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Modernized Partial-Body Total Skin Electron Therapy (TSET) Frame: Design, Construction, and Commissioning

Kyle Schaefer[1]; Abby Besemer, PhD[2]; Kristin Bradley, MD[2]; Claire Baniel, MD[2]; Stephanie Bailey, RTT[3];
[1] UW Hospital Healthcare Technology Management • [2] UW Madison - Department of Radiation Medicine • [3] UW Hospital Radiation Oncology

ABSTRACT

A multi disciplinary team was assembled to design, construct, and prepare for commissioning a modernized partial-body Total Skin Electron Therapy (TSET) frame for clinical use at UW Health Eastpark Medical Center since no commercially available options exist that meet the specified design parameters.
The goal was to replace an aging wooden frame structure with an easy-to-clean aluminum frame, improve therapist ergonomics, support modular shielding configurations, and ensure compatibility with multiple room constraints while maintaining compliance with AAPM TG-30 treatment uniformity guidelines.

The completed frame met all structural and ergonomic design requirements. The aluminum base demonstrated sufficient stability to support the 1.5 m scattering foil and approximately 150 pounds of acrylic shielding without tipping. The frame successfully fit through multiple treatment room doors and could be stored behind the treatment machines without restricting gantry rotation. Vertically adjustable handles, bars, and sliding panel brackets improved therapist usability. The tactile feedback web design was improved from the previous version and provides sufficient sensory information to the patient to minimize swaying and loss of balance during treatment. The final assembled height (212 cm) supported treatment of most patients up to approximately 6 ½ feet tall while still fitting through treatment room doors and remaining within TG-30 vertical uniformity expectations. The frame was fully assembled by January 19, 2026, with final commissioning January 31, 2026.

CONTACT

Kyle Schaefer
University of Wisconsin
Hospitals and Clinics
4621 Eastpark Boulevard, Madison, WI
kschaefer2@uwhealth.org
+1 (608) 219-3375

UWHealth | Carbone Cancer Center

INTRODUCTION

Total Skin Electron Therapy requires specialized fixtures to achieve uniform dose delivery across large treatment surfaces. Existing wooden frames at UW Health were aging, difficult to disinfect, and lacked modular shielding flexibility. No commercial partial-body TSET frame met the required design parameters. A multidisciplinary team collaborated to specify and design a modernized, mobile, clinically flexible, infection control compatible, aluminum frame capable of supporting upper-, lower-, and mid-body treatments while maintaining AAPM TG-30 uniformity guidelines.

METHODS AND MATERIALS

Design Requirements Included:

- Modular acrylic shielding (ten 15-cm panels + one 25-cm lower panel). Low-Z materials (aluminum + acrylic) minimizing bremsstrahlung.
- Sliding brackets enabling therapists to attach panels at chest height. Door-clearance compatibility without tipping the frame. Counter-weighted base supporting ~150 lbs of acrylic shielding. Spoiler closest to the beam; patient stands 10 cm behind. Adjustable vertical bars for patient handles and tactile webbing.
- Compatibility with existing TSET workflows and room storage.
- Iterative CAD modeling was performed to optimize frame height, wheel profile, and structural stability while ensuring the device could be rolled through treatment room doorways without the need to tip the device on its side. The final design incorporated a full-height aluminum frame, variable height patient handles, a spoiler, a tactile feedback web of HDPE strands to aid in patient proprioception, and a modular acrylic shielding system composed of ten 15-cm interlocking panels. Acrylic was selected for its low-Z properties, transparency, and ease of replacement. Room logistics, storage feasibility, and clinical workflow integration were evaluated across all treatment rooms at multiple UW Health locations.
- A multidisciplinary team of clinical physicists, radiation oncologists, and Healthcare Technology Management (HTM) engineering staff collaborated to define design requirements.

RESULTS

- Final assembled height: 212 cm, supporting patients up to ~6.5 ft tall. The aluminum base demonstrated excellent stability with ~150 pounds of acrylic shielding. The frame fits through treatment room doors without needing to be tipped on its side or disassembled and stores behind machines without restricting gantry rotation.
- Sliding brackets and adjustable vertical bars improved therapist and patient ergonomics. The redesigned tactile feedback web improved proprioceptive stability for patients.
- Assembly completed January 19, 2026; shielding delivered January 23; commissioning began January 24 and was completed January 31. This design is scalable for future replication at additional UW Health sites.

