

Radiation hardness measurements of PbWO₄ crystals at IPN-Orsay

Ho San KO

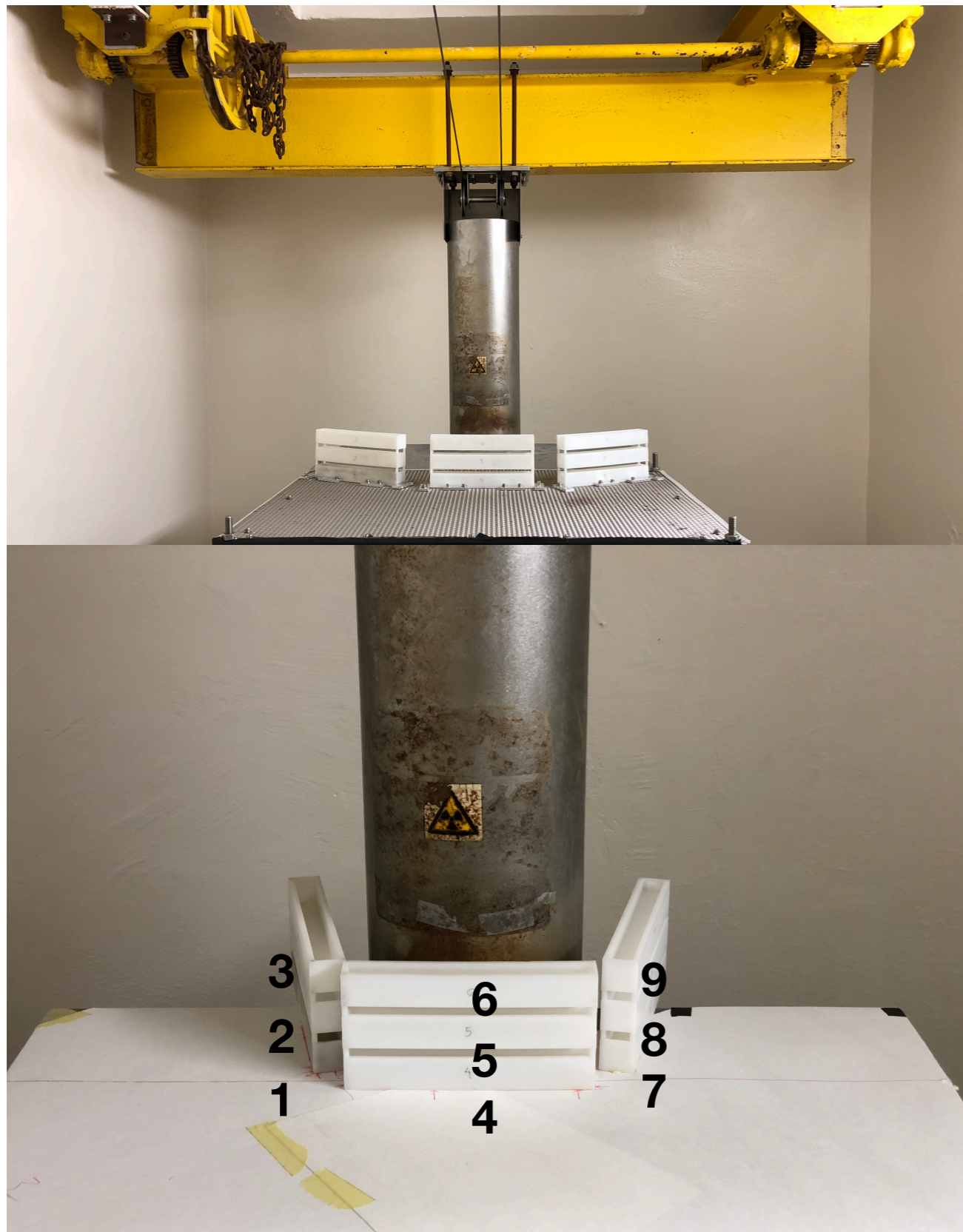
PHEN Institut de Physique Nucléaire d'Orsay

31. May. 2018

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

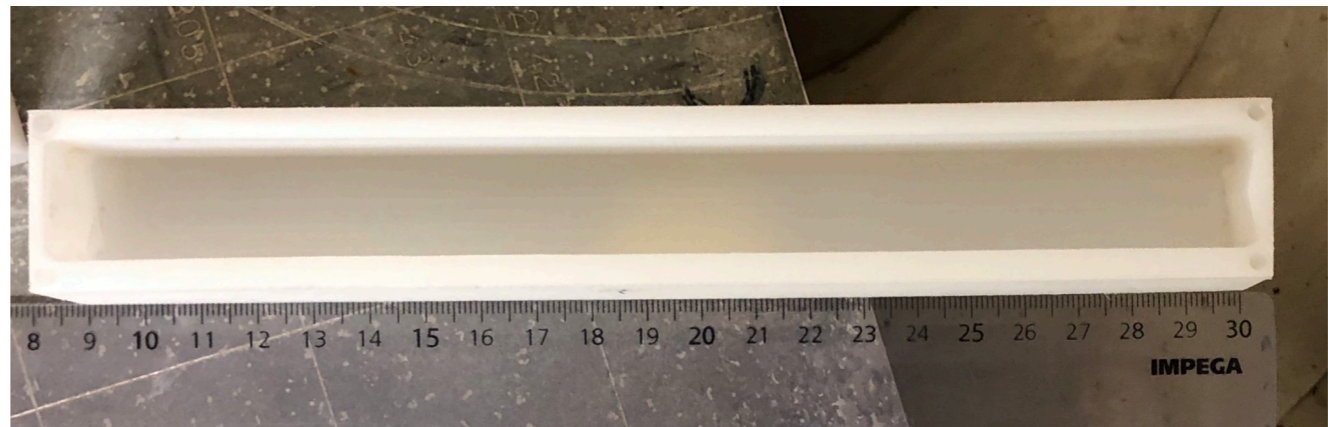
Irradiation Facility



- 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
- (top picture)

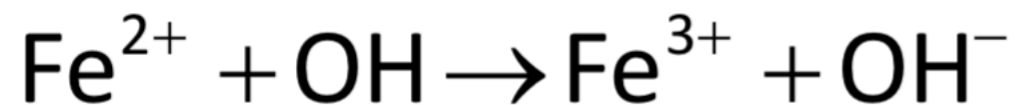
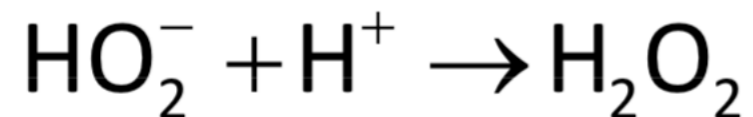
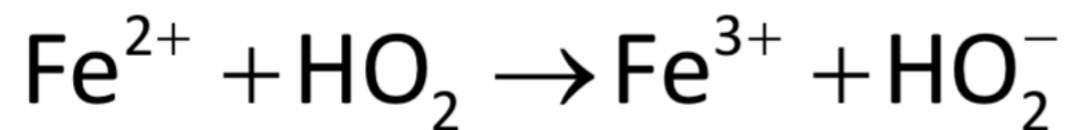
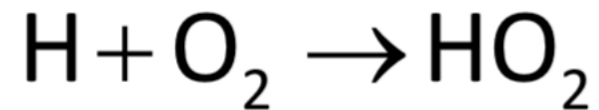
Irradiation Facility

- 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($\sim 200\text{Gy}$).

