ICPP-II, Istanbul

2nd International Conference on Particle Physics

in Memoriam Engin Arık and Her Colleagues

Doğuş University, İstanbul, Turkey

20 - 25 June 2011

The Status and Road Map of Turkish Accelerator Center (TAC)

Dr. Ömer Yavas

Director of TAC Project and
The Institute of Accelerator Technologies
Ankara University, Ankara, Turkey

In memory of our colleagues…

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

Accelerator Physics in Turkey - PAST

- 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 γp colliders.

- Feasibility project presented to SPO for **Turkish Accelerator Center (TAC)** in 1997 by Ankara University

Forming an accelerator physics community -1

- Scientific collaboration agreements
  - Ankara University - DESY : 1996
  - Ankara University - CLIC-CERN : 2004
  - Ankara University – HZB, BESSY : 2007
  - Ankara University – HZDR : 2007
  - Ankara University – CI : 2011

- 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.

Forming an accelerator physics community -2

- International Workshops
  - First international workshop on linac-ring type ep and γp 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

- 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

- 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), SR, SASE FEL, PF and PA Facilities**

- Accelerator Technologies Institute at Ankara University (2010)

- TAEK's Proton Cyclotron

- Medical Applications

Collaborations with major Accelerator Centers
CERN (Switzerland)

- **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)

- **S**ynchrotron-light **E**xperimental **S**cience and **A**pplications in **M**iddle **E**ast
- Turkey is member of SESAME Project since 2002
  - Other members: Bahrain, Cyprus, Egypt, Iran, Israel, Jordan, Pakistan, Palestine Authority
- Council:
  - Presidents: C. L. Smith (UK)
  - Vice President: D. Ülkü (Turkey),
  - Head of Scientific Com.: Z. Sayers (Turkey)
- Contributions
  - Design of beam lines and exp. stations & financial support

Institute of Accelerator Technologies

- Established on February 26, 2010 by Ankara University
  - At Gölbasi 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.

Opening Ceremony of Buildings:
May 9, 2011

TAEK Proton Accelerator Facility

- 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

There are ~150 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	80
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

CERN Membership of Turkey

- CERN Council approved full membership candidate of Turkey to CERN in December 2010.

- It is expected that, Turkey will be a full member of CERN in near future.

TURKISH ACCELERATOR CENTER (TAC)

Mission of the TAC collaboration

- 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

- 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

- 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

- 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 of TAC will be ready in 2013.

TAC collaboration

- **TAC: An Inter University Collaboration**
- **Project Team: 55 staff with PhD + 73 graduate students (21 Universities)**

Ankara University (Coordinator)

