RESEARCH POTENTIAL OF TAC IR FEL FACILITY

Müge TURAL
Ankara University
October 30, 2008

Contents

- *TAC IR FEL Facility*
- *Advantages of FEL*
- *Some applications of Infrared FEL (IR FEL)*
- *Planning for exp. Stations for TAC IR FEL*
- *Conclusion*

TAC IR FEL Facility

As an initial attempt of Turkish Accelerator Center, the construction of infrared free electron laser facility (TAC IR FEL) based on an electron linac is planned up to 2011.

=> with the support of State Planning Organization (SPO)

=> 70 scientists from 10 Turkish universities are studying under the coordination of Ankara University

=>Facility will be built in Golbasi Campus area of Ankara University


ANKARA
GÖLBAŞI
Town Gölbaşı
A. Ü. Yerleşkesi (50. Yıl) Kampüsü
HTE ve THM IR-SEL Laboratuvarı İnşaat Alanı
Örencik
Place of First Facility
Lake
Mogan
Yaylabağ
Yurtbeyi
Ankara Çevreyolu
Ankara-Konya Otoyolu
Maymana Yolu
Image © 2008 DigitalGlobe
© 2008 Tele Atlas
Google

National Collaboration for TAC Project

In 2006, 10 Turkish Universities with 70 researchers collaborated in order to write Techinal Design Report (TDR) and to construct first facility (IR FEL Facility) of TAC.

Ankara University (Coordinator)

Gazi University

İstanbul University

Uludağ University

Dumlupınar University

Boğaziçi University

Doğuş University

Erciyes University

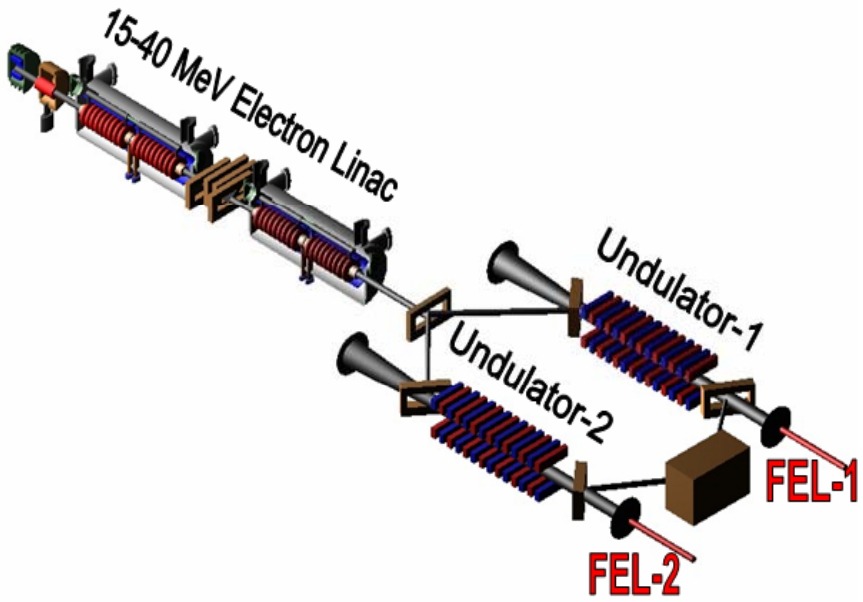
Süleyman Demirel University

Niğde University

- TAC IR-FEL Project will contain an electron linac in 15-40 MeV energy range and two optical resonators.

