LGAD Tracking and Timing Layers improved detector design

ECCE Tracking Meeting
August 13, 2021

Nicolas Schmidt

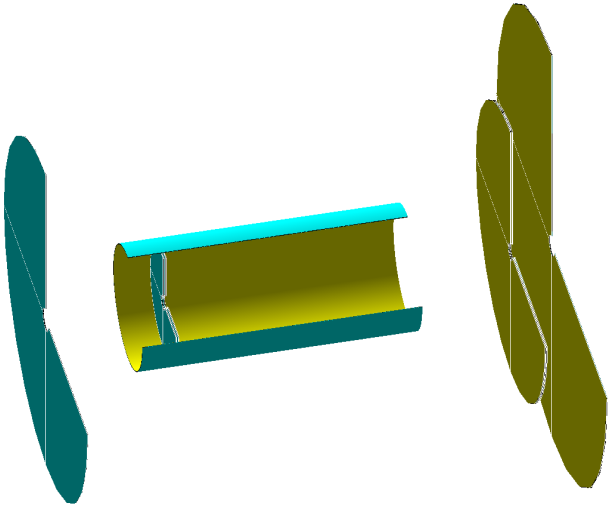
OAK RIDGE National Laboratory

EIC

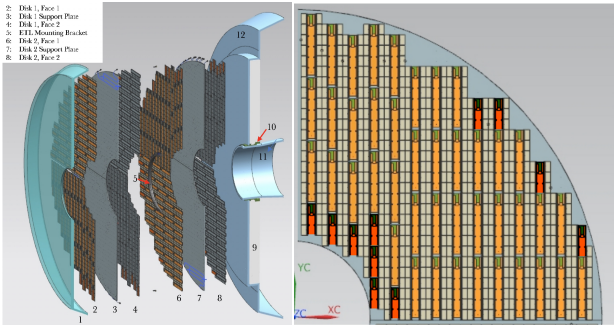
Previous TTL layer setup

Design:

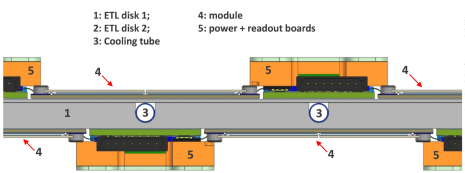
- barrel: basic cylinder layers
- forward/backward: basic disk layers
- no supports or readout
- underestimated material budget
  $\rightarrow$ 85μm silicon, 100μm Al, 20μm Kapton, 100μm water, 50μm graphite, 1cm air, 50μm graphite
- homogeneously distributed silicon layer considered as active material

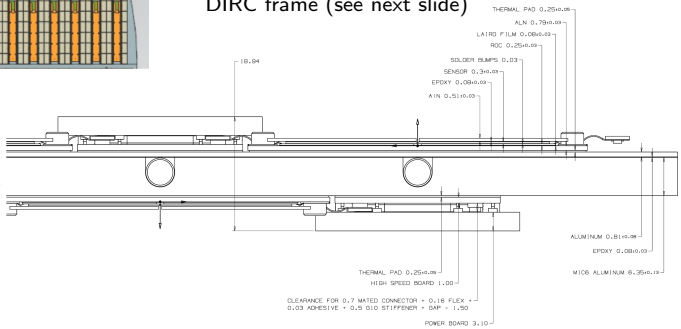


Basic design update principles

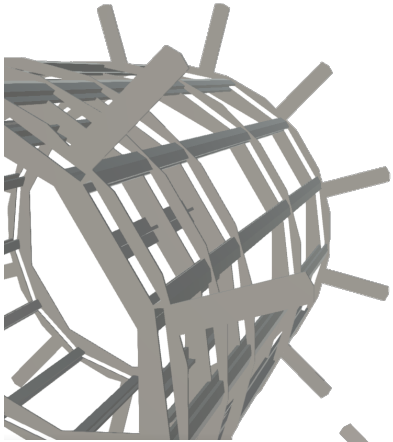


- Design based on the CMS forward upgrade [link]
- Basic elements: ladders of 3 or 6 LGAD sensors with service hybrid (for readout and power)
- Sensors mounted on aluminum plate (currently 6mm thick) and contains cooling
- Sensors on back side of plate shifted to cover service hybrid dead area (see bottom figure)
- Barrel layer to be mounted on inner or outer part of DIRC frame (see next slide)

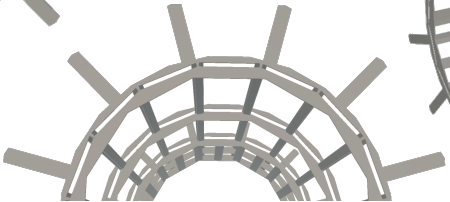


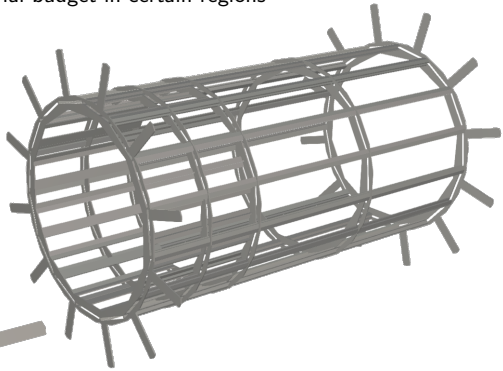


DIRC frame in barrel



- Currently only stepping files of this frame exist (sent around by Tanja)
  → porting to Fun4All needed
- Frame allows to mount modules on various radial positions
- Considered material is steel at the moment
  → significant material budget in certain regions

