A scheme of fully coherent X-ray free electron laser for the SHINE based on fresh-slice

Y. Liu and T. Liu

Shanghai Institute of Applied Physics, Chinese Academy of Sciences, Shanghai 201800, China

University of Chinese Academy of Sciences, Beijing 100049, China

Shanghai Advanced Research Institute, Chinese Academy of Sciences, Shanghai 201210, China

Abstract

In this paper, the fresh-slice self-seeding free electron laser scheme is studied, and the feasibility of its application in the SHINE project is analyzed. The scheme used the fresh-slice method to generate the beam with adjustable spatial distribution, which can effectively improve the longitudinal coherence and stability of the self-seeding output radiation. Through the FEL simulation, we demonstrated that this scheme can produce a highly stable, narrow bandwidth pulse output under the SHINE's parametric conditions, which will be beneficial to further improve the performance of this device in the future.

Principle

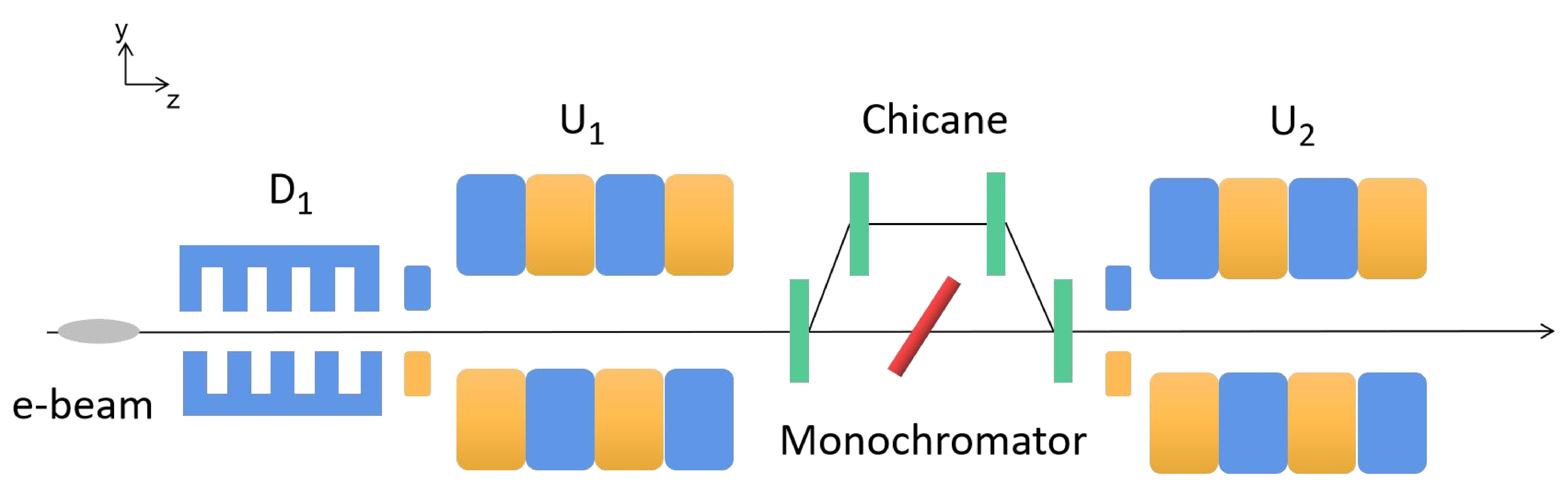

Figure 1: Schematic layout of the proposed scheme based on fresh slices.

Parameters

Parameters	Value
Beam energy	8 GeV
Energy spread	0.1%
Undulator stength K	1.3415
Undulator drift length	2.6 cm
Fundamental wavelength	0.1 nm

