JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

Stimulated Recovery Studies of PWO Crystals

P. Orsich, K.-T. Brinkmann, V. Dormenev, M. Moritz, R.-W. Novotny, H.-G. Zaunick

II. Physics Institute JLU, Giessen

HIC for FAIR
Helmholtz International Center

GSI

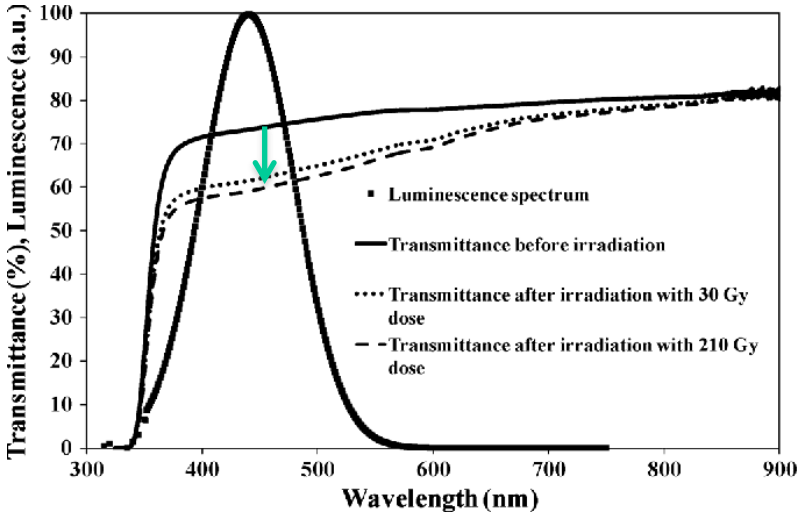
Federal Ministry of Education and Research

JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

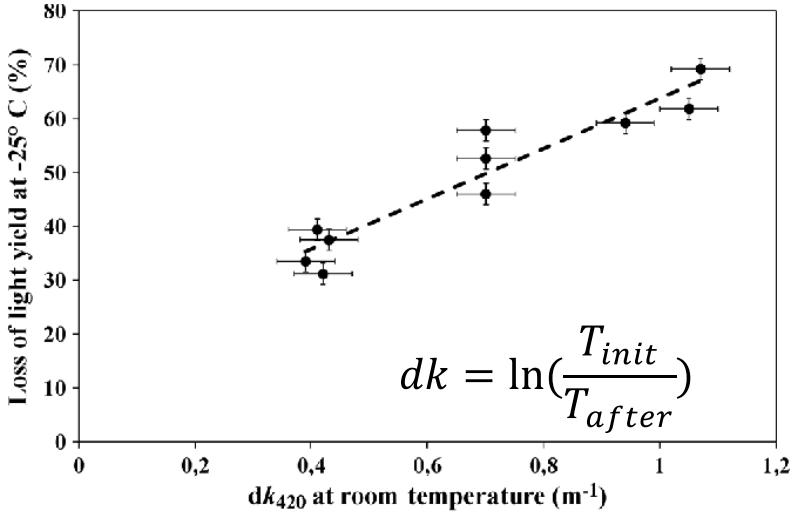
- **Introduction**
- **Experimental setup**
- **Results**
- **Summary and outlook**

JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

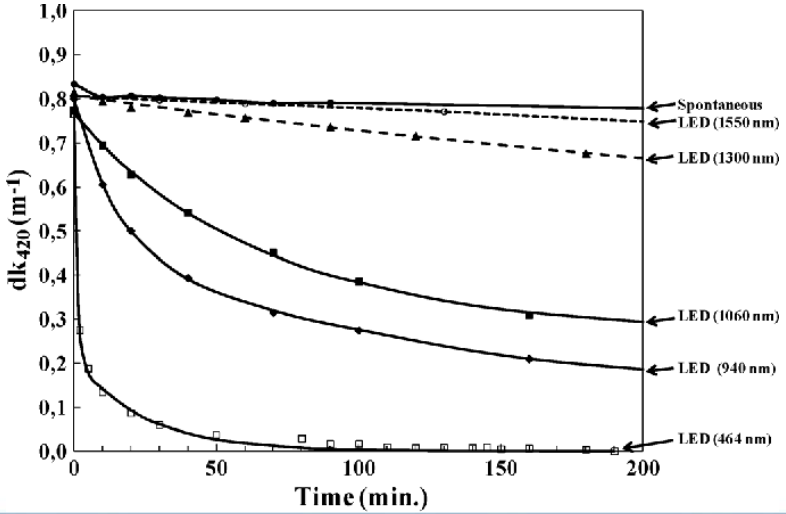
Transmission after the irradiation of crystals with different radiation doses



Induced absorbtion vs light yield



Stimulated recovery with different LED types



The irradiation leads to the population of color centers (induced absorbtion) => Degragation of the transmission