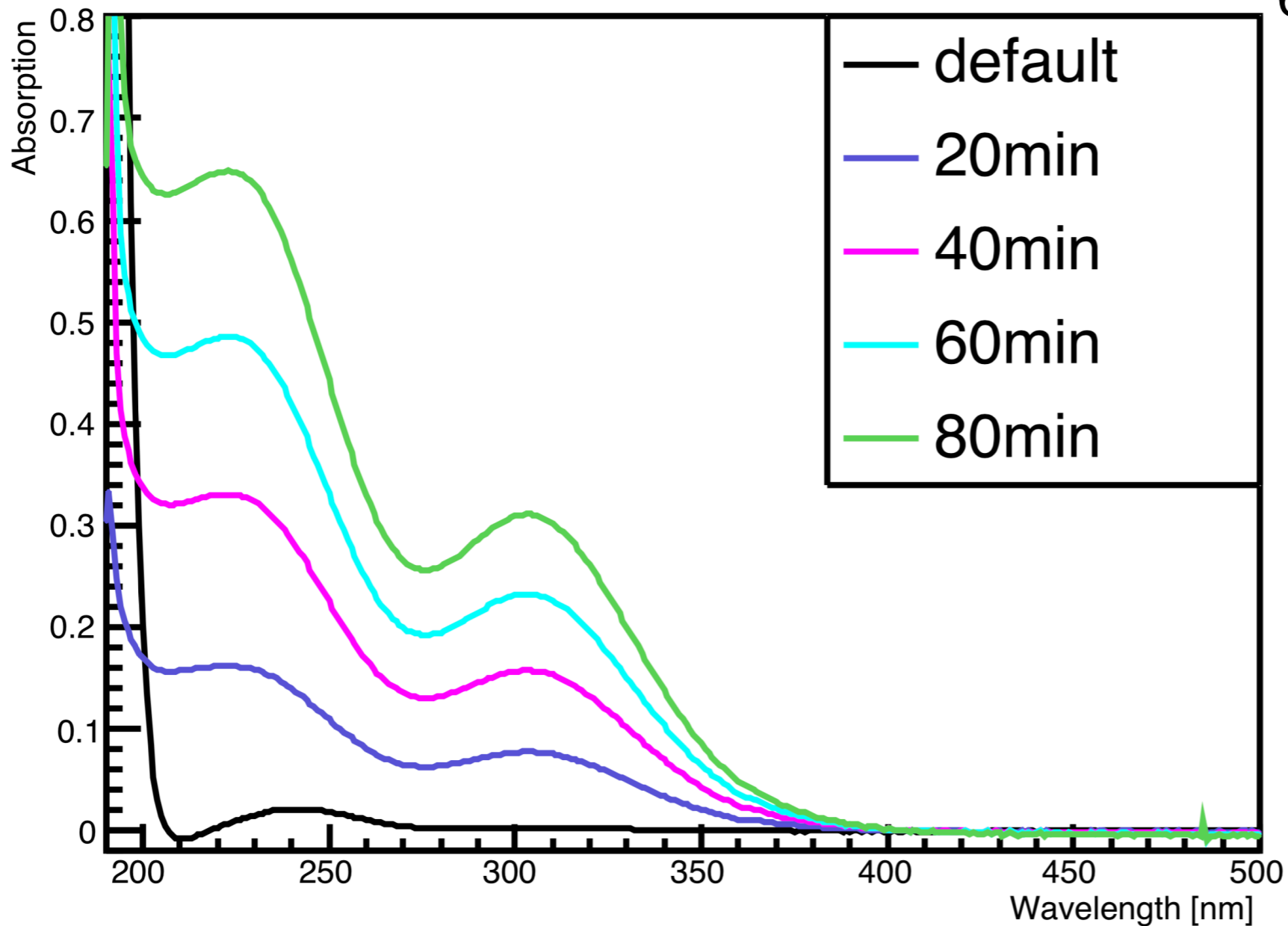
Fricke solution



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

Water Irradiation Results

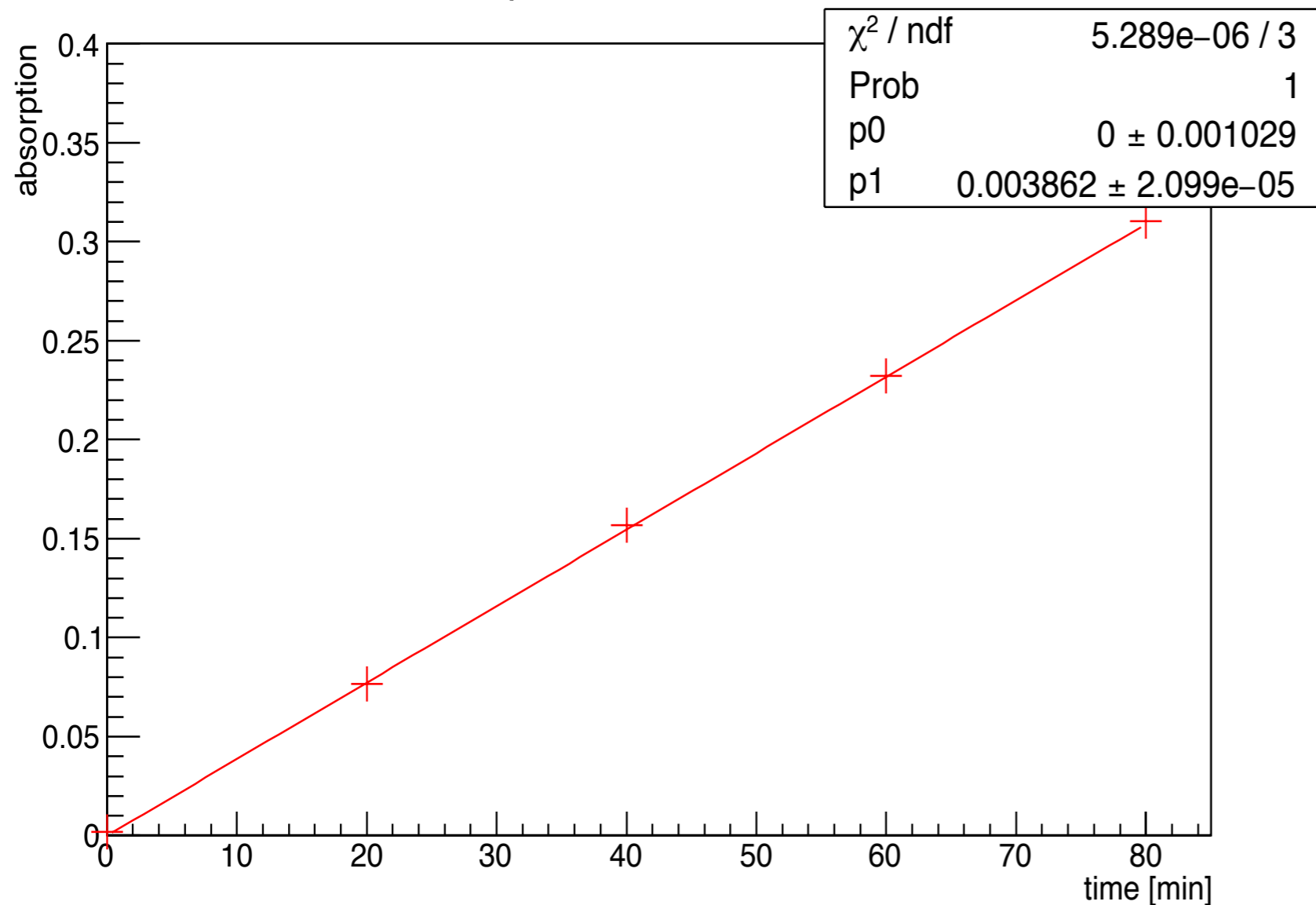
60cm away from the source



- ▶ 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.



- Increase of light absorption throughout irradiation time
- With the absorption change rate, we can get the dose rate.

60cm away from the source

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

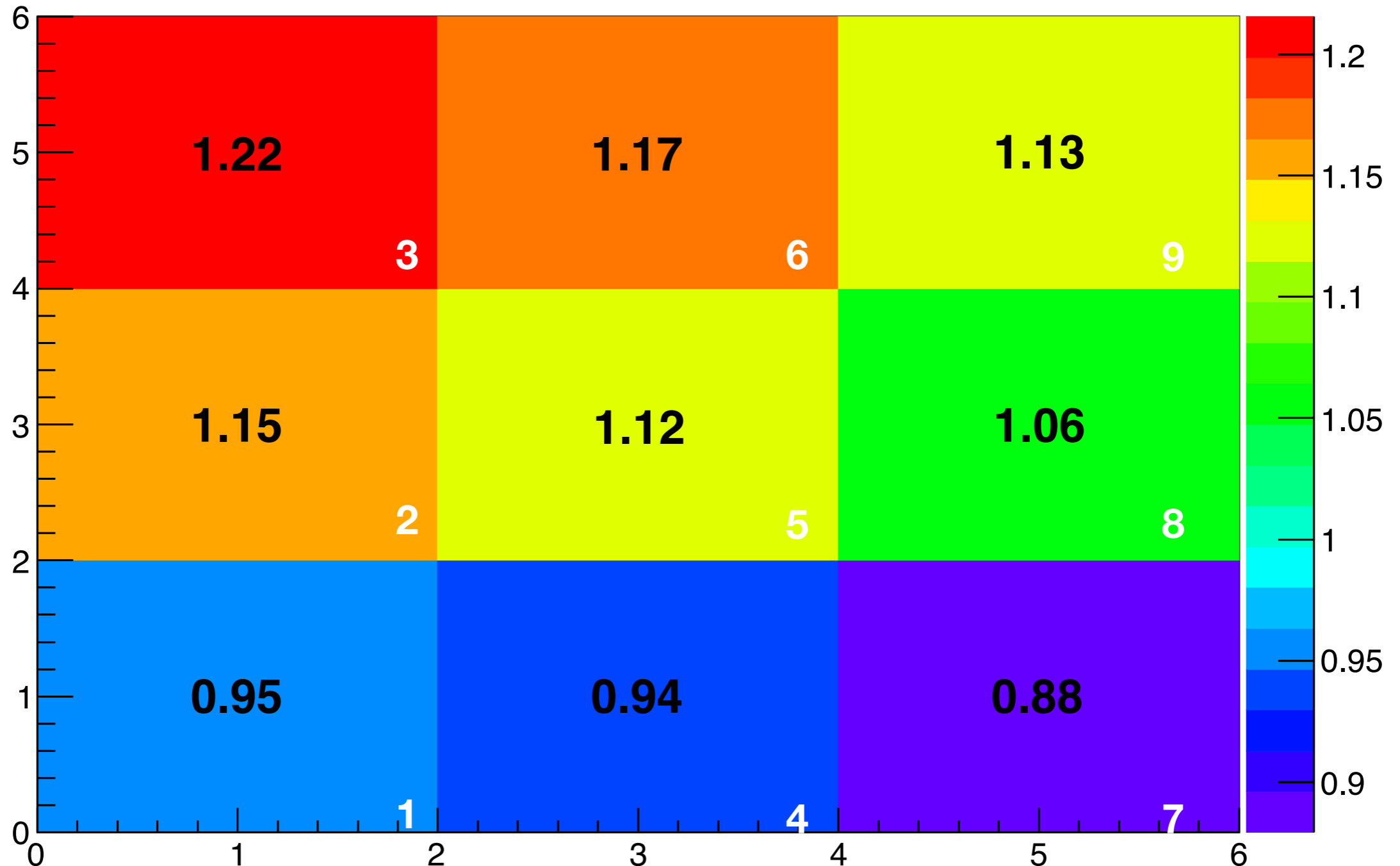
G : efficiency for appearance of Fe³⁺ 1.62×10^{-7} mole/J

ρ : mass density of the solution

$D(t)$: radiation dose

Water Irradiation Results

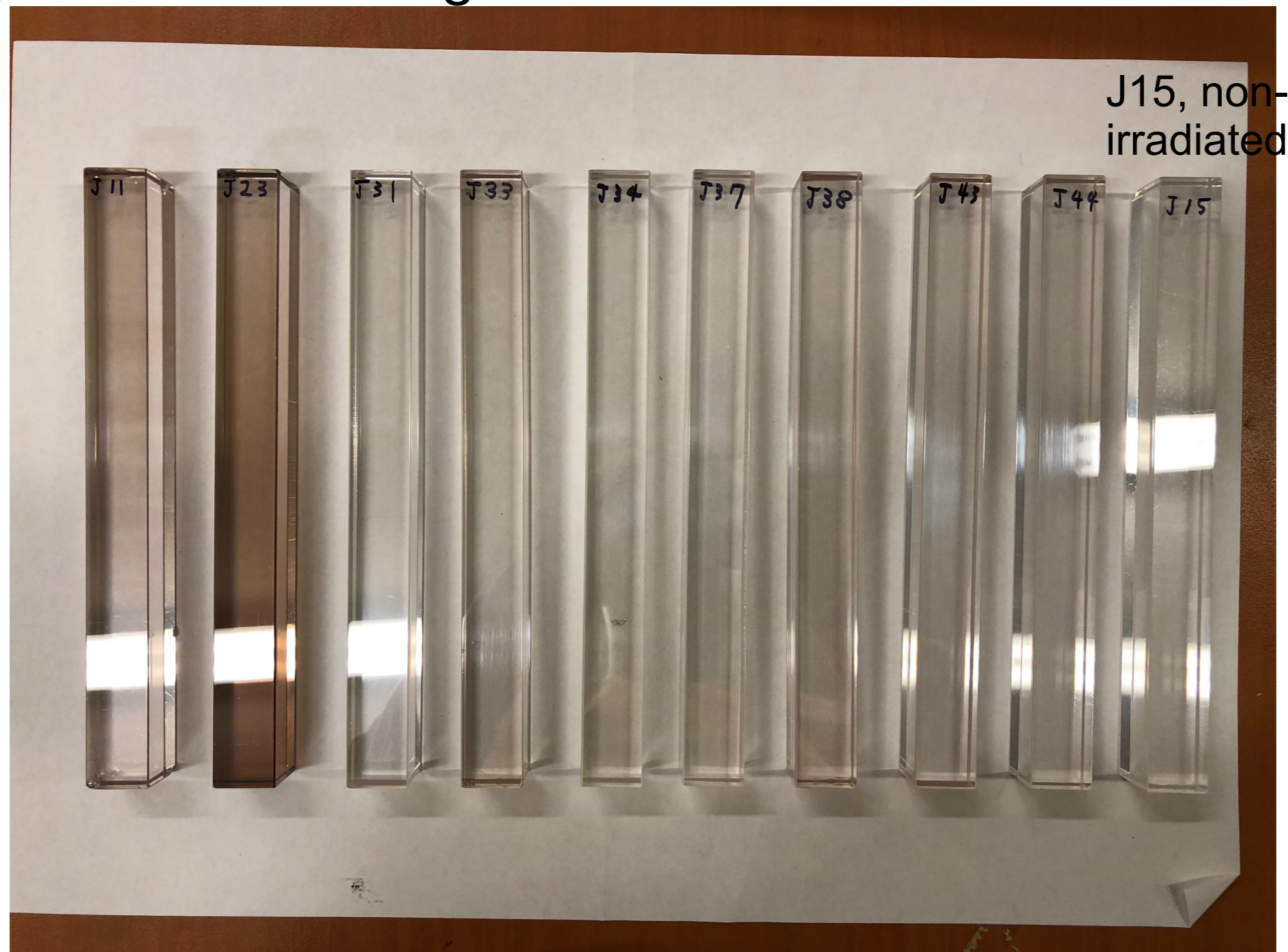
Dose rate. 60cm away from the source



- Dose rate average of 1.07Gy/min (Giessen's : 1.16Gy/min)

