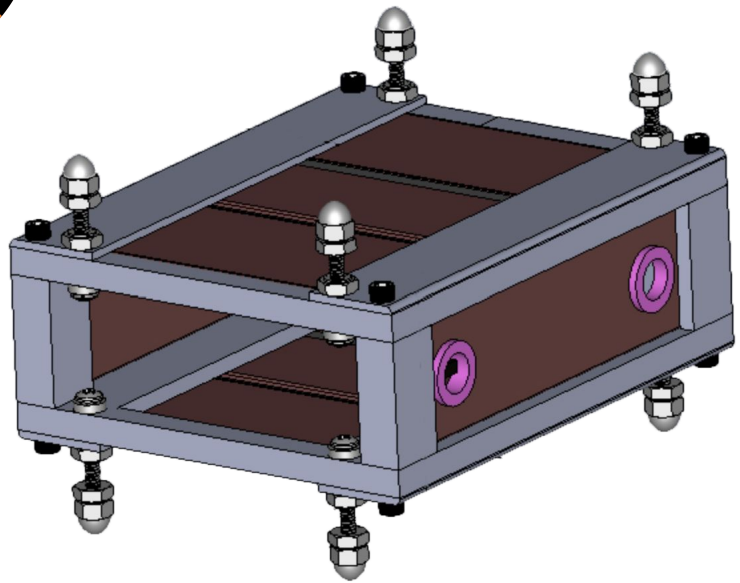
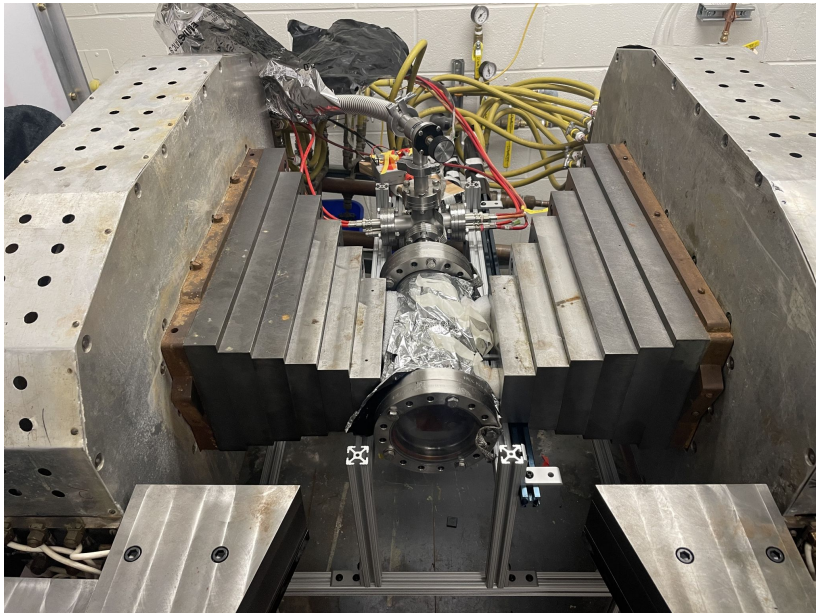
Electron ExB Slow Drift Demonstration

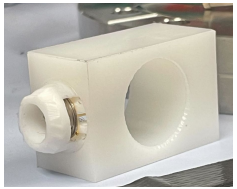


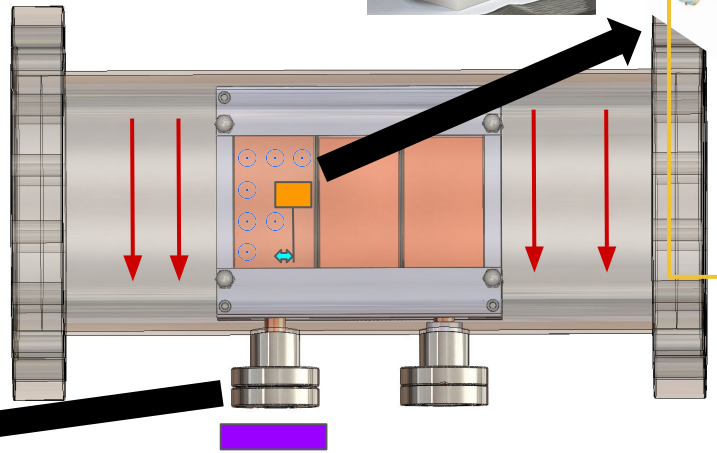


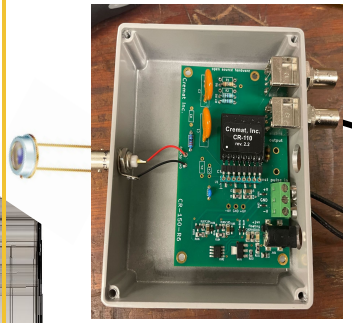
Mark Farino, Andi Tan

At Pollica…

Successfully measured difference in event rates of electrons emitted by **C-14** (through **Kapton** film) using windowless **PIN Diode** based on **ExB** drift



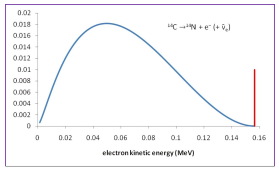




Readout system consists of BPX-61 PIN Diode with protective glass removed, Cremat Evaluation Board, and shaping amplifier
(presented March 2024)

Electron-permeable thin film window.
Electrons pass losing ~15-20 keV
(presented april 2023)

