French children exposure to 50 Hz magnetic field

Isabelle Magne[1], Martine Souques[2], Jacques Lambrozo[2], Mfoihaya Bedja[3], Gilles Fleury[3], Laurent Le Brusquet[3], Alexandre Carlsberg[4,] François Deschamps[5], Gilbert Belardi[6]

[1] *EDF R &D, Moret sur Loing, France*

[2] *EDF Service des Etudes Médicales, Levallois-Perret, France*

[3] *Supelec, Gif-sur-Yvette, France*

[4] *MV2, Montrouge, France*

[5] *RTE, Paris La Défense, France*

[6] *ERDF, Paris La Défense, France*

CHANGER L'ÉNERGIE ENSEMBLE

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Introduction and aim

- 1979: Wertheimer study
- 2001: classification II B of ELF magnetic field by IARC (*possibly carcinogenic to human*)
- 2007: collective assessment by international expert groups WHO
  - Statistic association observed between childhood leukemia and magnetic field exposure higher than 0.4µT in mean over 24h
  - No causal relationship demonstrated
- Aim of the study: what is the exposure of the French population?
  - 2007: EXPERS study initiated by the Health Ministry

Recruitment of volunteers

- Recruit 1000 adults and 1000 children representatives of the French population

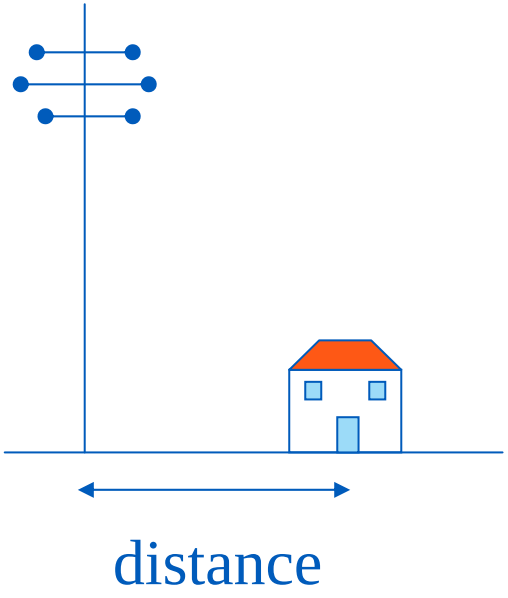
- MV2 Conseil in charge of data collection
  - Method of random lottery
  - Start file 95 362 phone numbers (no professional)
  - Recruitment by phone, then pollster on site
  - Criteria of distribution according to the distribution of the French population by region
  - 3 campaigns (February-April 2007, October 2007-April 2008 and October 2008-January 2009).

Collection of data

- Measurements during 24h with an EMDEX II worn by the volunteer
  - 1 measurement every 3 s
  - Measurement of broadband (40-800 Hz) and harmonics (100-800 Hz)
  - Measurement range: 0.01 to 300µT
  - Not disturbed by GSM
- Timetable filled in by the volunteer
  - Activities
  - Locations
  - Hours
- Questionnaire filled in at the end with the pollster
  - Information on the volunteer (age, profession, etc..)
  - Information on the home (year built, heating, etc...)
- Measurement of GPS coordinates at the home front door
  - Search afterwards of proximity of electric networks

Electric networks close to home

- Definition of distance “close to home”



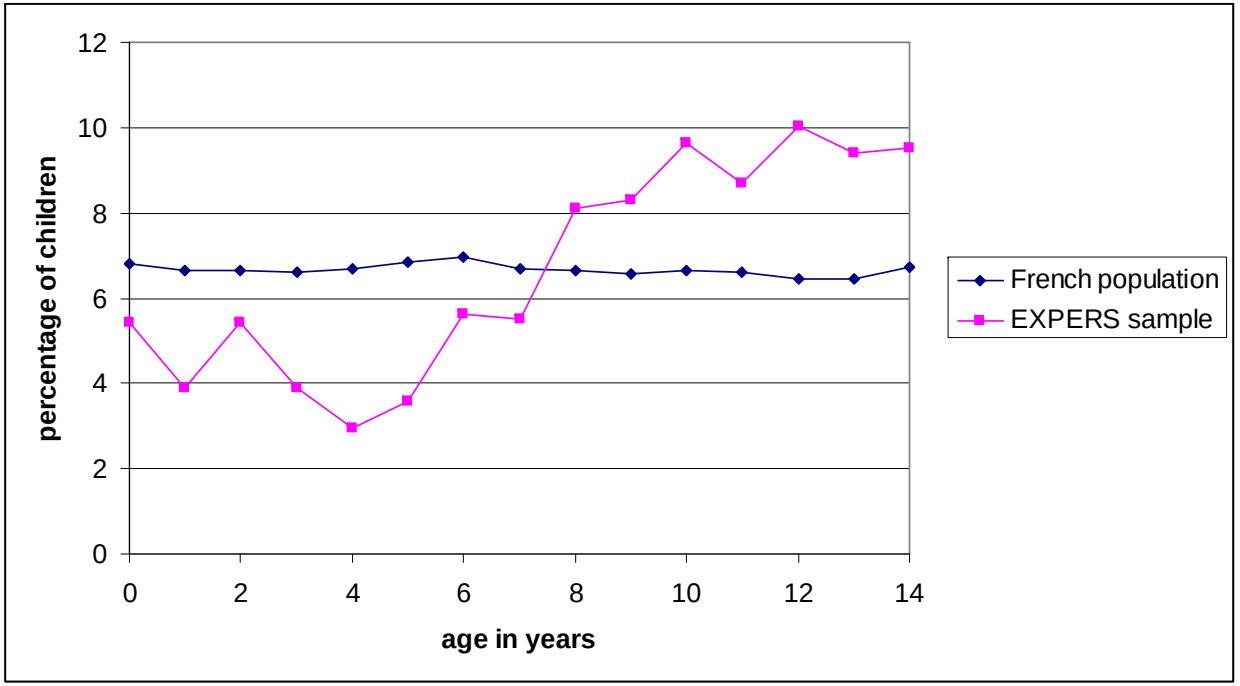
Type of network	Distance (m)
Overhead line 400 kV	200
Overhead line 225 kV	120
Overhead line 150 kV	100
Overhead line 63 and 90 kV	70
Overhead line LV and 20 kV	20
Train network	200
Underground cable 225 kV	20
Underground cable 63 to 150 kV	20
Underground cable LV and 20 kV	20
MV/LV substation	20

