TURKISH ACCELERATOR CENTER (TAC) PROJECT
FIRST FACILITY & ROAD MAP

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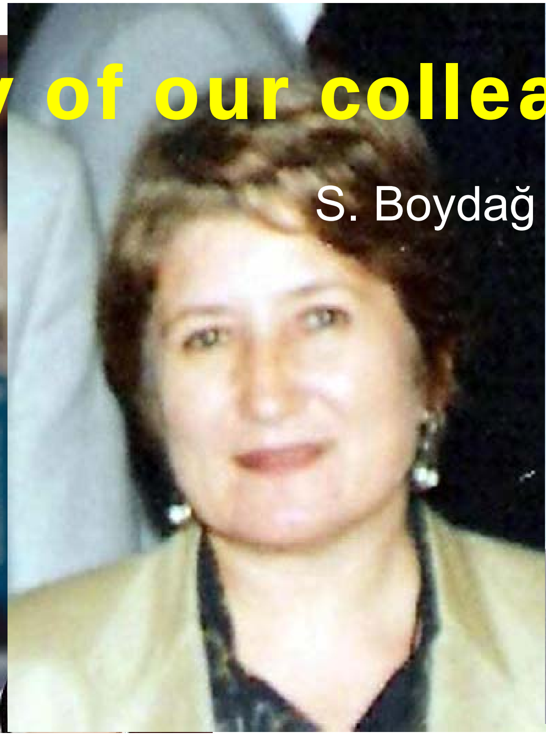
***for TAC Collaboration**

ICPP, 27-31 Oct.,2008, BU, Istanbul

In memory of our colleagues...



http://thm.ankara.edu.tr

THM means TAC in Turkish

TÜRK HIZLANDIRICI MERKEZİ

TAC

TURKIC ACCELERATOR CENTER

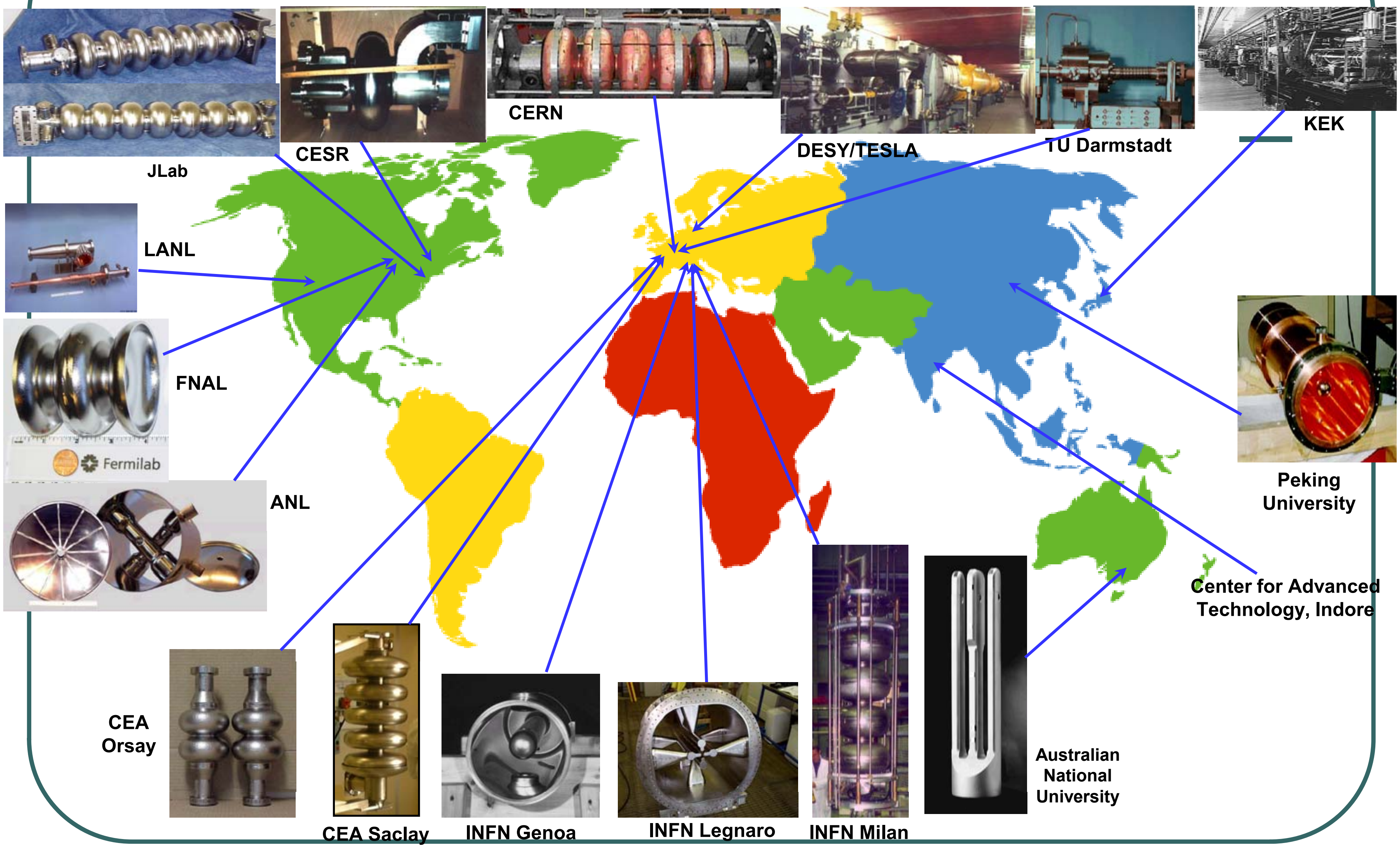
Contents

- Introduction
- Turkish Accelerator Center (TAC) Project
- First facility (IR FEL & Brems.)
- Road map for TAC
- Conclusion

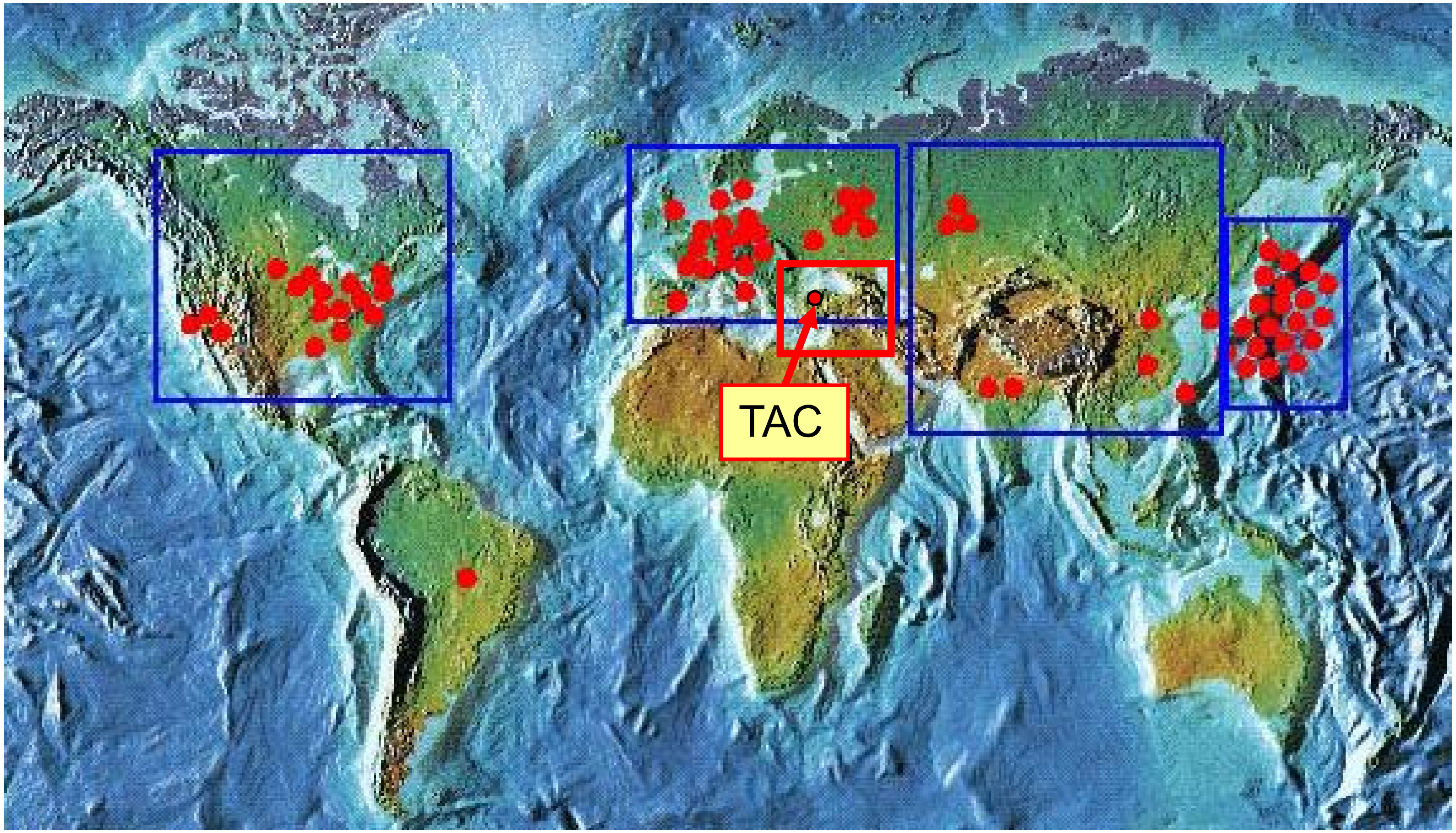
Introduction

- Accelerator technology ➲ a generic technology ➲ locomotive of the development in almost all fields of science and technology.
- Accelerator technology should become widespread all over the world.
- Existing situation: a large portion of the world (the South and Mid-East) is poor on the accelerator technology.

