Elettra Sincrotrone Trieste

School on TANGO Control System

Introduction

Marco Lonza

Outline

- ✓ Introduction to the School
- ✓ Overview of Elettra
- ✓ What is a Control System?
- ✓ Architectures and Technologies
- ✓ Introduction to TANGO

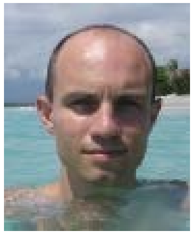
TANGO School Lecturers


Giulio Gaio

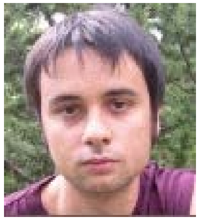

Roberto Passuello


Marco Lonza


Lorenzo Pivetta


Graziano Scalamera


Claudio Scafuri


Giacomo Strangolino

School Programme

Monday

09:00 12:30	Presentation of Elettra and introduction to control systems	Marco Lonza

14:00 17:30	Basics of TANGO	Claudio Scafuri

Tuesday

09:00 12:30	TANGO Device Servers	Graziano Scalamera

14:00 17:30	TANGO Clients and Events	Claudio Scafuri

Wednesday

09:00	Alarms, Archiving and Tools	Graziano Scalamera, Claudio Scafuri
12:30	Graphical User Interfaces (GUI)	Giacomo Strangolino

14:00	Graphical User Interfaces (GUI)	Giacomo Strangolino
17:30	Visit of Elettra	

Thursday

09:00	TANGO installation and setup	Roberto Passuello
12:30	Hands on: Device Server development	Giulio Gaio

14:00 17:30	Hands on: Device Server development	Giulio Gaio

Friday

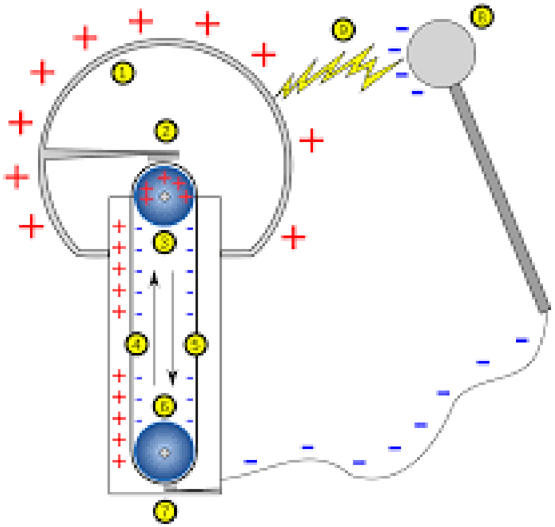
09:00 12:30	Hands on: Device Server development	Giulio Gaio

14:00 17:30	Final test	Lorenzo Pivetta

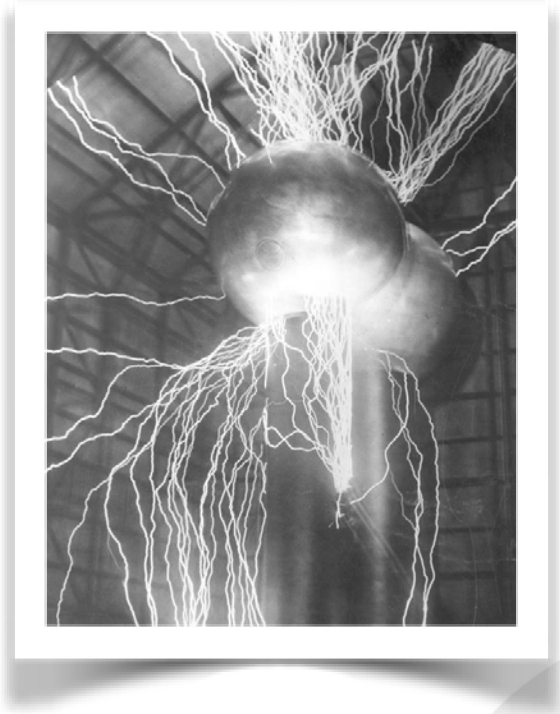
Elettra
Sincrotrone
Trieste

www.elettra.eu

Van Der Graaf accelerator (1929)



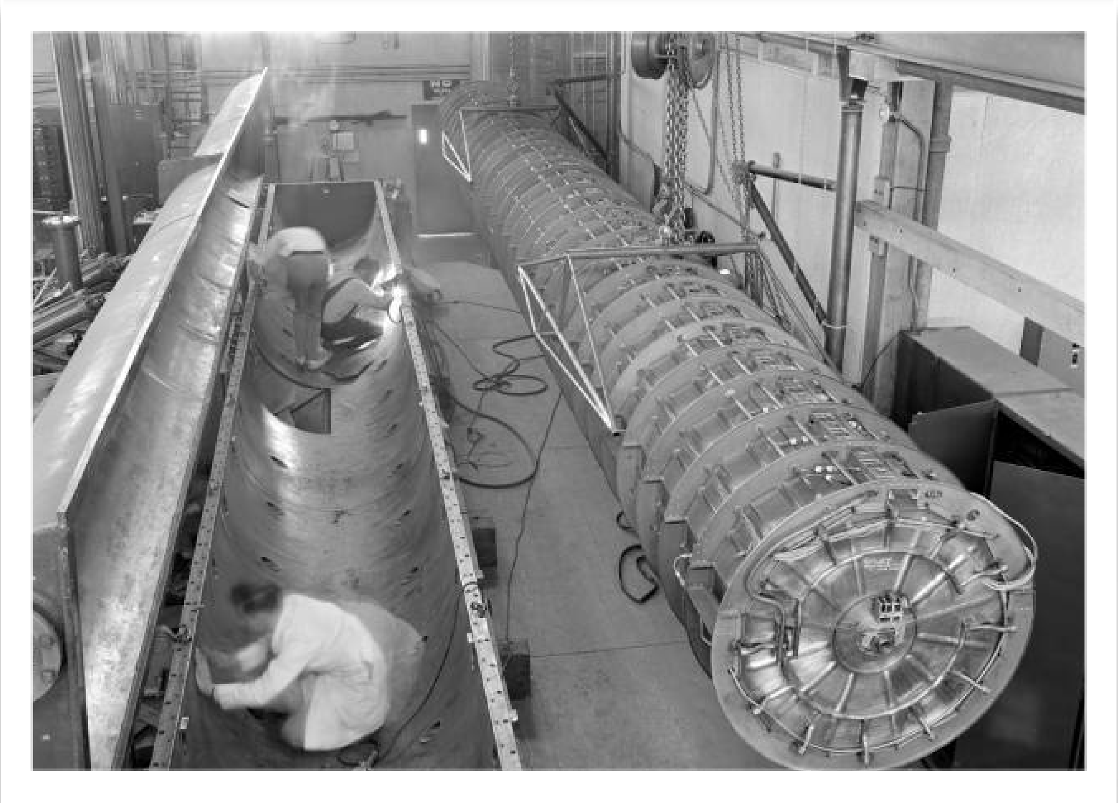
New ideas for charge insulation systems



Voltages obtained up to 25 MV
Used to accelerate subatomic particles

The Linear Accelerator (LINAC)

In 1917 Wideroe develops a first prototype with two sections accelerating electrons up to 50 KV at 50 Hz

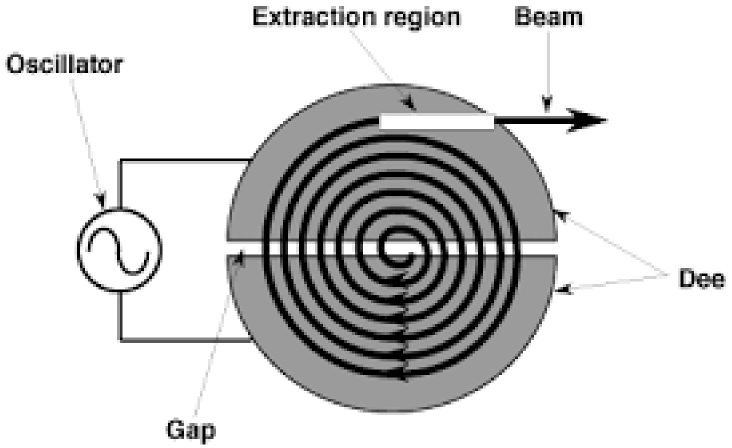


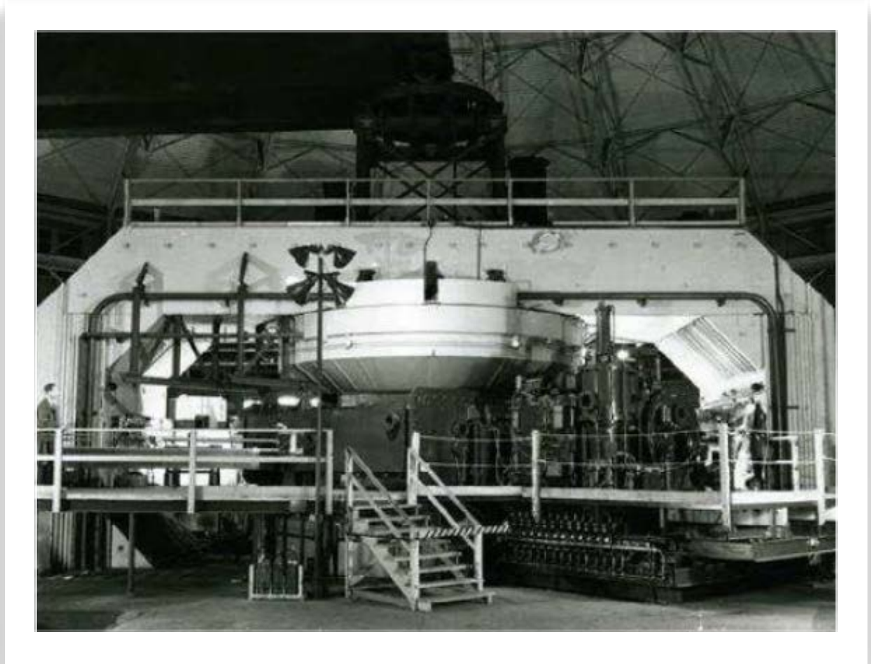
Sloan and Lawrence in 1931 built a LINAC with 20 sections accelerating Hg^+ ions up to **1.26 MV**

The Cyclotron

E.O. Lawrence in 1929

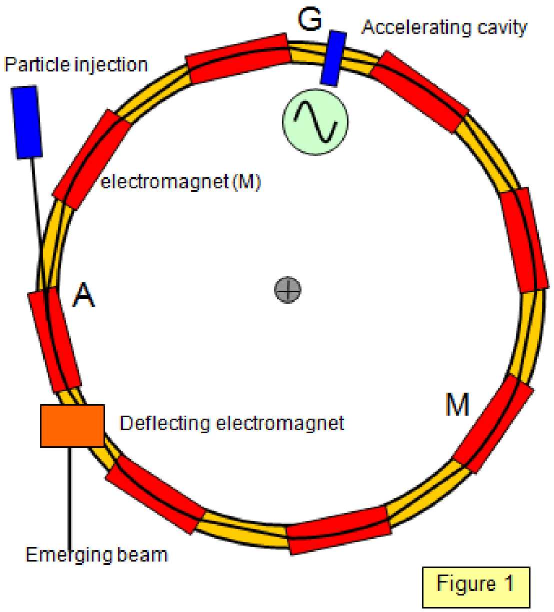
Same accelerating voltage gap used many times by a particle beam bent by a magnetic field





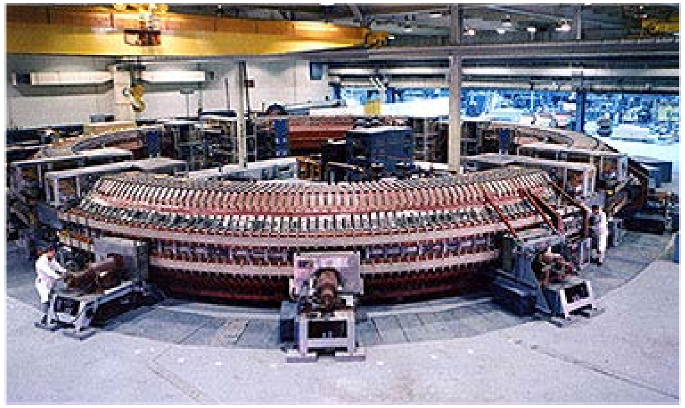
Oggi - 6M $
Cancer the

The Synchrotron



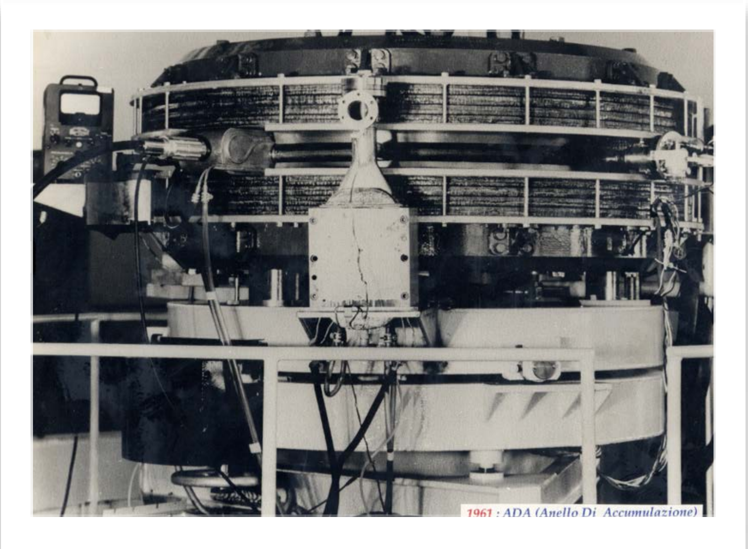
Principle of the Synchrotron invented by Vladimir Veksler in 1944. Edwin McMillan built the first synchrotron of electrons in 1945.