10uCi source with maximum electron energy ~160 keV



System maintained at ~10e-6 Torr and immersed in 0.3 T magnetic field

At Pollica…

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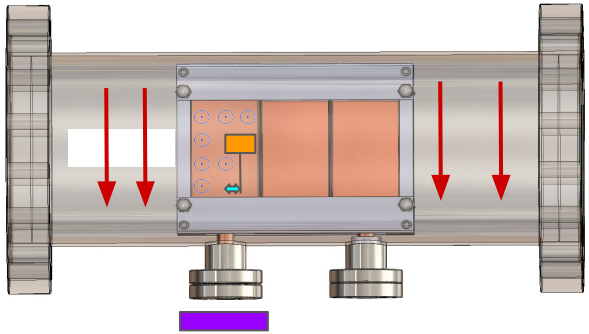
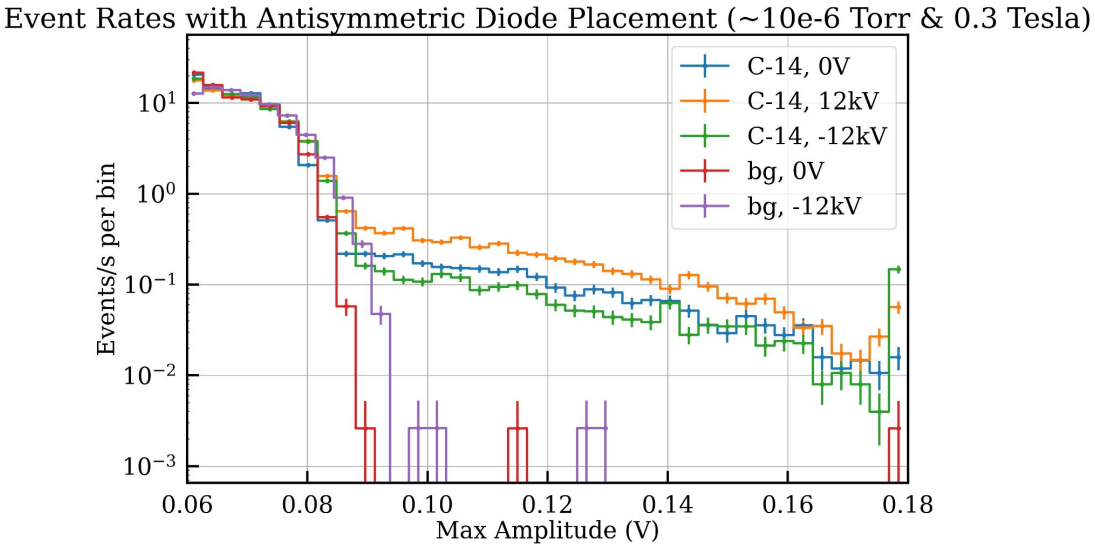
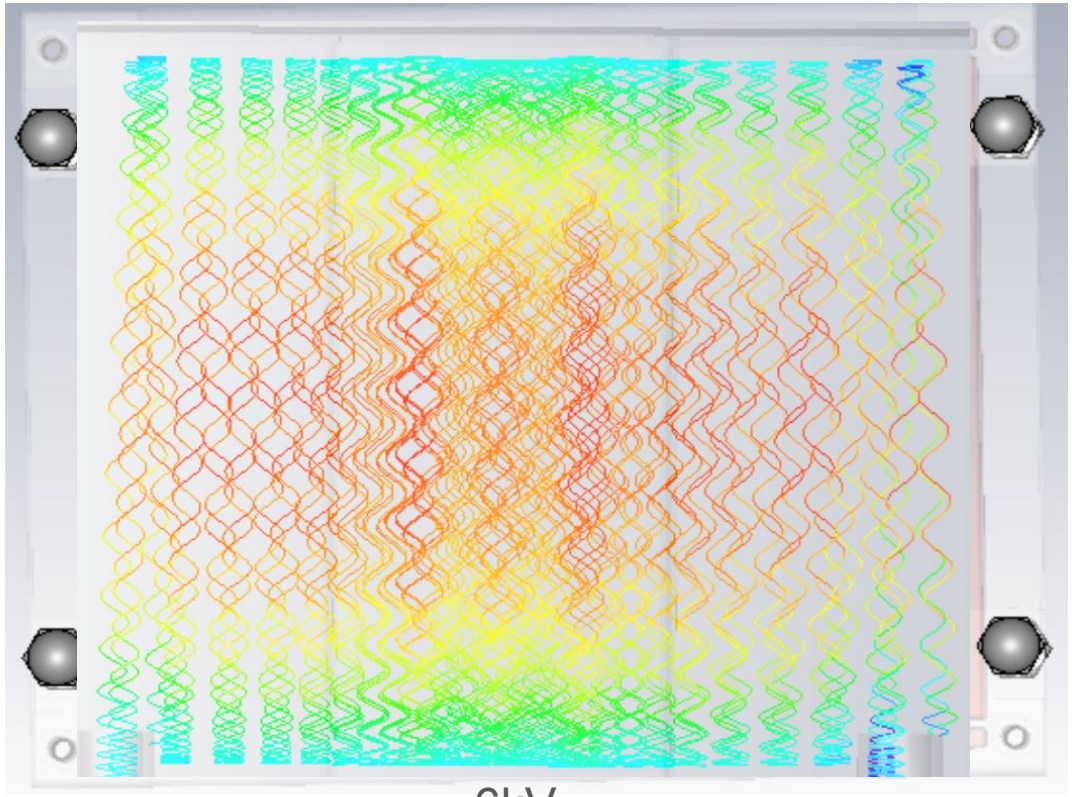




Steps Toward Multibounce Slow Drift

-6kV

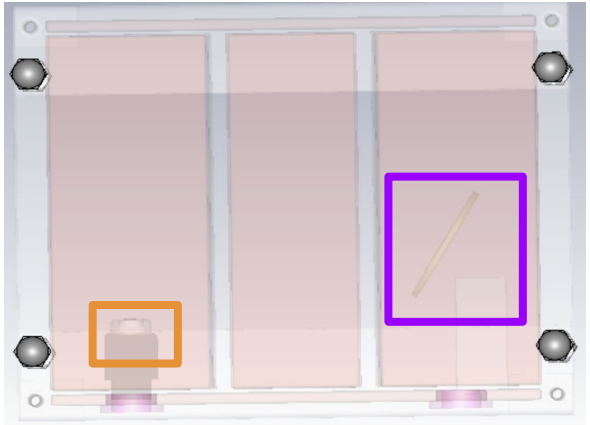


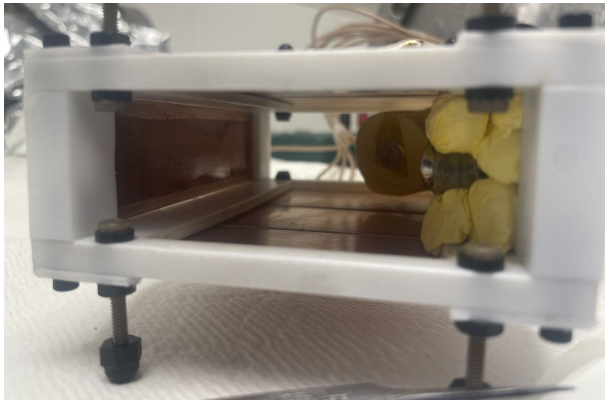
-6kV

Steps Toward Multibounce Slow Drift

To increase event rate:

- **C-14** source disk and **PIN Diode** placed inside chamber



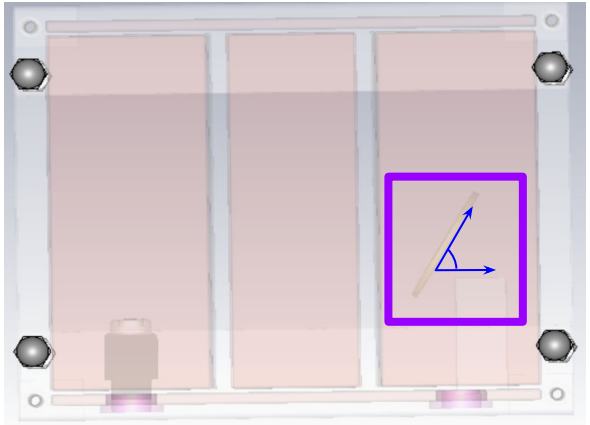


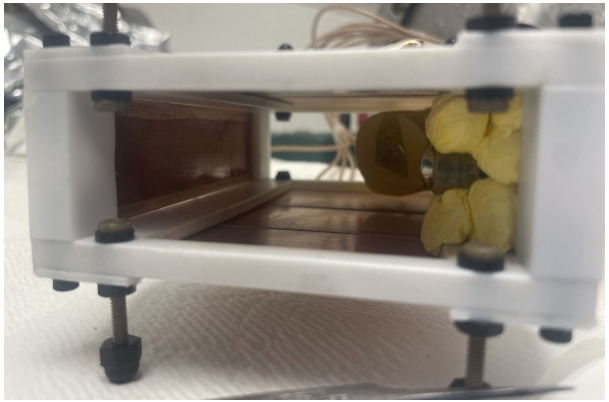
Steps Toward Multibounce Slow Drift

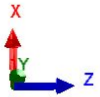
To increase event rate:

- **C-14** source disk and PIN Diode placed inside chamber

- **C-14** source disk set at **60 degree angle**



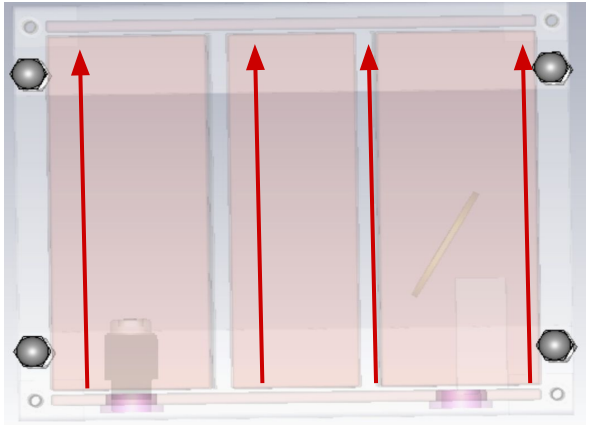




Steps Toward Multibounce Slow Drift

To increase event rate:

- C-14 source disk and PIN Diode placed inside chamber
- C-14 source disk set at 60 degree angle
- **B-field** lowered to 0.16 T



$$\boldsymbol{v}_E = \frac{\boldsymbol{E} \times \boldsymbol{B}}{B^2}$$

Steps Toward Multibounce Slow Drift

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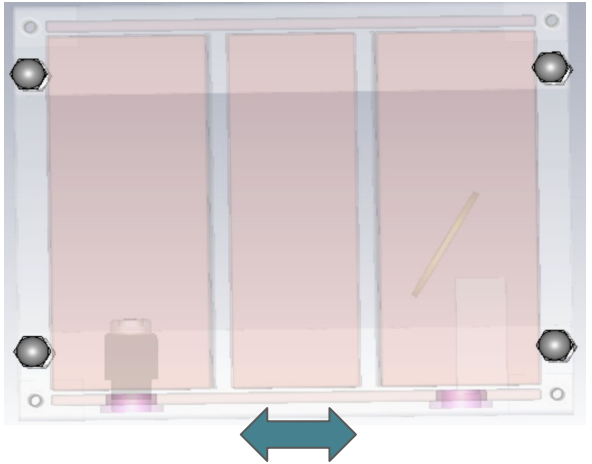
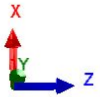


To mitigate backgrounds & sparking:

- **Center Electrodes** width reduced (1.25” => 1”)



Steps Toward Multibounce Slow Drift

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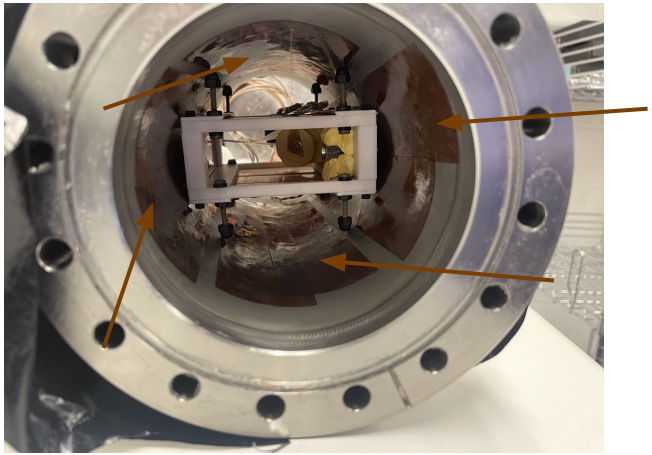
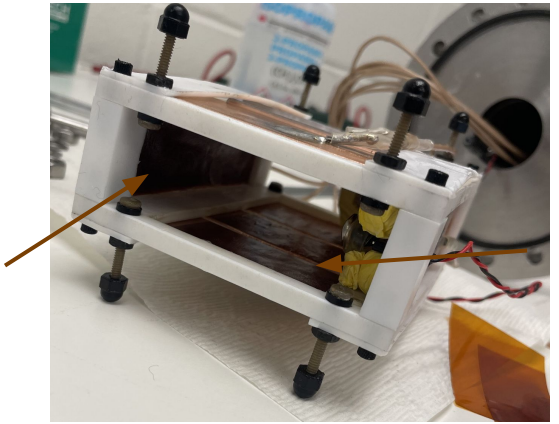
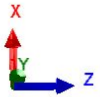
- C-14 source disk and PIN Diode placed inside chamber
- C-14 source disk set at 60 degree angle
- B-field lowered to 0.16 T

To mitigate backgrounds & sparking:

- Center Electrodes width reduced (1.25” => 1”)
- 3 mil thick **Kapton** lined inside vacuum chamber & electrodes







Steps Toward Multibounce Slow Drift

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- C-14 source disk and PIN Diode placed inside chamber
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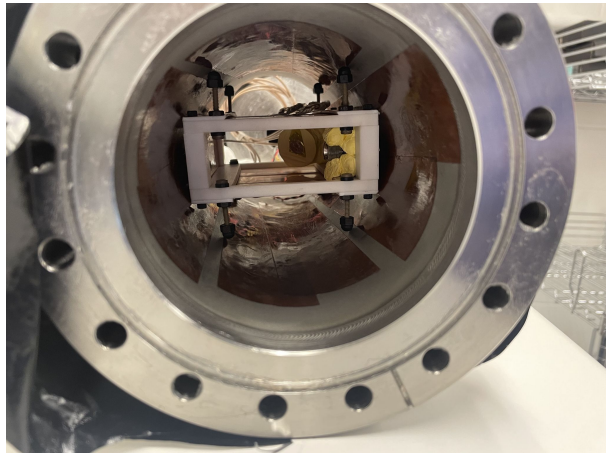
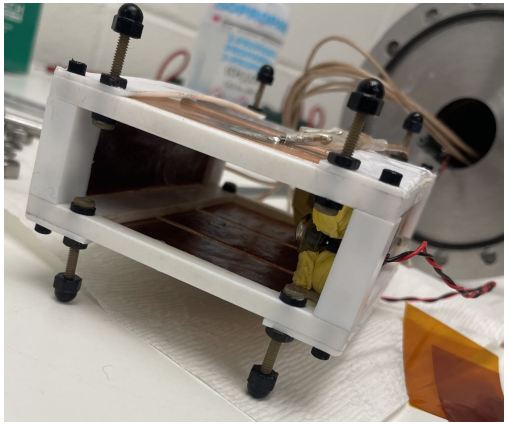
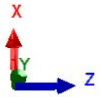
- B-field lowered to 0.16 T

To mitigate backgrounds & sparking:

- Center Electrodes width reduced (1.25” => 1”)
- 3 mil thick Kapton lined inside vacuum chamber & electrodes
- Entire system cleaned, polished, and rewired

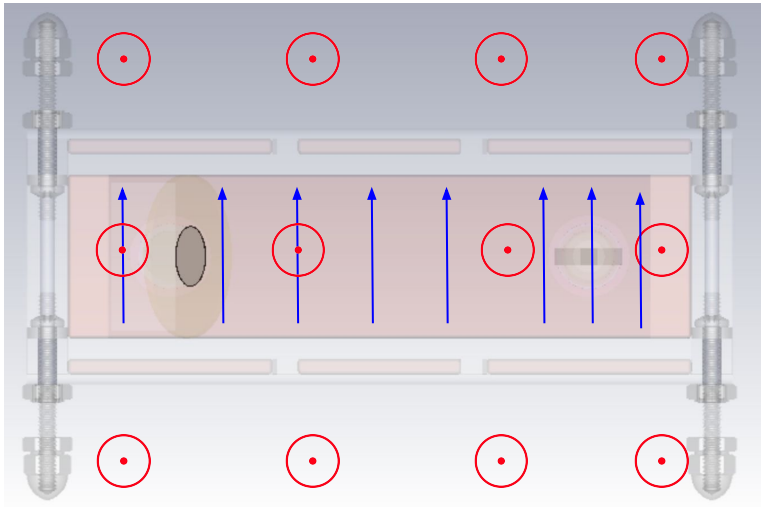


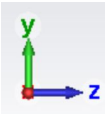




Procedure

- Operate 0.16 T **B field** and set voltages on drift electrodes to generate an upward **E field**





