THE STATUS OF TAC IR FEL AND BREMSSTRAHLUNG PROJECT *

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Abstract

Turkish Accelerator Center Infrared Free Electron Laser and Bremsstrahlung (TAC IR FEL&Brems.) project aims to produce cw mode FEL in 2.5-250 microns range and to produce bremsstrahlung photons using 15-40 MeV electron beam. The project is supported by State Planning Organization (SPO) of Turkey and is proceeded with inter university collaboration under the coordination of Ankara University. This facility is now called Turkish Accelerator and Radiation Laboratory at Ankara (TARLA) since its building located at Golbasi town 15 km south of Ankara, Turkey. It is proposed that the facility will consist of 300 keV thermionic DC gun, two superconducting RF module and two optical resonator systems with 25 and 90 mm period lengths. In this study, the status and road map of the project is presented including some technical details on accelerator and FEL. In addition the research potential of facility is summarized.

INTRODUCTION

The TARLA [1, 2] aims to obtain FEL between 2.5-250 microns using Continious Wave (CW) electron beam in the range of15-40 MeV. The electron source is high average current thermionic DC gun running at up to 300keV, which is in manufacturing phase at the moment. The injector system will be completely based on normal conducting technology with two bunchers that operate 260 MHz and 1.3 GHz, respectively [3]. The injector will be sufficient to establish well definedbeam before electron enters the first superconducting accelerator (SC) modules.

Available two ELBE module that each houses two TESLA 9-cell SC structure is proposed to be used as main accelerator [4]. This module is currently designed to accelerate an electron beam at 1 mA of average beam current for continious wave operation (CW) but has the capability to operate at higher beam power at 1.6 mA [5]. We propose to use the same technology with increased electron current (1,6 mA instead of 1 mA) as an update option in order to run FEL. Thus, this increased beam current is essential to achieve more power of the secondary beams in our facility. To achieve the higher electron beam power it is planned to use solid state RF amplifiers which gives power up to 16 KW [6]. Main parameters of electron beam of TARLA is given with Table 1.

Table 1: Main e^- beam parameters of TARLA

Parameter	Value
Max Beam Eenergy (MeV)	40
Bunch Charge (pC)	120
Average Current (mA)	1.6
Rms Bunch Length (ps)	0.6-8
Micropulse Repetition (MHz)	13-26
Nor.rms Tran.Emt.(mm.mrad)	<15
Nor.rms Long.Emt.(keV.ps)	<50
Macropulse Repetition (Hz)	1-25
Macropulse Duration (μs)	40-100

In order to scan desired wavelength range 2-250 μm range, it was decided to use 2.5 cm and 9 cm period length undulators located in two different optical resonators. There will be a transport line for Bremsstrahlung after the second accelerating cavity. The layout of the IR FEL & Bremsstrahlung laboratory is shown in figure 1.

FEL SIMULATIONS

As the main part for the FEL, the design of the undulator is most crucial for obtaining the necessary wavelength range and spectral properties. An available permanent magnet material Sm_2Co_{17} with related period length have been chosen to scan desired wavelength range. The basic parameters of resonators and undulators parameters are given with Table 2

FEL optimisation is performed using FELO code which is one-dimensional free electron laser oscillator simulation code (developed by ASTeC CCLRC Daresbury Laboratory, UK [7]) and Mathematica [8] were utilized. Some results for FEL optimization are given with figures (2 - 6) below.

As it can be seen in figure 2 and figure 3 FEL wavelenghts obtained from U25 and U90 overlaps between 15-20 microns range. This range allows us to be on safe about scanning whole range. On the other hand it is also difficult to reach wavelengths more than 250 microns. In order to solve this difficulty we propose to run the machine lover energies than 15 MeV.

