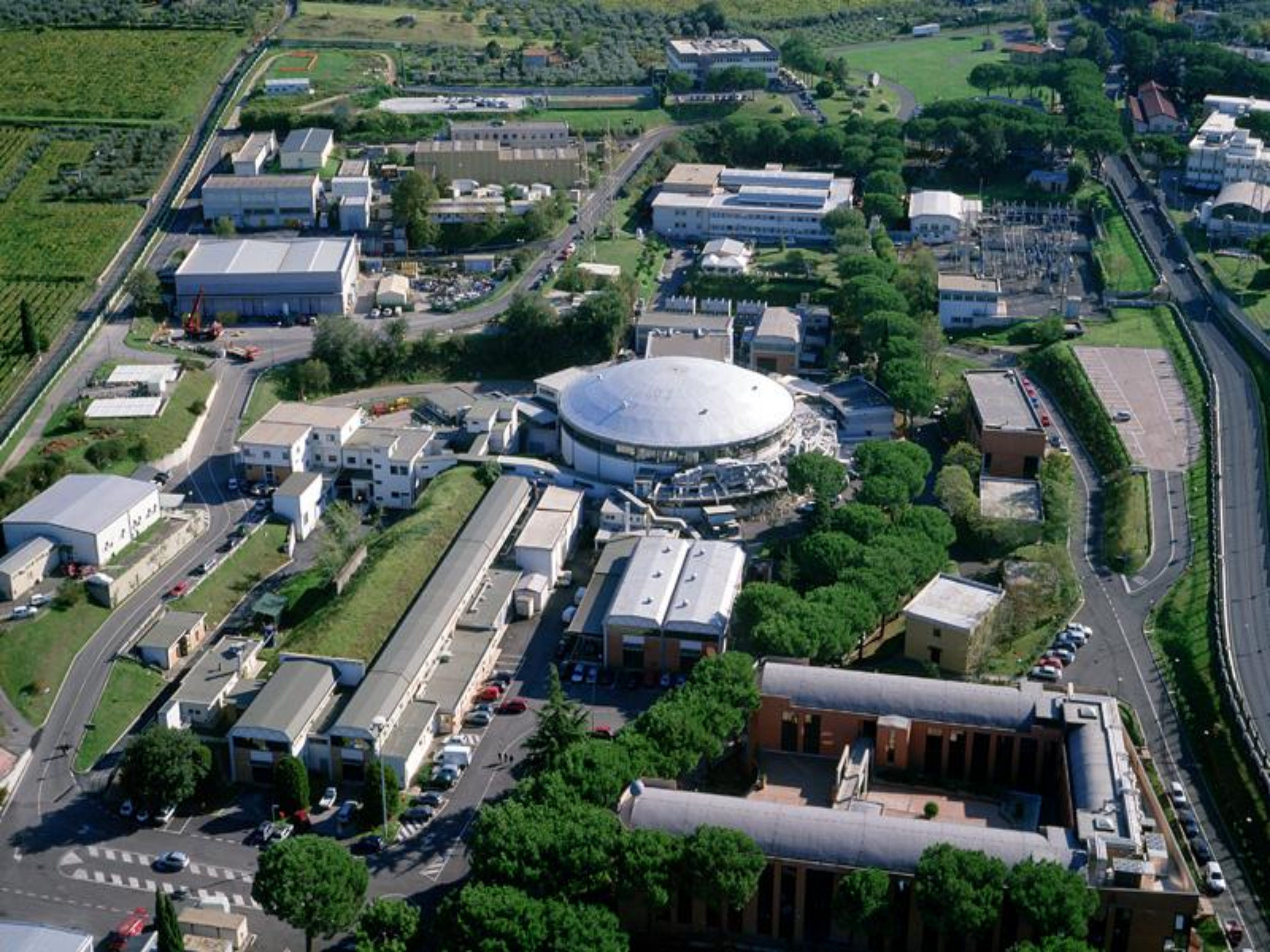
Use of CLIC_0 for Accelerator R&D

Andrea Ghigo on behalf of INFN-LNF Accelerator Division

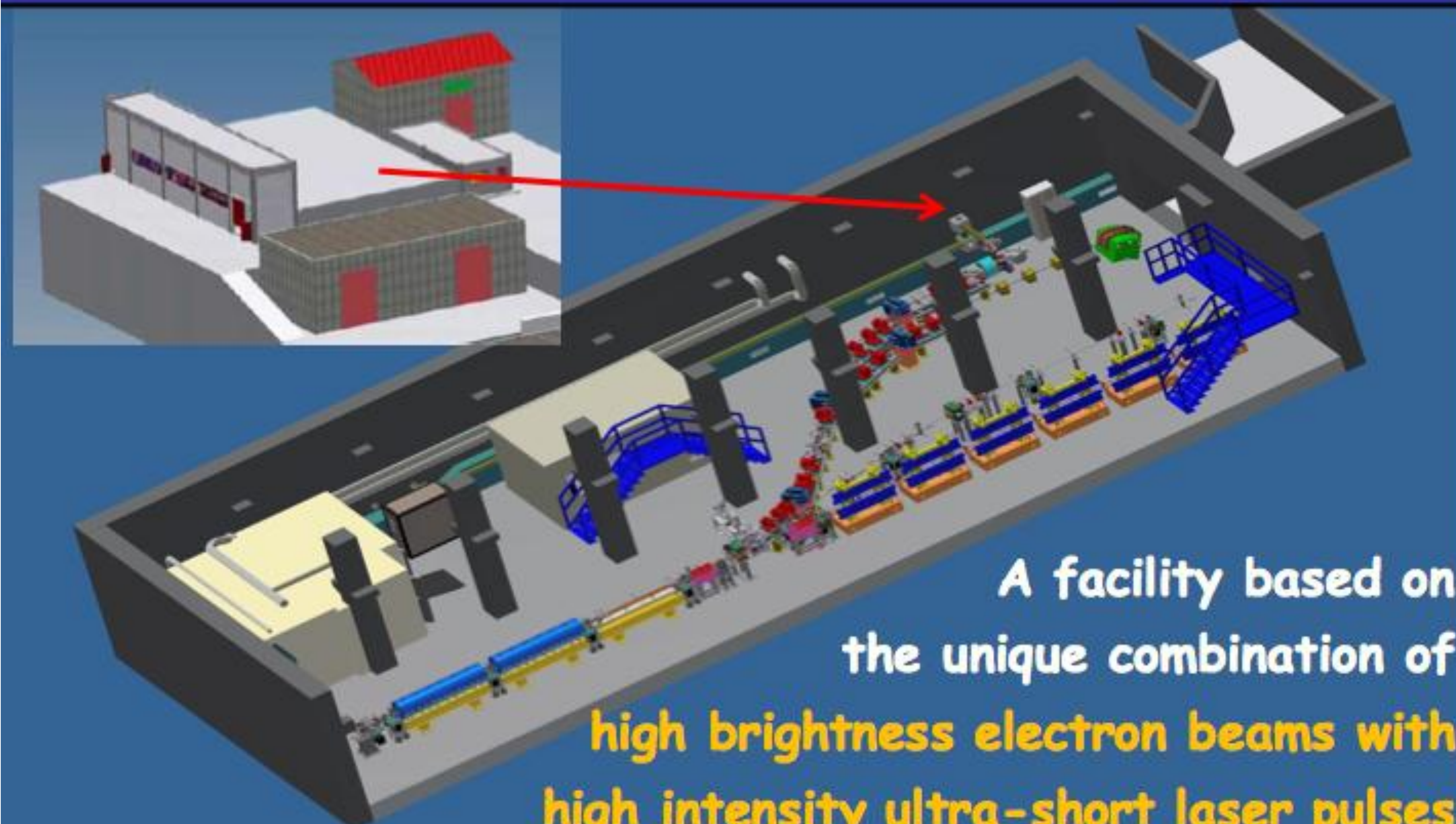
Slides from M.Ferrario, L.Serafini, G.Mazzitelli

