Radiation hardnes measurements of PbWO4 crystals at IPN-Orsay

Ho San KO
PHEN Institut de Physique Nucléaire d'Orsay
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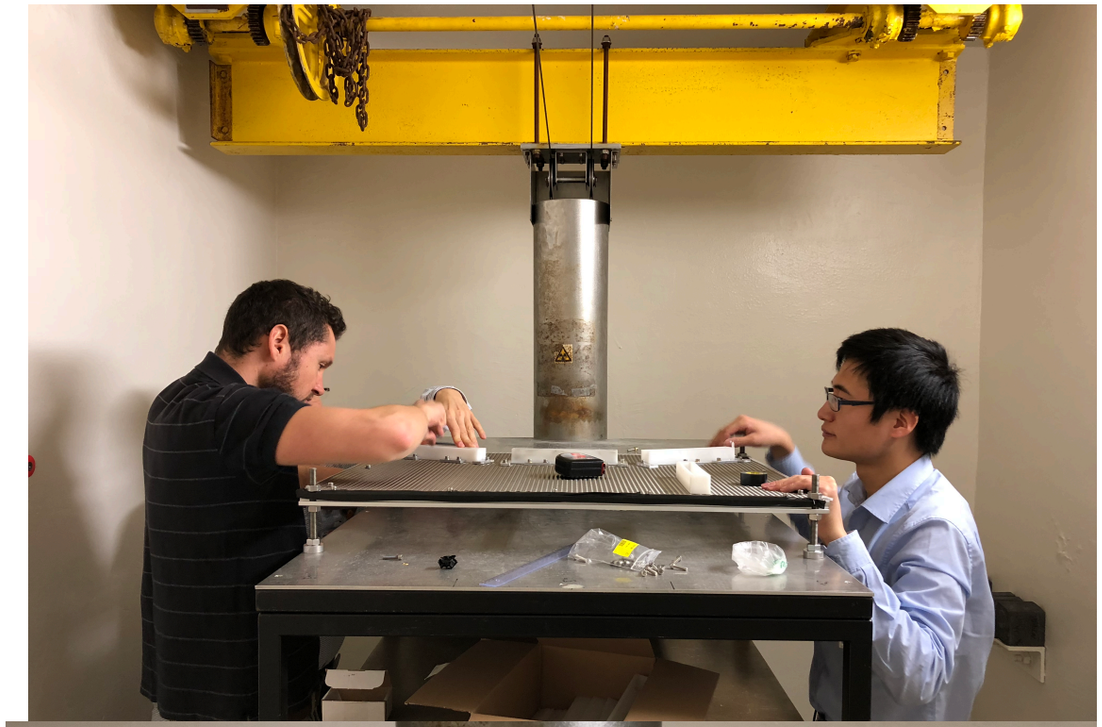
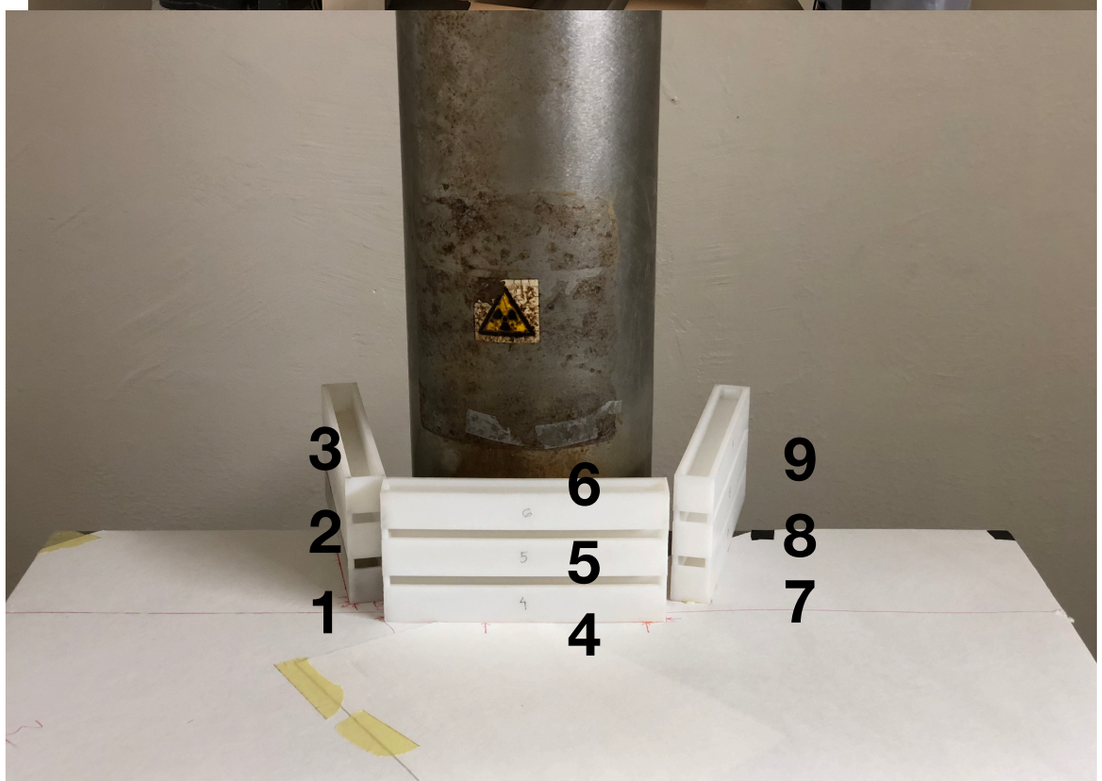
Outline

- Orsay irradiation Facility
  -Fricke dosimetry to measure the gamma dose and dose rate
  -PbWO4 Irradiation

- PbWO4 transmittance and dK results comparisons with Giessen’s

Irradiation Facility





- Co60 source, 222TBq
- With simple mechanical design, the distance from the source can be reproduced.
- With this setup, we can irradiate 9 crystals/water at the same time.
- Bottom figure is to irradiate with higher dose rate.

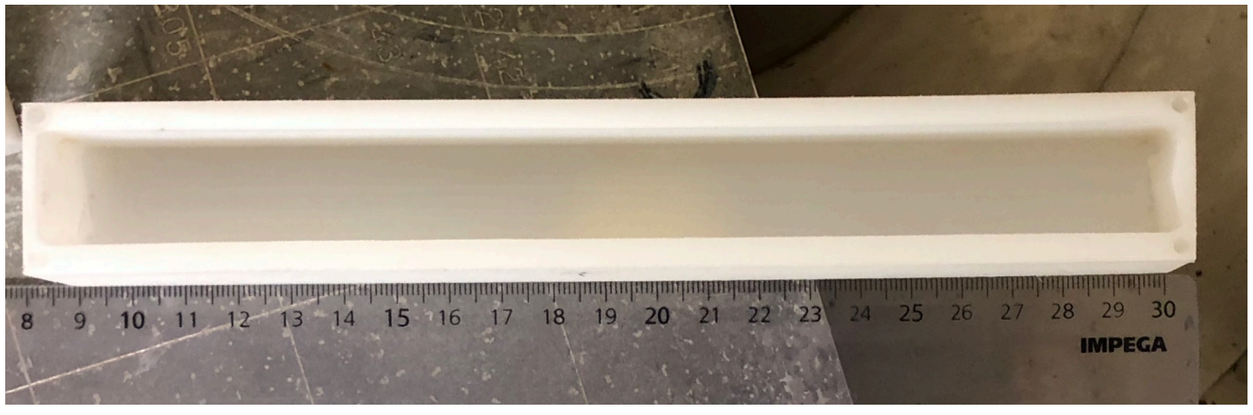
(15cm from the source)

- Results to be shown today were irradiated 60cm from the source

Irradiation Facility

- To estimate the dose and dose rate in crystals

-We irradiated water(Fricke solution) with the same positions(distance from the gamma source) and the same shape and volume of those of the crystals.



-Fricke dosimetry is well studied. It changes the light absorption linearly by the irradiation at certain wavelength until certain amount of dose(~200Gy).

Fricke solution

$$H + O_2 \rightarrow HO_2$$

$$Fe^{2+} + HO_2 \rightarrow Fe^{3+} + HO_2^-$$

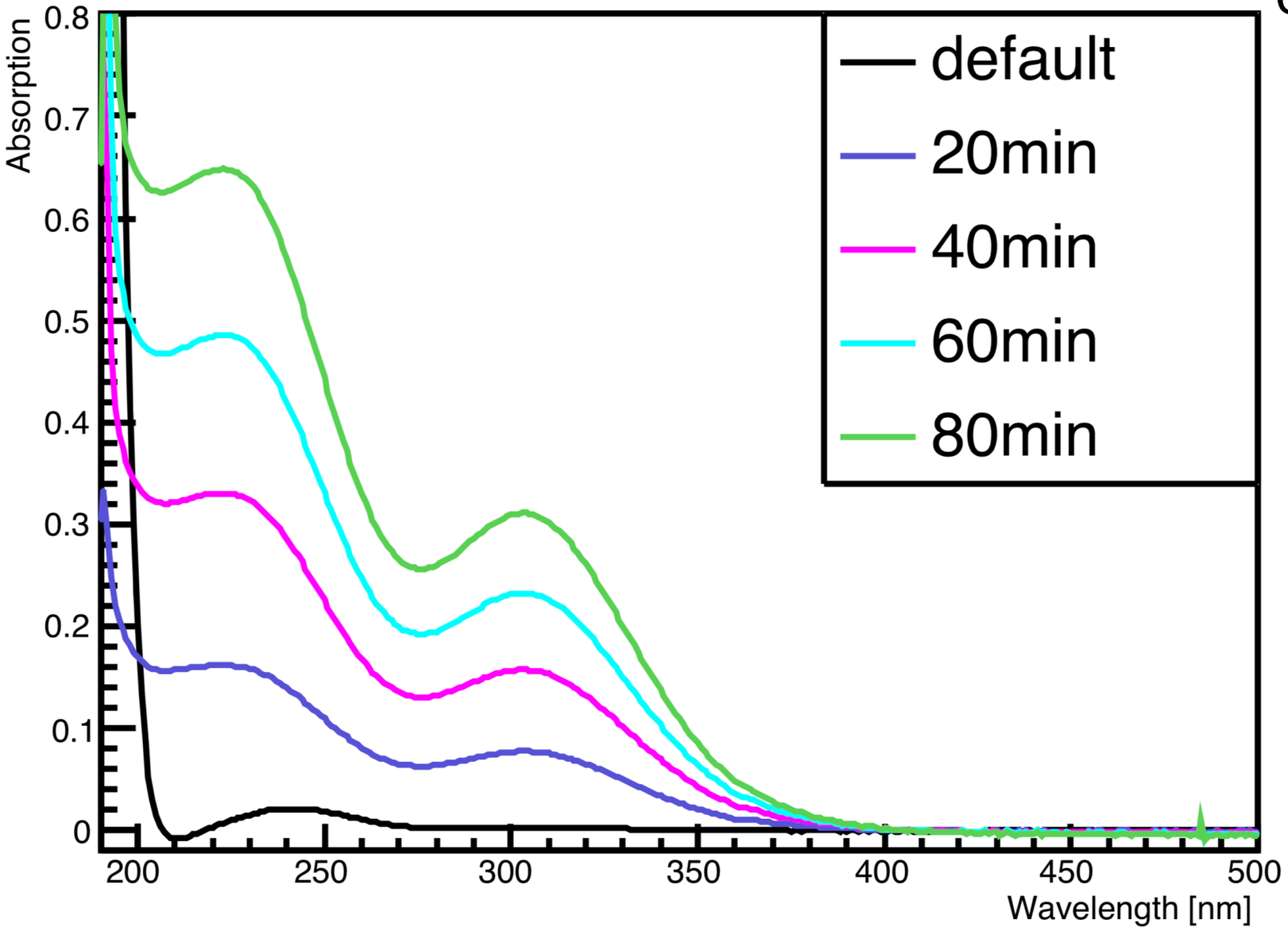
$$HO_2^- + H^+ \rightarrow H_2O_2$$

$$Fe^{2+} + H_2O_2 \rightarrow Fe^{3+} + OH + OH^-$$

$$Fe^{2+} + OH \rightarrow Fe^{3+} + OH^-$$

- Solution of Fe2+
- Gamma irradiates water -> Ferrous ions(Fe2+) to Ferric ions(Fe3+)
- Fe3+ absorbs light. Peak at 304nm

