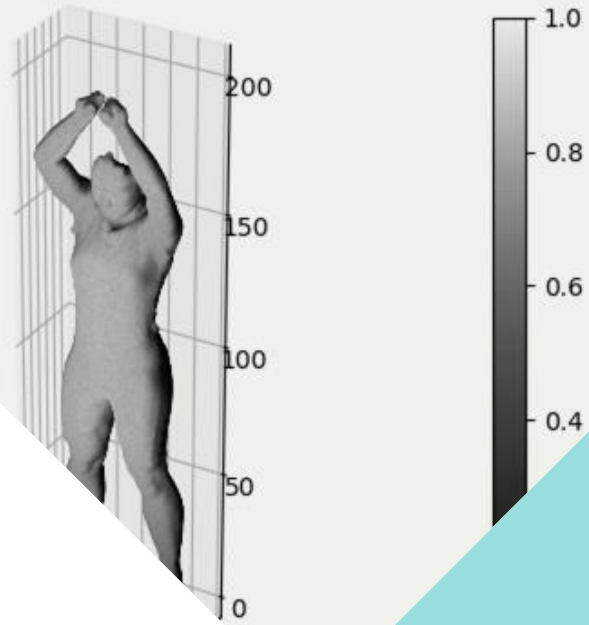

Total skin electron therapy dose calculations using photogrammetry-derived synthetic CT data

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Disclosures

The authors have no financial interests or relationships with any of the manufacturers or vendors of equipment described in this presentation, nor with any of the commercial supporters of the EPSM Conference.

This study was approved by the Royal Brisbane and Women's Hospital Human Research Ethics Committee (LNR/2020/QRBW/66064) and has been performed in accordance with the tenets of the Declaration of Helsinki. The authors acknowledge the volunteer participants for their time.

Aspects of this project have previously been presented at the March 2023 ASMIRT QLD Branch Arthur Knight Meeting.

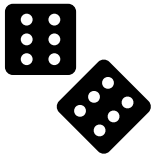
Total Skin Electron Therapy

Total skin electron therapy is a mature treatment modality that generally requires manual planning supported by in-vivo dose monitoring. Dose calculations are complicated because:

Extended SSDs, spoiler screens, large dose grids can be problems for treatment planning systems.

In the Stanford technique, patients are treated in six standing positions incompatible with CT imaging.

We have solutions for these issues!



Monte Carlo methods are able to simulate complex geometries, and have been previously used for TSET dose calculations.

BUT Monte Carlo models need to be developed and commissioned.

Photogrammetry and 3D scanning can be used to obtain detailed surface models, and skin dose is what we are interested in!

BUT Accurate whole body human scans can be challenging to obtain.

