G. Dattoli
&
A. Petralia

Compact FEL devices in VUV-Soft X-ray region There is any room for oscillators and Bi-harmonic undulator?

The possibility of exploiting oscillators for X-ray FELs has been invoked by K.J.-Kim

But the proposed scheme is neither cheap or compact

Jinhua Dai Haixiao Deng* Zhimin Dai

Proposal for an X-Ray Free Electron Laser Oscillator with Intermediate Energy Electron Beam

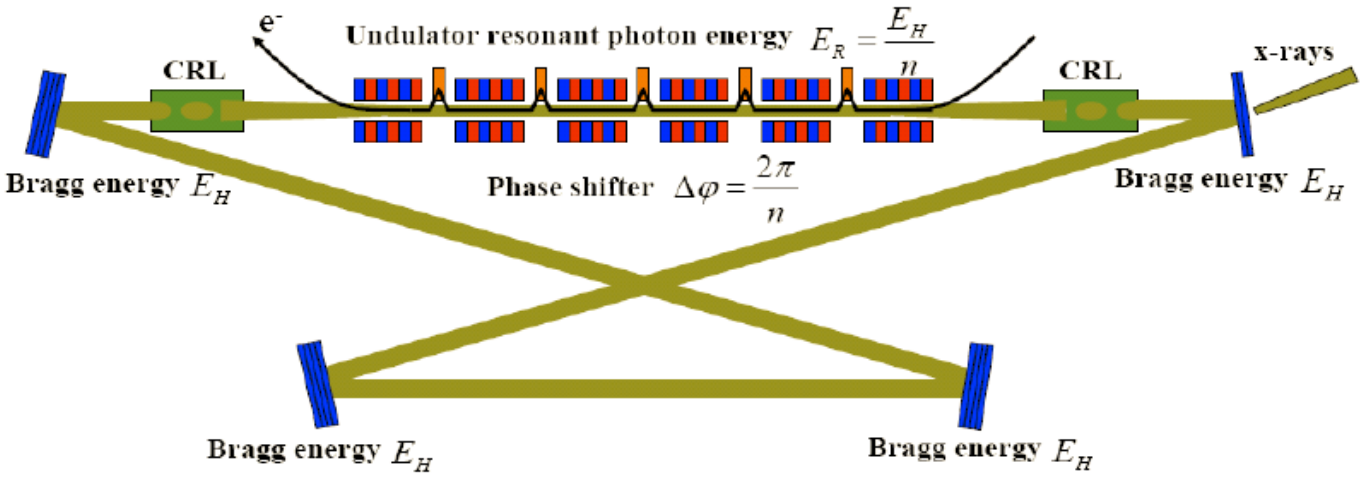
- *Required parameter*

TABLE 1. The main parameters of harmonic lasing XFELO.

