GOLD NANOPARTICLES AS RADIOSENSITIZERS IN CANCER RADIOTHERAPY: A MONTE CARLO STUDY

Joana Antunes[1,2], Jorge Miguel Sampaio[1,2], Filipa Mendes[3], António Paulo[3]

[1]LIP - Laboratório de Instrumentação e Física Experimental de Partículas, Dosimetria, Lisbon, Portugal.
[2]FCUL - Faculdade de Ciências da Universidade de Lisboa, Physics, Lisbon, Portugal.
[3]C2TN - Centro de Ciências e Tecnologias Nucleares, DECN - Departamento de Engenharia e Ciências Nucleares, IST, Portugal.

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RADIOTHERAPY COMBINED WITH AuNPs

The combination of high-Z nanoparticles and external radiotherapy leads to an **increased radiation effect in tumoral cells** without an increase of the patient dose [1].

Emission of secondary particles
Increase the production of ROS
→ Increase the radiobiological effect

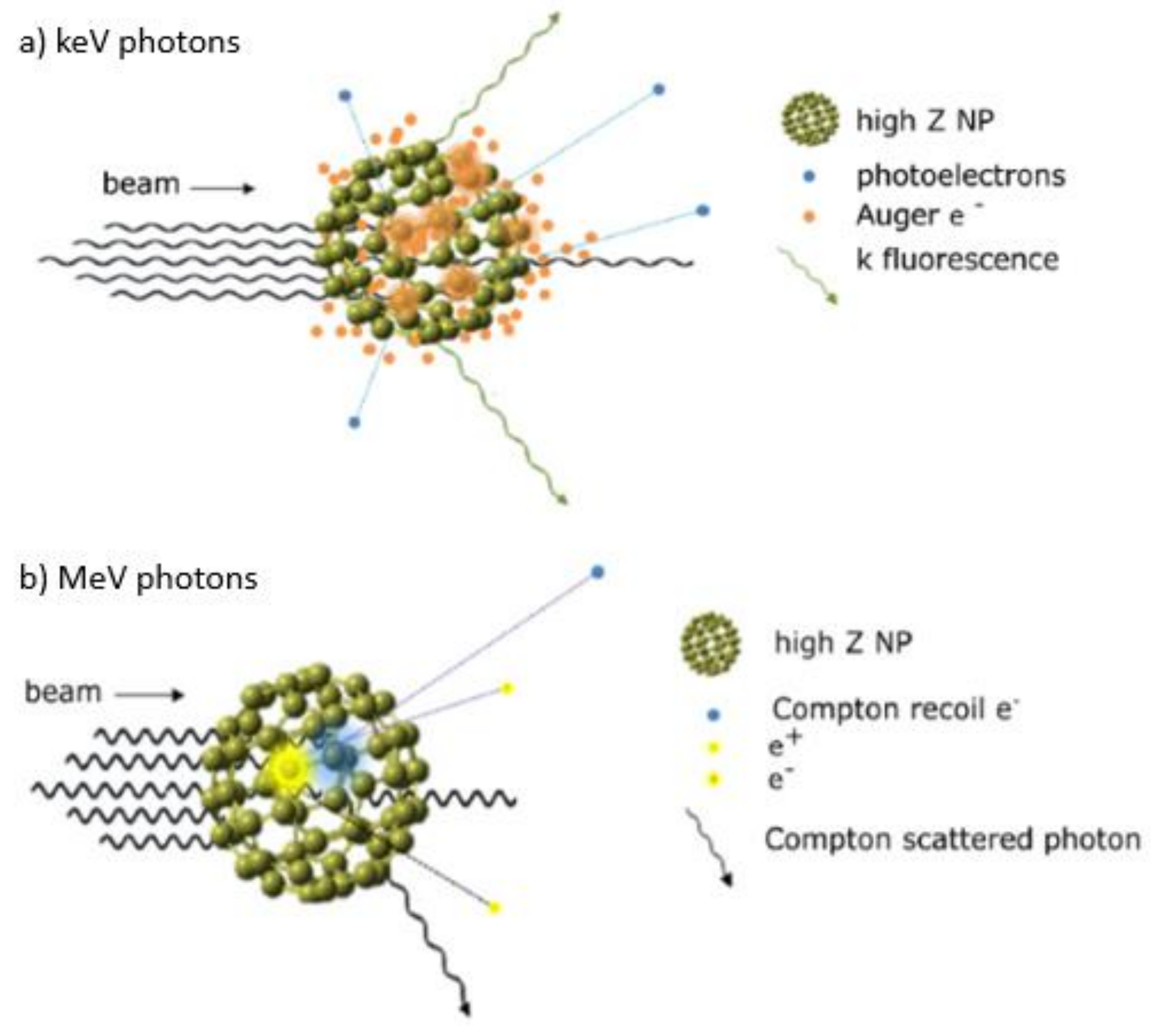

Figure 1. Interaction between the radiation and the NP [1].

