# Implementation of CepC Detector in CEPCSW

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(on behalf of CEPC software work group)

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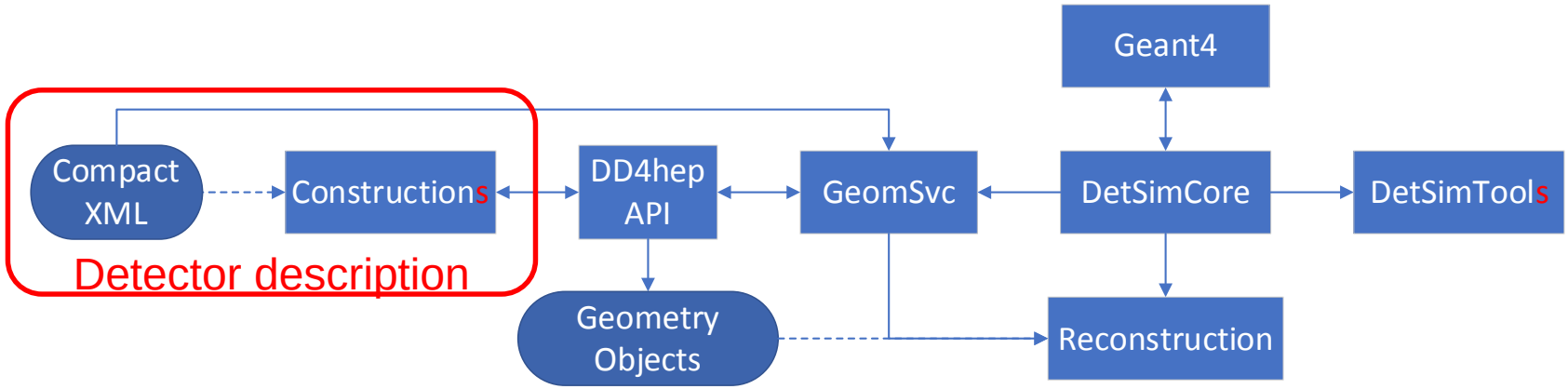
# Introduction

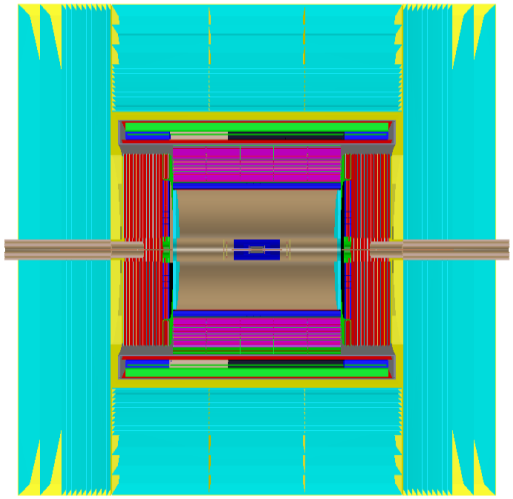
- DD4hep help use (CEPCSW) to make a complete detector description with a single source of information and cover the full life cycle of an experiment
- Detector description is a basic node for detector simulation

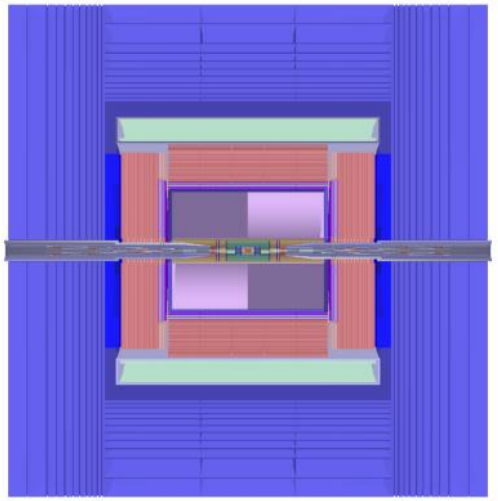



- Many physics analysis have been done based on the baseline detector in CDR, therefore to repeat the results in CEPCSW will help us to understand this new software framework well.
- Reference detector study is ongoing, with new detector modules such as drift chamber and crystal bar calorimeter, require to implement these detectors into CEPCSW to do full simulation.

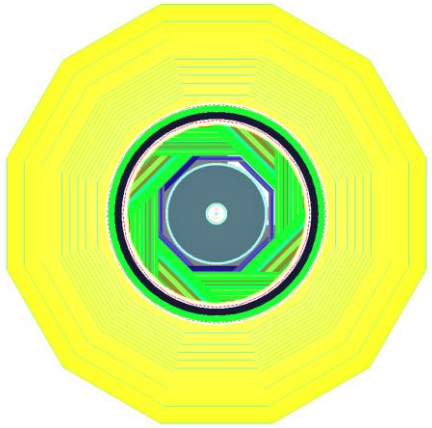
# CDR Baseline Detector

- Complete
  - Beam pipe: same at Z=0-700mm
  - VXD
  - FTD
  - SIT&SET
  - TPC
  - Ecal
  - Hcal
  - Coil
  - Yoke
- new MDI patch (code ready)
  - needs new DD4hep commit into Key4hep
- Validation
  - key parameters check
  - material scan (shape, repeat …)
  - hit distributions
  - performance: ongoing

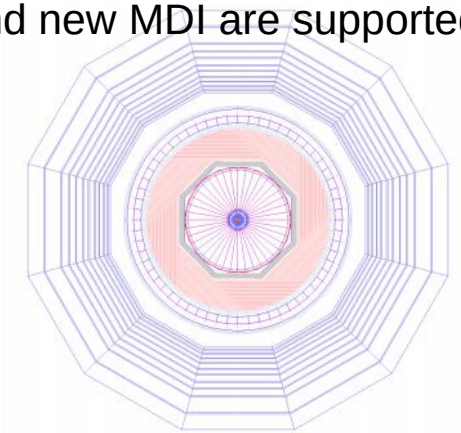




In MokkaC, both old MDI and new MDI are supported



(by CEPCSW)

