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MULTIPLE DETECTOR STAGE AT THE MID INSTRUMENT OF EUROPEAN XFEL

A. Schmidt, G. Ansaldi, A. Bartmann, U. Boesenberg, T. Falk, J. Hallmann,
J. Möller, K. Sukharnikov, A. Madsen
European X-Ray Free-Electron Laser Facility, Schenefeld, Germany

Abstract

The Multiple Detector Stage (MDS) is an ancillary detector setup for the Materials Imaging and Dynamics (MID) instrument at the European X-Ray Free-Electron Laser Facility (EuXFEL). It is developed to improve the current capabilities concerning X-ray detection and make entirely new experiments possible.

A unique feature of the MID instrument is the large flexibility in positioning of the AGIPD detector relative to the sample. This enables a large variety of instrument configurations ranging from small-angle (SAXS) to wide-angle (WAXS) X-ray scattering setups. A recurrent request from the users, which is currently not enabled, is the option of simultaneously recording both wide- and the small angle scattering by using two area detectors.

The aim of developing MDS is to provide this missing capability at MID so that SAXS and WAXS experiments can be performed in parallel. The MDS will not be installed permanently at the instrument but only on request to provide as much flexibility as possible.

In this article, the background and status of the MDS project is described in detail.

INTRODUCTION

The basis for the MDS is a vacuum chamber which can host two small area detectors simultaneously. The detectors inside the vacuum chamber can be arranged differently with the help of two translation stages. The full chamber is assembled on a platform which includes a vertical motion. The platform also carries electronics required for the X-ray detectors, motors, and the vacuum system.

An important feature of MDS is that it can be positioned either on the existing arm of the XSIS instrumentation at MID [1], together with the AGIPD detector [2], or as a standalone device on a separate girder (Figs. 1 and 2). The girder stands on air pads, suitable for the floor in the MID experimental hutch. With this the MDS can be positioned inside the hutch and operated in parallel with the AGIPD detector. Space constrains and cable routing are limiting factors for the positioning. As day-1 configuration the MDS is used only in SAXS geometry, either mounted behind AGIPD on the XSIS arm, or on its own girder if AGIPD is positioned in WAXS.

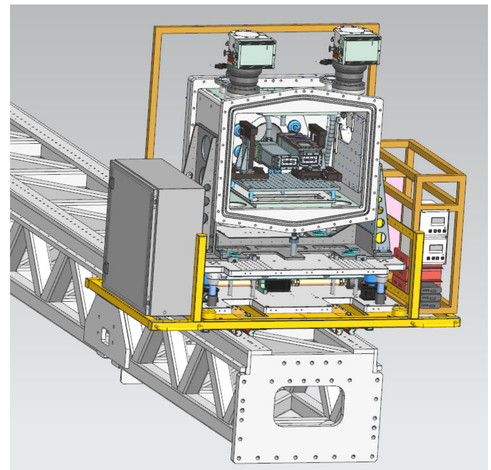

Figure 1: Vacuum chamber with detectors and platform with electronics of the MDS on the arm of the AGIPD at the MID instrument (CAD model).

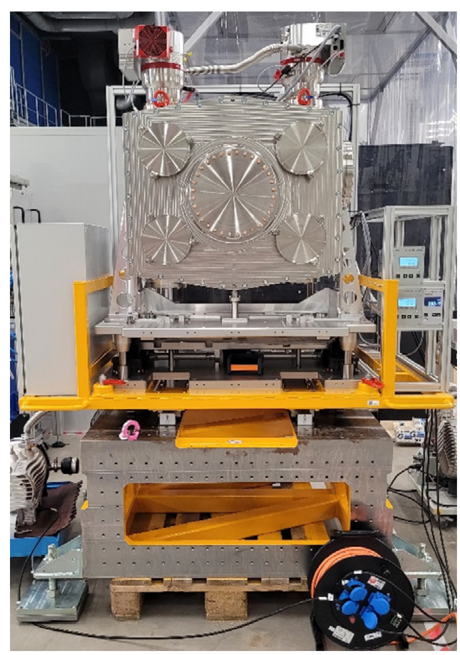

Figure 2: Assembled mechanics of the MDS on separate girder with air pads.

CONFIGURATIONS

The recurrent request of the user community for simultaneous wide- and small-angle scattering capabilities is the motivation behind the MDS project.

Experiments, where information about the scattering sample is required in-situ on both atomic (nm and sub-nm)

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and larger length scales (μm and sub-μm) would benefit enormously from such a setup. Another frequent request is to move a detector into the direct beam, for example for beam characterization, X-ray holography, or other X-ray imaging applications.

