

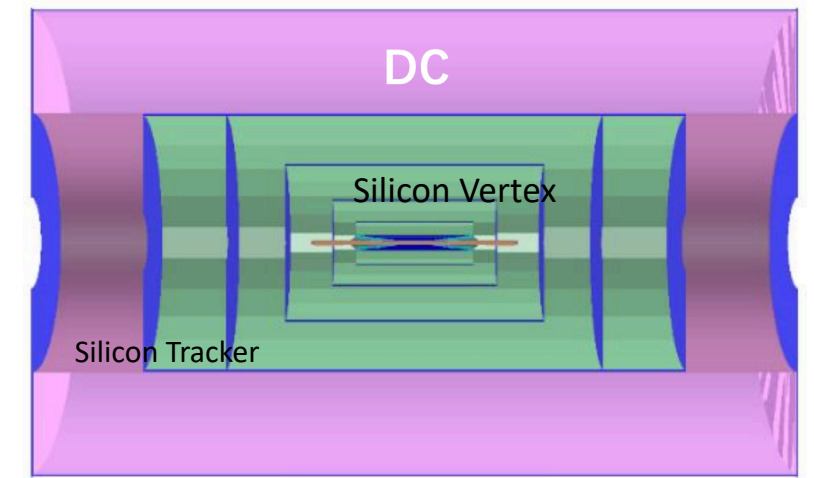
Particle identification with cluster counting technique for the drift chamber at CEPC

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Introduction

One trillion Z bosons are going to be produced at the CEPC operated at Z-pole, which offers an unmatched opportunity for precision tests of the SM and searches for BSM physics for the flavor physics.

A good identification of charged kaons is essential for the flavor physics study and benefits the determination of jet flavor and jet charge at CEPC for Z-pole operation. To achieve these physics goals, a design of tracking system combining a silicon tracker and a drift chamber is proposed. The drift chamber could provide dN/dx measurements with cluster counting technique, as well as those of dE/dx.

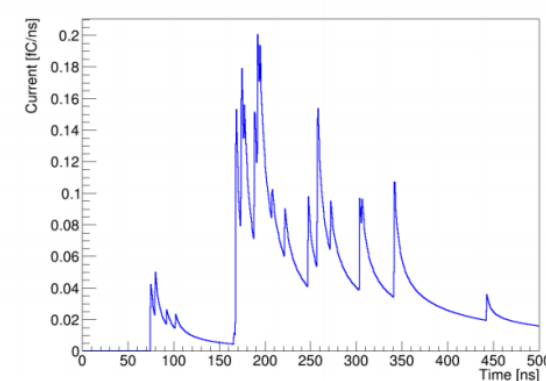


The fourth conceptual detector design

Full simulation method

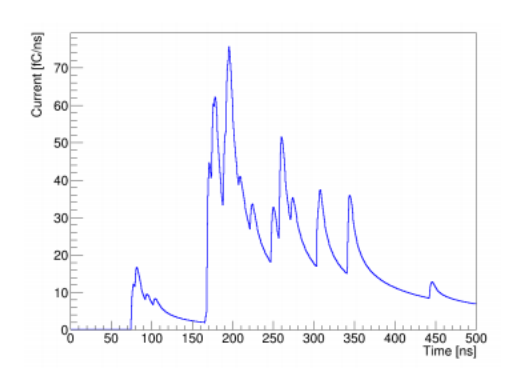
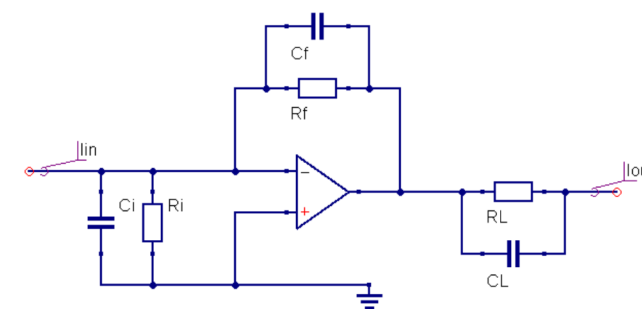
1. Generating Induced current

- Preforming simulation with Garfield++
 - Heed: ionization process.
 - Magboltz: gas properties. (drift/diffusion).
 - Signal generation.
- 10GeV pion goes through 1x1cm cell with He/iC₄H₁₀(9:1) gas mixture.



