

Non-invasive sun protection factor determination using LED light

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CHARITÉ
KRANKENHAUS

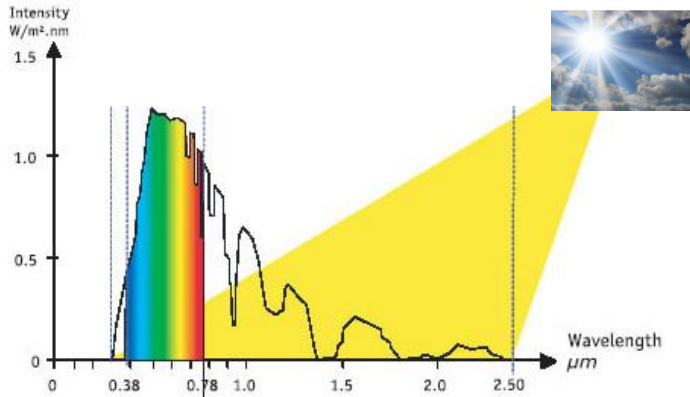
Outline

1. Introduction
 - UV light and its effects
 - What is the sun protection factor (SPF) ?
 - Current method for SPF determination
2. Materials and methods of our approach
3. Results of proof of principle studies
4. Conclusion and outlook on forthcoming system

Introduction

Introduction

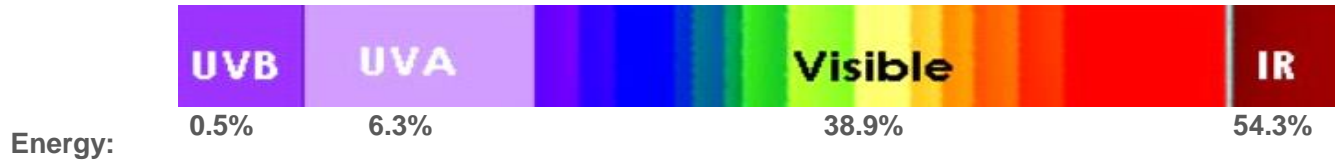
Relative spectral distribution of sun irradiation near the equator



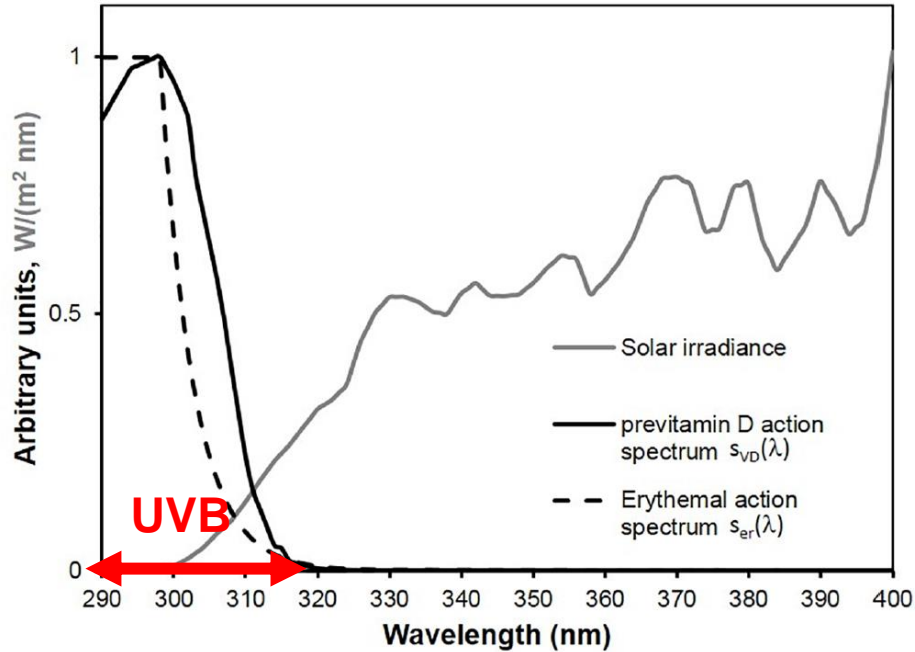
Wavelengths reaching Earth's surface:

