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Solar exposure and influencing parameters on the endogenous vitamin D production

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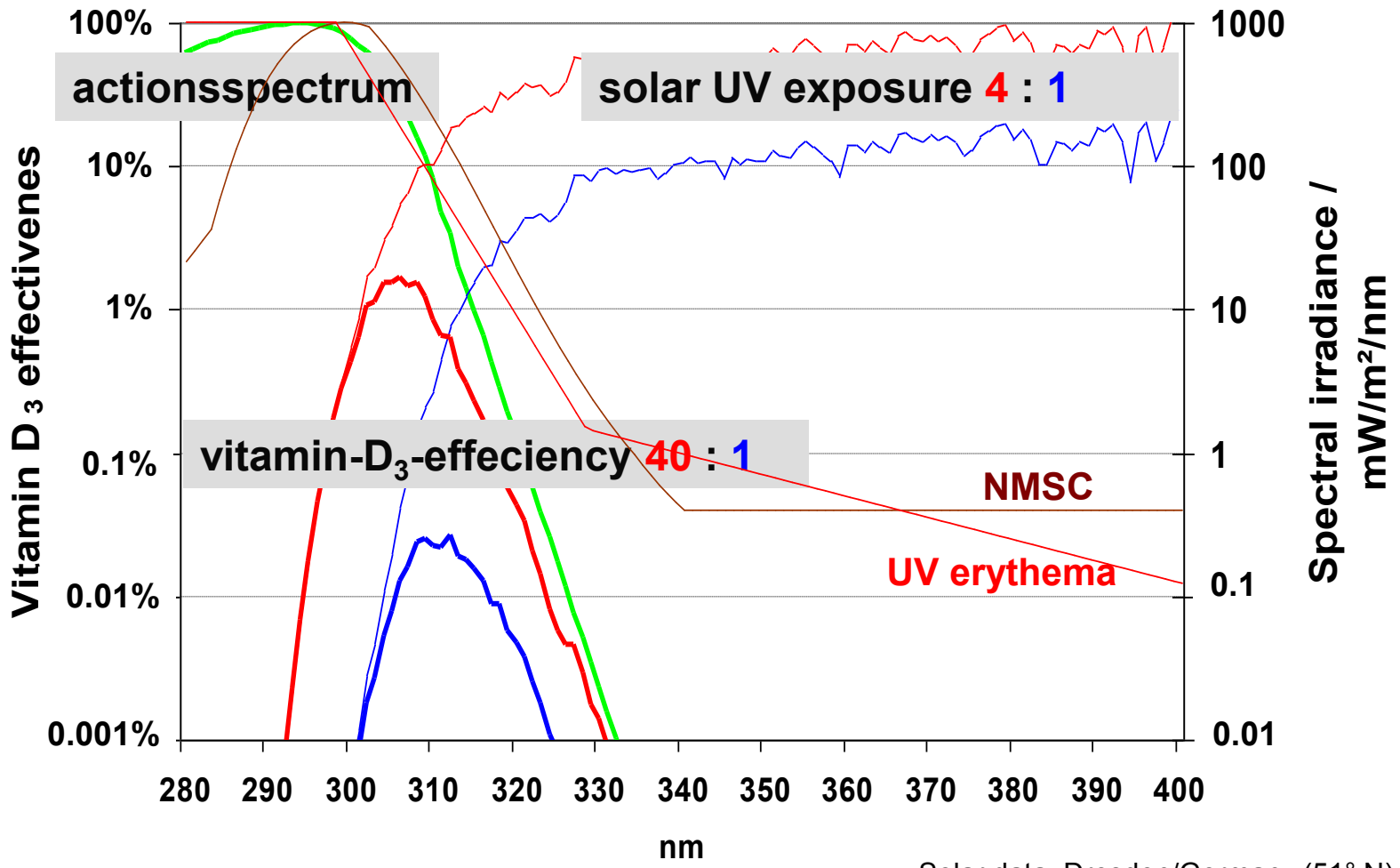
8th Workshop on ULTRAVIOLET RADIATION MEASUREMENTS
Davos / CH, 15-16 July 2014

Effects of solar UV radiation on humans

bio-positive
vitamin D

adverse

Synthesis of vitamin D_3
Efficiency of solar UV radiation
(summer : winter)



Solar data: Dresden/Germany (51° N)

Epidemiological studies proofed a correlation

UV radiation

!

Skin tumours

Risk of squamous cell carcinoma

Outdoor workers	:	Indoor workers
1,8	:	1

Metaanalysis from 18 epidemiological Studies (Schmitt J et al., BJD 2011):

Investigation of lowest UV exposure level to realize an increase in 25OHD$_3$-serum level and the influencing factors

- **2007/2011:** „UV-dependent vitamin D$_3$ synthesis – balancing of UV exposure time and the production of an optimal vitamin D$_3$ status in men “
  Knuschke P, Lehmann B, Püschel A, Rönsch H. UV-abhängige Vitamin-D-Synthese - Bilanzierung der Expositionszeit durch UV zur Produktion des optimalen Vitamin-D3Bedarfs im menschlichen Körper. (2012) urn:nbn:de:0221-201210029658
  (BMU/BfS support-N°: StSch 4538)

- **2013/2015:** „Optimization of recommendations to the public on UV radiation and vitamin D status by investigation of everyday life related influences in realization of an optimal vitamin D status by minimization of solar UV radiation “
  (BMU/BfS support-N°: FV 3612S70026)

To characterize the vitamin-D-status:

→ serum level of 25-OHD_3

- **Basing on bone metabolism (high evidence)**

  < 12 ng/ml: health risk

  > 20 ng/ml: no risk > 97,5 % of the population

- **Optimal status in discussion with respect to several diseases (low evidence)**

  ≥ 30 ng/ml

unit for 25OHD_3 i.S.:	**1 ng/ml = 2,5 nmol/l**

Studies A. – E.

