中国科学院高能物理研究所

Institute of High Energy Physics Chinese Academy of Sciences


# Gas gain study for drift tubes in beam test

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# Introduction

- The setting up of voltage in a drift chamber experiment is important.

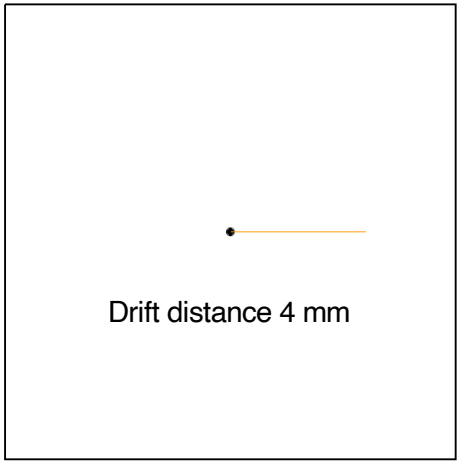
- Study the gas gain properties for the dift tubes that will be used in the beam test.

# Simulation for Beam Test

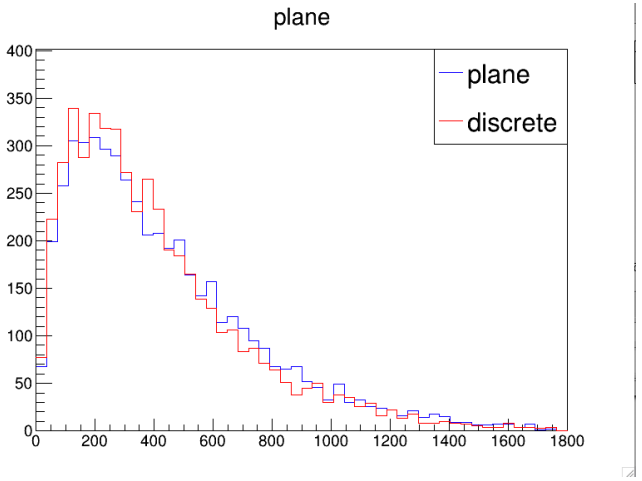
- Equipments: 8 tubes x 4 (75%,80%,85%,90%)gas mixtures, 32 settings in total.
- Pressure 1 atm, Temperature 20° C

| Tubes cm | node size (um) | | | |
|---|---|---|---|---|
| | 15 | 20 | 25 | 30 |
| 1 | x | x | x | |
| 2 | | x | x | |
| 3 | | | x | x |

- Two considerations
  - A continuous cathode at ground voltage.
  - A dense sequence of field wires.



