Tracker optimization for the Fourth Detector Concept of CEPC

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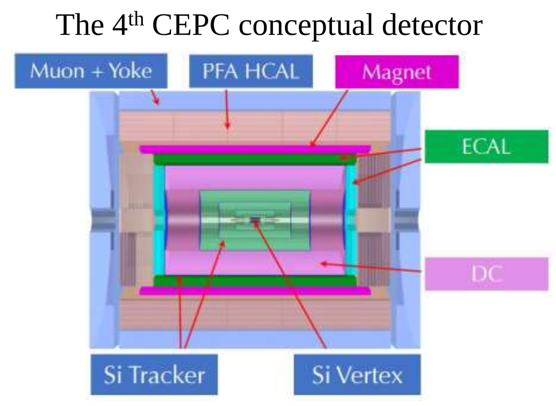
1.Abstract

The tracking system of the fourth conceptual detector at CEPC consists of a silicon pixel vertex detector, a silicon tracker of HV-CMOS, and a drift chamber (DC). In addition to tracking, the DC plays an important role in particle identification which is essential for flavour physics programme. The layout design will be a trade-off between optimal tracking and PID performance. Large DC volume will benefit identification of various hadrons, but should not cost deterioration of momentum resolution of tracks. The study of **tracking performance** as function of CEPC **DC volume** is necessary, using two fast-simulation tool and two full-simulation tools validating each other.

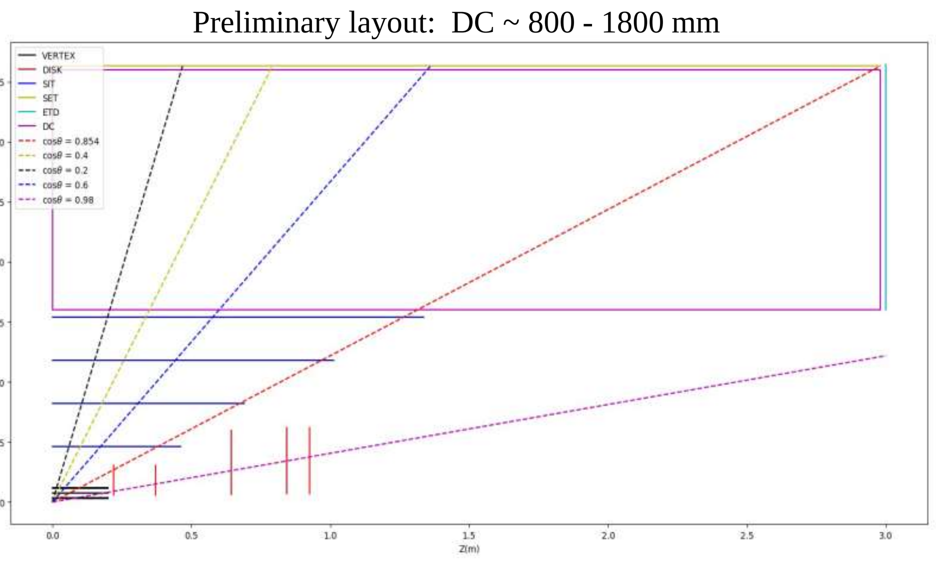
2.Introduction

- Tracking system consists with a silicon pixel vertex detector(VXD), a silicon tracker (SIT and SET) of HV-CMOS, and a drift chamber (DC)
  - ☐ Particle ID with a drift chamber is a key feature for the 4th conceptual detector
  - ☐ Most hadrons (K/pi) of CEPC are below 20 GeV/c
  - ☐ The tracker must have sufficient good momentum resolution for tracks < 20 GeV/c (flavor and jet study)
  - ☐ VXD has already been optimized by others

