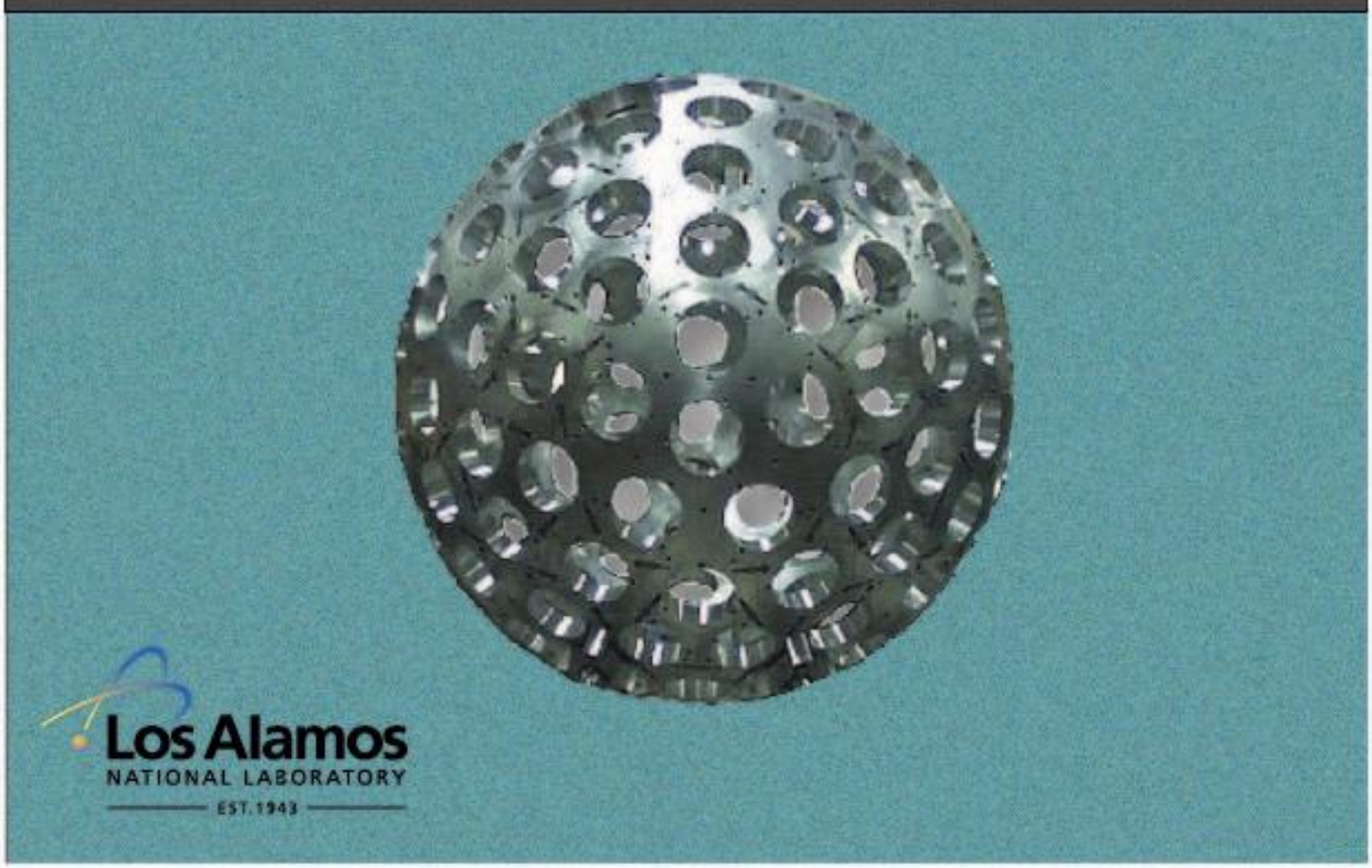
LANSCE

User Guide

Nuclear Science Research Facilities



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East Jemez Road - Road to LANSCE

Introduction

The Los Alamos Neutron Science Center (LANSCE) provides the scientific community with intense sources of neutrons for experiments supporting national security, academic and industrial research. LANSCE has two spallation neutron sources: the Manuel Lujan Jr. Neutron Scattering Center (Target-1) and the Weapons Neutron Research facility (Target-4). Together they provide neutrons over a range of energies—extending from sub-milli electron volts to hundreds of million electron volts—that are used for both material science and nuclear science research. In addition, LANSCE provides protons for radiography of dynamically evolving systems as well as for materials irradiation and isotope production. LANSCE also has an intense source of ultra-cold neutrons for fundamental physics research. Users of the facility span a broad spectrum of scientific disciplines and institutions in the U.S. and abroad. As described below, our proposal process provides access to these neutron sources for the entire research community. This user guide focuses on Nuclear Science research.

Nuclear Science Research Facility

The Nuclear Science or Weapons Neutron Research (WNR) facilities consist of a high-energy “white” neutron source (Target 4) with 6 flight paths, three low-energy nuclear science flight paths at the Lujan Center (Target-1), and a proton reaction area (Target-2). The neutron beams produced at the WNR Target 4 complement those produced at the Lujan Center because they are of much higher energy and have shorter pulse widths. The neutron sources are driven by the 800 MeV proton beam of the LANSCE linear accelerator or linac.

Neutron beams with energies ranging from approximately 0.1 MeV to greater than 600 MeV are produced in Target-4. The neutron production target at Target-4 is a bare unmoderated tungsten cylinder that is bombarded by the 800 MeV pulsed proton beam from the LANSCE linear accelerator and produces neutrons via spallation reactions. Because the proton beam is pulsed, the energy of the neutrons can be determined by time-of-flight (TOF) techniques. The time structure of the proton beam can be easily changed to optimize a particular experiment. Presently, target-4 operates with a proton beam current of approximately 1.5 μA, 1.8 μsec between pulses and approximately 14,000 pulses/sec. Target-4 is the most intense high-energy neutron source in the world and has 6 flight paths instrumented for a variety of measurements. With the completion of planned accelerator radio-frequency generator upgrades, the beam current to Target-4 will be increased by a factor of 2.5 to provide beam currents up to 5 μA.

In the Target-2 area (Blue Room) samples can be exposed to the 800 MeV proton beam directly from the linac, or beam that has been compressed in time from the Proton Storage Ring (PSR). Although the total beam current is limited by the shielding in Target-2, the PSR beam provides significantly more peak intensity than the direct beam from the accelerator. Target-2 is used for proton irradiations and hosts the high-flux Lead Slowing-Down Spectrometer (LSDS). For lower energy proton experiments, proton beams with energies as low as 200 MeV have been transported to Target-2.

At present there are three flight paths at the Lujan Center that are devoted to Nuclear Science research. The other flight paths support the DOE / Basic Energy Sciences (BES) Materials Science User Program. These flight paths view a moderated target and have neutron energies that range from sub-thermal to approximately 500 keV.

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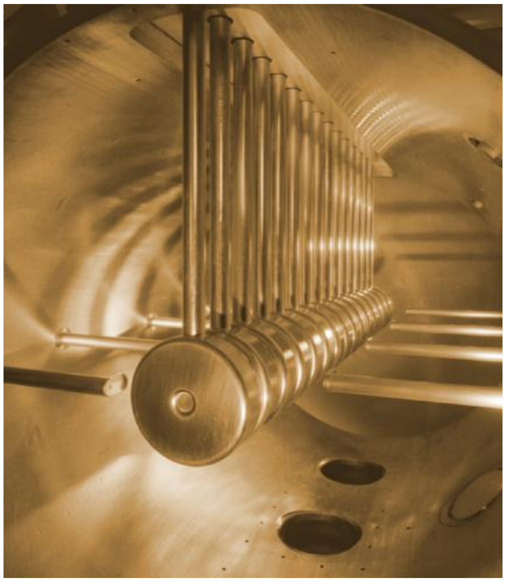
With these facilities, LANSCE is able to deliver neutrons with energies ranging from small fractions of an electron volt to several hundreds of MeV as well as a proton beam with a wide range of time and intensity characteristics



The LANSCE Accelerator

The LANSCE accelerator produces beams of protons which are the nuclei of hydrogen atoms. The protons are accelerated by the electric fields produced by radio frequency voltages that are applied to accelerating structures called drift tubes. The protons are accelerated by these electric fields over the length of the linear accelerator (linac) and are then directed to the various experimental areas.

The half-mile long LANSCE linac consists of three-stages. The protons begin their journey in an ion source at the top of a 750,000 volt Cockcroft-Walton power supply. There are two ion sources: one produces positive hydrogen ions by ionizing the hydrogen atom, the second ion source produces negative hydrogen ions by adding an electron to the atom giving it a net negative charge. By the time the particles leave this section, they have been accelerated to 750 keV and are traveling at 7,440 miles per second or 4 percent of the speed of light.

From the Cockcroft-Walton injectors, the beams pass through the low-energy beam transport system where they are steered, focused, and bunched into pulses for injection into the second stage of the accelerator, the drift-tube linac. The time of arrival of these proton bunches relative to the radiofrequency drive at the linac is crucial to ensure their acceleration.

The LANSCE linac can accelerate both positive and negative hydrogen atoms on alternate sides of the radiofrequency drive. The two beams are accelerated simultaneously. The positive beam is used for isotope production, and in the future we plan to use this beam to drive a materials test station at the 1 megawatt beam power level . The negative hydrogen ion beam is used to drive the two neutron production sources, proton radiography and the ultra-cold neutron source.

In the second stage of the accelerator, the drift-tube linac, particles are accelerated to 100 MeV with a velocity of 80,000 miles per second or 43 percent of the velocity of light.

The third and longest stage of the accelerator is the side-coupled-cavity linac which is 731 meters long. In this section the protons continue to be accelerated as in the drift-tube linac. The protons gain momentum as they pass through forty-eight modules containing forty-eight hundred cells. When the protons leave the accelerator they have reached their final energy of 800,000,000 electron volts and are moving at about 157,000 miles per second or 84 percent of the velocity of light.

Time structure of the LANSCE beam

One of the greatest strengths of the LANSCE facility is that it can produce proton beams with a wide range of time structures. The time structure of the LANSCE proton beam can be optimized for particular experiments within the constraints of the accelerator operating parameters. The linac accelerates beam during the time that the radiofrequency (RF) drive is applied to the accelerating elements. The time that the radiofrequency drive is on defines a macropulse of beam. Because of limitations in the RF power that can be produced and the cooling that can be provided to the elements, the linac is limited to a maximum of 120 macropulses/second. The duration of the macropulse is set by the Master Timer and is typically 625 μs long although longer and shorter macropulses are possible. Within each macropulse, are micropulses. The width of the micropulses is dominated by the frequency and tuning of the radiofrequency driver and is typically less than 100 ps at the exit of the linac. The minimum separation of the micropulses is determined by the operating frequency of the 201 MHz drift tube linac. Because the frequency is 201 MHz, the minimum micropulse separation is 5 ns. The separation between micropulses determines the number of pulses per unit time and thus the average current that is accelerated in the linac. The time structure is programmed in the Master Timer which controls choppers in the low-energy beam transport between the ion source and the beginning of the drift-tube linac. Below we will look at the time structure of the beam for three cases: target-1 (low-energy neutron production), Target-4 (high-energy production) and Target-2 (proton beam experiments) to aid the interested user in understanding the beam parameters and available beam delivery options.

Target-1 operation:

The proton beam is delivered to Target-1 after passing through the proton storage ring (PSR). The time it takes an 800 MeV proton to travel one circuit of the PSR is 360 ns. The beam entering the PSR is filled with micropulses separated by 5 nsec (the minimum separation) for a duration of 270 ns. There is then a gap of no beam for 90 ns for each 360 ns cycle. This pattern is repeated for the entire macropulse or 625μsec / 360 ns = 1736 times. The 90 ns gap is required for the magnets to switch, then the beam is extracted from the ring. Figure 1 shows the time structure of linac beam that is injected into the PSR. The beam that exits from the PSR consists of a triangular pulse approximately 270 ns wide at the base.

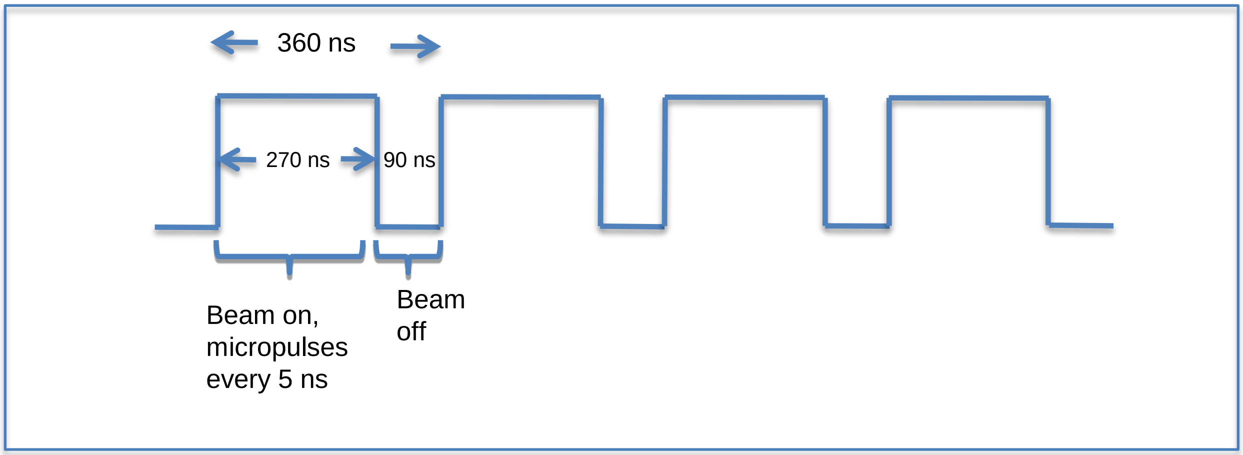


Figure 1. Diagram of the linac beam that is injected into the PSR

Time structure of the LANSCE beam (continued)

Target-4 operation

For time-of-flight measurements, the beam pulses must be separated by enough time so that the slowest neutrons of interest reach the detector before the highest energy neutrons from the next pulse arrive. If this condition is not achieved, then backgrounds may occur in the measurement that may be difficult to remove. For typical operation of Target-4, we separate micropulses by 1.8 μs. This allows observing neutrons down to approximately 160 keV for a 10m flight path. Should experiments require measuring lower energy neutrons, the pulse-to-pulse spacing may be increased with fewer pulses and lower beam current. Figure 2 shows the time structure for typical operation of Target-4.

