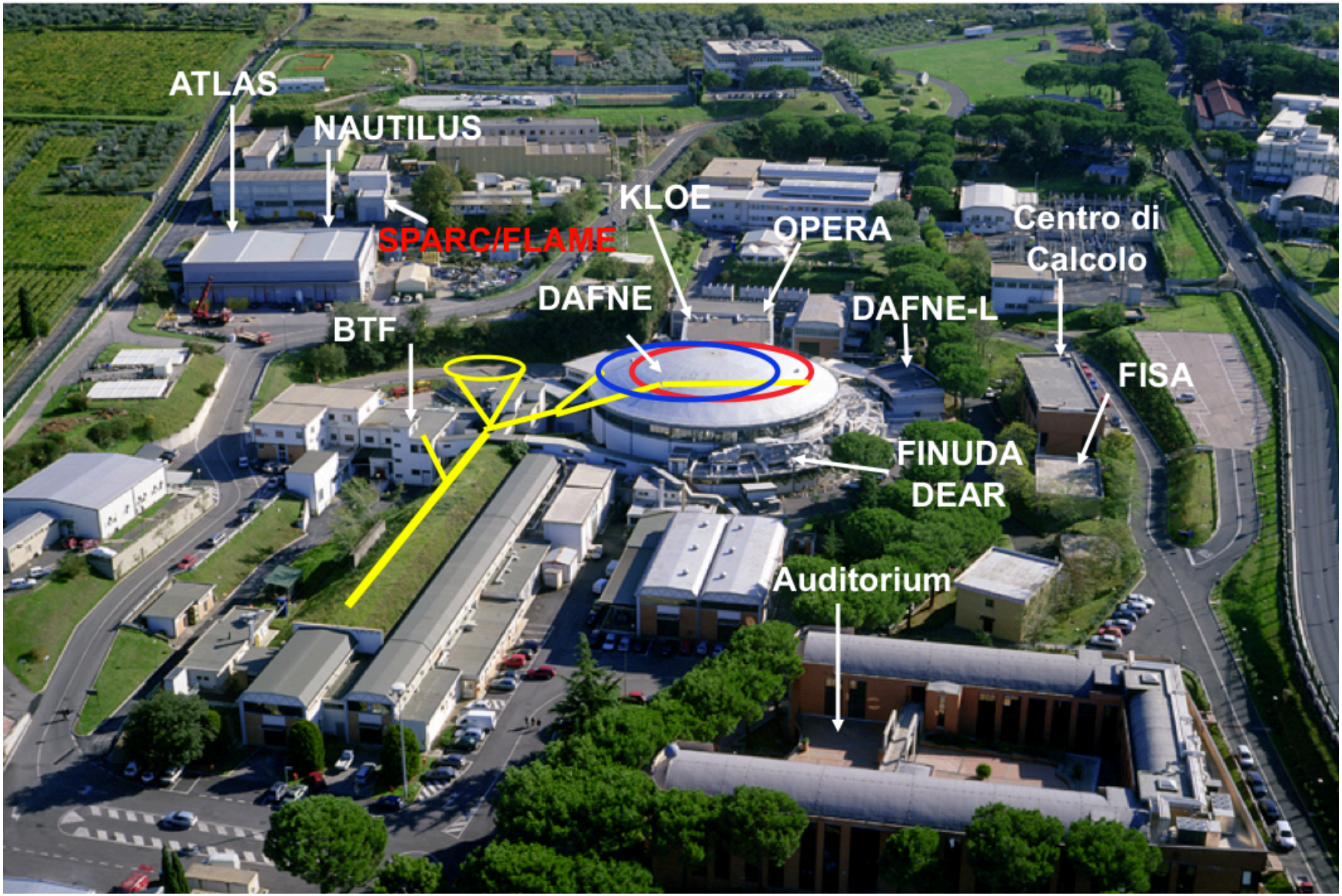
Introduction to SPARC-Lab

A. Mostacci

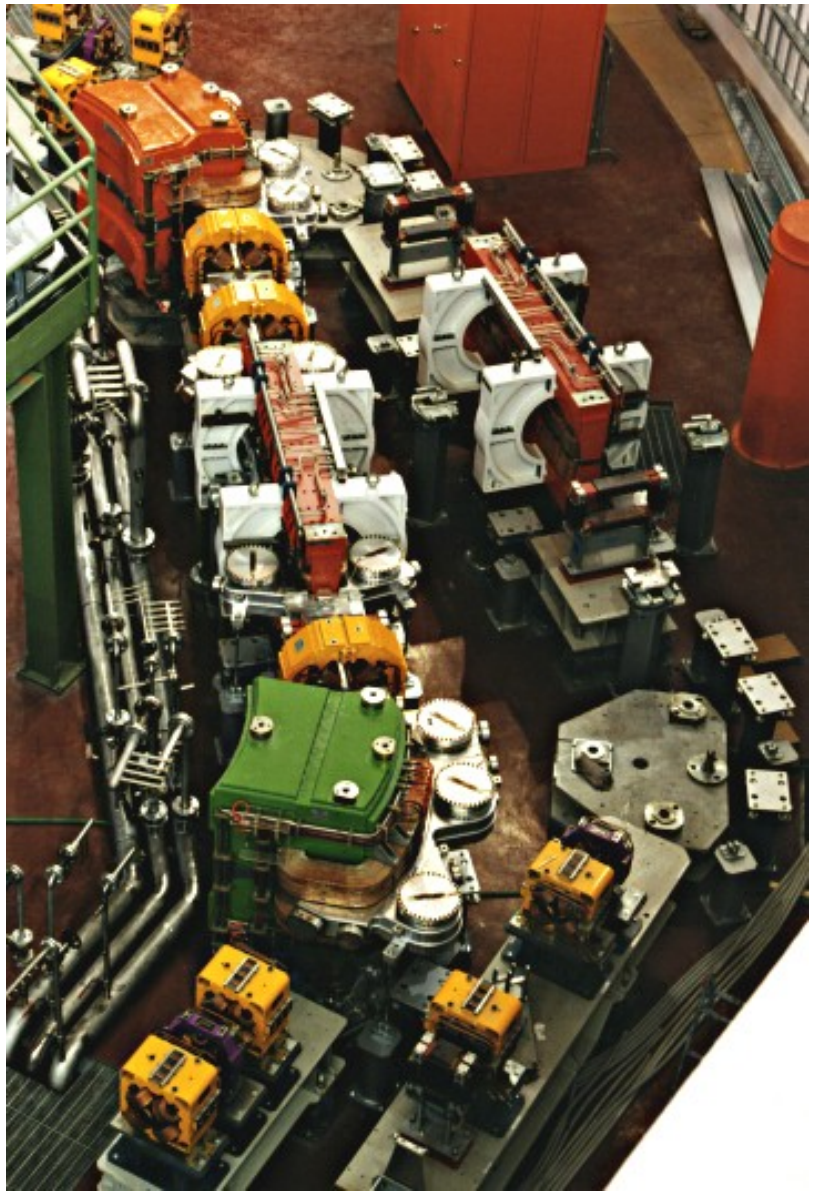
SPARC in Frascati is a high brightness photo-injector used to drive Free Electron Laser experiments and explore advanced beam manipulation techniques. The R&D effort made for the optimization of the beam parameters will be presented here, together with the major experimental results achieved. In particular, we will focus on the generation of sub-picosecond, high brightness electron bunch trains via velocity bunching technique (the so called comb beam). Such bunch trains can be used to drive tunable and narrow band THz sources, FELs and plasma wake field accelerators.

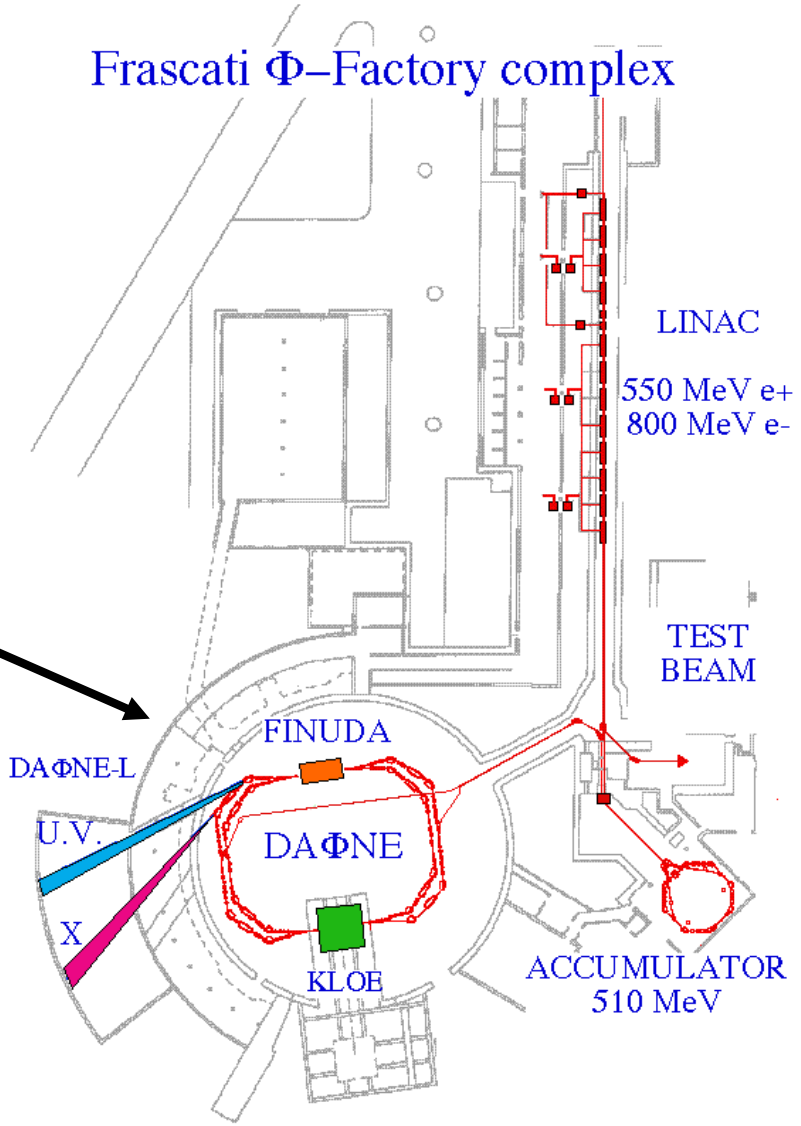
FLAME is a 250 TW, 30 fs pulse duration laser. At the moment the laser FLAME has been focused on a 4 mm gas-jet with the goal of producing sub-GeV electron bunches from laser–plasma interactions. The present installation will allow to the laser wake-field acceleration of externally injected electron bunches.

INFN - LABORATORI NAZIONALI DI FRASCATI

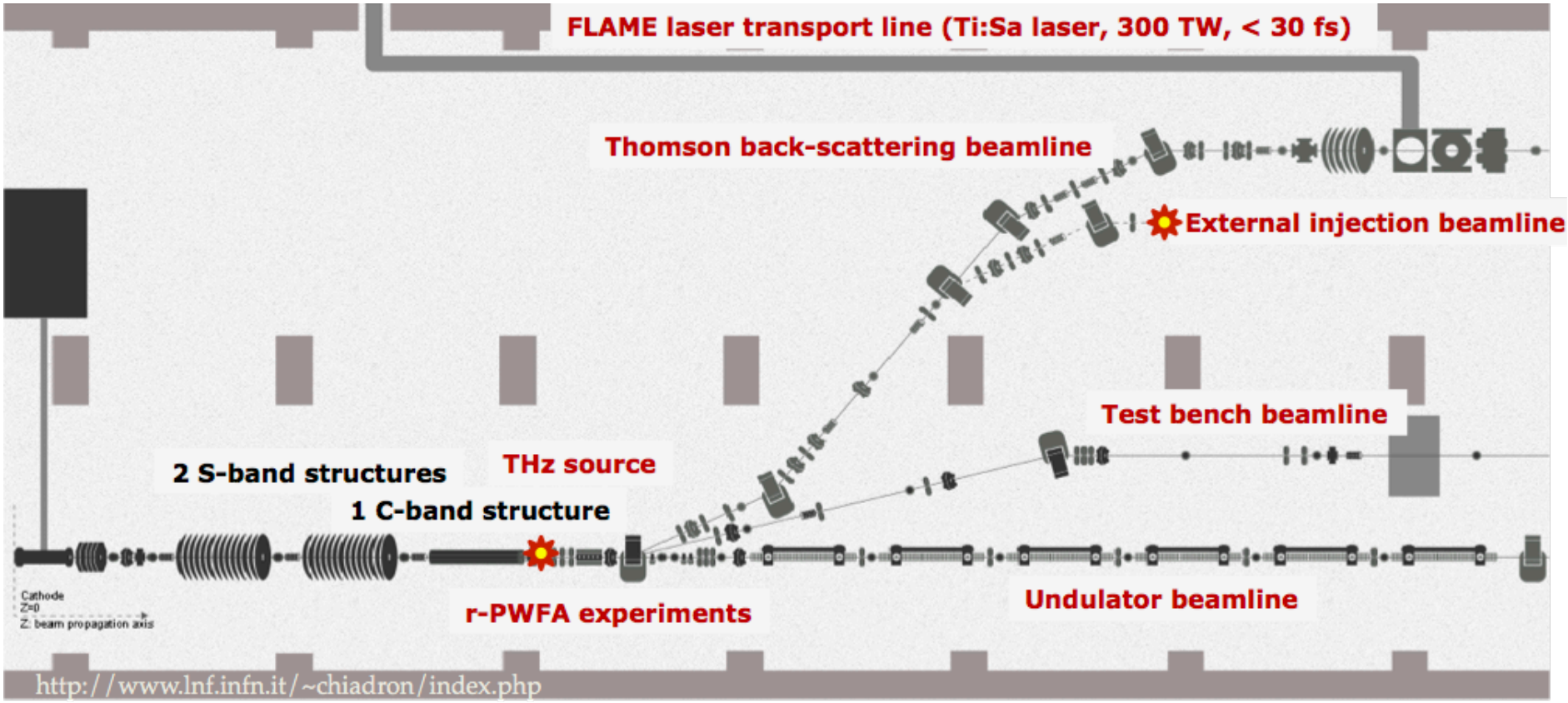


DAFNE



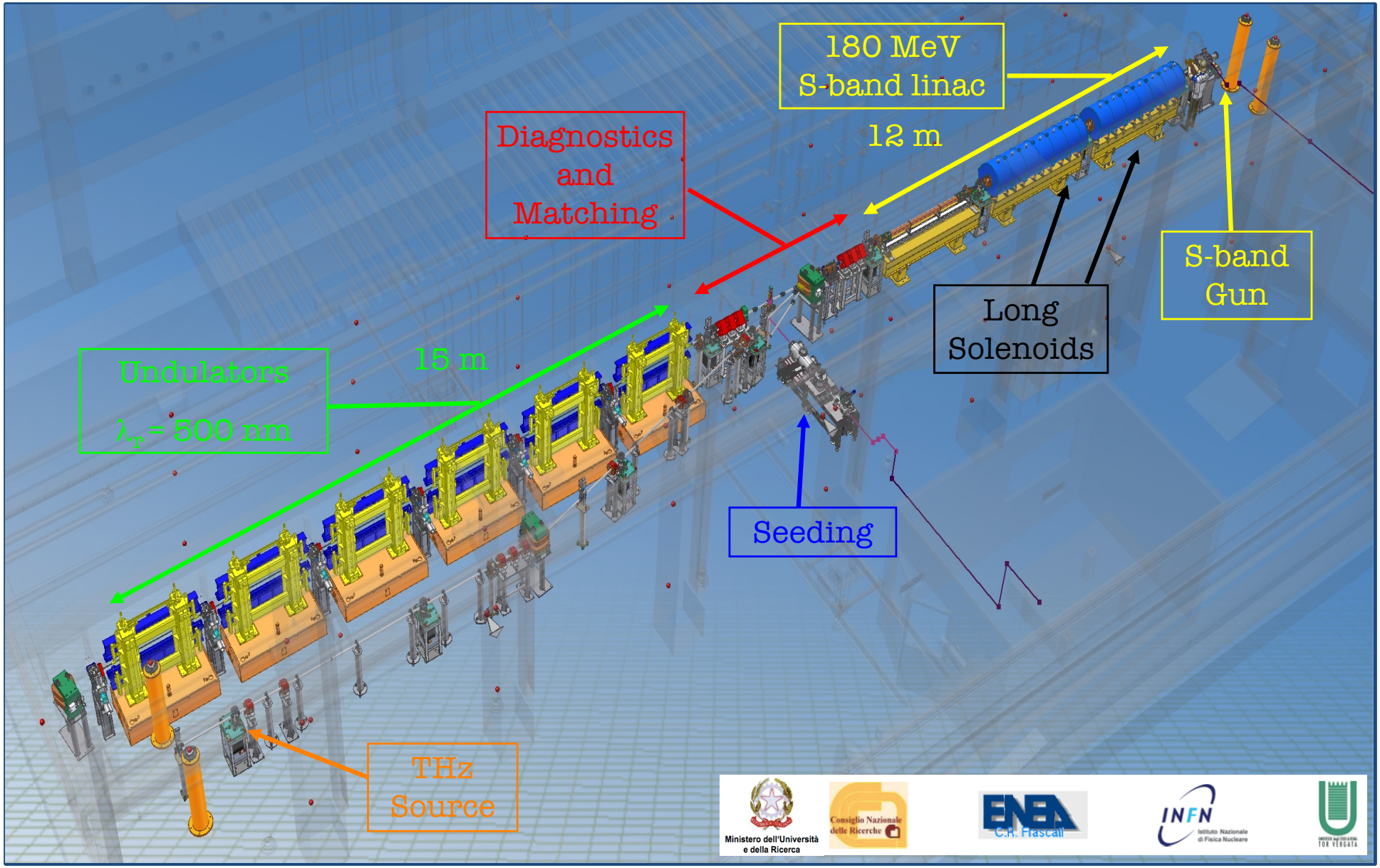

Frascati Φ–Factory complex
LINAC
550 MeV e+
800 MeV e-
TEST
BEAM
FINUDA
DAΦNE-L
U.V.
X
DAΦNE
KLOE
ACCUMULATOR
510 MeV

