Drift Chamber layout with Garfield simulation

Shuiting Xin, Linghui Wu

Feb 22.2021

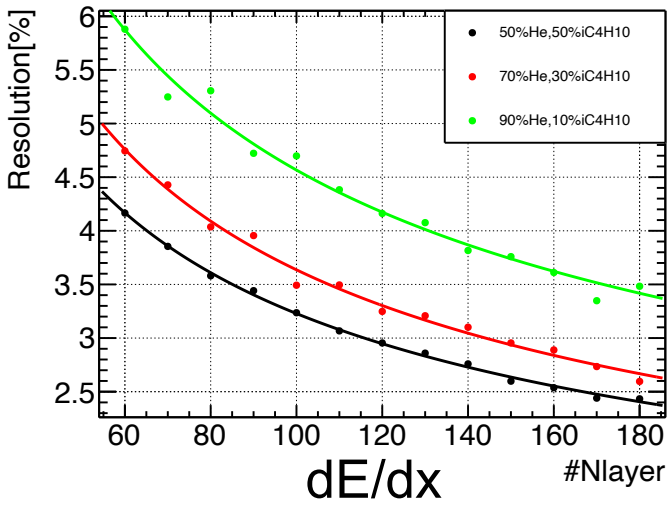
CEPC tracker layout meeting

Introduction

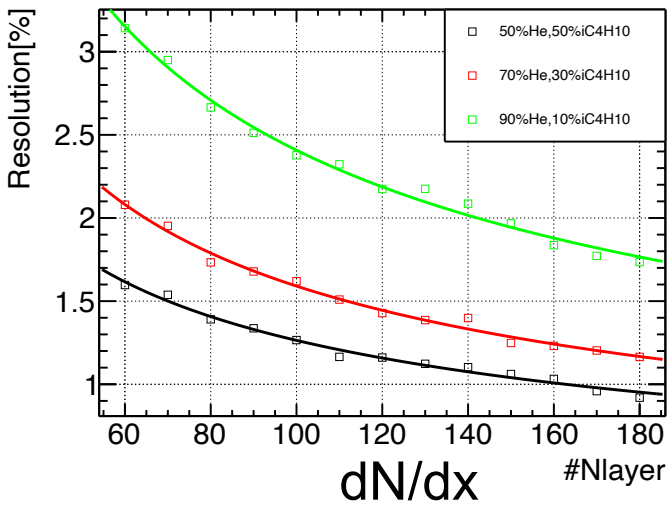
- Investigated configuration(gas mixture, number of layers, gas pressure) of CEPC drift chamber.
- Energy loss(dE/dx) and cluster counting(dN/dx) are simulated at primary ionization level: Only number fluctuations and energy transfer(to δ electron) fluctuations.
- To reach a conclusion on Drift chamber barrel part.

Resolution vs #Layer 20GeV pion

- To analyze energy loss distribution, 75% truncated mean is applied.

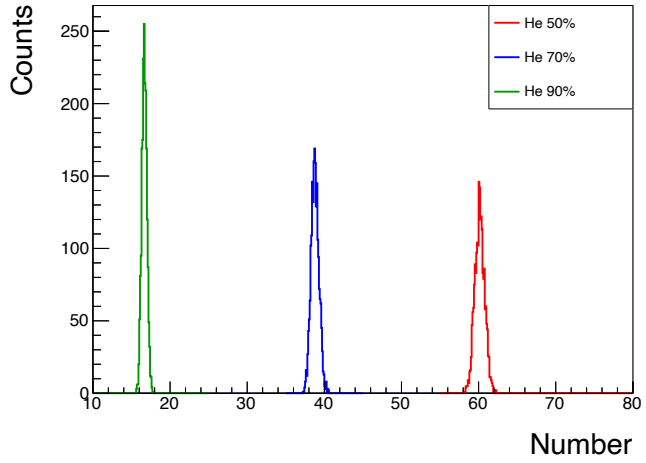


- $\sigma_1 \propto 32.3 * N^{-0.50}$
- $\sigma_3 \propto 41.2 * N^{-0.52}$
- $\sigma_4 \propto 44.2 * N^{-0.49}$

