

Brazilian Synchrotron Light Laboratory

IDS

Diagnose of beam tilt at PAINÉIRA beamline

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1 Introduction

Following the commissioning of the new PAINEIRA photon source (IVU18 undulator), a tilted photon beam was observed in the beamline. The origin of this tilt—whether attributable to misalignment of beamline components or inherent to the electron beam itself—remained uncertain. This study aimed to determine the root cause by analyzing the flux density distribution in even harmonics.

2 Simulations

Due to the inherent asymmetric characteristic of the spatial flux density distribution of the even harmonics, an angle between the electron beam distribution and the photon beam emitted by a single particle can generate asymmetric flux distributions for the observed photon beam in the beamline. Figures 1, 2, and 3 show the photon flux density distribution for three different gaps of the IVU18 undulator while the DCM energy is kept fixed. The images on the left are obtained for a perfectly aligned electron beam while the images on the right consider an electron beam tilt of 4 degrees. The selected harmonic was $n = 8$.

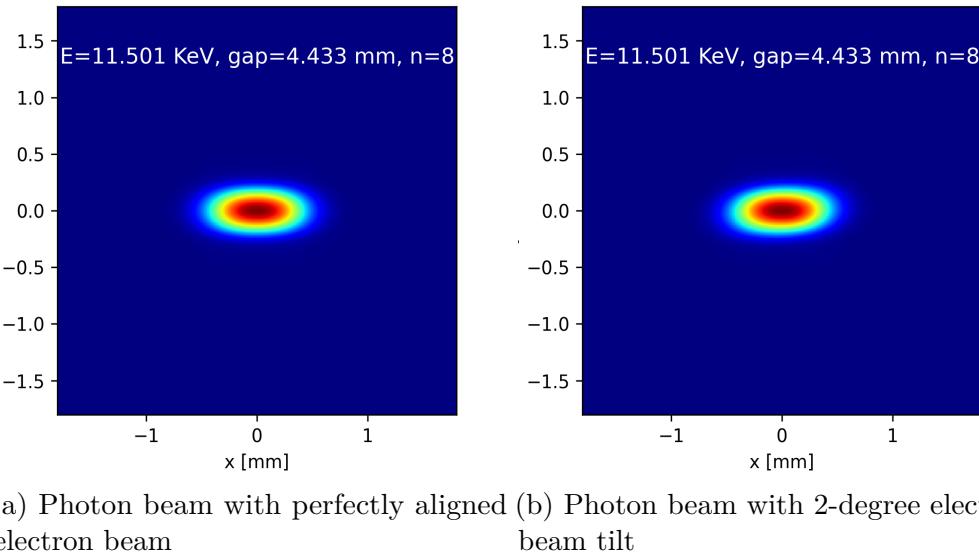
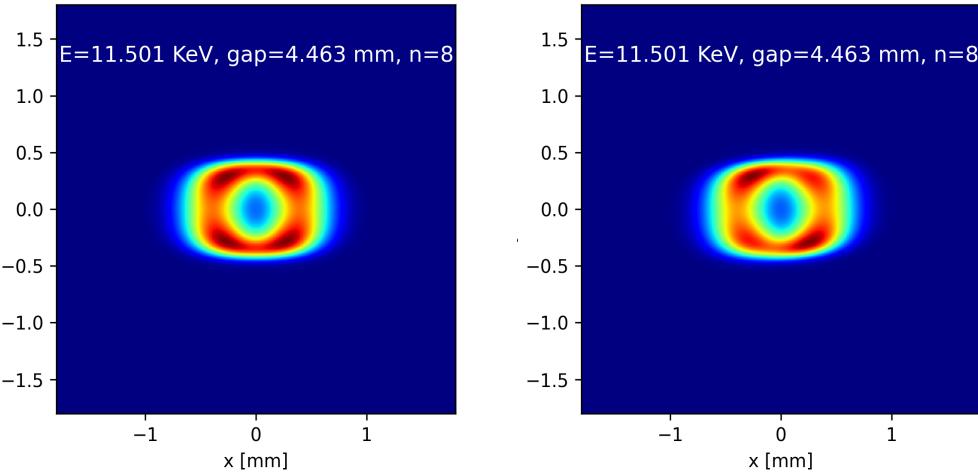
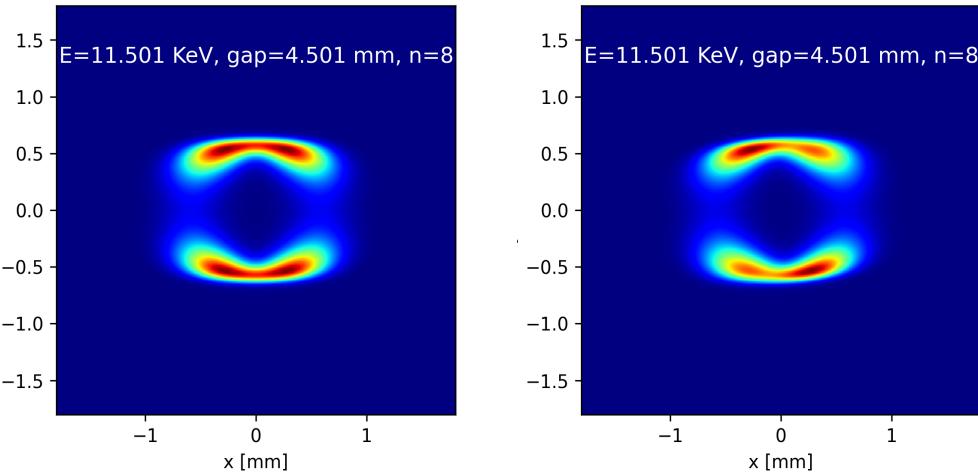


