

Status of dN/dx in CEPCSW

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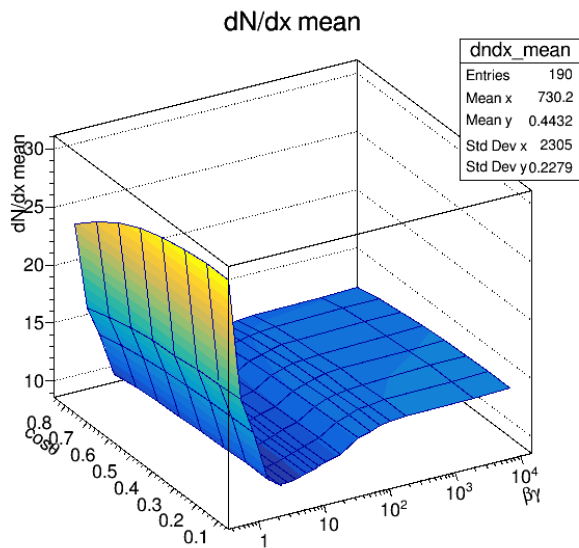
Introduction

- **Detector simulation/reconstruction in CEPCSW is an essential task for CEPC TDR study**
- **CEPCSW release plan in May (tdr 24.5)**
 - PID software: **dN/dx (TPC, DCH)**, ToF
 - Muon software
- **Goal: Implement dN/dx model in CEPCSW**
 - Method: Track-level parameterization → provide valid PID information for physics analysis
 - Merge request #33: [dN/dx for TPC and DCH \(!33\) · Merge requests](#)

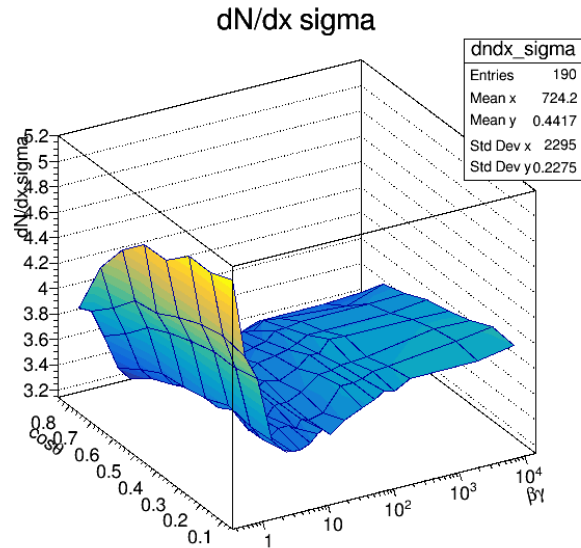
dN/dx model in CEPCSW

- **Track-level dN/dx by parameterization** from Garfield++-based full simulation
 - dN/dx mean vs. $\beta\gamma$ and $\cos\theta$
 - dN/dx sigma vs. $\beta\gamma$ and $\cos\theta$ (for 1 cm track length)
- **Track length** calculation based on reconstructed track helices

