Status of ACTS integration to CEPC tracking

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Outline

- Motivations

- Introduction to ACTS

- Status of CEPC-ACTS integration

- Summary and outlook

Motivations

Motivations

◆ CEPC detector design:
  - ◆ More detailed and technical issues taken into consideration
  - ◆ Increasing requirements for (tracking) software
  - ◆ Current CEPC geometry tool is trivial **->** *more flexible and more functions tools for tracking geometry building and layout optimizations are needed*

➤ Tools/software of interest :
  - ➤ Well tested (material budget, reliable tracking results …)
  - ➤ Alive group for the developing, improvement, and maintenance
  - ➤ Modern art of algorithm design – multi threads, fit for modern CPU
  - ➤ ….

● Benefit from software upgrade projects for other experiments

ACTS: A Common Tracking Software

- Aims **to provide a tracking toolkit for the future tracking community** (currently mainly based on ATLAS experience)

ATLAS

- Well tested code
- High tracking performance
- Not thread safe – (improving to be AthenaMT)
- Grown structure, not long-time maintainable
- …

ACTS

- Encapsulate existed code from ATLAS (or other experiments)
- Thread safe/long vectorization
- Modern C++ 17, minimal requirements …
- **Experiments independent**
- **Open-source**

Introduction to ACTS

ACTS modules layout and Basic Design

	Plugins: DD4HEP, TGEO, Geant4…
	Core

Geometry
Surface
EDM
Material
MagneticField
Utilities
Propagator
- ✓ RKN Stepper
- ✓ StraightLine Stepper
- ✓ Navigator

Fitter
- ✓ Kalman Fitter
- • Gaussian Sum Fitter
Seeding
Vertexing
☐ Track Finding
- • CKF
☐ Calibration – no need
☐ Alignment – no need

A light-weight Gaudi framework for integration and concurrency test

FATRAS: ATLAS fast simulation

Thread-safe code and configurations

- • Const-correctness and visitor pattern
- • The caller create the cache which stays local to the thread
- • Constant configuration as config struct at construction

```
struct MyTool {
  struct Config { double value{42}; };
  struct State{};
  MyTool(Config cfg)
    : m_cfg(std::move(cfg)) {}
  void doSomething(State& state)
    const { /* ... */ };
  Config m_cfg;
};
```

Tracking Geometry

● Tracking Geometry =

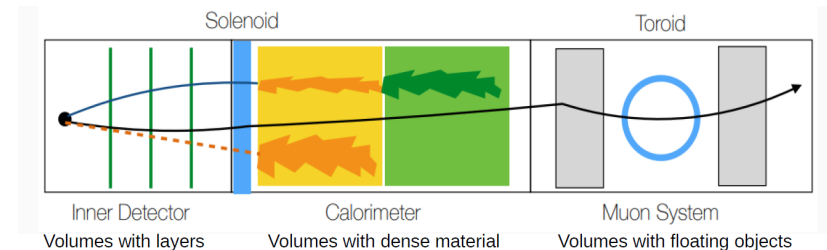**Simplified geometry + approximated material**

- full detailed detection module
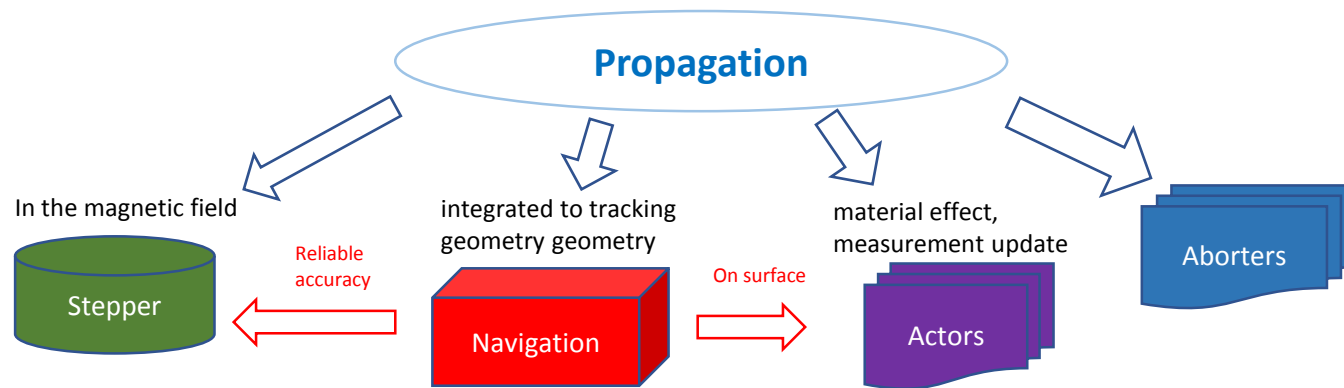- Simplified material description

