

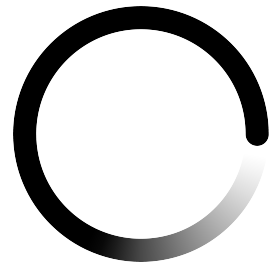
IDEA Drift Chamber in DD4hep

Detector segmentation

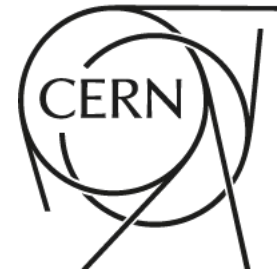
Brieuc Francois (CERN)

FCC Detector Full Sim Working Meeting

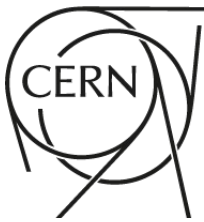
Jul. 24th, 2023



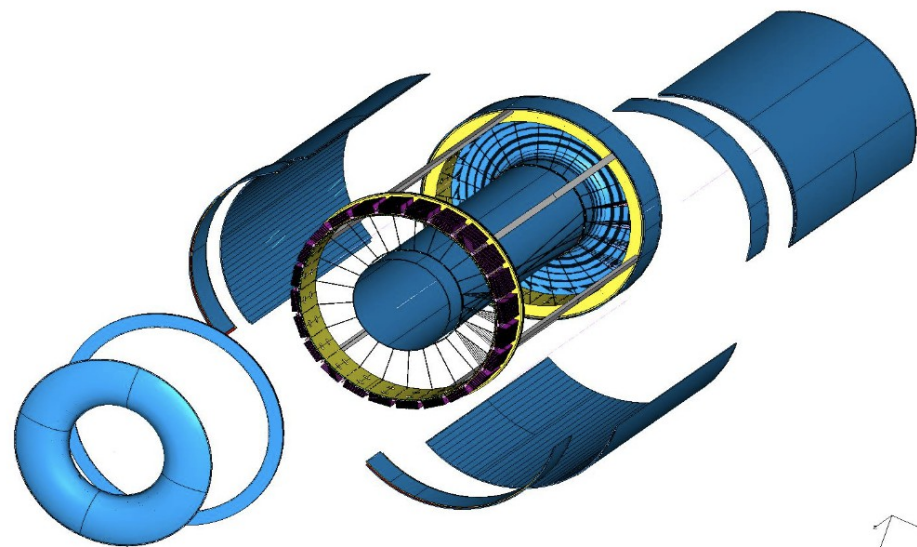
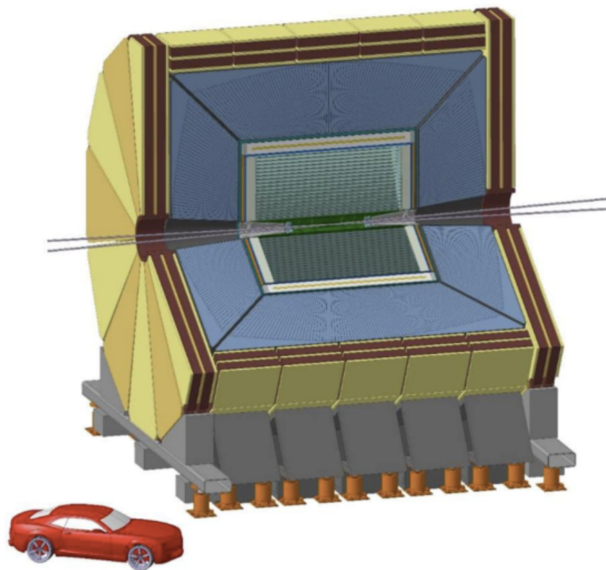
**FUTURE
CIRCULAR
COLLIDER**



