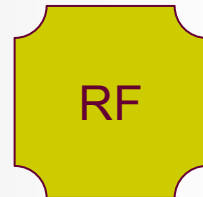# Exposure assessment and other challenges in non-ionizing radiation studies

Leeka Kheifets

Professor

UCLA

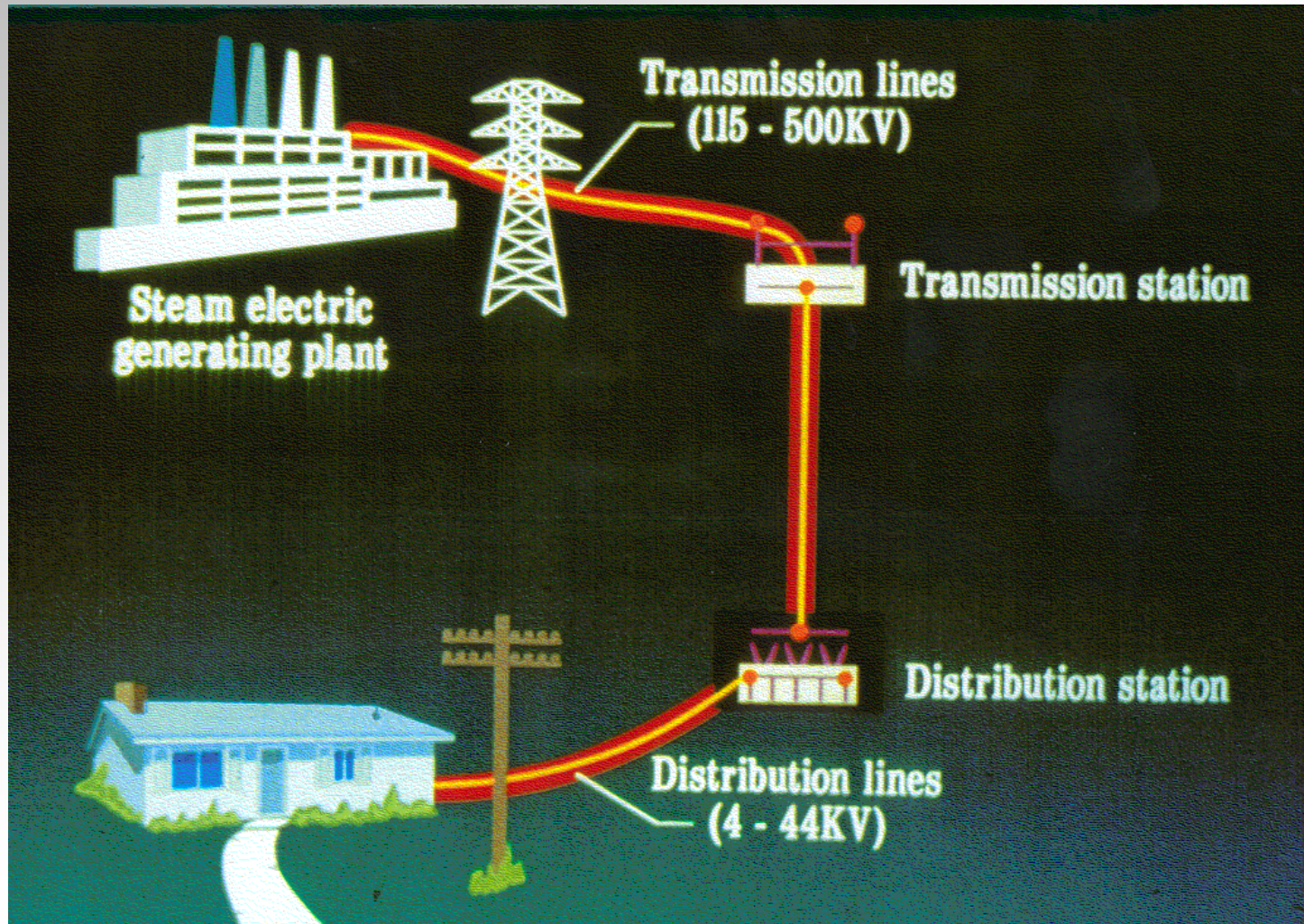# Overview

- Exposure Assesment
- Other Challenges
- Look to the Future

ELF

RF

N.B. Special thanks to Drs. Maria Feychting and John Swanson for some of the slides

