Particle Physics Seminar 05.02.2026

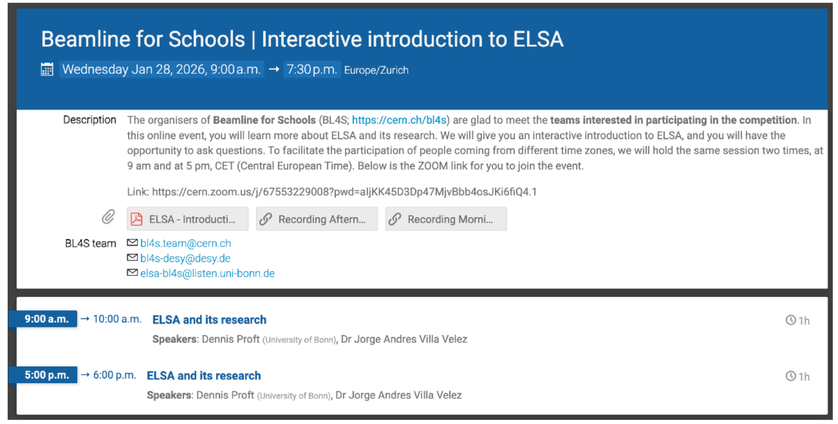
Pragmatic Transition Radiation Targets: BL4S 2025 Results from Team XTReme at ELSA

Saime Gürbüz & Rasmus Partzsch

ELSA Team:
Sebastian Laudage, Dennis Proft, Kristof Schmieden,
Christian Bespin, Frank Frommberger, Philip Bechtle, Klaus Desch
Team XTReme:
Avin Gupta, Chuming Li, Ryan Antony Pius, Wei Yee Pua,
Sanjana Rajaram, Justin Thomas Szela

What is BL4S?

- A world-wide physics competition for high-school students since 2014. ELSA joined the team in 2025.
- Yearly schedule:
  - October / November: Publicity
  - November to March: Pre-registration,
    Online Events: https://indico.cern.ch/category/20551/
  - BL4S2026 Deadline: 13 March, 23:59 CEST
  - March to end of April: Evaluation
  - May to August: Preparation (+Beam tests)
  - 12-26 August: Winners come to CERN / DESY / ELSA
- More info: https://beamlineforschools.cern/



Jan 14	DESY	Facility Talk	Introduction to DESY's laboratories and experimental beamlines.
Jan 19	DESY	Scientist Talk	A DESY scientist shares their experience and current research.
Jan 28	ELSA	Facility Talk	Learn about ELSA's accelerator and research programmes.
Feb 11	ELSA	Scientist Talk	Meet a scientist from ELSA and discover their work.

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ROLEX

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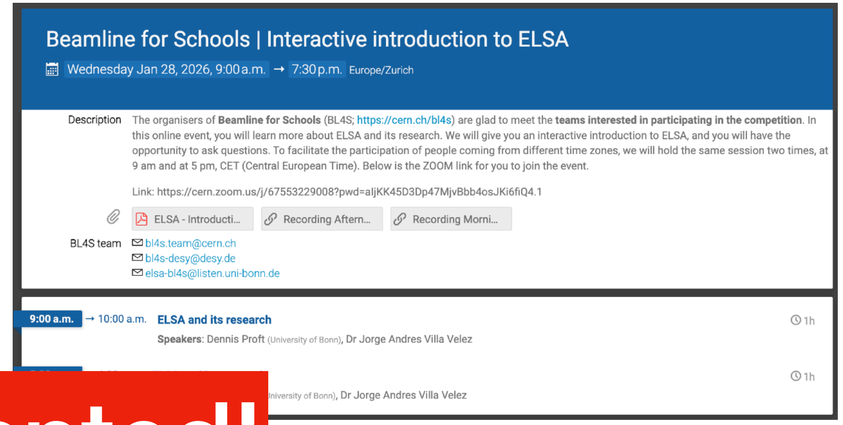
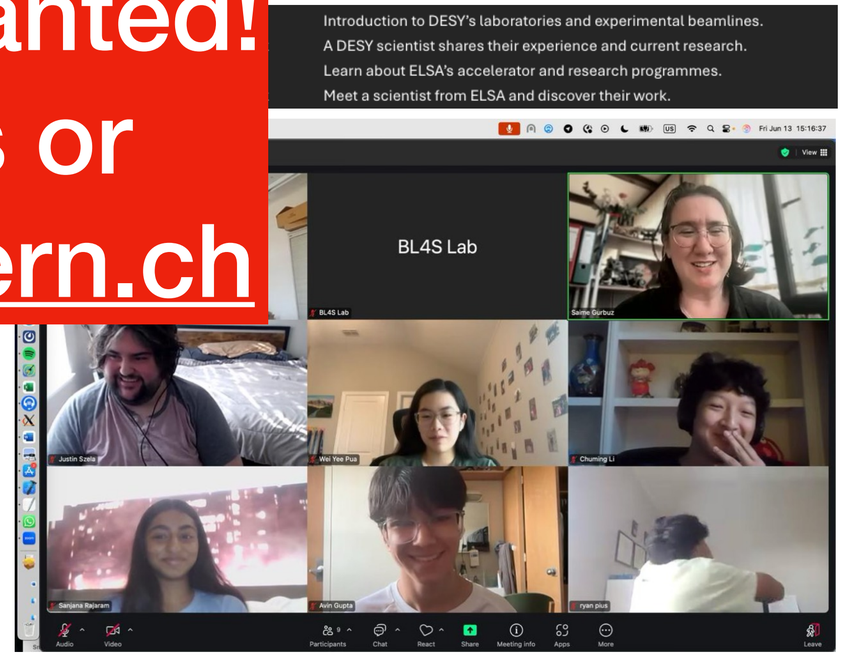


