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Broadly tunable THz FEL amplifier

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Abstract

In this paper we present a broadly tunable high-power THz FEL amplifier driven by a photoinjector with a seed source tunable between 0.7-2.0 THz. A fully synchronized THz seed pulse is provided by an optical parametric amplifier pumped by the very driver laser of the electron injector. The FEL amplification gain is almost 3000 at 2 THz for nominal beam parameters.

Introduction

In this paper, we propose a 4.5-m long FEL system with a tunable frequency in THz range (0.7 to 2.0 THz). This compact FEL consists of a phtocathode RF gun (PG), an emittance compensated solenoid magnet and a 2-m long planer undulator. The compensated electron bunches are modulated by the fields in the RF gun and the solenoid magnet before entering the undulator. The tunable THz seeding is generated by an optical parametric amplifier (OPA), and the single pass electron bunch radiates coherently with a frequency the same as that of the seeding laser. The proposed FEL can be regarded as a THz FEL amplifier, its radiation frequency can be adjusted by tuning the beam energy and seeding laser frequency.

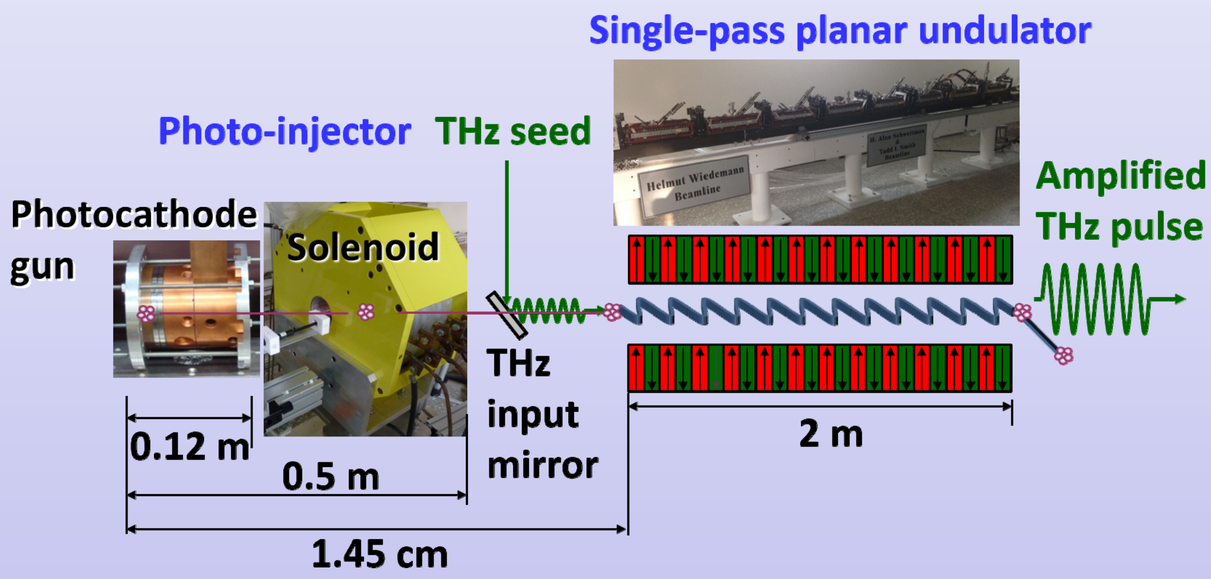
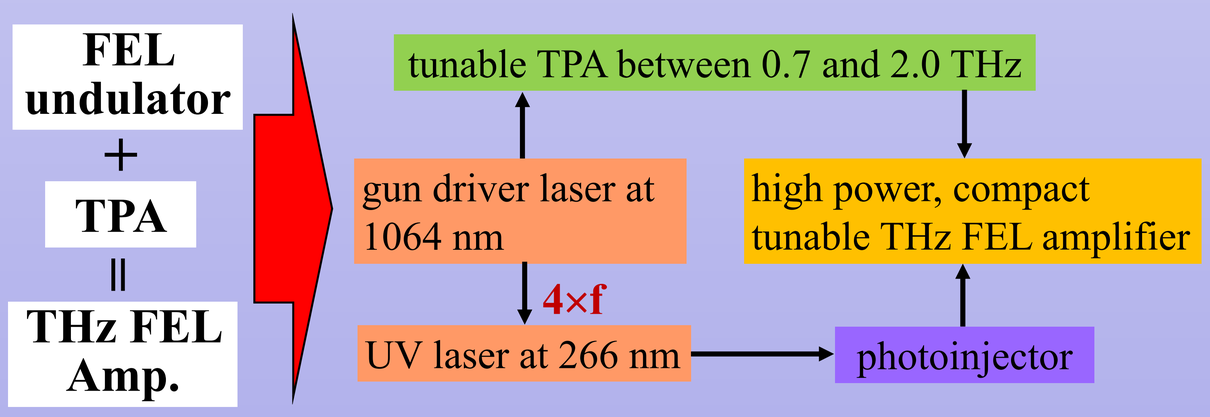