CLIC Collaboration Working Meeting CERN 9-11 May 2012

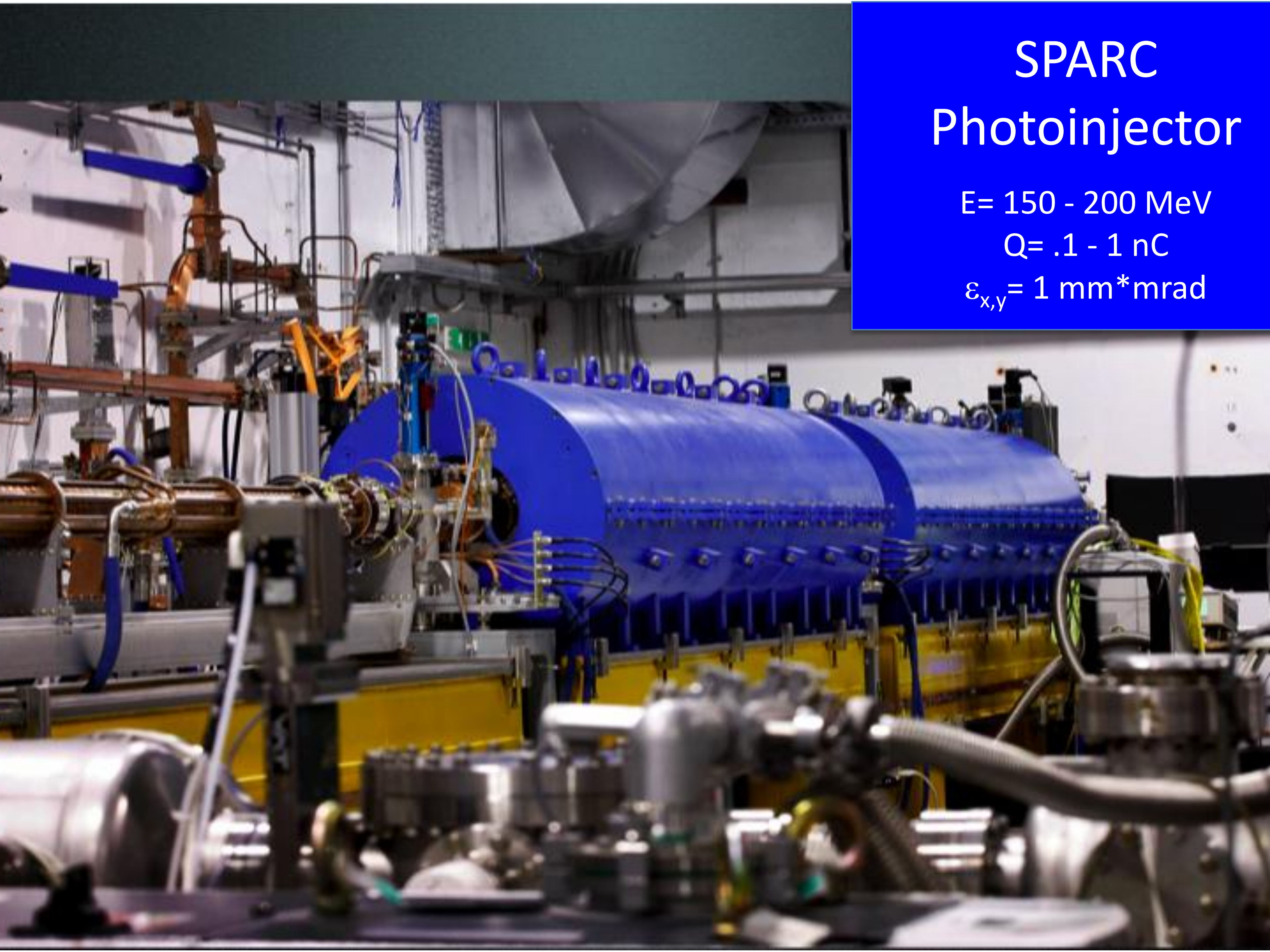


SPARC_LAB

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



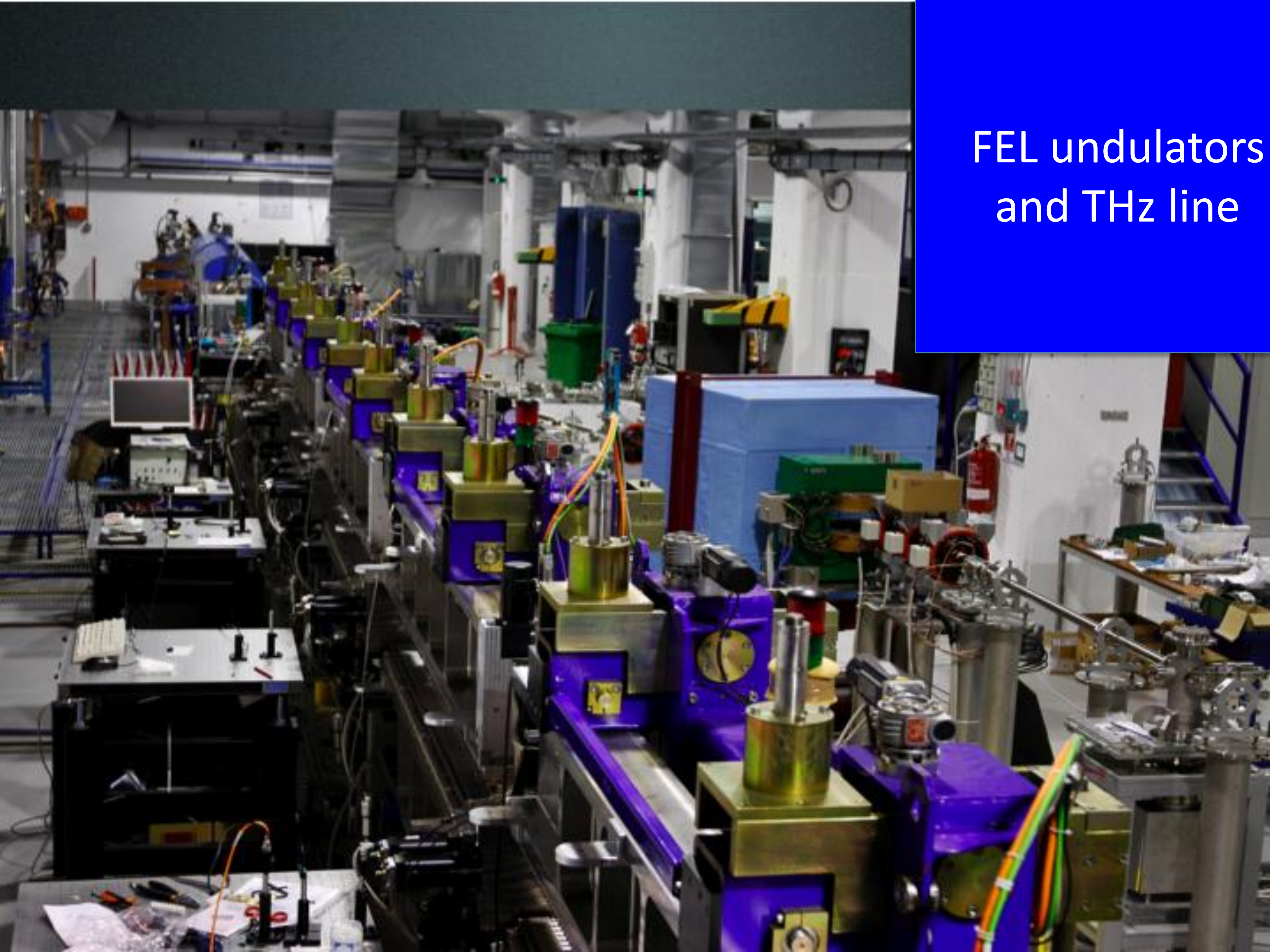
SPARC Photoinjector

E= 150 - 200 MeV

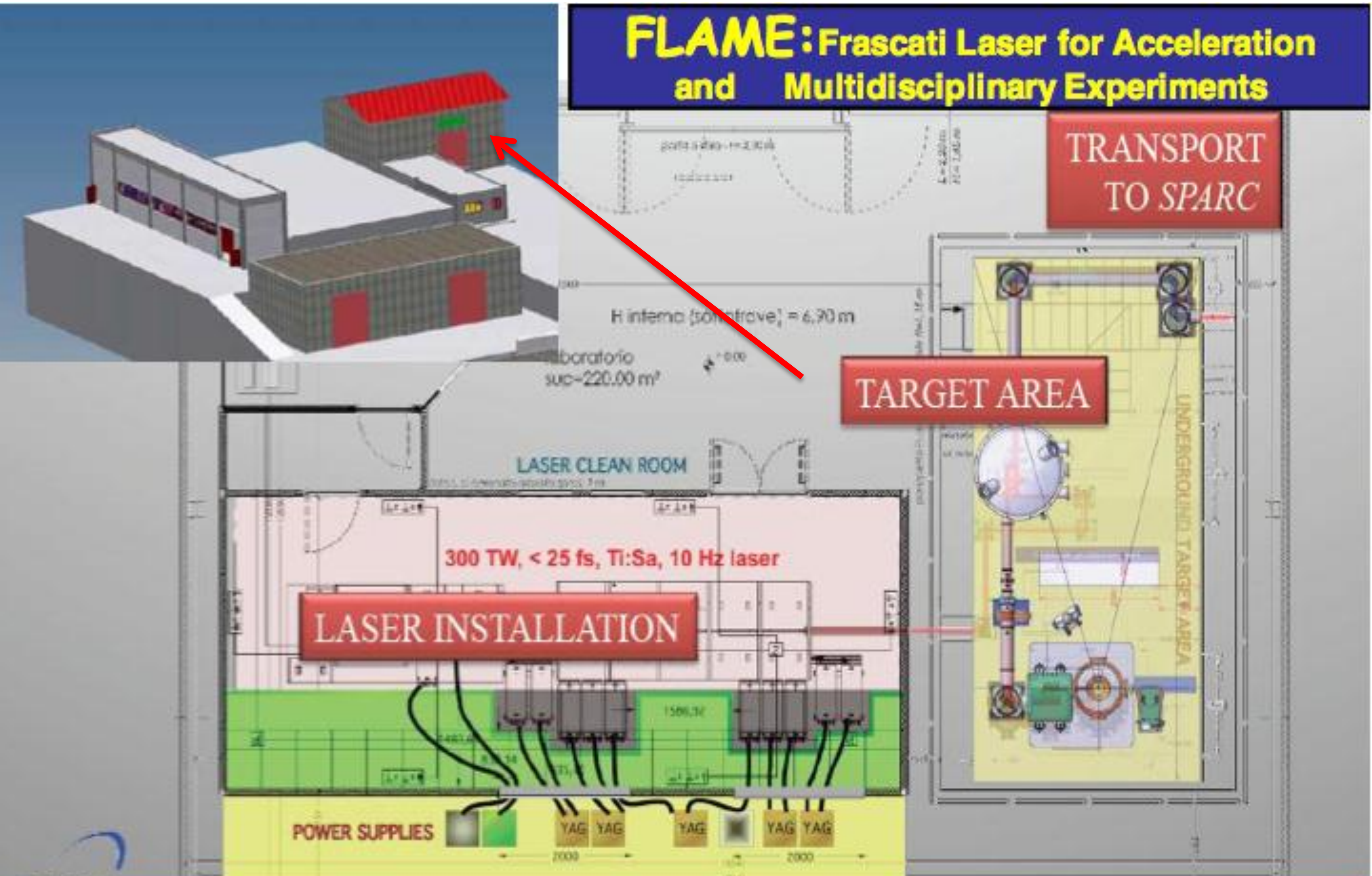
Q= .1 - 1 nC

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

FEL undulators and THz line



FLAME: Frascati Laser for Acceleration and Multidisciplinary Experiments



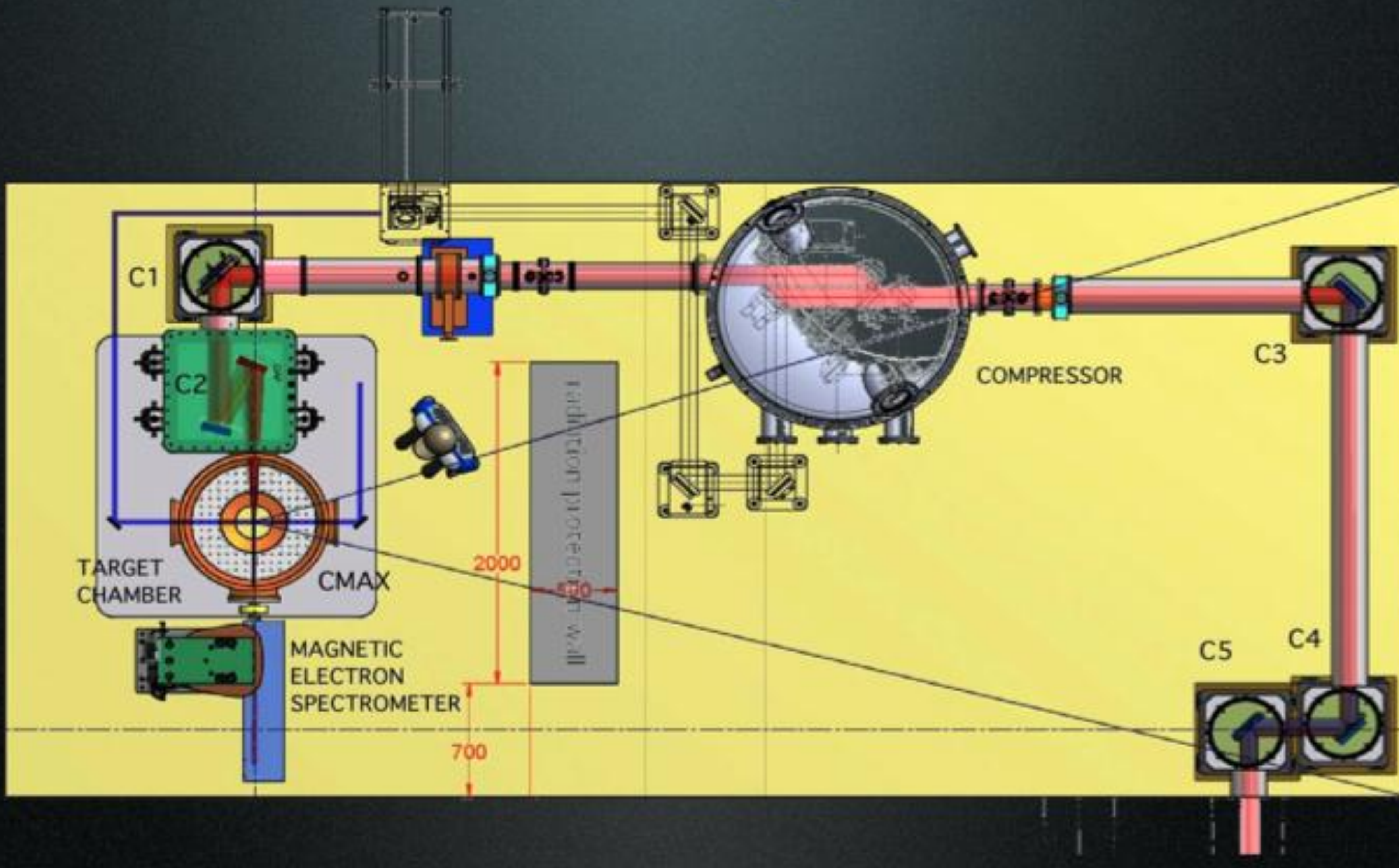
FLAME Laser, gas-jet target, beam transport fully commissioned in ***2010.***
-200 TW achieved.
-**Beam focused into gas cell** for plasma acceleration.