SPARC-LAB

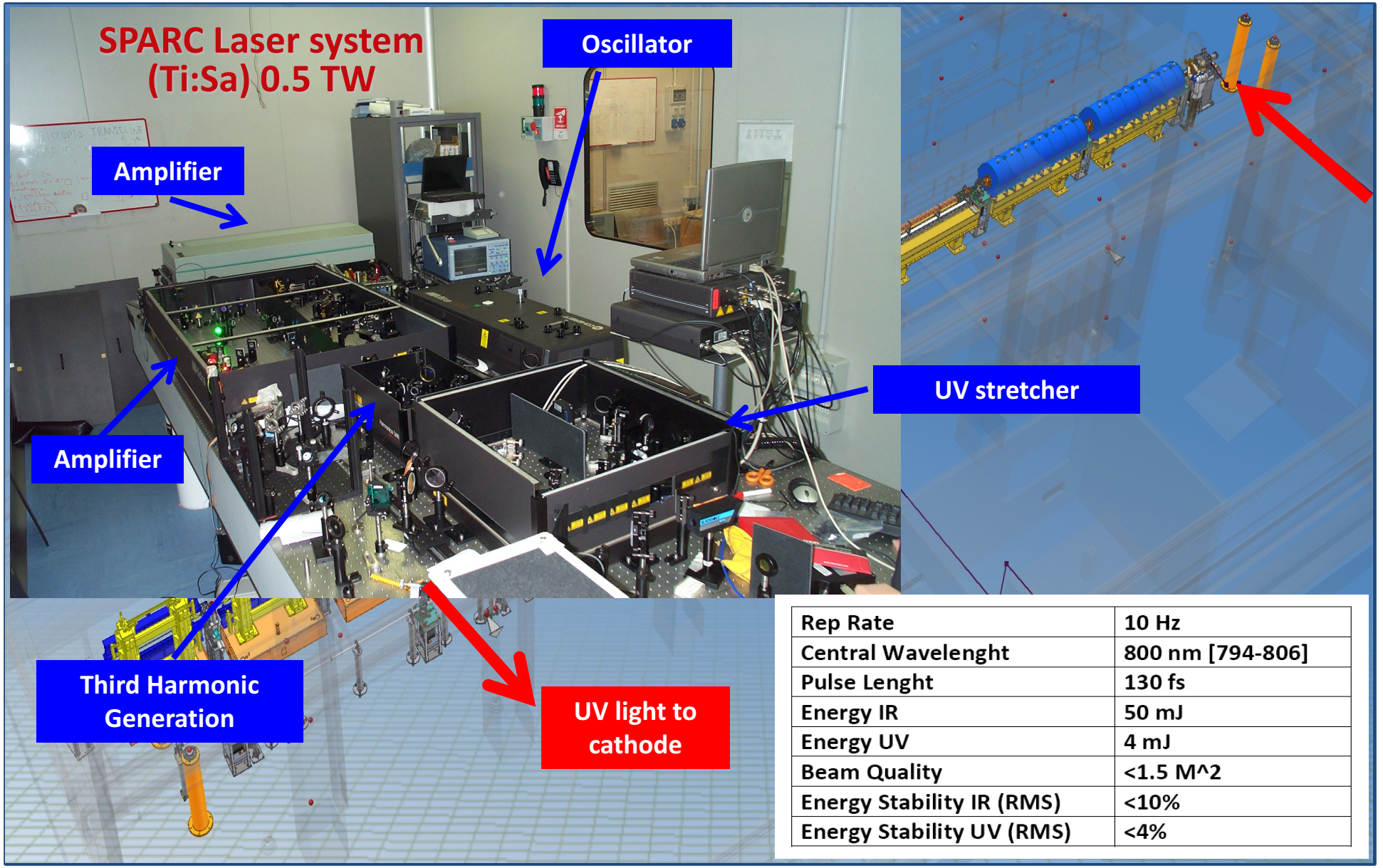


Sources for **P**lasma **A**ccelerators and **R**adiation **C**ompton with **L**asers **A**nd **B**eams

SPARC

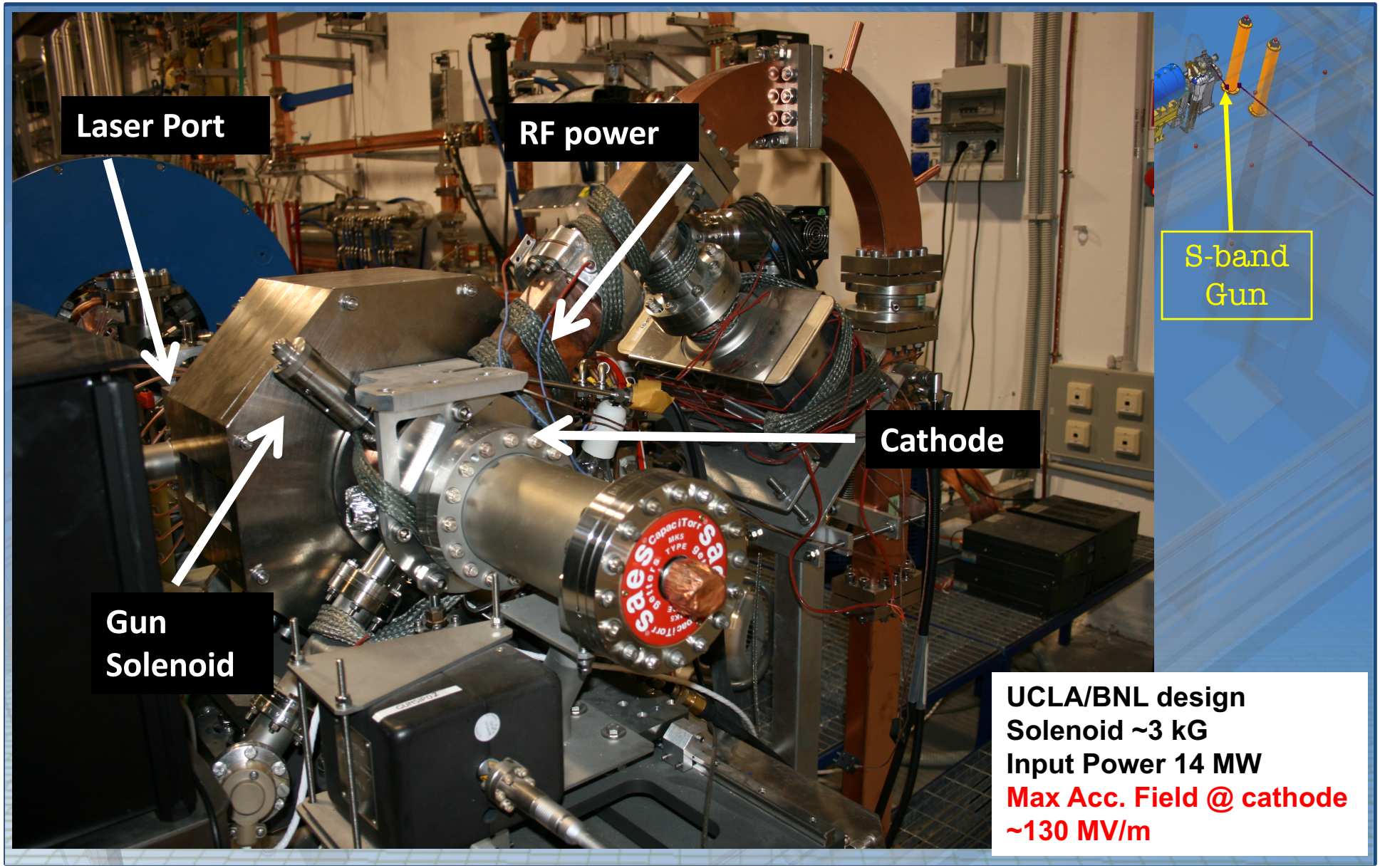

180 MeV
S-band linac
12 m
Diagnostics
and
Matching
S-band
Gun
Long
Solenoids
Undulators
λ_r = 500 nm
15 m
Seeding
THz
Source
Ministero dell'Università
e della Ricerca
Consiglio Nazionale
delle Ricerche
ENEA
C.R. Frascati
INFN
Istituto Nazionale
di Fisica Nucleare

SPARC LAYOUT: LASER SYSTEM

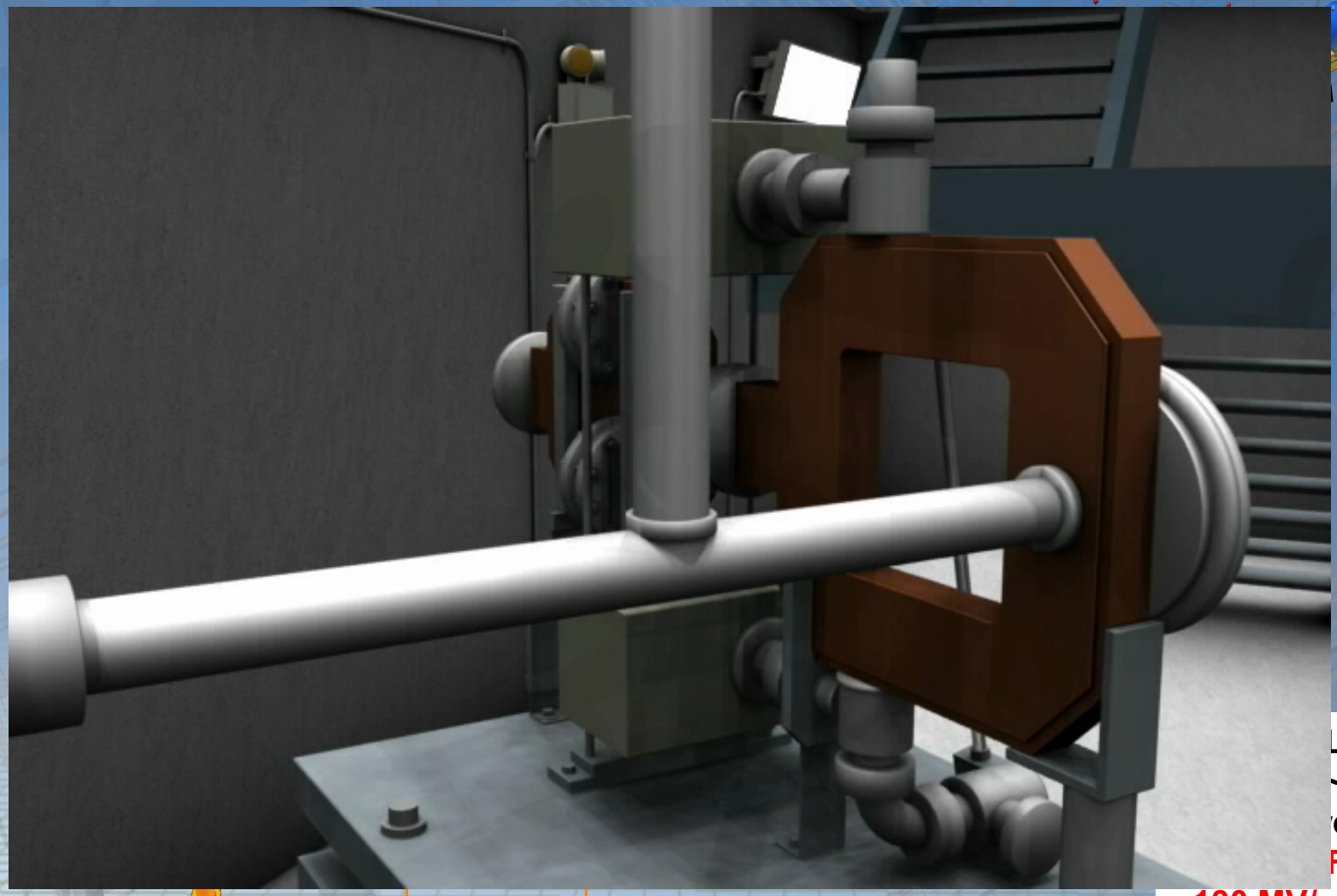


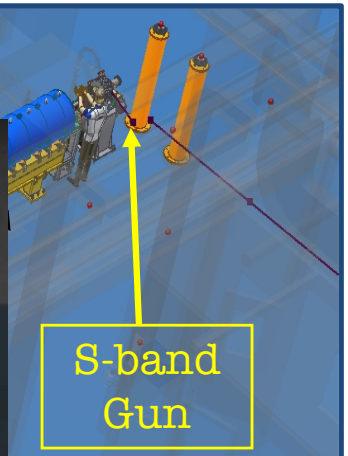
Rep Rate	10 Hz
Central Wavelenght	800 nm [794-806]
Pulse Lenght	130 fs
Energy IR	50 mJ
Energy UV	4 mJ
Beam Quality	<1.5 M^2
Energy Stability IR (RMS)	<10%
Energy Stability UV (RMS)	<4%