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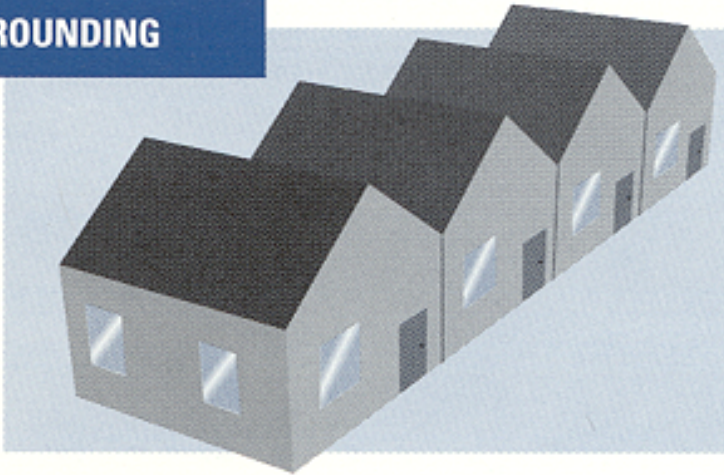
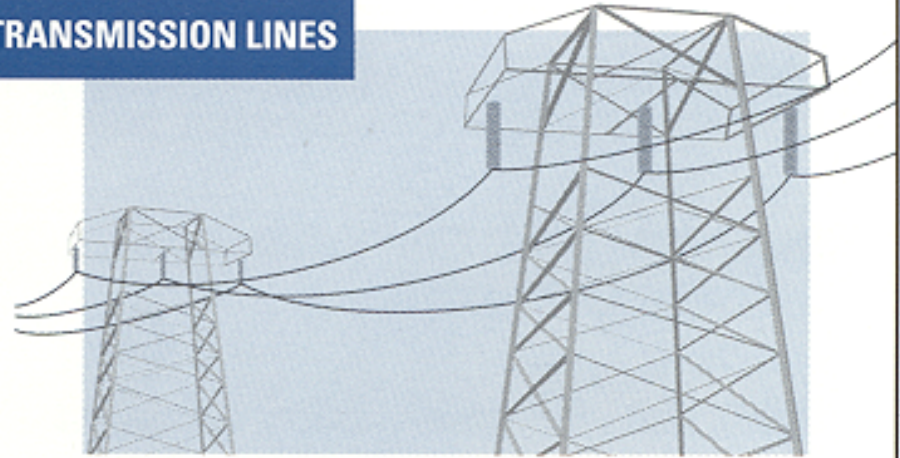# Utility Power Network