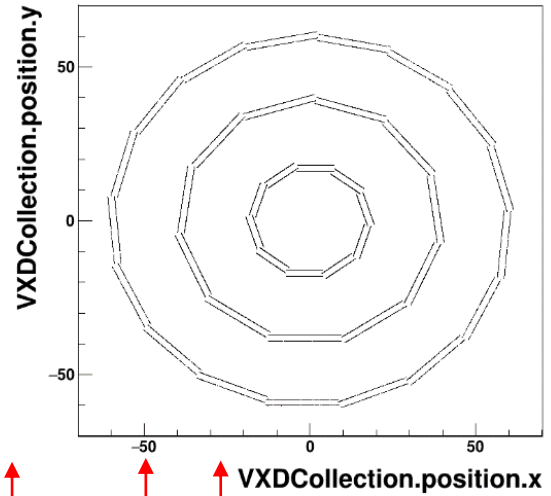


(by MokkaC)

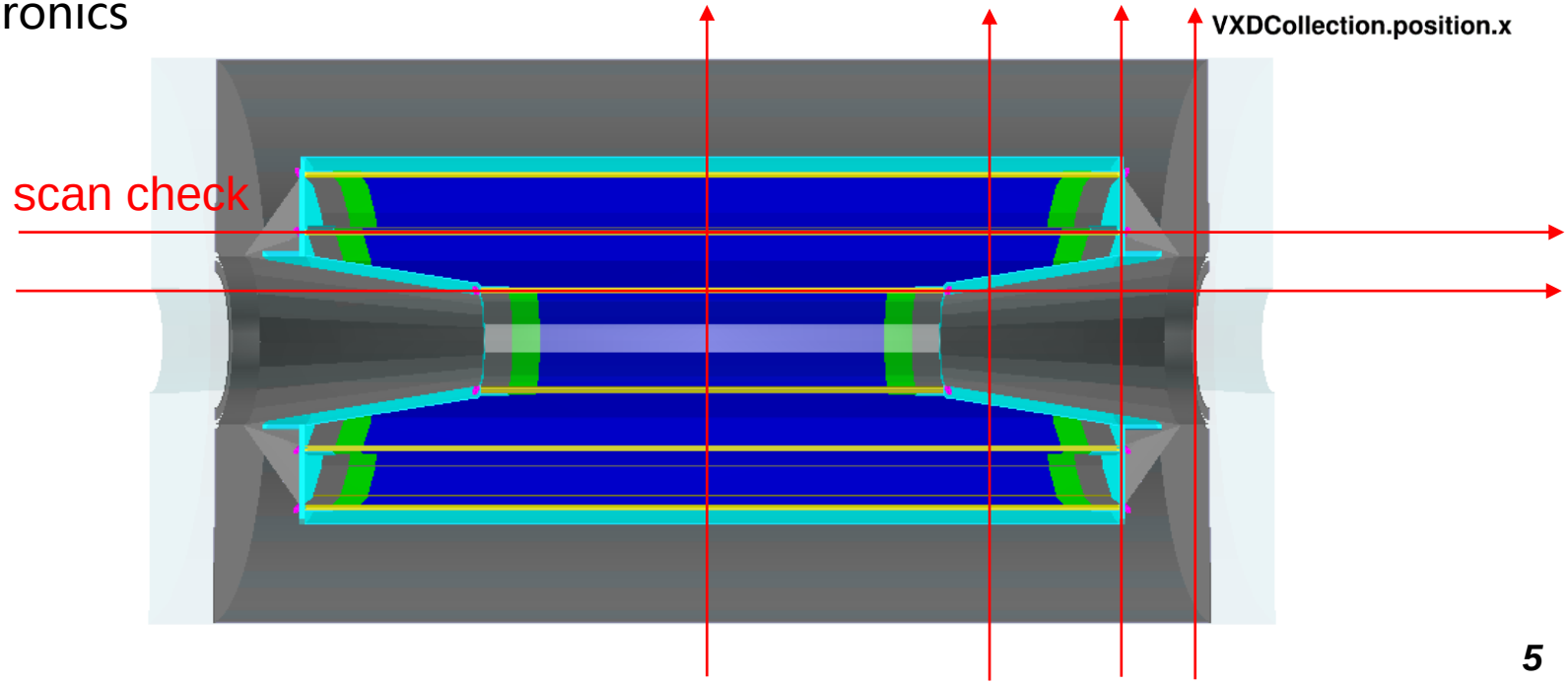
automatic validation tool in considering

# VXD

- layer
  - support
  - sensor
  - electronics endplate
  - side electronics plate
- outer support tube
- end support plate
- electronics

