General Overview of the TAC Project

http://thm.ankara.edu.tr

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in collaboration with Ankara University

Tuesday, August 3rd , 2010

Mission

- Purpose of the TAC (Turkish Accelerator Center) Project is to provide a meeting of our country with accelerator technologies and so that coordinate R&D activities based on this technology.
- Turkish Accelerator Center's first establishment will be IR FEL laboratory between 2008-2011.
- At this center, fundamental and applied science based on accelerator research will be studied in 2012 in Ankara, Turkey.
- Complete of TAC Project will be built in 2020s.
- The project is supported by State Planning Organization (SPO) of Turkey and is proceeded with inter university collaboration under the coordination of Ankara University.

TAC collaboration and project team

- TAC: An Inter University Collaboration (10 Turkish Universities)
- Project Team: 43 staff with PhD + 61 graduate students

Ankara University (Coordinator)

Gazi University

İstanbul University

Uludağ University

Dumlupınar University

Boğaziçi University

Doğuş University

Erciyes University

Süleyman Demirel University

Niğde University

Collaborations with International Laboratories and Institues

- ATLAS, CMS, CLIC, CAST (CERN, Switzerland)
- ELBE (FZD, Germany)
- BESSY (HZB, Germany)
- FLASH, HASYLAB (DESY, Germany)
- Cockroft Inst. (Daresbury, England)
- APS (ANL, USA)
- JLab FEL (JLab, USA)
- LCLS, SSRL (SLAC, USA)
- FNAL (USA)
- Koyoto Univ. (Japan)
- INFN (Perugia, Italy)
- RIKEN (Japan)
- PSI (Switzerland)

International Committees

International Scientific Advisory Committee (ISAC)

- Ercan ALP (Argonne National Laboratory, USA) (Head)
- Behçet ALPAT (INFN Perugia, Italy)
- David M. ASNER (CLEO, Canada)
- Swapan CHATTOPADHYAY (Cockroft Institute, UK)
- Wolfgang EBERHARDT (HZB - BESSY, Germany)
- Eisuke J. MINEHARA (JAERI, Japan)
- Luigi PALUMBO (INFN Frascati, Italy)
- Ken PEACH (JAI, Oxford University, UK)
- Roland SAUERBREY (FZD, Germany)
- Zehra SAYERS (Sabancı University, Turkey)
- Saleh SULTANSOY (TOBB ETU, Turkey)
- Gökhan UNEL (CERN, Switzerland)
- Helmut WIEDEMANN (Stanford University, USA)
- Frank ZIMMERMANN (CERN, Switzerland)

International Committees

International Machine Advisory Comittee (IMAC)

- Peter Michel (FZD, Germany) (Head)
- Hideaki Ohgaki (Kyoto University, Japan)
- Dieter Trines (DESY, Germany)
- Ernst Weihreter (BESSY, Germany)
- John Delayen (JLab, USA)

First Meeting: December 4-5, 2009, Ankara University, Ankara

Second Meeting: September 2-3, 2010, Bodrum

Proposed facilities

- The First Facility (TARLA)
  Sc linac based IR FEL & Bremstrahlung facility

- TAC SASE FEL Facility
  A fourth generation light source based on 1 GeV electron linac

- TAC Particle Factory
  Electron-positron collider (charm factory), Ec.m.= 3.77 GeV

- TAC Synchrotron Radiaton Facility
  A third generation light source based on dedicated 4.5 GeV electron synchrotron

- TAC Proton Accelerator Facility
  A high power and high flux proton accelerator up to 3 GeV energy

Institute of Accelerator Technologies of Ankara University

- Established on February 26, 2010.

- Three main branches planned for graduate education are:

  - Particle Accelerators & Technologies
  - Accelerator Based Light Sources
  - Detector & Data Acquisition Technologies

After the approval of Higher Education Council of Turkey, we expect to start the graduate

education in Fall 2011

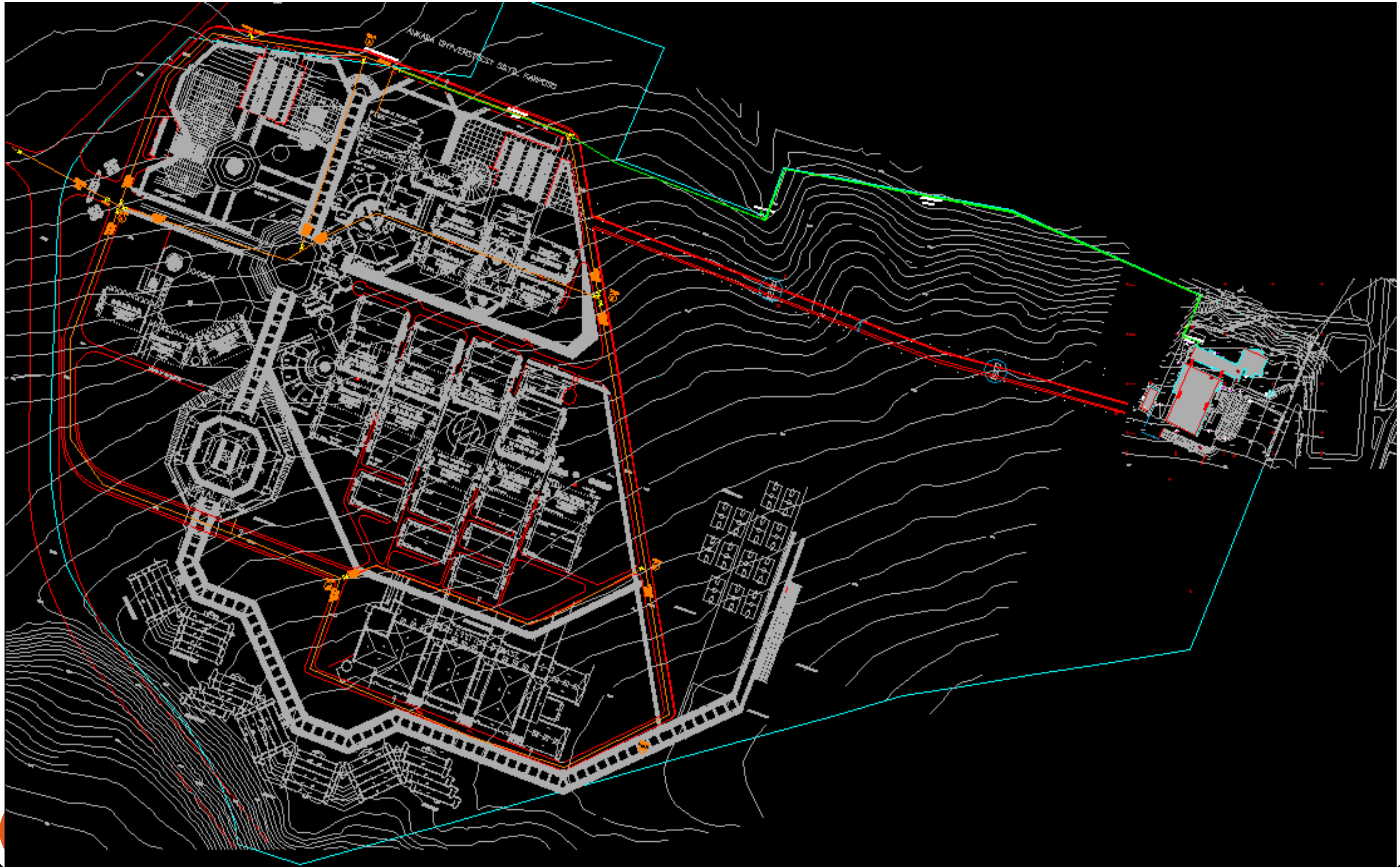
Location: Gölbaşı Campus of Ankara University

