Childhood Leukaemia in Relation to Radiofrequency Radiation (RFR) Emitted from Television and Radio Broadcast Transmitters

- Supported by the Federal Office for Radiation Protection -

- German Mobile Telecommunication Research Programme -

Workshop on Long Term Effects,

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Case-Control Study on RFR

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Study Question

Is there an increased risk of childhood leukaemia in populations exposed to radio frequency radiation (RFR*) from TV and/or Radio towers?

*High frequency electromagnetic fields:
10 kHz to 1GHz

Background

Most RFR is emitted by local radio and television stations, with smaller contributions from mobile phone transmitters.

Epidemiological studies addressing RFR from broadcast transmission → No clear evidence for a relation between RFR and disease risk:

- Ecological correlation studies
- Insufficient exposure assessment

Study Design

- Case – Control – Study:
  March 2005 – December 2007
- Retrospective exposure assessment using data from transmitter operators (1983-2003)
- Selection of high power* broadcasting towers located in West-Germany
  - 17 AM transmitters (AM amplitude modulated)
  - 8 FM/TV transmitters (FM frequency modulated)

** 200kW Effective Radiated Power (ERP) / effective monopole radiated power (EMRP)*

Selection of transmitters

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- Current and/or past effective radiated power:
  ≥ 200kW ERP/EMRP

- Exclusion of transmitters in transmitter regions with low population density (< 10 expected cases)

AM Transmitters

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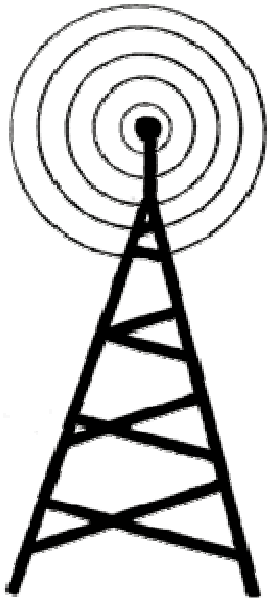
- Mainly located in rural areas
- High exposure (up to 10V/m) in the local vicinity
- Declining exposure with increasing distance to the emission source
- Omnidirectional radiation



FM/TV Transmitters

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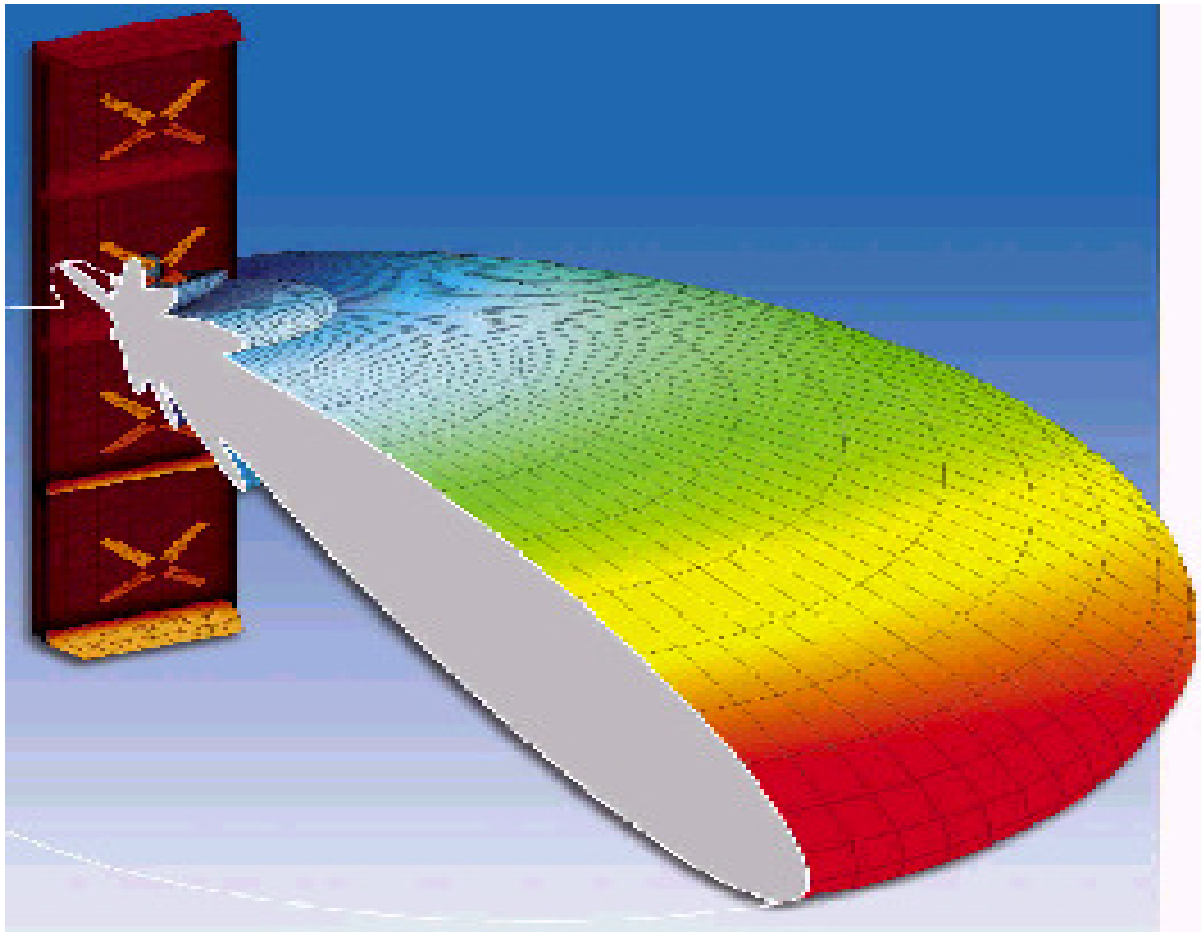
Antennas:
directed radiation



FM/ TV Transmitters

- High variability of field strengths in the vicinity of the tower
- Expected low correlation between exposure and distance to the tower
- Mainly located in urban areas

Definition of the Study Region

What is the appropriate area centred on a broadcast station?

