DATA REDUCTION IN LUMINESCENCE MEASUREMENTS

Andrzej Bluszcz

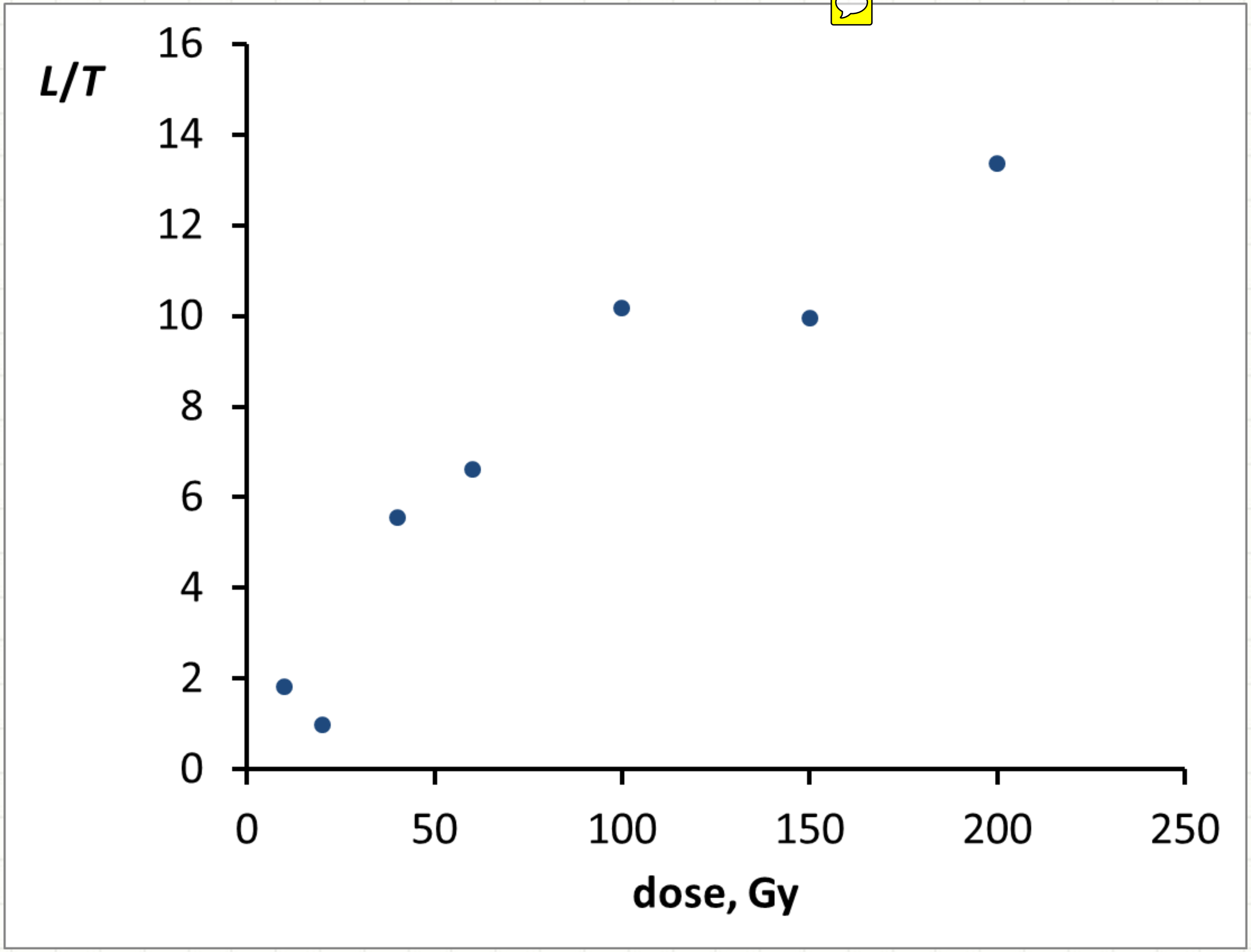
LED2011 Workshop

Toruń, 10 July 2011

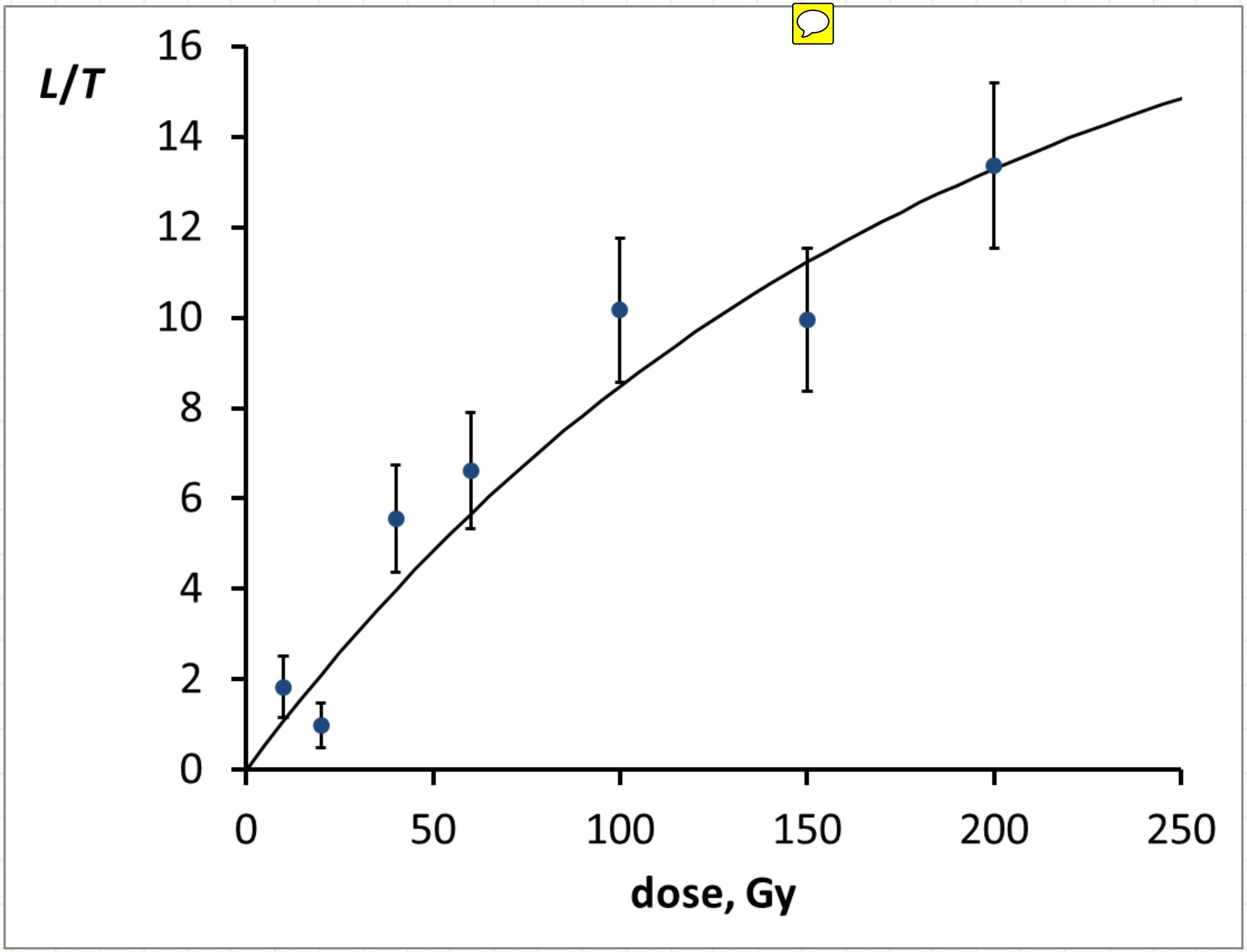
Plan of lecture

- Introduction
- Measurement errors and uncertainties
- Reduction of data
  - analysis of OSL shine down curves
  - analysis of OSL growth curves – calibration
  - calculation of D_E value and reporting
- Summary

Introduction



Introduction



Measurement errors and uncertainties

Measurement errors
- random errors
- systematic errors

Accuracy and precision of measurements

Uncertainty of measurements

Measurement errors

Error is the difference between the result of measurement and the value of the measurand.

Measurement errors are usually categorized as **random errors** and **systematic errors**.

When measurements are repeated under stable conditions:

- random errors have unpredictable values, that follow some statistical distribution (normal, Poisson, etc.),
- systematic errors have the same value.

