

## Polarized Target Shift Instructions

Proper operation of the target is essential to success of the experiment, and although complicated, can be learned after some hours of hands-on training. This chapter will outline the aspects of target operation. Following chapters will expand on each of the topics introduced here.

### Training Levels

- **Target Operator:** This level is designed so that an interested collaborator can arrive from out of town for shifts, become trained (including running a practice shift), and then contribute to the experiment by running the target during normal operations without further supervision. Part of the training process for prospective Target Operators will include instruction of what tasks and situations require the assistance of more experienced persons.
- **Target Expert:** This level designates those people who have significant experience in the field of polarized targets in general, and the UVa polarized target in particular. This level requires familiarization with most if not all of the subsystems of the target.

### Typical Target Operator Tasks

- **Microwaves:** The DNP process used to enhance the target polarization requires properly tuned microwave energy to be directed onto the target material for as long as enhanced polarization is desired. The main task, and perhaps the most frequent action needed during a target shift, is to adjust slightly the microwave frequency. This is done by briefly applying power to a small electrical motor that mechanically tunes the microwave tube, and then observing the impact of the change on the target polarization. Other tasks include turning microwaves off when a non-polarized target is needed, and operating the microwave switch that directs power to the proper target cell.
- **NMR System:** The target polarization is measured using an NMR system. The Target Operator operates the NMR to perform continuous measurement of the polarization during polarization buildup, and production running. Tasks include starting and stopping of data taking, recognizing the need for and performing a calibration step known as a baseline measurement, and changing NMR channels to reflect the target cell currently in the beam path.
- **Cryogenics:** The target material sits in a bath of liquid helium essential for polarization enhancement. The magnet coils sit in a separate bath equally crucial to their operation. The delivery system used to maintain these levels is quite complicated, but recent work has allowed many aspects of it to be controlled automatically. Under normal running, most of the cryogenic system should require little attention, but periodic observations of important temperatures, pressures, and liquid levels are nonetheless required in order to detect problems. During other times, such as during a target anneal or insert change, user intervention is required to interrupt delivery of cryogens to the target tailpiece.
- **Magnet:** The 5T magnet used to polarize the material, as well as the software that controls it, is quite robust, but proper respect and care must be observed regarding the magnet due to the amount of energy stored in the field (0.75 megajoules) and the forces that the field may exert on metal objects. Tasks involving the magnet include adjusting the field slightly to perform NMR baseline measurements, and ramping the field down

completely should the hall need to go to Restricted Access, as required by the experimental safety procedures.

- **Target Motion:** During the experiment, the run plan will require running on one or more of 6 different target positions available. Assuring that the beam is off and then moving the target insert to the proper position is a typical job for the Target Operator.
- **Target Annealing:** Radiation damage to the target material eventually degrades the polarization to the point that efficient running is no longer possible. It is often possible to recover performance lost because of this damage by annealing the material at a certain temperature for a short length of time. Typically this procedure is required less than once per eight-hour shift.
- **Target Security:** Several of the parts of the target, such as the NMR and the microwave system, can be damaged by what might not be thought of as rough treatment. Further, most of the systems of the target present unique life-safety hazards. An alert Target Operator is the first line of defense against disaster to people and property. The attention of the Target Operator should extend across the entire target platform, under it, on any adjoining structures, and to the target equipment in the Counting House. Cameras are installed to provide view of all areas of the target from the Operator's position in the Counting House. It is the responsibility of the Target Operator to request that any unescorted personnel in or around the target without proper training and without sufficient reason should leave the target area. Again, the Target Operator is the first, and in many times the only, defense.

#### **Some Tasks Requiring a Target Expert**

- **Target Insert Removal/Change:** Removal of the target insert and installation of a new one involves several steps that must be performed in a specific order and in a careful manner. Most important is removing the insert without introducing air to the target, which could freeze and cause an ice block, and recovering the target material into a proper cold storage container.
- **Thermal Equilibrium Calibration:** Proper calibration of the NMR system propagates directly to the accuracy of the experiment. If calibration is done too early, or during unstable cryogenic or magnetic conditions, a false reading may be obtained leading to polarization measurements being either under- or overestimated. Although general guidelines exist, only through experience can someone reliably determine when a calibration measurement may be performed accurately.
- **Magnet Quench Recovery:** Collapse of the magnetic field of the target through a quench in the superconducting coils of the magnet can have several consequences that may not be obvious to a non-expert. In addition, diagnosis of the cause of the quench is best performed by a person familiar with the history of the magnet, the magnet power supply, and other systems in the target.
- **Software Repair/Modification:** The control software for the target consists of several programs that communicate with each other through a message passing system. Maintenance of this software should only be performed by those deeply familiar with it.
- **Equipment Repair/Replacement:** As with software repair, non-trivial problems with any target equipment should be referred to a target expert for advice and assistance on methods of repair.