

MODELLING CELL SURVIVAL IN AUNP-ENHANCED RADIOTHERAPY USING VOXELIZED CELL GEOMETRIES

8th LIP/IDPASC PhD Students Workshop

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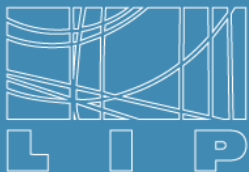
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LABORATÓRIO DE INSTRUMENTAÇÃO
E FÍSICA EXPERIMENTAL DE PARTÍCULAS



Ciências
ULisboa



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Braga

RADIOTHERAPY COMBINED WITH AuNPs

Consists in irradiate the cells with **ionizing radiation** to destroy the macromolecules, as DNA.

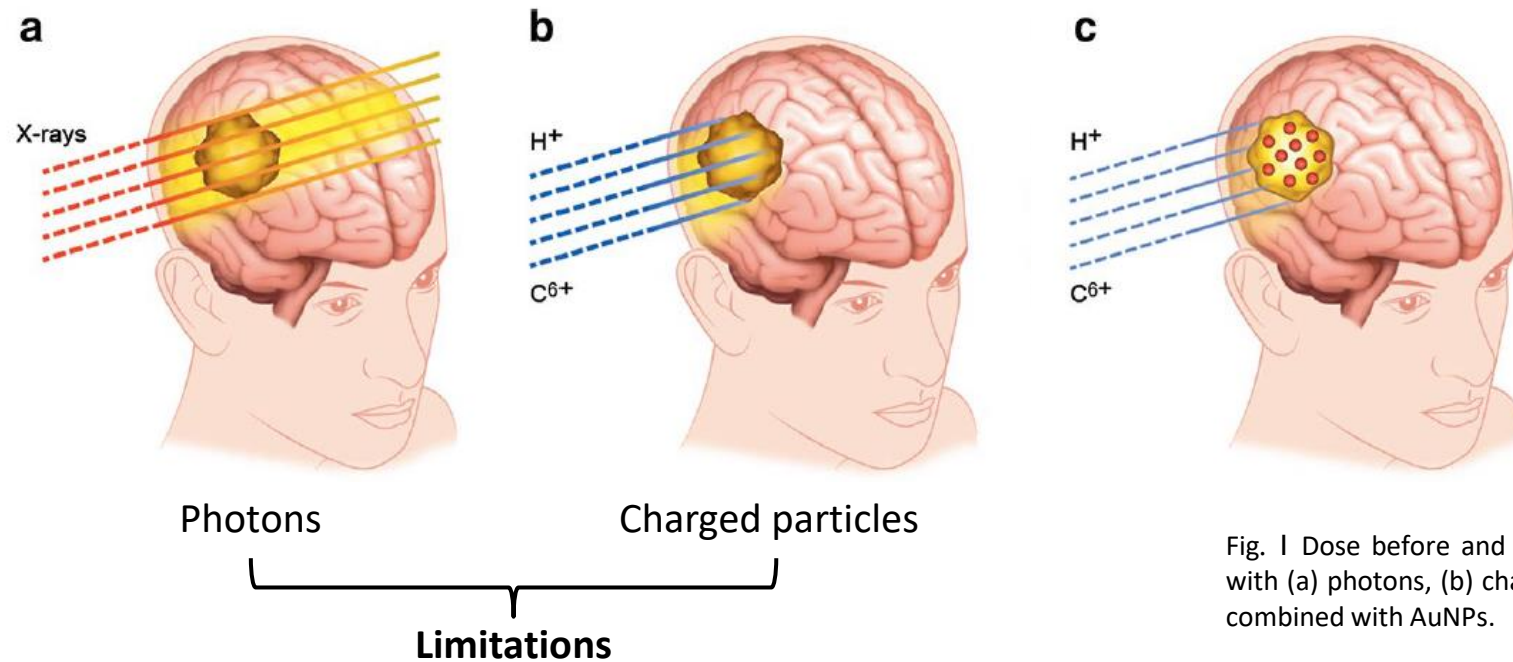
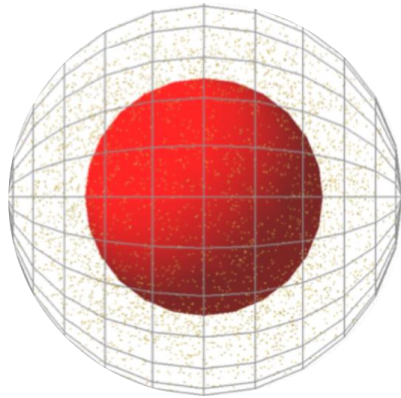


Fig. 1 Dose before and after the tumor due to radiotherapy with (a) photons, (b) charge particles and (c) charge particles combined with AuNPs.

