

DMF Workshop, Long Term Effects, 11.-12.10.2007

**Consistent Outcome of Exposure
of Pre-Leukaemic AKR/J Mice to
Magnetic (50 Hz, 1, 100, and 1000 μ T)
and Electromagnetic Fields
(900 MHz, 1966 MHz, 0.4 W kg⁻¹)
Projects 5 and 6**

Alexander Lerchl, Angela M. Sommer

School of Engineering and Science
Jacobs University Bremen, Germany

Background

- Are MFs / EMFs associated with the initiation or promotion of malignancies?
- Epidemiological data suggest a higher incidence of childhood leukemia at flux densities $> 0.4 \mu\text{T}$ (IARC, 2002), or at close proximity to high voltage power lines (Draper et al., 2005), supporting an earlier assessment published by NIEHS (1998).

AKR/J mice as an animal model

- Viremic (retrovirus AKV) from birth
- High incidence to develop leukaemia (60 – 100 %) after a symptom-free time of approximately 4 months
- Tendency for obesity
- Widely used model in cancer research

Studies

- In our laboratory, a series of experiments has been performed investigating the effects of MF / RF-EMF on the development of leukemia in AKR/J mice:
 - 50 Hz, 1 μ T and 100 μ T, and 1000 μ T
 - For 1000 μ T, animals were exposed for 12 or for 24 hrs / day.
 - 900 MHz, GSM, and approx. 1966 MHz (UMTS) at 0.4 W/kg SAR

Questions:

Does exposure affect

- survival
- body weight
- blood cells

in AKR/J mice ?

General Methods:

- Power analysis to verify animal numbers
- At n=160 animals per group, a shift by approx. 1 month would have been detected (survival sensitivity)
- Blinded design
- For each group: 160 female AKR/J mice (Jackson Laboratories, Bar Harbor, ME), age 4 – 5 weeks
- Temperature = $20^{\circ}\text{C} \pm 2^{\circ}\text{C}$ Photoperiod: 12:12
- Inspections daily; weighed and palpated weekly
- Animals were sacrificed by CO_2 as soon as first signs of disease were evident, or when animals were older than 42 weeks.

Exposure to Magnetic Fields

- Merritt design (4 coils, 27, 11, 11, 27 turns)
- 16 mm² coils
- For 1 and 100 μT : sine wave generators
- For 1000 μT : step-down transformer
- Measurements with fluxmeters
- Deviations inside the coils < 2%

Exposure Units for MF

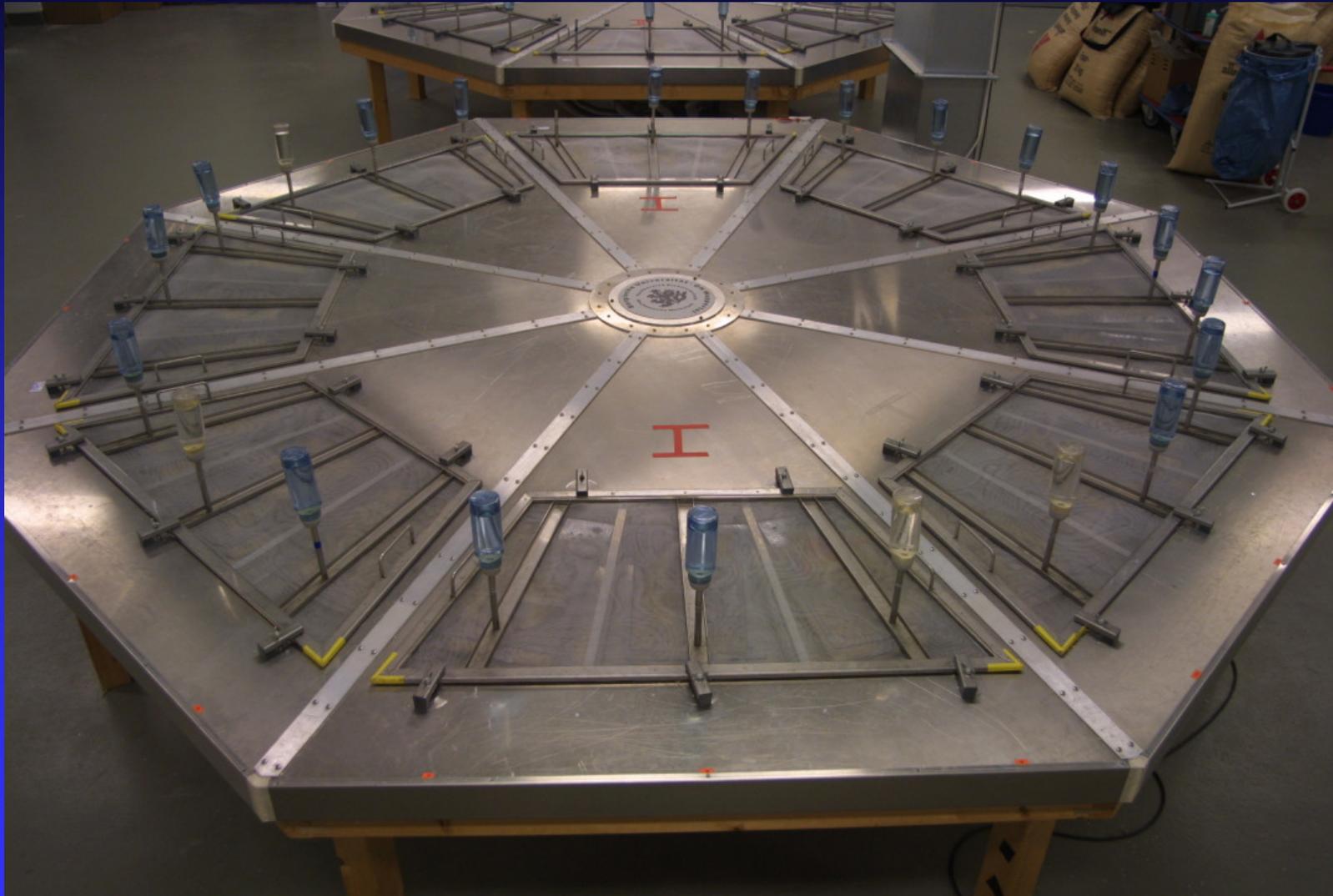


Aluminum foil
for elimination
of electric fields
(bridged)

Exposure to RF-EMF

- Design: Radial waveguides; diameter 4 m, vertical plate distance 14 cm (900 MHz) and 8 cm (1966 MHz).
- SAR = 0.40 W/kg (average) at 35 W (900 MHz) and 15 W (1966 MHz) RF input. Modulation: GSM (900 MHz) and generic UMTS signal (Ndoumbè Mbonjo Mbonjo et al., Bioelectromagnetics 25: 415-425 (2004)).
- Exposure for 24 hrs/day except periods of inspections, cleaning.

Exposure Units for RF-EMF (n = 2)

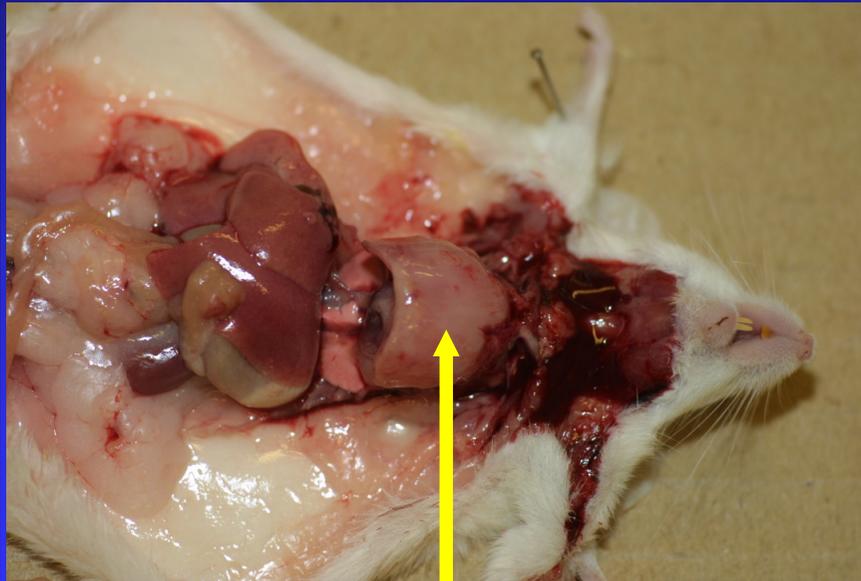


Exposure Units (detail)

