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FADING OF GLASS DOSIMETERS

PRELIMINARY RESULTS

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1. Introduction

The coloration of Schott glass PDG 11 has been used for radiation dose measurements. A calibration curve has been supplied by M. van de Voorde taking account of a rapid colour fading during the first day.

But the dosimeters continue to fade and it is probable that, when they are left for a long time in the ring, the readings give too low radiation values.

We suspect that this effect contributes to the fact that glass dosimeter readings were in average a factor of 1 to 1.4 too low compared to predictions when they were left one month in the ring. Anyway, this effect is very difficult to check because predictions, as well as other dosimeter measurements, are not precise enough.

We have left several dosimeters in a dark and non irradiated place and present the results below. All measurements have been made using 1.5 mm thick dosimeters.

2. Calibration

On Fig. 1 we can see the absorbance spectrum of two samples which were irradiated at respectively $1.8 \cdot 10^7$ and $1.5 \cdot 10^6$ rad. (All measurements and spectra were made by use of a Beckman spectrophotometer.) The M. van de Voorde calibration has been made at a wavelength of 510 nm, corresponding to the maximum sensitivity peak. In order to measure a higher dose, we have tried to extrapolate this calibration using the minimum just before the UV peak at 330 nm. But of course this extrapolation has not yet been checked by real calibration tests.

Roughly speaking, the calibration curves for a 1.5 mm thick glass, look more or less like

$$\frac{A}{A_\lambda} = \log \left(1 + \frac{R}{1.2 \cdot 10^5}\right) \qquad (1a)$$

or

$$R = 1.2 \cdot 10^5 \left(e^{A/k_\lambda} - 1\right) \qquad (1b)$$

where A is the measured absorbance and R the equivalent absorbed dose in rad.

At 510 nm : $A_{510} = 0.873$, $k_{510} = 0{,}377$

At 330 nm : $A_{330} = 0.565$, $k_{330} = 0{,}245$

These calibrations are more or less valid for A between 0.2 and 2. (Probably it is just by coincidence that $A_{510}/A_{330} = 510/330$!)

3. Fading

On Fig. 2 we can see the absorbance fading versus days in a logarithmic scale, for two samples having received a short but strong irradiation at the two wavelengths. It is far from negligible and gives approximatively

$$\log \left(\frac{1}{t}\right) = - 8.7 \left(\frac{At}{A_1} \cdot 1\right) \qquad (2a)$$

or

$$A_t = A_2 \cdot 1.036 \left[1 + 0.115 \log \frac{1}{t}\right] \qquad (2b)$$

where t is the free fading time in days ($t \geq 2$) and A_t, A_2 are the measured absorbances respectively at time t = t and t = 2. We have chosen t = 2 as a reference because we generally collect dosimeters on a Monday, two days after the high energy physics stop, and because we have generally checked the calibration curve under these conditions. (The factor 1.036 is just $[1 - 0.115 \log 2]^{-1}$). Therefore, for 10 days after the second day, the absorbance reading decreases by 9.3%. In rad reading this corresponds to a decrease of $\Delta R = 1.56 \cdot 10^7$ (equation 1b) for an original reading of $R_2 = 3.78 \cdot 10^7$. The decrease in rad reading for these 10 days after the second day is 41% or a factor 1.7!!

Even in 24 hours between second and third days, the rad reading should have decreased by a factor of 1.14 in this example. But this fading depends upon the initial value. For the first curve from bottom in Fig. 2, $R_2 = 1.3 \cdot 10^6$ rad, and $R_{12} = 1.04 \cdot 10^6$ which corresponds to a decrease in rad reading by a factor of 1.25 in 10 days, or by a factor of 1.06 in one day. So, considering that generally we measure in the ring radiation values between 10^6 and 10^7 rad for a monthly period, the glass dosimeters being left in position for the complete period, we could understand now that the fading effect could largely explain the discrepancies between their readings and other dosimeter results which is, as we have said, between 1 and 1.4, specially for high doses near the 10^7 rad region.

Unfortunately we do not know in how much glass dosimeter readings are affected by a very long period of continuous irradiation and this research should be the next step. It seems nevertheless that readings after one year of irradiation should be very difficult to interpret.

