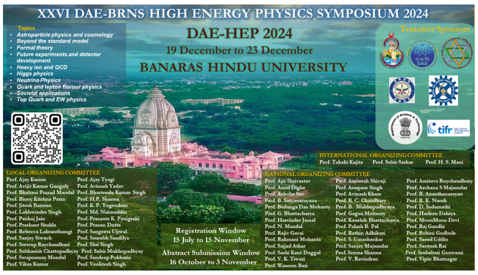

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Prospects of thermal protection advancements in large-scale cryostats for rare event search experiments

Experimentalists worldwide are dedicating tremendous efforts to the design of cryostats aimed at minimizing the dominant radiation-induced heat load on the cryogenic liquid housed within. These advancements are crucial for maintaining the safe, stable, and reliable operation of detectors, particularly in large-scale experiments aimed at investigating rare physics phenomena with increasing sensitivity at ton-scale capacities [1]. In these experiments, ensuring a stable cryogenic liquid temperature is crucial for minimizing both thermal noise and liquid evaporation. This can be achieved by mitigating the ambient heat transfer from the hot outer wall to the cold inner wall of the cryostat [2, 3]. Current work investigated the effects of no insulation, single-layer insulation, and multilayer insulation on reducing environmental heat load at the cryostat's cold wall boundary, with particular emphasis on the efficacy of single-layer insulation against radiative heat transfer. The GERDA cryostat was utilized as a practical case study to illustrate these effects. Positioning an ultra-low emissivity intermediate layer near the cryostat's cold wall can achieve a remarkable reduction in heat load, estimated between 40-60 %, thereby decreasing the cryogenic liquid's evaporation rate significantly. This presentation will provide an overview of our research endeavors and emphasize the latest developments in cryogenics, particularly focusing on their implications for rare event search experiments.

References:
[1] M.K. Singh, V. Singh et al. In: International Journal of Heat and Mass Transfer 236 (2025), p. 126254.
[2] D. Singh, M.K. Singh et al. In: Heat and Mass Transfer 59
(2023), p. 1365.
[3] D. Singh, A. Pandey, M.K. Singh et al. In: Journal of Instrumentation 15.07 (2020), P07032.

Field of contribution

Experiment

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Track Classification: Future experiments and detector development