WORKSHOP:
II RADON-IN-FIELD INTERCOMPARISON
Milan - 21st – 22nd September 2017

One parameter semi-empirical function for the saturation correction in Radon CR-39 detectors

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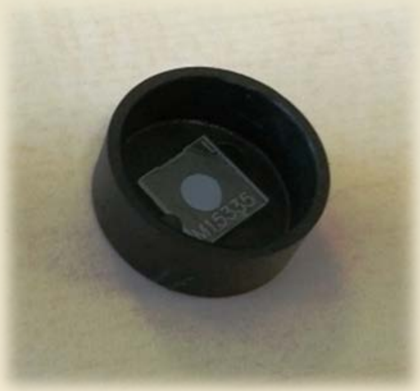
Brief overview on CR-39 passive dosimeters

As SSNTD, CR-39 passive dosimeters are widely used in the long-term radon indoor concentrations measurements.



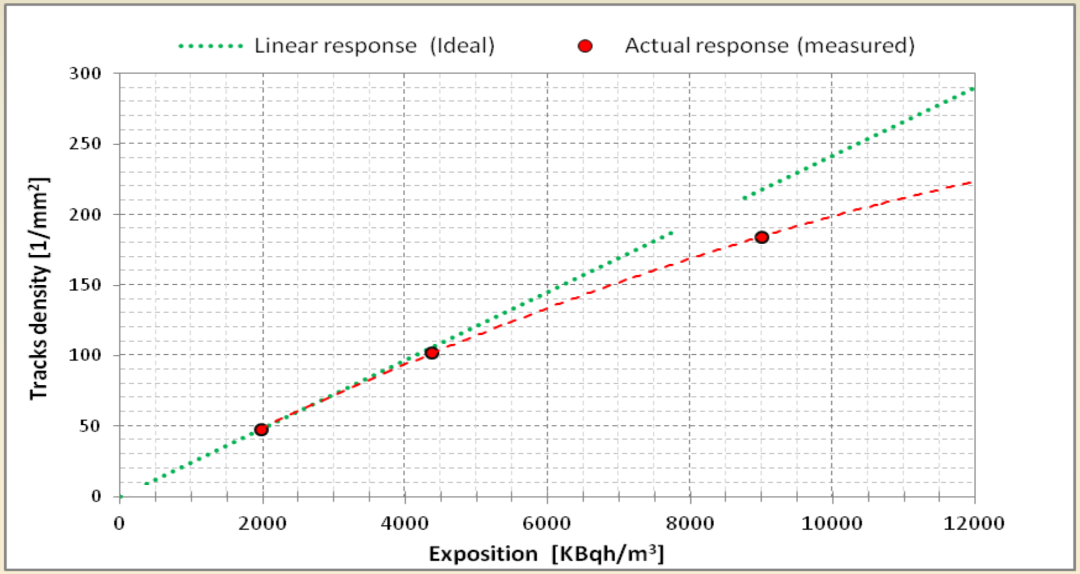
Advantages:

- <u>if correctly used</u>, provide ***reliable measurements***
  (low temperature storage before and after exposure; exposure for not too months; …….)
- are ***robust***
- are ***cheap***
- are ***easy to handle for the etching and reading processes***

Brief overview on CR-39 passive dosimeters

Criticality:

For <u>*medium-high* exposures</u> there is a ***saturation effect.***

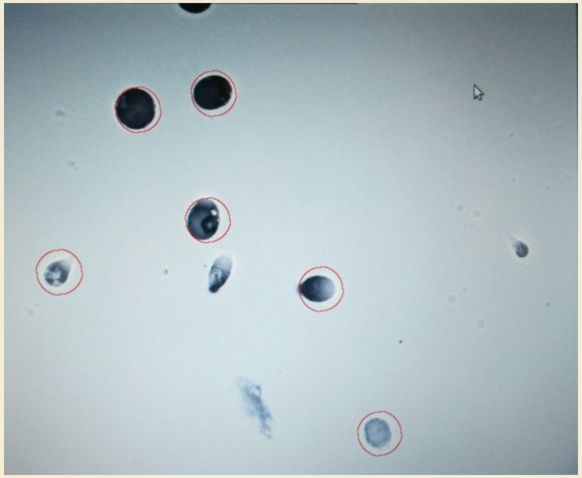
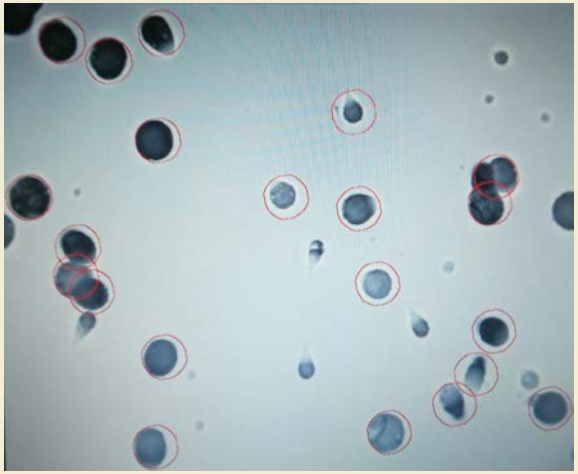
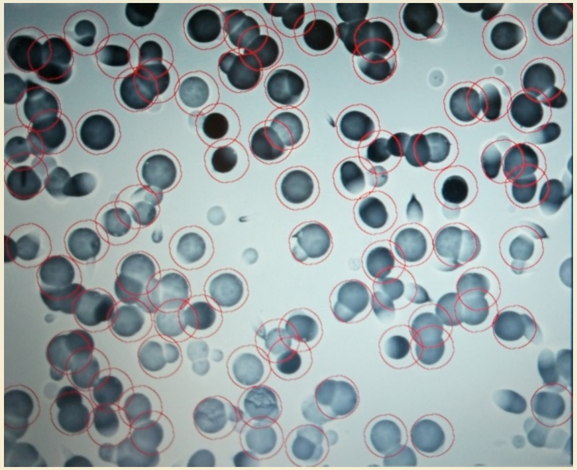


Consequence:

- ➢ underestimate the real concentration of radon
- ➢ increase measurement error
- ➢ several exposition at certified values should be performed in order to interpolate a *calibration curve* for high exposures

