# THE STATUS OF TURKISH ACCELERATOR CENTER PROJECT*

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*Abstract*

The Turkish Accelerator Complex (TAC) was proposed to Turkish State Planning Organization (DPT) as a regional facility for accelerator based fundamental and applied research center in 1997 [1]. After completing Feasibility Report (FR, 2000) [2,3], and Conceptual Design Repot (CDR, 2005) [4], third phase of project is started in 2006 as an inter-universities project with support of DPT. TAC collaboration includes ten Turkish Universities: Ankara, Gazi, İstanbul, Boğaziçi, Doğuş, Uludağ, Dumlupınar, Niğde, Erciyes and S. Demirel and around hundred scientists and students. Third phase of project has two main scientific goals: to write Technical Design Report (TDR) of TAC and to establish an Infrared Free Electron Laser (IR FEL) facility as a first step.

The TAC complex will include a 1 GeV electron linac and a 3.56 (4.5) GeV positron ring for linac on ring type electron-positron collider as a charm factory and a few GeV proton linac. Besides the particle factory, it is also planned to produce SASE FEL from electron linac and synchrotron radiation from positron ring. It is planned that the Technical Design Report (TDR) of TAC Project will be completed in 2013.

Furthermore, as the first step, an Infrared Free Electron Laser (IR-FEL) facility in oscillator mode will be established in order to become familiar to accelerator technology. This facility is now called **T**urkish **A**ccelerator and **R**adiation **L**aboratory at **A**nkara (TARLA) since located at Golbasi town 15 km South of Ankara, Turkey.

In this study, the status of TAC project is presented and latest considerations are given.

## INTRODUCTION

The general layout of TAC project is given in Fig. 1. The TAC projects has four main parts:

- A SASE FEL facility based on a 1 GeV electron linac with a wavelength of few nanometers,
- Third generation light source "Synchrotron Radiation" based on 3.56(4.5) GeV positron ring.
- A Linac-ring type electron-positron collider as a "Charm" factory,
- GeV scale proton accelerator consists of 100 MeV linear pre-accelerator and 1 GeV main ring,

Also, the TARLA facility as a Free Electron Laser is planned for accelerator based training and research which will be completed in 2013.

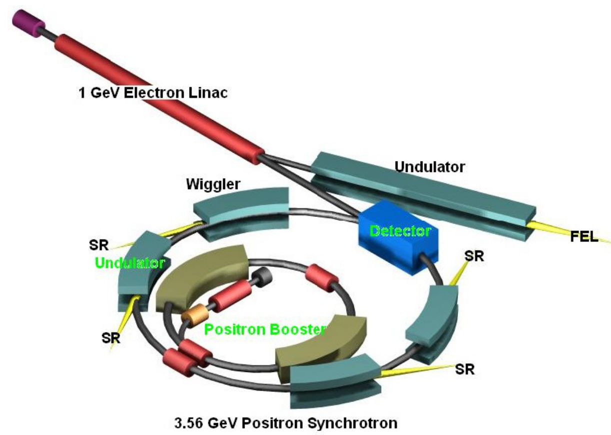


Figure 1: The General Layout of TAC project.

## *TAC IR FEL*

The TARLA [5] aims to obtain FEL between 2-250 μm range with two undulators ($\lambda_{U1}$ = 25 mm; $\lambda_{U2}$ = 90 mm) using 15-40 MeV energy range electron beam. The schematic of TARLA facility is given fin Fig. 2. The electron source is a high average current thermionic DC gun running at up to 350keV, which is in manufacturing phase at the moment. The superconducting cavities are based on TESLA design with the gradient of 20MV/m at $1.8^0$K. The power source will be IOT's with solid-state amplifiers to achieve 1.6mA average beam current. The electron beam parameters are given in Table 1 and expected FEL parameters in Table 2. There will be a transport line for Bremsstrahlung after the second accelerating cavity.

