PhD Open Days

CENTRO DE CIÊNCIAS E TECNOLOGIAS NUCLEARES

DEUTSCHES KREBSFORSCHUNGSZENTRUM IN DER HELMHOLTZ-GEMEINSCHAFT

Nanodosimetry and Radiobiological Studies in Different Tumor Phenotypes for Combined Radionuclide and Proton Beam Therapy

DOCTORAL PROGRAMME IN TECHNOLOGICAL PHYSICS ENGINEERING

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Introduction

- Recent studies have used multi-parametric imaging to distinguish between different tumor phenotypes [1, 2].
- There are different types of cancer treatment evolving radiation, such as photon external beam radiotherapy (EBRT), Radionuclide Therapy (RNT), proton therapy (PBT), among others.
- An innovative trend is emerging in clinical oncology to shift from monotherapy toward combined cancer therapy, which can result in higher therapeutic effect [3].
- In the vast majority of RT cases in clinical environment, treatment planning is performed considering that the tumor mass is homogenous.

Tumors often display different types of heterogeneity at the time of diagnosis.

Tumor phenotype: tumor sub-volume comprised of cells with different genetic characteristics (and possibly different responses to ionizing radiation) than other cells in the tumor.

Not considering tumor phenotypes may compromise radiation therapy efficacy and entail higher damage to the surrounding tissues.

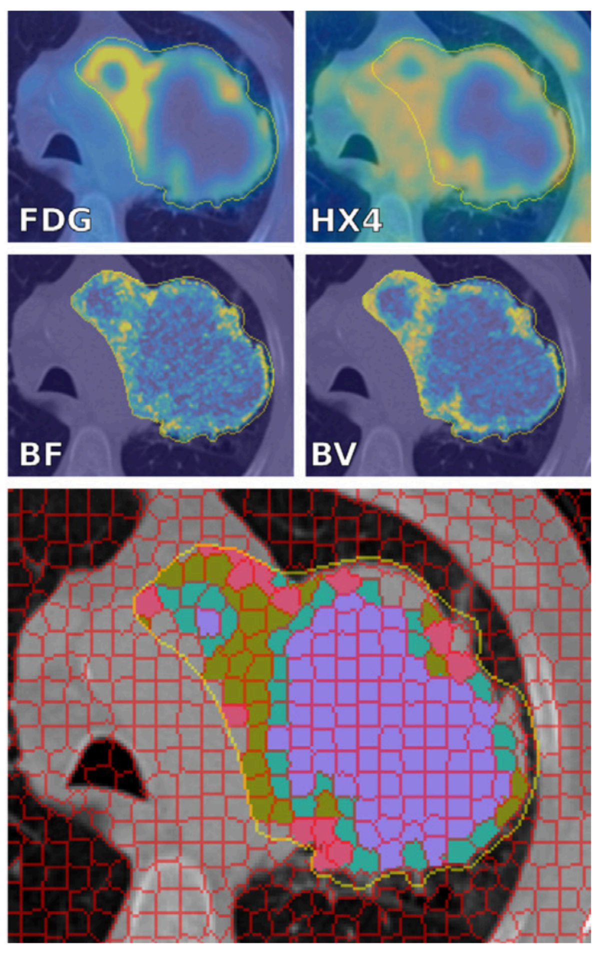


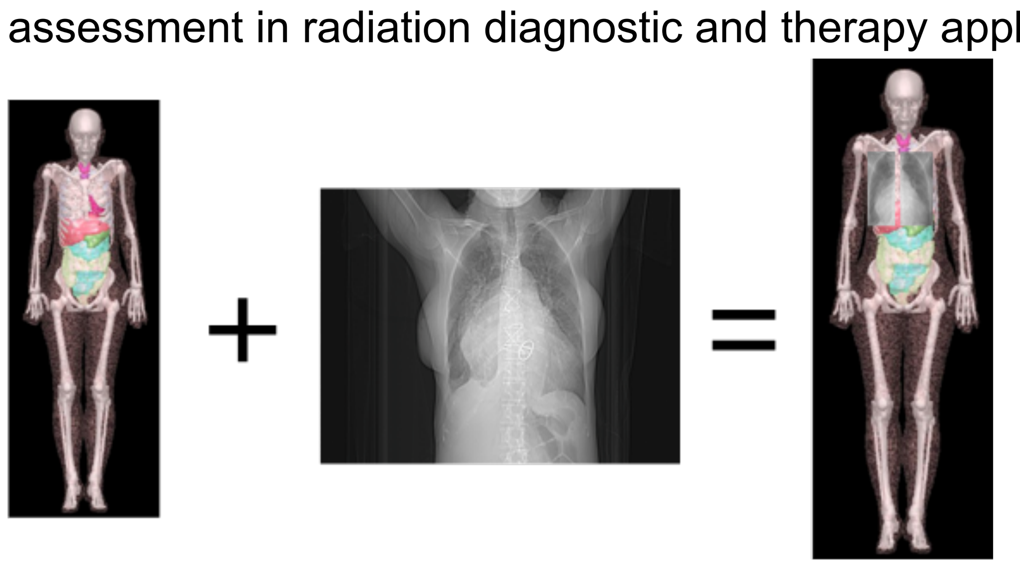
FIG. 1: Recent studies have aimed to identify tumor sub-volumes based on radiomics methods, such as anatomical and functional imaging [1].

Main objectives of the work:

- To identify tumor phenotypes using the anatomical and functional information present in PET-CT images.
- To ascertain if targeting different radionuclides to different phenotypes in a tumor mass has a significant effect on dose distribution and determine the optimal beam quality (radionuclide) – tumor phenotype combination, using both MC calculations and radiobiological studies.
- To study the dosimetric feasibility of an innovative combined Radionuclide Therapy (RNT) and Proton Beam Therapy (PBT).