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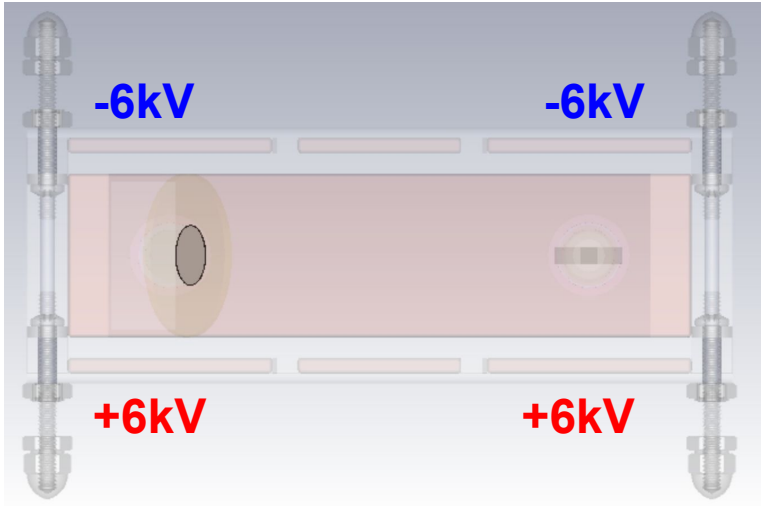
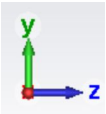
- Operate 0.16 T B field and set voltages on drift electrodes to generate an upward E field

- Apply maximum voltage difference (**± 6kV**) to outer pairs of electrodes (maximal drift velocity).





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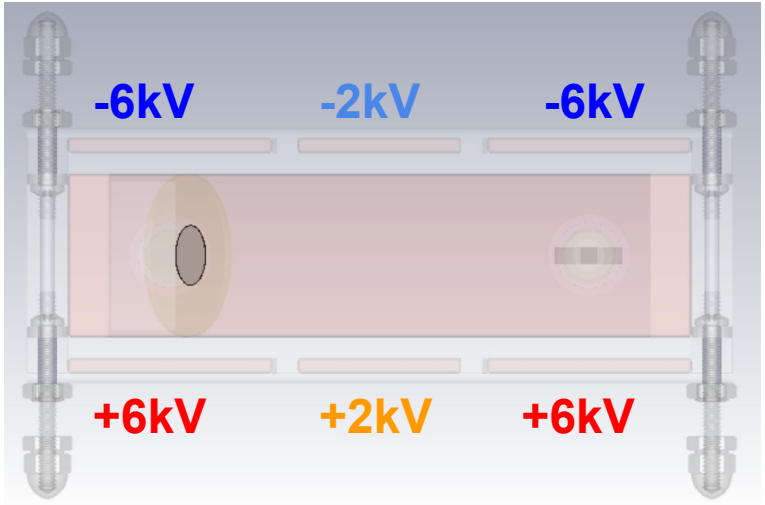
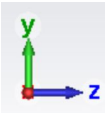
- Apply maximum voltage difference (**± 6kV**) to outer pairs of electrodes (maximal drift velocity).
- Set center pair to smaller voltage difference to achieve slow drift (e.g., **+ 2kV** for ⅓ drift speed)





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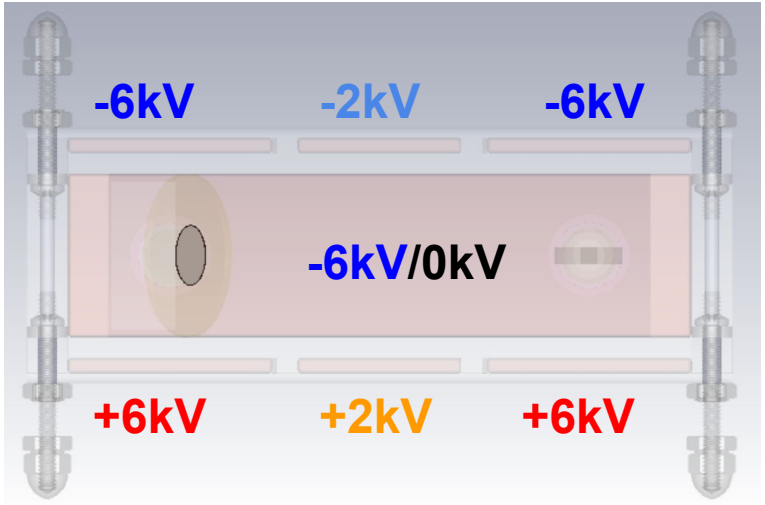
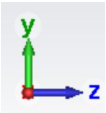
- Record data with bouncing plate operated *both* at **-6kV** and **0kV** (to account for scattering). Difference between rates indicates successful transport





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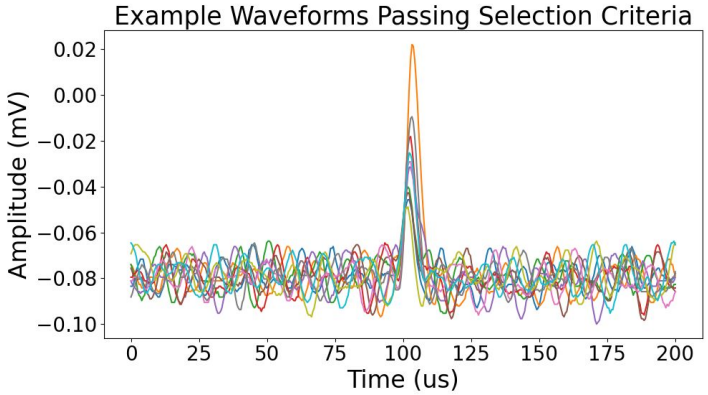
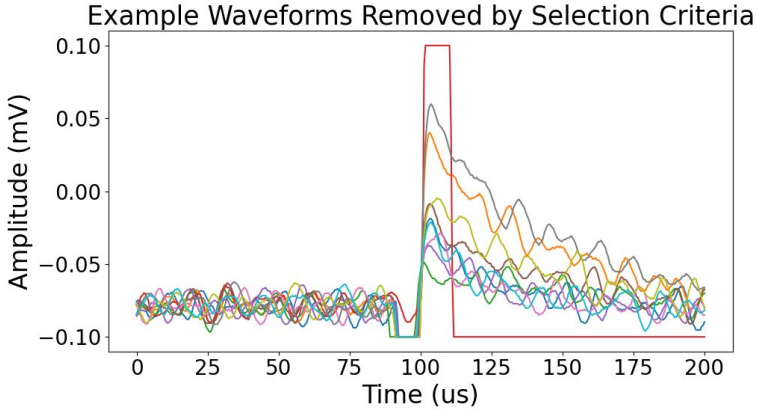
- Discard remaining noise/background via mean and standard deviation selection criteria (~97% efficient)





