

November 25-26, 2010
CERN



- **Vision of the Turkish Accelerator Center**

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A short review on the past and present of
Accelerator Physics in Turkey

Accelerator Physics in Turkey - PAST

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- There has been isolated cases of work with accelerators in Turkey before 1994. Examples are:
 - ▣ Van De Graff generator (Istanbul University)
 - ▣ Microtron (Military Academy of Medicine, GATA) etc.
- Accelerator physics research in Turkey formally started with the establishment of the **Ankara University** Accelerator Physics Research Group in 1994 and first papers are published on linac on ring type ep and γ p colliders.
 - ▣ The first paper discussing a regional accelerator complex was published in Turkish Journal of Physics in 1993 by Prof. Saleh Sultansoy
 - ▣ Feasibility project presented to SPO for **Turkish Accelerator Center (TAC)** in 1997 by Ankara University

Forming an accelerator physics community -1

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□ Scientific collaboration agreements

- ▣ Ankara University - DESY : 1996
- ▣ Ankara University - CLIC-CERN : 2004
- ▣ Ankara University - BESSY : 2007
- ▣ Ankara University – FZD : 2007

□ National Congress on Particle Accelerators and Their Applications (UPHUK)

- ▣ UPHUK Congress are organized since 2001 in every three years by Turkish Physical Society together with TAEK and Universities. Recently, UPHUK-IV was held on August 2010.

Invited Speakers of UPHUK-IV

Steve MYERS - **CERN**, SWITZERLAND
Roland GAROBY - **CERN**, SWITZERLAND
Roberto SABAN - **CERN**, SWITZERLAND
Frank ZIMMERMANN - **CERN**, SWITZERLAND
Gökhan UNEL - **U.C. Irvine**, USA
Siegfried SCHREIBER – **DESY**, GERMANY
Florian WEISSBACH - **GSI**, GERMANY
Peter MICHEL - **ELBE-FZD**, GERMANY
Ernst WEIHRETER, **HZB-BESSY**, GERMANY
George R. NEIL - **JLAB**, USA
Ugur AKGÜN - **The University of Iowa**, USA
Naumiddin NAYEEM- **FNAL**, USA
Georg BERG - **University of Notre Dame**, USA
Tetsuya ISHIKAWA - **RIKEN**, JAPAN

Forming an accelerator physics community -2

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□ International Workshops

- ▣ First international workshop on linac-ring type ep and γ p colliders, April 7-9, 1997 (Ankara University)
 - Proceedings: Turkish J. of Phys. 22, 1998.

- ▣ Miniworkshop on Machine and Physics Aspects of CLIC based Future Collider Options, August 30, 2004 (CERN)
 - Speakers:
 - A. De Roeck, H. Braun, R. Corsini and D. Schulte (CERN)
 - S. Sultansoy, O. Yavas, A.K. Ciftci and O. Çakır (Turkey)

Forming an accelerator physics community -3

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- National Summer School on Particle Accelerators and Detectors (UPHDYO)
 - ▣ UPHDYO schools are organized since 2005 in every year.
 - ▣ Recently, UPHDYO-VI was held on September 2010.
- Participation in International Accelerator Activities
 - ▣ THERA (TESLA on HERA) & Photon Collider Collaboration at DESY
 - 1998-2001 with AU Acc. Phys. Research group
 - ▣ CTF3 and Compact Linear Collider (CLIC) Collaboration
 - 2004- Cont. with 35 people from 7 Universities (AU coordinator)
 - ▣ Large Hadron-Electron Collider (LHeC) Collaboration
 - 2008- Cont. with 10 people from 4 universities (TOBB ETU coordinator)

Accelerator Physics in Turkey - PRESENT

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- Accelerator Physics' role as the driving force behind scientific and technological advances is recognized by a wide community in Turkey.
- Consequently, ongoing projects are:
 - **Collaborations with major Accelerator Centers**
 - At CERN: CLIC, LHeC;
 - At Jordan: SESAME
 - **UPHUK and UPHDYO**
 - **Turkish Accelerator Center (TAC)**
 - **IR SEL&Brems. (First Facility), PF, SR, SASE FEL and PA Facilities**
 - **Accelerator Technologies Institute at Ankara University**
 - **TAEK's proton synchrotron**
 - **Medical Applications**

Collaborations with major Accelerator Centers

CERN (Switzerland)

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□ **CTF3 and Compact Linear Collider (CLIC) Collaboration**

- Ankara University (Coordinator) & S. Demirel U, Dumlupınar U, TOBB ETU, Uludag U, Gazi U, Nigde U.
- ~35 people in 3 local projects by TAEK, since 2004
- Scientific Contributions.
 - CLIC collaboration started with the AU's signature. Turkish scientists have contributed to new accelerating structure tests, beam diagnostics, injector complex, detector, SM and BSM studies.

