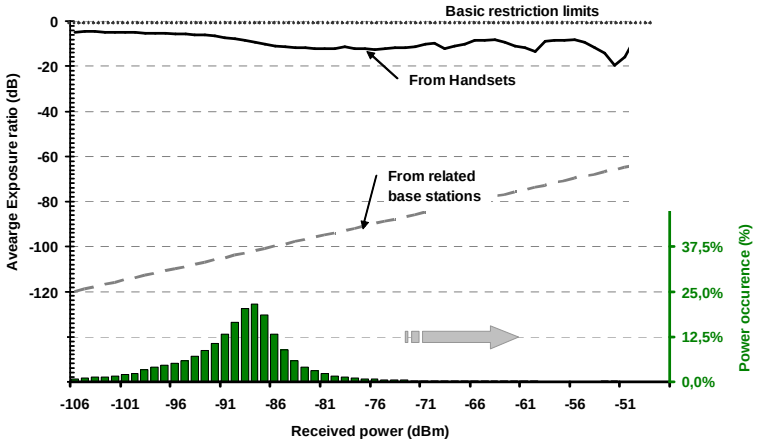
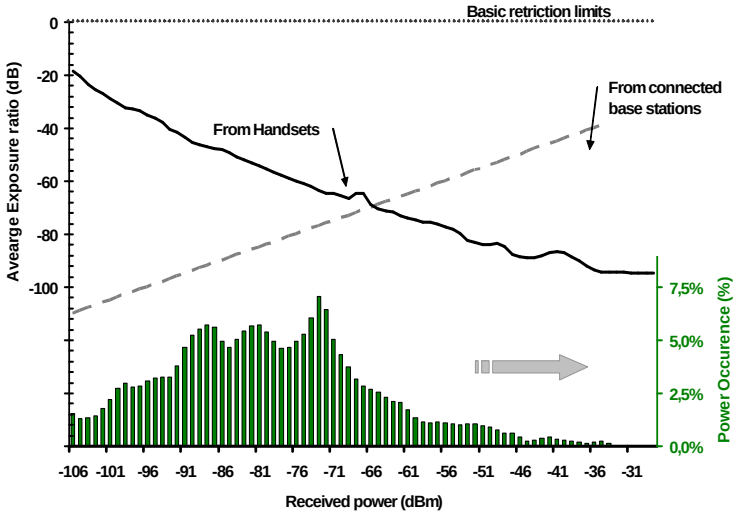
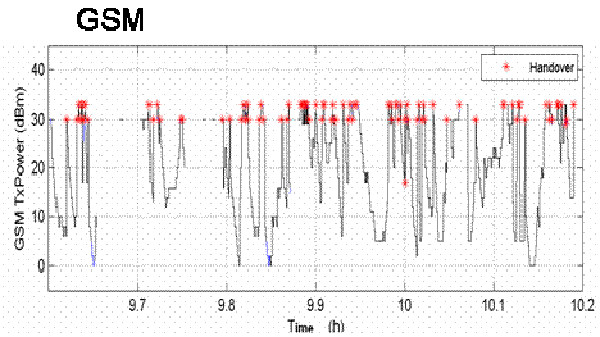
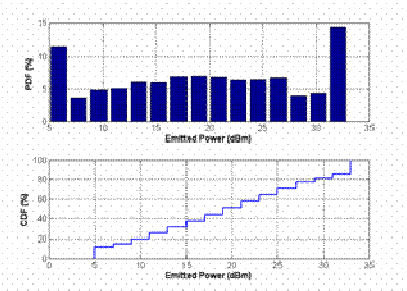
Power emitted by devices and relative exposure depend on the system