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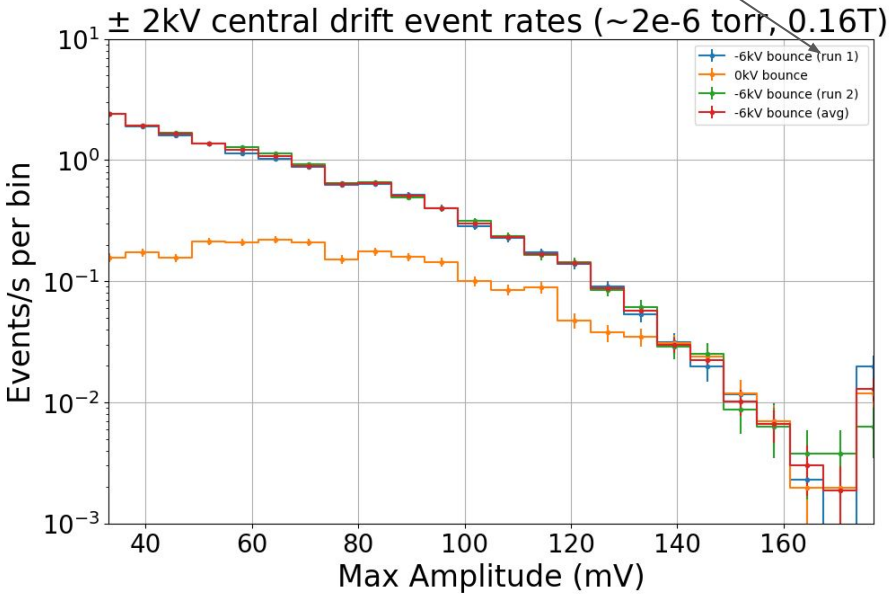
Multiple runs taken to ensure consistent behavior

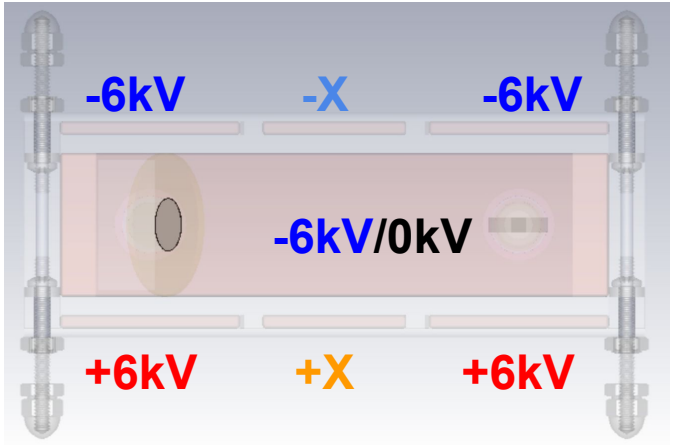


Max amplitude of waveform output

Modes of Operation

Symmetric Slow Drift

- Symmetrically lower magnitude of top and bottom electrodes

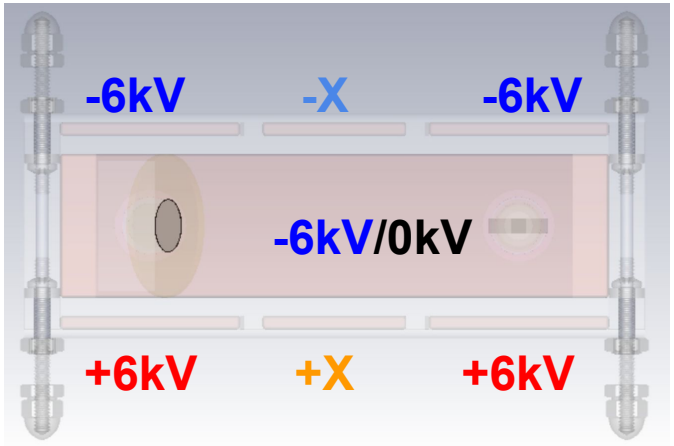


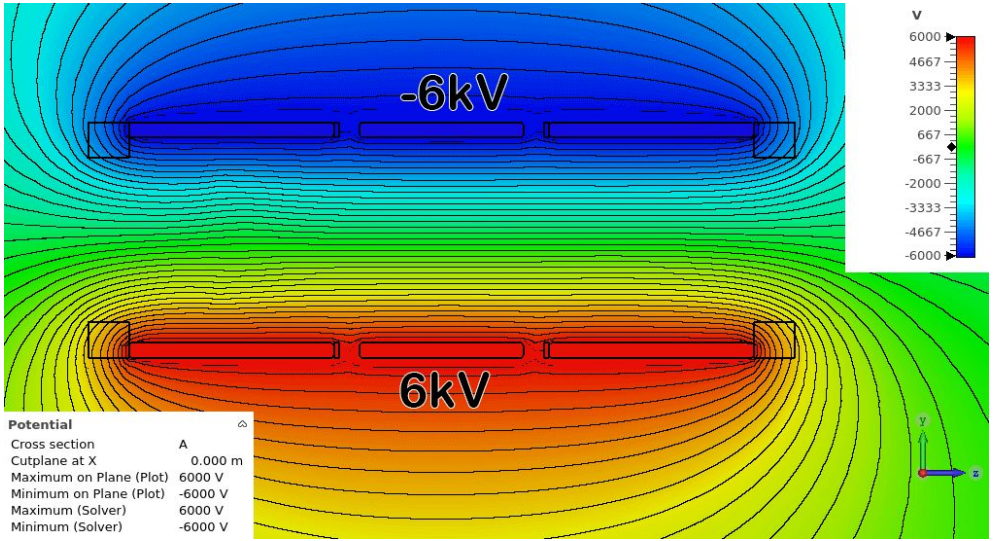
Modes of Operation

Symmetric Slow Drift

- Symmetrically lower magnitude of top and bottom electrodes

- Expectation: as X decreases, so too does event rate (electrons, following potential lines, more likely to terminate on wall)

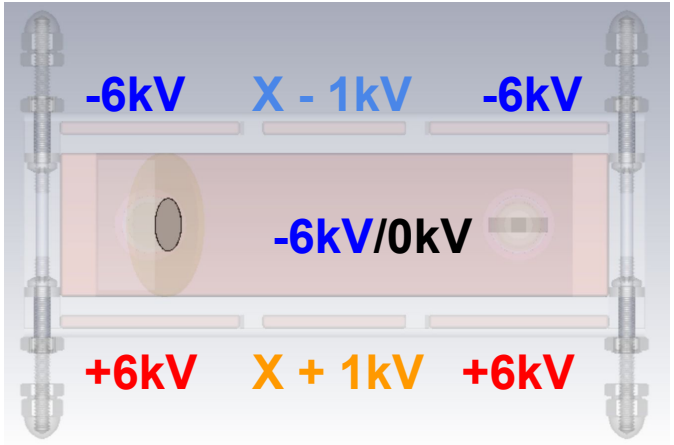




Modes of Operation

Voltage Scan (2kV)