Structure of the study groups

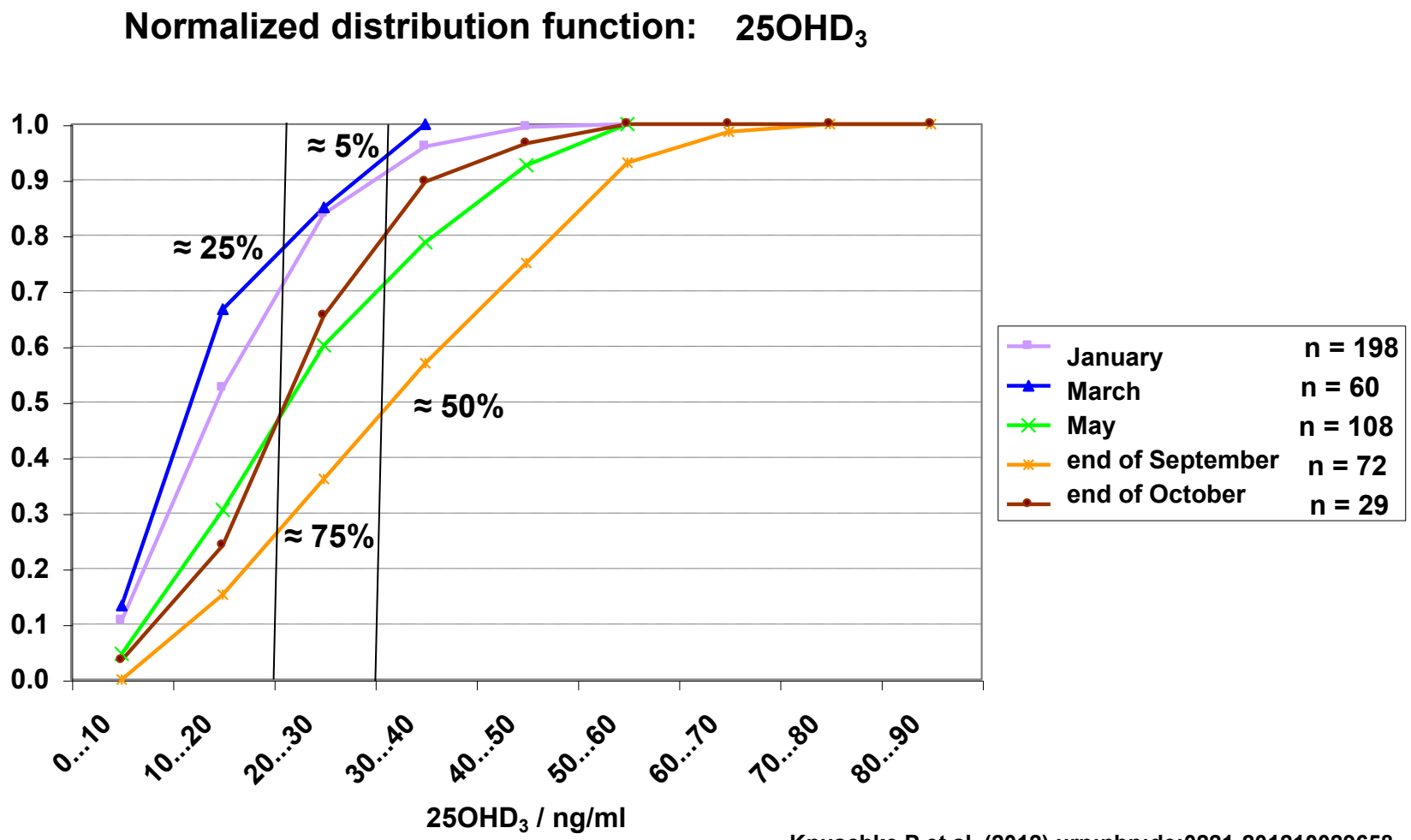
- UV skin type: SkT II, normal pigmentation (n = 20)
  SkT III, normal pigmentation (n = 20)

subgroups:

- age: 18-30 y; 40-65 y
- gender: male; female

Season dependences of vitamin D status

Normalized distribution functions of 25OHD$_3$ serum level in the volunteers of the project studies



