Sinergie tra i dipartimenti universitari e i laboratori di acceleratori; l'esperienza della Sapienza

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Dipartimento di Scienze
di Base e Applicate
per l'Ingegneria

Sapienza
Università di Roma

Outline

Sinergie tra i dipartimenti universitari e i laboratori di acceleratori; l'esperienza della Sapienza

Synergies with national laboratories for

- **Research in accelerator physics and technology**
- **Students training**

Group at **Department of Basic and Applied Sciences for Engineering**

Prof. Luigi Palumbo (PO)
Prof. Mauro Migliorati (PA)
Prof. Andrea Mostacci (PA)
Prof. Massimo Petrarca (PA)

Giovanni Castorina, PhD (post-doc)
Luca Ficcadenti, PhD (researcher)
Massimuliano Sciscò, PhD (post-doc)
+ PhD students

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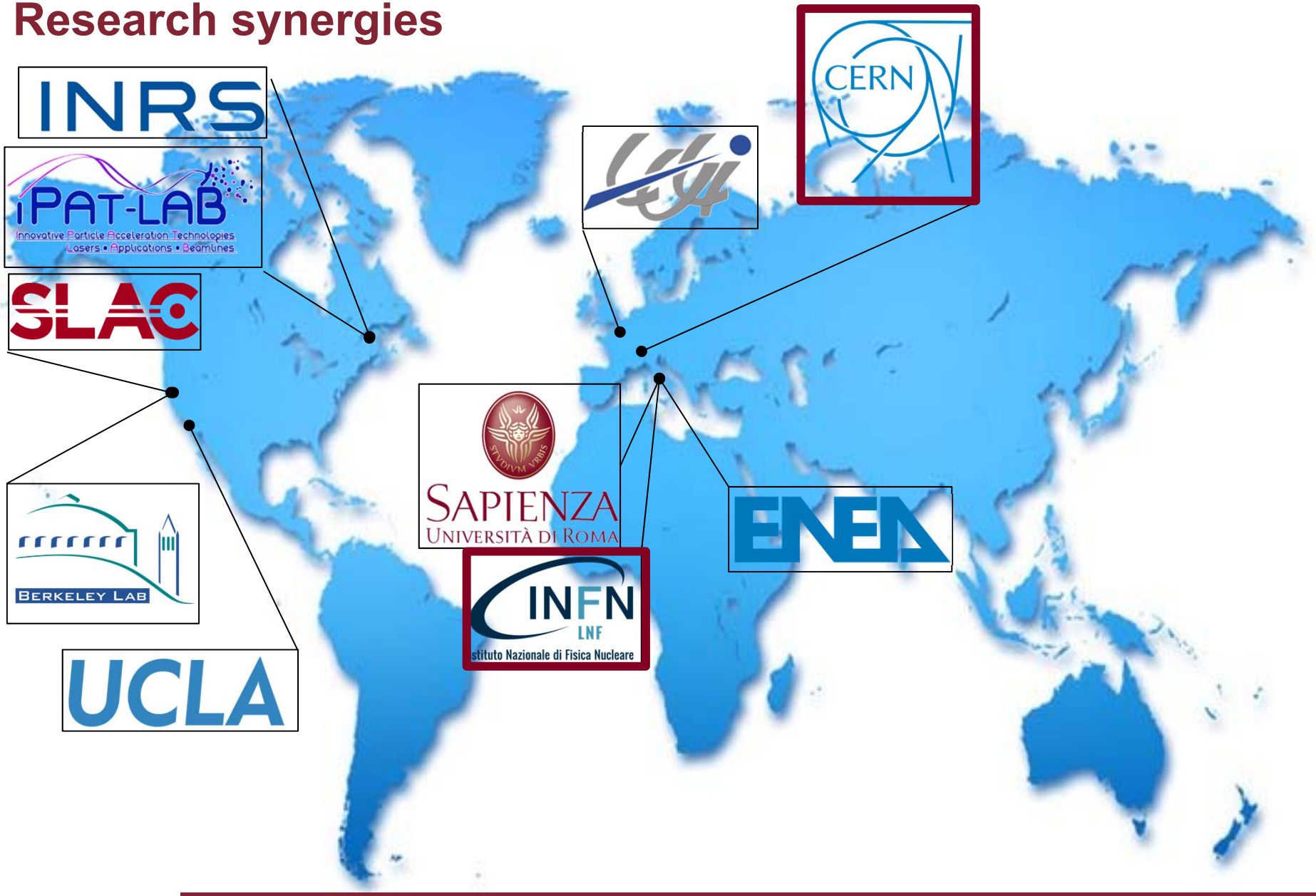
Research synergies



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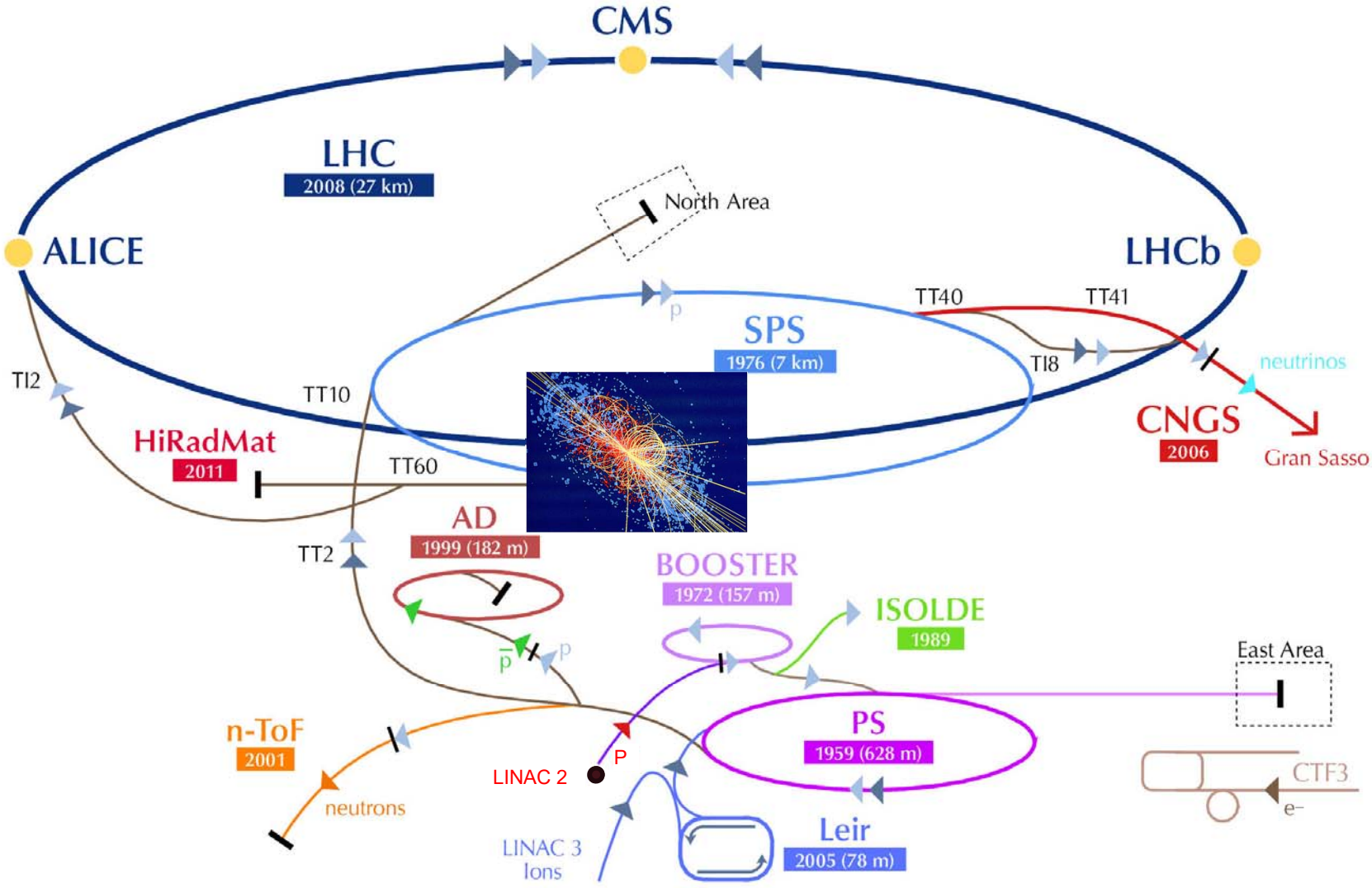
An example: CERN accelerator complex