Definition of the Study Region

Measurement campaigns conducted in the area of an **AM Transmitter**:

- ➔ Detection of >1V/m within a 5km circle
- ➔ Average exposure due to mobile phone stations: 0,108V/m and 0,479V/m

Definition of the Study Region

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AM Transmitters

- Determination of the theoretical 1V/m (120 dB(µV/m))-circle for each AM-transmitter using exposure data derived from transmitter network operators*
- Doubling of the 1V/m – Radius
- The transmitter area was defined as all communities at least partially within this circle

** Calculated by the network operator „Südwestrundfunk"*
Recommendation ITU-1546

Definition of the Study Region

FM/ TV - Transmitters

- Determination of the theoretical 90dB(µV/m) (0,03 V/m)-circle for each FM/ TV-transmitter using exposure data derived from transmitter network operators*
- The 90dB(µV/m)-circle includes the higher exposed population

* *Calculated by the network operator „Südwestrundfunk"*
Recommendation ITU-1546

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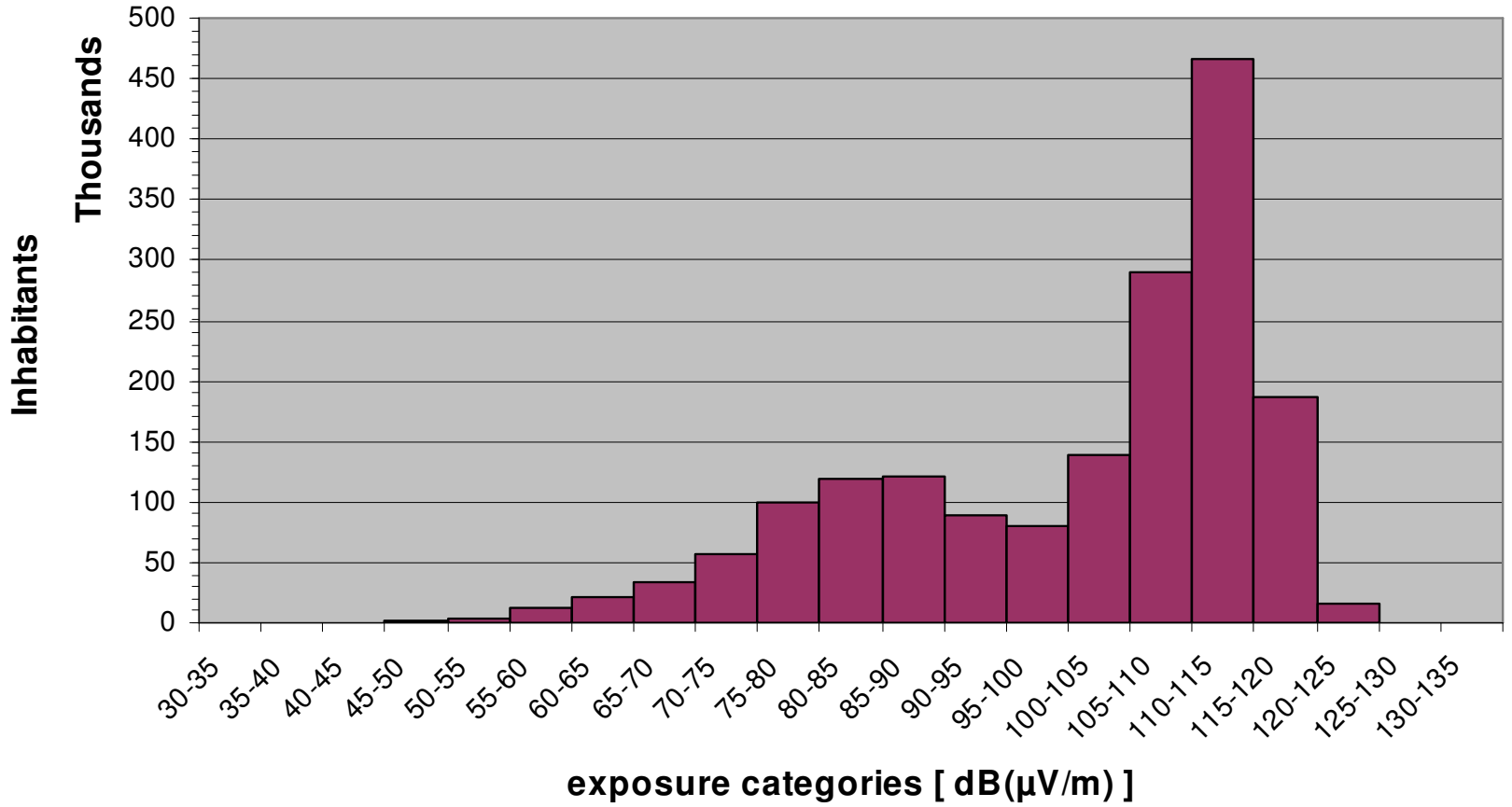
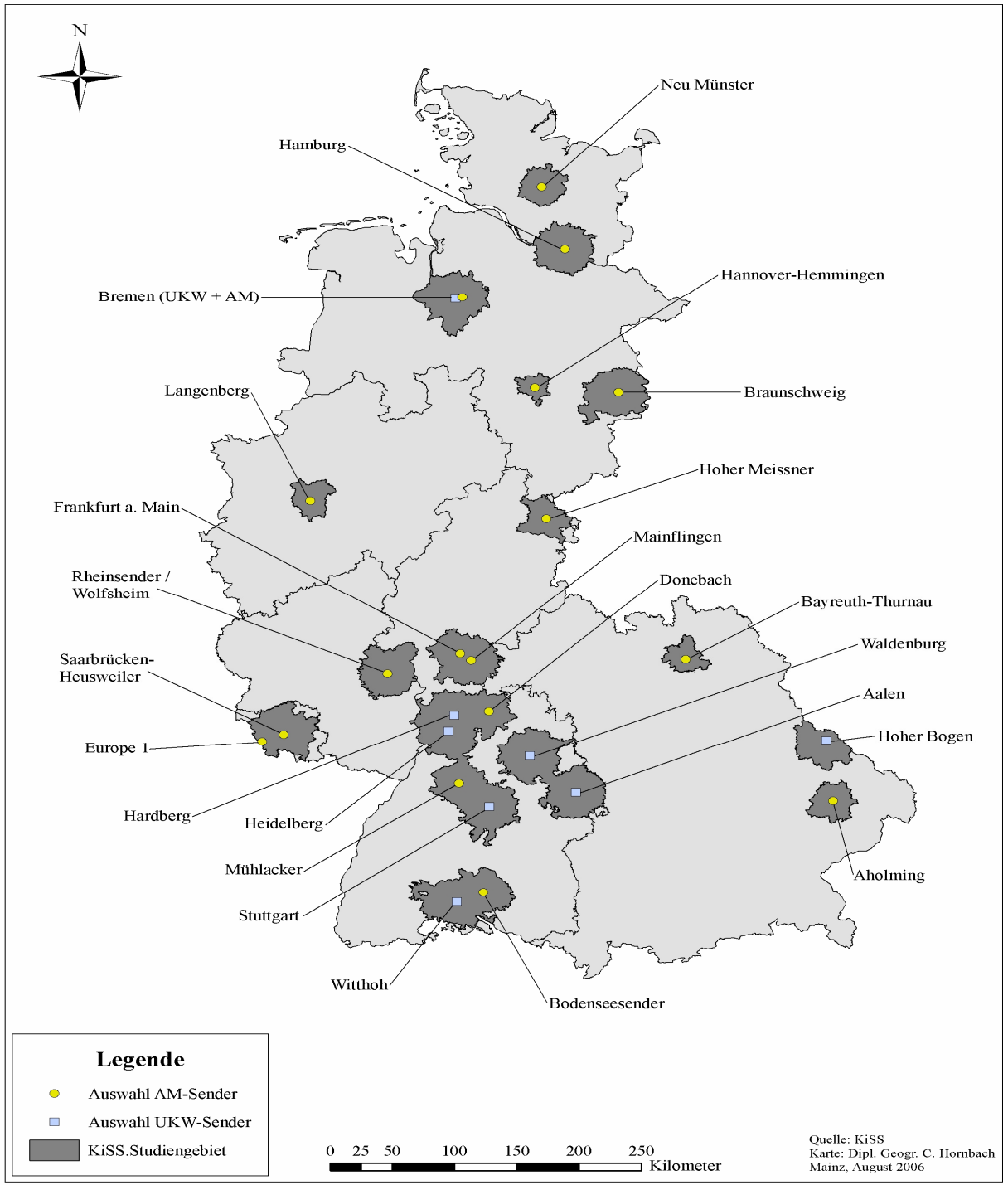
Histogram of exposure (20 km area)
FM/TV transmitter Stuttgart




N
Neu Münster
Hamburg
Hannover-Hemmingen
Bremen (UKW + AM)
Braunschweig
Langenberg
Hoher Meissner
Frankfurt a. Main
Mainflingen
Rheinsender /
Wolfsheim
Donebach
Bayreuth-Thurnau
Waldenburg
Saarbrücken-
Heusweiler
Aalen
Hoher Bogen
Europe 1
Hardberg
Heidelberg
Mühlacker
Aholming
Stuttgart
Witthoh
Bodenseesender
Legende
Auswahl AM-Sender
Auswahl UKW-Sender
KiSS.Studiengebiet
0 25 50 100 150 200 250
Kilometer
Quelle: KiSS
Karte: Dipl. Geogr. C. Hornbach
