Online version

Compton imaging of undepleted regions of germanium detectors

Felix Hagemann

DPG Spring Meeting 2023
March 23rd, 2023

DPG

$\Delta p \cdot \Delta q \geq \frac{1}{2}\hbar$

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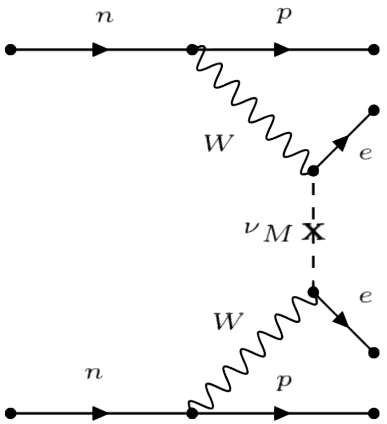
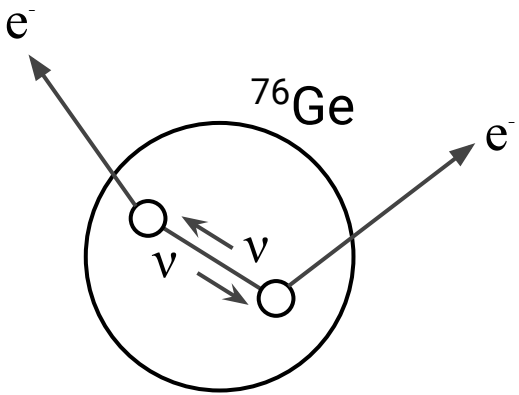
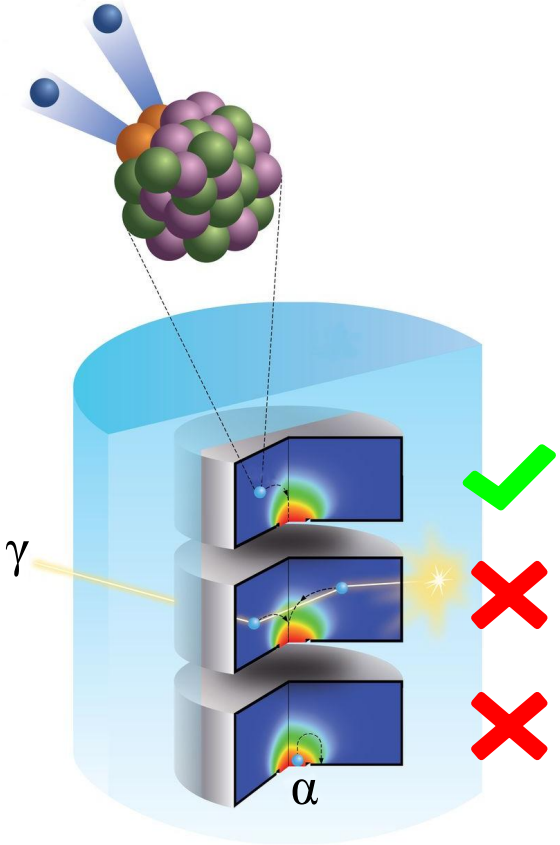
Motivation

LEGEND
Large Enriched
Germanium Experiment
for Neutrinoless ββ Decay







T 15.4: **LEGEND Experiment**
Monday, March 20, 2023, 17:15–17:30

Solid State Detectors

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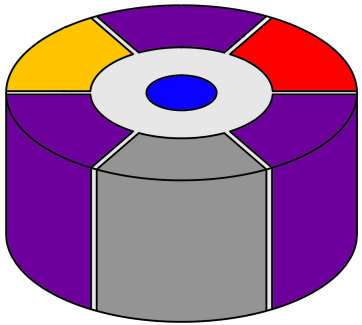
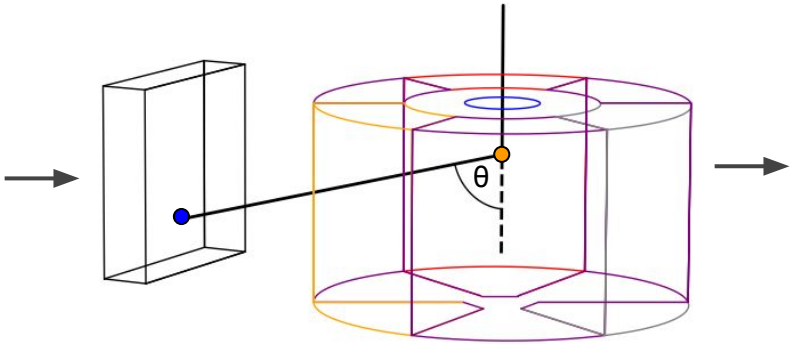
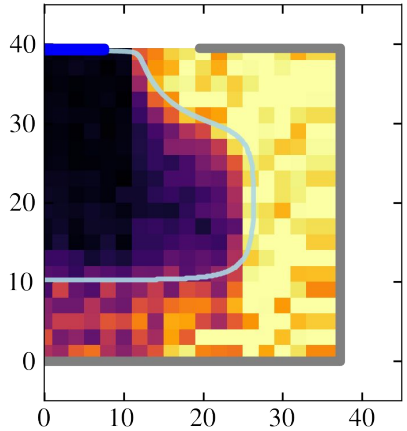
Outline