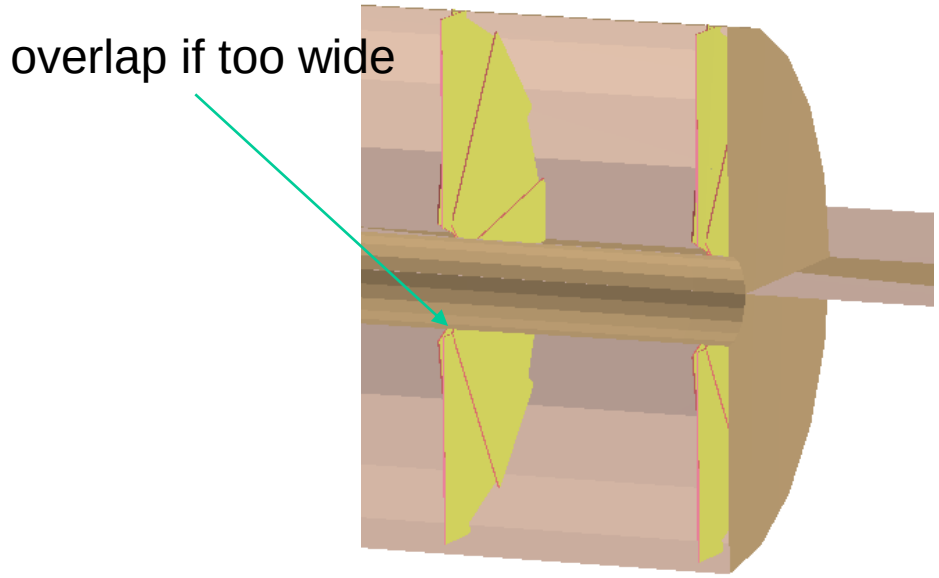


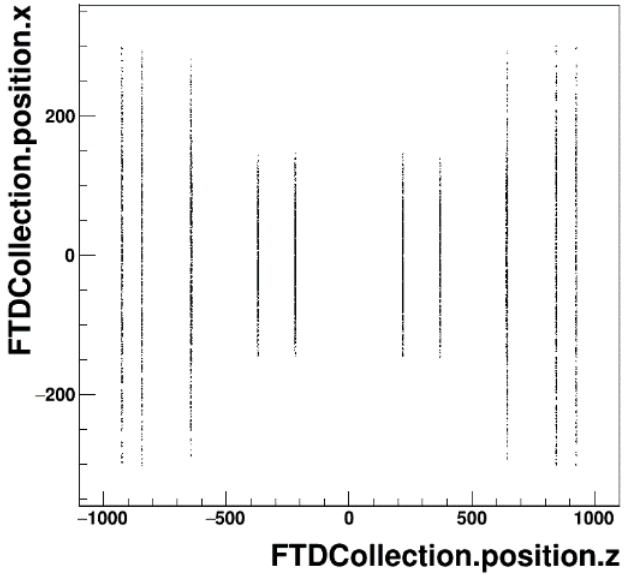

material scan check

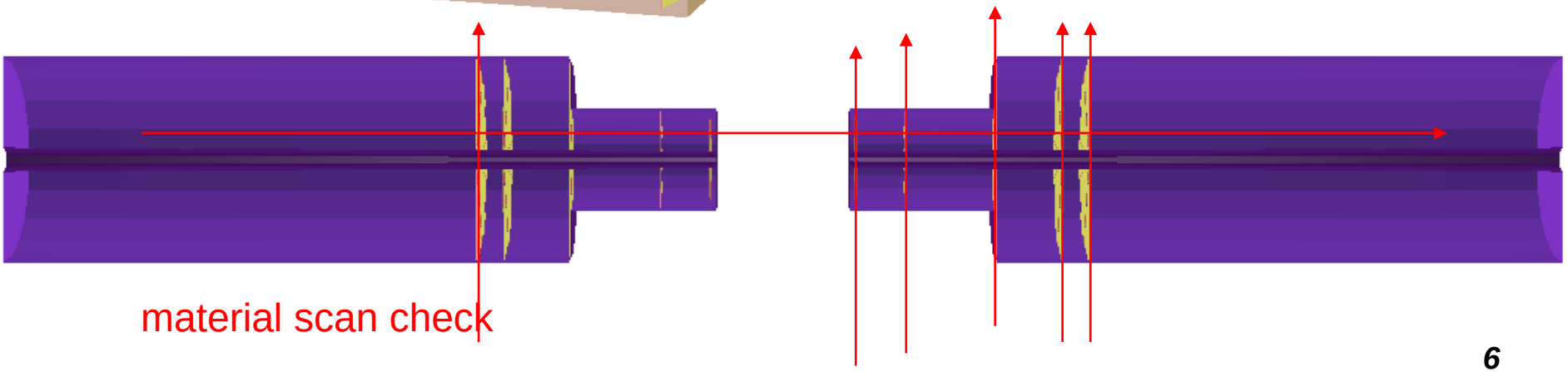


# FTD

- overlap existing in MokkaC, fixed in CEPCSW

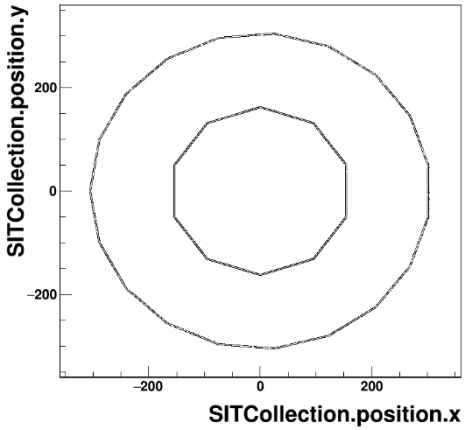