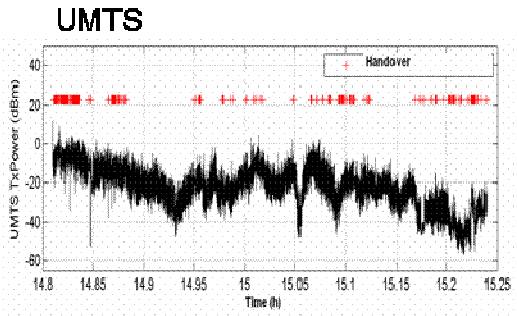
- Exposition downlink vs uplink

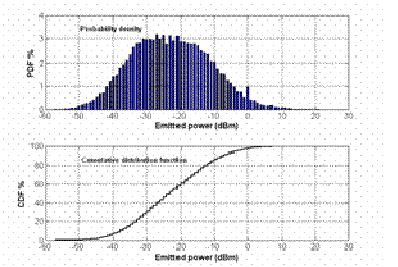






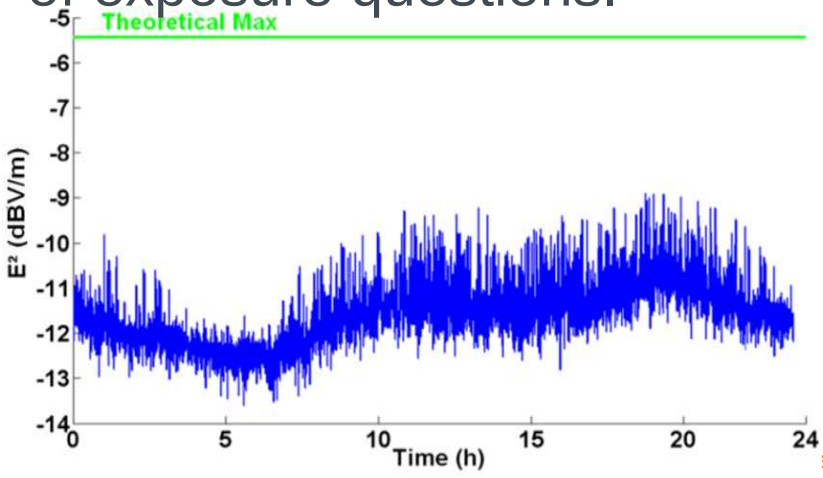


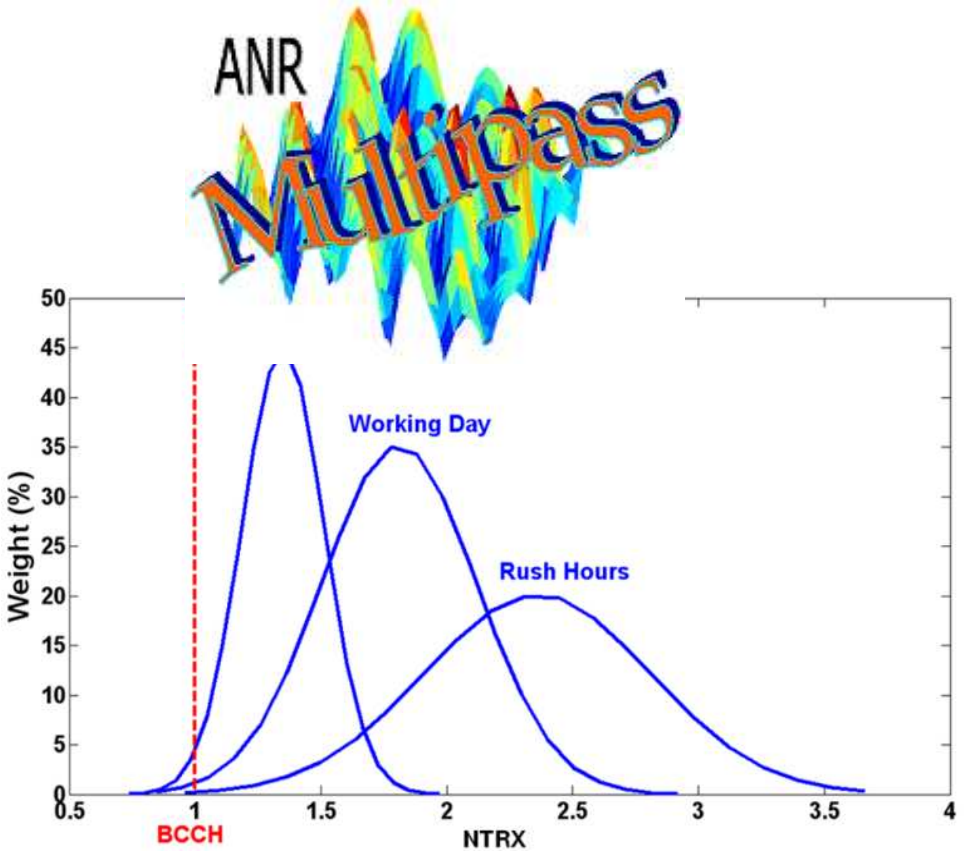




Real exposure is a sum of exposure

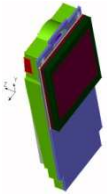
- Current methods for assessing exposure are not suitable for low exposures and cumulative exposures.
- The use of "worst case" leads to unrealistic estimates that do not allow an objective management of exposure questions.

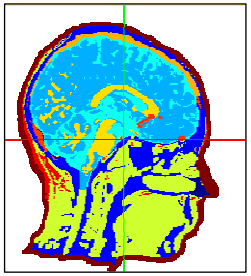




Numerical methods have been improved

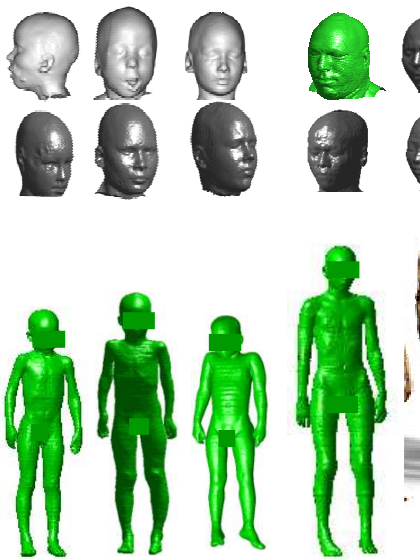
- Large efforts carried out since 15 years

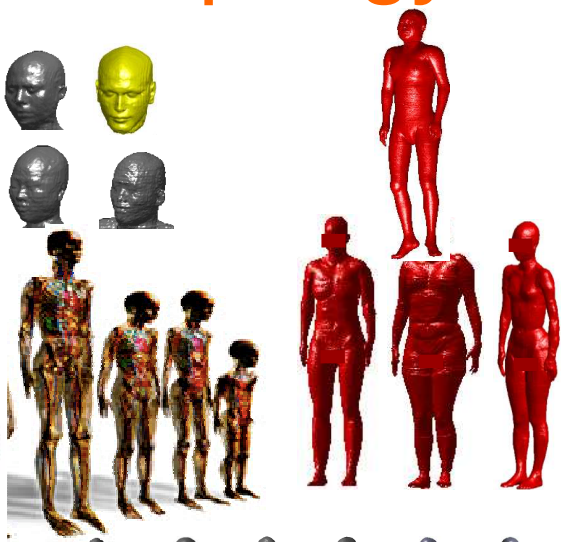


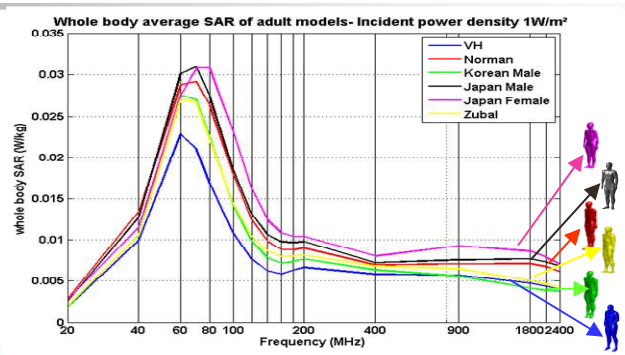


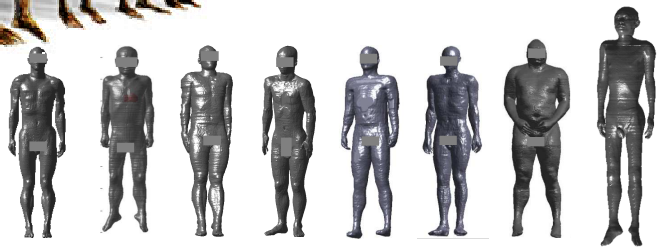
- Simulations are larger and larger, faster and faster
  - GPU are nowadays used to run the FDTD
  - Dual quadri processors ..