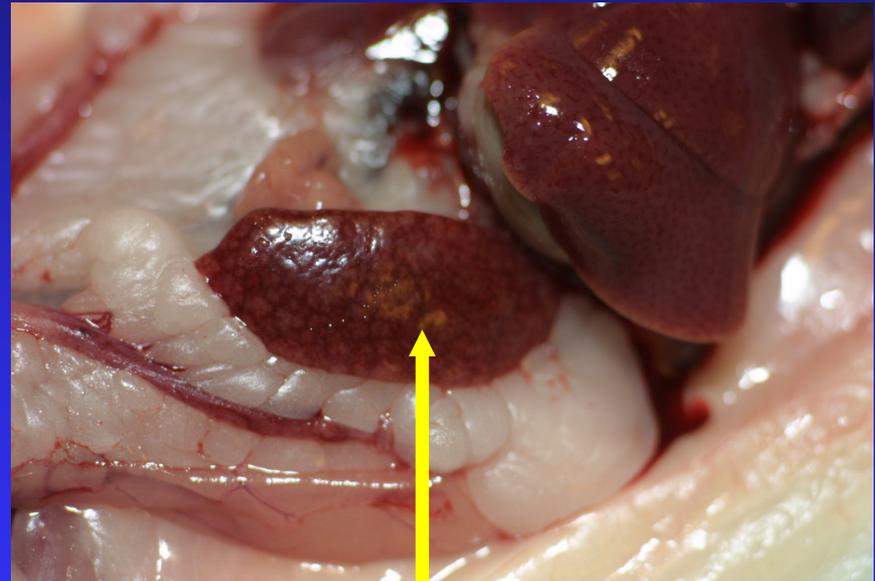


Results: Gross Pathology

Most of the mortality was related to the development of Lymphoblastic Lymphomas

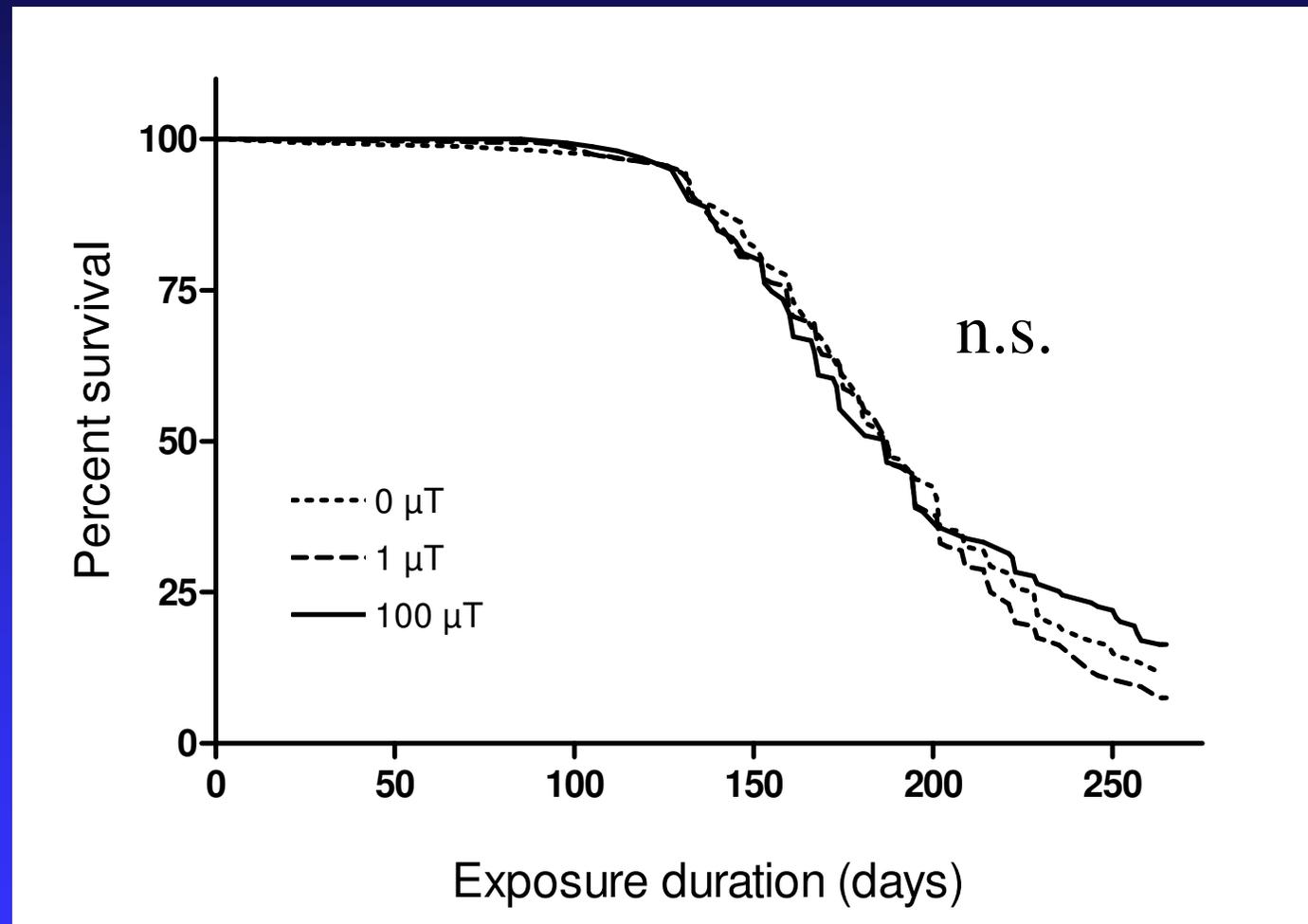


Enlarged Thymus



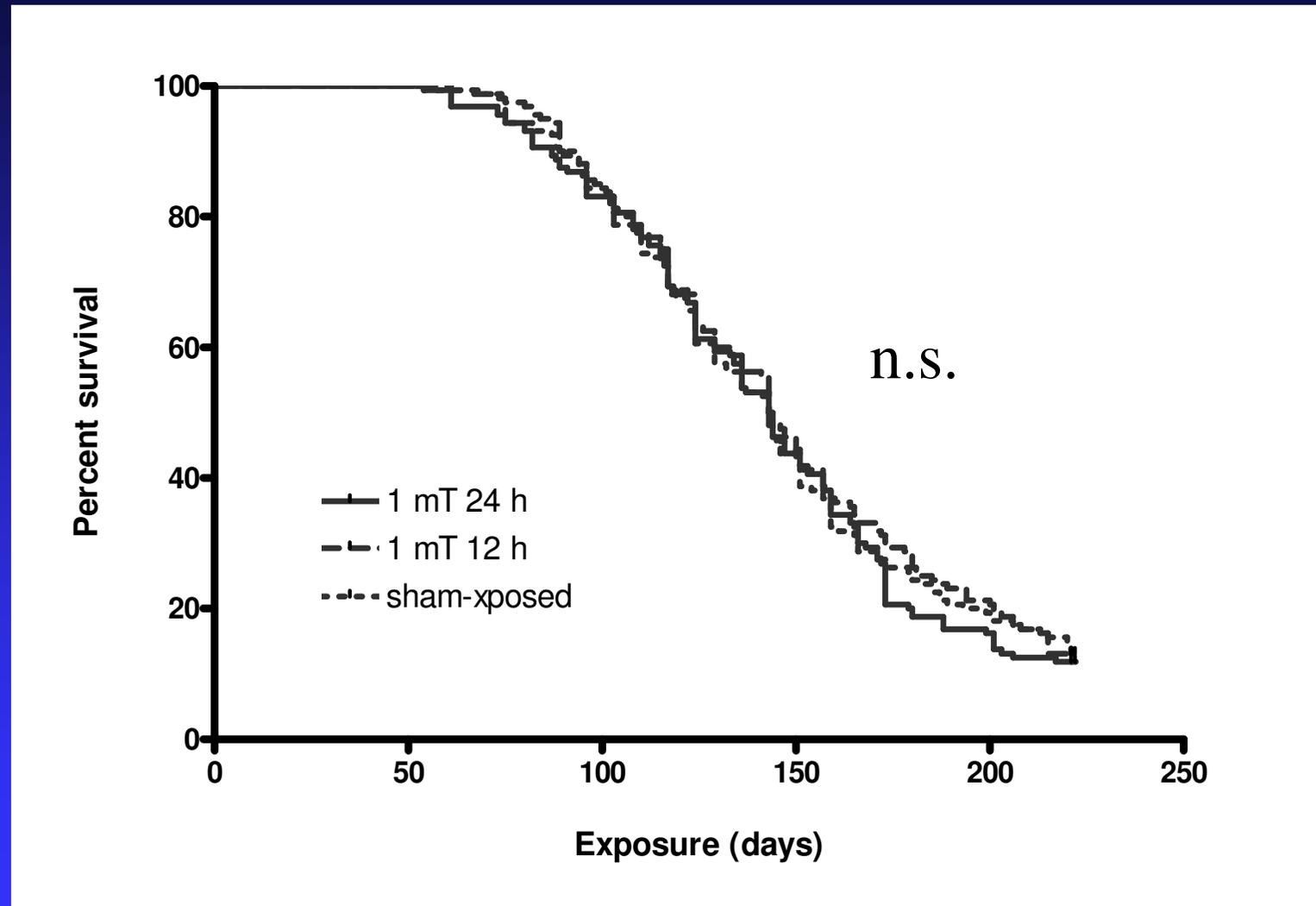
Enlarged Spleen