□ **Large Hadron-Electron Collider (LHeC) Collaboration**

- Ankara U, TOBB ETU, Nigde U, Uludag U, Dogus U.
- ~10 people in 1 local project by TAEK, since 2008
- Scientific Contributions
 - Hitting LHC protons with an electron beam was initially proposed by Turkish scientists under the name QCD Explorer.
 - Turkish scientists are currently contributing to detector and interaction region design, QCD studies, new Physics searches and to the write-up of LHeC CDR.

Collaborations with major Accelerator Centers

SESAME (Jordan)

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- **Synchrotron-light Experimental Science and Applications in Middle East**
- **Turkey is member of SESAME Project since 2002**
 - ▣ Other members: Bahrain, Cyprus, Egypt, Iran, Israel, Jordan, Pakistan, Palestine Authority
- **Council:**
 - ▣ Presidents: C. L. Smith (CERN)
 - ▣ Vice President: D. Ülkü (Turkey),
 - ▣ Head of Scientific Com.: Z. Sayers (Turkey)
- **Contributions**
 - ▣ Design of beam lines and exp. stations & fina



Institute of Accelerator Technologies

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- Established on February 26, 2010 by Ankara University
 - ▣ At Gölbaşı Campus of A. U. together with the IR FEL facility
- 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



TAEK Proton Accelerator Facility

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□ The machine

- ▣ 15-30 MeV proton cyclotron
 - (Cyclon 30, IBA)

□ Purpose

- ▣ Radioisotope production
- ▣ R&D with proton beam

□ Facility Location:

- ▣ Sarayköy Nuclear Research and Training Center (SANAEM), Ankara, being built.

□ The facility is expected be commissioned in 2011



Accelerators for Medical Applications in Turkey

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There are 140 Medical Linacs for electron and photon therapy in Turkey*

Accelerator	Electron Energy (MeV)	Photon Energy (MV)	Number
Linac	4-6-7-8-10-12-14	6-15	70
Linac	4-6-8-10-12-14-16	6-18	62
Linac	8-10-12-14	10-15	1
Linac	4-6-8-10-12-15-18-20-25	6-25	2
Linac	4-6-7-8-10-12-14	6-10-15	2
Linac		6	3

*Dr. B. Dirican, GATA, Ankara

TURKISH ACCELERATOR CENTER (TAC)

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- Mission
- Phases of the project
- TAC collaboration & project team
- Proposed facilities & road map
- Local committees & study groups
- International committees & collaborations

Mission of the TAC collaboration

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- To design, construct and use of high energy particle (electron, positron and proton) accelerators for scientific research and technological development in basic and applied sciences in Turkey and the region.
- To collaborate with international accelerator community

Phases of the project: 1997 - 2001

First Phase: Feasibility

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- State Planning Organization (SPO) of Turkey supported a feasibility project entitled “Particle Accelerators: What can be done in Turkey?”
 - A collaboration between Ankara and Gazi Universities
- Outcome: a Feasibility report in 2001, 130 p in Turkish
 - Turkey must establish a national accelerator center:
 - **Turkish Accelerator Center (TAC)**
 - TAC must include:
 - **A particle factory to study particle physics**
 - **3rd generation synchrotron radiation facility**
 - **4th generation free electron laser facility**
 - **A proton accelerator facility**
 - An Institute on Accelerator Technologies must be established
 - Closer collaboration with international accelerator community is needed

Phases of the project: 2002 - 2005

Second Phase: General Design



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- SPO of Turkey supported two General Design Report (GDR) projects:
 - ▣ General Design of TAC Particle Factory & Proton Facility
 - ▣ General Design for TAC Light Sources (SR and FEL)
 - A collaboration between Ankara and Gazi Universities
- Outcome
 - ▣ Main parameters, types and technologies of accelerators and research potential of facilities are described in General Design Reports

Phases of the project: 2006 - 2013

Third Phase: TDR and the First Facility

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- SPO of Turkey supported a project for
 - ▣ Writing the TAC Technical Design Report
 - ▣ Building the First Facility for TAC : an IR FEL&Brems. Facility
 - As a collaboration between 10 Turkish Universities

- Outcome
 - ▣ The Institute of Accelerator Technologies is established.
 - ▣ First facility is fully funded and buildings are completed.
 - ▣ First facility (IR FEL) will be commissioned and Technical Design Report (TDR) of TAC will be ready in 2013.