Magnetic Field Sources

ELF

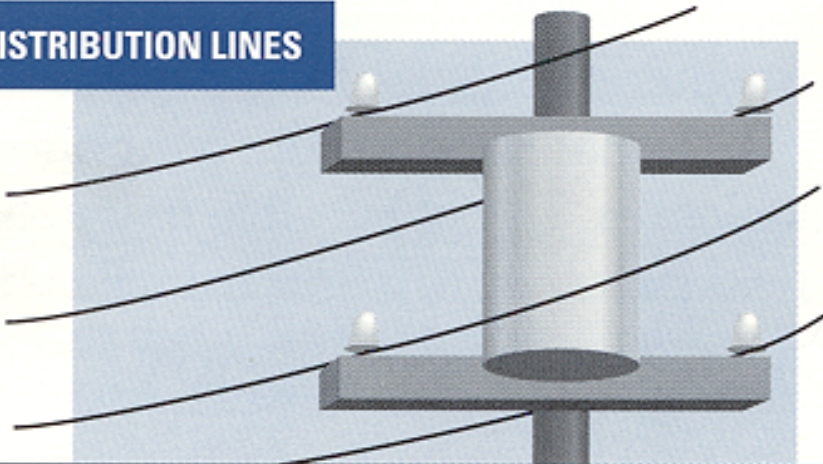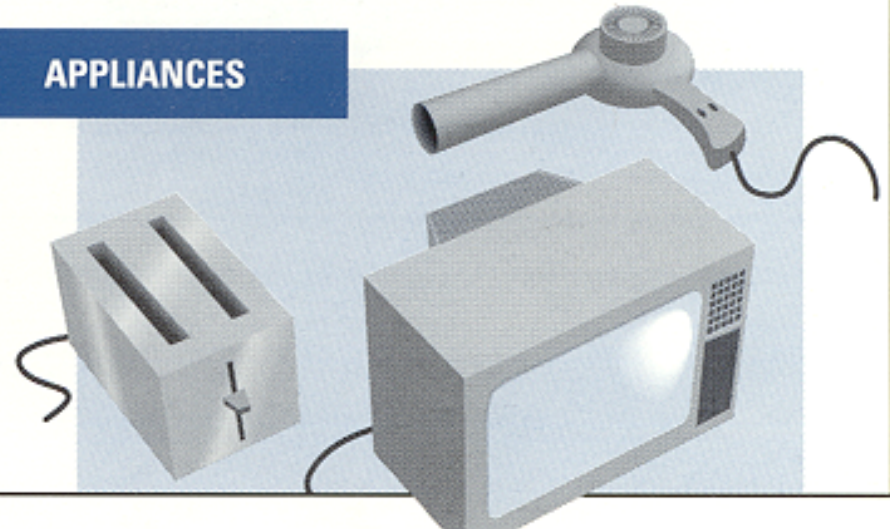## Sources of Residential Magnetic Fields