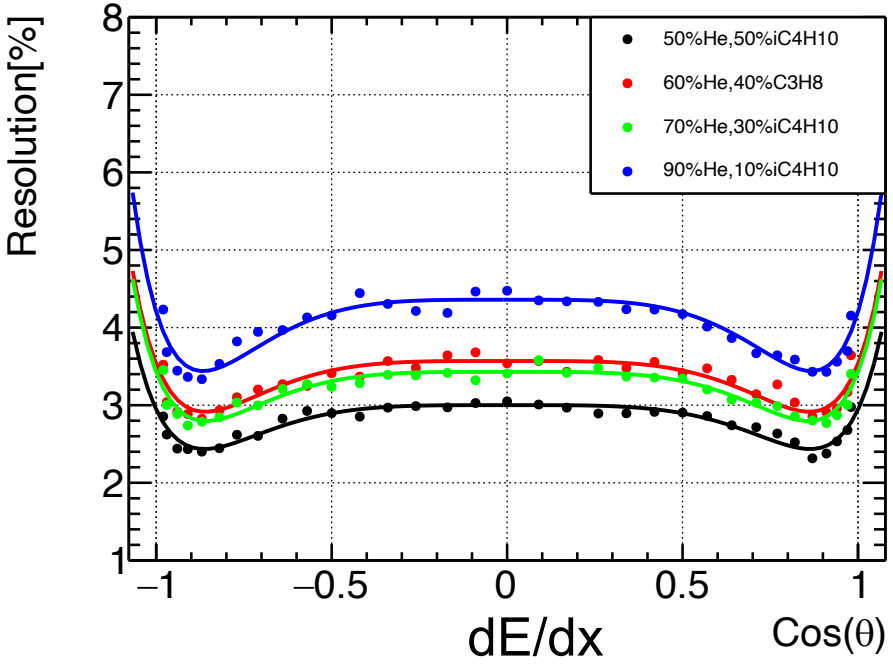


- $\sigma_1 \propto 11.6 * N^{-0.48}$
- $\sigma_3 \propto 18.0 * N^{-0.52}$
- $\sigma_4 \propto 27.3 * N^{-0.52}$

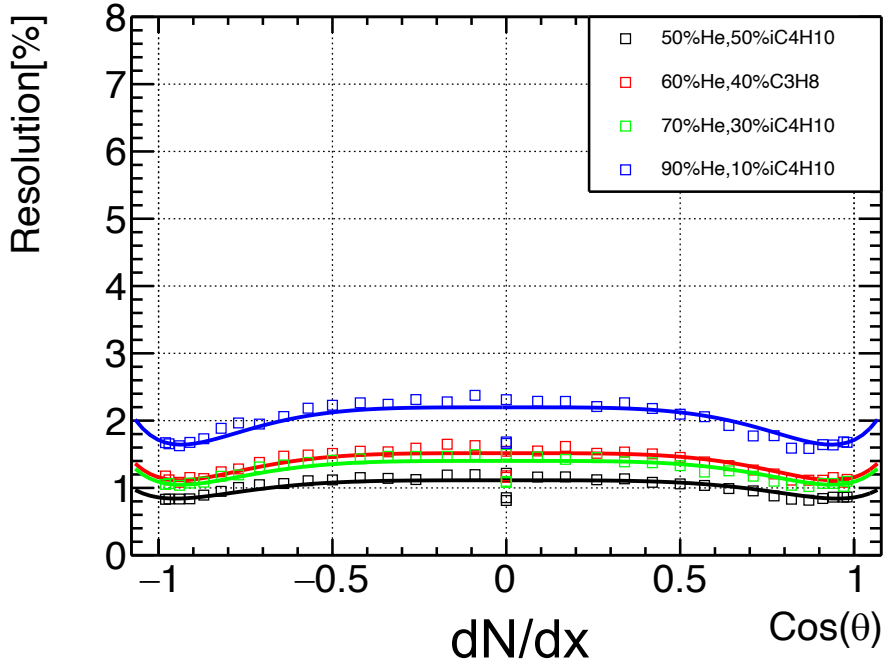
- Cell Size: 1cm
- $\sigma_{90\%} > \sigma_{70\%} > \sigma_{50\%}$
- Quenching gas:iC4H10