- UVB: (290 – 320) nm
- UVA: (320 – 400) nm
- VIS: (400 – 760) nm
- NIR: (760 – 3000) nm

Wavelength: 290nm 320nm 400nm 760nm 3000nm



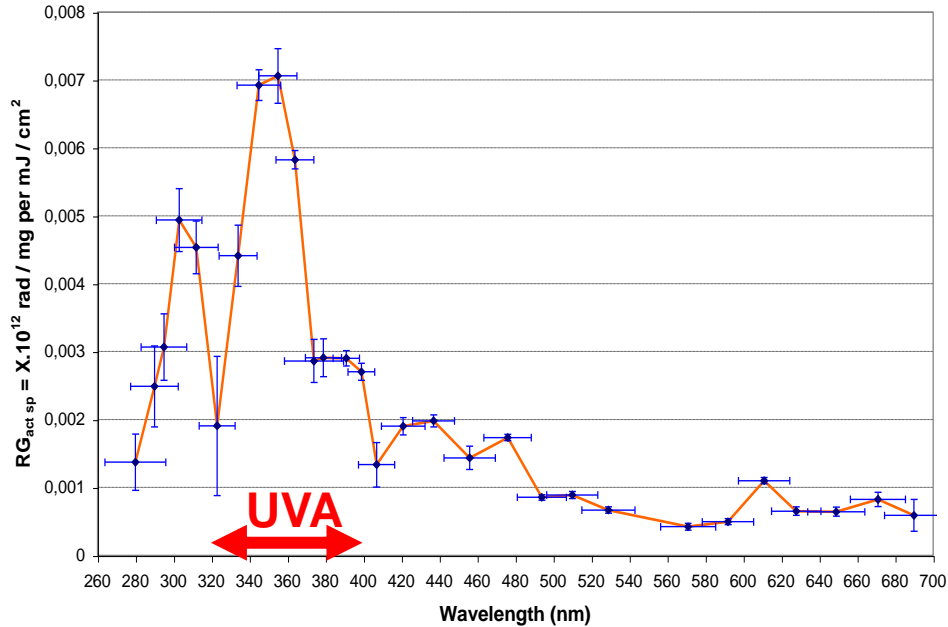
Action spectra for erythema and for previtamin D formation in human skin



UVB causes e.g.

- Sunburn
- Previtamin D production
- Tanning (by melanin synthesis)
- Skin cancer

Action spectrum of the formation of free radicals in the human skin *ex vivo*



UVA causes e.g.

- Premature skin aging
- Increased melanoma risk

Zastrow L et al. Skin Pharmacol Physiol, 22: 31-44, 2009

In vivo SPF test (current standard method)



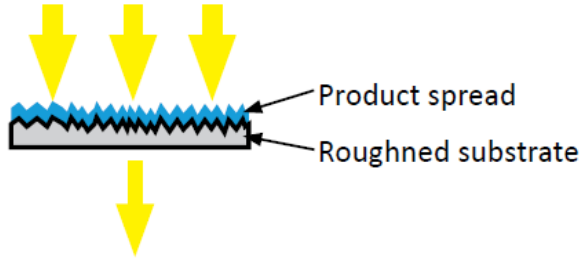
<http://www.schrader-institute.de/home/pruefung/haut-pruefung/sonnenschutz/>



1. UVB irradiation applied at different doses
2. Evaluation of erythema 24h post irradiation
3. MED = minimal dose causing erythema
4.
$$\text{SPF} = \frac{\text{MED}_{\text{with sunscreen}}}{\text{MED}_{\text{without sunscreen}}}$$
5. >10 test subjects per sunscreen required