Global View of Accelerator Technology



Distribution of main accelerator centers around the world

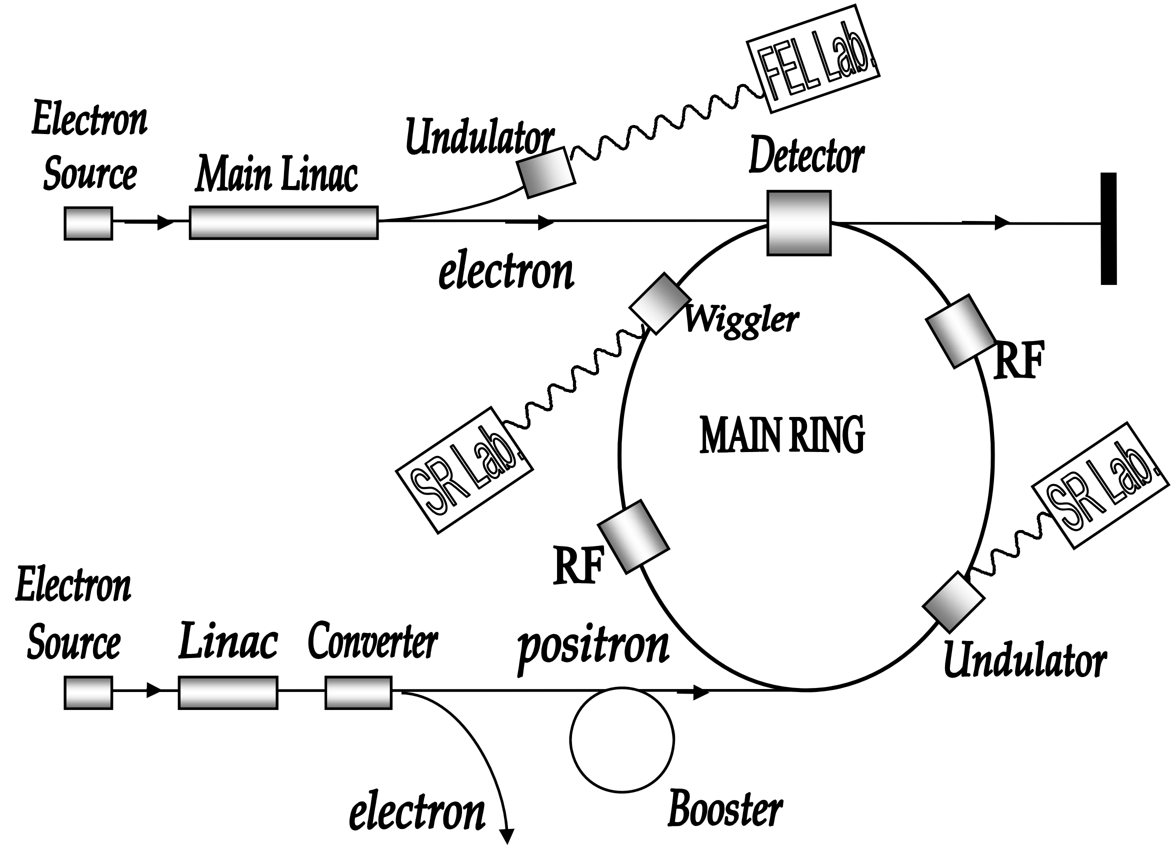


Projects in Middle East

- SESAME in Jordan (by UNESCO) } SR
- CANDLE in Armenia

- Turkish Accelerator Center (TAC)
  - Light sources (IR FEL, Brems., SR and SASE FEL)
  - Particle physics experiments
  - Proton and secondary beam applications

Turkish Accelerator Center



- Schematic view of the TAC (from Feasibility Report, 2000)

Short chronology of the TAC project

- Approximately 15 years ago, linac-ring type charm-tau factory with synchrotron light source was proposed as a regional project for elementary particle physics.
  - S. Sultansoy, Turk. J. Phys. 17 (1993) 591; Turk. J. Phys. 19 (1995) 785.
- Starting from 1997, a small group from Ankara and Gazi Universities begins a feasibility study for the possible accelerator complex in Turkey with the support of Turkish State Planning Organization (DPT).
  - **http://thm.ankara.edu.tr**

Short chronology of the TAC project (cont.)

- The results of the study are published in

  A. K. Çiftçi et al., Turk. J. Phys. 24 (2000) 747

  and presented at EPACs

  Ö. Yavaş, A. K. Çiftçi, S. Sultansoy, EPAC 2000, p. 1008.

  A. K. Çiftçi et al., EPAC 2002, p. 1100.

- Starting from 2002, the conceptual design study of the TAC project has started with a relatively enlarged group (again with the DPT support). This stage is completed in 2005. The results are published in

  S. Sultansoy et al., PAC 2005, USA

Short chronology of the TAC project (cont.)

Present Status (Technical Design & First facility Phase of TAC)

Turkish State Planning Organization YUUP Project
(Grant No: DPT2006K-120470)
Period: 2006-2011

National Collaboration (10 Turkish Universities)
Ankara Univ. (Coordinator) + Boğaziçi, Dumlupınar, Dogus, Erciyes, Gazi, İstanbul, Niğde, S. Demirel, Uludağ Universities
27 staff + 43 graduate students

Main Goals of the Present Phase of Project:

- To establish Institute of Accelerator Technologies
- To prepare TDR of TAC
- To construct TAC Test Facility (Infrared FEL&Bremsstrahlung)

Main presentations about TAC Project after 2006 (Third Phase)

- **Ö. Yavas, et al., EPAC06, ENGLAND**
- **Ö. Yavaş, et al., XI. VUV, 2007, GERMANY**
- **Ö. Yavaş, et al., WIRMS07, JAPAN**
- **Ö. Yavaş, et al., EPAC08, ITALY**
- **Ö. Yavaş, et al., FEL08, KOREA**
- **Ö. Yavaş, et al., V. Euroasia Conf. on Nuclear Sciences (October 08, Ankara, Turkey)**

International Collaborations

Scientific Collaboration Agreements:

- **CERN** (Geneva) (2005-2011)
- **DESY** (Hamburg) (1996-2011)
- **BESSY** (Berlin) (1997-2011)
- **FZR** (1997-2011)

Scientific Contacts:

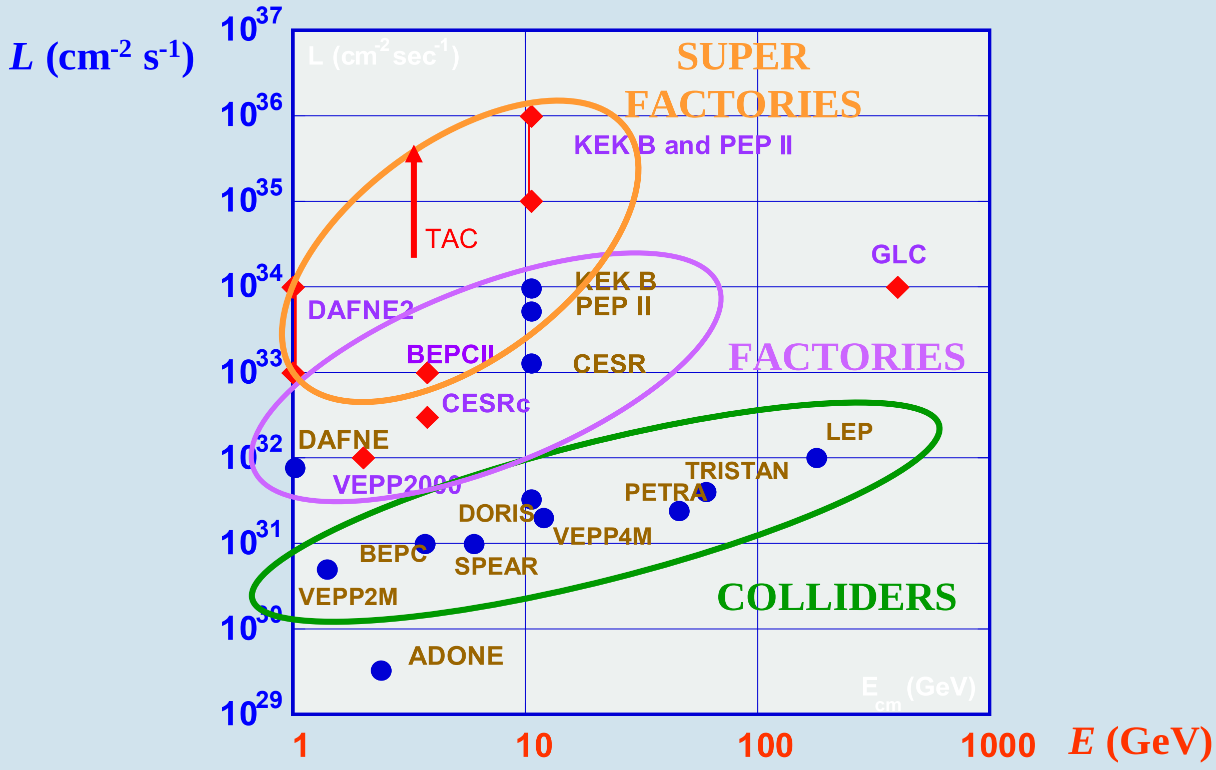
- **4GLS (Daresbury)**
- **iFEL (Osaka Univ.)**
- **John Adams Inst. (Oxford Univ.)**
- **ELETTRA (Trieste)**
- **FNAL (USA)**
- **ANL APS (USA)**
- **SESAME (Jordan)**

TAC Project includes

- Linac-ring type charm factory
- Synchrotron light source based on positron ring (SR)
- Free electron laser based on electron linac (SASE FEL)
- GeV scale proton accelerator
- First Facility (IR-FEL & Brems.)

from D. Asner "Status of BES" (TAC is added)

e^+-e^- Colliders: Past, Present and Future



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TAC Particle Factory

- Considered:
  - linac-ring type ϕ factory,
  - **linac-ring type charm factory**,
  - linac-ring type τ factory
- $L = 10^{34} cm^{-2} s^{-1}$ can be achieved for all three options.

Tentative parameters of TAC charm factory

Parameter	**e^--linac**	**e^+-ring**
Energy, GeV	1.00	3.56
Particles per bunch, 10^{10}	0.55	11.00
β function at IP, cm	0.45	0.45
Normalized emittance, μm·rad	6.17	22.00
Bunch length, cm	0.10	0.45
Transverse size at IP, μm	3.76	3.76
Beam-beam tune shift	-	0.056
Collision frequency, MHz	30	
Luminosity (H_D·L)	$1.4\ 10^{34}$ cm^{-2}s^{-1}	

Synchrotron Light Source

- Is additional positron storage ring dedicated for production of synchrotron radiation necessary?
- Ring-ring collider: beam-beam tune shift restriction ➲large emittance ➲ high luminosity:

$$L = f_c \frac{4\pi\gamma_p\gamma_e\Delta Q_p\Delta Q_e\varepsilon_p}{r_0^2\beta_e^*}$$

