



**Functional Requirement
Specification
PXIE LEBT Beam Transverse
Emittance Station**

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1. Introduction:

Project X is a high intensity proton facility conceived to support a world-leading physics program at Fermilab.^[1] Project X will provide high intensity beams for neutrino, kaon, muon, and nuclei based experiments and for studies supporting energy applications. The Project X Injector Experiment (PXIE) will be a prototype Front End linear accelerator,^[2] that will validate the concept for the Project X front end, thereby minimizing a large portion of the technical risk within Project X.

Included in the PXIE LEBT design^[3] is a transverse emittance diagnostics station. This specification discusses the transverse emittance station performance requirements and interfaces to interconnecting equipment and adjacent beam line elements.

2. Scope:

The function of the emittance station is to map both the vertical and horizontal transverse phase space of the beam ($x - x'$ and $y - y'$). This station will primarily be used to measure beam quality after the first focusing element during normal PXIE beam operations. In addition, during LEBT commissioning (before the arrival of the RFQ) this station will be used to measure beam at the end of the LEBT.

3. Key Assumptions, Interfaces and Constraints:

- The LEBT transverse emittance station is completely evasive and will inhibit part or all beam current when in operation.
- Beam measurements for horizontal or vertical planes will be taken at separate times.
- The LEBT transverse emittance station will be movable such that measurements can be taken at various stages of the LEBT installation.
 - ♦ Its final and permanent location for nominal operation will be right after the 1st solenoid.
- The transverse emittance station will be water-cooled.
- The emittance station vacuum chamber will provide a port for vacuum pumping.
- The LEBT transverse emittance station will conform to FNAL Engineering^[4] and ES&H Standards.^[5]
- All interfaces (e.g. power, vacuum, controls) will be further discussed and agreed upon by the PXIE Project Engineer.

4. Functional Requirements:

Beam		
	Ion type	H ⁻
	Kinetic energy	30 keV
	Energy stability	0.5% RMS
	Nominal beam current	5 mA
	Maximum beam current	10 mA
	Minimum beam current	0.5 mA
	Duty factor	100%
	Nominal rms transverse emittance – (horz. and vert. over 1-10 mA current range)	< 0.25 mm-mrad
Vacuum		
	Nominal operating pressure	< 10 ⁻⁶ torr
Emittance Station		
	Vacuum chamber Length (flange-to-flange)	≤ 200 mm
	Vacuum chamber Width (horizontal)	≤ 250 mm
	Vacuum chamber Height [#] (vertical)	≤ 280 mm
	Measurement planes	2 (horz. and vert.)
	Position measurement range (from beam center)	±30 mm
	Position measurement resolution	100 μm
	Angular measurement range	±80 mrad
	Angular measurement resolution	0.5 mrad
	Phase density dynamic range	10 ³
	Max. beam power dissipation	300 W
	Min. beam radius (2 rms)	0.5 mm
	Max. power density	375 W/mm ²
	Time slice resolution	1 μsec
	Measurement time (for 60 position steps)	≤ 60 s
	Fully retracted position	40 mm from beam line center [†]

[#] The critical dimension is the distance from the centerline (i.e. ideal beam trajectory) to the top of the vacuum chamber, which should not exceed 140 mm. If needed, the bottom of the chamber can extend closer to the floor.

[†] For the emittance probe i.e. assuming a 3" diameter pipe, all elements of the emittance scanner would lay within the connecting port.



5. References:

Documents with reference numbers listed are in the Project X DocDB:

<http://projectx-docdb.fnal.gov>

[1] Project X Functional Requirements Specification

Document #: Project-X-doc-658

[2] Project X Injector Experiment Functional Requirements Specification

Document #: Project-X-doc-xxx

[3] PXIE LEBT Functional Requirement Specification

Document #: Project-X-doc-912

[4] Fermilab Engineering Manual

[http://www.fnal.gov/directorate/documents/FNAL_Engineering_Manual REVIS ED_070810.pdf](http://www.fnal.gov/directorate/documents/FNAL_Engineering_Manual_REVIS ED_070810.pdf)

[5] Fermilab ES&H Manual

http://www-esh.fnal.gov/pls/default/esh_home_page.page?this_page=15053