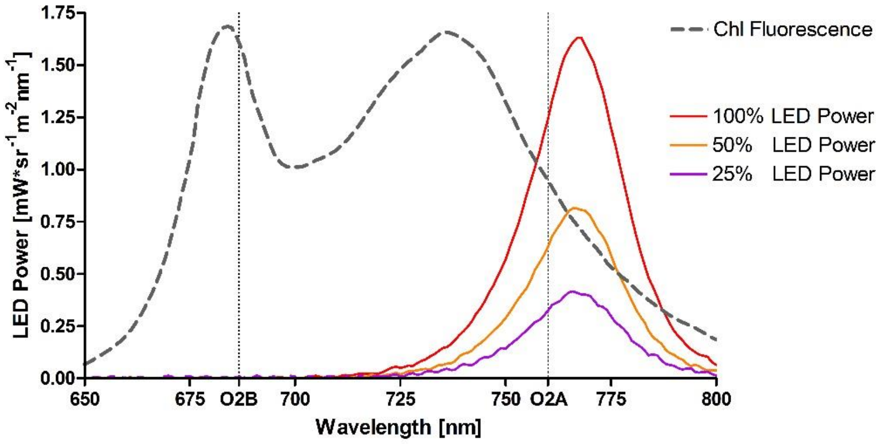
Fluorescence retrieval accuracy estimations using active references in the field



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Forschungszentrum Jülich, Germany

OPTIMISE Workshop, Madrid, 2015-03-30

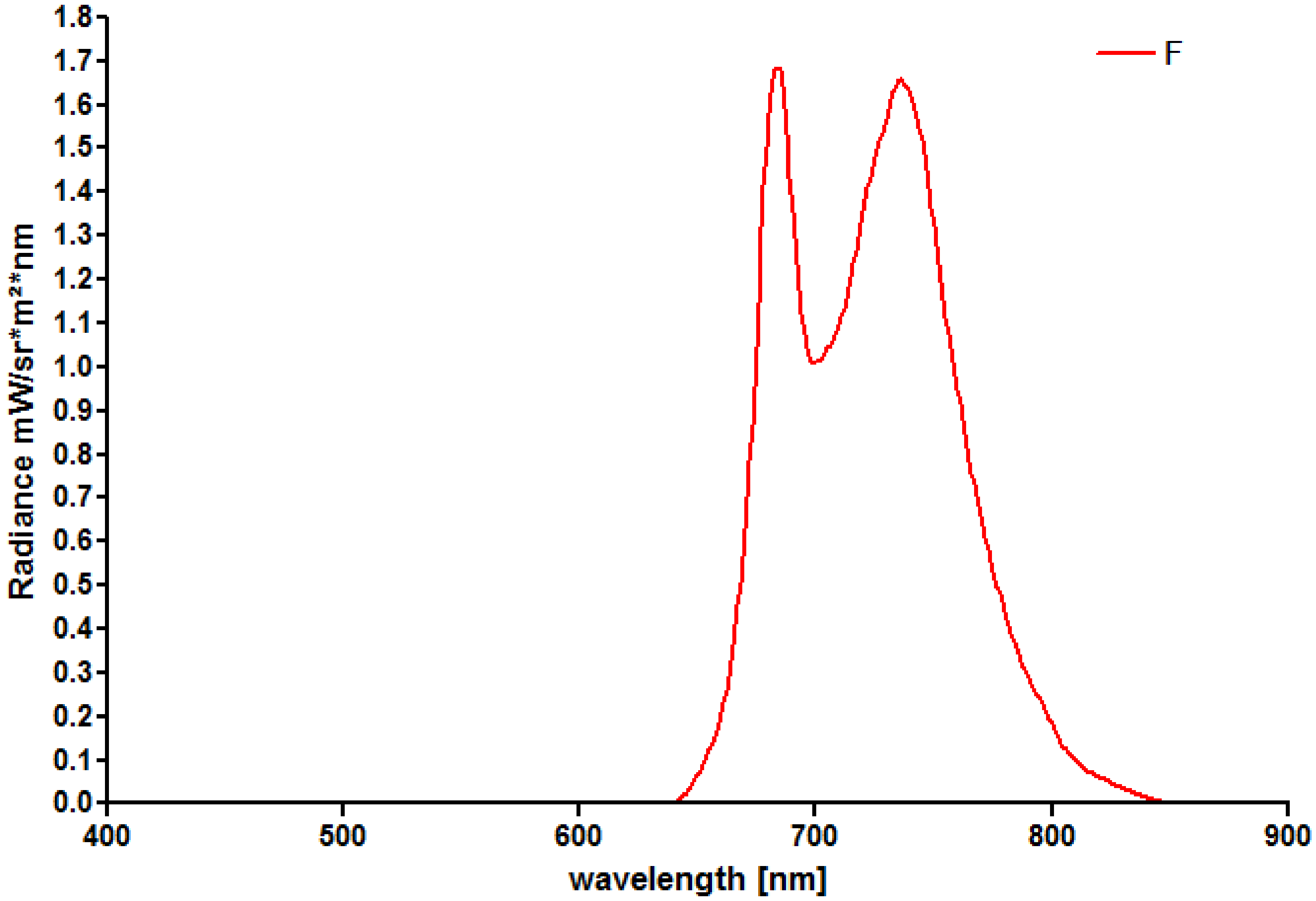
Sun Induced Fluorescence (SIF)

