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

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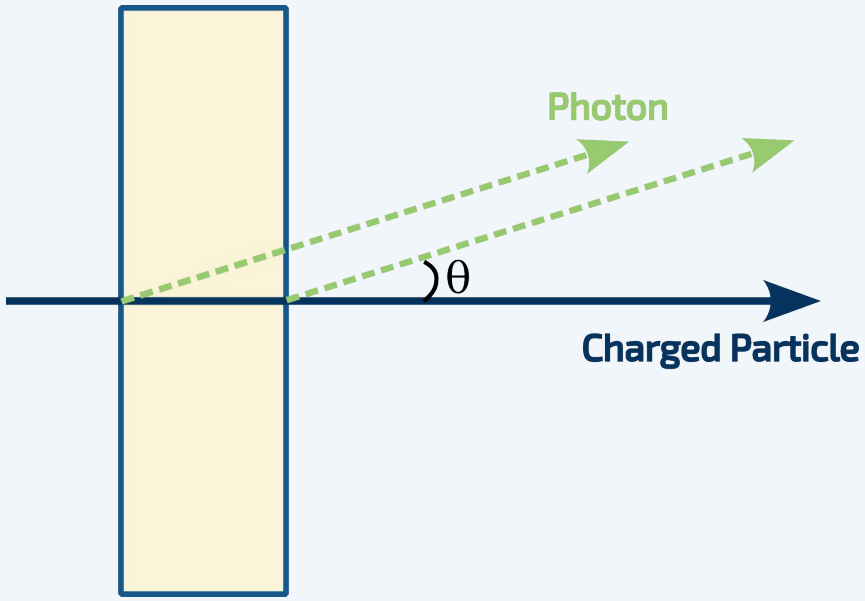
Transition Radiation Production

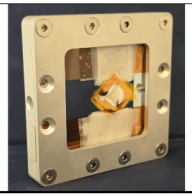
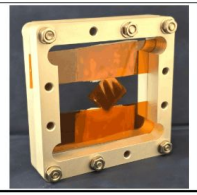
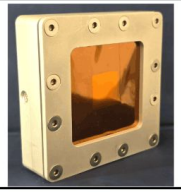
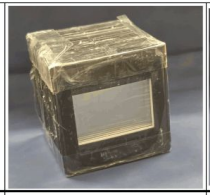
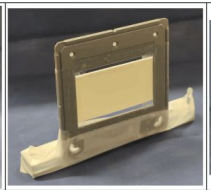
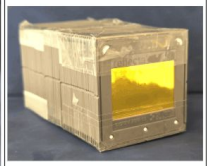


TR: emitted when charged particles traverses boundary between two materials with different dielectric constants

Angle of TR Emission dependent on particle energy (θ = ~1/γ), target material, and target structure