Results: Survival; Magnetic Fields



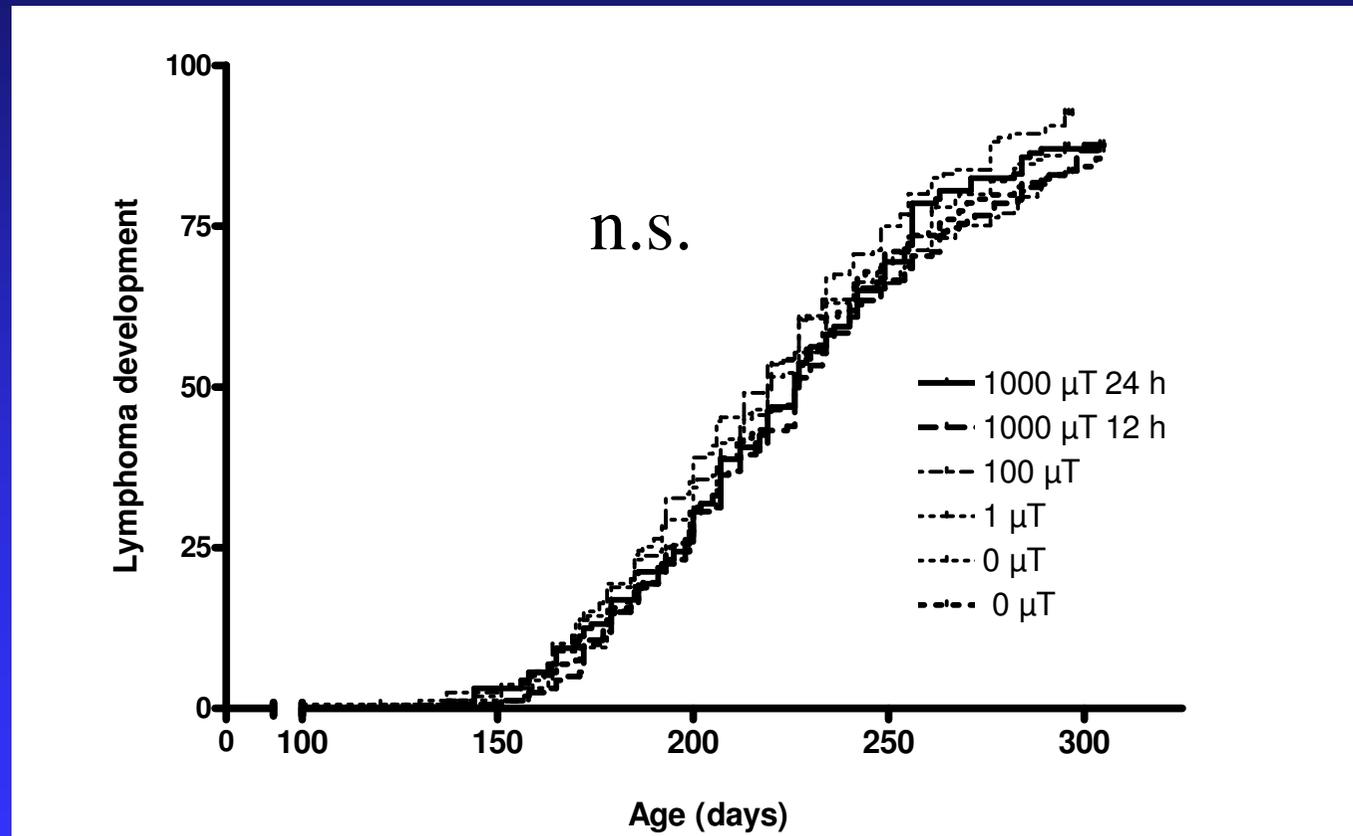
Sommer et al., 2004

Results: Survival; Magnetic Fields

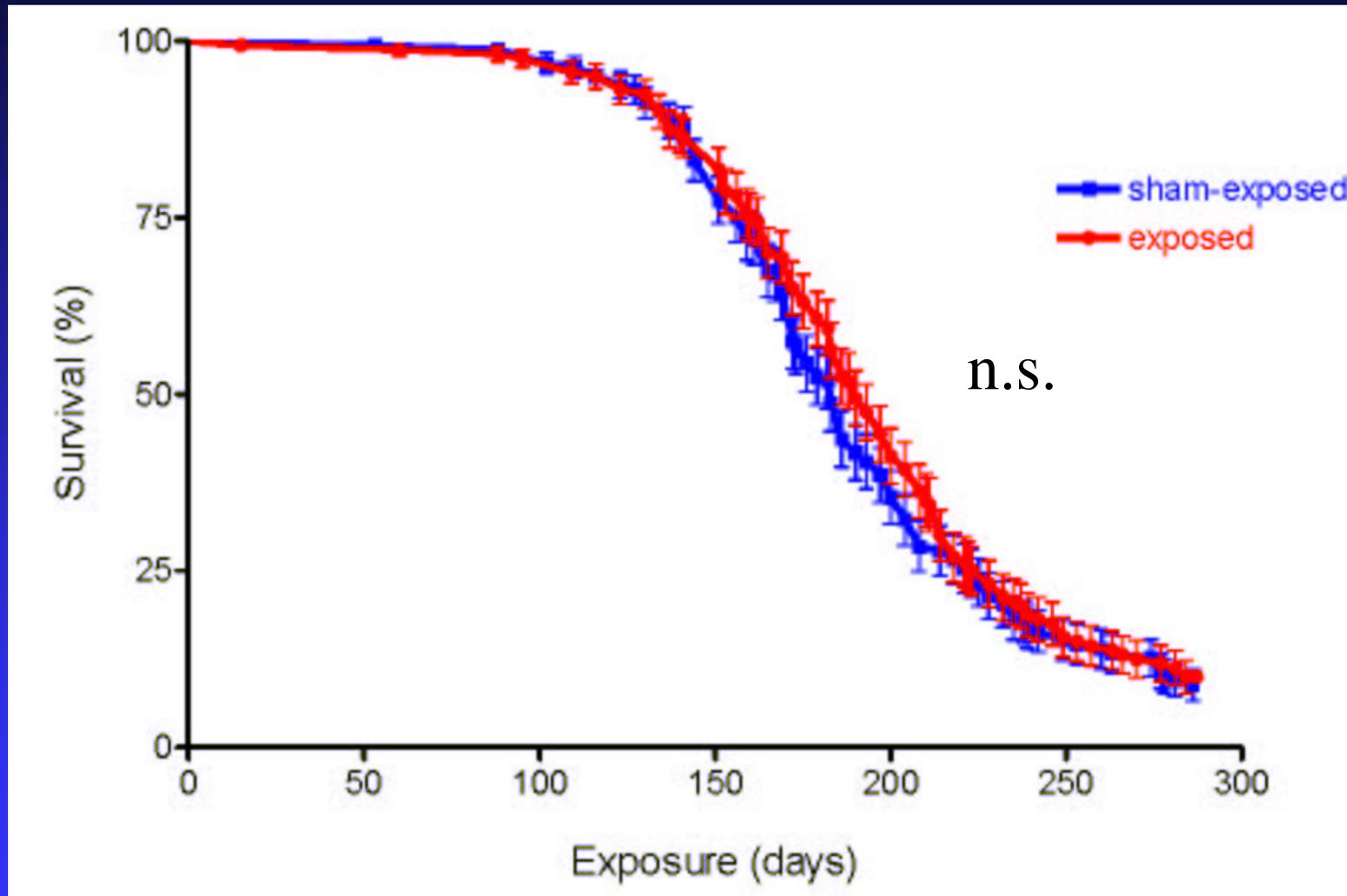


Sommer et al., 2006

Results Lymphoma Development; Magnetic Fields (all results)

