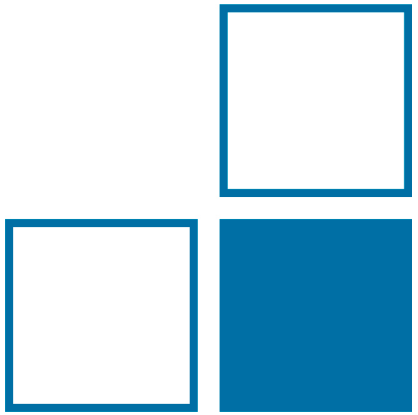
Physikalisch-Technische Bundesanstalt
Braunschweig and Berlin
National Metrology Institute

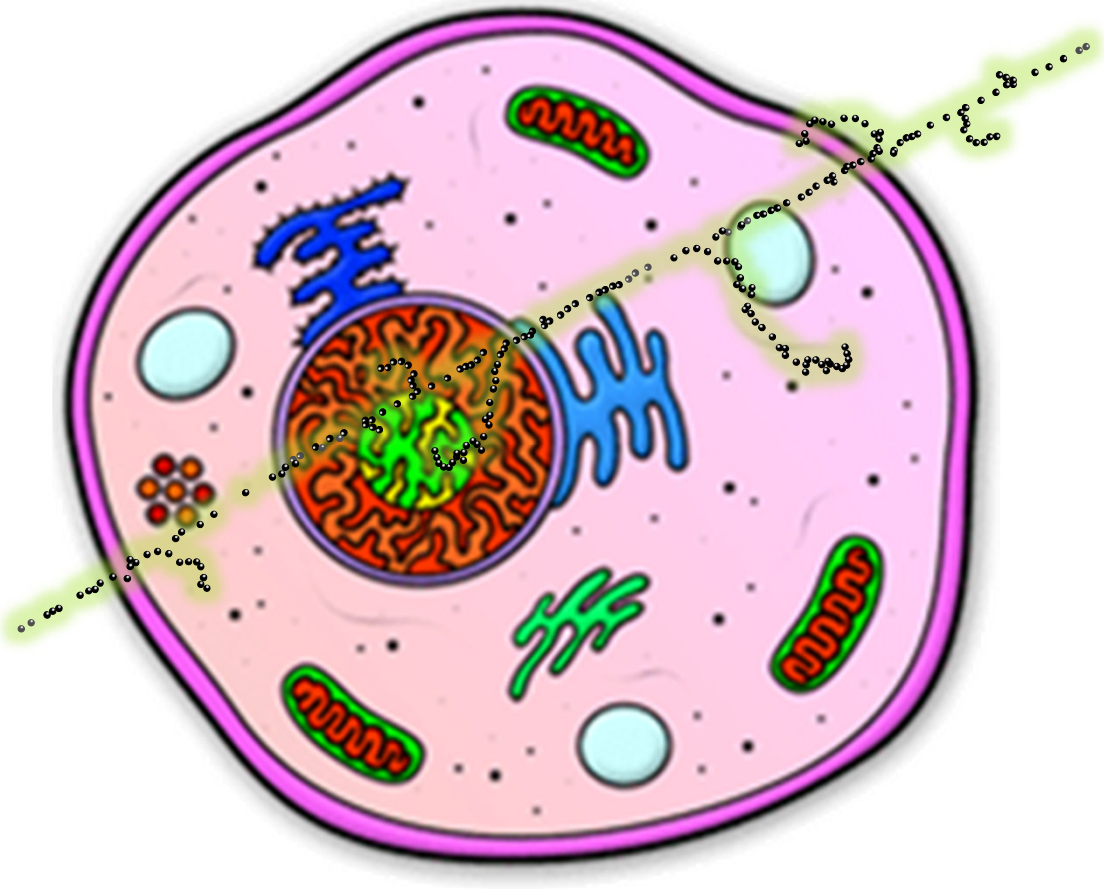
Relation between experimental nanodosimetry and radiobiological effects

Hans Rabus



Characterisation of particle track structure in microdosimetry and nanodosimetry

Charged particle track traversing a cell



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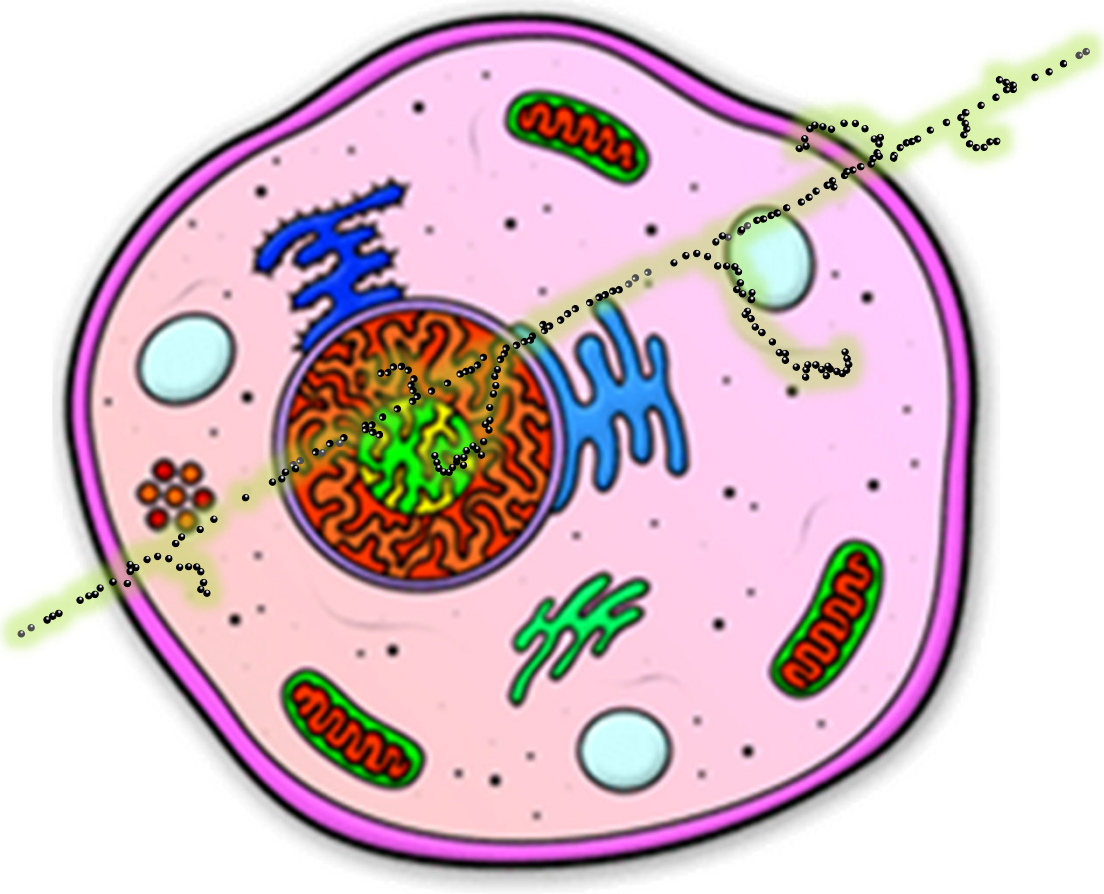