20GeV pion, N=120

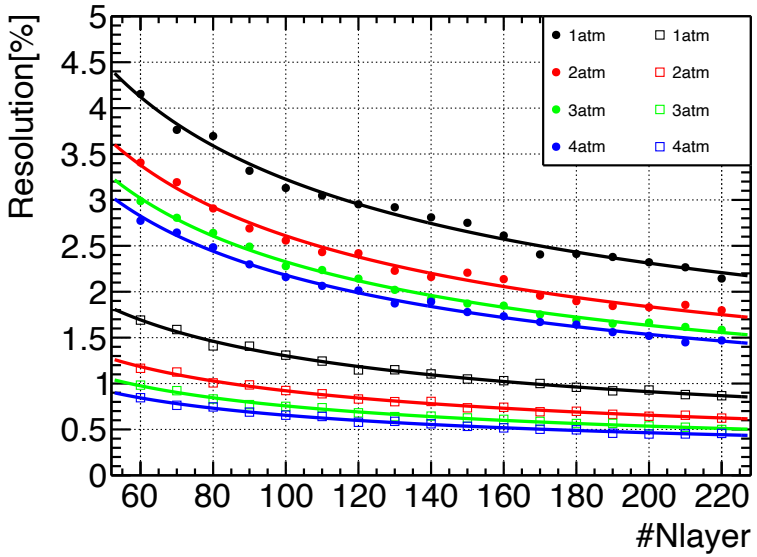


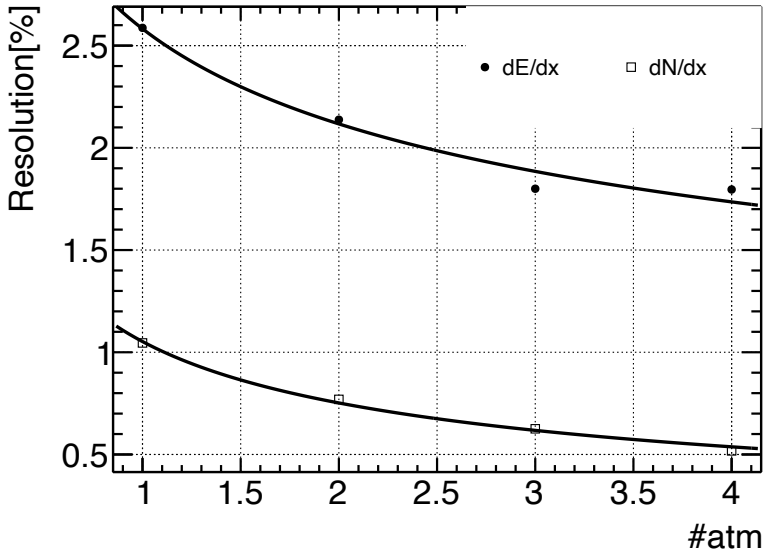
- $\sigma_1 = 3.00 - 1.69\cos^4\theta + 1.64\cos^{10}\theta$
- $\sigma_2 = 3.42 - 1.94\cos^4\theta + 1.93\cos^{10}\theta$
- $\sigma_3 = 4.35 - 2.71\cos^4\theta + 2.55\cos^{10}\theta$



- $\sigma_1 = 1.11 - 0.55\cos^4\theta + 2.98\cos^{10}\theta$
- $\sigma_2 = 1.40 - 0.77\cos^4\theta + 1.40\cos^{10}\theta$
- $\sigma_3 = 2.19 - 1.21\cos^4\theta + 1.93\cos^{10}\theta$

