Determination of effective drift voltage in a new nanodosimetric prototype

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Universität Zürich[UZH]

Content

- FIRE detector
- Effective drift voltage
- Outlook

FIRE Detector

Frequency of Ion REgistration

History

TIDe imaging detector
(**T**rack **I**maging **De**tector)
Developed by Vladimir Bashkirov and Reinhard Schulte at Loma Linda University

2009

2014

Further developed by Margeritha Casiraghi at Loma Linda University, PSI and Gaseous Detector Development Laboratory CERN.

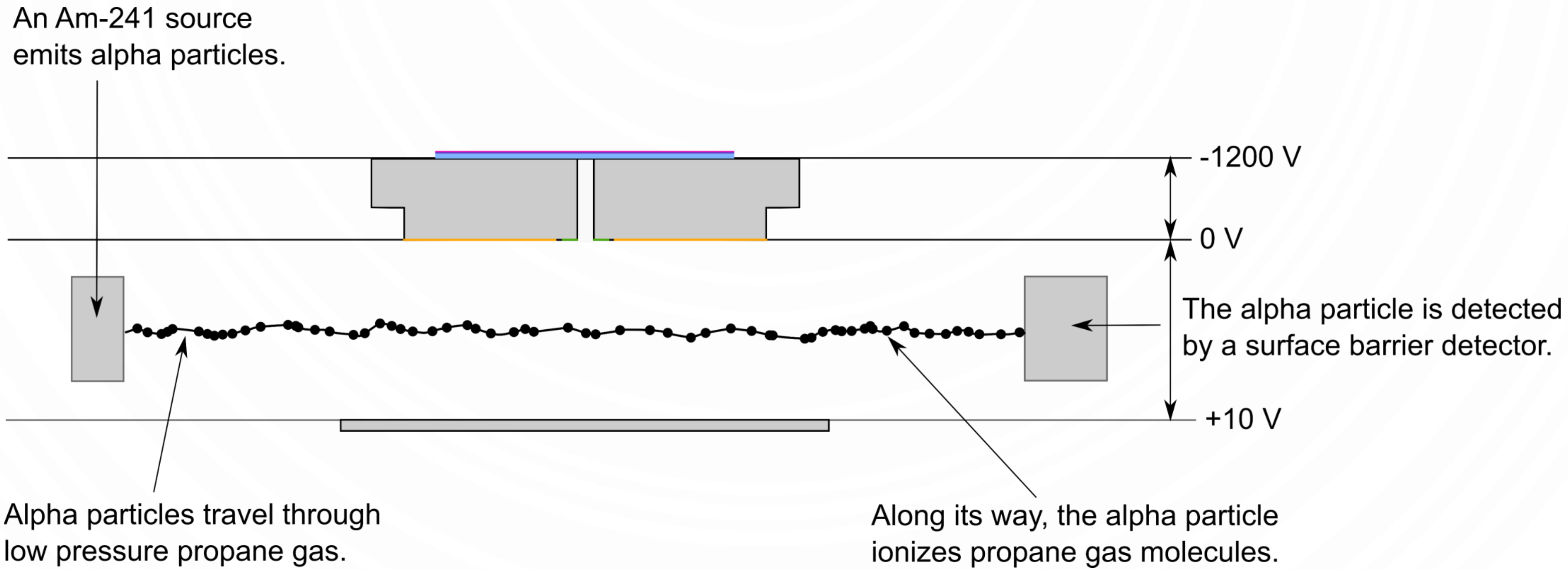
FIRE detector
(**F**requency of **I**on **Re**gistration)
Continued development by Fabiano Vasi during his PhD

2016

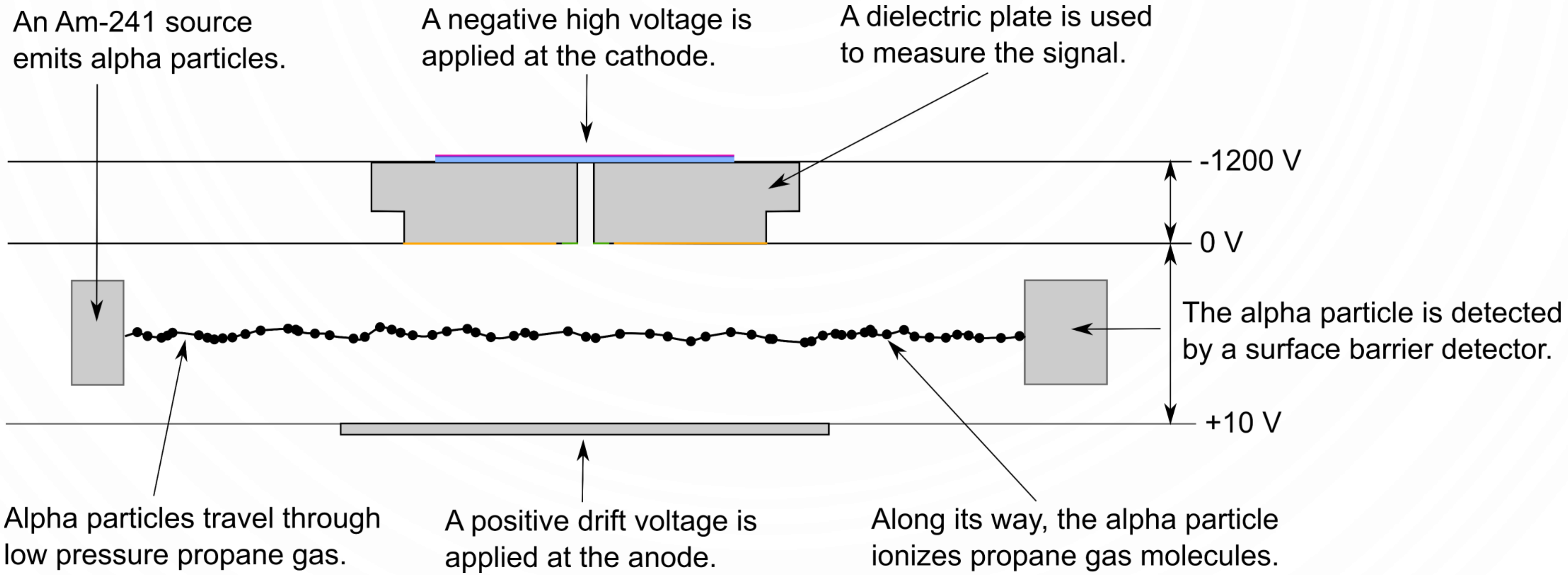
2020

Further development of FIRE detector during PhD of Irina Kempf.

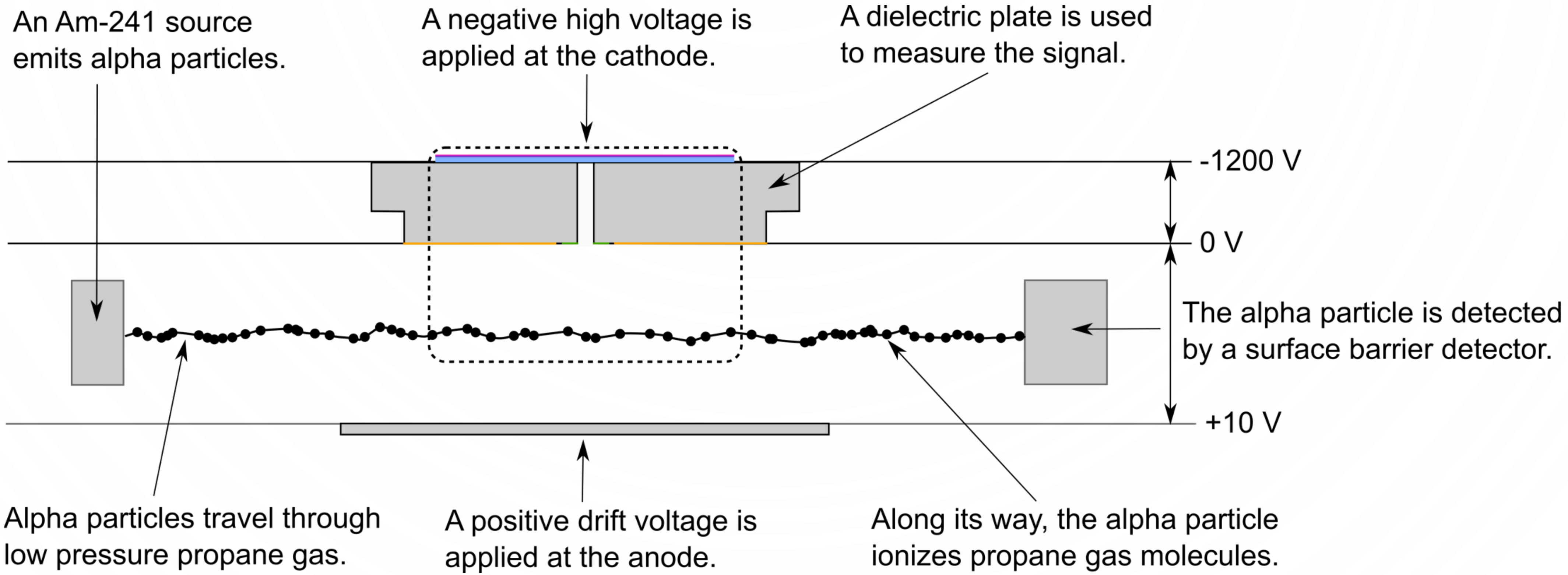
What is inside the detector chamber?



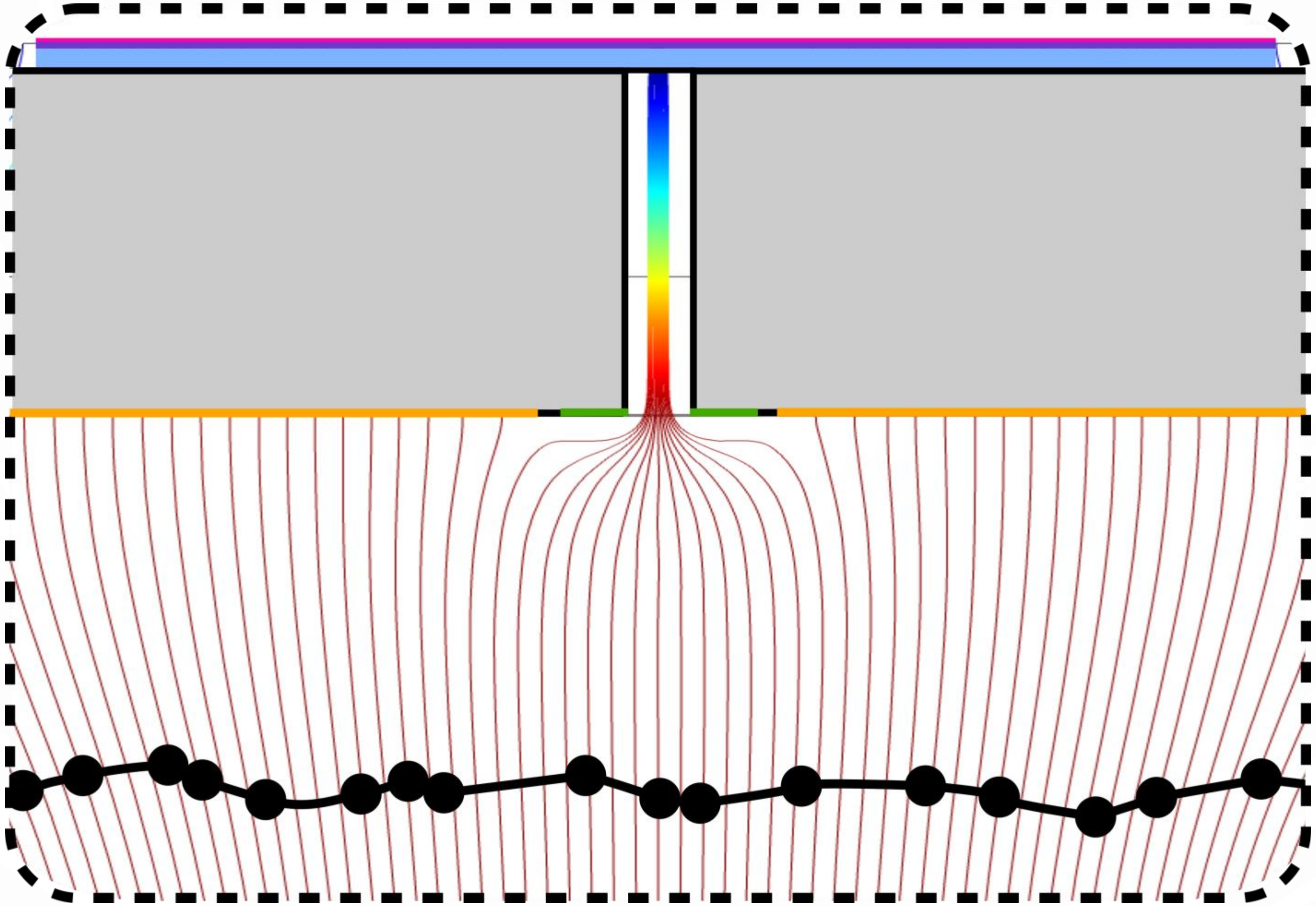
What is inside the detector chamber?