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⇨ **microdosimetry**:

lineal energy $y = \frac{\varepsilon}{\bar{l}}$

ε: energy imparted

$\bar{l}$: mean chord length

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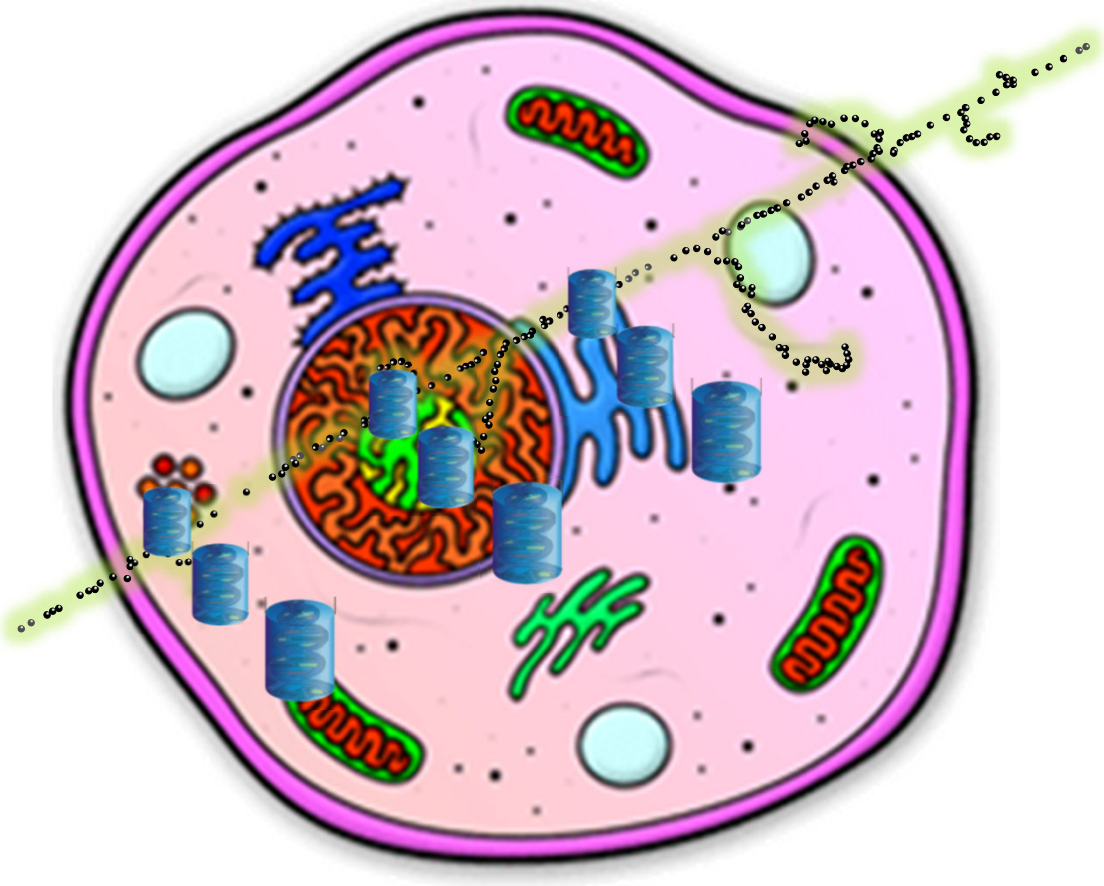

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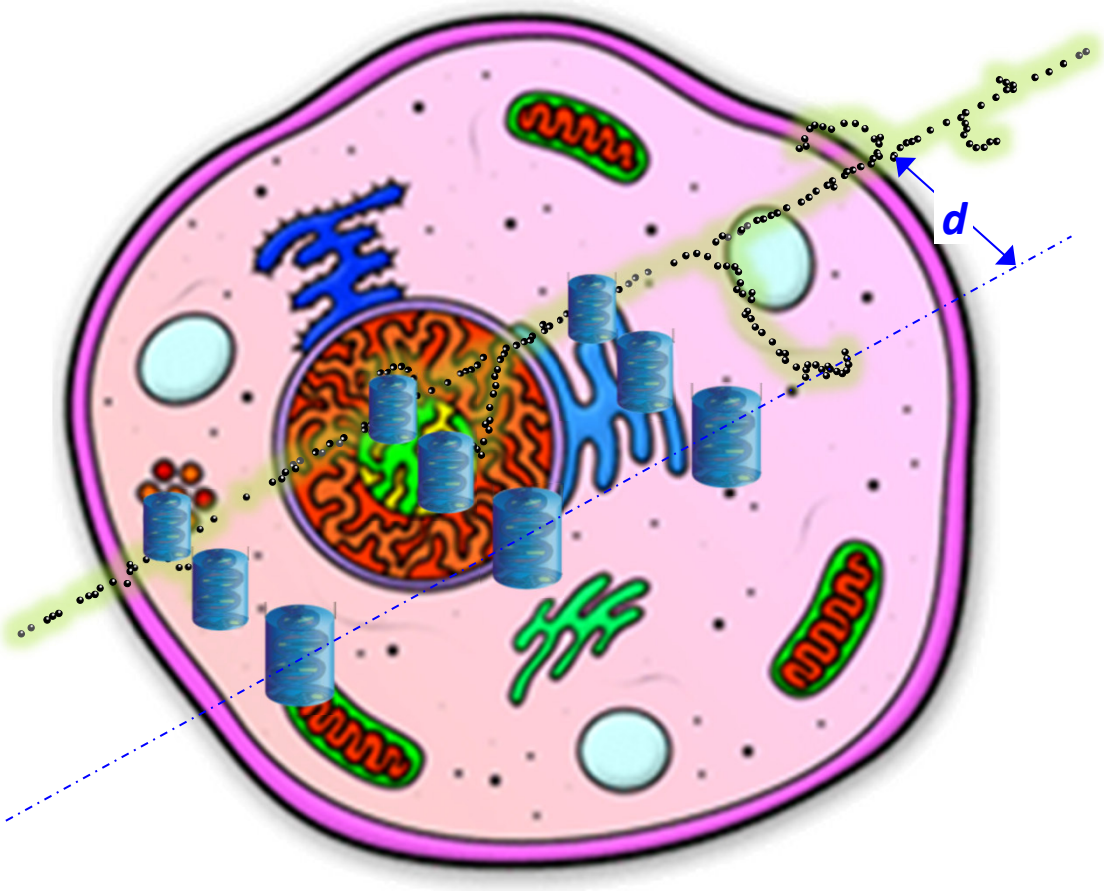

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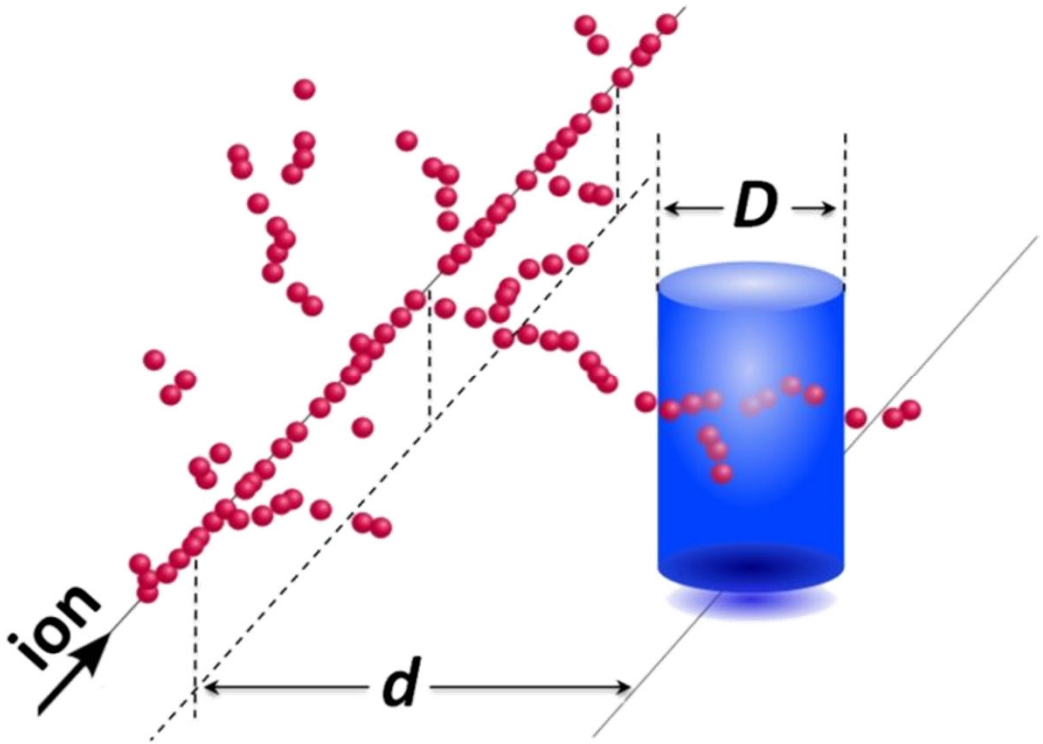
⇨ **nanodosimetry:**

