Detector Configurations in Simulations

ECCE Calorimetry Working Group

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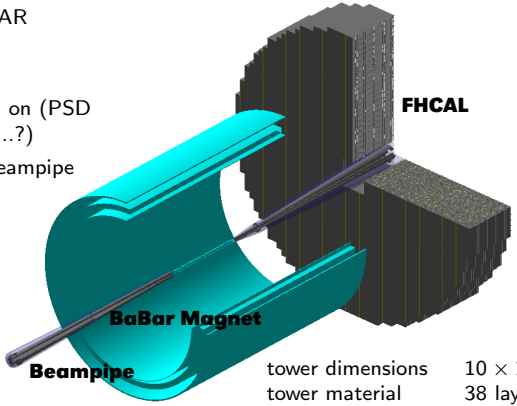
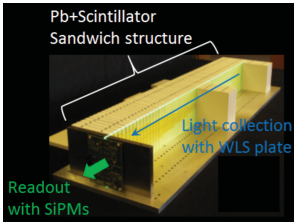
Calorimeter Setups in Fun4All - FHCAL

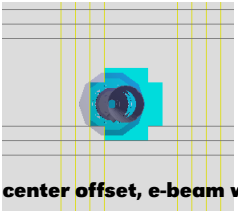
fun4all_eicdetectors/simulation/g4simulation/g4eiccalos/PHG4ForwardHcalSubsystem.cc

Forward HCAL:

- Baseline design based on the STAR forward update
- See [link] for more info
- Alternative designs being worked on (PSD style, Dual-Readout (see later), ...?)
- Offset of center-cutout due to beampipe tilt available
  → partially recovers high η






center offset, e-beam view

Caveats:

- no support structures and services implemented
- no light propagation and electronics simulation
- steel material required for flux return
- calibration factors not yet determined

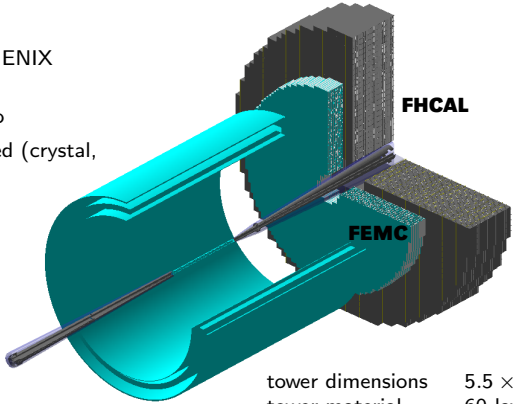
tower dimensions	$10 \times 10 \times 81$ cm^3 (2044 towers)
tower material	38 layers: 20mm Fe and 2.3mm Sci
	3mm WLS plates
interaction length	$L \sim 4.5\lambda$
pseudorapidity	$1.11 < \eta < 3.47$
global position	$3.5 < z < 4.5$m
	radius of ~ 2.62m

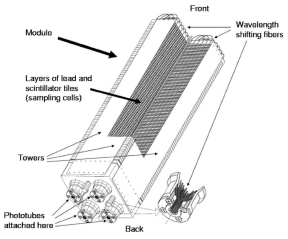
Calorimeter Setups in Fun4All - FEMC

fun4all_eicdetectors/simulation/g4simulation/g4eiccalos/PHG4ForwardEcalSubsystem.cc

Forward EMCAL:

- Baseline design based on the PHENIX Shashlik ECal
- See [link] and [link] for more info
- Alternative designs being explored (crystal, other materials, ...)





Caveats:

- no support structures and services implemented
- no light propagation and electronics simulation
- calibration factors not yet determined

tower dimensions	$5.5 \times 5.5 \times 37.5$ cm^3 (3244 towers)
tower material	60 layers: 1.5mm Pb and 4mm Sci
interaction length	$L \sim 18X_0$
pseudorapidity	$1.24 < \eta < 3.5$
global position	center at 3.1m from IP
	radius of $\sim$ 1.8m