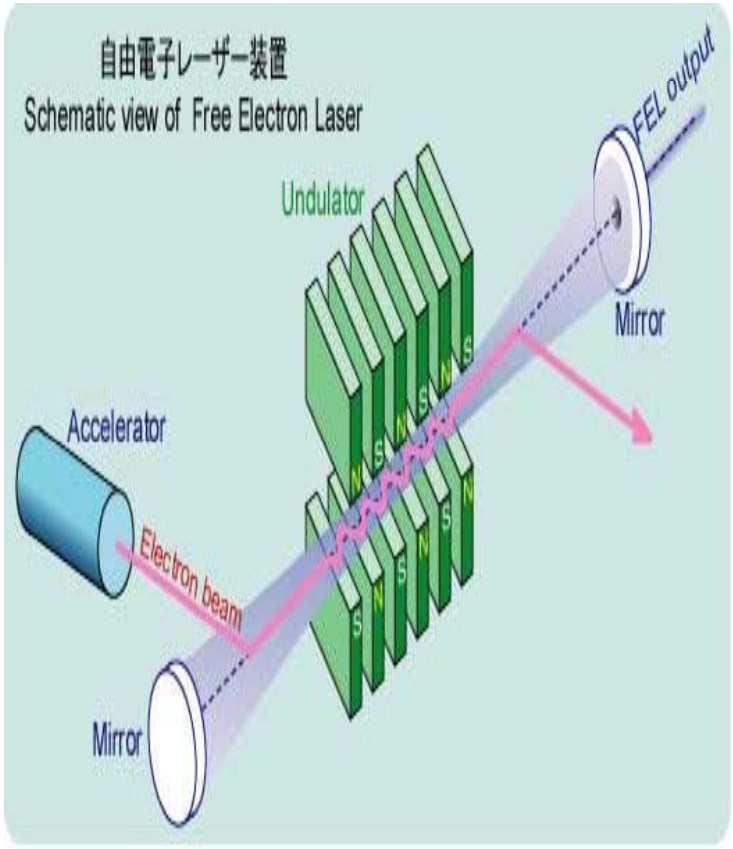
Parameter	10 kW RF	16 kW RF
Max beam energy (MeV)	40	40
Bunch charge (pC)	80	120
Average current (mA)	1	1.6
Rms bunch length (ps)	1-10	1-10
Bunch separation (ns)	77	77
Nor.rms tran. emittance (mm.mrad)	<15	<15
Nor.rms Long. emittance (keV.deg)	<35	<38
RMS Energy spread (%)	0.05	0.08

Parameter	FEL1	FEL2
Wavelength [μm]	2.7-30	10-190
Pulse energy @ 80 pC [μJ]	2	4
Pulse energy @ 120 pC[μJ]	4	10
Max peak pow. @ 80 pC [MW]	8	10
Max peak pow. @ 120 pC [MW]	12	15
Pulse length [ps]	1-10	1-10



Advantages of FEL

FEL is a laser that uses electrons which are not confined to an atomic or molecular bound state. A relativistic electron beam coming from a linac is inserted to a sinusoidal magnetic field called undulator magnet. While passing through the undulator, electron beam losses some of its energy and emits radiation. The radiation emitted from the beam is trapped between two mirrors. When the radiation power is saturated, it is taken out of one of the mirrors via a hole.



http://www.fel.eng.osaka-u.ac.jp/FEL.html

IR FEL Facilities	μm
LURE CLIO (Orsay, France)	3-90
FELBE (Dresden, Germany)	3-150
iFEL (Osaka, Japan)	1-22
FOM FELIX (Holland)	3.1-35
Jefferson FEL (USA)	3.2 - 4.8
JAERI (Japan)	17-30
FEL-SUT (Tokyo, Japan)	5 -16
LANLAFEL (LosAlamos, USA)	4-8
SDALINAC IR-FEL (Darmstadt)	6.6 - 7.8
SCA-FEL (Stanford, USA)	3-10
IHEP Beijing FEL (China)	5-25
ISIR FEL (Osaka, Japan)	21-126
Duke MK III (Duke, USA)	1.7-9.1
TAC IR FEL	**2-190**

Advantages of FEL :

- tunable and coherent light
- high peak power
- high average power
- high flux and brightness
- short pulse structure

Some applications of Infrared FEL (IR FEL)