PbWO₄ Irradiation Results

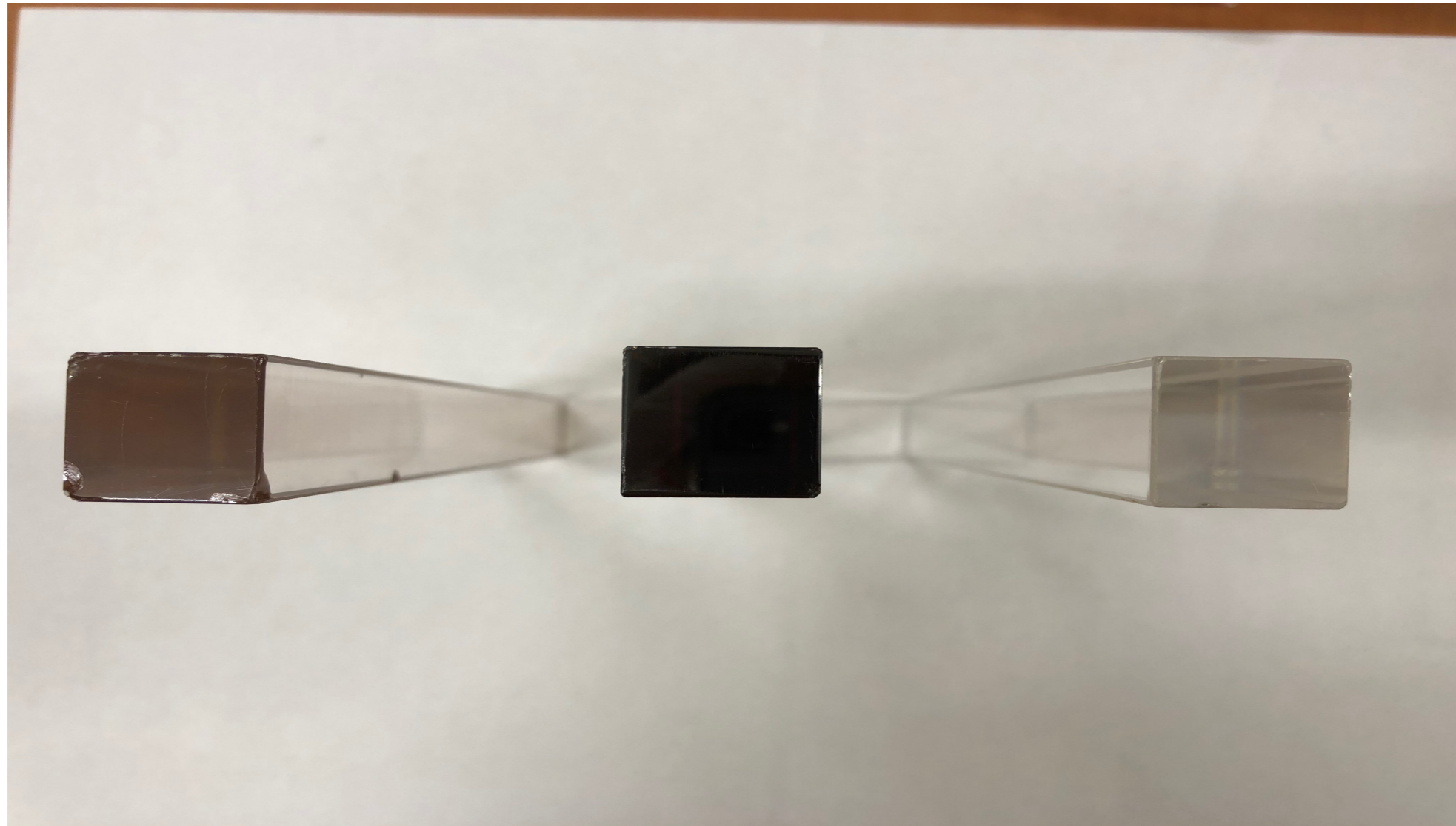
- Crystals' color changes after irradiation.



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

PbWO₄ Irradiation Results

- Crystals' color changes after irradiation.



