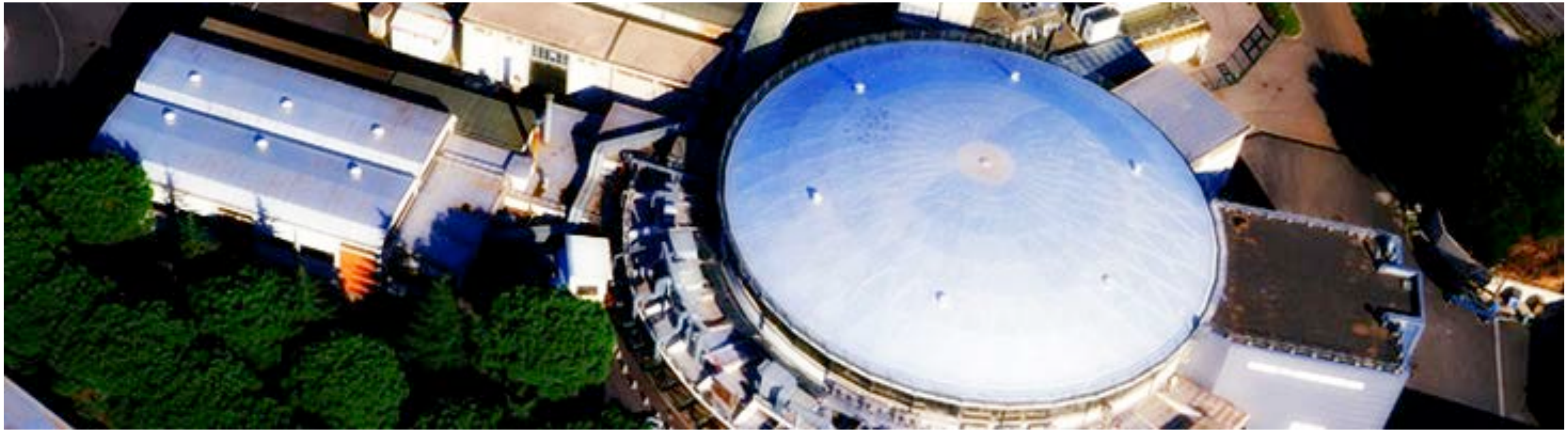


INFN – Frascati National Laboratory

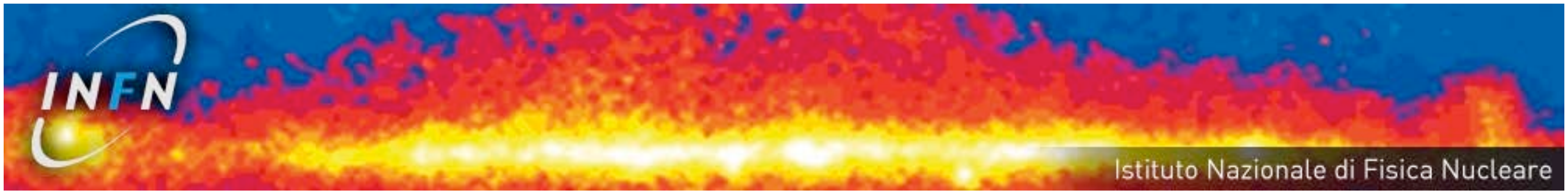
P.Gianotti

INFN Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

The Italian Institute for Nuclear Physics

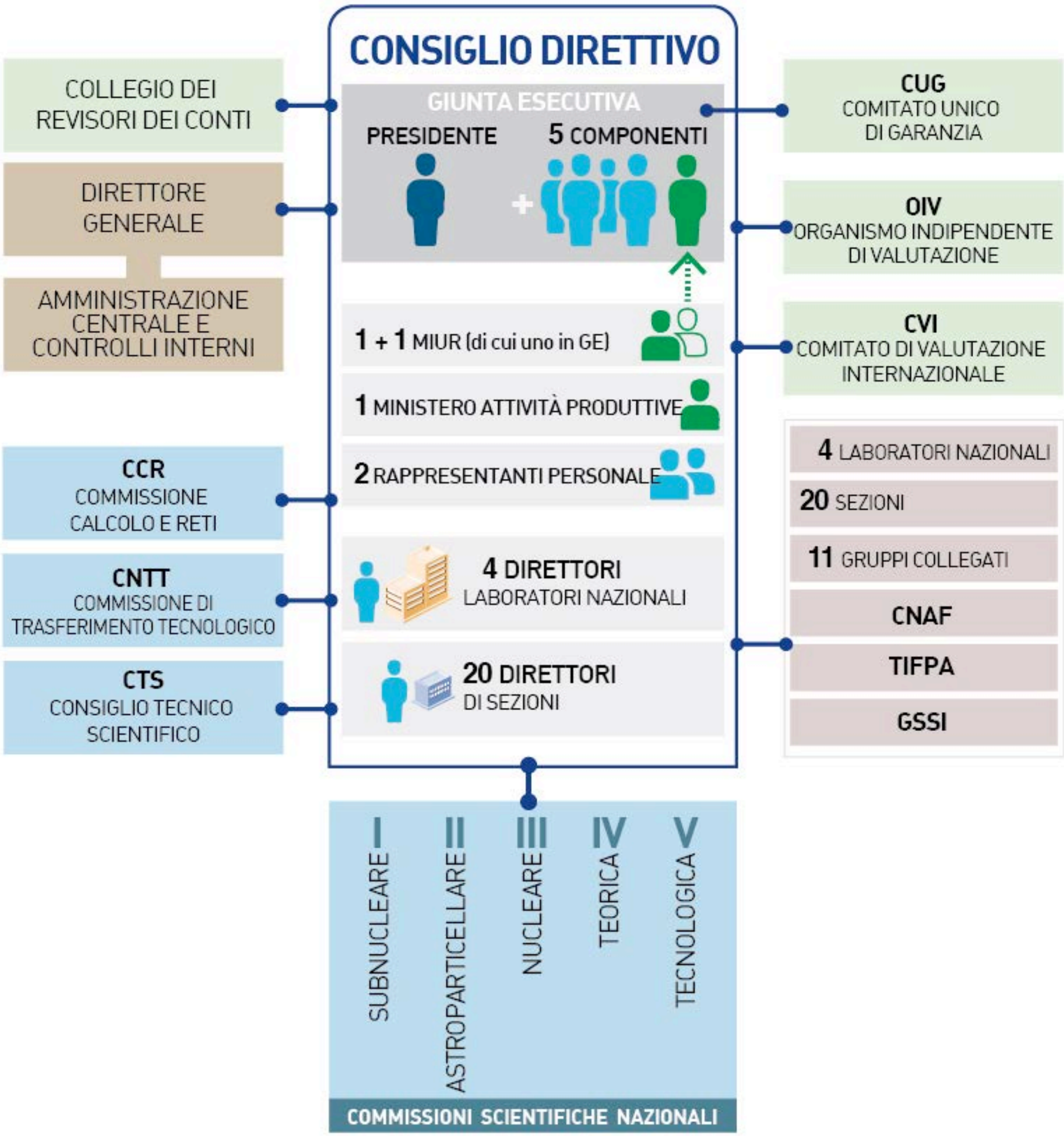
The National Institute for Nuclear Physics (INFN) is the Italian research agency that study the **fundamental constituents of matter and the forces** that govern them.

- It conducts **theoretical** and **experimental** research in the fields of **subnuclear**, **nuclear** and **astroparticle** physics.
- Fundamental research in these areas requires the use of **cutting-edge technology and instruments,** developed by the INFN at its own laboratories and in collaboration with industries.
- All of the INFN’s research activities are undertaken within a framework of an international environment, in close collaboration with Italian universities.



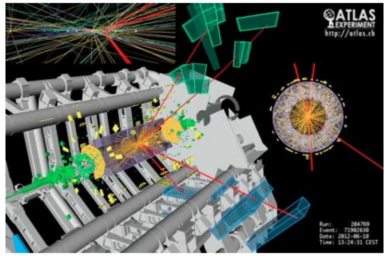
Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

INFN organization

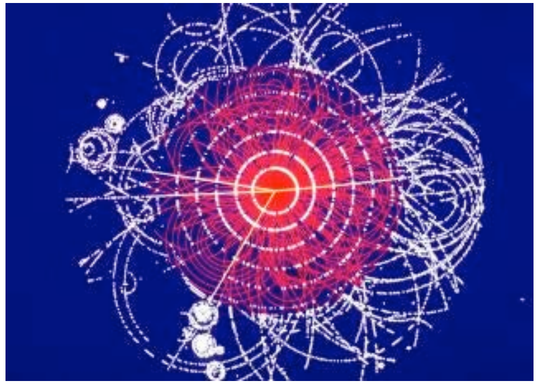


INFN
Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

INFN organization



CSN1 studies **fundamental interactions** of matter in experiments using **particle accelerators**.
At present, the best theory scientists have to describe our knowledge of subnuclear physics is the **Standard Model**.
Scientists are hopeful that ongoing experiments will also enable them to discover **new phenomena**.



At present, the main subject of research is the search for **supersymmetric particles**, which could be candidates for the Universe dark matter, and the discovery of new signals that explain the **asymmetry between matter and antimatter** in our universe, or proof of the existence of further space-time dimensions.

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di Fisica Nucleare
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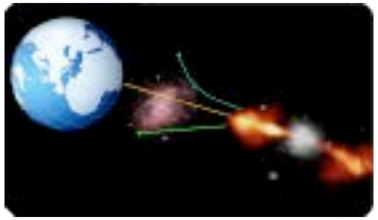
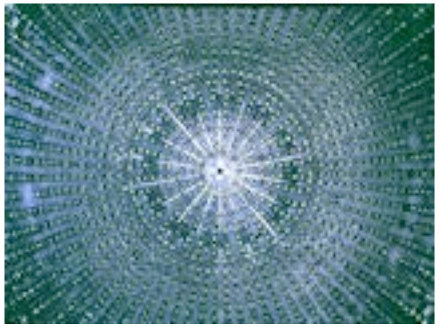
INFN organization

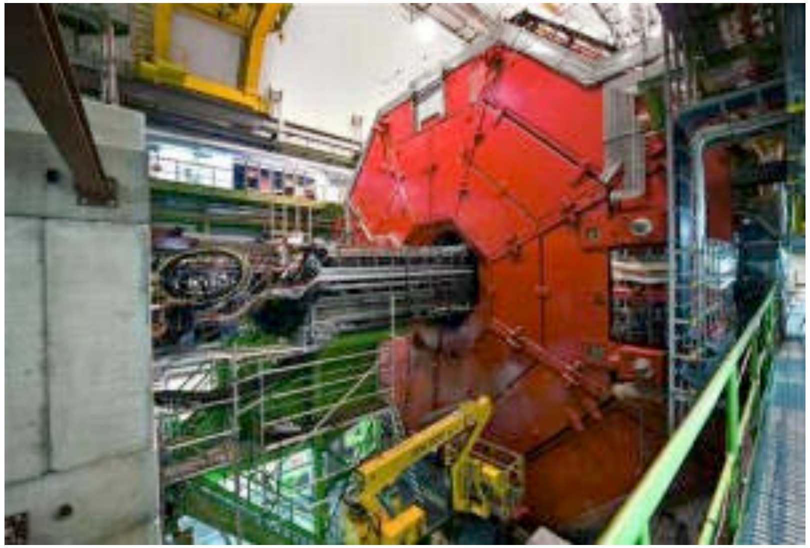


CSN2 coordinates research in the field of **astroparticle physics**.
Laboratories on the ground, underground, under the sea, at high altitudes and in space provide the natural settings to study cosmic background radiation, cosmic rays, neutrinos, gravitational waves, very-high-energy gamma rays, other rare particles that could provide important clues to explain the matter-antimatter asymmetry in the universe, and particles that are thought to constitute the dark matter.



INFN organization

CSN3 coordinates research into the structure and dynamics of nuclear matter.

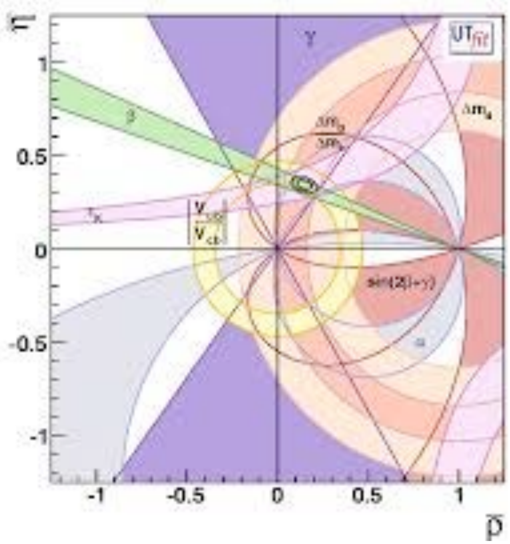


Current experiments use **high-energy particle collisions** to study how the elementary particles of matter, quarks, come together to form the **nuclei of atoms.**

The knowledge of nuclear reactions is also used for applications of nuclear techniques in different fields: energy, art, medicine.

INFN organization

CSN4 coordinates **theoretical physics research**, which is concerned with developing hypotheses, models and physics theories to explain the results of experiments and open up new scenarios for physics.

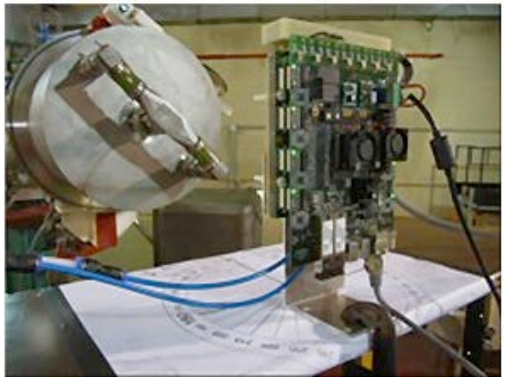


Theoretical physicists are currently mainly engaged in researching on the **origin of the mass**, on the nature and characteristics of the **dark matter**, on the explanation of the **matter-antimatter asymmetry** in the universe and the fundamental quantum unification of all interactions, including gravity.

INFN organization

CSN5 coordinates technological research and promotion of the use of fundamental physics instruments, methods and technologies for socio-economic sectors:

- industrial and medical application of accelerators;
- medical imaging, cancer treatment, dosimetry and the study of cell growth and neurological models;
- Cultural heritage and environment monitoring;



A bit of history...

In1937, Fermi proposed to the CNR to constitute an Italian Institute of Radioactivity

UNIVERSITA' DI ROMA

Istituto di Fisica

Roma, 29 gennaio 1937-XV

Onorevole Consiglio Nazionale delle Ricerche

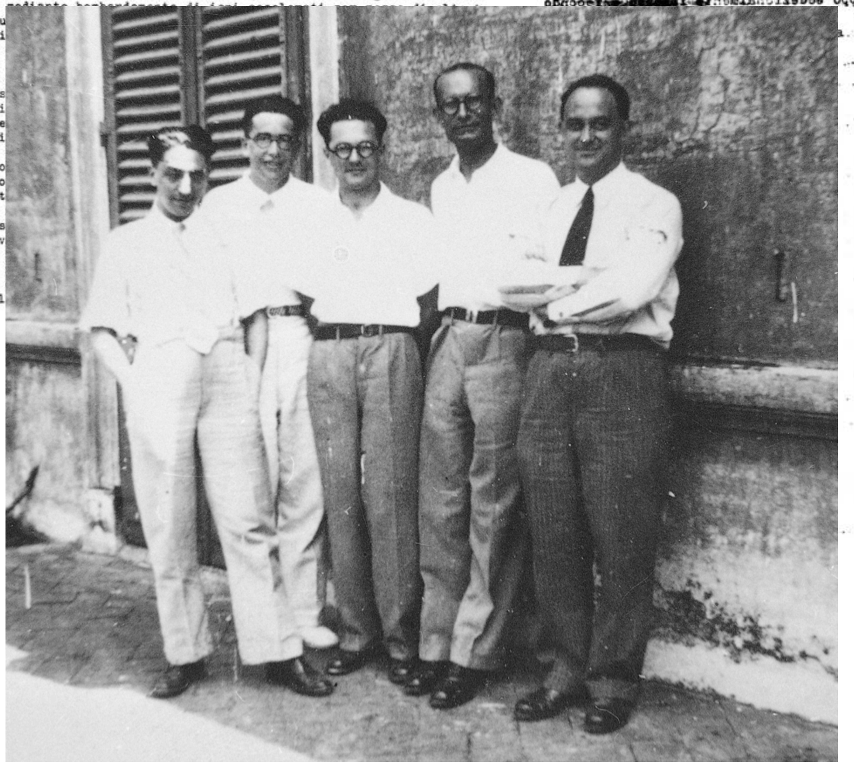
- R O M A -

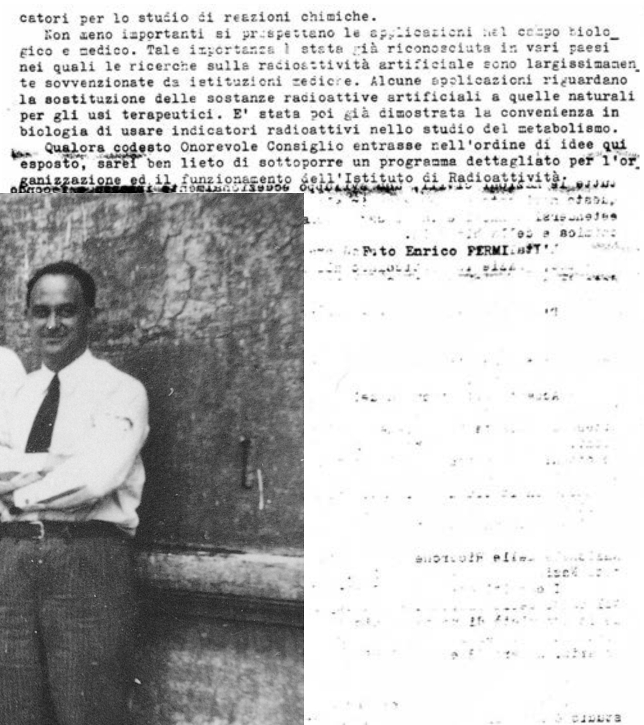
Le ricerche di Radioattività hanno avuto negli ultimi anni, pres[so] tutte le nazioni civili, uno sviluppo eccezionalmente intenso e fecond[o] quest[o] sviluppo non accenna in alcun modo a declinare, ma tende anzi [a] estendersi a nuovi e vasti campi non solo della fisica, ma anche della chimica e della biologia.

L'Italia ha avuto fino ad ora una posizione preminente in queste ricerche, grazie in particolare all'illuminato aiuto che ad esse è stat[o] dato da codesto Onorevole Consiglio ed è ovvio l'interesse scientifico nazionale che il nostro Paese non perda questa favorevole situazione.

D'altra parte la tecnica radioattiva ha potuto fino ad ora impie[ga]re in gran parte come sorgenti primarie le sostanze radioattive natural[i]. In questa fase i mezzi ordinari di un laboratorio fisico universitario hanno potuto, con limitati aiuti esterni, essere sufficienti allo svilu[p]po delle ricerche.

Accanto alla tecnica delle sorgenti naturali si è però andata sv[i]luppando in tutti i grandi paesi esteri quella delle sorgenti artificia[li] ottenute ...



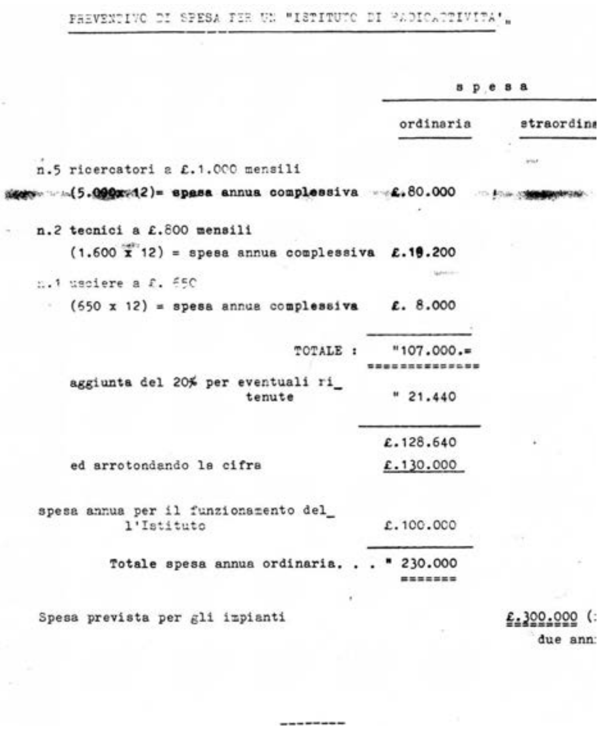


catori per lo studio di reazioni chimiche.

Non meno importanti si prospettano le applicazioni nel campo biolo_gico e medico. Tale importanza è stata già riconosciuta in vari paesi nei quali le ricerche sulla radioattività artificiale sono largissimamen_te sovvenzionate da istituzioni mediche. Alcune applicazioni riguardano la sostituzione delle sostanze radioattive artificiali a quelle naturali per gli usi terapeutici. E' stata poi già dimostrata la convenienza in biologia di usare indicatori radioattivi nello studio del metabolismo.