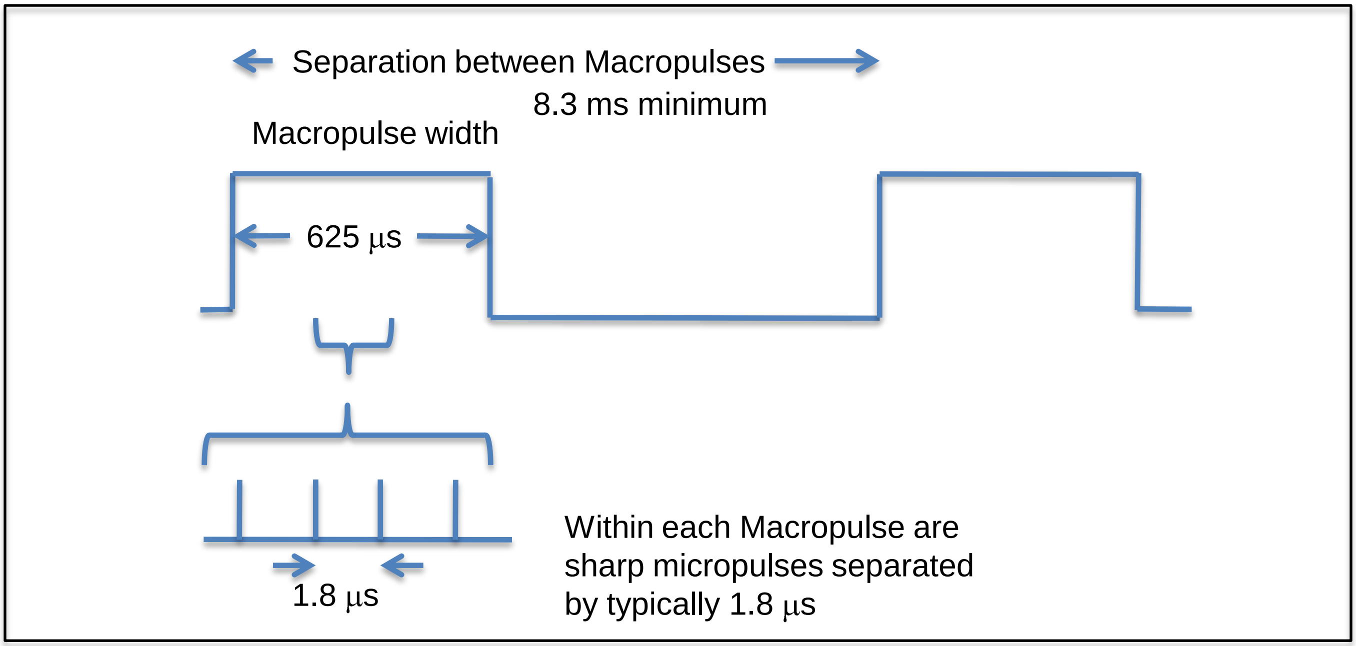


Figure 2. Time structure of the proton beam for typical Target-4 operation

If we operate with 40 macropulses / s which are 625 μs long with 1.8 μs between micropulses, the number of micropulses / s is [625]/ [1.8] *[40] = 13889 pulses / s. If we assume there are 7 10^8 protons in a micropulse, there will be 7 10^8 *13889 ~ 10^{13} protons / sec or ~1.5 μA of beam.

Time structure of the LANSCE beam (continued)

Target-2 operation

Beam can be transported to Target-2 (aka the Blue Room) both directly from the linac or after being compressed in the PSR. At this time, the beam current is limited by the radiation shielding surrounding Target-2 to approximately 80 nA for an unshielded sample. Because the Lead Slowing-Down Spectrometer shields the target with 0.6 m of lead in all directions, the beam current can be raised to the 1 μA level. The limitations to the time structure that can be delivered to Target-2 can be estimated assuming there are 7×10^8 protons in a micropulse. For example, if we operate with a 625 μs wide macropulse at a repetition rate of 10 macropulses / s with a micropulse separation of 10 μs, the beam current will be [10] * [625/10] * [7e8] * 1.6E-19 = 70 nA which is within the operating limits for an unshielded target. Single proton pulses on demand can also be delivered.

Beam Transport

Figure 3 Shows a simplified drawing of the beam transport system from the linac to Target-1 (Lujan Center), Target-2 (Blue Room) and Target-4. In usual operation beam is transported from the linac through the pulsed Ring Injection Kicker (RIKI) magnet. When RIKI is switched on, the beam is injected into the storage ring with the time structure shown in Figure 1. The beam is accumulated in the PSR and then transported to Target-1.

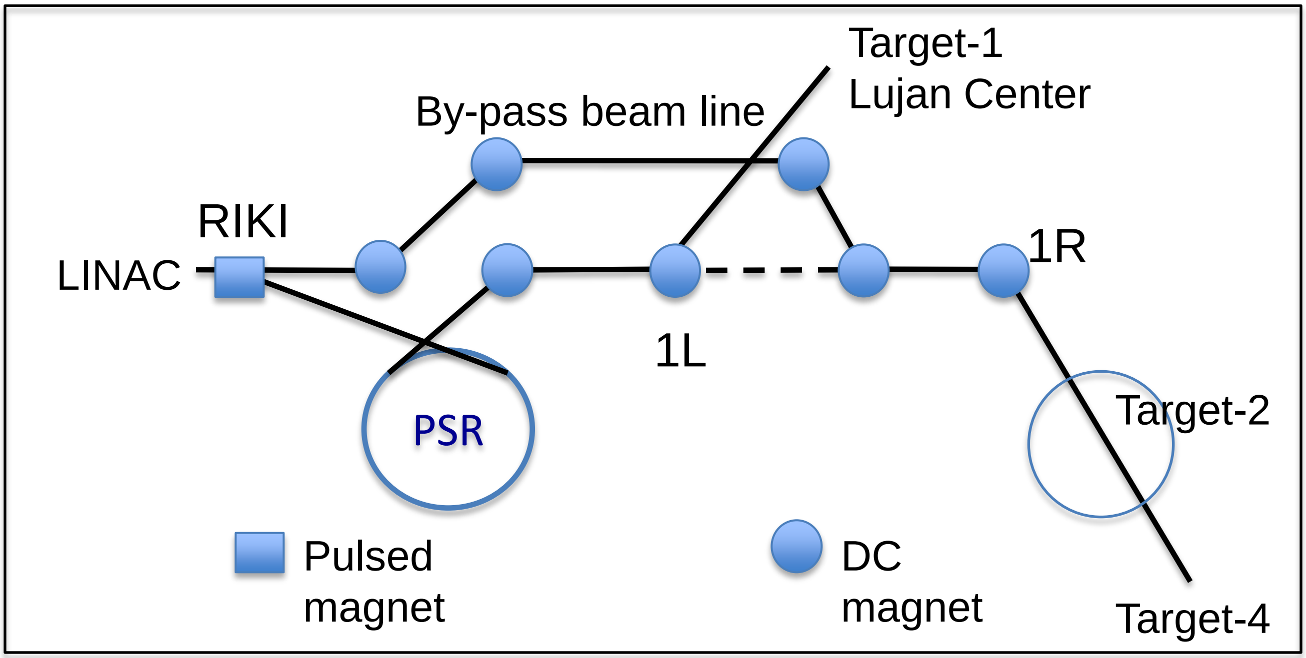


Figure 3. Simplified drawing of the beam transport beam lines

Beam transport (continued)

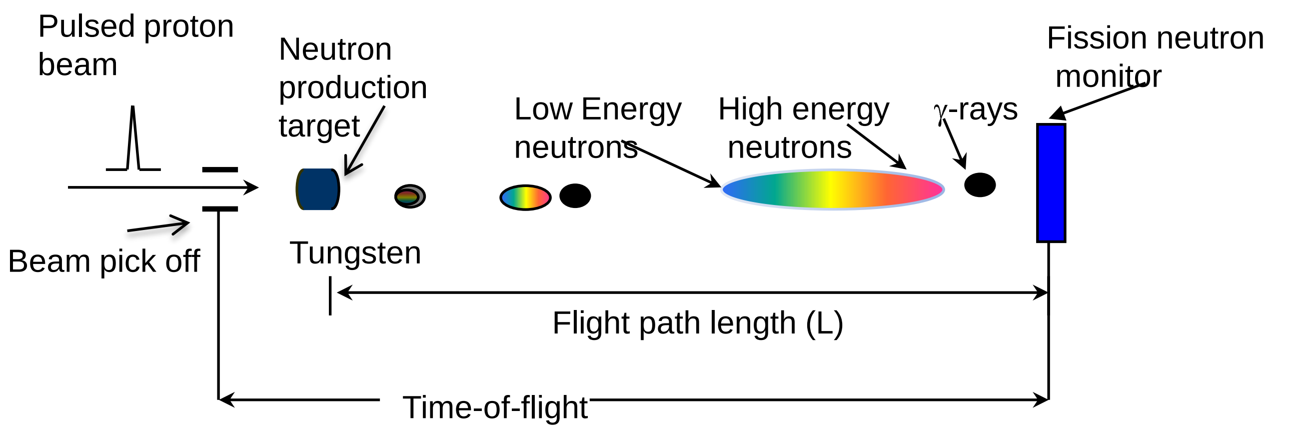
When RIKI is switched off, the beam is transported through the "bypass beam line" to Target-2 or Target-4. RIKI switches between macropulses. Typically, 20 macropulses / s are sent to the Lujan Center and the remainder are delivered to Target-2 or Target-4. Presently, the linac is accelerating 60 macropulses / s so 40 macropulses / s go to Target-2/4.

Sole use operation

Sole use operation is when beam conditions are such that the Lujan Center (Target-1) cannot receive beam. For example, when PSR beam is transported to Target-2, the 1-L magnet is turned off and beam goes through the dashed line to Target-2. Since the 1-L magnet is not pulsed no beam can go to Target-1.
Another example of sole use operation is when proton beam energies other than 800 MeV are used for Target-2 experiments. In this case, the magnets upstream from RIKI in the beam line are set for non-800 MeV operation, and since they are the same magnets that are used for transporting beam to Target-1, Target-1and the Lujan Center cannot be used.

Neutron time-of-flight

Since the LANSCE proton beam is pulsed, the energy of the neutrons that are produced can be determined by Time-of-Flight (TOF) techniques. The technique is shown diagrammatically in figure 4. The proton beam pulse strikes the tungsten neutron production target and neutrons, gamma rays and charged particles are produced. The charged particles are removed from the beam by permanent



Neutron TOF = $\frac{72.3\,L}{\sqrt{E_n}}$ (non-relativistic)

γ-ray TOF = $\frac{L}{c}$ c is velocity of light

Example: L= 20m TOF_γ = 67 ns E_n = 1 MeV TOF_n= 1.5 μs
E_n = 100 MeV TOF_n= 150 ns

Figure 4. Time-of-Flight technique

Time-of-Flight (continued)

magnets. The neutrons and gamma rays travel the distance of the flight path to arrive at a sample or detector. Because gamma rays travel at the speed of light, the gamma rays arrive first. As the neutrons traverse the flight path distance, the neutron pulse becomes broader with the highest energy neutrons arriving before the lower energy neutrons. A measurement of the time between the proton beam pulse and the detection of a signal from the detector gives the velocity or the energy of the neutron.

Depending on the micropulse spacing, gamma rays and high-energy neutrons produced by the following proton pulse will arrive at the same time as low-energy neutrons. This is called "wrap around" and sets a lower limit for the neutron energy that can be used in an experiment.

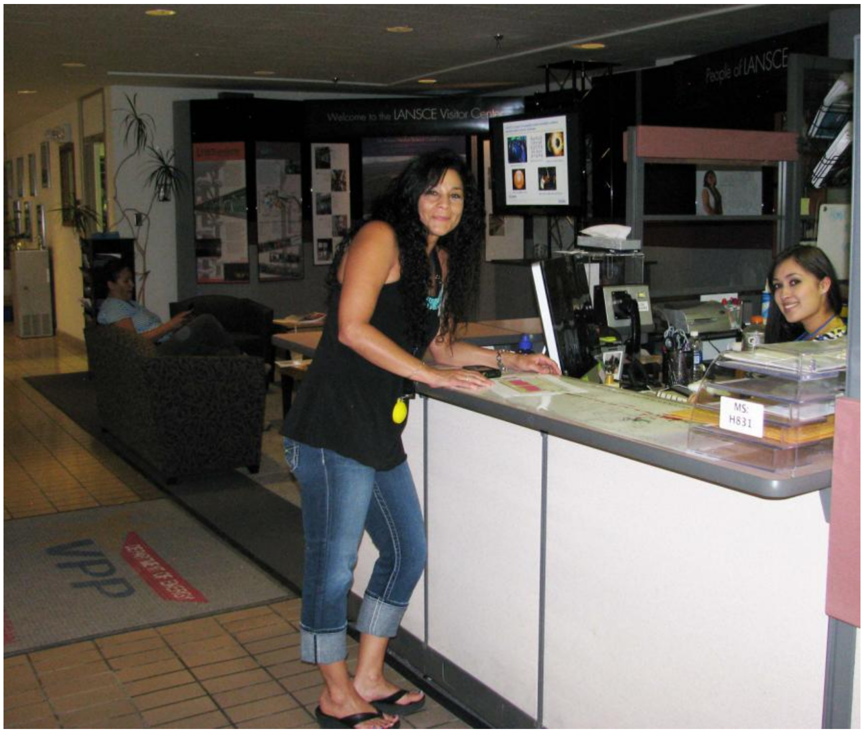
One contribution to the incident neutron energy resolution in a TOF experiment is the time resolution of the detector system. The energy resolution is given by $\Delta E/E = 2\,\Delta T/T$, where ΔE is the neutron energy resolution, ΔT is the time resolution of the detector and T is the TOF of the neutron. Table 1 give values for neutron and gamma ray TOF, wrap-around energy for 1.8 μs and 3.6 μs spacing and energy resolution for various flight path lengths assuming 1 ns detector time resolution.