SIF - A proxy to photosynthesis

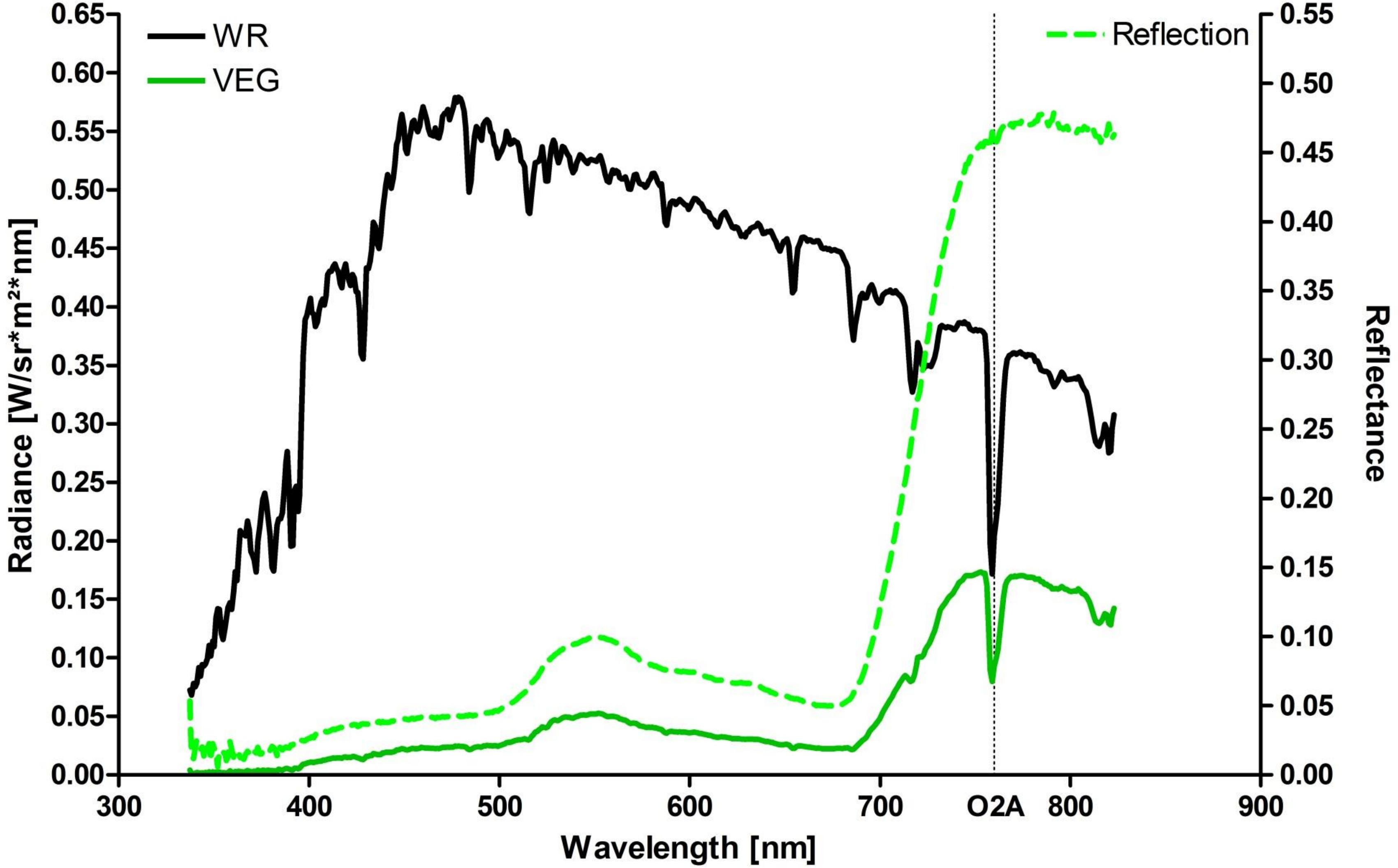
But how to measure it passive?

SIF is between 0 – 5% of the reflected radiance
SIF is highly variable over the day
SIF is dependent on the amount of sun irradiance
SIF has a variable spectral shape