Measurement errors

A reason for a random error is all uncontrolled factors that influence the result of measurement or the stochastic nature of the process (radioactive or excited state decay, interaction of radiation with matter, etc.).

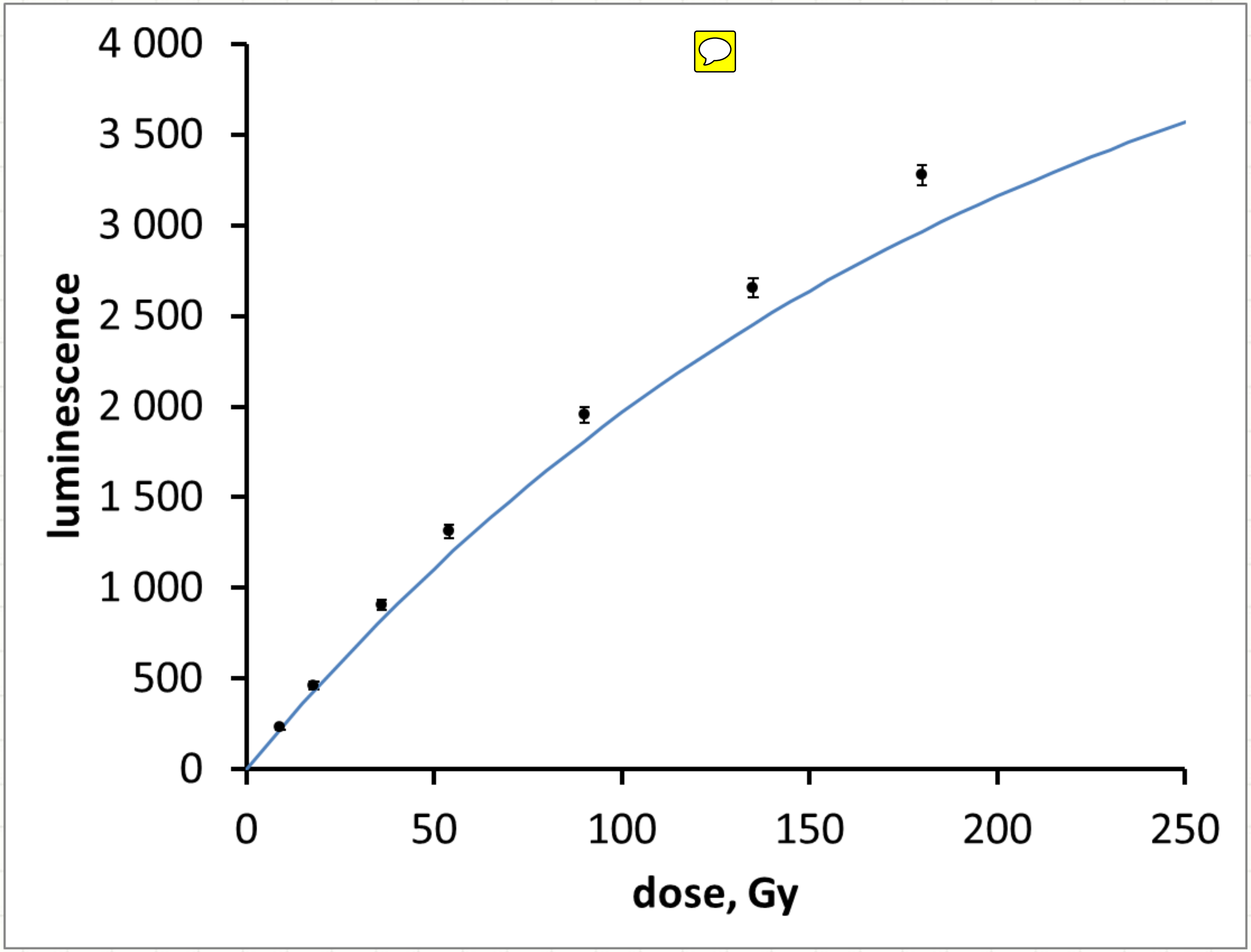
A reason for a systematic error may be incorrectly calibrated meter, improper physical model used in the measurement process (a real pendulum described as a mathematical pendulum), etc.

