

Garfield++ Simulations of Readout Chamber Gains

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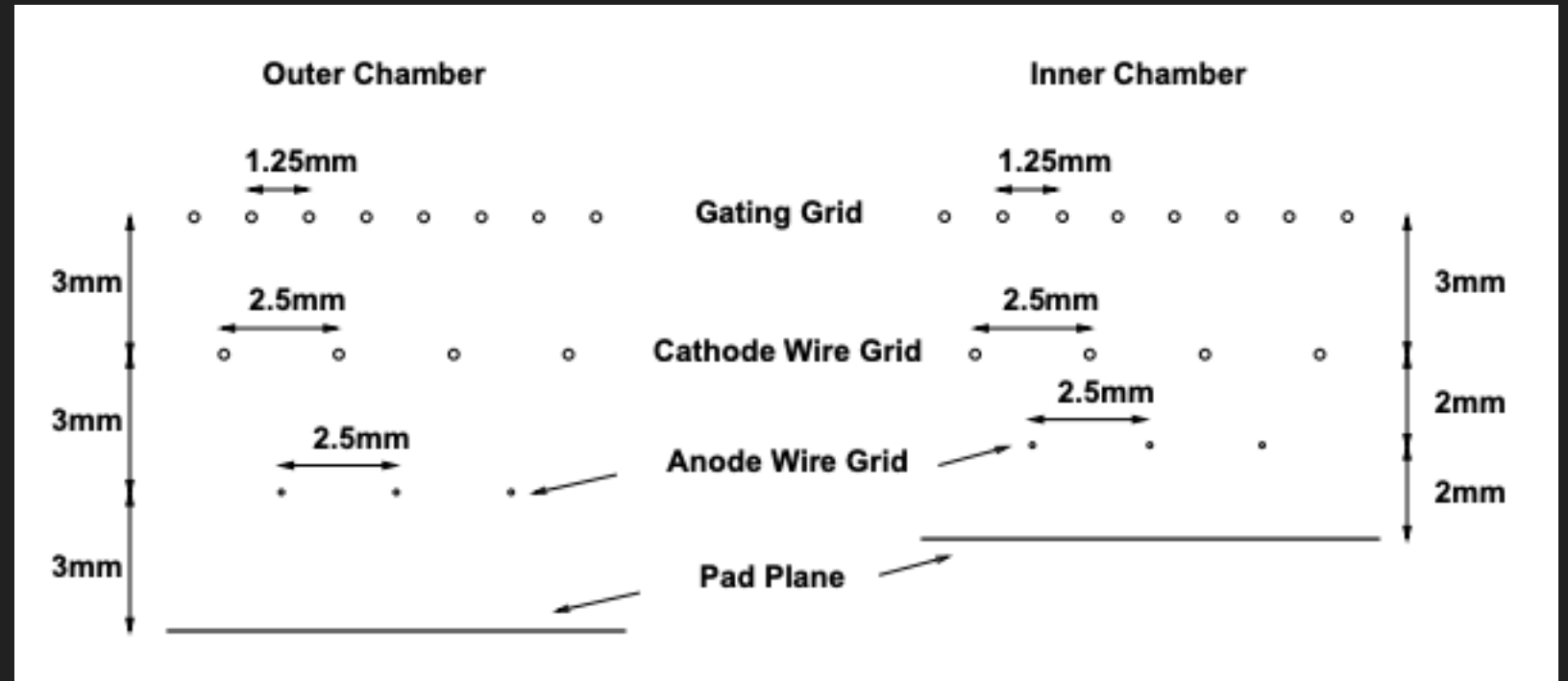
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Background

- Repurposing ALICE TPC
 - New gas mixture (Uncertain)
 - Higher pressure
 - Readout electronics
- ALICE TPC configuration
 - Drift chamber
 - Gating grid
 - Cathode wires
 - Anode wires
 - Pad plane