Fig. 1: The hardware arrangement of the proposed THz FEL amplifier. (planar undulator)

Motivation



THz parametric amplifier

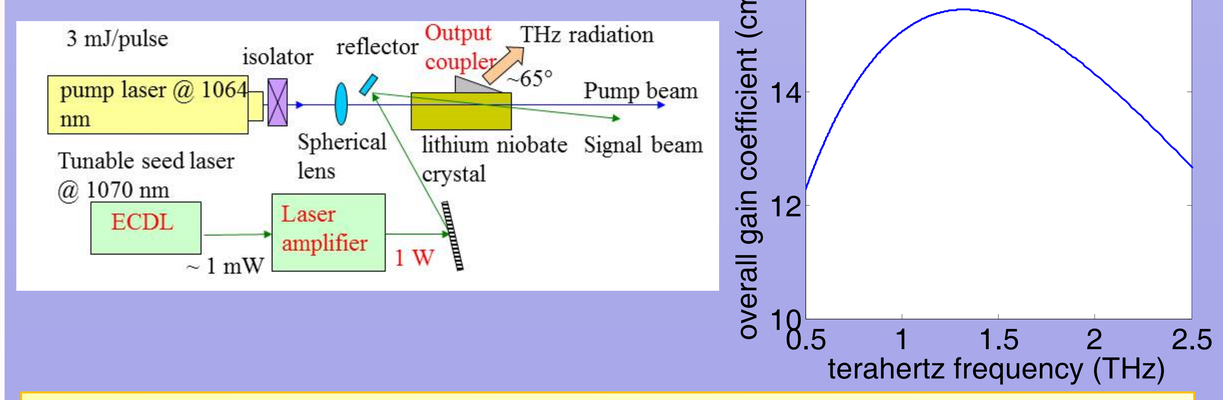


Fig. 2: Configuration of a proposed TPA to seed the FEL undulator. (the right curve shows the calculated gain coefficient for the proposed TPA with 1 GW/cm2 pumping intensity at 1064 nm.)

Parameters in the beam line

photoinjector	
Charge, Q (pC)	500
Accel. Field E_p (MV/m)	72 ~ 120
Solenoid strength (Tesla)	0.14 ~ 0.21
beam at the entrance of undulator (1.45 m)	
Beam energy (MeV)	3.3 ~ 5.5
Bunch length (rms), σ_t (ps)	~ 10
Energy spread (rms), σ_γ (%)	1.6 ~ 4.2
Peak current, I_p (A)	~ 100
Emittance, ε_{nx} (πmm-mrad)	3.1 ~ 3.5
Beam size, σ_x (μm)	< 500
Seeding power (W)	1 ~ 1000
Fundamental radiation frequency (THz)	0.7~2.0

undulator	
Type	Planar
Total length (m)	2
Period length (cm)	1.8
Period number	110
RMS undulator parameter (K)	0.98

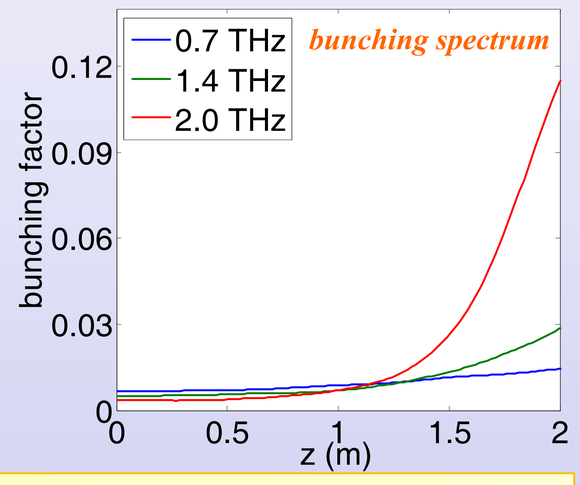


Fig. 3: Variation of the bunching factors in the undulator with 1 kW seed power at 0.7, 1.4, and 2.0 THz. (Results obtained from simulation in GENESIS)

