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BeamNetUS PILOT YEAR REPORT: ENABLING ACCESS TO BEAM TEST FACILITIES*

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Abstract

BeamNetUS is a network of facilities united in a common mission to advance accelerator research and applications of accelerator technology through improving awareness and access to these unique facilities. For its pilot campaign, the network includes facilities at Argonne National Laboratory (ANL), Brookhaven National Laboratory (BNL), Fermi National Accelerator Laboratory (FNAL), Lawrence Berkeley National Laboratory (LBNL), SLAC National Accelerator Laboratory, and Thomas Jefferson National Accelerator Facility (JLab). These facilities provide complementary capabilities enabling research in plasma physics, beam physics, material science, radiofrequency sources and structures, nuclear physics and electron beam irradiation. In 2025, BeamNetUS awarded time at the facilities through a competitive review process with a remit towards creating new, productive engagements. User awards were given to universities, industry and other laboratories. At NAPAC25 in a satellite meeting, we reflect on the BeamNetUS experience in its pilot year and plans for the future.

INTRODUCTION

The Department of Energy (DOE) National Laboratories represent immense investment into basic research facilities. The ten DOE Office of Science National Laboratories operate 13 User Facilities based around accelerators, serving more than 16,800 users each year, researching topics in physics, chemistry, material science and biology.

Less well known are the R&D facilities where the accelerator technologies and new applications are first developed. The National Laboratories build and run these facilities for R&D when they have a need, such as the NLCTA which originated for R&D for the "Next Linear Collider", or HiRES which was originally a novel gun technology demonstration, or UITF which was first used by NASA to study space radiation effects on materials.

These facilities are hidden gems of the National Laboratory system with unique equipment and experts. Raising awareness of their existence and facilitating external access to them is BeamNetUS's core mission.

The initial BeamNetUS network formed in 2024 (Fig. 1 and Table 1). Representatives from nine beam test facilities spanning six National Laboratories started the network with a mission to:

- Advance accelerator research and applications of accelerator technology;
- Provide access to unique accelerator and accelerator component resources;
- Foster collaboration to exchange ideas, skills and resources.

The network meets its mission by:

- Coordinating outreach and targeting communities not currently engaged in research at the facilities;
- Executing a program for external user engagements.

IMPROVING ACCESS AND AWARENESS

The main barrier to outside-use of the beam facilities at the National Laboratories is a lack of awareness of facilities' capabilities and availability. The Lab Partnering Service is a resource that lists facilities and expertise at the National Laboratories [1], however, it has a broad remit to cover all capabilities and lacks details of the beam test facilities.

BeamNetUS seeks to become the established brand for those looking for beam test facilities in the US, to simplify the process to find the best fit for the research. BeamNetUS launched a website [2] in 2024 that summarizes the facilities and provides a point of contact at each facility for direct

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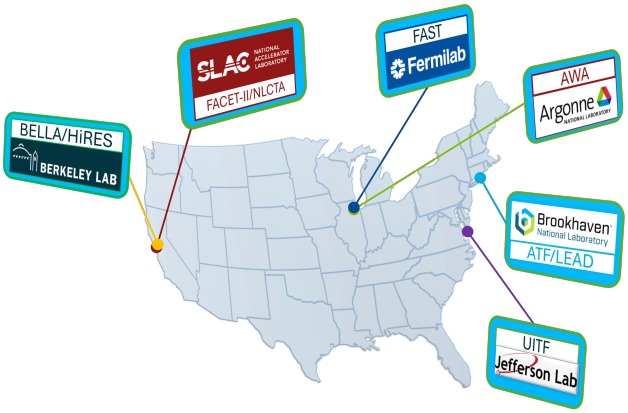

Figure 1: Pilot year network. Nine facilities across six DOE Office of Science National Laboratories formed the BeamNetUS network. The network is expected to grow to include new institutions in future years, driven by community-needs.

correspondence on prospective collaboration. Conversations with potential users were held at numerous conferences and meetings where BeamNetUS organized a booth presence. A well attended online seminar series with a presentation from each facility was recorded and the videos are now important resources that can be viewed on the BeamNetUS website.