Background

- OROC
 - Anode: 1570V
- IROC
 - Anode: 1460V



From ALICE Technical Design Report page 45

Introduction

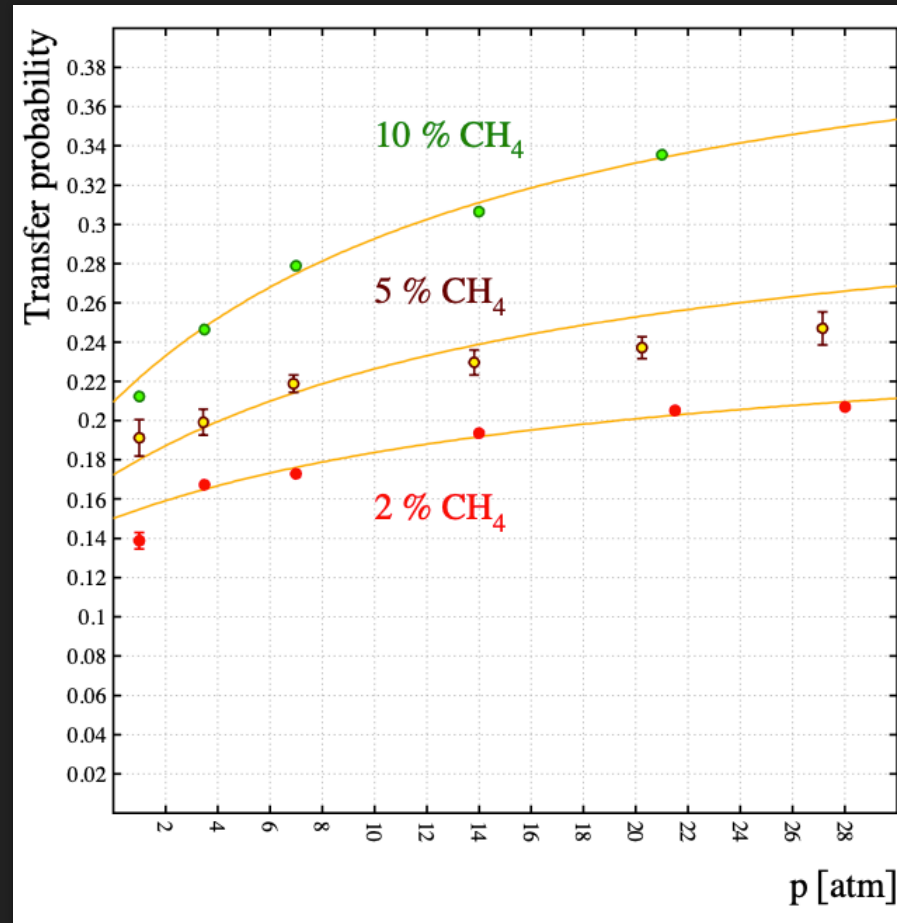
- Garfield++
 - ALICE TPC example (Ne & CO₂)
 - DriftLineRKF (Runge-Kutta-Fehlberg)
 - MagBoltz integration
- MagBoltz
 - Interface with Garfield
 - Townsend coefficients
 - Penning transfers

Penning Transfers

- Effect of mixing different gases
- Happens when an excited gas particle ionizes a gas with a lower ionization energy
- Argon in excited state ionizes methane in P10
- Depends on transfer probability coefficient (varies in different mixtures and pressures)
- Can cause upwards of an order of magnitude difference in gain
- Can be simulated in MagBoltz and Garfield
- Garfield's implementation does not match expected results (we use MagBoltz)
- MagBoltz must be slightly modified to change the transfer coefficient