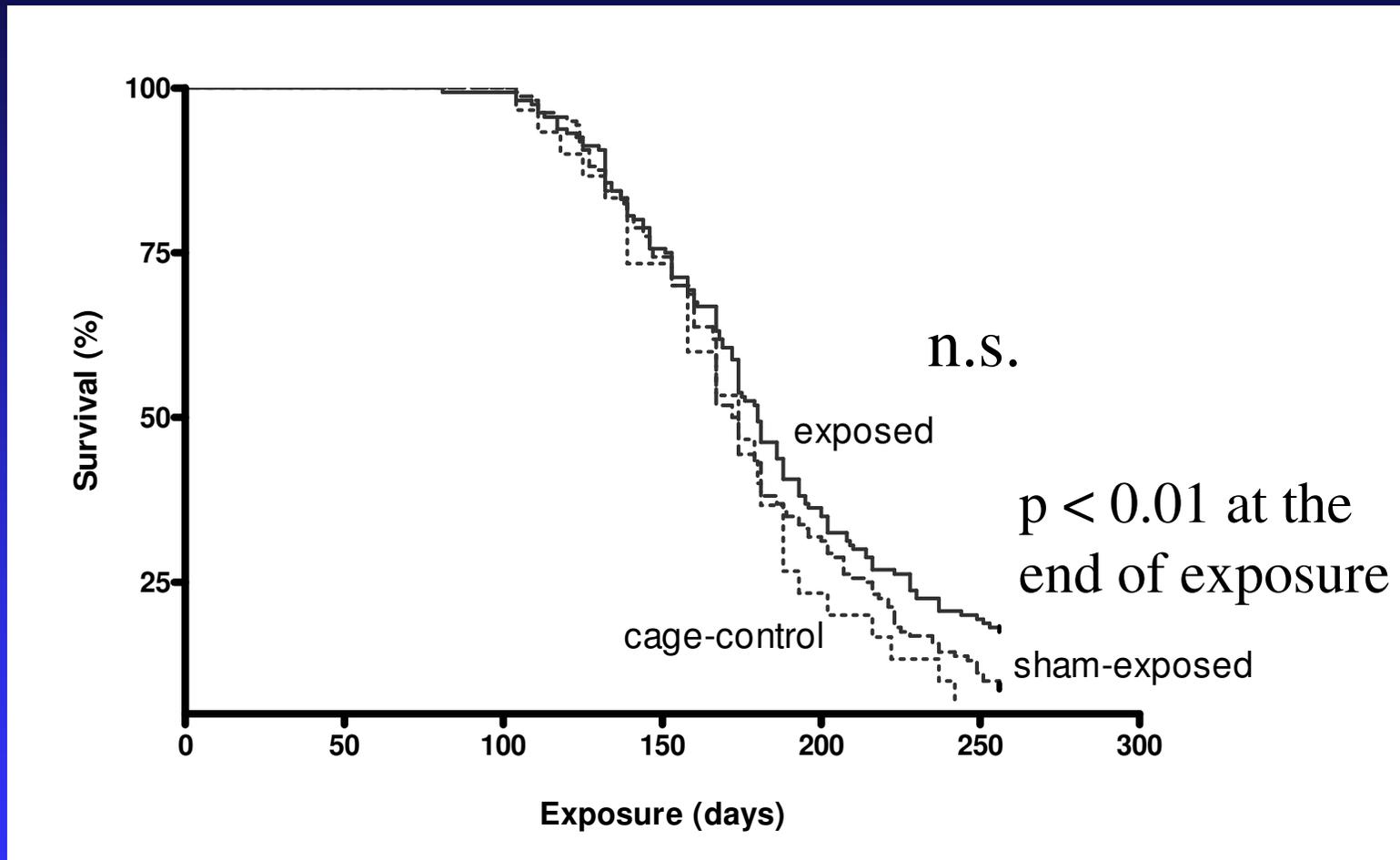


Results: Survival; 900 MHz



Sommer et al., 2004, BMC Cancer

Results: Survival; 1996 MHz

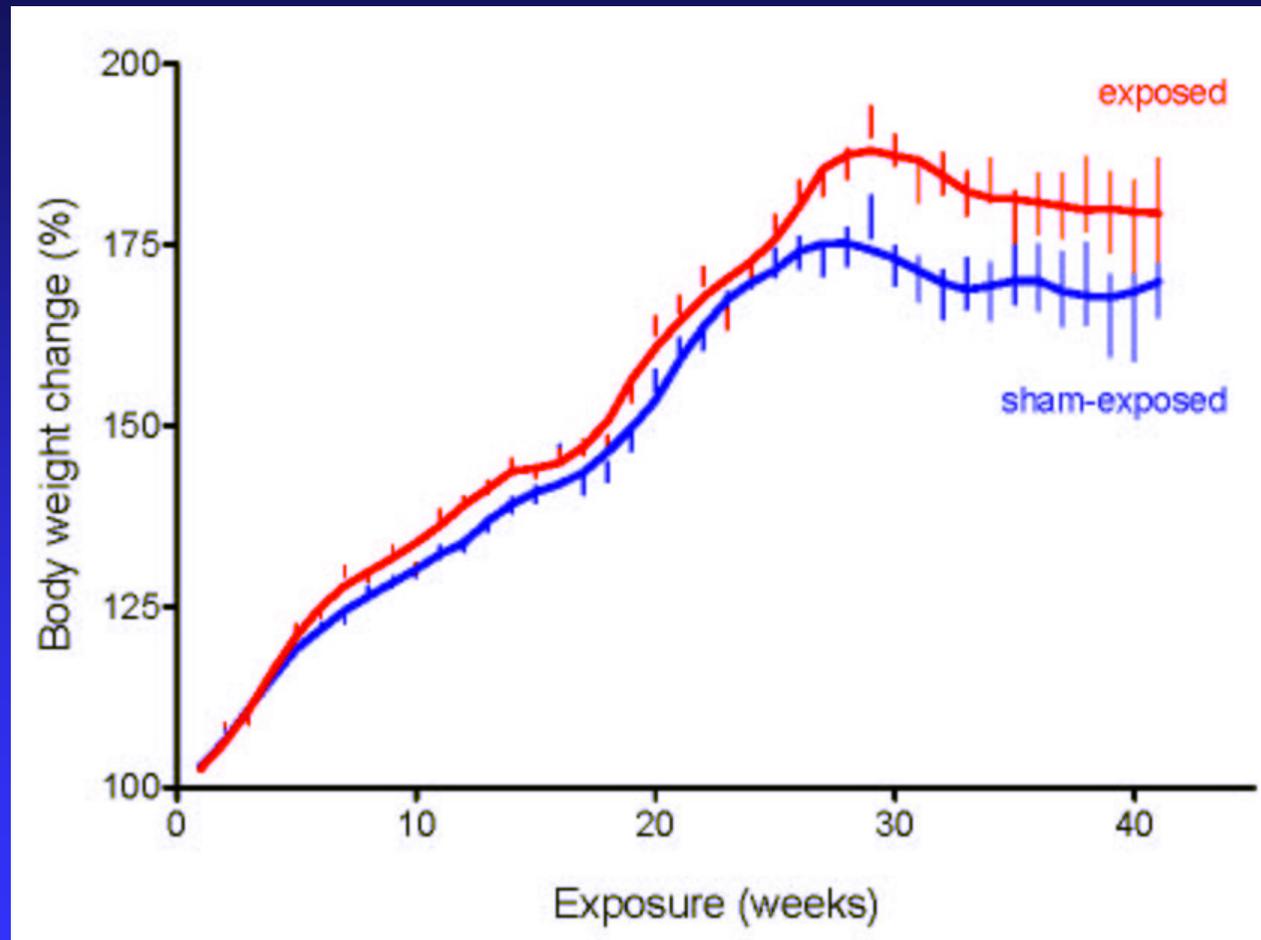


Sommer et al., 2007, Radiation Research

Other Results

- No effects of exposure on blood cell counts and hematocrit values. No effects on body weight (except 900 MHz)
- All results are published:
 - ◆ Radiation Research 2004 (1 and 100 μ T MF)
 - ◆ Radiation Research 2006 (1000 μ T MF)
 - ◆ BMC Cancer 2004 (900 MHz EMF)
 - ◆ Radiation Research 2007 (1966 MHz EMF)

