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A NOVEL FLEXIBLE DESIGN OF THE FaXToR END STATION AT ALBA

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Abstract

FaXToR is one of the beamlines currently in construction and commissioning phase at ALBA, dedicated to fast hard X-ray imaging. It will offer absorption and phase contrast imaging to users. Possible applications of the beamline include 3D static and dynamic inspections in a wide range of applications. FaXToR aims to provide both white and monochromatic beam of maximum 36x14 mm (HxV) at sample position with a photon energy up to 70 keV. The optical layout of the beamline will tune the beam depending on the specific experimental conditions. Among the required optical elements, there is a multilayer monochromator, the cooled slits, the filtering elements, the intensity monitor and the beam absorption elements. The end station will be equipped with a rotary sample stage and a detector system table to accommodate a dual detection thus simultaneously scanning the samples with high spatial and temporal resolutions. On top of it, a motorized auxiliary table dedicated to complex sample environment or future upgrades will translate along the total table length, independently from the two detector system bridges. The design and construction process of the beamline will be presented.

INTRODUCTION

The FaXToR - Fast X-ray Tomography and Radioscopy beamline at ALBA will operate a micro-tomography station working in the hard x-ray regime. The beamline will provide users with sub-second computed tomography capabilities in both absorption and phase-contrast imaging regimes [1]. FaXToR will give service for material science and engineering, health, biology, food science, archaeology, cultural heritage, geology, paleoethology, environment. The capability of performing simultaneous fast 3D acquisition with a multi-resolution approach and the presence of a versatile detector environment will make the beamline unique thus providing the opportunity to users to access a novel data package, which can be reconstructed and analysed directly at the facility site or remotely.

FaXToR LAYOUT

FaXToR source is an in-vacuum multipole wiggler. The front-end angular opening is set to 1×0.4 mrad^2 (H×V). The main optical element of the beamline is a Double Multilayer crystal Monochromator (DMM). No other optics elements besides attenuators, slits and diagnostics are included in the design.

The experimental hutch includes a beam conditioning elements table holding the sample slits, a second CVD diamond window and a fast shutter. It follows a fly tube equipped with Kapton foil windows to minimize the air absorption at lower x-ray energies and the exhaust ozone in white beam conditions. Such a pipe will be directly link to the tomography stage, located at 36.5 m from the source. Samples of different dimensions up to 5 cm in diameter and 30 cm in height will be located on top of the rotary stage, reaching a maximum speed of 750 rpm depending on the sample weight. The detector table is 4 meters long and is supporting two detection systems: a triple magnification microscope and a low resolution macroscope, together with a dedicated positioning stage and an auxiliary table. All those mentioned elements are able to be displaced along the beam direction. FaXToR foresees two detectors and four cameras to be positioned at a short distance from the sample (for scanning in absorption mode) or at a longer distance (to implement the free space propagation modality in the case of low absorbing matters). Such a configuration is easily interchangeable according to the user experimental requirements. Figure 1 represents the previously mentioned elements.

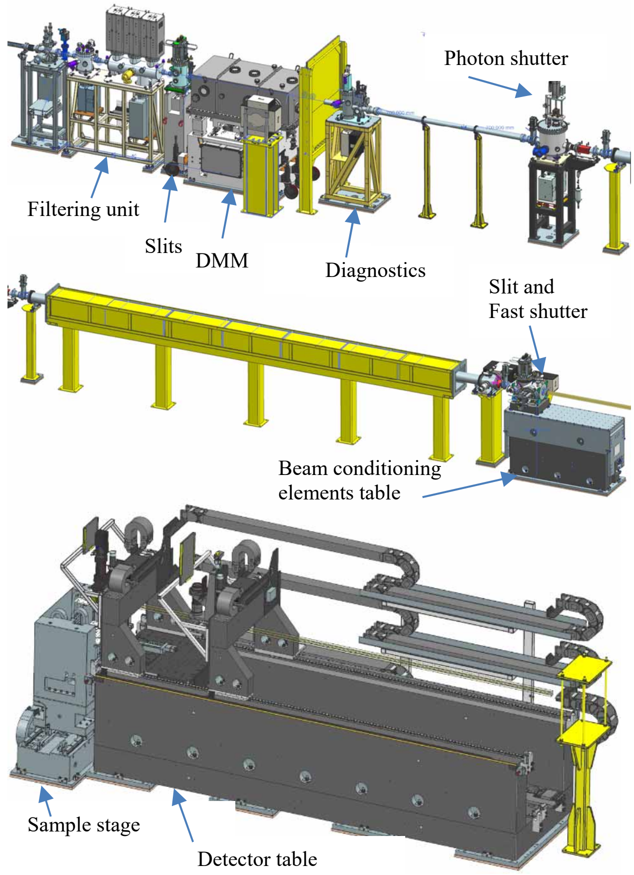

Figure 1: Layout of FaXToR: optics (top), shielded transfer pipe (middle) and end station (Bottom).

