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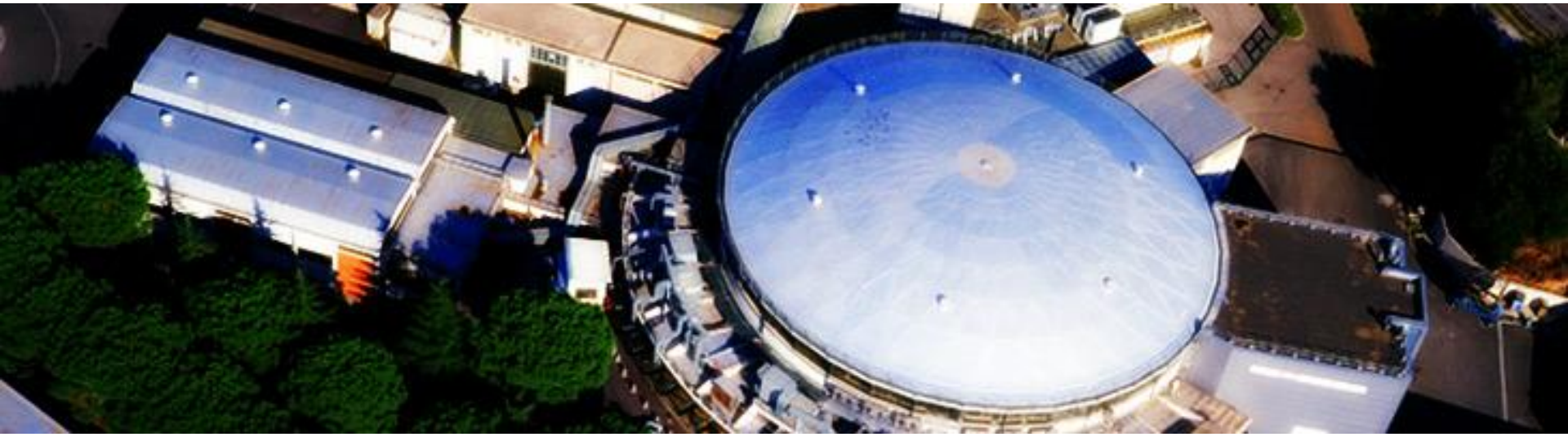


INFN – LNF Perspective

G. Mazzitelli - Workshop on Tau Charm at High Luminosity
26-31 My 2013 - La Biodola, Isola d'Elba

INFN infrastructure & divisions

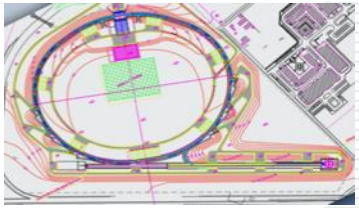
Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

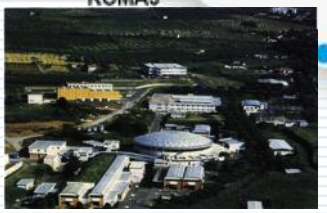
LNL

CNAF

20 divisions at university sites

VIRGO-EGO
European
Gravitational
Observatory





4 National Laboratories
CNAF
EGO
Cabibbo-LAB

LNF

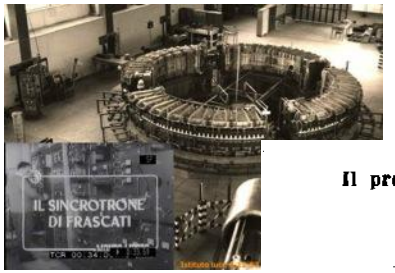
LNS

LNGS

The LNF accelerators history

Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

Electron Synchrotron (1959-1975) E=1 GeV



AdA 1960-1965 250 MeV

ADONE (1968- 1993) 3 GeV 100 m

DAFNE (1999) 510 MeV 100 m

SPARC_LAB (2004) 150 MeV LINAC

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

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)

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)

N. Cabibbo

the "bible"

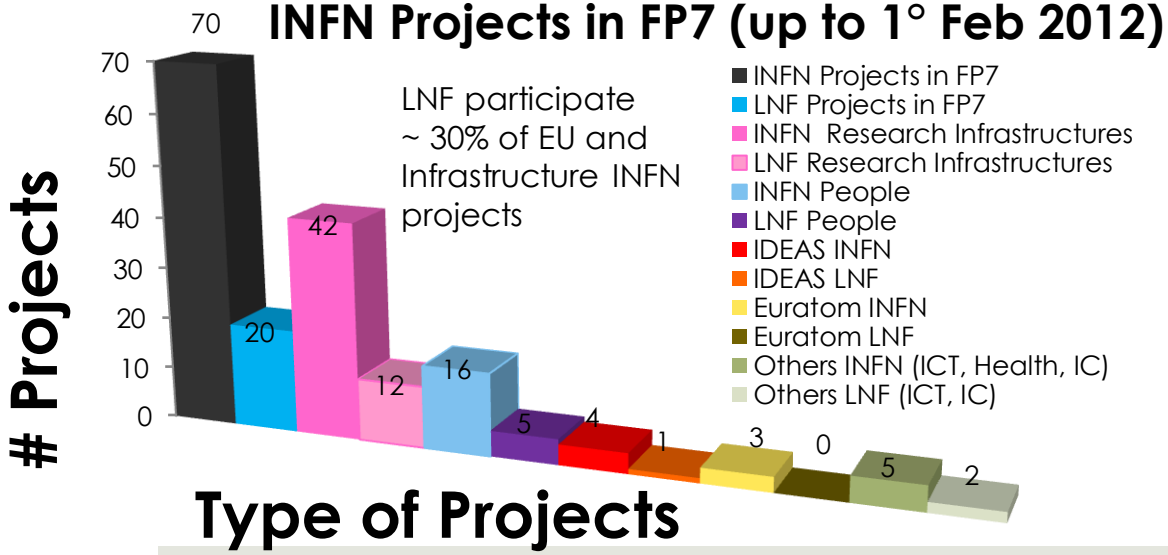
AdA was the first matter antimatter storage ring with a single magnet (weak focusing) in which e+/e- were stored at *250 MeV*

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

collider in the world

The Frascati INFN National Laboratory

Total Staff **293**	Researchers 80	Technologist Engineers 38	Technicians 142	Administration Services 33
External Users **501**	Italian 257		Foreign 244	
Visitors **3426**	Stages 184	Conference Workshops 21	Participants to Seminars 765	Course for teachers of high school 172



Hadron Physics 2 In FP7 (end December 2011)

Transnational Access Activities
1880 assigned days in 2009
1673 assigned days in 2010
2853 assigned days in 2011

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Accelerators infrastructure at LNF today

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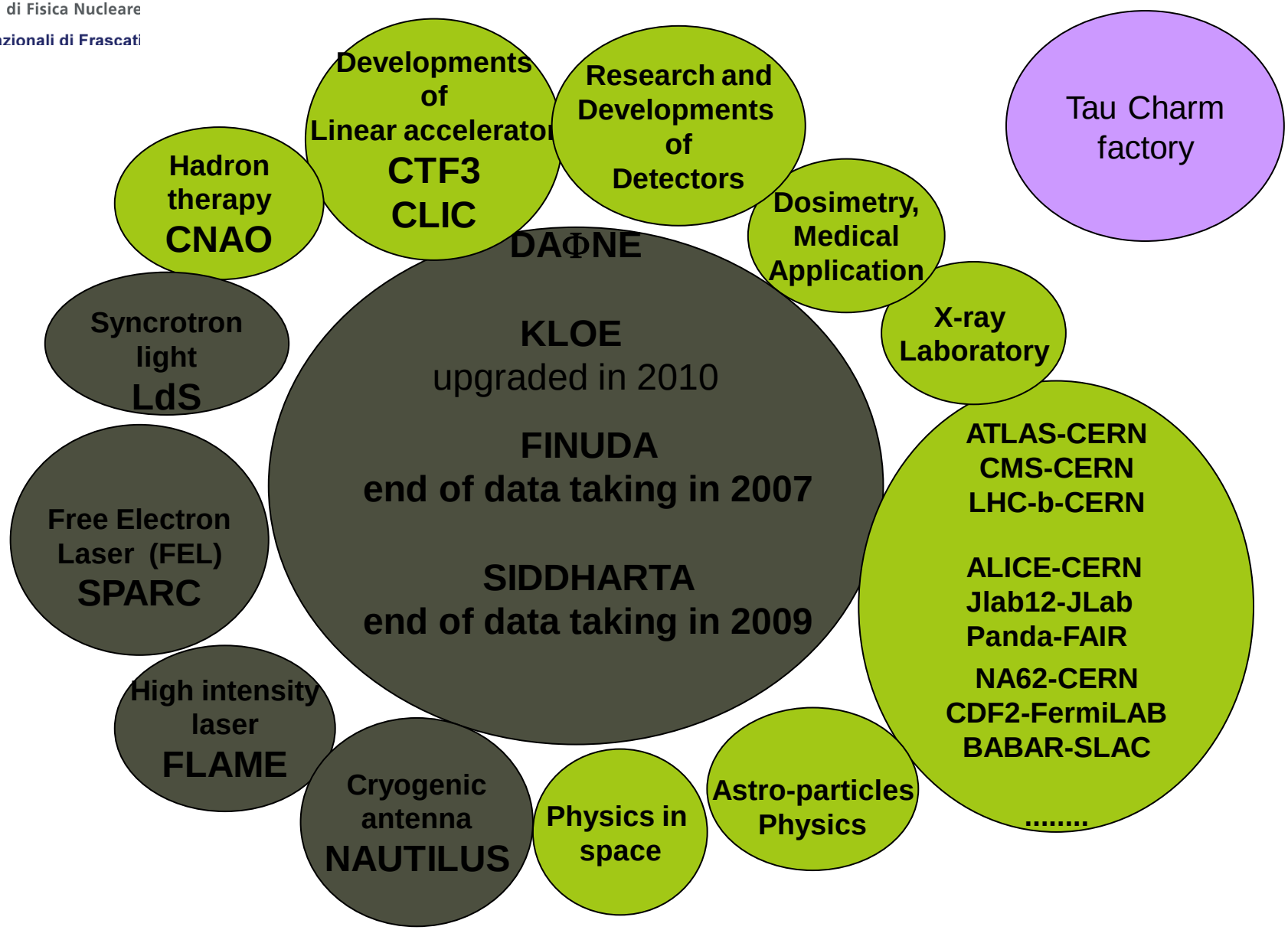
The LNF research areas



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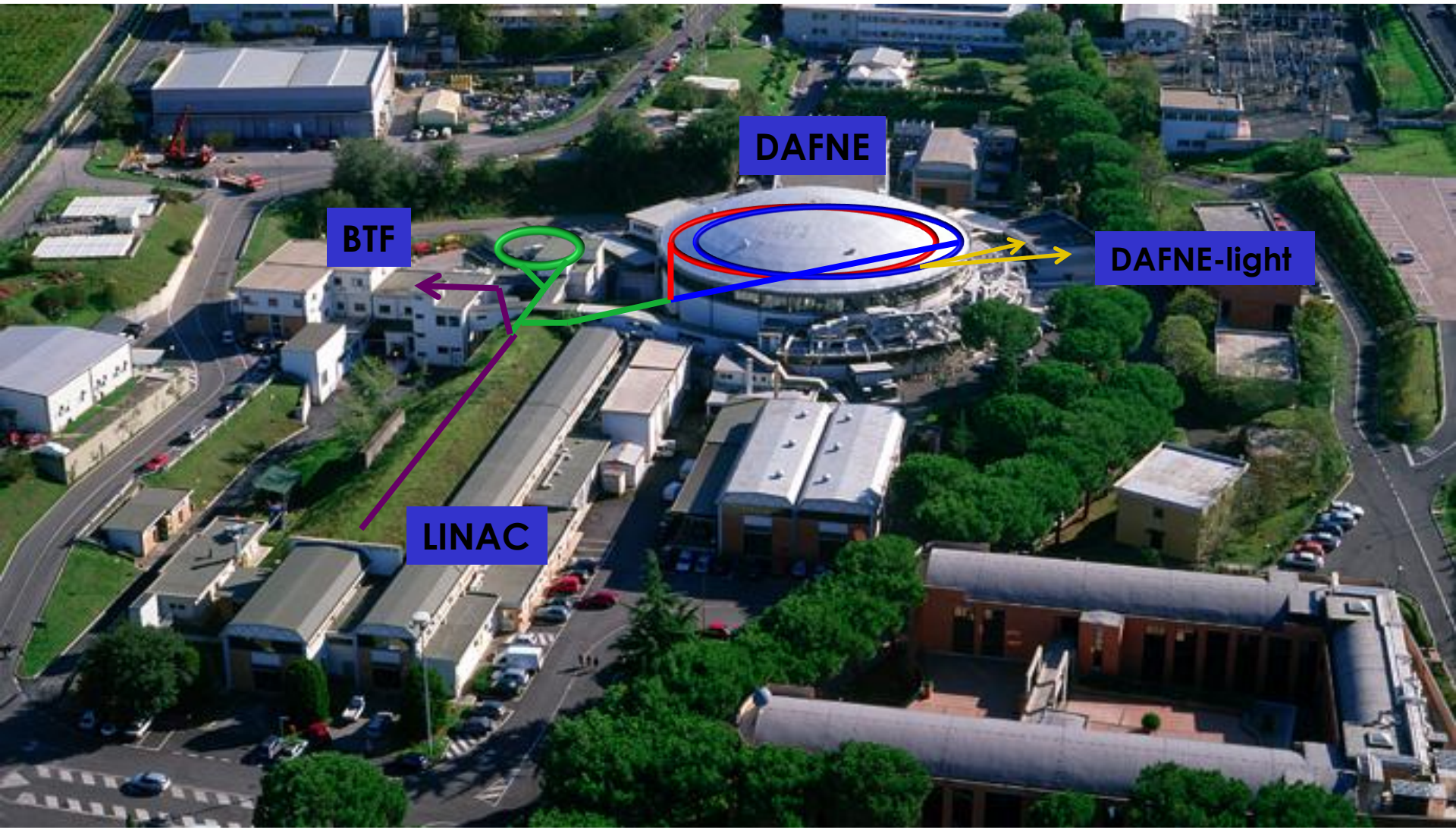
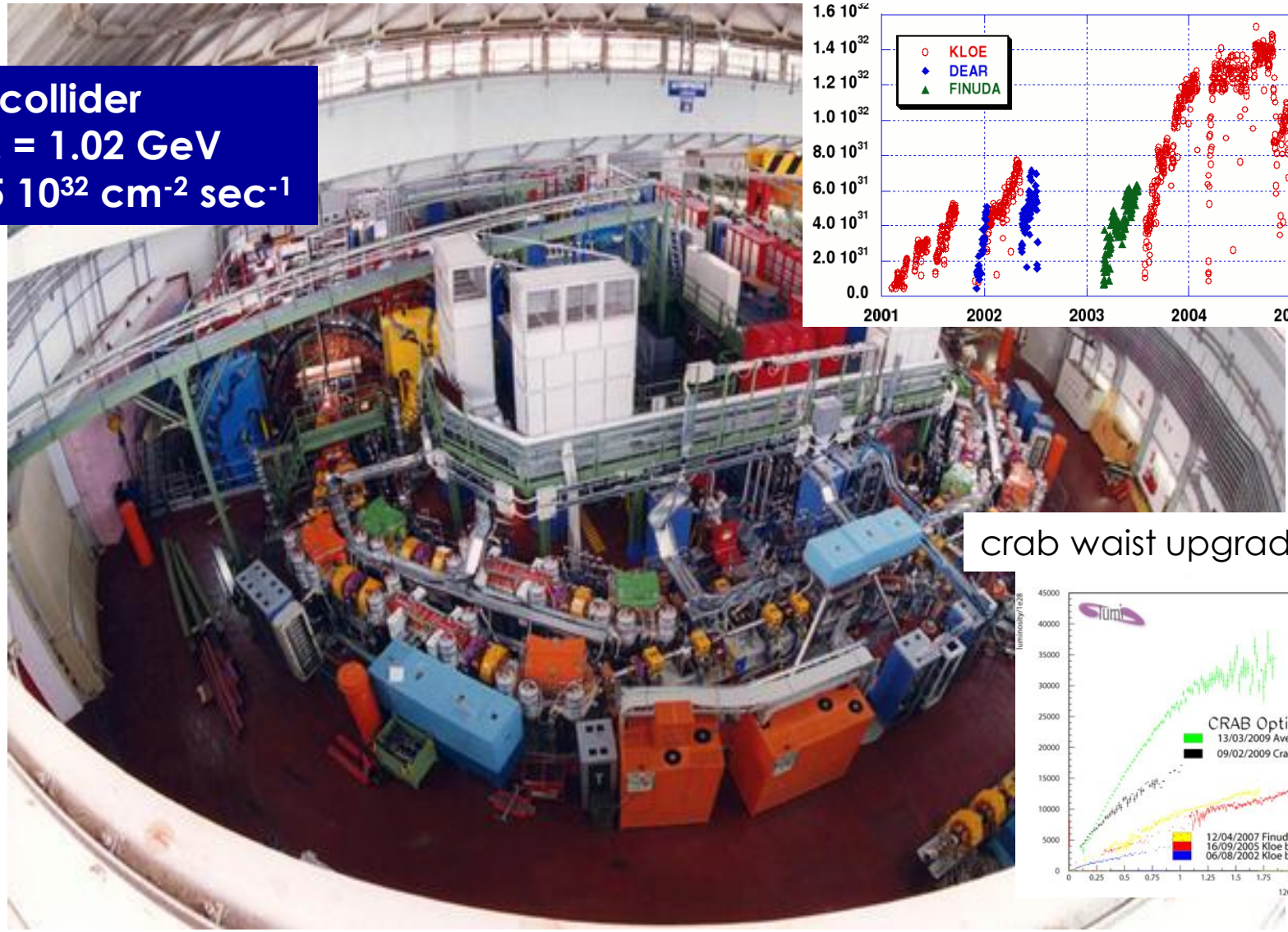
The Φ-Factory complex