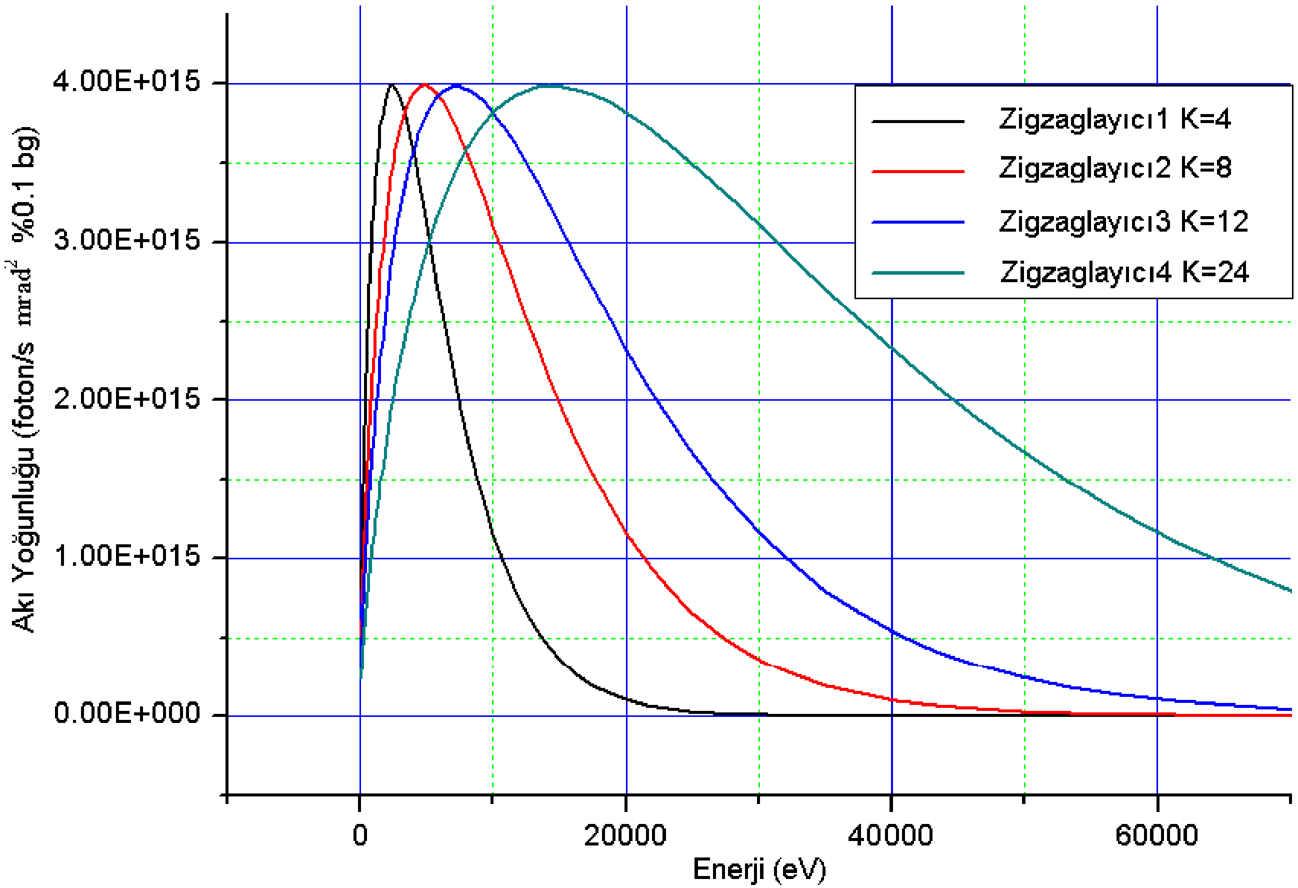
SR in linac-ring type machines

- Luminosity independent of emittance

$$L = f_c \frac{\gamma_p \Delta Q_p N_p}{r_0 \beta_p^*}$$

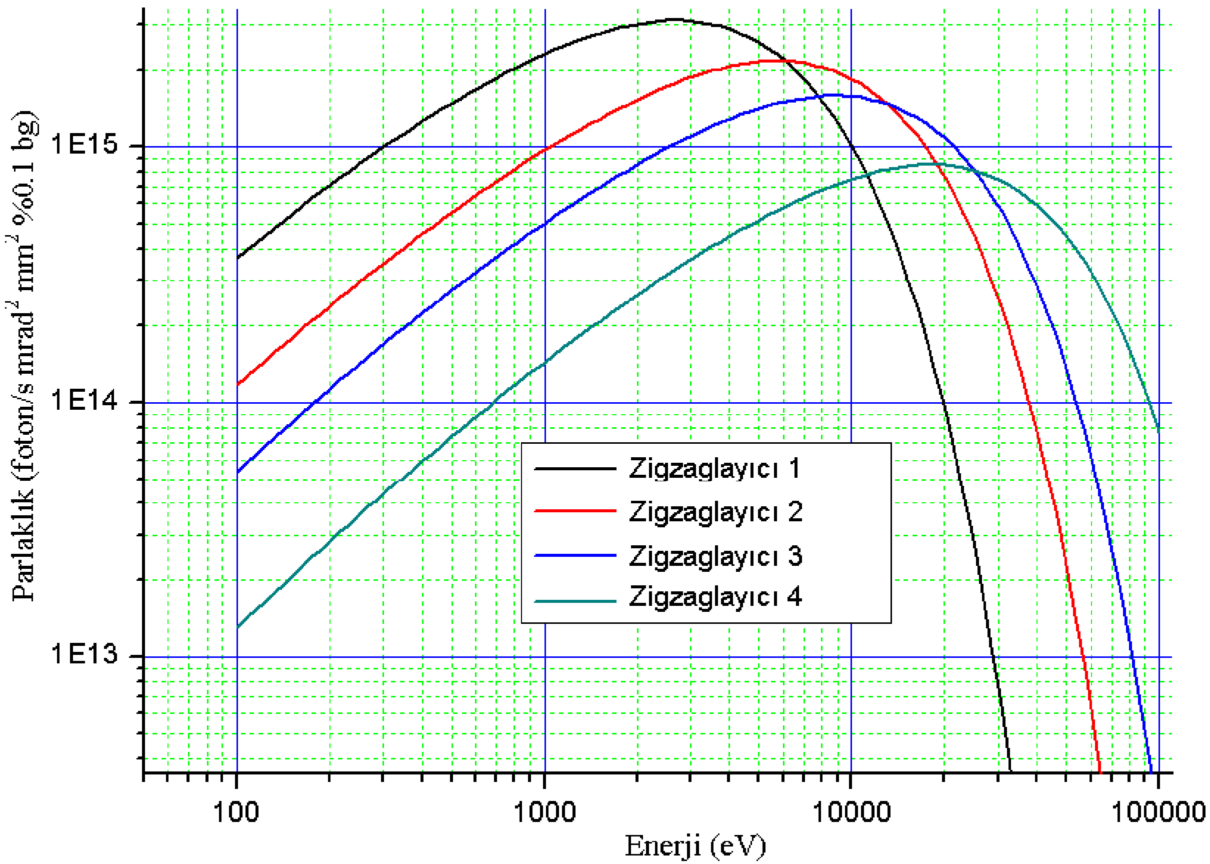
- Chosen emittance (3 nm·rad) of the positron small enough ➲ a third generation light source (< 20 nm·rad)
- Number of insertion devices and beam lines of TAC SR Facility and their specifications depend on realization of **SESAME** and **CANDLE** projects as well as on user potential in our region.

Flux of SR



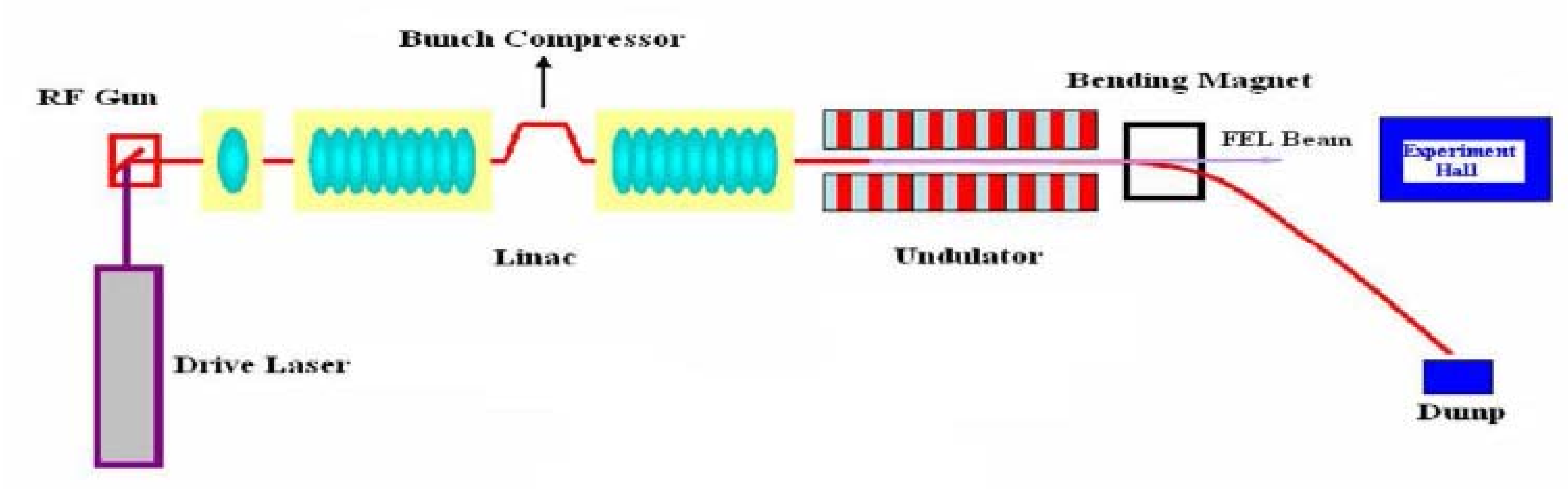
4.00E+015
3.00E+015
2.00E+015
1.00E+015
0.00E+000
Akı Yoğunluğu (foton/s mrad^2 %0.1 bg)
0
20000
40000
60000
Enerji (eV)
Zigzaglayıcı1 K=4
Zigzaglayıcı2 K=8
Zigzaglayıcı3 K=12
Zigzaglayıcı4 K=24