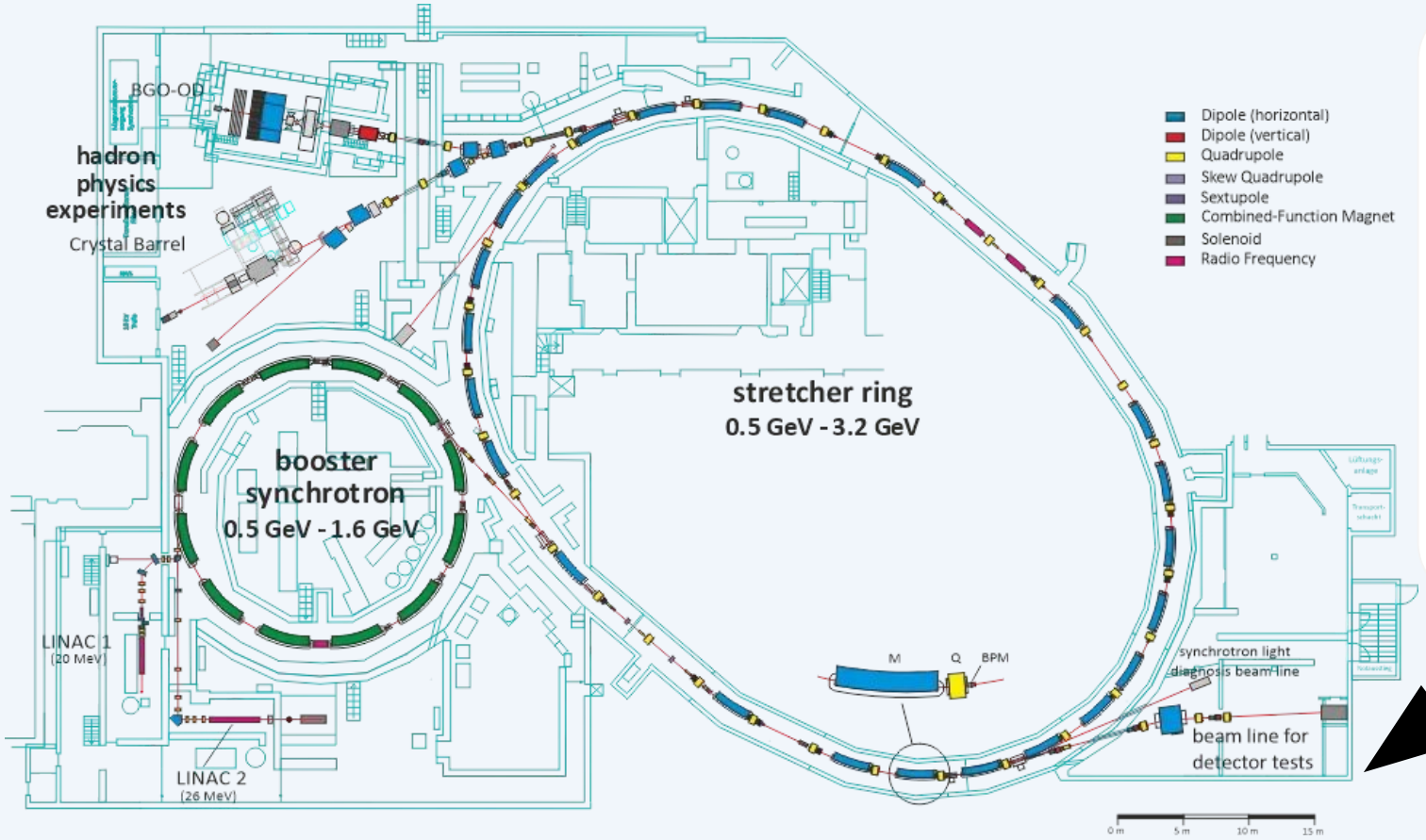
Target Construction

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

Goal: Investigate TR photon production of different materials and multilayer structures