Description of the database (1/2)

- Summary of the phone numbers called
  - 95 362 numbers called :
    - 47% answered
    - 3047 agreements on principle (3%)
    - 2148 measurements performed (2,25%)
- Mean time to recruit 1 volunteer = 70 min
- Pertinence of data
  - 2148 measurements performed
  - 2048 measurements validated par MV2 Conseil
  - 1525 addresses (523 paired adult/child)

Description of the database (2/2)

- Distribution by age

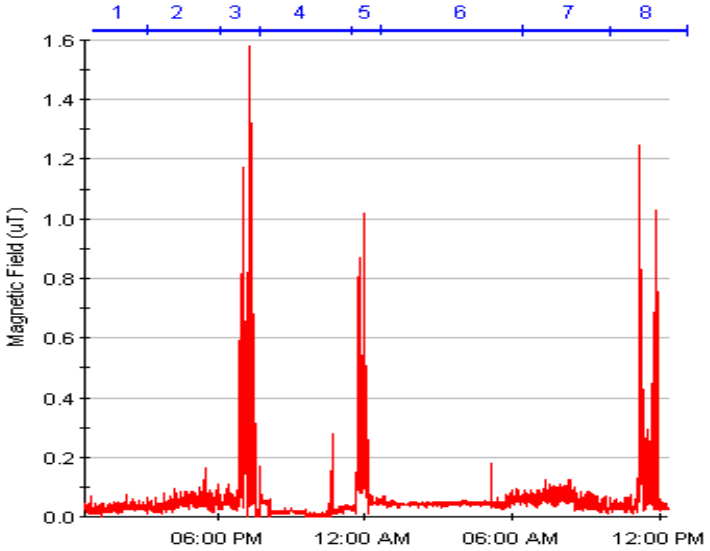


- Distribution by gender

% M/F	French population	database
children	51/49	49/51

Analysis of the database

- 2048 measurements validated par MV2 Conseil
- Keying in of timetable and questionnaires
  - 19 series deleted for different reasons
  - 2029 measurements analysed
    - 977 measurements recorded by children (0-14 years).
    - 1 052 measurements recorded by adults (15 years and over)
- Example of refined temporal cutting