Mainz, August 2006

Definition of Cases

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- Incident cases of leukaemia
- Diagnosis between 1984 – 2003
- 0-14 years and residence in the study region at the time of diagnosis
- Recruitment of cases through the German Childhood Cancer Registry

► 17 AM-transmitters: 1.481 cases

► 8 FM/TV-transmitters: 749 cases

Control Population

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Matching criteria:

- Transmitter area
- Time of residency according to month/ year of diagnosis
- Age at diagnosis
- Gender

Matching ratio 1:3

Exposure Assessment

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Case ascertainment: 1984-2003

Exposure assessment: 1983-2003

➔ 1983 – 1992: RFR exposure mainly related to broadcast transmission

➔ 1993 – 2003: development of the cellular phone network

Exposure Assessment

- An exposure assessment which only based on the distance between place of residence of cases/controls and the transmitter is not sufficient
- The individual exposure assessment should consider:

  (1) the specific radiation characteristics of the transmitters

  (2) the time-dependent variability of the RFR transmission for the entire time period

Exposure Assessment

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- The transmitter operators provide data describing the operation of the transmitters throughout the total study period from 1983 to 2003
- All stations contributing significantly to the exposure level in the respective regions are considered
- Gauß-Krüger coordinates available for the individual place of residence of cases and controls at time of diagnosis of the case.