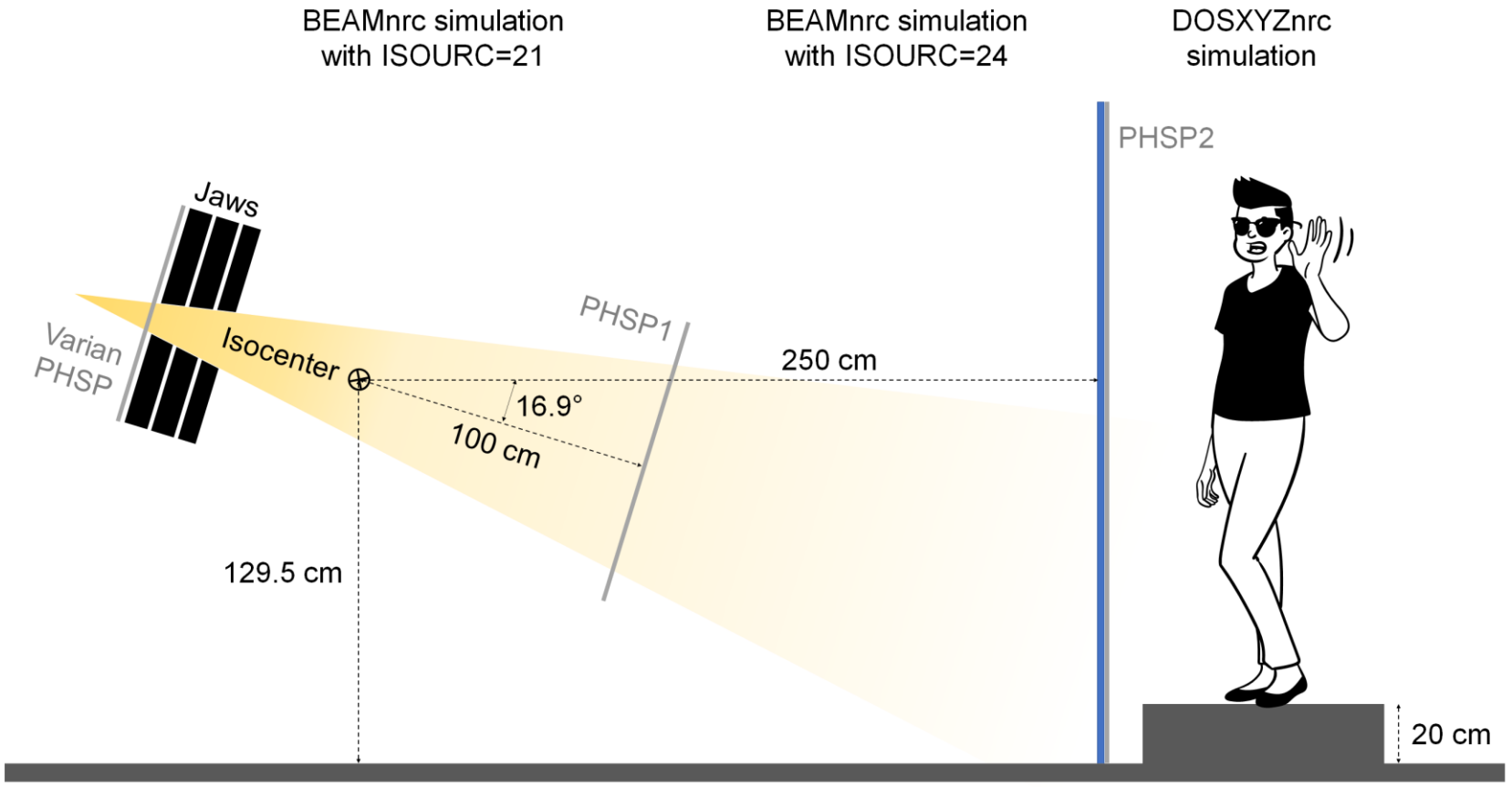
Monte Carlo modelling

BEAMnrc / DOSXYZnrc model developed using Varian-distributed 6E phase space files for TrueBeam system.

Needed to be done in 3 parts to definition of non-parallel jaws and spoiler.

Dual fields simulated by rotating PHSP2.

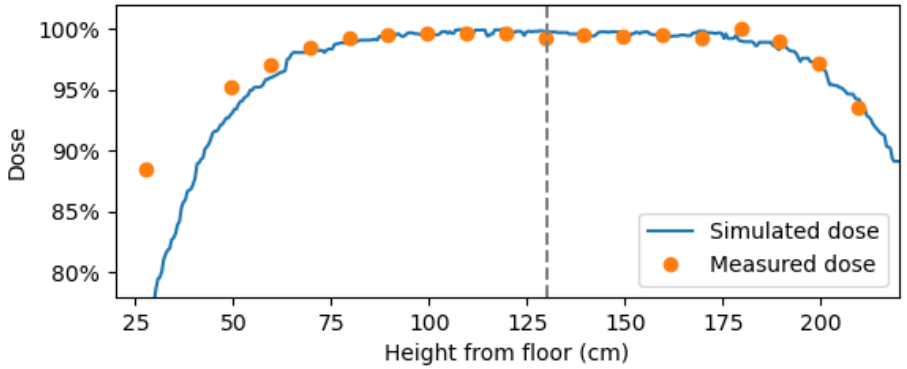
Floor wasn't modelled – more on that later!



Monte Carlo validation

Compared dose simulations against commissioning measurements done with Virtual Water at varying heights.

Disagreement near the floor, which wasn't modelled. Consistent with impact reported by Nevelsky et al.

