Status of CEPCSW

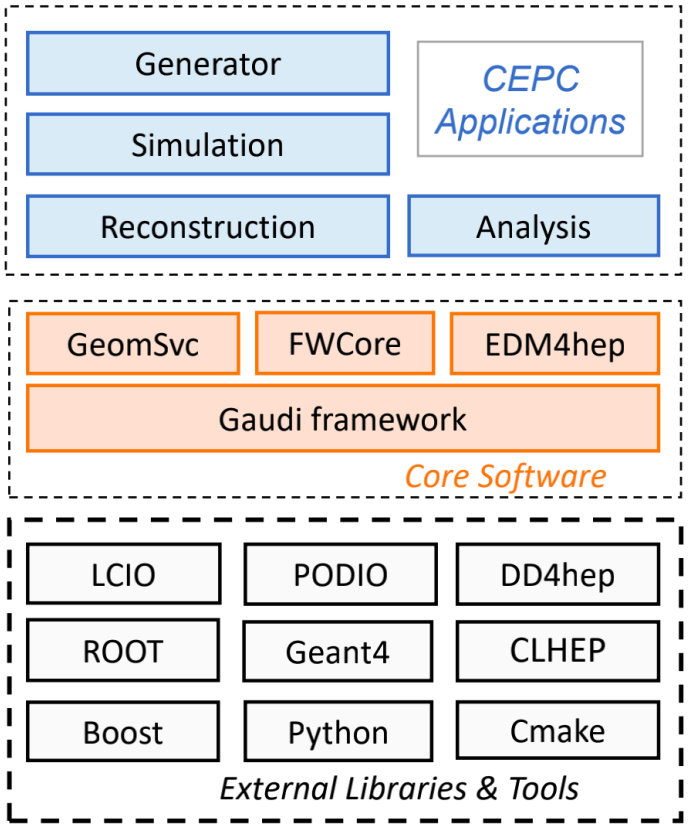
Collaborative R&D Meeting

9 Aug 2024

Overview of CEPCSW

- CEPCSW software structure
  - Applications: simulation, reconstruction and analysis
  - Core software
  - External libraries
- Key components of core software
  - Gaudi: defines interfaces to all software components and controls their execution
  - EDM4hep: generic event data model
  - K4FWCore: manages the event data
  - DD4hep: geometry description
  - CEPC-specific framework software: generator, Geant4 simulation, beam background mixing, fast simulation, machine learning interface, etc.

Key4hep based software stack



https://code.ihep.ac.cn/cepc/CEPCSW

Detector Description

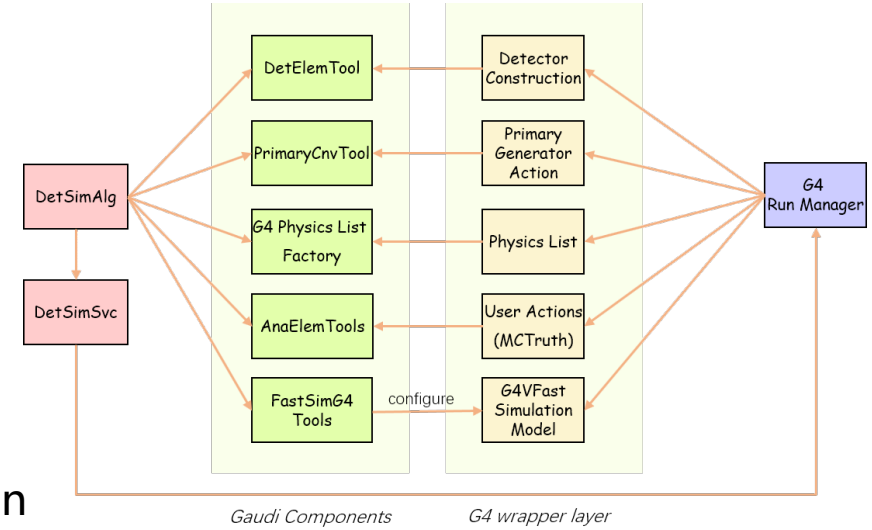
- DD4hep is adopted to provide the full detector description with a single source of information.
- Different detector options are managed in a git repository.
  - Easy to setup detectors and compare between different options.
- Available options in CEPCSW
  - CEPCv4: baseline detector in Conceptual Design Report
  - TDR: The TDR Detector