- additional geometry parameter ***d***
- conversion ionization to lineal energy fails

Quantities in Nanodosimetry

A particle track passes a target volume of size D at an impact parameter d



Ionization cluster size: Number ν of ionizations in target volume (stochastic quantity)

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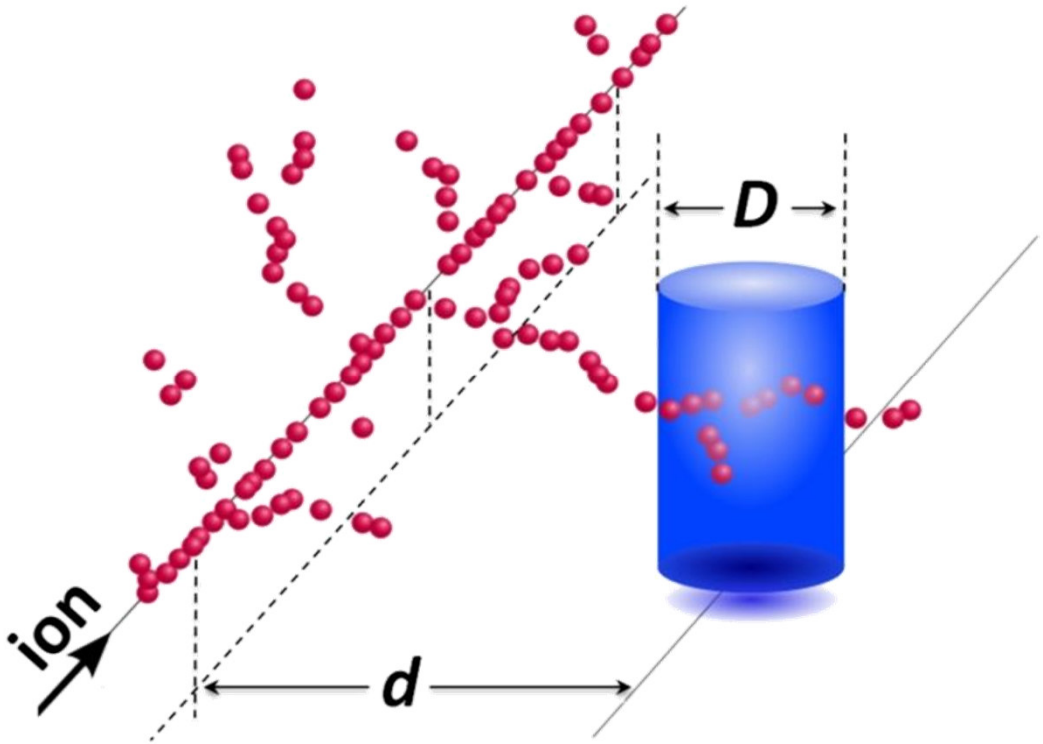

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Frequency distribution: $P(\nu|Q)$

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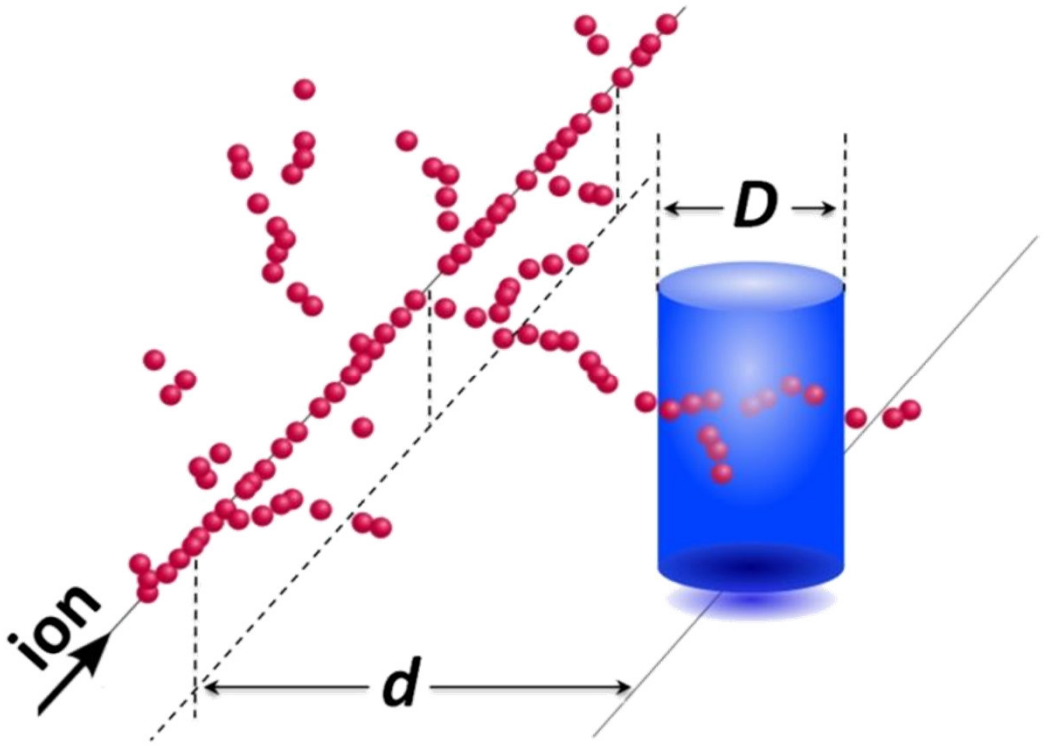

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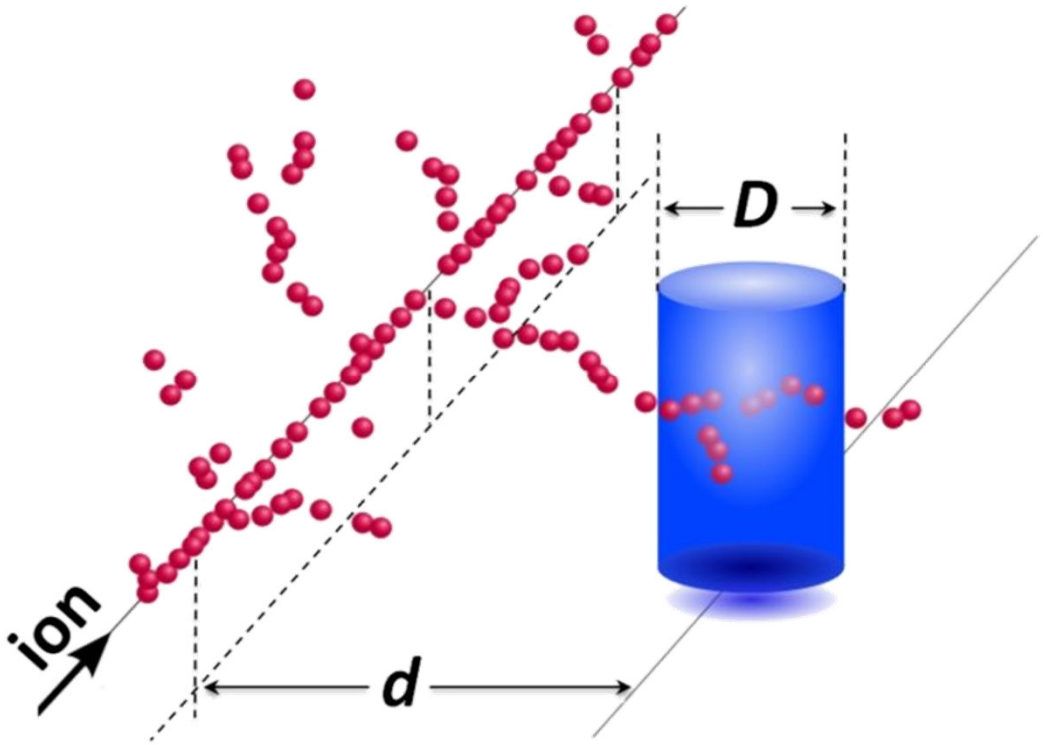