Qualora codesto Onorevole Consiglio entrasse nell'ordine di idee qui esposto, sarei ben lieto di sottoporre un programma dettagliato per l'or_ganizzazione ed il funzionamento dell'Istituto di Radioattività.

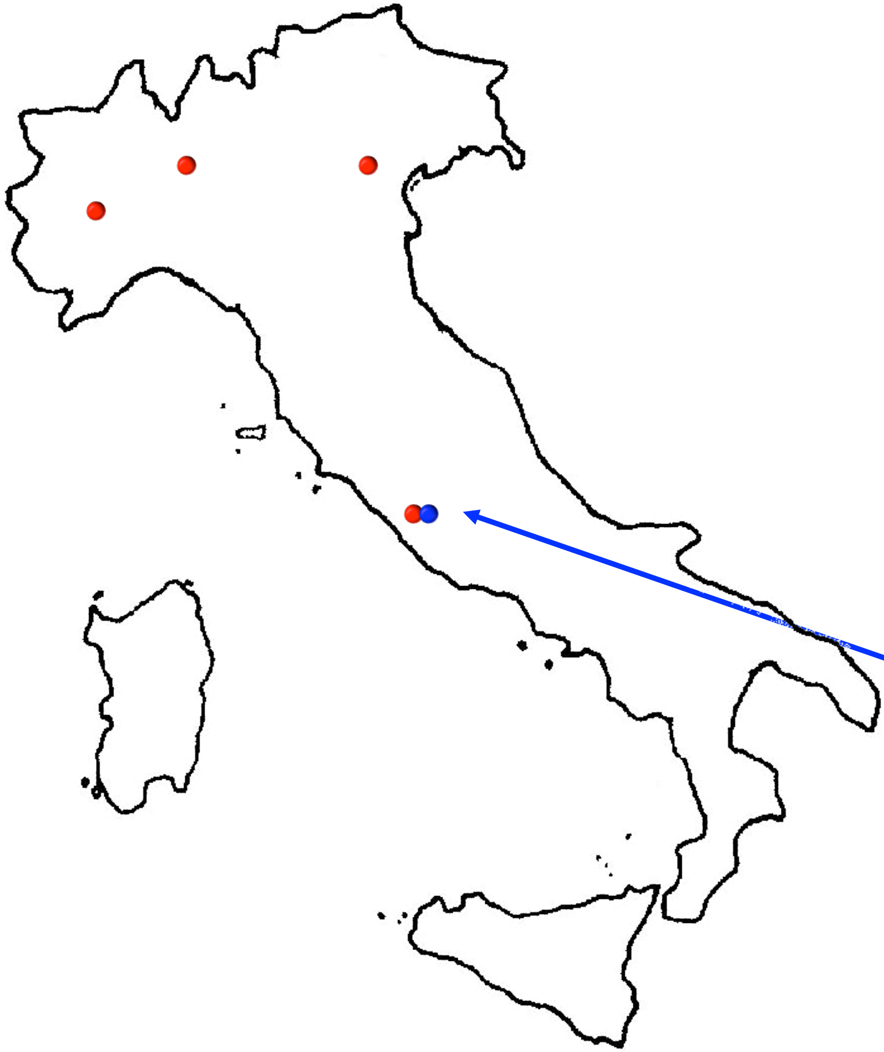
F.to Enrico FERMI



PREVENTIVO DI SPESA PER UN "ISTITUTO DI RADIOATTIVITA'.

	spesa ordinaria	spesa straordina[ria]
n.5 ricercatori a £.1.000 mensili (5.000x12)= spesa annua complessiva	£.80.000	
n.2 tecnici a £.800 mensili (1.600 x 12) = spesa annua complessiva	£.19.200	
n.1 usciere a £. 650 (650 x 12) = spesa annua complessiva	£. 8.000	
TOTALE :	"107.000.=	
aggiunta del 20% per eventuali ri_tenute	" 21.440	
	£.128.640	
ed arrotondando la cifra	£.130.000	
spesa annua per il funzionamento del_l'Istituto	£.100.000	
Totale spesa annua ordinaria. . .	" 230.000	
Spesa prevista per gli impianti		£.300.000 (... due ann[i])

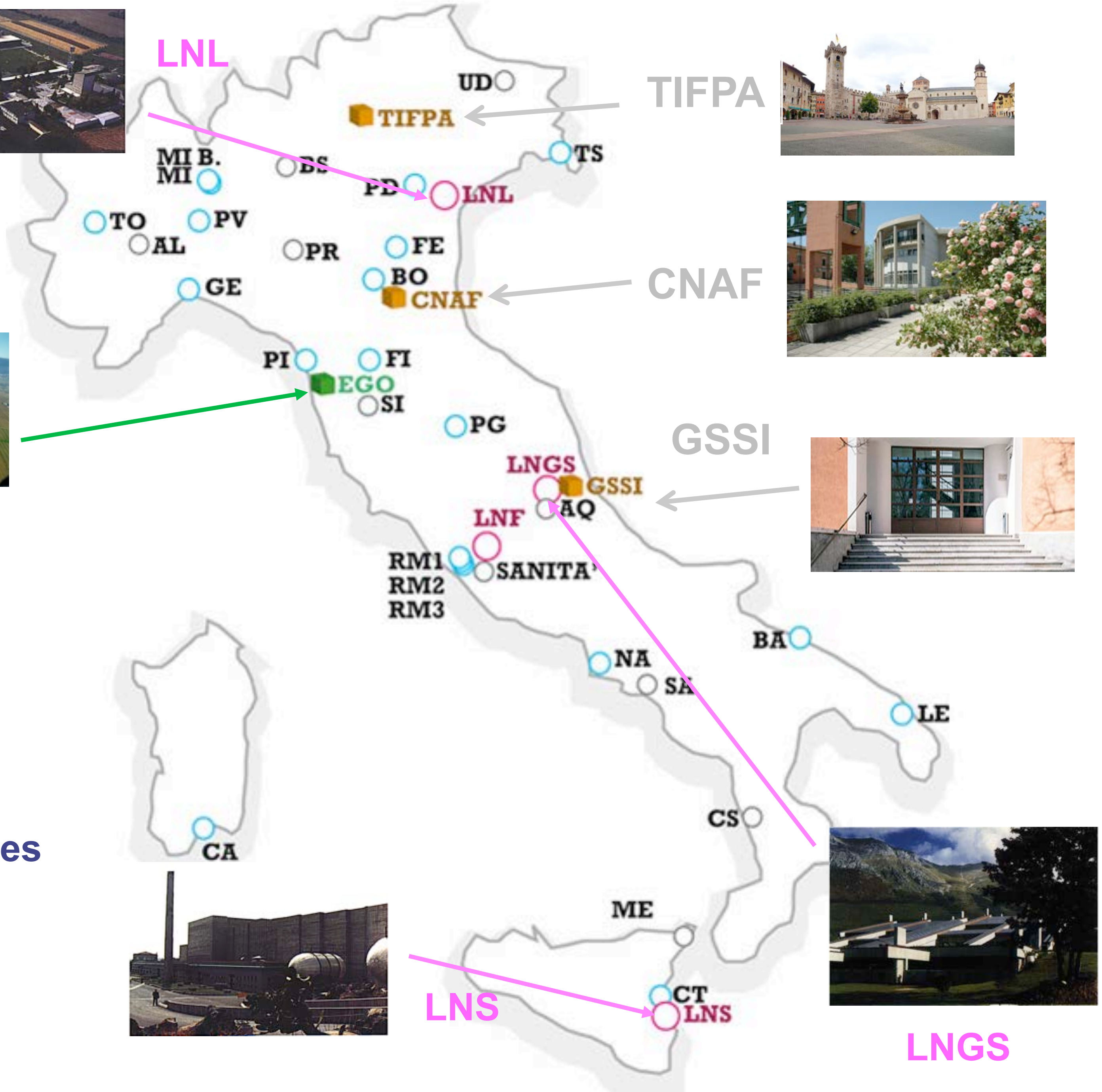
Born of INFN

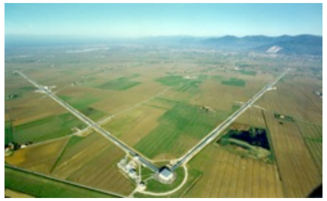


1951
4 University Groups
Milano, Torino, Padova, e Roma

1957
Frascati National Lab is founded

Frascati





VIRGO-EGO
European
Gravitational
Observatory

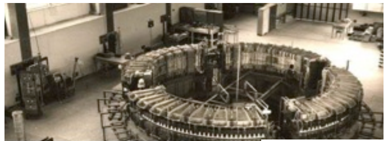
20 divisions at university sites

4 National Laboratories
- CNAF
- EGO
- GSSI
- TIFPA

The LNF accelerators history

INFN Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

Electron Synchrotron (1959-1975) E=1 GeV



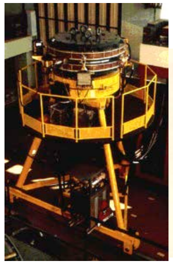
LNF-54/48 (1954)

Il progetto italiano di un elettrosincrotone.

G. Salvini

Istituto di Fisica dell'Università - Pisa
Istituto Nazionale di Fisica Nucleare - Sezione Acceleratore

AdA 1960-1965
250 MeV



The Frascati Storage Ring.

C. Bernardini, G. F. Corazza, G. Ghigo
Laboratori Nazionali del CNEN - Frascati

B. Touschek
Istituto di Fisica dell'Università - Roma
Istituto Nazionale di Fisica Nucleare - Sezione di Roma

(ricevuto il 7 Novembre 1960)

ADONE (1968- 1993)
3 GeV 100 m

DAFNE (1999)
510 MeV 100 m

SPARC_LAB (2004)
150 MeV LINAC

N. Cabibbo

VOLUME 124, NUMBER 5

Electron-Positron Colliding Beam Experiments

N. Cabibbo and R. Gatto
Istituti di Fisica delle Università di Roma e di Cagliari, Italy and Laboratori Nazionali di Frascati del C.N.E.N., Frascati, Roma, Italy
(Received June 8, 1961)

the "bible"

AdA was the first matter antimatter storage ring with a single magnet (weak focusing) in which e+/e- were stored at *250 MeV*

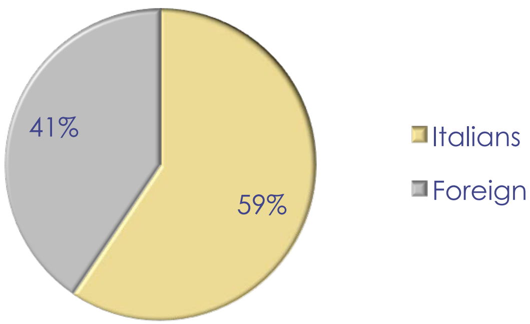
1961	AdA	Frascati	Italy
1964	VEPP2	Novosibirsk	URSS
1965	ACO	Orsay	France
1969	ADONE	Frascati	Italy
1971	CEA	Cambridge	USA
1972	SPEAR	Stanford	USA
1974	DORIS	Hamburg	Germany
1975	VEPP-2M	Novosibirsk	URSS
1977	VEPP-3	Novosibirsk	URSS
1978	VEPP-4	Novosibirsk	URSS
1978	PETRA	Hamburg	Germany
1979	CESR	Cornell	USA
1980	PEP	Stanford	USA
1981	Sp-pbarS	CERN	Switzerland
1982	p-pbar	Fermilab	USA
1987	TEVATRON	Fermilab	USA
1989	SLC	Stanford	USA
1989	BEPC	Beijing	China
1989	LEP ,	CERN,	Switzerland
1992	HERA	Hamburg	Germany
1994	VEPP-4M	Novosibirsk	Russia
1999	DAΦNE	Frascati	Italy
1999	KEKB	Tsukuba	Japan
2000	RHIC	Brookhaven	USA
2003	VEPP-2000	Novosibirsk	Russia
2008	BEPCII	Beijing	China
2009	LHC	CERN	Switzerland

colliders in the world

The Frascati INFN National Laboratory

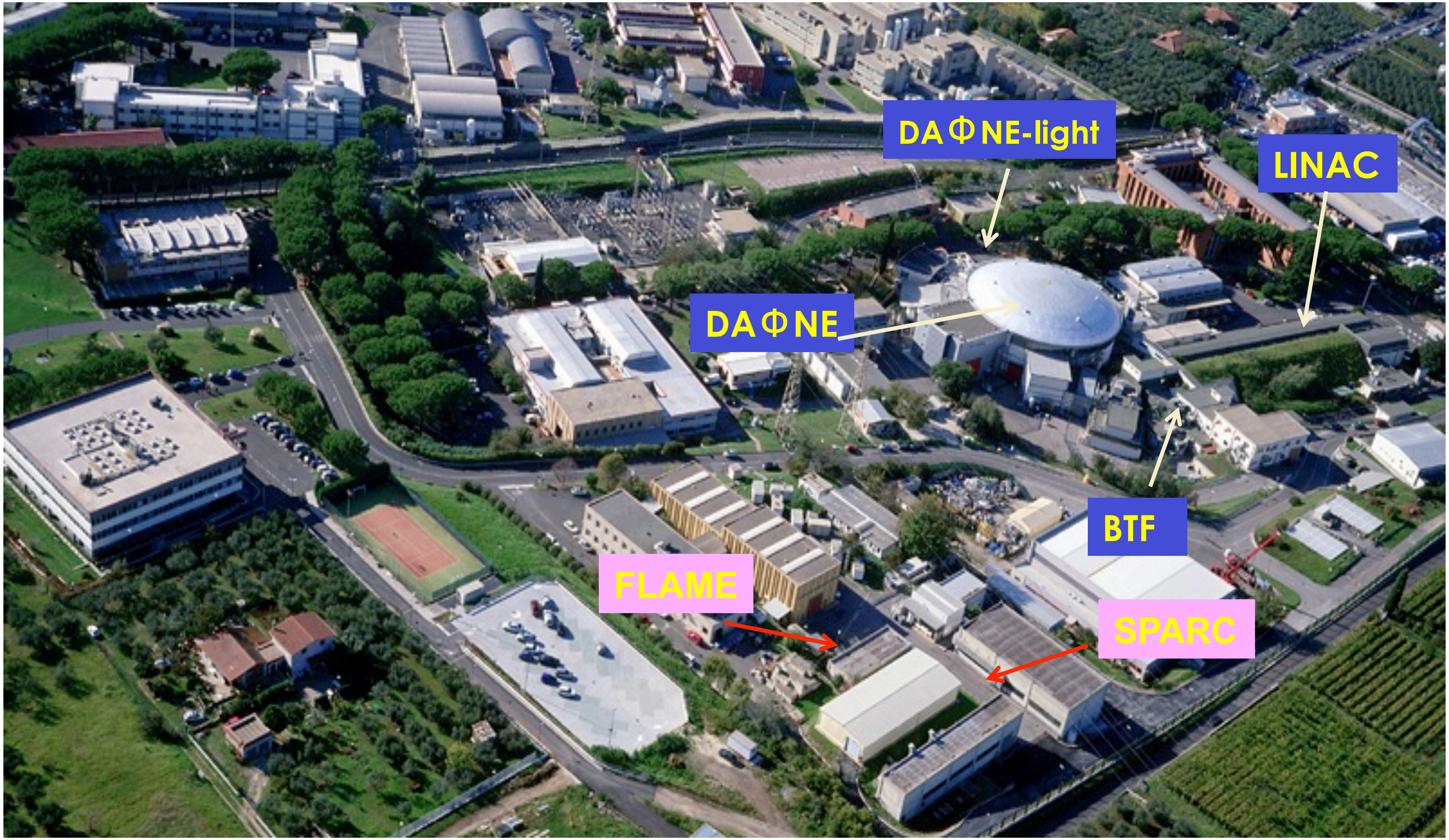
Total Staff **280**	Researchers 76	Technologists Engineers 35	Technicians 137	Administration Services 32
External Users **549**	Italian 404		Foreign 145	
Visitors **5200**	Stages 259	Conferences Workshops 16	Seminars 20	High school Teachers 210

Conferences and workshops participants
year 2013
TOT 822

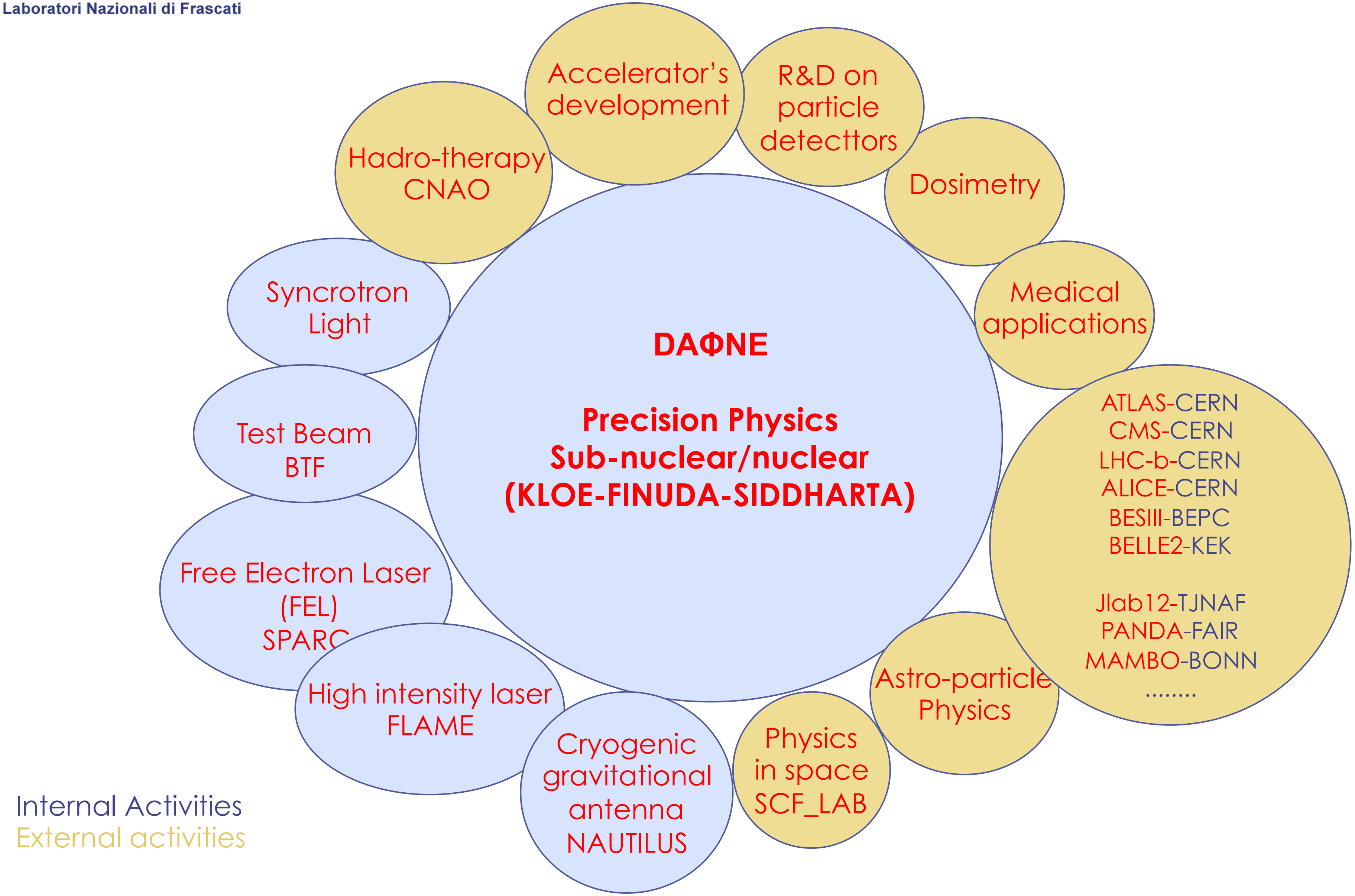


Hadron Physics 2 In FP7 (termimato Dicembre 2011)
Transnational Access 1880 giorni assegnati 2009 1673 giorni assegnati 2010 2853 giorni assegnati 2011

