Distributed multi-platform sub-micrometer motion synchronization architecture and implementation for on-the-fly X-ray synchrotron measurements.

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Abstract

At the Brazilian Synchrotron Light Laboratory (LNLS), the SABIÁ (Soft X-ray ABsorption spectroscopy and ImAging) beamline operates in the soft X-ray region, using the Delta Undulator (DU525) for polarization control and the Plane Grating Monochromator (PGM) for filtering X-ray energy. These components are used in conjunction to perform X-ray magnetic linear dichroism (XMLD) and X-ray magnetic circular dichroism (XMCD) techniques, which are specific cases of X-ray absorption spectroscopy (XAS).

The DU525 produces radiation whose spectrum has a photon flux peak that varies with its position, in addition to controlling the polarization of the beam. It consists of four linear axes, managed by a Rockwell PLC and servo controllers. The PGM, responsible for filtering a finer band of X-ray energy, is made up of two rotating axes - one for the grating and one for the mirror - controlled in closed loop by an Omron Power Brick LV (PBLV) motion controller.

Synchronized movement between the DU525 and the PGM is crucial for the XAS technique, with positional discrepancies limited to 2 µm to avoid an attenuation of photon flux up to 2% during experiments measurements. In addition, it is vital that the data acquired by the beamline detectors is synchronized with the PGM's data.

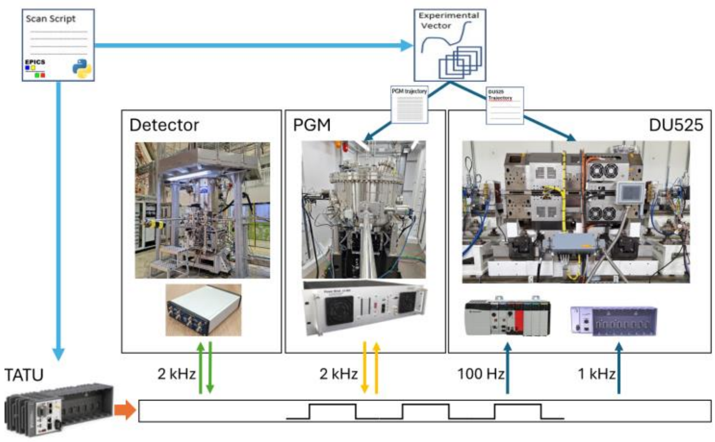

Figure 1: Synchronism architecture for SABIA beamline on-the-fly XAS experiments.

To achieve movement synchronization between the DU525 and the PGM, as well as synchronized data acquisition amoung the PGM and the beamline detectors, a synchronization architecture was developed (see Figure 1). This architecture is based on the external TATU (Triggering and Timing Unit) clock, which generates pulses that provide a common clock base for all devices - PBLV, Rockwell PLC and detectors. Each motion device is assigned a calculated trajectory (calibrated in function of DU525 and PGM) that must be executed, with the start of the movement synchronized with the first rising edge of the TATU pulse train.

Also, each motion device captures the position of its position encoders on the rising edge of the pulse train. The encoder data is then used to compensate the input trajectories for fine-tuning, if necessary.

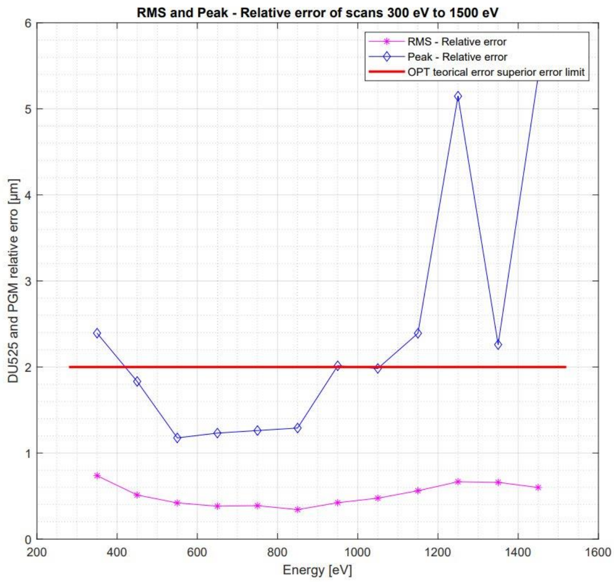

Figure 2: Relative RMS and peak errors between DU525 and PGM devices.

The synchronization results of this implementation are presented in Figure 2. The angular positions of the PGM were translated into linear positions of the DU525 using kinematic equations based on the photon energy. When comparing both positions, the RMS error remained below 2 µm across the full range, which is within the acceptable limits for the beamline. Thus, this work aims to detail the architecture and implementation technics, presenting the technical commissioning results. The current design is undergoing scientific commissioning by the beamline team.