Dependence of microdosimetric mean values on the cell nucleus size and eccentricity for radiopharmaceutical alpha emitters

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Huelva (Spain)

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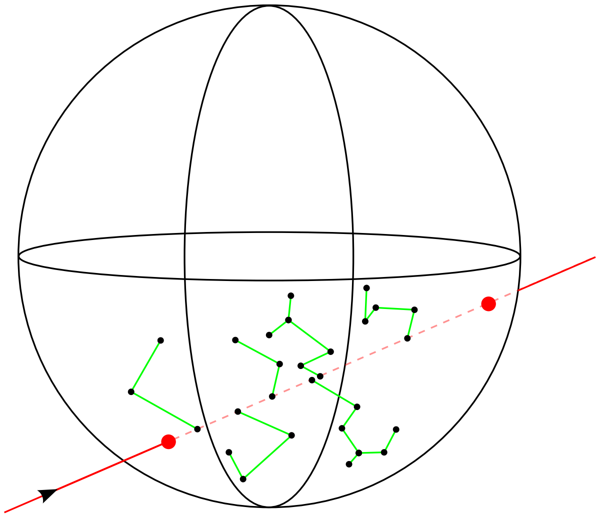

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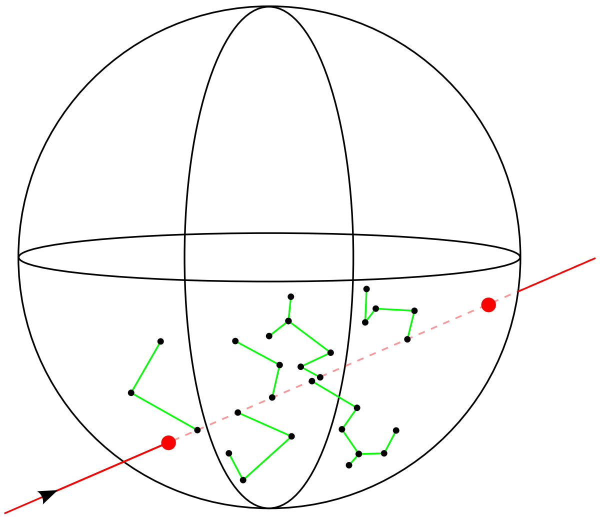

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- Lineal energy $y = \frac{\varepsilon}{\bar{l}}$ — ε → Energy absorbed; $\bar{l}$ → Mean chord length

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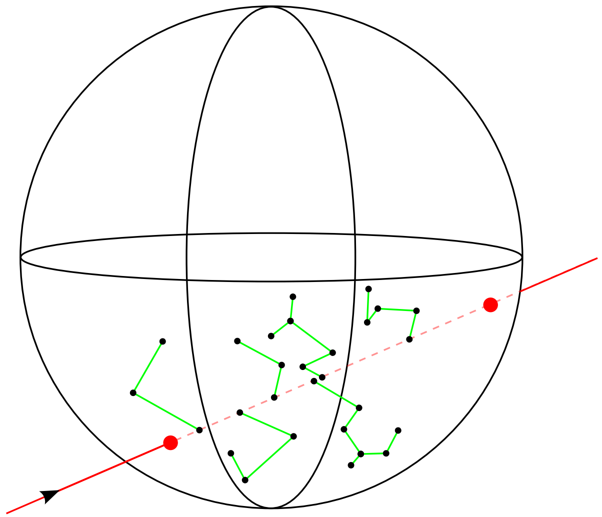

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- Dose-weighted average → defined in terms of the absorbed dose

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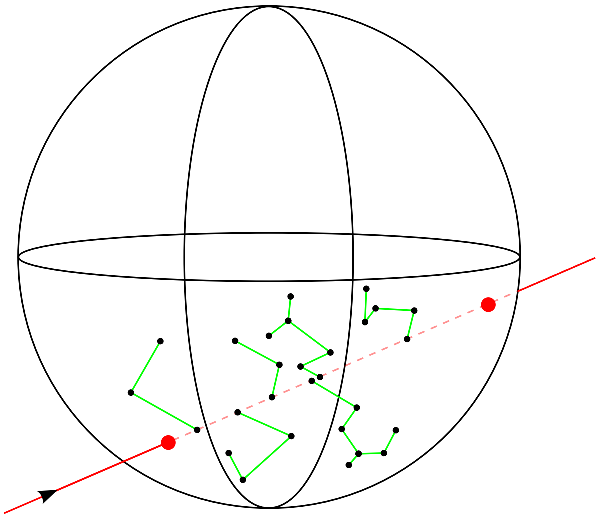

