The **Turkish Accelerator Center** (TAC) Project

Bora Ketenoğlu

Department of Engineering Physics
Ankara University / TURKEY
Contents

- The emblem & homepage
- Why do we want to build an accelerator complex?
- Where do we plan to build the complex?
- A short chronology of the TAC project
- Present status
- Five main goals of the TAC project
- The goals planned to be achieved in near future
- International collaborations
The Emblem & Homepage

http://thm.ankara.edu.tr

The literary language of the homepage is just “Turkish” for the present, but also “English” version is under construction...
Why do we want to build an accelerator complex?

1) Our region is very poor on the accelerator technologies and all of the scientific & technologic applications based on them.

2) Turkey has an urgent necessity of qualified people and experts in this area.
Where do we plan to build the complex?

It is planned to be build in a small town (named “Gölbaşı”) of Ankara, the capital of TURKEY.
A Short Chronology of the TAC Project

~14 years ago, the linac-ring type charm / tau factory with synchrotron light source, was proposed as a regional project of TURKEY.


In 1997, Ankara and Gazi Universities began a feasibility study for the possible accelerator complex in TURKEY, with the support of Turkish State Planning Organization.

Ö. Yavaş et al., EPAC 2006

Between 2002-2005, the CDR of the TAC project was completed with the support of Turkish State Planning Organization again.

S. Sultansoy et al., PAC 2005
10 Turkish universities (approximately 30 staff and 60 graduate students) are working for the TAC project now:

Ankara University (Coordinator)  
Boğaziçi University  
Gazi University  
Doğuş University  
İstanbul University  
Erciyes University  
Uludağ University  
Süleyman Demirel University  
Dumlupınar University  
Niğde University
The TAC Project Has Five Main Goals:

1) To construct the IR-FEL Test Facility for the first step:

TAC Oscillator IR-FEL includes:
- an electron linac (15-40 MeV energy range)
- two optical resonators
- two undulators ($\lambda_{U1}=3$ cm, $\lambda_{U2}=9$ cm).
Situation of the TAC Oscillator IR-FEL

TAC IR-FEL is planned to be built on an electron linac (15 - 40 MeV), and the tunable wavelength range of the laser is, 2 ~ 180 μm.

<table>
<thead>
<tr>
<th>Wavelength (μm)</th>
<th>Electron Energy (MeV)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Possible energy range for IR FEL</td>
</tr>
<tr>
<td>Technological limits of IR FEL</td>
<td></td>
</tr>
</tbody>
</table>

TAC IR FEL
Schematic view of TAC IR-FEL Facility
## Electron Beam Parameters of TAC Oscillator IR-FEL

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value 1</th>
<th>Value 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bunch Charge [pC]</td>
<td>80</td>
<td>120</td>
</tr>
<tr>
<td>Micro Bunch Duration [ps]</td>
<td>1-10</td>
<td>1-10</td>
</tr>
<tr>
<td>Micro Bunch Repetition Frequency [MHz]</td>
<td>13 (77 ns)</td>
<td>13 (77 ns)</td>
</tr>
<tr>
<td>Average Current [mA]</td>
<td>1</td>
<td>1.6</td>
</tr>
<tr>
<td>Macro Pulse Duration [ms]</td>
<td>cw / tunable</td>
<td></td>
</tr>
<tr>
<td>Normalized Transverse Emittance [mm mrad] (rms)</td>
<td>≤ 20</td>
<td>≤ 20</td>
</tr>
<tr>
<td>Normalized Longitudinal Emittance [keV ps] (rms)</td>
<td>≤ 100</td>
<td>≤ 100</td>
</tr>
</tbody>
</table>
Some parameters of the TAC IR-FEL

<table>
<thead>
<tr>
<th>Two Undulators (U₁ &amp; U₂)</th>
<th>U₁ (λₚ = 3 cm)</th>
<th>U₂ (λₚ = 9 cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bunch Charge [pC]</strong></td>
<td>80</td>
<td>120</td>
</tr>
<tr>
<td></td>
<td>80</td>
<td>120</td>
</tr>
<tr>
<td><strong>Wavelength Range [µm]</strong></td>
<td>2.6 - 27</td>
<td>10 - 185</td>
</tr>
<tr>
<td><strong>Maximum Peak Power [MW]</strong></td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td><strong>Maximum Puls Energy [µJ]</strong></td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td><strong>Photon Flux [photon/s/mrad/%0.1BG]</strong></td>
<td>~ $10^{16}$</td>
<td>~ $10^{16}$</td>
</tr>
<tr>
<td><strong>Laser Peak Brightness [photon/s/mm²/mrad/%.1BG]</strong></td>
<td>~ $10^{31}$</td>
<td>~ $10^{31}$</td>
</tr>
</tbody>
</table>
Scientific And Technological Applications of IR-FEL

- Biomedical Science
- Semiconductors
- Non-linear Optics
- Material Science
- Nanotechnology
- Photo-Chemistry
The TAC Project Has Five Main Goals:

2) Linac-Ring Type Collider to achieve “Charm” Factory

The electrons are coming through the linac with an energy of 1 GeV.