real

ideal
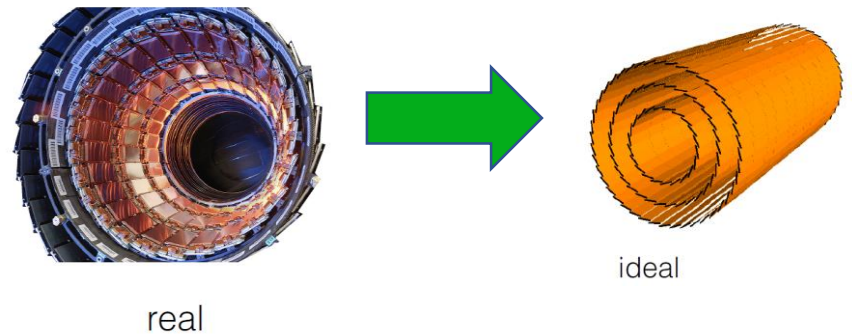
● ACTS : DD4HEP and TGeo

➡ G4, fast simulation and reconstruction

✓ Silicon tracker + Calorimeter
☐ Other type of detector (wire chamber/TPC are taking consideration)

Solenoid   Toroid

Inner Detector   Calorimeter   Muon System
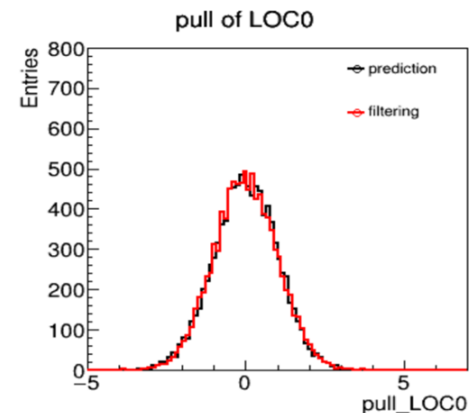Volumes with layers   Volumes with dense material   Volumes with floating objects

Propagation and Kalman Filter

Kalman Filter in ACTS

- Implemented as an Actor

- Update direction, uncertainties after filtering step

- Aims to minimize heap allocation

- Study of numerical performance (From Xiaocong Ai)

◆ These tools serve for the track reconstruction chain/support (convenient mechanism of validation for geometry building)
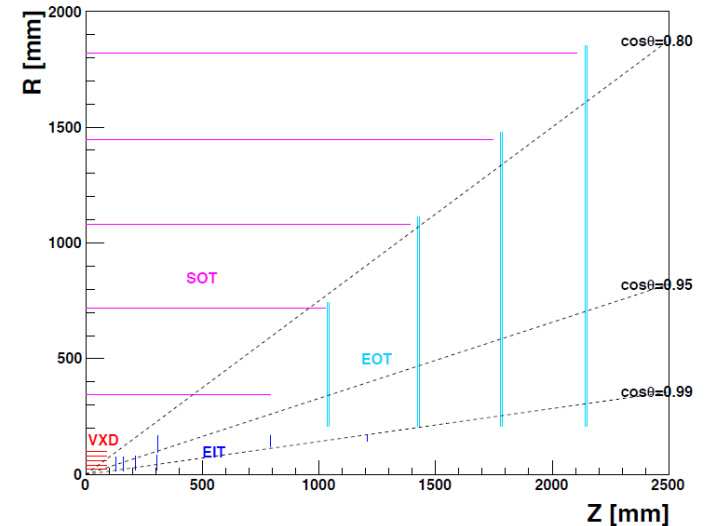
Status of CEPC-ACTS integration

CEPC Tracker

1.CEPC Baseline tracker

Beampipe
Vertex Detector
Silicon Inner Tracker && Silicon External Tracker
Forward Tracking Detector && Endcap Tracking Detector
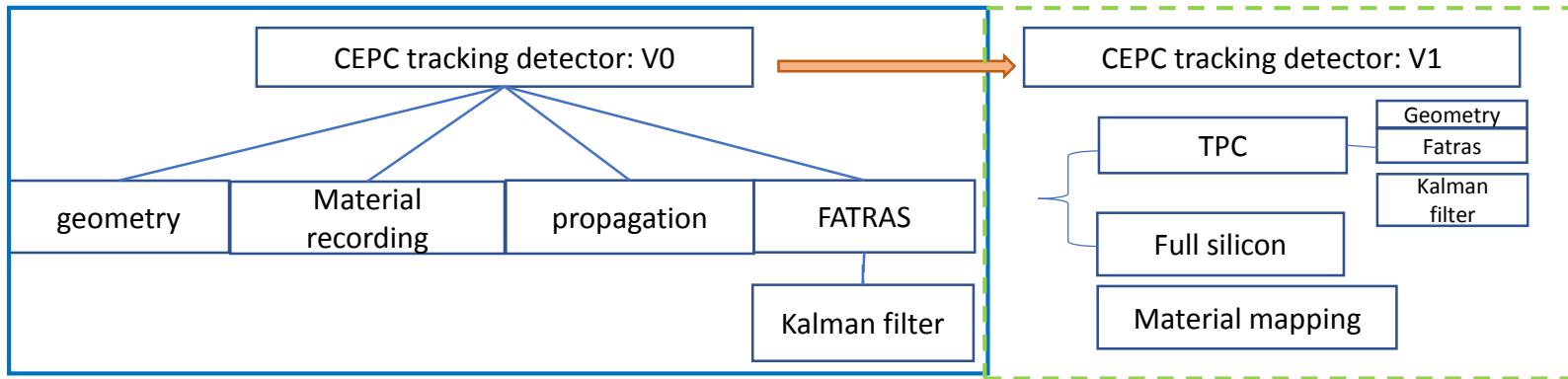**Time Projection Chamber**
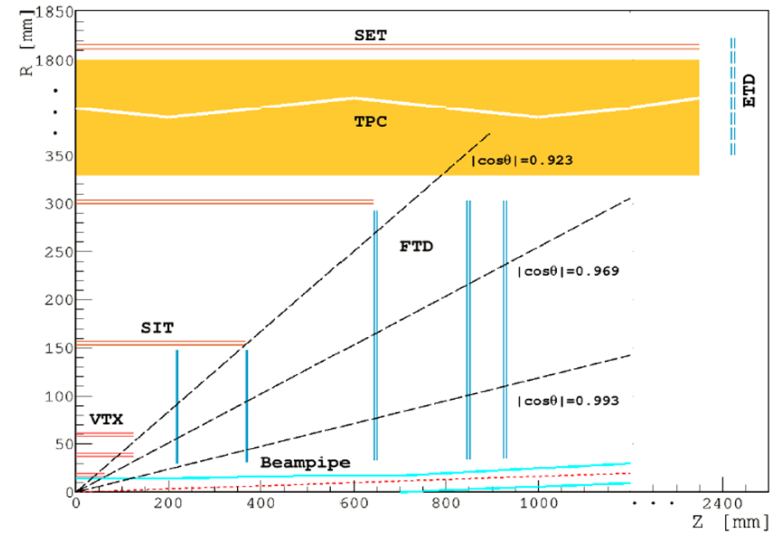
2.FST-2