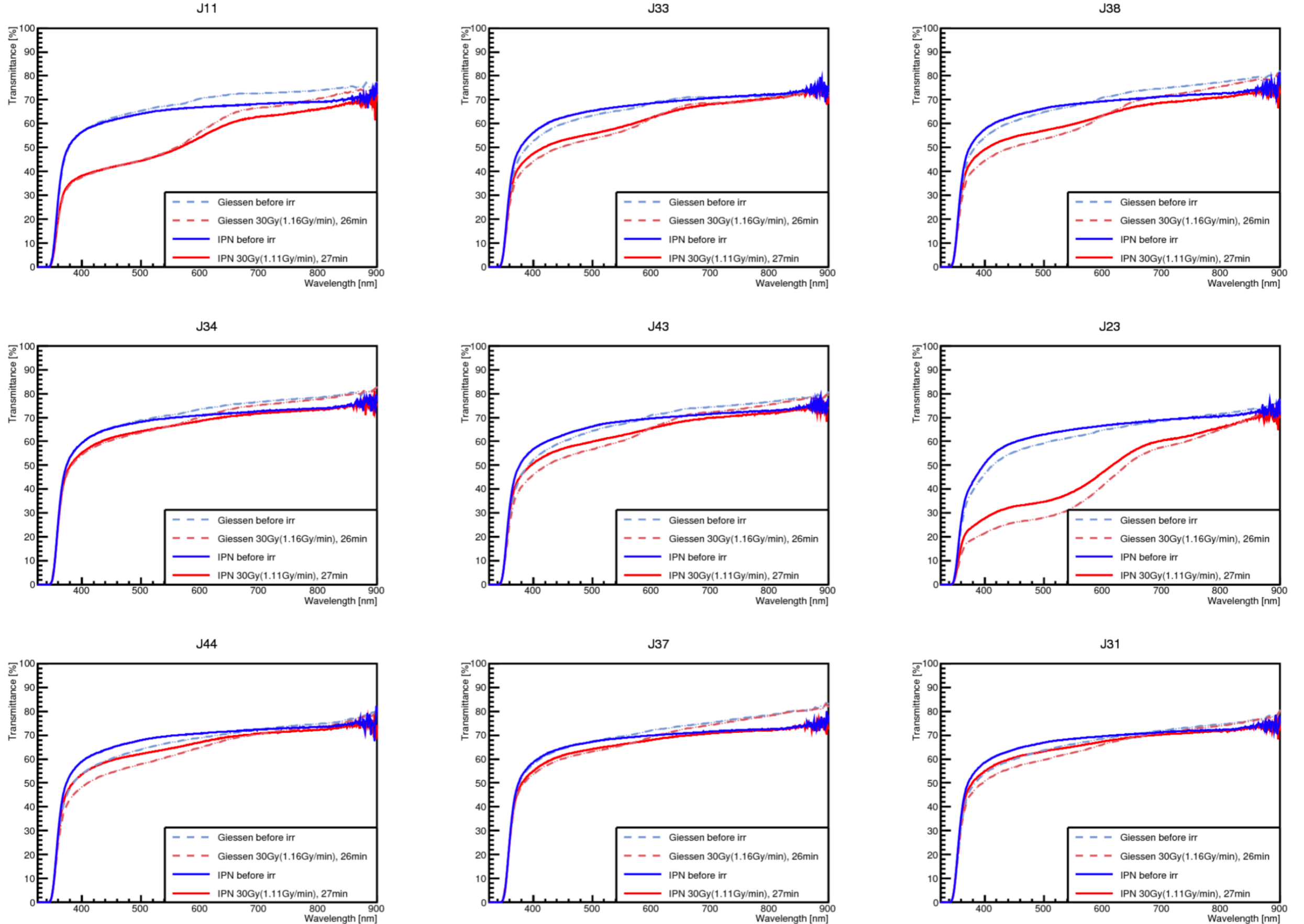
J11

J23, damaged the most

J15, non-irradiated

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

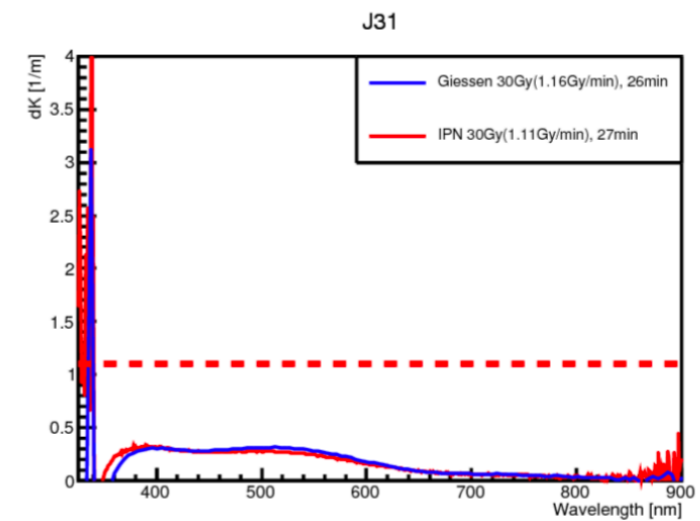
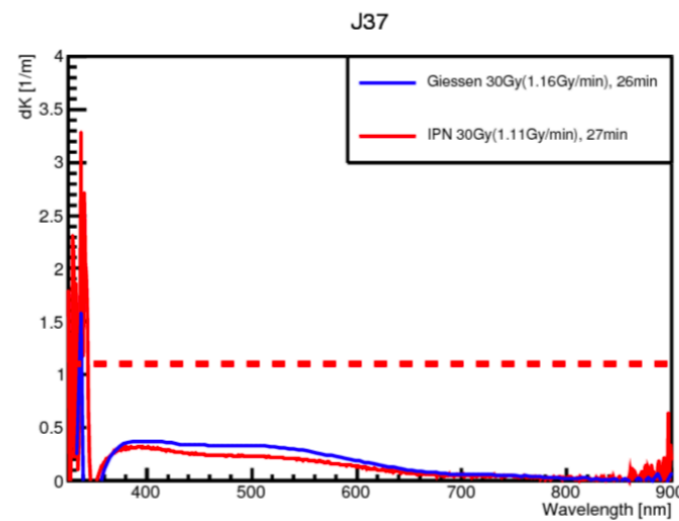
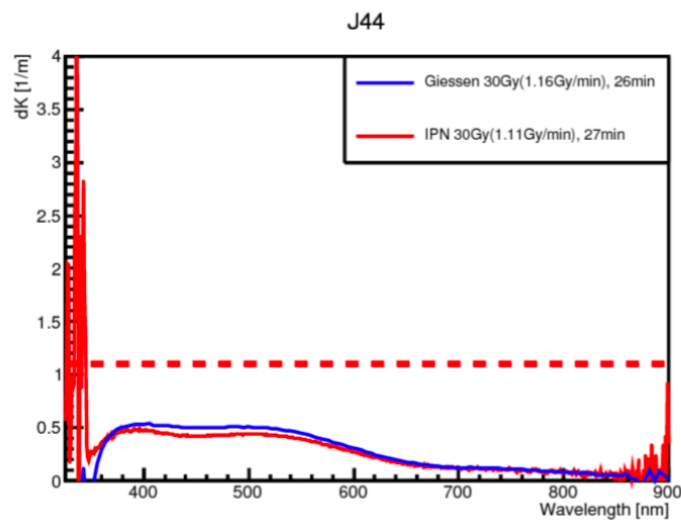
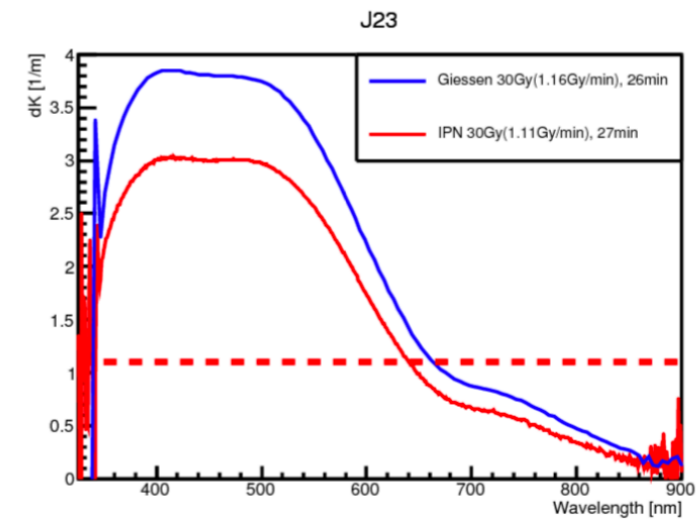
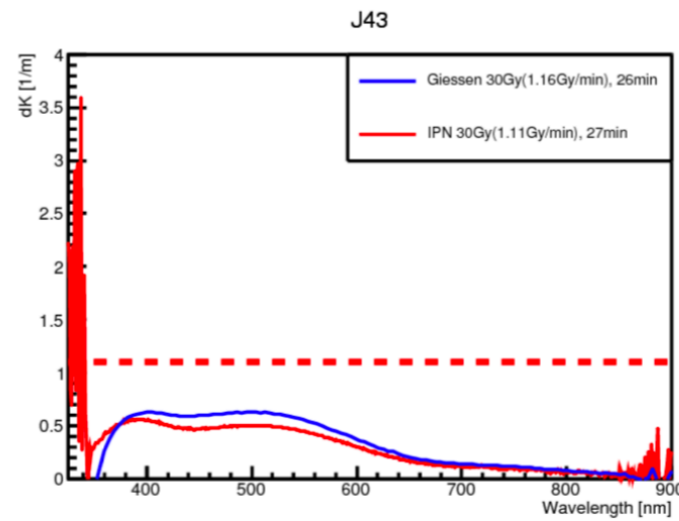
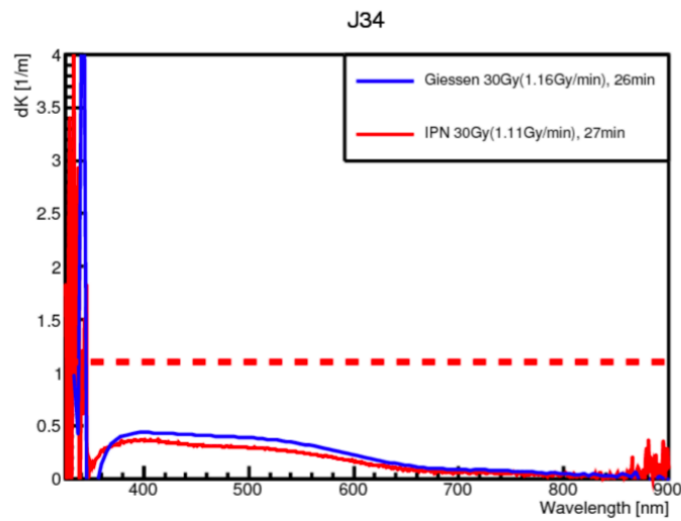
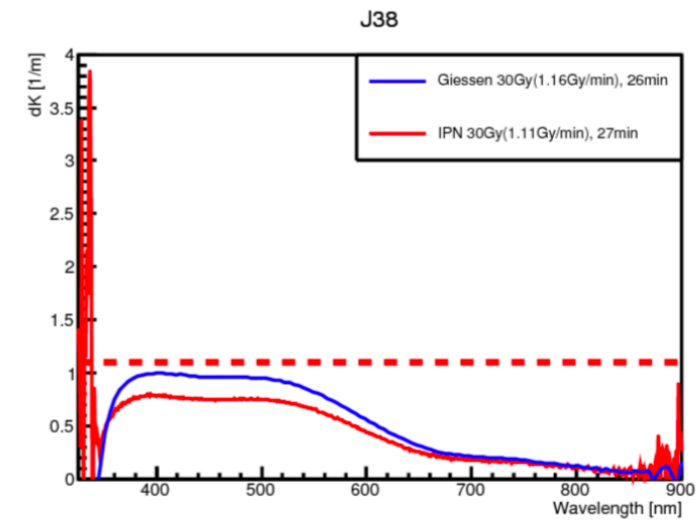
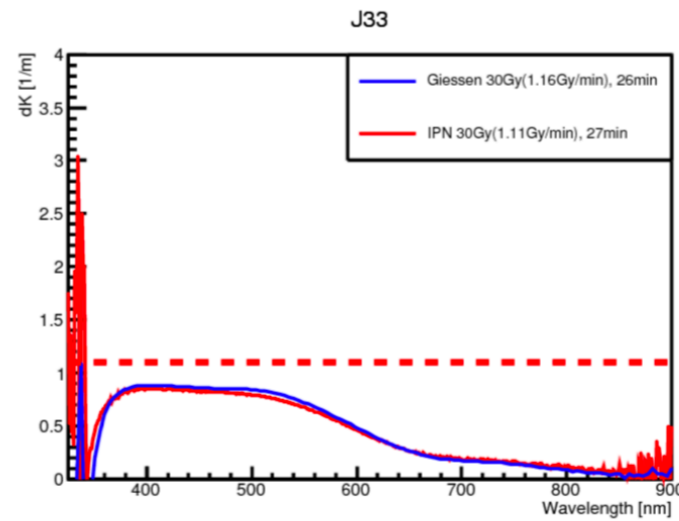
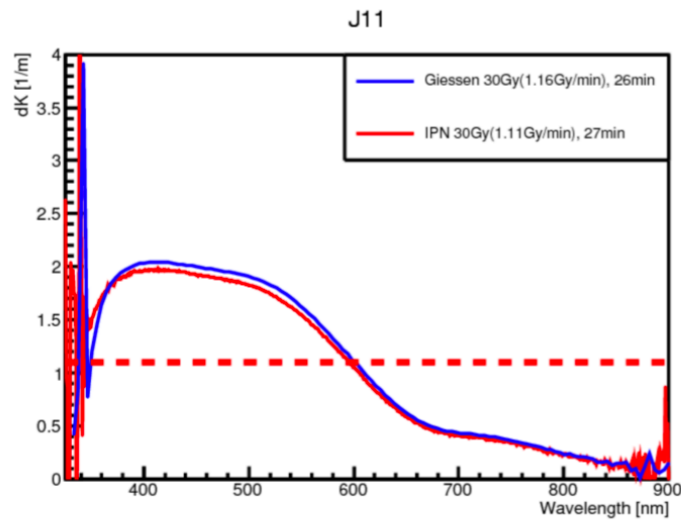
PbWO4 Irradiation Results