Gas pressure

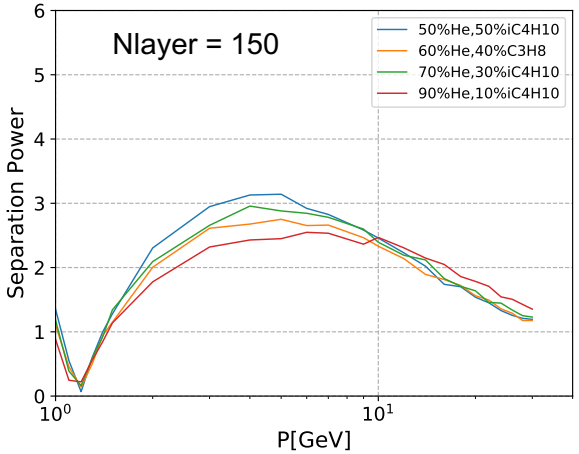


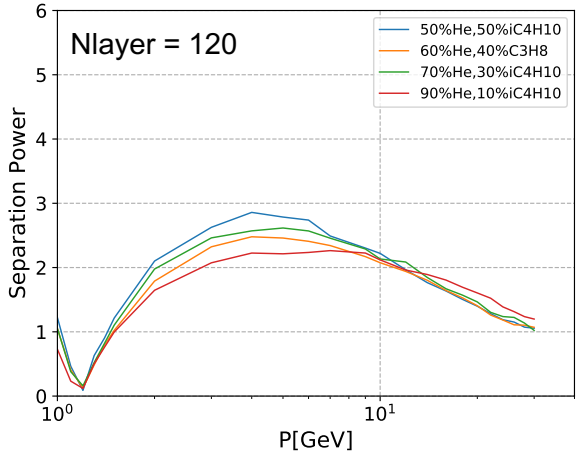


- dE/dx $\sigma = 2.5823 * atm^{-0.286}$
- dN/dx $\sigma = 1.0524 * atm^{-0.48}$

Pi/K separation

- Fixed theta = 90, Nlayer = 120/150





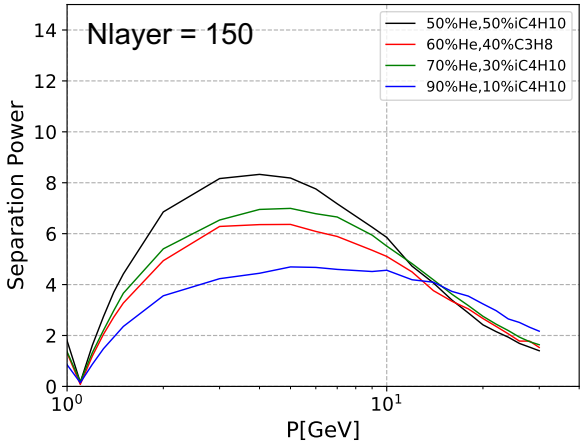
- Smaller fraction of He gives better dE/dx sigma and pi/K separation.
- Critical point :

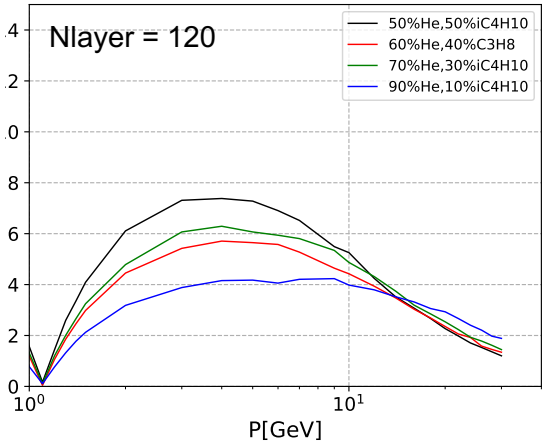
Number of layers	Gas mixture	dE/dx resolution of 20GeV pion (1/2/3 atm)	Separation power of pi/k (1atm)	
			10GeV	20GeV
N = 120	He 50%	2.96% / 2.43% / 2.16%	2.22	1.39
	He 70%	3.32% / 2.72% / 2.42%	2.13	1.46
	He 90%	4.17% / 3.42% / 3.05%	2.11	1.60
N = 150	He 50%	2.64% / 2.16% / 1.92%	2.45	1.53
	He 70%	2.95% / 2.41% / 2.15%	2.33	1.56
	He 90%	3.74% / 3.06% / 2.73%	2.39	1.63

$$\sigma_{dE/dx}(He50) = 10.954 * (N^{-0.50}) * (2.96 - 1.69\cos^4\theta + 1.64\cos^{10}\theta)^* (atm^{-0.286})$$

