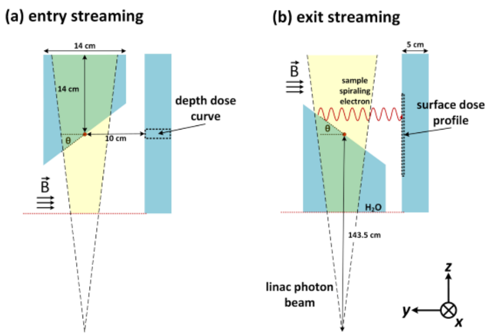

Figure 1: Schematic of EGSnrc simulation set-up of the (a) entry and (b) exit inclined phantoms.

Results

As the magnetic field increases, in the entry and exit simulations, the dose distributions become sharper, as shown in Figure 2 for the exit streaming case. The maximum doses for the 0.35T exit simulations are 22.9%, 38.0%, and 42.8% for the respective 10, 30, and 45° simulations. For 1.5T, for the same angles, the maximum values are 16.7%, 29.6%, and 36.4%. Dose values drop to below 2% within the first 1cm of the out-of-field water phantom. For the entry simulation, the largest ESE doses were observed for the 45° simulation and were 4.5% and 8.0% for the 0.35 and 1.5T magnetic fields, respectively. Percentages are with respect to the maximum deliverable dose by the beam to a large water phantom.

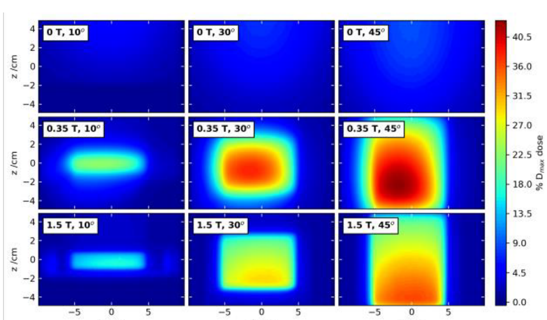

Figure 2: Surface dose profiles in the out-of-field for the exit streaming simulation

Conclusion

The ESE can contribute to notable out-of-field doses and should be considered during treatment planning for MRgRT systems. Treatments often include several beams which will spread out the overall effect. In situation where ESE doses are unavoidable, a 1cm bolus or the already mounted RF coils would greatly reduce the effect. Further exploration is required into the capabilities of the treatment planning system to capture this effect.

EP-1689 Implementation of ultra-low dose CBCT for children using an optimised bowtie filter

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Purpose or Objective

Cone beam CT (CBCT) image guidance can lead to excessive doses to children undergoing radiotherapy due to incorrect use of imaging protocols designed for adults. But even with correct protocols, there are concerns of late effects due to imaging dose, affecting the use of image guidance in children (e.g. choice of imaging modality and frequency of acquisition). The aim of this work is to implement ultra-low dose CBCT through use of a bowtie filter specifically designed for paediatric CBCT: it provides additional attenuation to reduce exposure and is shaped to fit the smaller body size of children. Here, we quantitatively evaluate the effect of implementing such a filter on image quality, registration accuracy and dose.

Material and Methods

The paediatric bowtie filter (Fig.1) provides additional attenuation compared to the standard (adult) Elekta XVI bowtie filter and produces uniform X-ray intensity across the average paediatric patient in the lateral direction, as derived from 15 paediatric CBCT scans. This bowtie filter was used to scan an ATOM 10-year-old paediatric phantom at the lowest dose in the brain, thorax and abdominal regions. Registration accuracy was recorded as a measure of image quality and its suitability for IGRT. Each CBCT was automatically registered to the planning CT, matching on bony anatomy. The couch shift derived from the low dose scans was compared to that for the standard dose scans (100kV, 0.16mAs per frame, 200 frames). In addition, CBCT scans with the paediatric bowtie filter were simulated for 23 paediatric patients using a noise addition method, and the registration results were compared to that of the original acquisition.

Fig 1: The paediatric bowtie filter. The thick central part of the filter reduced exposure fivefold.

Results

The lowest exposure acquired was equivalent to 15.6% of the standard low dose exposure used for children (0.8mGy to 0.13mGy). This dose level is well below the leakage dose of head and MLC. Bone-equivalent material in the phantom scans and bony anatomy in the simulated paediatric scans remained clearly visible, although increased noise was apparent in the images (Fig. 2). All acquired phantom scans and simulated patient scans had registration discrepancies of less than 1mm compared to the standard paediatric exposure. The filter can also be used at higher exposures, giving a greater range of ultra-low dose imaging protocols than is currently clinically available, such that optimised paediatric imaging protocols can be developed for different age groups.