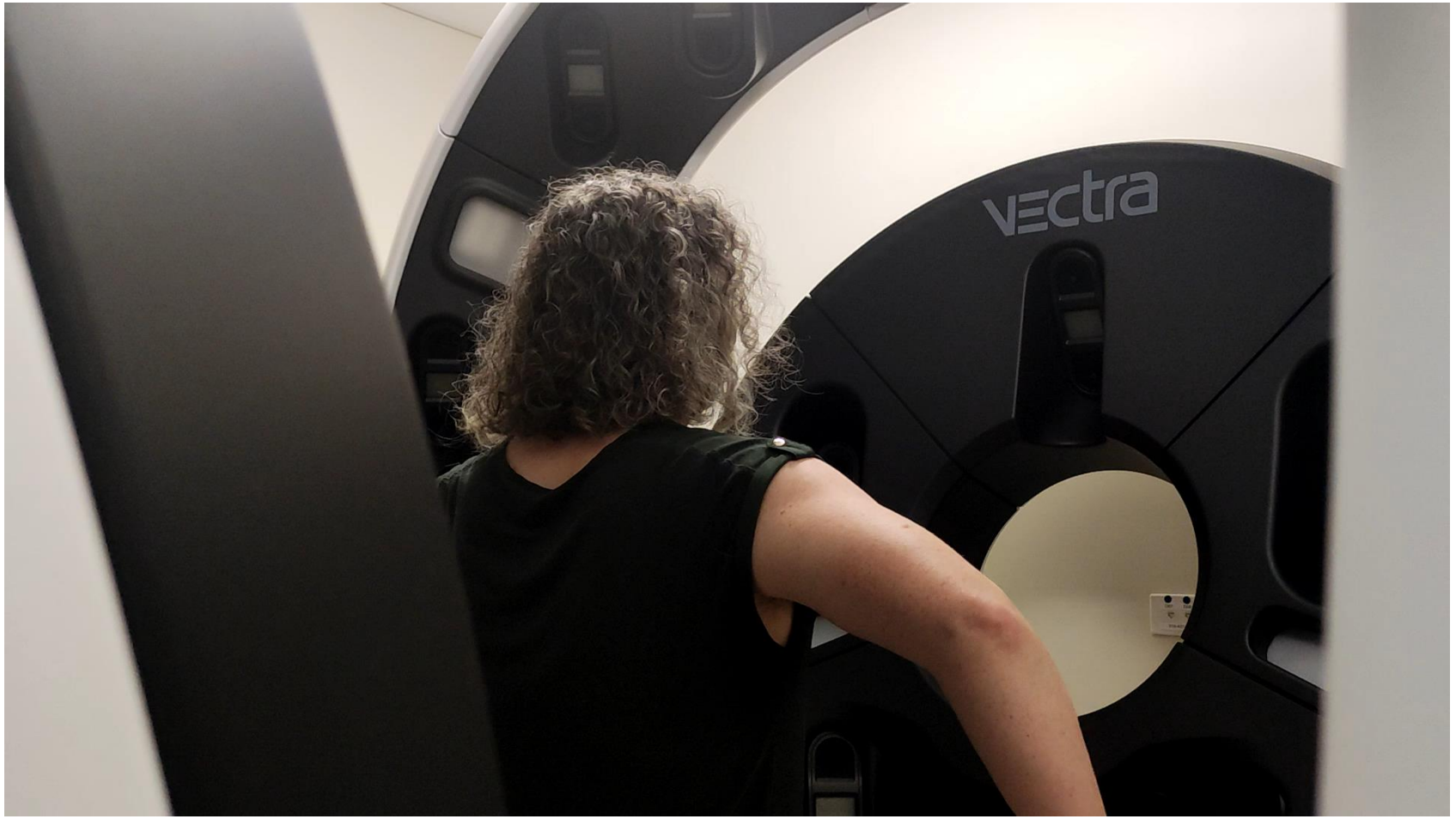


Whole body scanning

VECTRA 360 is a whole body photogrammetry solution for dermatology

Currently being used for the ACEMID melanoma detection study across 15 Australian sites

Frame with 92 cameras and associated lighting, acquiring images in seconds and producing a model in ~15 minutes.