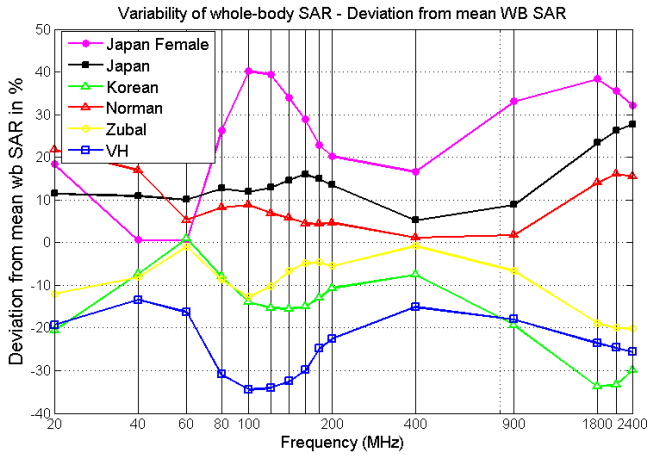
Human body models have been developed and confirmed the influence of the morphogy

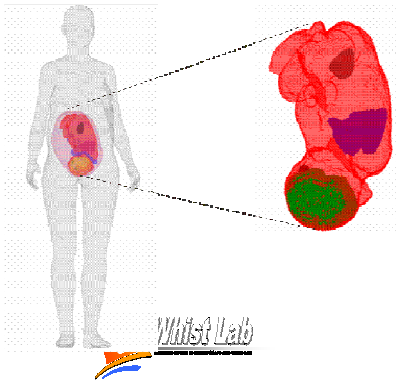


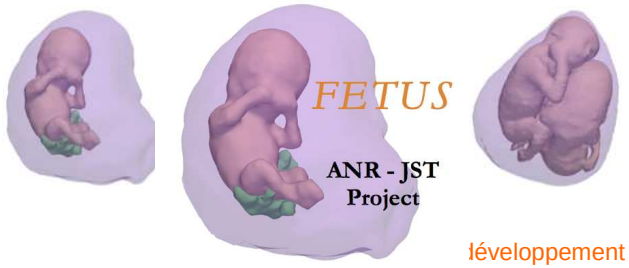




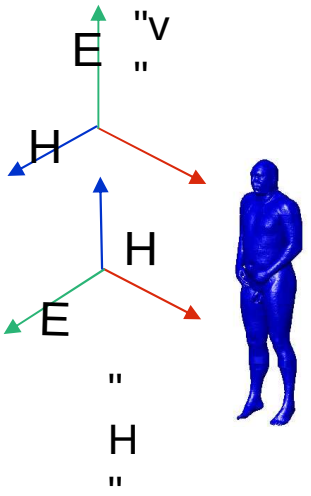


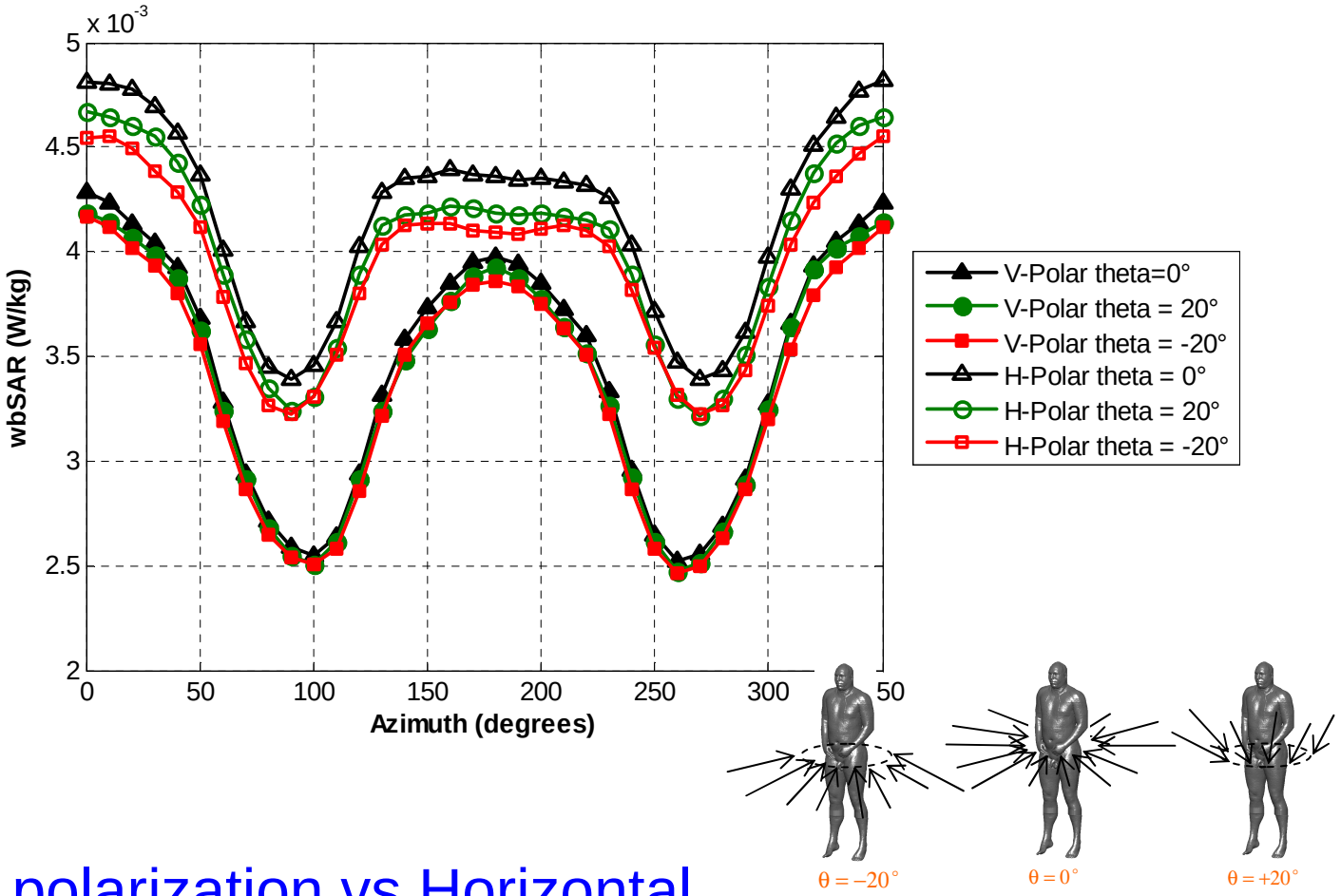






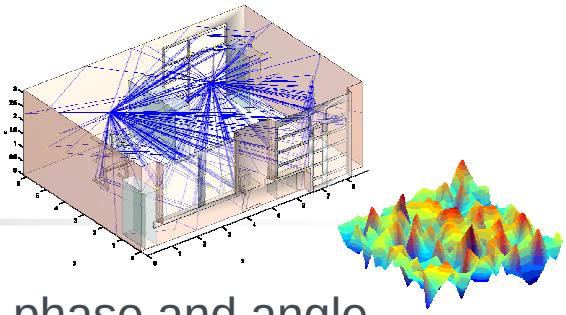
Absorption depends on the source e.g polarisation





