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DESIGN OF A FLEXIBLE RIXS SETUP

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Abstract

We present a new mechanical design for a RIXS experiment setup consisting of a sample environment vacuum chamber and corresponding spectrometer. It allows variable beam incidence angles to the sample as well as observation angles of the spectrometer.

The dispersive element of the spectrometer can be aligned in five DOF by motors inside the UHV chamber. The alignment of the CCD detector can be adjusted independently in the lateral and longitudinal position as well as incidence angle. In combination with a tiltable detector chamber this design allows for multiple observation methods, not limited to variable energies but also for use of different optics or direct observations of the sample.

REQUIREMENTS AND EXPERIMENT SETUP

Requirements for the setup are according to Fig. 1, as well as Table 1. In Addition the entire spectrometer Setup must rotate around the Sample Chamber.

The setup need not support changing the entire scattering angle field without breaking vacuum. Rather a cost effective yet easy to use and quickly changeable support structure has to be chosen.

The design of the sample chamber is fixed from the beginning of the design phase which also restricts placement of mechanics and supporting infrastructure.

To observe RIXS photons at the energy spectrum from 50 eV to 650 eV the positions of grid and detector have to be changed. The optical parameters are optimized to space constraints (available area at end station as well as placement of objects and assembly space required) and imaging qualities on the detector.

In addition to the ranges of movement of grid and detector according to Fig. 1 and Table 1 the setup can move the detector to any position in the rectangle defined by the two extreme points. Also horizontal view from sample to detector is possible.

SAMPLE ENVIRONMENT AND SUPPORT STRUCTURE

Figure 2 shows an overview of the experiment. The sample is located in a vertical, cylindrical vacuum chamber and is inserted from the top. Figure 3 shows the sample holder mechanism. The top flange of the chamber is a rotating feedthrough which supports the sample holder and additional infrastructure. The sample can be cooled to 25K or heated to about 350K.

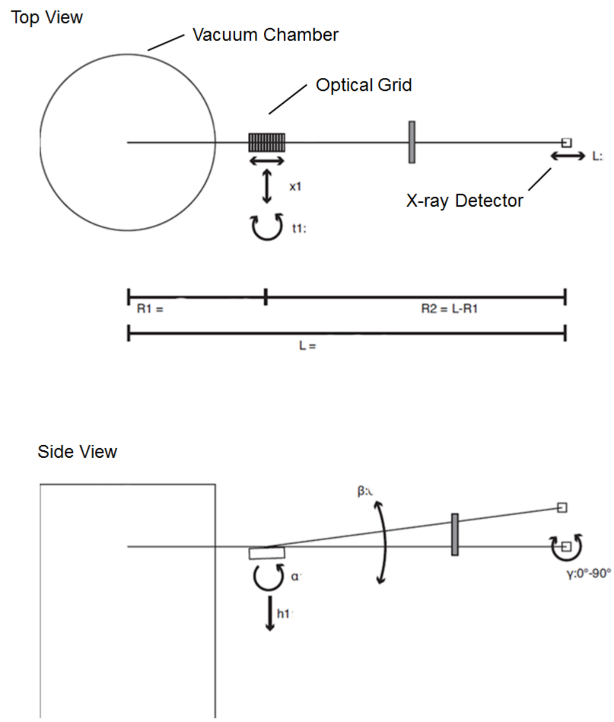

Figure 1: Position and movement parameters for optical elements.

Table 1: Correlation of RIXS Photon Energy and Positions of Optical Elements (Refer to Figs. 2 and 5)

Energy eV	R_1 mm	L mm	α deg	β deg	γ deg
50	300	1347	87,9	75,8	53,5
200	364	1240	87,9	82,7	23,1
400	399	1183	87,9	84,6	17,4
650	422	1146	87,9	85,6	13,9

To vary the angles between beam incidence on the sample and observation angle of the spectrometer a cost-effective solution was chosen. The beamline is connected to the chamber by a motor driven bellow system (see Fig. 4) that can vary incidence angles of $\pm 15°$. For larger changes of incidence angle however the vacuum connection has to be broken and the bellow system has to be attached to another flange. By using all ports on the sample chamber any scattering angle can be reached.