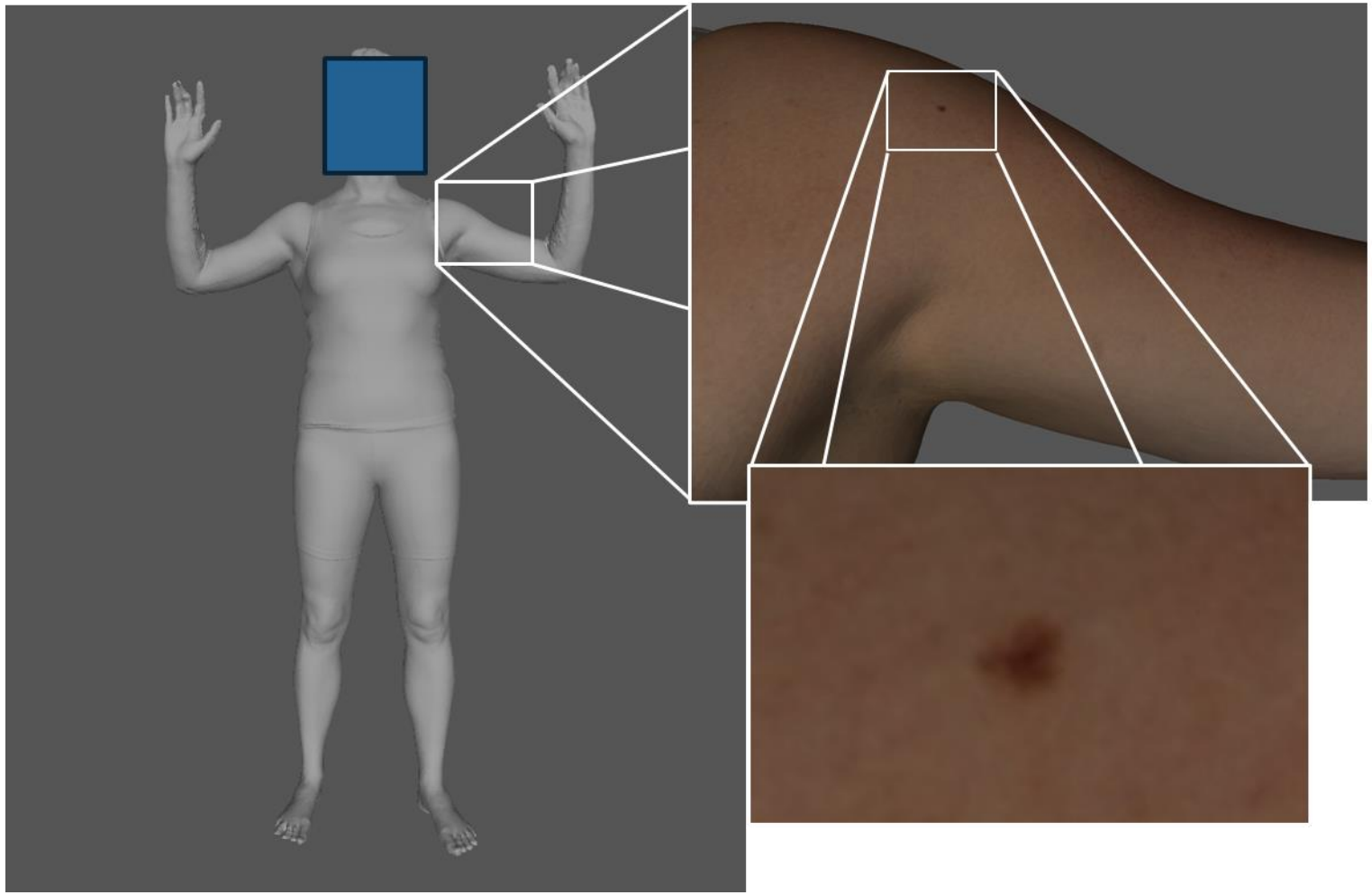


TSET position imaging

Capable of acquiring images of people in TSET positions with high precision.

Acquired 42 images across 8 participants and 1 RANDO phantom, including Stanford poses, w/ and w/o positioning errors, arms above head, and neutral ‘A’ and ‘T’ poses.

Includes skin data, so perhaps useful for monitoring treatment response / progression with BSA% calculations.



