The University of Leicester Long Beamline Test Facility (LLBTF)

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The University of Leicester (UL) Long beamline test facility (LLBTF) is a nominal 27.5m vacuum beamline with an X-ray source enclosure at one end and an experimental chamber at the other. The experimental chamber opens into a class 1000 clean room to allow samples to be loaded and unloaded in a clean environment.

X-ray source

The X-ray source chamber is pumped by a turbomolecular pump and normally achieves pressures of order $5x10^{-7}$mbar. The source can be isolated from the beamline so that either part can be vented independently. A number of different sources can be used:

1. Low voltage electron bombardment source with Cu anode. Various characteristic X-ray lines can be generated by coating the anode with other materials. Maximum anode voltage approx 8kV
2. 50kV 1mA sealed tubes with Mo target and Be window
3. 100kV 3kW Tungsten anode Philips tube
4. 100kV 3kW Scandium anode Philips tube
5. Deuterium lamp and monochromator

Included in the chamber is a filter wheel for provision of transmission filters and or collimating apertures. A range of standard filters are available for C-K, Cu-L, Al-K and Si-K (count rate and spectral purity TBC), please check for other energies. The Philips tube can also be configured to bombard a target to produce fluorescence X-rays. In principle a Penning source and momochromater can also be fitted but this would require additional modifications to the equipment.

Note that the X-ray sources use thin film transmission filters only, no X-ray monochromator is available.

Any proposal to use the 50kV or 100kV tubes needs to give due consideration to radiation safety at the experiment and must be discussed with UL staff as soon as possible in the planning stages. The X-ray source enclosure shielding allows both tubes to be safely operated at maximum power and voltage but additional shielding may be required at the experiment chamber.

Beamline

The beamline (Figure 1) has an experimental chamber located at the mid-way point which is scheduled to include a high precision linear drive station (Newport M-MTM200PE.1V6 200mm travel 0.1µm resolution). This equipment will not be integrated with the system control software. Four other (non instrumented) access ports are available between the centre point and the experimental chamber for user-provided equipment (see Figure 1, Figure 4 and Figure 5).