TPC

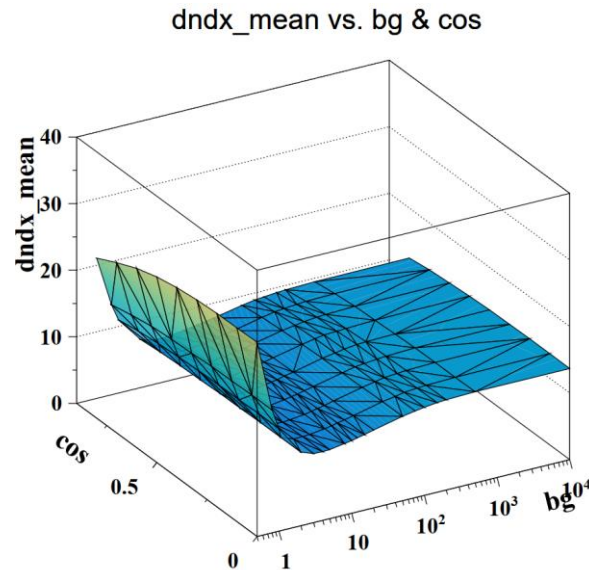


dN/dx mean

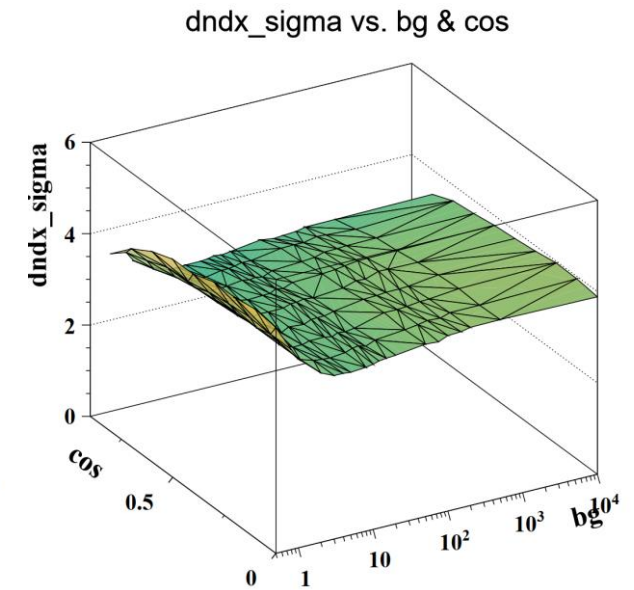


dN/dx sigma

DCH



dN/dx mean



dN/dx sigma³

dN/dx model in CEPCSW (II)

- dN/dx calculation

- Sampling dN/dx from the mean and sigma functions, under (e, μ, π, K, p) hypotheses:
 - $\mu_{dN/dx} = f(\beta\gamma, \cos \theta)$
 - $\sigma_{dN/dx} = g(\beta\gamma, \cos \theta) / \sqrt{L}$

- Event data model in EDM4HEP: **edm4hep::RecDqdx**

```
edm4hep::RecDqdx:  
Description: "dN/dx or dE/dx info of Track."  
Author: "EDM4hep authors"  
Members:  
- edm4hep::Quantity dQdx // the reconstructed dEdx or dNdx and its error  
- int16_t particleType // particle type, e(0),mu(1),pi(2),K(3),p(4)  
- int16_t type // type  
- std::array<edm4hep::Hypothesis, 5> hypotheses // 5 particle hypothesis  
VectorMembers:  
- edm4hep::HitLevelData hitData // hit level data  
OneToOneRelations:  
- edm4hep::Track track // the corresponding track
```