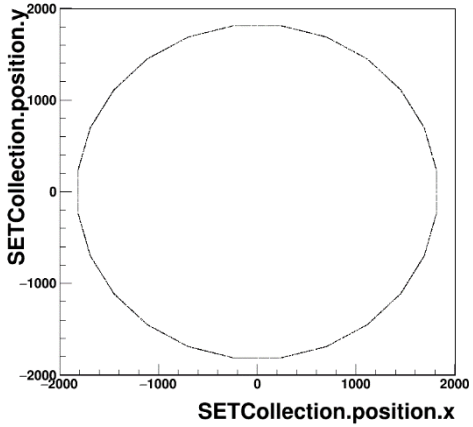



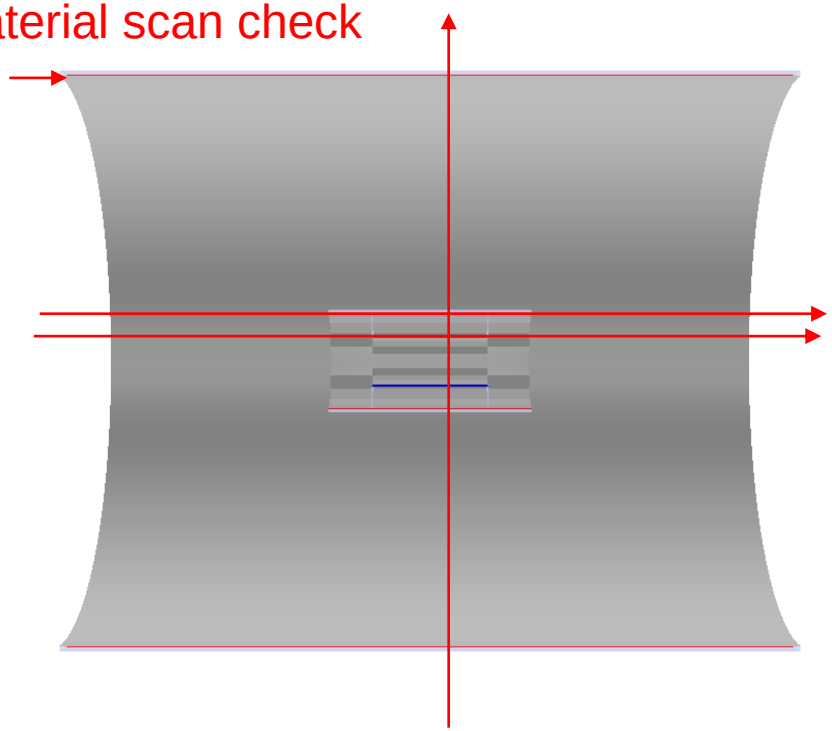
# SIT & SET

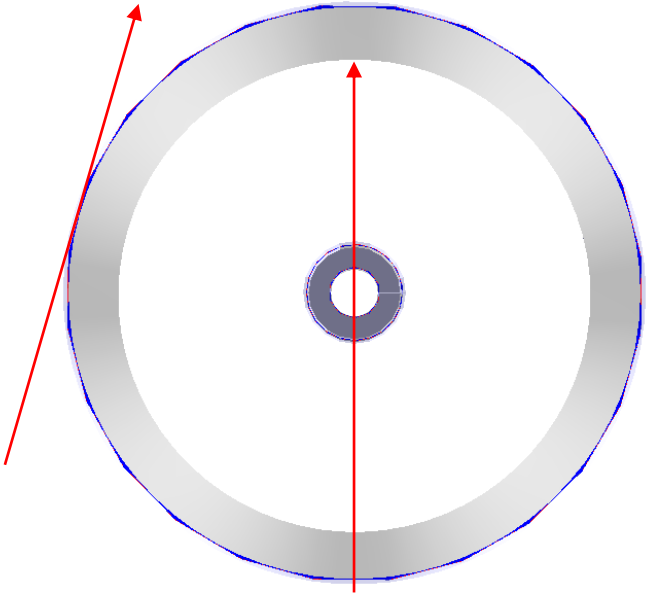
- keep same as MokkaC's



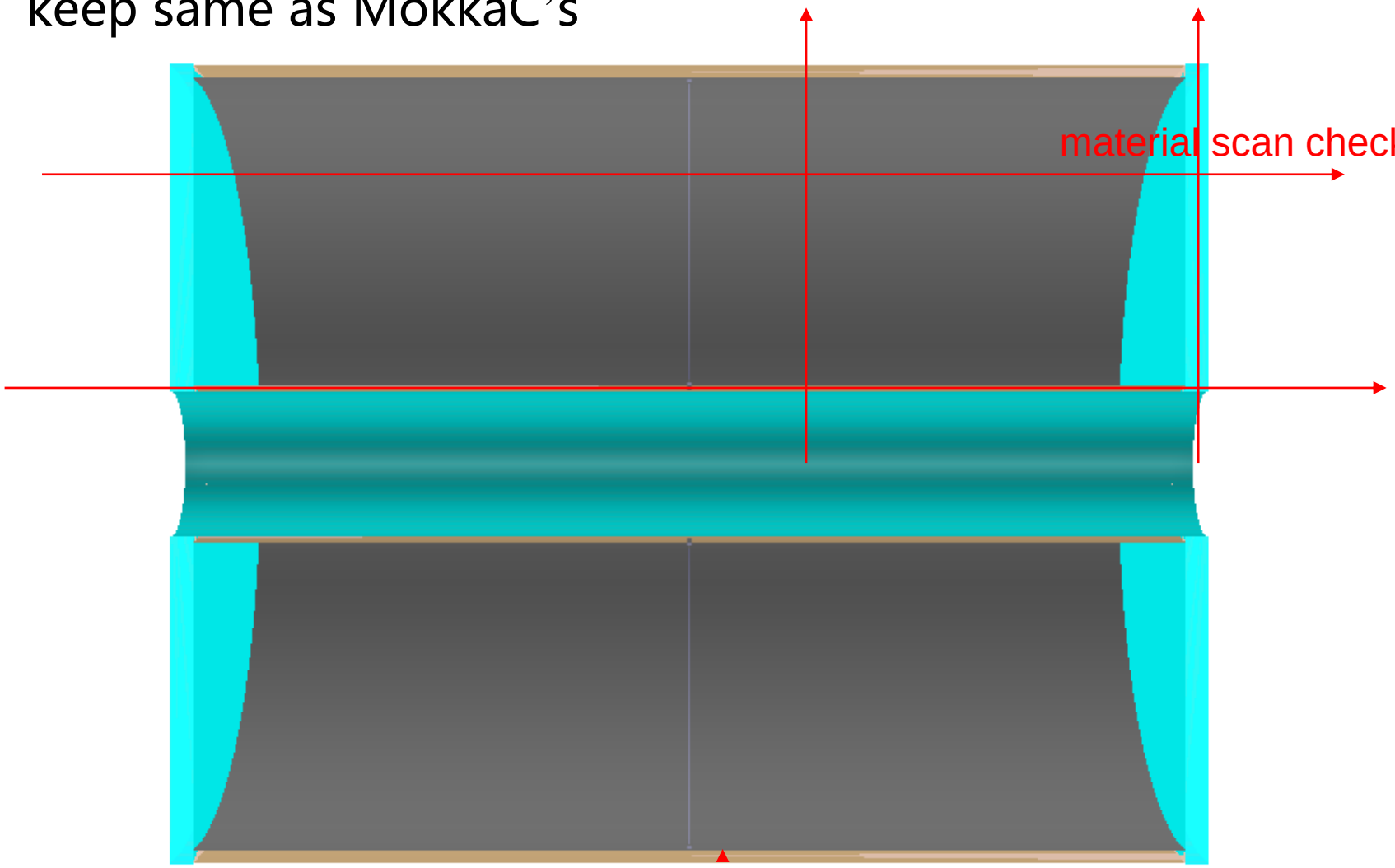

material scan check





