EUROPEAN SYNCHROTRON RADIATION FACILITY

INSTALLATION EUROPEENNE DE RAYONNEMENT SYNCHROTRON

Experiment Report Form

The double page inside this form is to be filled in by all users or groups of users who have had access to beam time for measurements at the ESRF.

Once completed, the report should be submitted electronically to the User Office via the User Portal:

https://wwws.esrf.fr/misapps/SMISWebClient/protected/welcome.do

Reports supporting requests for additional beam time

Reports can be submitted independently of new proposals – it is necessary simply to indicate the number of the report(s) supporting a new proposal on the proposal form.

The Review Committees reserve the right to reject new proposals from groups who have not reported on the use of beam time allocated previously.

Reports on experiments relating to long term projects

Proposers awarded beam time for a long term project are required to submit an interim report at the end of each year, irrespective of the number of shifts of beam time they have used.

Published papers

All users must give proper credit to ESRF staff members and proper mention to ESRF facilities which were essential for the results described in any ensuing publication. Further, they are obliged to send to the Joint ESRF/ ILL library the complete reference and the abstract of all papers appearing in print, and resulting from the use of the ESRF.

Should you wish to make more general comments on the experiment, please note them on the User Evaluation Form, and send both the Report and the Evaluation Form to the User Office.

Deadlines for submission of Experimental Reports

- 1st March for experiments carried out up until June of the previous year;
- 1st September for experiments carried out up until January of the same year.

Instructions for preparing your Report

- fill in a separate form for each project or series of measurements.
- type your report, in English.
- include the reference number of the proposal to which the report refers.
- make sure that the text, tables and figures fit into the space available.
- if your work is published or is in press, you may prefer to paste in the abstract, and add full reference details. If the abstract is in a language other than English, please include an English translation.

ESRF	**Experiment title:** Radiation therapy dosimetry using a uniform monochromatic X-ray beam	**Experiment number**: MD-1144
Beamline: ID17	**Date of experiment**: from: 11 April 2018 to: 14 April 2018	**Date of report**: 16/04/2008
Shifts: 9	**Local contact(s)**: Herwig Requardt (email: requardt@esrf.fr) Alberto Bravin (email: bravin@esrf.fr)	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

Jenny Spiga – Warwick University
Jonathan Duffy – Warwick University
Sam Manger – Warwick University
Local contacts:
Alberto Bravin – ESRF
Herwig Requardt – ESRF
In-loco experimentalists:
Paolo Pellicioli – ESRF
Mariele Romano - ESRF

Report:

The aim of our experiment was to calibrate and benchmark the depth dose curves simulated with the Monte Carlo code Geant4 using a monochromatic X-ray beam. This step is essential to prepare the dose prescription for the *in-vivo* preclinical studies. As indicated in the proposal, the experiment has been performed at the ID17 hutch, which can provide intense and uniform quasi monochromatic beams in the energy range 30 – 140 keV, and where similar experiments have been conducted in the past using different parameters.

In the first part of it, we irradiated a solid water phantom made of slabs with different width (typically 0.5-1cm width), so the final dimension was of 30x30x12 cm^3. After the initial alignment, we conducted a dosimetry calibration using a PTW semiflex chamber before each measurement. In terms of dosimeters, we used Gafchromic films of two types: EBT3, widely used in clinics (sensitivity dose range 0.1 – 20 Gy), and HD-V2, typically used in Microbeam Radiation Therapy for dose evaluation (dose range 10 – 1000 Gy). The irradiation of HD- V2 films required three times the time compared to EBT3, being the sensitivity lower. The films were inserted at different depths in the phantom (surface, 5-10-20-30-40-60-100 mm). The measurements were performed using two different beam sizes (1x1 cm^2 and 2x2 cm^2), and at 10 energies (30-35-40-45-50-55-60-80-120-140 keV). In each case we gave an entrance dose of 2Gy.
In figure 1 we report the preliminary comparison of three depth dose profiles obtained with Geant4 simulations with the experimental data. They appear to be in good agreement, although it looks like Geant4 slightly underestimates the dose delivered for very low energies (30 keV). In order to be able to read our films with the scanner we took three calibration curves at 30, 50 and 100 keV. For each energy, we delivered a dose of 0.5-1-2-5-10-15 Gy on a EBT3 gafchromic film positioned at 0.5 cm depth in the phantom. We couldn't read the films as they require at least 4-5 days to stabilise, but the ionization chamber gave us immediate comparable results. It took us two days to complete this first part of the experiment.