Water Irradiation Results

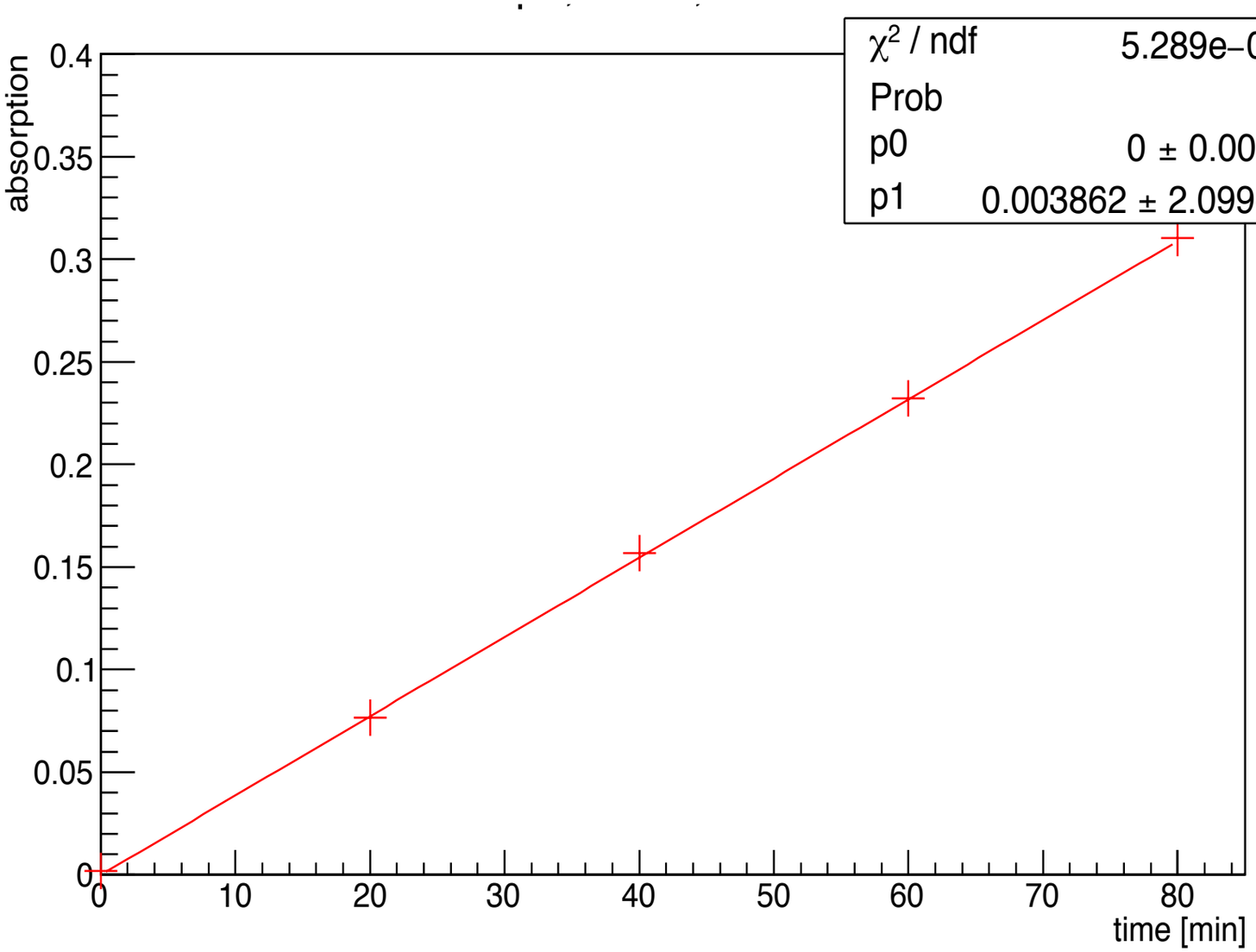


60cm away from the source

- Light absorption increases with respect to the dose.
- Get the peak values at 304nm to get the absorption change rate

Water Irradiation Results

- Absorbance changes throughout irradiation.



60cm away from the source

- Increase of light absorption throughout irradiation time

- With the absorption change rate, we can get the dose rate.

Water Irradiation Results

- Dose rate calculation from solution's absorbance

$$\text{Absorbance } (A) = log\frac{I_0}{I} = \varepsilon \times l \times C = \varepsilon \times l \times G \times \rho \times D(t)$$

$$\text{Dose rate}(Gy/min) = \frac{\Delta A(cm^{-1})}{\varepsilon(L\ mol^{-1}) \times G(mol\ J^{-1}) \times \rho(kg\ L^{-1})} \times \frac{1}{\Delta t(min)}$$

I : measured light intensity through the material

ε : molar extinction coefficient. 2160 + 15(T - 25) at 304nm

l : optical path

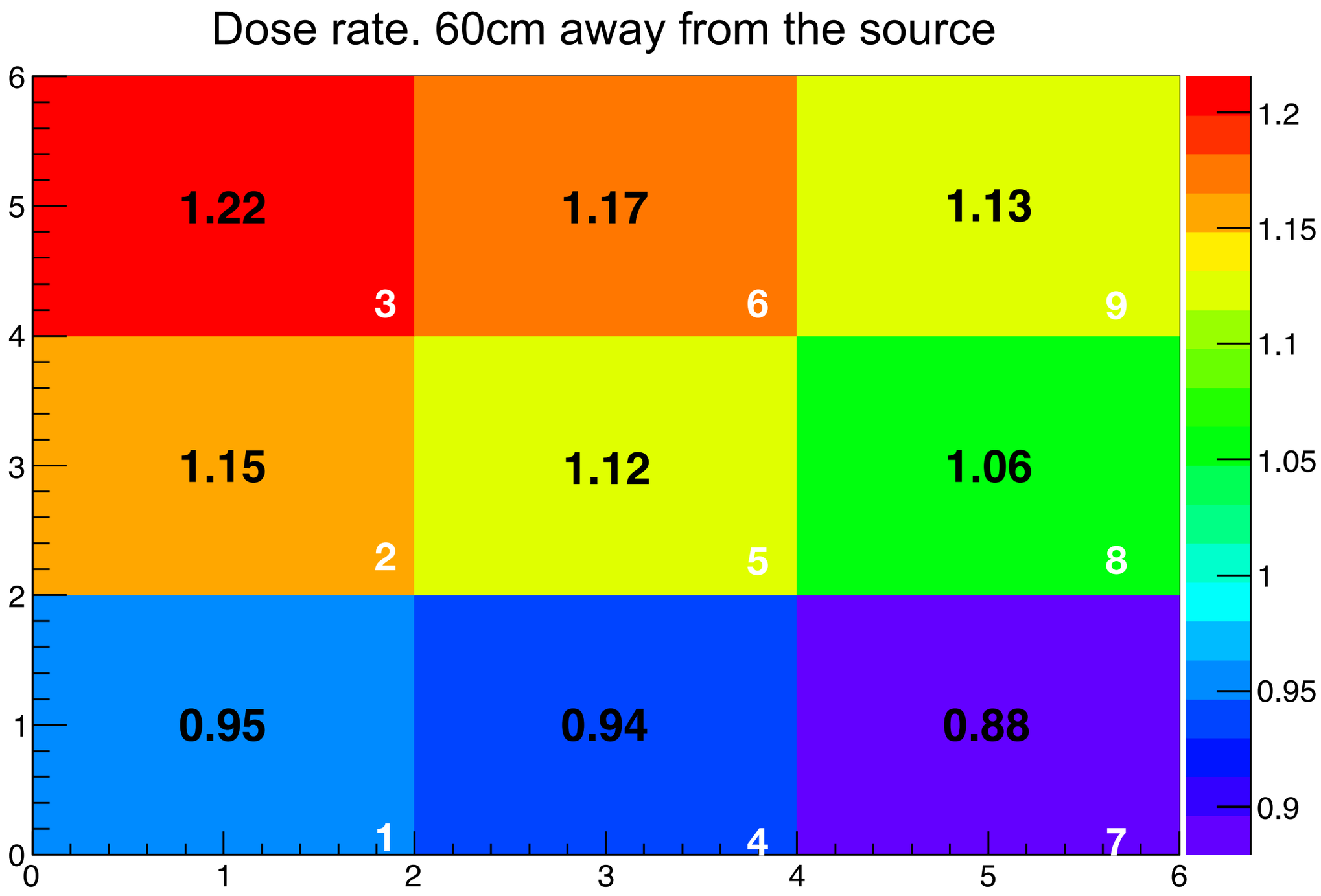
C : number of moles transformed by the irradiation

G : efficiency for appearance of Fe3+ 1.62 X 10-7 mole/J

ρ : mass density of the solution

$D(t)$: radiation dose

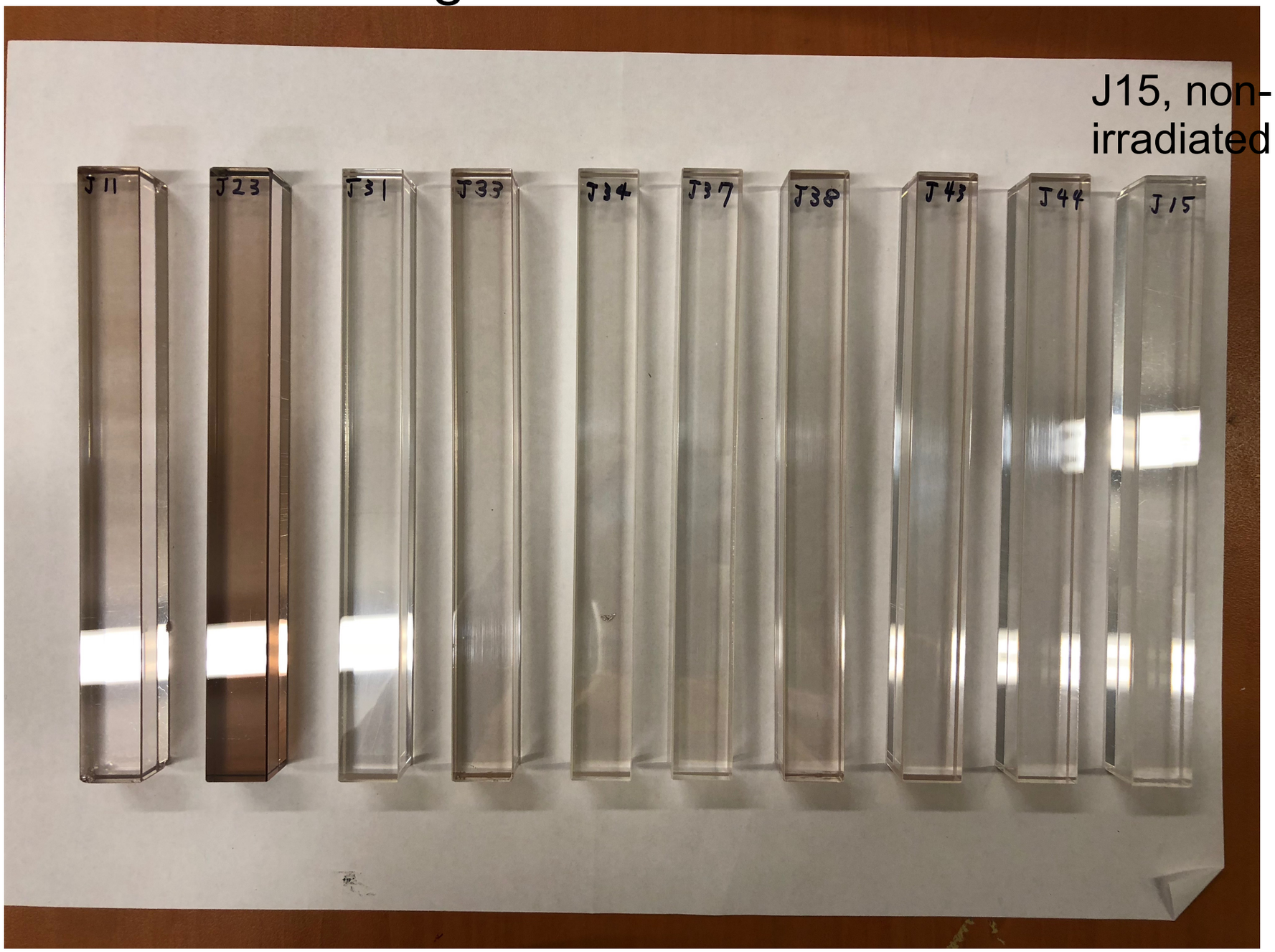
Water Irradiation Results



- Dose rate average of 1.11Gy/min (Giessen's : 1.16Gy/min)

PbWO4 Irradiation Results

- Crystals' color changes after irradiation.



- The picture was taken after higher dose rate(>17Gy/min)

PbWO4 Irradiation Results

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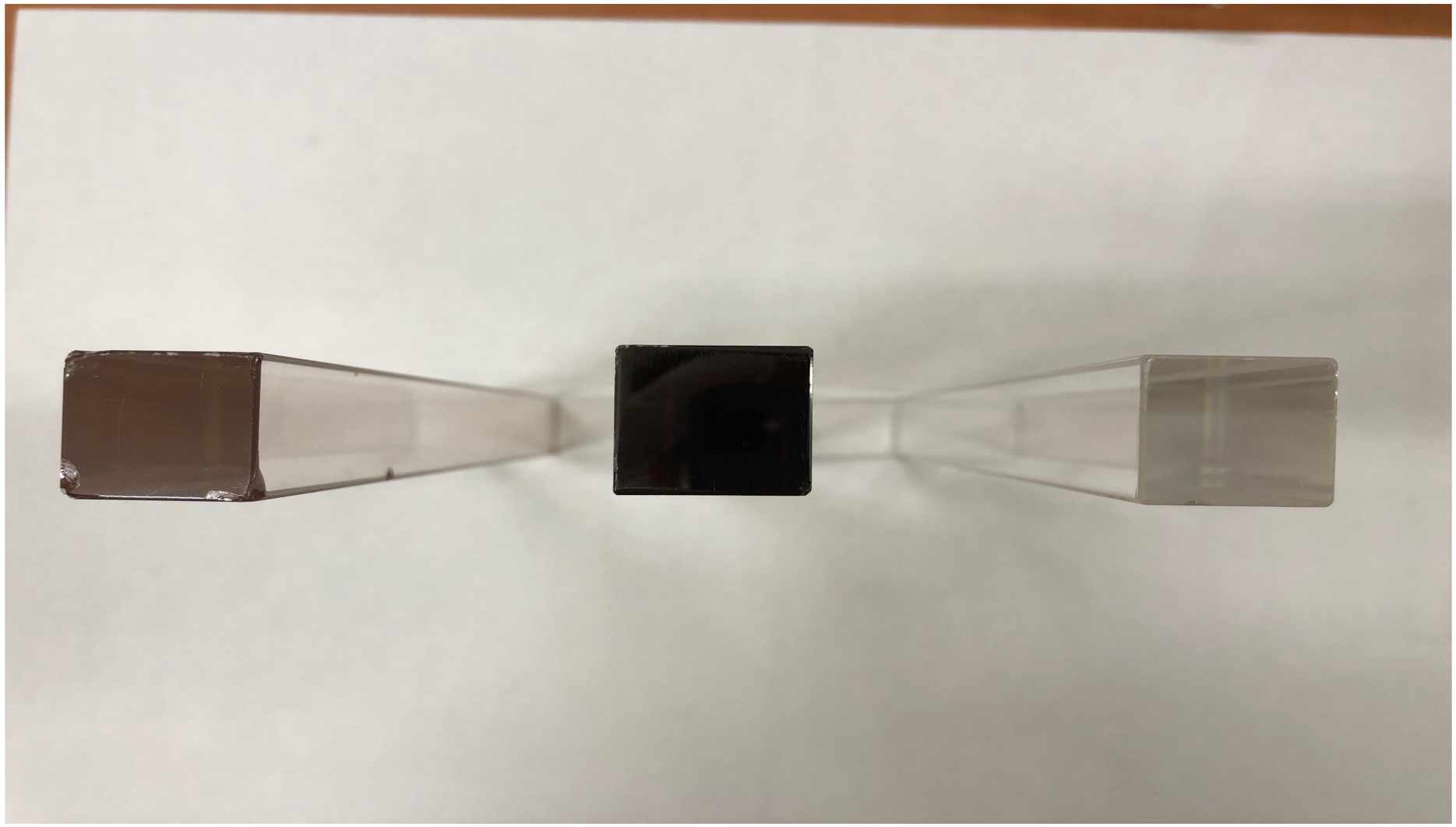
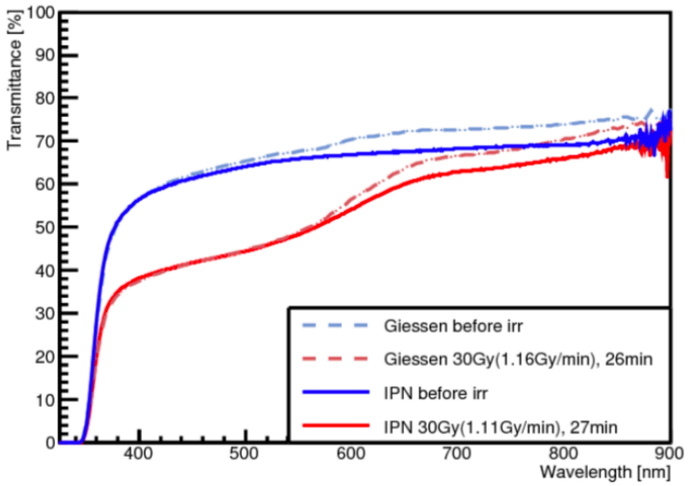