Gazi University

İstanbul University

Uludağ University

Dumlupınar University

Boğaziçi University

Doğuş University

Erciyes University

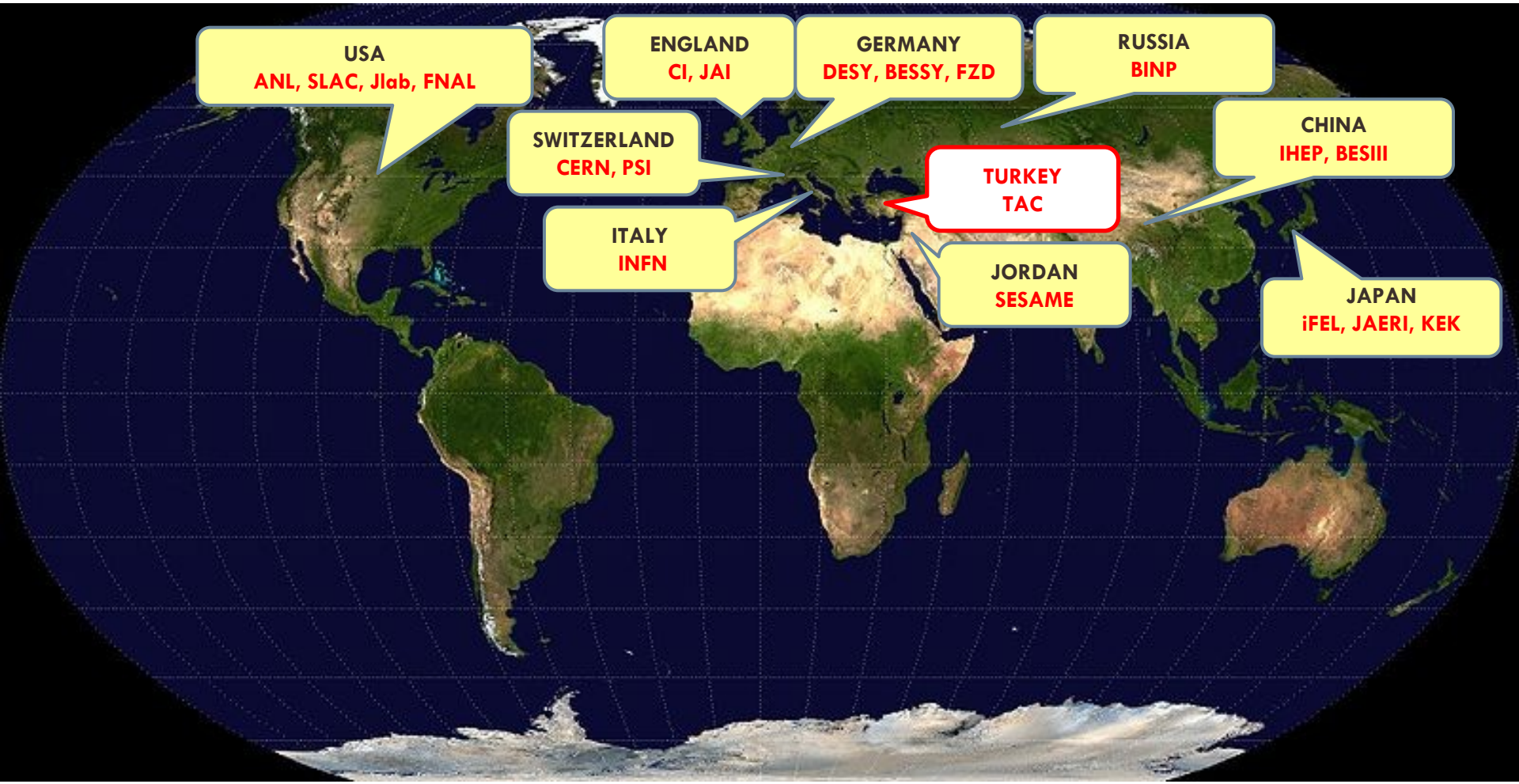
Süleyman Demirel University

Niğde University

National Collaboration

Contributions from 21 Universities

International Collaboration



International Advisory Committees

International Scientific Advisory Comittee (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)

1st Meeting:
October 8-9, 2009
Ankara University
Ankara, Turkey

2nd Meeting:
June 21-22, 2010
Haziran 2010
Boğaziçi University
Istanbul, Turkey

3rd Meeting:
May 9-10, 2011
Ankara University
Ankara, Turkey

I. Meeting, 2009, Ankara

II. Meeting, 2010, Istanbul

III. Meeting, 2011, Ankara

Pictures from ISAC-TAC Meetings

International Advisory Committees

- **International Machine Advisory Comittee (IMAC)**

Peter MICHAL (HZDR-ELBE, Germany) (Head)

Hideaki OHGAKI (Kyoto University, Japan)

Dieter TRINES (DESY, Germany)

Ernst WEIHRETER (HZB-BESSY, Germany)

Jean R. DELAYEN (JLab, USA)

3rd Meeting, IAT, Ankara

First Meeting:
December 4-5, 2009
Ankara University

Second Meeting:
September 2-3, 2010
Bodrum, Mugla

Third Meeting:
May 12-13,
IAT, Ankara University

Main Activities (2010-2011)

- VI. National Summer School, September 2010, Bodrum
- IV. National Congress on Particle Accelerators, August 2010, Bodrum
- 13th Board of TAC Meeting, October 16-17, 2010, Ankara University
- 88th ECFA Meeting, October 2010 (Presentation of TAC)
- 5th SPL Workshop, October 2010 (Presentation of TAC PA)
- ISAC-OsC Meeting I, November 29, 2010, Ankara University
- 1st Meeting of National Advisory Council of TAC, December 2010, AU
- IX. TAC Workshop, December 5-7, 2010, Ankara University
- 14th Board of TAC Meeting, December 7, 2010, Ankara University
- ELBE-TARLA Workshop, 31.01-02.02.2011, Antalya
- 3rd Workshop on TAC PA, April 8-9, 2011, EOGU, Eskisehir
- 15th Board of TAC Meeting, April 16, 2011, Ankara University
- ISAC III Meeting, May 9-10, 2011, Ankara University
- IMAC III Meeting, May 12-13, 2011, Ankara University

Project Management

- **Management of TAC Collaboration**
- **Director: Dr. O. Yavas**
- **Vice Directors:** Dr. P. Arikan, Dr. S.A. Çetin, Dr. E. Kasap, Dr. S. Ozkorucuklu, Dr. H.D. Yıldız
- **Board of TAC:** Director, Vice Directors and Representatives of Universities (14 persons)

- **Management of TARLA Project**
- **Director: Dr. S. Ozkorucuklu**
- **Vice Directors:** Dr. P. Arikan, Dr. I. Akkurt
- **Technical Menager:** A. Aksoy

- **Management of Sub-Projects** (Directors and Vice-Directors):
- **TAC Synchrotron Radiation Facility** (**Dr. A.K. Ciftci** (head), Dr. H. Aksakal, Dr. Z. Nergiz)
- **TAC SASE FEL Facility** (**Dr. H. D. Yildiz** (head), Dr. I. Tapan)
- **TAC Particle Factory** (**Dr. O. Cakir** (head), Dr. S. A. Cetin, Dr. A.K. Ciftci)
- **TAC Proton Accelerator Facility** (**Dr. B. Akkus** (head), Dr. E. Algin, Dr. L. Sahin, Dr. M. Yilmaz)

National Advisory Council of TAC

- Members:
- Directors of TAC
- Rectors of Universities of TAC Collaboration
- Turkish Atomic Energy Authority (TAEK)
- The Scientific and Technological Research Council of Turkey (TUBİTAK)
- Academy of Sciences of Turkey (TUBA)
- The Union of Chambers of Commodity Exchanges of Turkey (TOBB)
- Higher Education Council of Turkey (YÖK)
- Ministry of State of Science and Technology
- Ministry of Energy and Natural Resources
- Ministry of Industry and Trade
- Ministry of Foreign Affairs
- Secretariat General for EU Affairs

First Meeting of National Advisory Committe of TAC
December 03, 2010, Ankara University

Facilities of TAC

- **The First Facility (TARLA)** (Under construction…)
  Sc linac based IR FEL & Bremstrahlung facility

- **TAC Synchrotron Radiaton Facility (SR)**
  A third generation light source based on dedicated 3-3.5 GeV electron synchrotron

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

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

- **TAC Proton Accelerator Facility (PA)**
  LE PA: 3-100 MeV, HE PA: 1 GeV
  High power and high flux proton accelerator

The First Facility of TAC (TARLA)

- **T**urkish **A**ccelerator and **R**adiation **L**aboratory in **A**nkara **(TARLA)**