Beampipe
Vertex Detector && Silicon Outer Tracker
Endcap Inner Tracker && EndCap Outer Tracker
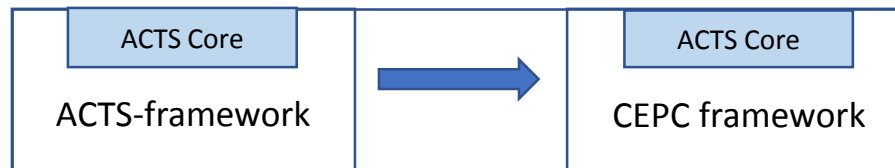
CEPC-ACTS Integration Status

✓ V0 of CEPC baseline detector(without TPC) is implemented

◆ V1 of CEPC detector are ready with the geometry
- Silicon detectors
- TPC implemented with 220 cylinder layers currently
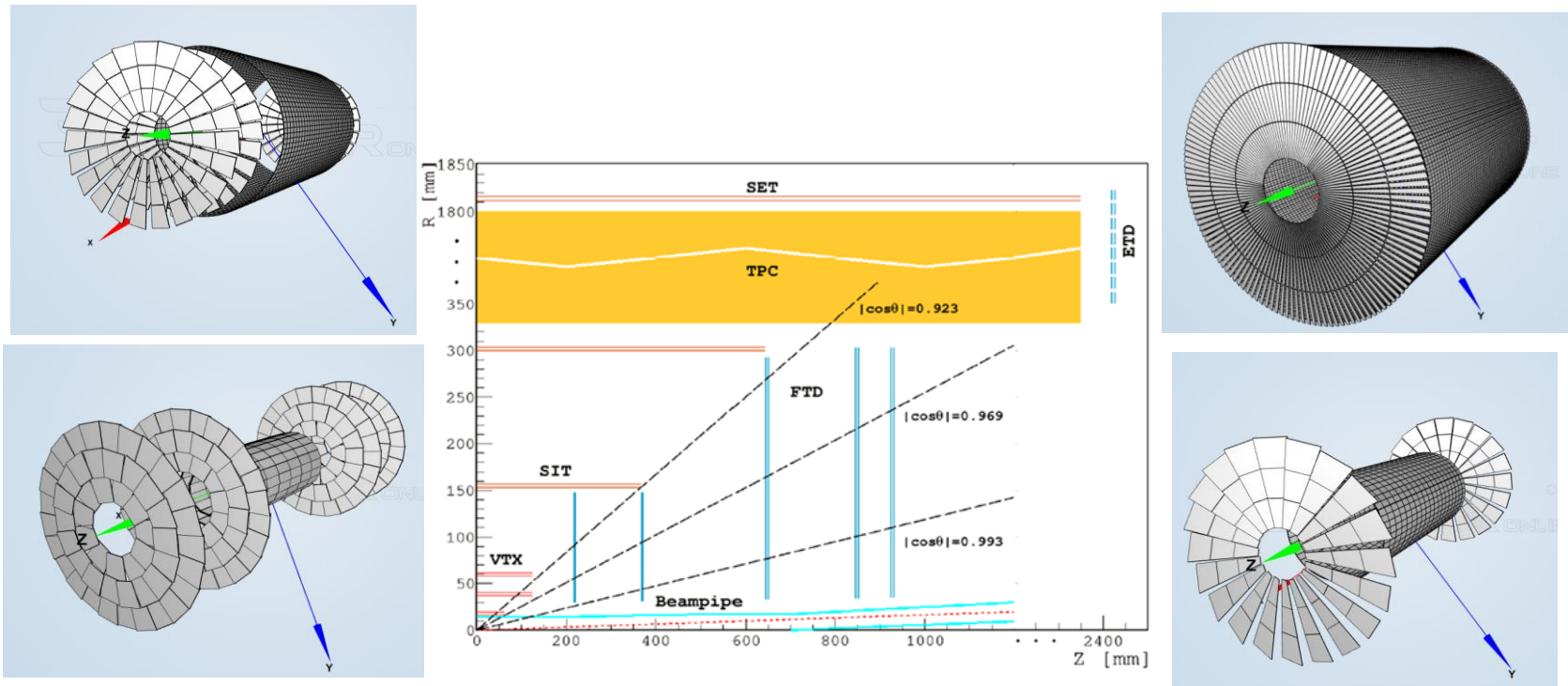- Material mapping is on going
- Validations to be done

