Ursinus/NSCL Liquid H/D Target Service Level Description

The present document describes the level of support provided by NSCL to the Ursinus/NSCL liquid hydrogen/deuterium target. Section I concerns general technical details about this device. The NSCL level of support is described in Section II, followed by user's responsibilities in Section III.

I. Technical Details

A. General

The Ursinus/NSCL liquid hydrogen/deuterium target provides a high-density, proton or deuteron target which avoids the characteristic C-induced background of typical plastic targets like polyethylene. It can be used in experiments using nucleon scattering, transfer, secondary fragmentation, or charge-exchange reactions. The system fills a cylindrical cell with gas (hydrogen or deuterium) and condenses it by cooling it down near its triple point. Thus, besides avoiding the C-background problem, this system provides higher H/D densities than regular gaseous targets for the same volume.

In its standard configuration, the Ursinus/NSCL target system is used with hydrogen or deuterium in the N2 or S3 vaults. It consists of five main components, namely, target cell; vacuum chamber; cryogenic system; gas handling system; and temperature control system. Usage of the system with other gases and in different experiment areas is non-standard, and may require modifications of some of these parts, and implementation of safety features and procedures that need to be evaluated on a case-by-case basis. Therefore, use of gases other than Hydrogen and Deuterium are outside the scope of this SLD.

- **Target Cell**

The target cell consist of an aluminum cylinder with its symmetry axis parallel to the beam axis. The hydrogen/deuterium is enclosed inside the cylinder with two 125-µm thick Kapton windows perpendicular to the beam axis. In its standard configuration, the gas cell has a 30-mm diameter and two possible thicknesses: 7 mm and 30 mm. Due to the pressure gradient between the filled cell and the vacuum around it, the Kapton windows bulge, adding 1-2 mm extra thickness for each foil. The density thickness depends on the cell volume and the temperature during the experiment.

- **Vacuum chamber**

The gas cell is held by a vacuum chamber interfacing with the existing beam-line sections. A special bellow system allows for fine position adjustment of the gas cell inside the chamber. A special rotary pump PASCAL 2015 C2 is used to provide auxiliary fore-vacuum to the turbo pump.

The type of chamber used depends ultimately on the vault and type of experiment. At present, two vacuum chambers are available for use of the Ursinus/NSCL target in the S3 and N2 vaults. Usage in other experimental areas would require the design and construction of a suitable chamber, which are beyond the scope of this SLD.

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- **Cryogenic System**

  The cryogenic system is used to cool down the gaseous hydrogen/deuterium contained in the target cell. It consists of a CKW-21A Sumitomo compressor, a RDK-205D Sumitomo cryocooler (or cold head), a heater block, and a heat shield. Helium is pumped by the compressor into the cold head which operates in a closed liquid He cycle. A heater block interfacing with the cold head and the gas cell counter-acts the cryocooler to prevent the hydrogen/deuterium gas in the cell from freezing and clogging the gas lines. The cell is partly surrounded by a heat shield to reduce thermal load. In order to maintain the hydrogen/deuterium temperature (and density) stable, it is recommended to wrap the cell with 5-μm thick aluminized reflective Mylar film. Background from reactions in this foil has been found to be negligible thus far.

- **Gas handling system**

  The main goal of the gas handling system is to deliver/evacuate gas to/from the target cell and reservoir. A series of hoses, valves, regulators, and flowmeters, along with a 100-liter gas reservoir and a special rotary pump PASCAL 2015 C2 are used to control the flow of hydrogen/deuterium, dry nitrogen, and air through the system. During regular operations, the gas pressure in the gas cell, gas handling system, and reservoir are read out by MKS manometers. The voltage reported by the manometer reading the target-cell pressure can be remotely monitored through EPICS channel. The operation of the gas handling system is described in the Ursinus/NSCL target manual, which can be obtained from the Device Physicist.

- **Temperature control system**

  Temperature of the gas cell is regulated by the heater block controlled by a Lakeshore 331S temperature controller module. Two silicon diodes connected to the controller measure the temperatures of the heater block and the target cell. The first one provides a feedback loop to the controller. The second one is remotely monitored using a designated EPICS channel. The temperature control unit is operated remotely using a laptop PC running a LabView control program.

- **Monitoring of temperature and pressure**

  During regular operations, the voltages of the EPICS channels assigned to the gas temperature and pressure in the target cell are continuously recorded using e.g. the ChannelLog application. These recorded voltage values are converted into Kelvin and Torr units, and numerically and graphically displayed in a P-T diagram in real time. Thus, it is possible to continuously track the thermal phase of the hydrogen/deuterium contained in the target cell.

II. Support Level

A. General

The preparation and run of NSCL experiments with the Ursinus/NSCL liquid hydrogen/deuterium target system involve four standard phases: preparation, installation, operation, and disassembly. The support provided by the Device Physicist during these phases covers only the standard configuration. Besides the Device Physicist, the NSCL Charge-Exchange group led by Prof. Remco Zegers can provide trained personnel for experiments using the Ursinus/NSCL target. The operations supported by NSCL are listed below:

- Preparation
  - Answer technical questions from users during preparation of proposals and planning of experiments.
  - Train users in monitoring the status of the device during experiments

- Installation
  - Transportation of the system to the experiment area
  - Assembly of target cell
  - Installation of target cell, and cold head in beam line
  - Alignment of target cell with respect to beam axis
  - Installation of cryogenic system
  - Installation of gas handling system including manometers and temperature controller
  - Leak check
  - Test of whole system with neon, helium, or nitrogen

- Operation
  - Filling of reservoir and target cell with gas
  - Cooling and liquefaction of gas
  - Monitoring of pressure and temperature on real time
  - Provide emergency "on-call" support during experiment to ensure proper functioning of the system

- Disassembly
  - Evacuation of target cell and gas handling system with dry nitrogen
  - Disassembly of gas handling system, target cell, and cryogenic system
  - Clean up

B. Details

- In order to guarantee complete 24/7 support, Prof. Remco Zegers and some members of his group can provide on-call assistance. Device physicist should coordinate the on-call schedule prior to the experiment.
- Emergency support (on-call duty) is provided 24/7. For all emergency support, users are required to first inform the Operator in Charge, who will then decide to call the Device Physicist for help
- In case the Device Physicist is also one of the experimenters, his/her research time can also be allocated to device support

III. User responsibilities

During the experiment, the spokesperson is expected to:

- Take a leading role in decision making during the running phase of the experiment
- Discuss necessary changes to the experiment with the Device Physicist in a timely manner
- Schedule changes in the target system (empty, filled, cooling down) in advance and in coordination with the Device and Beam Physicists.
- Monitor and check integrity of the target system and instruct experimenters in charge how to do so

During the experiment, the experimenter in charge is expected to:

- Monitor and check integrity of the target system
- Communicate any unexpected incident involving the target system to the Operator in Charge

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