Average Brightness of SR



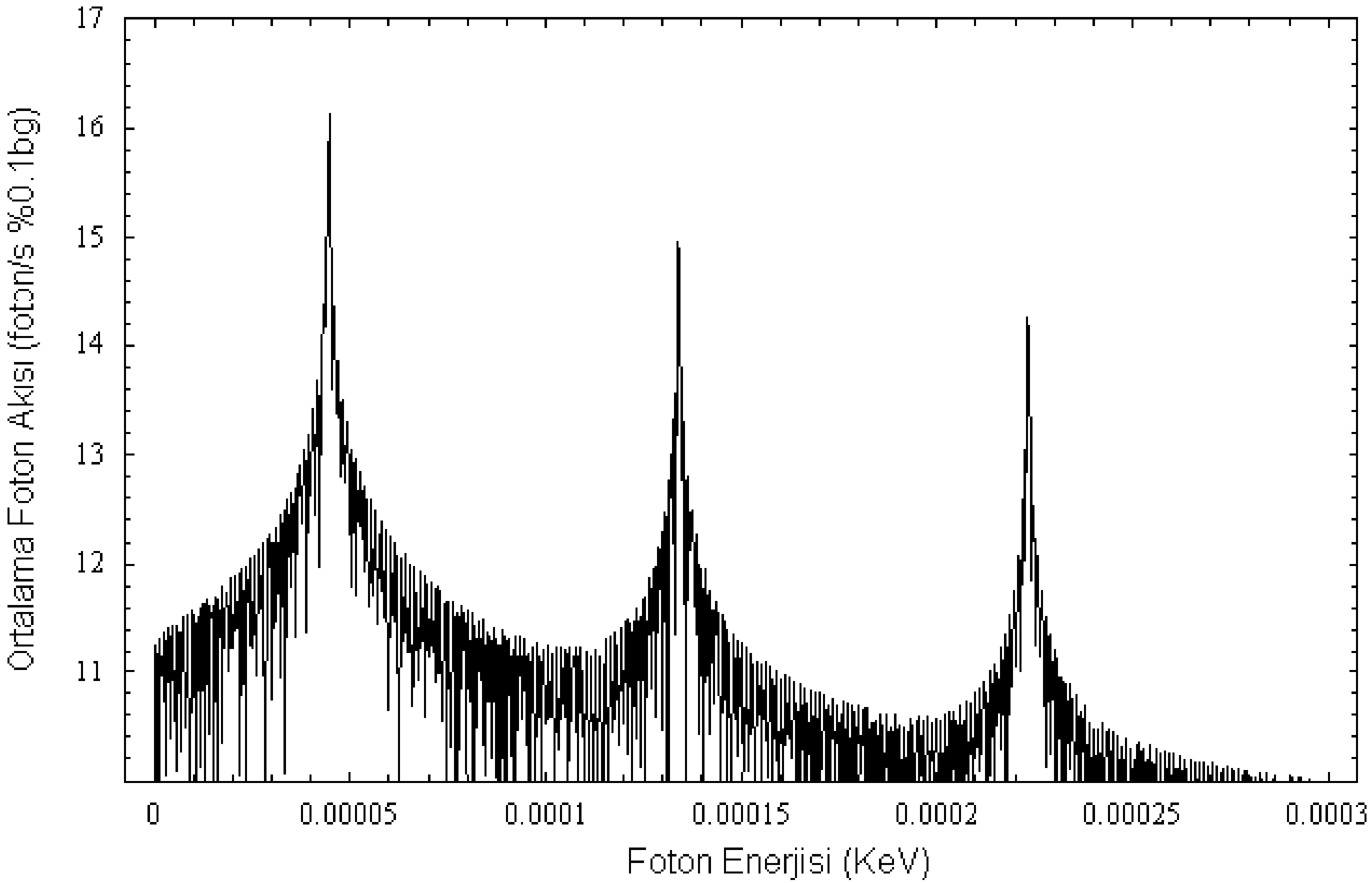
SASE Free Electron Laser

- With 1 GeV electron beam, wave length of SASE FEL photons is expected to be a few nm.



Schematic view of TAC SASE FEL Facility

Average Flux of SASE FEL



Proton Accelerator

- TAC proton accelerator proposal consists of a **100 MeV** energy pre-accelerator and **1 GeV** energy linac or synchrotron.

- Proton beams from two different points of the synchrotron will be forwarded to **neutron** and **muon regions**, where a wide spectrum of applied research is planned.

Planned uses of proton accelerator

- Muon region
  - **Fundamental investigations**
    - **test of QED and**
    - **muonium-antimuonium oscillations...**
  - **Applied investigations with μSR method**
    - **High-T_c superconductivity**
    - **phase transitions**
    - **impurities in semiconductors...**
- Neutron region
  - **applied physics**
  - **molecular biology**
  - **fundamental physics**
- ADS Applications…

Technical Design Report (TDR) of TAC by 2010)

- **Particle Factory**
  Charm Factory ($E_{c.m.}$=3.77 GeV)
- **3rd Generation Synchrotron Radiation**
  ($E_{positron}$= 3.56 GeV)
- **SASE FEL**
  ($E_{electron}$= 1 GeV)
- **Proton Accelerator**
  (E_{proton} =1 – 3 GeV)

Road Map of TAC Project

- **I. Step: Feasibility Report for TAC**
- **(1997-2000)**

- **II. Step: Conceptual Design Report (CDR) of TAC**
- **(2002-2005)**

- **III. Step: - Technical Design Report (TDR) of TAC**
- **- First Facility (IR FEL & Brems.)**
- **- Institute of Accelerator Technologies**
- **(2006-2011)**

- **IV. Step: Completion of TAC**
- **(2012-2022)**

Next pages

First Facility of TAC

- Infrared Free Electron Laser (IR FEL)