☐ Temporarily using acts-framework, planning to migrate ACTS into Gaudi for CEPC
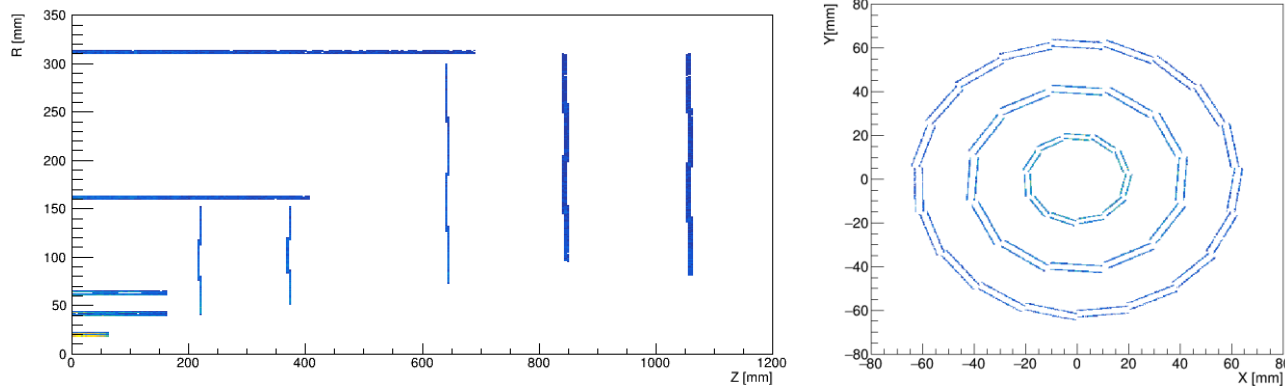
Geometry

- Validated silicon tracker construction process (e.g. ATLAS)
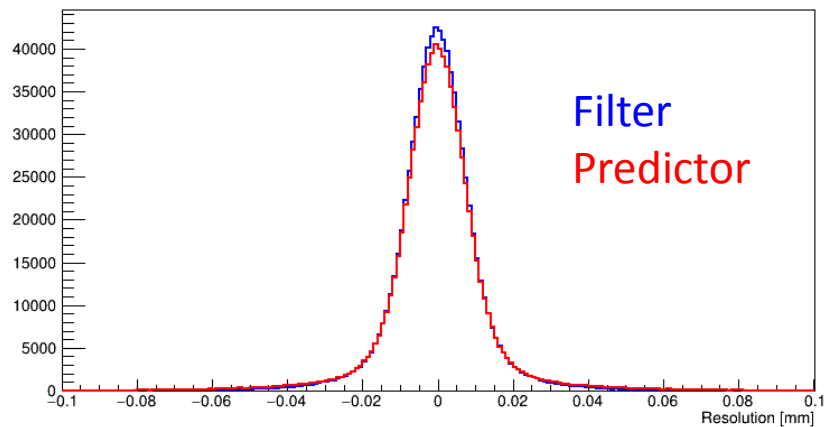- Built with ACTS typical building method

FATRAS and Kalman Filtering

Baseline tracker

- Tracking Geometry debugged with the propagation tool
- Validation of Kalman filter in progress