Penning Transfer Probability

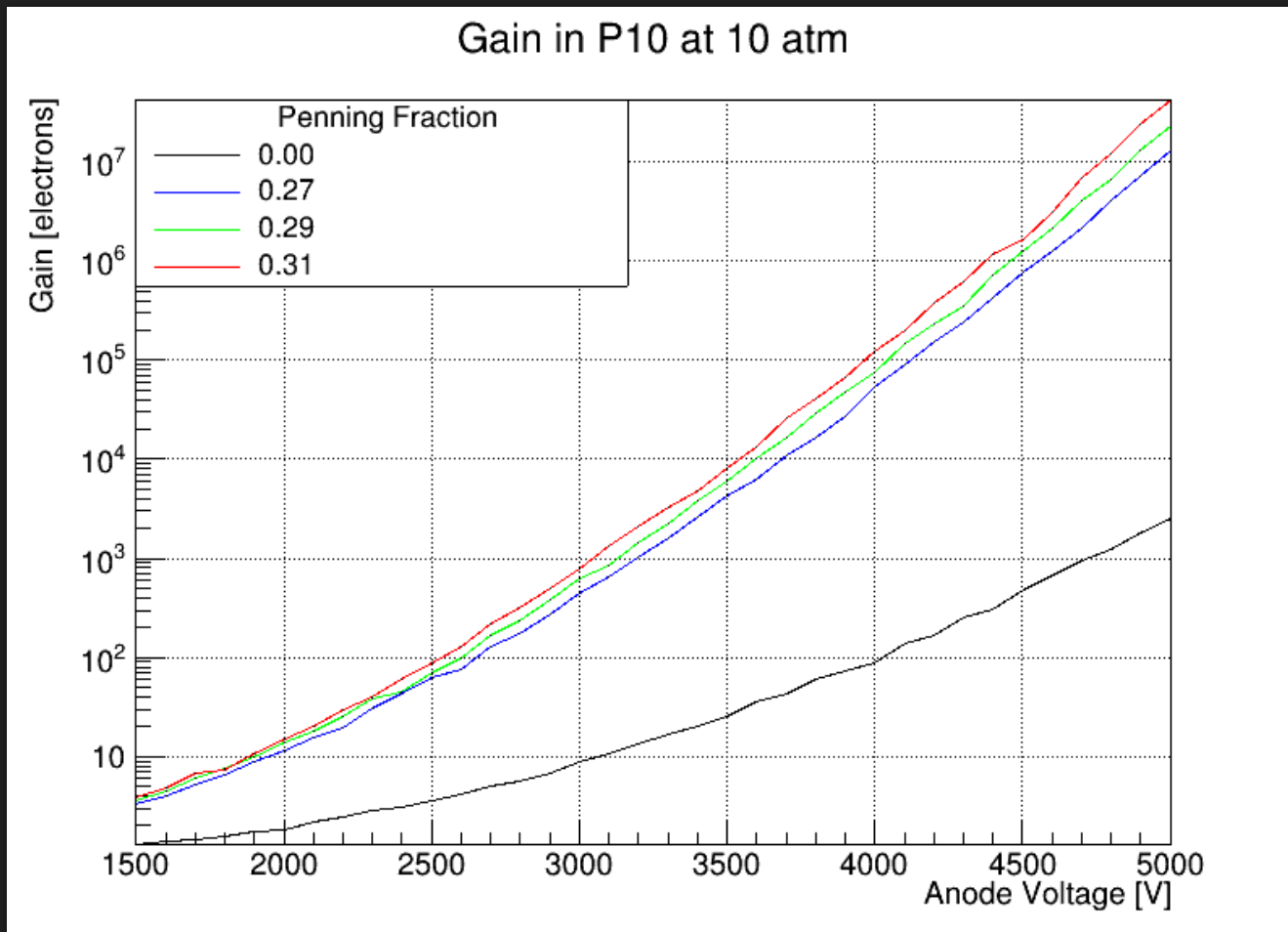
- Plot of curves fitted to experimental data for Argon CH₄ mixtures
- At 10atm, the transfer probability is close to 0.29 for 10% CH₄