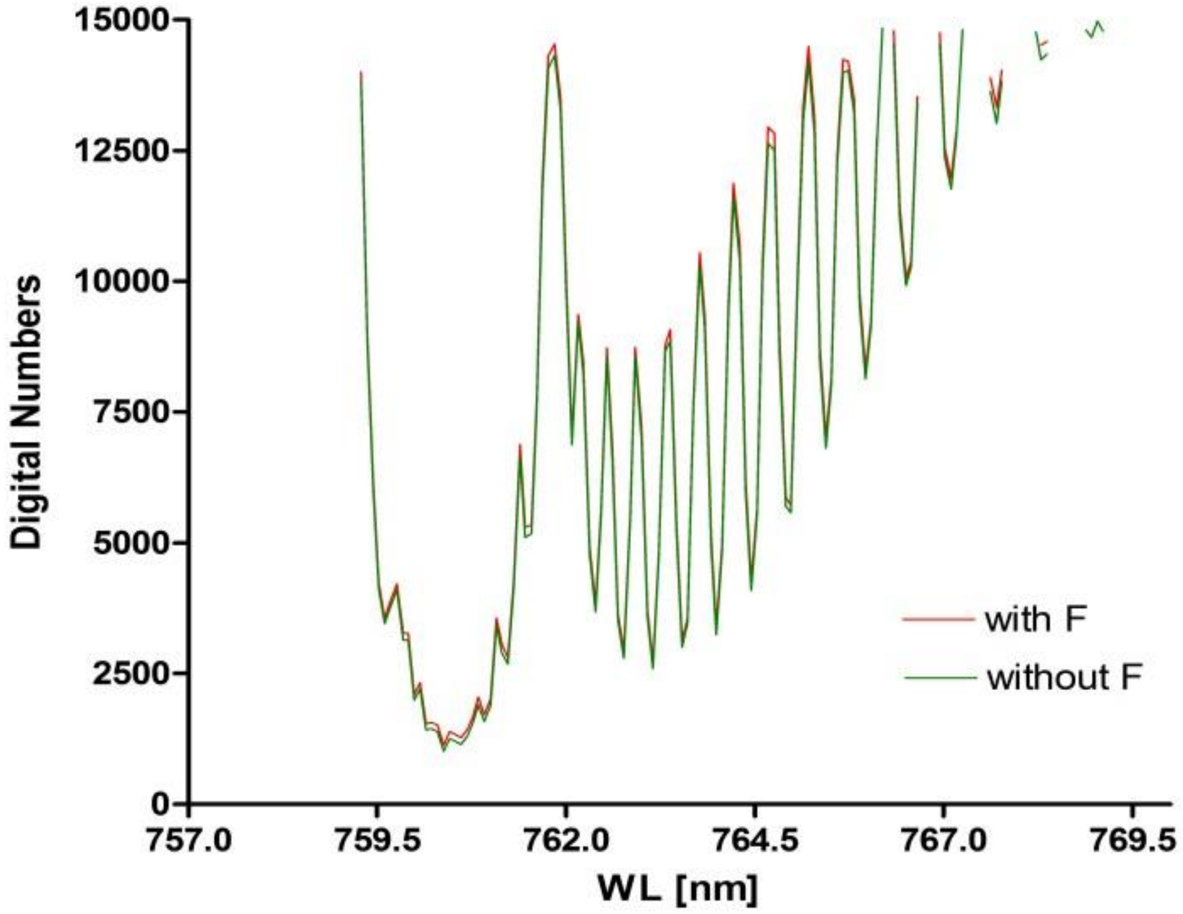
F – Spectral Shape



Sunlight Spectral Shape



Radiance + F

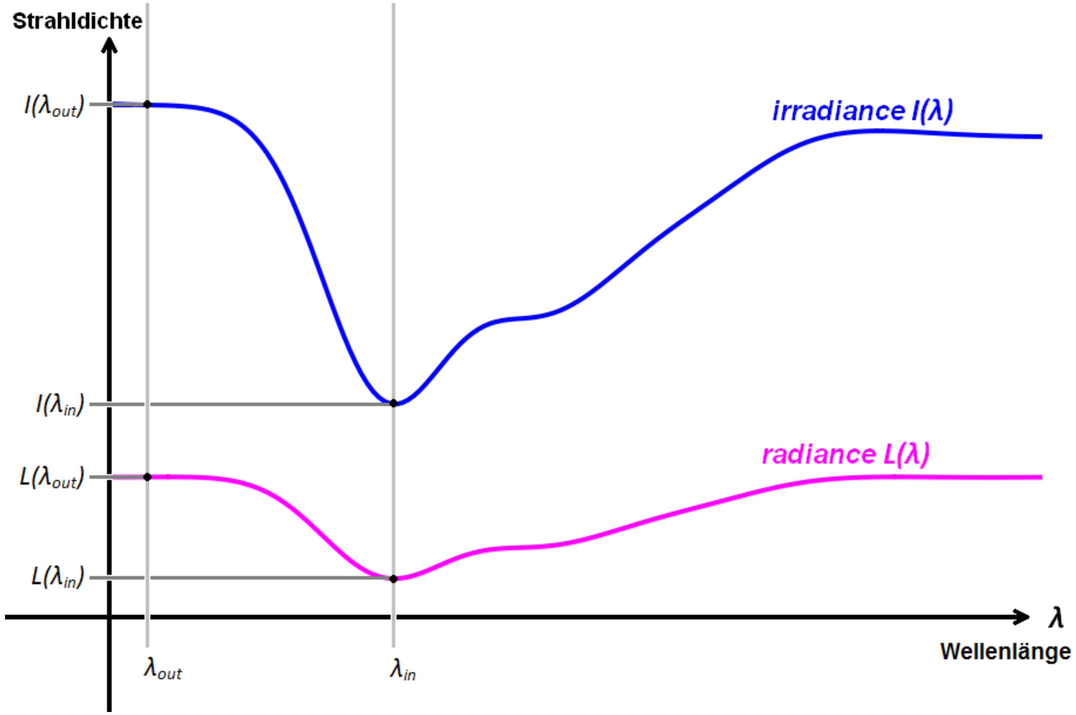


15000
12500
10000
7500
5000
2500
0
Digital Numbers
757.0
759.5
762.0
764.5
767.0
769.5
WL [nm]
with F
without F

The FLD Method

The Fraunhofer Line Discrimination (FLD) method is a mathematical approach to retrieve the tiny signal of F from the hyperspectral measurements inside and outside of the the Fraunhofer Lines.

I = irradiance
L = reflectance (at wavelength λ inside/outside the Fraunhofer line)