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DETECTOR TABLE SPECIFICATION

The detector table consists of two detector positioners and an auxiliary table. The detector positioners are bridge shaped and are designed to accommodate the two microscopes equipped with scintillators and CMOS cameras on top. Furthermore, an auxiliary table is integrated in the design to be positioned along the full detector longitudinal range and to be aligned in height accordingly to the beam position.

A schematic view of the detector table and its main parts are represented at Fig. 2. A front view of the design is included, showing the auxiliary table embedded into the detector table which can move independently from the bridges.

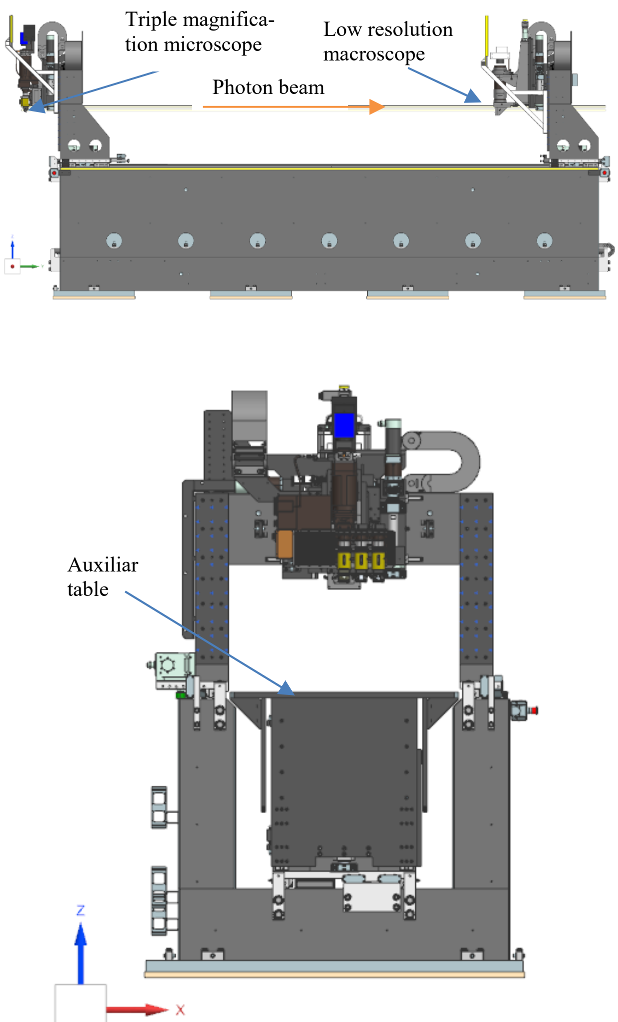

Figure 2: Top: side view of the detector table, bottom: front view.

The specification for full equipment is summarized in Table 1.

Table 1: Specification

parameter	value	comments
Detectors positioning in Y	3225 mm	
Detector positioning in X	+/-50 mm	
Detector positioning in Z	0/+100 mm	To position depending on beam height and to put detector fully apart from beam path
Resolution Y	100 µm	Along the beam
Accuracy Y	50 µm	Guiding accuracy in full length
Resolution X, Z	2 µm	Transversal to the beam,
Auxiliary table Y range	3500 mm	
Auxiliary table Z range	350 mm	Height of top surface from 1000 to 1350 mm
Auxiliary table max. supported weight	95 kg	

DETECTOR BRIDGES

The detector bridge design is identical for both detectors, as the positioning specifications are the same. The guiding in Z and X has solved with recirculating ball linear guides, and force transmission for their movements are by ball spindles. In order to maximize vibration stability, matched pairs of roller linear guide assemblies are chosen for guiding the detector bridge along the photon beam direction. In the case of the force transmission, a rack and pinion system were considered optimal, due to its long stroke and because the resolution requested for this axis is not as high as needed in the transversal plane.

The detector plane perpendicular to the beam can be aligned in yaw with the use of a goniometer designed to be guided by circular guides and driven by a linear movement actuated by spindle. The transmission of the force is given by a flexure.

All those mentioned movements are foreseen to be moved by stepper motors while their position is known by the read of an absolute encoder. Limit switch between detector bridges has been implemented in order to avoid collisions during operation.

The bridge is composed by three granite pieces assembly similar to the base table which presents a U shape and has been designed to support the two bridges and the auxiliary table on the floor. In Fig. 3, an overview of the bridges elements is shown.