OBJECTIVE

Develop **realistic simulations** to model the effect of **AuNPs** on the biological response of GBMs and **compare** the results obtained using a **spherical cell geometry and a realistic cell model with the experimental values.** .

MONTE CARLO SIMULATIONS

Simulations were carried out using **TOPAS** [2] and **TOPAS-nBio** [3].

Geometry: Realistic vs **Spherical** Cell Models

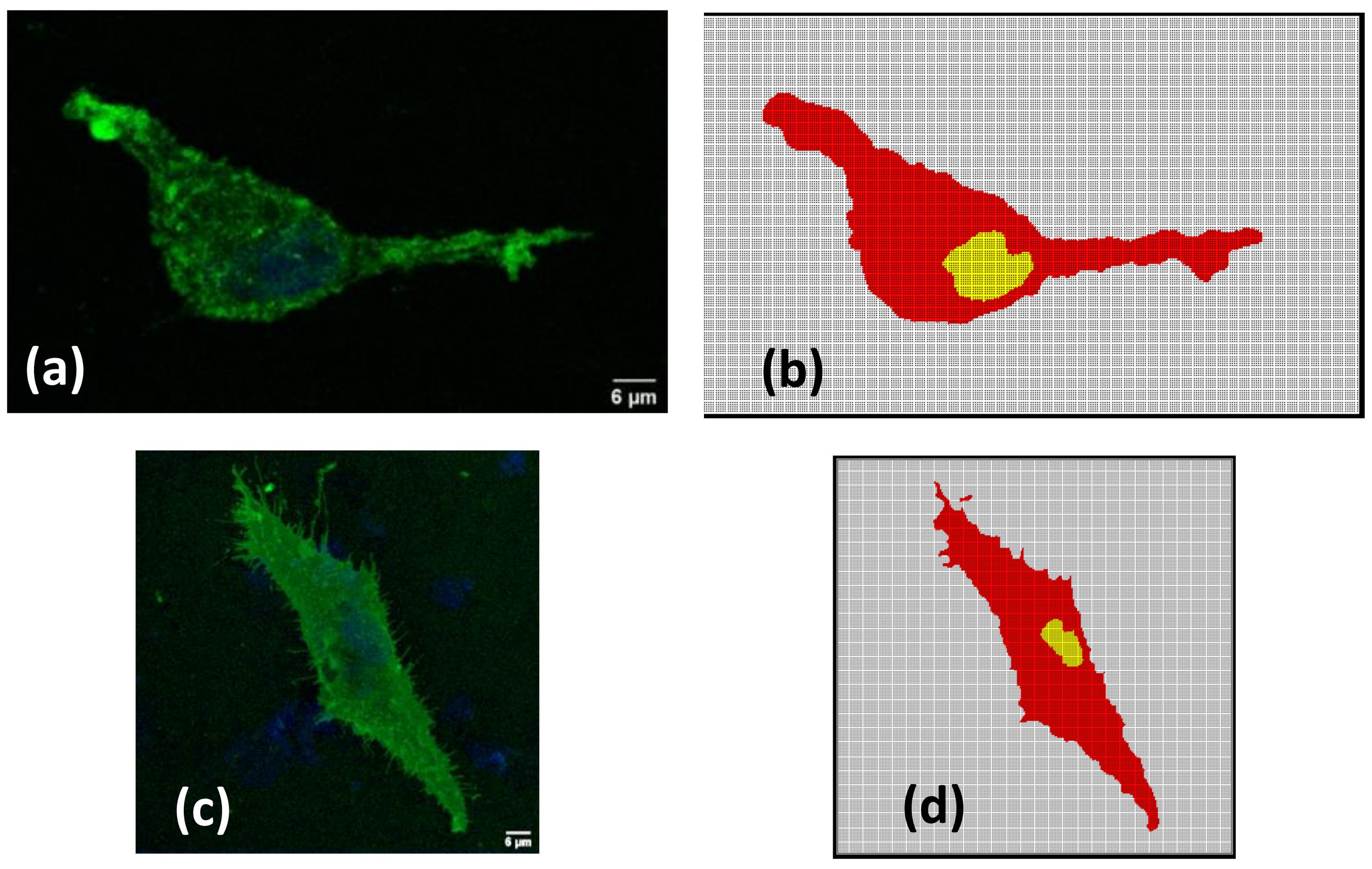

Figure 2. Realistic cell geometry modeling. **(a)** central slice of the confocal microscopy image and **(b)** the reconstructed cell phantom defined in TOPAS of GBM cell line U87; **(c)** central slice of the confocal microscopy stack and **(d)** the equivalent slice of the reconstructed cell phantom defined in TOPAS of GBM cell line U373.