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

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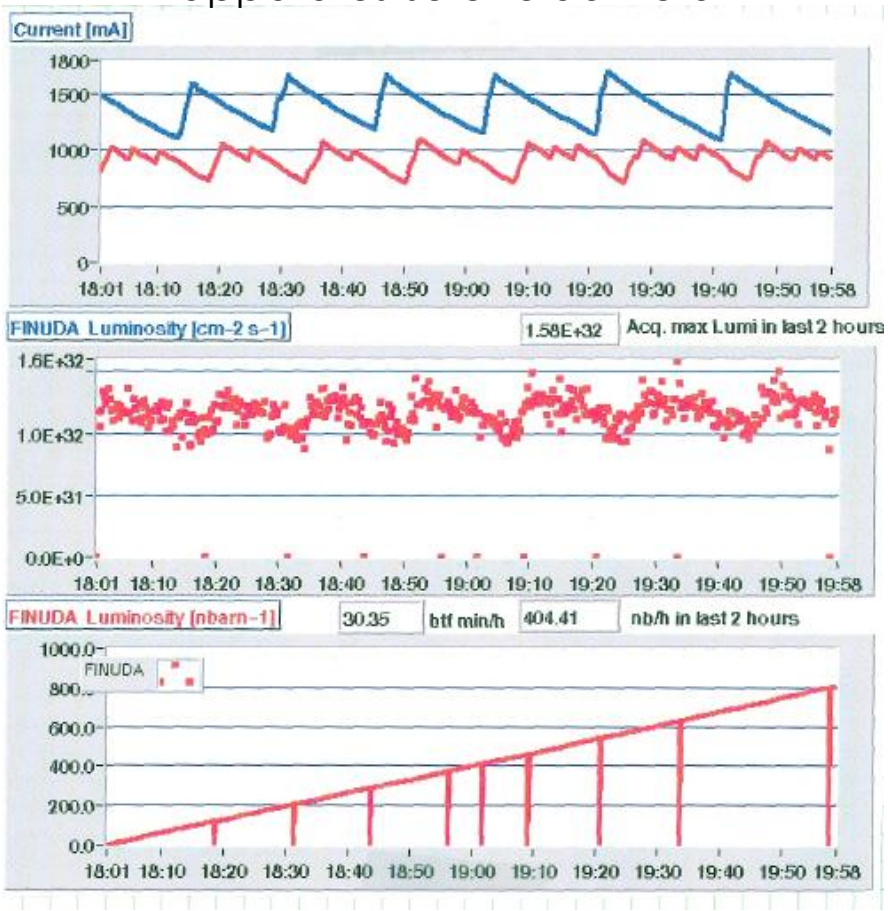
DAFNE gain in luminosity with micro-beam, large crossing angle and crab waist

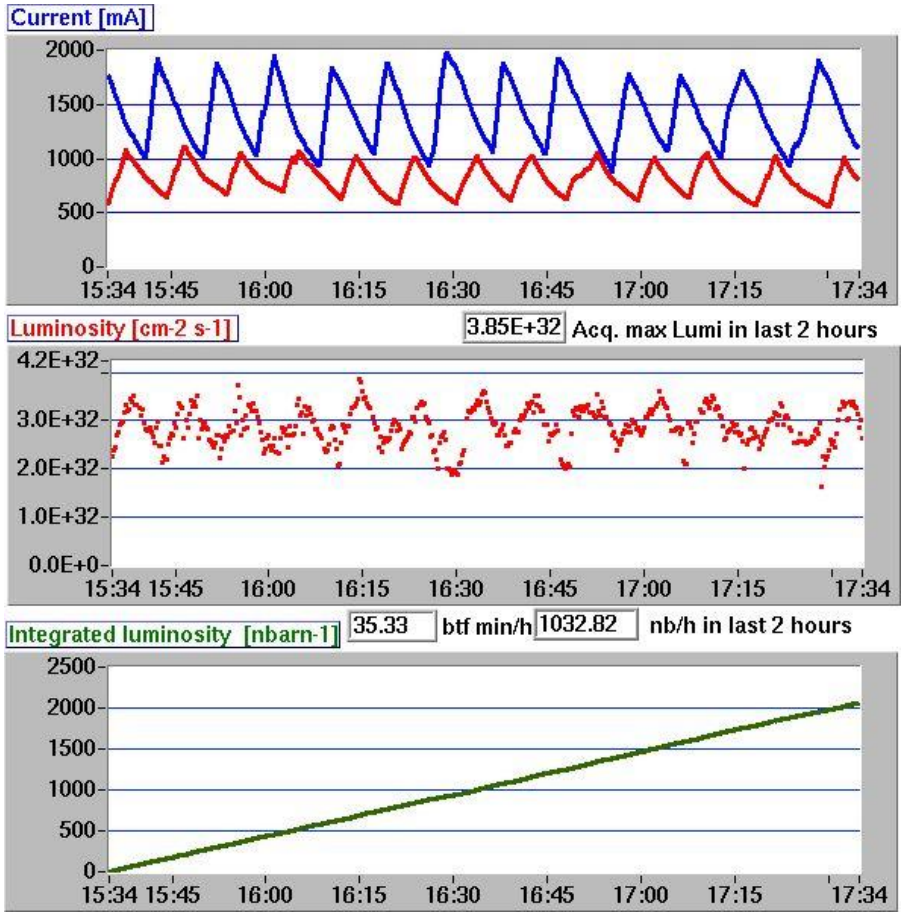
KLOE classical with apparatus solenoidal field



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

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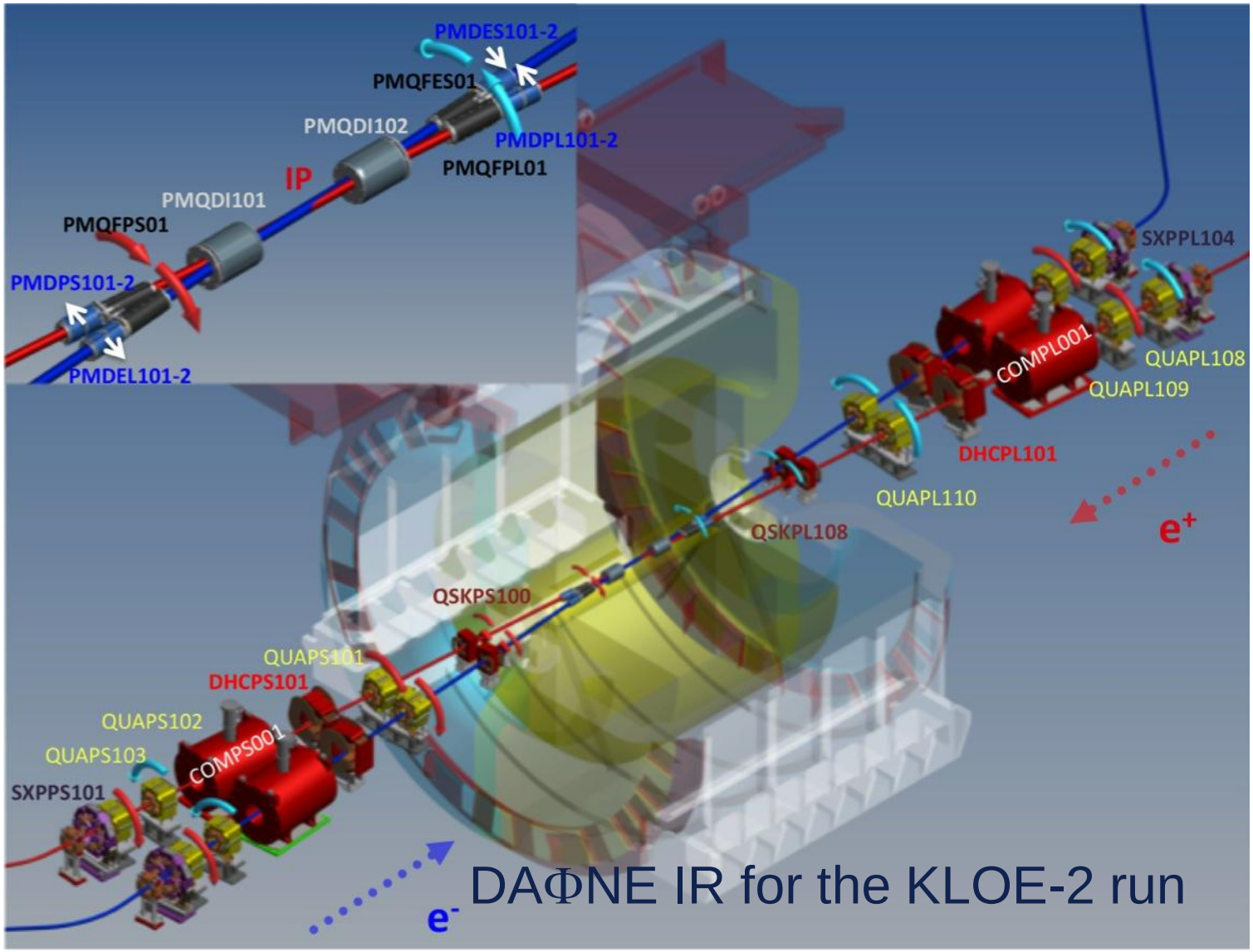
DAFNE scheme for KLOE2



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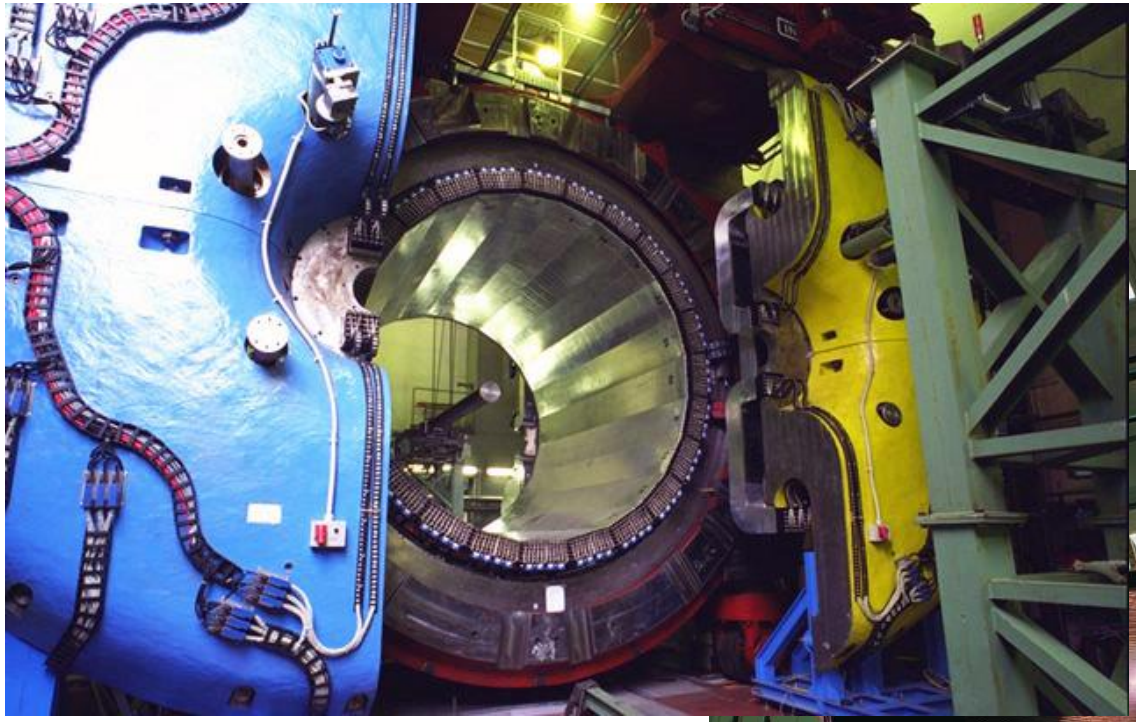
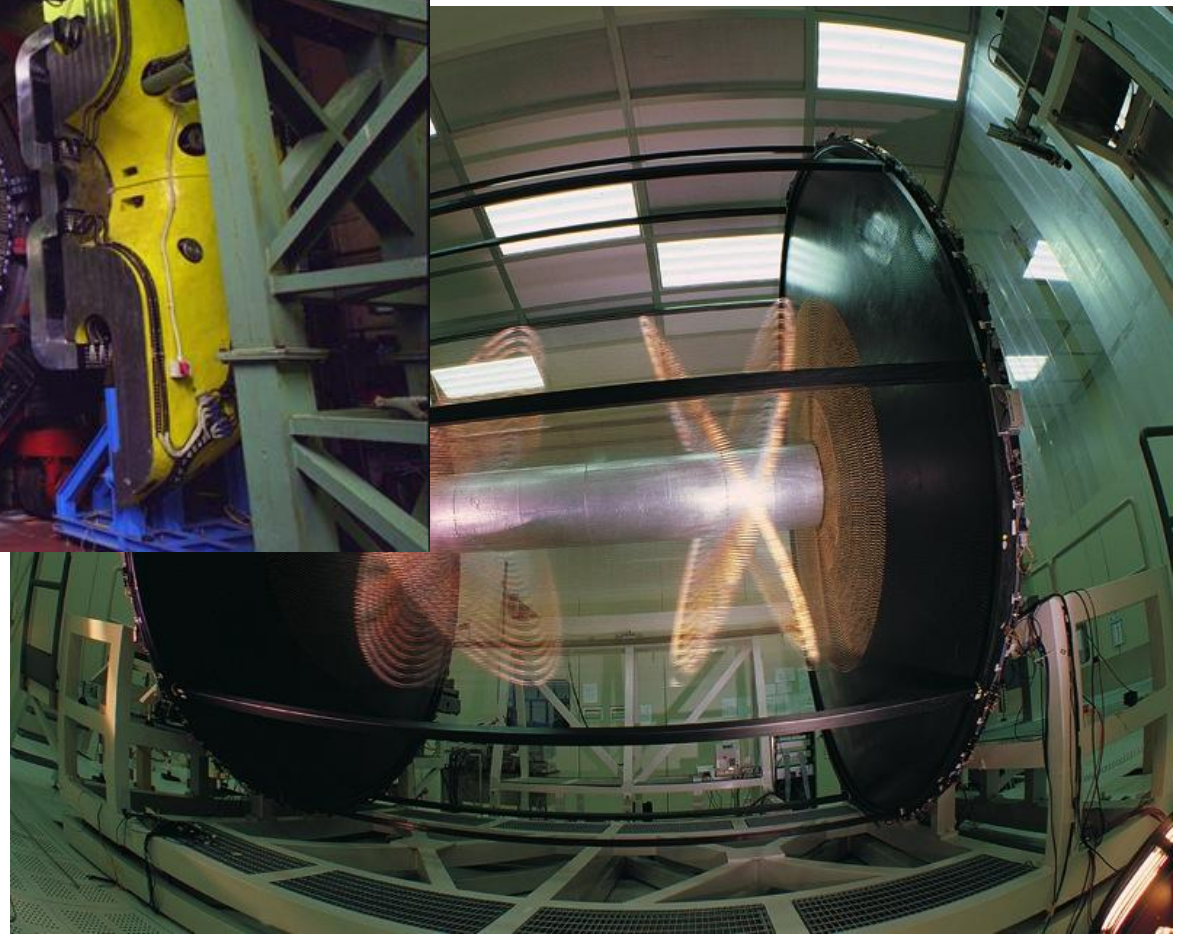
KLOE Detector





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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 ⇨

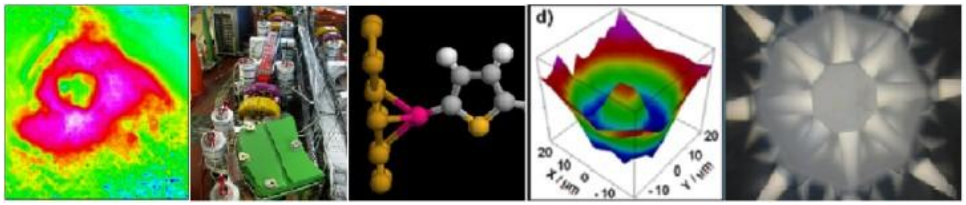
- Charged vertex efficiency near the IP
- Acceptance for photons emitted at low polar angles

KLOE-2

Taggers for $\gamma\gamma$ reactions installed.