Solution: Enrich the tumor with radiosensitizers in order to increase the selectivity of the tumor to radiation.

MONTE CARLO SIMULATIONS



Easy to simulate
Several models available



Do not use a realistic morphology

At nanoscale, this can be problematic!



Implementation of detailed computational cell models in MC simulations

Acquisition of a confocal
microscopy z-stack



For each slice of the z-stack:

Preprocessing



Segmentation



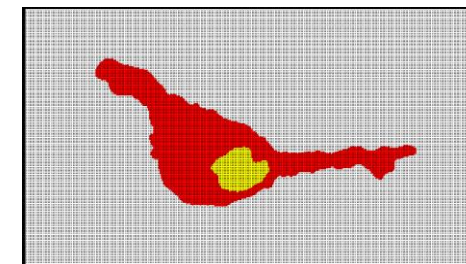
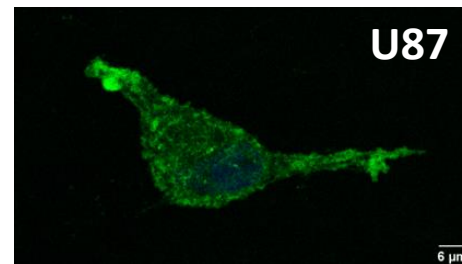
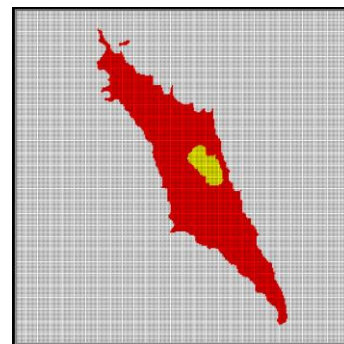
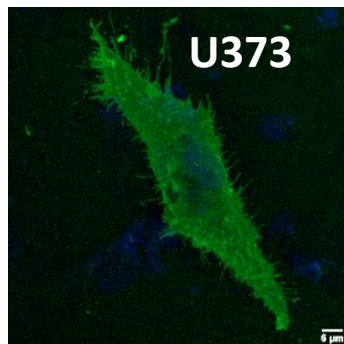
A specific tag number was associated
to each segmented component



Binary File



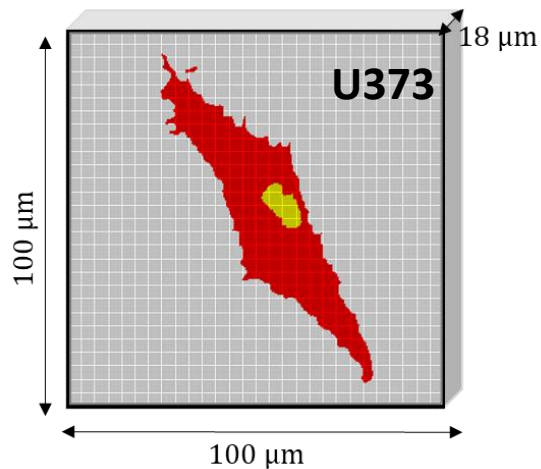
Import to TOPAS



MONTE CARLO SIMULATIONS – U373 CELL LINE

Our first objective was to reproduce the radiobiological experiments performed at ICNAS and C2TN, in the absence and in the presence of AuNPs.

GEOMETRY



In the presence of AuNPs, simulations were conducted considering:

- the experimentally determined uptake of the AuNP-BBN
- the size of the AuNP core
- a uniform distribution within the cell cytoplasm

SOURCE

- Co-60 γ -rays
- 160 kVp X-ray
- Proton beam - ICNAS

SIMULATION OUTUP

Deposited energy in each voxel of the detailed computational cell model.



