Precision Insertion Device Control and Simultaneous Monochromator Fly Scanning for NSLS-II

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Introduction

Beginning in January 2019, eight of 10 IVUs at NSLSII underwent in-house in-situ control systems upgrades. This was to correct under-performance and improve reliability as well as in preparation for Insertion Device (ID) and monochromator synchronization (synchronous fly scanning). Control of the gap at the level of nearly 50 [nm] during motion and nearly 5 [nm] in final position (at scale) has been achieved. The first ID-monochromator synchronous fly scanning has been realized with an Elliptically Polarizing Undulator (EPU) for the In situ and Operando Soft X-ray Spectroscopy (IOS) beamline at NSLSII with another IVU and EPU to follow shortly.

IVU Controls Upgrade

In-house in-situ upgrades were performed for

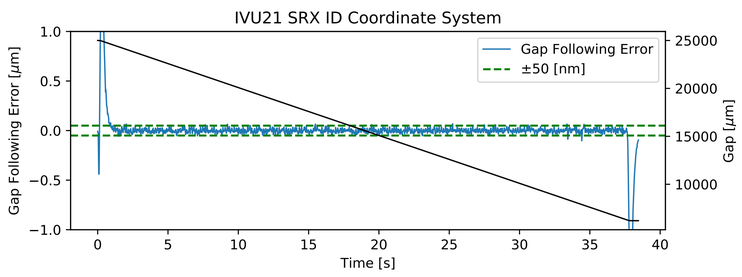
- Two 3 [m] long 20 [mm] period (IVU20)
- Three 2.8 [m] long 23 [mm] period (IVU23)
- Three 1.5 [m] long 21 [mm] period (IVU21)

For the IVU23s and IVU21s the 4 motor axes (TU. TD. BU, BD) are remapped to the useful coordinates

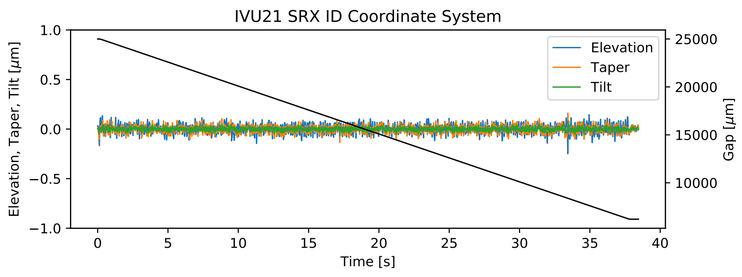
$$\begin{bmatrix} gap \\ elevation \\ taper \\ tilt \end{bmatrix} = \begin{bmatrix} \frac{1}{2} & \frac{1}{2} & \frac{1}{2} & \frac{1}{2} \\ \frac{1}{4} & \frac{1}{4} & -\frac{1}{4} & -\frac{1}{4} \\ 1 & 1 & -1 & -1 \\ \frac{1}{2} & -\frac{1}{2} & -\frac{1}{2} & \frac{1}{2} \end{bmatrix} \begin{bmatrix} TU \\ TD \\ BU \\ BD \end{bmatrix}$$

where T, B, U, D are: Top, Bottom, Upstream, Downstream. The same transformation is used in the forward and inverse kinematics.

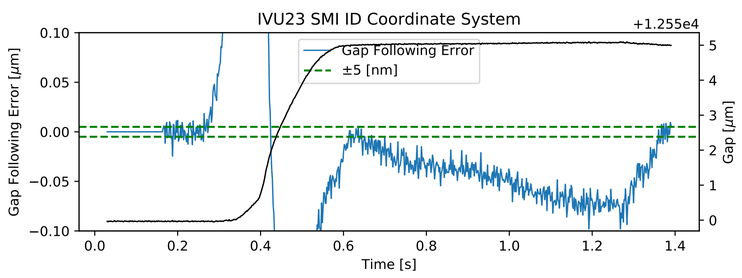
- The precision of magnetic gap control during motion is nearly 50 [nm]



- Other coordinates also well behaved



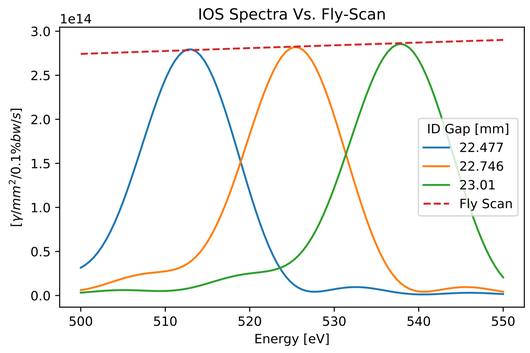
- Final position is nearly 5 [nm] (at scale)



Fly Scan

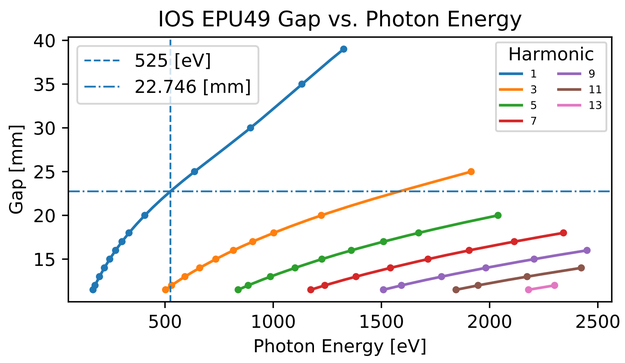
It is highly desirable to coordinate gap motion with monochromator motion