- Record event rates within 2kV window around varying center voltage **X**

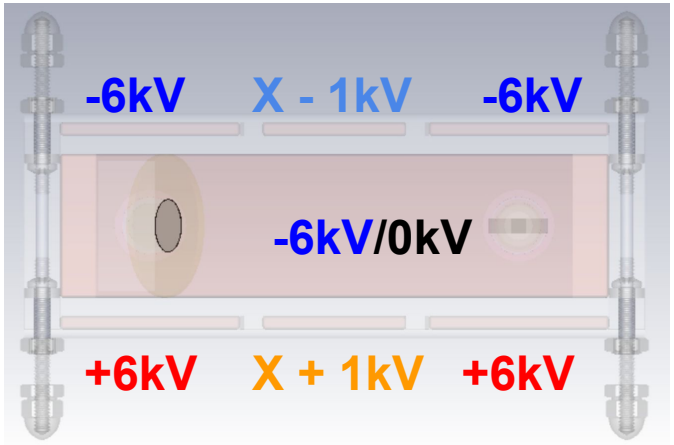


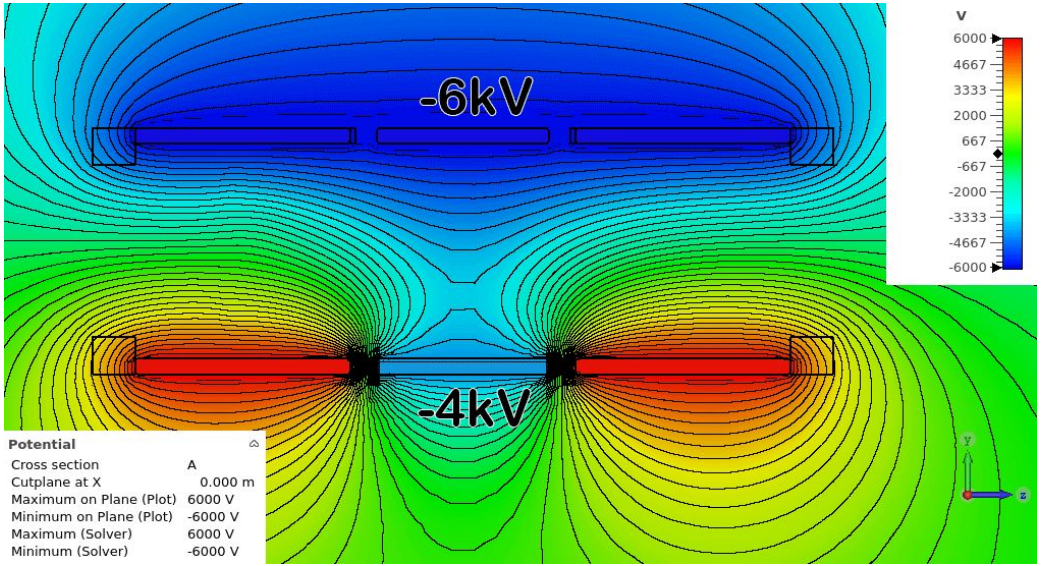
Modes of Operation

Voltage Scan (2kV)

- Record event rates within 2kV window around varying center voltage **X**

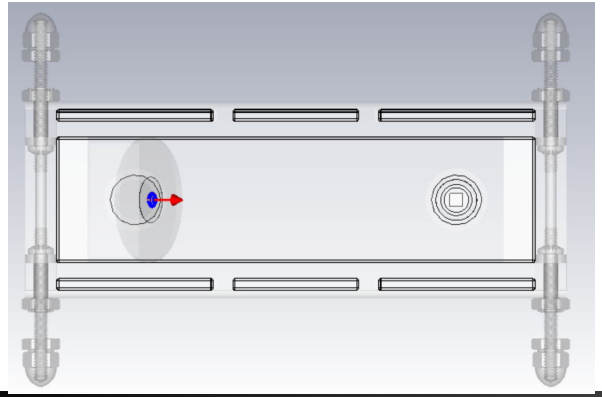
- Useful to study profile of source activity by ‘zooming in’ on a specific potential window





Simulation

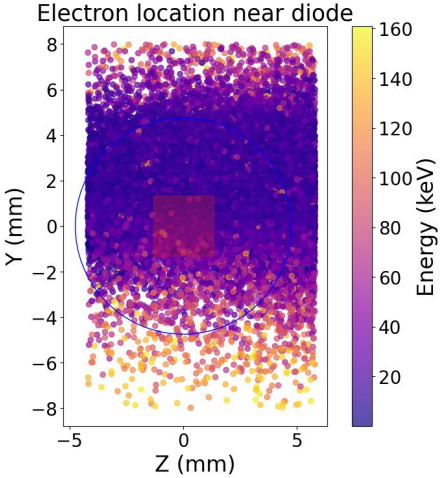
- 1 million particles (2pi solid angle, uniform energy distribution) between 0-160keV launched for each voltage setting

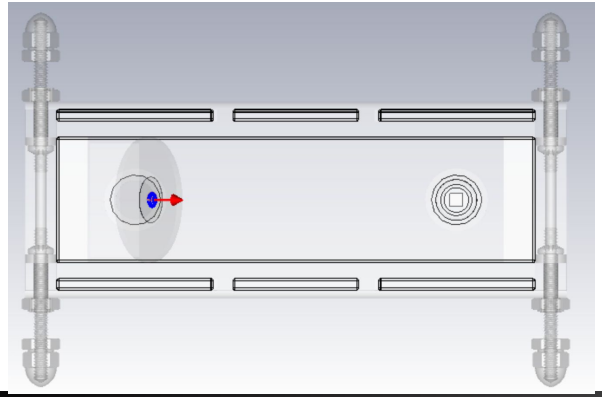


Simulation

- 1 million particles (2pi solid angle, uniform energy distribution) between 0-160keV launched for each voltage setting

- Terminal location recorded via particle monitor; those impinging silicon active region of diode are saved





Simulation

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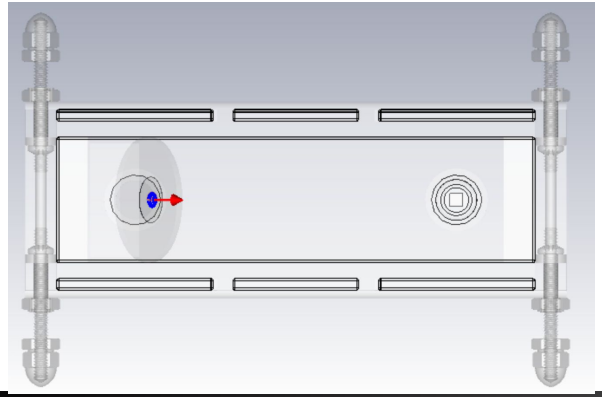
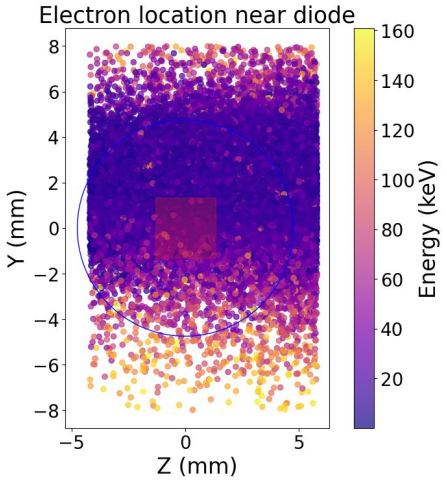
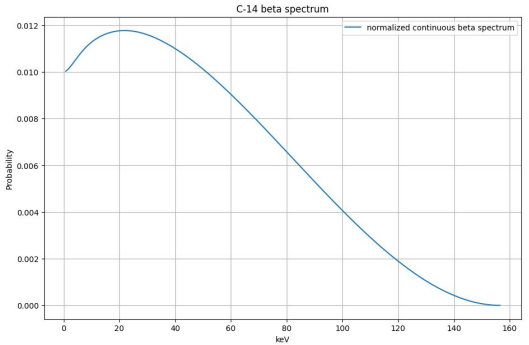
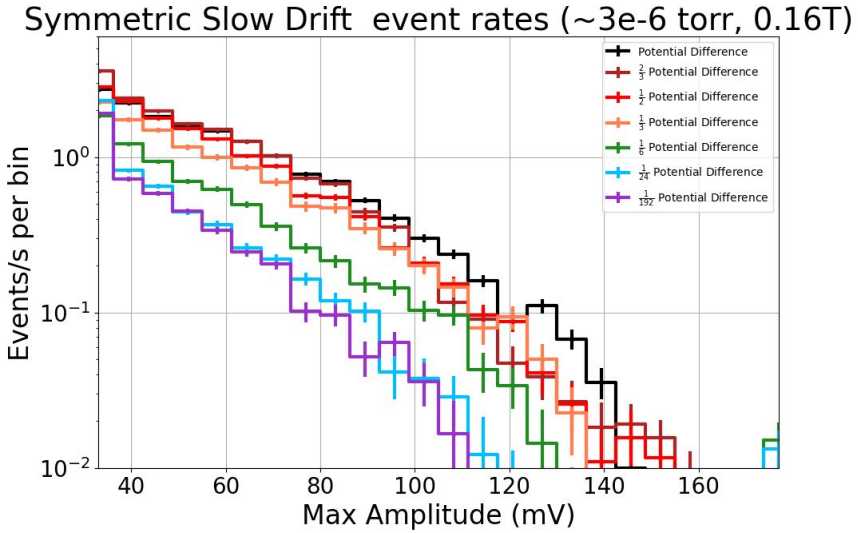
- Terminal location recorded via particle monitor; those impinging silicon active region of diode are saved
- Output weighted (relatively) by C-14 spectrum (convolved with gaussian based on posited energy resolution)