⇒ **FDA and EU call for non-invasive method**

In vitro test



www.helioscreen.fr

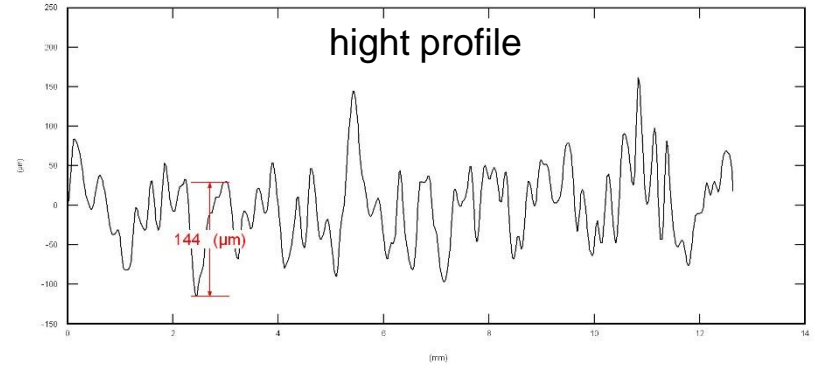
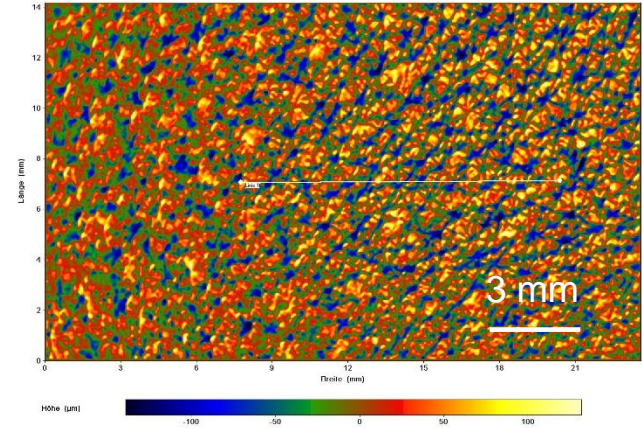
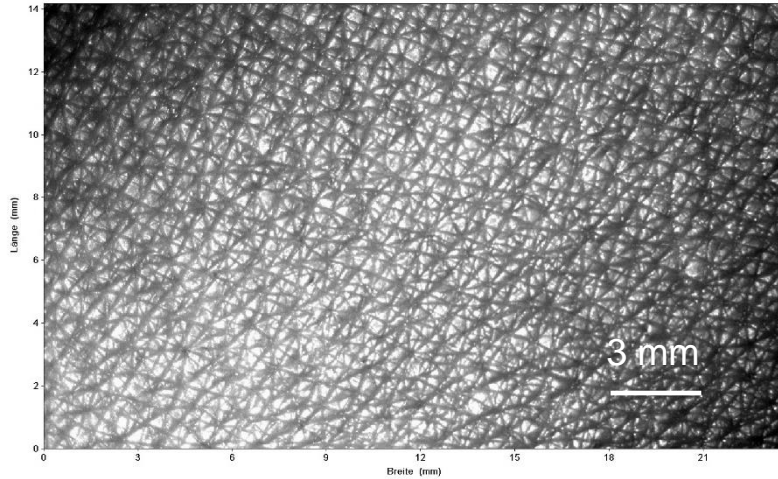
- Spectroscopic transmission measurement
- Substrate with roughness similar to skin required
- Poor agreement on absolute scale e.g. due to other specific properties of skin
- Only successfully used to measure attenuation of UVA range (UVA-PF) relativ to UVB range (SPF) if SPF is known a priori (ISO 2443:2012)