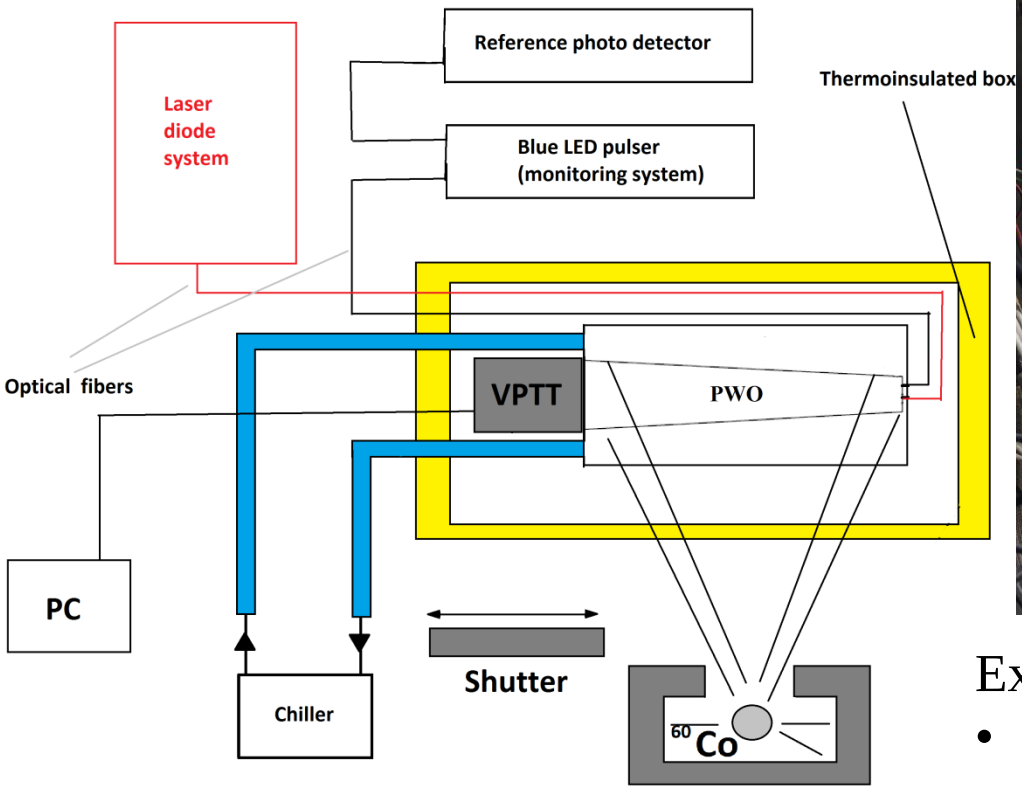
=>Reduction of the light yield

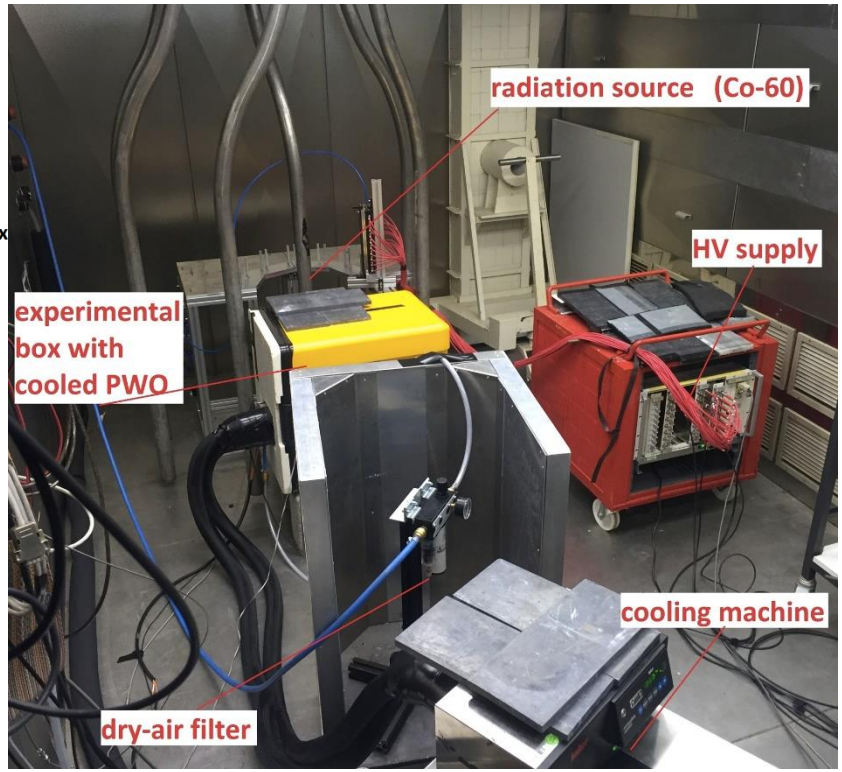
=>Deterioration of the energy resolution

