Radiation damage recovery of lead tungstate crystals under light illumination

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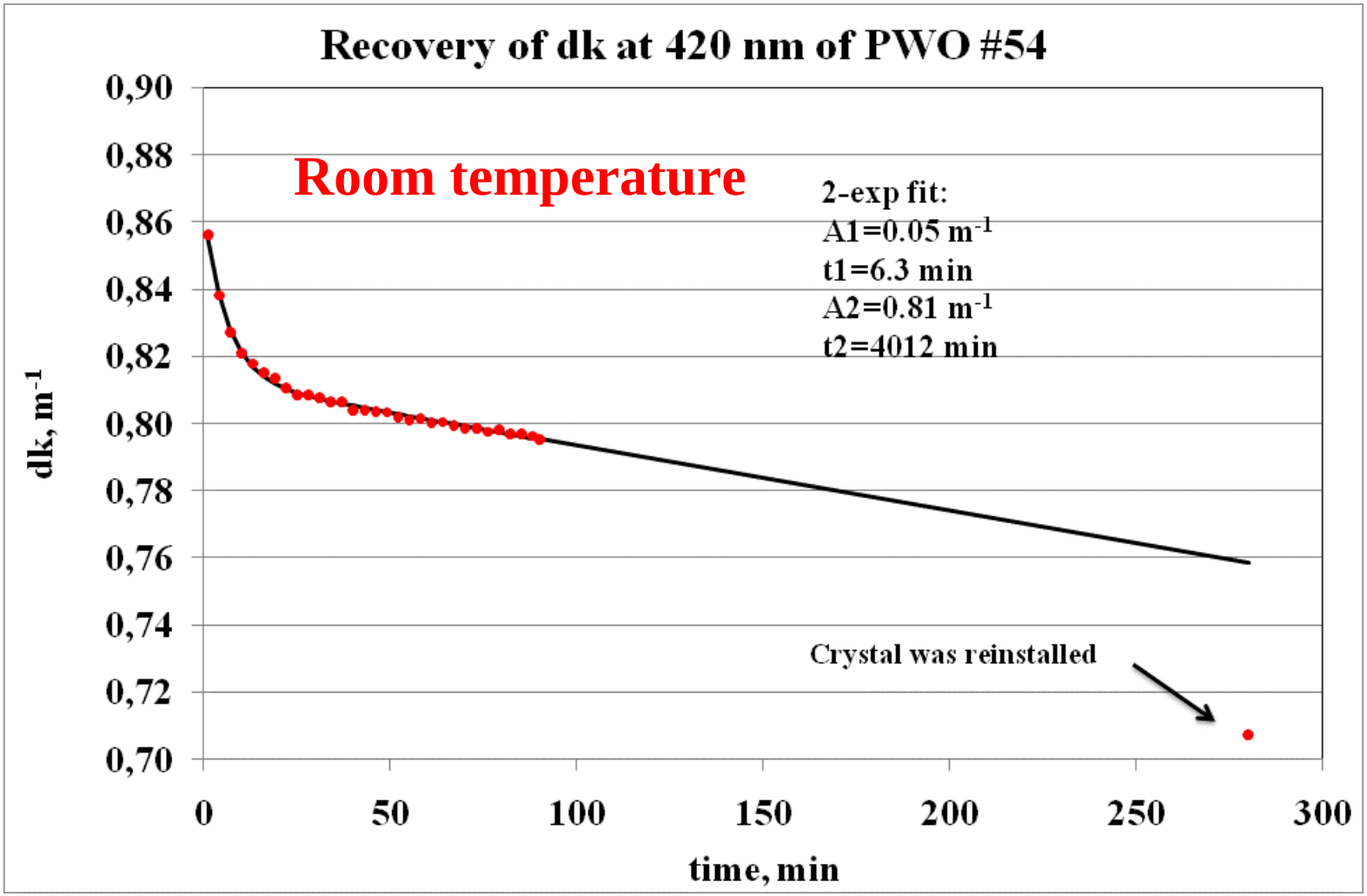