=> *In vitro* test could not replace the erythema based SPF test so far

Introduction

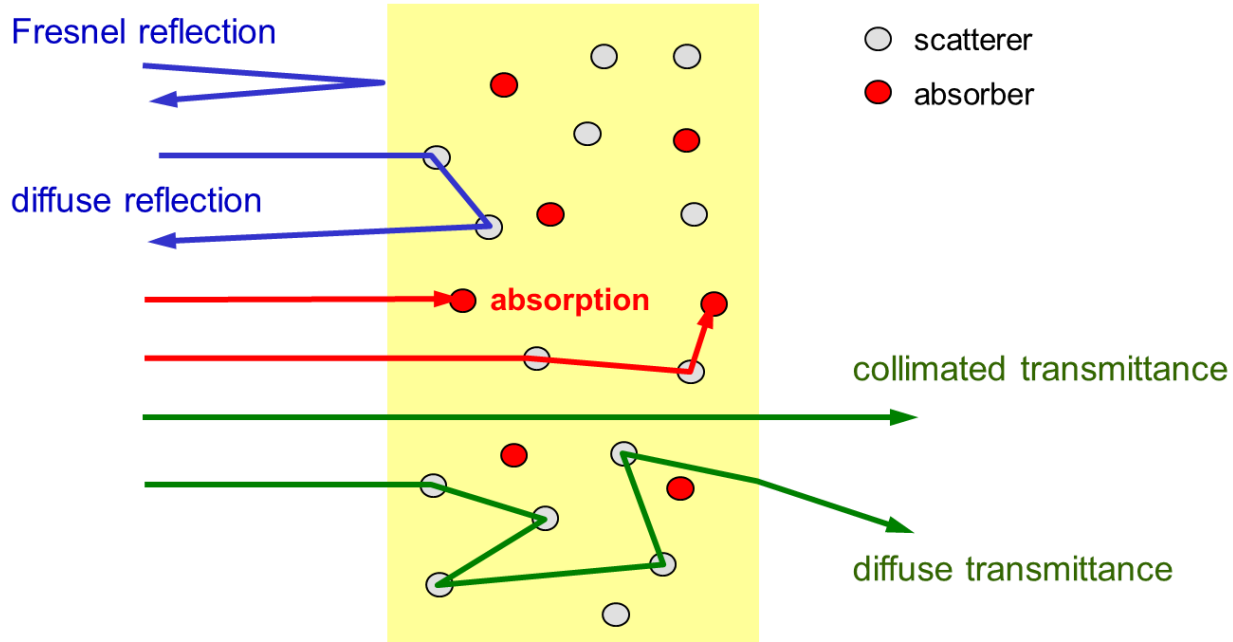
Roughness of the skin

picture of the skin surface

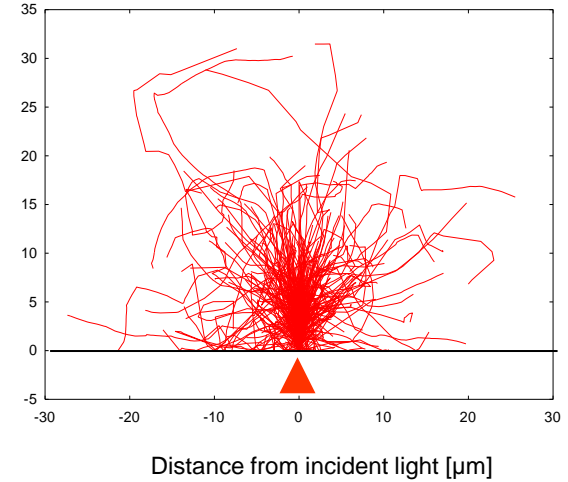


Introduction

light tissue interaction

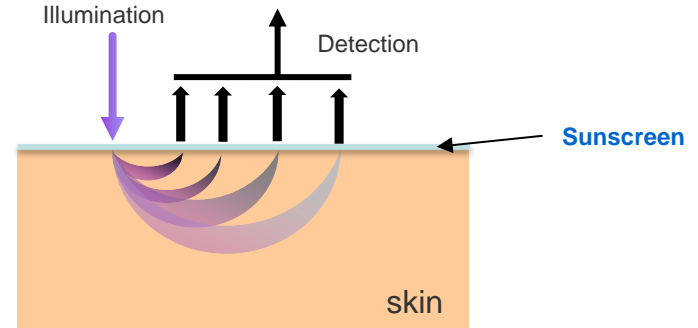


Monte Carlo Simulation



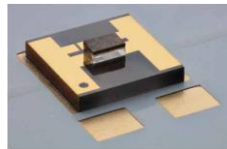
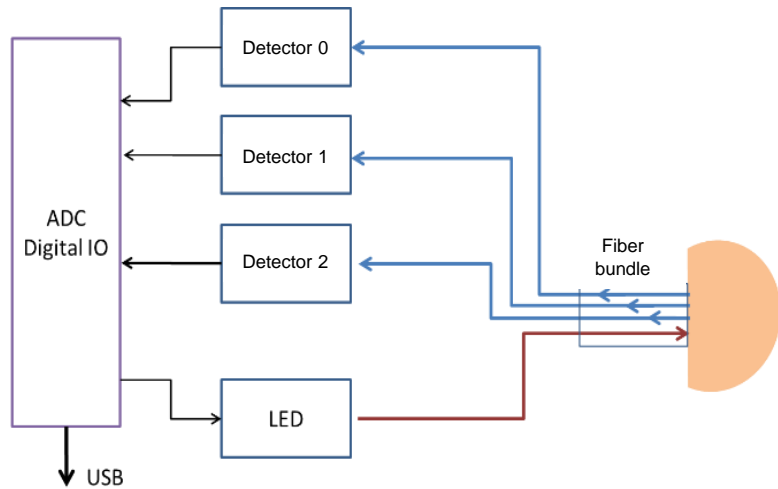
diffuse reflectance spectroscopy on skin

- Skin is the best substrate