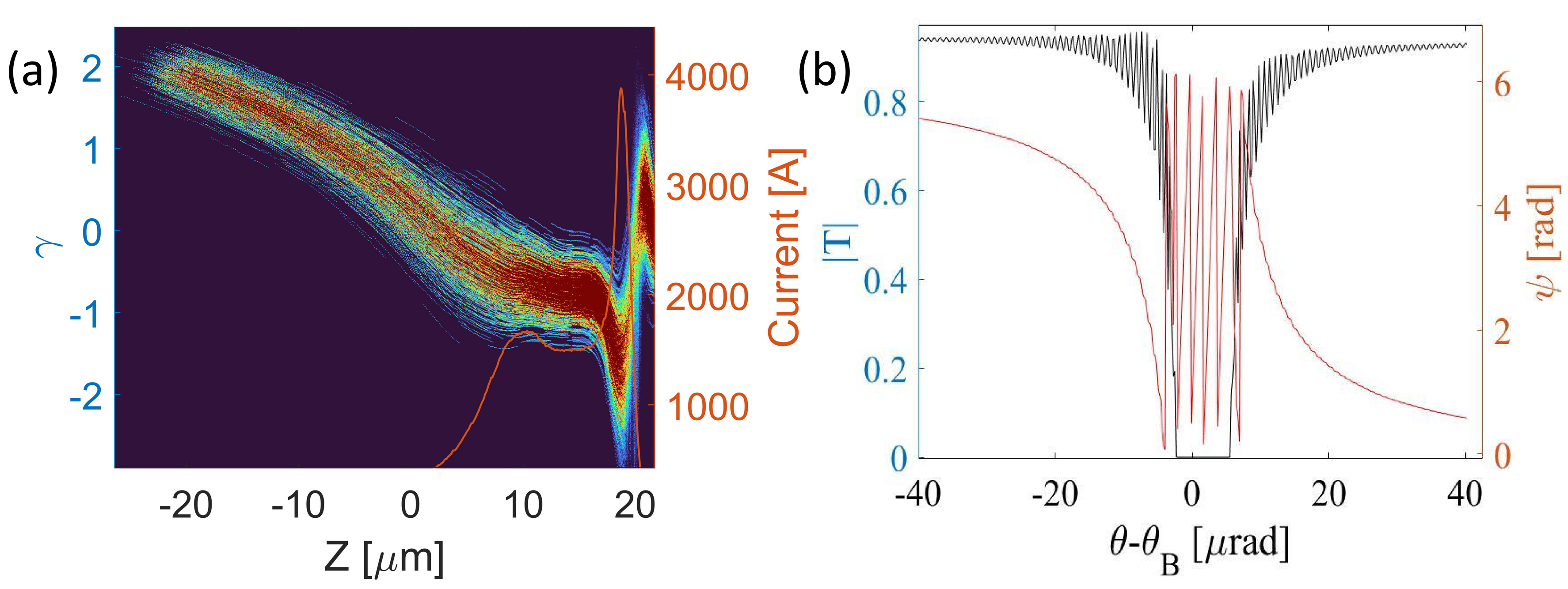

Figure 2: Beam longtitude phsae space and current profile (a) and the The modulus and phase of the transmissivity function of the monochromator.

In the first stage of the scheme, the on-axis high-current head of the bunch generates saturated single-spike-like SASE pulses which will effectively modulate the bunch tail in the second stage, so as to maintain the energy spread and improve output stability.