Spherical cell models - three variants were simulated:

- **Geometry 1**: volume-based sizing
- **Geometry 2:** cross-sectional area and ratio cytoplasm/nucleus sizing
- **Geometry 3:** thickness and ratio cytoplasm/nucleus sizing

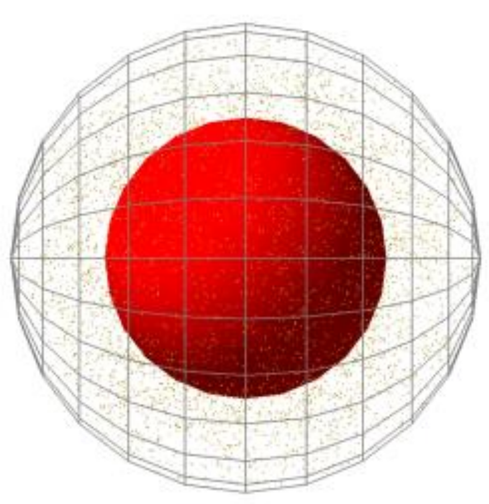

Figure 3. Spherical cell model.

Irradiation: Cobalt-60 source

- Beam direction perpendicular to the cell plane

Physics List: Geant4-DNA and Livermore

Score: Deposited energy in each voxel of the phantom.

↓

Deposited Dose per primary particle D_N on the Nucleus → **Linear Quadratic Model**

$$d = N * D_N$$

$$L_n = \begin{cases} \alpha d + \beta d^2, d \leq D_t \\ (\alpha + 2\beta D_t)d - \beta D_t^2), \quad d > D_t \end{cases}$$

$$S = \exp(-L_n)$$

Results: EXPERIMENTAL VS MC SIMULATION

The **best agreement** with the experimental data is obtained when simulations using the **realistic cell model** are performed, in the absence and in the presence of AuNPs.

The results obtained using a **spherical cell model vary a lot with the size** of the cell and the nucleus [4].

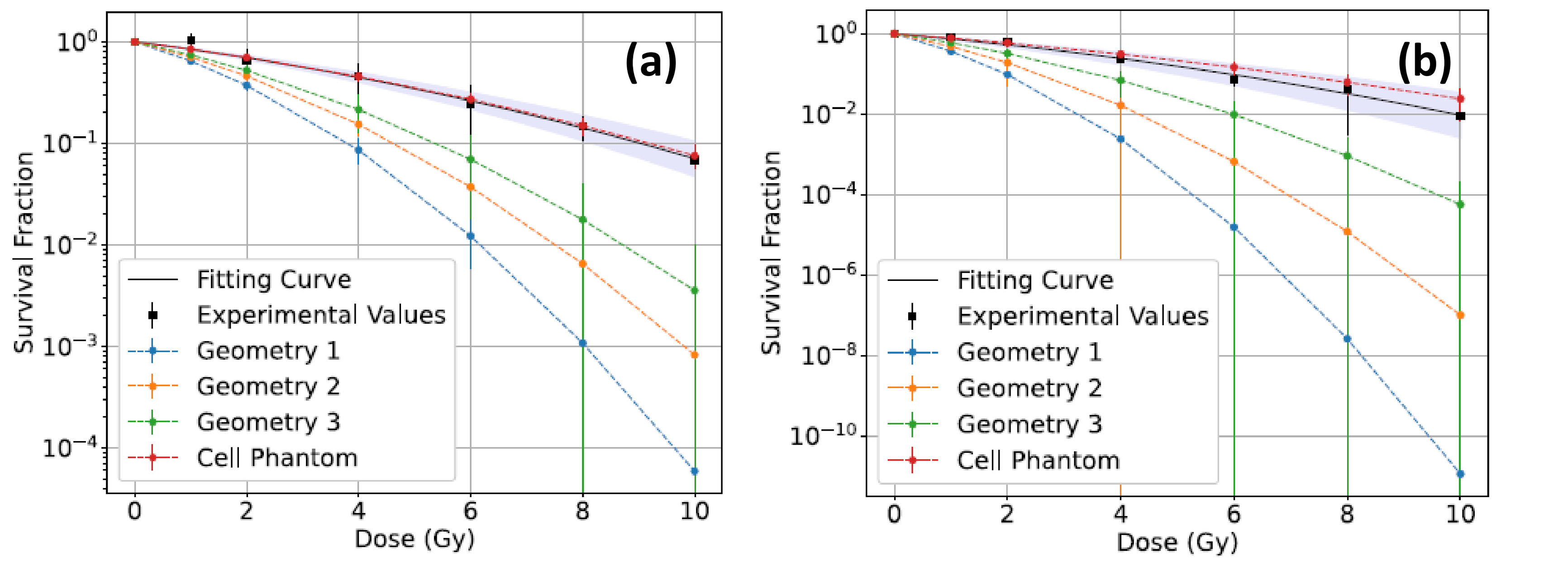

Figure 4. Comparison of the experimental survival curve with the ones obtained by MC simulation, in the absence of AuNPs, for (a) U87 and (b) U373 cell lines.