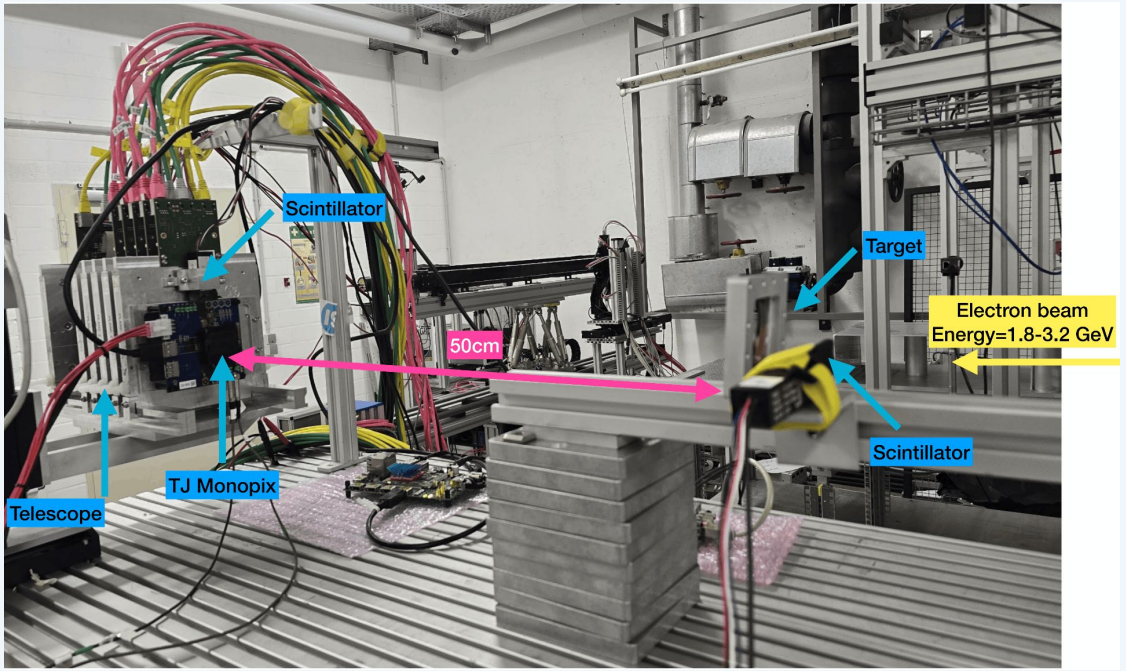
ELSA Beamline

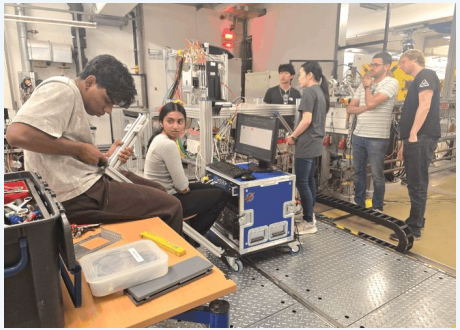


40 runs across 3 energies and 6 targets

10 million total events recorded

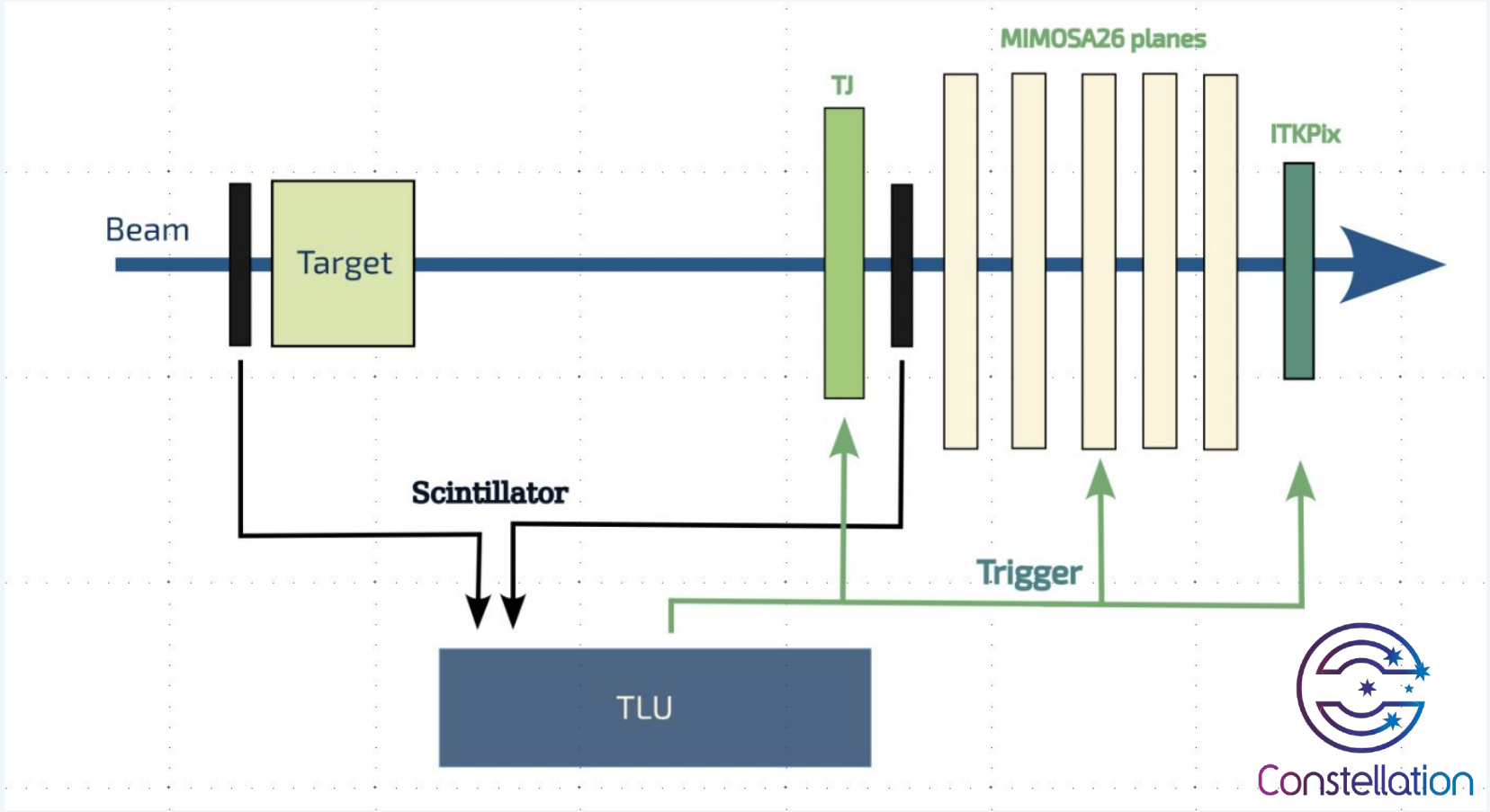
Target Construction and Experiment





+ Avin participating virtually!

Test Beam Setup



TR Measurement Procedures

Approach #1
Spatial Distribution
