Protons

Monte Carlo water-equivalence study of two PRESAGE® formulations for proton beam dosimetry

T Gorjiara, Z Kuncic, J Adamovics and C Baldock
2013 **J. Phys.: Conf. Ser.** 444 012090

PRESAGE® is a radiochromic solid dosimeter which shows promising potential for 3D proton beam dosimetry. Since an idea dosimeter should be water-equivalent, total depth dose distributions in two PRESAGE® formulations irradiated by a 62 MeV proton beam were compared with that in water using GEANT4 Monte Carlo simulations. The dose delivered by secondary particles was also calculated. Our results show that after water-equivalent depth scaling, PRESAGE® can be considered water equivalent for dosimetry of a 62 MeV clinical proton beam

Investigation of photon and proton overlapping fields in PRESAGE® dosimeters

M Carroll, G Ibbott, R Grant, M Gillin and J Adamovics
2013 **J. Phys.: Conf. Ser**. 444 012059

To evaluate the effects of overlapping dose volumes for varying field arrangements in PRESAGE®, several sequential beam irradiations were delivered each to formulations intended for, and irradiated with, proton beams as well as photon beams. The dosimeters were irradiated within timespans consistent of overlapping fields in clinical treatment plans. Dose profiles taken along the beam direction indicated slight over-responses in higher dose regions relative to similar irradiations given in a single fraction. These results will aid future measurements of overlapping field treatment plans delivered to PRESAGE® for treatment verification of proton and photon 3D dosimetry.

Preliminary characterization of PRESAGE® for 3D dosimetry of 62 MeV proton beam

T Gorjiara, A Kacperek, Z Kuncic, C Baldock,and S Doran
2013 **J. Phys.: Conf. Ser**. 444 012058

PRESAGE® has previously shown potential for 3D dosimetry of heavy particles. A new formulation has specifically developed for dosimetry of protons/heavy ions. This work provides a preliminary characterization the new formulation of PRESAGE® by measuring optical absorbance and dose response after irradiating by a 62 MeV proton beam for a dose range of 0.5 – 20 Gy. Results show linear dose response and the evolution over time of the optical density of the 3D dosimeter.

Water and tissue equivalence of a new PRESAGE formulation for 3D proton beam dosimetry: A Monte Carlo study

Gorjiara, Tina; Kuncic, Zdenka; Doran, Simon; Adamovics, John; Baldock, Clive
Medical Physics (2012), 39(11), 7071-7079. I
Purpose: To evaluate the water and tissue equivalence of a new PRESAGE 3D dosimeter for proton therapy. Methods: The GEANT4 software toolkit was used to calc. and compare total dose delivered by a proton beam with mean energy 62 MeV in a PRESAGE dosimeter, water, and soft tissue. The dose delivered by primary protons and secondary particles was calcd. Depth-dose profiles and isodose contours of deposited energy were compared for the materials of interest. Results: The proton beam range was found to be ≈27 mm for PRESAGE, 29.9 mm for soft tissue, and 30.5 mm for water.

Investigation of PRESAGE® Dosimeters for Proton Therapy
M Carroll, G Ibbott, R Grant, M Gillin and J Adamovics
2013 ***J. Phys.: Conf. Ser.*** **444** 012059

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Dosimetric assessment of the PRESAGE dosimeter for a proton pencil beam delivered to PRESAGE® for treatment verification of proton and photon 3D dosimetr

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2013 *J. Phys.: Conf. Ser.* 444 012055

The objective of this study is to assess the feasibility of using PRESAGE dosimeters for proton pencil beam dosimetry. Two different formulations of phantom materials were tested for their suitability in characterizing a single proton pencil beam. The dosimetric response of PRESAGE was found to be linear up to 4Gy. First-generation optical CT scanner, OCTOPUS^{TM} was used to implement dose distributions for proton pencil beams since it provides most accurate readout. Percentage depth dose curves and beam profiles for two proton energy, 110 MeV, and 93 MeV, were used to evaluate the dosimetric performance of two PRESAGE phantom formulas. The findings from this study show that the dosimetric properties of the phantom materials match with basic physics of proton beams.

