Drift Chamber layout with Garfield simulation

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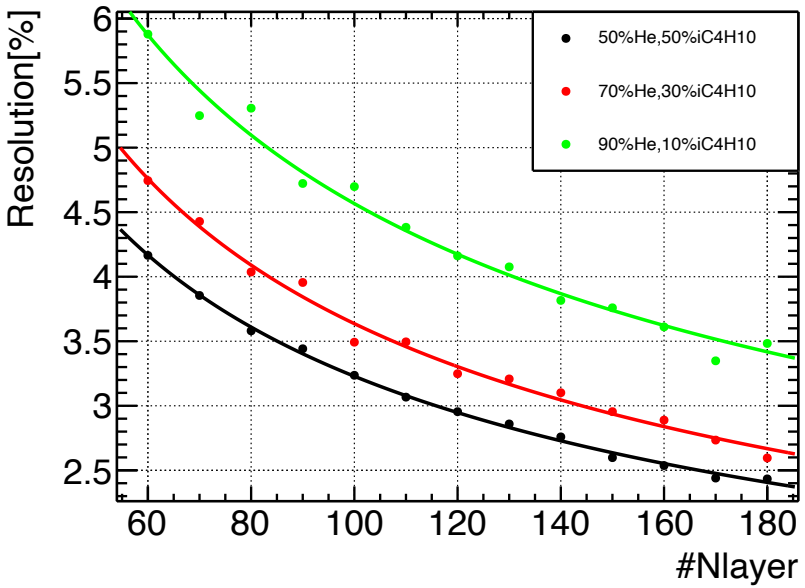
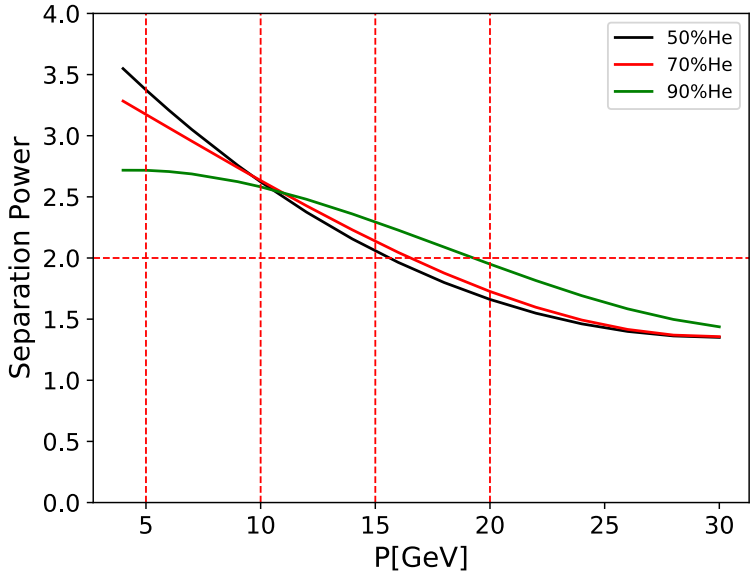
Introduction

- “physics requirement” for CEPC Drift Chamber:
  - 2sigma k/pi separation power at 20GeV
  - 2% resolution of dE/dx.
- Optimization the layout from two aspects
  - dE/dx
  - dN/dx

dE/dx vs #layer

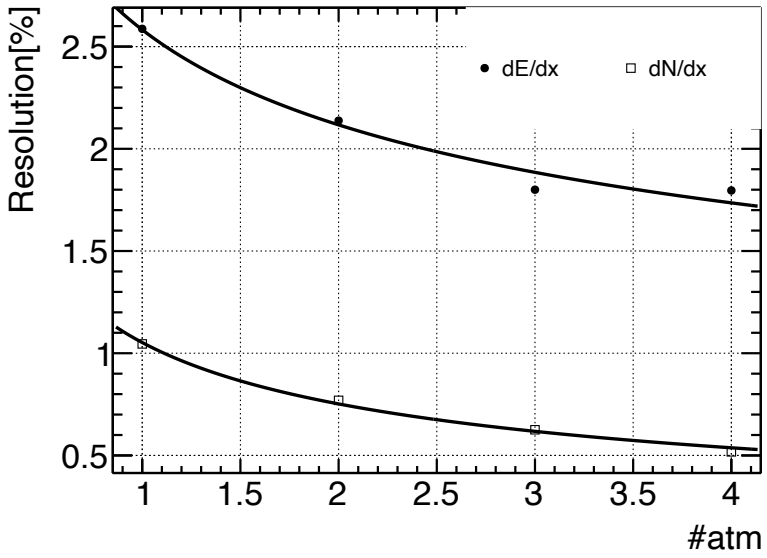
- Smooth method is used : Fitting mean, sigma of k,pi energy loss to obtain separation curve. $\mu \sim constant, \sigma \sim 1/\sqrt{N}$