SPARC LAYOUT: S-BAND GUN



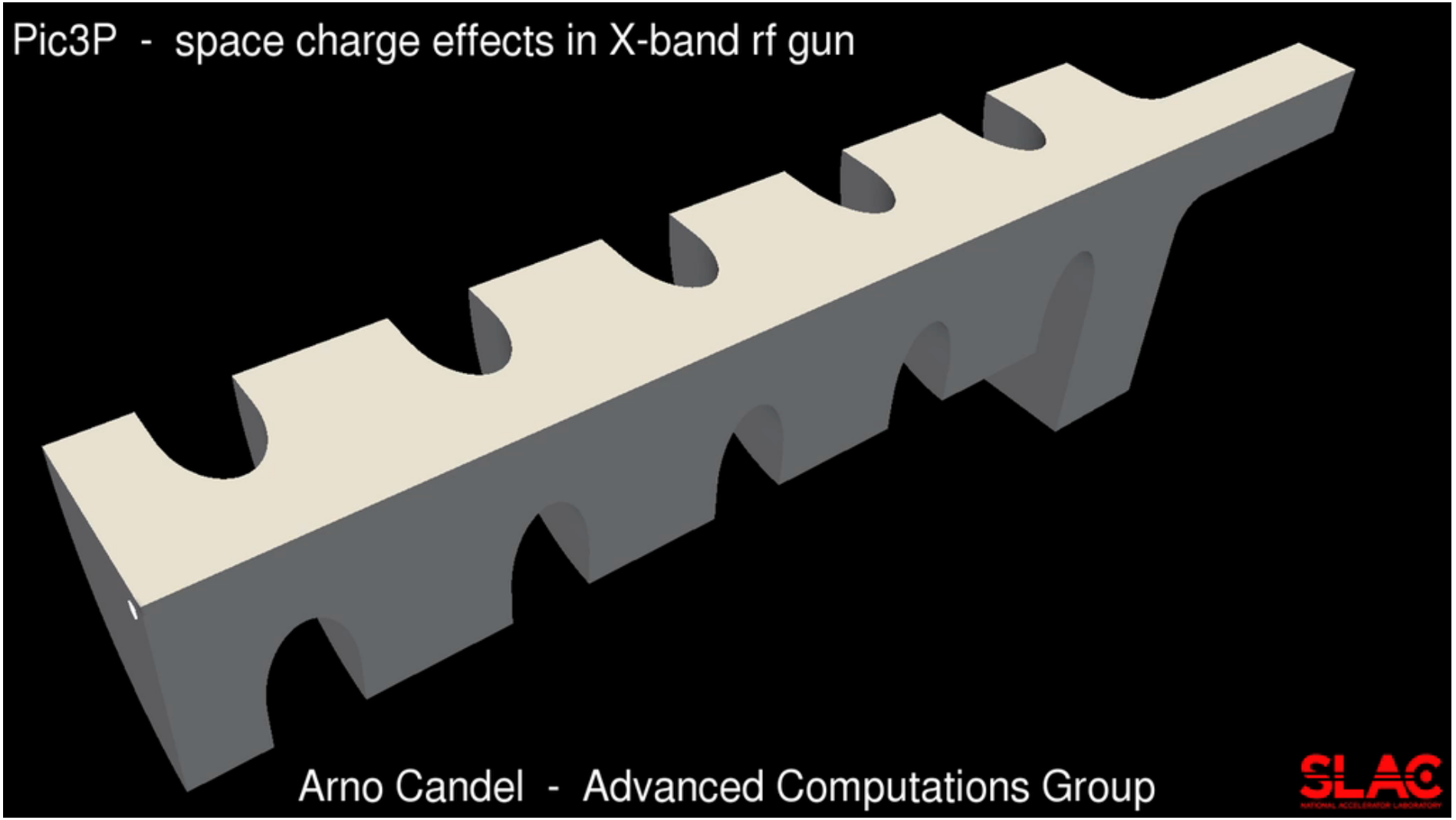
SPARC LAYOUT: S-BAND GUN





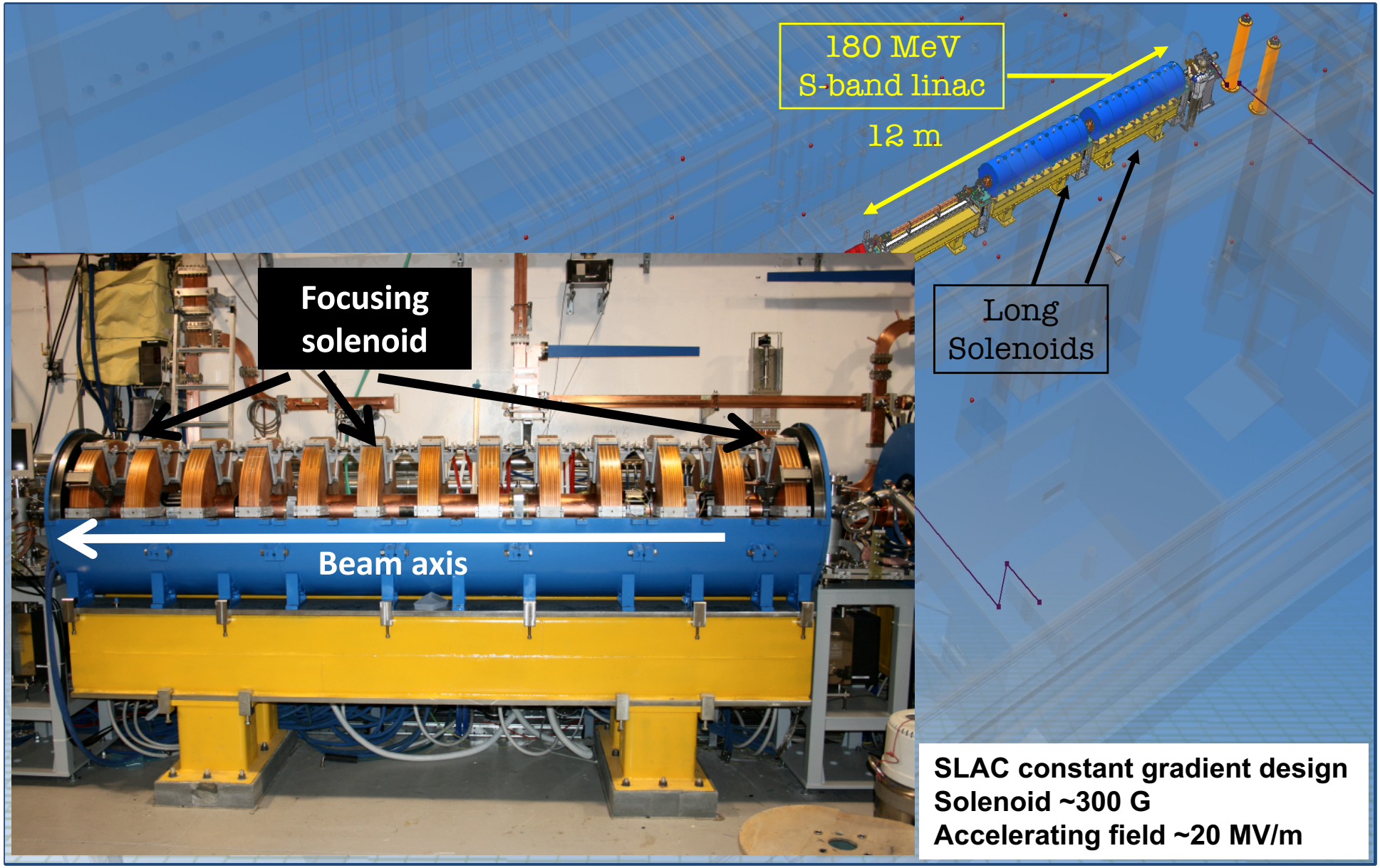
L design
~3 kG
er 14 MW
Field @ cathode
~130 MV/m

RF GUNS



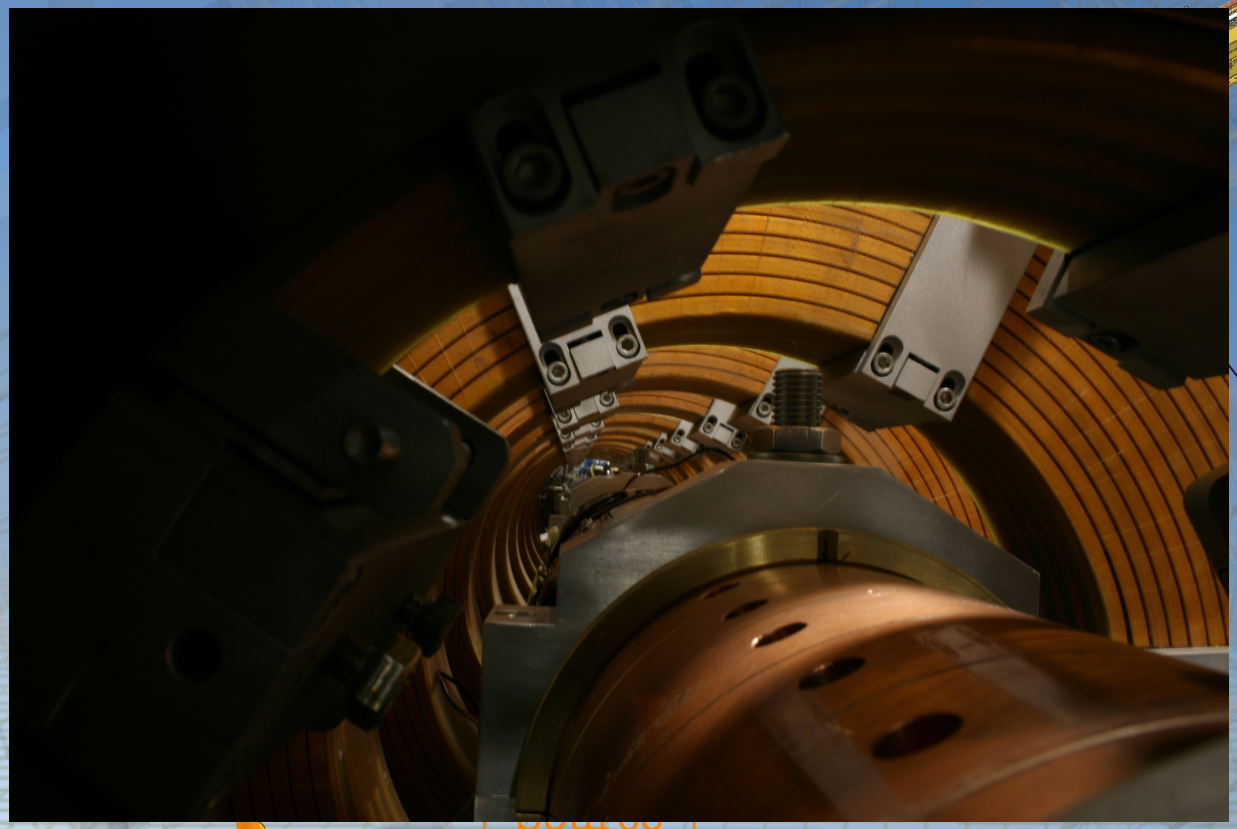
Courtesy of Cho Ng, SLAC

SPARC LAYOUT: S-BAND LINAC



SLAC constant gradient design
Solenoid ~300 G
Accelerating field ~20 MV/m

SPARC LAYOUT: S-BAND LINAC



180 MeV
S-band linac

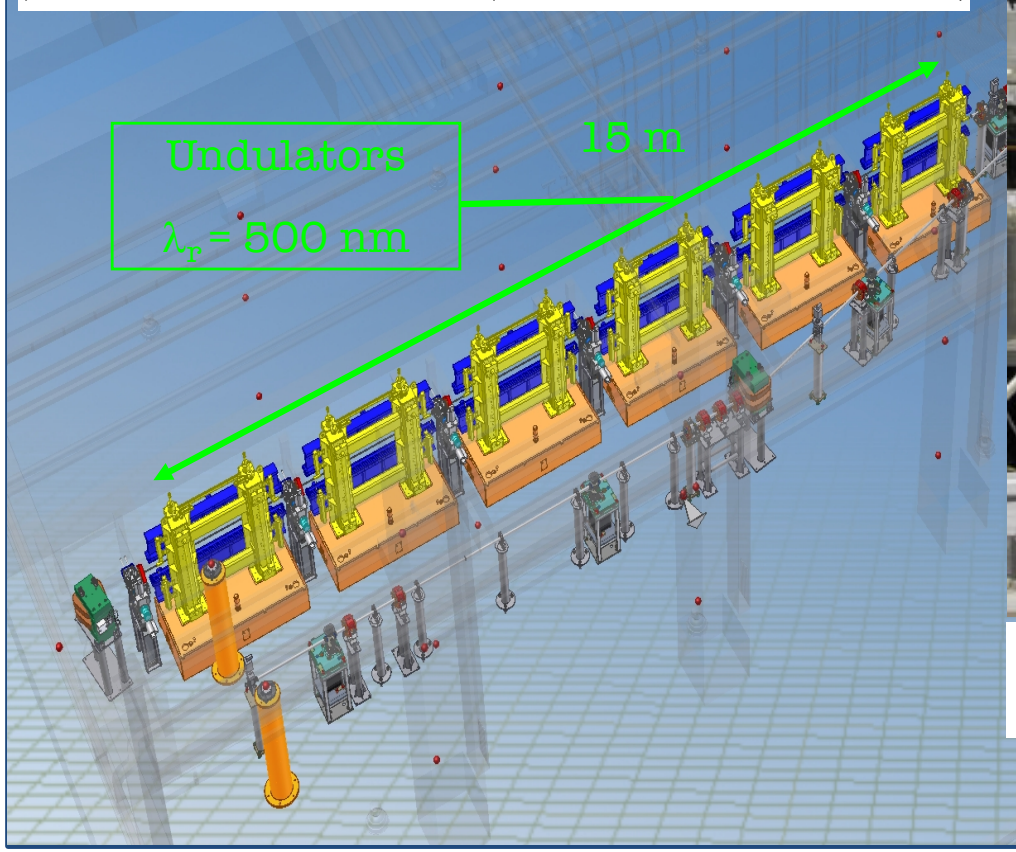
12 m

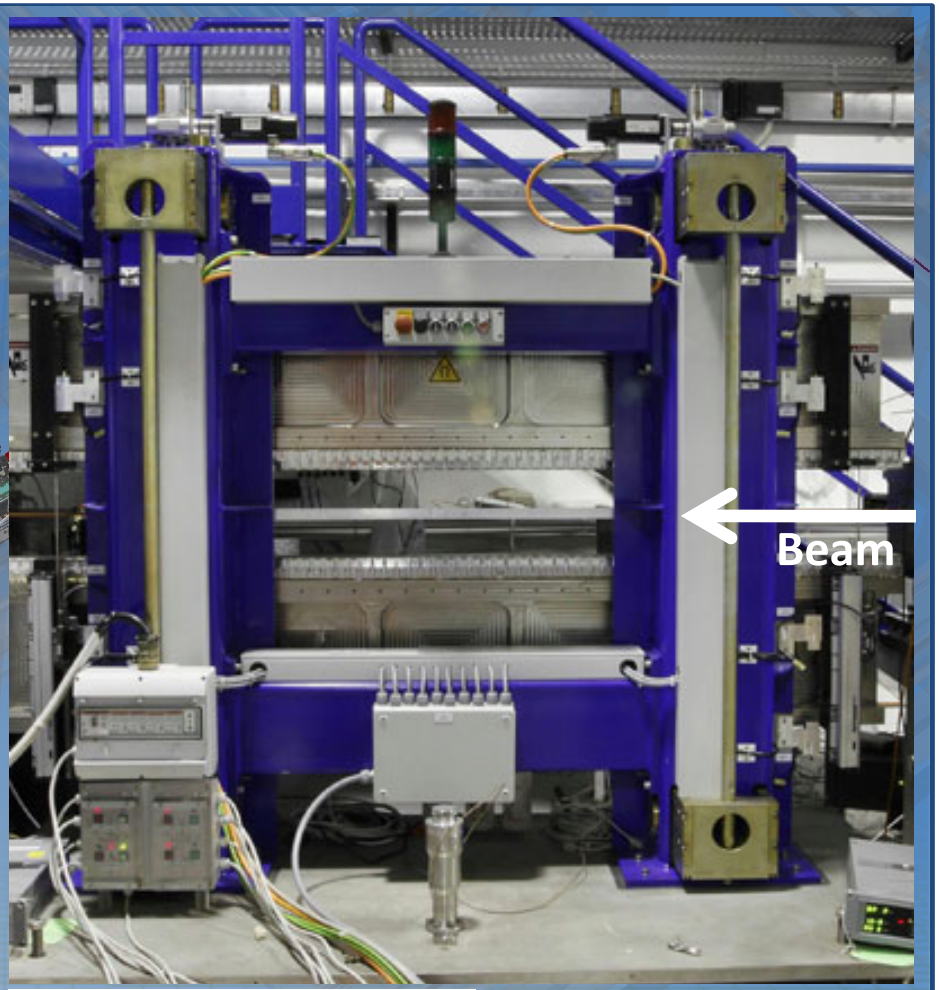
Long
Solenoids

SLAC constant gradient design
Solenoid ~300 G
Accelerating field ~20 MV/m

SPARC LAYOUT: UNDULATORS

Period	2.8 cm
Undulator length	2.156.m
No of Periods	77
Gap (nom./min/max)	0.958 / 0.6 / 2.5 cm
K (nom./max/min)	2.145 / 3.2 / 0.38
Remanent field	1.31 T
Blocks per period	4
Block size (h x l x w)	2 x 0.7 x 5 cm

