TUAAU03

30th International **Free Electron Laser** Conference

Design study on THz seeded FEL using photocathode RF gun and short period undulator

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1. Introduction

Why Table Top THz FEL?

2. Concept

3. Devices

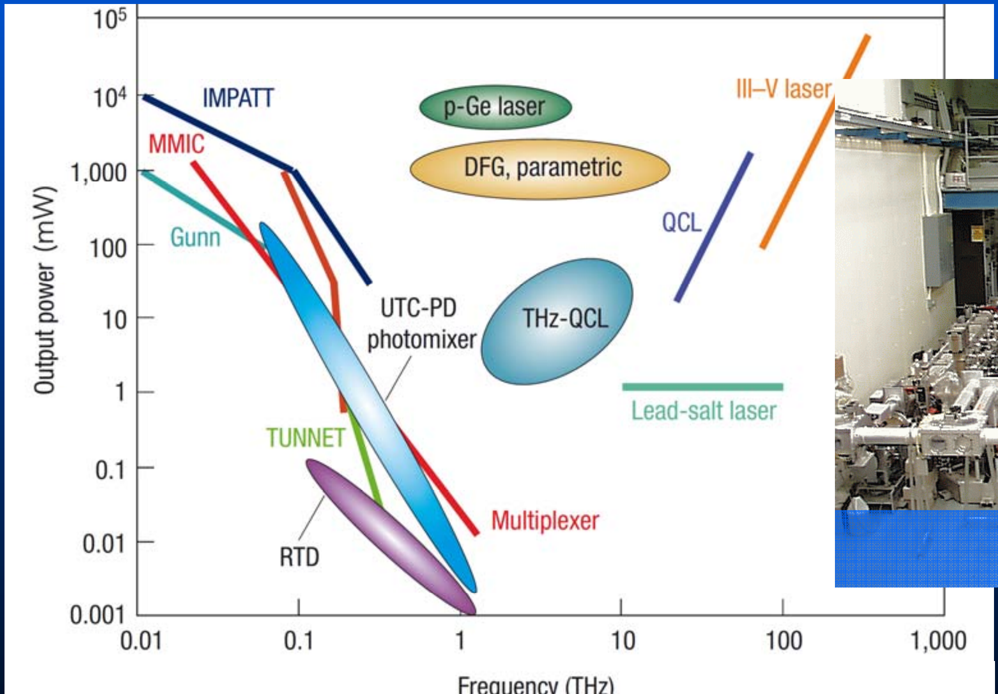
4. Numerical study

5. Conclusion

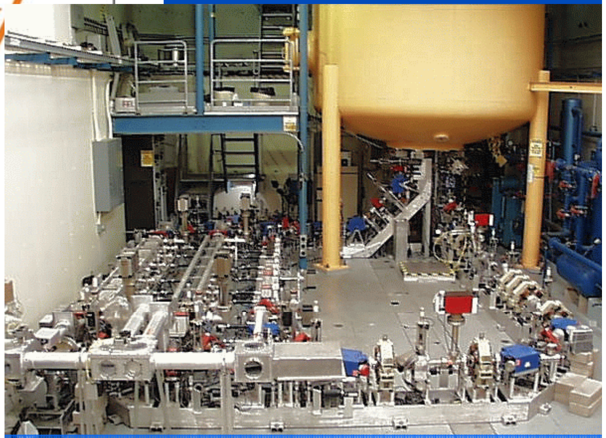
THz gap? Although FEL covers mm to nm

…

Electron energy
3~7 MeV
Peak current
> 200 A
System
Seeded SASE
Physical size
2 m x 4 m
Peak power
> 1 MW



M.**Tonouchi**, **Nature Photonics** 1 (2), **97** (2007)