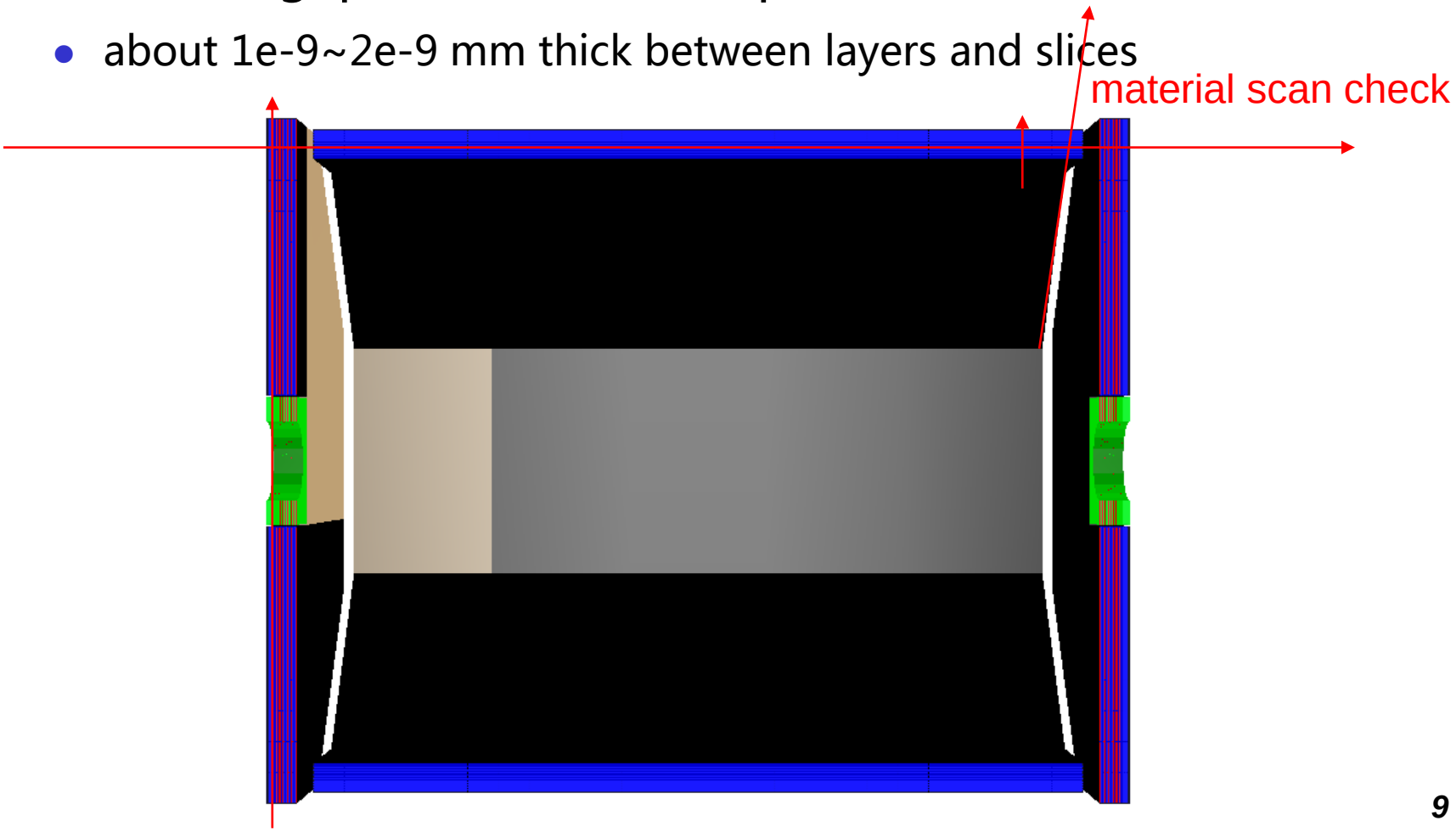
# TPC

- keep same as MokkaC's



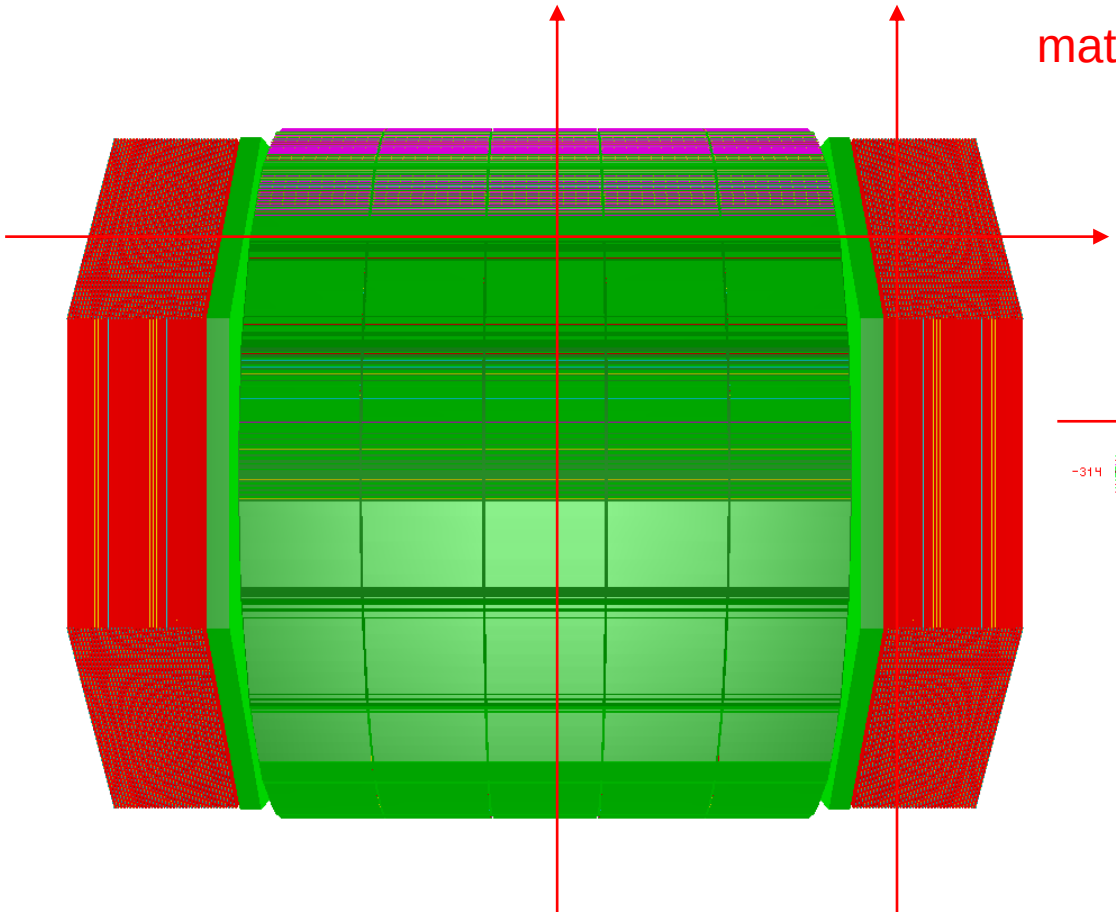
# Ecal

- EcalBarrel, EcalEndcaps, EcalECRing
- Tolerance gap (to avoid overlap in Mokka) removed
  - about 1e-9~2e-9 mm thick between layers and slices