Propagation (sensitive) output

Filter
Predictor

Material mapping

- Material recording(geant4 plugin) and material mapping have been validated:
    - Plugin for Geant4: Recording the detailed full material
    - Mapping the material recorded onto the chosen binned surface
- More validations and detailed to be double checked
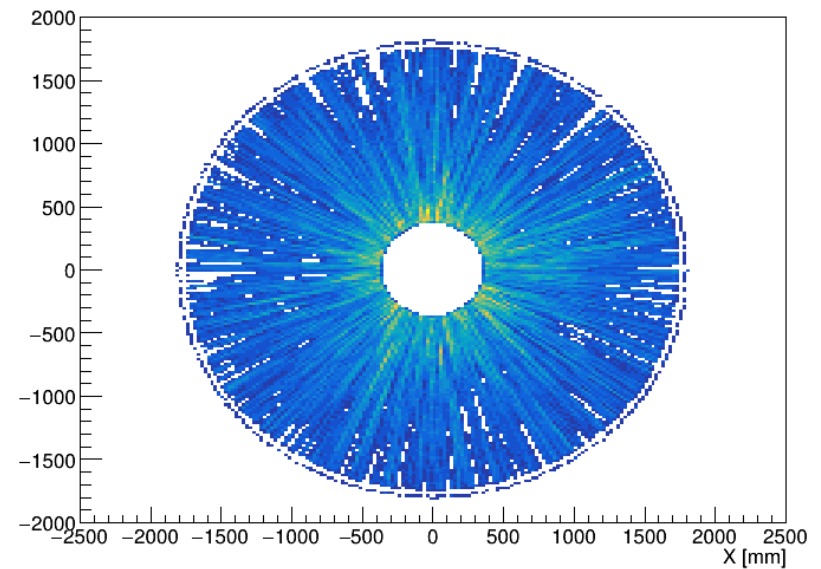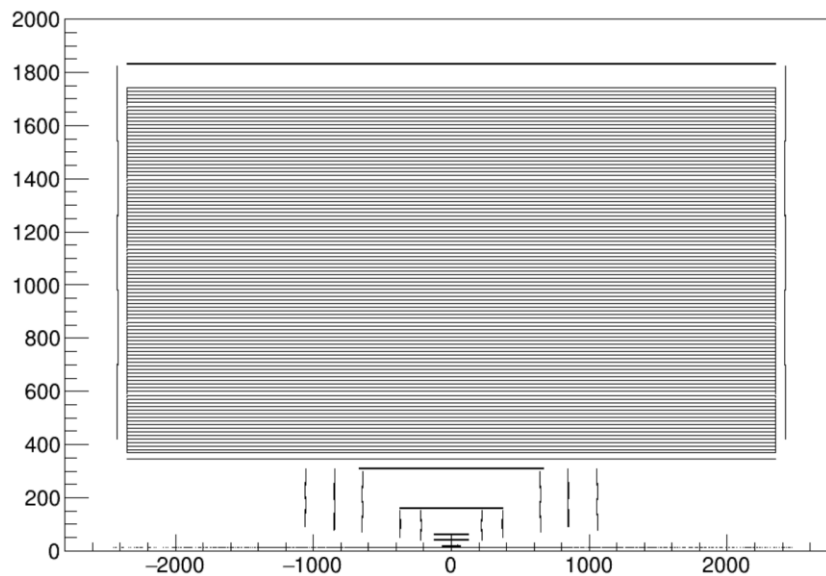- Detailed material description is working in progress
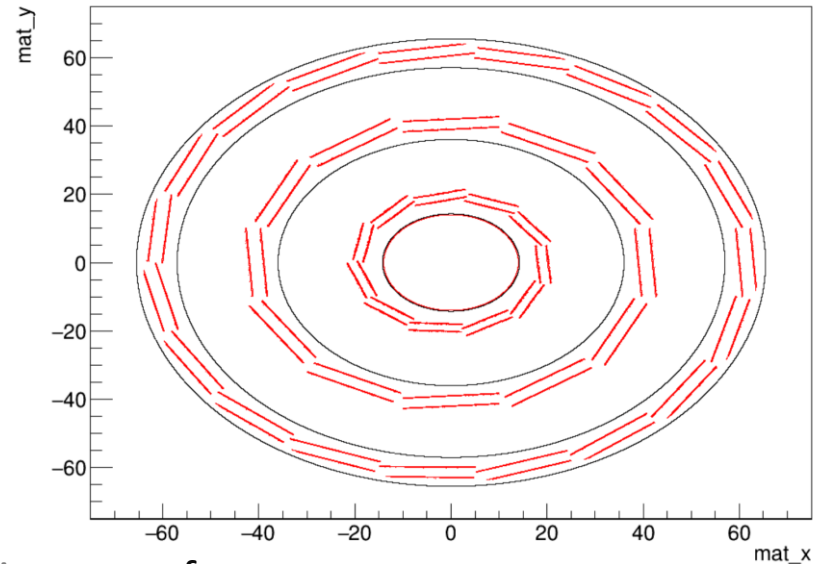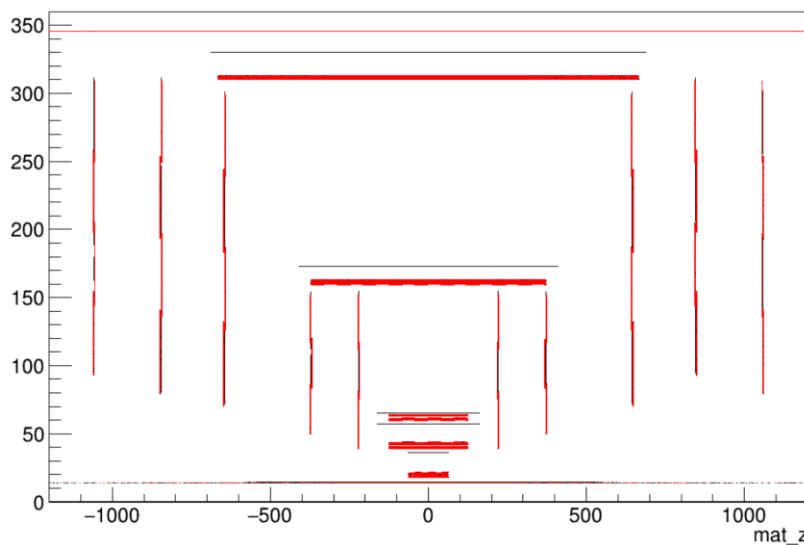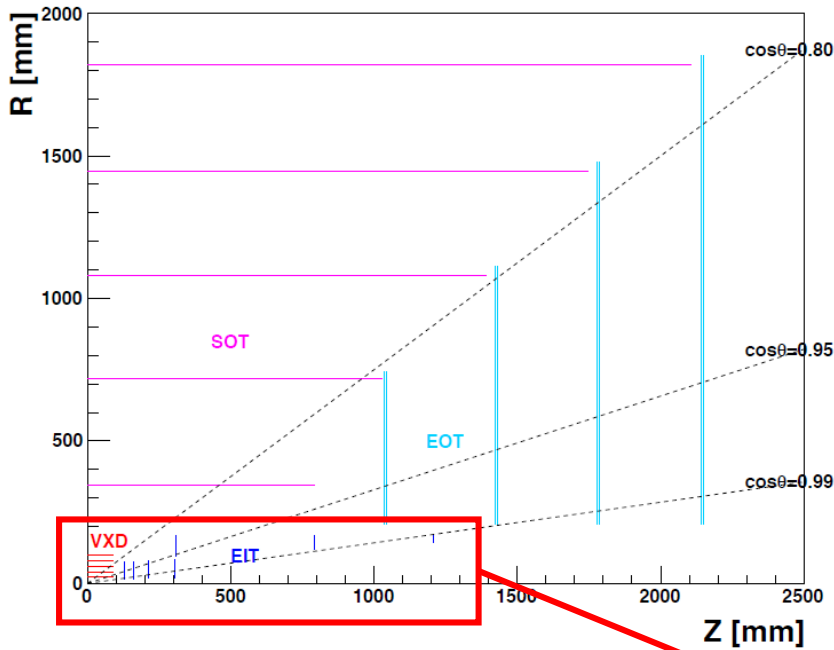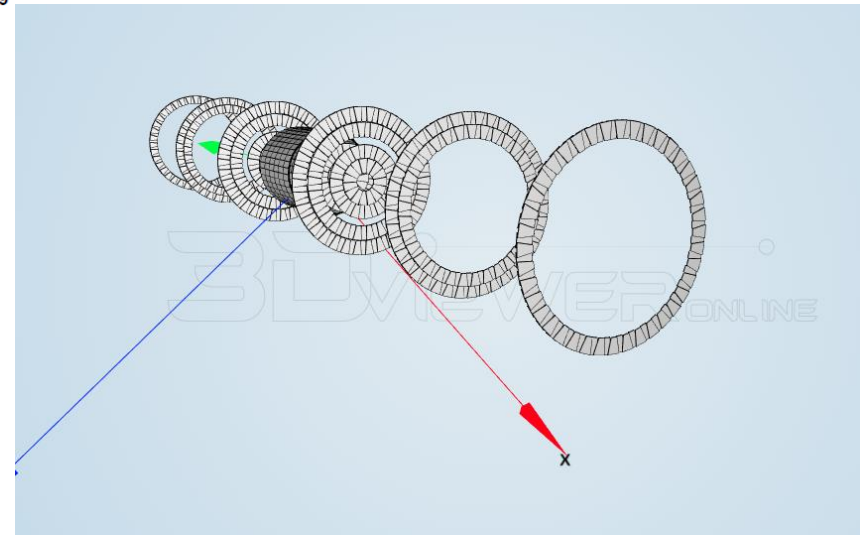