By positioning of the MDS on the XSIS arm behind AGIPD, such measurements are feasible (Fig. 3).

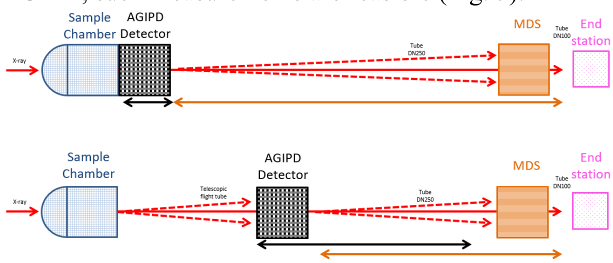

Figure 3: Sketch of the geometry with MDS positioned behind AGIPD on a common detector arm.

Another option provided by the MDS is its individual positioning independent of the AGIPD detector arm. For this purpose, a support girder was built were the MDS can reside on. The girder sits on air pads and can be moved freely on the high-quality floor of MID. Figure 4 shows that when the AGIPD detector is moved to WAXS, the MDS can cover the SAXS configuration. For further information about the girder see also the poster and paper [3] presented at this conference..

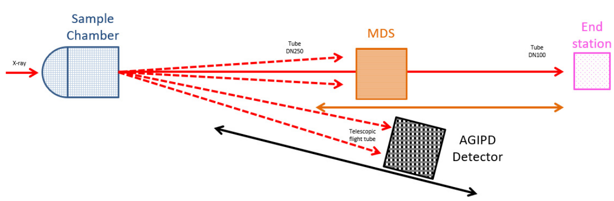

Figure 4: Sketch of the geometry with AGIPD in WAXS while MDS covers the SAXS region mounted on its own girder.

Detectors / Orientation

The MDS contains a high vacuum chamber with two detectors mounted on individual horizontal and vertical stages. The chamber can host versatile configurations and different types of small detectors. For instance, two ePix [4] or two Jungfrau [5] detectors can be operated in parallel and positioned in “elongated” and “square” arrangements (Figs. 5 and 6).

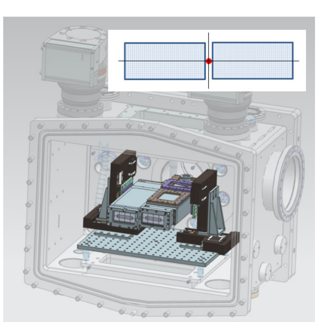

Figure 1: Elongated setup of two Jungfrau detectors.

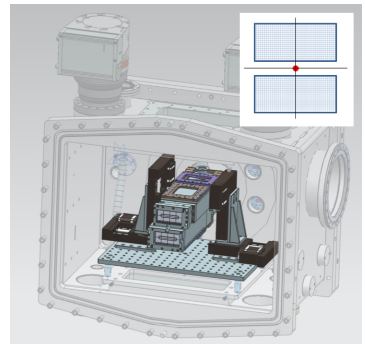

Figure 6: Square setup of two Jungfrau detectors.

Jungfrau Detector

The Jungfrau detector [4] must operate in air which means that for vacuum integration special precautions must be taken. For this purpose, an air housing was developed by the HED instrument of EuXFEL and also used at the MDS of MID (Fig. 7). The cables of the Jungfrau detector are guided out of the chamber from the air housing through a bellow mounted with an “inside-out” ISO-KF flange.

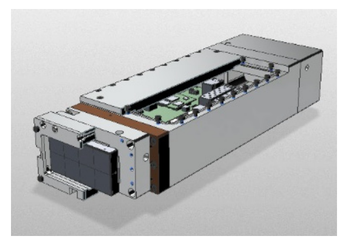

Figure 7: Jungfrau detector in air housing.

ePix

The ePix100 detector [5] can be operated in vacuum without any further measures and is hence installed in the MDS directly (Fig. 8).

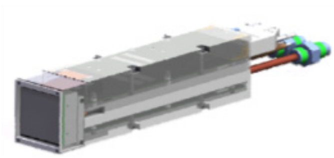

Figure 8: ePix100 detector.

Both detectors require cooling water which will be provided via the platform.

Relevant pixel and sensor parameters of the Jungfrau and ePix detector can be seen in Table 1.

