

# Simulation Toolkit and Detector Geometries for the CepC

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The 2018 International Workshop on the CepC

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# Outline

- ▶ Introduction
- ▶ Software for full simulation
- ▶ Detector geometry
- ▶ Discussion and Conclusion

# Introduction

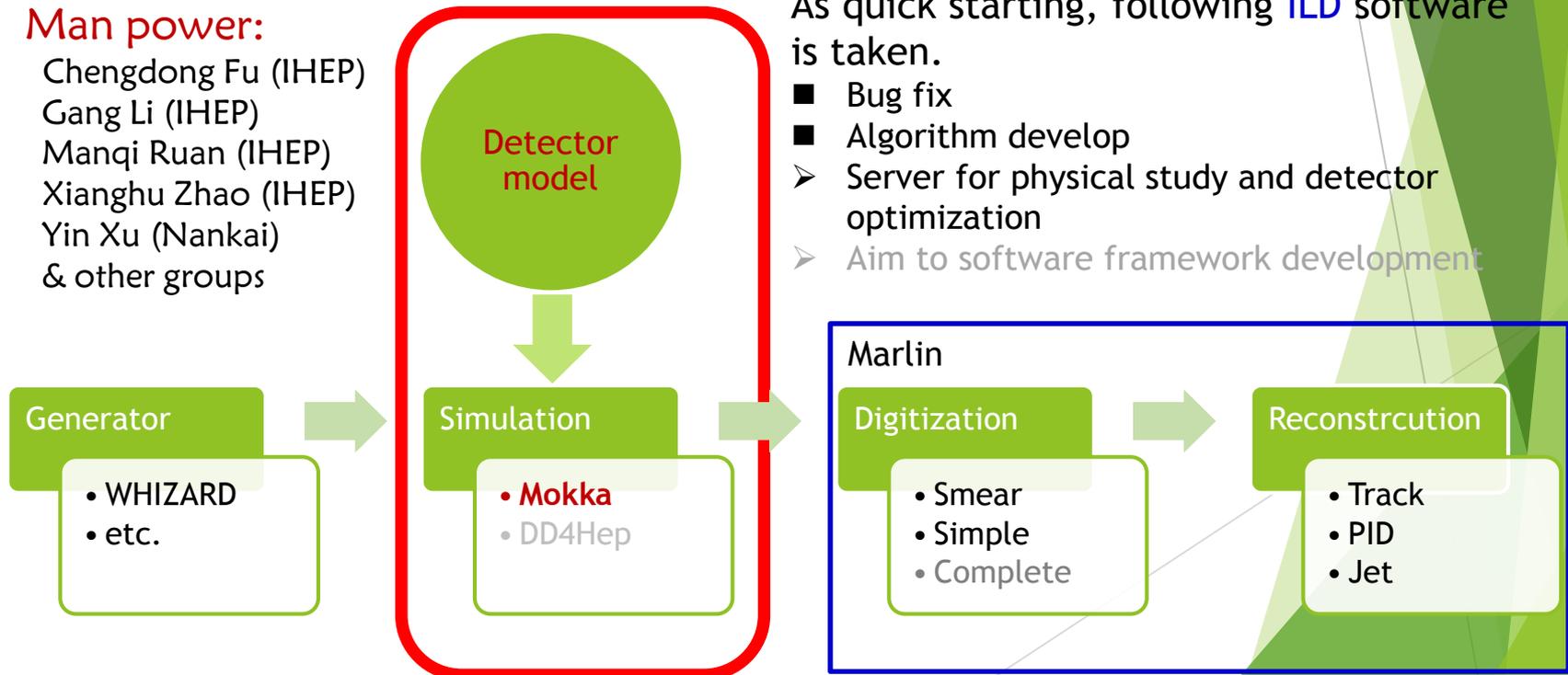
- ▶ A high energy **Circular Electron Positron Collider (CepC)** is being planned as a Higgs and/or Z factory in future. The CDR of CepC has been released.



- ▶ In order to study and optimize the **CepC** detector, software as tools is necessary, which include simulation and reconstruction.

## Man power:

Chengdong Fu (IHEP)  
Gang Li (IHEP)  
Manqi Ruan (IHEP)  
Xianghu Zhao (IHEP)  
Yin Xu (Nankai)  
& other groups



As quick starting, following **ILD** software is taken.

- Bug fix
- Algorithm develop
- Server for physical study and detector optimization
- Aim to software framework development

# Simulation Tools—MokkaC

- ▶ **Mokka** at **CepC** or **Mokka** for **collider**
- ▶ Code development
  - ▶ <http://cepcgit.ihep.ac.cn/cepcsoft/Mokka>
- ▶ Documents
  - ▶ Notes:
    - ▶ Full Simulation Software at CEPC (CEPC-SIMU-2017-001)
- ▶ How to use ([http://cepcsoft.ihep.ac.cn/guides/scratch/docs/quick\\_start/](http://cepcsoft.ihep.ac.cn/guides/scratch/docs/quick_start/))
  - ▶ Default ILCsoft environment has included Mokka. If use a developing version
    - ▶ `export MOKKA="$WORKDIR/MokkaC/MokkaC-00-01"`
    - ▶ `export PATH="$MOKKA/bin:$PATH"`
    - ▶ `export LD_LIBRARY_PATH="$MOKKA/lib:$LD_LIBRARY_PATH"`
  - ▶ Running MokkaC at foreground
    - ▶ `Mokka [-option] <steering.macro>`

# Mokka VS MokkaC

- ▶ Modellierung mit Objekten eines Kompakten Kalorimeters
- ▶ Object Modeling for compact calorimeters
- ▶ Mokka is a Geant4-based full simulation framework, in the original version, its detector data driven model is strongly based on MySQL
  - ▶ Store models information
  - ▶ Store geometry parameters
- ▶ It is modified to break away from database partly, in order to compact new sub-detectors quickly and modify them flexibly.
  - ▶ Add new sub-detector into CEPC model
  - ▶ Input parameters through steering file
- ▶ New more type of sub-detectors have been built.
  - ▶ A simple general calorimeter: silicon-based, BGO, LGO, Scintillator, THGEM, RPC, LYSO, BC420...
  - ▶ Silicon-based tracker: replace TPC
  - ▶ GeneralInterface: to intergrate sub-detector quickly