G4 mapping to surface

Geometry – TPC first version

- Surface-based concept
  - Geometry: 220 cylindrical surface
  - Propagation/Kalman filter: with the typical ACTS tool
  - ☐ Digitization: a Cylinder Digitization model is needed

Full silicon detector option

- The other part to be validated ...

Summary and Next

- CEPC baseline detector tracker V1 preliminary realized in ACTS-FW

- https://gitlab.cern.ch/jinz/acts-framework-cepc

Next:

- A stable version of Geometry and its layout optimization

- Comparison with current CEPC tracking SW

- Further migration to CEPC-FW ..
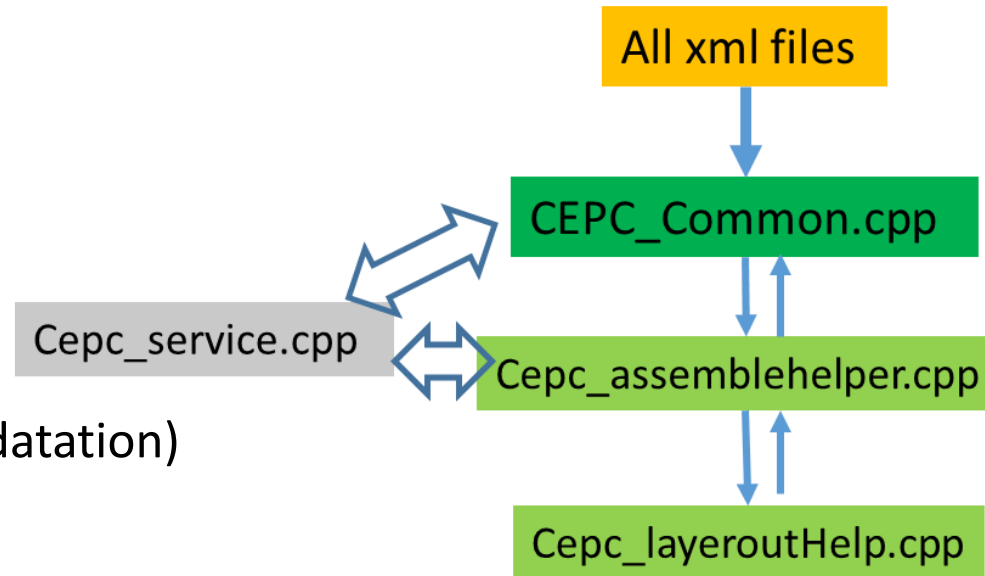
Thanks!

Thanks for ACTS development team!

BACKUP

Implementation into ACTS-FW

- ACTS provides TGeo and DD4hep plugins for Geometry description

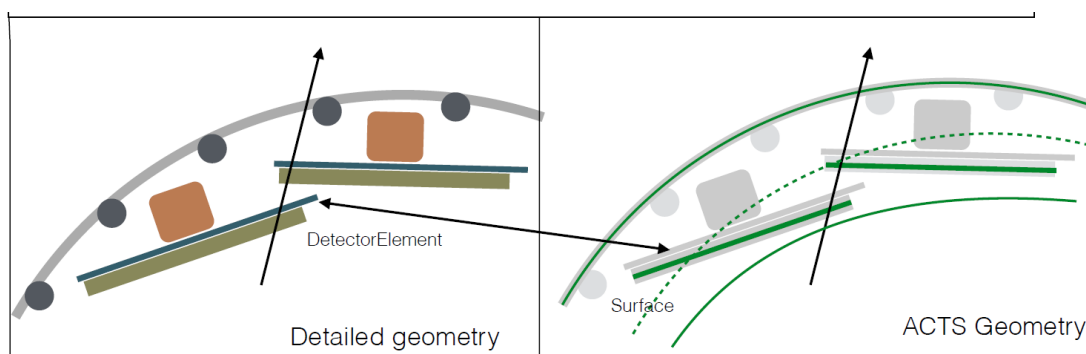- DD4HEP: generic detector description for simulation and reconstruction