Table 1: Compatible Detectors in Use for the MDS

Parameters	ePix (SLAC)	Jungfrau (PSI)
Sensor	300 μm Si	320 μm Si
Sensor size	704×768	512×1024
Pixel size	50 μm	75 μm
Repetition	120	2000 (200 tested)

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ENVIRONMENT

The MID instrument is designed with a "window less" option were all components in the beam are under vacuum. Therefore, vacuum beam pipes can be installed upstream and downstream of the MDS assuring vacuum conditions along the beam. Segmented flight tubes provide feasibility that the MDS can be installed at several positions along the beam direction (Fig. 9).

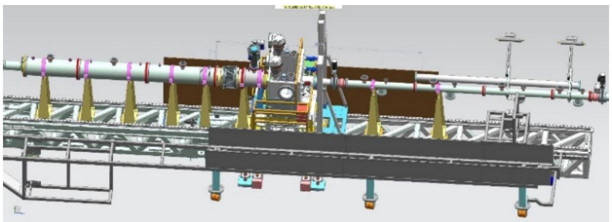

Figure 9: MDS integrated into MID beam line.

The front flange of the MDS detector chamber hosts four ISO-K window flanges were cameras can be installed but the flanges can also be used for quick access to the inner mechanics. A motorized beam stop is positioned in front of the MDS, directly attached to the front flange. It consists of a tungsten piece and can be placed to block the direct beam, if required. A small X correction is integrated in the Y Stage of the beam stop (Fig. 10).

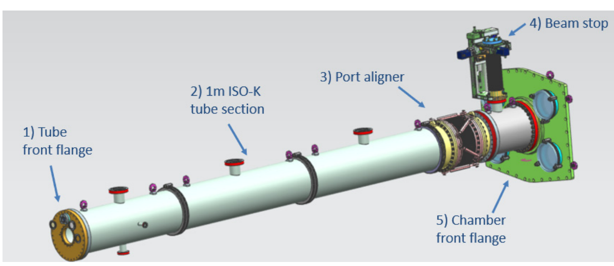

Figure 10: 1) Tube front flange, 2) Flight tubes, 3) port aligner, 4) beam stop, and 5) front flange.

For more details of the Front assembly please see [3].

ELECTRICAL COMPONENTS

All the relevant electronical components are located on the sides of the platform. A local crate on the left side will host the power supply and Beckhoff modules for driving the motors (Fig. 11). On the right-hand wing, IT patch panels, detector electronics, and the vacuum pump controller are located.

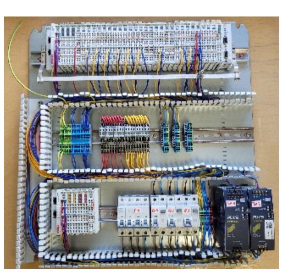

Figure 11: Electronics of the local crate with Beckhoff PLC for the motors.

VACUUM SYSTEM

Two turbo pumps (Pfeiffer, HiPace 300M) connected at the top of the chamber will assure the requested vacuum level of < 5×10^{-6} mbar. They are backed by a scroll pump (Edwards, nXDS20i). A venting unit with particle filter, pressure relief valve, and an angle valve for rough pumping (if requested) are attached at the back of the chamber at DN40 ports (Fig. 12). All this is provided by VAT. All components can be controlled remotely with the EuXFEL control system KARABO [6].

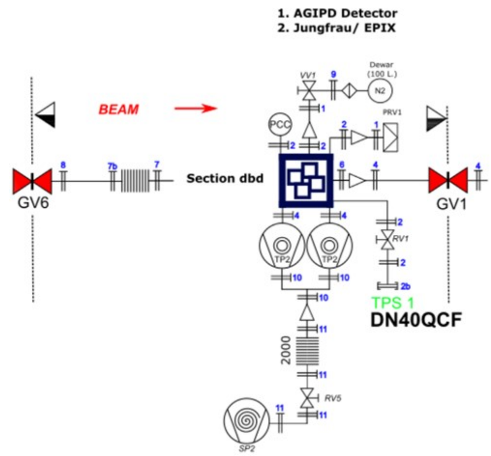

Figure 12: Vacuum scheme of MDS.

STATUS AND OUTLOOK

The MDS is not in operation so far. Most of the mechanical parts are available or under procurement and manufacturing of the electronics is at an advanced stage. A first vacuum test has been performed of the chamber in a realistic configuration and 5×10^{-7} mbar was reached. The detectors are in use at the instrument and will be integrated into the MDS soon.

Once the requirements of the day-1 configuration are fulfilled by the setup, a day-2 configuration will be studied. The aim of day-2 is to employ the MDS in WAXS position, independent of AGIPD.

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