Saturation Effect

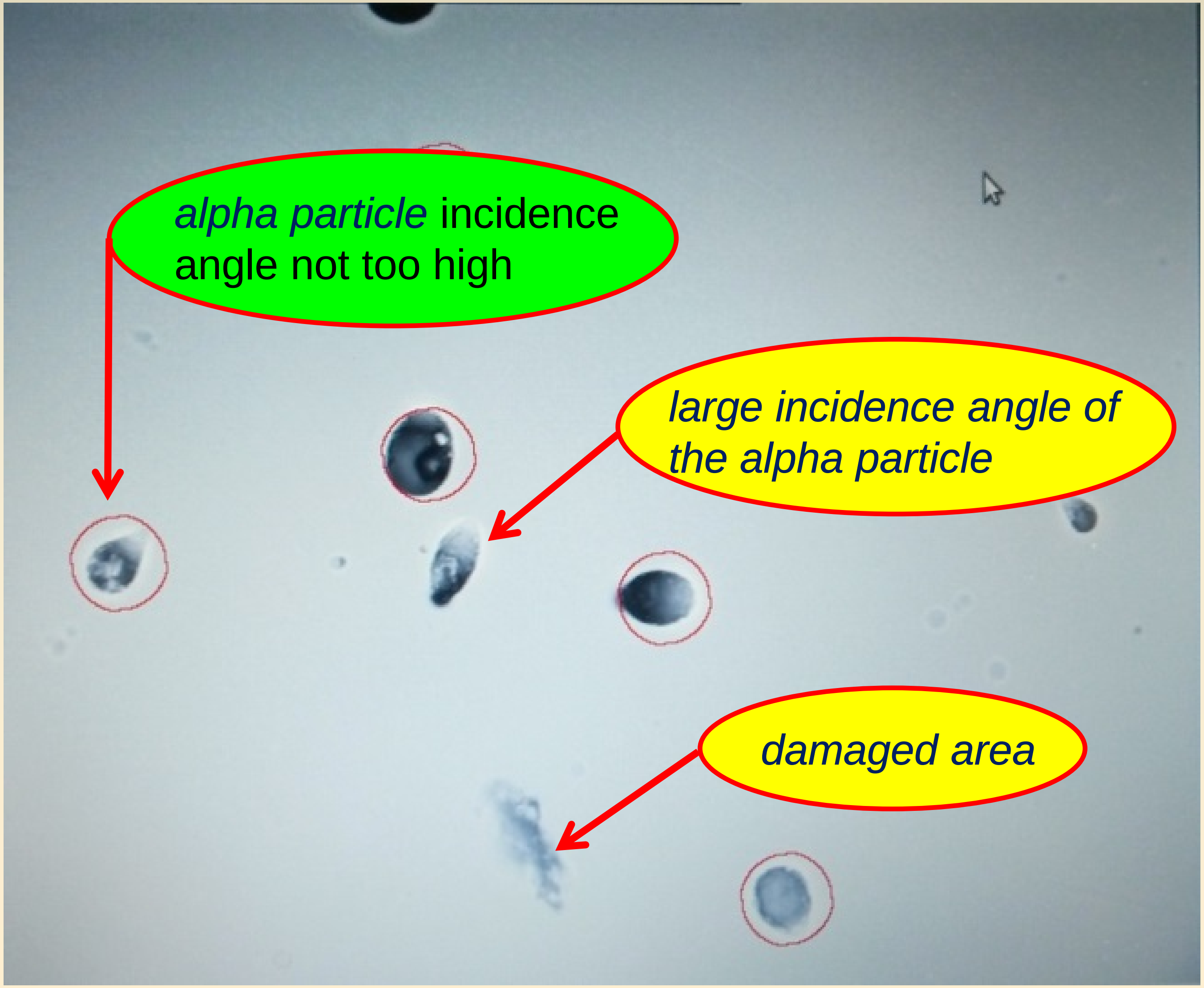
Layout of the nuclear tracks for different exposition levels

low exposure	*medium exposure*	*high exposure*
		
No overlap is the rule	tracks begin to overlap gradually	all the tracks overlap with different degrees

CR-39 RSKS detectors - RadoSys System - V.2006
Elements of optical scansion (Area: 0.65 mm x 0.48 mm)

