MINIMIZING EXPERIMENTAL SETUP TIME AND EFFORT AT APS BEAMLINE 1-ID THROUGH INSTRUMENTATION DESIGN

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MECHANICAL ENGINEERING DESIGN OF SYNCHROTRON RADIATION EQUIPMENT AND INSTRUMENTATION

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ABSTRACT

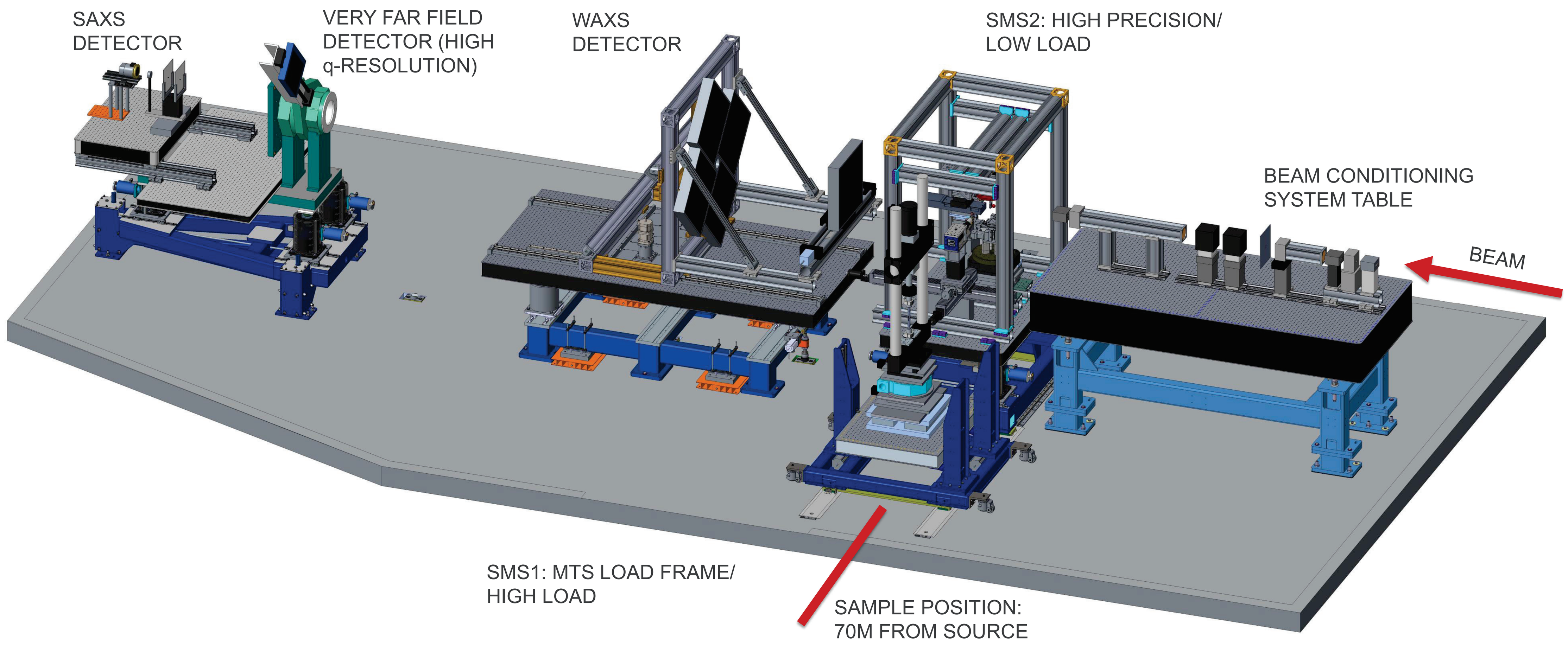
Sector 1-ID at the APS accommodates a number of different experimental techniques in the same spatial envelope of the E-hutch end station. These include high energy small and wide angle x-ray scattering (SAXS and WAXS), high energy diffraction microscopy (HEDM, both near and far field modes) and X-ray tomography. These techniques are frequently combined to allow the users to obtain multimodal data with 1 um spatial resolution and 0.05º angular resolution. Furthermore, these techniques are utilized while the sample is thermo-mechanically loaded to mimic real operating conditions. The instrumentation required for each of these techniques has been designed and configured in a modular way with a focus on stability and repeatability between changeovers. This not only allows the end station to be used for a greater number of techniques but it also results in a reduction of time and effort typically required for set up and alignment. Key instrumentation design features and layout of the end station are presented.