- Material science
- Semiconductors
- Photochemistry
- Nonlinear optics
- Radio-chemistry
- Photon science
- Biotechnological research
- Medical applications
- Protein dynamics

By using techniques:

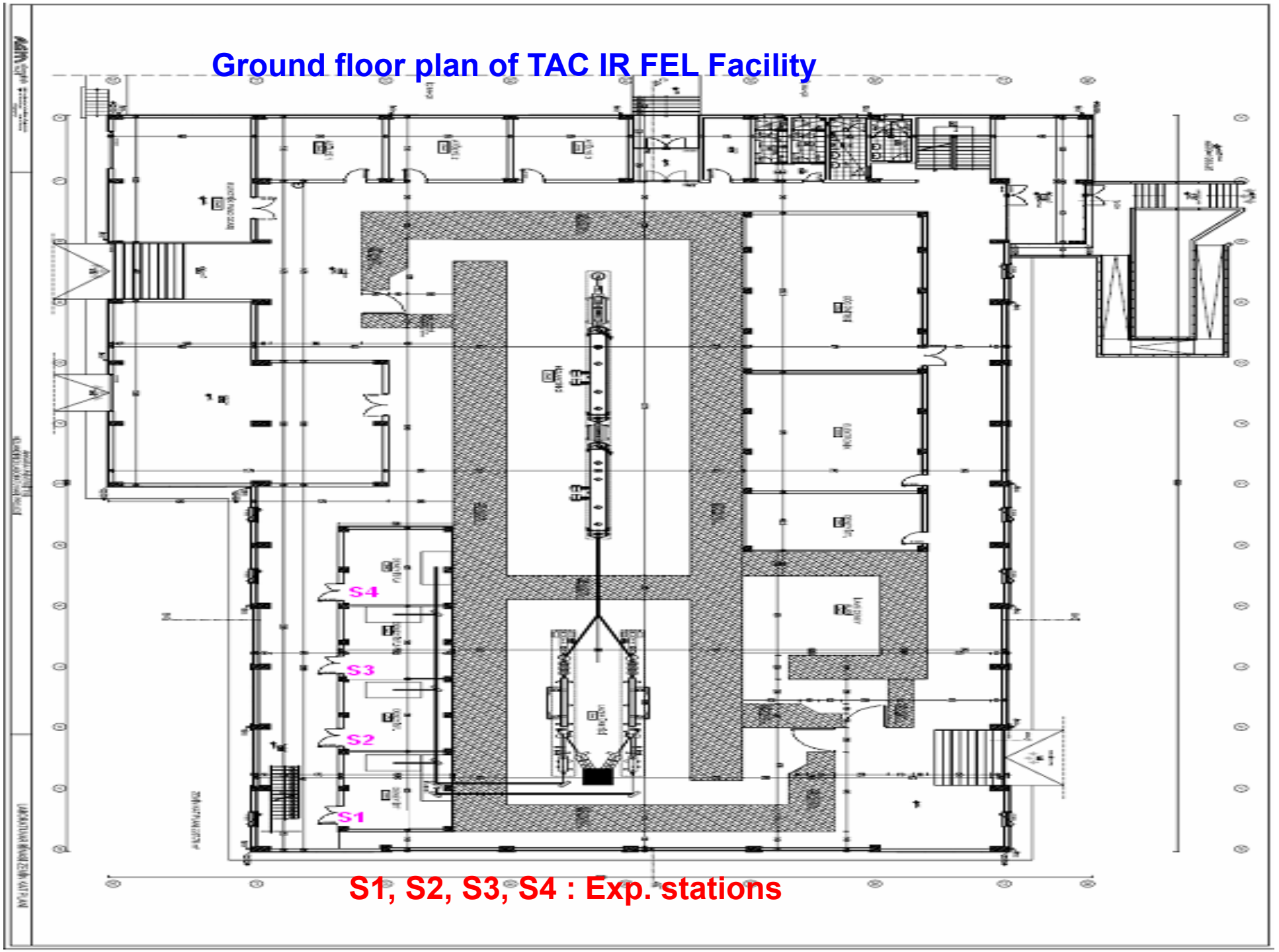
✓Infrared spectroscopy
✓Infrared microscopy
✓Infrared imaging
✓Elipsometry
✓THz spectroscopy
✓Photo-thermal spectroscopy
✓Photo-acustic spectroscopy
✓Sum frequency spectroscopy
✓Near field optical microscopy
✓Pumb-prob measurements
✓Vibrational and rotational spectroscopy
✓Multi photon ionization