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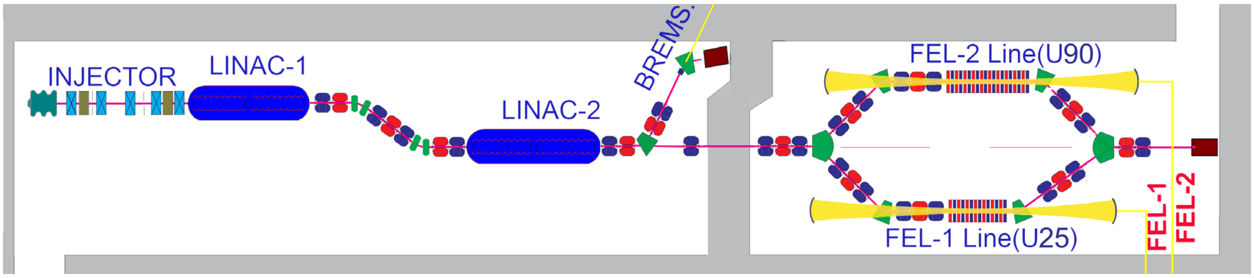

Figure 1: General layout of TAC IR-FEL Facility.

Table 2: Main Parameters of TARLA Resonators

Parameter	U1	U2
Undulator material	Sm_2Co_{17}	Sm_2Co_{17}
Undulator period [cm]	2.5	9
Magnetic gap [cm]	1.5	4
Effective Field [T]	0.35	0.42
Rms undulator strength	0.25-0.7	0.7-2.5
Number of period	60	40
Resonator length [m]	11.53	11.53
Radii of curve of mir.[m]	5.92	6.51
Rayleigh length [m]	0.97	2.08

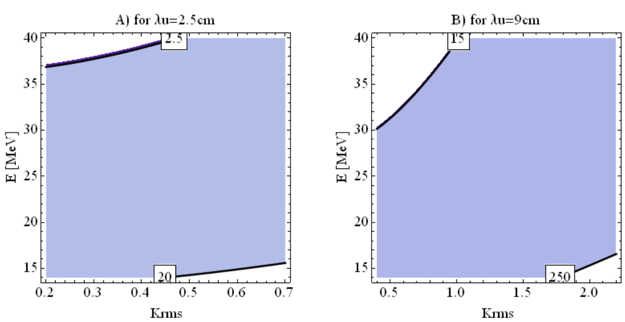

Figure 2: The FEL wavelength tunability vs the undulators' gaps with respect to beam energy. (a)U25 (λ_U=2.5 cm) (b)U90 (λ_U=9 cm)

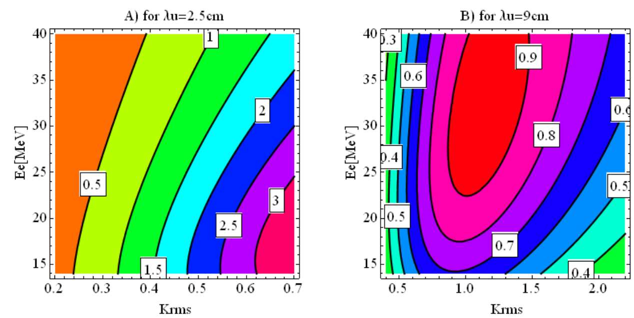

Figure 3: Single pass gain respect to E and K_{rms} (a)λ_U=2.5 cm (b)λ_U=9 cm

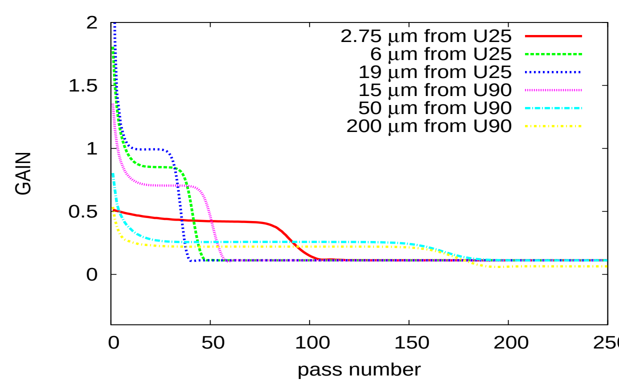

Figure 4: Gain variation through saturation process for some wavelenghts obtainable from U25 (λ_U=2.5 cm) and u90 (λ_U=9 cm)

PROPOSED RESEARCH AREAS

It has been planned that the facility will have been eight experimental stations. The beam will be used in various research programs under cooperation with the national and regional users and research groups. The tunability and short pulse structures of the FEL have opened up new applications in such areas as material sciences, biotechnology, nonlinear optics, nanotechnology, photochemistry and semiconductors. The quality and kinds of scientific researches in Turkey will rise with the use of FEL [9].