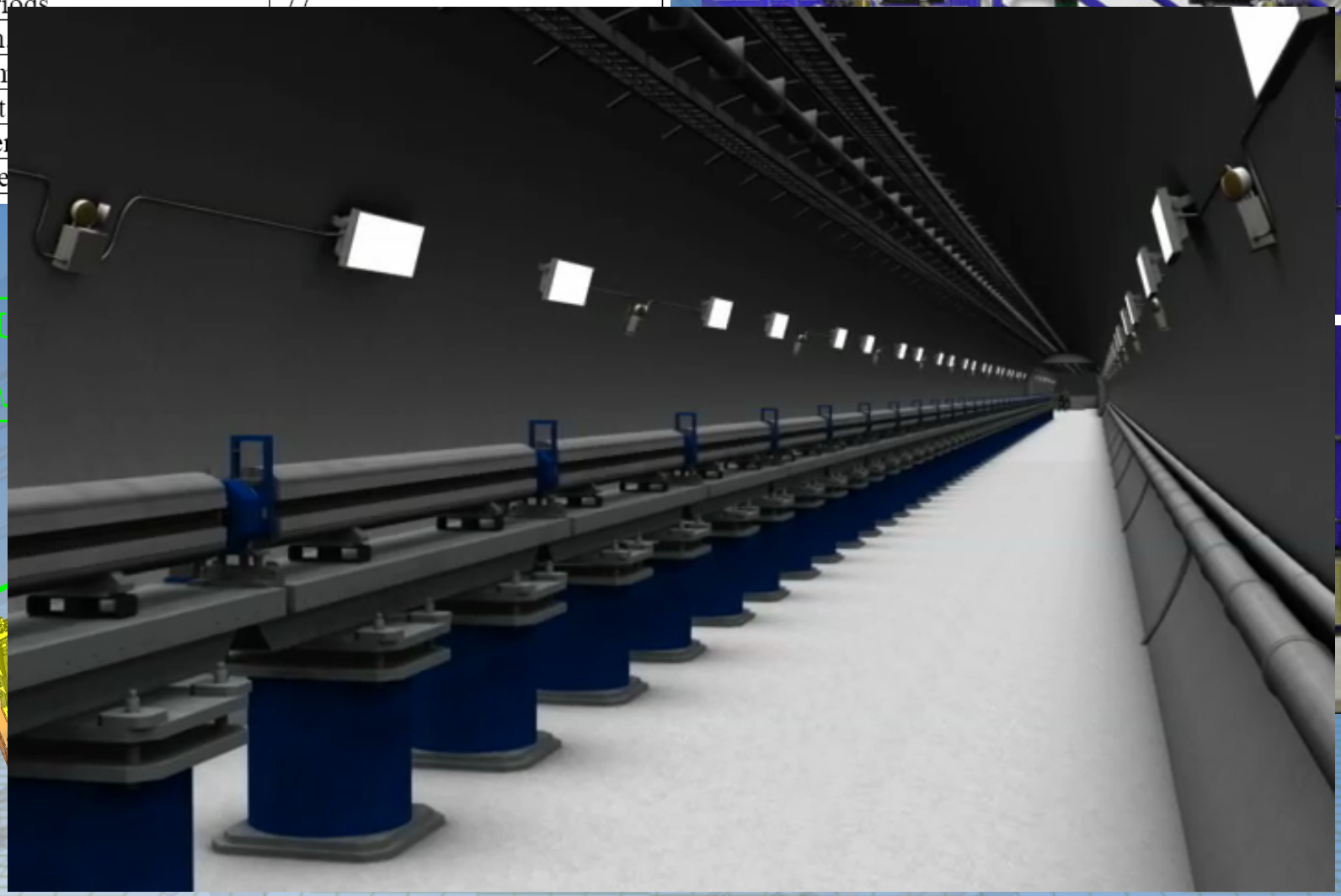


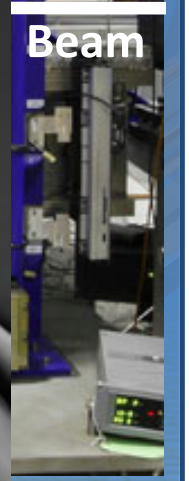


Variable gap undulator
Halbach type

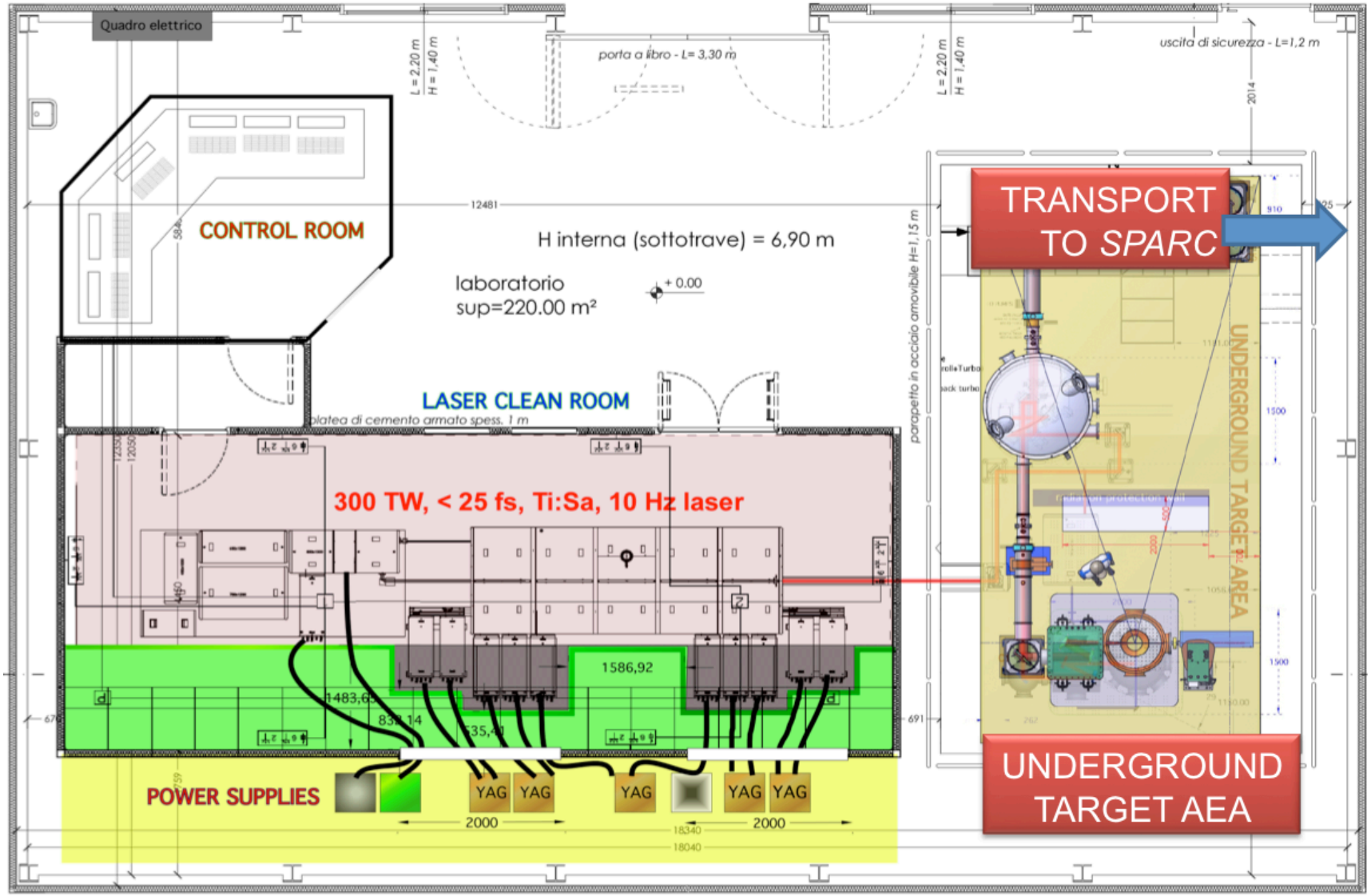
SPARC LAYOUT: UNDULATORS

Period	2.8 cm
Undulator length	2.156.m
No of Periods	77
Gap (nom.	
K (nom./m	
Remanent	
Blocks per	
Block size	





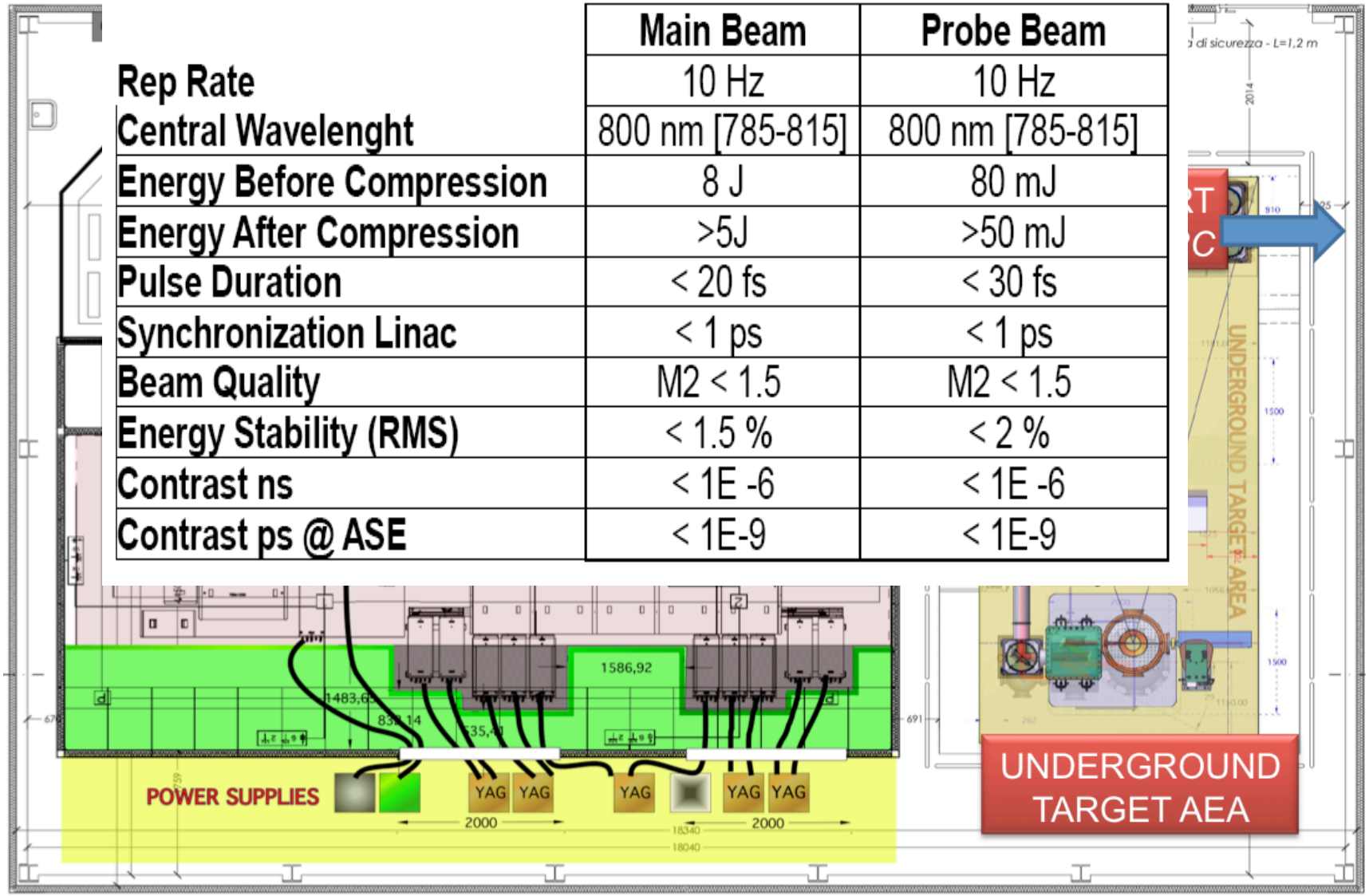
FLAME: A 300 TW TI:SA LASER



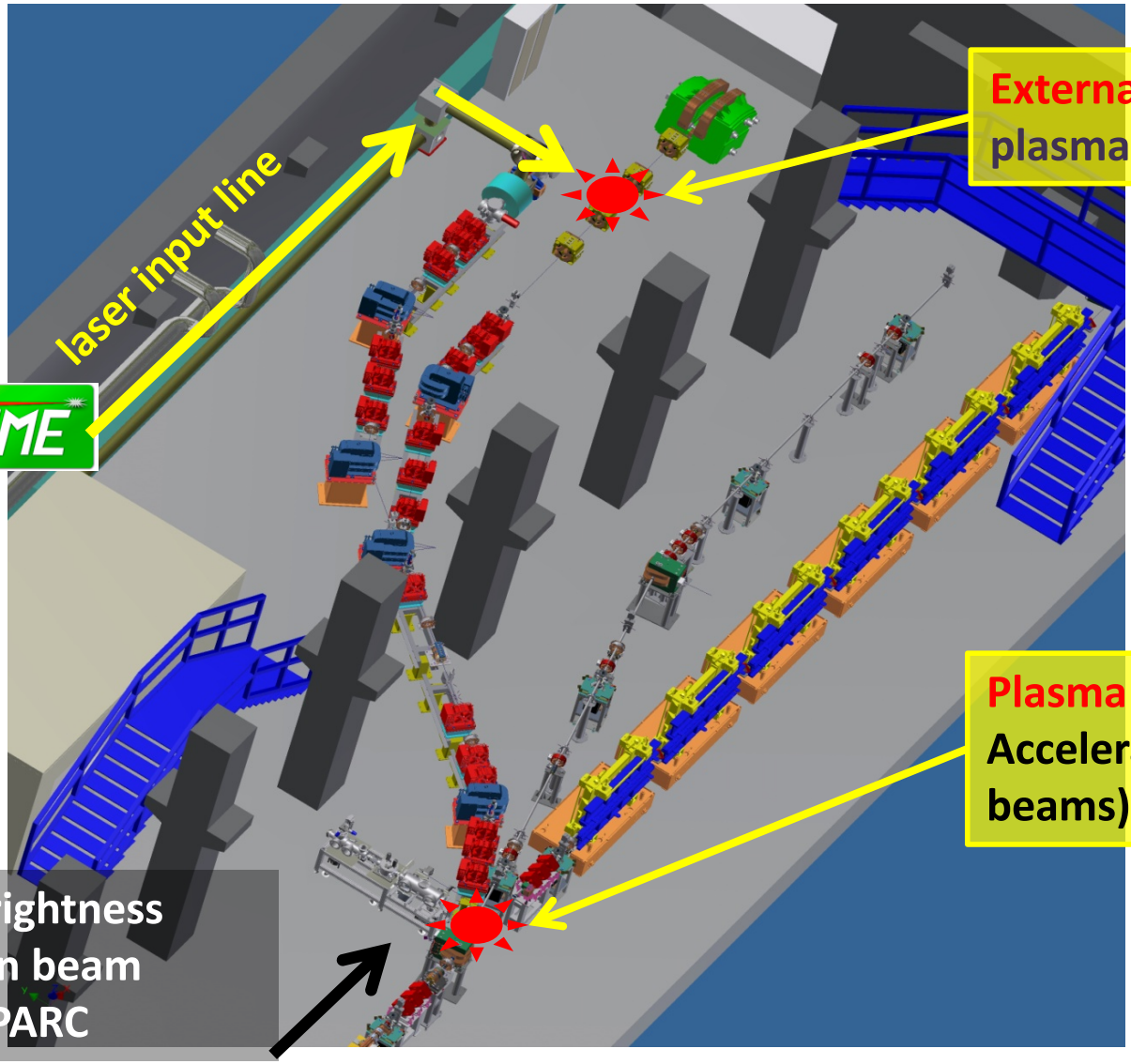
FLAME: A 300 TW TI:SA LASER

FLAME: A 300 TW TI:SA LASER

	Main Beam	Probe Beam
Rep Rate	10 Hz	10 Hz
Central Wavelenght	800 nm [785-815]	800 nm [785-815]
Energy Before Compression	8 J	80 mJ
Energy After Compression	>5J	>50 mJ
Pulse Duration	< 20 fs	< 30 fs
Synchronization Linac	< 1 ps	< 1 ps
Beam Quality	M2 < 1.5	M2 < 1.5
Energy Stability (RMS)	< 1.5 %	< 2 %
Contrast ns	< 1E -6	< 1E -6
Contrast ps @ ASE	< 1E-9	< 1E-9

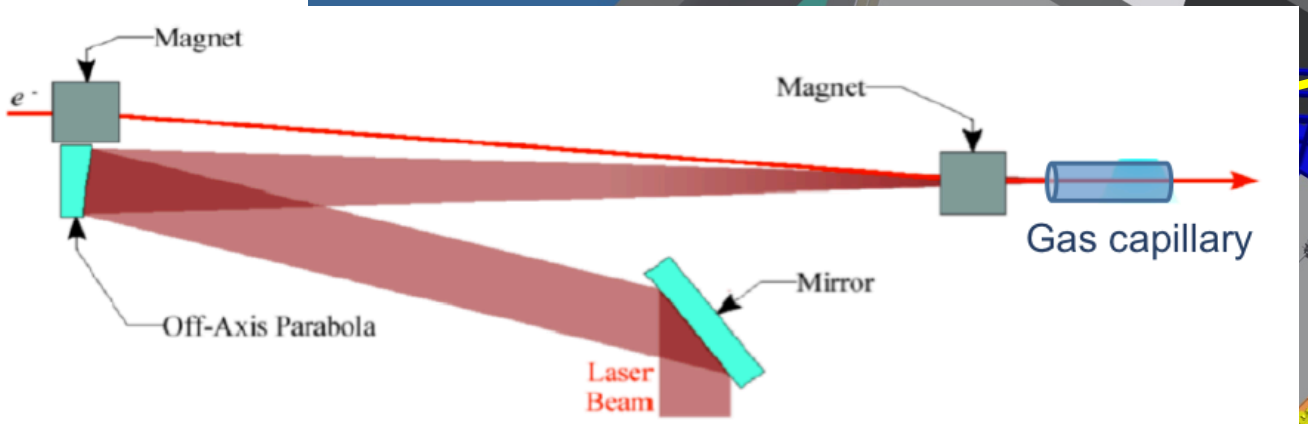


PLASMA ACCELERATION @ SPARC-LAB



300 TW, < 25 fs
Ti:Sa laser

PLASMA ACCELERATION @ SPARC-LAB



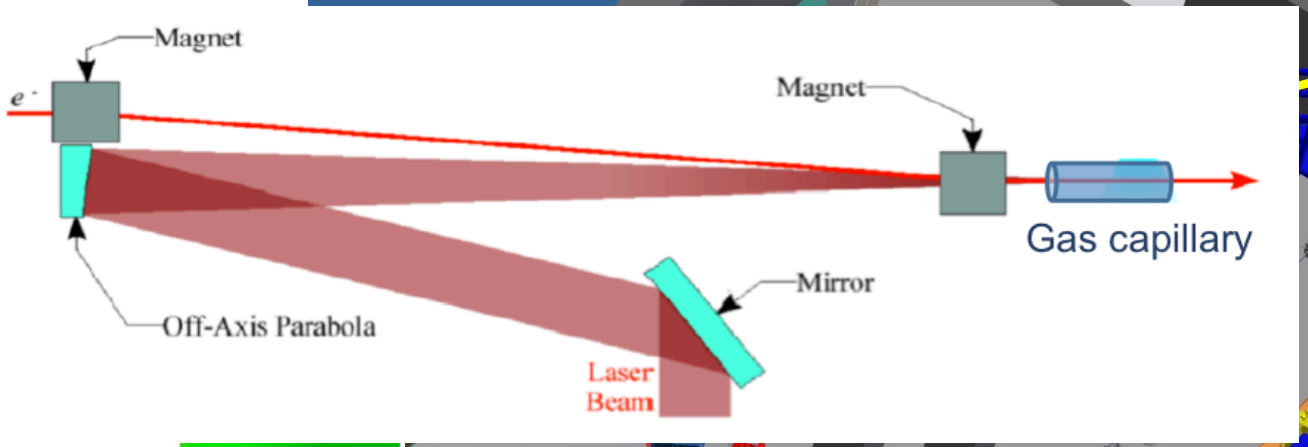
External Injection into plasma

300 TW, < 25 fs
Ti:Sa laser

Plasma Wakefield Acceleration (COMB beams)

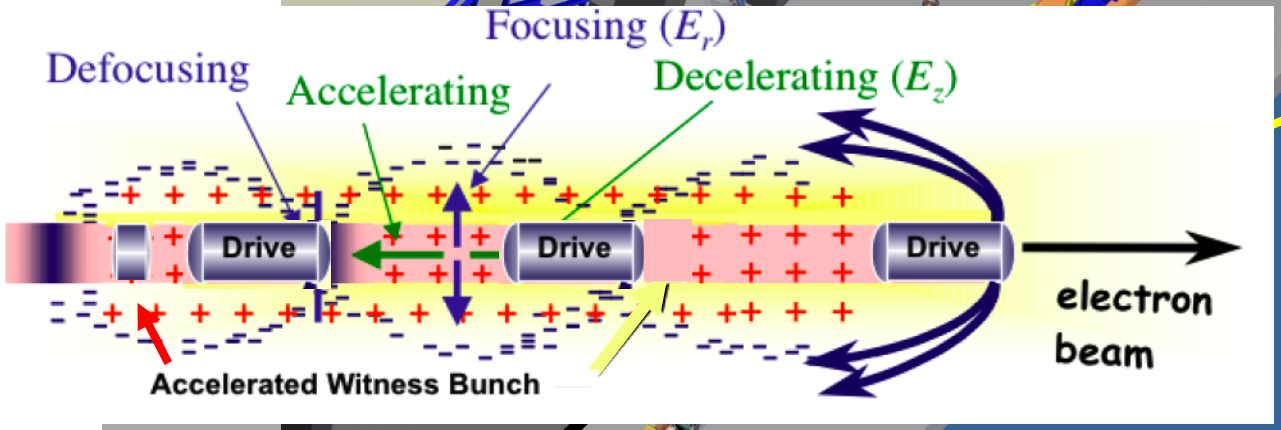
High Brightness electron beam from SPARC