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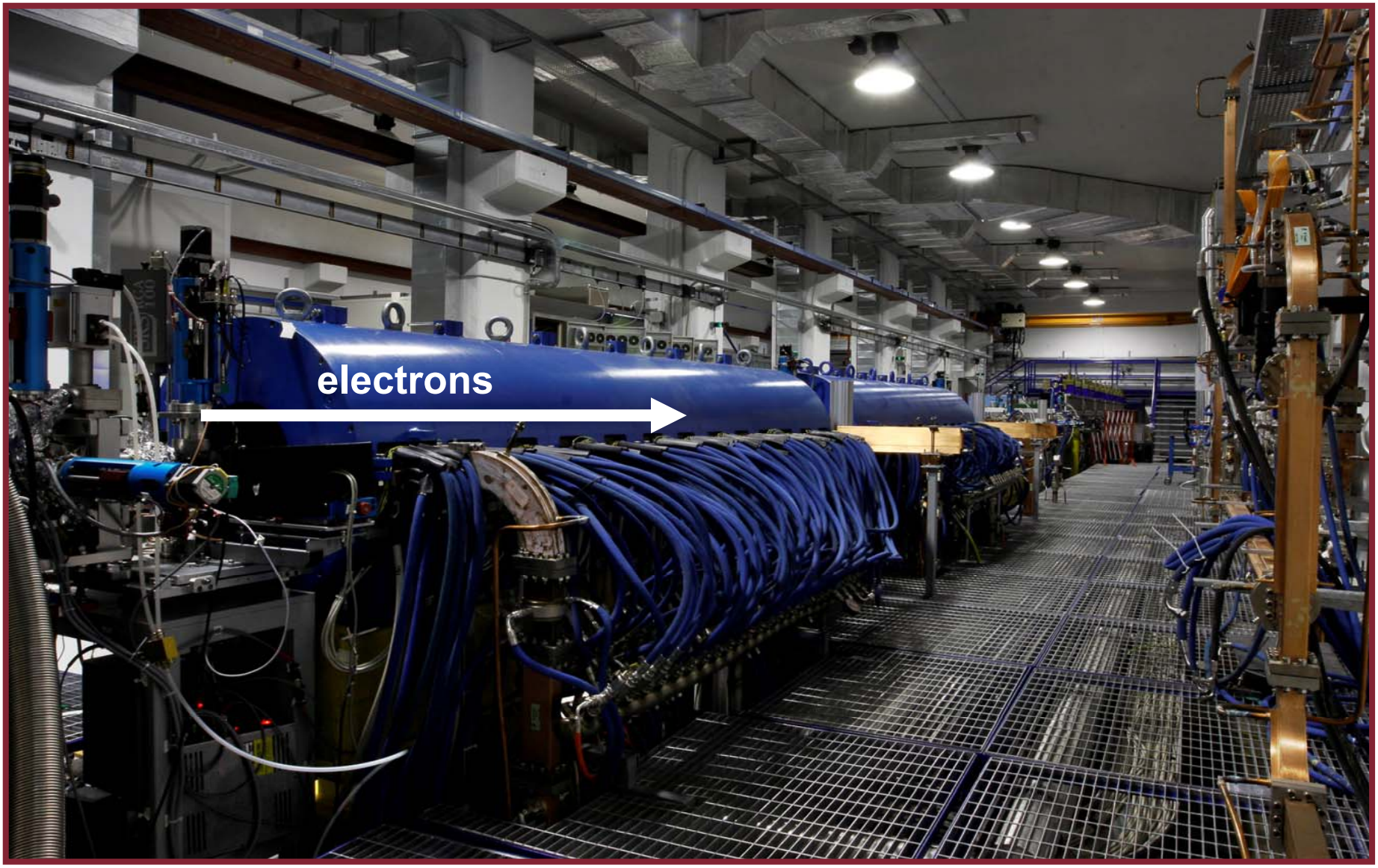
An example: Linac R&D @ LNF



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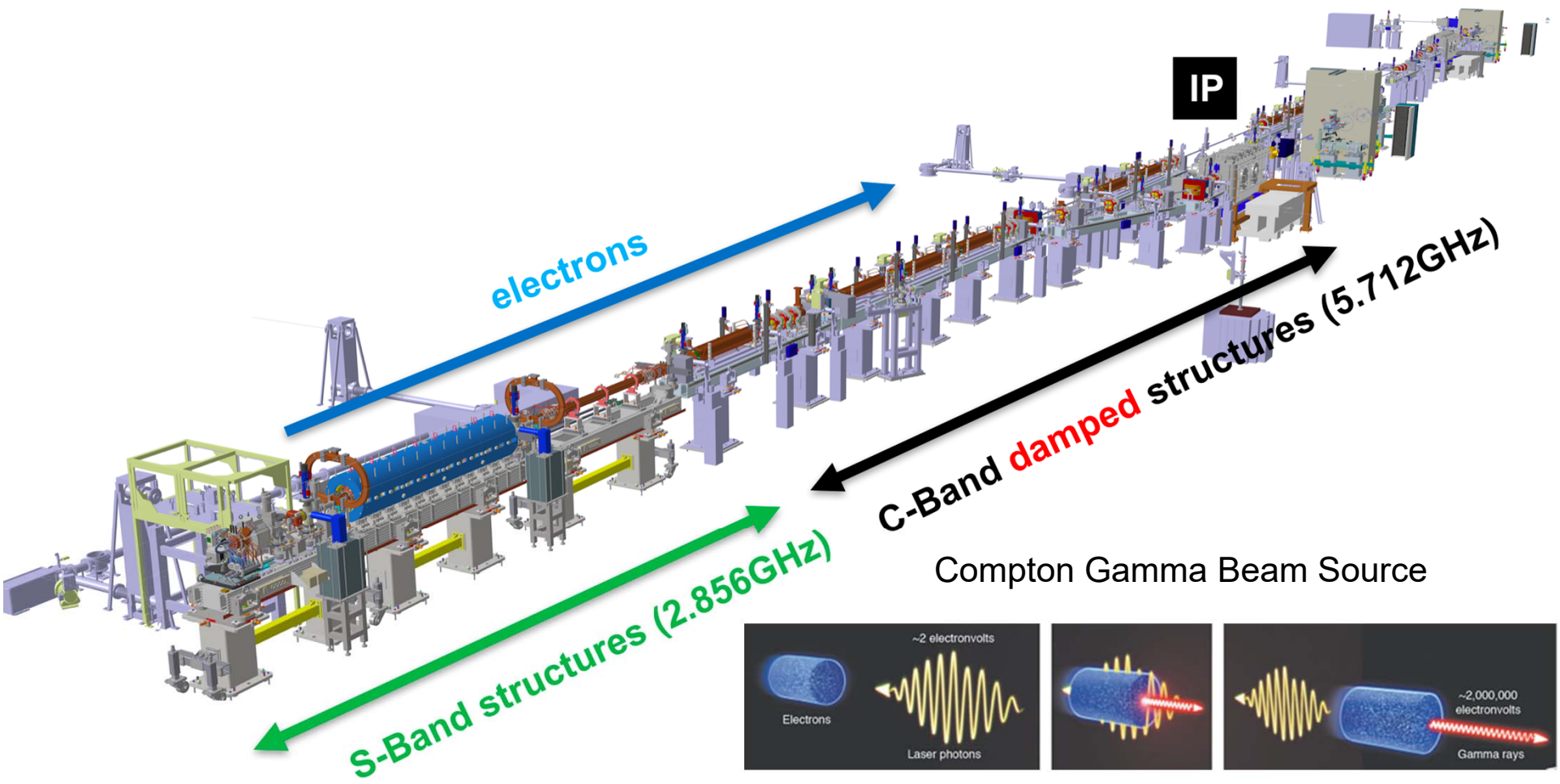
An example: Linac R&D @ LNF