GROUNDING

TRANSMISSION LINES

DISTRIBUTION LINES

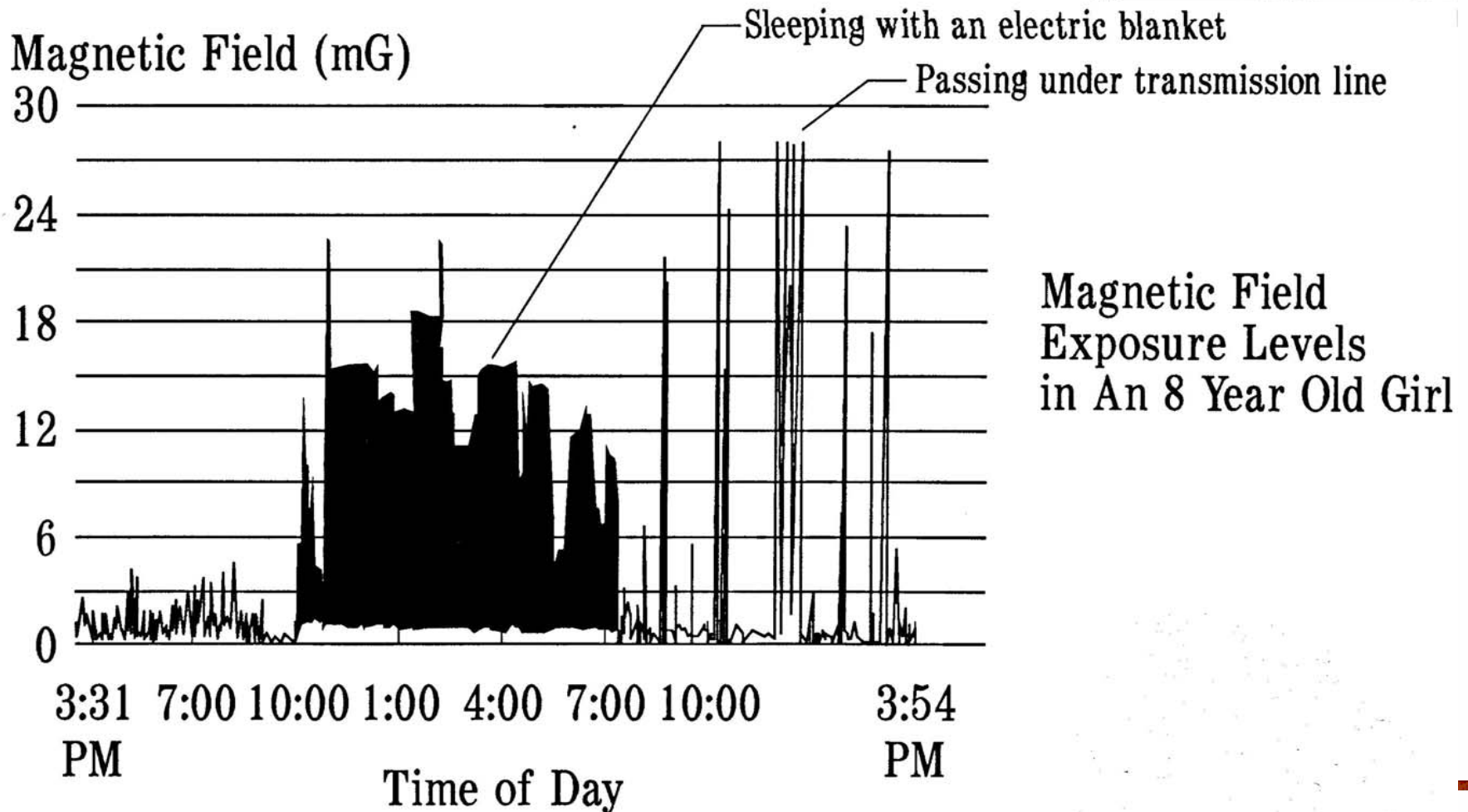APPLIANCES

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Personal EMF Exposure

Magnetic Field (mG)

Sleeping with an electric blanket

Passing under transmission line

Magnetic Field Exposure Levels in An 8 Year Old Girl

30, 24, 18, 12, 6, 0

3:31 PM 7:00 10:00 1:00 4:00 7:00 10:00 3:54 PM

Time of Day

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Estimated Distribution of Average 24-Hour Magnetic Field and 95% Confidence Interval

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Percentage of People with Field Greater than Given Value

**Upper Limit
of 95% Confidence Interval**

Estimated Distribution of 24-Hour Average Magnetic Fields and 95 % Confidence Interval

**Lower Limit
of 95% Confidence Interval**

Average 24-Hour Magnetic Field (mG)

From Zafanella Thousand Person Survey 1998

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Personal exposure

Background field in home

Appliances in home

School

Elsewhere

Our measurements of background field in home

Sources and contributions

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Residential Exposure Surrogates (magnetic fields)

- Distance

- Wire-codes

- Calculated fields

- Measurements
  - Spot measurements
  - 24-48 h measurements
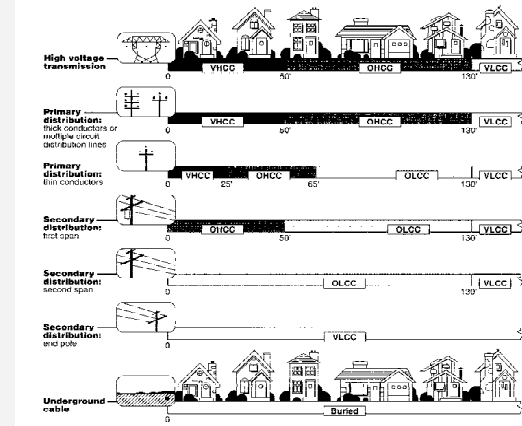 - Personal measurements

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Distance to power line

- Crude estimate of magnetic field level in the home

- Correct only very close to high voltage transmission lines
  - i.e. less than 40-50 meters from largest transmission lines (>200 kV)

- Few people live close to high voltage transmission lines

ELF

Wire-codes

- Originates from Wertheimer & Leeper, 1979

- Takes into account distance and **potential** load

- Higher specificity than distance alone - but
  - Does not take variation in power line load into consideration
  - Fields are high mostly in high category

ELF

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Calculated fields

Take into account:

- Distance to power line

- Power line load – historical estimates

- Characteristics of the line
  - Height of towers
  - Distance between conductors
  - Ordering of phases
  - Direction of current
  - Other nearby power lines

