

Low-Gain Avalanche Detectors for Beam Monitoring in Radiobiological FLASH Proton Irradiation (LhARA)



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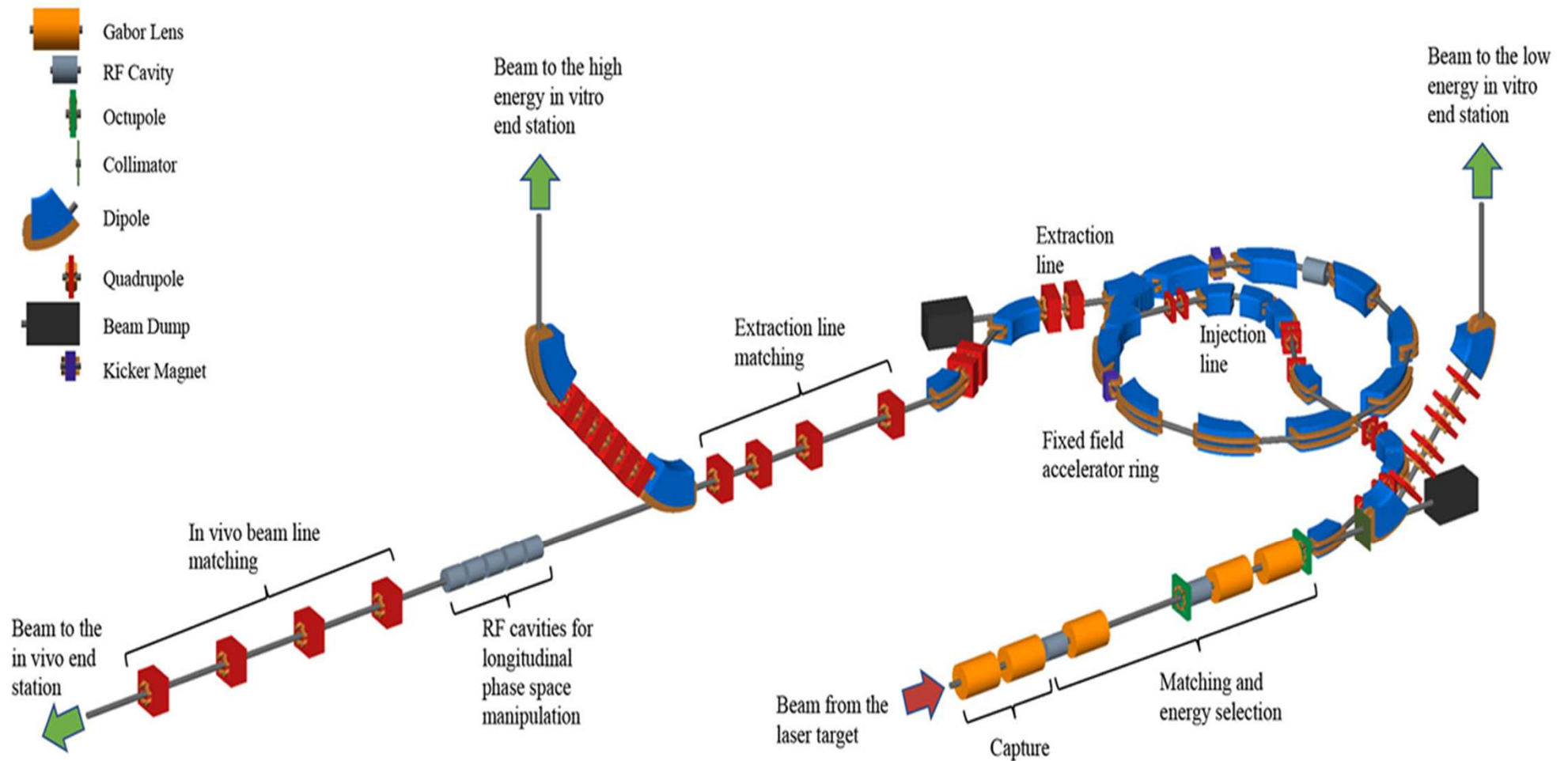
28 JULY 2026



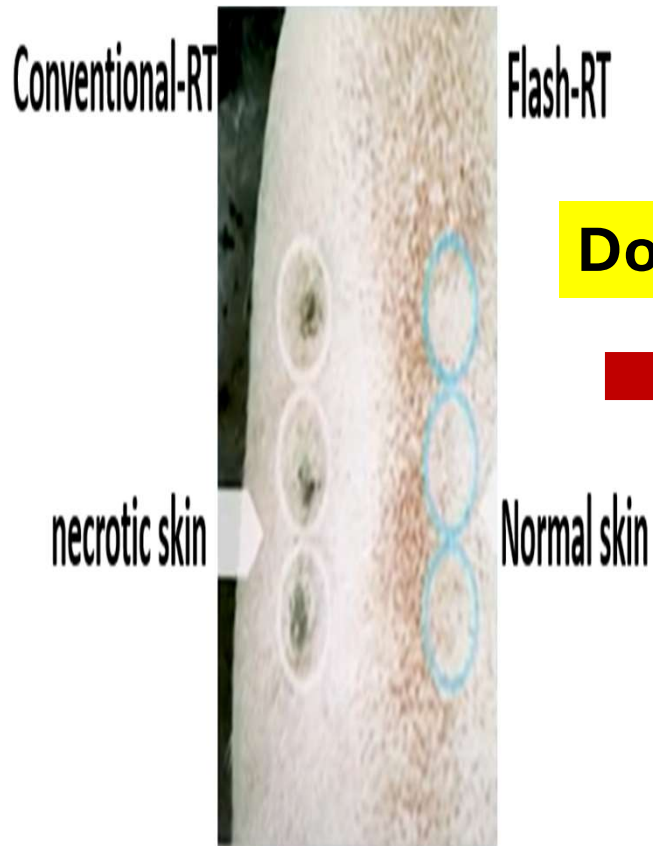
Outlines

- 1. The LhARA Project**
- 2. FLASH Radiotherapy Dosimetry Challenges**
- 3. Monte Carlo Beam Characterization & Detector Modelling**
- 4. Main Results**
- 5. Conclusion & perspective**

Introduction to the LhARA project

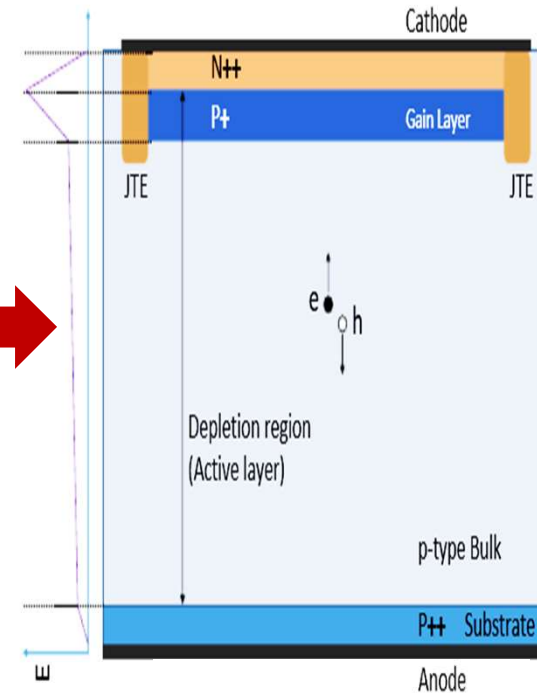
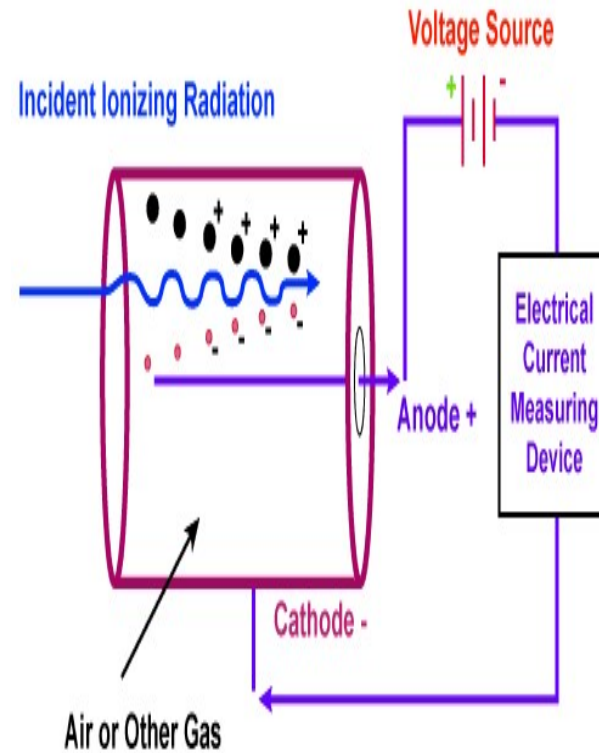


Flash Radiotherapy Dosimetry?