TAC collaboration and current project team

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- TAC: An Inter-University Collaboration (10 Turkish Universities)
- Project Team: 52 staff with PhD + 64 graduate students

Ankara University (Coordinator)



Gazi University

İstanbul University



Uludağ University

Dumlupınar University



Boğaziçi University



Doğuş University

Erciyes University



Süleyman Demirel University

Niğde University



Proposed facilities

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- **The First Facility**

Sc linac based IR FEL & Bremstrahlung facility

- **TAC Particle Factory**

Electron-positron collider (charm factory), $E_{c.m.} = 3.77$ GeV

- **TAC Synchrotron Radiation Facility**

A third generation light source based on dedicated 3.56 GeV (positron/electron) synchrotron

- **TAC SASE FEL Facility**

A fourth generation light source based on 1 GeV electron linac

- **TAC Proton Accelerator Facility**

A high power and high flux proton accelerator up to 3 GeV energy

TAC Road map

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Step I (1997-2001)

- ▣ Feasibility Report (FR) of TAC

Step II (2002-2005)

- ▣ General Design Report (GDR) of TAC

Step III (2006-2013)

- ▣ Technical Design Report (TDR) of TAC
- ▣ First Facility (IR FEL & Brems.)
- ▣ Institute of Accelerator Technologies

Step IV (2014-...)

- ▣ Construction of Turkish Accelerator Center (TAC)

Local committees & Study groups

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- **Local Committees for IR FEL & Brems. Facility**
 - Machine Committee (Head: Dr. S. Ozkorucuklu)
 - Experimental Stations Committee (Head: Dr. P. Arıkan)
 - Bremsstrahlung Committee (Head: Dr. İ. Akkurt)

- **TDR Study Groups for TAC**
 - TAC Particle (Charm) Factory Study Group (Coordinator: Dr. O. Çakır)
 - TAC Synchrotron Radiation Facility Study Group (Coordinator: Dr. A.K. Çiftçi)
 - TAC SASE FEL Facility Study Group (Coordinator: Dr. H. D. Yıldız)
 - TAC Proton Accelerator Facility Study Group (Coordinator: Dr. B. Akkuş)

International committees -I

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- **International Scientific Advisory Committee (ISAC)**
- Ercan ALP (Argonne National Laboratory, USA) **(Chair)**
- 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)

ISAC Meetings

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First Meeting: October 8-9, 2009,
Ankara University, Ankara



Second Meeting: June 21-22, 2010,
Bogazici University, Istanbul



International committees -II

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□ International Machine Advisory Committee (IMAC)

Peter Michel (FZD, Germany) (**Head**)

Hideaki Ohgaki (Kyoto University, Japan)

Dieter Trines (DESY, Germany)

Ernst Weihreter (BESSY, Germany)

Jean R. Delayen (JLab, USA)



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

Second Meeting: September 2-3, 2010, Bodrum, Turkey.

The First TAC Facility (TARLA)

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- **T**urkish **A**ccelerator and **R**adiation **L**aboratory in **A**nkara (**TARLA**)
- TARLA will be a **Free Electron Laser & Bremstrahlung Facility***
- Buildings of the facility are now completed.
- It is planned that the facility will be completed in 2013