ELF

Measurements
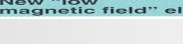
- Short term spot measurements
  - May not be representative of long term historical exposure
  - Highly sensitive to variation of the exposure during the day, year and location

- 24-48 hour measurements
  - Better than spot-measurements, but may still not capture historical exposures
  - Sensitive to exposure variation over different seasons and to location

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Measurements

- Capture all sources of exposure

- Cannot be made historically

- More variable over time - less reproducible

- Personal measurements

  - Problematic in case-control studies due to change in age and especially **disease**

Appliances

Distance from source		
0.03 m	**0.3 m**	**1 m**
Clothes washer 0.8–40 µT	0.2–3µT	0.01–0.2 µT
Television 2.5–50	0.04–2	0.01–0.2
Electric range 6–200	0.4–4	0.01–0.1
Microwave oven 75–200	4–8	0.3–0.8
Fluorescent lamp 40–400	0.5–2	0.01–0.3
Electric razor 15–15,000	0.1–9	0.04–0.3
Hair dryer 6–2,000	0.1–7	0.01–0.3

	0.01 m	**avg. in body**	**1 m**
Conventional electric blanket	10 µT	1.5 µT	< 0.1 µT
New "low magnetic field" electric blanket	1	0.15	< 0.01 "

- Magnetic fields fall of rapidly with distance
- Can give high localized peak exposures
- Small contribution to TWA 24-h exposure
- Historically unstable – need to rely on self reports
  - Recall bias a potential problem
- One appliance at a time

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Note that…

- Exposure comes from many sources
- Distance to the source is the major determinant of exposure
- Exposures are prevalent and highly variable
- High, prolonged exposures are rare

ELF

When exposure is rare

- High ***specificity*** of exposure estimate very important
  - Specificity = probability that unexposed individual is classified as unexposed
- Even a slight reduction in specificity may dilute risk estimate ***considerably***
- Not important to find everyone who is exposed, i.e. high *sensitivity* is **not** needed
  - Misclassification of exposed subjects as unexposed does not affect results much

Improvments in Specifity

- **Distance has low specificity** – majority of persons categorized as exposed will be unexposed
- Calculated fields Has primarily improved the **specificity** of the exposure assessment

Relevant exposure metric unknown

Biophysical plausibility: dubious below 50 µT

No known biological mechanism

at low levels of exposure

- Time weighted average ?

- Peak exposure ?

- Intermittent exposure ?

NB. No one is unexposed!