Summary of performance (to date)

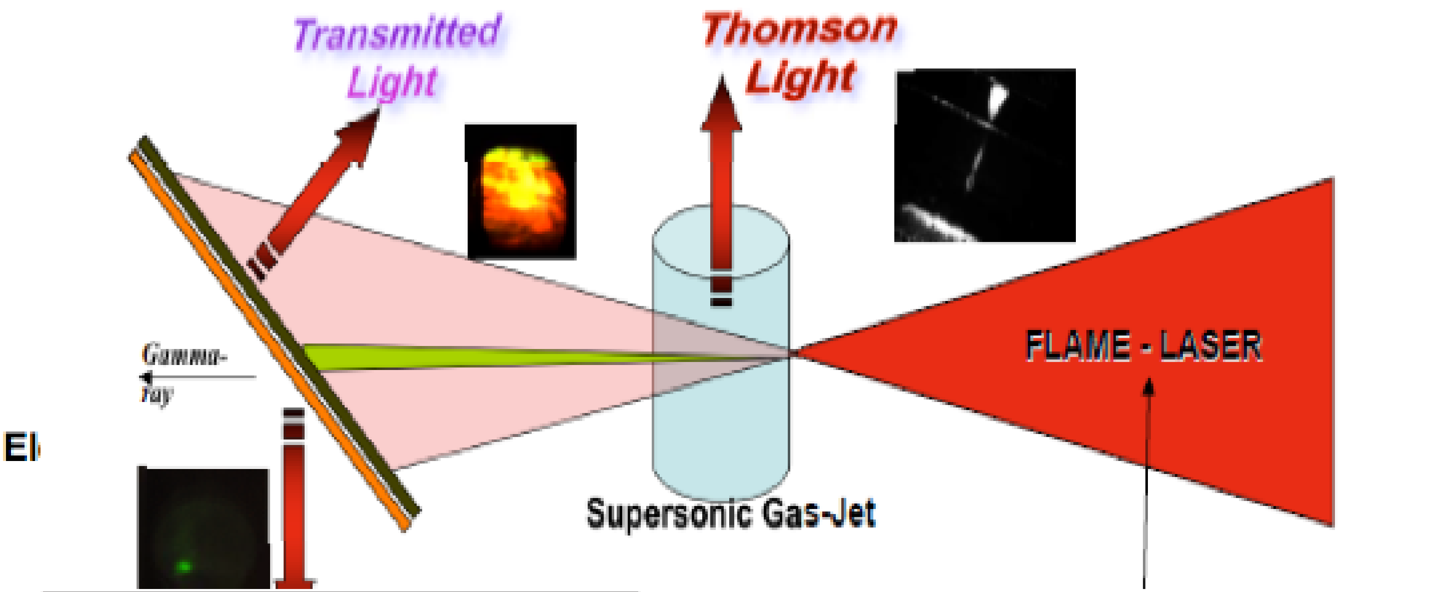
- Energy before compression @ 7.3 J
- Vacuum compressor transmission > 70%
- Pulse duration down to 23 fs
- ASE Contrast ratio: better than 2×10^9
- Pre-Pulse Contrast better than 10^8
- RMS Pulse Stability @ 0.8 %
- Pointing Stability (incl. path) < 2μrad
- Phase front correction needed – adaptive optics;

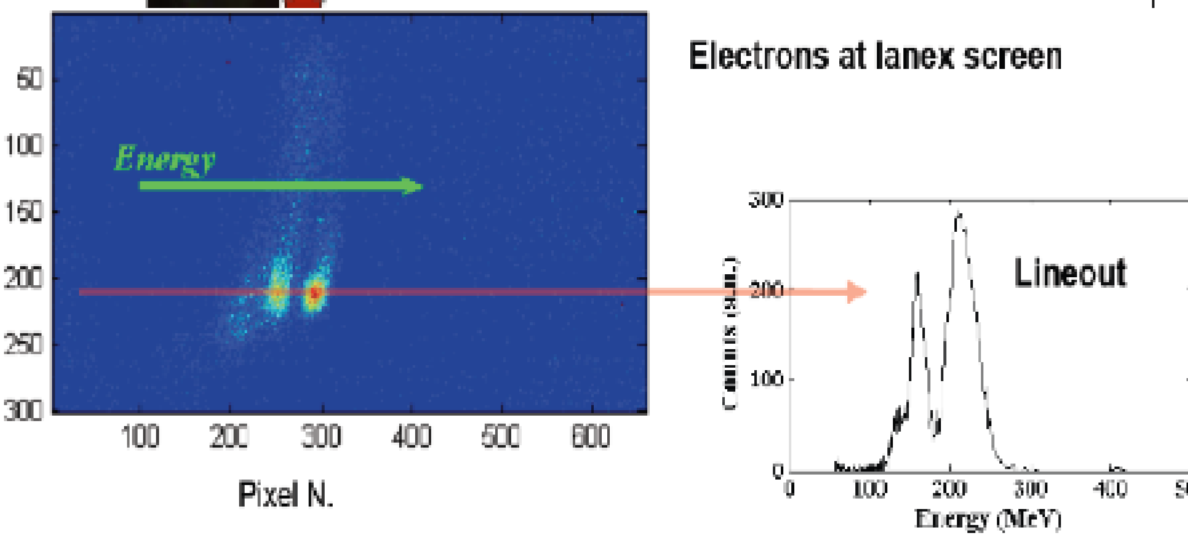
Next: Installation of Adaptive Optics, to reach 10^{21} W/cm^2

FLAME Target Area



First laser accelerated electron bunches from self-injection



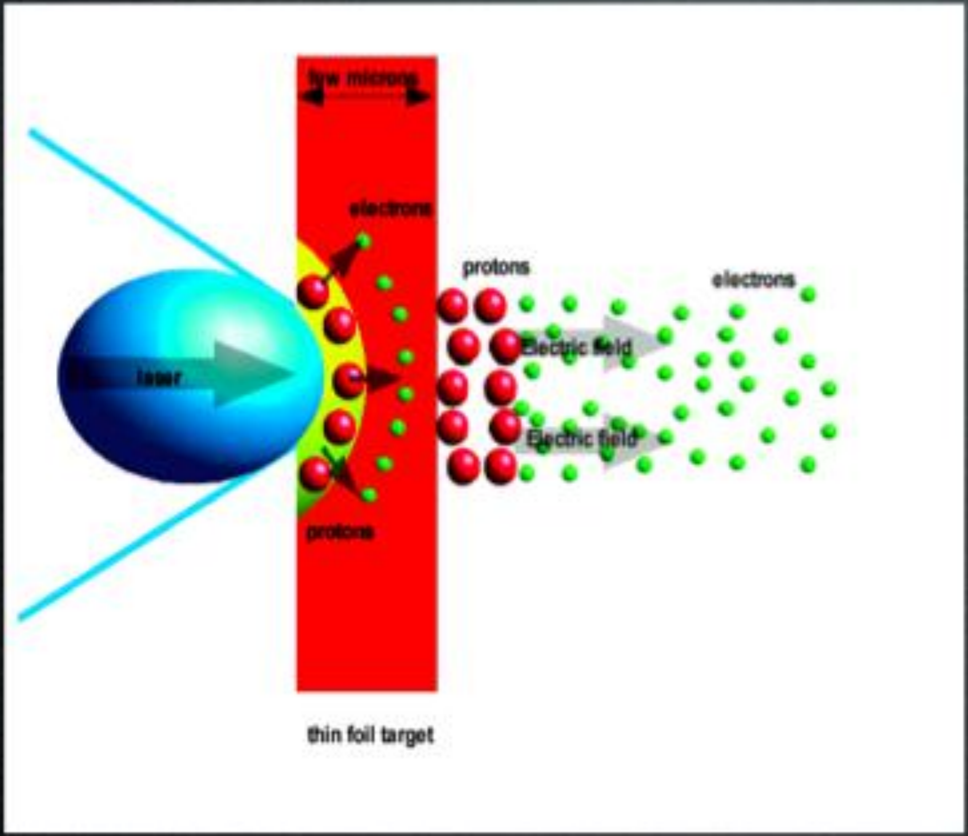


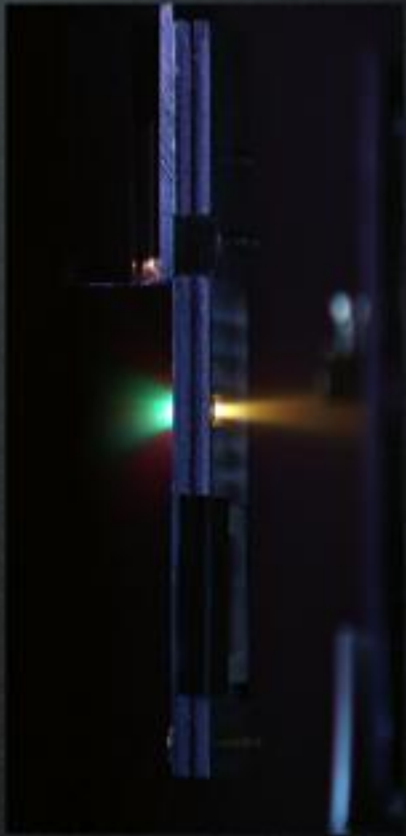
Electron energies between 200 and 250 MeV were achieved in the self-injection mode.