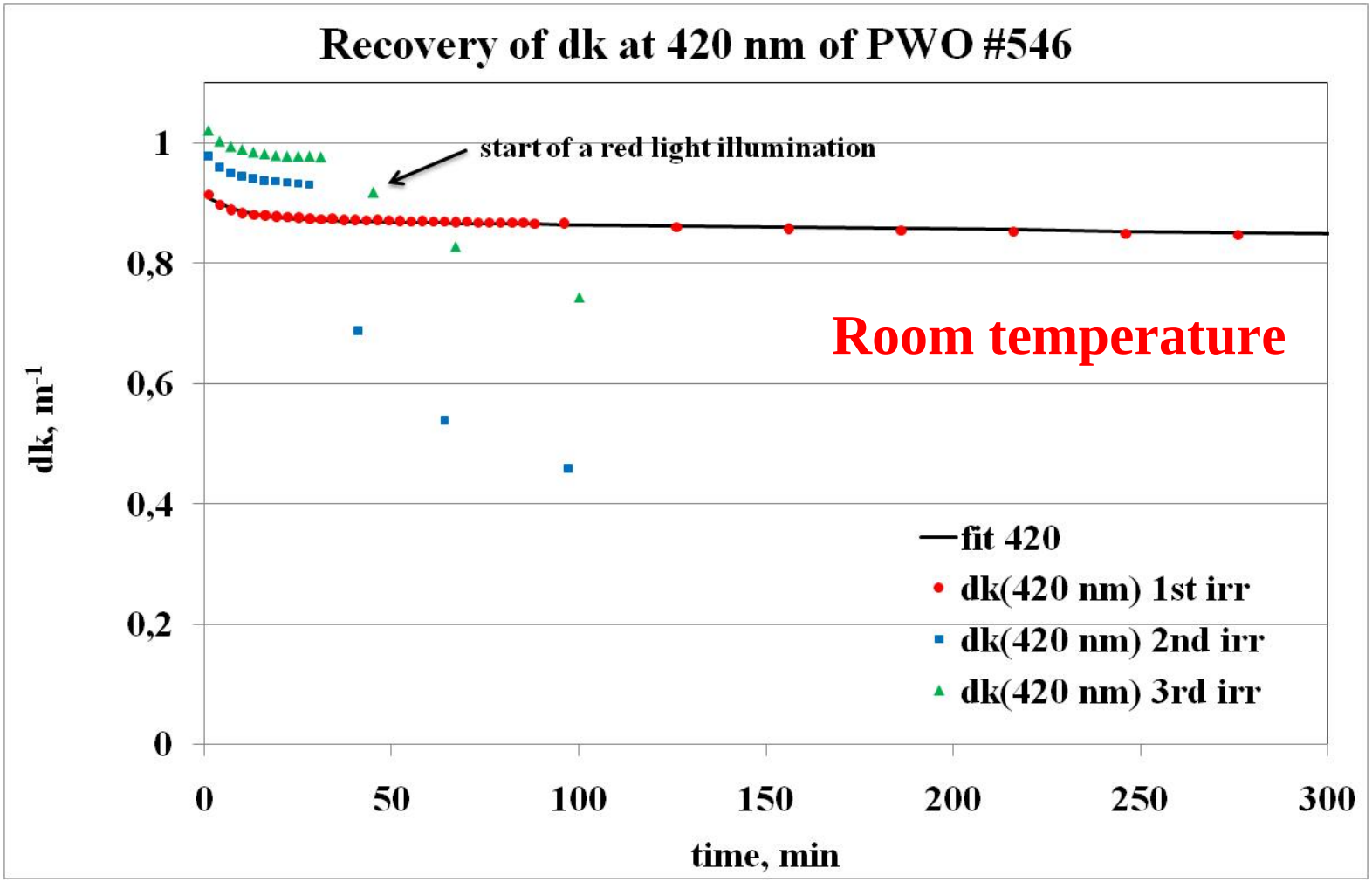
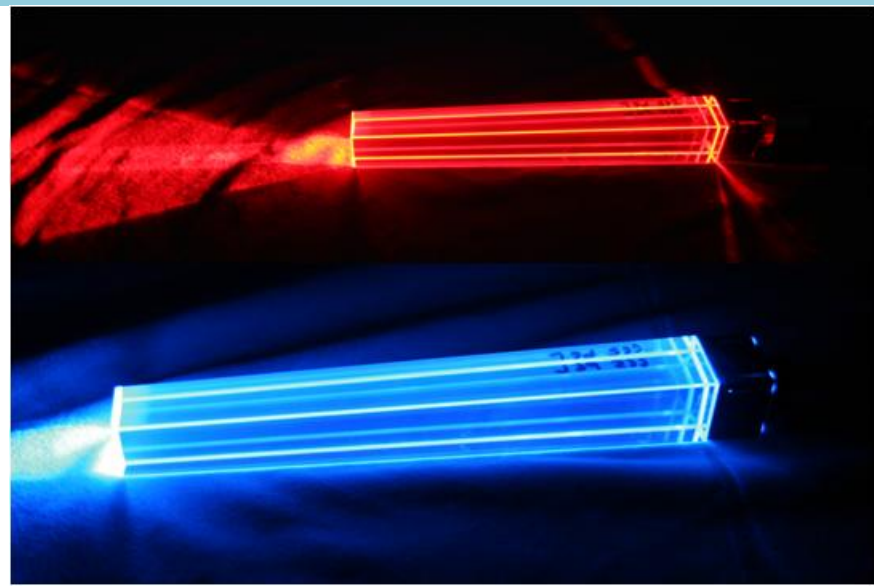
Recovery of PWO radiation absorption at 420 nm