Saturation Effect

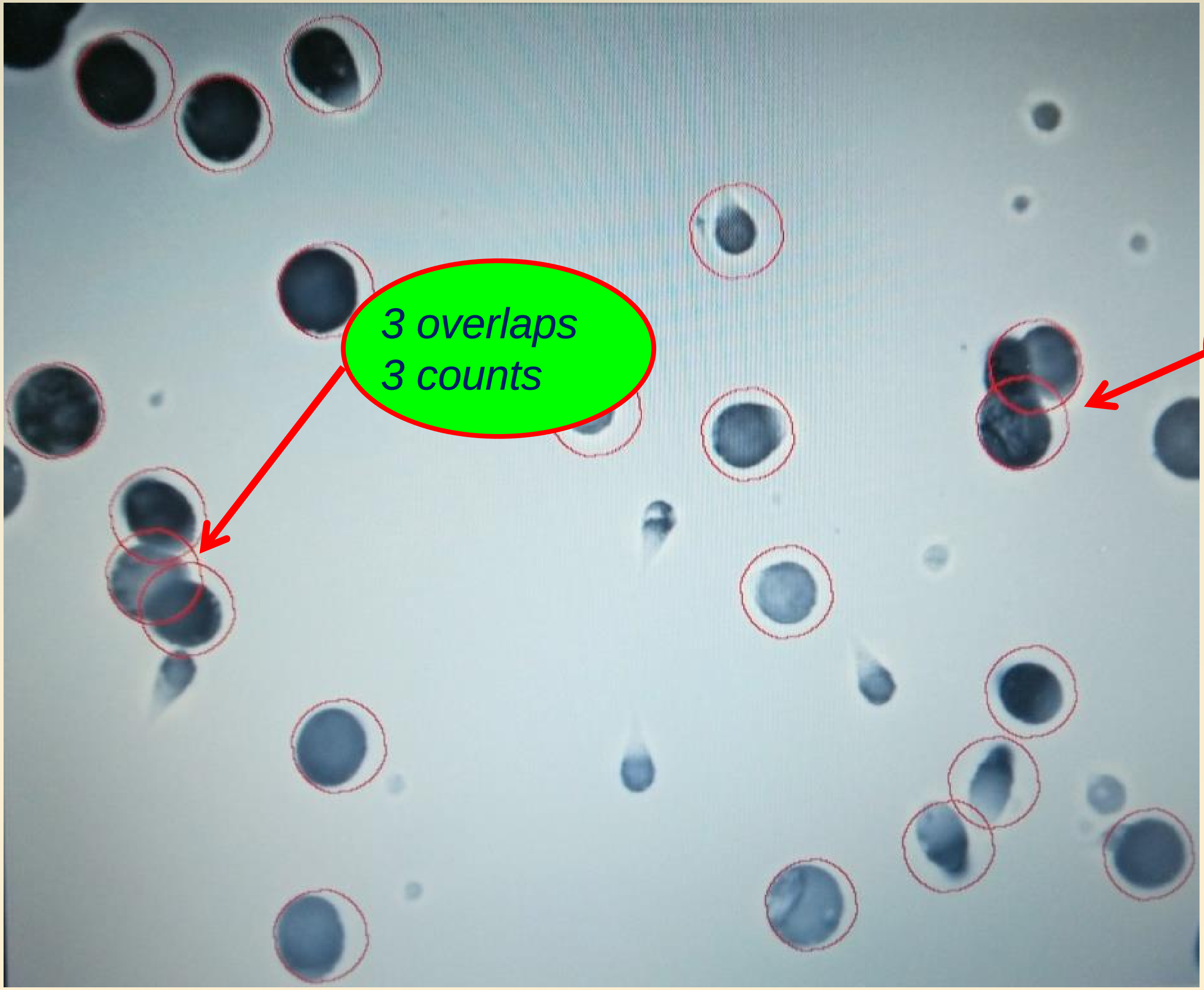
low exposure



No overlap is the rule

Saturation Effect

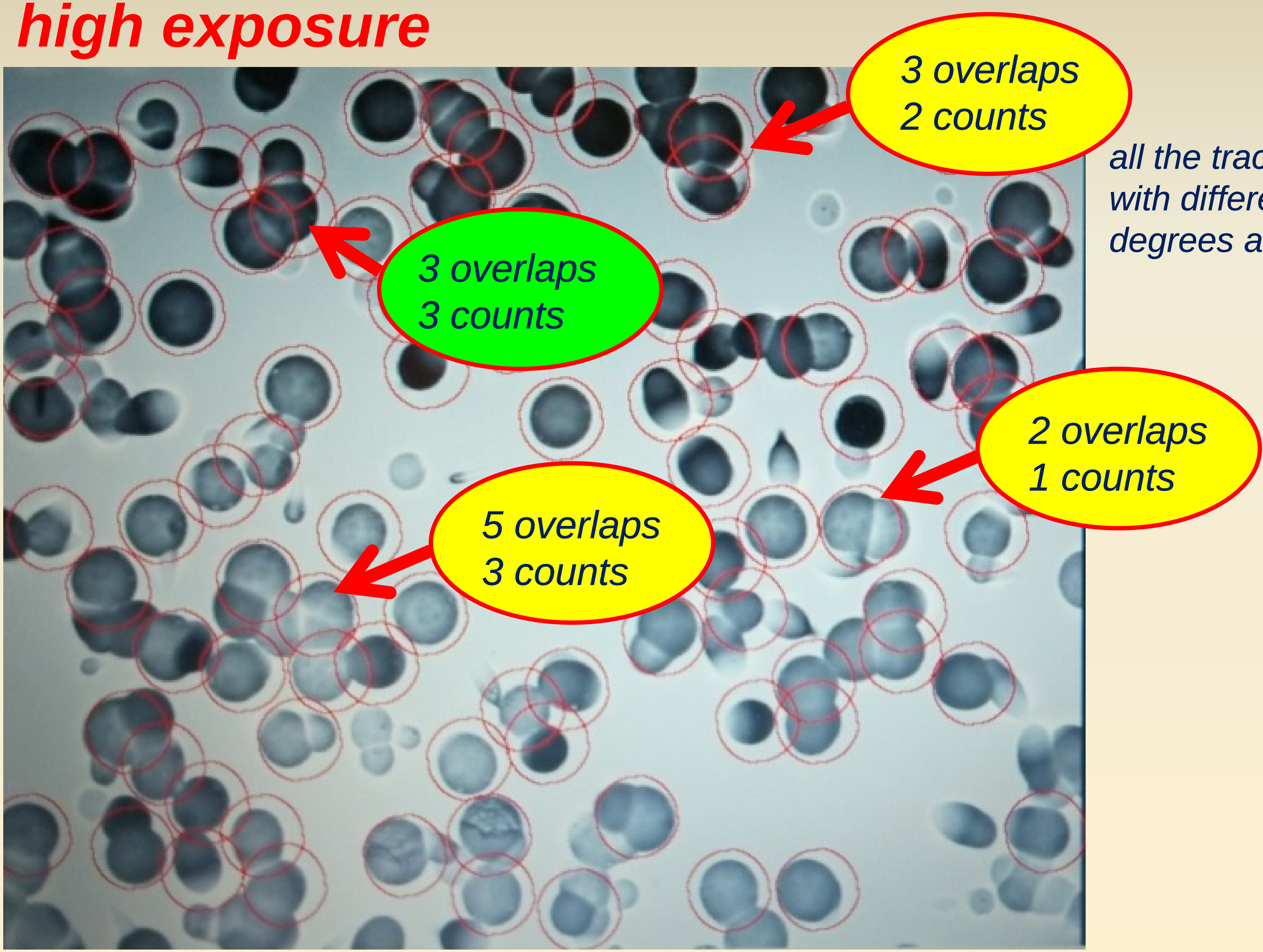
medium exposure



tracks begin to overlap gradually

Saturation Effect

high exposure



all the tracks overlap with different degrees and number

Evaluation of the Saturation Effect

- measured *track density* d_m is always less than the track density d_i of the ideal case, without saturation
- exists a *track density* d_{sup} (dependent on the system as a whole) that cannot be exceeded

By these hypotheses, we assume that, at least for $d_m \ll d_{sup}$, the *relative difference* between d_i and d_m can be estimated as follows

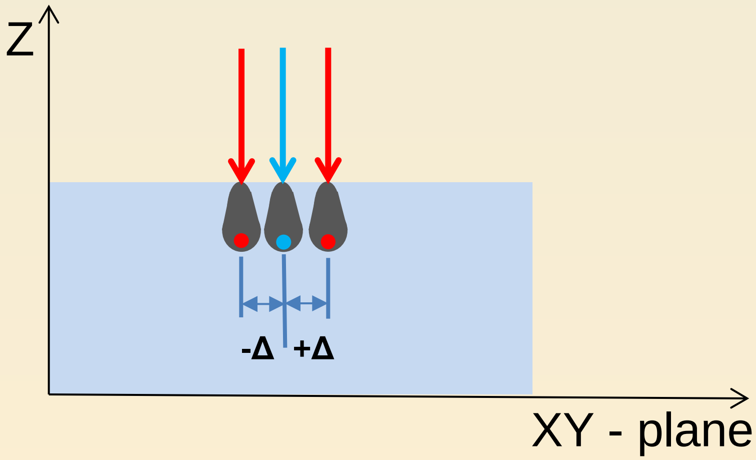
$$\frac{d_i - d_m}{d_i} \approx \left(\frac{d_m}{d_{sup}}\right)^{\alpha}$$

where, in general, we can search the best agreement for $\alpha \neq 1$

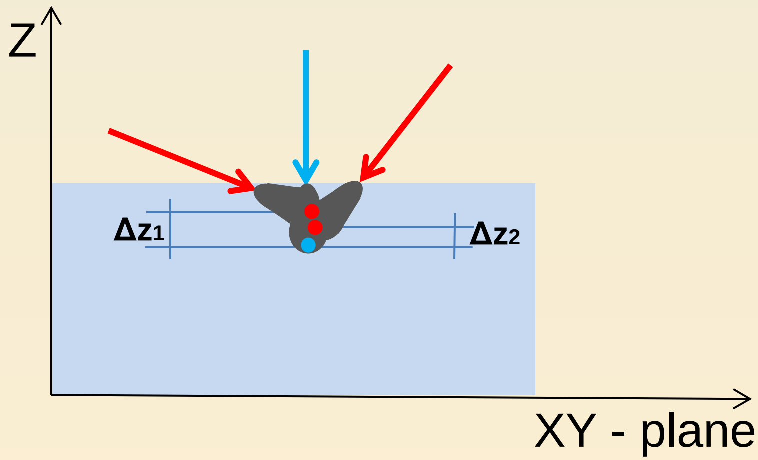
Evaluation of the Saturation Effect

$$\frac{d_i - d_m}{d_i} \approx \left(\frac{d_m}{d_{sup}}\right)^{\alpha}$$

we hypothesize that α represent the degrees of freedom in the process of overlapping tracks