Segmented Broad Energy germanium detector

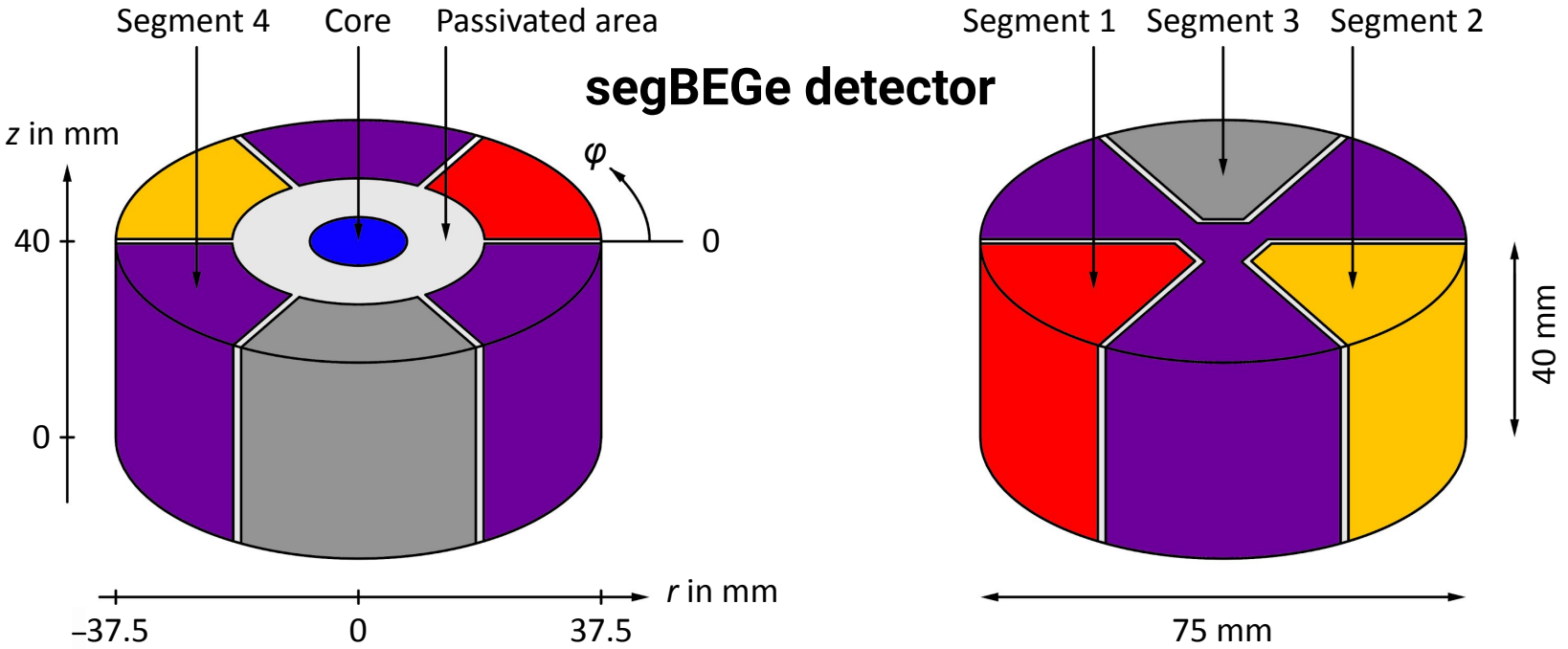


Experimental setup: Compton Scanner



Compton imaging of undepleted regions

Segmented Broad Energy Germanium Detector



I. Abt et al., Nucl. Instr. Meth. A **925**: 172 (2019)
doi:10.1016/j.nima.2019.02.005, arXiv: 1810.10332

Solid State Detectors

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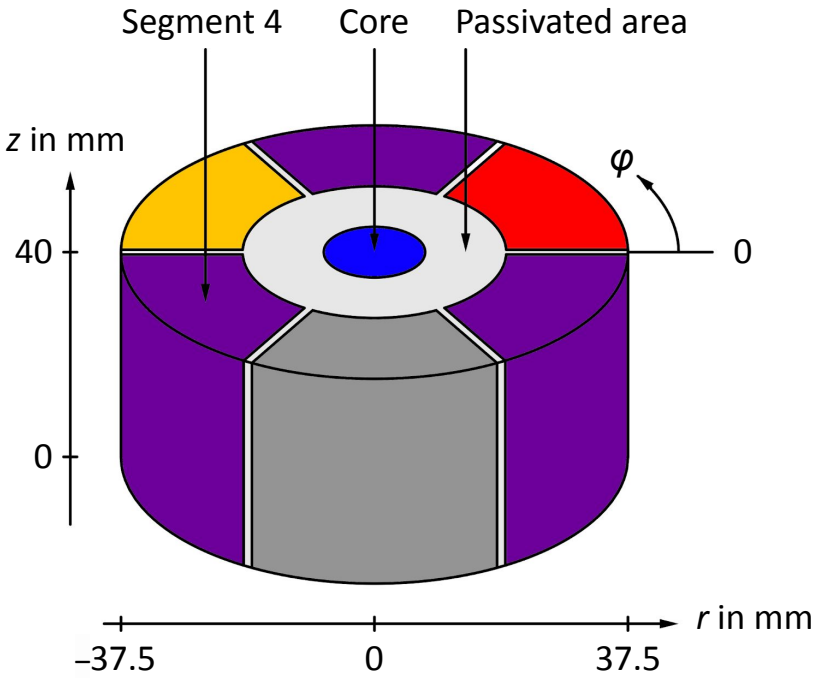
Segmented Broad Energy Germanium Detector



Values in the specification sheet of the detector:

Net carrier concentration:

- Top surface: $0.65 \cdot 10^{10}\ \mathrm{cm}^{-3}$
- Bottom surface: $0.58 \cdot 10^{10}\ \mathrm{cm}^{-3}$

Note: The net impurity concentration is given by the crystal grower and could be different than the values calculated from depletion measurements.

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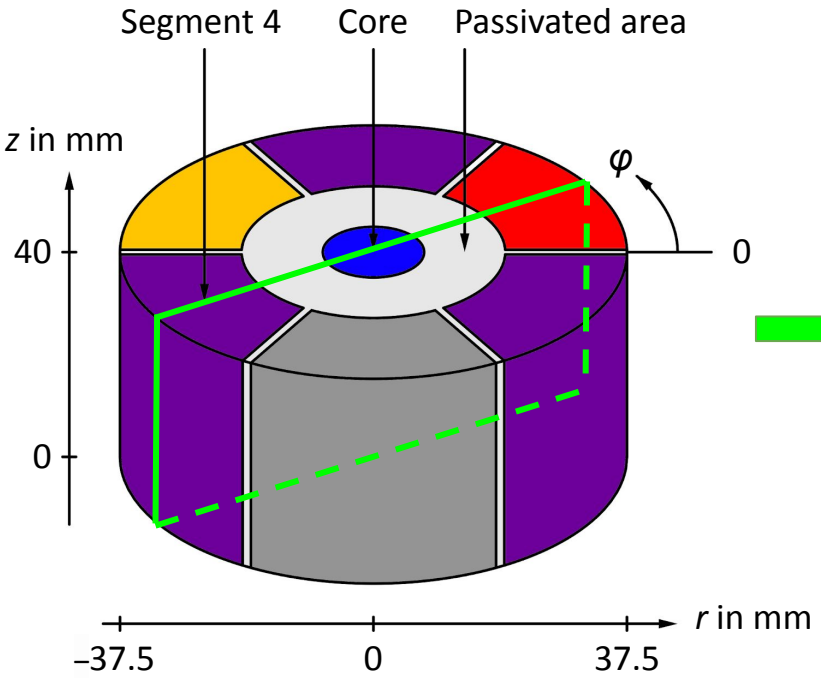

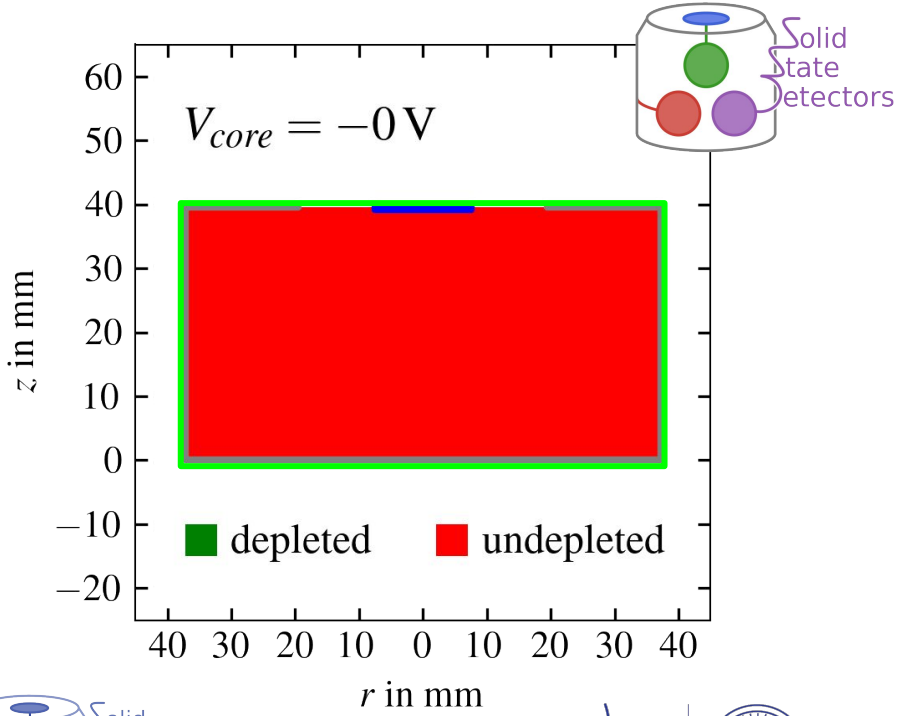

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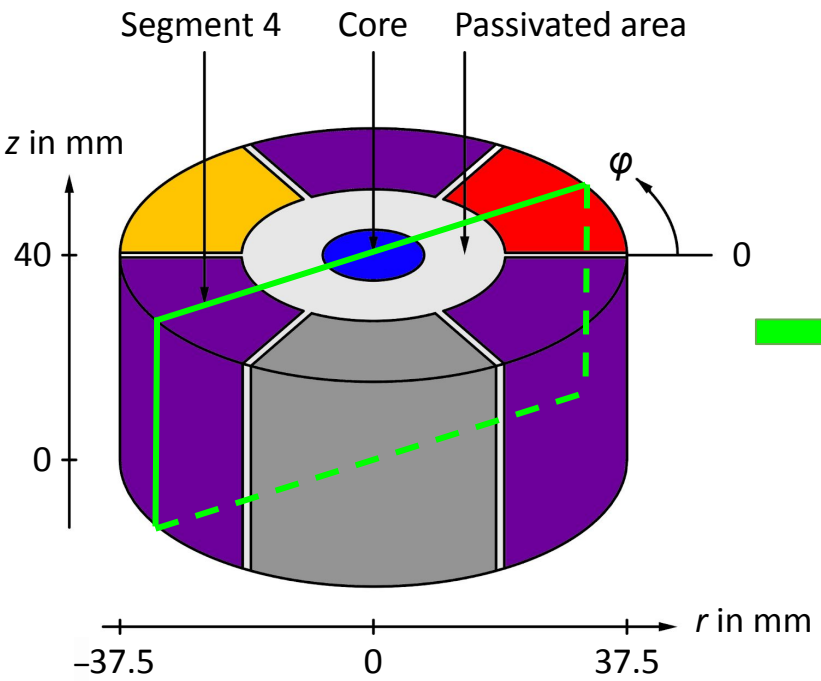