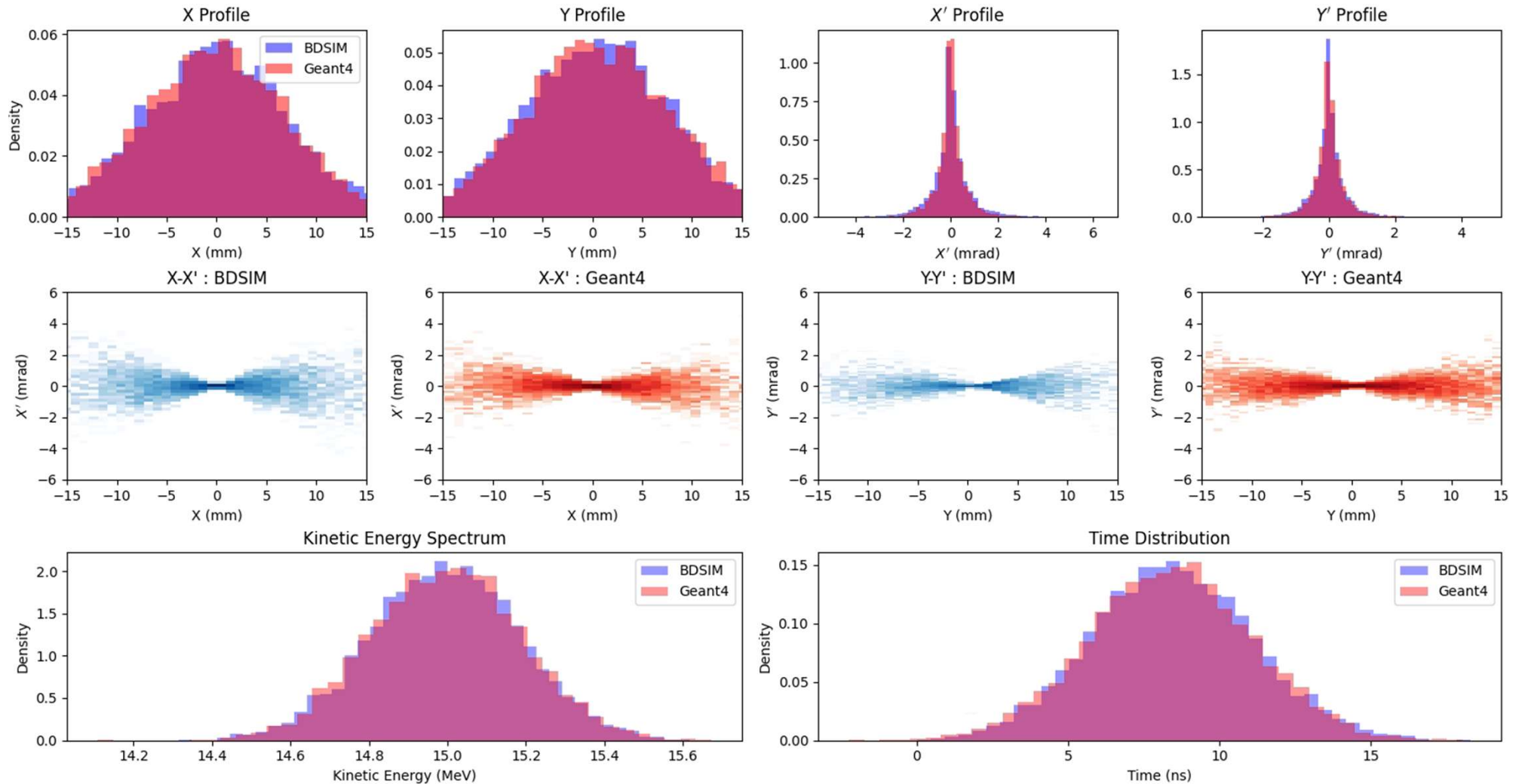


Comparative study on pig skin

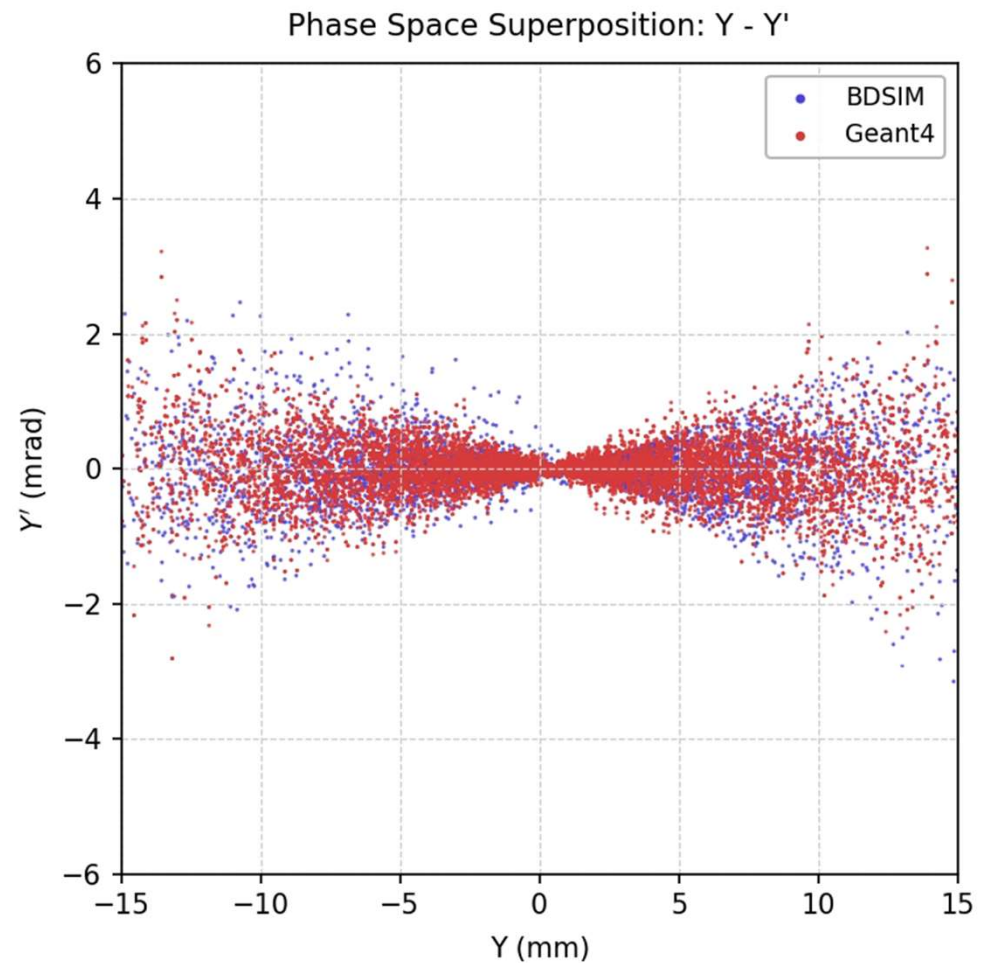
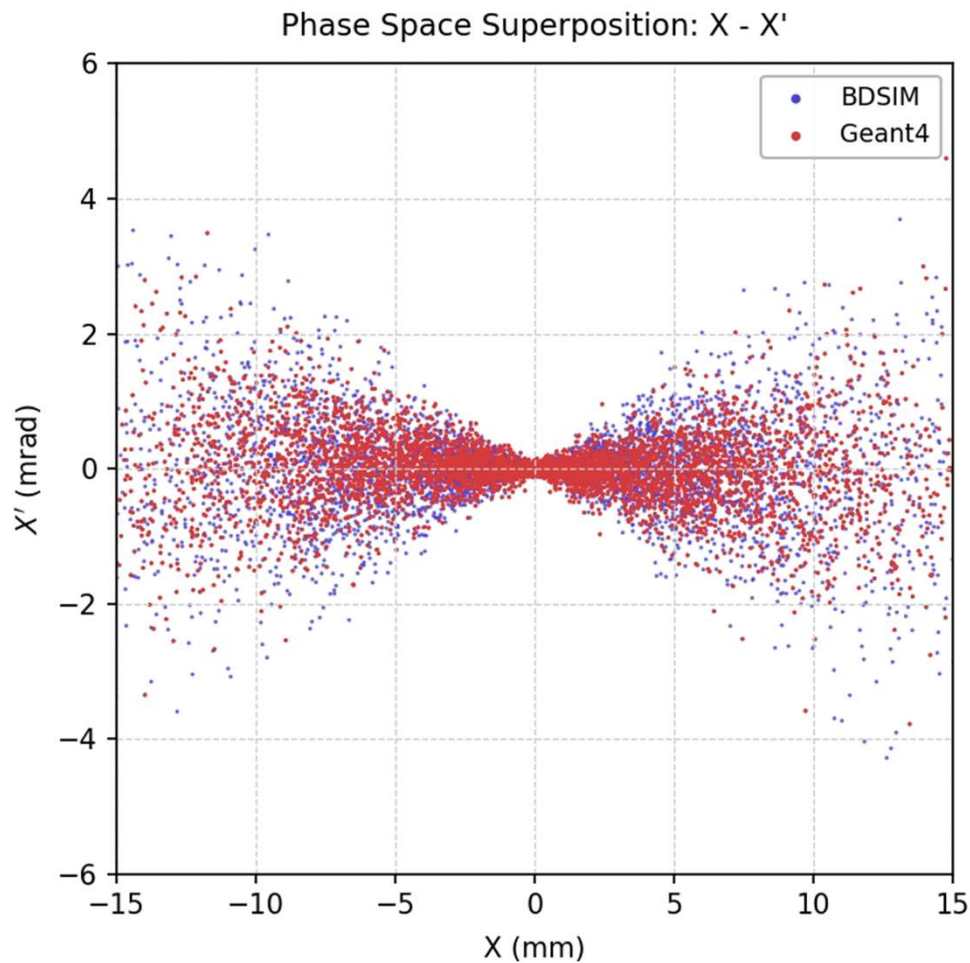
Dosimetry



