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# MAIN CHARACTERISTICS OF TAC IR FEL

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**Abstract. -** As a first facility of Turkish Accelerator Center (TAC) an Infrared Free Electron Laser (IR FEL) facility is planned. Two optical cavities are planned to obtain two FEL beams to cover 2-185 microns wavelength based on 15-40 MeV electron beam. TAC IR FEL will be an oscillator FEL. Most important part of an oscillator FEL system is optical cavity. An optical cavity contains undulator magnet to obtain radiation from electron beam, waveguide and mirrors to reach power saturation of radiation. In this study, main parameters and gain mechanism of two optical cavities of TAC IR FEL are explained. Main parameters of electron linac and undulator magnets are given. Some important characteristics like optical intensity, gain, average power and pulse energy of FEL beams are given that are obtained by FELO code. (http://thm.ankara.edu.tr ).

## 1. INTRODUCTION

Turkish Accelerator Center (TAC) Project propose a collider, light sources (SR and FEL) and a proton accelerator [1-3]. Before having the complex, to become experienced with the accelerator based light source technologies, it is proposed to establish an Infrared Free Electron Laser (IR FEL) laboratory as a first facility until 2011 [4,5]. Up to now, it is optimized that the facility will produce an infrared laser beam in mid and far infrared regions. The facility will contain a Sc electron linac with 15-40 MeV energy range in order to obtain laser at 2-185 micron wavelengths range [6-8]. Moreover, a Bremsstrahlung experimental station is planned using the same electron linac in the 20 MeV electron beam energy range to study nuclear physics.

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## 2. FEL OSCILLATOR

The main components of the FEL oscillator are; undulator magnets, electron beam and mirrors. When a relativistic electron beam obtained from a linear accelerator is passed through an undulator magnet, an undulator radiation occurs in a narrow cone. The emitted radiation is trapped between two mirrors and interacts with the electron bunches in the undulator. The interaction between the electron bunches and the electromagnetic field causes the coherency of the radiation wavelength. The main gain mechanism of the FEL is the energy exchange between electron beam and radiation.

## 3. TAC IR FEL FACILITY

It is optimized that two optical cavities which contain two undulator magnets with different undulator periods ($\lambda_{u1}$=3 cm and $\lambda_{u2}$=9 cm) must be used because of the desired large wavelength range. The accelerator structure was taken into consideration as a superconducting form and in 15-40 MeV energy range. The obtained beam will be between 2-185 micron wavelengths [6-8, 14]. The general layout of the TAC IR-FEL facility is shown in Fig. 1. In addition, an oscillator Infrared Free Electron Laser (IR-FEL) facility covering 2-185 $\mu m$ wavelength range based on an 15-40 MeV electron linac and a bremsstrahlung station will be constructed in the 2008-2011 period as a first facility of TAC for the aim of research, education and training [7, 8].

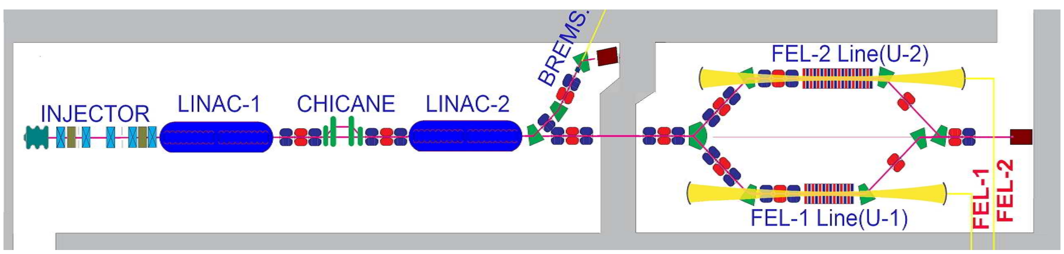



Figure 1: General layout of TAC IR FEL

In order to obtain necessary wavelength and spectral properties with the laser beam, the undulator is the most important part of the FEL. The available permanent magnet materials have been chosen Sm2Co17 with 3 cm and 9 cm undulator period lengths for two undulator magnets. During the optimization studies, both 1 mA and 1.6 mA electron beam average current options were taken into account [6-8]. Some of the main electron beam, resonator and FEL parameters and were given in Table 1 and 2, respectively.

To examine the radiation characteristics in optimization studies, SDDS adapted, time depended, one dimensional oscillator free electron code "FELO" (developed by ASTeC CCLRC Daresbury Laboratory, UK) and Mathematica were utilized [15]. FEL

Table 1: Main e$^-$ beam parameters of TAC IR-FEL

| **Parameter** | **10kW RF** | **16kW RF** |
|---|---|---|
| Max beam energy (MeV) | 40 | 40 |
| Bunch charge (pC) | 80 | 120 |
| Average current (mA) | 1 | 1.6 |
| Rms bunch length (ps) | 1-10 | 1-10 |
| Bunch separation (ns) | 77 | 77 |
| Nor.rms tran.emt.(mm.mrad) | <15 | <15 |
| Nor.rms long.emt.(keV.deg) | <35 | <38 |
| Rms energy spread (%) | 0.05 | 0.08 |

Table 2: Main parameters of resonators and FEL

| **Undulator Magnets** | **U1** | **U2** |
|---|---|---|
| Undulator material | $Sm_2Co_{17}$ | $Sm_2Co_{17}$ |
| Undulator period [cm] | 3 | 9 |
| Undulator gap [cm] | 1.5-3 | 4-9 |
| Rms undulator strength | 0.2-0.8 | 0.4-2.5 |
| Number of period | 56 | 40 |
| Resonator length [m] | 11.53 | 11.53 |
| **Free Electron Laser** | **FEL-1** | **FEL-2** |
| Wavelength [$\mu m$] | 2.7-30 | 10-190 |
| Pulse energy @80 pC [$\mu J$] | 2 | 4 |
| Pulse energy @120 pC [$\mu J$] | 4 | 10 |
| Max peak power @80 pC [MW] | 8 | 10 |
| Max peak power @80 pC [MW] | 12 | 15 |
| Pulse length (ps) | 1-10 | 1-10 |

characterization results were given in figures both for the 1 mA and 1.6 mA options.