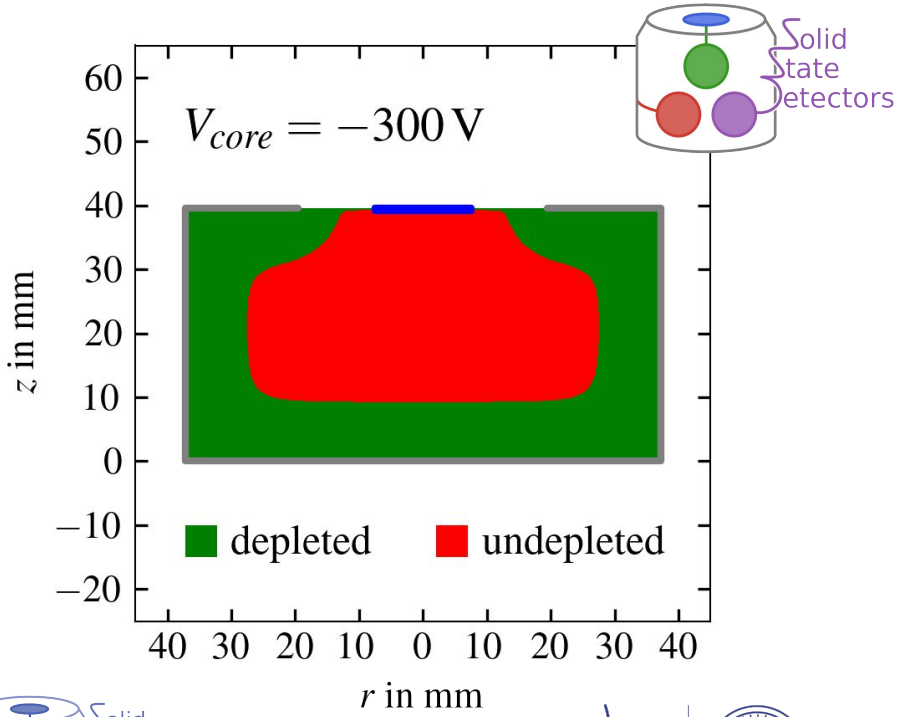

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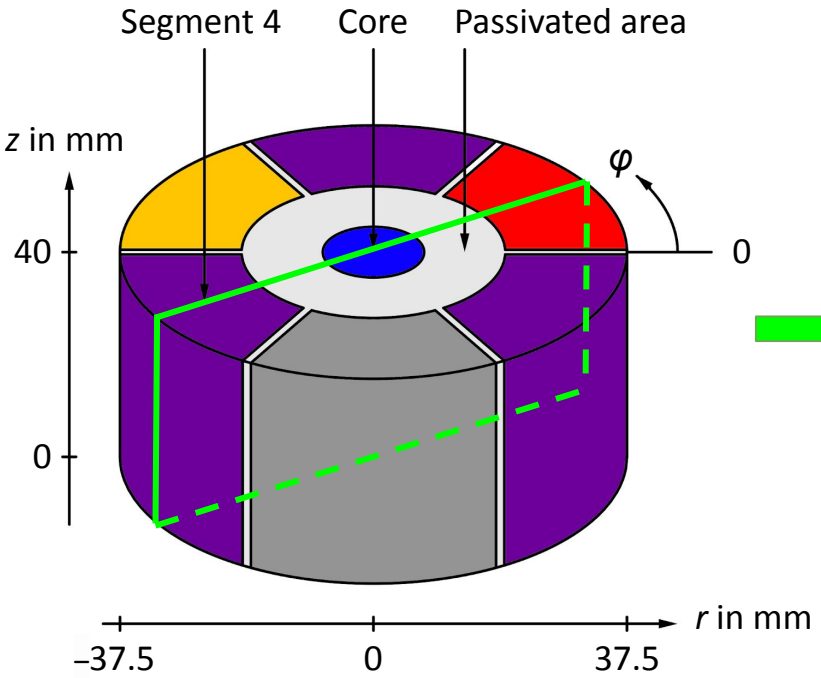