(Cluster Position)

- Different trajectories from photons/electrons
- Spatial paths can also differentiate photon versus electron hit

Approach #2
Energy Distribution
(Cluster Charge)

- Different energy deposition from photons and electrons
- Charge can differentiate photon versus electron hit

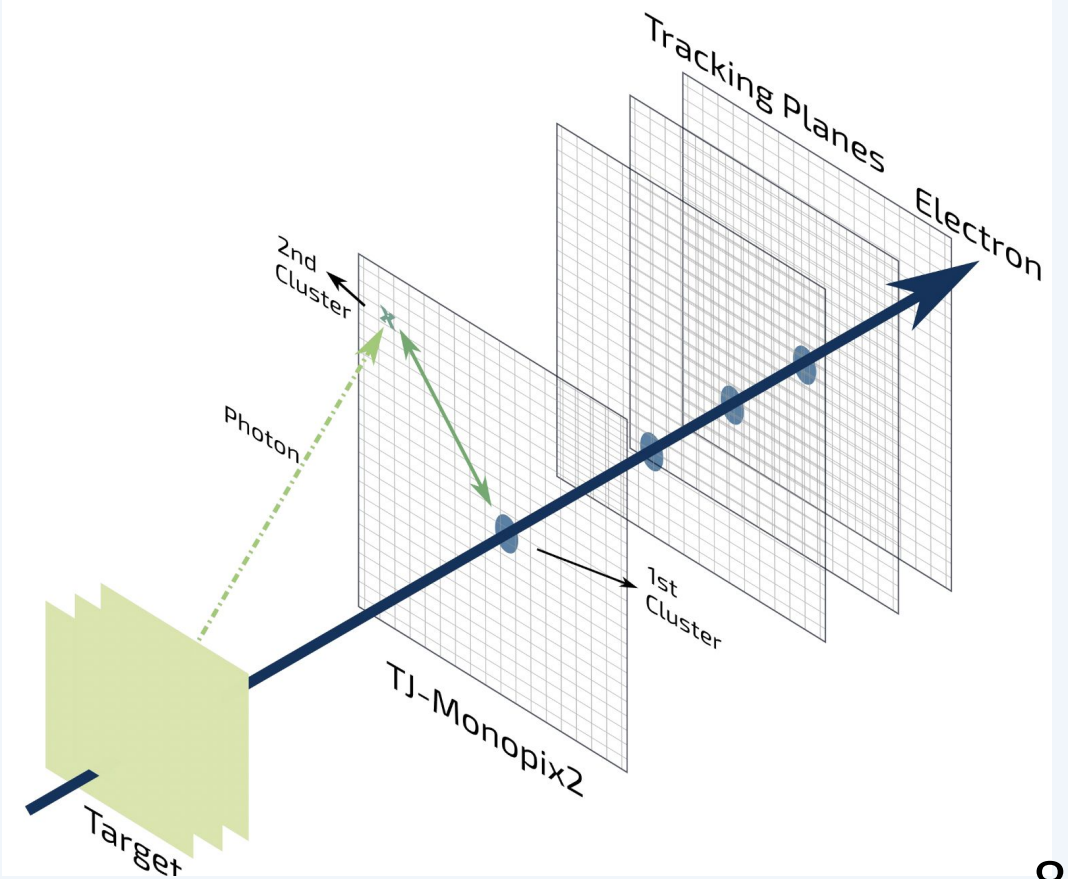
Data analysis performed using Corryvreckan

