MOTION CONTROL ARCHITECTURE AND KINEMATICS FOR MULTI-DOF KIRKPATRICK-BAEZ FOCUSING MIRRORS SYSTEM AT LNLS-SIRIUS

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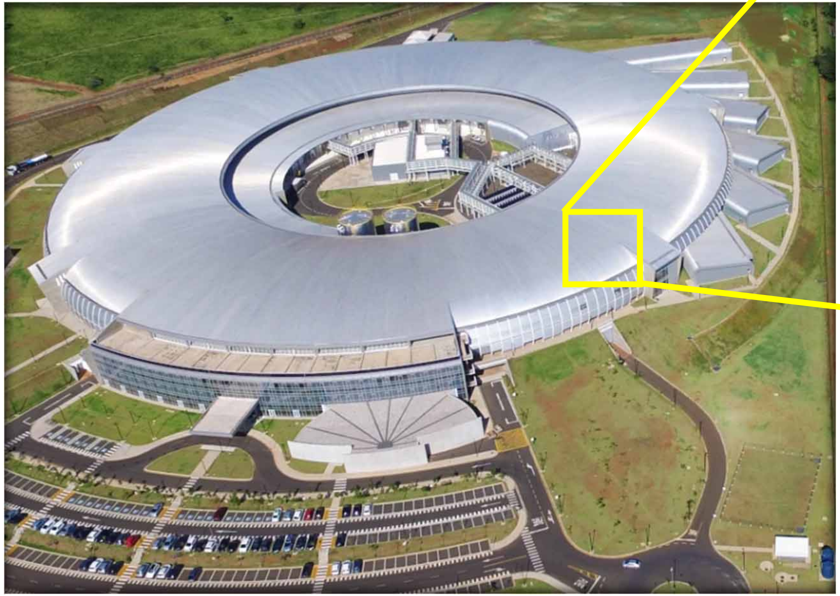
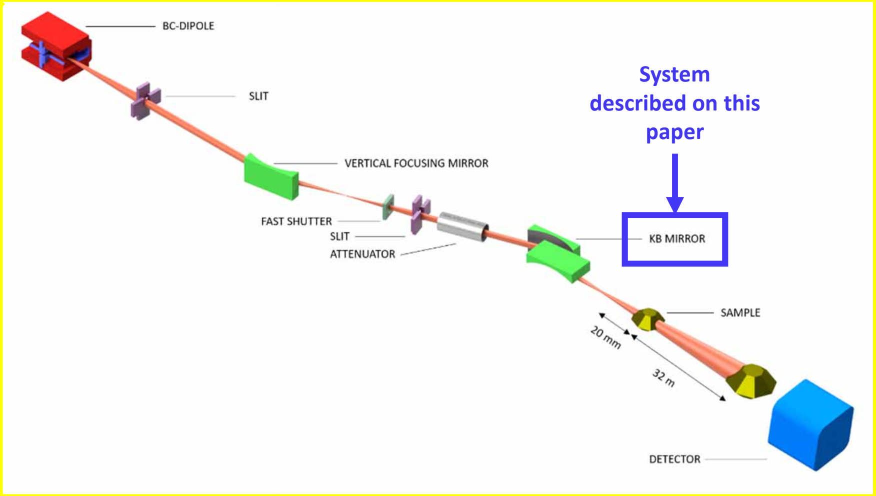
INTRODUCTION

- SIRIUS Light Source.
- MOGNO Beamline.





MOGNO is a world leader in micro and nano images using X-Ray techniques in continuous zoom:

- Tender X-Ray (22 and 39 keV);
- Hard X-Ray (67.5 keV).