Accuracy and precision

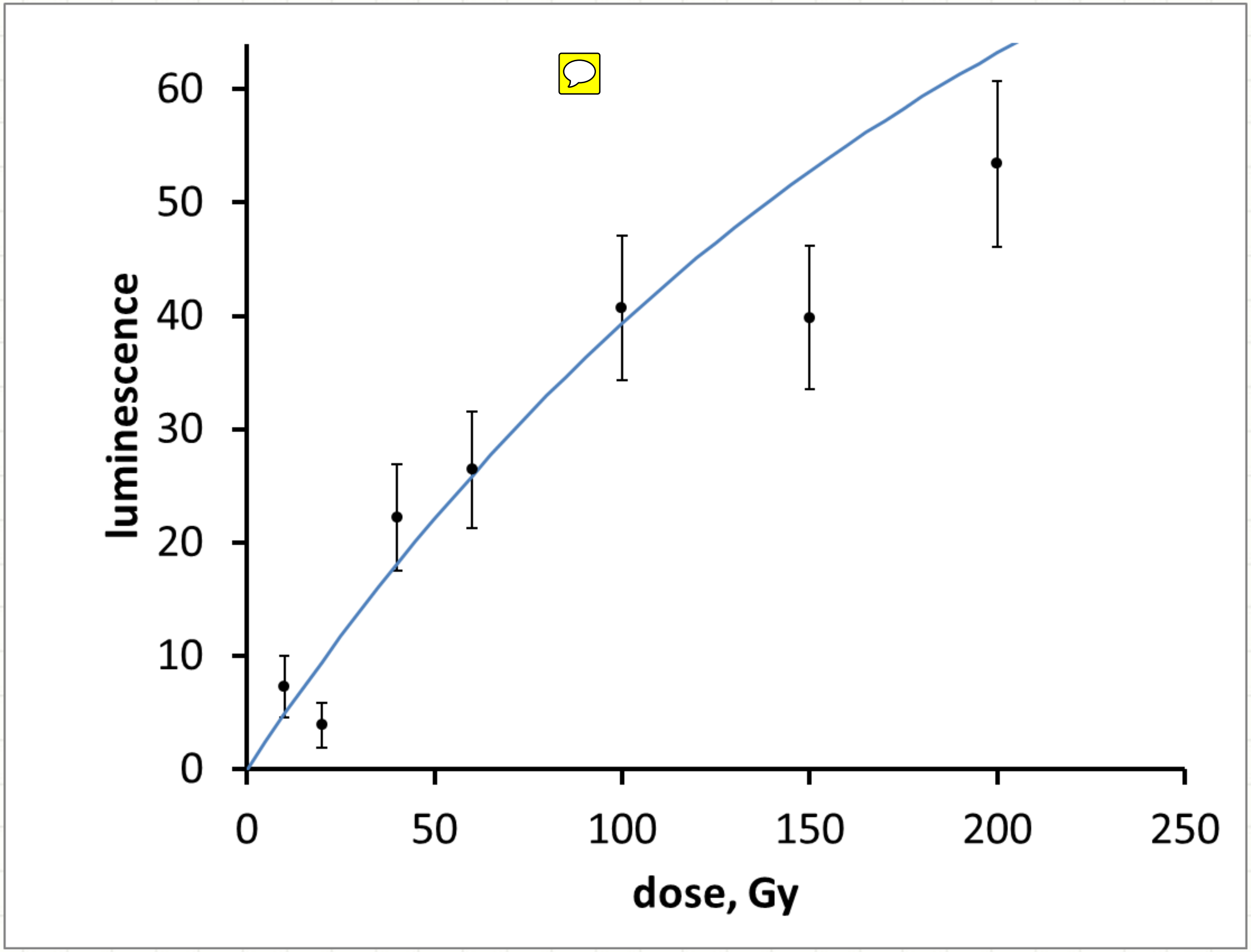
Accuracy – concordance of the mean value of measurements with the value of measurand

Precision – concordance of results of repeated measurements (under same conditions)

Systematic errors influence accuracy, but not precision.



Random errors influence precision, but not accuracy.



Uncertainty of result of measurement

Uncertainty is a parameter associated with the result of measurement, that characterizes the dispersion of results.

The basic type of uncertainty is the standard uncertainty which is a standard deviation of results (square root of variance of results).