Local Effect Model

Survival Curve

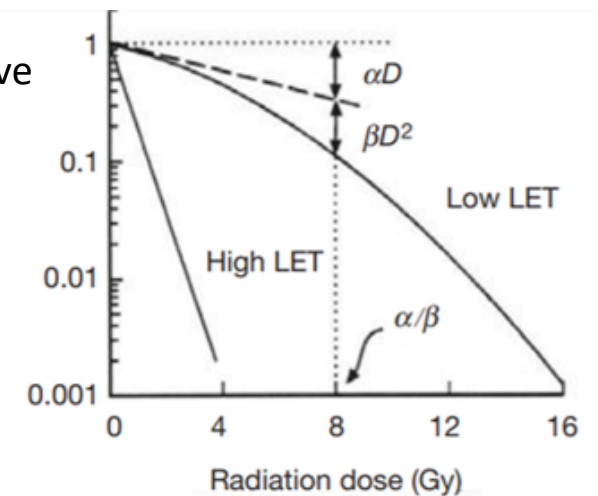


Fig. 3 Typical cell survival curves for high and low LET radiation.

SURVIVAL FRACTION

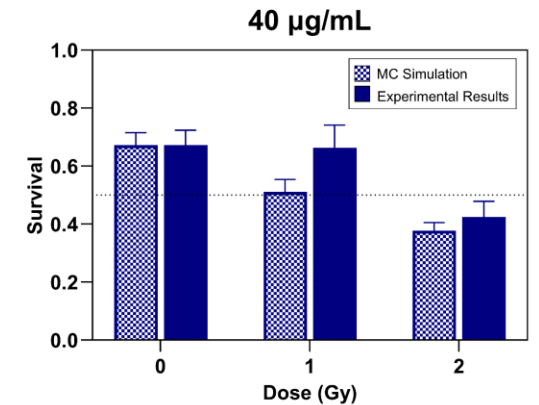
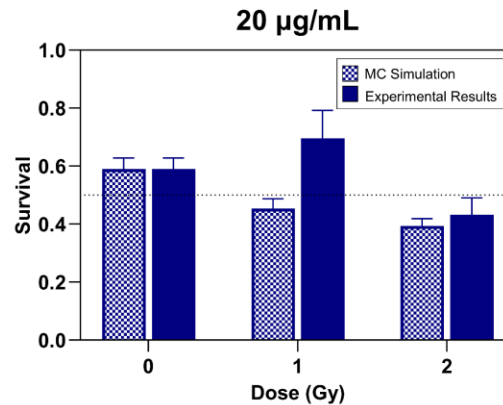
