



Status of I-LUCE

Jan, 2024

Pablo Cirrone, INFN-LNS



Lasers and particle
acceleration?

3

A laser

- High power (TW - PW)
- Short pulse duration (ps - fs)
- Intensity $> 10^{16} \text{ W/cm}^2$

A Target:

- Thin/thick solid/liquid/gassous

...

Other useful things

- High contrast laser
- High quality target fabrication
- High quality wave front-end

.....

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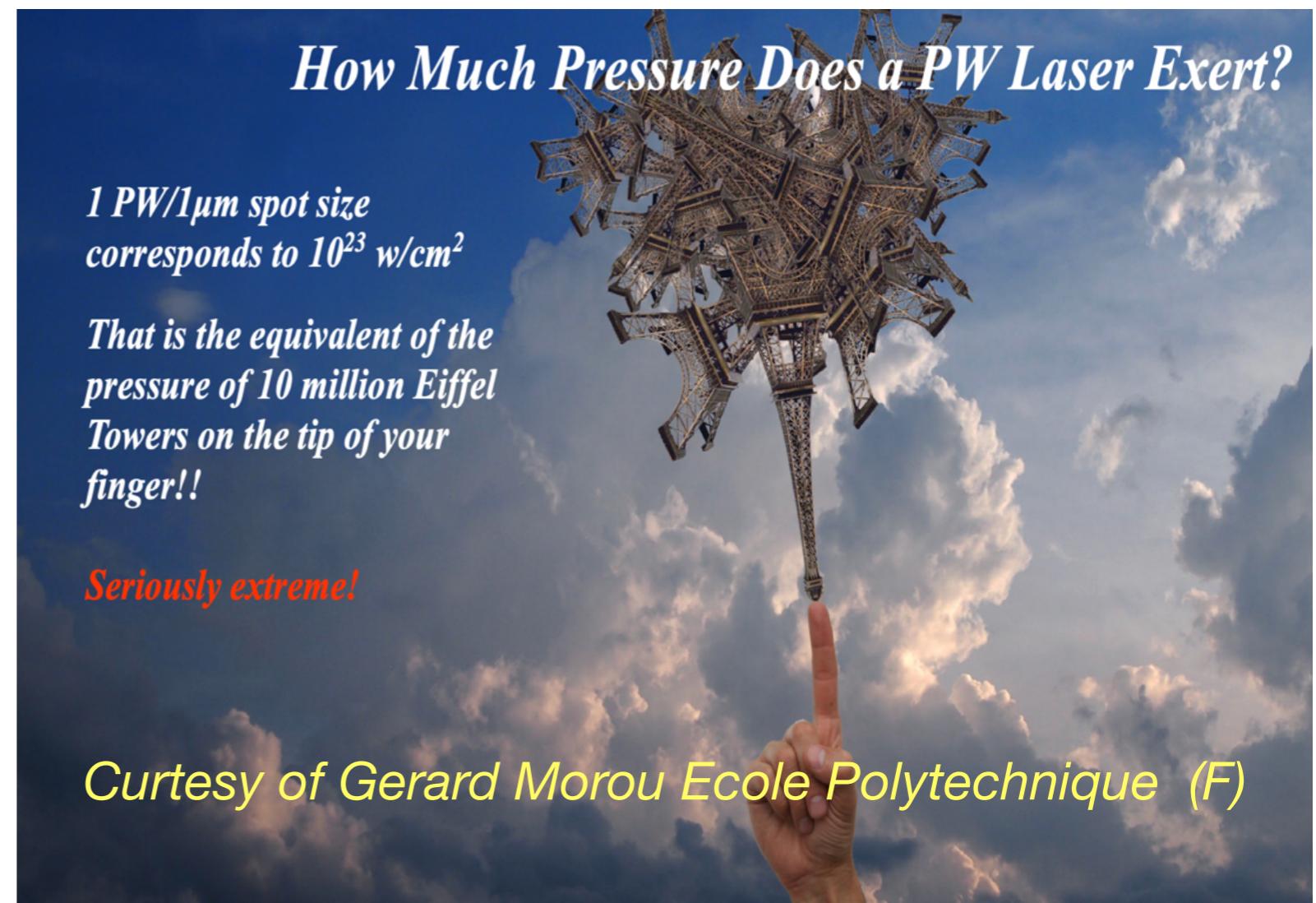
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The main ingredients for radiation productions

4

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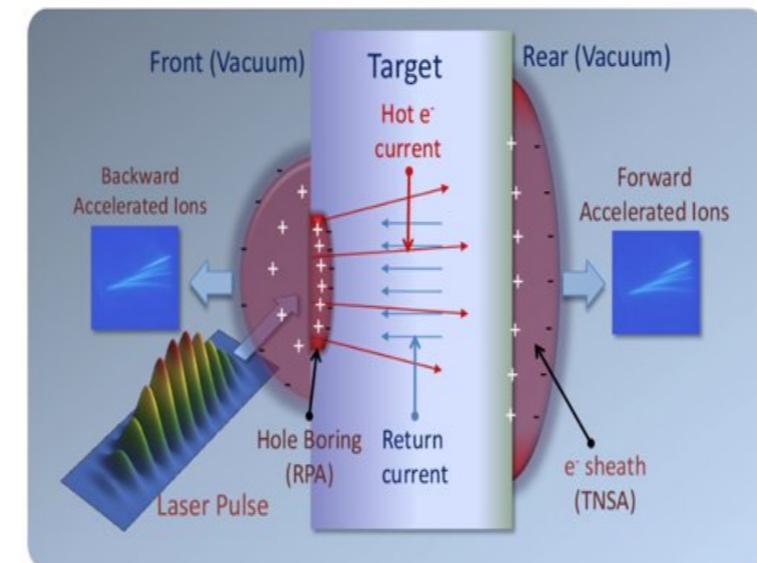
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Laser-solid target interaction for protons, ions acceleration



- Multi species production: g, e-, p, ions

- Emax $\sim 10 \text{ TV/m}$

- Short distance ($\sim \mu\text{m}$)

Proton characteristics

High energy: up to $\sim 100 \text{ MeV}$

Pulse duration $\approx 10\text{s fs} - 100\text{s ps}$

ppb $\approx 10^8-10^{11}$

Broad energy spectra (100%)

Wide angular divergence ($\approx 10^\circ-20^\circ$)