Spatial Tracking Analysis

Track Interpolation onto TJ (larger distance - 50 cm)

Discard closest (electron) cluster to track, left with photon candidates

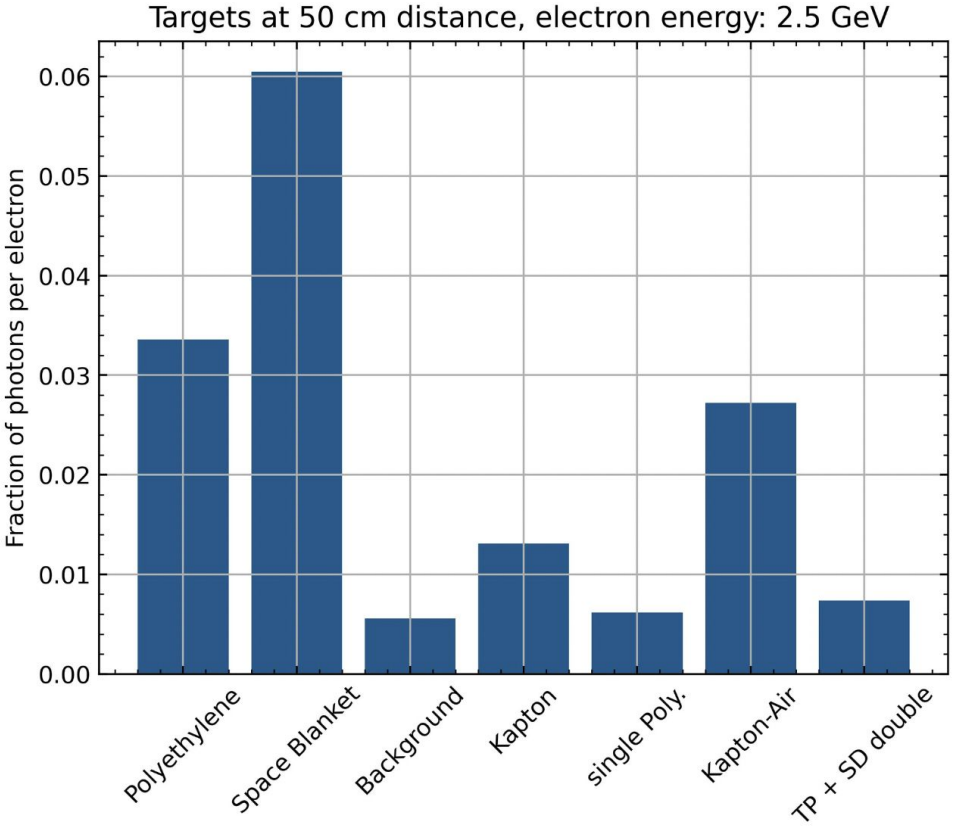
1st track belongs to electron, 2nd track is photon candidates