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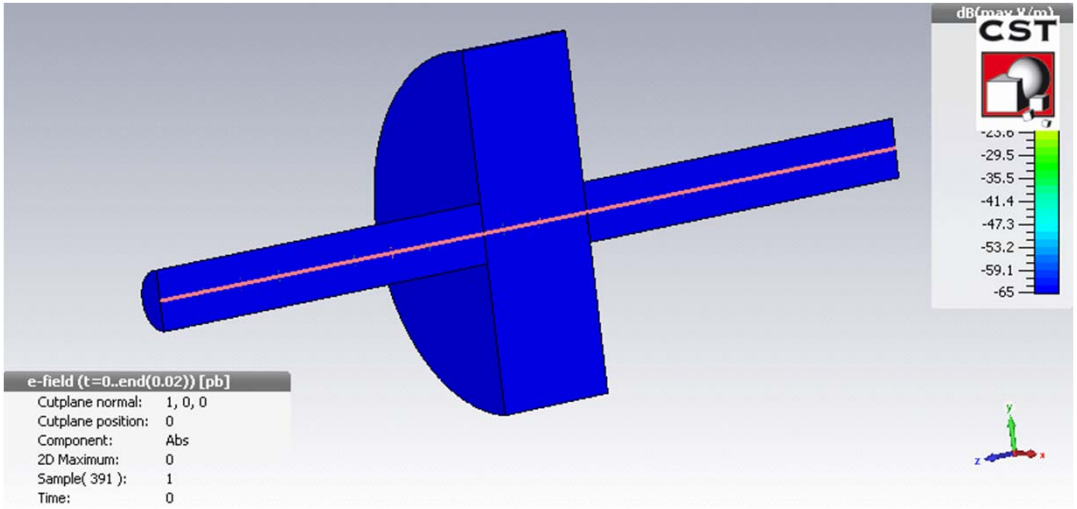
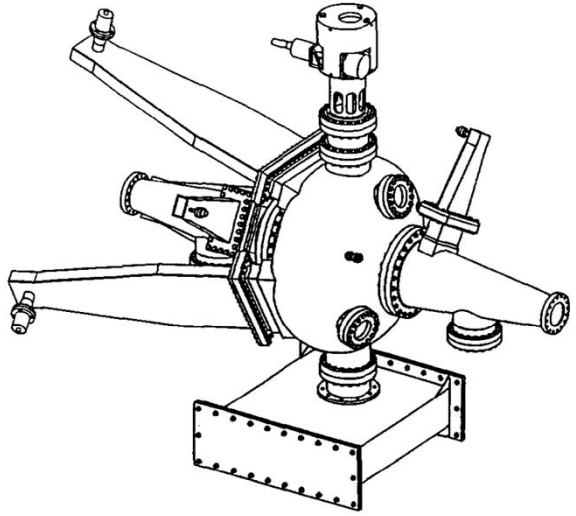
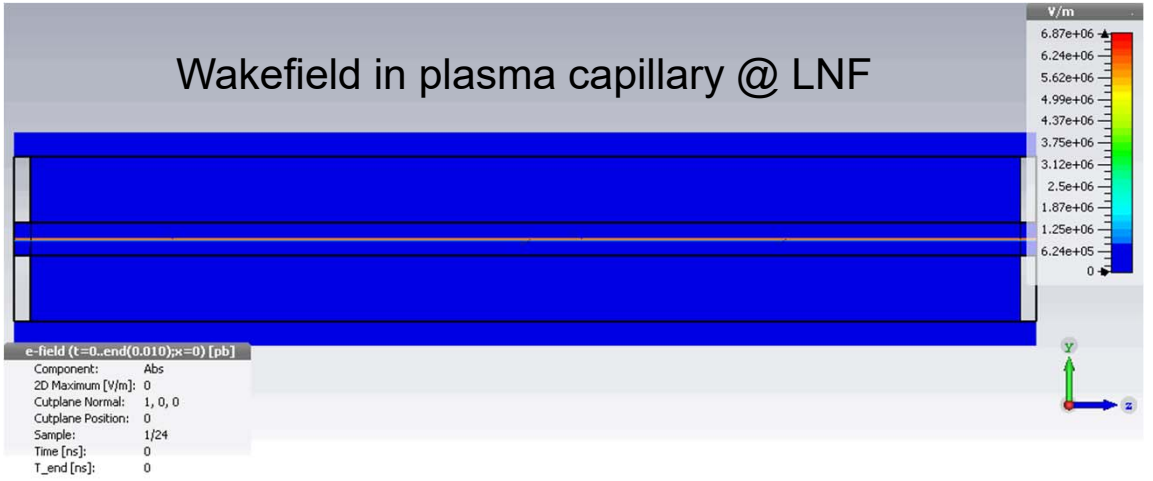
Control of wakefield (few examples)





Damped cavity Dafne @ LNF



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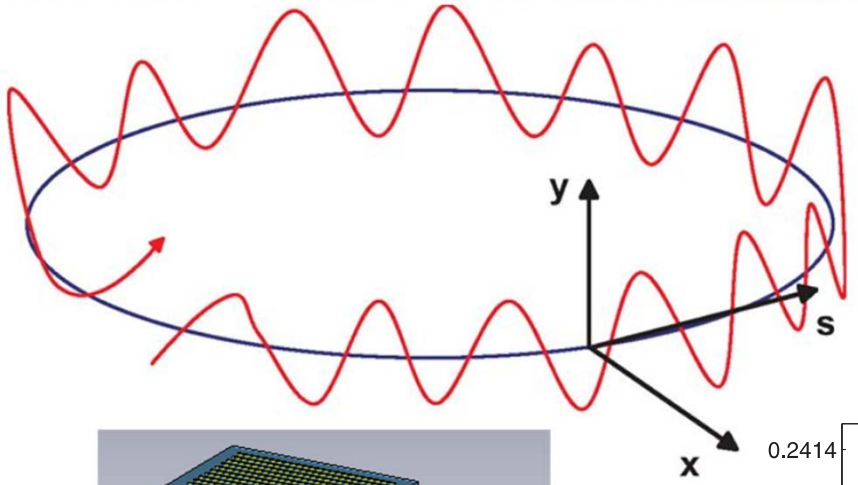
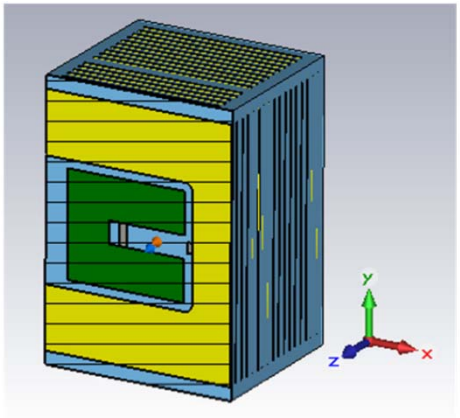
From wakefield and impedances to instabilities





