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## Optimization and characterization of externally seeded FLASH1

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Externally seeded Free Electron Lasers (FELs), such as the upgraded FLASH1 at DESY, utilize external lasers to initiate bunching, contrasting with the self-amplification of spontaneous emission (SASE). This upgraded facility will offer simultaneous seeded and SASE pulses. Introducing a chirped electron bunch and high repetition rate seed lasers with unique spectral features will significantly influence the electron bunching and the spectral properties of the output. This work discusses our computational strategies to align model predictions closely with experimental outcomes, focusing on the dynamics of chirped bunch interactions and the integration of seed laser characteristics to optimize the performance and predictability of FEL outputs.

### Footnotes

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