Knuschke P et al. (2012) urn:nbn:de:0221-201210029658

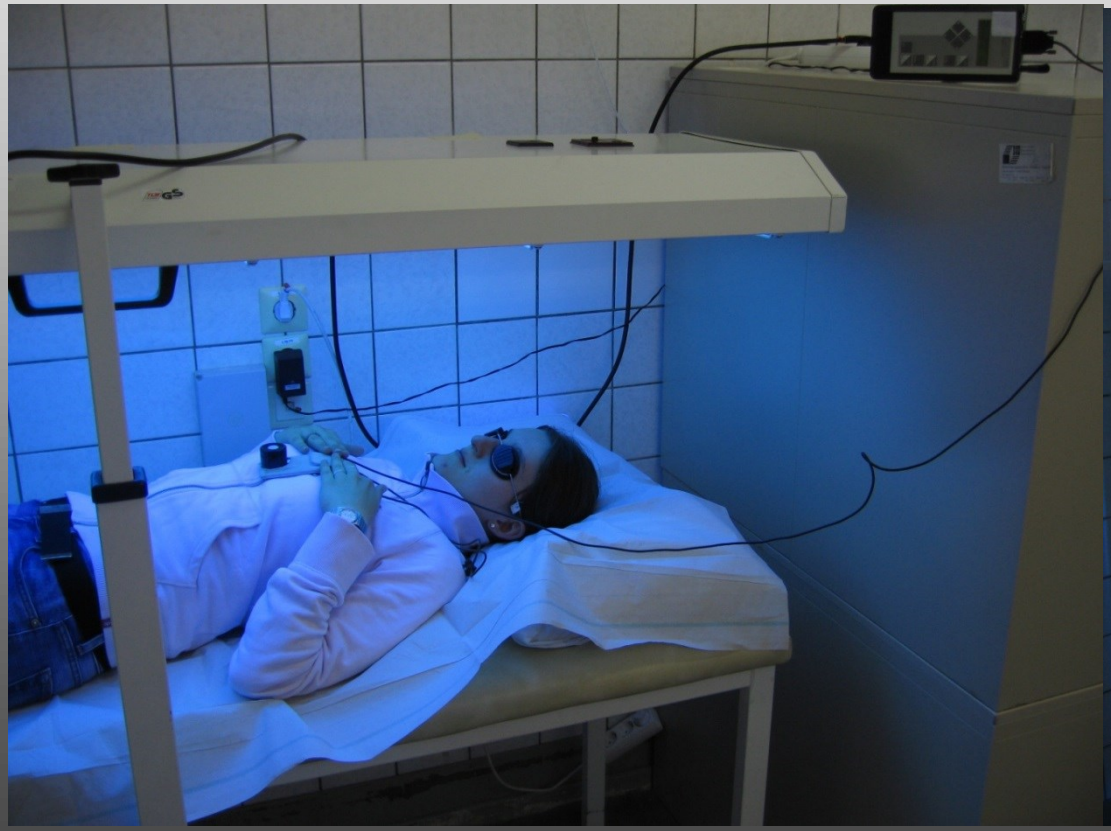
Study C.1 – C.3 and D.1 – D.3

MED-controlled applications of UV exposure

on

- face and hands
- whole body

to determine the **effect on 25OHD$_3$ increase**



UV exposure to induce vitamin D synthesis with respect to the individual erythemal sensitivity

Photodiagnostic to detect the MED

1 MED

Study C.1 / C.2 / C.3

„Erythemal-effective exposure H_{er} = 0.1 MED / 0.3 MED / 0.7 MED;

solar simulated radiation (Arimed B)“

Study D.1 / D.2 / D.3

„Erythemal-effective exposure H_{er} = 0.1 MED / 0.3 MED / 0.7 MED;

sunbed lamp radiation (H_{er}(UVB) : H_{er}(UVA) = 1 : 1.5 / Cosmolux RAplus)“

UV exposure schedule

6x face+hands for 3 weeks - 3 weeks break - 6x whole body for 3 weeks

MED-controlled application of solar UV exposure

by

- RB-type-meter
- PSF-dosemeter

to

- face and hands
- whole body

to determine the **effect on 25OHD$_3$ increase**

Study E.1.1 / E1.2

„Erythemal-effective exposure H_{er} = 0.3 MED / 0.7 MED;

solar radiation "

UV exposure schedule

4x face + hands for 2 weeks - 4x face + hands for 2 weeks

Study E.2.1 / E2.2

„Erythemal-effective exposure H_{er} = 0.1 MED / 0.3 MED;

solar radiation "

UV exposure schedule

4x whole body for 2 weeks - 4x whole body for 2 weeks

SSR vs. solar radiation vs. sunbed lamps
- increase in 25OHD$_3$ serum level -

UV exposure (dose; skin area)	Δ25OHD$_3$ / ng/ml (mean per 1x UV exposure)		
	SSR	Solar radiation	Sunbed lamp
0,1 MED (face + hands)	0,27	n. d.	0.28 =
0,3 MED (face + hands)	0,55	0,54	0.49 ↓
0,7 MED (face + hands)	0,82	0,58	0.32 ↓↓
0,1 MED (whole body)	0,99	1,10	0.75 ↓
0,3 MED (whole body)	1,53	1,36	1.01 ↓↓
0,7 MED (whole body)	2,72	n. d.	0.92 ↓↓↓

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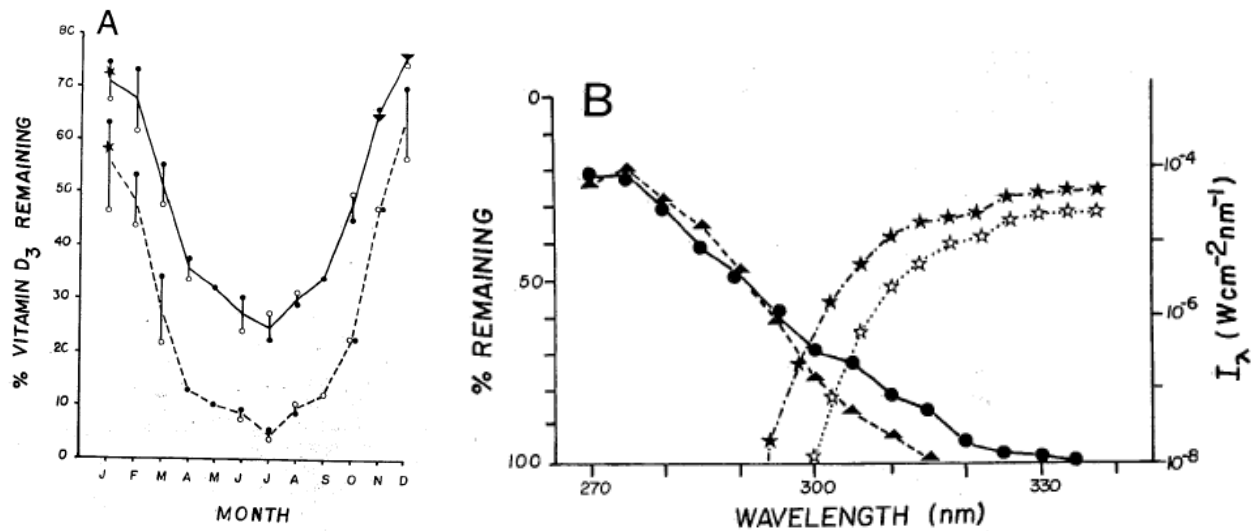
Possible explanation:

Vitamin D destruction by the high UVA content of sunbed lamps

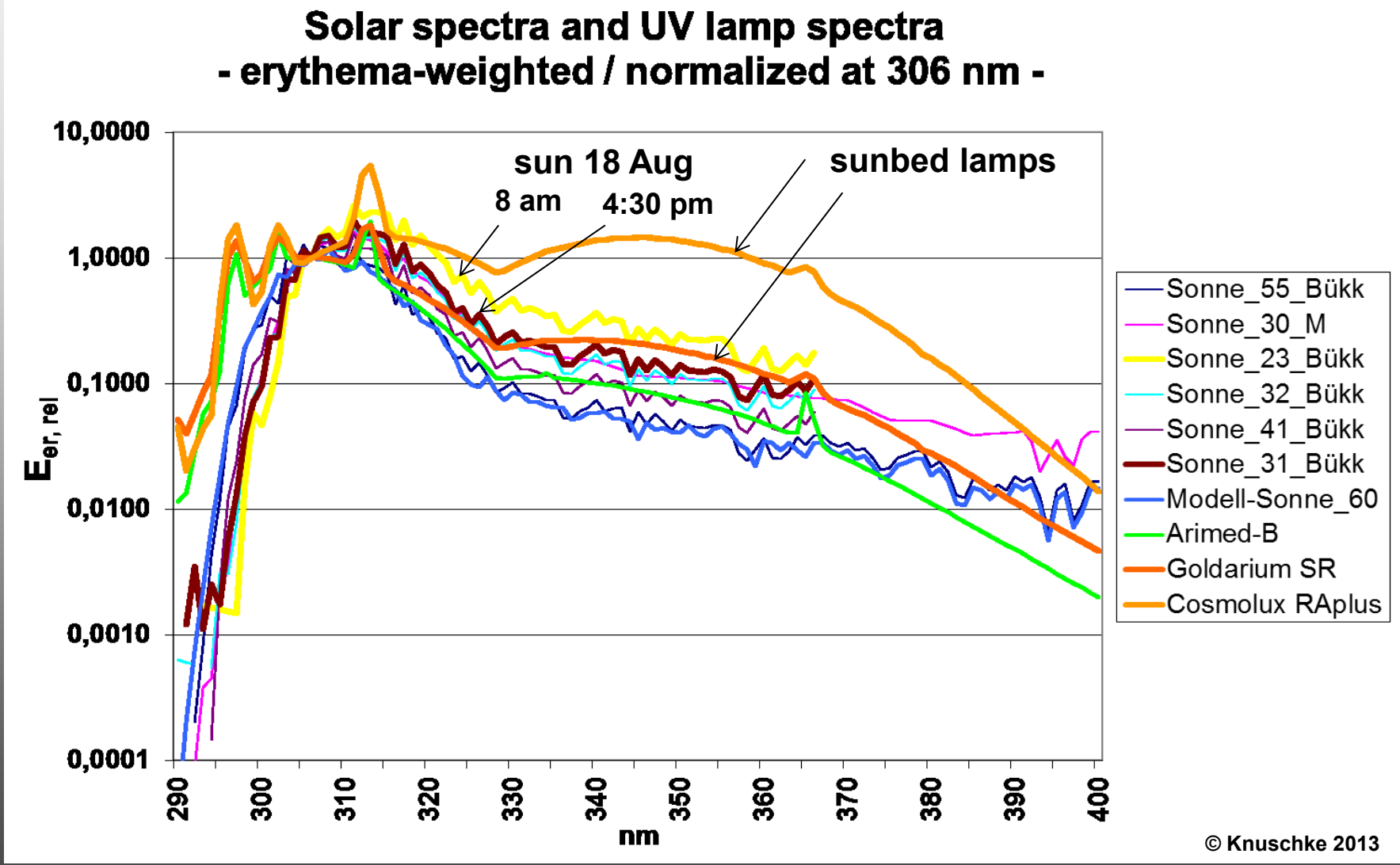
FIG. 3. A, The percentage of [^{3}H]vitamin D_3 remaining after exposure to 1 and 3 h of sunlight in each month of the year. Each *point* represents the mean ± SE of three determinations. B, Action spectra for the photoconversion of 7-DHC to previtamin D_3 (▲--▲) and the photodegradation of vitamin D_3 (●—●). Also shown are two solar spectra measured in Boston at noon on clear days: June (★-·-★) and January (☆· · ·☆). Note that in January 300 nm was the shortest detectable wavelength, whereas in June the intensity at 300 nm was 2 orders of magnitude greater than that in January, and the shortest detectable wavelength was 294 nm.