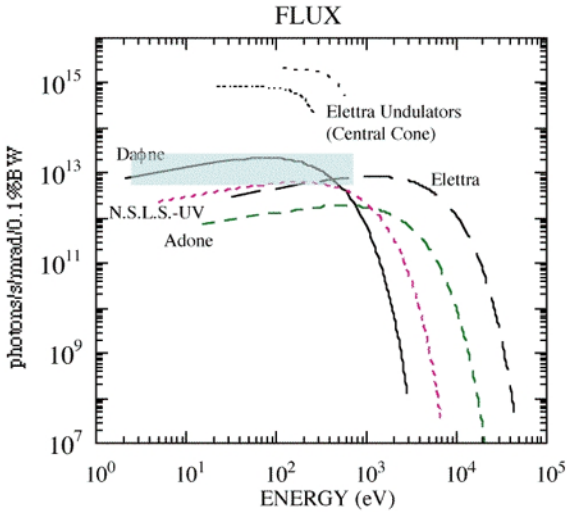
Low and high energy Tagger installations

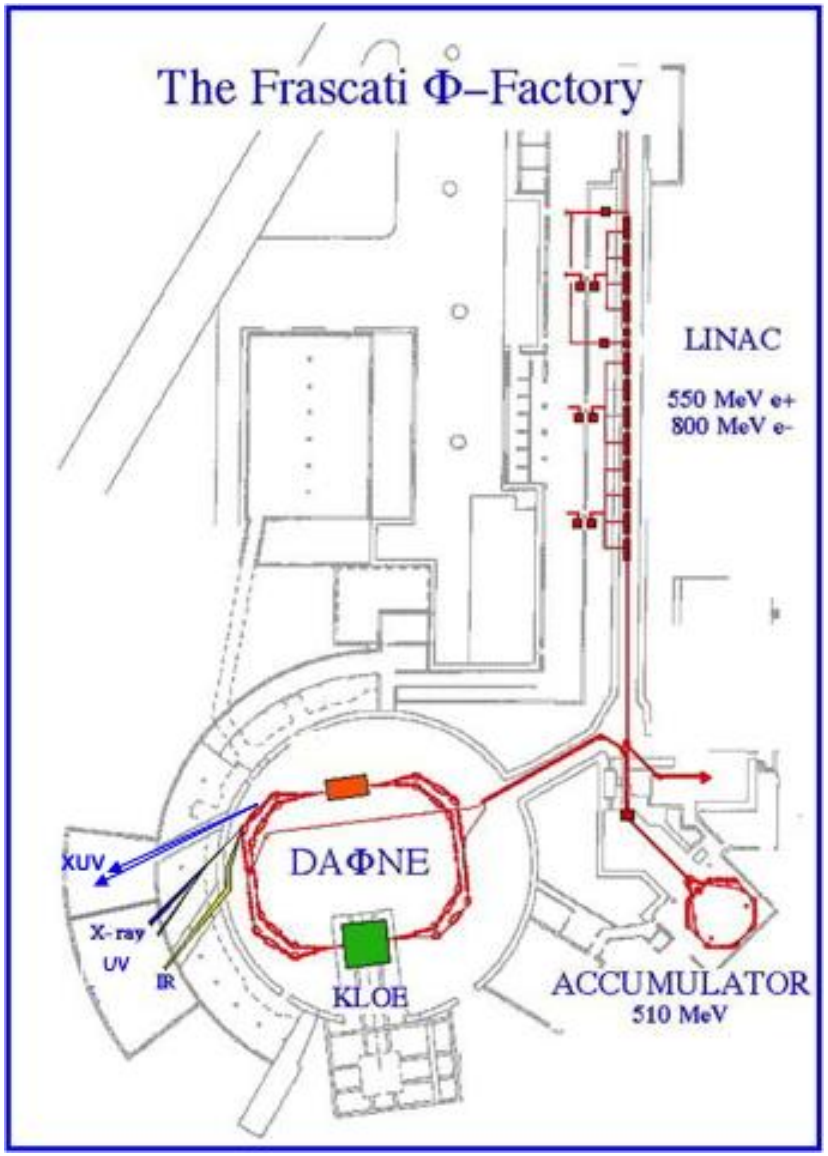
Beamlines @ DA□NE-Light



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

Open to Italian and EU users





Beam Test Facility (BTF)

Kiyotomo Kawagoe, International Linear Collider Workshop 2010 (LCWS2010)

Facility	Primary beam energy (GeV)	Particle types	Beam lines	Beam Inst.	Availability and plans
CERN PS	1–15	e, h, μ	4	Cherenkov, TOF, MWPC	Available, but reduced services during LHC commissioning
CERN SPS	10–400	e, h, μ	4	Cherenkov, TOF, MWPC	Available, but reduced services during LHC commissioning
DESY	1–6	e	3	Pixels	Available over 3 mo/yr
FNAL-MTBF	0.25–0.75	p, e, h, μ	1	Cherenkov, TOF, MWPC, Si-strips, Pixels	Continuous at 5% duty factor, except for summer shutdowns
Frascati	0.25–0.75	e	1		Available 6 mo/yr
IHEP-Beijing	1.1–1.5 0.4–1.2 (secondary)	e e, π, μ	3 3	Cherenkov, TOF, MWPC	Available in March 2008 or later
IHEP-Protvino	1–45	e, h, μ	4	Cherenkov, TOF, MWPC	Two one-month periods per year
KEK-Fuji	0.35–3.4	e	1		Available in fall 2007, for 8 mo/yr, as long as KEKB operates
LBNL	1.5; $\leq$ 0.06; $\leq$ 0.03	e; p; n	1	Pixels	Continuous
SLAC	28.5 1–20 (secondary)	e e, π, p	1		Shutdown in 2008-2009, with certain plans beyond

Table 1: Summary of test beam facilities along with their beam instrumentation, availability and plans.

applications

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

Study of Strongly Interacting Matter

HadronPhysics

Transnational Access to Research Infrastructure (TARI)

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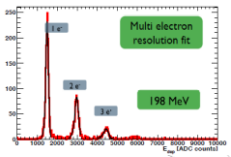
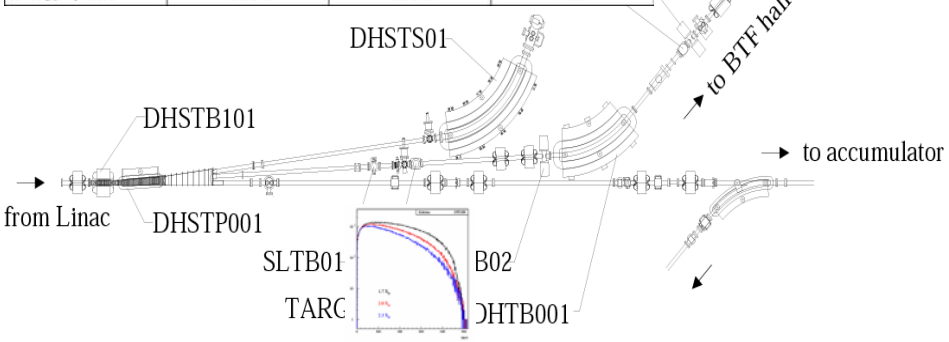
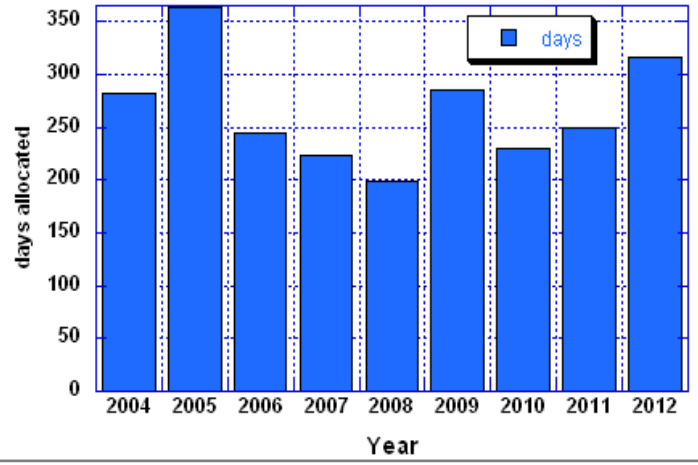
Beam Test Facility (BTF)

Operation mode	e^+ / e^- beam	γ beam	Neutrons beam
Energy range [MeV]	25-500 25-750(*)	100-500 100 -750 (*)	10^{-9} → 200
Bunch Rate [Hz]	User triggered (*) 1 → 24 49 (*)		
Bunch length [nsec]	10 3 or 10 (*)		
Multiplicity [#/bunch]	1 → 10^9 1 → 10^{10} (*)		$4*10^5$ (@1.5m) [n/cm²/sec]
Duty cycle [%]	~80% ~96% (*)		~40% ~96%(*)
Spot size ($\sigma_x \cdot \sigma_y$) [mm]	~ 2x2 ~5.5x5.5	>20	N.D.
Divergence [mrad]	~ 1 – 1.7	>15	N.D
Energy spread	1.00%	7.00%	N.D.





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



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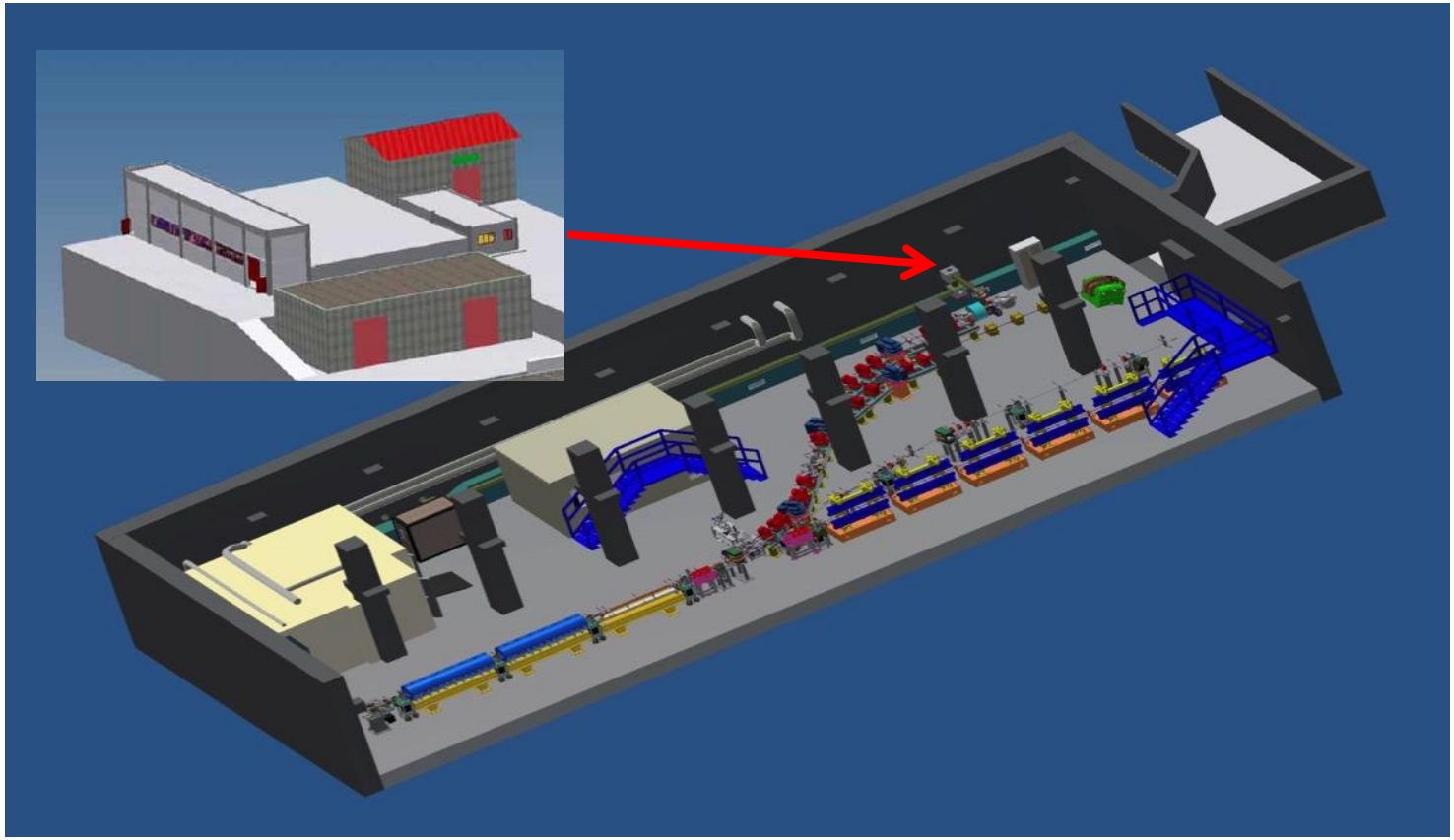
SPARC_LAB

Sources for **P**lasma **A**ccelerators and **R**adiation **C**ompton with **L**asers **A**nd **B**eams



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

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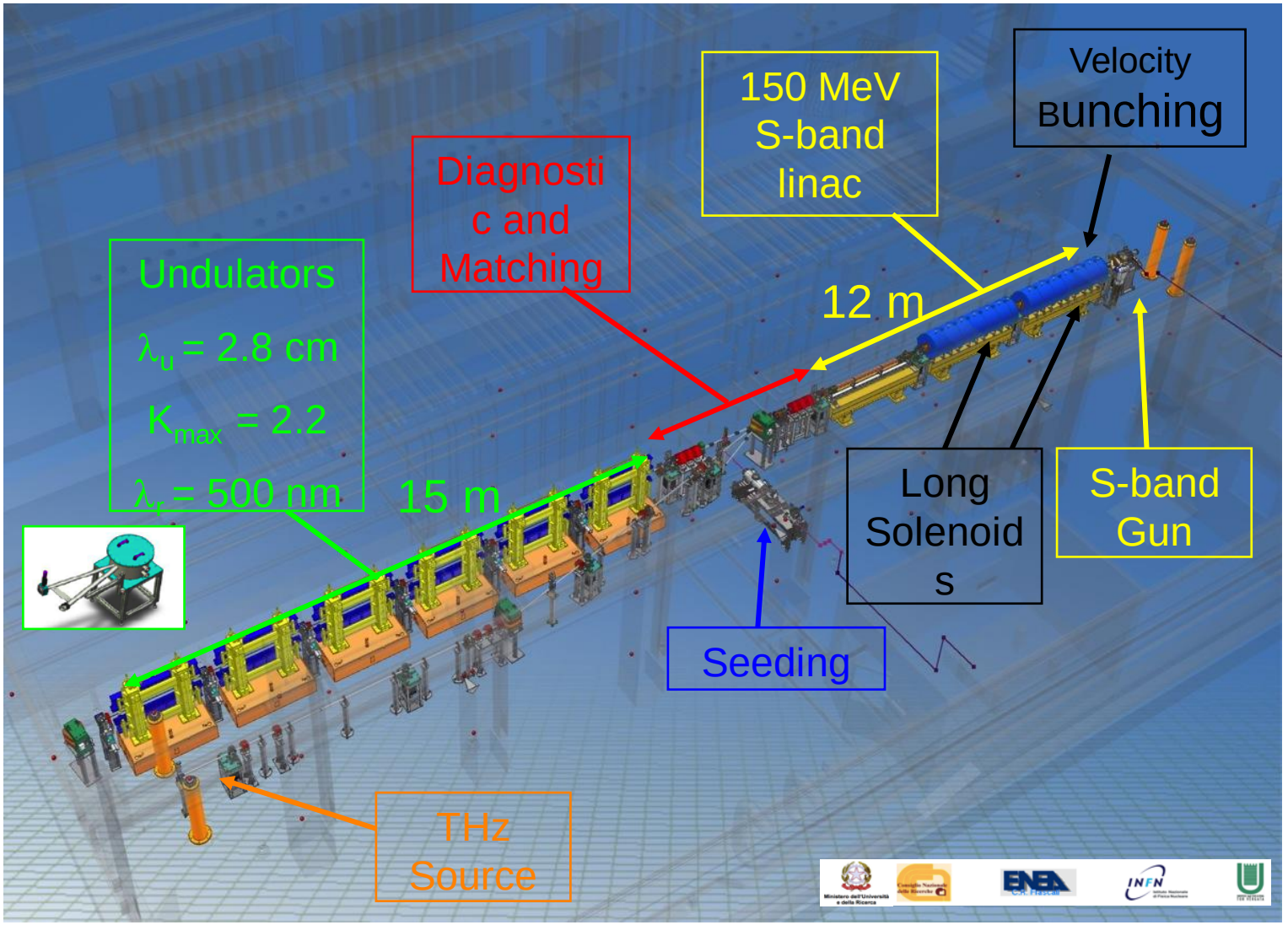
The SPARC Facility