Collision point to produce Charm particle with a center of mass energy $\sqrt{s} = 3.77$ GeV

The positrons are coming from the synchrotron with an energy of 3.56 GeV
### Tentative Parameters of TAC Charm Factory

<table>
<thead>
<tr>
<th>Parameter</th>
<th>$e^-$ linac</th>
<th>$e^+$ ring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy (GeV)</td>
<td>1.00</td>
<td>3.56</td>
</tr>
<tr>
<td>Particles per bunch ($x10^{10}$)</td>
<td>0.55</td>
<td>11.00</td>
</tr>
<tr>
<td>$\beta$ function at IP (cm)</td>
<td>0.45</td>
<td>0.45</td>
</tr>
<tr>
<td>Normalized emittance ($\mu$m.rad)</td>
<td>6.17</td>
<td>22.00</td>
</tr>
<tr>
<td>Bunch length (cm)</td>
<td>0.10</td>
<td>0.45</td>
</tr>
<tr>
<td>Transverse size at IP ($\mu$m)</td>
<td>3.76</td>
<td>3.76</td>
</tr>
<tr>
<td>Beam-beam tune shift</td>
<td>-</td>
<td>0.056</td>
</tr>
<tr>
<td>Collision frequency (MHz)</td>
<td></td>
<td>30</td>
</tr>
<tr>
<td>Luminosity ($H_D\cdot L$) cm$^{-2}$s$^{-1}$</td>
<td>1.4 $10^{34}$</td>
<td></td>
</tr>
</tbody>
</table>
The TAC Project Has Five Main Goals:

3) SASE FEL Based On 1 GeV Electron Linac:

4th generation light source (SASE FEL) with a wavelength of a few nanometers.
Calculated Electron Beam Parameters for
1 GeV Linac up to now:

<table>
<thead>
<tr>
<th>Electron Beam Parameters</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Beam Energy (GeV)</td>
<td>1</td>
</tr>
<tr>
<td>Number of Electrons per Bunch (x 10^9)</td>
<td>5.5</td>
</tr>
<tr>
<td>Average Beam Current (mA)</td>
<td>26.4</td>
</tr>
<tr>
<td>Peak Current (A)</td>
<td>2106</td>
</tr>
<tr>
<td>Energy Spread (%)</td>
<td>0.05</td>
</tr>
<tr>
<td>Normalized Emittance (μm.rad)</td>
<td>3.1</td>
</tr>
<tr>
<td>Transverse Beam Size (μm)</td>
<td>75.2</td>
</tr>
<tr>
<td>Longitudinal Bunch Length (mm)</td>
<td>0.05</td>
</tr>
</tbody>
</table>
The TAC Project Has Five Main Goals:

4) 3\textsuperscript{rd} Generation Light Source Based On Positron Ring (Synchrotron Radiation):
The TAC Project Has Five Main Goals:

5) GeV Scale Proton Accelerator

TAC proton accelerator proposal consists of 100 MeV linear pre-accelerator and 1 GeV main ring. 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.

In muon region:

**Fundamental investigations:**
- Test of QED
- Muonium-antimuonium oscillations

**Applied investigations:**
- By μSR method
  - High-T<sub>c</sub> superconductivity
  - Phase transitions
  - Impurities in semiconductors

In neutron region:

- Applied physics
- Engineering
- Molecular biology
- Fundamental physics
Nuclear reactors can be classified in four main groups:

- Fission reactors
- Fusion reactors
- Hybrid (fission + fusion) reactors
- Accelerator Driven Systems (ADS)

Only fission reactors are used nowadays. The other three reactor groups are just under research or laboratory status. At the beginning of 1990’s, Italian physicist Prof. Dr. C. Rubbia (nobel prized), developed a new energy power station in CERN, called “energy amplifier”. ADS or energy amplifier; is a new generation reactor which is operated together with a reactor system and an accelerator complex with a high proton current (>10 mA) and energy (1-1.5 GeV).
The Goals Planned to be Achieved in Near Future:

Up to the end of 2010’s;

- To establish the “Institute of Accelerator Technologies”
- To prepare the TDR of the TAC Project
- To construct the IR-FEL Facility
International Collaborations

✓ DESY *(since 1996)*
✓ CERN
✓ BESSY
✓ FZR
✓ 4GLS
✓ İFEL
✓ John Adams Institute
✓ ELETTRA
Thanks a lot for your attention...