Planning for exp. Stations for TAC IR FEL:

The main goal of the TAC IR FEL facility is to foster new researches in different scientific areas in Turkey and our region. We propose to use IR FEL in following main research areas:

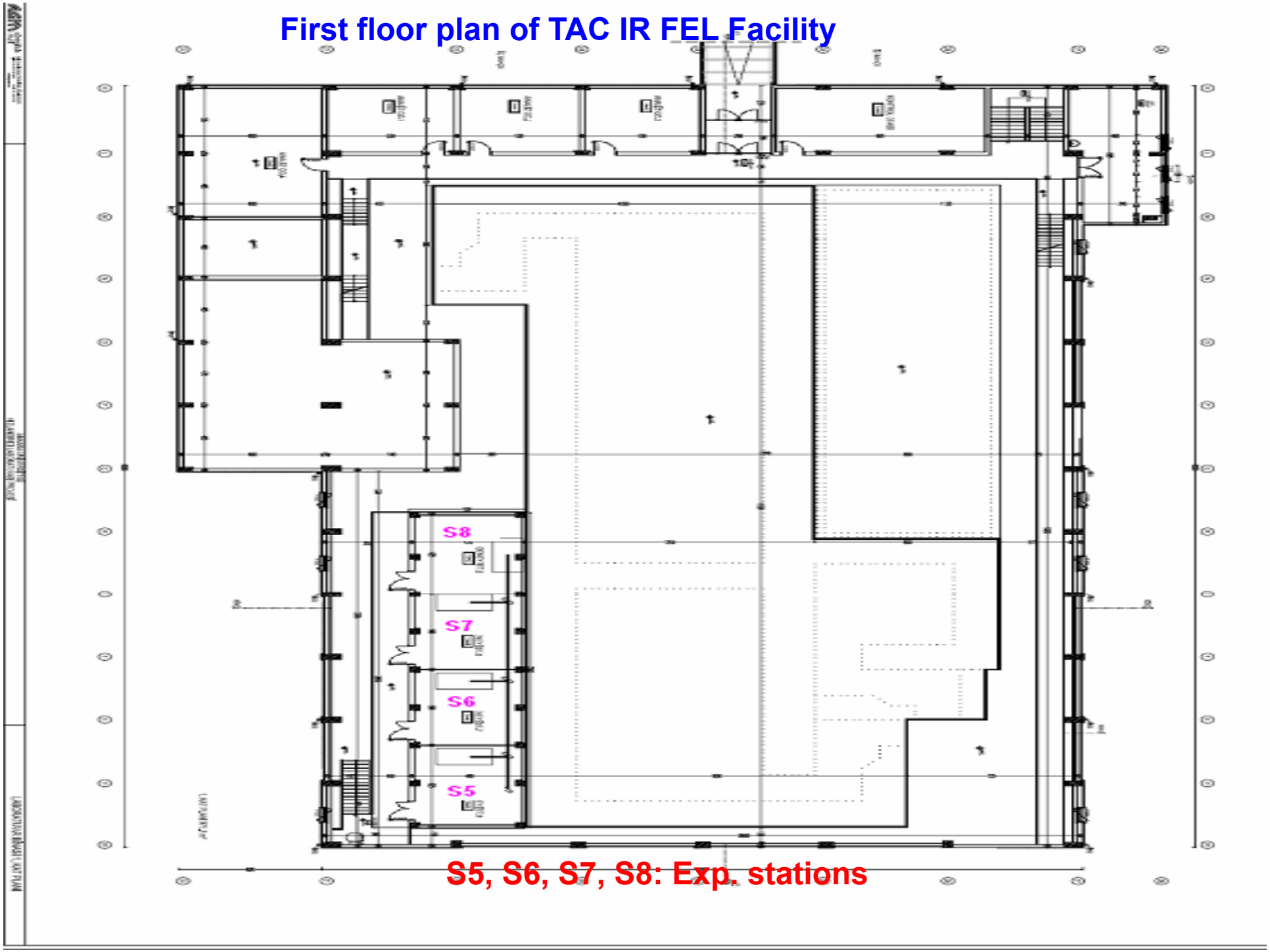
- Photon Science
- Material Science
- Semiconductors
- Biotechnology
- Medical research
- Non-linear Optics
- Nanotechnology
- Photo-Chemistry

