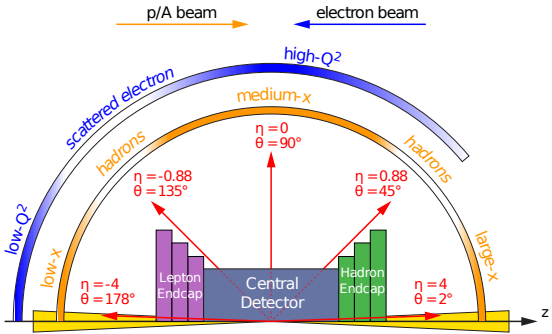
Calorimeter Working Group - Update

July 26, 2022

Friederike Bock (ORNL), Carlos Muñoz Camacho (IJCLAB), Paul Reimer (ANL), Oleg Tsai (UCLA)

Generalized detector design considerations

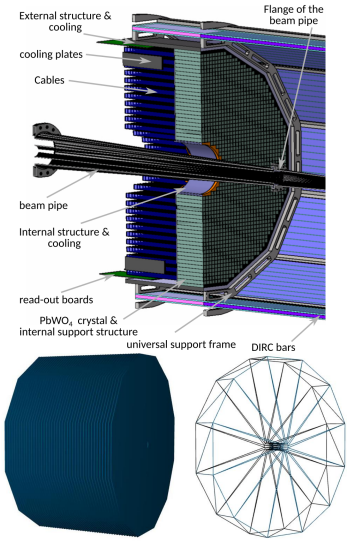


- Large rapidity coverage for central detector
- Specialized far-forward detectors for p kinematics measurements
- High precision low mass tracking
- Hermetic coverage of tracking, electromagnetic & hadronic calorimetry
- High performance single track PID for π, K, p seperation
- High efficiency & resolution for scattered electron detection

Highly integrated design between detector and machine for IR

Electron-Endcap Calorimeters

Electron-Endcap Calorimeters



ATHENA endcap design with 41 layers of steel/scintillator arranged in 12 sectors

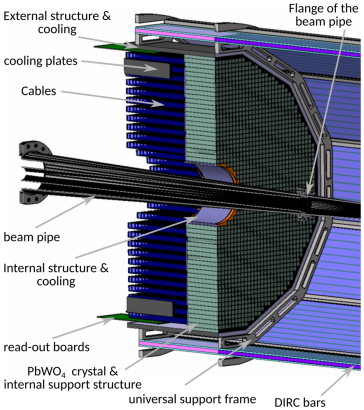
EMCal

- Non-projective $PbWO_4$ - crystal calorimeter as proposed by EEEMC-Consortium
- Increased coverage in η through inlay around beam pipe - exact details to be worked out
- Detailed mechanical design in the works
- R&D coordinated by EEEMC Consortium, contact Tanja Horn/Carlos Munoz

HCal

- Reference design contains no backward HCAL
- Some amount of steel is needed for flux return
- Consensus within the calorimetry WG that the detector design should not preclude the possibility of adding an HCAL as an future upgrade
- Preparing stronger physics case (Brian Page) and infra-structure for possible upgrade path

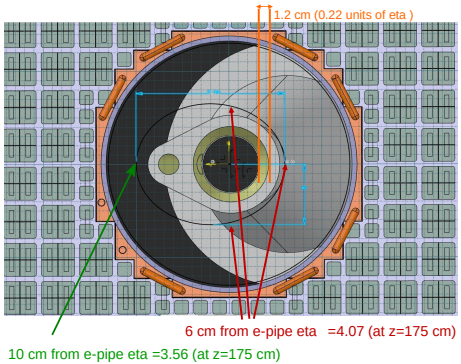
EEMC mechanical design & read-out updates



Mechanical design

- Updated CAD models available with new DIRC frame
- Main concern increasing η coverage towards beam pipe
  - Flange in front of EEMC needs to fit through calo for pipe diassembly
  - Integration in DIRC frame as whole detector
- Solution: New beam pipe (6/24/2022) allows for larger η coverage possibility without inlay