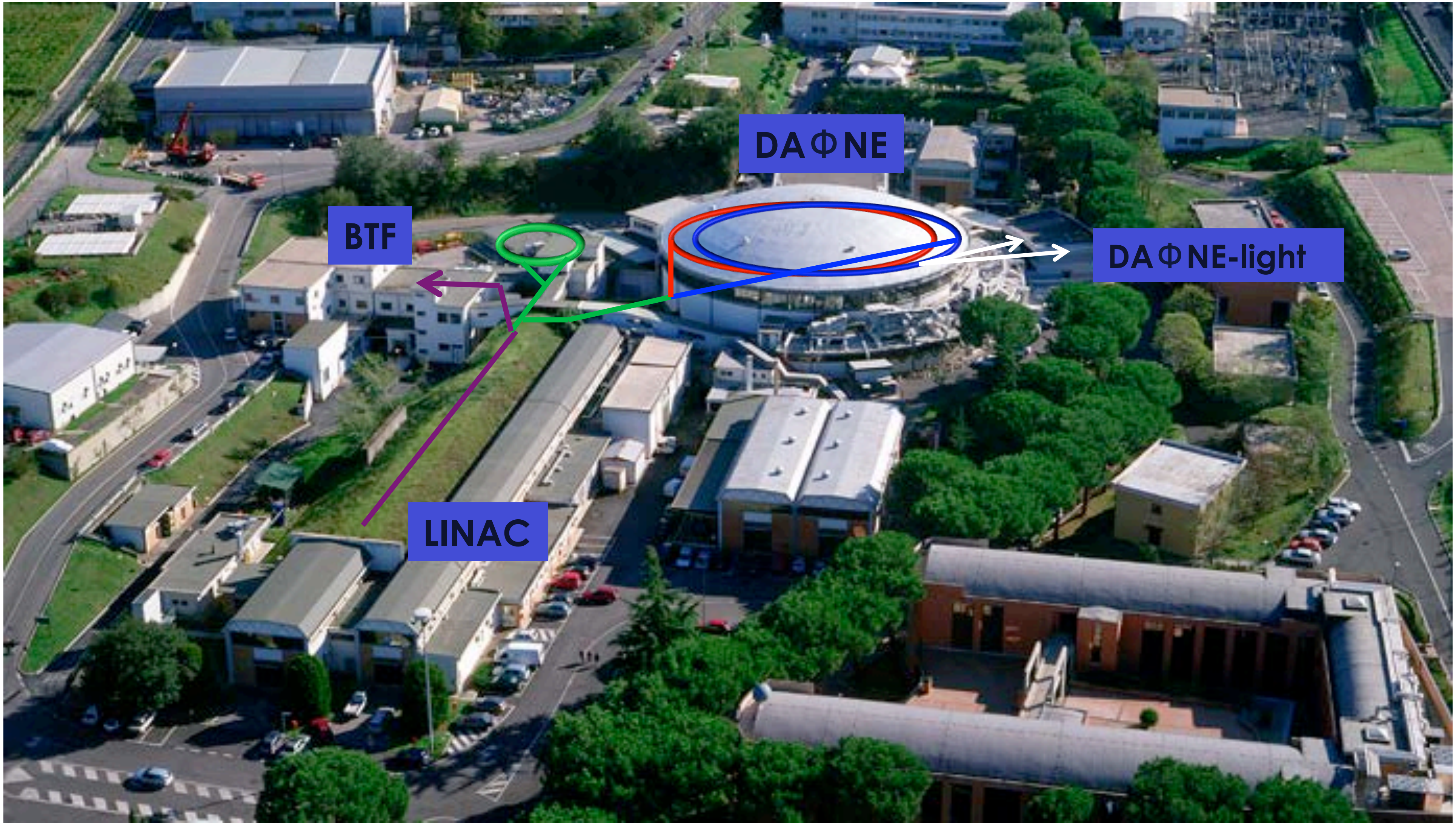
LNF Accelerators and infrastructures



The LNF research areas

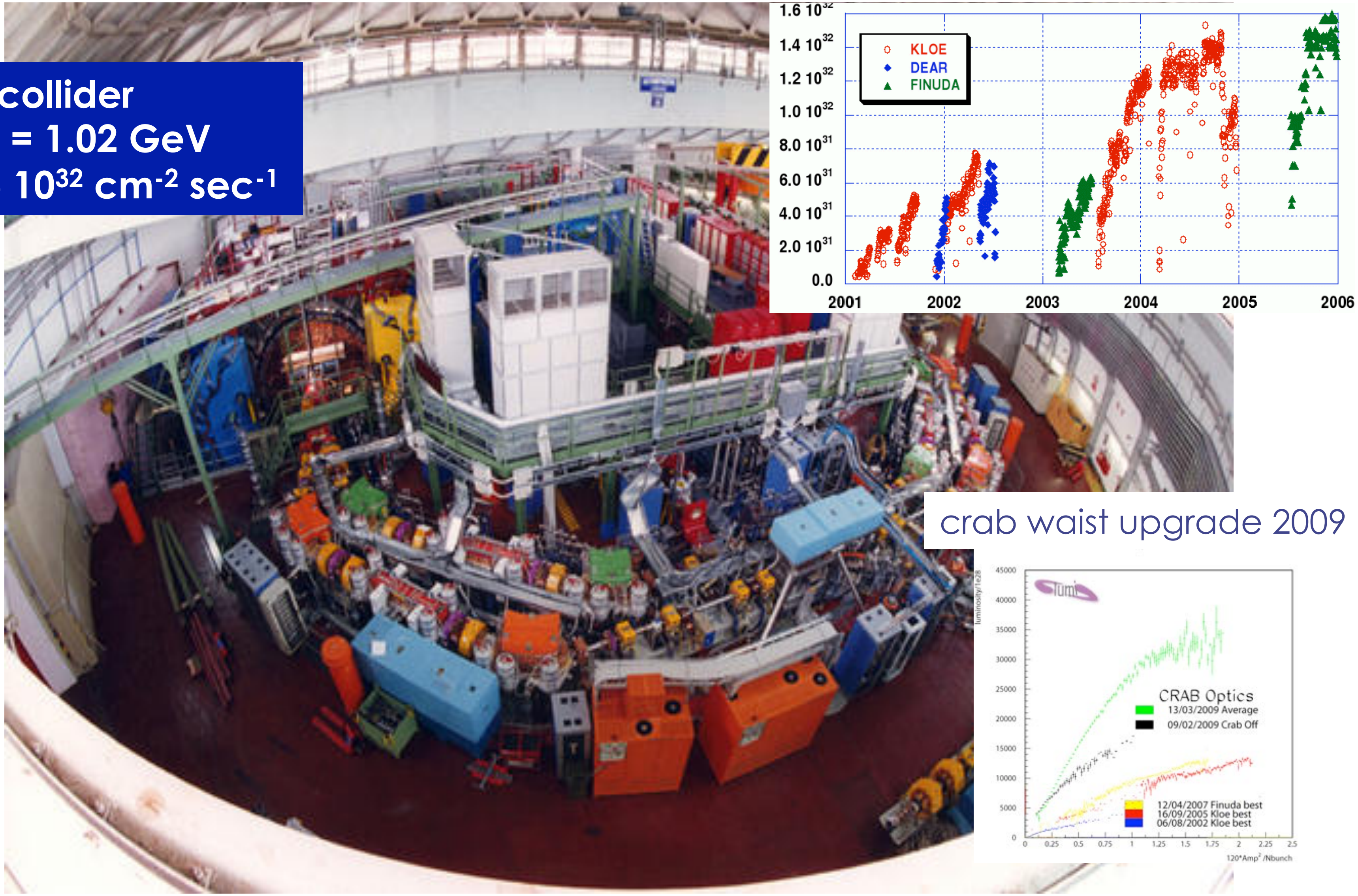


The Φ-Factory complex



The DAΦNE collider

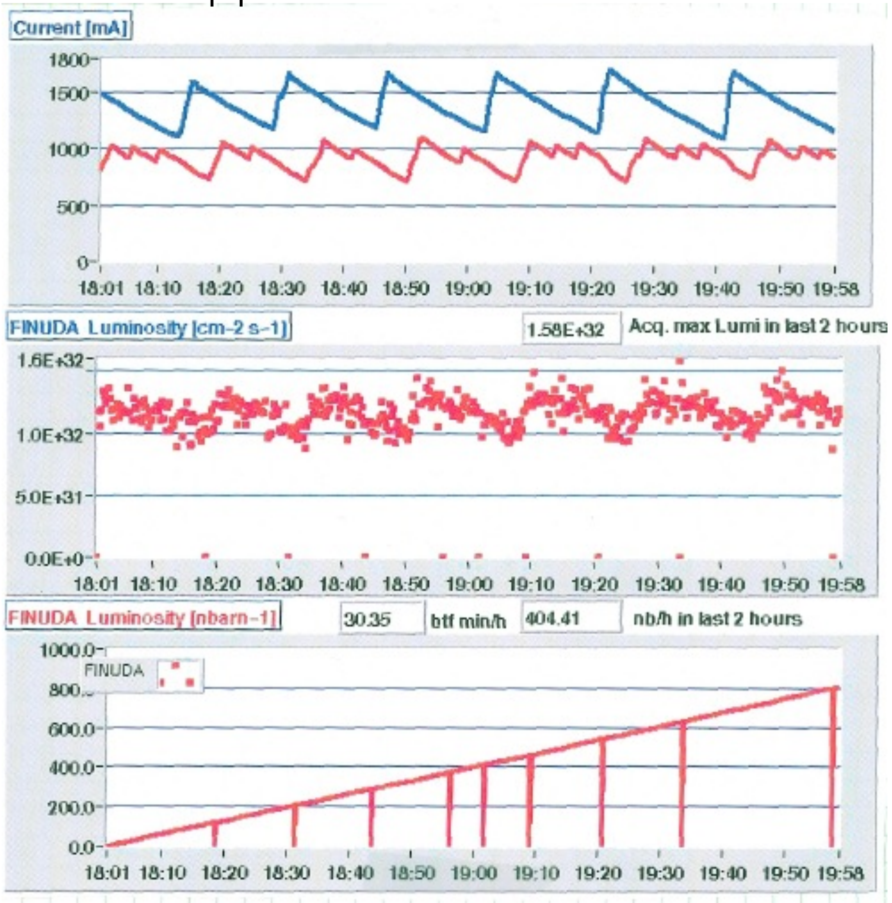
e+ e- collider
E c.m. = 1.02 GeV
L = 4.5 10^{32} cm^{-2} sec^{-1}



crab waist upgrade 2009

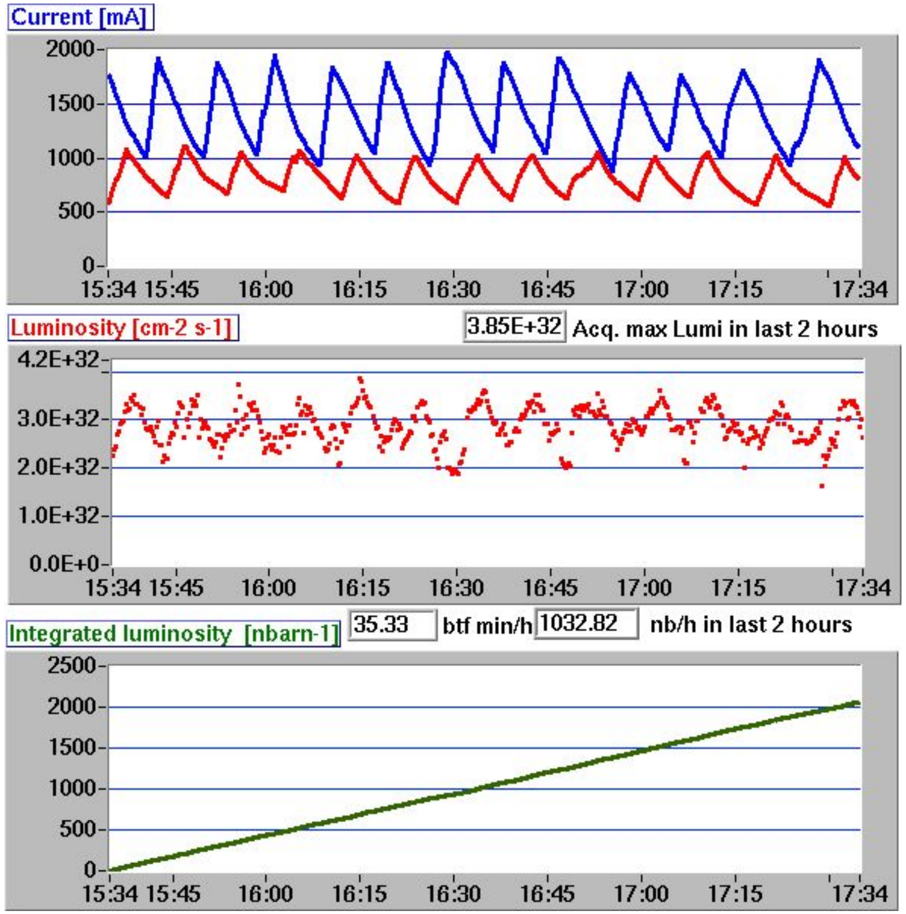
DAFNE gain in luminosity with micro-beam, large crossing angle and crab waist

KLOE classical with apparatus solenoidal field



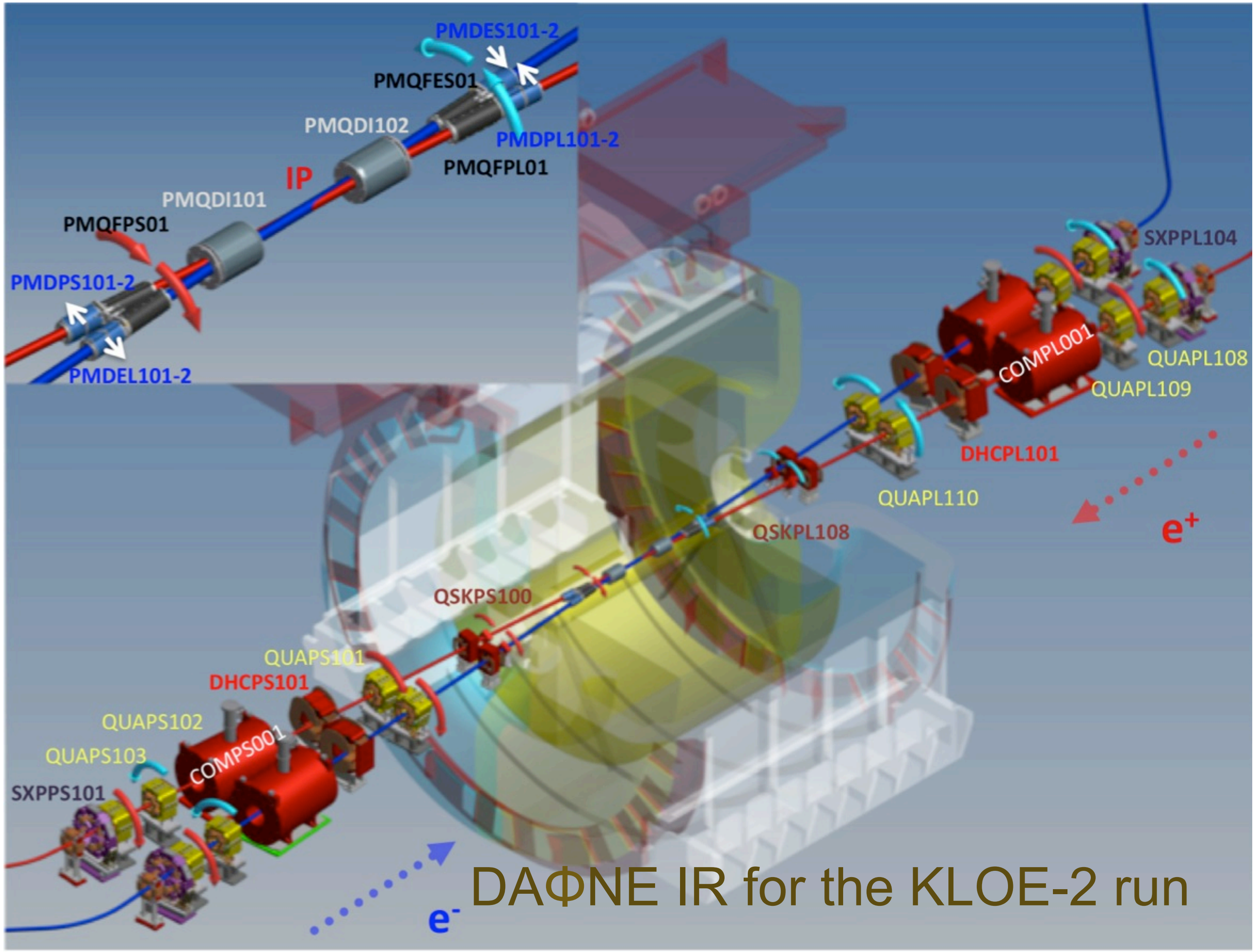
L_{max} =1.7 10^{32} cm^{-2} sec^{-1}
0.4 $pbarn^{-1}$ / hour

Siddharta CRAB waist without solenoidal field

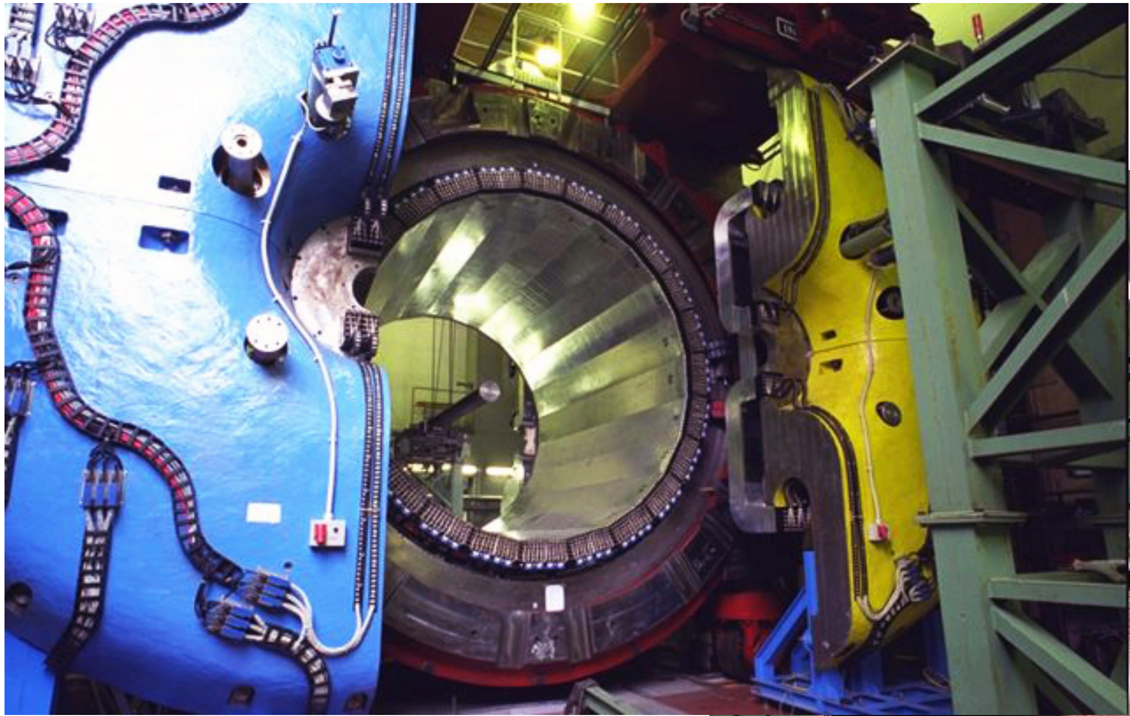


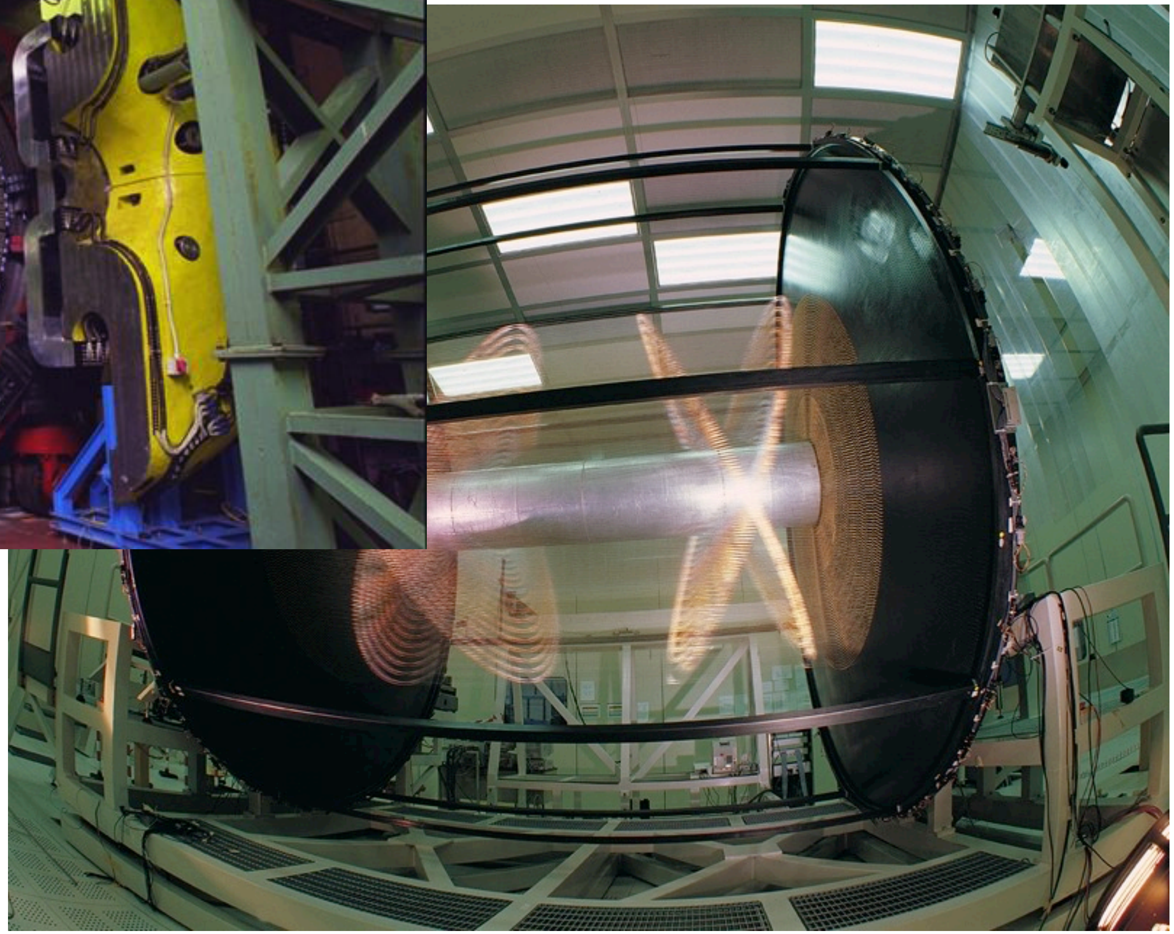
L_{max} = 4.5 10^{32} cm^{-2} sec^{-1}
1.0 $pbarn^{-1}$ / hour