From Ö Şahin *et al* 2010 *JINST* **5** P050 02, Penning transfer in argon-based gas mixtures

Results

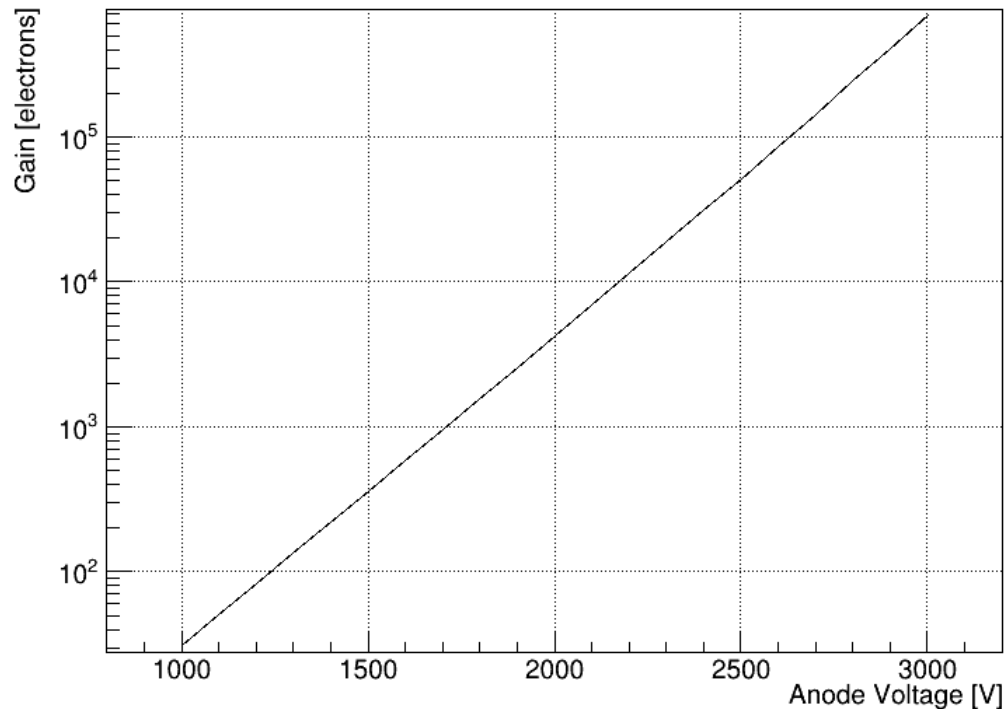
- Using ALICE OROC
- Penning transfer probability varied in MagBoltz due to uncertainty in quantity 0.29
- Gain calculated using GetGain function
 - Integrates townsend coefficients along drift line
- Electrons released just above gating grid



