

Status of CEPC Drift Chamber Software

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on behalf of CEPC drift chamber software group

IHEP

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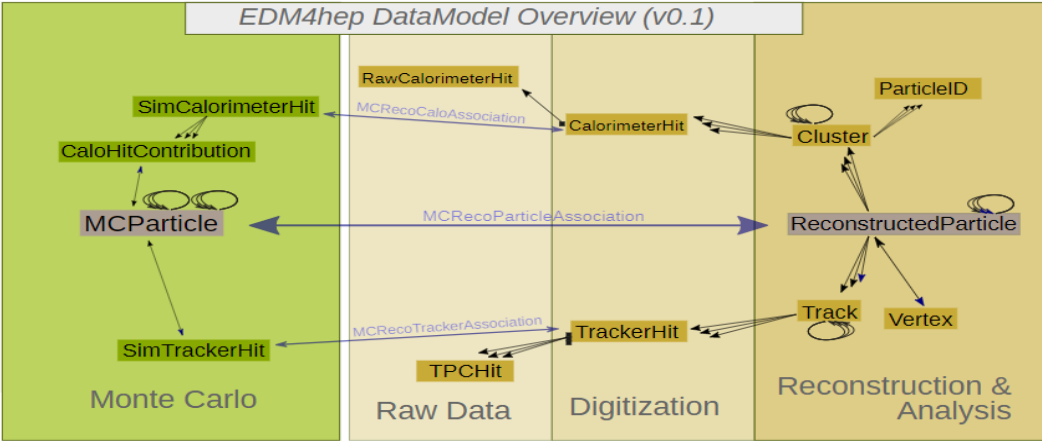
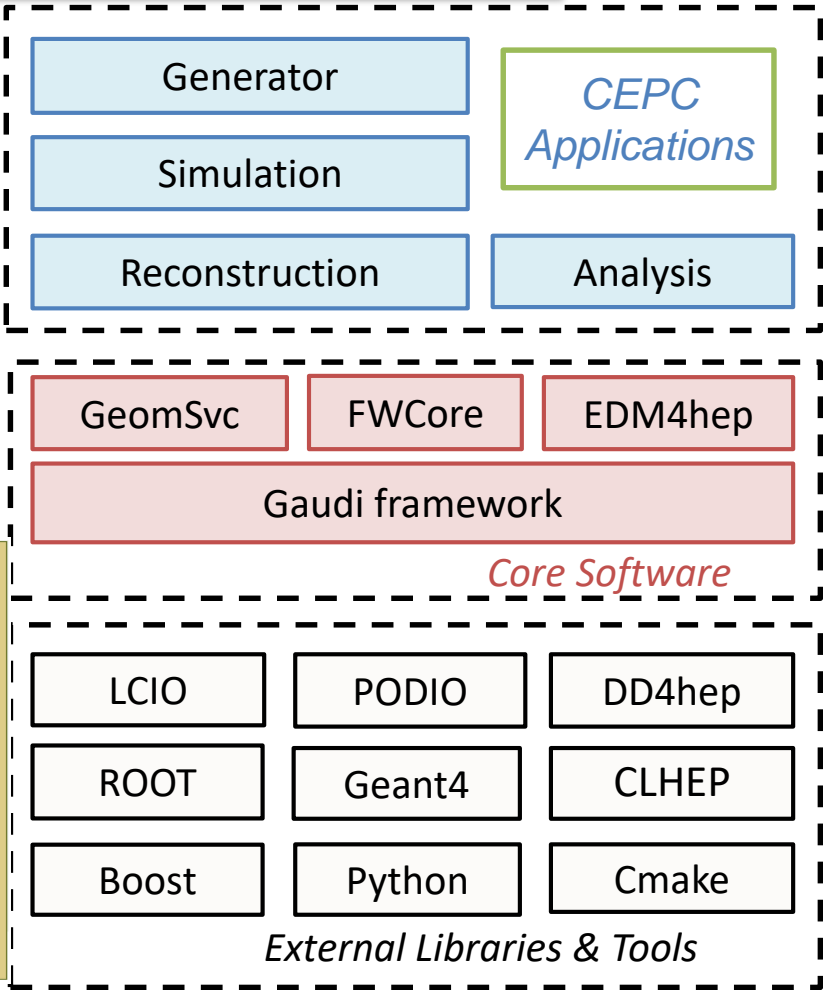
CEPC Drift Chamber(DC) software