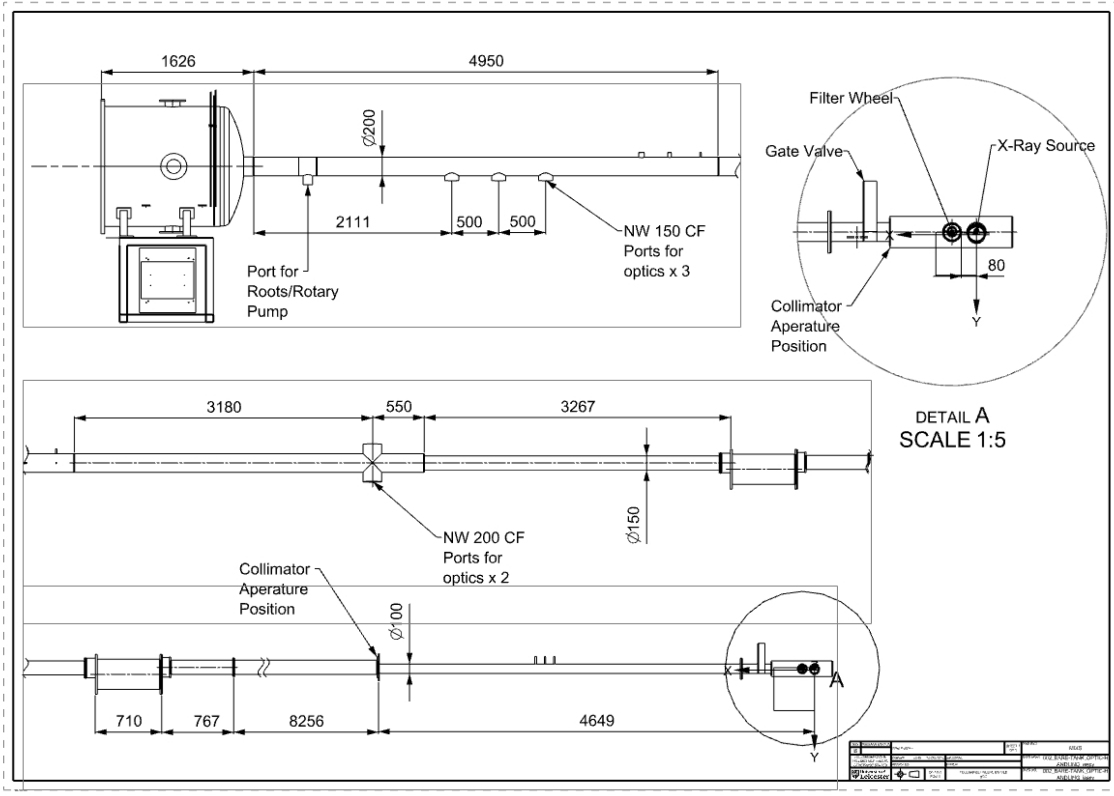

Figure 1: Beamline dimensions from X-ray source to main chamber flange

Experimental chamber

The experimental tank consists of a main chamber which is 1.25m in diameter and 1.5m long. In addition there is a permanently attached extension chamber which is approximately 0.76m diameter by 0.7m long (Figure 2). The tank is pumped by a cryogenic pump and roughed out using a roots/rotary pump combination. The tank base pressure is $<2\times10^{-6}$mbar. The cryo pump is floor mounted and coupled to the tank using edge welded bellows to ensure that vibration from the pump is not transferred to the chamber. A number of facilities are available inside the chamber as described below. All adjustments can be made while the system is under vacuum and operational using UHV-compatible vacuum stepper motors.

The system is designed to uniformly illuminate optics up to 200mm diameter.

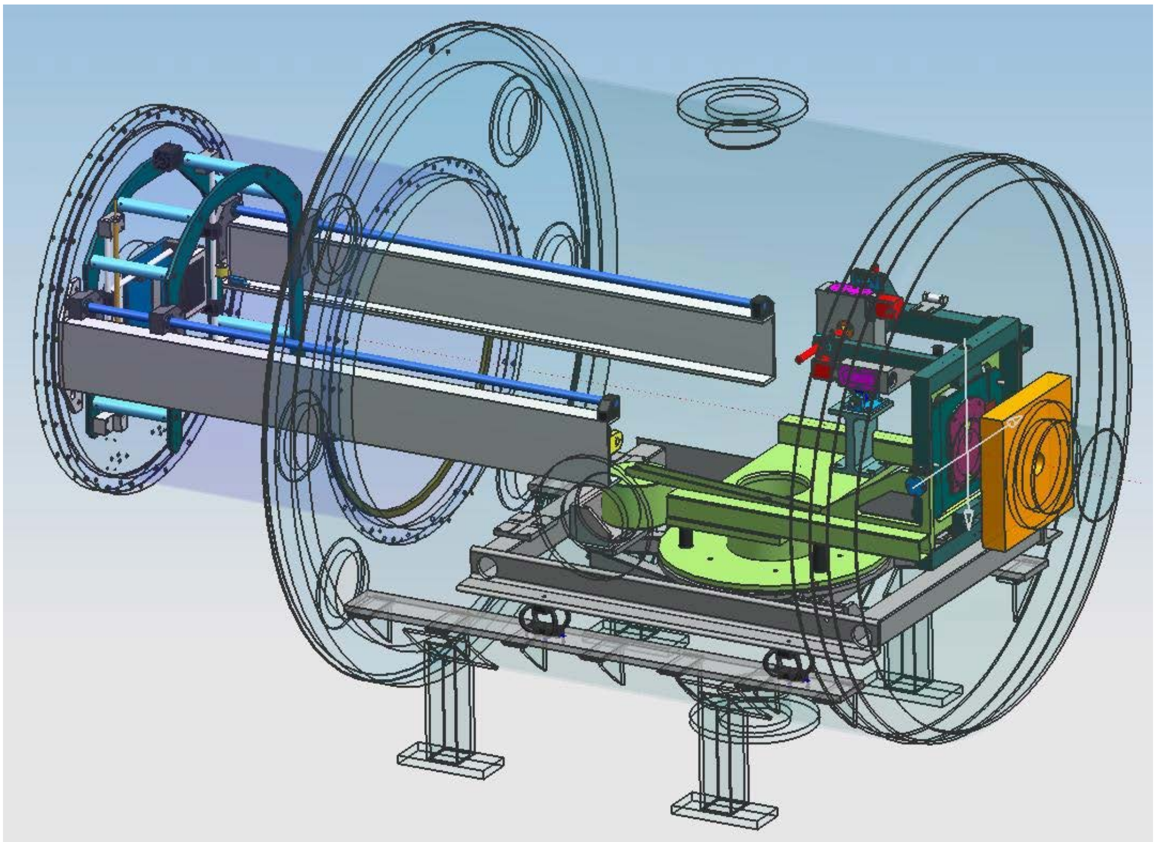

Figure 2: CAD model of experimental chamber. X-rays enter the chamber from the right with the main flange and extension tank being inside the clean room

Beam monitor

A PN diode beam monitor is fitted to the end of the beampipe as it enters the experimental chamber. The $10mm^2$ active area diode is fitted onto a Y-Z scanning system to allow the spatial and spectral variability of the beam to be mapped. The scanner can also take various collimating apertures to allow illumination of restricted areas of the item under test. Collimating apertures can be easily manufactured to suit for low energy applications. The energy range of the diode is 250eV to 15keV with an energy resolution of 132eV at 5.9keV.

