DIAGNOSTIC SYSTEM OF TAC IR FEL FACILITY*

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Abstract

The TAC (Turkish Accelerator Center) IR FEL facility which is named as Turkish Accelerator and Radiation Laboratory at Ankara, TARLA will be based on a 15-40 MeV electron linac accompanying two different undulators with 2.5 cm and 9 cm periods in order to obtain IR FEL ranging between 2-250 microns. The electron linac will consist of two sequenced modules, each housing two 9-cell superconducting TESLA cavities for cw operation. It is planned that the TARLA facility will be will be completed in 2013 at Golbasi campus of Ankara University. This facility will give an opportunity to the scientists and industry to use FEL in research and development in Turkey and our region. In this study, the main structure of the facility and planned electron beam diagnostics system is given in detail.

INTRODUCTION

It is generally accepted that to obtain high quality FEL, the electron beam should have high peak current, short bunches (depending on wavelength), minimum energy spread and low emittance, so on. Furthermore, in order to serve wide range of experimental needs of users, the time structure of electron should have both continuous wave and pulsed mode. In addition, the system should have minimum setup time, maximum beam time and stable parameters.

The TARLA [1],[2] aims to obtain FEL between 2.5-250 μm using electron beam in the range of 15-40 MeV and two undulators with 25 and 90 mm period lengths. The electron source is chosen to be a high average current thermionic DC gun running at up to 250 keV, 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. The injector will be sufficient to establish well-defined beam before electron enters the first superconducting accelerator (SC) module. The main acceleration structures will consist of two ELBE modules that each houses two TESLA 9-cell SC structures. These modules are designed to operate at 1mA electron beam current but they are capable of operating at 1.6mA continuous wave operation (CW) that we plan to achieve in the further upgrade. The main parameters of TARLA electron beam are given in Table 1. General layout of TARLA is showed in Fig. 1.

Table 1: TARLA Expected Beam Parameters

Parameters	**Current**	**Upgrade**
Energy [MeV]	15-40	15-40
Bunch Charge [pC]	80	120
Average Beam Current [mA]	1.0	1.6
Micro Bunch Rep. Rate [MHz]	13-26	13-26
Macro Pulse Duration [μs]	10 to CW	10 to CW
Macro Pulse Rep. Rate [Hz]	1 to CW	1 to CW
Bunch Length [ps]	0.5-8	0.6-8
Nor. RMS trans. Emit. [mm mrad]	<12	<15
Nor. RMS Long. Emit. [keV.ps]	<40	<50

DIAGNOSTIC REQUIRMENTS

In the installation and running process of the FEL, high quality electron beam is needed. Therefore the beam properties and parameters such as beam charge, beam position and beam losses should be viewed and measured along the beam line. Also some parameters such as beam profile, emittance, longitudinal bunch length, energy and energy spread should be determined in the installation and maintenance of FEL.

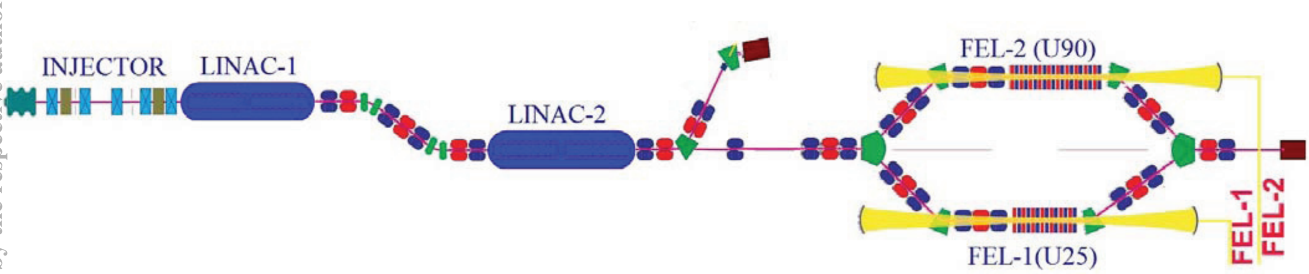

Figure 1: General layout of TARLA.

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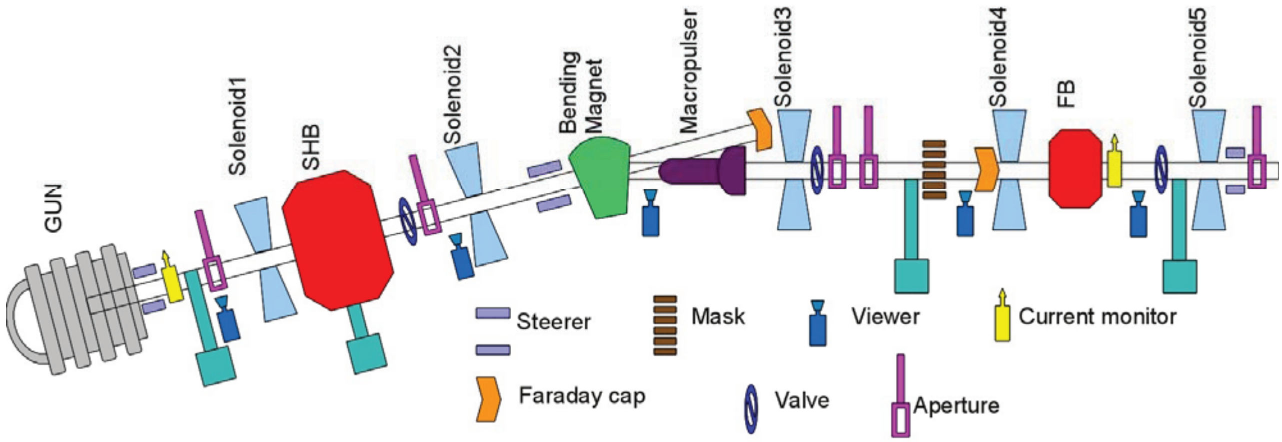

Figure 2: Layout of the injector of TARLA.