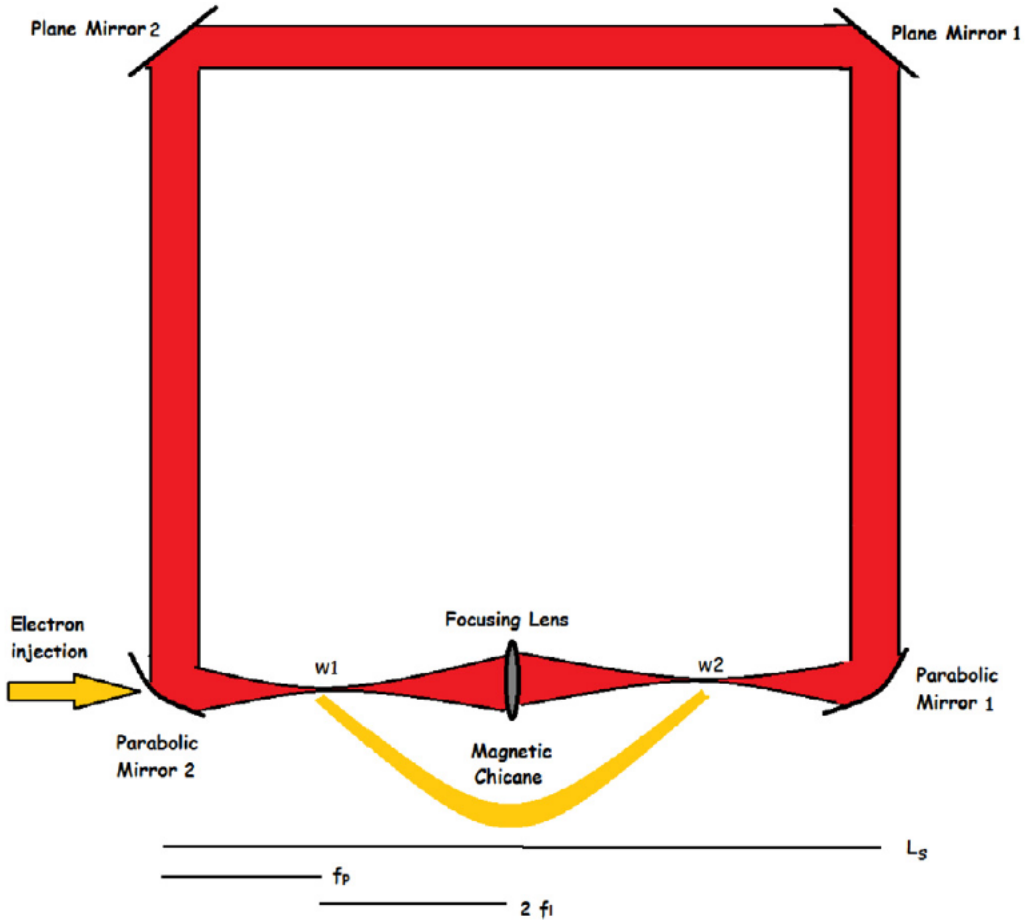
Parameters	**3rd harmonic**	**5th harmonic**
Crystal Bragg energy E_H	12.42keV	20.71keV
Phase jump $\Delta\varphi$	$4\pi/3$	$6\pi/5$
Undulator period λ_u	15mm	15mm
Undulator number N_u	1200	1200
Undulator parameter K	1.3244	1.3244
Beam energy E	3.5GeV	3.5GeV
Slice energy spread σ	100keV	100keV
Beam peak current I	20A	100A
Single-pass gain g_h	65%	72%
Total Cavity reflection r	80%	80%
Cavity length L_c	150m	150m
Bragg crystal	C(4,4,4)	C(5,5,9)
FWHM spectral width	5.5meV	24.6meV
FWHM temporal width	463fs	107fs
Photons / pulse	0.86×10^8	0.24×10^8
Output peak power	0.35MW	0.74MW

…And of the layout

- .



Curcio, Dattoli, Ferrario, Giulietti , Nguyen OPT. Commun. 2017



The necessity of compact FEL devices operating in the X-ray region and amenable for operation in relatively small scientific environments has emerged since the first proposals of the Pharaonic Facilities we are used to.

