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TWO-ROTATION MECHANISM FOR AN IN VACUUM BEAMSTOP

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Abstract

At Small-angle X-ray Scattering beamlines (SAXS), beamstops are needed to block the intense primary beam that has not been scattered by the sample in order to protect the detector from any damage. Beamstops are usually confined inside a vacuum tube minimizing air space between the sample and the detector. For certain experiments, a motorized beamstop is required to achieve a precise positioning in different regions of the detector active area. ALBA has developed a new motorized beamstop consisting of a two-rotation mechanism inside vacuum that composes a movement able to cover all range of the active area of the detector. The presented solution involves a main rotation reached by a gear and a worm drive actuated by a stepper motor and a second rotation relative to the main one produced by a piezo rotation stage. For each position appears two different solutions. This characteristic permits take two equivalent images in the detector with the same beamstop position but different orientation in the beamstop support; thus permitting the compensation of the support shadow on the active area of the detector.

INTRODUCTION

At SAXS beamlines, beamstops are needed to block the intense primary beam that has not been scattered by the sample in order to protect the detector from any damaged. Beamstops are usually confined inside a vacuum tube minimizing air space between the sample and the detector. For certain experiments (for example SAXS/WAXS or GSAXS), a motorized beamstop is required to achieve a precise positioning in different regions of the detector active area.

ALBA has developed a new motorized beamstop consisting of a two-rotation mechanism inside vacuum that composes a movement able to cover all range of the active area of the detector (Fig. 1), permitting for each position appears two different solutions.

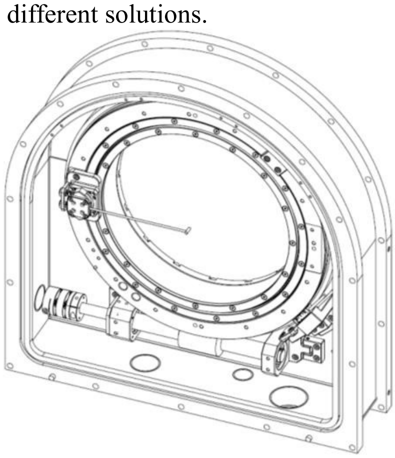

Figure 1: Beamstop main view.

TECHNICAL SPECIFICATIONS

The motorized beamstop must comply with the following specifications:

- Cover all range of the active area of the SAXS detector (210x210mm).
- Obtain two solutions for each position demanded.
- In vacuum motorized movements.
- 5µm resolution.
- 1 rpm speed.
- Compact and integrated in the current Flight Tube of the End Station.
- Mounting interface DN320 ISO-K.
- Vacuum compatible (10^{-2}mbar).

DESIGN

The complete mechanism is confined in a vacuum chamber that belongs to the vacuum flight tube between the sample and the detector. The mechanism involves a main rotation reached by a gear and a worm drive actuated by a stepper motor and a second rotation relative to the main one produced by a piezo rotation stage (Fig. 2). The vacuum chamber contains fixed supports for appropriate bearings which permit the main rotation of the axis. The relative rotation holds the beamstop support that consists of a rod usually made of a material partially transparent to the beam. Finally, the beamstop itself is mounted in the extreme of this support and consists of a cylindrical block of an opaque material to the beam.

This motorized beamstop is more compact and shows a better stability than other conventional alternatives such as linear stages due to a shorter and stiffer beamstop rod and a more packed mechanism.

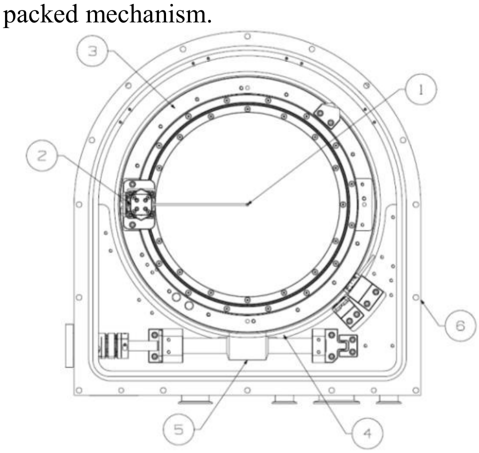

Figure 2: Parts breakdown. (1) Beamstop, (2) second rotation, (3) main rotation, (4) gear, (5) worm drive, (6) vacuum chamber.