- Drift chamber is one of the components of CEPC Reference Detector (CRD)
- Motivation
 - Provide good PID with **dE/dx resolution better than 2%**
 - A demonstration for the development of CEPC offline software
- **The drift chamber software has been developed from nothing**
- Requirements for drift chamber software
 - Configurable simulation
 - Adaptive tracking
 - Track length measurement with high precision for dE/dx
- Manpower
 - IHEP(6): Y. Zhang, T. Lin, W. X. Fang, C. D. Fu, Y. Yuan, W. D. Li
 - SDU(3): M. Y. Liu, X. Y. Zhang, X. T. Huang



Implementation of drift chamber in CEPCSW

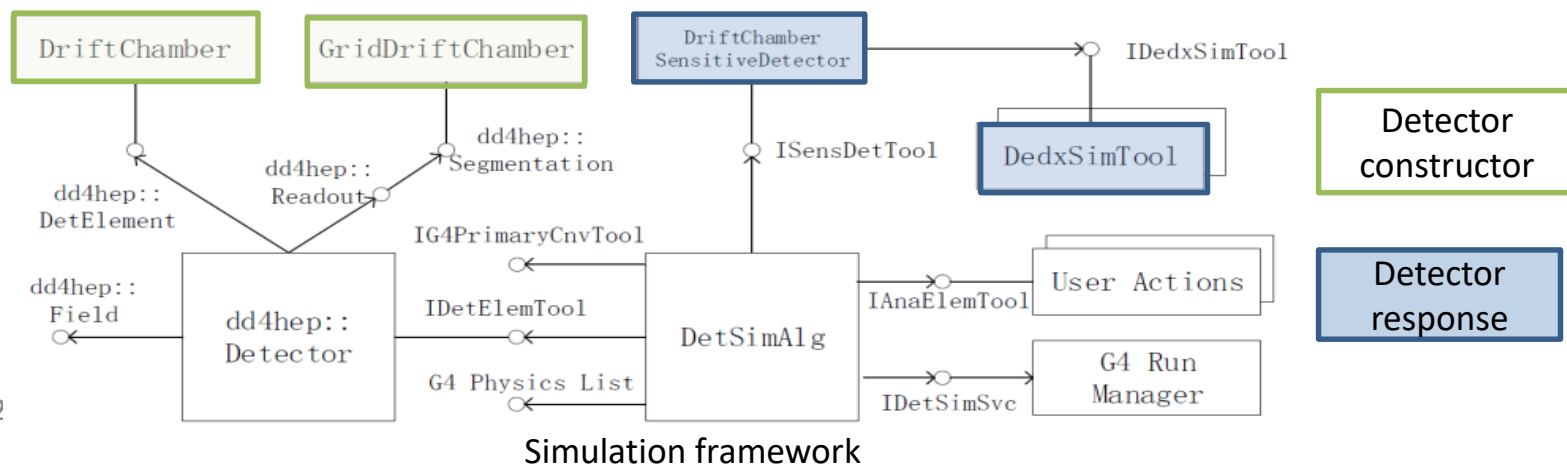
- CEPCSW:
 - Gaudi based framework
 - External libraries and tools
- Geometry : DD4hep
- Data model: EDM4hep and FWCore



<https://github.com/cepc/CEPCSW>

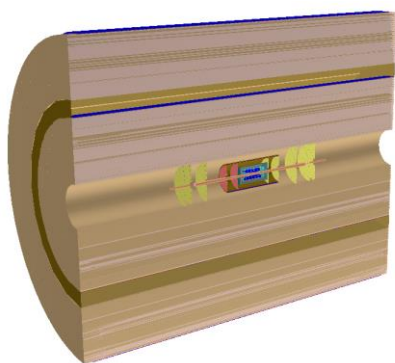
Simulation(I)

- The simulation of DC is implemented in the simulation framework
- **Detector description**
 - Following the common scheme for detector description
 - Following naming convention of CEPCSW
 - XML based compact files for drift chamber detector description:
 - DC : Detector/DetDriftChamber/compact/det.xml
 - CRD: Detector/DetCRD/compact/CRD_o1_v01/CRD_o1_v01.xml
 - DC constructor (two versions -- axial and stereo layers) :
 - Detector/DetDriftChamber/src/driftchamber/DriftChamber.cpp
 - Detector/DetSegmentation/src/GridDriftChamber.cpp
 - Cell partitioning with the segmentation method (consistent with tracking)