UCSB FEL

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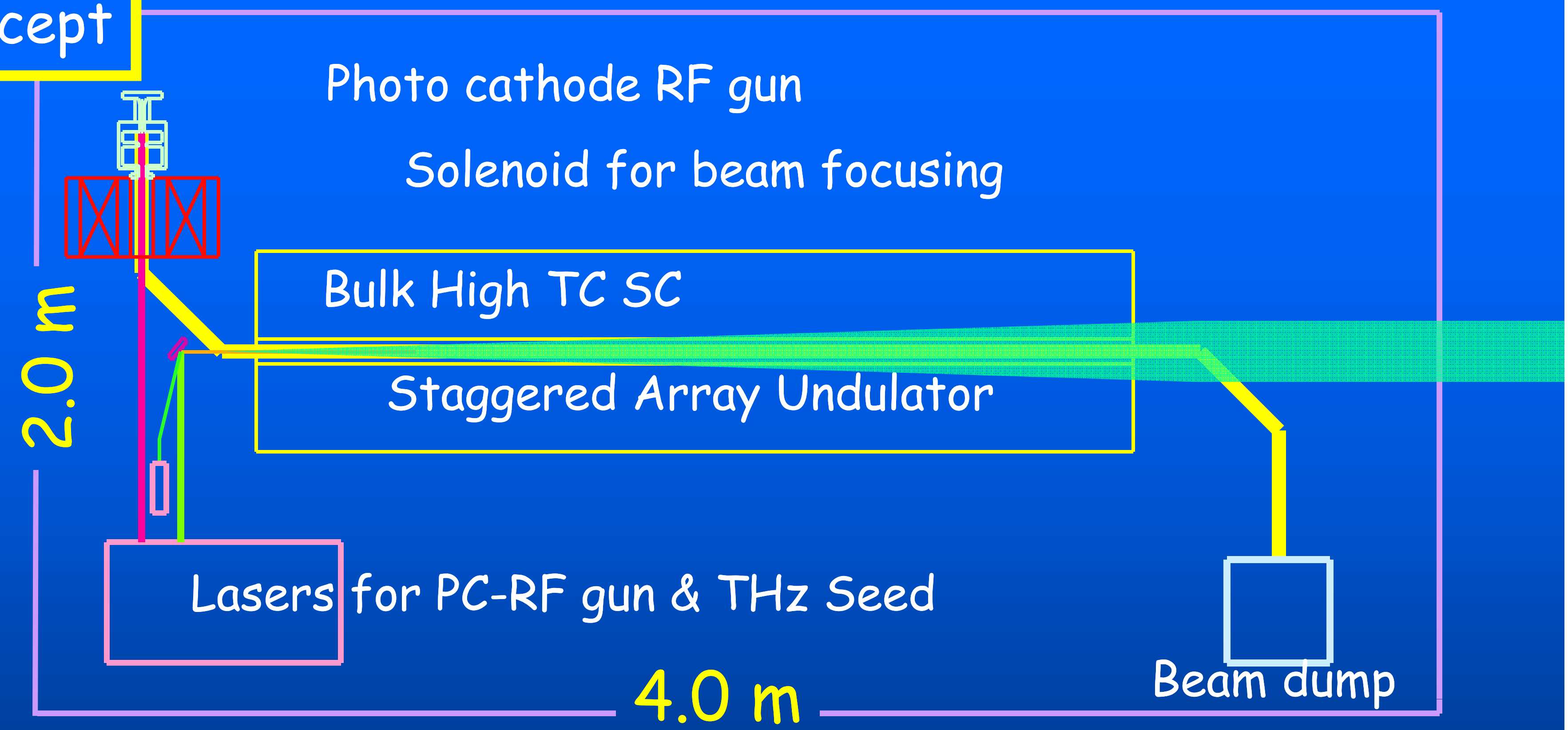
How to realize
Table Top THz FEL

¤ Photocathode RF gun

¤ Bulk High TC superconducting undulator

¤ Injection seeded THz parametric generator

Concept



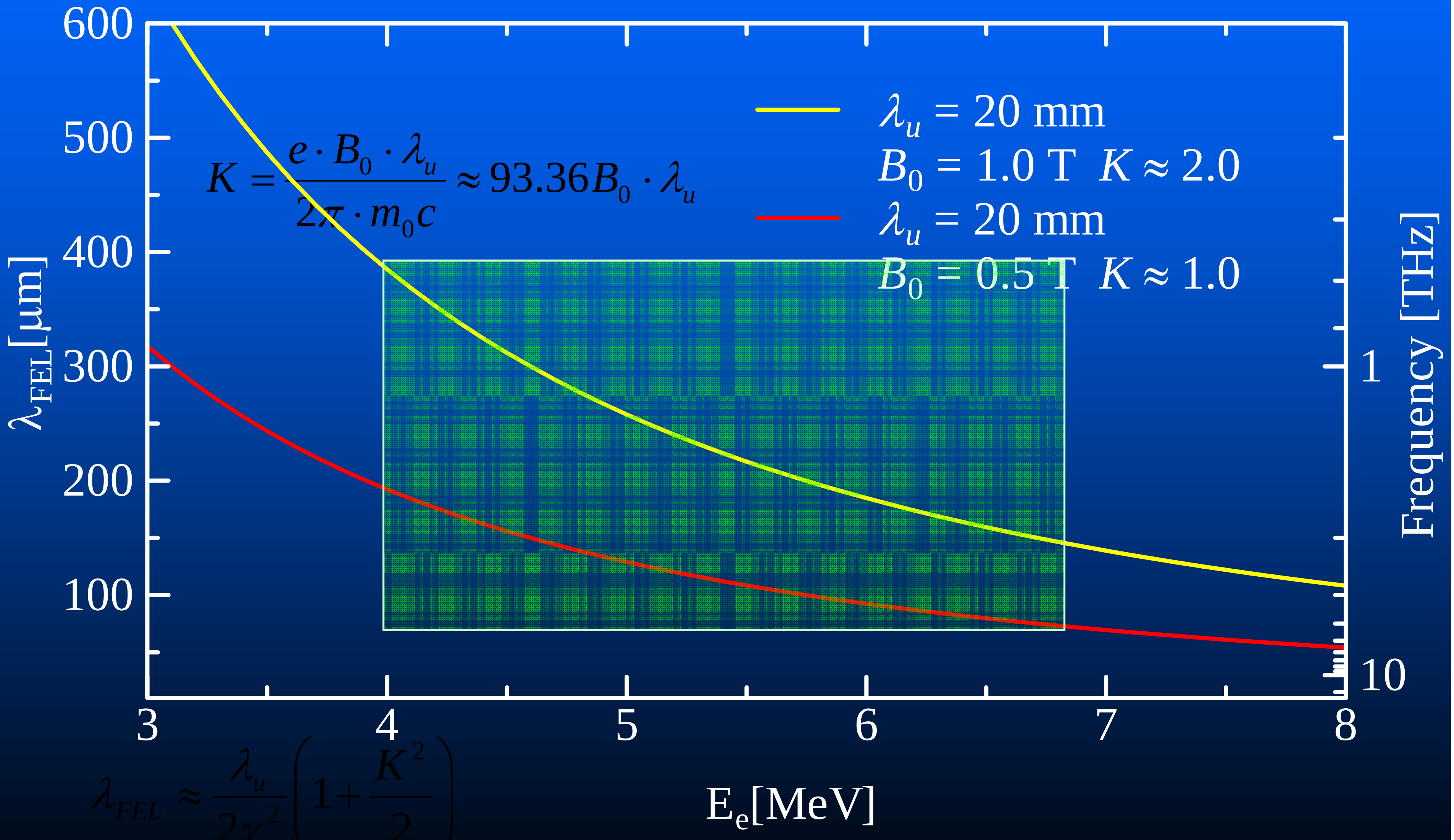
Electron beam : E_e = 3~7 MeV, I_e ~ 1 nC,
ε ~ 2π mm mrad, dE/E ~ 1%