- CEPC baseline tracker:
  - ✓ Source files
  - ✓ Xml files
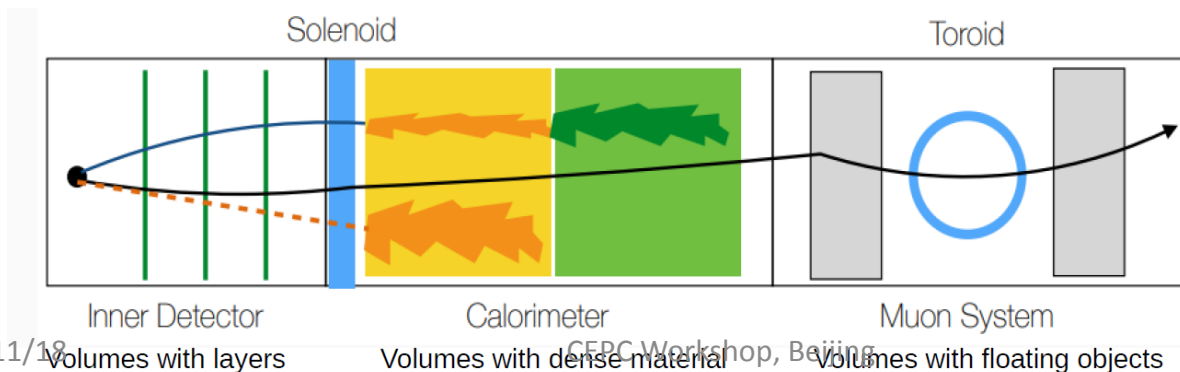 - • Material service (further validatation)
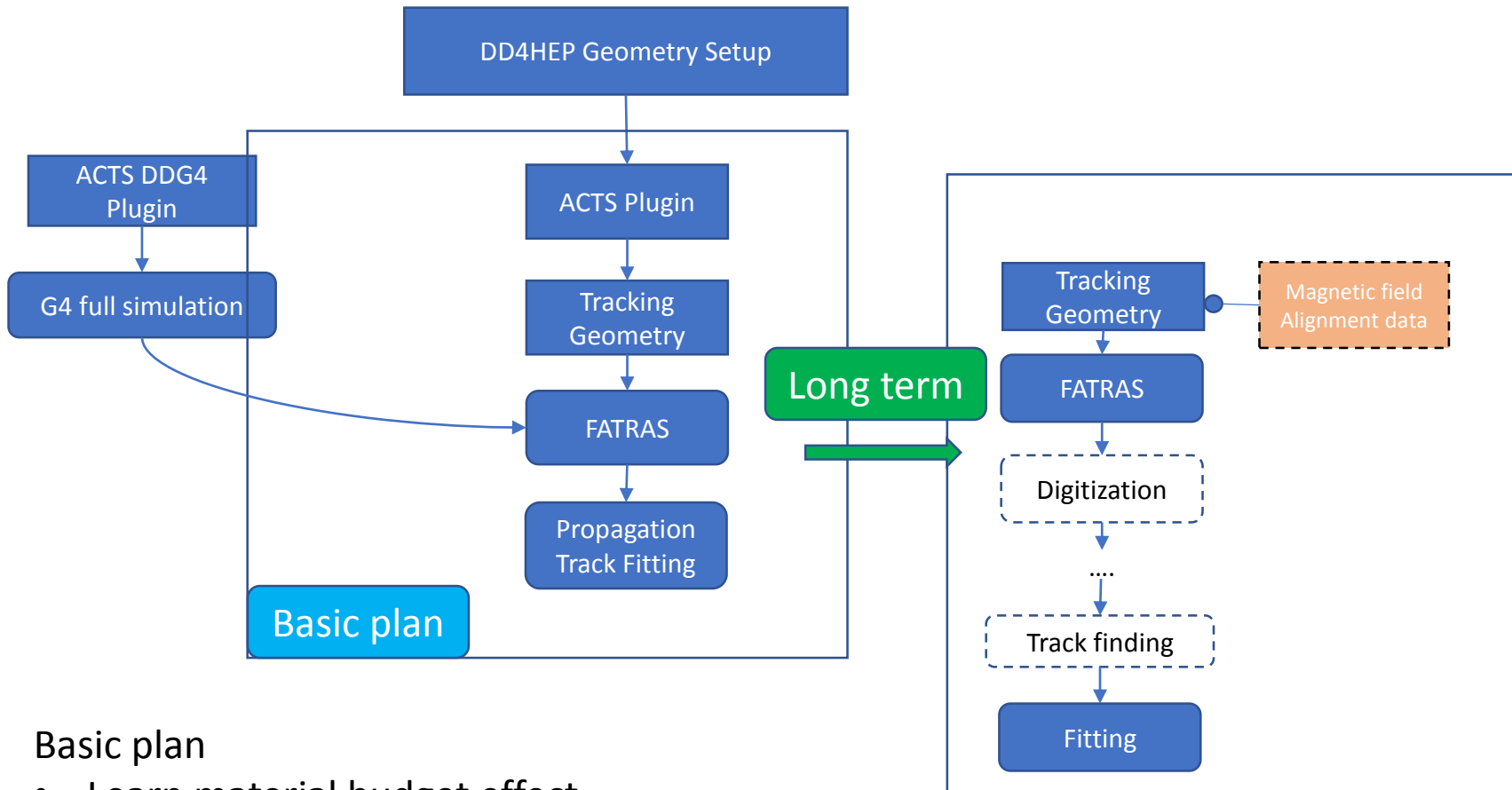
Tracking geometry

- Each ACTS Geometry object is based on Surface or extended from Surface
- Surface keeps the full details of the sensitive detector element

- Supporting geometry implementation
  - Silicon tracker + Calorimeter + Muon
 - Other type of detector (wire chamber/TPC are taking consideration)

Basic plan
- Learn material budget effect
- Detector layout optimization
- Provide track information to Carlo and others in fast way

Long perspective
- Research on if ACTS can be the future CEPC tracking sw
- Performance study and comparison from current CEPC tracking sw
- Some tools should be adapted for our detector (from *common* to *specific*)

Kalman filtering

- Kalman filter implemented as an Actor
- Called automatically during propagation
- Can update direction, uncertainties after filtering step
- Aim to minimize heap allocation
- Study of numerical performance (se by Xiancong Ai)

pull of LOC0
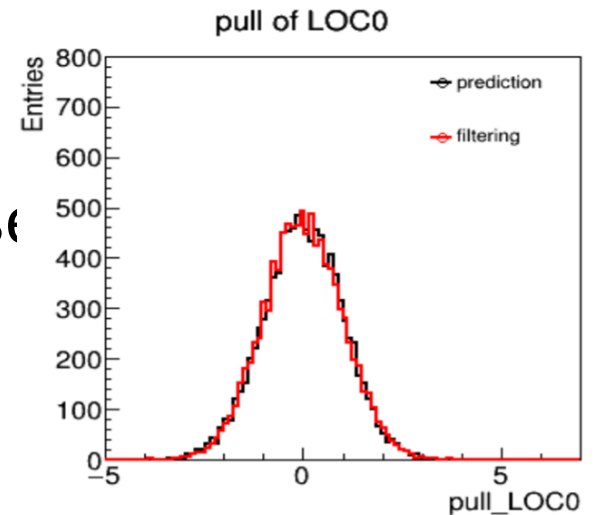
CEPC Integration

- Valid a tool for
  - The tracking geometry should put in a right way (with propagation tool)
  - The material should put correct (material validation)
  - Tuning FATRAS to Geant4 (e.g. record the energy loss)
  - Kalman filter validations