http://hte.ankara.edu.tr

First Facility of TAC

- Turkish Accelerator and Radiation Laboratory in Ankara (TARLA)
- TARLA will be a Free Electron Laser & Bremstrahlung Facility
- Buildings of the facility will be completed in 2010
- It is planned that the facility will be completed in 2013

Gölbası Campus of Ankara University

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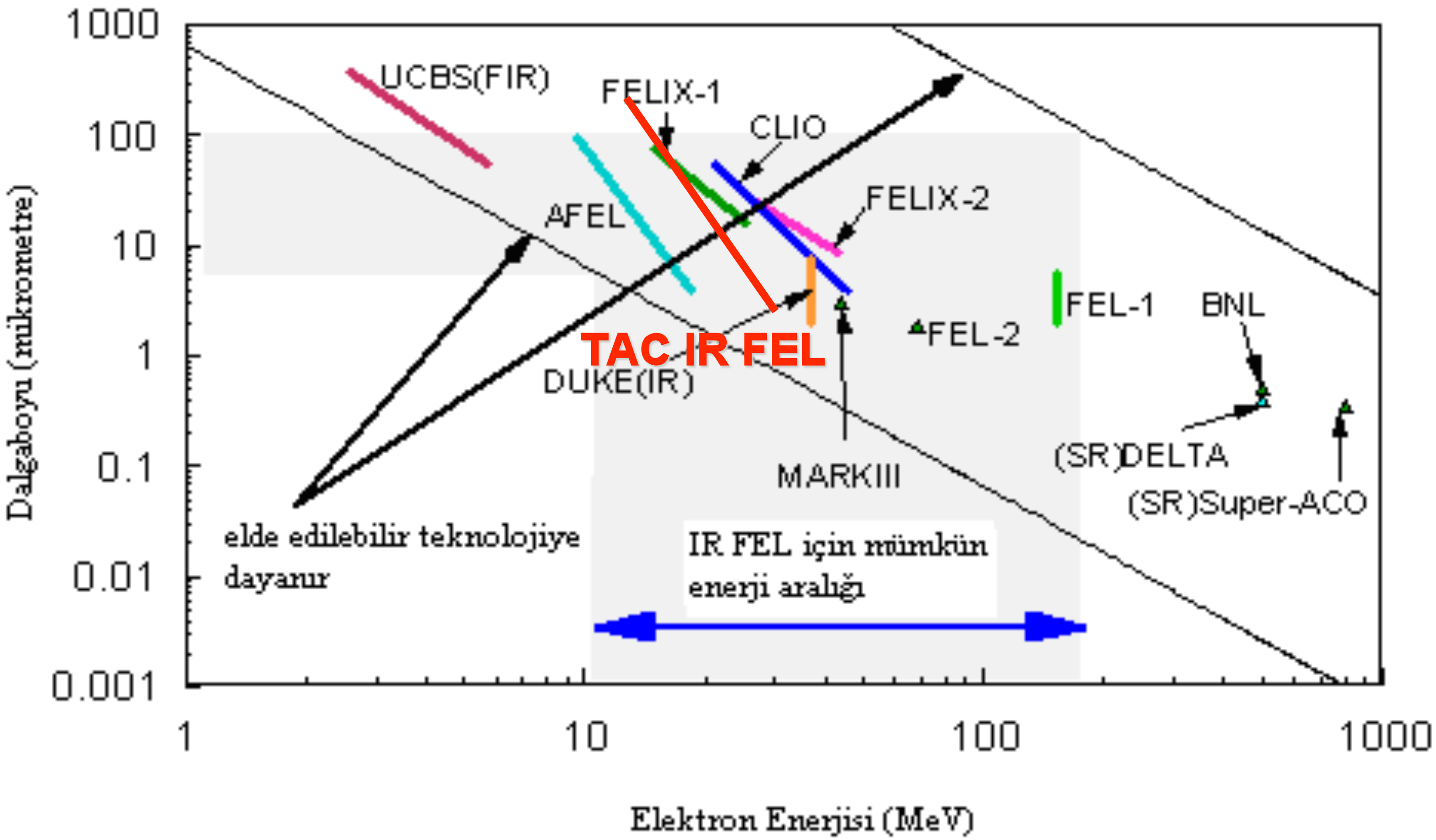
TARLA Facility