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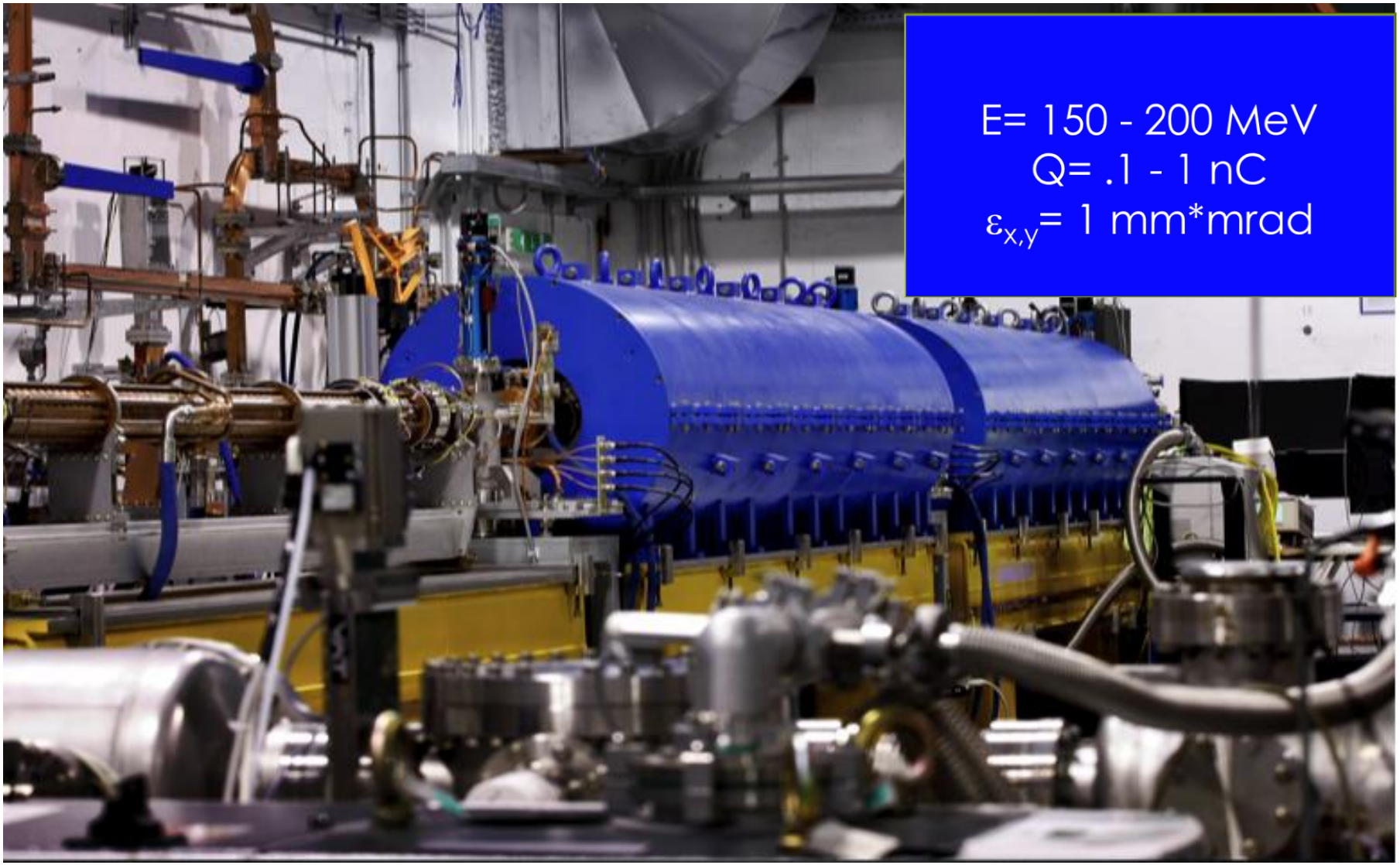
SPARC Photoinjector



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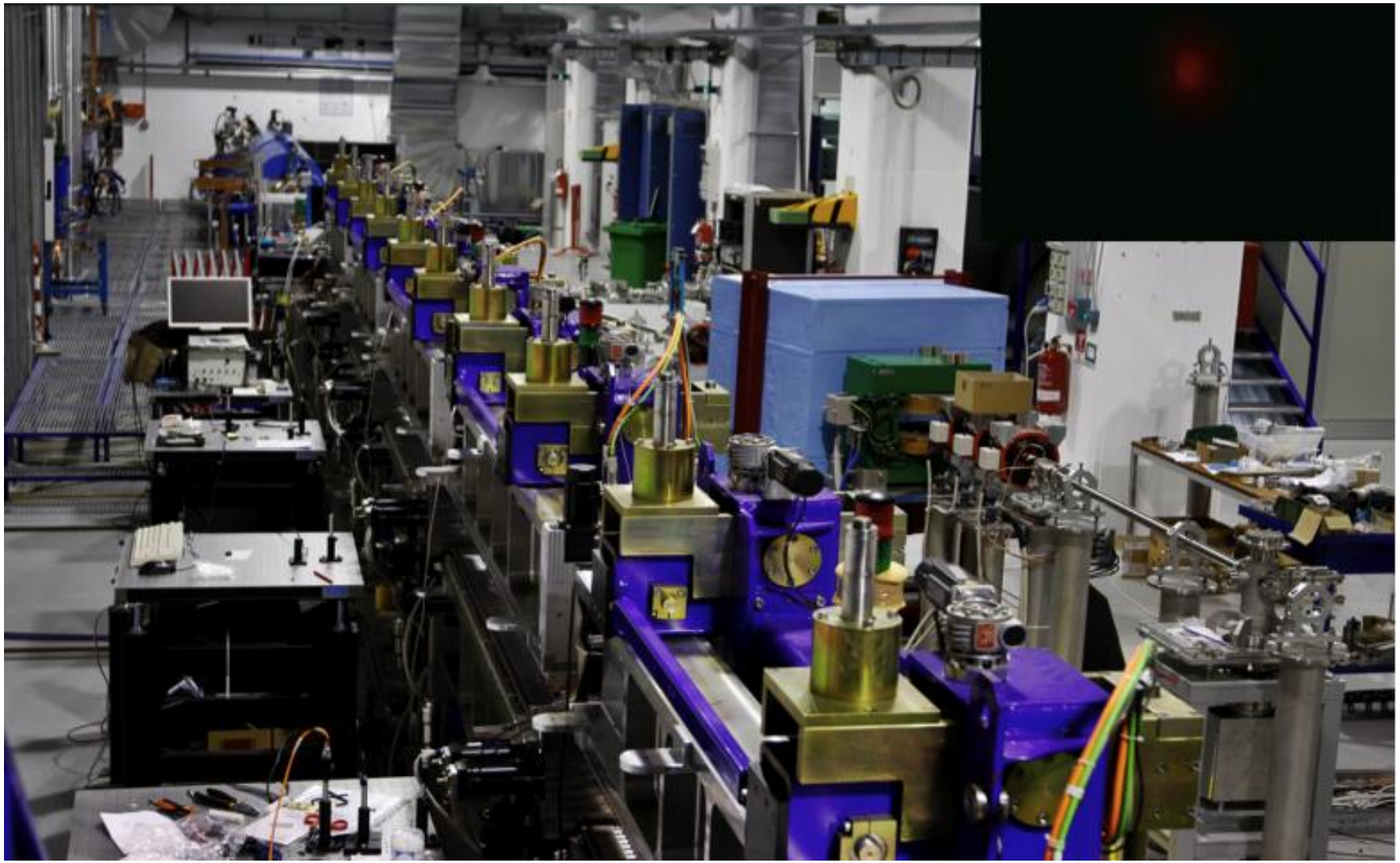
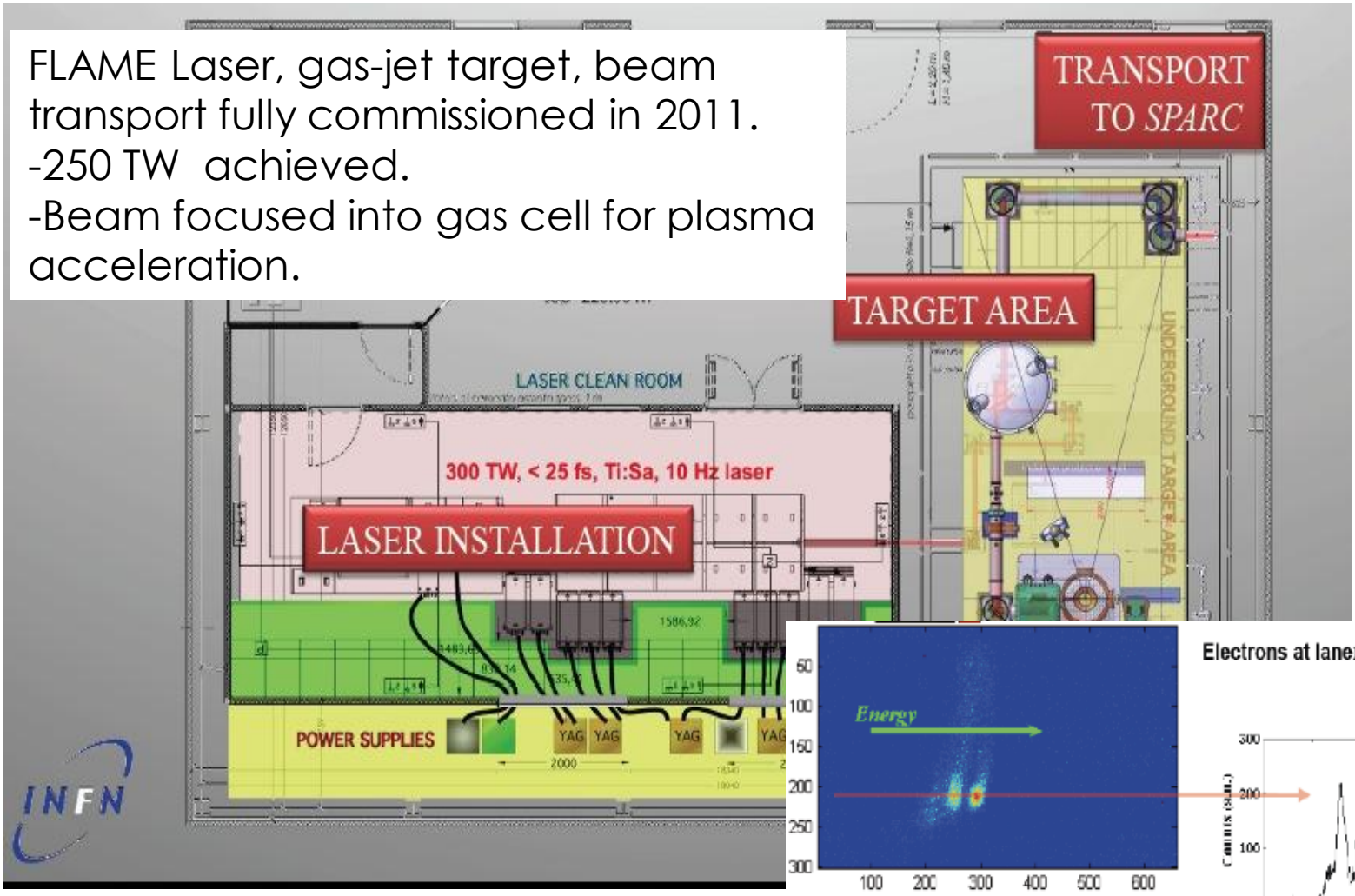
FEL undulators



FLAME: Frascati Laser for Acceleration and Multidisciplinary Experiments

FLAME Laser, gas-jet target, beam transport fully commissioned in 2011.
-250 TW achieved.
-Beam focused into gas cell for plasma acceleration.



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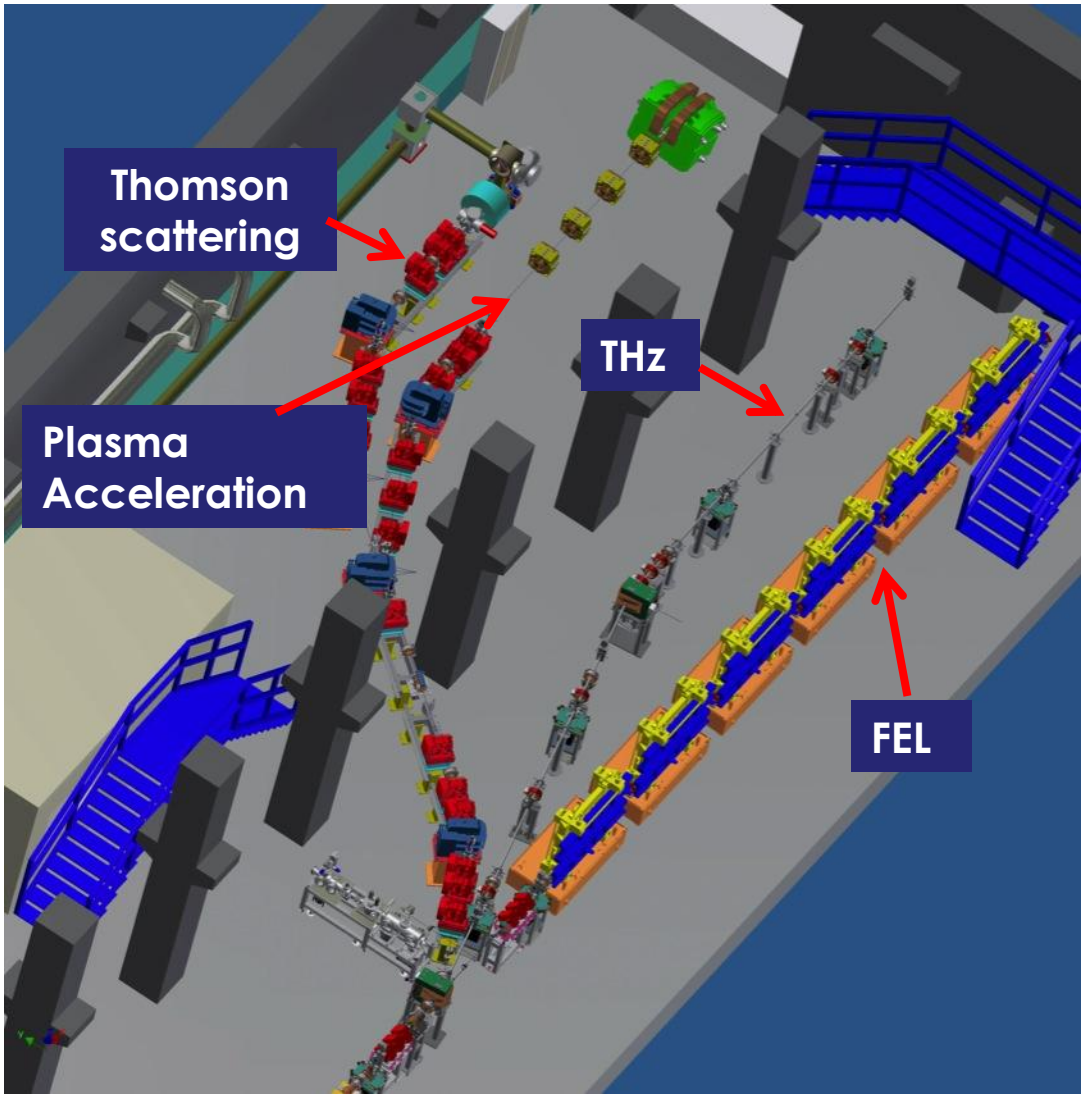
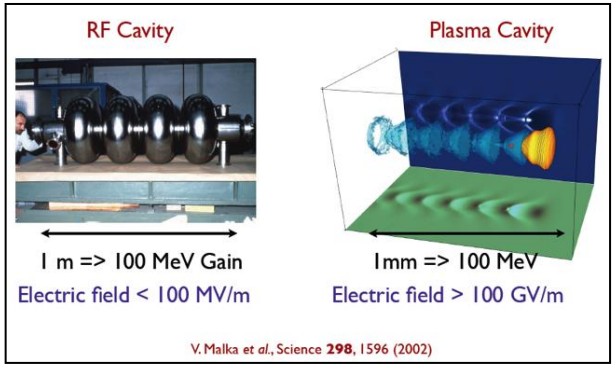
SPARC_LAB Facility