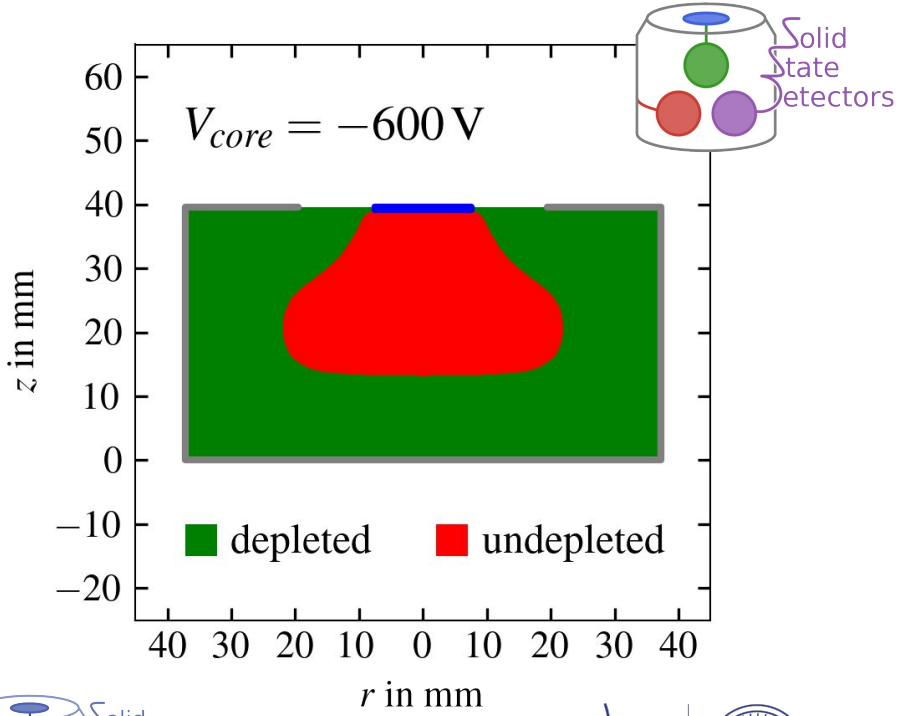

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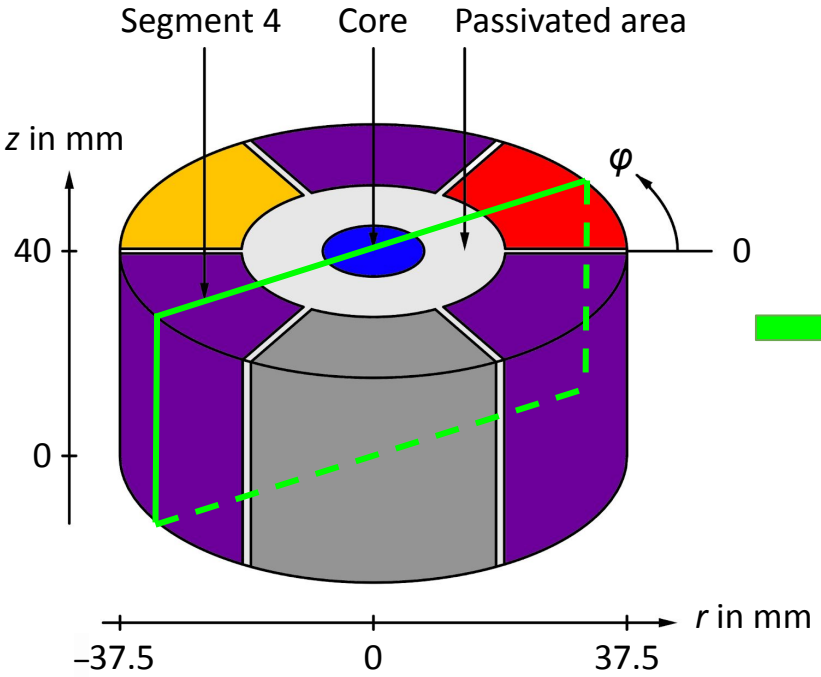

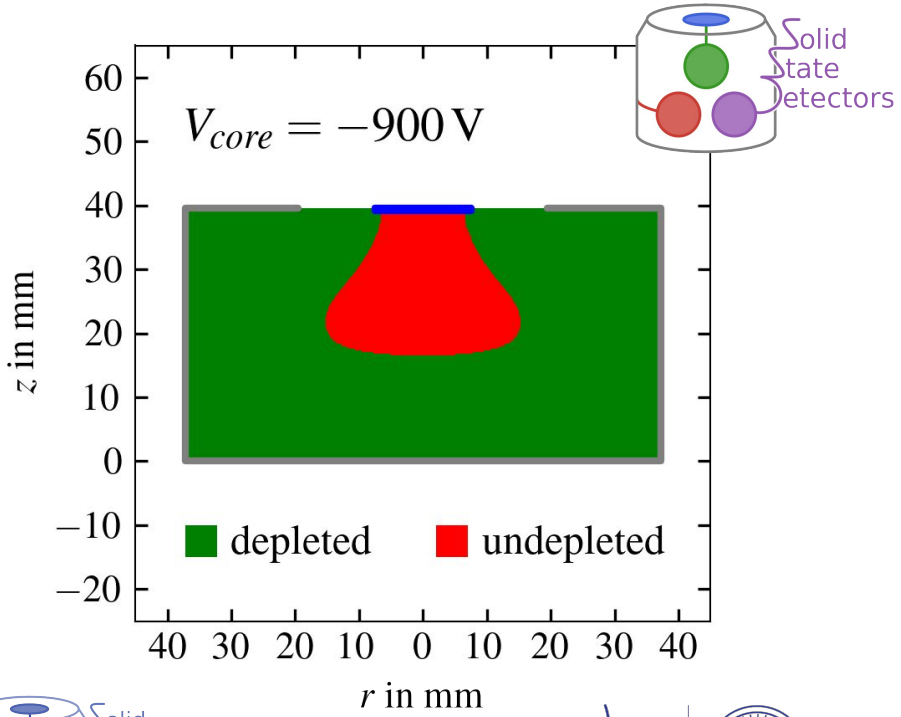

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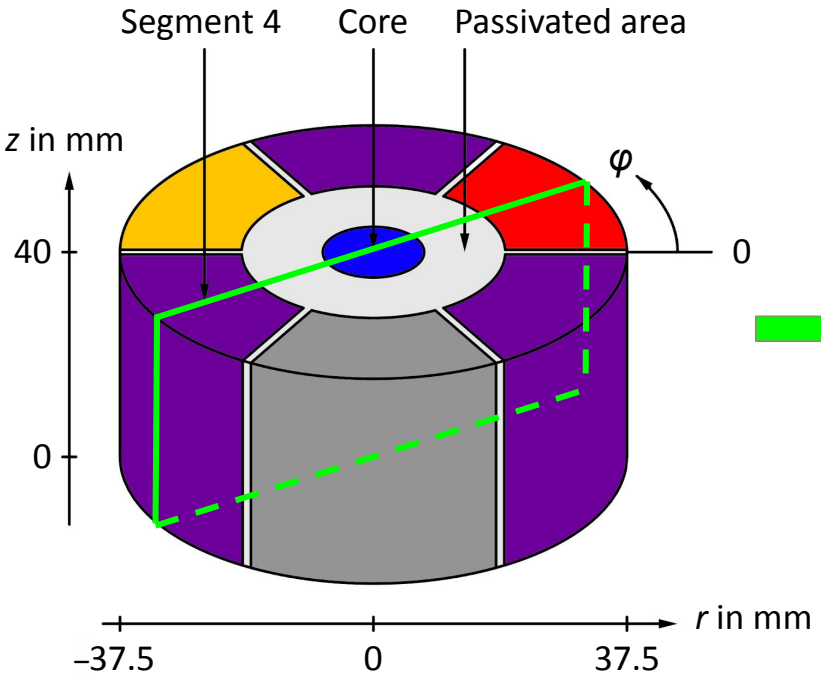

