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Development of virtual beamline technology for advanced light sources : simulation and application of key components

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This study develops a virtual beamline technology for advanced light sources, with a focus on simulating the fundamental operational functions of critical devices including motors, double-crystal monochromators (DCM), fluorescent screens (FS), X-ray detectors, and X-ray beam position monitors (XBPM). By establishing parametric models, the simulation of device actions is achieved. It supports users in setting the displacement of motors, adjusting the Bragg angle of the DCM, and configuring the parameters of the slit aperture, and generates the corresponding state feedback signals of the devices.An interactive visualization interface is designed. Based on the state feedback signals of the devices, it generates the spot images on the fluorescent screen and synchronously displays the position trajectory of the beam measured by the XBPM, providing a visual reference for the beam tuning process. Through preliminary beam tuning simulations, the platform enables standardized operational workflows (e.g., energy selection) and optimizes parameter configuration sequences, effectively reducing trial-and-error adjustments during physical commissioning. The lightweight simulation framework proposed in this work offers a scalable and practical reference for advancing virtual commissioning technologies in synchrotron radiation facilities and other large-scale scientific installations.

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Footnotes

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