- TARLA will be a **Free Electron Laser & Bremstrahlung** Facility*

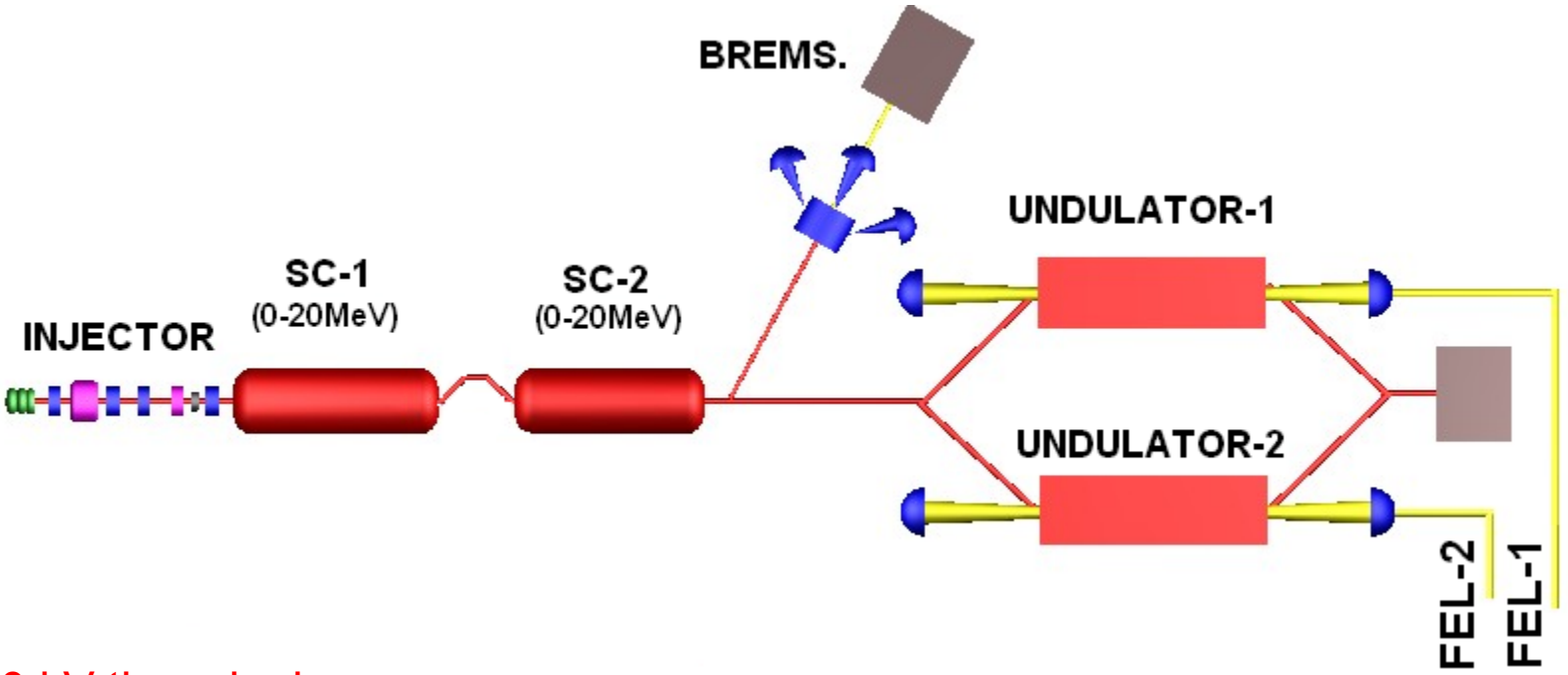
- Buildings of the facility are yet completed
- It is planned that the facility will be completed in 2013

TARLA Facility

- TARLA project aims to produce FEL in oscillator mode between 2-250 microns 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.

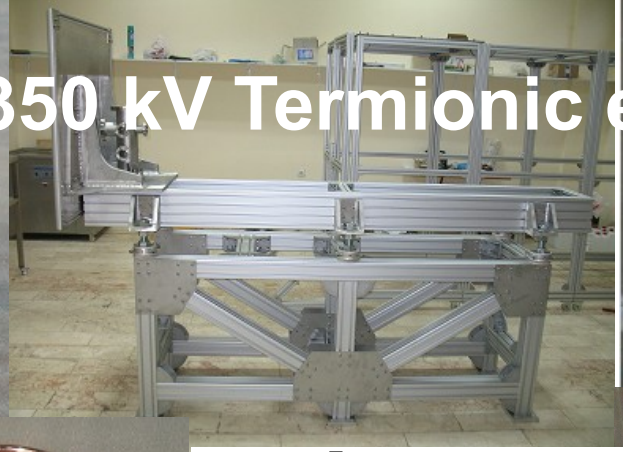
TARLA Facility

Schematic view of TARLA Facility

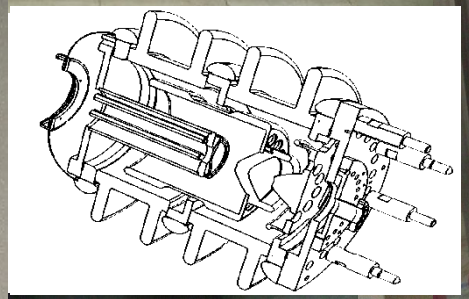


350 kV thermionic e-gun
to be produced in Ankara.