1 degree of freedom along the X axis
1 degree of freedom along the Y axis



1/2 degree of freedom along the Z axis

Evaluation of the Saturation Effect

(α = 2.5) →

$$\frac{d_i - d_m}{d_i} \approx \left(\frac{d_m}{d_{sup}}\right)^{2.5}$$

renaming d_i as d_{corr} (*track density corrected from the saturation*) and inverting

$$d_{corr} = \frac{d_m}{1 - \left(\frac{d_m}{d_{sup}}\right)^{2.5}}$$

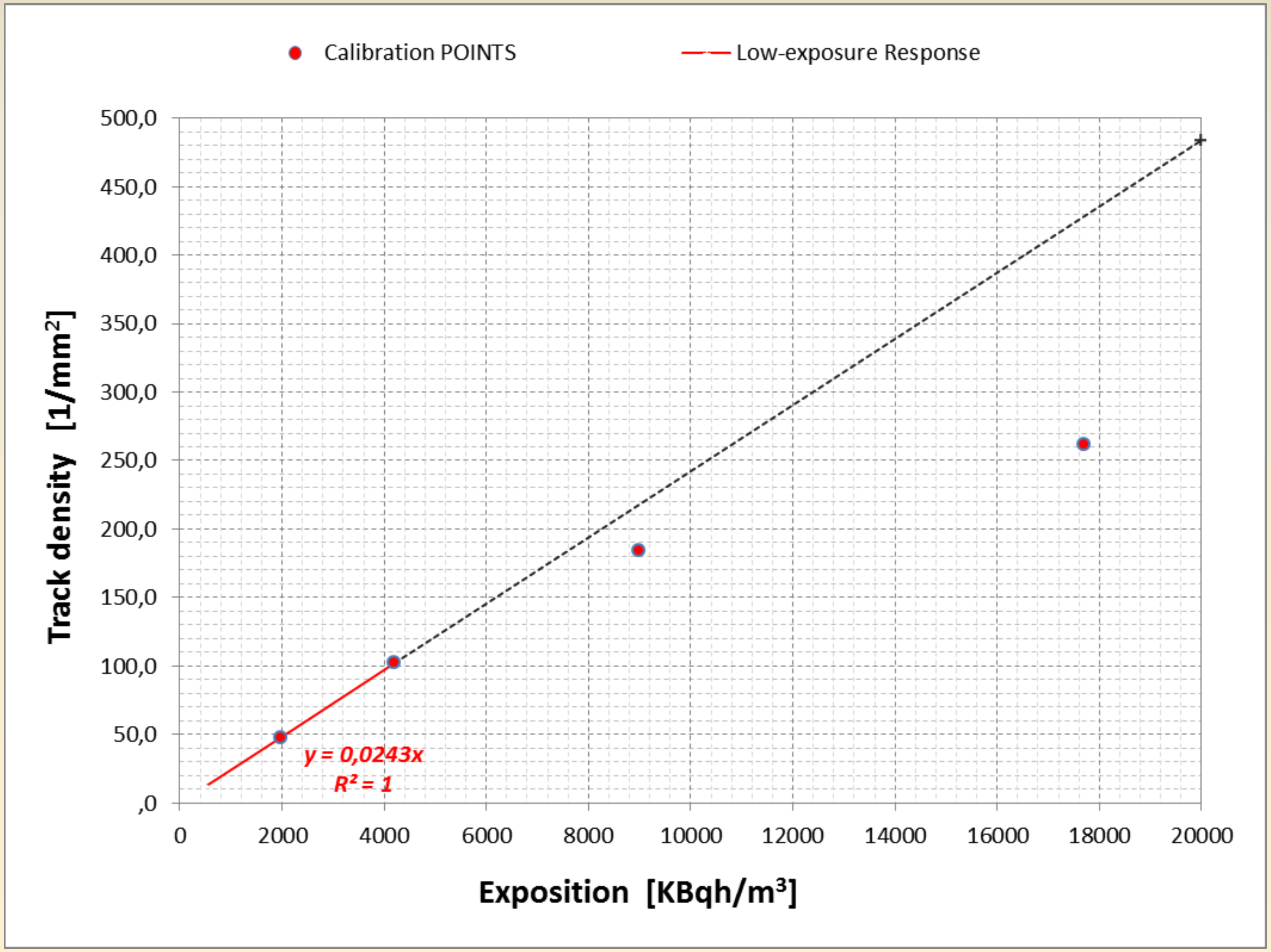
($d_m << d_{sup}$)

NOTE:

- d_{sup} is the only parameter to be determined experimentally
- d_m is the only value to be read on the CR-39 detector

How the saturation correction works on our system

(dosimeters of a same batch were considered and the results of four controlled exposures)



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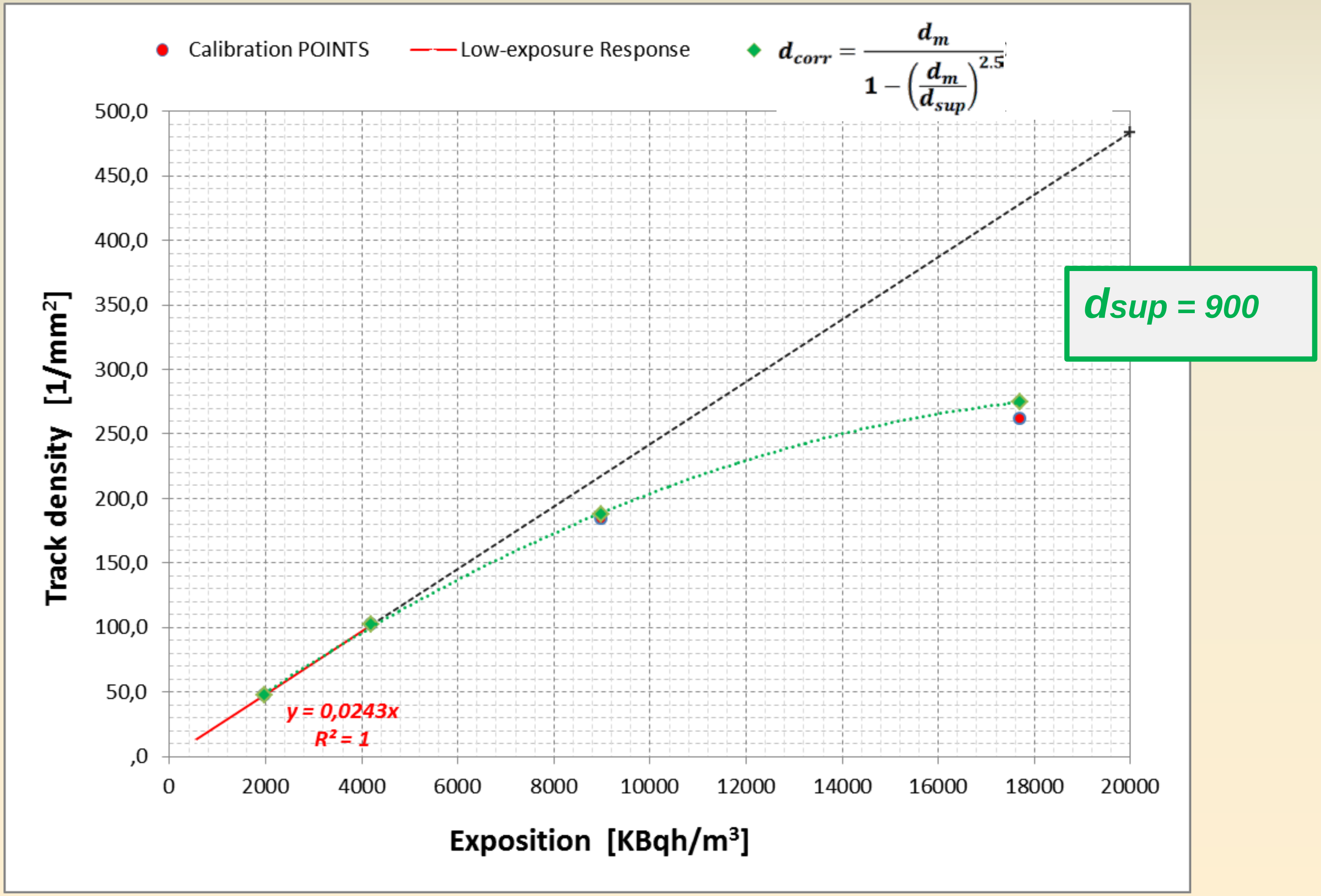