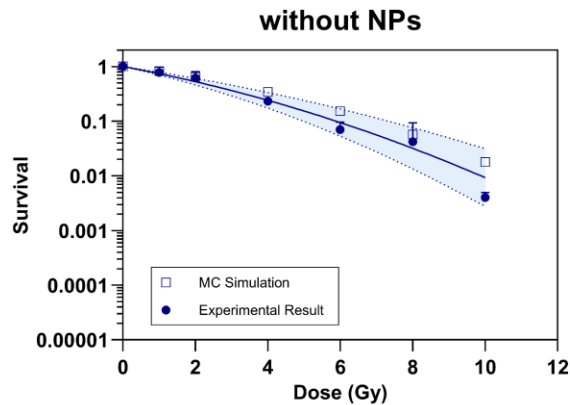
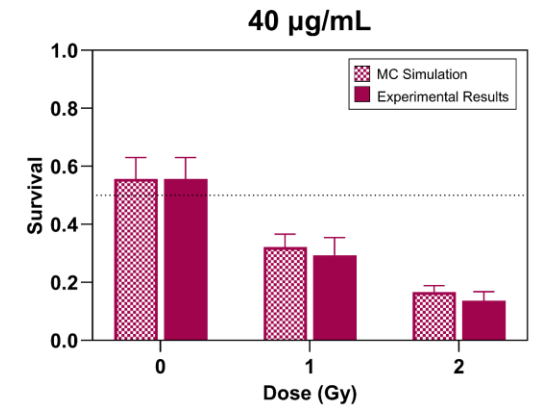
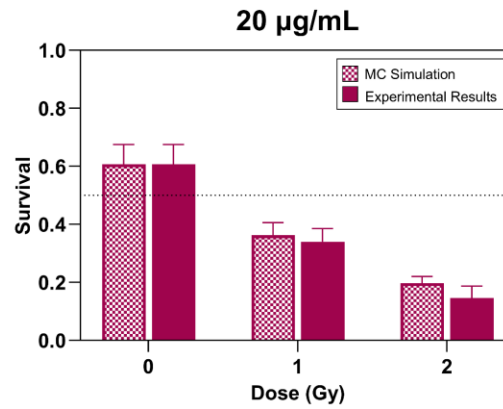
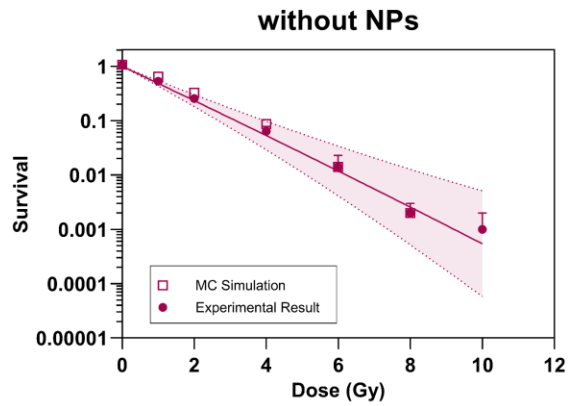
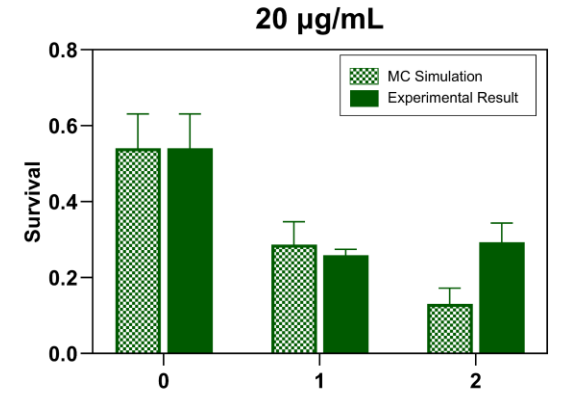
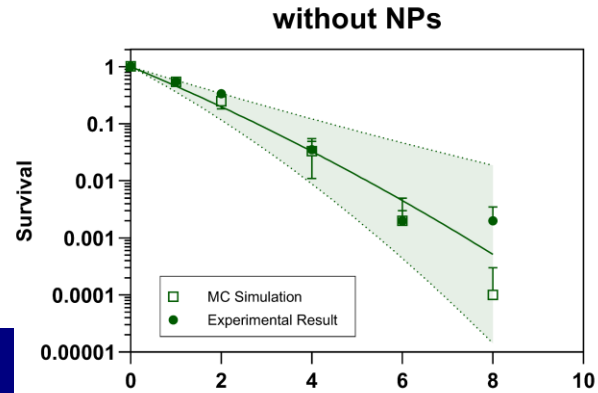
Experimental vs MC simulation

