

# Every Polarized Neutron Beam Wishes It Had a Polarized Target: A History of Polarized Nuclear Targets at the Triangle Universities Nuclear Laboratory

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The Polarized Target Group of the Triangle Universities Nuclear Laboratory over the period 1980 to 2004 conducted neutron scattering experiments using cryogenic polarized targets. During that time the program produced eight Ph.D. graduates from NCSU and Duke. The program used three cryogenic target systems, including a novel rotating single crystal holmium target that was built and used for a time reversal test.

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In the fall of 1978, Dr. Thomas Clegg of the Physics Department at UNC Chapel Hill gave a colloquium at the Physics Department at North Carolina State University. The colloquium focussed on plans for a new polarized ion source at the Triangle Universities Nuclear Laboratory (TUNL), located on the campus of Duke University. TUNL is co-managed by the three campuses and supported by contracts with the US Department of Energy. The author recalls a statement by Dr. Clegg of the sort of "It would be great to have a polarized target for the polarized proton and deuteron beams." At that time the author was aware that there had been recent improvements in  $^3\text{He}$ - $^4\text{He}$  dilution refrigerators, which would be able to provide the lower temperatures and higher magnetic fields required for polarized nuclear targets. So began a collaboration to build and use polarized targets at TUNL.

This led to a successful proposal to the US Dept. of Energy for construction of a polarized target facility at TUNL, which began funding in 1980. The faculty leadership of the group included C. R. Gould, L. W. Seagondollar, and D. G. Haase of NCSU, and N. R. Roberson and W. Tornow of Duke. The last TUNL cryogenic polarized target experiments at TUNL ended in 2004. The success of the program was also produced by the efforts of the postdoctoral associates - Jesse Dave, W. Scott Wilburn, John Soderstrum, Stephen Whisenant, Mikell Seely, and Dianne Markoff. During that period the program produced eight Ph.D. graduates from NCSU and Duke. The program used three cryogenic target systems, including a novel rotating single crystal holmium target that was built and used for a time reversal test. This experiment was the basis of the American Physical Society Dissertation Award to James Koster.

Notable papers that describe the experiments are:

"A Brute Force Polarized Target For Neutron Scattering Experiments," D.G. Haase, C.R. Gould, and L. W. Seagondollar. *Nuclear Inst. and Meth. A* 243, 305 (1986).

"Polarized targets at triangle universities nuclear laboratory," M.L. Seely, et al, *Nuclear Instr. and Meth. A* 356, 142 (1995).

Below is a list of the graduate students who built and nurtured the sometimes complex and cranky cryogenic and electronic equipment, worked the night shifts and finally reached graduation, and have gone on to productive and notable careers. Many of these dissertations are found at [https://nucldata.tunl.duke.edu/Theses/TUNL\\_Theses.shtml](https://nucldata.tunl.duke.edu/Theses/TUNL_Theses.shtml)

James Koster - "A Test of Time Reversal Invariance with Polarized Neutrons and Aligned  $^{165}\text{Ho}$ ," Ph.D., NCSU, 1990.

C.D. Keith - "Application of  $^3\text{He}$  Melting Curve Thermometry in a Nuclear Orientation Cryostat," M.S., NCSU, 1990.

Timothy P. Murphy - "Construction and Testing of a Novel Dilution Refrigerator," M.S., NCSU, 1993.

W. Scott Wilburn - "Measurements of the Transverse Spin-Dependent Total Cross Section Difference  $\Delta\sigma_T$  for the Scattering of Polarized Neutrons from Polarized Protons." Ph.D., Duke University, 1993.

C.D. Keith - "Total Cross Section Measurements for the Scattering of Polarized Neutrons from Polarized  $^3\text{He}$ ," Ph.D., NCSU, 1994.

Paul R. Huffman - "A Measurement of the Parity-Conserving Time-Reversal Violating Cross Section of Polarized Neutrons on Aligned Holmium," Ph.D., Duke University, 1995.

B.W. Raichle - "A Dynamically Polarized Proton Target for Measurements of the Transverse Spin-Dependent Total n - p Cross section Difference,  $\Delta\sigma_T$ ", Ph.D., NCSU, 1997.

J.R. Walston - "Determination of the Nucleon - Nucleon Tensor Force Through n-p Scattering Measurements", Ph.D., NCSU, 1998.

R.D. Foster - "A Measurement of the Longitudinal Spin-Dependent Total Cross Section Difference  $\Delta\sigma_L$  in the n-d System," Ph.D., NCSU, 2004.