ELF

Exposure Metric

peak: 149 µT

mean: 0.11 µT

magnetic field / µT

time / hours
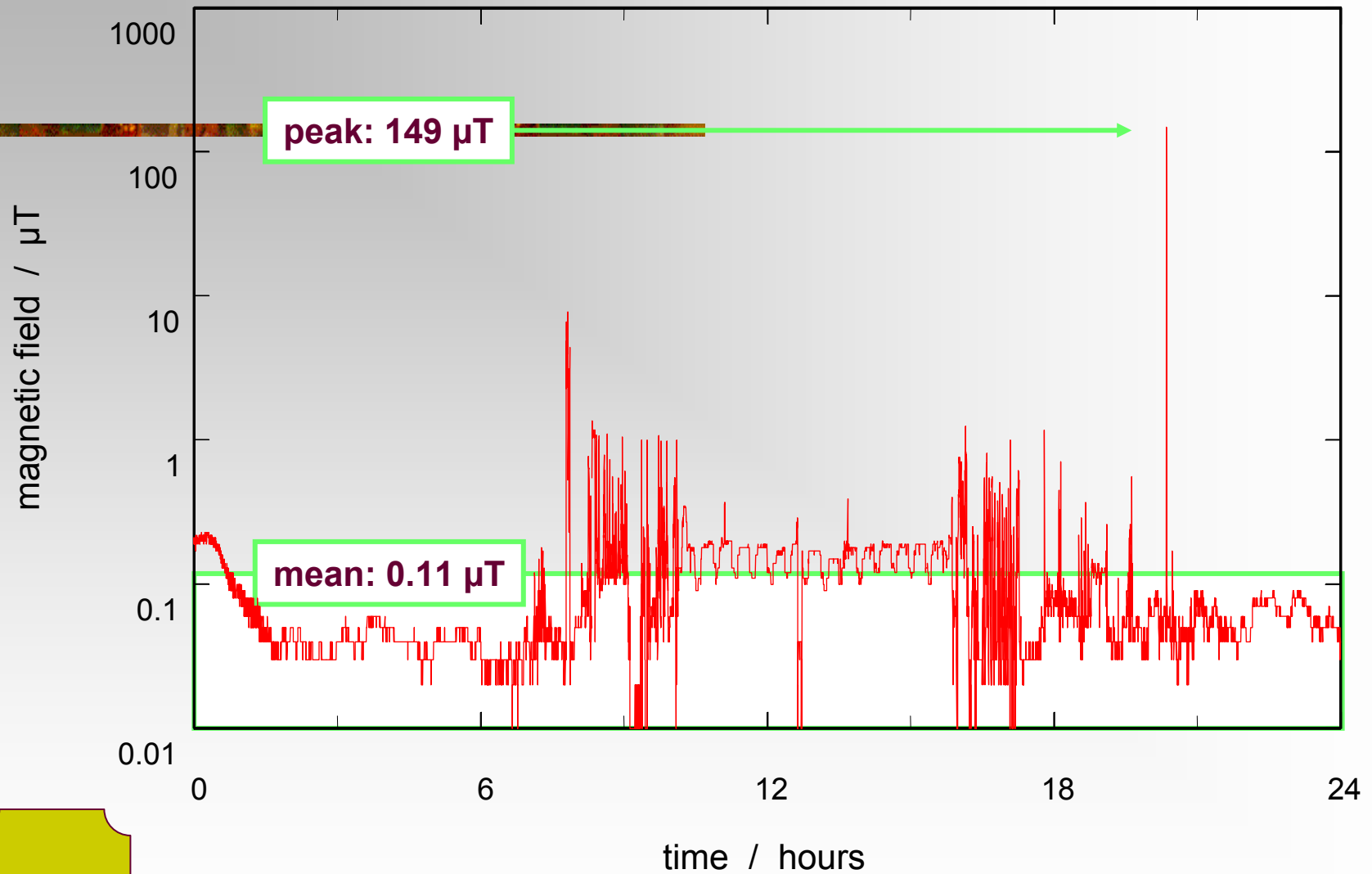
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Time-weighted average (TWA)

- Majority of studies have focused on TWA

- For population exposure: high specificity (91-98%) when using TWA as an estimate of other metrics

  - e.g. time above 0.4 µT, time above 1.6 µT, maximum fields, sudden changes >0.1 µT, intermittence, length of time in a constant field above 0.2 µT

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Exposure Metric:
"Some other aspect of exposure"

- Threshold/peak/high fields

- Polarisation

- Waveform
  - harmonics, transients

- Rate of change/intermittency

- AC/DC

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Exposure Metric: Related exposures

- **Power line specific**
  - characteristic of the field
  - SES/mobility/demographic
  - E-field
  - corona ions
- **Contact currents**

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Consistent association between childhood leukemia and exposure > 0.3-0.4 μT

Possible explanations:

- Chance????
- Misclassification???
- Confounding??
- Selection bias?
- Other?
- Causal relationship?

ELF
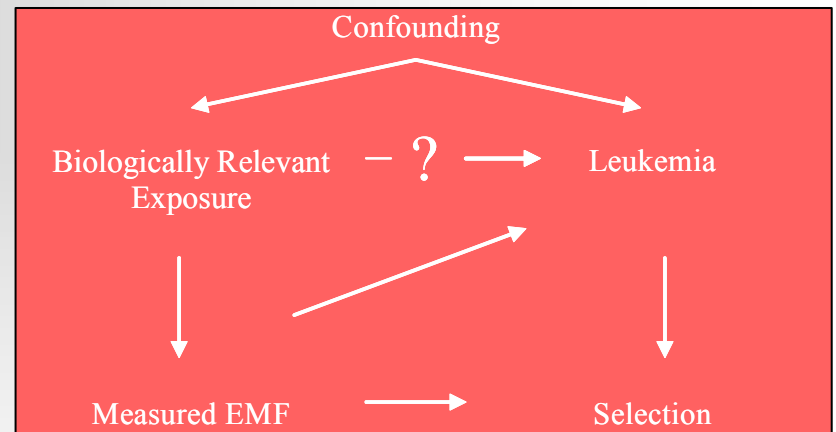
Challenges

- Biophysical plausibility
- Good animal model for childhood leukemia
- Evaluating Selection Bias
- Other Explanations?