Pi/K separation

❖ Fixed theta = 90, Nlayer = 120/150





❖ Critical point :

Number of layers	Gas mixture	dN/dx resolution of 20GeV pion (1/2/3 atm)	Separation power of pi/k (1atm)	
			10GeV	20GeV
N = 120	He 50%	1.16% / 1.62% / 1.97%	5.25	2.27
	He 70%	1.43% / 1.56% / 1.28%	4.86	2.53
	He 90%	2.17% / 3.42% / 3.05%	3.98	2.93
N = 150	He 50%	1.06% / 0.83% / 0.69%	5.85	2.42
	He 70%	1.25% / 0.89% / 0.74%	5.52	2.75
	He 90%	1.97% / 1.41% / 1.16%	4.69	3.24

$$\sigma_{dN/dx}(He50) = 11.076 * (N^{-0.48}) * (1.16 - 0.55\cos^4\theta + 2.98\cos^{10}\theta)^* (atm^{-0.48})$$

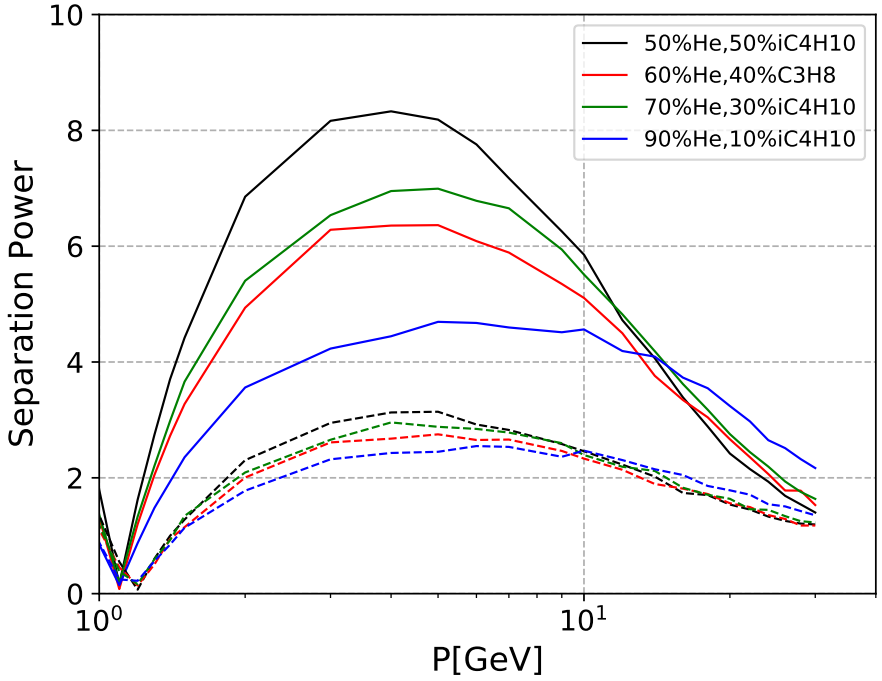
❖ An optimistic estimation : no noise, electronics considered. The cluster counting performance relays on hardware.

Conclusion

- Quenching gas : iC4H10 instead of C3H8
- Studied Nlayers, theta, pressure, dependence, the expected resolution could be calculated using the parameterized function.
- 2.64% dE/dx resolution and 2.45 sigma k/pi separation at 10GeV could be achieved with Nlayer = 150, 50% He 50 iC4H10 gas mixture.

Backup

- K/pi separation for different gas.



Backup

❖ K/pi separation for different gas pressure.(%50 He)