Seed : λ 100 ~ 300 μm
Power 0.2 W

Undulator : Period = 20 mm
Peak Field = 0 ~ 1 T

Feasibility study have been carried out.

Radiation Wavelength vs. Electron Energy



$$\lambda_{FEL} \approx \frac{\lambda_u}{2\gamma^2}\left(1 + \frac{K^2}{2}\right)$$

1. Introduction
2. Concept
3. Devices
   - PC RF-gun
   - Bulk HTSC SA undulator
   - is-TPG
4. Numerical study
5. Conclusion

Device : Photocathode RF gun

Improved design
in tuner and brazing
High vacuum
Low dark current
→
High gradient
> 100 MV/m

1.6 cell Photocathode RF gun

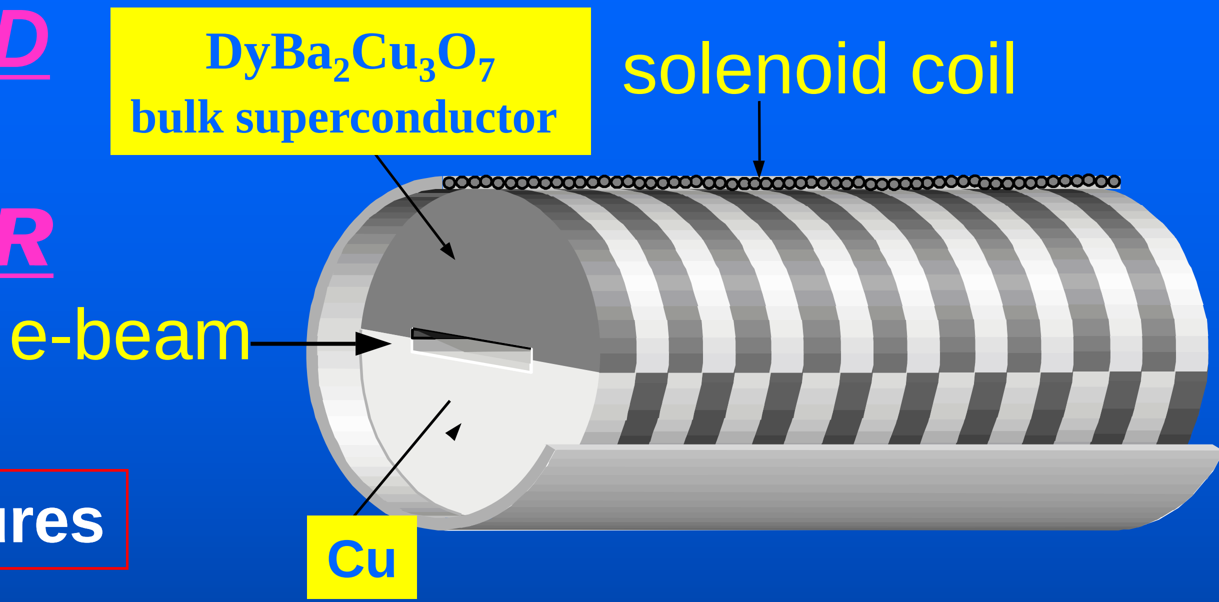
Collaboration with KEK-ATF, AIST, Waseda Univ., Osaka Univ

Estimated beam parameter

emittance	< 2 π mm-mrad
energy spread	< 1.0%
bunch charge	> 1nC
beam energy	~ 7 MeV