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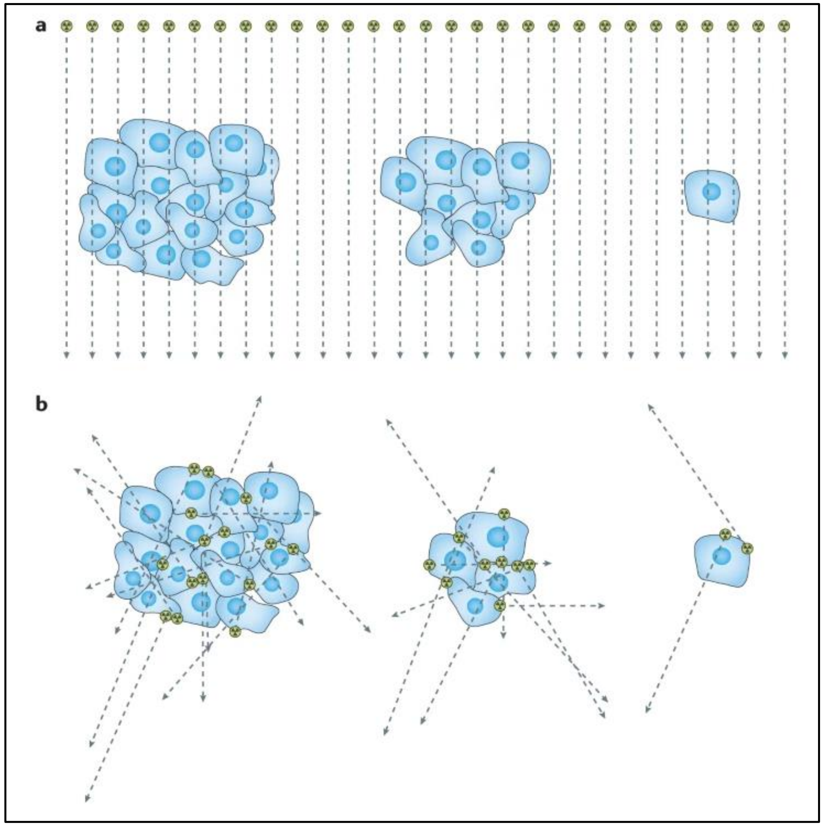

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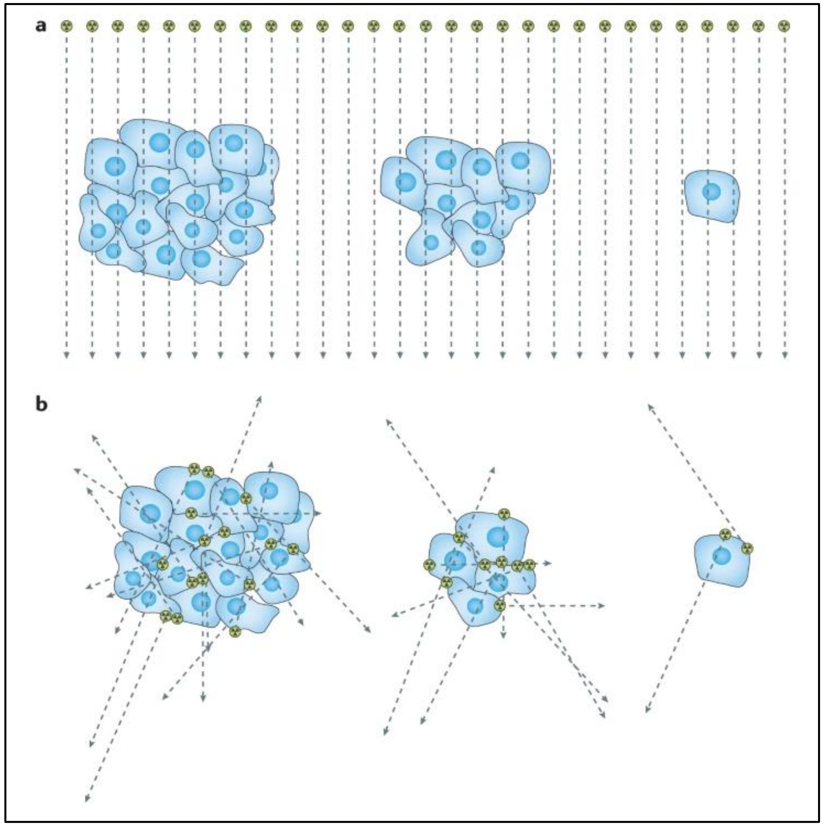

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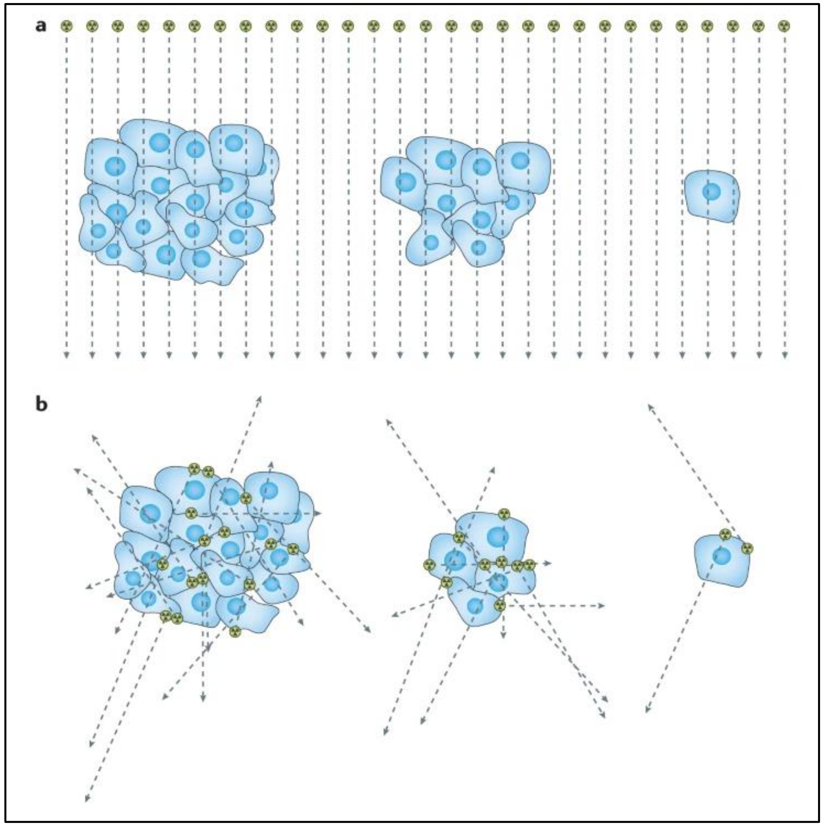