EXPERIMENTAL TECHNIQUES AT BEAMLINE 1-ID

Three primary techniques are supported at the 1-ID-E end station:

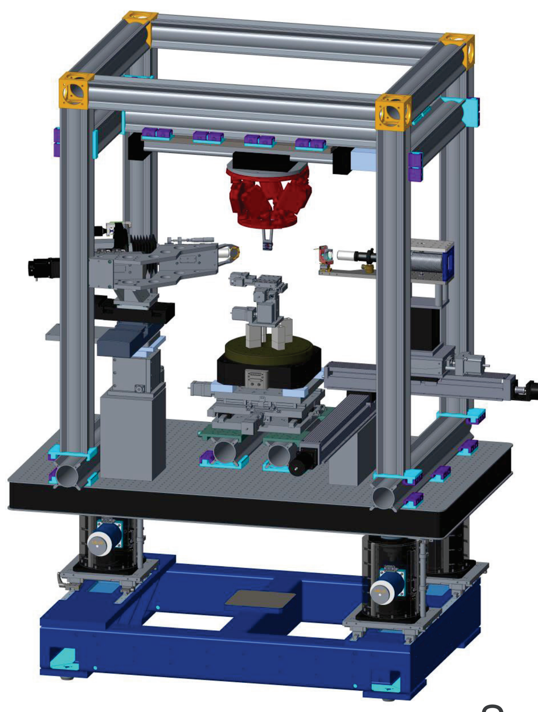
- **Small and wide angle X-ray scattering (SAXS/WAXS):** While these two techniques are typically supported individually, the unique WAXS detector array at the 1-ID-E end station allows the combination of the two techniques. WAXS provides information such as phase volume fraction, preferred crystallographic orientation, and aggregate-average strain. SAXS provides information such as precipitate or void size distribution. The combined technique is capable of interrogating a wide range of length scales and is particularly useful in investigating polycrystalline materials with small grains (1 um or less) and/or large prior deformations.
- **High-energy diffraction microscopy (HEDM):** This novel technique is capable of non-destructively characterizing individual constituent grain in a polycrystalline aggregate. Several variants of this technique exist; depending on the location of the detector, the morphologies and intragranular crystallographic orientation information of the grains (near-field) or the average crystallographic orientations, positions, and stress tensors associated with the individual grains (far-field) can be obtained.
- **Tomography:** While tomography is a widely available technique by itself , the ability to combine SAXS/WAXS or HEDM with high resolution (1 um) phase or absorption contrast tomography is quite unique and allows the users to gain a more complete picture of material behavior at these length scales.

BEAMLINE 1 ID CONFIGURATION



The configuration of the hutch has been largely driven by user requirements. The user groups supported by the 1-ID beamline are diverse, ranging from university research groups investigating the micromechanics of materials at a more fundamental level to large corporate users interested in process optimization. In addition to utilizing the instrumentation already existing at the beamline, many users want to bring their own experimental components such as custom load frames, environmental chambers or heaters. The modular configuration and organization of the hutch are critical to accommodating these custom components and handling frequent setup changeovers with the least amount of time and effort.