Figure 1: Photon flux density distribution for different electron beam configurations at $E = 11.501 \text{ KeV}$, $\text{gap} = 4.433 \text{ mm}$, and $n = 8$.



(a) Photon beam with perfectly aligned electron beam (gap = 4.463 mm)
(b) Photon beam with 4-degree electron beam tilt (gap = 4.463 mm)

Figure 2: Photon flux density distribution at $E = 11.501$ KeV and $n = 8$ for gap = 4.463 mm.



(a) Photon beam with perfectly aligned electron beam (gap = 4.501 mm)
(b) Photon beam with 4-degree electron beam tilt (gap = 4.501 mm)

Figure 3: Photon flux density distribution at $E = 11.501$ KeV and $n = 8$ for gap = 4.501 mm.

The figures above demonstrate that when the electron beam is tilted, the photon beam flux density loses its symmetry during detuning. This was the objective of the experiment: to alter the energy of the emitted photons by adjusting the undulator gap, record the corresponding spatial distribution of the flux and analyze the distribution.

3 Experiment

Figures ?? present flux density distributions measured at various undulator gap settings. Notably, an asymmetry in the flux distribution becomes apparent when the undulator is detuned,

particularly at the last two gap settings (4.496 mm and 4.511 mm). According to simulations, this asymmetry suggests the presence of an electron beam tilt in this straight section of the storage ring.