Body Weight Increase in 900 MHz Exposed Mice



Sommer et al., 2004

Conclusions

- Magnetic and electromagnetic fields did not affect survival or the development of lymphomas in AKR/J mice at relevant exposure levels.
- The data do not support the hypothesis that magnetic or electromagnetic fields promote leukemia.

Limitations

■ SAR = SAR?

- ◆ BMR in mice approx. 7 W kg^{-1}
- ◆ BMR in humans approx. 1 W kg^{-1}

■ $\mu\text{T} = \mu\text{T}$?

- ◆ Induced currents depend on body dimensions

■ Life long = life long?

- ◆ Mice were exposed for approx. 1 year
- ◆ Humans live much longer

Acknowledgements

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- Reprints: a.lerchl@jacobs-university.de

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**Influence of Electromagnetic Fields of
Mobile Phone Communication on the
Metabolic Rate in Rodents
(Project 7)**

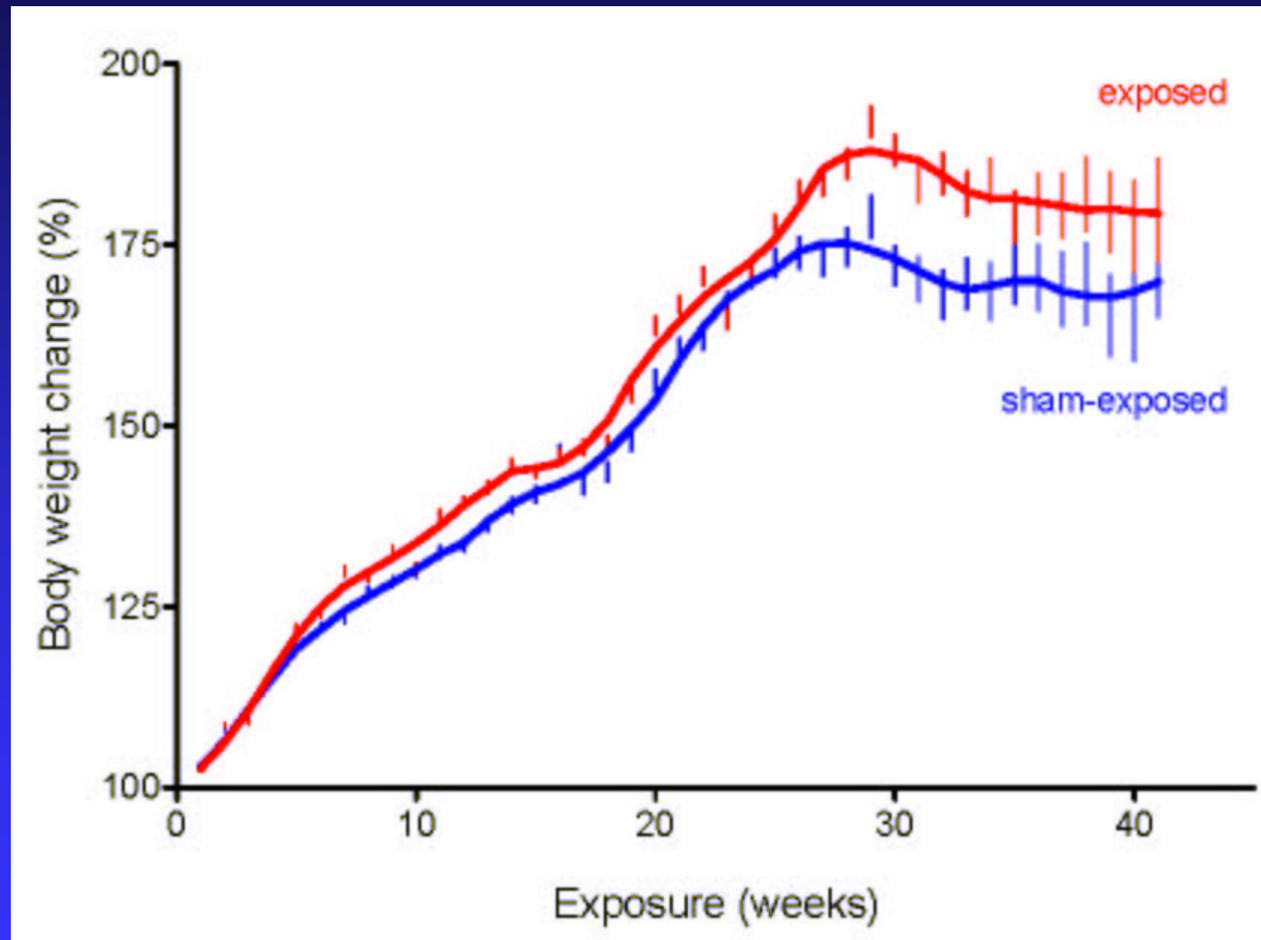
Alexander Lerchl, Kirstin Schwarzpaul

School of Engineering and Science
Jacobs University Bremen, Germany

Background

- Increases of body weight were observed in some studies in mice and hamsters:

Body Weight Increase in 900 MHz Exposed Mice at 0.4 W kg^{-1}



Sommer et al., 2004, BMC Cancer

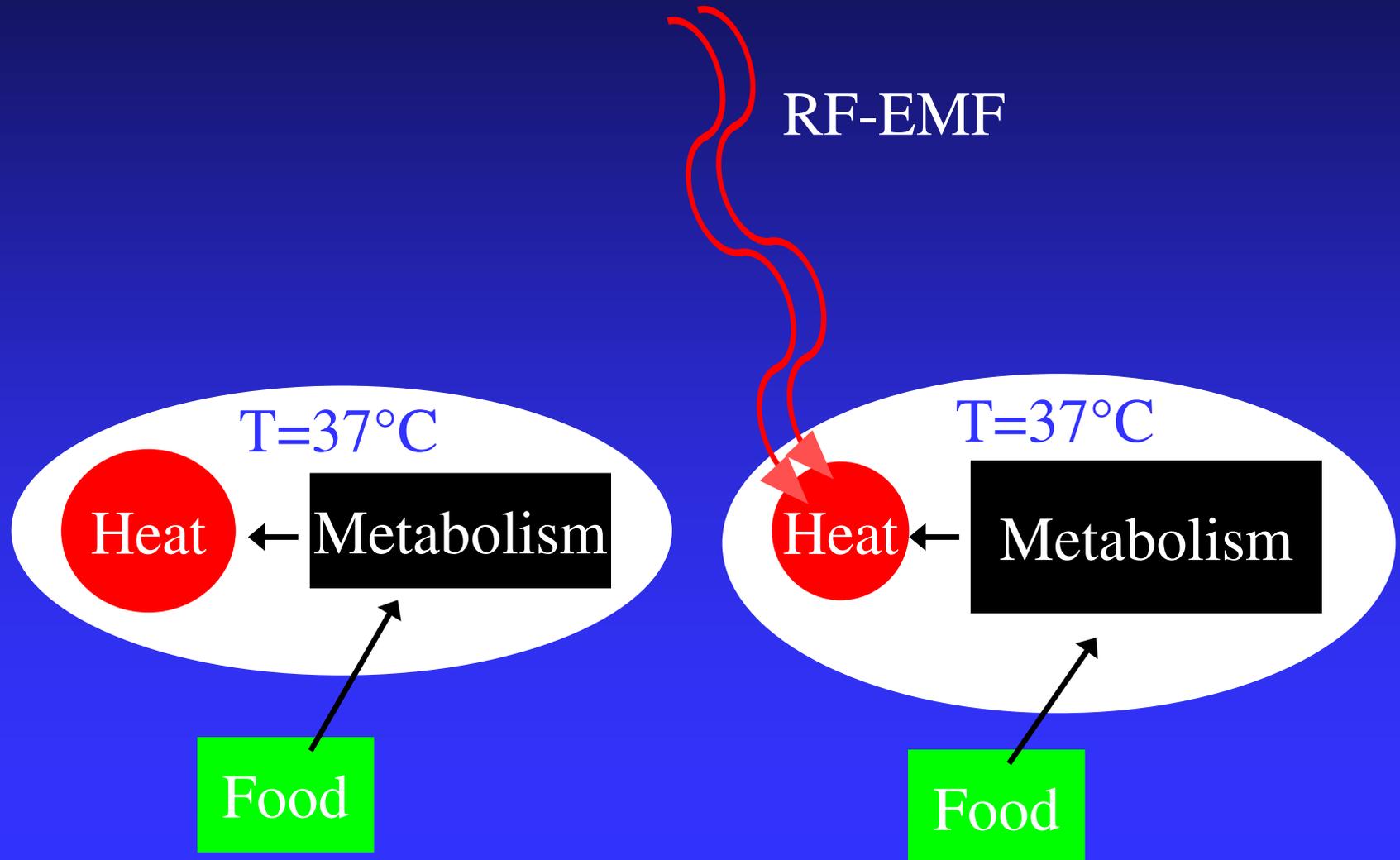
Therefore,

- Body weight may be affected by electromagnetic fields
- This effect seems to be frequency-dependent

Question

- How can non-thermal EMFs affect the body weight?
- Possible explanations
 - ◆ RMF energy is used for heat production, less energy from food is therefore needed for heat production. Food energy may be stored as fat or muscle tissue
 - ◆ Other explanations? Hormones?

Hypothesis: Schematic View



Some more Hints

- Basal metabolic rates (BMR) in hamsters and mice are on the order of $5-7 \text{ W kg}^{-1}$.
- Roughly 30% of BMR is used for heat production (approx. 2 W kg^{-1}).
- At 80 mW kg^{-1} SAR, this corresponds to 4% of BMR, interestingly in the range of body mass increase.

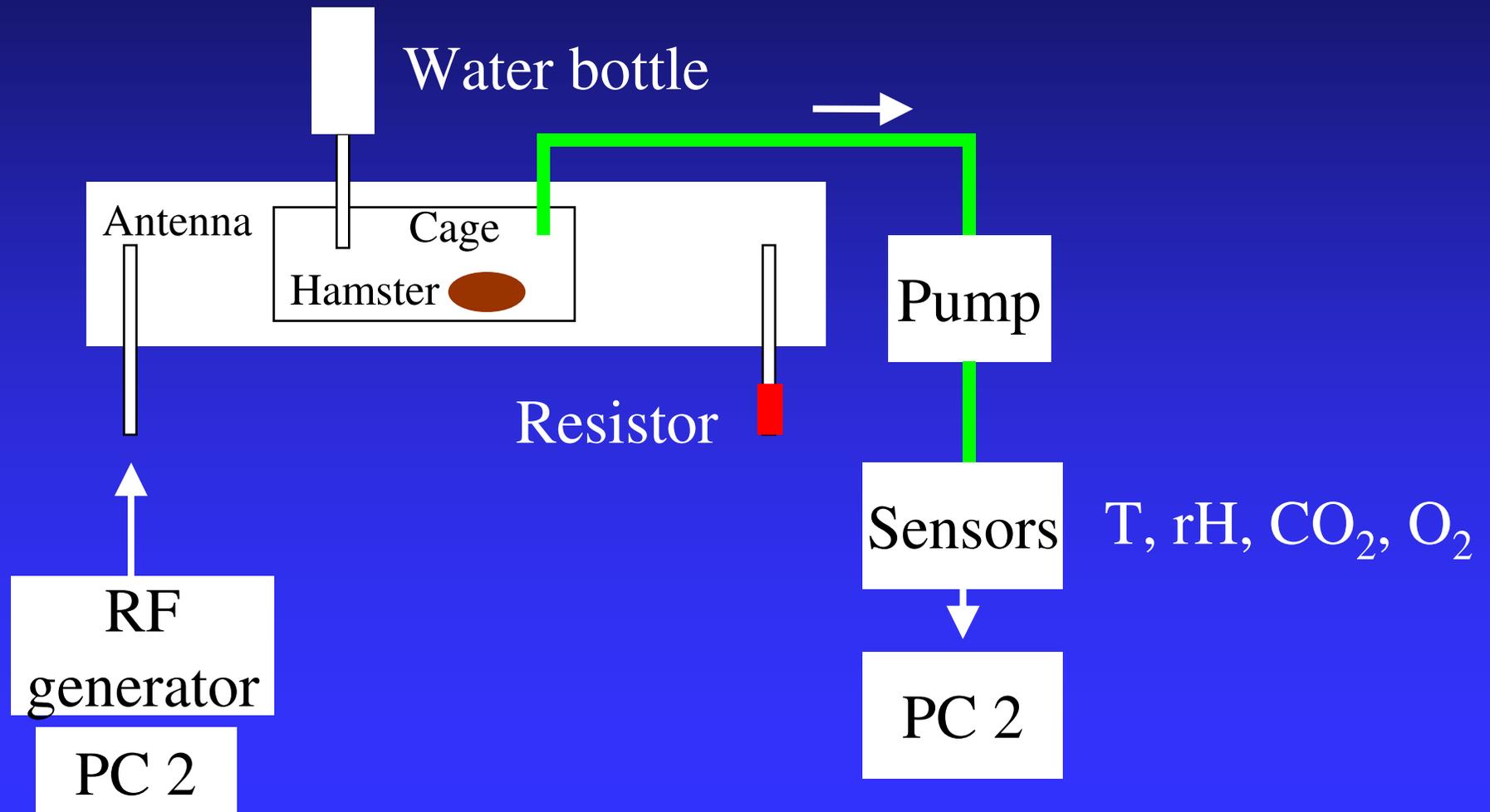
Aims of the Study

- Investigating the effects of sub-chronic effects of EMF on CO₂ production and O₂ consumption in hamsters at SAR levels of 0, 0.08, 0.4 and 4 Wkg⁻¹ for 1 week (random).