Results

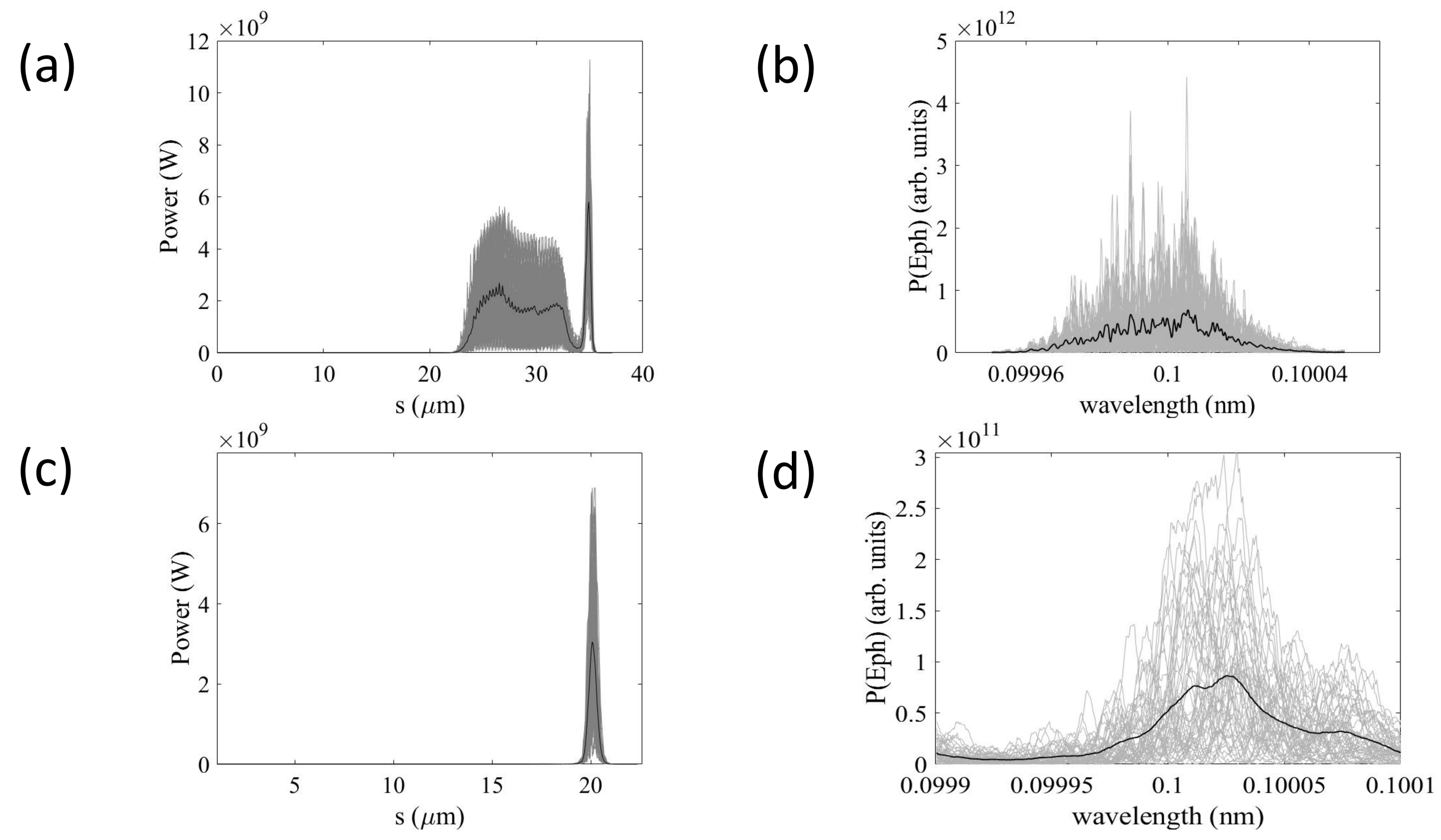

Figure 3: The saturation power distribution (left) and the spectrum (right) of 50 SASE pulses. (Top) Ehanced self-seeding. (Bottom) With fresh-slice method.