➡ Measured dN/dx

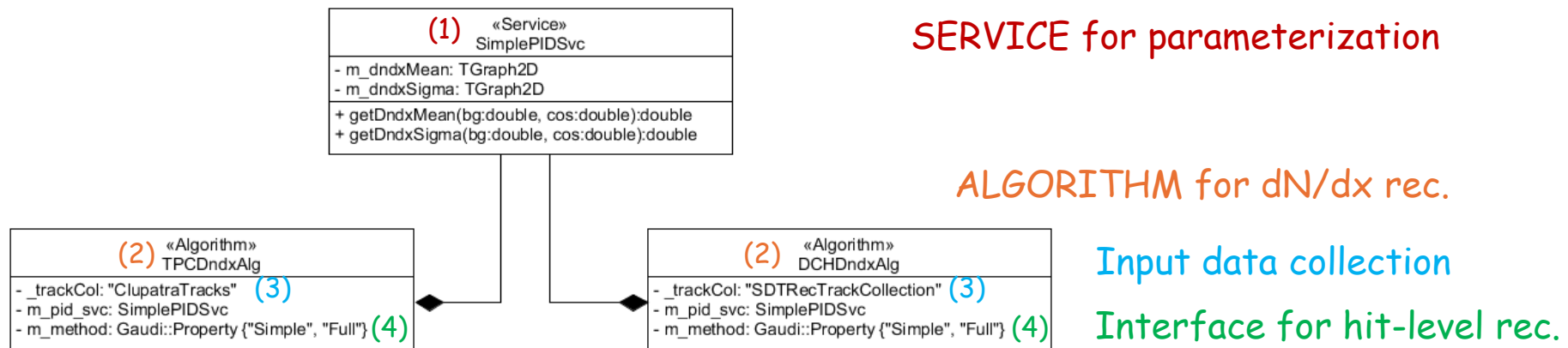
➡ Expected dN/dx (e, μ, π, K, p) and

$$\chi_{dN/dx} = \frac{dN/dx_{mean} - dN/dx_{exp}}{\sigma_{exp}}$$

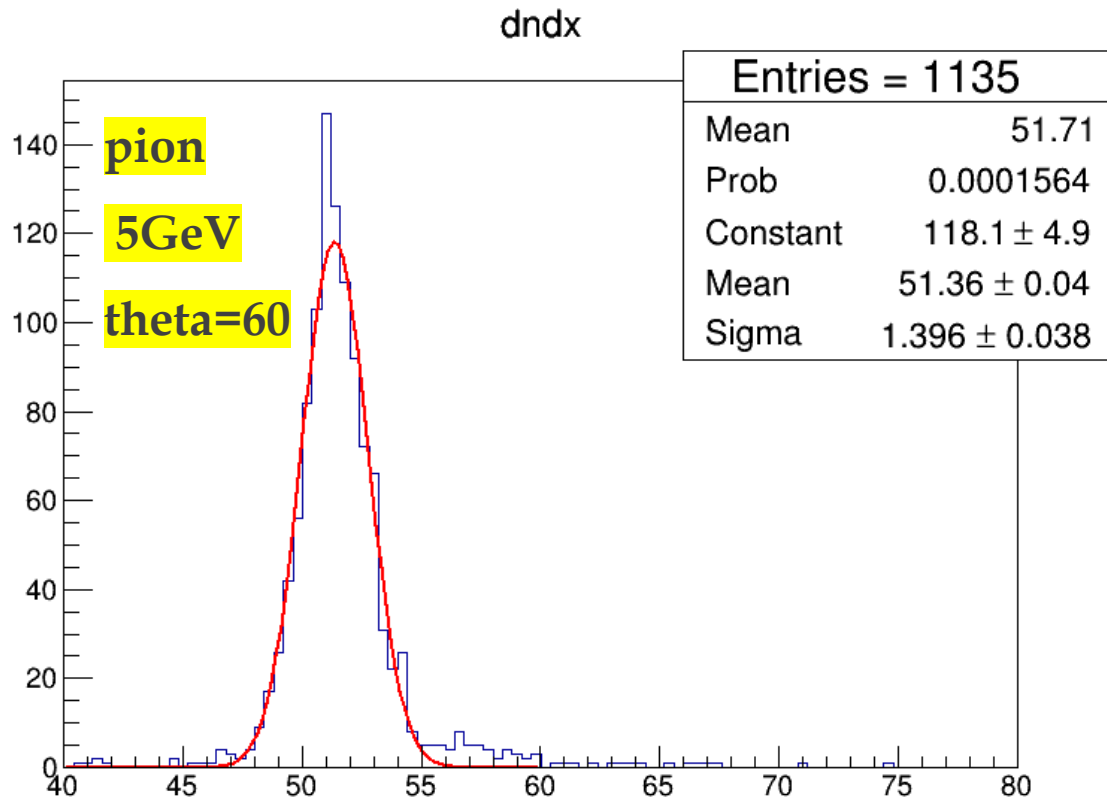
➡ $\chi_{dN/dx}$ for further particle identification