- Transmission measurement is not possible in vivo on skin
- Diffusely reflected light is measured
- Spatial offset of illumination and detection => Light passes sunscreen layer twice

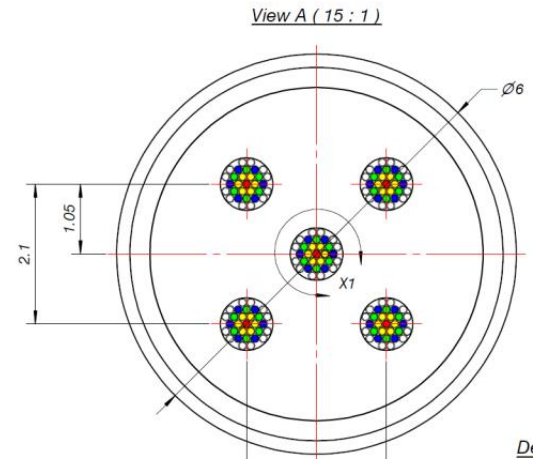


Materials and Methods

Schematic of first functional sensor design



Fiber bundle



One LED at 308nm (0.6mW, FBH)

Study I on porcine skin



- Carefully cleaning of the ear
- 2 mg/cm² cream application (4 x 4 cm²)
- 30 min incubation time
- 30 measurements per area