TARLA Facility

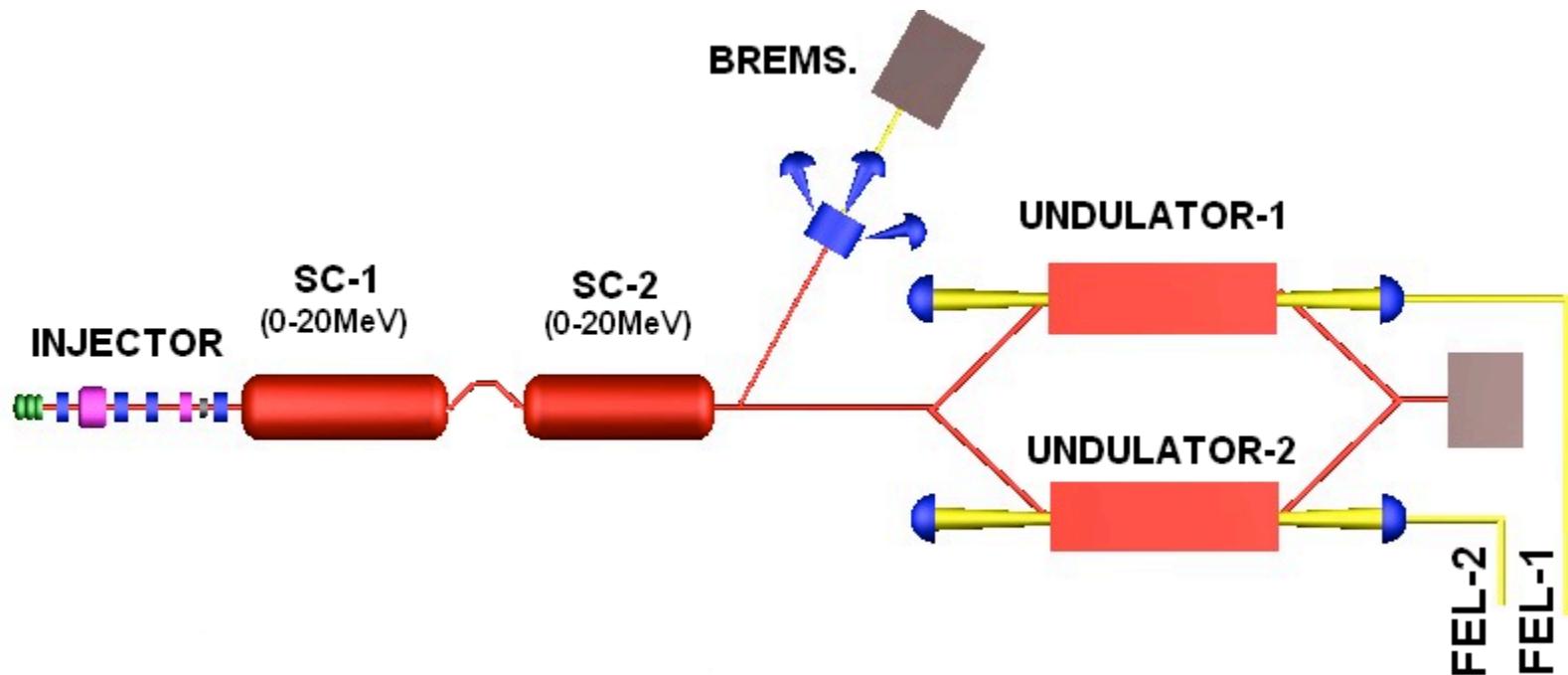
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- TARLA project aims to produce FEL in oscillator mode between 2-250 micron range using 15-40 MeV electron beam.
- In order to have wide research area we request to have CW electron beam with high average current as well as pulsed beam with low current.
- 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.

TARLA Facility

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Schematic view of TARLA Facility



350 kV thermionic e-gun
to be produced in Ankara.



Plans about Experimental stations of TARLA

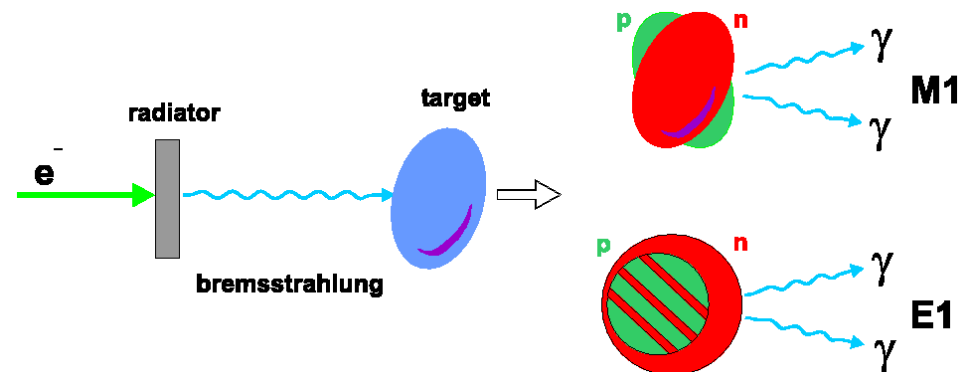
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- 8 experimental stations are planned.
- IR FEL will be used with different techniques for research on
 - material science**
 - photon science**
 - optics**
 - chemistry**
 - medicine**
 - biotechnology**
 - nanotechnology**

Bremsstrahlung station

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- A Bremsstrahlung beam line and experimental station is planned for nuclear physics studies. in TARLA
- It is planned that, electron beam of 15-35 MeV energy will be used to produce Bremsstrahlung radiation.
- Main aim of Bremsstrahlung station is to study nuclear spectroscopy