J11 J23, damaged the most J15, non-irradiated

- The picture was taken after higher dose rate(>17Gy/min)

PbWO4 Irradiation Results

J11



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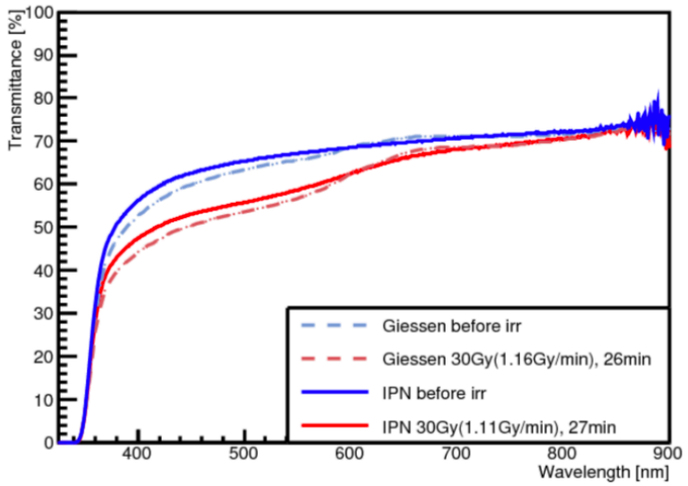

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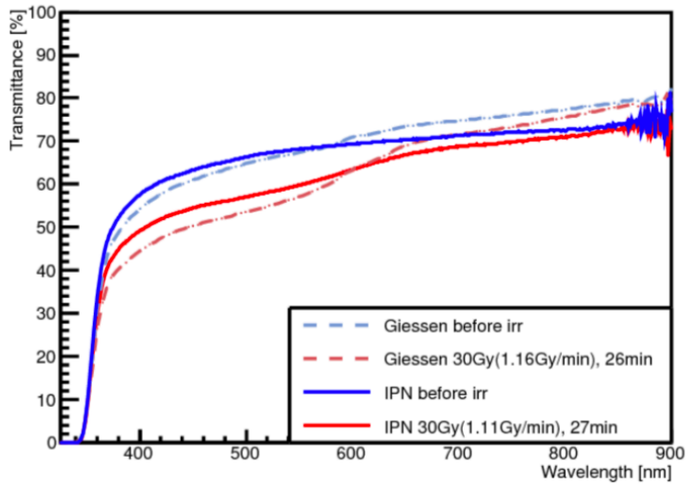

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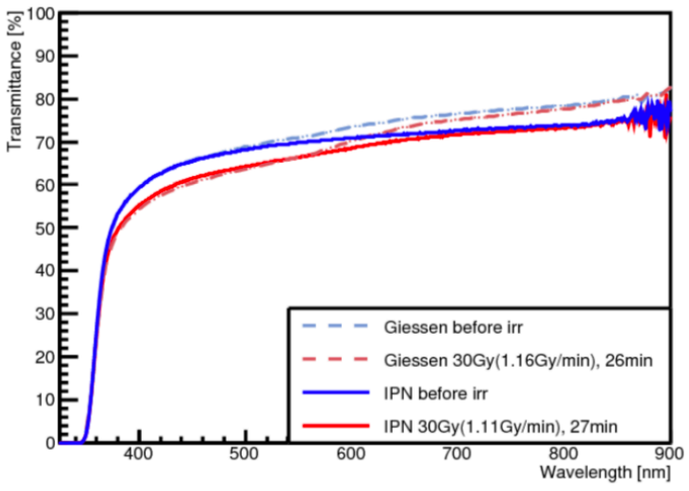

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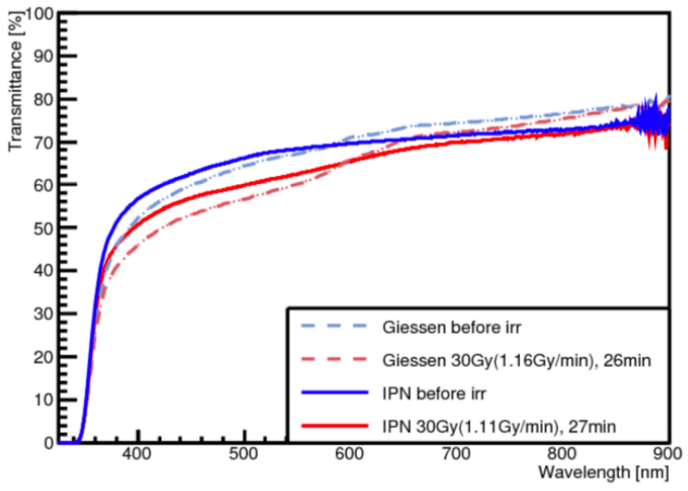
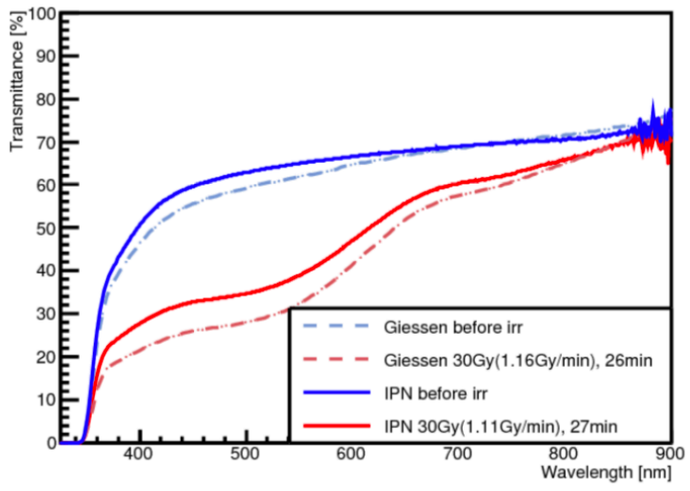


J23



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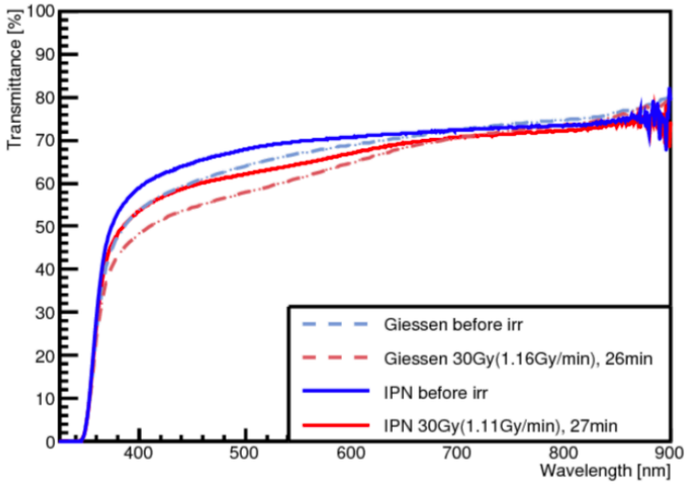

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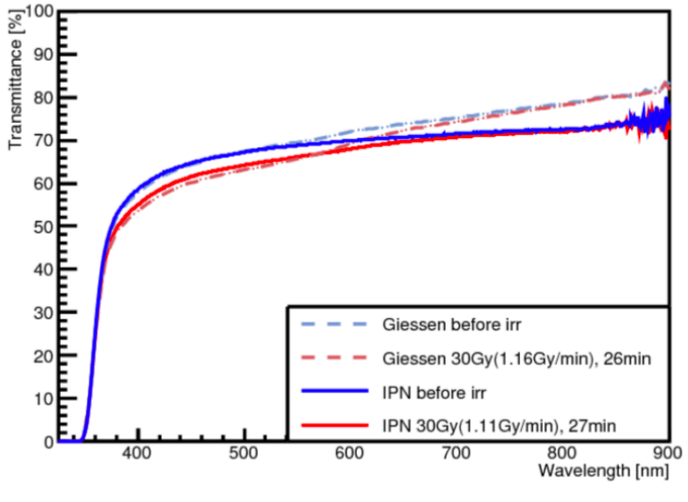

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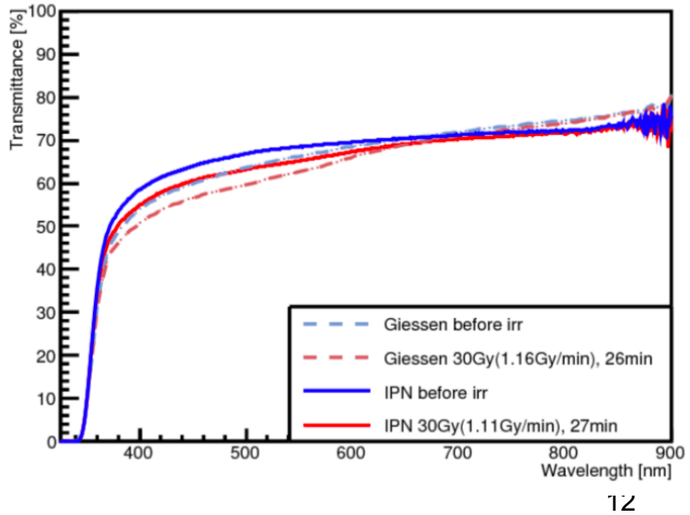
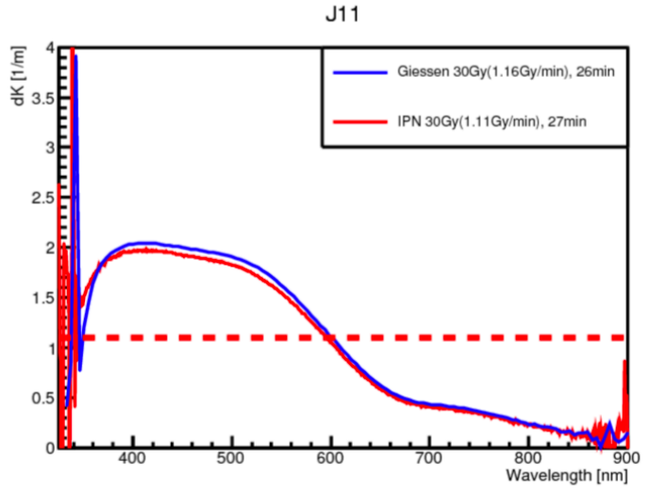
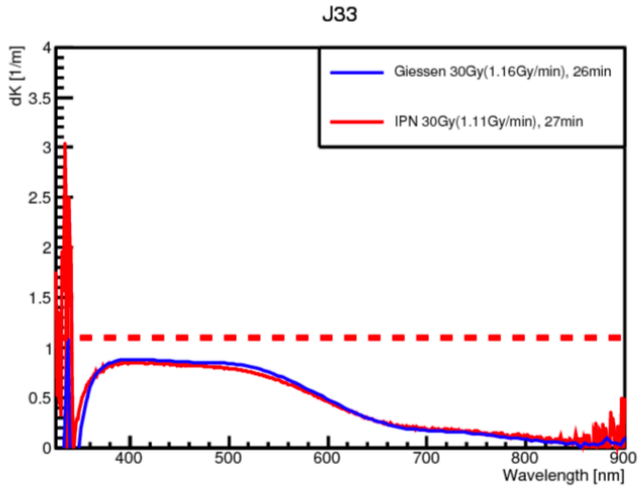
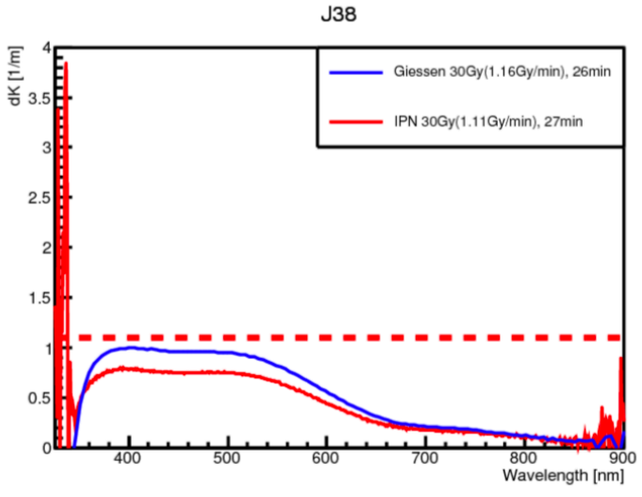