The best laser-plasma acceleration results achieved worldwide

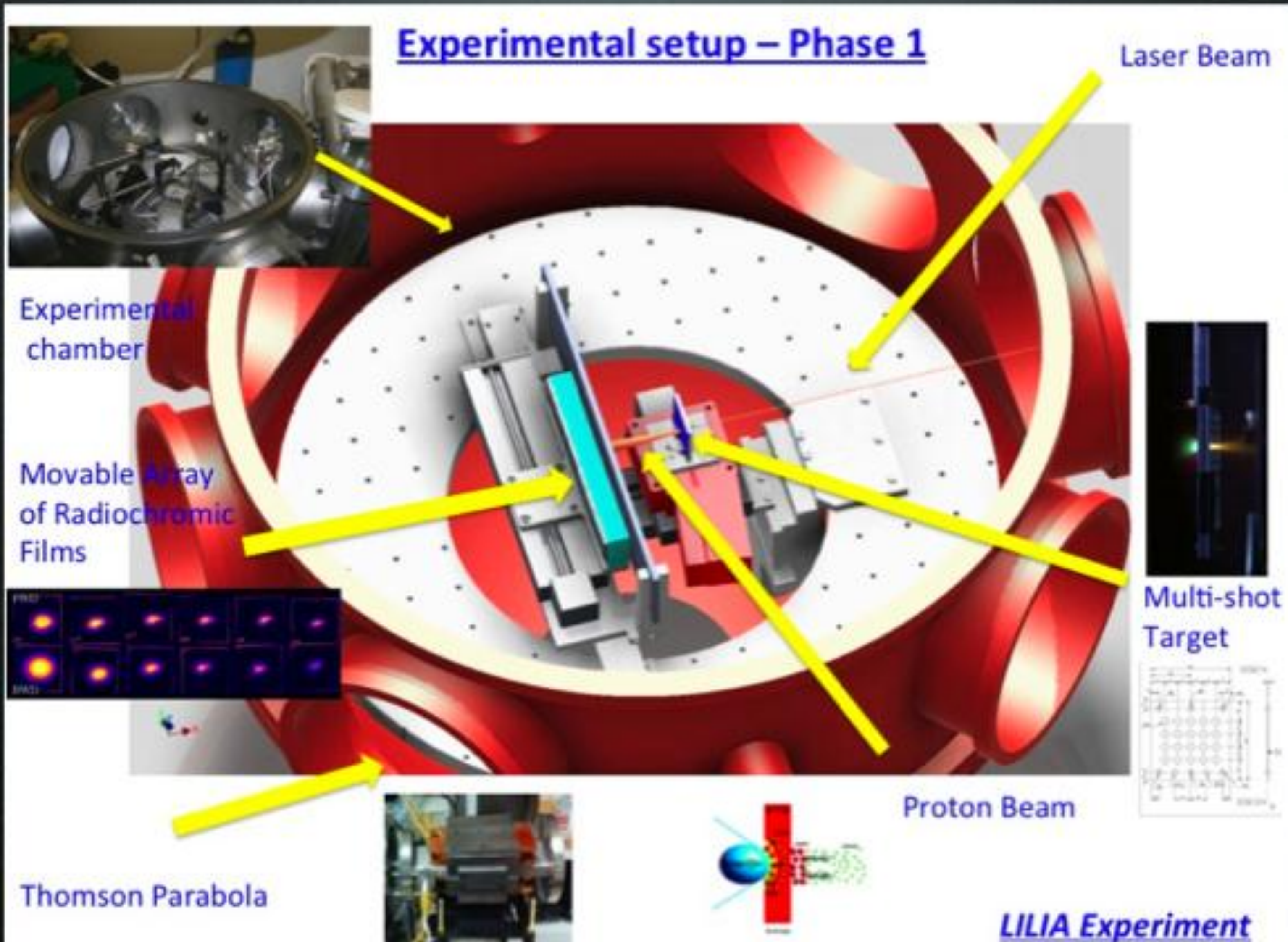
LILIA

Laser Induced Light Ions Acceleration

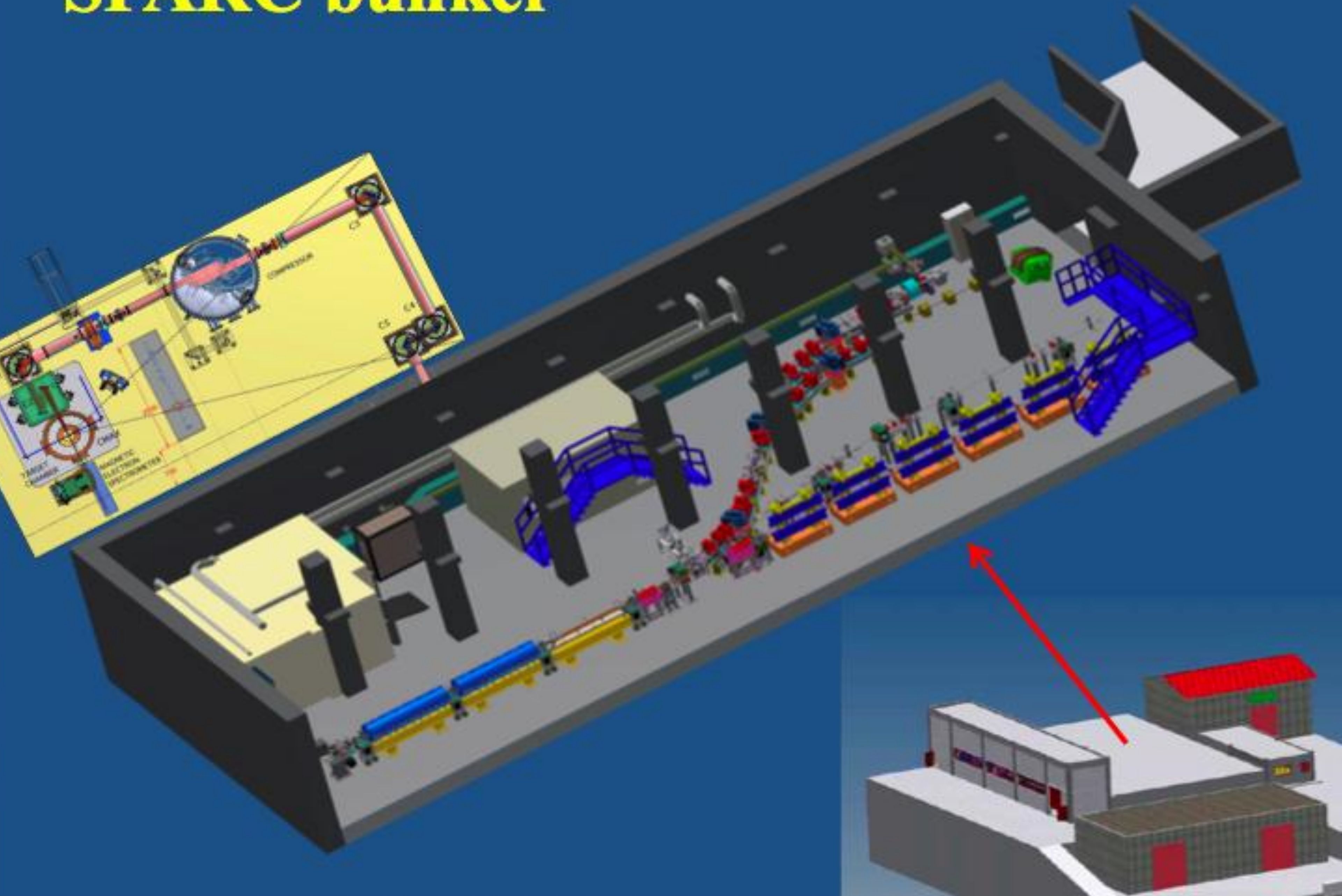


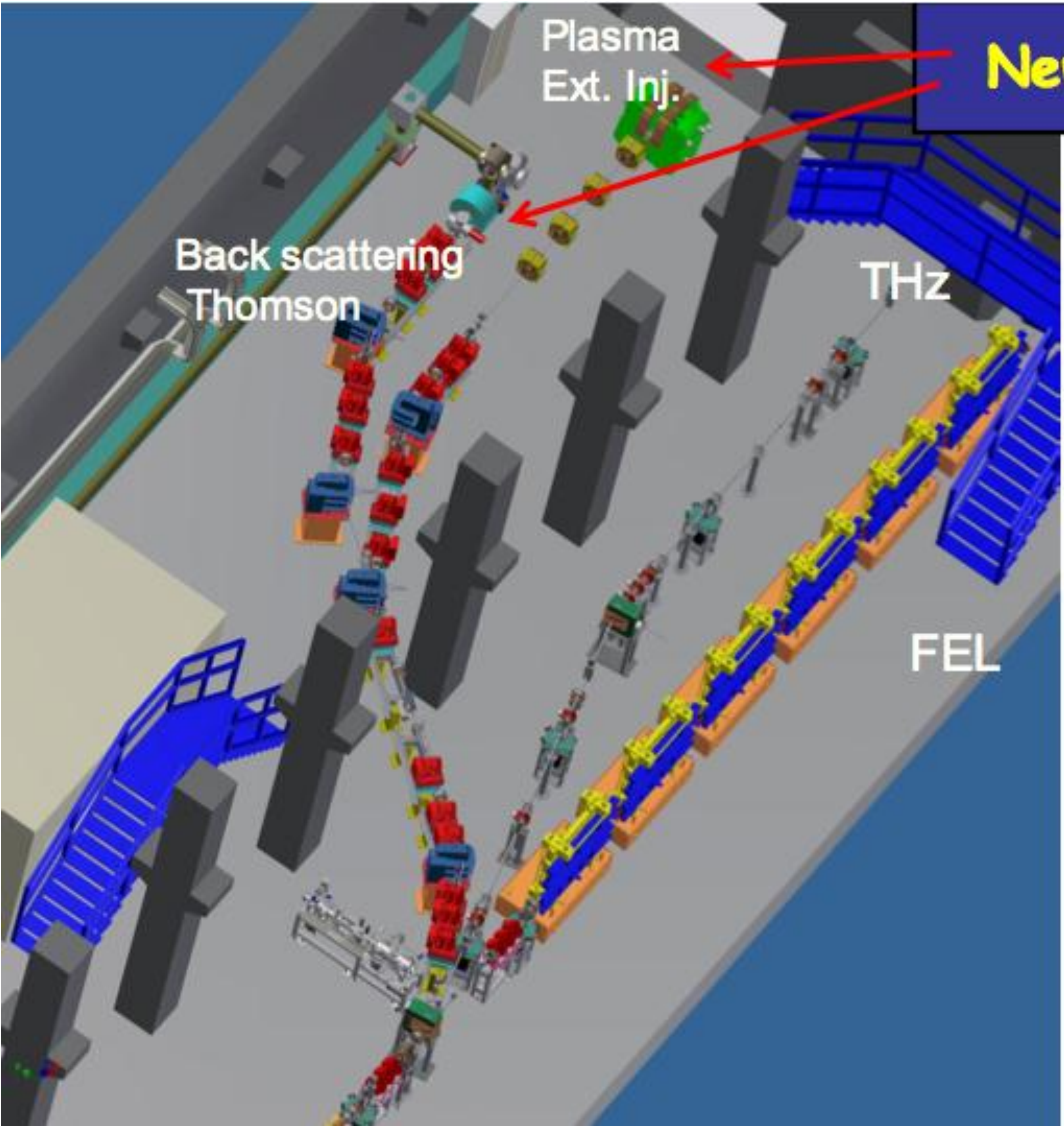


ourtesy C. De Martinis


Experimental setup – Phase 1
Laser Beam
Experimental chamber
Movable Array of Radiochromic Films
Multi-shot Target
Proton Beam
Thomson Parabola
LILIA Experiment

SPARC bunker

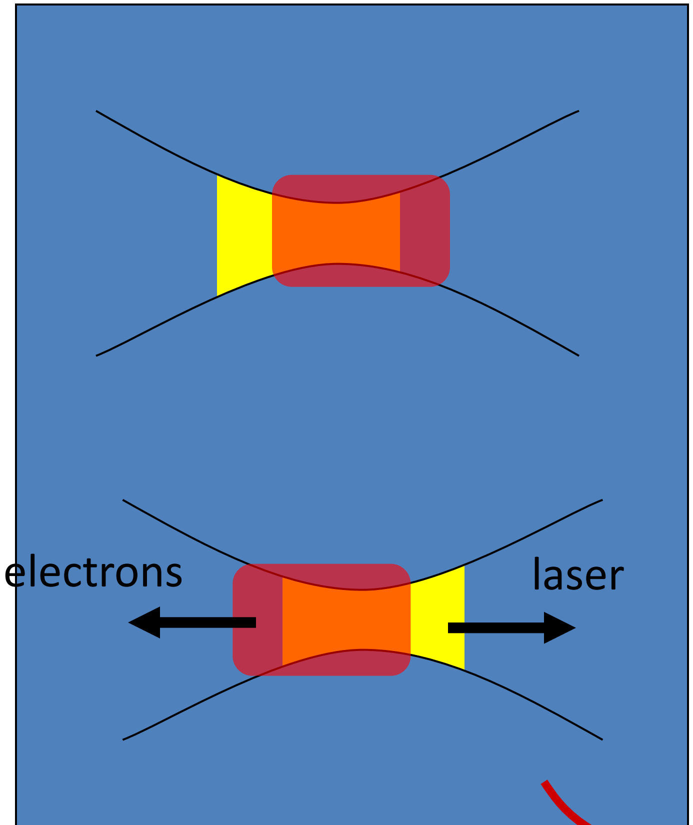




New installations

- Investigation of different configurations of plasma accelerator.
- Production of monochromatic ultra-fast X-rays by Thomson b-s driven by high-quality electron beam.