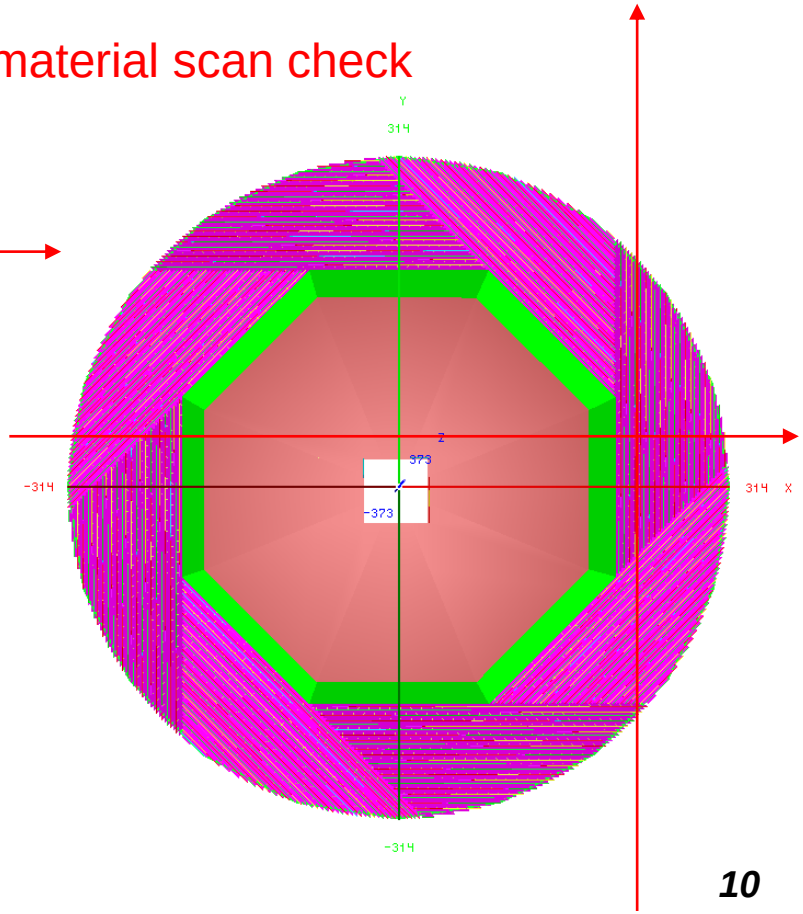


# Hcal

- RPC-based Hcal (Digital Hadron Calorimeter)
  - HcalBarrel, HcalEndcaps, HcalEndcapRing