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Challenges

- Confounding: Numerous factors examined:
    - SES
    - Traffic Density
    - Chemical exposures
    - Environmental tobacco smoke
    - Dietary agents
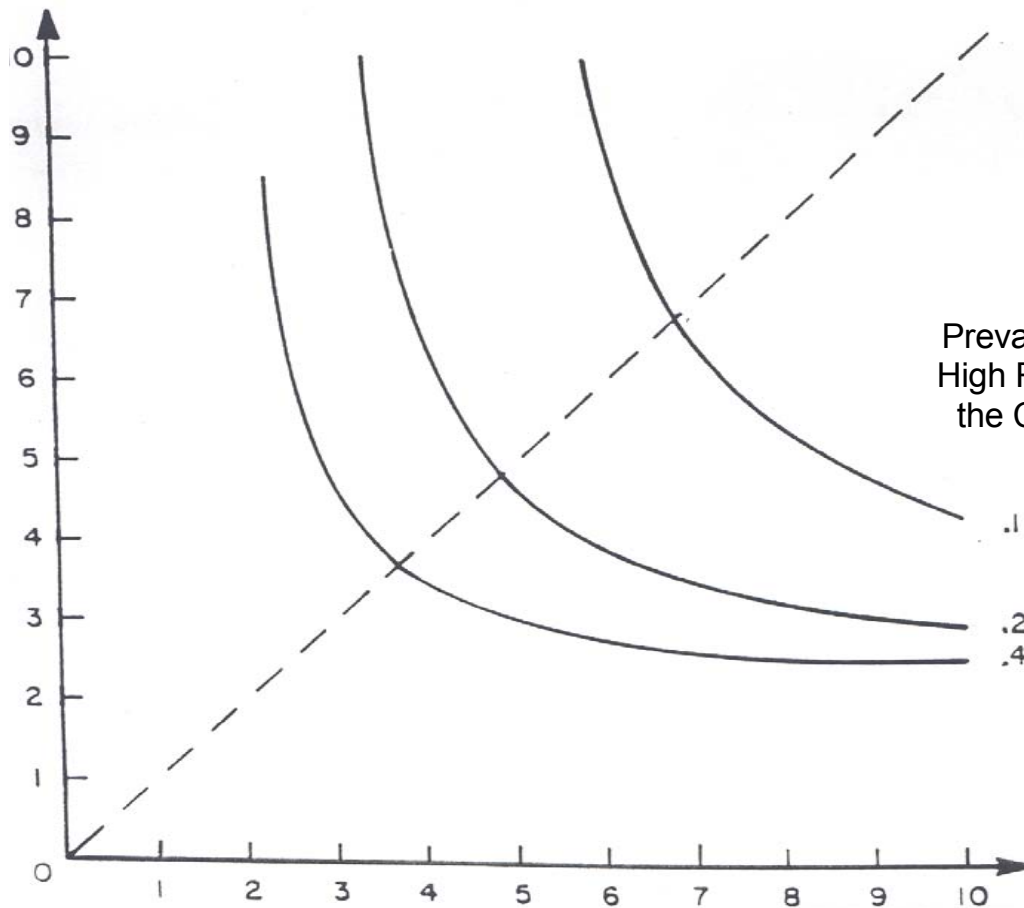   - Viral or other infectious agents

Not one confounds the association

    - Simultaneous effect?