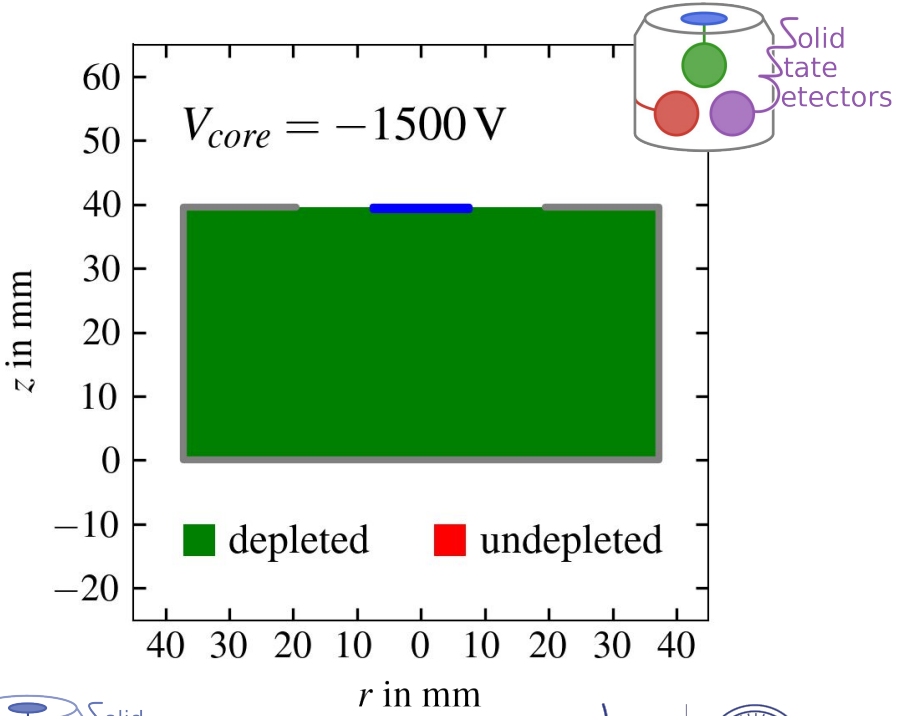

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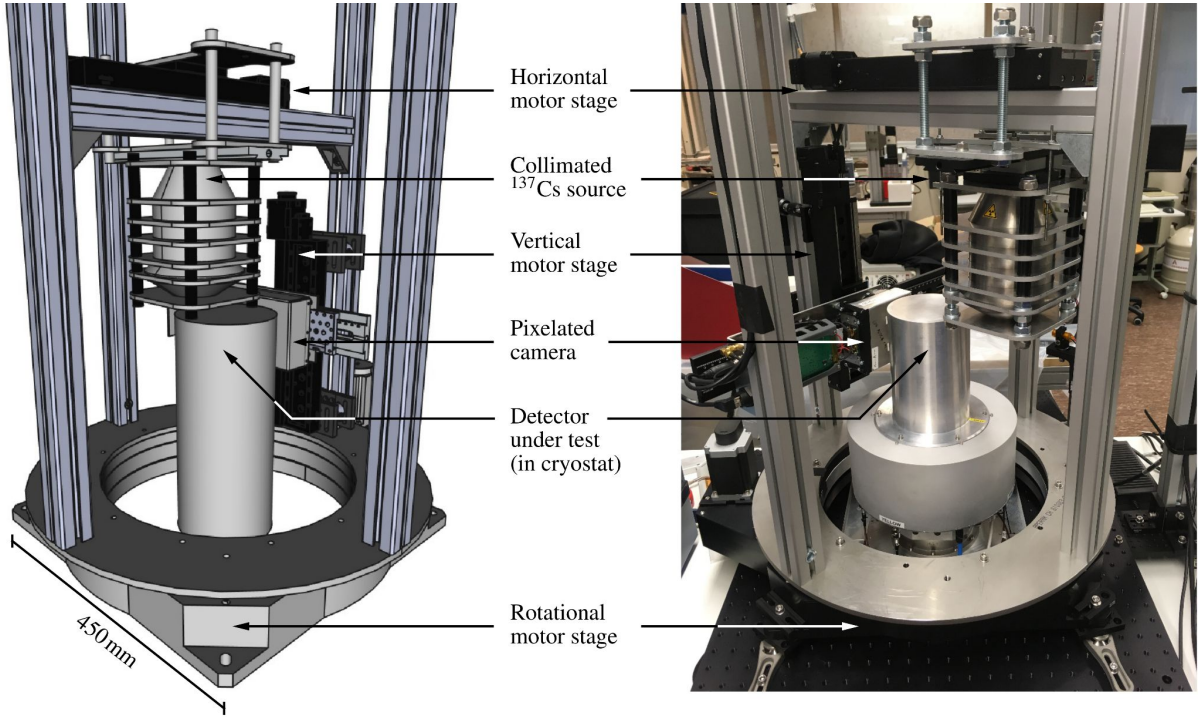
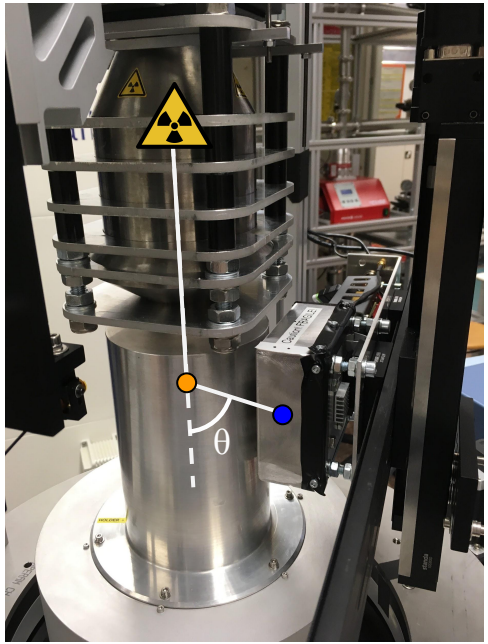
Compton Scanner Setup





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doi:10.1140/epjc/s10052-022-11064-8, arXiv: 2202.03116

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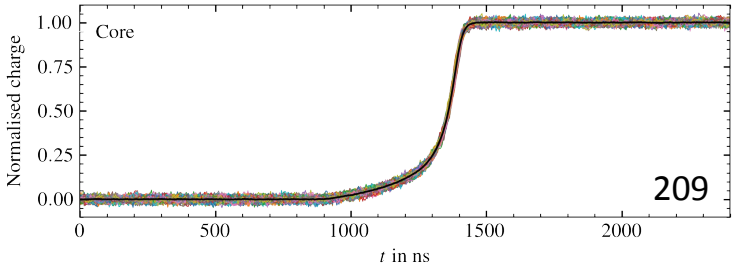
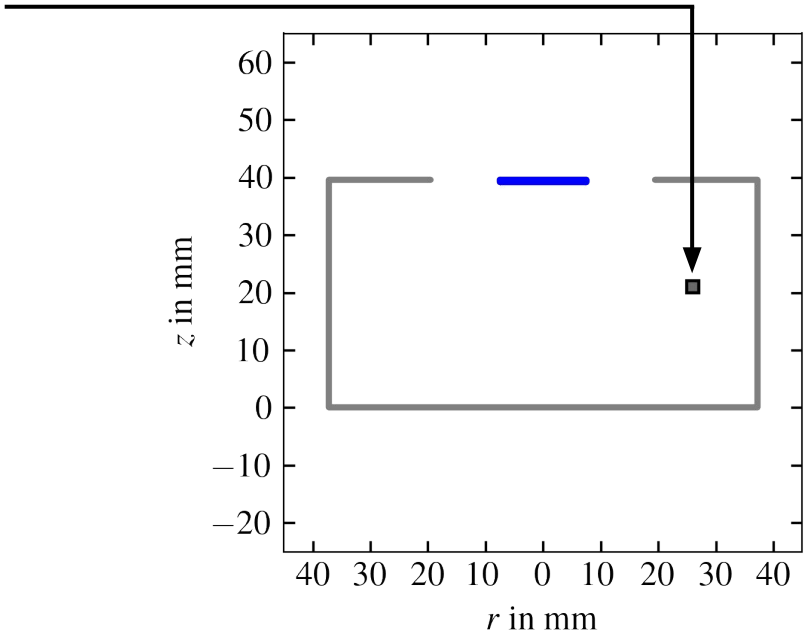
Creating Pulse Shape Libraries

From events with **2 hits** in the camera:





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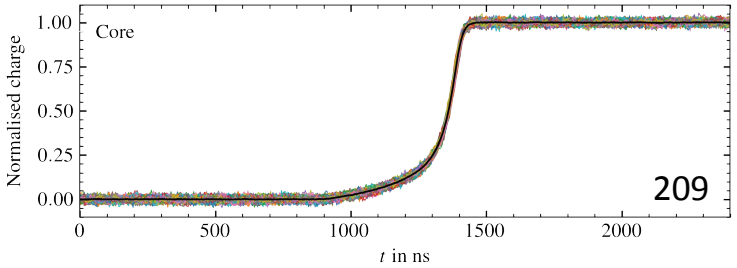

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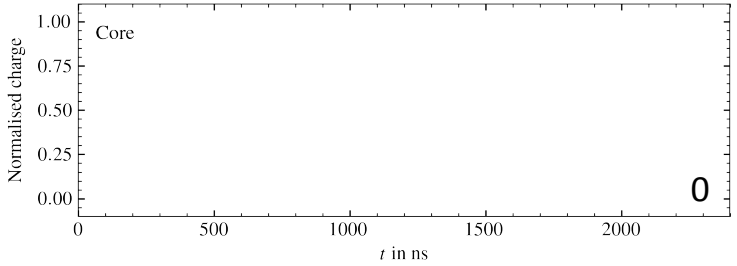