In January 2025, BeamNetUS put out a call for proposals for beam time awards at its facilities. Proposals were evaluated by an independent review committee chaired by Dr. Patric Muggli (Max Planck Institute for Physics in Munich, Germany), external to the facilities, for intellectual merit (75%) and broader impact (25%). Important merit criteria were whether the proposed activities advanced knowledge and understanding within its own field or across different fields, and whether they explored creative, original, or potentially transformative concepts. Proposals were also evaluated according to whether they provided academic or training opportunities to students or early career researchers or engaged with a new research group or institution that has not previously been involved with the facility.

Eight awards were offered across the BeamNetUS facilities. Goals for this first year of awards are to test out the processes at our facilities and get feedback for improvement prior to expanding the time available to more experiments or adding more facilities. The eight awardees represented a mix of user types (from universities, business and laboratories both domestic and international). The beam time to the awardees has started with the awardees from Harvey Mudd College being the very first BeamNetUS users to complete their time (at NLCTA). Feedback from the pilot year awardees will be important to streamline the processes for lab access in the future.

THE FACILITIES

ATF

The Accelerator Test Facility (ATF) at BNL combines high brightness 15-75 MeV electrons with lasers. This is the only facility in the network that provides access to a CO_2 laser (at 9.2 µm) [3]. A near-IR laser source is also available. Research proposed at ATF may fall into the categories of particle and photon source development, wakefield accelerators [4], inverse Compton scattering [5], and laser-driven plasma ion acceleration. Researchers can take advantage of a mature set of beam diagnostics and continue their association with ATF through access with the ongoing User Facility program.

AWA

The Argonne Wakefield Accelerator (AWA) at ANL is a dedicated user facility that hosts multiple beamlines tailored for accelerator research. One beamline serves as a low-energy (few MeV) cathode test stand, while the two others accelerate electrons to energies of 15 MeV and 70 MeV, respectively. The AWA supports both an internal research program and a collaborator-driven experimental program, providing access to a broad range of collaborators. Distinctive capabilities include precise shaping of the beam's temporal profile [6], wide range of attainable beam parameters (e.g. used for AI/ML-based diagnostics [7] and autonomous control deployment), generation of trains consisting of up to 8~ 50-nC bunches [8], and a versatile reconfigurable beamline capable of accommodating several parallel experimental setups.

BELLA

The Berkeley Lab Laser Accelerator (BELLA) center at LBNL is part of both BeamNetUS and LaserNetUS [9], with BeamNetUS research emphasizing the technologies and applications of the electron beams from laser-plasma accelerators (LPAs). The beams from LPAs have a unique structure unlike conventional accelerators and R&D into diagnostics, control, and applications is important to drive this technique into societal use. BELLA has two systems available for BeamNetUS users: the Hundred Terawatt Thomson (HTT) and the Hundred Terawatt Undulator (HTU). Both systems have a wide range of laser, plasma and electron beam diagnostics, dynamic and flexible control system, suitable for AI/ML, and expert teams. HTU is recommended for research of FEL applications of LPAs [10] and HTT generates secondary particle beams that can be applied for, e.g., nuclear physics applications [11], hard X-ray generation and applications [12], and focused electron beam applications.