- ✓ Orbit of a particle beam inside a torus-shaped (donut) vacuum pipe with vacuum inside
- ✓ Accelerating RF electromagnetic field and bending and focusing static magnetic field



The Synchrotron as a collider

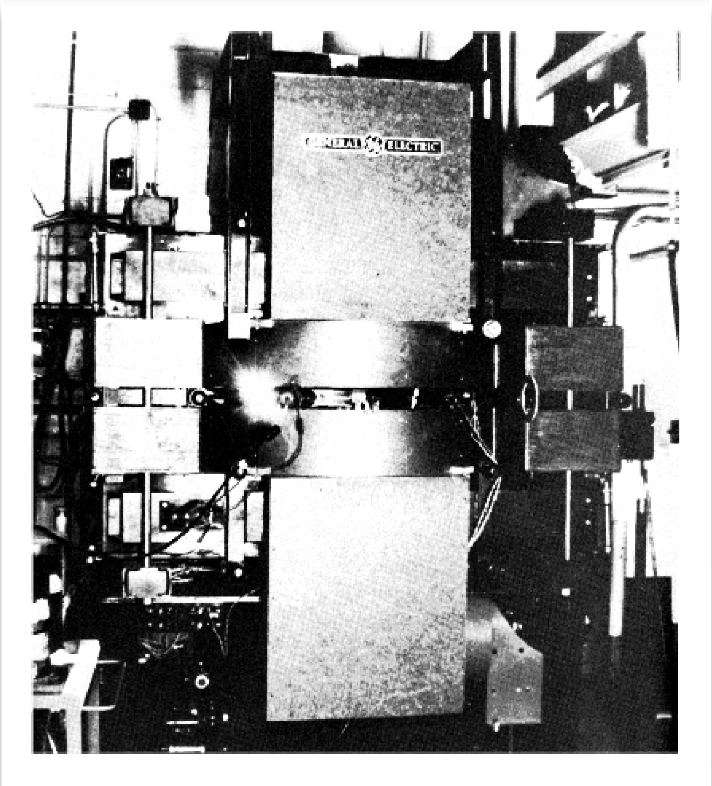
Ada - Frascati - 1961: e - e collider, 200MeV, 5m circumference



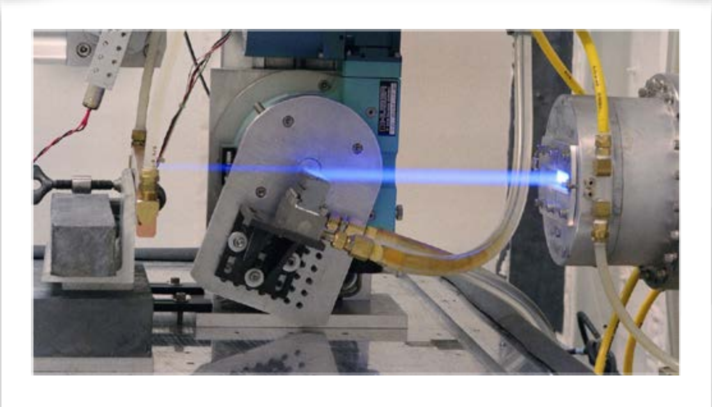
LHC - CERN Ginevra - 2007: p - p collider, 14TeV, 27km circumference

The Synchrotron as a light source

In 1947, the General Electric laboratories near New York built a 70 MeV synchrotron having some glass windows

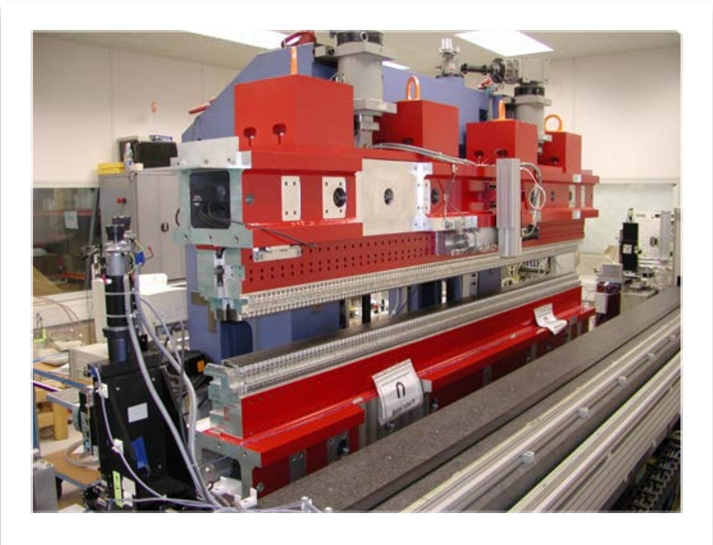


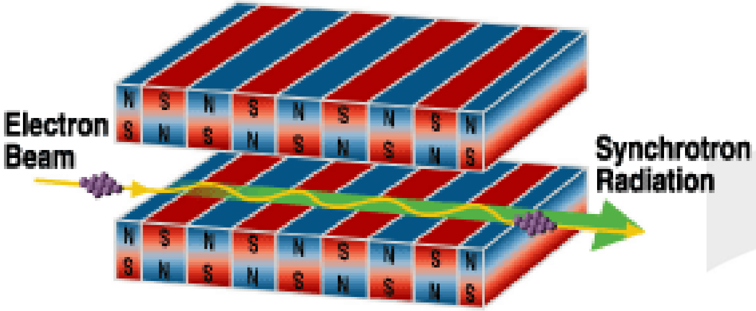
Only by chance a technician noticed some light coming out from a windows and discovered for the first time the synchrotron light



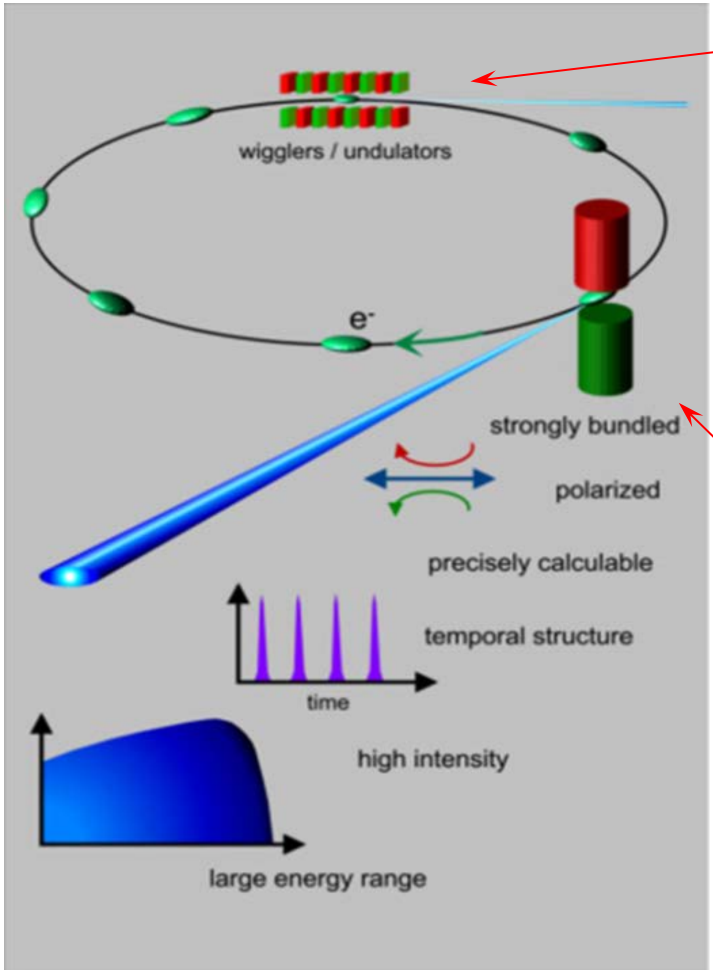
The Synchrotron as a light source

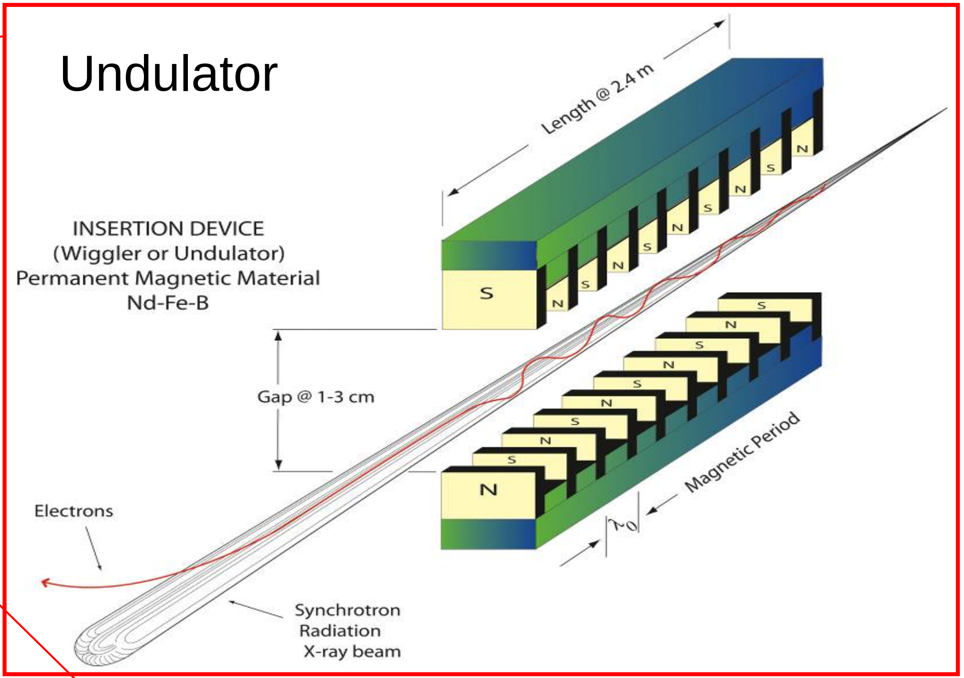
Synchrotrons built in the '90s are primarily built for generating photon beams.
They feature magnetic systems designed to stimulate the electromagnetic radiation.
These systems force electrons to follow sinusoidal or spiral trajectories, thus producing collimated photon beams which can also be polarized