Table 1

Flight path length (m)	Neutron Energy (MeV)	TOF-γ (ns)	TOF n (ns)	Wrap around 1.8 μs (keV)	Wrap around 3.6 μs (keV)	ΔE (keV)
10	1	33	722	161.34	40.33	3
	2		511			8
	10		230			87
	20		164			244
	100		78			2569
	500		44			22739
20	1	67	1445	645.34	161.34	1
	2		1023			4
	10		460			43
	20		328			122
	100		156			1285
	500		88			11369
90	1	300	6502	13068.23	3267.06	0
	2		4601			1
	10		2071			10
	20		1476			27
	100		701			285
	500		396			2527

Nuclear Science User Program

User Office building (MPF-1)



LANSCE User Office desk

Nuclear Science User Program Proposal Process

Those interested in obtaining beam time for experiments at one of the LANSCE neutron sources should follow the proposal process. Calls for proposals to all potential users are made yearly. The proposal consists of information about the research team, amount of beam time requested and a description of the proposed experiment. Urgent post-proposal-call beam requests may be addressed through a "Fast Access" proposal process if necessary. Please contact the LANSCE User Office for more information and help with your proposal. If you are a first time facility user, we encourage you to contact a flight path scientist to discuss your planned work to help ensure that the most appropriate flight path is chosen. A list of flight path scientists is given in the section on user contacts.

Every activity on any flight path requires a proposal. Proposals are submitted using a web interface. To submit a proposal for a flight path operated by the Nuclear Science group, go to http://LANSCE.LANL.GOV, click the User Resources tab then click on Proposals then Proposal Submission under the WNR heading. The instructions now depend on whether you are a first time or returning user. All proposals are reviewed for scientific merit by the Program Advisory Committee (PAC). In the case of proprietary proposals, such as the case for Industry, users pay for beam time and no scientific merit review is conducted.

The PAC is divided into three subcommittees: Basic Science, Nuclear Technology and Defense-related research. The goal of these committees is to select those experiments that are thought to be the most important in a particular field, will have the greatest impact in the particular area of research and have the greatest chance for success. The PAC rates the proposals and these ratings are used as input to the scheduling process. Users are given an opportunity to present their proposal either in person or by telephone before the committee and to answer questions.

If a proposal is rated highly, it will be scheduled for beam time. Before the experiment is actually run, it must undergo a Safety and Technical review. If the experiment is "routine" in the sense that it is very similar to experiments that have been done before and does not have any significant safety or compliance issues, it will be approved for beam time. If there are safety, compliance, security or other concerns, the experiment will be reviewed in more depth by a committee of subject matter experts. The result of the safety review may be additional requirements, procedures and documentation. The safety review form is available on the web and is accessed as part of your proposal submission process.

If you have any questions please contact the LANSCE User Office Administrator, Tanya Herrera (tanyah@lanl.gov 505-667-6797).

Information for Prospective Users

The Department of Energy (DOE) has different access rules and procedures for US citizens and non-US citizens.

US citizens

Before You Arrive:

- After submitting a proposal and having your beam time approved, the WNR User Program Administrator will contact you and schedule your visit. To inform the User Office of when you will be visiting and who from your group will be arriving, you *must* *register by* going to https://wnr-proposals.lanl.gov/Visits . Every person visiting LANSCE must register with the User Office. We ask the Principal Investigator to make sure that all the members of their team are registered.
- If necessary arrange with the WNR User Program Administrator to have your equipment shipped to and from LANSCE.
- To use the LANSCE facilities, you will need training. The WNR User Program administrator will schedule appropriate training and send an email with logistics two weeks prior to your visit.
- Please read our educational and training materials available online at http://www.lansce.lanl.gov/training/index.shtml
- Discuss your experiment with the Flight Path Scientist you plan to work with.
- If you need training, plan to arrive here at least 1 day before your experiment is scheduled to begin.
- If your work is proprietary, you may need to have a User Facility Agreement in place. The WNR Program Administrator will help you arrange for this agreement.

When you arrive:

- US citizens may go directly to the LANSCE site (TA-53). The guard should have your name and you will need to show a picture ID. After you pass though the guard station, go to the LANSCE Visitor Center (MPF-1, see map). The LANSCE Visitor Center is where you will receive your training, your identification badge, and your radiation dosimeters. Complete training typically takes from 1 – 3 hours.
- If you are bringing a personal laptop or other Portable Electronic Device (PED) other than a cell phone you will need to fill out paperwork at the Visitor Center to register it and receive a password to access the Visitor Network.
- When you have completed your training, the Visitor Office will contact the flight path scientist to arrange your access to the experimental area.

When you leave:

- Please check with the WNR User Program Administrator to arrange for the return of your equipment if necessary. In some cases, your sample or equipment may become activated and will have to remain at LANSCE until it is no longer radioactive.
- Please fill out our Satisfaction Survey. Our survey is included in your LANSCE User Packet, or at https://wnr-proposals.lanl.gov/Surveys. Your responses to our Satisfaction Survey are essential to us—we use your comments to improve our services.

Information for Prospective Users

- All badges must be returned either to the WNR Program Administrator at TA-53, Building 31, Room 252 or to the Building 1 LANSCE Visitor Center.
- Please be sure to inform your Flight Path Scientist of any publications or reports you create that include your research at WNR. The DOE and WNR management use the total number of WNR user-publications to justify future funding for our facility

Non-US Citizens

Although we encourage the use of LANSCE by non-US citizens, a DOE approval process must be followed.

Before You Arrive:

- *Approval from the US Department of Energy is required prior to getting on site.* After submitting a proposal and your beam time is approved, the WNR Program Administrator will contact you and schedule your visit. To ensure sufficient time to receive DOE approval, inform the WNR User Program Administrator that you are a non-US citizen *at least 3 months before your scheduled arrival.*
- *. To inform the User Office of your visit, y*ou ***must*** go to https://wnr-proposals.lanl.gov/Visits to register. Every person visiting LANSCE must register with the User Office. In the case of non-US citizens, you must register three months prior to your visit. We ask the Principal Investigator to make sure that all the members of their team are registered.
- Arrange with the WNR Program Administrator to have your equipment shipped to and from LANSCE.
- You will need training before you can do experiments at WNR. Schedule your training with the WNR Program Administrator.
- Please read our educational and training materials available online at http://www.lansce.lanl.gov/training/index.shtml
- Discuss your experiment with the Instrument Scientist you plan to work with.
- Plan to arrive at LANSCE at least 1 day before your experiment is scheduled to allow time for training.
- If your work is proprietary, you may need to have a User Facility Agreement in place. The WNR Program Administrator will help you arrange for this agreement

When you arrive:

- *You must bring your current visa, passport, and any other documents necessary.*
- First, go to the Los Alamos National Laboratory's Badge Office at TA-3 to obtain your identification badge (see map).
- You must have this identification badge with you at all times.
- After receiving your identification badge, go to the LANSCE Visitor Center at the LANSCE site (TA-53, see map). The LANSCE Visitor Center is where you will receive your training (if needed), your LANSCE identification badge, and your dosimeters. Training typically takes from 1 – 3 hours.

Information for Prospective Users

- If you are bringing a personal laptop or Portable Electronic Device (PED) other than a cell phone, you will need to fill out paperwork at the Visitor Center to register it and receive a password to access the Visitor Network.
- When you have completed your training, the Visitor Office will contact the flight path scientist to arrange your access to the experimental area

When you leave:

- Please check with the WNR Program Administrator to arrange for the return of your equipment if necessary. In some cases, your sample or equipment may become activated and will have to remain at LANSCE until it is no longer radioactive.

- Please fill out our Satisfaction Survey. Our survey is included in your LANSCE User Packet or at https://wnr-proposals.lanl.gov/Surveys. Your responses to our Satisfaction Survey are essential to us—we use your comments to improve our services.

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- Please be sure to inform your Flight Path Scientist of any publications or reports you create that include your research at WNR. The DOE and the WNR management use the total number of WNR user-publications to justify future funding for our facility.

Flight Path Overviews

LANSCE accelerator Operations Building

Overview of Flight Paths (FPs)

Each Flight Path's name identifies the target and the direction of the flight path (FP) with respect to the proton beam. For example, 4FP15R is a FP (flight path) that starts at Target 4 and is 15 degrees to the right (15R) of the incoming proton beam. The beams are transmitted at three different vertical levels: Target 4, Target 2, and Lujan Center (Target 1). Figure 5 shows the layout of the flight paths at the LANSCE neuron sources. Figure 6 shows a schematic drawing of the Target-2 and Target-4 flight paths. In the next few pages, we describe the flight paths and the major research program that are on each flight path.

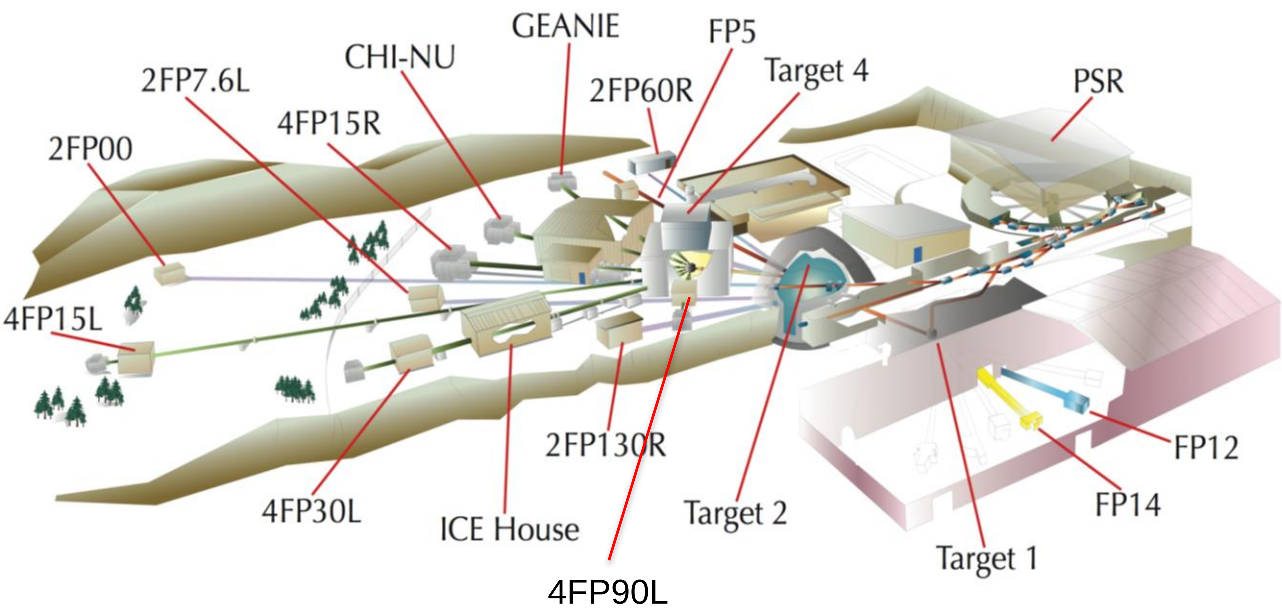


Figure 5. The layout of the LANSCE neutron sources and Nuclear Science flight paths

Overview of Flight Paths (continued)

Target 4 Flight Paths (FP)

4FP90L – This FP is the location of the time-Projection Chamber (TPC) that is used to measure fission cross sections to high precision.

4FP30L – This FP has two experimental stations. The first station (ICE House) is approximately 20 m from the production target and is used by industry, universities, and other national laboratories to measure neutron-induced failures in semiconductor devices.

4FP15L – This FP is the longest neutron FP and therefore provides the highest neutron-energy resolution. At present, the approximately 90-m-long FP is a general purpose FP and is being used for dosimetry, neutron transport, radiation effects, detector characterization and neutron-spectra experiments.

4FP15R – This FP is being used to study few-body nuclear physics. The current experiment involves measuring the n-p capture cross section which is important for understanding big bang nucleosynthesis.

4FP30R- This FP serves two experiments. Neutron-induced charged particle reactions are measured at the 15m station and neutron output spectra following fission are measured at a FP length of ~23m (FIGARO).

4FP60R – This flight path is the location of the GEANIE spectrometer which consists of 26 Compton-suppressed, high-resolution germanium γ-ray detectors at a distance of 20-m. The GEANIE instrument is used to address issues of nuclear structure, spectroscopy, and cross-section measurements for both stockpile stewardship, nuclear technology and basic science.

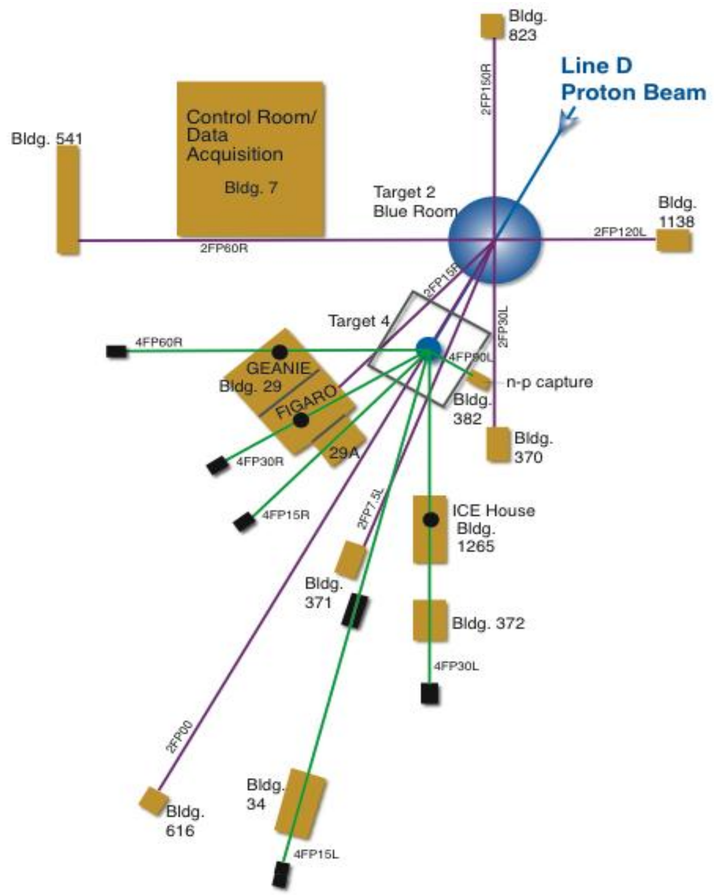


Figure 6. Schematic drawing of the Target-2 and Target-4 flight paths

Target 2 (Blue Room)

Target 2 is used for proton beam irradiation experiments. Beam is available directly from the linac or from the proton storage ring (PSR).
Present and past experiments include:

- A lead slowing-down spectrometer (LSDS) for measuring cross sections with ultra-small samples.