# More update

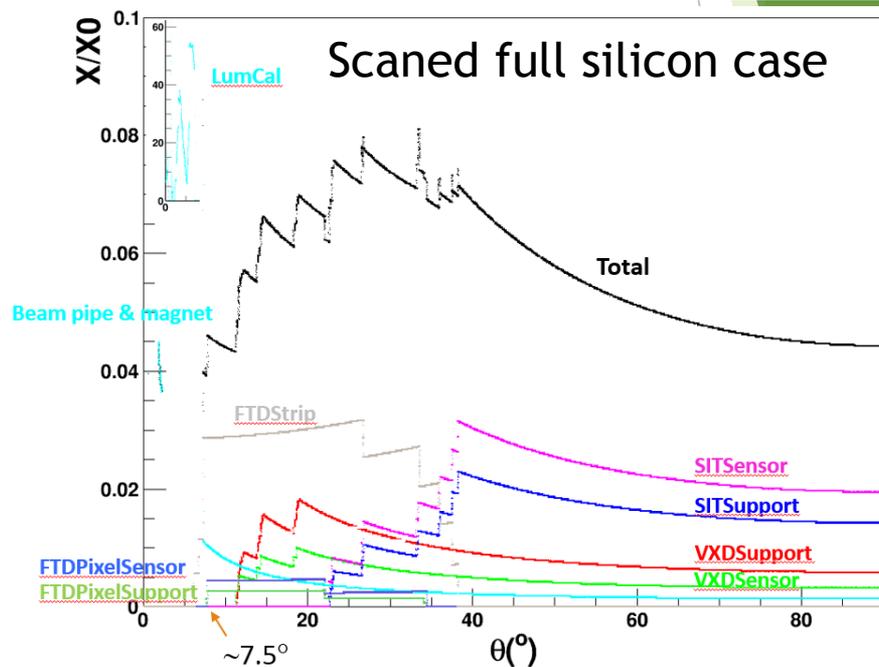
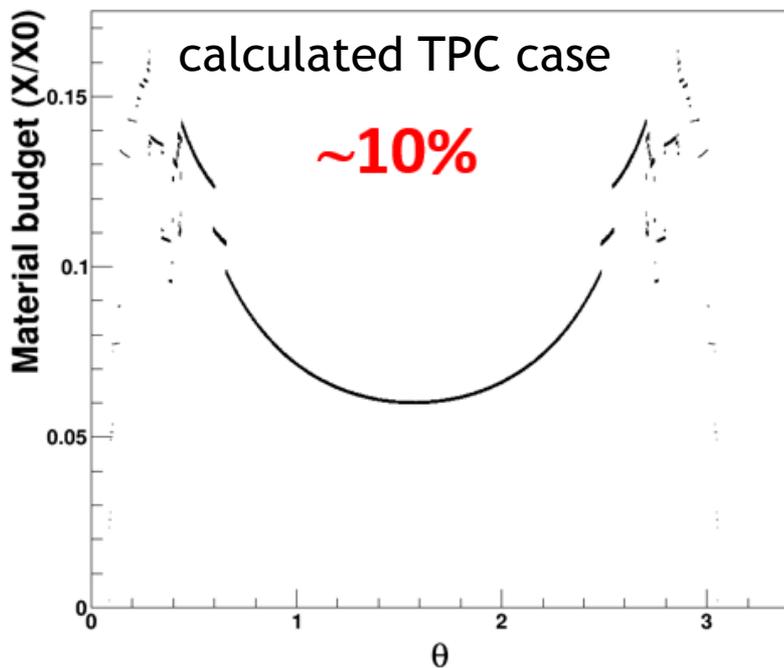
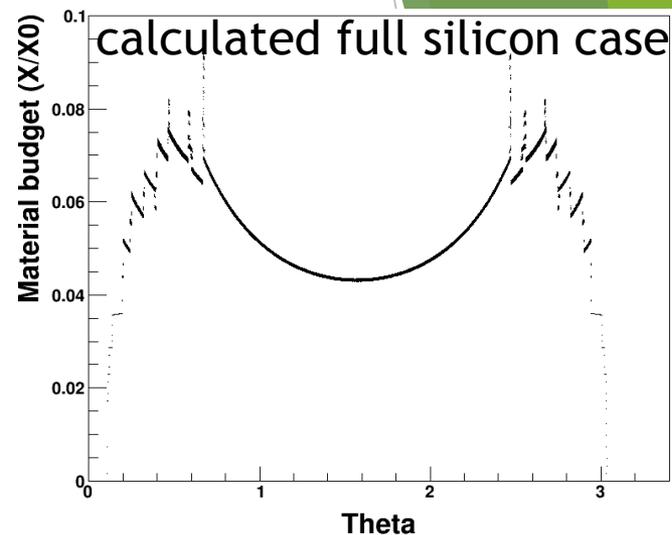
- ▶ Support to change database of driver in steering file
  - ▶ Previous:
    - ▶ /Mokka/init/EditGeometry/addSubDetector tube\_cepc
    - ▶ /Mokka/init/EditGeometry/newSubDetector SiTracker01
  - ▶ Current:
    - ▶ /Mokka/init/EditGeometry/newSubDetector new\_tube 150  
Tube\_cepc TMP\_DB03\_33\_Cu
- ▶ Support scintillator for SHcalRpc01 driver
- ▶ Add optional parameters for VXD (scale of thickness) through steering file
- ▶ Add optional parameters for Yoke (layer number and thickness) through steering file
- ▶ Correct FTD Gear output for radiation length of support

```
rInner="4.000000000e+01" radLength="9.366070445e+01" />  
" rInner="4.000000000e+01" radLength="9.366070445e+01" />
```

```
950000000e+01" radLength="2.860837413e+02" />  
1.950000000e+01" radLength="9.366070445e+01" />
```

# New tool—BudgetPlugin

- ▶ /Mokka/init/registerPlugin BudgetPlugin
- ▶ /Mokka/init/userInitString OutputFile budget.root
- ▶ /Mokka/init/userInitDouble zCut 2350
- ▶ /Mokka/init/userInitDouble rCut 1850
  