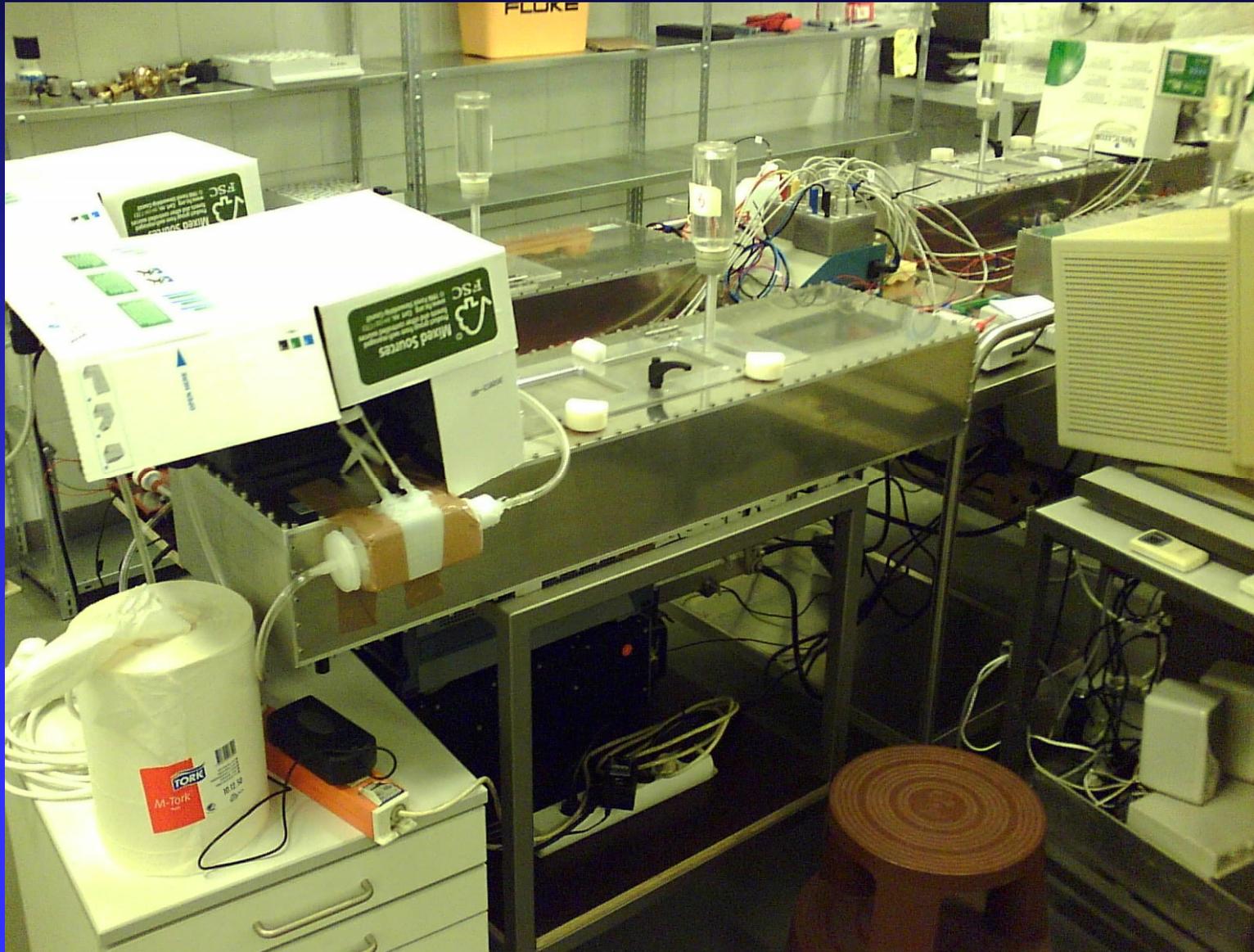


- Establishment of exposure setup.
- Validation of experimental procedure for future experiments.

