

## **Project X Front End R&D Program - PXIE**

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The front end of the Project X linac is key to the unique capabilities provided by the Reference Design. Fermilab, with national and international collaborators, is planning a program of research and development aimed at integrated systems testing of critical components comprising the Project X front end. This program is being undertaken as a major element of the ongoing Project X R&D program. Successful completion of this program will validate the concept for the front end, thereby minimizing the primary technical risk element within Project X. Successful systems testing will also demonstrate the viability of novel front end technologies that will find applications beyond Project X in the longer term. Integrated systems testing, known as the Project X Injector Experiment (PXIE), will be completed over the period FY12-16.

### Mission Goals

The goal of the PXIE program is to validate critical technologies required to support the Project X Reference Design concept. PXIE will provide a platform for demonstrating operations of Project X front end components at full design parameters. Specific goals of the integrated systems test are:

- Deliver 1 mA average current with 80% bunch-by-bunch chopping of beam delivered from the RFQ.
- Demonstrate efficient acceleration with minimal emittance dilution through at least 15 MeV.

### Scope

The scope of PXIE includes:

- CW H<sup>-</sup> 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 at least 15 MeV
- Associated beam diagnostics
- Beam dump capable of accommodating 1 mA at full beam energy 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 either 1 or 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 proton beams requires a linac front end capable of efficient acceleration of low- $\beta$  beams with minimal halo formation. The utilization of superconducting accelerating structures in this regime is unique and presents significant technical challenges. In addition the outlined 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 40 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. PXIE will utilize components constructed to Project X specifications wherever possible and will explore, and provide feedback into the Project X Front End design regarding, the following specific technical concerns:

- Ion source lifetime
- LEBT pre-chopping
- Vacuum management in the LEBT/RFQ region,
- Validation of chopper performance
- Measurement of kicker extinction levels
- Effectiveness of MEBT beam absorber
- MEBT vacuum management
- Operation of HWR in close proximity to 10 kW absorber
- Operation of SSR with beam
- Emittance preservation and beam halo formation through the front end

PXIE will be developed by U.S. and Indian institutions who are expected to participate in the proposed Project X construction. PXIE will thus provide an opportunity to develop the working relationships and management processes necessary for the construction phase.

## Plan

PXIE is part of the Project X R&D program and the development of PXIE will be coordinated from within the Project X organization. PXIE development will require close cooperation with the SRF 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 colleagues who are developing similar systems for their domestic programs. Opportunities to integrate additional collaborators with similar interests will be pursued.

PXIE will be located in a shielded enclosure sited within the newly constructed Cryomodule Test Facility (CMTF) at Fermilab. 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

## 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. It is assumed that these funding levels will remain fixed at FY12 levels over the duration of the PXIE program.
- Project X schedule: While a schedule for Project X construction does not currently exist, the R&D program is developed within the context of a construction start in the FY17 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 LEPT received at Fermilab; installation begins;
Apr 2014	Start RFQ high-power testing without beam;
Nov 2015	Beam delivered to the end of MEPT 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)