PLASMA ACCELERATION @ SPARC-LAB



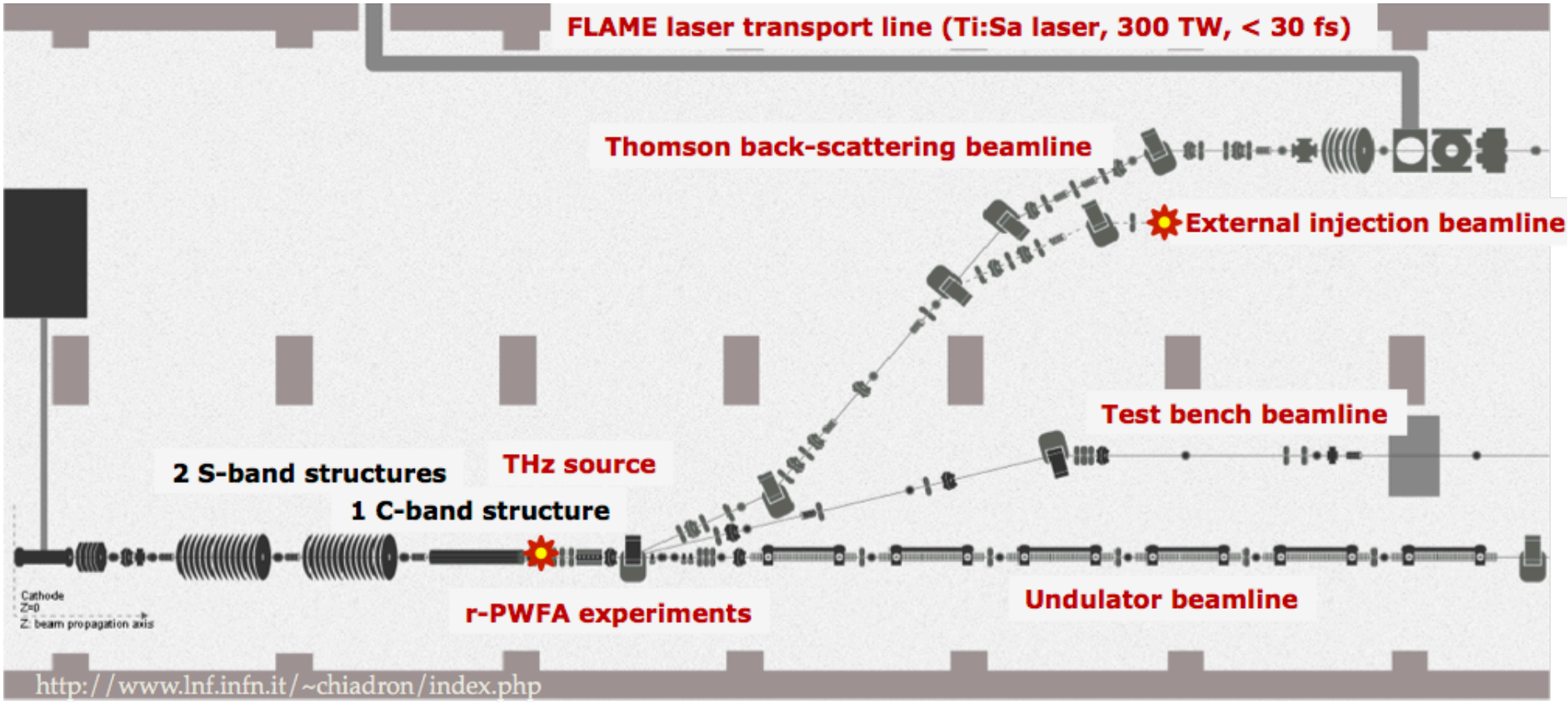
External Injection into plasma

300 TW, < 25 fs
Ti:Sa laser



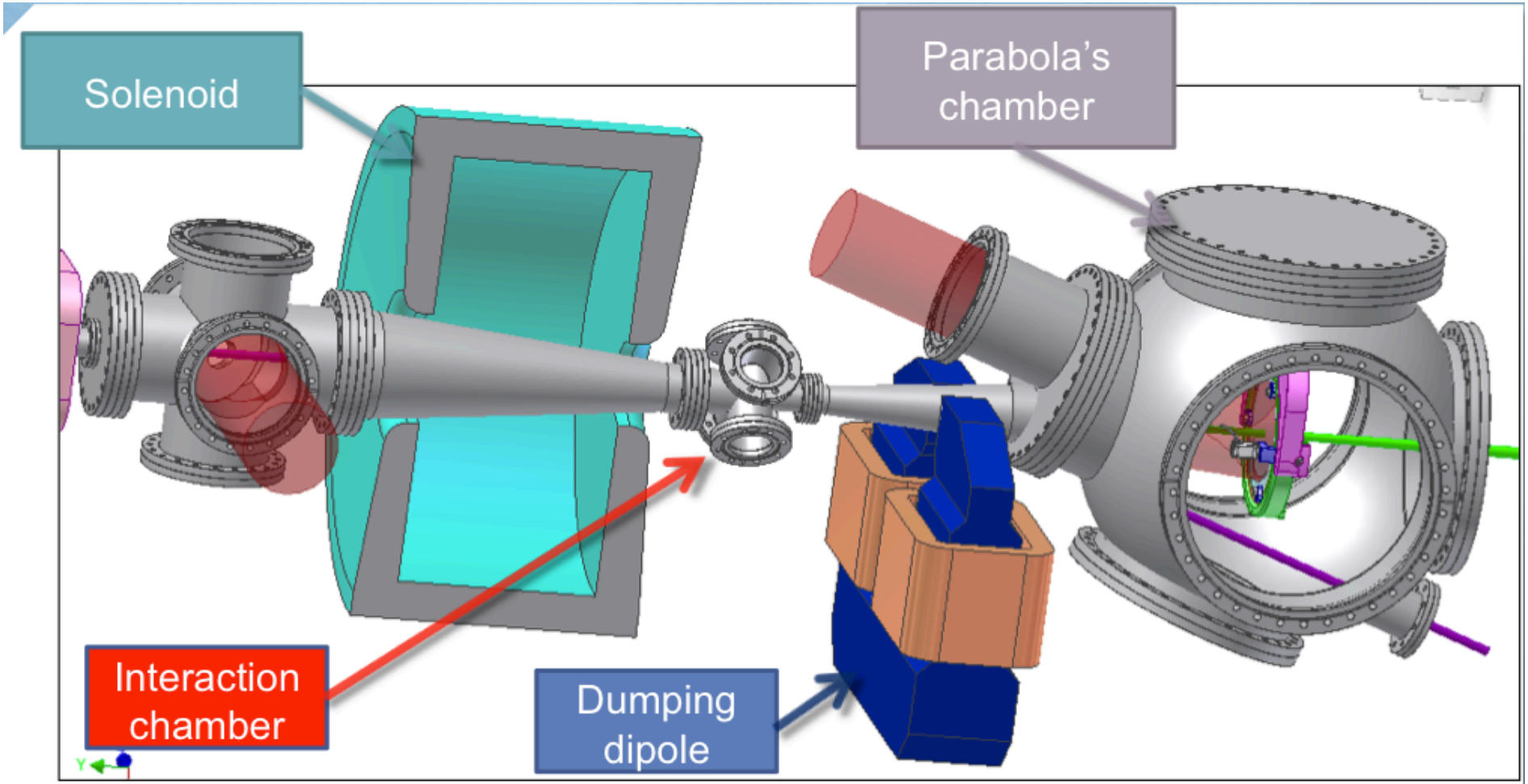
Plasma Wakefield Acceleration (COMB beams)

SPARC-LAB



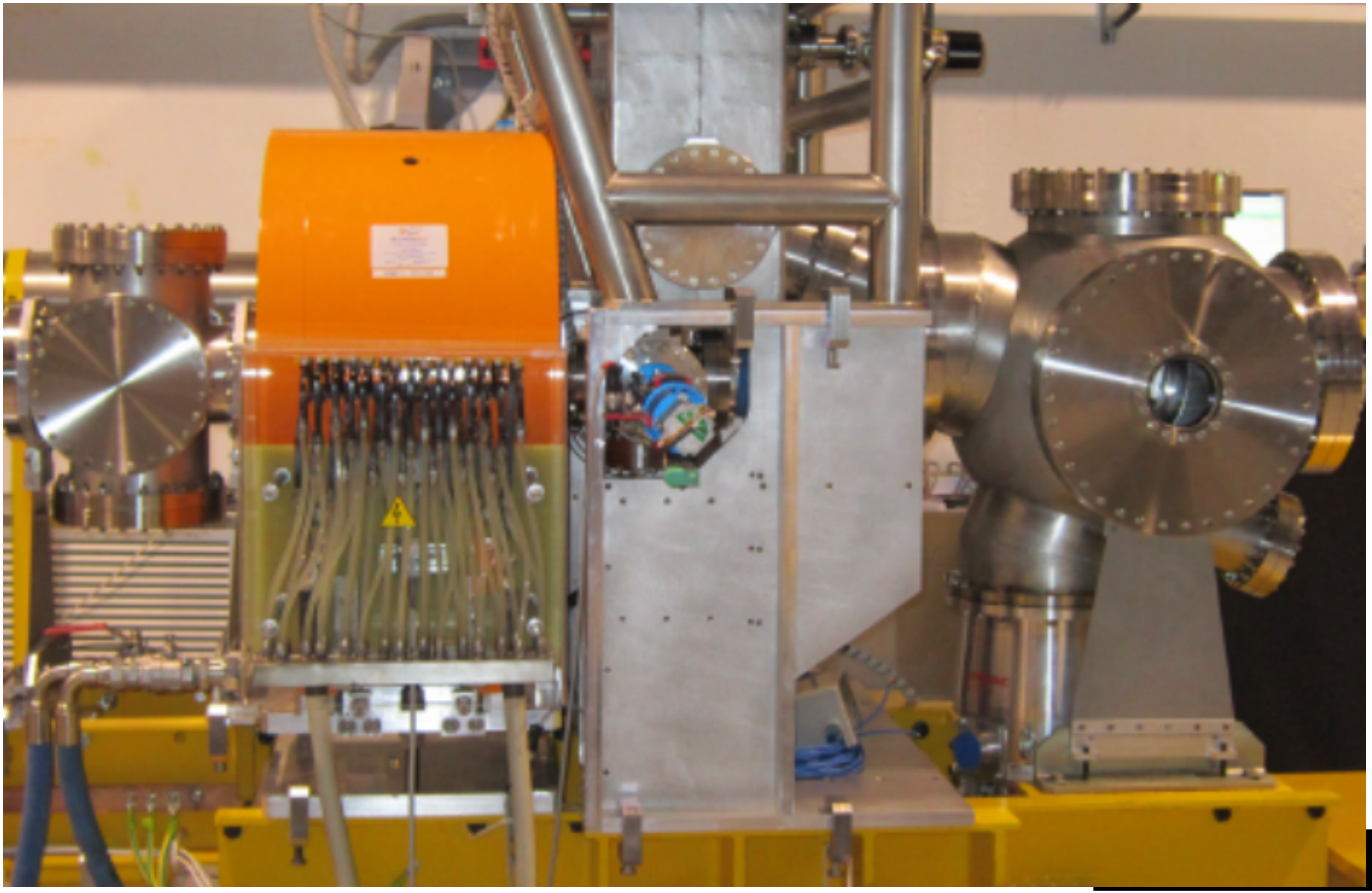
Sources for **P**lasma **A**ccelerators and **R**adiation **C**ompton with **L**asers **A**nd **B**eams