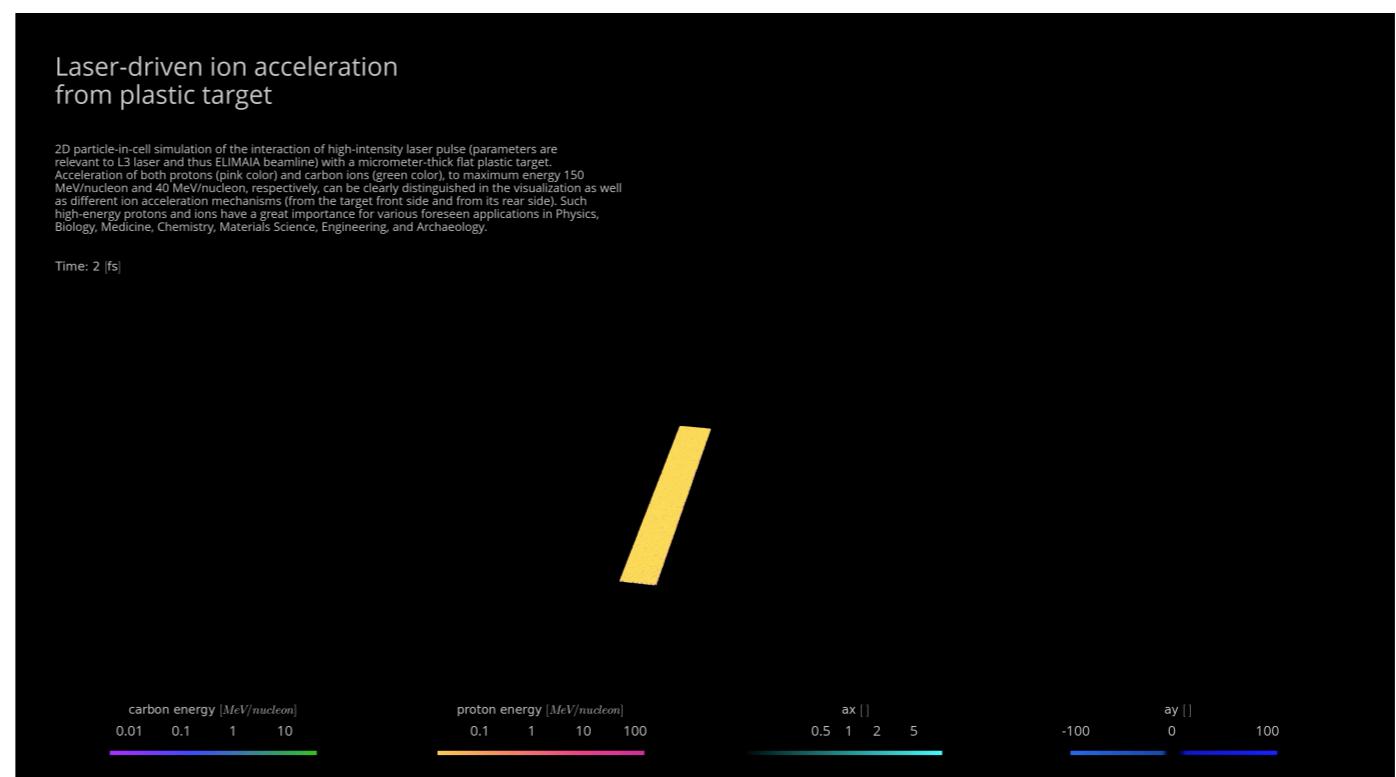
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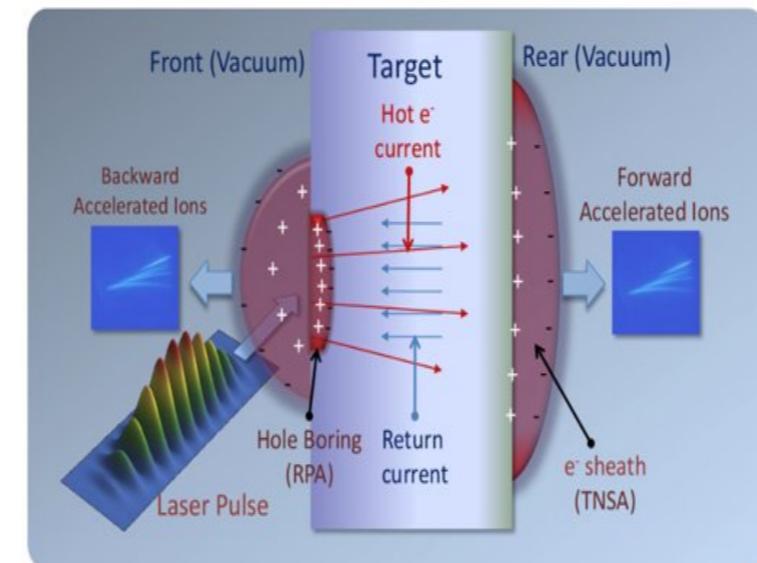
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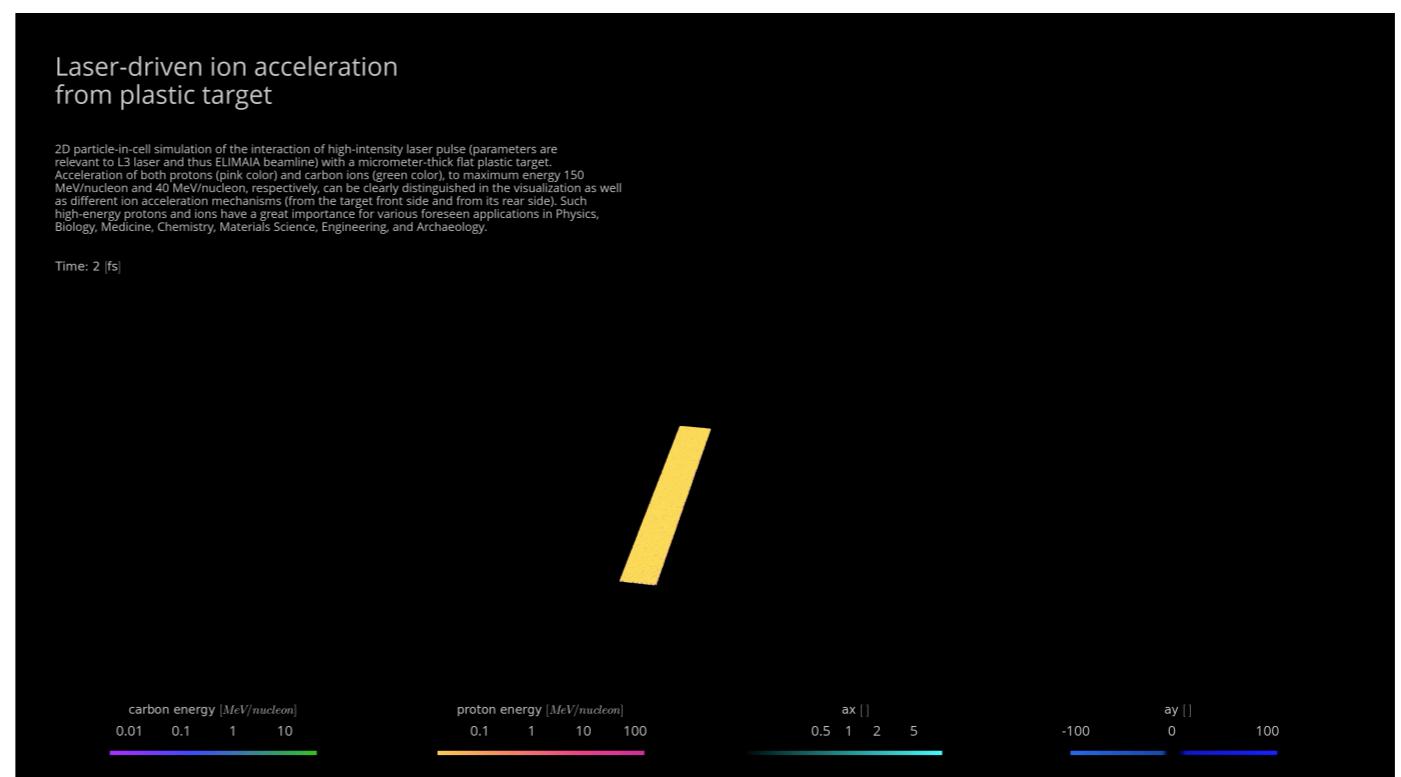
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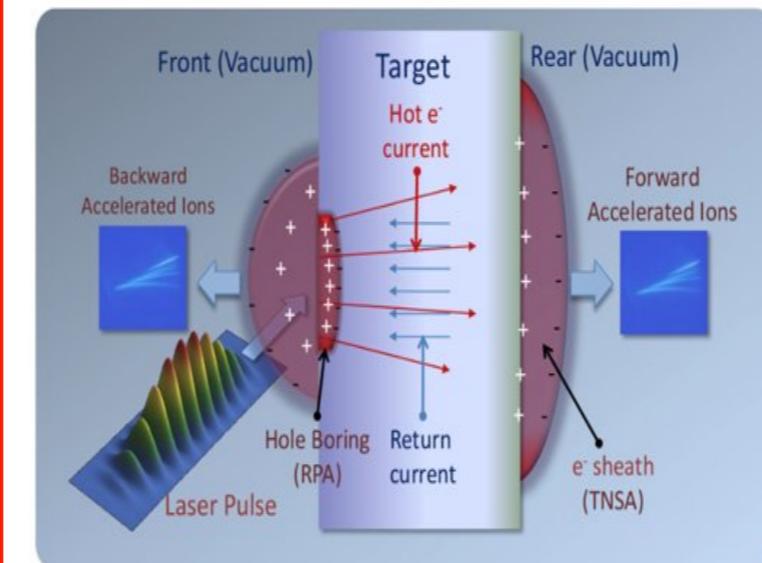
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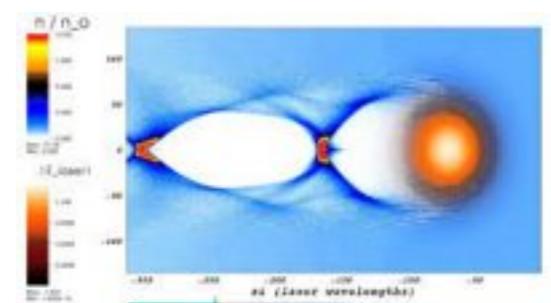
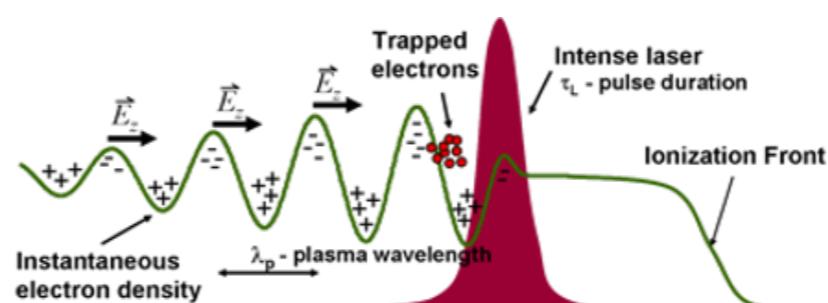
High contrast laser