The proposed TAC facilities

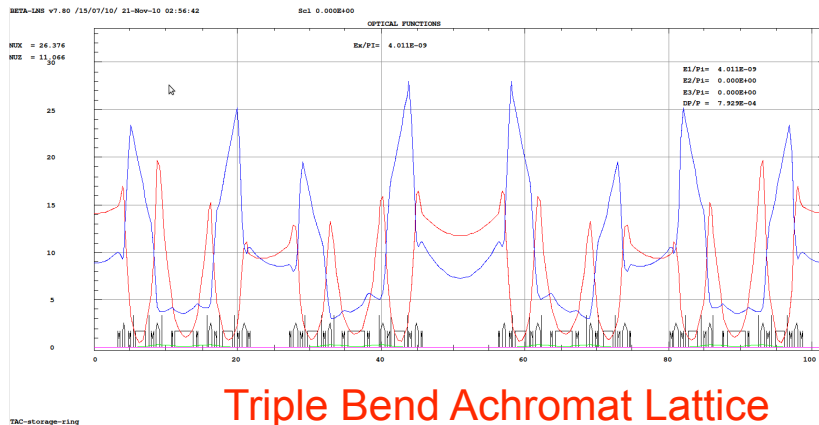
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- Technical Design Report studies are ongoing for
 1. Synchrotron Radiation Facility (TAC SR)
 2. SASE FEL Facility (TAC SASE FEL)
 3. Proton Accelerator Facility (TAC PA)
 4. Particle (Charm) Factory (TAC PF)

1. Synchrotron Radiation Facility (TAC SR)

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A 3.56 GeV positron synchrotron is proposed as 3rd generation SR source to cover 10 eV – 100 keV photon energy range.

