dN/dx study on the CEPC drift chmaber

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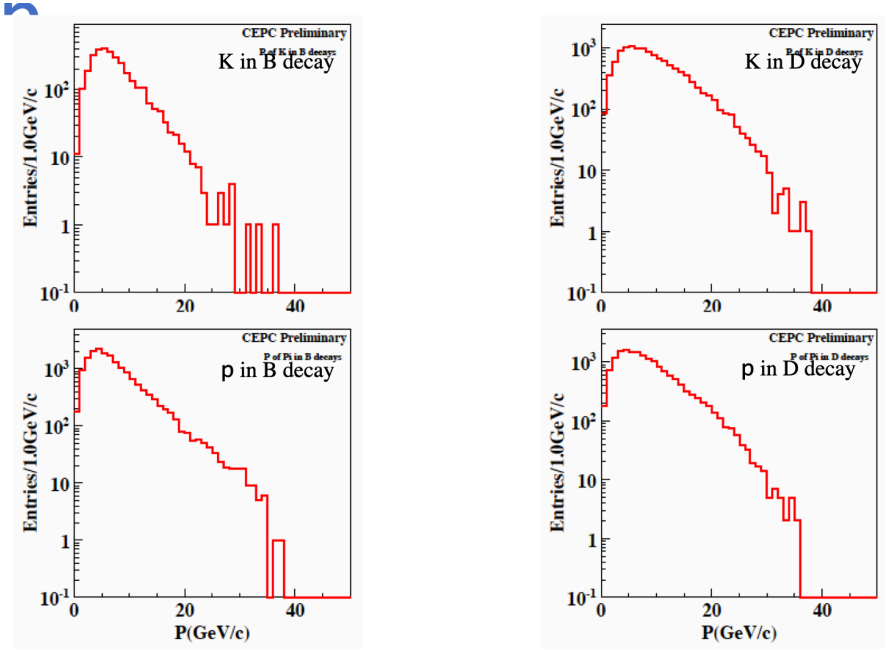
March 8.2021

Introduction

❖CEPC Drift Chamber layout

- ◇ “physics requirement” for CEPC Drift Chamber:
  - ◇ 2sigma k/pi separation power at 20GeV
  - ◇ 2% resolution of dE/dx.