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

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IPN Radiation Facility

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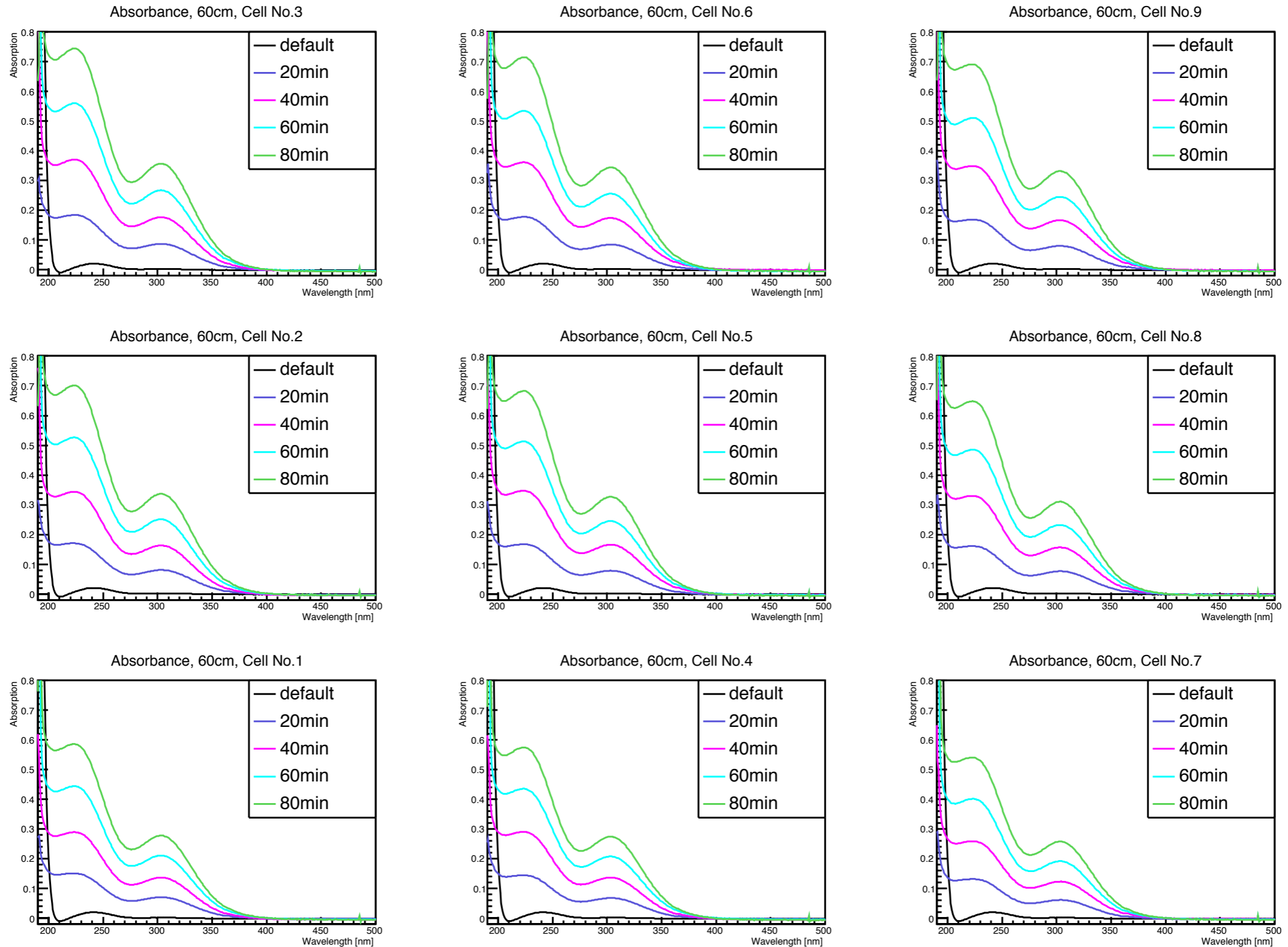
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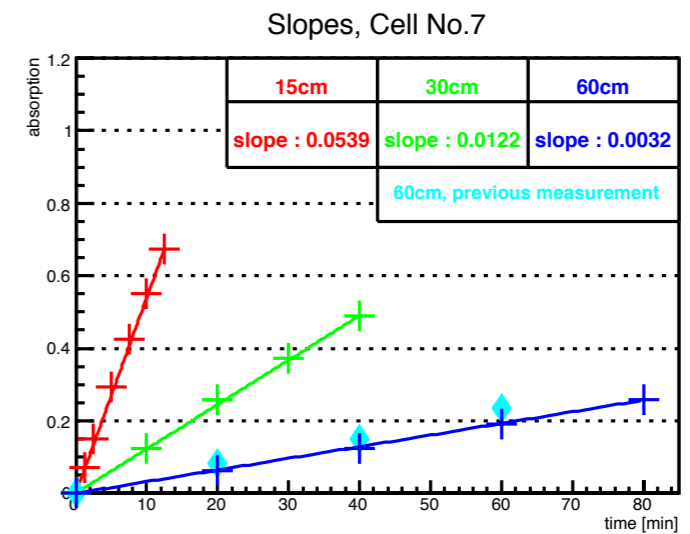
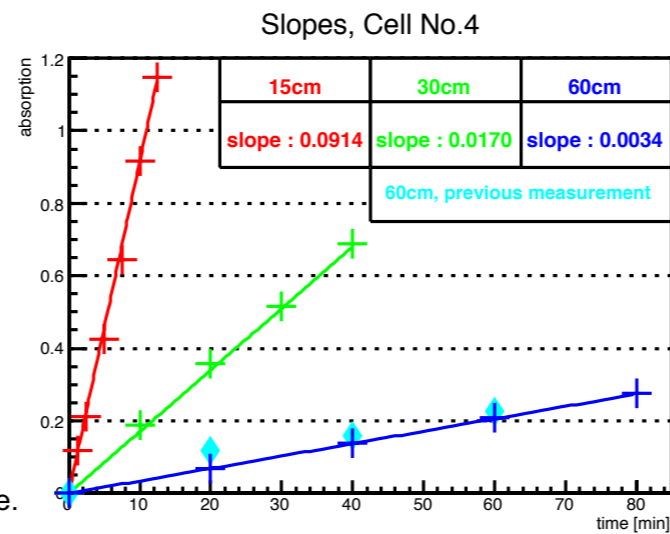
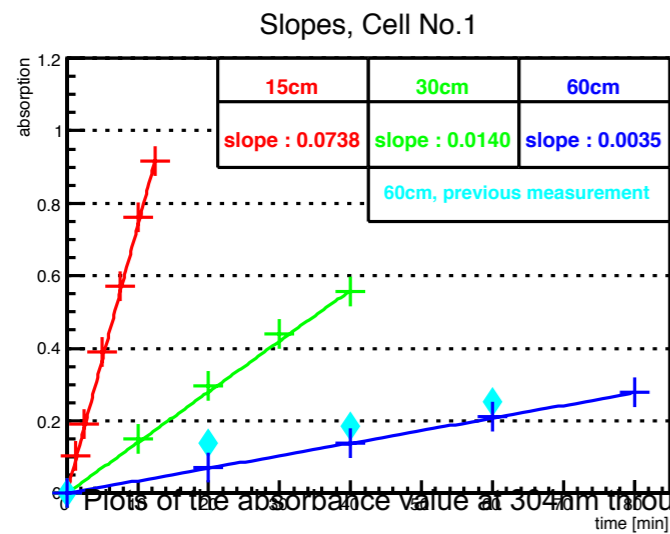
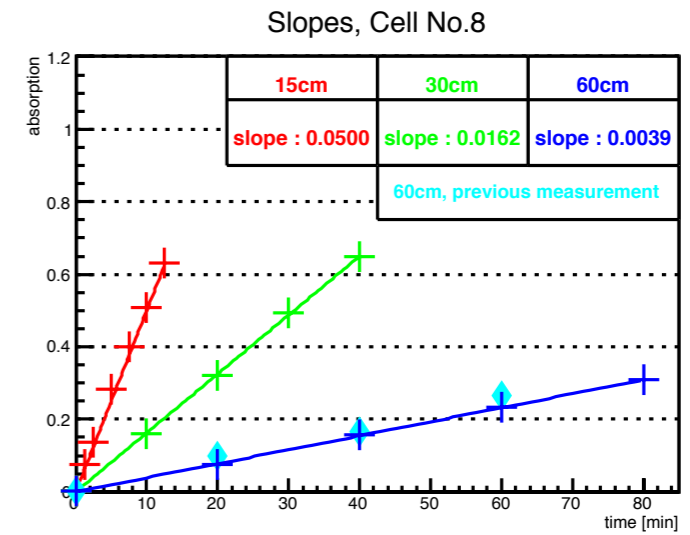
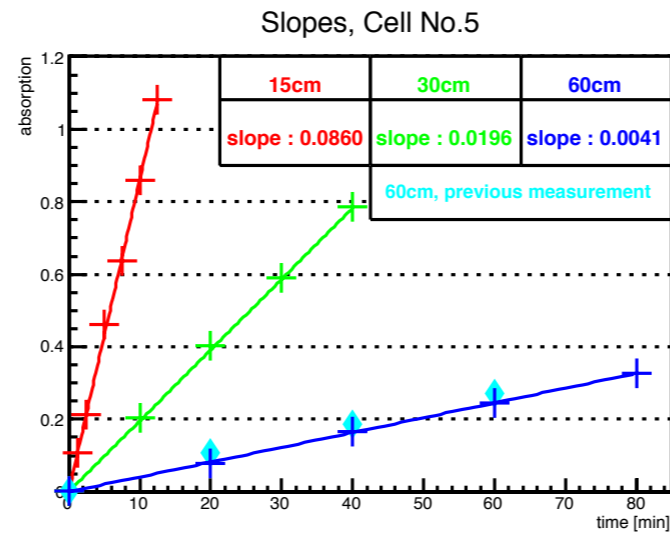
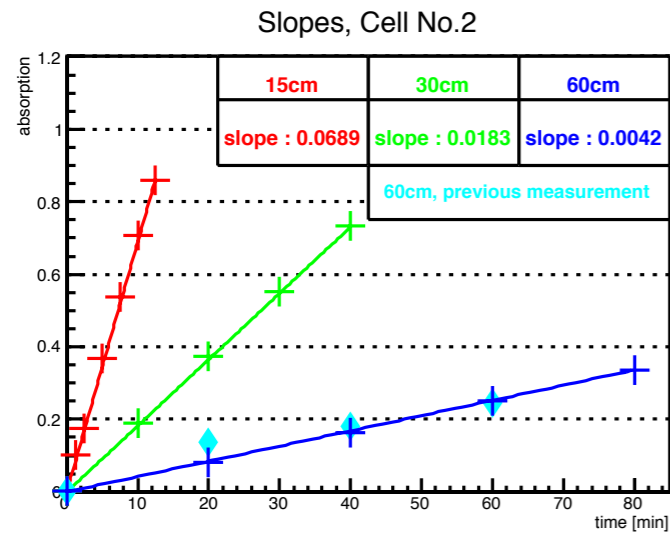
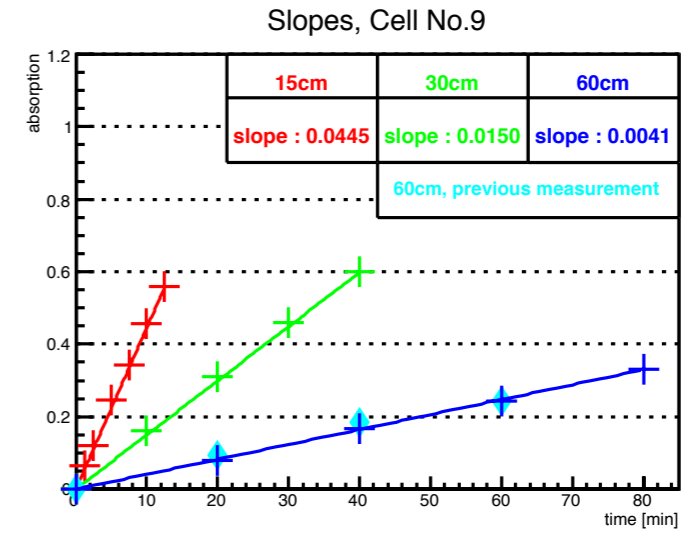
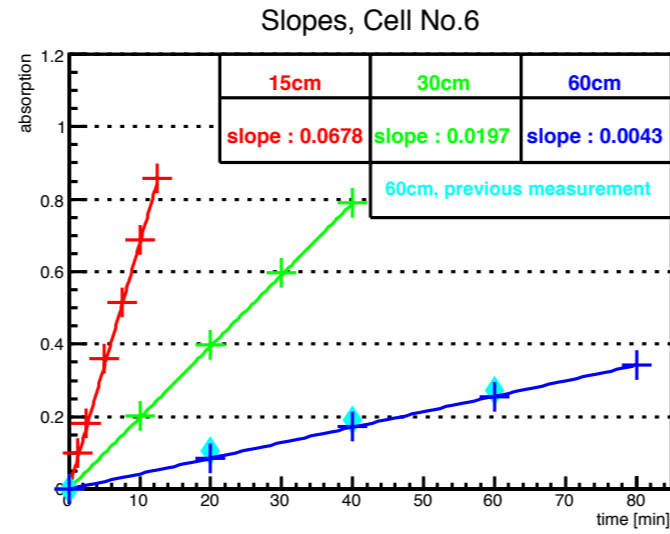
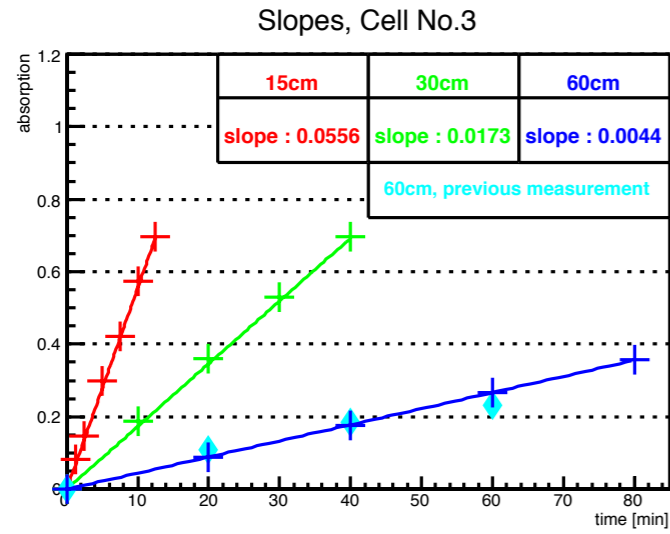
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Water Irradiation Results



