Migration of Dual-Readout Calorimeter Design and Simulation package from Full GEANT4 to Fun4All

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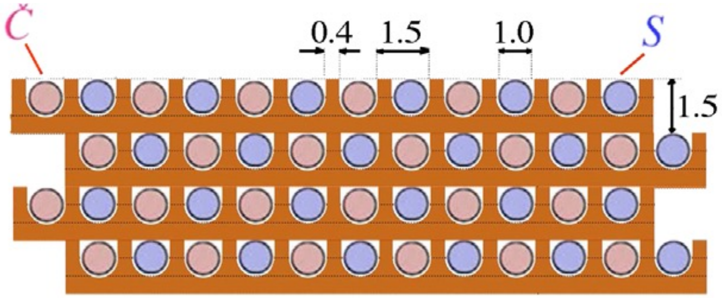
Dual-Readout Calorimeter Simulation: FCC-DRC vs. Fun4All

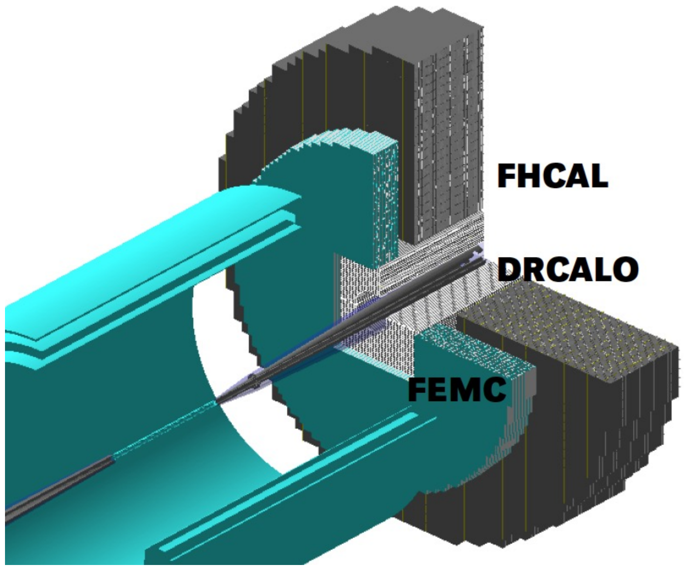
- Dual-readout Calorimeter(DRC):
  - full geometry with detailed features of DRC is implemented in FCC DRC simulation
  - basic geometry (absorber and fibers) is already implemented in Fun4All
  - no light propagation and readout simulation yet (optical photons are used directly)

https://indico.bnl.gov/event/11918/contributions/50512/attachments/35032/56968/210608_shKo_EIC.pdf
https://indico.bnl.gov/event/11917/contributions/50327/attachments/34872/56681/HDYOO_EICcal_06012021.pdf