Exposure Assessment

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- Aim of the exposure assessment: Calculation of the specific exposure for *place of residence* and *time of diagnosis*

- Short latency period of childhood leukaemia: mean exposure *ONE year before diagnosis*

Exposure Assessment

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- Field strength prediction software has been developed to assure an adequate supply of all Radio/TV consumers
- Useful tool for retrospective exposure assessment considering the time-dependent variability of the RFR transmission*

* *Adjustments: MININEC Modelling; van der Pol/Bremmer differential equation for AM transmitters. Application of the Meeks algorithm for FM/TV transmitters (Performance: Südwestrundfunk, Stuttgart)*

Exposure Data (1983-2003)

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Average (mean) field strength per month

- Field-strength for frequency ranges (AM, FM/TV)
- Sum exposure
  - V/m^2 (AM plus FM/TV)
  - fraction of the limit values of the 26^{th} Federal Immission Protection Regulation in percent

Analysis: Study Questions

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- Increased risk of childhood leukaemia in populations exposed to RFR from TV and/or Radio towers (high exposure vs. low-exposure)?
- Different disease risk for AM and FM/TV-transmitters?

- *Dose-response-relationship?*
- *Secular trends detectable?*

Current stage of study

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- Recruitment of cases and controls was completed in August 2007
- Exclusion of cases due to overlap of transmitter regions and incomplete addresses: final study population with 1.962 cases and 5.857 controls
- Information about the duration of stay at the place of residence for each case/control available

Current stage of the study

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- Point-specific* exposure assessment for place of residents of cases and controls will be completed in October/November 2007

- Data processing and final analysis : running

* values for grids of 100m×100m pixels

Analysis

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- Stratification for age groups ➔ nearly 55% of the study population are below 5 years of age
- Classification according to population density ➔ consideration of possible confounders
- Relevant exposure periods ➔ 1983 – 1992: RFR exposure mainly related to broadcast transmission

Analysis

- Information on duration of stay at the place of residence available ➔ Restriction to cases/controls who did not move between birth and diagnosis

- Risk estimation: distance between transmitter and place of residence vs. assessment of field strength?

Validation: exposure assessment

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- The quality of the field-strength predictions have been validated by comparison with data from historical and current field measurements.

