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1L TARGET HARP DIAGNOSTIC DISPLAY TOOL*

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Abstract

The Los Alamos Neutron Science Center (LANSCE) completed upgrades to its 1L Target Facility, which included installing the new Mark IV target assembly. This added a third tungsten target located upstream of the other two targets. Prior to Mark IV, beam centering on target was achieved by using thermocouples mounted to the quadrants and center of the upper target coolant chamber. It is slightly offset from center of the old upper target and it shadows several of the thermocouples previously used to center beam on target. This required adjustments to the diagnostic tools utilized to monitor position of the H- beam that is being delivered to the 1L target. The original display included the thermocouple readouts and displayed a visual beam profile and position taken from an upstream harp. With some of the thermocouples now being shadowed, an image overlay was added to show where the harp's measured beam position is relative to both the upper and middle targets. This gives the beam operations team an additional level of awareness when it comes to thermocouple temperatures, beam steering, and beam tuning. Details of the display tool and its associated upgrades are presented.

INTRODUCTION

1L HARP Purpose

The purpose of the 1L Target [1] HARP is to provide a profile of beam location as it strikes the target stack. The HARP works in tandem with wire scanners to assist the operations team in beam tuning and loss minimization. The HARP is an extremely valuable tool since the new Mark IV target has been installed. The HARP has a similar program to the wire scanners to show beam position.

1L HARP Diagnostic Display Purpose

The 1L Target HARP Display is an aid to the operations team to provide a graphical representation of beam position. The display aggregates the data from the 1L HARP and utilizes a Gaussian distribution algorithm to provide a "heat map" graphical representation. The display also shows a set of thermocouples that are utilized to further analyze the beam position and intensity.

1L HARP CONSTRUCTION

The 1L Target HARP diagnostic is a set of wires spaced out in the beam line in a grid formation to gather a beam profile. An electrical current is induced in them proportional to beam intensity, which shows the beam profile similar to the wire scanners. The upside to the HARP is it is constantly in the beam line and due to that can be provide constant updates to the beam position. The 1L HARP data can be utilized in a Gaussian fit algorithm to provide a beam position and intensity map. Figure 1 below shows the 1L HARP assembly and wire harness that is part of the 1L Target assembly.

Figure 1: 1L HARP Diagnostic Assembly.

WIRE SCANNERS

1L (Target 1) wire scanner 1, 2, and 3 provides a picture of the beam profile as it is being directed to the target, but don't provide a "live" status of the beam in the event of a tune change. They utilize a single wire inserted in steps in order to get a beam profile. This "live" status is extremely important, and the wire scanners cause significant beam spill making them ineffective for the information needed to visualize. Figure 2 shows a wire scan performed to show beam position in the X and Y axis.

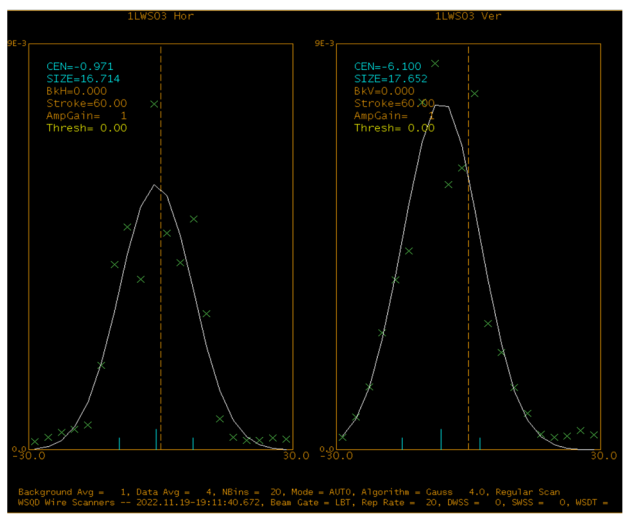

Figure 2: Wire Scanner Diagnostic Tool.

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NEW MARK IV TARGET

The Mark IV target was installed during the beam outage in 2022. Initial testing and commissioning was performed during the beam run cycle for 2022, and beam on target from 60 to 85 microamps. 2023 expects to see full production beam of 90+ microamps. Installation of the new target required some changes to the diagnostics to better serve the operations team with applicable information. Better analysis of the diagnostics and indications that the operations team needs will continue to be done to further improve the ability to tune the beam on the target.