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Cumulative frequencies:

$$F_k(Q) = \sum_{\nu=k}^{\infty} P(\nu|Q)$$

Moments: $$M_i(Q) = \sum_{\nu=0}^{\infty} \nu^i \cdot P(\nu|Q)$$

Nanodosimetric track structure quantities

In this presentation, the following nanodosimetric parameters of track structure in a single site (target volume) appear:

M_1 **mean number** of ionizations in the site

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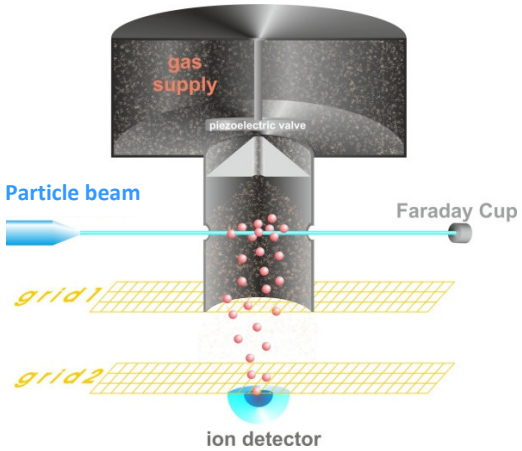
F_3 **probability** for occurrence of a ***complex*** ionization ***cluster*** (3 or more ionizations) in the site

Instrumentation in nanodosimetry

Jet Counter



S. Pszona et al., Nucl. Instrum. and Meth. A 447, 601 (2000)

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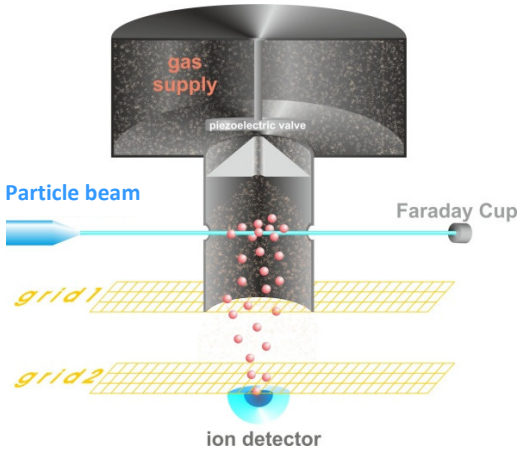

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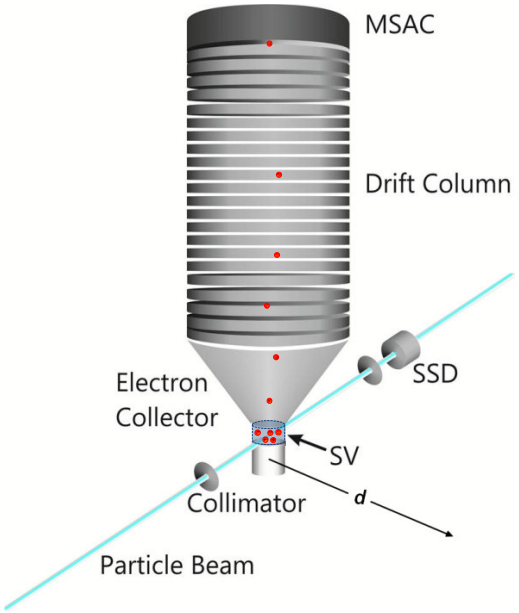

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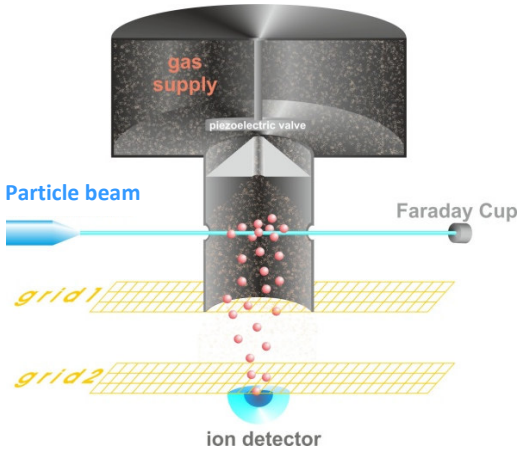

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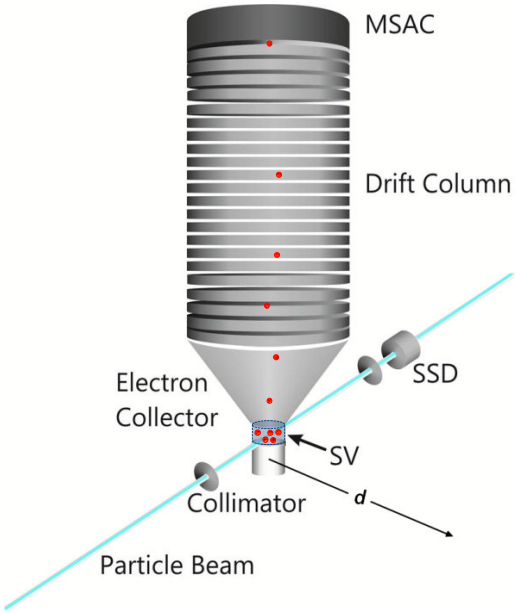

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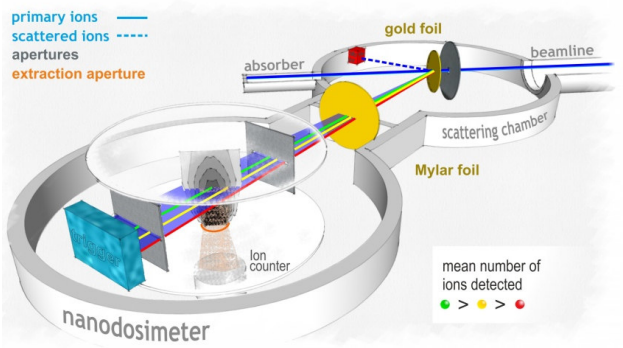
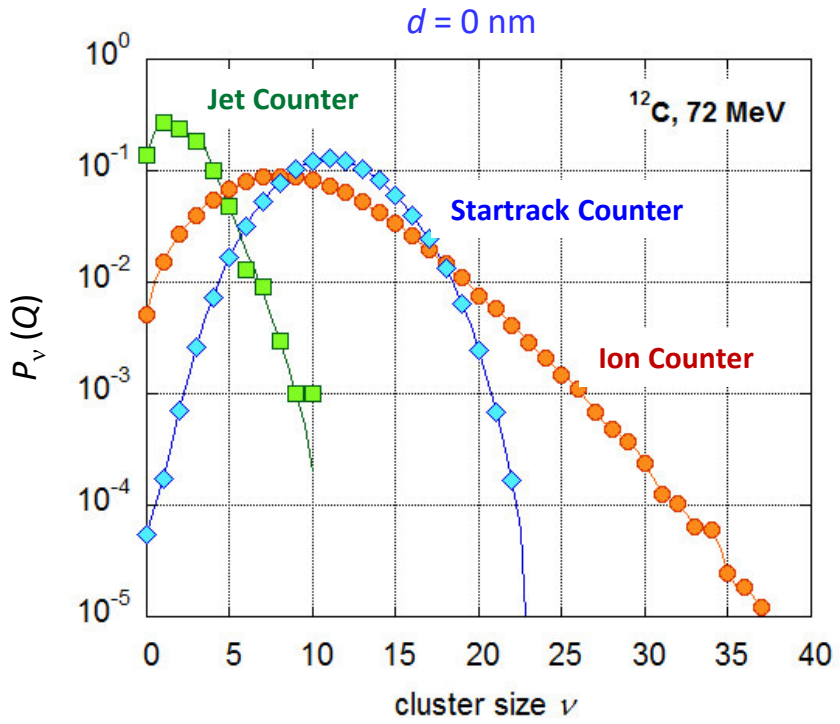
Ion Counter



G. Garty et al., Radiat. Prot. Dosim. 99, 325 (2002)

Universal nanodosimetric relation

ICSDs measured with the three different devices for the same radiation quality



Ionisation cluster size distributions are different due to different target size and geometry