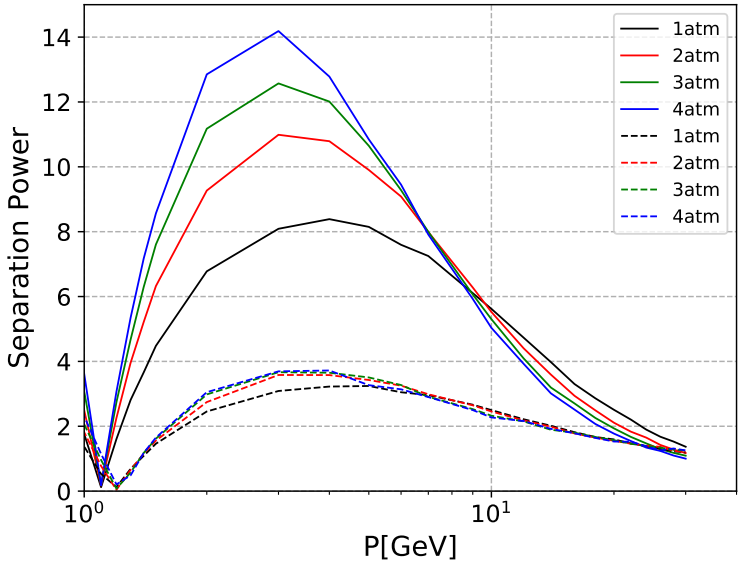




- 3 gas mixture -> no big difference between 50% and 70% in separation plot.
- 50%He and 90%He will be discussed in the following page.
- Above 10GeV, separation with 90%He is better than with 50%He.

dE/dx and dN/dx: Gas pressure

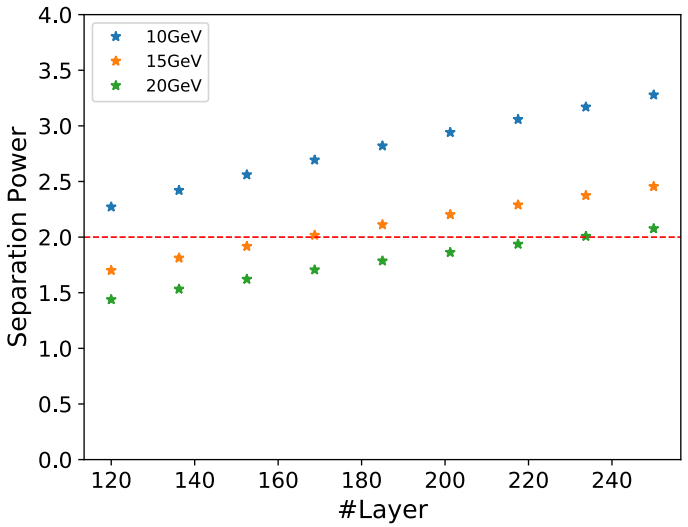




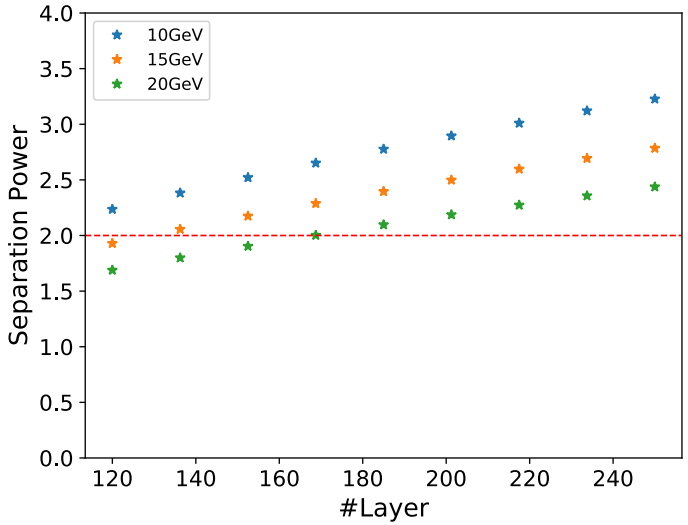
- ◇ dN/dx: solid line
- ◇ dE/dx: dash line

