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Extrusion Deposition Additive Manufacturing of carbon fiber reinforced composite parts and tools for particle detector mechanics

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Detector mechanics play a significant role in in a detector's performance and improvements are often tied to reduction of total mass to save on material budget. Particle detectors at future colliders rely on ever more precise charged particle tracking devices, which are supported by structures manufactured from composite materials. This talk 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 for prediction of part production and performance are highlighted with case studies from the High-Luminosity Phase Upgrade project for the CMS detector. The material selection method is reviewed along with radiation effects on material properties for in-performance part dimensional stability. The process simulations using Additive3D, a simulation tool developed at Composites Manufacturing and Simulation Center, Purdue University help identify the manufacturing challenges and shape changes in the EDAM parts like the inner tracker rails. 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.

Primary authors: KARMARKAR, Sushrut Rajendra (Purdue University (US)); HICKS, Justin Lawrence (Purdue University (US)); Mr GULLEY, John G. (Purdue University); DENOS, Ben (Purdue University (US))

Co-authors: Dr BAROCIO, Eduardo (Purdue University); Mr RICHARDSON, Lucas (Purdue University); Mr WHEELER, Jack (Purdue University); JUNG, Andreas Werner (Purdue University (US))

Presenter: KARMARKAR, Sushrut Rajendra (Purdue University (US))