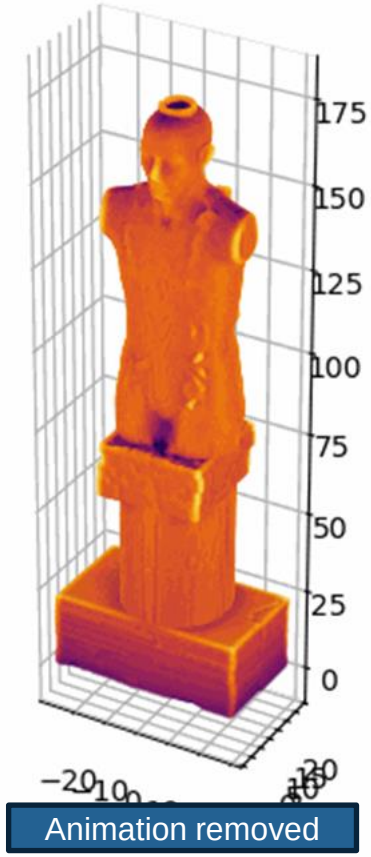
Simulations with scanned models

3D models exported as STLs, converted to water-equivalent EGSPHANT phantoms. Uniform 3 mm resolution across phantom.

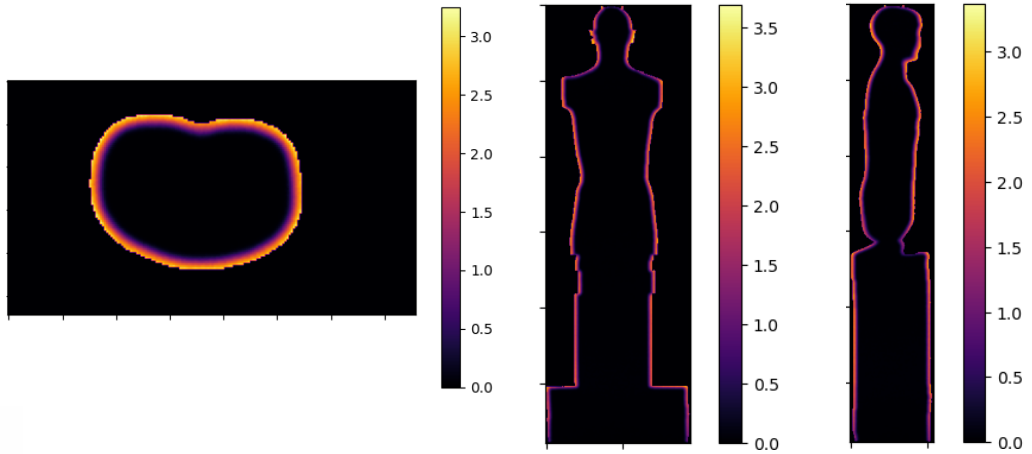
Doses calibrated as B-factors, relative to dose simulated in reference conditions.

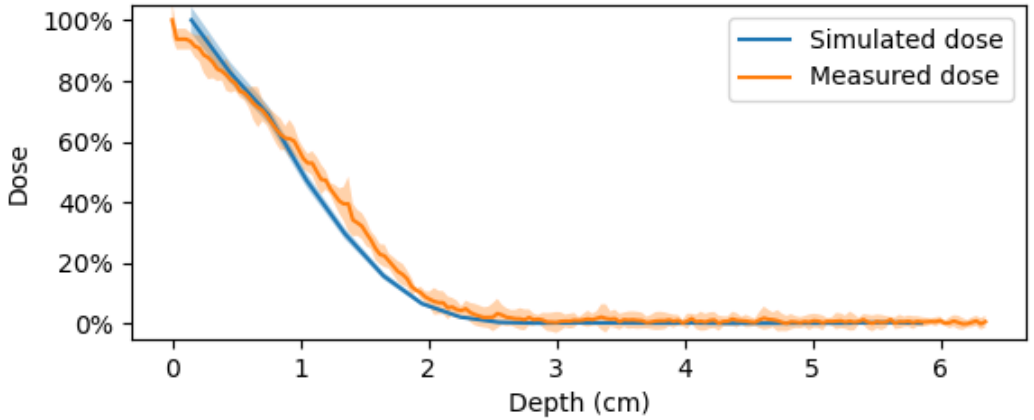
For RANDO, six dual-fields simulated with 60° separation (AP, LAO, LPO, PA, RPO, RAO).

B-factors were appropriate, and PDD looked reasonable.



