BfS Workshop May 9-10, 2007

Effects of HF Signals on the Melatonin Synthesis in Isolated Pineal Organs of Djungarian Hamsters

(Untersuchungen zu Wirkungsmechanismen an Zellen unter Exposition mit hochfrequenten elektromagnetischen Feldern der Mobilfunktechnologie. B. Pinealdrüse BfS StSch 4318)

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1800 MHz electromagnetic field effects on melatonin release from isolated pineal glands

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Abstract: Isolated pineal glands of Djungarian hamsters (*Phodopus sungorus*) were continuously perifused by Krebs–Ringer buffer, stimulated with the beta-adrenergic receptor agonist isoproterenol to induce melatonin synthesis, and exposed for 7 hr to a 1800 MHz continuous wave (CW) or pulsed GSM (Global System for Mobile Communications)-modulated electromagnetic signal at specific absorption rate (SAR) rates of 8, 80, 800, and 2700 mW/kg. Experiments were performed in a blind fashion. Perifusate samples were collected every hour, and melatonin concentrations were measured by a specific radioimmunoassay. Both types of signal significantly enhanced melatonin release at 800 mW/kg SAR, while at 2700 mW/kg SAR, melatonin levels were elevated in the CW, but suppressed in the GSM-exposed pineal glands. As a temperature rise of approximately 1.2°C was measured at 2700 mW/kg SAR, effects at this level are thermal. With regard to radiofrequency electromagnetic fields, the data do not support the 'melatonin hypothesis,' according to which nonthermal exposure suppresses melatonin synthesis.

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Key words: electromagnetic fields, hamsters, melatonin, mobile phone, pineal gland

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Introduction

In the discussion about the possible mechanisms that are involved in the biologic effects of ELF-MF or RF-EMF, the melatonin hypothesis plays a central role, based on experimental data from the late 1970s showing reduced melatonin values after exposure to electric or magnetic fields.

Original Model:

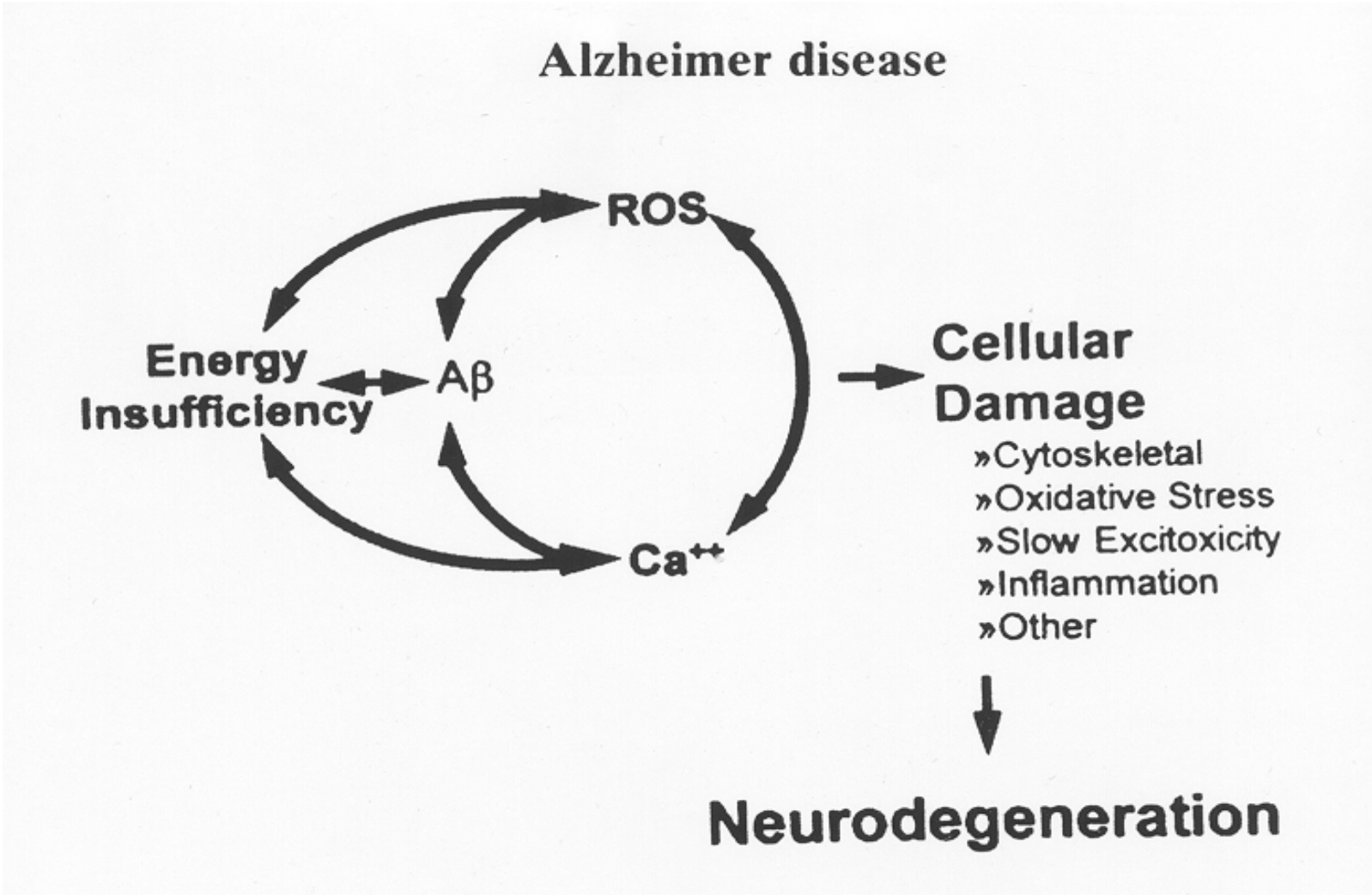
ELF MF/EF → low melatonin → high estrogens → increased breast tumor growth

Introduction

In the mean time (since the early 1990s) it became clear that melatonin has in fact some properties which may be relevant for many diseases.