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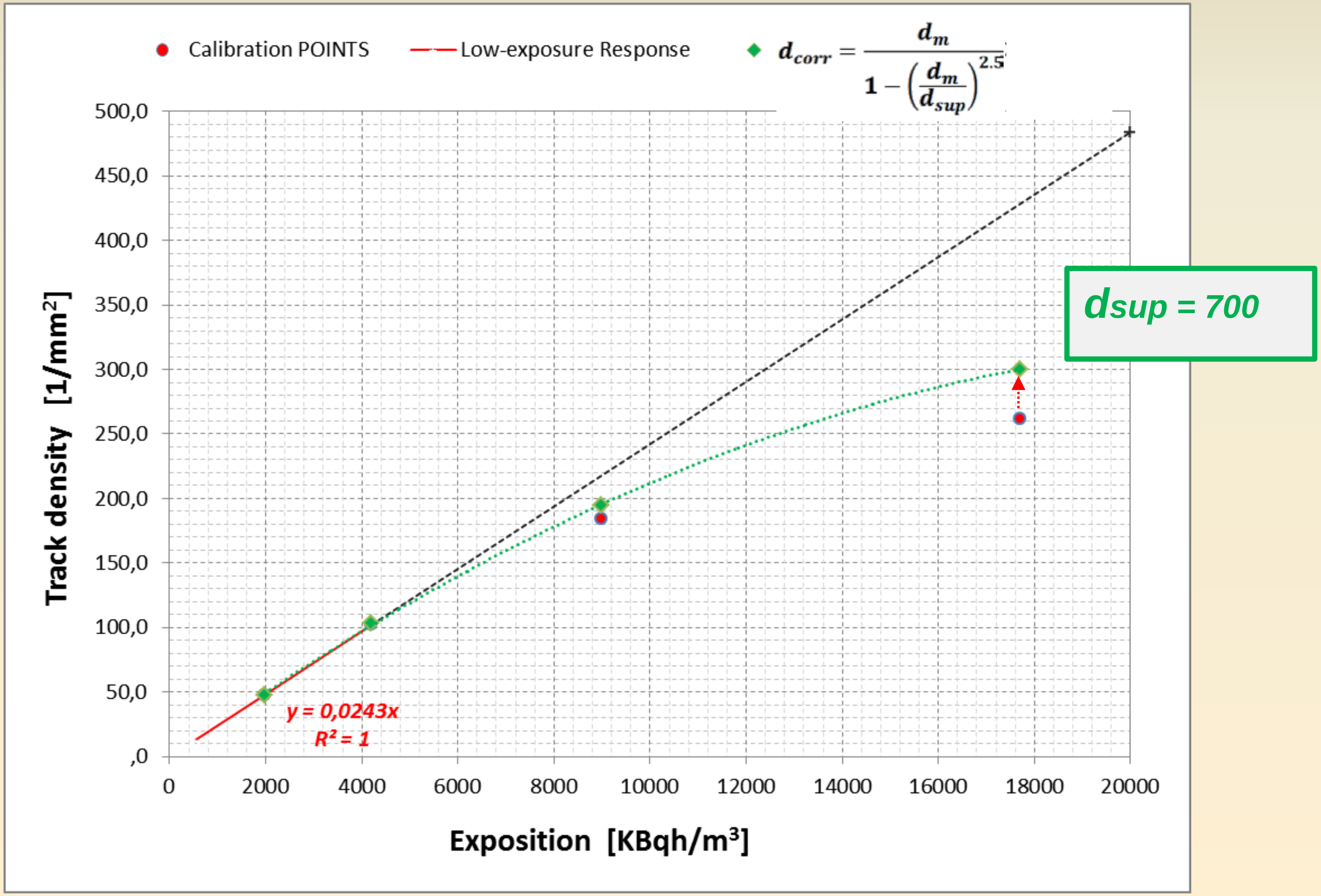

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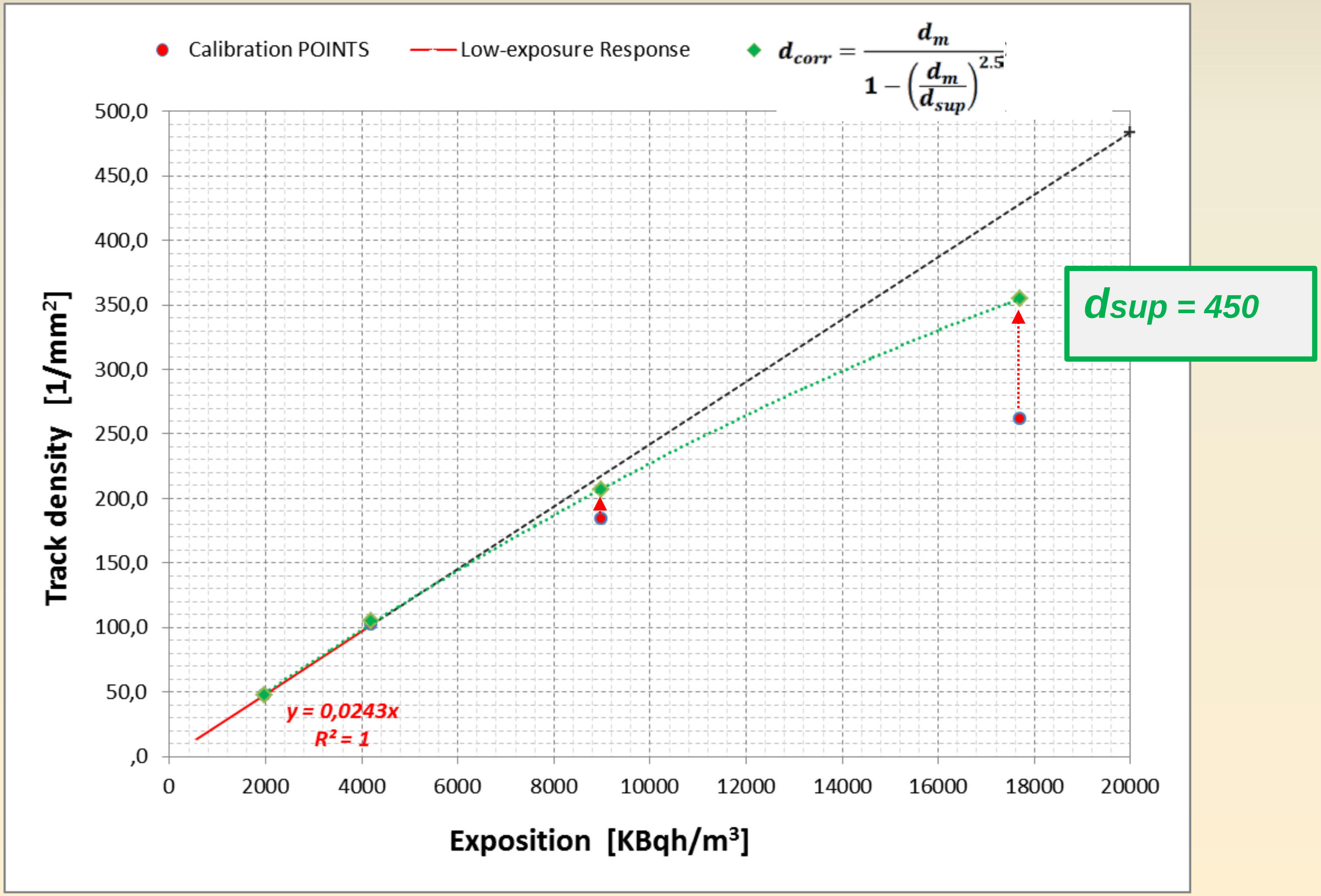