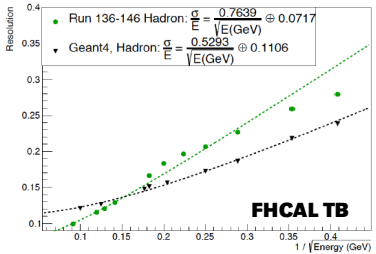
Calorimeter Performance in Fun4All - FHCAL/FEMC

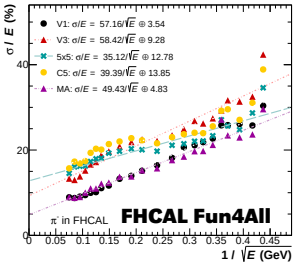
- YR requirements:
  → FHCAL: $\sigma/E \approx 50\%/\sqrt{E} \oplus 10\%$
  → FEMC: $\sigma/E \approx (4-12)\%/\sqrt{E} \oplus 2\%$

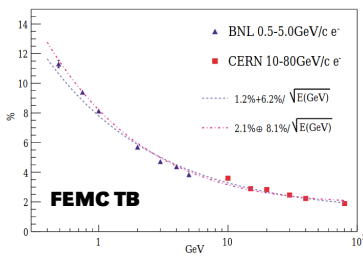
- Resolution from testbeams compared to Fun4All simulation performance for chgarged pions (FHCAL) and photons (FEMC)

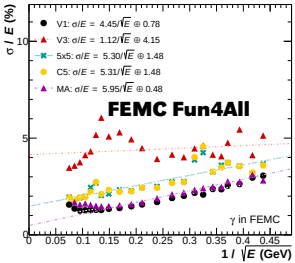
- Clusterizer-dependence of resolution visible (best clusterizers MA and Template V1)

- Fun4All detectors over-perform
  → for physics studies artificially deteriorate performance to match test beam for individual detectors
  → largely attributed to lack of light propagation and electronics simulation







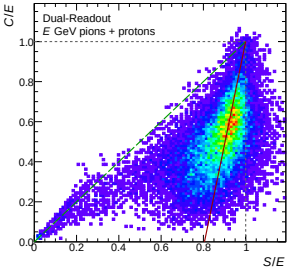


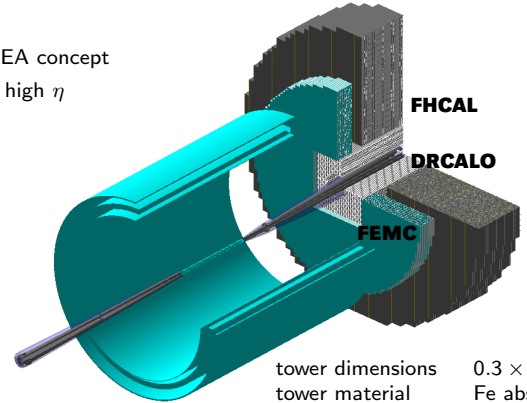
Calorimeter Setups in Fun4All - Dual Readout

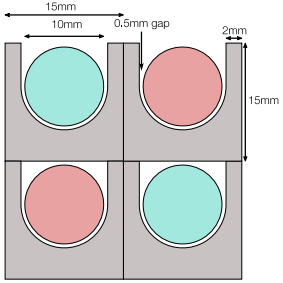
`fun4all_eicdetectors/simulation/g4simulation/g4drcalo/PHG4ForwardDualReadoutSubsystem.cc`

Forward Dual Readout Calorimeter:

- Baseline design derived from IDEA concept
- Replaces FEMC and FHCAL at high η
- See [link] for more info
- Tower design being worked on
  $\rightarrow$ resolution of current design:
  $\sigma/E \approx 16\%/\sqrt{E} \oplus 2\%$







Caveats:

- no support structures and services implemented
- no light propagation and electronics simulation
- clusterization not solved (ML?)
- steel material required for flux return