maximum annual dose 125 Gy ~15-30 mGy/h -TDR

JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

Schematic layout of the experimental setup



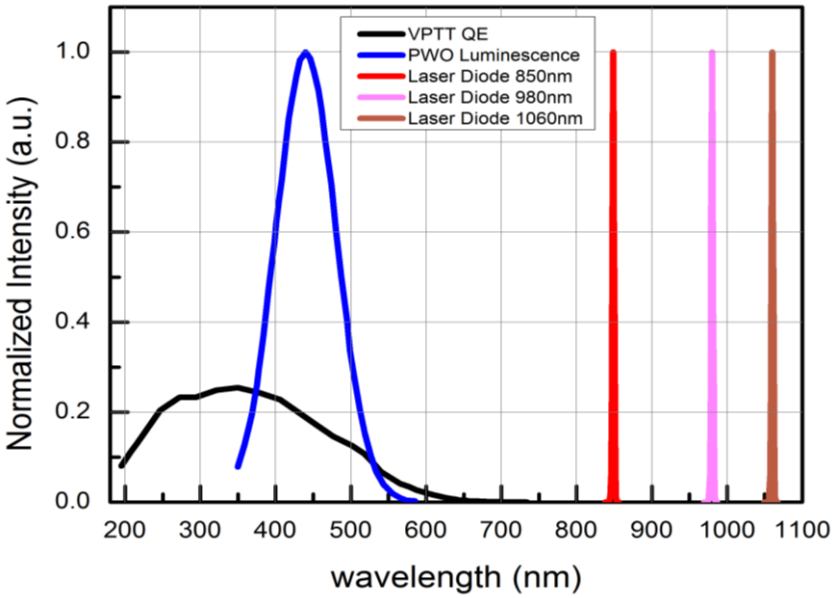


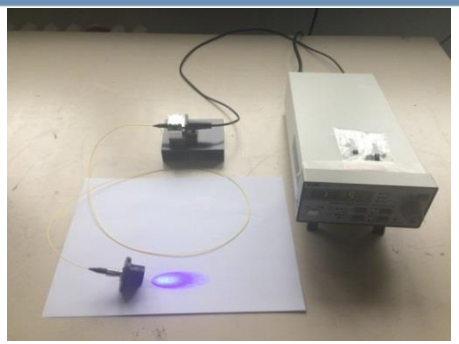
Experimental setup was updated:

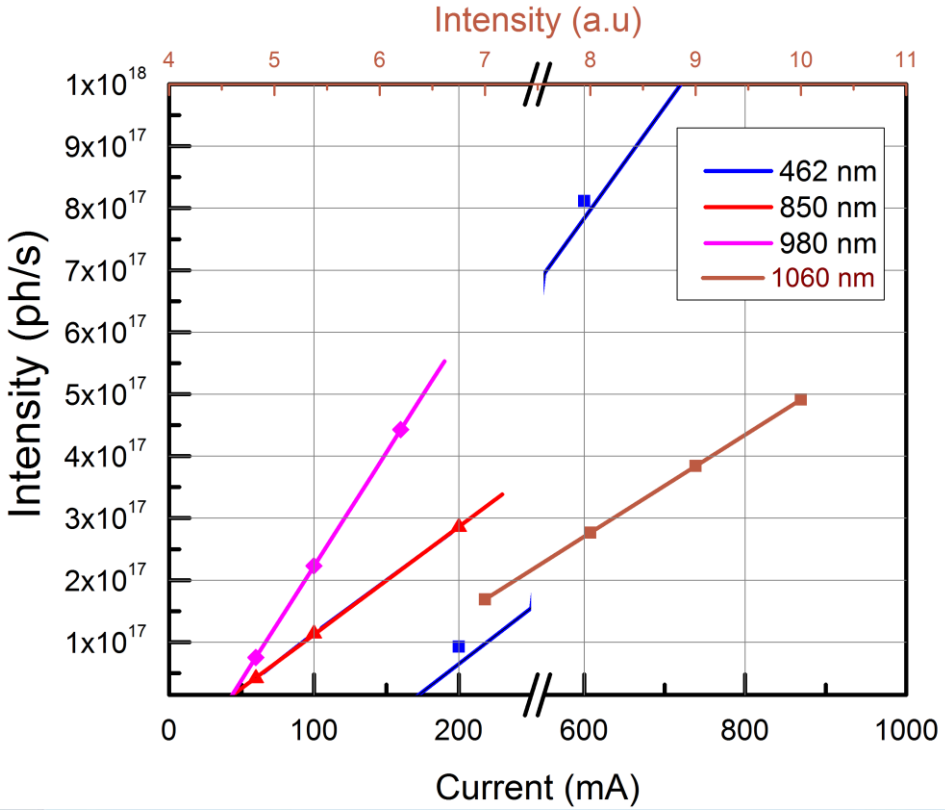
- to reduce light leakage from crystal;
- to optimize light reflection and collection .

JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

- Laser diode system





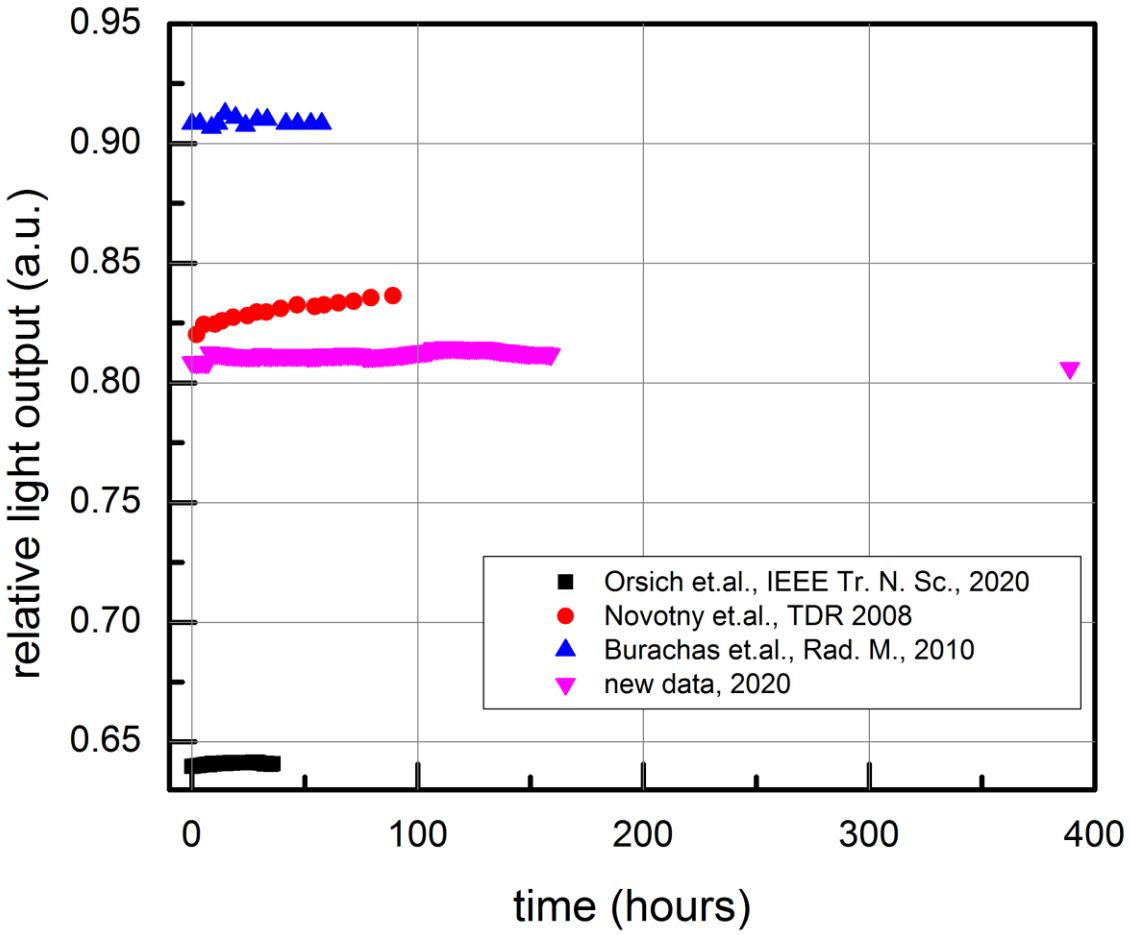


- Test with set of laser diodes were done: 462, 850, 980, 1060 nm

- The intensity of laser diodes was measured by optical power meter for whole system (include optical fibers)

JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

Spontaneous recovery of the PWO crystal after the irradiation at -25° C



Dose rate for new data was 6.4 Gy/h during 4.5 h (integral dose = 30 Gy)