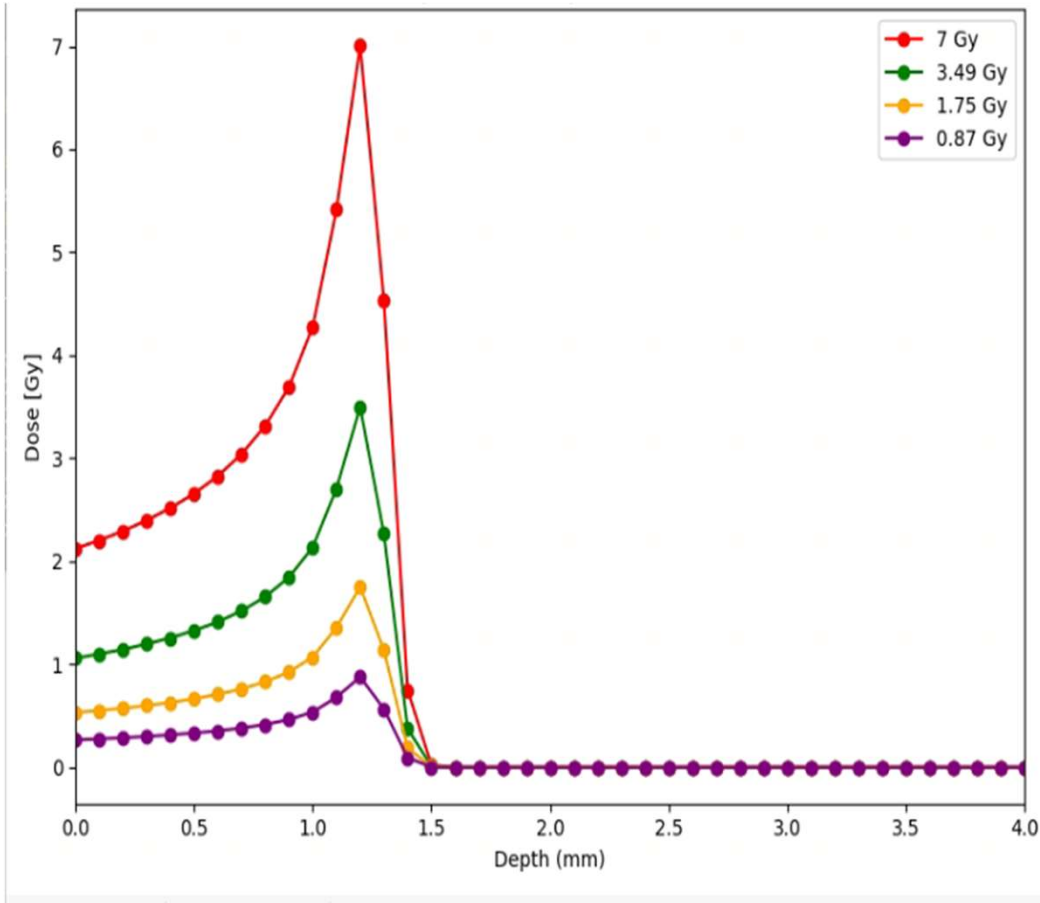
Phase Space Analyses Results (Geant4 Vs BDSIM)



