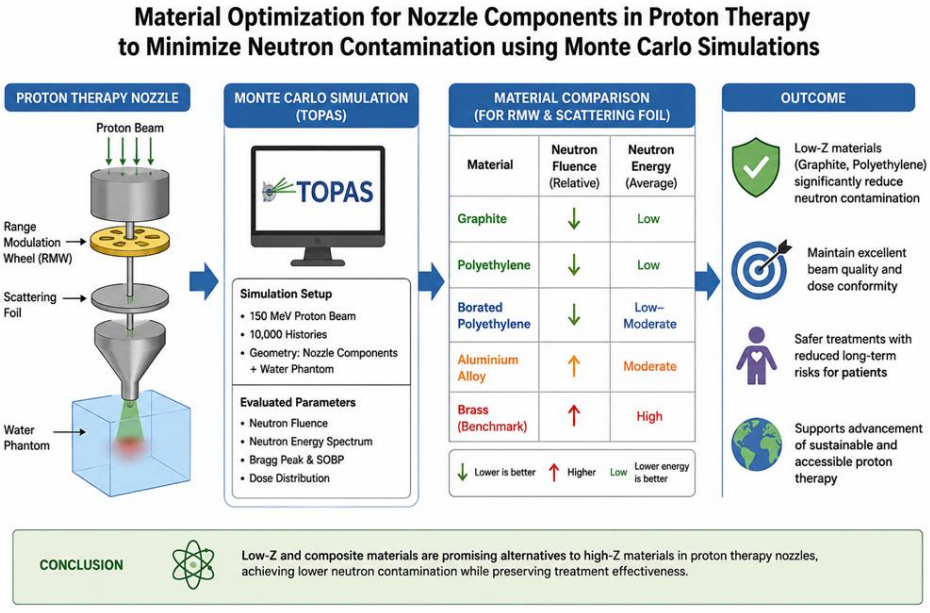
Masters Thesis Information Showcase
Spring Semester-2026
Year 2026

	Department: Physics Programme: Masters of Science Specialization: Medical Physics
1	**Title of the Thesis** Material Optimization for Nozzle Components in Proton Therapy to Minimize Neutron Contamination using Monte Carlo simulations
2	**Abstract** (min 300 to 500 words) The aim of this study is to investigate and optimize alternative materials for key passive components in proton therapy nozzles—specifically range modulation wheels (RMWs) and scattering foils—with the goal of reducing neutron contamination and secondary particle production. Passive scattering proton therapy is associated with undesirable neutron production due to the interaction of high-energy protons with materials commonly used in nozzle components, such as brass and tungsten. These secondary neutrons contribute to unnecessary dose to healthy tissues, increasing the risk of secondary malignancies. This research involved a comparative simulation study using TOPAS (Tool for Particle Simulation) to assess neutron yields and energy spectra resulting from various candidate materials, including low-Z and composite alternatives (graphite, polyethylene, borated polyethylene, aluminium alloys, and brass as benchmark). Key evaluation metrics included total neutron fluence, energy distribution of secondary particles, and impact on therapeutic proton beam quality (Bragg peak fidelity, SOBP conformity, beam modulation, and dose distribution in a water phantom). Simulations were performed with a 150 MeV proton beam and 10,000 particle histories per configuration. Results demonstrated that low-Z materials, particularly graphite and polyethylene, significantly reduced neutron fluence and produced lower-energy neutrons compared to high-Z materials like brass, while maintaining excellent beam quality and dose conformity. Borated polyethylene showed promising neutron absorption but moderate energy characteristics. Aluminium alloys and brass exhibited higher neutron contamination and some beam degradation. The outcome of this work contributes to the development of safer passive proton therapy systems by offering viable material replacements that maintain treatment efficacy while reducing long-term patient risks. This project is highly relevant to the advancement of radiation oncology instrumentation and the optimization of proton therapy technology in resource-limited settings.
3	**Impact on SDG# 3: Good Health and Well-being" (min 500 words)** The project is directly associated with SDG 3: Good Health and Well-being because it enhances cancer treatment practices, particularly by optimizing proton therapy. This research reduces risks associated with traditional therapies and improves patient safety by minimizing secondary radiation exposure (neutron contamination) and improving the accuracy and conformity of proton beams. Proton therapy's Bragg peak allows precise dose delivery to tumors while sparing healthy tissues, but nozzle components (RMWs, scattering foils) made of high-Z materials like

	brass generate secondary neutrons. These neutrons increase out-of-field dose, elevating risks of secondary malignancies, especially in pediatric patients with longer lifespans. By identifying and validating low-Z materials (graphite, polyethylene) through TOPAS Monte Carlo simulations, this study demonstrates substantial reductions in neutron fluence and energy spectra without compromising beam quality, SOBP uniformity, or dose distribution. Clinical relevance includes safer treatments with fewer side effects, improved tumor conformity, and enhanced quality of life for cancer patients. Optimization makes proton therapy more accessible and cost-effective, particularly in resource-limited settings, by using affordable, available materials. This aligns with global health objectives by advancing radiation oncology, reducing treatment-related morbidity, and supporting equitable access to advanced cancer care. Broader impacts extend to innovation in medical physics (SDG 9) and sustainable healthcare infrastructure. Future experimental validation and hybrid materials could further amplify these benefits, contributing to reduced inequalities in cancer outcomes worldwide.
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6	**Graphical Abstract**