KEY INSTRUMENTATION DESIGN FEATURES FOR SIMPLIFYING SET UP AND ALIGNMENT EFFORT

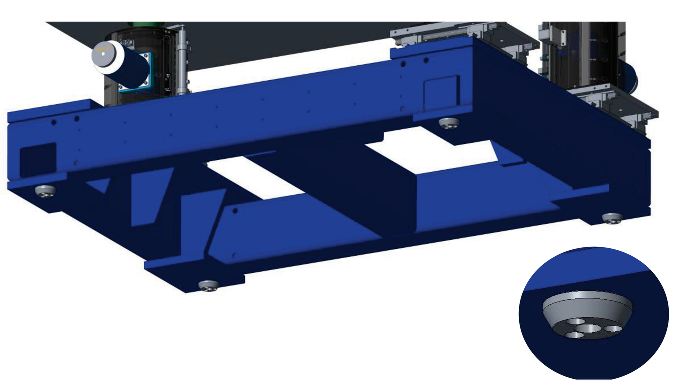


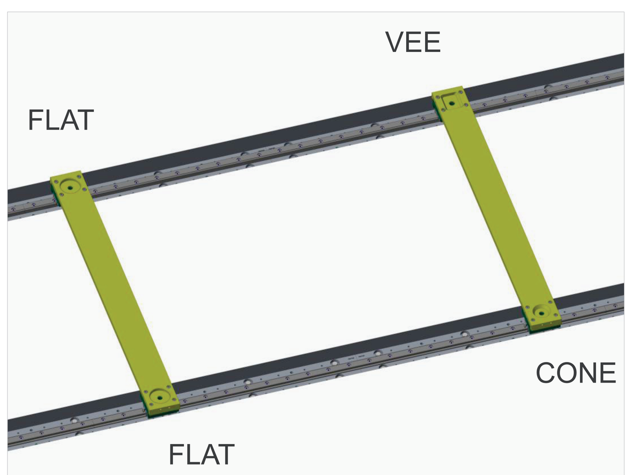
OVERHEAD RAIL SYSTEM

The high-precision/ low load SMS is equipped with an extruded aluminum rail frame mounted to the support table. The cube shaped structure is used for mounting auxiliary components including their motion systems. The sample remains in a fixed position while equipment is repositioned around it.

Supported components include:

- Digital imaging correlation (DIC) camera
- Conical slit cell and manipulator
- Furnaces
- Laser distance sensors
- Radiation shielding
- Numerous cables and lines





FLOOR RAIL SYSTEM

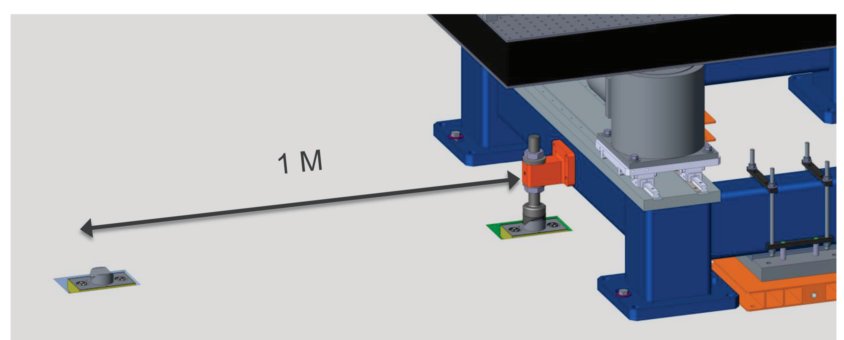
A set of two parallel linear profile rails have been installed in recessed pockets in the concrete floor. Each SMS is permanently mounted to the rail system and can translate transverse to beam direction into or out of position.

In the case that custom equipment which does not use the rails must be brought in, a set of low profile trough covers are put into position to cover the rail system. Equipment can then be wheeled over the rails and people can safely walk over the troughs as well.

WAXS DETECTOR

Since the initial installation, the detector's support table has been retrofitted with air pads and upstream and downstream locators to increase its range and coverage. The alignment scheme consists of one vee on the downstream end of the table and one cone on the upstream end of the table. Two sets of receivers installed into the concrete floor are in line with the beam and allow the table to gain an additional 1m in panel throw.

The air pads and locating system are also used to position the detector panel array asymmetrically from the beam to increase or change coverage or to be moved out of the way completely for use of the VFF detector setup.



FUTURE PLANS: NEW OVERHEAD FRAME

A permanent overhead frame made out of structural steel tubing is currently in design to replace the temporary extruded frame. The new structure will span the width of the hutch and provide a universal framework with additional motions incorporated (both manual and motorized) which can allow components to be moved into position as needed without repeated mounting and alignment. The near field and tomography detectors may join the group of components which will be suspended from the structure.

SUMMARY

Beamline 1-ID accommodates a number of complimentary techniques and sample environments in the same spatial envelope. The configuration of the hutch has evolved to minimize the time and effort required for changeovers between techniques. Instrumentation design features have been incorporated to achieve maximum stability and repeatability of both the instruments and sample. In addition, flexibility exists for users to install their own custom sample environments. New instrumentation can be designed or modified to adapt for installation to the floor rail system. The configuration of the end station will continue to evolve with the needs of users.

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