350 kV Termionic e-Gun (OSTİM, Ankara)






Electron Beam Parameters of TARLA

Beam Energy [MeV]	15-38
Max. Average Beam current [mA]	1.6
Bunch Repetition Rate [Mhz]	26-13
Bunch Length [ps]	1-10
Norm. rms Trans. Emit. [mm mrad]	<15
Norm. rms Long. Emit. [keV.ps]	<100
Macropulse Length and Repetition	CW/tunable

Free Electron Laser Parameters of TARLA

	U25	U90
• Wavelength [μm]	2-30	15-250
• Micropulse Repetition [Mhz]	13-26	13-26
• Max. Peak Power [MW] *	0.1 – 6	0.01-2
• Average Power [W] *	1-100	1-100
• Max. Pulse Energy [μJ] *	0.1-3	0.1-3
• Peak Brightness (ph/(s mm^2 $mrad^2$ 0.1% bw))*	~10^30	~10^29
• Pulse Length [ps] *	1-10	1-10

* Depending on wavelengths


ANKARA (15km)
GÖLBAŞI
Town Gölbaşı
Yaylabağ
A. Ü. Vırançık (50. Yıl) Kampüsü
HTE ve THM IR-SEL Laboratuvarı İnşaat Alanı
TARLA
Örencik
Lake
Mogan
Gölbasi Campus of
Ankara University
Haymana Yolu
Ankara-Konya Otoyolu
Ankara Çevreyolu
D-20
D-240

TARLA Facility, June 2011

Plans about Experimental stations of TARLA

- 8 experimental stations are planned.
- IR FEL will be used with different techniques for research on

material science

photon science

optics

chemistry

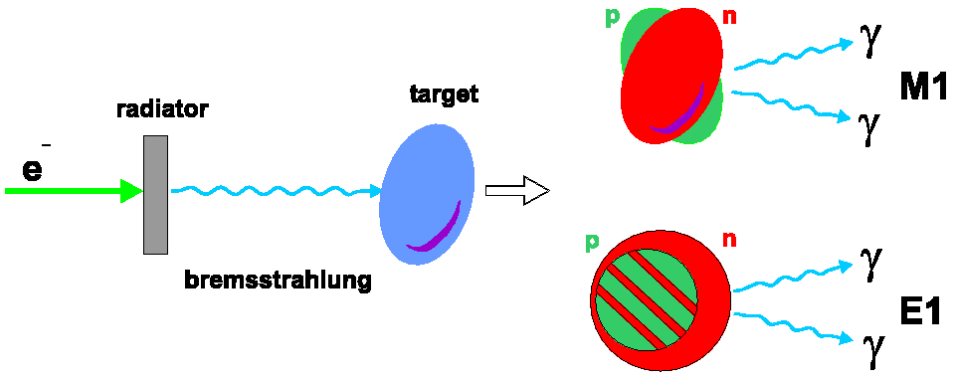
medicine

biotechnology

nanotechnology

Bremsstrahlung station

- 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



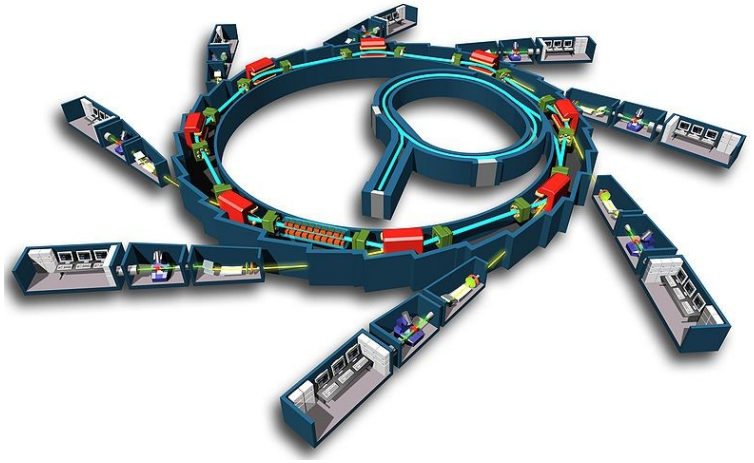
Proposed Facilities of TAC

- **Synchrotron Radiation Facility (SR)**
- **SASE FEL Facility**
- **Particle (Charm) Factory (PF)**
- **Proton Accelerator Facility (PA)**