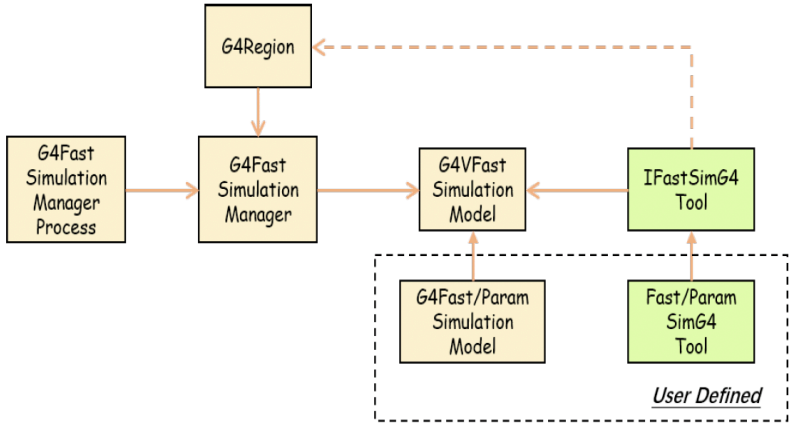
Geometry: Chengdong Fu

Model	Description	MainTracker	Ecal	Hcal	Status
TDR_o1_v01	long barrel vertex, TPC	SIT+TPC+SET	crystal	Glass	developing
TDR_o1_v02	short barrel vertex, TPC	SIT+TPC+SET	crystal	Glass	developing
TDR_o2_v01	long barrel vertex, DC	SIT+DC +SET	crystal	Glass	developing
TDR_o2_v02	short barrel vertex, DC	SIT+DC +SET	crystal	Glass	developing

Detector Simulation

- Full detector simulation has been developed based on Geant4.
  - A unified simulation framework: integrate Geant4 and Gaudi.
  - Event data: SimTrackerHit and SimCalorimeterHit
  - Generator interfaces: HepMC, LCIO, StdHep, Beam background, Particle Gun
  - Fast simulation interfaces: Geant4 Region based.
  - Detector responses: trackers, DC, TPC, calorimeter
  - Monte Carlo truth: association between hits and MC particles
- The background mixing algorithm is based on hit level mixing.





Reconstruction

- Existing algorithms are migrated from Marlin to CEPCSW.
- New reconstruction algorithms are developed as well.

Detector	Package	Status
Silicon	SiliconTracking	Migration Done
	ForwardTracking	Migration Done
	TrackSubset	Migration Done
	FullLDCTracking	Migration Done
TPC	Clupatra	Migration Done
DC	RecGenfitAlg	Under development
ECAL/HCAL	CRDEcalRec	Under development
Muon		Under development

Towards Reference Detector TDR

- Motivation
  - Support the fast iterations of the reference detector design.
  - Release the latest versions of detectors to support physics and performance studies.