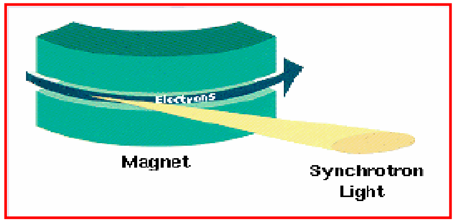




Bending magnets and Undulators



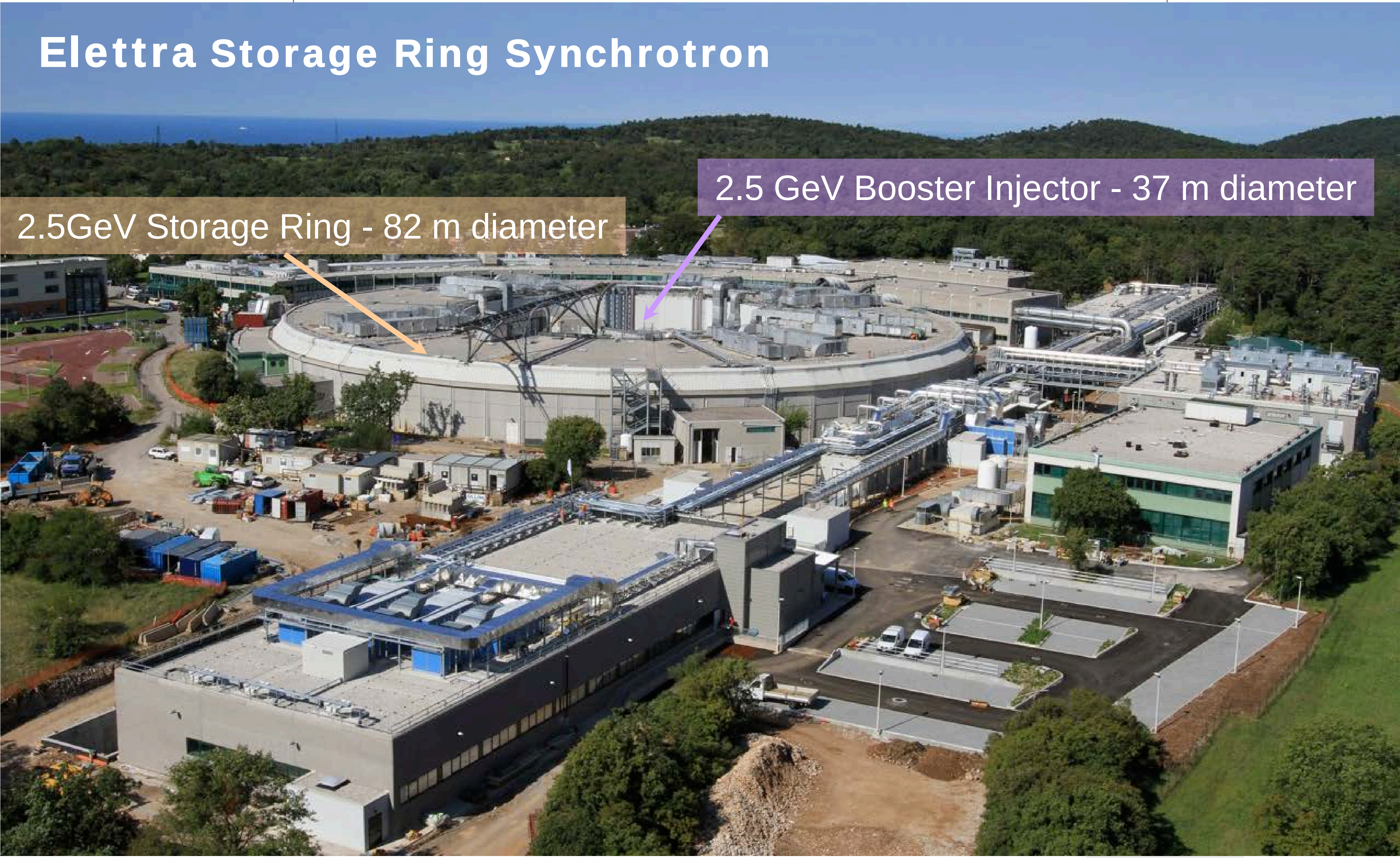




Bending Magnet

Elettra Synchrotron Light Source

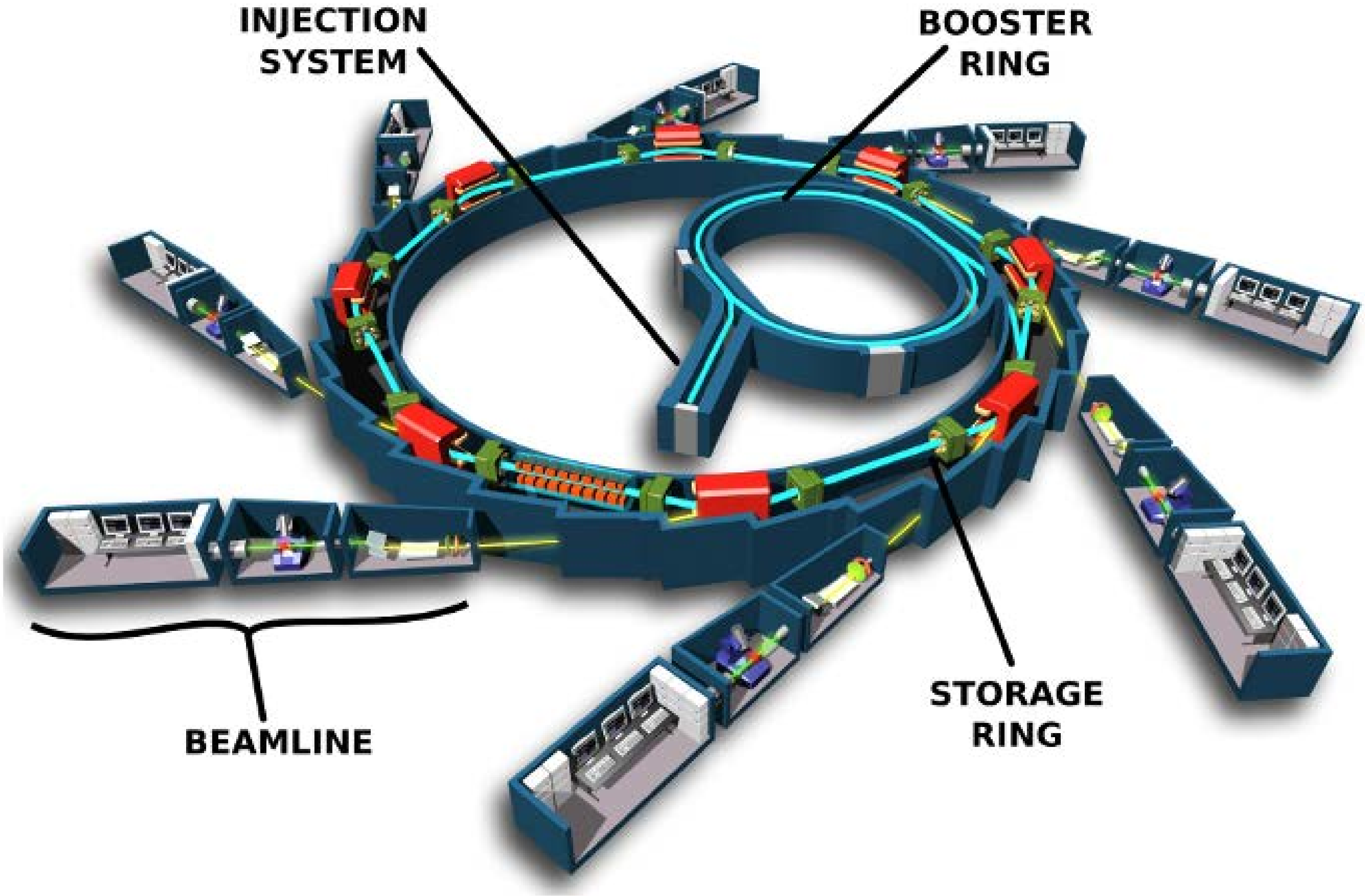
Elettra Storage Ring Synchrotron



2.5 GeV Booster Injector - 37 m diameter

2.5GeV Storage Ring - 82 m diameter

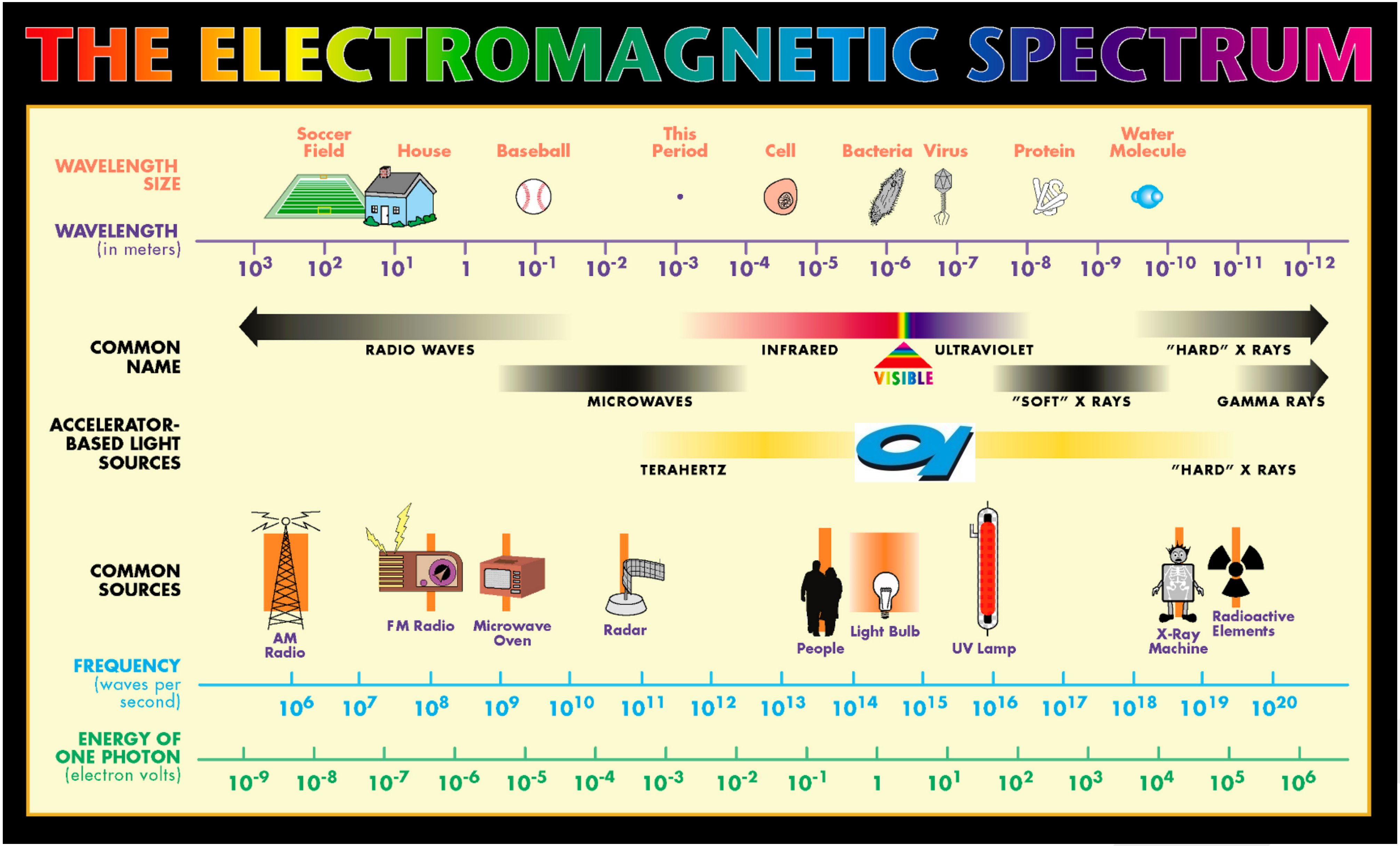
Elettra Synchrotron Light Source



Elettra Synchrotron Light Source

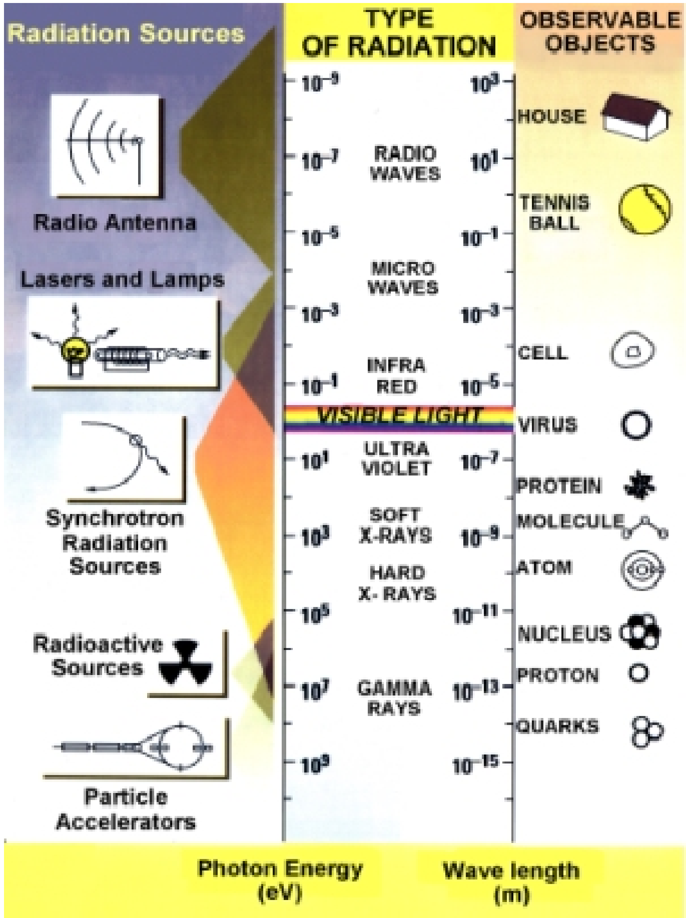
Video

The Electromagnetic Spectrum



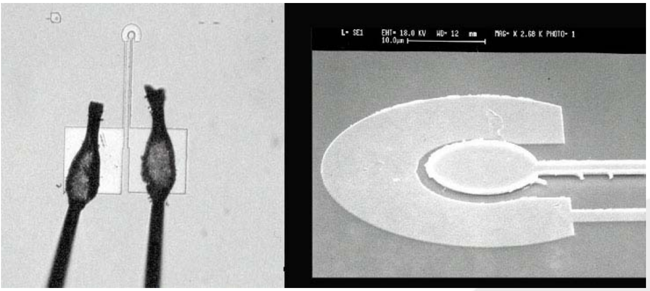
Why“UV” and X-rays are so useful?

In order to "see" an object, the waveleght of the light used to observe it should be similar to the dimension of the object itself

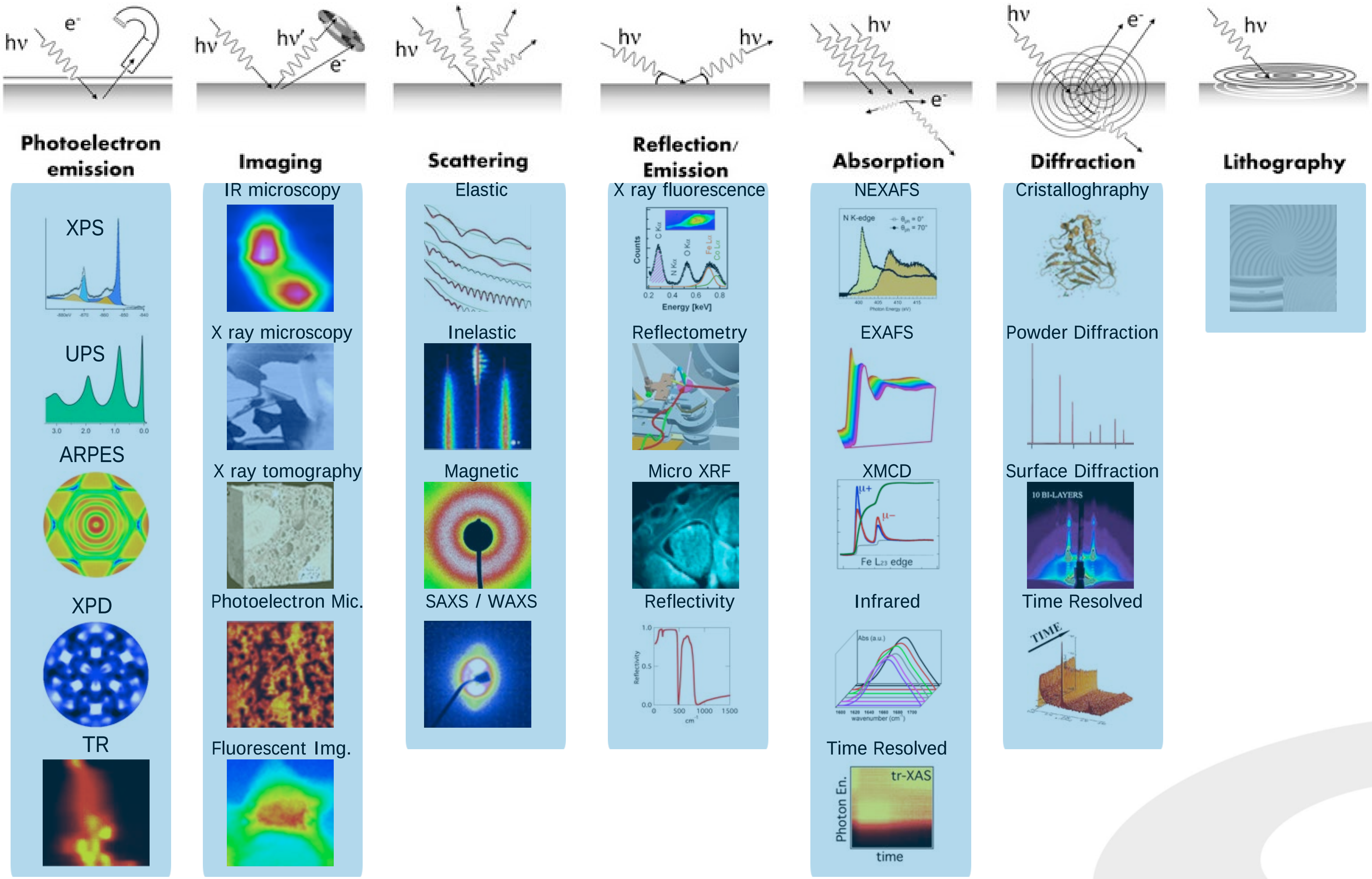


- ✓ In the visible light band the smaller objects we can see are bacteria
- ✓ In order to analyze viruses, proteins, atoms or build micro devices we need

... UVs and X-Rays



How do we use the light?