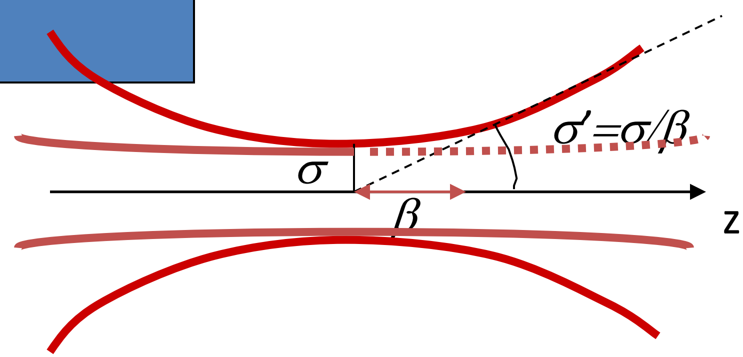
Scattered photons in collision

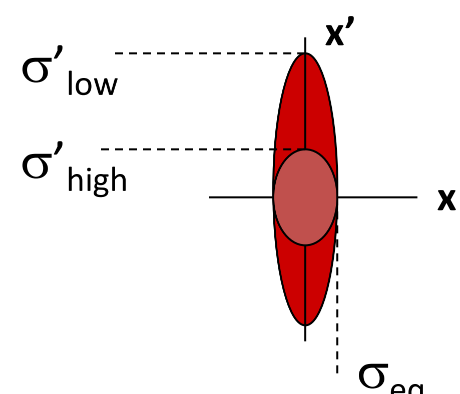


Thomson cross-section

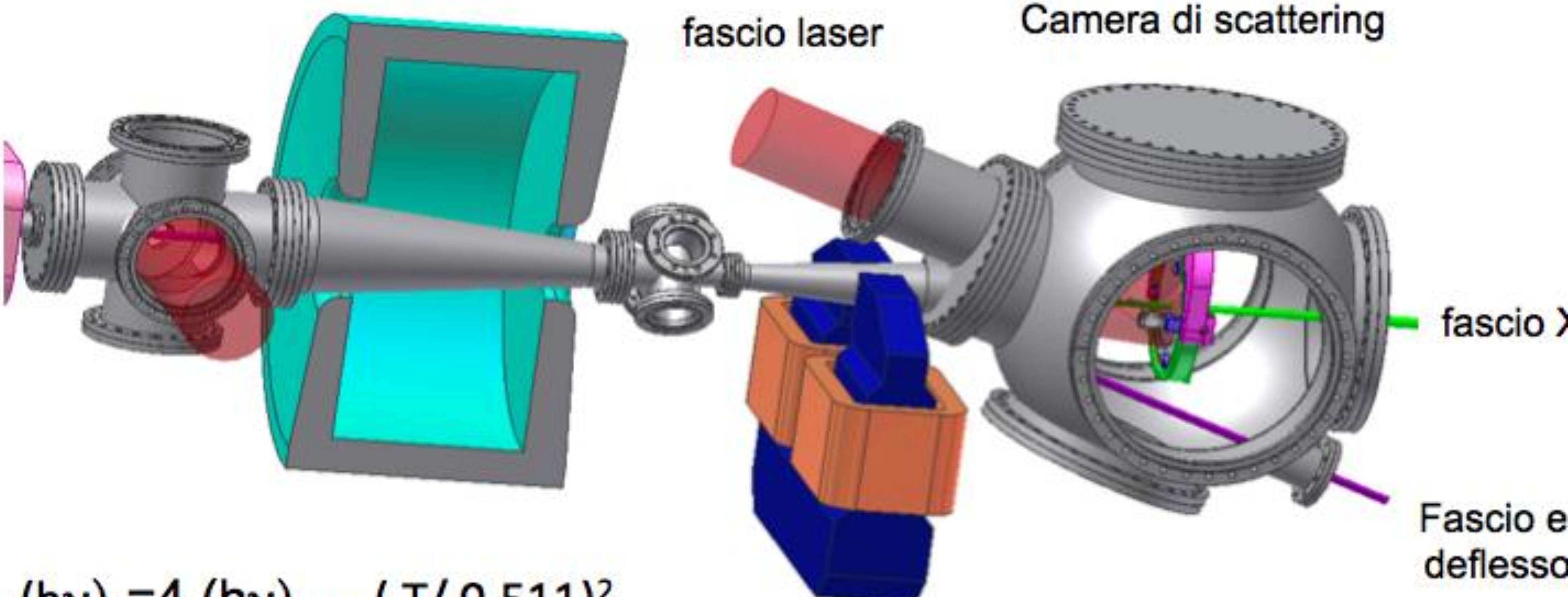
- Scattered flux $N_\gamma = \mathbf{L}\sigma_T$ $\sigma_T = \frac{8\pi}{3} r_e^2$
- Luminosity as in HEP collisions
  - Many photons, electrons
  - Focus tightly

$$\mathbf{L} = \frac{N_L N_{e-}}{4\pi\sigma_x^2}$$





Thomson Interaction region (20-550 keV)

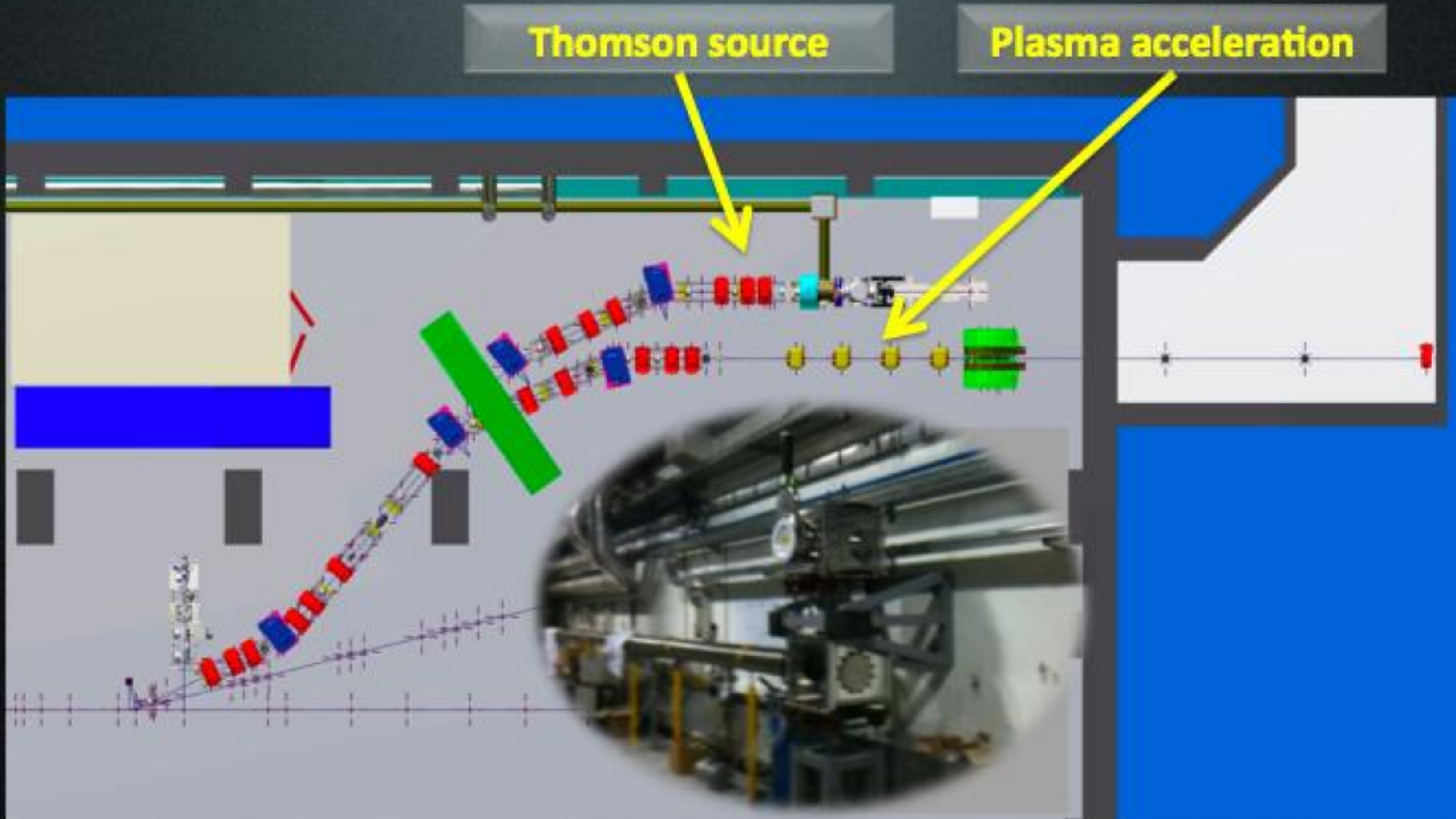


$$(h\nu)_X = 4\,(h\nu)_{laser}\,(T/0.511)^2$$

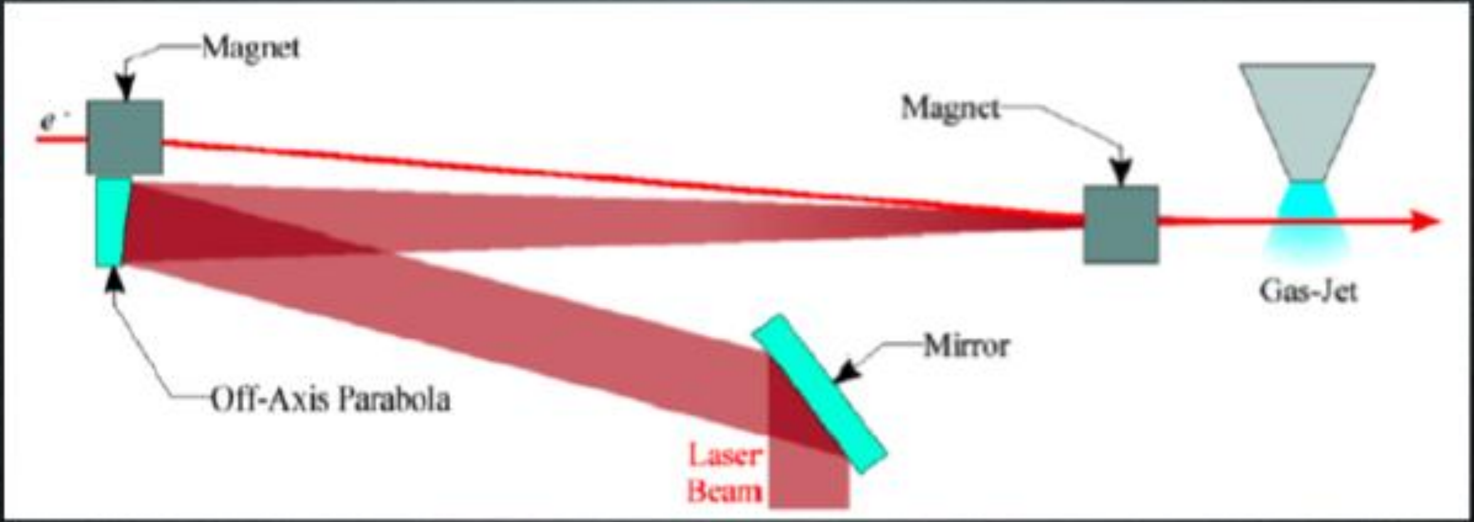
$(h\nu)_{laser}$ = 1.2 eV
T = 30.28 MeV
$(h\nu)_X$ = 20 keV mammografia