Device : Bulk HTSC Staggered Array undulator

STAGGERED ARRAY UNDULATOR



Main Features

(1) control of magnetic field through solenoid current

(2) economic and easy to manufacture

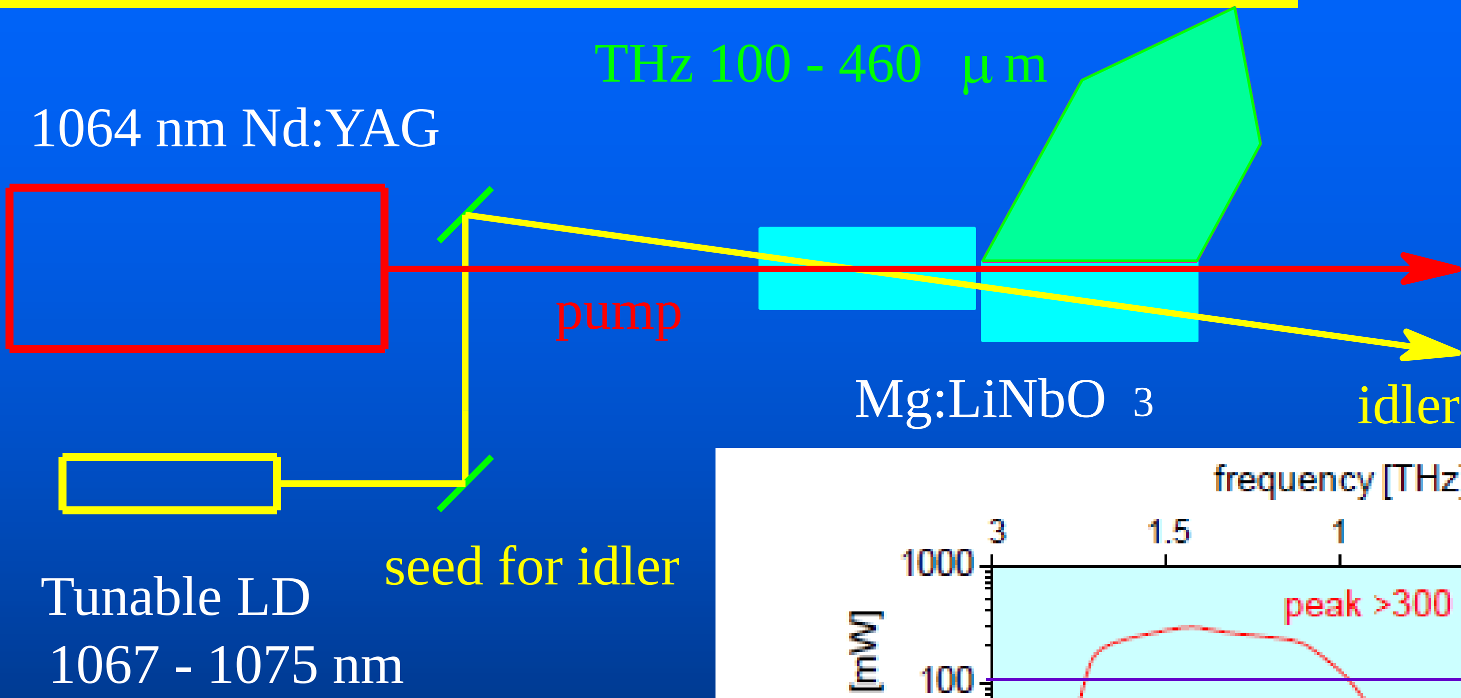
(3) focusing of electron beam with axial magnetic field

(4) less radiation damage

(5) compact and high magnetic field

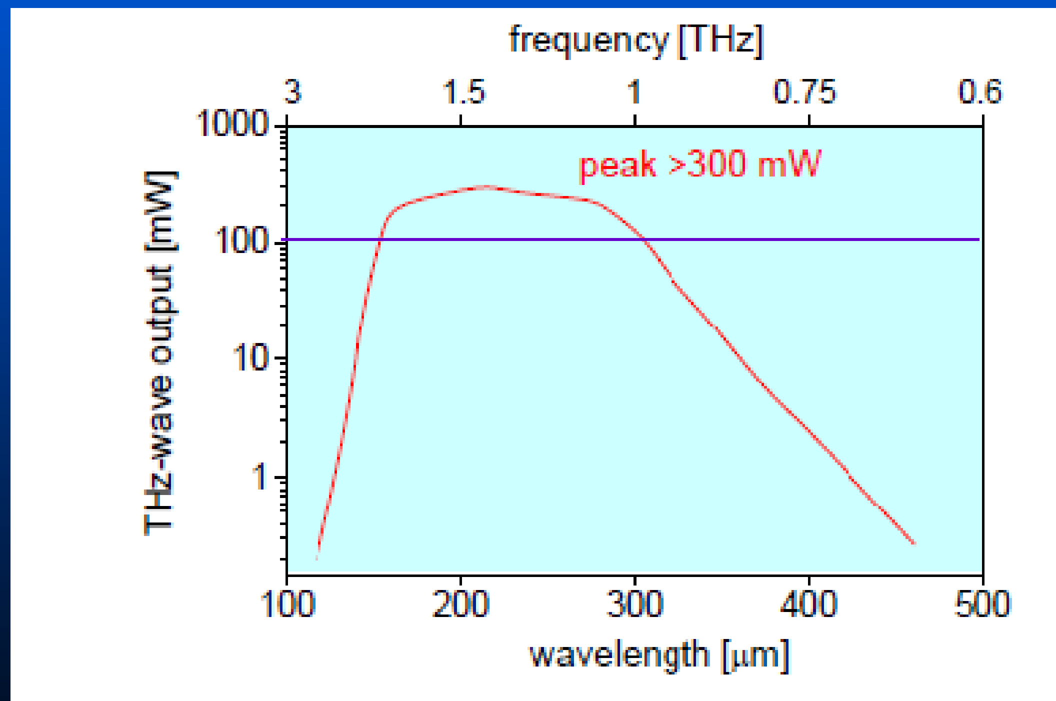
REF: Y.C.Huang, H.C.Wang, R.H.Pantell, J.Feinstein, and J.W.Lewellen, Nucl.Instr.Methods in Phys.Res., **A318** (1992)765-771.