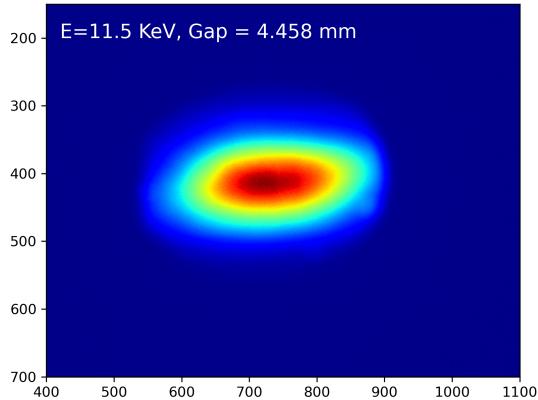


Figure 4: Measured flux density distribution for gap 4.458 mm

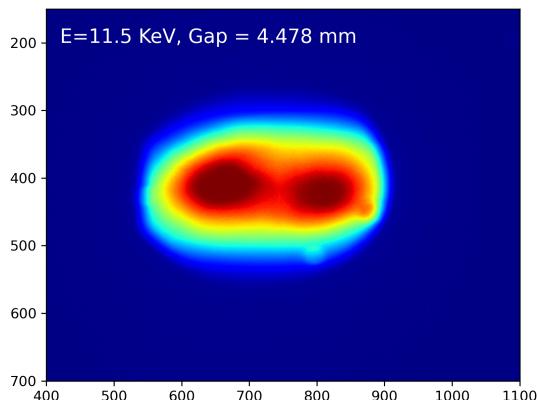


Figure 5: Measured flux density distribution for gap 4.478 mm

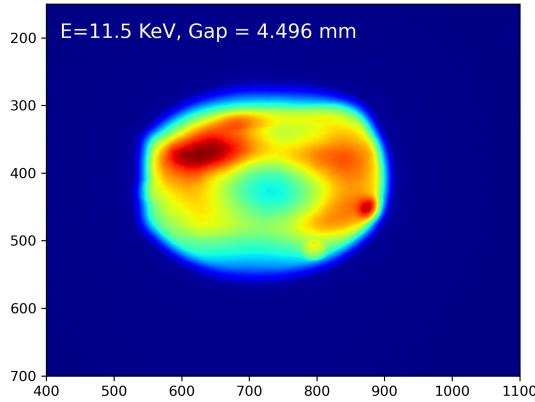


Figure 6: Measured flux density distribution for gap 4.496 mm

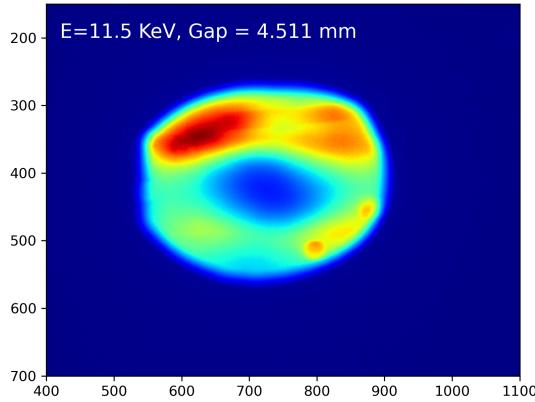
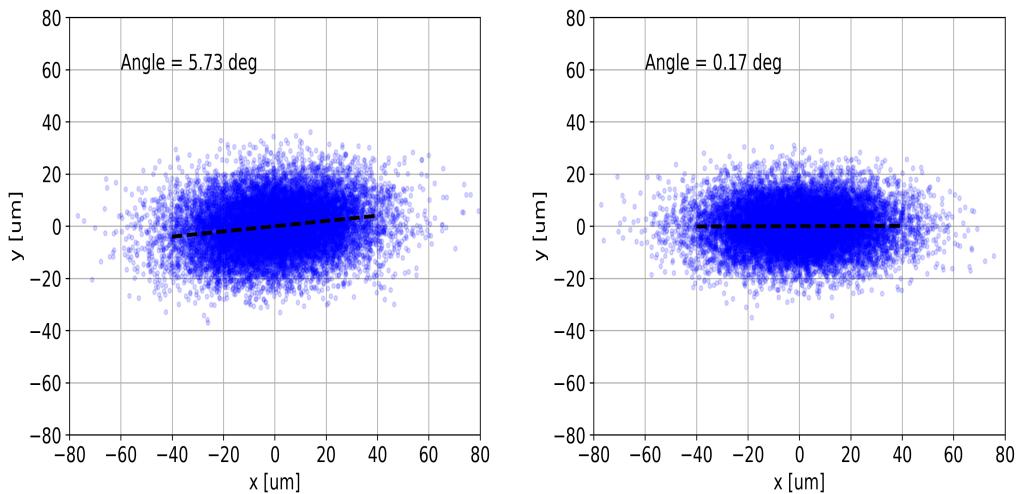


Figure 7: Measured flux density distribution for gap 4.511 mm

To verify the hypothesis of an electron beam tilt, an attempt was made to correct the tilt by adjusting the machine's skew quadrupoles. The first step involved estimating the tilt using a fitted model of the storage ring, based on the most recent orbit response matrix. The fitting was performed using LOCO. A set of skew quadrupole adjustments that corrected the beam tilt in the PAINEIRA straight section was identified. This correction can be seen in the figure below: the image on the left shows the electron beam distribution after fitting but without skew correction, while the image on the right shows the distribution after applying the skew correction.