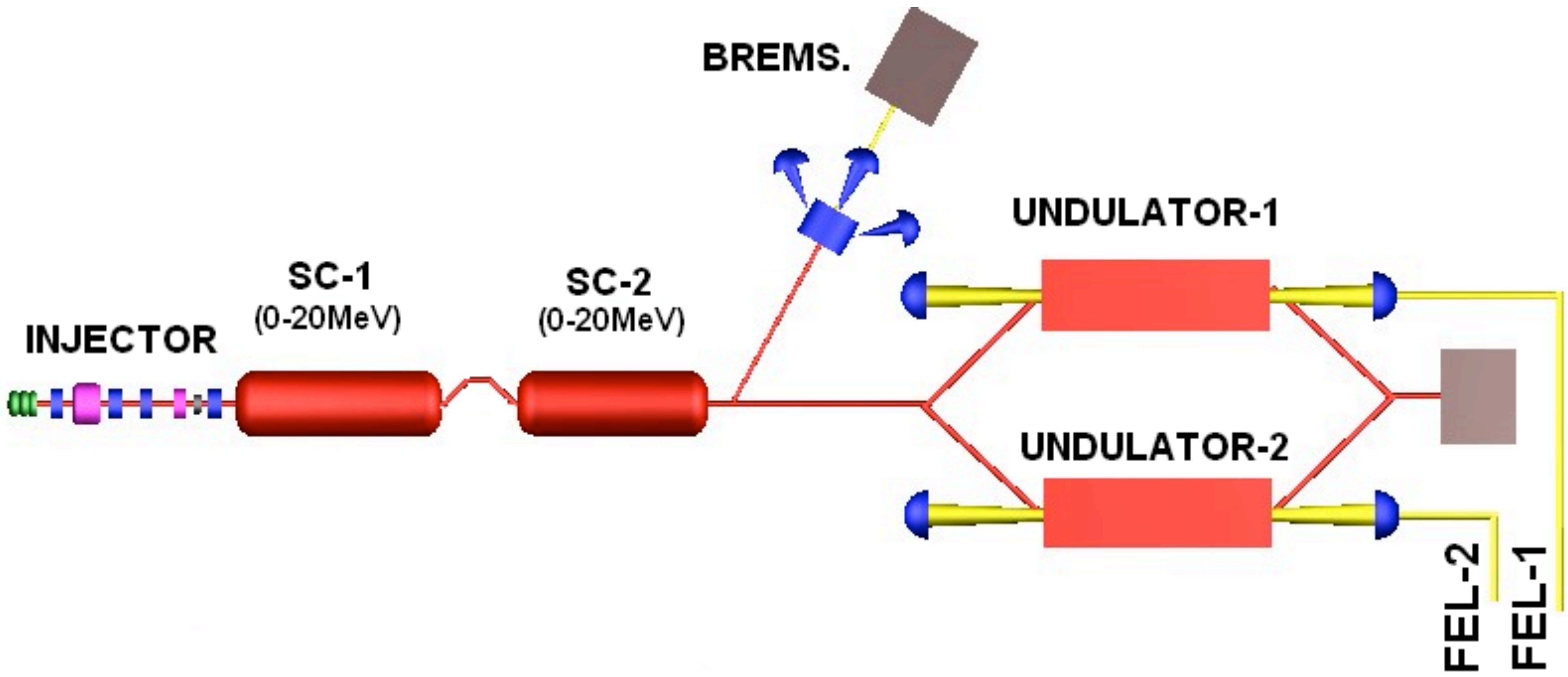
- TARLA project aims to produce FEL in oscillator mode between 2-250 micron range using 15-40 MeV electron beam.
- In order to have wide research area we request to have CW electron beam with high average current as well as pulsed beam with low current.
- Therefore we plan to use high average current thermionic gun and superconducting RF cavities with solid state amplifiers.
- To obtain FEL in 2-250 microns range, undulators with 2.5 and 9 cm period length will be used with two optical resonators.

The Place of TAC IR-FEL



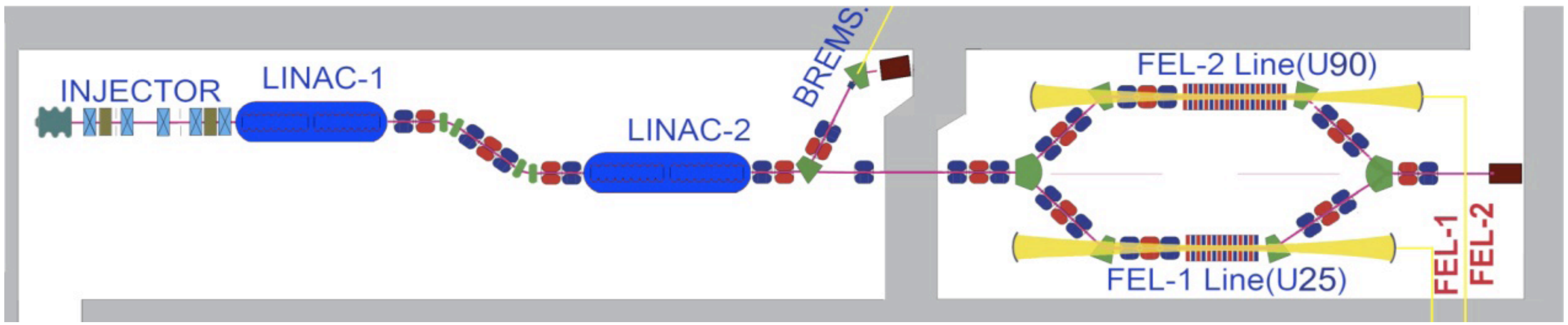
TARLA Facility

Schematic view of TARLA Facility

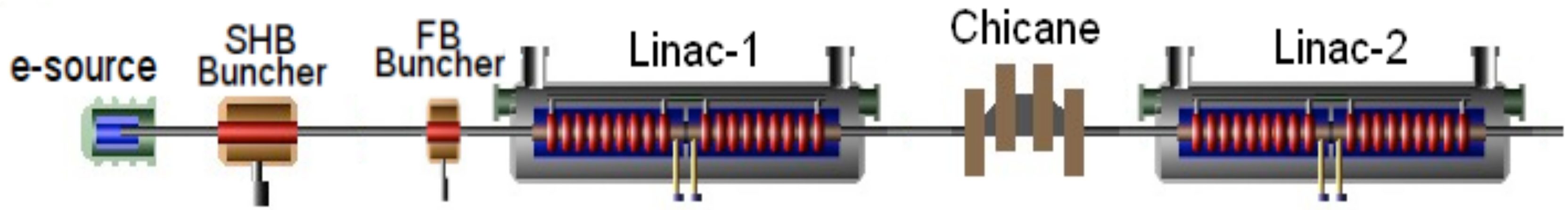


TARLA Facility

- The electron source is chosen to be a high average current thermionic DC gun running at up to 250keV, which is in manufacturing phase at the moment.
- The injector system will be completely based on normal conducting technology with two buncher cavities that operate 260 MHz and 1.3 GHz, respectively
- The main acceleration structure will consists of two ELBE modules that each houses two TESLA 9-cell SC structure. These modules are designed to operate at 1mA electron beam current but they are capable of operating at 1.6mA continuous wave operation (CW)



Electron Beam Parameters



Parameters	Current	Updates
Energy [MeV]	15-40	15-40
Bunch Charge [pC]	77	120
Average Beam Current [mA]	1.0	1.6
Bunch Repetition Rate [MHz]	13 - 26	13 - 26
Bunch Length [ps]	0.5 - 6	0.6 - 6
Norm. RMS Trans. Emit. [mm mrad]	<12	<15
Norm. RMS Long. Emit. [keV.ps]	<40	<50
Macro pulse Duration [µs]	40 – 100/CW	40 – 100/CW
Macro pulse Reputation Rate [Hz]	1 – 25/CW	1 – 25/CW