Reduction of data

Luminescence signals after regenerative dose and test dose are usually denoted as $L(D_{reg}),\ T(D_{test})$, their ratio is a normalized OSL and let us denote it by

$$P = \frac{L}{T}$$

They are obtained from analysis of an OSL shine down curve by either

- simple integration and subtraction or by
- isolating the fast OSL component through a complex curve fitting procedure.

Analysis of OSL shine down curve

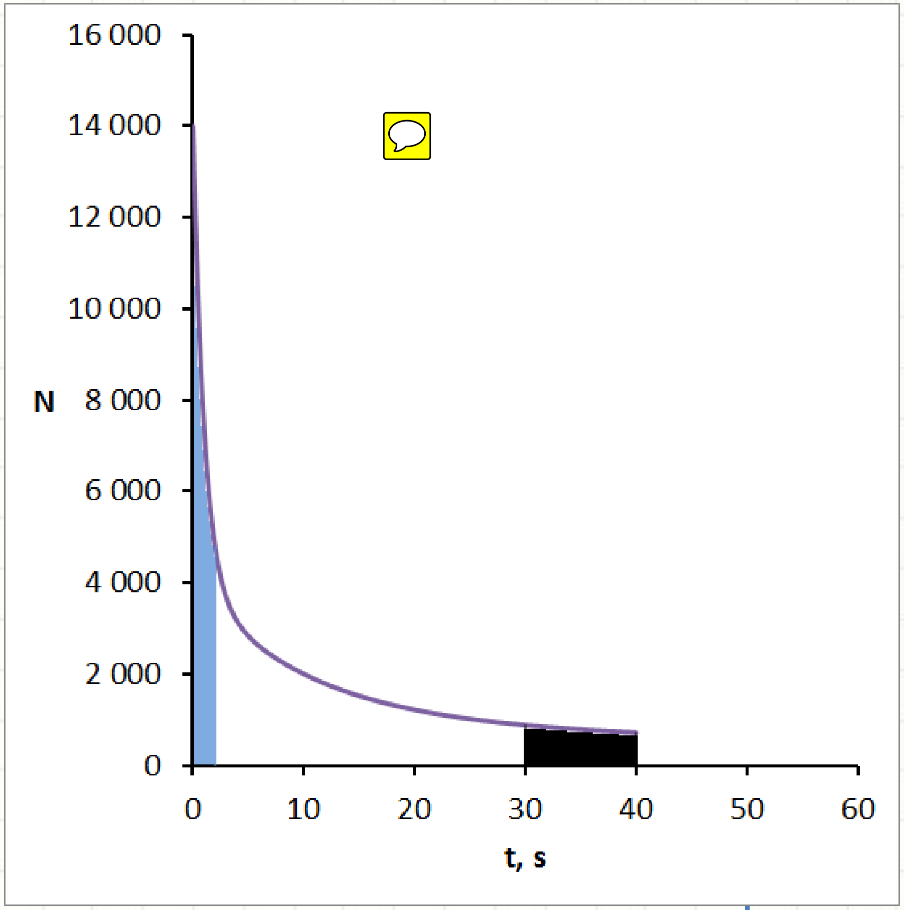
$$N_f = \sum_{i=1}^{f} N_i \qquad t_f = \sum_{i=1}^{f} t_i$$