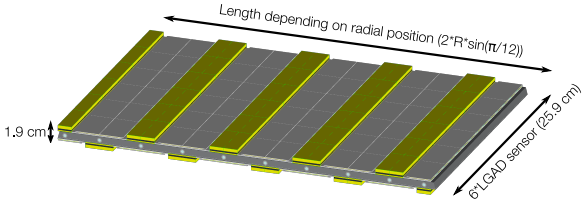


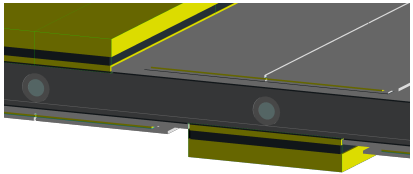


New Layers in Geant4

fun4all_eicdetectors/simulation/g4simulation/g4ttl

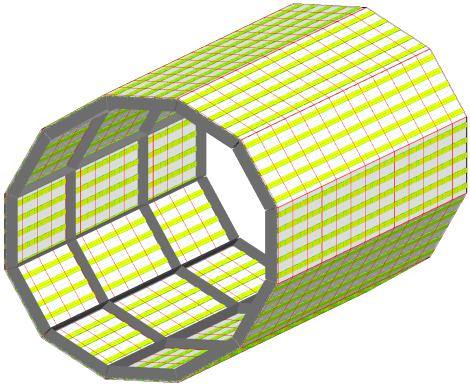
- LGAD sensors ($21 \times 42\text{mm}^2$) mounted on readout chips ($21 \times 21\text{mm}^2$) on top of Aluminum Nitride substrate for thermal conduction to aluminum plate
- Al plate in total 7.16mm thick and contains 5mm diam. cooling tubes
- Service hybrids (big yellow boxes) made of various materials, dominated by the power boards
- Sensors placed on both sides of plate for full coverage (total thickness $\sim$ 1.9 cm)
- Each barrel module is 6 LGAD sensors long and width depends on radial position

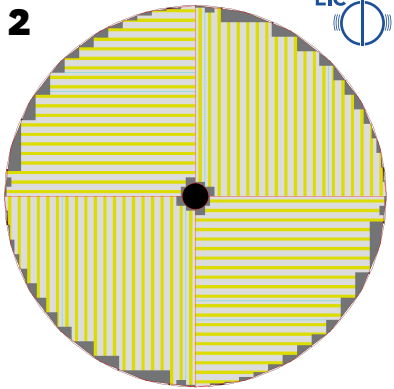


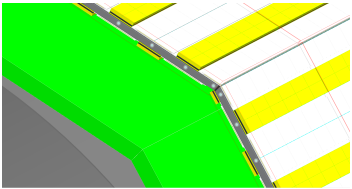


New Layers in Geant4 - 2

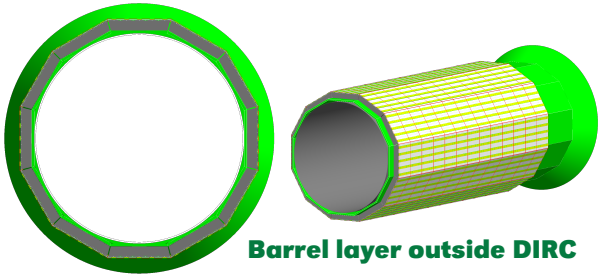
- Barrel made of 12 modules in azimuth and multiple modules along z-axis
  $\rightarrow$ implemented additional temporary support structure based on DIRC frame principles (support $\sim$7 cm high and 6mm thick)
- Forward layers mounted on identical 1/4 disk slices ($\rightarrow$ 4 modules) which are rotated by 90 degrees (see image)



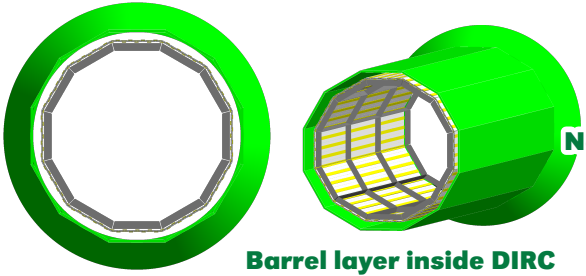




New Layers in Geant4 - 3

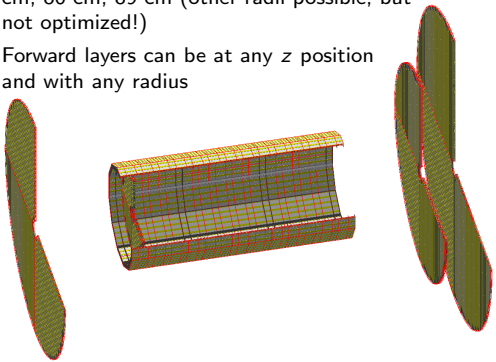


Barrel layer outside DIRC



Barrel layer inside DIRC

- Implemented barrel radial positions: 50 cm, 80 cm, 89 cm (other radii possible, but not optimized!)
- Forward layers can be at any z position and with any radius



New TTL layers in default ECCE configuration

Summary and next Steps

- New TTL layer geometries implemented
  $\rightarrow$ barrel allows for all currently required radial positions
  $\rightarrow$ forward layers are fully flexible in inner and outer radius
- Parts of the detector design could be further improved (e.g. sensor placement on forward layers at high η)
- Material budget is much more realistic now
- Full ECCE tracking soon needs to be transitioned from fast tracking to actual detector-hit based tracking
  $\rightarrow$ work on digitizer ongoing to have digits (encoded hits in LGADs with x,y,z,t) available
- DIRC frame needs to be ported from CAD file to Fun4All (also requires changes to DIRC itself)