Basis of Validation

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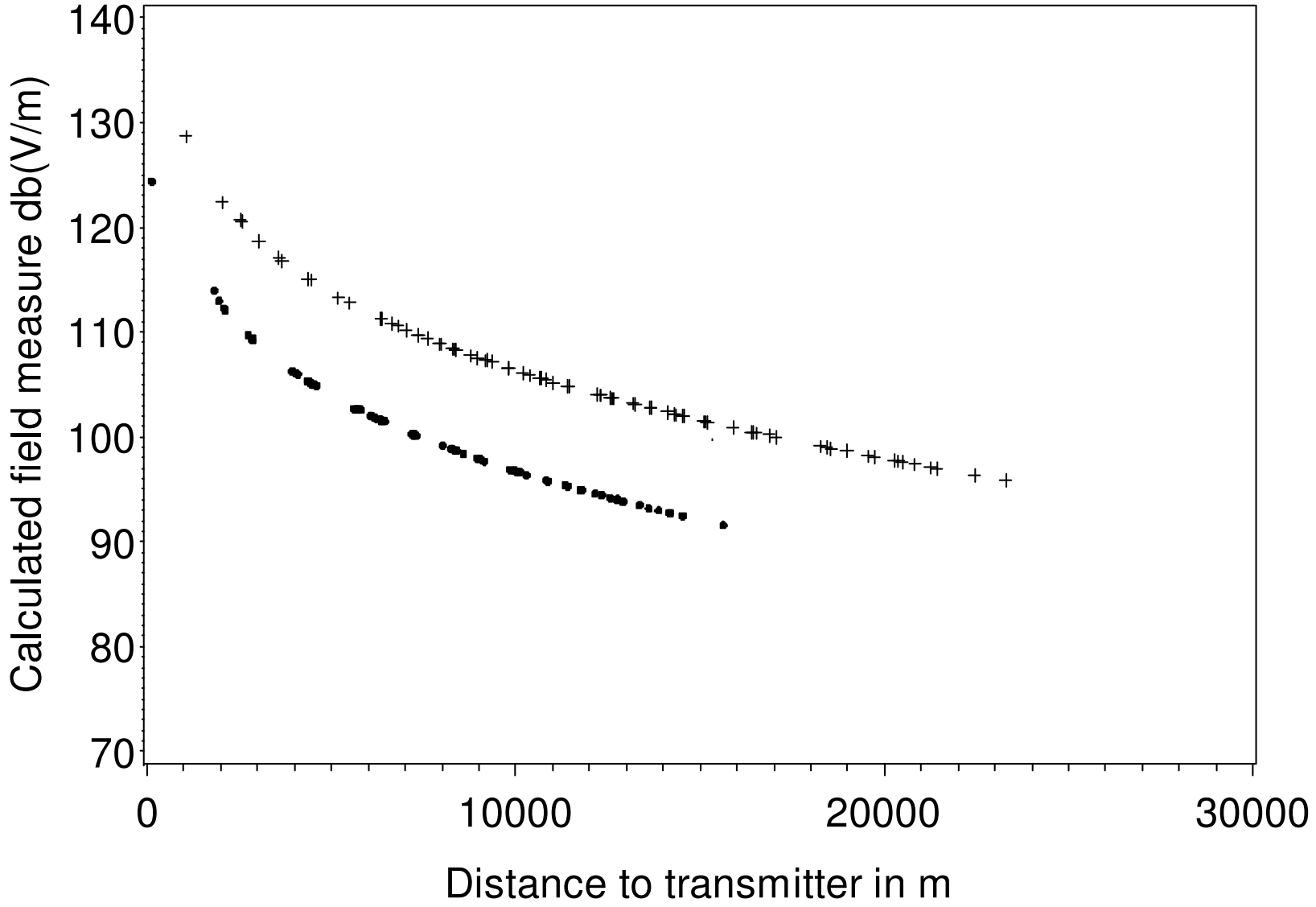
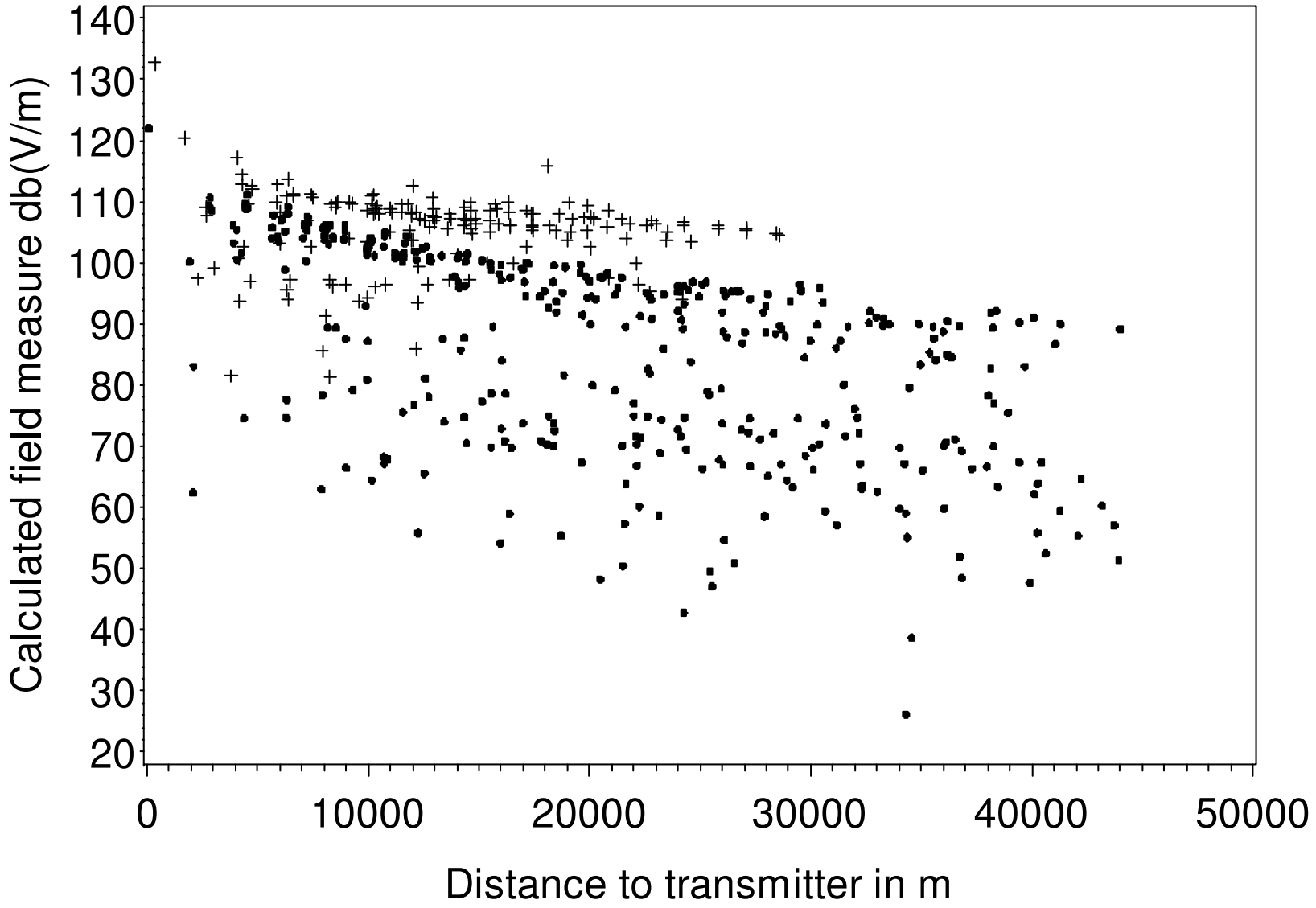
- 679 data pairs (calculated and measured)
  - 154 AM
  - 525 FM
- Areas
  - Stuttgart (FM)
  - Freiburg (AM)
  - Bodensee (FM)