LHC injector upgrade @ CERN

M. Migliorati, Sapienza/CERN

Vertical tune shift with beam intensity at different energies @ CERN PS

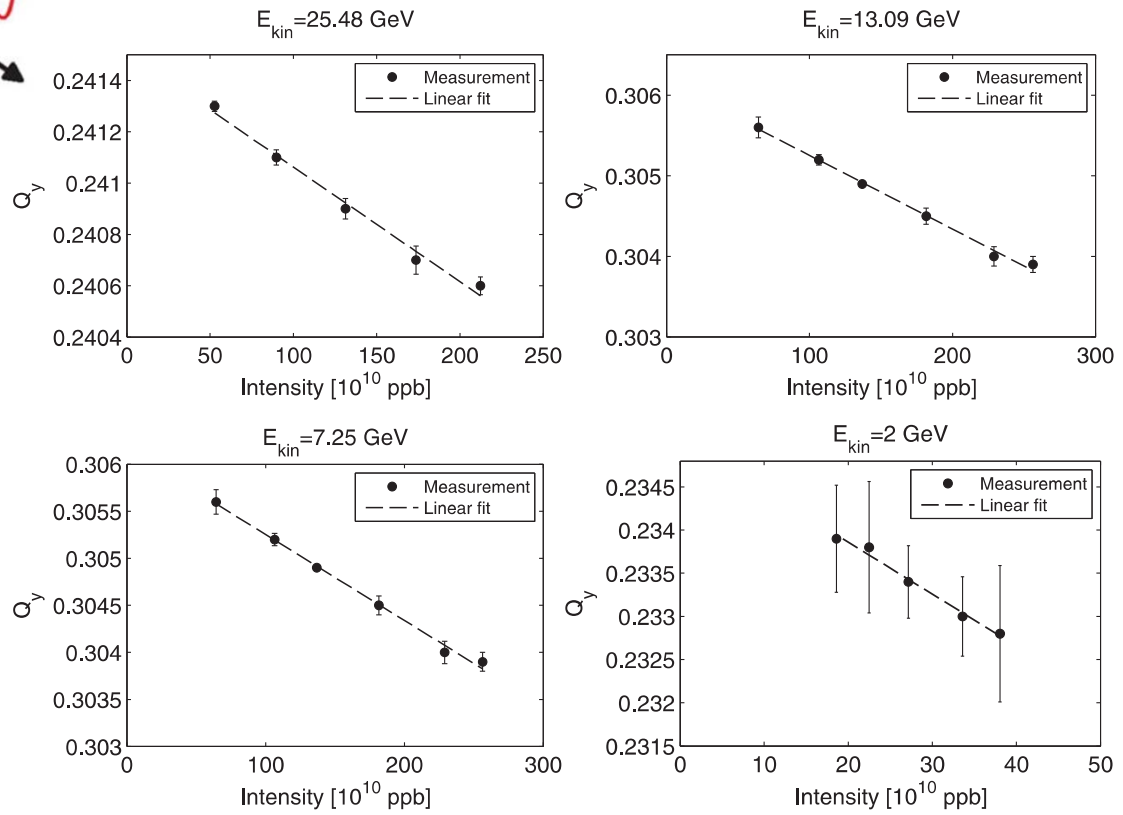


TABLE VII. Contribution of the different machine elements to the vertical effective impedance budget 2 GeV.

	Z_y^{eff} [MΩ/m]	Contribution
Space charge	3	58.5%
Kickers	1.4	24.9%
Resistive wall	0.3	5.8%
Vacuum	0.55	10.7%

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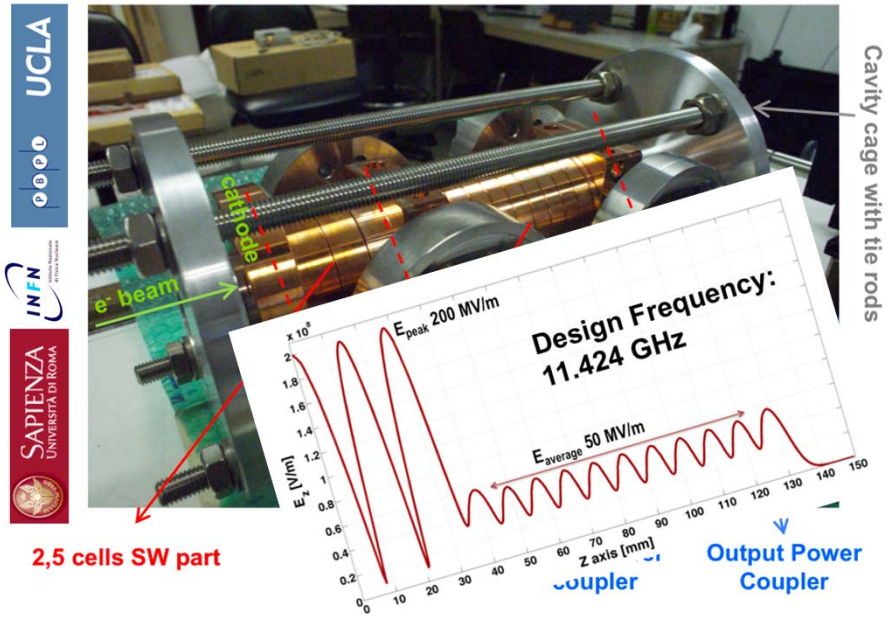
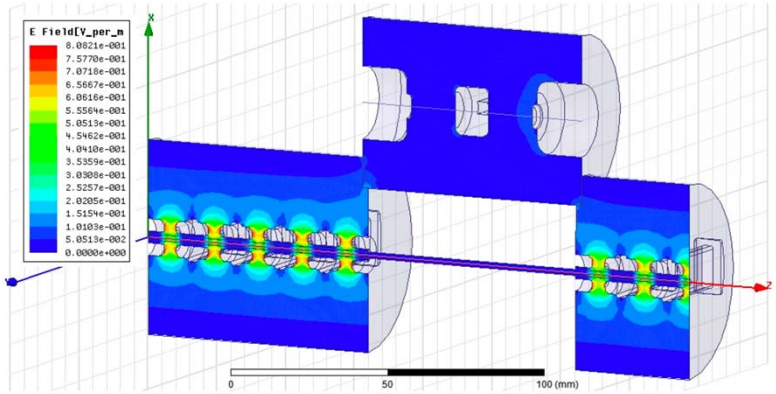
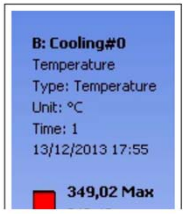
Design of Radio Frequency structures for beam manipulation

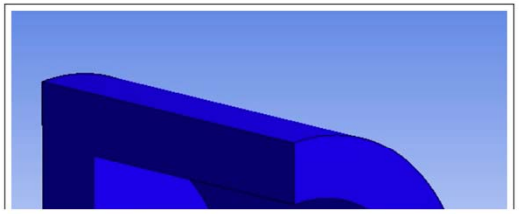
11GHz RF gun @ UCLA, LNF

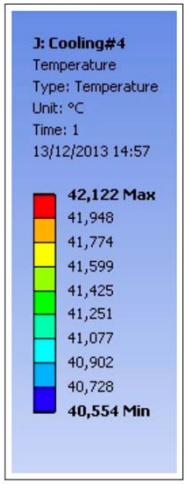


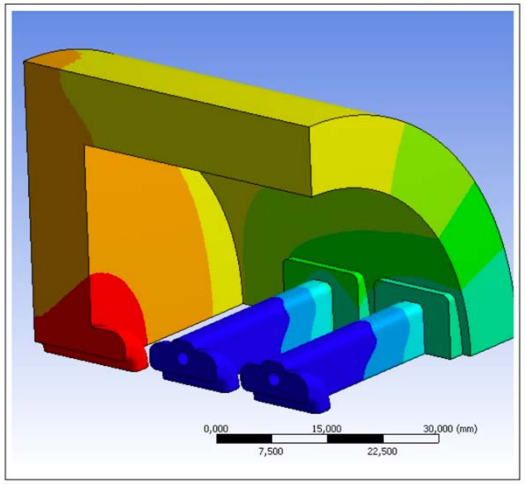
Medical Proton accelerator @ ENEA



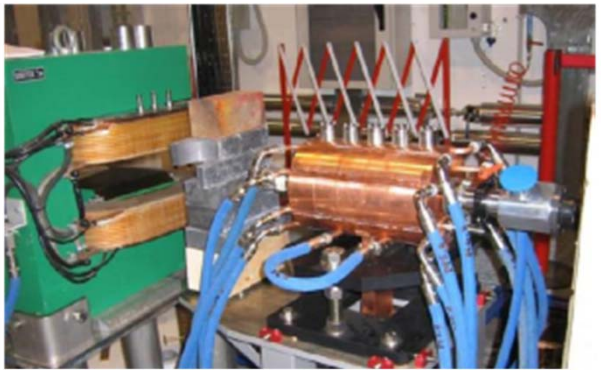


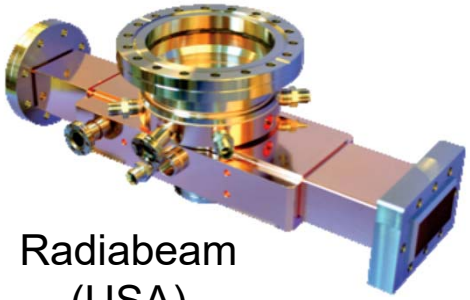






RF Deflector @ LNF





Radiabeam
(USA)