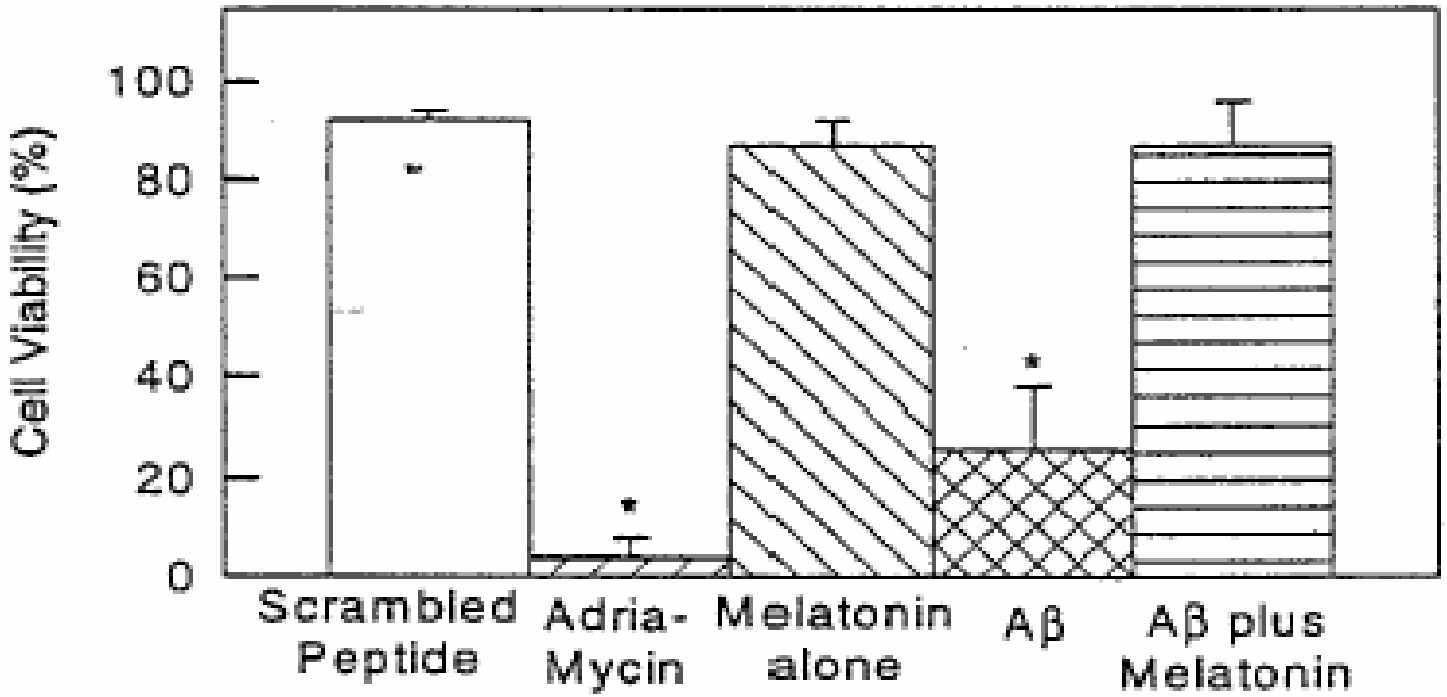
-Cancer
-Stroke (reperfusion)
-Coronary infarction
-and other diseases which are caused by / related to ROS

Melatonin is a Radical Scavenger for Reactive Oxygen Species (ROS)