CEPCSW Implementation

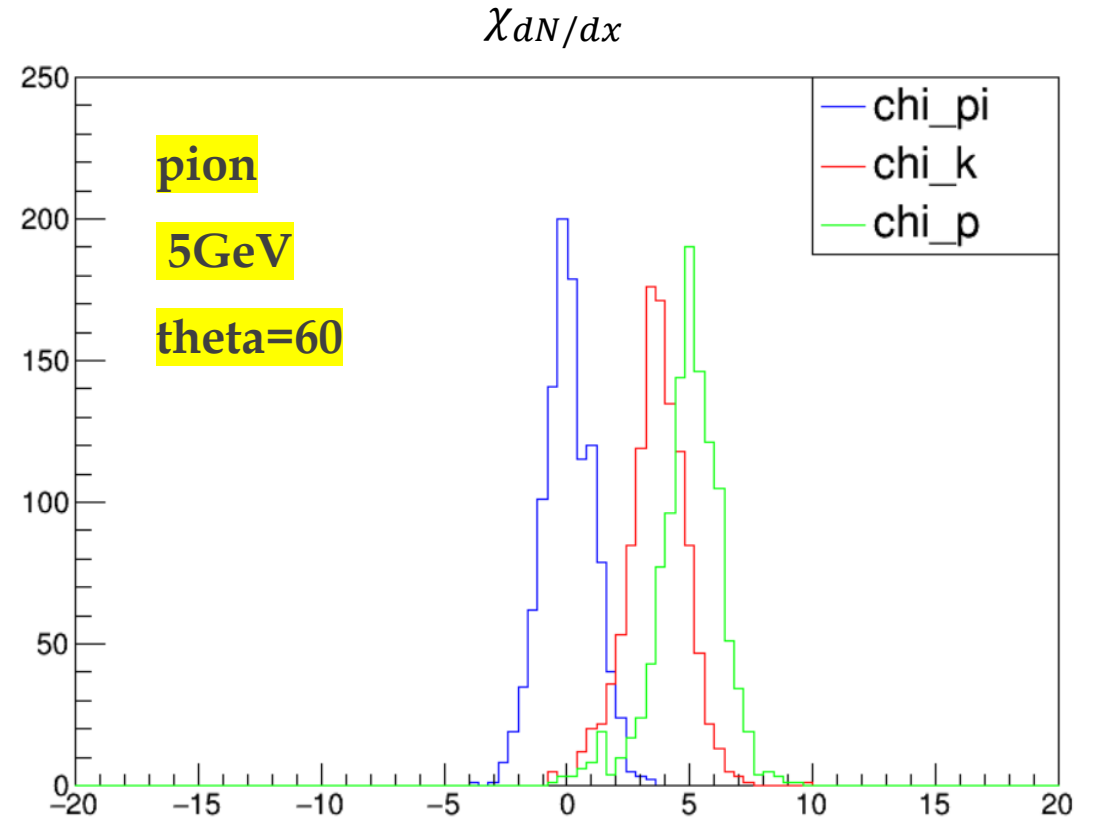
- **Developed 2 Gaudi ALGORITHMs** for TPC and DCH dN/dx reconstruction
 - TPC and DCH have different readout schemas
- **Developed a single Gaudi SERVICE** for the track-level parameterization
 - For track-level reconstruction, TPC and DCH have the same parameterization interface
- **Reserved an interface** for future hit-level reconstruction
 - Configured by the Gaudi Property



Performance checks (TPC)

