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A study of simulation tools and manufacturing methods for multi-functional carbon composite particle detector mechanics and support structures

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Improvements in Detector mechanics need in-depth study of thermal and mechanical loading conditions to have more integrated design concepts that save on material budgets and optimize performance. Particle detectors at future colliders rely on ever more lightweight and radiation-hard charged particle tracking devices, which are supported by structures manufactured from composite materials. This article lays out engineering techniques able to solve challenges related to the design and manufacturing of future support structures. Novel manufacturing methods like Extrusion Deposition Additive Manufacturing (EDAM) along with associated simulation tools like Additive3D for prediction of part production and performance are highlighted with case studies from the High-Luminosity Phase Upgrade project for the CMS detector. Methodology for manufacturing of integrated support structures using simulation tools like COMPRO from Convergent Manufacturing Technologies is showcased for lightweight and highly thermally conductive support structures for future tracking detectors. Examples of current efforts at Purdue University related to the high-luminosity upgrade of the CMS detector are provided to demonstrate the prospects of suggested approaches for detectors at new colliders: a future circular collider or a muon collider. Specific geometric and design considerations for the proposed CMS Inner Tracker Rails are discussed to illustrate advantages and constraints for additively manufactured structures. The applicability, benefits, and uses of this technique to replace conventional tooling methodologies for composite layup part manufacturing are also highlighted.

In-person or Virtual?

In-person

Primary author: KARMARKAR, Sushrut (Purdue University)

Co-authors: JUNG, Andreas (Fermilab); Dr DENOS, Benjamin (Purdue University); Dr BAROCIO, Eduardo (Purdue University); Dr HICKS, Justin (Purdue University)

Presenter: KARMARKAR, Sushrut (Purdue University)

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