1- home

2 – work on PC

3 – train

4 – meeting room

5 – bus

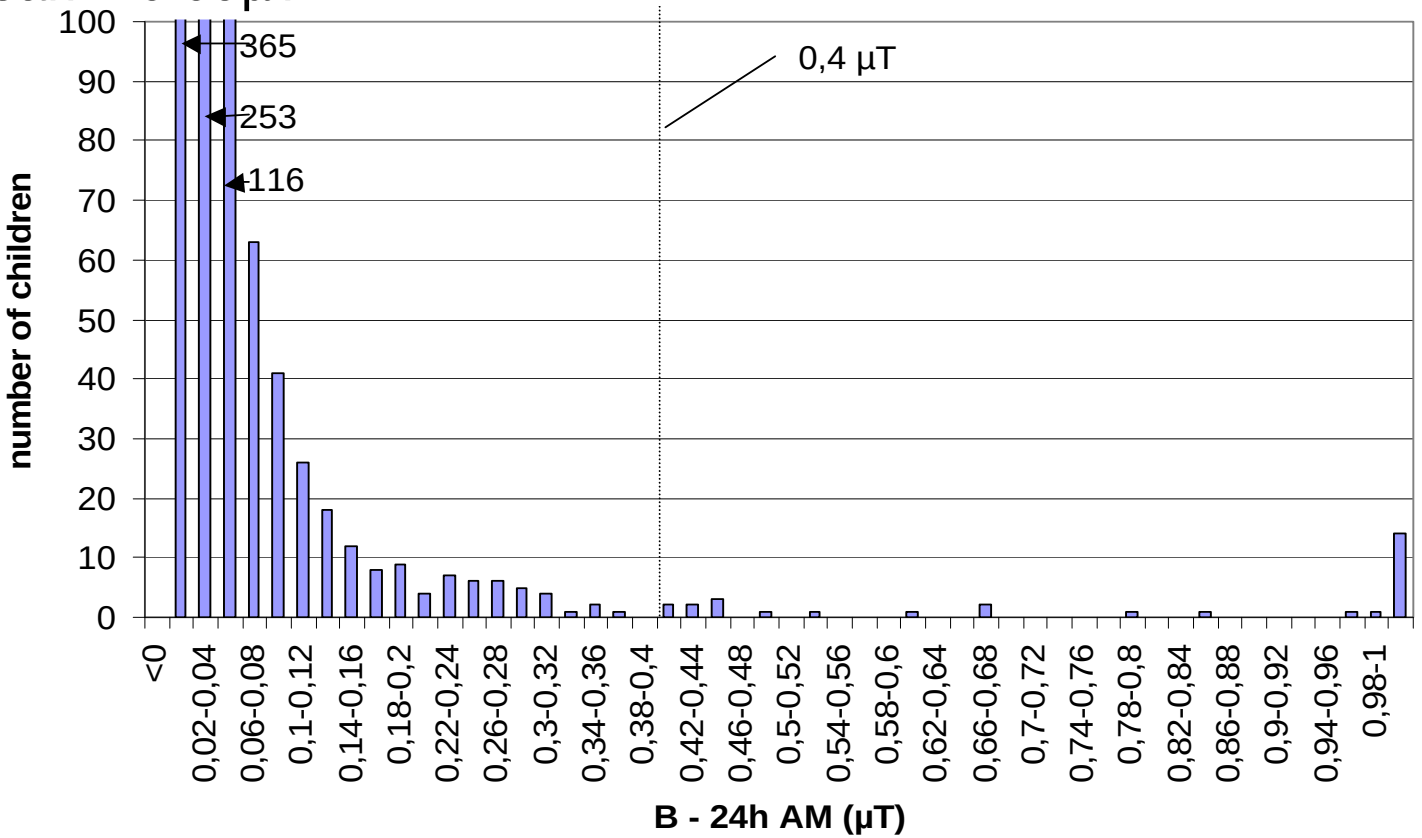
6 – home

7 – housework

8 - shopping

Mean exposures over 24 h – arithmetic mean (AM)

