A Measurement of Parity Violation in the Capture of Cold Neutrons on Helium-3
A wire chamber as a Target and Detector

The n^{3}He experiment aims to measure the parity violating asymmetry in the direction of proton emission from the capture polarized cold neutrons in an unpolarized gaseous ^{3}He target from the reaction n + ^{3}He → T + p. The size of the asymmetry is estimated to be $(-9.5 \rightarrow 2.5)\times10^{-8}$, and our goal measurement accuracy is 2×10^{-8}. The asymmetry is a result of the low energy weak interaction between quarks and its measurement will provide a benchmark for modern effective field theory calculations.

The experiment uses a ^{3}He multiwire ionization chamber as the combined target and detector operated in current mode. The 144 signal wires are read out individually from the chamber. The frame stack consists of 16 signal wire planes and 17 HV planes. I will discuss the design, construction and assembly of the detector.

As simulation is required to study the performance of the chamber and verify it works as expected Garfield++ is used to simulate charge collection, electron avalanches and ion mobility in the HV field. Garfield++ does not simulate gas ionization by low energy particles, in our case protons and tritons, so it is paired with a Geant4 simulation for charge deposition in the chamber. The n3He experiment is currently running at the Oak Ridge National Laboratory.

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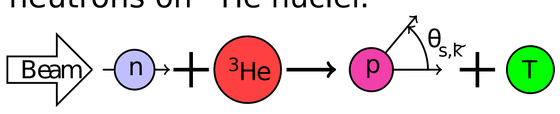
Motivation

The n^{3}He experiment aims to make a high precision measurement of the parity violating directional asymmetry in the proton emission from the capture of polarized cold neutrons on ^{3}He nuclei.

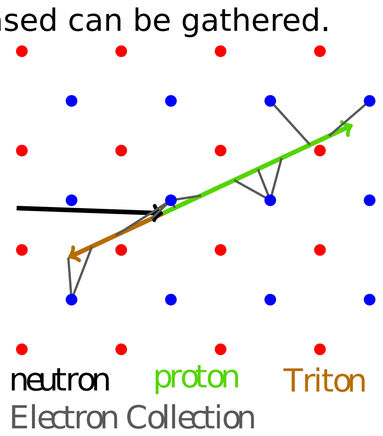


The asymmetry is expected to be small in the range of (-9.5 → 2.5)x10^{-8}, and our goal is to measure it to a precision of 2x10^{-8}.

n3He is running at the Spallation Neutron Source (SNS) in the Oak Ridge National Laboratory in Tennessee. The SNS is a high intensity 60 Hz pulsed spallation neutron source.

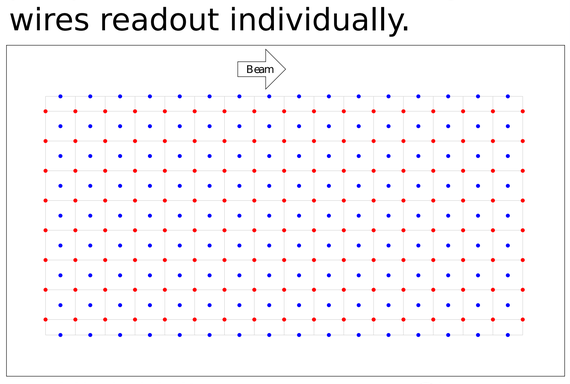
Measuring the Asymmetry

The target is a multiwire ionization chamber that uses pure ^{3}He gas as both the neutron target and ionization medium. The high voltage (HV) wires around each signal wire define the volume it will collect charge within. By reading out each signal wire individually the information on the ionization caused by the proton and triton released can be gathered.

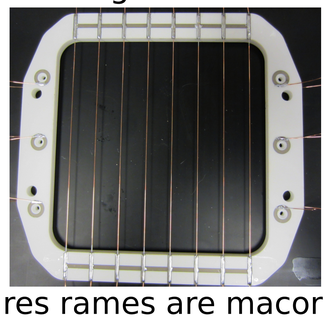


^{3}He Target/Detector

It has 17 HV planes and 16 signal planes. There are 9 signal wires per plane with a total 144 signal wires readout individually.

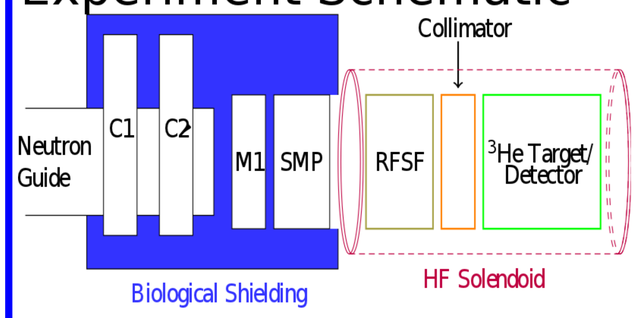


•High Voltage •Signal



The Wires rames are macor ceramic with copper wire soldered to them.