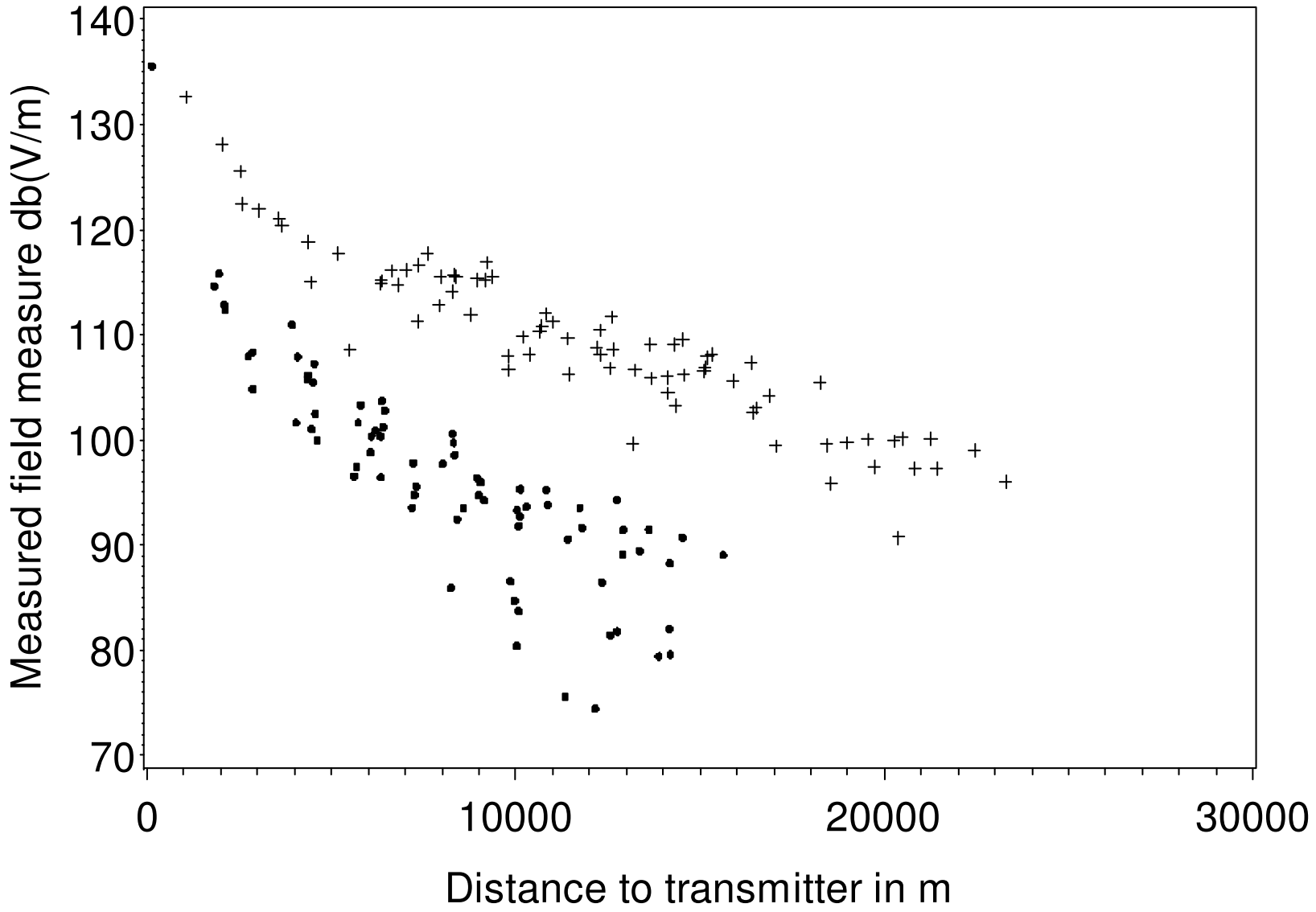
AM calculated - distance



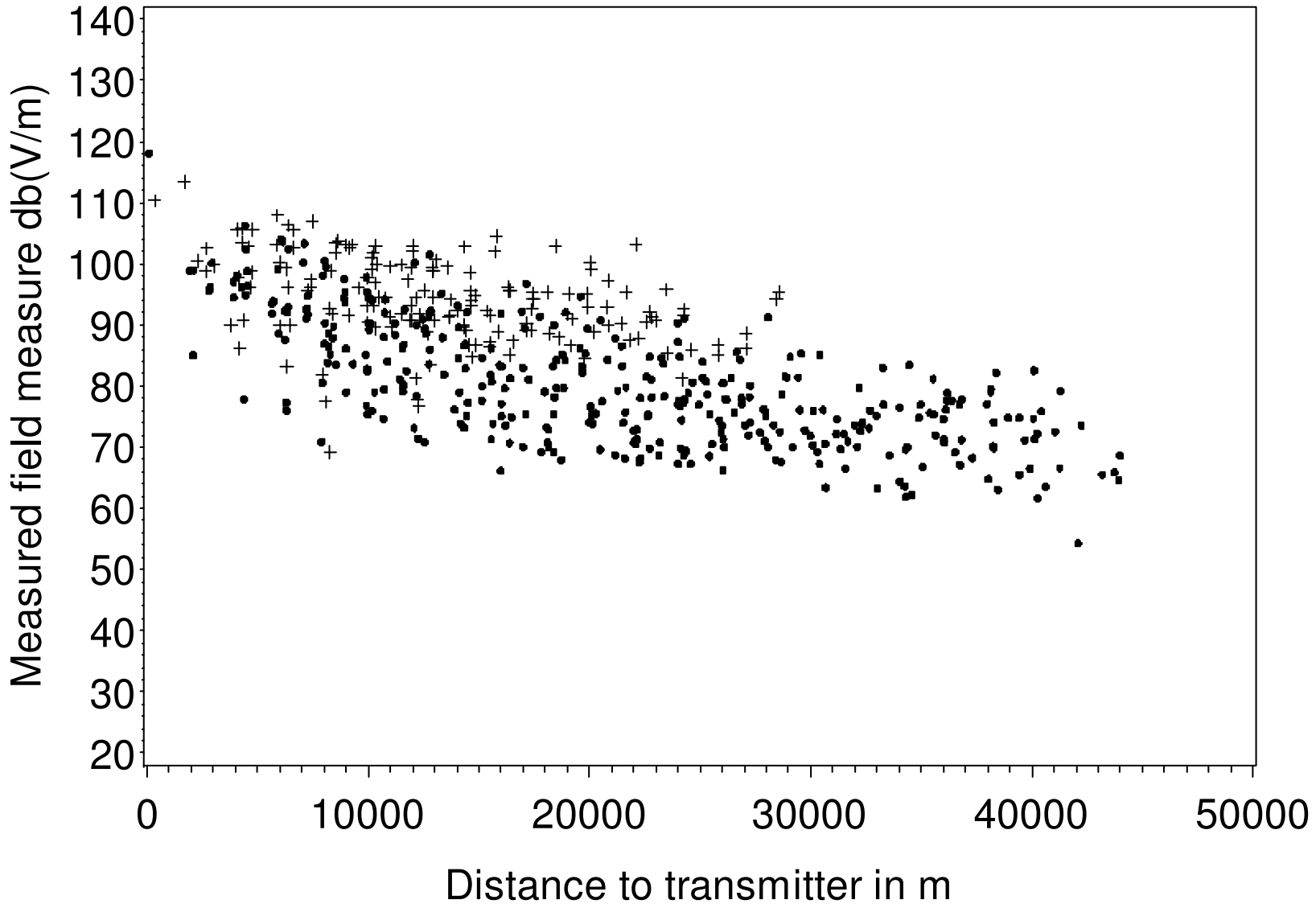
FM calculated - distance



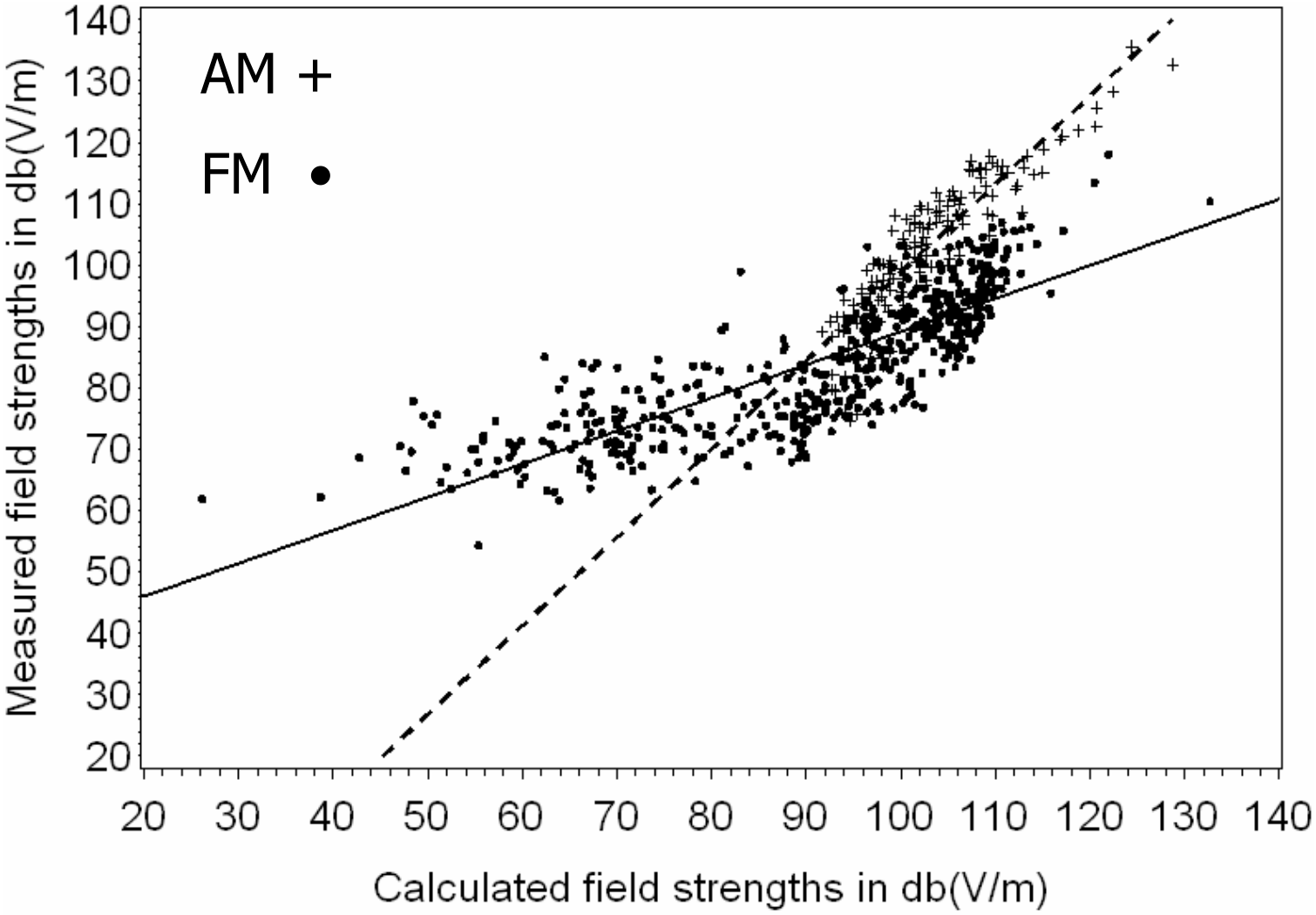
AM measured - distance



FM measured - distance



Measured against calculated field strengths



Exposed – non exposed and measurement error

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- According to the study protocol
  - Every field strength in the upper 90%-quantile is classified as exposed
- Measurement error is evaluated by sensitivity and specificity and its effect on power