Characterization of the optical properties and stability of Presage following irradiation with photons and carbon ions

Yates, Esben S.; Balling, Peter; Petersen, Joorgen B. B.; Christensen, Mehrnaz N.; Skyt, Peter S.; Bassler, Niels; Kaiser, Franz-Joachim; Muren, Ludvig P.
Acta Oncologica (2011), 50(6), 829-834. l
Background: The on-going development of both intensity-modulated radiotherapy(IMRT), including the more recent intensity-modulated arc therapy, as well as particle beam therapy, has created a clear need for accurate verification of dose distributions in three dimensions (3D). Presage is a new 3D dosimetry material that exhibits a radiochromic response when exposed to ionizing radiation. In this study we have 1) developed an improved optical set-up for measurements of changes in OD of Presage point dosimeters, 2) investigated the dose response of Presage for photons and carbon ion

Investigation of PRESAGE® Dosimeters for Proton Therapy
R Grant, G Ibbott, X Zhu, M Carroll, J Adamovics, M Oldham, and D Followill
Med. Phys. 38, 3571 (2011) SU-E-T-363
Purpose: To evaluate a formulation of PRESAGE® intended for proton therapy and to use it to compare measurements with calculations for a spot scanning pencil proton beam and a passively scattered proton beam. Methods: Two 7.5 cm high by 9.5 cm diameter cylindrical PRESAGE® dosimeters were used. CT images were used to design two treatment plans with an Eclipse treatment planning system (TPS). The first plan used a single pencil beam of energy 153.2 MeV to provide a range of 16 cm in water. Four regions of the dosimeter were irradiated delivering doses in the peak of approximately 6, 10, 13 and 19 Gy(RBE) by rotating the dosimeter between spot deliveries. The second plan used a single passively scattered field with a spread out Bragg peak (SOBP) of 4 cm. This plan delivered approximately 10 Gy(RBE). The dosimeters were analyzed using an optical CT scanner. The measured optical densities were converted to dose via a calibration curve, exported to the CERR environment and fused to the treatment plan. Dose distributions were scaled to the SOBP plan. Dose profiles were taken along the axis of each spot and the SOBP and perpendicularly across the SOBP. Results: The dose measured in the peak of single spot irradiations increased proportionally to the MU setting. The distal falloff was steeper than predicted by the TPS. The cross profiles for the SOBP plan matched within 2 mm with the TPS. The depth profile was noisy within the modulated area. Noise decreased as dose increased for both dosimeters Conclusions: This formulation of PRESAGE® shows promise as a 3D dosimeter for proton therapy. A dose calibration specific to protons will facilitate further analysis and enable measurement of complex distributions.

3D Dosimetry for Small Irregular Proton Fields Using a New PRESAGE® Dosimeter.

By L Zhao, J Newton, J Adamovics, M Oldham, C Cheng, and I Das
From **Med. Phys**. 38, 3506 (2011)
Purpose: Small field dosimetry is challenging that impacts patient specific QA in proton beam therapy due to detector size, aperture scattering and disequilibrium. Therefore, itis urgent to develop an accurate and efficient method to quantify the uncertainty of 3D dosimetry of small fields. This study investigated the feasibility of using a new formula PRESAGE® for 3D dosimetry of small irregular field in proton therapy.
Methods: Three cylindrical shape PRESAGE® dosimeters (10 cm or 4 cm in diameter, 6 cm in length) of a new formula (C304H510N20O71SBr) were irradiated with three irregular patient fields (field size 2–4 cm) either with or without range compensators, respectively. A proton range 6 cm with three different SOBP widths were used. To test the sensitivity of the dosimeter, three different dose levels, 150, 300, and 500 cGy were delivered. Uniform scanning proton beams with energy stacking were used for beam delivery. Three corresponding treatment plans created on the CMS XiO treatment planning system using pencil beam algorithm were compared with the experimental results in the form of relative dose distributions, including isodose plots, dose profiles and gamma index maps. Results: Transverse dose profile comparison showed spatial agreement within 1–2 mm. The measured depth dose results showed a sharper distal fall off compared to the calculations with negligible quenching effect (< 5%). Most differences were observed in the high dose gradient region (field edges and distal end). Majority of the data points in the target region passed the 3% dose difference and 3 mm DTA gamma analysis. Conclusions: Good agreement was observed between planned and measured 3D dose distributions. Overall, the new formula PRESAGE® dosimeter was found to be suitable for verifying the 3D dose distribution for small irregular fields in proton therapy with single shot irradiation.

