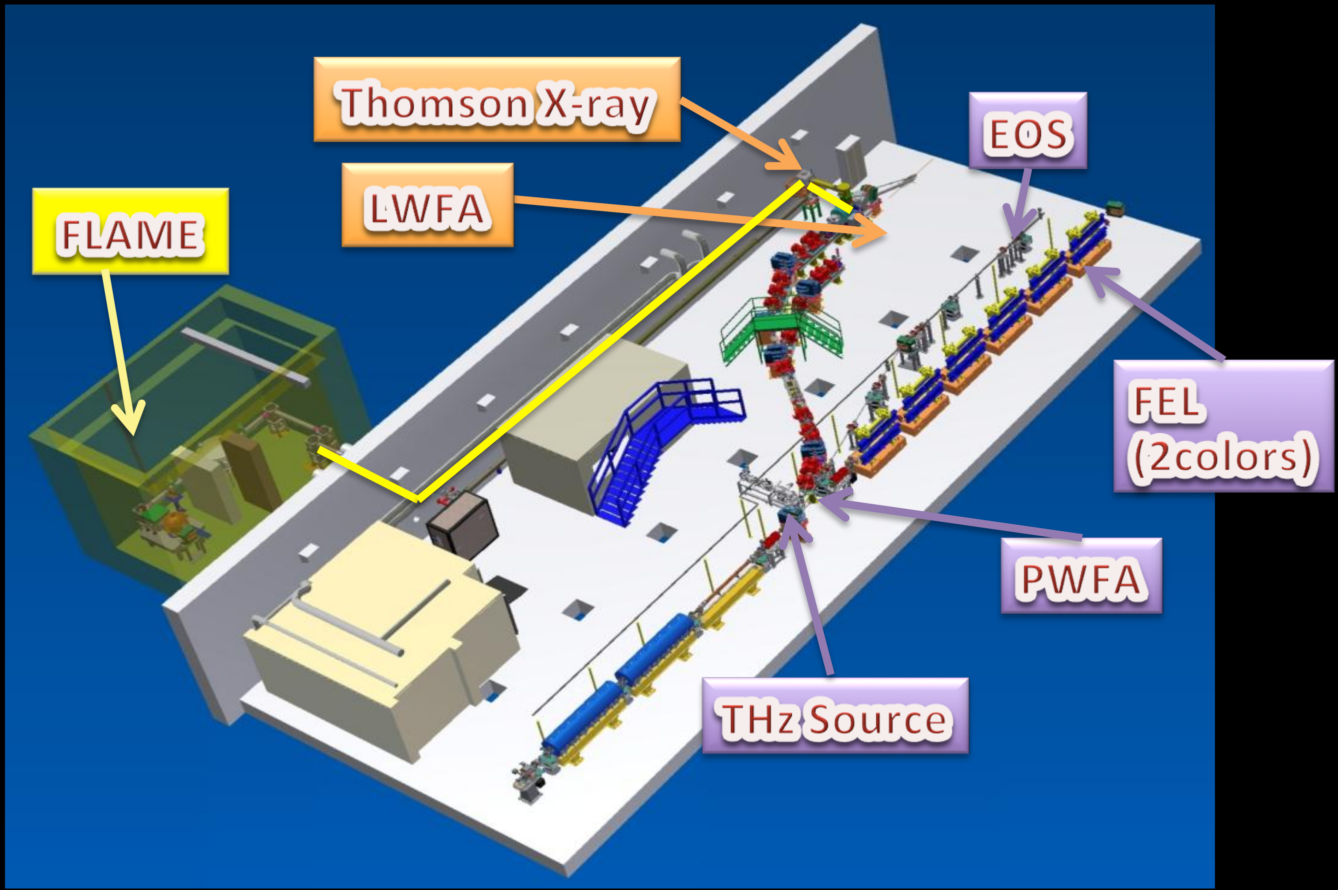
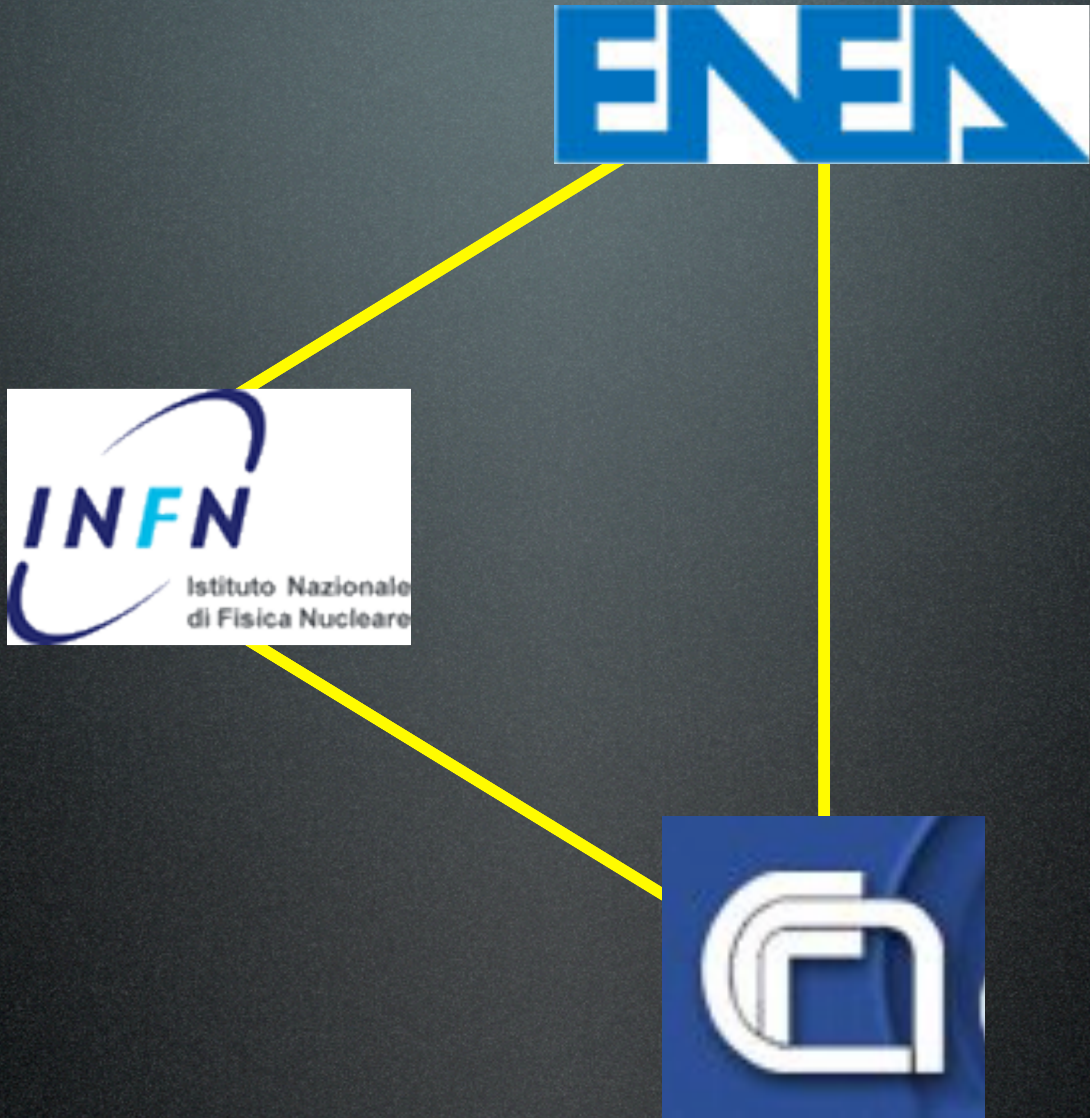
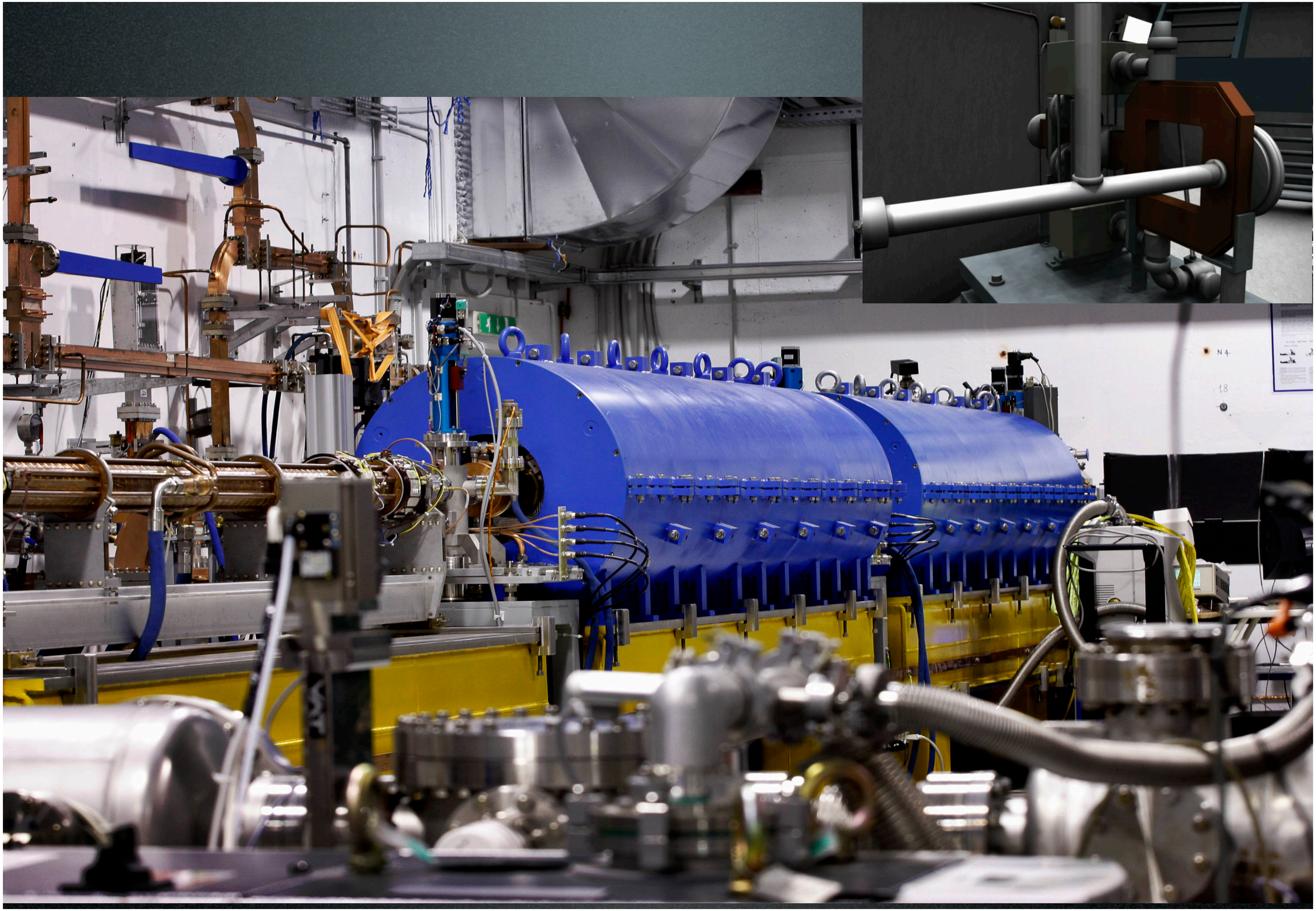
SPARC_LAB