An earlier proposal (1999) came from

G. D. and P. L. Ottaviani

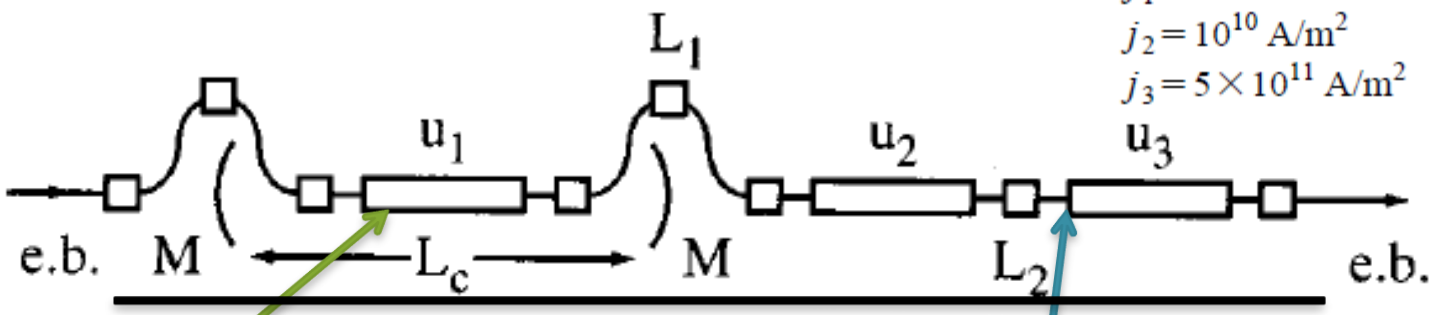
Design considerations for x-ray free electron lasers

Journal of Applied Physics 86, 5331 (1999)

Layout

- .
- Oscillator & Radiator

$N_1 = 25$
$\lambda_{u_1} = 40$ cm
$N_2 = 50$
$\lambda_{u_2} = 8$ cm
$N_3 = 200$
$\lambda_{u_3} = 1.6$ cm
$K_{1,2,3} = 1.1$
$L_1 = 150$ cm
$L_2 = 100$ cm
$j_1 = 5 \times 10^8$ A/m^2
$j_2 = 10^{10}$ A/m^2
$j_3 = 5 \times 10^{11}$ A/m^2