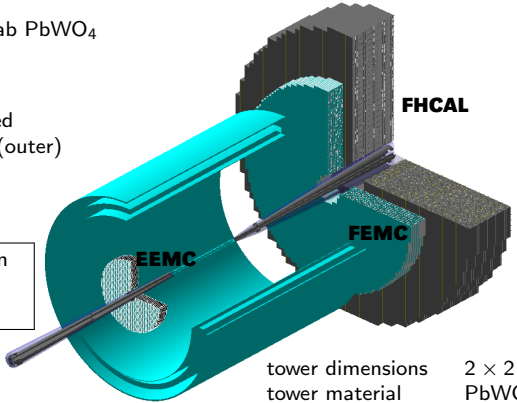
tower dimensions	$0.3 \times 0.3 \times 150$ cm^3
tower material	Fe absorber 2 Sci fibers, 2 quartz fibers
interaction length	$L \sim 6\lambda$
pseudorapidity	$2.7 < \eta < 3.7$
global position	center at 3.75m from IP width of $\sim$ 55cm

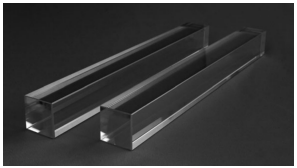
Calorimeter Setups in Fun4All - EEMC

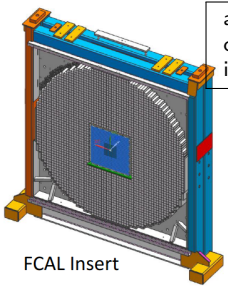
fun4all_eicdetectors/simulation/g4simulation/g4eiccalos/PHG4CrystalCalorimeterSubsystem.cc

e-side EMCAL:

- Baseline design based on the JLab $PbWO_4$ crystals
- See [link] for more info
- Alternative designs being explored
  → $PbW0_4$ (inner) and SciGlass (outer)
- YR performance requirement:
  → $\sigma/E \approx 2\%/\sqrt{E} \oplus (1-3)\%$







FCAL Insert

alternative design currently being implemented

Caveats:

- no support structures and services implemented
- no light propagation and electronics simulation
- position/size not studied yet

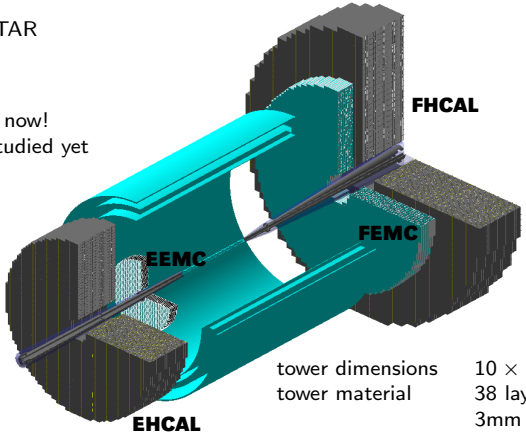
tower dimensions	$2 \times 2 \times 18$ cm^3 (2900 towers)
tower material	$PbWO_4$ crystals with 90μm carbon shell
interaction length	$L \sim 20X_0$
pseudorapidity	$-3.77 < \eta < -1.63$
global position	center at -1.7m from IP
	radial: $7.8 < r < 65.6$cm

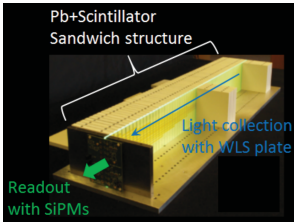
Calorimeter Setups in Fun4All - EHCAL

fun4all_eicdetectors/simulation/g4simulation/g4eiccalos/PHG4BackwardHcalSubsystem.cc

e-side HCAL:

- Baseline design based on the STAR forward update HCAL
- See [link] for more info
- Placeholder implementation for now! Position, size, design, etc not studied yet
- YR performance requirement: $\rightarrow \sigma/E \approx 45\%/\sqrt{E} \oplus 6\%$





tower dimensions	$10 \times 10 \times 81$ cm^3 (2044 towers)
tower material	38 layers: 20mm Fe and 2.3mm Sci
	3mm WLS plates
interaction length	$L \sim 4.5\lambda$
pseudorapidity	$1.11 < \eta < 3.47$
global position	$-3.3 < z < -2.4$m
	radius of ~ 2.62m

Caveats:

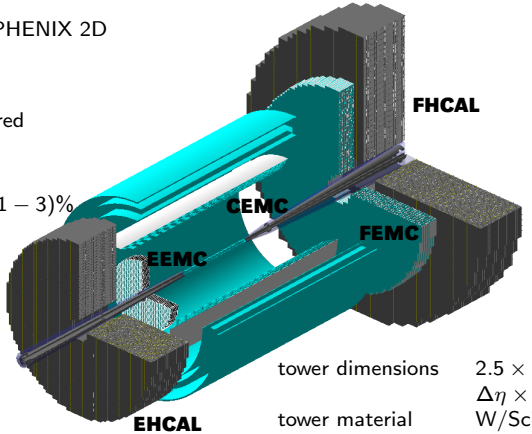
- no support structures and services implemented
- no light propagation and electronics simulation
- steel material might be required for flux return

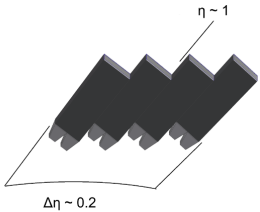
Calorimeter Setups in Fun4All - CEMC

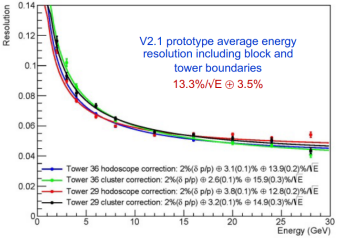
coresoftware/simulation/g4simulation/g4detectors/PHG4CylinderSubsystem.cc

Central EMCAL:

- Baseline design based on the sPHENIX 2D Projective ECal
- See [link] for more info
- Alternative designs being explored (W/Cu/SciTile, ...)
- YR performance requirement: $\rightarrow \sigma/E \approx (10-12)\%/\sqrt{E} \oplus (1-3)\%$







tower dimensions	$2.5 \times 2.5 \times 14$ cm^3 (projective)
	$\Delta\eta \times \Delta\varphi \approx 0.025 \times 0.025$mrad^2
tower material	W/SciFi: Tungsten+Epoxy+Fibers
	667 Sci fibers (0.47mm) embedded
interaction length	$L \sim 20X_0$
pseudorapidity	$\lvert\eta\rvert < 0.85$
global position	$92 < r < 116$cm

Caveats:

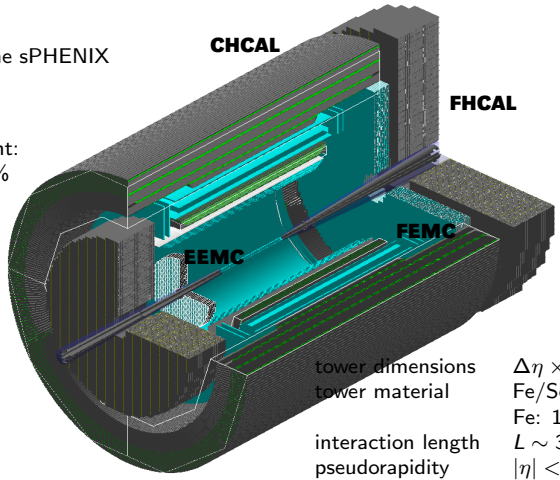
- in-depth performance studies for EIC needed

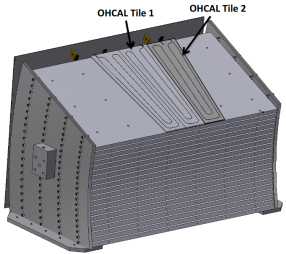
Calorimeter Setups in Fun4All - CHCAL

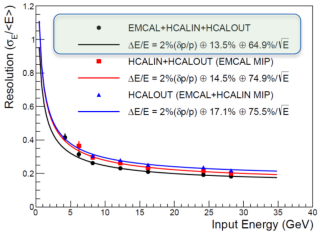
coresoftware/simulation/g4simulation/g4detectors/PHG4InnerHcalSubsystem(PHG4OuterHcalSubsystem).cc

Central HCAL:

- Baseline design based on the sPHENIX inner and outer HCal
- See [link] for more info
- YR performance requirement: $\rightarrow \sigma/E \approx 100\%/\sqrt{E} \oplus 10\%$







tower dimensions $\Delta\eta \times \Delta\varphi \approx 0.1 \times 0.1\text{mrad}^2$
tower material Fe/SciTile: Scintillator 0.7cm
Fe: 1.0–1.5cm (in), 2.6–4.3cm (out)
interaction length $L \sim 3.5\lambda$
pseudorapidity $|\eta| < 1.0(1.1)$
global position radius (inner) $116 < r < 137$cm
radius (outer) $182 < r < 269$cm

Caveats:

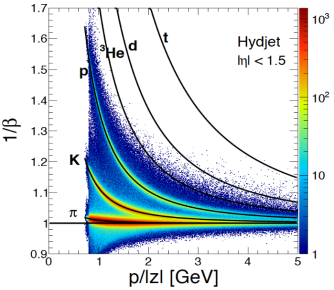
- in-depth performance studies for EIC needed

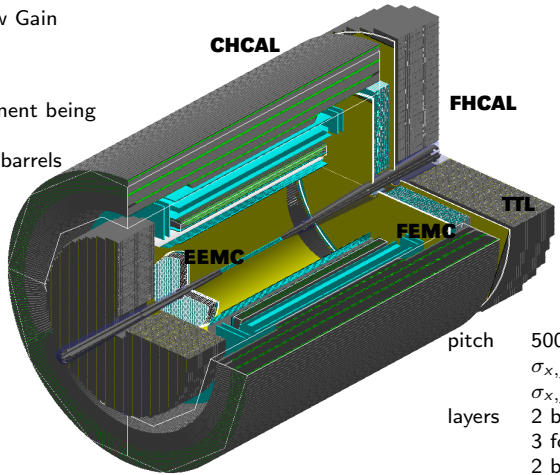
Calorimeter Setups in Fun4All - TTL

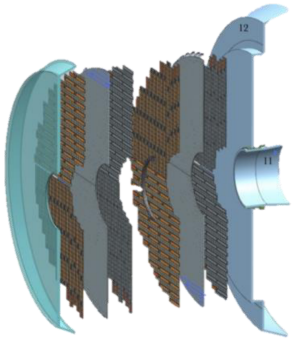
coresoftware/simulation/g4simulation/g4detectors/PHG4SectorSubsystem.cc

Timing and Tracking Layers (TTL):

- Baseline design based on Low Gain Avalanche Diodes (LGADs)
- See [link] for more info
- Pitch, dimensions and placement being explored
  → forward disks and central barrels possible







pitch	500μm
	$\sigma_{x,y} \sim 30\mu$m (AC-LGAD)
	$\sigma_{x,y} \sim 145\mu$m (std)
layers	2 barrel layers (1 after ECal)
	3 forward layers (1 after ECal)
	2 backward layers
η	$-3.7 < \eta < 3.7$
PID	$\sigma_t \sim 20$ps (single layer)

Caveats:

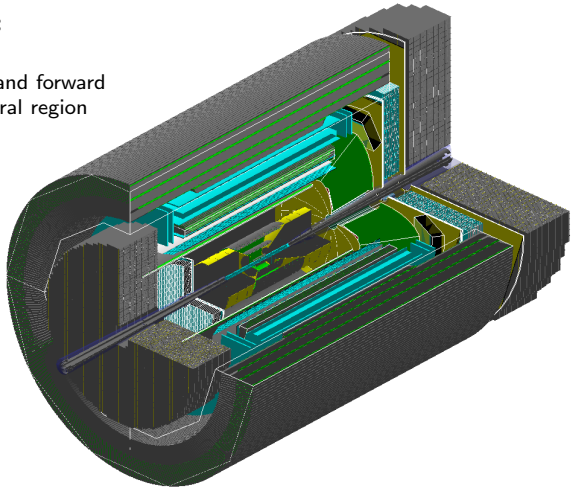
- currently idealized tracking
- no module structure and still full coverage

Calorimeter Setups in Fun4All - ECCE full

`fun4all_eicmacros/detectors/Modular/Fun4All_G4_FullDetectorModular.C`

Full detector in Fun4All:

- Tracking detectors:
  → silicon trackers central and forward
  → alternative TPC in central region
  → GEM trackers
- PID detectors:
  → forward RICH



Physics performance should be evaluated with all detector systems.