Study II on human volunteers

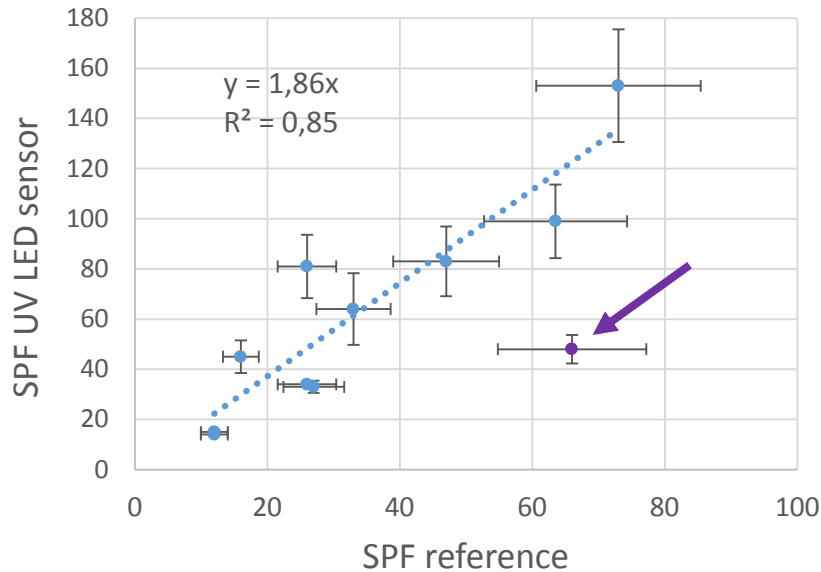


- 2 mg/cm² cream application on the back of the volunteers
- Area = 10 x 10 cm²
- 30 min incubation time
- 30 measurements per area

Results

Results

on porcine skin



each cream was tested on 6 subjects

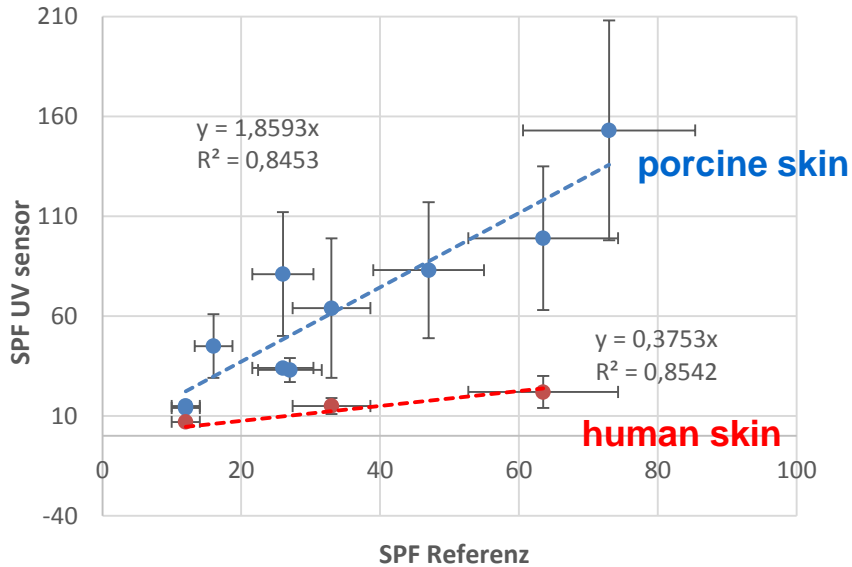
- Very good correlation with the results from the test institutes (SPF reference)
- Applicable for formulations containing chemical UV-filters only or in combination with particulate filters
- Samples with fluorescence disturb the SPF determination



Spectrometer is necessary

Reble C, Meinke MC, Rass J et al., No more sun burn, Optik & Photonik, Volume 13, Issue 1, 32-35 (2018)

porcine skin compared to human skin at the forearm



- Comparison using three selected creams
- different slope compared to porcine skin
- Human skin shows lower backscattered signal