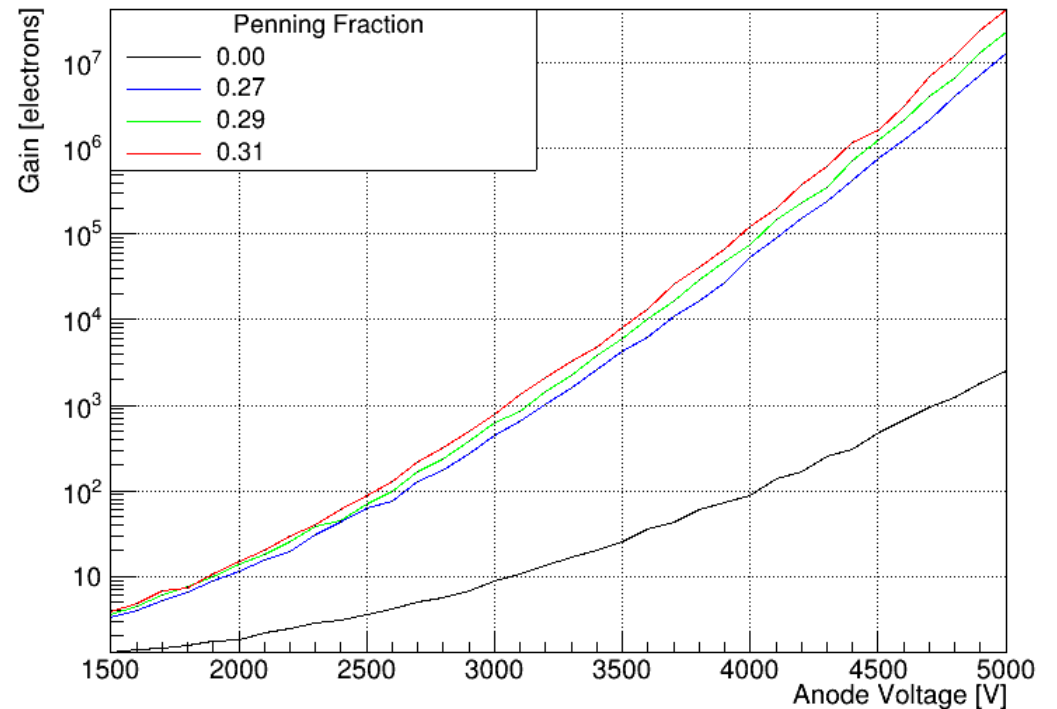
Comparison to ALICE Gas

At 1570V, ALICE gas has gain of 700 by this metric.
Similar gain in P10 at 10atm requires 2500V-3000V.