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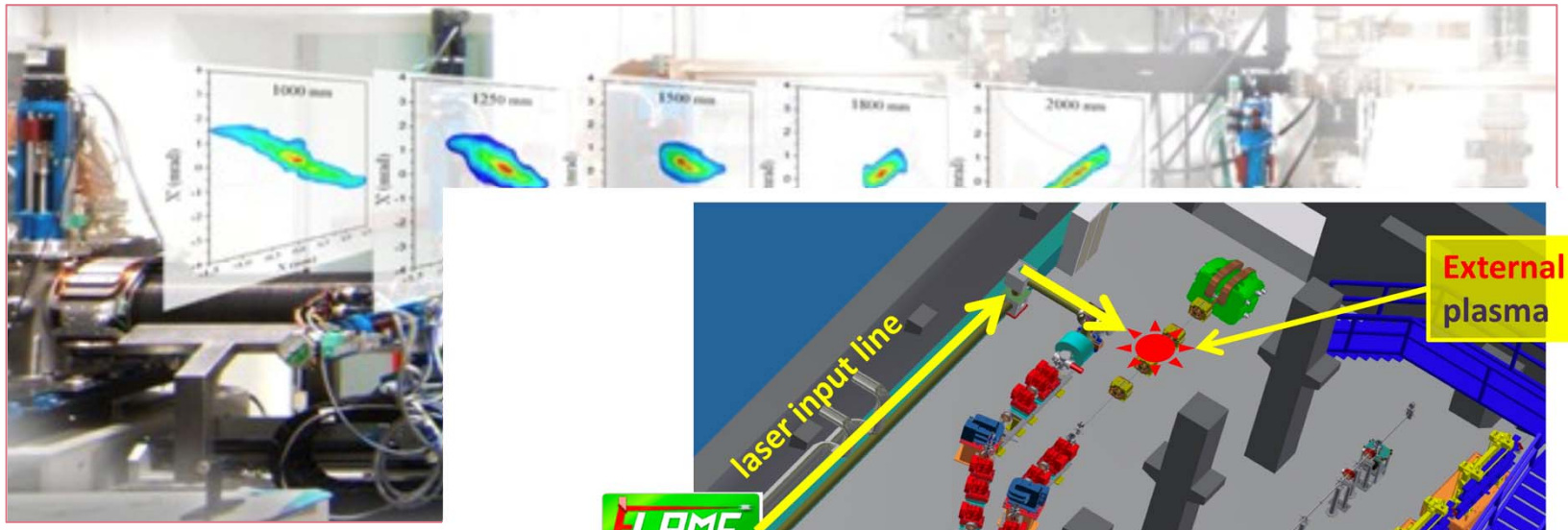
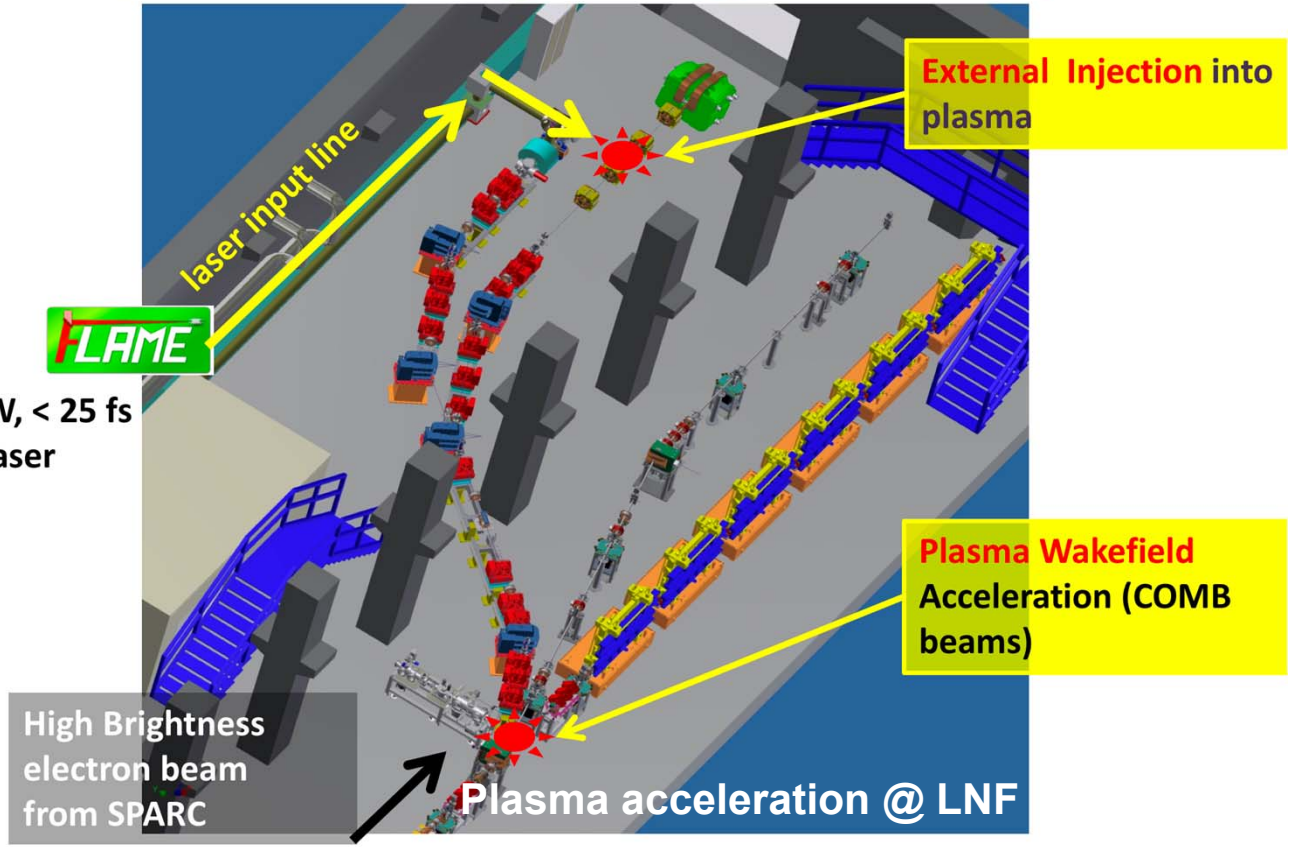
Sinergy with INFN-LNF: from SPARC to SPARC_LAB

Beam emittance oscillation after a RF photinjector @ SPARC-LNF





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Synergy with laser facilities: LULI @ Paris