What is inside the detector chamber?



How is the signal produced?



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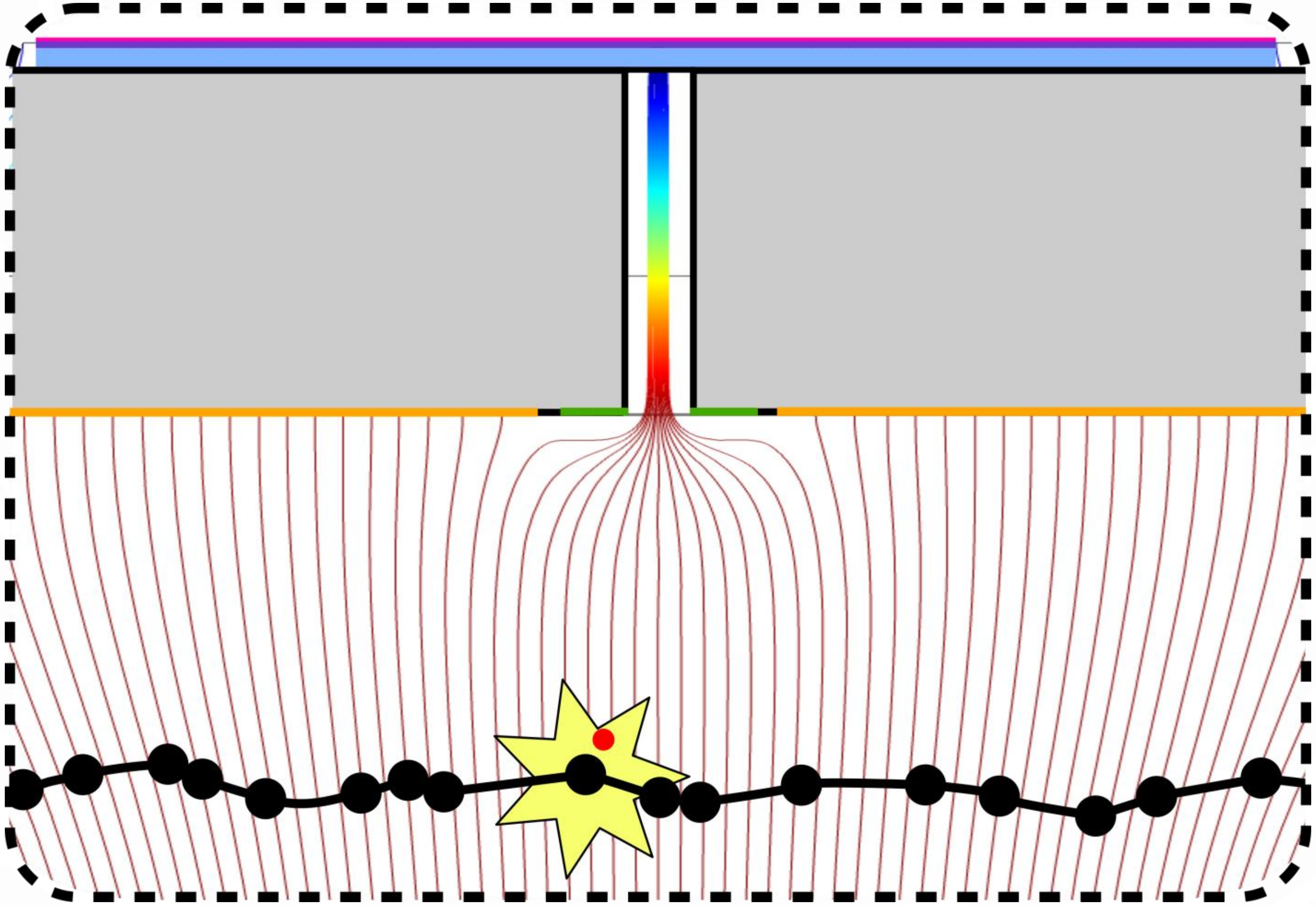

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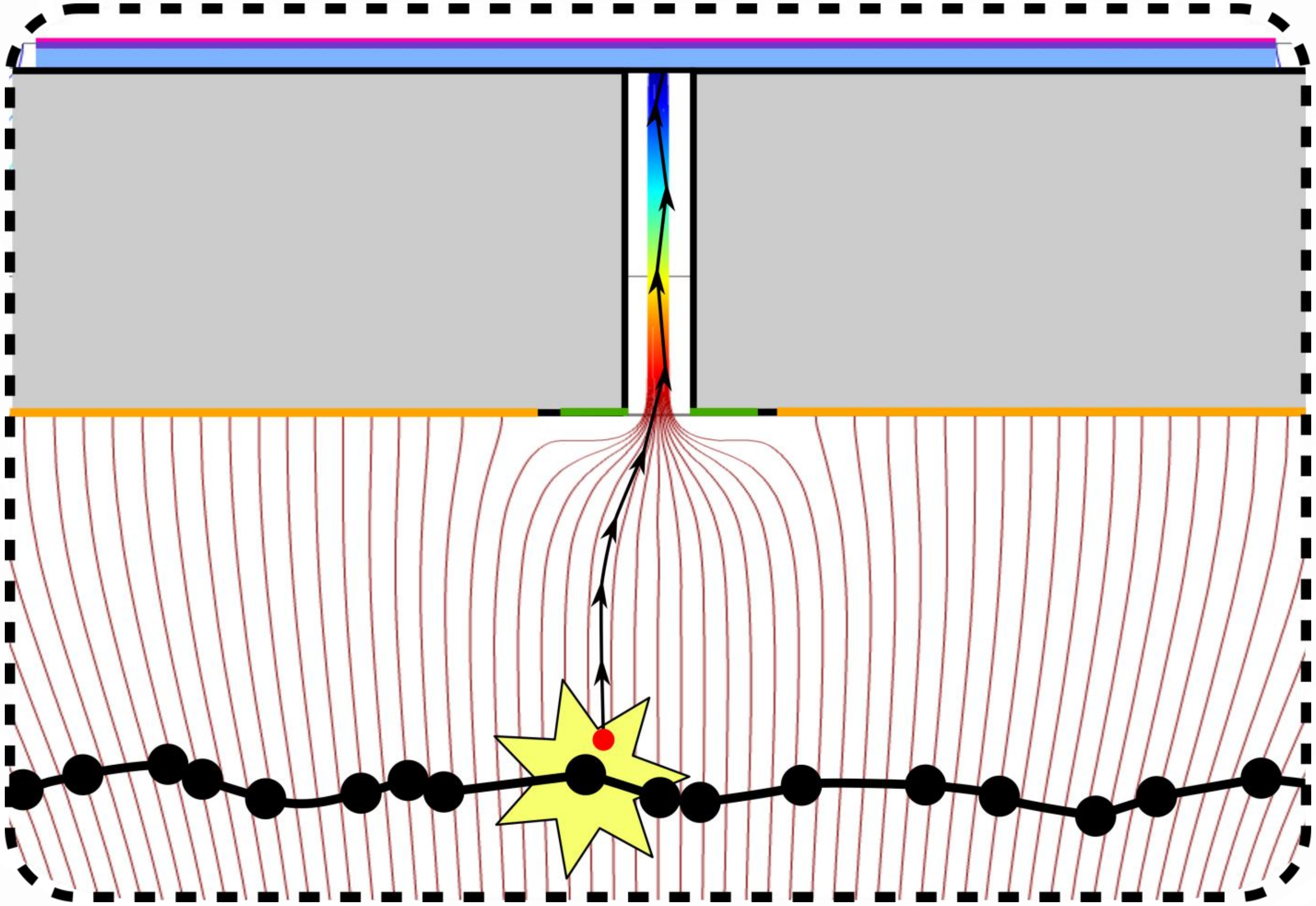

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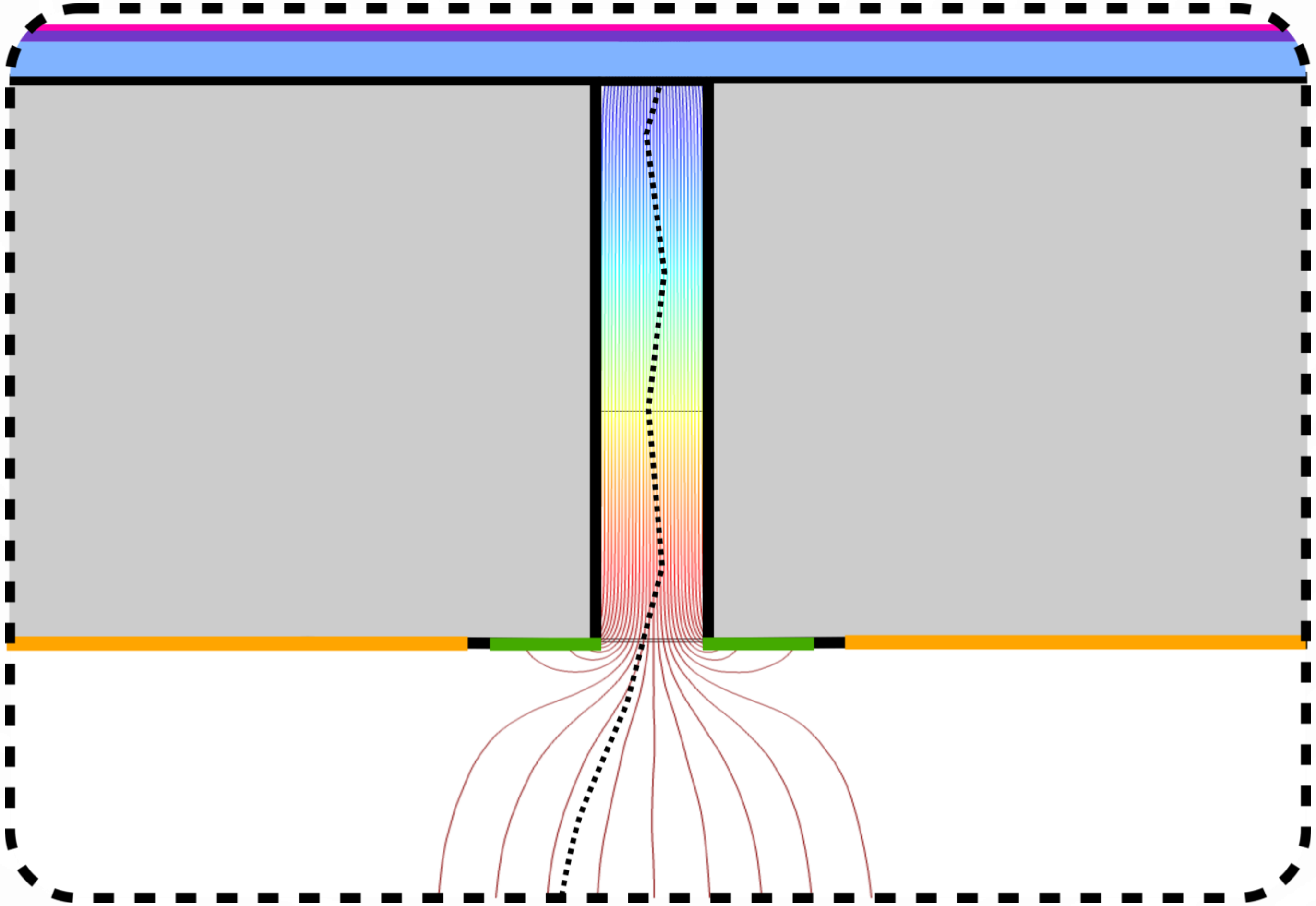