EEMC mechanical design & read-out updates



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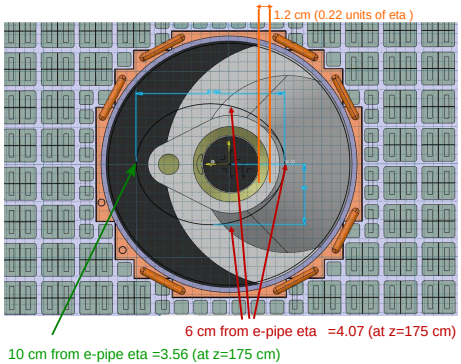

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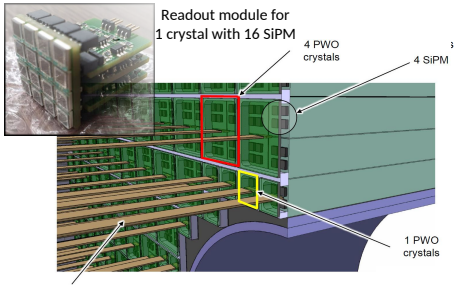
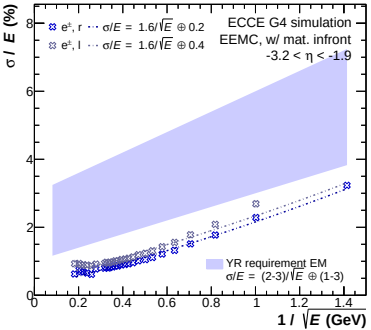


Read-out design

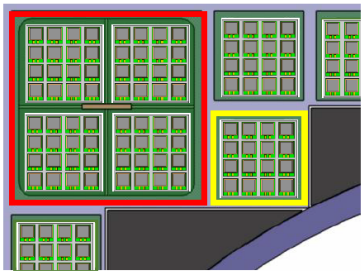
- 1 crystal read out by 16 SiPMs
- Test beams at DESY & JLAB 2022/23
  Goal: Test SiPM readout & triggerless DAQ

EEMC performance studies



With geometry of the proposed detector, tails dominated by the material between towers rather than material in front

- Trying to reduce material in between towers
  a) thinner carbon
  b) carbon frame front & back
  c) 2x2 assemblies with foil in between
- Close interaction between engineers & physicists needed for quick turn-around



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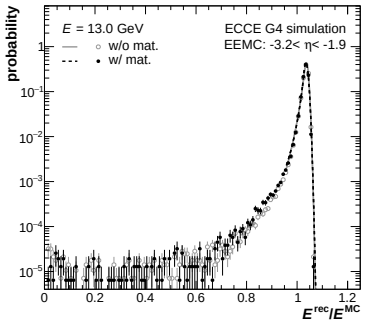

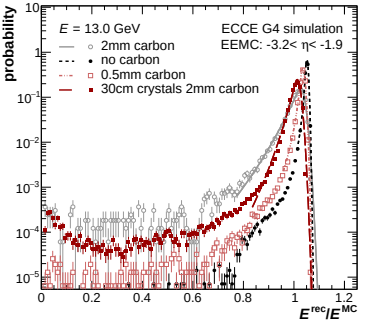

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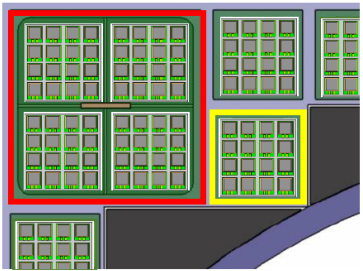
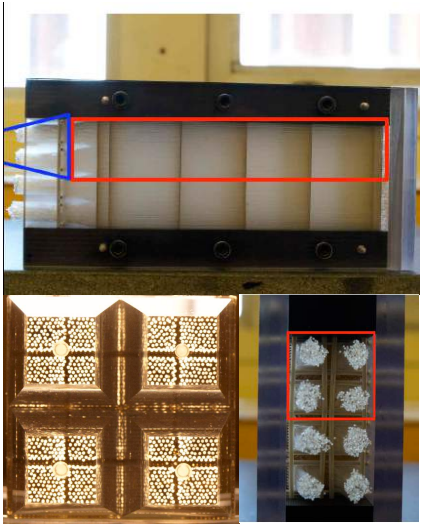