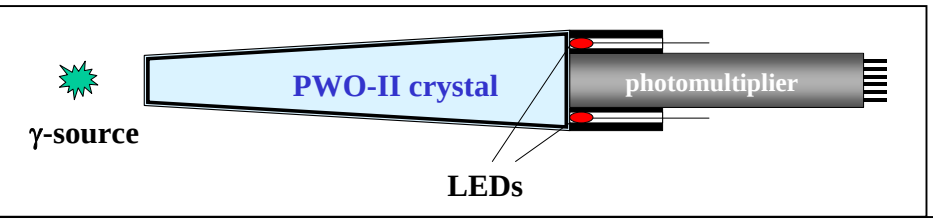


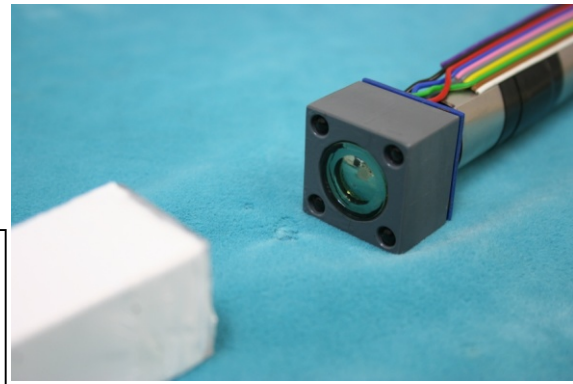
Recovery of PWO radiation absorption at 420 nm under red light illumination (standard red lamp)



Experimental Setup







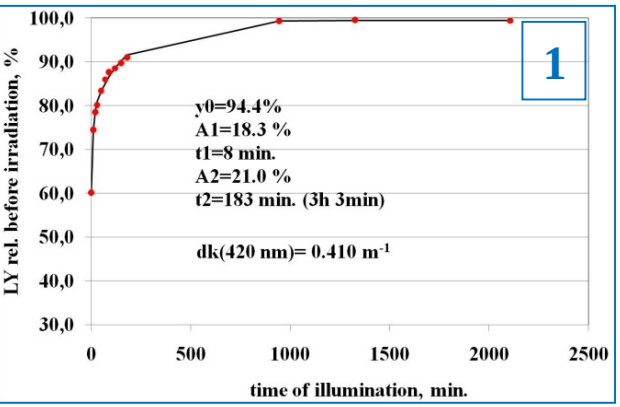
- measurement at T=-25°C
- irradiation with 30Gy and 0,4 Gy (^{60}Co)
- damage and recovery characterized by light yield (^{60}Co)
- illumination with LEDs of different color
- crystals of different radiation hardness (dk)

