^{137}Cs source, respectively. The spatial resolution of this detector so far has been determined to be about 5 mm, using the k-nearest-neighbour algorithm (k-NN) [1].
Moreover, the Compton camera has been commissioned at different particle beam facilities. The time-of-flight (TOF) capability of the system was evaluated at the Garching Tandem accelerator, using a 20 MeV pulsed (400 ns) deuteron beam hitting a water phantom, showing prompt γ rays well separated from the slower neutrons. The camera was further tested with different clinical proton beams from the research area of the University Proton Therapy Dresden (100, 160 and 225 MeV) stopping in either a water or a PMMA phantom, as indicated in Fig.1. For all three proton beam energies, the analysis of the prompt γ energy versus the TOF showed no significant neutron background. The Compton electron energy loss was extracted from each DSSSD layer, showing a gradual sequential increase of the energy loss from the first to the last layer.

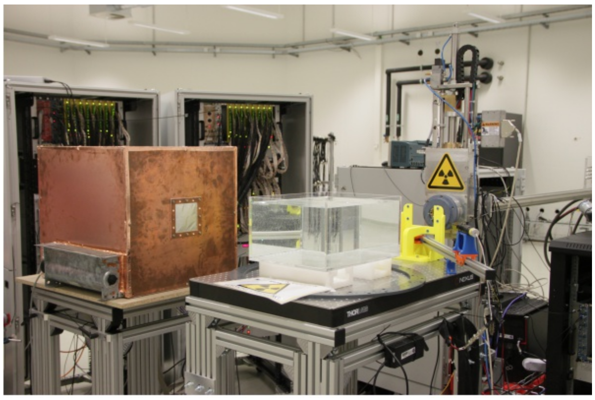

Figure 1: The Compton camera, enclosed in a Faraday light tight cage, is placed under 90º relative to the proton beam that hits a water phantom (here at the OncoRay facility, Universitäts Protonen Therapie Dresden).

Conclusion: A Compton camera is under development in Garching, designed for online ion beam range verification via prompt γ detection. The monolithic $LaBr_3$ detector was characterized in the laboratory exhibiting excellent energy and time resolution as well as a sufficient position resolution. The Compton camera was commissioned with a low-energy pulsed deuteron beam at the Garching Tandem accelerator and with high-energy clinical proton beams at the OncoRay facility, Dresden.

Keywords: Prompt γ imaging, Compton camera, Proton range verification

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RBE for Carbon ions In Vivo for Tumor Control and Normal Tissue Damage
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Purpose: Particle therapy provide a more favorable dose distribution compared to x-rays, but limited focus has been on the actual biological responses. Effects of carbon ion radiation in experimental tumor models has been investigated in a limited number of studies, the majority of these with tumor growth delay as biological endpoint. To elucidate the biological variation in radiation response in particle therapy, more in vivo studies are needed. The aim of the present study was to compare the biological effectiveness of carbon ions relative to x-rays between the clinical relevant endpoint tumor control and normal tissue damage, both acute and late effects.
Materials and Methods: CDF1 mice with C3H mouse mammary carcinoma placed subcutaneously on the foot of the right hind limb were irradiated with single fractions of either photons or ^{12}C ions, using a 30-mm spread-out Bragg peak. Endpoint of the study was local control (no tumor recurrence within 90 days). For the acute skin reaction, non-tumor bearing CDF1 mice were irradiated with a comparable radiation scheme, and monitored for acute skin damage. Late radiation induced fibrosis was measured up to 322 days following treatment.
Results: The TCD_{50} (dose producing tumor control in 50% of mice) values with 95% confidence interval were 29.7 (25.37-34.78) Gy for C ions and 43.94 (39.24- 49.2) Gy for photons. The corresponding RBE values were 1.48 (1.28-1.72). For acute skin damage the MDD_{50} (dose to produce moist desquamation in 50% of mice) values with 95% confidence interval were 26.34 (22.99-30.19) Gy for C ions and 35.84 (32.94-38.98) Gy for photons, resulting in a RBE of 1.36 (1.20-1.45). For late radiation-induced fibrosis the FD_{50} (dose to produce severe fibrosis in 50% of the mice) with 95% confidence interval were 26.5 (23.1 – 30.3) Gy for carbon ions and 39.8 (37.8 – 41.8) Gy for photons, with a RBE of 1.50 (1.33 – 1.69).
Conclusions: We have established TCD_{50}, MDD_{50} and FD_{50} values for local tumor control and normal tissue damage and the corresponding RBE values for carbon ions in a mouse model. The observed RBE values were very similar for tumor response, acute skin damage and late RIF when irradiated with large doses of high- linear energy transfer (LET) carbon ions. This study add information to the variation in biological effectiveness in different tumor and normal tissue models.
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PET scanning of ocular melanoma after proton irradiation
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The Proton Therapy Facility at TRIUMF is now in routine operation treating ocular tumours using 74 MeV protons extracted from the 500 MeV H^- cyclotron. In this work, the feasibility of using PET scanning for proton dose monitoring is investigated. Different lucite phantoms have been irradiated with a raw Bragg peak and a spread out Bragg peak of 74 MeV and scanned using two PET scanners at UBC hospital. Simulation programs GEANT4 and FLUKA are being used to validate against experimental measurements. GEANT4 has been coupled with EXFOR cross section data of proton induced reactions to calculate the axial activity of the phantoms. Despite the very simple setup, significant discrepancies between the codes have been observed for the activity profiles of ^{11}C and ^{15}O and ^{13}N, whereas the beam range in lucite has been found to have good agreement.

Keywords: PET, proton therapy

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Radiation treatment monitoring using multifunctional imaging in prostate tumour xenografts
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