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MOVEMENTS DESCRIPTION

The beamstop is moved with the relative rotation and in turn, the latter is driven by the main rotation (Fig. 3). Moving each rotation a certain angle, the mechanism covers the full active area of the detector and permits the positioning of the beamstop at any point.

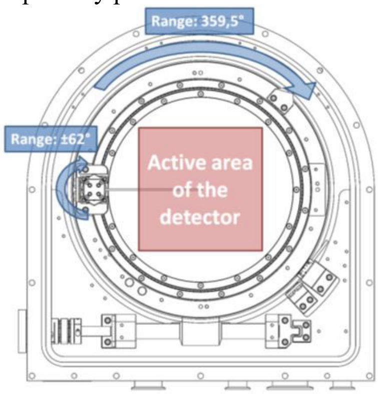

Figure 3: Movements description.

For a position of the beamstop given by the coordinates (a,b), the solutions of a system of polynomial equations of two circumferences, one with the centre in the main rotation (0,0) and the other with the centre in the beamstop position (a,b), are the two points of intersection between them. With these two intersection points it is possible to resolve the two angles for each of the two solutions (Fig. 4).

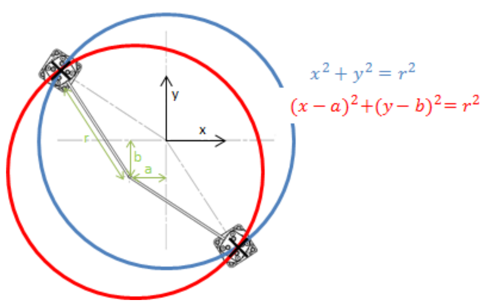

Figure 4: Polynomial equations.

At the same time, these two solutions allow to take two identical images in the detector with the same beamstop position but different orientation in the beamstop support (see example in Fig. 5).

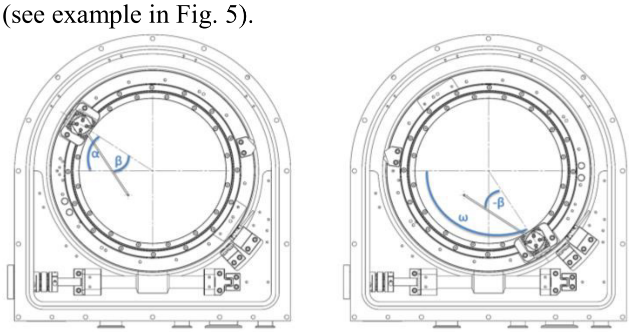

Figure 5: Two solutions for the same position.

ASSEMBLY, TESTS & INSTALLATION

The manufacturing of the parts and their assembly have been performed following high vacuum cleaning procedures (Fig. 6).

Figure 6: Vacuum cleaning procedures during assembly.

In order to test the pseudo motors (x-y movements based in the two rotation movements), a laser tracker and a prism attached to a beamstop dummy has been used. The laser tracker provided several positions of the beamstop dummy and these measurements were correlated with the theoretical position given by the equations in order to validate the control system.

Finally, the beamstop was installed in the Flight Tube section in the End Station of NCD beamline.

RESULTS

Figure 7 shows an example of two equivalent scattering patterns of the same collagen fiber with the same beamstop position but with different orientation of the beamstop support.

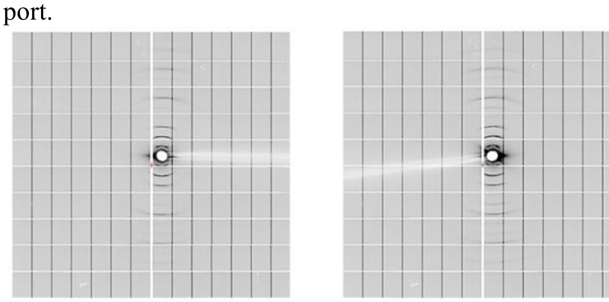

Figure 7: Two equivalent scattering patterns of the same collagen fiber.

CONCLUSION

In summary, a design of an in-vacuum motorized beamstop based in a two-rotation mechanism that composes a movement able to cover all range of the active area of the detector and permits two solutions for each position has been presented. This design has been patented under the Spanish Patent and Trademark Office and No. P201631058 [1].

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Saló; Engineering Alignment Group, Marta Llonch; Vacuum Group, David Calderón, and Lluis Ginés.

REFERENCES

[1] J.B. González & C. Colldelram, “Dispositivo de tope para haces de radiación”, Spanish Patent and Trademark Office and No. P201631058, Aug. 1, 2016.