- ◇ 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.

dE/dx: Separation Limit



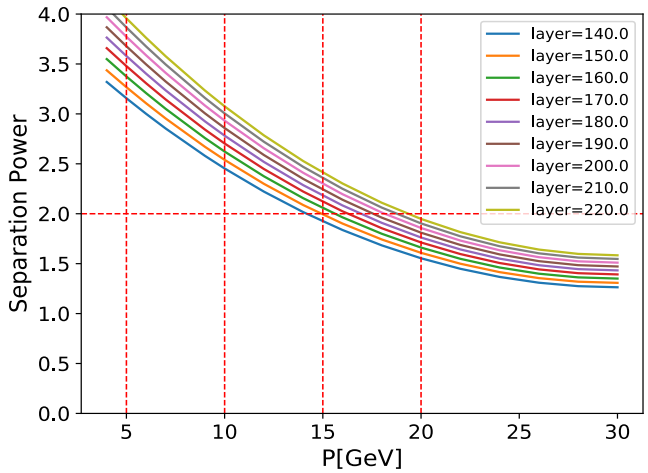
50%He



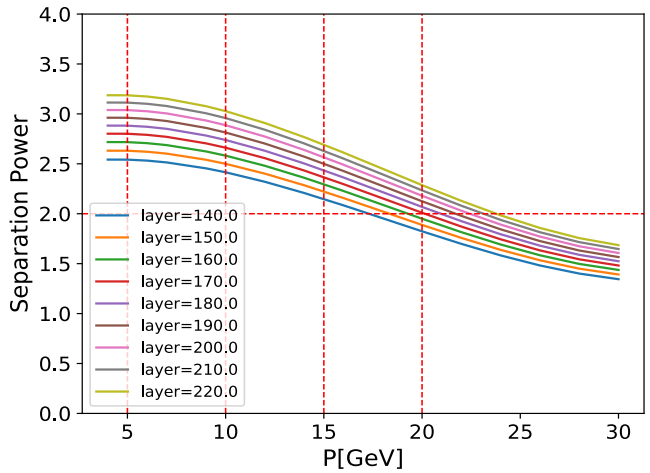
90%He

- To achieve 2 sigma k/pi separation at 20GeV:
  - 240 layers, 170 layers are needed with 50%He,90%He gas respectively.
- To achieve 2 sigma k/pi separation at 15GeV:
  - 170 layers, 140 layers are needed with 50%He,90%He gas respectively.

dE/dx: Separation vs different nlayers



50%He



90%He

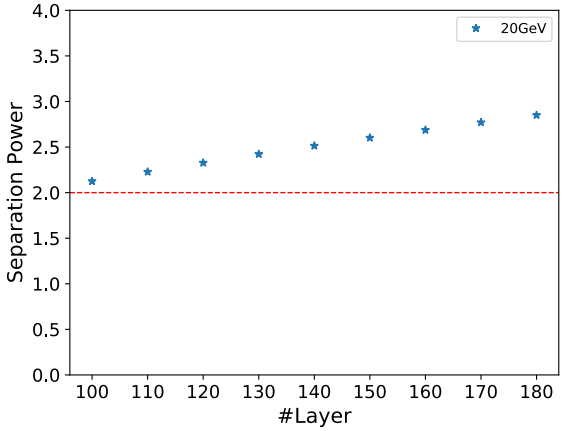
Number of layers	Gas mixture	dE/dx resolution of 20GeV pion	Separation power of pi/k at different momentum			
			5GeV	10GeV	15GeV	20GeV
N = 150	He 50%	2.53%	3.3	2.5	2.0	1.6
	He 90%	2.24%	2.6	2.5	2.25	1.8
N = 170	He 50%	2.64%	3.5	2.7	2.1	1.7
	He 90%	3.35%	2.7	2.6	2.4	2

- The momentum corresponded to 2 sigma separation at 1.8m(N=150):
  - For 50%He,15GeV
  - For 90%He,18GeV
- 90%He gas with 170 layers configuration is possible to reach 2sigma separation.