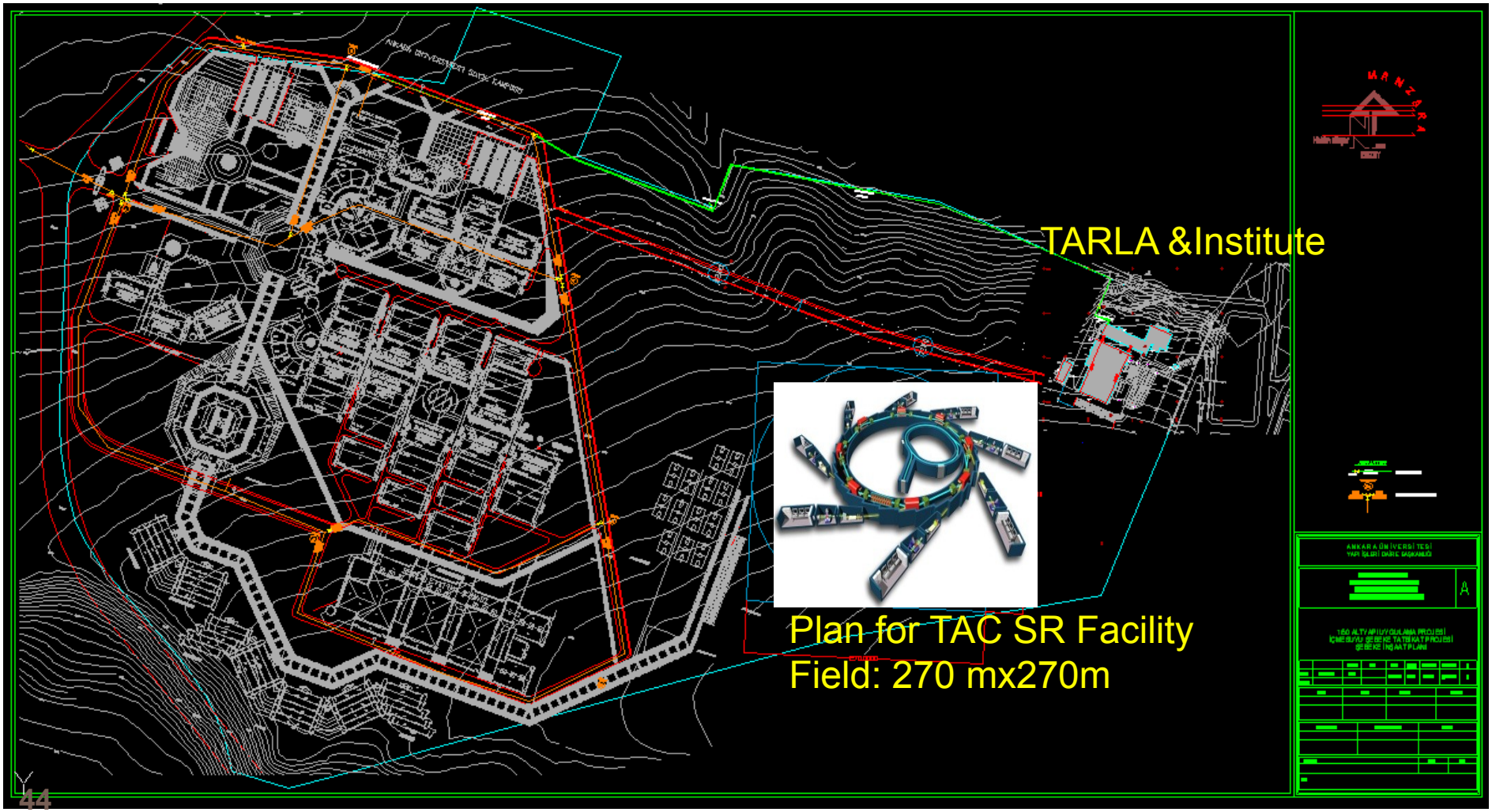
TAC Synchrotron Radiation Facility

Some results for dedicated design of TAC SR Facility:

- Machine: Dedicated electron synchrotron.
- Beam energy: 3-3.5 GeV
- Bem current: 500 mA
- Beam emittance: 1.18 nm
- Lattice: TBA
- Circumference: 546 m
- Straight sections: 10x10.5m, 10x5.5m



Gölbası Campus of Ankara University



Synchrotron Radiation Facility (TAC SR)

User potential of SR in Turkey and our region

- **Turkey**

- 160 Universities in 81 cities
- National Institutes on

  Biotechnology, Nanotechnology, Accelerator,

  Mine, Medicine, Pharmachology,

  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

International Workshop

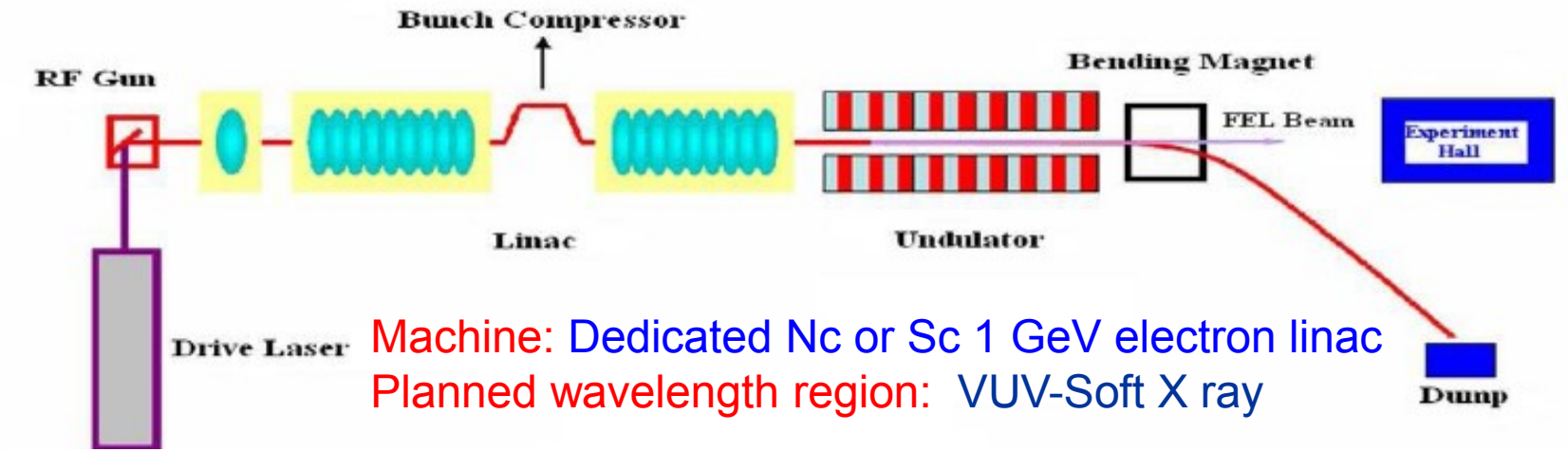
- **First International Workshop on Machine and Research Aspects of the Proposed Turkish Light Sources**
  4-6 July 2011
  Dogus University
  ISTANBUL