Ground floor plan of TAC IR FEL Facility



S1, S2, S3, S4 : Exp. stations

First floor plan of TAC IR FEL Facility



S5, S6, S7, S8: Exp. stations

- **Exp. Station No 1:**

  Research on Photon (FEL) Science

  The quality of the laser beam will be examined such as the time structure, intensity, spectroscopic bandwidth and other properties of the FEL and then transported to each experimental room.

- **Exp. Station No 2:**

  General IR FEL Spectroscopy (vibrational and rotational IR spectroscopy for solid, gases and liquid materials)

  FTIR spectroscopy, Raman spectroscopy

- identification of all types of organic and many types of inorganic compounds,
- determination of functional groups in organic materials,
- determination of the molecular composition of surfaces,
- quantitative determination of compounds in mixtures,
- determination of molecular conformation and stereochemistry,
- determination of molecular orientation.

- **Exp. Station No 3:**

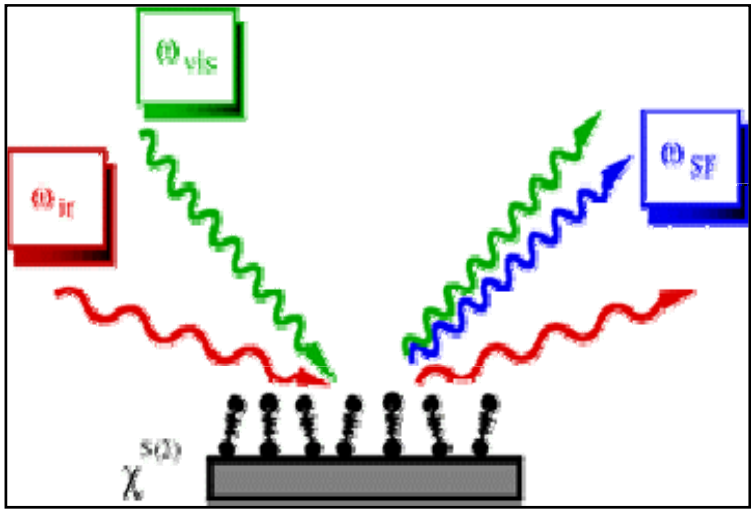
  IR FEL Spectroscopy and microscopy for material science and semiconductors

  SFG & Pump probe techniques

=>These techniques are related with vibrational spectrum of molecules. Thus, the fingerprint region is important for these techniques.

- Sum frequency Generation:

Visible-infrared sum frequency generation (SFG) is a nonlinear optical technique capable of generating vibrational spectra. A FEL is used as the IR source in spectroscopic infrared-visible sum-frequency generation.

