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Design, prototyping and heat transfer simulation for EIC-EPIC AC-LGAD time of flight barrel detector

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The upcoming Electron-Ion Collider (EIC) at Brookhaven National Laboratory features a state-of-the-art time-of-flight barrel detector, comprising 144 staves that extend over a 2.7-meter length and support strip silicon sensors. Managing the thermal gradient along these staves is critical for optimizing sensor performance and is a primary focus of the design challenge. This research investigates various stave configurations to achieve minimal mass and deflection under self-weight across the entire length, enhancing the structural integrity and operational stability of the detector. We conducted a series of heat transfer analyses to evaluate temperature gradients on the stave surfaces, guiding multiple design iterations. These analyses involved comparing different cooling methodologies, including water, glycol, and nitrogen-based systems, to determine their effectiveness in maintaining optimal sensor temperatures. Each cooling option was modeled to assess its impact on the thermal performance and mechanical properties of the staves. Prototyping and manufacturing of the staves were carried out at Purdue University. Validation of the heat transfer models was performed through experimental testing using a dedicated water-cooling circuit at National Cheng Kung University (NCKU) in Taiwan. This poster presents a comprehensive overview of the design process, prototyping, manufacturing techniques, and the results from both simulation and experimental validation of the thermal management system. Our findings provide crucial insights into the thermal and mechanical considerations necessary for the successful deployment of the EIC's time-of-flight detector.

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