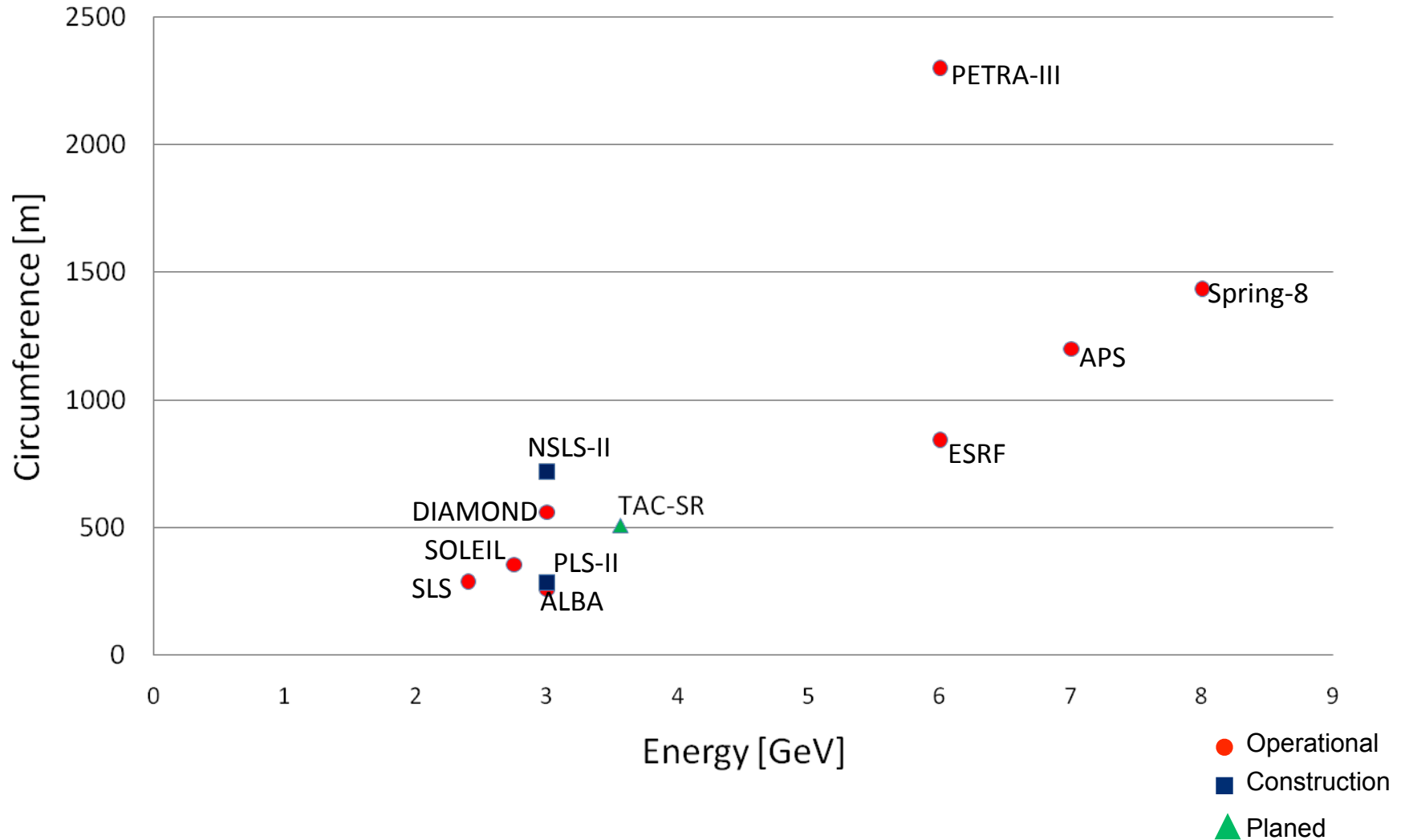


Main Parameters of TAC-SR

Energy	GeV	3.56
Lattice Type		TBA
Period		5
Circumference	m	509
Emittance, e_x	nm.rad	4.011
Energy Spread	%	0.0793
Energy Loss / Turn	keV	911
Betatron Tunes, Q_x / Q_y		26.4 / 11.1
Natural Chromaticity, x_x / x_y		-55.7 / -28.3
Straight Sections		
Short	m	10 x 5.5
Medium	m	5 x 6.5
Long	m	5 x 10.5

TAC SR compared to similar facilities

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TAC SR User potential in Turkey and our region

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□ Turkey

- ▣ 145 Universities in 81 cities
- ▣ National Institutes on
 - Biotechnology, Nanotechnology, Accelerator,
 - Mine, Medicine, Pharmacology,
 - Metrology, etc.
- ▣ National Authorities:
 - TUBİTAK , TAEK, MAM
- ▣ Industry, Technocities, Technoparks, Army