Adapted from slides provided by Valeria Conte

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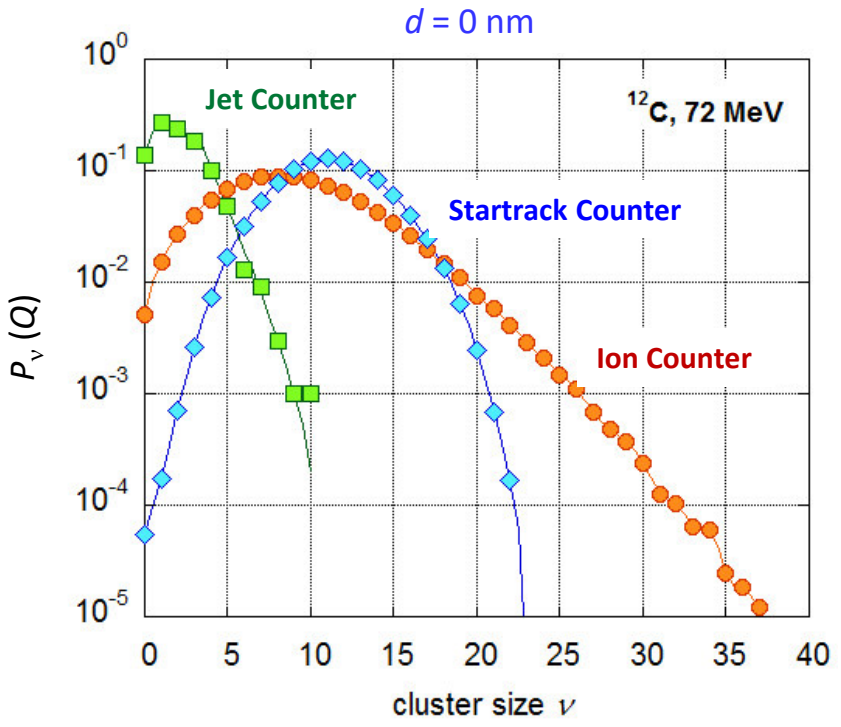

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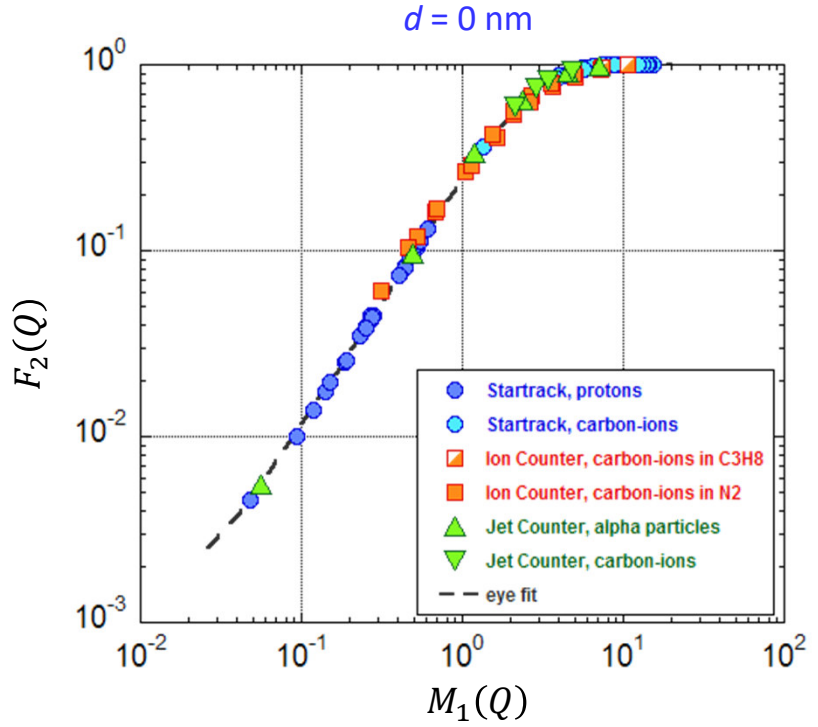

ICSD parameters show universal dependence on mean cluster size for central passage of target

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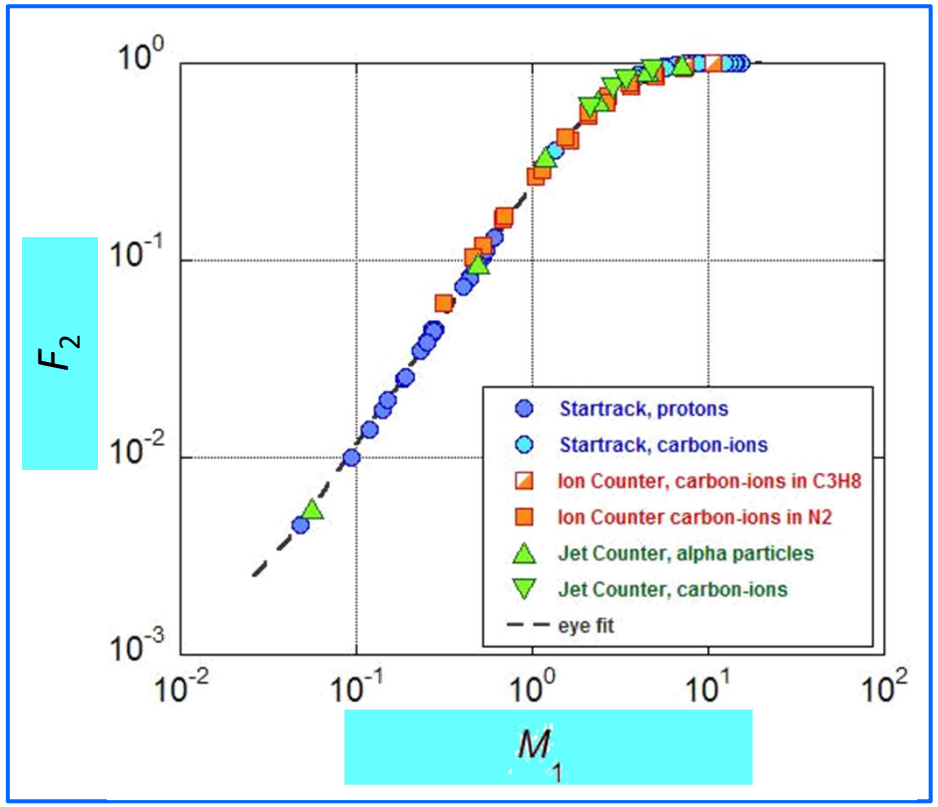
Nanodosimetry & inactivation of V79 cells by protons or carbon ions