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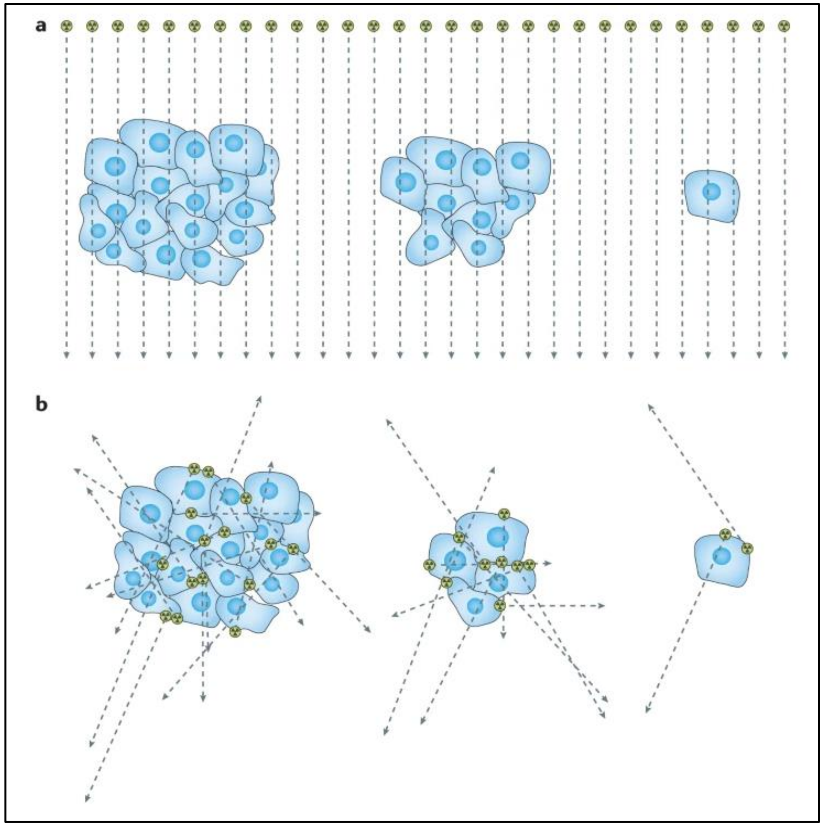

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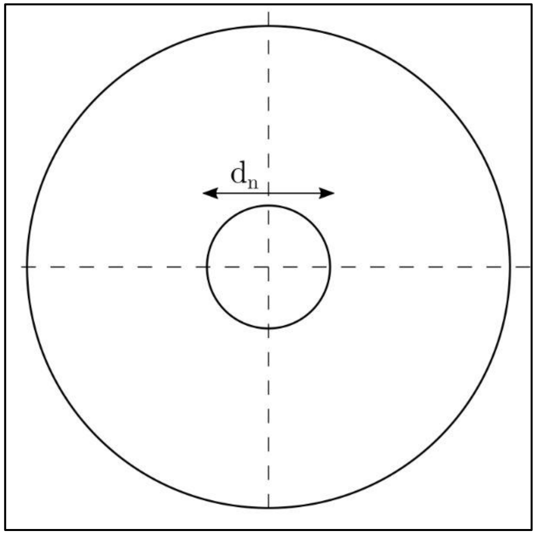

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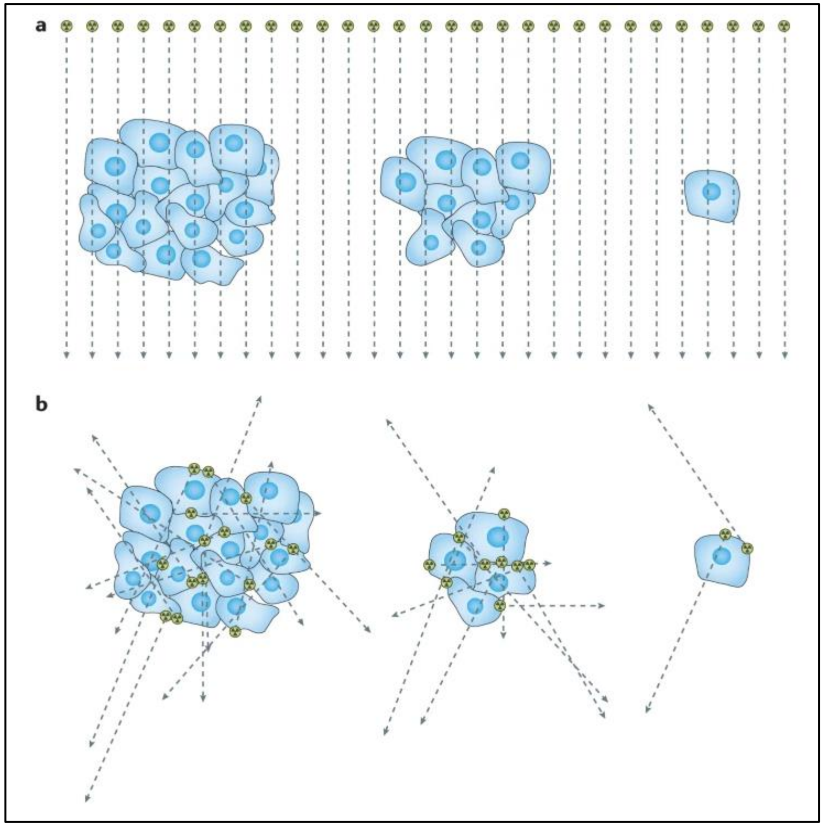