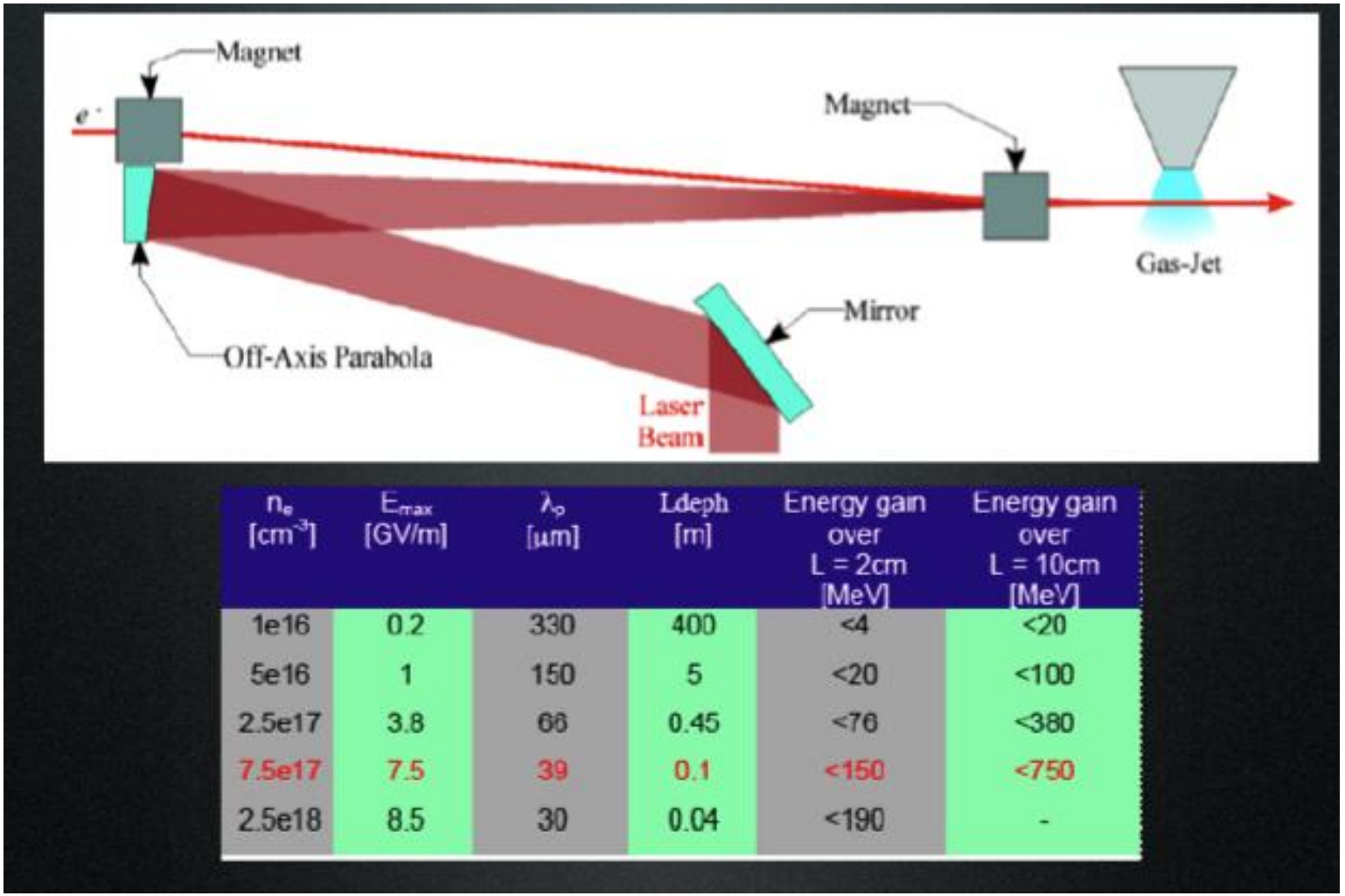


- Investigation of different configurations of **plasma** accelerator.



- Production of monochromatic ultra-fast X-rays by **Thomson** b-s driven by high-quality electron beam.

EXIN (**EX**ternal **IN**jection)

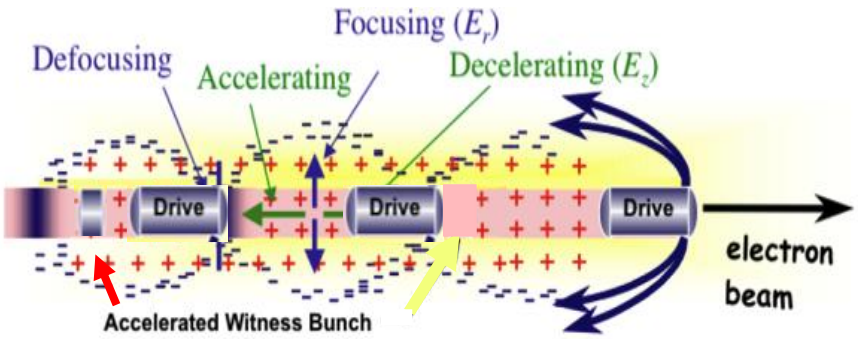


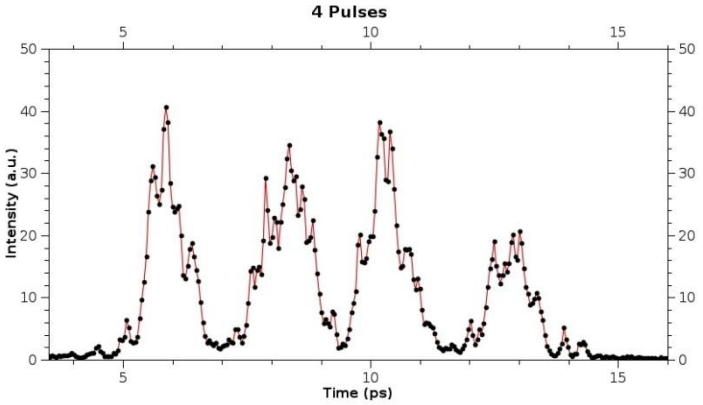
n_e [cm^{-3}]	E_{max} [GV/m]	λ_p [μm]	Ldeph [m]	Energy gain over L = 2cm [MeV]	Energy gain over L = 10cm [MeV]
1e16	0.2	330	400	<4	<20
5e16	1	150	5	<20	<100
2.5e17	3.8	66	0.45	<76	<380
7.5e17	7.5	39	0.1	<150	<750
2.5e18	8.5	30	0.04	<190	-

acceleration of the electron bunch by a plasma wave driven by the laser pulse

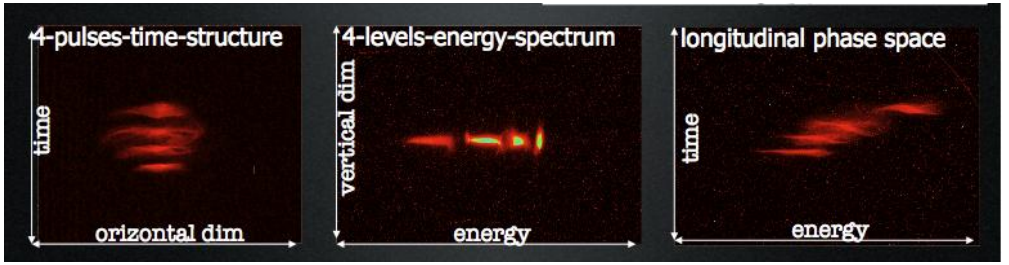
COMB (Laser Comb Technique)

the photocathode is illuminated by a comb-like laser pulse in order to produce a train of sub-picosecond high-charge density pulses within the same RF gun accelerating bucket. Downstream of the gun exit, the work done by the space charge force produces a linear energy chirp along each pulse, which can be exploited to compress the initial charge profile with an RF accelerating structure, operating in the velocity bunching mode

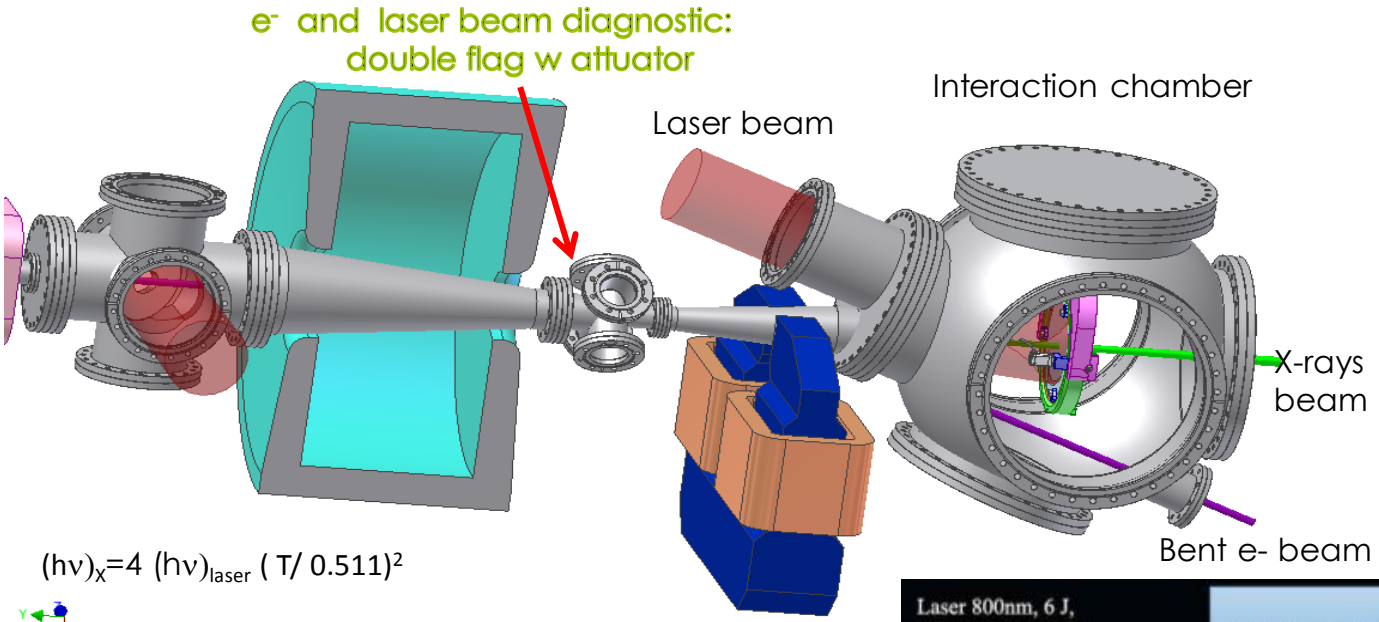




Resonant plasma Oscillations by Multiple electron Bunches



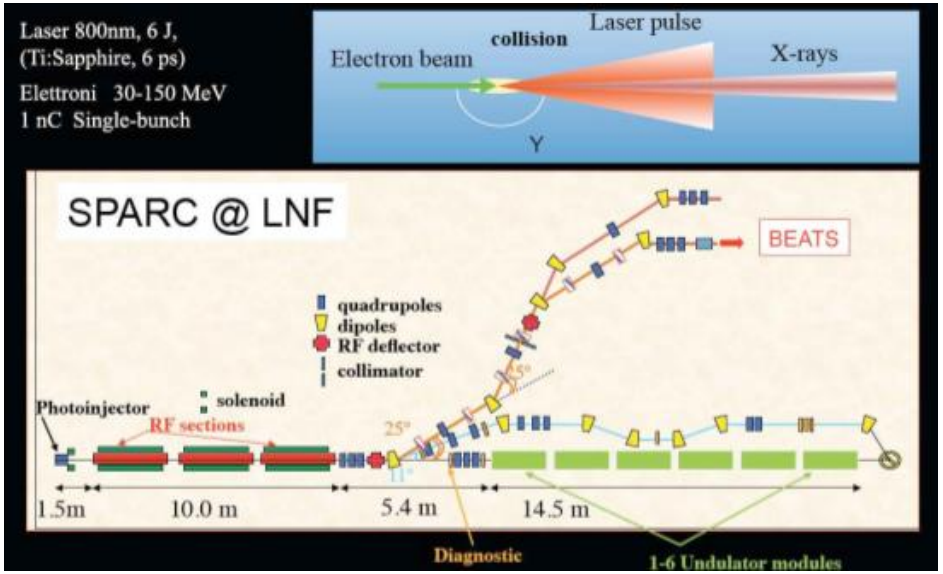
Thomson Interaction region (20-550 keV)



$(h\nu)_X = 4\,(h\nu)_{laser}\,(T/0.511)^2$

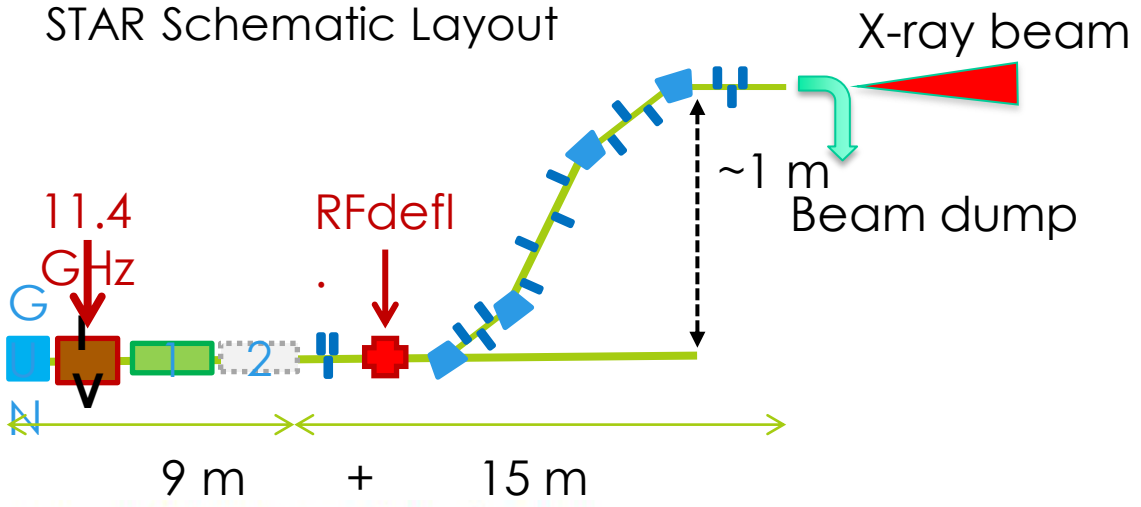
$(h\nu)_{laser}$ = 1.2 eV
T = 30.28 MeV

laser: pulse 6 ps, 5 J
e^- bunch: 1 nC , I: 2 mm (rms)
X ray pulse: 10 ps, 10^9 fotoni per interactionj
α emission: 12 mrad



STAR: Southern Europe Thomson back-scattering source for Applied Research

PON-MATERIA (Calabria) 15Me, LNF are in charge for the construction of the STAR accelerator Thompson-Scattering Facility