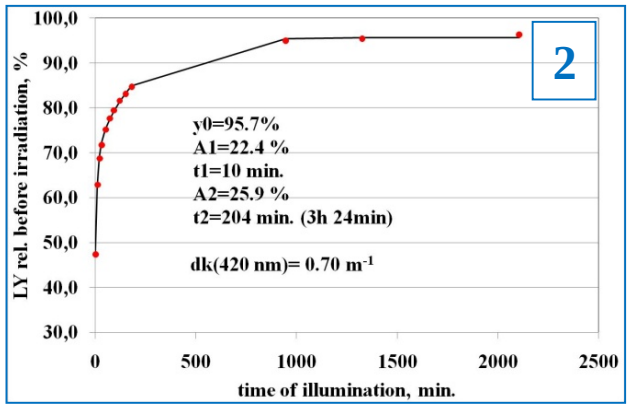
LED's characteristics

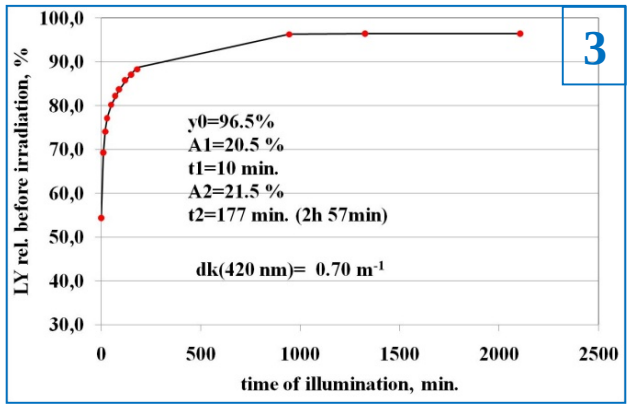
#	LED	Power, mW	Intensity, 10^{16} ph/s	λ_{max}, nm	FWHM, nm	full line range, nm
1	blue	25,74	6,0	464	22	420-520
2	blue	22,94	5,4	464	22	420-520
3	blue	19,58	4,6	464	22	420-520
4	green	8,492	2,2	525	30	460-610
5	green	9,131	2,4	525	30	460-610
6	green	9,441	2,5	525	30	460-610
7	red	10,69	3,4	639	17	590-670
8	red	9,578	3,1	639	17	590-670
9	red	9,167	3,0	639	17	590-670
10	infrared	17,41	7,5	860	50	790-930

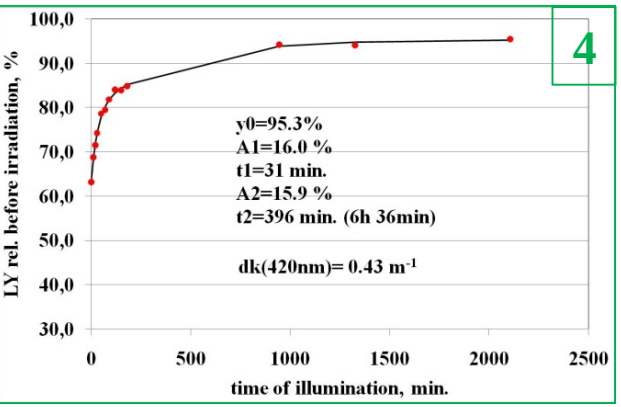
Recovery of PWO crystals light Yield under blue and green light illumination at -25º C

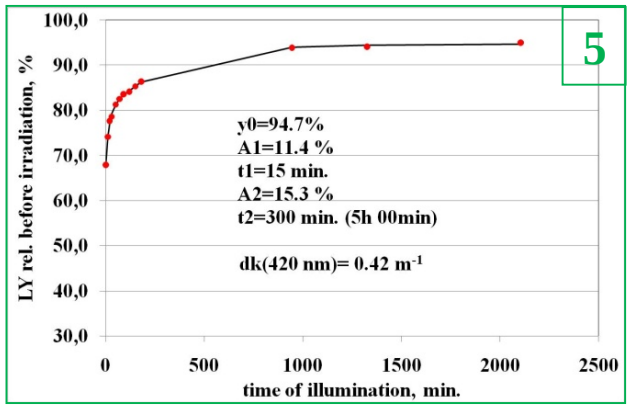
Dose rate=10,9 Gy/hour; Integrated dose=30 Gy.