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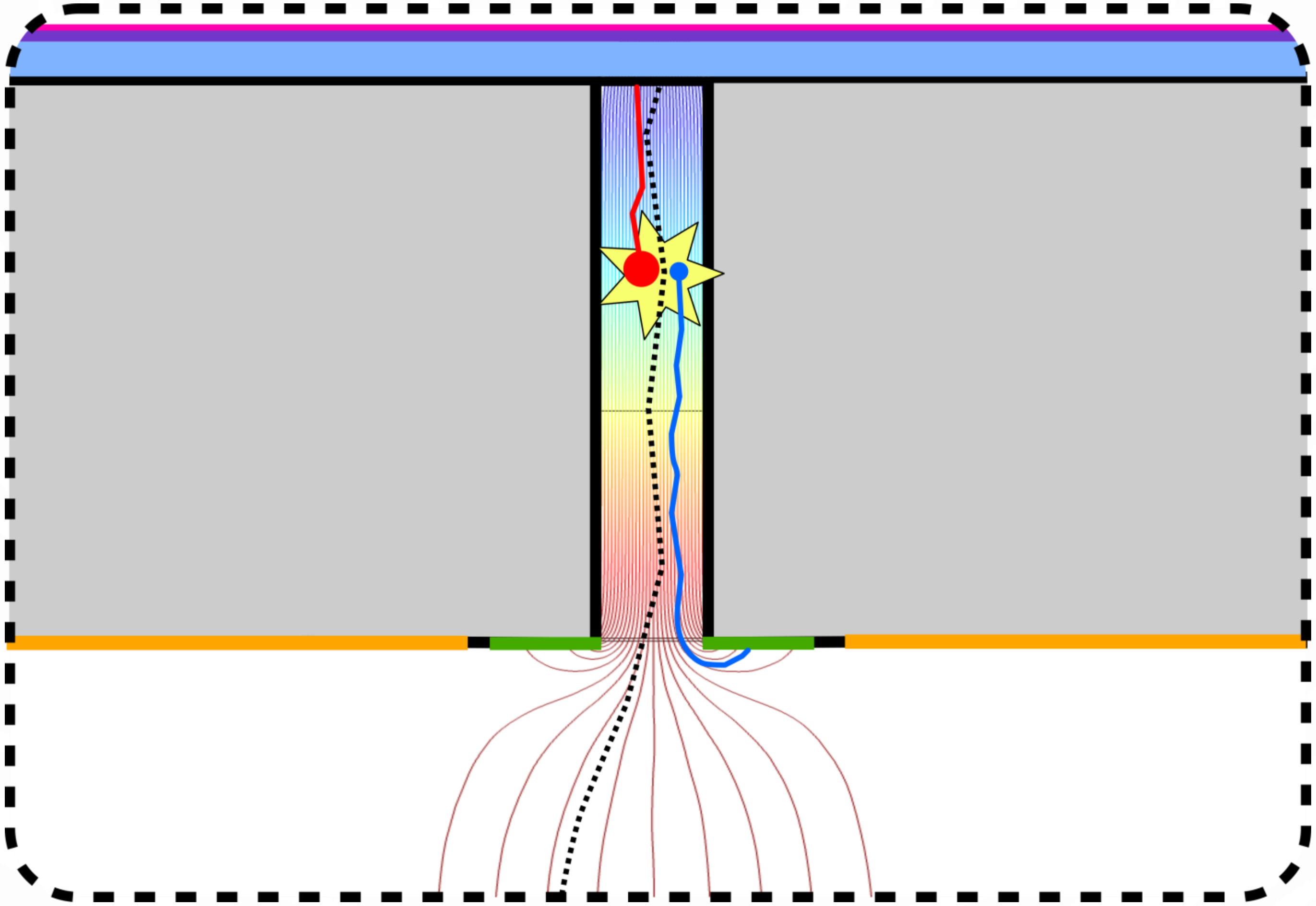
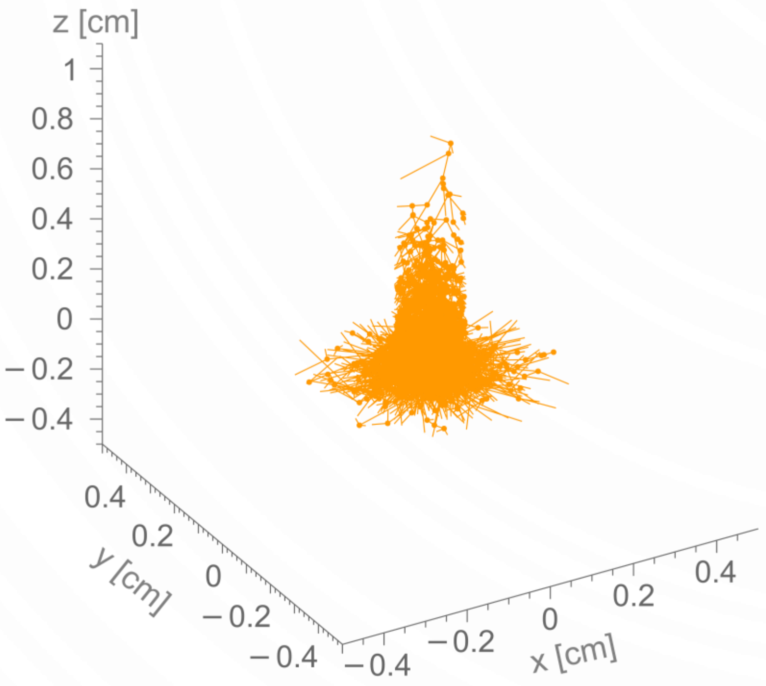
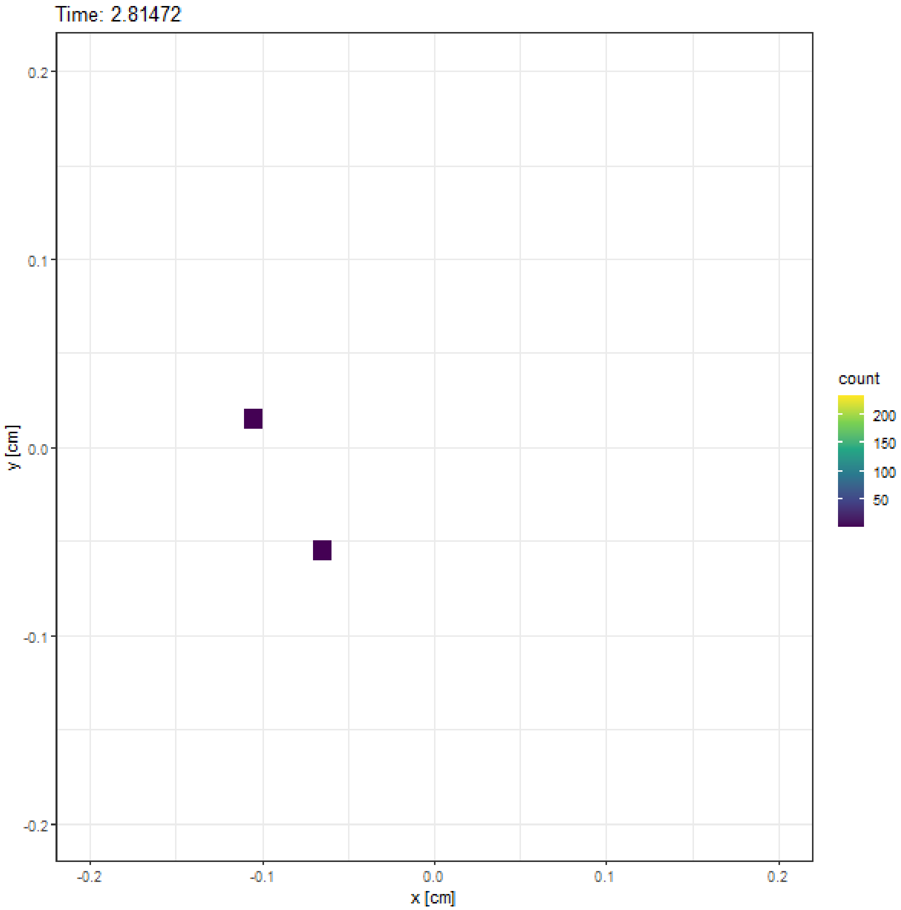