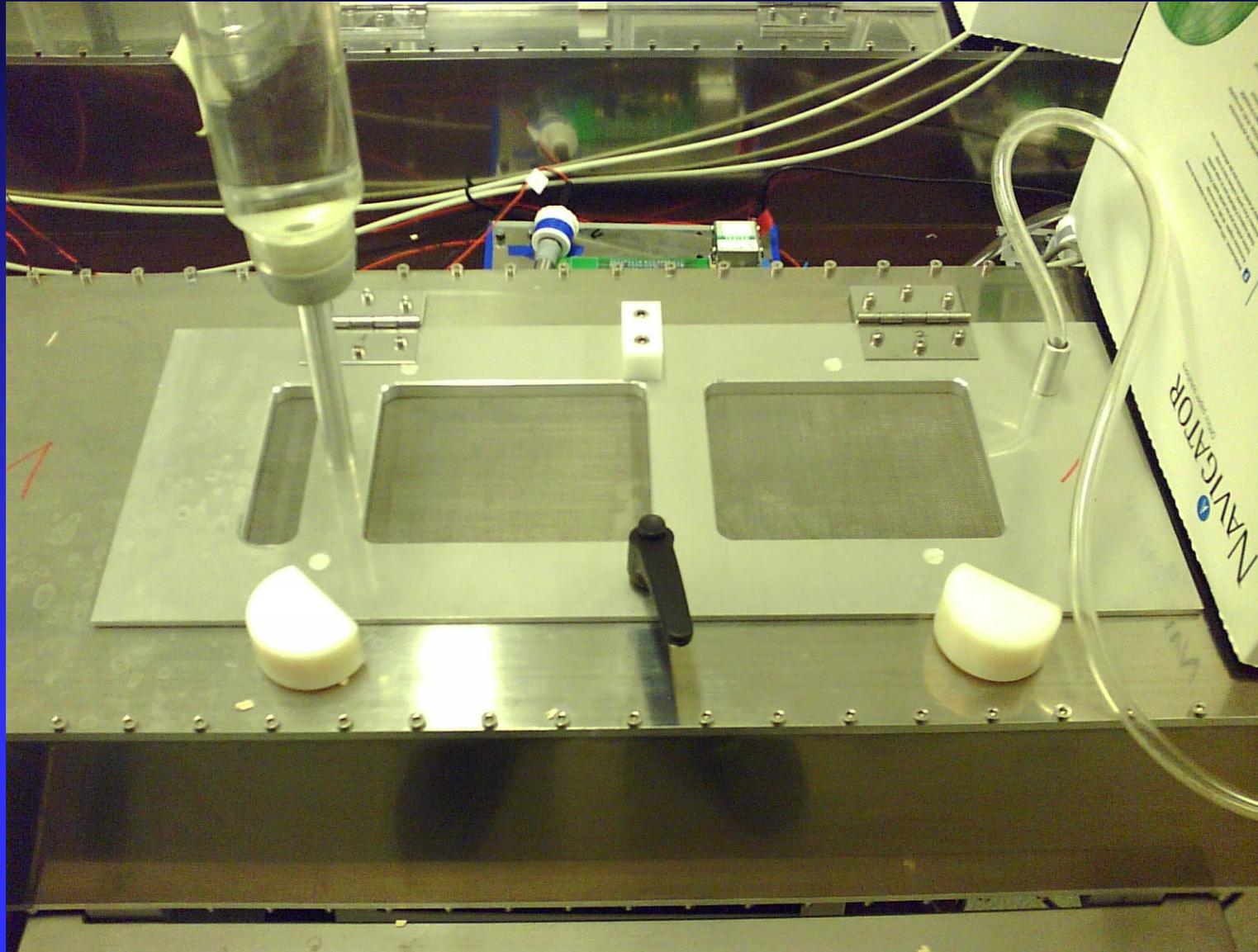
Experimental Setup



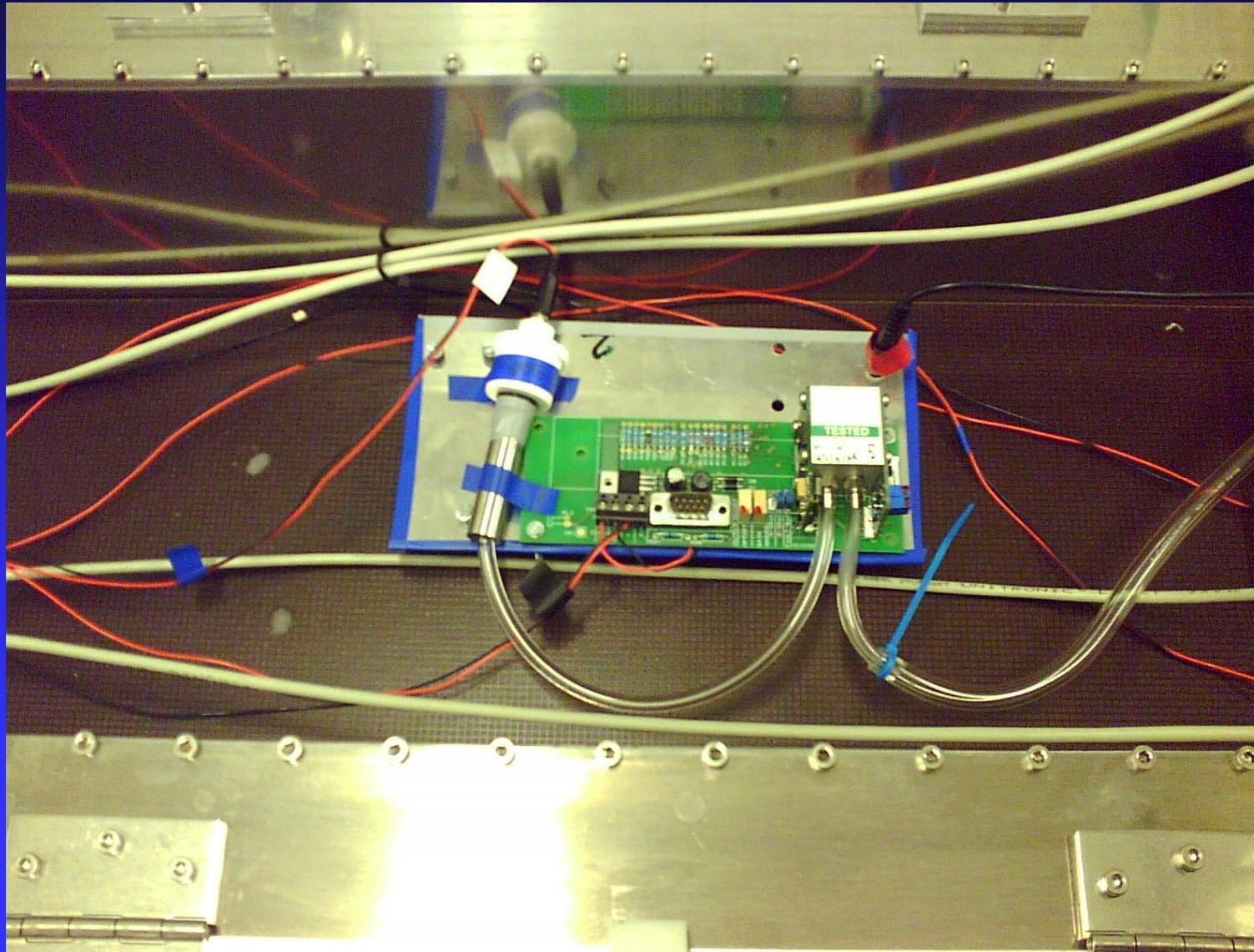
Experimental Setup



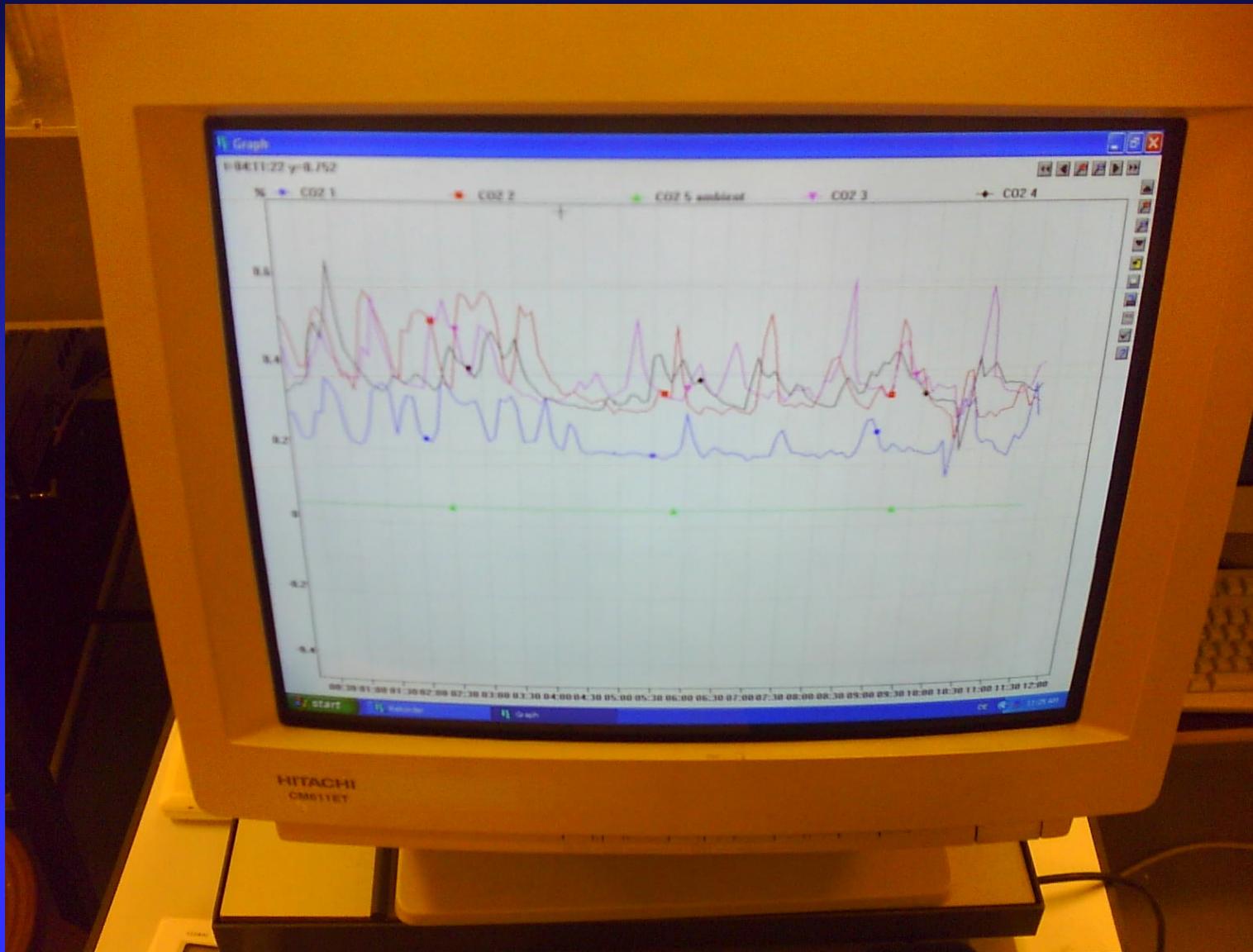
Experimental Setup



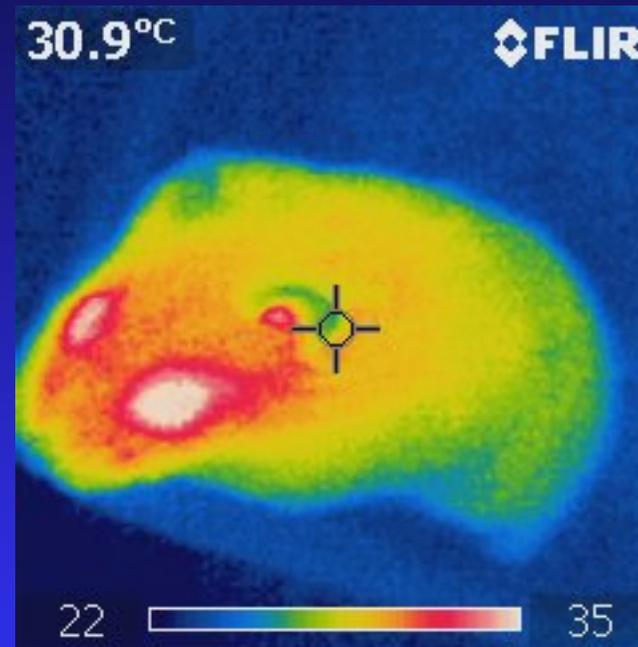
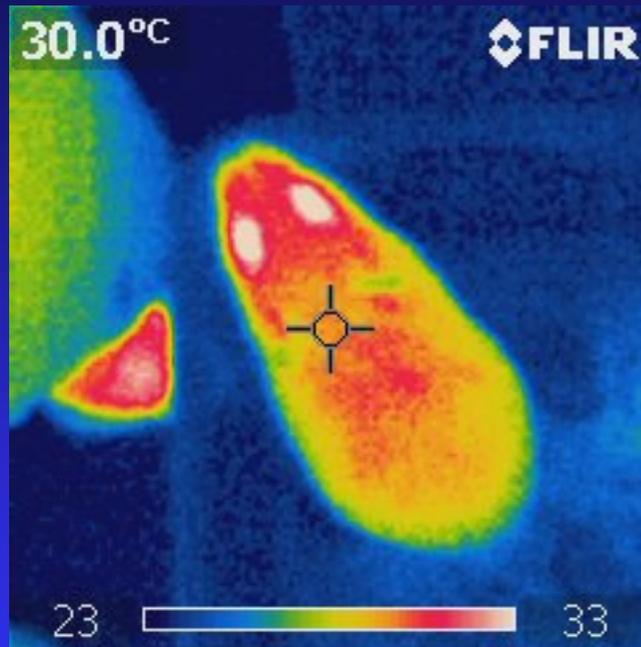
Experimental Setup



Experimental Setup



Thermography



Thank you!