An investigation of the response of the radiochromic dosimeter PRESAGE to irradiation by 62 MeV protons
Al Nowais, Shamsa; Kacperek, Andrzej; Brunt, John N. H.; Adamovics, John; Nisbet, Andrew; Doran, Simon J.
Journal of Physics: Conference Series (2010), 250
Measurements of the 62 MeV proton beam at the Clatterbridge Center for Oncol. using the radiosensitive plastic PRESAGE have previously shown a dependence of the dosimeter sensitivity (dose-response slope) on the linear energy transfer (LET) of the ionising particles. This work focuses on a possible explanation in terms of track structure theory (TST). Exptl. measurements of highly irradiated PRESAGE samples established the D37 parameter of the theory to be of the order of 1000 Gy. Initial attempts at applying the theory showed good agreement of the theor. and exptl. values.

Determination of the depth dose distribution of proton beam using PRESAGE dosimeter

Zhao, L.; Das, I. J.; Zhao, Q.; Thomas, A.; Adamovics, J.; Oldman, M.
Journal of Physics: Conference Series (2010), 250
PRESAGE dosimeter dosimeter has been proved useful for 3D dosimetry in conventional photon therapy and IMRT. Our objective is to examine the use of PRESAGE dosimeter for verification of depth dose distribution in proton beam therapy. Three PRESAGE samples were irradiated with a 79 MeV unmodulated proton beam. Percent depth dose profile measured from the PRESAGE dosimeter is compared with data obtained in a water phantom using a parallel plate Advanced Markus chamber. The Bragg-peak position detd. from the PRESAGE is within 2 mm compared to measurements in water. A preliminary analysis of LET effects in the dosimetry of proton beams using PRESAGE and optical CT

A preliminary analysis of LET effects in the dosimetry of proton beams using PRESAGE™ and optical CT

Al-Nowais, S.; Doran, S.; Kacperek, A.; Krstajic, N.; Adamovics, J.; Bradley, D.
Applied Radiation and Isotopes (2009),67(3),415-418.
PRESAGE is a solid dosimeter based on a clear polyurethane matrix doped with radiochromic components (leuco dyes). On exposure to ionizing radiation a color change is generated in the dosimeter, and hence an optical absorption or optical d. change that can be read out by optical CT. The main focus of present investigations has been to investigate the possible LET dependence of PRESAGE to the dose deposited at the Bragg maxima using proton beam absorbed dose measurements, and the linearity of response of the dosimeter. Proton irradiations were performed using the UK proton beam facility.

Measurement of a 200 MeV proton beam using a polyurethane dosimeter

Heard, Malcolm; Adamovics, John; Ibbott, Geoffrey
Journal of Physics:Conference Series (2006),56,228-230.
PRESAGE is a 3-dimensional polyurethane dosimeter contg. a leuco dye that generates a color change when irradiated and responds monotonically to both photons and electrons. The response of PRESAGE to proton beam radiotherapy was studied. The under-response of polymer gels in the distal region of the spread-out Bragg peak (SOBP) was obsd. in a previous study. The under-response of the PRESAGE is expected because free radicals can recombine in the high LET region resulting in fewer radicals for initiation of the response in the dosimeter. This applies particularly to the distal edge of the SOBP .