	measured / calculated ++	-+	+-	--	Sensitivity in %	Specificity in %	Kappa	Correlation*
All data 679 data pairs, cutpoint 106.6db(µV/m)	30	37	38	574	44.1 [32.1; 56.7]	93.9 [91.8; 95.7]	0.38 [0.27; 0.50]	0.83 [0.81; 0.86]

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FM 525 data pairs, cutpoint 99.5db(µV/m)	31	22	21	451	59.6 [45.1; 73.0]	95.4 [93.0; 97.1]	0.54 [0.42; 0.67]	0.86 [0.84; 0.88]
AM 154 data pairs, cutpoint 115.9db(µV/m)	10	5	5	134	66.7 [38.4; 88.2]	96.4 [91.8; 98.8]	0.63 [0.42; 0.84]	0.92 [0.89; 0.94]

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609 data pairs excluding 80%-90% quantile, cutpoint 106.6db(µV/m)	30	37	25	517	54.6 [40.6; 68.0]	93.3 [90.9; 95.3]	0.44 [0.32; 0.55]	0.84 [0.82; 0.87]

		Sensitivity 44.1% Specificity 93.9% (2,000 cases, 6,000 controls)		Sensitivity 59.6% Specificity 95.4% quantile between 80%-90% is excluded (1,800 cases, 5,400 controls)	
True OR	Power	OR measured with misclassification	Power with misclassification	OR measured with misclassification	Power with misclassification
2.00	99.9	1.36	96.4	1.43	98.7
1.70	99.9	1.26	79.7	1.30	85.6
1.50	99.9	1.19	54.8	1.22	62.1
1.30	89.0	1.11	23.1	1.13	25.0

Limitations

- Measurements along a grid → not representative of distribution of probands in main study
- Historical measurements not available
- Calculation is an estimate for a 100m*100m grid → local variations are not considered

Strengths

- Effect on power could be estimated
- Calculated field strengths are more reliable as the use of distance as exposure-proxy
- Inclusion of historical data of the transmitters in main study

Discussion

Min Ha et al. :

" Radio-Frequency Radiation Exposure from AM Radio Transmitters and Childhood leukaemia and Brain Cancer"

Department of Preventive Medicine, Dankook University, South Korea

American Journal of Epidemiology, 2007

Study design, Korea

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- Case-control study, recruitment 1993-1999
- 1.928 leukaemia patients recruited in 14 Korean hospitals; hospital controls with a respiratory disease
- Assessment of residential addresses at the time of diagnosis
- Matching 1:1
- Matching criteria: age at diagnosis, sex, year of first diagnosis

Exposure Assessment, Korea

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- 31 AM transmitters were included (>20kW EMRP)
- Prediction program considered distance, altitude, electrical characteristics of the area, ground type classification
- Validation of the prediction program
- Calculation of the peak exposure (the highest exposure estimate obtained for each transmitter established before the subjects' year of diagnosis) and the total exposure

Korea Study: Odds Ratios for childhood leukaemia according to RFR exposure to AM transmitters

			Lymphocytic leukaemia	
Exposure **V/m**	No. controls	No. Cases	OR	95% CI
Q1 <0,5	513	514	1.0	referent
Q2	514	241	1.39	1.04, 1.86
Q3	515	188	1.59	1.19, 2.11
Q4 >0,9	513	353	1.08	0.80, 1.45
Unknown	9	4	2.66	0.58, 12.2

Korea Study: Odds Ratios for childhood leukaemia according to RFR exposure to AM transmitters

		All leukaemia	
Distance	No. Cases	OR	95% CI
≤2 km	36	2.15	1.00, 4.67
>2-4	73	0.66	0.44, 0.99
>4-6	120	1.07	0.77, 1.49
>6-8	218	1.26	0.96, 1.65
>8-10	276	1.10	0.85, 1.41
>10-20	428	0.80	0.65, 0.99
>20	772	1.00	referent
unknown	5	0.48	0.12, 1.95

Comparison: Korea Study vs. German Study

- Hospital controls vs. population controls
- Matching age, sex, year of diagnosis & transmitter region
- Transmitter selection: >20kW vs. >200kW
- Consideration of time-varying exposures of transmitters: no vs. yes
- Consideration of movements of cases/controls: no vs. yes
- Definition of high exposure: Q4 vs. 10%-fractile
- Exposure to AM and FM/TV: no vs. yes

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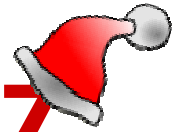
First Results of the German Case-Control Study expected for December 2007



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Jost Wendler (SWR)	Conduct of exposure assessment
Wolfgang Schroeter (TSI) Harry Korr (TSI)	Data from network operator (ZDF)
Sabrina Bennack (IMBEI)	Field study: recruitment of study population, data management