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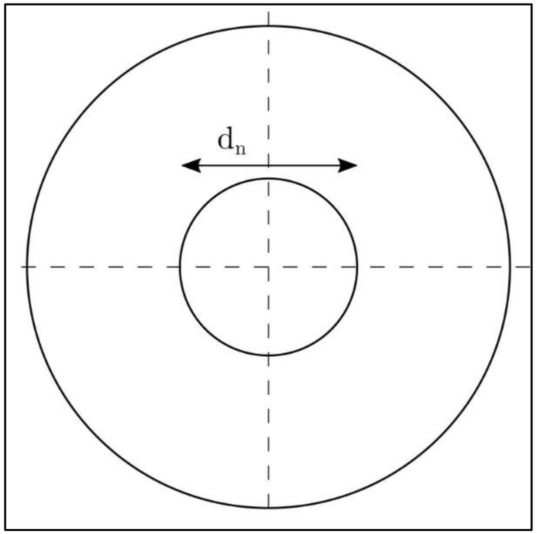

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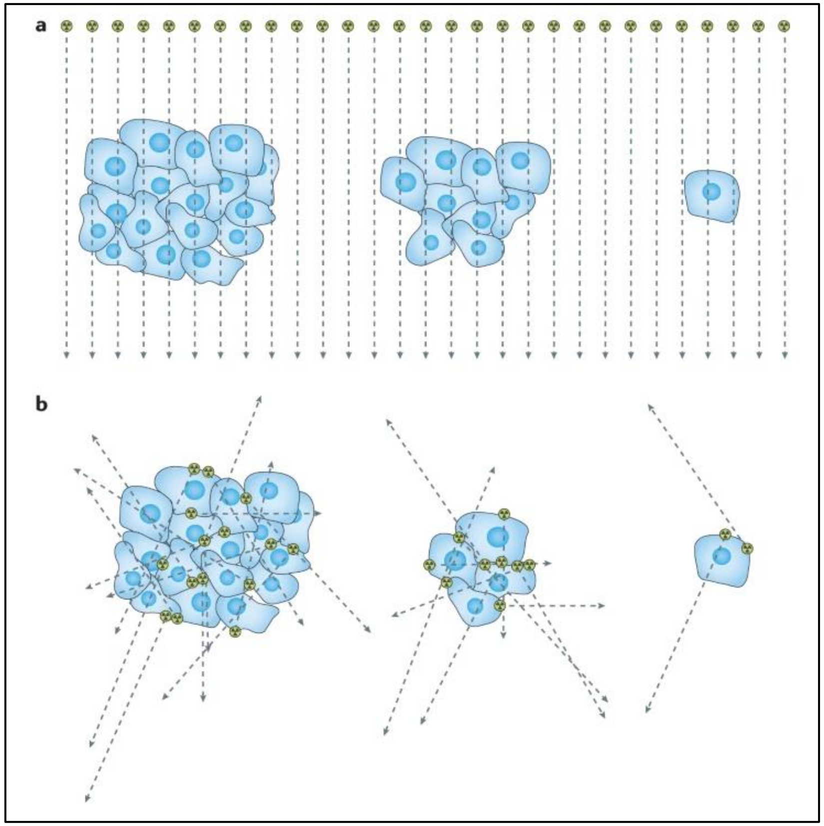