- Bmean = 0.09µT

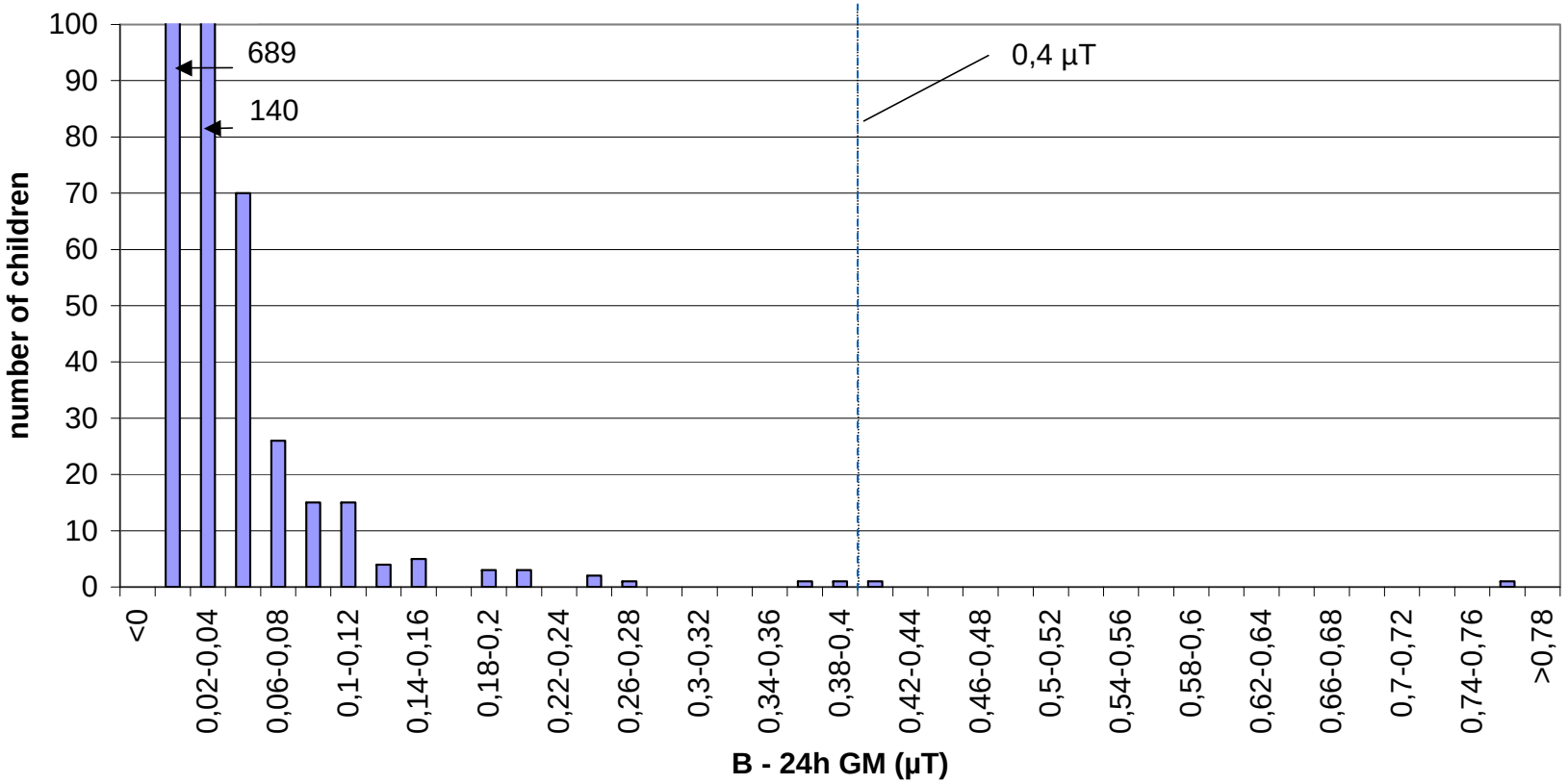


- 30 children with AM > 0.4 µT (3.1%)

Proportion (%)	25	50	75	99
Quartile in µT	0.01	0.03	0.06	1.22

Mean exposures over 24 h – geometric mean

- Bmean = 0.02µT

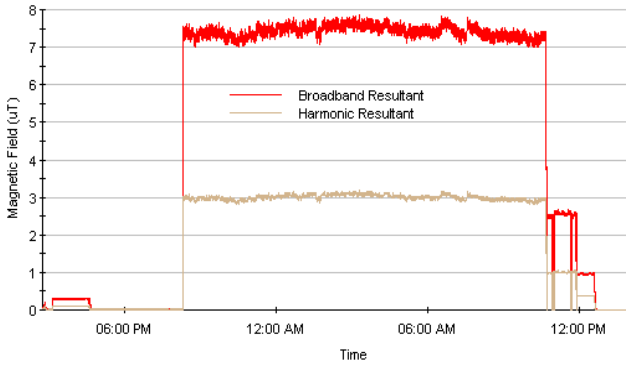


- 2 children with GM > 0.4µT

Proportion (%)	25	50	75	99
Quartile in µT	0.00	0.01	0.02	0.20

Exposures of type “clock-radio”

- Proportion of children with AM > 0.4µT higher than in literature
- Search for explanations for these high exposures
  - Signal high during the night
  - 1/3 of harmonics
  - Correspond to the field measured close to a clock-radio
- Additional investigations
  - High variation of B from a clock-radio to another
  - Source = transformer
  - B decreases very quickly with the distance (negligible at 50 cm)