Undulators' Parameters

Parameters	U1	U2
Undulator Magnet Material	SmCo	
Undulator Period[cm]	2.5	9
Magnetic Gap [cm]	1.5	4
Effective Field [T]	0.35	0.42
Undulator Strength	0.25-0.7	0.7-2.5
Number of Undulator Periods [N]	60	40
Undulator Length [m]	1.5	3.6
Resonator length [m]	11.53	11.53
Radii of curve of the Mirror [m]	5.92	6.51
Rayleigh Length [m]	0.97	2.08
Mirror Metarial	Au/Cu	Au/Cu
Radius of OutCoupling Hole [mm]	0.5/2	0.5/2
Resonator Type	Symmetric ,Concentric	

FEL Optimization

- FEL optimization is performed using Mathematica and FELO code which is written to simulate one-dimensional free electron laser.
- FEL wavelengths obtained from U25 and U90 overlaps between 15 - 20 microns 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 at energies lower than 15 MeV.

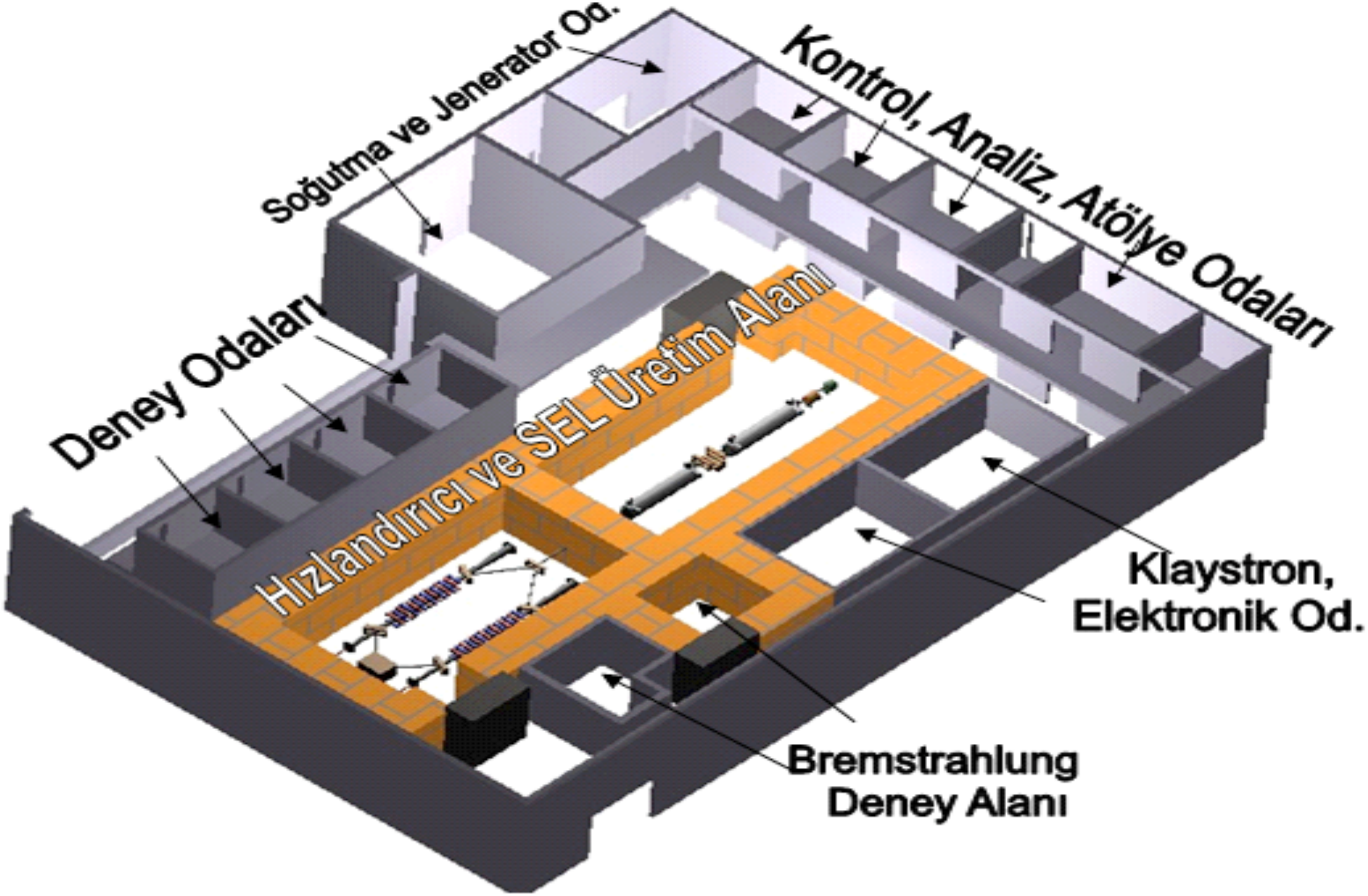
Plans for Experimental Stations

- IR FEL will be used with different techniques for reserach on material science, optics, photon science, chemistry, medicine, biotechnology and nanotechnology.

- Considering the tunability, high power and short pulse structure of the FEL, we propose to use IR FEL in following research areas at 8 experimental stations:

- 1 Photon diagnostic room
- 7 Experimental stations

Experimental Hall Overview



Planning for Experimental Stations

- **Exp. Station No 1:**
  Photon (FEL) Diagnostics

- **Exp. Station No 2:**
  General IR FEL Spectroscopy (vibrational and rotational IR spectroscopy for
  solids, gases and liquid materials)
  FTIR spectroscopy, Raman spectroscopy

- **Exp. Station No 3:**
  IR FEL Spectroscopy and microscopy for material science and semiconductors
  SFG & Pump probe techniques

- **Exp. Stations 4-7: These four stations will be planned to use existing FEL after completion of two FEL lines to use in non-linear optics, nanotechnology, photochemistry and biotechnological research**

Experimental Techniques

1 - Sum Frequency Generation

2 - Photon Echo Experiment

3 - Photoacustic Spectroscopy

4 - Pump-Probe Experiments

5 - IR-MALDI (IR matrix assisted laser desorption/ionization)

6 - IR-MAPLE (IR matrix assisted pulsed laser evaporation)

7 - IR-REMPI (IR resonance enhanced multiphoton ionization)