High quality target fabrication

High quality wave front-end

.... [many other laser and target parameters]

Laser Wake Field Acceleration (LWFA) for electrons

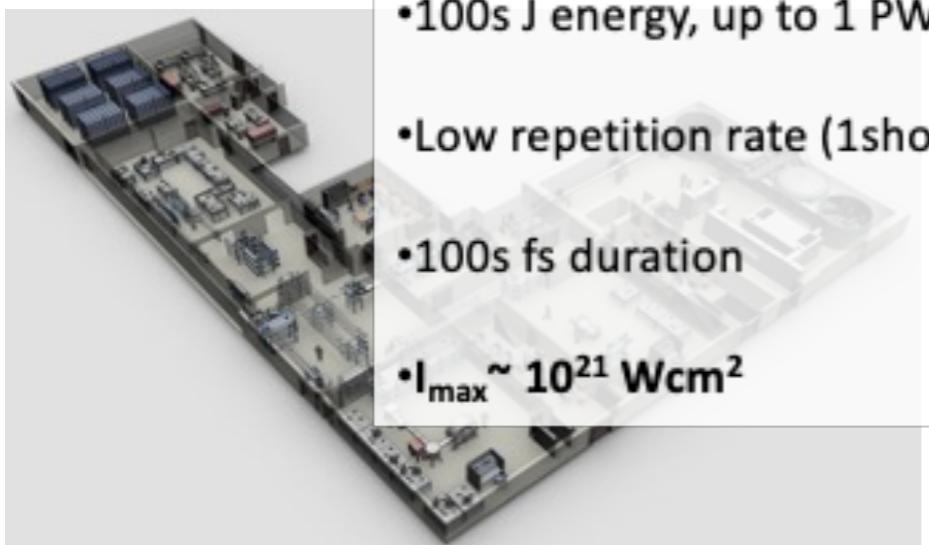


7.8 GeV have been reached at the BELLA (Berkeley Lab) in 2019 using two lasers

Laser plasma ion-acceleration

current facilities

5



High energy CPA systems

- Nd: Glass technology
- 100s J energy, up to 1 PW power
- Low repetition rate (1shot/30min)
- 100s fs duration
- $I_{max} \sim 10^{21} \text{ Wcm}^2$

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VULCAN, RAL (UK)
Phelix, GSI (De)
Texas PW (US)

...

