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Global Mechanics Challenges for Materials and Structures in Future Collider Detectors

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Future particle detectors will present unprecedented global mechanics challenges in multiple disciplines. For example, FCC detectors are expected to be substantially larger than the current ATLAS and CMS detectors, with structures approximately twice the diameter and two to three times the active area. Furthermore, they will face similarly stringent requirements with other detectors —for example, ePIC for the EIC —on the overall mass budget, which will require novel design solutions and construction technologies. In general, detectors are expected to employ a wide range of technologies, such as strips, hybrid pixels, or MAPS. A major goal is reducing mass, with lower sensing, support, and service material budgets. Here we present the most promising technologies to achieve these goals: MAPS sensing for low mass, carbon conductors for lighter services, thermoformed polyimide for very low mass structures, and multi-functional components to combine portions of the material budget. Some of these technologies are already under development at certain institutions; others are currently being developed in different fields (e.g., aerospace, automotive) and may be ready for implementation in future detectors. We highlight the most promising of these technologies that are worth exploring, along with the key areas where further development is needed for practical implementation. In this context, we also emphasize the importance of proper characterization of materials —such as elastomers used to support silicon —to ensure correct early design choices. These studies should be carried out within the community to evaluate performance in the unique high-radiation environments in which future detectors will operate.

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