Volunteers wanted!
Contact us or
jorge.villa@cern.ch



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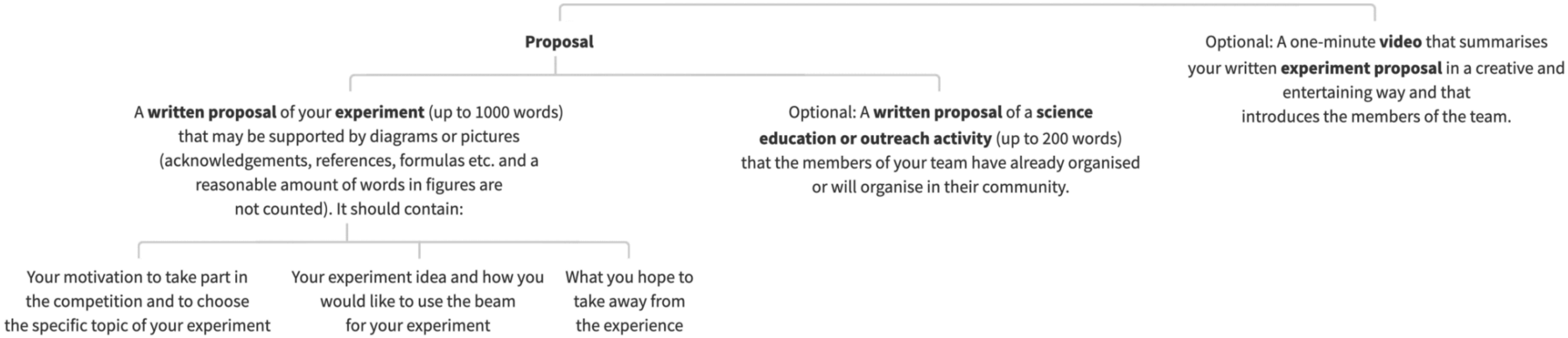
Structure of the Competition and Prizes



The evaluation will take into account the following criteria:

- Feasibility of the experiment
- Scientific method
- Motivation of the experiment
- Motivation to participate in BL4S
- Creativity of the experiment

Prizes:

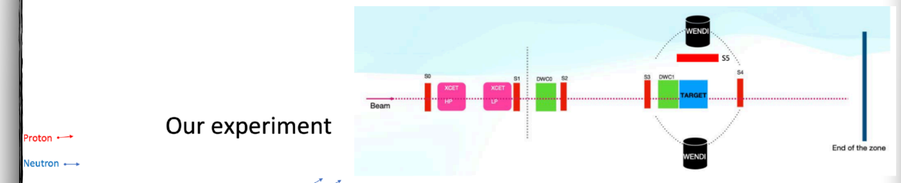
- **5 winning teams** -> 2 weeks at CERN/DESY/ELSA
- **50 shortlisted teams** -> Special prizes (A portable particle detector for their school and BL4S T-shirts for each team member)
- **3 best video awards** -> Special prizes
- **15 best outreach awards** -> “Stars Shine For Everyone” (SSVI) project will award optical telescopes

2025 Winners

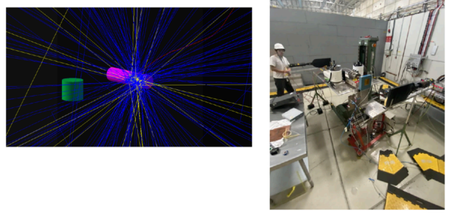
(https://beamlineforschools.cern/2025-edition/)

CERN

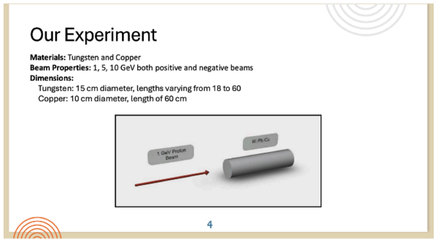
Team Spallateam (Belgium, 2025)

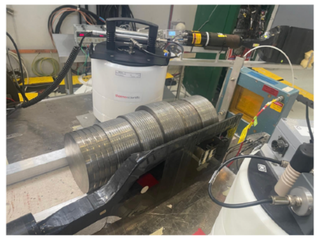


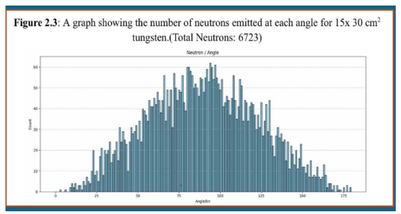
Simulations & experiments

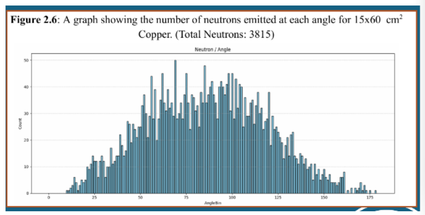


Team Physical (Türkiye, 2025)



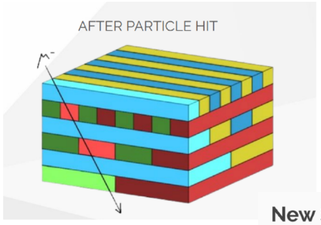




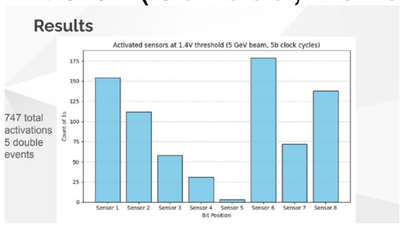


DESY

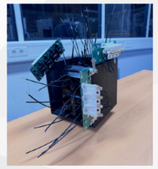
Team Dawson Technicolor (Canada, 2025)



Results



New SiPM Boards Setup

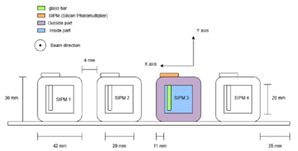


[FIG. 6] The previous setup. The SiPM board's position made the task of connecting the optical fibers to it harder because of the different lengths of the fibers and the stress it would apply on some of them. bending them.