Nanodosimetric quantities



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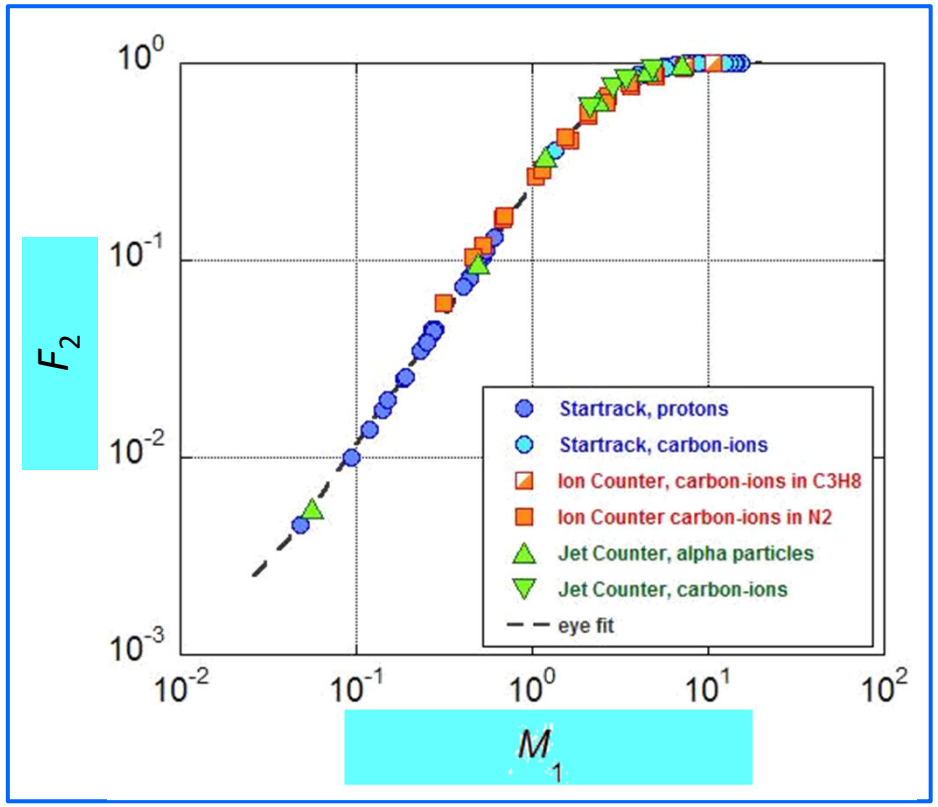
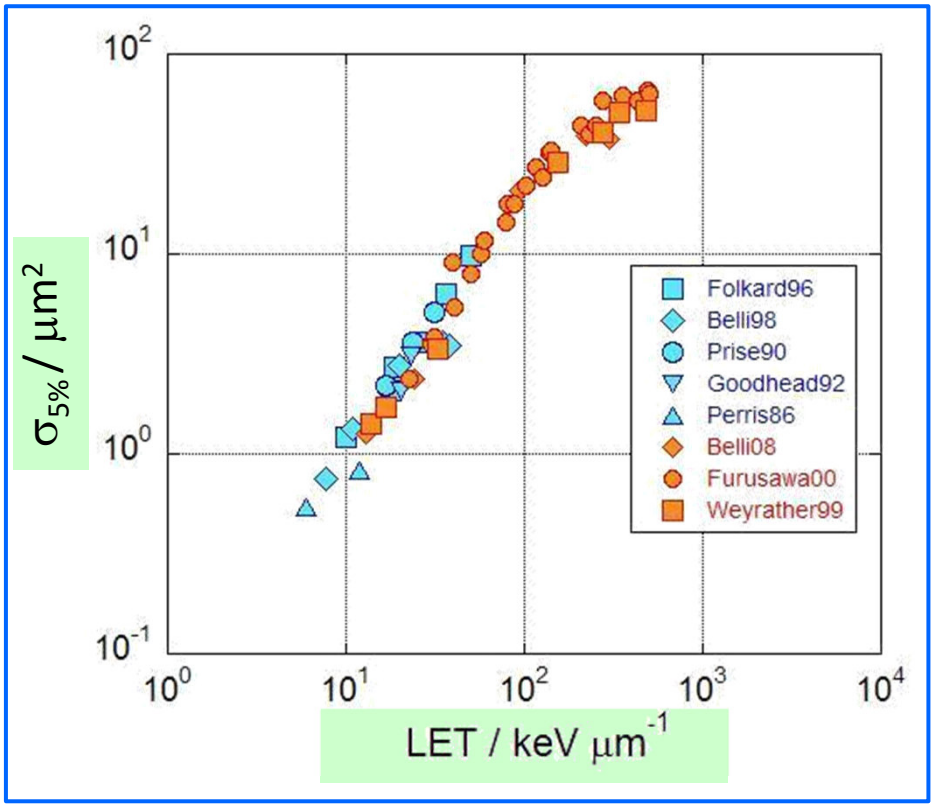


Inactivation cross sections vs *LET*



Inactivation cross sections calculated from survival curves of V79 cells (data from *gsi.de/bio-pide*) at 5% survival level.

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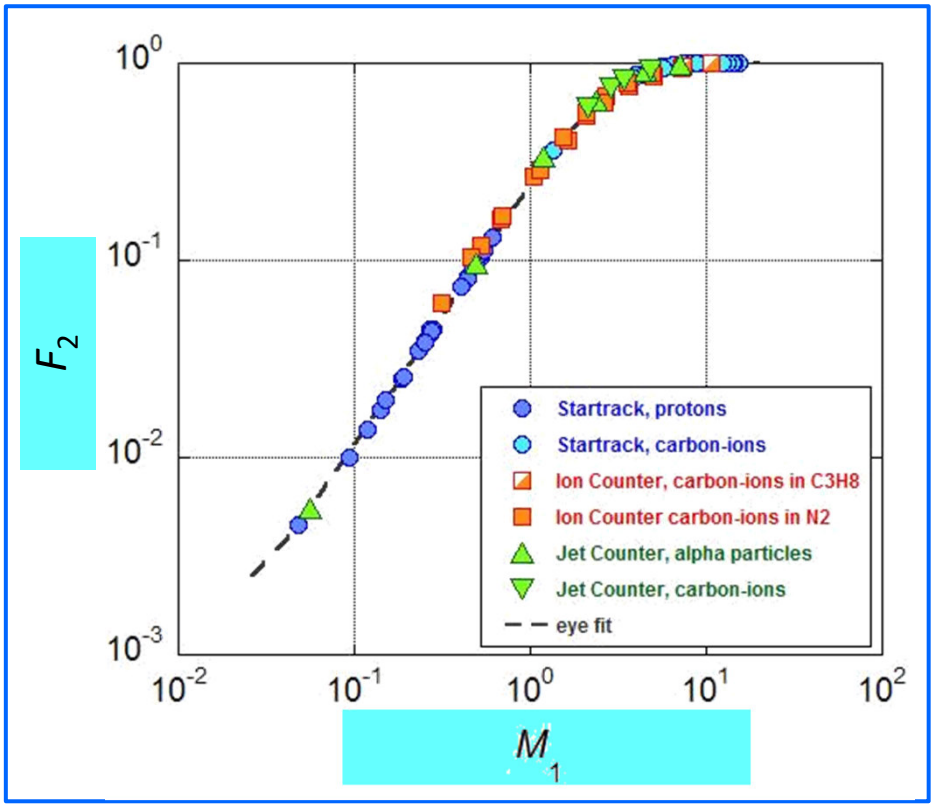
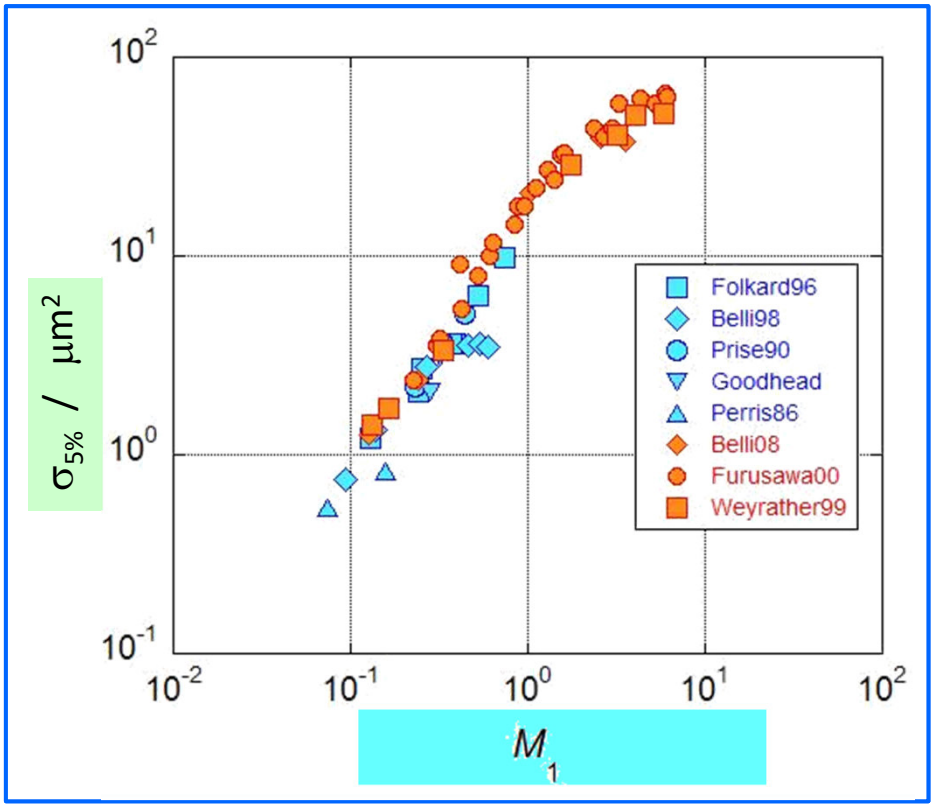


M_1 obtained from measurement with nitrogen or propane filled target volumes of the three nanodosimeters.