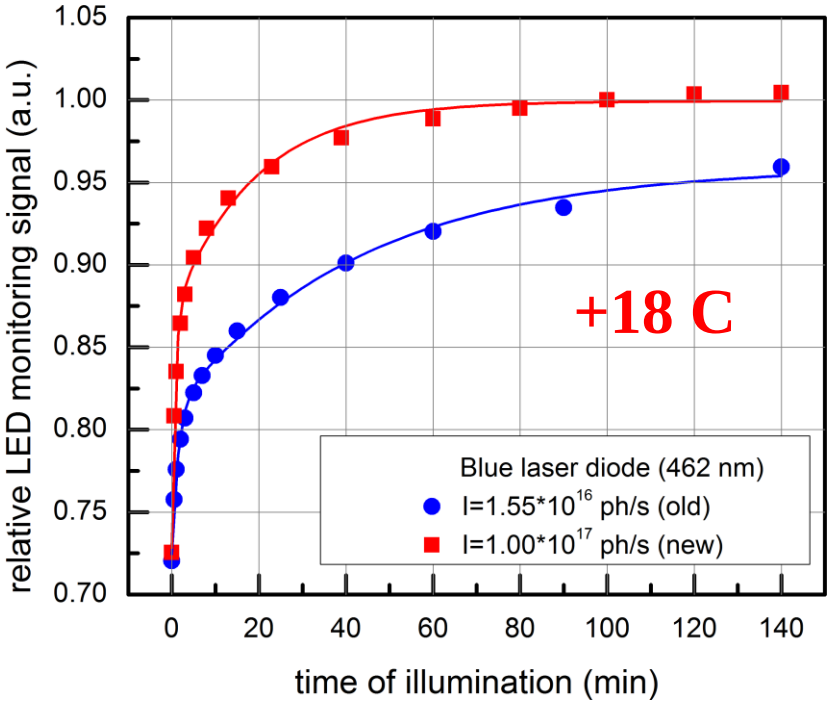
- comparison with previous study

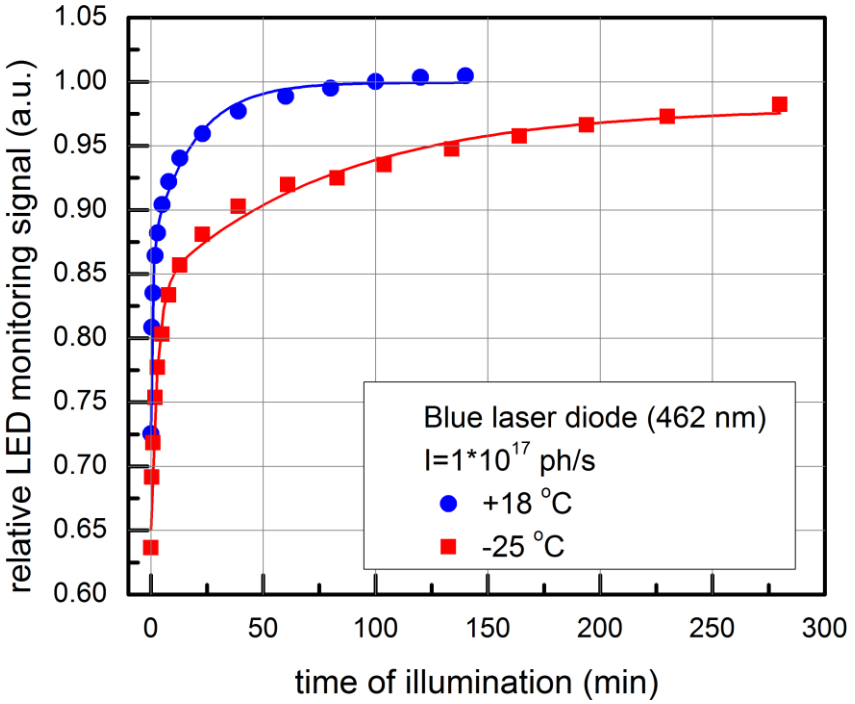
- no significant spontaneous recovery at the low temperature during **380** hours of the measurement.

JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

Recovery curves of the PWO crystal after the irradiation as a function of the integral duration of the illumination with blue laser diodes at +18° C and -25° C.

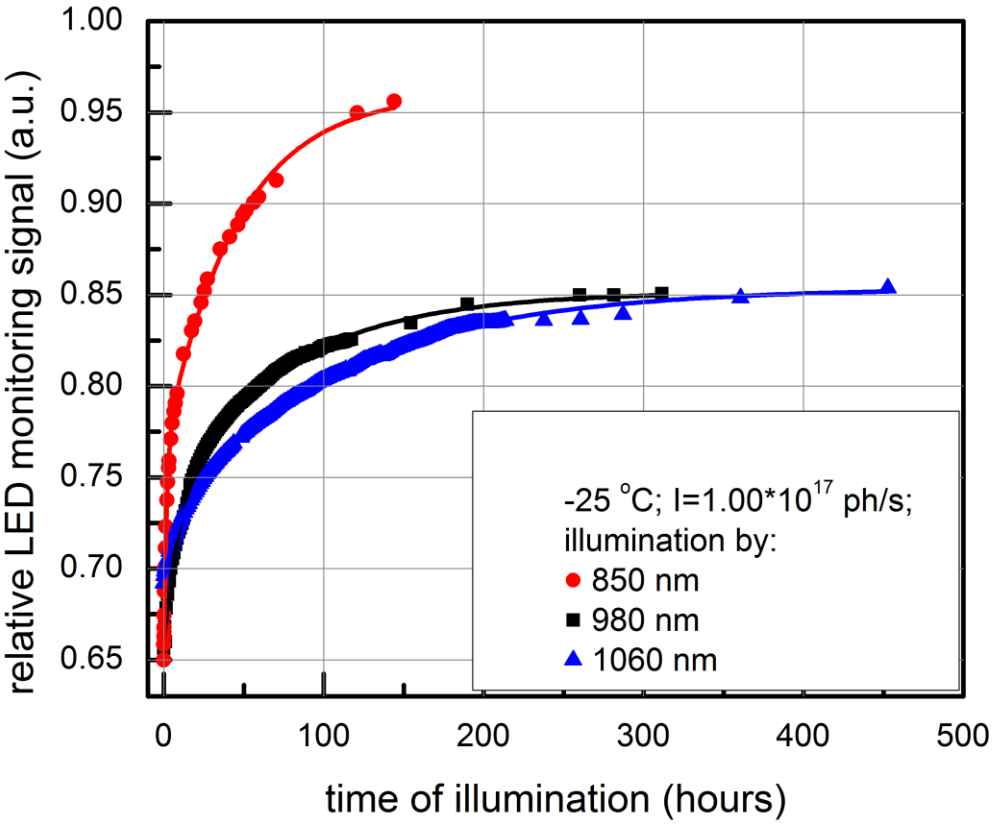
Dose rate of 6.4 Gy/h during 4.5 h (integral dose of 30 Gy)





JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

Recovery curves after irradiation at -25° C.