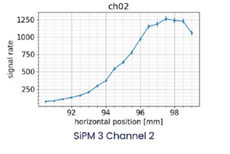
[FIG. 7] The newly optimized setup. This avoids any unnecessary stress on the fragile optical fibers and other issues.

Team Pumas in Kollision (Mexico, 2025)

SETUP DIAGRAM



PRELIMINARY DATA



SiPM 3 Channel 2

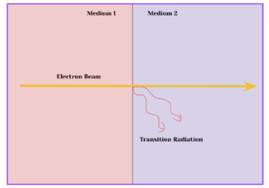
The X axis represents the position in X, the y axis represents the average amplitude in mV

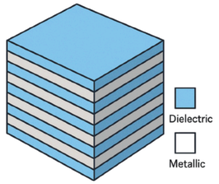
Figure 5: A) Sample of Eysenhardtia polystachya (kidneywood) infusion using purified water. B) Stationary phase (opaline) absorbing pigments contained in the infusion.

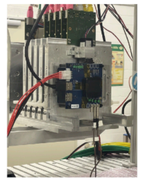
ELSA

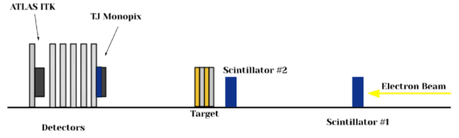
Team XTReme (USA, 2025)

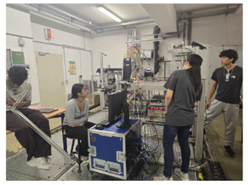
Transition Radiation (TR) in Multi-Layer Systems

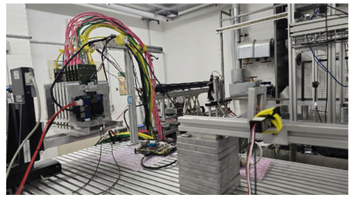










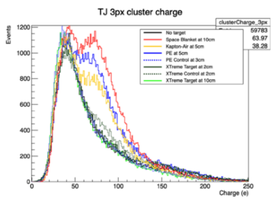


DATA!

Total Run Count: **42**

Total Trigger Events: **441.4 million**

Target	1.8GeV	2.5GeV	3.2GeV
BKG No Target	run26: 3M run32: 15M	run19: 15M	run5: 15M run13: 10M
Polyethylene and Air (51 layers)	run27: 3M@5cm run34:15M@50cm	run24: 15M@5cm run17: 15M@50cm	run14: 40M@50cm run 4: 15M@63cm
Polyethylene Control Target (1 thick layer)	run40: 3M@2cm run37:15M@50cm	run21: 15M@50cm	runXX: 15M@50cm
TaZOS & SiO2 (102 layers)	run28: 3M@2cm run41: 3M@10cm run35:15M@50cm	run25: 15M@1cm run15: 10M@50cm run23: 15M@63cm	runXX: 15M@50cm runXX: 15M@63cm
TaZOS & SiO2 Control Target (6 layer kapton) *(26 layer kapton)	run38:15M@50cm *run30: 3M@2cm	runXX: 15M@50cm *run20: 15M@50cm	runXX: 15M@50cm *runXX: 15M@63cm
Space Blanket and Air (51 Layers)	run31: 3M@10cm run36:15M@50cm	run18: 15M@50cm	run9: 10M@63cm
Kapton and Air (51 Layers)	run33: 3M@5cm run39: 15M@50cm	run22: 15M@50cm	run11: 10M@45cm run10: 35M@63cm



https://www.youtube.com/watch?v=iDHy5AXsDlA

Team XTReme

Transition Radiation in Multi-Layered Dielectric–Metallic Targets for Soft X-Ray Generation and Beam Diagnostics

Team XTReme

Centennial High School, Frisco, TX, USA

Avin Gupta, Chuming Li, Ryan Pius, Weiyee Pua, Sanjana Rajaram

April 10, 2025

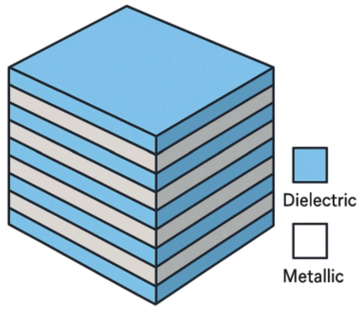


Figure 2: Targets of alternating dielectric and metallic layers

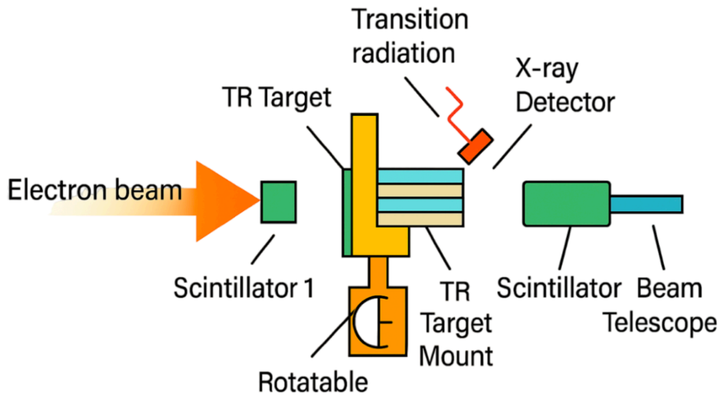


Figure 4: Experimental set up to measure the transition radiation emitted by different types of multilayer targets