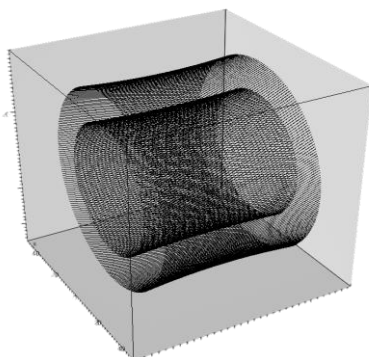


Simulation(II)

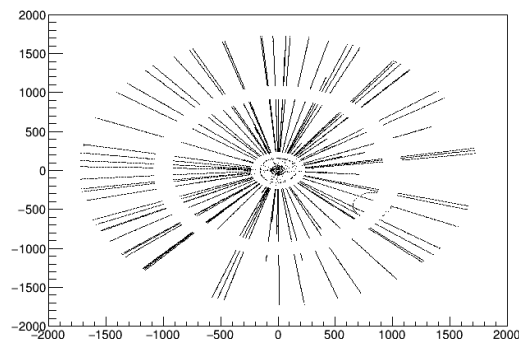
- **Detector response**
 - One MC hit is generated for each G4Step
 - dE/dx : deposite energy of the hit
 - dN/dx : Geant4 PAI physics list could be used in the DC region
 - Association between MC hits and primary MC particles are recorded
 - Both material and BField effects are taken into account by G4
- **Baseline configuration**
 - Two drift chambers with silicon layers
 - Radius **1.8m**, **130** layers, He: iC_4H_{10} =**90:10**