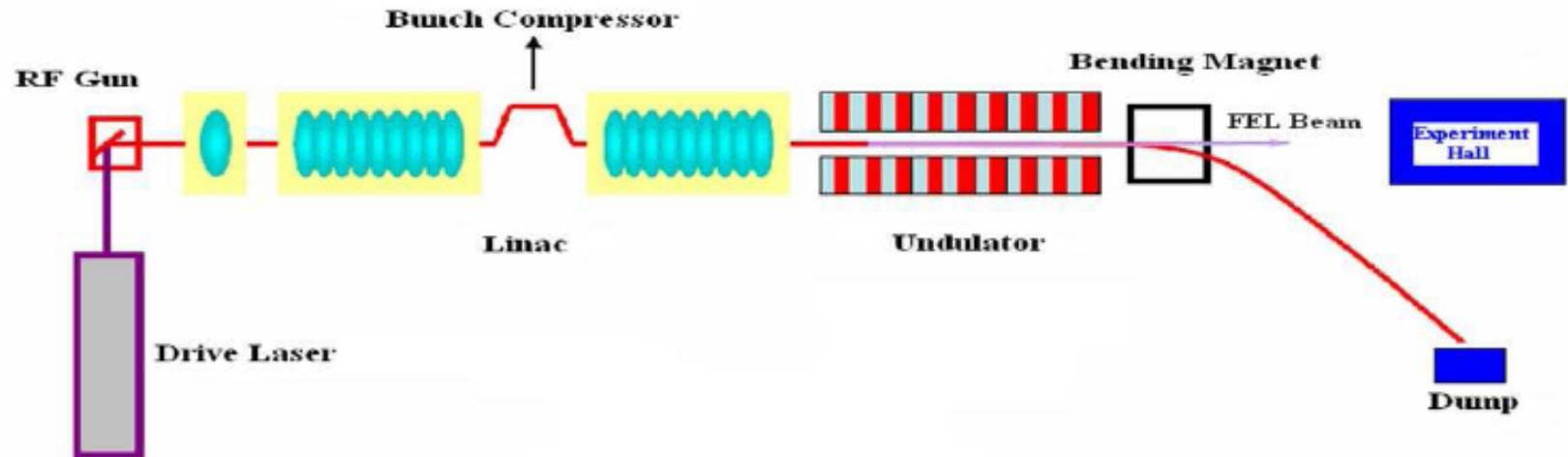
☒ Our region

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

2. SASE FEL Facility (TAC SASE FEL)

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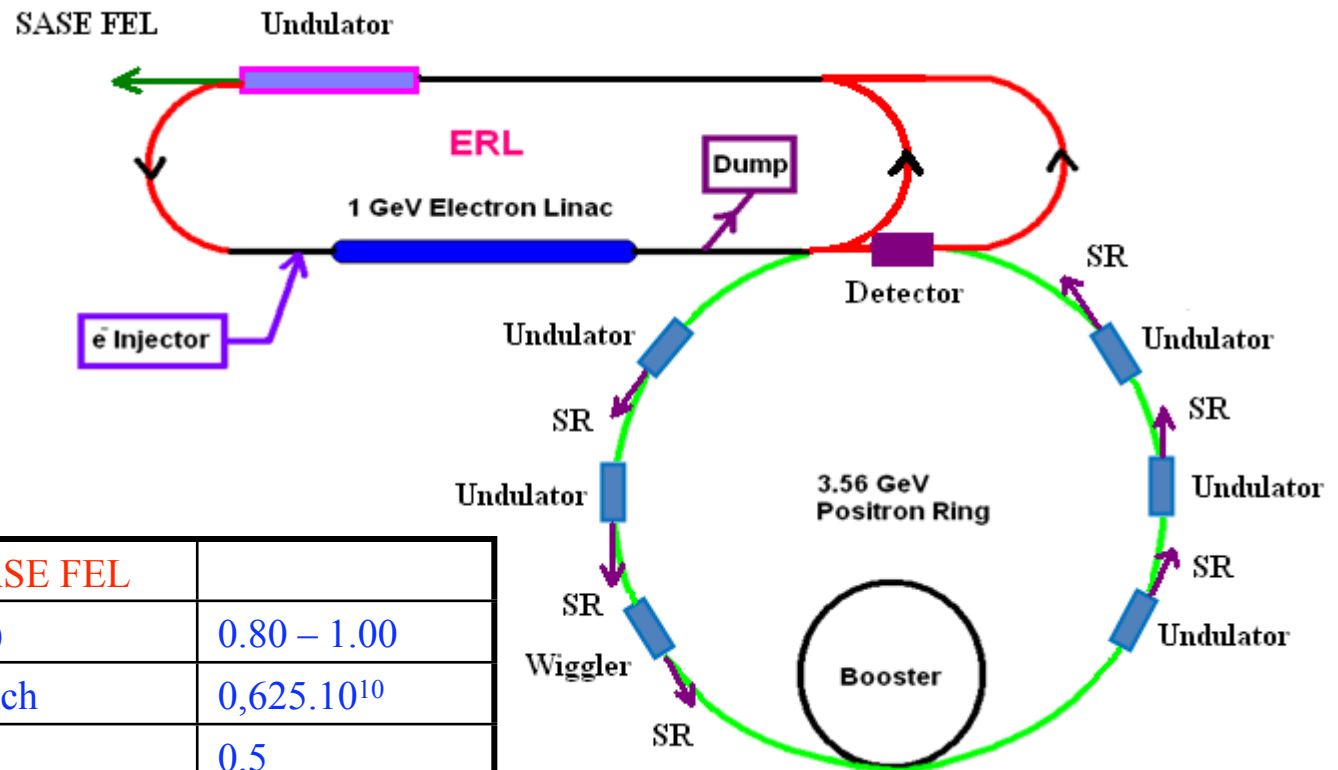
- With 0.8-1 GeV electron beam, wave length range of SASE FEL is planned as 1-800 nm
- We have two options for linac structure: RF Linac or ERL



SASE FEL Facility (TAC SASE FEL)

ERL option

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Main Parameters of TAC SASE FEL	
Electron beam energy (GeV)	0.80 – 1.00
Number of electrons per bunch	$0,625 \cdot 10^{10}$
Average current (A)	0.5
Repetition rate ($1/T_\mu$) (MHz)	500
Bunch length (t_μ) @ undulator entrance (ps)	0.5
Planned FEL wavelength range (nm)	1-800