Structure of DRC

- Main goal:
  - migration of FCC DRC features to Fun4All as much as possible



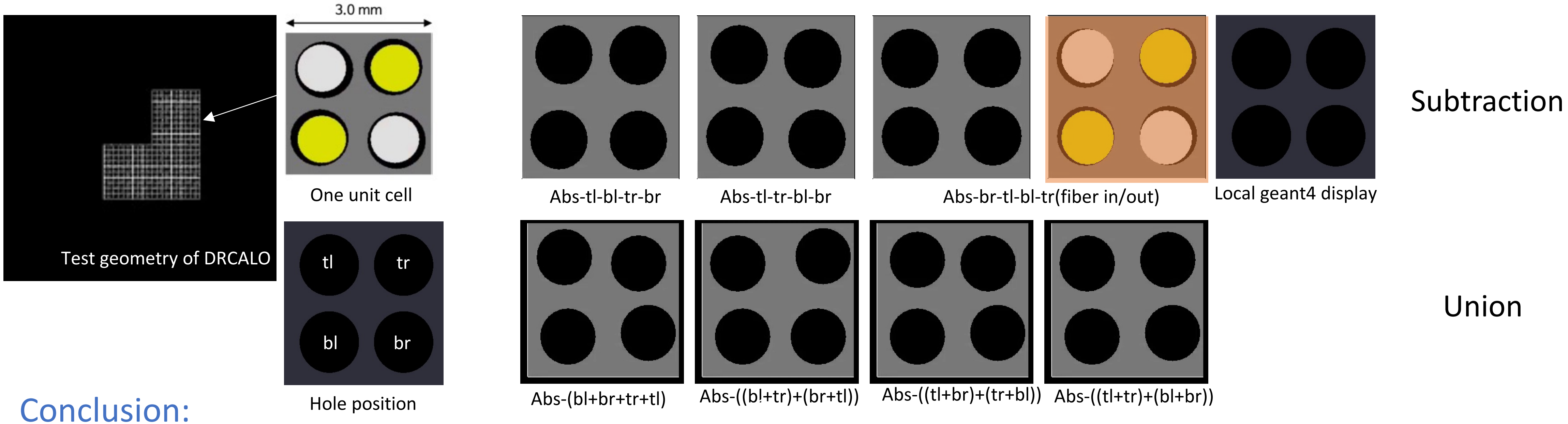
Fun4All display with Inlay DRCALO

detector	z [m]	depth [cm]	radial coverage [cm]	pseudorapidity	tower size [cm]
ECAL:					
PHENIX/ALICE reuse	$z = 2.9$	37.5	$20 < r < 183$	$1.24 < \eta < 3.50$	5x5 (6x6)
HCAL:					
LHCAL	$z < 3.5$	100	$20 < r < 262$	$1.11 < \eta < 3.47$	5x5
DRCALO :					
(full)	$3.0 < z < 4.5$	150	$20 < r < 220$	$1.11 < \eta < 3.47$	0.3x0.3
(inlay)	$3.0 < z < 4.5$	150	$20 < r < 50$	$2.70 < \eta < 3.70$	0.3x0.3

Tower geometry in Fun4All

Hole alignment study

- Issue with the current 'encirclement' geometry in Fun4All:
  - hole locations are dependent on the order of the GEANT4 volume subtraction
  - good alignment display in local GEANT4 in contrast
- Comparison of various approaches :
  - G4UnionSolid method : Abs – (h^1 + h^2) – (h^3 + h^4) or Abs – (h^1 + h^2 + h^3 + h^4)
  - G4SubtractionSolid method: Abs – h^1 – h^2 – h^3 – h^4
  - named according to hole position : (top, bottom), (left, right)



- Conclusion:
  - Nicolas Schmidt also noticed the same problem
  - A temporary solution (highlighted) will be used for the moment

Readout Implementation : SiPM & optical photon

Difference between FCC-DRC and Fun4All-DRCALO

- Readout procedure
  - Fun4All-DRCALO : deposited energy in fibers
  - FCC-DRC : deposited energy in SiPM from propagated optical photons