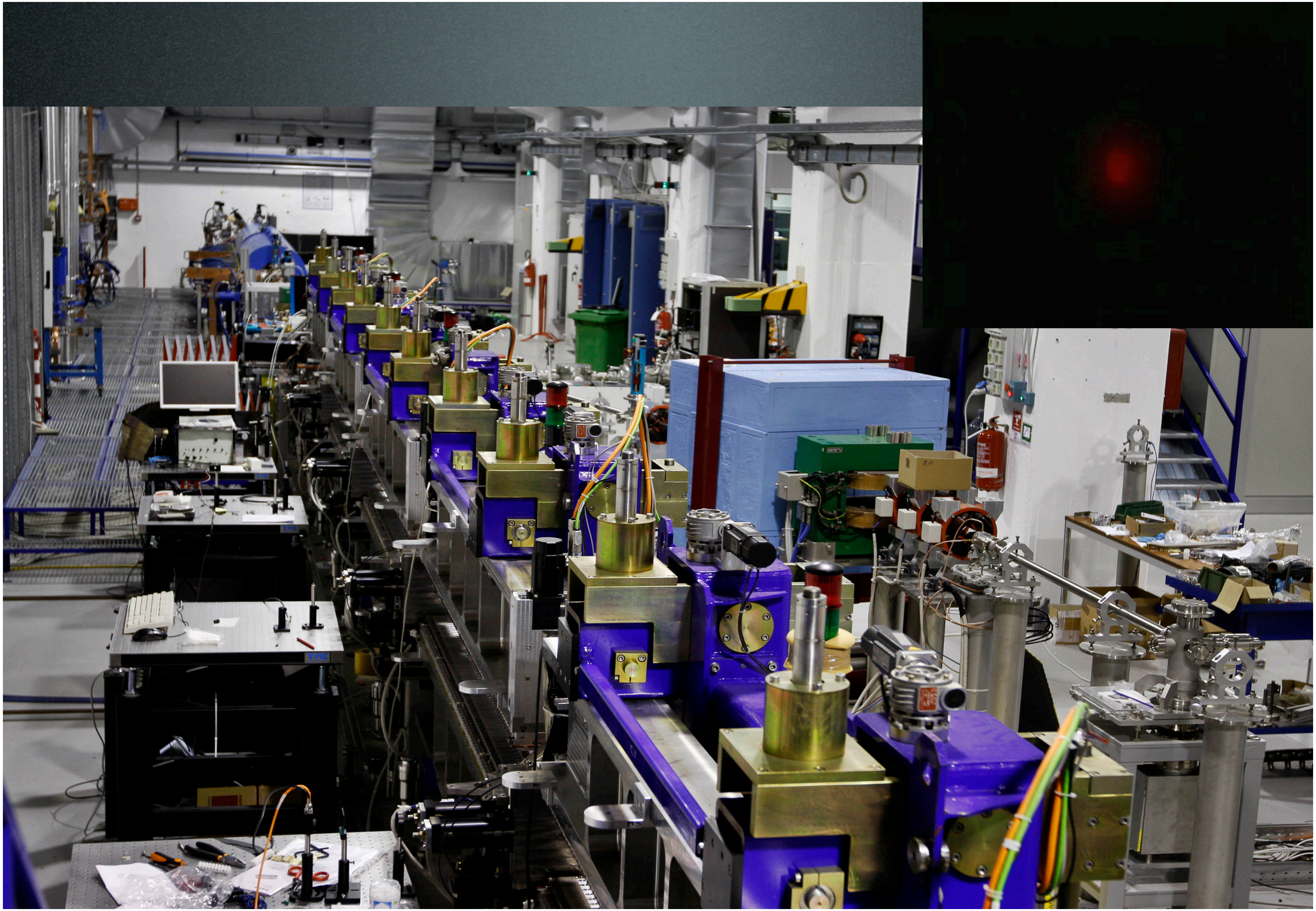
Massimo.Ferrario@LNF.INFN.IT
On behalf of the SPARC_LAB collaboration



