**EV055 / #120**

## EFFICIENT COMPUTATIONAL MODELLING OF THE ELECTRONIC STOPPING OF IONS WITH IMPLICATIONS FOR PROTON THERAPY

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**Background and Aims:** Radiotherapy is one of the most commonly employed methods for cancer treatment, utilizing ionizing radiation to destroy malignant cells. Among its modalities, proton therapy stands out for its precision in dose delivery, minimizing damage to surrounding healthy tissues. Achieving this precision requires a thorough understanding of the interactions between ionizing radiation and biological matter, which is crucial for accurate dose control and proton beam positioning. Liquid water is often used as a substitute for biological tissues in studies of radiation-induced damage due to its comparable physical and radiological properties. By analyzing proton interactions with water, it is possible to gain valuable insights into energy deposition and biological effects, thereby improving the accuracy and efficacy of proton therapy. In view of this, this work aims to apply advanced computational methods to enhance the understanding of proton energy deposition in water and its applications.

**Methods:** Recent developments in computational modeling have significantly improved the accuracy of electronic stopping power estimates for ions in materials. This study utilizes a combination of time-dependent density functional theory (TDDFT) and the Penn method to analyze ion-matter interactions. The Penn method, based on the energy loss function at $k = 0$, accurately accounts for the contributions of different components of the electron gas within the target material. Initial results for protons in organic polymers and silicon have already demonstrated the method's robustness.

**Results:** In this research, the TDDFT-Penn approach was applied to protons in different phases of water. This technique revealed notable variations in electronic stopping cross-sections, particularly in the magnitude and position of the stopping maximum, which directly influence energy deposition patterns.

**Conclusions:** These findings deepen the understanding of proton interactions with biological media, offering critical insights for refining dosimetric calculations and clinical treatment planning. By advancing the precision of proton therapy, this research contributes to optimizing oncological outcomes, reinforcing the technique's role as a cornerstone of modern radiotherapy.

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## MONTE CARLO MODEL OF THE ARGENTINE PROTON THERAPY CENTER FOR THE CALCULATION OF RADIATION PROTECTION QUANTITIES AND ACTIVATION PRODUCTS

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**Background and Aims:** Within the context of the licensing process of the Argentine Proton Therapy Center (CeArP), and with the purpose of calculating radiation protection quantities, a complete 3D computational model (Fig.1) of the proton vault, clinical rooms and experimental room was created by means of the Monte Carlo code PHITS (1). Figure 1: Section through the median plane of the 3D model of the CeArP proton therapy facility

**Methods:** The model comprises the full concrete building, including the cyclotron vault and beam line, the two clinical rooms and the experimental room, labyrinths and control rooms, the IBA C230® cyclotron, and energy selection and transport systems. Twenty-nine proton sources for three representative proton energies (230, 180 and 150 MeV) were defined, to simulate the main beam interactions with different material structures that produce secondary neutron and photon fields through proton collisions. These structures comprise the cyclotron D's and the extraction septum, degrader, collimator, divergence and momentum slits, and spherical water phantoms located at the isocenters of the two clinical rooms and the experimental room, equipped with a horizontal nozzle. Additionally, a dynamic annual workload model that considers clinical as well experimental beam time requests was established, allowing estimates of different quantities of interest such as neutron and photon fluxes, ambient dose equivalent, concrete and air activation, based on the total amount of proton charge accelerated by the cyclotron per year.

**Results:** In addition to general 3D maps of all the quantities of interest, we were able to determine the location of the maximum ambient dose equivalent point, which is situated near the cyclotron and the degrader. We derived the distribution of fast neutron activation products, thermal neutron flux distributions (Fig. 2) and profiles through the walls, floor and ceilings from which thermal neutron capture activation products can be derived. Figure 2: thermal neutron flux distribution on the floor of the CeArP proton therapy facility

**Conclusions:** The model is sufficiently adaptable to consider, in the future, real parameters associated with the CeArP routine operation and can be improved based on experimental measurements. References 1. T. Sato et al., J Nucl. Sci. Technol. 55, 684-690 (2018).

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## COMPREHENSIVE MONTE CARLO ANALYSIS OF PROTON BEAM TRANSPORT IN WATER USING PENHAN-PENELOPE

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