4.3 Theoretical Framework

The spectral-angular distribution of TR [8] from a single interface is given by

$$\frac{d^2W}{d\omega d\Omega} = \frac{e^2}{\pi^2 c} \cdot \frac{\beta^2 sin^2\theta}{(1-\beta^2 cos^2\theta)^2} \cdot \left|\frac{\epsilon_2 - \epsilon_1}{\epsilon_2 + \epsilon_1}\right|^2$$

where θ is the emission angle, ω is the photon frequency, β is the velocity ratio $\frac{v}{c}$, and ϵ_1, ϵ_2 are the dielectric constants of the adjacent media. In this equation, $\frac{d^2W}{d\omega\, d\Omega}$ represents the differential energy emitted as transition radiation per unit angular frequency ω and per unit solid angle Ω.

In multilayer systems with N layers of thickness d [9], constructive interference leads to

$$W_{total} \propto N \cdot \left(1 + cos\left(\frac{2\pi d}{\lambda}\right)\right)$$

This formula highlights the sensitivity of TR yield to layer thickness and photon wavelength, motivating our choice to explore graded chirped stacks. W_{total} represents the total transition radiation energy emitted, and λ represents the emitted photon wavelength.

4.4 Data Collection Plan

The experiment will span five operational days, scheduled as follows:

Day	Activity
1	System setup, alignment, and calibration
2	T1 data collection across all energies
3	T2 data collection across all energies
4	T3 data collection across all energies
5	Background runs, dark runs, cross-checks

At each beam energy (1, 3, and 6 GeV), data will be collected with and without filters to isolate spectral components. Background subtraction using dark and no-target runs will isolate the true TR signal.

4.6 Feasibility and safety

All chosen target materials (e.g., Kapton, SiO_2, Al, TiO_2) are non-toxic, thermally stable, and commonly used in accelerator environments. No cryogenic, radioactive, or chemically reactive substances are involved. In addition, all detectors used are standard BL4S components, meaning power, cooling, and data acquisition needs are minimal. Mirrors are extremely effective sources of PXR, and highlight the role of multilayer structures in tailoring X-ray emission.

Training Day

Safety First, Then We Do Physics

Radiation Safety Instructions

for users of the ELSA accelerator facility

ELSA
Electron Stretcher Accelerator

September 2025

Safety Instruction

Beamline 4 Schools Participants

Dennis Proft

Electron Stretcher Facility ELSA, Physics Institute, University of Bonn

12.09.2025

ELSA

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1

THE BIGGEST CAMERA FOR THE SMALLEST PARTICLES

2025 Beamline for Schools – ELSA in Bonn

Prof. Dr. Ingrid Maria Gregor
DESY/Universität Bonn

University of Bonn

Polarized Target Group

(Hartmut Dutz, Stefan Goertz, Sascha Heinz, Victoria Lagerquist, Annabel Ibel)

A *Brief* Introduction to Polarized Targets

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ELSA

Introduction to Experimental Hadron physics at ELSA

Beam Lines for Schools

Dr. Tom Jude, 12th September 2025

Beam test experiments

For detector characterization and beyond

Dr. Christian Bespin

BL4S 2025 @ Bonn

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SILAB Bildum Labor Bonn

MEASUREMENTS WITH ANEMONE AN EUDET-TYPE BEAM TELESCOPE

Rasmus Partzsch

BL4S

13/09/25 Rasmus Partzsch – rasmus.partzsch@uni-bonn.de

BL4S Sponsor's (VIP) Day

Hybrid format, on-site at CERN, DESY, ELSA and online

- We hosted
  - Rektor Prof. Michael Hoch
  - Barbara Solich (Head of Partnerships & Fundraising at CERN)
  - Stefan Jorda (WE-Heraeus-Stiftung)
  - Sascha Schmeling (CERN)
  - Alexandra Shema from U.S. Consulate General Duesseldorf
  - Many of you….
- The students presented their experience and results.
- Followed by a ELSA visit and reception

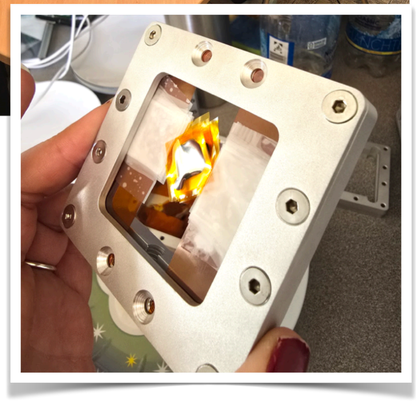


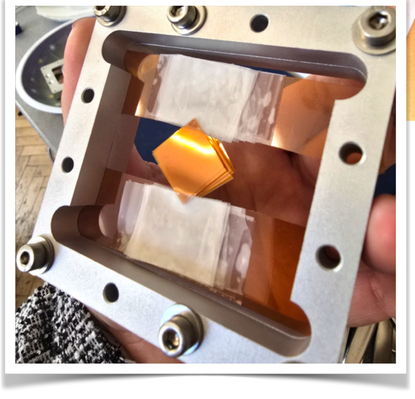



Target Preparation

Dielectric layered target

- The students prepared layered dielectric targets at Linden Lab in FTD.
- Prof Linden prepared the samples using Electron Beam Evaporator.
- 25μm Kapton 8x (Ta2O5-SiO) each layer: 100nm
- Such 20 layers are stacked to construct the target
- Control target is constructed only with 20 layers of 25μm bare kapton