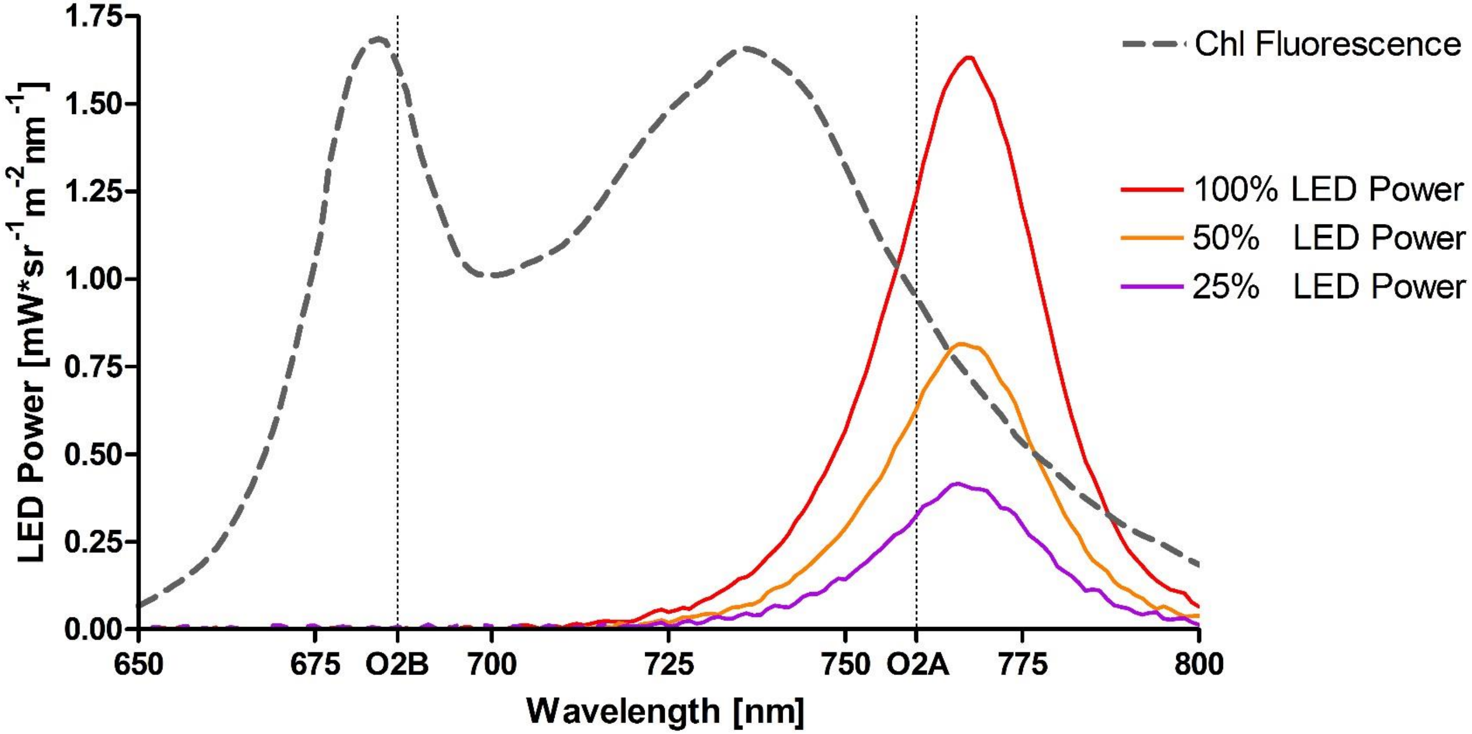
$$F = \frac{(L(\lambda_{in}) \cdot I(\lambda_{out}) - L(\lambda_{out}) \cdot I(\lambda_{in}))}{(I(\lambda_{out}) - I(\lambda_{in}))}$$