DAΦNE colliding scheme for KLOE2



The KLOE detector





KLOE-2 Physics Program

"Natural" extension of the KLOE program in the field of flavour and hadronic physics, with some additions, such as $\gamma\gamma$ **interactions, or searches for new light gauge bosons.**

Studies on **CPT** and **QM violation** with neutral kaons **interferometry**

Tests of **Lepton Flavor Violation** with K_{e2} decays

Studies on **C, P, CP** violation using rare η and K_S decays

Tests of **Chiral Perturbation Theory** with η, η', and K_S decays

Searches for signals of a **Secluded Gauge Symmetry**

Most of them involve decay processes at or very close the interaction point ⇨

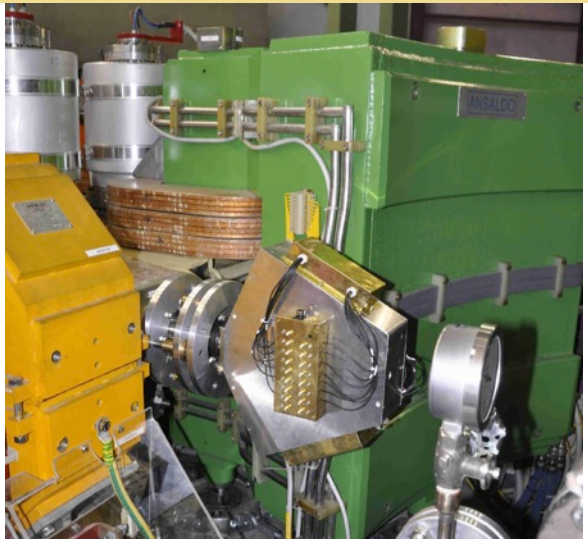
- Charged vertex efficiency near the IP
- Acceptance for photons emitted at low polar angles

INFN Istituto Nazionale di Fisica Nucleare
Laborat

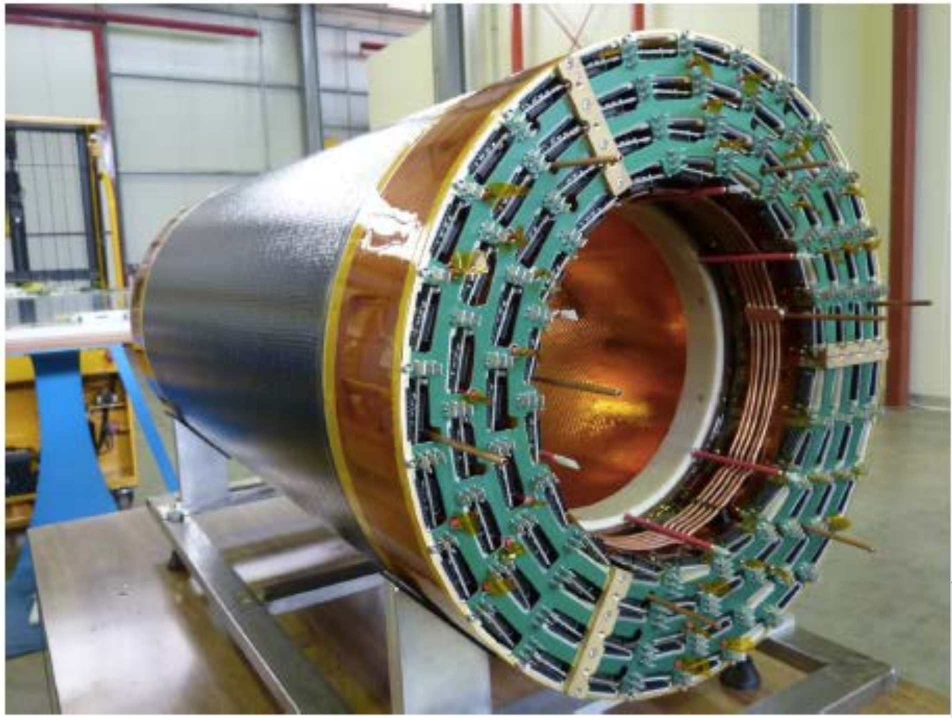
KLOE-2

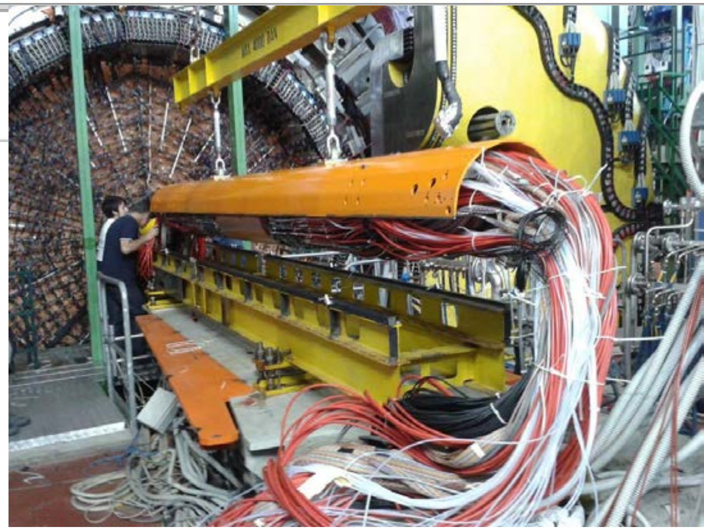
Taggers for γγ reactions installed.

Low and high energy
Tagger installations



New KLOE inner tracker: 4 layers cylindrical GEM (world first)





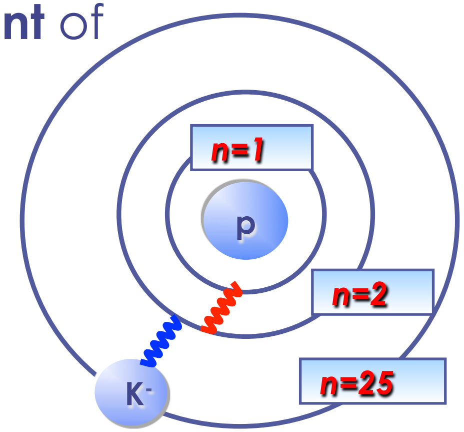
SIDDHARTA

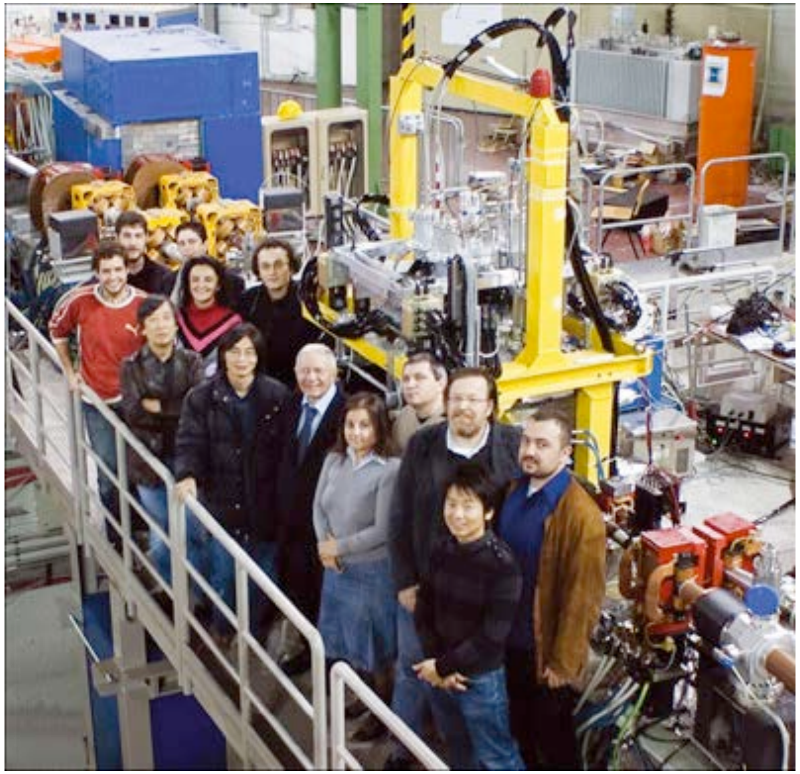
SIlicon Drift Detector for Hadronic Atom Research by Timing Applications

The goal is the determination of the isospin dependent $\bar{K}N$ scattering lengths through a precision measurement of the **shift** and of the **width**

(induced by the strong interaction)

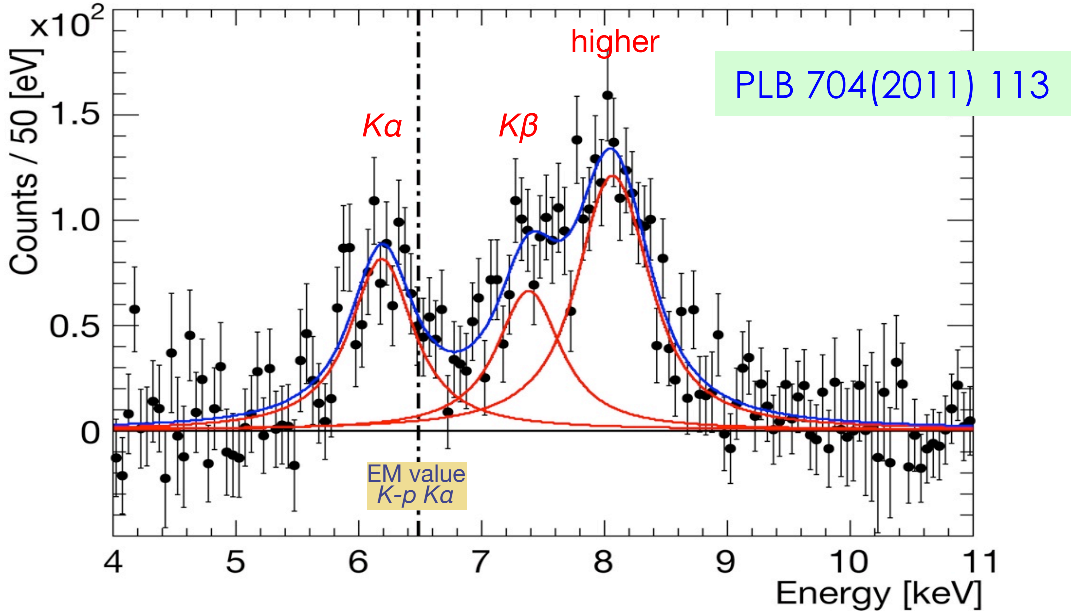
of the K_α line of kaonic hydrogen and the **first measurement** of kaonic deuterium

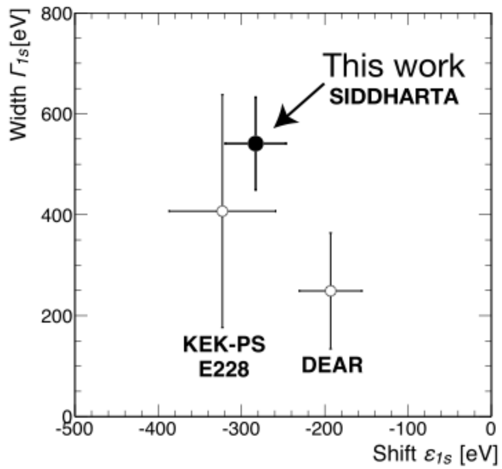




Measuring the $\bar{K}N$ scattering lengths with the precision of a few percent will improve the knowledge of low-energy $\bar{K}N$ phenomenology and provide a clear assessment of the SU(3) chiral effective Lagrangian approach to low energy hadron interactions.

Kaonic-hydrogen results



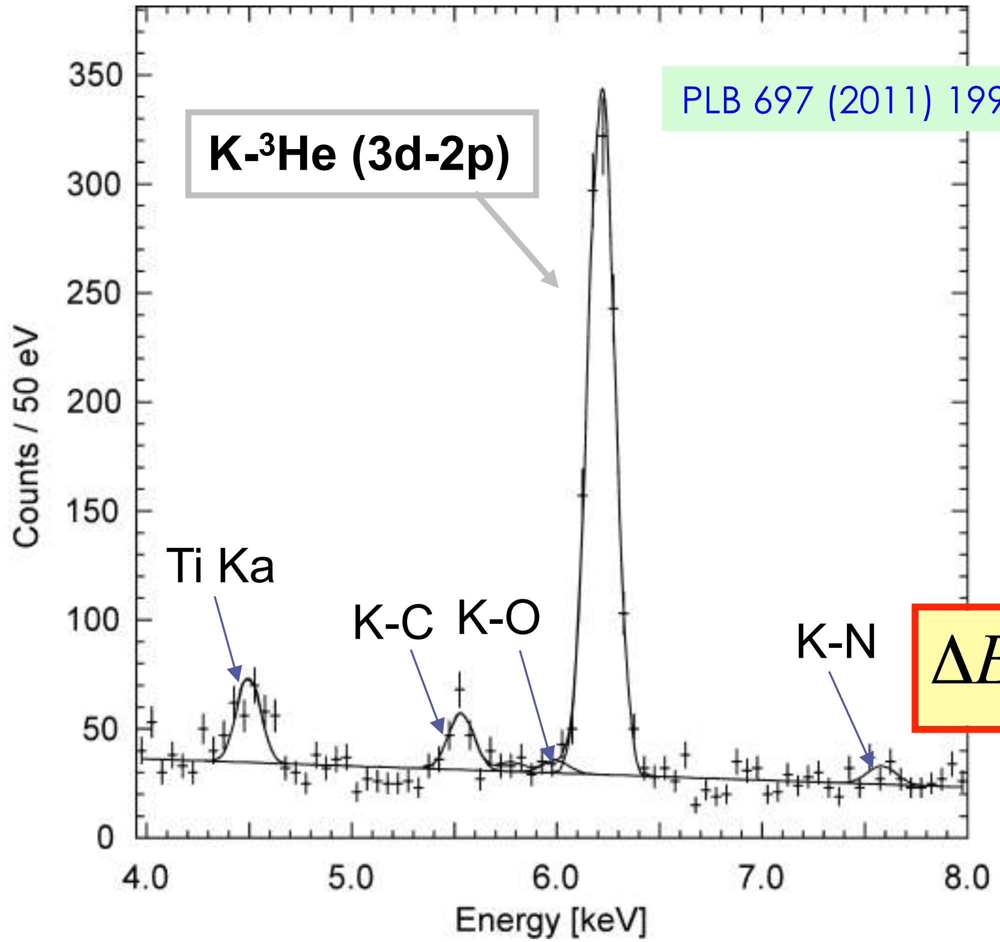


ε_{1S}= −283 ± 36(stat) ± 6(syst) eV

Γ_{1S}= 541 ± 89(stat) ± 22(syst) eV

This is the most precise measurement done up to now of the strong-interaction energy-level shift and width of the 1s atomic state.

K-^{3}He results



PLB 697 (2011) 199

X-ray energy of K-3He 3d-2p

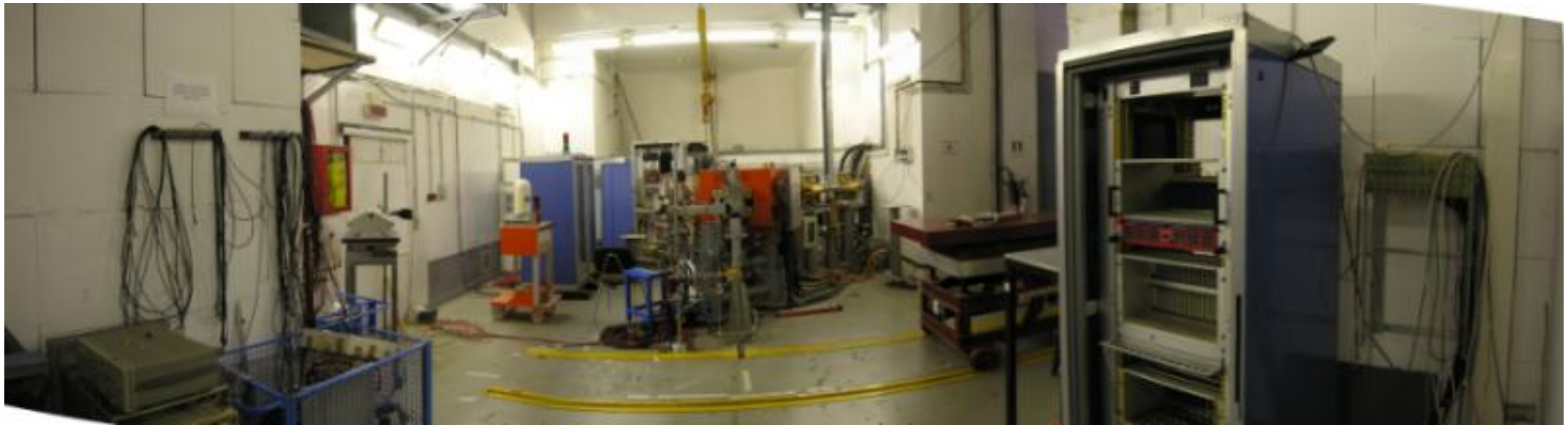
QED value: $E_{e.m.} = 6224.6 \text{ eV}$

$$\Delta E_{2p} = E_{\exp} - E_{e.m.}$$

$$\Delta E_{2p} = -2 \pm 2(sta) \pm 4(sys) \text{ eV}$$

World First !
Observation of K-^{3}He X-rays
Determination of strong-interaction shift

Beam Test Facility (BTF) Infrastructure



The Frascati **Beam Test Facility** infrastructure is a beam extraction line optimized to produce **electrons**, **positrons**, **photons** and **neutrons** mainly for HEP detector **calibration** purposes. The quality of the beam, energy and intensity is also of interest for **experiments** (~ 20% of the users) studying the **electromagnetic interaction with matter**

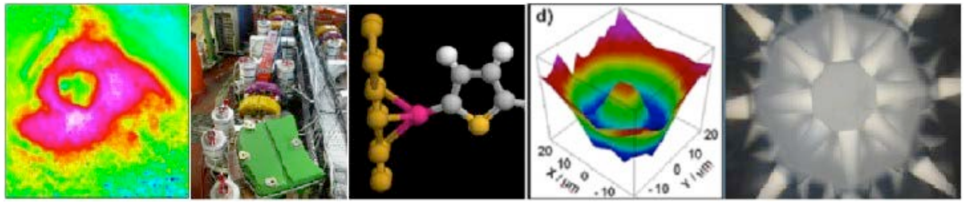
Beam Test Facility e^+/e^- characteristic

	parasitic	dedicated
Number (particles/pulse)	$1 \div 10^5$	$1 \div 10^{10}$
Energy (MeV)	25-500	$25 \div 750$
Repetition rate (Hz)	20-50	50
Pulse Duration (ns)	10	1 or 10
p resolution	1%	
Spot size (mm)	$s_{x,y} \approx 2$ (single particle)	
Divergence (mmrad)	$s'_{x,y} \approx 2$ (single particle)	

Main applications

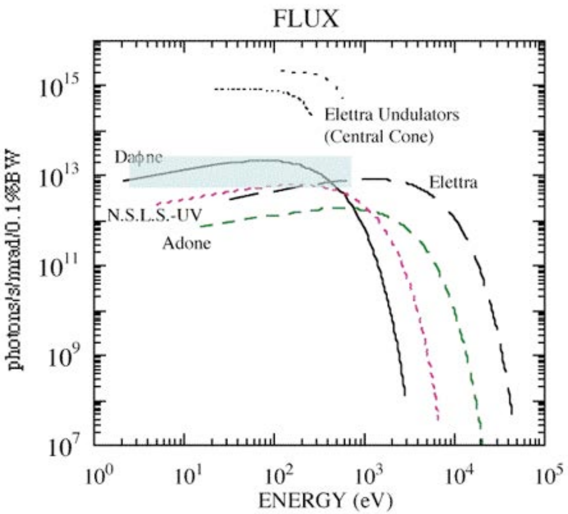
- HEP detector calibration and setup
- Low energy calorimetry & resolution
- Low energy electromagnetic interaction studies
- High multiplicity efficiency
- Detectors aging and efficiency
- Beam diagnostics