Hadron-Endcap Calorimeters

Hadron-Endcap Calorimeters -EMCal



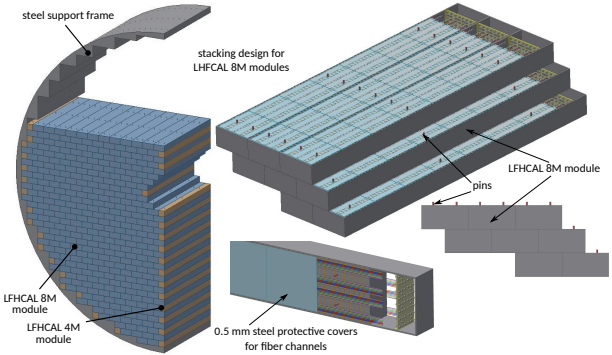
- Two mature EMCal concepts proposed:
  ECCE Pb-Scint-Shashlik vs. ATHENA WSciFi
- Using below R_M tower sizes which can vary as function of R
- Significantly easier construction for WSciFi calorimeter
- Less space needed for WSciFi calorimeter & higher EM-shower containment
- Cost comparable after adjustment for Uniplast unvailabilty & calorimeter dimensions

$\Rightarrow$ WG recommended ATHENA WSciFi for implementation & construction, accepted by GDI

$\Rightarrow$ eRD106 plans being adapted, contact Oleg Tsai

$\Rightarrow$ Exploring higher granularily & density inlay around beam pipe mathing beam pipe cut out shape (UC-EIC Consortium)

Hadron-Endcap Calorimeters -HCal



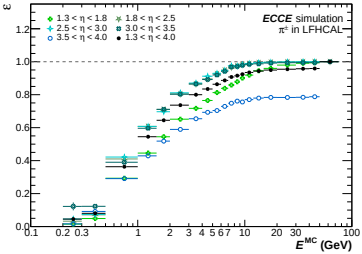
- Both detector concepts using longitudinally separated Steel-Scintilator HCal
- ECCE LFHCal with additional W-layers offers larger shower containment
- Cost increase due to Sci-plate main vendor unavailabilty under investigation
- Construction method allows to vary tower sizes as function of R to possibly reduce cost

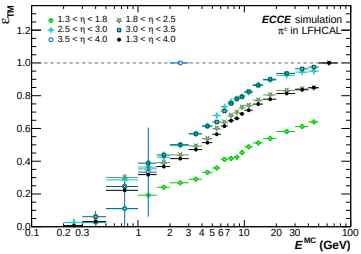
$\Rightarrow$ WG to recommended ECCE LFHCal for implementation & construction, accepted by GDI

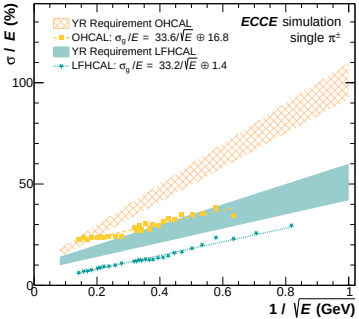
$\Rightarrow$ eRD107 plans being adapted, contact Friederike Bock

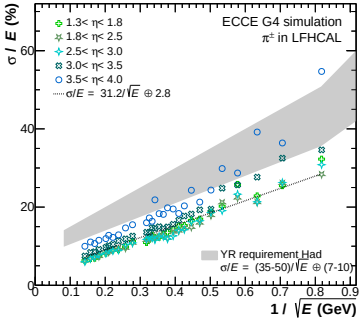
$\Rightarrow$ Exploring highly granular/pixelized inlay around beam pipe similar to W-CALICE design (UC-EIC Consortium)