- PSR pulse-on-demand beam to study the shock induced by the incident beam on a liquid-mercury target for the ORNL Spallation Neutron Source (SNS).

- Pulsed beam experiments to simulate intense neutron environments for semiconductor certification.

- Proton irradiation of detectors and component testing for the Large Hadron Collider at CERN.

Overview of Flight Paths (continued)

Target 4 Flight Paths (FP)

For the Target-4 flight paths, the neutron spectrum depends on the angle of the flight path with respect to the proton beam. Figure 7 shows the calculated neutron spectra for various flight paths at Target-4. As seen in this plot, the most forward angle flight paths at 15 degrees have the most intensity at high energy and somewhat lower intensity at lower neutron energy. The more backward angle flight paths at 90 degrees have significantly lower intensity at high energy and more intensity at lower energies. The flight paths at 30 and 60 degrees fit between those extremes. The shape of the neutron spectrum at the different flight path angles must be considered when choosing a flight path for a particular experiment.

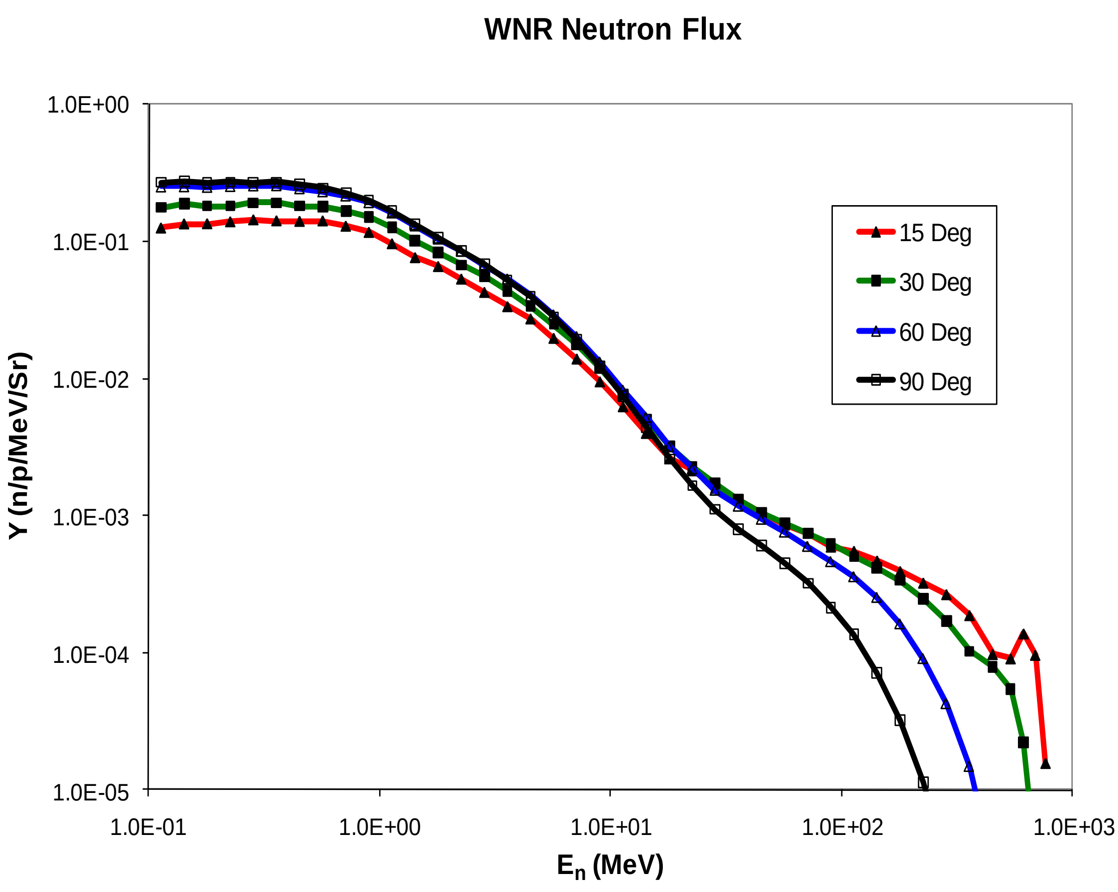


Figure 7. Calculated neutron spectrum for various flight path angles

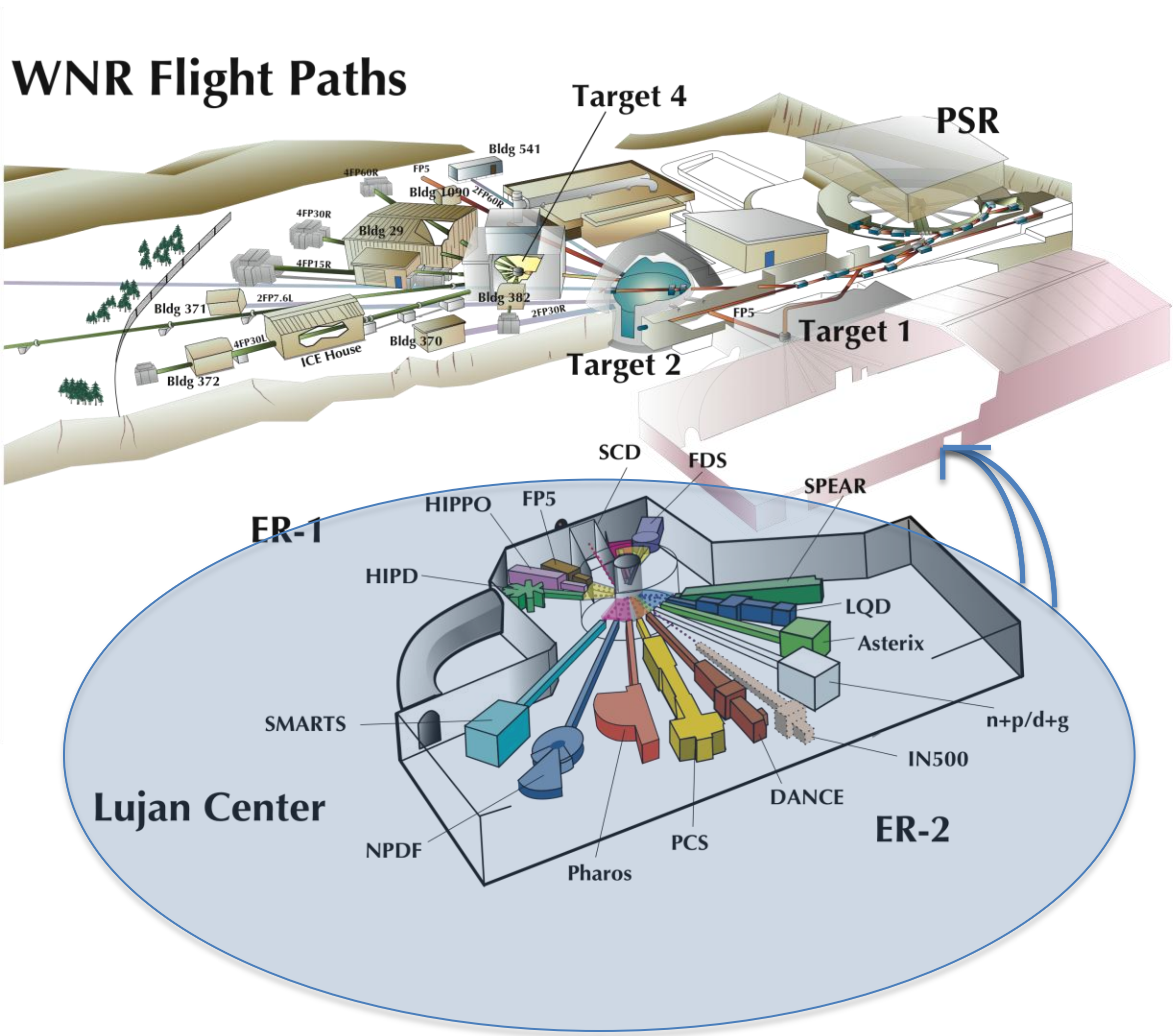
Overview of Flight Paths-Continued

Lujan Center Flight Paths

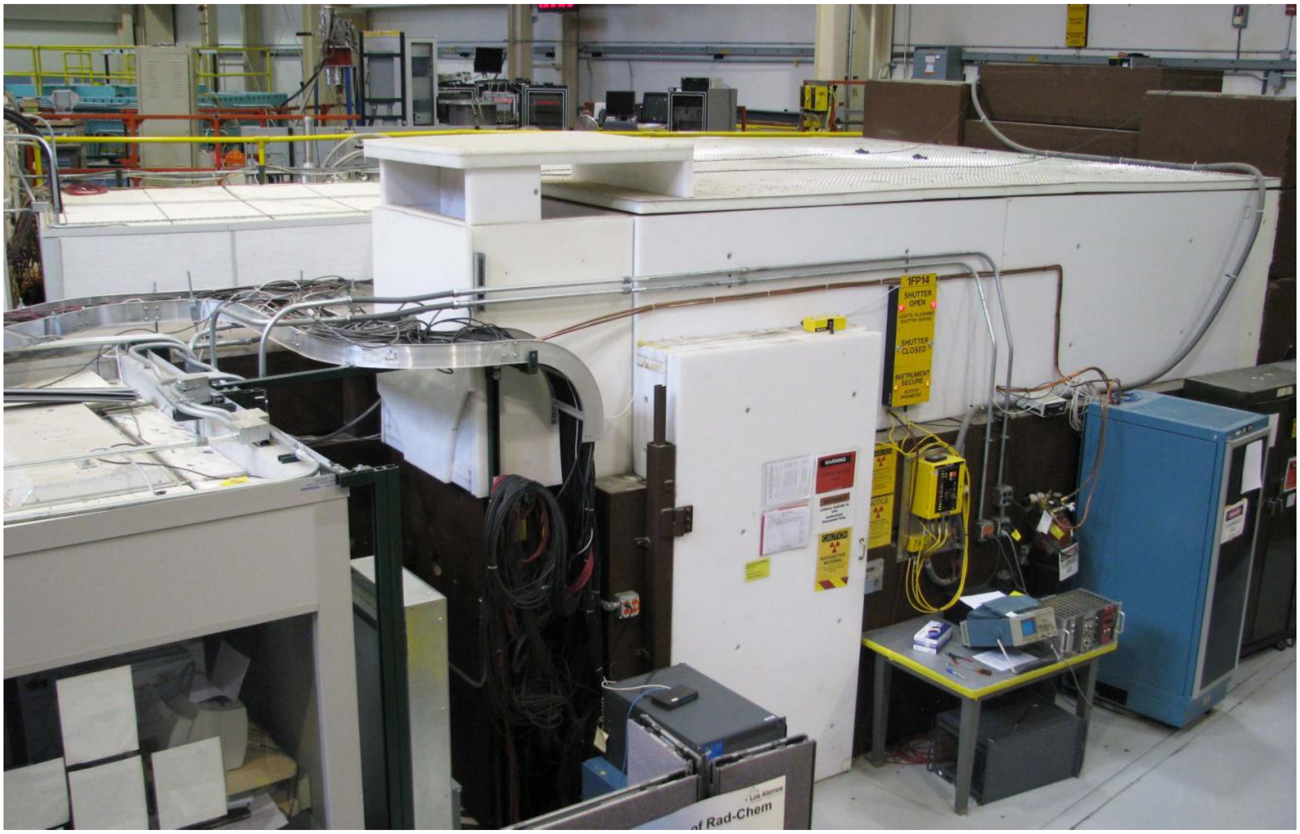
FP5- is a general purpose flight path that is currently being used for low-energy fission cross sections and neutron radiography. It has two detector areas: one at approximately 10m in ER-1 and the second at a distance of 60 m that is reached from the Target-4 yard.

FP14- This FP is the location of the Detector for Advanced Neutron Capture Experiments (DANCE) It consists of a 4-π array of BaF_2 scintillators. It was designed for neutron capture measurements on sub-milligram and radioactive samples. These measurements support Radchem measurements for Defense Programs, cross section measurements for the Advanced Fuel Cycle Initiative and basic nuclear astrophysics.

FP12- This flight path has a neutron guide and is used primarily for fundamental neutron physics experiments such as developing a new ultra-cold neutron source using solid oxygen.



Flight Path Descriptions



Flight Path 14– DANCE Array

Target 4 Flight Path 60R (GEANIE)

Matt Devlin
Phone: (505) 665-0421
E-Mail:
devlin@lanl.gov

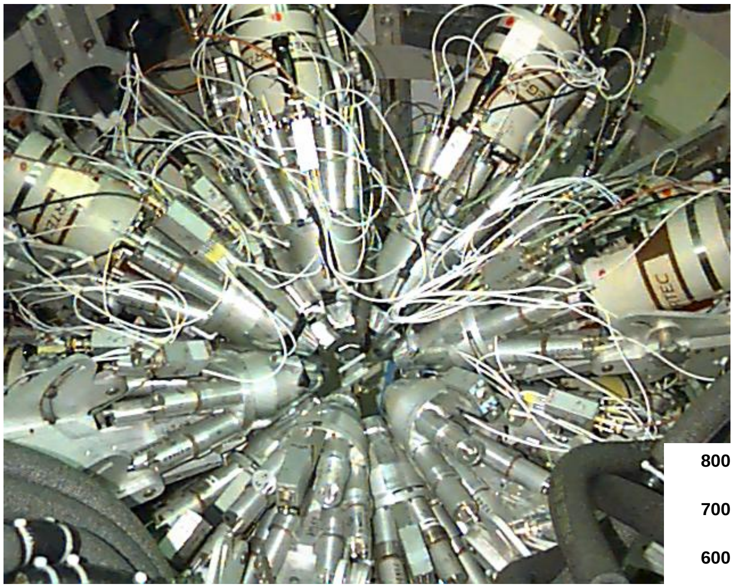
Facility:

1. Collimated neutron beam line in building MPF29 with samples 20.34 m from Target 4.
2. Magnets in flight path to deflect charged particles.
3. Beam spot size options include 1.3 cm and 1.9 cm diameter.