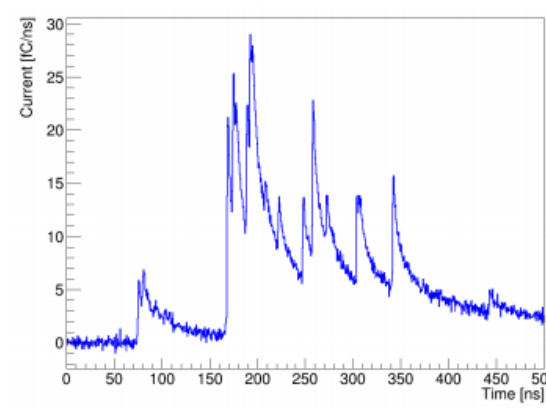
2. Considering electronics

- Assuming a simple current-sensitive preamplifier that broaden raw signal.



3. Simulating noises

- Adding white noises to the raw signal.
- Noise can also be generated by FFT from experiment measurement using preamplifier to allow a more realistic waveform for further study (On going).

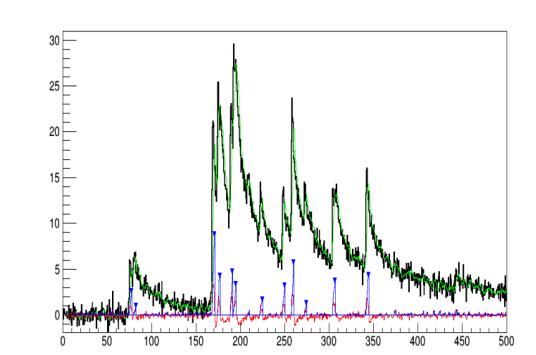


4. Peak finding analysis

- Two algorithm are developed
 - Moving average (MA) filter.

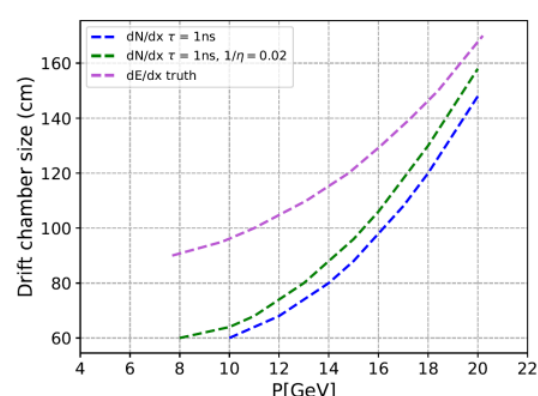
$$MA[i] = \frac{1}{M} \times \sum_{k=0}^{M-1} S[i-k] (\text{smoothing})$$
 - First difference (D1) filter.

$$D1[i] = MA[i] - MA[i-1].$$
- Peaks are identified then when local maximum is found above some threshold.

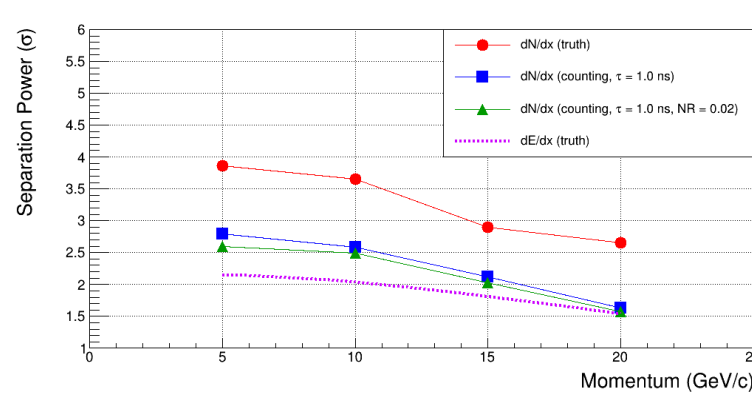


Performance study

- A fast simulation implemented in CEPSCW to replace time consuming full simulation enables the study of PID performance.
- To consider the degradation due to peak counting a effective model is multiplied to primary ionization distribution. The counting efficiency is regarded as the function of number of clusters.