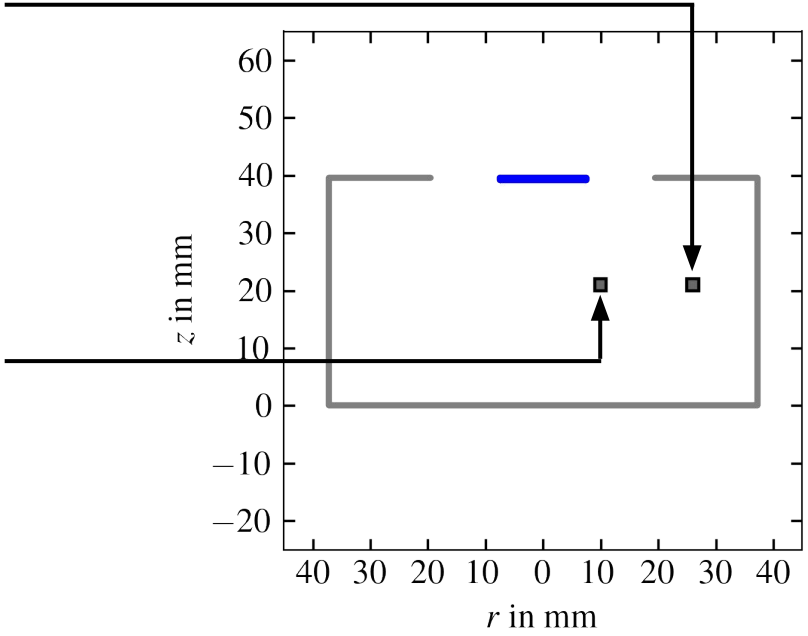

Compton Imaging of Undepleted Regions

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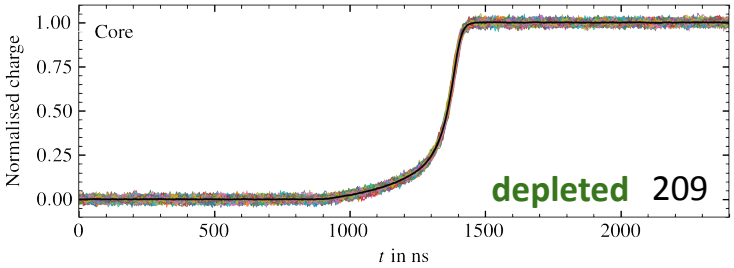

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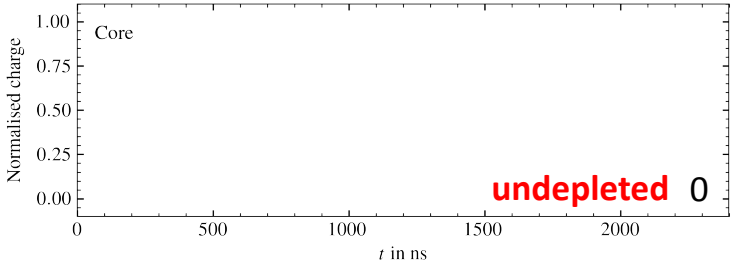

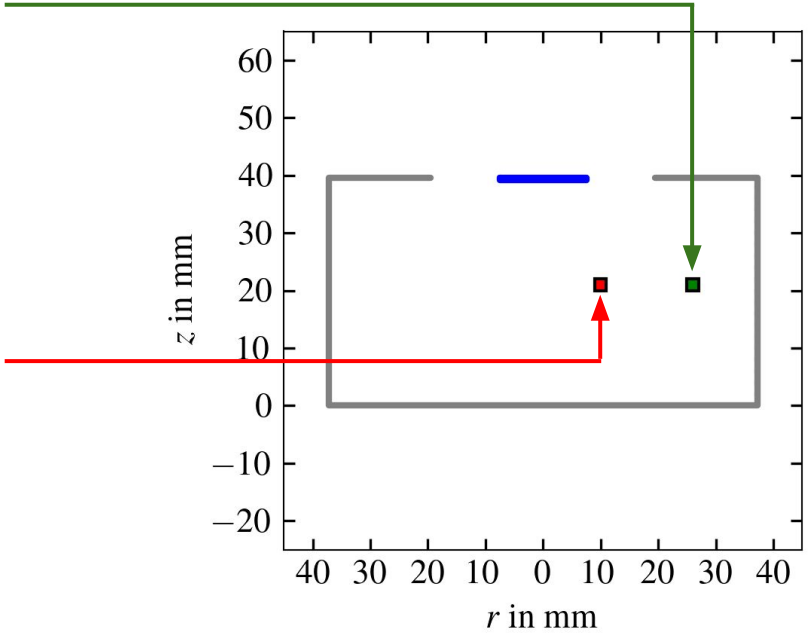

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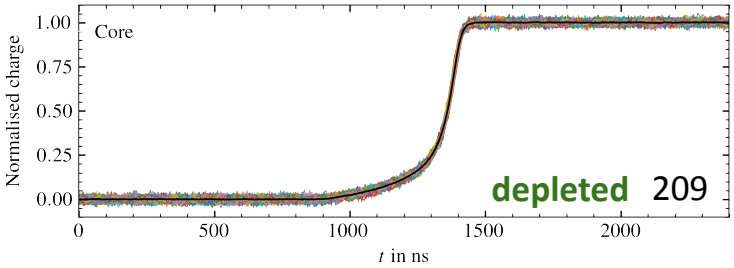

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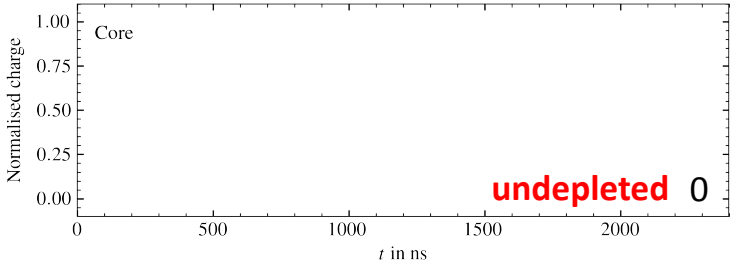
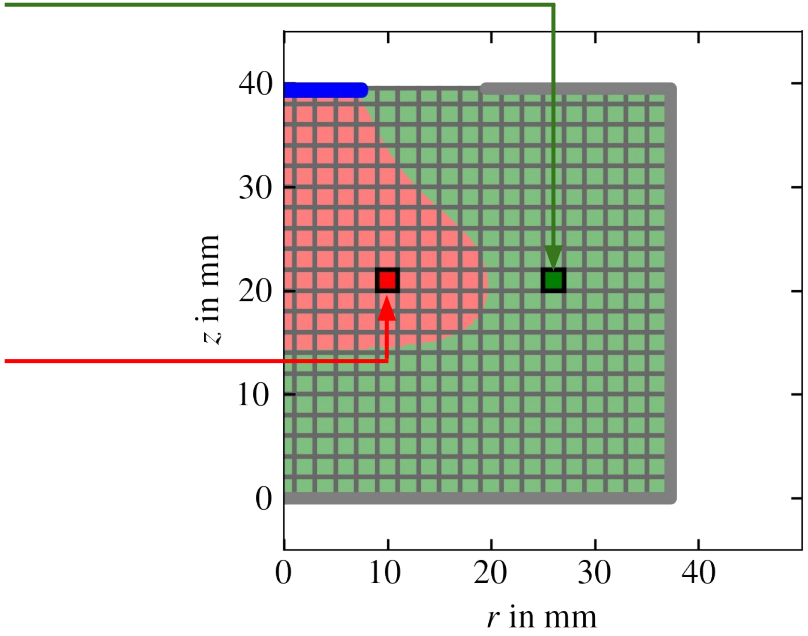
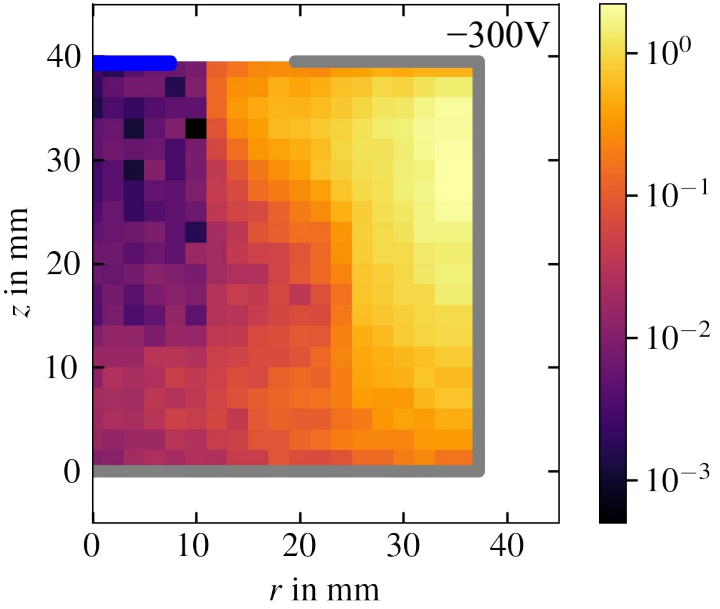
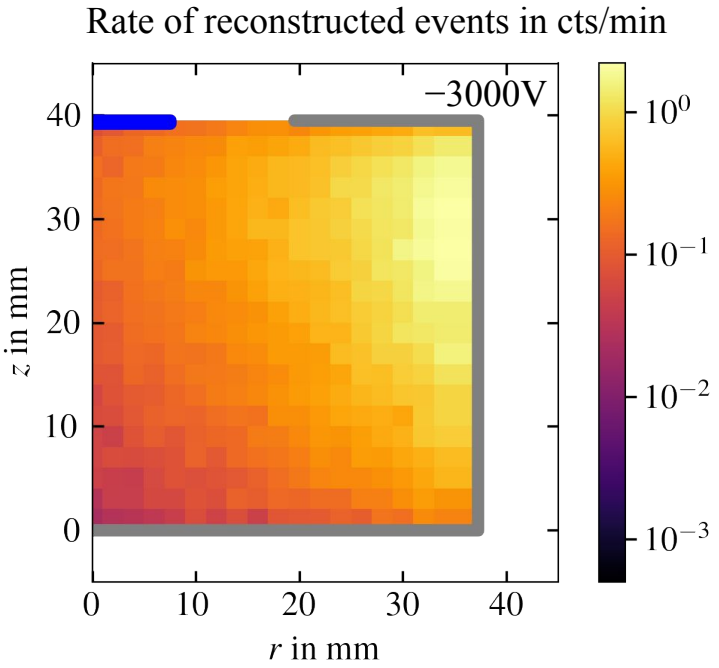