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

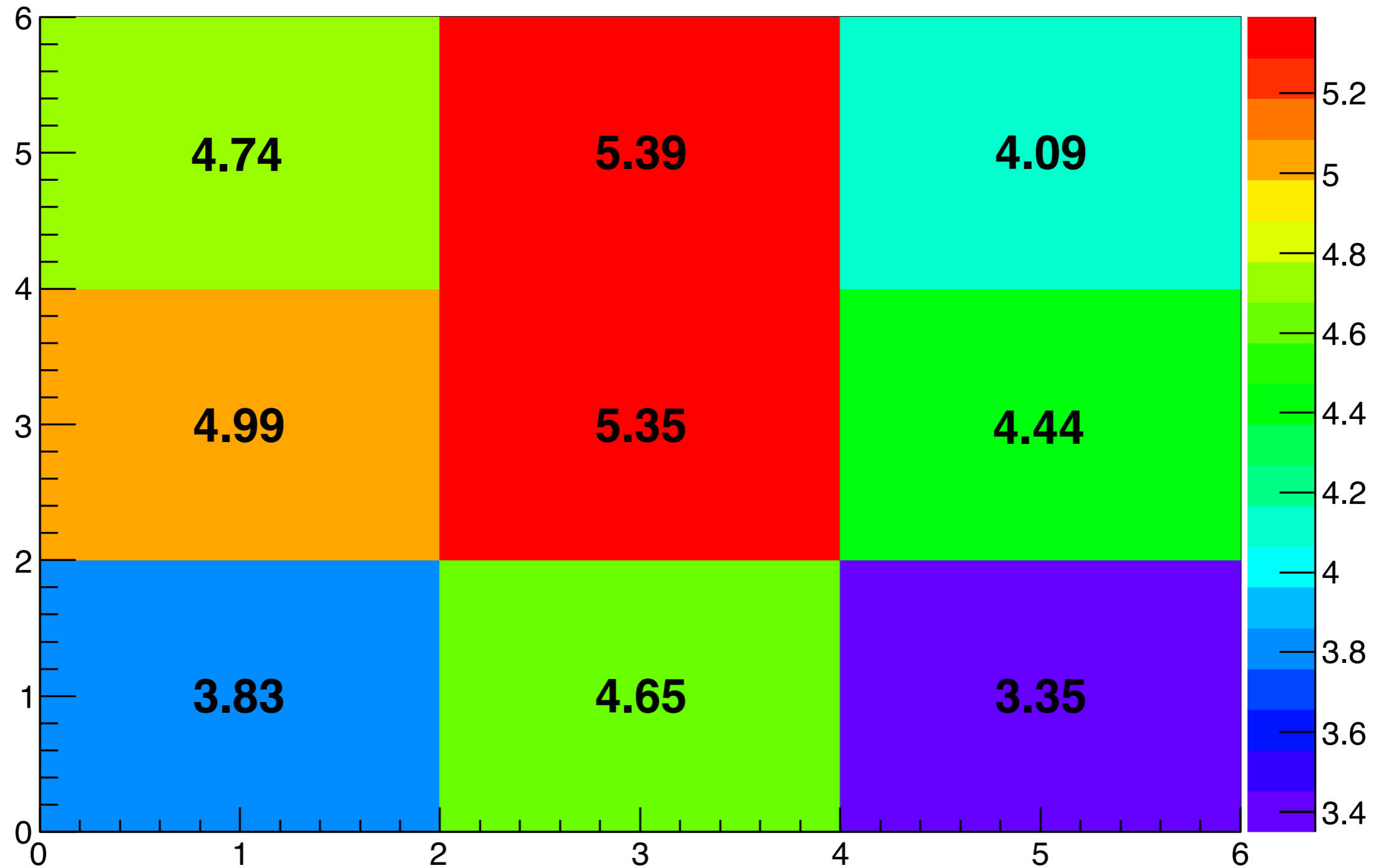
Water Irradiation Results



Plots of the absorbance value at 304nm throughout time.

Water Irradiation Results

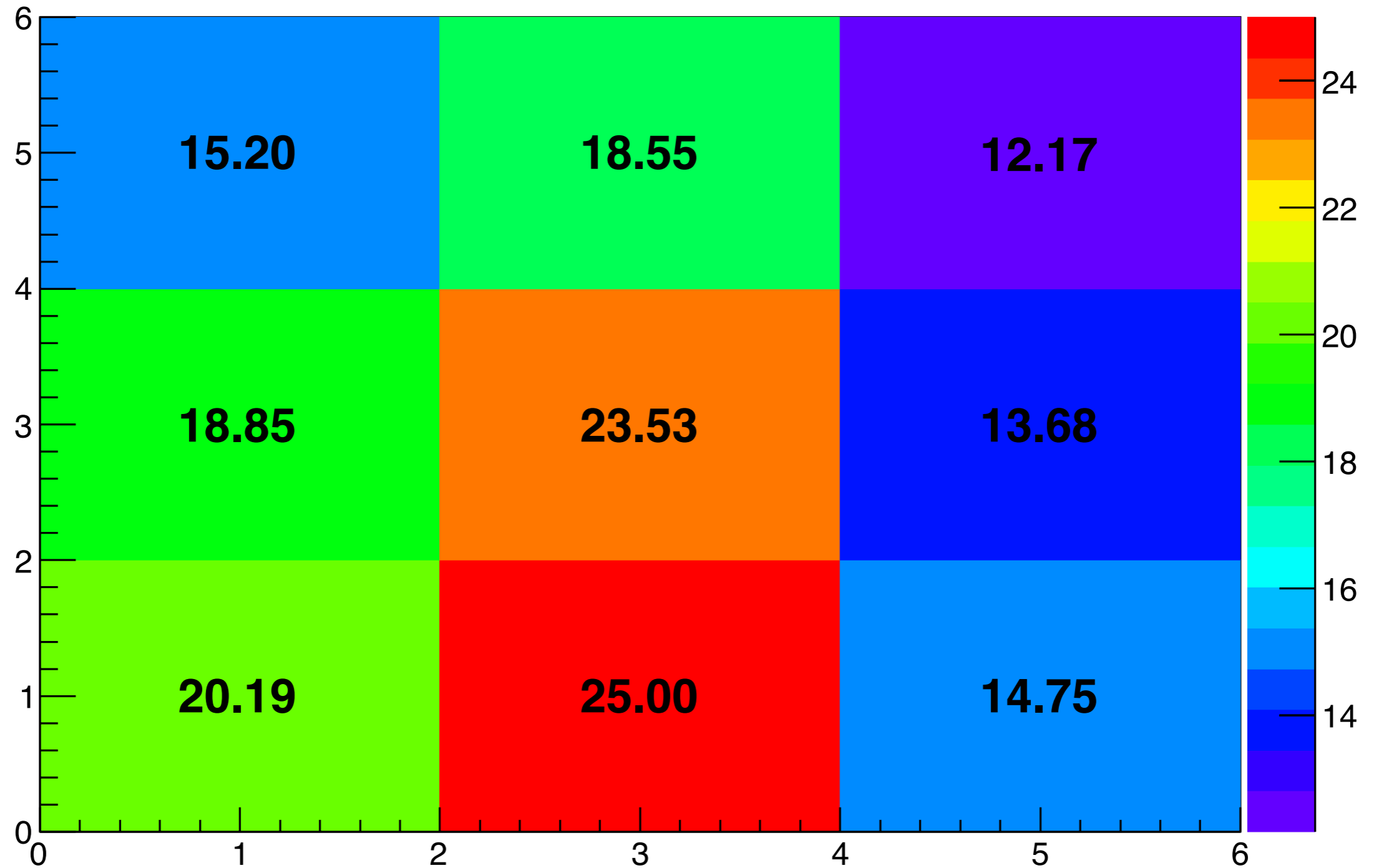
dose rate, 30cm



Plots of the absorbance value at 304nm throughout time.