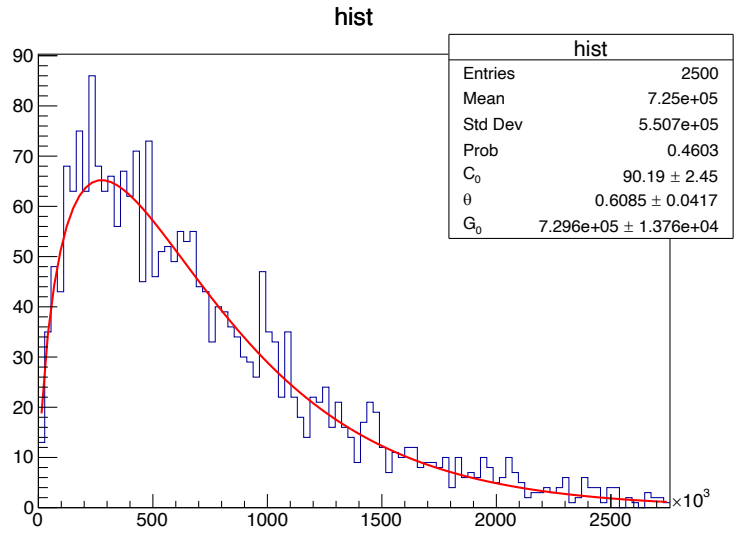

geometry



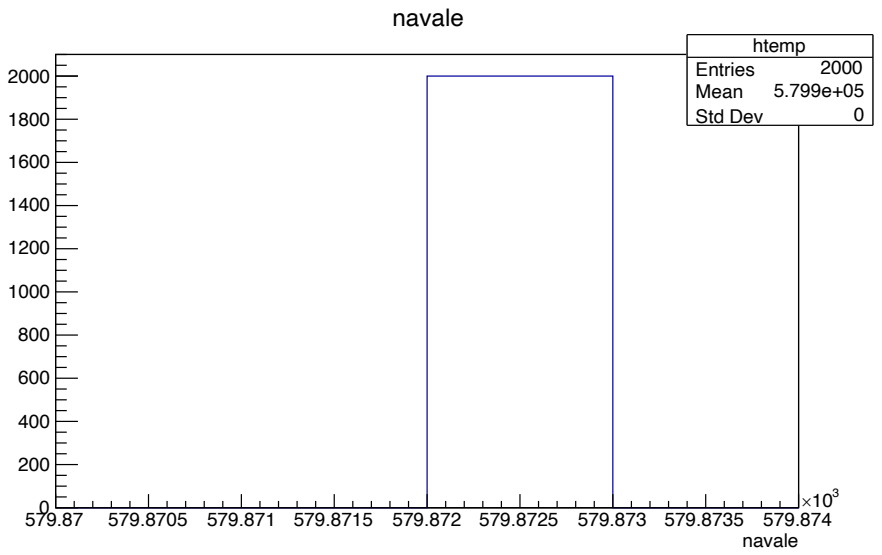

gain

# Comparison of AvalancheMicroscopic and DriftLineRKF

- AvalancheMicroscopic: Accurate simulations of electron trajectories in small-scale structures.
- DriftLineRKF: Runge-Kutta-Fehlberg integration to solve the first order equation of motion.




AvalancheMicroscopic




DriftLineRKF

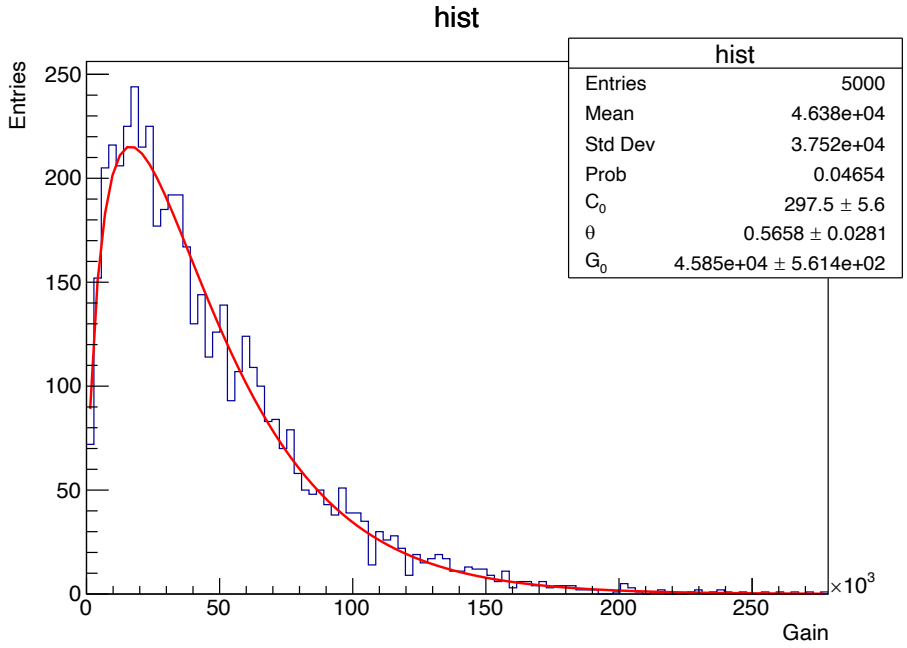
- The following results were generated by AvalancheMicroscopic