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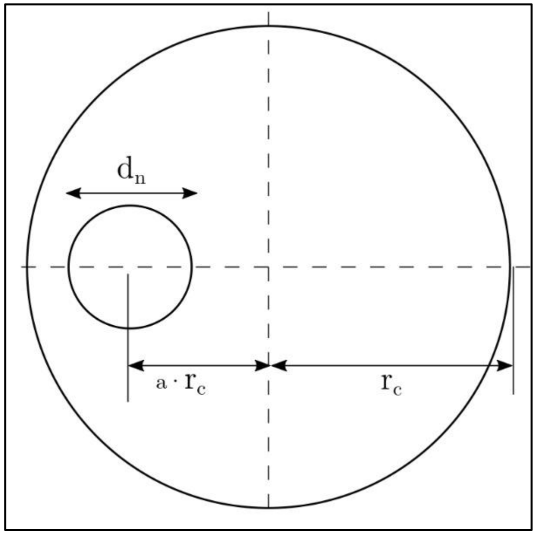
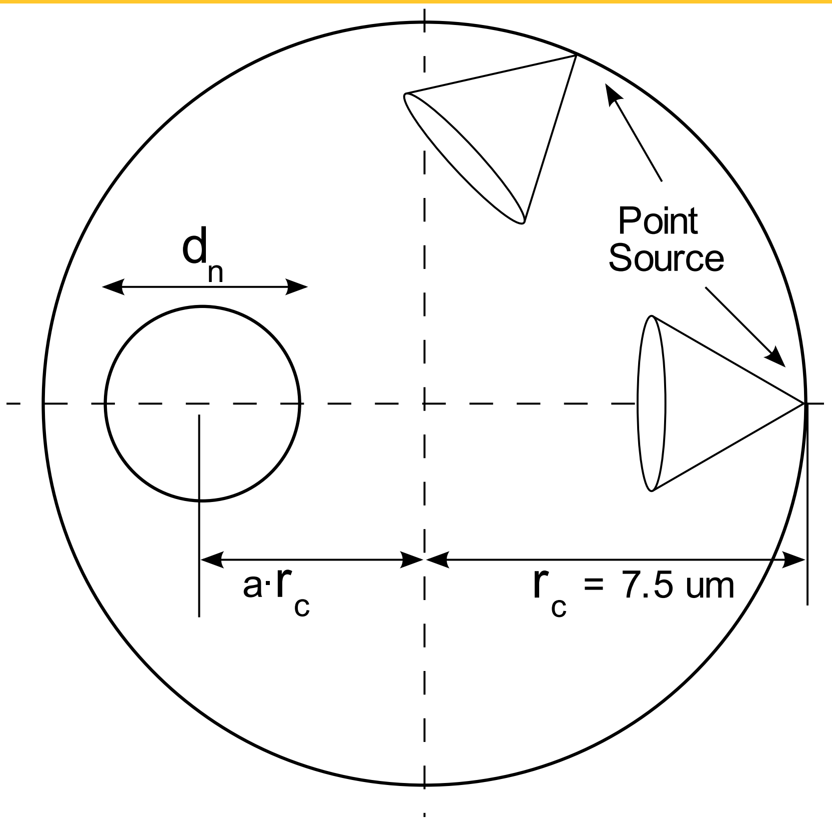


Geant4 Simulation



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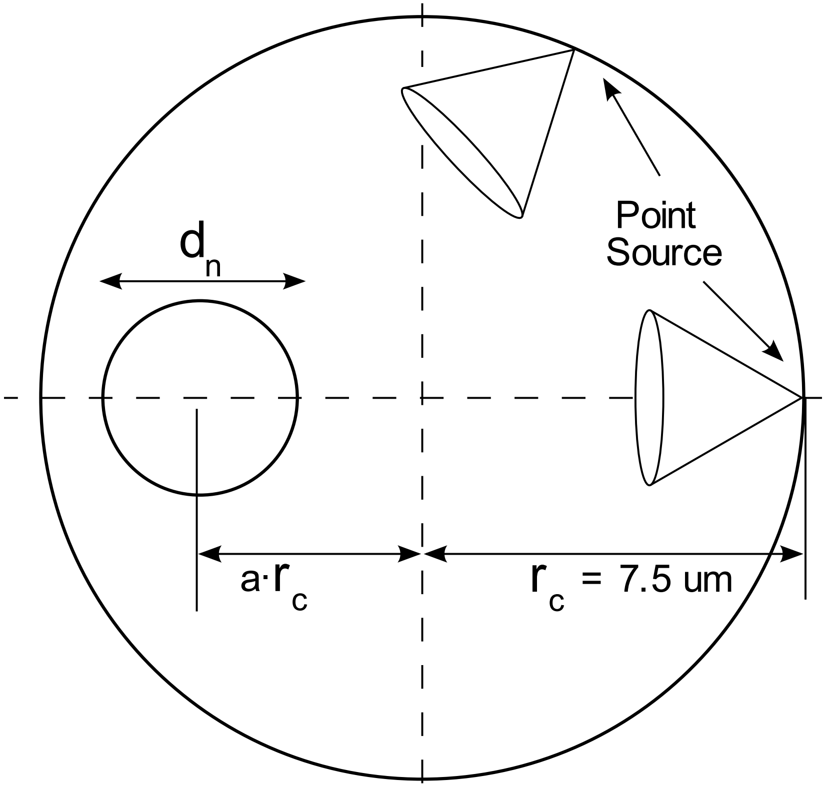