Device : THz Seed (is-TPG)
Injection seeded THz parametric generator



Tunable range
- 0.6 ~ 2.6 THz

Peak power
- ~ 300 mW
- > 200 mW
  - @ 1.05 ~ 1.88 THz



Kawase, et al., Applied Physic Letters 80 (2002), pp. 195

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Optimizing parameters

Laser phase, solenoid field

FEL simulations

saturation length

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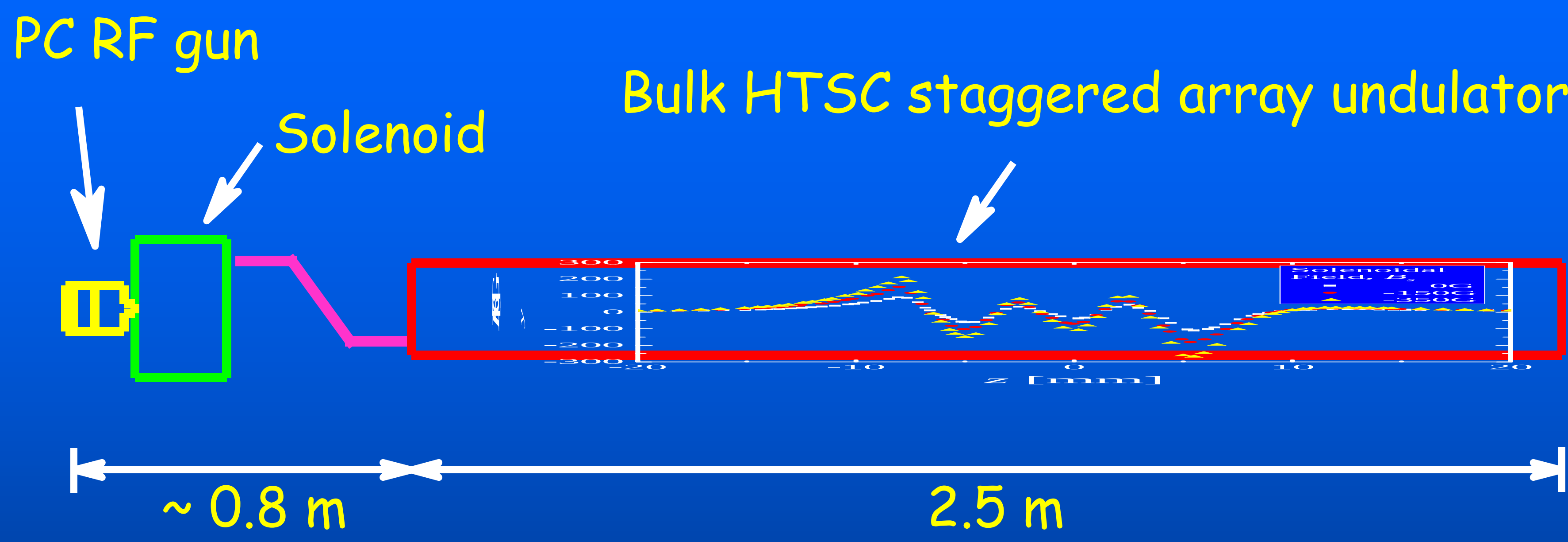
Numerical Study



optimize the electron beam

- Beam energy
- Energy spread
- Peak current
- Emittance

electric field
laser injection phase

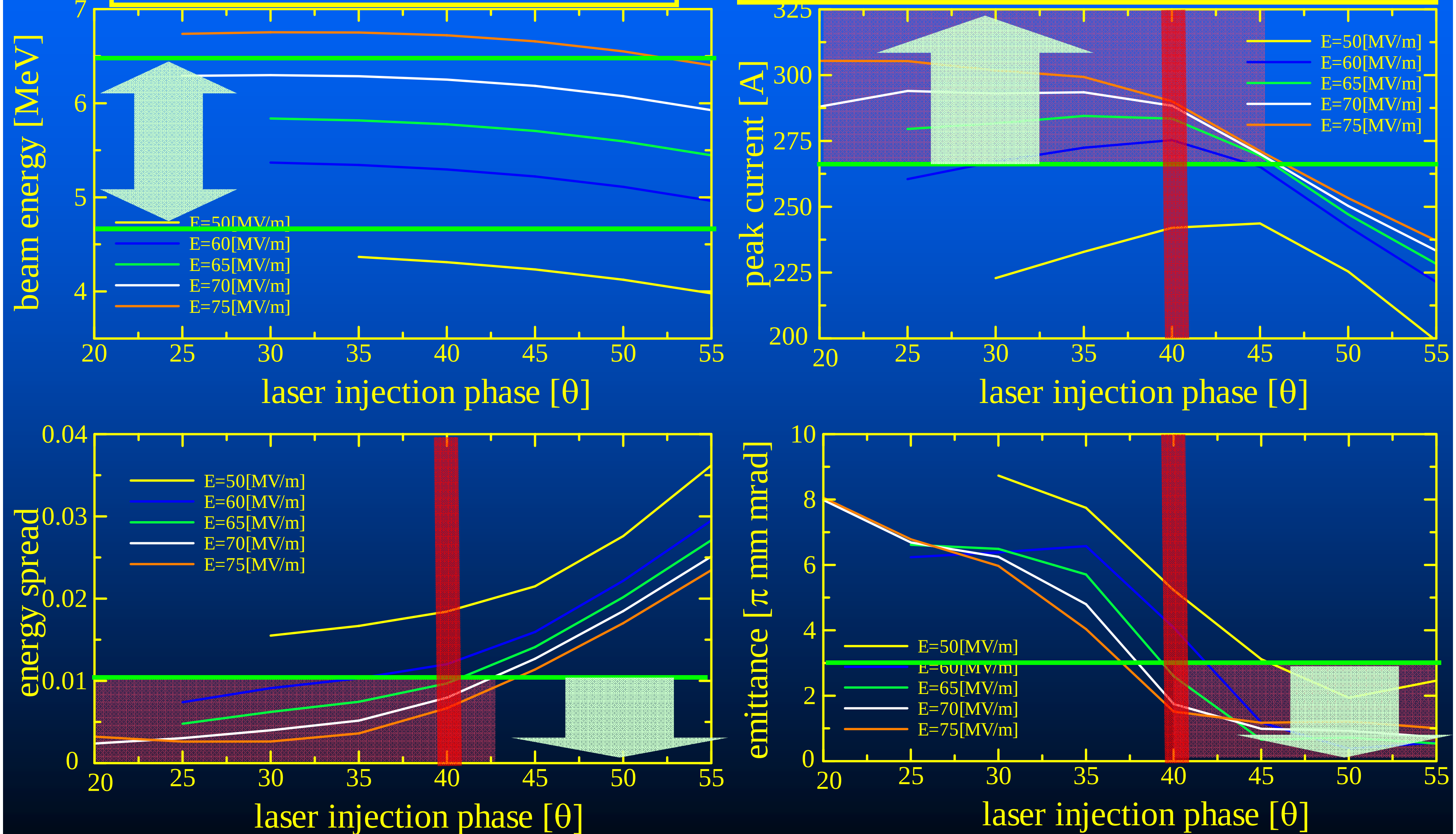
optimize the beam focusing in the undulator