THz FEL amplifier

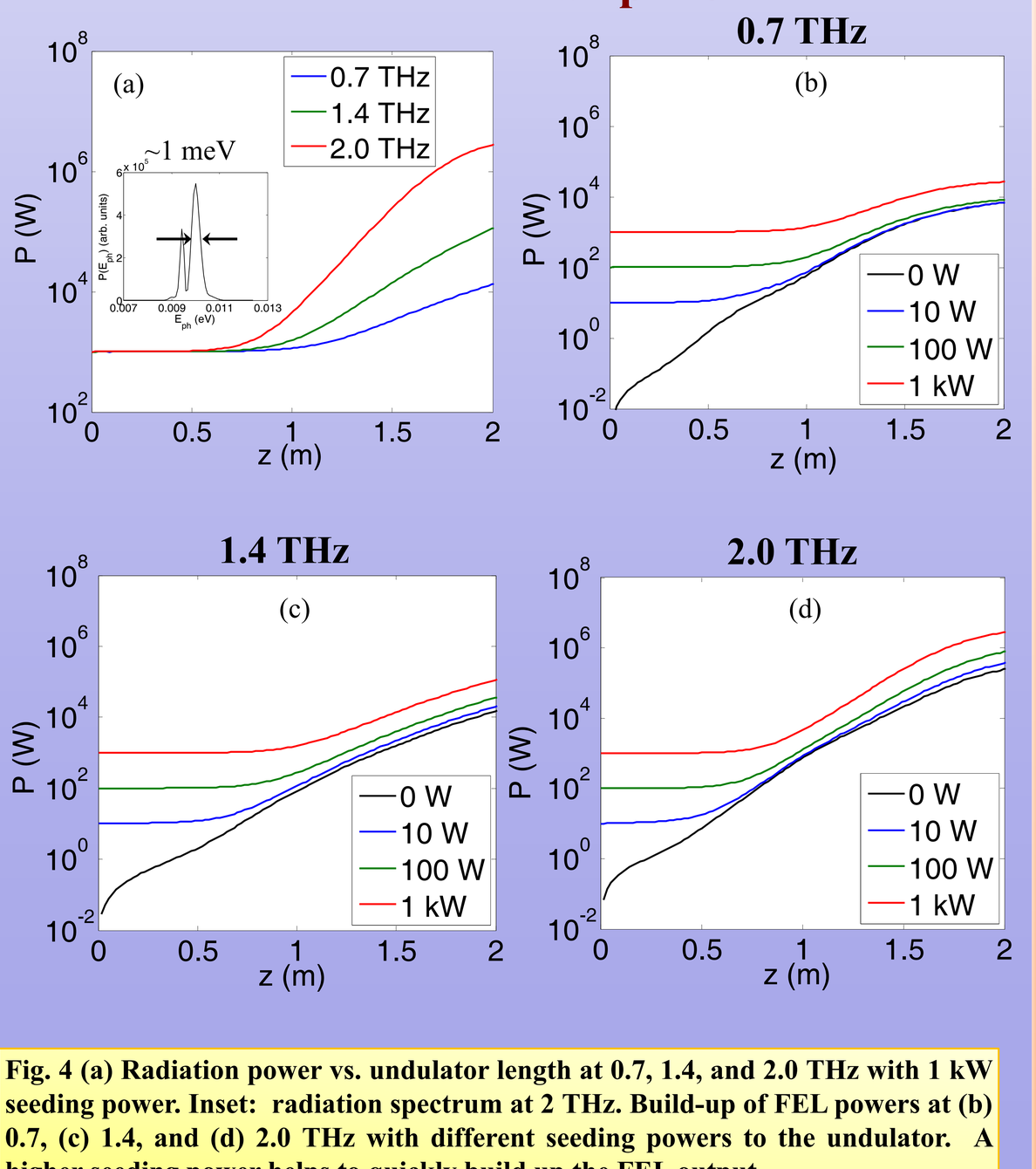


Fig. 4 (a) Radiation power vs. undulator length at 0.7, 1.4, and 2.0 THz with 1 kW seeding power. Inset: radiation spectrum at 2 THz. Build-up of FEL powers at (b) 0.7, (c) 1.4, and (d) 2.0 THz with different seeding powers to the undulator. A higher seeding power helps to quickly build up the FEL output.