EUCALL - WP6 – HIREP

Milestone 6.1: M2 / 30.11.2015

„Specification for sample holder and sample stages“

In WP6 (HIREP) there exist two kinds of user communities in different scientific fields and there are contradictive demands regarding the sample holders and sample stages. Thus the decision was made to split the specifications for these components into two standards which will satisfy the needs of each community relating to their specific samples and experiments. For the exchange of samples between the two user communities the use of adapter components is foreseen.

The two specifications meet the following experimental demands:

1. **Small sample holder and ultra-high precision cryo sample stage.**
   Serial crystallography and imaging experiments at both XFEL and synchrotron facilities require a large number of particles such as small crystals or cells to be presented to the beam with rapid sample exchange. The sample presentation can be achieved either by a jet or, as proposed here, by a chip with a large number of particles. Particles size are typically below 5 µm or larger. Each particle can only be exposed once due to the radiation damage but the damage is local. The particles are arranged on a 2-dimensional grid with a typical spacing / period of 10 µm, or though the spacing can also be much larger depending on the sample holder design. The translation stages must be compatible with a vacuum environment and with the sample holder being held at cryogenic temperatures (typically liquid nitrogen temperature).

   The specifications defined here are based on already existing sample holders and on what can be expected to be developed in the coming years. The design will allow different types of sample holders to be inserted in a common support frame with standardized fiducial marks to allow accommodating different sample holders developed by the user community.
   The small sample size requires a positioning accuracy (with respect to the sample holder fiducials) better than 100 nm to allow 10% error with an assumed minimal sample size of 1 µm. A continuous scan at 100 Hz with a 1 µm beam would require a speed of 1 mm/s to reach the next sample at a distance of 10 µm. Experiments with kHz frame rates would require even higher translation speeds.
   We plan to have a unique identification label for every sample holder to assign the correct target position dataset and to generate a history for each sample holder. Due to the small size of the sample holder the possibility of an identifier has to be further investigated.

table 1.1 specification of the sample stage for the small sample holder		
attribute	**value min**	**value max**
travel range	2 mm	10 mm
accuracy	10 nm	100 nm
speed	1 mm/s	5 mm/s

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table 1.2 specification of the small sample holder		
attribute	**value min**	**value max**
target area width	1 mm	10 mm
target area height	1 mm	10 mm
sample frame thickness	10 µm	200 µm
# of reference marks	3	4
types of reference marks	knife edge, pinhole, fluorescence marker	
ID label	to be defined	

2. **Large sample holder and high precision sample stage.**
   Experiments with high power lasers are greedy in terms of target area. One full-power pulse will destroy the surrounding material in a diameter up to several millimeters. Thus the sample holder has to provide a sufficient large usable area for long-lasting measurements and the stage must supply the necessary speed to reach the next target spot in the interim time between two laser pulses.

The precision of the three translations which are performed by the sample stage are defined by the dimensions of sample, focus and overlap volume using pump-probe-setups. Taking the requirements of the performed and planned experiments into account the accuracy of such stage should be better than 1µm in all three dimensions. Moreover, the electronic devices and equipment within the target chamber and in the surrounding rooms are susceptible to damage and malfunction by EMP (**e**lectro**m**agnetic **p**ulse) induced voltages. Due to the high electromagnetic fields generated by the laser-target interaction close to the sample, the electronic components of the sample stage have to be protected by shielding or located in a safe distance.

For the large sample holder we specify a modular system consisting of a **carrier frame** whose outer shape is specific to each facility, laboratory and/or instrument and an inner **sample frame** which fulfills the requirements relating to the different samples and the specific types of experiments.
Firstly, this concept allows the WP partners to design a highly specialized carrier frame for their instruments taking into account restricting boundary conditions:

- design limiting space requirements (optics, detectors,. .. around the sample stage)
- optical access to the sample (alignment procedures,)
- vacuum environments (UHV compatible materials and design)
- cryogenic environment
- magnetic environment (space requirements in matters of twin coil magnets)
- storage and transfer systems (automated handling of the carrier frames)
- radiation protection (target activation depending on the material)
- stage / scanner design (motor concept, fixation mechanism)

Secondly, the inner sample frame can be designed to fulfill the requirements of a specific experiment and/or type of sample.
The standard, which will follow this specification, will define:

- the interface between the carrier frame and the sample frame (geometry and fixation)
- the dimension of the target area inside the sample frame
- the overall thickness of the sample frame to fit into the devices of all participating partners

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- the possible types and positions of the reference marks on the sample frame or on the target itself, that are used for:
    - the optical target localization before the high repetition rate experiment
    - the alignment of the sample holder before and during the actual experiment
- the consecutive numbering of the sample frames by either QR- or bar code to link the target position data to the correct frame

Users of the participating facilities would mount their samples on target frames, which are optimized for their experiment and sample and could be fixed in the carrier frames of every participating facility. The target locations inside the sample frame would be determined before the experiment by optical (2D/3D) microscopy using the reference marks on the sample frame or on the target itself. The target position list would be independent from the carrier frame and can be used at every facility.
The sample frame or the target itself exhibits a unique identification label to assign the correct target position dataset and to generate a history for each sample frame or target.

table 2.1 specification of the sample stage for the large sample holder

attribute	value min	value max
travel range	100 mm	120 mm
accuracy	1 µm	10 µm
speed	1 mm @ 10 Hz start/stop	5 mm @ 10 Hz start/stop
EMP	hard by build or disconnected during laser pulse	
heating	none	120 °C

table 2.2 specification of the large sample holder

attribute	value min	value max
target area width	100 mm	120 mm
target area height	100 mm	120 mm
sample frame thickness	6 mm	10 mm
# of reference marks	3	4
types of reference marks	knife edge, pinhole, fluorescence marker	
ID label	numbers and (bar code or QR code)	
temperature range	room temperature	150 °C

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