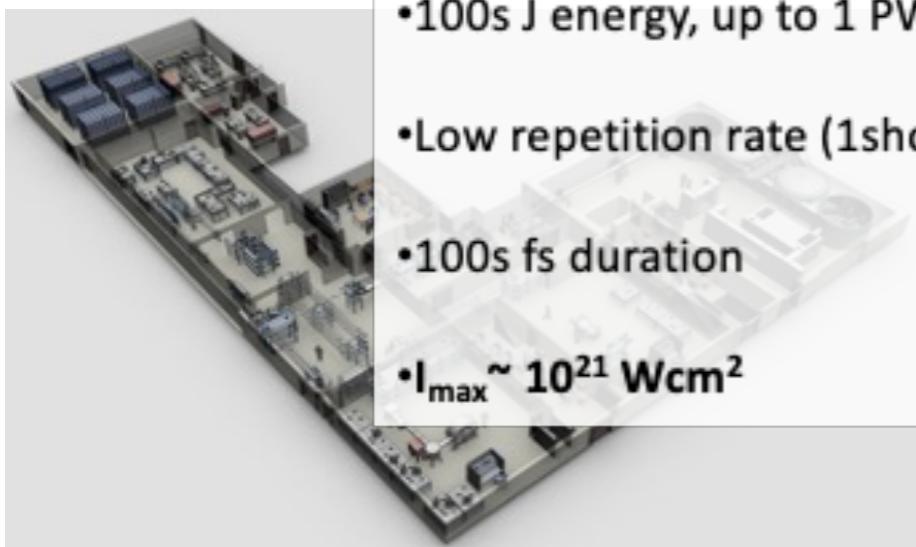
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10 PW (1.5kJ/150fs)

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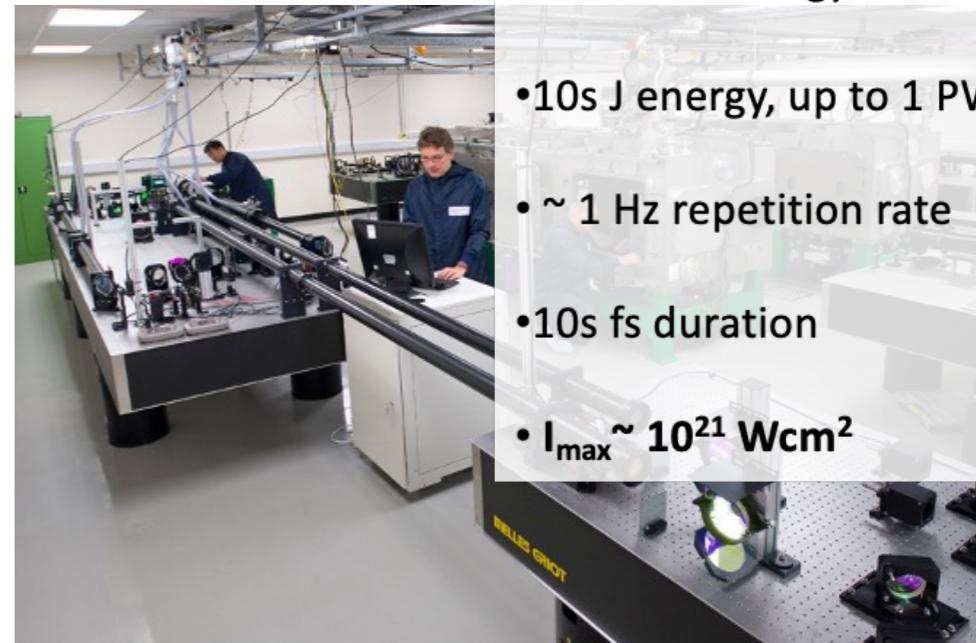
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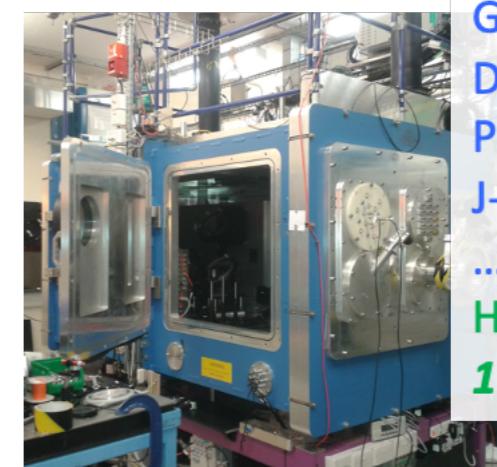
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Ultrashort CPA systems

- Ti:Sa technology
- 10s J energy, up to 1 PW power
- ~ 1 Hz repetition rate
- 10s fs duration
- $I_{max} \sim 10^{21} \text{ Wcm}^2$