  Based on 15-40 MeV e-beam

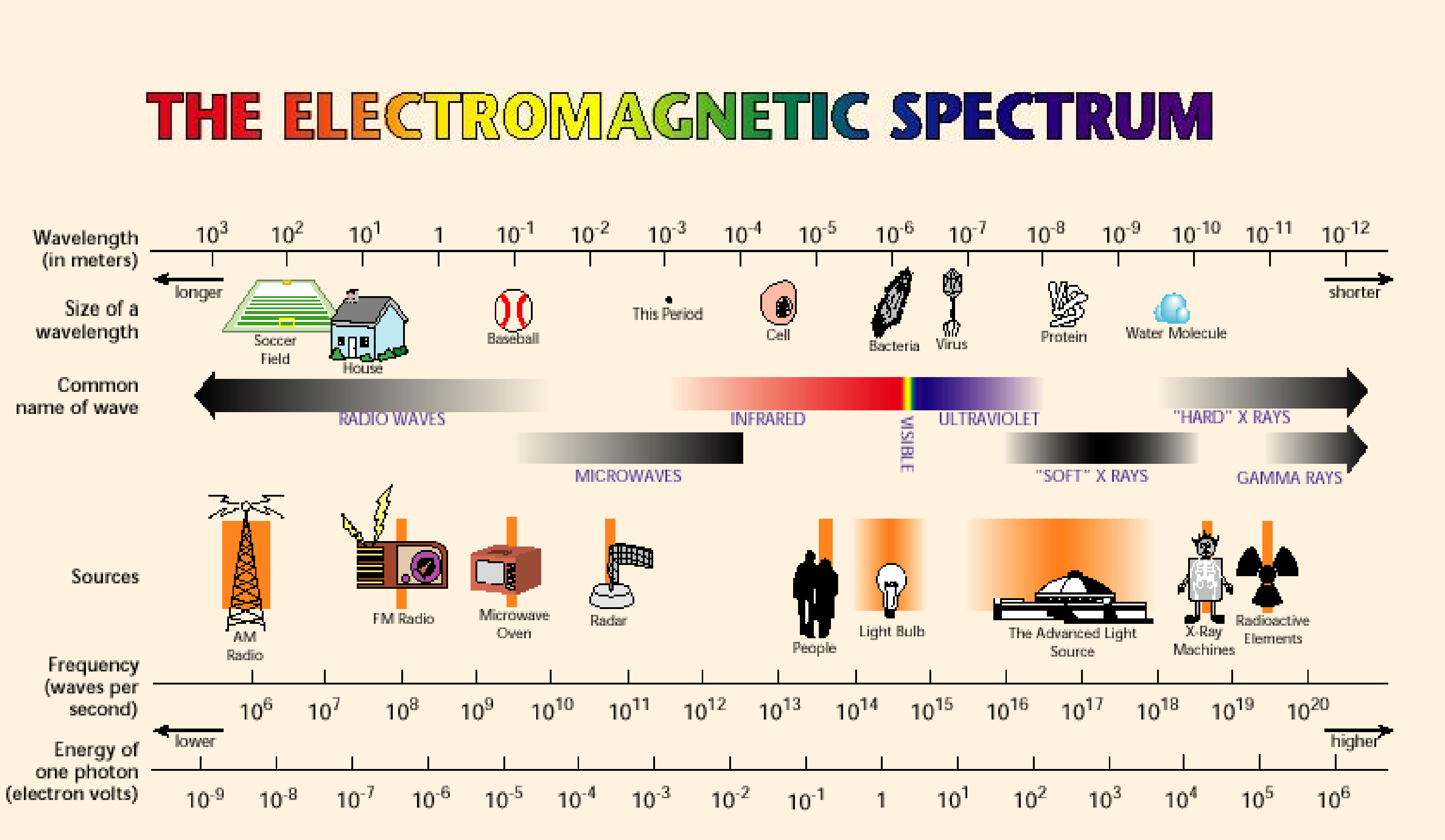
  2-185 microns laser wavelength

- Bremsstrahlung Station

  Based on 20 MeV e-beam

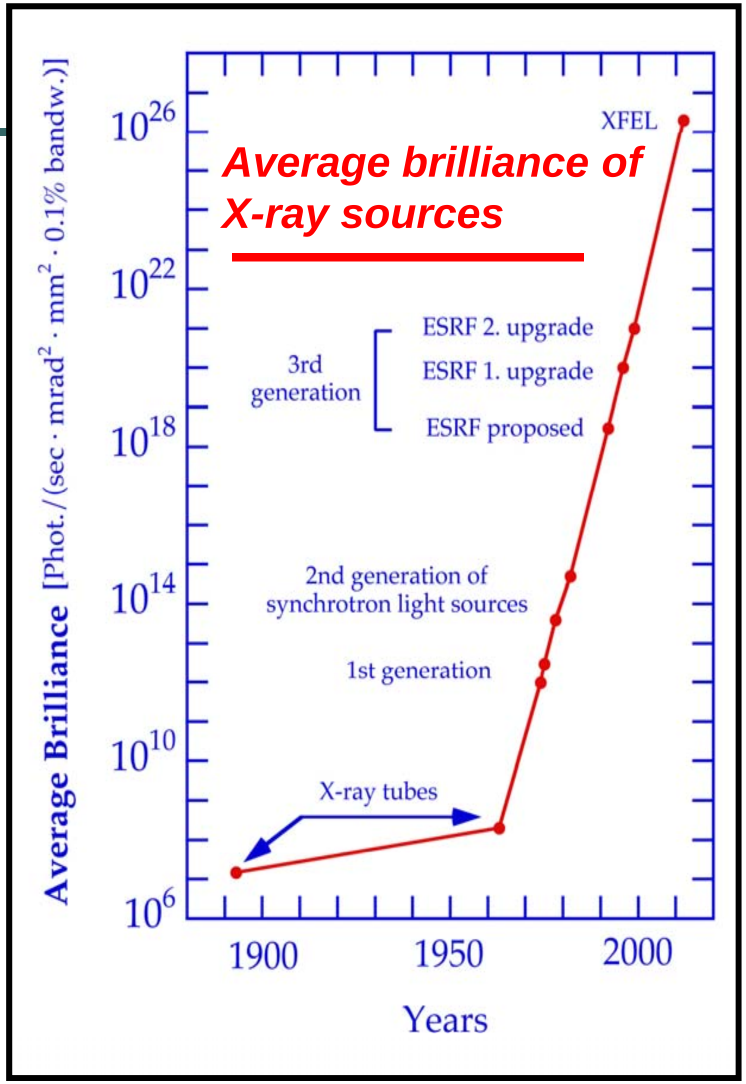
Planned date of commissioning: 2012

E.m. Spectrum and IR region

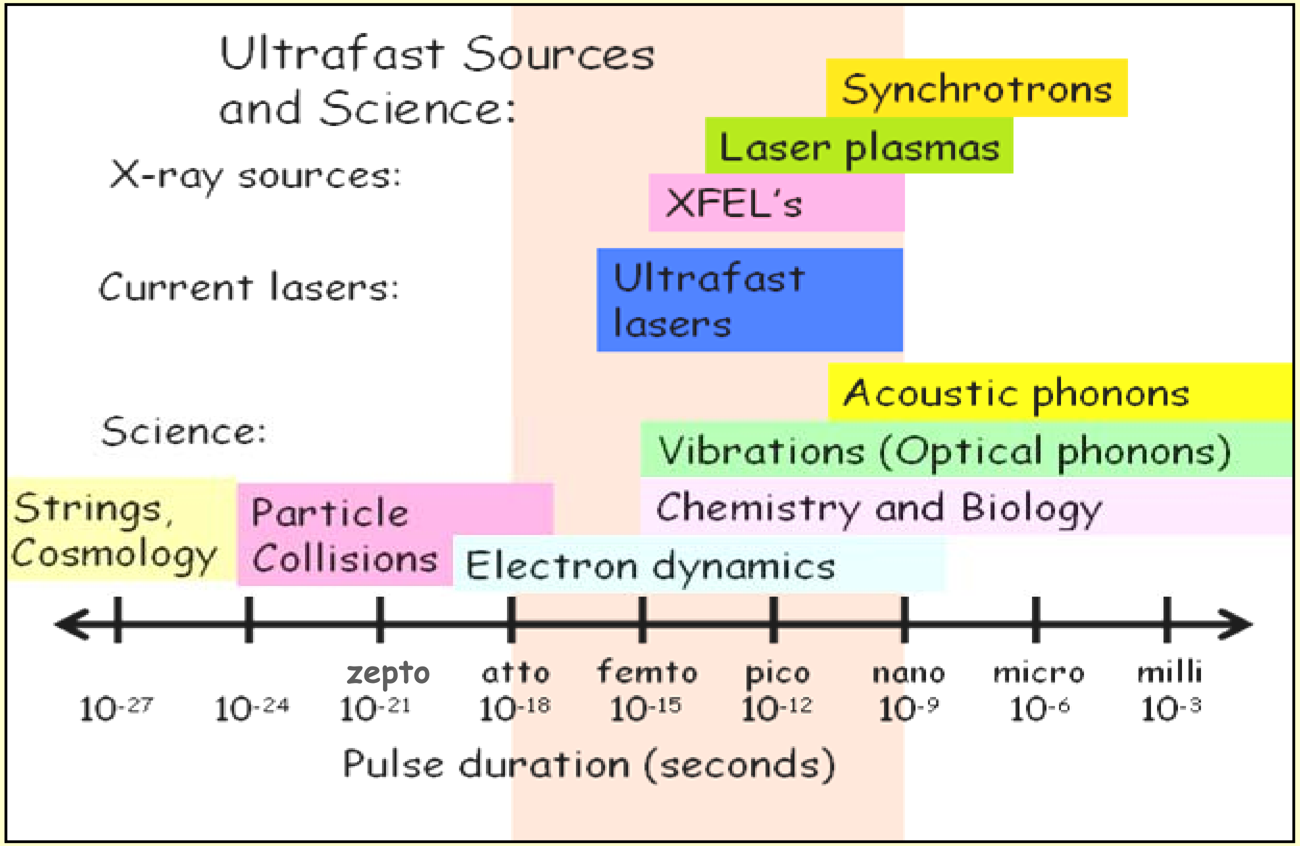


Discovery of X-rays in 1895

Wilhelm Conrad Röntgen

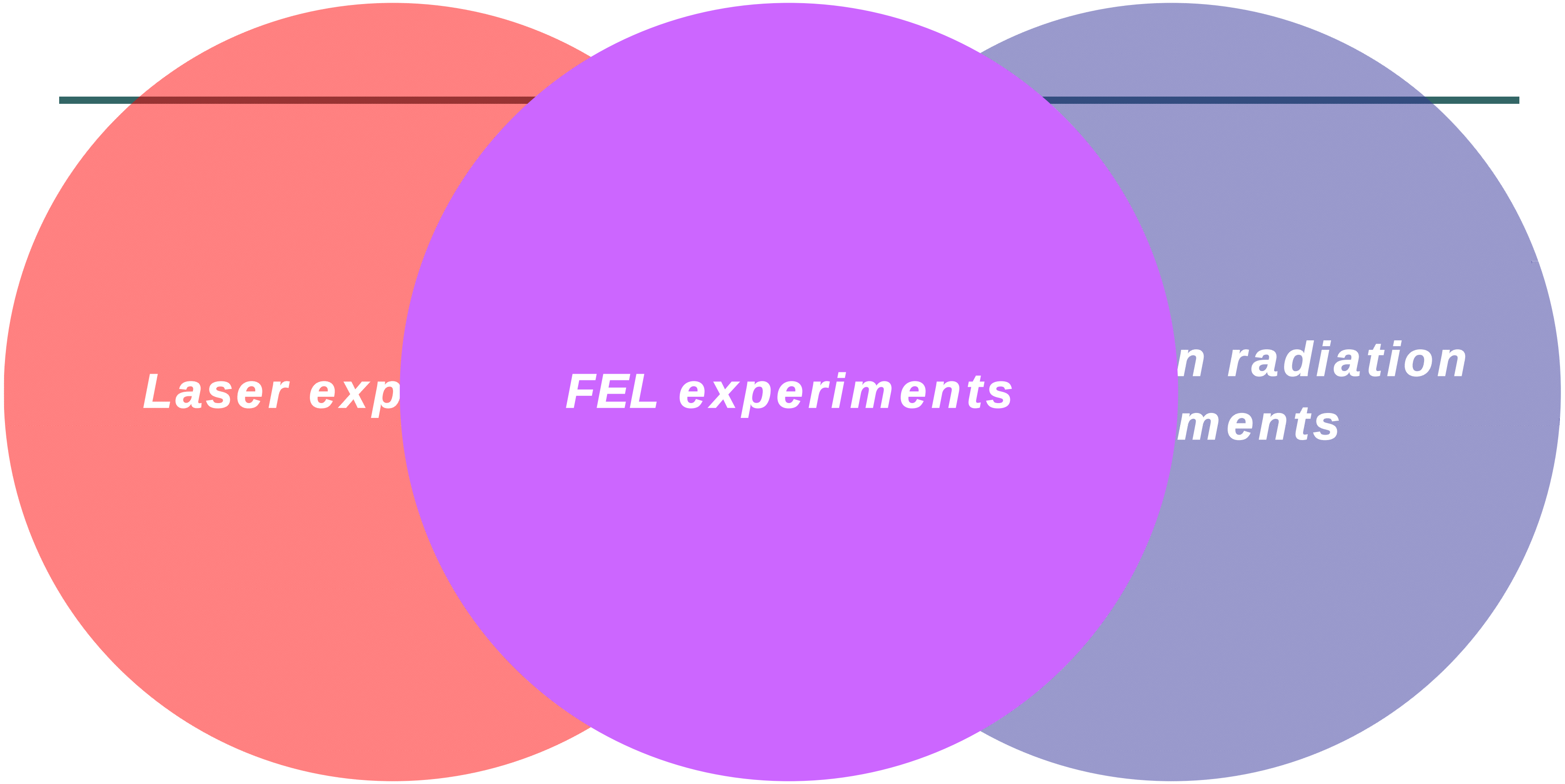


Nature's time scales



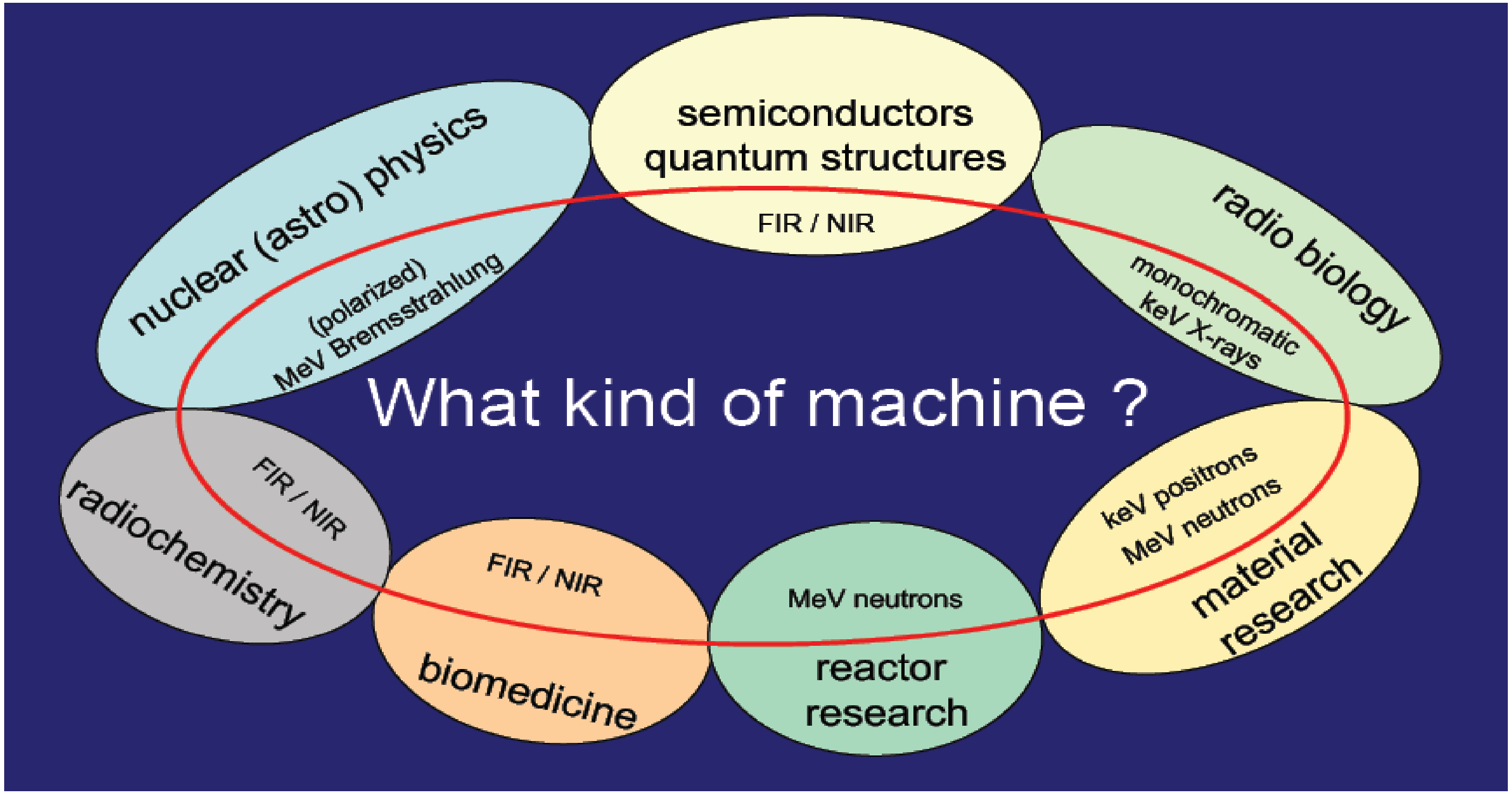
***Femtoseconds:* The new dimension in nano-space**