How is the signal produced? Electron Avalanche

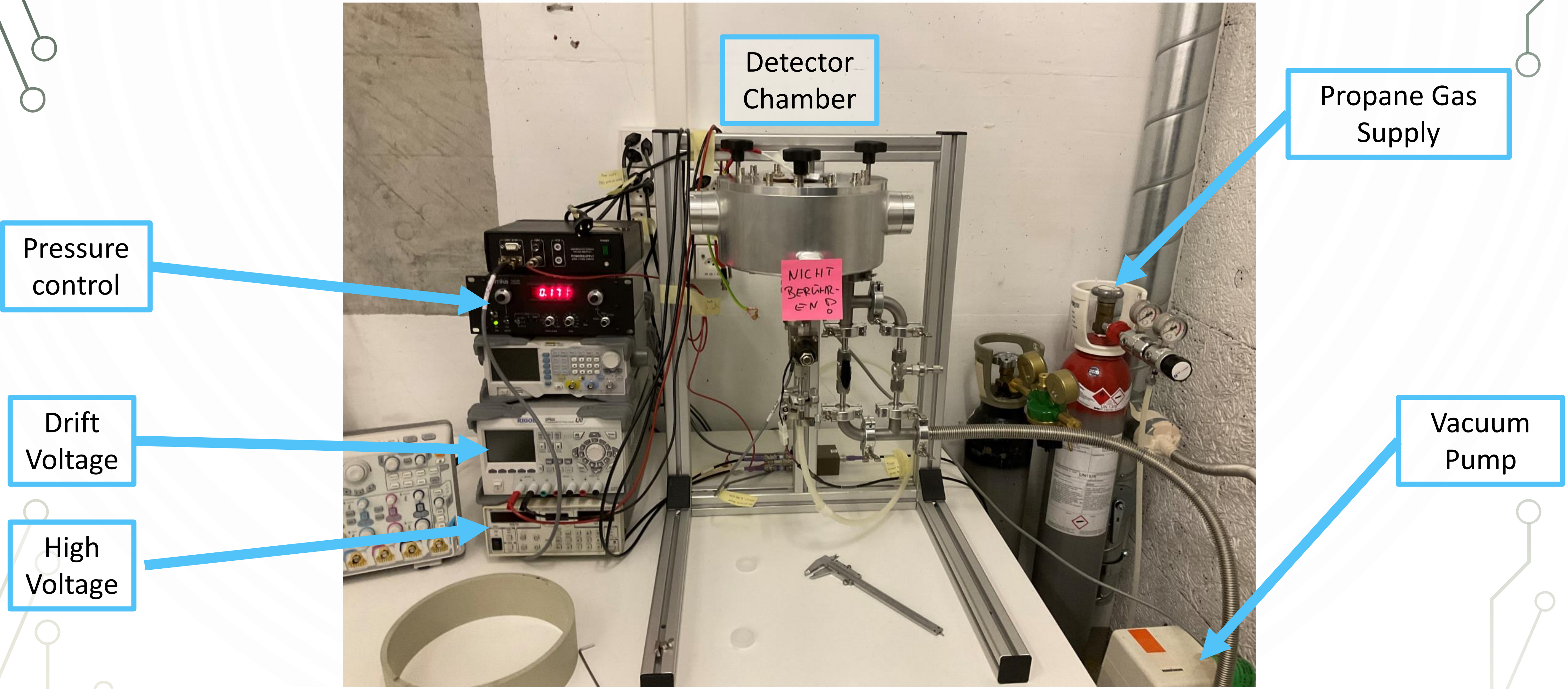


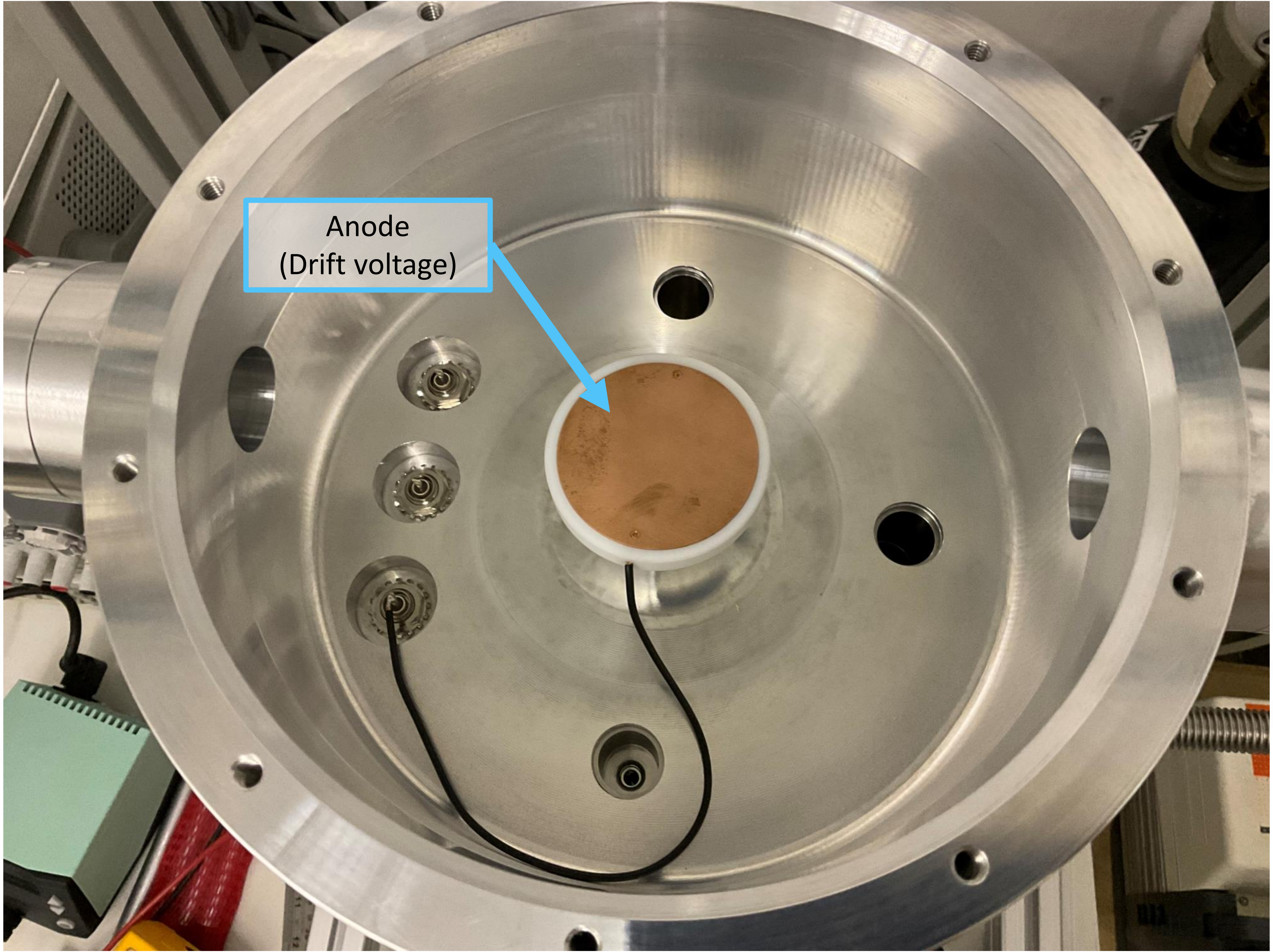
3D view of Monte Carlo simulation of Electron Avalanche

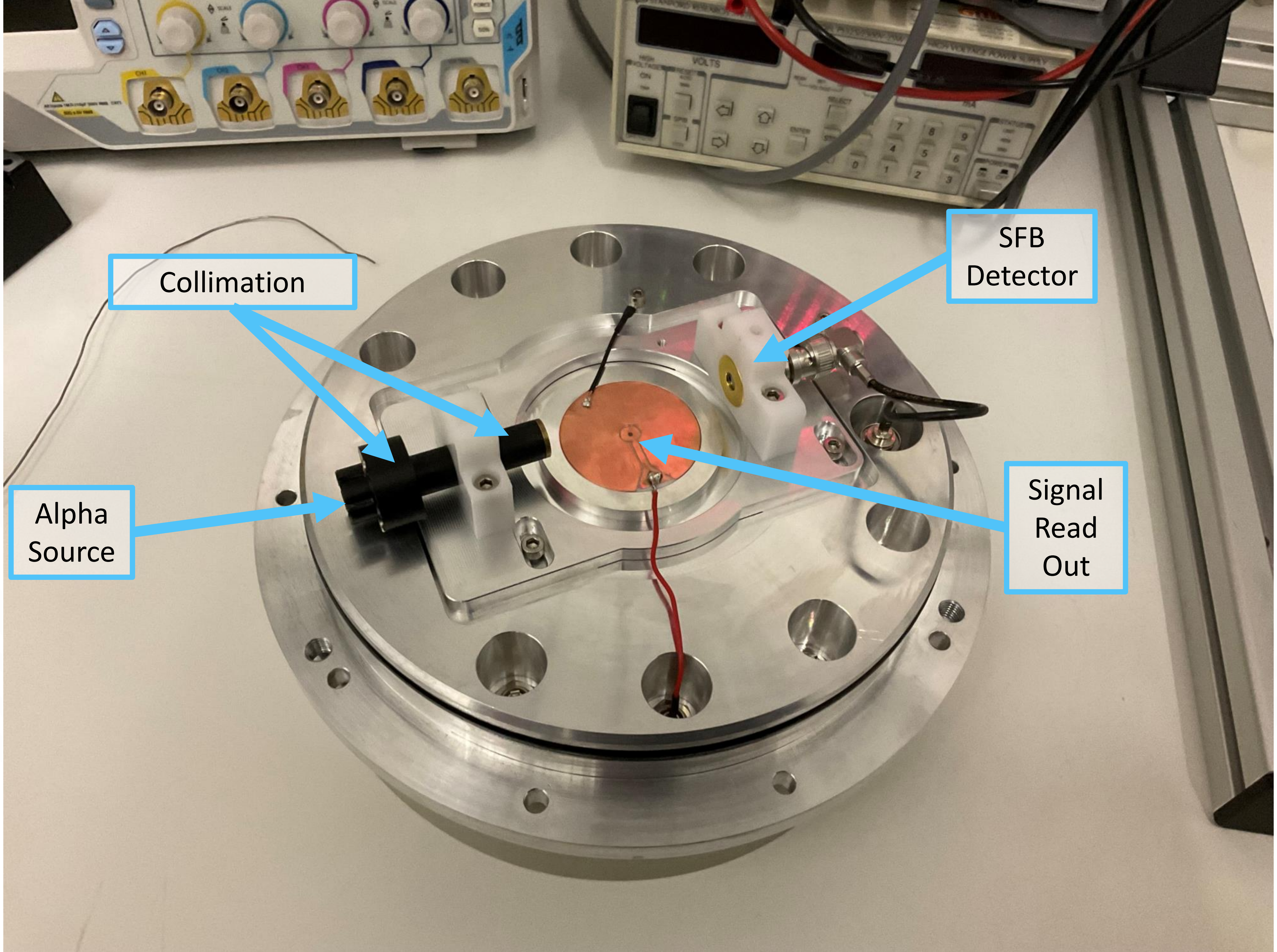


Monte Carlo simulation of electron avalanche arrival at signal read out

Frequency of Ion Registration Detector




Anode
(Drift voltage)

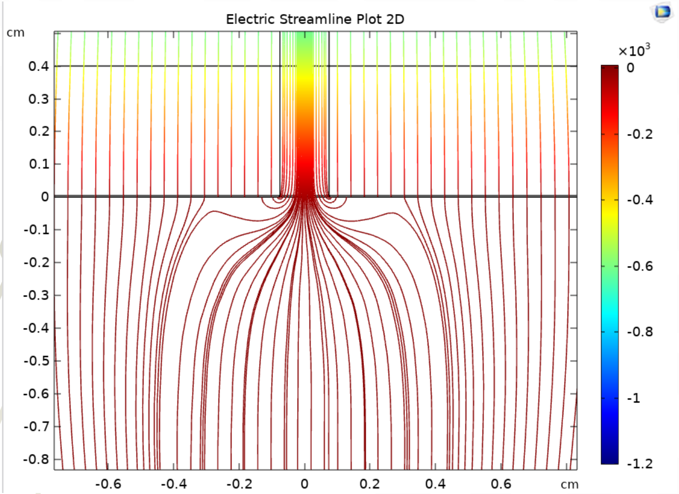

Collimation
SFB Detector
Alpha Source
Signal Read Out

Effective Drift Voltage

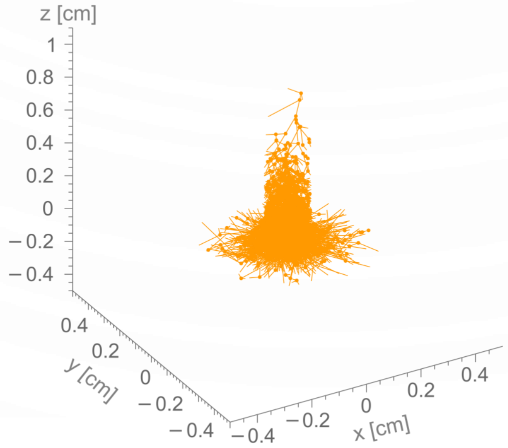
Why do we need to consider effective drift voltage?

- COMSOL Multiphysics
  - → (Electric Field) → In-house Monte Carlo → Ion drift simulations
  - → (Electric Field, Mesh) → Garfield++ (CERN)
    - → Electron avalanche simulations
    - ⇢ Ion drift simulations
  - → Simulation of electrostatic Fields