$I_{max} \sim 10^{21} \text{ W/cm}^2$

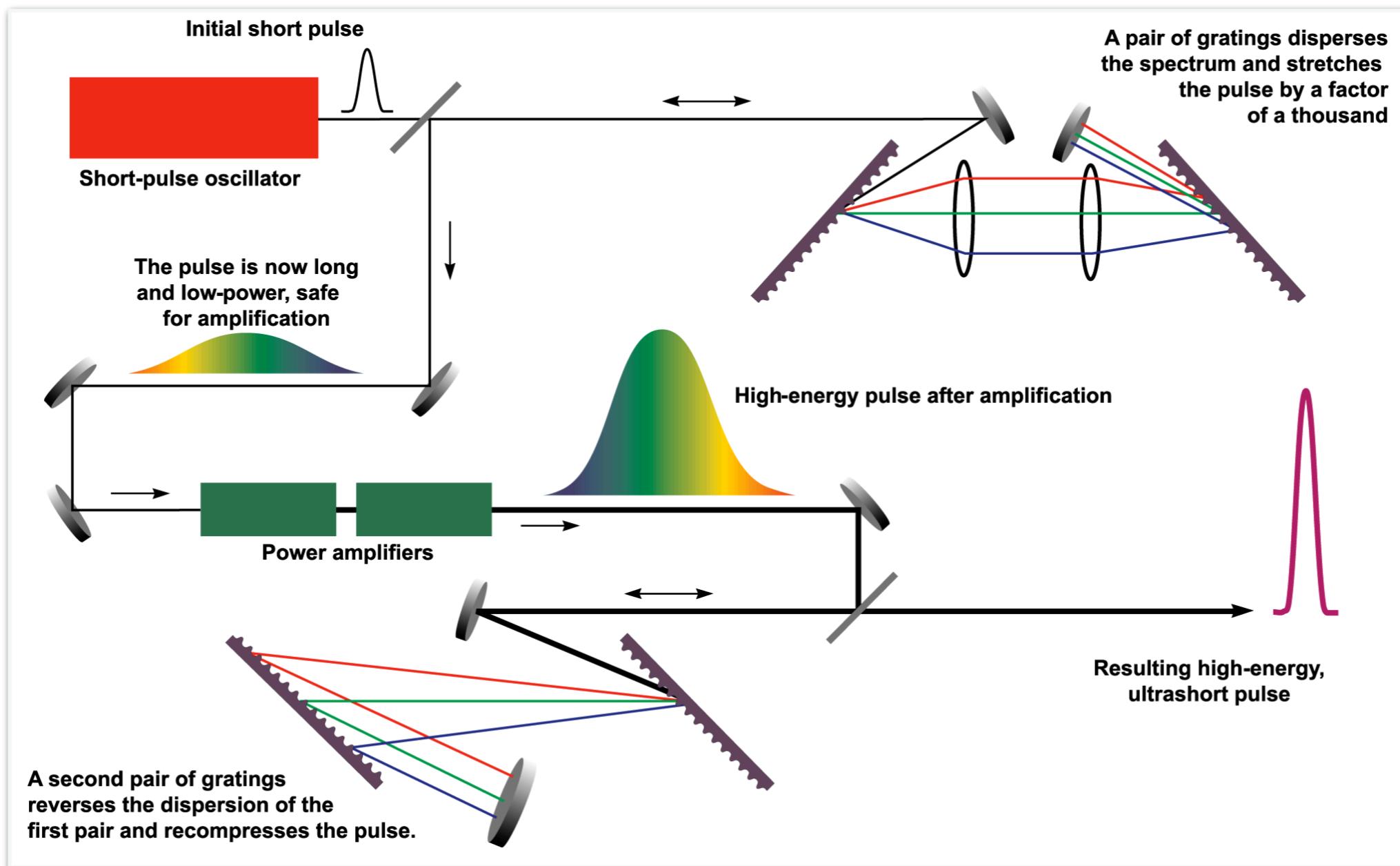
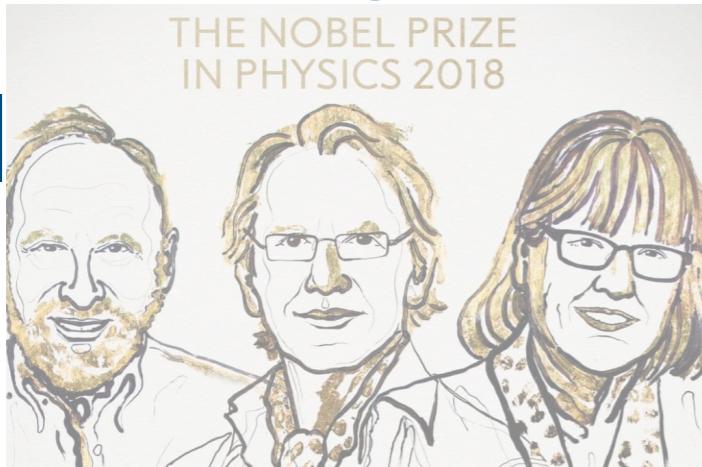


GEMINI, RAL (UK)
Draco, HZDR (De)
Pulser I, APRI (Kr)
J-Karen, JAEA (J)
...
HAPLS-L3, (ELI Beamlines)
1 PW (30J/30fs/10Hz)