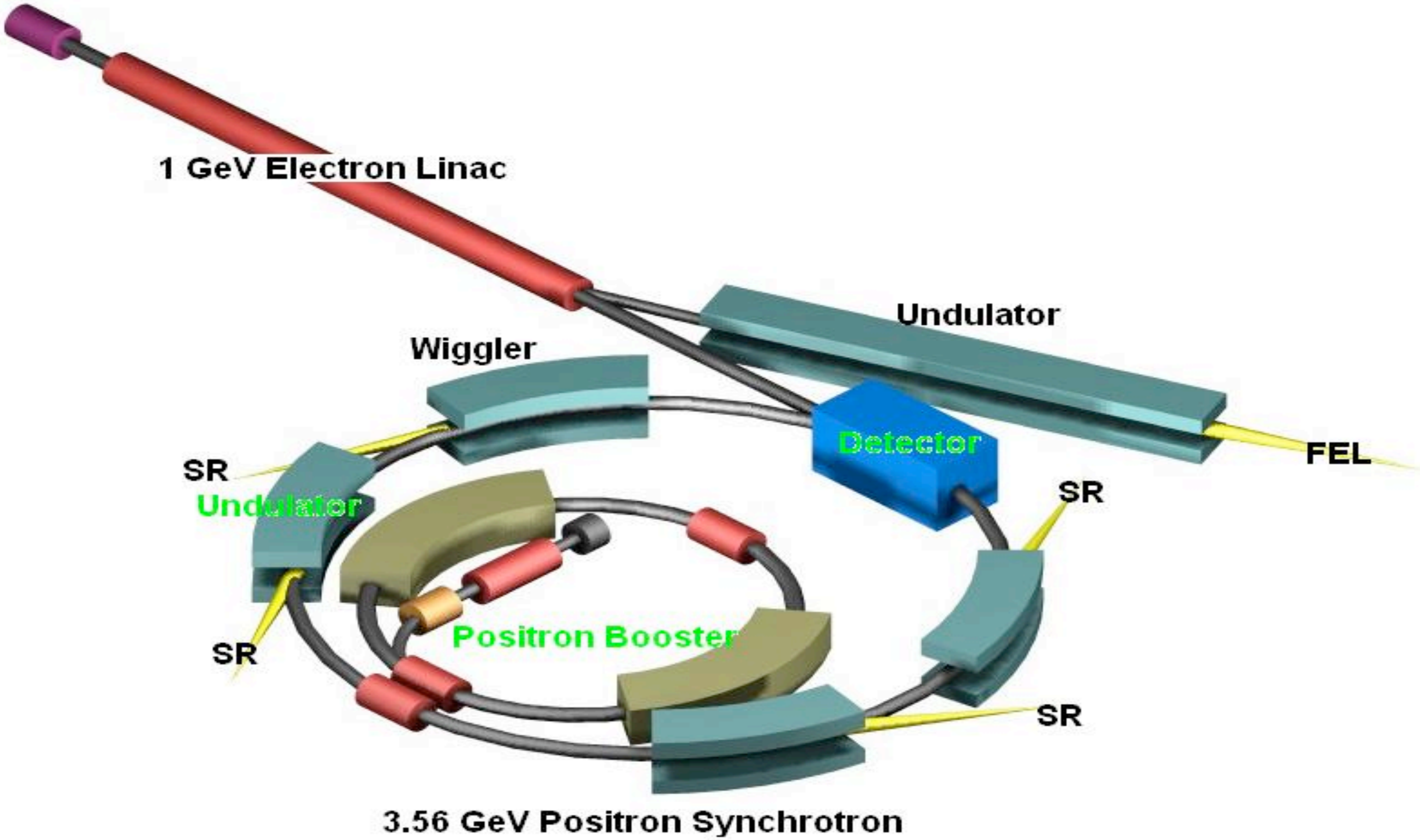
8 - Near Field Microscopy

9 - Gas-Phase IR Spectroscopy

TAC SASE FEL

- A SASE FEL facility is also planned as 4th generation light source in the frame of TAC.
- 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 colliders

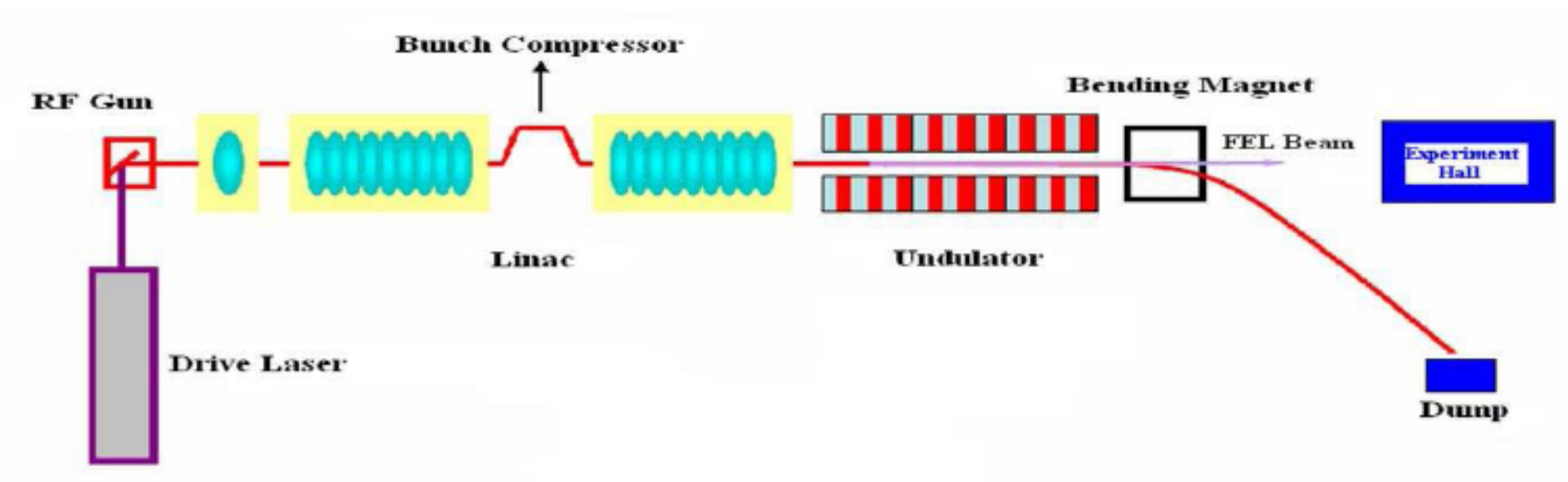


TAC SASE FEL

- 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

SASE FEL

- Such a facility may be based on 1 GeV electron linac of the collider or a special independent linac.



- As an alternative, electron accelerator which will drive SASE FEL, energy recovery linac (ERL) can be proposed.