- ▶ /gun/particle geantino
- ▶ /run/beamOn 100000



# CepC Detector implemented by DD4hep

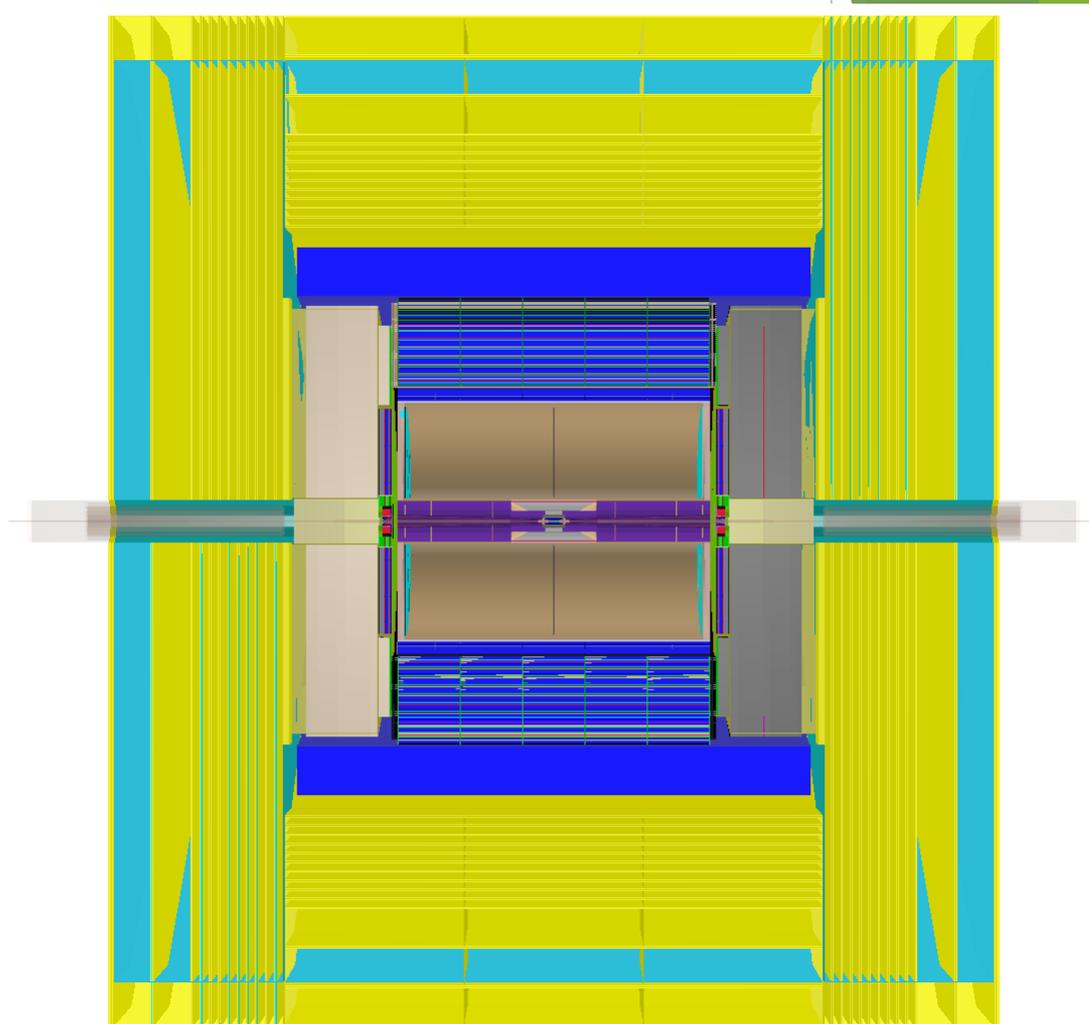
## ▶ DD4hep:

- ▶ <https://dd4hep.web.cern.ch/dd4hep/>
- ▶ xml to input detector geometry
- ▶ testing for CepC

## ▶ Issues:

- ▶ have not realized CEPC\_v4 fully same as in MokkaC

Close to CEPC\_v4

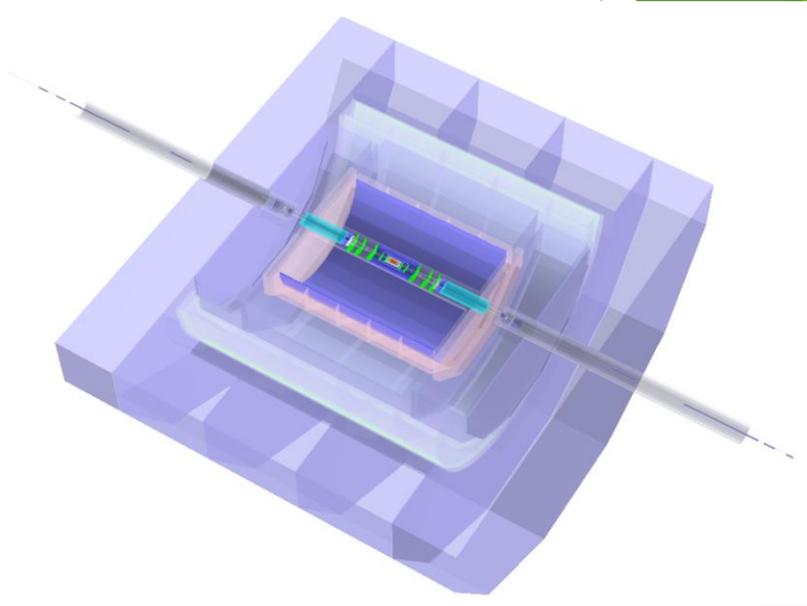
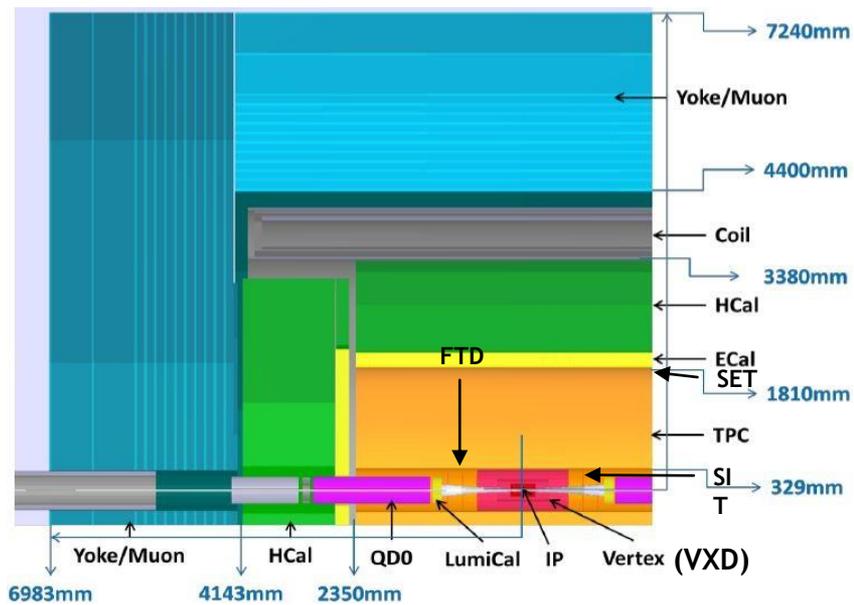


