NPDGamma 20 Liter Liquid Parahydrogen Target and Gas Handling System

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IUCF has designed and constructed the liquid parahydrogen target for the NPDGamma experiment, which consists of a refrigeration system to liquefy 20 liters of hydrogen, convert it to parahydrogen, and maintain the hydrogen target continuously and safely at 17 K and 1 bar pressure. The system consists of a cryostat with two mechanical refrigerators and the liquid hydrogen target vessel, a fill-vent tube which extends vertically outside the enclosure and a vent stack, a hydrogen gas handling/purification/monitoring system, and a SLC–based control system to monitor the state of the target. The target has been designed and constructed and will be operated jointly by NPDG collaborators from Indiana University and Los Alamos. As discussed in the Memorandum of Understanding (MOU), Indiana University has the major responsibility for target design, construction, and non-LH_2 testing at Indiana and LANL has the main responsibility for target safety and the integration and final testing of the system at LANL. The target was tested at IUCF for cryogenic performance and simulated accident scenarios without liquid hydrogen and delivered to LANL in fall of 2003. Bill Lozowski and Walt Fox made significant contributions to the design, construction, and safety analysis.

The liquid hydrogen target shown in Fig. 1 for the NPDGamma experiment must (1) absorb ~60% of the polarized cold neutron beam flux without depolarizing the neutron beam before capture, (2) possess negligible attenuation for the 2.2-MeV gammas from neutron capture, (3) be free from extra noise in the capture gamma signal due to density fluctuations in the target from bubbles or pressure/temperature fluctuations, (4) be free from parity violation introduced by gammas produced by polarized slow neutron capture on target materials other than hydrogen, (5) be nonmagnetic near the beam and detectors to avoid magnetic field gradients and potential systematic effects from circularly polarized gamma scattering from polarized electrons, (6) be safe. The need to prevent neutron depolarization requires the target to consist of liquid parahydrogen at a temperature of 17 K because neutron spin flip scattering is forbidden in parahydrogen for neutron energies below 15 meV. The target and vacuum system is made mostly of aluminum and other low Z materials to allow the gammas to reach the CsI array. The liquid in the target is superheated with a heater on the exhaust line of the target which can maintain the pressure in the (recirculating) target chamber at a value above that of the equilibrium vapor pressure at 17 K (this is also required for safety).

Figure 1: *Liquid parahydrogen cryostat and h gas handling system installed at Los Alamos in preparation for hydrogen tests.*

Commercial temperature monitors produce the feedback power to the refrigerators to control the temperatures. This information, along with pressures, the status of automatic valves on the GHS, and the information from the RGA, is fed into a SLC-based control system whose function is to monitor the status of the target, to take appropriate action if any measured parameters are out-of-range, to record and display the history of these parameters, to communicate the status of the target to appropriate LANL areas, and to present the status of the target visually to operators using a convenient front-panel display.