1 GeV Electron Beam, Undulator and SASE FEL Parameters

Beam energy (GeV)	1
Peak current (A)	2106
Normalized emittance (μm.rad)	3.1
Period length, l_u (cm)	3.0
Peak magnetic field, B_u (T)	0.498
K parameter	1.395
SASE FEL wavelength, λ_uFEL (nm)	7.7
Average power, (kW)	21.8
Peak brightness (photons/s/mrad^2/0.1%bg)	1.7x10^{29}
Peak brilliance (photons/s/mm^2/mrad^2/0.1%bg)	2.9x10^{30}

Possible User Potential Areas of TAC SASE-FEL

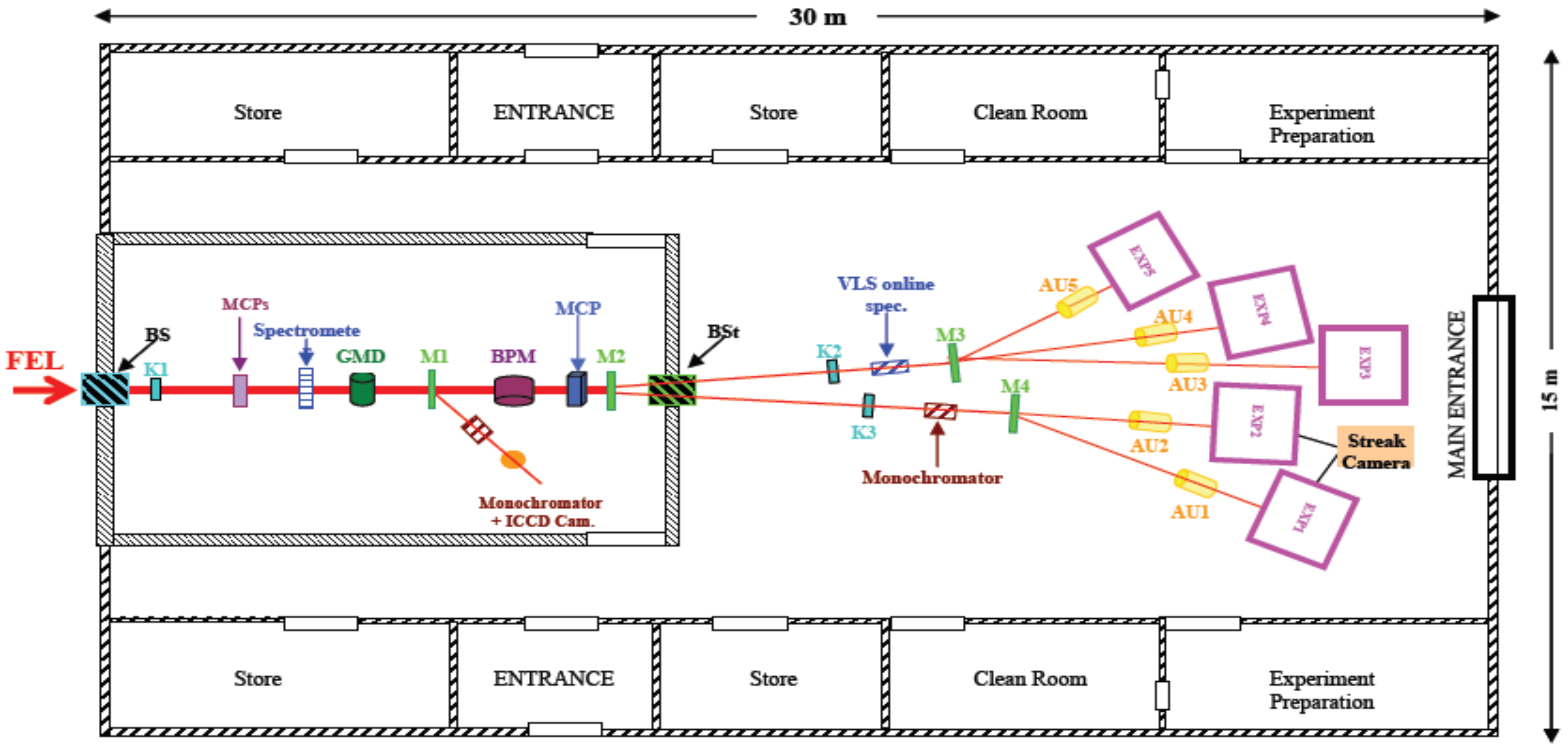
Atomic, molecular and cluster phenomena, plasma physics

- Non-linear processes
- Quantum optics
- Condensed matter physics
- Materials science
- Ultra-fast chemistry
- Life sciences
- Nanotechnology

Possible techniques that will be learned:

Pump-Probe technique, X-ray Emission Spectroscopy (XES), X-ray Photoelectron Spectroscopy (XPS), X-ray Absorption Spectroscopy (XAS), Coherent Imaging, Fourier Transform Holography, …