Animation removed





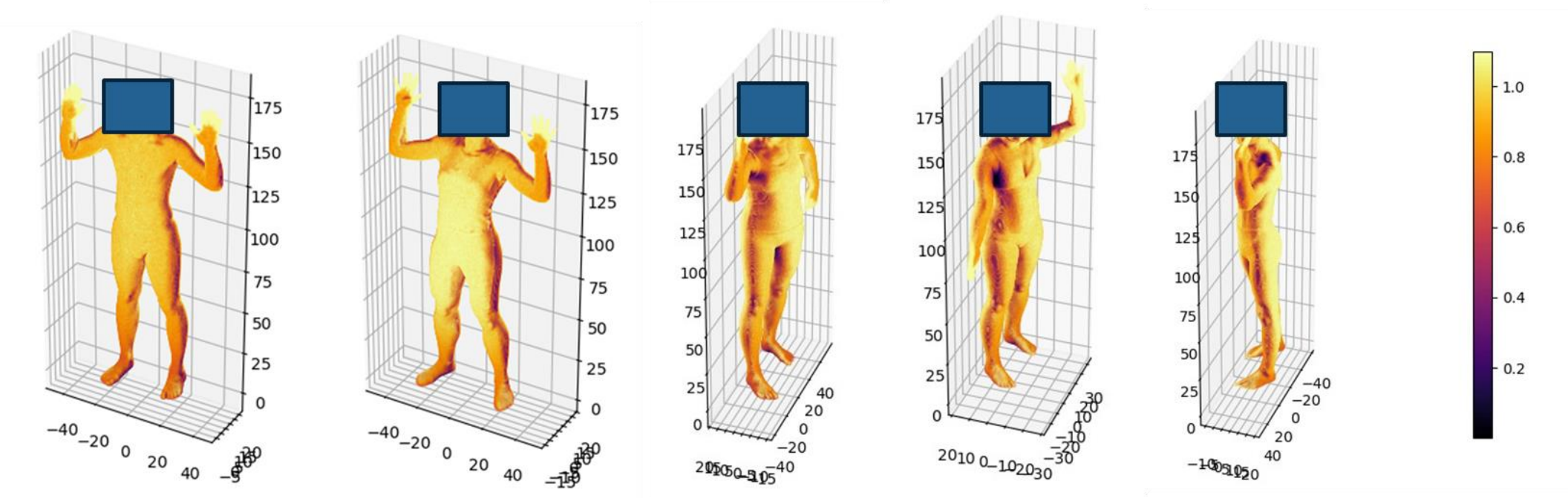
Participant dose simulations

Observations

High dose to inside of fingers and ears, which is logical, given overlapping PDDs in thin structures.

Expected low dose areas where line-of-sight did not exist (e.g. left and right sides for AP/PA pose).

Variations in dose homogeneity existed with body shape and posture. The origin of the synthetic CT dataset was the centre of the scanner – easy to identify those standing off-centre when imaged.



Scale is B-factor for beam pairs, with maximum set at 1.1 – dose to fingers is very high!

Clinical comparison

Results were compared against OSLD measurements performed clinically, by manual sampling and summation of dose across different positions. Note: small cohorts on both sides of this comparison.

Statistically significant differences at inner thigh and perineum, probably due to high dose gradients and occlusion.

Large, but not statistically significant differences at cranial vertex, shoulder, and outer elbow (similar reasons to above), and ankle, and top of foot (lack of floor scatter).

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Original research article

In vivo monitoring of total skin electron dose using optically stimulated luminescence dosimeters