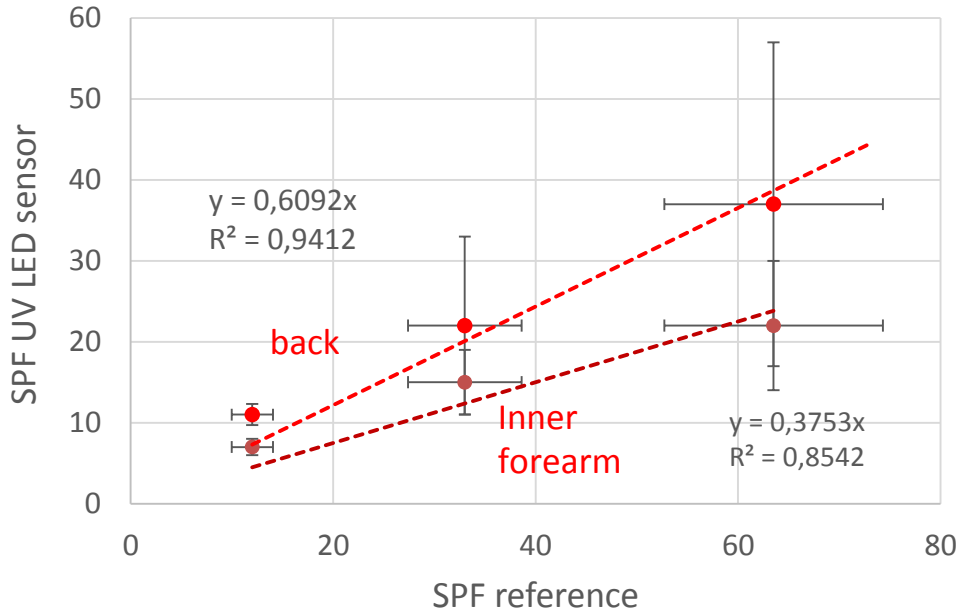


Is the back of the volunteers a better area?

each cream was tested on 6 subjects

Results

comparison of inner forearm and back



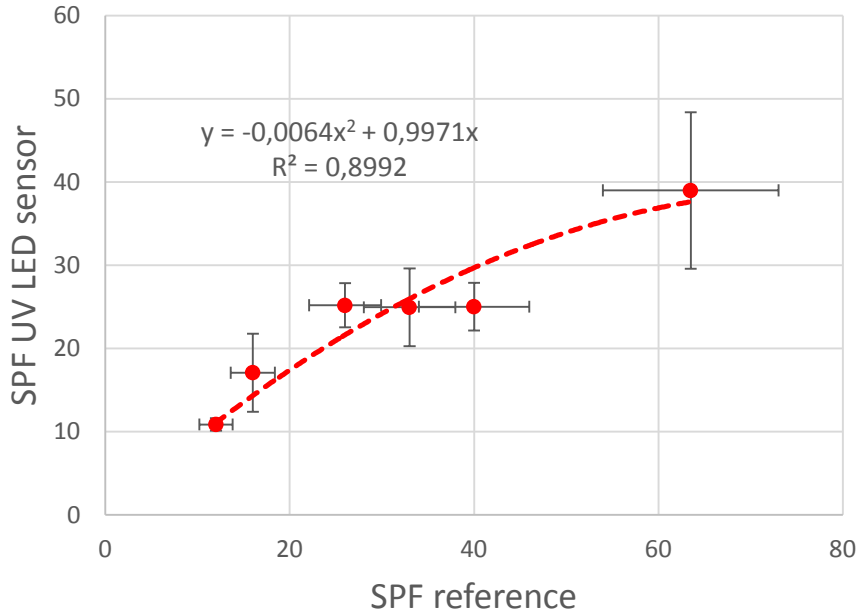
- comparison with three creams on 6 volunteers each
- the back provides higher signal



Measurements should be performed on the back of the volunteers

Results

on human skin at the back of volunteers



- Very good correlation with the results from the test institutes
- Verification on 7 creams in total
- Repetition using an UVA LED is planned

Each cream was tested on 3 to 9 subjects

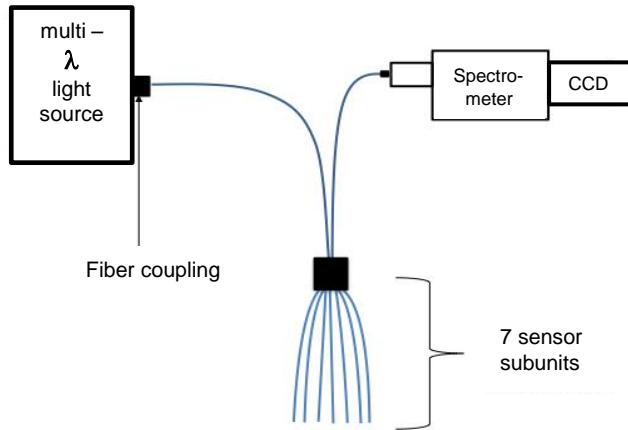
Conclusions

- Measurements using one LED at 308 nm showed already very good correlation to the results of the test institutes
- Applicable on porcine skin and human skin
- The back is more suitable than the forearm
- The method is non-invasive (no sunburn)
- Quick method (don't need to wait 24 hours for the erythema formation)
- Possible fluorescence of the cream could interfere with the backscattered light



