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TURKISH ACCELERATOR CENTER: THE STATUS AND ROAD MAP

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Abstract

Turkish Accelerator Center (TAC) Project has started with support of the Ministry of Development (MD) of Turkey under the coordination of Ankara University. TAC is an inter-university collaboration with 12 Turkish Universities. An IR FEL facility (TARLA) based on Sc linac with 15-40 MeV energy under construction in Ankara as the first facility of TAC. It is expected that the TARLA facility will be commissioned in 2017. In addition to the TARLA, it is planned that Turkish Accelerator Center will include a third generation synchrotron radiation facility based on 3 GeV electron synchrotron (TAC SR), a fourth generation SASE FEL facility based on 3 GeV electron linac (TAC SASE FEL), a multi-purpose proton accelerator facility with 3 MeV - 2 GeV beam energy (TAC PAF) and an electron-positron collider as a super charm factory (TAC PF) Construction phase of the proposed GeV scale accelerator facilities will cover next decades. In this presentation, main goals and road map of Turkish Accelerator Center will be explained.

INTRODUCTION

To use accelerator and detector technologies and accelerator based light sources for R&D in Turkey and the region, Turkish Accelerator Center (TAC) is proposed in 2001 [1] and since 2006, the TAC become an inter-university collaboration with 12 Turkish Universities under the coordination of Ankara University with support of Ministry of Development of Turkey. Turkish Accelerator and Radiation Laboratory in Ankara (TARLA) facility is under construction as the first facility of TAC and it is planned as an IR FEL and Bremsstrahlung facility based on superconducting electron linac [2]. IAT of Ankara University is established in 2010 [3] and the buildings of IAT and TARLA are opened to the service in 2011 in Gölbaşı Campus of Ankara University in Ankara, Turkey. In frame of TAC project, International Scientific Advisory Committee (ISAC) with 14 members and International Machine Advisory Committee (IMAC) with 5 members are established in 2009 and the committee meetings were held annually since 2009. Ankara University is signed MoUs with well-known centers CERN (Switzerland), DESY, HZB, HZDR, Euro XFEL (Germany), ESS (Sweden), IHEP (China) and Cockcroft Institute (UK) as coordinator of the project. Results of the feasibility and conceptual design phases of proposed TAC facilities can be found in literature [4,5].

TAC TARLA FACILITY

The TAC TARLA (**T**urkish **A**ccelerator and **R**adiation **L**aboratory in **A**nkara) facility is an Infrared FEL and Bremsstrahlung facility based on superconducting electron linac. The facility aims to obtain IR FEL between 3-250 μm range with two undulators (λ_{U1} = 25 mm; λ_{U2} = 90 mm) and Bremsstrahlung photons with 5-30 MeV energy region [6,7]. The schematic view of TARLA facility is given in Fig. 1. The installation of TARLA facility is started in 2011 and recently DC thermionic gun installed and tested up to 250 keV energy. Installation of injector line is continuing and the installation of SRF modules and helium cryogenics system will cover next one year. The commissioning of electron linac will be in 2015 and the completion of the facility to use IR FEL beams for research will cover next three years. Main parameters of electron beam and FEL beams of TARLA facility are given in Tables 1 and 2, respectively

Table 1: Main Parameters of TARLA e-beam

Parameter	**Unit**	**Value**
Beam Energy	MeV	16-40
Max. Bunch Charge (@ 13 MHz)	pC	77
Max. Average Beam Current	mA	1
Horizontal Emittance	mm mrad	<15
Vertical Emittance	mm mrad	<12
Longitudinal Emittance	keV ps	<85
Bunch Length	ps	0.4-6
Bunch Repetition	MHz	13
Macropulse Duration	μs	50- CW
Macropulse Repetition	Hz	1- CW

TARLA facility will give good research opportunities in basic and applied sciences to the scientists in our region especially who need to use laser in middle and far infrared region. At the beginning, we are planning to start up three of seven experimental stations for laser diagnostics, IR spectroscopy and microscopy, material science based on user proposals. After taken some experiences and according to our region needs the rest of four stations will be carried out including medical science and optics and chemistry laboratories as well.