# Detector models

- ▶ Dominant difference between CEPC\_v1 and CEPC\_v4 is MDI
- ▶ Model based on full silicon tracker: CEPC\_v4 patch through steering file
- ▶ IDEA: wire chamber + dual-readout calorimeter
- ▶ CEPC\_v5 is being considered

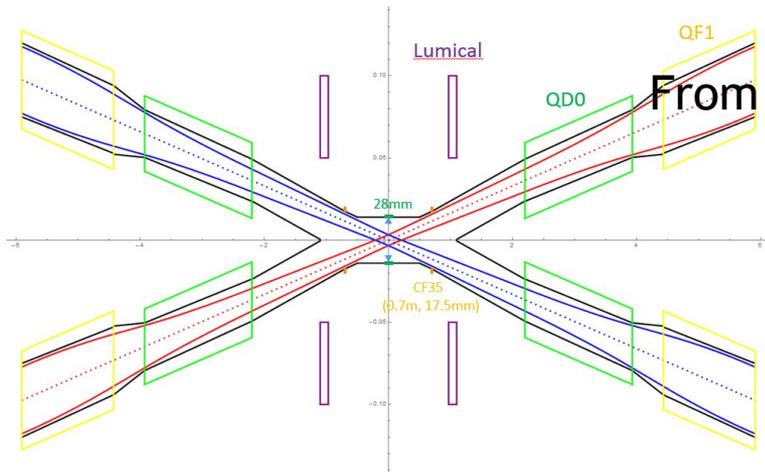
Sub-detector	CEPC_v1	CEPC_v4
Tube & Mask	Single pipe	New MDI design—doubly pipe
Lcal	R: 60 mm ~ 172 mm	R: 30 mm ~ 100 mm
VXD	16mm/62.5mm, 37mm/125mm, 58/125mm	Same as CEPC_v1
FTD	220mm, 371.3mm, 645mm, 846mm, 1057.5mm	220mm, 371.3mm, 643mm, 844mm, 925mm
SIT & SET	153mm, 300mm, 1811mm, 1813.5mm	Same as CEPC_v1
TPC	Sensitive Radius: 384mm ~ 1718mm	Same as CEPC_v1
Ecal	R: 1843mm ~ 2028mm; Z: 2450mm ~ 2635mm; Cell size: 5.0833mm Rin_endcap: 226.8 mm	Cell size: 10.1667mm Rin_endcap: 245 mm
Hcal	R: 2058mm ~ 3385.53mm; Cell size: 10.408 mm; 48 layers	R: 2058mm ~ 3143.43mm; Z: 2650mm ~ 3736.43mm; 40 layers
Yoke	Rin = 4415(barrel), 300(endcap)	Rin = 4174(barrel), 300(endcap) (240 for MDI)
Field	3.5 T	3.0 T

# CEPC\_v1



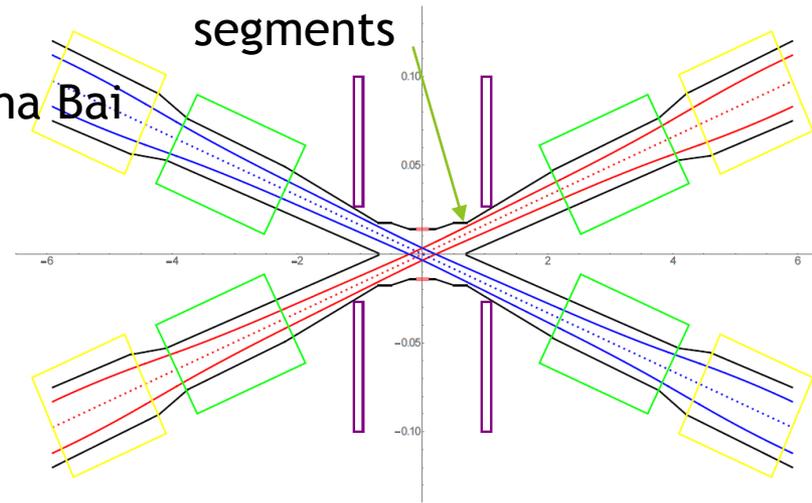
# MDI in CEPC\_v4

- ▶ There are two version of MDI with crossing angle now
  - ▶ First doubly-pipe: default in CEPC\_v4
  - ▶ Sep.26, 2017



From Sha Bai

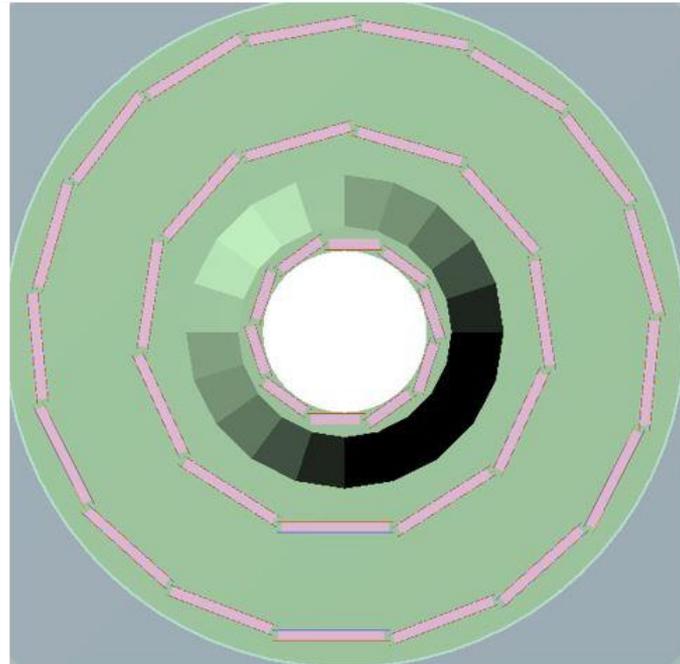
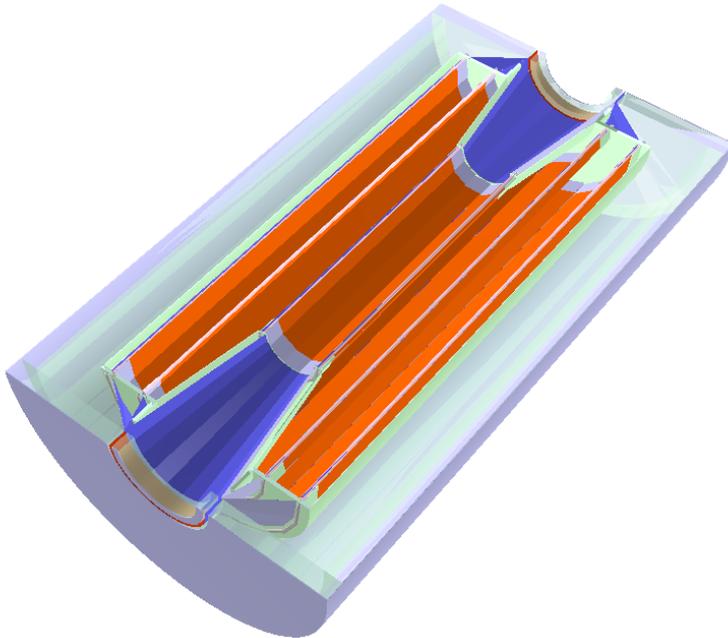
Designer is considering to use copper for these pipe segments