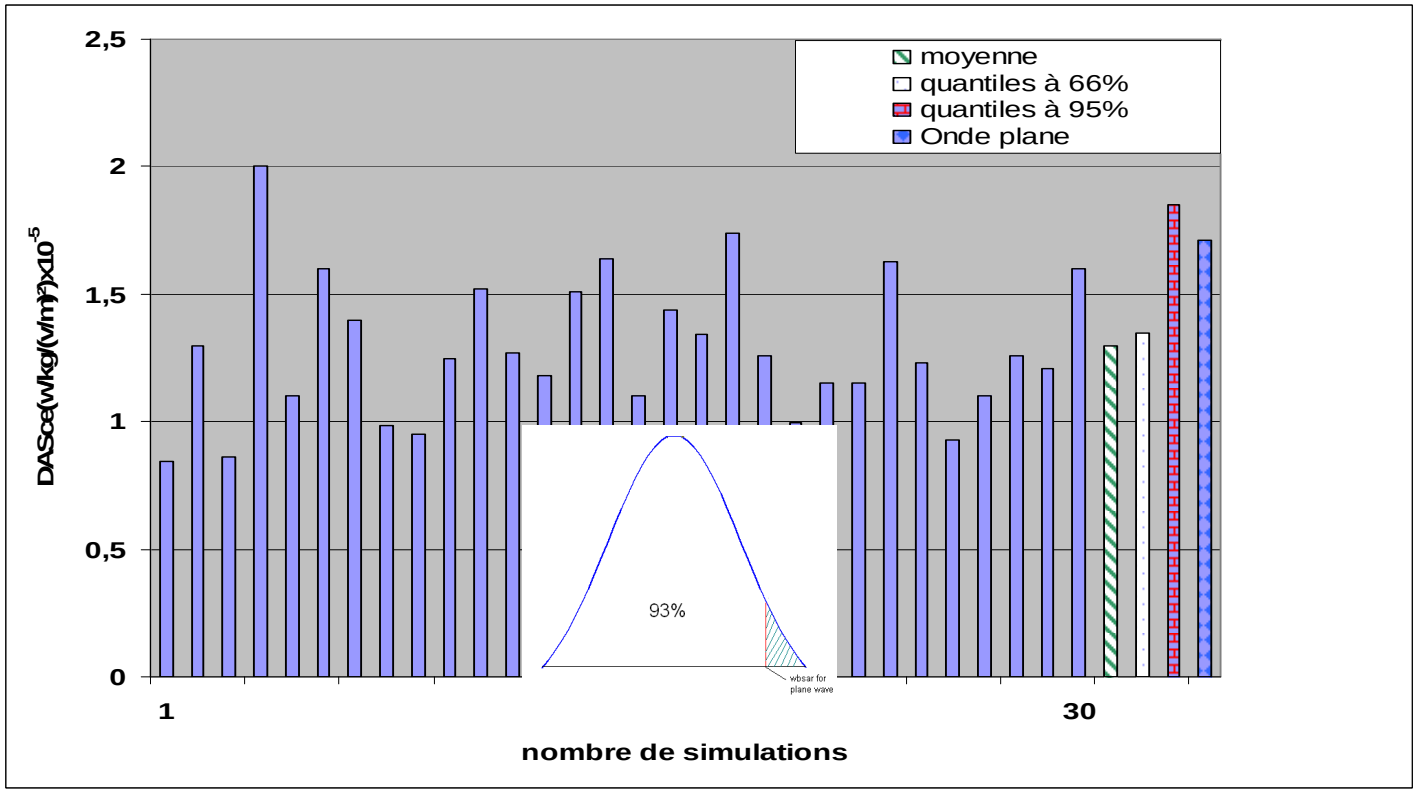
Vertical polarization vs Horizontal..

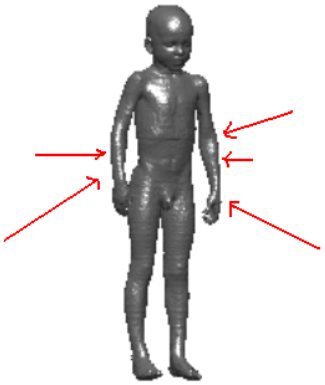
E.G Multipath exposure



- 5 incidents Plane Wave, Log normal field strength, uniform phase and angle
- Depending on the objective mean, max or 95% can be the target….

@ 2400 MHz





ANR Multipass

Groupe France Télécom

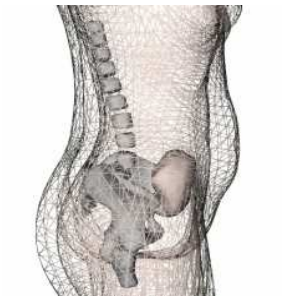
Deformation tools have been created

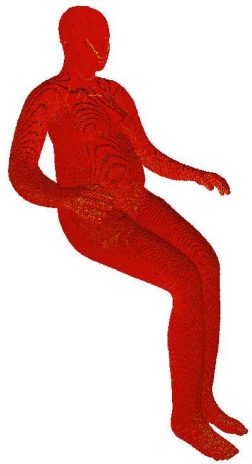
- Image acquisitions do not represent all the postures

- Usually in lying position
  - Internal organ shape is affected
    - by self-weight
    - by posture.