LABORATOIRE POUR L'UTILISATION DES LASERS INTENSES
LULI

Rayonnements
Particules
Plasmas
Fusion
Astrophysique
Planétologie

ÉCOLE POLYTECHNIQUE

High-power laser facility for high-energy-density plasma physics

LULI 2000
CPA pulse of 100 J in 1 ps

LULI ELFIE
CPA pulse of 30 J in 0.35 ps

used for

Inertial fusion

Laser-matter interaction

Warm-dense-matter

Laser-driven particle acceleration

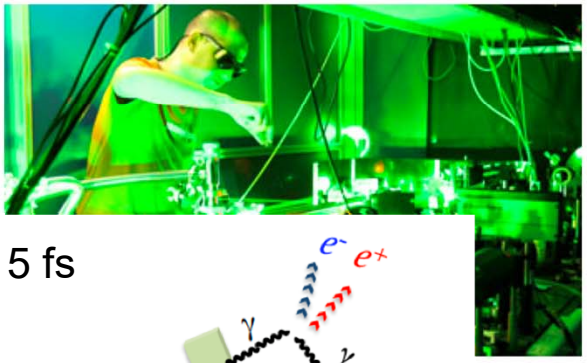
Laboratory astrophysics

Experimental activities:

Brillouin backscattering laser-amplification

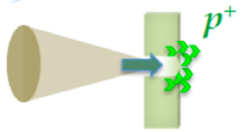
Isochoric heating

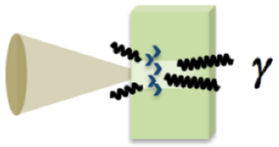
Laser-plasma proton acceleration and applications

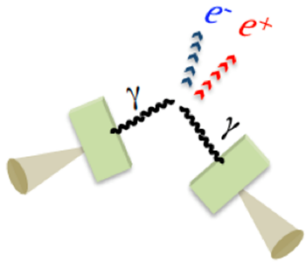


CilexApollon

1PW = 15 Joules in 15 fs







10^{20} Wcm^{-2} — 10^{22} Wcm^{-2}

Contact Person:
Livia Lancia
livia.lancia@polytechnique.edu

Synergy with laser facilities: INRS @ Montreal

INRS Université d'avant-garde — Centre - Énergie Matériaux Télécommunications

iPAT-LAB Innovative Particle Acceleration Technologies Lasers • Applications • Beamlines

Multidisciplinary research activity

Nanoscience and femtoscience
Nanomaterials
Ultra-fast optics
Laser-matter interaction

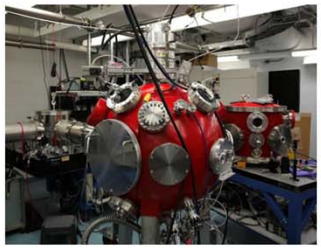
Novel energy sources
Electrochemistry
Photovoltaic
Nanoplasmonics

Telecommunications
Ultra-fast photonics
Quantum-communication

Biomedical applications
Bio-nanotechnologies
Novel imaging techniques

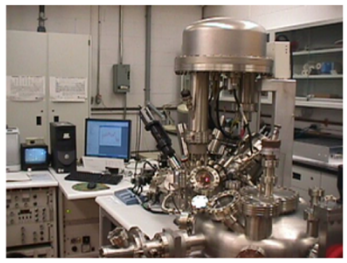
Equipment and facilities

Short-pulse laser systems (up to 500-TW power) for **laser-driven particle acceleration**



- Numerical simulations of laser-plasma interaction
- Particle beam dynamics studies
- Studies of electromagnetic pollution
- Accelerator diagnostics

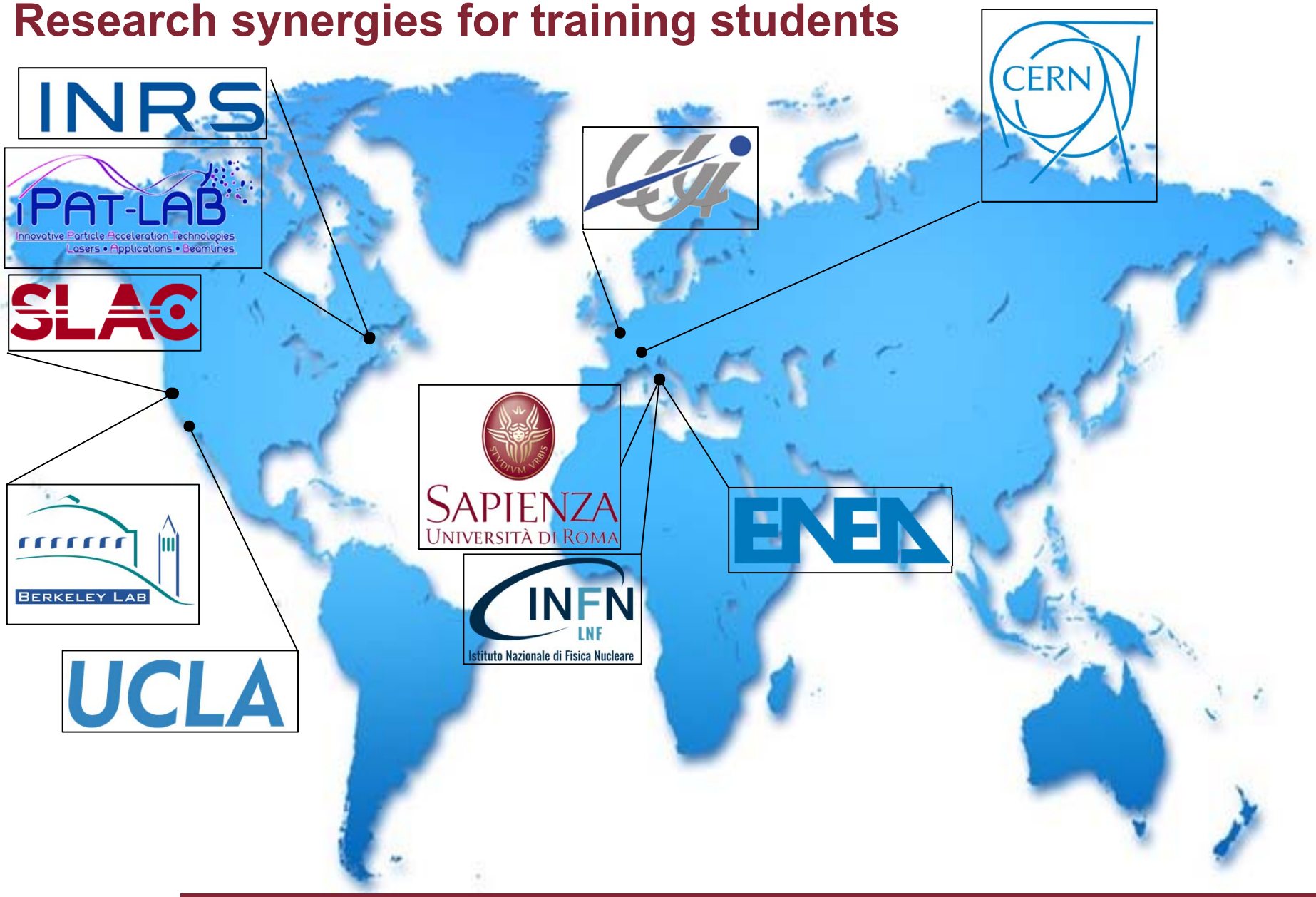
Nano-material and material analysis laboratories for **material science applications**