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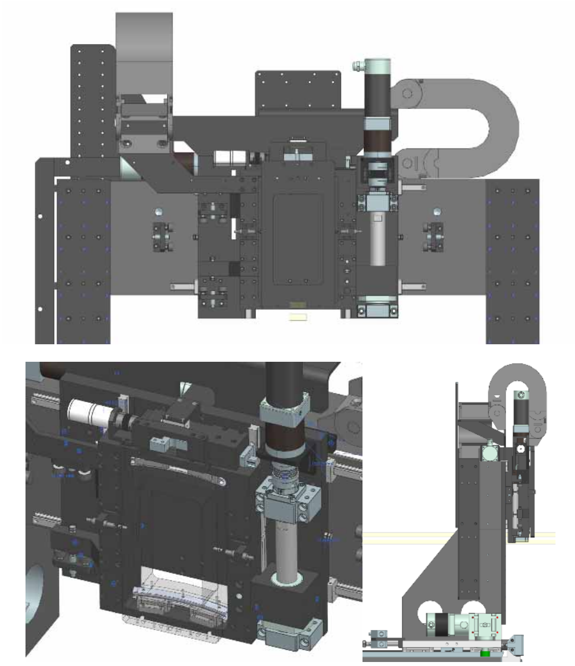

Figure 3: XY stage of the detector positioning bridge. transversal and longitudinal guiding, and spindle for vertical movement can be appreciated. Bottom left: Detail of the integrated goniometer for yaw adjustment, the circular guides are represented in top view. Bottom right: left side view of the detector positioning bridge where the rack and pinion are located.

THE AUXILIARY TABLE

The auxiliary table, which is integrated into the main detector table, as it can be seen in Fig. 2, is able to be displaced along the beam direction independently of the position of the two detectors. This makes the design very flexible in terms of the its capability for user operation.

The auxiliary table has been designed to be stable enough to support in-situ sample devices, or other setups that require high stability. The top interface of the table is 800 mm^2 with a standard hole pattern to provide flexibility on the preparation of different setups.

The height is variable from 1000 to 1350 mm and is driven by a double actuator driven by ball linear guides and spindles. Both actuators are driven with a single motor and a gear box. The system is designed to be irreversible when no power is holding the torque of the motor.

Same as the detector bridges, the auxiliary table is driven along beam direction by roller linear guides and a rack and pinion system for transmission. All the mentioned elements can be seen in Fig. 4.

FEA CALCULATION

Final geometry has been optimized after several runs of FEA. The results are shown in Fig. 5.

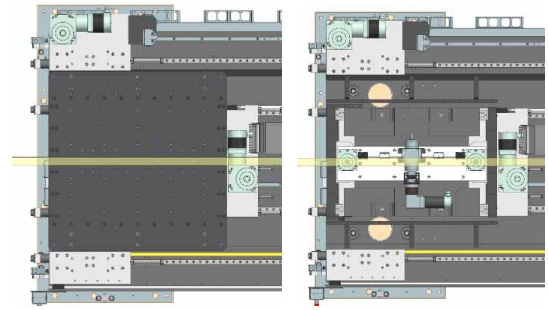

Figure 4: left: the top surface of the auxiliary table. Right: same view without top plate where the driving mechanism are shown.

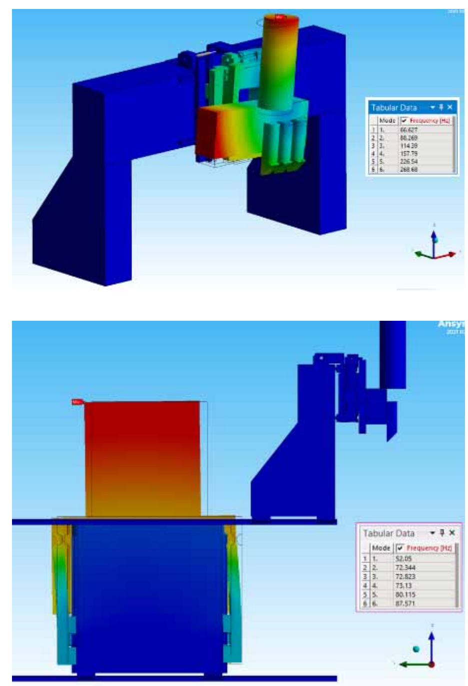

Figure 5: First eigenmodes on the detector bridge (top). eigenmodes on top of auxiliary table, with a mass of 100 kg on top (bottom).

CONCLUSION AND NEXT STEPS

A flexible design for the tomography end station has been conceived, as the detector position can be independent on the position of the auxiliary table. Both detectors can be moved in three linear axis and can rotate on the vertical axis. The triple magnification microscope and the macroscope can be interchangeable, same for the four cameras. The detector table will be assembled and commissioned on the first half of 2024, when all the motorized axis is going to be tested in terms of guiding accuracy and repeatability. FaXToR will provide light to the users on the second half of 2024.

REFERENCES

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