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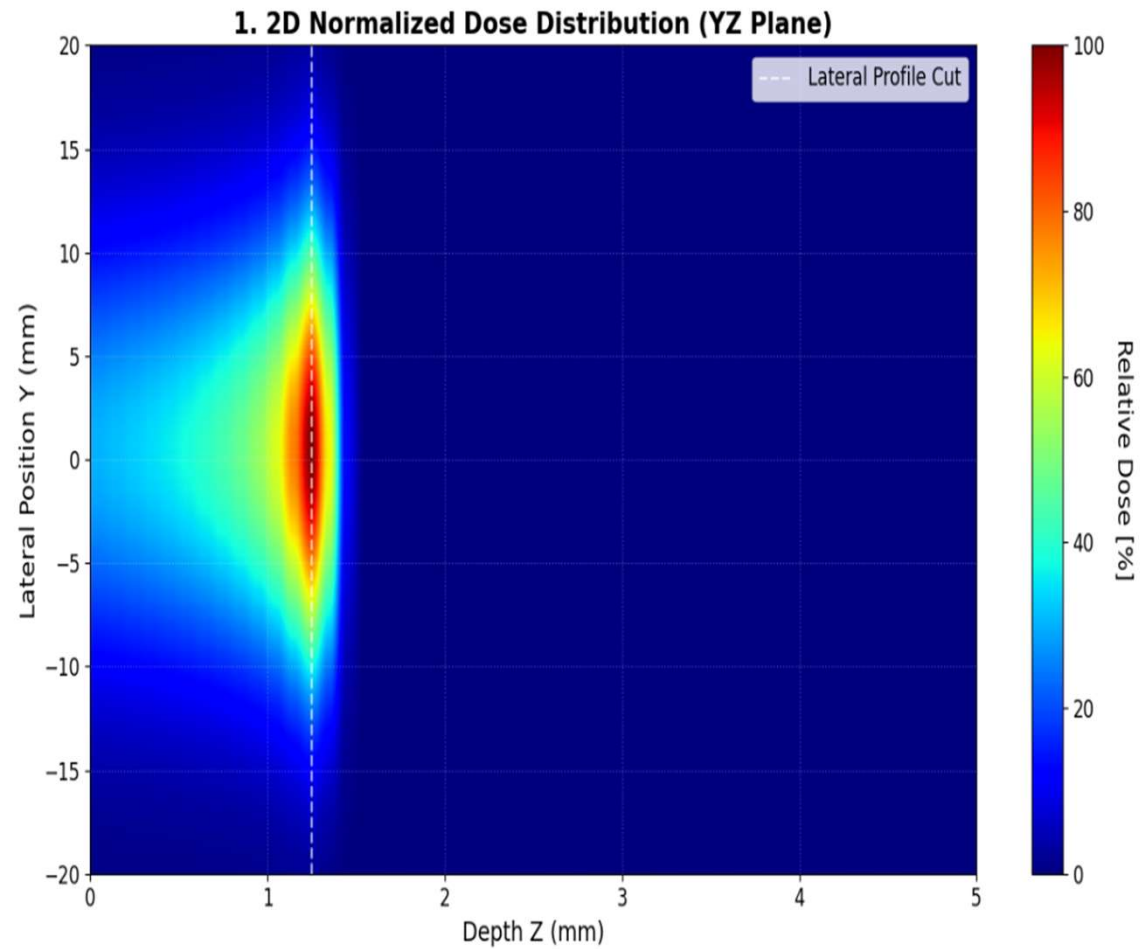
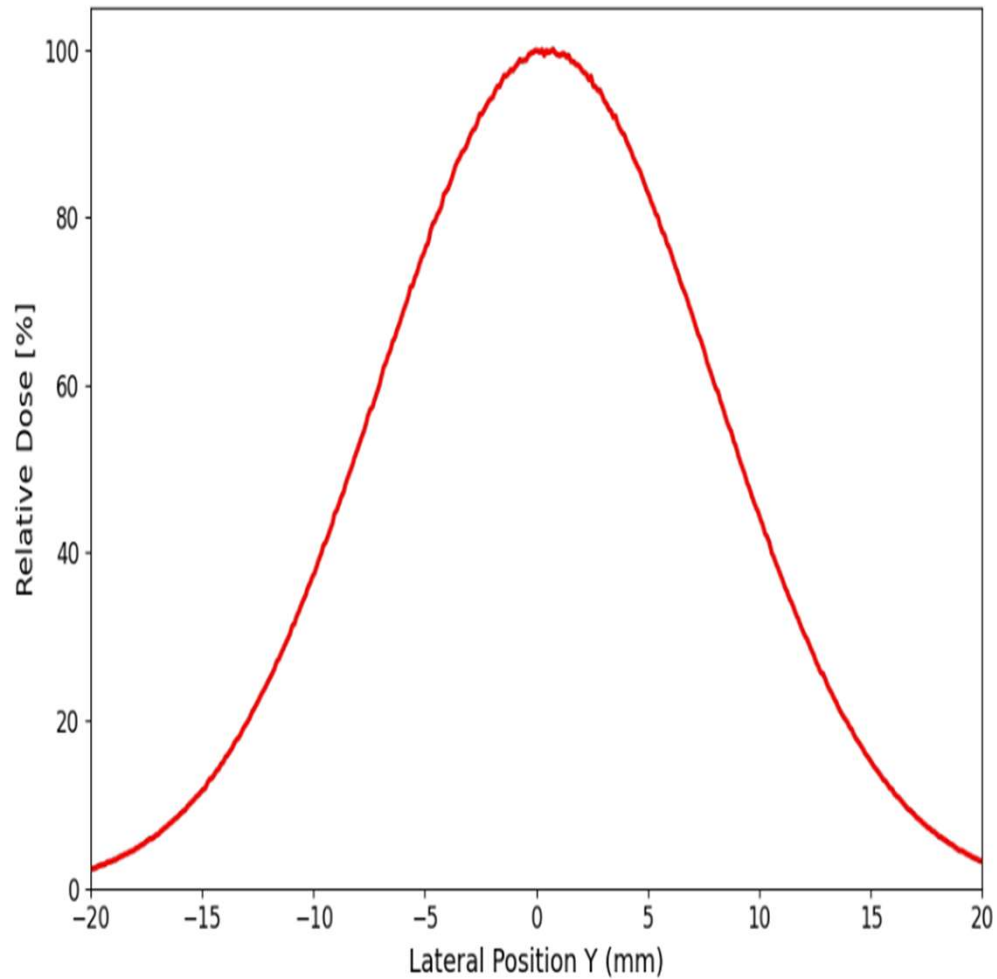


Dose Analyses Results (Geant4)



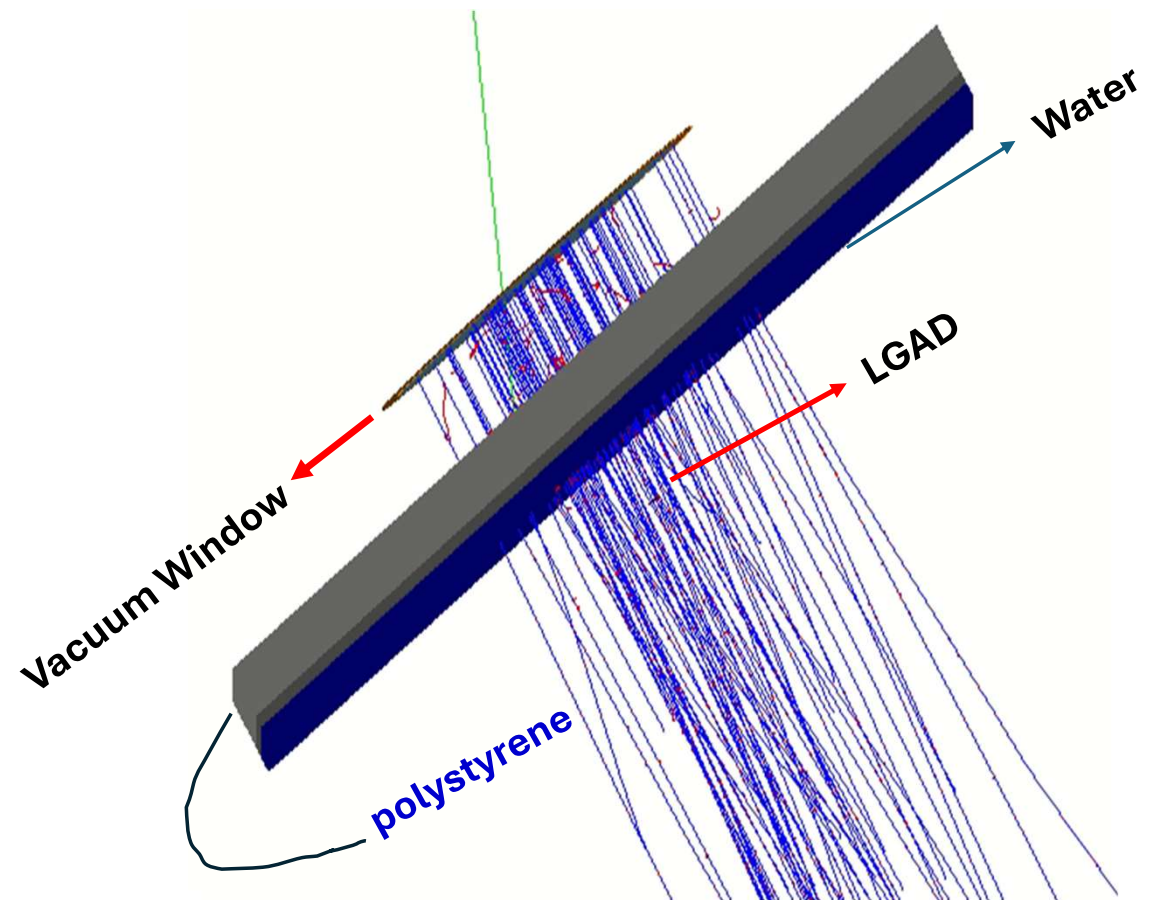
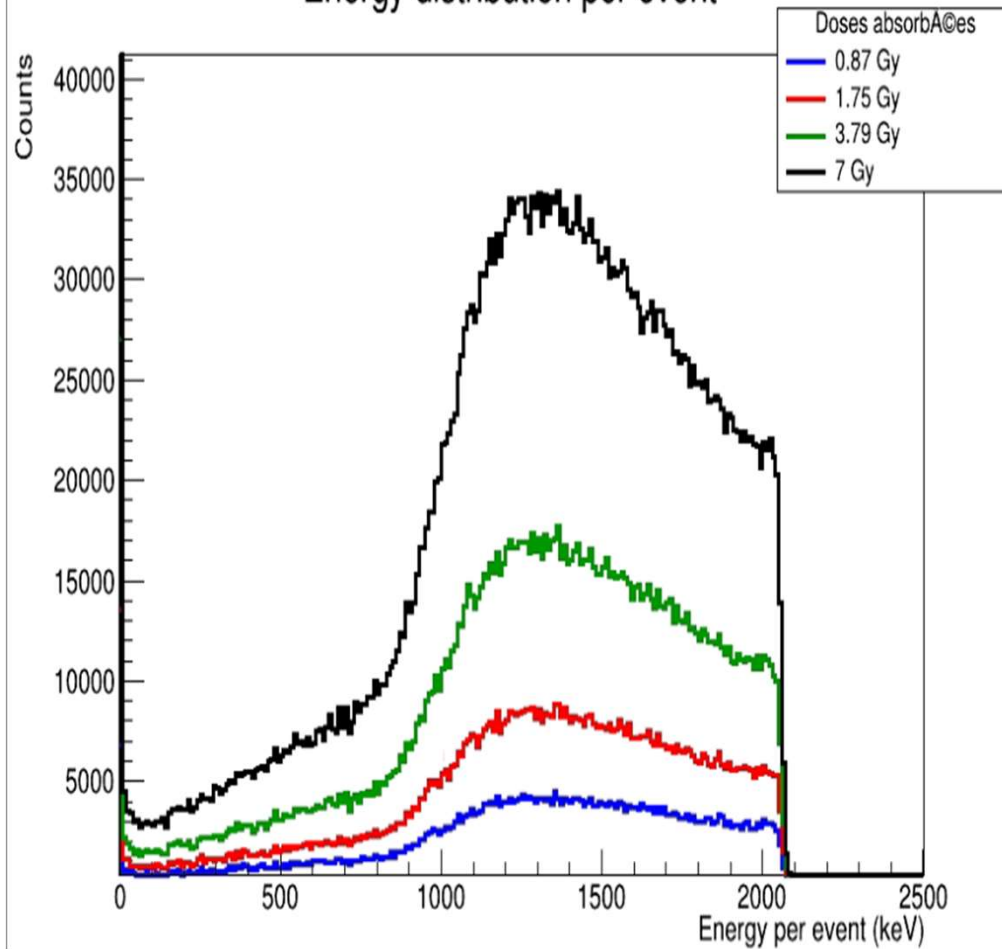
Dose per pulse (Gy)	R100(mm)	Ins. Dose Rate (Gy/S)
7.00	1.20	6.75×10^8
3.49	1.20	3.37×10^8
1.75	1.20	1.69×10^8
0.87	1.20	8.40×10^7