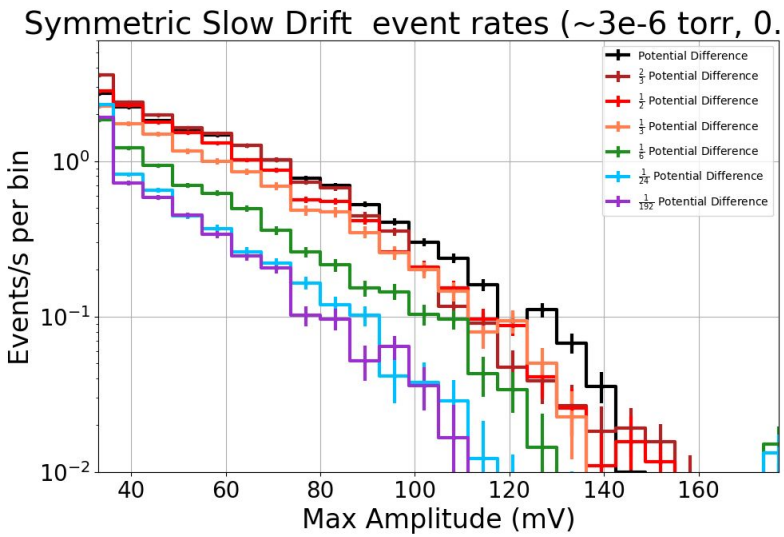


Symmetric Slow Drift Results

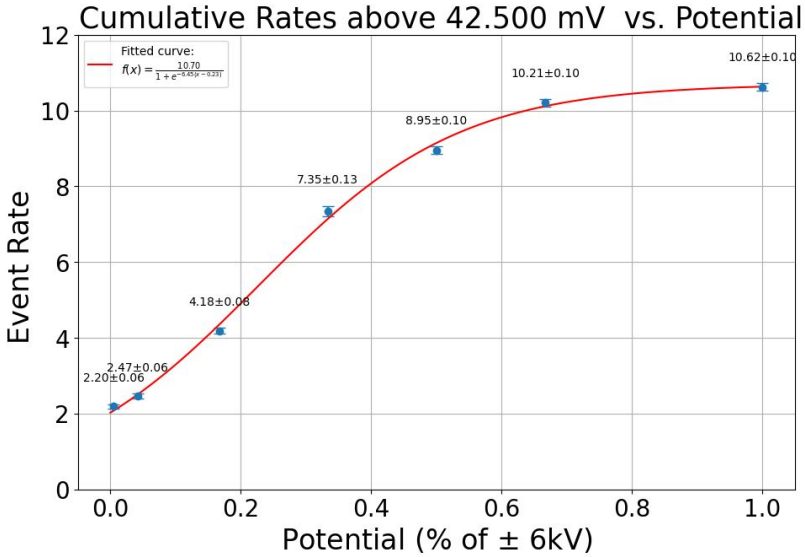


- Reduction in event rate corresponding to potential difference
- Fewer high-energy events as potential difference decreases

Symmetric Slow Drift Results



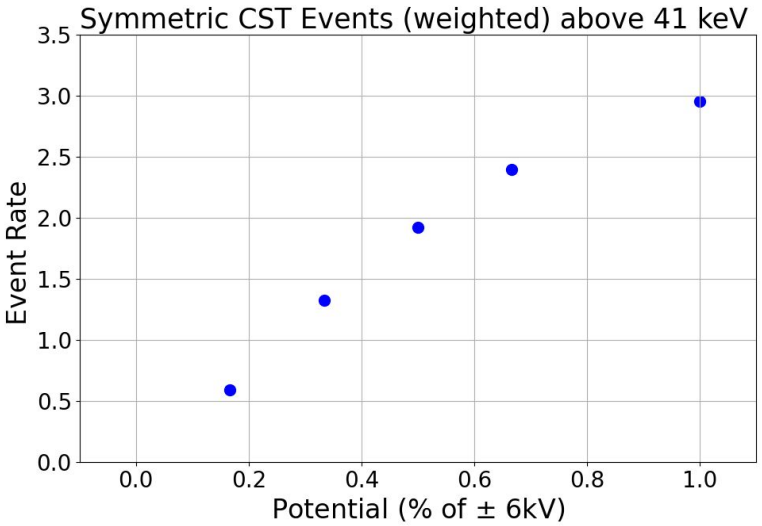
Count event rate above certain threshold

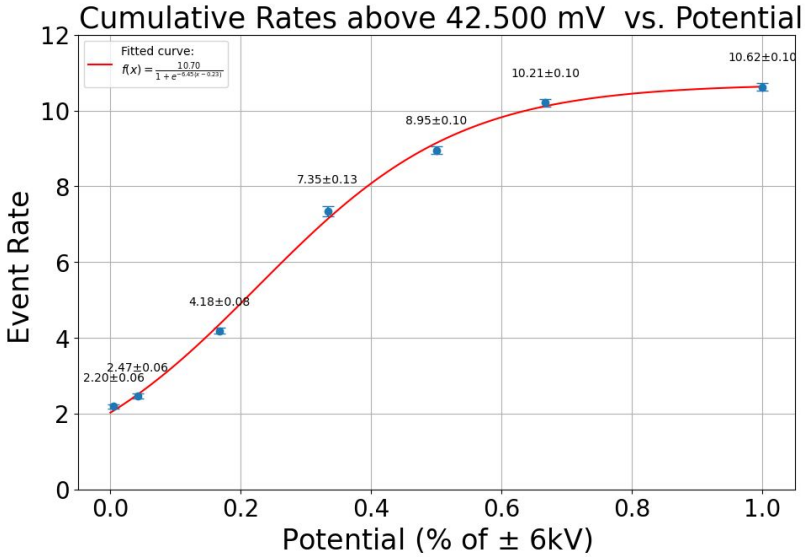


- Reduction in event rate corresponding to potential difference
- Fewer high-energy events as potential difference decreases

- Increases, though rate of change plateaus as potential % -> 1
- Non-zero event rate at 0

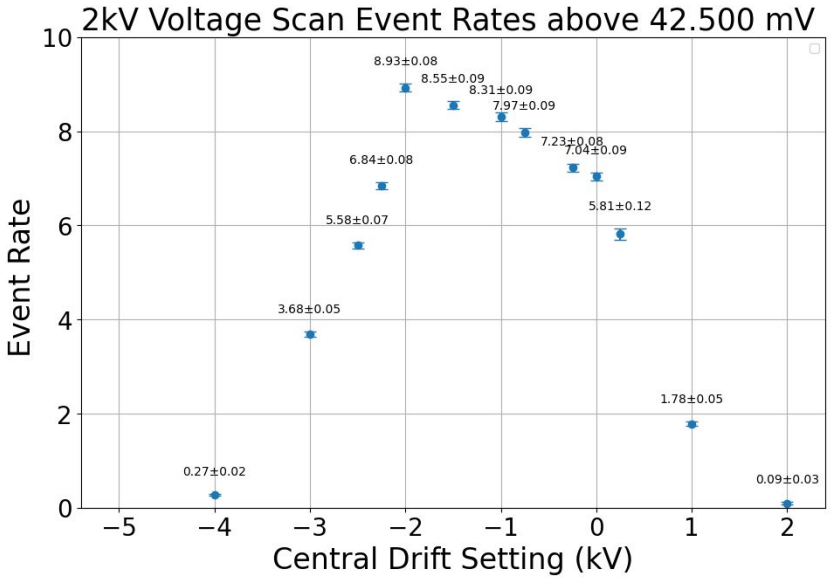
Symmetric Slow Drift Simulation Comparison