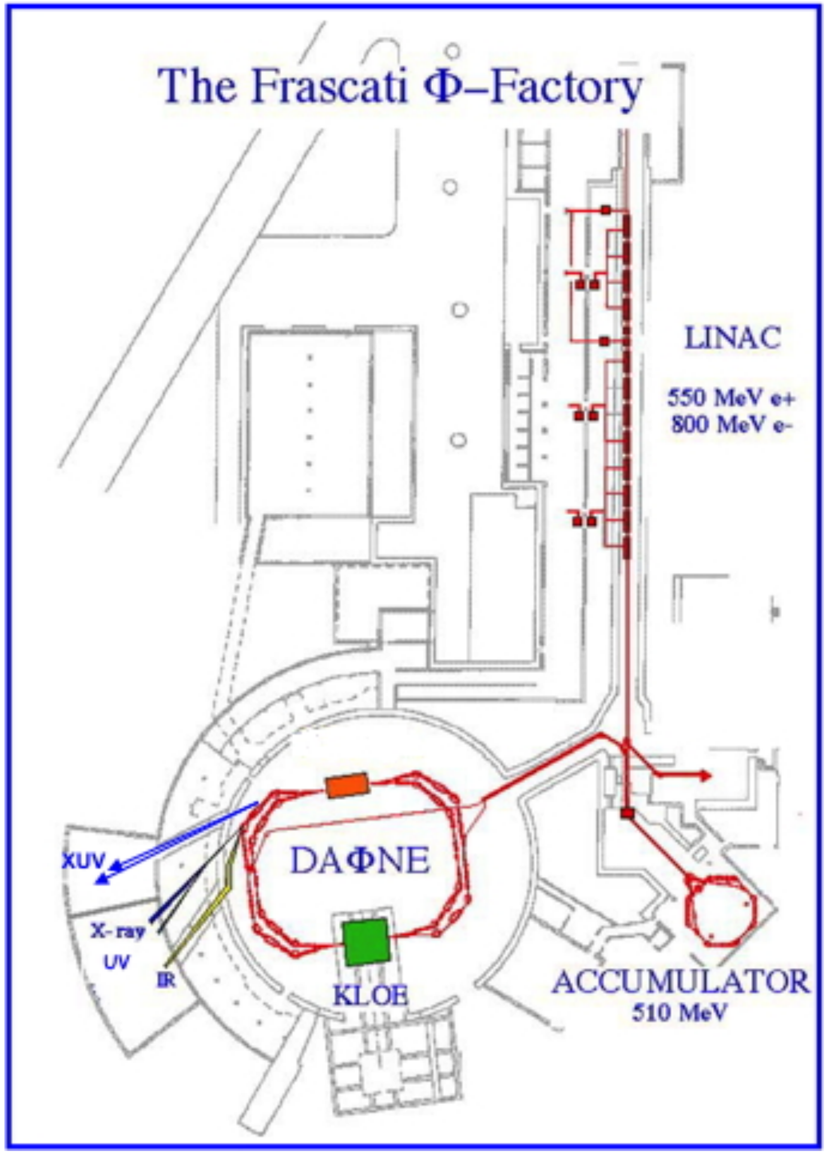
Beamlines @ DAΦNE-Light



DXR1 Soft X-ray beamline
DXR2 UV beamline
SINBAD InfraRed beamline
DXUV XUV beamlines

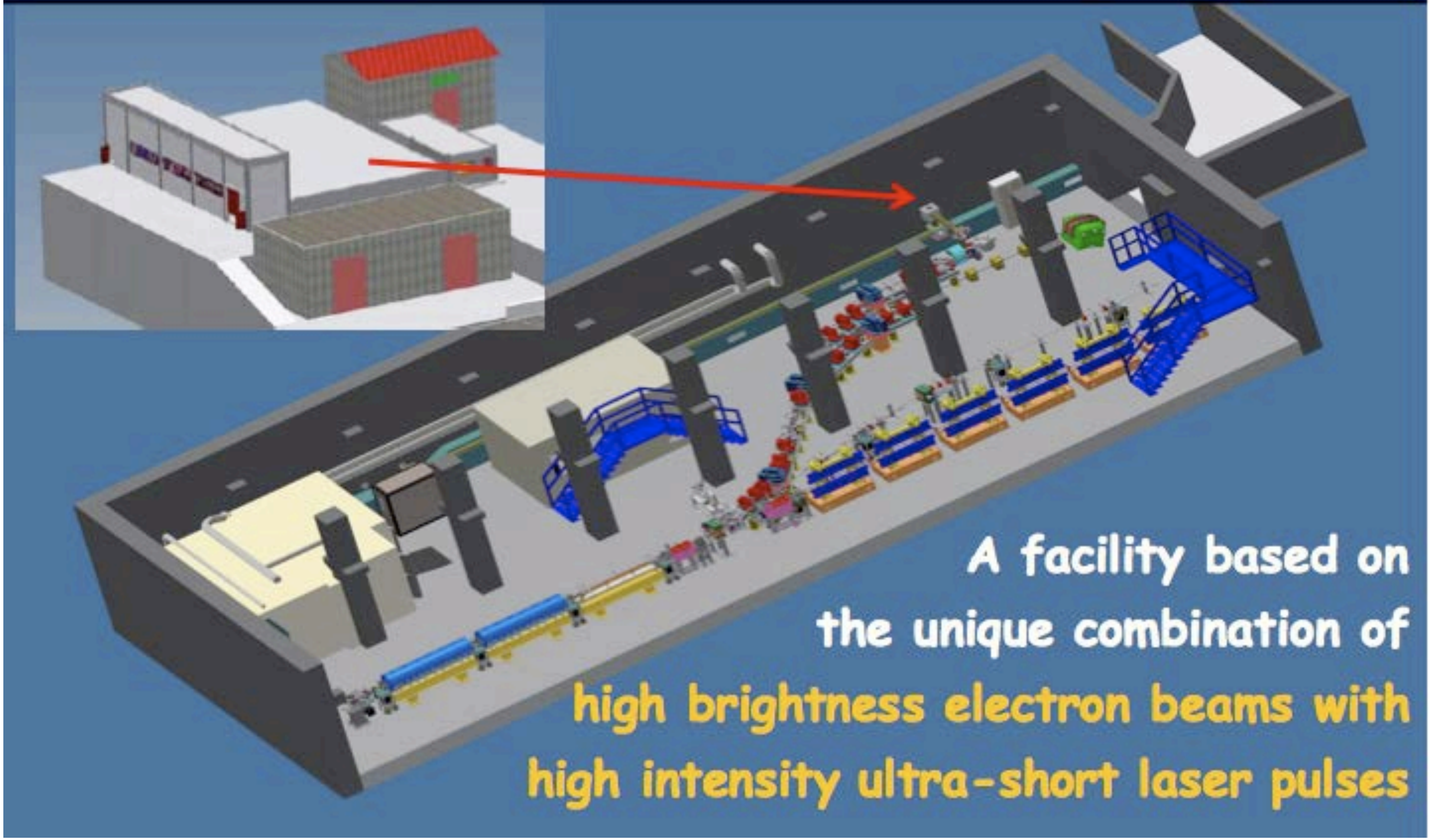
Open to Italian and EU users



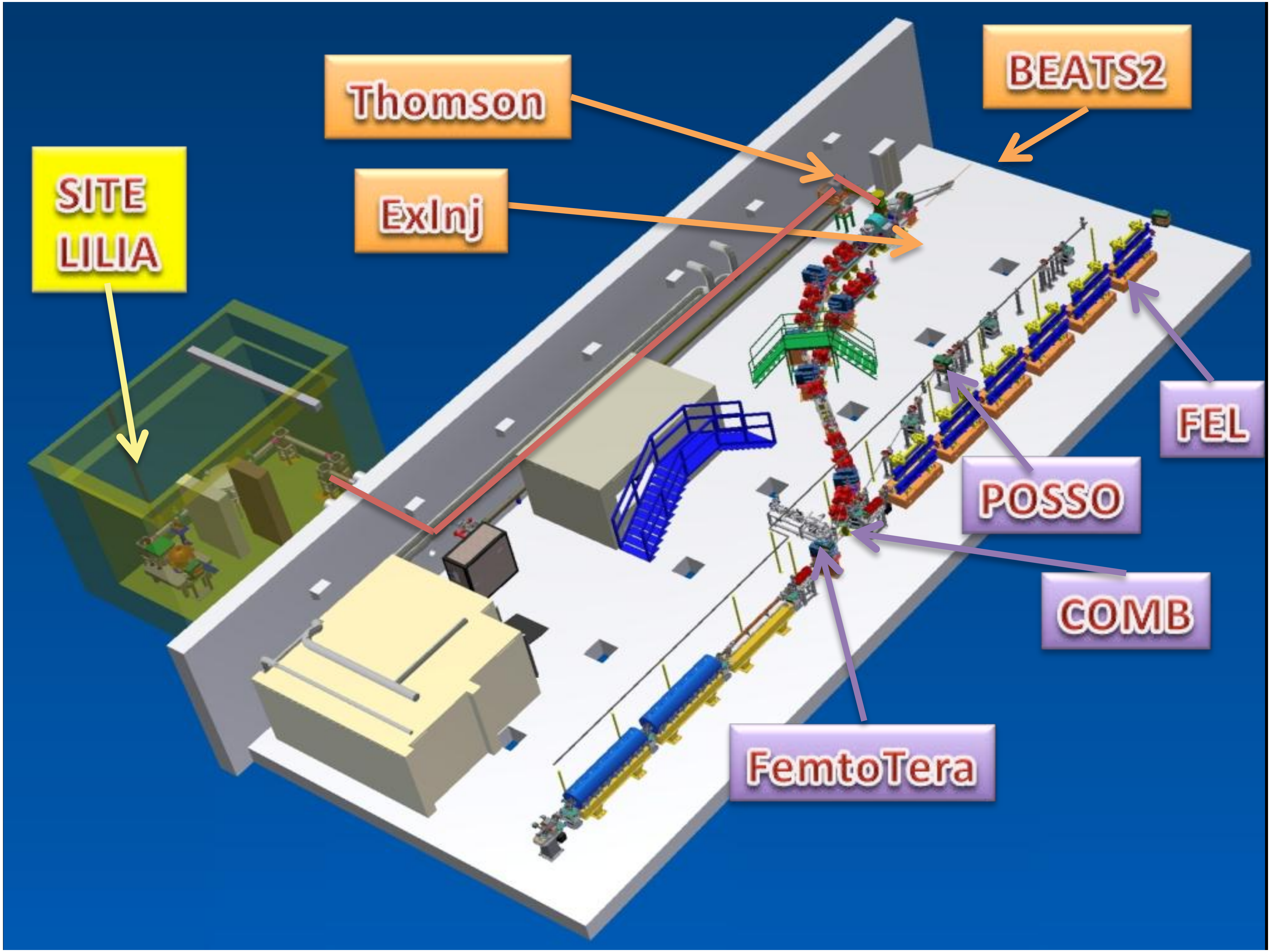


SPARC_LAB

Sources for Plasma Accelerators and Radiation Compton with Lasers And Beams



A facility based on
the unique combination of
high brightness electron beams with
high intensity ultra-short laser pulses



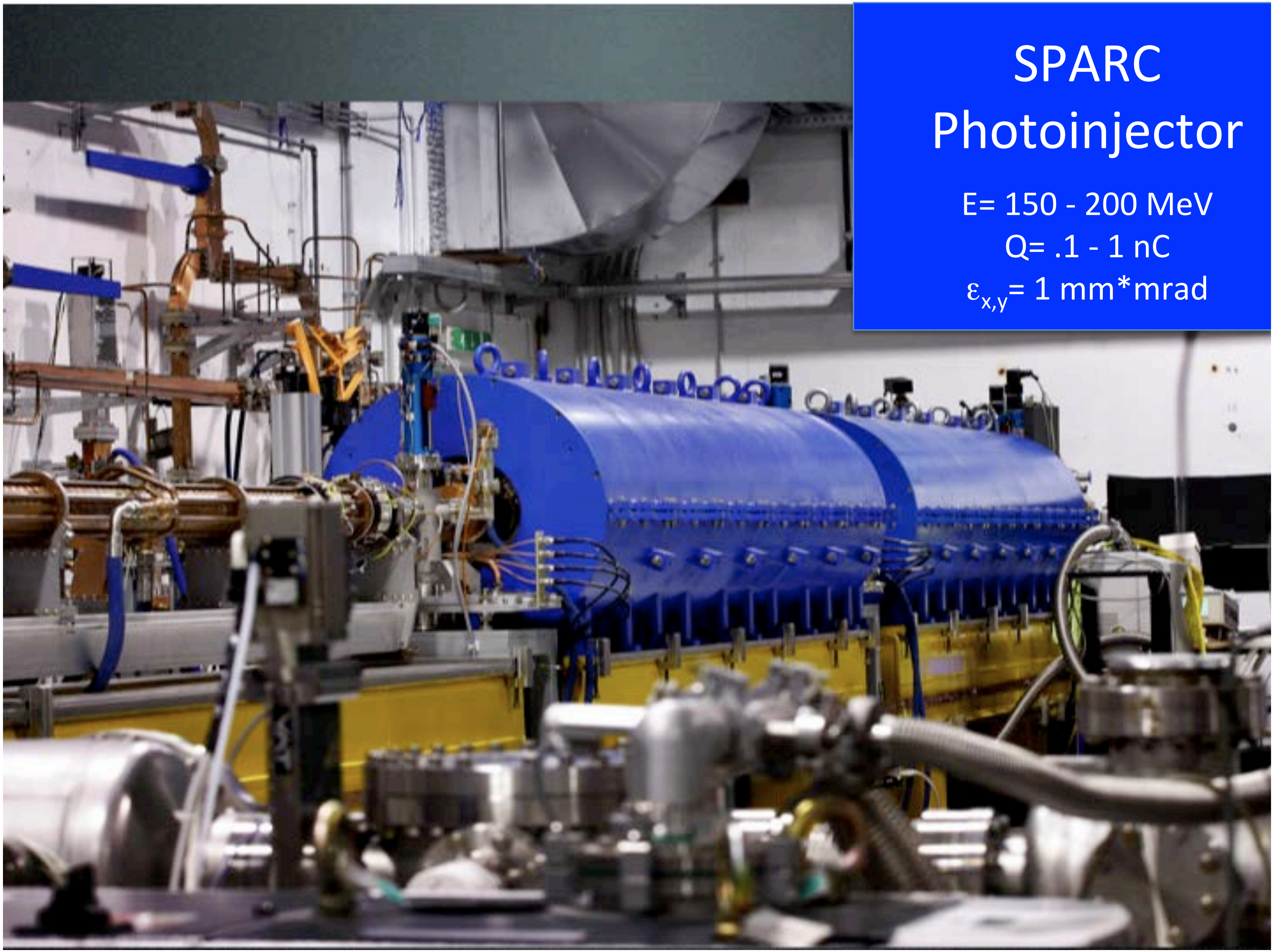
Thomson
BEATS2
SITE
LILIA
ExInj
FEL
POSSO
COMB
FemtoTera