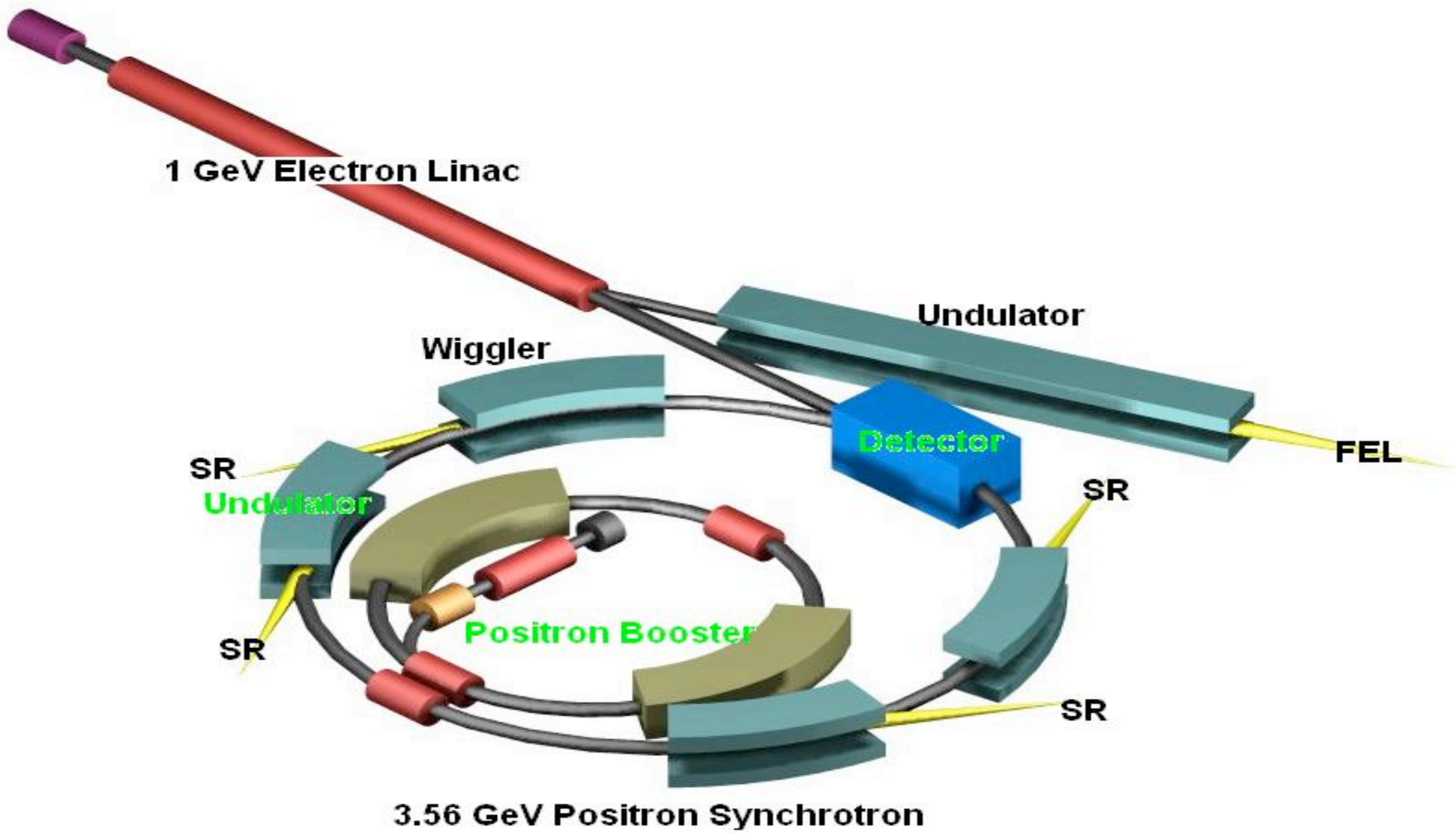
The Preliminary Design of the TAC SASE-FEL Photon Diagnostics System



BS	: Beam Shutters	M1-M4	: FEL Mirrors
K1- K3	: Collimator	BPM	: Beam Position Monitor
MCP	: Micro Channel Plate Detector	BSt	: Beam Stop
GMD	: Gas Monitor Detector	AU1-AU5	: Autocorrelator

TAC Particle (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.



TAC Particle (Charm) Factory

- 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 $L=5 \cdot 10^{32} cm^{-2} s^{-1}$ and possible upgrades to higher luminosities are under consideration.

TAC Particle (Charm) Factory

- Physics search potential for the φ factory will be essentially exhausted before TAC commissioning.

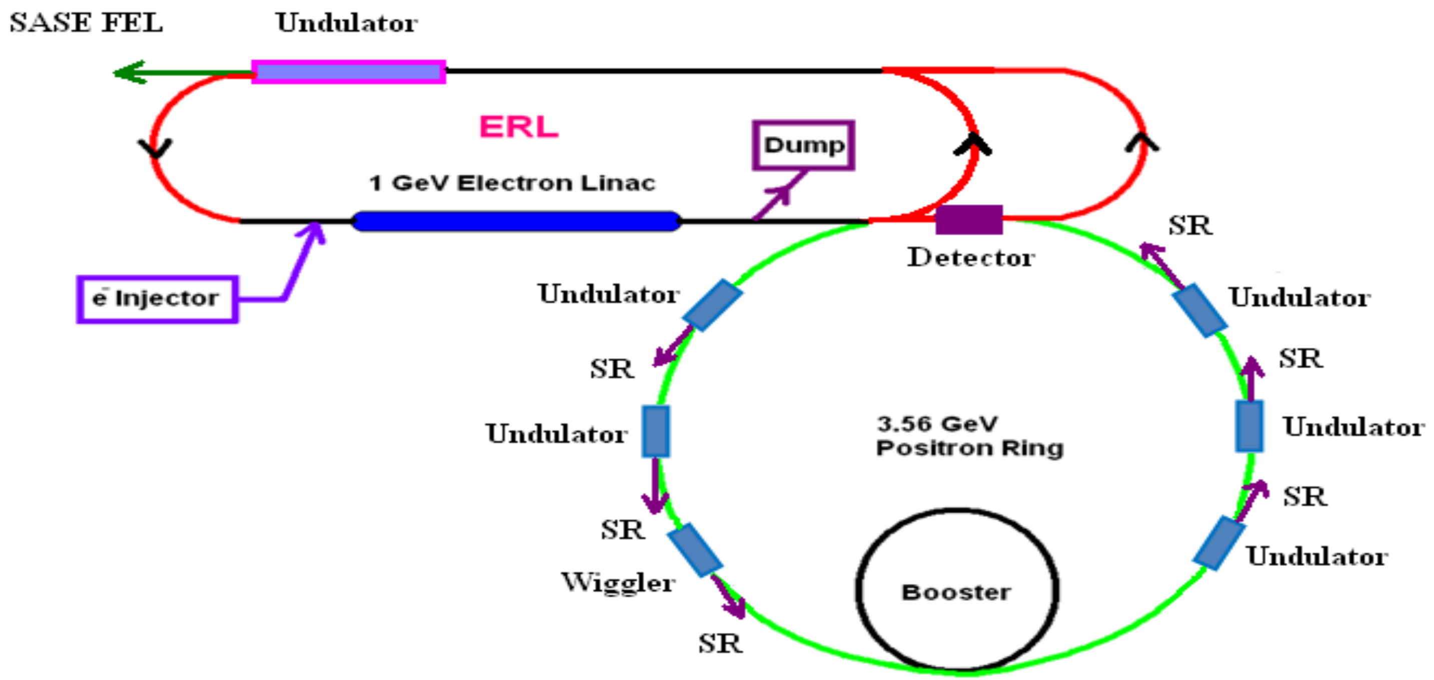
- Concerning φ factory option, whereas $e^+e^- \to \tau^+\tau^-$ cross section achieves a maximum value at $\sqrt{s} = 4.2$ GeV, this advantage is dissipated with success of b-factories which has luminosity of $10^{34}cm^{-2}s^{-1}$ already. Moreover super b-factories with $L = 10^{36}cm^{-2}s^{-1}$ is intensively discussed