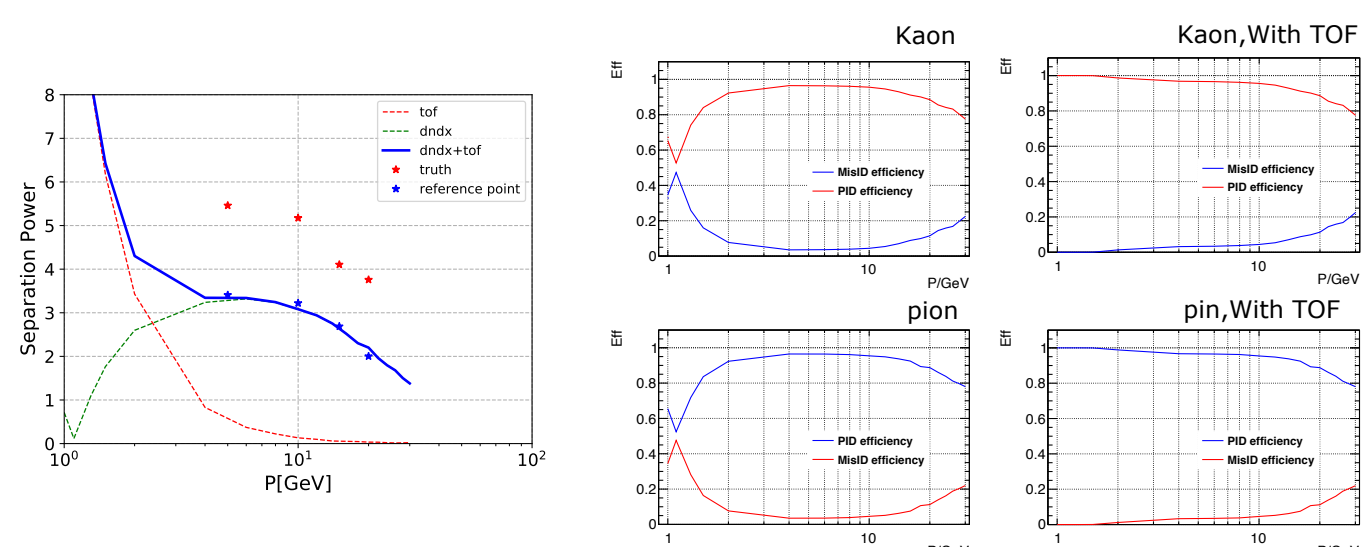


Detector size requirement for k/π separation > 2σ



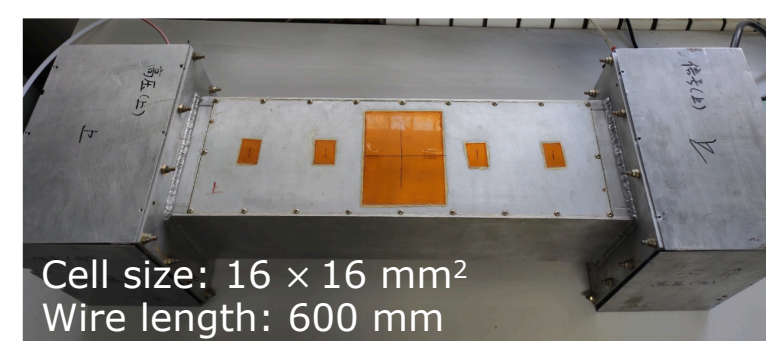
k/π separation from full simulation (thickness = 1 m)

- Combined with a TOF detector surrounded outer layer of Drifter Chamber barrel at R = 1.8 m, with 50 ps precision, a PID performance result on K and π is given by fast simulation.

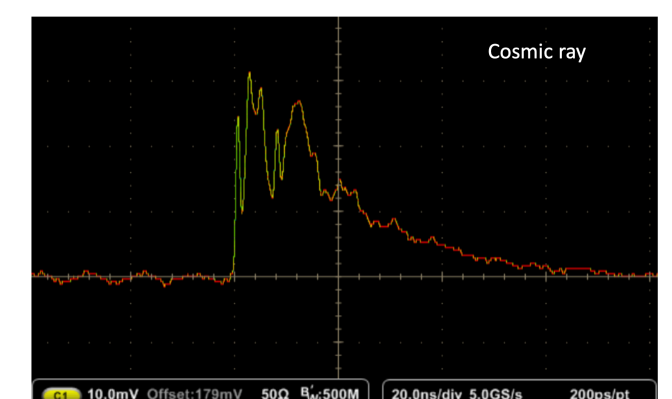


Prototype test

- Experiment setup
 - A 4 layer (6 cells/layer) prototype filled with He/iC₄H₁₀ (8:2).
 - Read out by an oscilloscope connected to the preamplifier chip, LMH5401EVM Board.



- Signal with 1ns rise time can be observed.
- Gain is not enough to detect whole signal.
- Next plan : Change the R_f to improve the gain.



Summary

- A simulation workflow for the drift chamber with cluster counting method is ready. Preliminary results show that K/p separation can achieve 3(2) for 10(20) GeV/c with the thickness of DC about 1m.
- A fast simulation parameterized from full simulation is implemented and preliminary PID performances are studied.
- A prototype test system has been setup to validate the simulation and help to understand the requirements of electronics.