Impulso laser: 6 ps, 5 J
pacchetto e^- : 1 nC , l: 2 mm (rms)
Impulso X: 10 ps, 10^9 fotoni per interazione
α emissione: 12 mrad

New installations



EXIN (EXternal INjection)

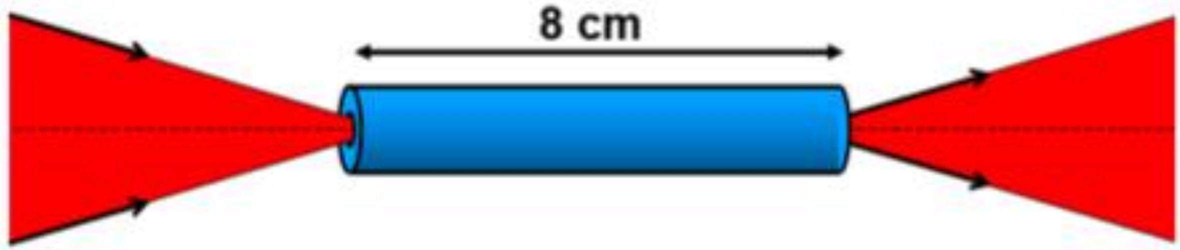


n_e [cm^{-3}]	E_{max} [GV/m]	λ_p [μm]	Ldeph [m]	Energy gain over L = 2cm [MeV]	Energy gain over L = 10cm [MeV]
1e16	0.2	330	400	<4	<20
5e16	1	150	5	<20	<100
2.5e17	3.8	66	0.45	<76	<380
7.5e17	7.5	39	0.1	<150	<750
2.5e18	8.5	30	0.04	<190	-

Courtesy L. Serafini

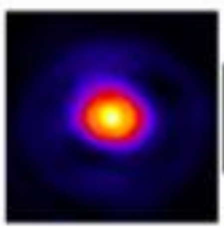
Hollow Dielectric Waveguide Capillaries

With LPGP Orsay, Brigitte Cros *et al.*



Recent achievements

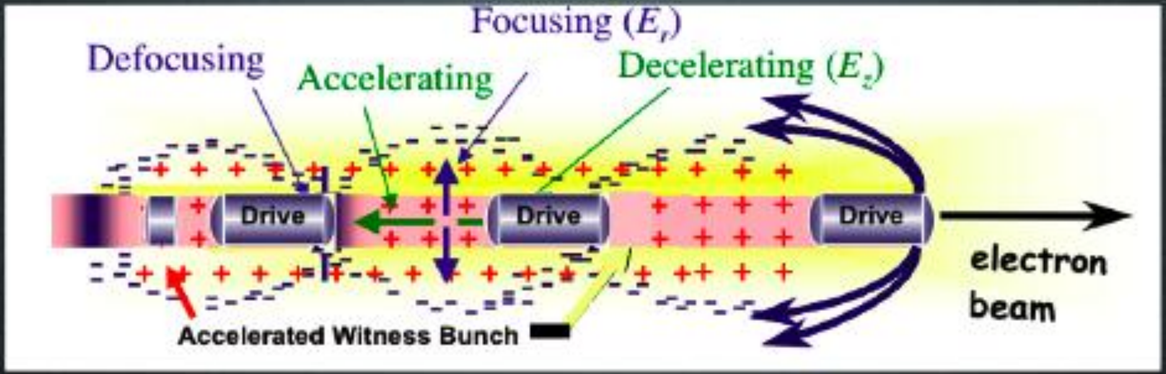
- Optimisation of laser guiding using capillary tubes (10cm):
  - vacuum or under-dense plasmas
  - Relevant for moderate intensities in laser wakefield schemes
  - Active control of laser properties to improve coupling



- Measurement of a plasma wave in the wake of an intense laser beam guided in a capillary tube over 8 cm, using optical diagnostics. Measured field up to 7GV/m over 8 cm.

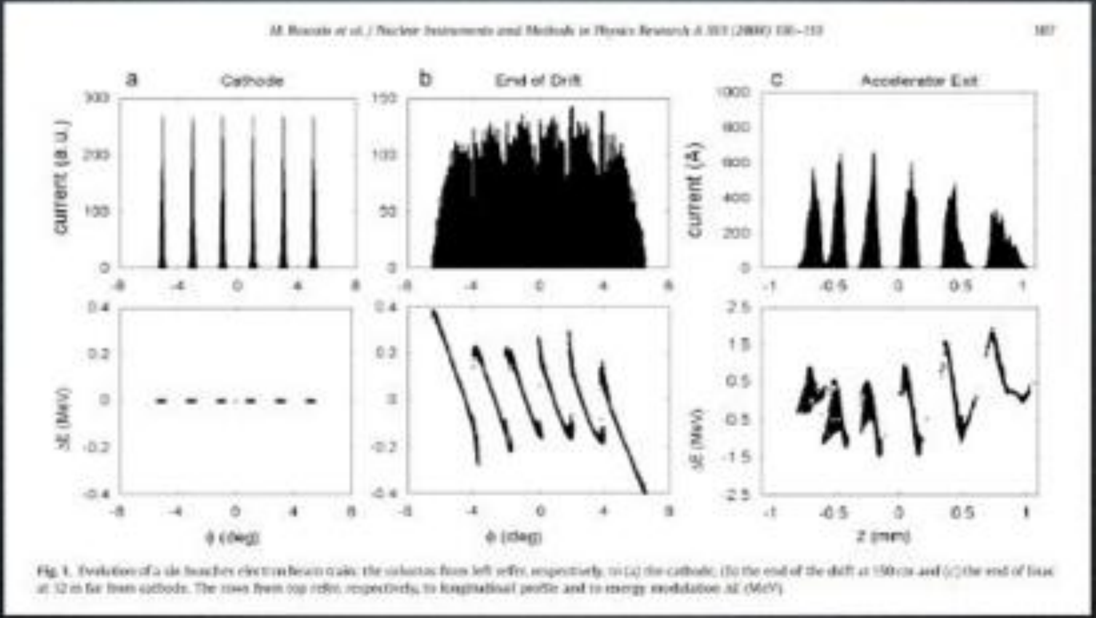
ourtesy B. Cros

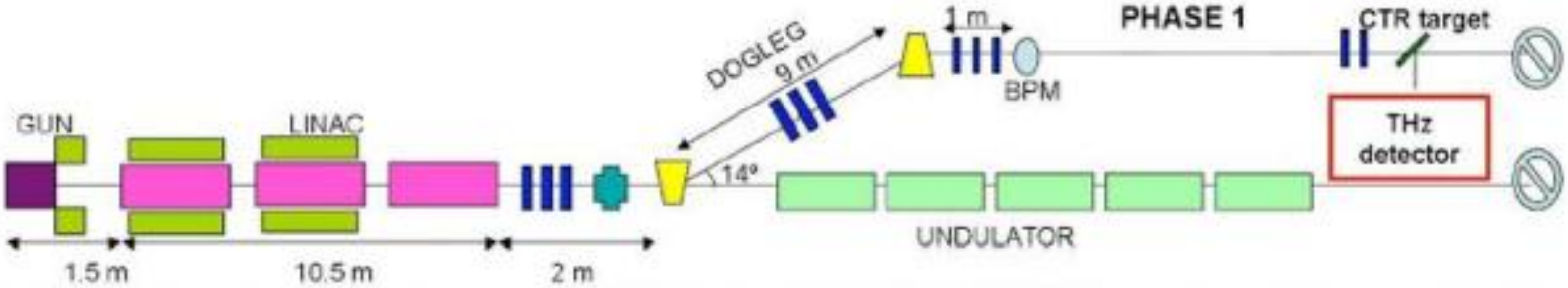
Resonant plasma Oscillations by Multiple electron Bunches



- **Weak blowout regime** with resonant amplification of plasma wave by a train of high Brightness electron bunches produced by **Laser Comb** technique ==> **5 GV/m** with a train of 3 bunches, 100 pC/bunch, 50 μm long, 20 μm spot size, in a plasma of density 10^{22} e^-/m^3 at λ_p=300 μm ?
- **Ramped bunch train configuration** to enhance tranformer ratio?
- **High quality bunch** preservation during acceleration and transport?
- **Strong blowout regime** with pC/fs bunches ==> **TV/m** regime ?

