

# Bridging Simulation and Reality: EPICS controls for xrt Beamline Digital Twins

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Synchrotron beamline simulation codes have long been essential for designing new beamlines and troubleshooting existing ones. However, there remains a noticeable gap between the idealized simulation results and the performance of real beamlines. *xrt* X-ray tracing package addresses this challenge by employing a global coordinate system for positioning and orienting optical elements, along with embedded support for material properties, thereby introducing the flexibility needed to realistically simulate beamline imperfections. To bring the simulation even closer to the real-world experience, we have employed the *pythonSoftIO* library to integrate the support for EPICS controls across the entire beamline model—from the source to the detector. This integration enables end users to leverage familiar tools like CSS and Phoebus to monitor and control the beamline digital twin in near real-time, thanks to the efficiency of the *xrt* code. Furthermore, when combined with higher-level tools like *Bluesky* and *Blop*, beamline scientists can evaluate optimization tasks with high fidelity. Users can determine realistic beam dimensions, shapes, and intensities at various positions and estimate the data requirements for training optimization agents before applying these insights to the real beamline.

The entire process can be monitored live and in detail using the 3D beamline visualization tool, *xrtGlow*, providing a comprehensive and interactive environment that bridges simulation and reality.

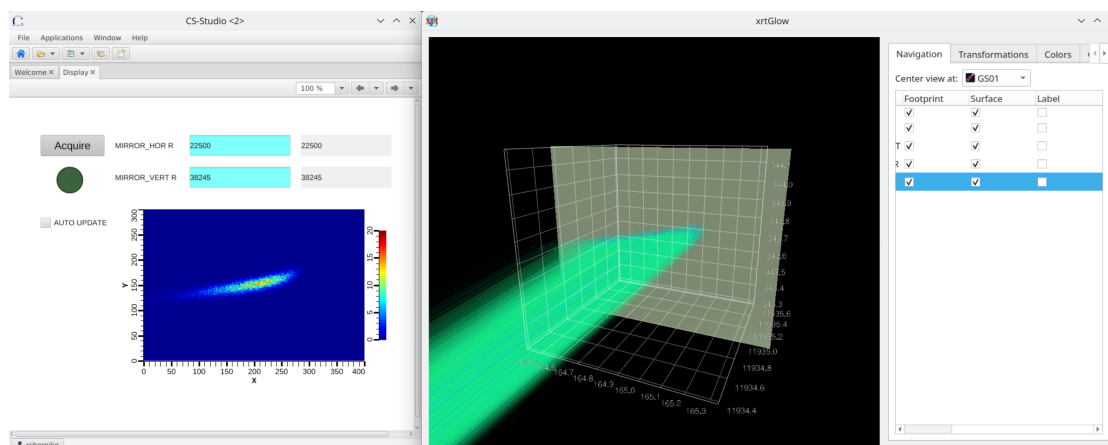


Figure 1: xrt Beamline Controlled With Phoebus

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