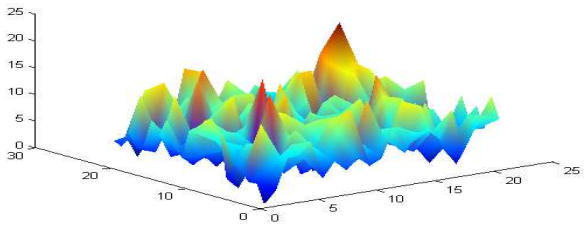
KIDPOCKET ANR

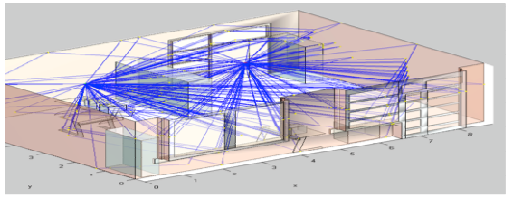
- Deformation toll were developed
  - ANR JST FETUS project
  - ANR KIDPOCKET project

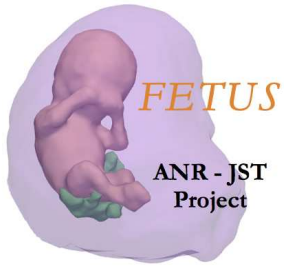


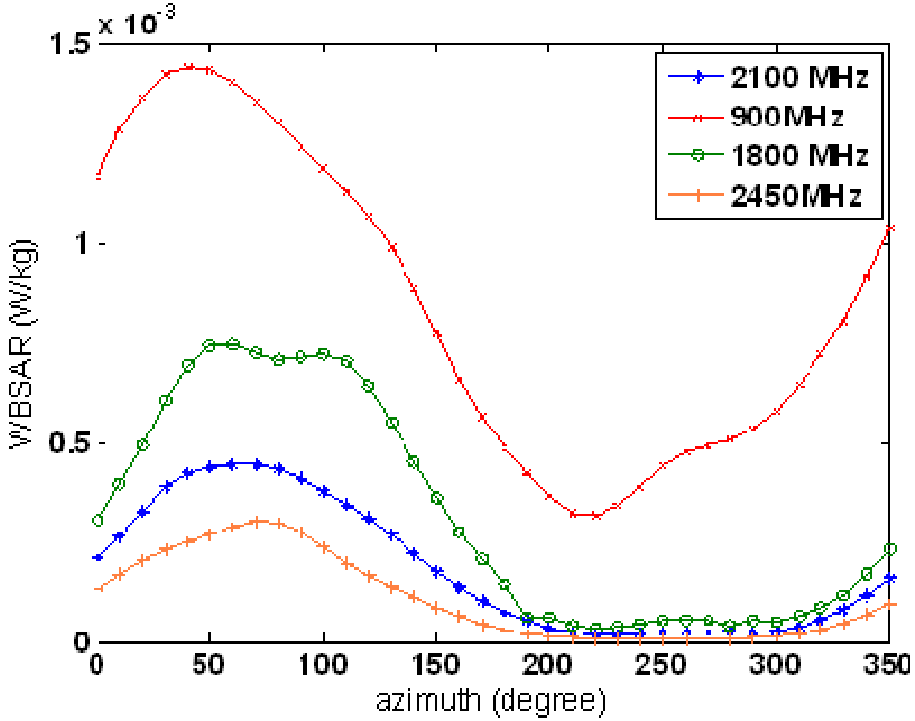


Fetus exposure to far sources is variable









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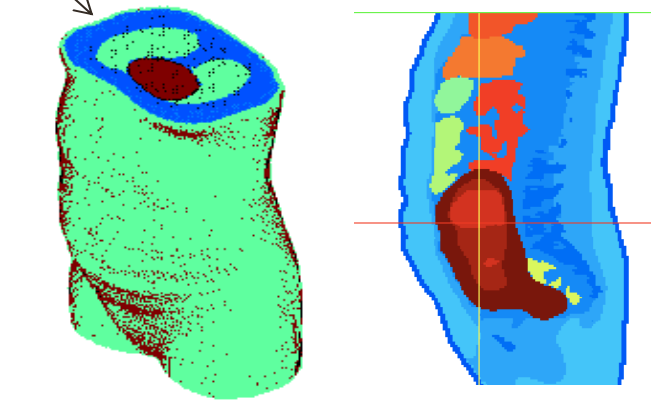
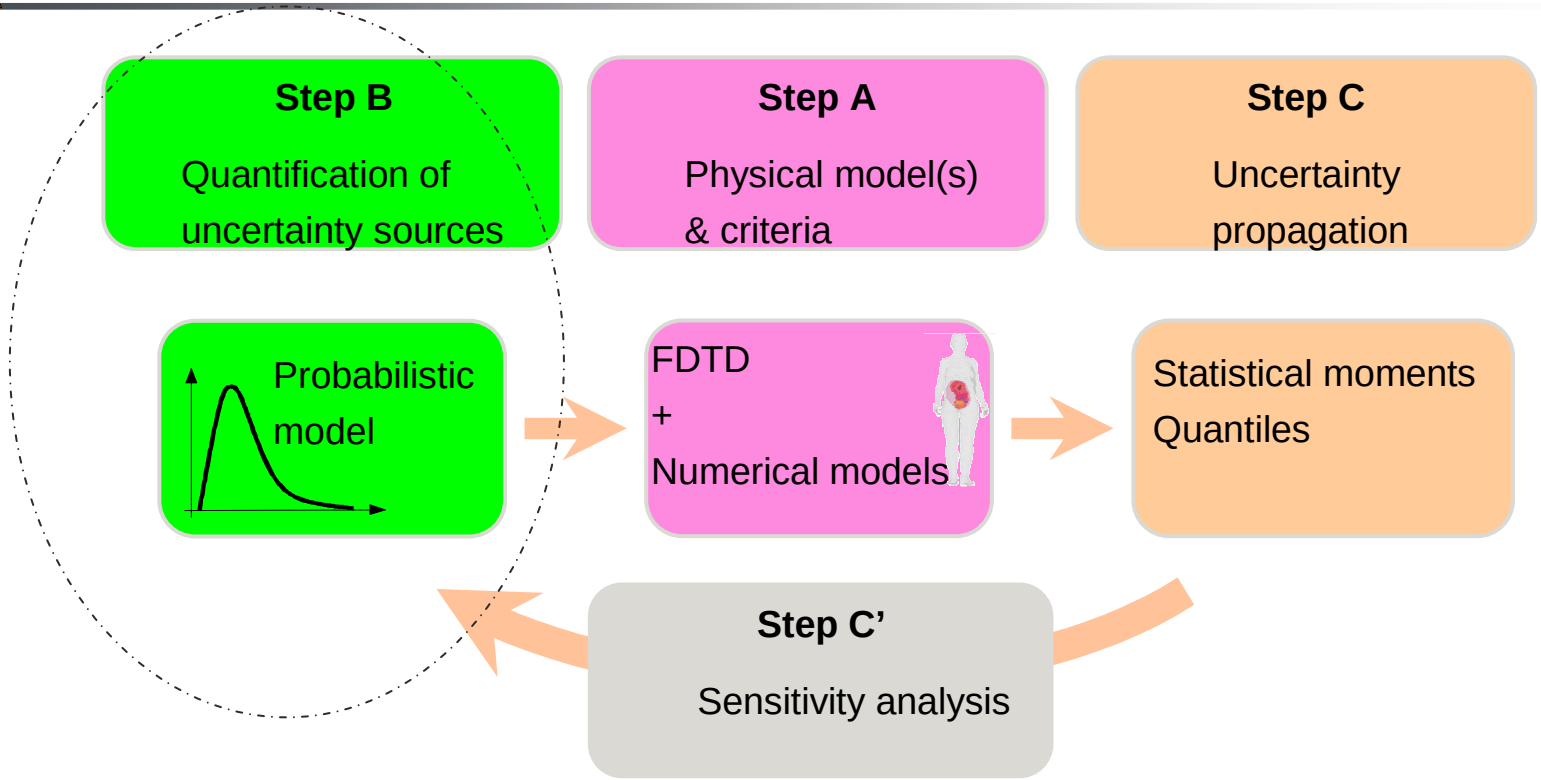