Webb AR, DeCosta BR, Holick MF. Sunlight regulates the cutaneous production of vitamin D by causing its photodegradation. JCE&M 68(1989)5, 882-887

Traceability for surface spectral solar ultraviolet radiation

- one example the necessity



Study E.3

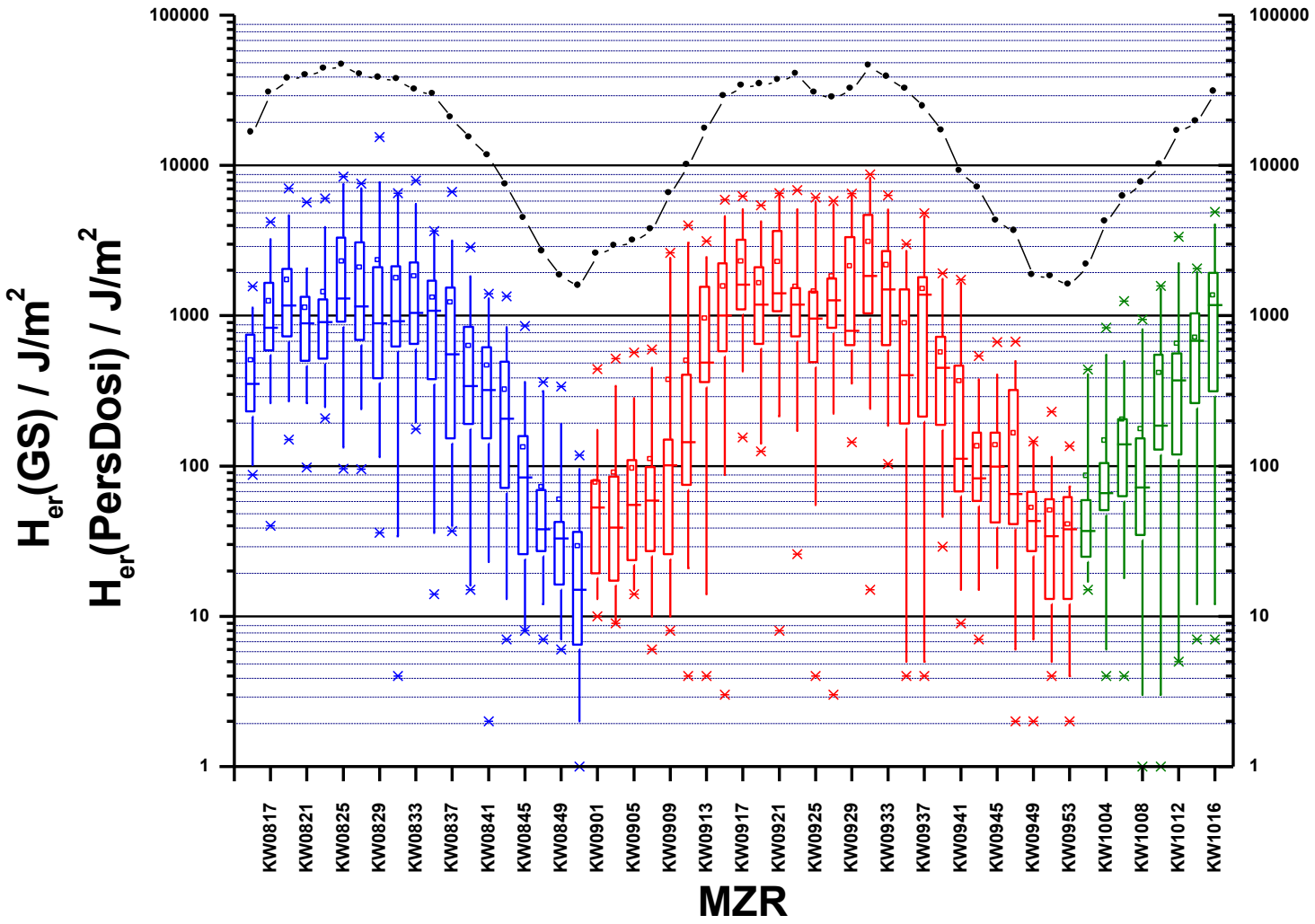
„Follow up of 25OHD$_3$ serum levels

under every day life conditions for two years

including control of

personal UV-monitoring and global radiation"

- 25OHD$_3$-controls:	**Sep/Jan/Mai/Sep/Jan/Mai**
- personal UV monitoring:	**continuously for 2 year** **1 PSF-dosemeter per 2 weeks**