LFHCAL Performance



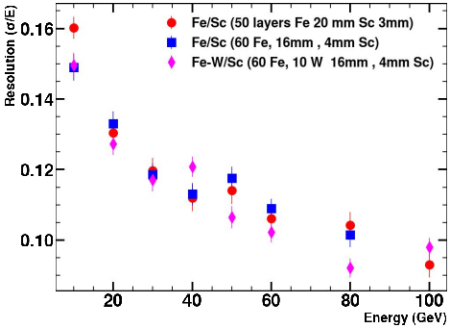






- Cluster finding and track matching efficiencies good in center of LFHCAL, losses towards edges
- Meeting YR energy resolution requirements even without ML based clusterizer optimization
- Small η dependence for energy resolution
- Studies to improve clusterization further using ML started

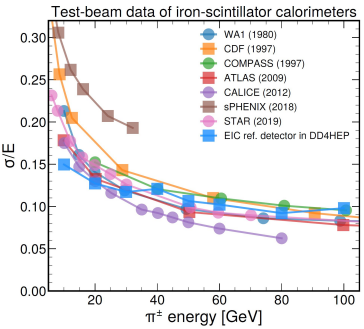
LFHCAL updates



Simulations

- Detailed geometry implementation in Fun4All & improved clusterization (N. Schmidt)
- First implementation of simple LFHCal in DD4HEP [link]
- Significant progress in steel based calo performance simulations (B. Karki)

LFHCAL updates



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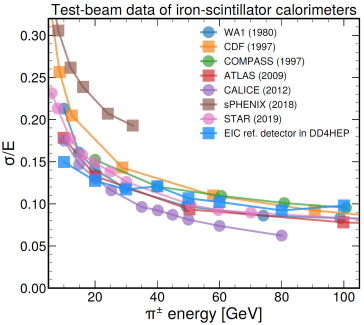

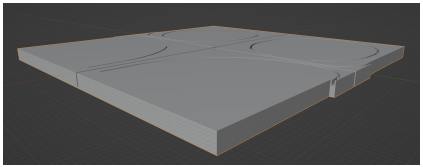

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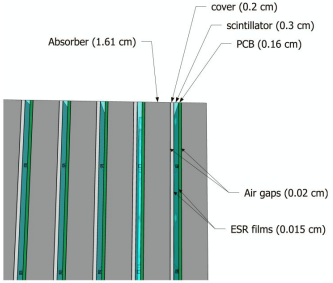
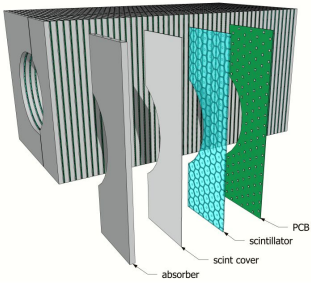
Mechanics & R&D

- Improved CAD models available including support structure
- Preparations for new eRD107 submission ongoing
- Exploring injection molding for scintilator tiles (ORNL/FNAL) → additional generic R&D for larger scale injection molding submitted (O. Hartbrich)
- Exploring automation for fiber installation

Forward HCal Insert



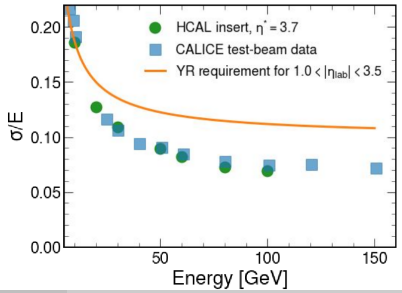


Concept (M. Arratia)

- High-granularity Scintillator-Tungsten/Steel calorimeter with SiPM-on-tile tech (CALICE, CMS)
- Maximize acceptance by having each layer adapted to angled beam pipe, inner sipport for LFHCAL