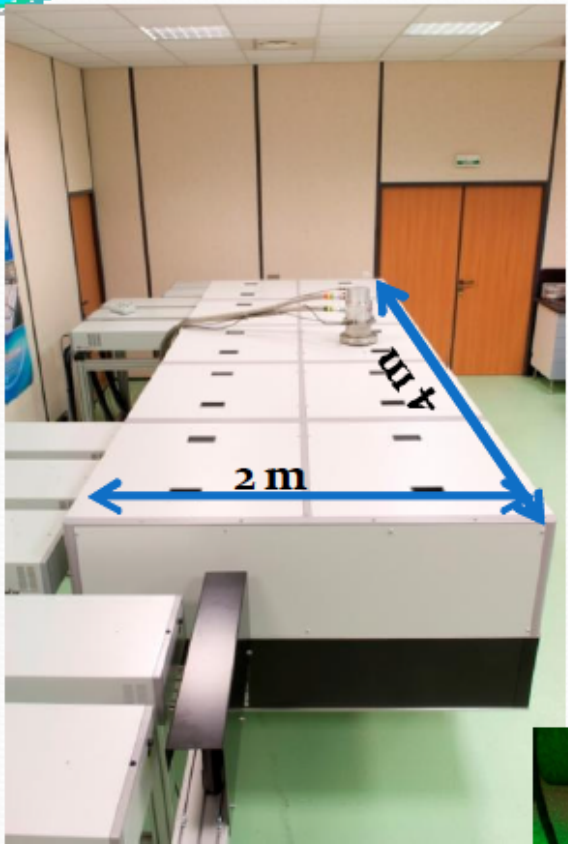

ENEA
INFN
Istituto Nazionale
di Fisica Nucleare

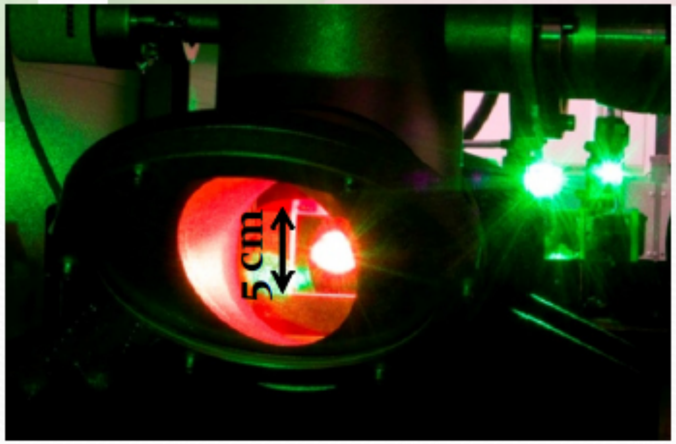
SPARC_LAB related INFN units





Il laser FLAME





Energia massima: 7J

Energia massima sul target: ~5J

Durata minima: 23 fs

Lunghezza d'onda: 800 nm

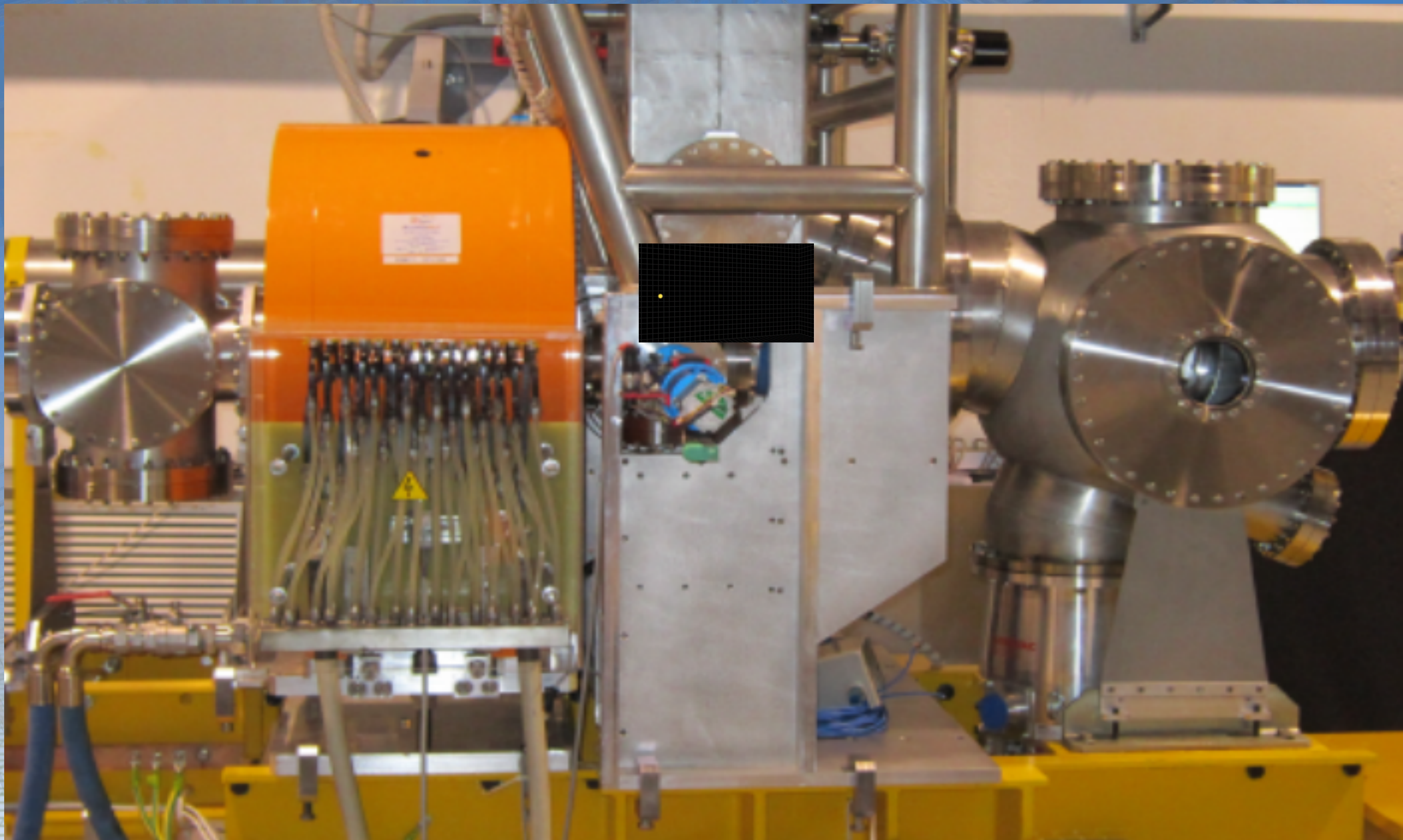
Larghezza di banda: 60/80 nm

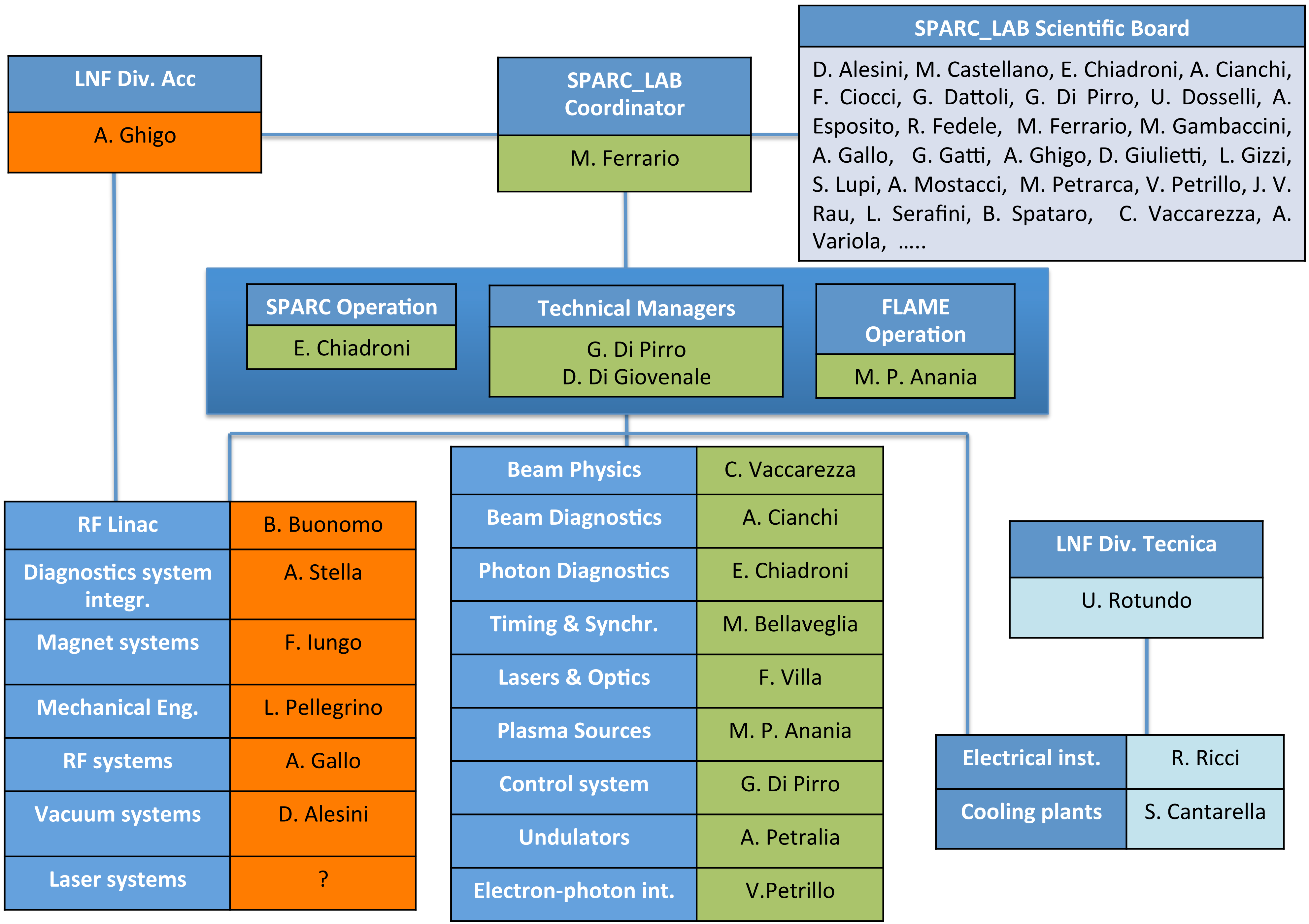
Spot-size @ focus: 10 μm

Potenza massima: ~300 TW

Contrasto: 10^{10}

Thomson back-scattering source




SPARC_LAB Scientific Board
D. Alesini, M. Castellano, E. Chiadroni, A. Cianchi, F. Ciocci, G. Dattoli, G. Di Pirro, U. Dosselli, A. Esposito, R. Fedele, M. Ferrario, M. Gambaccini, A. Gallo, G. Gatti, A. Ghigo, D. Giulietti, L. Gizzi, S. Lupi, A. Mostacci, M. Petrarca, V. Petrillo, J. V. Rau, L. Serafini, B. Spataro, C. Vaccarezza, A. Variola, ...
LNF Div. Acc
A. Ghigo
SPARC_LAB Coordinator
M. Ferrario
SPARC Operation
E. Chiadroni
Technical Managers
G. Di Pirro
D. Di Giovenale
FLAME Operation
M. P. Anania
RF Linac
B. Buonomo
Diagnostics system integr.
A. Stella
Magnet systems
F. Iungo
Mechanical Eng.
L. Pellegrino
RF systems
A. Gallo
Vacuum systems
D. Alesini
Laser systems
?
Beam Physics
C. Vaccarezza
Beam Diagnostics
A. Cianchi
Photon Diagnostics
E. Chiadroni
Timing & Synchr.
M. Bellaveglia
Lasers & Optics
F. Villa
Plasma Sources
M. P. Anania
Control system
G. Di Pirro
Undulators
A. Petralia
Electron-photon int.
V.Petrillo
LNF Div. Tecnica
U. Rotundo
Electrical inst.
R. Ricci
Cooling plants
S. Cantarella