- **IR FEL, Bremsstrahlung, SR, SASE FEL**
- **~ 100 participants**

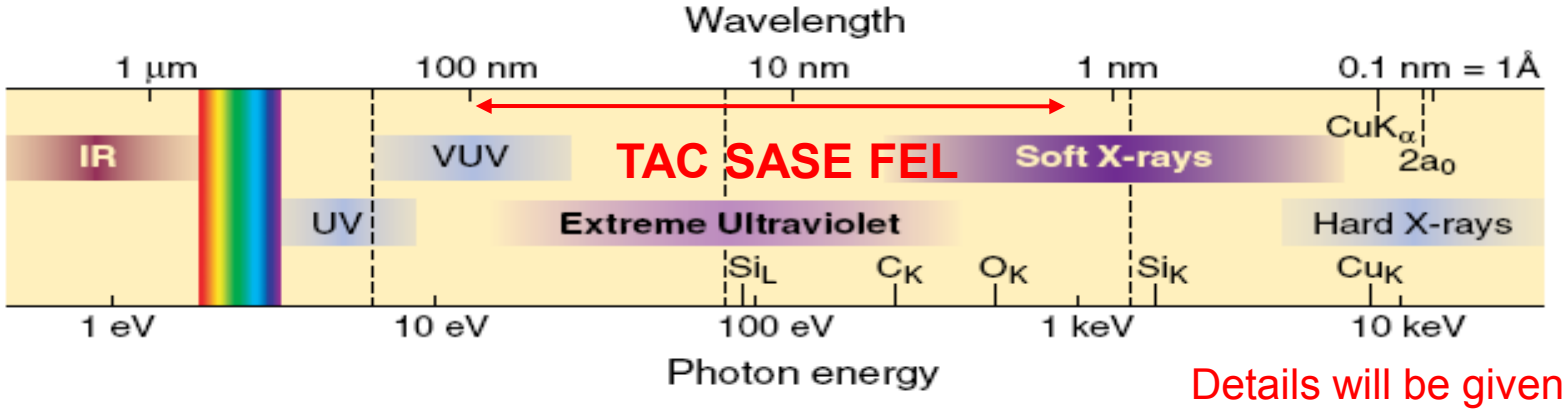
Invited speakers

Funda Aksoy (ALS, USA)
Ahmet Alataş (APS, USA)
Ercan Alp (APS, USA)
Mehmet Aslantaş (KSU, Turkey)
Clément Blanchet (DESY, Germany)
Michael Borland (APS, USA)
Dean Chapman (U.Saskatchewan, UK)
Joel Chavanne (ESRF, France)
A. Kenan Çiftçi (Ankara U.-TAC, Turkey)
Louis Emery (APS, USA)
Zahid Hussain (ALS, USA)
Ömer İlday (Bilkent U.-TAC, Turkey)
Sarp Kaya (SLAC, USA)
Miroslav Kobas (DECTRIS, Switzerland)
Ian McNulty (APS, USA)
Amor Nadji (SOLEIL, France)
Suat Özkorucuklu (SDU, Turkey)
Claudio Pellegrini (UCLA, USA)
Ullrich Pietsch (U.Siegen, Germany)
Trevor Rayment (Diamond, UK)
Sven Reiche (PSI, Switzerland)
Ian Robinson (UCL, UK)
Zehra Sayers (Sabancı U., Turkey)
Ali Serpengüzel (Koç U., Turkey)
Thomas Toellner(APS, USA)
Dinçer Ülkü (Hacettepe U., Turkey)
Herman Winick (SLAC, USA)
Ömer Yavaş (Ankara U.-TAC, Turkey)
Hatice D.Yıldız (Dumlupınar U.-TAC, Turkey)
Ercan Yılmaz (İBU, Turkey)

TAC SASE FEL Facility



Machine: Dedicated Nc or Sc 1 GeV electron linac
Planned wavelength region: VUV-Soft X ray



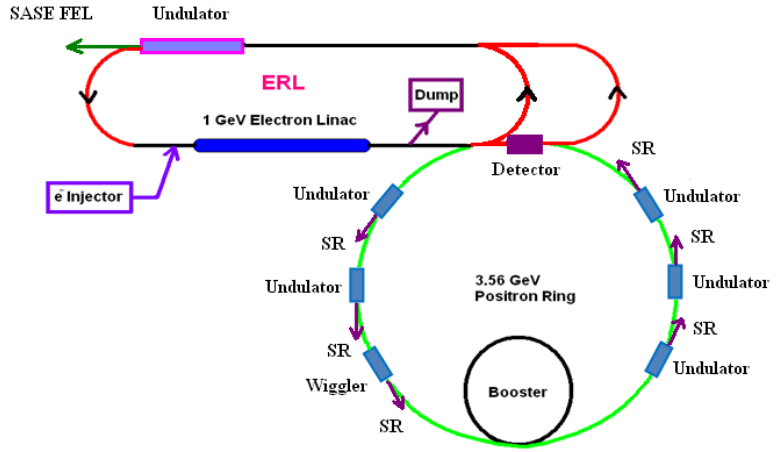
Details will be given by Dr. H. D. Yıldız

TAC Particle (Charm) Factory

- Linac on ERL electron-positron collider

PF design:
ERL on Ring collider

Ring design:
3.5 GeV
long straight regions of ~10 m or a few straight sections



Detector design:
Study on EMC
Simulation with electron energies (0-2 GeV)

ISAC suggestion for Linac: a dedicated linac (1 GeV)