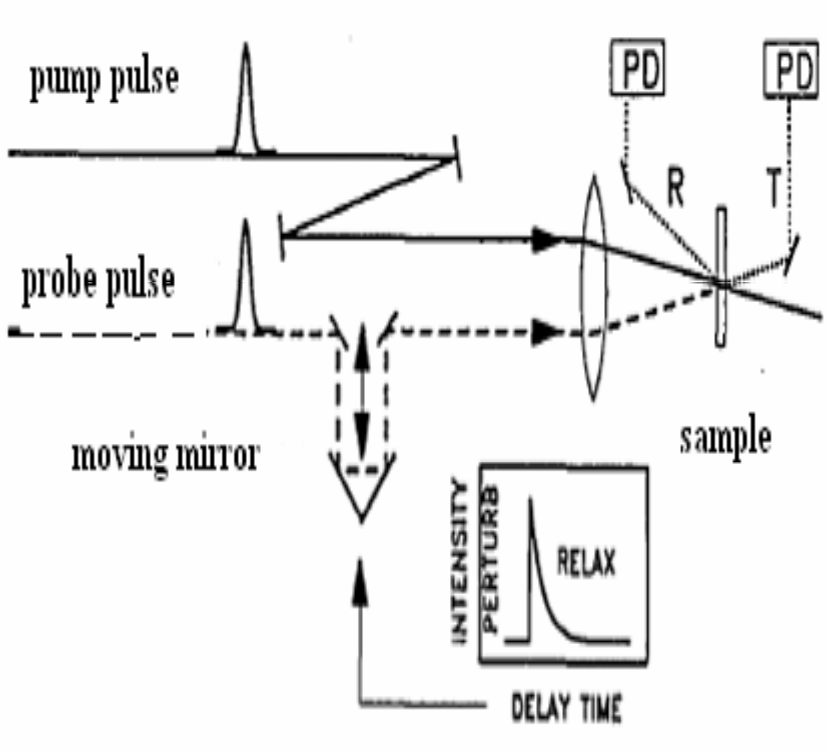


Chemical species can be identified and molecular surface density can be measured with this technique.

Pump-probe:

Pump-probe techniques to be used to study energy transfer processes at the surface.

By using time-resolved pump-probe techniques it will be possible to investigate the temporal evolution of a variety of processes, like electronic relaxation of autoionization states, coupling between two autoionization states, coupling between electronic and nuclear motion in molecular systems, fast dissociation of molecules upon inner- and outer-shell photoexcitation…



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
- biotechnological reserach

- Some basic equipments for experimental stations :

- cooled IR-detectors (INSB, HgCdTe...),
- optical tables and optical devices
- monochromators,
- cryostat,
- FTIR spectroscope,
- visible and infrared Optical Parametric Oscillators (OPO), pumped by YAG and YLF lasers,
- Ti:sapphire

Conclusion

- TAC IR FEL facility will give some opportunities to scientists from Turkey and the region, to enhance and foster their basic and applied research in different fields by using new generation light source.

- The outstanding success of this project will be reflected and resulted as an initialization another new accelerator based facilities such as synchrotron radiation (SR) and SASE FEL .

Thank you for your attention…

References

- [1] http://thm.ankara.edu.tr
- [2] P. Shea et al., Free-Electron Lasers: Status and Applications.Science. Vol.292:1853-1858, (2001).
- [3] Krishnagopal, S. Free Electron Lasers Current science Vol. 87, No. 8, 2004
- [4] A. Aksoy et. al, *The Status of TAC IR FEL Facility*, EPAC 2008, Italy. EPAC 08. (ID: 3898 – MOPC001).
- [5] Anonymous. 2008. FEL Laboratories all around the world, http://sbfel3.ucsb.edu/www/fel_table.html
- [6] Akkurt, I. et. al. *Turkish Accelerator Center IR-FEL Project* Design Report, 2008
- [7] C.-P. Sherman Hsu, Handbook of Instrumental Techniques for Analytical Chemistry, 1996
- [8] Y.R. Shen, Pure Appl. Chem., Vol. 73, No. 10, pp. 1589–1598, 2001
- [9]M. Barmentlo et. al., Physical Review A Volume 50, Number 1, 1994.
- [10] M. Heya et al. Proceedings of the 2004 FEL Conference, 689-691, 2004