Source ^{211}At

- 5.87 MeV --- 42%
- 7.45 MeV --- 58%

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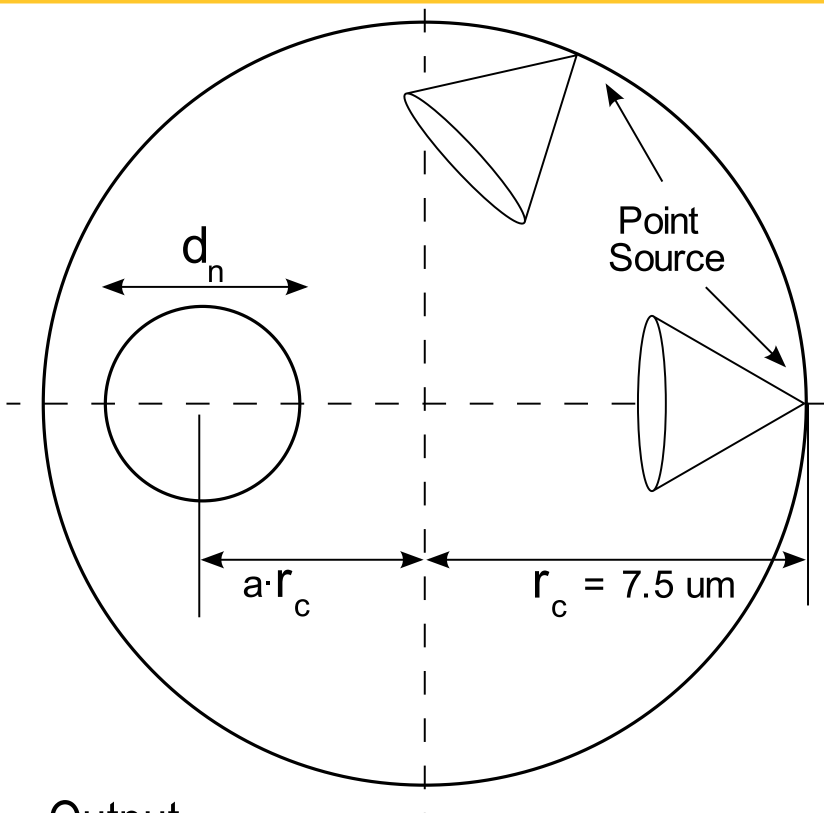

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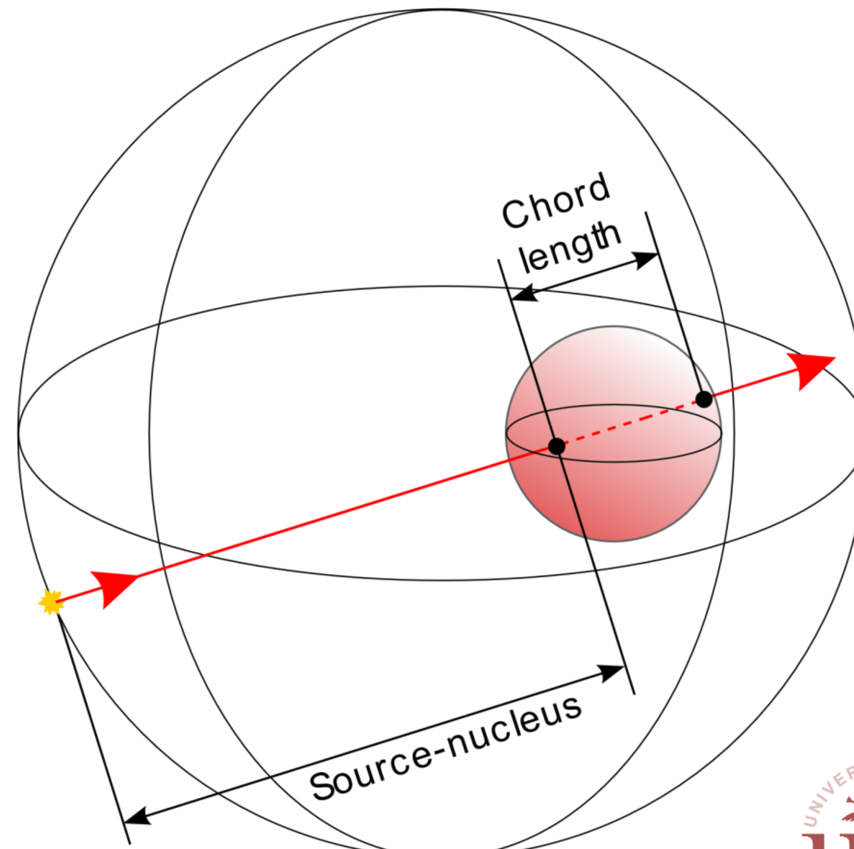

<u>Output</u>

- Distribution of deposited energy
- Distribution of distance source-nucleus
- Distribution of mean chord lenght

Analytical method - Bertolet et al. Radiat. Res. (2020)

- $\overline{\varepsilon_s}(E) \rightarrow$ Mean energy absorbed as a function of the incident energy

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We can get the mean energy absorbed of a polyenergetic beam if the incident spectrum is known

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Similar process with σ_ε^2

$$\overline{z_F} \quad \overline{z_D} \quad \overline{y_F} \quad \overline{y_D}$$