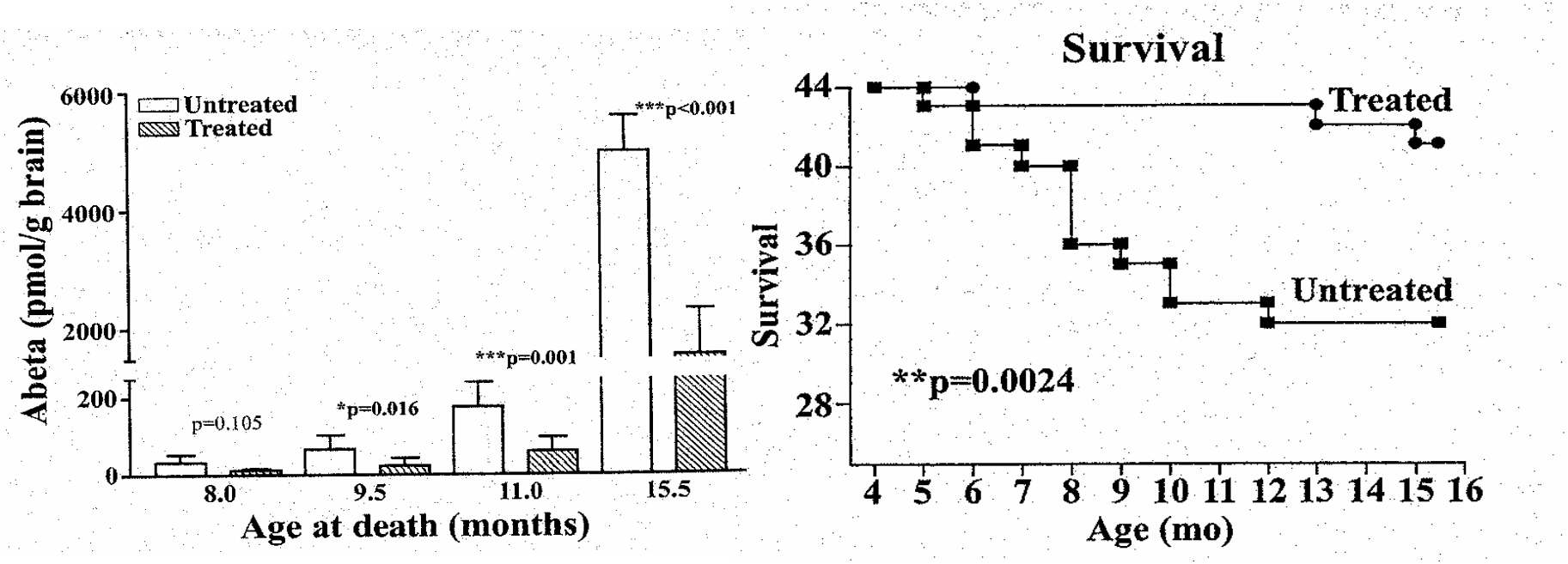
Melatonin and Alzheimer‘s Disease

Effects of the Amyloid-ß Peptide on Cell Survival in Neuroblastoma Cells



Pappolla et al., 1997

Prevention of Alzheimer‘s Disease by Melatonin in Transgenic Mice



Matsubara et al., 2003

RF-EMF effects on Melatonin

Hamster / Rat	EMF, 900 MHz, 0,04-0,36 W/Kg	15 min-6 hrs	Melatonin +/-	Vollrath et al. 1997
Rat	EMF, 900 and 1800 MHz, 100 / 20 µW/cm²	2 hrs per day, 14 days	6-OHMS +/-	Bakos et al., 2003
Human	Mobile phone use	2 weeks, questionaire	6-OHMS -	Burch et al., 2002
Human	EMF, 900 MHz, 1 W/m²	4 hrs	Melatonin +/-	Radon et al. 2001
Human	900 and 1800 MHz	2 hrs / day, 5 days / week, 4 weeks	Melatonin +/-	De Seze et al., 1999
Human	EMF, 900 MHz (GSM)	night	Melatonin +/-	Mann et al. 1998

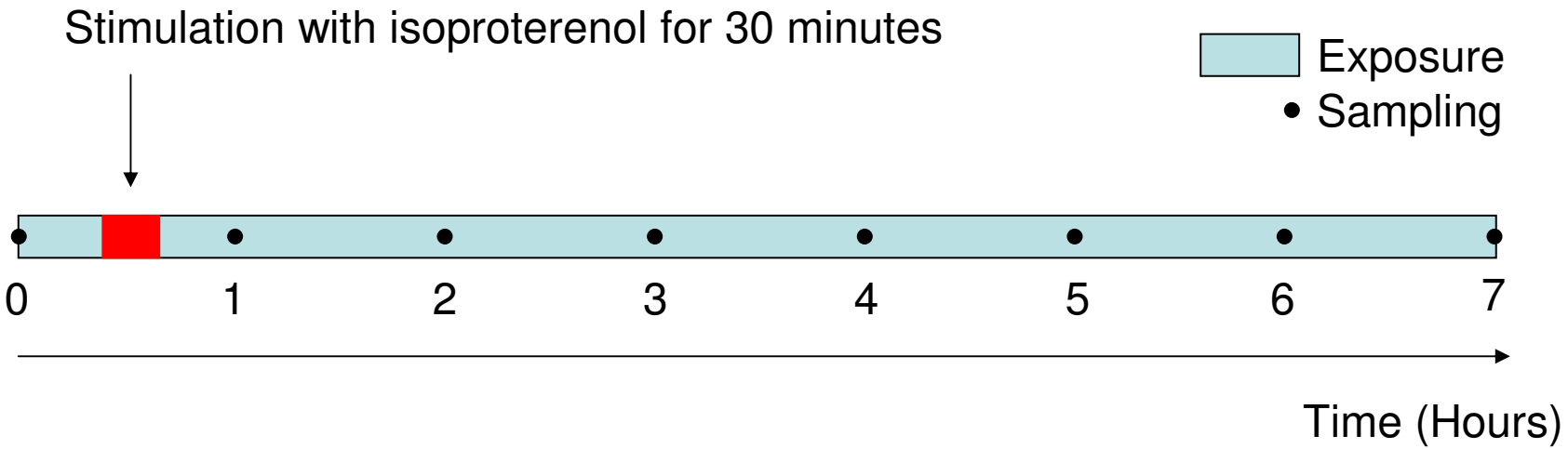
Aims of the Study

Relatively little is known about the effect of RF-EMF on pineal function. In the present study, we investigated the **direct** effects of high frequency 1800 MHz electromagnetic fields of 8, 80, 800, and 2700 mW/kg SAR levels on melatonin release by isolated pineal organs from Djungarian hamsters. Both CW and pulsed signals were used. The pulse signals were modulated according to the GSM.