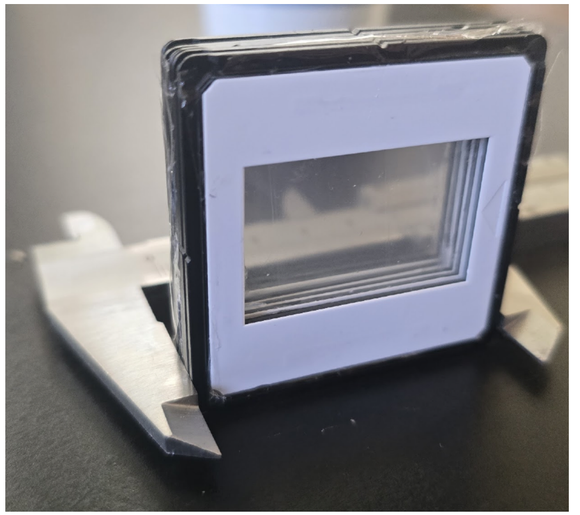
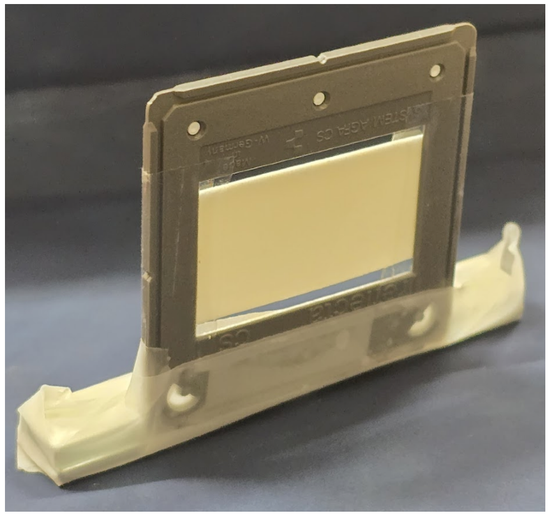
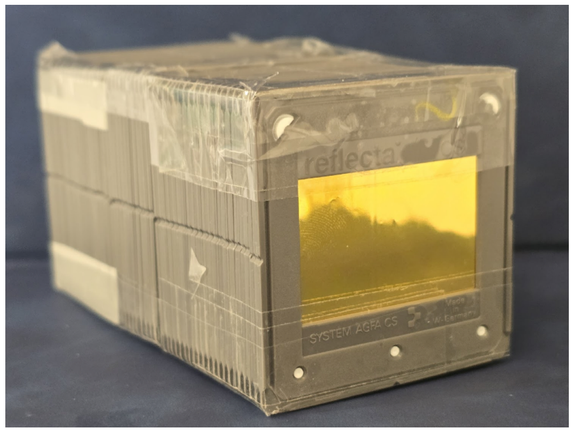
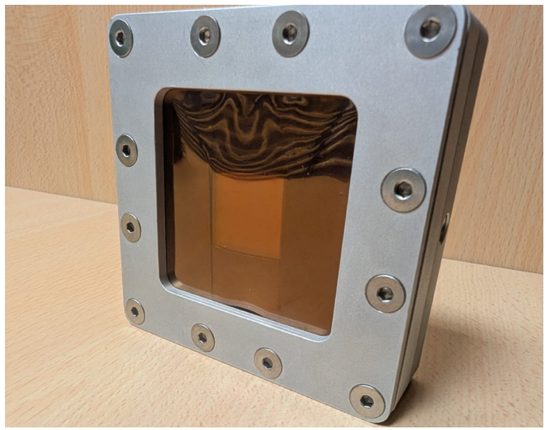




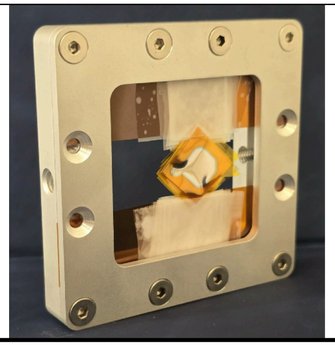
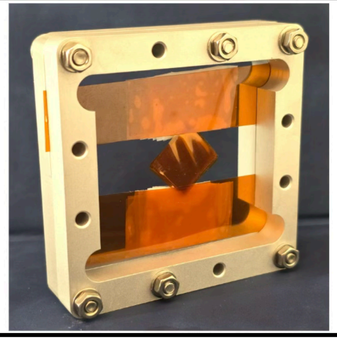
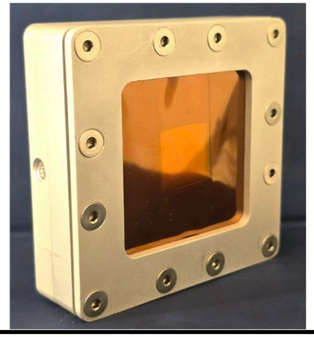
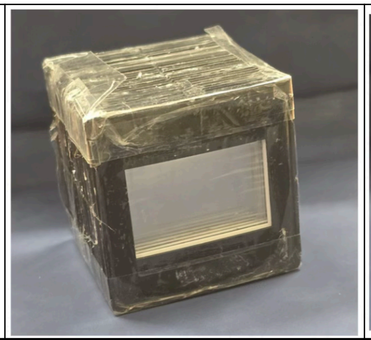
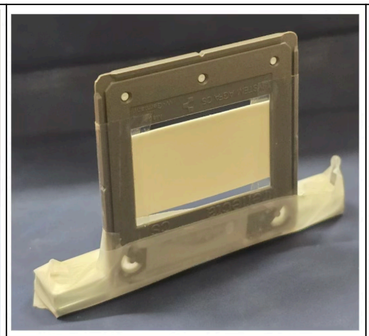
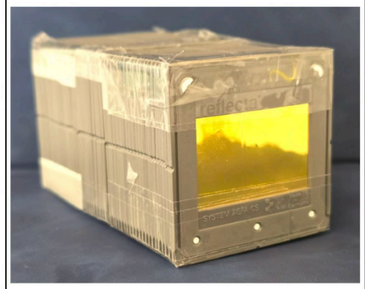
Target Preparation
PE/Space Blanket/Kapton