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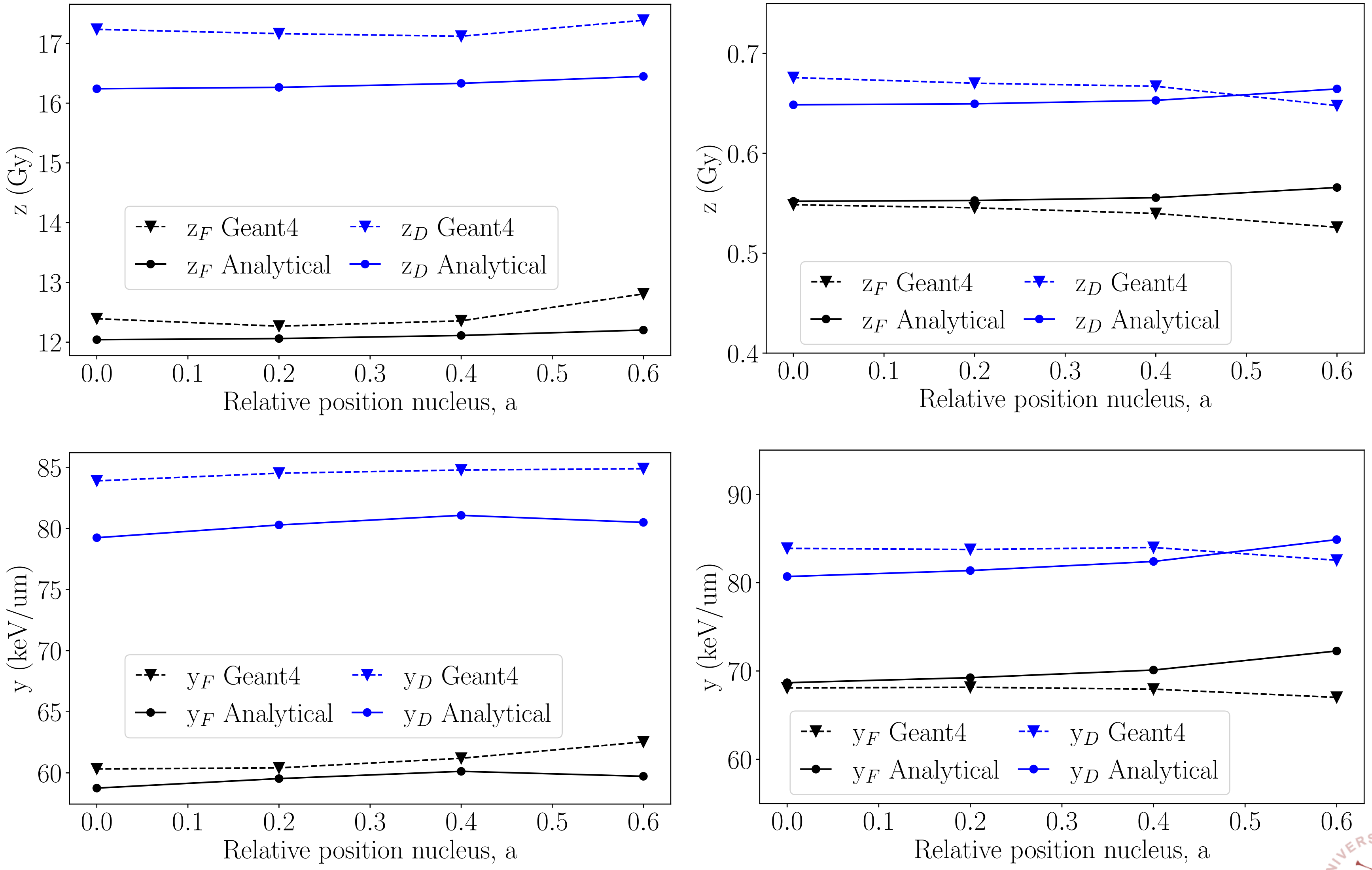
Results

Nucleus radius 0.5 um

Nucleus radius 2.5 um



Conclusions

- Our preliminary results show that the analytical method agrees reasonably well with the Geant4 simulations, even when the cell nucleus is displaced.
- Microdosimetic quantities are not affected significantly by the cell nucleus position.
- The dependence of these microdosimetric quantities on the nucleus radius is clearly more significant.
- In simulations with similar conditions, the displacement of the nucleus within the cell can be disregarded. This phenomenon can help to simplify future studies.

Future…

- To explore the cases where the cell size is comparable with the range of the alpha emitted

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Acknowledgments

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Analytical method - Bertolet et al. Radiat. Res. (2020)

Energy absorbed as a function of the energy of the incident particle

$$\overline{\varepsilon_s}(E) = C_s \cdot \mathrm{erf}(k_s E^{q_s}) \cdot \log(a \cdot E + b_s) \cdot \frac{\alpha \cdot E^{p-1} + e_s}{\alpha \cdot E^p + \frac{4r_s}{3}}$$

$$\sigma_{\varepsilon_s}(E) = C'_s \cdot \mathrm{erf}(k'_s E^{q_{s'}}) \cdot \log(a \cdot E + b'_s) \cdot \frac{\alpha \cdot E^{p-f_{s'}} + e'_s}{\alpha \cdot E^p + \frac{4r_s}{3}}$$

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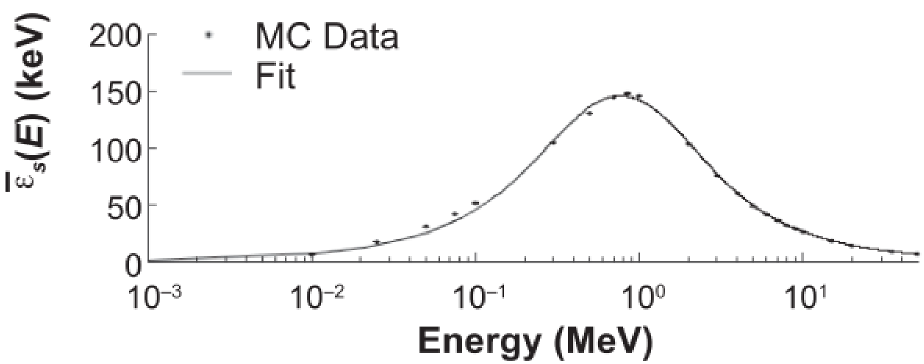