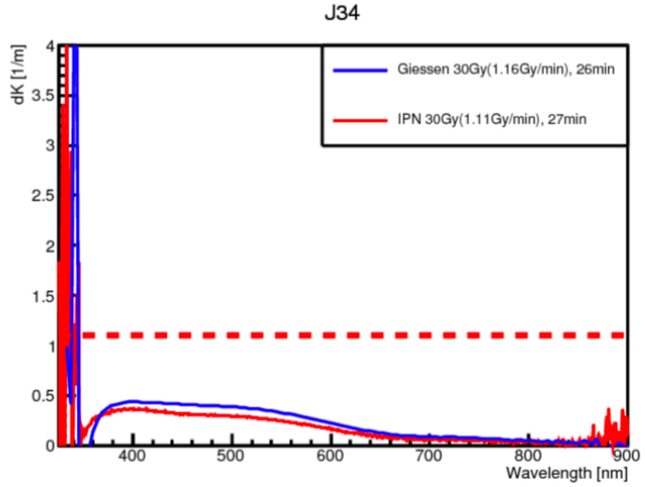
PbWO4 Irradiation Results

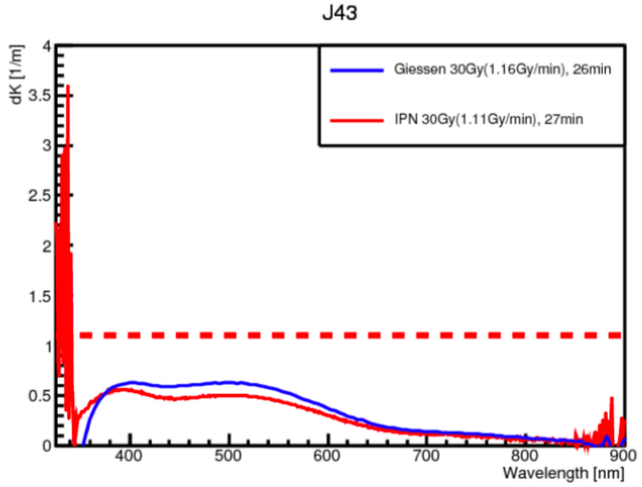
- Delta K $dk = ln(T_b/T_a)/l$ dK limit used for PANDA : 1.1/m

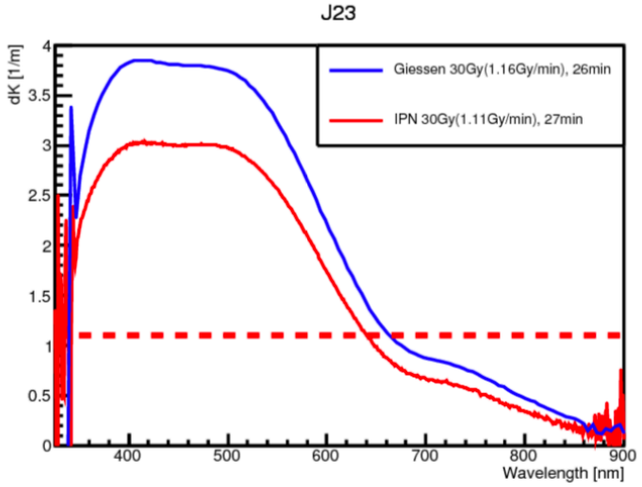


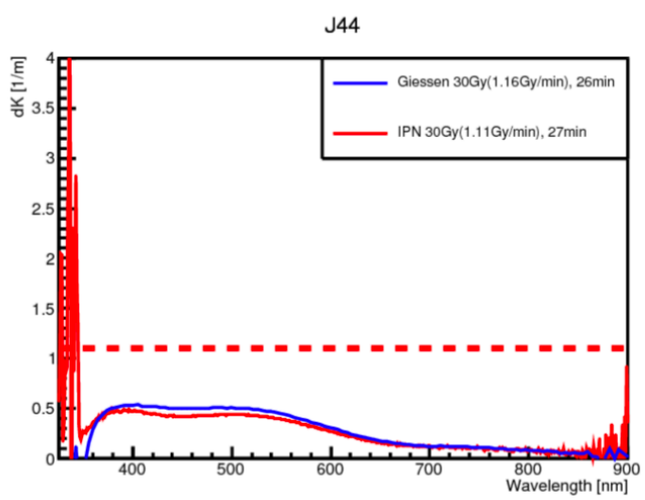


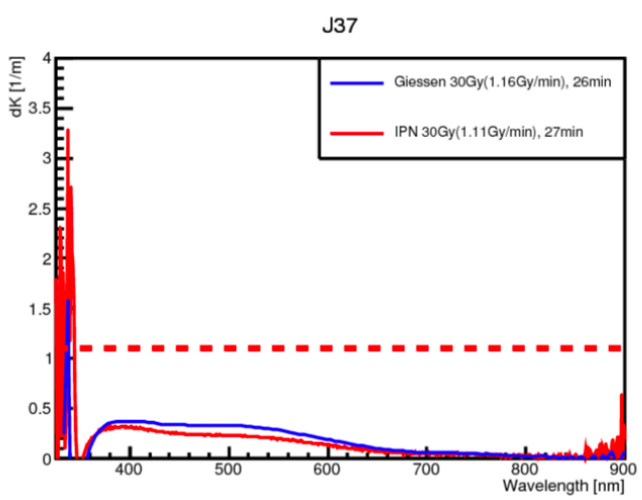


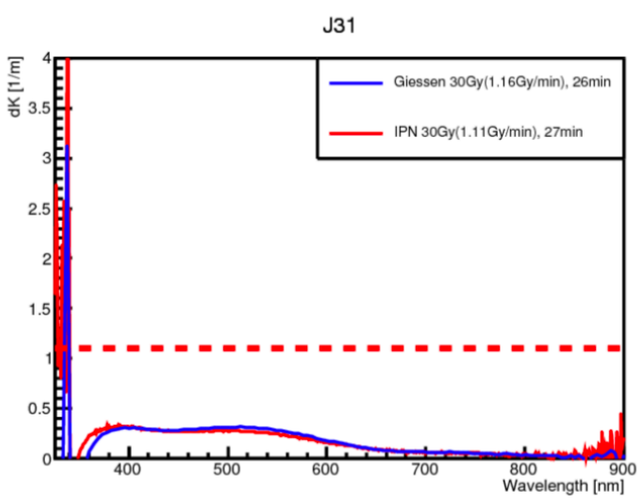












Summary

- Using water irradiation, we can measure the dose rate.
- IPN’s & Giessens’ transmittance & dK results are in very good agreement.
- Upcoming curing system test

Backups

IPN Radiation Facility

- Dose rate calculation from solution's absorbance

$$\text{Absorbance } (A) = log\frac{I_0}{I} = \varepsilon \times l \times C = \varepsilon \times l \times G \times \rho \times D(t)$$

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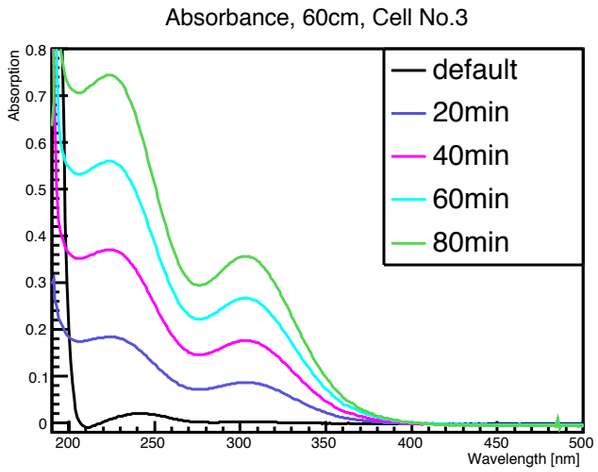
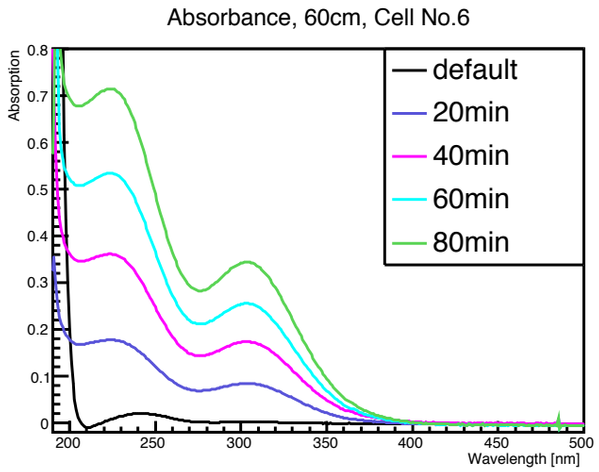
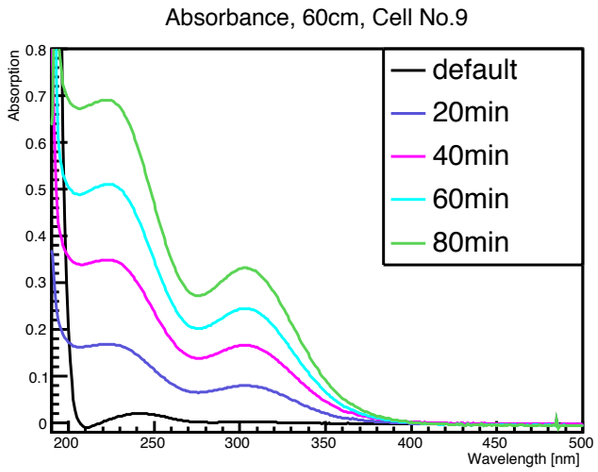
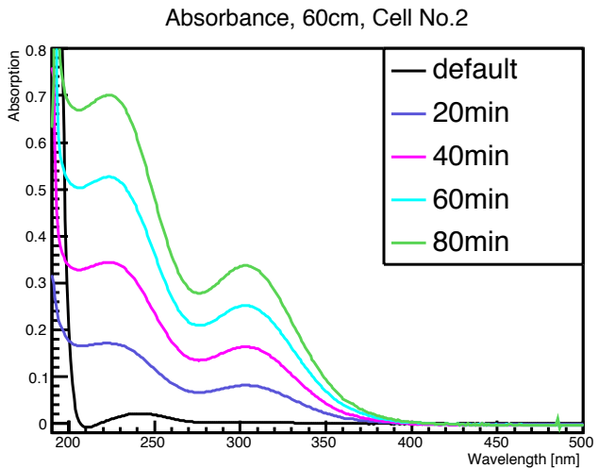
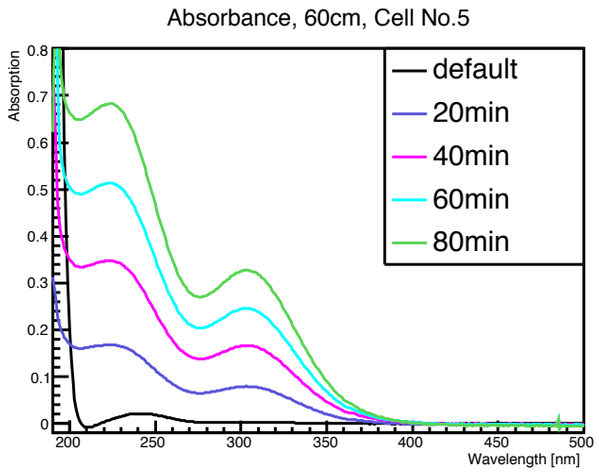
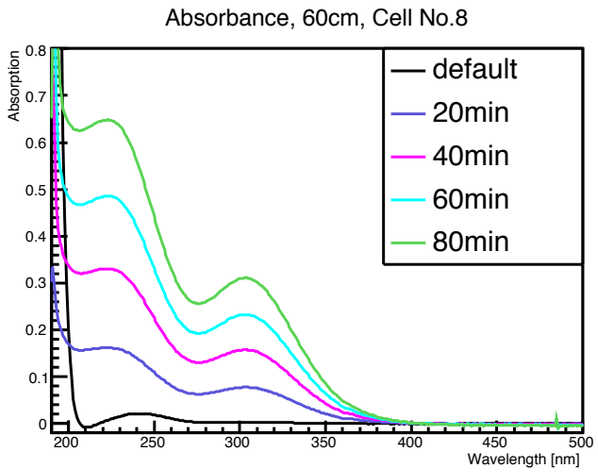