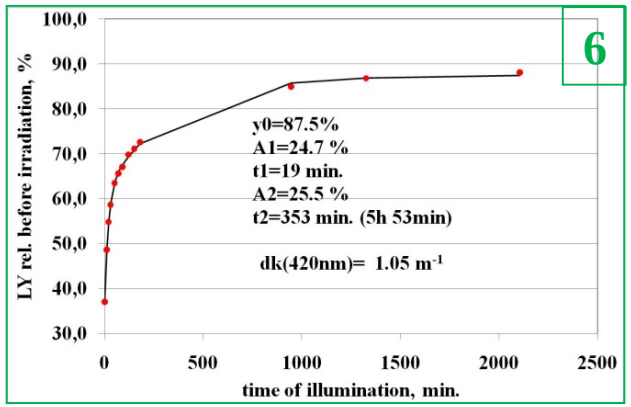






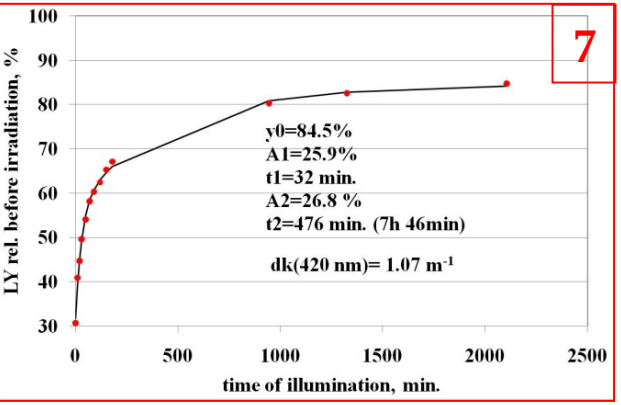


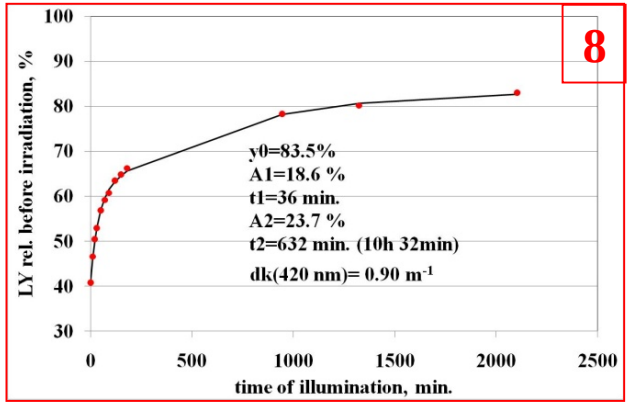


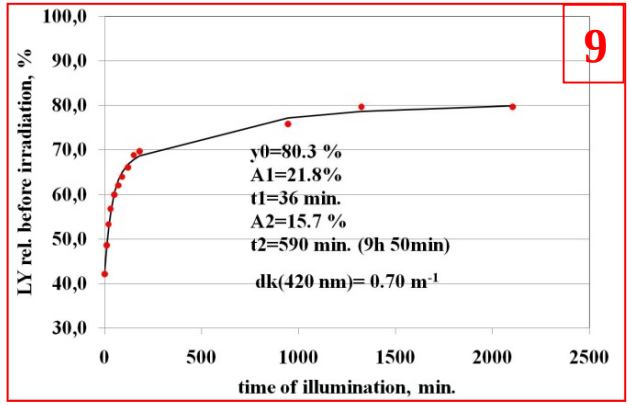


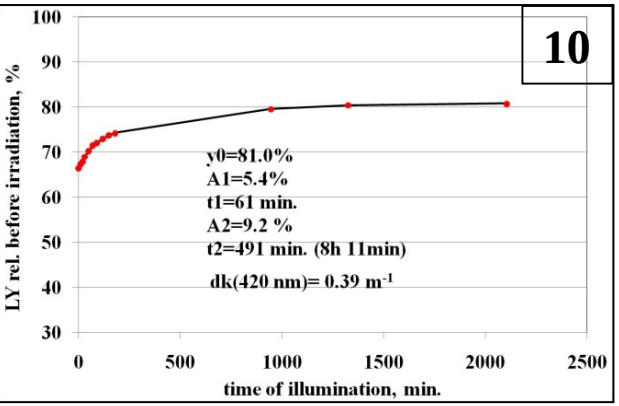
Recovery of PWO crystals light Yield under red and infrared light illumination at -25º C

Dose rate=10,9 Gy/hour; Integrated dose=30 Gy.