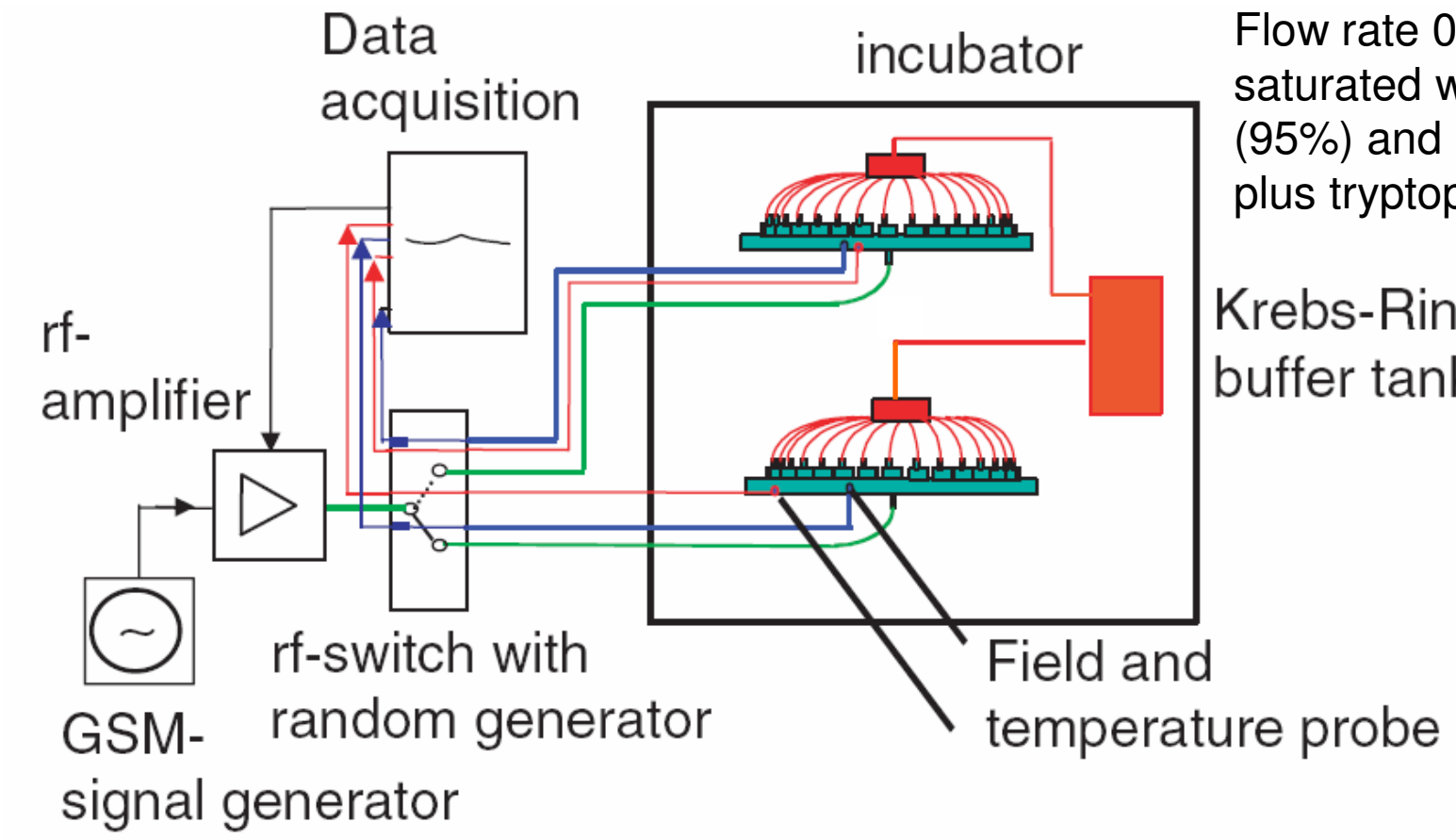
Methods

- n=20 pineal organs per experiment (based on statistical pre-analyses: 25% difference detectable at α=0.05 and ß=0.80)
- Sham-exposed and exposed (shielding better than -70dB), blind design
- Incubation for 7 hrs, sampling every hour
- Stimulation with isoproterenol for 30 min.
- Measurement of melatonin production by specific radioimmunoassay
- Calculation of pg melatonin mL^{-1} hr^{-1}

