Contribution ID: **417** Type: **Poster**

C1Po1A-04: Design calculation and analysis of a coiled-tube heat exchanger and a condenser for a cryocooler-cooled LH2 target cooling system

Monday 19 May 2025 09:15 (1h 45m)

A LH2 target cell and a vertex tracking detector system will be specifically optimized to fit inside the spherical target region of the Gamma-Ray Energy Tracking Array (GRETA) and are expected to operate at the Facility for Rare Isotope Beams (FRIB). The LH2 target-cell and windows will be made of thin Mylar of order 100um. The target thickness is in the range of 10˜15 cm with an effective diameter of order 50˜60 mm. A cryocooler-based hydrogen cooling system is under design and development at the Lawrence Berkeley National Lab (LBL) to cool down the target, liquefy gas hydrogen, deliver and maintain liquid hydrogen in the target while operating, and recover and store gas hydrogen. The whole cooling system consists of a cryocooler-based cooling cryostat, a subsystem equipped with safety devices to handle and store gas hydrogen and gas nitrogen, and instrument rack and PLC control system. The warm gas hydrogen is cooled through a coiled-tube heat exchanger attached to cold heads of a two-stage GM cryocooler and then liquefied in a condenser mounted to the second-stage cold head in the cryostat. The vaporized hydrogen is re-liquefied in the condenser and the liquefied hydrogen flows into the target through its gravity-driven thermos-syphon cooling circuit. A thermal radiation shield at around 30-40 K is mounted on the first stage of the cold head to reduce the radiation heat. A cryogenic control valve mounted on the cryostat is used to manipulate the hydrogen cooling circuit at different operating modes including cool-down, liquefaction and re-liquefaction, physics operation, background measurement and warm-up. The paper primarily presents the design calculation and analysis of the coiled-tube heat exchanger and the condenser in the LH2 target cooling cryostat.

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Session Classification: C1Po1A - Hydrogen Cooling and Test Facilities