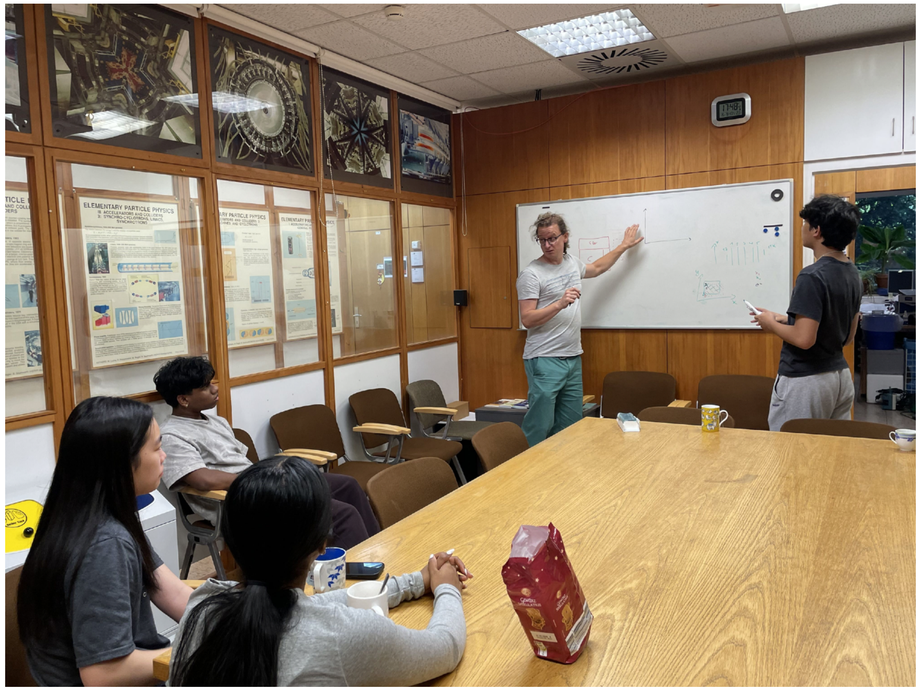
- PE Target (Cling Wrap)
    - thickness = 7-10μm
- Control Target for PE (Shampoo bottle)
    - thickness = 650μm
- Space Blanket Target
    - thickness = 7-10μm
- Kapton Target
    - thickness = 55μm