- ▶ How to use newer MDI
  - ▶ `/Mokka/init/EditGeometry/rmSubDetector tube_cepc_v4`
  - ▶ `/Mokka/init/EditGeometry/rmSubDetector mask_cepc_v4`
  - ▶ `/Mokka/init/EditGeometry/newSubDetector new_tube 150 Tube_cepc tube_cepc_MDI20171220pre`
  - ▶ `/Mokka/init/EditGeometry/newSubDetector new_mask 160 Mask_cepc mask_cepc_MDI20170508before`

# VXD

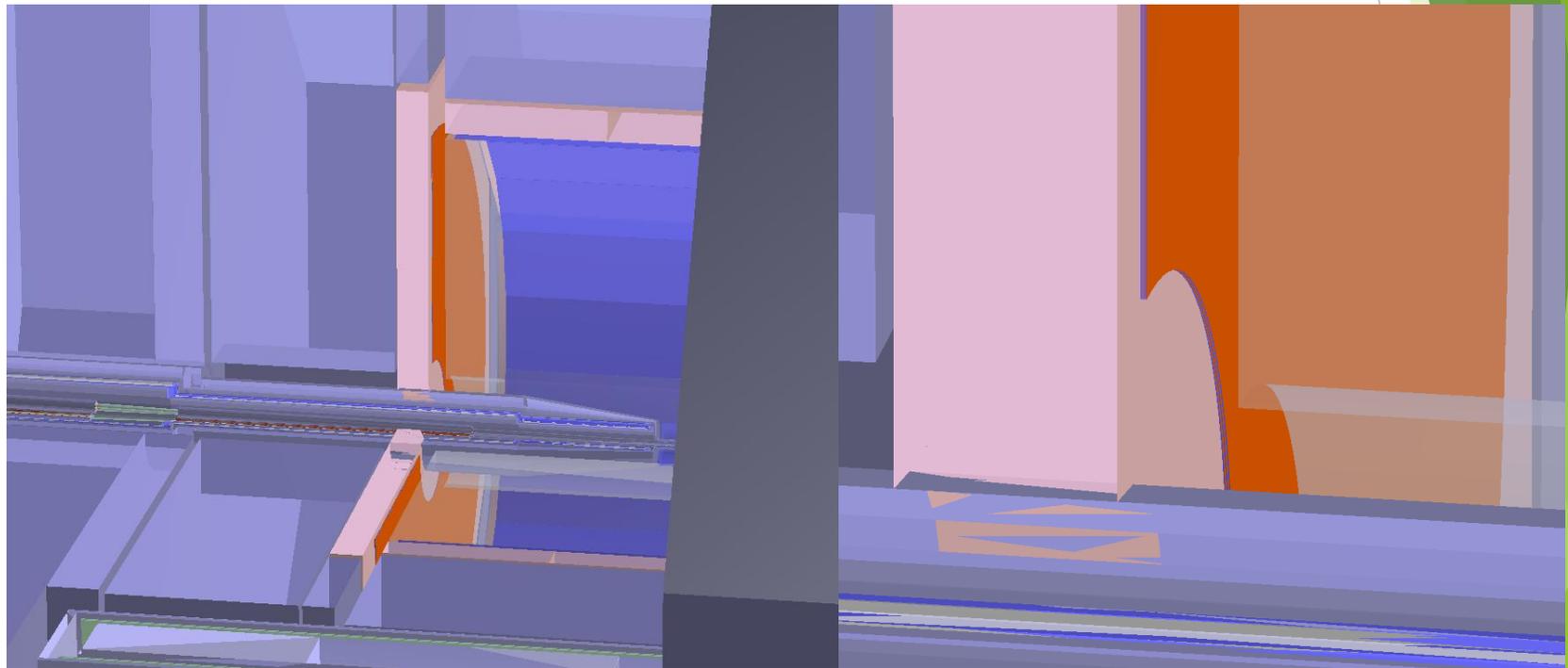
- ▶ like as **ILD**, electronics, cables, cooling pipe and support endplate included
- ▶ Option for material budget through density
  - ▶ /Mokka/init/globalModelParameter VXDSupportScale 2
  - ▶ /Mokka/init/globalModelParameter VXDSiliconScale 1



# Geometry of ETD (not included in CEPC\_v1 and CEPC\_v4)

- ▶ Simplify
  - ▶ Disc: G4Tubs, sensitive + support
  - ▶ 3 layers? determined in future
- ▶ Usage
  - ▶ Driver: ETD\_cepc
  - ▶ Mokka version: xx, currently /workfs/bes/fucd/MokkaC/
  - ▶ Add into steering file:
    - ▶ /Mokka/init/EditGeometry/newSubDetector MyETD 240 ETD\_cepc etd03