Target Assembly

Three different target assemblies are utilized to provide neutrons to up to 15 different flight paths for experiments at varying energies. The upper target sits vertically and is housed in tungsten, so getting an accurate picture of the beam profile is key due to thermocouple shadowing and neutron moderation. Below the upper target is the Middle Target which is surrounded by a reflector constructed of beryllium. The lower target also has a liquid hydrogen moderator to further thermalize neutrons being sent to the flight paths. Beam passes down through the top of the assembly and strikes the vertically aligned Upper Target Assembly before passing to the Middle and Lower targets. Figure 3 shows the entire Mark IV Target assembly and its associated components, while Figure 4 (across) shows the upper target assembly portion of the Mark IV Target.

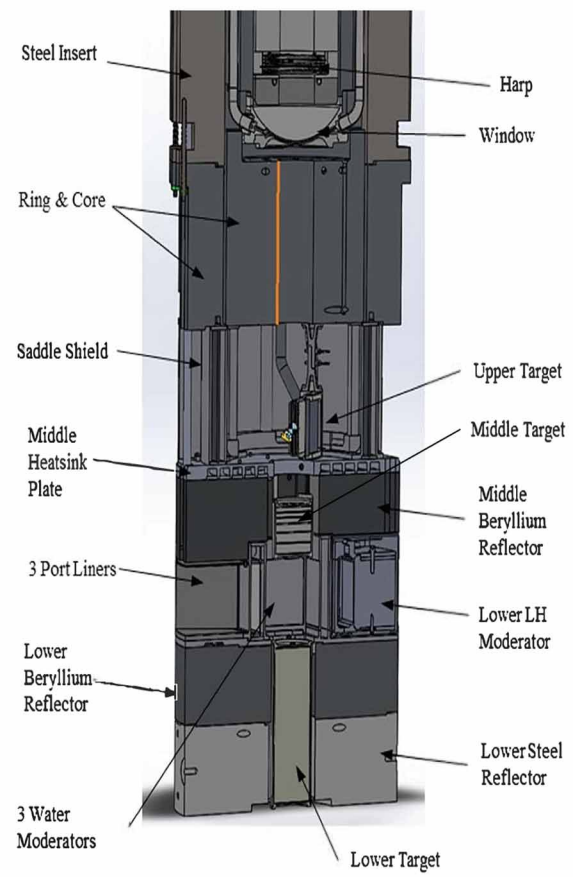

Figure 3: New Mark IV Target.

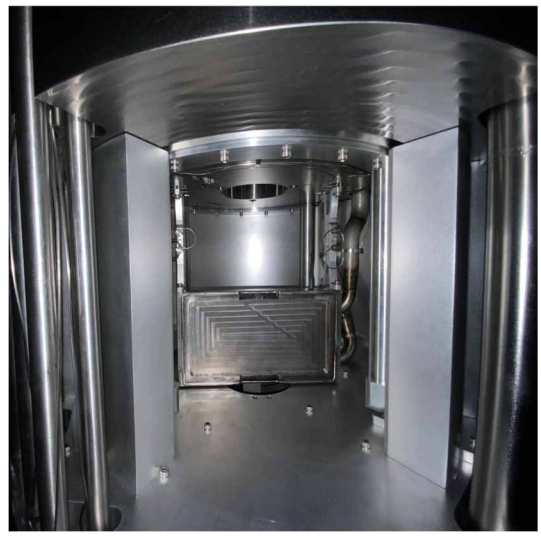

Figure 4: Mark IV Upper Target Assembly.

Thermocouples

Thermocouples are placed in a cross pattern below the upper target assembly to aid operations in determining both the location of the beam striking the target and the intensity of that beam. With the old target assembly there was nothing to "shadow" the thermocouples and potentially hide some of that intensity, so when the Mark IV Target was installed there needed to be some adjustments in order to make operations aware of this beam "shadowing". In the center of the target assembly is the tungsten upper target assembly shadowing the center, half of the lower, and a portion of the upper thermocouple. To the left of the tungsten upper target assembly is water that is shadowing the left, and roughly half of the upper thermocouple. There is no shadowing of the right thermocouple, so reliance solely on thermocouple indications for beam position would be highly unreliable due to three different densities of material covering the different thermocouples.

1L HARP DISPLAY TOOL

The 1L HARP Display Tool is a graphical representation of beam position. It has been in use since 2019 to give the operations team a constantly updating picture of beam position on the 1L Target. It has graphical representations for the thermocouples, vertical upper target assembly, and the water moderator. Thermocouple temperature indications are also shown on the tool to assist operations in beam tuning. Below is a snapshot of the tool without any beam position indication. The pink color is the beam pipe (the circle) and the thermocouples (squares arranged in the cross pattern), the gold color in the upper left in the diagonal shape is the water moderator that is shadowing some thermocouples, and the silver color is the vertical tungsten upper target assembly. Off to the right and the far left is air. Prior to the Mark IV Target installation, there was no need to aid the operations team with this sort of overlay. The HARP tool and wire scanners were sufficient in providing an indication of beam position. However, once the new target was installed, modifications had to be made to ensure

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that the correct indications were being utilized due to thermocouple shadowing affecting the temperature indications. Figure 5 is a screenshot of the 1L HARP Display tool without beam on.