- Material analysis

Contact Person:
Patrizio Antici
antici@emt.inrs.ca

Research synergies for training students



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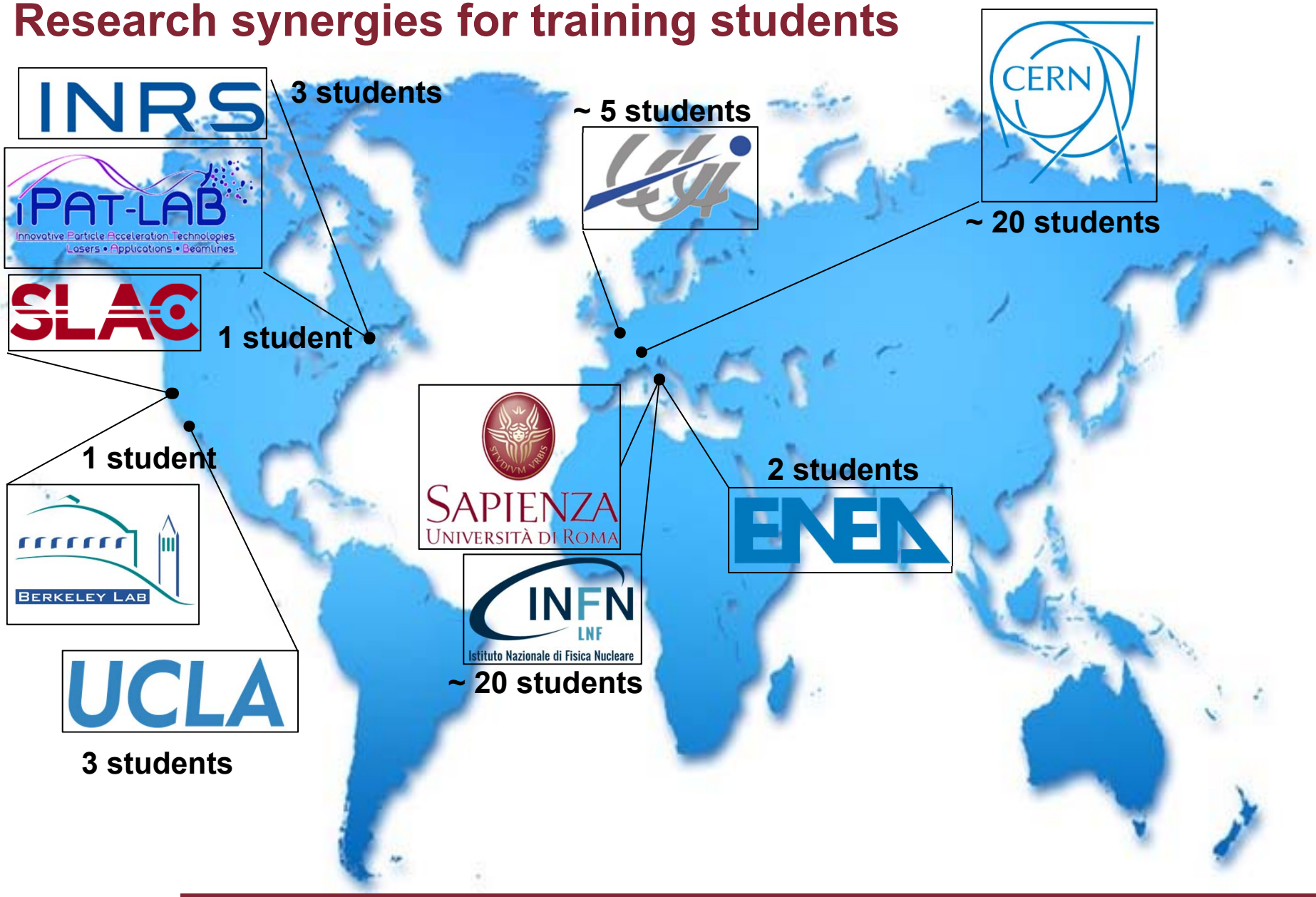
Research synergies for training students



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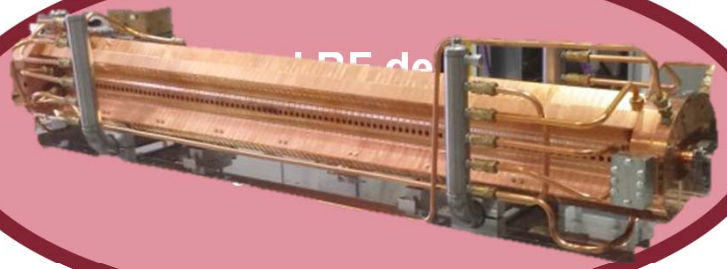
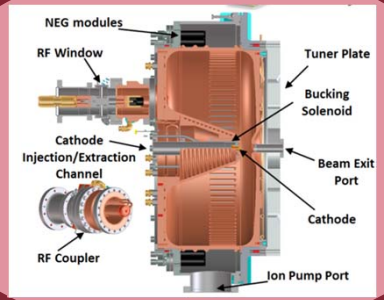
Former students are now working on …

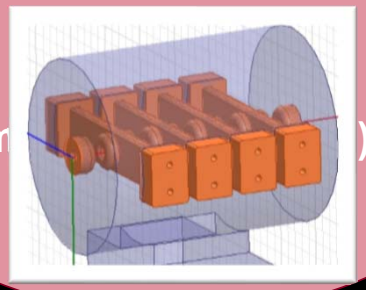
Klystrons design

Operation of accelerators (LNF, CERN, …)

”Conventional” (RF based) accelerators







Impedance theory and measurement

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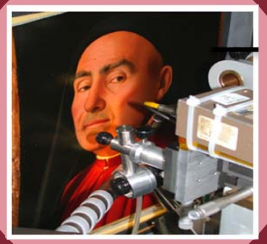
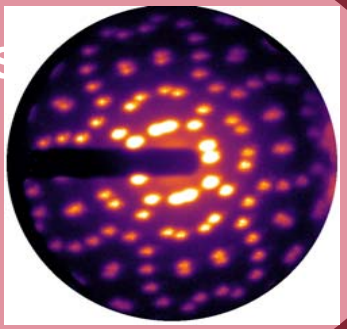
Former students are now working on …

FEL @ SLAC, PSI

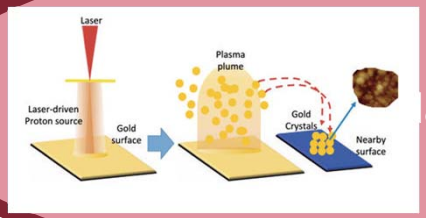


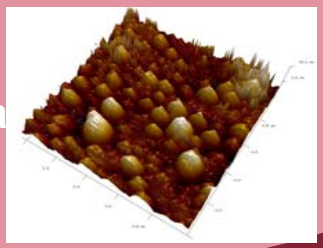
Accelerated Particles based applications

Protons for stress testing of materials



Proton radiography of electro-magnetic field in plasmas





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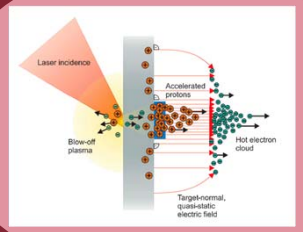
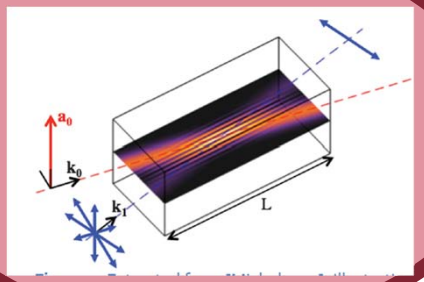
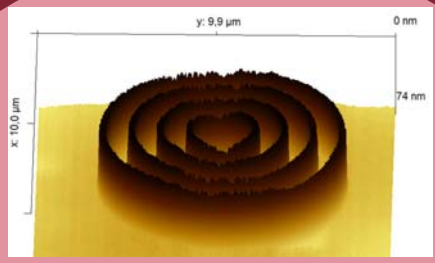
Former students are now working on …

Future particle Accelerators + plasma applications





R&D of plasma accelerators



Plasma physics and simulations

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If you want to know more …

David Alesini, LNF

Primo Tecnolgo

Electron machines

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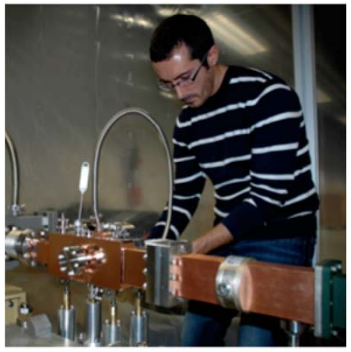

Luigi Faillace, LNF

Researcher

Industrial applications (e^-, p^+)

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Post-doc

Laser generated protons

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Applications of high brightness beams