Gain in ALICE OROC



Gain in P10 at 10 atm

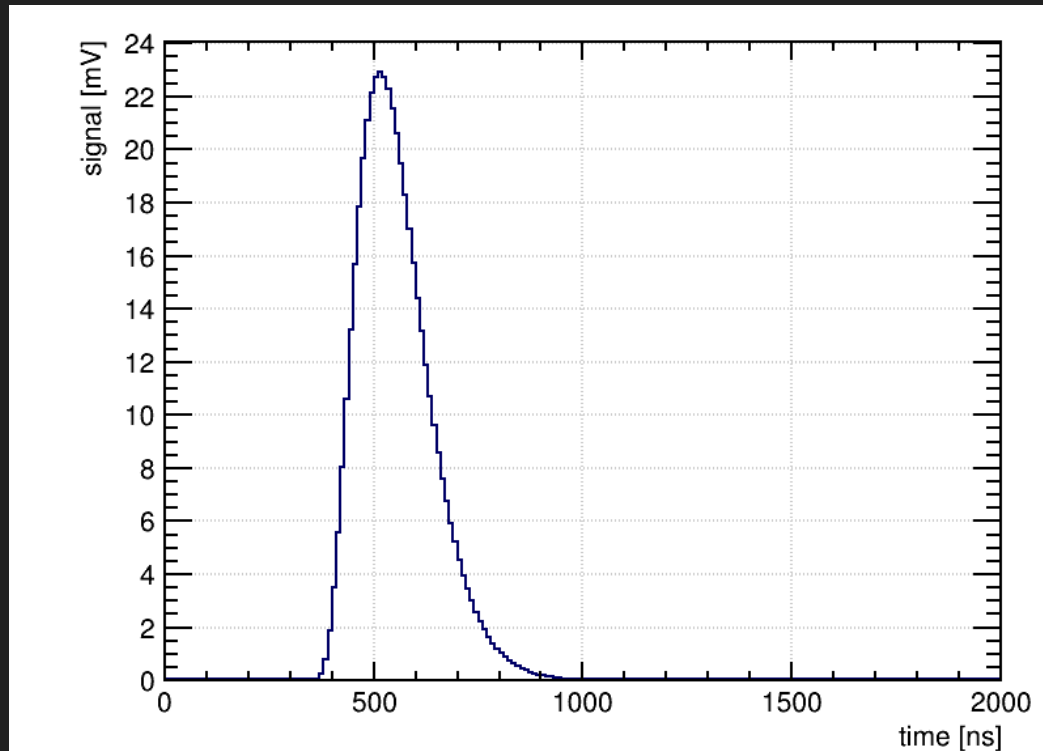


Additional Considerations

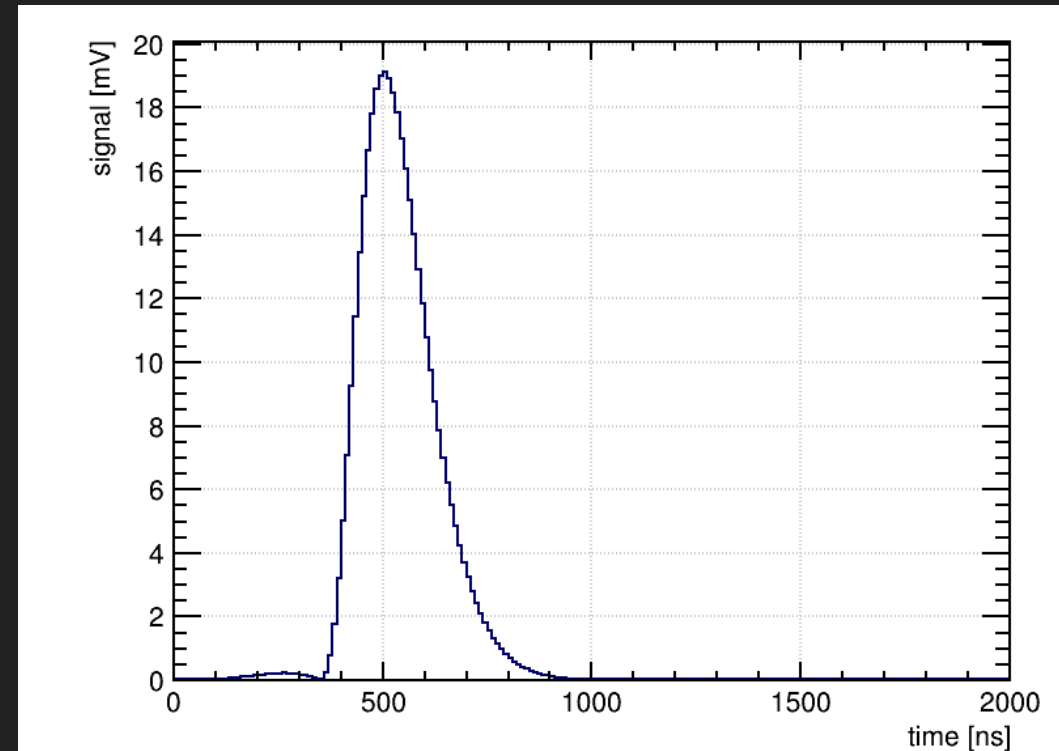
- It is expected that there will be more ionizations per unit length in 10atm P10 than 1atm Ne-CO₂
- This could boost the final signal in the P10 considerably since previous slide assumed an equal number of initial electrons
- Evaluate total signal by simulating a pion passing through the center of the drift chamber. This is also based on part of the example that comes with Garfield++