Milano	Roma 1	Roma 2	Napoli	Pisa	Lecce	LNF
L. Serafini	*A. Mostacci*	*A. Cianchi*	*R. Fedele*	*L. Gizzi*	*W. Perrone*	*M. Ferrario*
A. Bacci (A23) *AR. Rossi (A23)* *A.Petrillo (UniMi)* *C. Curatolo (PhD)* *D. Palmer (INFN)* *M. Potenza (UniMi)* *B. Paroli (UniMi)*	*A. Giribono (PhD)* *F. Filippi (PhD)* *F. Giorgianni (PhD)* *F. Massimo (PhD)* *M. Petrarca (A23)* *A.Marocchino (A23)* *S. Lupi* *S. Pioli (PhD)* *L. Piersanti (ELI)* *F. Cardelli (ELI)*		*T. Fatema (AR)*	*L. Labate* *D. Giulietti*	*A. Lorusso (A23)*	E. Chiadroni G. Di Pirro D. Di Giovenale C. Vaccarezza M. Bellaveglia F. Villa M.P. Anania V. Shpakov (AR) A.Biagioni (A36) R. Pompili (AR) M. Croia (PhD) J. Scifo (PhD) S. Romeo (PhD) F. Bisesto (PhD - STAR) A.Curcio (PhD) F. Anelli (Tec)

Distribuzione per sezioni INFN

EUROFEL_MIUR

- fondi FOE
- progetto nazionale (LNF, MI, RM1, TS)
- durata 2012-2014, i finanziamenti sono stati erogati sempre con un anno di ritardo

Quadro riassuntivo finanziamento EUROFEL_MIUR in kEuro

	Tot. Naz.	Overhead INFN	Assegnazione Totale LNF	Di cui per Personale LNF
2012+1	2700	1040 (38%)	920	350
2013+1	1350	235 (17%)	640	250
2014+1	1150	230 (20%)	520	100
Totale	**5200**	**1505**	**2080**	**700**

SPARC_LAB_MIUR

- fondi PREMIALE
- progetto locale (LNF)
- durata 2013-2016, i finanziamenti sono stati erogati con un anno di ritardo

Quadro riassuntivo finanziamento SPARC_LAB_MIUR in kEuro

	Assegnazione Totale	Overhead INFN	Assegnazione Totale LNF	Di cui per Personale LNF
2013+1	5653	1695 (30%)	3957	965

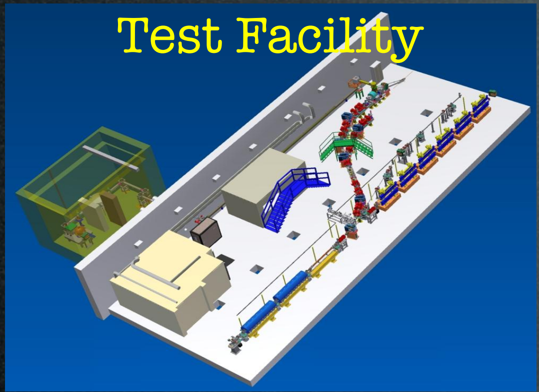
SPARC_LAB

- fondi INFN per manutenzione e funzionamento, sempre erogati verso fine Maggio

Quadro riassuntivo finanziamento SPARC_LAB in kEuro

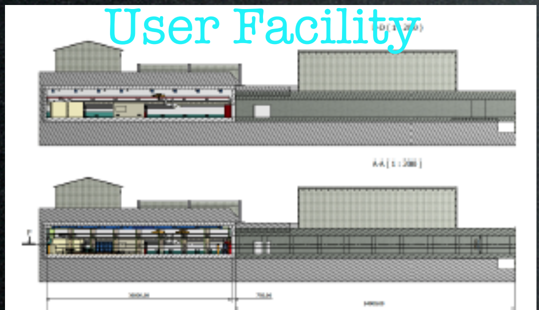
2012	350
2013	360
2014	350
2015	350
Totale	**1410**

Future scenarios



Consolidation: on going, ~3 years

- FLAME maintenance
- Injector upgrade (C-band, X-band)
- THz user beam line upgrade
- Thomson and Plasma beam lines final commissioning
- FEL new short period undulator



Upgrade: proposed, ~5 years

- Infrastructure extension
- Linac upgrade ~1 GeV (C-X-band, multibunch)
- THz, X-ray Compton and FEL user facility)
- Advanced FEL schemes (oscillator?)
- FLAME upgrade towards 1 PW
- plasma, dielectric and high frequency acceleration
- Positron production and acceleration with plasma
- AND RELIABILITY !!!!

European Facility, ~10 years, ~200 M€

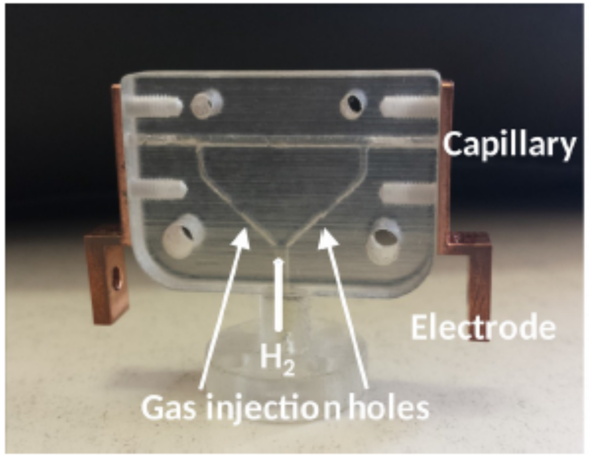
- Plasma based FEL Pilot User Facility
- Plasma based HEP beam line

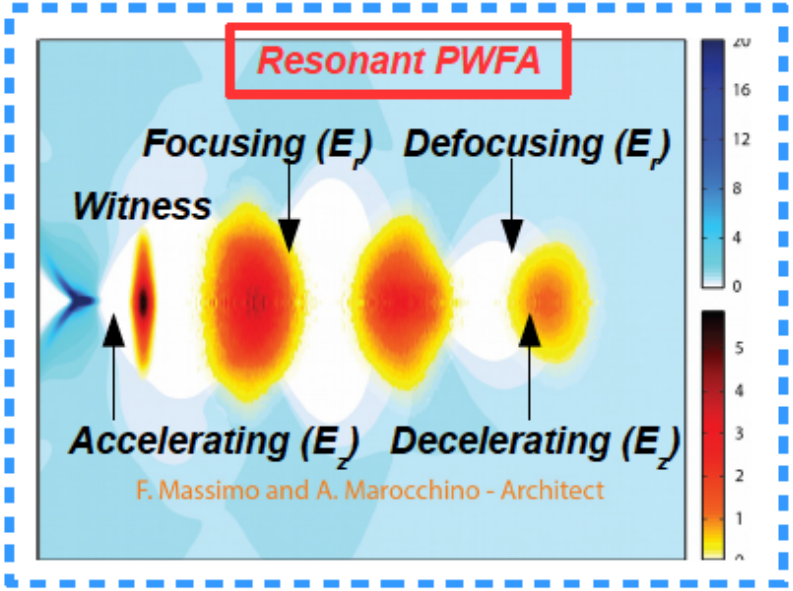
Richieste FTE servizi 2016

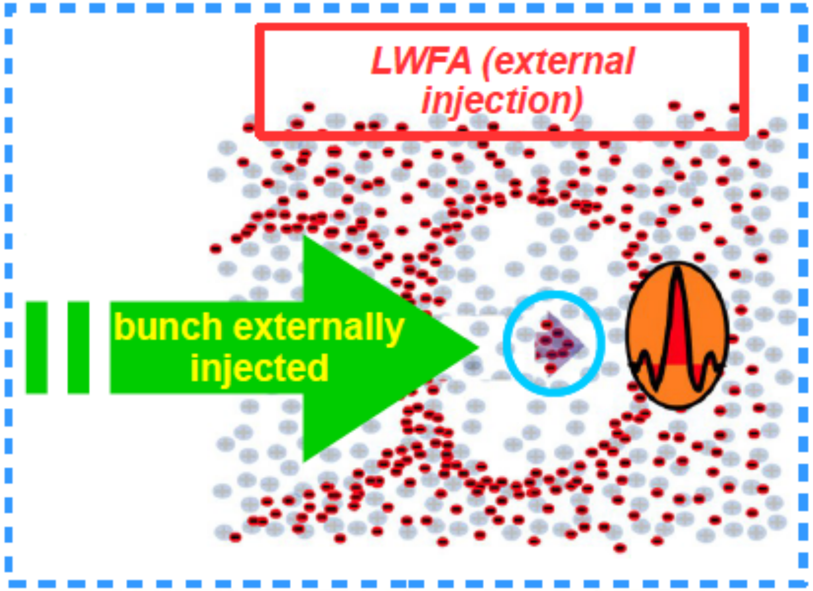
SERVIZI/SIGLE	FEL	EXIN	Thomson	Comb	THz	TOTALE	
Linac				0,2		0,2	
Diagnostica		0,2				0,2	
Magneti		0,2	0,3	0,2		0,7	
RF				0,2		0,2	
Vuoto	0,1	0,2	0,3	0,5	0,2	1,3	
Laser		0,5	0,3			0,8	
Meccanica	0,1	0,5	0,3	0,5	0,2	1,6	
Fluidi		0,1				0,1	
Impianti	0,1	0,1				0,2	
Totale	0,3	1,8	1,2	1,6	0,4	5,3	TOTALE FTE