THOMSON SOURCE

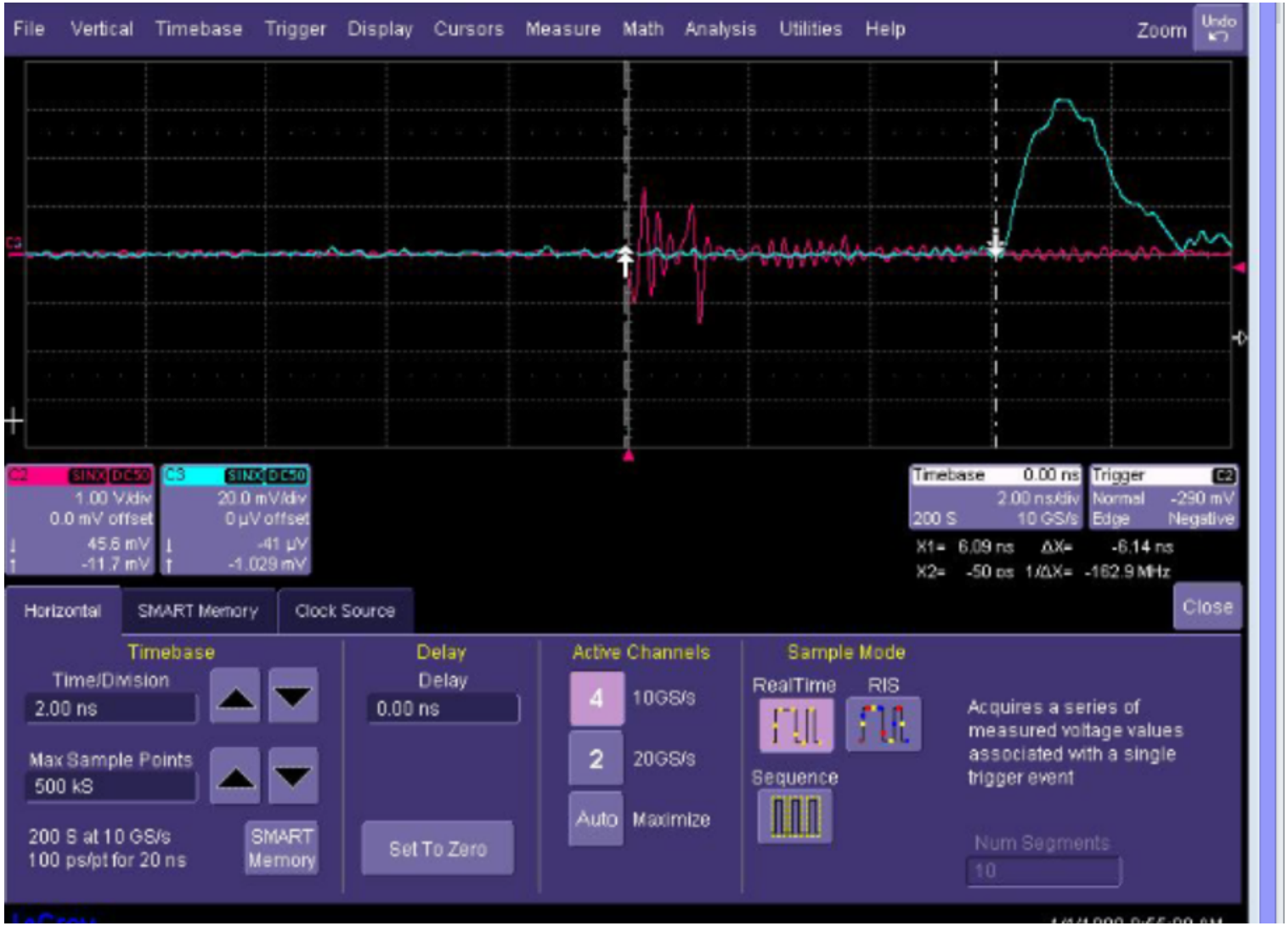


C. Vaccarezza

THOMSON SOURCE

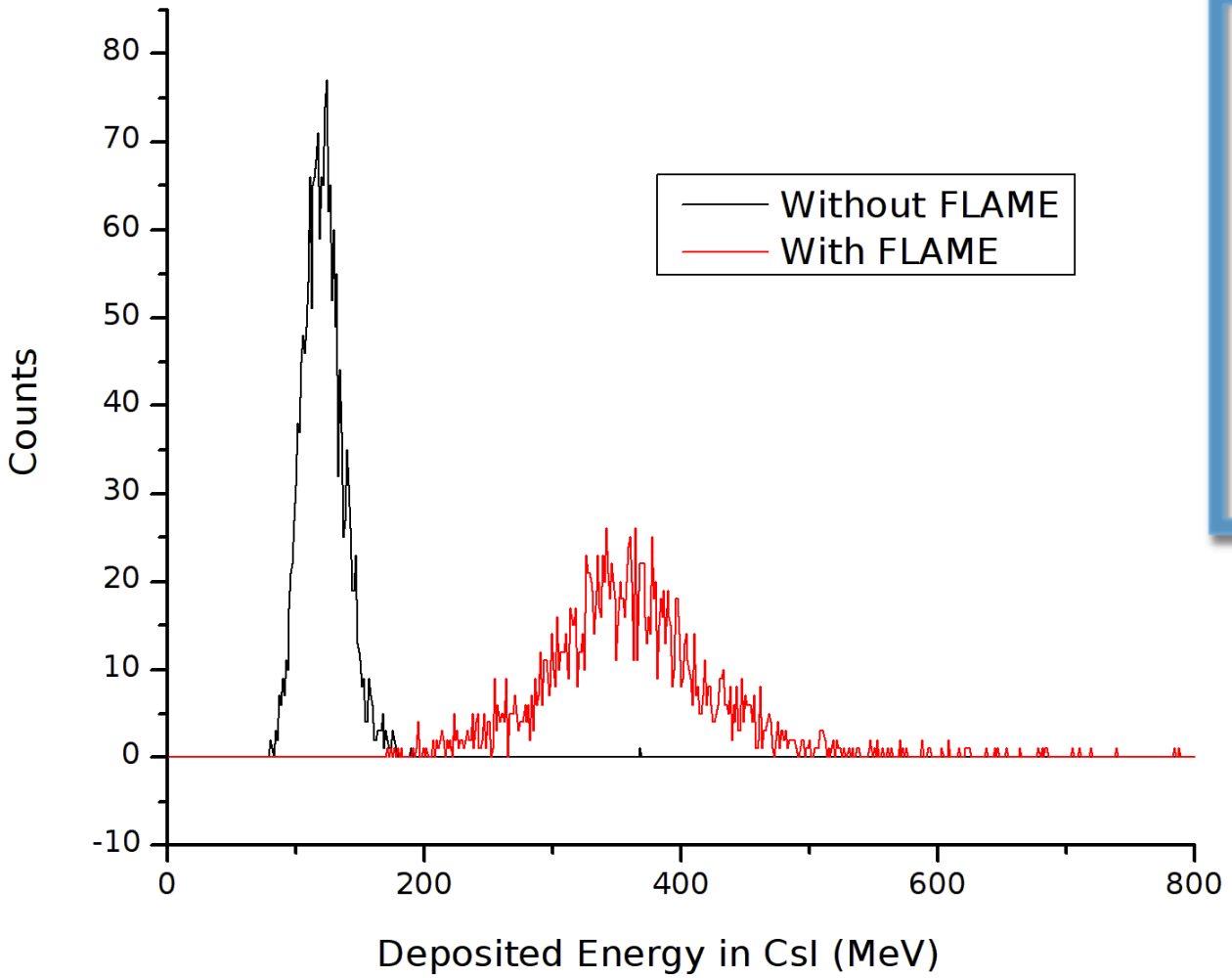


THOMSON SOURCE: SYNCHRONISATION

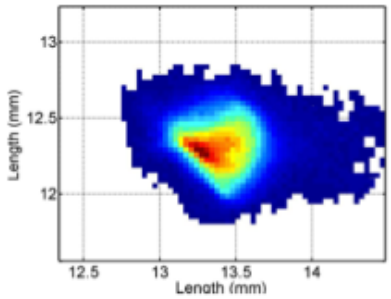


C. Vaccarezza

THOMSON SOURCE: RESULTS

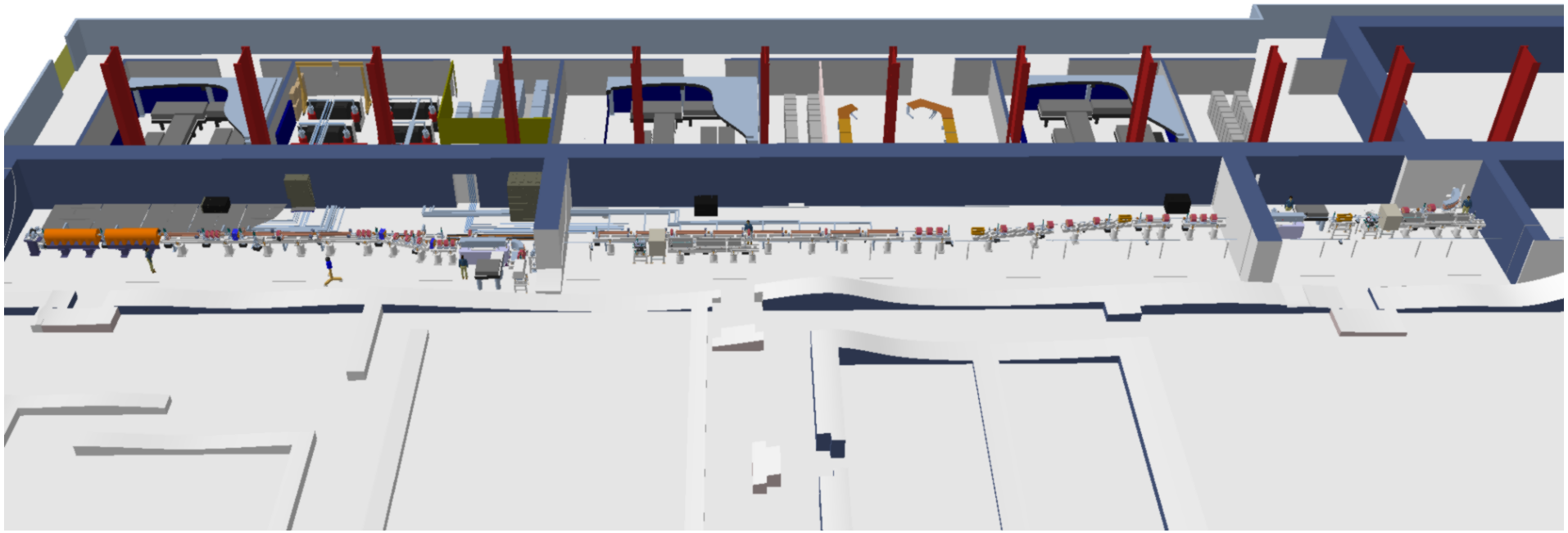


e⁻ beam at IP:
σ_x=0.16±0.01 mm
σ_y=0.24±0.01 mm



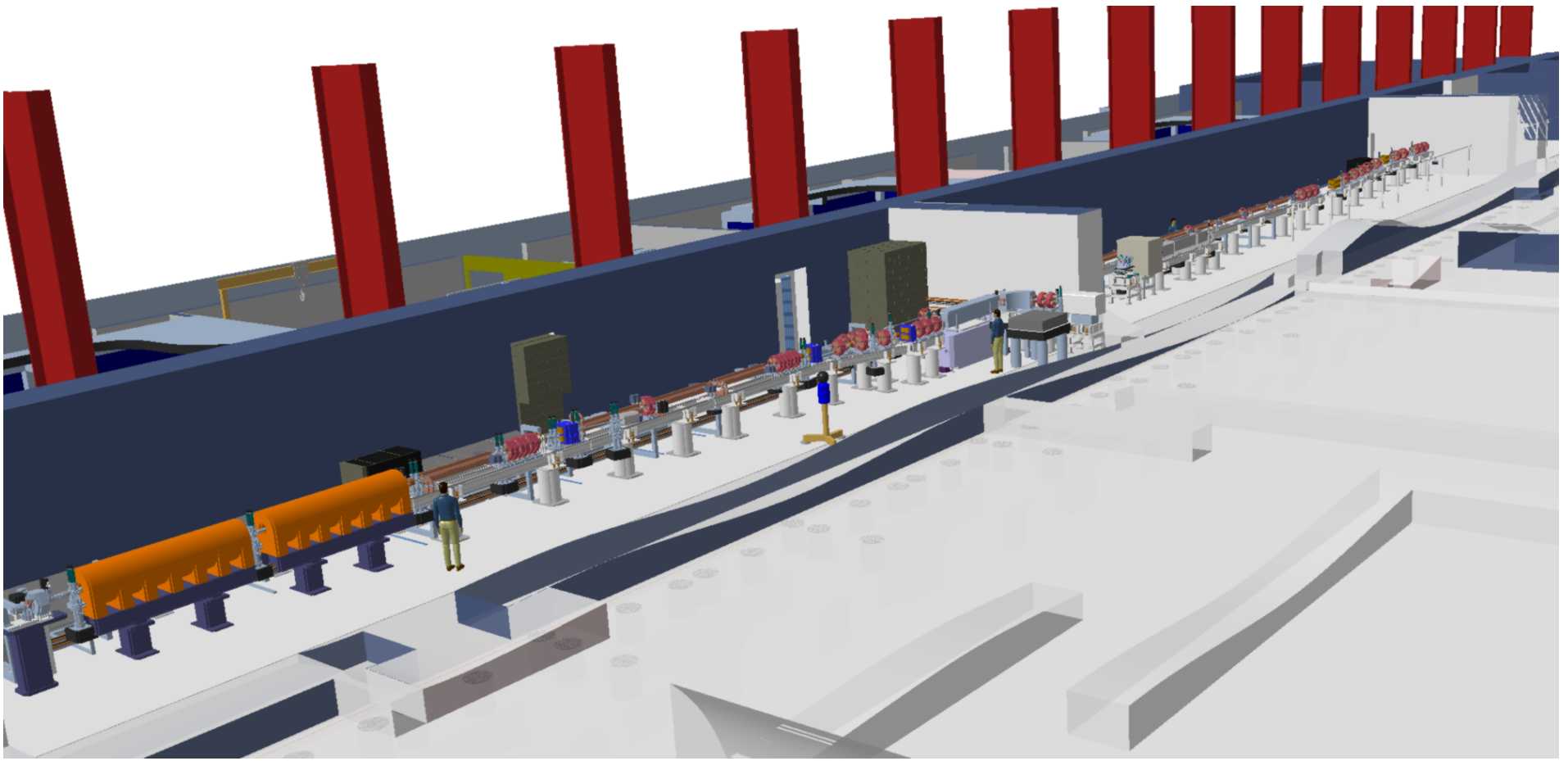
C. Vaccarezza

GAMMA SOURCES FOR ELI



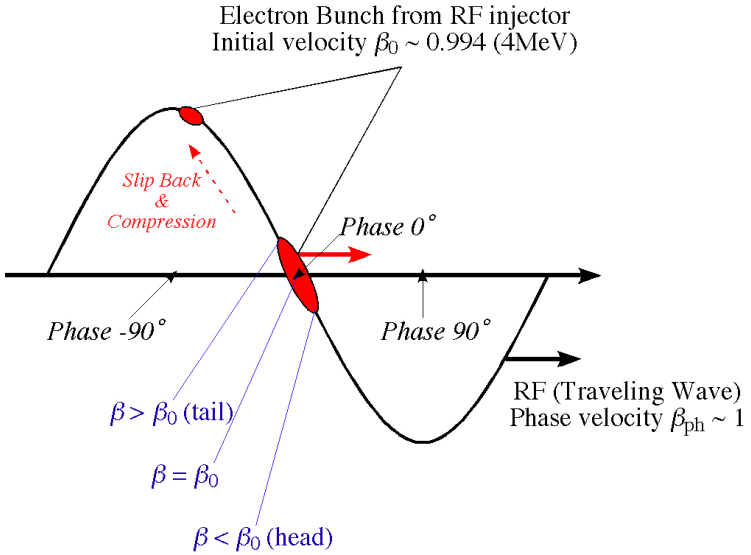
Courtesy of STFC

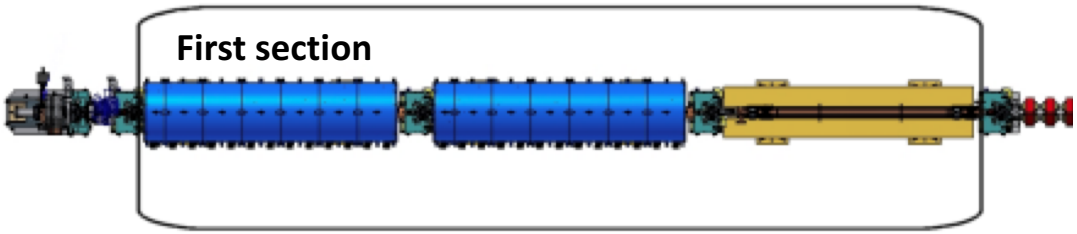
GAMMA SOURCES FOR ELI



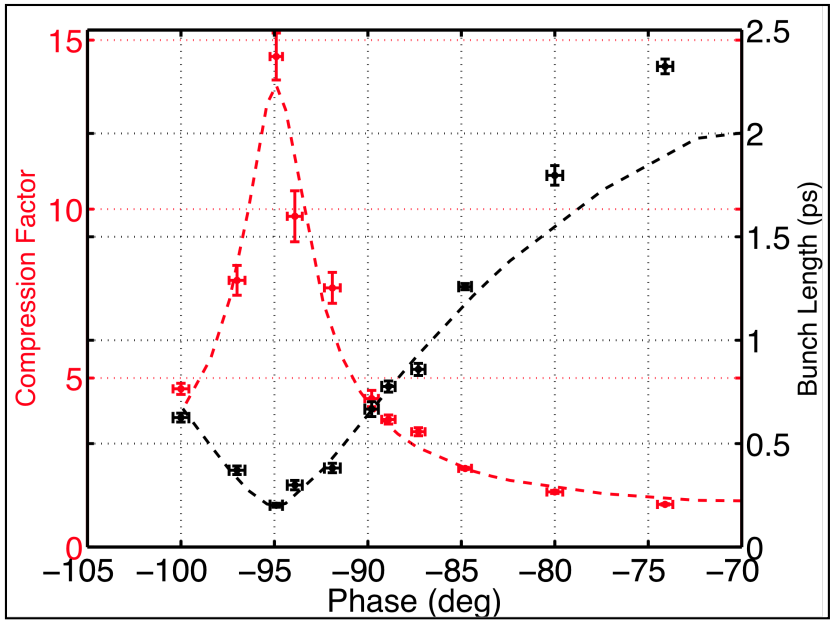
Courtesy of STFC

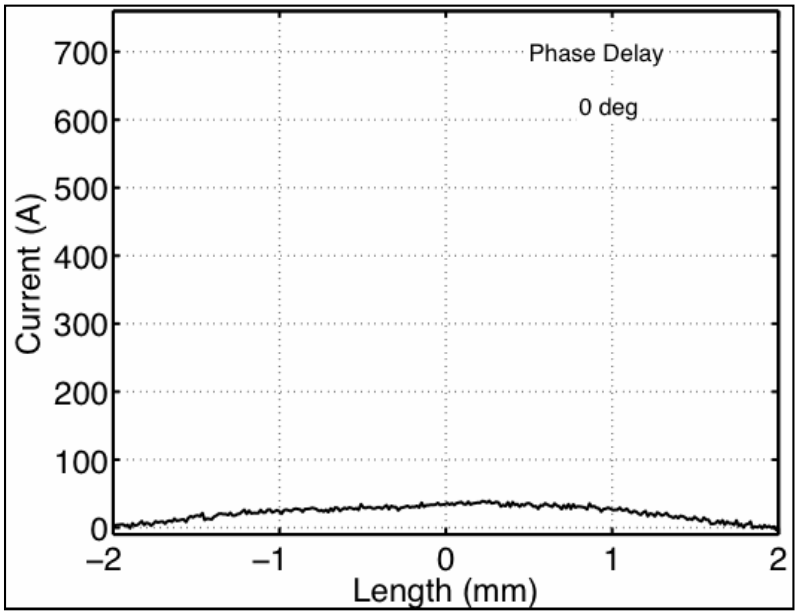
THE VELOCITY BUNCHING



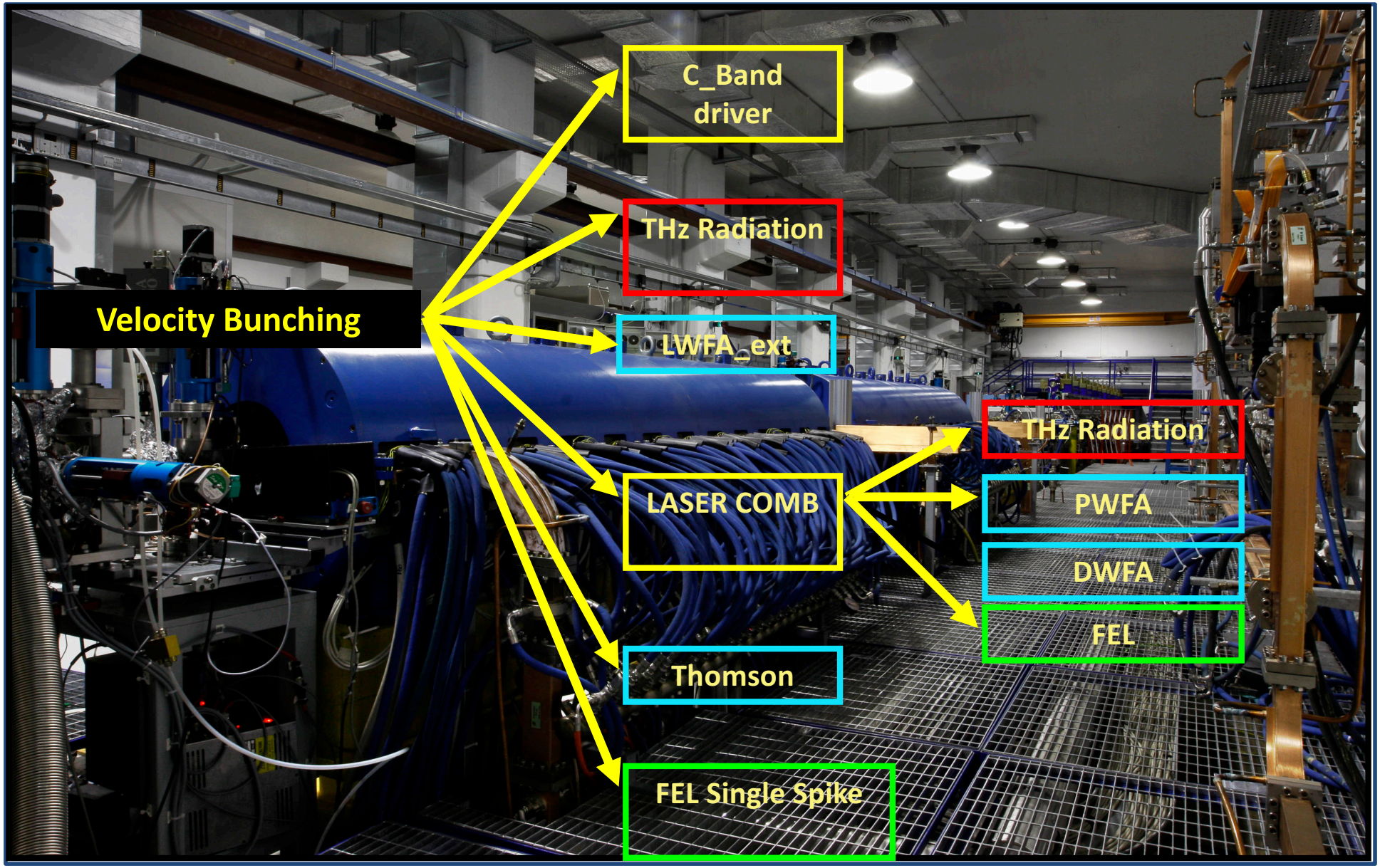


By shifting phase of the first accelerating section, one can modify the bunch length and current profile.