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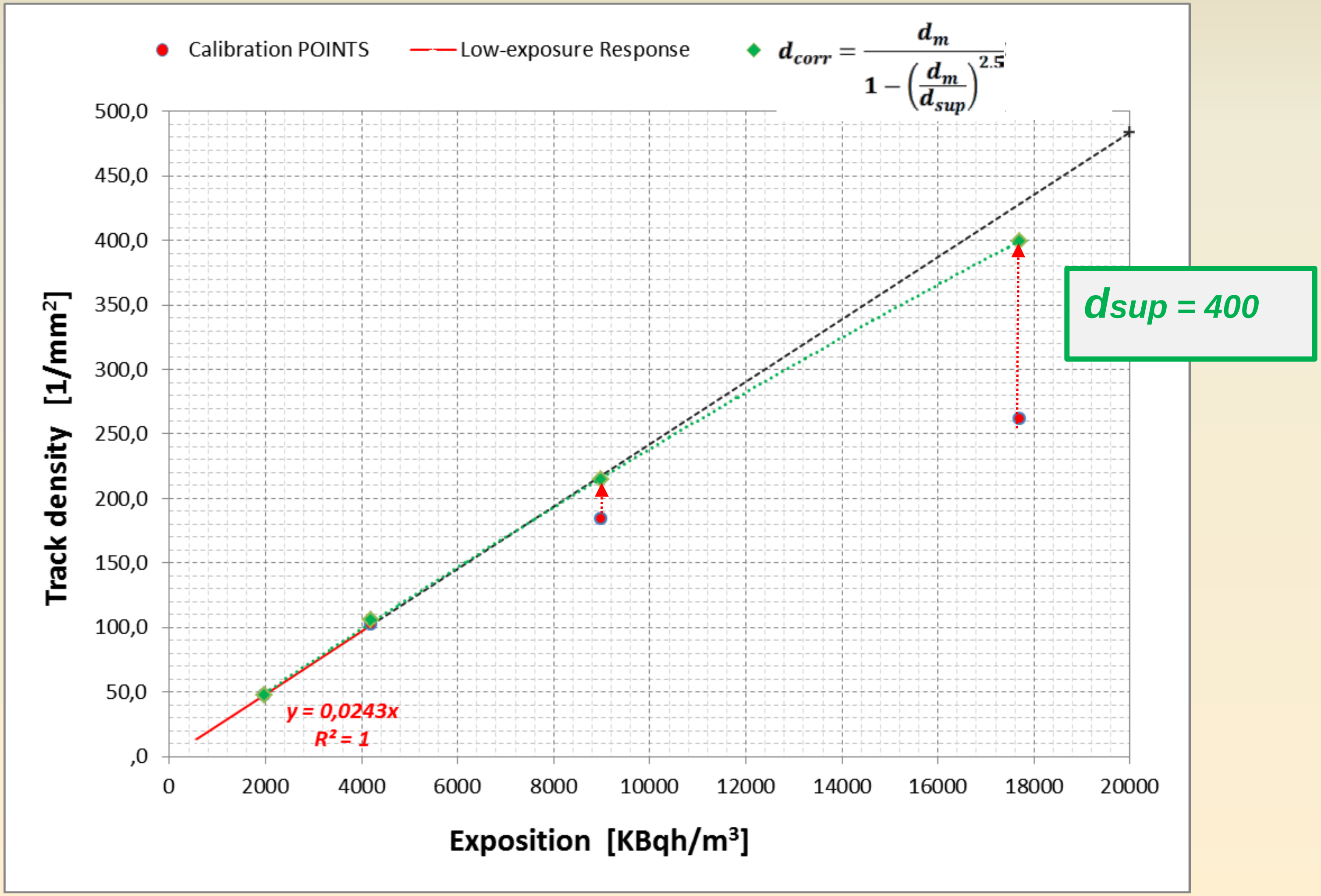