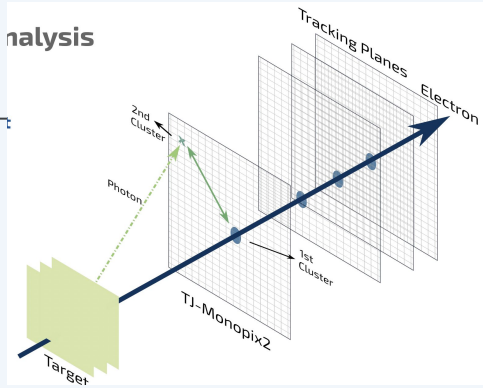
Approximated Photon Production

1 Cluster Events = electrons

2 Cluster Events = electrons + photons

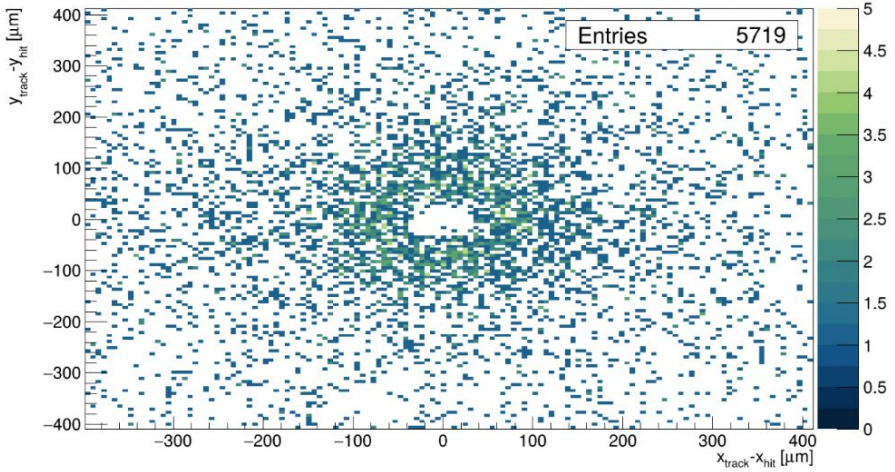


2D Residual Analysis

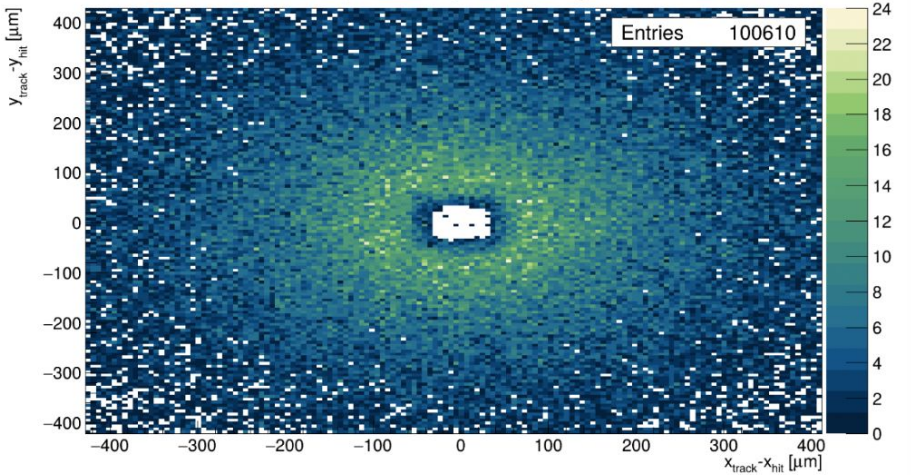


Filtering: Nearest track to cluster is removed, only clusters with size 1 and charge > 20 selected