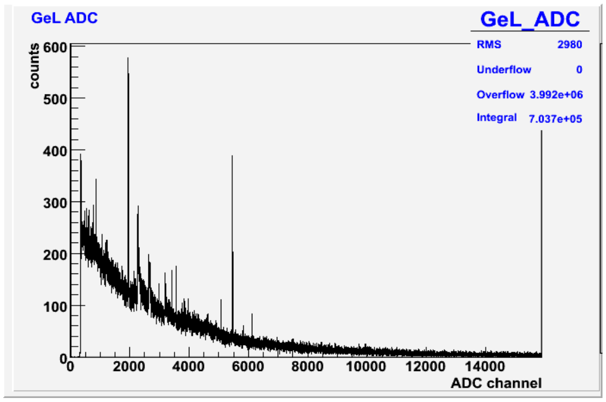
Instrumentation: Array of 26 HPGe detectors for γ-ray detection: up to 11 of these are planar detectors for low-energy γ-ray detection, and 20 of these HPGe detectors also have Compton suppression shields. Fission ionization chamber for measuring neutron flux, equipped with both ^{235}U and ^{238}U foils.

Present research efforts

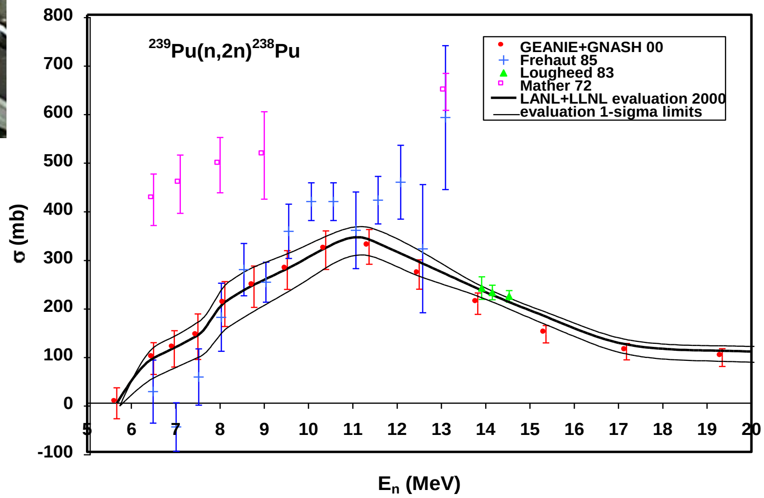
1. Neutron-induced reaction cross section measurements for basic and applied physics.
2. Nuclear structure studies and γ-ray spectroscopy.
3. Studies of potential neutron-induced backgrounds for $\beta\beta$ experiments.
4. Neutron-induced γ-ray production measurements for applied science.



The GEANIE Array



A sample γ-ray spectrum from n + ^{136}Xe



GEANIE measurement of the cross section of the ^{239}Pu(n,2n)^{238}Pu reaction

Target 4 Flight Path 30R (N,Z)

Robert Haight
Phone: (505) 667-2829
E-Mail: haight@lanl.gov

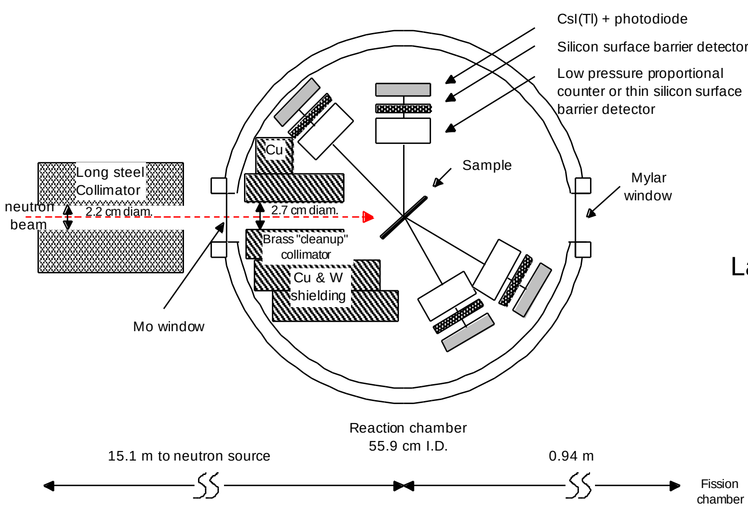
Facility:

1. Light charged-particle emission from neutron-induced reactions
2. Collimated neutron beam in building MPF29 with samples 15.1 m from source
3. Incident neutron energy measured by time-of-flight
4. Array of four charged-particle telescopes for identifying and measuring the energies of protons, deuterons, tritons, ^{3}He and ^{4}He.

Instrumentation: Four counter telescopes each consisting of a proportional counter, a silicon surface barrier detector and a 3 cm-long CsI(Tl) scintillator, which can stop 100 MeV protons; fission ionization chamber for measuring neutron flux.

Present research efforts

1. Analysis of previously obtained data relevant to hydrogen and helium production (radiation damage) and basic physics (nuclear level densities)



Layout of the reaction chamber

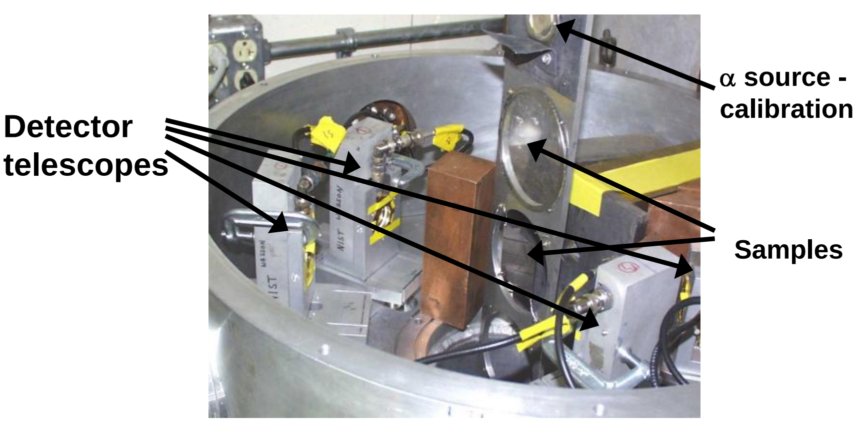
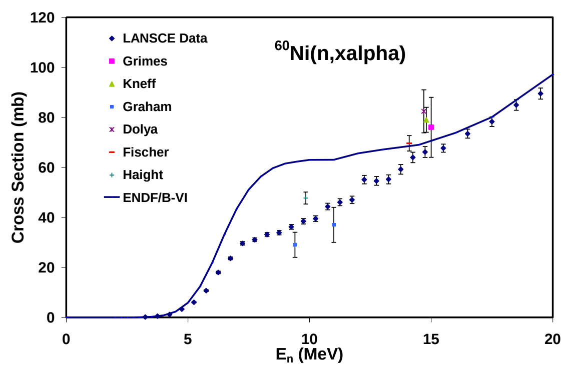


Photo of the (n,z) reaction chamber.



Example of data: Helium production by neutrons on the ^{60}Ni isotope for incident neutron energies up to 20 MeV. The data continue up to 100 MeV (not shown here).

Robert Haight
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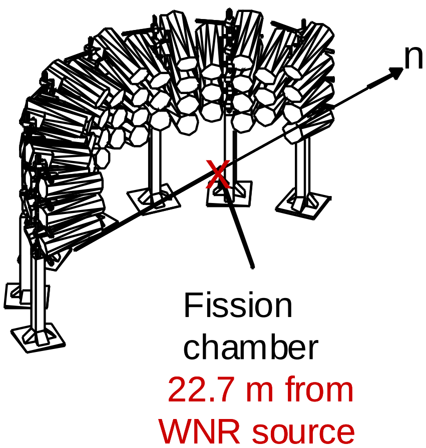
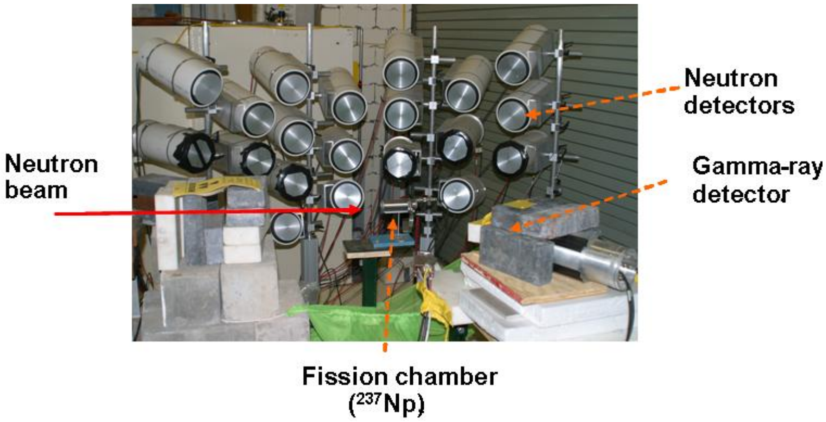
Target 4 Flight Path 30R (Chi-Nu, formerly FIGARO)

Facility:
1. Neutron and gamma-ray emission from neutron-induced reactions
2. Collimated neutron beam in building MPF29 with samples 22.7m from source
3. Incident neutron energy measured by time of flight
4. Array of neutron and gamma-ray detectors to detect emitted radiations
5. Emitted neutron energies measured by time of flight over flight paths 30 to 200 cm

Instrumentation: Array of 20 neutron and 3 gamma-ray detectors; neutron detectors include liquid scintillators 5" diameter and 2" thick and ^{6}Li-glass scintillators; gamma ray detectors include BaF_2, NaI(Tl), and HPGe.

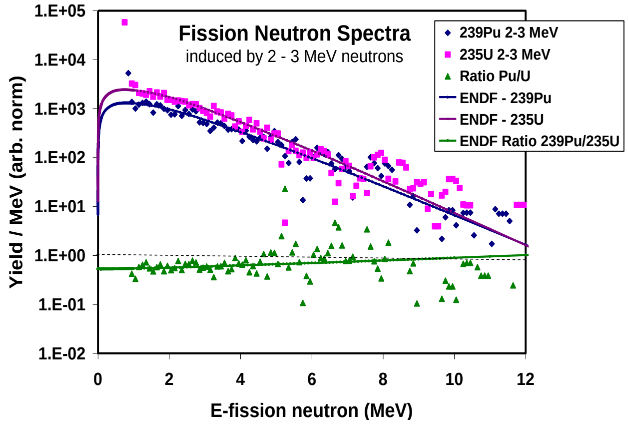
Present research efforts
1. Prompt fission neutron spectra
2. Neutron emission from inelastic scattering and other reactions
3. Detector development



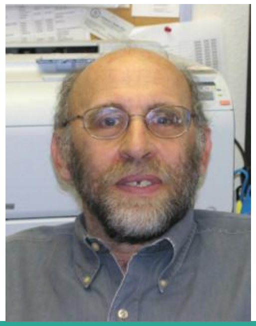


Chi-Nu apparatus: Incident neutron energies are measured by time of flight over a 22.7 meter flight path; emitted neutron energies are measured by time of flight over flight paths of 30 to 200 cm. Fission events or gamma rays serve as time markers when incident neutrons interact with the sample.

Example of data for neutron emission from fission of ^{235}U and ^{239}Pu induced by neutrons with energies of 2 to 3 MeV.



Target 4 Flight Path 15R



Steve Wender
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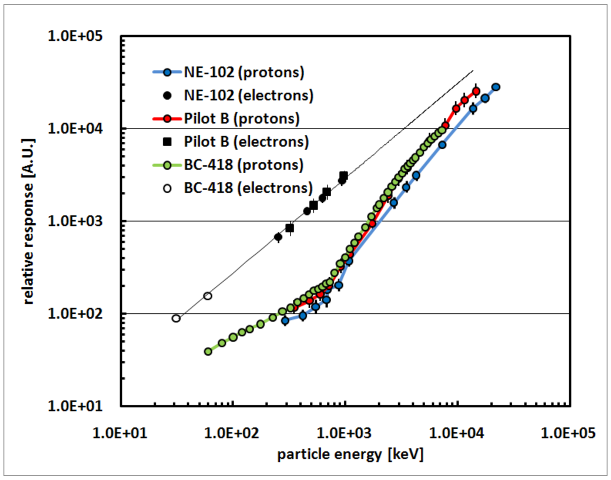
wender@lanl.gov

Facility: 1. Detector shed (MPF29) located at approximately 15m-21m
2. Magnets in flight path to deflect charged particles
3. Variable jaw shutter up to 5" square

Instrumentation: Flexible experimental area that can be used for a wide range of experiments. Fission ionization chamber for measuring neutron flux

Present research efforts

1. Few-body physics
2. n-d breakup reactions
3. n-p capture in 100 KeV to several MeV range
4. Total cross section on hydrogen
5. Gamma-ray blind neutron detector development
6. Detector characterization and light response



Recently measured (preliminary) light response of scintillator BC-418 in green

Adjusting active sample for n-p capture experiment on 15R flight path

Nikolaos Fotiadis
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E-Mail: fotia@lanl.gov

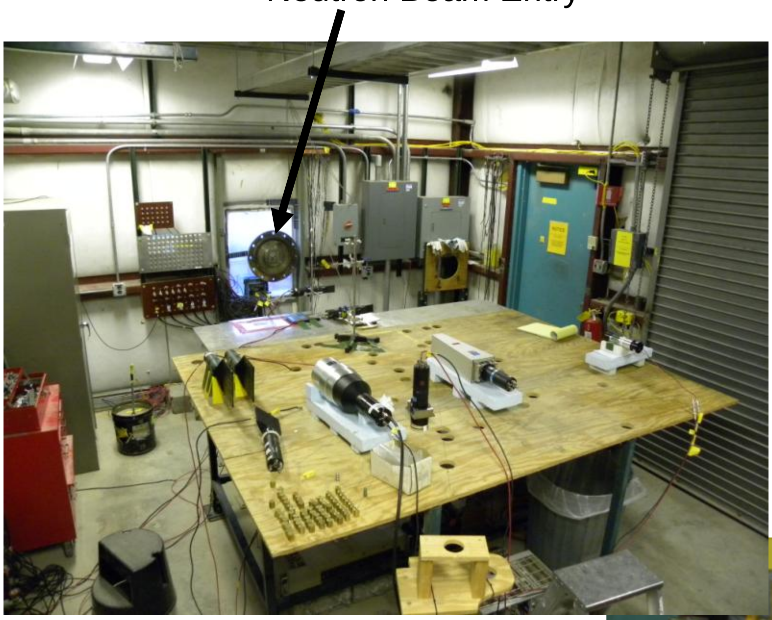
Target 4 Flight Path 15L (4FP15L)

Facility: 1. General purpose flight path. It has two experimental locations available at distances of 18m and 90m from the spallation target. A 15 x 20 sq ft building at 90 m and a smaller experimental shed is located in the Target-4 yard at a distance of approximately 20 m. The data room for 90-m shed is in MPF-17.