Methods

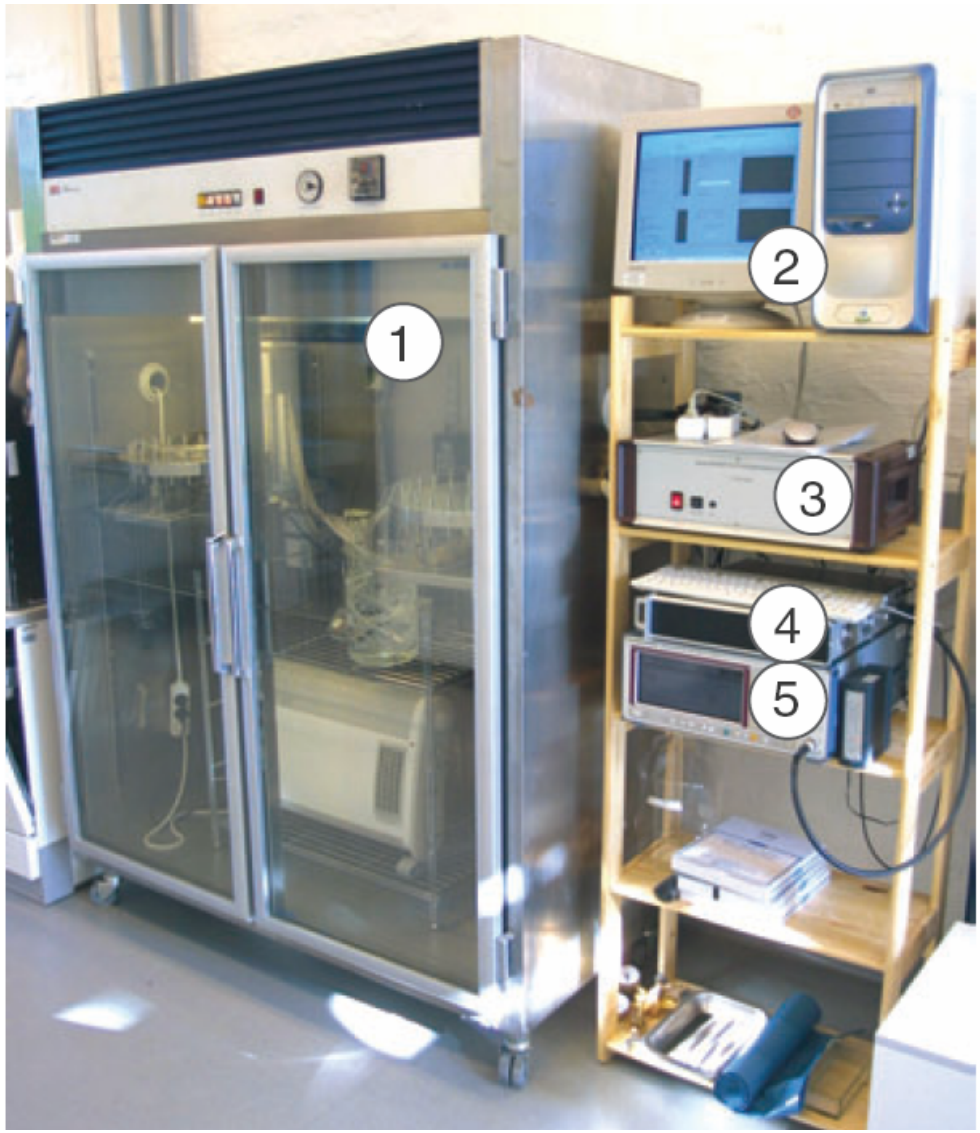

Stimulation with isoproterenol for 30 minutes
Exposure
Sampling
0
1
2
3
4
5
6
7
Time (Hours)

Methods: Overview

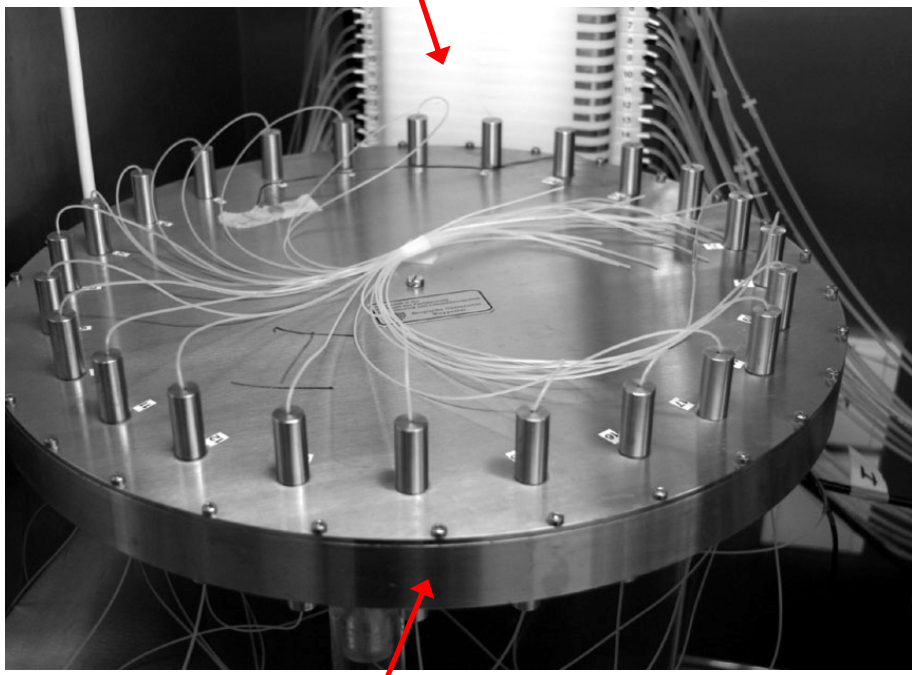


Flow rate 0.4 mL/min saturated with oxygen (95%) and CO_2 (5%) plus tryptophan (10^{-4}M)