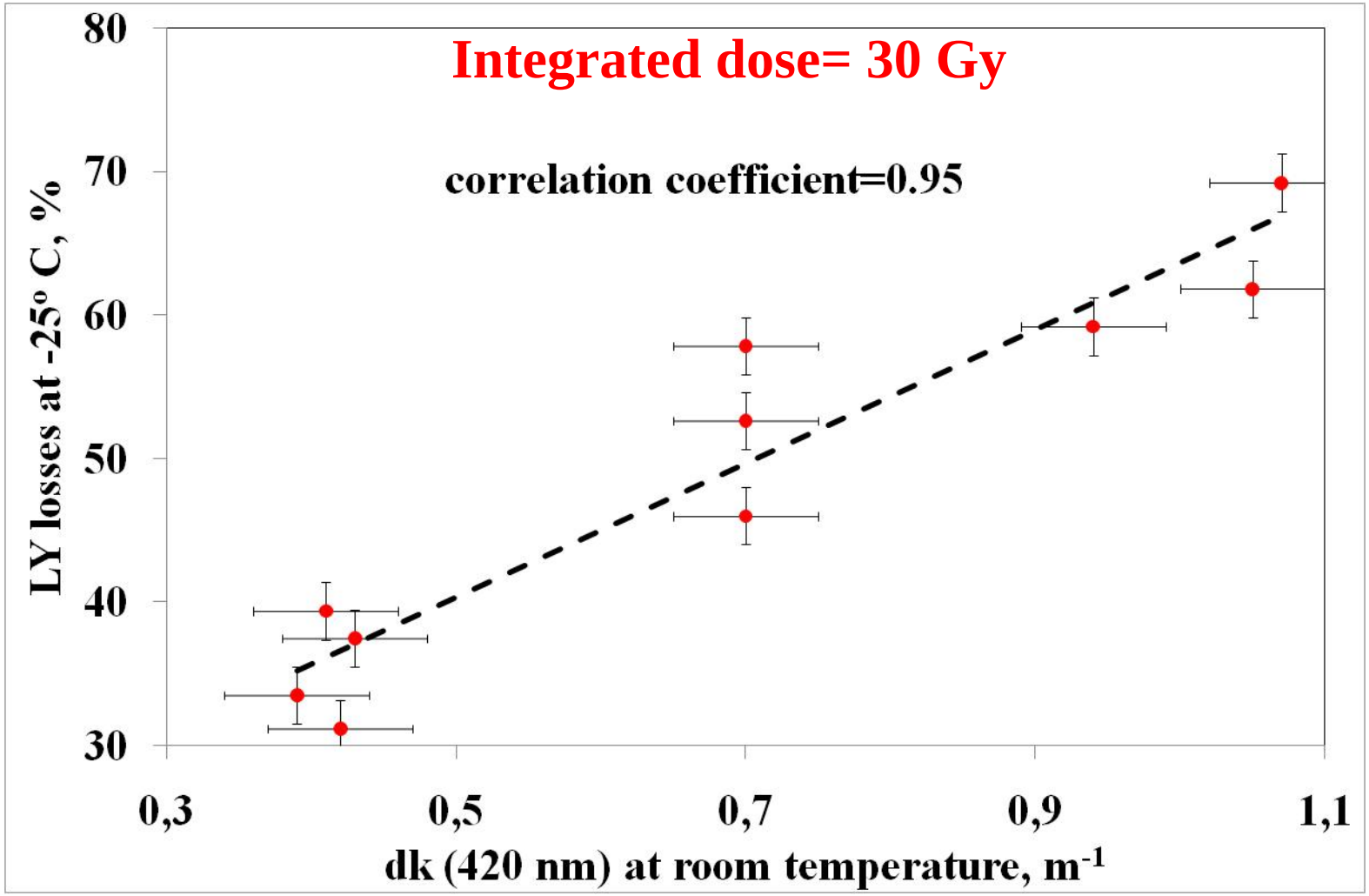








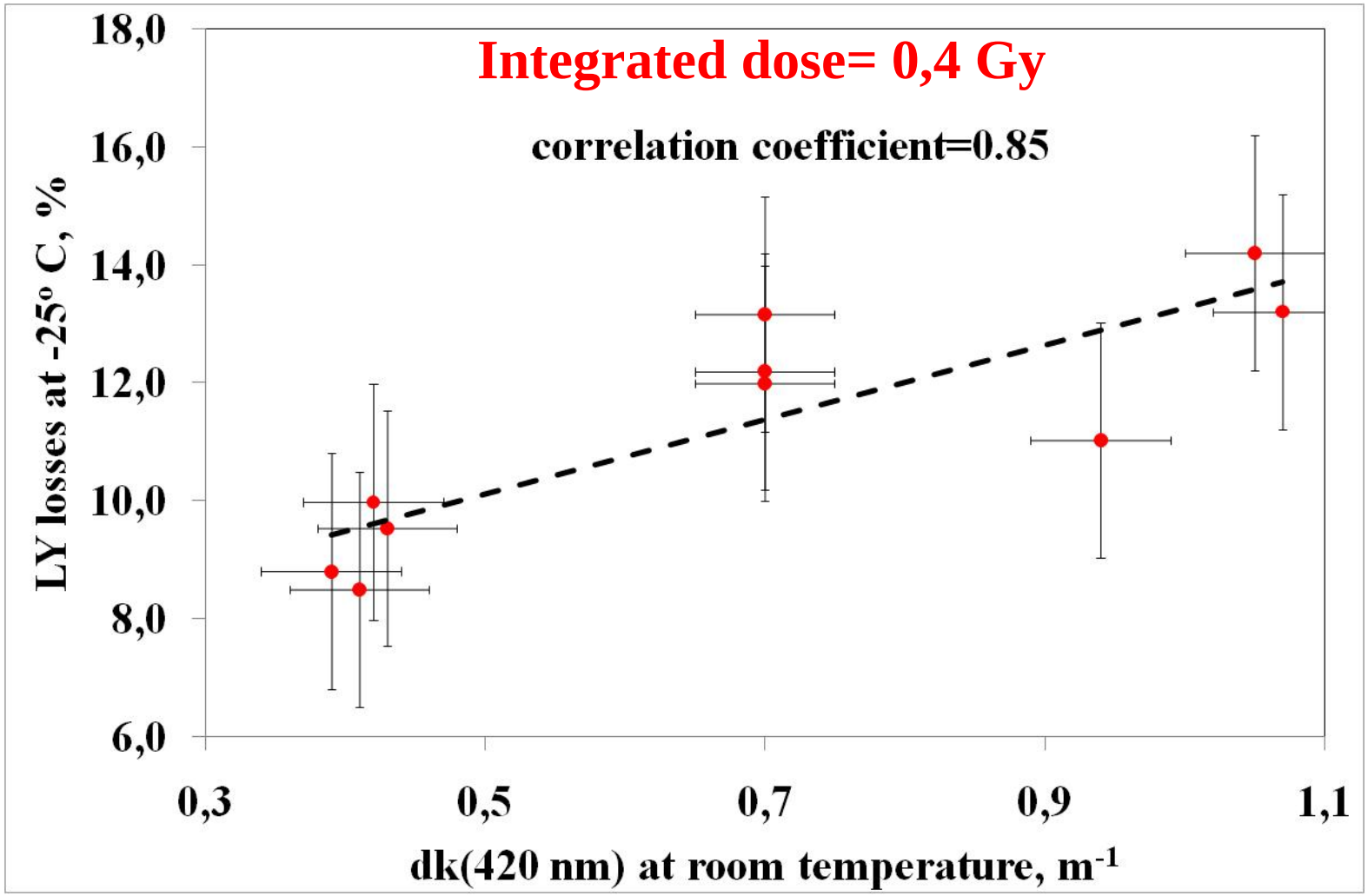
Correlation Light Yield losses vs dk@420 nm after γ-quanta irradiation



Results of the radiation damage after irradiation with 30 Gy dose (10,9 Gy/hour dose rate) at -25° C

#	LED	dk (420 nm), m^{-1}	LY losses (**offline**), %	LY losses (**online**), %
1	blue	0,41	**39,4**	**20,2**
2	blue	0,7	**52,6**	**27,9**
3	blue	0,7	**46,0**	**24,6**
4	green	0,43	**37,5**	**27,5**
5	green	0,42	**31,2**	**26,9**
6	green	1,05	**61,9**	**39,5**
7	red	1,07	**69,2**	**45,8**
8	red	0,94	**59,2**	**47,0**
9	red	0,7	**57,9**	**40,0**
10	infrared	0,39	**33,5**	**25,5**