Dose Analyses Results (Geant4)

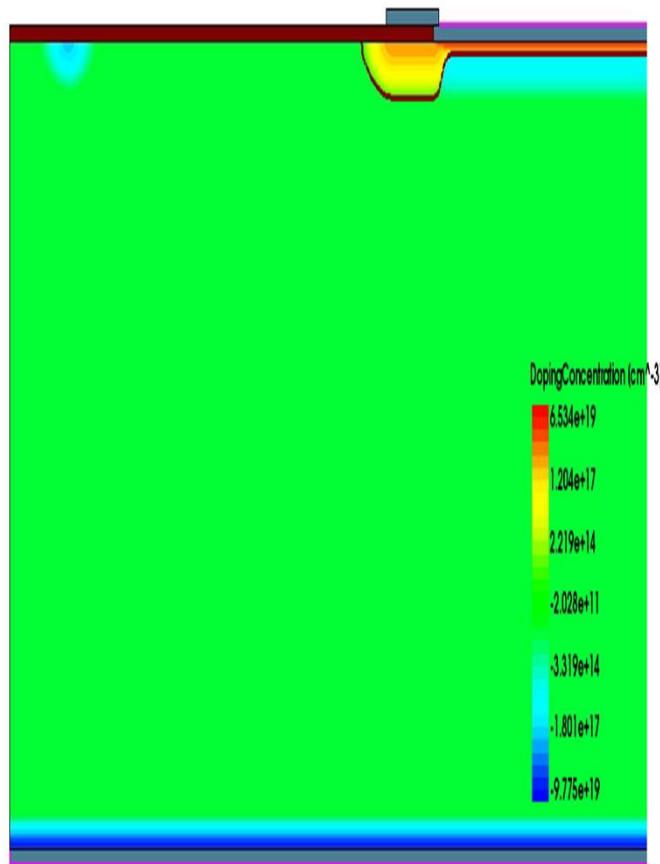


Monte Carlo Set Up & Deposited Energy in LGAD

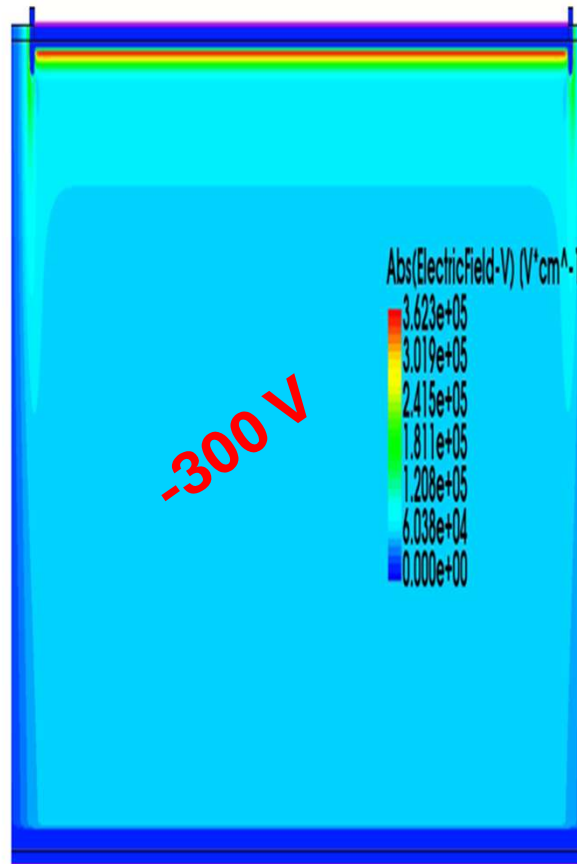
Energy distribution per event



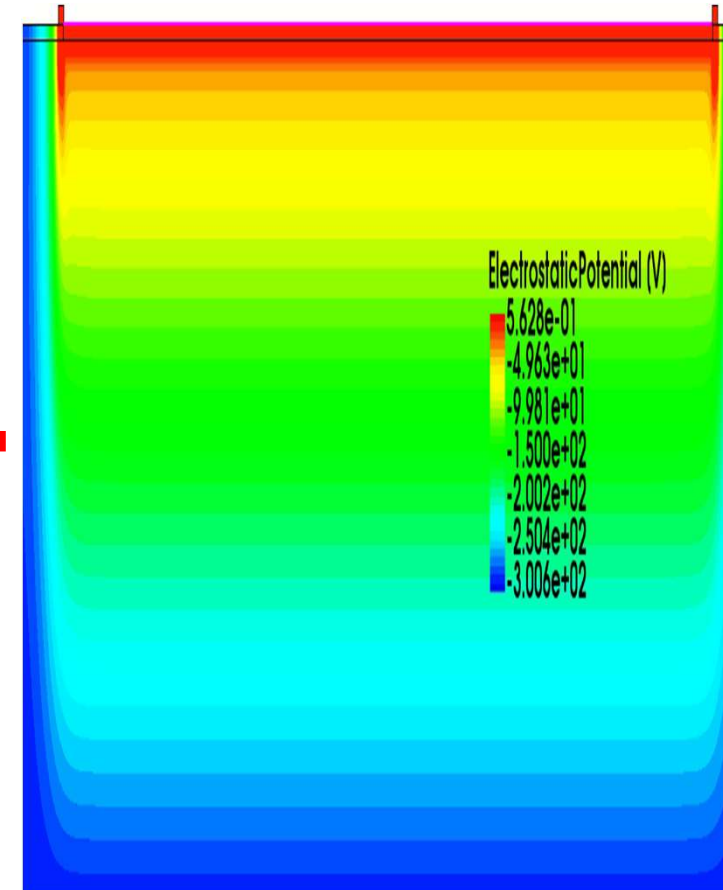
Transient Propagation Simulation Input



Doping Profile



Electric Field



