



Fermilab

PIP-II
PXIE Wire Scanner
Functional Requirements Specification

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- Electronic signatures managed via Teamcenter approval process.



Revision History

| Revision | Date | Section No. | Revision Description |
|----------|------------|-------------|----------------------|
| 0 | 01/08/2016 | ALL | Initial Draft |
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**Introduction**

The specification describes the requirements for a Wire Scanner (WS) intended for measurements of the transverse profile of the H^- beam at PXIE [1]. The WS is a set of two wires mounted on the same frame, which moves at a 45° angle with respect to the beam line X-coordinate axis. The wires are mounted perpendicular to one another and at a 45° angle with respect to the axis of the WS drive, so that one of them is parallel to the beam line X-axis and another to the Y-axis. When the frame moves through the vacuum chamber, the wires cross the beam, one at a time, and the current imposed by the beam to the wires is recorded. This current as a function of the frame position represents the X and Y beam profiles.

The WS will be mounted in the diagonal port of the scraper can.

Relevant beam parameters

For the purpose of the WS measurements, the beam is assumed coming in trains (pulses) of 162.5 MHz bunches with parameters indicated in Table 1.

Table 1. Relevant beam parameters

| Parameter | Unit | Nominal value | Range |
|---------------------------------|---------|---------------|-----------|
| Particles type | | H^- | |
| Energy | MeV | 2.1 | 2.0 – 2.2 |
| Bunch frequency | MHz | 162.5 | |
| Pulse repetition rate | Hz | 60 | 0.1 - 60 |
| Pulse length | μs | 20 | 5 - 20 |
| Current averaged over 1 μs | mA | 5 | 1 - 10 |
| Rms beam size (X/Y) | mm | 2/2 | 1- 4 |



WS functional requirements

For the nominal beam parameters listed in Table 1, the WS should provide X and Y profiles with requirements listed in Table 2. The requirements, when applicable, are identical for X and Y profiles.

Table 2. WS requirements

| Parameter | Unit | Value |
|--|------|--------------|
| Spatial resolution | mm | ≤ 0.1 |
| Dynamic range ^{*1} | | 10^3 |
| Distance range for measurements ^{*2} | mm | ± 15 |
| Time of measuring X and Y profiles ^{*3} | min | ≤ 5 |
| Clear aperture radius with WS parked ^{*4} | mm | $R \geq 80$ |
| Positioning accuracy with respect to limit switch position ^{*5} | mm | ≤ 0.2 |
| Absolute positioning accuracy ^{*2} | mm | ≤ 1 |
| Angle between wires | ° | 90 ± 0.5 |
| Yaw and pitch angles error | ° | ≤ 5 |
| Roll angle error (angle between X wire and PXIE X) | ° | ≤ 1 |

^{*1} Ratio of the maximum signal for 10 mA, 2 mm rms beam to the signal noise at 3σ level.

^{*2} With respect to the PXIE beam line axis, see Fig. 1.

^{*3} Assuming 60 Hz pulsing and 85mm frame travel with 0.14 mm steps, including return to the initial position.

^{*4} To prevent interference with scraper insertion. Measured with respect to the PXIE beam line axis.

^{*5} In the case of moving with the constant speed through the measurement area, this requirement refers to accuracy of measuring the position.

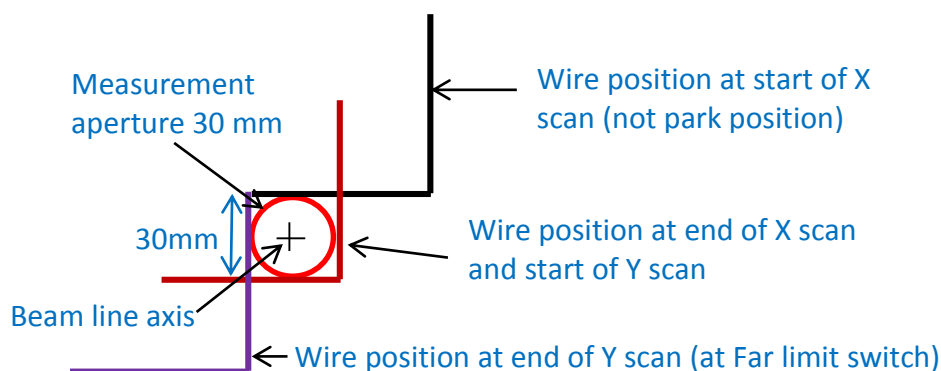


Figure 1. Illustration of wire positions during the measurement of two profiles. The total shift of the frame along the WS axis is $2 \cdot 30 \text{ mm} \cdot \sqrt{2} = 85 \text{ mm}$. Only one wire segment (horizontal or vertical) is allowed in the 30 mm beam aperture region at any time during the scan.