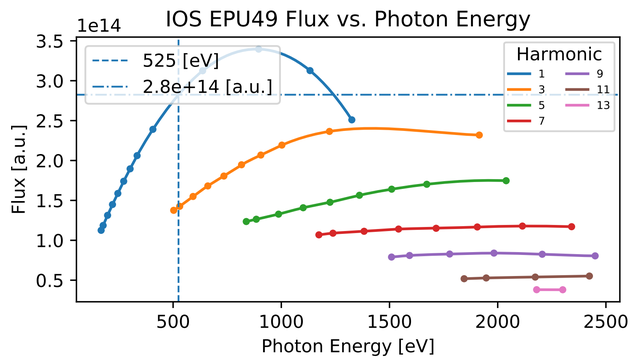
- Stay on undulator spectral peak
- Maintain highest possible flux
- Magnetic field non-linear with magnetic gap, requires non-linear coordinated motion



Gap and Flux vs. Energy

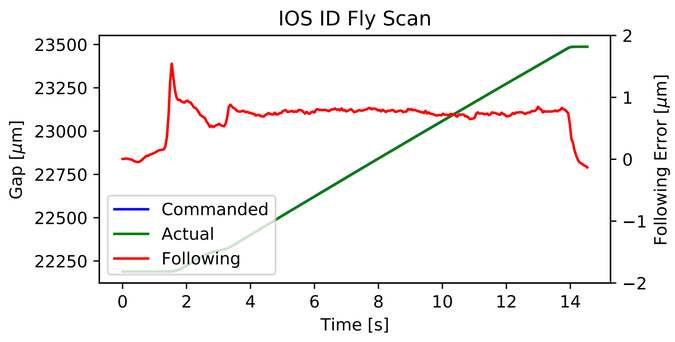
Gap/Flux vs photon energy curves for insertion devices can be calculated from magnetic field measurements and from beamline data. Below is an example showing the non-linear behavior for both magnetic gap and output flux for different harmonics of the IOS EPU49.

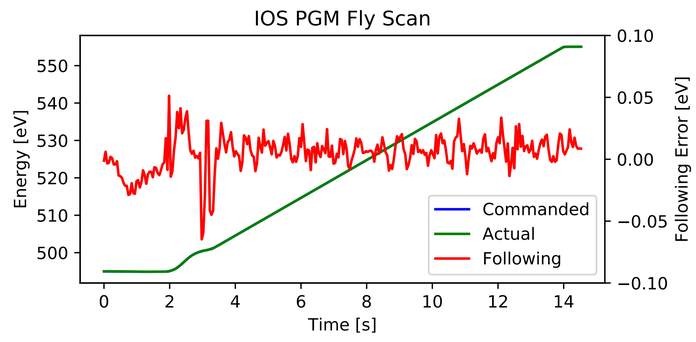




ID Monochromator Fly Scan Performance

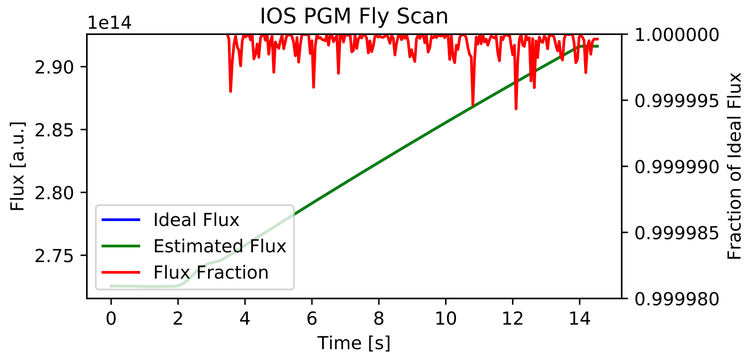
Position data is collected real-time on ID and monochromator during fly scan. The following errors in terms of gap and monochromator energy are shown below.





Fly Scan Flux

Below is the estimated fraction of the ideal flux based off of a 10 [eV] width Gaussian (artificially small to exaggerate the effect)

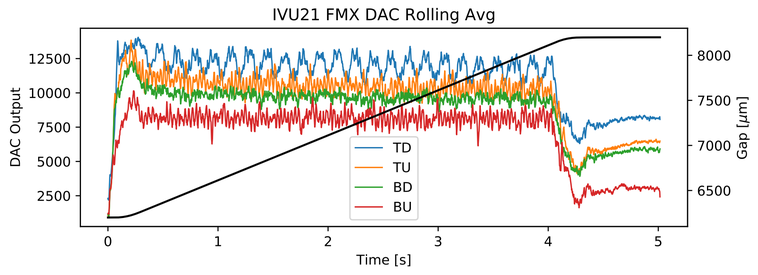


Future

- IVU21 + Double Crystal Monochromator (simpler mechanics)
- Stabilization, reduce mono motor coupling
- Higher accuracy triggers possible

Diagnostics

Can additionally look at DAC output as a diagnostic for misalignment or wear over time



Conclusions

In-situ control system upgrades provide very high accuracy magnetic gap control for IVUs at NSLSII. A system of synchronous ID-Monochromator control has been developed for fast fly scanning.

Acknowledgments

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