## 4. CONCLUSION

TAC IR-FEL optimization studies have been still continuing. In this study, superconducting accelerator option results were given. Since the choice of the accelerator will directly affect to the obtained FEL's time structure, it will affect the choice of the kinds of experiments at the same time. To select the most convenient structure, it has been taken into consideration that new research areas, and the need of users in our region. The first commissioning of TAC IR-FEL will be in 2011. It will be the pioneer for the national complex. The research potential of TAC IR FEL facility has been covered quite wide range [9-13].

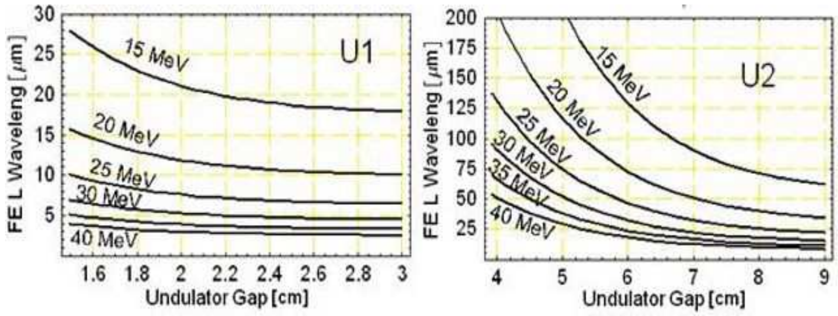



Figure 2: FEL wavelength tunability vs the undulators' gaps with respect to beam energy. (a)U1 (b)U2.

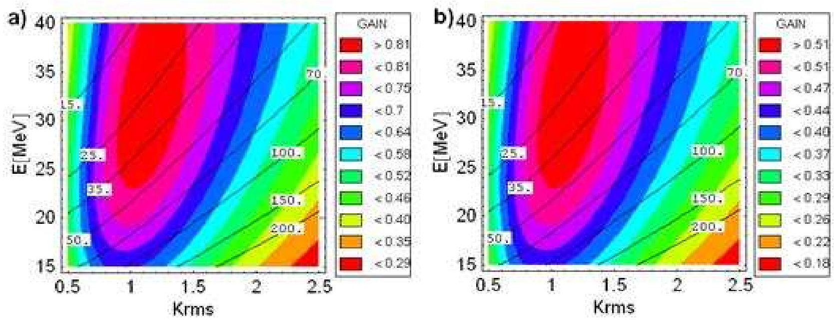



Figure 3: Single pass gain respect to E and Krms for $\lambda_{U1}$=3cm a) Iavg=1.6 mA, b) Iavg=1 mA.

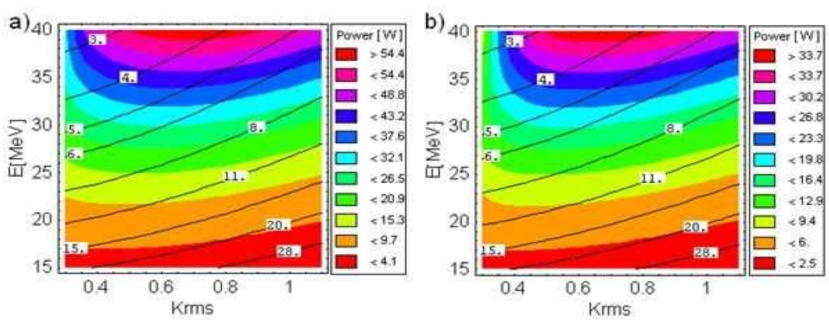
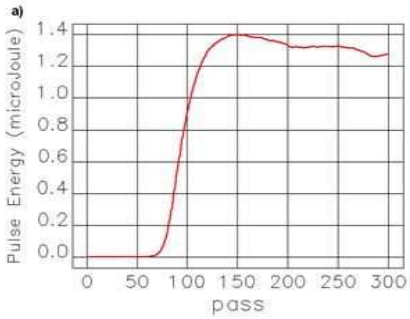



Figure 4: FEL expected output power respect to E and Krms for $\lambda_{U1}$=3cm a) Iavg=1.6 mA, b)Iavg=1 mA.



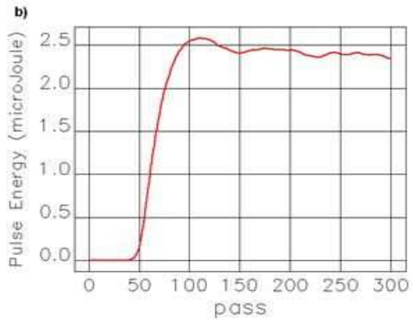




Figure 5: Pulse energy propagation vs passes for 3 $\mu m$ obtained with U1 (a)Iavg=1 mA,(b)Iavg=1.6 mA.

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