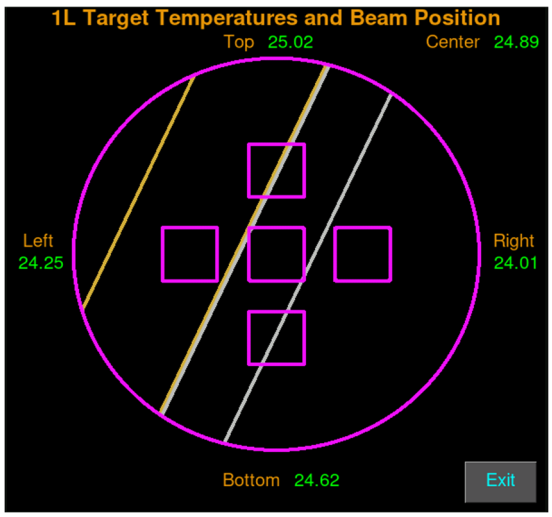

Figure 5: 1L HARP Display Tool (Without Beam).

1L Harp Display Tool (With Beam)

The 1L Harp Display Tool retrieves the HARP data from the EPICS control system and performs a Gaussian fit algorithm to determine the beam position for both the horizontal and vertical positions. This algorithm also determines beam intensity, so a very beneficial indication of both beam location and intensity is provided as an overlay to the thermocouples. This overlay, in addition to the thermocouples and wire scanners is what the operations team utilizes to tune beam as it reaches the 1L Target. The next image is an image with simulated beam position, in order to provide a visual representation of similar to what the operations team would see when tuning. The beam profile would look significantly smaller and would be within the pink circle, but this is a good representation of both the position indication and intensity indications the Gaussian algorithm provides. Figure 6 has simulated beam placed on it to show what the beam position indication looks like.

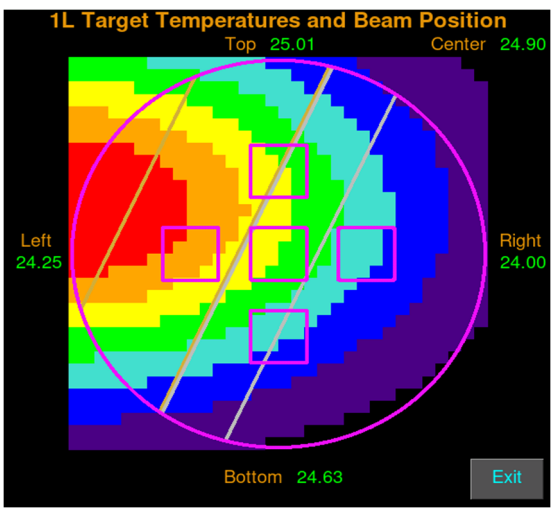

Figure 6: 1L HARP Display Tool (With Simulated Beam).

CHALLENGES

First operation with the new Mark IV Target showed several challenges.

It was unknown how much shadowing the different materials would provide to the various thermocouples. To investigate this, beam was attempted to be centered on each thermocouple to see how each reacted to a given current of beam placed on each. During this evolution, a new problem cropped up that needed to be resolved first.

Steering the beam vertically towards the top thermocouple (the top thermocouple rose in temperature and the bottom lowered) gave the reverse indication with the HARP data and the Gaussian indication (position indication showed the beam moving towards the bottom thermocouple and away from the top thermocouple). This was checked for the horizontal axis and found to respond properly. After utilizing our other diagnostic tools, it was determined that the HARP wires were likely wired backwards. To correct this, a software change was made to reverse the values in the array for the vertical axis. This corrected the position indication issue.

CONCLUSION

Further testing of the thermocouples to determine the extent of shadowing needs to be completed in order to better aid the operations team. Adding the layer of indications for the thermocouples and different moderators has been a benefit to the operations team with their efforts to reliably deliver beam to a newer, smaller beam target.

REFERENCES

[1] E. Kerstiens, *"1L Target, Moderator, Reflector System,"* Reading, Los Alamos National Laboratory, April, 2023.