Plasma-based acceleration activities

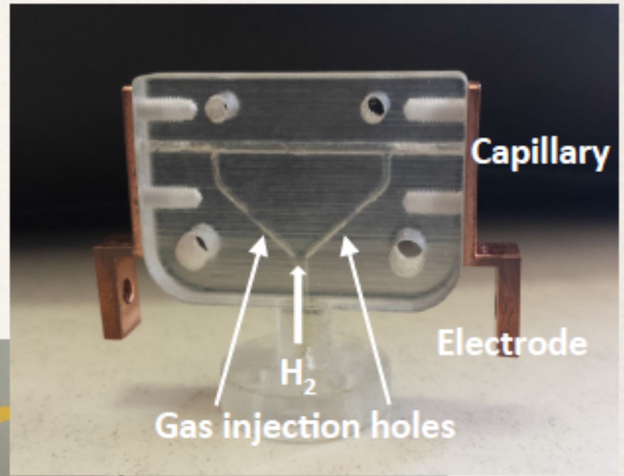
- Several plasma-based schemes will be tested
  - ***PWFA** resonant scheme → **1-2 GV/m** expected*
    - ***n_e~10^{16} cm^{-3}, 1 mm diameter capillary, Hydrogen***
  - ***LWFA**, external injection → **5-10 GV/m** expected*
    - ***n_e~10^{17} cm^{-3}, 100 μm diameter capillary, Hydrogen***
- Goal: **high quality** accelerated beams
  - *Maintain the high brightness of injected beams*

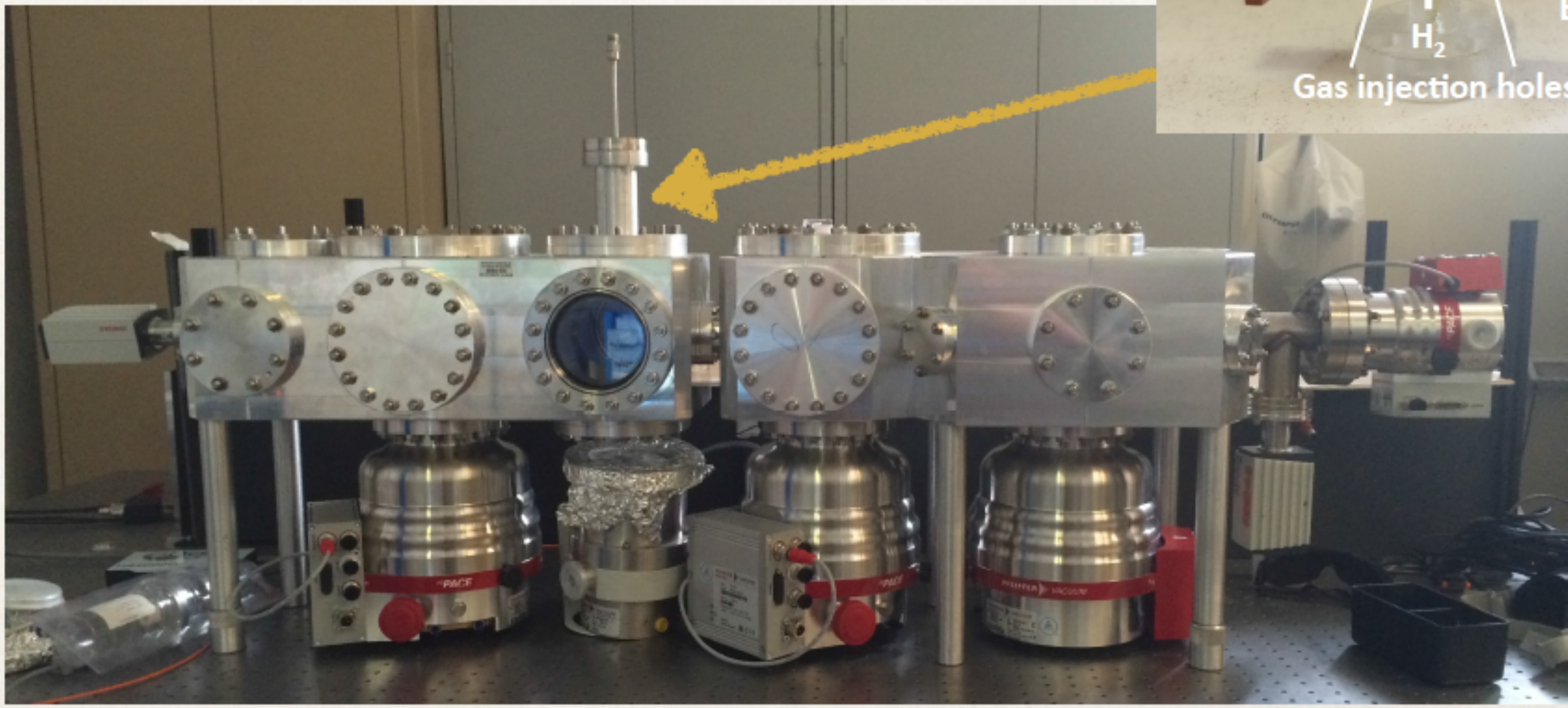






- **Characterization of the COMB chamber in Lab**
  - Vacuum tests with capillary, using He and Ar
    - The capillary has been 3D printed
  - Design, construction and tests of the discharge box with a 50 Ohm load

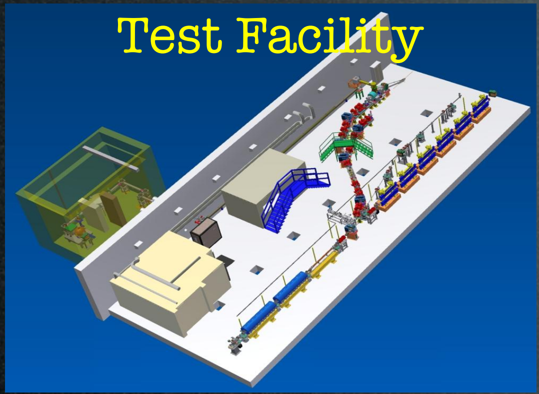




Milestones 2016

Descrizione	Data completamento
commissioning of the COMB chamber installed on the SPARC main line	31-03-2016
Start-to-End simulation (i.e. beam dynamics from the gun, transport and matching to the plasma, interaction with the plasma, extraction out of the plasma and matching to the FEL) to characterize the working point with 1 driver and 1 witness	31-03-2016
fully setup the plasma diagnostics based on Stark effect to measure the plasma density	30-04-2016
experimentally characterization of the driver/witness bunch interaction with the plasma	31-05-2016
study of the fringing effects on the capillary (plasma lens)	30-06-2016
measurement of the plasma density profile in the capillary	30-06-2016
Start-to-End simulation to characterize the working point with 4 drivers and 1 witness to demonstrate the resonant excitation of the plasma wave.	31-07-2016
test of the electron beam diagnostics at the plasma exit	30-09-2016
study of beam loading and energy spread correction (plasma dechirper)	30-11-2016

Future scenarios



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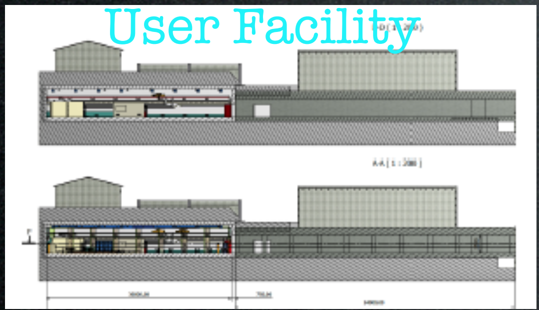

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European Facility, ~10 years, ~200 M€

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- Plasma based HEP beam line

SPARC_EU_LAB?