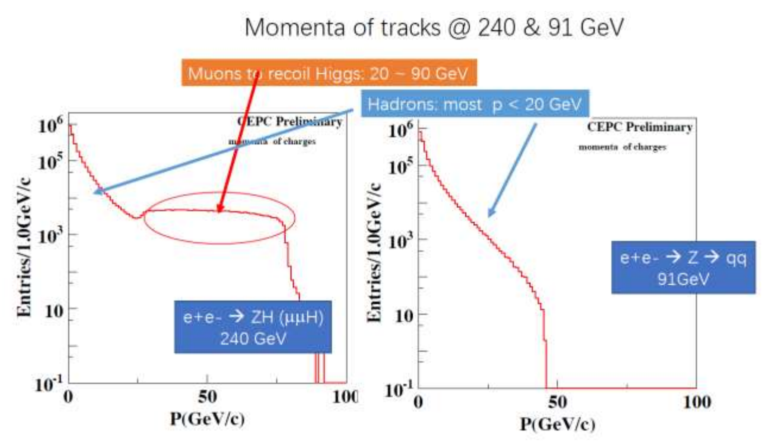
The 4[th] CEPC conceptual detector



Preliminary layout: DC ~ 800 - 1800 mm



Momenta of tracks @ 240 & 91 GeV

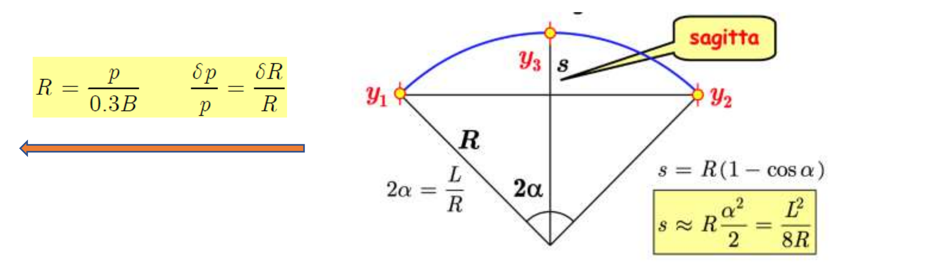


- Tools used for calculation & simulation
  - ☐ Two fast tools
    - Analytic calculation based on python developed by Gang Li et al
    - LDT: a matlab fast simulation package developed by Wiener group
  - ☐ Full simulation implemented in CEPCSW, CKF (Combined Kalman Filter) is used to track finding, reconstructed by
    - GenFit: developed by Yao Zhang et al
    - MarlinTrk: ILCSoft tracking maintained by Chengdong Fu

3. Momentum Uncertainty

- Momentum error -Sagitta measurement without multiple scattering

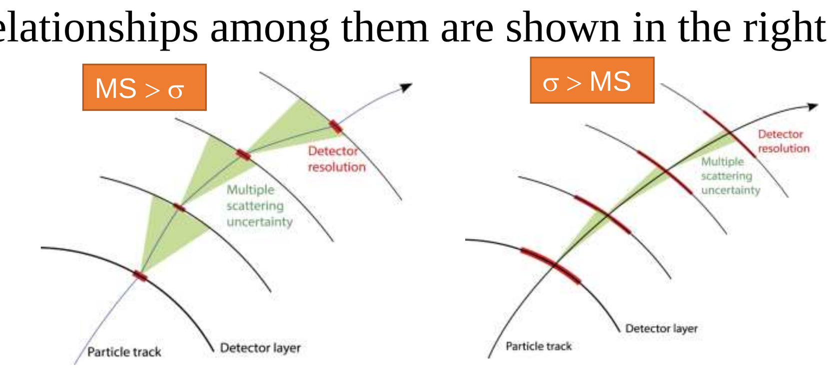
$$\frac{\delta p}{p} = \frac{8p\sigma_{r\phi}}{0.3BL^2}$$

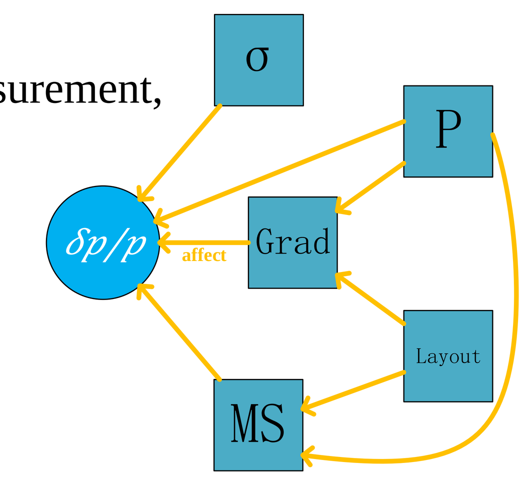


$$s = y_3 - \frac{y_1 + y_2}{2}$$

$$\delta s = \delta y_3 - \frac{1}{2}\delta y_1 - \frac{1}{2}\delta y_2$$

- ☐ Important features：
  - the percentage error is proportional to the p itself
  - the error is inversely proportional to B
  - the error is inversely proportional to 1/L2
  - the error is proportional to spatial resolution
- ☐ The error on the radius is related to the sagitta error→momentum error, and it's easy to get the relationship between sagitta and the 3 measurements:
  - Necessary to have more measurements at the middle for better resolution
  - The optimal allocation of measurements is 1:2:1
- Momentum error with multiple scattering (MS)
  - ☐ It is found to be complicated, when considering more factors on the momentum measurement.
  - ☐ The left figures indicate that the MS affect the tracks, and the MS was influenced by the amount of materials, layout, momentum, and so on
  - ☐ There are quite a few factors affect the momentum measurement, the relationships among them are shown in the right