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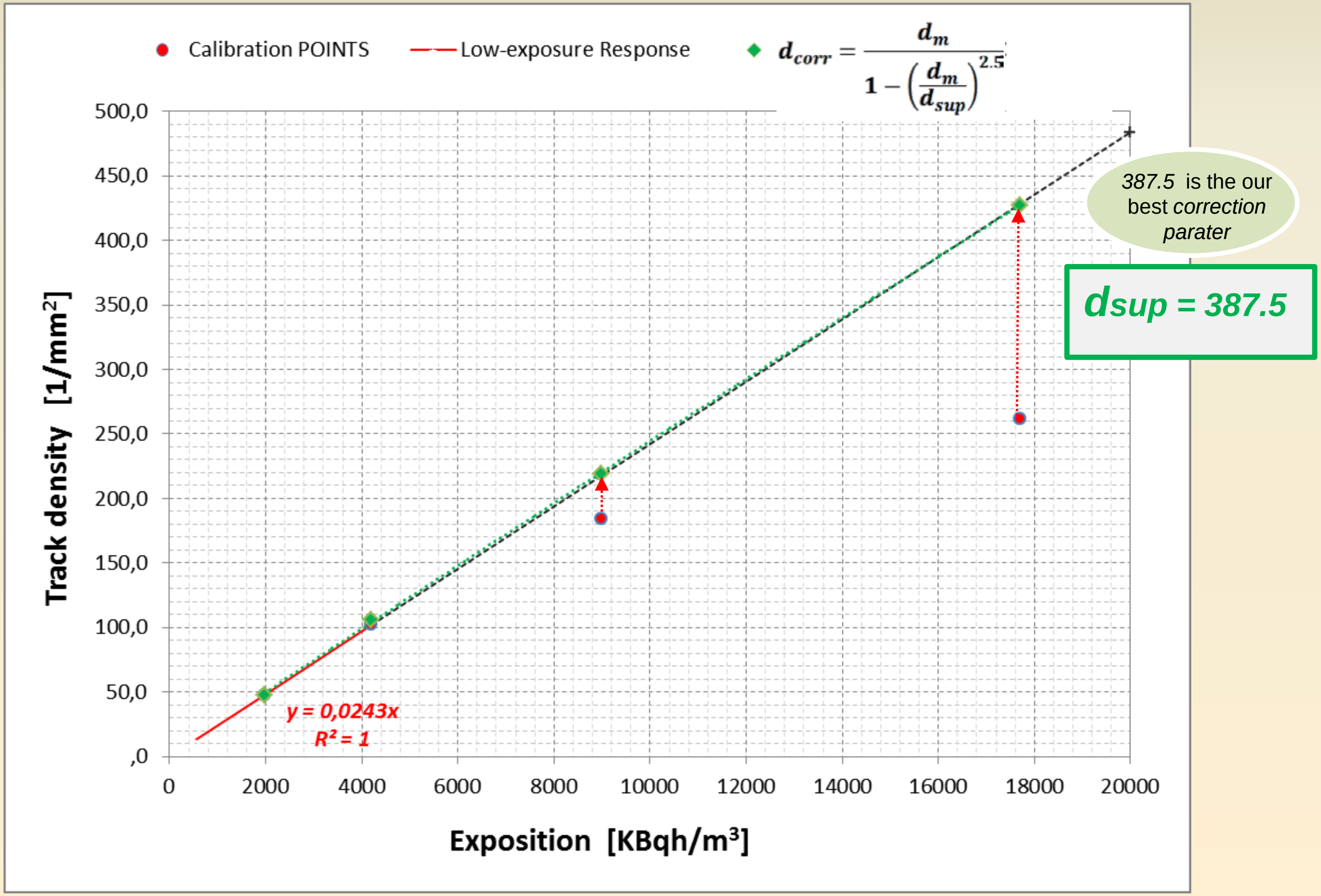
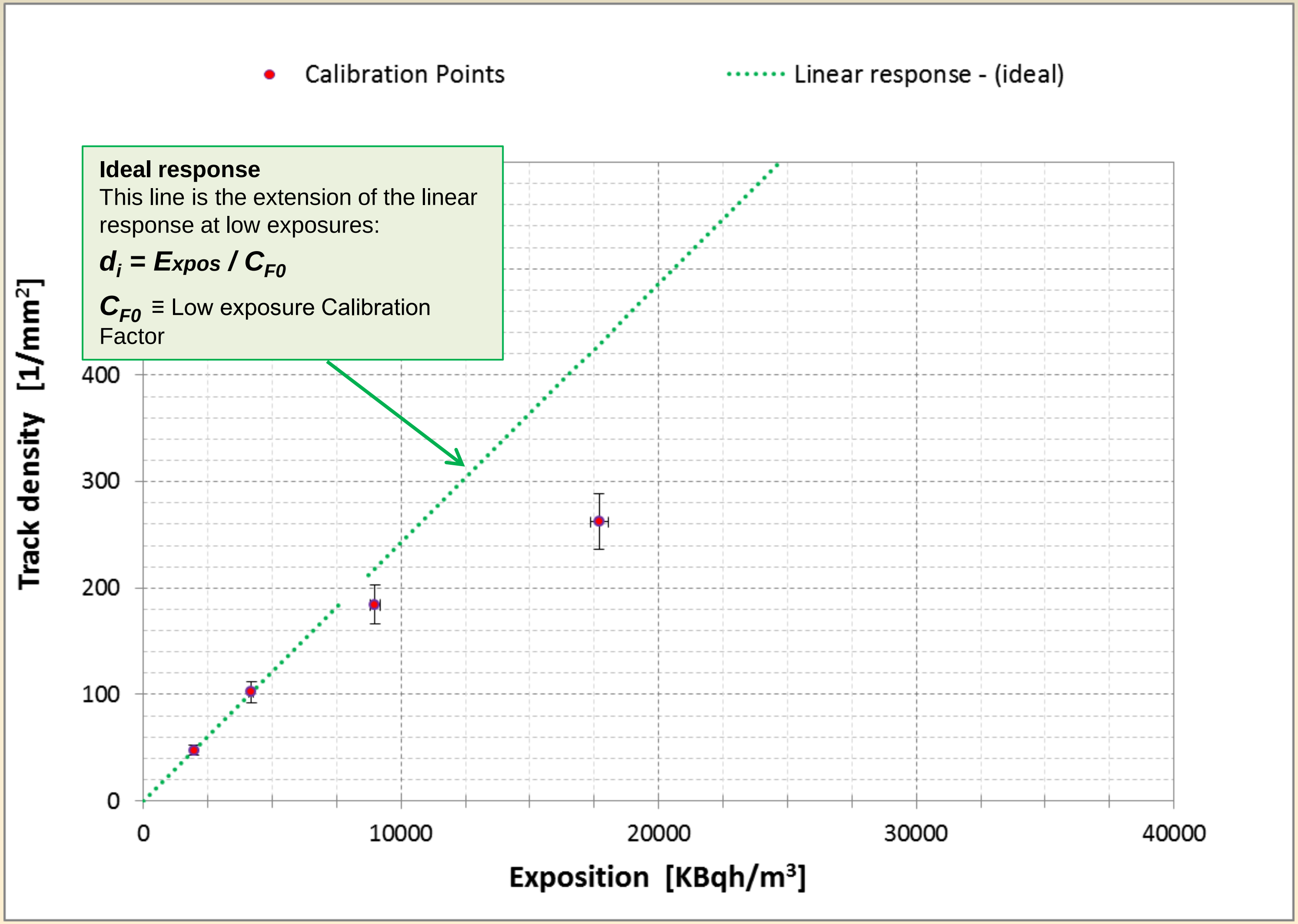


Best Fits of the real calibration curve

They were used 5-6 dosimeters in each controlled exposure and each dosimeter was read three times