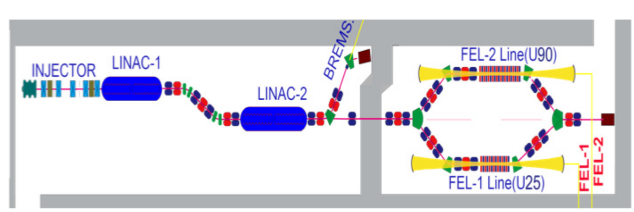


Figure 2: The General Layout of TARLA

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Table 1: Electron Beam Parameters of TARLA

| Parameters | Values |
|---|---|
| Energy [MeV] | 15-40 |
| Bunch Charge [pC] | 120 |
| Average Beam Current [mA] | 1.6 |
| Bunch Repetition Rate [MHz] | 260-13 |
| Bunch Length [ps] | 1-10 |
| Norm. RMS Trans. Emit. [mm mrad] | <15 |
| Norm. RMS Long. Emit. [keV.ps] | <100 |
| Pulse Duration | CW/tunable |

Table 2: Expected FEL of TARLA for 1,6 mA average beam current

| Parameters | Und.-1 | Und.-2 |
|---|---|---|
| Wavelength [μm] | 2-30 | 18-300 |
| Micropulse repetition rate [MHz] | 13 | 13 |
| Max. Peak Power [MW] | ~5 | ~2.5 |
| Average Power [W] | 0.1-40 | 0.1-30 |
| Max. Pulse energy [μJ] | ~10 | ~8 |
| Pulse length [ps] | 1-10 | 1-10 |

## *TAC SASE FEL*

A SASE FEL facility is also planned as 4th generation light source in the frame of TAC (See Fig. 3). In the beginning of the proposal the FEL facility may be based on 1 GeV electron linac of the collider. For SASE FEL production, in order to achieve the peak power about ~GW, the required peak current must be about ~kA. To raise the peak current, modifications for bunch sizes and emittance shows that the linac which will operate for SASE FEL must be performed completely different from the collider's [5]. Basic parameters of SASE FEL facility is given with Table 3.

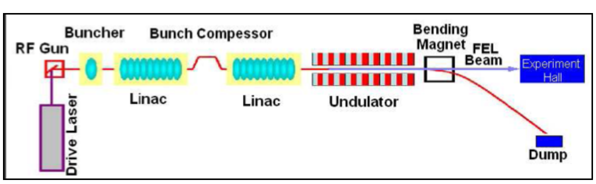


Figure 3: Schematic view of TAC SASE FEL

TAC 1 GeV superconducting linac was planned to be based on a photo-cathode RF gun. Electrons released from the gun, are accelerated in superconducting RF cavities and compressed by magnetic chicanes between the modules. After several diagnostic units, accelerated electron bunches (up to 1 GeV) pass through the undulator to achieve FEL process, as shown in Fig. 3.

## *TAC Synchrotron Radiation*

The proposed synchrotron radiation facility of TAC was consisted of 3.56 GeV positron ring for a third generation light source. In the first study, it was shown that the insertion devices with the proposed parameter sets produce maximal spectral brightness to cover 10 eV - 100 keV photon energy range [6].

Now, it is considered that the electron beam energy will be increased to 4.5 GeV, in order to obtain more brightness light and wide energy spectrum range, also the beam emittance reduced to 1 nm.rad [7]. Table 4 gives main parameters of the storage ring.

Table 3: SASE FEL Parameters

| Parameters | Value |
|---|---|
| Wavelength (nm) | 7.7 |
| Photon energy (eV) | 160.5 |
| ρ parameter | 0.0018 |
| Peak power (GW) | 1.4 |
| Average power (kW) | 21.8 |
| Gain length, $L_g$ (m) | 0.75 |
| Gain length, 3D $L_g$ (m) | 1.57 |
| Peak flux (photons/s) | $1.5\times10^{26}$ |
| Peak brightness (photons/s/mrad$^2$/0.1%bg) | $1.7\times10^{29}$ |
| Peak brilliance (photons/s/mm$^2$/mrad$^2$/0.1%bg) | $2.9\times10^{30}$ |