To illustrate this point, we have drawn on figure 3 the curves showing the fading time after which the readings in rad could be wrong by a factor α, for different values of the initial reading R_2 at two days. For example, for an initial reading at two days of $5 \cdot 10^6$ rad, we have already lost 30% in the rad reading ($\alpha = 0.7$) at the 12^{th} day. So, instead of reading $5 \cdot 10^6$ we would read $3.5 \cdot 10^6$ rad. For an initial reading of 10^7 rad, we would read half of it ($\alpha = 0.5$), that is to say $5 \cdot 10^6$ rad, already after 40 days.

In this note we just wanted to show the possible orders of magnitude of the fading effect, but one should keep in mind that formulae 1 and 2 are only mathematical simplifications of a reality which is more complex. This problem needs further investigation in order to check if we are not too pessimistic.

R. Gouiran

Distribution : Open

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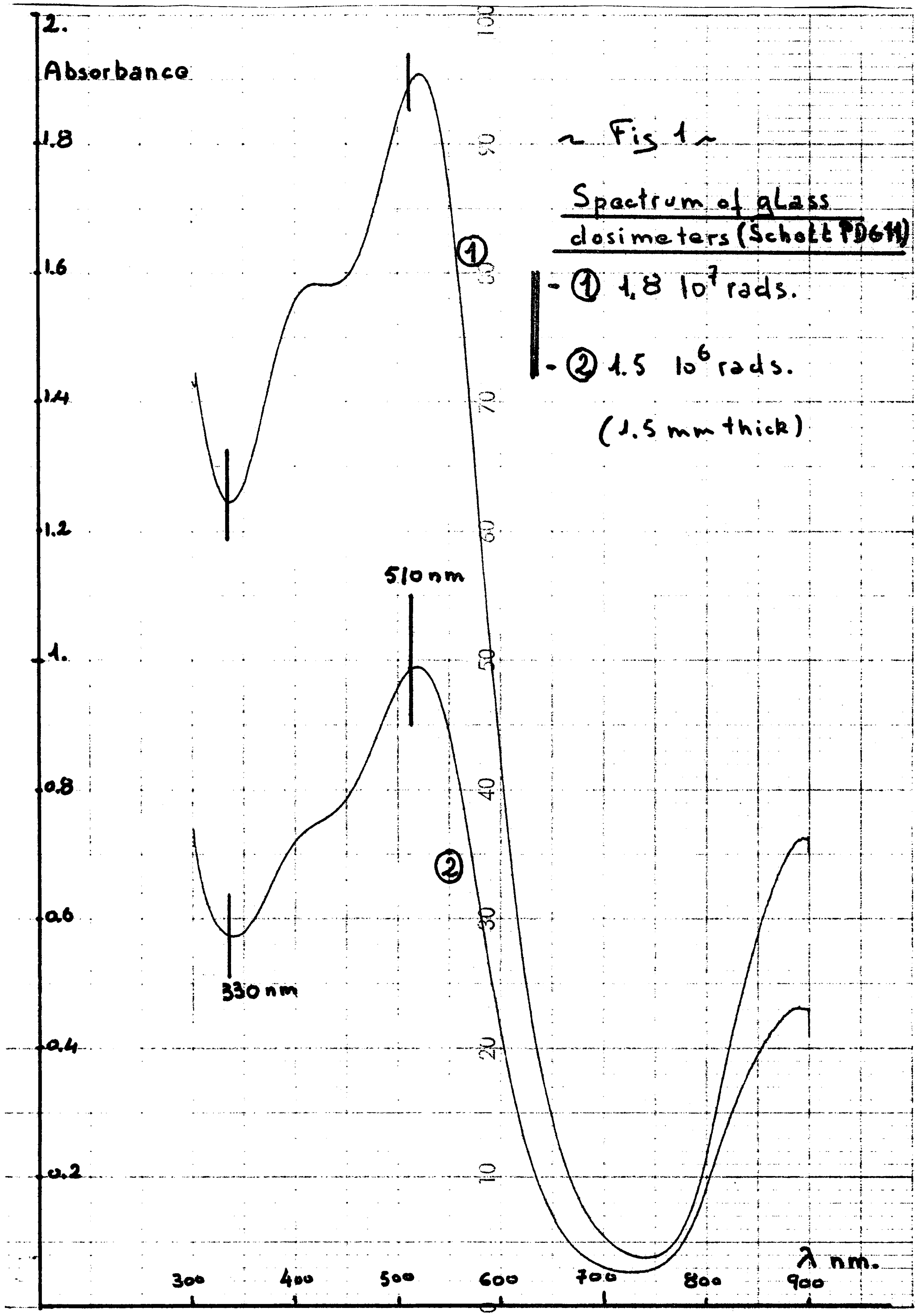
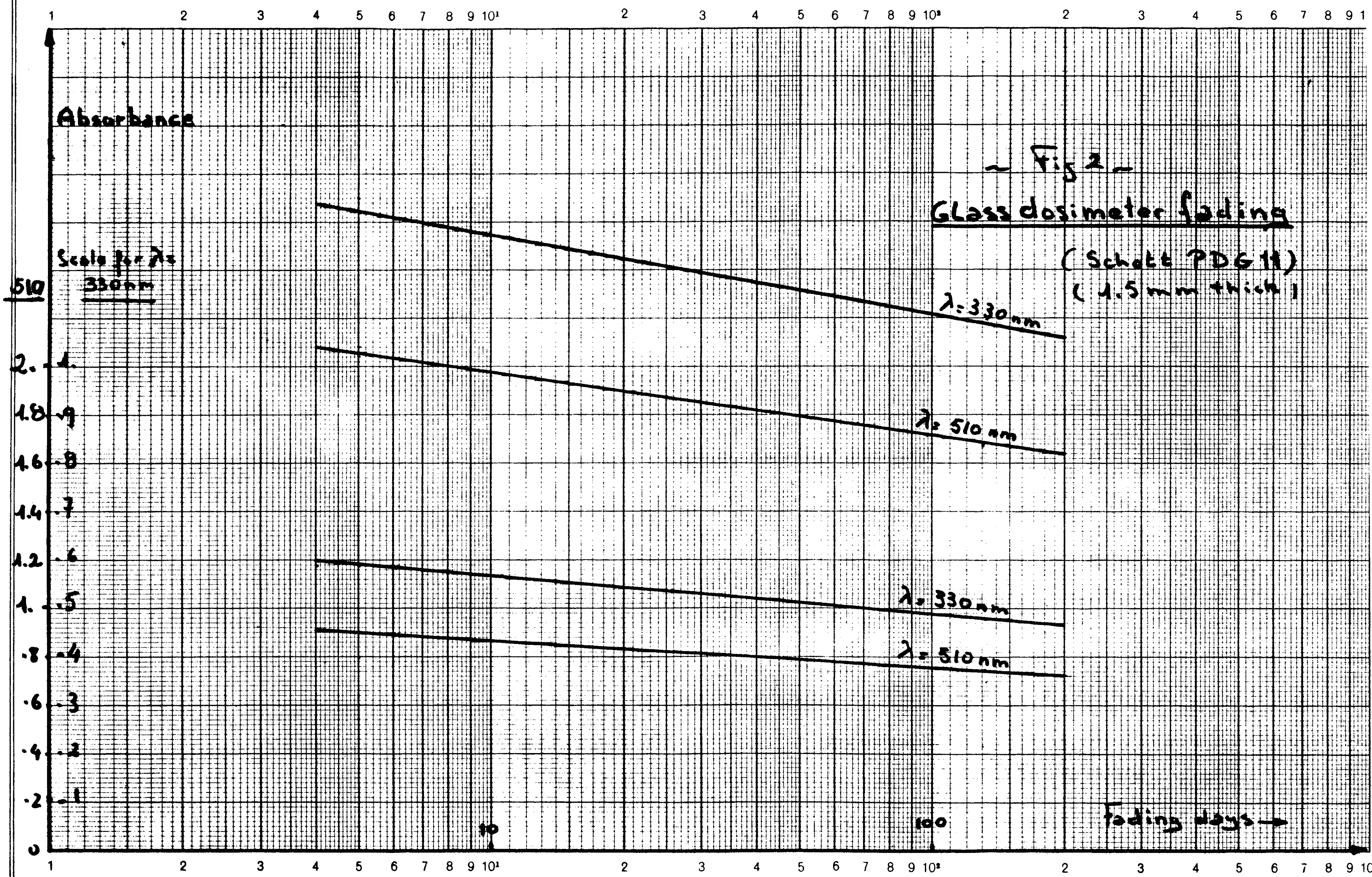