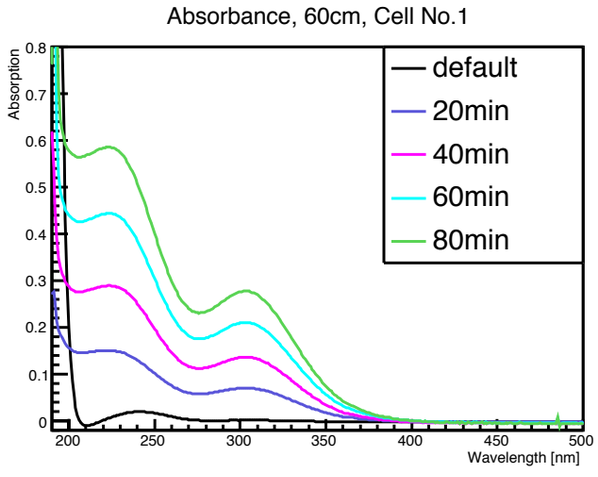


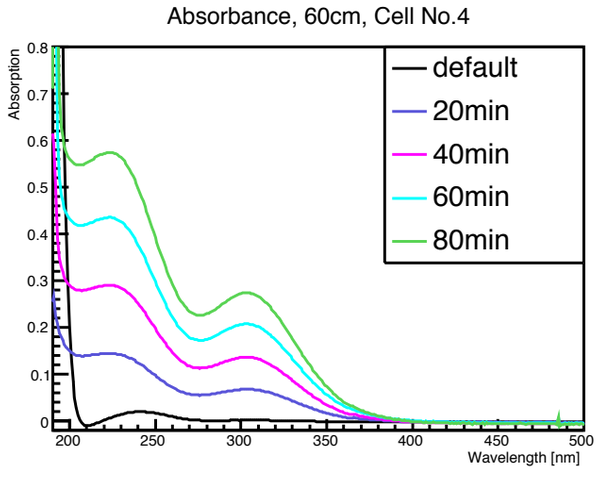


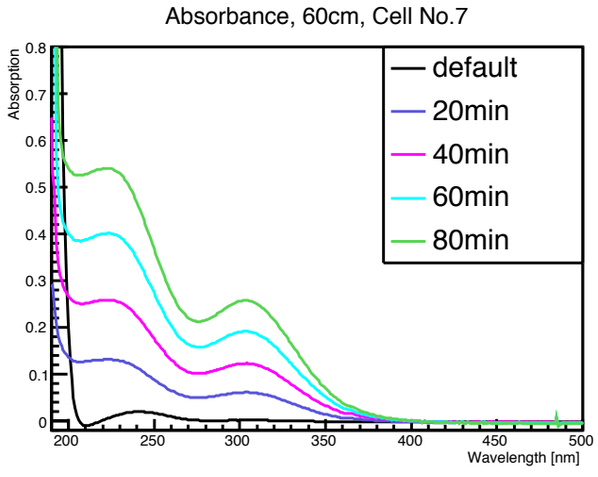








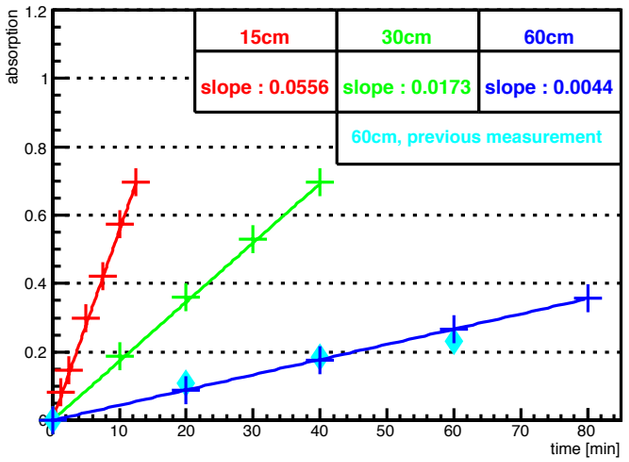




Light absorption increases with respect to the dose.
Peak at 304nm

Water Irradiation Results

Slopes, Cell No.3



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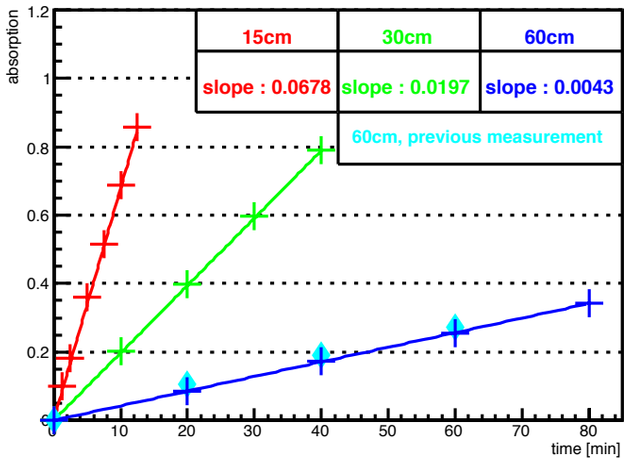

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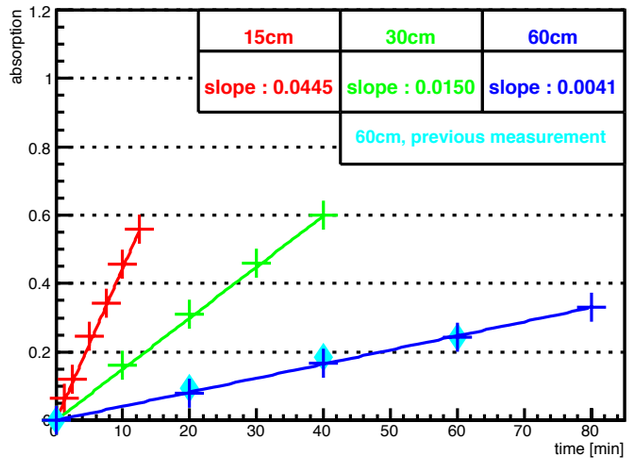

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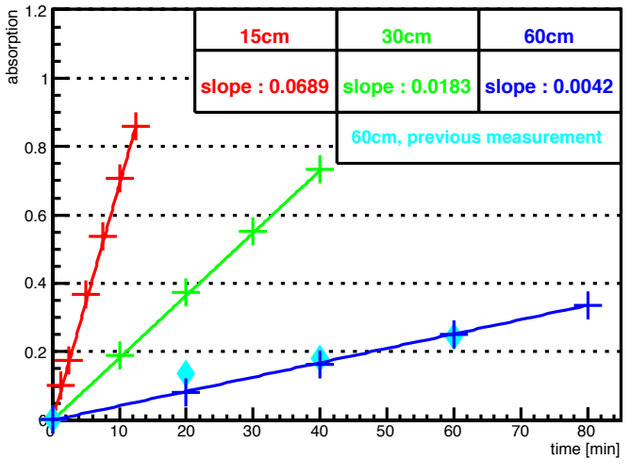

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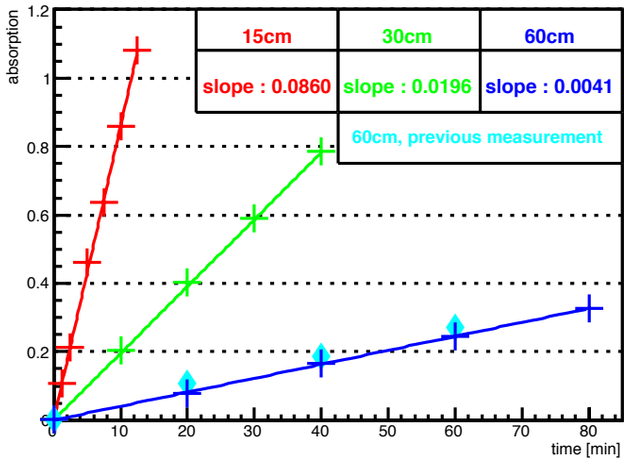

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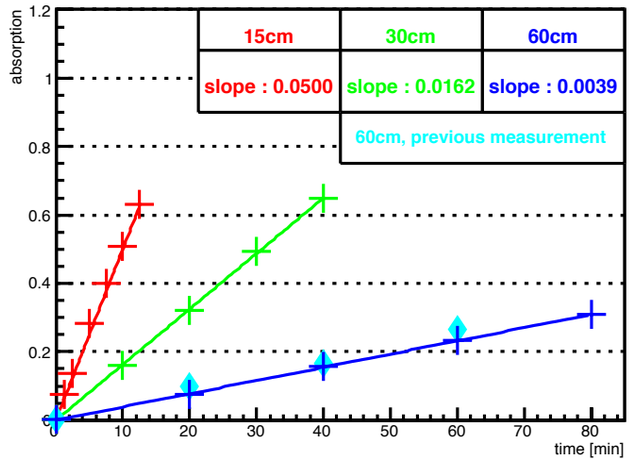
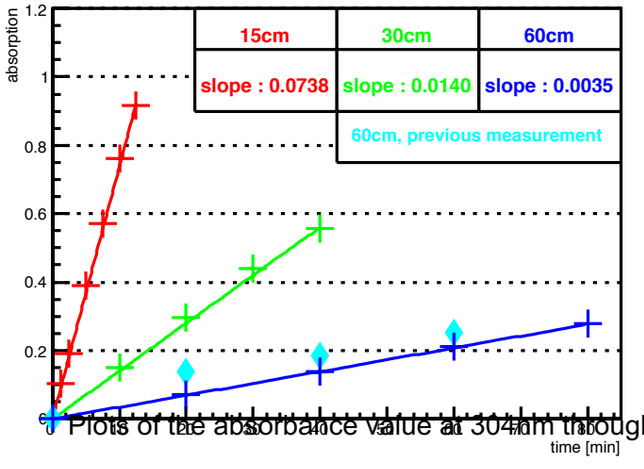


Slopes, Cell No.1



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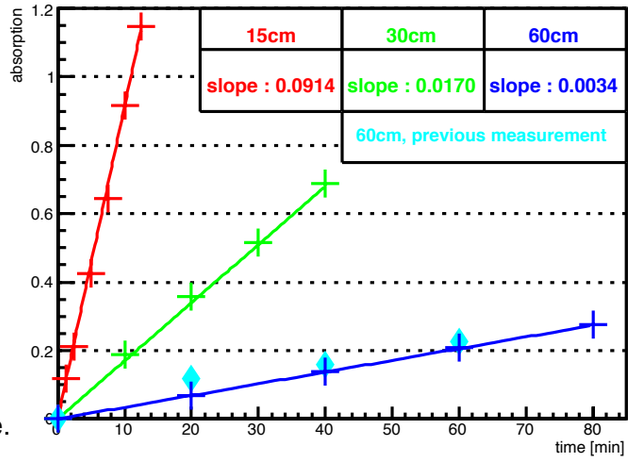
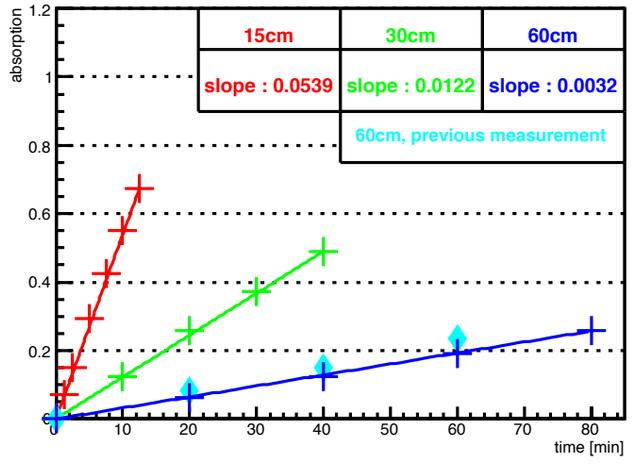
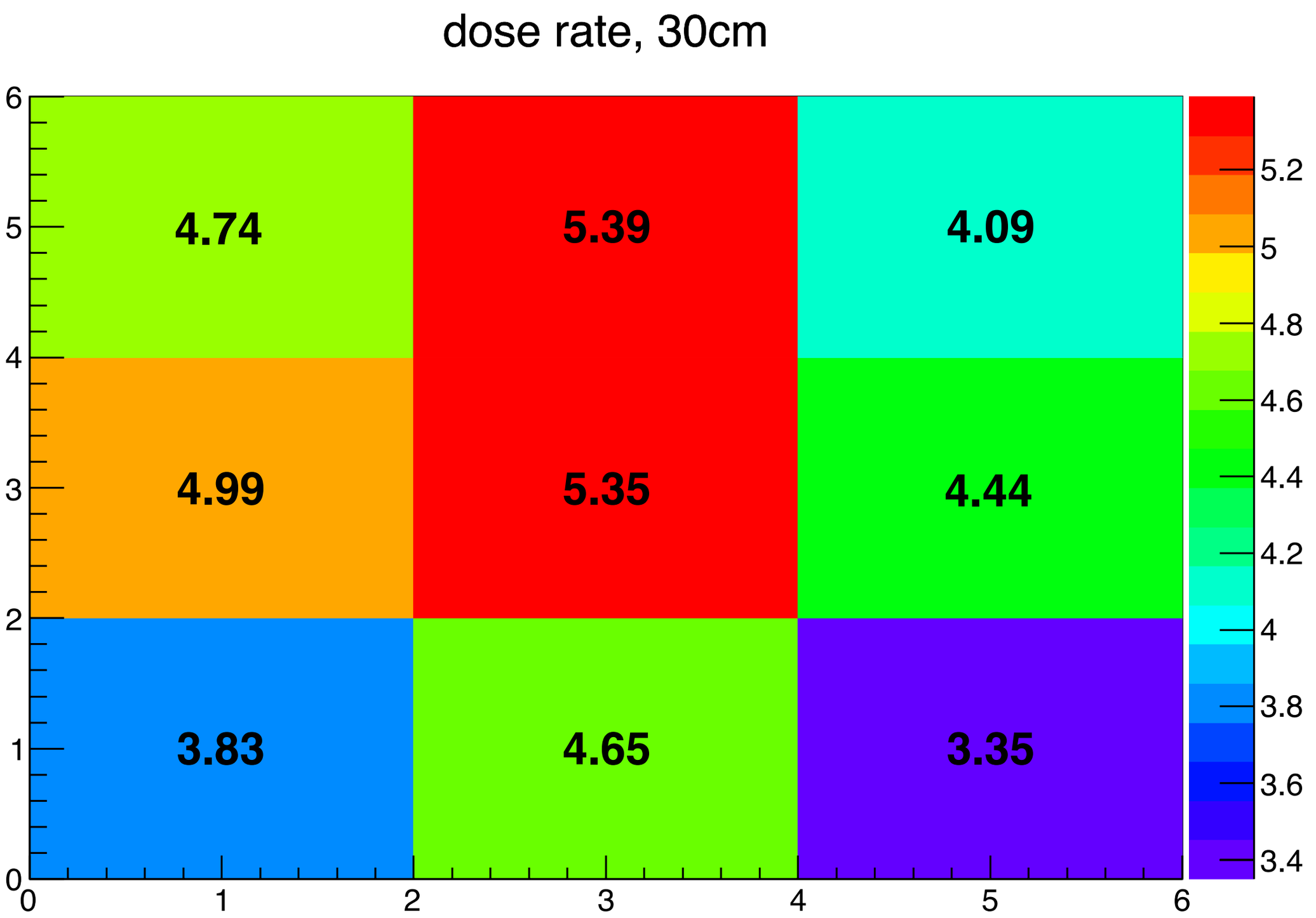


Slopes, Cell No.7



- Plots of the absorbance value at 304nm throughout time.

