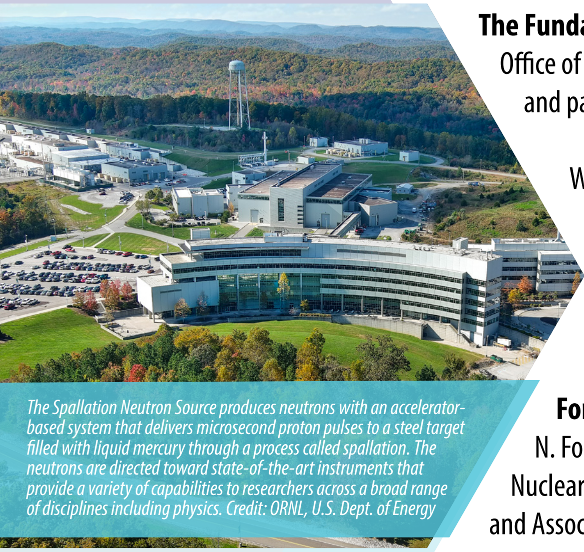
Fundamental Neutron Physics Beamline at the ORNL Spallation Neutron Source



The Spallation Neutron Source produces neutrons with an accelerator-based system that delivers microsecond proton pulses to a steel target filled with liquid mercury through a process called spallation. The neutrons are directed toward state-of-the-art instruments that provide a variety of capabilities to researchers across a broad range of disciplines including physics. Credit: ORNL, U.S. Dept. of Energy

The Fundamental Neutron Physics Beamline (FnPB) at the Spallation Neutron Source (SNS), a DOE Office of Science user facility at Oak Ridge National Laboratory, is an intense beamline dedicated to nuclear and particle physics experiments. It is operated by ORNL's Physics Division.

With access and time allocated by peer review, the beamline was designed to support a wide variety of fundamental physics experiments that aim to answer questions about the nature and existence of matter in the universe. Because this class of experiments is almost always statistics-limited, the beamline was designed to provide the highest intensity possible of pulsed neutrons, and especially cold neutrons, while also providing ample floor space for installation of experiments.

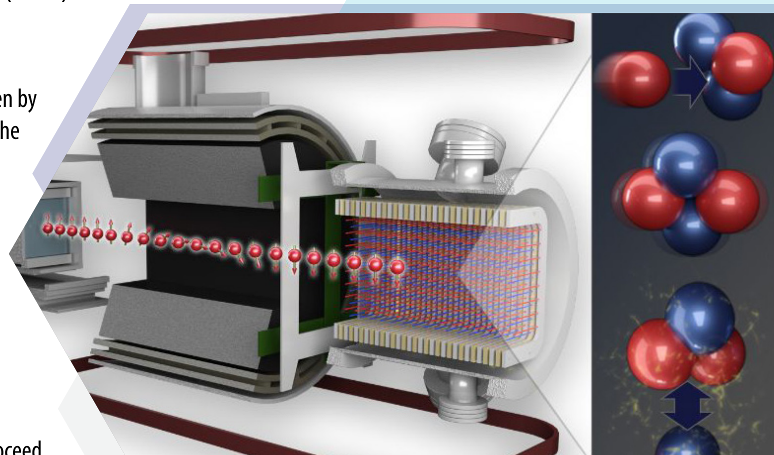
For beamline details:

N. Fomin et al., "Fundamental neutron physics beamline at the spallation neutron source at ORNL," Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment 773, p. 45 (2015).

The FnPB, called Beamline 13 or BL13, is coupled to a 20K liquid parahydrogen moderator driven by the liquid mercury spallation target of the SNS. Right after exiting the target shield monolith, the beamline splits into two coupled beamlines, BL13-A and BL13-B, which deliver beams to two different experimental areas.

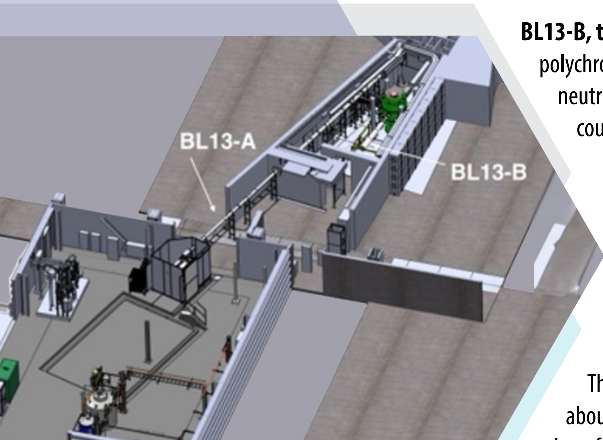
BL13-A is fed by a double crystal monochromator inserted into the main beamline and is separated from BL13-B by 9°. The monochromator extracts 8.9 Å neutrons, chosen because they can be efficiently coupled to the superthermal production of **ultracold neutrons** in superfluid helium, into BL13-A. It also selects the higher harmonics of 8.9 Å, albeit with lower efficiency.

The remaining neutrons proceed down BL13-B. The monochromator permits all neutrons to proceed untouched down BL13-B. The beamline contains two rotating choppers to allow the selection of neutron velocities. One is located upstream of the monochromator and thus affects both BL13-A and BL13-B; the other, downstream of the monochromator, affects BL13-B only.



SPLIT INTO MONOCHROMATIC AND POLYCHROMATIC BEAMS.

The n-helium-3 precision experiment, conducted at ORNL, measured the weak force between protons and neutrons by detecting the tiny electrical signal produced when a neutron and a helium-3 nucleus combine and then decay as they move through the helium gas target cell. Credit: Andy Sproles/ORNL, U.S. Dept. of Energy

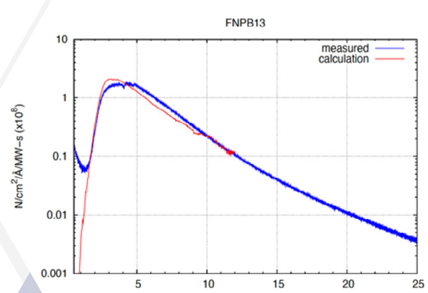


Overhead view of FnPB. BL13-A (left) was originally designed to drive an ultracold neutron source; BL13-B (right) supplies an intense flux of cold neutrons. Credit: ORNL, U.S. Dept. of Energy

BL13-B, the intense cold beam, ends in a beamstop in the shielded experimental enclosure. This beamline is polychromatic. The Nab neutron beta decay experiment currently occupies the enclosure. Only a tiny fraction of the cold neutrons decay in the experiment apparatus; the remainder arrive unchanged at the beamstop. A parasitic experiment could possibly be installed downstream of the Nab experiment and use the excess neutrons for further study.

BL13-A, the 8.9 Å monochromatic beam, is much less intense than BL13-B, and thus does not require a shielded enclosure. Its neutrons are directed through a non-guiding flight tube into an experiment building, EB-1. There, they can be used for low intensity neutron experiments.

The brightness of BL13-B was calculated and measured to peak at about 2×10^8 n cm^{-2} Å^{-1} MJ^{-1}. The full spectrum and results are presented in the reference paper. BL13-A is much less intense; a flux of about 10^4 n/s, at an SNS proton power of 1.7 MW, was recently measured near its beamstop in EB-1.



Measured and calculated neutron brightness per MW of proton beam power as function of neutron wavelength.