- Similar plateauing shape
- Simulations still running to study event rate at 0

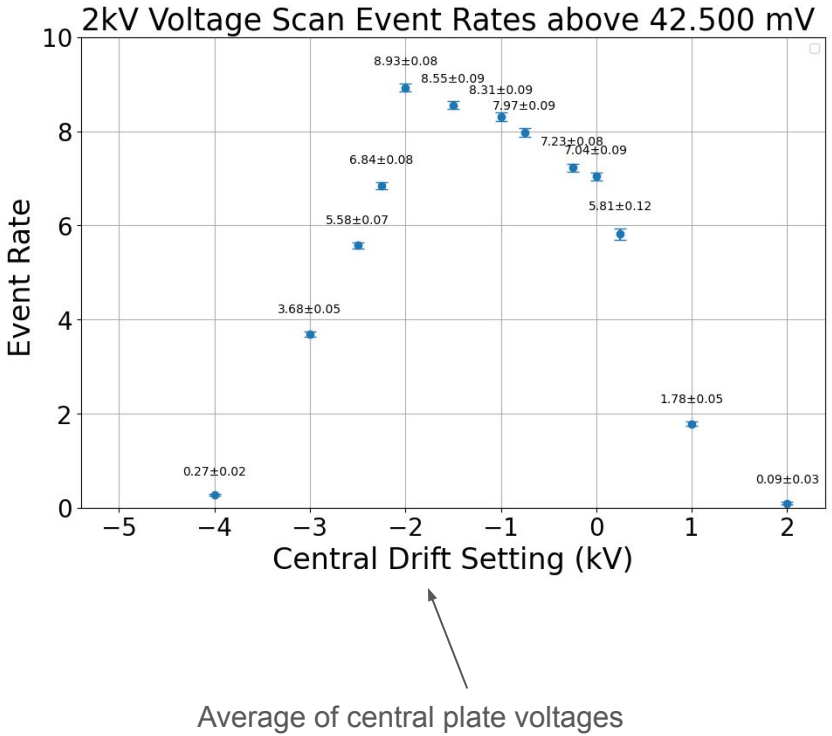
2kV Voltage Scan Results



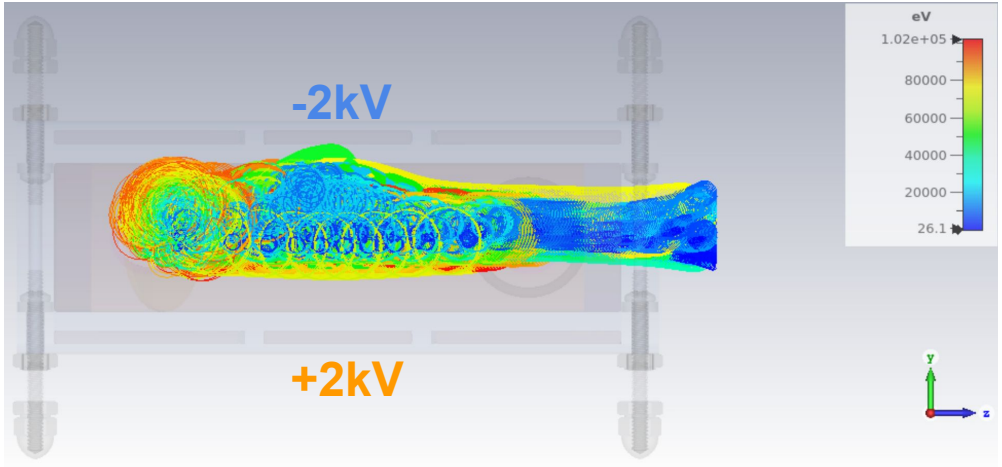
Average of central plate voltages

Asymmetric and ***not*** centered around 0, why?

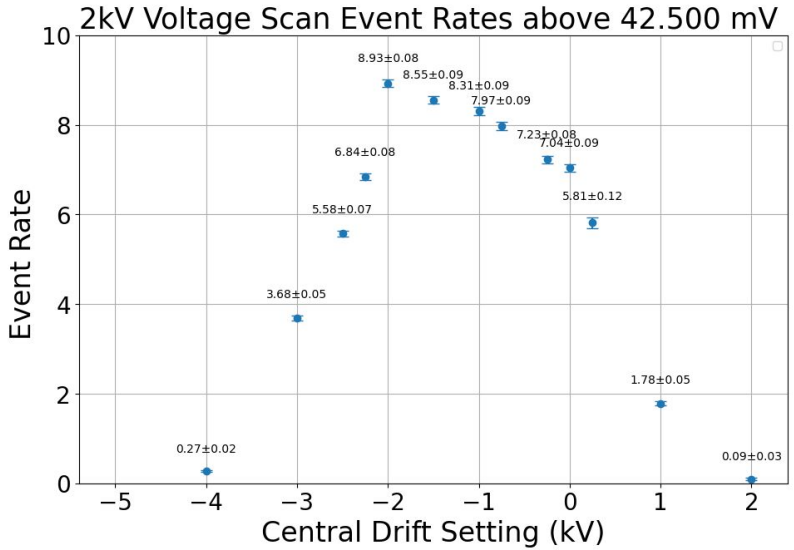
2kV Voltage Scan Results



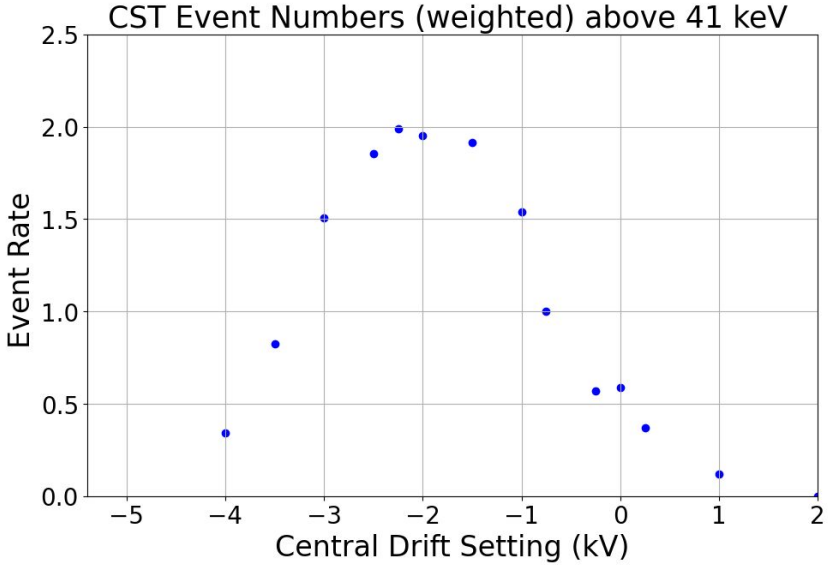
Asymmetric and ***not*** centered around 0 because tilting the source disk favors electrons with cyclotron radii located in the ***upper half*** of the cage



2kV Voltage Scan Simulation Comparison



Resembles shape of data, though horizontally *offset* with a smaller plateau



Next Steps & Outlook

- Run more voltage scan settings
- Develop more rigorous methods to compare data and simulation
- Document findings and draft paper