CEPC axial drift chamber with silicon layers



A view of two stereo layers in DC

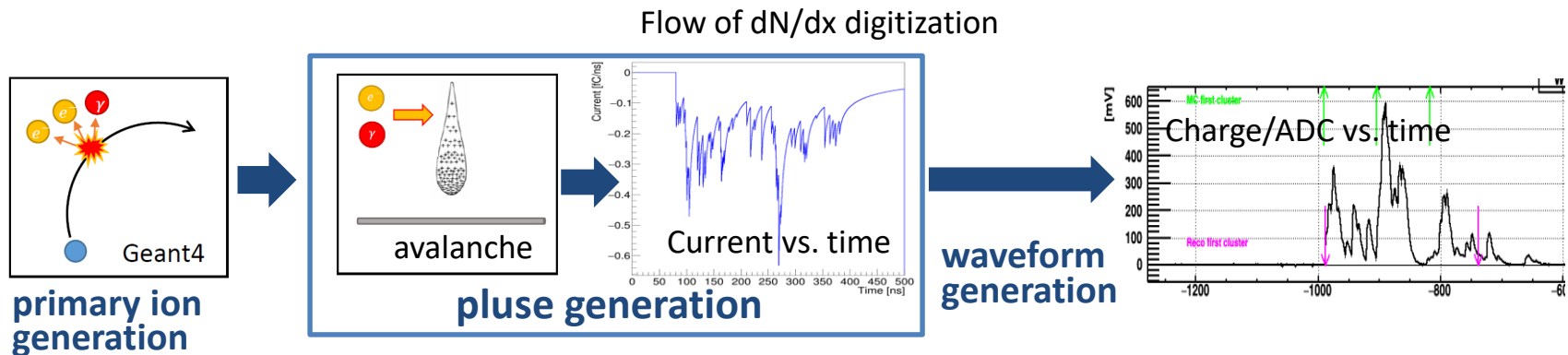


Display of MC hits in DC and silicon



Digitization

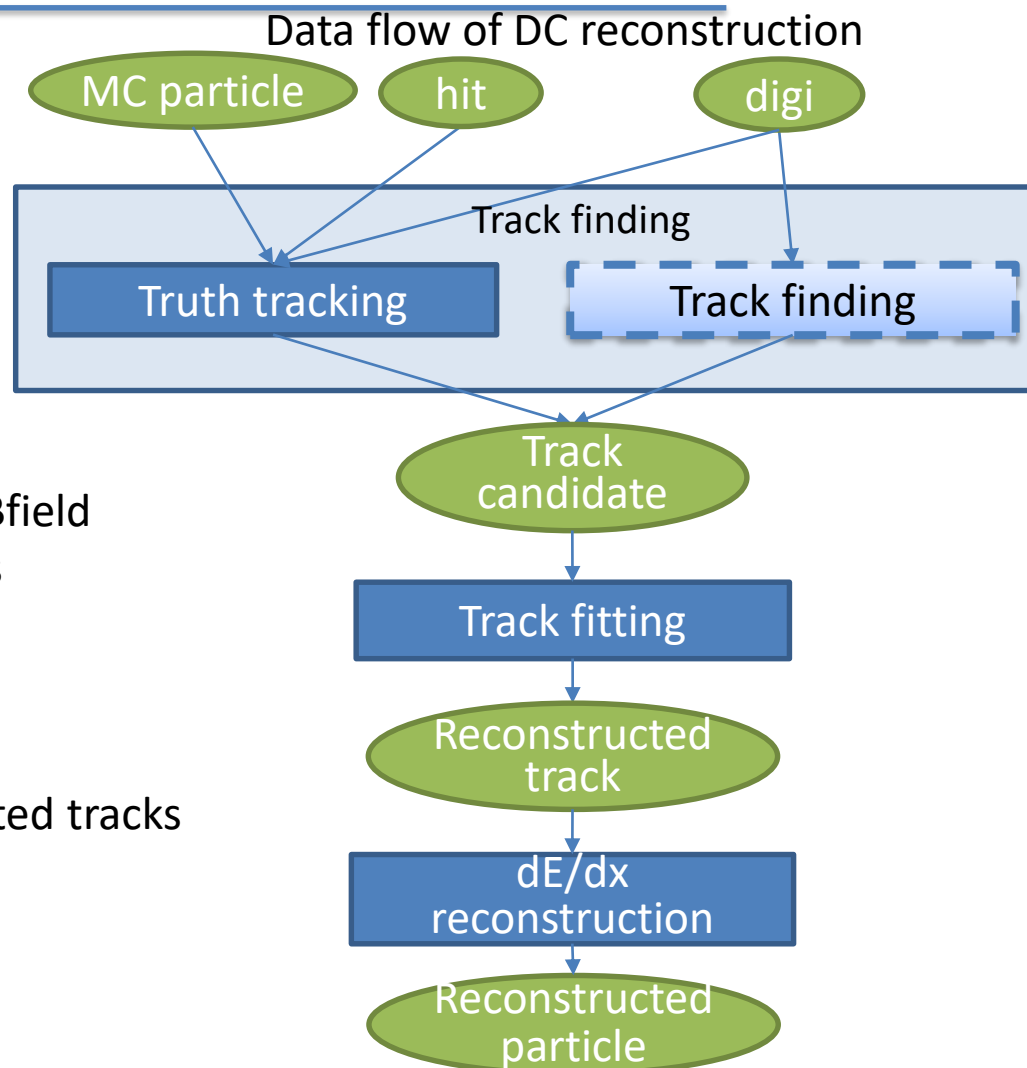
- Simplified digitization
 - Constant X-T ($V_{\text{drift}}=40\mu\text{m/ns}$) and fixed spatial resolution ($110\mu\text{m}$)
- dN/dx digitization
 1. **Pulse generation**: sampling from dN/dx model or Garfield++
 2. **Waveform generation**: electronics simulation and dark noise etc.





Reconstruction

- Track finding
 - Truth tracking has been realized
 - Track finding algorithm is in the plan
- Track fitting
 - Consider material and non-uniform Bfield effects for different types of particles
- dE/dx reconstruction
 - Provide dE/dx (dN/dx) of reconstructed tracks





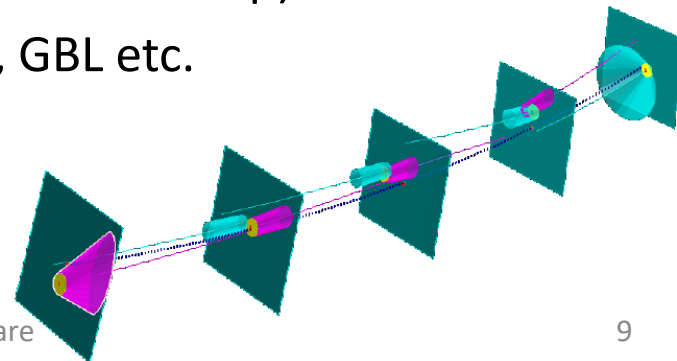
Track finding

- TruthTracker algorithm: tracking based on MC truth information
 - An algorithm implemented in CEPCSW framework
 - Use EDM4hep event model
 - Geometry get through GeomSvc
 - A fake track finding
 - Digi selection: Create digi list according to the relation between MC particles and hits
 - Track candidate: Smear track momentum
- Track finding plan
 1. DC track following method use track seed from silicon detector
 2. DC self track finding
 3. Combine silicon and DC tracking