Electrostatic Potential

Collected Charge In LGAD

Transient Propagation (Shockley-Ramo theorem) →

$$Q_n^{ind} = \int_{t_0}^{t_1} I_n^{ind} = q (\phi(x_1) - \phi(x_0))$$

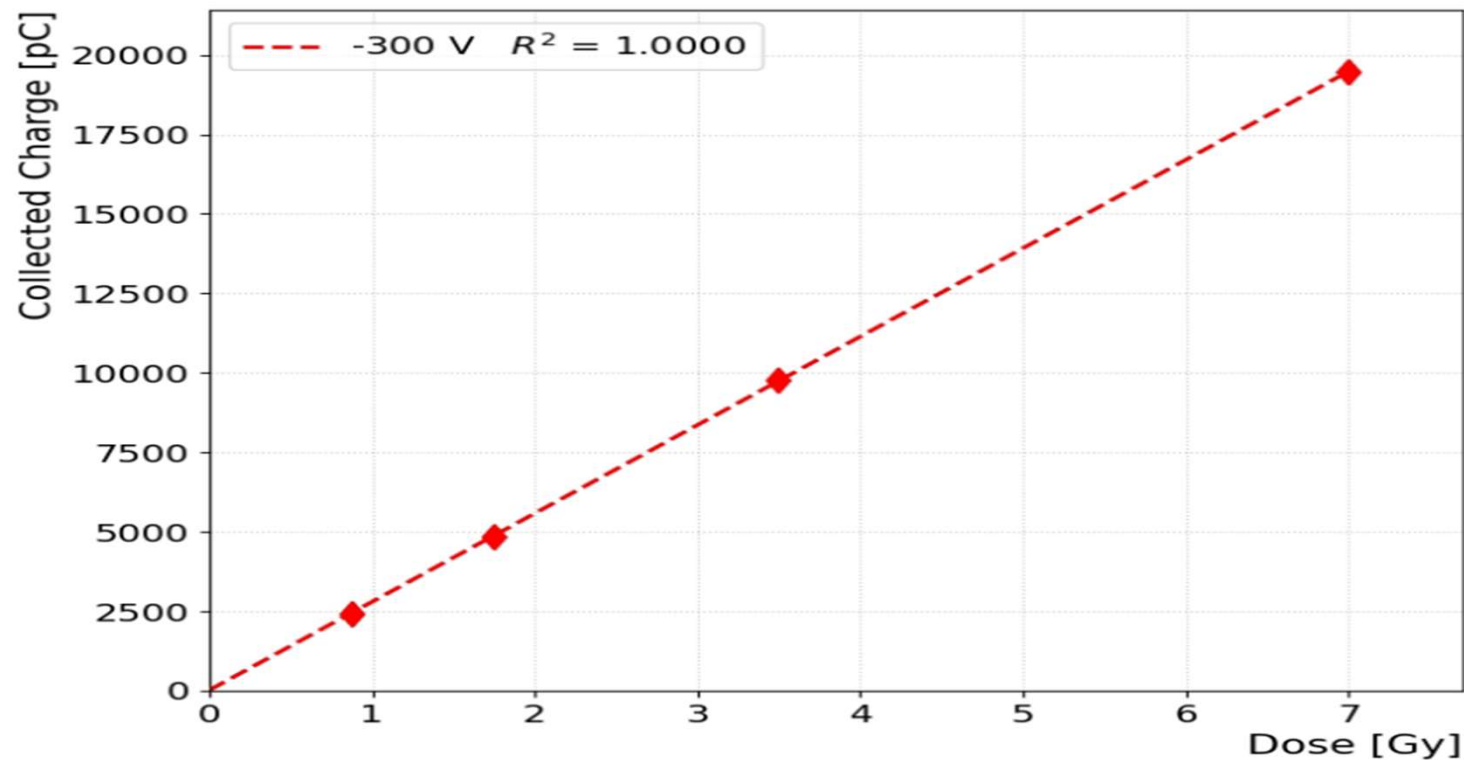
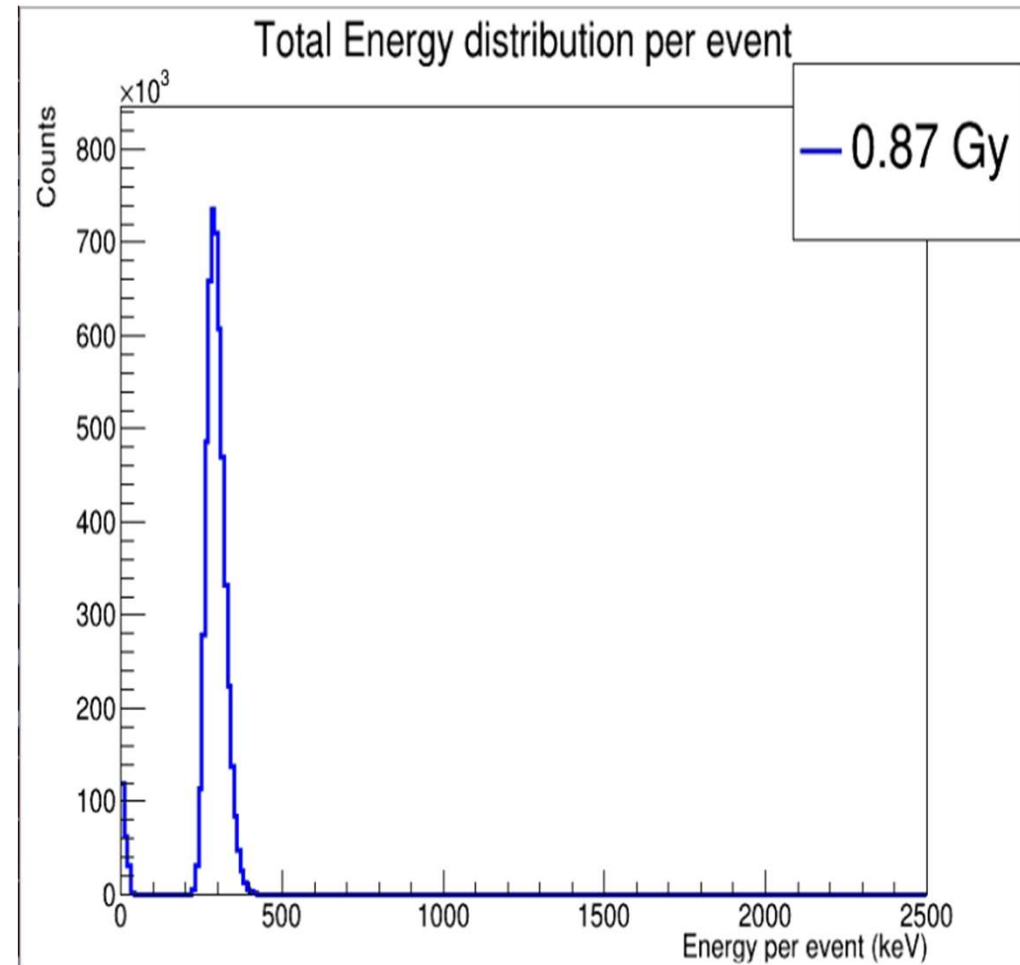
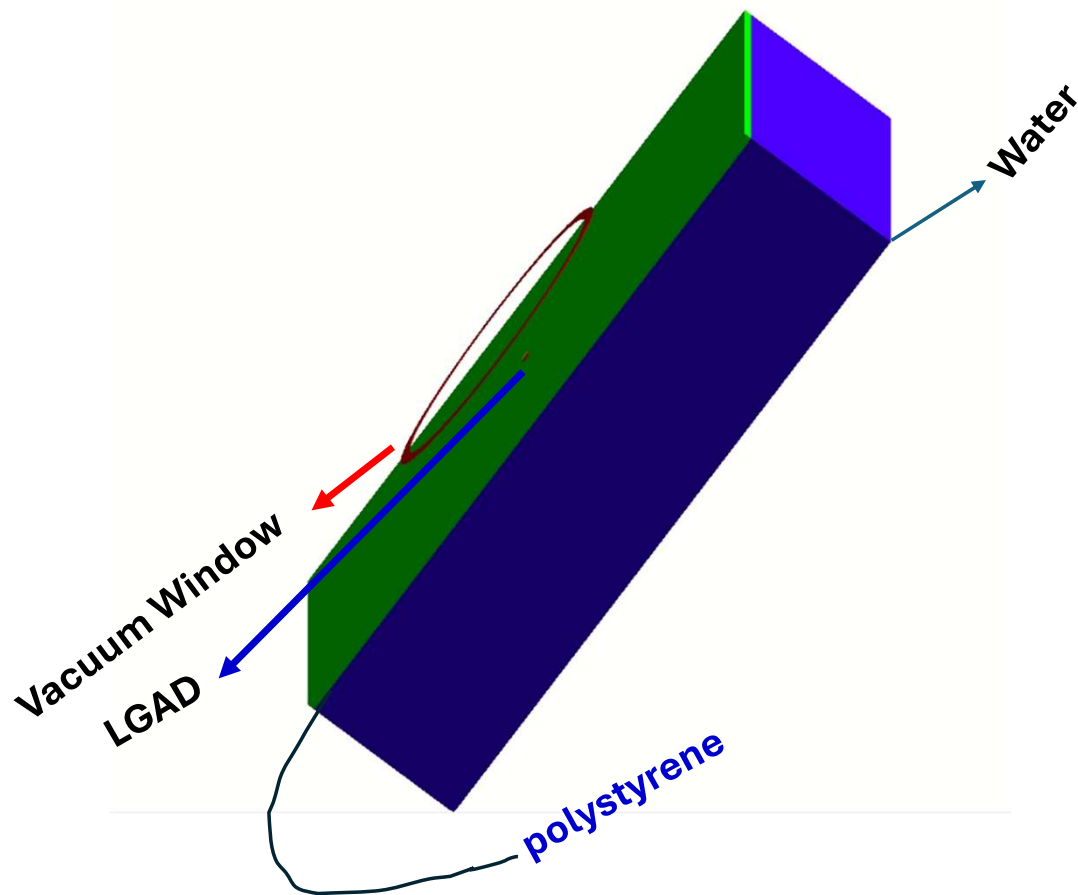
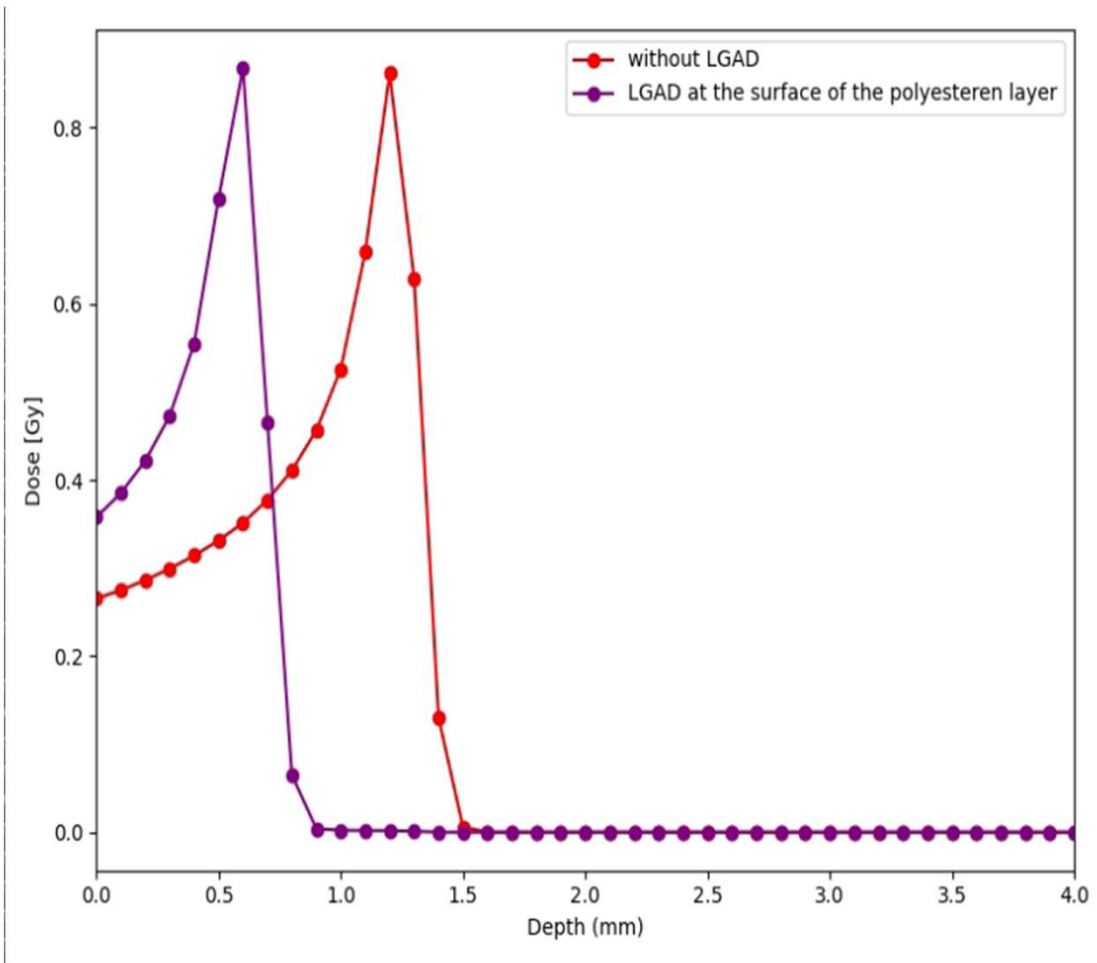