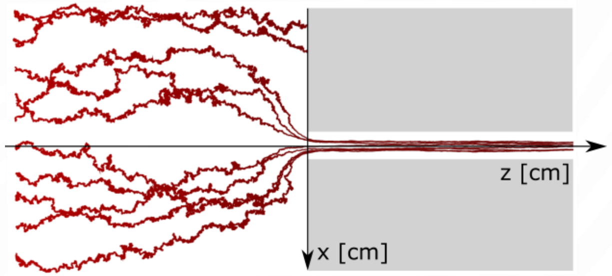
Simulation of electrostatic Fields



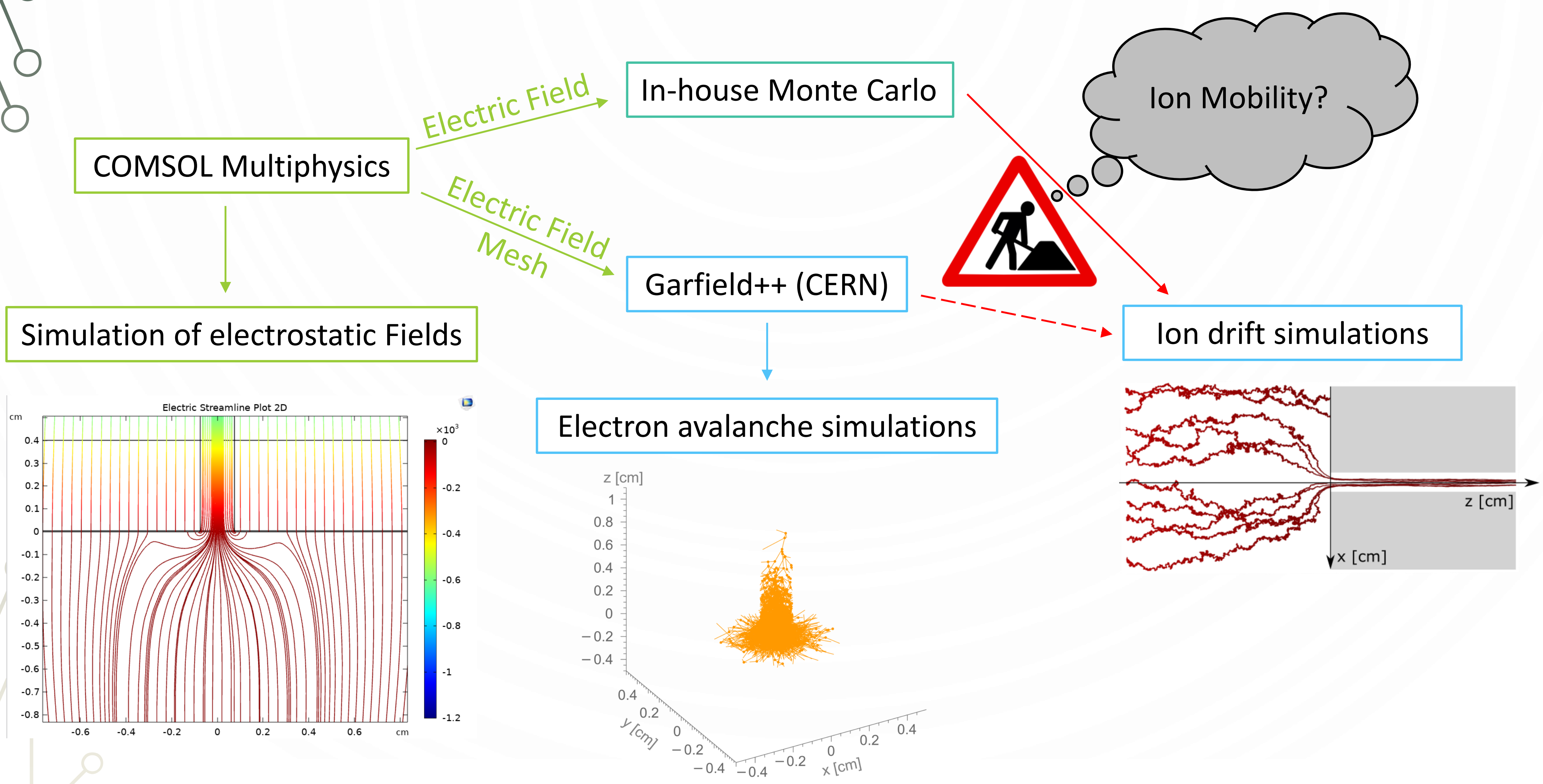
Electron avalanche simulations



Ion drift simulations



Why do we need to consider effective drift voltage?



Ion Mobility – What is our problem?

$$K = \frac{v_{drift}}{E}$$

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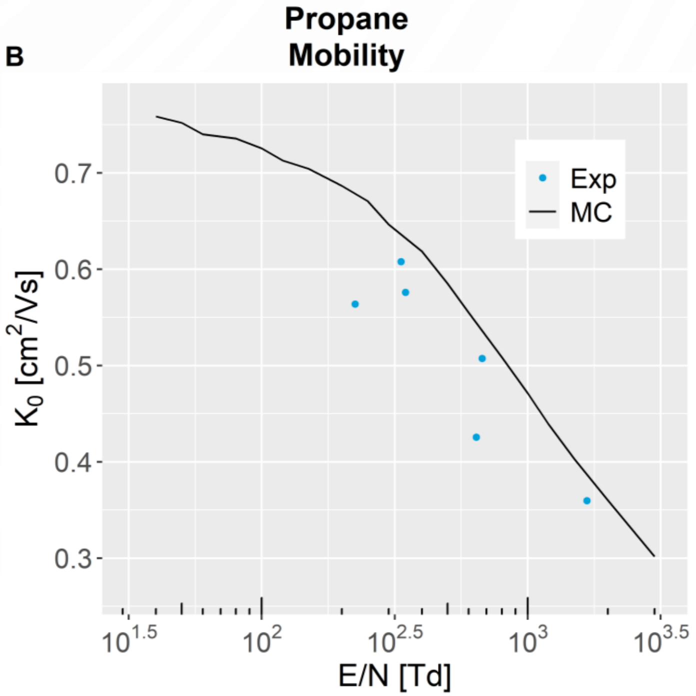
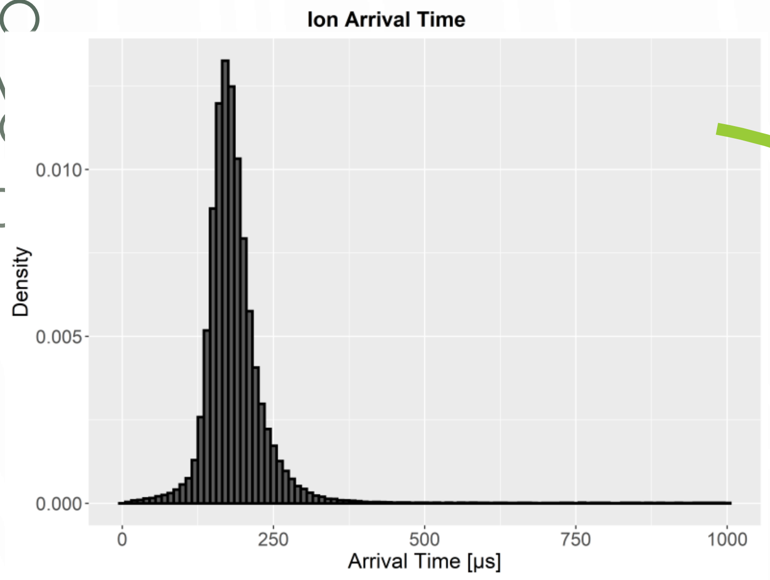
$$K = \frac{v_{drift}}{E}$$

$$K_0 = \frac{p\,[Torr]}{760}\frac{273}{T\,[K]}K$$



Experimental data by Shchemelinin et al. [7]

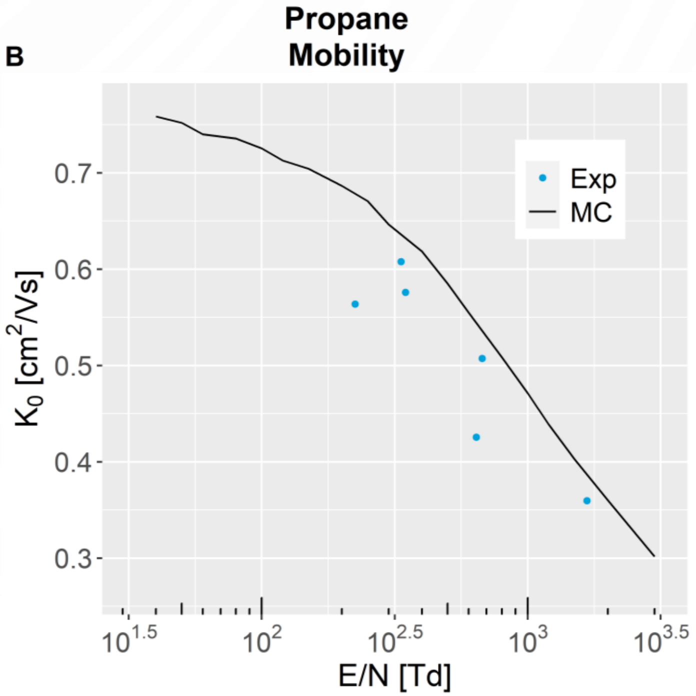
Ion Mobility – What is our problem?



v_{drift}

$$K = \frac{v_{drift}}{E}$$

$$K_0 = \frac{p\,[Torr]}{760}\frac{273}{T\,[K]}K$$



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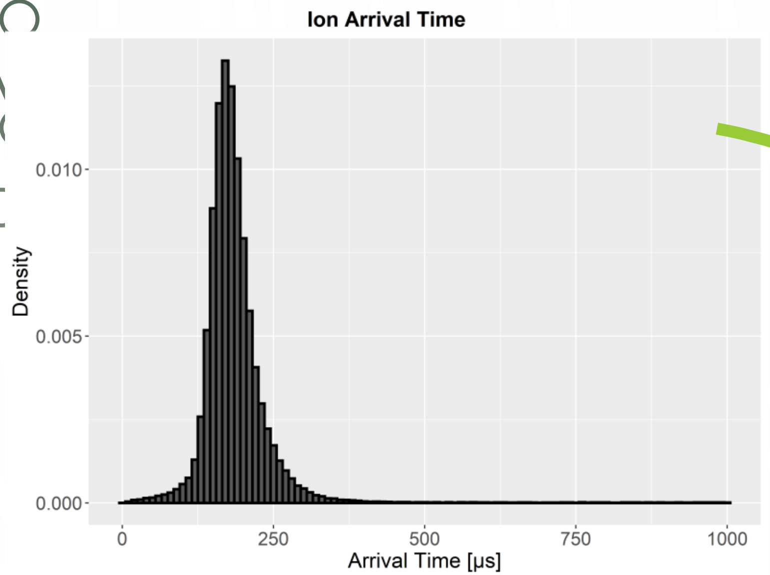
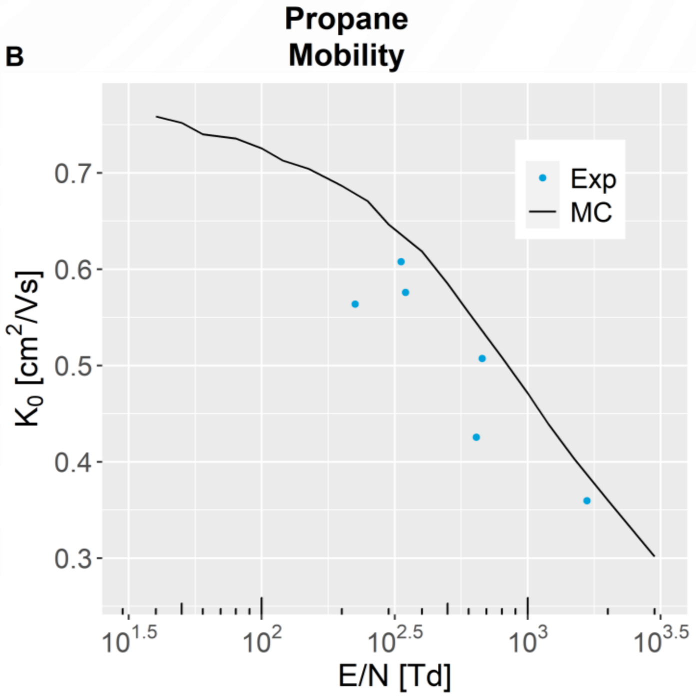