$$N_b = \sum_{i=l-b+1}^{l} N_i \qquad t_b = \sum_{i=l-b+1}^{l} t_i$$

$$u(N) = k\sqrt{N}, k \geq 1 \qquad u(t) = 0$$

$$L = N_f - N_b \frac{t_f}{t_b}$$

$$u_c(L) = \sqrt{u^2(N_f) + u^2(N_b)\left(\frac{t_f}{t_b}\right)^2}$$



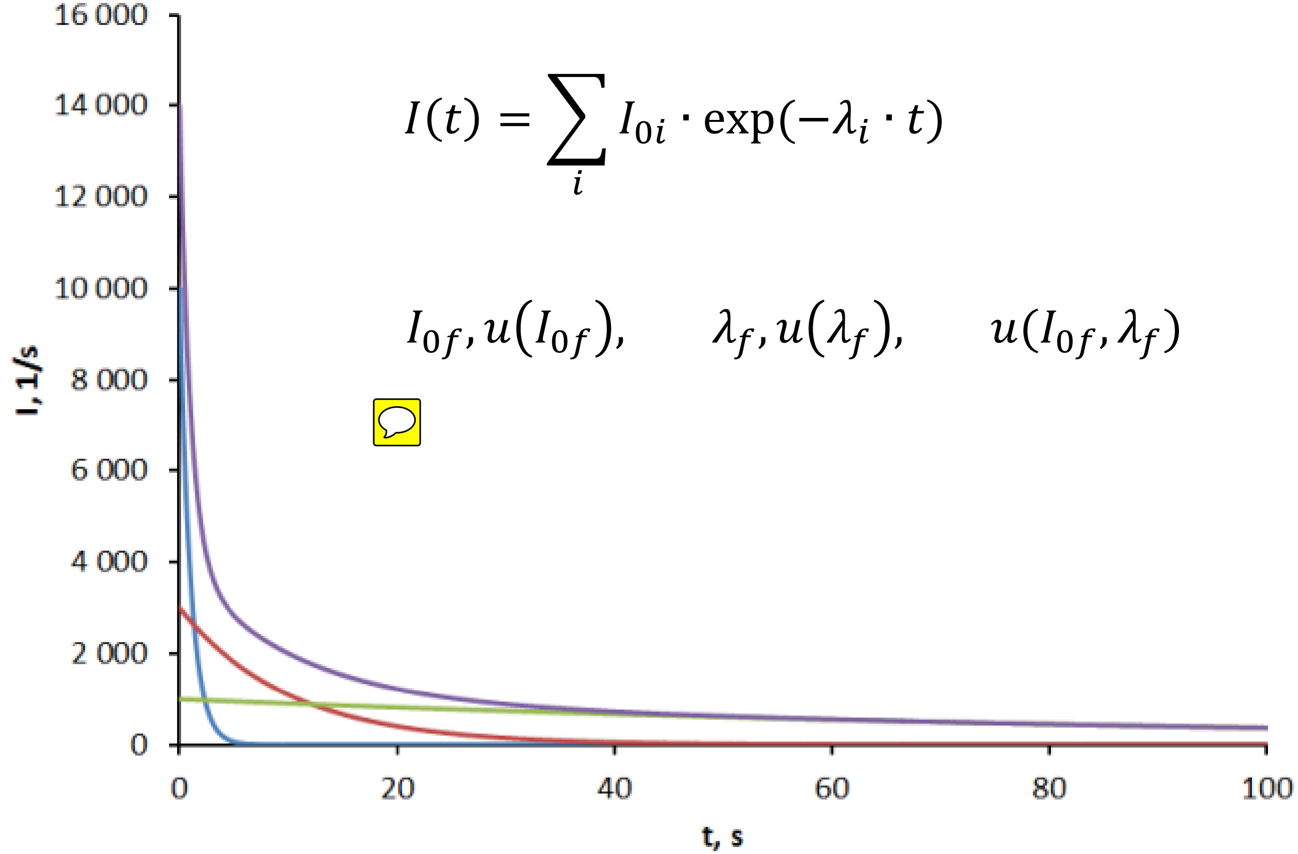
$L, u_c(L)$

$T, u_c(T)$

Analysis of OSL shine down curve