Synergies for new science at FELs

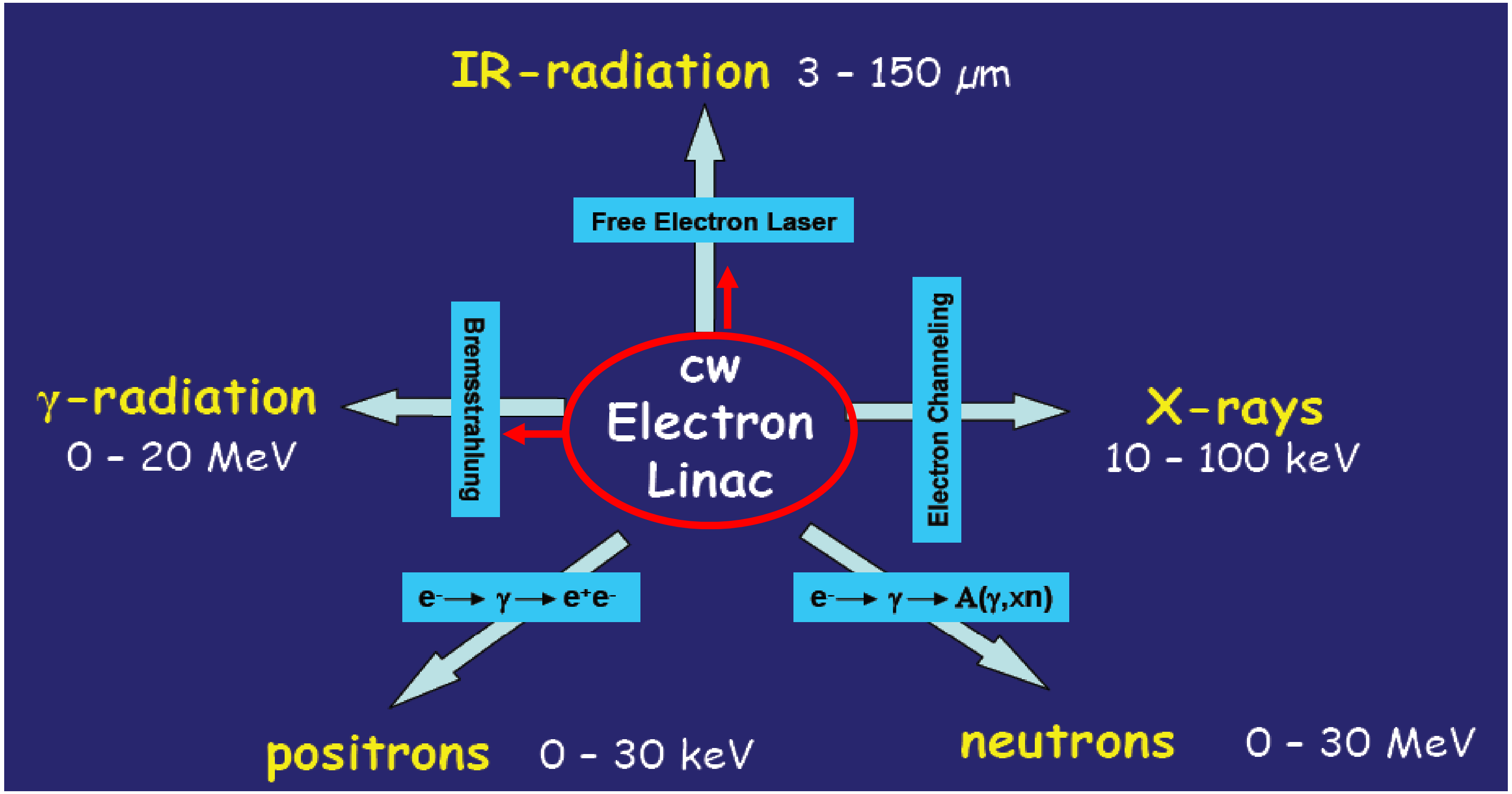


Accelerator Science & Particle Physics methodology

What kind of Machine?

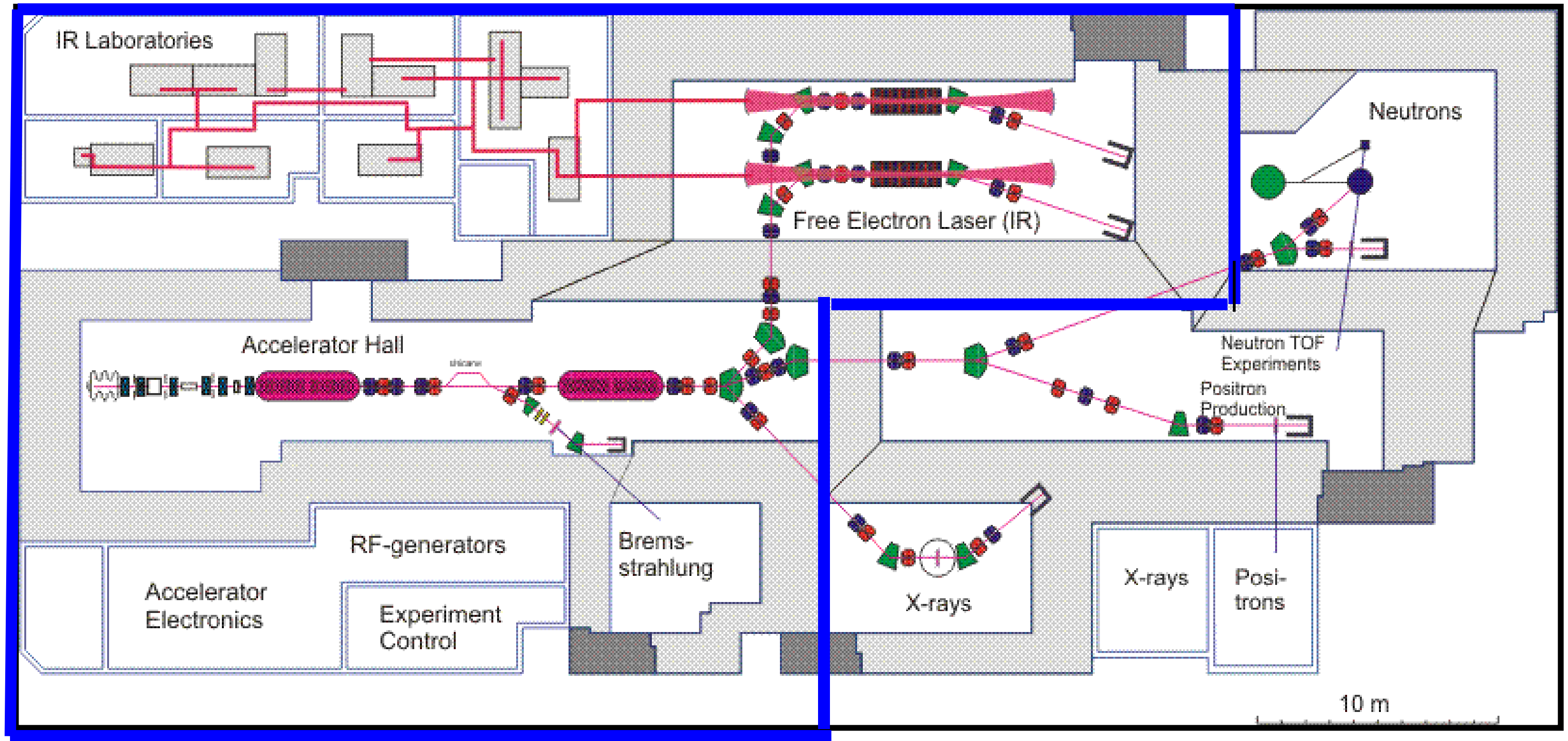


Research spectrum based on MeV Energy Electron Linac



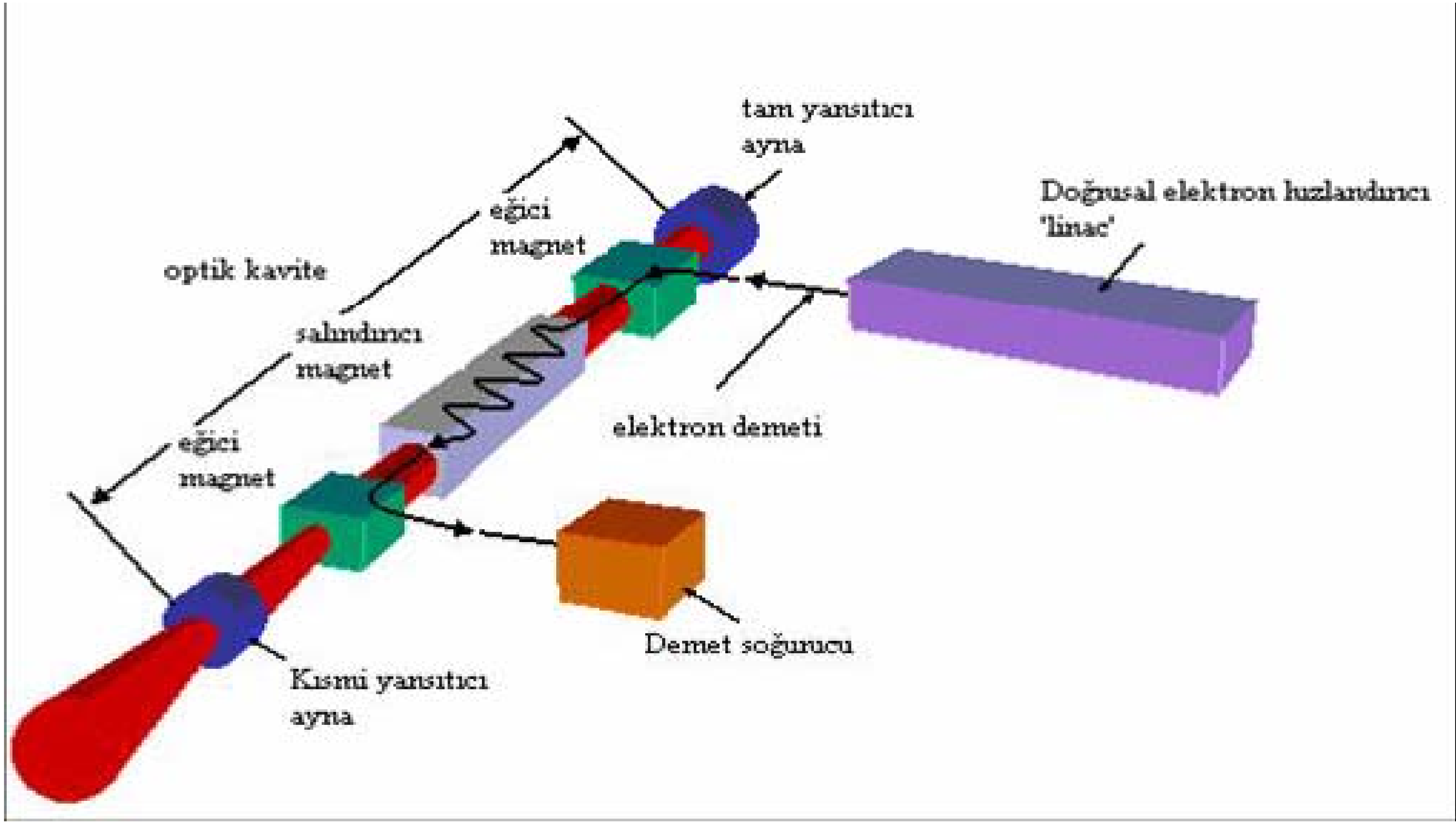
ELBE Lab. (FZD, Dresden)

(Choosed model for First Facility of TAC)



Typical Structure for TAC First Facility (IR FEL & Brems.)