Photoelectron emission
- XPS
- UPS
- ARPES
- XPD
- TR

Imaging
- IR microscopy
- X ray microscopy
- X ray tomography
- Photoelectron Mic.
- Fluorescent Img.

Scattering
- Elastic
- Inelastic
- Magnetic
- SAXS / WAXS

Reflection/ Emission
- X ray fluorescence
- Reflectometry
- Micro XRF
- Reflectivity

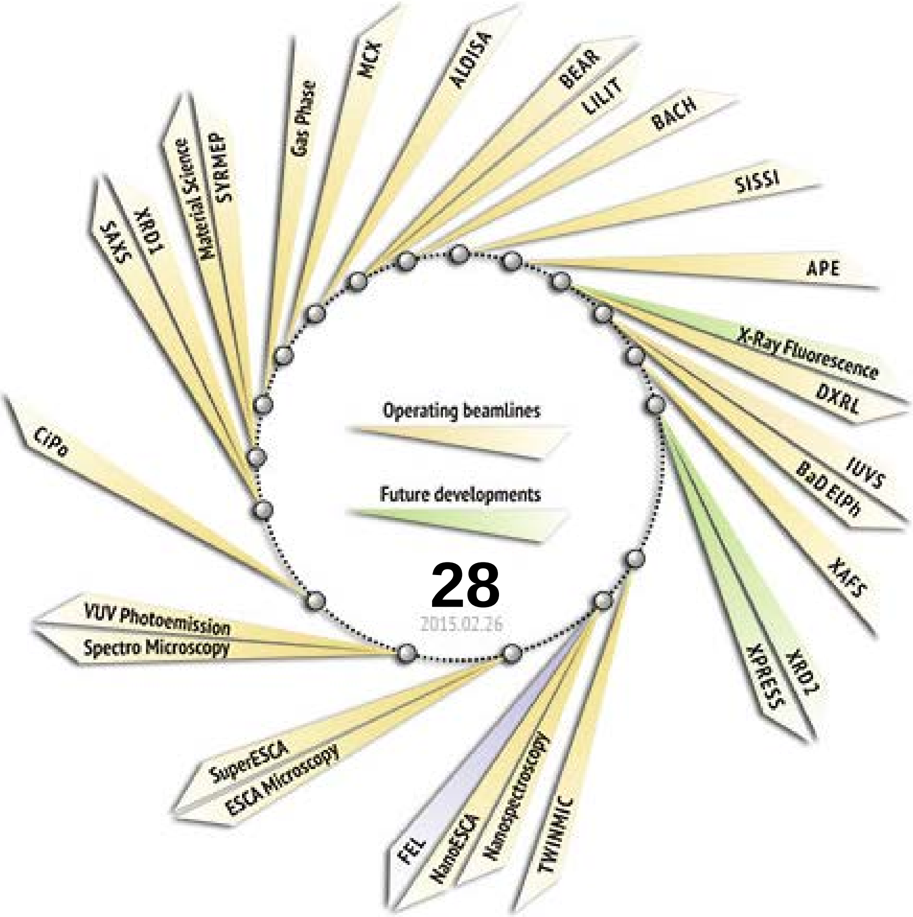
Absorption
- NEXAFS
- EXAFS
- XMCD
- Infrared
- Time Resolved

Diffraction
- Cristallography
- Powder Diffraction
- Surface Diffraction
- Time Resolved

Lithography

The Elettra beamlines

1.1L	TwinMic
1.2L	Nanospectroscopy
1.2L	NanoESCA
1.2R	FEL
2.2L	ESCA Microscopy
2.2R	SuperESCA
3.2L	Spectro Microscopy
3.2R	VUV Photoemission
4.2	CiPo
5.2L	SAXS
5.2R	XRD1
6.1L	Materials Science
6.1R	SYRMEP
6.2R	GasPhase



MCX	7.1
ALOISA	7.2
BEAR	8.1L
LILIT	8.1R
BACH	8.2
SISSI	9.1
APE	9.2
X-Ray Fluorescence	10.1L
DXRL	10.1R
IUVS	10.2L
BaDElPh	10.2R
XAFS	11.1R
XRD2	11.2C
Xpress	11.2R

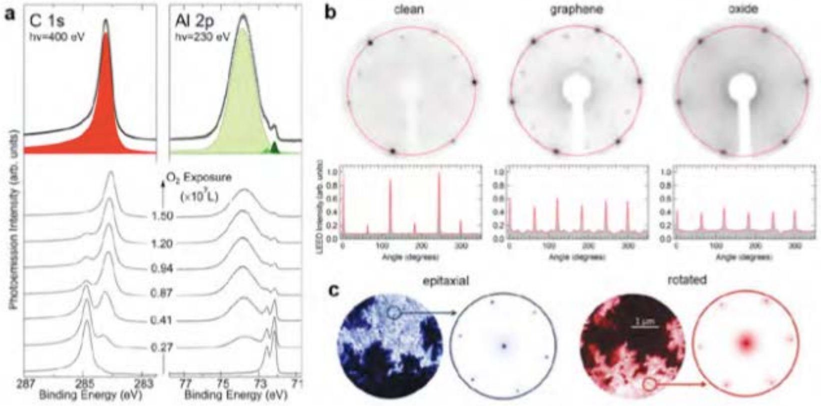
Synchrotrons in Europe

Synchrotrons in the world

Basic Research and ...

Bottom-up approach for the low-cost synthesis of graphene-alumina nanosheet interfaces using bimetallic alloys

The common methods for the production of graphene-oxide interfaces come with a series of issues: they are complex, costly and easily introduce defects and contaminants, with detrimental effects on the carrier mobility. Here we show that the epitaxial growth of graphene on a Ni_3Al alloy, and its subsequent exposure to oxygen result in the selective oxidation of the Al atoms at the interface and to the formation of a 1.5 nm thick alumina nanosheet underneath graphene. This new strategy opens a promising route to the direct synthesis on a number of graphene/high-κ dielectrics interfaces.



Tomography of a Violin

FRESH THINKING IMAGING TECHNOLOGY

THE STRAD PAPERS

LEARNING THE FINER POINTS

Researchers have used particle-accelerator technology to unlock a Guadagnini's tiniest secrets. FRANCO ZANINI explains how

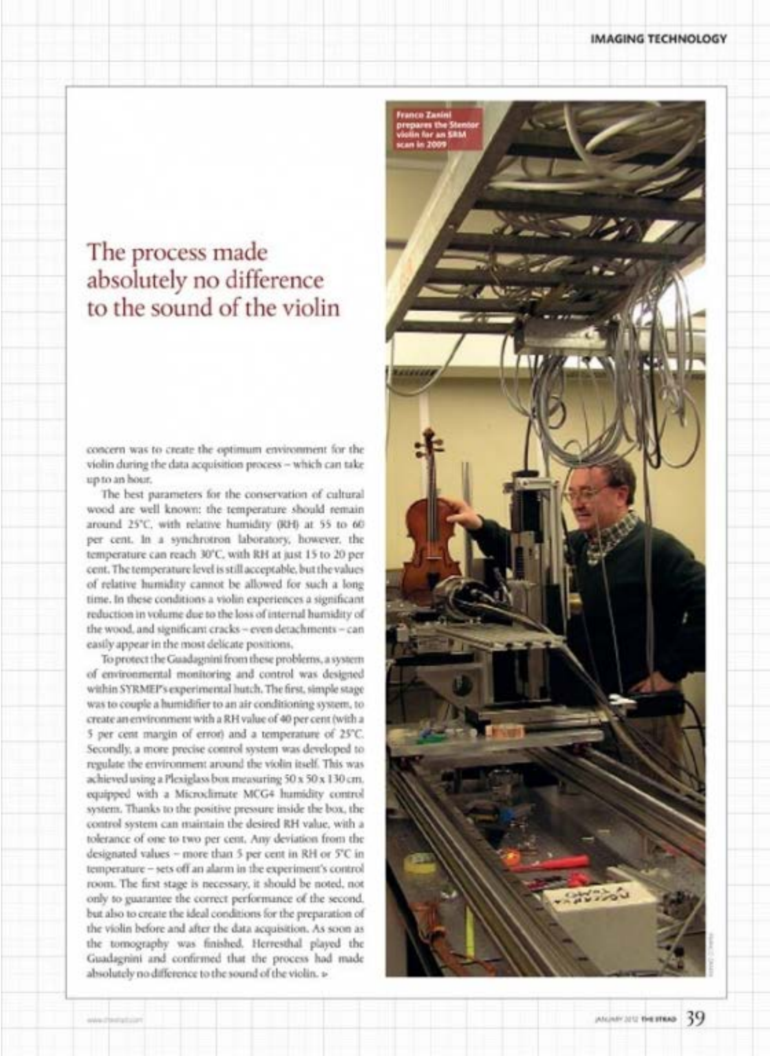
FOR THE RESTORATION AND CONSERVATION OF stringed instruments, the most crucial stage comes at the very beginning: how to analyse the composition of the instrument fully, cleanly, and without the slightest hint of damage. In the past 15 years, computed tomography (CT) has become the most popular solution, primarily due to its non-invasive approach – absolutely necessary when applied to unique instruments of historical, artistic and economic value. Now, a team of physicists, wood experts and luthiers based in Trieste, Italy, has created a method that we believe will build on the success of CT, and allow us to obtain 3D microstructural information in digital format.

The limitations of CT are well known. Even using the best clinical instruments, the spatial resolution (around 300 microns) remains far too low to highlight various important features. Tiny cracks, the condition of the glue and fillers, the presence of thin patches and of xylophagous insects (such as woodworm) – even their eggs – commonly go undetected in the process. The limited dynamic range of CT is also a problem for instruments with metal strings that cannot be removed. To overcome these problems, the Trieste team worked at Elettra, one of the most advanced European particle accelerators, to develop a technique known as 'synchrotron radiation microtomography' (SRM).

A synchrotron is an X-ray generator that produces 3D data with uniquely high intensity (several orders of magnitude higher than conventional instruments) and incorporates many microscopic analytical tools. It is also possible to tune the X-ray wavelength to correspond with the material under examination, while the coherence of the beam allows the detection of chemicals usually undetectable via X-rays (such as glues or varnishes), even inside a dense sample.

OUR FIRST SRM EXPERIMENTS on period instruments took place in September 2008, on a rare organ dating from 1494. Made by Lorenzo Gusnasco da Pavia, the organ is the only surviving instrument of its kind, with pipes made from layers of paper. The importance of the instrument has always limited any kind of analysis, and the non-destructivity of the techniques has always been a fundamental requirement. The SRM process, however, determined the number and thickness of the paper layers, as well as critical information about the wooden parts. The different kinds of wood used were determined with

An experiment on a Stentor violin in 2009 produced impressive results



IMAGING TECHNOLOGY

Franco Zanini prepares the Stentor violin for an SRM scan in 2009

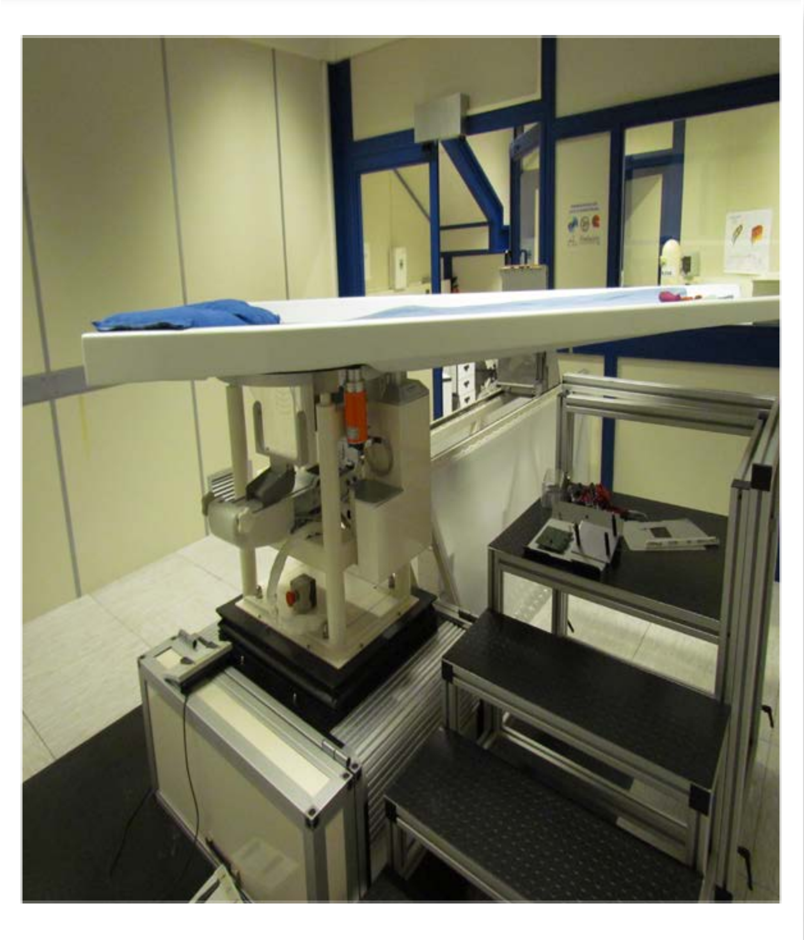
The process made absolutely no difference to the sound of the violin

concern was to create the optimum environment for the violin during the data acquisition process – which can take up to an hour.