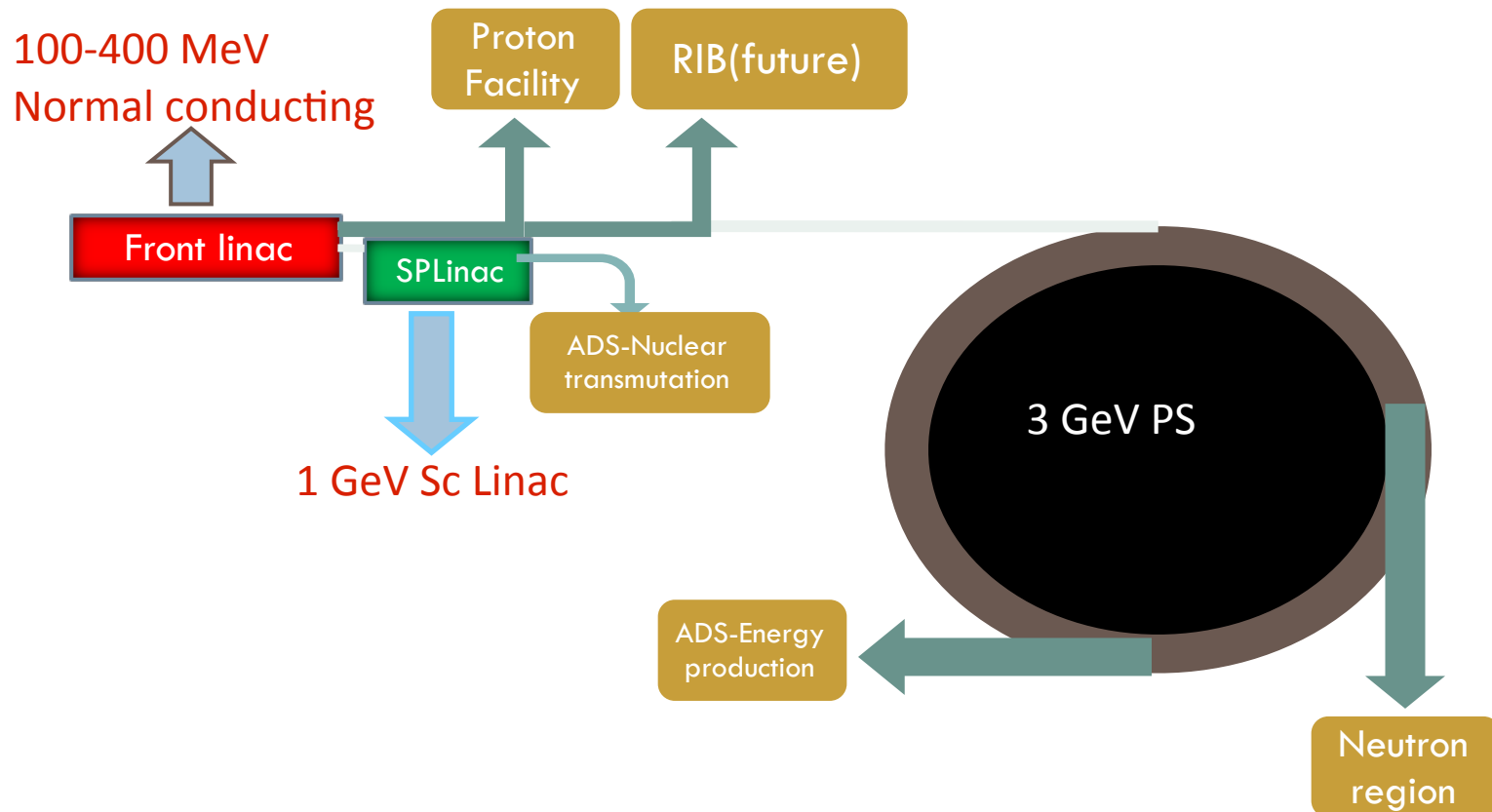
3. Proton Accelerator Facility (TAC PA)

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- 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.)

Proton Accelerator Facility (TAC PA) a possible layout

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4. Particle (Charm) Factory (TAC SR)

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The status and future plans will be presented by
Prof. Dr. Saleh Sultansoy
in the subsequent talk

TAC Project Team



References - Main publications in the last 10 years:

41

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- Linac-Ring Type Phi Factory For Basic and Applied Research, **Turkish J. of Physics**, 24 (2000)
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- A Lattice Study for the Synchrotron Radiation Facility of the TAC with 3.56 GeV, **PAC09**, Vancouver, Canada (2009)
- The TAC IR FEL Oscillator Facility Project, **FEL09**, Liverpool, England (2009)
- Technical Design Studies of TAC SASE FEL Proposal, **FEL09**, Liverpool, England (2009)
- Turkish Accelerator Center Project: Status and Regional Importance, **7th Balkan Phys. Conference**, Greece (2009)
- An update of the Lattice Design of the TAC Synchrotron Radiation and Insertion Devices, **PAC10**, Koyoto, Japan (2010)
- The Status of Turkish Accelerator Center Project, **PAC10**, Koyoto, Japan (2010)
- The Status of TAC IR FEL and Bremsstrahlung Project, **PAC10**, Koyoto, Japan (2010)
- Turkish Accelerator Center Project: Status and Road Map, **27th Int. Phys. Congress**, İstanbul, Turkey (2010)
- In National Part. Accel. Congress (UPHUK I(2001)-II(2004)-III(2007)-IV(2010)): **83 presentations on TAC**

Conclusions

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- The first TAC facility TARLA, and Technical Design Report of TAC will be completed in 2013. The completion of construction of TAC is planned for first half of 2020's.
- Priority of proposed facilities in TAC will be determined depending on reports of ISAC and new trends on accelerator science and applications.
- Turkey's full membership to CERN will play a crucial role on accelerator and detector based research and developments in our country. We look forward for synergy between TAC and CERN based projects.
- Accelerator driven generic technologies will accelerate the development in almost all fields of science and technology in Turkey and in our region.
- **Turkey has very big potential with 15th largest GDP and young population to use accelerator and detector based technologies in all areas of science and technology.**



Thank you for your attention...

TAC Project:

<http://thm.ankara.edu.tr>

The Institute of Accelerator Technologies:

<http://hte.ankara.edu.tr>