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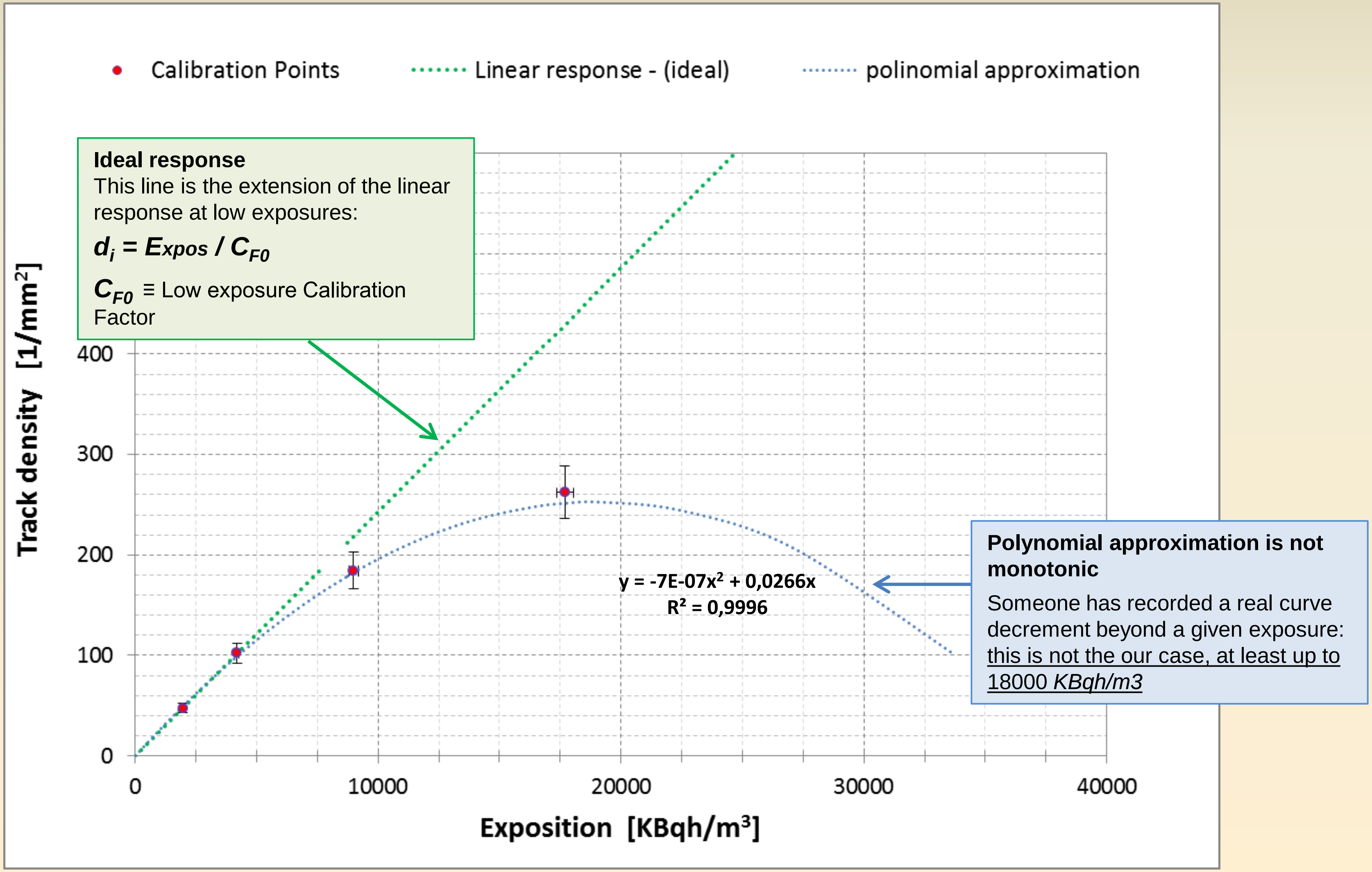

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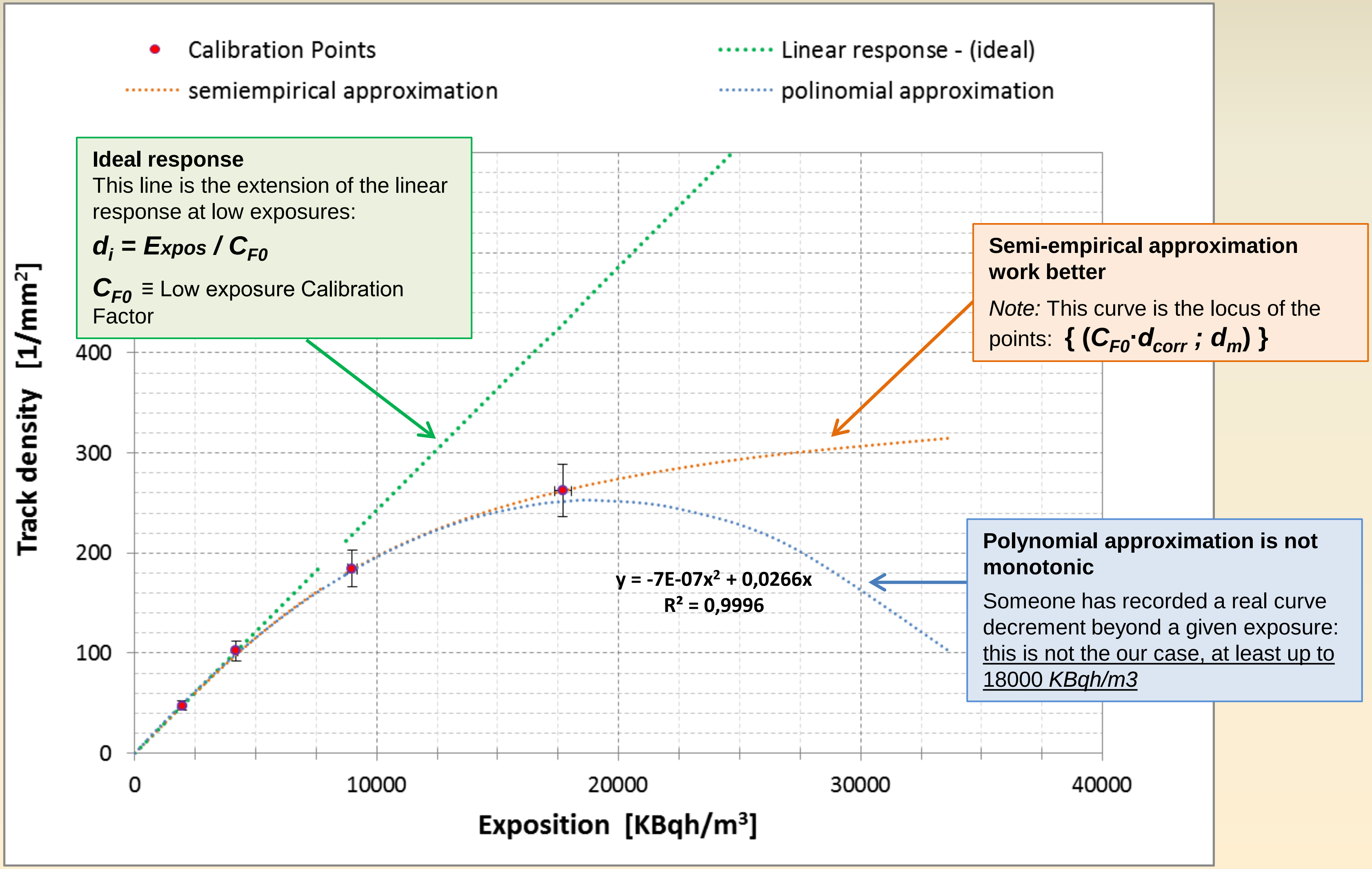

Conclusion

A semi-empirical function has been provided to correct the saturation effect on radon CR-39 detectors, with the following advantages:

- ➢ it has shown to fit better the calibration data than the polynomial approximation

- ➢ depends on one experimental parameter to determine which, only two calibration points are enough :

  - a first low- exposure calibration (in linear range)
  - and a second high-exposure calibration (saturation zone)

- ➢ even if it was giustified in the $d_m \ll d_{sup}$ condition, it has been proved that the function gives a good approximation at least until d_m is about 70% d_{sup}
  (*The highest value of* d_m *was obtained with a controlled exposure of approximately 18000 KBqh/m3)*

Further tests can determine:

- ► to what level of exposure the function continues to deliver good results;
- ► how much d_{sup} can depend on the batch of dosimeters, using the same etching /reading system in the same conditions;
- ► if the *correction method* is independent by the reading algorithm used.

Thanks for your attention