SPARC Photoinjector

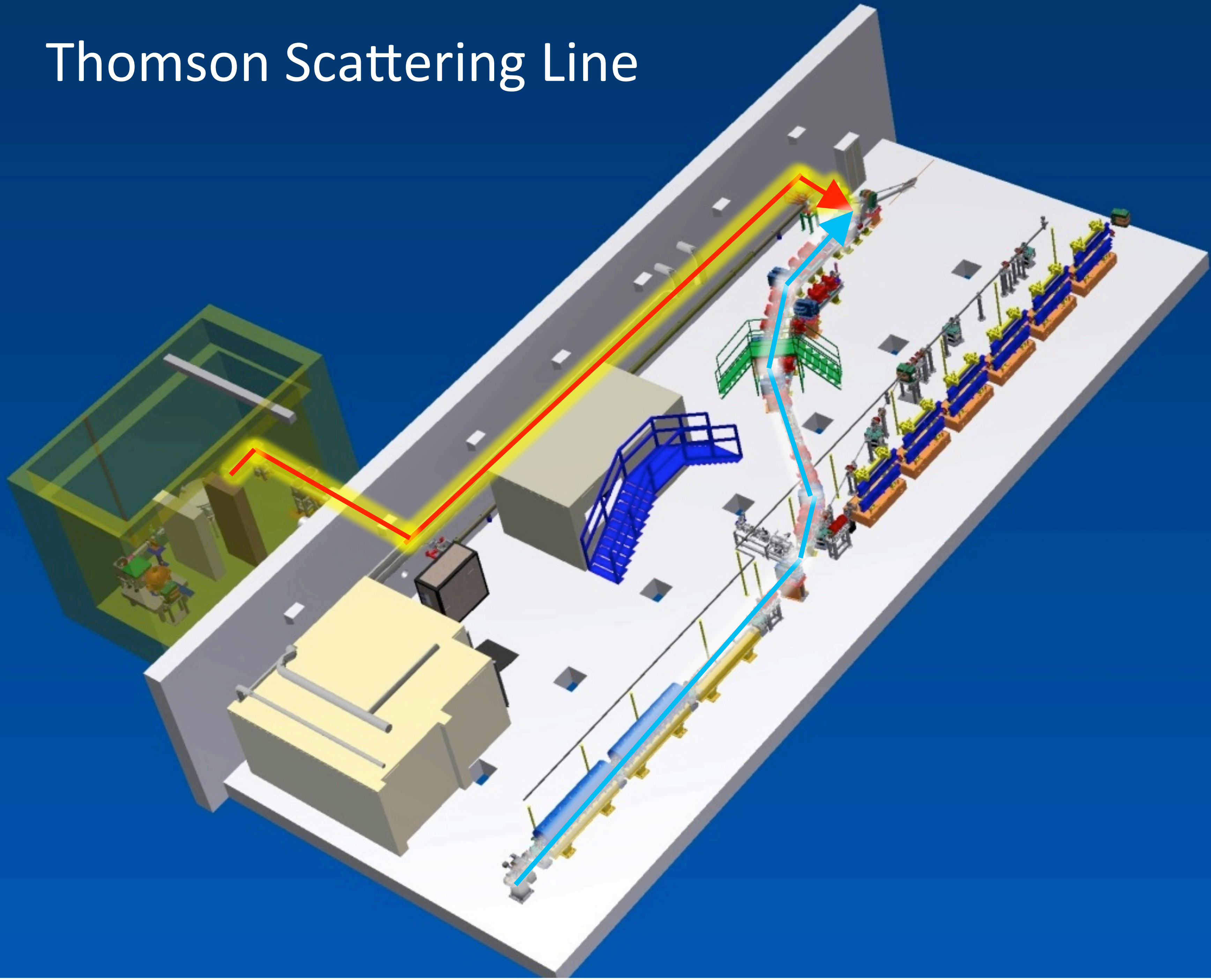
E= 150 - 200 MeV

Q= .1 - 1 nC

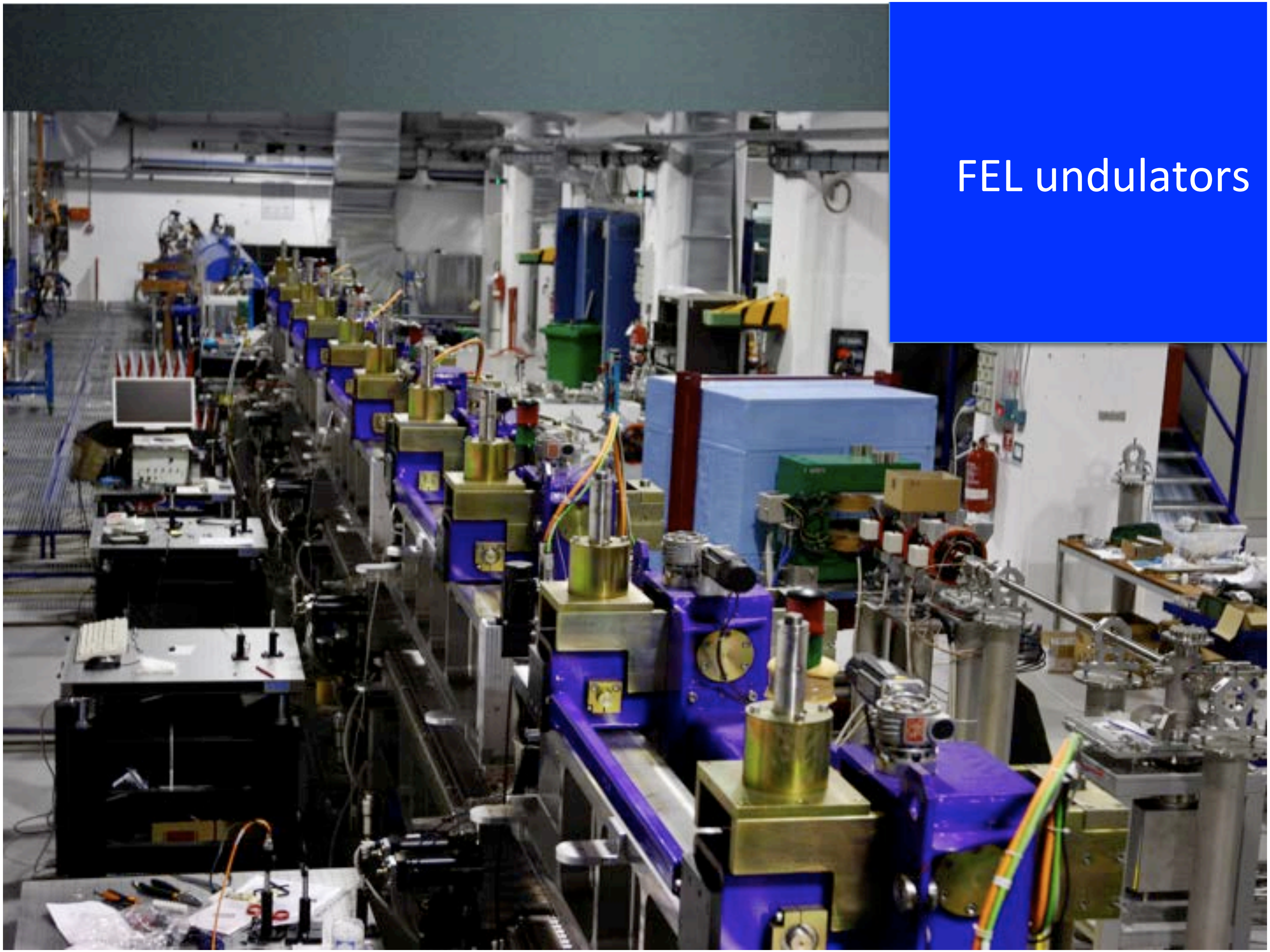
$\varepsilon_{x,y}$= 1 mm*mrad



Thomson Scattering Line

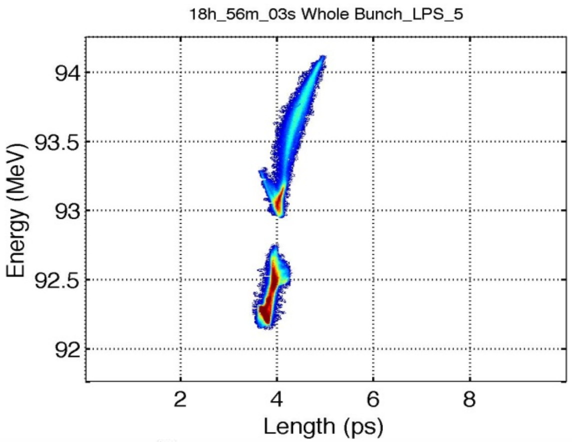


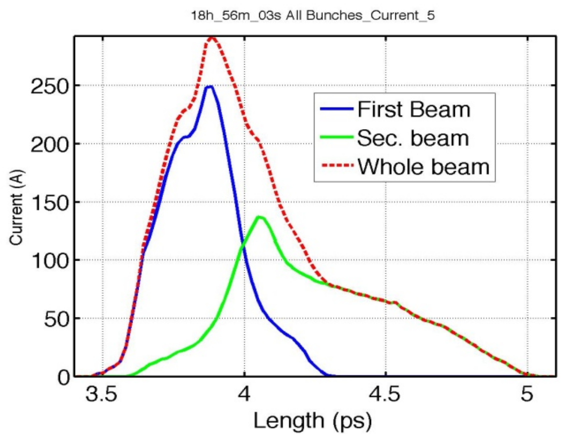
FEL undulators



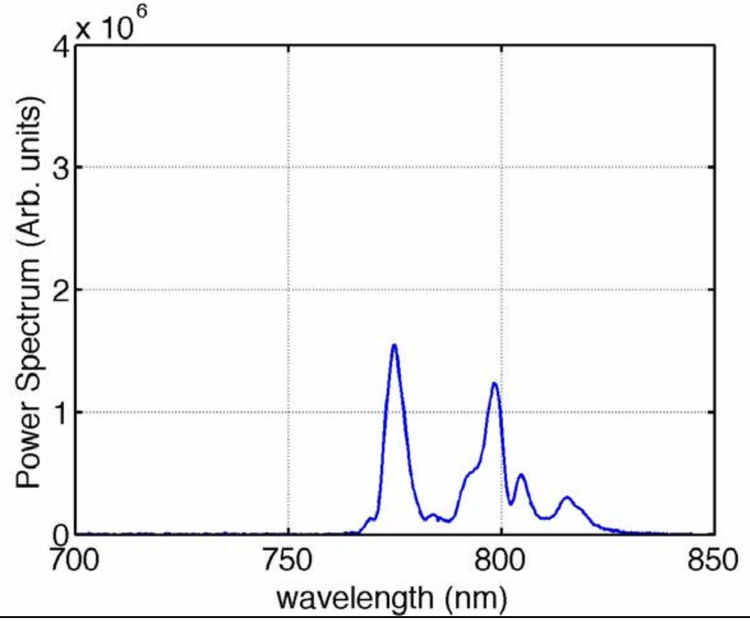
EVIDENCE OF 2-COLORS FEL EMISSION

Spectrometer analysis





The first electron beam is the one with lower energy and higher current: it is responsible of the slight asymmetry in the FEL emission spectra. Indeed, the peak at longer wavelength is more intense due to the higher current.

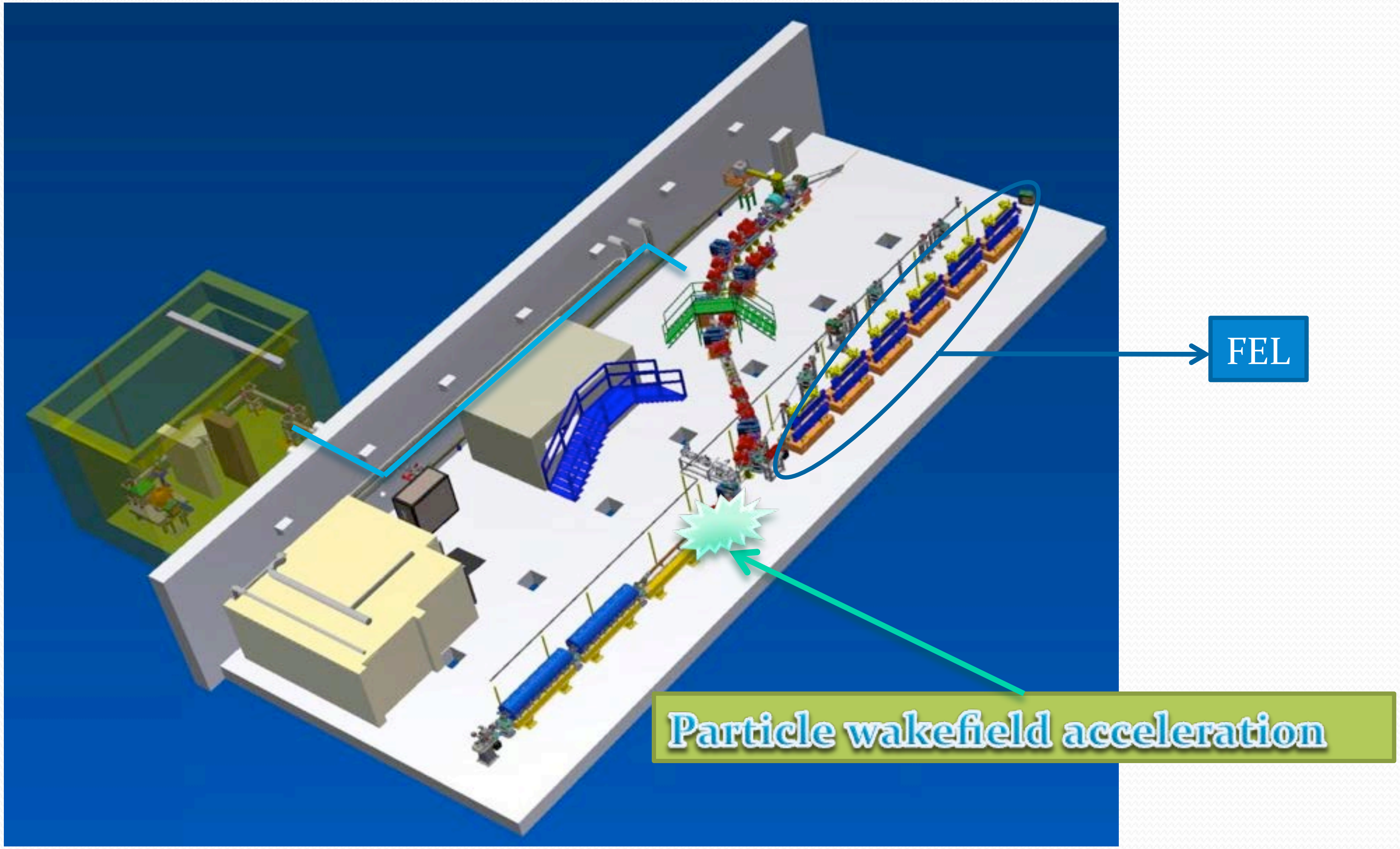


Mean FEL parameters	
λ_{min} (nm)	778.3 (5.7)
$BW_{\lambda min}$ (%)	0.65
λ_{Max} (nm)	804.0 (4.6)
$BW_{\lambda Max}$ (%)	0.88
$\Delta\lambda$ (nm)	25.8 (4.5)
Energy (μJ)	> 37

Corresponding to a mean energy separation of 1.47 (0.26) MeV

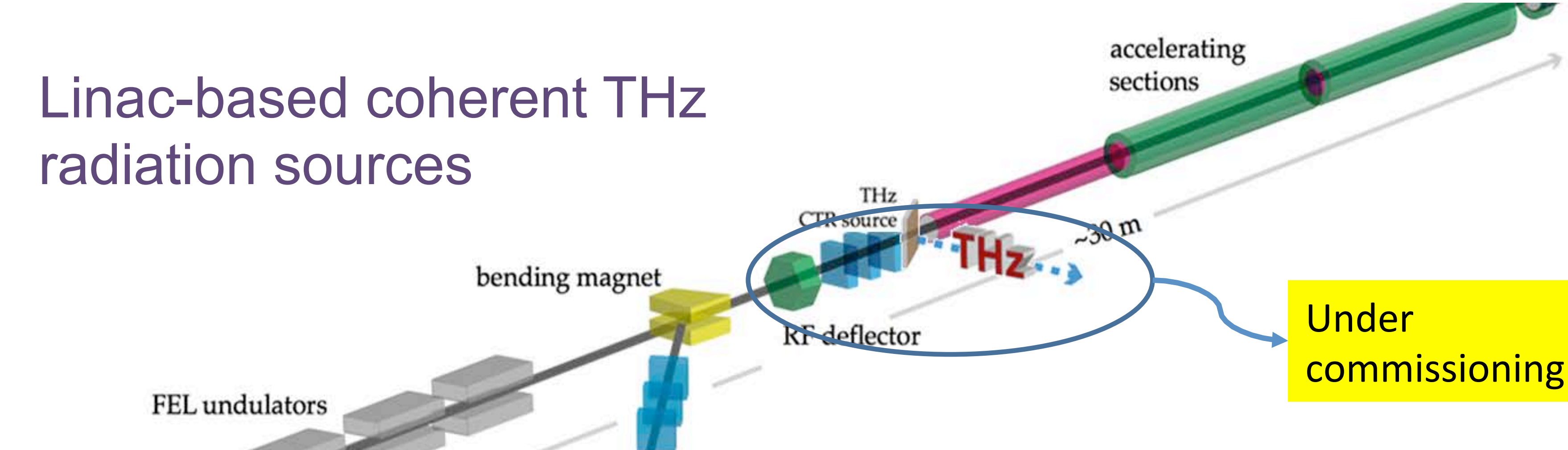
From Joulemeter measurement

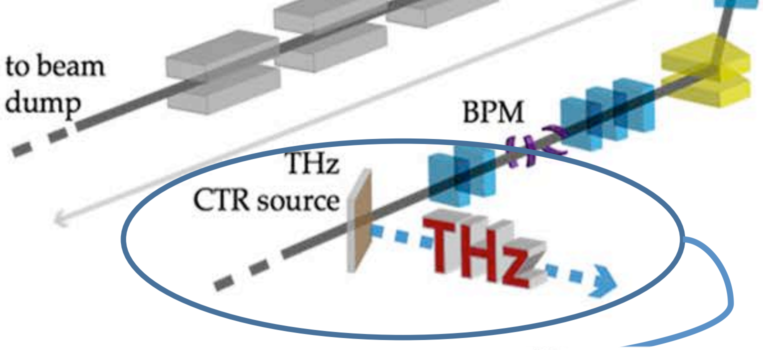
Particle wakefield acceleration



Femtosecond THz Radiation at SPARC_LAB

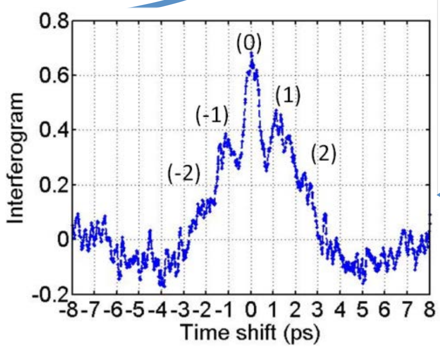
Linac-based coherent THz radiation sources

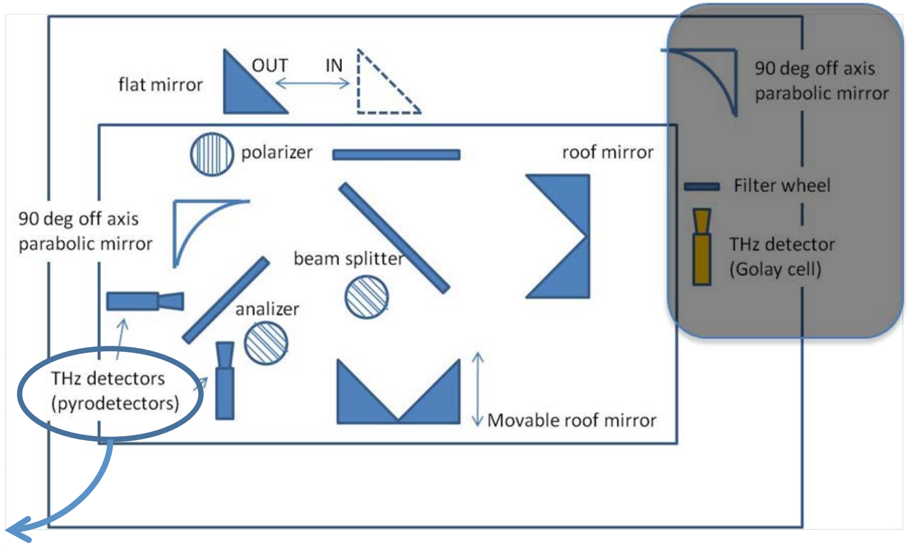




Under commissioning

Successfully in operation under TERASPARC (2010-2012)





Normalized interferogram

… other contributions in Accelerator Physics

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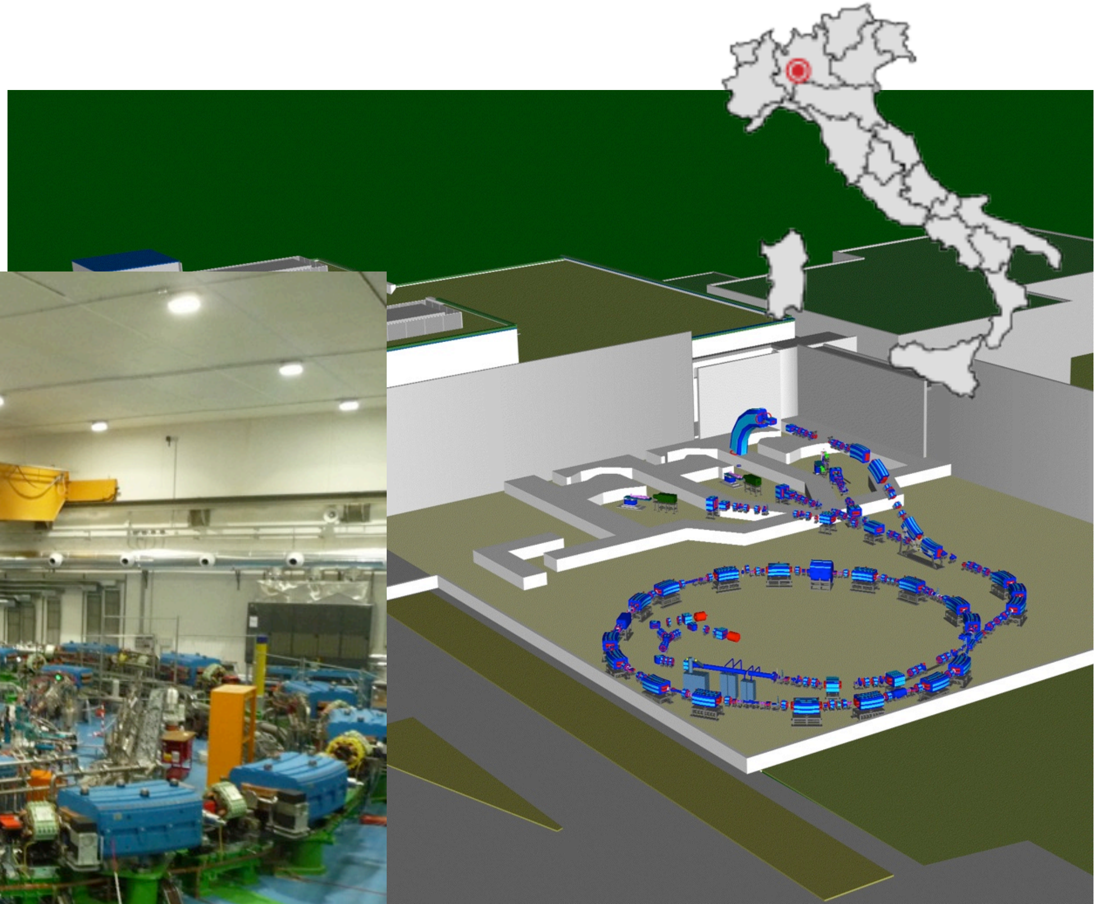
Laboratori Nazionali di Frascati

CNAO – PAVIA

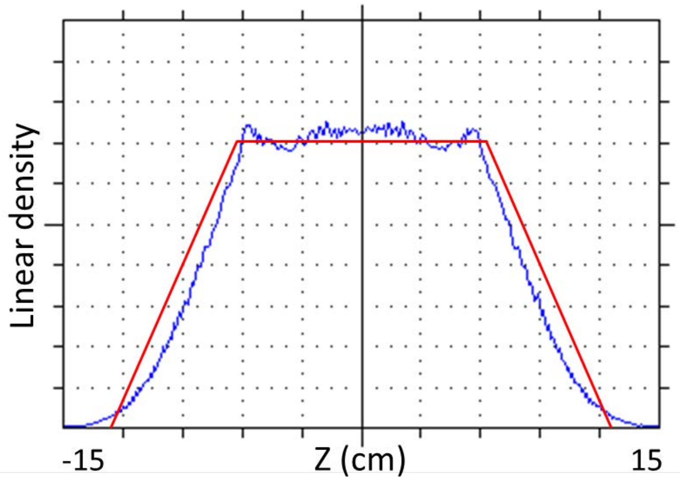
patients treated with protons from September 2011 and today also with carbon ions