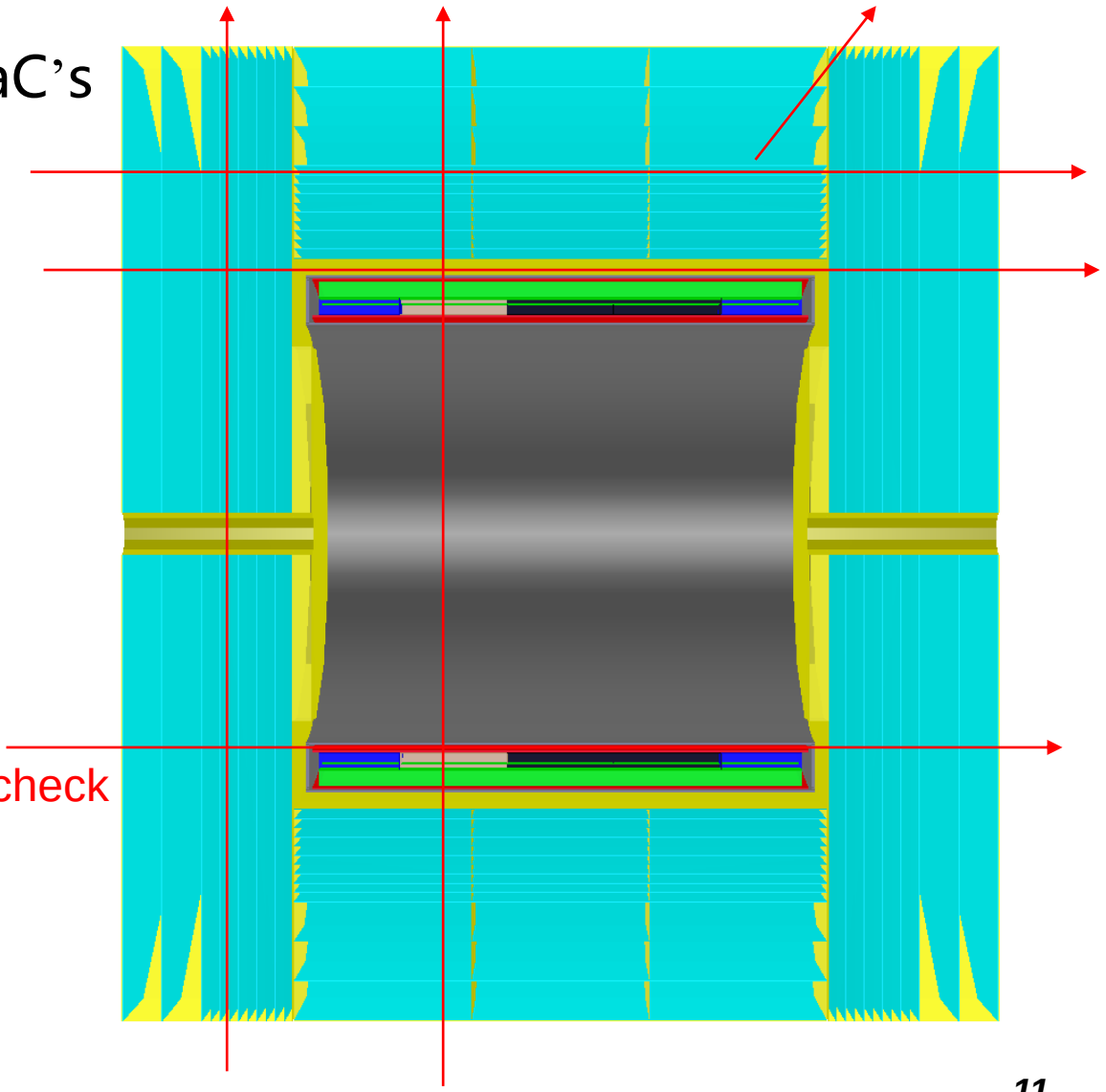
material scan check



# Coil & Yoke

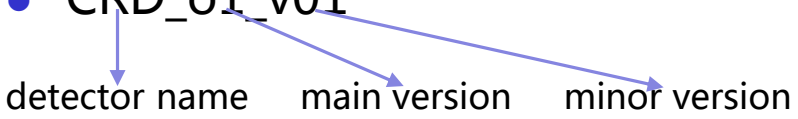
- keep same as MokkaC's
- Coil
- Yoke
  - YokeBarrel
  - YokeEndcaps
  - YokePlug

material scan check

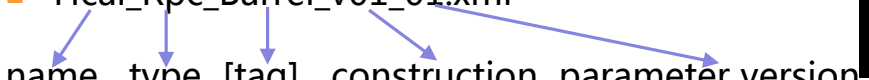


# Detector Manager

- Version
  - CRD_o1_v01




- construction to build geometry and compact files [XML] carry parameters
  - current: simulation and reconstruction use same compact files
  - considering:
    - simulated data carry compact file
    - simulated data carry version and save compact file into DB
- compact files
  - Main : CRD_o1_v01.xml
  - include:
    - elements.xml and materials.xml
    - CRD_Dimensions_o1_v01.xml
    - Hcal_Rpc_Barrel_v01_01.xml




    - ...

```
<includes>
  <gdmlFile  ref="${DD4hepINSTALL}/DDDetectors/compact/elements.xml"/>
  <gdmlFile  ref="../CRD_common_v01/materials.xml"/>
</includes>

<define>
  <constant name="world_size" value="25*m"/>
  <constant name="world_x" value="world_size"/>
  <constant name="world_y" value="world_size"/>
  <constant name="world_z" value="world_size"/>

  <include ref="${DD4hepINSTALL}/DDDetectors/compact/detector_types.xml"/>
</define>

<include ref="./CRD_Dimensions_v01_01.xml"/>

<include ref="../CRD_common_v01/Beampipe_v01_01.xml"/>
<include ref="../CRD_common_v01/VXD_v01_01.xml"/>
<include ref="../CRD_common_v01/FTD_SimpleStaggered_v01_01.xml"/>
<include ref="../CRD_common_v01/SIT_SimplePlanar_v01_01.xml"/>
<include ref="../CRD_common_v01/DC_Simple_v01_01.xml"/>
<include ref="../CRD_common_v01/SET_SimplePlanar_v01_01.xml"/>
<include ref="../CRD_common_v01/Ecal_Crystal_Barrel_v01_01.xml"/>
```

# Dimensions

- Global dimensions describe in CRD_Dimensions_o1_v01.xml
  - sub-detector IDs
  - crossing angle
  - nominal value of magnetic field
  - limit definitions
  - region definitions
  - display definitions
  - inner radius and outer radius
  - half length for barrel
  - zmin and zmax for endcap
  - other dimensions

```
<constant name="Yoke_barrel_inner_radius" value="3710*mm"/>
<constant name="Yoke_barrel_outer_radius" value="6951*mm"/>
<constant name="Yoke_barrel_half_length" value="Hcal_endcap_zmax"/>
<constant name="Yoke_barrel_symmetry" value="8"/>
```

easy to locate the edge of every sub-detector, avoiding overlap between sub-detectors while updating, quick to modify dimensions to replace with new type of sub-detector

- Module dimensions (optional) describe in sub-detector compact file
  - avoid fixed parameters in construction, easy to update

# Magnet inside or outside

- Module dimensions
  - calculated by global dimension
  - set for those parameters not dependent on global dimension
    - slice thickness
    - material
    - module gap
    - etc.
- Easy to exchange the positions of two sub-detectors through global dimensions
  - Coil inside
    - Solenoid_inner_radius: Ecal_barrel_outer_radius + Ecal_Coil_gap
    - Hcal_barrel_inner_radius: Solenoid_outer_radius + Hcal_Coil_gap
  - Coil outside
    - Solenoid_inner_radius: Hcal_barrel_outer_radius + Coil_Hcal_gap
    - Hcal_barrel_inner_radius: Ecal_barrel_outer_radius + Ecal_Hcal_gap

# Replace sub-detector

- one sub-detector ↔ one or more compact files, forbid to load two sub-detectors in one file
  - Hcal: HcalBarrel, HcalEndcaps, [HcalEndcapRing]
- Add sub-detector by include corresponding compact file
- Remove sub-detector by comment/remove include its compact file

```
<include ref="../CRD_common_v01/Hcal_Rpc_Barrel_v01_01.xml"/>
<include ref="../CRD_common_v01/Hcal_Rpc_Endcaps_v01_01.xml"/>
<!--include ref="../CRD_common_v01/Hcal_Rpc_EndcapRing_v01_01.xml"/-->
```

- To replace a sub-detector with another new sub-detector TPC → DriftChamber

```
<include ref="sit_simple_planar_sensors_01.xml"/>
<include ref="tpc10_01.xml"/>
<include ref="set_simple_planar_sensors_01.xml"/>
```

```
<include ref="../CRD_common_v01/SIT_SimplePlanar_v01_01.xml"/>
<include ref="../CRD_common_v01/DC_Simple_v01_01.xml"/>
<include ref="../CRD_common_v01/SET_SimplePlanar_v01_01.xml"/>
```