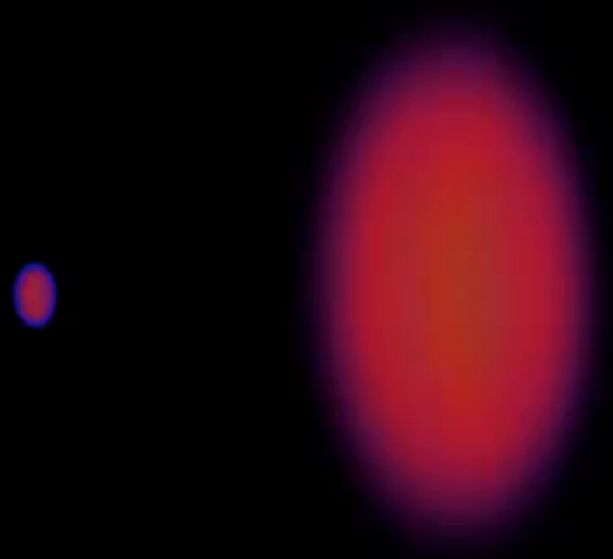




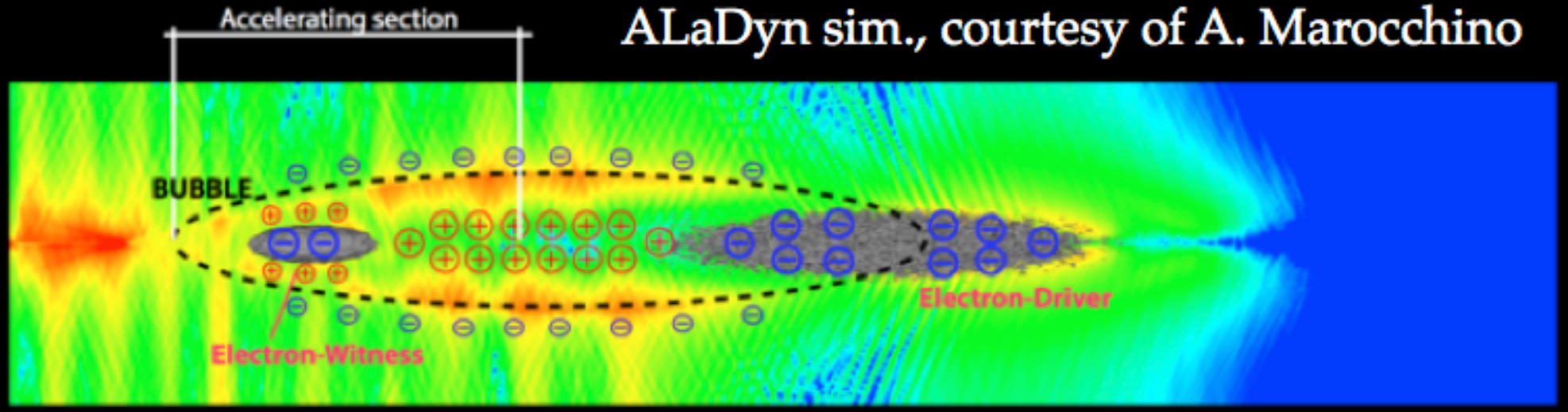
FRONTIERS IN MODERN ACCELERATOR PHYSICS



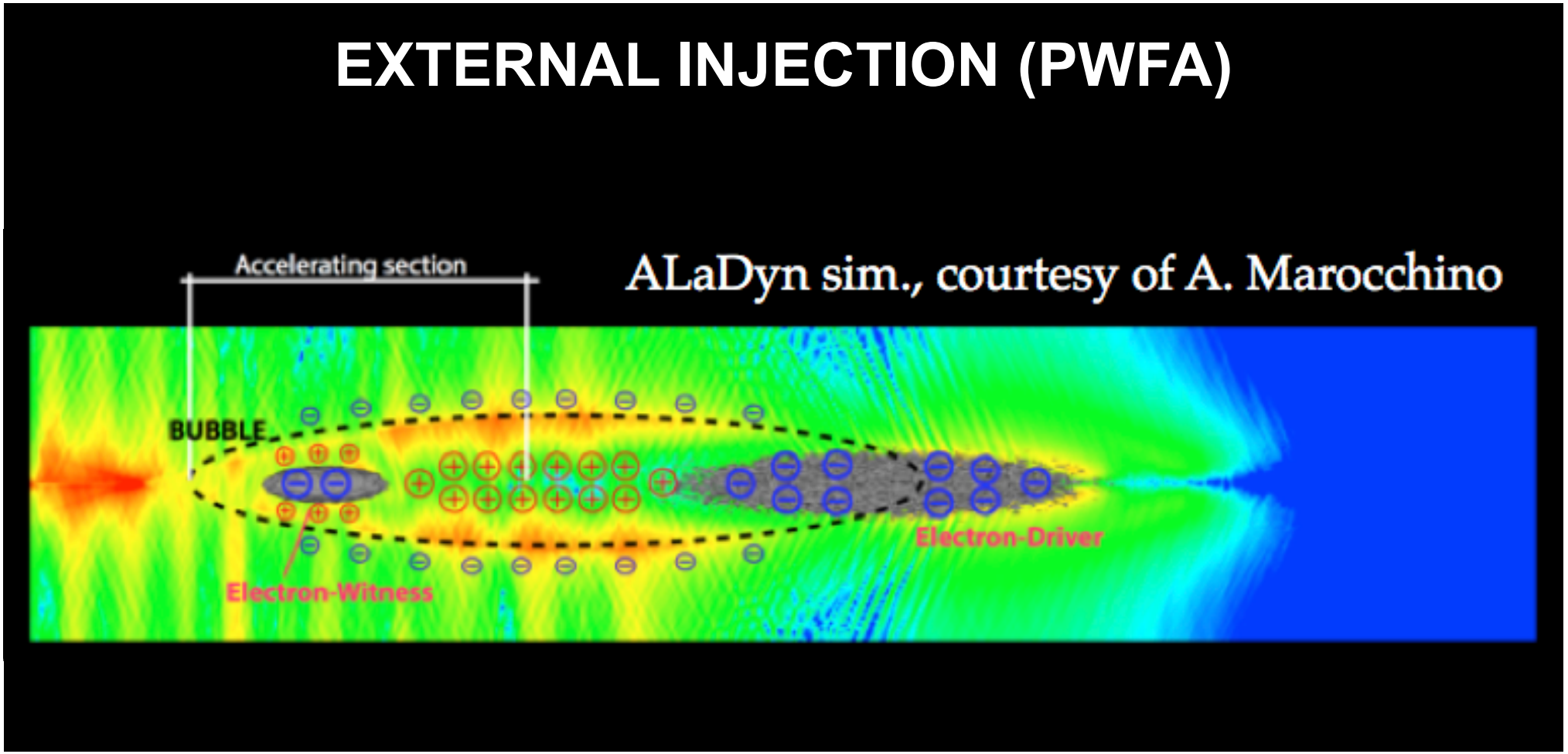
EXTERNAL INJECTION (LWFA OR PWFA)

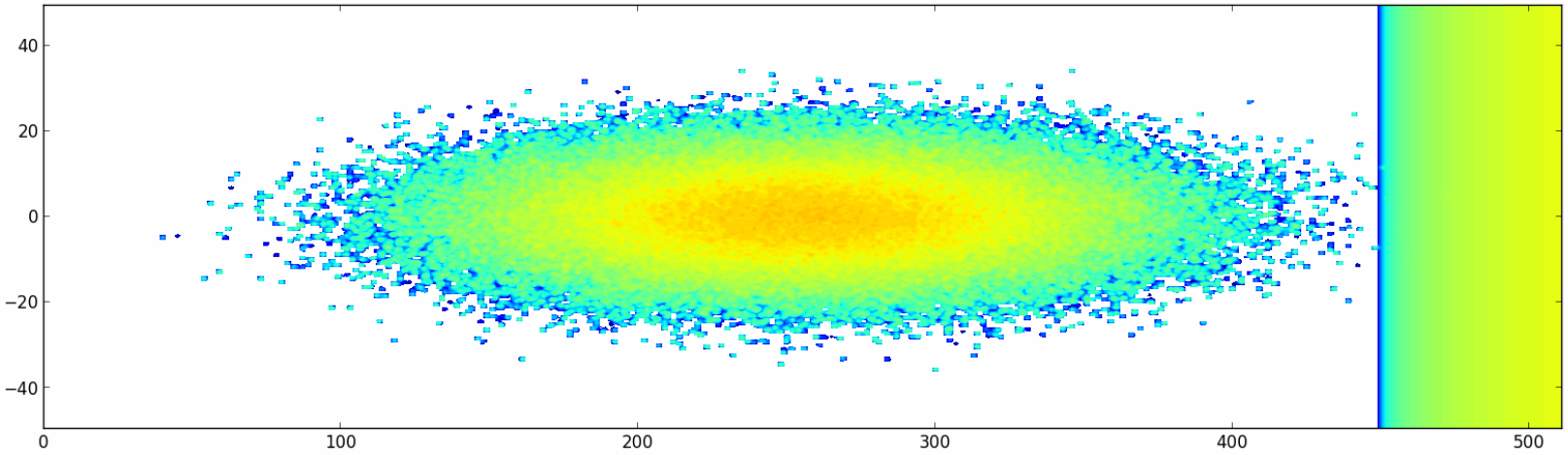


EXTERNAL INJECTION (PWFA)

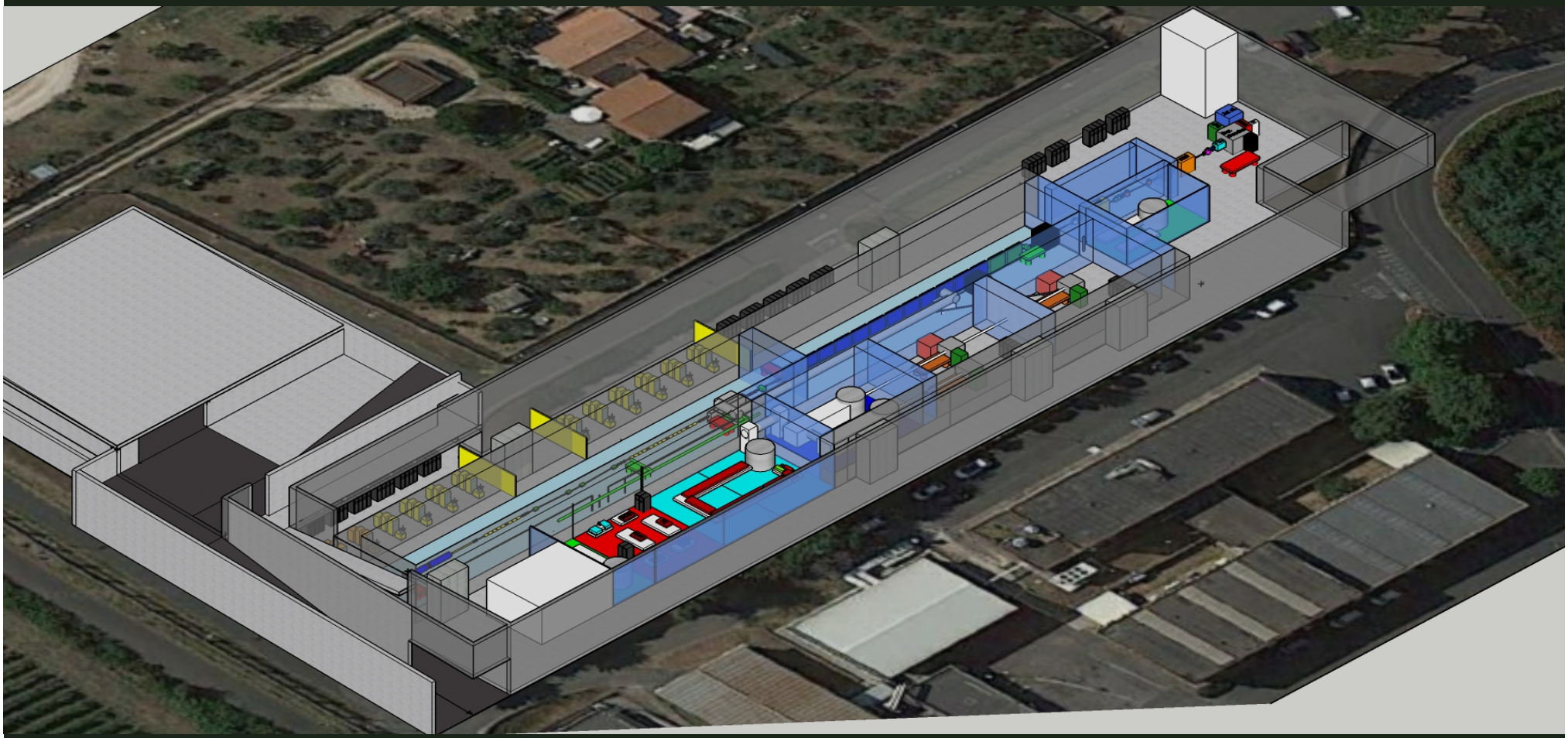


EXTERNAL INJECTION (PWFA)

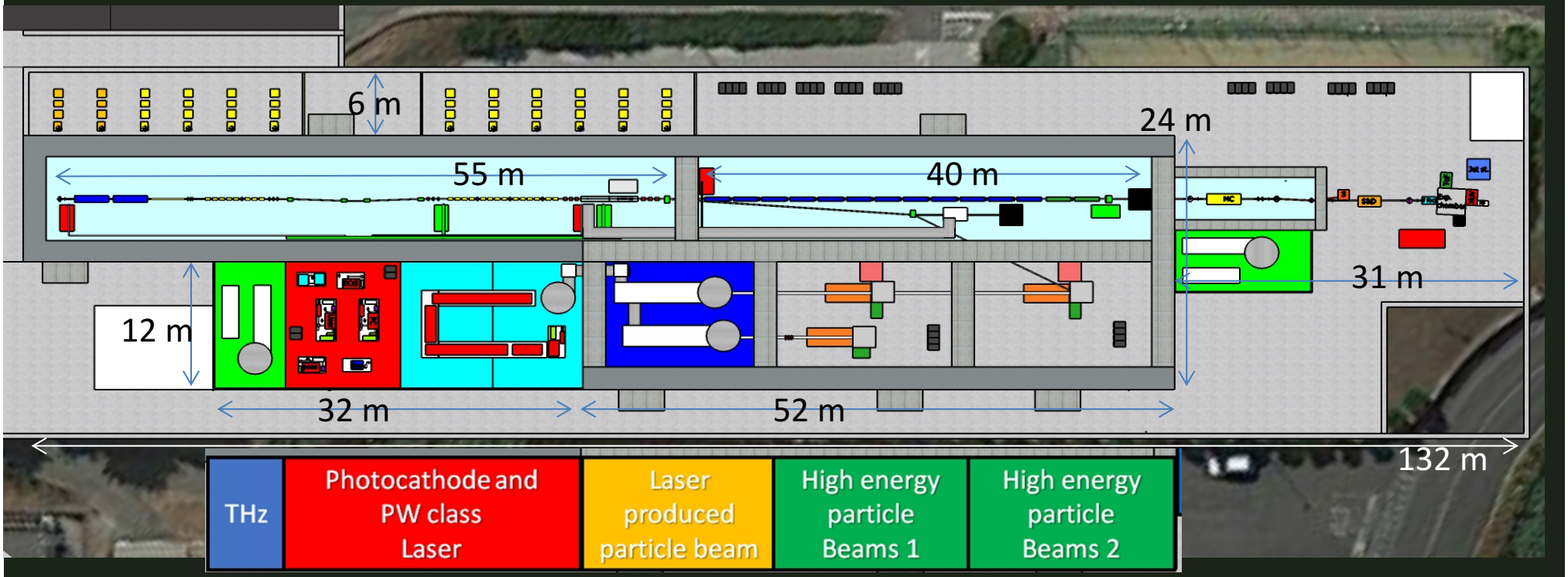




EuPRAXIA@SPARC_LAB

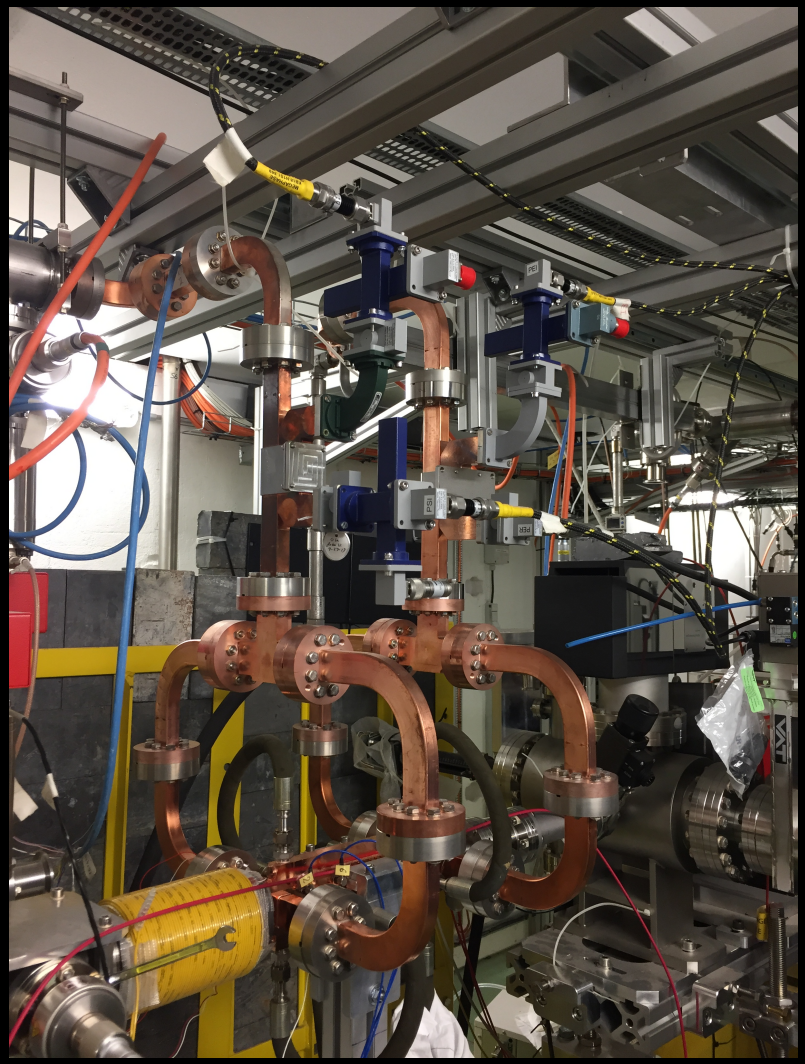


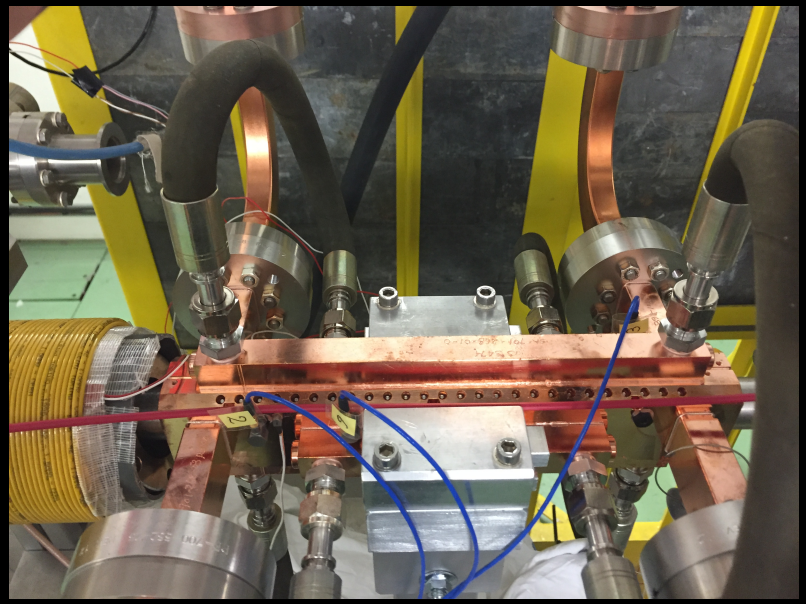
- Candidate LNF to host EuPRAXIA (1-5 GeV)
- FEL user facility (1 GeV – 3nm)
- Advanced Accelerator Test facility (LC) + CERN