Exposure

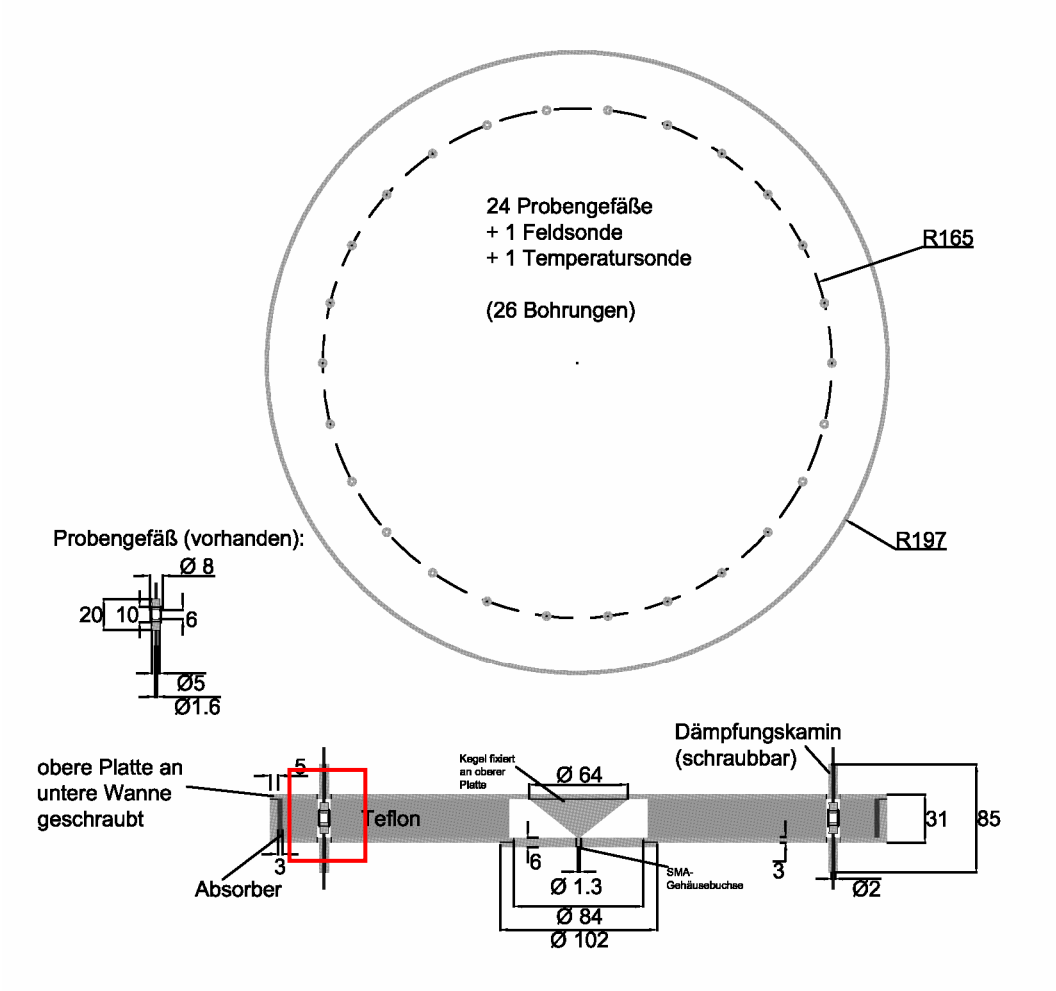


Peristaltik Pump

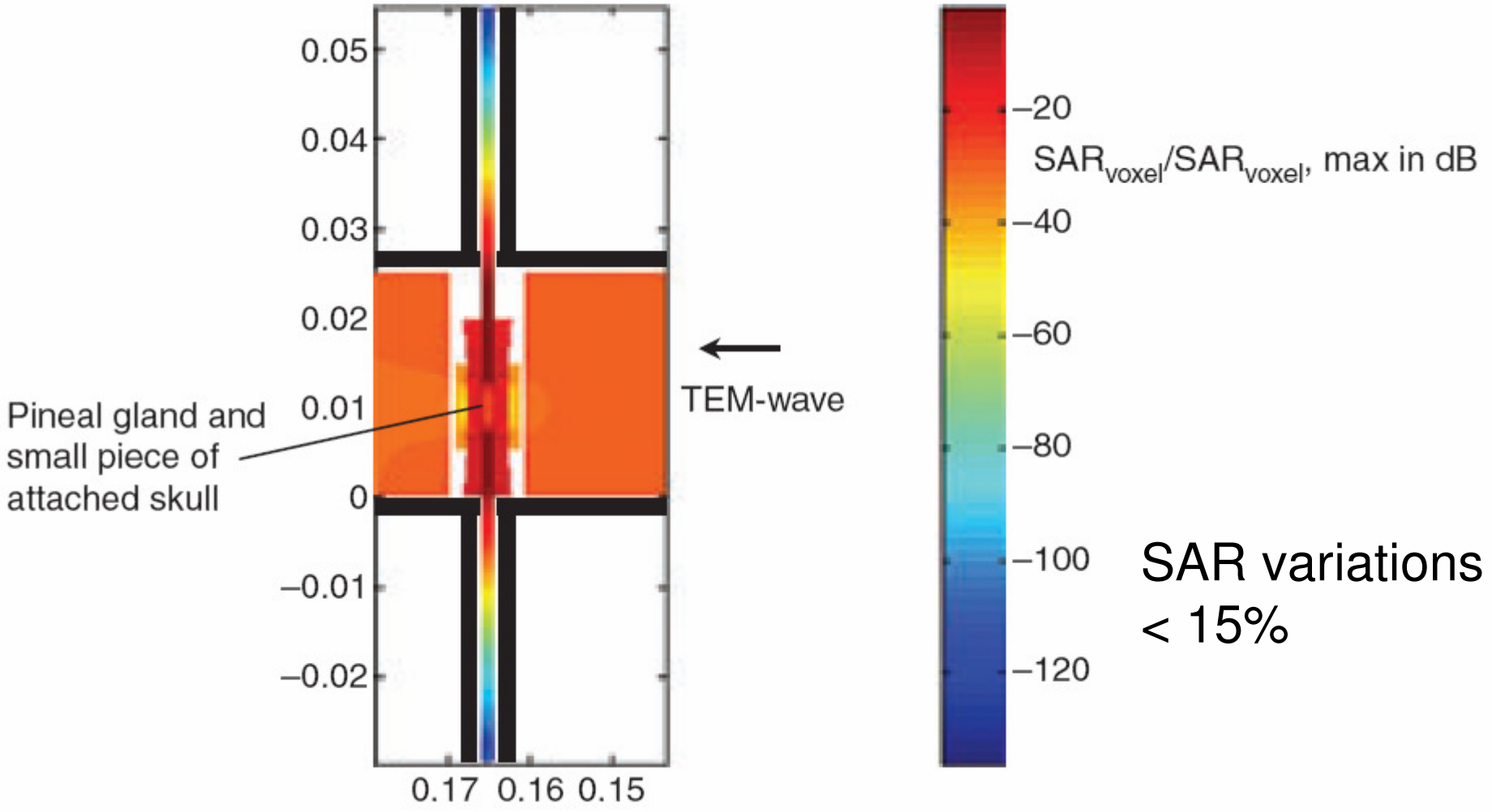


Radial Waveguide

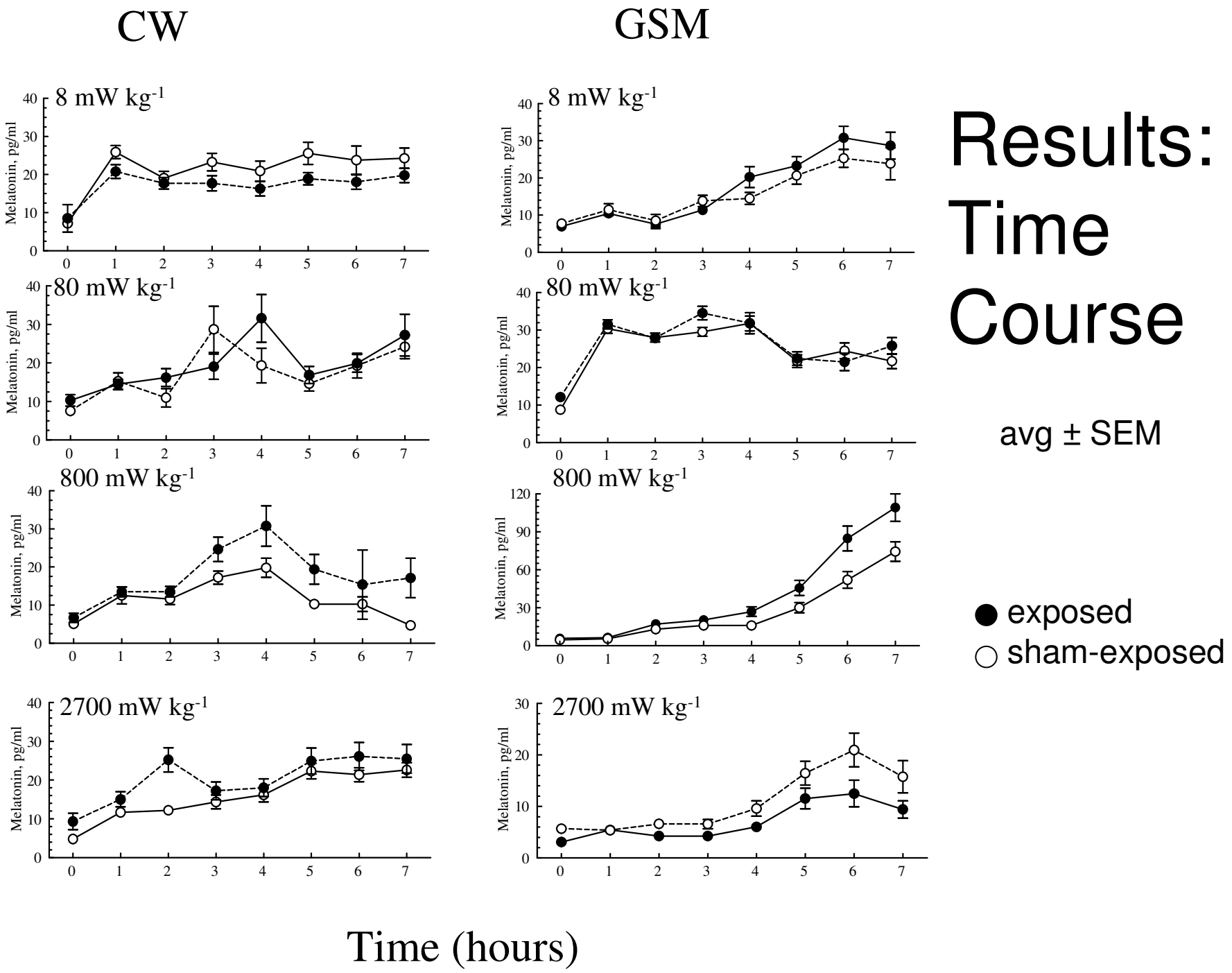
Radial Waveguides



Dosimetry



SAR variations < 15%

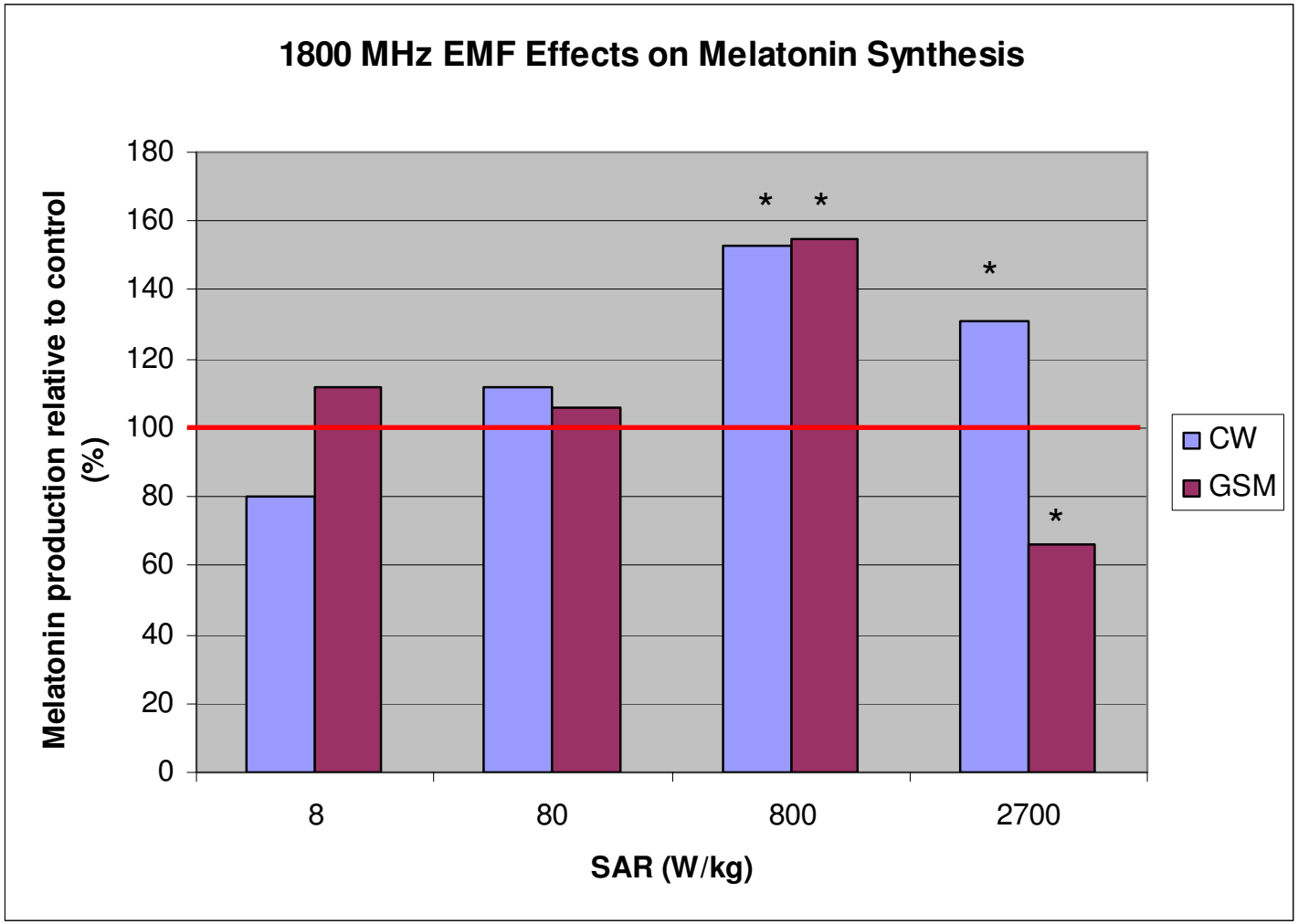

CW
GSM
8 mW kg-1
80 mW kg-1
800 mW kg-1
2700 mW kg-1
Melatonin, pg/ml
Time (hours)
Results: Time Course
avg ± SEM
exposed
sham-exposed

Results: Table

Melatonin production	Dose (mW/kg) 8	80	800	2700
CW				
In control pineal glands	21.75 ± 0.29	17.24 ± 0.31	11.47 ± 0.28	15.65 ± 0.28
In exposed pineal glands	17.22 ± 0.30	19.31 ± 0.31	17.54 ± 0.32	20.45 ± 0.29