Rates of Compton Reconstructed Events





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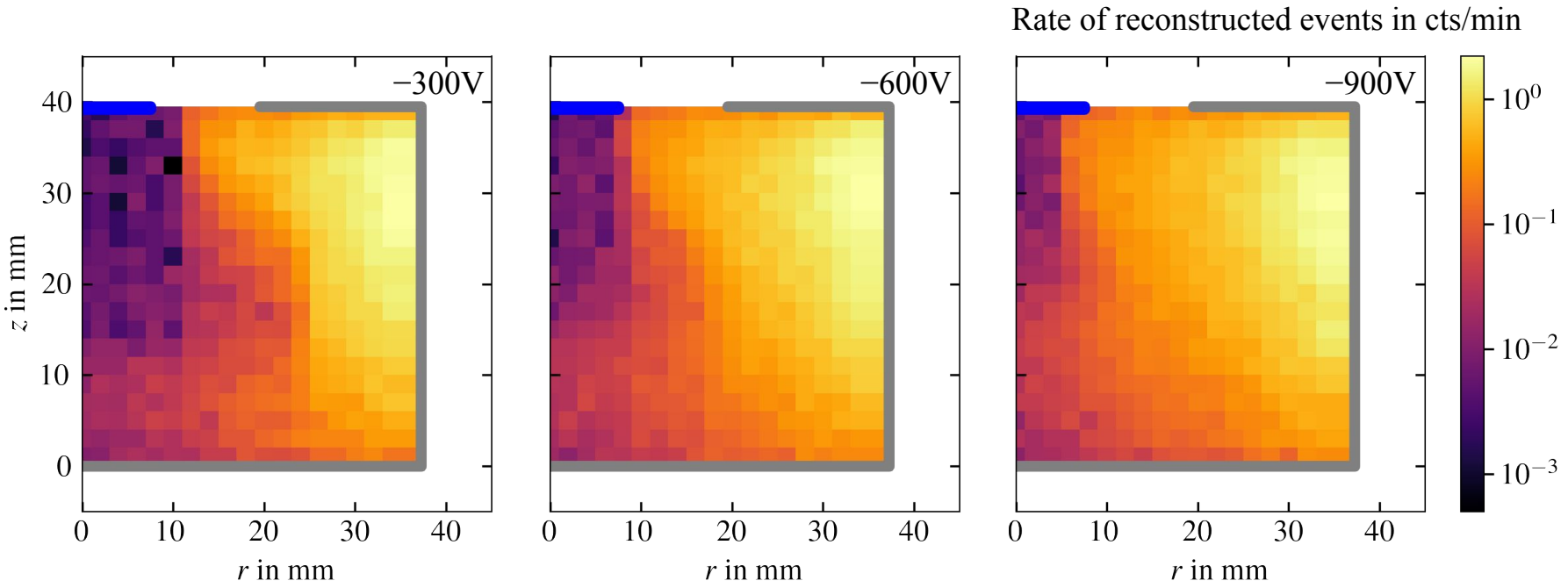
Rates of Compton Reconstructed Events



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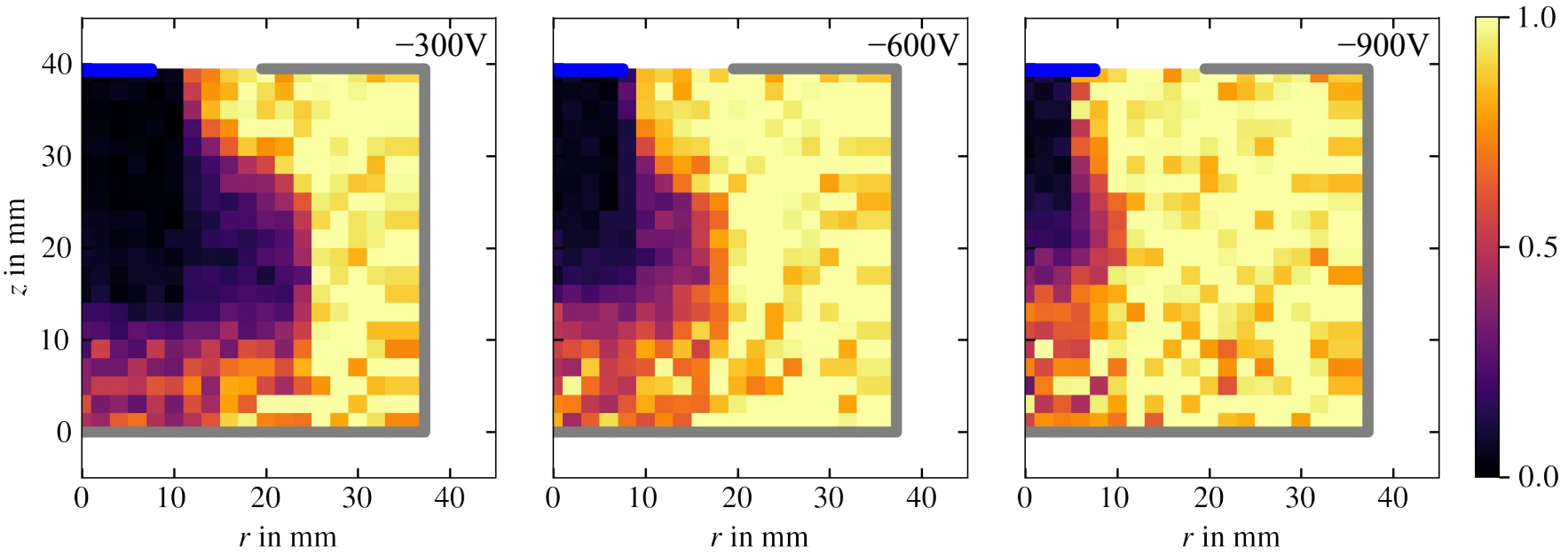
Efficiency

$$\text{Efficiency} = \frac{\text{Event rate and undepleted voltage}}{\text{Event rate and reference voltage } -3000\text{V}}$$