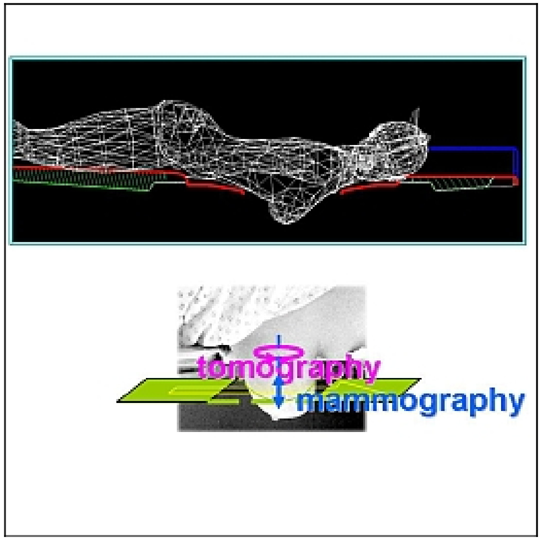
The best parameters for the conservation of cultural wood are well known: the temperature should remain around 25°C, with relative humidity (RH) at 55 to 60 per cent. In a synchrotron laboratory, however, the temperature can reach 30°C, with RH at just 15 to 20 per cent. The temperature level is still acceptable, but the values of relative humidity cannot be allowed for such a long time. In these conditions a violin experiences a significant reduction in volume due to the loss of internal humidity of the wood, and significant cracks – even detachments – can easily appear in the most delicate positions.

To protect the Guadagnini from these problems, a system of environmental monitoring and control was designed within SYRMEP's experimental hutch. The first, simple stage was to couple a humidifier to an air conditioning system, to create an environment with a RH value of 40 per cent (with a 5 per cent margin of error) and a temperature of 25°C. Secondly, a more precise control system was developed to regulate the environment around the violin itself. This was achieved using a Plexiglass box measuring 50 x 50 x 130 cm, equipped with a Microclimate MCG4 humidity control system. Thanks to the positive pressure inside the box, the control system can maintain the desired RH value, with a tolerance of one to two per cent. Any deviation from the designated values – more than 5 per cent in RH or 5°C in temperature – sets off an alarm in the experiment's control room. The first stage is necessary, it should be noted, not only to guarantee the correct performance of the second, but also to create the ideal conditions for the preparation of the violin before and after the data acquisition. As soon as the tomography was finished, Herresthal played the Guadagnini and confirmed that the process had made absolutely no difference to the sound of the violin. »

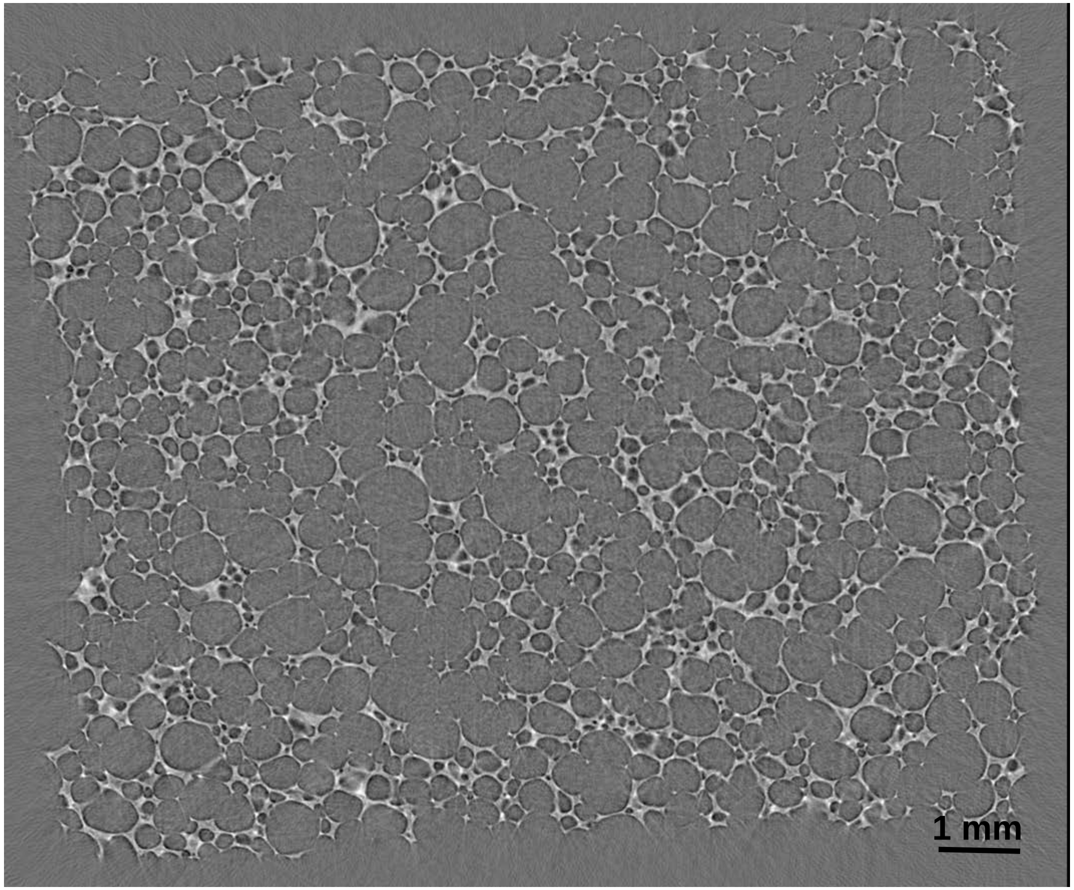
Mammography



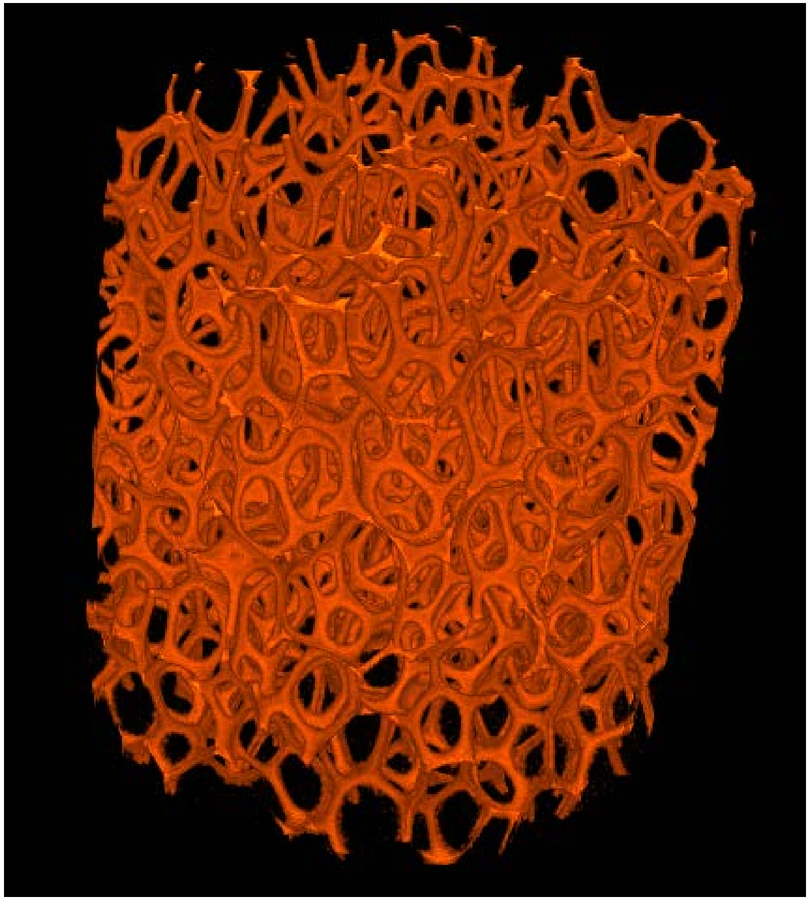
Better image quality, less radiation dose to the patients with respect to conventional X-Rays sources



Internal Structure of Polymeric Foams



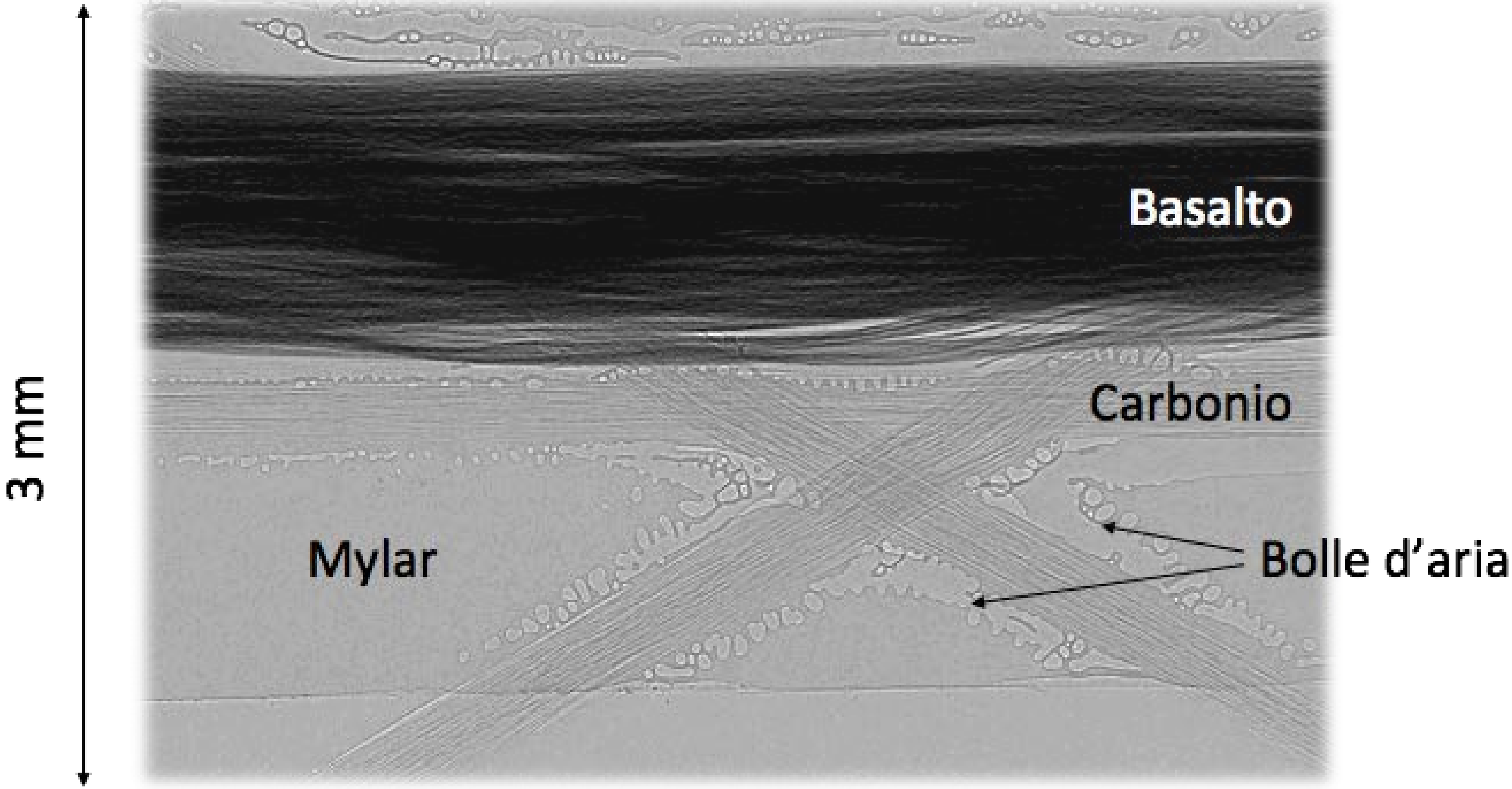
“Slice”