Signal on Readout Plane

Signal due to pion passing through center of drift chamber



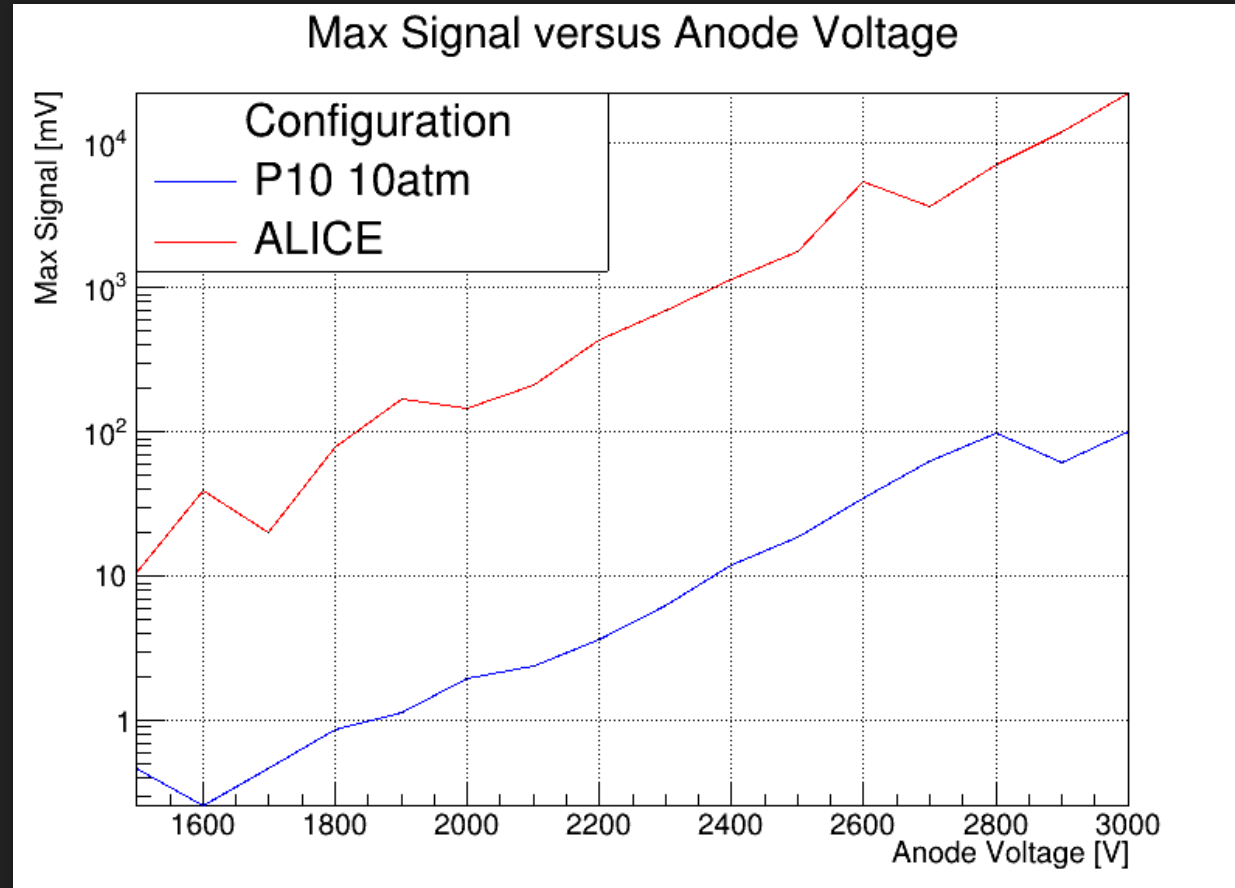
Signal in ALICE gas at 1570V



Signal in P10 at 2600V

Signal Peak Trends

- Plotting signal peak voltage against anode voltage
- Still simulating a pion passing through the drift chamber
- ALICE gas still has 2 orders of magnitude higher peak than P10 at the same voltage
- Difference remains consistent across range of voltages



Conclusion

- For anyone looking to simulate gain with Garfield
 - Penning effects necessary (but only through MagBoltz or PyBoltz*)
- In the context of configuring the MPD (GArGON?)
 - Anode wire voltages will have to be nearly doubled from nominal voltage in ALICE to achieve same signal size

Future Studies

- Compare breakdown voltage in P10 to voltage required for this level of gain
- Comparison to GOAT project, which is running with an argon based mix at 10atm (uses CO₂ instead of CH₄)
- Gas mix may change depending on decision of gas safety committee