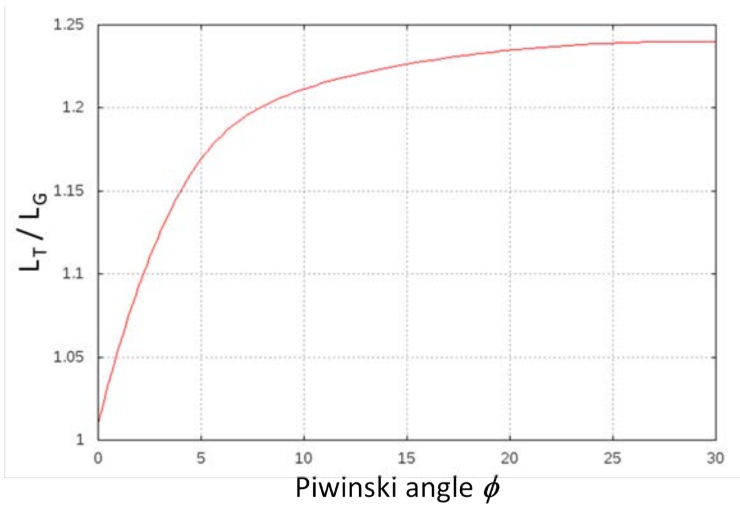


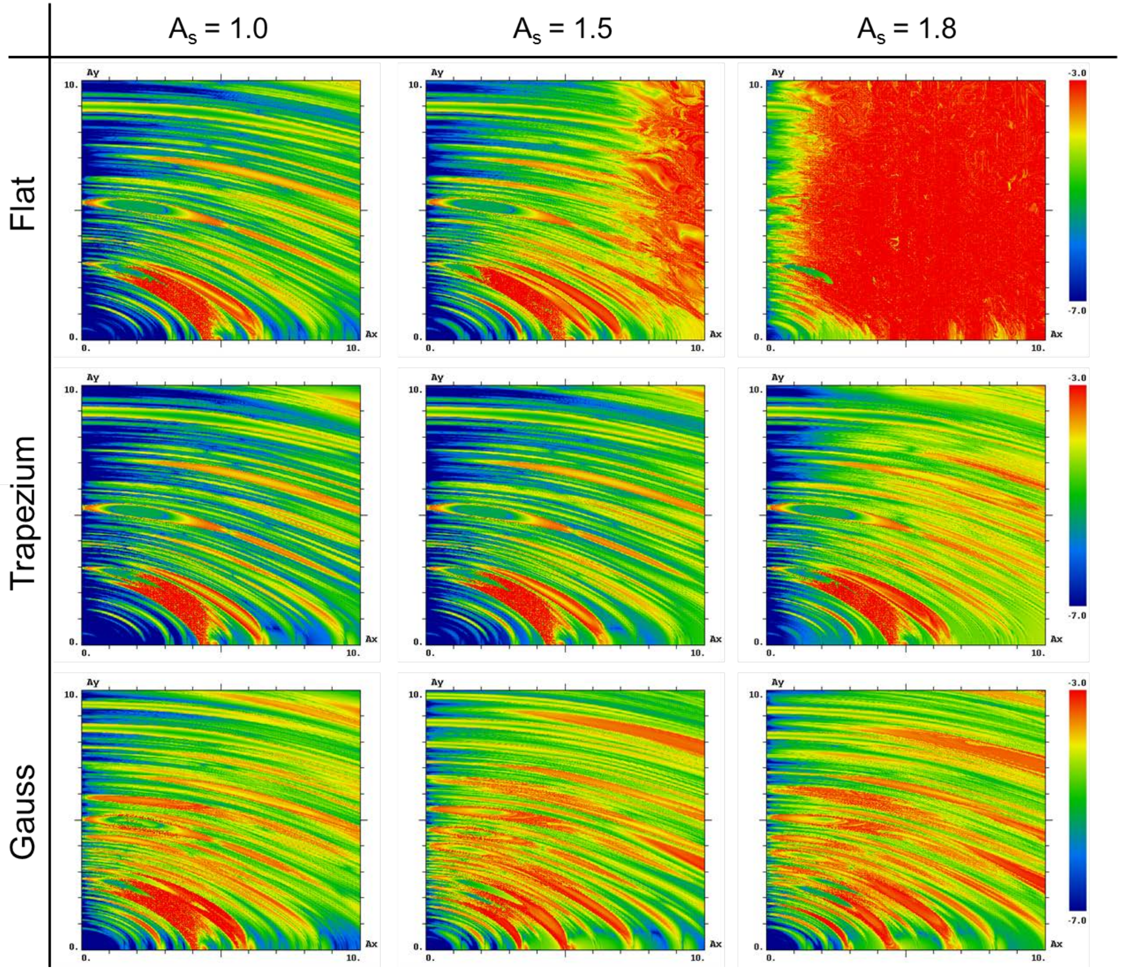
Synchrotron hall
Proton – 200 MeV
Carbon ions – 450 MeV/u

Study of flat beam collisions for LHC upgrade

(D.Shatilov, M.Zobov)

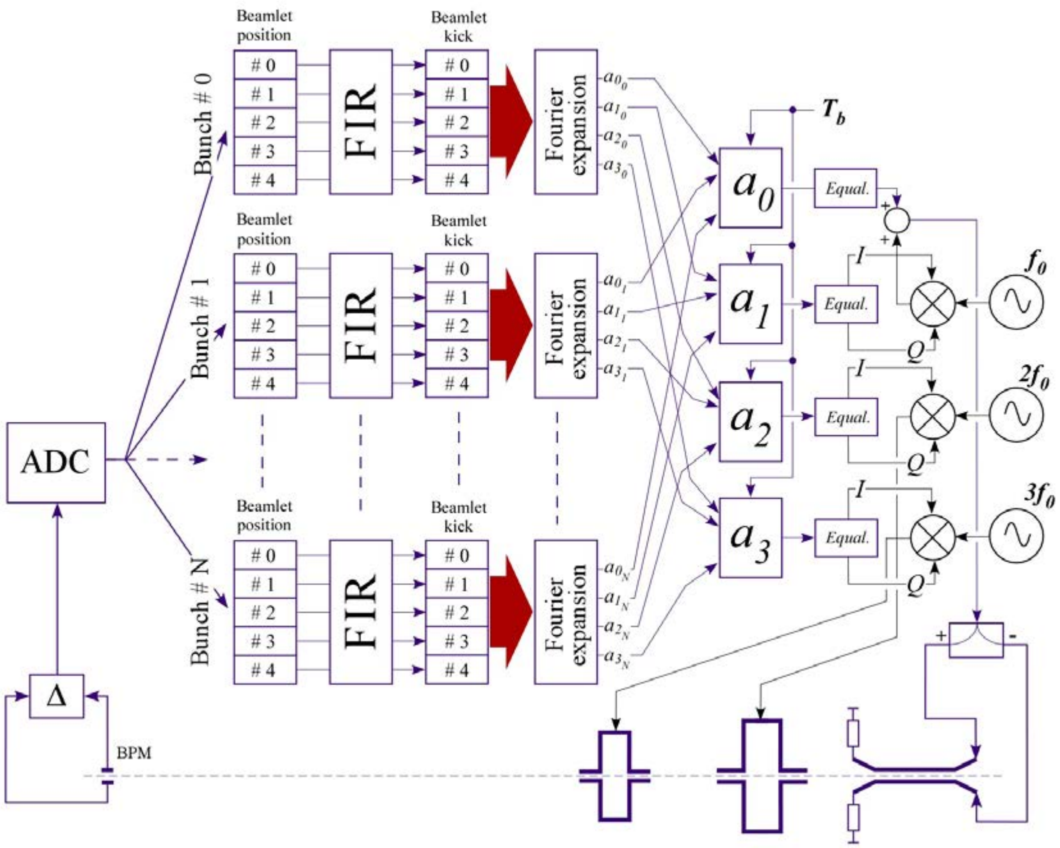


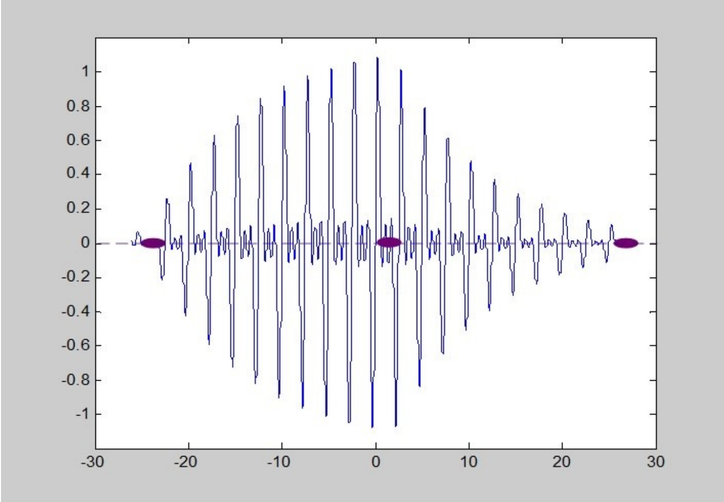


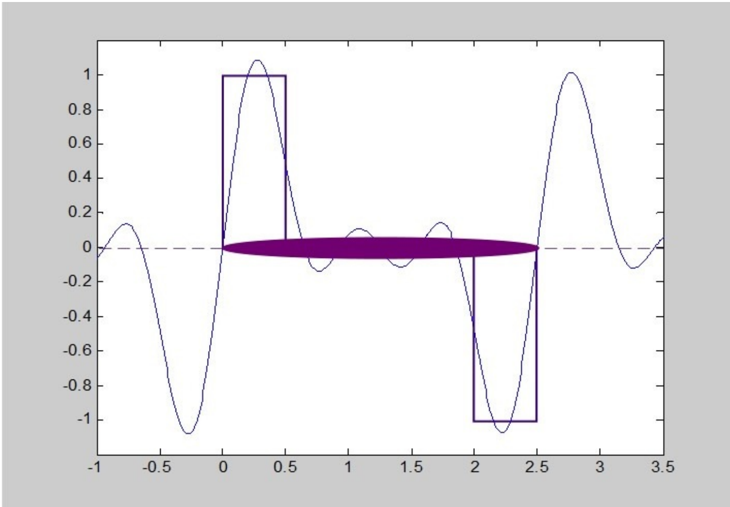


Scheme of the intrabunch feedback system

proposed by A.Gallo

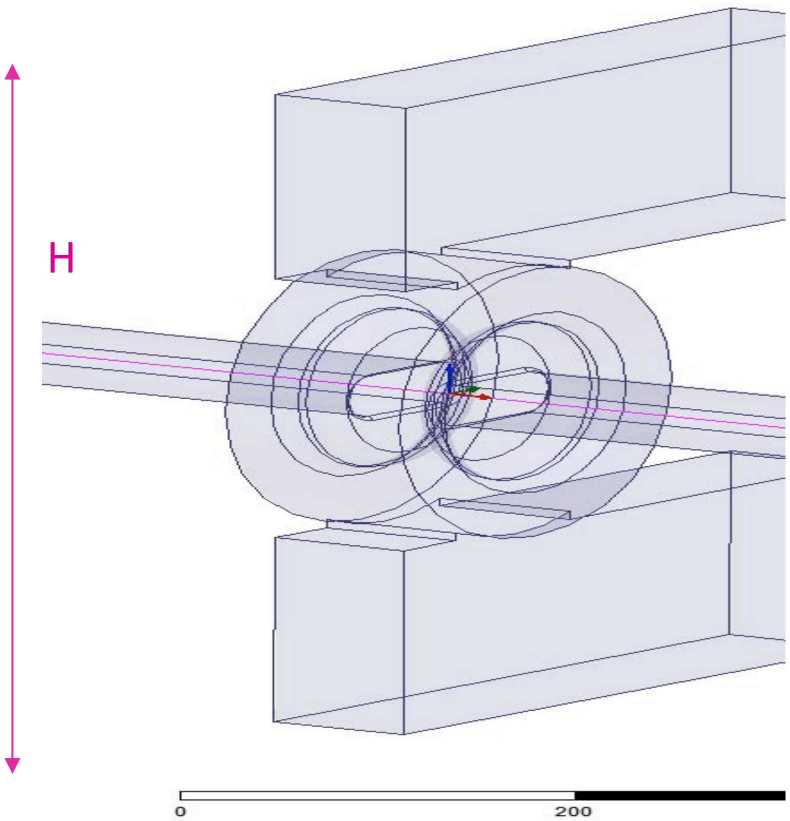


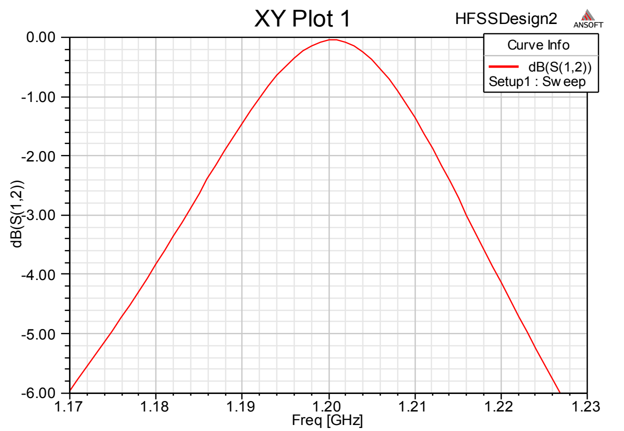


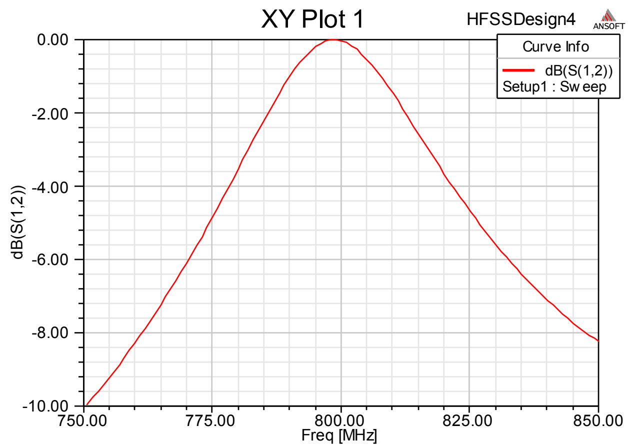


Broad-band kicker for SPS intrabunch feedback system

F. Marcellini

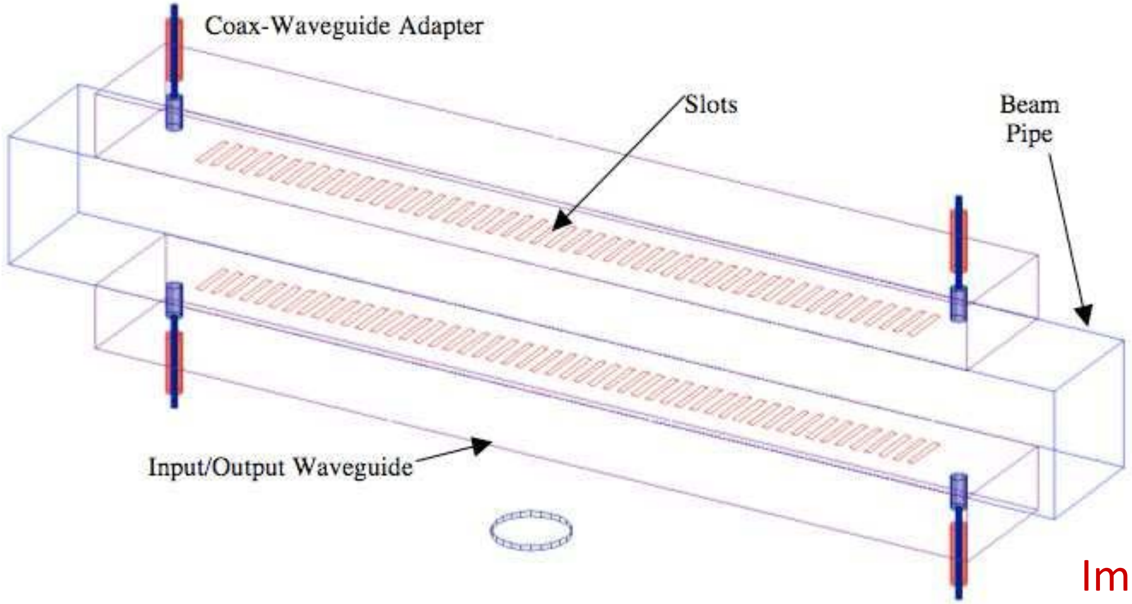




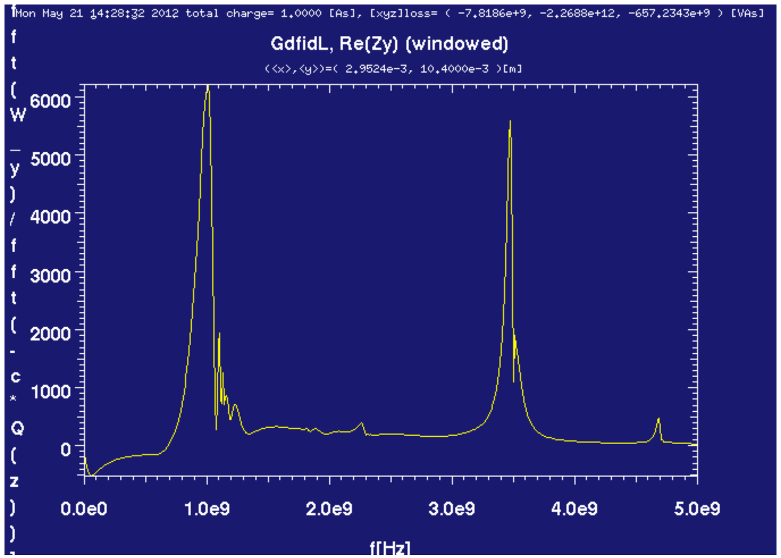


Frequency	0.8GHz	1.2 GHz
Q	23	38
Vertical shunt impedance	2.1 kΩ	3.3 kΩ
H	≈ 100 cm	≈ 60 cm

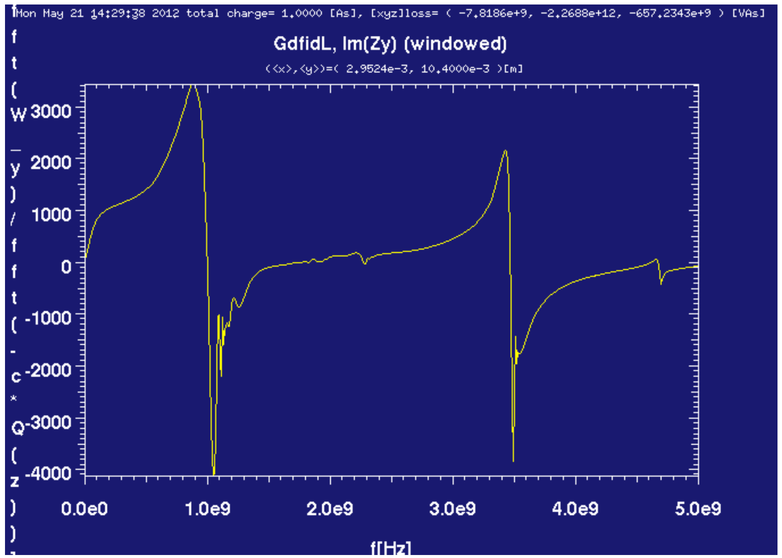
Coupling impedance calculations for slotted kicker (M.Zobov)