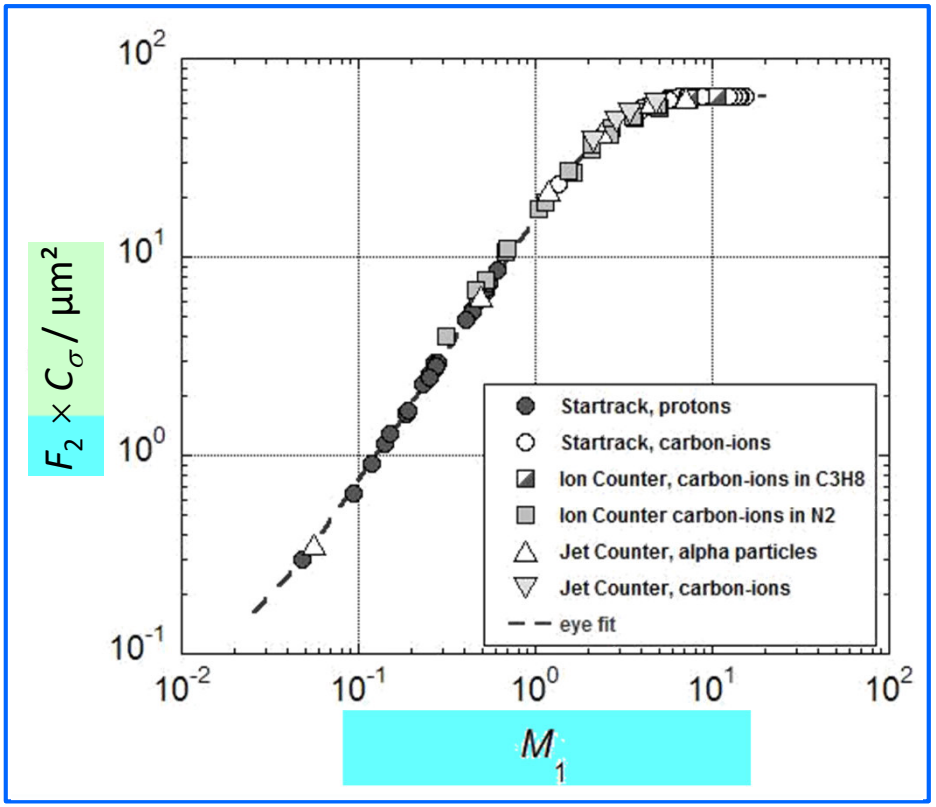
Inactivation cross sections vs M_1



M_1 for a cylinder of $D \approx 1$ nm filled with liquid water (obtained by MC simulations).

Nanodosimetry & inactivation of V79 cells by protons or carbon ions

Scaled nanodosimetric quantities



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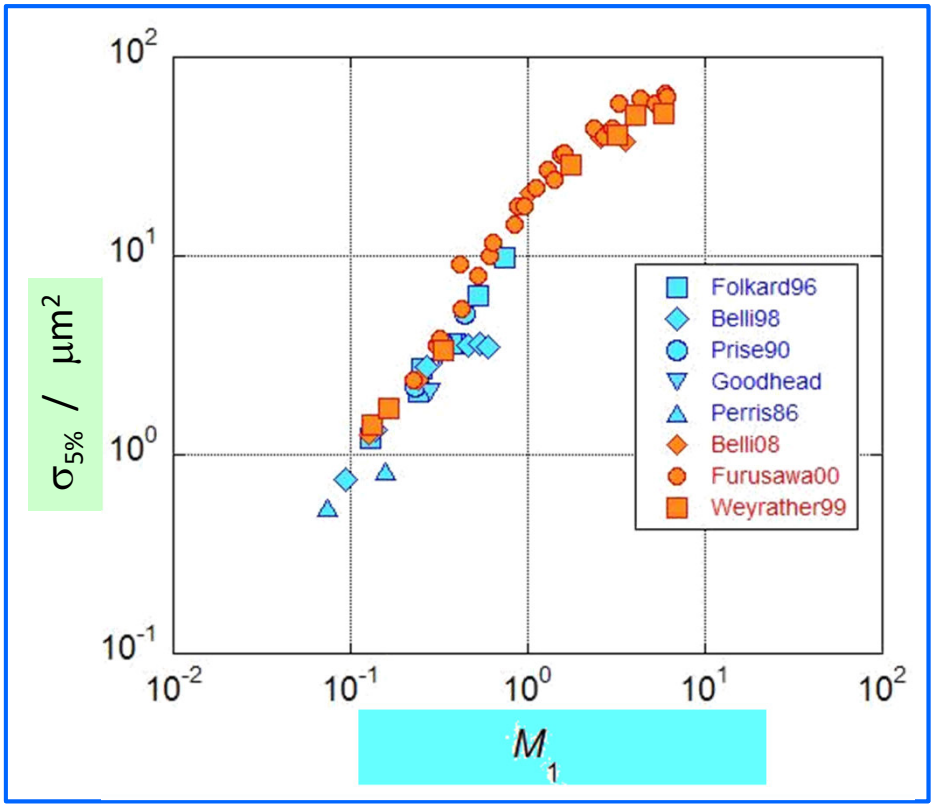

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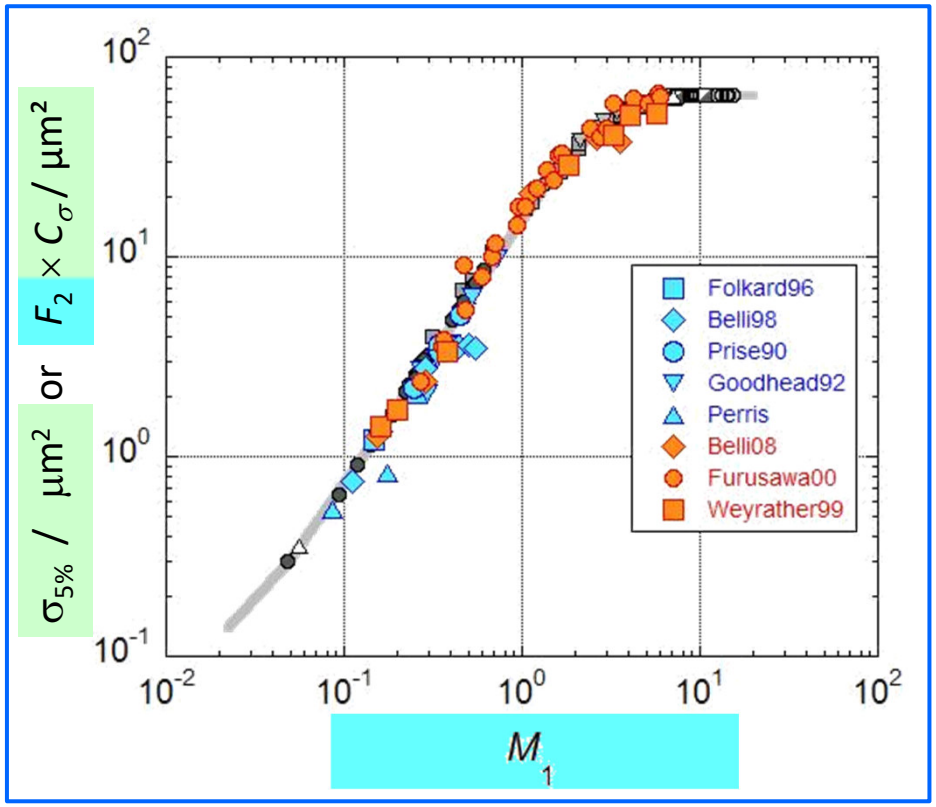