ELF

Combination of Selected Values Suffiecient for a Confounder to Account for an obsrved Relative Risk of 2

Association between Exposure and Confounder (Relative Prevalence)

Prevalence of the High Risk Level of the Confounder

.1
.2
.4

Association between Confounder and Disease (Relative Risk)

Look to the Future

- **Second hit :**

multistage sampling within Birth Cohorts

- Influence of Exposure among those with translocations

- **TRANSEXPO: Cohort of Highly Exposed Children**

  - Apartments above transformers
  - Selection bias minimized

ELF

Map labels:

Hornsby

Extends 7.5 km   Extends 15 km

Ku-ring-gai

Warringah

Ryde

Willoughby

Manly

Lane
Cove

2   3

1

Hunters
Hill

North
Sydney

Mosman

Drummoyne

Sydney

Leichhardt   Woollahra

RF

1 0 1 2 3 4 5
Kilometres

Wireless Communication Technologies

- Mobile Communication
  - GSM (Global System for Mobile Communication)
  - CDMA 2000 (Code Division Multiple Access)
  - DECT (Digital Enhanced Cordless Communication),
  - UMTS (Universal Mobile Telecommunication Systems)
- Local area networks
  - WLAN (Wireless Local Area Network)
  - Bluetooth
  - UWB (Ultrawideband),
  - Hiperlan (High Performance Local Area Network),
  - WiMax (Worldwide Interoperability for Microwave Access)
- Broadcasting
  - DAB (Digital Audio Broadcasting)
  - DVB-T (DigitalVideo Broadcasting –Terrestrial)
  - DRM (Digital Radio Mondiale)

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Residential Exposure Surrogates

- Distance

- Calculated fields (modeling)

- Measurements
  - Spot measurements
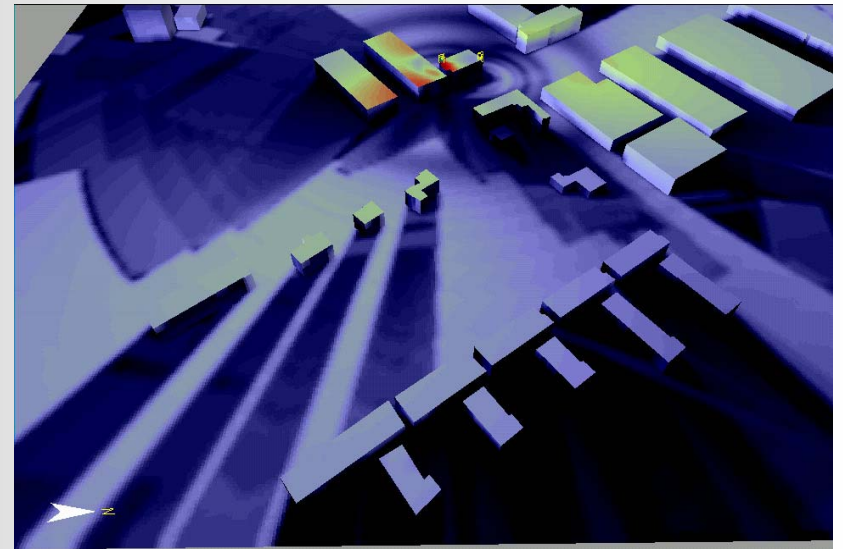 - 24-48 h measurements
  - Personal measurements

RF

Distance

- Might be OK from AM/FM transmitters

- Not good for base stations
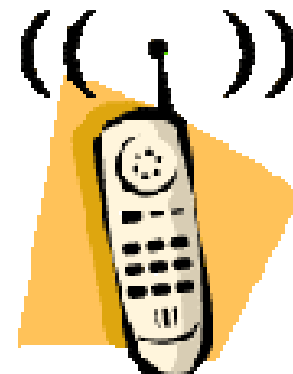
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Calculated Fields

- Mostly done for sources rather than people

- To find places of high exposure and compliance

- Need development to estimate exposure of Individuals

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Measurements

- Meters suitable for CL study?

- Meters tend to underestimate "real exposure"

RF

Challenges

- Better Exposure assessment

- Broadband-Measurement vs. freq specific

- Studies designed to test specific hypotheses

  (NOT Previously identified clusters)

RF

- Large Numbers

Look to the Future

- Need information on Sources
- Need meters that can be used in large scale studies of children
- Appliances might be more important

    Baby monitors, Mobile phones, Computers

- ELF exposure from mobile phones

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