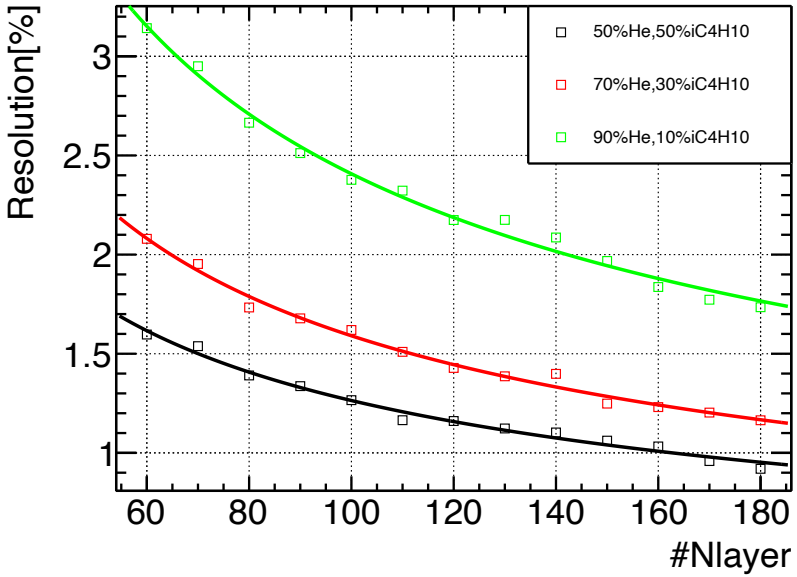


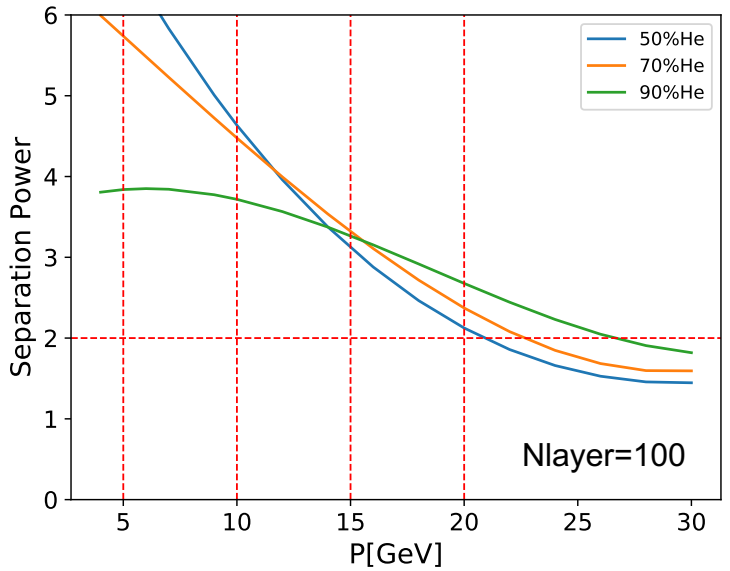
Most of K & p with the momentum less than 20 GeV/c

- ◇ Optimization the layout with Garfield++ simulation.
- ◇ Electronic simulation progress.

dN/dx vs #layer

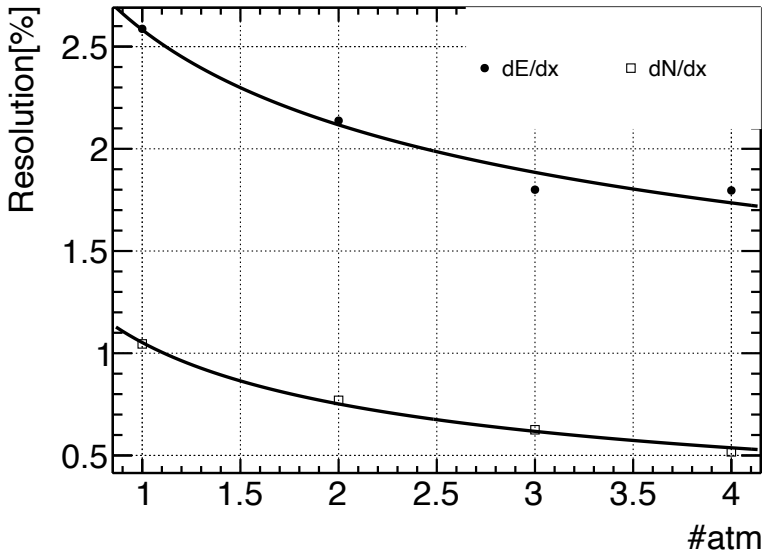
- A smooth method is used : Fitting mean, sigma of k,pi energy loss to obtain the separation curve. $\mu \sim constant, \sigma \sim 1/\sqrt{N}$

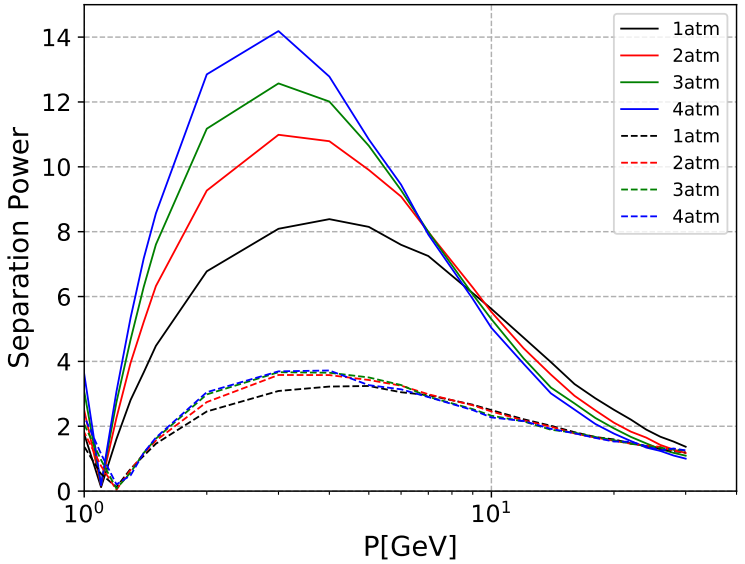




- 3 gas mixture -> no big difference between 50% and 70% in separation plot.
- 50%He and 90%He will be discussed in the following page.
- Above 10GeV, separation with 90%He is better than with 50%He.