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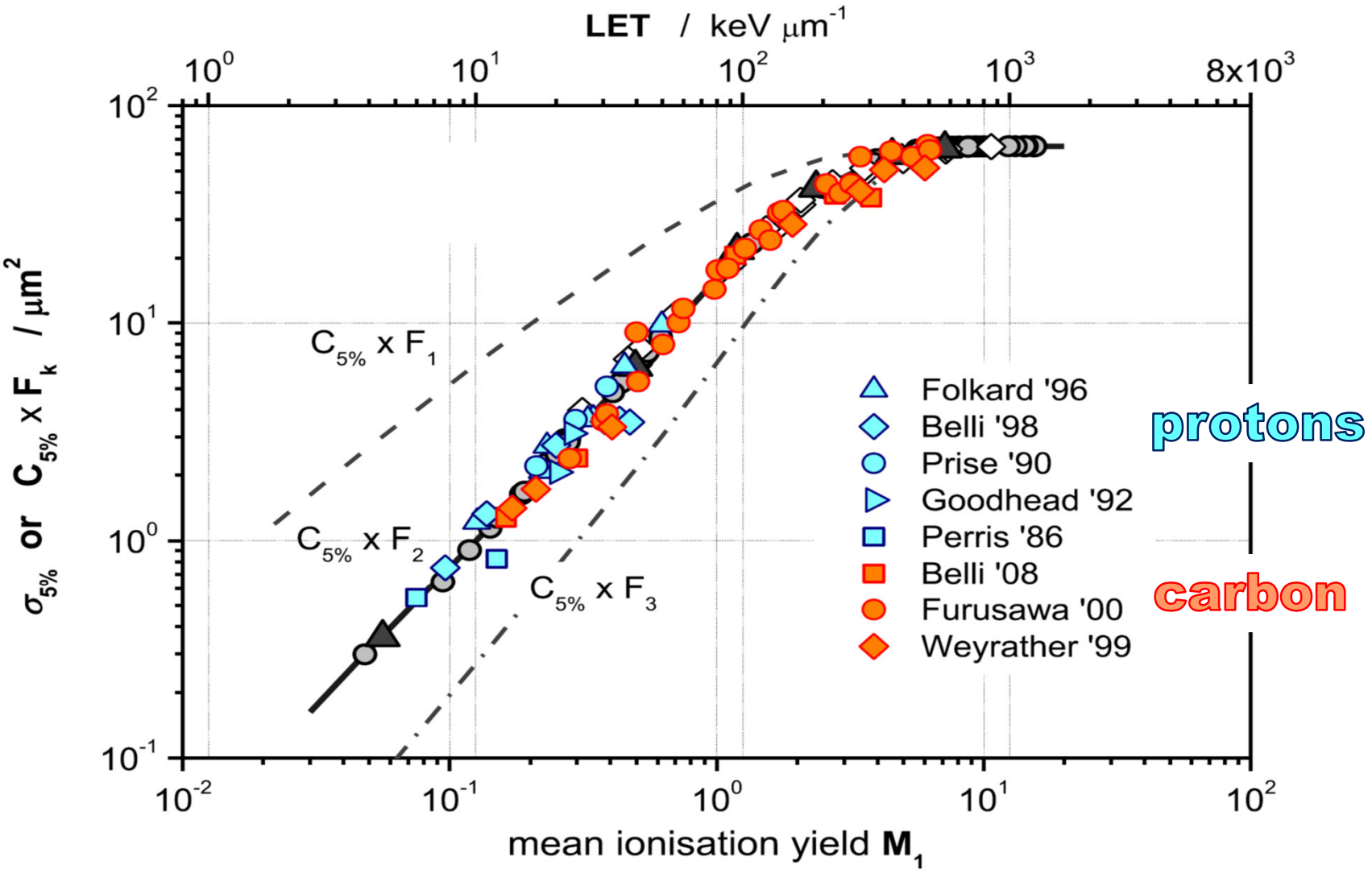

V. Conte et al., Radiat. Meas. 106 (2017) 506-511

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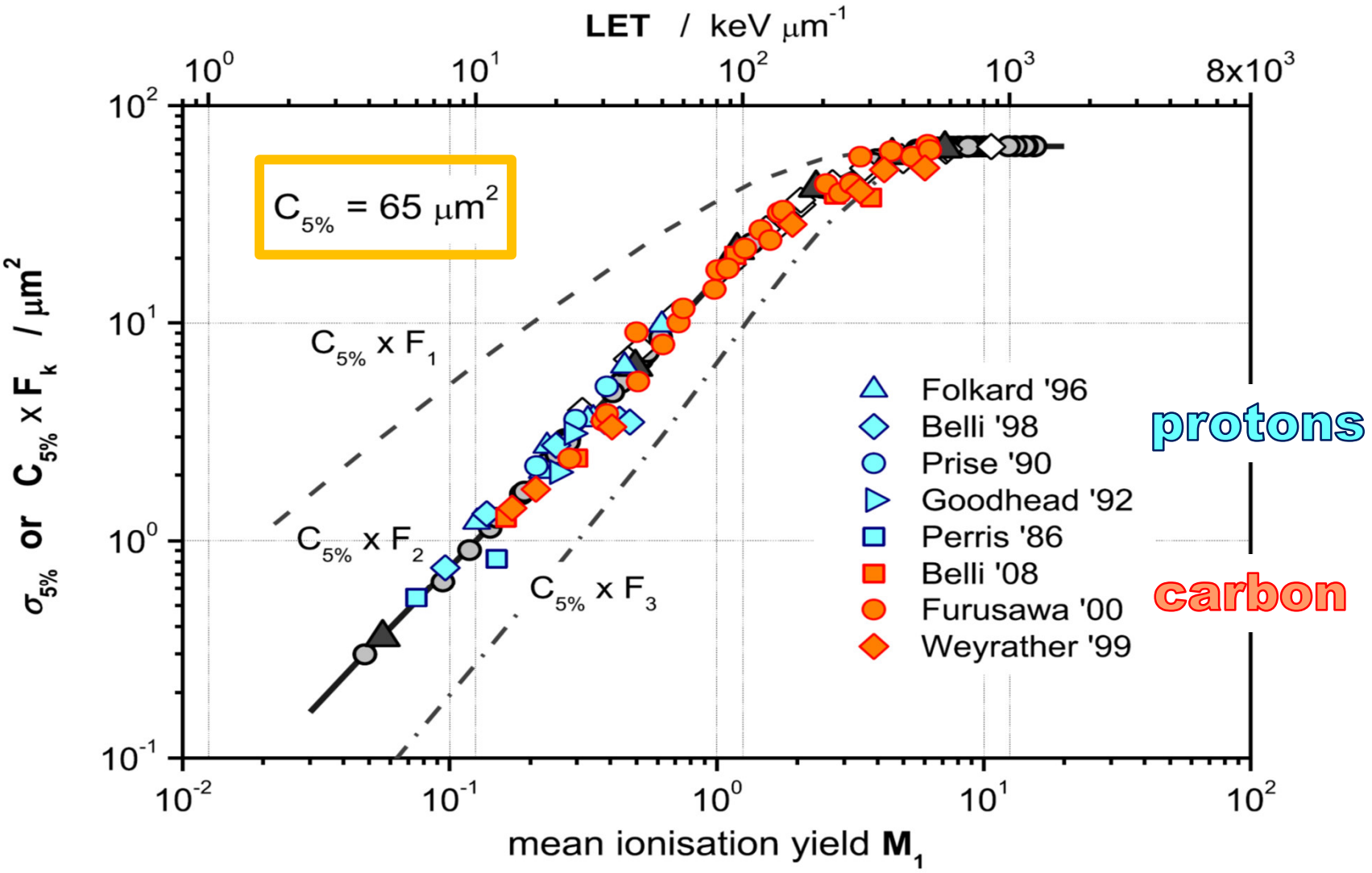

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- Measurements with three different types nanodosimeters showed unique relation between mean number of ionizations and probability of ionization cluster formation
- The shape of this universal curve reproduces quantitatively dependence of radiobiological effects on radiation quality
- This has also been used to derive parameters of the L-Q-model from nanodosimetric charactersistics of track structure

  →Conte et al., Radiat. Prot. Dosim. 80, 150-156 (2018)

Please write your questions in the chat or send email to hans.rabus@ptb.de

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