# Parameterization

The gain can be described as Polya distribution

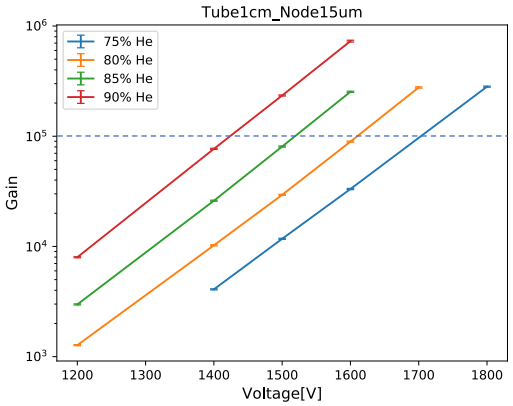
$$\mathbf{P}(\boldsymbol{G}) = \boldsymbol{C_0}\frac{(1+\boldsymbol{\theta})^{(1+\boldsymbol{\theta})}}{\boldsymbol{\Gamma}(1+\boldsymbol{\theta})}\left(\frac{\boldsymbol{G}}{\boldsymbol{G_0}}\right)^{\boldsymbol{\theta}} \boldsymbol{exp}\left[-(\mathbf{1}+\boldsymbol{\theta})\frac{\boldsymbol{G}}{\boldsymbol{G_0}}\right],$$

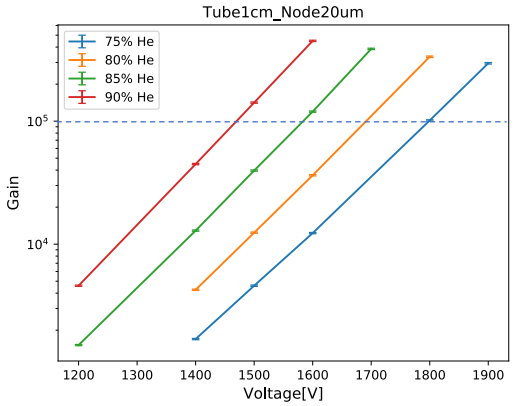
Where G0 the average effective gain of a single electron.
Theta the variance of Polya distribution