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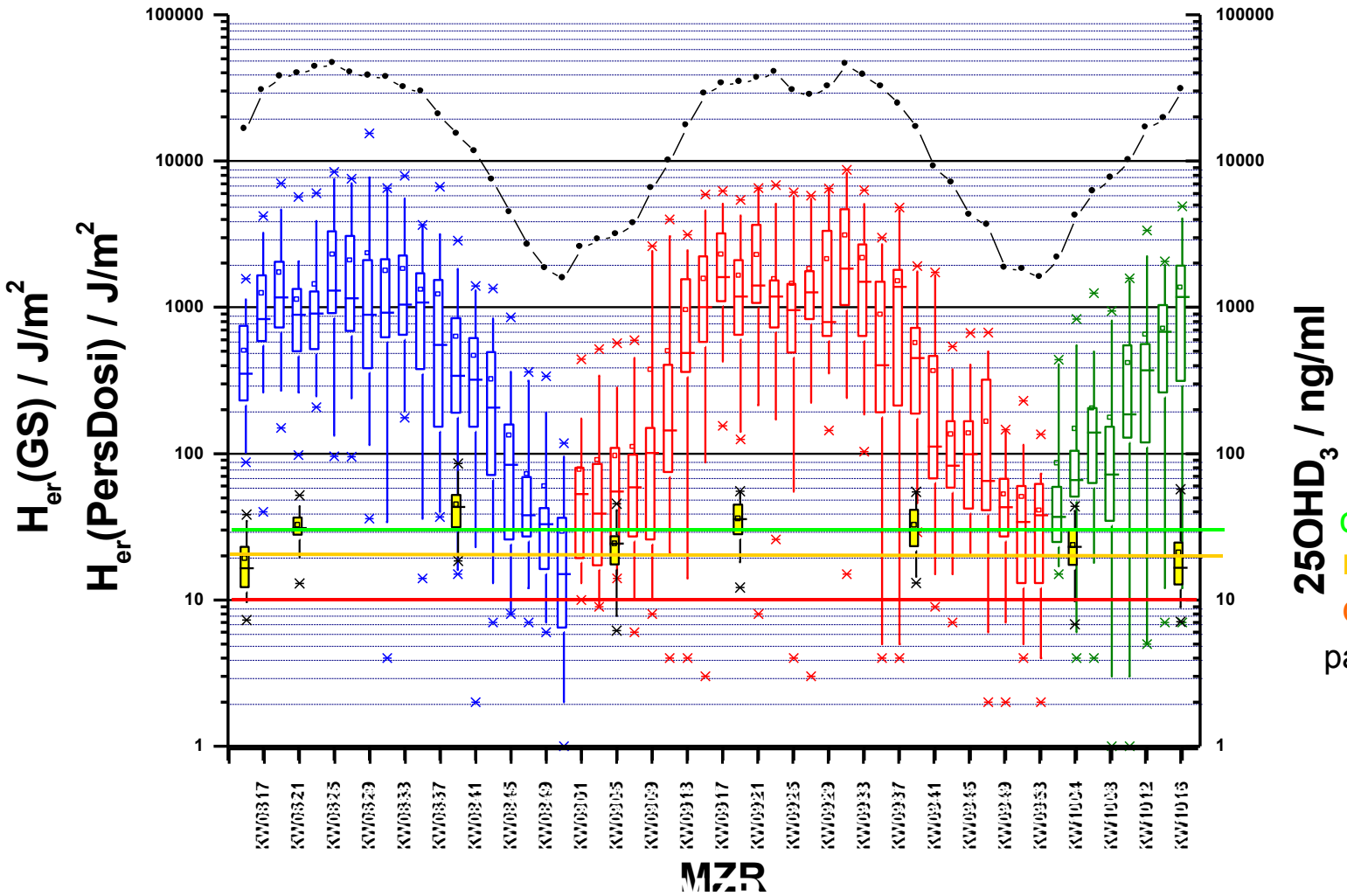

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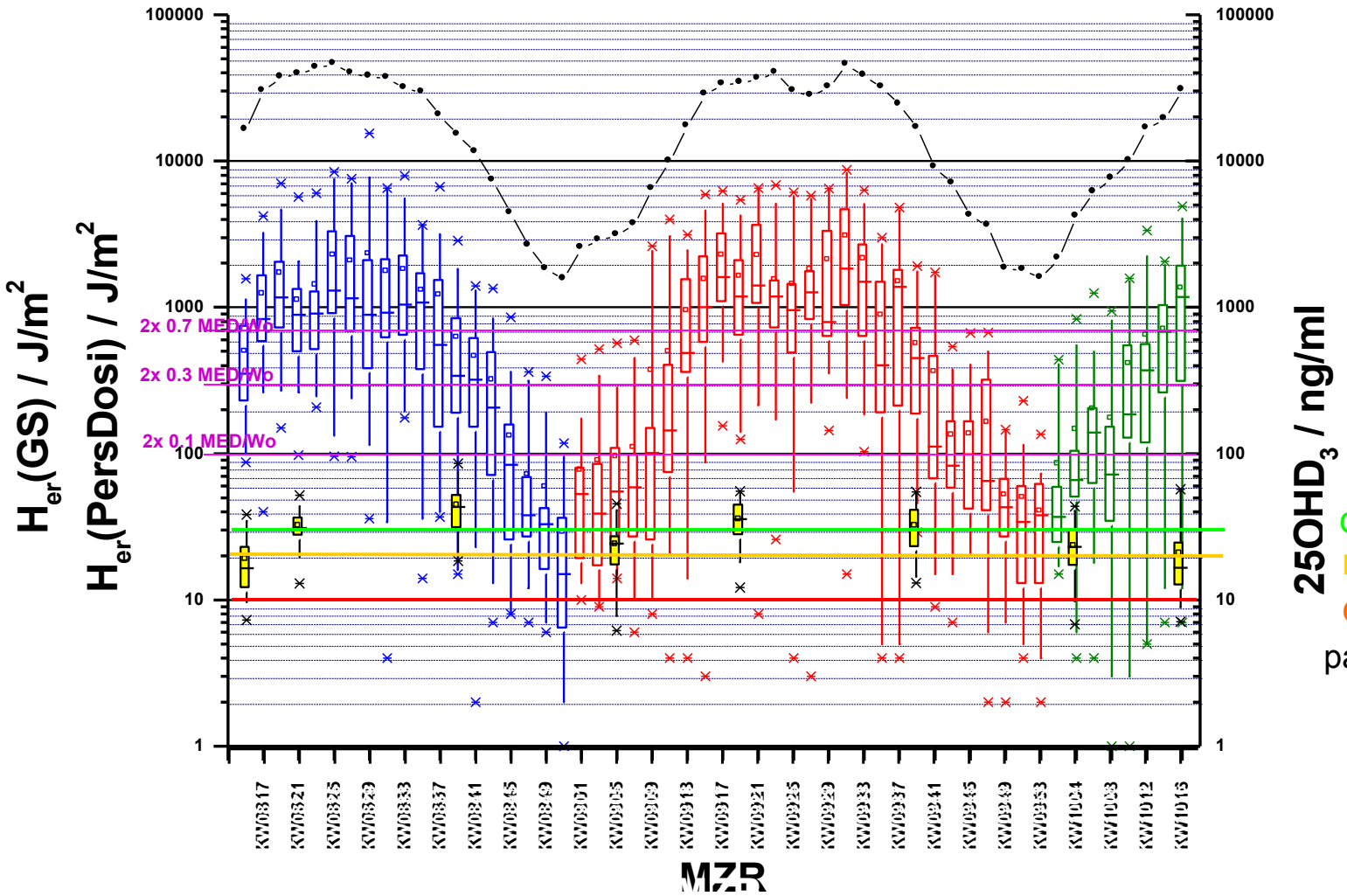