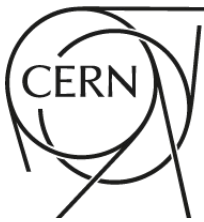
Reminder



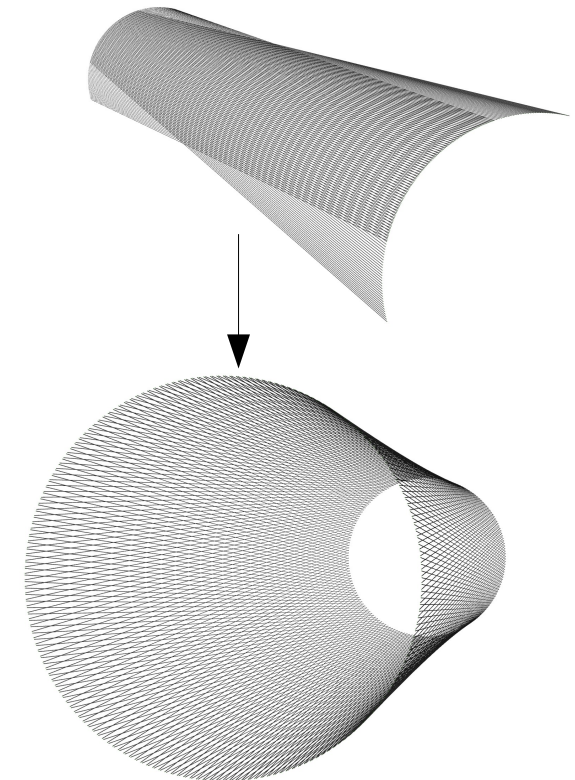
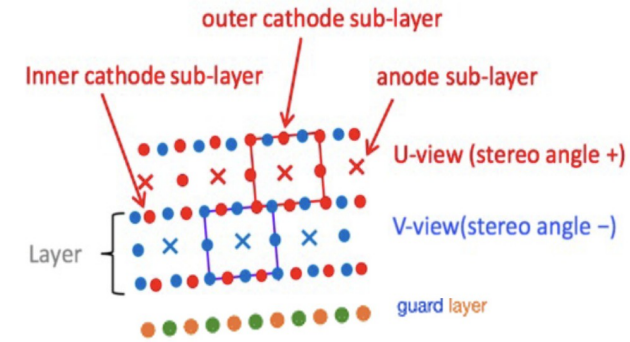
- Goal: implement the IDEA drift chamber (DC) geometry in DD4hep and its reconstruction in Key4hep
- Partial implementation made available earlier this year
 - Main developer no longer available to work on this
- Few fixes + first plots with sensitive DC presented [here](#)
- Today: more fixes + definition of sensitive volumes (Cell ID)



Bug fix



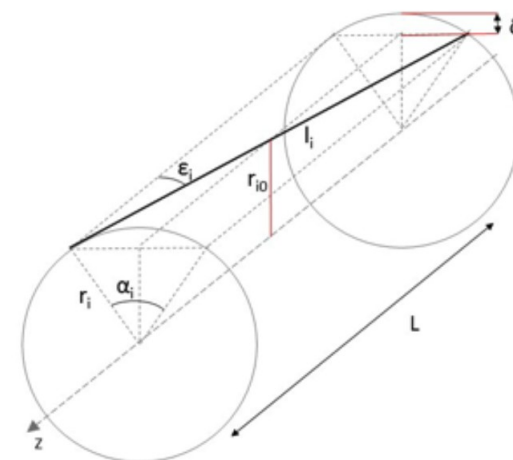
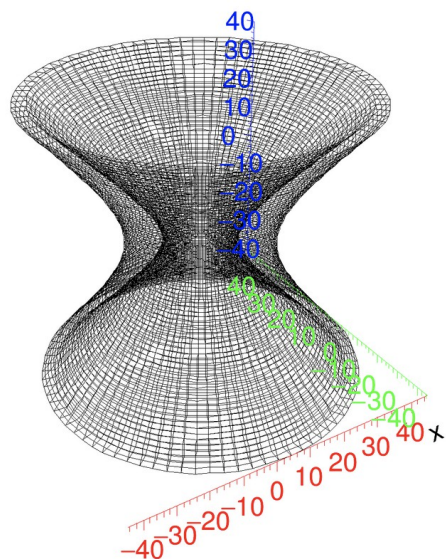
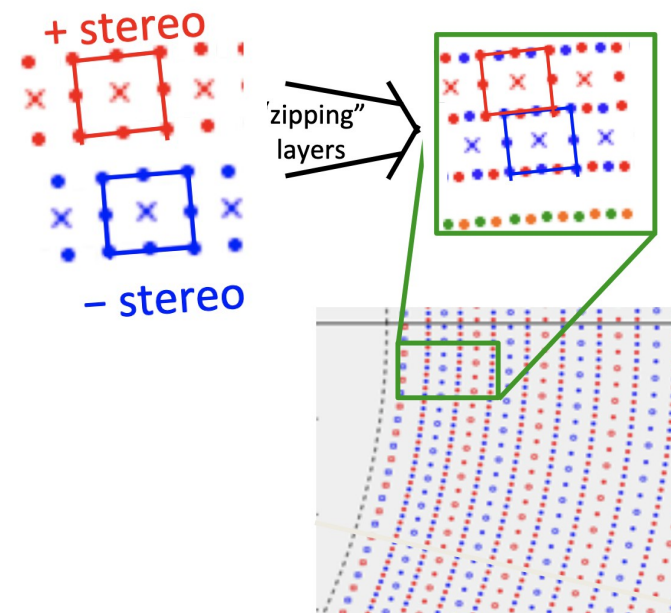
- Guard layer
 - Wires outside of the sensitive volume to improve field homogeneity
 - Was missing wires
 - Fixed
- Stereo angle of the last field wire layer was hardcoded
 - Wrong stereo angle if we change the number of layer
 - Fixed ([PR#50](#))



