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## Comparison of the Spectro-Temporal Properties of Echo-Enabled and High-Gain Harmonic Generation Free-Electron Laser Pulses at the 15th Harmonic

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The external seeding scheme Echo-Enabled Harmonic Generation (EEHG) utilizes two modulators and two chicanes to manipulate the longitudinal phase space of an electron beam to achieve bunching at higher harmonics of the seed laser wavelength. Different combinations of energy modulation and longitudinal dispersion can result in the same amount of bunching at a certain harmonic. This study investigates the impact of the choice of the energy modulation amplitudes on the bunching properties and the spectro-temporal characteristics of the free-electron laser (FEL) radiation. Finally, a comparison between EEHG and the single modulator-chicane seeding scheme High-Gain Harmonic Generation (HG) at the 15th harmonic of the seed laser wavelength is presented. The corresponding numerical modelling and simulations are performed within the parameter range of the future upgrade of the FEL user facility FLASH at DESY.

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