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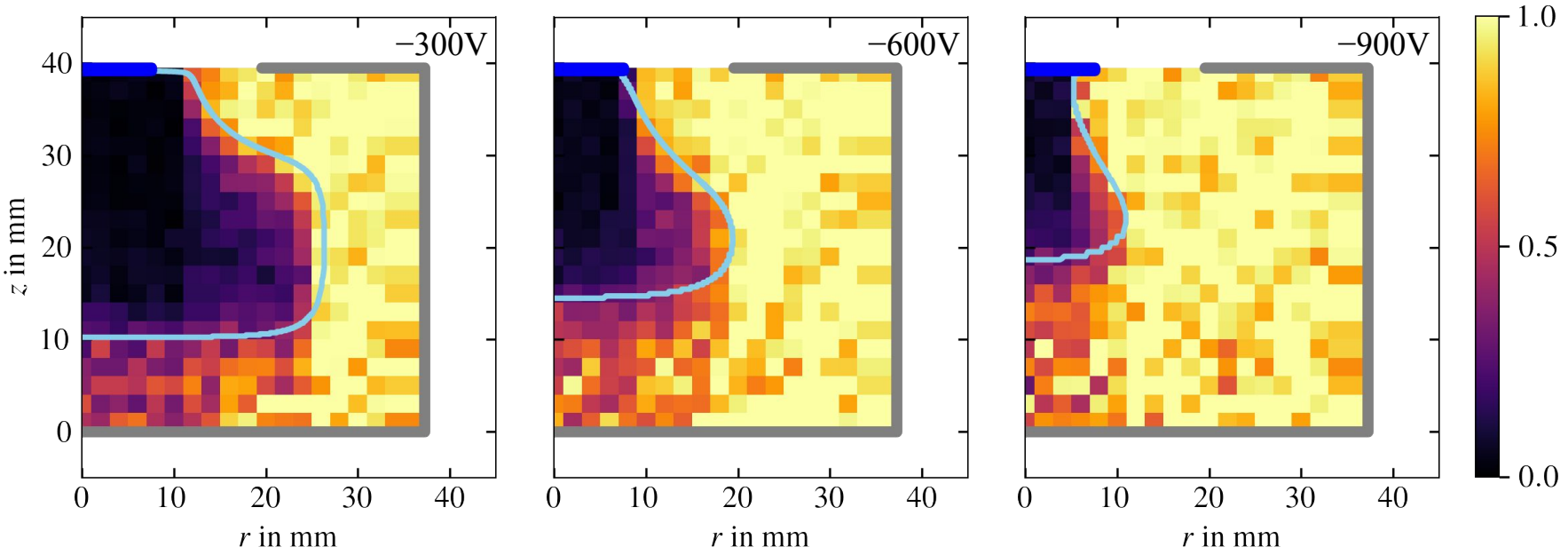
Comparison to Simulation

— Simulated undepleted region using the manufacturer values
(scaled by a factor to match the measured depletion voltage)

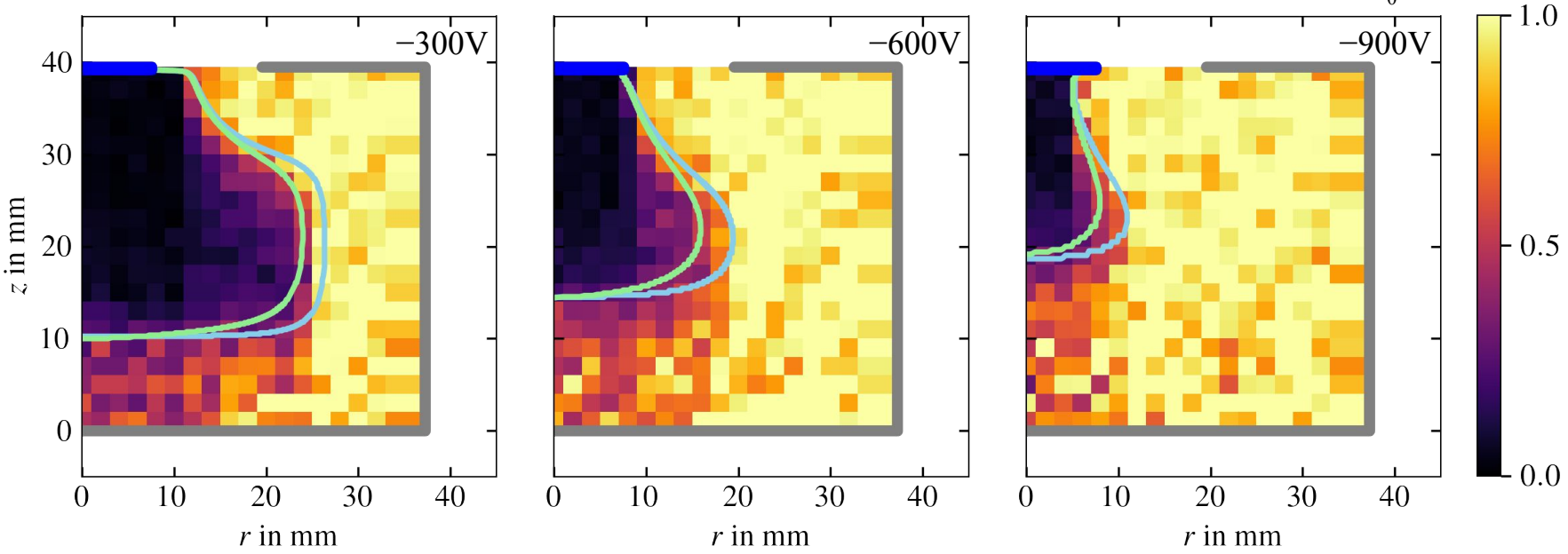


I. Abt et al., J. Instr. **16**: P08007 (2021)
doi:10.1088/1748-0221/16/08/P08007, arXiv: 2104.00109

Comparison to Simulation

Simulated undepleted region using the manufacturer values (scaled by a factor to match the measured depletion voltage)

Simulated undepleted region using an impurity profile with a linear radial dependence: $\rho(r) = \rho_0 \cdot (1 - r/R)$



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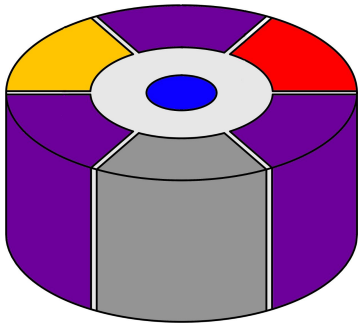
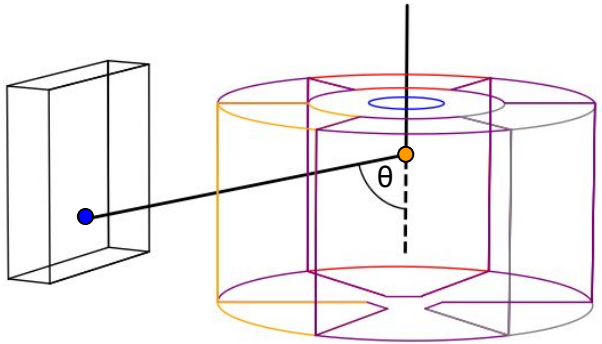
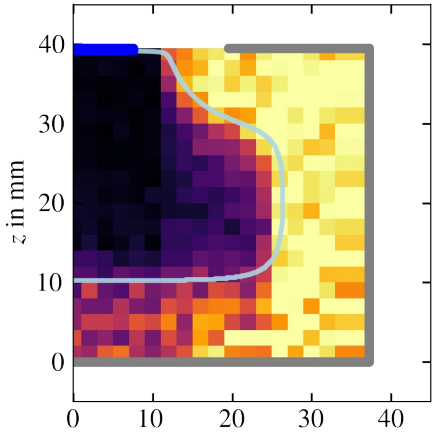
Summary







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Comparison to simulation to estimate the impurity density

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