Drift Chamber Geometry

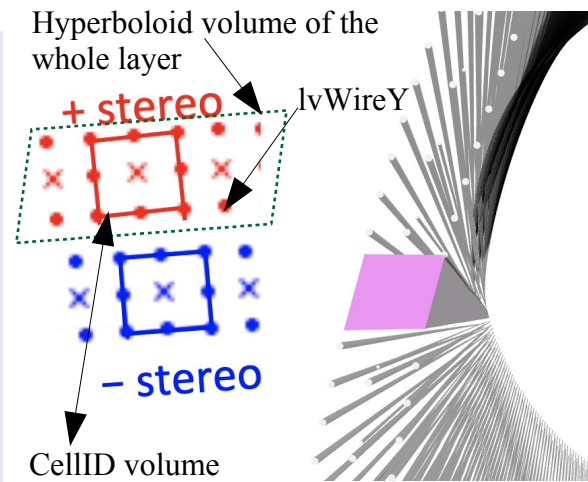
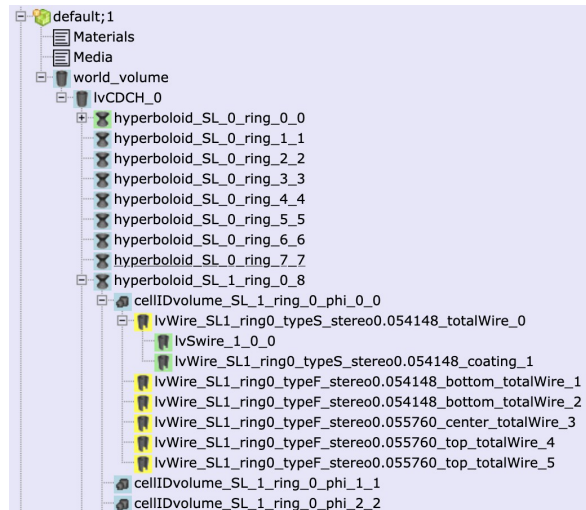
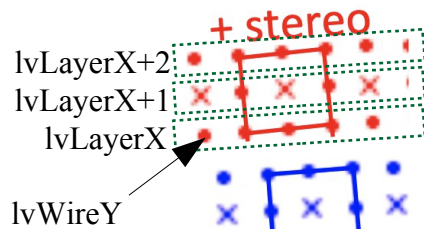


- Grounded **field wires** (dot), high potential **sense wires** to collect the signal (cross), **guard wires** (field uniformity at the radial extrema)
 - Sensitive cell volume centered on sense wire and span radially over three 'rings'
- Wires are tilted w.r.t. the z-axis (stereo angle)
 - Different radial positions at $z = 0$ and at $z = \pm z_{\text{Max}}$
 - The cell sensitive volume as a hyperbolic shape



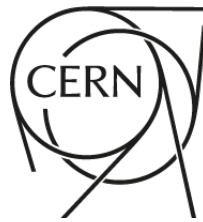
Sensitive Volume

- In the previous implementation, each wire radial 'ring' had its own hyperboloid volume
 - Regardless of its type (field/sense) → no definition of the volume associated to the sensitive cell possible
 - [PR#52](#) defines one hyperboloid per sensitive layer (instead of per wire layer), spanning over three 'rings' and centered on the sense wire (kept the old version as well)
 - Allows us to define sensitive cell volumes
 - Intersection of a tilted tube segment with the layer hyperboloid
 - Speeded up geometry construction time by a factor ~ 4 (12 min → 3 min)