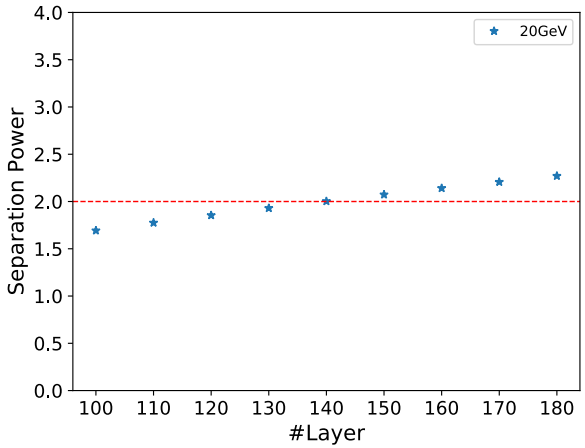
dN/dx study

- Don’t have enough confidence on how much can the actual dN/dx be achieved
- Have to estimate the effect from noise and electronic
  - Suppose a factor on detector efficiency: (assume 10% resolution)
  - 50%, gaus(0.5,0.05)
  - 30%, gaus(0.3,0.05)
  - The performance highly depends on efficiency both mean and sigma.

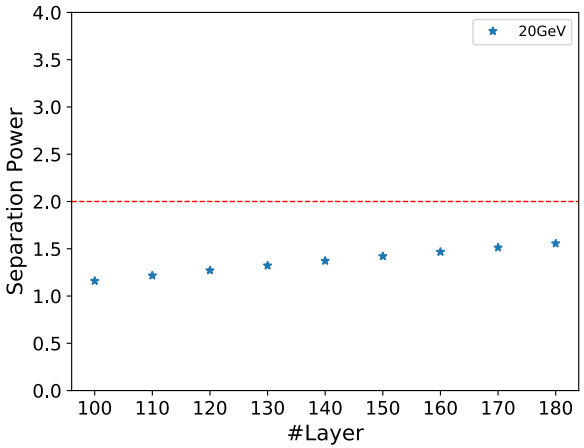
- Separation plots for different efficiency assumption



Prefect counting



50%

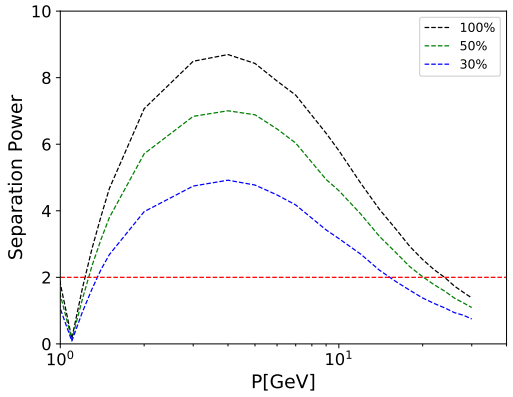


30%

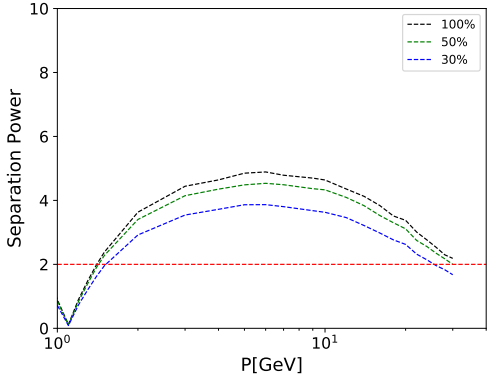
- 50% efficiency of this technique seems to be the lower band to satisfy the physics requirement.

dN/dx: Pi/K separation

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



50%He



90%He

- Critical point :

Number of layers	Gas mixture	dE/dx resolution of 20GeV pion	Separation power of pi/k at different counting efficiency		
			$100 \pm 0\%$	$50 \pm 5\%$	$30 \pm 5\%$
N = 140	He 50%	1.1%	>2	2.0	1.4
	He 90%	2%	3.1	2.9	2.5
N = 160	He 50%	1%	>2	2.2	1.5
	He 90%	1.9%	3.3	3.1	2.6

- With 50% counting efficiency, the minimum number of layers for reaching 2 sigma separation is 140.

Summary

- Focusing on PID performance in >10GeV range
- 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).

Backup

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