Water Irradiation Results



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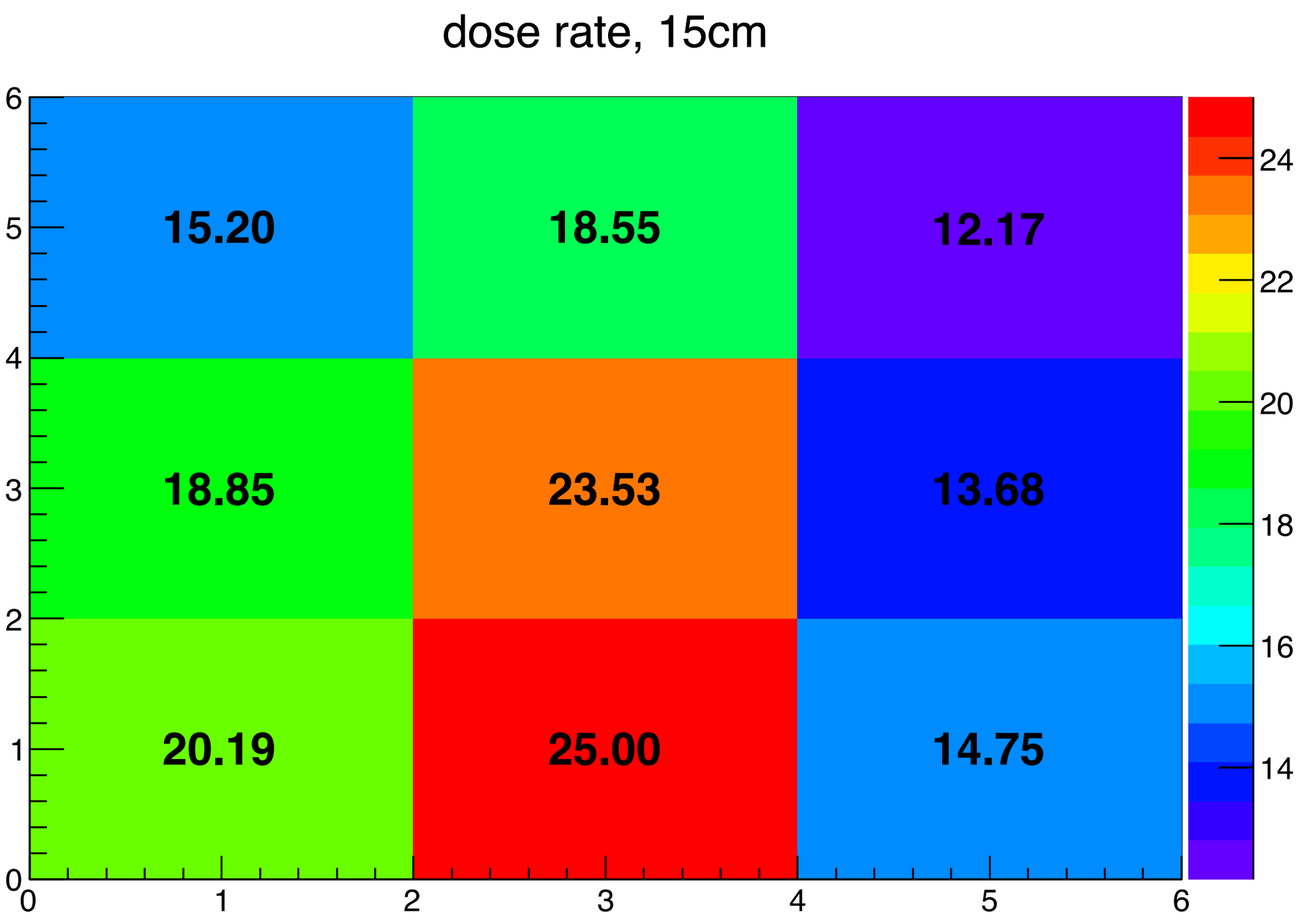
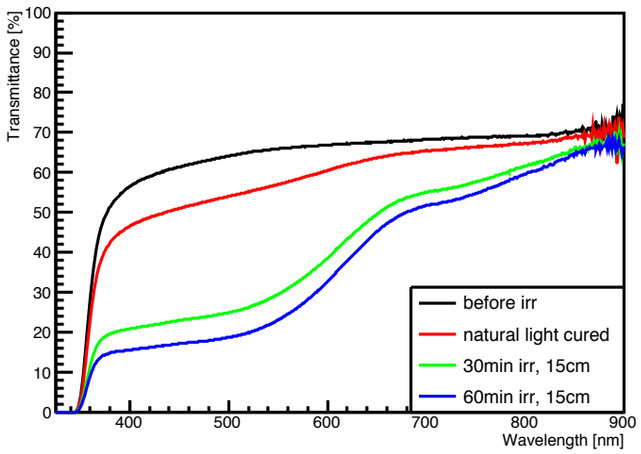


Plots of the absorbance value at 304nm throughout time.

Crystal Irradiation Results

J11



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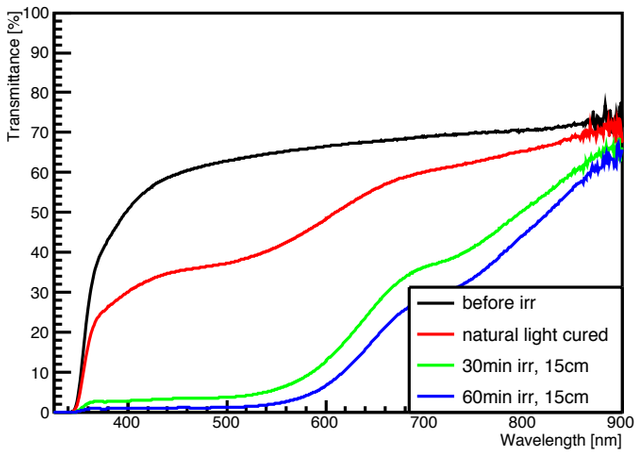

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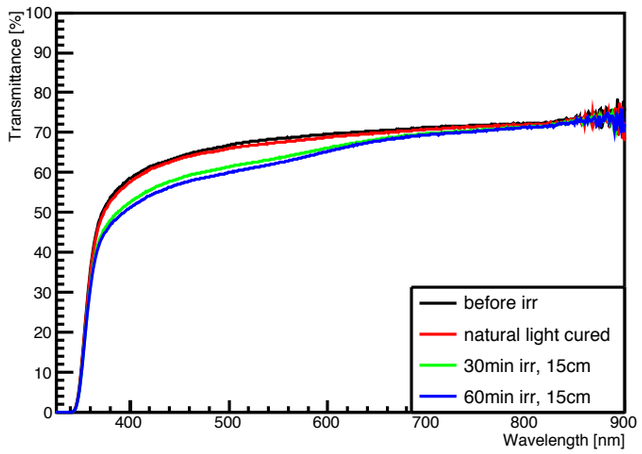

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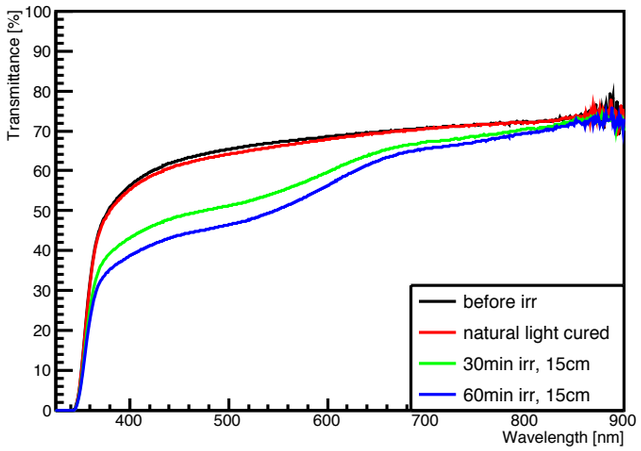

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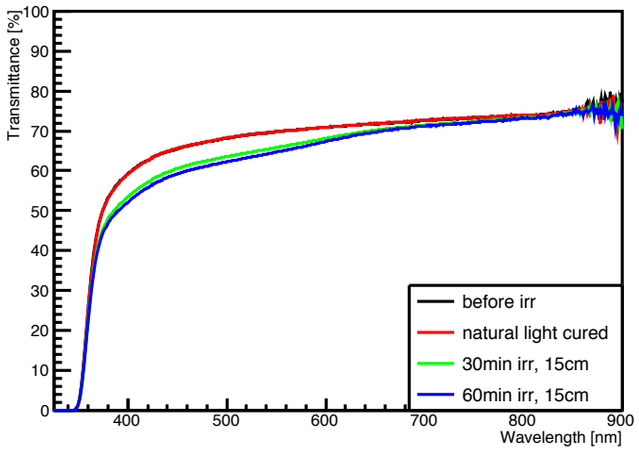

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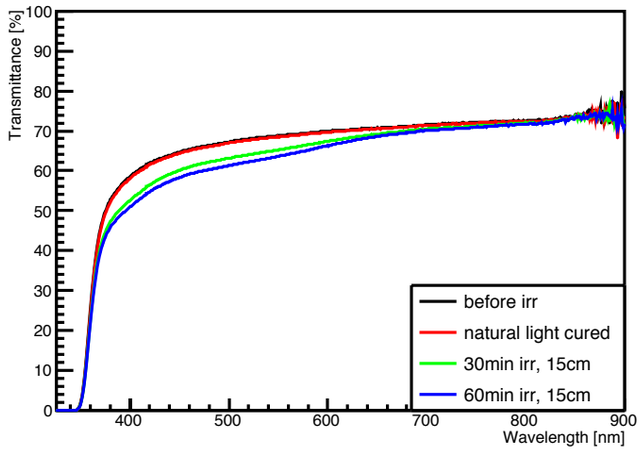

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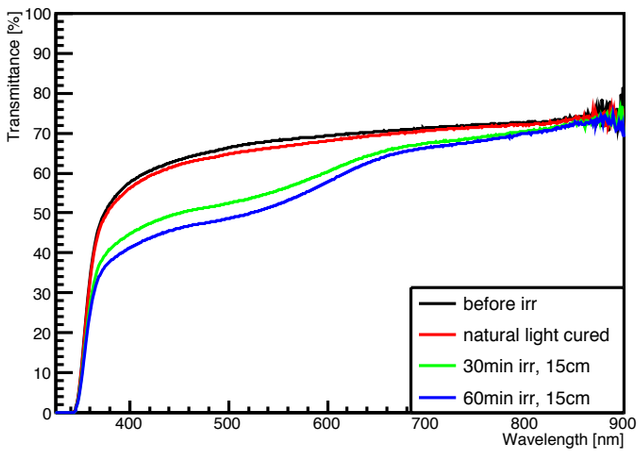

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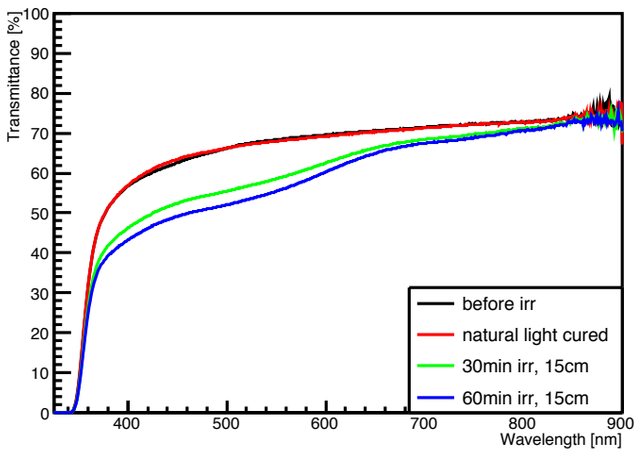