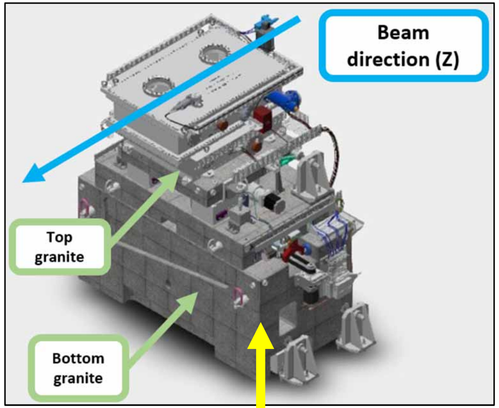
Optimized for 4D acquisitions (time resolved)

Kinematics by Layers structure

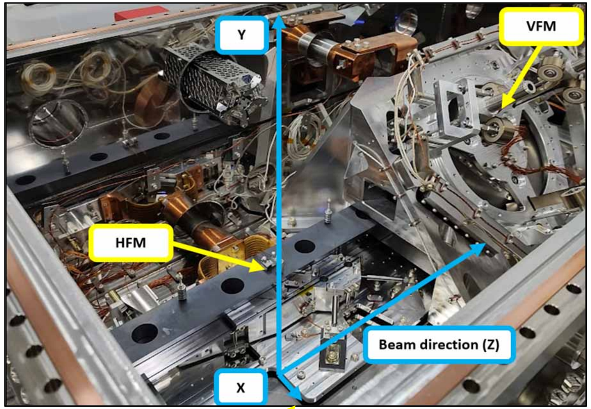
Objective of the structure

The construction between a long-stroke and a short-stroke allows a flexible changing between stripes in short periods, without losing the primal functionality, which is guaranteeing the beam stability.

Long-Stroke (granite bench)
Short-Stroke (internal mechanism)



Internal mechanism: horizontal focusing mirror (HFM) and vertical focusing mirror (HFM)



Controls the bench motors (steppers)

DELTA TAU Data Systems Inc.

Control architecture in RT (described in the next slides)

PI

Moves internal mechanism in open-loop using piezos (**nano precision!**)

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Forward Kinematics of the internal mechanism: modelling

Tripod construction (VFM)

To model the Forward Kinematics equations of VFM, the following relations must be applied:

$$p_1 = \begin{bmatrix} 0 & 1 & 0 \end{bmatrix} \cdot \left(Rot_x(\theta_{x'}) \cdot Rot_z(\theta_{z'}) \cdot \begin{bmatrix} r_{1,x'} \\ r_{1,y'} \\ r_{1,z'} \end{bmatrix} + \begin{bmatrix} 0 \\ T_{y'} \\ 0 \end{bmatrix} \right)$$

$$p_2 = \begin{bmatrix} 0 & 1 & 0 \end{bmatrix} \cdot \left(Rot_x(\theta_{x'}) \cdot Rot_z(\theta_{z'}) \cdot \begin{bmatrix} r_{2,x'} \\ r_{2,y'} \\ r_{2,z'} \end{bmatrix} + \begin{bmatrix} 0 \\ T_{y'} \\ 0 \end{bmatrix} \right)$$

$$p_3 = \begin{bmatrix} 0 & 1 & 0 \end{bmatrix} \cdot \left(Rot_x(\theta_{x'}) \cdot Rot_z(\theta_{z'}) \cdot \begin{bmatrix} r_{3,x'} \\ r_{3,y'} \\ r_{3,z'} \end{bmatrix} + \begin{bmatrix} 0 \\ T_{y'} \\ 0 \end{bmatrix} \right)$$

...in which:

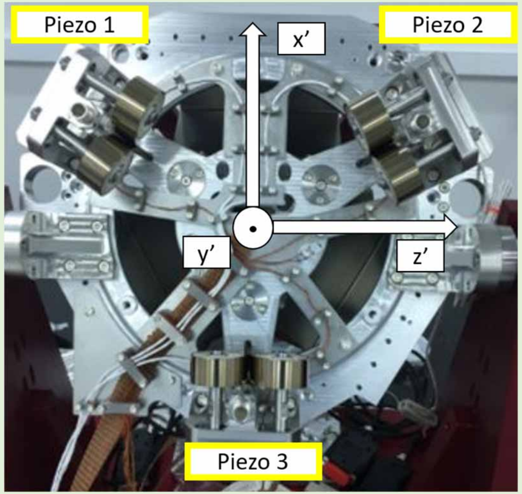
$$Rot_x(\alpha) = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos(\alpha) & \sin(\alpha) \\ 0 & -\sin(\alpha) & \cos(\alpha) \end{bmatrix}$$

$$Rot_z(\alpha) = \begin{bmatrix} \cos(\alpha) & -\sin(\alpha) & 0 \\ \sin(\alpha) & \cos(\alpha) & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

This construction:

- Allows a flexible Stripes update (movement in Y' axis brings movement in Y and X axes) ✓
- Allows a kinematic construction solvable numerically inside PowerBrick LV controller in RT ✓

Tripod construction

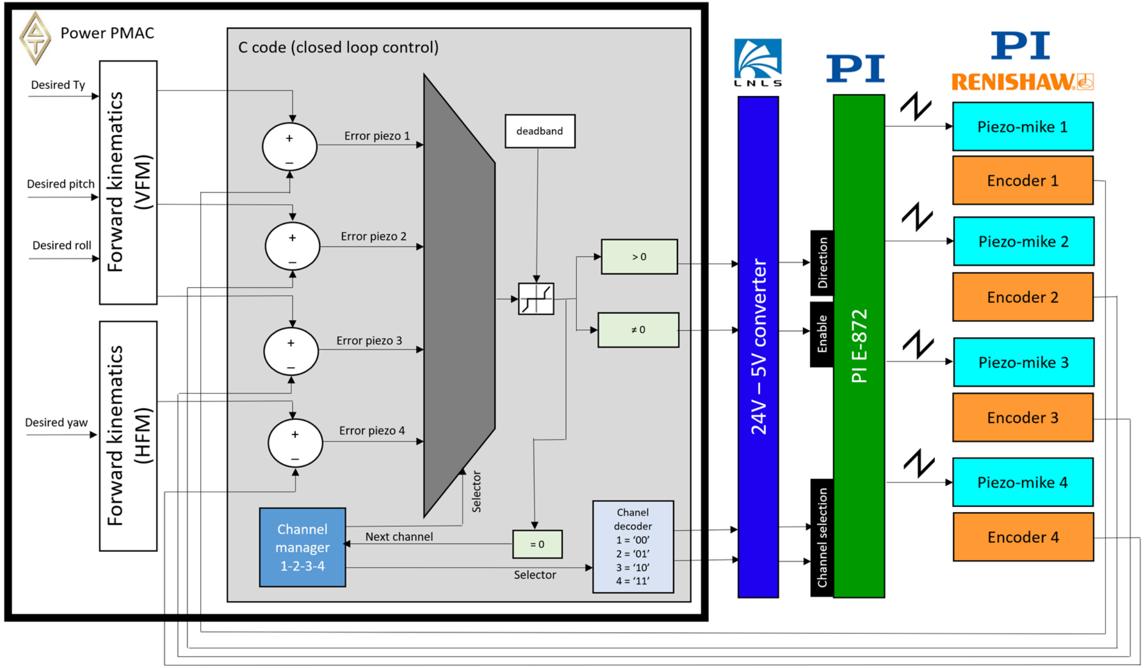


Obs.:
- Plane composed by piezos is rotated in 45° around Z axis.
- Piezos act in Y' direction.
- Encoders aligned with piezos measure in Y' direction (1nm/count).

Closed-loop control in RT

Control architecture for the internal mechanism

The following architecture was proposed to control the internal mechanism: (architecture in a compiled C code running inside Delta-Tau controller)



Guarantees beam stability:

- **10 nm** (RMS) for VFM;
- **50 nrad** (RMS) for HFM.

THANK YOU

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