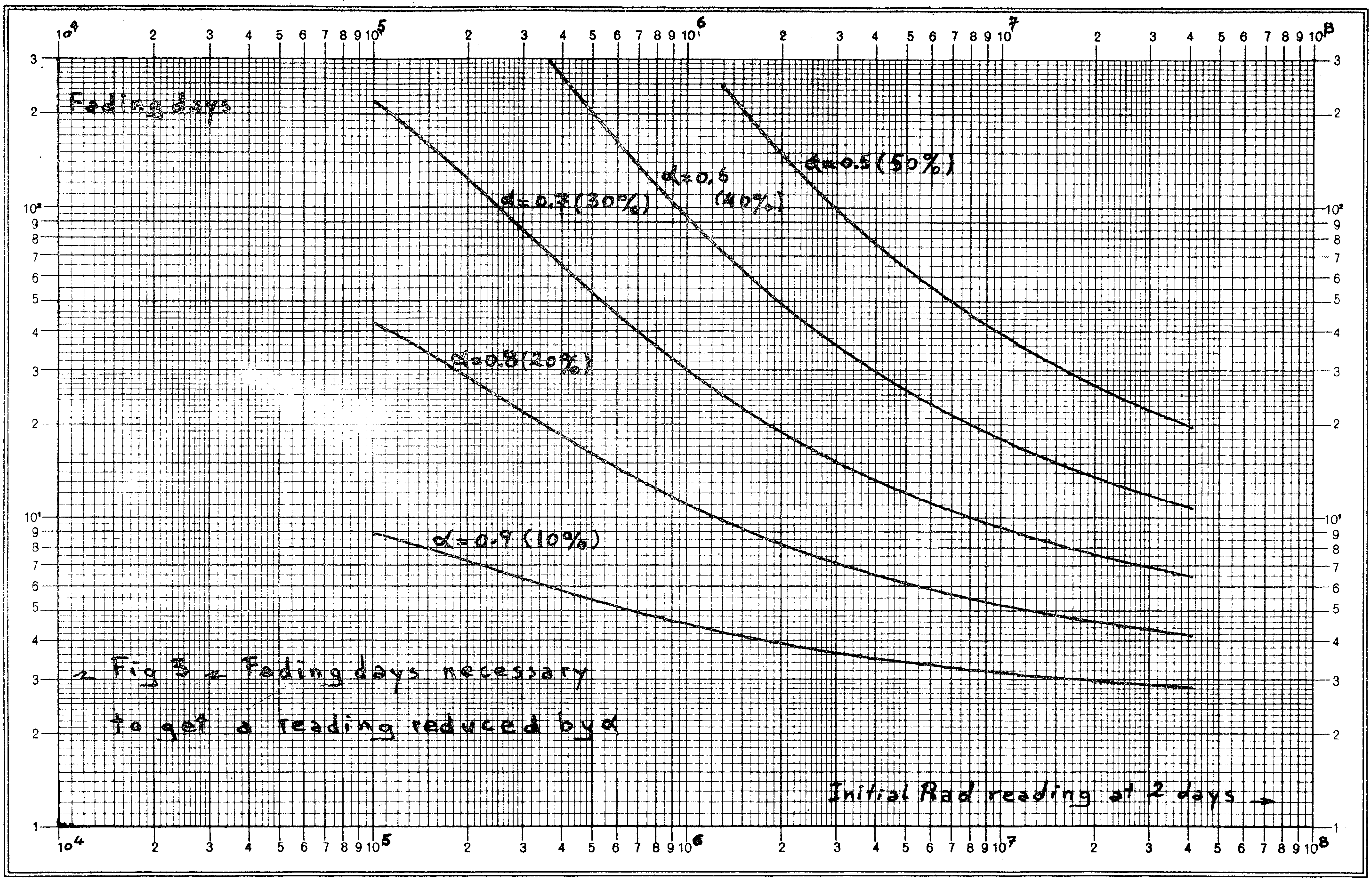

2.
Absorbance
1.8
1.6
1.4
1.2
1.
0.8
0.6
0.4
0.2
~ Fig 1 ~
Spectrum of glass dosimeters (Schott PD611)
- ① 1.8 10^7 rads.
- ② 1.5 10^6 rads.
(1.5 mm thick)
①
②
510 nm
330 nm
300
400
500
600
700
800
900
λ nm.

~ Fig 2 ~



Glass dosimeter fading
(Schott PDG 11)
(1.5 mm thick)
Absorbance
Scale for λ= 510 330nm
λ=330nm
λ= 510 nm
λ= 330nm
λ= 510nm
10
100
fading days →



Logar. Teilung / Division } 1-300 u. 1-10000 Einheit / Unité } 62,5 mm

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