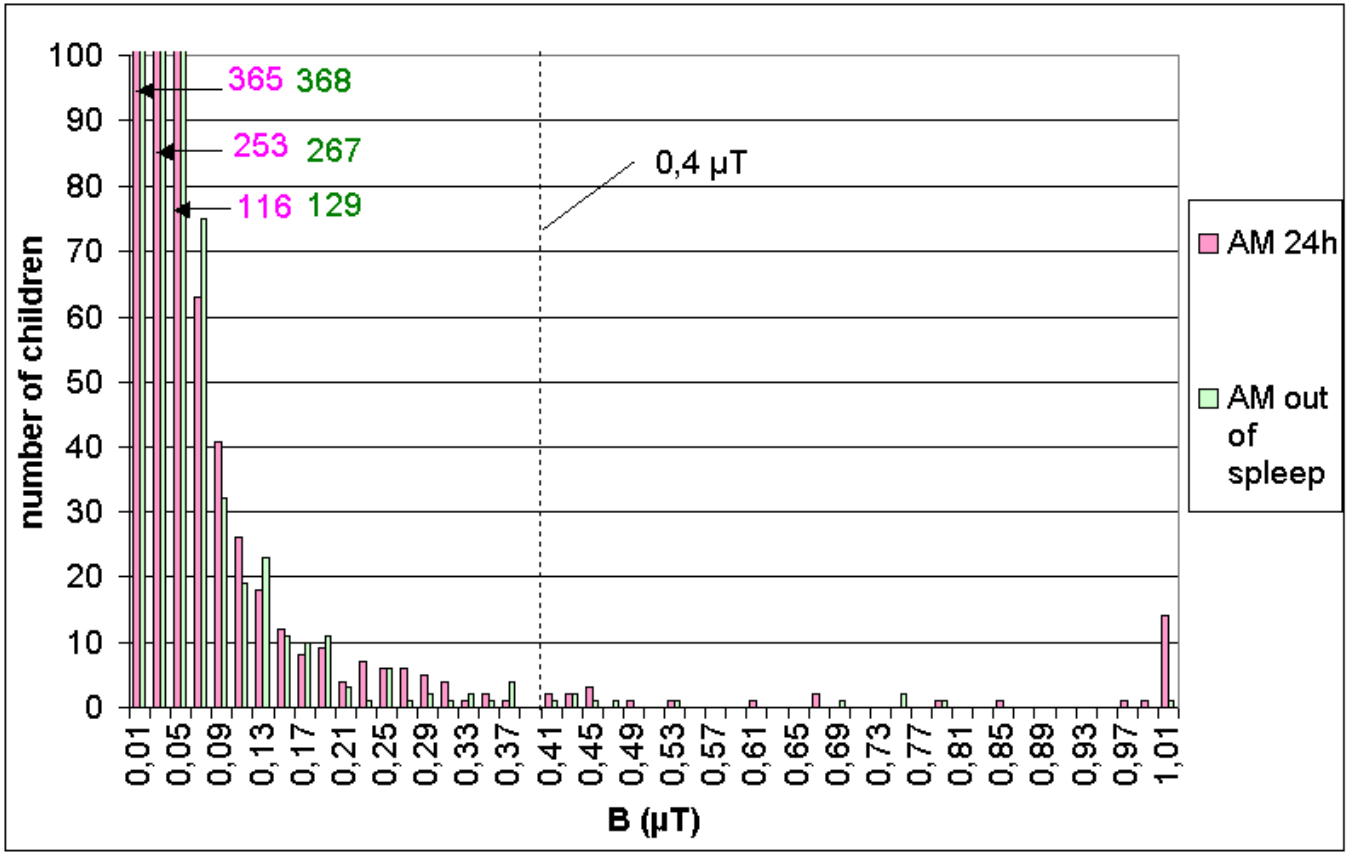
- Are these measurements representative of the personal exposure?
  - Respect a distance of 50 cm between the EMDEX and any electric appliances during the night
  - Question asked in the questionnaire in order to check
  - The measurements over 24h overestimate the exposure
- Distinguish the exposure over 24h and the exposure outside sleep period

Mean exposures outside sleep period

AM = 0.05 µT

- 11 children with AM > 0.4 µT (1.1%)

GM = 0.02 µT



The sources of high mean exposures

- Example of children, AM over 24h
  - 24 cases of EMDEX put very close to clock-radios during the night
  - 2 cases of EMDEX put close to electric appliance with a transformer during the day
  - 1 case of EMDEX put close to unknown electric appliance at home during the night and the day
  - 1 case of EMDEX put close to electric appliance with a transformer at school
  - 1 case on AC electrified train network close to the home and the school
  - 1 case of overhead low voltage line close to the home
- Example of children, AM outside period of sleep
  - 5 cases of EMDEX put close to electric appliance with a transformer during the day
  - 1 case of EMDEX put close to unknown electric appliance at home the day
  - 1 case of EMDEX put close to electric appliance with a transformer at school
  - 1 case on AC electrified train network close to the home and the school
  - 1 case of overhead low voltage line close to the home
  - 1 case of electric network close to the school (to be confirmed)
  - 1 case of EMDEX put close to electric cable on the floor of a car

Comparison of exposures (1/2)

- Children / adults
  - Children are less exposed than adults (over 24h and outside sleep period)
- Home / outside
  - Children are more exposed at home than outside (over 24h and outside sleep period)
- Day / night
  - At home, children are more exposed during the day than during the night
- Region
  - Children living in Ile-de-France are more exposed than in the other regions (over 24h and outside sleep period)

Comparison of exposures (2/2)

- Results electric networks
  - Mean exposures (at home and over 24h) are higher for children living close to electric networks than for those living far away from these networks
  - Mean exposures (at home and over 24h) are not different for children living close to high voltage networks and for those living close to 50 Hz train networks
  - Calculation to be done for distribution network (low voltage and 20 kV)

Characterisation of exposure

- Example of children (distribution network and type of train alimentation not taken into account yet)

Name of the variable	Children over 24h		Children outside period of sleep	
	AM	GM	AM	GM
Density of population of the department	x	x	x	x
To have put the EMDEX close to a clock-radio	+	+		
Home close to high voltage overhead power lines	+	+	+	+
Home close to electric train networks	+	+	+	+
Population of the city (> 2 000 inhabitants)	+	+	+	+
Age	+		x	
To live in a building	+	+	+	+
Heating energy = electric	-	-		-
Time spent on computer		+	+	+
Time spent in shopping centre				x
Time spent in train transports		x	x	x
Time spent watching TV				+
Time spent in non electric transports		x		x
Time spent at school	-	-	x	-
Level of explained variance	**17,2%**	**27,2%**	**17,7%**	**29,8%**