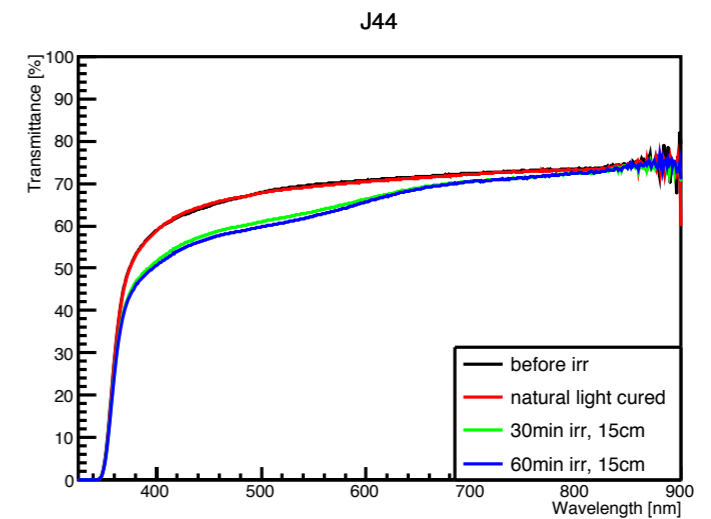
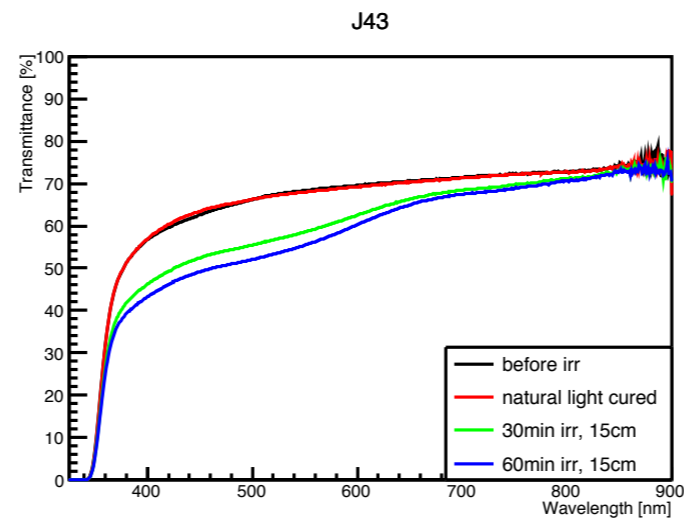
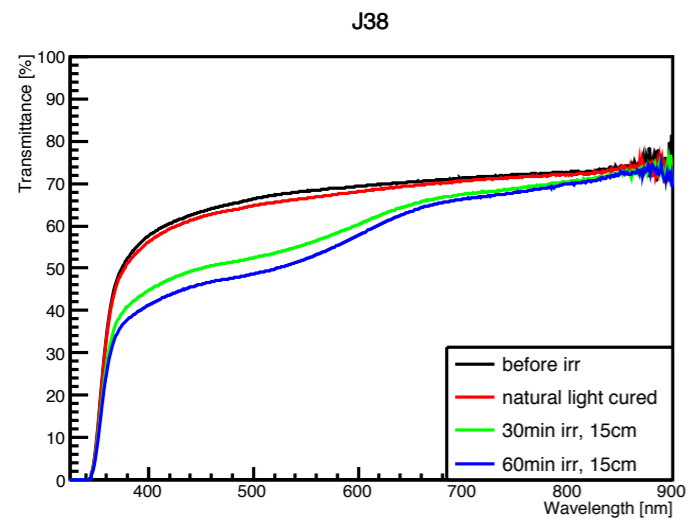
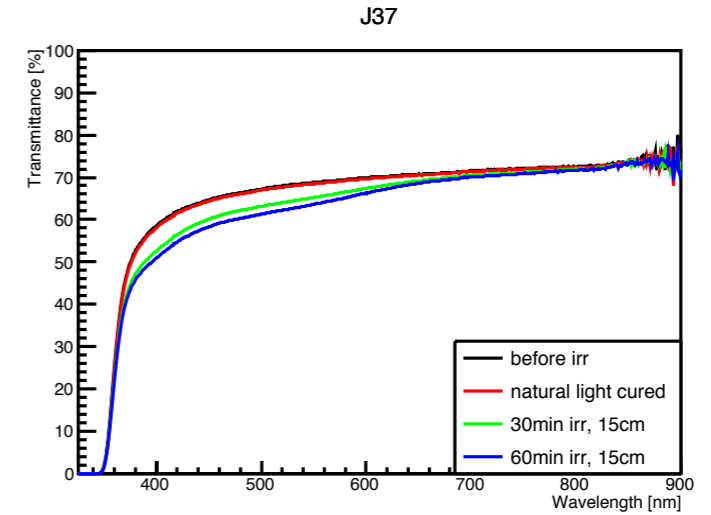
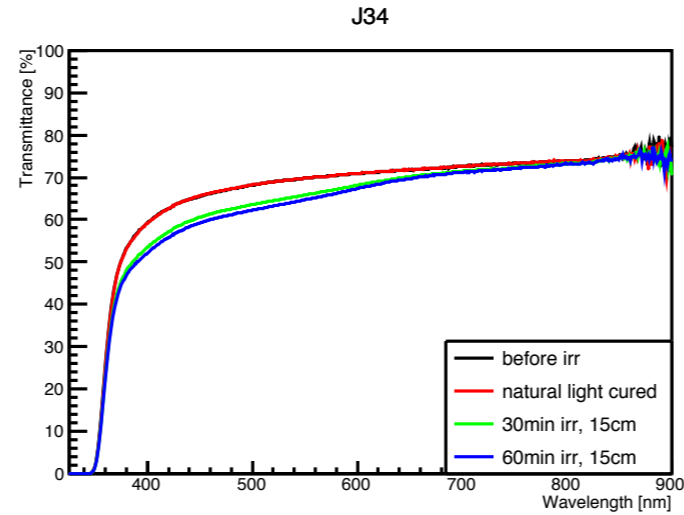
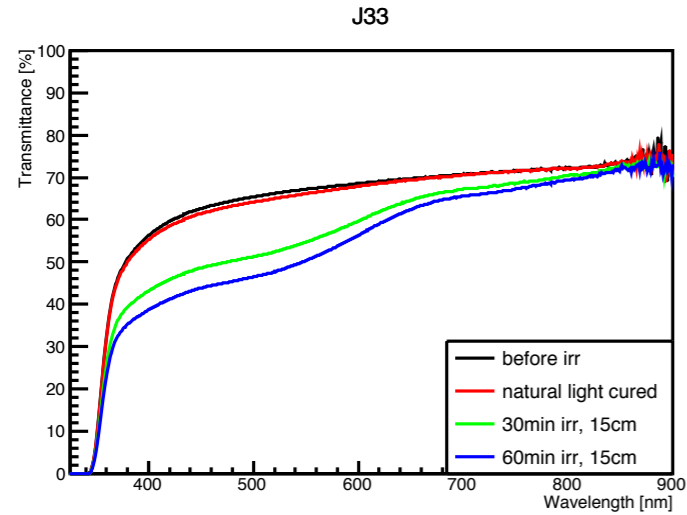
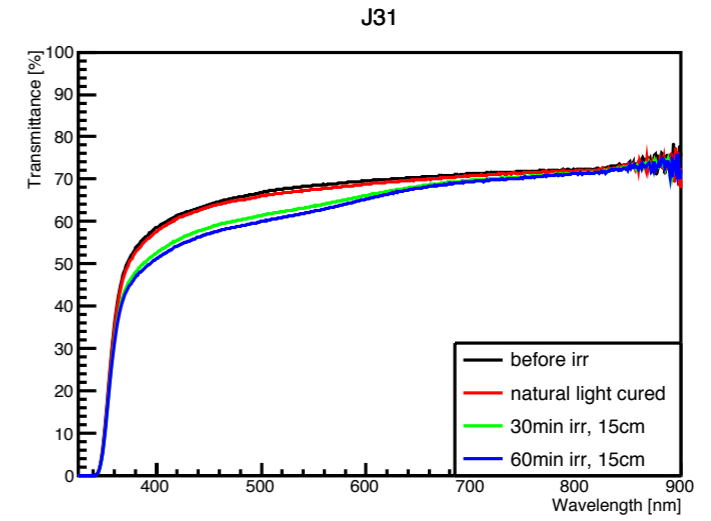
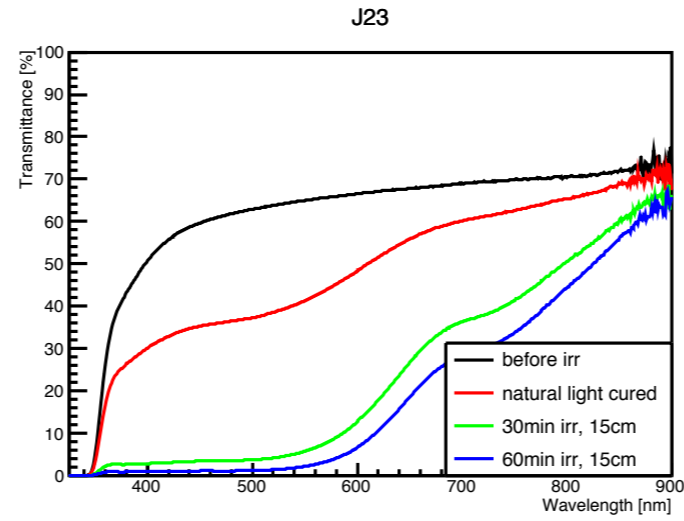
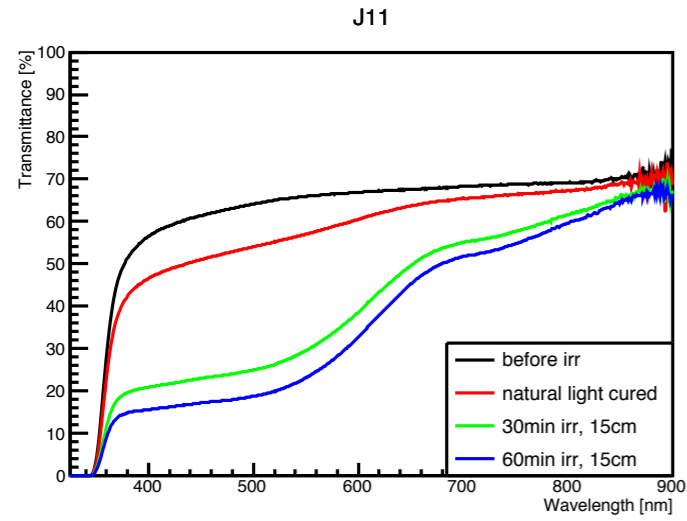
Water Irradiation Results