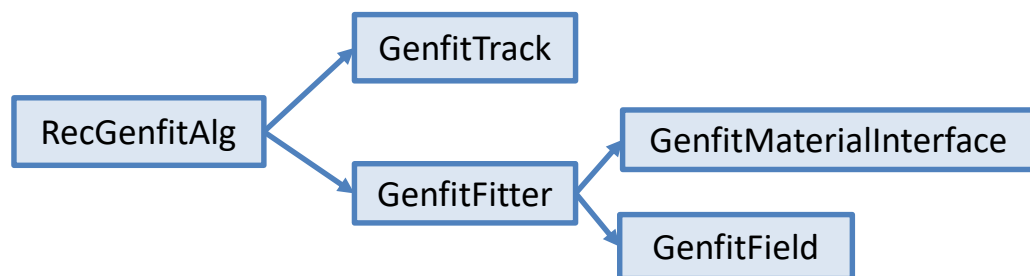
Track fitting(I)

- Based on Genfit <https://github.com/GenFit/GenFit/>
 - An experiment-independent **generic track fitting** framework
 - Open sourced, active development and large user community
 - **Official track fitting for BelleII**, also used by PANDA, COMET, GEM-TPC etc.
 - **We have join the development of Genfit**
- Main features of Genfit
 - **Supporting detector types:**
 - pixel, strip, TPC, drift chamber or tube and combinations of above
 - Detector geometry: ROOT(easy to integrate with DD4hep)
 - Various fitting algorithms: Kalman filter, DAF, GBL etc.
 - Extrapolation tools

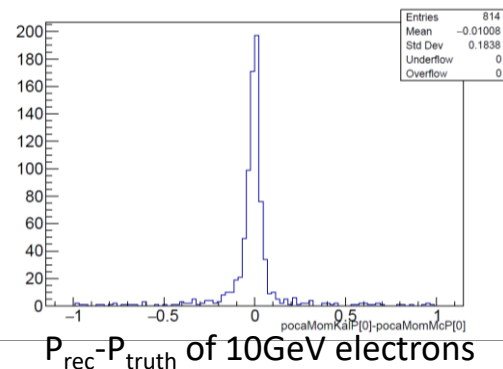


Track fitting(II)

- Integration with Genfit
 - Implemented `Genfitfield` class to get BField from DD4hep
 - Implemented `GenfitMaterialInterface` class to get material and geometry from DD4hep
 - A track converter with `GenfitTrack` with EDM4hep and do unit conversion
 - A wrapper class `GenfitFitter` to the Genfit track fitters
- RecGenfitAlg algorithm: track fitting using Genfit
 1. Fitting with MC truth hit
 2. Combination fitting of silicon and drift chamber

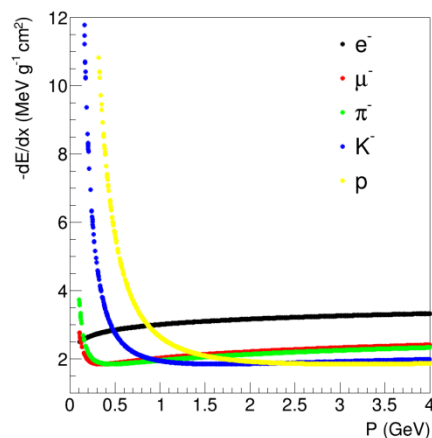


Interface classes to the Genfit in CEPSCSW



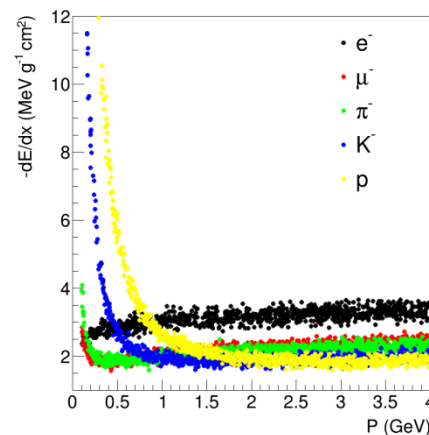
dE/dx reconstruction

- Dummy algorithm for dE/dx reconstruction
 - Get primary MC particle information of reconstructed track and do sampling based on Bethe-Bloch equation
- Plan
 - Calculate dE/dx of tracker hit from reconstructed track and use truncate mean method to get dE/dx



dE/dx from Bethe-Bloch equation.