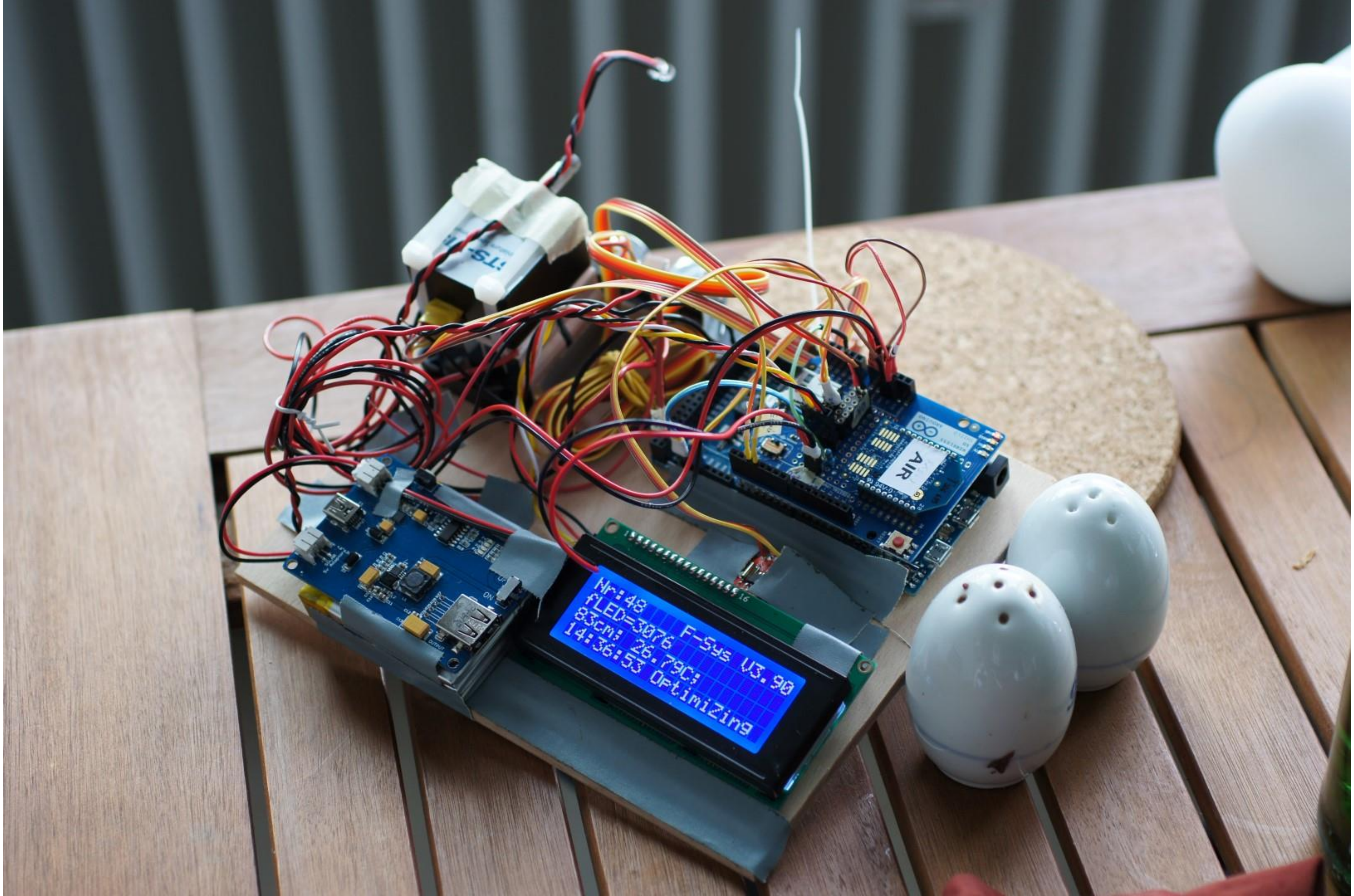
Problems

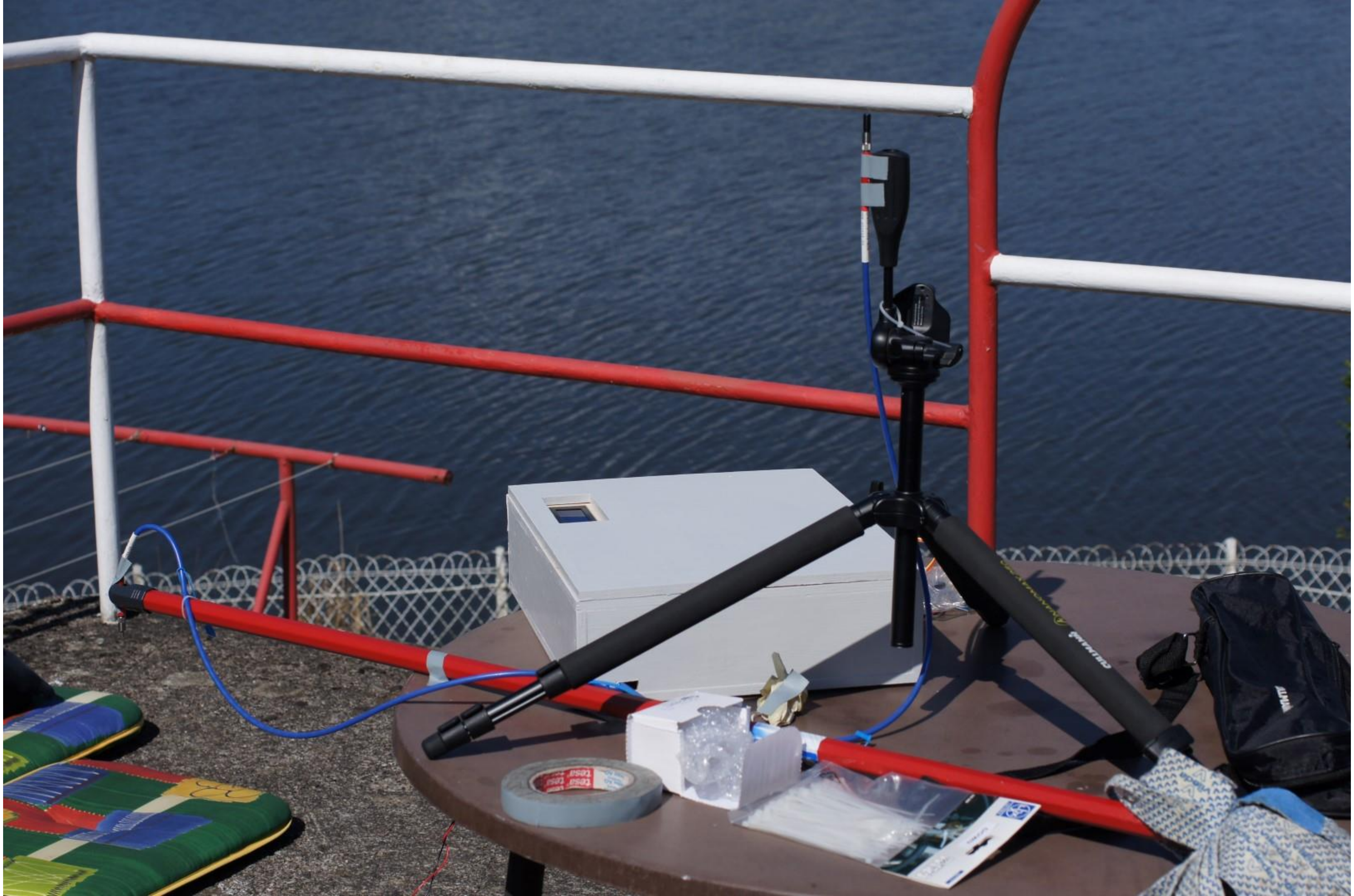
- The contribution of F is unknown
- The irradiance changes
  - high/low - directional/diffuse
- Noise of the spectrometer is measured as SIF
  - Temperature changes introduce noise
  - Temperature changes introduce spectral shifts
- There might be other problems we don´t even know

How can we now that our devices are really measuring solely SIF?