dE/dx and dN/dx: Gas pressure





- ◇ dN/dx: solid line
- ◇ dE/dx: dash line

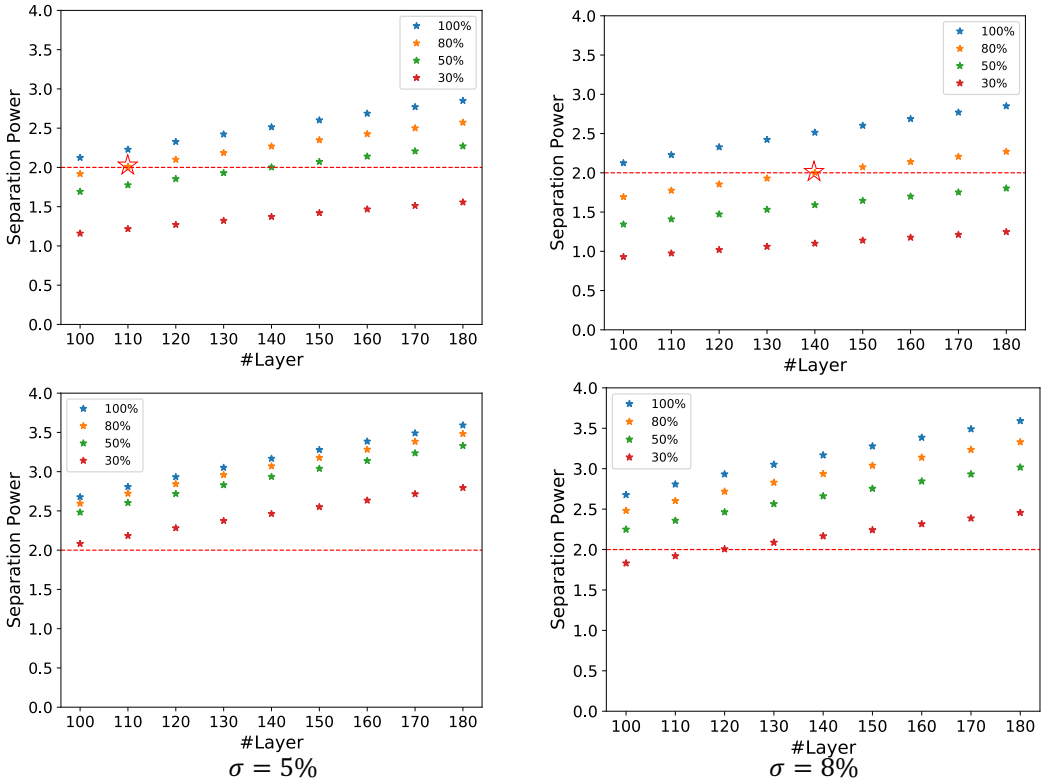
- ◇ dE/dx $\sigma = 2.5823 * atm^{-0.286}$
- ◇ dN/dx $\sigma = 1.0524 * atm^{-0.48}$
- ◇ For both dE/dx and dN/dx, no significant improvement above 10GeV, 1 atm gas is enough.

dN/dx study

- Don't have enough confidence on how much can the actual dN/dx be achieved
- Have to estimate the effect from noise and electronic
  - Assume a factor on detector efficiency: $F(N_{final}) = Possion(N_{truth}) * Gaus(\mu, \sigma)$
  - μ = 30%, 50% or 80%, $\sigma = 5\%\ or\ 8\%$.
  - The performance highly depends on efficiency both mean and sigma
- Separation plots for different efficiency assumption at 20GeV.

50%He

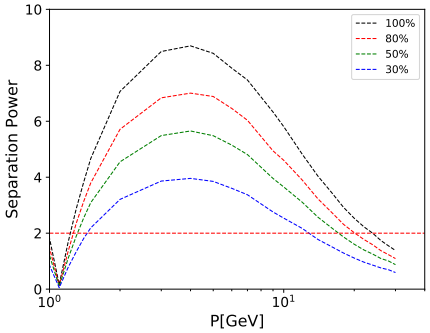
90%He



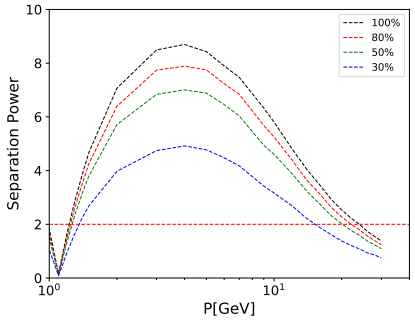
- 2 sigma separation using 50%He with efficiency $80 \pm 5\%(80 \pm 8\%)$ refer to 110(140) layers.
- 90%He surpass 50% He at 20GeV.