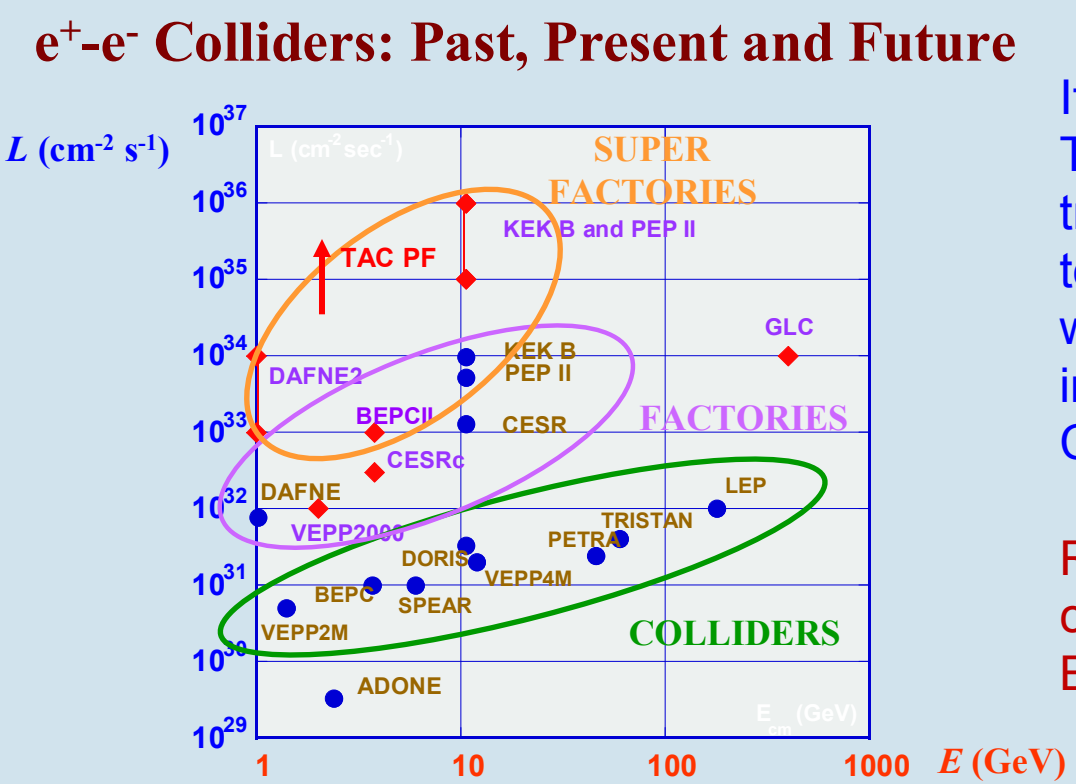
ISAC suggestion for Ring: one very long section or a few straight sections on ring (3.5 GeV)

Tentative parameters of ERL on Ring based PF

Positron ring	
Positron beam energy (GeV)	**3.56**
Number of positrons per bunch (10^{11})	2
Beta functions at IP β_x / β_y (mm)	80/5
Normalized emittances $\varepsilon_x^N / \varepsilon_y^N$ (μm)	110/0.36
σ_x / σ_y (μm)	36/0.5
σ_z (mm)	5
Beam-beam tune shift	0.012/0.13
Energy loss / turn (MeV)	0.7
Number of bucles, n_b	300
Revolution frequency (MHz)	0.5
Circumference, C (m)	600
Beam current (A)	4.8

Electron ERL	
Electron beam energy (GeV)	**1**
Number of electrons per bunch (10^{10})	2
Beta functions at IP β_x / β_y (mm)	80/5
Normalized emittances $\varepsilon_x^N / \varepsilon_y^N$ (μm)	31/0.1
σ_x / σ_y (μm)	36/0.5
σ_z (mm)	5
Disruption Dx/Dy	0.33/60
Beam current (A)	0.48
Colliler Parameters	
Crossing angle (mrad)	34
Collision frequency (MHz)	150
Luminosty	$1.4 \cdot 10^{35}$

TAC Particle (Charm) Factory



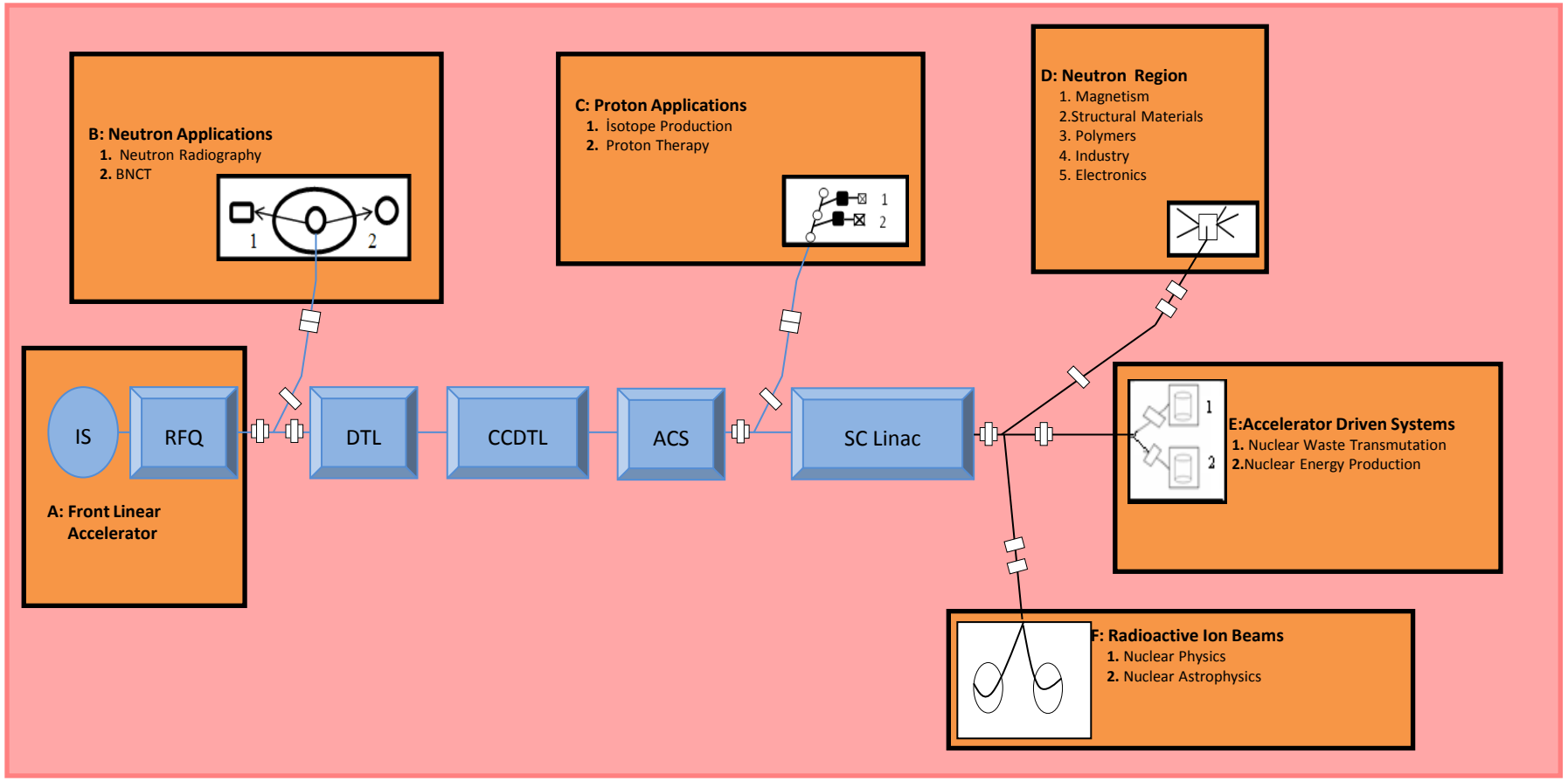
It is planned that, TAC PF will be transformed to a global project with international Collaborations.