Repartition to children around electric networks

- Number of children living “close to electric networks”

Total of children = 977

Type of network	Number of children
Overhead line 400 kV	4
Overhead line 225 kV	7
Overhead line 63 to 150 kV	11
Overhead line 20 kV	24
Overhead line LV	371
50 Hz train network	41
Underground cable 225 kV	11
Underground cable 63 to 150 kV	10
Underground cable 20 kV	331
Underground cable LV	524
MV/LV substation	45
MV/LV substation in building	13

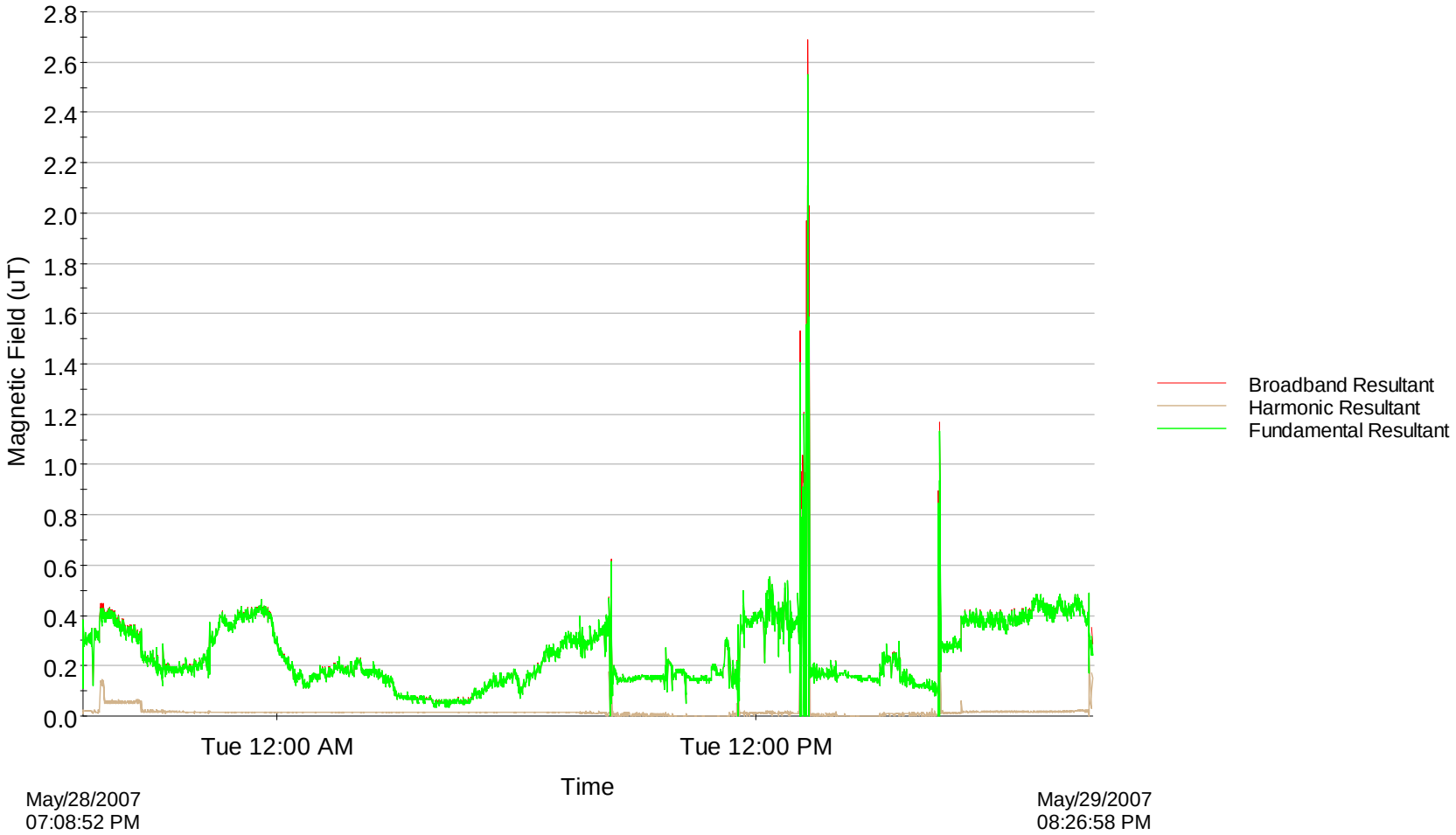
How much is the distance indicator conservative?