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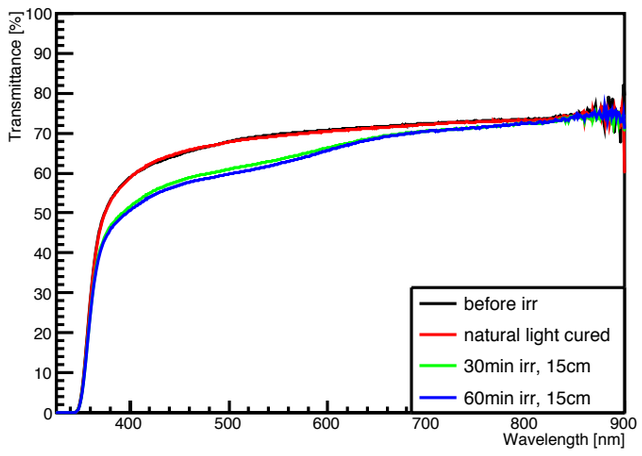
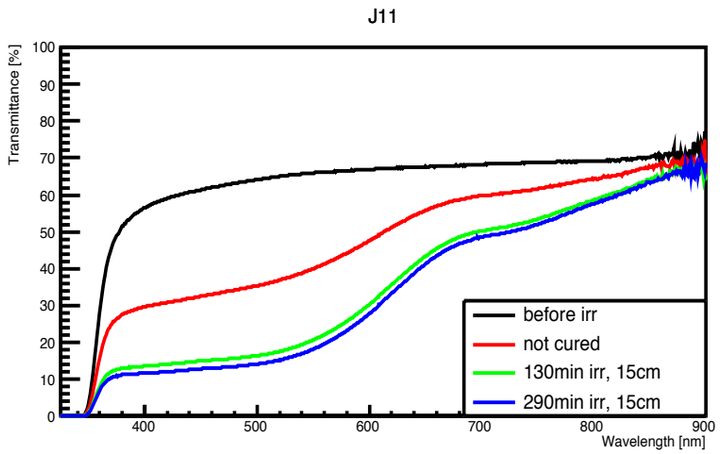
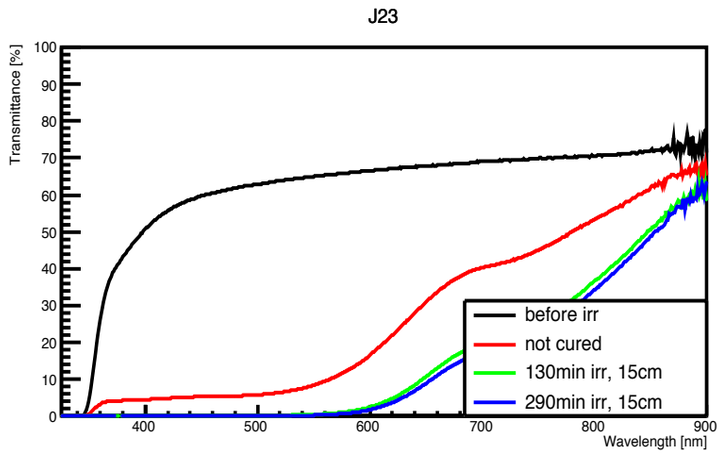
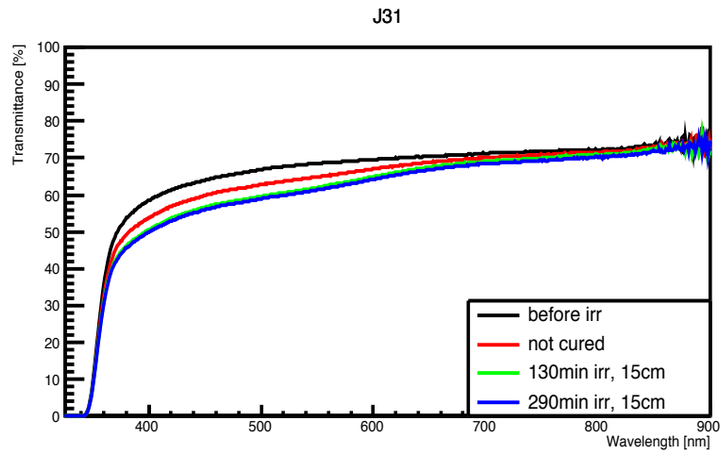
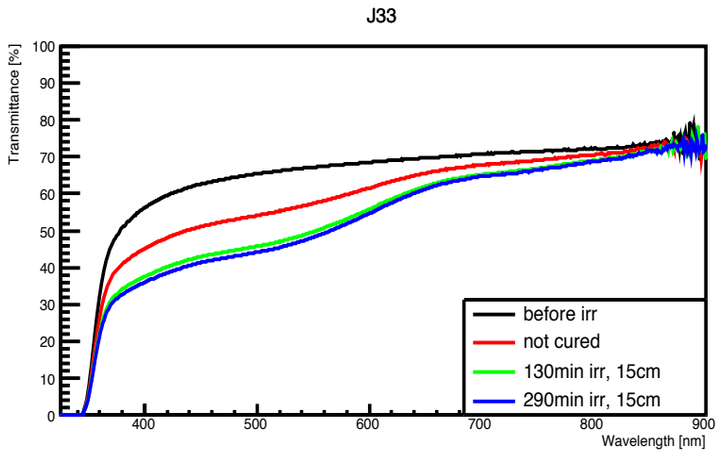


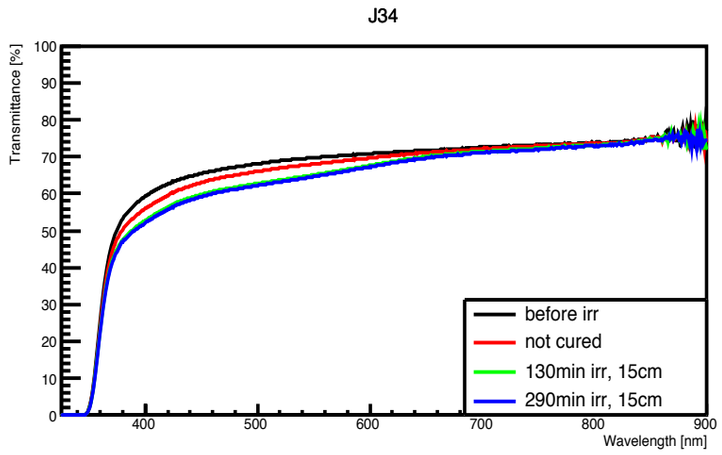
Crystal Irradiation Results

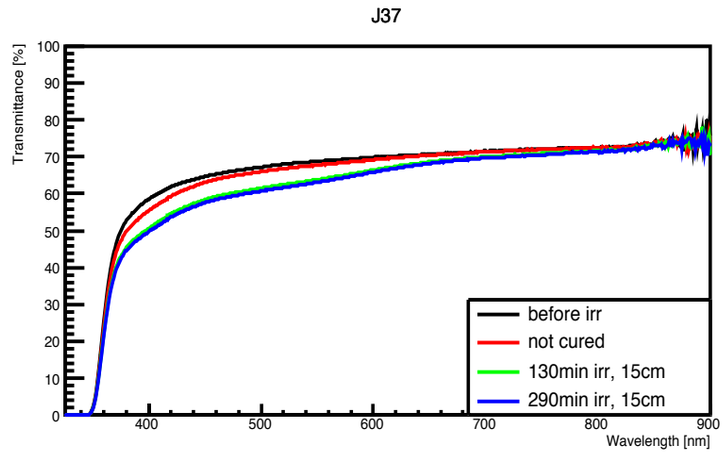


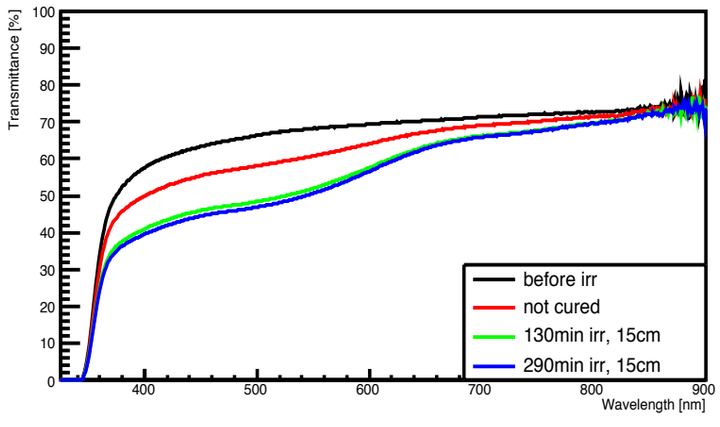


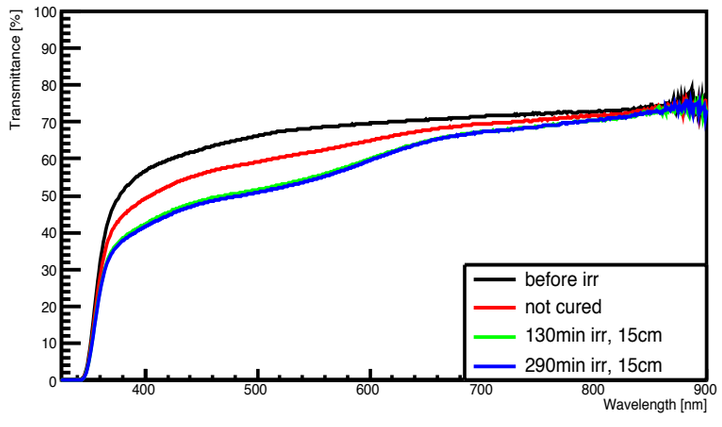


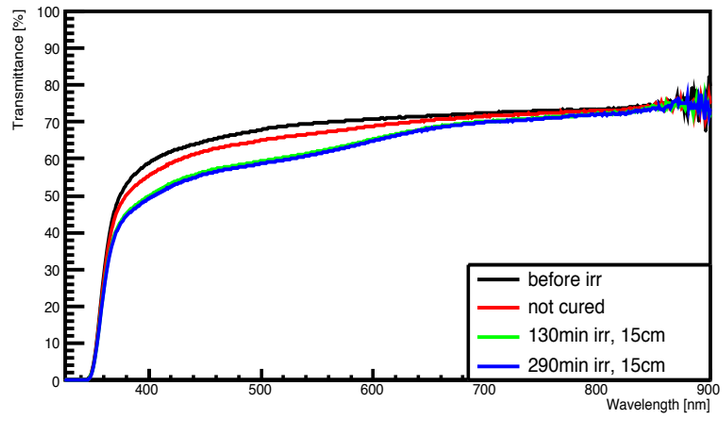








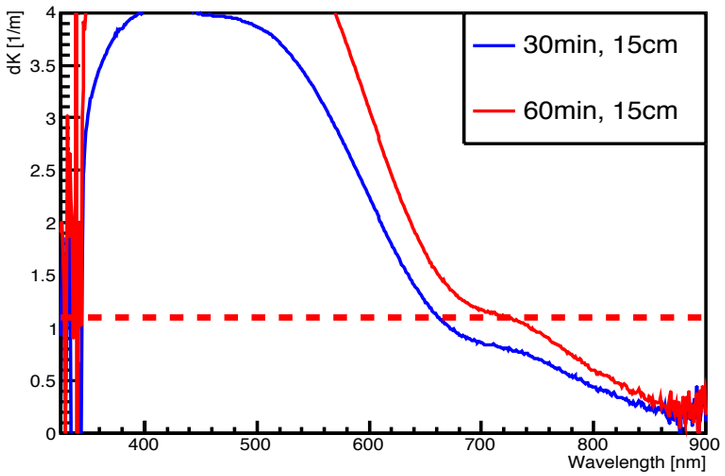




Plots of the absorbance value at 304nm throughout time.

Crystal Irradiation Results

J11



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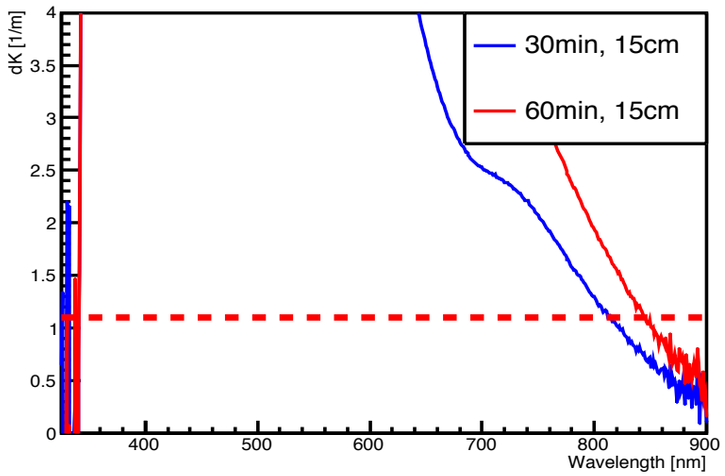

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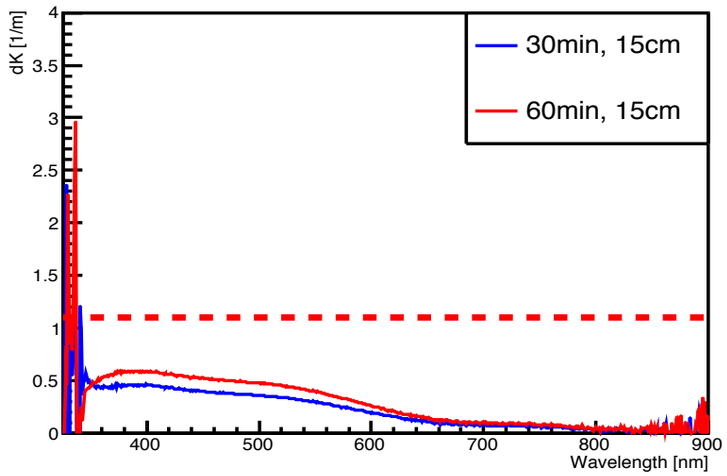

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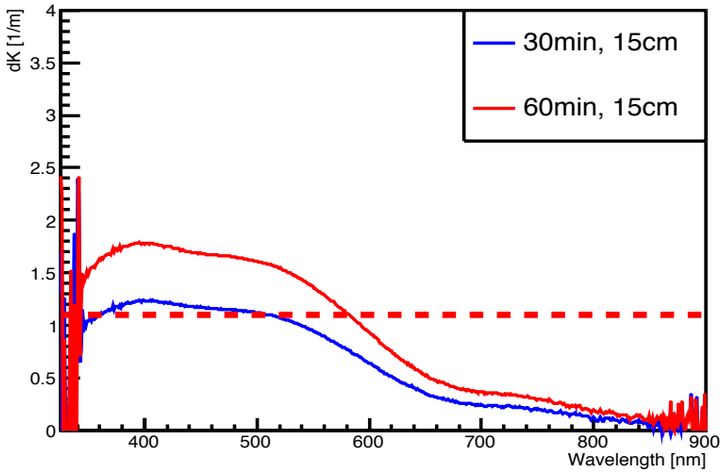

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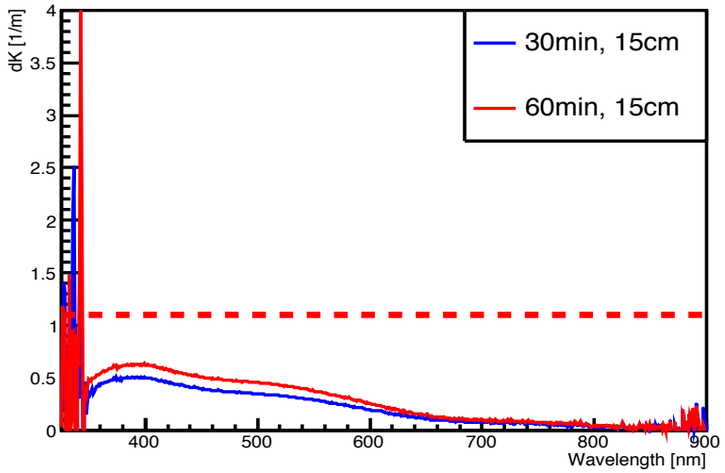