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Table 2: Parameters of Undulators and FEL Beams

Parameter	Unit	U25	U90
Period Length	mm	25	90
Magnetic Gap	mm	14	40
Number of Poles	#	60	40
Undulator Strength	#	0.25-0.72	0.7-23
Resonator Length	m	11.53	11.53
Wavelength	µm	3-20	18-250
Max. Peak Power	MW	5	2.5
Max. Average Power	W	0.1-40	0.1-30
Max. Pulse Energy	µJ	10	8
Pulse Length	ps	1-10	1-10

TAC SR FACILITY

TAC Synchrotron Radiation (SR) facility is planned a 3 GeV dedicated electron synchrotron based light source. The main parameters are given in Table 3 and schematic view of accelerators is given in Figure 1.

Table 3: The Main Parameters of TAC SR Main Ring

Parameters	Value
Energy (GeV)	3
Circumference (m)	477
Beam current (mA)	500
Horizontal emittance (nmrad)	0.51
RF frequency (MHz)	500
RMS bunch length (mm)	2.1

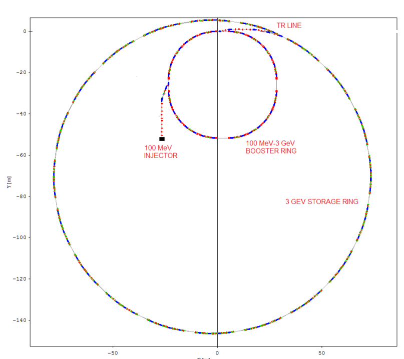

Figure 1: Schematic view of proposed TAC SR facility.

A nationwide light source user community is growing up in recent years for SR and FEL facilities and National User Committee prepared a “scientific case report” for first ten beam lines of TAC SR facility. Details on machine design, insertion devices and their spectrum characteristics, activities of national user committee and “scientific case report” studies may be found in [8].

TAC SASE FEL FACILITY

TAC SASE FEL facility is planned to be 3 GeV electron linac based fourth generation light source. TAC SASE-FEL facility aims to obtain FEL beams to cover 1-100 nm wavelength region with the GW peak laser output power. It is planned that, electron gun will be a 3½ cell Sc cavity with Cs2Te photocathode and 12×9 cavity-cell are considered for main accelerator part. The schematic view of proposed facility is given in Fig. 2.

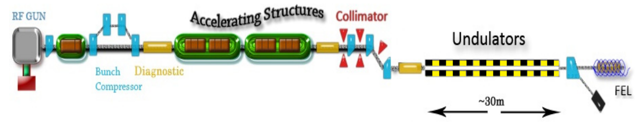

Figure 2: Schematic view of TAC SASE FEL Facility.

RF frequency is considered 1.3 GHz for Sc cavities and well known codes Poisson/Superfish, Astra, CST, Elegant and Genesis 1.3 codes are used for start-to-end simulations to design the facility [9,10]. The main electron beam and laser parameters of proposed SASE facility are given in Table 4 and Table 5, respectively.

Table 4: Main Parameters of e-beam for TAC SASE FEL

Parameter	Unit	Value
Beam energy	GeV	3
RF frequency	GHz	1.3
Number of Sc Nb cavities	-	12 x 9 cell cavity
Accelerating gradient	MV/m	<40.7
Cell to cell coupling, k	-	1.8
Quality factor, Q_0	-	$>10^9$
Peak current	kA	2

Table 5: Parameters of U15 Undulator and SASE FEL

Parameter	Unit	U15
Period length	mm	15
Magnetic gap	mm	12
Central magnetic field	T	0.48
Undulator material	-	NdFeB
Wavelength	nm	1-100
Saturation FEL power	GW	1.4
Saturation length	m	28
Peak brilliance (photons/s/mrad^2/mm^2/0.1%bw)		10^{29}

TAC SASE FEL facility aims to use beams in many fields as material science, biotechnology, nanotechnology, chemistry, space, environment etc. with its unique properties.

TAC PROTON ACCELERATOR FACILITY

TAC Proton Accelerator Facility (PAF) is planned to be as a multi-purpose facility based on up to 2 GeV energy proton linac to use protons and neutrons in scientific research in all branches of basic applied sciences. TAC PAF project has three stages – a “Front End” taking protons to around 3 MeV, a normal conducting linear accelerator raising the energy to around 65 MeV and a superconducting linear accelerator increasing the energy in stages to 2 GeV. At each stage, there is potential to exploit the facility for research, and to develop the local research community. Low Energy (PAF-LE) sections are

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normal (room-temperature) conducting components while high energy (PAF-HE) sections are the superconducting modules held at cryogenic temperatures as shown in Figure 3.