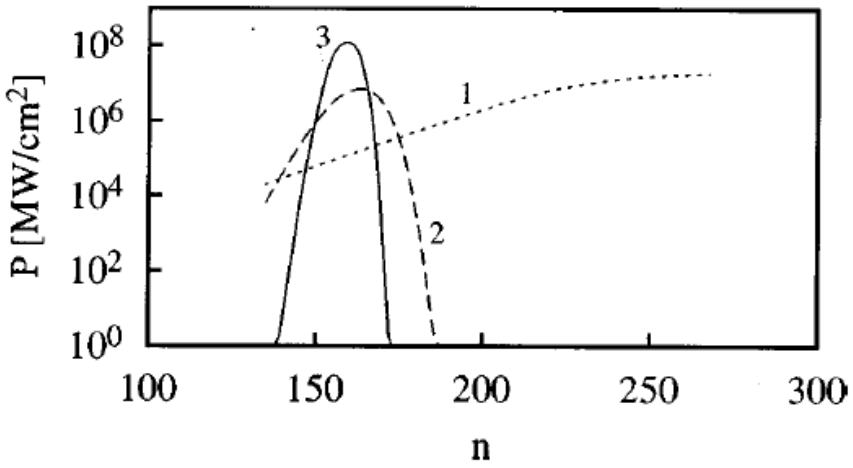


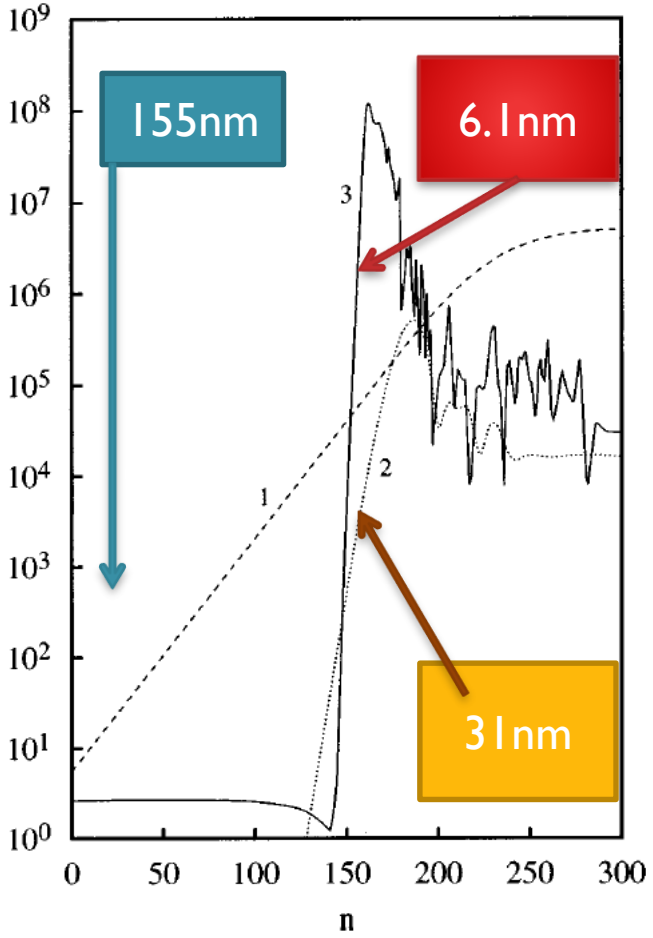
20<L<25

Oscillator

Radiator

Power Growth in the Oscillator and radiators





G. D., L. Giannessi, P.L. Ottaviani, A. Renieri, H. Freund and S. Milton

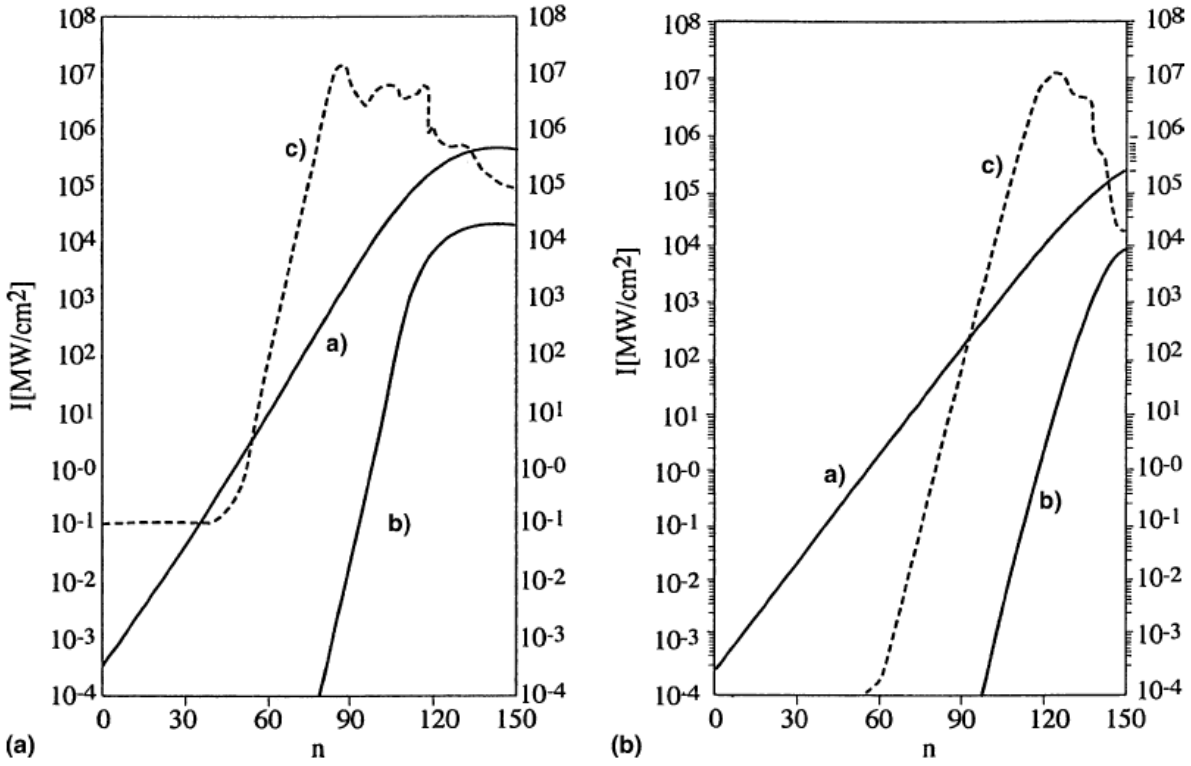


Fig. 12. (a) Same as Fig. 8b $\eta = 49\%$, $\sigma_\varepsilon = 5 \times 10^{-4}$; (b) same as before $\eta = 51\%$, $N_2 = 90$.

Oscillator Seeding of a high gain harmonic Free Electron Laser