Instrumentation: Fission ionization chamber for neutron dosimetry.

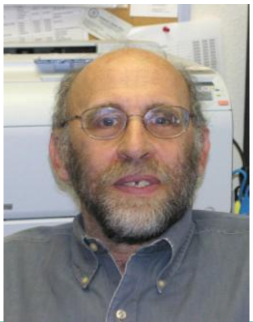
Present research efforts:

The 90 m flight path provides the highest neutron energy resolution for high-energy neutrons. The long flight path also provides reduced intensity for detector calibrations. The shorter distance flight path has been used for radiations and SEU testing.



90m experimental area including a typical set-up

A user positioning a sample for irradiation at 90m



Steve Wender
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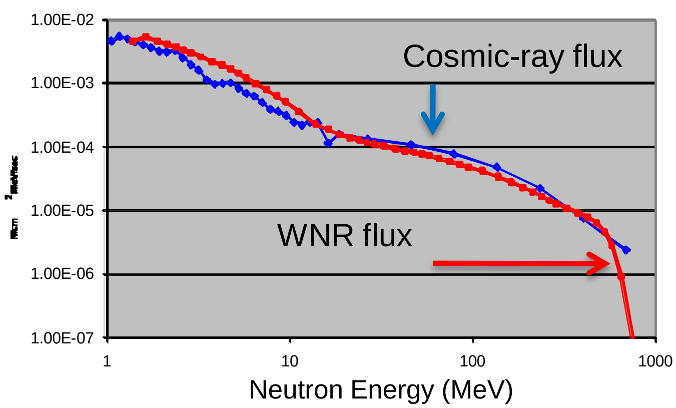
Target 4 Flight Path 30L (Ice House)

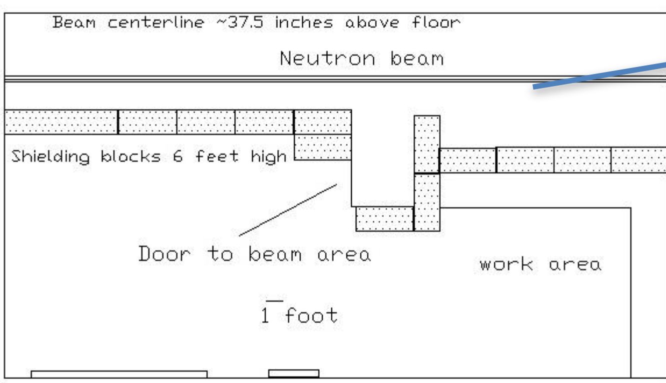
Facility: 1. Detector shed (MPF-1265) located at 20-33m (ICE House)
2. Detector shed (MPF-370) located at 40-47m.
3. Magnets in flight path to deflect charged particles
4. Spot size in first detector shed : 7.6 cm, 5.1 cm, 2.5 cm dia.

Instrumentation: Fission ionization chamber for measuring neutron flux

Present research efforts

The major use of this flight path is for Single-event effect testing. The Irradiation of Chips & Electronics (ICE House) is used by industry, national laboratories and universities to test the effects of neutrons on semiconductor devices. At this angle, the shape of the neutron spectrum is very similar to that of neutrons produced in the atmosphere by cosmic rays. The intensity of the neutron beam is approximately 10^7 times the cosmic-ray induced neutron flux . This large flux allows testing of semiconductor devices at greatly accelerated rates. Companies from around the world can use the WNR high-energy-neutron source to characterize components and study various failure modes caused by neutron radiation.





Floor plan of ICE House

Beam area in ICE House

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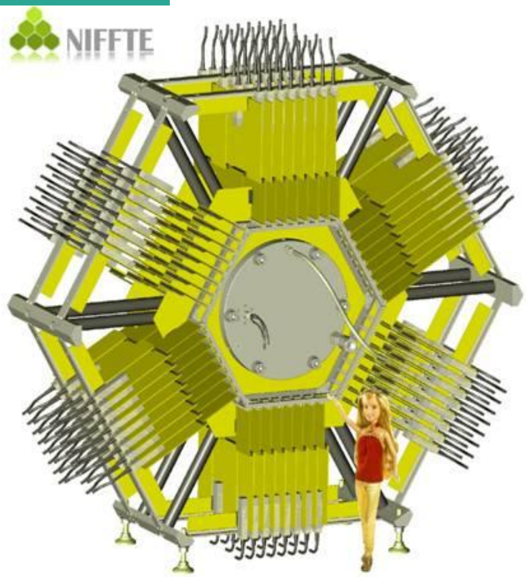
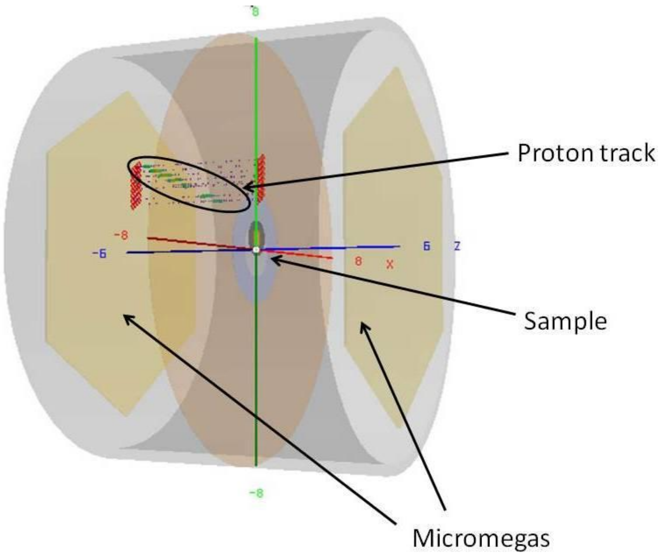
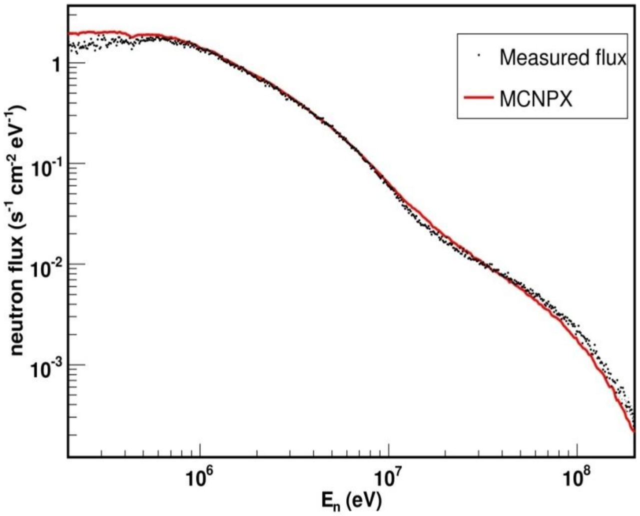
Target 4 Flight Path 90L

Target 4 Flight Path 90L is primarily used for fission cross section measurements. The flight path length is approximately 7 to 15m long. Instruments used on the flight path are fission chambers and the fission Time-Projection Chamber (TPC). The TPC is being developed by the Neutron Induced Fission Fragment Experiment (NIFFTE) collaboration, and was designed to provide fission cross sections with unprecedented precision. It is also a powerful tool for other types of fission studies, such as ternary fission research.

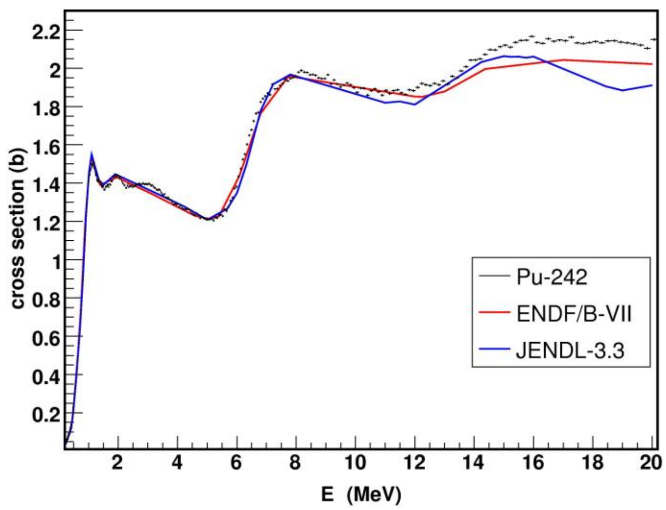




Drawing of the fission Time Projection Chamber.



Measured and calculated neutron flux at the 4FP90L flight path. The calculation was done with MCNPX.



The neutron induced fission cross section of Pu-242 measured at 4FP90L

Target 1 Flight Path 5 (ER-1 and Silo)

Target 1 Flight Path 05 (1FP05) utilizes low-energy neutrons from a water moderator on the 1L target. This flight path has two detector areas: (1) In experiment building ER-1 (MPF-30) at a distance of approximately 6 m and (2) in a detector shed in the Target-4 yard at a flight path length of approximately 60 m. The relatively short flight path (6 meters) is ideal for experiments that benefit from a high neutron flux. This flight path is primarily used for fission and total cross section measurements using parallel-plate ionization chambers.

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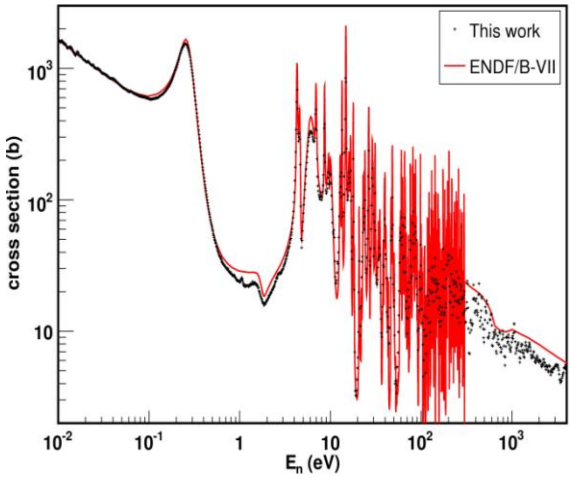
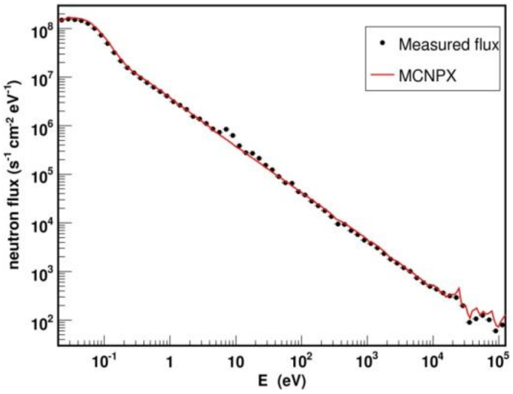
Present research efforts:

1. Low-energy fission cross section measurements for Nuclear Energy and Defense Programs applications.
2. Bragg-Edge Diffraction studies of material properties.
3. Neutron total cross section measurements.



The neutron induced fission cross section of Pu-241 measured at 1FP5



Measured and calculated neutron flux at the 1FP5 flight path. The calculation was done with MCNPX.

Picture of a fission chamber with the front window removed A U-235 foil is seen in the center.

Ron Nelson
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RNelson@lanl.gov

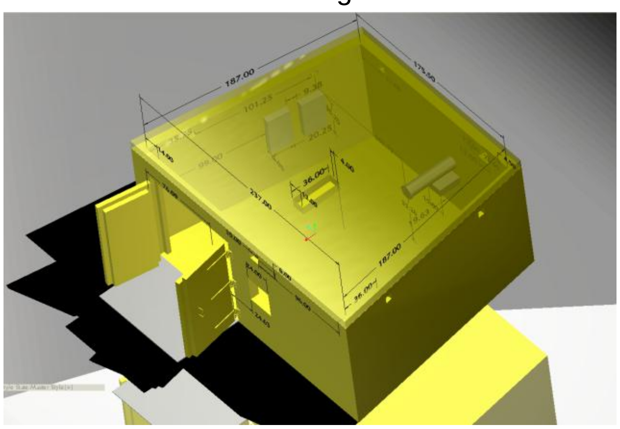
Target 1 Flight Path 12 (1FP12)

Facility: Target 1 Flight Path 12 (1FP12) utilizes cold neutrons from the Lujan neutron target/moderator system. This flight path is located in experimental room ER-2 (MPF-30) at the Manual Lujan Jr. Neutron Scattering Center. The flight path views the partially-coupled cold hydrogen moderator. A neutron guide is installed to enhance the transport of cold neutrons to the sample position. The flight path is a multi-use flight path that can accommodate a variety of experiments requiring a cold neutron spectrum. Two neutron beam choppers are available.

