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Designing optimal beamlines for Australian Synchrotron 2 by maximising Fisher information

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The Australian Synchrotron 2.0 (AS2), a proposed 4th generation light source for Australia, aims to deliver ultra-low emittance (˜100 pm) and highly coherent, bright light, enabling critical scientific applications. However, its sensitivity to minor magnet misalignments and field errors necessitates rigorous beamline optimisation, which is computationally intensive due to a large parameter space. Beam Position Monitor (BPM) placement is one such key parameter influencing beam stability.
In this work, we propose a novel experimental design method for optimal BPM placement by leveraging Fisher Information. By computing Fisher Information Matrices (FIMs) for the AS2 system and maximising information gain, we derive optimal BPM placements that minimise variance in the model. To achieve this, we utilise the fully-differentiable accelerator code Cheetah, integrating accelerator modelling with automatic differentiation to compute computationally demanding Hessians efficiently using fast, low-fidelity simulations, thus offering a robust solution for BPM placement optimisation in AS2 as well as possibly other next-generation synchrotrons and accelerators.

Footnotes

Paper preparation format

Region represented

Asia

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