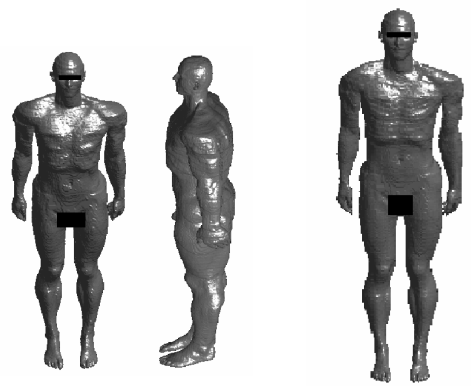
How manage the Uncertainty?



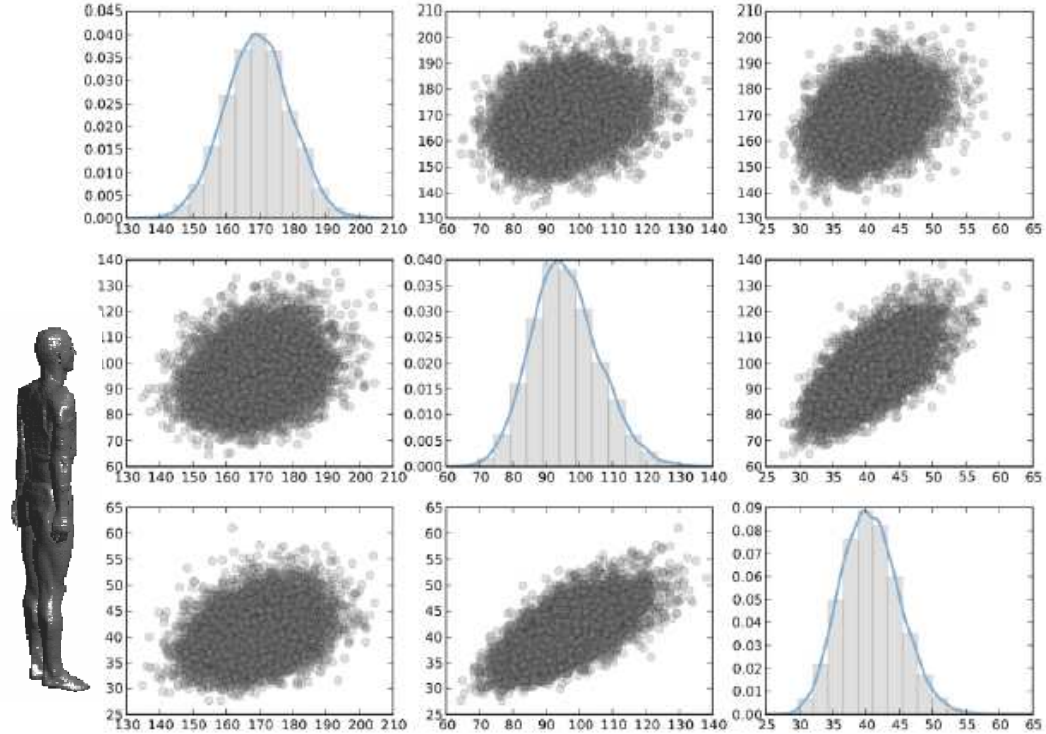
First : charaterize the input…

Morphology

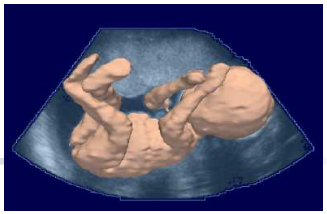
- Large correlation between parameters

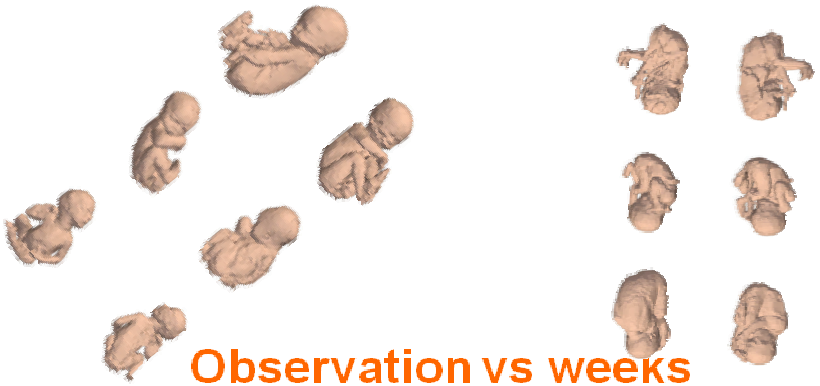


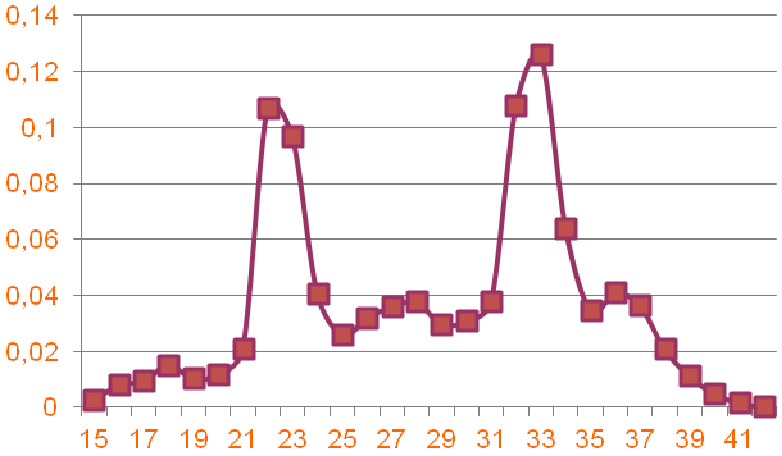
Taille, carrure devant, tour de poitrine



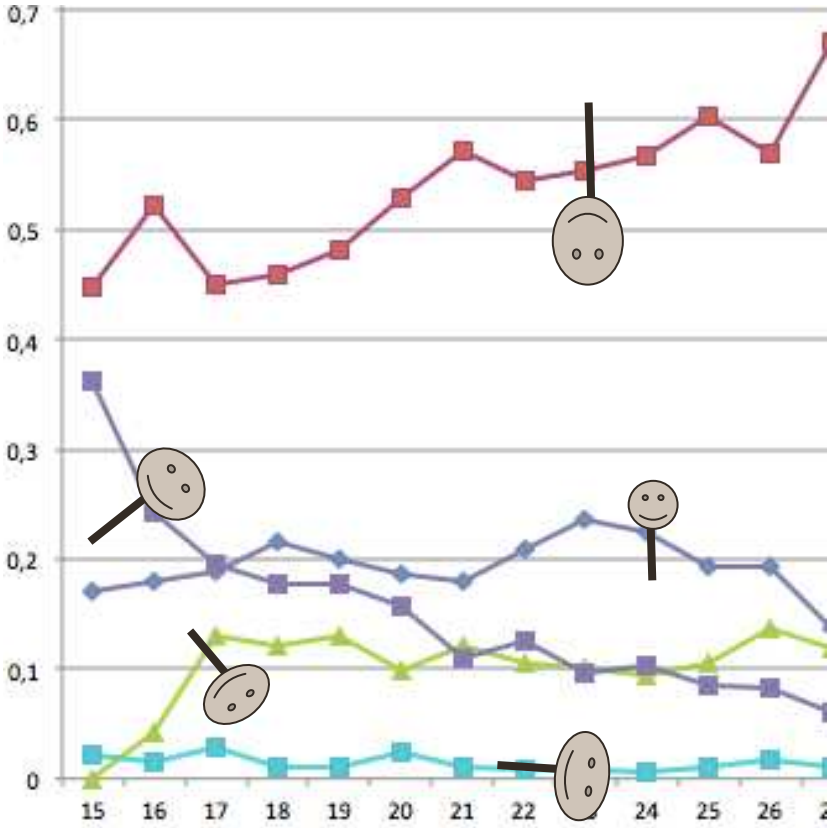
Fetus posture







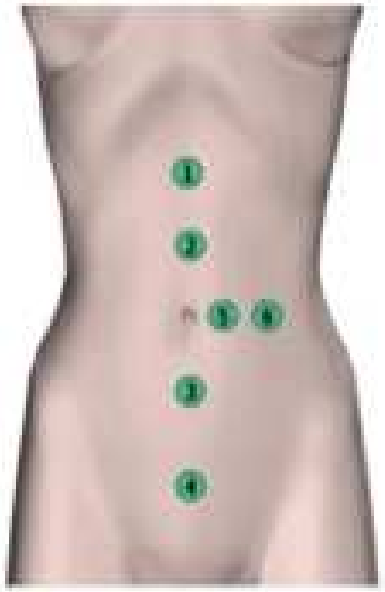
More than 15000 observations performed at Maternité Port Royal under the responsability of Docteur Gilles Grangé



Posture occurrence vs weeks of pregnancy

Fat thickness

- Measurement performed in Japan and France.
  - Fat thickness is variable
  - The fat distribution depends on the country.



In Japan

N=75 (ave. 32.8 weeks, SD 2.2)

Pt	Mean	Sd	Min	Max
2	11.1	5.7	1	21.7
3	11.5	4.7	4.8	18.4
5	13.9	5.4	3.9	30
6	15	5.8	4.1	33.4