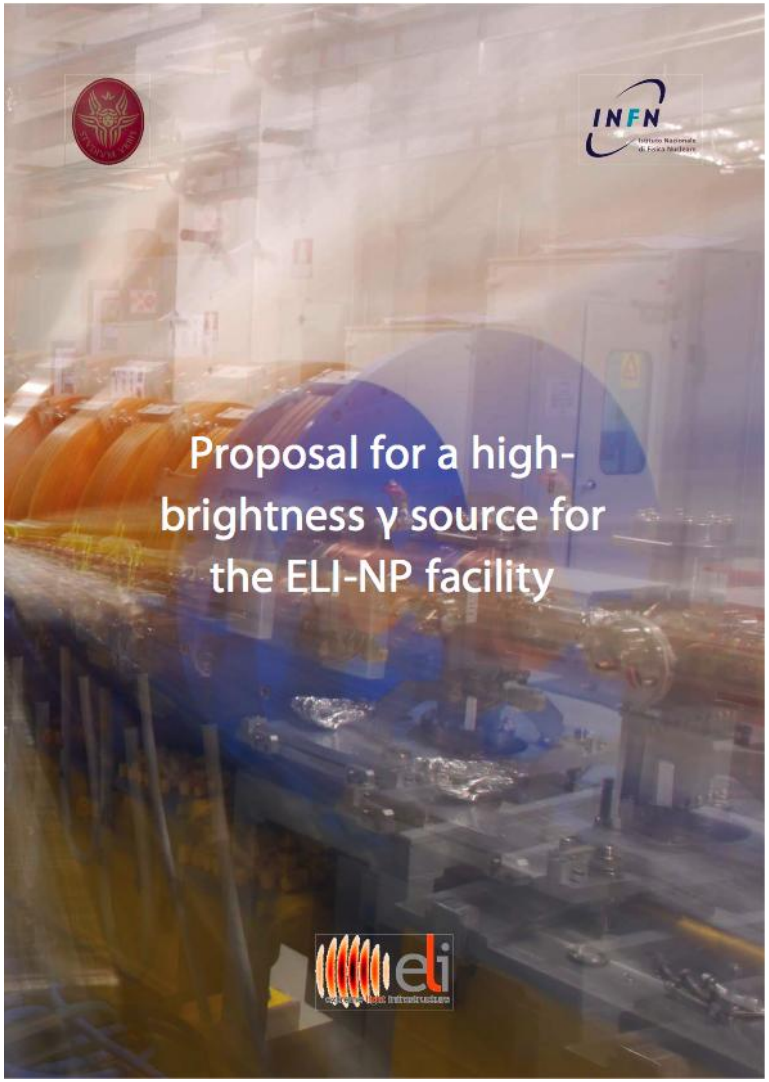


Thomson/Compton X-ray Sources in Europe

Laboratory	Machine type	Electron bunch	Laser	X-ray Energy (keV)	Phot. per pulse	Phot. per sec	Band-width	Pulse (psec)	Applications	Since year
INFN-LNF	S-band 150 MeV Linac	1 nC	5 J Ti:Sa	20-500	10^{9}	10^{10}	5 %	0.15-5	Radiol. Imaging Mat. Studies	2011
ThomX	50 MeV Storage Ring	1 nC	0.1-1 MW supercavity	10-40	no op.	10^{12}	5 %	5	Radiol. Imaging Mat. Studies	? 2013
Daresbury	SC 30 MeV ERL Linac	40 pC	800 mJ $Nd:YVO_4$	20	no op.	$1.6\,10^{5}$	10 %	10	Test (closed)	Nov.'09
ELSA	UHF 19 MeV Linac	2 nC	0.2 J Nd:YAG	5-14	no op.	10^{8}	5 %	30	Test	? 2011

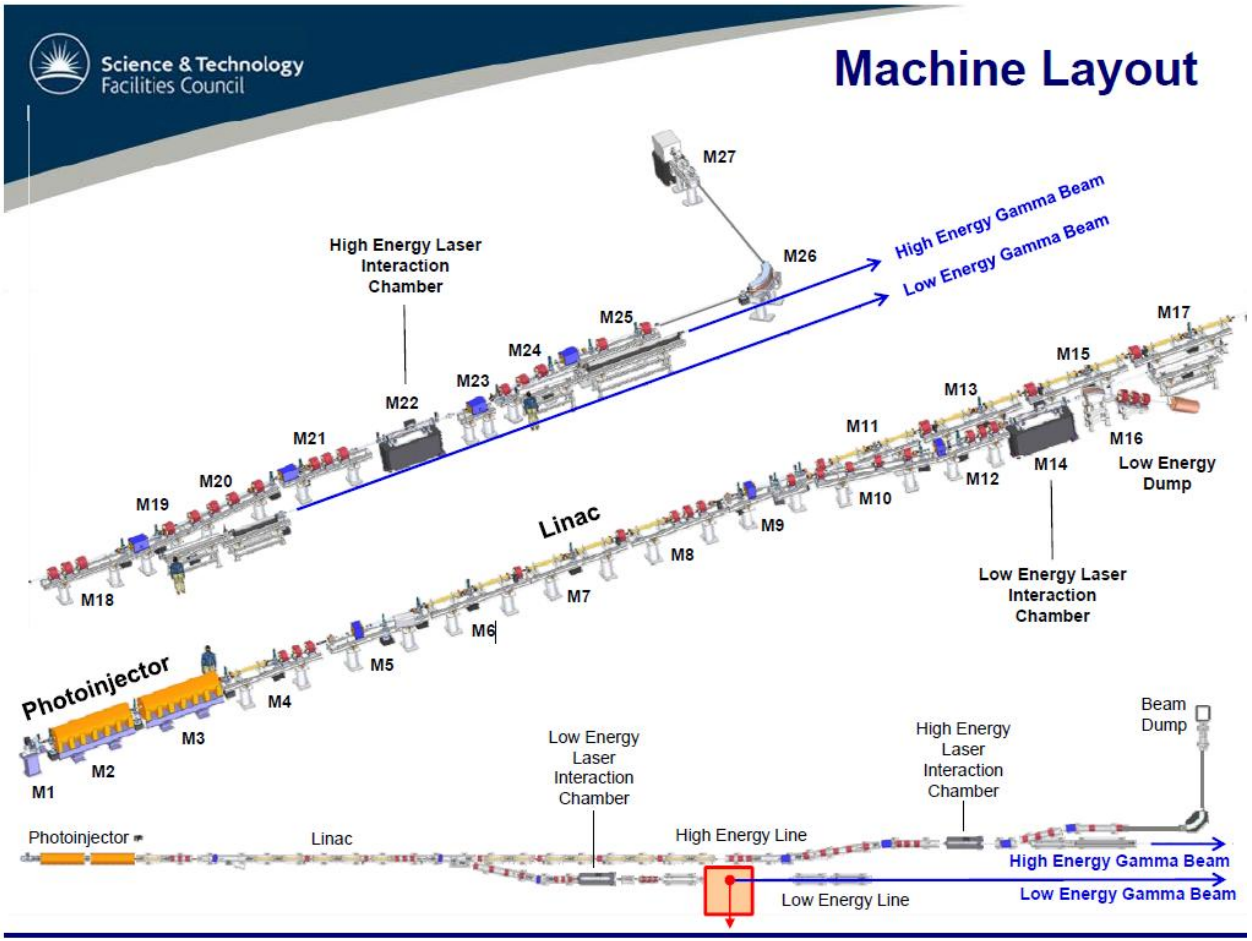
STAR 100 Hz Linac 65 MeV ; 0.5 nC ; 0.5 J Yb; 7-120 keV ; $5{\cdot}10^{7\text{-}8}$; $5{\cdot}10^{9\text{-}10}$; 2-10% ; 0.1-5 ; **user facility** ; 2015
100 Hz Linac 300 MeV ; < 3 MeV ; $5{\cdot}10^{9\text{-}10}$; $5{\cdot}10^{11\text{-}12}$; 2-10% ; 0.1-5 ; **user facility** ; ??

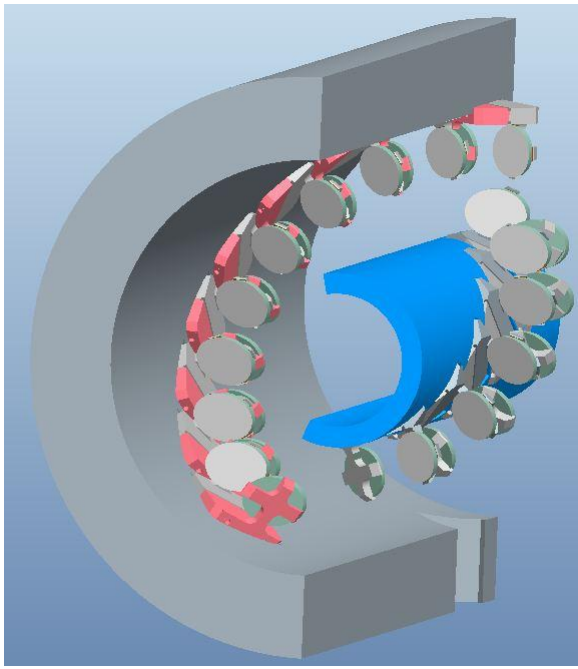
ELI-NP


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


ELI-NP
Bucharest (Magurele)
Romania for ELI

TDR ready in Oct. 2012
To be built in 4 years





E beam energy : 720 MeV
Photon energy : 20 MeV
Laser pulse energy : 0.5 J

Laser wavelength: 2.4 eV
Rep rate : 100 Hz
# of recirculations: up to 40

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High Luminosity Large Hadron Collider Design Study (HiLumi LHC)

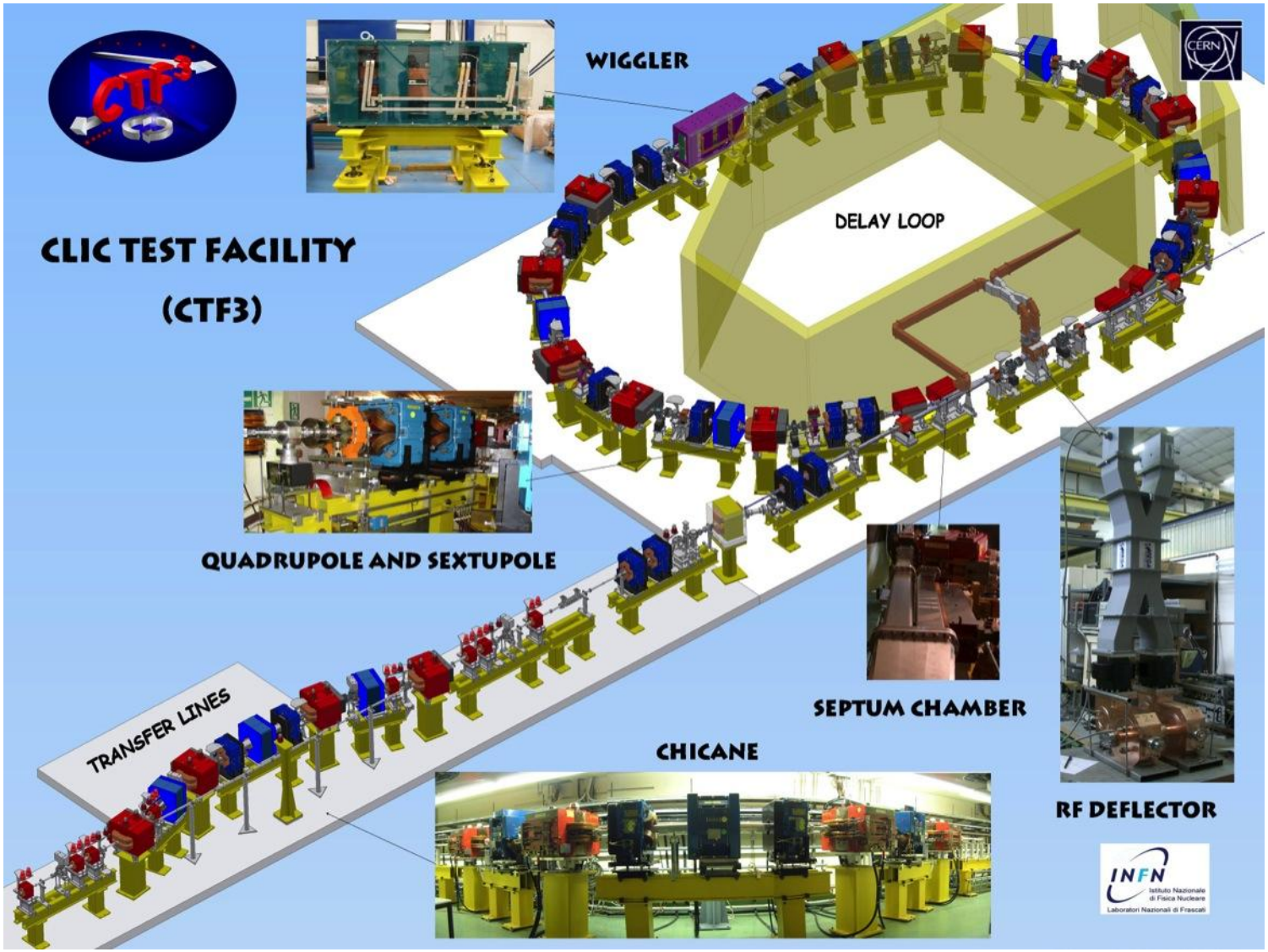
1. The Project goal is the design of the LHC upgrade configuration with luminosity of 10^{35} cm^{-2} s^{-1}
2. It involves participants from 20 research institutions from European Union, Russia, USA and Japan
3. HiLumi LHC has been approved with the highest score 15/15 and it will get European funding of 4.900.000,00 Euro out of 4.950.000,00 Euro requested
4. The INFN President has signed the Grant Preparation Form of the Collaborative Agreement (21/06/2011)
5. INFN will get the second biggest European funding (after CERN) for participation in the Project

High Luminosity LHC

Subjects to Study for LHC Upgrade (WP2)

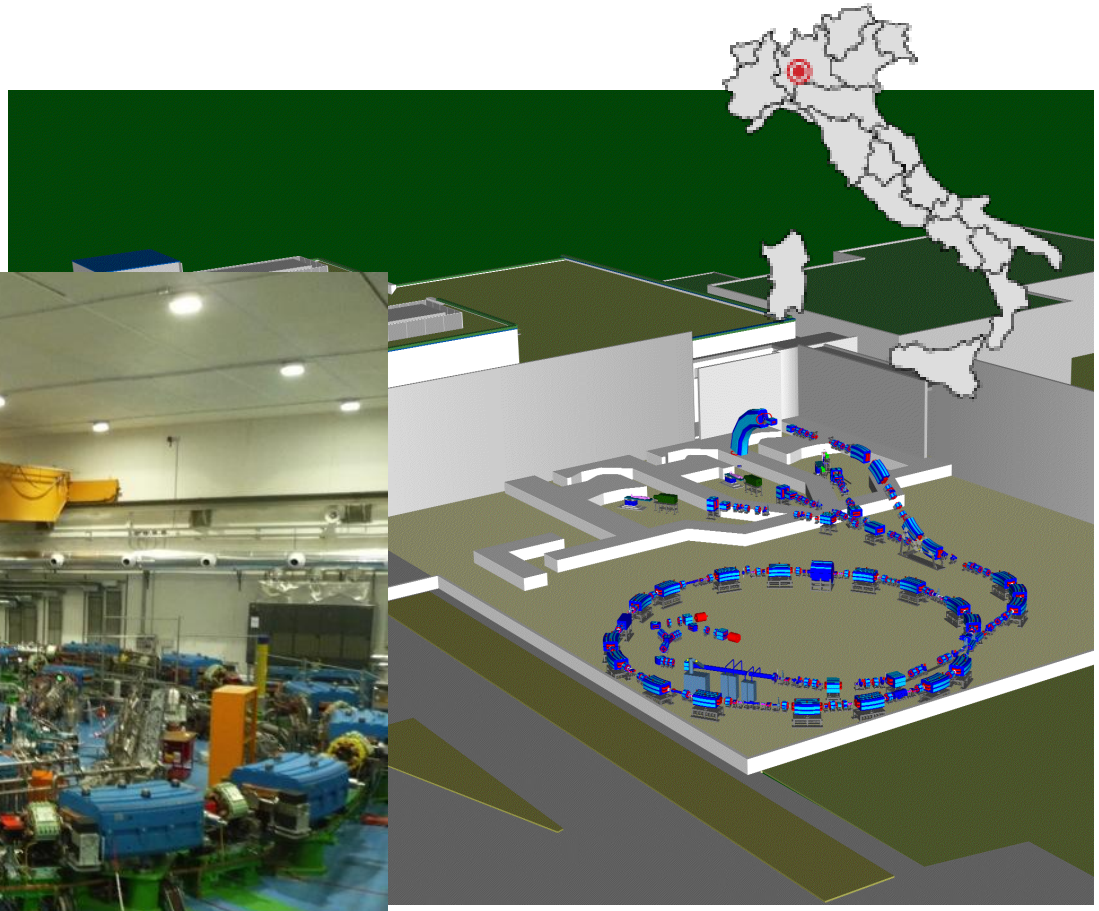
1. Linear and Nonlinear Optics
2. Vacuum Chamber Design and Beam Impedance Evaluation
3. Collective Effects and Beam Instabilities (including e-Cloud)
4. Beam-Beam Effects

