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

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The upcoming ePIC detector at the Electron-Ion Collider at Brookhaven National Laboratory features a state-of-the-art Time Of Flight (TOF) 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. Prototyping, manufacturing, and heat transfer analysis of the staves was conducted at Purdue University, providing crucial insights into the thermal and structural considerations necessary for the successful deployment of the ePIC bTOF detector.

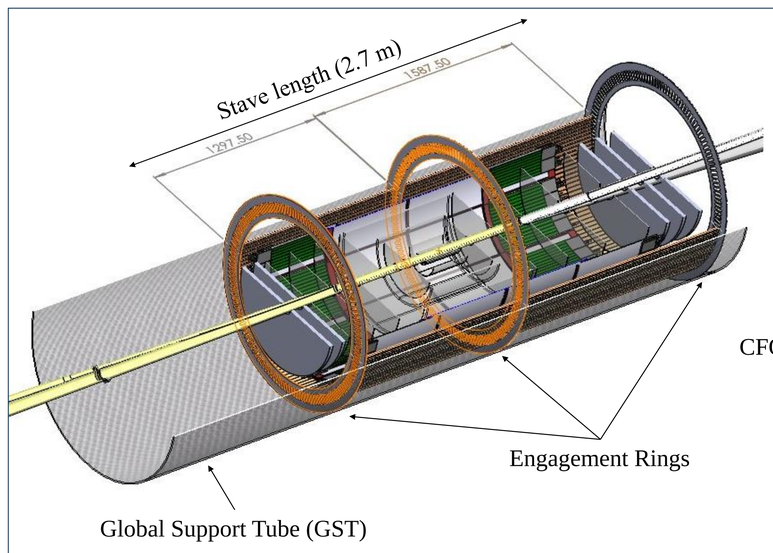

Figure 1: ePIC barrel TOF (AC-LGAD) detector

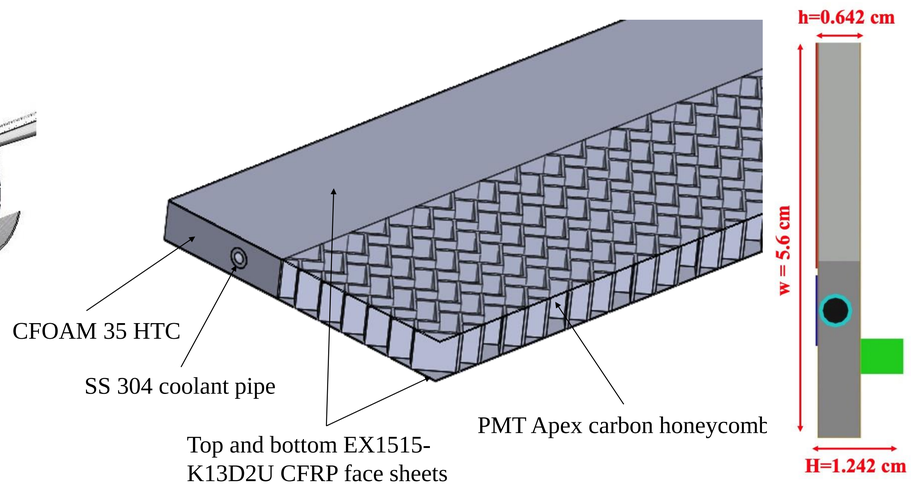

Figure 2: Stave cross-section dimensions and material composition

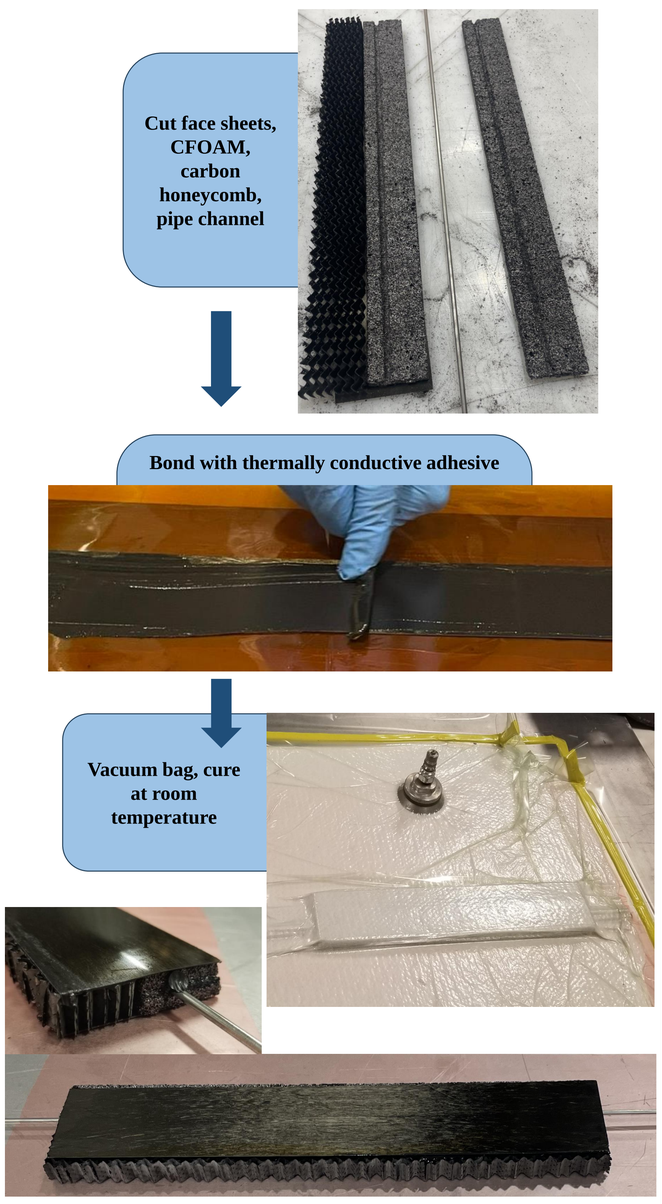

Figure 4: miniSTAVE (300 mm) prototyping process

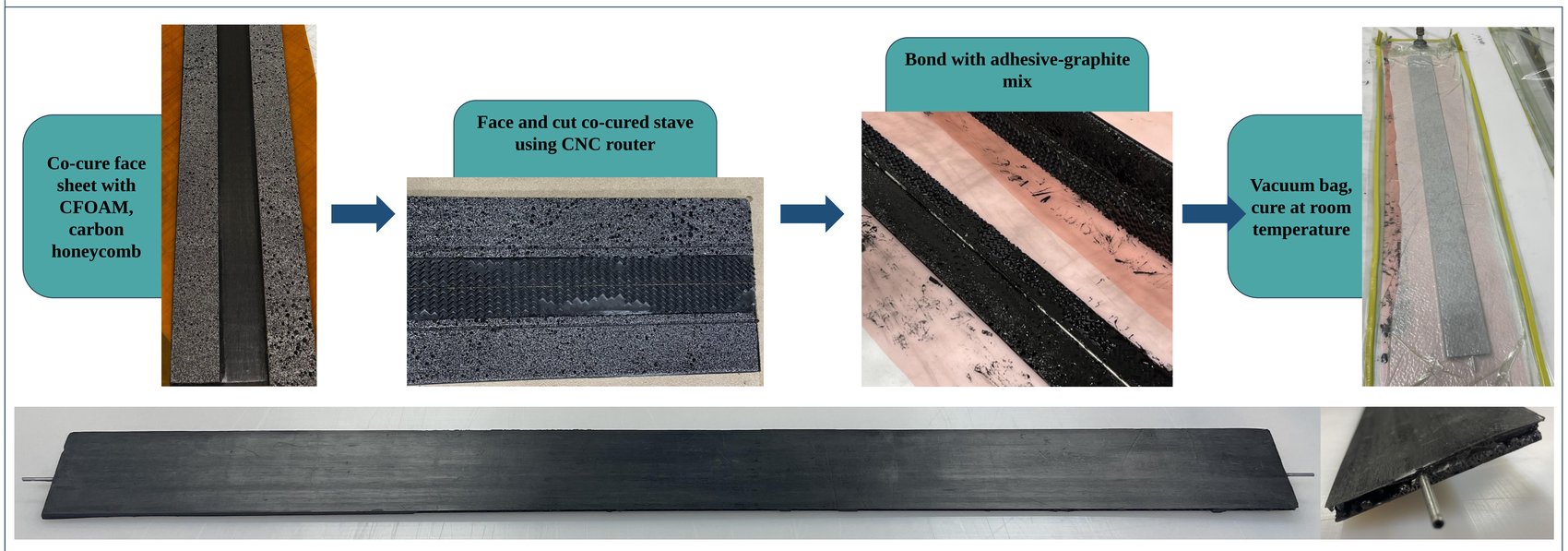

Figure 5: halfSTAVE (1 m) prototyping process

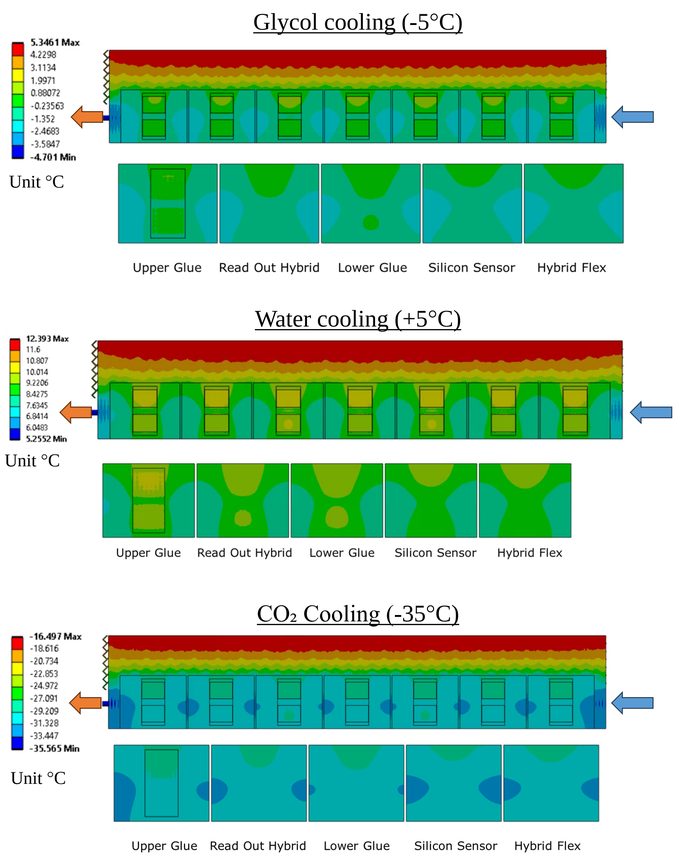

Figure 6: Cooling simulation results for miniSTAVE

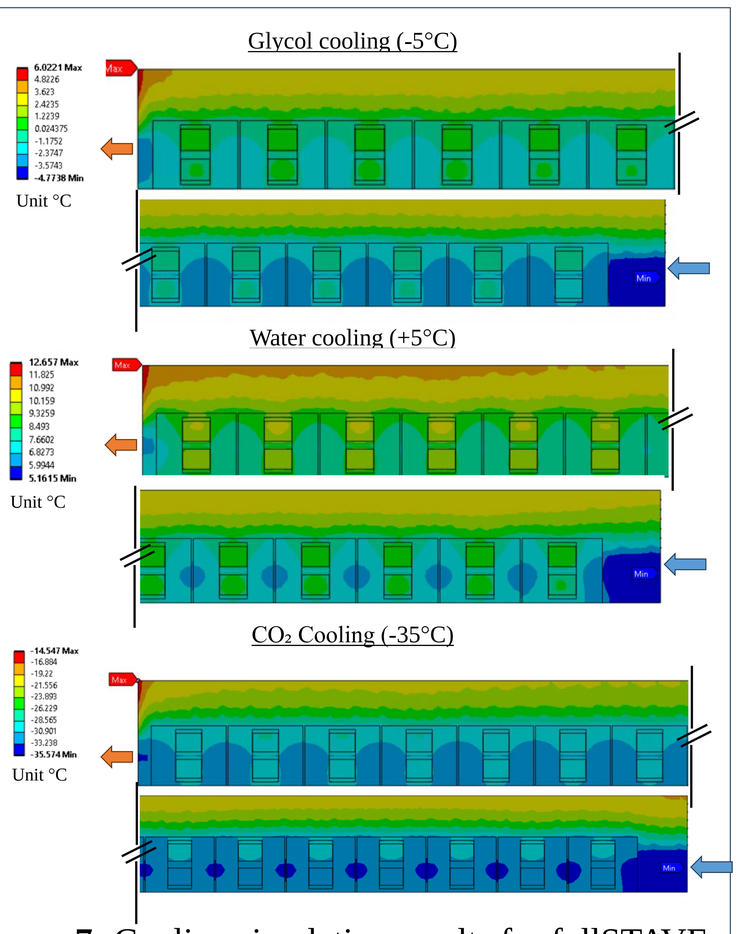

Figure 7: Cooling simulation results for fullSTAVE

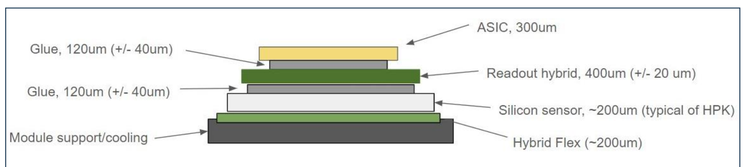

Figure 8: Silicon sensor module cross-section

For full-length staves, further prototyping efforts are aimed at determining suitable manufacturing methods, measuring deflection, and designing angled mounts. Additionally, validation of heat transfer models will be performed by testing staves using a dedicated cooling circuit at National Cheng Kung University (NCKU) in Taiwan and a carbon dioxide blowout cooling system at Purdue University's Department of Physics.

ON BEHALF OF THE ePIC bTOF collaboration