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Livia Lancia, LULI

Senior Researcher

Physics with high intensity lasers

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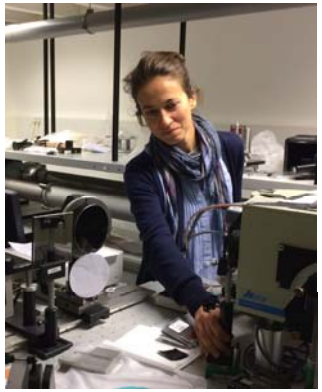

Luca Piersanti, LNF

Researcher

RF technology and medical applications of protons

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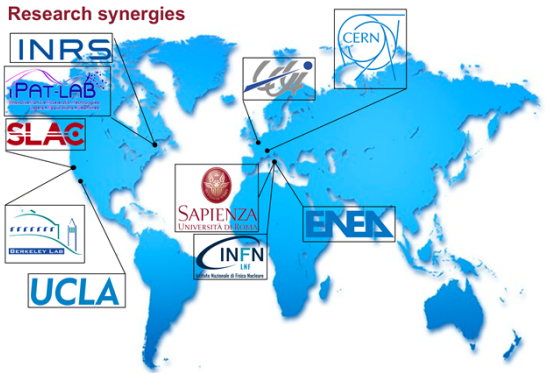
Conclusions

Research synergies typic
research.

Use o ork developed for
r ent training and mobility.

Thank you



EuPRAXIA

From synergy with LNF and CERN also a practical laboratory course of advanced RF measurement (40 students/year)

Synergy with national laboratories has been fundamental for accomplish the mission of a university group (research and training students).

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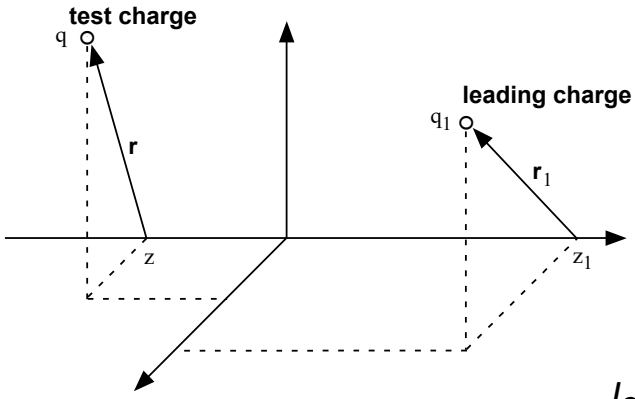
Definition of wake field and coupling impedance



$$\boldsymbol{F} = q\left[E_z\hat{z} + \left(E_x - vB_y\right)\hat{x} + \left(E_y + vB_x\right)\hat{y}\right] \equiv \boldsymbol{F}_{//} + \boldsymbol{F}_{\perp}$$

Longitudinally: (energy change)

$$U(z) = \int_0^L F_{//}\,ds \quad \Rightarrow \quad w_{//}(z) = -\frac{U(z)}{q^2}$$

Longitudinal wake field

Transversally: (momentum kick)

$$\boldsymbol{M}(r_1, z) = \int_0^L \mathbf{F}_{\perp}\,ds \quad \Rightarrow \quad \boldsymbol{w}_{\perp}(z) = \frac{1}{r_1}\frac{\boldsymbol{M}(r_1, z)}{q^2}$$

Transverse wake field

$$Z_{//}(\omega) = \frac{1}{v}\int_{-\infty}^{\infty} w_{//}(z)e^{-i\frac{\omega z}{v}}\,dz$$

Coupling impedance

$$\boldsymbol{Z}_{\perp}(\omega) = \frac{i}{v}\int_{-\infty}^{\infty} \boldsymbol{w}_{\perp}(z)e^{-i\frac{\omega z}{v}}\,dz$$

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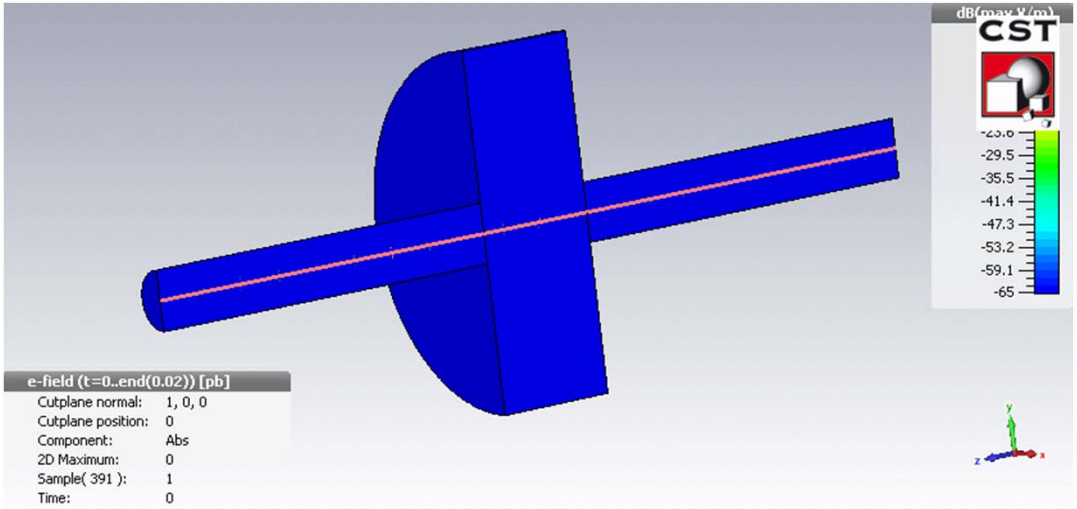
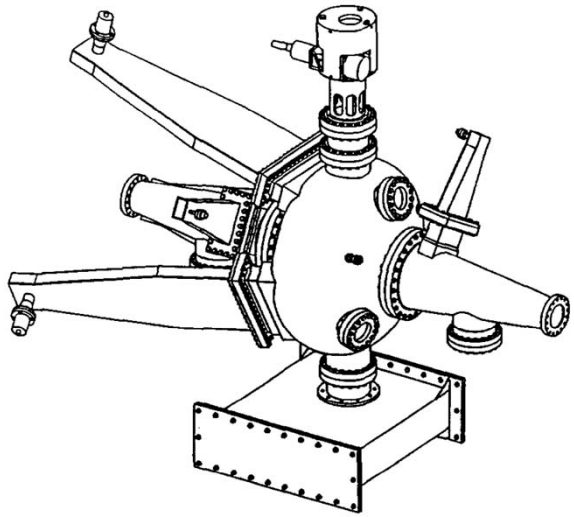
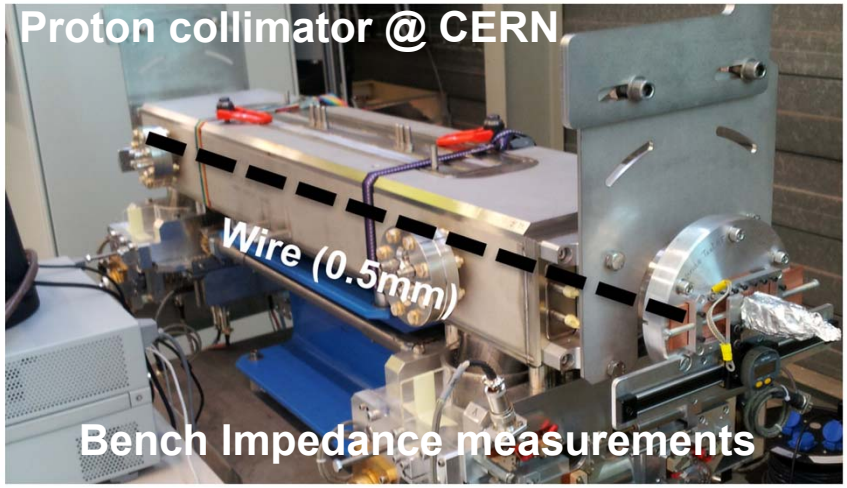
Control of wakefield and impedances (few examples)





Damped cavity Dafne @ LNF



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