U373 cell line

Protons - ICNAS

160 kVp X-rays

Co-60 γ -rays



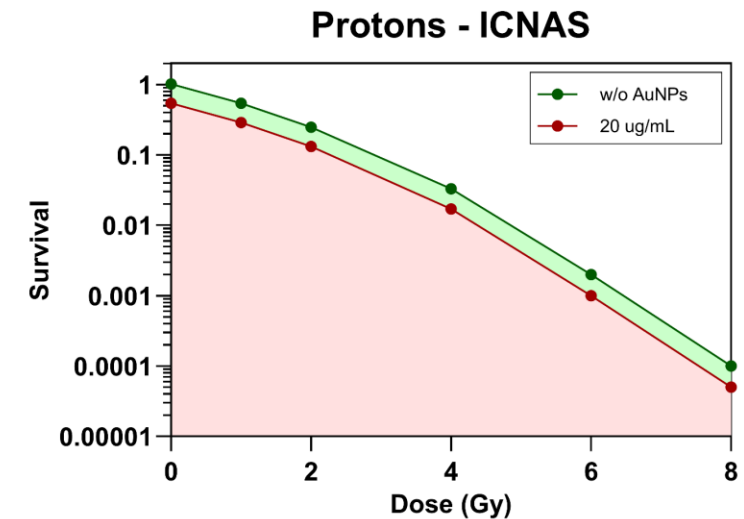
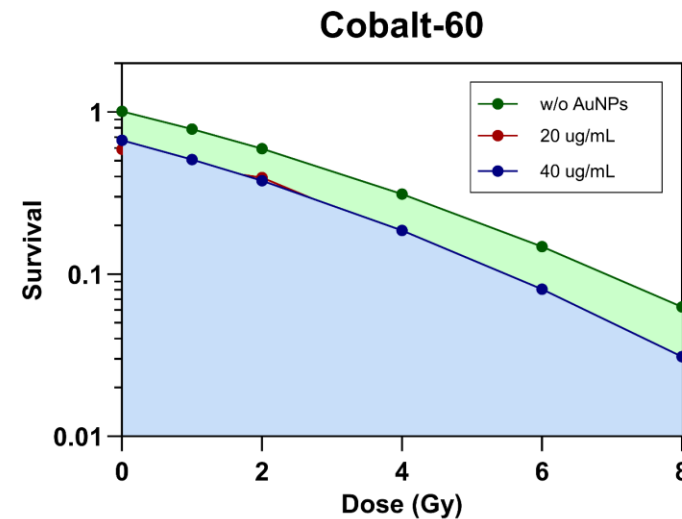
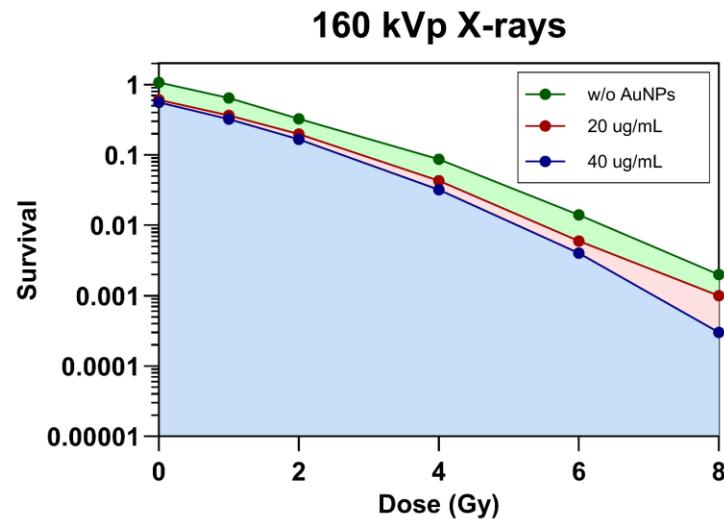
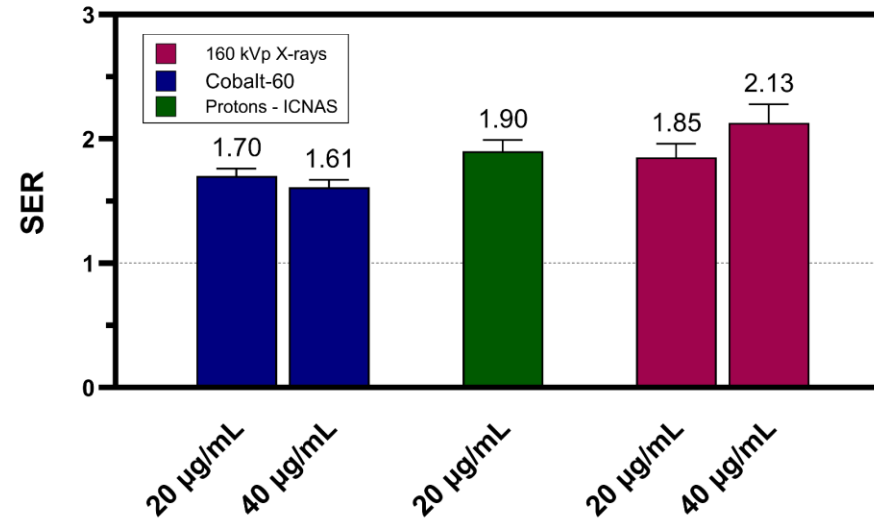
SENSITIVE ENHANCEMENT RATIO

MC SIMULATION

U373 CELL LINE

$$SER = \frac{MID_{\text{without AuNPs}}}{MID_{\text{with AuNPs}}}$$

Mean Inactivation Dose



FUTURE WORK



Estimation of the direct and indirect DNA damage

Ongoing



Evaluating the ROS production as a function of NP size and number

Ongoing



Cell irradiation with RT protons (MDACC-UT)



Compare the results with experimental data.

ACKNOWLEDGMENTS



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FCT UIDP/50007/2020

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QUESTIONS?