- 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 Particle (Charm) Factory

- Linac on ERL electron-positron collider



http://thm.ankara.edu.tr/thmpf/anasayfa.html

Particle Factory Parameters

$$E(e+) = 3.56 GeV$$

$$E(e-) = 1 GeV$$

$$N(e+) = 2x10^{11}$$

$$N(e-) = 2x10^{10}$$

$$\beta x / \beta y(e+, e-) = 80 / 5mm$$

$$\sigma x / \sigma y(e+, e-) = 3.6 / 0.5 \mu m$$

$$\sigma z(e+, e-) = 5mm$$

$$nb(e+) = 125, f_{rev}(e+) = 1.2 MHz$$

$$Circumference = 250m$$

$$Ib(e+) = 4.8A, Ib(e-) = 4.8A$$

$$fc = 150 Mhz$$

$$L = 1.4x10^{34} cm^{-2} s^{-1}$$

TAC Synchrotron Radiation

- In order to obtain more brightness, electron beam energy is increased to 4.5 GeV, 50 keV hard X-ray regime energy spectrum range, also the beam emittance is reduced to 1 nm rad.
- We have designed double-double bend achromat (DDBA) lattice with damping wigglers so as to obtain ultra low emittance for the electron storage ring of TAC.
- We have determined properties of the radiation produced at undulators. In our design we use separated function magnets. We present also the effects of insertion devices (IDs) and damping wigglers (DWs) at the ring on the beam parameters and spectral brightness that obtained from IDs

TAC Synchrotron Radiation

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

User Potential of SR in Turkey and Our Region

TURKEY

150 Universities in 81 cities

- National Institutes:

  Biotechnology, Nanotechnology, Accelerator, Mine, Medicine, Pharmachology, Metrology, etc.

- National Authorities:

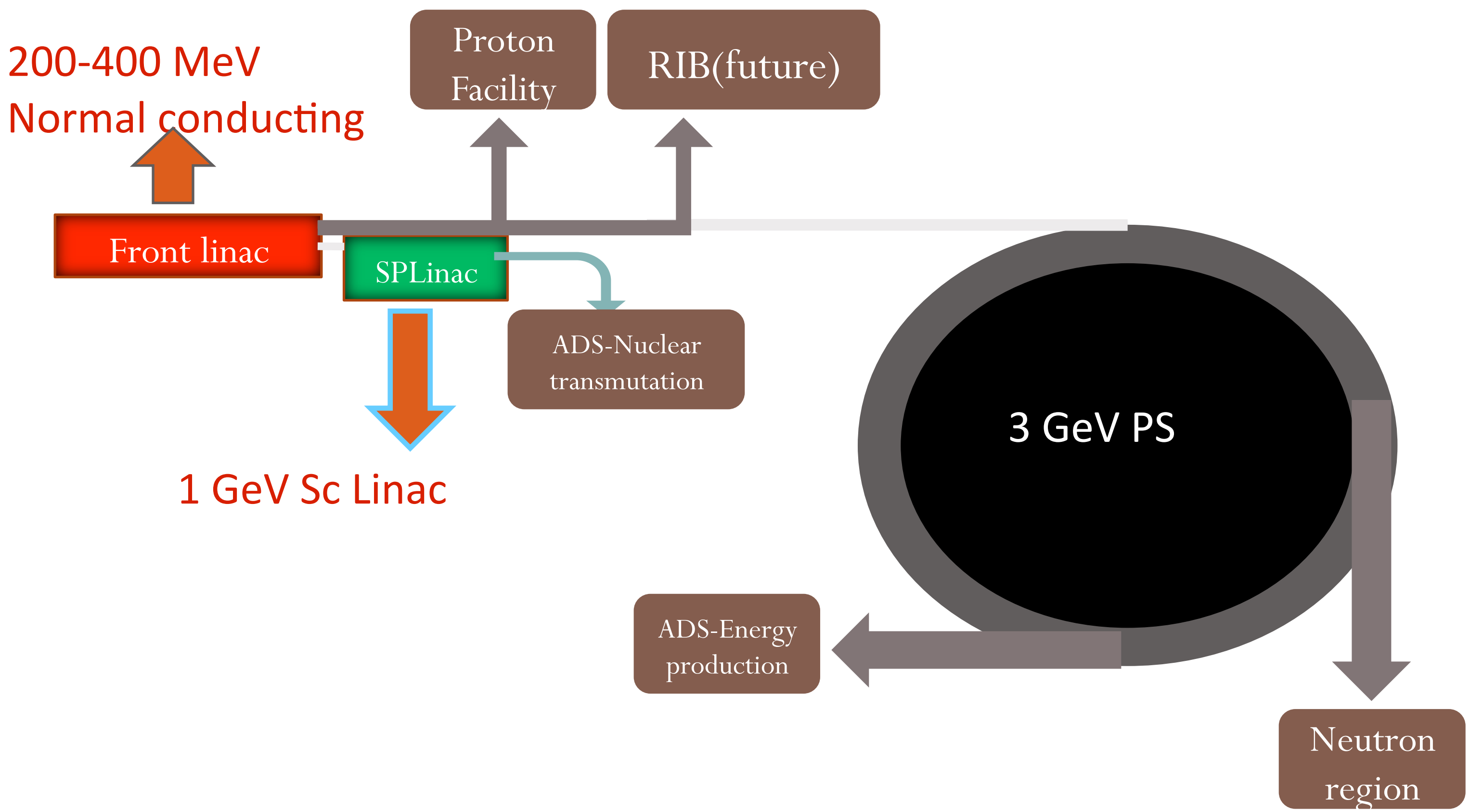
  TUBITAK ,TAEK, MAM

  Industry, Technocities, Technoparks, Army

OUR REGION

Turkic States, West South Asia, Balkan Countries, Middle East and North Africa

TAC Proton Accelerator Facility



TAC Proton Accelerator Facility

- Proposed as a multipurpose facility
- Beam power 1 MW and 1-3 GeV Energy
- A 3 MeV test stand and 55 MeV DTL will be included as low energy part of chain
- A world class pulsed neutron source for neutron scattering for engineering and industrial applications
- Medical facility for cancer therapy
- Irradiation and isotope production facility
- Radioactive Ion beam facility (in future)
- Nuclear transmutation facility and ADS applications (EA etc.)

What we are planning to do!

- A multi-purpose proton accelerator facility

Short Term Goals:

- Medical facility for cancer therapy (BNCT, Proton)
- Irradiation and isotope production facility
- Neutron radiography.

Long Term Goals:

- Neutron spallation facility
- Radioactive ion beam facility
- Research on ADS

Conclusions

- Priority of proposed facilities in TAC will be described depending on reports of ISAC and new trends on accelerator science and applications.

- It is planned that first facility (TARLA) and Technical Design Report of TAC will be completed in 2013. The completion of construction of TAC is planned as 2023.

- Realization of the TAC project will accelerate the development in almost all fields of science and technology in Turkey and in our region.

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Thanks for your attention…