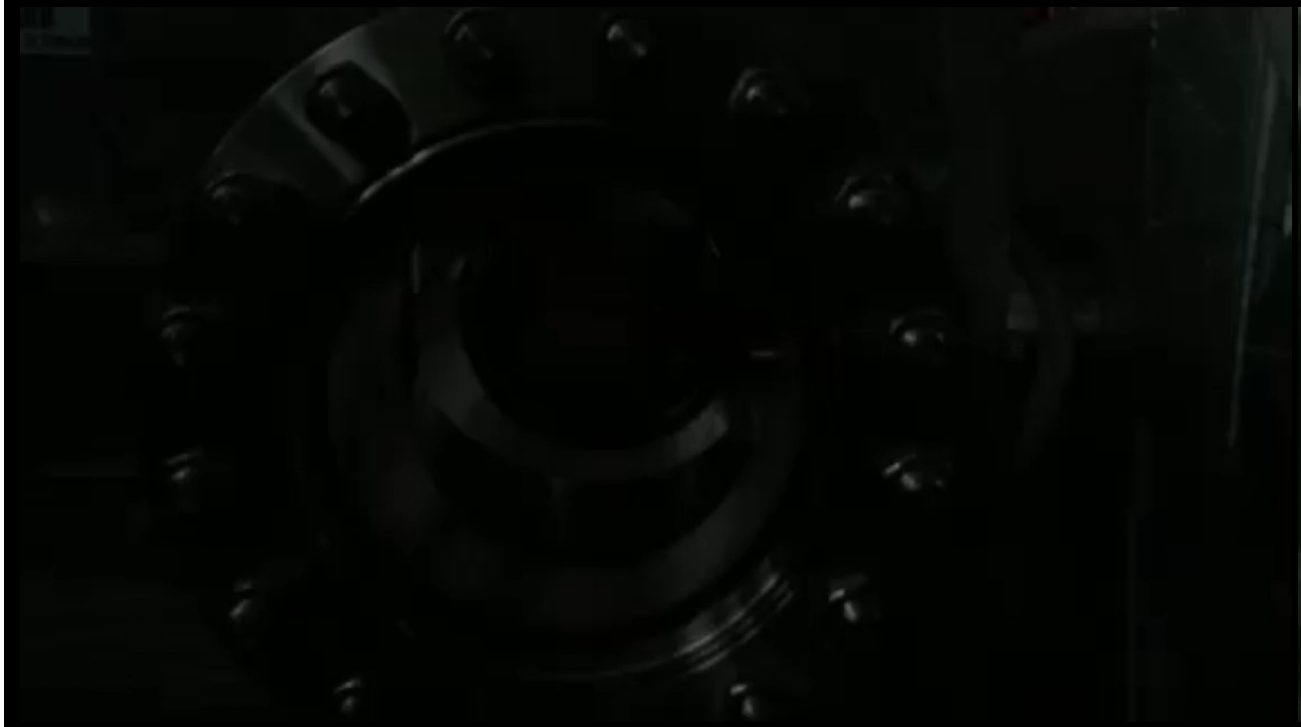
- 500 MeV by RF Linac + 500 MeV by Plasma (LWFA or PWFA)
- 1 GeV by X-band RF Linac only
- Final goal compact 5 GeV accelerator

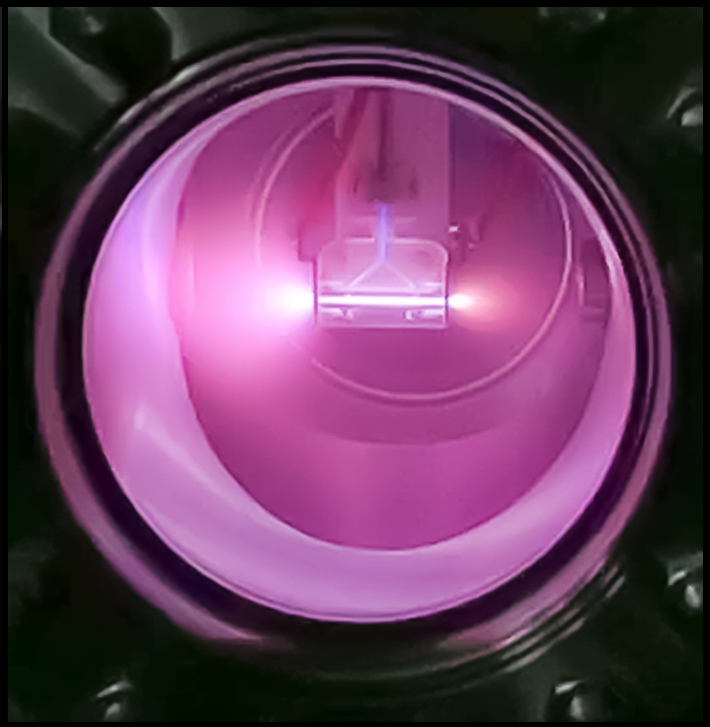
X-band Linac



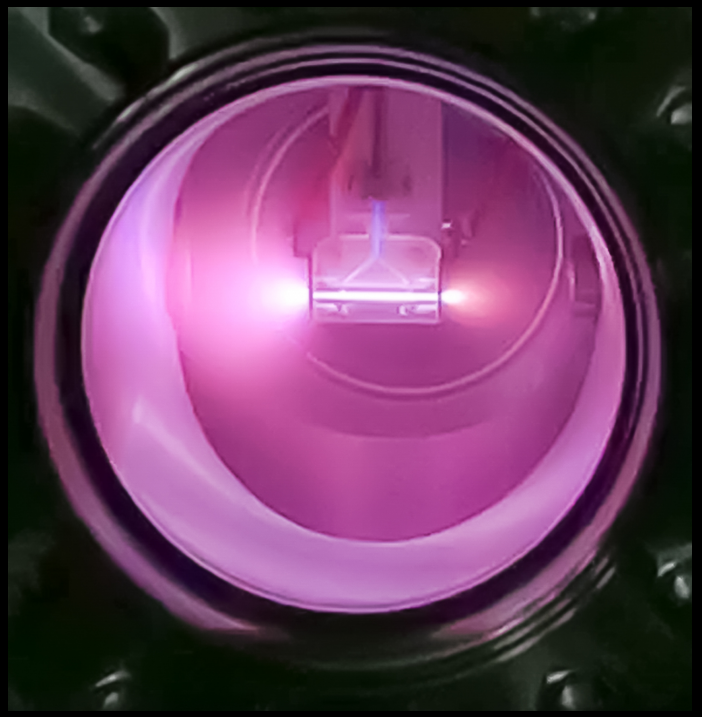


CAPILLARY DISCHARGE





CAPILLARY DISCHARGE



20 images separated by 100 ns => 2 µs
Gate: 10 ns
Area: 1000 x 500 pixel

velocity of plasma

EuPRAXIA@SPARC_LAB

Scientific goals

- X-band RF technology implementation, ➔ CompactLight
- Science with short wavelength Free Electron Laser (FEL)
- Physics with high power lasers and secondary particle source
- Compact Neutron Source
- R&D on compact radiation sources for medical applications
- Detector development and test for X-ray FEL and HEP
- Science with THz radiation sources
- Nuclear photonics with γ-rays Compton sources
- R&D on polarized positron sources
- R&D in accelerator physics and industrial spin – off

OPPORTUNITIES FOR STUDENTS

Joint Universities Accelerator School

8 January - 16 March 2018, Archamps, France

Applications deadline : 15th October 2017

(late applications will be consider depending on the places available : don't hesitate to apply !)

Taught by leading European particle accelerators specialists, JUAS delivers a regularly updated, academically accredited training programme in partnership with CERN and a cluster of 16 European universities.

The school comprises 2 five-week courses:

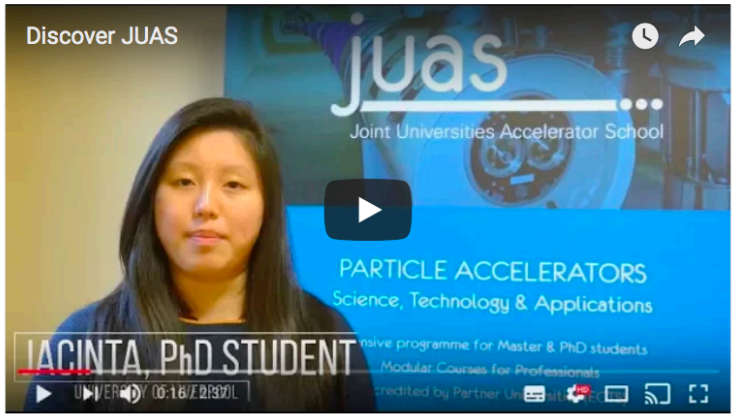
- **Course 1 (8 Jan. - 9 Feb.): The science of particle accelerators**
- **Course 2 (12 Feb. - 16 March): The technology and applications of particle accelerators**

Each course is concluded by examinations which allow students to earn ECTS credits attributed by their home university.

=> JUAS Mission Statement

Discover JUAS

Credits: www.enviedo.com



JUAS is organised by the European Scientific Institute in partnership with 16 major European Universities and CERN:

European School of Instrumentation in Particle & Astroparticle Physics

22 January - 16 March 2018, Archamps, France

Applications deadline : 30th November 2017

(late applications will be consider depending on the places available : don't hesitate to apply !)

The school offers an intensive programme taught by experts in the field.
Applications are welcome from 2nd year Master and PhD students as well as professionals.

ESIPAP, the European School of Instrumentation for Particle and Astroparticle Physics, was launched in 2014 at the initiative of ENIGMASS (a federative structure comprising the University of Grenoble-Alpes and four academic research facilities: LPSC, LAPP, LAPTH and LSM).

ESIPAP comprises two month-long courses which can be followed consecutively or over two years.
The school is selective : only 16 places are available.

- **Course 1 (22 Jan. - 16 Feb.) : Physics of Particle and Astroparticle Detectors - a 4 week course**
- **Course 2 (19 Feb. - 16 March) : Technologies and Applications - 4 separate modules**
  - Module 1 - Detector Technologies & Electronics
  - Module 2 - Real Time Computing & Data Handling
  - Module 3 - Mechanics & Medical Applications
  - Module 4 - Offline Computing

Discover ESIPAP

Credits: www.enviedo.com

CERN and LPSC Grenoble organise and hosts practical courses in the form of « lab sessions ».
Both modules are concluded by an evaluation which enables students to gain ECTS credits recognised by the European partner universities.

APPUNTAMENTI CON LA SCIENZA – SEMINARI DIVULGATIVI 2017

I seminari sono a ingresso libero e gratuito, **su prenotazione**.
Sarà possibile seguire gli eventi anche in **live streaming** collegandosi al seguente **LINK (non e' necessaria la registrazione)**.

Contatti: divulgazione@lists.lnf.infn.it

Clicca sulla locandina per informazioni sugli eventi:

24 Gennaio 2017

L'inseguimento Laser dei Satelliti e della Luna

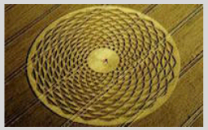
Simone Dell'Agnello (INFN-LNF)

10 Febbraio 2017

International day of women and girls in science 2017

Conferenze a cura delle Ricercatrici LNF

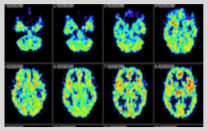
21 Febbraio 2017



Tre piccioni con una fava: indagare i misteri per raccontare la scienza

Stefano Bagnasco (INFN - TO)

22 Marzo 2017



Ospedale nucleare: cosa ci fa la fisica nucleare in un ospedale?

Vincenzo Patera (Univ. La Sapienza - Roma)

8 Novembre 2017

A tu per tu con l'Intelligenza Artificiale

Paola Mello (Univ. di Bologna)

4 Dicembre 2017

Il lato oscuro dell'Universo

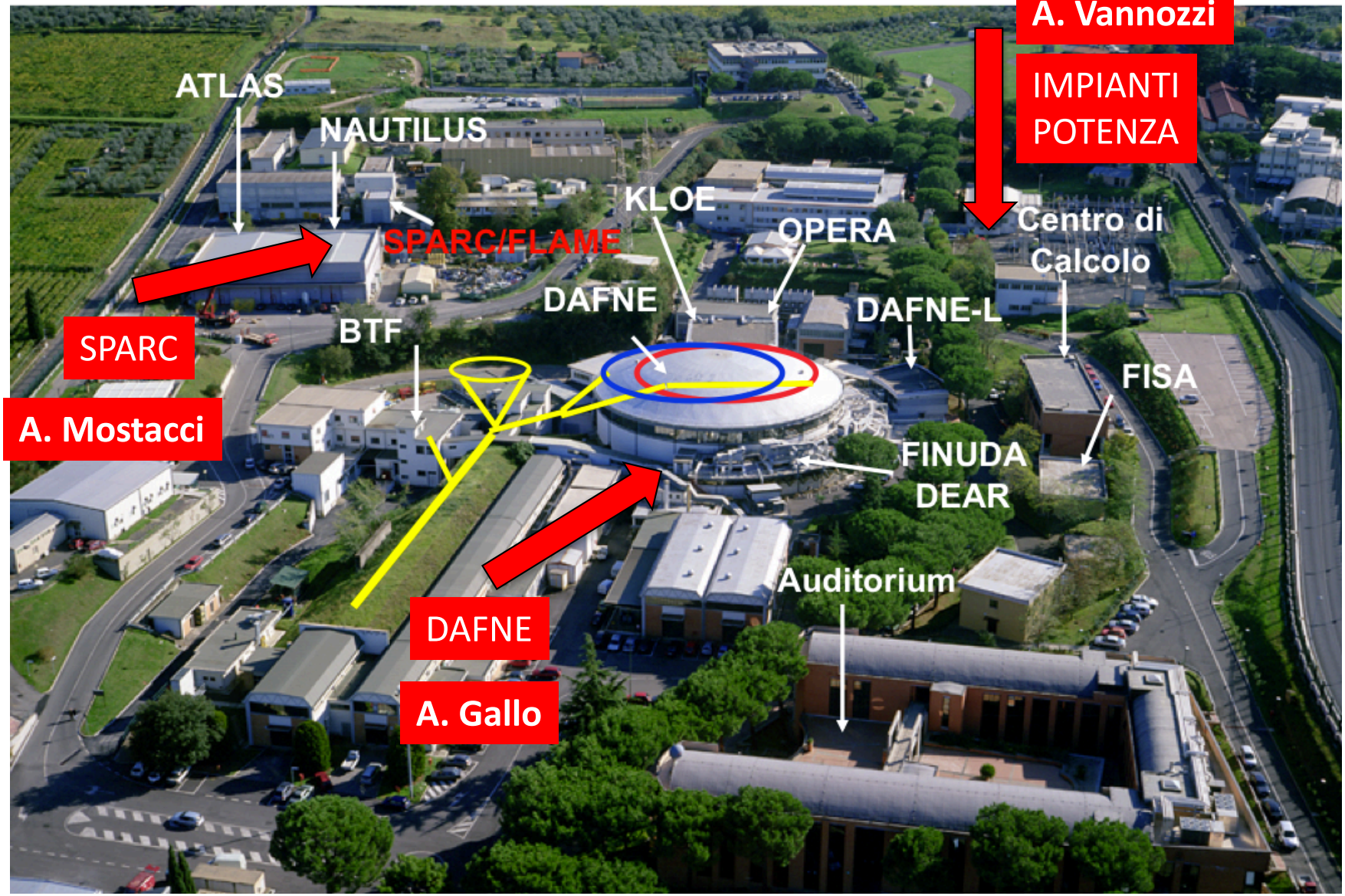
Danilo Babusci (INFN-LNF)
Alfonso Berardinelli (critico letterario)
Fabio Bossi (INFN-Lecce)

INFN LNF - Laboratori Nazionali di Frascati
134 videos

Subscribed 5K

YouTube

VISITA @ LNF


A. Vannozzi
IMPIANTI
POTENZA
ATLAS
NAUTILUS
SPARC/FLAME
KLOE
OPERA
Centro di
Calcolo
DAFNE
DAFNE-L
BTF
SPARC
A. Mostacci
FISA
FINUDA
DEAR
Auditorium
DAFNE
A. Gallo