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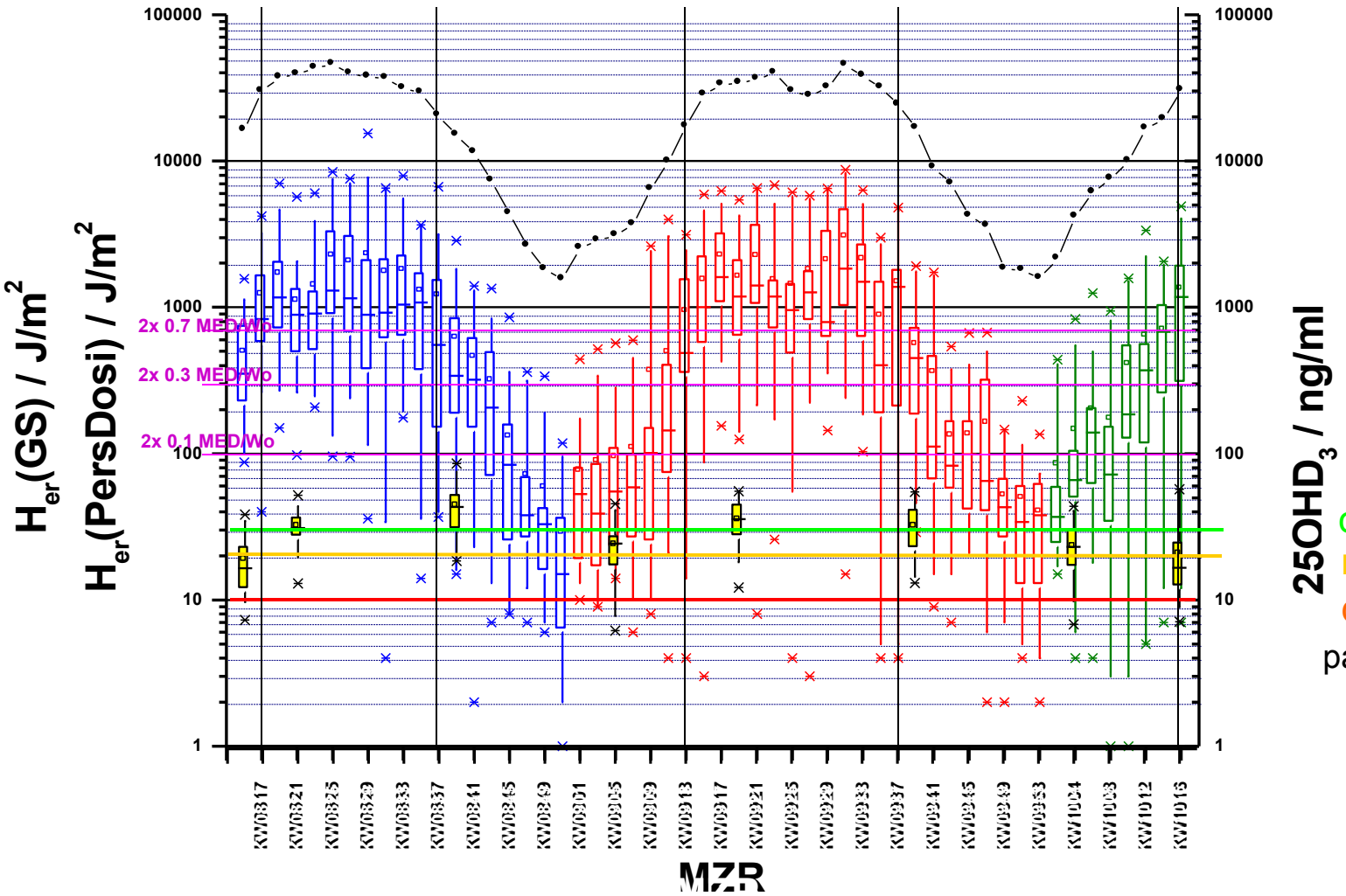

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Summary

Endogenous vitamin D production:

- also in field control: 2x/week 30 % MED → $25OHD_3$ > 20 ng/ml
- down to 0,1 MED 2x/week (perpendicular on face+hands): $25OHD_3$ ↑
- behaviour influences: (on endogenous VD_3-production) important up to primarily (more than constitutional effects skin type I-IV)
- Influence of UVA-2, UVA-1: morning/evening sun ? current sunbed lamps?

