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PHYSICS REQUIREMENT DOCUMENT (PRD)	Doc. No. SP-391-001-33 R0	LUSI SUB-SYSTEM XCS
Physics Requirements Document for the XCS Large Angle Detector Stage		
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1. Overview

The Large Angle Detector Stage (LADS) is a component of the XCS Instrument. It positions the XCS pixelated detector (or any future detector available) in reciprocal space to perform X-ray Photon Correlation Spectroscopy experiments. The LADS vacuum flight path provides the capability to reduce air-scattering and air-absorption between the sample location (i.e located at the Center Of Rotation of the XCS diffractometer system) and the detector. The XCS Diffractometer system is described in SP-39100132.

The Large Angle Detector Stage serves the following purposes:

- Positioning the XCS pixelated detector (or future detectors available) at the location of interest in the reciprocal space in the vicinity of the horizontal scattering plane.
- Allowing a large sample-detector distance enabling to resolve speckle patterns (i.e coherent diffraction patterns)
- Allowing to reach scattering angles 2θ up to 55 degrees for diffraction experiments
- Allowing some Small Angle X-ray Scattering capability when $2\theta=0^\circ$.
- Allowing Grazing Incidence scattering and diffraction experiments.

The positioning of the detector must be obtained in a precise and reproducible fashion. The Large Angle Detector Stage motion should be totally decoupled from the XCS diffractometer system.

As for the XCS diffractometer system, **the joint use of the XCS diffractometer system and the LADS will perform as a 4-circle horizontal scattering geometry diffractometer.**

The specification of the LADS is defined in this document.

The coordinate system is defined in Design Standards Supplement DS39100036. The angular motion labels relative to the coordinate system (i.e Center Of Rotation of the XCS diffractometer system) are displayed in Figure1.

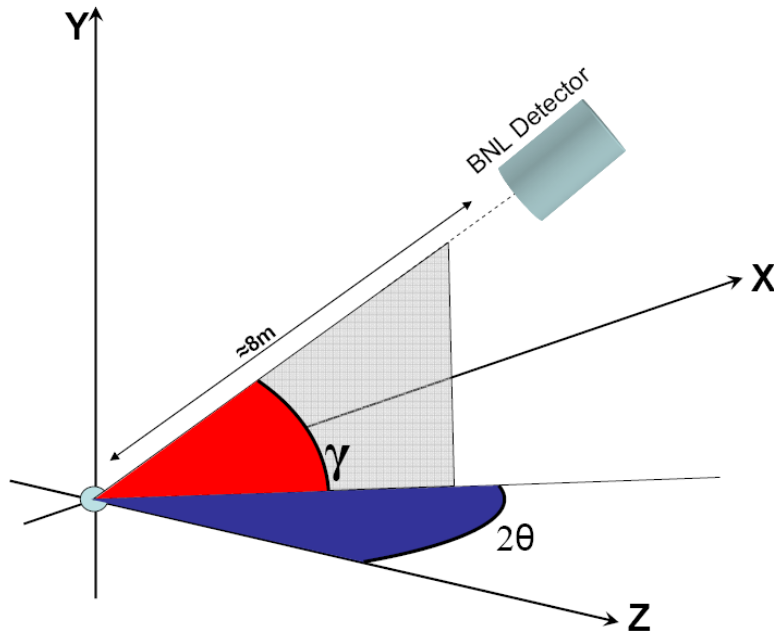


Figure 1 Motion labels for the XCS LADS

2. Description of the LADS and LADS-subsystems functionalities

The LADS includes multiple components (referred here as subsystems) which are described here and in the symbolic representation Fig2.

- 2.1. The LADS defines the overall motion of the whole assembly (i.e. including all the subsystems).
- 2.2. The LADS is equipped with a vacuum chamber subsystem reducing air-absorption/scattering to the extent possible between the sample and the pixelated detector.
- 2.3. The LADS is equipped with a diode/slits system (i.e a “local detector”) for alignment purpose. It is located at the end of the LADS
- 2.4. The LADS should be equipped with a beamstop system, located at the end and within the evacuated flight path.
- 2.5. The XCS pixelated detector local motion should be decoupled from the LADS motion and be located between the beamstop system and the local detector system
- 2.6. For now the XCS pixelated detector and its local motion does not need to be included for now in the evacuated flight path.
- 2.7. The overall LADS design should accommodate the future addition of an evacuated enclosure containing the XCS pixelated detector (or other) with its local motion, as well as the diode/slit system.