FACET-II

The Facility for Advanced Accelerator Experimental Tests (FACET) was recently upgraded and now produces an ultrashort electron beam with five times more peak current than any other facility in the world [13–15]. Experiments best for FACET-II are ones that can take advantage of such super-intense electron beams at high (10 GeV) energies. A Ti:Sapph 800 nm laser (up to 270 mJ) can be used in combination with the kiloampère-class electron beam. FACET-II is actively seeking research related to future colliders and welcomes use of the beam at any part of the accelerator,

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Table 1: Beam Parameters

Facility	ATF	AWA	BELLA	FACET-II	FAST	HiRES	LEAD	NLCTA	UITF
Particle	e^-	e^-	e^-	e^-	e^- (p)	e^-	e^-	e^-	e^-
Beam Energy (MeV)	15 - 75	6.5 - 63	1 - 500	10,000	20 - 300 (2.5)	0.7 - 0.9	3	75	0.2 - 8
Repetition Rate (Hz)	1.5	1 - 2	1	1 - 30	5	1 - 1×10^6	1 - 48	0.5 - 30	1497×10^6
Bunch charge (nC)	0.02 - 2	0.001 - 100	0.01 - 0.2	1.6	0.01 - 3.2	0.016	~ fC	0.001 - 0.1	~ fC

opening up research in, for example, jitter in kilometer-scale linacs, emittance growth after compression, and laser beam collimation.

FAST

The Fermilab Accelerator Science and Technology (FAST) facility at FNAL operates both electrons (20 - 300 MeV) and protons (2.5 MeV) [16]. A central feature of the facility is the unique storage ring "IOTA" [17]. The ring has a flexible lattice and can enable a wide variety of studies for example in beam instabilities and losses. The electron accelerator feeding the ring is a high brightness, high intensity superconducting RF linac [18]. The electron beam has a bunch train structure nominally with 3000 bunches at 3 MHz. The ring can also be fed by a proton injector providing intense space-charge dominated beams.

HiRES

The High Repetition-rate Electron Scattering (HiRES) facility serves as a testbed for advancing high-average-current, high-brightness particle accelerator technologies [19]. Powered by the APEX gun [20] - a continuous-wave, VHF-band RF photoinjector - HiRES delivers electron beams with high brightness at repetition rates reaching the megahertz regime. It also supports ultrafast electron diffraction (UED) experiments enabled by a 1030 nm pump laser with pulse energies up to 200 μJ for time-resolved pump-probe measurements. This compact beamline is ideal for AI/ML-driven control algorithm development [21], the testing of advanced beam diagnostics and instrumentation, and ultrafast structural dynamics studies.

LEAD

The Low Energy Accelerator Development (LEAD) facility at BNL incorporates the BNL Ultrafast Electron Diffraction (UED) beamline together with two shielded bunkers for accelerator component testing [22]. The UED beamline has been used for materials science studies [23] and machine learning development [24], and is currently being upgraded to support single-event effect testing. LEAD is designed to be a flexible facility, able to accommodate a wide variety of experiments using low energy electron beams.

NLCTA

NLCTA has a historical focus on X-band accelerator technology and has a stand-alone high power X-band Test Accelerator (XTA) beamline [25, 26] available to BeamNetUS users. It currently hosts experiments for the irradiation of samples as well as X-band structure testing with beam. XTA is also a test-bed for LLRF active feedback and the development of new beam diagnostics and THz-based beam manipulation. In addition to the XTA beamline, test areas within NLCTA include cryogenic testing capabilities down to 4 K with high power RF at X-band and S-band and a planned area for high power RF testing in external magnetic fields with a 5 T superconducting solenoid.

UITF

The Upgraded Injector Test Facility (UITF) at JLab is uniquely able to offer up to 90% polarized electron beams. It accelerates electrons up to 5 MeV through superconducting RF cavities, operating at high repetition rate (1497 MHz continuous wave) making this well suited to research of electron beam irradiation [27]. It is a "nimble" place to test new hardware and accelerator applications and a place for getting some hands-on accelerator experience.

CONCLUSION

BeamNetUS has in its pilot year tested mechanisms for access to laboratories at six National Laboratories. In the second year, more facilities at those laboratories will be added to the network.

In future years, BeamNetUS intends to add more National Laboratories and also extend the network to facilities at universities.

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