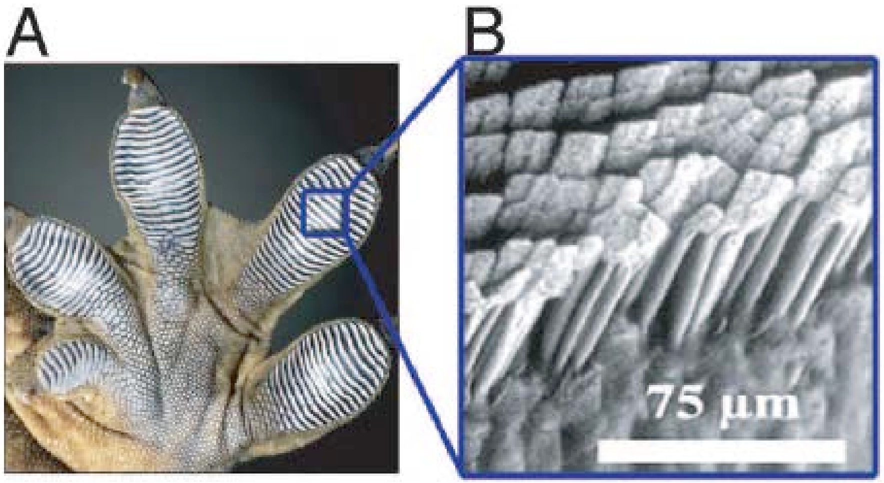
3D reconstruction of the sample

(3.2 x 3.0 x 1.4) mm

Radiography of hi-tech sails

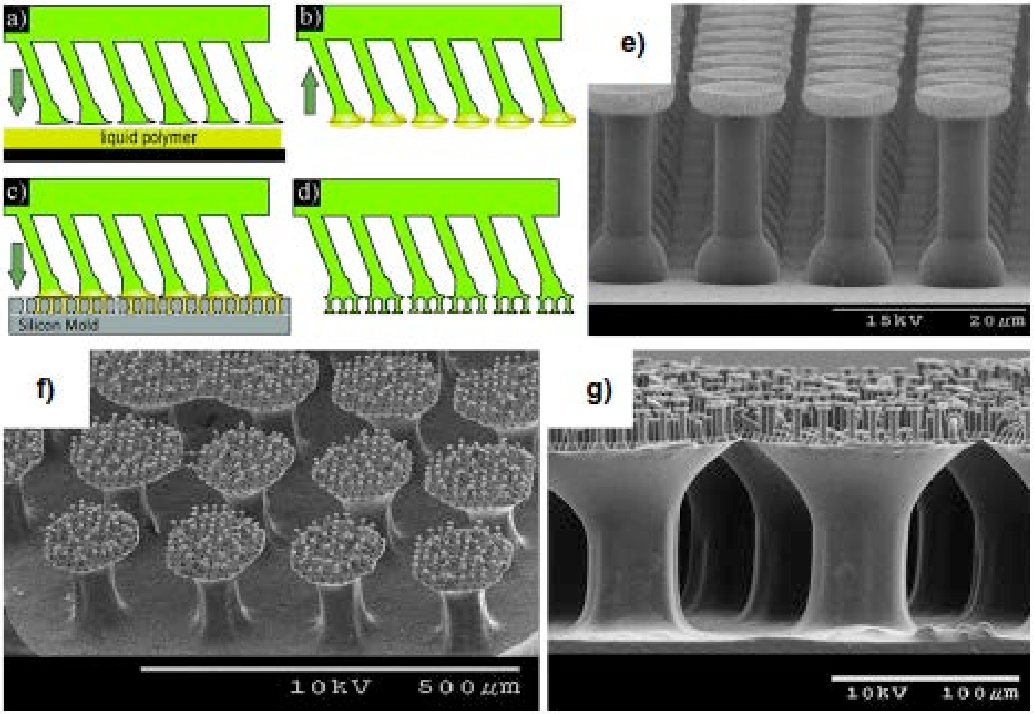


Micro-mechanics: Gecko Project with ESA



esa space for europe
European Space Agency

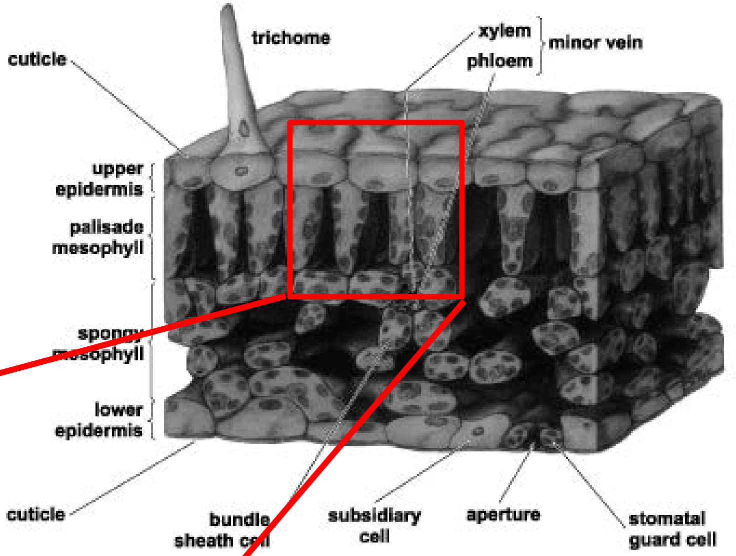
“Gecko” project

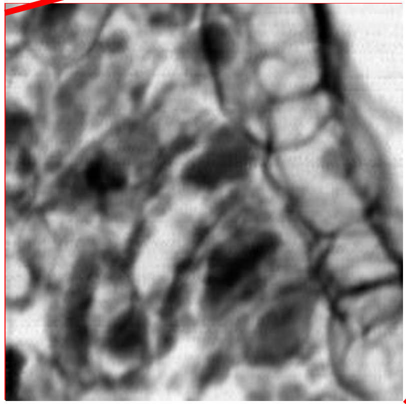


Spettrometric Micro-analysis

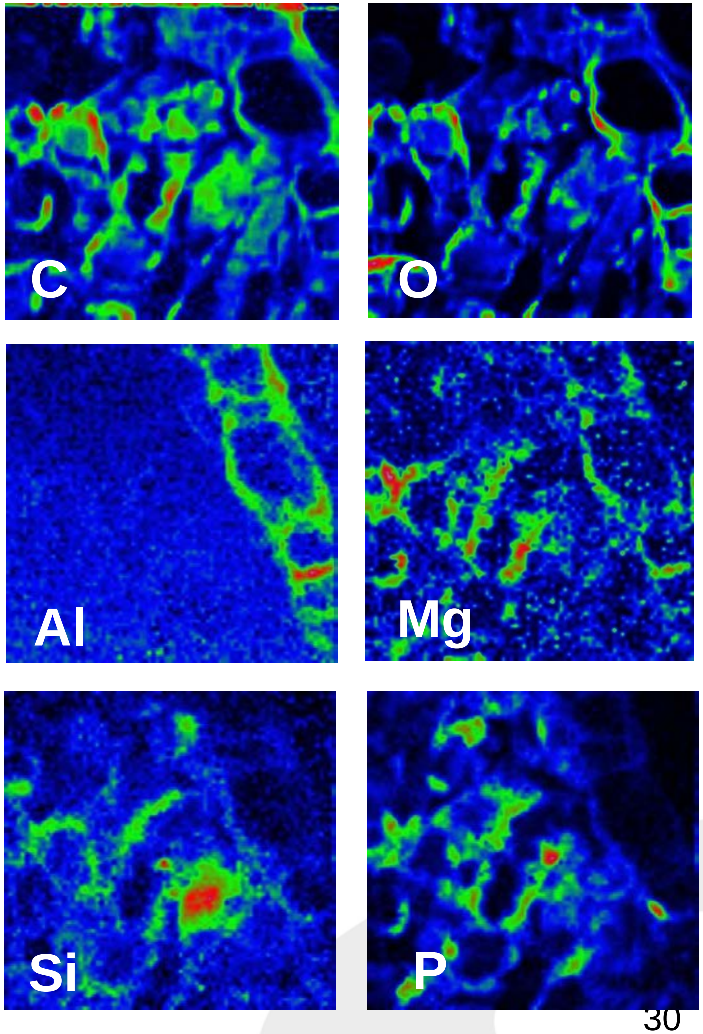
Contaminating Metals on tea leaves

Section of a leaf





E=2.19 keV
80 x 80 mm



Elettra Users

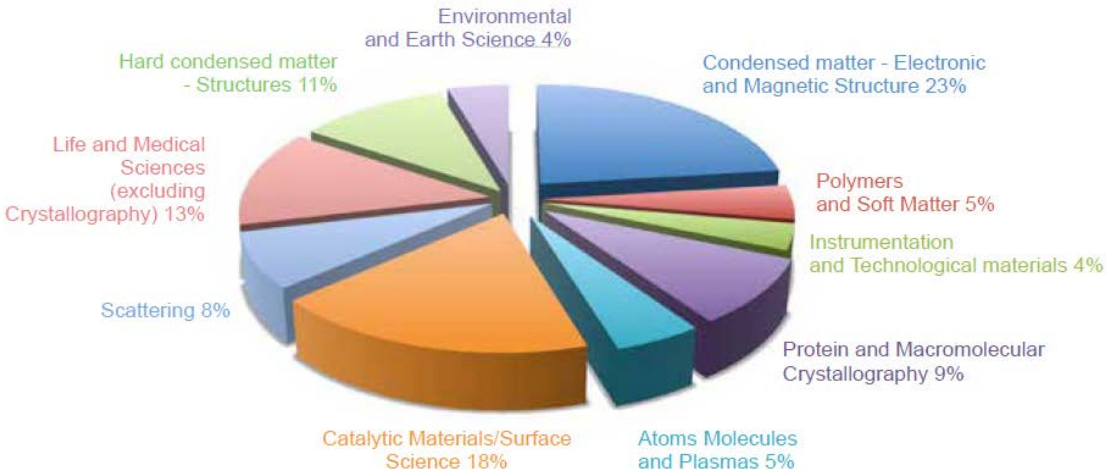
Users at Elettra

II semester 2014 - I semester 2015

Proposals submitted: 832

Proposals allocated: 508

Elettra proposals allocated by Research Area



Elettra allocated Users

EU funded users	149
Italian funded users	165
General users (not funded)	1078
Total Users	**1392**

AUSTRIA	54
BELGIUM	11
CROATIA	28
CZECH REPUBLIC	26
DENMARK	12
FRANCE	125
GERMANY	192
GREECE	18
HUNGARY	3
IRELAND	2
ITALY	**458**
LATVIA	4
NETHERLANDS	2
POLAND	10
ROMANIA	6
SLOVENIA	80
SPAIN	41
SWEDEN	40
UNITED KINGDOM	75
European Union	**1187**

ARGENTINA	1
AUSTRALIA	2
BELARUS	1
BRAZIL	10
CANADA	1
CHINA	14
EGYPT	5
INDIA	55
INDONESIA	2
IRAN, ISLAMIC REPUBLIC OF	3
ISRAEL	3
JAPAN	11
JORDAN	3
KOREA, REPUBLIC OF	4
MEXICO	3
PAKISTAN	11
QATAR	2
RUSSIAN FEDERATION	14
SOUTH AFRICA	6
SRI LANKA	1
SWITZERLAND	13
THAILAND	3
UKRAINE	4
UNITED STATES	33
Others	**205**

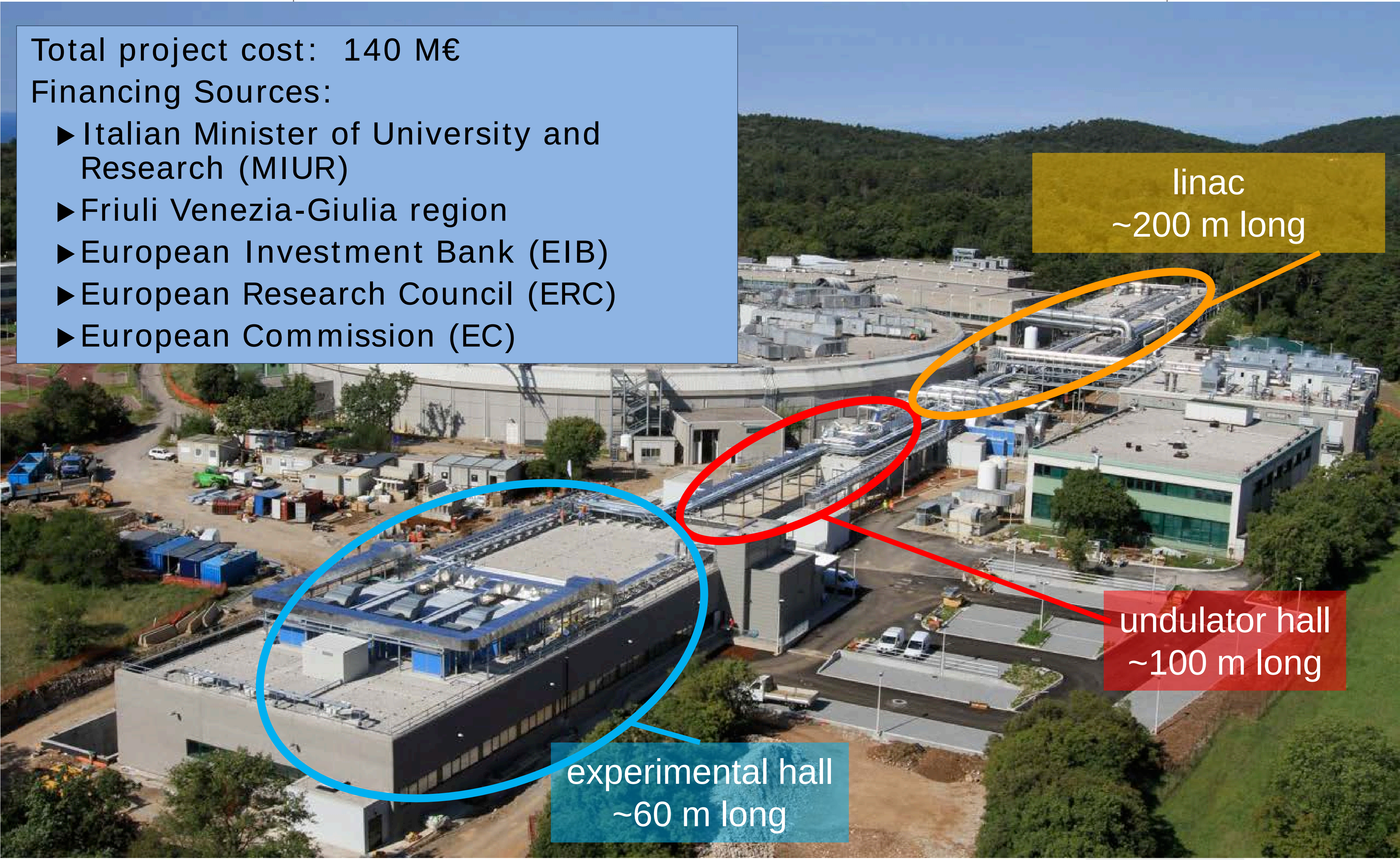
Total Users	**1392**

FERMI Free Electron Laser

Total project cost: 140 M€

Financing Sources:

- Italian Minister of University and Research (MIUR)
- Friuli Venezia-Giulia region
- European Investment Bank (EIB)
- European Research Council (ERC)
- European Commission (EC)



linac
~200 m long

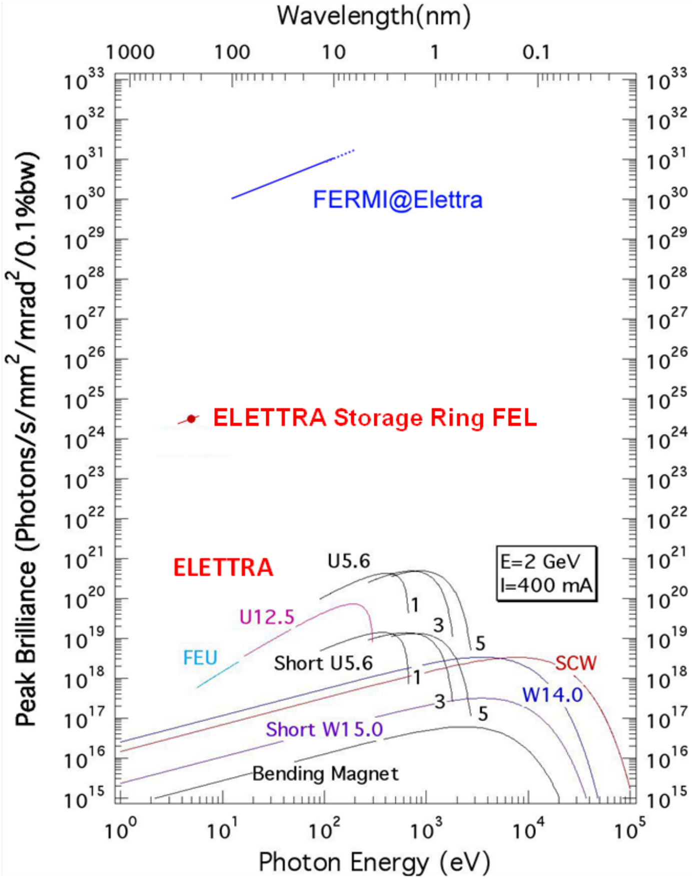
undulator hall
~100 m long

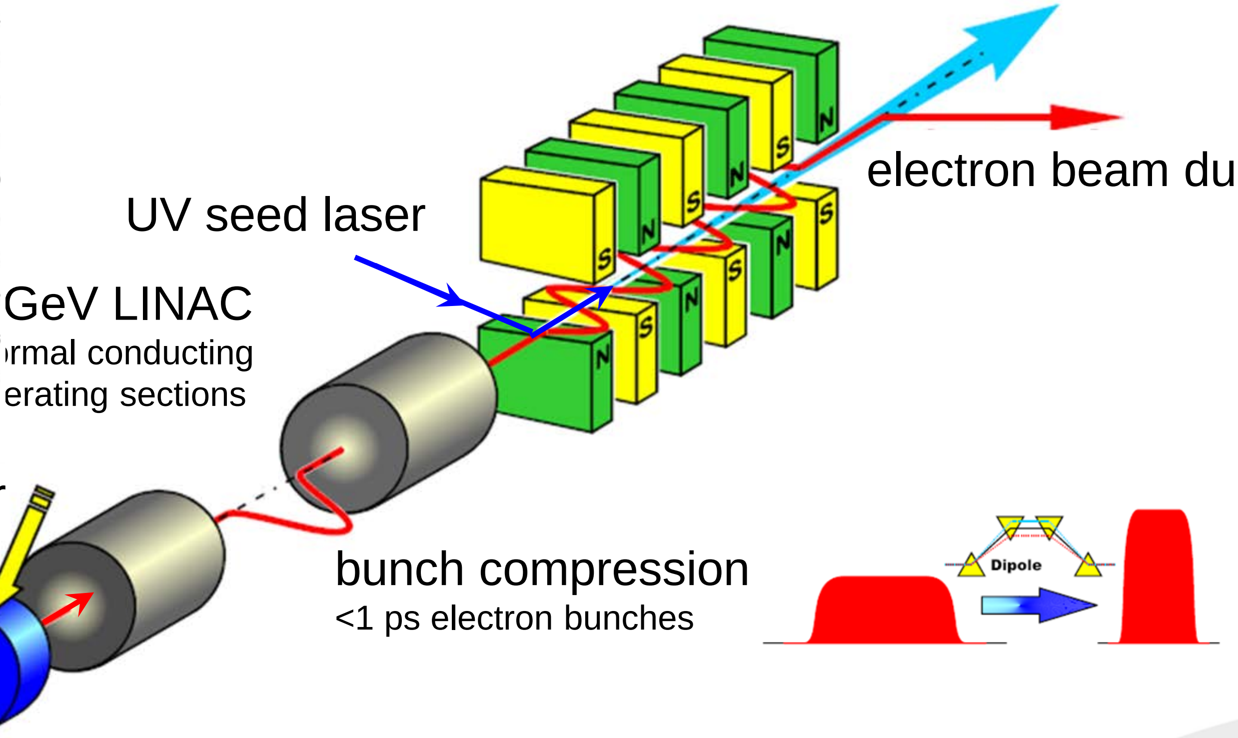
experimental hall
~60 m long

FERMI Free Electron Laser

Video

FERMI Free Electron Laser





FEL photon beam

high peak power (>GWs), short pulse length (<100 fs)
full spatial and temporal coherence

tunable wavelength (100-4 nm), variable polarization

electron beam dump

UV seed laser

GeV LINAC
rmal conducting
erating sections

injector
laser

bunch compression
<1 ps electron bunches

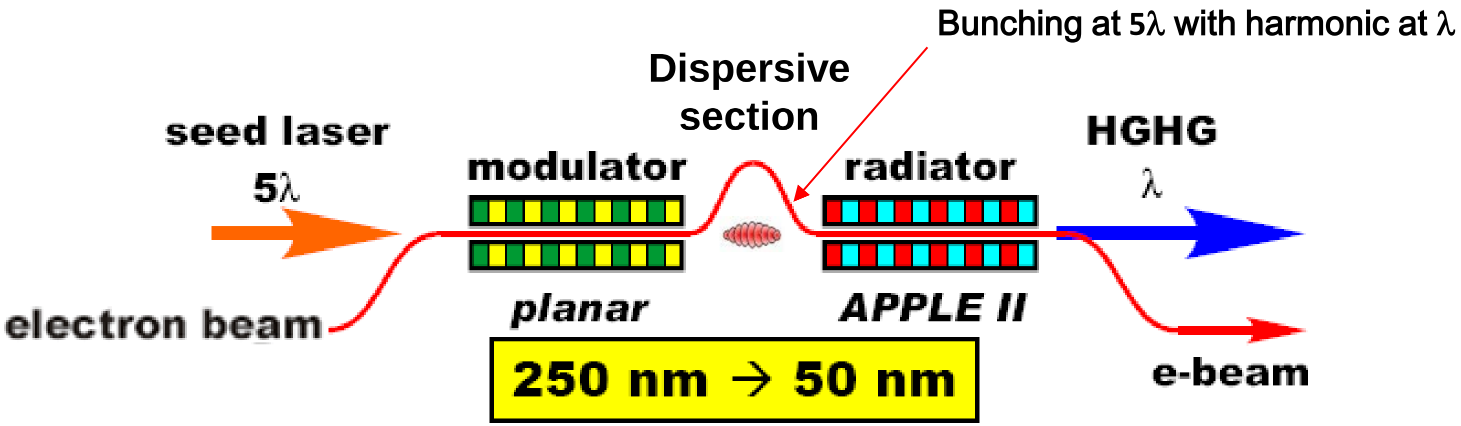
photo-cathode GUN
low emittance electron beam
50 Hz repetition rate

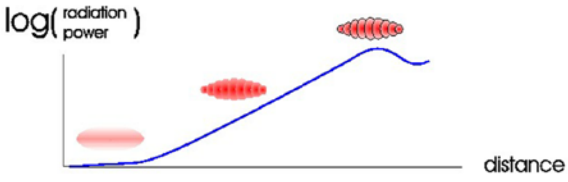
High-Gain Harmonic Generation

FERMI: First seeded FEL designed to produce fundamental output wavelength of 4 nm with **High Gain Harmonic Generation**