focusing solenoid

Results

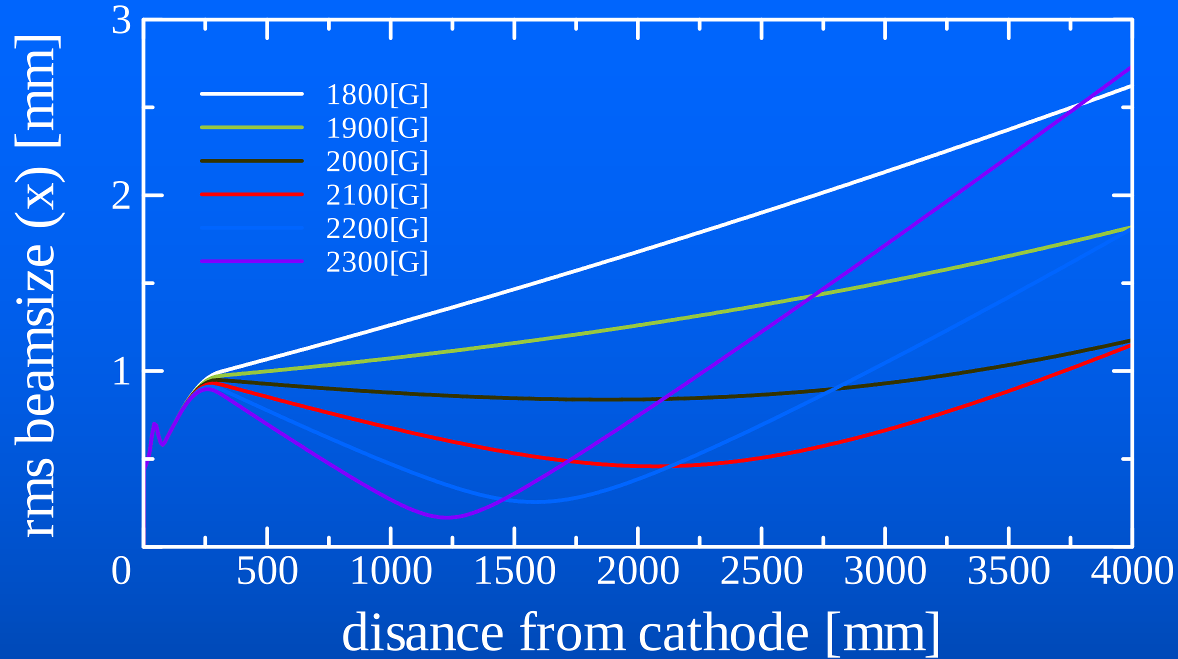
Small energy spread with high peak current