$$I(t) = \sum_i I_{0i} \cdot \exp(-\lambda_i \cdot t)$$

$$I_{0f}, u(I_{0f}), \quad \lambda_f, u(\lambda_f), \quad u(I_{0f}, \lambda_f)$$



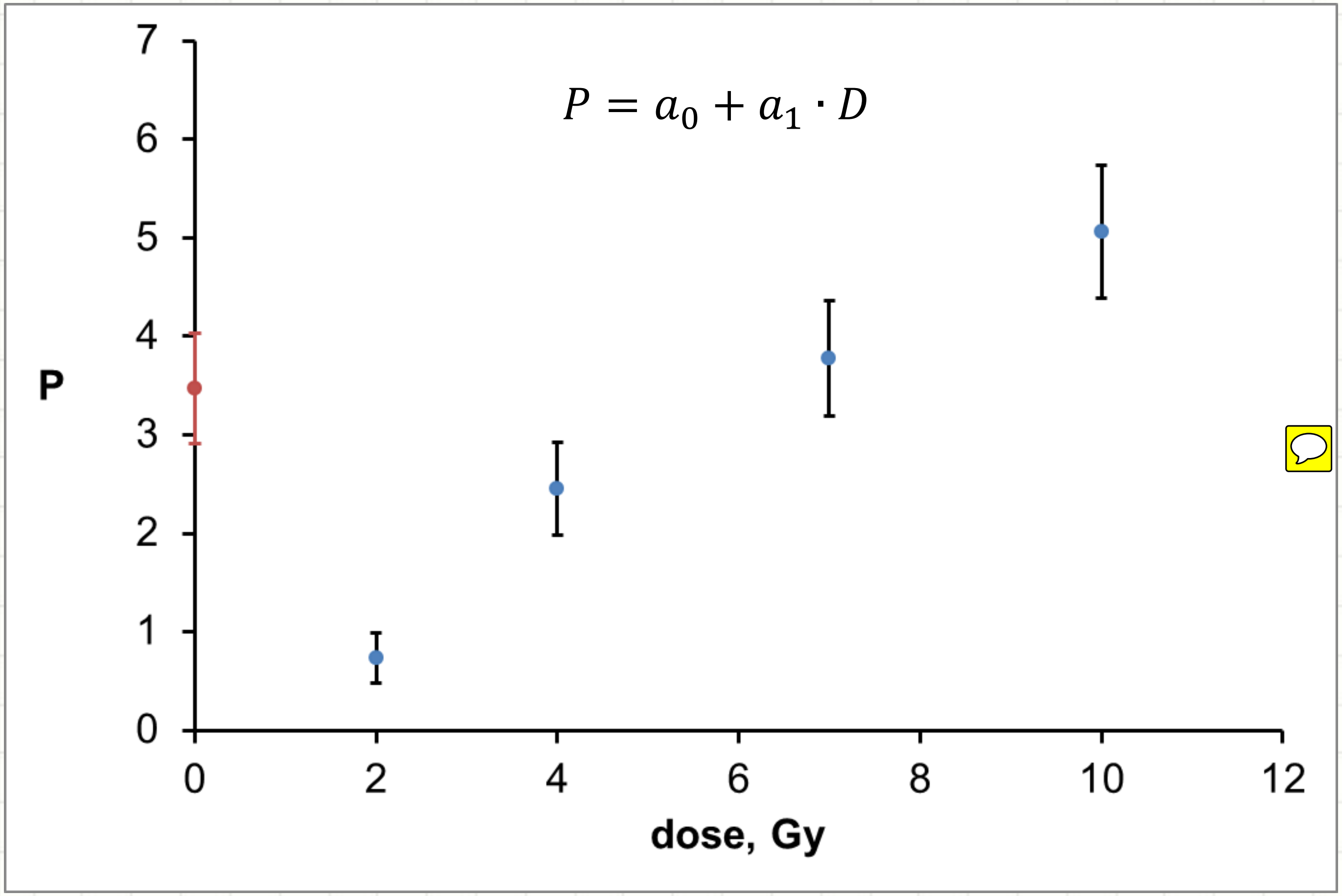
$$L = \frac{I_{0f}}{\lambda_f}$$

$$u_c(L) = L\sqrt{\left[\frac{u(I_{0f})}{I_{0f}}\right]^2 + \left[\frac{u(\lambda_f)}{\lambda_f}\right]^2 - 2\frac{u(I_{0f}, \lambda_f)}{I_{0f} \cdot \lambda_f}}$$