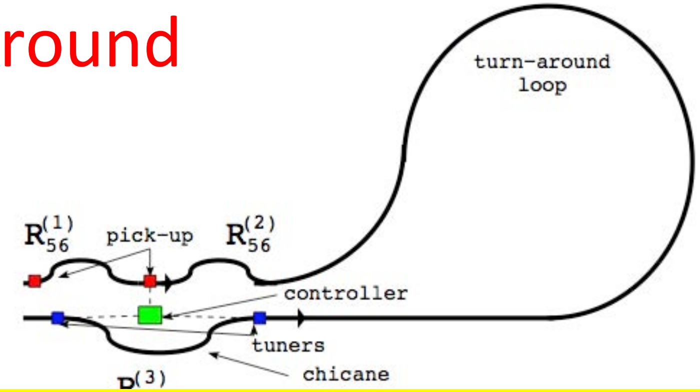
Real Part

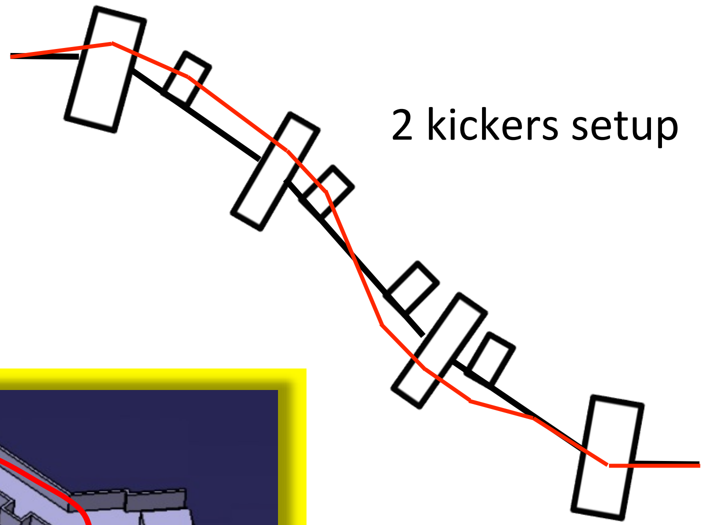


Imaginary Part

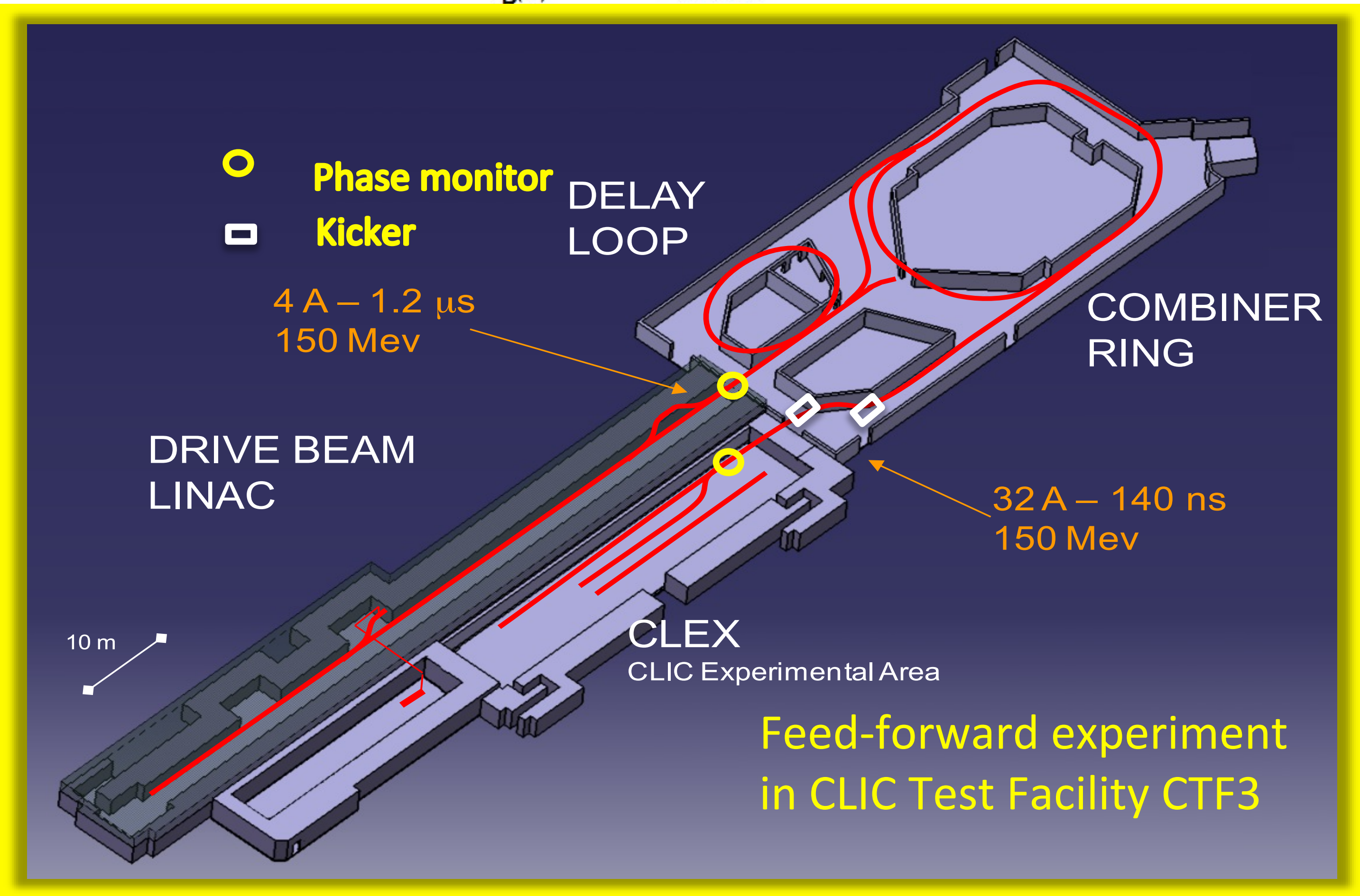


Drive Beam phase measurement and correction in CLIC turn around



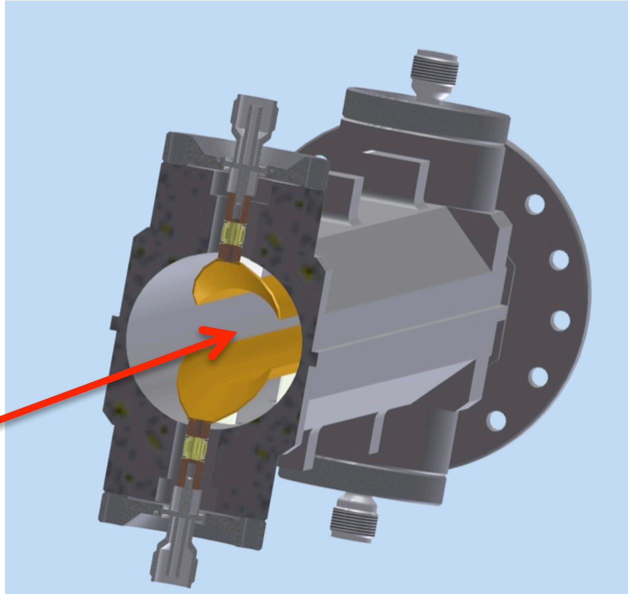


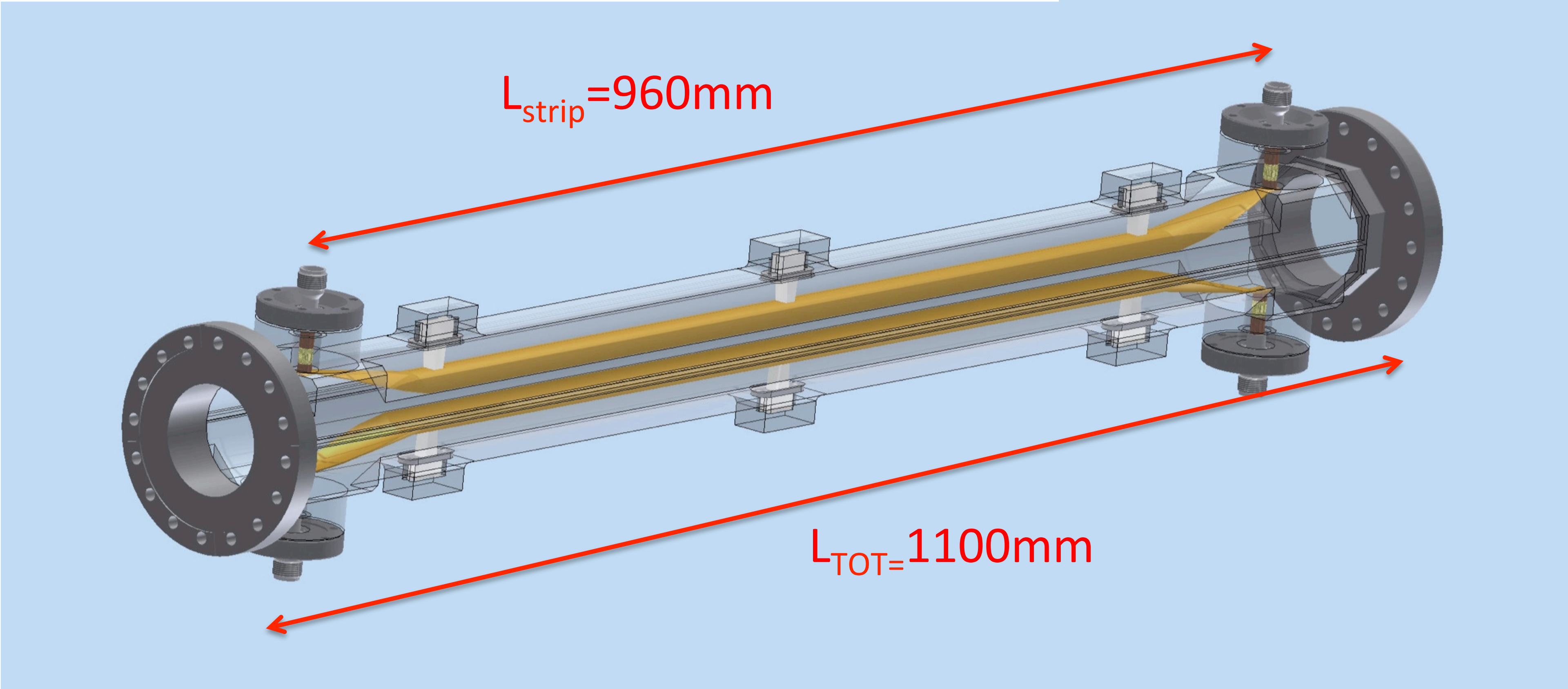
2 kickers setup



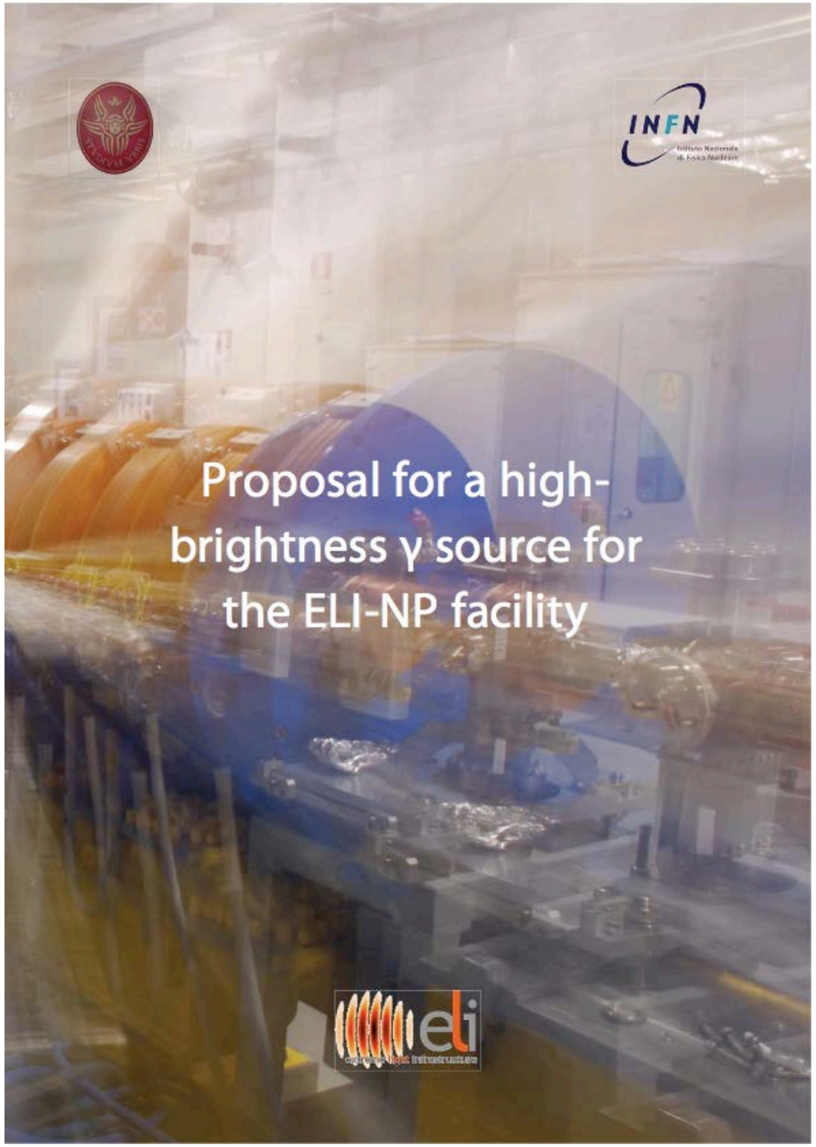
Transverse orbit distortion in the transfer line change the longitudinal path length -> the beam phase

Kicker mechanical design





ELI-NP


Proposal for a high-brightness γ source for the ELI-NP facility


ELI-NP
Bucharest (Magurele)
Romania for ELI

Interdisciplinary (a couple of example)

X-Ray LAB

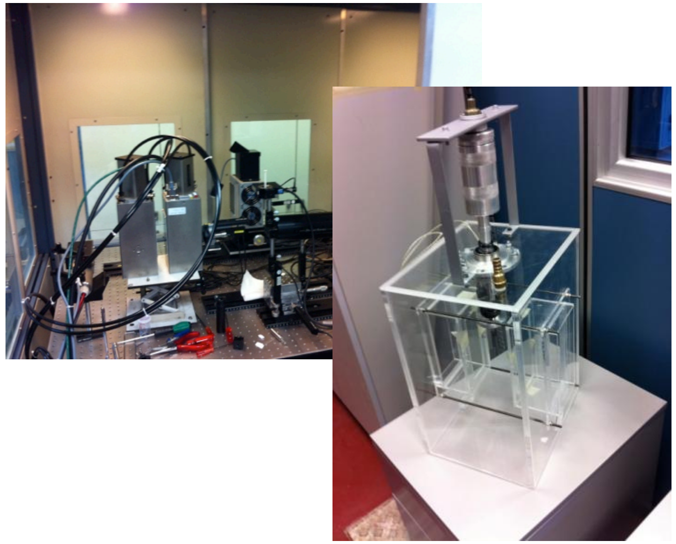
X-ray Optics: Polycapillary and Compound Refractive Optics

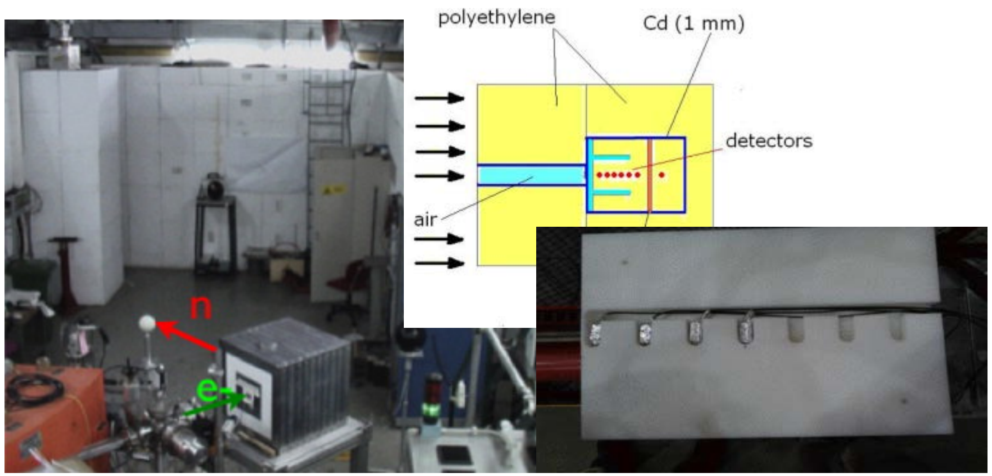
Material Analisys // X-ray Spectroscopy: X-ray Fluorescence, X-ray Diffraction, X-ray Imaging

Diagnostic Applications: X-ray Imaging for large object with high spatial resolution

Crystal Characterization for hadron beam collimation by crystal channeling

Novel technologies and experimental setup: Prototype for XRF – TXRF and X-ray Imaging; X-ray tube based on Carbon Nanotube Cold Cathod





Monitor realtime of energy-integrated neutron field

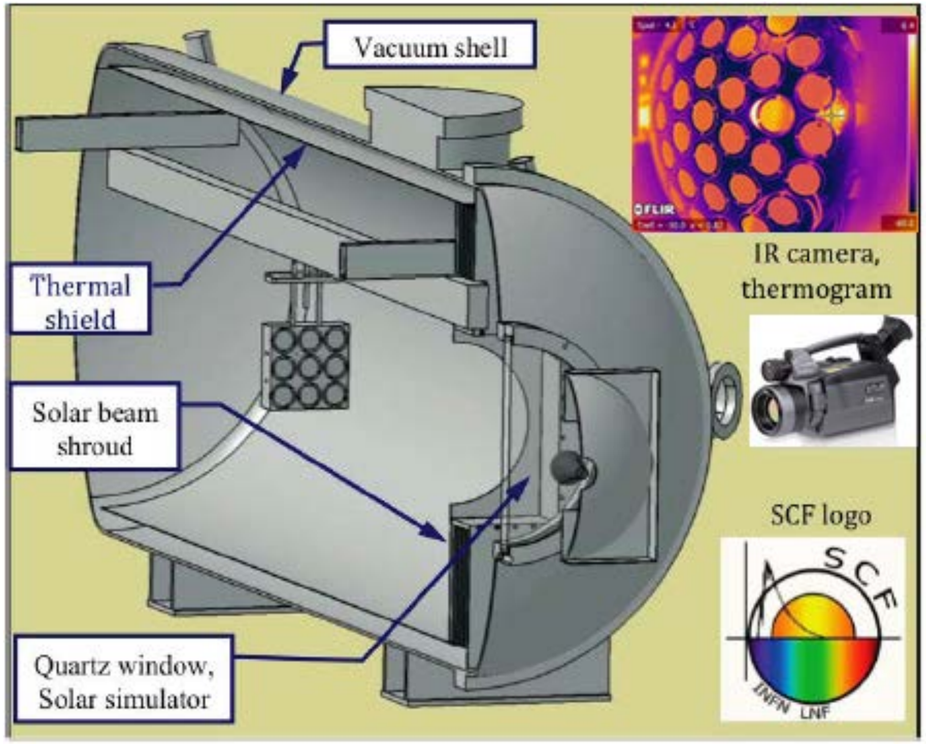
NESCOFI@BTF have the aim of developing innovative neutron sensitive instruments for the spectrometric and dosimetric characterization of neutron fields, intentionally produced or present as parasitic effects, in particle accelerators used in industry, research and medical fields

SCF_Lab

Satellite/Lunar/GNSS laser ranging and altimetry Characterization Facility Laboratory

Two unique **OGSE** (**Optical Ground Support Equipment**) facilities in ISO 7 clean room, two sun simulators, to characterize SLR/LLR/GNSS space segment

SCF for SLR/LLR/Altimetry

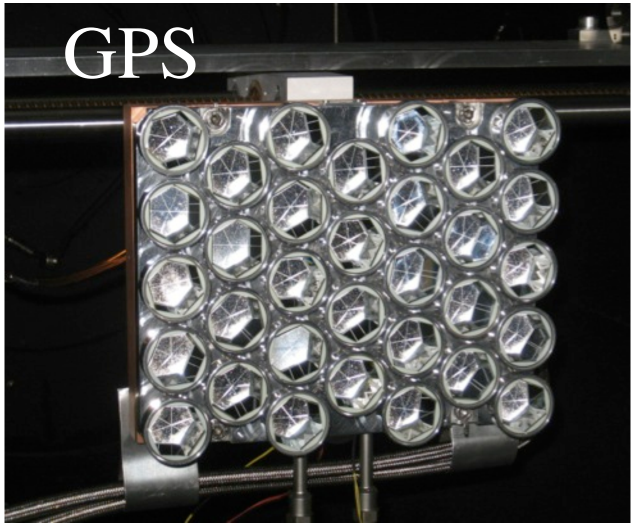


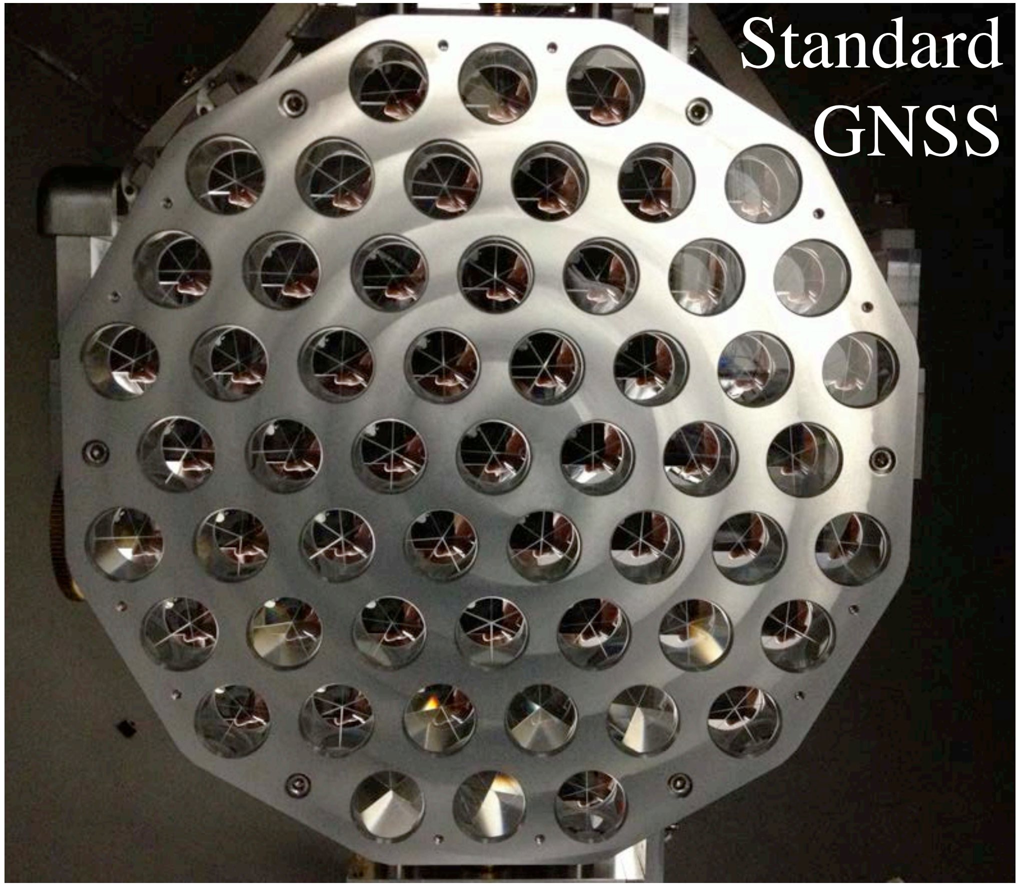
SCF-G for GNSS

Some SCF-Tested retroreflector arrays:

LAGEOS, GLONASS, GPS, GNSS array for Galileo by INFN-ASI.

Contracts with: ASI, ESA, ISRO, Italian Ministry of Defense





We also did industrial optical acceptance test of LARES (in-air nominal specs, NO SCF-TEST!)

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... path to the future ...

- Working on the “after Dafne” era
- Boundary conditions challenging for everybody
- Possible projects are presently under study