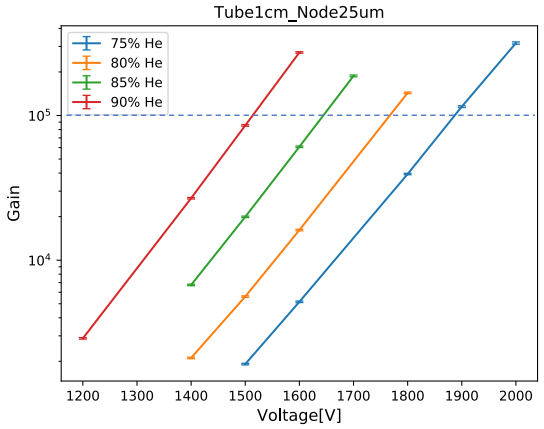



Tube3cm_Node30um_90percent 1800V

# Gain vs Voltage: 1cm tube

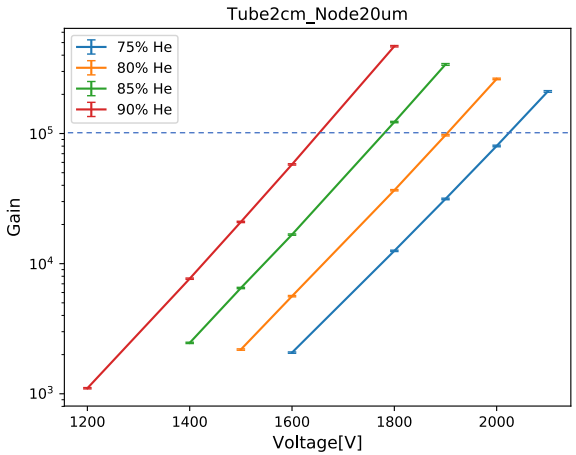


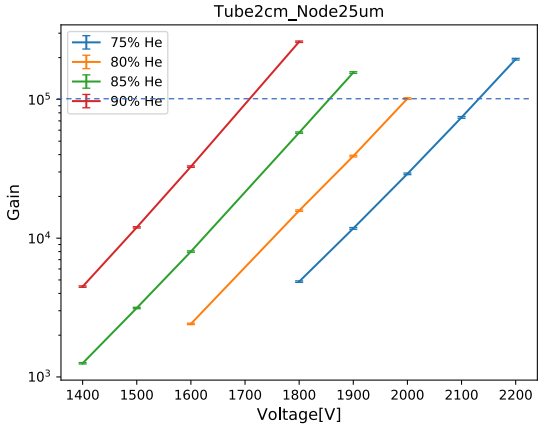



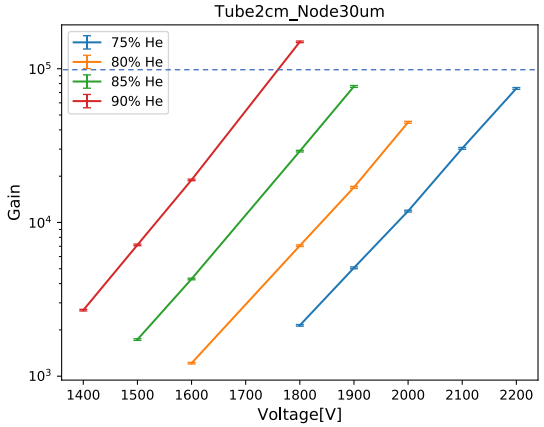




- Larger fraction of Helium results in higher gain.
- Larger radius of node -> lower linear charge density
  - Leads to lower gain .

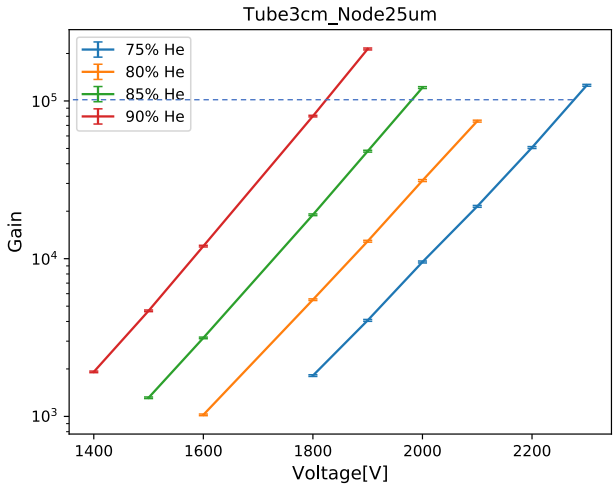
# 2cm tube

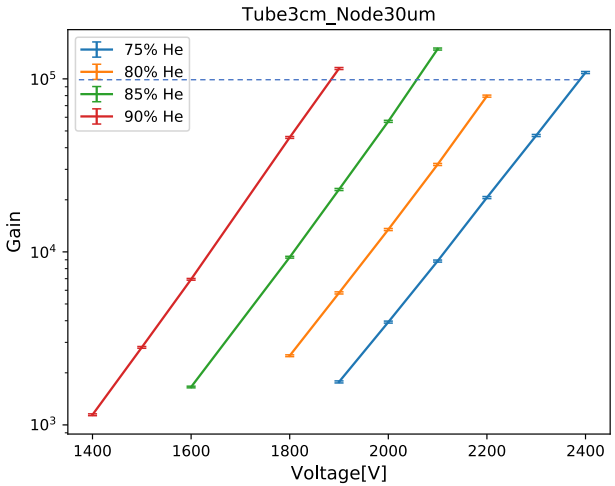

Tube2cm_Node20um
75% He
80% He
85% He
90% He
Gain
Voltage[V]


Tube2cm_Node25um
75% He
80% He
85% He
90% He
Gain
Voltage[V]


Tube2cm_Node30um
75% He
80% He
85% He
90% He
Gain
Voltage[V]

# 3cm tube


Tube3cm_Node25um
75% He
80% He
85% He
90% He
Gain
Voltage[V]


Tube3cm_Node30um
75% He
80% He
85% He
90% He
Gain
Voltage[V]