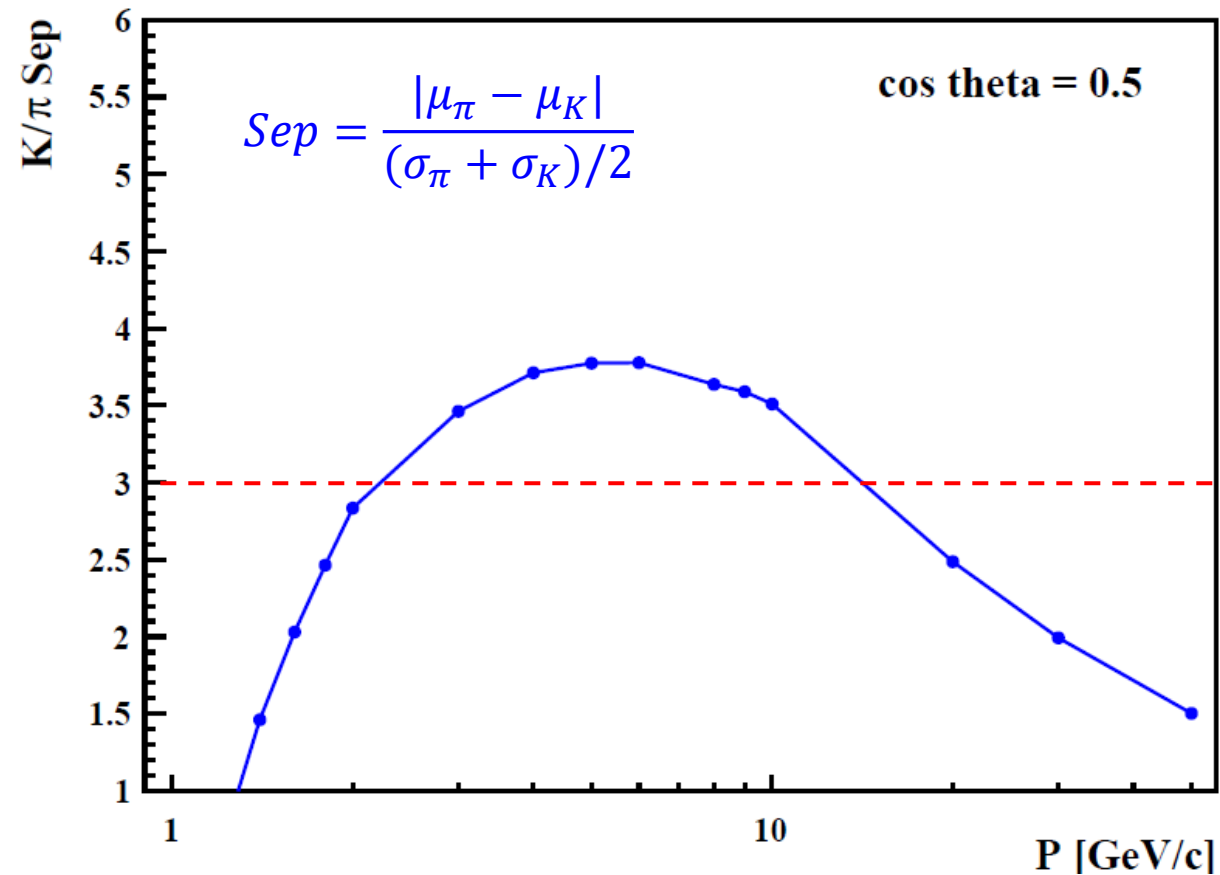


Relative resolution: $\sim 2.7\%$ (Sigma/Mean)



χ with pion (correct) hypothesis is centered around 0

Performance checks (TPC) (II)



Remarks:

- Overall K/pi separation power tendency is reasonable. Good PID power for [2, 20] GeV/c tracks.
- K/pi separation power @ 20 GeV/c could not achieve 3σ , because
 - efficiency depend on drift distance, need calibration
 - current geometry has a large non-sensitive region ($R_{\text{first}} = 65.8$ cm, $R_{\text{last}} = 170.2$ cm), will be updated soon

Summary and outlook

- **Implemented the dN/dx model for TPC and DCH in CEPCSW. Tests show reasonable performance. A merge request is created.**
- **Plans:**
 - More tests for samples with more polar angles
 - Calibration the efficiency dependence on drift distances
 - Pad-size optimization
 - More sophisticated reconstruction; consider to combine dE/dx and dN/dx
 - Hit-level implementation in future CEPCSW versions