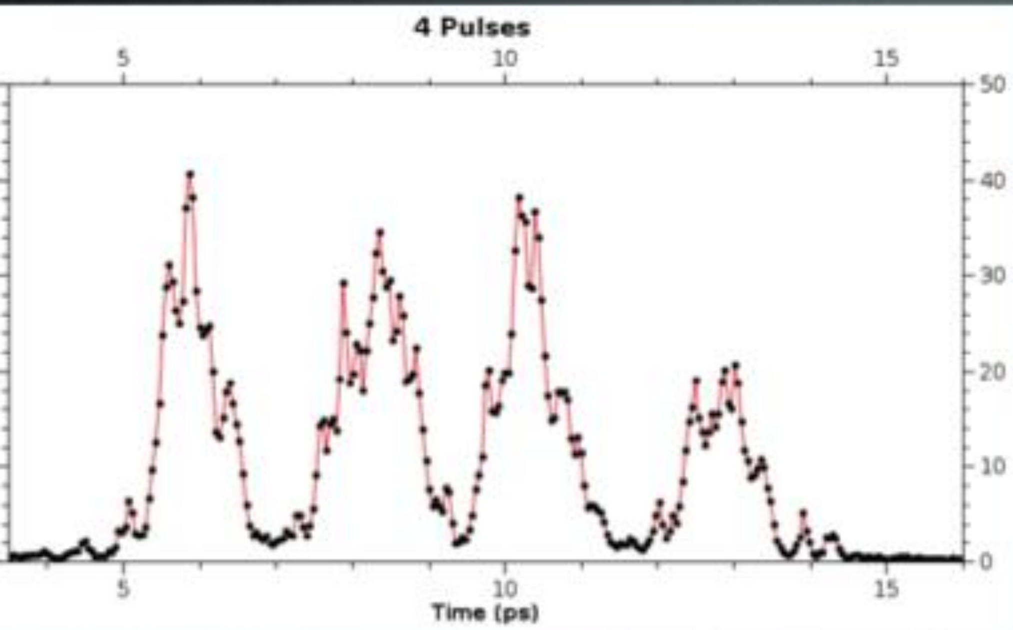
Laser Comb: a train of THz bunches

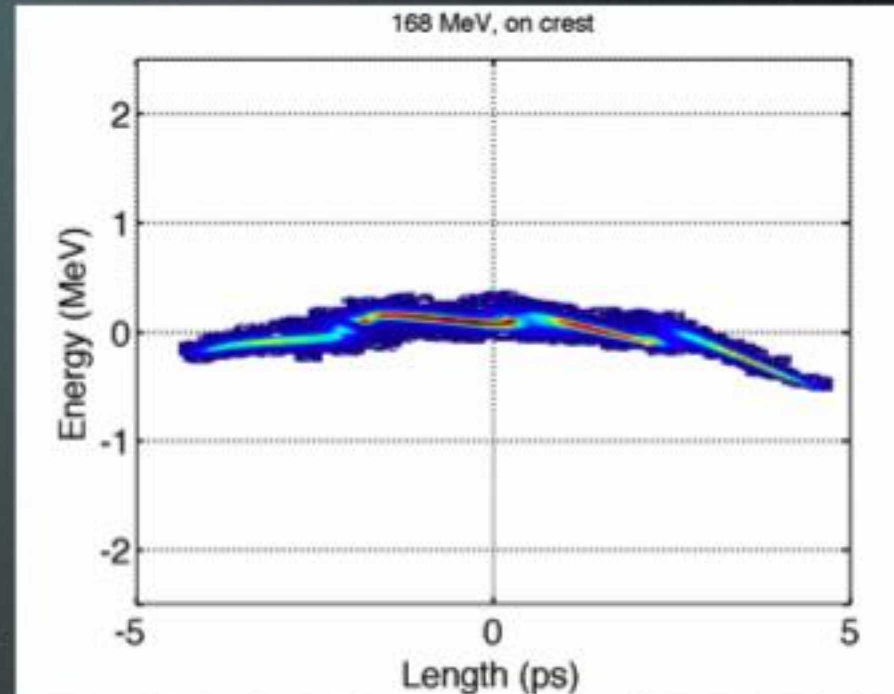


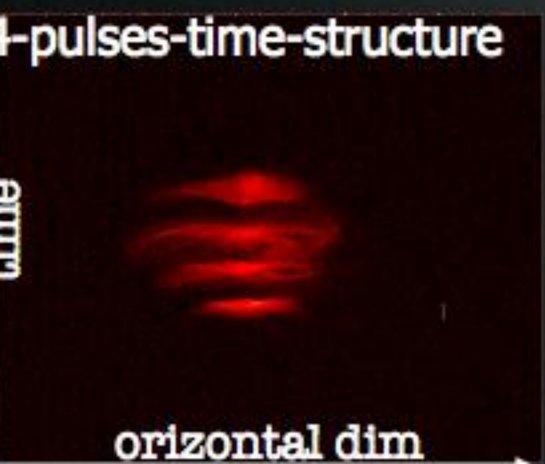


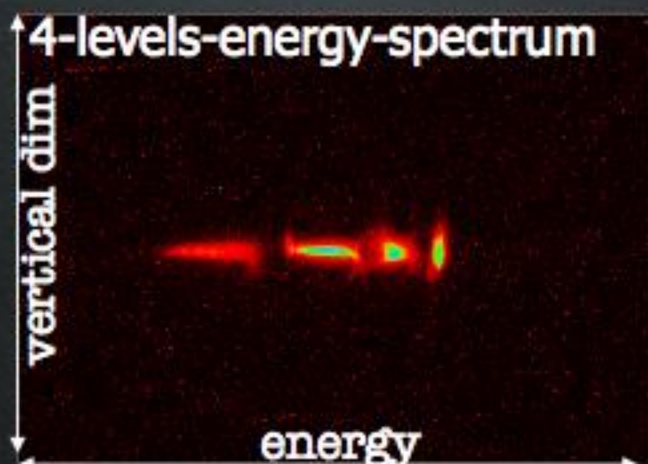
- P.O.Shea et al., Proc. of 2001 IEEE PAC, Chicago, USA (2001) p.704.
- M. Ferrario. M. Boscolo et al., Int. J. of Mod. Phys. B, 2006 (Taipei 05 Workshop)

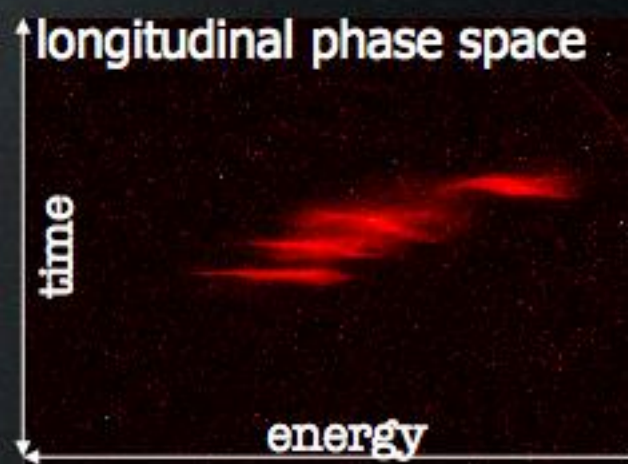
Laser COMB technique



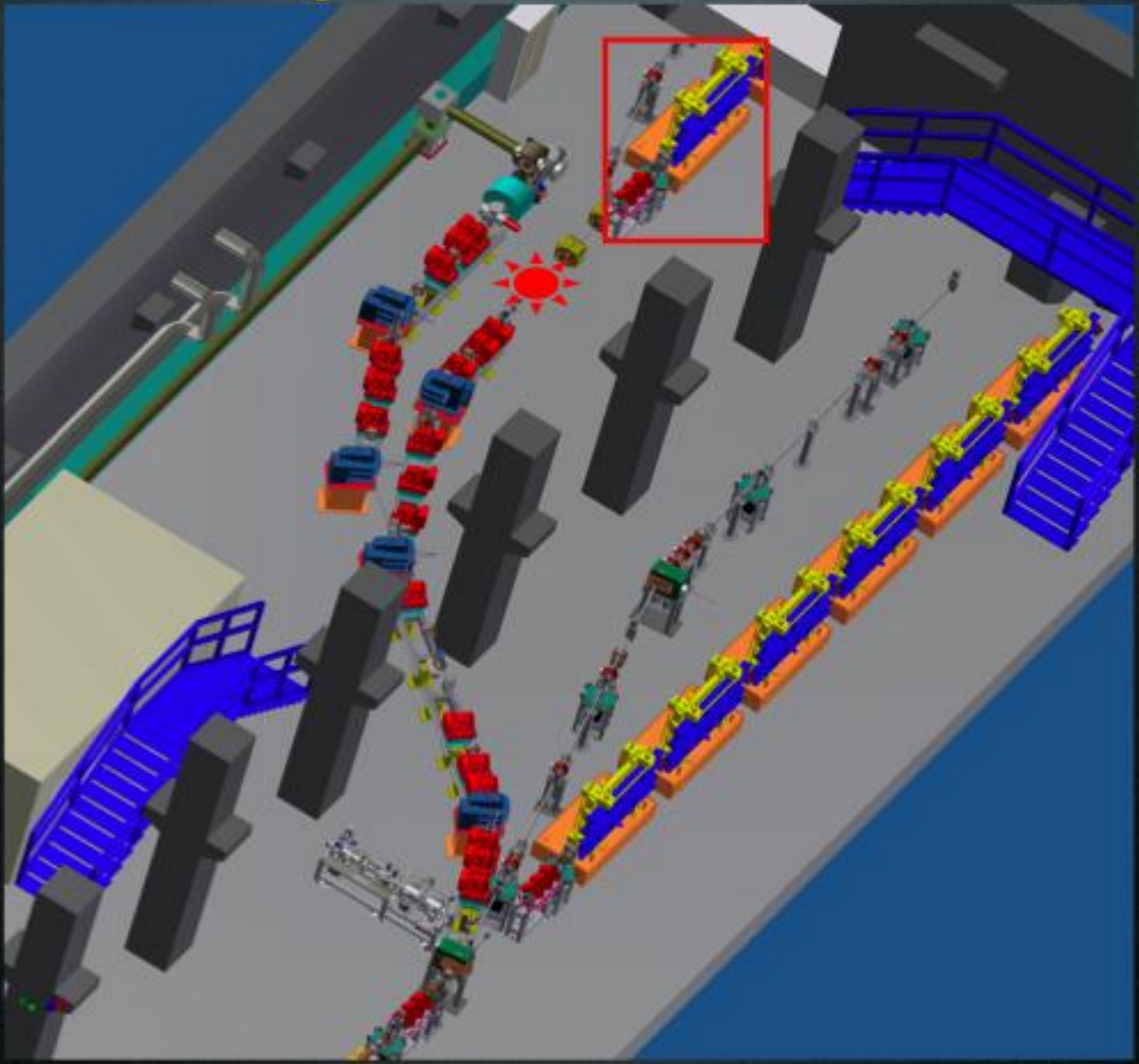




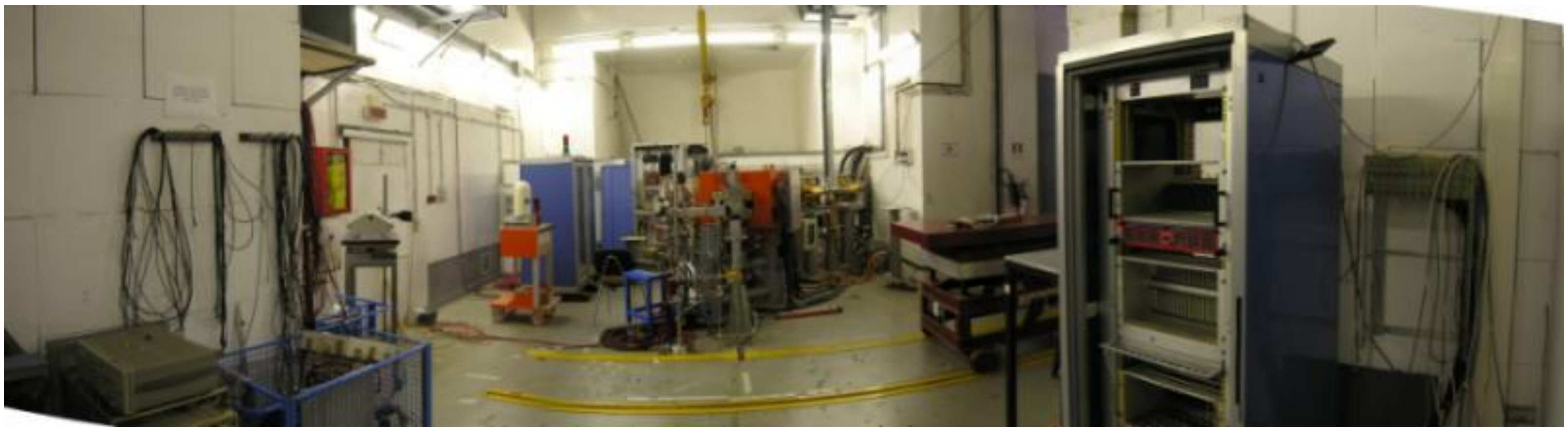




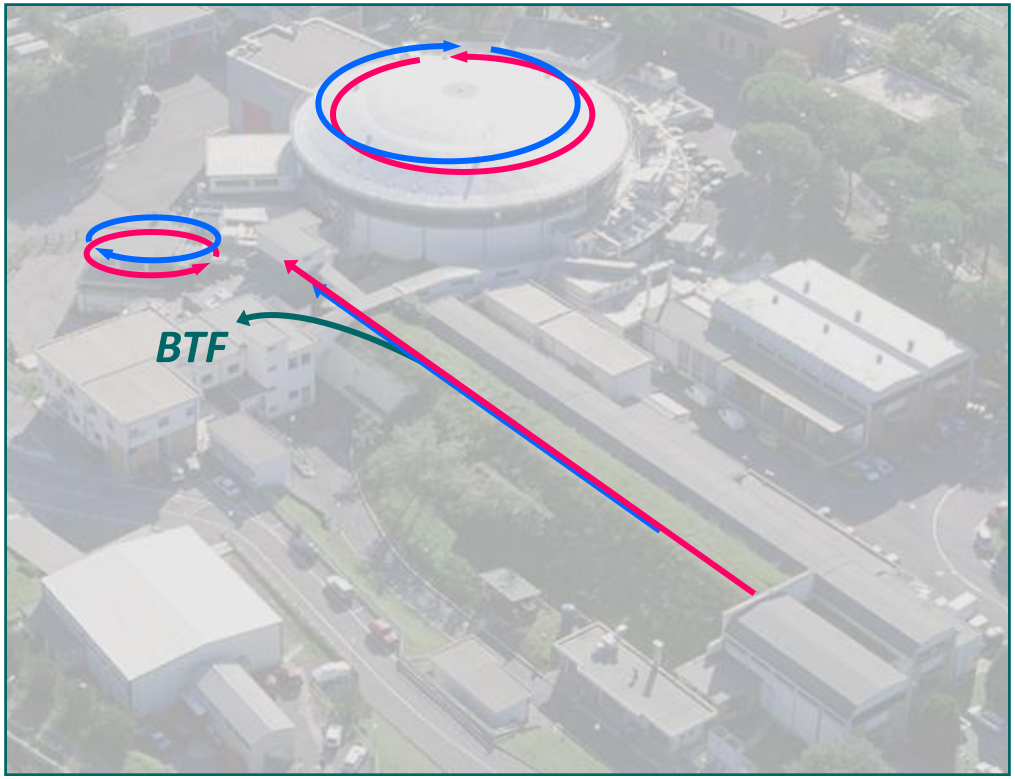
A FEL driven by Plasma Accelerator at LNF?