database



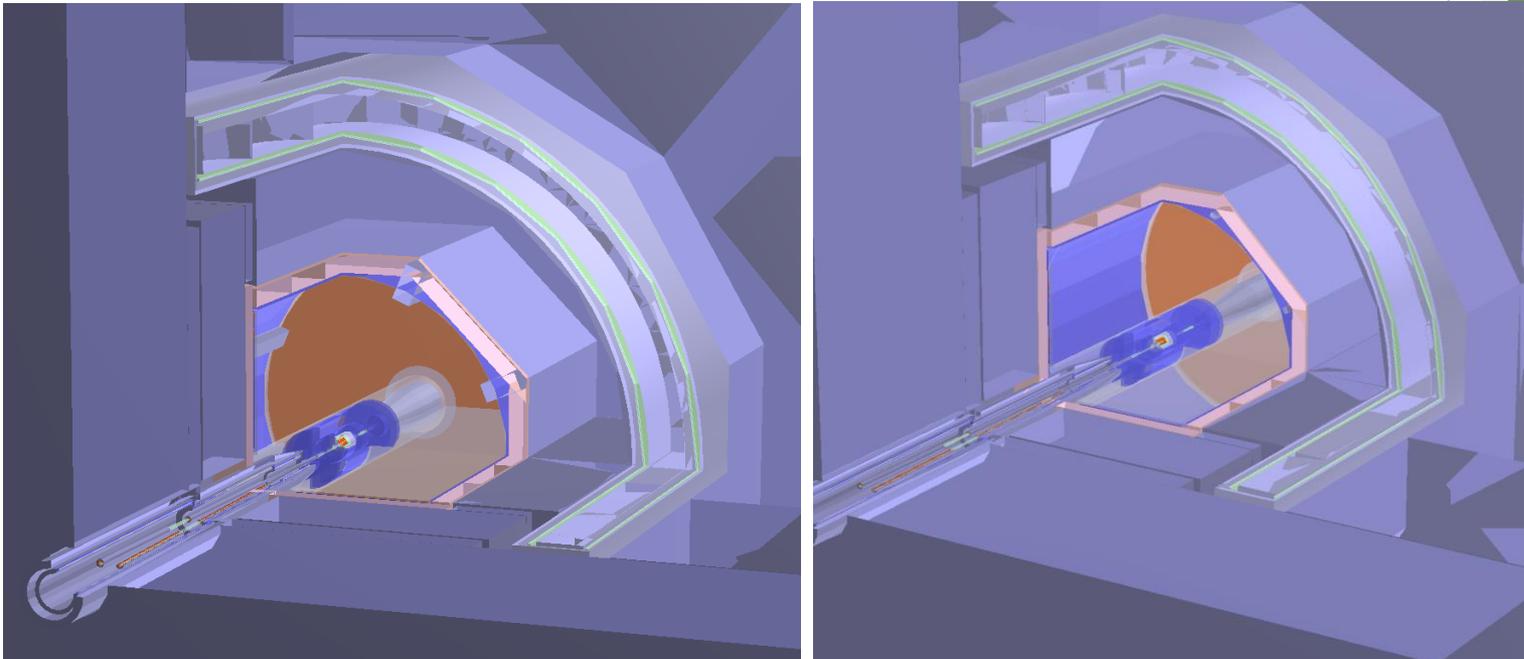
# Geometry of Laser Calibration System (Not included in CEPC\_v4 and CEPC\_v4)

## ► Simplify

- No support and electronic: stainless\_steel and TDR\_gas (95.667%Ar+2.067%CH4+2.267%CO2)
- Square tube: 4cm width and 5\*mm thickness

## ► Usage

- Driver: LaserCalibration
- Mokka version: xx, currently /workfs/bes/fucd/MokkaC/
- Add into steering file:
  - /Mokka/init/EditGeometry/newSubDetector LaserCalibration 250
  - /Mokka/init/userInitDouble LaserCalibrationPhi0 22.5



# Ecal option

## ▶ Default

- ▶ 20 layers + 10 layers
  - ▶ 0.5 mm silicon
  - ▶ 2.1 mm (4.2 mm) tungsten
- ▶ cell size: 10 mm

## ▶ To change

- ▶ `/Mokka/init/globalModelParameter Ecal_Si_thickness 1`
- ▶ `/Mokka/init/globalModelParameter Ecal_nlayers1 10`
- ▶ `/Mokka/init/globalModelParameter Ecal_nlayers2 9`
- ▶ `/Mokka/init/globalModelParameter Ecal_Sc_Si_mix 0000000000`

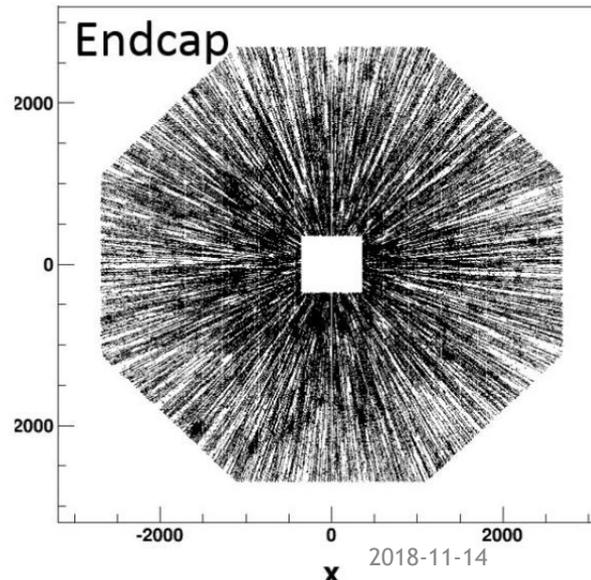
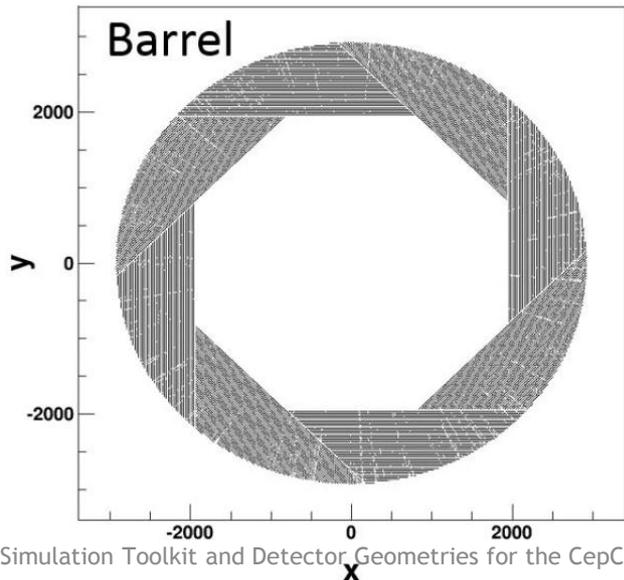
# Hcal option