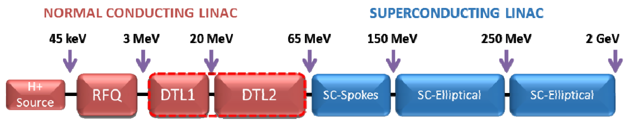

Figure 3: A general layout of the TAC PAF.

TAC-PAF applications can be grouped under “neutron science” (not only traditional neutron research and radiography, but also research studies into the physics required for waste transmutation and accelerator driven systems), as well as a number of other applications in physics, engineering and biology in lower energy regions. Research collaborations have been established with ESS and INFN-LNS. The details of the TAC-PAF facility can be found elsewhere [10,11].

TAC PARTICLE FACTORY

TAC Particle Factory Facility (TAC PF) is planned a “super charm factory”. It is a linac on ring type collider that a 1 GeV electron beam from linac will collide with a 3.6 GeV energy positron beam from ring to obtain L=10^35 cm^(-2) s^(-1) luminosity √s = 3.77 GeV center of mass energy [12]. The physics potential of the facility is projected from the precision measurement of charmed hadrons to the new physics studies with more statistics. A super charm factory will give opportunity to investigate charm physics well further than *B* factories at the same experimental conditions, benefiting from a boost parameter (beta*gamma=0.68) for some processes. The detector of factory will be constructed for the detection of the producing particles from this collision. The detector is configured around a 1 T superconducting solenoid magnet (SSM) for precise momentum measurements for charged tracks [13]. Main parameters of accelerators for the factory (linac and ring) are given in Table 6.

Table 6: Main Parameters of PAC PF Facility

Parameter	***Positron beam***	**Electron beam**
Beam energy (GeV)	3.6	1
Number of particles per bunch (10^{11})	2	0.2
Beta functions at IP β_x/β_y (mm)	80/5	80/5
Normalized emittance $\varepsilon_x^N/\varepsilon_y^N$ (µm rad)	111/0.36	31/0.1
σ_x/σ_y (µm)	36/0.5	36/0.5
σ_z (mm)	5	5
Number of bunches	300	
Circumference (m)	600	
Luminosity ($cm^{-2}s^{-1}$)	$1.4x10^{35}$	

CONCLUSION

The third phase of Turkish Accelerator Center (TAC) studies is continuing since 2006 and it is expected in near future that by a new law from government a new statute will be defined and TAC will be established officially with a new financial support and technically control mechanism. After this new and next step, the construction phase of proposed GeV scale facilities will start. Based on international scientific advisory committee of TAC (ISAC) recommendations and needs of research community in Turkey, it is planned that, low energy proton accelerator facility (LE TAC PAF) and third generation synchrotron radiation facility (TAC SR) will take place as a second big construction step for next decade just after the operation of first facility TARLA.

ACKNOWLEDGEMENT

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REFERENCES

[1] http://thm.ankara.edu.tr
[2] http://www.tarla.org.tr
[3] http://hte.ankara.edu.tr
[4] Ö. Yavaş,A. K. Çiftçi S. Sultansoy, EPAC 2000, p. 1008 (2002); http://jacow.org
[5] S. Sultansoy et al., “The Status of Turkic Accelerator Complex Proposal”, PAC05, p. 449 (2005).
[6] A. Aksoy et al., “The Turkish Accelerator Complex IR FEL Facility”, Infrared Physics & Technology 51, 378 (2008).
[7] A. Aksoy et al., “Design Parameters and Current Status of the TARLA Project”, THPRO026, these proceedings, IPAC2014.
[8] http://tac.ankara.edu.tr/sr
[9] H. Duran Yıldız, “Start-to-end simulation of TAC SASE FEL facility”, 2nd Int. Conf. on Particle Physics, Jour. of Physics, Conf. Series 347, 012037 (2012) and http://tac.ankara.edu.tr/sase-fel
[10] Fifth TAC Status Report to International Scientific Advisory Committee (ISAC) of TAC (2013) Ankara, Turkey (internal report).
[11] E. Algin et al., “TAC Proton Accelerator Facility: Normal Conducting Part” IPAC14, In this conference & http://tac.ankara.edu.tr/paf
[12] http://tac.ankara.edu.tr/pf
[13] I. Tapan and F. Koçak, Journal of Physics, Conference Series 404, 012053 (2012).