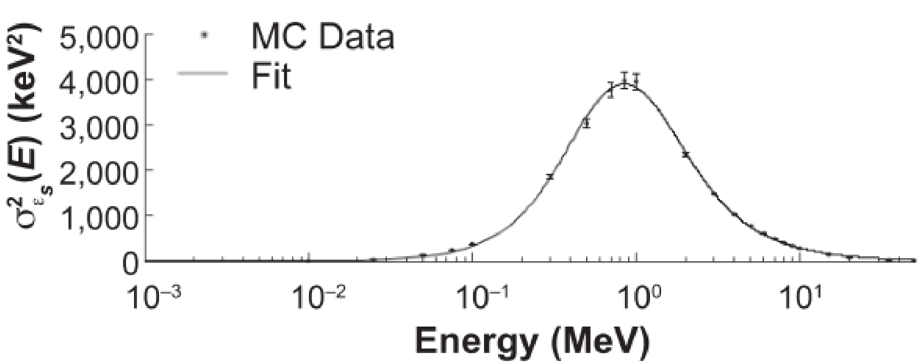

spherical sites with diameters of 1 um

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Energy absorbed as a function of the energy of the incident particle

Distribution of distance source-nucleus → ϕ_{E} (E) Distribution of incident energy

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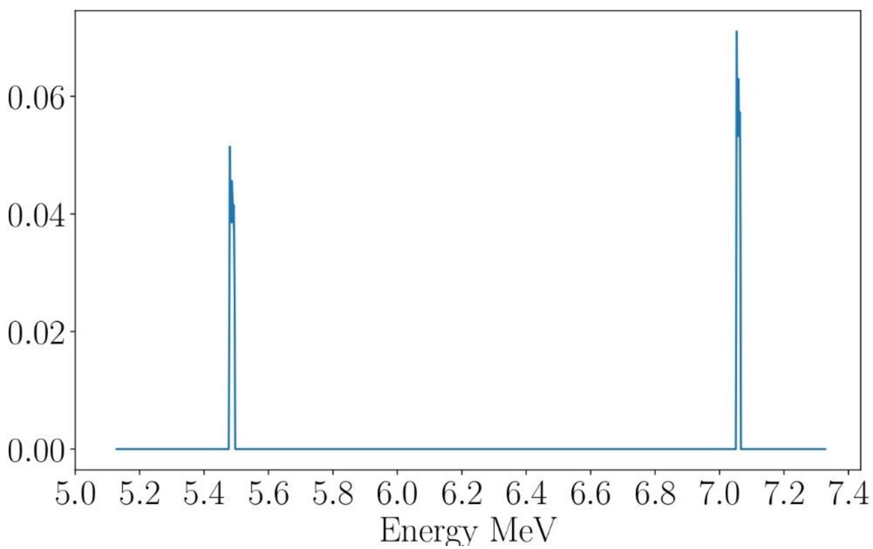
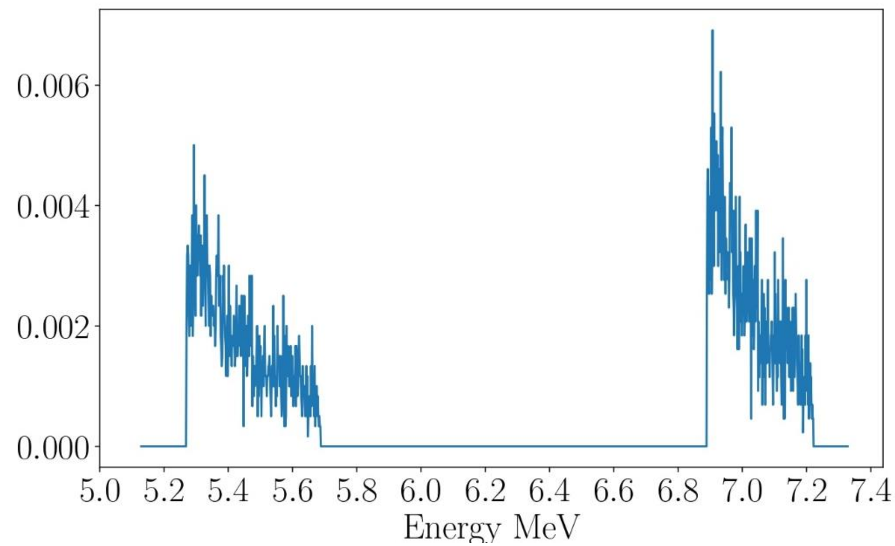


r_n = 2.5 um a = 0.00



r_n = 2.5 um a = 0.60

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$$\sigma^2_{\varepsilon_s} = \frac{\int \phi_E(E)\sigma^2_{\varepsilon_s}(E)dE}{\int \phi_E(E)dE} + \frac{\int \phi(E)(\bar{\varepsilon}_s(E) - \bar{\varepsilon}_s)^2\, dE}{\int \phi_E(E)\, dE}$$

Mean energy absorbed and variance for polyenergetic beams

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Mean energy absorbed and variance for polyenergetic beams

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$$\overline{y_F} = \frac{\overline{\varepsilon_s}}{\bar{l}}$$

$$\overline{z_D} = \frac{\overline{\varepsilon_s}}{m}\left(1 + \frac{\sigma^2_{\varepsilon_s}}{\overline{\varepsilon_s}^2}\right)$$

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