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** 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**



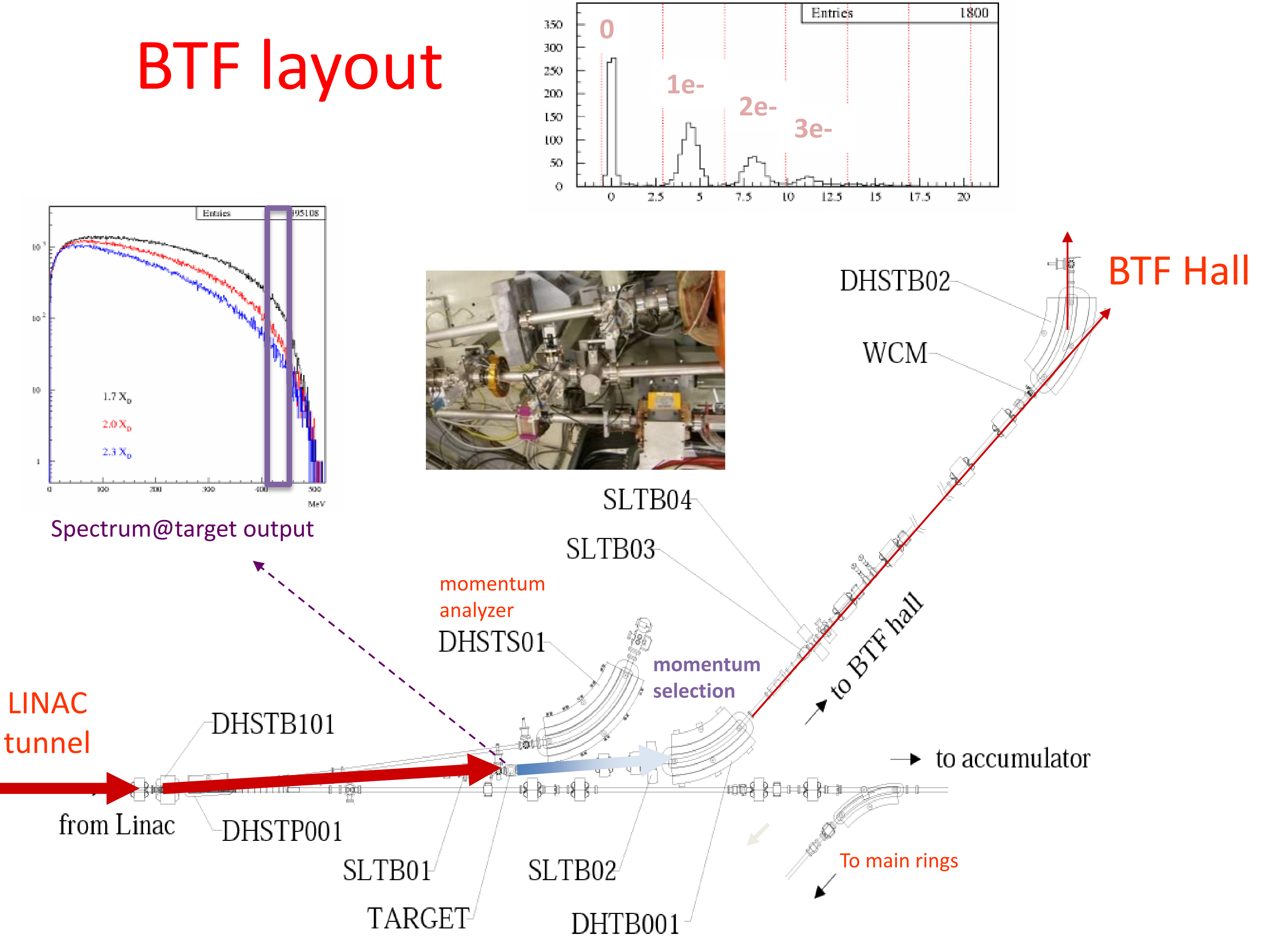
DAFNE-BTF

The **BTF** is a e^-/e^+ **test-beam facility** in the Frascati DAΦNE collider complex

high current Linac:
- 1 – 500 mA e^- 100 mA e^+,
- 1 - 10 ns pulses, at least 10^7 particles

Need to attenuate the primary beam:
- **Single particle** regime is ideal for detector testing purposes
- Allows to tune the beam intensity
- Allows to tune the beam energy

BTF layout



Entries 1800
0
1e-
2e-
3e-
Entries 95108
1.7 X0
2.0 X0
2.3 X0
MeV
Spectrum@target output
BTF Hall
DHSTB02
WCM
SLTB04
SLTB03
to BTF hall
momentum analyzer
DHSTS01
momentum selection
LINAC tunnel
DHSTB101
to accumulator
from Linac
DHSTP001
SLTB01
SLTB02
TARGET
DHTB001
To main rings

Beam Test Facility e^+/e^- characteristic

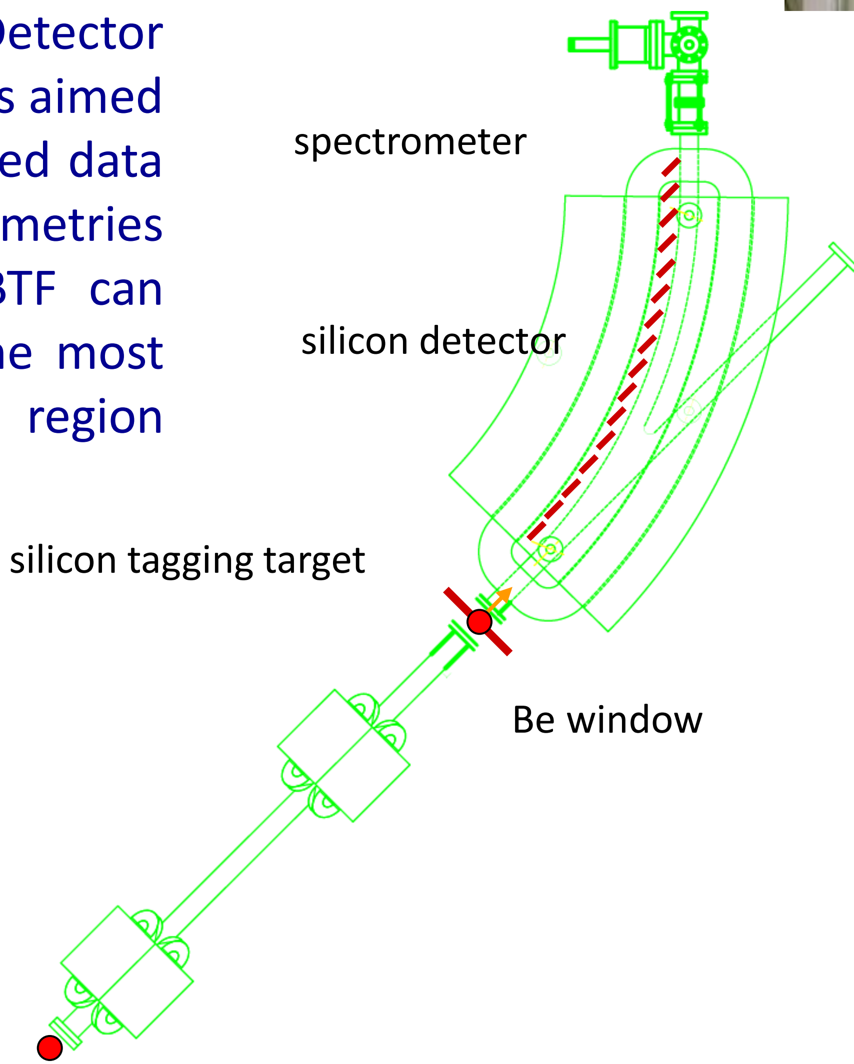
	parasitic	dedicated
Number (particles/pulse)	$1 \div 10^5$	$1 \div 10^{10}$
Energy (MeV)	25-500	$25 \div 750$
Repetition rate (Hz)	20-50	50
Pulse Duration (ns)	10	1 or 10
p resolution	1%	
Spot size (mm)	$s_{x,y} \approx 2$ (single particle)	
Divergence (mmrad)	$s'_{x,y} \approx 2$ (single particle)	

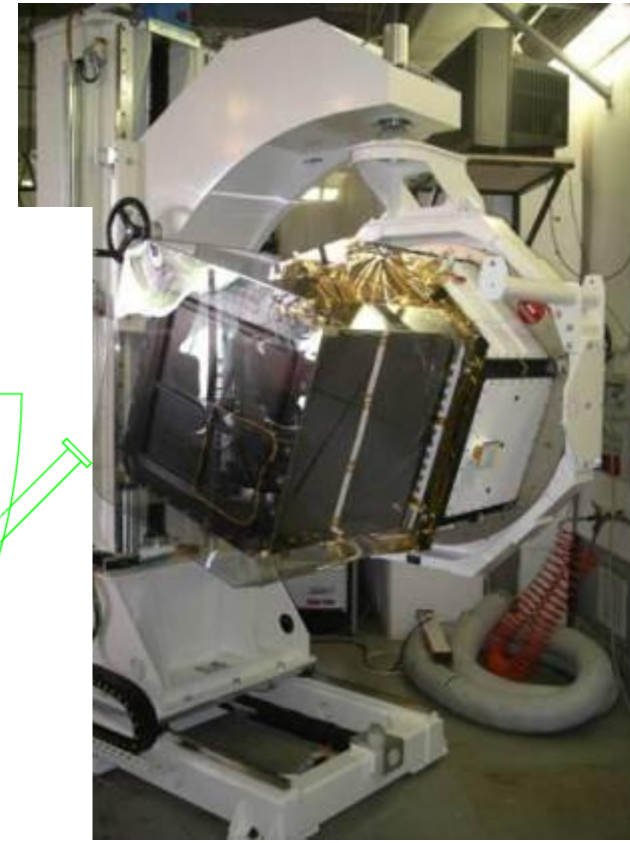
Main applications

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

BTF photon tagged source AGILE GRID photon calibration

The AGILE Gamma Ray Imaging Detector calibration at BTF is aimed at obtaining detailed data on all possible geometries and conditions. BTF can provide data in the most significant energy region (20-700 MeV)





AGILE GRID