During the third day, we focalised on the dose enhancement evaluation using three different enhancers: Iodine (10 mg/ml), Gadolinium (10 mg/ml) and Gold (1.8 mg/ml).
We made the measurements using a PTW semiflex chamber situated at different depths in a phantom comprising a combination of pmma slabs of about 5x5x2 cm^3 and two sample containers. We wanted to study the attenuation of the X-ray beam due to the presence of the dose enhancers. To be able to take into account the k-edges of the fluids (Iodine 33.17keV, Gadolinium 50.2 keV and Gold 80.7249 keV) and appreciate the

differences, we considered three sets of energies: 30-35 keV, 45-55 keV and 75-85 keV. For each energy, we conducted a characterization filling the containers with water. This second part of the experiment comprises a total of 195 measurements and some preliminary results are shown in figure 2 for Iodine. We report the linear attenuation coefficient and it looks like we can expect a dose enhancement with iodine. Surely there is some more investigation needed, which will be the aim of our next proposal. The local contacts at the beamline have been really helpful and were keen on giving their scientific opinion, who gave some input for interesting discussions on what to investigate next.

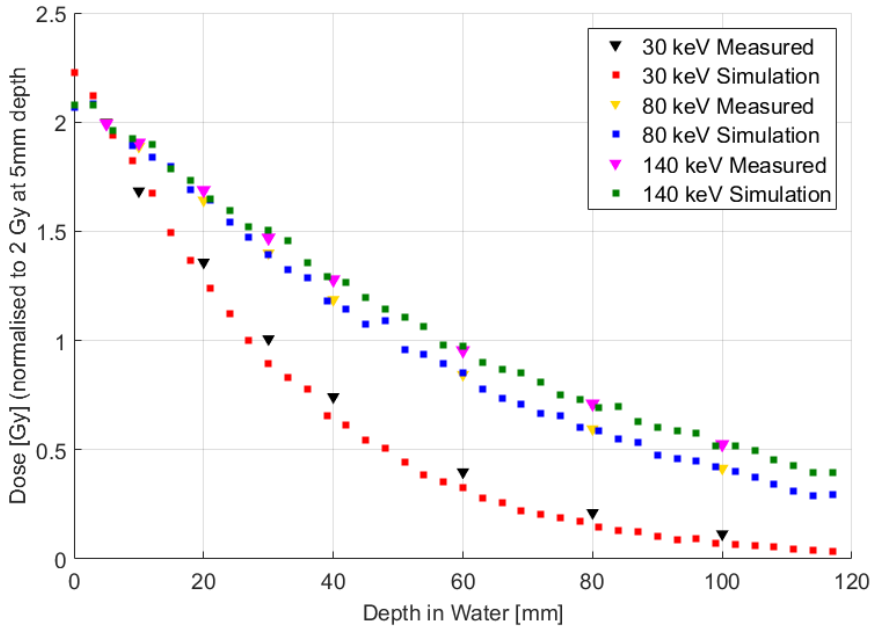

Figure 1 – Comparison of simulated and experimental depth dose curves

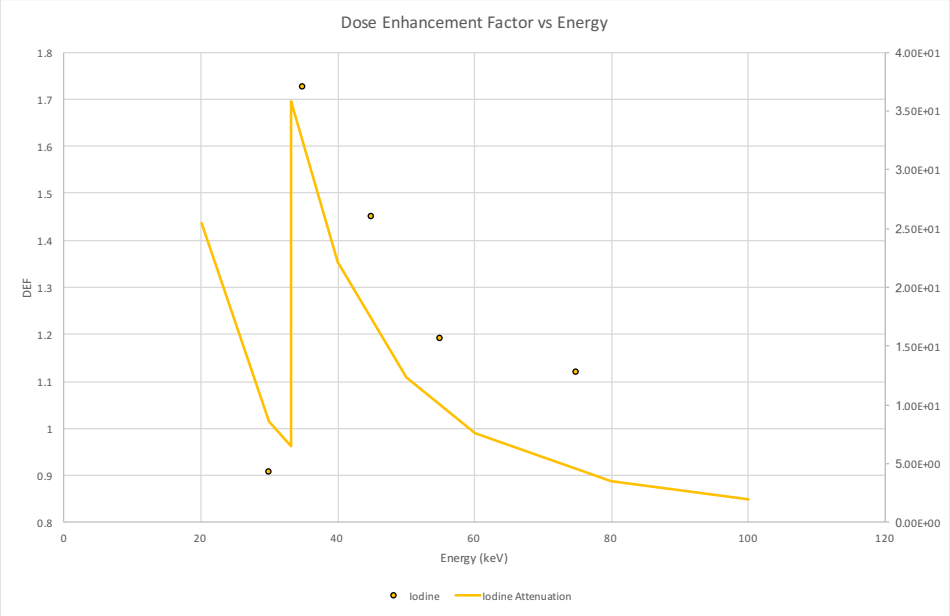

Figure 2 – Dose Enhacement Factor vs Energy