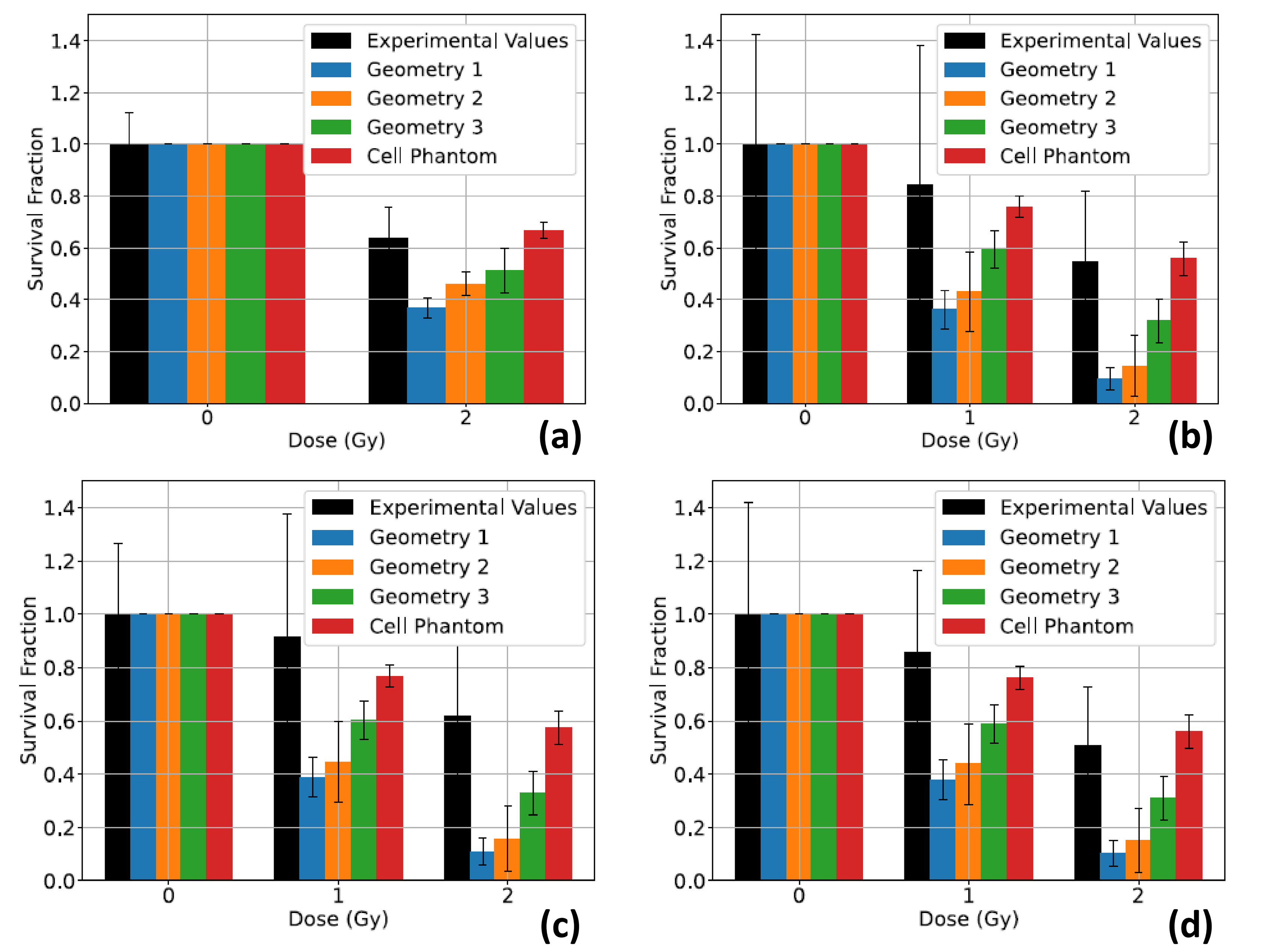

Figure 5. Comparison between the measured survival fractions and MC simulations for different AuNPs concentrations and the two GBM cell lines: (a) 20 µg/ml for the U87 line; (b) 10 µg/ml, (c) 20 µg/ml, and (c) 40 µg/ml for the U373 line.

CONCLUSION

Realistic cell geometry modeling was **essential** to **benchmark** the simulations against the **experimental** results with a Co-60 source.

References

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