Experiment Schematic

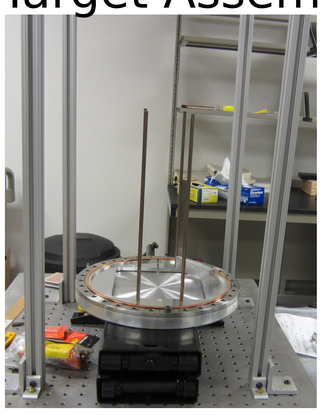


C1, C2 - Pulse Choppers
M1 - beam monitor
SMP - Super Mirror Polarizer
RFSF - Radio Frequency Spin Flipper

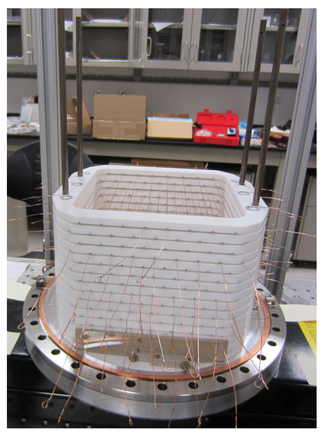
Target Housing

- Aluminum body
- 10" Conflat end flanges
- 1mm Al end windows
- 4 Signal Feed Thrus
- 2 Gas Feed Thrus
- 2 HV Feed Thrus
- Stainless Steel Knife Edges

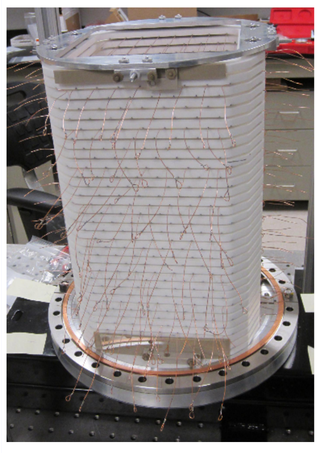
Target Assembly



Target assembly began by fixing the mount flange to a scissor lift.

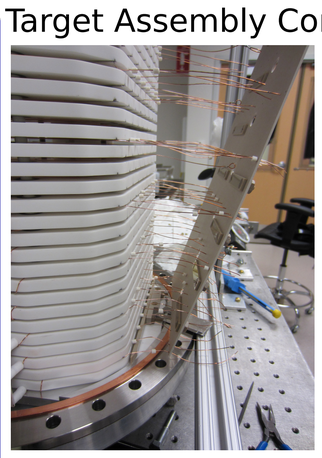


Alternating signal and HV frames were stacked separated by 3 ceramic ball in cone joints.



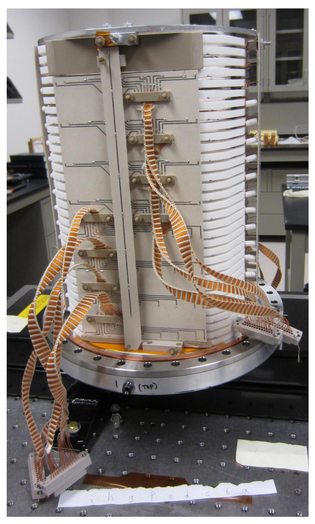
Once assembled the frame stack was held together by an aluminum compression plate bolted to the 4 copper rods.

Target Assembly Contintued

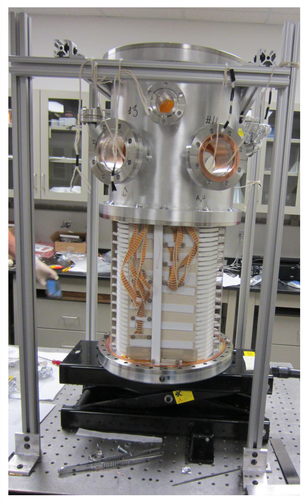


Roger's Duroid 6010 was used for the circuit boards

Circuit boards were attached by slowly feeding the wires into the thru holes starting at the bottom.

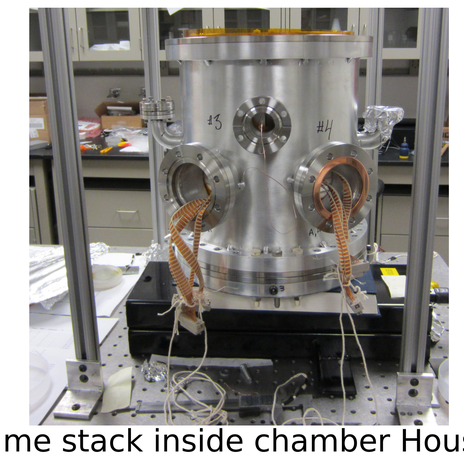


Once the PCBs were pushed into place the wires were trimmed and soldered along with the readout cables