Dose rate of 6.4 Gy/h during 4.5 h (integral dose of 30 Gy)

- Fitting function:

$$1 - a_1 e^{-\frac{x}{t_1}} - a_2 e^{-\frac{x}{t_2}} - c\,,$$

where $a = a_1 + a_2$-sum of recovery;
t_1 – fast recovery constant;
t_2 – slow recovery constant
c – residual damage

JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

Fit parameters of recovery

Fitting function: $1 - a_1 e^{-\frac{x}{t_1}} - a_2 e^{-\frac{x}{t_2}} - c;$

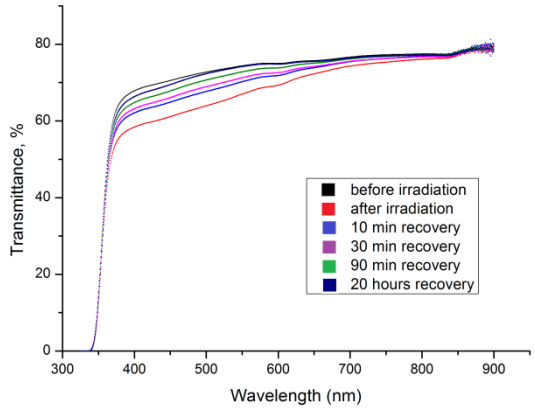
$R_i = \frac{a_i t_i}{\sum_{i=1}^{2} a_i t_i}$, where $a = a_1 + a_2$

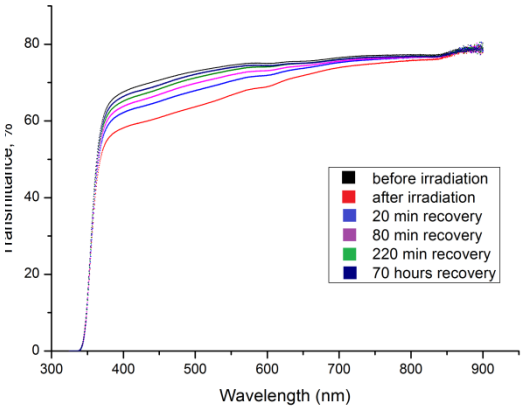
Wavelength of light illumination	'a', sum recovery (%)	't_1', fast recovery constant (hours)	'R_1', contribution fast constant(%)	't_2', slow recovery constant (hours)	'R_2', contribution slow constant (%)	'c', residual damage (%)
464 nm	33.0	0.047	4.5	1.34	95.5	2
850 nm	33.0	1.77	2.5	45.3	97.5	4
980 nm	19.6	10.14	8.9	74.77	91.1	15
1060 nm	15.2	10.4	2.0	106.3	98.0	15

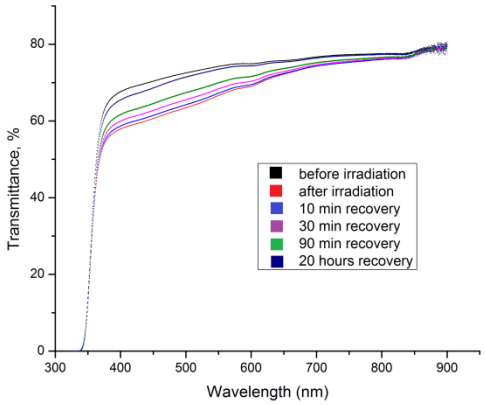
- **Limit of implementation the «online» mode recovery placed between 850 nm and 980 nm!!**

JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

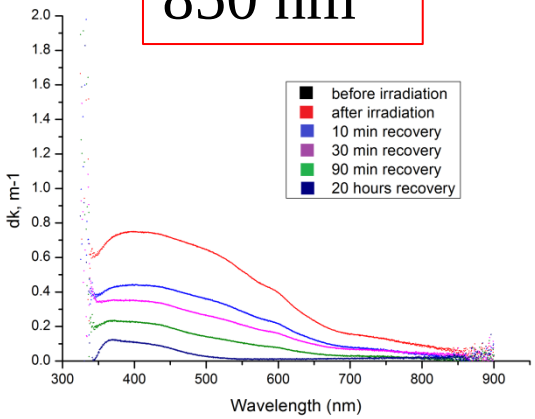
Recovery spectra of the transmittance and dk @ RT