Background run: no target

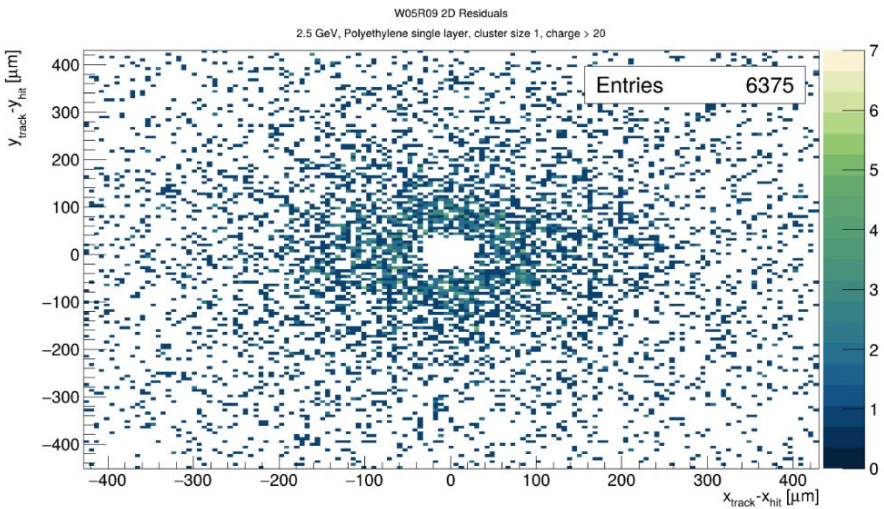


Space blanket target

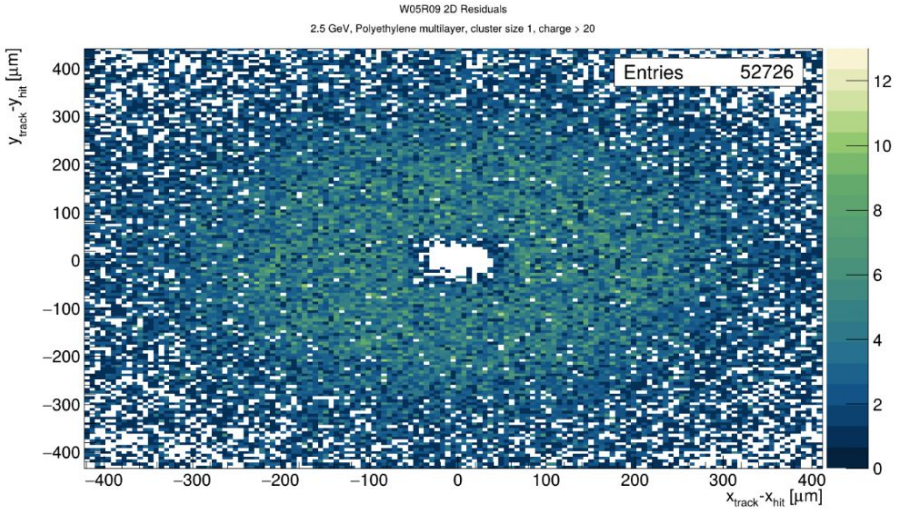


2D Residual Analysis

Single layer Polyethylene control target



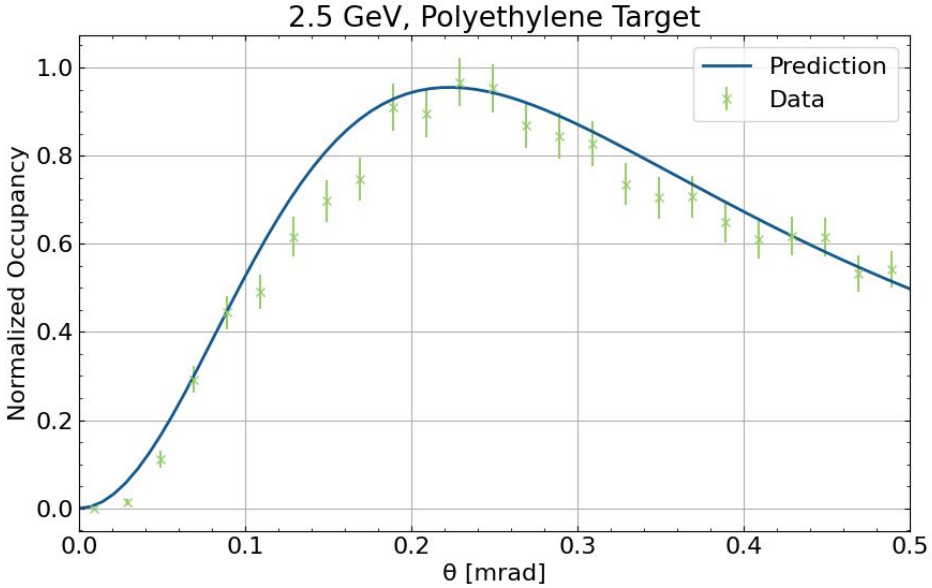
Multi layer Polyethylene target



Angular Distribution Comparison

Target reproduces theoretical peak and reduction at larger angles

Collected data consistent with TR model



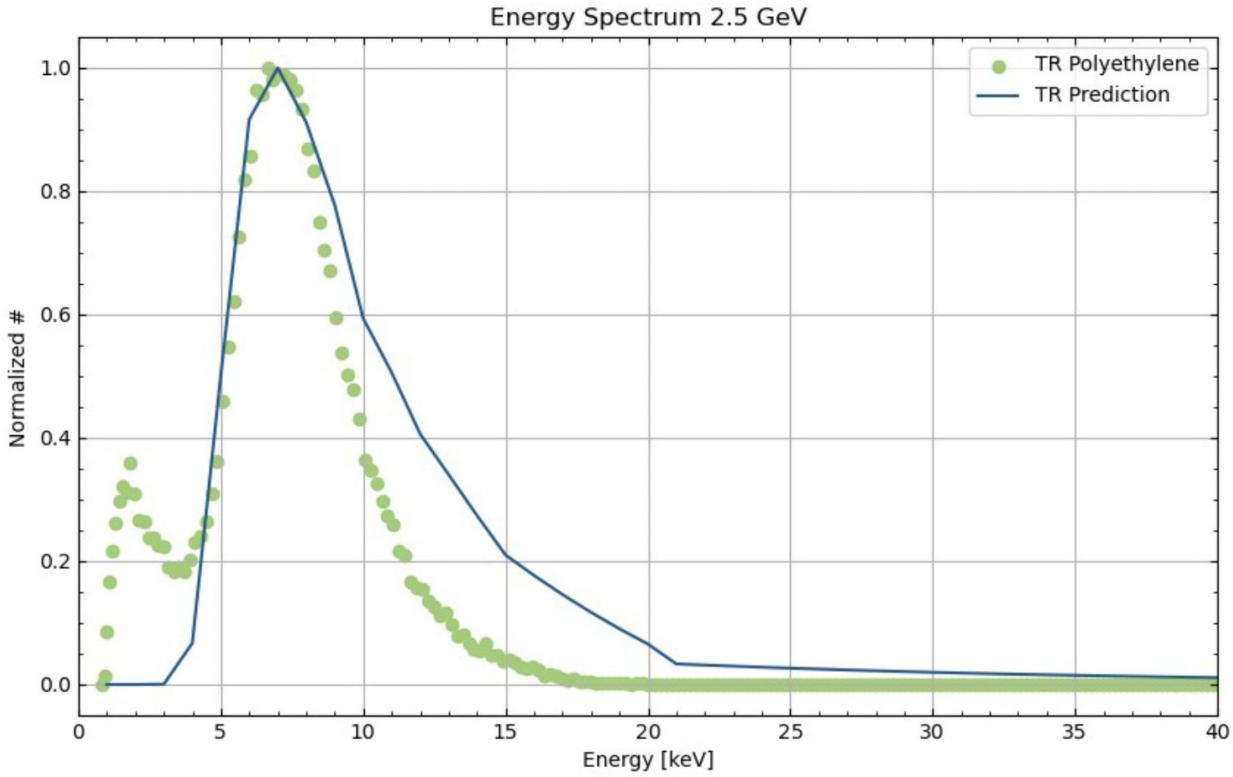
$$\frac{d^2W}{d\omega d\Omega} = \frac{e^2}{\pi^2 c} \cdot \frac{\beta^2 sin^2\theta}{(1-\beta^2 cos^2\theta)^2} \cdot \left| \frac{\epsilon_2 - \epsilon_1}{\epsilon_2 + \epsilon_1} \right|^2$$

B. Dolgoshein, Transition Radiation Detectors, Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment 326, 434 (1993).