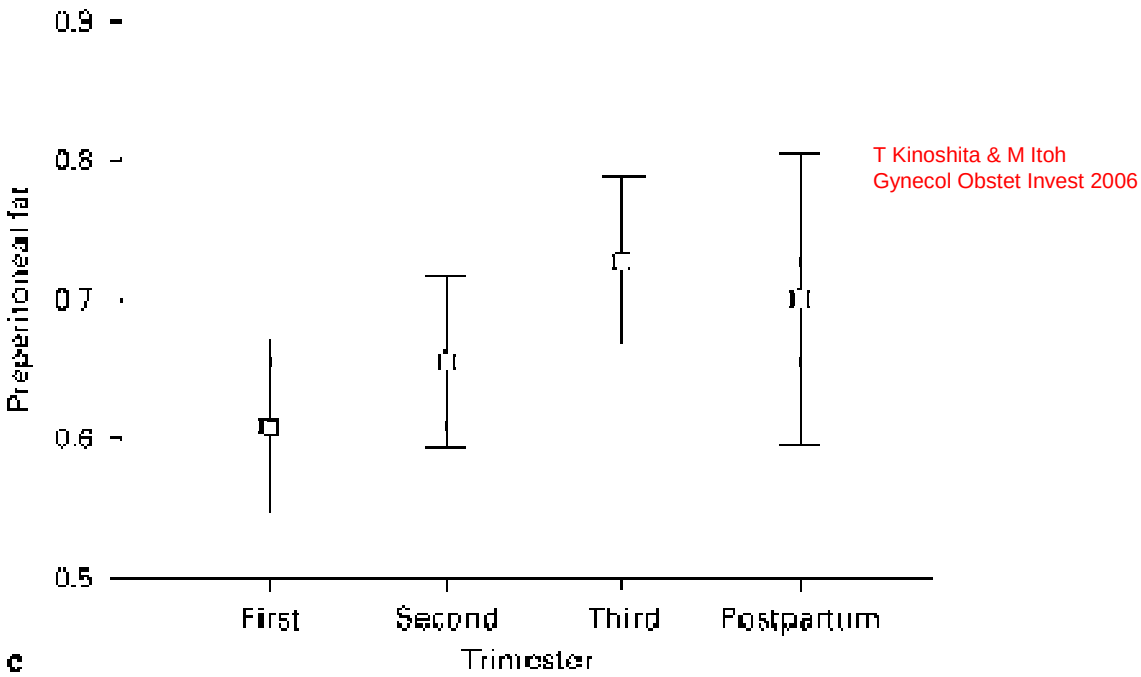
In France

Pt	Mean	Sd	Min	Max
1	29.2	9.17	9	36
2	22.2	12.87	10	49
3	22	13.37	10	46
4	11.8	3.65	4	17
5	20.7	10.42	10	42
6	16.2	11.17	6	34

The pregnancy induces morphological changes

- The pregnancy has an influence on fat distribution

The total fat ratio (subcutaneous & visceral) vs stage of pregnancy



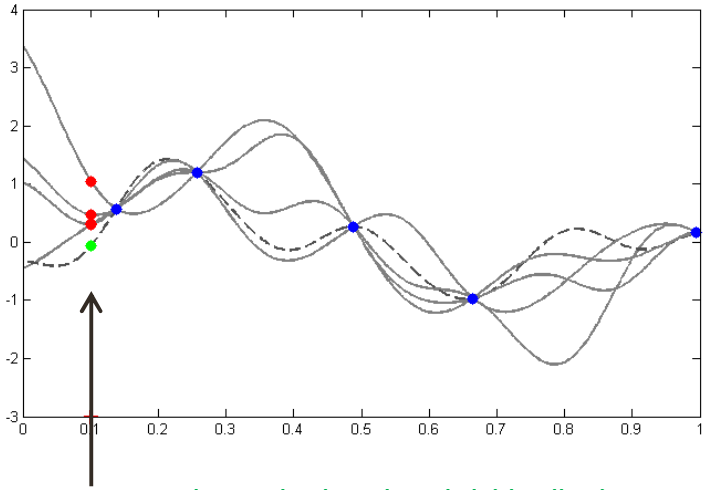
T Kinoshita & M Itoh
Gynecol Obstet Invest 2006

How propagate the variability?

- Computation facilities have been improved
- But Monte Carlo is still not possible…

Bayesian approach

- *Y = f (**X**)* f is continuous, smooth
- prior of Gaussian process on f → posterior distribution = GP
- step by step procedure to assess the 95% quintile (q95) of f



testing point i and path j (dot line)

Chaos polynomial

$$Y = M(X)$$ With $$E(Y^2) < \infty$$

Polynomial expansion (wiener 1938)

$$Y = \sum_k \beta_k \Psi_k(X)$$

β_k the coef

Ψ_k the basis.

Stochastic variables	Polynomials
N(0,1)	Hermite Chaos
U(-1,1)	Legendre Chaos

En multidimension:

$$\Psi_k^{nd}(X) = \prod_{i=1}^{n} \Psi_{\alpha_i}^{1d}(X_i)$$

e.G Legendre with 2 variables

$$\begin{aligned}
\Phi_0(\xi_1,\xi_2) &= 1 & \& \quad \alpha_0 &= (0,0)\\
\Phi_1(\xi_1,\xi_2) &= \xi_1 & \& \quad \alpha_1 &= (1,0)\\
\Phi_2(\xi_1,\xi_2) &= \xi_2 & \& \quad \alpha_2 &= (0,1)\\
\Phi_3(\xi_1,\xi_2) &= \tfrac{3}{2}\xi_1^2 - \tfrac{1}{2} & \& \quad \alpha_3 &= (2,0)\\
\Phi_4(\xi_1,\xi_2) &= \xi_1\xi_2 & \& \quad \alpha_4 &= (1,1)\\
\Phi_5(\xi_1,\xi_2) &= \tfrac{3}{2}\xi_2^2 - \tfrac{1}{2} & \& \quad \alpha_5 &= (2,0)
\end{aligned}$$

Challenge : estimer, à moindre coût, les coefficients

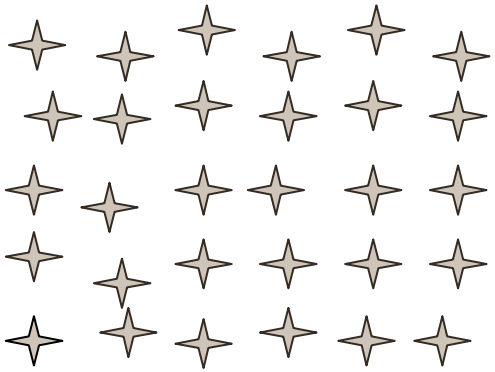
$$Y = \sum_k \beta_k \Psi_k(X)$$

Option 1: par projection .

- avantage pas d'hypothèse sur la troncature
- limite cout de calcul

Option 2 par régression

- avantage cout limité
- limite la qualité du modèle dépend de la base



$$Z = \begin{pmatrix} \Psi_0(\xi^{(1)}) & \Psi_1(\xi^{(1)}) & \dots & \Psi_P(\xi^{(1)}) \\ \Psi_0(\xi^{(2)}) & \Psi_1(\xi^{(2)}) & \dots & \Psi_P(\xi^{(2)}) \\ \vdots & \vdots & \ddots & \vdots \\ \Psi_0(\xi^{(n)}) & \Psi_1(\xi^{(n)}) & \dots & \Psi_P(\xi^{(n)}) \end{pmatrix} \quad \hat{y} = \begin{pmatrix} \hat{y}_0 \\ \hat{y}_1 \\ \vdots \\ \hat{y}_P \end{pmatrix}$$

$$\hat{\beta} = (Z^T Z)^{-1} Z^T y$$

As conclusion

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