v_{drift}

$$E = \frac{U_{drift}}{d}$$

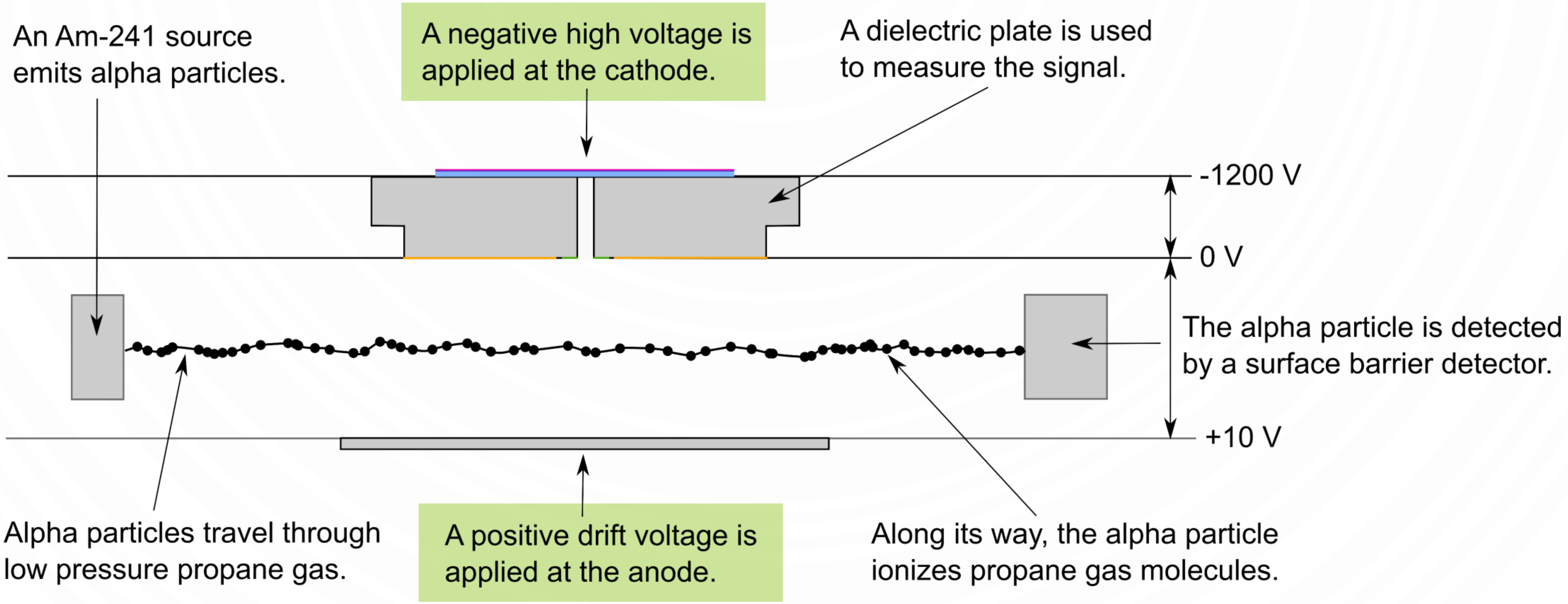
$$K = \frac{v_{drift}}{E}$$

$$K_0 = \frac{p\ [Torr]}{760} \frac{273}{T\ [K]} K$$



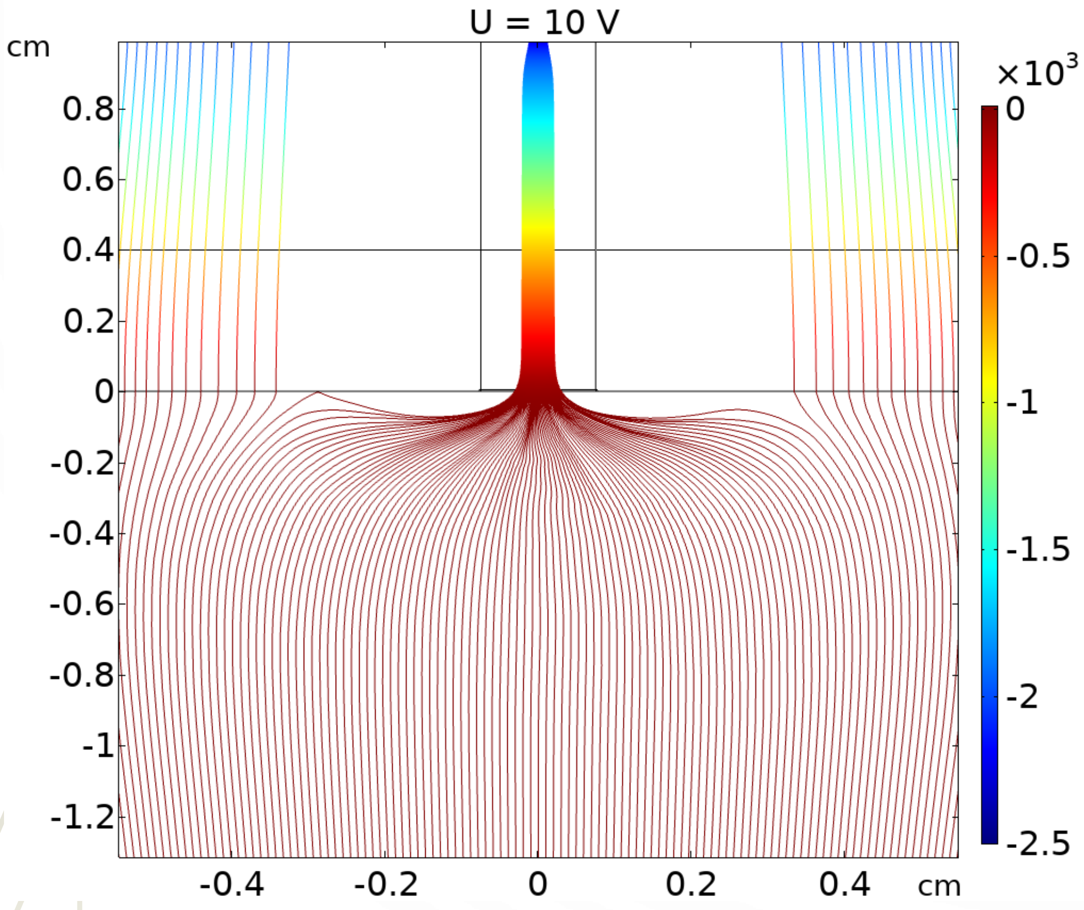
Experimental data by Shchemelinin et al. [7]

Experiment: Drift Voltage

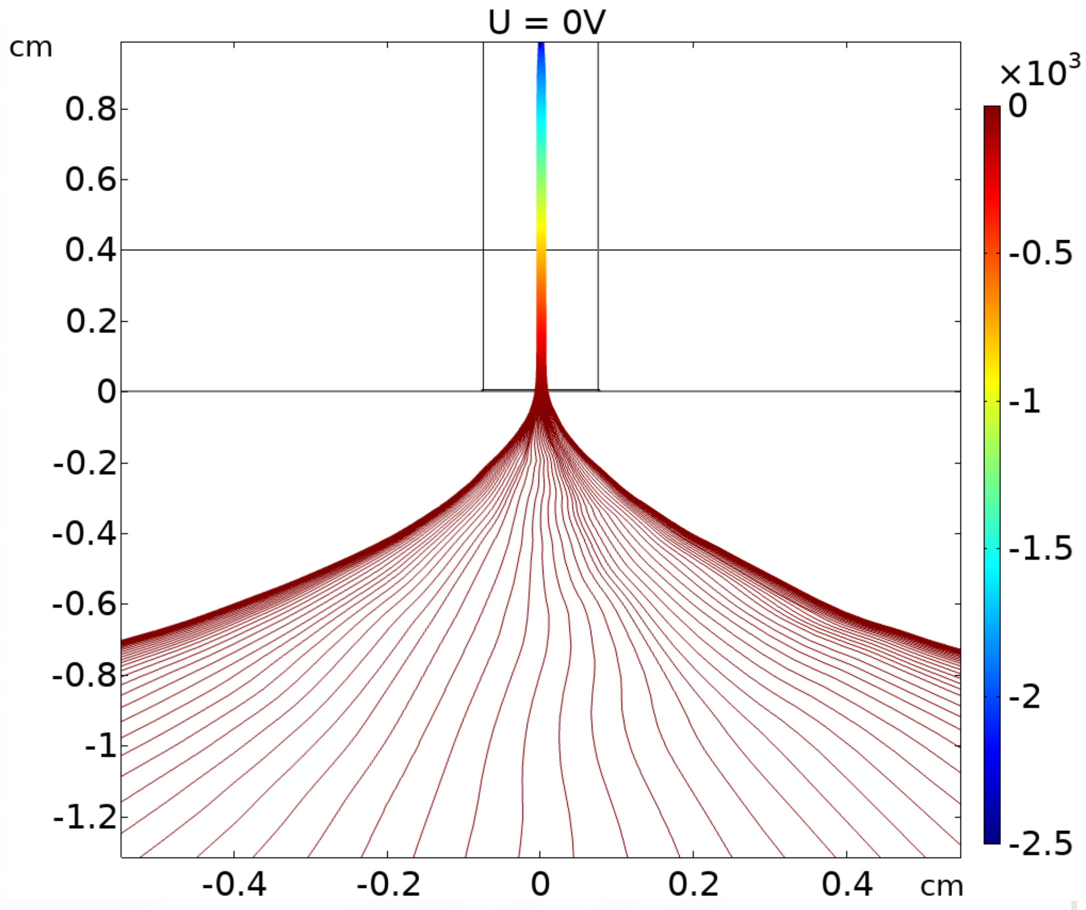


Experiment: Influence of Cathode Voltage

Drift & High Voltage



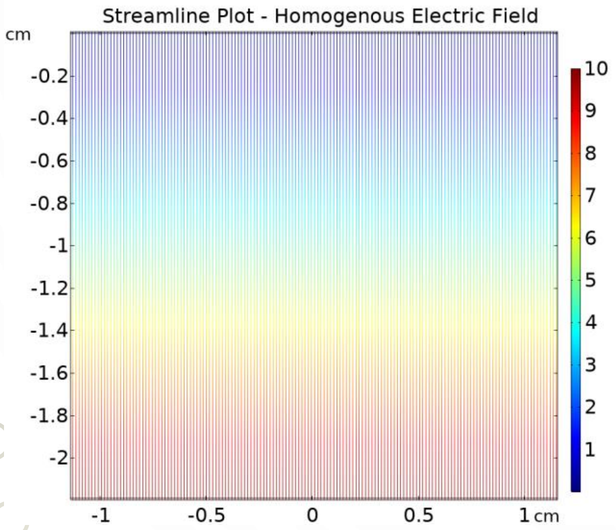
Only High Voltage

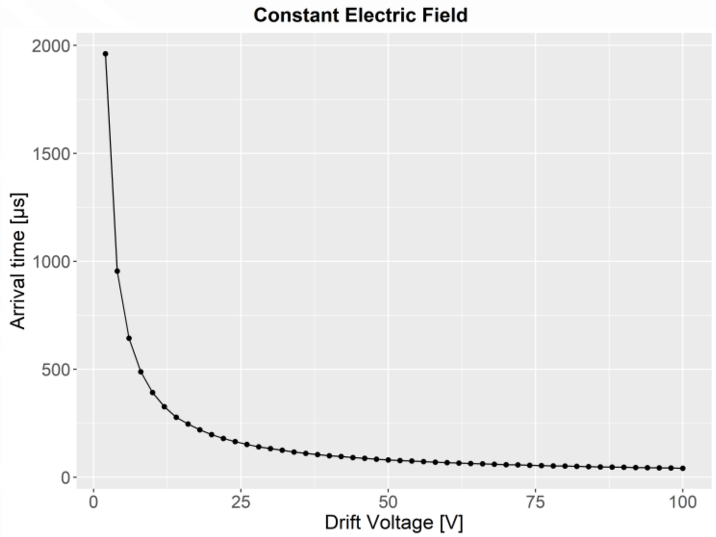


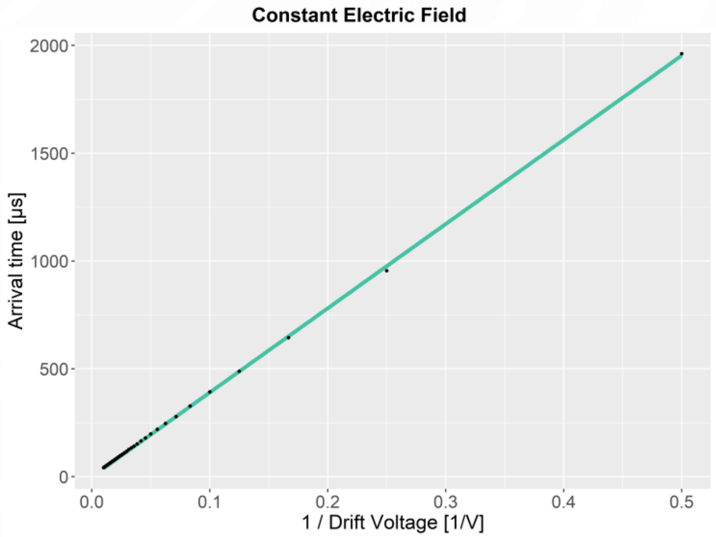
Streamline plots: Electric field strength is not proportional to line density!