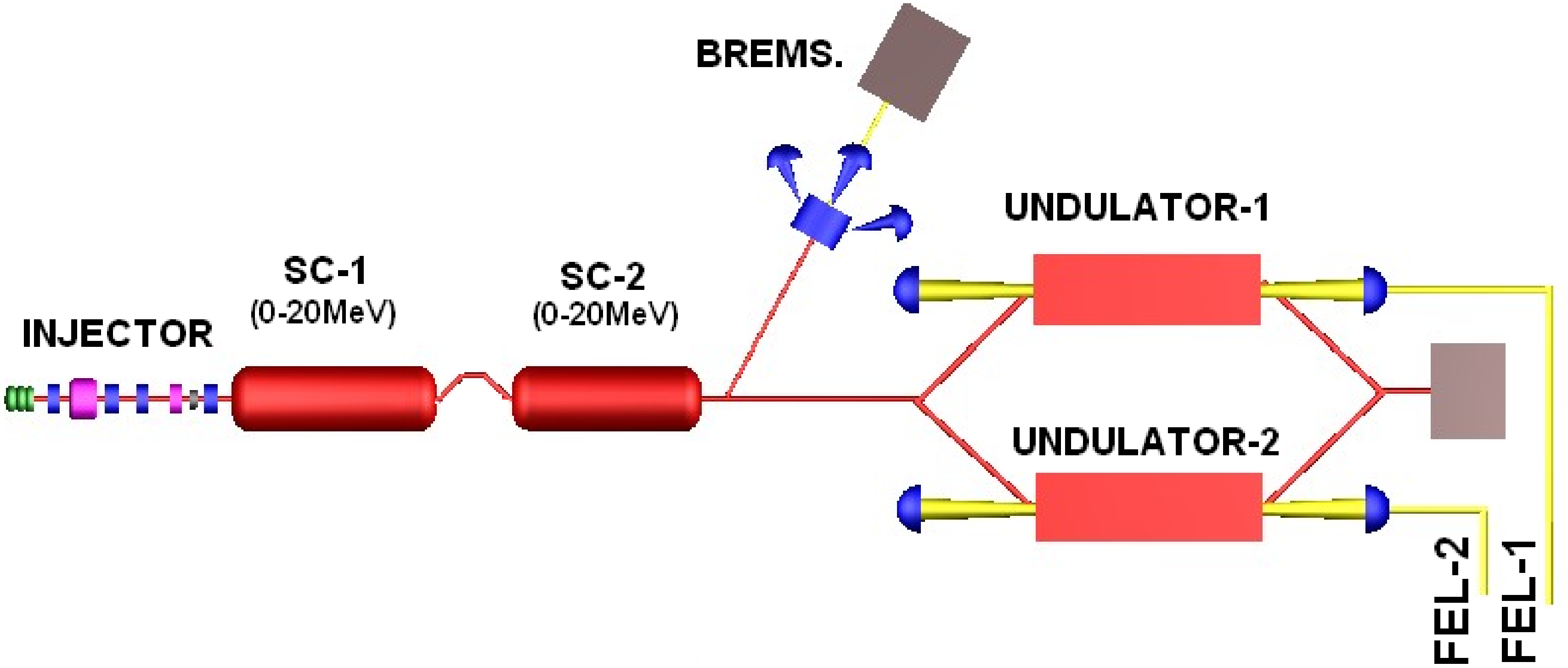
Schematic view of FEL Oscillator



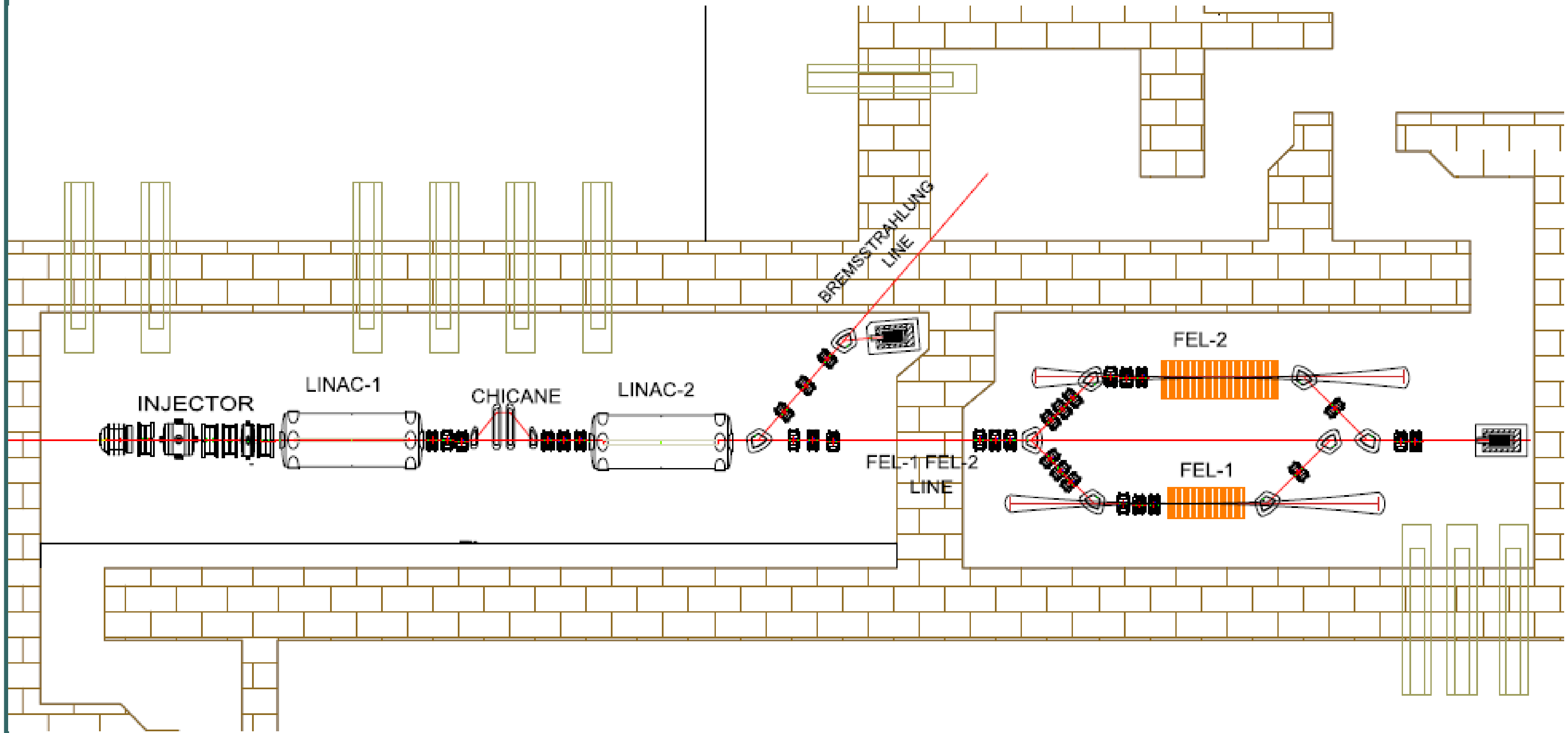
Some IR FEL Labs Around the World

iFEL (Osaka, Japan)	: 1-22 µm
Duke MK III (Duke, USA)	: 1.7-9.1 µm
FOM FELIX (Holland)	: 3.1-35 µm
SCA-FEL (Stanford, USA)	: 3-10 µm
LURE CLIO (Orsay, France)	: 3-90 µm
Jefferson FEL (USA)	: 3.2 - 4.8 µm
FEL-SUT (Tokyo, Japan)	: 5 -16 µm
FELBE (Dresden, Germany)	: 3-150 µm
LANL AFEL (Los Alamos, USA)	: 4-8 µm
SDALINAC IR-FEL (Darmstadt)	: 6.6 - 7.8 µm
IHEP Beijing FEL (China)	: 5-25 µm
ISIR FEL (Osaka, Japan)	: 21-126 µm
JAERI (Japan)	: 17-30 µm
TAC IR FEL (Turkey)	**: 2-185 µm**

Schematic view of TAC IR FEL & Brems.



Layout of TAC IR-FEL Facility



FEL-1 based on 3 cm undulator

FEL-2 based on 9 cm undulator

Electron beam parameters (two options)

Maximum beam energy	Up to 40 MeV	Up to 40 MeV
Bunch Charge	85 pC	125 pC
Average current	1 mA	1.6 mA
Minimum RMS bunch length	3 ps	3 ps
Bunch separation	77ns	77ns
Normalized rms transverse emittance	~15 mm.mrad	~15 mm.mrad
Normalized rms longitudinal emittance	~35 keV. deg	~40 keV. deg
Rms energy spread	%0.05	%0.08

Main optimized parameters of undulators & IR FELs

Undulator Magnets	**U1**	**U2**
Undulator material	Sm_2Co_{17}	Sm_2Co_{17}
Undulator period [cm]	3	9
Undulator gap [cm]	1.5-3	4-9
Rms undulator strength	0.2-0.8	0.4-2.5
Number of period	56	40
Resonator length [m]	11.53	11.53
Free Electron Laser	**FEL-1**	**FEL-2**
Wavelength [μm]	2.7-30	10-190
Pulse energy @80 pC [μJ]	2	4
Pulse energy @120 pC [μJ]	4	10
Max peak power @80 pC [MW]	8	10
Max peak power @80 pC [MW]	12	15
Pulse length (ps)	1-10	1-10

Application fields of Infrared FEL (IR FEL)

- Infrared spectroscopy
- Infrared microscopy
- Infrared imaging
- Material science
- Semiconductors
- Photochemistry
- Impurities
- Elipsometry
- THz spectroscopy
- Photo-thermal spectroscopy
- Photo-acustic spectroscopy
- Sum frequency spectroscopy
- Near field optical microscopy
- Pumb-prob measurements
- Vibrational and rotational spectroscopy
- Characterization of molecular structures

- Structural changes in DNA
- Protein dynamics
- Nonlinear optics
- Quantum dots
- Super lattices
- Photo-chemistry
- Radio-chemistry
- Photon science
- Photoconductivity
- Electron spin resonance
- Magnetic properties of matter
- Multi photon ionization
- Biotechnological research
- Medical applications
- Human neurosurgery and ophtalmic surgery

Main application fields of IR FEL

- 1 Photon diagnostics room
- 7 Experimental stations

- Photon Science
- Material Science
- Semiconductors
- Biotechnological and medical research
- Non-linear Optics
- Nanotechnology
- Photo-Chemistry