- Optical properties :
  - check the track of optical photon of two types of fiber
  - found a different optical photon yields in scintillation fiber

```
tab->AddConstProperty("SCINTILLATIONYIELD", 200/MeV); //fun4all
tab->AddConstProperty("SCINTILLATIONYIELD", 13.9/keV); //FCC-DRC
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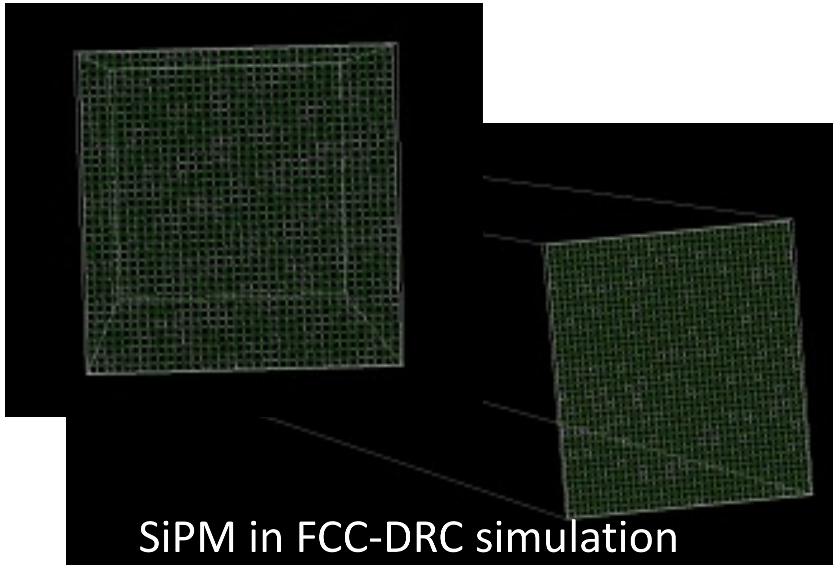
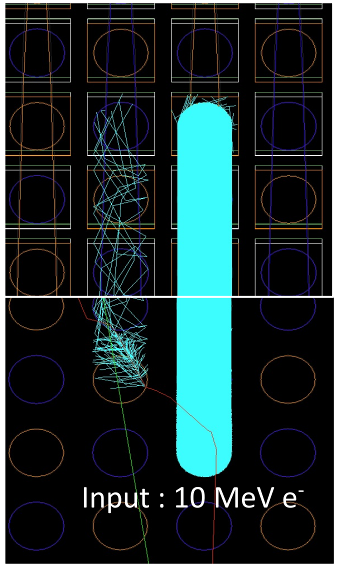




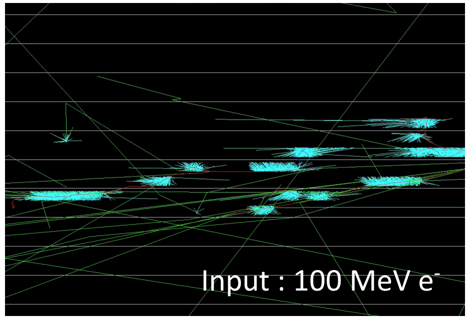
Top : end of fiber

Bottom : begin of fiber

Left fiber: Cherenkov

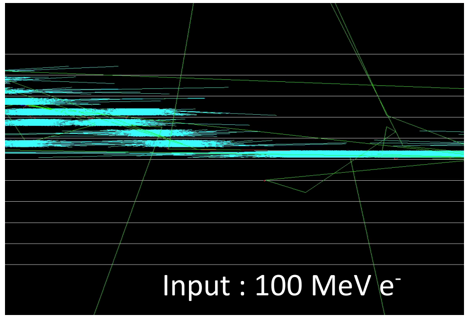
Right fiber: Scintillation

Default optical property

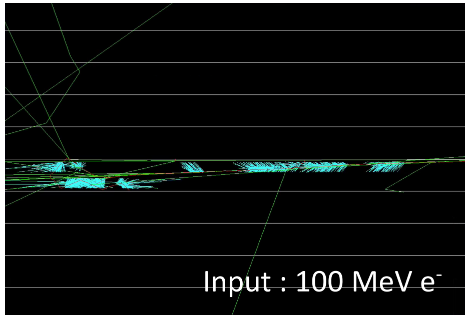


Display of only scintillation fiber

Modified Scintillation Yield 200/MeV -> 13.9/keV



Display of only Scintillation fiber



Display of only Cherenkov fiber

Summary & Plan

- Issue with the hole geometry:
  - hole locations are dependent on the volme subtraction order
  - temporary 'best-looking' soluion is being used at the moment

- Procedure in the FCC-DRC simulation:
  - full propagation or fast simulation of optical photons to the end of fibers
  - energy deposit in SiPM (active detector) for each fiber
  - SiPM hit object containing information such as position, energy, number of photons, and others
  - reconstruction with SiPM hit objects

- Plan for Fun4all
  - recently started to play DRCALO geometry in Fun4all
  - implementation of SiPM geometry at the end of fibers
  - procedure to store hit information compatible with the existing hit object and reconstruction step