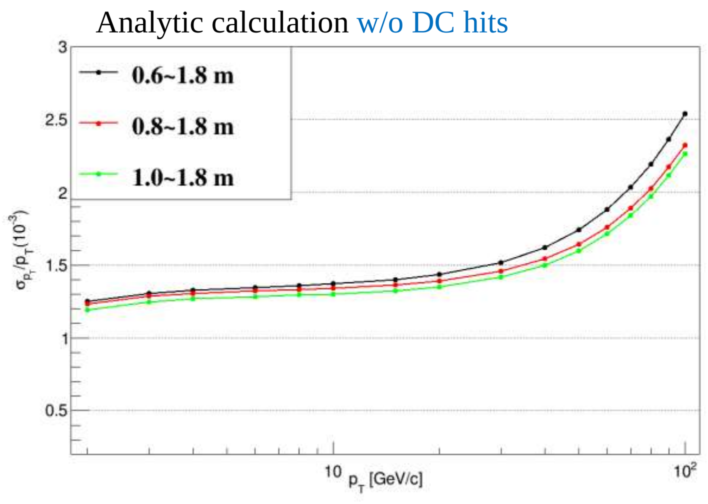




4. Preliminary Results

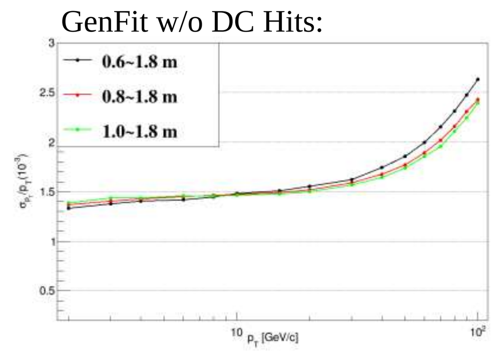
- Without DC hits

Analytic calculation w/o DC hits

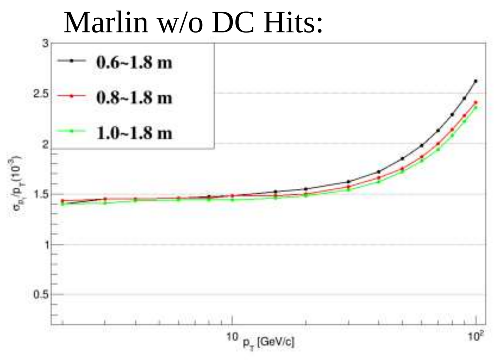


- ☐ Analytic calculation comparison w/o DC hits
  - The three lines has a small difference without DC hits but with DC materials
  - SIT's location has a small effect on momentum measurement
  - DC inner radius at 1.0m is better than 0.6 or 0.8m

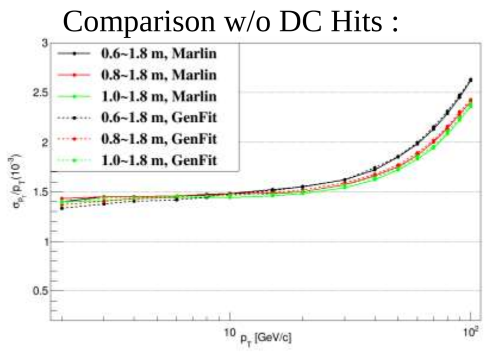
GenFit w/o DC Hits:



Marlin w/o DC Hits:



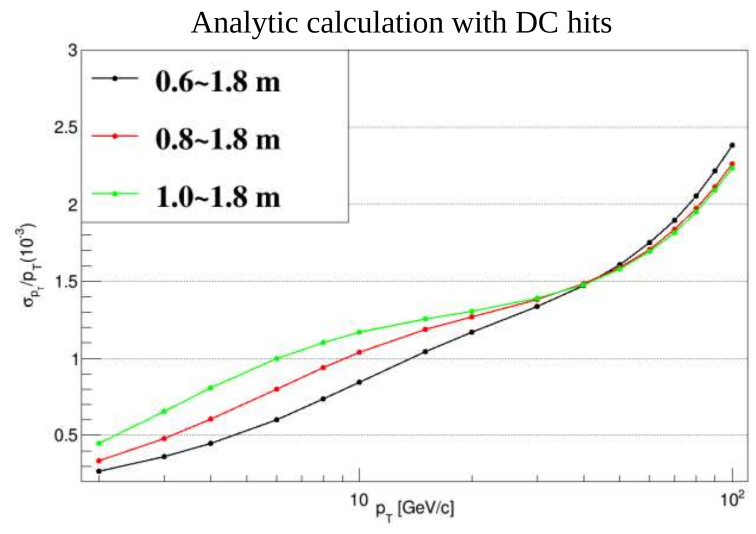
Comparison w/o DC Hits :



- ☐ Validation: GenFit and MarlinTrk, w/o DC Hits
  - The results are very similar when we don't use the DC hits,
  - There are a little differences between these two, especially at low momentum

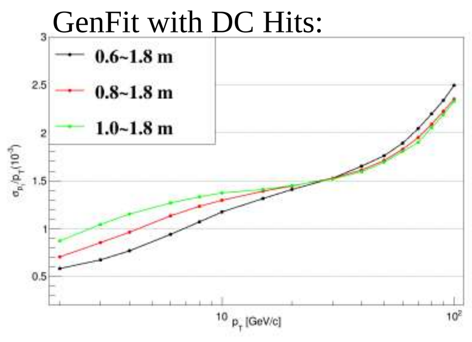
- With DC hits

Analytic calculation with DC hits

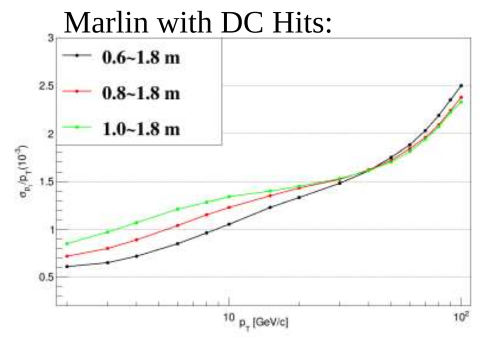


- ☐ Analytic calculation with DC hits
  - The difference becomes **more significant** when DC Hits are used, in particular at low momentum
  - DC inner radius at 0.6m is better for tracks < 40 GeV/c

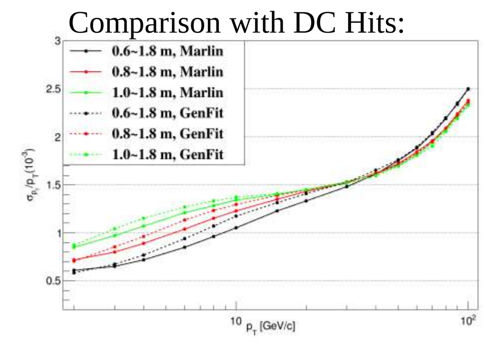
GenFit with DC Hits:



Marlin with DC Hits:



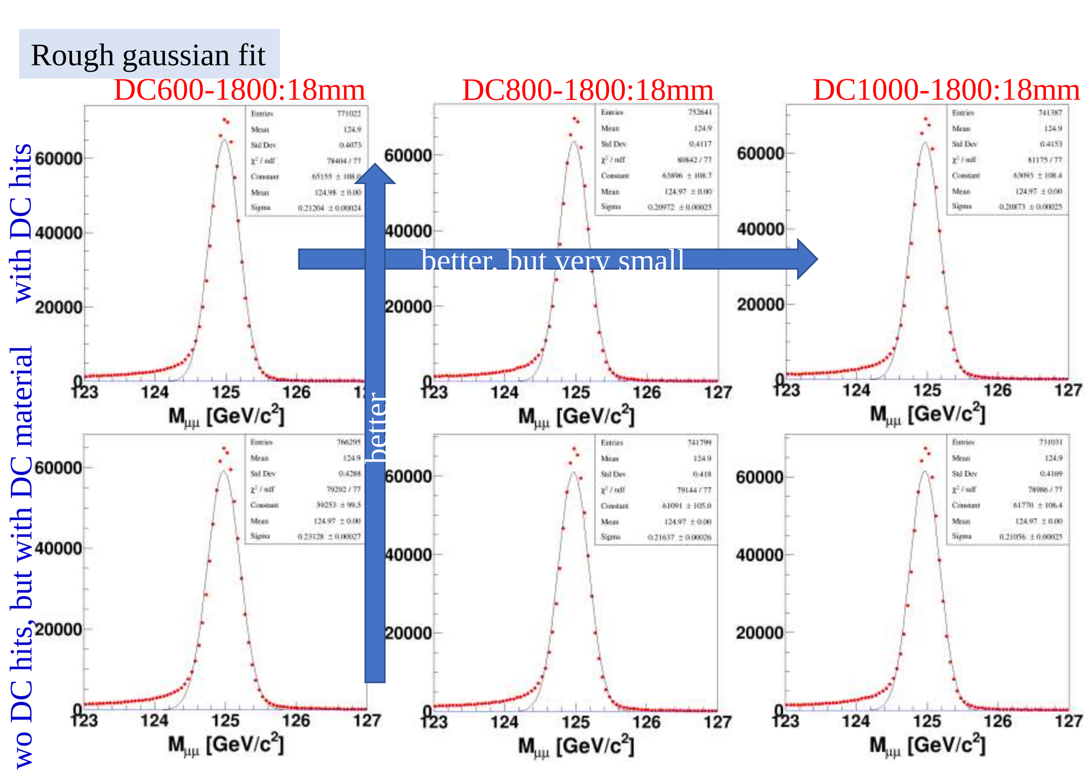
Comparison with DC Hits:



- ☐ Validation: GenFit and MarlinTrk , with DC Hits
  - The difference becomes **more significant** when DC Hits are used, in particular at low momentum
  - The results of other simulations are consistent with the analytic calculation

5. Physics Performance

- Resolution of Higgs Mass (H→μμ)



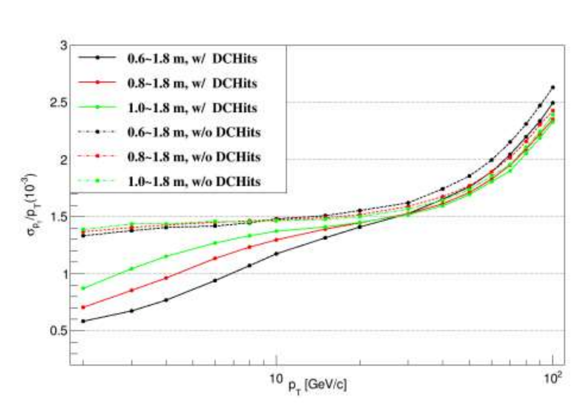
The sigmas of Higgs Mass (H→μμ)

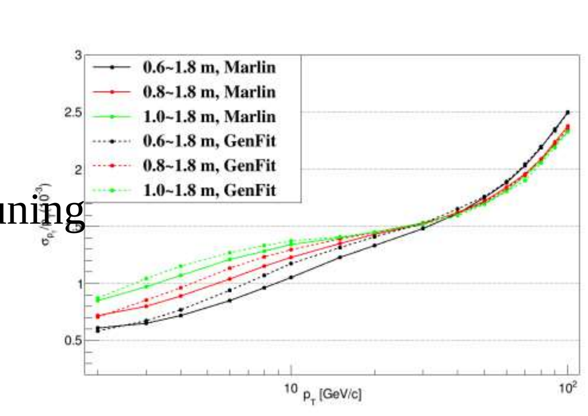
DC volume	0.6-1.8(m)	0.8-1.8(m)	1.0-1.8(m)
w/ DCHits(GeV)	0.212	0.210	0.209
w/o DCHits(GeV)	0.231	0.216	0.211

- ☐ For Higgs physics(at high momentum), the DC volume has little effect on momentum measurement
- ☐ Using DC will significantly improve higgs momentum measurement

6. Conclusion & Discussion

- Comments on tools
  - ☐ Good agreement between AnaCalc & LDT
  - ☐ Good agreement between GenFit and MarlinTrk w/o DC
  - ☐ Rough agreement between GenFit and MarlinTrks w/ DC
  - ☐ **All trends of different tools are consistent**
- Preliminary conclusion
  - ☐ DC useful for momentum measurement
    - Shapes and trends are constantly consistent for all results
    - More consistent results of different methods need more tuning
  - ☐ Larger DC favored by low momentum (<20 GeV) tracks
  - ☐ Larger DC also benefits PID





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