Case: Homogenous Electric Field

Homogenous Electric Field → MC Simulation: Ion arrival time → Calculate linear fit



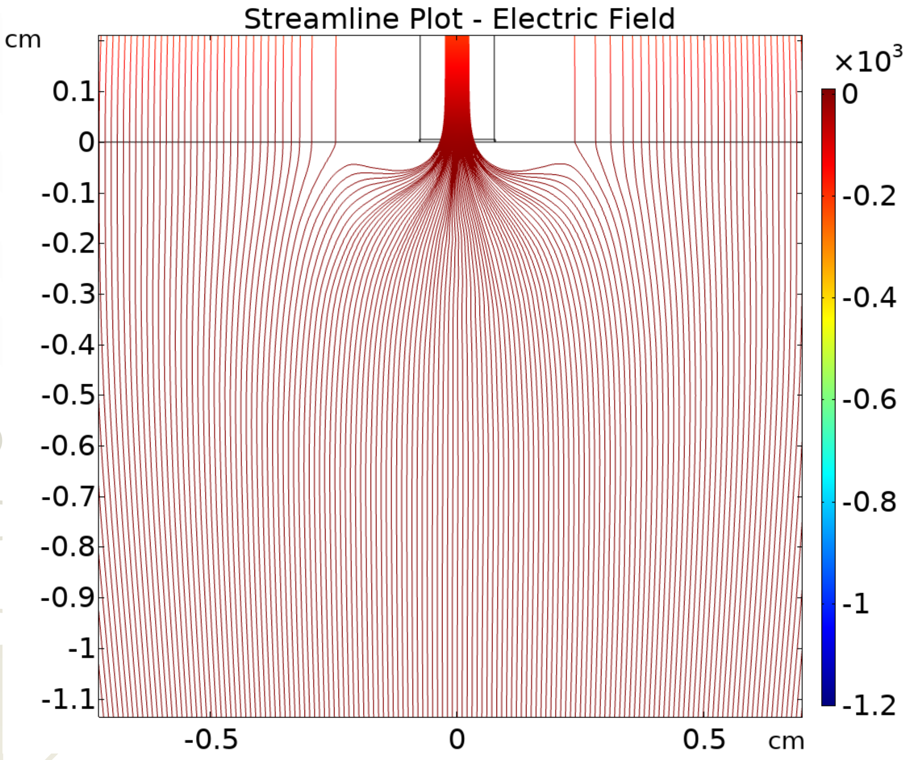




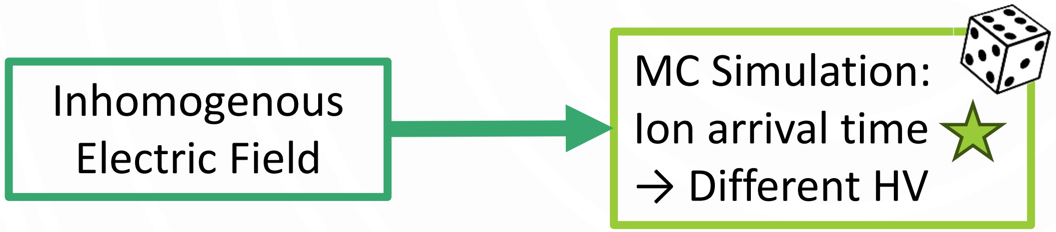
$$t_{Arrival} = a \cdot \frac{1}{U_{drift}}$$