Figure 1: End-to-end testing with TLDs and the ATOM Phantom

Figure 2: CAD Rendering of TSET Frame, Helmet, and QA Rail

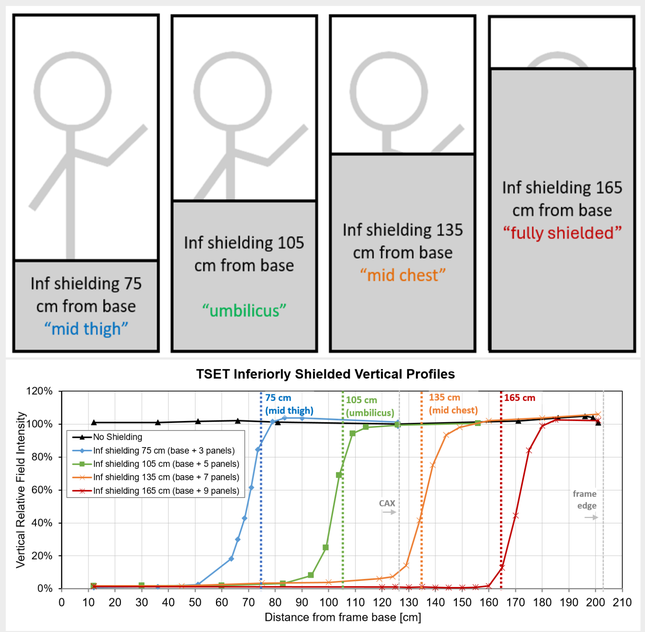

Figure 3: Inferior Shielding Profiles for Commissioning

Table 1: TSET Shielded Profile Overview

Shielding Configuration	Approx anatomical height of shielding	Height of <2% Dose (cm)	Height of 10% Dose (cm)	10% to Shielding Edge Dist (cm)	Shielding Edge Height (cm)	90% to Shielding Edge Dist (cm)	Height of 90% Dose (cm)	90% to 10% Dist (cm)	90% to 10% Gradient (%/cm)
Inf shielding 75 cm (base + 3 panels)	mid thigh	N/A (min 6%)	50	25	75	0	75	26	3
Inf shielding 105 cm (base + 5 panels)	umbilicus	60	94	11	105	3	108	14	6
Inf shielding 135 cm (base + 7 panels)	mid chest	49	126	9	135	8	143	17	5
Inf shielding 165 cm (base + 9 panels)	eye-level	160	164	1	165	12	177	13	2

DISCUSSION

- This modernized TSET frame utilizes acrylic shielding provides transparency for positioning, reduced claustrophobia for the patient, and avoids the bremsstrahlung production from high-Z shielding materials. Interlocking stair-step grooves minimize leakage between panels.
- The modular design supports upper-body, lower-body, and mid-body treatments with flexible cut-off lengths. Four shielding levels were measured initially during commissioning (Figure 3) – Mid thigh (75cm from base), Umbilicus (105cm from base), Mid chest (135cm from base), and Fully shielded (165cm from base).
- Surface measurements were made for multiple skin surface locations using the Sun Nuclear ATOM Phantom (Figure 1) and TLDs to determine effectiveness of both the treatment scattering foil and dose distribution but also to verify shielding effectiveness.
- Therapist ergonomics were a major design driver, and the sliding bracket system significantly improves usability. Threaded studs were chosen to make panel attachment easier for therapists. This design supports the weight of the panel while the threaded retaining knobs are attached reducing arm fatigue.
- Additional design elements (Figure 2) that are being implemented include:
  - A half-height acrylic shielding panel to be able to more finely set the shielding height
  - A 3D printed PETG and Tungsten shielding helmet to reduce alopecia
  - A measurement rail to make commissioning and QA measurements easier using a farmer chamber. The rail is made from carbon fiber and the shuttle and chamber holder are made from Delrin to reduce the likelihood of measurement contamination from backscatter.

CONCLUSIONS

A clinically robust, modular, and ergonomically optimized partial-body TSET frame was successfully designed, constructed, and prepared for commissioning. The device meets structural, workflow, and infection-control requirements while supporting flexible shielding configurations.

REFERENCES

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Department of Radiation Medicine
UNIVERSITY OF WISCONSIN
SCHOOL OF MEDICINE AND PUBLIC HEALTH

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