Papers uploaded to Academia
get 69% more citations.

UPLOAD YOUR PAPERS NOW

HOME MENTIONS ANALYTICS UPLOAD TOOLS Try Premium for CHF1 ian

Evaluation of resistive-plate-chamber-based TOF-PET applied to in-beam particle therapy monitoring

Irene Espallardo

2015, Physics in medicine and biology

9 Views 23 Pages 1 File

Biomedical Engineering

Show more

Particle therapy is a highly conformal radiotherapy technique which reduces the dose deposited to the surrounding normal tissues. In order to fully exploit its advantages, treatment monitoring is necessary to minimize uncertainties related to the dose delivery. Up to now, the only clinically feasible technique for the monitoring of therapeutic irradiation ...read more

Download PDF Download Full PDF Package Translate PDF

Original PDF Summary Related

IOPscience iopscience.iop.org

Home Search Collections Journals About Contact us My IOPscience

Evaluation of resistive-plate-chamber-based TOF-PET applied to in-beam particle therapy monitoring

This content has been downloaded from IOPscience. Please scroll down to see the full text.

2015 Phys. Med. Biol. 60 N187

(http://iopscience.iop.org/0031-9155/60/9/N187)

View the table of contents for this issue, or go to the journal homepage for more

Download details:

IP Address: 157.193.227.128
This content was downloaded on 20/04/2015 at 12:09

Please note that terms and conditions apply.

IOP Publishing | Institute of Physics and Engineering in Medicine Physics in Medicine & Biology

Phys. Med. Biol. **60** (2015) N187–N208 doi:10.1088/0031-9155/60/9/N187

Note

Evaluation of resistive-plate-chamber-based TOF-PET applied to in-beam particle therapy monitoring

I Torres-Espallardo[1,6], F Diblen[2,6], H Rohling[3,6], P Solevi[1], J Gillam[1,4], D Watts[5], S España[2], S Vandenberghe[2], F Fiedler[3] and M Rafecas[1]

[1] Instituto de Física Corpuscular—IFIC (UV/CSIC), E-46071 Valencia, Spain
[2] Department of Electronics and Information Systems, MEDISIP, Ghent-University, iMinds Medical IT-IBiTech, B-9000 Ghent, Belgium
[3] Helmholtz-Zentrum Dresden-Rossendorf, D-01328 Dresden, Germany
[4] Brain and Mind Research Institute—BMRI, Univesity of Sydney, Camperdown NSW 2050, Australia
[5] TERA Foundation, I-28100 Novara, Italy

E-mail: irene.torres@uv.es

Received 13 August 2014, revised 24 February 2015
Accepted for publication 10 March 2015
Published 17 April 2015

Abstract

Particle therapy is a highly conformal radiotherapy technique which reduces the dose deposited to the surrounding normal tissues. In order to fully exploit its advantages, treatment monitoring is necessary to minimize uncertainties related to the dose delivery. Up to now, the only clinically feasible technique for the monitoring of therapeutic irradiation with particle beams is Positron Emission Tomography (PET). In this work we have compared a Resistive Plate Chamber (RPC)-based PET scanner with a scintillation-crystal-based PET scanner for this application. In general, the main advantages of the RPC-PET system are its excellent timing resolution, low cost, and the possibility of building large area systems. We simulated a partial-ring scanner based on an RPC prototype under construction within the Fondazione per Adroterapia Oncologica (TERA). For comparison with the crystal-based PET scanner we have chosen the geometry of a commercially available PET scanner, the Philips Gemini TF. The coincidence time resolution used in the simulations takes into account the current achievable values as well as expected improvements of both technologies. Several scenarios (including patient data) have been simulated to evaluate the performance of different scanners. Initial results have shown that the low sensitivity of the RPC hampers its application to hadron-

[6] These authors contributed equally to the work.

0031-9155/15/09N187+22$33.00 © 2015 Institute of Physics and Engineering in Medicine Printed in the UK

05/07/2024, 15:06 (79) Evaluation of resistive-plate-chamber-based TOF-PET applied to in-beam particle therapy monitoring | Irene Espallardo…

beam monitoring, which has an intrinsically low positron yield compared to diagnostic PET. In addition, for in-beam PET there is a further data loss due to the partial ring configuration. In order to improve the performance of the RPC-based scanner, an improved version of the RPC detector (modifying the thickness of the gas and glass layers), providing a larger sensitivity, has been simulated and compared with an axially extended version of the crystal-based device. The improved version of the RPC shows better performance than the prototype, but the extended version of the crystal-based PET outperforms all other options.

Keywords: PET, in-beam, RPC, particle therapy, TOF, range deviation, partial-ring

(Some figures may appear in colour only in the online journal)

1. Introduction

The number of particle therapy facilities for the treatment of cancer with proton or carbon ions (PTCOG 2014) is increasing worldwide. Particle therapy (PT) provides precise dose deposition and a sparing of normal tissue due to the favorable depth dose distribution of hadrons in matter. At the end of the particle range the specific energy loss of a particle energy shows a maximum (Bragg peak), producing dose distributions with high conformity. However, there are uncertainties resulting from patient positioning errors, conversions of attenuation coefficients from computer tomography (CT) to proton stopping power, intra-fraction motion and inter-fraction anatomy changes. These uncertainties can compromise the benefits of PT and can lead to under-coverage of the tumor or delivery of extra dose to normal tissue (Paganetti 2012, Knopf and Lomax 2013). Non-invasive monitoring of the particle range is highly desired. When particles (protons, carbon ions) traverse the tissue, positron emitting isotopes are generated due to nuclear reactions. The posterior annihilation of the emitted positron is followed by two coincident photons traveling in opposite directions that can be detected using Positron Emission Tomography (PET). The distribution of the β^+ radioisotopes is related to the dose distribution of the particle beam. Although the relationship is not straightforward, this technique can be used for the quality control of the treatment and currently PET is the only clinically applied technique for PT monitoring (Oelfke *et al* 1996, Parodi and Bortfeld 2006, Parodi *et al* 2007, Min *et al* 2013, Remmele *et al* 2011). The feasibility of acquiring PET data during treatment (in-beam PET) was proven at GSI Helmholtzzentrum für Schwerionenforschung (Darmstadt, Germany) for stable carbon ions (Enghardt *et al* 2004). In Nishio *et al* (2006) the on-line monitoring of proton irradiation by PET was analyzed and Parodi *et al* (2007) proved by a clinical study that PET-CT measurements after proton irradiation are feasible. Other emerging techniques for treatment monitoring based on secondary radiation generated during the delivery, such prompt photons and protons, which are the product of nuclear reactions are beyond the scope of this article.

When the PET acquisition is performed within the treatment room during or directly after one fraction of the therapeutic irradiation, the PET technique is named in-beam and in-room, respectively. If the PET acquisition is done out of the treatment room (usually 10–30 min after the irradiation), it is referred to as off-line or off-beam PET. Off-line PET suffers from a further reduction of activity due to two factors. On the one hand, the isotopes produced during treatment have a short half-life (few seconds to 20 min) so that a large fraction of β^+ decays

https://www.academia.edu/57057315/Evaluation_of_resistive_plate_chamber_based_TOF_PET_applied_to_in_beam_particle_therapy_monitori… 4/24

About Press Blog People Papers Topics Academia.edu Journals We're Hiring! Help Center

Terms Privacy Copyright Academia ©2024