- Arbitral classification of subjects within the corridors as “exposed” to magnetic fields generated by electric networks
- But the width of the corridors is overestimated

- Do the magnetic field measurements of the “exposed” subjects show the influence of electric networks or not?
- 24h variation of magnetic field generated by electric networks is quite characteristic

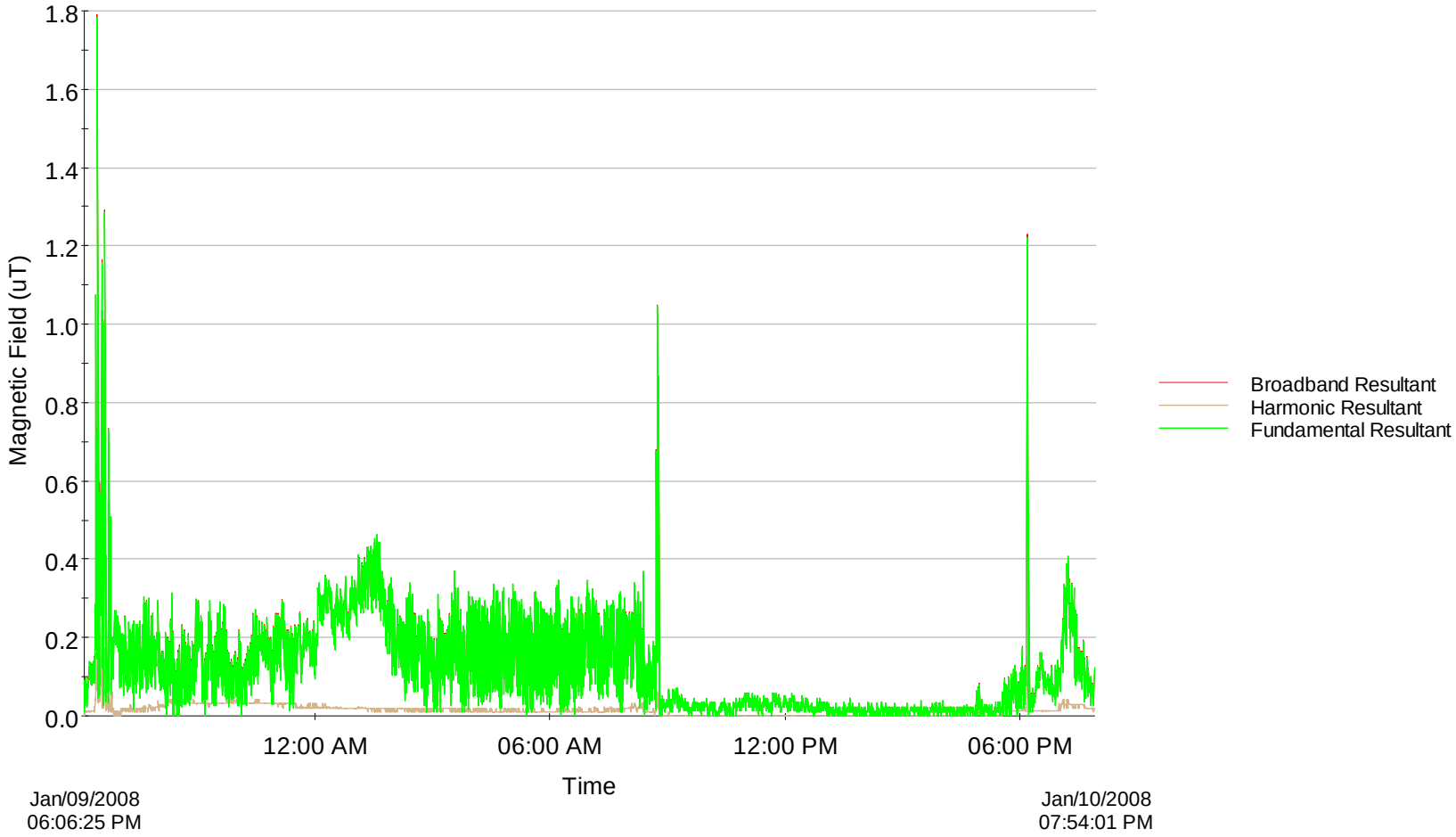
- Visual check

Example of a child – source = power line



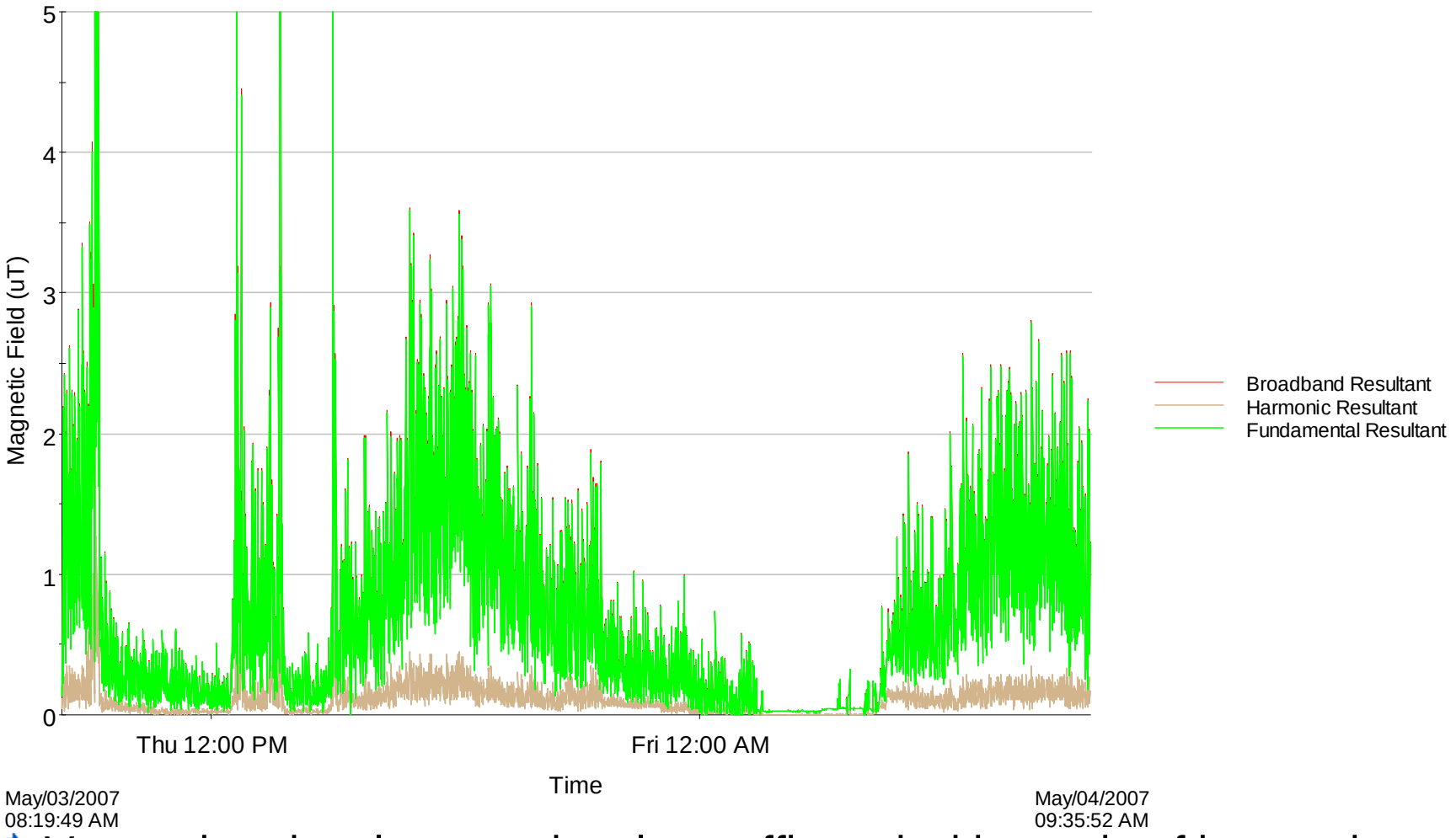
- Signal with little noise and proportional to a load curve of a power line

Example of a child – source = middle voltage underground cable ?



- Signal with a trend of a load curve during the night, but noisy

Example of a child – source = train network



- Very noisy signal, proportional to traffic and with a ratio of harmonic above zero

Measurements with influence of an electric network

Type of network	Number of children living close to electric network	Number of children with influence of electric network
Overhead line 400 kV	4	4
Overhead line 225 kV	7	6
Overhead line 63 to 150 kV	11	3
Overhead line 20 kV	24	1
Overhead line LV	371	53
50 Hz train network	41	12
Underground cable 225 kV	11	4
Underground cable 63 to 150 kV	10	5
Underground cable 20 kV	331	60
Underground cable LV	524	75
MV/LV substation	45	9
MV/LV substation in building	13	3

- Note that:
  - B measured = summation of all sources
  - Signal is often at the limit of ground noise and non specific
  - Taking into account the floor of buildings, the numbers for underground networks and substation in buildings would decrease

Conclusion (1/2)