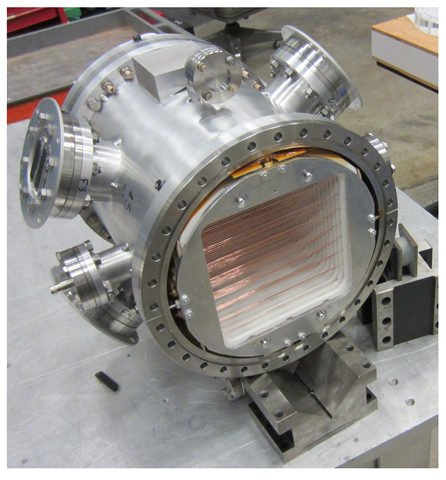


Teflon Shielding was used over the PCBs to prevent sparking in the chamber.

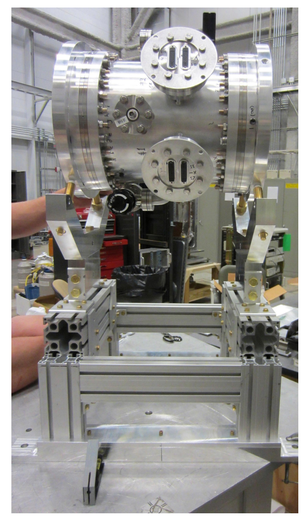
The housing is now supported over the frames stack ready to be inserted.



Frame stack inside chamber Housing

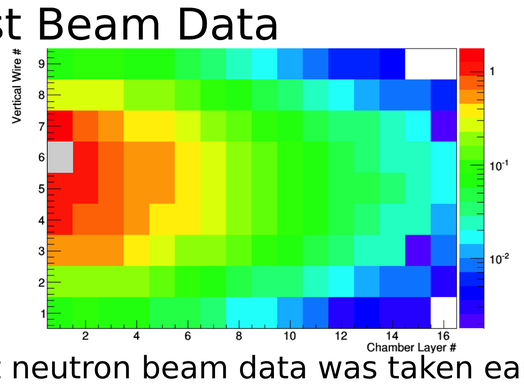


To align the frame stack to the beam optical and mechanical measurements were taken during and after assembly of the frame stack.



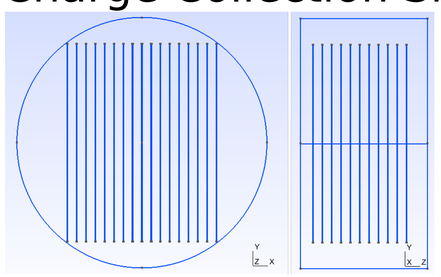
A 4 point adjustable stand was made to hold the target chamber in the beam. The height, and angles of the chamber can be adjusted on the stand.

First Beam Data

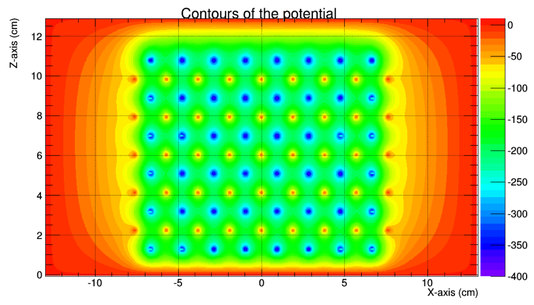


First neutron beam data was taken early 2015. Each cell in the plot is is the signal from one signal wire. The beam enters on the left hand side. The greyed out cell 6 did not provide a good signal.

Charge Collection Simulation

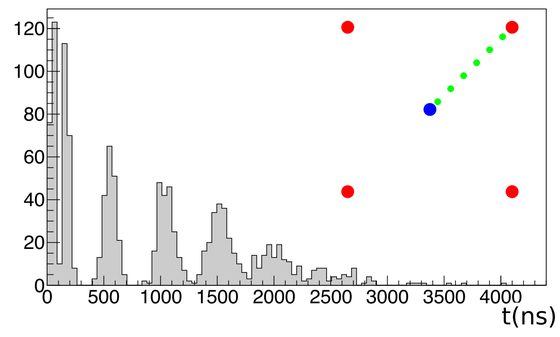


Gmsh was used to define the simulation geometry.



The Elmer simulation software was used to calculate the fields in the chamber model.

Electron Collection Times



One simulation was to avalanche 200 electron-ion pairs from 6 locations evenly spaced between a signal and HV wire to compare to published mobilities.

References

C. Geuzaine and J.-F. Remacle. Gmsh: a three-dimensional finite element mesh generator with built-in pre- and post-processing facilities. International Journal for Numerical Methods in Engineering 79(11), pp. 1309-1331, 2009. (geuz.org/gmsh)

Elmer finite element software homepage, http://www.csc.fi/elmer

Garfield++ garfieldpp.web.cern.ch/