Excellent Science
Developing new world-class research infrastructures
H2020-INFRADEV-1-2014-1
Deadlines: 02/09/2014
Opening Date: 11/12/2013

ESFRI
European Strategy Forum on Research Infrastructures

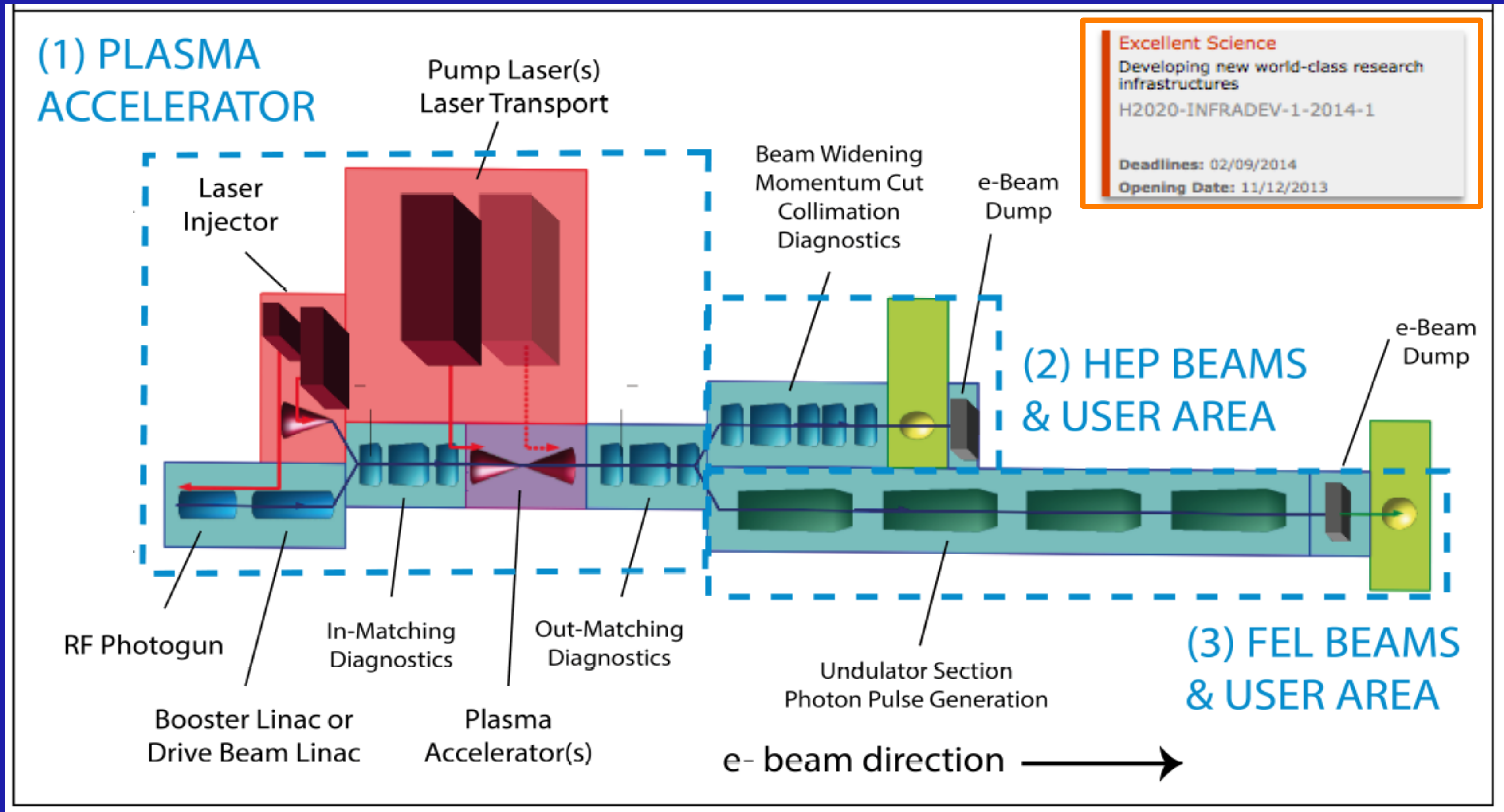
~200 M€

- Design Studies with at least 3 Countries,
- Cost. Schedule, Siting?
- What is the governance model?
- What is the intended user community?
- Will it be open access?
- Apply for H2020 preparatory phase (PP)?

- Support will be provided by Horizon2020 and MIUR for the implementation (PP) and operation of the research infrastructures listed on the ESFRI Roadmap and ERIC.

Design Study on the "European Plasma Research Accelerator with eXcellence In Applications" (EuPRAXIA)

Approved as HORIZON 2020 INFRADEV, 4 years, 3 M€



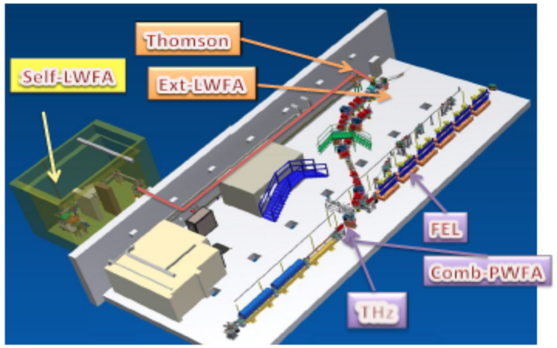
An upgraded (~1 GeV, ~1 PW) SPARC_LAB facility could be a strong candidate for the EuPRAXIA site

WHAT NEXT AT SPARC_LAB ?
M. Ferrario on behalf of the SPARC_LAB Collaboration

April 24, 2014

1- INTRODUCTION

SPARC_LAB [1] (Sources for Plasma Accelerators and Radiation Compton with Lasers And Beams) is an inter-disciplinary laboratory with unique features in the world. Born from the integration of a last generation photo-injector (SPARC)[2-7], able to produce electron beams up to 200 MeV energy with high peak current (> 1 kA) and low emittance (<2 mm-mrad), and of a high power laser (> 200 TW) (FLAME) [8,9], able to produce ultra-short pulses (<30 fs), SPARC_LAB has already enabled the development of innovative radiation sources and the test of new techniques for particle acceleration using lasers.



Layout of SPARC_LAB beam lines

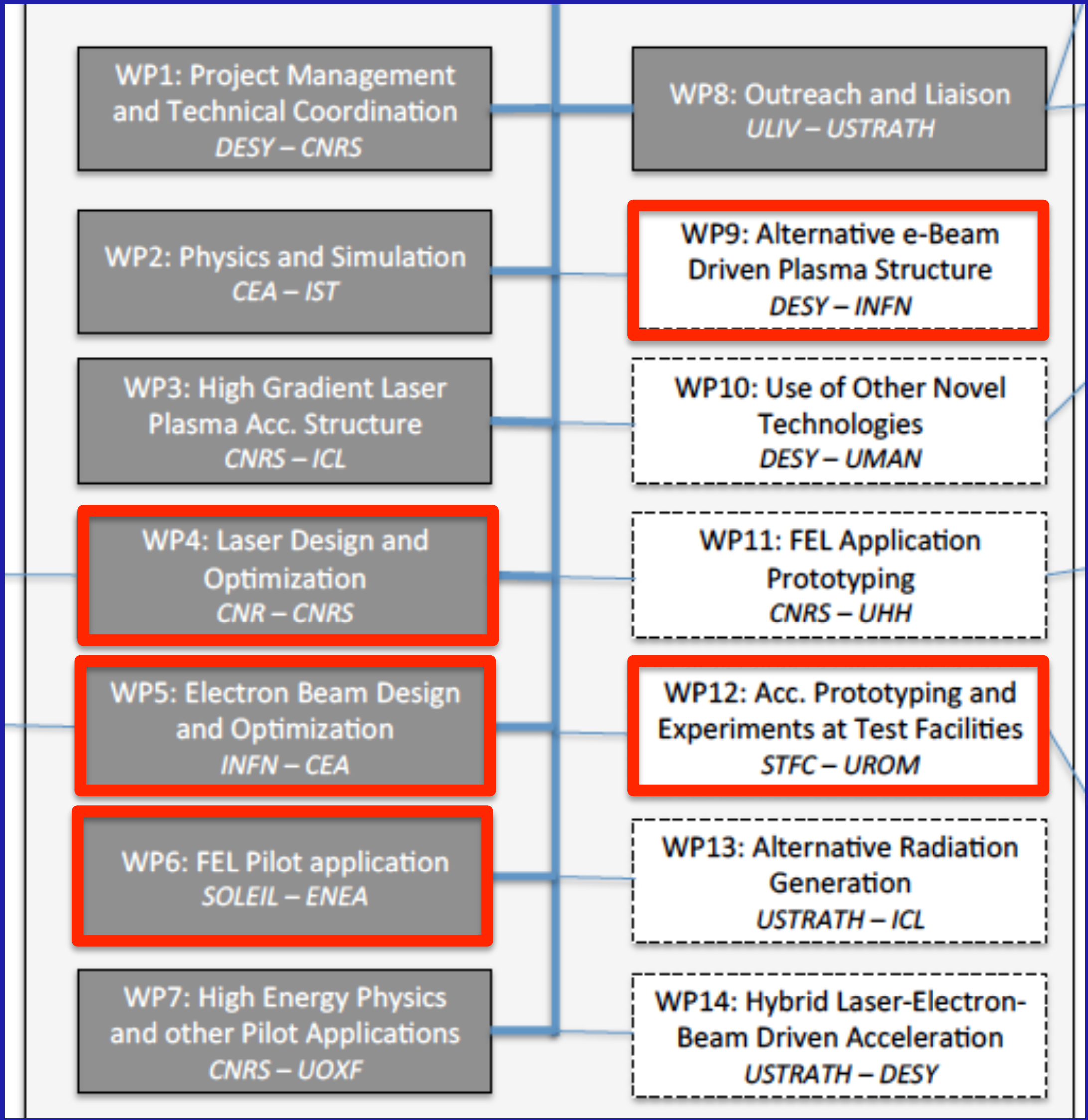
In particular the following highlight results have been achieved:

- a Free Electron Laser has been commissioned producing coherent radiation tunable from 500 nm down to 40 nm and new regimes of operation like Seeding, Single Spike, Harmonic Generation and Two Colors have been observed [10-14];
- a source of both broad band, narrow band (<30%) and high energy (> 10 μJ) THz radiation has been tested, first experiments with users are underway [15,16];
- electrons have been accelerated up to 100 MeV in 4 mm long plasma wave excited by the high power laser FLAME [9];

EuPRAXIA Participants

Participant no.	Participant organisation name	Short name	Country
1 (Coordinator)	Stiftung Deutsches Elektronen Synchrotron	DESY	Germany
2	Istituto Nazionale di Fisica Nucleare	INFN	Italy
3	Consiglio Nazionale delle Ricerche	CNR	Italy
4	Centre National de la Recherche Scientifique	CNRS	France
5	University of Strathclyde	USTRATH	UK
6	Instituto Superior Técnico	IST	Portugal
7	Science & Technology Facilities Council	STFC	UK
8	Synchrotron SOLEIL – French National Synchrotron	SOLEIL	France
9	University of Manchester	UMAN	UK
10	University of Liverpool	ULIV	UK
11	Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenible	ENEA	Italy
12	Commissariat à l'Énergie Atomique et aux énergies alternatives	CEA	France
13	Sapienza Universita di Roma	UROM	Italy
14	Universität Hansestadt Hamburg	UHH	Germany
15	Imperial College London	ICL	UK
16	University of Oxford	UOXF	UK

EuPRAXIA WPs and SPARC_LAB responsibilities (SPARC_LAB WG leaders or deputy leaders)



L. Gizzi

E. Chiadroni

G. Dattoli

M. Ferrario

A. Mostacci

Table 3.4c: Overall budget table for EU funded resources, split by participant. The DESY other direct costs include 48,000€ of travel budget for associate partners.

No	Partner	Country	Direct personnel costs	Other direct costs	Indirect costs (25%)	Sub-contracting costs	Requested EU grant (100%)
1	DESY	Germany	264,000	99,200	90,800	0	454,000
2	INFN	Italy	132,000	25,600	39,400	0	197,000
3	CNR	Italy	132,000	25,600	39,400	0	197,000
4	CNRS	France	383,040	38,400	105,360	0	526,800
5	USTRATH	UK	132,000	44,800	44,200	0	221,000
6	IST ID	Portugal	132,000	25,600	39,400	0	197,000
7	STFC	UK	0	19,200	4,800	0	24,000
8	SOLEIL	France	95,760	9,600	26,340	0	131,700
9	UMAN	UK	0	9,600	2,400	0	12,000
10	ULIV	UK	132,000	16,000	37,000	0	185,000
11	ENEA	Italy	132,000	16,000	37,000	0	185,000
12	CEA	France	191,520	19,200	52,680	0	263,400
13	UROM	Italy	0	9,600	2,400	0	12,000
14	UHH	Germany	132,000	25,600	39,400	0	197,000
15	ICL	UK	132,000	16,000	37,000	0	185,000
16	UOXF	UK	0	9,600	2,400	0	12,000
Total			1,990,320	409,600	599,980	0	2,999,900

3.4 Resources to be committed (Tables 3.4a and 3.4b)

Table 3.4a: Summary of staff effort for EU project (EU funded, exluding in-kind contributions).

	WP1	WP2	WP3	WP4	WP5	WP6	WP7	WP8	Total person months per participant
DESY	24	18	0	0	18	0	0	0	60
INFN	0	0	0	0	36	0	0	0	36
CNR	0	0	0	24	0	0	0	0	24
CNRS	0	0	24	33	0	36	36	0	129
USTRATH	0	14	0	0	0	0	0	14	28
IST	0	25	0	0	0	0	0	0	25
STFC	0	0	0	0	0	0	0	0	0
SOLEIL	0	6	0	0	0	30	0	0	36
UMAN	0	0	0	0	0	0	0	0	0
ULIV	0	0	0	0	0	0	0	36	36
ENEA	0	0	0	0	0	36	0	0	36
CEA	0	25	0	0	24	0	0	0	49
UROM	0	0	0	0	0	0	0	0	0
UHH	0	0	0	0	0	24	0	0	24
ICL	0	0	18	0	0	0	0	0	18
UOXF	0	0	0	0	0	0	0	0	0
Total	24	88	42	57	78	126	36	50	501

Table 3.4a-with-in-kind: Summary of staff effort for EU project (total effort, including in-kind contributions).

	WP1	WP2	WP3	WP4	WP5	WP6	WP7	WP8	Total person months per participant
DESY	72	60	6	0	48	0	6	6	198
INFN	0	24	0	0	60	0	0	0	84
CNR	0	0	0	48	0	0	0	0	48
CNRS	3	5	30	35	0	40	42	0	155
USTRATH	0	90	34	0	6	0	0	18	148
IST	0	30	0	0	0	0	0	0	30
STFC	0	0	6	0	0	6	0	0	12
SOLEIL	2	8	0	0	0	140	0	0	150
UMAN	3	0	0	0	0	0	0	0	3
ULIV	0	0	18	0	18	0	0	36	72
ENEA	2	0	0	0	0	40	0	0	42
CEA	12	73	10	0	72	0	0	0	167
UROM	0	0	0	0	12	0	0	0	12
UHH	2	0	2	0	2	40	0	0	46
ICL	0	0	36	0	0	0	0	0	36
UOXF	0	0	0	0	0	0	6	0	6
Total	96	290	142	83	218	266	54	60	1209

An upgraded (~1 GeV, ~1 PW) SPARC_LAB facility could be a strong candidate for the EuPRAXIA site

WHAT NEXT AT SPARC_LAB ?

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April 24, 2014

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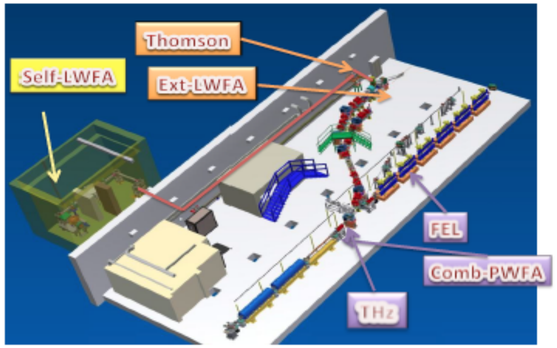

Layout of SPARC_LAB beam lines

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- electrons have been accelerated up to 100 MeV in 4 mm long plasma wave excited by the high power laser FLAME [9];

INFRASTRUCTURE EXTENSION AND LINAC ENERGY UPGRADE TOWARDS 1 GeV

- Multi bunch operation

ADVANCED ACCELERAROR CONCEPTS

- High quality electron beam from plasma to drive a compact FEL source
- Test of palsma accelerator staging
- Positron acceleration in a plasma: a demonstrative experiment
- Low emittance Positron Source (Channelling – Compton)

X-RAYS THOMSON SOURCE BEAM LINE UPGRADE

- Low-medium energy, ultra fast X-ray microscope (>10keV)
- Optimizing chemotherapy through quasi-monochromatic radiation (30-100keV)
- Breast CT with quasi-monochromatic and spatially coherent source (30-100 keV)
- High energy applications (>500 keV)

FEL BEAM LINE UPGRADE

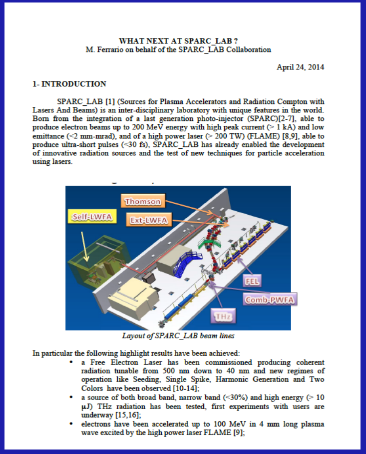
- FEL oscillator, intra-cavity Compton, short Period Undulators
- Low energy beam lines 5–35 eV (250 - 35 nm)
- High energy beamline ~10 keV

THz RADIATION SOURCE UPGRADE

- Dedicated undulator

FLAME LASER UPGRADE TOWARDS 1 PW

- Electron acceleration with self-injection beyond the GeV;
- QED and generation of high energy radiation;
- Proton and ion acceleration beyond the TNSA regime.