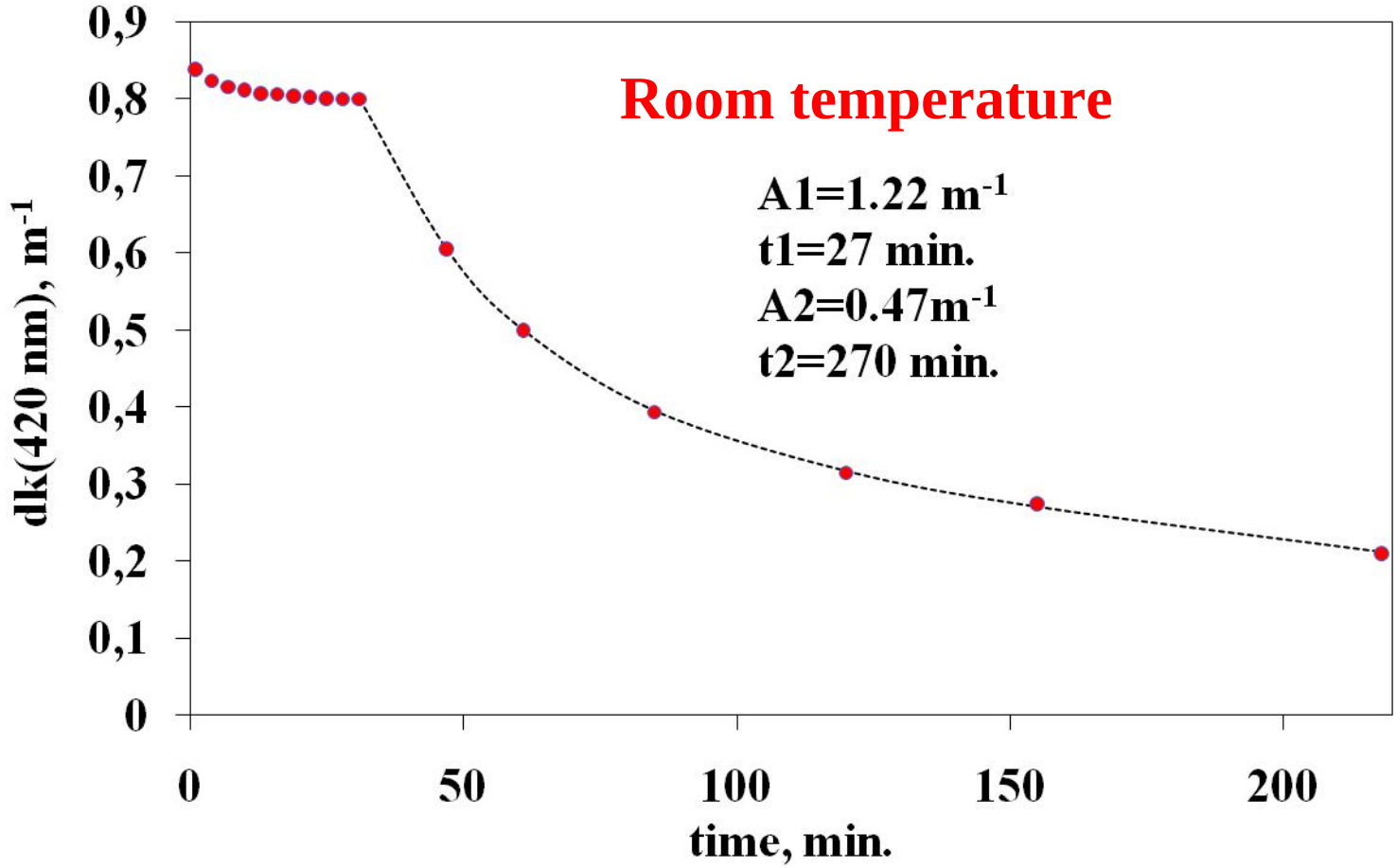
Correlation Light Yield losses vs dk@420 nm after γ-quanta irradiation



Results of the radiation damage after irradiation with 0,4 Gy dose (0,1 Gy/hour dose rate) at -25° C

#	LED	dk (420 nm), m^{-1}	LY losses (**offline**), %	LY losses (**online**), %
1	blue	0,41	**8,5**	**-3,4**
2	blue	0,7	**12,2**	**-5,0**
3	blue	0,7	**13,2**	**-3,0**
4	green	0,43	**9,5**	**-4,3**
5	green	0,42	**10,0**	**-4,0**
6	green	1,05	**14,2**	**-2,0**
7	red	1,07	**13,2**	**-8,6**
8	red	0,94	**11,0**	**-3,8**
9	red	0,7	**12,0**	**-4,6**
10	infrared	0,39	**8,8**	**-0,5**

Recovery of PWO radiation absorption at 420 nm under red LED (λ_{max}= 940 nm) light



Conclusion

1) Results of tests with high dose- 30 Gy (10,9 Gy/hour):

- **Full recovery after irradiation with blue (464 nm) and green (525 nm) light at low temperature**
- **No full "online" recovery with light in 460-860 nm wavelength range**

2) Results of tests with low dose- 0,4 Gy (0,1 Gy/hour):

Full "online" recovery in 460-860 nm wavelength range

3) Good correlation between Light Yield losses at -25^{o} C and dk(420 nm) at room temperature

4) At present time infrared edge of the recovery = 940 nm at room temperature

Future plans

Is it possible to perform "online" recovery of the radiation damage of PANDA EMC?

1) Define minimum energy (maximum wavelength) of light photons, when the recovery process is possible

2) Define minimum light intensity, when "online" recovery is possible (parity between rates of the radiation damage and recovery processes)