$E_{max} \sim 70-110 \text{ MeV}$

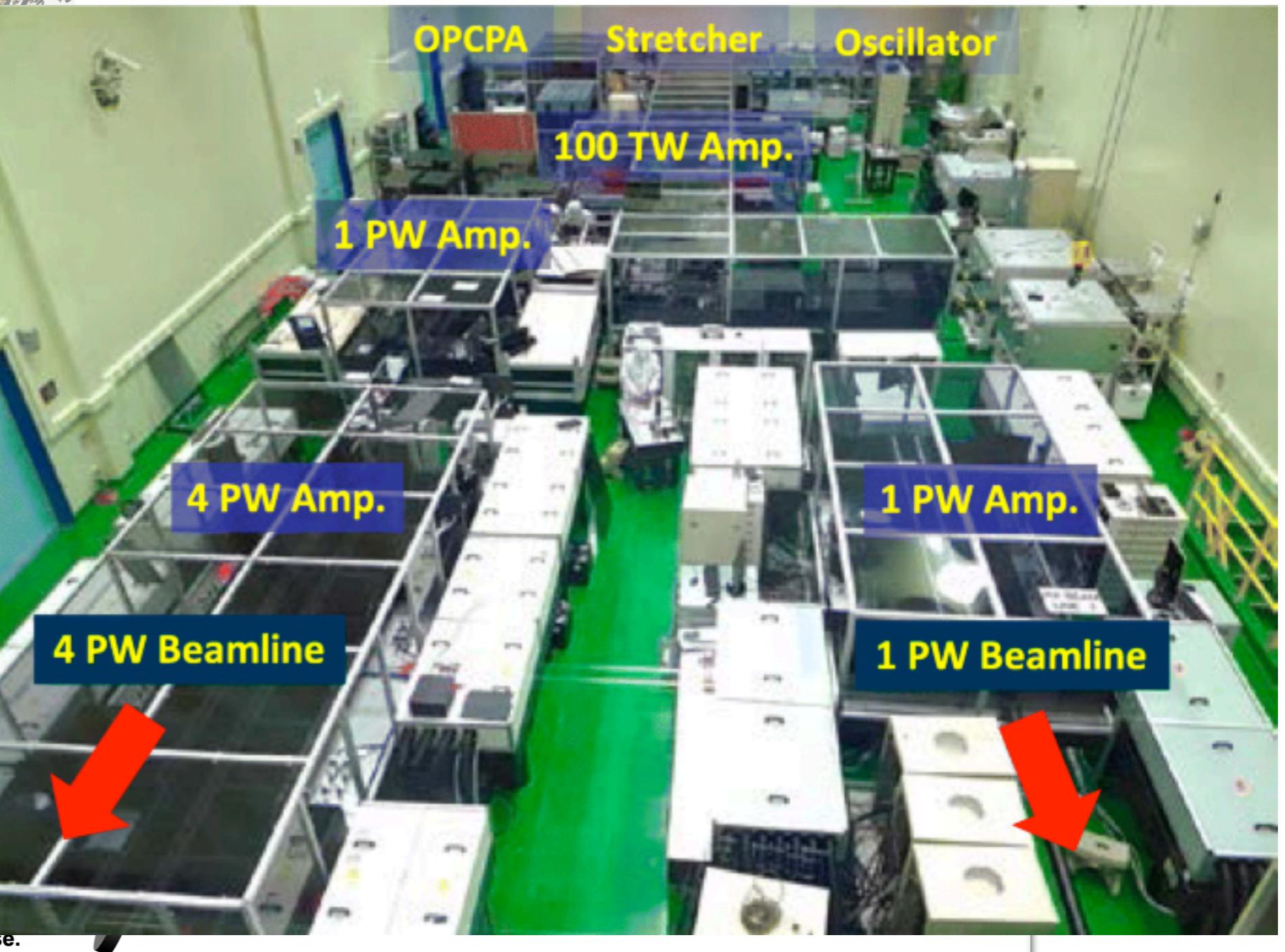
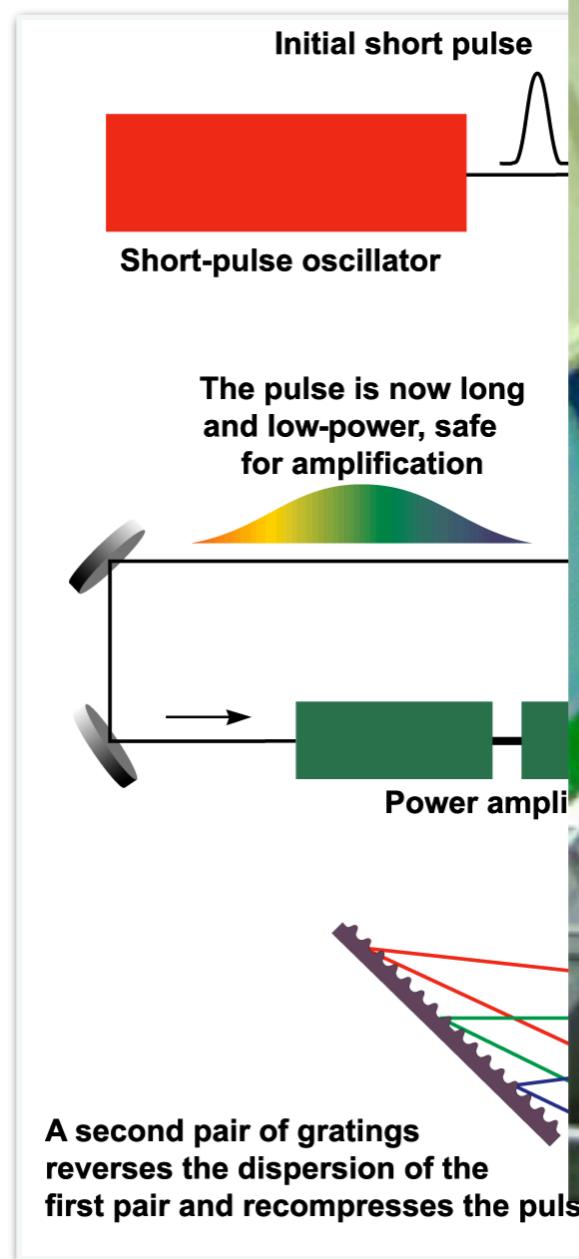
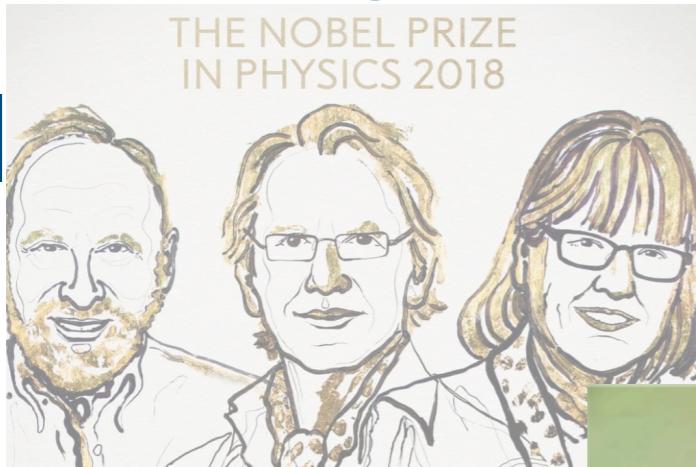
The basic ingredients: an high-power, short-pulse laser