Turret assembly

The turret assembly is a high precision rotation stage which allows the item under test to be rotated in ψ and φ (Figure 3). The turret is mounted on anti-vibration mounts to ensure stability of the test system. Nominal stability and repeatability of the rotation is better than 10 arc seconds (may be as good as 1 arc second TBC). The system is also set up to rotate up to six samples into the beam one after the other by rotating a sample carrier about the X-ray beam (θ). The accuracy of the rotation in θ is much lower than for the other axes at approximately 14 arc minutes.

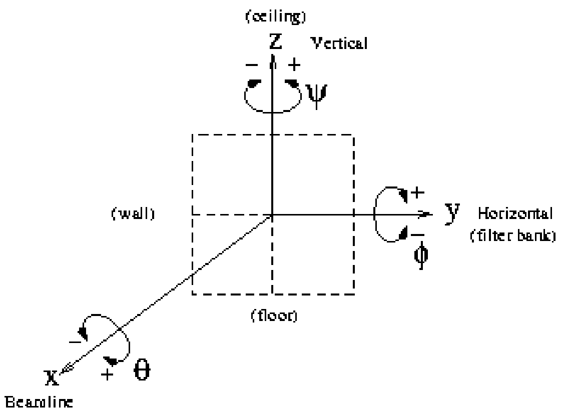

Figure 3: Axes definition in the test facility-

The turret can be rotated through 180 degrees to allow easy loading of samples and can be used in the forward position, as shown in Figure 2, or in the back position facing the detector. There is no translation movement on the turret; this facility is provided by the detector assembly. The nominal mounting area for items on the turret is 208mm (h) by 250mm (v), it may be possible to accommodate larger items please contact UL to discuss the application. The maximum mass that can be accommodated on the turret is 5kg (TBC) and the centre of mass should lie close to the rotation axes.

Detector assembly

The system includes a large active area, 90mm x 90mm, imaging MCP detector which is mounted on a three-axis movement. The detector carriage can be moved 1035mm along the optical axis and in addition approximately +140mm, -30mm in the horizontal axis and approximately +90mm –40mm in the vertical axis. Note that the quantum efficiency of the MCP detector is a function of both energy and angle of incidence and this should be considered when analysing data. The availability of precision calibration data is TBC.

Provision has been made in the design for the installation of a cooled X-ray CCD detector but there are no firm plans or timescale for this addition.

Control software

A set of, IDL-based, image acquisition and control programs are used to adjust the position of the detector, turret and beam monitor and acquire image data from the detector. The system allows manual control but is also designed to automatically take multiple data sets under computer control.

Image data from the MCP detector will be provided as either event lists or as linearised images. The file format will be agreed with the experimenter prior to the run. Data can be transferred by SFTP connection to a remote computer or via a suitable USB drive. All files will be archived using standard UL procedures.

All data will be the property of the experimenter but UL reserve the right to retain a copy of the data and to use the data to check the operation and calibration of the facility.

Laboratory area

Normal control of the system is from a laboratory area outside the clean room (Figure 5). Access to the clean room is only required when samples are being inserted or removed from the test facility.

	
Figure 4: Vacuum area showing 3 beamline access points	**Figure 5: laboratory area showing beamline access point**

Operating hours

The normal manned operating hours of the test facility are 0800 to 1800 Monday to Friday but the test facility can acquire data 24 hours a day under computer control. It will not normally be possible for visitors to access the test facility out of hours. It is not possible to control the facility using a remote connection, all measurement sequences have to be set up from within the University campus.

The operation of the facility will be done by UL employees with the aim of carrying out the experimental plan for the tests in the most efficient way.

User supplied equipment

All equipment to be tested under vacuum must be suitable for use in clean high vacuum. UL reserve the right to refuse an application if there is concern that contamination of the facility may occur.

All user supplied electrical equipment must have been tested for electrical safety within the last 12 months. Operation of any user supplied equipment will be the responsibility of the user subject to UL approval of the experimental plan. The provision of any additional vacuum feedthroughs is by negotiation. Approval must be obtained before bringing any hazardous material to the University.

History

The long beamline test facility is located in the basement of the Physics & Astronomy Building at the University of Leicester and is operated by staff from the Space Research Centre. The facility has been substantially refurbished over the last 10 years but has been in use since the mid-1970s and was used to calibrate detectors for Ariel 5, Ariel 6, Exosat and Ginga missions. Currently the facility is being used to test and calibrate the MIXS optics for ESA's BepiColombo mission to Mercury as well as supporting laboratory programmes in advanced X-ray Optics.