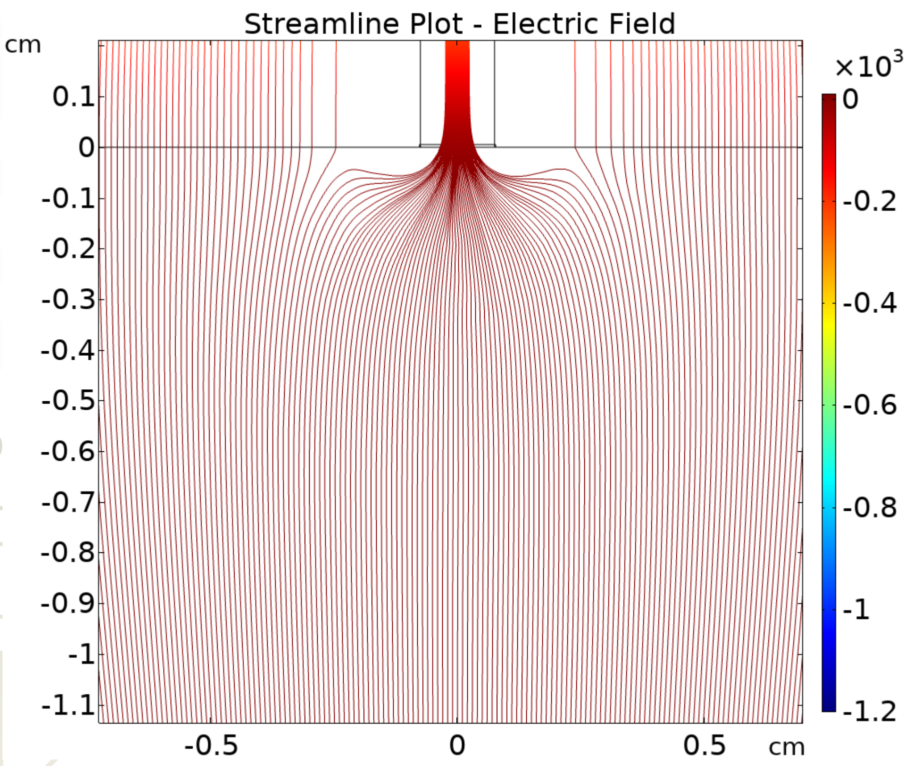
Case: Inhomogenous Electric Field

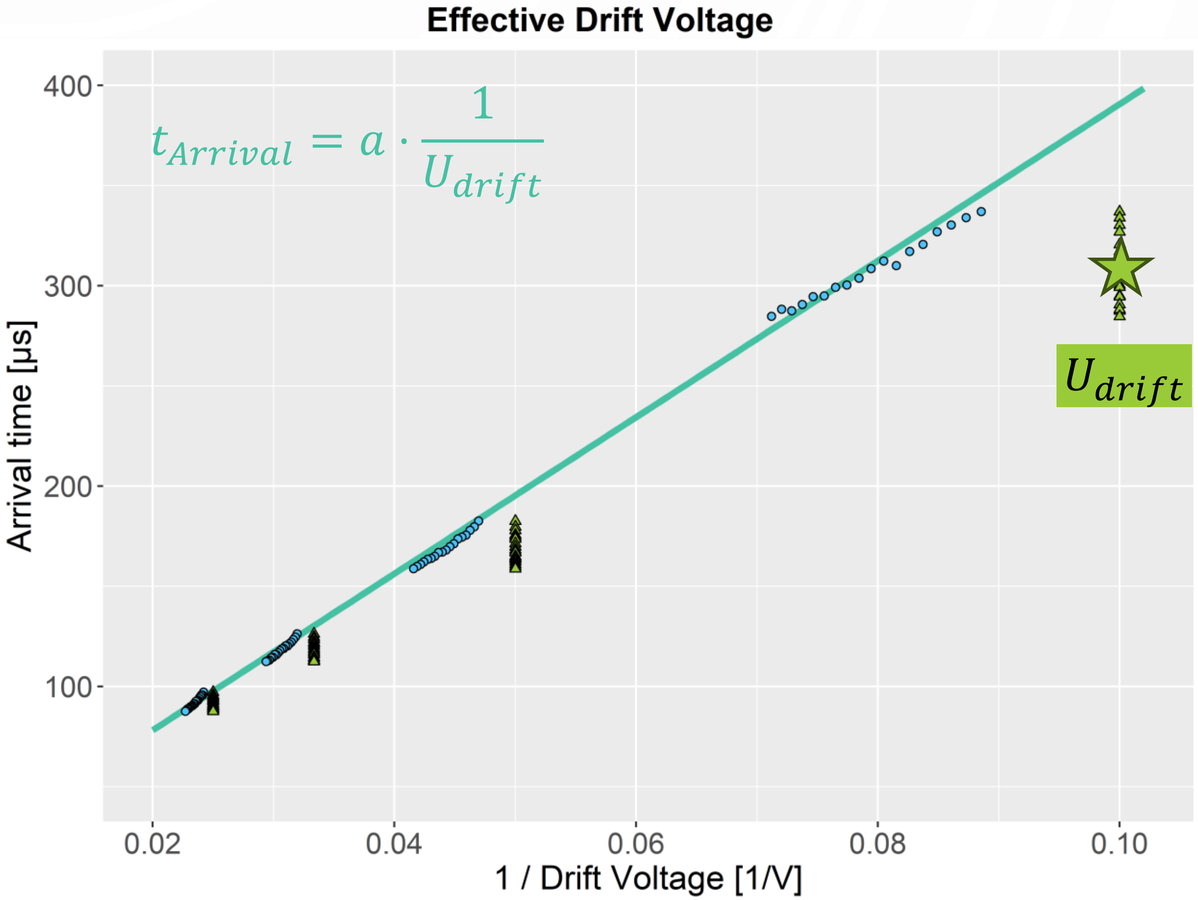
Inhomogenous
Electric Field



Case: Inhomogenous Electric Field

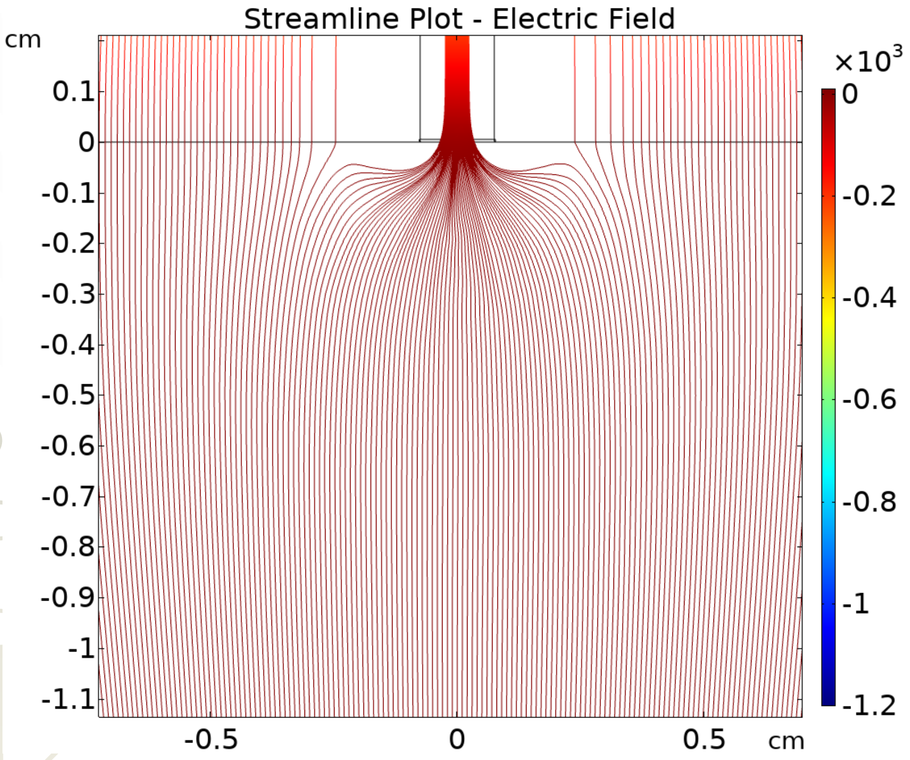


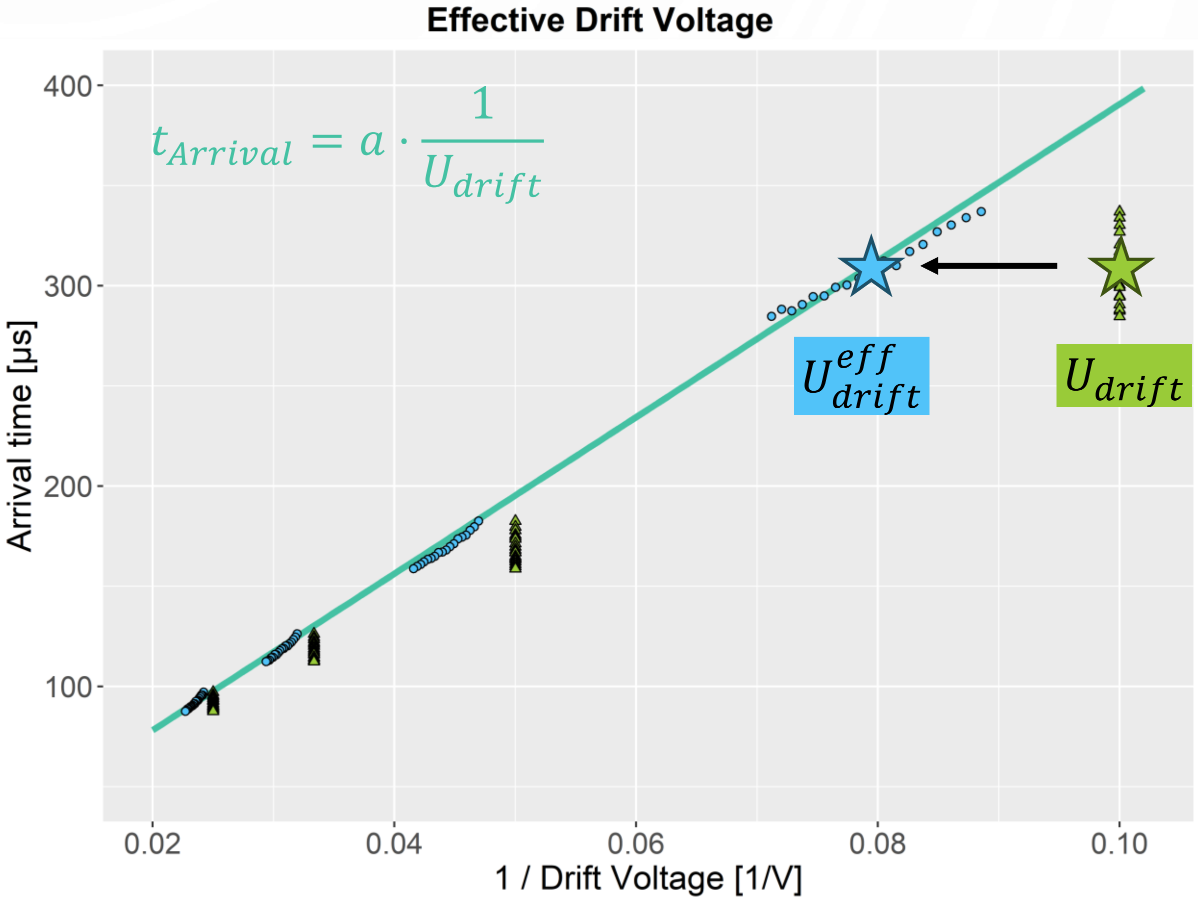




Case: Inhomogenous Electric Field

Inhomogenous Electric Field → MC Simulation: Ion arrival time → Different HV → Match arrival time to homogenous case

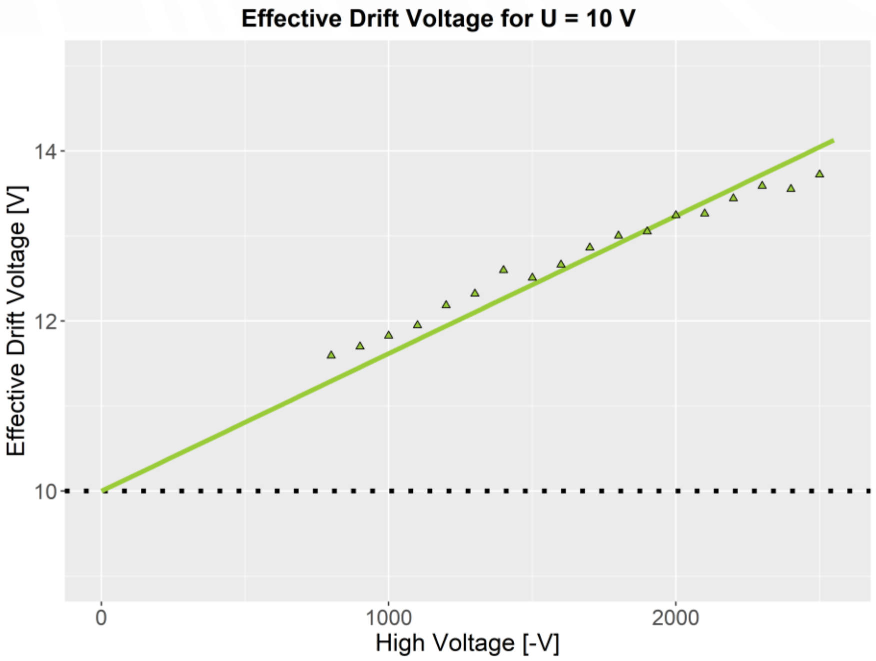




Case: Inhomogenous Electric Field

1) For each drift setting, calculate linear fit:

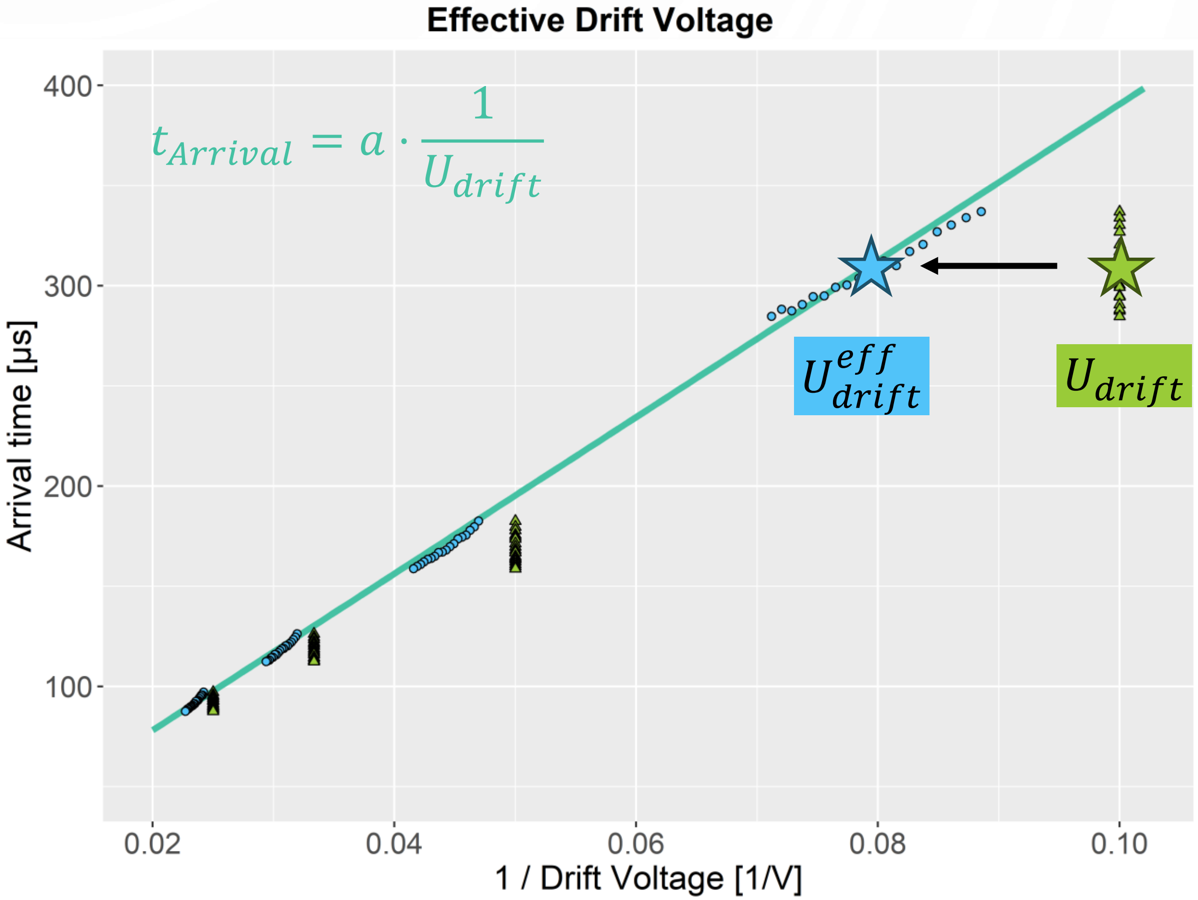
$$U_{drift}^{eff} = U_{drift} + b \cdot HV$$



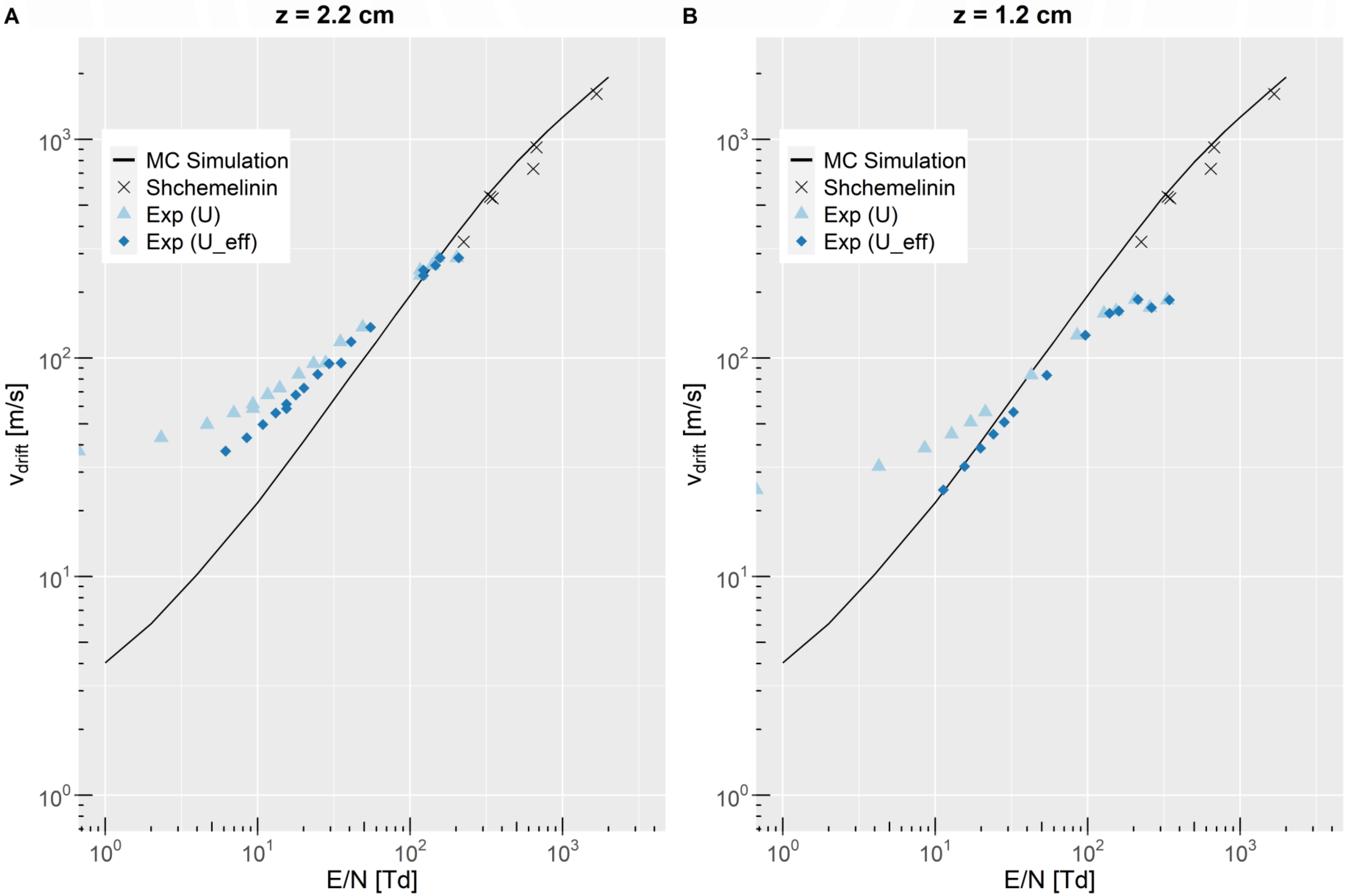
2) Average over different drift settings:

$$b = 0.001618629$$

Match arrival time to homogenous case



Applying Correction Factor to Experimental Data



Outlook

- Measurements with different gases
  - Nitrogen (N_2)

- Ion Mobility
  - Propane (C_3H_8)

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Thank you for your attention!

Universität Zürich[UZH]

Contact information & Sources

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