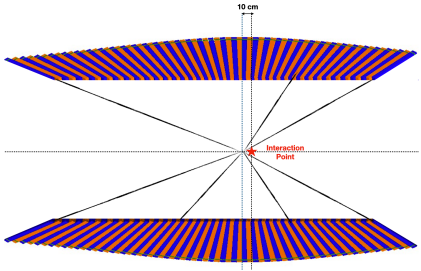
Simulations

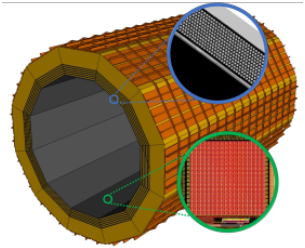
- Reproducing performance of CALICE test beam (B. Karki)
- First integrated simualation studies with LFHCAL
- Varying steel content to reduce fringe field



Barrel Calorimeters

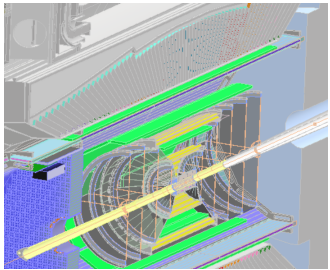
Barrel Electro-magnetic Calorimeter

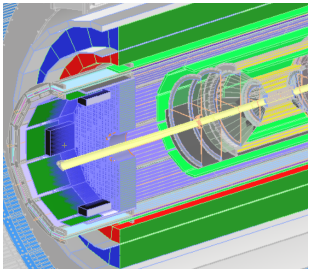




- Very complementary concepts ECCE SciGlass calorimeter & ATHENA imaging calorimeter
- Main concerns for SciGlass calorimeter
  - Possible R&D delays for SciGlass
  - Possible need for more space for tracker
  - Realism of performance studies with final geometry, shower containment
- Main concerns for imaging calorimeter
  - Shower separation in PbSciFi along same ϕ & matching with Si-layers
  - Cooling & data flow management in silicon layers
  - Realism of performance studies with final geometry & reconstruction limitations

Barrel ECAl update





Mechanics integration

- Progressing for both calorimeters (R. Wimmer)
- Adapting sizes and coverage to allow for cabeling & cooling of inner detectors

Adressing open questions

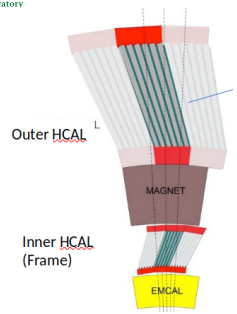
SciGlass calorimeter

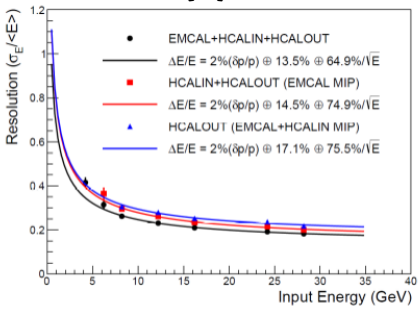
- Investigating tower sizes, spacing & material between towers
- DD4Hep implementation of first BEMC (W. Deconinck)
- Checking different tower size in different η regions & coverage towards high η

imaging calorimeter

- Generic R&D submitted (M. Zurek)
- Optimizing Imaging/SciFi layer segementation/position
- Studying use as inner HCal
- Simulation studies to address photon & e/π separation, energy sharing in same φ segment for SciFi

Barrel Hadronic Calorimeter(s)





- Re-use of sPHENIX outer HCal
- Refurbishment plans (contact J. Lajoie):
  - sPHENIX HCal & magnet will be diassembled for magnet refurbishment & moved to 1006
  - Replace SiPMs with modern generation
  - Upgrade electronics & readout (i.e bias dist. not only per sector, common readout for calorimeters)
  - Redo cosmics calibrations
  - Possibily modify one/multiple chimney sector
- Necessity and feasibility of inner HCal still to be determined, strongly depends on choice of ECal & tracker and available space

Convenors

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Indico

- **https://indico.bnl.gov/category/405/**

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