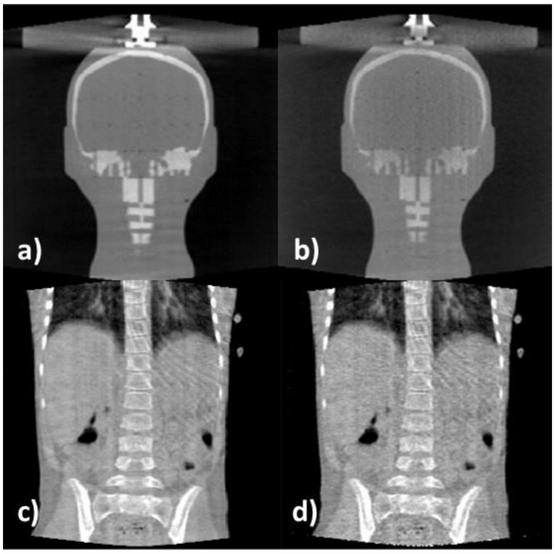

Fig 2: Comparison of image quality of a) A typical paediatric exposure scan of the ATOM 10 year old phantom. b) The lowest dose phantom scan at 15% of this exposure (0.13 mGy). c) A typical paediatric patient scan (100kV, 0.16mAs). d) Same as c but with the new bowtie filter simulated by adding non-uniform noise.

Conclusion
A bowtie filter optimised for children has been implemented and evaluated in phantom scans and simulated in patient CBCT data. Even at the lowest exposure setting, registration accuracy and image quality were sufficient, i.e., the filter provided considerable dose reduction to paediatric patients without affecting image guidance.
The authors are grateful to Elekta Oncology Systems for manufacture of the bowtie filter.

EP-1690 Induced radioactivity as a (un)helpful effect of particle therapy
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Purpose or Objective
Particle therapy is a rapidly developing form of radiation therapy of tumours, but it still has many secrets which are continually discovered. The main purpose of our project is to measure radioactivity induced in the human body during hadron therapy tumour treatment and assessment of its influence on therapy effects and causation of secondary tumours.
Material and Methods
In order to find the sources of induced radioactivity in the patient's body, the targets, which are very similar to humans tissues, have irradiated with commonly used beams in hadrontherapy. For that, the pig liver and bone meal were chosen and as projectiles, the proton beam of 60 MeV and neutron beam obtained from the neutron source were used. After irradiation, the samples measured using the low-background spectrometer, at INP PAS in Kraków. Based on Geant4, the Monte Carlo simulations were simultaneously performed. In our experiments, the proton beam of 60 MeV and neutron beam obtained from the neutron source were used.
Results
Table 1 presents the list of isotopes which were identified after bone tissue irradiation of 60 MeV proton beam. One can see that the total dose from induced radioactivity for prescribed dose as 80 Gy in 100 c.c. tumour volume is approximately 30 μGy.

Isotope	Dose [pGy c.c. /Gy_therapy]
Cl-34m	546 +/- 95
K-42	145.7 +/- 6.3
Sc-44	99.5 +/- 3.7
K-43	6.3 +/- 5.4
Sc-47	10.70 +/- 0.49
K-38	3100 +/- 1500
Sc-43	42.2 +/- 2.7

Conclusion
As we can see above the additional dose using a low energetic proton beam is not significant. But for bigger tumours and highly energetic beams, the contribution of induced radioactivity could be higher. Moreover, as we can see in case of Proton Boron Cancer Therapy that even a small amount of specific element (in the case of PBCT - B-8) can significantly change the therapy effects. That is why the effect of induced radioactivity cannot be omitted and have to be estimated and taken into consideration during treatment planning.

EP-1691 IORT and stray radiation: comparison of 2 commercial linacs
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Purpose or Objective
Intraoperative Radiation Therapy (IORT) is performed with a linear accelerator in a standard operating room mainly constructed with 7 cm drywall walls.An important safety issue of IORT is radiation protection and stray radiation. This stray radiation is mainly produced by the accelerator itself (leakage radiation) and the patient (Patient Stray Radiation), as per NCRP 151.Two IORT dedicated electron linacs (IntraOp Mobetron 1000 and SIT Liac HWL) have been installed in the same operating room in our institute, providing a unique opportunity to benchmark both with regard to radiation protection performances.
Material and Methods
The 2 linacs were positioned in the center of the Operating Room; measurements have been performed with a reference applicator (100 mm applicator with bevel 0°) positioned on a 15 cm thick RW3 phantom, at a height of 100 cm above the floor with their beamstopper. Both linacs were set up at an energy of 12 MeV and a dose rate (DR) of 1000 MU/min or 550 MU/min. Measurements for the Liac HWL were performed with and without mobile barriers provided by the manufacturer.Instantaneous dose rate (IDR) was measured at 5 points against the wall of the surrounding rooms in the patient plane and at the hotspot at groundlevel beneath the OR with 3 survey meters: Canberra Babyline 81, Canberra Babyline 81*, Fluke 451 P. Additional surveys were performed in the rooms surrounding the OR and personnel InLight dosimeters were placed at critical locations to assess the weekly dose equivalent during clinical use.