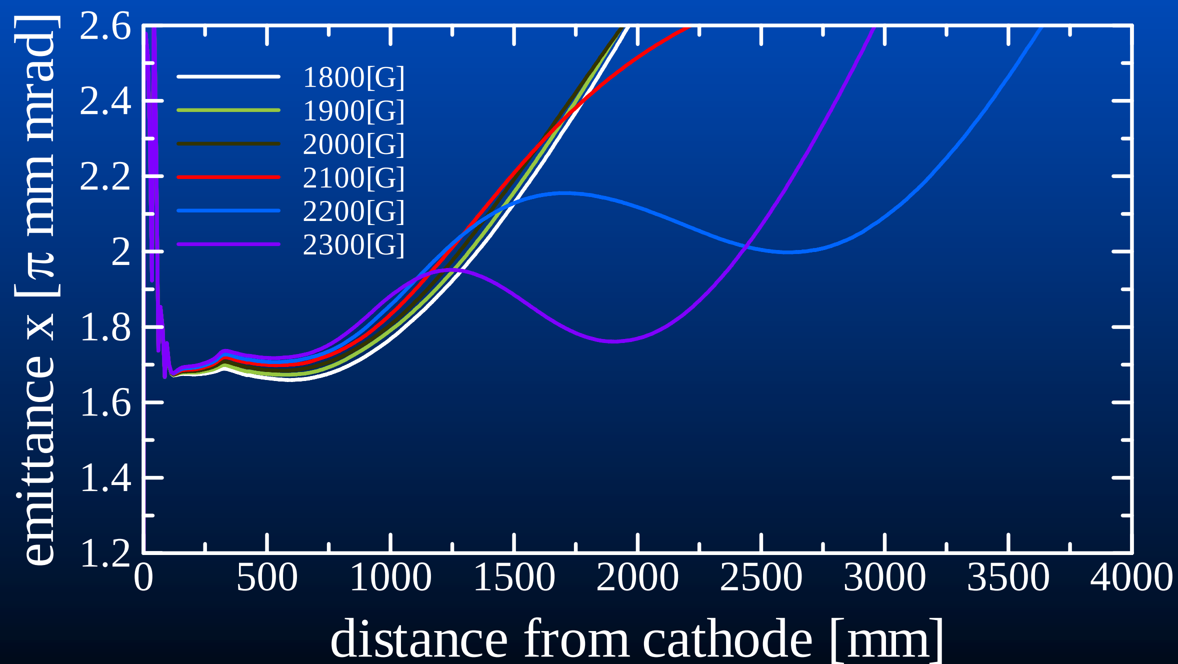
Optimized : Electric field 70 MV/m : Injection phase 40 degree