Both wires and the frame are electrically interconnected and can be biased up to 100V with respect to ground. The design should be compatible with using the WS in UHV and particle-free environment.

Interfaces

1. The WS should fit into the diagonal port of the scrapers vacuum chamber, F10015688 rev A.
2. The outside-vacuum portion of the WS shall not extend beyond the scrapers vacuum chamber beamline interface flanges in the longitudinal direction (i.e. maximum longitudinal length 180mm).
3. The in-vacuum portion of the WS shall fit within the scraper vacuum enclosure as shown in Fig. 2.
 - a. At all times, all in-vacuum parts of the WS must stay within the cylinder of 50 mm diameter and 400 mm long as measured from the interface flange of the scrapers vacuum chamber along the direction of the WS motion. It includes effects such as mechanical tolerance, gravity deflection, actuator wobble, etc.
 - b. In addition, in the parked position all in-vacuum parts of the WS must stay inside the cylinder of 50 mm diameter and 165 mm long as measured from the interface flange.
4. Information of whether the WS is in parked position should be available to the Machine Protection System (e.g. via a limit switch).
5. The program controlling the WS shall
 - a. Provide a user interface to fully control operation of the WS.
 - b. Graphically display the profiles, calculate the rms width and center positions, and save the results to a disk
 - c. In the case of WS mounted in the scrapers vacuum chamber, prevent the WS motion unless scrapers are in their fully retracted position
 - d. Be capable of independently moving the WS to a specified static position.
 - e. Provide ACNET parameters for the wire step size, scan interval, wire position, and readout current.

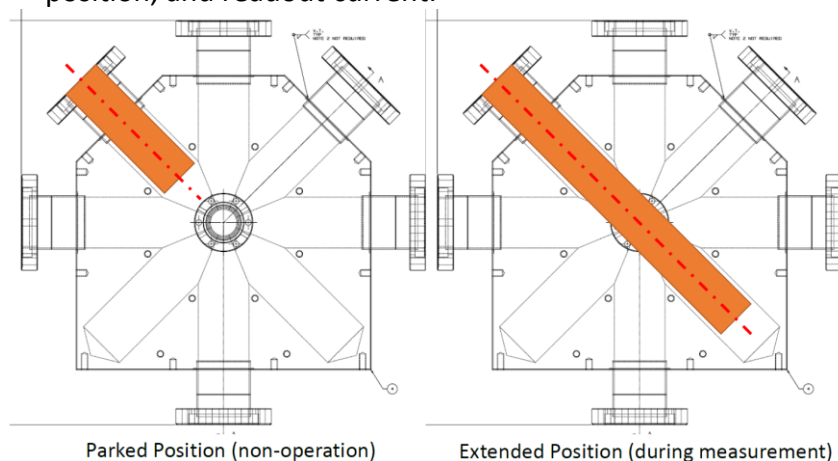




Figure 2. Illustration of not-to-exceed volume envelope for components residing inside the vacuum enclosure (F10015688) in both the Parked position (left) and during measurements (right).

Recommended technical parameters

Table 3. Recommended technical parameters for the WS. This information is meant as a guide for the WS but may be changed as the WS design evolves.

| Parameter | Unit | Value |
|---------------------------------|------|-------------------|
| Wire diameter | mm | 0.05 |
| Wire material | | W26Re |
| Wire sag (estimated) | mm | < 0.025 |
| Minimum full range of motion | mm | 121 ^{*1} |
| Minimum step size | mm | 0.05 |
| Electric isolation of the frame | V | ≥ 100 |

*¹. Calculated as a sum of 85 mm of the measurement range (Fig. 1) plus additional shift to move into the park position of $(80 - 30) / 2 \cdot \sqrt{2} = 35.4 \text{ mm}$.

References

1. PXIE Functional Requirements Specification, TC # ED0001223, uncontrolled copy is available at <http://projectx-docdb.fnal.gov/cgi-bin/ShowDocument?docid=980>
2. MEBT Functional Requirements Specification, TC# ED0001303, uncontrolled copy is available at <http://projectx-docdb.fnal.gov/cgi-bin/ShowDocument?docid=938>