- Objective to have a database of 1000 children and 1000 adults attained
- 1st study of personal exposure of a population at the scale of a country
- 3.1% of children have observed a AM > 0.4 µT
  - Main sources = clock-radio
  - The real exposure of the person was overestimated
- Outside period of sleep, 1.1% of children have observed a AM > 0.4 µT
  - More coherent with literature
- Children are less exposed than adults
- The analysis of the mean exposures has shown that the retained variables do not allow alone to characterise these means

Conclusion (2/2)

- Factors of exposure were identified
- These factors depends on the population considered (adults or children), the type of mean (arithmetic or geometric), and the scenario (over 24h or outside period of sleep)

- Qualitative analysis of electric networks data show that:
  - The part of the population whose exposure to 50 Hz magnetic field is influenced by high voltage power lines is small
  - The criteria of distance chosen in this study is maximizing and thus overestimates logically the number of people whose exposure to 50 Hz magnetic field is influenced by electric networks
  - It is not conclusive that underground electric networks are really the source of exposure seen in some measurements

Perspectives

- Continue the analysis
  - include electric distribution network
    - Improvement of the characterization of mean exposures (variance explained) ?
  - Improve data on train network
    - Take into account the frequency
- Other possible use of these data
  - validation of physical models used to estimate magnetic fields

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THANK YOU FOR YOUR ATTENTION !