The chamber is mounted on a support structure that can be adjusted to multiple beam heights above the floor and has

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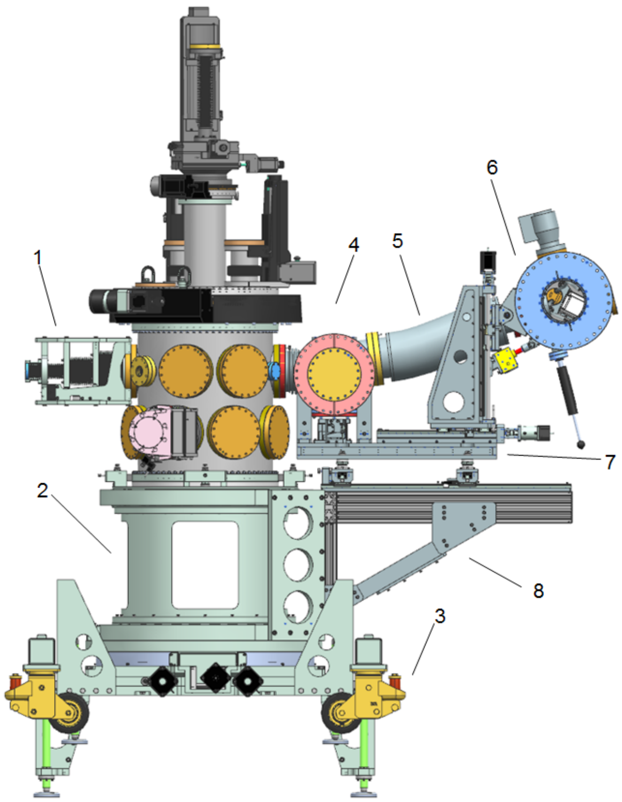

Figure 2: Overview of the experiment. Motor driven bellow system (1), support structure (2), gear system (3), grid chamber (4), DN150 bellow (5), detector chamber (6), spectrometer alignment table (7), rotating spectrometer support structure (8).

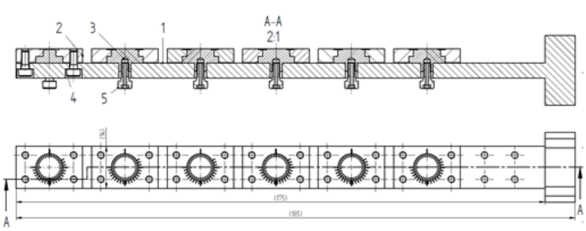

Figure 3: 6 way sample holder and adjustment system.

foldable wheels for easy transport of the entire setup. The lower alignment system of the setup has motor driven x- and y-stages as well as a rotational stage about the z axis for fine tuning of the position. Figure 5 shows an overview of the support structure.

To allow for variable observation angles with the spectrometer the support structure features a DN500 diameter rotational bearing that connects the spectrometer support to the chamber support. This rotational support can be locked in positions perfectly aligned with the flanges of the chamber.

SPECTROMETER DESIGN

The vacuum layout of the spectrometer consists of a grid chamber (DN250) that is connected to the sample chamber,

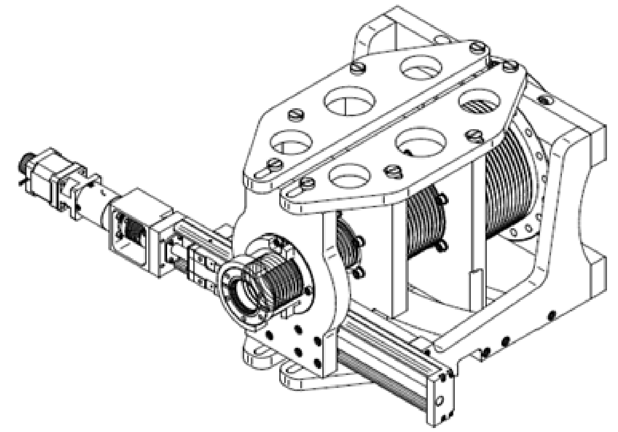

Figure 4: Motor driven bellow system to connect the beamline to the sample chamber.

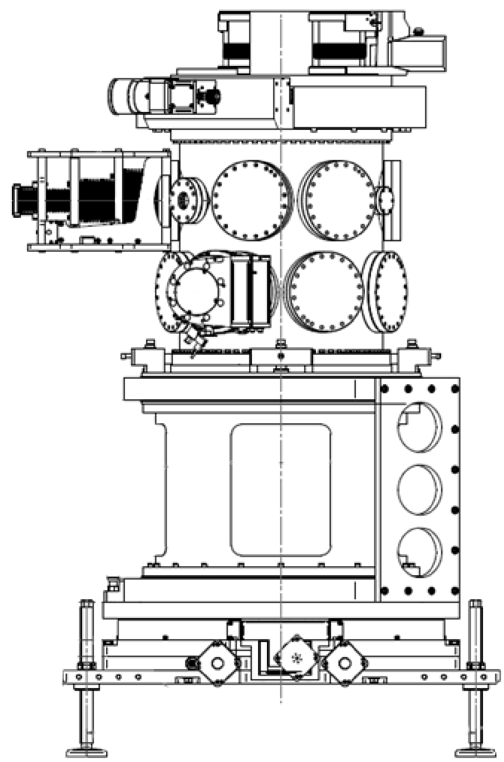

Figure 5: Support structure of the sample chamber.

and a detector chamber (DN300) connected to the grid chamber via a DN150 edge welded bellow. The grid chamber is fixed on a alignment table that sits on top of the rotating spectrometer support structure. It is used to perfectly align the spectrometer inlet flange with one of the sample chamber flanges. In addition it allows the spectrometer to be moved away from and clear the sample chamber during rotation to another sample chamber flange.