Spectrometer based set up is necessary

New system with spectrometer



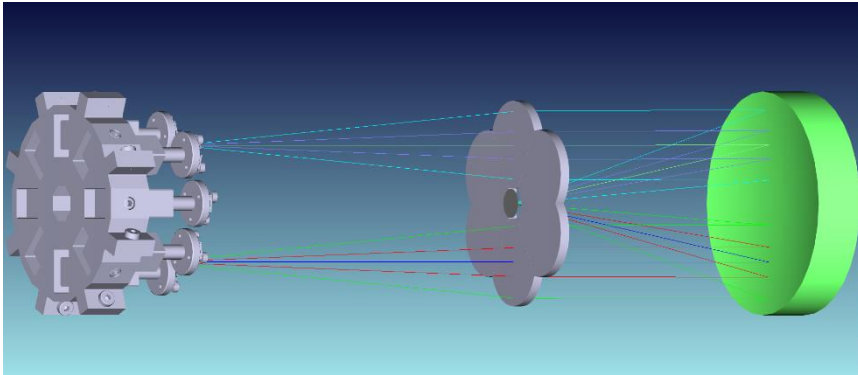
Spectrometer



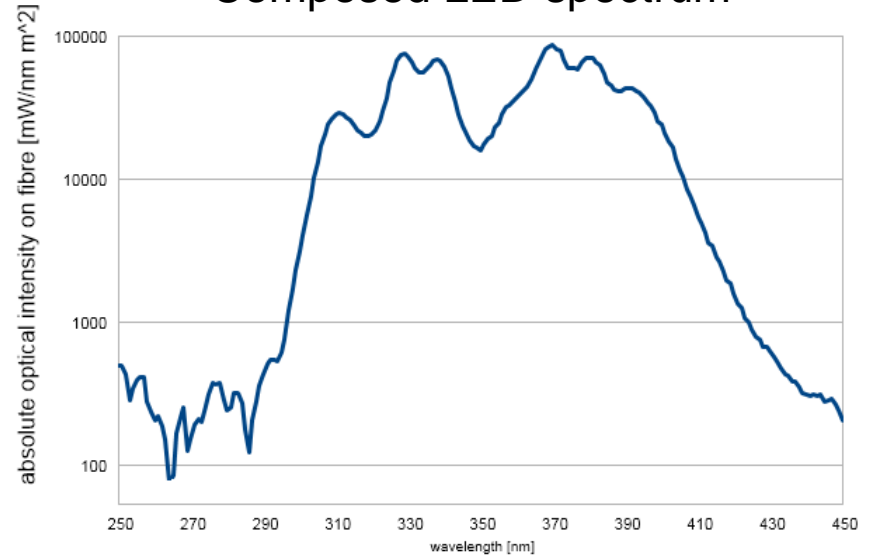
Outlook

New light source which cover the whole UV range

8 LED simulate the sun UV radiation



Composed LED spectrum



Acknowledgments

Charité project team:

- Prof. Dr. Jürgen Lademann
- Prof. Dr. Martina Meinke
- Sabine Schanzer
- Susanna Kobylinski
- Dr. Maxim Darwin

Cooperation partner:

- Courage &Khazaka
- Hans Karrer GmbH
- Freie Universität Berlin, Fachbereich
Wirtschaftswissenschaft



Thank you!



Weitere Informationen:
www.advanced-uv.de