Active SIF Reference LED

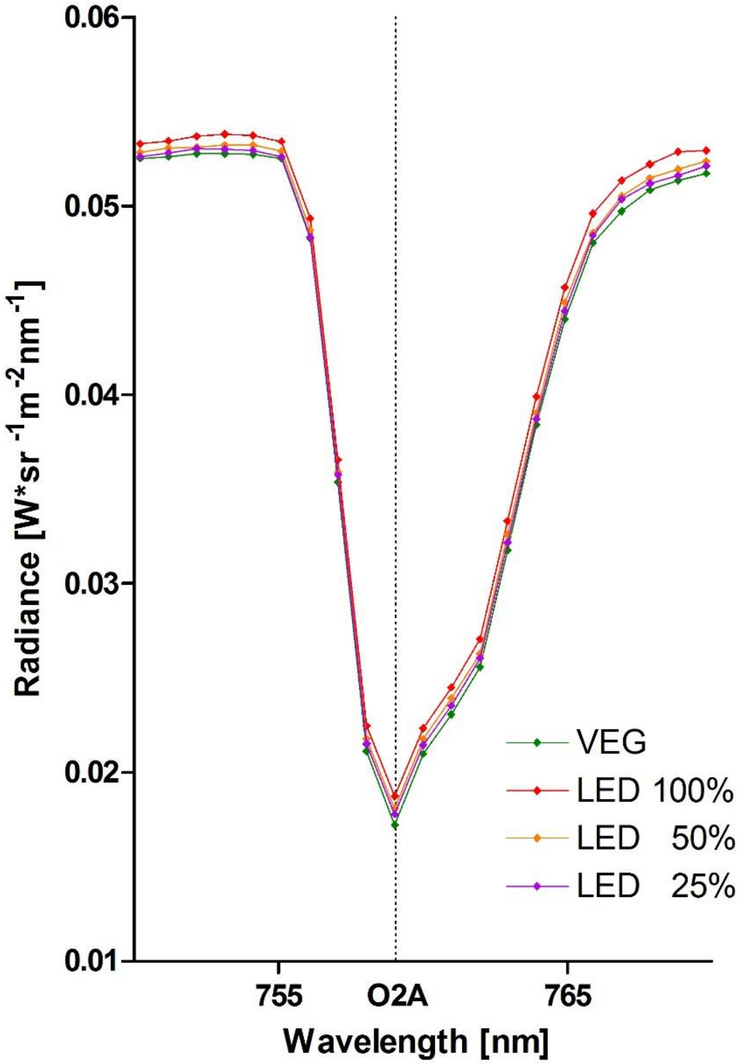


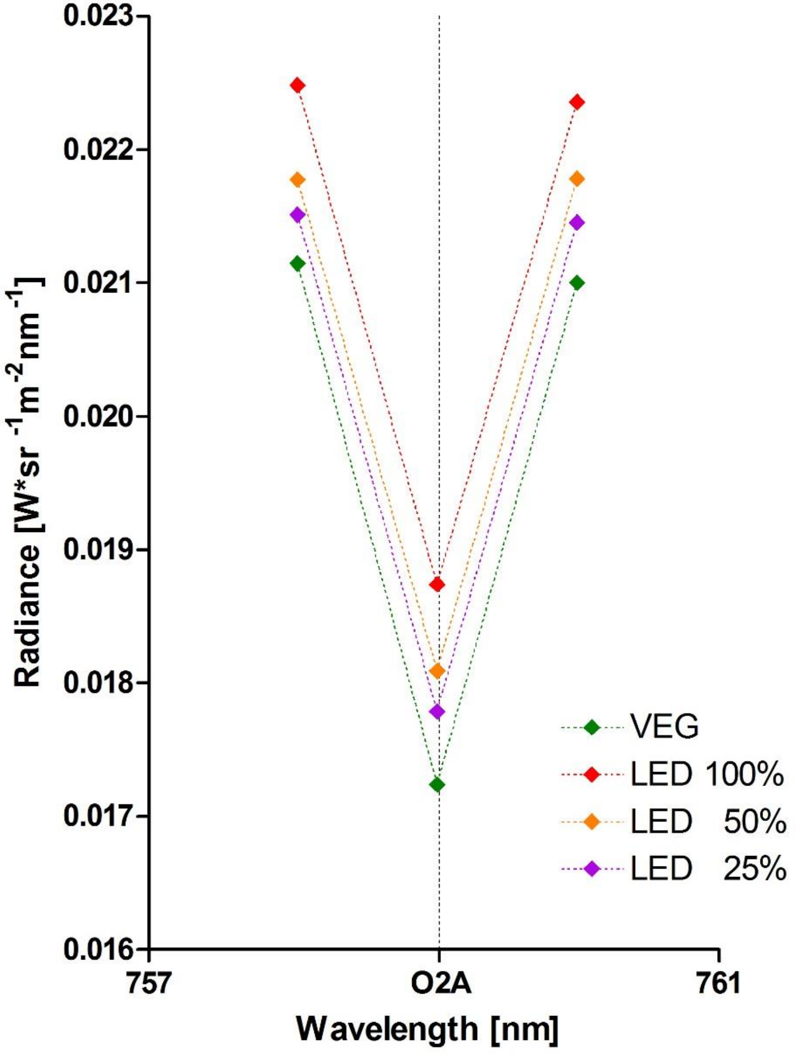

Nr:48 F-Sys V3.90
fLED=3076
83cm; 26.79C;
14:36:53 Optimizing
AIR



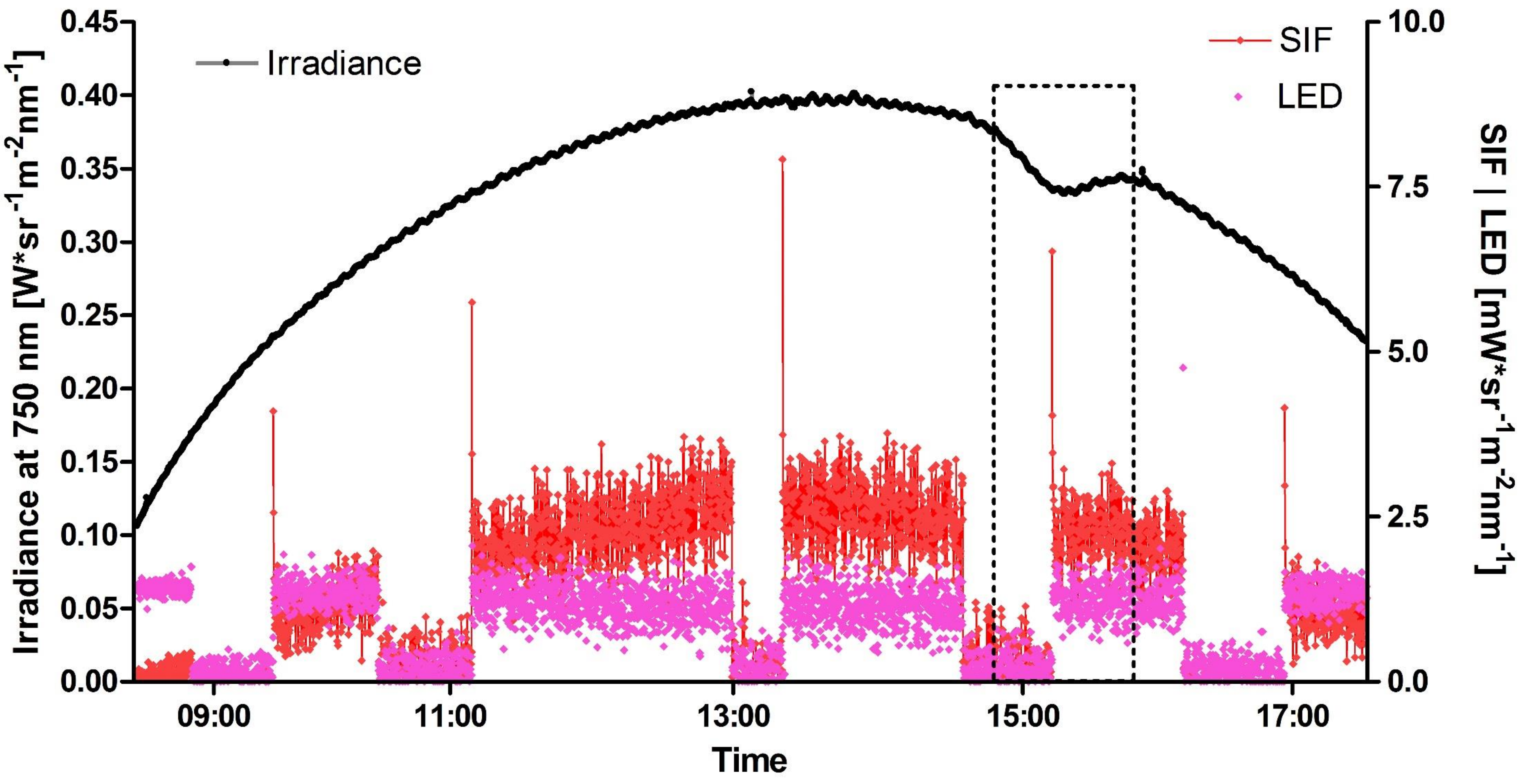
Measurement Setup

Raw Measurements of the Reference





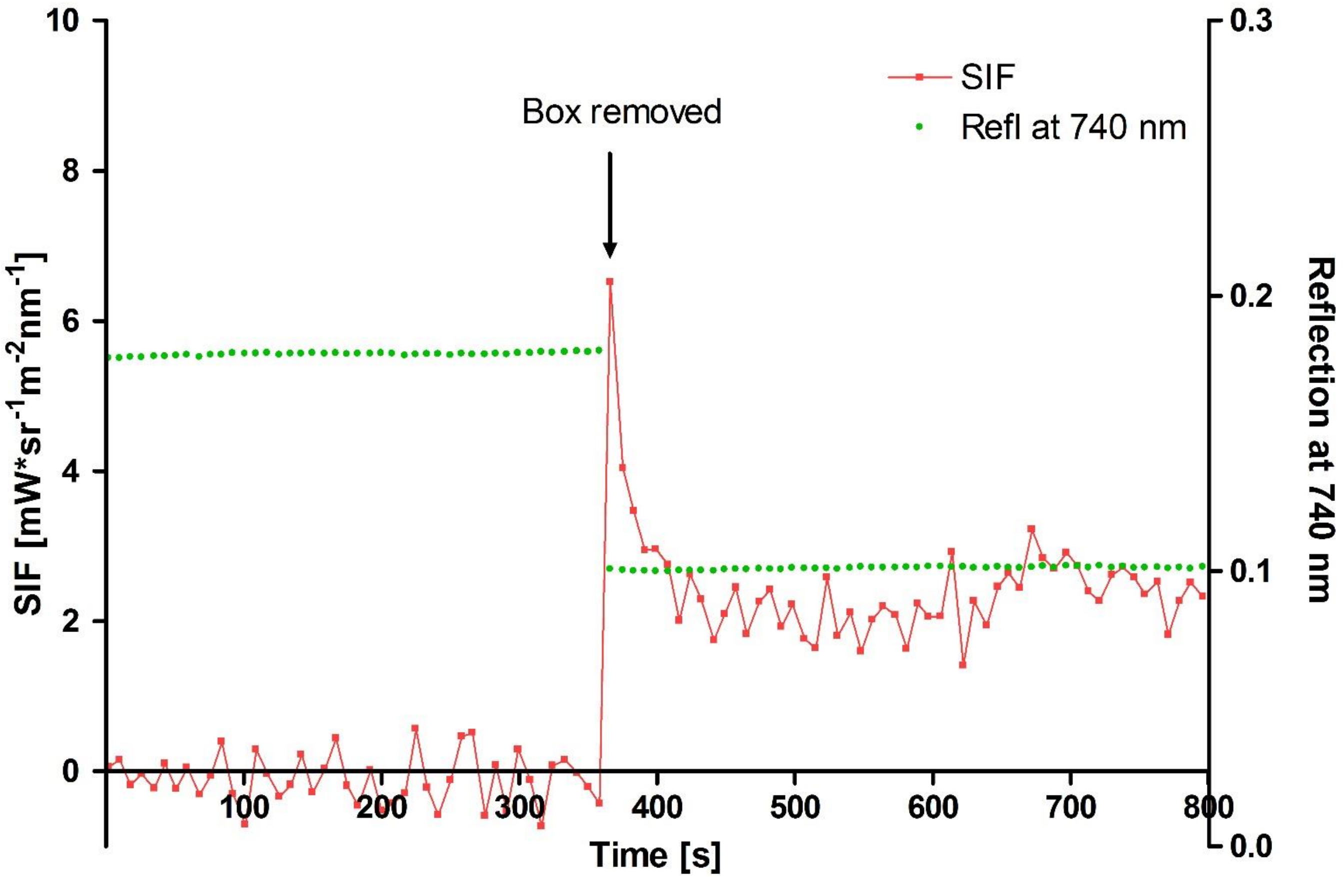
Diurnal Course of Reference and SIF



Kautsky Effect

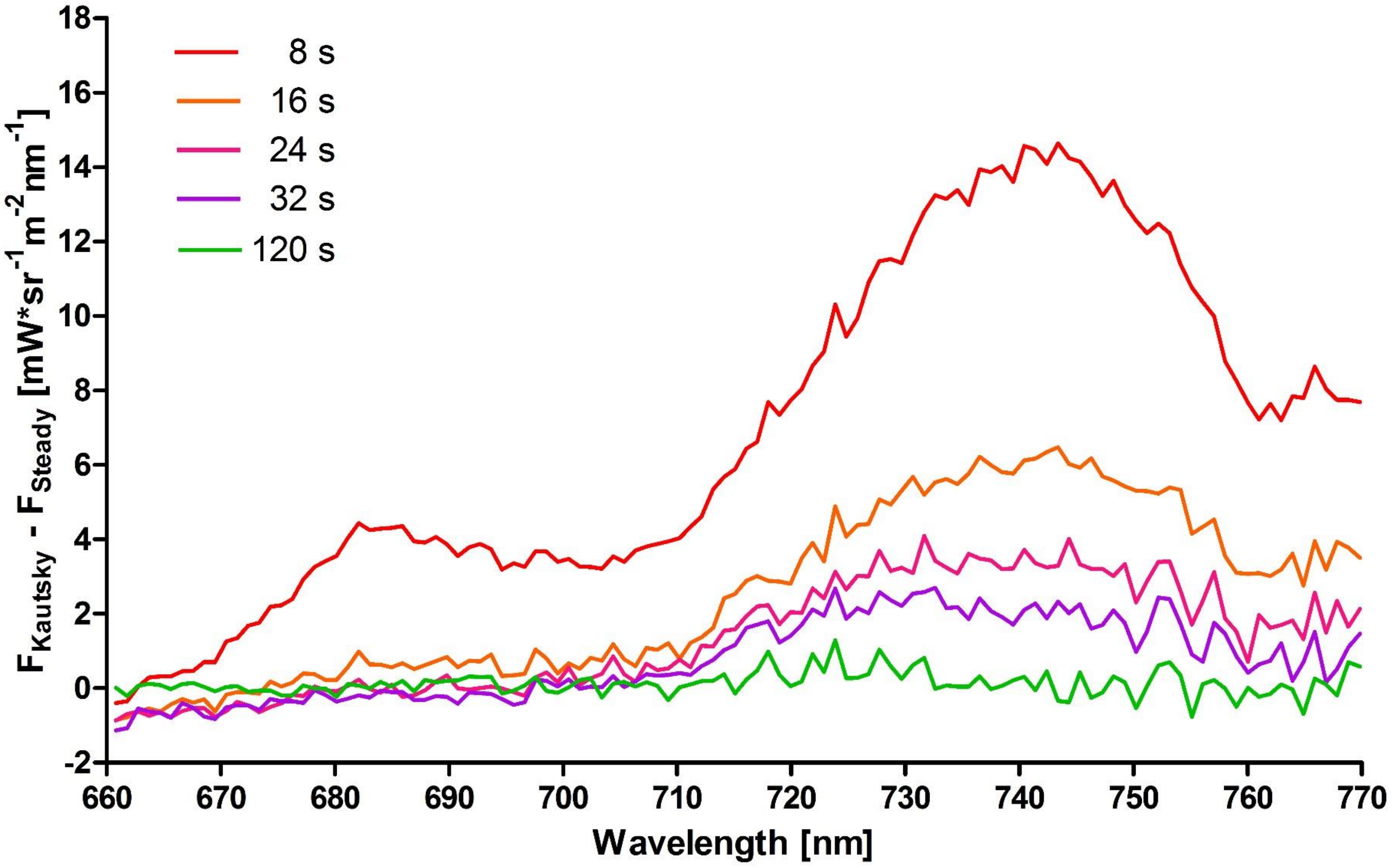
- Dark adapted plants show a strong increase in fluorescence, when suddenly exposed to strong light.
- The Kautsky effect is visible for about 60 seconds, until the plant has adapted to the new light conditions.
- This effect is useful to test a device that measures SIF.

Inducing Kautsky Effect



Spectral analysis of the Kautsky Effect

By comparing steady state spectra of the plant´s reflected radiance against spectra that are affected by the Kautsky effect, it´s spectral shape can be visualized.



Conclusion

Ways to check a device that is intended to measure SIF:

1. Measure a day-course of SIF
2. Measure the emission of a F-LED stable throughout the day
3. Measure the Kautsky-effect spectrally and over time
4. Measure a non-fluorescent target throughout the day

SIF changes from a hard to catch phantom into a physically measurable signal.