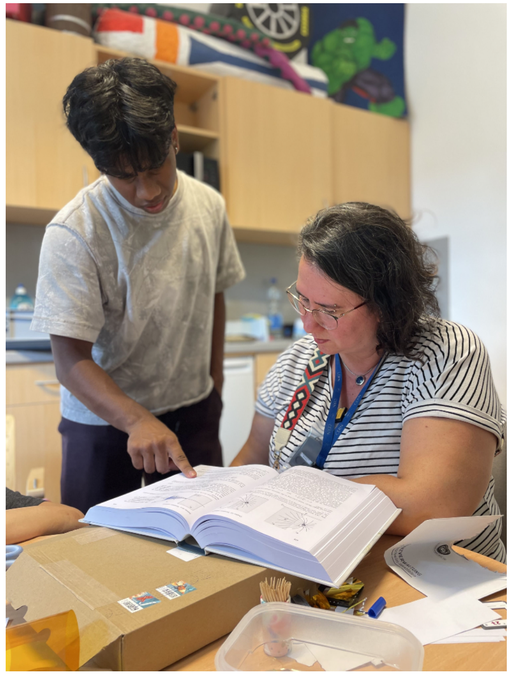


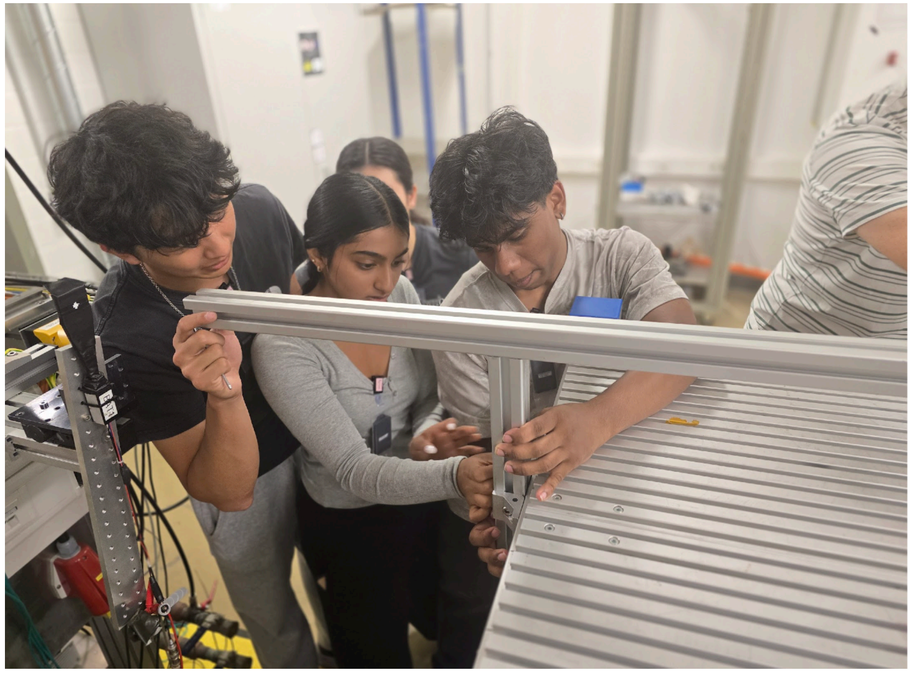





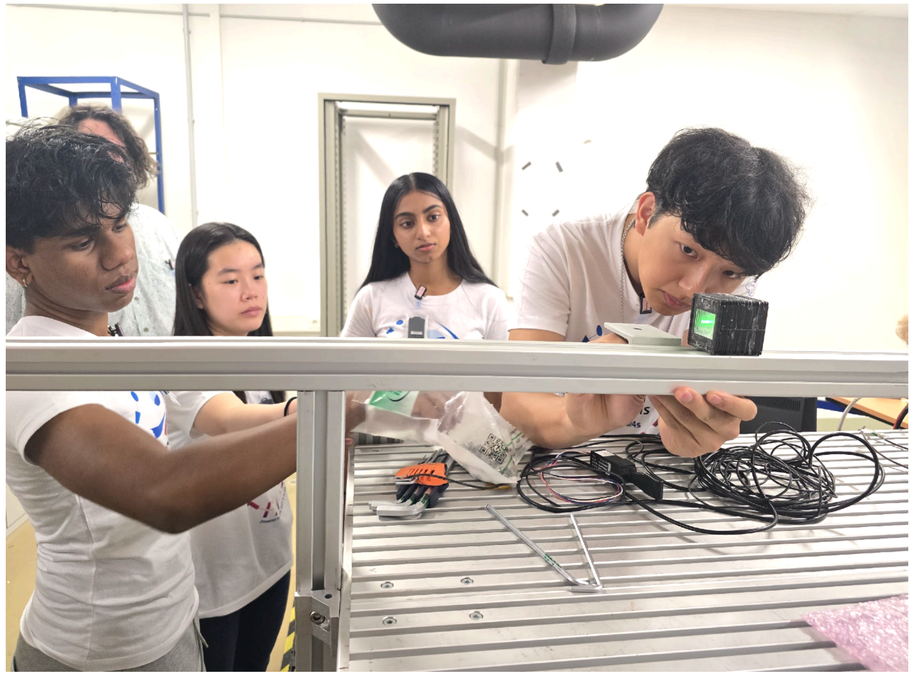
Transition Radiation Targets

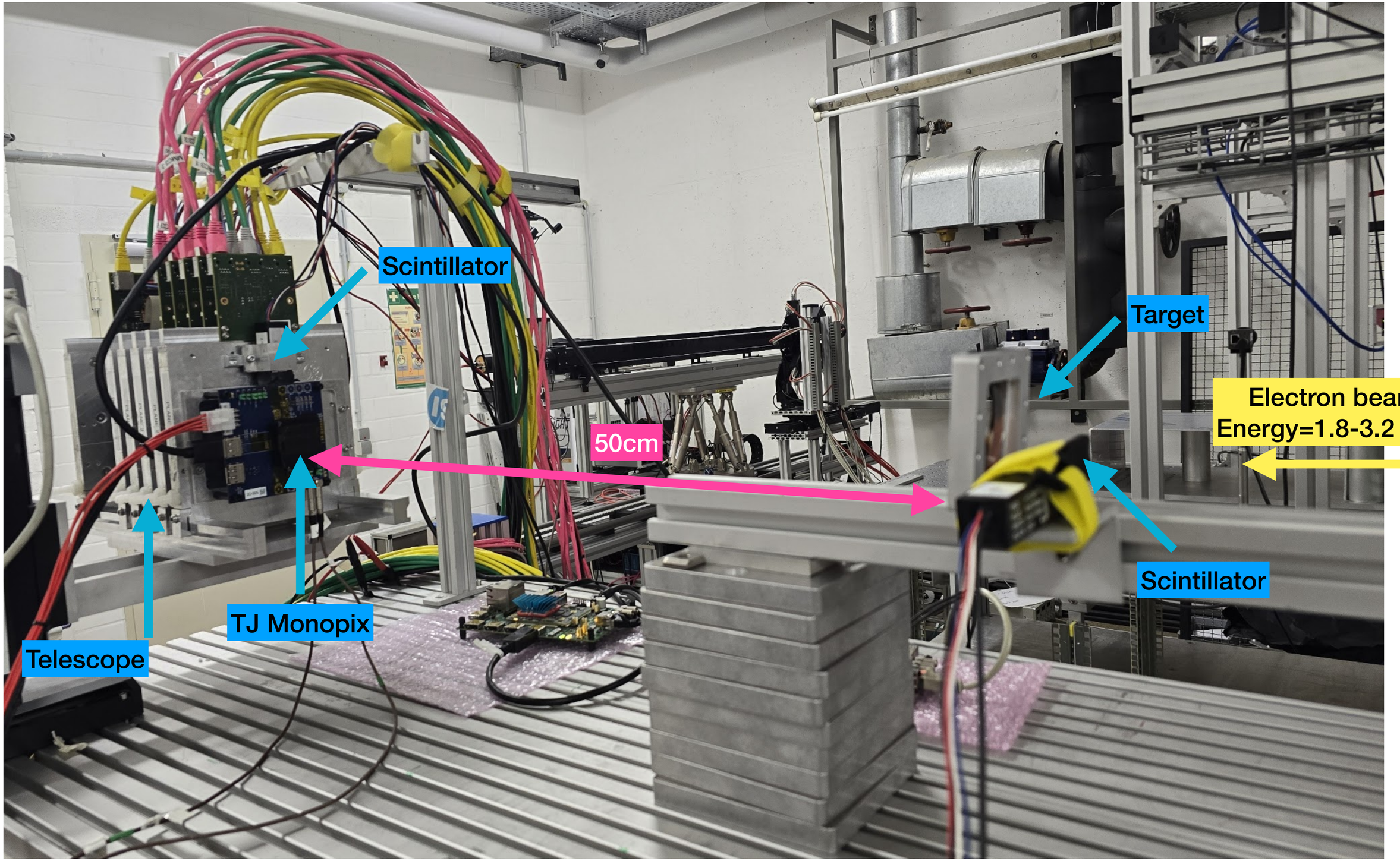
						
	Layered Dielectric	Control-LD	Kapton	Polyethylene Multi Layer	Polyethylene Control	Space Blanket
EACH LAYER	8 x (Ta2O5-SiO) on kapton	Kapton	Kapton	LDPE (cling wrap)	LDPE (shampoo bottle)	Aluminized mylar
LAYER THICKNESS	25μm	25μm	55μm	7-10μm	650μm	10μm
# of LAYERS	20	20	51	51	1	51
LAYER SEPERATION	~0μm	~0μm	125μm	955μm	-	1800μm


ELEMENTARY PARTICLE PHYSICS








Scintillator
Target
Electron beam
Energy=1.8-3.2 GeV
50cm
Scintillator
TJ Monopix
Telescope

Target	1.8GeV	2.5GeV	3.2GeV
BKG **No Target**	run26: 3M run32: 15M	run19: 15M	run5: 15M run13: 10M
Polyethylene and Air **(51 layers)**	run27: 3M@5cm run34:15M@50cm	run24: 15M@5cm run17: 15M@50cm	run14: 40M@50cm run 4: 15M@63cm
Polyethylene **Control Target** **(1 thick layer)**	run40: 3M@2cm run37:15M@50cm	run21: 15M@50cm	runXX: 15M@50cm
Ta2O5 & SiO2 **(102 layers)**	run28: 3M@2cm run41: 3M@10cm run35:15M@50cm	run25: 15M@1cm run15: 10M@50cm run23: 15M@63cm	runXX: 15M@50cm runXX: 15M@63cm?
Ta2O5 & SiO2 **Control Target** **(6 layer kapton)** ***(20 layer kapton)**	run38:15M@50cm *run30: 3M@2cm	runXX: 15M@50cm *run20: 15M@50cm	runXX: 15M@50cm *run6: 15M@63cm
Space Blanket and Air **(51 layers)**	run31: 3M@10cm run36:15M@50cm	run18: 15M@50cm	run9: 10M@63cm
Kapton and Air **(51 Layers)**	run33: 3M@5cm run39: 15M@50cm	run22: 15M@50cm	run11: 10M@45cm run10: 10M@63cm

14th Beam Telescopes and Test Beams Workshop

13 – 17 April 2026

Mainz, Germany

Topics

- Beam Lines and Infrastructures
- Beam Telescopes and Device Integration
- Data Analysis, Tracking, Alignment
- Simulations and Software Packages