Energy Distribution Comparison

Good agreement of peak position and shape, factoring in absorption from silicon/air

Difference at higher photon energies possibly due to absorption of photons in target



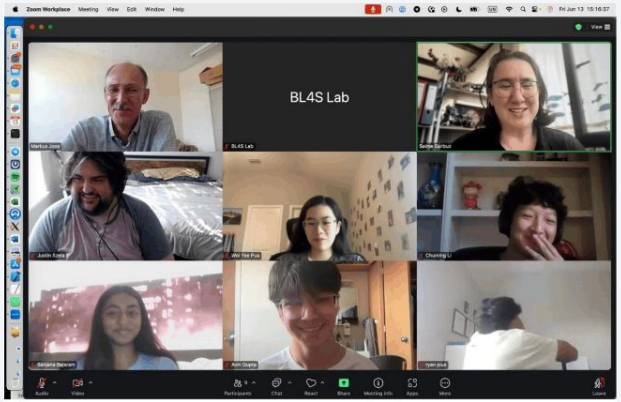
Summary

- Estimation of rate of production of photons for different low-cost targets
- ~A few percent of TR photons for electron track, highest efficiency achieved by Polyethylene and Space Blanket
- Comparison of angular and energy distributions with models, showed good agreement, exhibited measurable production of TR with our targets
- Paper currently in progress!

Thank You!

QUESTIONS?

beamline for schools
cern.ch/bl4s
powered by CERN, DESY & ELSA



14th edition of the Beam Telescopes and Test Beams Workshop

April 2026