dN/dx: Pi/K separation

- Nlayer = 160 for 50% and 90%He, assuming 100%,80%,50%,30% counting efficiency. But constraint on it's uncertainly maybe too strict.

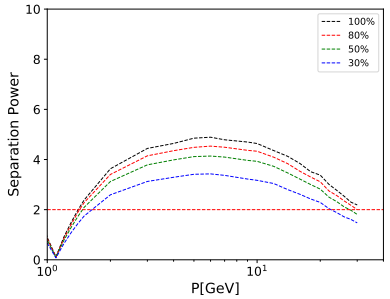


$\sigma = 8\%$



$\sigma = 5\%$

50%He



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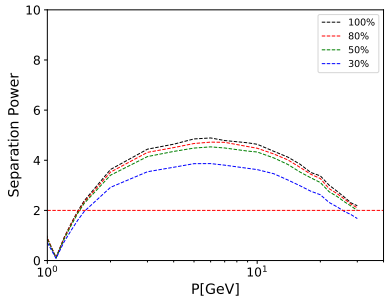


$\sigma = 5\%$

90%He

- Critical point :

Number of layers	Gas mixture	σ(dN/dx)20GeV pion	Separation power of pi/k at different counting efficiency						
			$100 \pm 0\%$	$80 \pm 8\%$	$80 \pm 5\%$	$50 \pm 8\%$	$50 \pm 5\%$	$30 \pm 8\%$	$30 \pm 5\%$
120(1.5m)	He 50%	<2%	2.4	1.8	2.1	1.4	1.8	1.0	1.2
	He 90%	<2%	2.9	2.6	2.7	2.5	2.6	2.0	2.3
160(1.9m)	He 50%	<2%	2.7	2.2	2.3	1.6	2.1	1.2	1.3
	He 90%	<2%	3.3	3.1	3.2	3.0	3.1	2.3	2.4

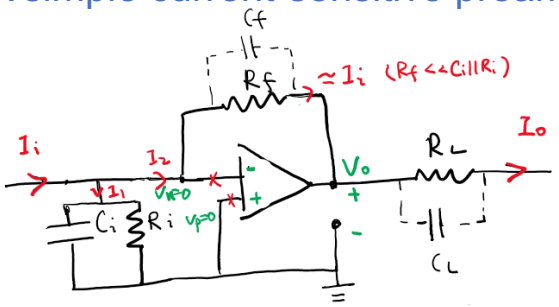
- With 80% counting efficiency, the minimum number of layers for reaching 2 sigma separation is 120.
- He 90% could full-fill the requirements with less Nlayers.

Simulation with preamplifier

Guang Zhao

- Electronics with high sampling frequency and low noises is necessary

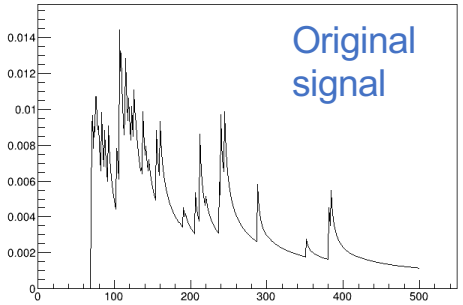
A simple current-sensitive preamplifier

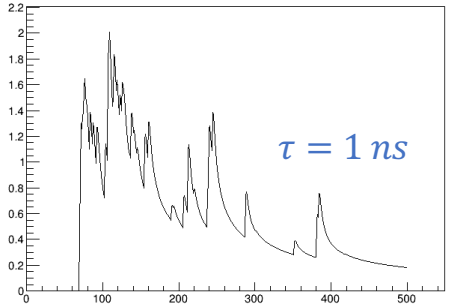


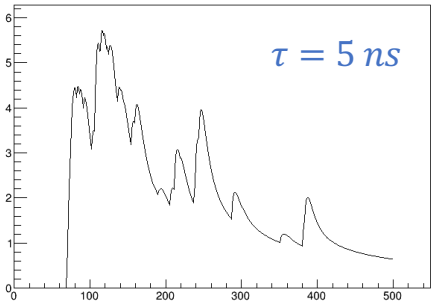
The impulse response in time domain is:

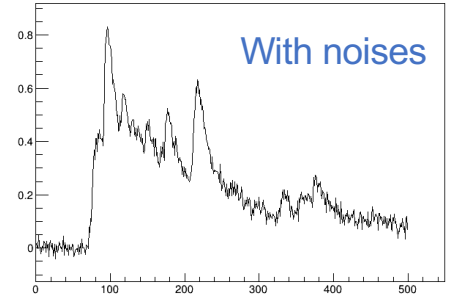
$$h(t) = \frac{R_f}{R_L R_f C_f} \times e^{-\frac{t}{R_f C_f}},$$

where $\tau \equiv R_f C_f$ is the time constant that can broaden the raw signal.









Thanks to electronics group with helpful discussion!

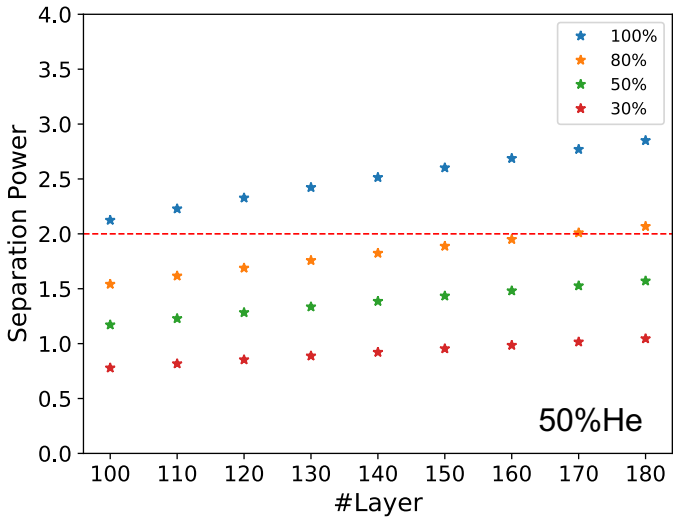
Summary

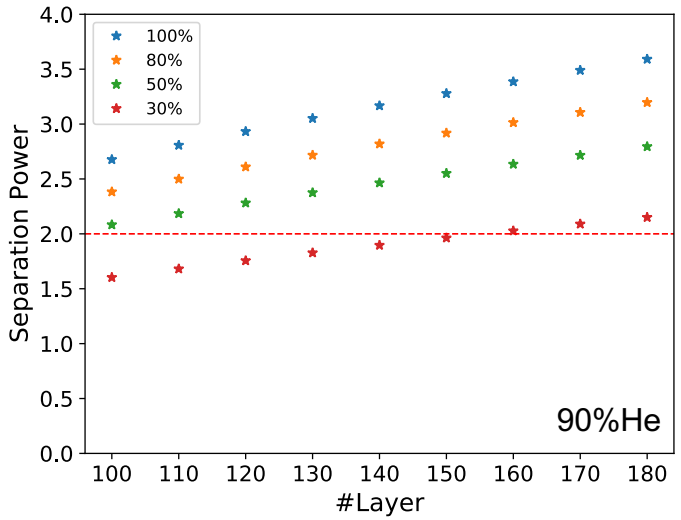
- Focusing on PID performance in the range of P>10GeV
- Configuration design:
  - For the gas choice: 50%He or 90%He
  - Gas pressure : 1atm
- Drift Chamber size consideration
  - With dE/dx measurement:
    - 90%He gas with 170 layers(2m), 50%He is hard to achieve the goal.
  - Hope that cluster counting could improve with:
    - 50% efficiency, N = 140(1.7m).
  - A Conservative design : 1.8m by 50% counting efficiency
  - A radical design: 1.5m by 80% counting efficiency

- Next step :
  - To implement Garfield++ simulation in CEPCSW.
  - Electronic and noise simulation

Backup

❖ 10% uncertainty of counting efficiency





Backup

- K/pi separation for different gas with dN/dx and dE/dx.