Recent research activities

-- neutron polarization measurements
-- ultra-cold neutron (UCN) production
-- incoherent neutron scattering
-- trace isotope identification from *γ/n* spectroscopy

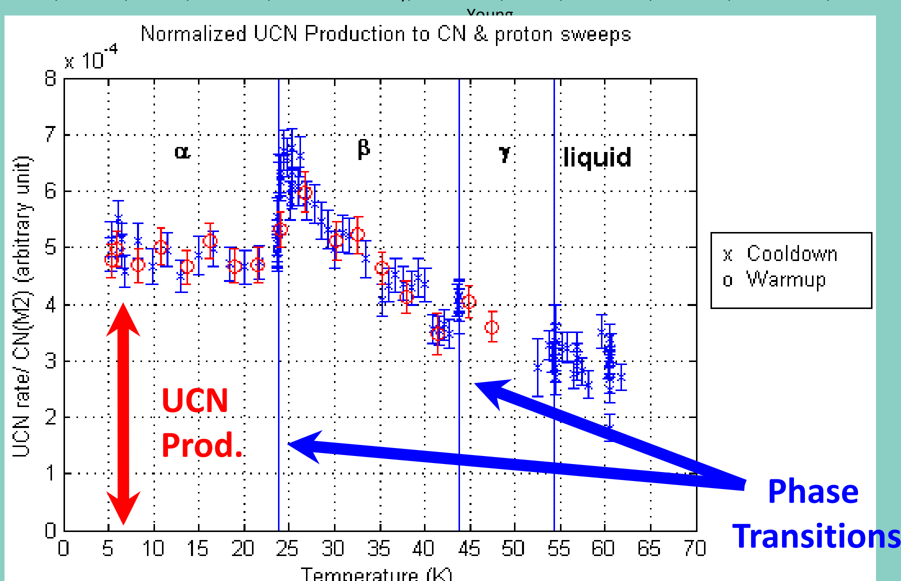
Mechanical drawing of FP12 cave



Users:
Students, faculty, and national lab scientists, both domestic and international come to use the cold neutron flux at FP12.

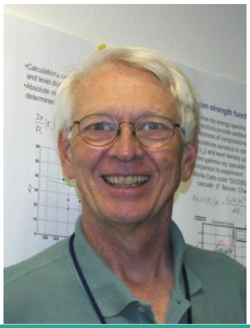
The first successful production of UCNs from solid-O_2

C. Lavelle, C.-Y. Liu, W. Fox, G. Manus, P. M. McChesney, D. J. Dalvat, Y. Shin, M. Makela, C. Morris, A. Saunders, A. Couture, and A. R. Young



- The observed UCN production is shown to the right as a function of the solid-O_2 temperature.
- The phase transitions are indicated by vertical lines.
- This was the first observation of UCNs produced from solid-O_2
- Measurements were also performed as a function of external B-field (not shown).

Target 1 Flight Path 14 (DANCE)



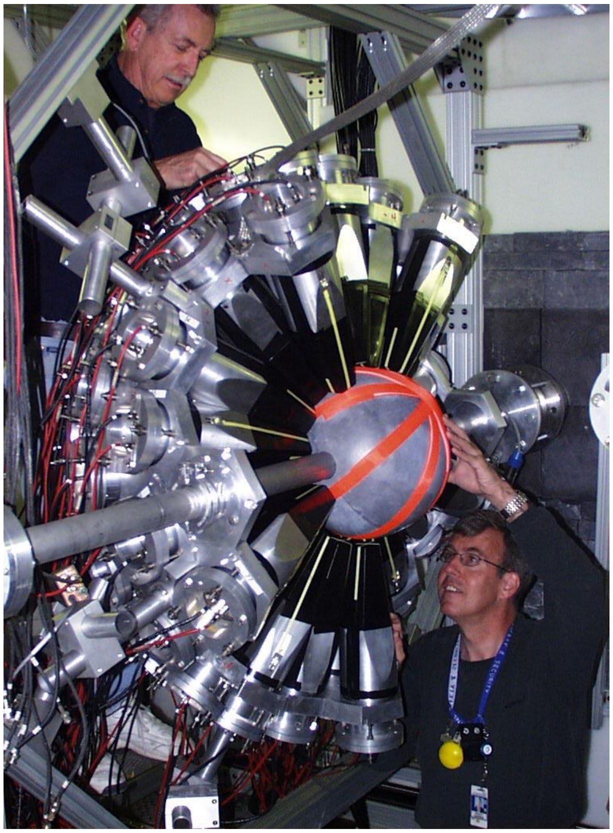
John Ullmann
Phone: (505) 667-2517
E-Mail: ullmann@lanl.gov

Facility Flight Path 14 views the upper-tier water moderator. It is configured with very tight collimation to produce a 0.7 cm diameter beam spot at the target location at 20.25 meters with minimal beam penumbra. The measured beam flux at the neutron monitor location (approximately 22.60 m) with 100 microamps of proton beam is shown in the figure.

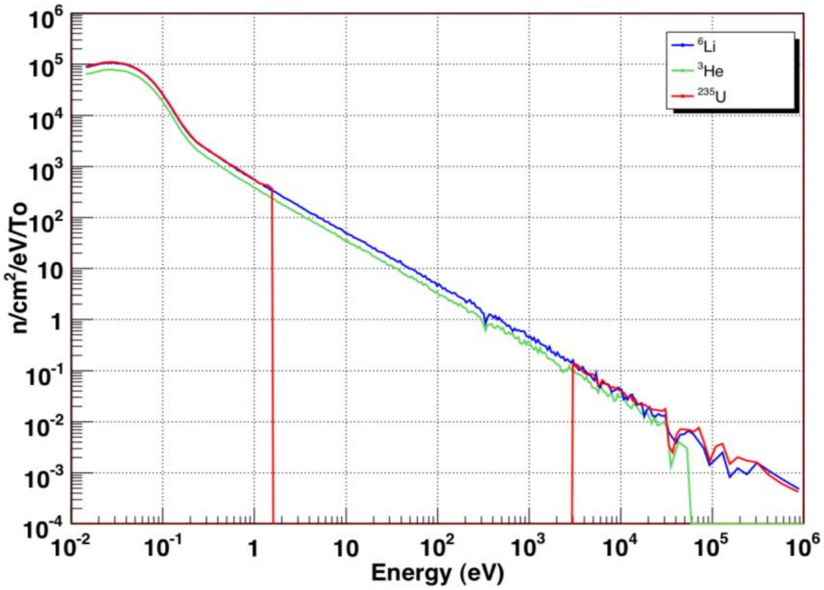
Instrumentation DANCE is a 4π BaF_2 scintillator ball with 160 segments centered on a target location of 20.25 m. It is a highly efficient array designed to measure gamma rays from neutron capture and other reactions on rare or radioactive samples at neutron energies ranging from thermal to around 100 keV. Measurements at epithermal energies can be made on sample masses of less than 1 milligram.

Present research efforts

1. Capture and fission measurements for radiochemical diagnostics for Defense Programs
2. Capture and fission measurements for advanced reactor design
3. Capture measurements for nuclear astrophysics



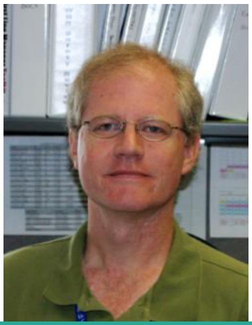
Inside of the DANCE ball. The large gray sphere in the center is a ^{6}LiH neutron absorber.



Flux measured with three different neutron detectors at 22.6 m. The proton beam current was 100 microamps.

Target 2

Facility



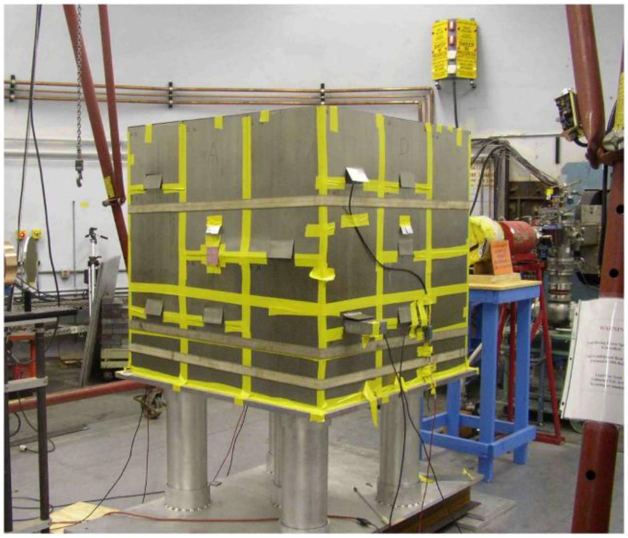
Leo Bitteker
Phone: (505) 667-0333
E-Mail: lbj@lanl.gov

Target 2 is housed in the Blue Room in MPF-7 at LANSCE and provides experimenters direct access to the LANSCE proton beam. The Blue Room is a domed room with a diameter of 40 feet. The main floor of the Blue Room is constructed primarily of aluminum and elevated 20 feet above the basement floor to minimize neutron wall return for experiments sensitive to such effects. The proton beam enters the Blue Room from the northeast and then exits to the southwest on its way to Target 4. During Target 2 operations, the beam line is removed in the middle of the Blue Room and experiments are installed at the center of the room in the path of the beam. The Blue Room also has several secondary flight paths for use in coordination with targets installed at Target 2.

Target 2 can use either the LANSCE linac beam directly, or the high peak intensity stacked beam from the Proton Storage Ring (PSR). The linac beam to the Blue Room can normally be run up to 80 nA with substructure available for experiments that require it. Normal linac operations provide 800 MeV protons, but the facility is capable of delivering protons with energy from 200 MeV to 800 MeV. The PSR beam can run from pulse-on-demand up to 40 Hz, and up to 1 μA average current. PSR beam pulse intensity can be as high as a few 10^{13} protons/pulse.

Target 2 has one permanent experiment installed, the Lead Slowing Down Spectrometer (LSDS). The LSDS is a 20-ton, 1.2-m cube of lead surrounding a cylindrical tungsten spallation target. The LSDS provides a neutron flux trap for nuclear physics experiments on ultra small (~nanogram) samples.

Target-2 experimental area



Lead Slowing-Down Spectrometer in Target-2

Robert Haight
Phone: (505) 667-2829
E-Mail: haight@lanl.gov

Target 2-- Lead Slowing-Down Spectrometer (Blue Room)

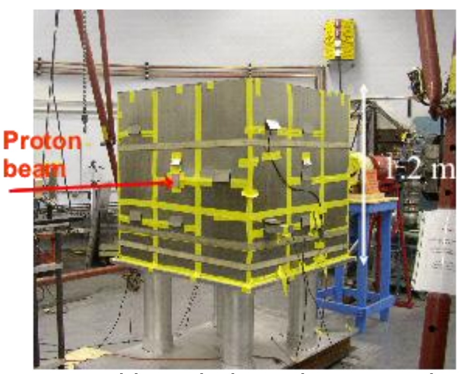
Facility:

1. 20-ton cube of pure lead; 1.2 meters on a side with many channels for experiments
2. Bunched 800-MeV proton beam (PSR or linac) on 25cm-long tungsten cylinder in the middle of the lead cube
3. Repetition rate up to 40 pulses per second
4. Samples and detectors are placed in channels in the lead cube
5. Neutron flux ~ 1000 times that of other LANSCE sources -- makes some cross section measurements possible on samples of only 10 ng
6. Neutron energy range – 0.1 eV – 100 keV
7. Neutron energy resolution – best is 30% in ΔE / E
8. Measure counting rate versus time after the beam pulse: $<E> = K / (t+ t_0)2$ where K = 161 keV μs**2 and t_0 = 0.37 μs

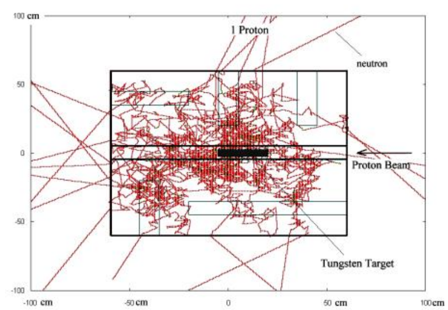
Instrumentation: Fission ionization chambers (compensated) and other detectors

Present research efforts

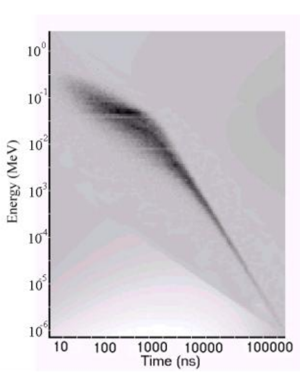
1. Fission cross section measurements
2. Development of reactor fuel-rod isotopic assay
3. (n,p) and (n,alpha) cross sections on radioactive isotopes for radchem and astrophysics applications



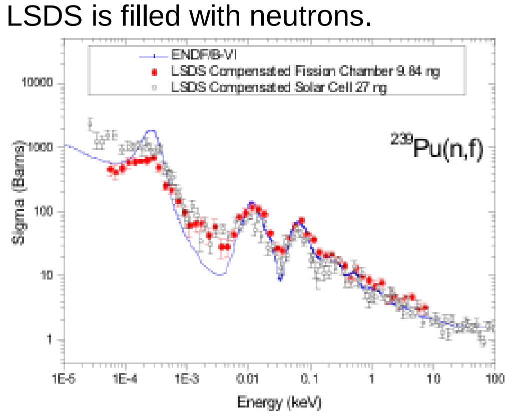
LSDS with cadmium sheets on the outside to reduce room-return neutrons.



Monte Carlo simulation of neutrons produced by one incident proton. For a beam burst of protons, the volume of the LSDS is filled with neutrons.



Calculated neutron energy versus time showing the focusing in neutron energy as time increases.



Fission cross section of 239Pu measured with a sample of only 9.8 ng.