(a) Electron beam distribution without skew correction (b) Electron beam distribution with skew correction

The force variation of the skew quadrupoles is shown in Figure 9.

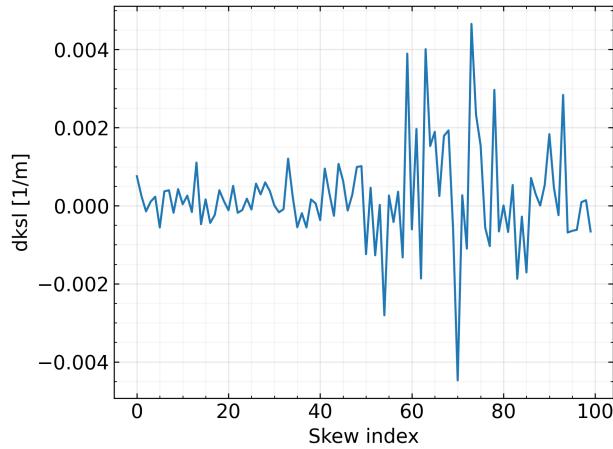
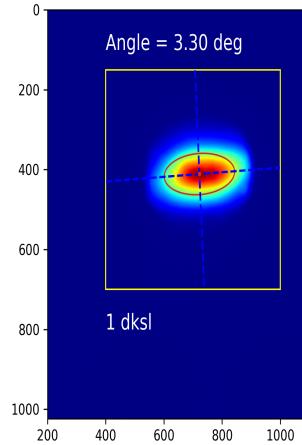
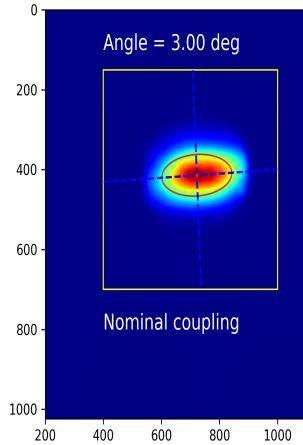
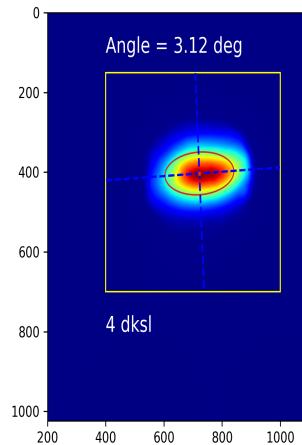
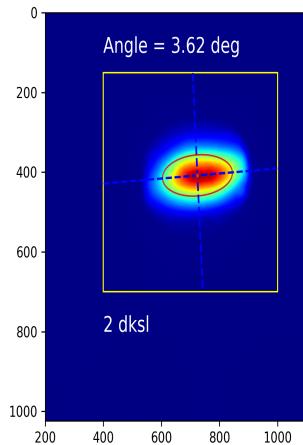


Figure 9

However, when the calculated skew adjustments were applied to the machine, no angle correction was observed in the beam as viewed on the DVF. Figures ??-?? illustrate the observed photon beam without skew correction, as well as after applying the full correction, double the correction strength, and quadruple the correction strength.



(a) Photon beam without skew correction (b) Photon beam with full skew correction



(a) Photon beam with double skew correction (b) Photon beam with quadruple skew correction

No angle variation was observed for any skew correction.

4 Conclusion

Although an asymmetry was observed in the detuned photon beam, the attempt to correct the angle using skew adjustments was unsuccessful. It is possible that the electron beam is indeed tilted in the straight section, and the algorithm used to calculate the skew forces may need to be revisited. A follow-up experiment could involve creating beam bumps to scan the entire flux density distribution, as even with fully open slits, the distribution remained larger than expected. Acquiring the full profile might provide a clearer view of the asymmetry.