## ▶ Default

- ▶ 40 layers
  - ▶ 6.73 mm RPC chamber
  - ▶ 20 mm stainless steel
- ▶ cell size: 10 mm

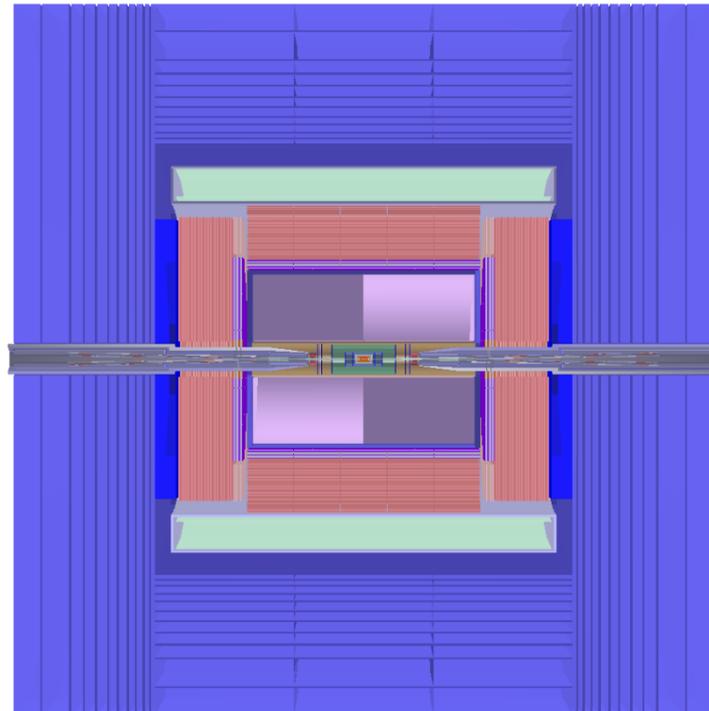
## ▶ To change

- ▶ `/Mokka/init/globalModelParameter Hcal_sensitive_model scintillator`
- ▶ `/Mokka/init/globalModelParameter Hcal_scintillator_thickness 3`
- ▶ `/Mokka/init/globalModelParameter Hcal_steel_cassette_thickness 0.5`
- ▶ `/Mokka/init/globalModelParameter Hcal_Cu_thickness 0.1`
- ▶ `/Mokka/init/globalModelParameter Hcal_PCB_thickness 0.7`
- ▶ `/Mokka/init/globalModelParameter Hcal_radiator_thickness 25`
- ▶ `/Mokka/init/globalModelParameter Hcal_nlayers 35`



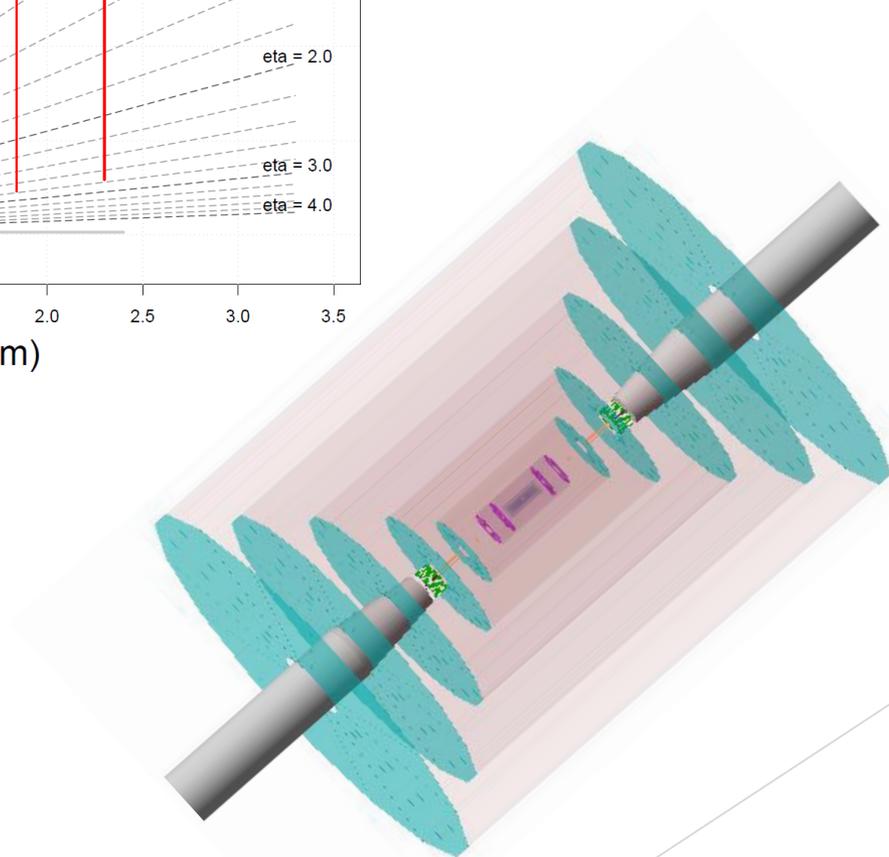
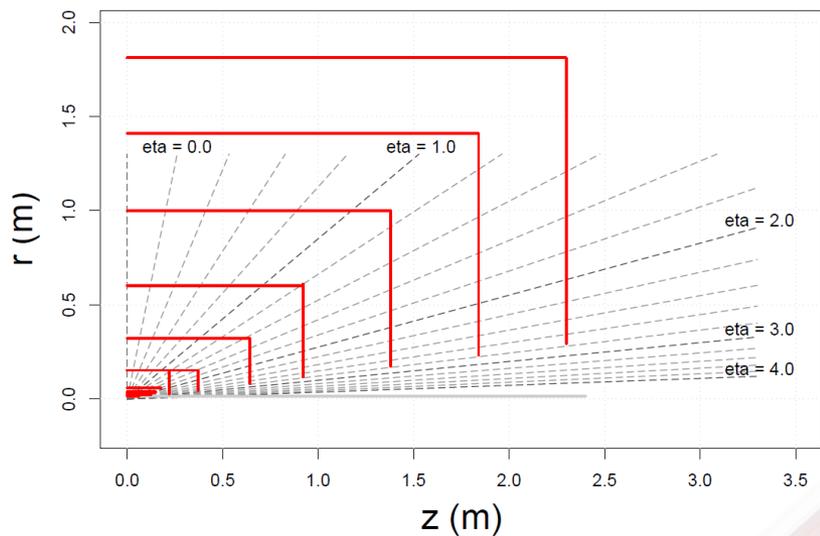
# Yoke (muon detector) option