# Summary

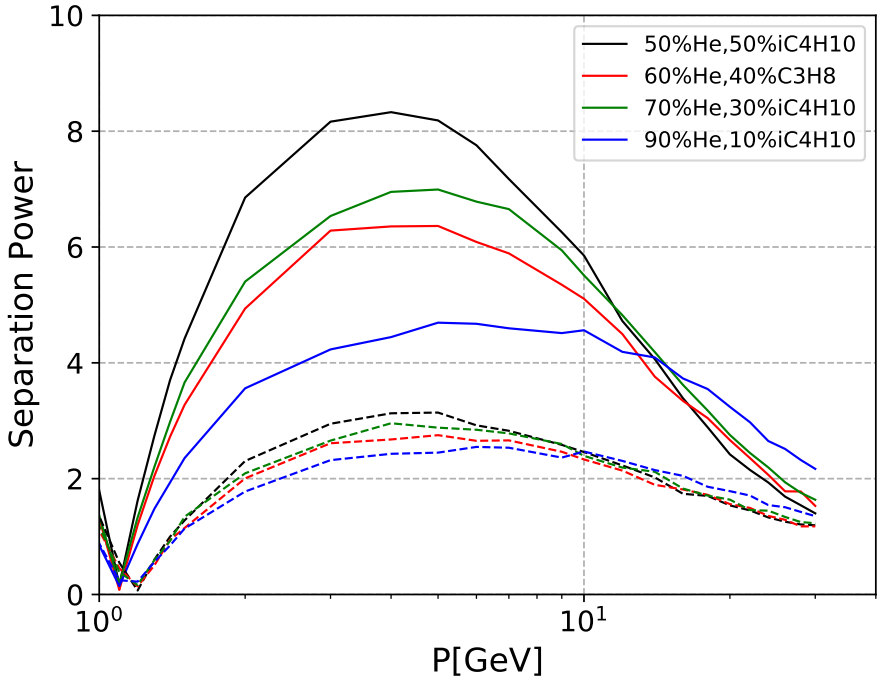
- The gas gain of tubes with different size is investigated using Garfield simulation.
- If $10^5$ is the desired avalanche size, from the plots we will need voltage.

| Voltage (V) Tubes cm | node size (um) (split into 4 gases 90/85/080/75) | | | |
|---|---|---|---|---|
| | 15 | 20 | 25 | 30 |
| 1 | 1450/1550/1600/1700 | 1450/1550/1700/1800 | 1500/1650/1750/1900 | |
| 2 | | 1700/1800/1900/2100 | 1700/1850/2000/2150 | 1800/1950/2000/2250 |
| 3 | | | 1800/2000/2100/2300 | 1900/2200/2300/2400 |

- We can also study the impact of pressure and temperature on the gain.

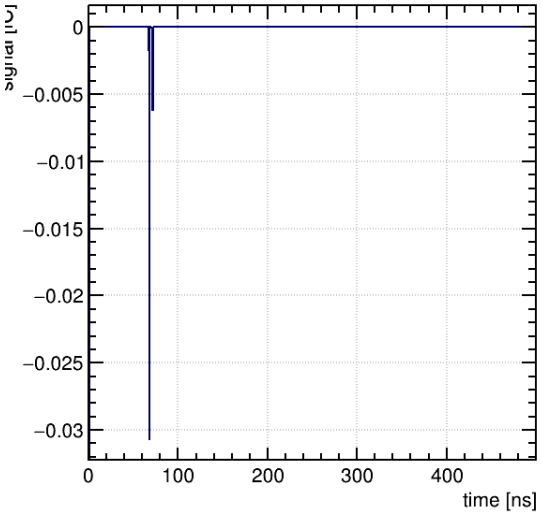
# Backup

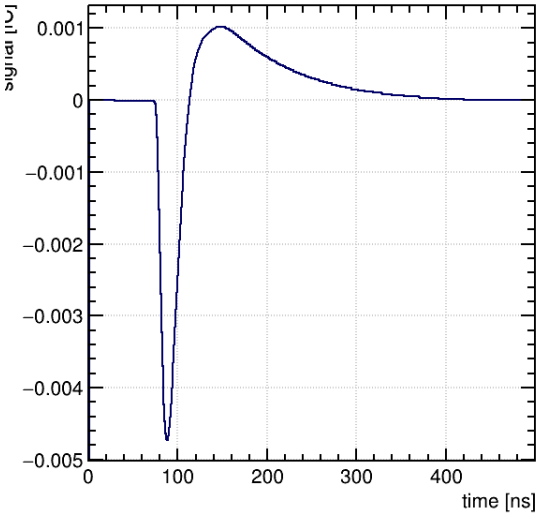
- K/pi separation for different gas with dN/dx(solid) and dE/dx(dash).



# backup

❖


signal [V]
0
−0.005
−0.01
−0.015
−0.02
−0.025
−0.03
0
100
200
300
400
time [ns]


signal [V]
0.001
0
−0.001
−0.002
−0.003
−0.004
−0.005
0
100
200
300
400
time [ns]

# Gain expression

$$M = \exp\left\{2\sqrt{\frac{kNCVR_a}{2\pi\varepsilon}}\left(\sqrt{\frac{V}{V_T}} - 1\right)\right\}$$