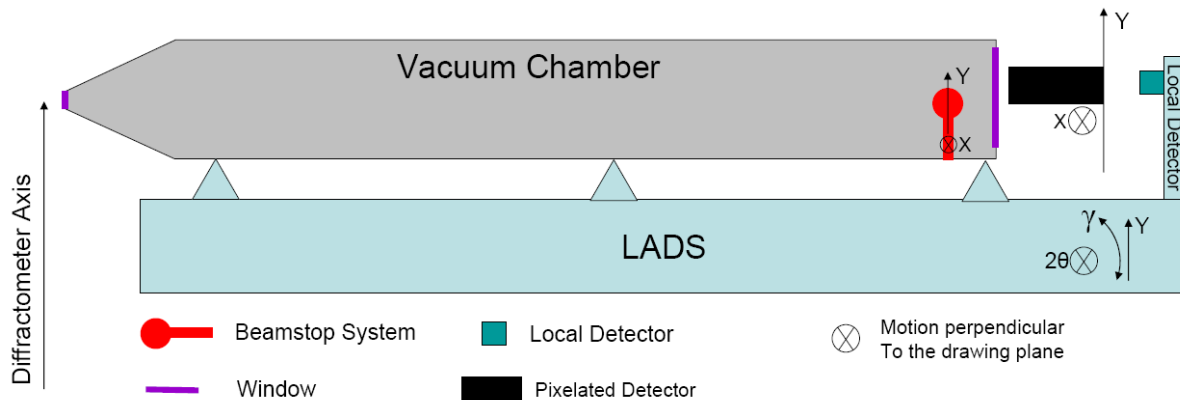


Figure 2 Block diagram of the LADS and LADS subsystems

3. LADS length and motion specifications

3.1. The LADS motion is to be decoupled from the XCS diffractometer system.

LADS size specifications

3.2. The LADS accommodates the motion described in sec. 3 and also maximizes the sample/detector distance to the extent possible within the experimental Hutch 4 in the FEH. The maximum sample-detector distance is of the order of 8 meters

Horizontal motion specifications

- 3.3. The LADS motion describes a rotation around the Center of Rotation of the diffractometer.
- 3.4. The LADS rotates in the horizontal plane from -1 to 55 degrees with a resolution of at least 1mDeg (corresponding to a position repeatability of $\pm 75\mu\text{m}$ at 8 meter from the COR).
- 3.5. The LADS motion accommodates for any change in the COR position of the diffractometer both in the X and Y directions. This is achieved by software control of the motorized motions.
- 3.6. The LADS must not interfere with the CXI beamline located 600mm south the XCS beamline.

Vertical motion specifications

- 3.7. The LADS has the capability to translate in the vertical plane in order to accommodate any change in the COR in the Y direction with a repeatability of $\pm 50\mu\text{m}$.
- 3.8. The LADS must also have the capability to rotate around the COR of the diffractometer in the vertical plane over a limited range ($-0.5^\circ < \gamma < 2^\circ$ to the extent possible).