CLIC Test Facility CERN – CTF3



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

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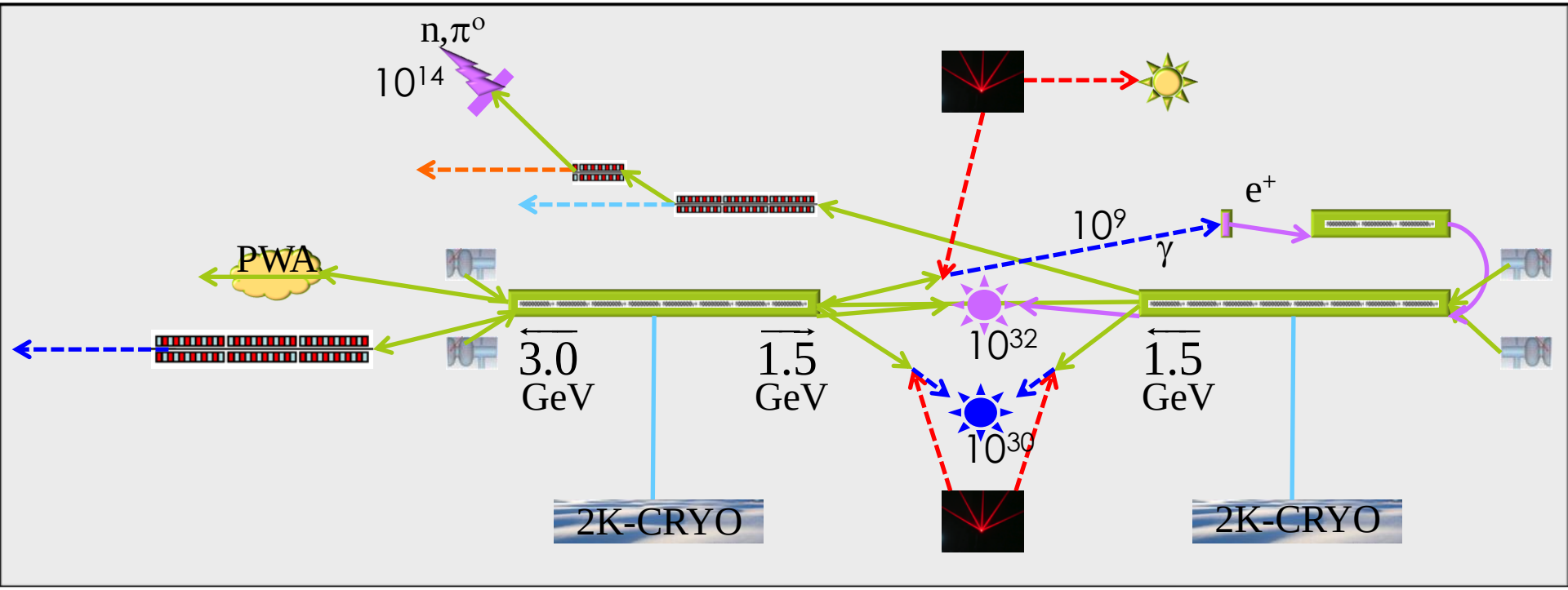
IRIDE

I R I D E is a **large infrastructure for fundamental and applied physics research**. Conceived as an innovative and evolutionary tool for **multi-disciplinary** investigations in a wide field of **scientific**, **technological** and **industrial** applications, it will be a high intensity "particle beams factory".



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IRIDE "white book"

- Science with **Free Electron Lasers** (FEL) from infrared to X-rays
- Nuclear photonics with **Compton back-scattering** g-rays sources
- Fundamental physics with **low energy linear colliders** ($e^-e^+/e^-\gamma/\gamma\gamma$)
- Advanced **Neutron sources** by photo-production
- Science with **THz radiation** sources
- Physics with **high power/intensity lasers**
- **R&D on advanced accelerator** concepts including plasma accelerators and polarized positron sources
- **ILC technology** implementation
- **Detector development** for X-ray FEL and Linear Colliders
- **R&D in accelerator** technology and **industrial spin – off**

From SuperB to Tau-Charm

- In 2012, after a careful costing review of the SuperB project a decision was taken by INFN to cancel it, due to the insufficient budget allocated by the Italian Governement. The Nicola Cabibbo Laboratory, entity in charge of building SuperB, has then **started in 2013 a study for a dedicated high luminosity (10^{35} cm^{-2} s^{-1}) τ/charm factory**

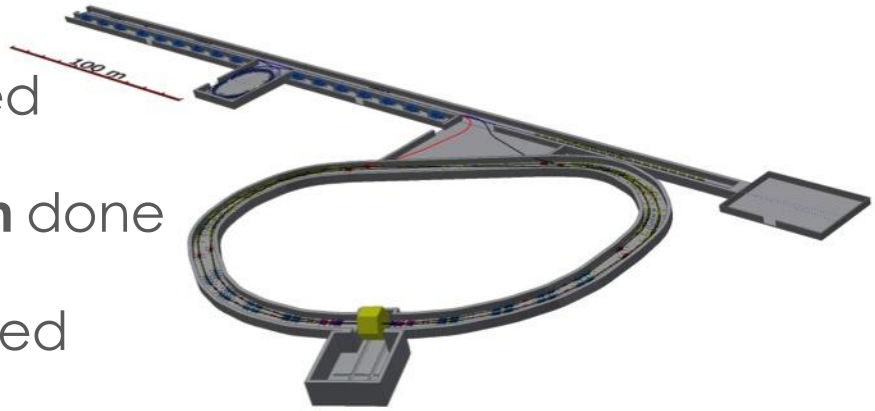
- This **program was already planned as a second phase of SuperB**, by decreasing the beams energies, so most of the work done in the past years for SuperB can be used for the new project

- The scope of the present design is to have a dedicated and optimized project, re-using all the competences, studies and tools developed for SuperB, **keeping costs in the allocated budget** (250 Meuro)

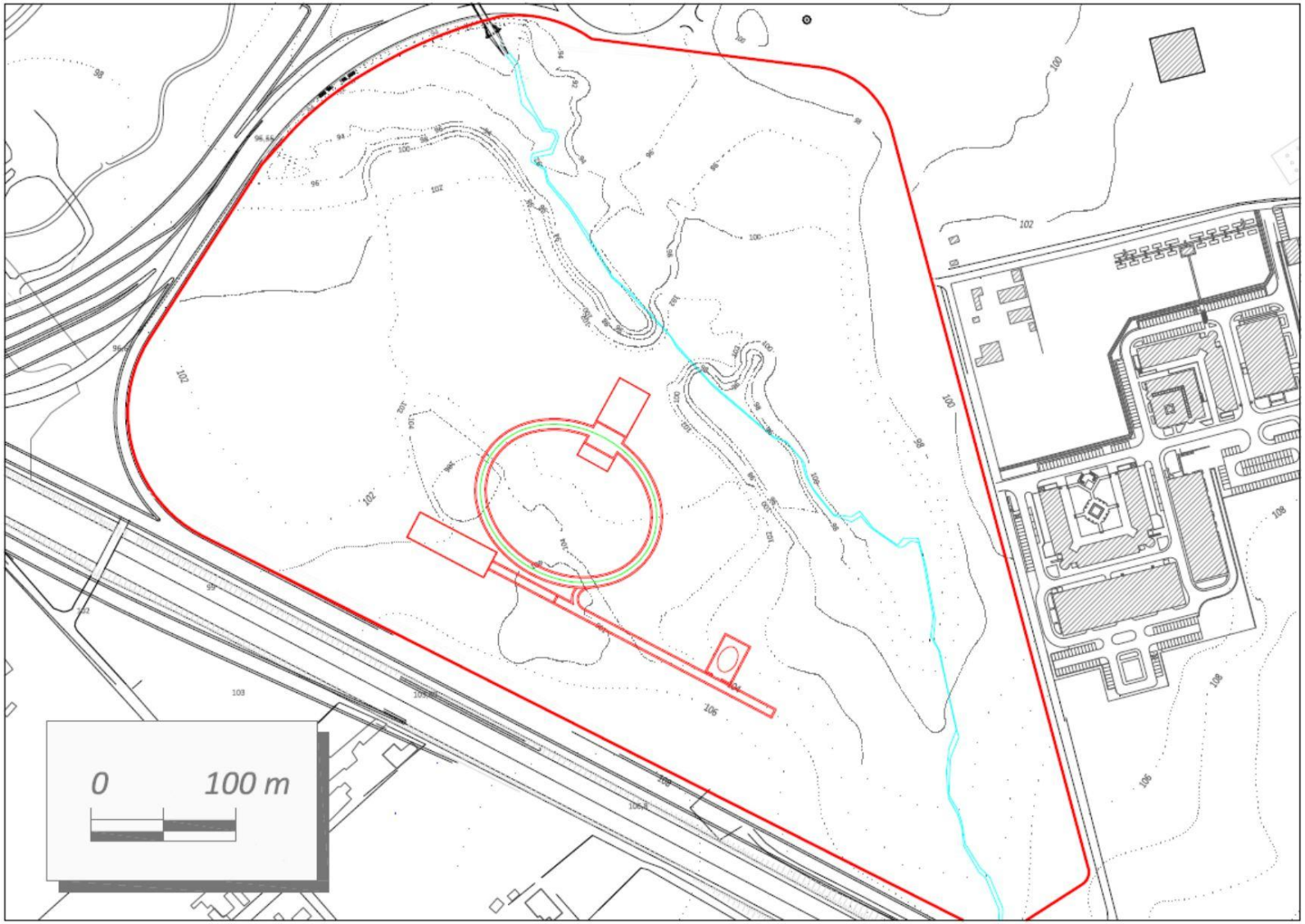
- The possibility to use the injection Linac for a **SASE FEL facility** is still valid and is part of the design

Tau-Charm design

- A small group from LNF AD and a group of CabibboLab engineers has started working on the design
- A new **lattice** has been designed (P. Raimondi, collaborating from ESRF)
- A new **parameters** set established
- Rescaling of the **injection system** done
- **Layout** of the new complex started
- **Vacuum** and other technical aspects started
- We expect to be able to produce by **summer a short document on the accelerator design**



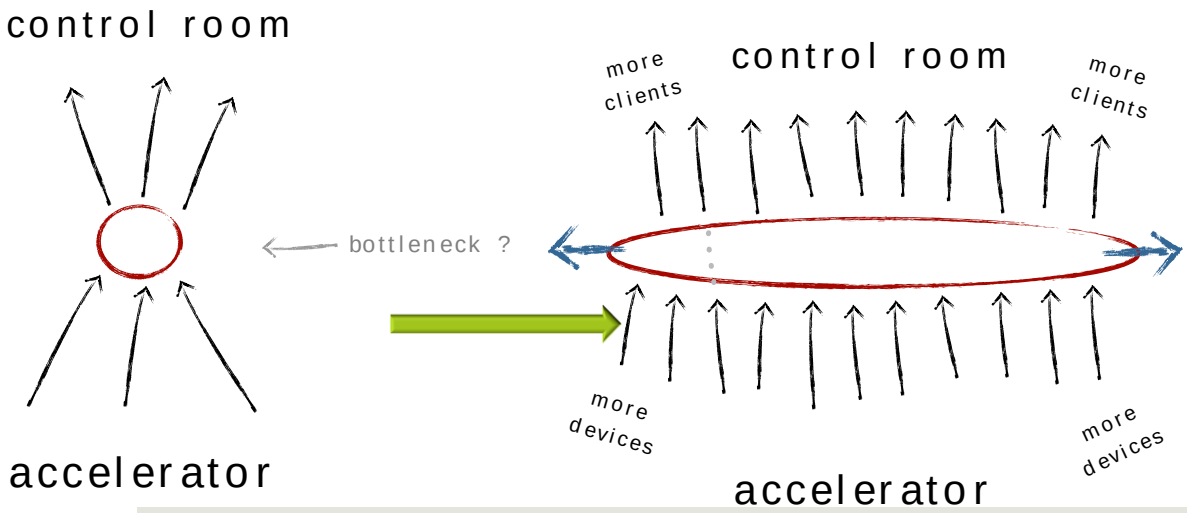
Tau-Charm Layout @ Vergata

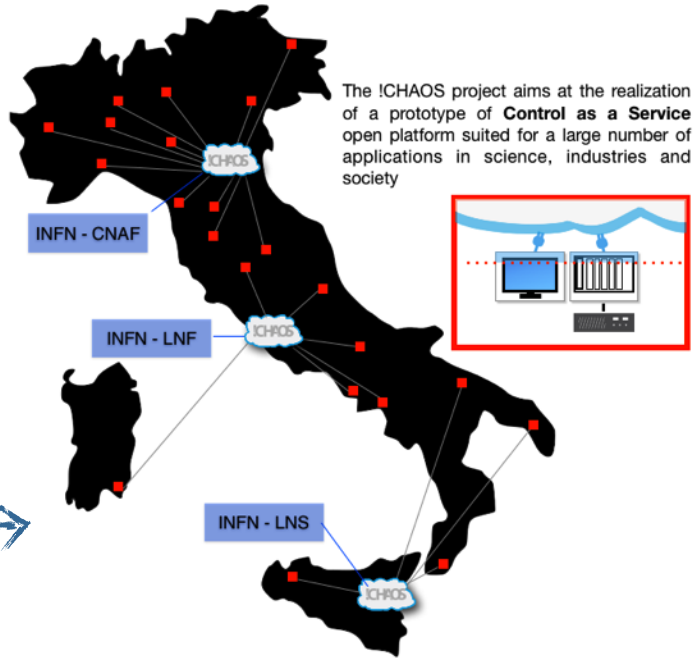


!CHAOS Project

!CHAOS, in addition to being the proposed control system for Tau Charm is an R&D of CSN5, and since February 2013 have collected a large INFN community interested in his development for more large scale applications.

!CHAOS has been designed to widely **scale** and to manage and store with high speed ensuring reliability and flexibility





Research at accelerators

Exp	Res	Tec	FTE	<FTE>
ATLAS	15	5	15.6	0.78
BABAR	7	0	3.3	0.47
BESIII	4	0	2.0	0.50
CDF2	5	0	2.3	0.46
CMS	9	4	9.7	0.75
KLOE	23	4	17.5	0.65
LHCb	10	2	8.2	0.68
NA62	7	1	5.3	0.66
SuperB	7	4	4.0	0.36
mu2e	4	0	1.2	0.30
UA9	6	2	2.1	0.27
DTZ	**97**	**22**	**71.2**	**0.60**

analysis and computing:

$h \to ZZ \to 4\ell$ $h \to WW \to \ell n \ell n$

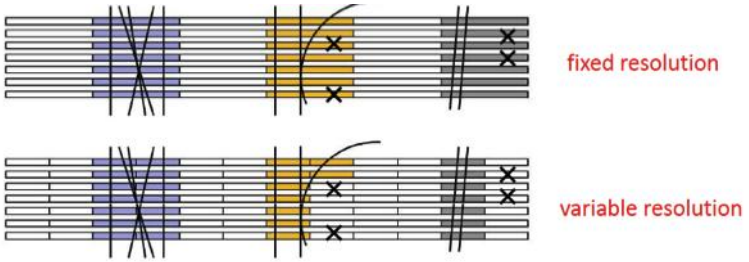
Missing Transverse Energy (MET)

Management of a local Tier-2

Track Finder (FTK)

- FE electronics, mechanical quality control, mechanical structure
- technological transfer from CERN to Italian company (ELTOS)
- front-end electronics for μTPC reconstruction
- Test beams (BTF) and Cosmic Ray

Invention of variable resolution patterns for the FTK input & clustering →



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Research at accelerators

Data taking: MWPC, GEM chambers, FEE electronics, ECS software

Muon detector performance studies: MWPC/GEM hardware efficiency online monitoring and offline μ identification algorithm

Data analysis: to $B_s \rightarrow \mu^+\mu^-$ search, $B_s \rightarrow e\mu$ (LFV) and CP violation in $D^0 \rightarrow e\gamma$ decay

Muon detector upgrade: development of new GEM detectors for central regions of M2/M3MWPC detectors (only site in Italy), FEE electronics to sustain a 40 MHz rate and upgrade of ECS software

Data taking

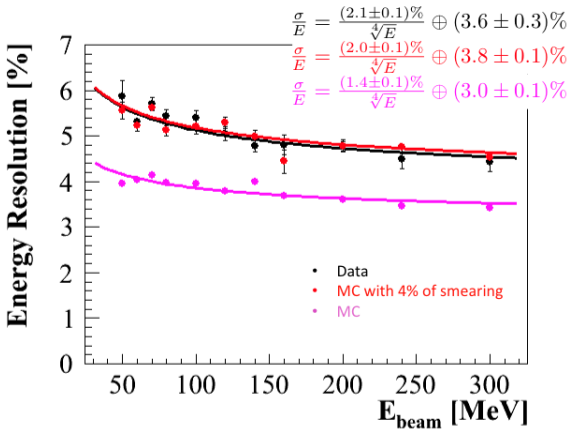
Physics analysis single top

RPC detector upgrades in Long Shutdown 1 (2013-2014)