Deadlines

Abstract Submission: **20.02.2026**

Registration: **20.03.2026**

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Achim Denig
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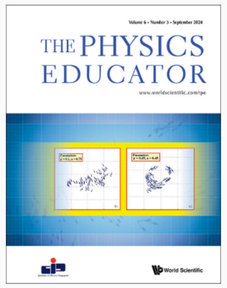

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Characterization of the Angular Distribution and Energy Spectrum of Transition Radiation from Polyethylene and Space Blankets

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January 30, 2026

Abstract: We designed and carried out an experiment to investigate the production of transition radiation X-rays generated by relativistic electrons traversing through low-cost and readily available radiator materials. The experiment was selected as one of the winning projects of the 2025 Beamline for Schools competition by CERN and was performed at the ELSA accelerator of the University of Bonn, using electron beams with energies between 1.8 and 3.2 GeV. Transition radiation was produced using polyethylene plastic film and aluminized mylar space blankets as budget-friendly multilayer radiators, with Kapton foils employed as a reference material for comparison. The angular distributions and energy spectra of the emitted X-rays were measured using a silicon pixel detector and the electron tracks are constructed using a beam telescope. The measured distributions show clear signatures of transition radiation and demonstrate that low-cost materials can produce radiation yields comparable to those of conventional radiator foils within the explored energy range. The results are in good agreement with theoretical expectations for multilayer transition radiation and highlight the potential of accessible materials for cost-efficient detector studies.