- ▶ Default
  - ▶ yoke05 (12 iron layers, 13 RPCs for barrel and 12 RPCs for endcap)
- ▶ To change (new driver yoke06)
  - ▶ `/Mokka/init/globalModelParameter YokeUserLayer 1`
  - ▶ `/Mokka/init/globalModelParameter YokeGapThickness 25,40,40,40,40,40,40,40,40,40,40`
  - ▶ `/Mokka/init/globalModelParameter YokeIronThickness 80,80,120,120,160,160,200,200,240,540,540`



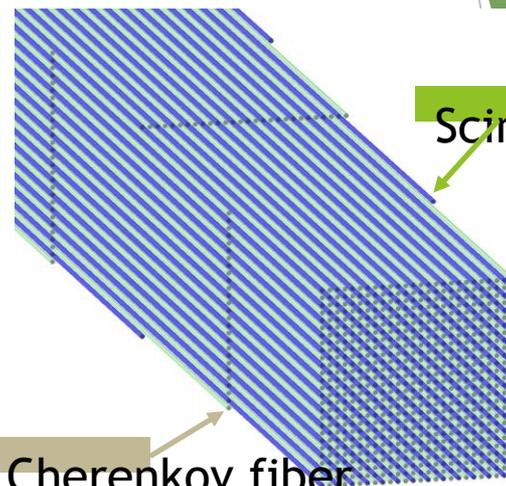
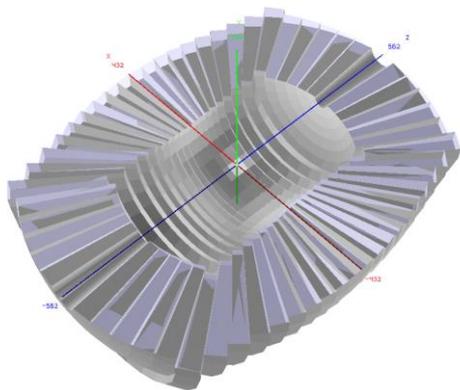
# Full Silicon-based Tracker

- ▶ Preliminary designed by Weimin YAO (LBNL)
- ▶ Use sub-detector driver
  - ▶ `/Mokka/init/EditGeometry/newSubDetector SiTracker01 100`



# IDEA Concept

- ▶ Preliminary version, but drivers have not been released



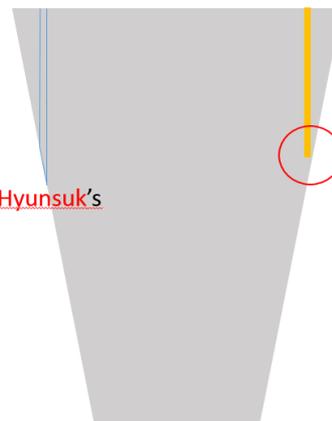
Scintillator fiber

Cherenkov fiber

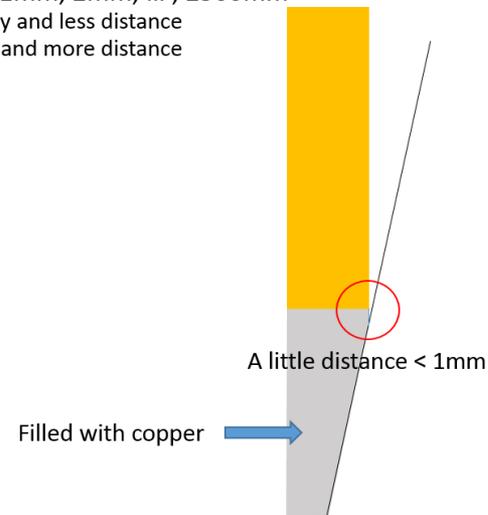
## Simplified method

- Add fiber...
  - Ignore cut
  - 2500 length of fibers: 1mm, 2mm, ... , 2500mm
    - >2500, more memory and less distance
    - <2500, less memory and more distance

This method need only 2500 volumes of class memory.

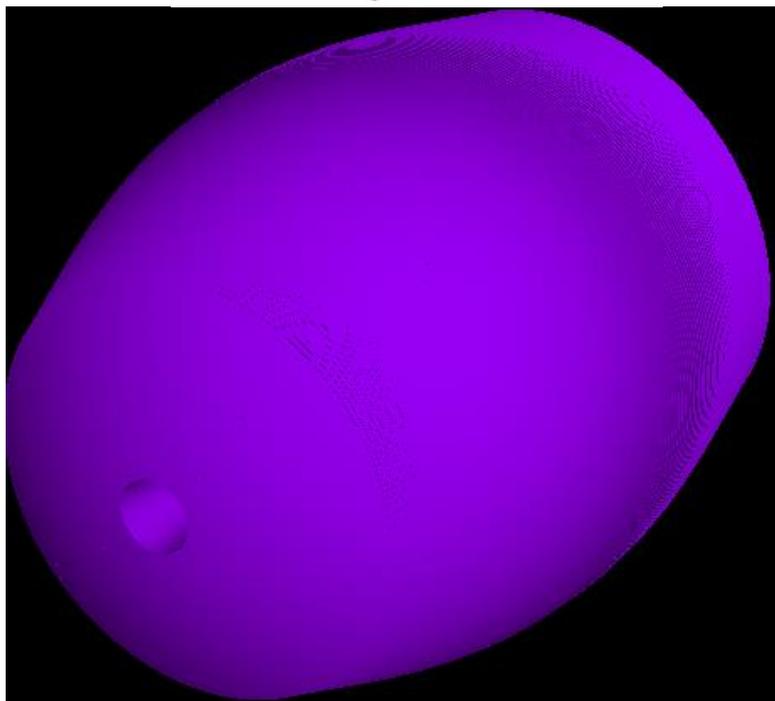


Hyunsuk's



A little distance < 1mm

Filled with copper



Simulation Toolkit and Detector Geometries for the CepC

# Discussion and Conclusion

- ▶ Many options available for simulation study
- ▶ In current MokkaC
  - ▶ MDI: DB, super driver to create temporary DB
  - ▶ VXD: DB and globalModelParameter
  - ▶ FTD, SIT, SET: DB
  - ▶ TPC: DB and globalModelParameter
  - ▶ Ecal: DB and globalModelParameter
  - ▶ Hcal: DB and globalModelParameter
  - ▶ Yoke: DB and globalModelParameter
- ▶ MokkaC→DD4hep, many validations needed

# Thanks!