Fig1. Total collected charge as a function of dose per pulse.

Real Time Dosimetry Set up



Monte Carlo Simulation of LGAD Detector



	Dose per pulse (Gy)	R100(mm)
without LGAD	0.86	1.2
withe LGAD	0.86	0.6

Reference

Reference: Ahmed, H., Alderton, M., Amos, R. A., Ariyanto, D. O., Baker, C. J., Bamber, J., ... & van der Werf, D. P. (2026). *ITRF/LhARA conceptual design report* (No. STFC-TR-2026-007). STFC.

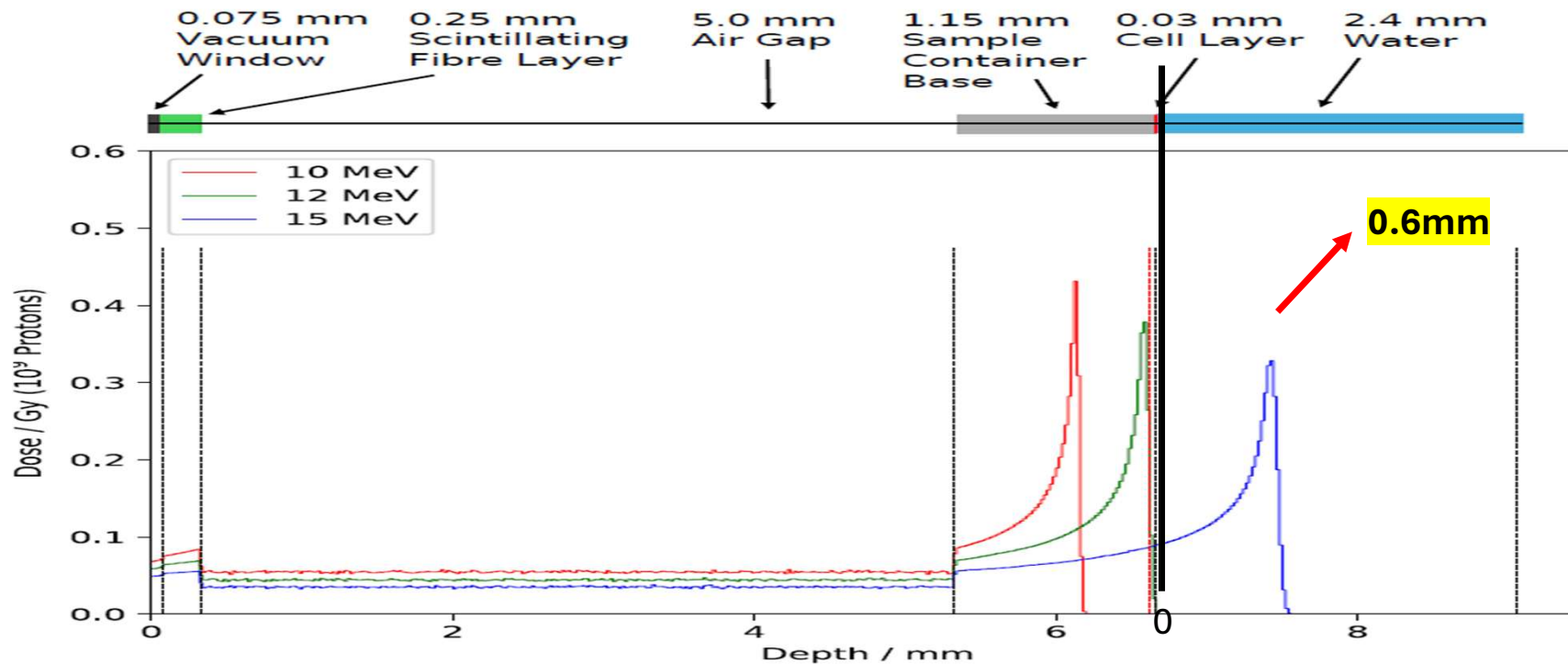


Figure 2.14: Depth dose curves for 10, 12, and 15 MeV proton beams in a BDSIM model of the LhARA Stage 1 *in-vitro* end station. The model includes a vacuum window, scintillation fibres, air gap, sample container, cell layer, and water. 10,000 protons are simulated, and the average dose per proton is scaled to the LhARA total bunch charge of 1×10^9 protons.