6



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6



Center for Relativistic Laser Science

Explore the interaction between ultra-intense light and matter

South Korea

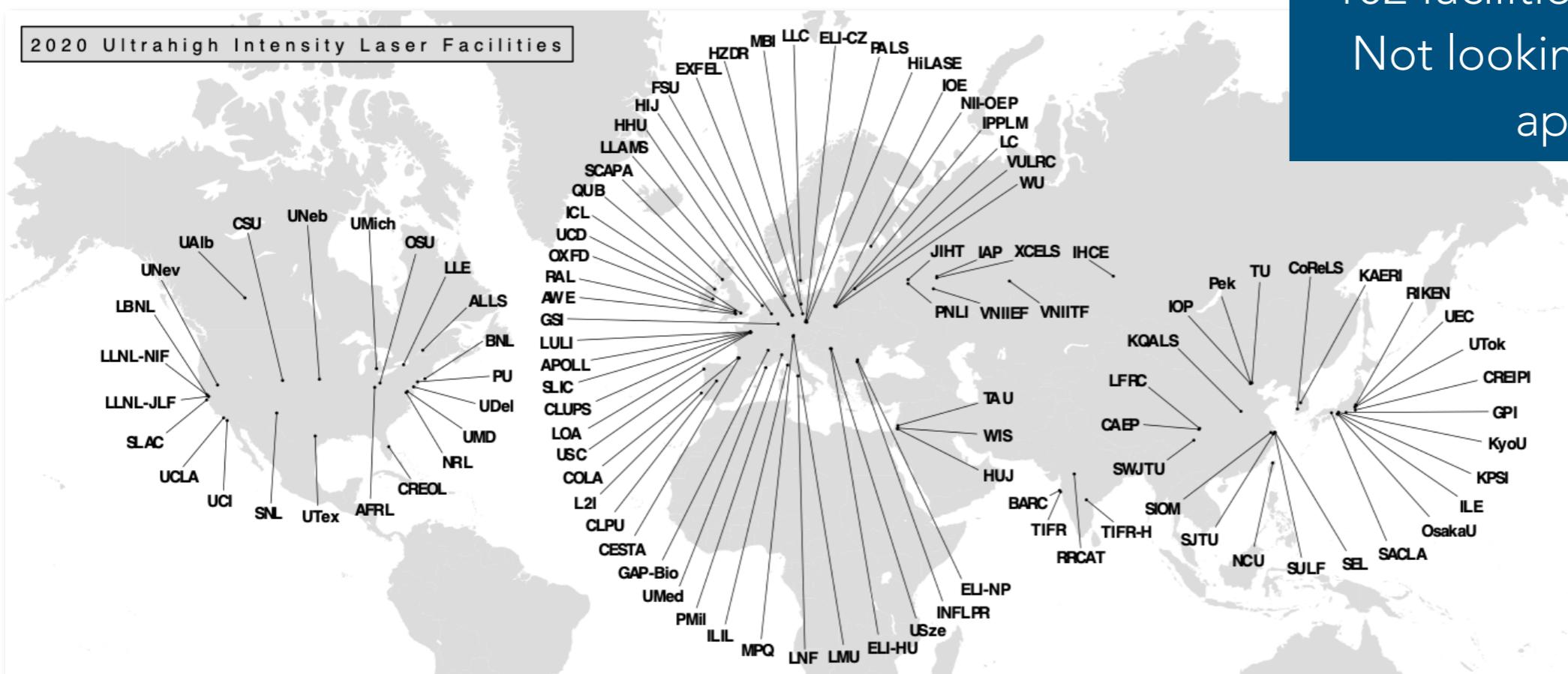
2020 world lasers facilities



Istituto Nazionale di Fisica Nucleare

7

102 facilities (approx > 1TW)
Not looking to the specific application



International Committee on Ultrahigh Intensity Lasers	
www.icull.org	
AFLR	Air Force Research Laboratory
ALLS	Advanced Laser Light Source
APOLL	APOLLON at Université Paris-Sud
AVCE	Atomic Weapons Establishment
BARC	Bhabha Atomic Research Centre
BNL	Brookhaven National Lab, ATF
CAP	Chinese Academy of Engineering Physics
COLA	Centre Optique et Laser en Aquitaine
CPLU	Centre de Physique et Techniques d'Aquitaine
CLIPS	Laser Center of the University of Paris - Sud
CoReLS	Center for Relativistic Laser Science
CREP	Central Research Institute of Electric Power Industry
CREOL	Center for Research in Electro-Optics and Lasers
CSU	Colorado State University
EIL-HU	Extreme Light Infrastructure Attosecond Light Pulse Source
EIL-CZ	Extreme Light Infrastructure Beamlines
EIL-HP	Extreme Light Infrastructure Nuclear Physics
	Dayton
	Varianes
	Saclay
	Aldermaston
	Mumbai
	Upton
	Menyang
	Bordeaux
	Le Bourget
	St. Petersburg
	Paris
	Georgia
	Yerevan
	Orlando
	Port Collins
	Seagard
	Dolni Březiny
	Magurele

FSU	IOW-Friedrich-Liste, University of Jena	Jena
GFZ-Bio	Universität Bremen, Geo-Biosphären	Cologne
Graduate School	for the Creation of New Photonics Industries	Hannover
GG	GG-Helmholtzzentrum für Schwerionenforschung GmbH	Darmstadt
HJU	Heinrich Heine Universität	Düsseldorf
HH	Helmholtz Institute Jena	Jena
HILAS	HLAISE	Dohn Bræse
HU	Hebrew University of Jerusalem	Jerusalem
HZDR	Helmholtz Zentrum Dresden - Rosendorf	Dresden
IAF	Institute of Applied Physics, Russian Academy of Sciences	Nizhny Novgorod
ICL	Imperial College London	London
IEE	Institute of Electrical Engineering	Toronto
IECE	Institute for Laser Engineering, Osaka University	Osaka
ILRF	Interstate Linear Radiation Laboratory	Pas
INFLIR	National Institute for Laser, Plasma, and Radiation Physics	Magnesrale
IPPT	Instytut Optoelektroniki, Wroclaw Akademia Technologii	Warsaw
IPR	Institute of Physics, Chinese Academy of Sciences	Beijing
IPPLM	Institute of Plasma Physics and Laser Microfusion	Moscow
JHT	Joint Institute for High Temperatures	Moscow
KARI	Korean Atomic Energy Research Institute	Seoul
KPS	Karen Photon Science Institute	Kiazugou

Ryu	Kyoto University, Institute for Chemical Research	Kyoto
Lam	Lam Research Corp.	Bethel
LBNL	Lawrence Berkeley National Laboratory	Walton
LC	Centrum Laseres, Instytutu Chemii Fizycznej	Marymont
LFRC	Laser Fusion Research Center at the GIP	Armento
LLAM	LaserLab Amsterdam	Lund
LLC	Lund Laser Center	Rochester
LLE	Laboratory for Laser Energetics	Urbana-Champaign
LNL-JNL	Lawrence Livermore National Lab - National Ignition Facility	München
LNL-JLF	Lawrence Livermore National Lab - Jupiter Laser Facility	Potsdam
Ludwig	Ludwig-Maximilians-Universität	Potsdam
LUR	Laser und Ultrahochfrequenz Institut für Praktische, SPARC Lab	Garching
LXa	Laboratoire d'Optique Appliquée-ENSTA-Ecole Polytech.	Taejon
LULI	Laboratoire pour l'Utilisation des Lasers Intenses	Covelo
MB	Max Born Institute	Washington
MPQ	Max Planck Institute for Quantum Optics	Oss
NCL	National Central University	Columbus
NIR-OEP	Scientific Research Inst. for Optoelectronic Instrum. Engin.	Osaka
	NRL Naval Research Laboratory	Scarlet
OtsukaU	Osaka University	Laser
OSU	Ore State University, Scarlet Laser Facility	State

IALS	Peking University Laser System Research Centre	P
IPR	Rutgers University	P
PAMI	Delft University	M
PLRI	PLA Lanzhou Institute of Russian Academy of Science	L
PU	Princeton University, Extreme Light-Matter Interactions Lab	P
QUB	Queen's University Belfast, Centre for Plasma Physics	P
NAL	STFC Rutherford Appleton Laboratory, Central Laser Facility	F
REGEN	Nagoya University, Kenkyusho	T
FRICAT	Rajya Ramanna Centre for Advanced Technology	I
SACLAC	SFSL 8 GeV Acmpton Free Electron Laser	S
SCOPA	Scottish Center for the Appl. of Plasma-based Accelerators	C
SESR	State Key Laboratory of Electronic Thin Film and Photovoltaic Materials	C
SDOM	Sichuan University of Optics and Fine Mechanics	C
SJTU	Shanghai Jiao Tong University	S
SLAC	Stanford Linear Accelerator Center	S
SLIC	Saclay Laser-matter Interaction Center	C
SNL	Sandia National Laboratory	J
SULF	Shanghai Superintense Ultralaser Facility	S
SWITU	Southwest Jiaotong University	S
TAU	Tel Aviv Univ., Intense Lasers and ULtralaser Science Group	T
TIFR	Tata Institute of Fundamental Research	I