FEL-1

One Stage

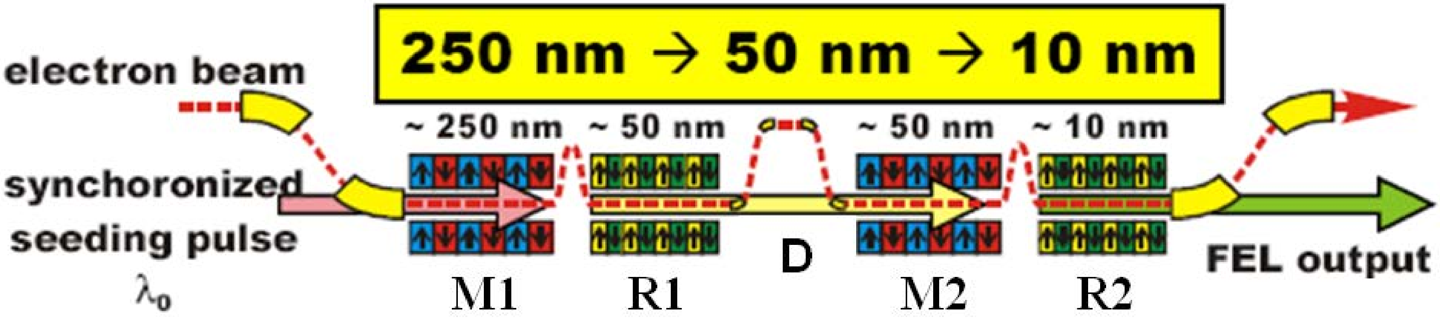




Micro Bunching

FEL-2

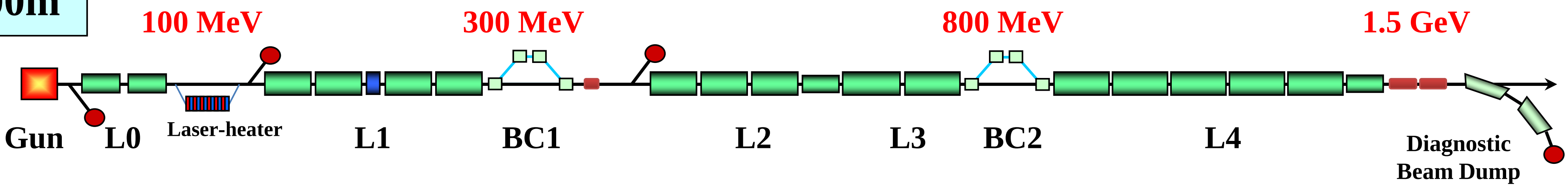
Two Stages



FERMI Layout

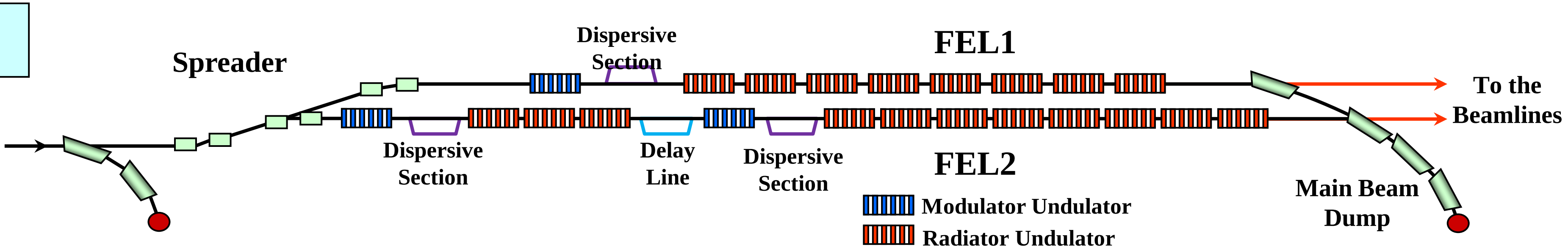
Linac

200m



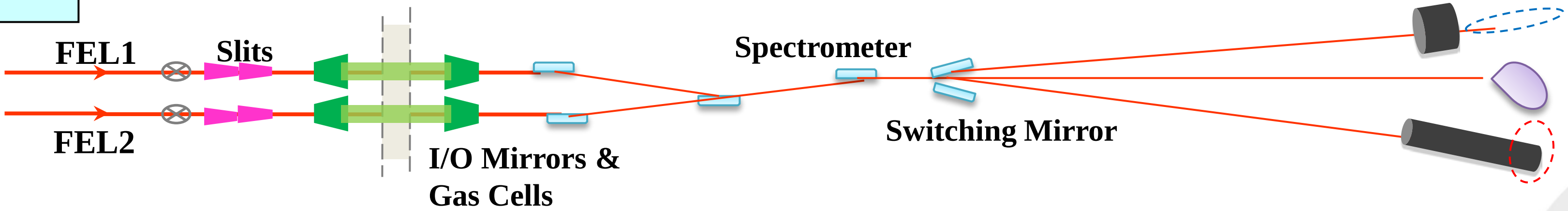
Undulator Hall

100m

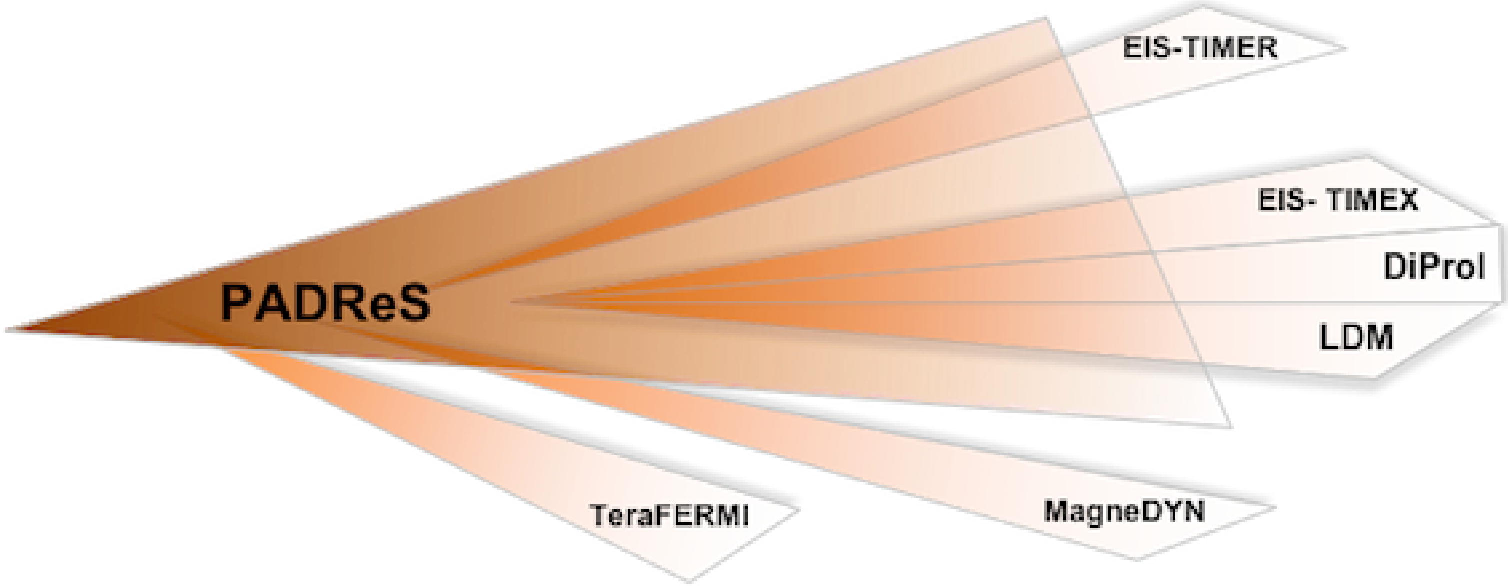


Experimental Hall

60m



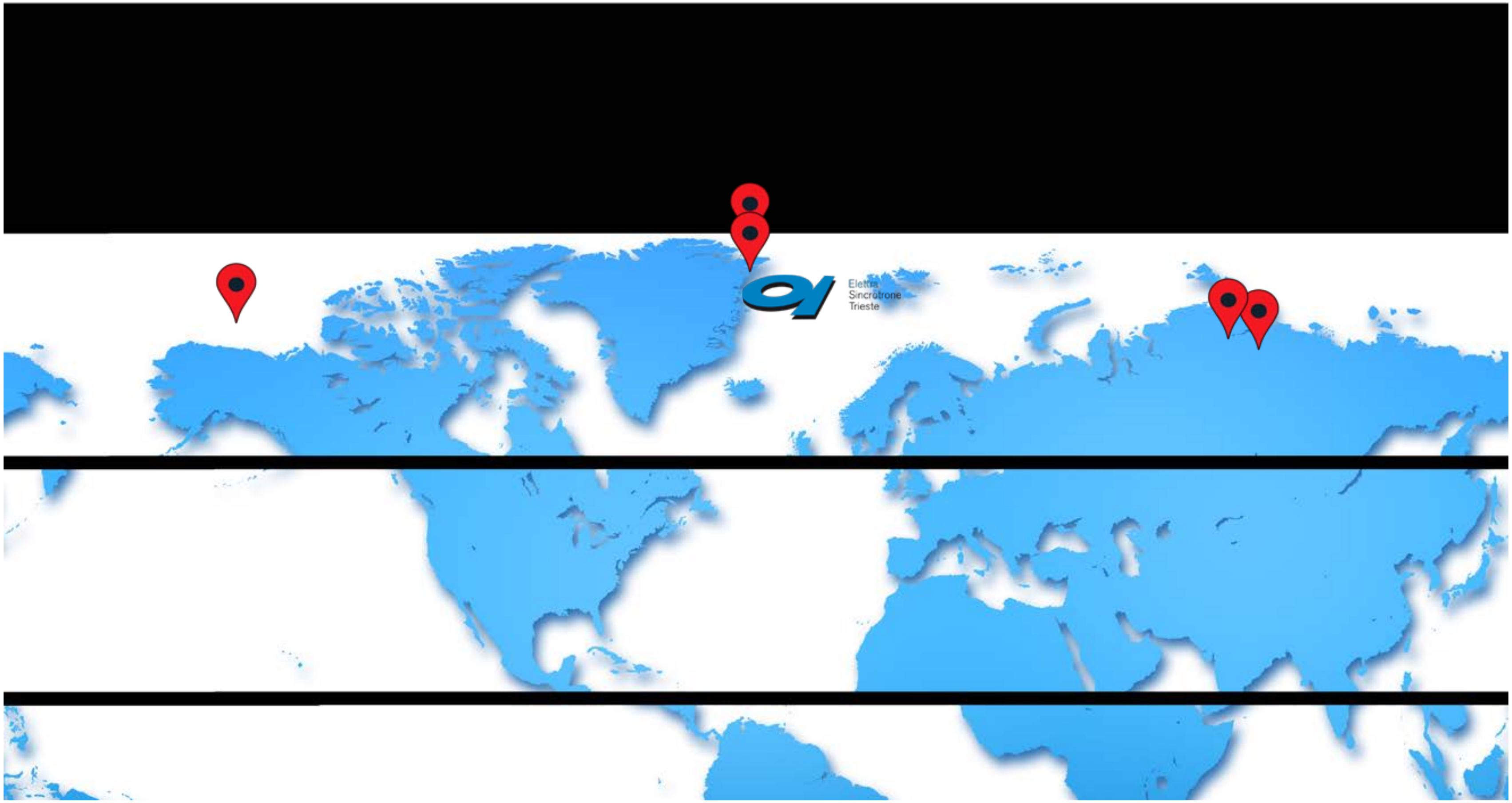
FERMI Beamlines



2015
Proposals submitted: 95
proposals allocated: 36

Users
44% Germany
25% Italy
11% France
8% Japan

Other FELs



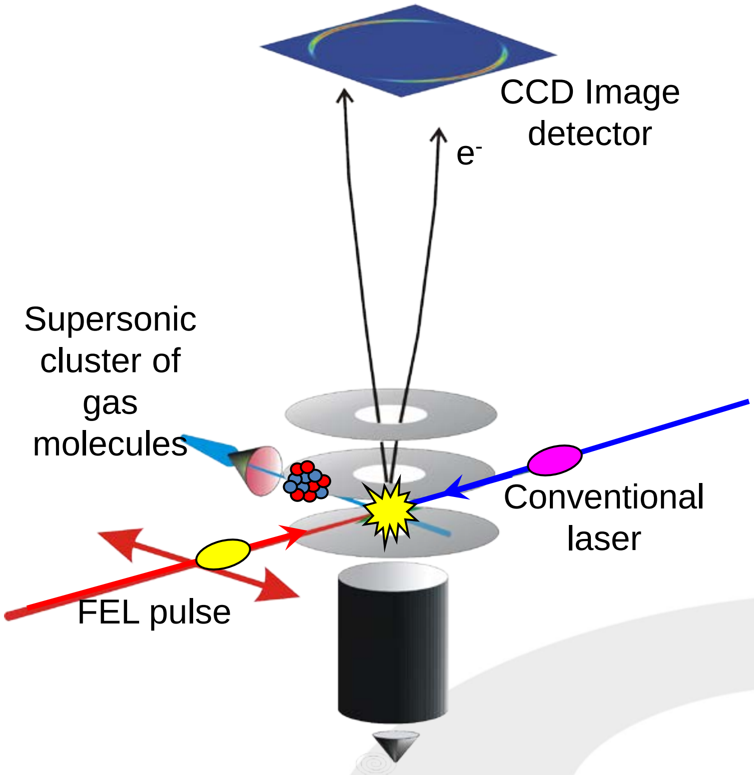
FEL for Users
- Flash - Germany
- LCLS - USA
- FERMI - Italy
- SACLA - Japan

FEL under construction
- X-FEL - Germany
- PAL - Korea
- SwissFEL - Switzerland

Science Case

The particular characteristics of the FEL photon beam enable time resolved experiments to study ultrafast dynamics and transient phenomena of matter under extreme irradiation conditions

- **Elastic and Inelastic Scattering**
  - ✓ Transient Grating Spectroscopy (collective dynamics at the nano-scale)
  - ✓ Pump & Probe Spectroscopy (meta-stable states of matter)
- **Diffraction and Projection Imaging**
  - ✓ Single-shot & Resonant Transverse Coherent Diffraction Imaging
  - ✓ Morphology and internal structure at the nm scale
  - ✓ Chemical and magnetic imaging
- **Low Density Matter**
  - ✓ Structure of nano-clusters
  - ✓ Ionization dynamics
  - ✓ Magnetism in nano-particles
  - ✓ Catalysis in nano-materials



Science Highlights

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NATURE PHOTONICS | ARTICLE

日本語要約

Highly coherent and stable pulses from the FERMI seeded free-electron laser in the extreme ultraviolet

E. Allaria, R. Appio, L. Badano, W.A. Barletta, S. Bassanese, S.G. Biedron, A. Borga, E. Busetto, D. Castronovo, P. Cinquegrana, S. Cleva, D. Cocco, M. Cornacchia, P. Craievich, Cudin, G. D'Auria, M. Dal Forno, M.B. Danailov, R. De Monte, G. De Ninno, P. Delgiusto, A. Demidovich, S. Di Mitri, B. Diviacco, A. Fabris, R. Fabris, W. Fawley, M. Ferianis, E. Ferrari, Ferry, L. Froehlich, P. Furlan, G. Gaio, F. Gelmetti, L. Giannessi, M. Giannini, R. Gobessi, Ivanov, E. Karantzoulis, M. Lonza, A. Lutman, B. Mahieu, M. Milloch, S.V. Milton, M. Musar Nikolov, S. Noe, F. Parmigiani, G. Penco, M. Petronio, L. Pivetta, M. Predonzani, F. Rossi, Rumiz, A. Salom, C. Scafuri, C. Serpico, P. Sigalotti, S. Spampinati, C. Spezzani, M. Svandr C. Svetina, S. Tazzari, M. Trovo, R. Umer, A. Vascotto, M. Veronese, R. Visintini, M. Zaccari Zangrando & M. Zangrando ⊟ Show fewer authors

Affiliations | Contributions | Corresponding author

Nature Photonics **6**, 699–704 (2012) | doi:10.1038/nphoton.2012.233

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NATURE PHOTONICS | ARTICLE

日本語要約

Two-stage seeded soft-X-ray free-electron laser

E. Allaria, D. Castronovo, P. Cinquegrana, P. Craievich, M. Dal Forno, M. B. Danailov, G. D'Auria, A. Demidovich, G. De Ninno, S. Di Mitri, B. Diviacco, W. M. Fawley, M. Ferianis, E. Ferrari, L. Froehlich, G. Gaio, D. Gauthier, L. Giannessi, R. Ivanov, B. Mahieu, N. Mahne, I. Nikolov, F. Parmigiani, G. Penco, L. Raimondi, C. Scafuri, C. Serpico, P. Sigalotti, S. Spampinati, C. Spezzani, M. Svandrlik, C. Svetina, M. Trovo, M. Veronese, D. Zangrando & M. Zangrando ⊟ Show fewer authors

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NATURE PHOTONICS | LETTER

Coherent control with a short-wavelength free-electron laser

K. C. Prince, E. Allaria, C. Callegari, R. Cucini, G. De Ninno, S. Di Mitri, B. Diviacco, E. Ferrari, P. Finetti, D. Gauthier, L. Giannessi, N. Mahne, G. Penco, O. Plekan, L. Raimondi, P. Rebernik, E. Roussel, C. Svetina, M. Trovò, M. Zangrando, M. Negro, P. Carpeggiani, M. Reduzzi, G. Sansone, A. N. Grum-Grzhimailo ⊞ *et al.*

Affiliations | Contributions | Corresponding authors

Nature Photonics **10**, 176–179 (2016) | doi:10.1038/nphoton.2016.13

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Extreme ultraviolet and X-ray free-electron lasers (FELs) produce short-wavelength pulses with high intensity, ultrashort duration, well-defined polarization and transverse coherence, and have been utilized for many experiments previously possible only at long wavelengths: multiphoton ionization[1], pumping an atomic laser[2] and four-wave mixing spectroscopy[3]. However one important optical technique, coherent control, has not yet been demonstrated, because self-amplified spontaneous emission FELs have limited longitudinal coherence[4, 5, 6, 7]. Single-colour pulses from the FERMI seeded FEL are longitudinally coherent[8, 9], and two-colour emission is predicted to be coherent. Here, we demonstrate the phase correlation of two colours, and manipulate it to control an experiment. Light of wavelengths 63.0 and 31.5 nm ionized neon, and we controlled the asymmetry of the photoelectron angular distribution[10, 11] by adjusting the phase, with a temporal resolution of 3 as. This opens the door to new short-wavelength coherent control experiments with ultrahigh time resolution and chemical sensitivity.

Elettra Sincrotrone Trieste in numbers

- ✓ 400 employees
- ✓ 28+ Beamlines ELETTRA and 6 FERMI
- ✓ 10 laboratories user support (biology, material preparation, micrometrics, ...)
- ✓ 5000 light hours/year of synchrotron radiation (Operation 24/7)
- ✓ More than 1000 users per year, from all over the world

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