

Project X Front End Test Facility - PXIE

September 1, 2011

We are planning the construction of a prototype of the front end of the Project X linac at Fermilab. The construction and successful operations of this facility will validate the concept for the Project X front end, thereby minimizing the primary technical risk element within the Project. Successful operations of the facility will also demonstrate the viability of novel front end technologies that will find applications beyond Project X in the longer term. The Project X Injector Experiment (PXIE) can be constructed over the period FY12-16.

Mission Goals

Validate critical technologies required to support the Project X Reference Design concept.

- Operate a prototype of the Project X front end at full design parameters
- Integrated systems test goals:
 - 1 mA average current with 80% bunch-by-bunch chopping of beam delivered from the RFQ
 - Efficient acceleration with minimal emittance dilution through 15 MeV
- Potential utilization in Project X facility following successful demonstration

Scope

The scope of the PXIE facility includes:

- CW H- source delivering 5 mA at 30 keV
- LEPT with beam pre-chopping
- CW RFQ operating at 162.5 MHz and delivering 5 mA at 2.1 MeV
- MEPT with integrated wide band chopper and beam absorbers capable of generating arbitrary bunch patterns at 162.5 MHz, and disposing of up to 5 mA average beam current
- Low beta superconducting cryomodules capable of accelerating 1 mA of beam to 15 MeV
- Associated beam diagnostics
- Beam dump capable of accommodating 1 mA at 15 MeV (15 kW) for extended periods.
- Associated utilities and shielding

Rationale

A concept for delivery of high power, high duty factor, beam to multiple experiments with differing beam structure requirements is incorporated into the Project X Reference Design. This capability is unique among high power proton facilities either operating or under development anywhere in the world. The concept is based on a fast programmable beam chopper (aka wideband chopper) integrated into the linac front end, capable of removing bunches spaced at 6

nsec in arbitrary patterns and paired with a transverse rf deflecting cavity to send beam to three different experimental areas at 3 GeV. While the utilization of rf deflection to support multiple experiments has already been demonstrated at the CEBAF facility at TJNAF, the wideband chopper is a unique device currently beyond the state of the art.

The delivery of multi-MW CW beams to 3 GeV requires a linac front end capable of efficient acceleration of low- β beams with minimal halo formation. These capabilities are critical to establishing routine operations meeting extremely stringent beam loss criteria – typically less than 1 W/m. At 3 GeV this translates into a fractional beam loss of $<3 \times 10^{-7}/\text{m}$. The initial stage of acceleration, utilizing accelerating structures at $\beta=0.1$ and 0.2 up to 15 MeV, is crucial in meeting this performance goal.

The purpose of PXIE is to demonstrate that the technologies selected for the Project X front end can indeed meet the performance requirements established in the Reference Design, thereby mitigating the primary technical risk element associated with Project X. This goal would ideally be achieved in advance of Project X construction so that results can be properly reflected in the final Project X machine.

Plan

The development of PXIE will be coordinated from within the Project X organization. However it will require close cooperation with the SRF, ILC, and General Accelerator Development programs at Fermilab. The effort will be provided initially by Fermilab, LBNL, ANL, and SLAC with opportunities for collaboration with Indian and Chinese colleagues who are developing similar systems for their ADS programs. Opportunities to integrate additional collaborators with similar interests will be pursued.

A simple shielded enclosure connected to the newly constructed Cryomodule Test Facility (CMTF) at Fermilab has been identified as the preferred location. This location has the following positive attributes:

1. Easy access to a cryogenic system with adequate capacity
2. Adequate length (at least 40 m)
3. Easy access to adequate AC Power, LCW, ICW, etc
4. Suitable location for a control room and office space
5. Ease of constructing and providing the required shielding

Joint Strategy with MDB

We do not believe the resources exist to carry on an extended program at the Meson Detector Building (MDB) Beam Test Facility in parallel with development of PXIE. A considerable investment has been made in the MDB facility over the last several years. However, with the decision to base Project X on a CW linac, the pulsed facility development at MDB no longer serves as a representative front end prototype for Project X. Therefore, the MDB beam program

will be wound down in a manner consistent with providing scientifically valuable results to the accelerator physics community and continuity of available low energy beams for development of Project X technologies.

We plan to continue to support beam operations at MDB for Project X instrumentation development until beam first becomes available for these activities at PXIE. This will require adjustment of the MDB schedule as the PXIE schedule is developed.

Timeline and Resources

We are in the initial stages of planning for PXIE. The overall schedule will be determined by consideration of the following:

- Available funding: The bulk of the funding will come from Project X R&D, augmented by SRF and GAD program funding.
- Project X schedule: At the moment we do not have a schedule for Project X. However, current Project X planning assumes a construction start in the FY2015-17 time frame.

For planning purposes the following schedule has been established:

Jan 2012	Complete PXIE design layout and preliminary cost/schedule estimates
Nov 2012	Complete RFQ design and begin fabrication
Jun 2013	Ion source and LEBT received at Fermilab; installation begins;
Apr 2014	Start RFQ high-power testing without beam;
Nov 2015	Beam delivered to the end of MEFT with nearly final parameters (2.1 MeV, 1 mA CW, 80% arbitrary chopping) Begin installation of beta=0.1 and beta=0.2 CMs
Oct 2016	Beam to 15 MeV with nearly final parameters (1 mA CW, 5 mA peak, arbitrary bunch chopping)

We believe this schedule can be met with resource levels currently available within Project X, GAD, and SRF programs. It will require a migration of resources from both the MDB and ILC_TA programs as the installation activities associated with these programs wind down. Some adjustments to the above timeline will undoubtedly be required as the plan is further developed.