Other Leading Edge Individual Dosimetry Activities at C2TN

- Manipulation of existing computational voxel phantoms and matching with patient CT data, in order to adapt organ anatomy to specific patients for individual and accurate dose assessment in radiation diagnostic and therapy applications [4].



Work Plan

- Collection of PET-CT phenotypes from research centers/hospitals. Segmentation (including tumor phenotype differentiation) and Monte Carlo (MC) implementation of segmented images.
- Validation using physical anthropomorphic phantoms and detector measurements. Comparison between measured and MC values.
- Determination of the optimal configuration beam quality – tumor phenotype, using both MC simulations and radiobiological assays.
- Nanodosimetric evalutation at the optimal tumor dosimetric configurations. Analysis of correlations between absorbed dose and nano scale parameters.

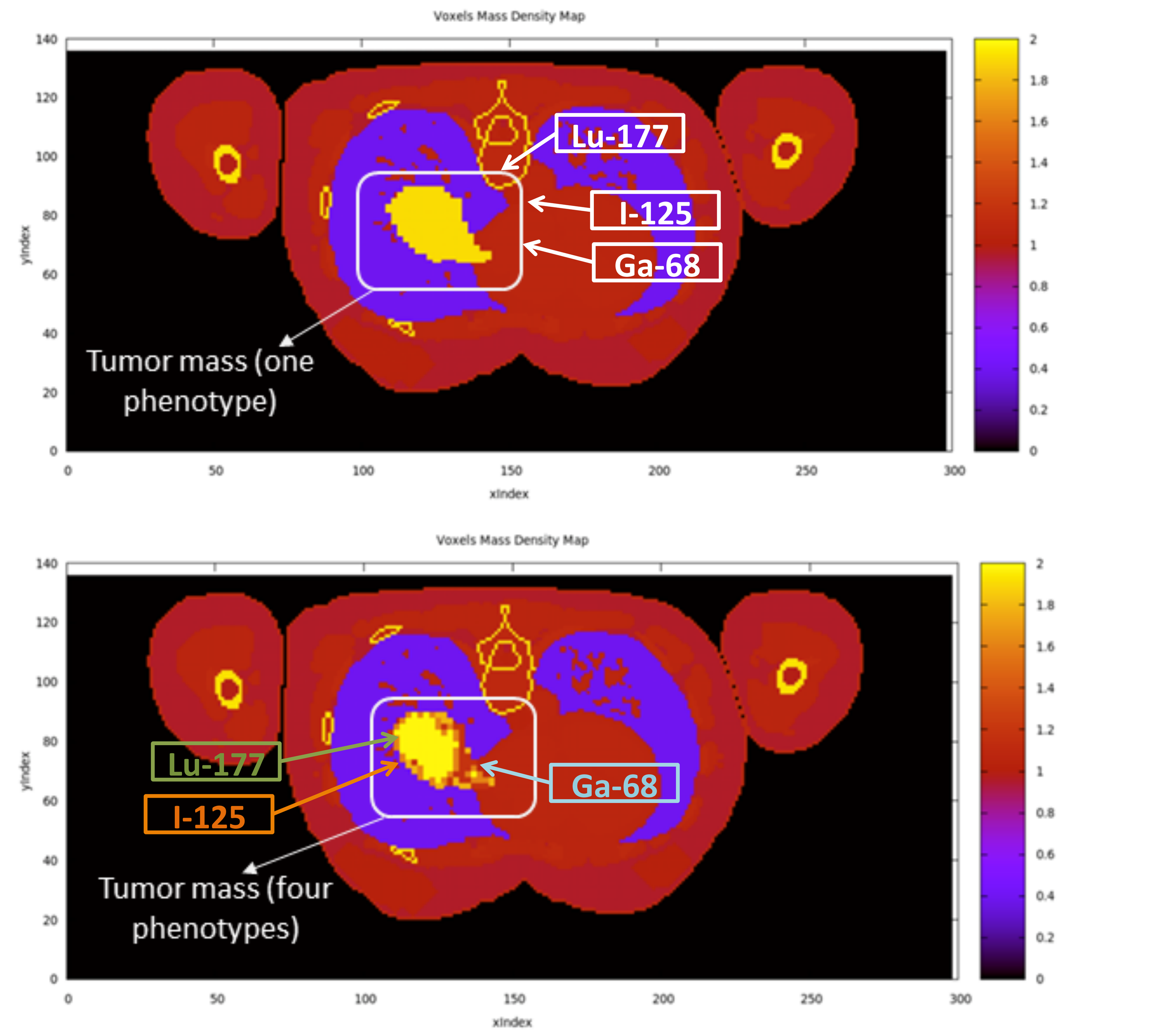


FIG. 2: Axial slice of a voxel phantom depicting a lung tumor, where two main radiation therapy scenarios were considered: (top) the whole tumor mass is irradiated homogenously with each considered radionuclide or therapy technique; (bottom) each tumor phenotype is irradiated with a different radionuclide/therapy technique.

Expected Implication For Patient Care

- This work merges the concepts of tumor heterogeneity and combined therapy, contemplating the genetic, biological and dosimetric differences between different tumor sub-volumes.

Not all tumor phenotypes exhibit the same resistance / sensitivity to the same treatment.

Optimize treatment to the phenotype.

Precision Medicine

Application of different therapy modalities in the same tumor mass and/or patient, i.e., personalize therapy to the patient.

Personalized Medicine

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[4] Borbinha J et al. Increasing organ dose accuracy through voxel phantom organ matching with individual patient anatomy. Rad Phys Chem 2019;159:35-46. doi: 10.1016/j.radphyschem.2019.02.014

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