PROCEEDINGS OF SCIENCE

Simulations of the calorimetry system for the ALLEGRO FCC-ee detector concept

Filoména Sopková*a*,*

a Charles University,
Prague, Czech Republic

E-mail: filomena.sopkova@cern.ch

The ALLEGRO detector concept is a proposal for the detector to be operating at the Future Circular Collider FCC-ee. The calorimetry system consists of a high granular noble liquid electromagnetic calorimeter and a hadronic calorimeter with scintillating tiles using wavelength shifting fibers. High granular calorimeters for future detectors are required to achieve high jet energy resolution. The individual components of the calorimetry system in the barrel and extended barrel regions will be shown. The common software developed for future detectors description will be introduced.

42nd International Conference on High Energy Physics (ICHEP2024)
18-24 July 2024
Prague, Czech Republic

*Speaker

1. ALLEGRO detector concept

Calorimeters based on liquified noble gases were successfully used in many high-energy physics experiments (D0 [1], ATLAS [2]) due to well proven technology. Its excellent energy and time resolutions, linearity, stability and uniformity of the response, and radiation hardness make it a strong candidate for future particle physics experiments. The ALLEGRO [3] (A Lepton coLlider Experiment with Granular Read-Out) is a general-purpose detector for the Future Circular Collider FCC-ee [4] based on highly granular noble liquid electromagnetic (ECal) calorimeter. Closest to the collision point is vertex detector, surrounding by drift chamber and ECal calorimeter immersed in 2T solenoid magnetic field followed by hadronic calorimeter. Calorimeter systems are surrounded by outermost layer, muon tagger. Design of the ALLEGRO detector is still being optimized.

1.1 Calorimetry system

Proposed ECal calorimeter is a sampling detector with lead or tungsten absorbers interleaved with liquid argon or liquid krypton gas. The signal from electromagnetic showers is picked-up by electrodes situated in the middle of the gap filled with noble liquid gas from which readout cells with twelve longitudinal compartments will be created.

Noble liquid calorimeter in central barrel region is a cylindrical detector made of straight absorbers, readout electrodes and active gaps with an inner radius of 2.1 m. Using liquid argon as active material, barrel region contains 1536 lead absorbers of total thickness 1.8 mm and 1.2 mm thick readout electrodes. Such a configuration with a total depth of 40 cm will lead to a calorimeter with an effective total thickness of ~22 radiation length and Moliere radius ~4 cm. Other option with tungsten as absorber and liquid krypton as active material will lead to results with smaller radiation length and Moliere radius.

In barrel region, straight inclined (50.4°) electrodes and absorber plates are arranged radially in 12 longitudinal layers with respect to the radial direction. Active gaps between two absorbers are radially increasing from 2×1.2 mm for inner radius to 2×2.4 mm for outer radius.

The electromagnetic endcap calorimeter consists of a wheel on each side of the electromagnetic barrel. Each wheel is divided into ~240 absorbers and electrodes. Design of endcap calorimeter is very similar to barrel but with turbine-like geometry symmetric in Φ. Thickness of the absorber can be increased as a function of radius [5].

HCal barrel is currently being simulated as TileCal-like calorimeter [6] with scintillating tiles. The scintillating tiles are placed perpendicular to the colliding beams and are radially staggered in depth. Steel absorber of 5mm thickness is alternating with 3mm scintillator plate. The calorimeter module is segmented into 13 longitudinal layers. The scintillating tiles are read-out by wavelength shifting fibers.

1.2 Performance of the calorimetry system

All possible detector concepts for future particle colliders rely on advanced software tools. These tools are needed for design optimization, technology choices and to estimate the performance of the detector. Possibility for full or parametrized detector simulation, tracks reconstruction, cluster reconstructions, jet clustering and physics analysis must be included.

Set of common software packages, tools and geometrie of different detector concepts at various future colliders are implemented in the Key4hep software [7]. This software provides complete data processing from generation, simulation, reconstruction to analysis tools. The event data model used in Key4hep is provided by EDM4hep [8]. This model includes types of data that represents process of simulation as well as reconstruction starts from raw detector data. Complete detector descriptions, geometry, materials, visualization and calibration for the next generation of experiments is provided by DD4hep [9].

All FCC software relies on Key4hep tool as a flexible solution for the full detector and experiment workflow. Proposed detector is completely described with help of Key4hep and DD4hep. Each detector description needs to be implemented with C++ builder and XML compact file. Most of well-known generators are already packed in Key4hep. Geometry description of ALLEGRO detector successfully migrated to Key4hep and is fully integrated under FCC software.

Conclusion

ALLEGRO is a new detector concept for FCC-ee based on noble liquid calorimeter with high granularity. Calorimetry system of ALLEGRO detector consists of noble liquid electromagnetic calorimeter and TileCal-like hadronic calorimeter with scintillating tiles. Detector concepts and performance studies for future experiments rely on the Key4hep project. Key4hep is important software tool for all future experiments based on EDM4hep data model. ALLEGRO detector is now fully integrated under FCC software and project is fast progressing on simulations.

References

[1] P.Franzini, Performance of the DØ uranium-liquid argon calorimeter modules, Nucl. Instr. and Meth. A 289 (1990) 3, https://doi.org/10.1016/0168-9002(90)91514-C

[2] The ATLAS Collaboration,ATLAS Liquid Argon Calorimeter : Technical Design Report, CERN-LHCC-96-041, http://dx.doi.org/10.17181/CERN.FWRW.FOOQ

[3] Noble Liquid Calorimetry for Future Accelerator Experiments, https://allegro.web.cern.ch/

[4] A.Abada, M.Abbrescia, S.S.AbdusSalam, et al., FCC-ee: The Lepton Collider, Eur. Phys. J. Spec. Top. 228, 261–623 (2019), https://doi.org/10.1140/epjst/e2019-900045-4

[5] Aleksa, M., Bedeschi, F., Ferrari, R., Sefkow, F., & Tully, C. G. (2021). Calorimetry at FCC-ee. *The European Physical Journal Plus*, *136*(10), 1066.

[6] The ATLAS Collaboration,ATLAS tile calorimeter: Technical Design Report, CERN-LHCC- 96-042, http://dx.doi.org/10.17181/CERN.JRBJ.7O28

[7] Key4hep software, https://key4hep.github.io/key4hep-doc/index.html

[8] F. Gaede, G. Ganis, B. Hegner, C. Helsens, T. Madlener, A. Sailer et al., EDM4hep and podio - The event data model of the Key4hep project and its implementation, EPJ Web Conf. **251** (2021) 03026.

[9] The DD4hep Project Repository, https://github.com/AIDASoft/DD4hep.

PoS(ICHEP2024)1141