$L, u_c(L)$

$T, u_c(T)$

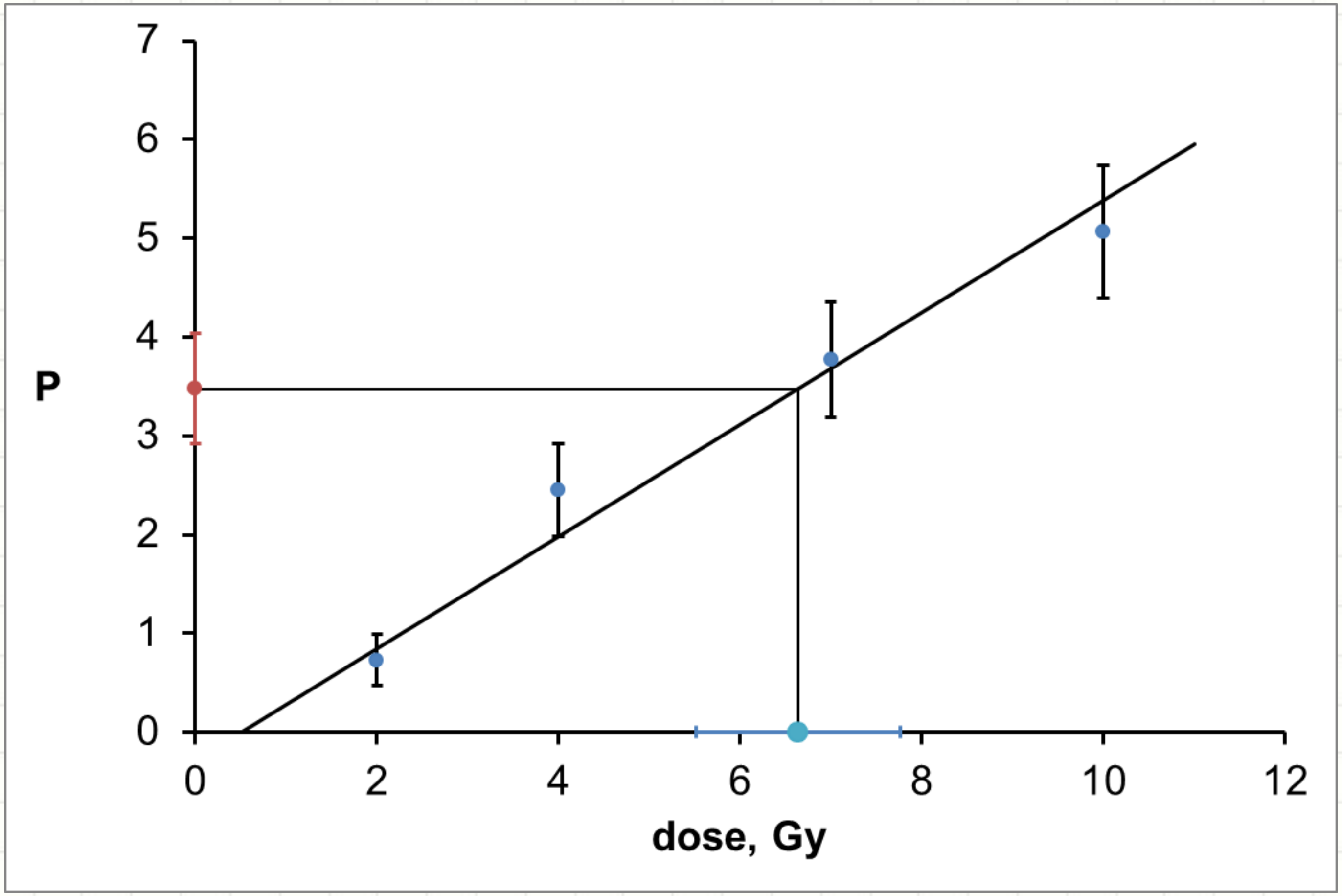
OSL growth



Fitting the linear function by LSM yields the calibration parameters

$$a_0, u(a_0), \quad a_1, u(a_1), \quad u(a_0, a_1)$$

that enable calculation of the absorbed equivalent dose:



$$D_E = \frac{P_0 - a_0}{a_1}$$

$$u_c(D_E) = \sqrt{\frac{u_c^2(P_0)}{a_1^2} + \frac{u^2(a_0)}{a_1^2} + \frac{(P_0 - a_0)^2}{a_1^4} u^2(a_1) + 2\left(\frac{P_0 - a_0}{a_1^3}\right) u(a_0, a_1)}$$

Uncertainty of calibration of the beta source

Assume that the relative standard uncertainty of the source calibration is *p* (for example 0,02 or 2%).

That means, we have to add this contribution to obtain the overall uncertainty in D_E

$$u_c(D_E) = \sqrt{\frac{u_c^2(P_0)}{a_1^2} + \frac{u^2(a_0)}{a_1^2} + \frac{(P_0 - a_0)^2}{a_1^4} u^2(a_1) + 2\left(\frac{P_0 - a_0}{a_1^3}\right) u(a_0, a_1) + (pD_E)^2}$$

Summary

We have seen how a dozen of OSL curves, containing thousands of raw numerical data, may be reduced, resulting in a value of equivalent dose and its combined uncertainty:

$$D_E, u_c(D_E)$$

Questions?

Thank You !