The first room which is placed in eight is the diagnostic room. FEL physics studies will be searched in this room and the obtained laser will be transported to the other seven rooms. IR spectroscopy, IR imaging and IR microscopy technics will be applied in two of other seven rooms for material science and semi-conductor studies.The other five experimental laboratories will be formed according to the potential of the researchers and to the user needs such as pump-probe experiments, vibrational relaxation time studies, photon echo experiments, sum-frequency generation techniques etc [10, 11, 12, 13, 14].

CONCLUSION

Manufacturing of the gun and gun-grid control electronics already started in Turkey with collaboration of FZD. In 2010, we propose to manufacture other main equipments

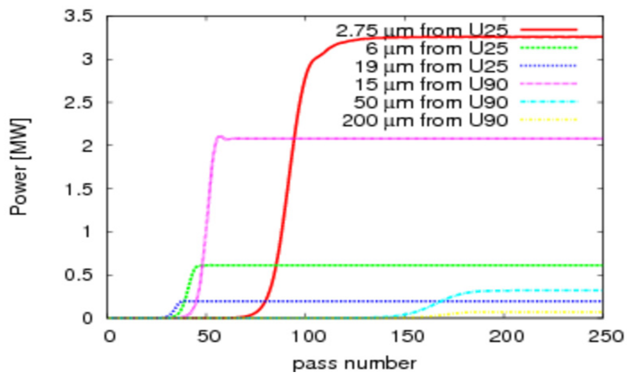

Figure 5: Power saturation process versus roundtrips for some wavelenghts obtainable from U25 (λ_U=2.5 cm) and u90 (λ_U=9 cm)

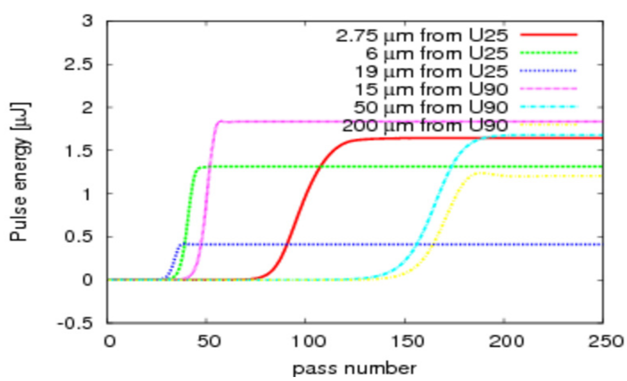

Figure 6: Intracavity pulse energy saturation versus roundtrips for some wavelenghts obtainable from U25 (λ_U=2.5 cm) and u90 (λ_U=9 cm)

of the injector after the tests of gun and install the injector test stand in our facility after the commissioning of the facility building by the end of 2010. It is planned to install the SC accelerating modules by the mid of 2012 with cyrogenic plant and commissioning of the FEL is planned by the beginning of 2013.

TAC IR FEL facility will give some new research opportunities in basic and applied sciences using FEL in middle and far infrared region. The expected FEL parameters of TARLA is given with Table 3.

Table 3: Expected Laser Parameters of TARLA

Parameter	U25	U90
Wavelength (μm)	2.5-20	15-250
Micropulse repetition (MHz)	13-26	13-26
Max. Peak Power (MW)	0.1 6	0.01-2
Average Power (W)	1-100	1-100
Max. Pulse energy (μJ)	0.1-3	0.1-3
Pulse length (ps)	1-10	1-10

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