Beam Position Monitors

For short bunch electron accelerator, mostly button BPM or stripline type beam position monitors are used. Button types monitors are consist of metal plates and their frequency range is 100 MHz < f_{acc} < 3 GHz and also mechanical realization is very simple. However, the signal of the button type BPM would not be strong enough for the bunch charge of electron beam of TARLA. Therefore stripline monitor will be more appropriate.

Beam Profile Monitors

To measure the beam profile scintillating viewers and Optical Transition Radiation (OTR) monitors can be used. OTR is the better way to monitoring the beam. The disadvantage of OTR is low efficiency at low energy. So, OTR monitors is appropriate at high energies (40 MeV) Therefore in the injector scintillating screens will be used. For this purpose, special types of material have been developed and they are usually referred as phosphors. A typical material is widely used in accelerators is aluminum oxide (alumina) doped with chromium (Chromox Al_2O_3:Cr) and monocrystals YAG [3]. The chromox has very good light emission yield and cheap. Therefore it is appropriate to use as phosphorus material in scintillating screen.

Bunch Charge Measurement

In the injector of TARLA the bunch charge will be measured with two different method; Faraday Cup and beam Current transformer. Faraday cup is the easiest way to measure the beam current. But it is destructive for the beam and it is placed at the end of the accelerator. It is made of a conductive material. The beam current can be measured directly by an ammeter (for D.C. current) or oscilloscope (for pulsed beam). 1 cm of cupper is enough for the electrons below 1 MeV. The current transformers that are convenient for TARLA-IR FEL can be found in the market [4]. A fast current transformer (FCT) has enough bandwidth for the high minipulse repetition rate. The current can be measured by ICT (Integrating current transformer) and the longitudinal beam profile can be viewed by FCT.

Emittance Measurement

Since the beam emittance is the measure of the beam size and beam divergence, it cannot be measured directly. So, different method is needed to measure emittance. At high energy (40 MeV) quadrupole scan method is appropriate. For low energy beam, space charge is dominated; therefore the emittance must be measured by multi-slit or pepper pot techniques in the injector [5].

Beam Loss Monitor

Long ionization chambers using a single coaxial cable is sufficient for one-shot accelerators or transport lines. The long chamber has to be split into short parts which are read out individually [6].

Energy and Energy Spread Measurements

Spectrometers determine the particle momentum by determining the deflection in a bending magnet. The deflection angle is proportional with the integral of magnetic field along the bending magnet and inversely proportional with the particle momentum: Very good precision is needed at the entrance and at the exit of the analyzing magnet. And also magnetic field must be very well determined. The energy spread can be determined with a bending magnet and an OTR viewer. When a beam deflected in bending magnet, high-energy particles deflection is more than the deflection of the low energy particles. Therefore, the size of the beam on the screen is proportional with the energy spread and it can be calculated.

Bunch Length Measurement

The longitudinal electron bunch length can be measured with two different methods. The first is to use the RF cavity operating in the TM_{110} mode (kicker cavity) at the end of the injector line. It has been used in many laboratories for low energy beams. Second method is Martin Puplett Interferometer (MPI) [7]. The MPI is a modified Michelson interferometer, where the beams are linearly polarized at specific orientations.

CONCLUSION

Diagnostic layout of the injector of TARLA is showed in Fig. 2. At the exit of the gun a current transformer will be used to measure the beam current. This device will be used also for preliminary test for the gun which is under manufacturing. The bunch charge will be measured several point of the beam line with faraday cup and current transformers. Beam profile is viewed by using the chromox and YAG:Ce screens at five point on the injector line. After the first linac the beam can be viewed by OTR monitors.

The energy spread will be measured by using the bending magnet and beam viewer in injector. A spectrometer can be used also to measure energy after the first and second linac. Multi-slit method will be used to measure the emittance after the third solenoid with a mask and beam viewer. Quadrupole scan method is appropriate after the second linac to measure the emittance. The beam diagnostic devices along the beam line are given in Table 2.

Table 2: Beam Diagnostic Devices of TARLA

Devices	Lovation	Number
BPM	All beam line	15
Scintillation Screen	Injector	5
OTR Screen	All beam line	16
Faraday Cup	Injector	1
FCT-ICT	Exit of the gun	1
ICT	All beam lline	6
Spectrometer	Exit of linac 1	1

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REFERENCES

[1] S. Sultansoy, Turk. J. Phys. 17 (1993) 591; Turk. J. Phys. 19 (1995) 785.
[2] Ö. Yavaş, A. K. Çiftçi S. Sultansoy, EPAC 2000, p. 1008.
[3] D. Brandt, CAS Proceedings, CERN-2009-05.
[4] Instrumentation, http://www.bergoz.com/
[5] M. Zhang, FERMILAB-TM-1998.
[6] P. Michel *et al.*, DIPAC 2003, Mainz, Germany.
[7] C. Kaya, U. Lehnert, DIPAC 2009, Basel, Switzerland.