Table 4. Main parameters of the storage ring

| **Achromatic structure** | | **with damping wigglers** |
|---|---|---|
| Nominal energy (GeV) | 4.5 | 4.5 |
| Superperiod | 18 | 18 |
| Circumference (m) | 973.08 | 991.08 |
| Max. Beam Current (mA) | 400 | 400 |
| Energy loss/turn (keV) | 1144.5 | 2523 |
| Energy spread | 0.000685 | 0.001061 |
| Horizontal emittance-εx(nm rad) | 3.121 | 1.28 |
| Vertical emittance-εy (pm rad) | 31.21 | 12.8 |
| Betatron tunes[Qx/Qy] | 39.5/14.9 | 40.9/14 |
| Chromaticities[ξx/ξy] | -110/-39 | -141/-59 |
| **Beta functions at long straight section** | | |
| Horizontal (m) | 0.89 | 0.75 |
| Vertical (m) | 2.75 | 1.48 |
| Dispersion (m) | 0 | 0 |
| Long straight section | 18 x 7.4m | 18 x 8m |
| Short straight section | 18 x 5.6m | 18 x 6m |

The parameters of complementary undulators are determined. Figure 4 shows brilliance of the synchrotron emitted from the undulators.

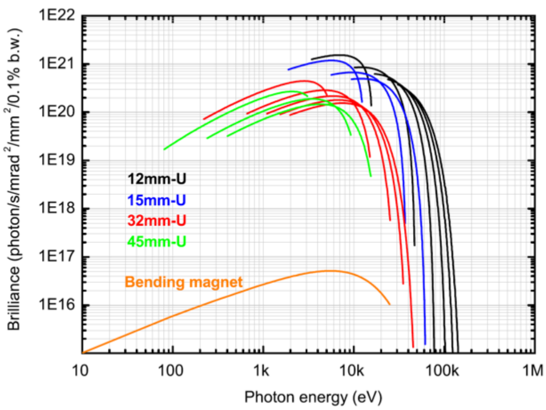


Figure 4. Brilliance of synchrotron radiation emitted from the undulators at the TAC storage ring.

### *TAC Charm Factory*

It is planned to collide the electrons coming through the linac with energy of 1 GeV with the positrons coming from the synchrotron with energy of 3.56 GeV (See Fig. 1). It is aimed to produce Charm particle with a center of mass energy $\sqrt{s}$ = 3.77 GeV. Up to now; φ-, τ-, and c-factory options were analyzed. In principle, $L=10^{34}cm^{-2}s^{-1}$ can be achieved for all three options. Concerning φ factory option, existing DAΦNE φ factory has nominal $L=5\cdot10^{32}cm^{-2}s^{-1}$ and possible upgrades to higher luminosities are under consideration [8]. Therefore, physics search potential for the φ factory will be essentially exhausted before TAC commissioning. Concerning τ factory option, whereas e+e → τ+τ cross section achieves a maximum value at $\sqrt{s}$ = 4.2 GeV, this advantage is dissipated with success of B-factories which has luminosity of $10^{34}cm^{-2}s^{-1}$ already. Moreover super B-factories with $L = 10^{36}cm^{-2}s^{-1}$ is intensively discussed [9]. With $L=10^{36}cm^{-2}s^{-1}$ super-charm factory will give opportunity to touch charm physics well further than super-B. The last option could be realized by using continues wave super conducting energy recovery linac (ERL).

### *TAC Proton Accelerator*

TAC proton accelerator proposal consists of 100÷300 MeV energy linear pre-accelerator and 1÷5 GeV main ring or linac. The average beam current values for these machines would be ~30 mA and ~0.3 mA, respectively. Proton beams from two different points of the synchrotron will be forwarded to neutron and muon regions, where a wide spectrum of applied research is planned. In muon region, together with fundamental investigations such as test of QED and muonium-antimuonium oscillations, a lot of applied investigations such as High-$T_c$ superconductivity, phase transitions, impurities in semiconductors *et cetera* will be performed using the powerful Muon Spin Resonance (∫SR) method. In neutron region investigations in different fields of applied physics, engineering, molecular biology and fundamental physics are plan

## CONCLUSION

Realization of the TAC project will accelerate the development in almost all fields of science and technology in Turkey and around. At the same time, TAC will be a major regional international research center in the field of particle physics, accelerator technology and applications.

## ACKNOWLEDGEMENT

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