5% smeared



= Release plan

	Tasks	V0	V1	v2
Detector description	DC axial layers			
	DC stereo layers			
Simulation & digitization	Track level dE/dx sampling with modeling			
	Track level dN/dx sampling with modeling			
	Waveform digitization			
Track finding	Truth tracker			
	Track following with seed			
Track fitting	Fitting with truth information			
	Fitting with DC measurement			
	Combined fitting with DC and silicon			

done

ongoing

Not implement

= Summary

- Significant progresses have been made for drift chamber software:
 - The DC simulation has been implemented, including dE/dx
 - The simplified digitization has been implemented
 - Truth tracker algorithm has been developed
 - The integration with Genfit has completed
 - A dummy dE/dx reconstruction algorithm has been developed
- Two software versions will be released soon:
 1. An axial drift chamber with truth tracking
 2. A stereo drift chamber with truth tracking and track fitting using DC hits

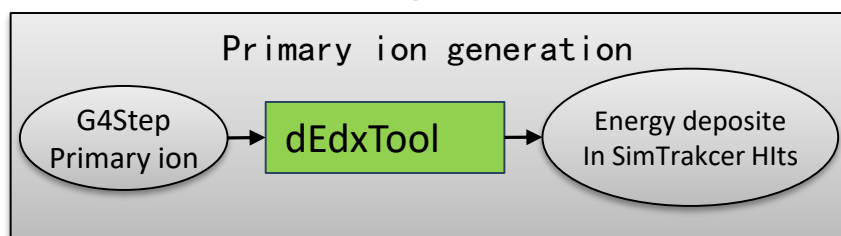


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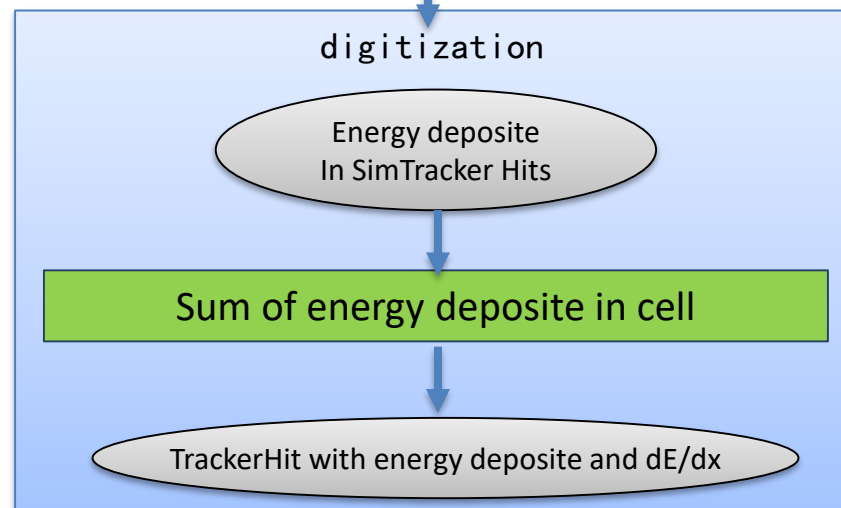
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Data flow of digitization

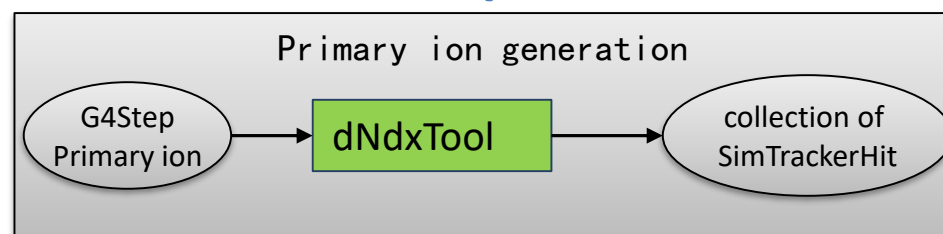
dE/dx



digitization



dN/dx



digitization