Relative to control (%)	79.8	112.0	152.9*	130.7*
GSM				
In control pineal glands	15.65 ± 0.30	24.62 ± 0.29	25.65 ± 0.38	10.44 ± 0.28
In exposed pineal glands	17.49 ± 0.31	26.04 ± 0.30	39.75 ± 0.23	6.9 ± 0.24
Relative to control (%)	111.8	105.8	155.0*	66.1*

CW = continuous (unmodulated) exposure, GSM = modulated exposure according to the GSM standard.
Data represent melatonin synthesis (pg/mL/hr) ± S.E.M.
*$P < 0.05$ versus control. For further statistical results see text.

Results: Figure



Discussion

- No effects were seen at 8 and 80 mW/kg SAR.
- Temperature rises at 2700 mW/kg were approximately 1.2℃, thus thermal effects were likely to have caused the effects.
- At 800 mW/kg SAR, a temperature rise of approximately 0.5 – 0.6℃ due to exposure may have contributed to the elevated melatonin levels.

Conclusions

- At SAR levels relevant to human exposure of the pineal organ*, no adverse effects on melatonin synthesis (i.e. decreases) were observed.
- These data therefore do not support the melatonin hypothesis for RF-EMF.

*maximum calculated average SAR levels

<0.1 W/kg in childrens‘ heads; Bit-Babik et al., 2005

Acknowledgements

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