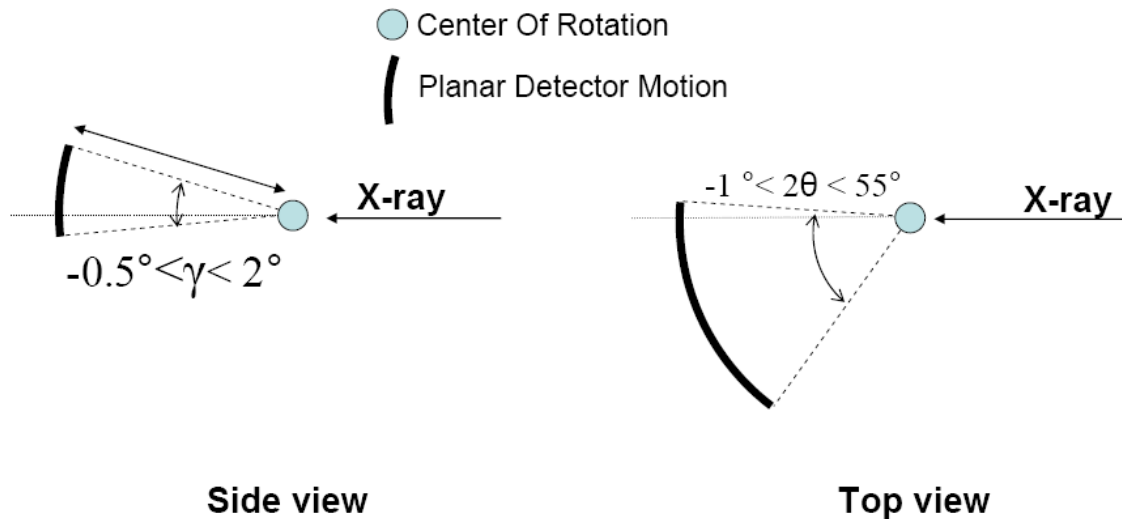


Figure 3 Description of the motion to be covered by the XCS LADS

4. LADS vacuum subsystem specifications

- 4.1. The LADS must have an evacuated flight path between the sample location and the pixelated and local detectors in order to minimize air scattering/absorption to the extent possible
- 4.2. The LADS flight path must accommodate the observation of scattered x-rays with a half opening angle 2θ of approx 1° , corresponding to a wavevector $Q=0.08\text{\AA}^{-1}$ at 8keV
- 4.3. The LADS, from the sample side, could be equipped either with a window (diamond, beryllium or Kapton could be investigated) or differential pumping but must satisfy 4.2.
- 4.4. The LADS on the detectors side must be equipped with a window, transparent to the extent possible to X-ray. (Kapton or beryllium could be investigated.)
- 4.5. The design of the LADS must accommodate for maintenance of any of the windows (i.e change of the window if damaged).
- 4.6. The sample side of the LADS must offer the possibility to get as close as possible from the sample without interfering with the XCS diffractometer system or the sample environment. This could be achieved with modular vacuum chamber structure.
- 4.7. The vacuum level of the LADS vacuum chamber must be better than 7.10^{-5} Torr.
- 4.8. The pumping procedures should ease the return of the LADS vacuum system to the atmospheric pressure.
- 4.9. The pumping time of the whole vacuum chamber down to the operational pressure described in 4.7, should be reasonable and of the order of $\frac{1}{2}$ hour.

5. LADS Beamstop subsystem specifications

- 5.1. The vacuum side of the LADS vacuum chamber exit must contain a beamstop system, which purpose is to block locally the transmission of x-rays.
- 5.2. The beamstop must be located as close as possible to the exit window of the vacuum chamber
- 5.3. The beamstop subsystem must consist of different beamstop sizes
- 5.4. The beamstop subsystem motion must be motorized and allow its motion in the X and Y direction, allowing the possibility to place the beamstop at any place before the exit window.
- 5.5. The beamstop subsystem motion must have a repeatability better than $\pm 35\mu\text{m}$ in both directions

6. LADS pixelated detector motion subsystem specifications

- 6.1. The XCS pixelated detector must be placed right after the exit window of the vacuum chamber of the LADS.
- 6.2. The XCS must have the capability to move over the whole range defined by the exit window side, both in the X and Y direction with a repeatability better than $\pm 35\mu\text{m}$.
- 6.3. Its motion must allow the capability to move the detector out of the window location, thus placing the detector in a safe position from any exposure to x-rays.

7. LADS “local detector” subsystem specifications

- 7.1. A “local detector” consisting of a diode and a pair of slits is to be mounted at the end of the LADS system. For now the diode/slits system will perform in air.
- 7.2. It does not need to be motorized.
- 7.3. Its position is to be centered to the center of the vacuum chamber.
- 7.4. A large interface plate is recommended in case the diode/slits assembly would be replaced by something else.
- 7.5. The slits will allow a minimum opening of 2 by 2 mm and a resolution better than 3 microns

8. LADS design flexibility and future upgrade

- 8.1. The LADS design must accommodate to the extent possible to place the pixelated detector system and its submotion at a shorter distance from the sample, thus reducing the length of the vacuum chamber.

The whole LADS design must accommodate for future capabilities such as but not limited to:

- 8.2. A larger vacuum chamber (larger diameter)
- 8.3. The integration of the definite pixelated detector and its motion in the vacuum chamber. This would also include the insertion of the diode/slits system in vacuum.

9. Controls Requirements

- 9.1. Positioning of the LADS must be performed remotely.
- 9.2. All adjustable electronic limits that will be provided for the LADS must be incorporated into the instrument control system.
- 9.3. A geometry calculation routine must be integrated into controls system that will drive the diffractometer and data acquisition system (i.e. ability to control the explored sample in reciprocal space).
- 9.4. The control system must also include a calibration routine of the LADS for each COR most probable positions. A possible solution is the use of laser alignment system.