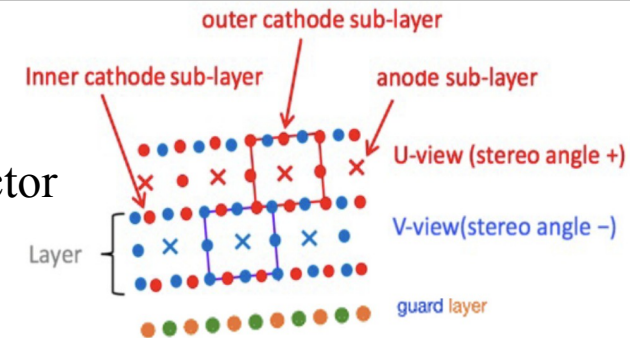


NB: a choice has to be made regarding the inclusion of lateral field wires in a given cell

Cell ID Readout Bit-field

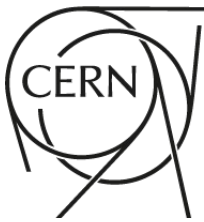


- DD4hep provides a bit-wise cell identification (64 bits)
 - Choose how many bits (X) are assigned to identify a given detector component
 - How many different values can we have: 2^X
 - Proposal
 - System (required): identify the drift chamber vs other sub-detectors
 - Super layer: self-explanatory
 - Ring: which layer inside the super layer (will probably change the name to 'layer')
 - Phi: identify which wire in phi inside the layer
 - The last three bit-fields are for dedicated studies (e.g. study hits occurring in the wires or in the detector walls, not available yet)
 - Hit origin: gas, walls, wires (can have different bit for field/sense/guard wire)
 - Stereo: needed in addition to phi because field wires have two (touching) layers with different stereo angles
 - LayerInCell: identify field wires inside a cell (bottom, middle, top)

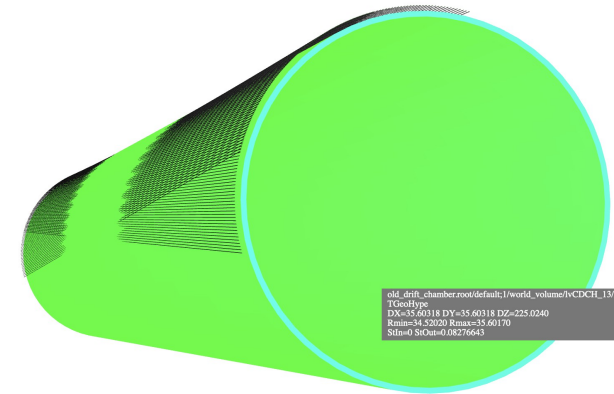


`<id>system:4,superLayer:5,ring:5,phi:11,hitorigin:3,stereo:1,layerInCell:2</id>`

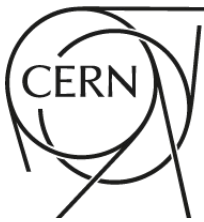
Still to be fixed



- More fixes to come
 - Dimensions/material for the various wires core and coating
 - Some wires protrude from their mother volume + overlaps
 - Number of guard wires to be checked
- Improvements
 - Lower number of free parameters
 - Some can be derived from others (e.g. number of guard wires)
 - Make the code more elegant and remove unused parameters
 - Introducing sensitive volume definition required to change the logic of the detector builder
 - Went for the 'minimal working modification' → a deeper refactoring would be good
 - Implement the possibility to make dead materials sensitive (wires, walls)
 - Useful for e.g. detailed background studies



Next step



- Digitization
 - Start simple
 - Drift time from distance w.r.t. sense wire + analytical formula (not linear)
 - Distance from the wire smeared with gaussian
 - Z position smeared with wider gaussian
 - Time window selection
 - Cluster counting from Garfield parametrization based on 'track' length, total energy loss in the cell, beta/gamma (Walaa Elmetenawee)
 - Go for the full waveform emulation in a second stage
 - May need Edm4hep data format extension (TrackerHit expect three well defined coordinates, no easy link to clusters)
- Tracking
 - To be discussed

Additional material