

PHYSICS REQUIREMENT DOCUMENT (PRD)	Doc. No. SP-391-000-30 R0	LUSI SUB-SYSTEM CXI
Physics Requirements for the CXI Ion Time-of-Flight		
Sébastien Boutet CXI Scientist, Author	_____	_____
	Signature	Date
Paul Montanez CXI Lead Engineer	_____	_____
	Signature	Date
	_____	_____
	Signature	Date
	_____	_____
	Signature	Date
Darren Marsh LCLS Quality Assurance Manager	_____	_____
	Signature	Date
Tom Fornek LUSI System Manager	_____	_____
	Signature	Date

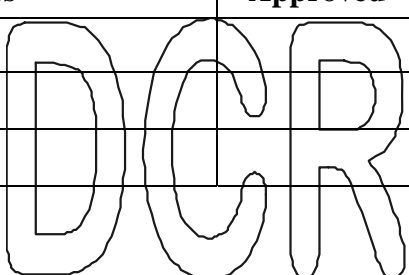
Revision	Date	Description of Changes	Approved
R0	18DEC08	Initial release	

Table of Contents

Table of Contents	2
1. Overview.....	2
2. Performance Requirements.....	3
3. Size Requirement	3
4. Positioning Requirements.....	3
5. Vacuum Requirements.....	3
6. Electrical Requirements.....	3
7. Controls Requirements	4
8. Data Acquisition Requirements.....	4
9. Interface Requirements.....	4
10. Safety Requirements.....	5

1. Overview

Samples illuminated by the LCLS beam in the CXI instrument will get highly ionized and undergo a Coulomb explosion. Detecting the products of this explosion is required in order to provide information about the chemical components of the sample and to provide a diagnostic on whether a particle was hit by the LCLS pulse. This document describes the requirements for an Ion Time-of-Flight (ITOF) mass spectrometer capable of performing these tasks.

The coordinate system is defined in Mechanical Design Standards Supplement DS-391-000-36.

2. Performance Requirements

- 2.1. The ion TOF shall detect the arrival time of charged particles at the ITOF detector plane.
- 2.2. The ion TOF shall have a mass resolution of 1 atomic mass unit over a range up to 100 atomic mass units, assuming the initial kinetic energy of the created ions is 10 eV or less.
- 2.3. For more energetic ions, in the range of 1-10 keV that will be produced with the 0.1 micron KB system of the CXI instrument, the resolution of the ion TOF shall be 1 atomic mass unit up to at least a mass of 20 AMU.
- 2.4. The ion TOF shall be used to veto diffraction images with the ITOF signal used to determine if a particle was hit by a given LCLS pulse.

3. Size Requirement

- 3.1. The ion TOF mechanical components and electrical feedthroughs shall all be attached to a single flange no larger than 8" O.D.
- 3.2. The ion TOF shall consist of a drift tube of 40 ± 5 mm inner diameter.
- 3.3. An electrode grid shall be positioned at the entrance of the drift tube.
- 3.4. The closest point of approach of the ion TOF drift tube from the interaction region shall be 25 ± 2 mm.
- 3.5. The drift tube of the ion TOF shall be at least 200 ± 25 mm long. Interface issues with the sample chamber may preclude the drift tube from being this long and 200 mm shall be the design goal.
- 3.6. A repeller electrode shall be located on the opposite side of the interaction region from the drift tube. This electrode shall be circular and of the same diameter as the drift tube.
- 3.7. The repeller electrode shall be located 25 ± 2 mm away from the interaction region.

4. Positioning Requirements

- 4.1. The long axis of the ion TOF shall be pointed directly at the interaction region to within ± 3 degrees.
- 4.2. The surface normal of the repeller electrode shall be parallel to the axis of the drift tube to within ± 2 degrees.

5. Vacuum Requirements

- 5.1. The ion TOF shall operate with a 10^{-7} Torr pressure environment or better under all operating conditions and the appropriate vacuum practice for the design, manufacturing, and installation of the system components shall be implemented.

6. Electrical Requirements

- 6.1. It shall be possible to apply voltages up to 5 kV (with either polarity) on the repeller electrode as well as on the drift tube and the entrance grid to the drift tube.

- 6.2. The components inside the Sample Chambers shall be precluded under all circumstances to come into contact with the electrodes of the ion TOF in order to prevent electrical discharges.
- 6.3. The electric field at the interaction region shall have lines parallel to the axis of the drift tube to within ± 2 degrees.

7. Controls Requirements

- 7.1. The voltage on up to 8 channels shall be controlled remotely via the instrument control system.
- 7.2. The voltages on up to two of the previously mentioned eight channels shall be pulsed at 120 Hz with synchronization to the LCLS pulse to within 100 picoseconds.
- 7.3. It shall be possible to delay the voltage pulse with respect to the LCLS by up to 1 μ sec with 0.1 nsec resolution.
- 7.4. The instrument control system shall display all controls and status of the high voltage supplies.
- 7.5. It shall be possible to lock the settings of the high voltage supplies with password protection.

8. Data Acquisition Requirements

- 8.1. The analog signal produced by the ions impinging on the TOF detector shall be digitized at a rate of 1 GHz or faster.
- 8.2. It shall be possible to digitize and record up to 100,000 samples for every LCLS pulse, at 120 Hz, at the digitization rate of Requirement 8.1.
- 8.3. It shall be possible for the user to set a trigger level on the digitized signal. This trigger shall be used to select which diffraction images will be saved by the system.
- 8.4. It shall be possible to set the trigger level on a limited window of the digitized waveform as well as on multiple independent windows.
- 8.5. The trigger shall be used as a particle hit counter by counting the number of trigger events per user defined time window.
- 8.6. The particle hit counter shall be used as a detector when aligning the particle injector.
- 8.7. The hit rate averaged over a desired time window shall be displayed at the control console at a refresh rate of 1 second.

9. Interface Requirements

- 9.1. The ion TOF shall be mounted on either of the CXI Sample Chambers (1 micron Sample Chamber PRD# SP-391-000-20 and 0.1 micron Sample Chamber PRD# SP-391-001-41).
- 9.2. The drift tube and the repeller electrode, along with their respective supports shall not encroach under any circumstance on the ± 45 degree angle from the interaction region to the 2D X-ray Detector (LCLS PRD # 1.6-002) which is mounted inside the CXI Detector Stage (PRD # SP-391-000-28).

- 9.3.** In the case where functionality of the ion TOF is in conflict with the functionality of the imaging system in the CXI Sample Chamber, the functionality of the Sample Chamber shall have precedence and lead to reduced functionality of the Ion TOF.
- 9.4.** The ion TOF shall be designed so it cannot interfere or collide with any of the components inside the Sample Chambers (PRD # SP-391-000-20 and PRD# SP-391-001-41).

10. Safety Requirements

- 10.1.** The vacuum system of the sample chamber on which the ion TOF is attached shall be interlocked with the high voltage power supplies of the ion TOF so that the system is not energized when the pressure is above 10^{-4} Torr.
- 10.2.** The pressure level at which the interlock is triggered shall be user-modifiable with password protection.
- 10.3.** All SLAC electrical safety requirements associated with the high voltages required for the Ion TOF shall be observed in the design, fabrication and operation of this device.