- Gandhi, Penn, Reinsch, Wurtele, Fawley
- PRSTAB (2015)

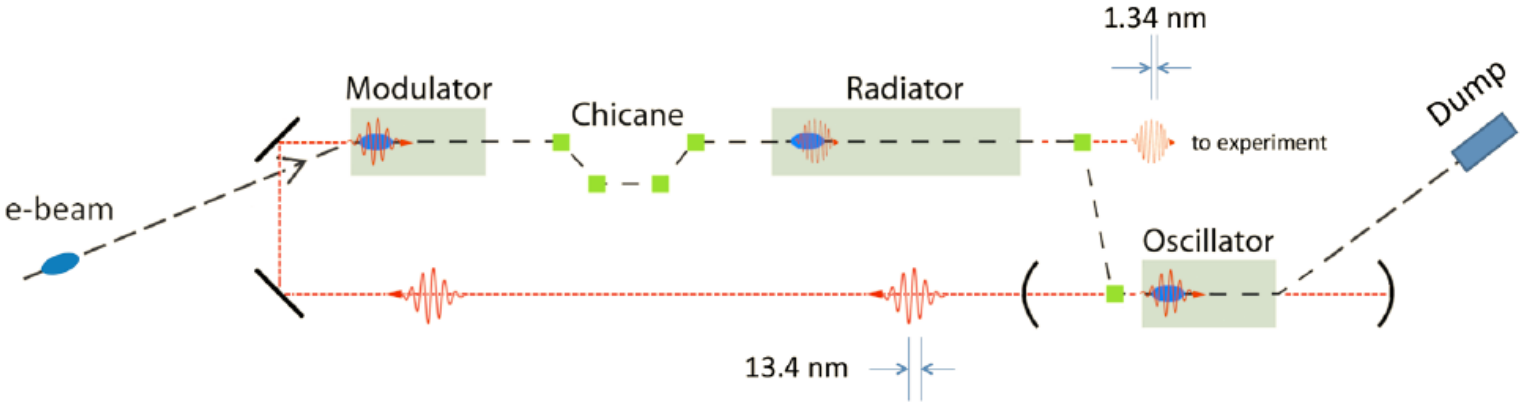
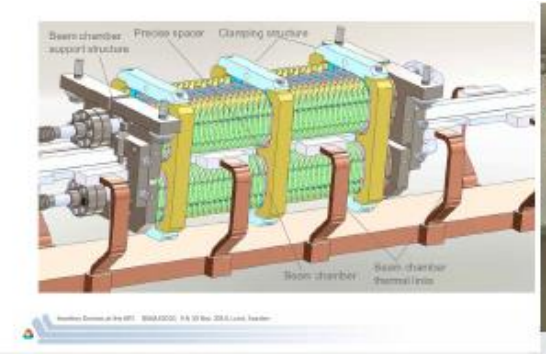


FIG. 1. A diagram of the HGHG "radiator-first" scheme.

Undulator Technology



Overview of Insertion Devices at SR facilities
Small gap & conventional undulators
Cryogenic devices

Bi-harmonic Undulators

On Axis Field Distribution

$$\vec{B} \equiv (B_h \sin(hk_u z),\ B_1 \sin(k_u z), 0)$$