New Test Beam Facility at Fermilab

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Introduction

The Fermilab Test Beam Facility (FTBF)[1] has been operating since 2005 serving more than 200 users and 20 experiments per year covering a broad range of physics. FTBF contains two beamlines and a variety of experimental spaces. The beamlines deliver 120 GeV primary protons and secondary/tertiary particles down to a few hundred MeV that are extracted from the Main Injector down the Switchyard beamline. The FTBF program provides an essential service to the High Energy Physics community and is heavily subscribed. FTBF is located at the end of over a mile of beam line which presents increasing maintenance issues and no physics benefit and the beam capabilities do not match all user requests. The program has significant need for a new purpose-built facility and beam lines in order to keep up with the demand of its user community in the coming decades.

Fermilab plans to upgrade its accelerator infrastructure to deliver a 2.4 MW 120 GeV proton beam for DUNE. The Booster Replacement (BR) will replace the current 8 GeV booster with a new accelerating facility (see LOI by contact author Jeffrey Eldred, Fermilab). Technology options for this upgrade include an extension of the PIP2 superconducting Linac, a rapid cycling synchrotron (RCS) as well as combinations thereof. High intensity, lower energy proton beams from initial acceleration stages, PIP2 and the BR, will be available for other experiments. The potential exists to produce lepton beams as well. Fermilab is engaging the community to explore the physics potential enabled by PIP2 and the BR, to inform technology choices, and to maximize science output.

We propose to locate a new FTBF facility in the vicinity of the PIP2 and BR complex with dedicated beam extraction in multiple beamlines. This would bring test beam operations to a more centralized location with a modern facility to better match community needs. There is also a submitted LOI for a new high intensity proton irradiation facility to be located in the same complex and developed in a complimentary fashion (contact author Petra Merkel, Fermilab).

Physics Goals, Motivation, and Setup

At least two beam lines should be available in the Test Beam area, but ideally 4-6 which would allow lines to deliver dedicated energies/particles without the need to insert targets. These lines should be capable of operating simultaneously and at independent energies and intensities. It is important at any energy that the beam focus to a manageable size, typically several centimeters or less, and have understood backgrounds and particle composition.

120 GeV proton beam remains highly desirable for many collider R&D efforts and tracking technologies. There should also be beam lines capable of lower energy mixed pions and leptons from 65 GeV down to a few hundred MeV. The most important feature here is that the beam composition be well understood, low background, controllable, and that sufficient particle identification tools exist. The new location would benefit from extracting dedicated low energy beam from the PIP2 and BR stages. It is desirable to have at least one beamline dedicated to low energy muons which are frequently requested and not readily achievable with the existing facility. The opportunities are well documented in the 2013 Snowmass Report[2].

The experimental space should have space for dedicated staff and staging equipment as well as electronics and mechanical work spaces. There should be a control room for monitoring by users. The facility should have multiple beam enclosures capable of supporting 4-6 experiments simultaneously. The facility should be instrumented to support beam monitoring, particle tracking and identification, gas systems, calorimetry, and motion tables. There should be 1-2 tracking telescopes available to meet the demand for sensor R&D and they should be compatible with DAQs used internationally. All beamline instrumentation should be implemented in a universal DAQ system that is accessible to users in all experimental spaces. At least one experimental space should have a high ceiling and be accessible by crane. There should be space to support experiments both on the scale of weeks and months. The floor plan should have the flexibility to accommodate installations of varying size from silicon chips up to several ton detectors. Dedicated space should support both tracking studies (i.e. testing of sensors for the HL-LHC) and calorimetry. There should be video conferencing spaces available. In addition, magnets should be available for users. There are use cases for spectrometer magnets and for a large bore magnet that devices can be placed inside of. Cryogenic cooling would benefit noble liquid detector R&D and is extremely useful to the community.

Timescales, R&D needs, and similar facilities

There is strong international demand for increased test beam resources. FTBF, CERN, DESY, and other test beams are heavily subscribed and subject to various operational limitations. A new facility at Fermilab would enable robust detector R&D across all frontiers looking forward. This project needs community driven input to identify the beam capabilities with the highest impact. Having facility planning begin now to come online in the later part of the 2020s would establish a clear course for detector development.

References

1. ftbf.fnal.gov
2. https://arxiv.org/pdf/1306.5009.pdf