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ABSTRACT

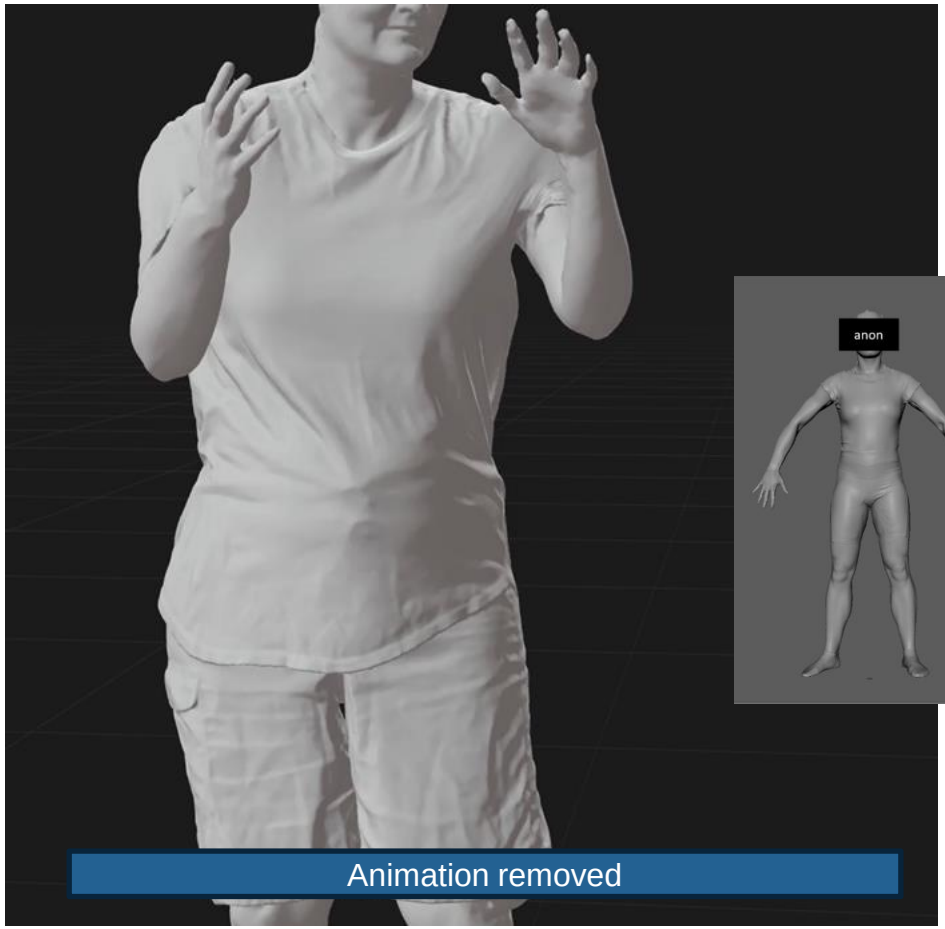
Aim: This study retrospectively analysed the results of using optically stimulated radiation dosimeters (OSLDs) for in vivo dose measurements during total skin electron therapy (TSET, also known as TSEI, TSEB, TSEBT, TSI or TBE) treatments of patients with mycosis fungoides.
Background: TSET treatments are generally delivered to standing patients, using treatment plans that are devised using manual dose calculations that require verification via in vivo dosimetry. Despite the increasing use of OSLDs for radiation dosimetry, there is minimal published guidance on the use of OSLDs for TSET verification.
Materials and methods: This study retrospectively reviewed in vivo dose measurements made during treatments of nine consecutive TSET patients, treated between 2013 and 2018. Landauer nanoDot OSLDs were used to measure the skin dose at reference locations on each patient, as well as at locations of clinical interest such as the head, hands, feet, axilla and groin.
Results: 1301 OSLD measurements were aggregated and analysed, producing results that were in broad agreement with previous TLD studies, while providing additional information about the variation of dose across concave surfaces and potentially guiding future refinement of treatment setup. In many cases these in vivo measurements were used to identify deviations from the planned dose in reference locations and to identify anatomical regions where additional shielding or boost treatments were required.
Conclusions: OSLDs can be used to obtain measurements of TSET dose that can inform monitor unit adjustments and identify regions of under and over dosage, while potentially informing continuous quality improvement in TSET treatment delivery.

Conclusions

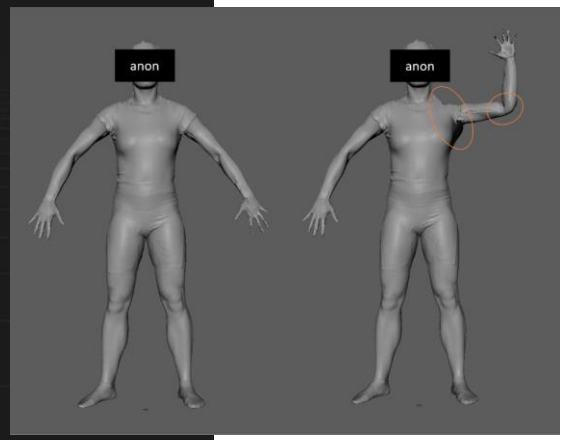
The results of the MC dose calculations may be useful to compare different TSET techniques, to predict potential patient-specific hot and cold spots, and as educational material for staff.

Future work could investigate modification of poses using skeletal rigging, to allow

1. Overcoming field-of-view limitations that complicate “arms-up” rotating poses.
2. Calculating for any pose from one scan.
3. Registration of surface dose across different poses.



Rigged 3D model acquired with VECTRA system at HIRF.



Adjusted pose using rigging, with some deformation artefacts.