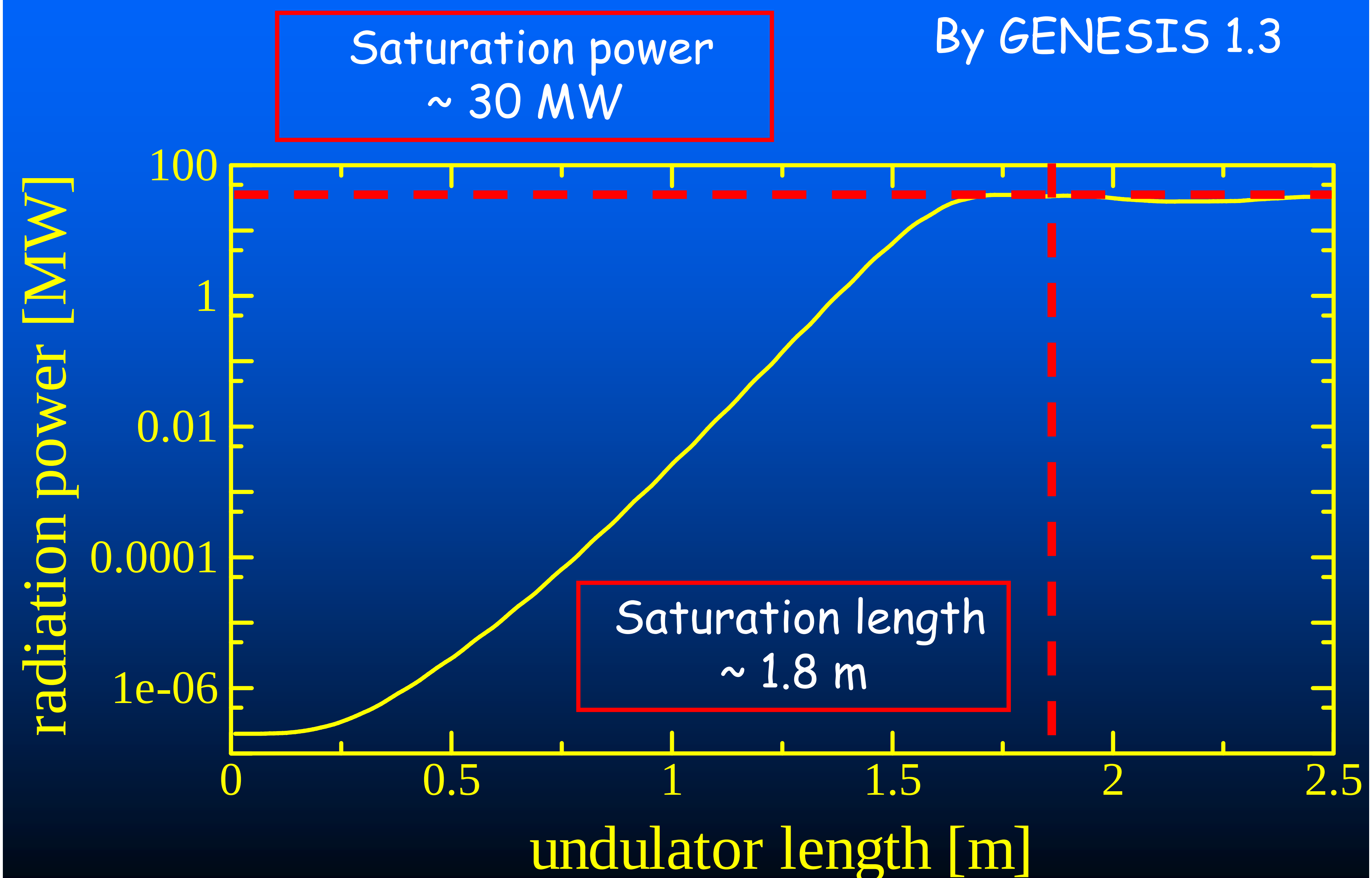
Results

Optimized :
Solenoid field
= 2100 G





Power evolution @ 1.62 THz



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Conclusion

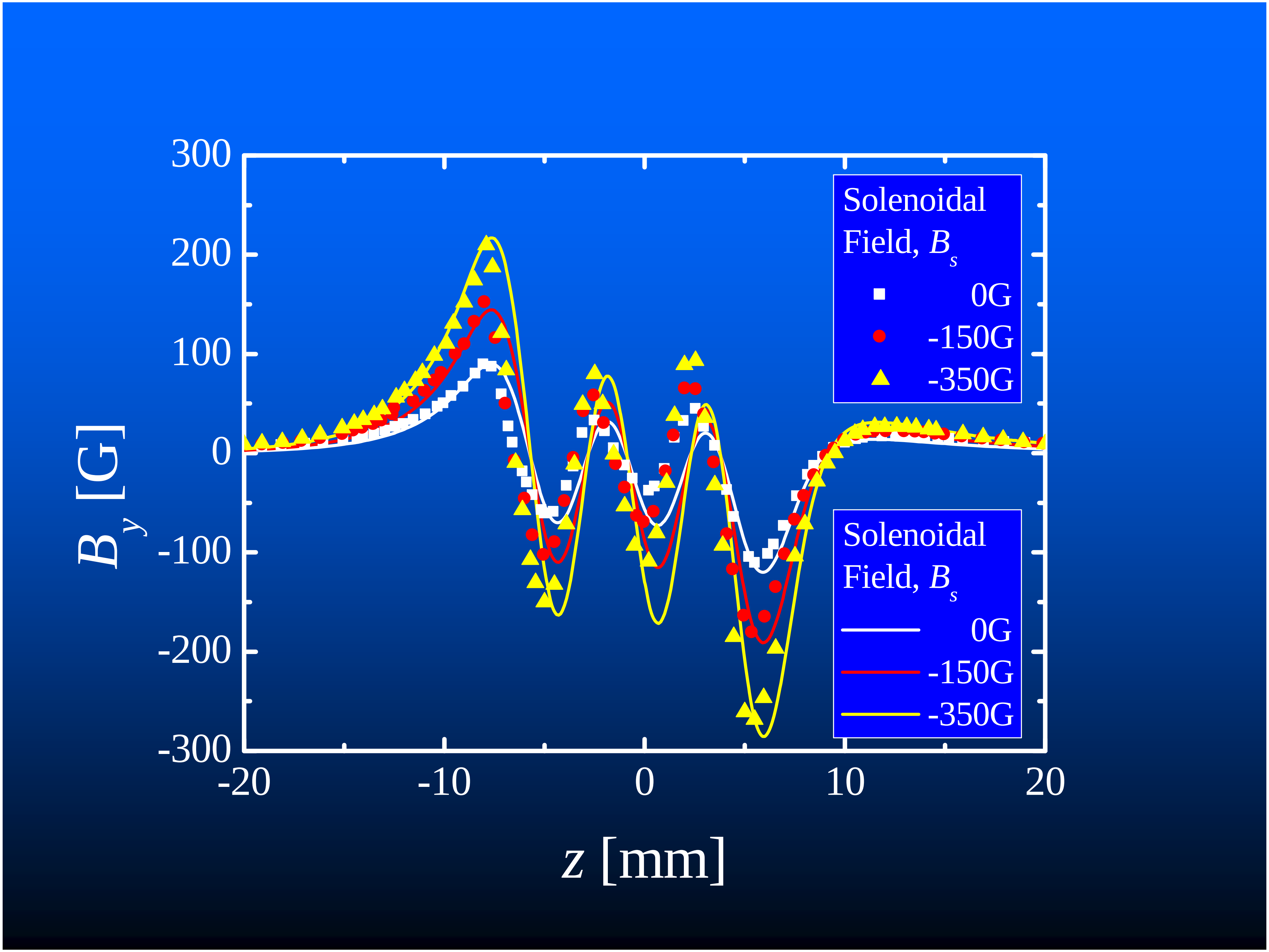
We have proposed a **compact seeded THz FEL amplifier** which consists of **PC RF gun**, **bulk HTSC** staggered array undulator and **is-TPG** .

Feasibility study have been carried out using PARMERA and GENESIS for **a simple configuration**.

The saturation length at **1.62 THz** was about **1.8 m** and saturation level was **30 MW**.

Calculation with realistic configuration will be continued to realize the table top THz FEL amplifier

Thank you for your attention.


300
200
100
0
-100
-200
-300
B_y [G]
-20
-10
0
10
20
z [mm]
Solenoidal Field, B_s
0G
-150G
-350G
Solenoidal Field, B_s
0G
-150G
-350G

Norm. emittance (x)	1.77 π mm-mrad
Norm. emittance (y)	1.63 π mm-mrad
Energy Spread	0.80 %
Beam radius (x)	0.74 mm
Beam radius (y)	0.72 mm
Twiss parameter α_x	2.95
Twiss parameter α_y	1.95
Peak current	288 A
Electron energy	6.25 MeV
Seed power	0.2 W