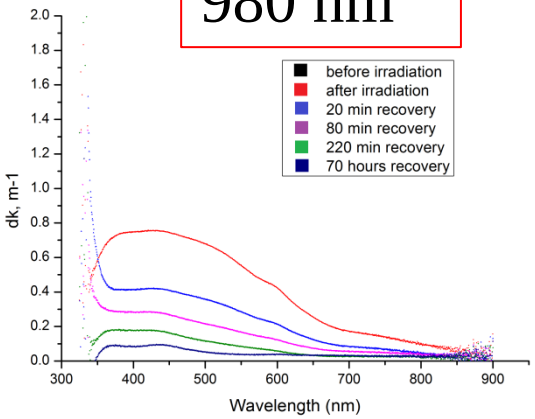




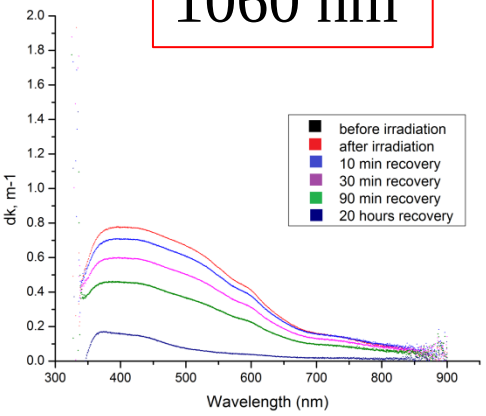
850 nm



980 nm



1060 nm

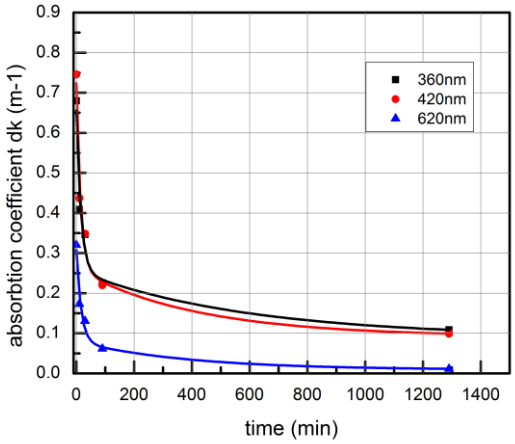


JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

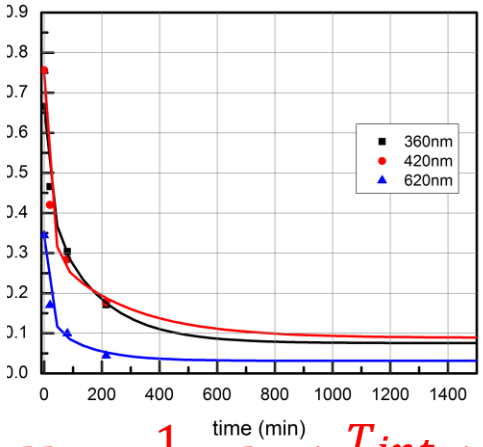
- Recovery of dk measured at 360, 420 and 620 nm @RT.
- The illumination with laser diodes: 850 nm, 980 nm, 1060 nm

Light illumination by:

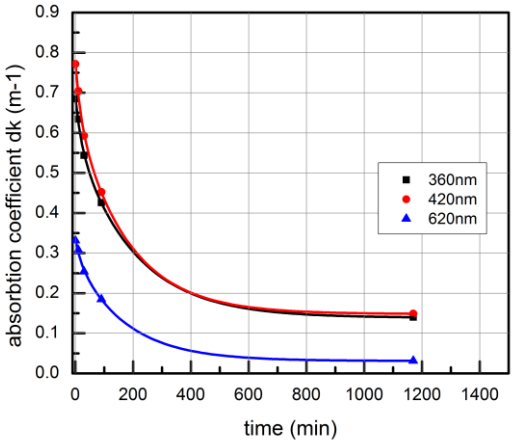
850 nm



980 nm



1060 nm



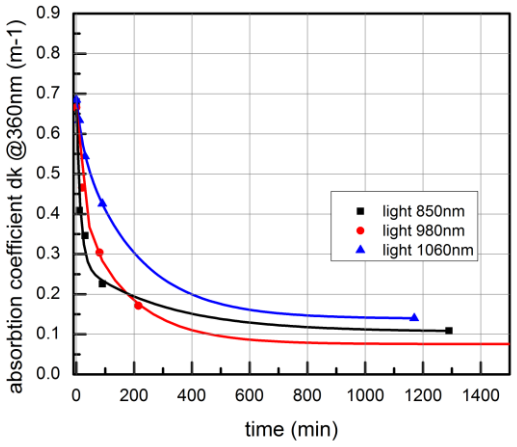
$$dk = \frac{1}{l} * \ln\left(\frac{T_{int}}{T_{after}}\right)$$

JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

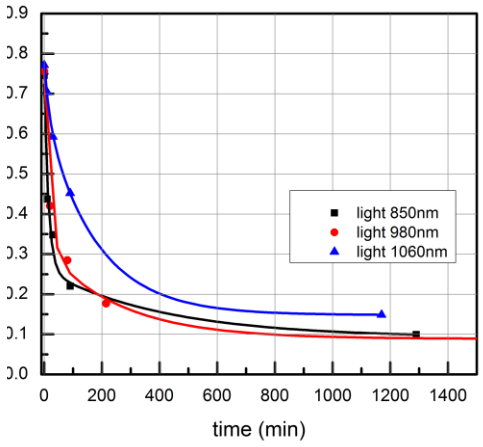
- Recovery of dk measured at 360, 420 and 620 nm @RT.
- The illumination with laser diodes: 850 nm, 980 nm, 1060 nm

Absorbtion coefficient at:

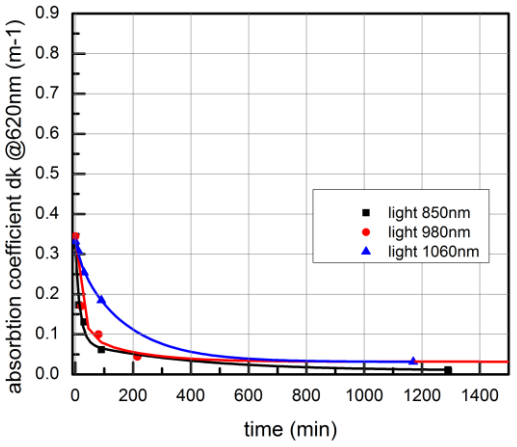
360 nm



420 nm



620 nm

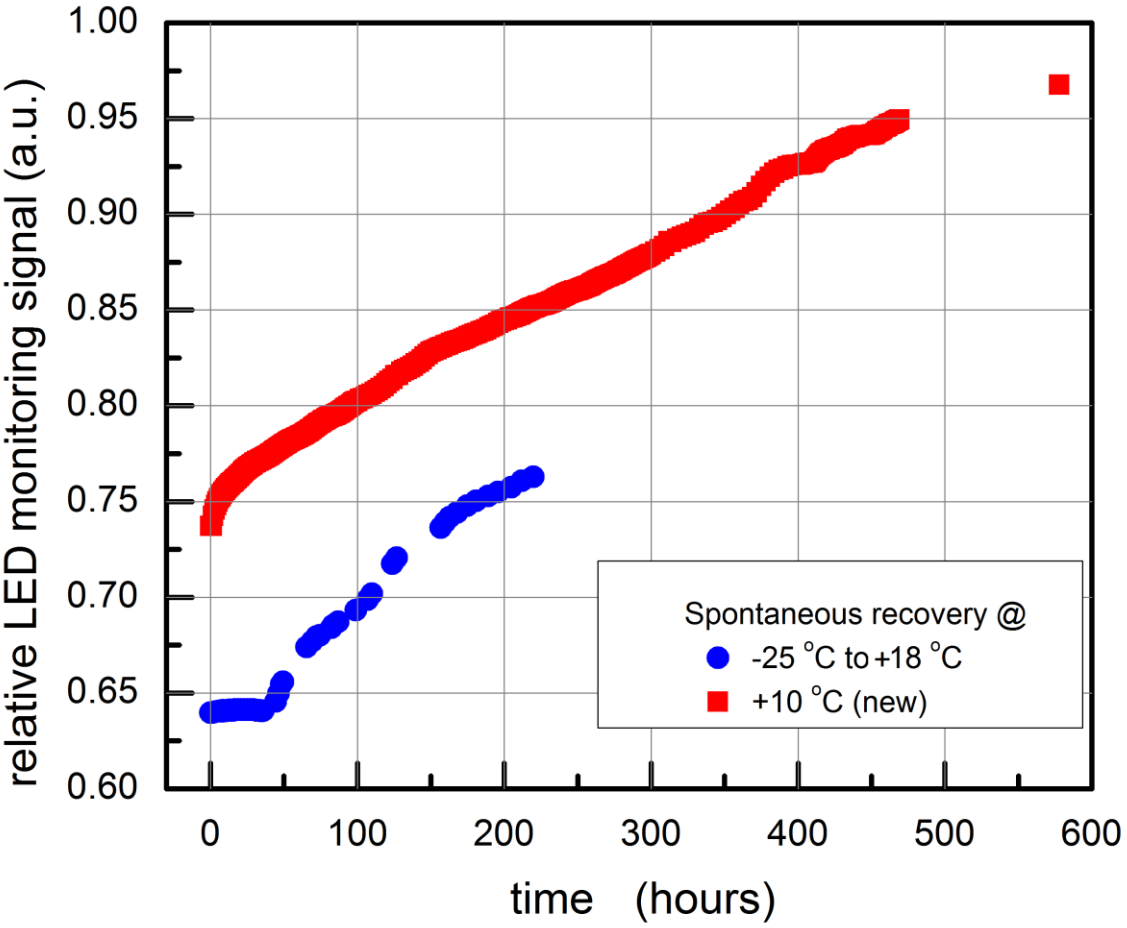


Summary

- The stimulated recovery process is an effective application to reduce radiation damage of the EMC units.
- Since VPTT has a negligible quantum efficiency in the infrared region, the stimulated recovery with light between **850 nm and 1100 nm** opens an opportunity for the "online" recovery mode mode at low temperature at low dose rate (5-30 mGy/h).
- The stimulated recovery with blue light can be implemented only in "offline" mode.
- Further tests to define intensity for 980/1060 nm light illumination at low dose rate (5-30 mGy/h) and PANDA EMC working temperature(-25° C).
- Radiation damage curve at low dose rate to evaluate time range for "offline" mode.

JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

Spontaneous recovery of the PWO crystal after the irradiation at +10° C (comparison with +18° C and -25° C)



Dose rate of 6.4 Gy/h during 4.5 h (integral dose of **30 Gy**) for 10° C and
4.6 Gy/h during 6.5 h (integral 30 Gy) for range from -25° C to +18° C.

JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

Back slides