Simulation study on the drift chamber of CEPC the 4th detector

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2023.6.26

Introduction

- A full simulation package is developed for PID study.
 - Guang Zhao's talk [link]
- We finalized a preliminary version of the simulation code.
- Perform waveform analysis with high statistics

From simulation to waveform analyais

The full simulation package

Waveform analysis





Signal generation Relay on Garfield++ simulation

Digitization MC Tuning from data

MC tuning

- Generate induced current waveforms from Garfield simulation
 - The same setup with data
- Digitization with models extracted from data
 - Noise: FFT analysis
 - Pre-amplifier response
 - Amplitude scale

- Data sample
 - Run 15/16/17
 - DRS channel 5
 - Gas mixture: 90/10 (He/iC₄H₁₀)
 - Cell size: 1 cm
 - Sampling rate: 1.5 GHz



Pre-amplifier response



- Last time uses a function with cutoff frequency of ~0.9 GHz
- Maybe too optimistic without considering connecting pre-amplifier with the cable and detector in data

Responses with more cutoff

- Add two responses with less cutoff frequencies.
- Use cutoff ~0.2 GHz / risetime ~6 ns in digitization



Scale the amplitude

Scale the MC to data by 0.0065 (max amp)



Simulation waveforms (1)



Data waveforms (1)



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Waveform analysis

• Simulation data:

- 20k events of k/pi are generated
- 2% noise ratio (noise tuned from data)
- tau = 2 (using old current-sensitive pre-amplifier)
- Cell size: 1.8 cm
- Gas mixture: 90% He 10% iC_4H_{10}

Peak finding

- Derivative algorithm is used.
- Adjusted parameters to minimize the fake rates
 - Performed peak finding on pure noise samples

• Parameters

- Moving average = 1
- Threshold = 0.04





Clusterization

- Merging algorithm using timing information of continuous peaks
 - The time cut is measured from MC. Fitted function: $t_{cut} = a * \sqrt{t_{drift}} + b$
- Clusterization method:
 - $t_{cluster}$ definition: time of the middle position of a cluster
 - If $\Delta t = abs(t_{cluster,i} t_{peaks,j}) < t_{cut}$, merged i to j, update $t_{cluster,i}$





Cluster reconstruction performance

• Preliminary performance:

- Peak reconstruction efficiency: eff = #reco peaks/ #truth peaks = 82%.
- Cluster reconstruction efficiency: eff = #reco cls/ #truth cls = 92.5%, 1m resolution ~ 2.7%



PID analysis

• Preliminary performance:

- 2% noise ratio, time constant = 2
- 2.84 sigma K/pi separation at 20 GeV/c



Conclusion

- Our simulation package works well. We updated electronic simulation including Pre-amplifier response, noise and scaled MC amplitude to data.
- A PID analysis is performed using events from the simulation package.
 - preliminary result for 2% noise ratio with 20k pi(K) events
- Todo: Assess the PID performance across a wider range of parameter values.

Backup slides

Simulation waveforms (2)



Data waveforms (2)