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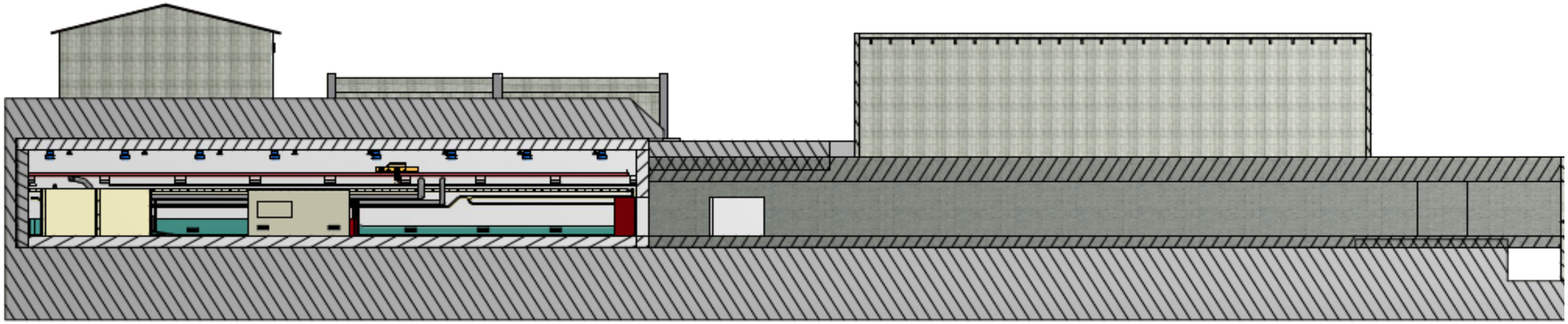
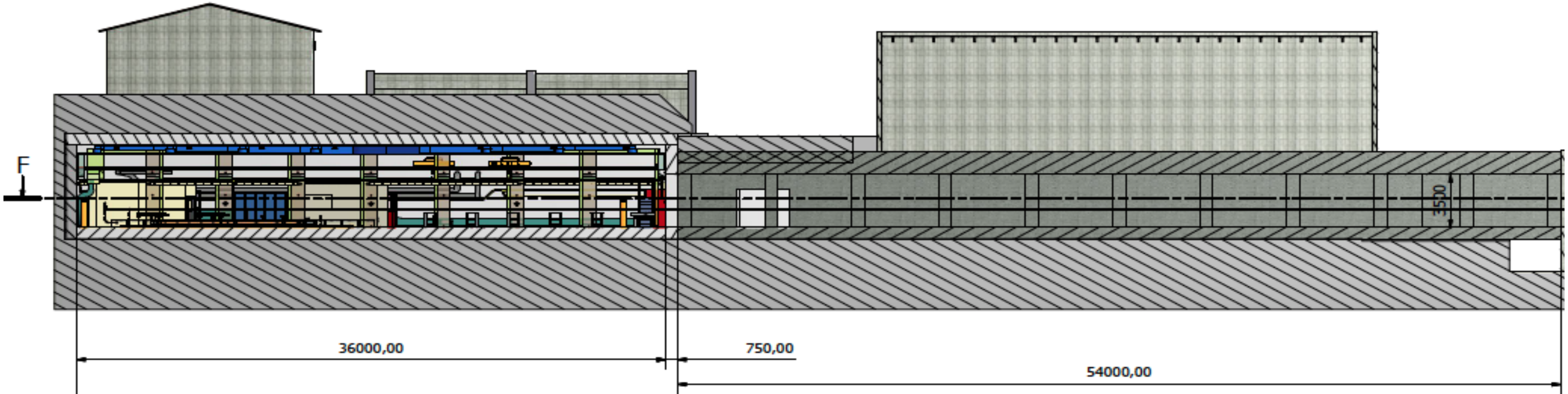
In particular the following highlight results have been achieved:

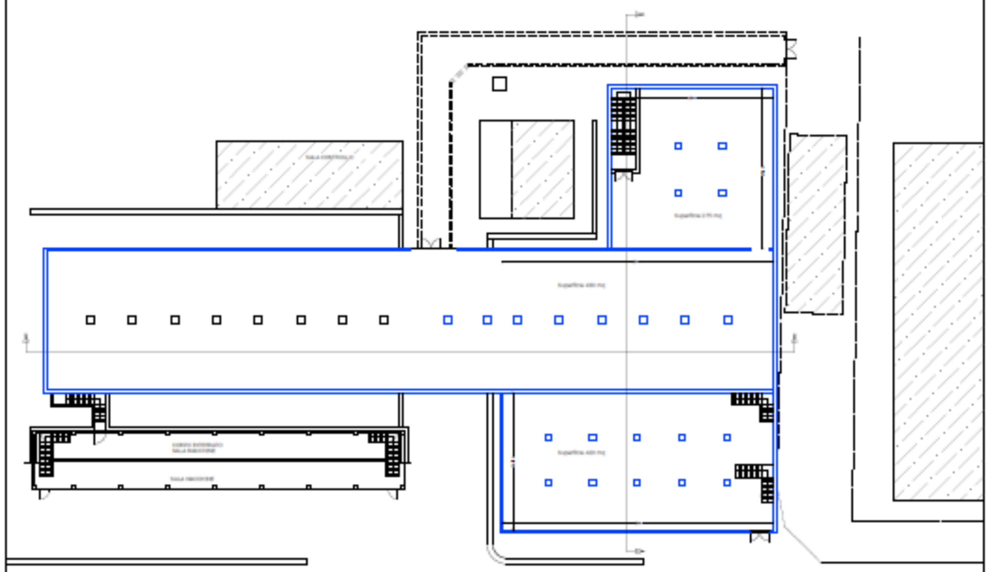
- a Free Electron Laser has been commissioned producing coherent radiation tunable from 500 nm down to 40 nm and new regimes of operation like Seeding, Single Spike, Harmonic Generation and Two Colors have been observed [10-14];
- a source of both broad band, narrow band (<30%) and high energy (> 10 μJ) THz radiation has been tested, first experiments with users are underway [15,16];
- electrons have been accelerated up to 100 MeV in 4 mm long plasma wave excited by the high power laser FLAME [9];

D-D (1 : 200)

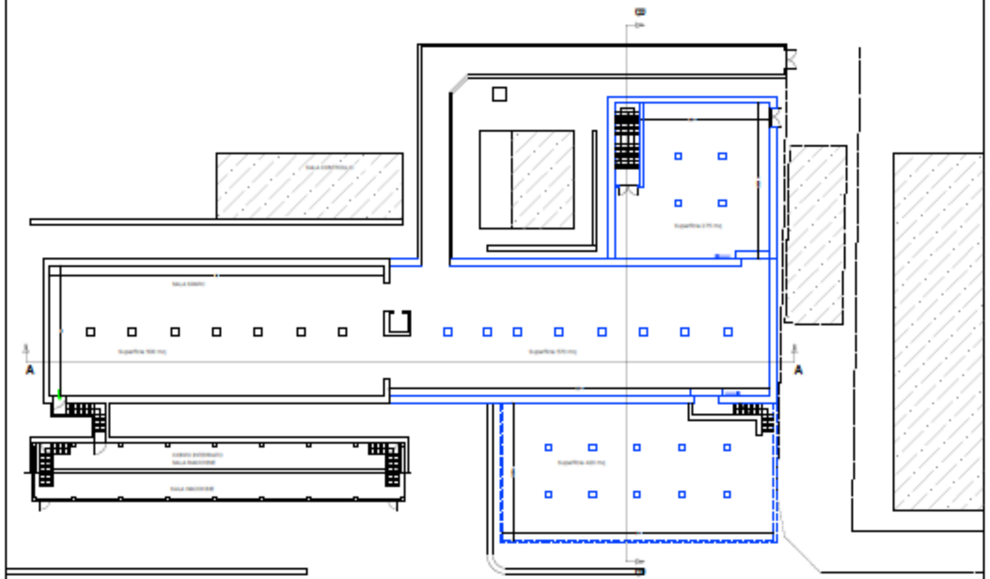


A-A (1 : 200)





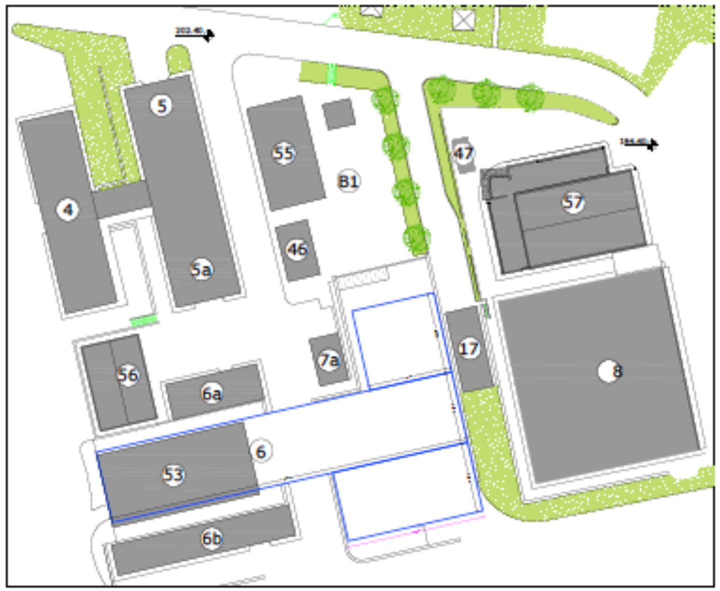
PIANTA PIANO TERRA



PIANTA PIANO INTERRATO _ QUOTA -6,00 m

SEZIONE A-A

SEZIONE B-B



STRALCIO PIANTA DEI LABORATORI