Planning for exp. stations

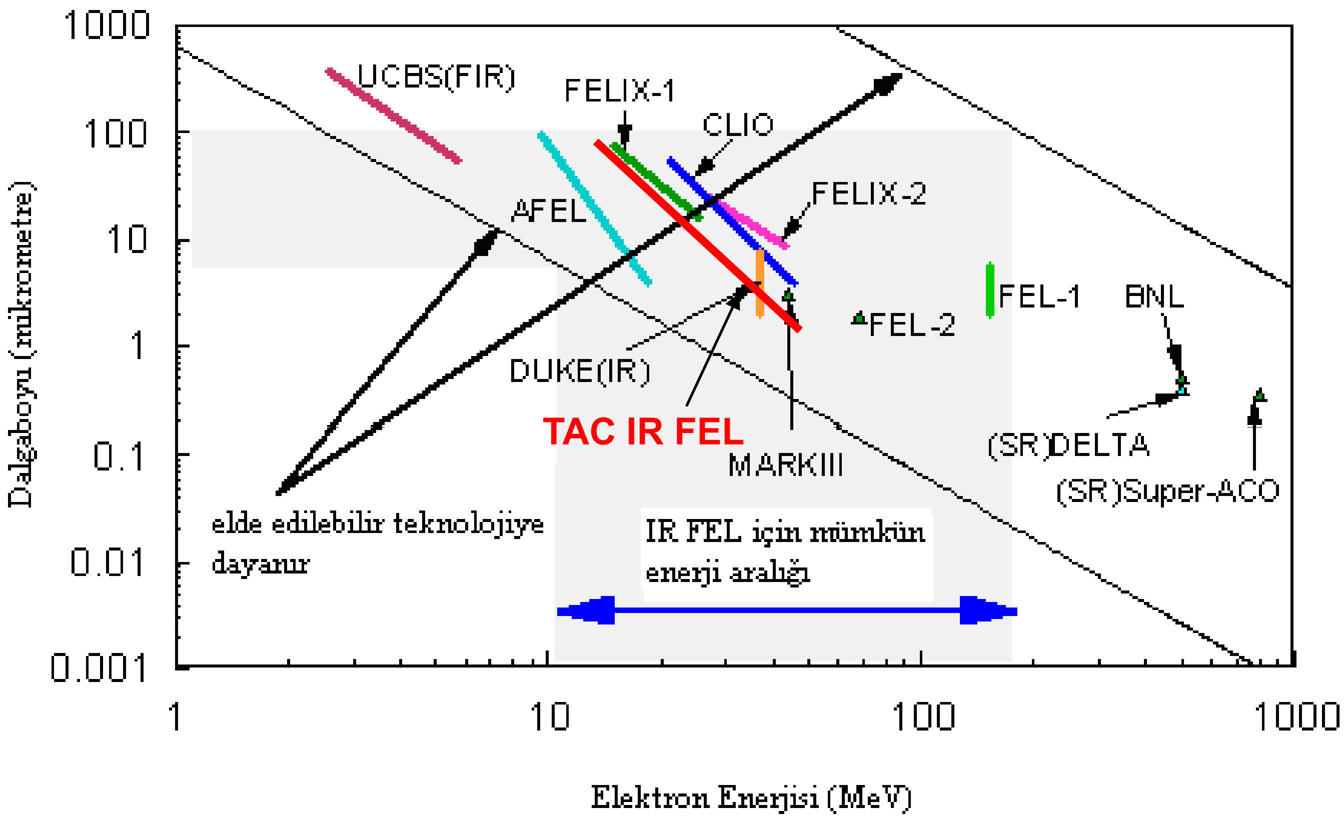
- Exp. Station No 1:
  Research on Photon (FEL) Science

- Exp. Station No 2:
  General IR FEL Spectroscopy (vibrational and rotational IR spectroscopy for solid, 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 4-8: These five stations will be planned to use existing FEL after completion of two FEL lines to use in non-linear optics, nanotechnology, photochemistry and biotechnological reserach

The Place of TAC IR-FEL




ANKARA
O-20
Ankara Çevreyolu
GÖLBAŞI
Town Gölbaşı
Yaylabağ
A. Ü. Vi ancık (50. Yıl) Kampüsü
HTE ve THM IR-SEL Laboratuvarı İnşaat Alanı
D-260
Örencik
Place of First Facility
Lake
Mogan
Haymana Yolu
Ankara-Konya Otoyolu
Yurtbeyi
Image © 2008 DigitalGlobe
© 2008 Tele Atlas
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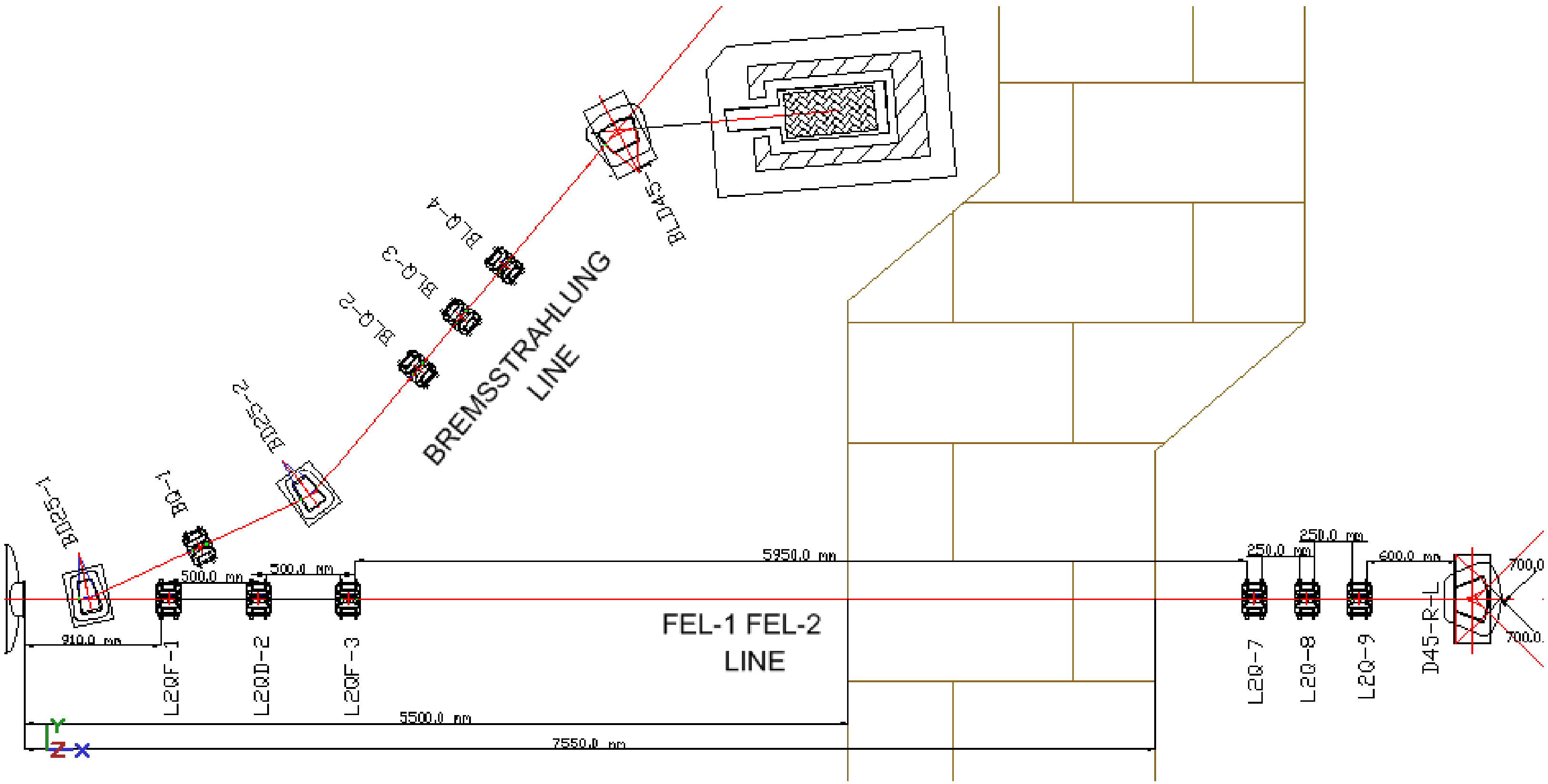
Google
Pointer 39°48'36.37" N 32°49'45.96" E Streaming |||||||| 100% Eye alt 11.05 km

Bremsstrahlung Station



Bremsstrahlung Facility of TAC

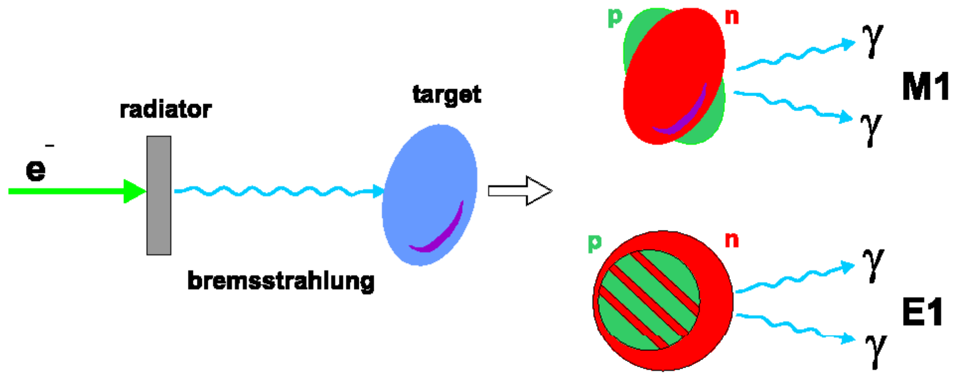
A Bremsstrahlung beam line and experimental stations for nuclear physics studies are planned for TAC.

The energy spectrum of photons due to bremsstrahlung of electrons decelerated in the electric field of atomic nuclei depends on the energy levels of the atomic electrons, due to the screening effect they have on the moving particle, and on the particle velocity. The spectrum extends up to quanta of the energy of the moving particle.

It is important to extract electron beam of 20 MeV energy from LINAC and sent it to the Bremsstrahlung experimental hall. Main aim of Bremsstrahlung station is to study nuclear spectroscopy.

Experiments with Bremsstrahlung

Electron beam of the superconducting linear accelerator with a maximum electron energy of 20 MeV.



The bremsstrahlung photons are used to irradiate the target which is made of the isotope to be investigated. Nuclei of the target material may then be excited by the photons and emit characteristic γ rays. A simplified picture of this process is shown in the figure.

For example, the neutrons in a deformed nucleus may oscillate against the protons, which causes magnetic dipole (M1) radiation (upper part). If in a nucleus with a neutron excess the neutrons vibrate against the protons, then electric dipole (E1) radiation is emitted (lower part).

Conclusion

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

TAC IR FEL facility will give some new research opportunities in basic and applied sciences using FEL in middle and far infrared region. It will have experimental stations for laser diagnostics, IR spectroscopy and microscopy, material science, medical science, optics and chemistry.

From Prof. Engin Arık's speech to TRT (2006)

- **We must start for TAC from one point…**
- We believe that TAC will be very important when completed for our country and our region…
- **Today, Turkey is to follow on 50 years late with respect to developed countries in science and technology…**
- **We must develop our own technologies…Due to fact that no country is developed using only copy and paste methods…**

Thank you for your attention…

Announcement:

Sixth TAC Workshop
December, 2-5, 2008
Ankara University
Ankara, Turkey

http://thm.ankara.edu.tr