The detector chamber is supported in a three axis motor driven frame which sits on top of the alignment table. This frame can move the chamber in the x and z direction and

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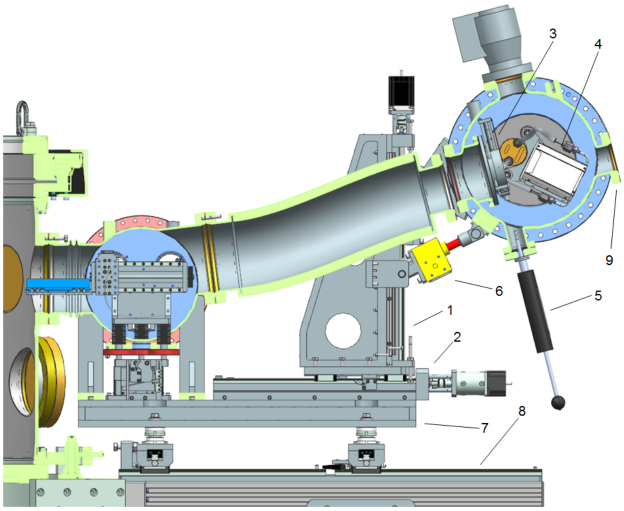

Figure 6: Cross-section view of the Spectrometer.

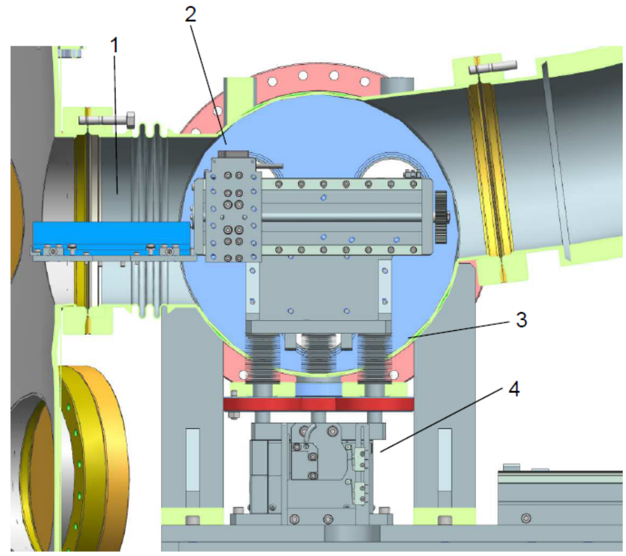

Figure 7: Cross section detail view of the grid chamber.

also tilt the chamber so that its inlet flange always points in the direction of the sample.

Figure 6 shows a cross-section overview of the spectrometer with the following positions: 1: Detector chamber z lift support and actuator, stepper motor with trapezoidal threaded shaft, two parallel linear guides; 2: Detector chamber x actuator and support, actuator same as for z lift; 3: Filter/Shutter Unit; 4: Detector, mounted on rotating feedthrough on the backside flange of detector chamber, electrical and cooling feedthrough; 5: manual linear feedthrough to operate Filter/Shutter unit Pos. 3; 6: Detector chamber tilt actuator. Allows to optimize the inlet aperture to be optimized and also to provide direct view to sample through flange Pos. 9; 7: Spectrometer support structure. Adjusts detector chamber to sample chamber and slides back on rails of rotating support Pos. 8 when changing flanges; 8: Rotating support structure. Fixed on sample chamber support structure, rotates 360°; 9: Observation port with DN63 window flange.

The internals of the grid chamber are shown in Fig. 7 with the following positions: 1: Grid holder, easily changeable; 2: Grid stage x axis (see Table 1, parameter R_1); 3: Grid z axis feedthrough, 4: Grid z axis actuator, lower the grid to allow direct incidence from sample to detector. The positioning unit that supports the grid from the x axis stage is not shown due to a pending patent application at the time of paper submission.

CONCLUSION AND OUTLOOK

Design, manufacturing and assembly of this first stage is complete and the first measurements are ongoing. Even with not all motorized axes yet available the alignment and handling of the setup is very easy. Also the alignment, handling and stability of the dispersive element and the detector is well within the specified parameters for precision.

The design of the positioning unit for the dispersive element is currently patent pending.

A planned upgrade of the setup will rotate the spectrometer by 90°so that the detector moves in the horizontal plane.