## Radiation damage recovery of lead tungstate crystals under light illumination

Valery Dormenev, Werner Döring, Till Kuske, Rainer Novotny, Rene Shubert II. Physics Institute JLU, Giessen

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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**



- irradiation with 30Gy and 0,4 Gy (<sup>60</sup>Co)
- damage and recovery characterized by light yield (<sup>60</sup>Co)
- illumination with LEDs of different color
- crystals of different radiation hardness (dk)

### **LED's characteristics**

#	LED	Power, mW	Intensity, 10 <sup>16</sup> ph/s	$\lambda_{max}$ , 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 -25° C



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

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## **Recovery of PWO crystals light Yield under red and** infrared light illumination at -25° C

100 100 100,0 7 8 \$ 90 % % 90 90.0 rel. before irradiation, irradiation, LY rel. before irradiation, 80 80,0 80 v0=84.5% 70 70 v0=83.5% 70,0 v0=80.3 % A1=25.9% A1=18.6 % A1=21.8% t1=32 min. rel. before 60 60,0 60 t1=36 min. t1=36 min. A2=26.8 % A2=23.7 % A2=15.7 % t2=476 min. (7h 46min) 50 50.0 50 t2=632 min. (10h 32min) t2=590 min. (9h 50min) dk(420 nm)= 1.07 m<sup>-1</sup>  $dk(420 \text{ nm}) = 0.90 \text{ m}^{-1}$ Z Z 40 40,0  $dk(420 \text{ nm}) = 0.70 \text{ m}^{-1}$ 40 30 30,0 30 0 500 1000 1500 2000 2500 0 500 1000 1500 2000 2500 500 1000 1500 2000 2500 0 time of illumination, min. time of illumination, min. time of illumination, min. 100 10 90 % LY rel. before irradiation, 80

70

60

50

40 30 0 v0=81.0% A1=5.4%

t1=61 min. A2=9.2 %

500

t2=491 min. (8h 11min)  $dk(420 \text{ nm}) = 0.39 \text{ m}^{-1}$ 

1000

time of illumination, min.

1500

2000

2500

#### **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

#LEDdk (420 nm), m <sup>-1</sup> LY losses (offline), %LY losses (online), %1blue0,4139,420,22blue0,752,627,93blue0,746,024,64green0,4337,527,55green0,4231,226,96green1,0561,939,57red1,0769,245,88red0,9459,247,09red0,757,940,010infrared0,3933,525,5					
1blue0,4139,420,22blue0,752,627,93blue0,746,024,64green0,4337,527,55green0,4231,226,96green1,0561,939,57red1,0769,245,88red0,9459,247,09red0,757,940,010infrared0,3933,525,5	#	LED	dk (420 nm), m <sup>-1</sup>	LY losses (offline), %	LY losses (online), %
2blue0,752,627,93blue0,746,024,64green0,4337,527,55green0,4231,226,96green1,0561,939,57red1,0769,245,88red0,9459,247,09red0,757,940,010infrared0,3933,525,5	1	blue	0,41	39,4	20,2
3blue0,746,024,64green0,4337,527,55green0,4231,226,96green1,0561,939,57red1,0769,245,88red0,9459,247,09red0,757,940,010infrared0,3933,525,5	2	blue	0,7	52,6	27,9
4green0,4337,527,55green0,4231,226,96green1,0561,939,57red1,0769,245,88red0,9459,247,09red0,757,940,010infrared0,3933,525,5	3	blue	0,7	46,0	24,6
5green0,4231,226,96green1,0561,939,57red1,0769,245,88red0,9459,247,09red0,757,940,010infrared0,3933,525,5	4	green	0,43	37,5	27,5
6green1,0561,939,57red1,0769,245,88red0,9459,247,09red0,757,940,010infrared0,3933,525,5	5	green	0,42	31,2	26,9
7red1,0769,245,88red0,9459,247,09red0,757,940,010infrared0,3933,525,5	6	green	1,05	61,9	39,5
8 red 0,94 59,2 47,0   9 red 0,7 57,9 40,0   10 infrared 0,39 33,5 25,5	7	red	1,07	69,2	45,8
9red0,757,940,010infrared0,3933,525,5	8	red	0,94	59,2	47,0
10 infrared 0,39 <b>33,5 25,5</b>	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 <sup>-1</sup>	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 ( $\lambda_{max}$ = 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° 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)