Collected Charge In LGAD

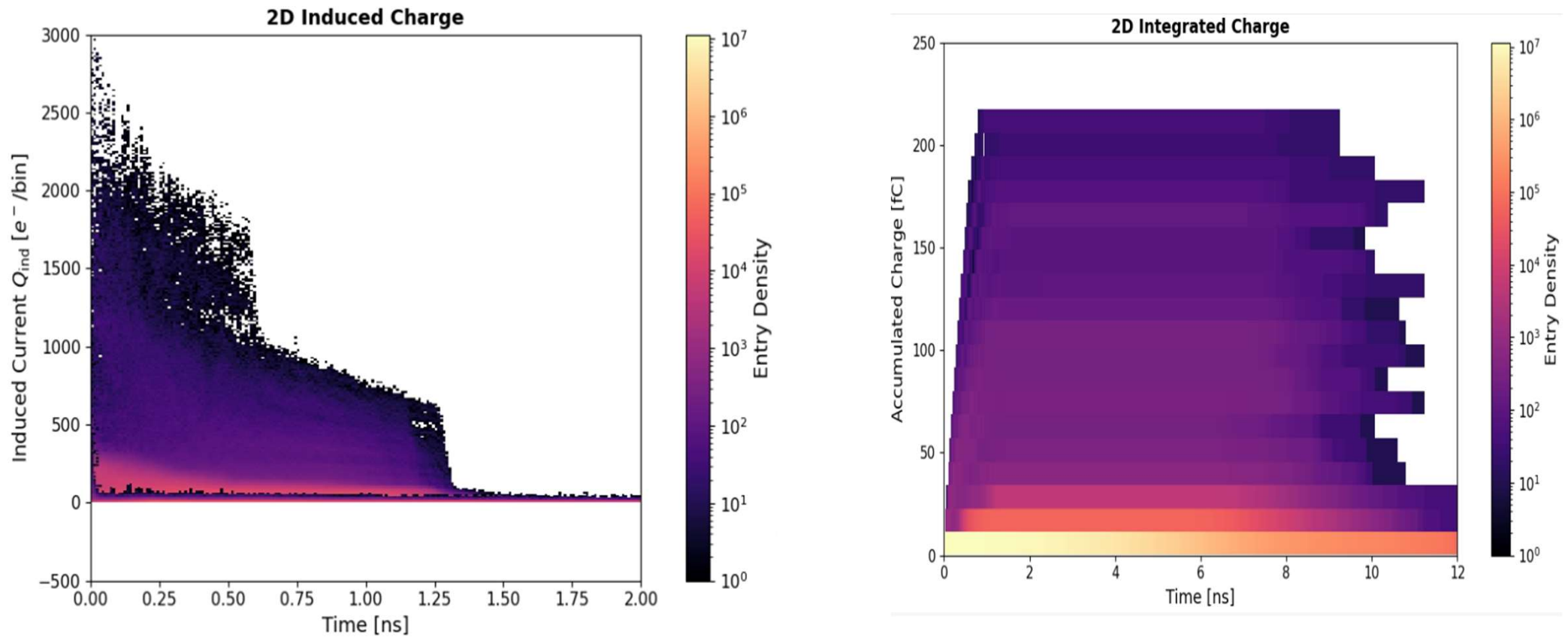


Fig2 . Two-dimensional distribution of transient induced charge per pixel as a function of time (left) and two-dimensional map of integrated transient charge $Q_{integ} t$ under proton irradiation (right).

Collected Charge In LGAD

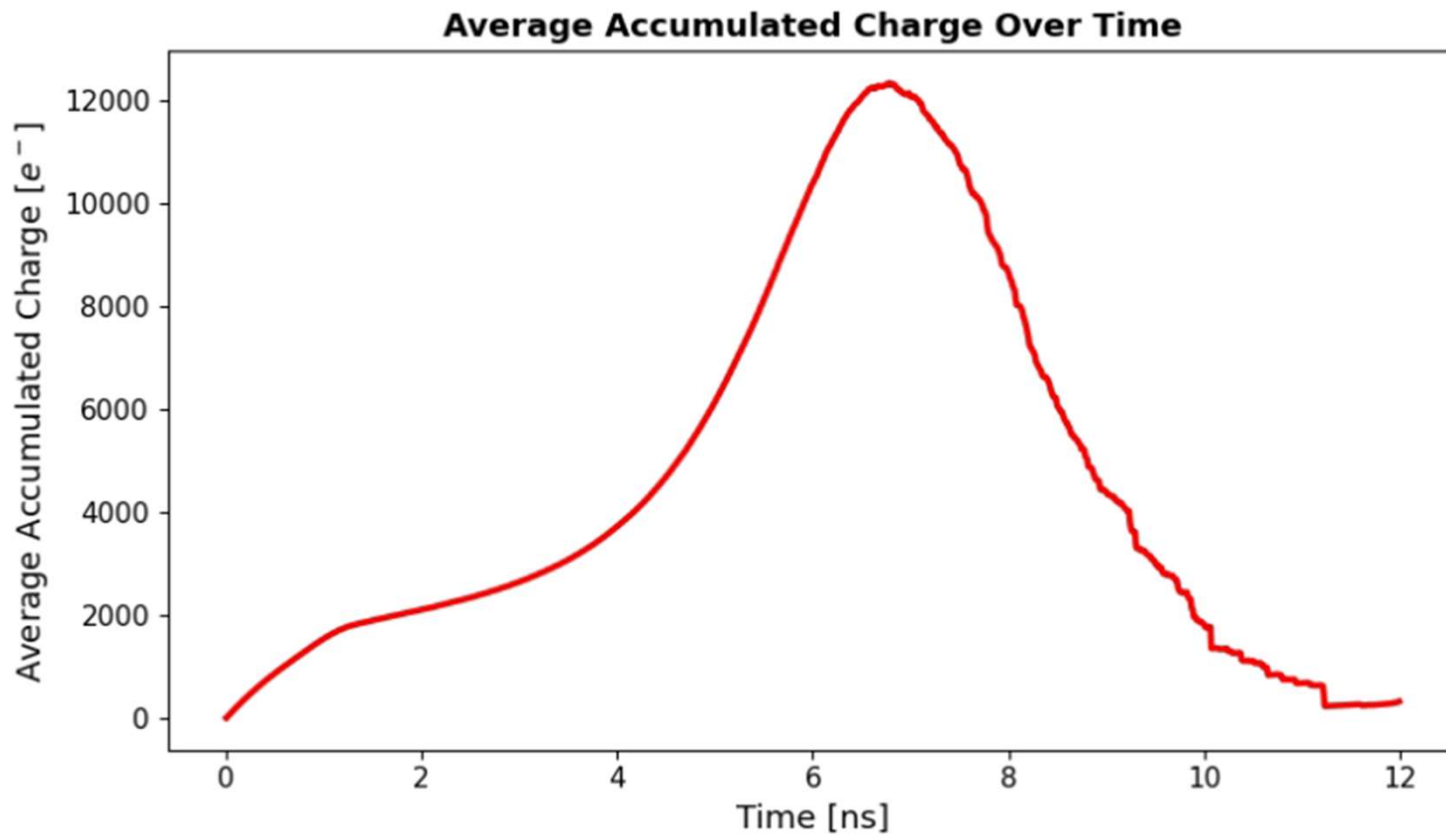


Fig3. Time evolution of the average accumulated charge.

Conclusion & Perspectives

LGAD Capabilities for Fast Beam Monitoring

Main charge collection completes within ~1.25 ns, demonstrating ideal timing capabilities for high-rate beam monitoring.

Charge Yield & TCAD Modelling

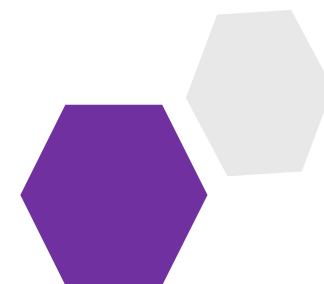
Integrated MC-TCAD approach yields an average accumulated charge of ~12,000 e^- , confirming robust signal formation.

Minimal Beam Perturbation

Inserting the LGAD produces a negligible Bragg peak shift, fully comparable to existing scintillating fibres.

Next Steps:

Readout Digitization: Implement front-end electronics to convert the internal signal into measurable output



THANK YOU FOR YOUR ATTENTION