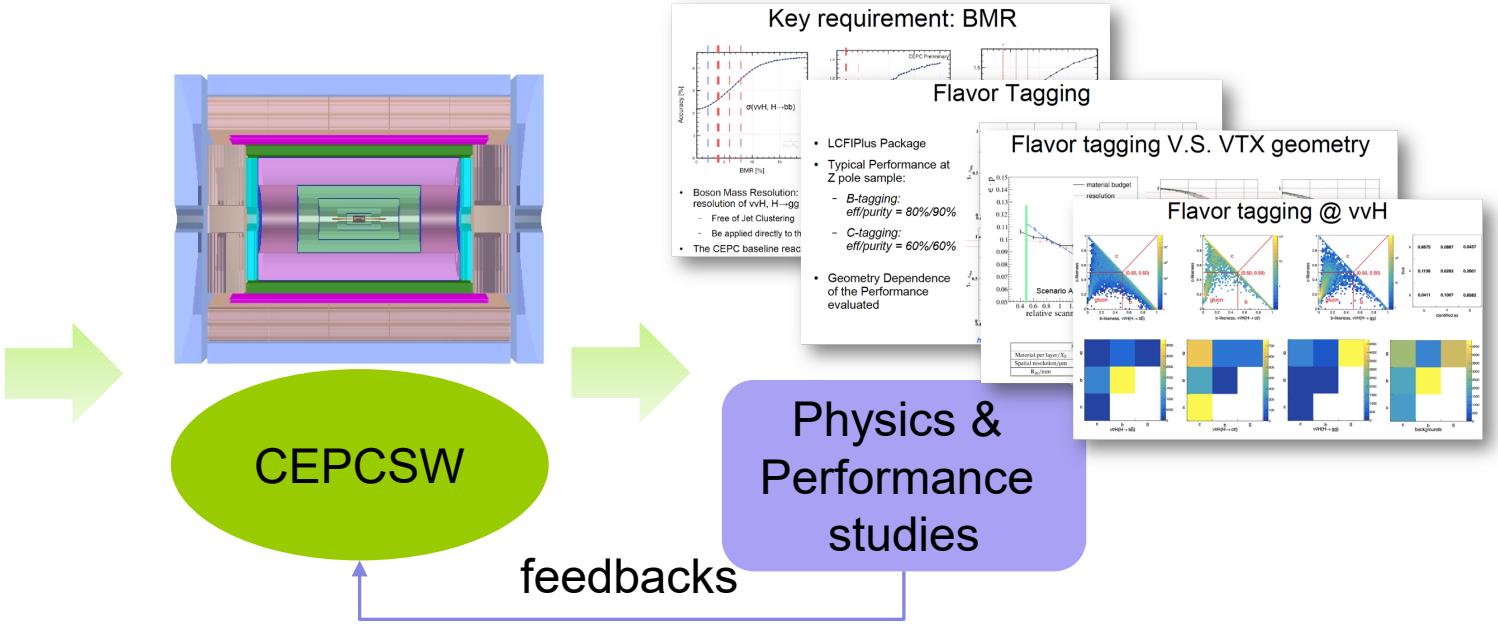
Mechanical

Vertex

Tracker

Calorimetry

Muon



Software Releases for TDR

- The software development
  - Adopt a new version scheme: tdr*YY.MM*
  - Driven by Issues and Merge Requests. Project management via milestones.
  - The repository is hosted at IHEP GitLab.
- Short-term plans before July.

Release	Timeline	Features
tdr24.3 √	March	Core software
tdr24.4 √	April	Tracking and Background mixing
tdr24.5 √	May	PID and muon
tdr24.6	June	Calorimeters

- Latest version (build at CentOS7) could be found in CVMFS:
  - /cvmfs/cepcsw.ihep.ac.cn/prototype/releases/tdr24.5.0
- Baseline performance will be released as well.

Detector Software Summary

Sub Detector	Options	Detector Description/Simulation	Digitization	Reconstruction
MDI+LumiCal		Implemented	None	None
VTX	Baseline	None		
VTX	Backup	Cooling, electronics, part of support structure	Smearing	Clusters are formed and then converted into space points. Track finding starts from the most outer layers in the ITK and searches for space points of a track from outside to inside.
ITK		Equivalent material for sensitive detector and support structure		
FTK				
OTK				After adding the OTK hits, track fitting will be executed to produce track parameters.
OTK-PID		Generation of TOF through a parametric model		None
TPC	Baseline	Implemented	Model based Garfield simulation	Searching for tracks in TPC first and then performing a combined fit to all the hits from both TPC and silicon trackers
TPC-PID		Generation of dEdx(or dN/dx) through a parametric model		None
ECAL-Barrel	Baseline	Materials and geometry from the preliminary design	Model based on test beam data	New PFA algorithm
ECAL-Endcap			None	Being validated
HCAL-Barrel			Model based on test beam data	Being developed
HCAL-Endcap			None	
MUON-Barrel		Added materials and geometry	None	The reconstructed tracks are extrapolated to the Muon Detector and matched with the muon track according to the truth information.
MUON-Endcap			None	

Summary

- CEPCSW is developed based on Key4hep.
- Towards the CEPC Reference Detector TDR, several major versions of CEPCSW are released.
- Long-term development is focus on the new technologies to boost CEPCSW performance.
  - Gaussino, ACTS/TRACC, ML, Phoenix

Source code:	https://code.ihep.ac.cn/cepc/CEPCSW
Mailing list:	cepc_software@maillist.ihep.ac.cn

Thank you for your attention!