Additional Information

Santa Fe Baldy in the Sangre de Cristo Mountains

User Contacts

Making phone calls

- For on-site calls dial the last 5 digits of LANL numbers (e.g. 7-xxxx)
- For outside calls , dial 8 for outside line, then 1 + area code and number or 7 digit local number.
- For life-threatening emergencies dial 911 or pull a fire alarm actuator
- LANL Directory Assistance (505) 664-5265 (664-LANL)

Important Phone Numbers

- **Emergency – life-threatening situations**
  - **911** or (505) 667-6211
  - Communicate: name, location (TA-53, building and room), and describe the situation
- **Central Control Room (CCR)**
  - (505) 66**7-5729**
- **Radiation Control Techs (RCT)**
  - (505) 66**7-7069**
- **Group Office Julie Quintana-Valdez**
  - (505) 66**7-5377**
- **WNR User Program Administrator Tanya Herrera**
  - (505) 66**7-6797**

- **Steve Wender** (WNR Area Manager)
  - (505) 667-1344 (office)
  - (505) 664-2185 (pager)
  - (505) 660-6458 (cell)
  - (505) 983-3634 (home)

- **Paul Lewis** (Lujan Area Manager)
  - (505) 665-0932 (office)
  - (505) 690-8943 (cell)

- **Ron Nelson** (Deputy Group Leader)
  - (505) 667-7107 (office)
  - (505) 664-2191 (pager)
  - (505) 690-4220 (cell)

- **Leo Bitteker** (Deputy Group Leader for Operations)
  - (505) 667-0333 (office)
  - (505) 664-7996 (pager)

User Contacts & Experimental Area Phone Numbers

Description	Contact	Phone	Location Bldg/Rm
LANSCE Division Office	George Dominguez	5-1010	1/Lobby
User/Foreign Visitor Liaison	Tanya Herrera	7-6797	31/252
LANSCE Training Office	Meghan Keresey	5-6256	1/B113
Data Room 1	LSDS	5-2895	7/106
Data Room 2		5-3069	7/104
Data Room 3	Fredrik Tovesson	7-9408	7/103
Data Room 4	Bob Haight	5-2896	7/102
Data Room 5	Leo Bitteker	5-2894	7/112B
Data Room 6	Steve Wender	5-6444	7/112A
1FP05 ER-1	Fredrik Tovesson	7-1188	7/24
1FP05 Silo	Fredrik Tovesson	7-2113	1090/100
1FP12	Ron Nelson	5-4362	30/ER-2
1FP14/DANCE	John Ullmann	7-2021	30/ER-2
4FP60R/GEANIE	Matt Devlin	7-4870 5-0916	29/100
4FP30R/FIGARO	Bob Haight	5-1845	29/101
4FP30L/ICE House	Steve Wender	7-8153 5-9296	1265
Blue Room	Leo Bitteker	5-7685	7/115
Electronics Lab	Chuck Alexander	none	7/105
MPF-17 Shop	Gregg Chaparro	6-0661	17/105
MPF-407 Server Room	Tamsen Schurman	5-5442	407/105
Detector Annealing Lab	Gregg Chaparro	5-5844	407/110

User Support Phone Numbers

Description	Contact	Phone	Fax	Pager	Location
Group Office	Julie Quintana	7-5377	5-3705		31/251
LANSCE-Division Office	George Dominguez	7-5051	7-9409		1/A208
Mechanical Support	Gregg Chaparro	5-2861		4-3023	406/104
Mechanical Support	Tim Medina	5-2847		4-3186	406/107
Electronics Support	Chuck Alexander	7-2561		4-1152	406/108
Data Acquisition Support	John O'Donnell	5-7695		4-3695	31/3982

Description	Phone	Location
CCR – Central Control Room	7-5729	4/201
Health Physics (RCT)	7-7069	3R
MPF-7 "old" WNR Control Room	7-0951	7/101
MPF-17 Lab	5-9764	17/109
1st Trailer Outside MPF-7	5-4129	541/100
TA-53 Guard Gate	5-7471	
Pest Control	7-6111	
LANL Closures/Delays	7-6622 877-723-4101	

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Building Manager

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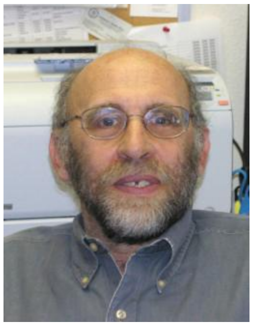
Bruce Wheeler,
Experimental Areas
MSS-LANSCE

Staff



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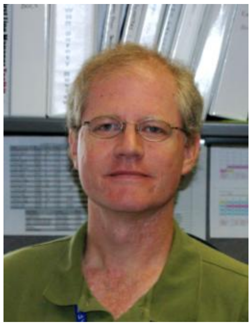

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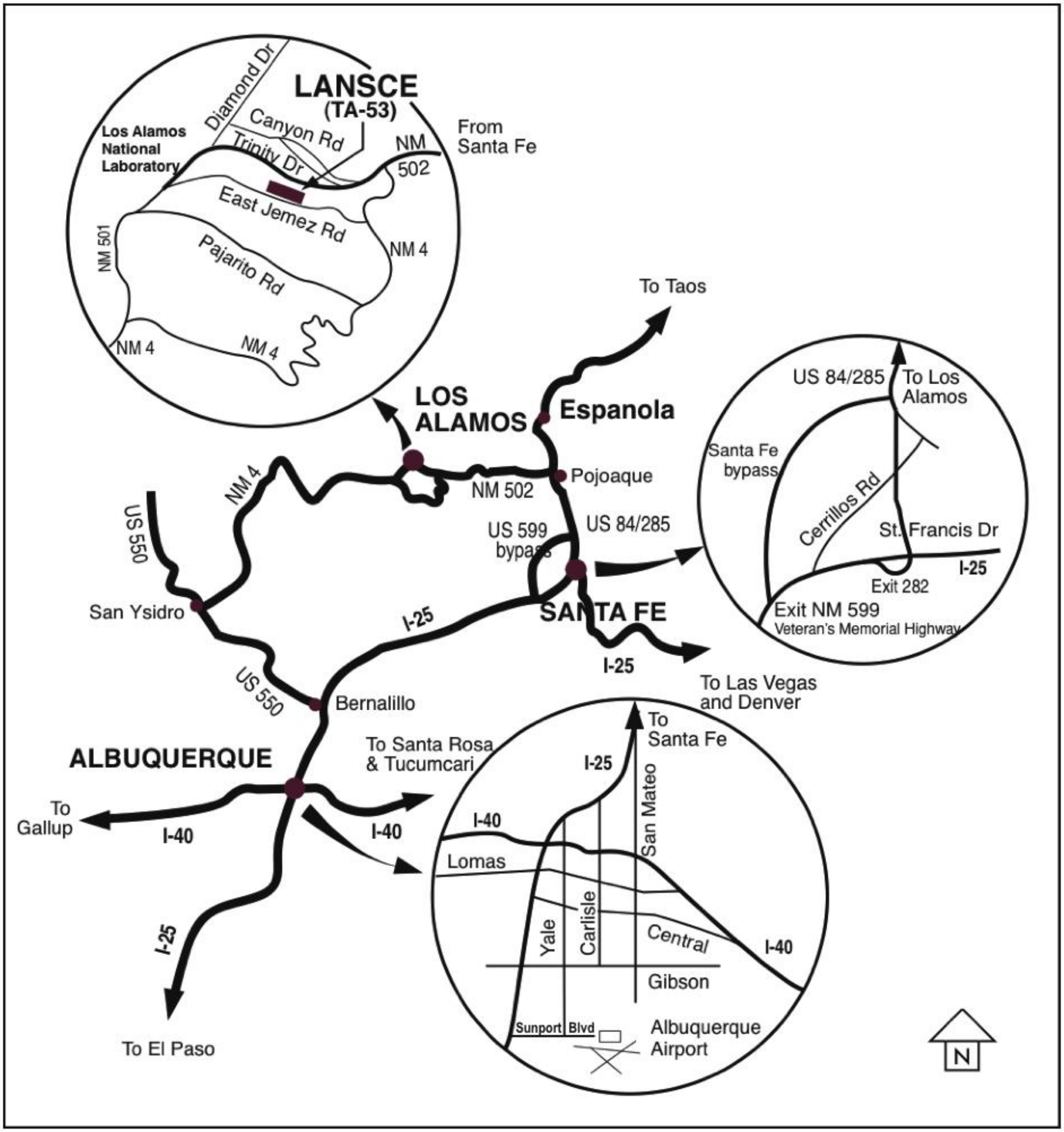
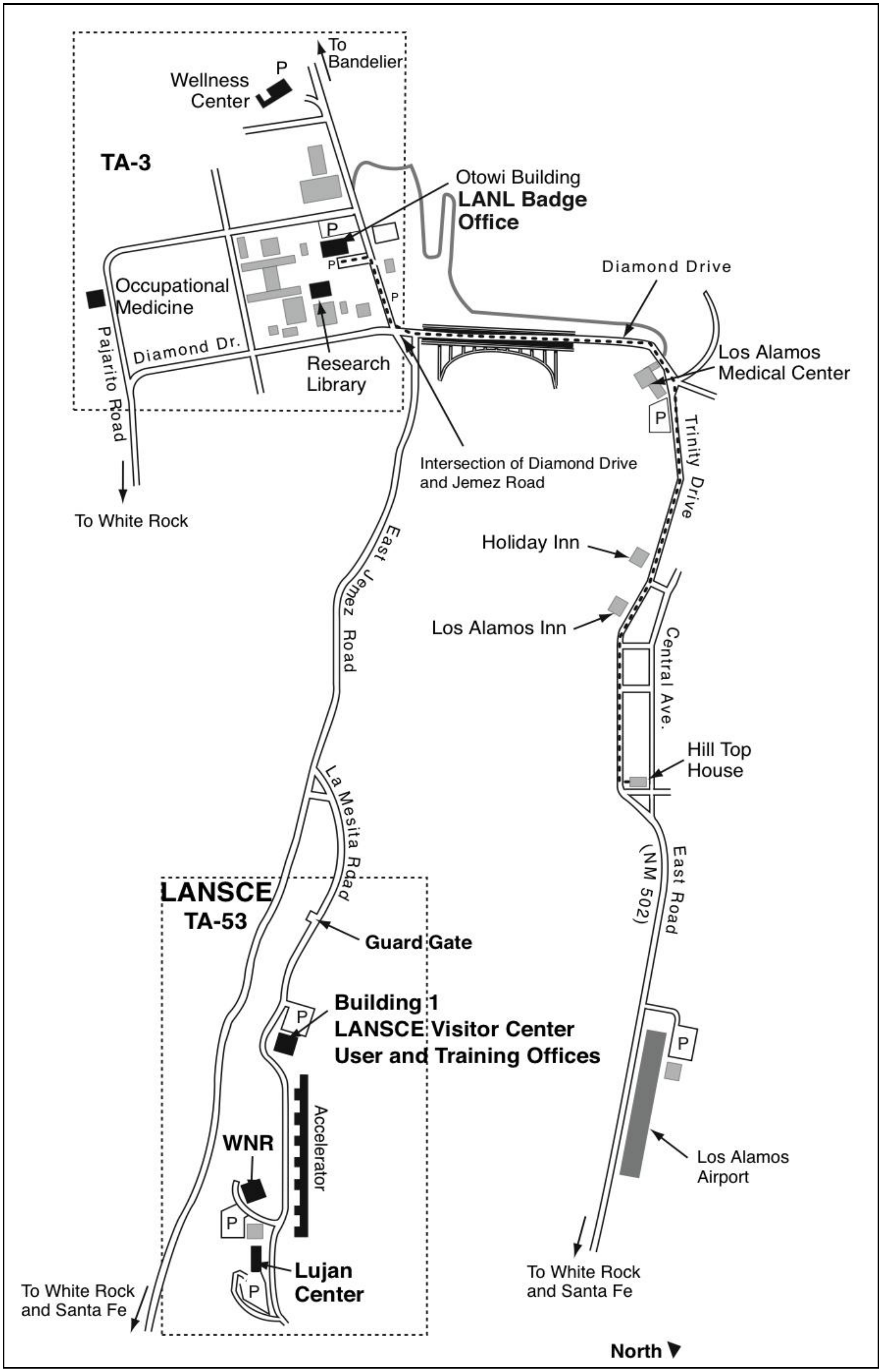
Maps

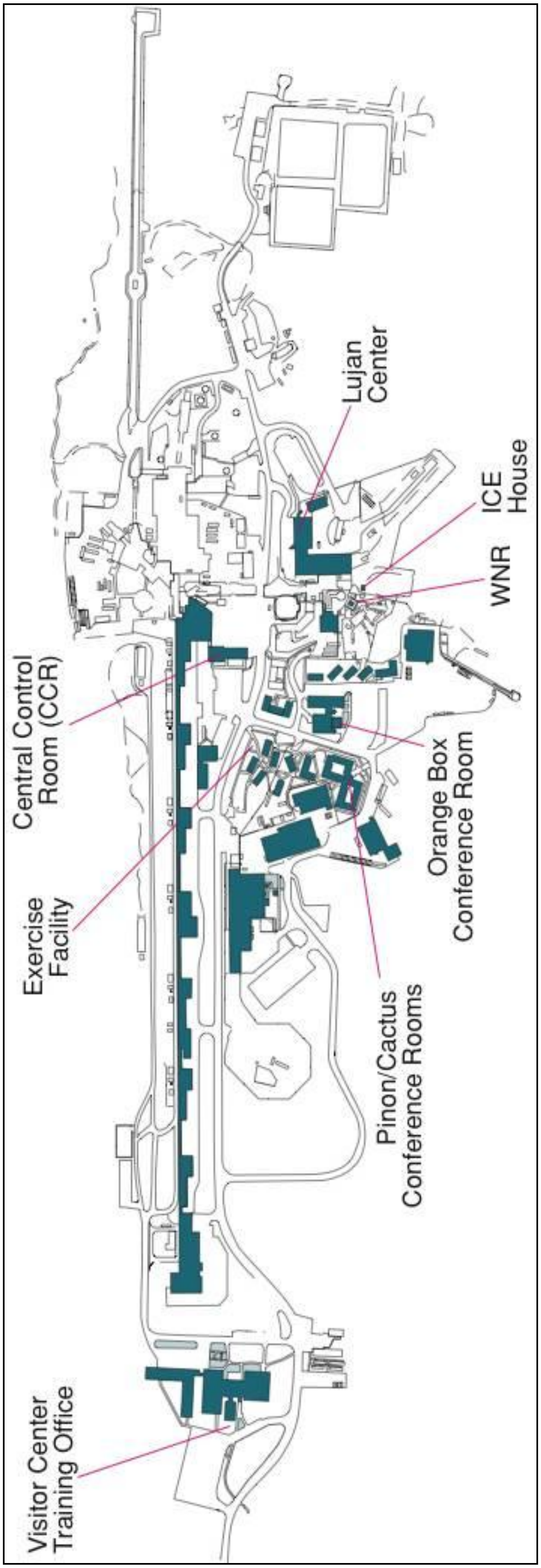
Albuquerque to Los Alamos



LANL Badge Office to TA-53



LANSCE TA-53


Lujan Center
ICE House
WNR
Central Control Room (CCR)
Exercise Facility
Orange Box Conference Room
Pinon/Cactus Conference Rooms
Visitor Center Training Office