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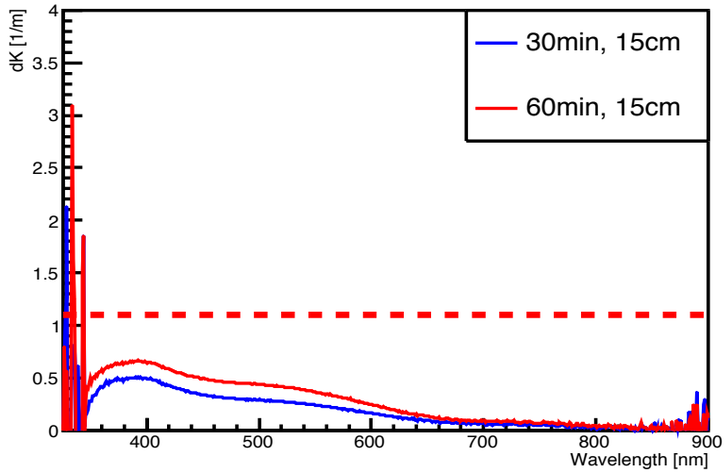

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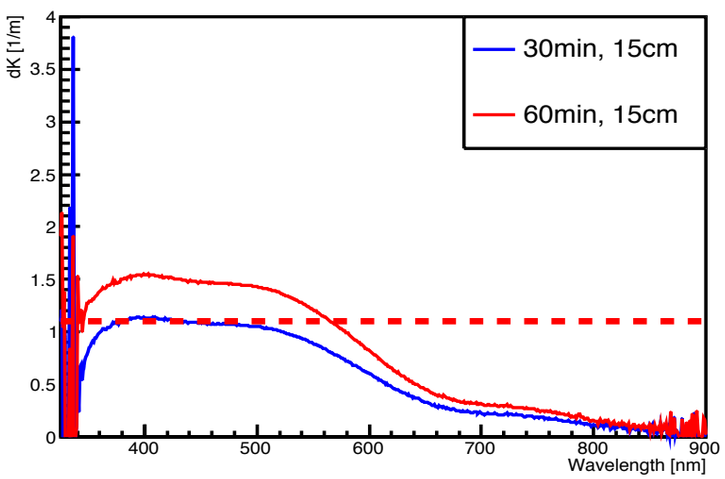

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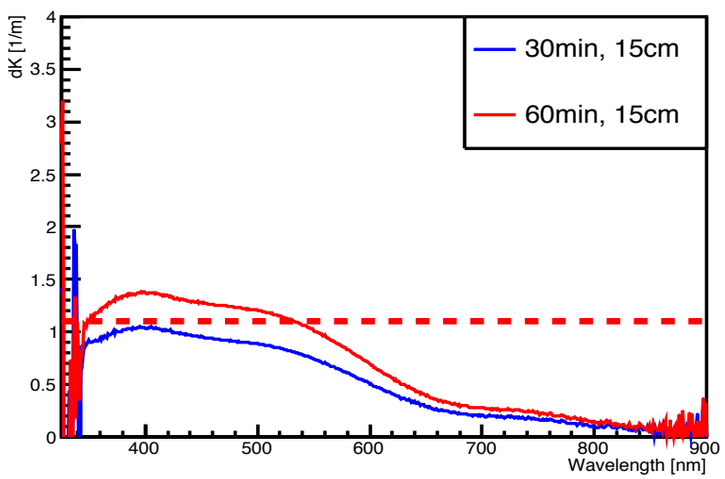

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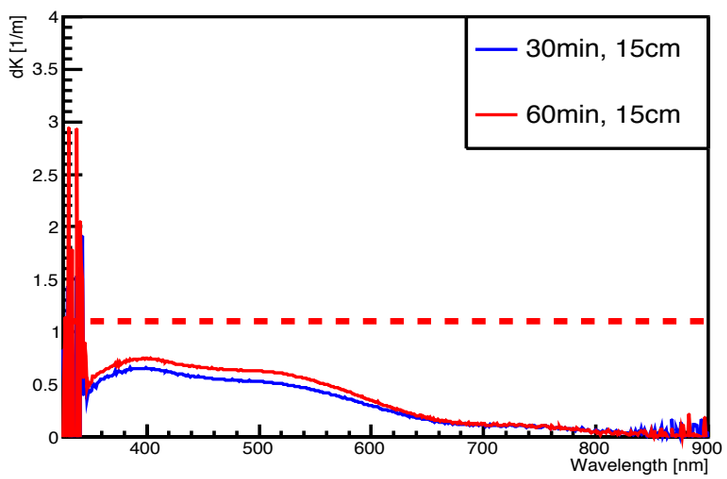
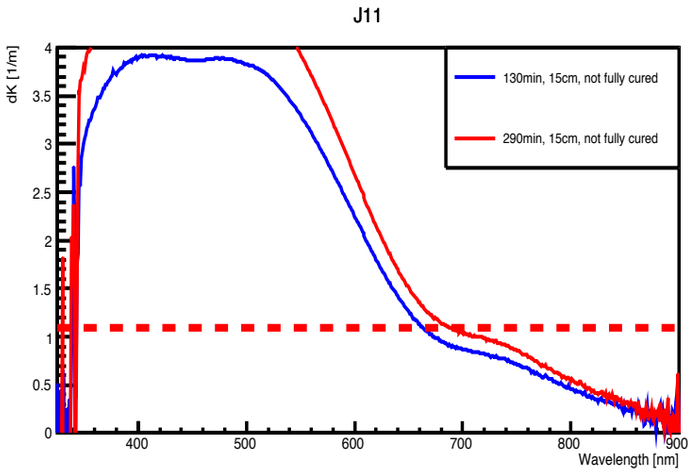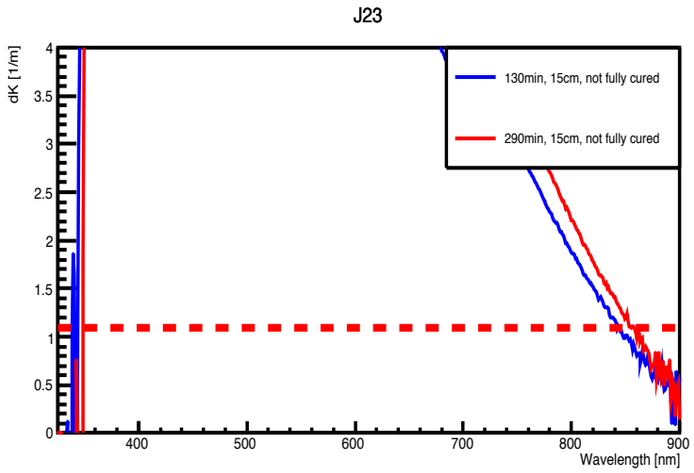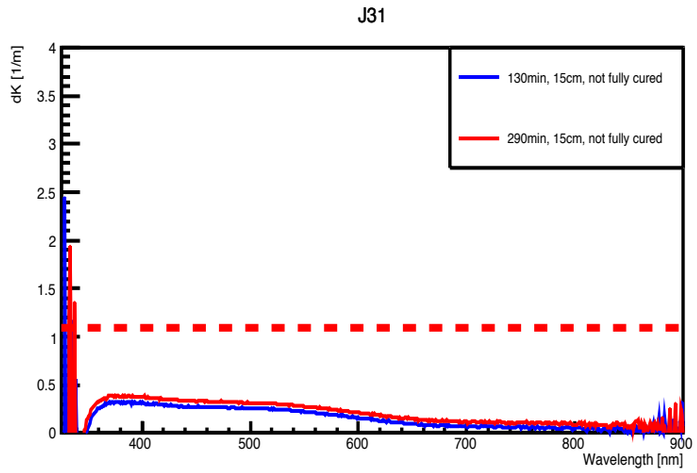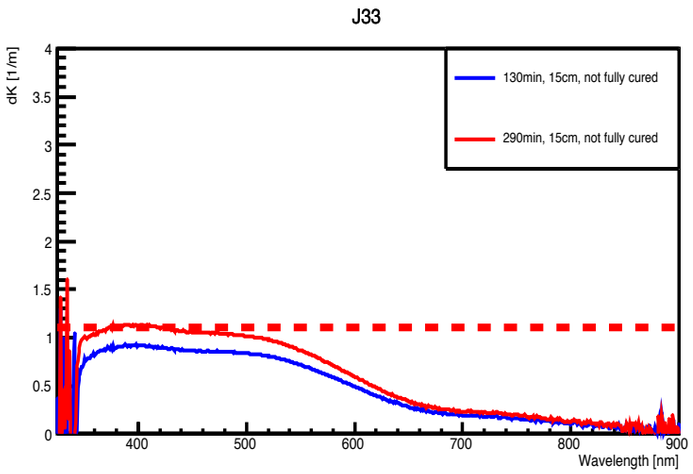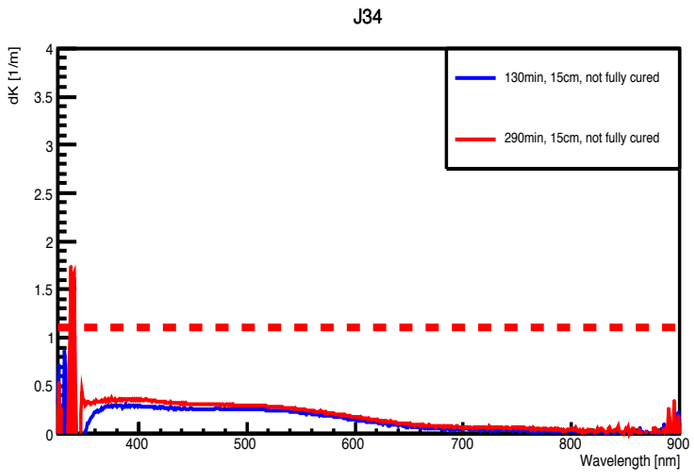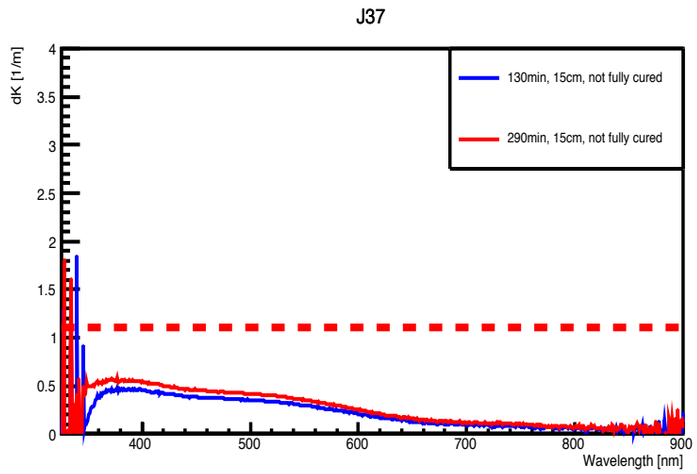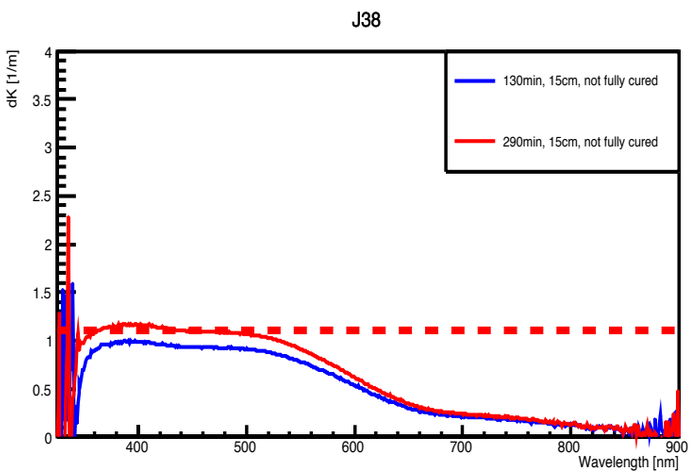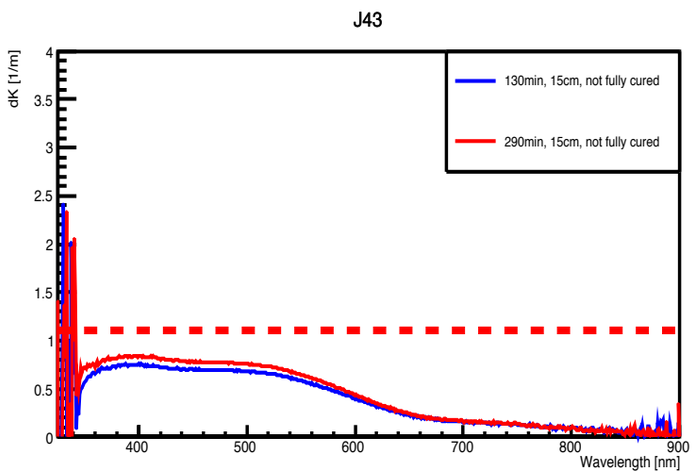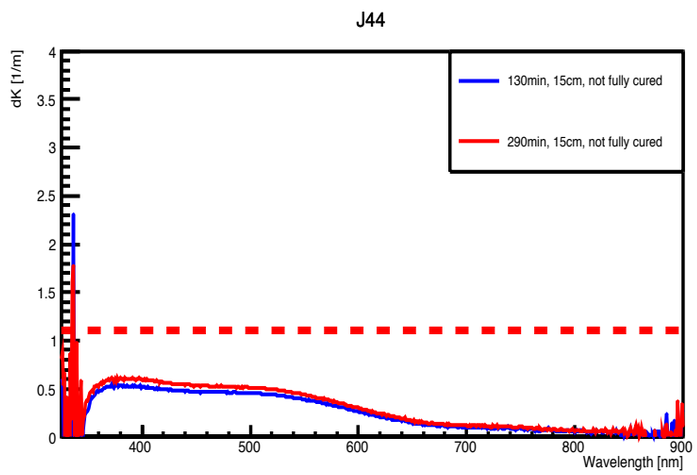
Crystal Irradiation Results