R&D on Gas Electron Multiplier (GEM) muon detectors for hi-eta region in Long Shutdown 2 (2017-2018)

Research at accelerators

LNF+INFN PI/Ud work on EMC R&D & design (LYSO crystals)
Development of **Quality Control stations**
Characterization of photo-sensors
Development of **Laser calibration**
Overall **calorimeter design**



LNF, PI, UD, RM2
Synergy with P-Mu2e at LNF (common R&D for calibration)
E.M. calorimeter PbF2, with online, **LASER-based calibration** system of the gain (in the inter-spill)

→ Studies of performance and reproducibility and light transmission linked to Mu2e calibration system

→ Common R&D for at least 1 year

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Nuclear Physics

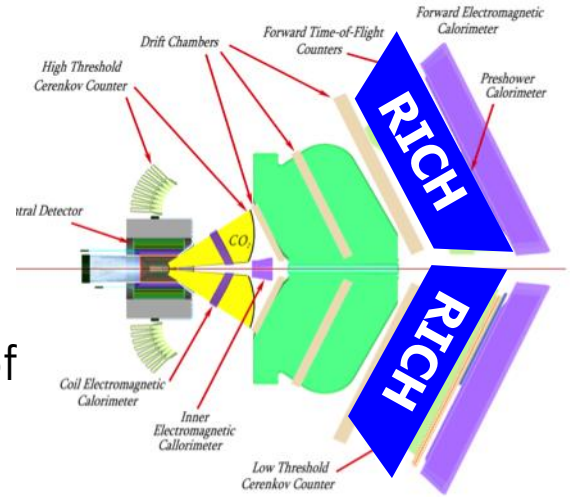
ALICE

@ CERN

Jet reconstruction and quenching in QGP (Quark Gluon Plasma)
Λ polarization in pp **analysis**
Data taking (online/offline) E.M. calorimeter
High Level Trigger E.M. calorimeter
DCAL Eu/Asia
Upgrade HLT EMCal
participation in the construction of the **VHMPid** (RICH in un range: 5-30 GeV)
Radiation hardness **test** ITS

e1Dvcs Lab12

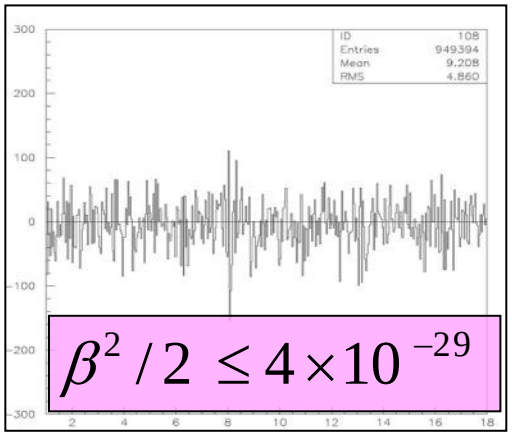
Analysis of 6 GeV CLAS data
Preparation for 12 GeV data taking
RICH: Kaon ID necessary for TMD flavor separation
RICH: Rejection factor >1000 because of relative p/K production rate



Nuclear Physics

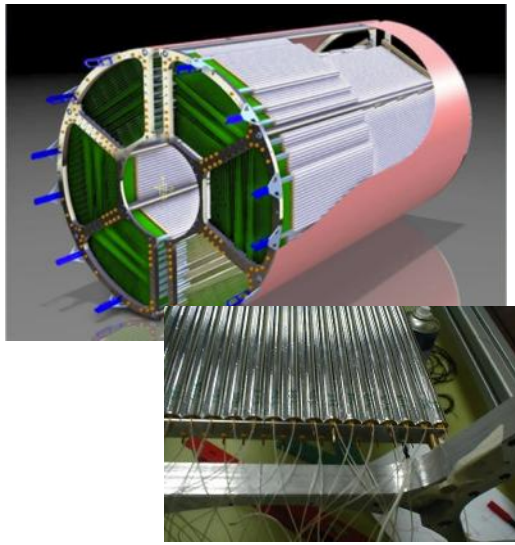
VIP @ LNGS

The VIP experiment aims to improve the current limit on the violation of the Pauli principle for electrons (O< 10^{-30})
upgrade is undergoing: SSD, bather efficiency and noise reduction



@ GSI

understand confinement quark in matter…
LNF is in charge of part tracking central straw tube System



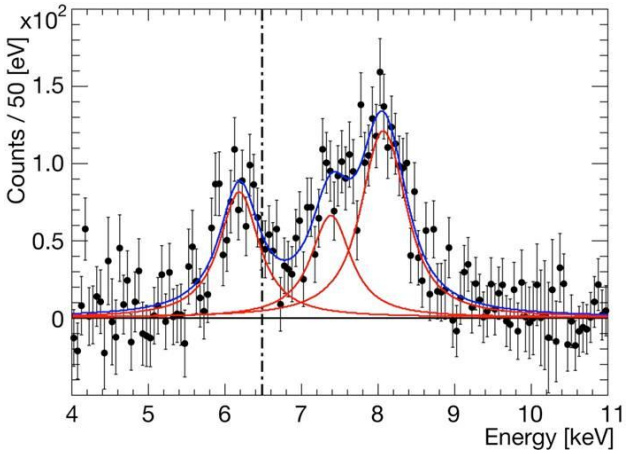
Nuclear Physics

SIDDHARTA @ LNF

The SIDDHARTHA experiment aim a precision measurement of the scattering lengths of the kaon-nucleon system

improve data analysis: Kaonic H, Kaonic D, Kaonic He4, Kaonic He3

Setup for **SIDDHARTA-2** (improvement in kaonic deuterium)



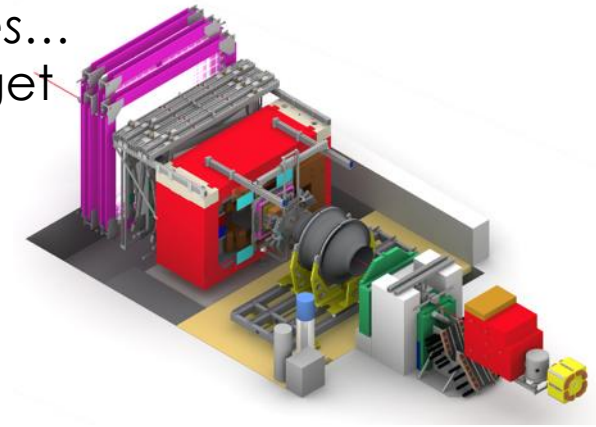
@ Bonn/Mainz

search for missing nuclear resonances…

commissioning of the barrel and target

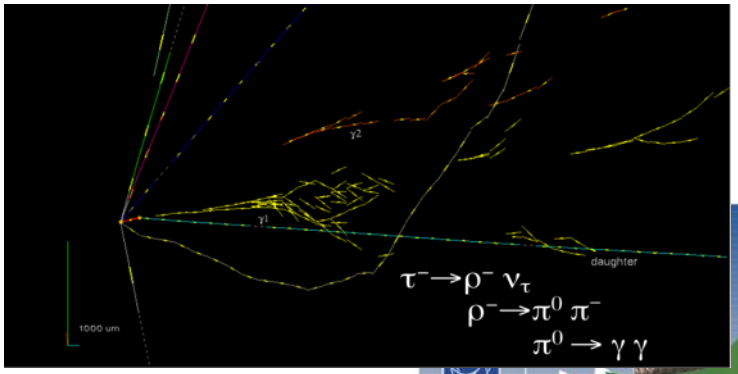
data analysis

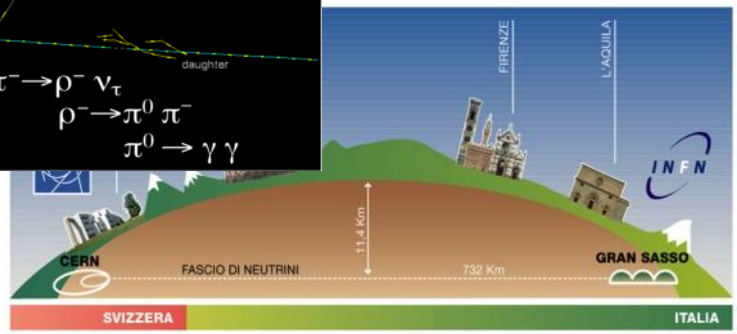
construction ad installation of the MRPC (Multigap Resistive Plate Chamber)



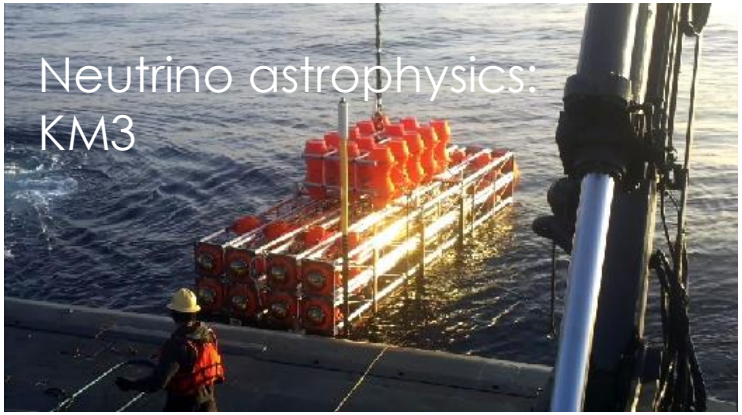
Present astroparticle activities at LNF

Neutrino oscillation physics:
OPERA, ICARUS @ LNGS
Neutrino-less double b decay:
CUORE (technical assistance)

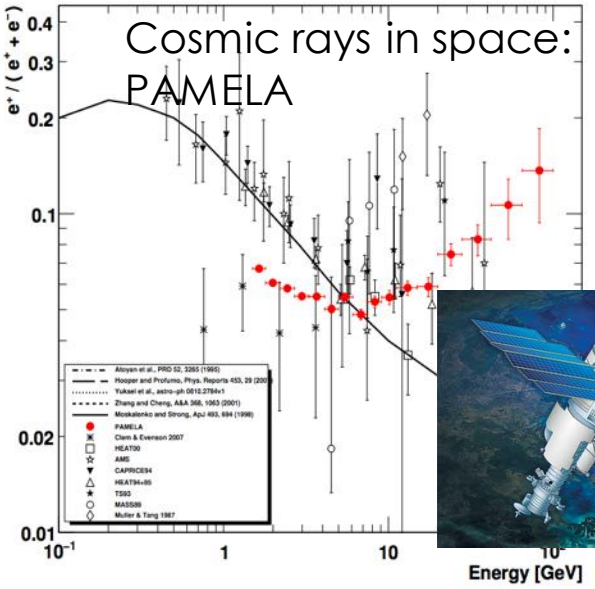




Gravitational wave detector NAUTILUS

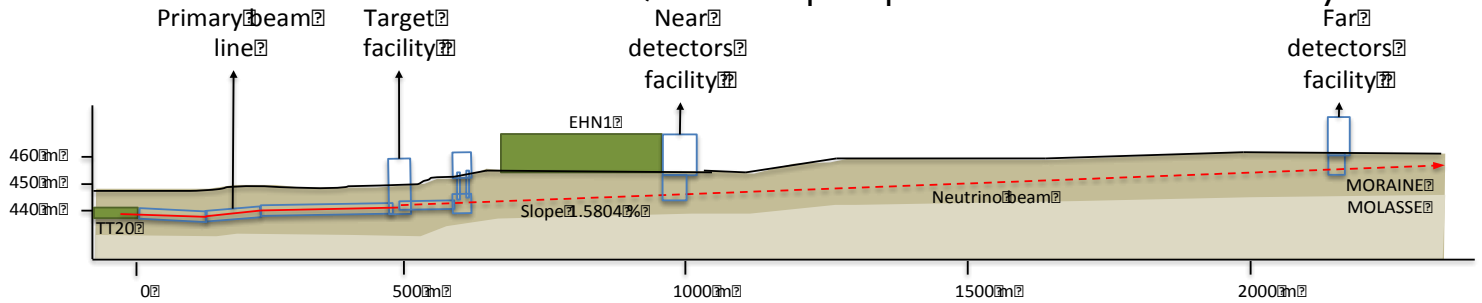


Cosmic rays in space:
PAMELA

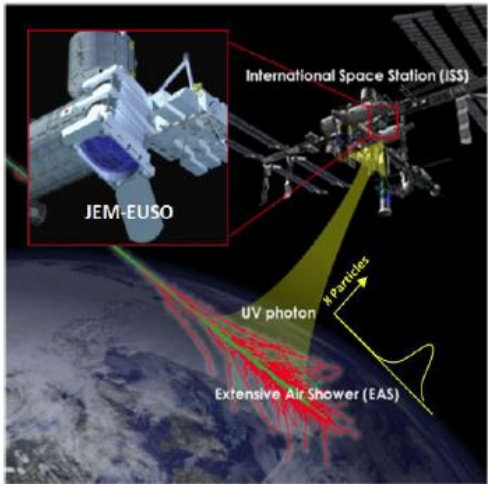


Next astroparticle activities at LNF

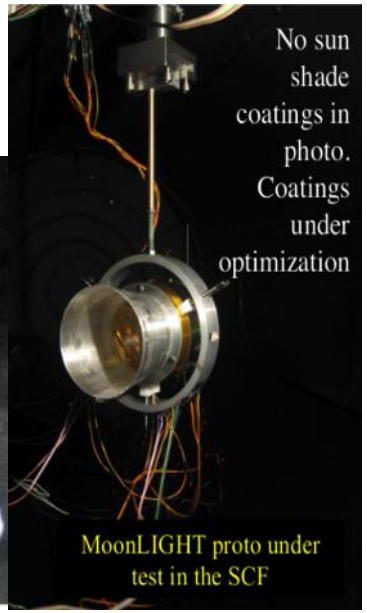
Besides CUORE and KM3, three proposals for the next years.....



Sterile neutrino search: ICARUS, NESSIE @ CENF (CERN Neutrino Facility)



Detection of extreme energy cosmic rays: JEM-EUSO on ISS



General relativity tests with Lunar Laser Ranging: Moonlight2

Interdisciplinary (a couple of example)

X-Ray LAB

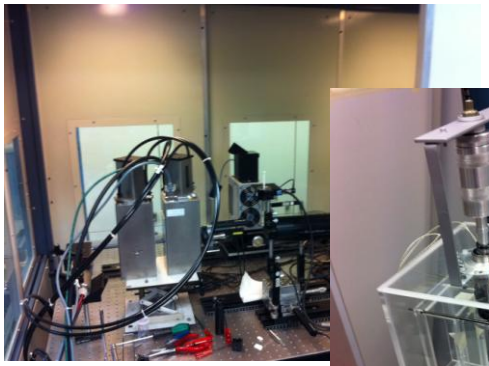
X-ray Optics: Polycapillary and Compound Refractive Optics

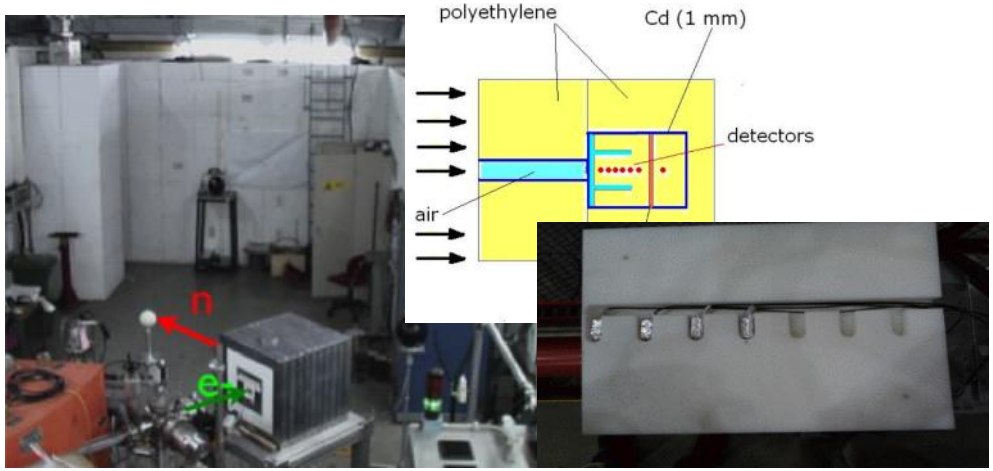
Material Analisys // X-ray Spectroscopy: X-ray Fluorescence, X-ray Diffraction, X-ray Imaging

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

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Thank you

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G. Mazzitelli