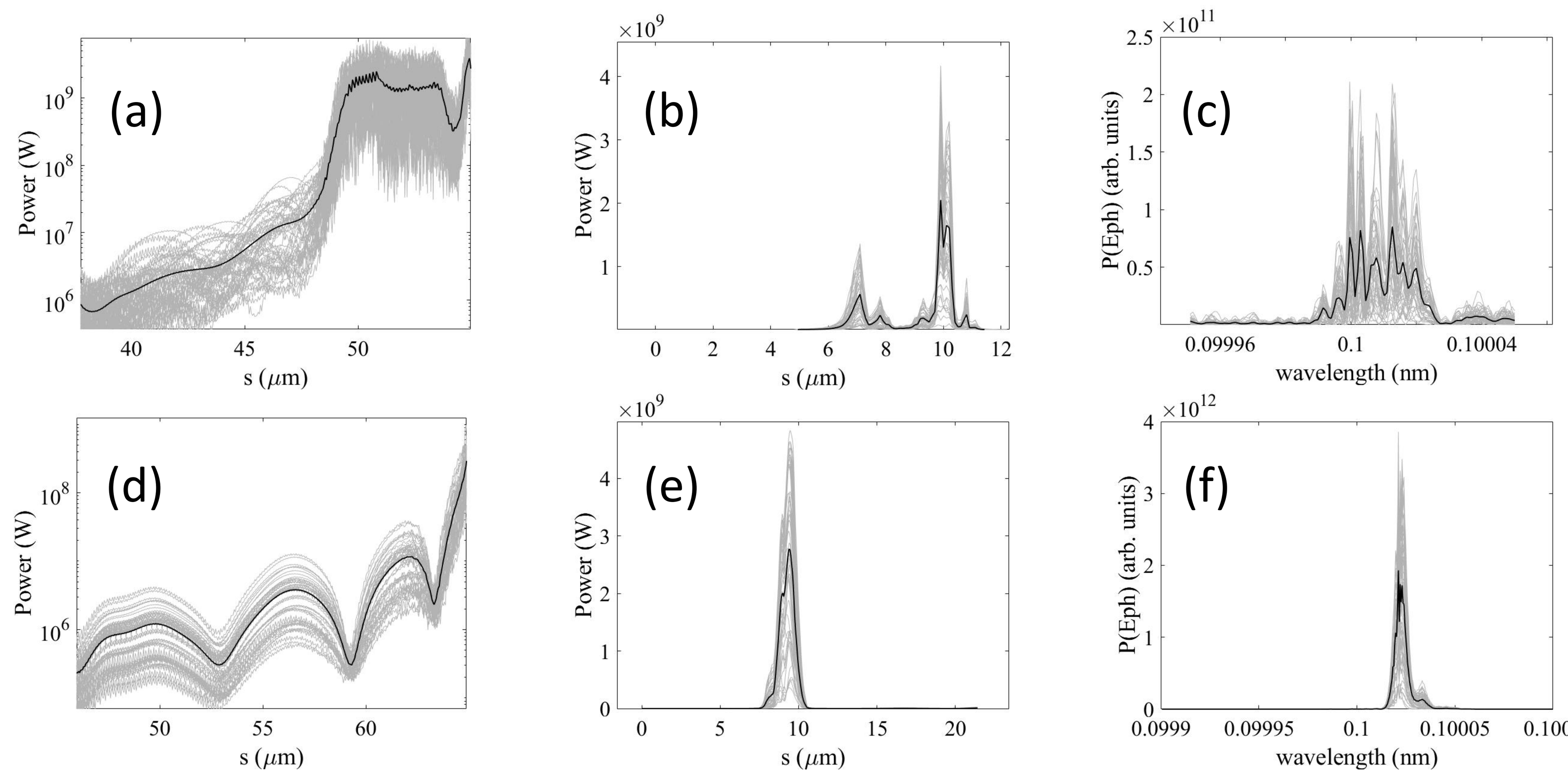

Figure 4: The seed power after the mono filter (a) . Results of power profile (b) and spectrum (c). (Bottom) With fresh-slice method.

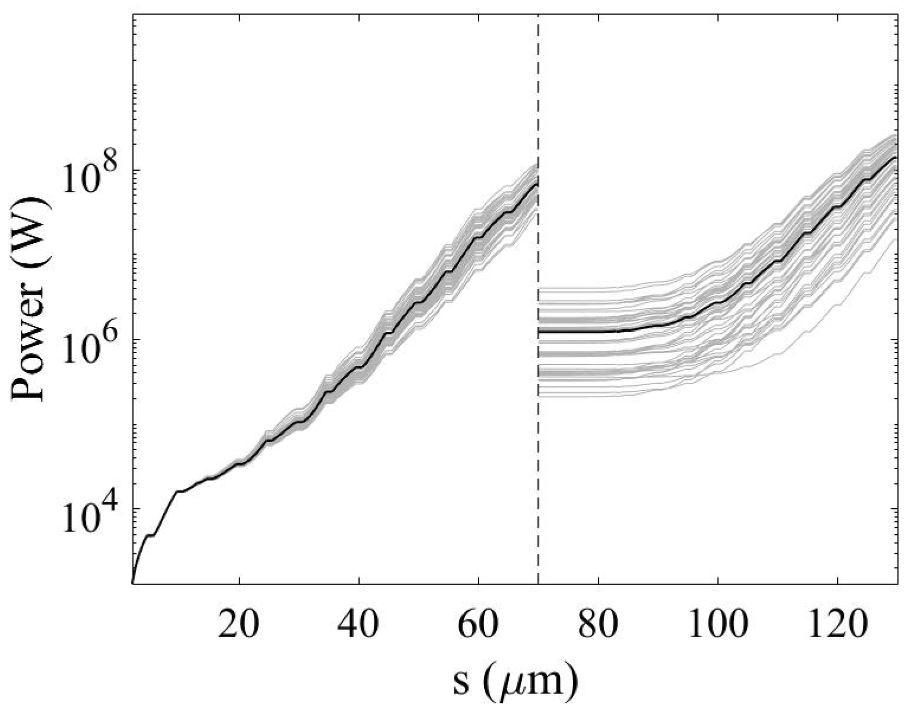

Figure 5: FEL power along the undulator beamline for this scheme.

A series of 50 separate GENESIS runs have been performed to analyze the statistical fluctuation on the radiation pulse. As shown in Fig.4, the output radiation at the exit of the radiation undulator is about 3 GW, with a normalized spectral width (FWHM) of 8×10^{-5}. Comparing wake monochromator power, the seed with a fresh-slice SASE pulse (d) has more stable mode than using a normal SASE pulse (a) with the same beam parameters.

Conclusion

Through the beam parameters of the SHINE, the enhanced self-seeding results combined with fresh-slice are simulated. Shot-to-shot results prove the reliability of the scheme. Under low current contrast, the fresh-slice method can still retain an acceptable output mode. This simulations lay the groundwork for future research on related harmonic schemes, and will provide valuable insights for the design of SHINE.