Season-depending $25OHD_3$-status

- in summer: 75/50 % > 20/30 ng/ml
- im winter: 25/ 5 % > 20/30 ng/ml

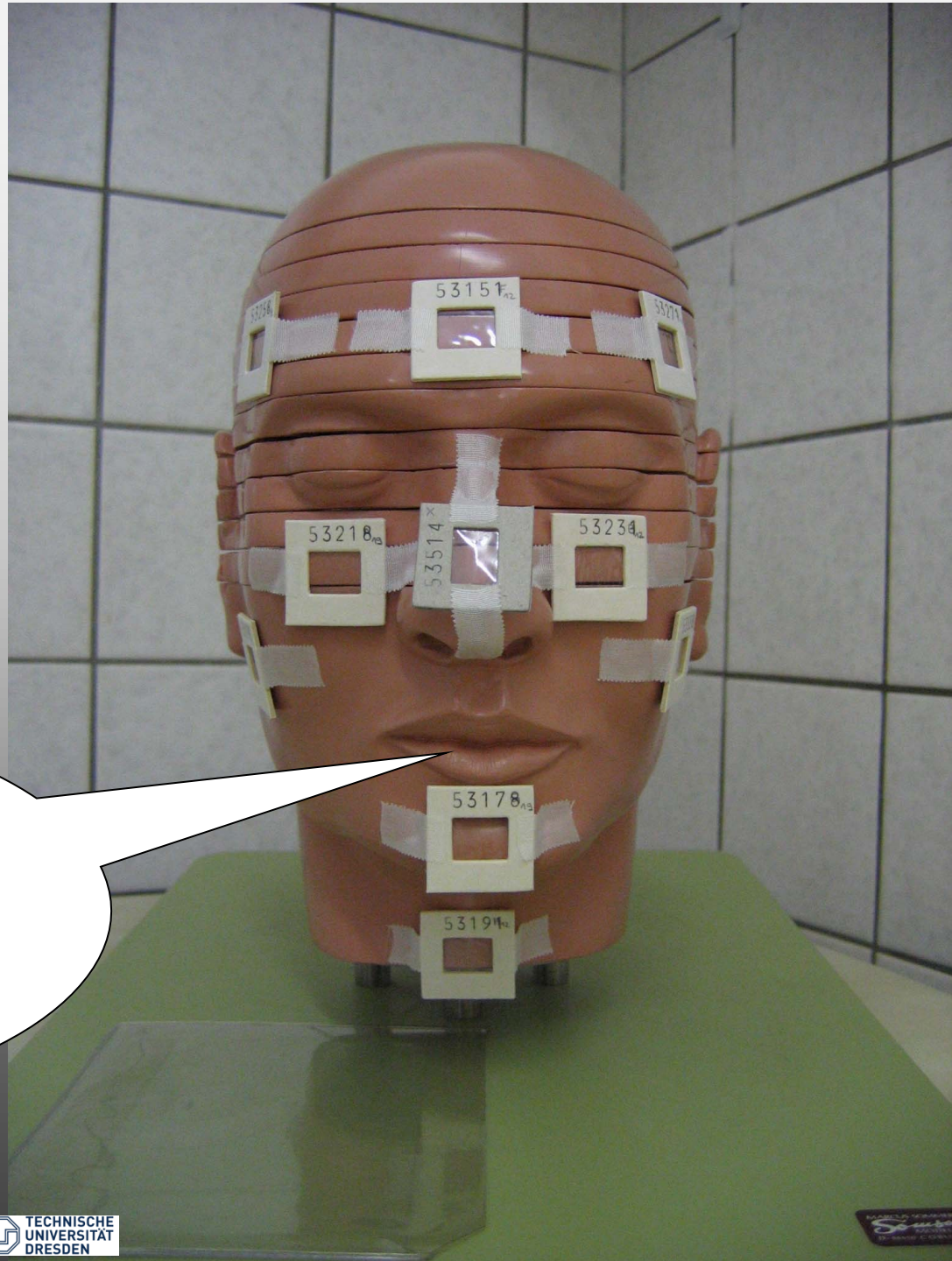
Facts on further results

- $25OHD_3$ efficiency of sun bed lamps: 30 % of solar radiation or SSR (VD_3-photodegradation caused by the high UVA-fraction?)
- $25OHD_3$-efficiency [UV-skin-serum]: anatomical variations up to **400 %**
- UVR only on face and hands: **>80 %** VD_3-production **via face skin**
- body distribution of solar UV-exposure: has to take into account for real skin exposure estimations!
- outdoor times in summer : (Central Europe) e. g. 2x/week, 20-30 min walking (60/10 min overcast sky/sun seeking)
- winter (Central Europe): 15. Oct to 1. Mar – no vitamin D production (essential times too long)
- Provitamin-D-content (7-DHC) in the skin: independent on age (up to 65 y)

On behalf of

the co-workers of the research project

- *Prof. Dr. med. Andrea Bauer*
- *Dr. rer. nat. Bodo Lehmann*
- *Dipl.-Chem. Andrea Püschel*
- *Schwester Kristin Mersiowsky*
- *Dipl.-Soz. Henriette Rönsch*



Thank you

for

your attention!