# Detector Information (README.md)

summary table

information for sub-detectors

## CRD detector models - Overview

The following CRD detector models are available in CEPCSW

| Model | Description | MainTracker | Ecal | Hcal | Status |
|---|---|---|---|---|---|
| CRD_o1_v01 | coil inside simulation model | DC | crystal | RPC | developing |
| CRD_o1_v02 | pixel SIT | DC | crystal | RPC | developing |
| ---------- | ---------- | ---------- | ---------- | ---------- | ---------- |

or frozen …

### Details

#### CRD_o1_v01 (to update)

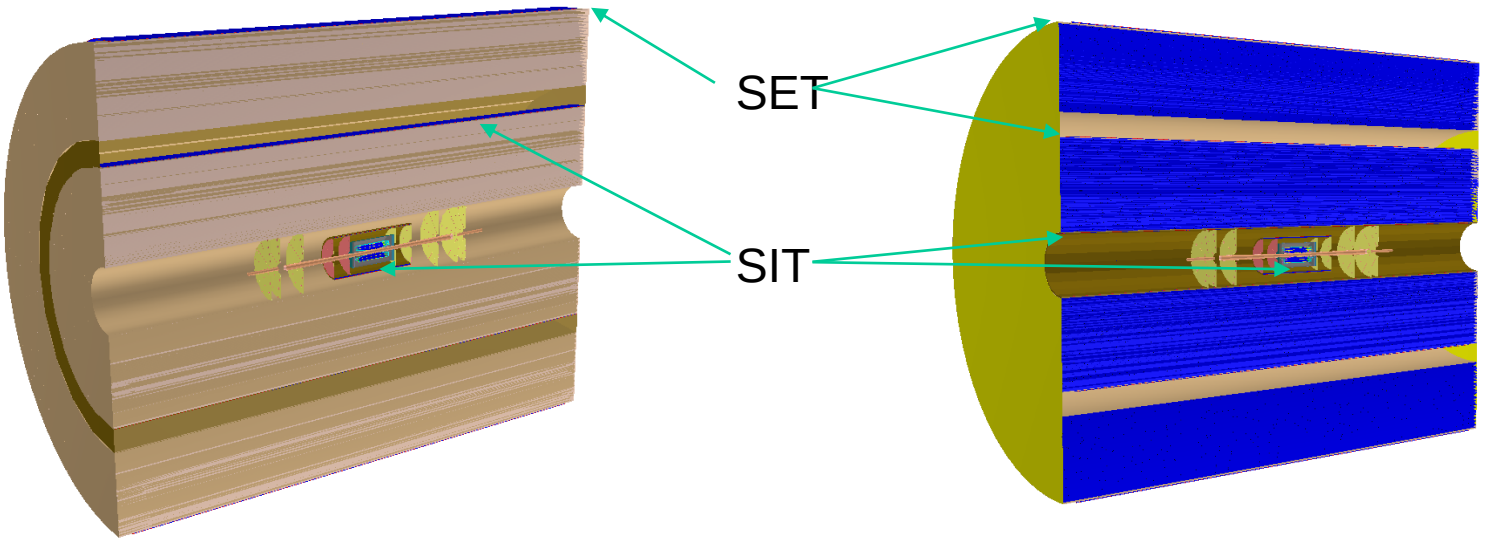
- coil inside CRD model
- BeamPipe - with center pipe + crotch link to doubly-pipe - Detector/DetCRD/src/Other/CRDBeamPipe_v01_geo.cpp
- Vertex - with silicon ladders (VXD + SIT12) - Detector/DetCEPCv4/src/tracker/VXD04_geo.cpp - Detector/DetCEPCv4/src/tracker/SIT_Simple_Planar_geo.cpp
- MainTracker - with Dirft Chamber + silicon layer between inner and outer chambers (DC + SIT34 + SET) - DC_outer_radius = 1716*mm - Detector/DetDriftChamber/src/driftchamber/DriftChamber.cpp - Detector/DetCEPCv4/src/tracker/SET_Simple_Planar_geo.cpp
- EndcapTracker - with silicon pestals (FTDPixel + FTDStrip) - Detector/DetCEPCv4/src/tracker/FTD_Simple_Staggered_geo.cpp
- Ecal - with crystal - Detector/DetCRD/src/Calorimeter/CRDEcal.cpp - Endcap (TODO)
- Hcal - with RPC readout - creates two sets of hit collections
- Coil - CEPC_v4 like
- Yoke - CEPC_v4 like
- compact files: - ./CRD_o1_v01/CRD_o1_v01.xml

#### CRD_o1_v02 (to update)

- based on CRD_o1_v01
- SIT: strip -> pixel
- SIT12->SIT1: r = 152.90 -> 140.00 mm (pixel SIT1)

# CRD_o1_v01 and CRD_o1_v02

- CRD_o1_v01
  - coil inside Hcal
  - Drift Chamber (Mengyao Liu, Tao Lin and Yao Zhang)
  - Crystal bar Ecal (Fangyi Guo)
  - new MDI
  - others CEPC_v4 like (dimension re-defined)
    - VXD, FTD, SIT, SET, Hcal, Coil, Yoke
- CRD_o1_v02 (pixel SIT)
  - SIT/SET: 3 → 4



# More Modules Implementation

- Beampipe
  - follow newest MDI design (Chengdong FU)
- vertex detector
  - Optimized layouts and mechanics (Hao ZENG & Kewei WU)
- silicon tracker
  - CMOS module
- Drift chamber
  - axial wires only → both axial and stereo wires (Mengyao LIU & Yao ZHANG)
- Crystal bar Ecal
  - optimization and Endcaps (Fangyi GUO)
- Hcal
  - Aanalog Hadron Calorimeter (scintillator as): coming soon (Chengdong FU)
- Coil
  - CEPC_v4 like → new design (Ling ZHAO's talk)
- Yoke
  - CEPC_v4 like → more general layers
  - easy to modify design through parameters (Xiaolong WANG)

# Plan

- Current preliminary CRD_o1_v01 and CRD_o1_v02 are been developing, will be frozen in future
  - replace some CEPC_v4 like sub-detectors with new modules
  - mechanics will be added according to study progress
- More versions will be released to support physical study and detector optimization
  - Magnet outside as comparison
  - DHCAL VS AHCAL
  - full silicon tracker
  - magnetic field variation
  - new sub-detectors on requirement (such as TOF, Cherenkov detector etc.)

# Summary

- The baseline detector in CDR has been implemented into CEPCSW, and keep almost same as Mokka's, ready for next study.
- There are two versions of reference detectors in developing
  - parts of sub-detectors are CEPC_v4 like
  - available as preliminary, to update
- More implementations of modules and more release detector versions are in plan.

Thank You !

謝謝