dose rate, 15cm

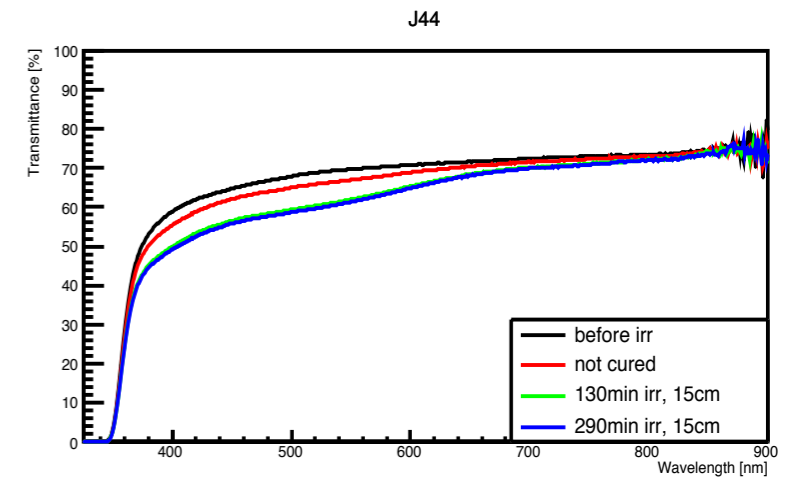
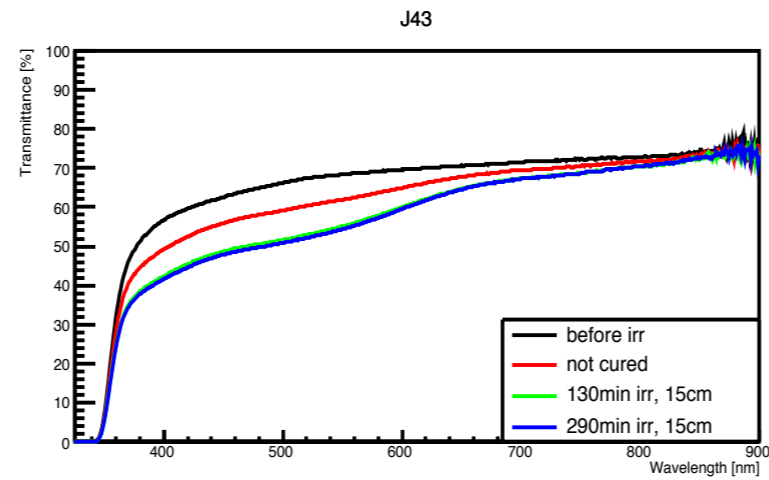
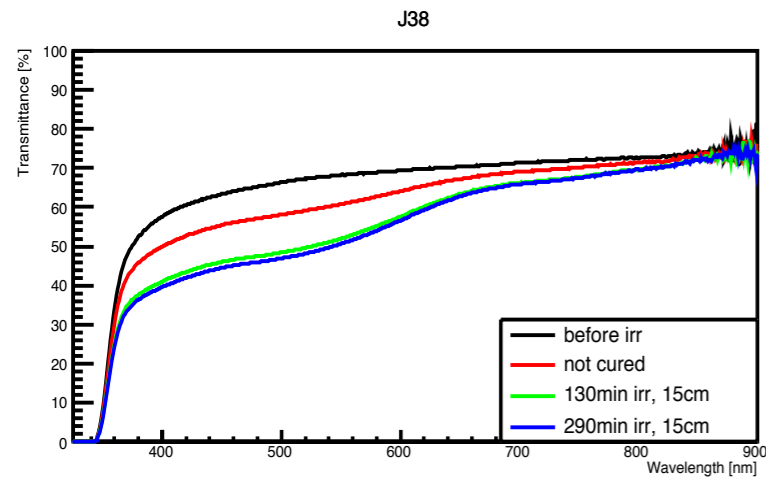
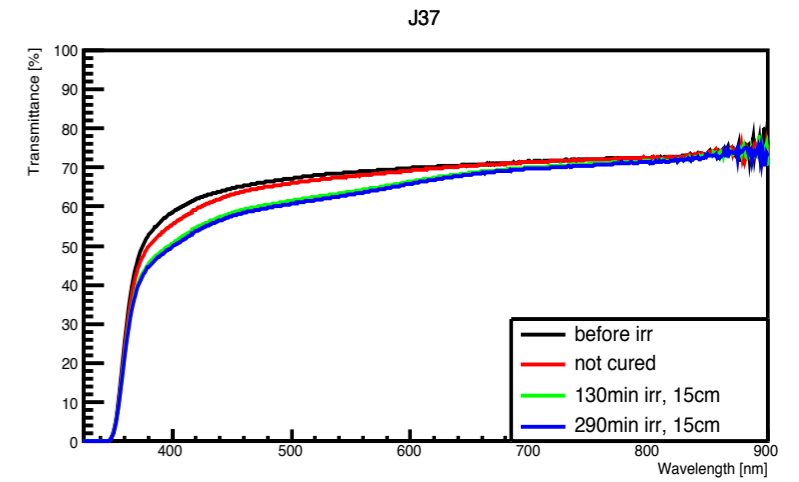
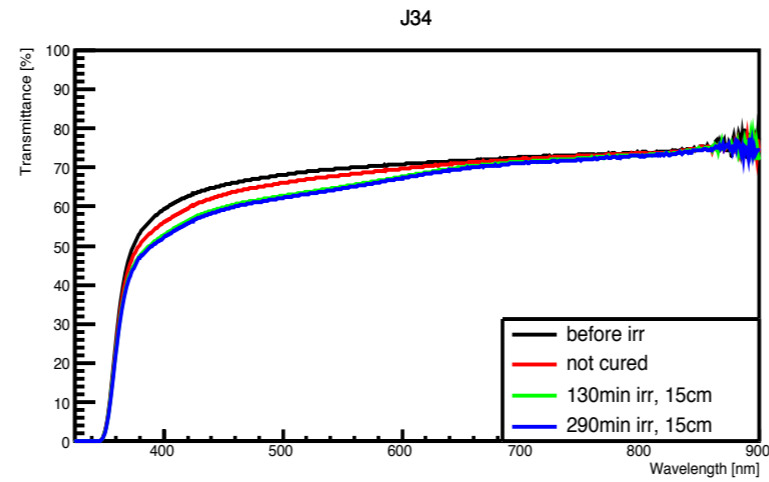
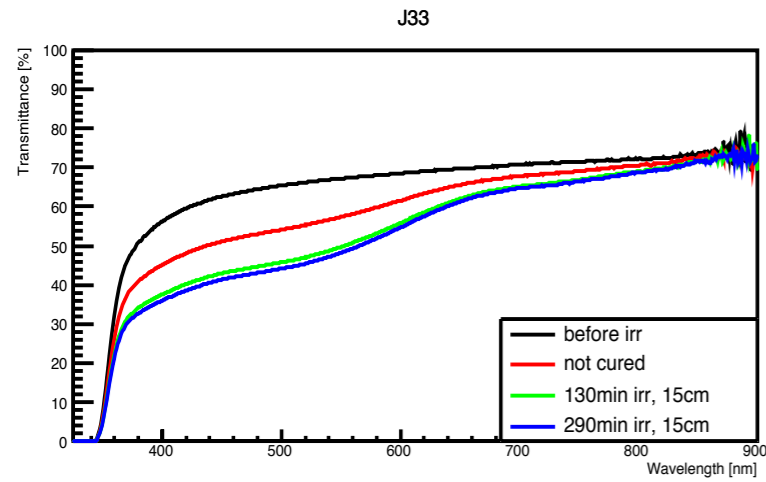
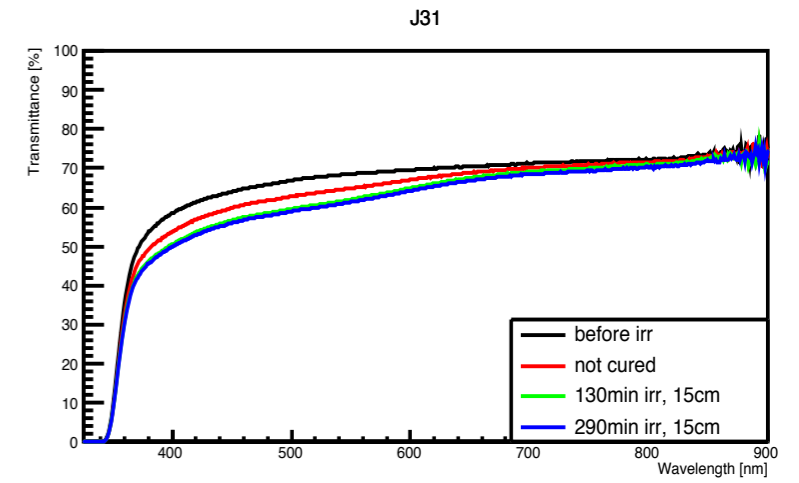
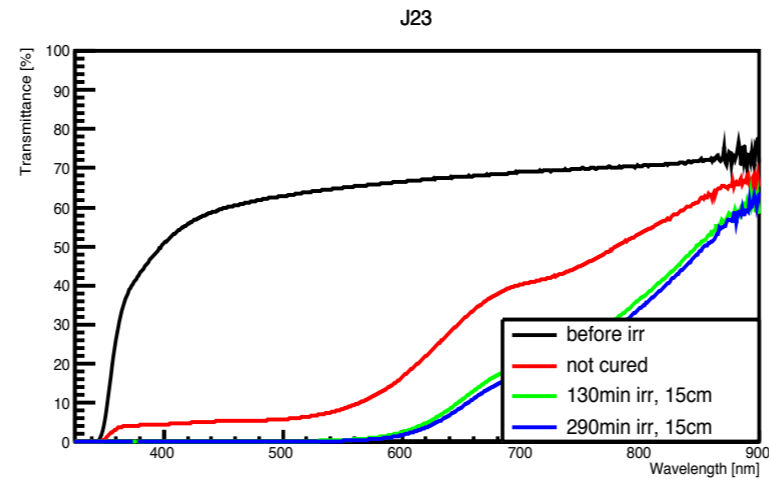
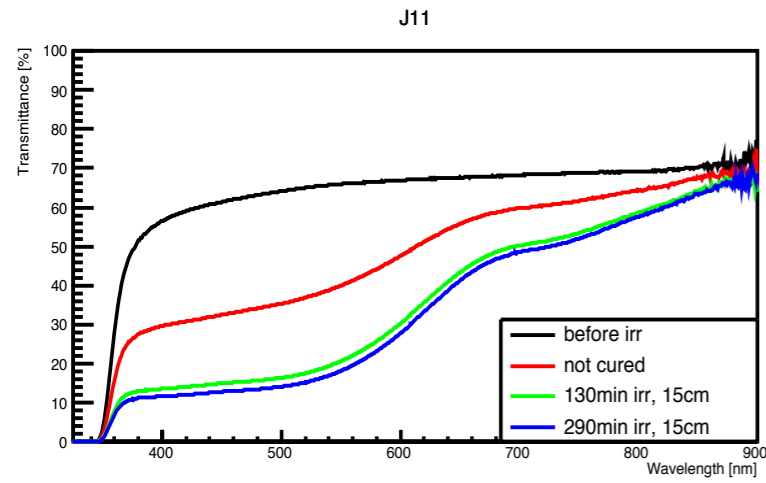


Plots of the absorbance value at 304nm throughout time.

Crystal Irradiation Results

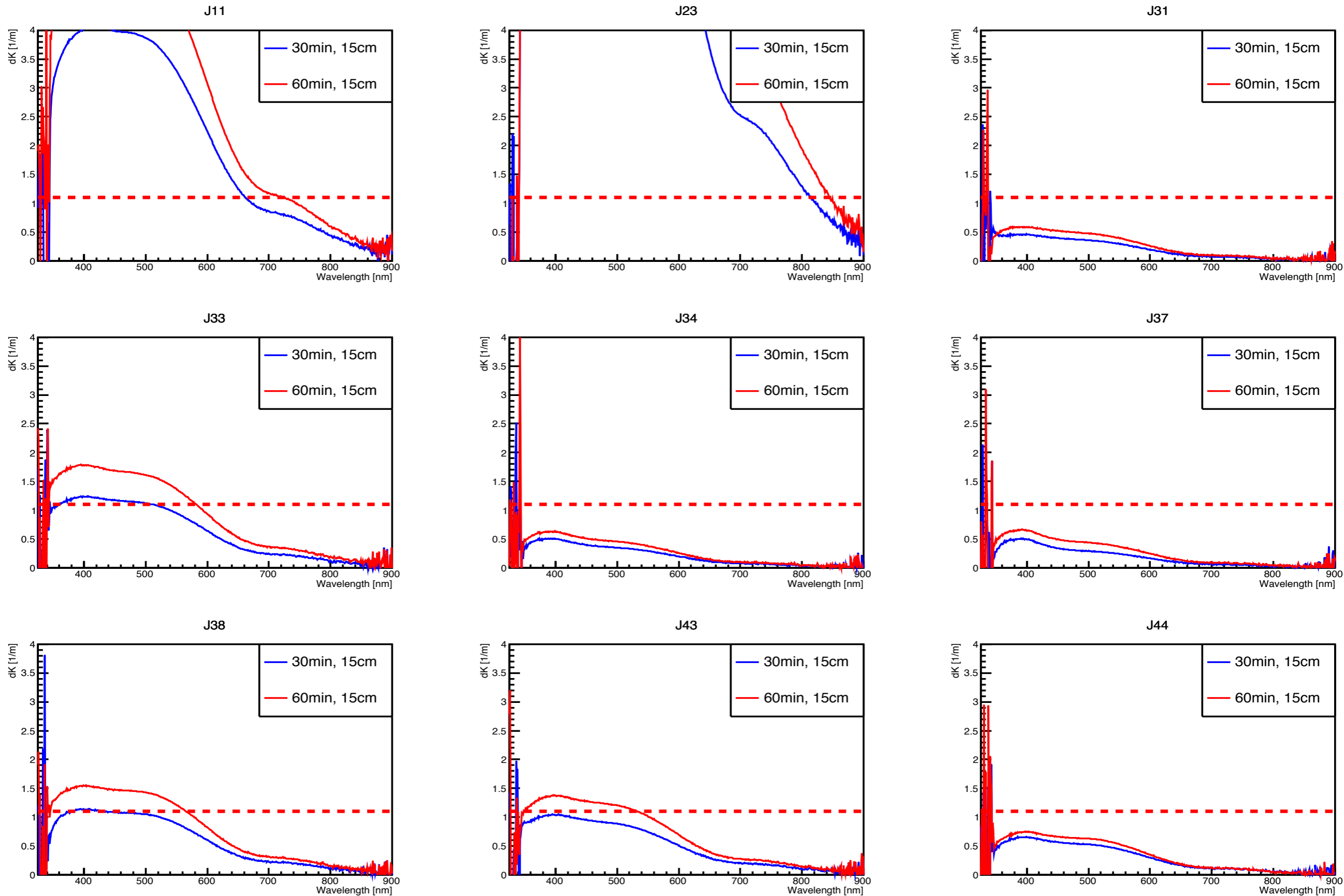


Crystal Irradiation Results



Plots of the absorbance value at 304nm throughout time.

Crystal Irradiation Results



Crystal Irradiation Results