Recently, we collaborated with BESIII, China

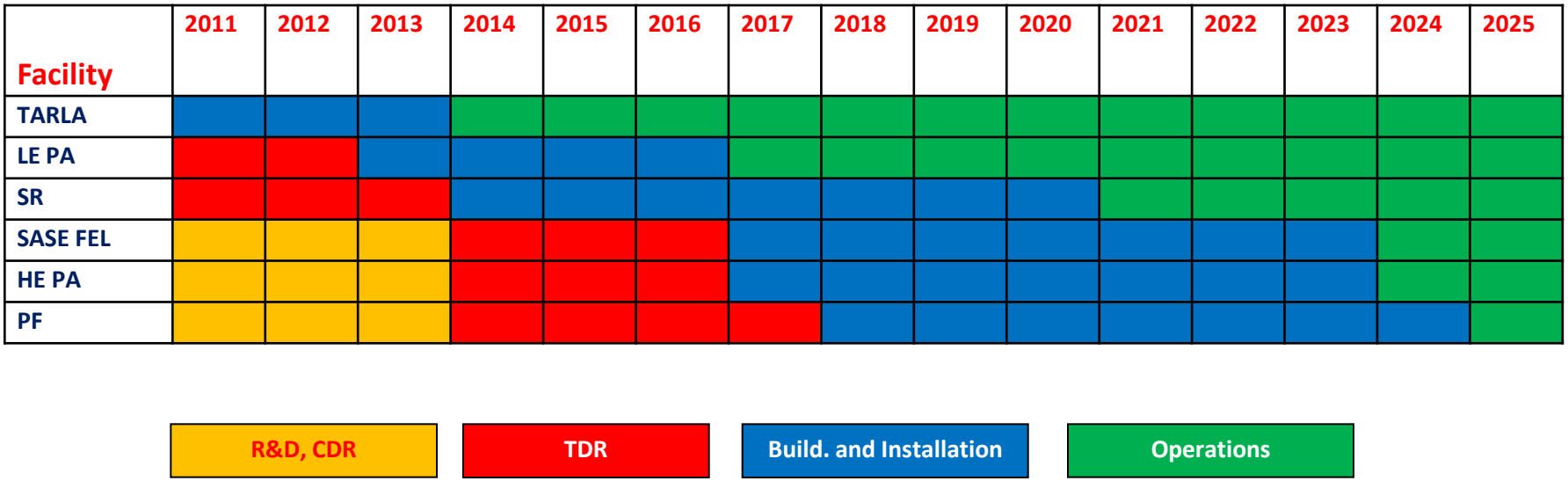
Proton Accelerator Facility (TAC PA)

- 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.)

Schematic view of LE and HE parts of TAC PA facility including possible research potential



Proposed time schedule for TAC (2011-2025)



Main scientific activities (2011)

- ***7th National Summer School***
  August 21-27, 2011, BODRUM
- ***28th International Physics Conference (TPS-28)***
  September 6-9, 2011, BODRUM
- ***3rd User Meeting for TAC IR FEL Facility***
  October 2011, IAT, ANKARA
- ***10th TAC Workshop***
  December 2011, IAT, ANKARA

Conclusions

- We plan to get first beam for experiment at TARLA at the end of 2013
- We developed a time schedule for different stages of proposed TAC facilities up to mid of 2020's.
- IAT will help us to get permenant positions for qualified engineers, and technicians. We will have enough postdoc positions for scientists, also.
- LE PA (in 2012) and SR (in 2013) will be presented to the SPO to get support to construction in addition to other design studies.
- It is clear that, we need closer collaboration with national and international accelerator community to realize TAC

Thank you for your attention…

TAC Web Page : http://thm.ankara.edu.tr

ITA Web Page : http://hte.ankara.edu.tr