TU	Taipei University	Bething
UBC	University of Alberta	Edmonton
UCD	University College Dublin	Dublin
UCI	University of California, Irvine	Irvine
UCLA	University of California, Los Angeles	Los Angeles
UDel	University of Delaware	Newark
UEC	University of Electro-Communications Inst. for Laser Science	Tokyo
UMD	University of Maryland	College Park
UMed	Université de Méditerranée, Laboratoire LP3	Marseille
UMich	University of Michigan, Center for Ultracold Atomic Science	Ann Arbor
UNebr	University of Nebraska-Lincoln, Extreme Light Laboratory	Lincoln
UNev	University of Nevada at Reno, Nevada Terawatt Facility	Reno
UNCL	University of New Mexico, Los Alamos	Santos
UNice	University of Nice Sophia Antipolis	Seinged
UTex	University of Texas at Austin	Austin
UTok	University of Tokyo, Institute for Solid State Physics	Tokyo
VNIIF	IFIIC-All-Russian Research Institute of Experimental Physics	Sarov
VNSTF	IFIIC-Russian Research Institute of Technical Physics	Chechos
VUJIC	Vilnius University Laser Research Center	Lithuania
WIS	Weizmann Institute of Science	Rehovot
WU	Warren University, Ultrafast Phenomena Lab	Wasew

From ICUIL (International Committee on Ultra-High Intensity Lasers)
<https://www.icuil.org/>



Let's concentrate on
ion acceleration

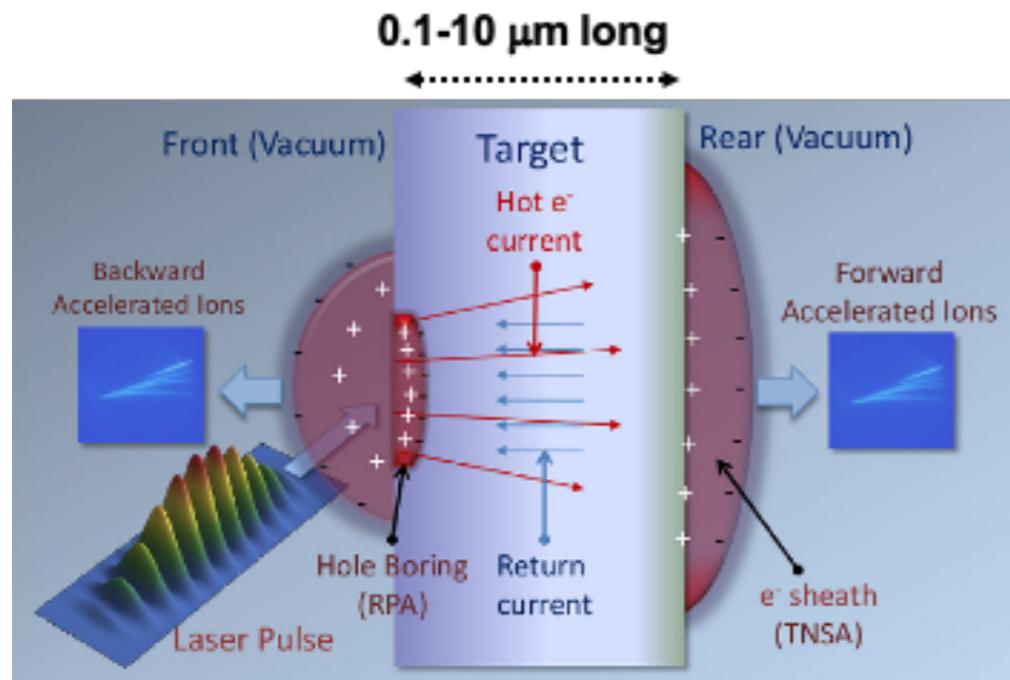
Laser plasma ion-acceleration

physical picture



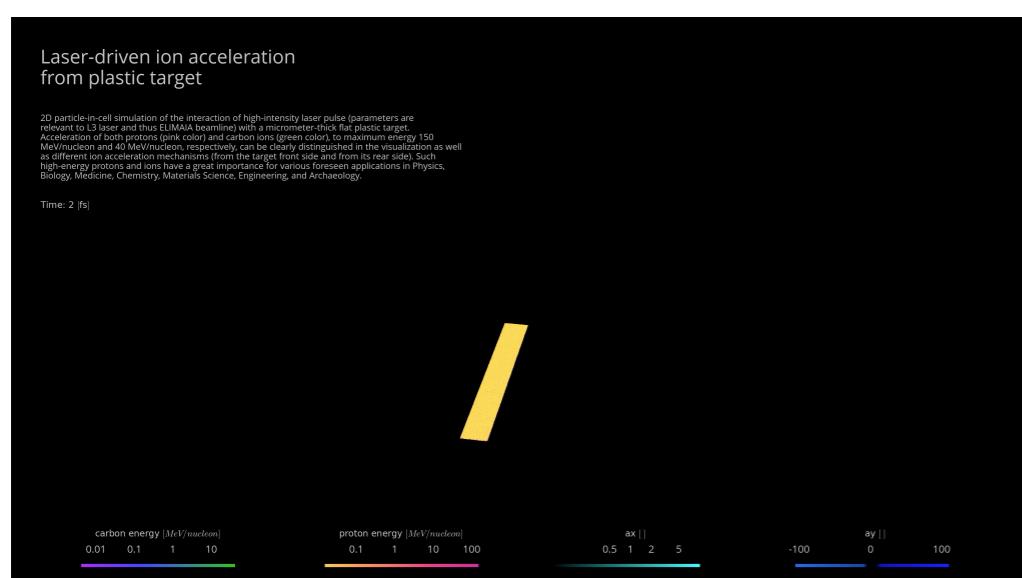
9

Target Normal Sheath Acceleration



REVIEW PAPERS:

- Macchi, Borghesi, Passoni, *Rev. Mod. Phys.* 85 (2013) 751
- Borghesi et al, *Springer Proc. Phys.* 231 (2019) 143



Role of the ponderomotive force on electrons energy gain

In an oscillating, quasi-monochromatic electromagnetic field described by a vector potential $\mathbf{a}(\mathbf{r},t)$, the relativistic ponderomotive force is given by:

$$f_p = - m_e c^2 \nabla \sqrt{(1 + \langle a \rangle^2)}$$

$$f_p = \frac{dp^s}{dt} = - mc^2 \nabla \gamma$$

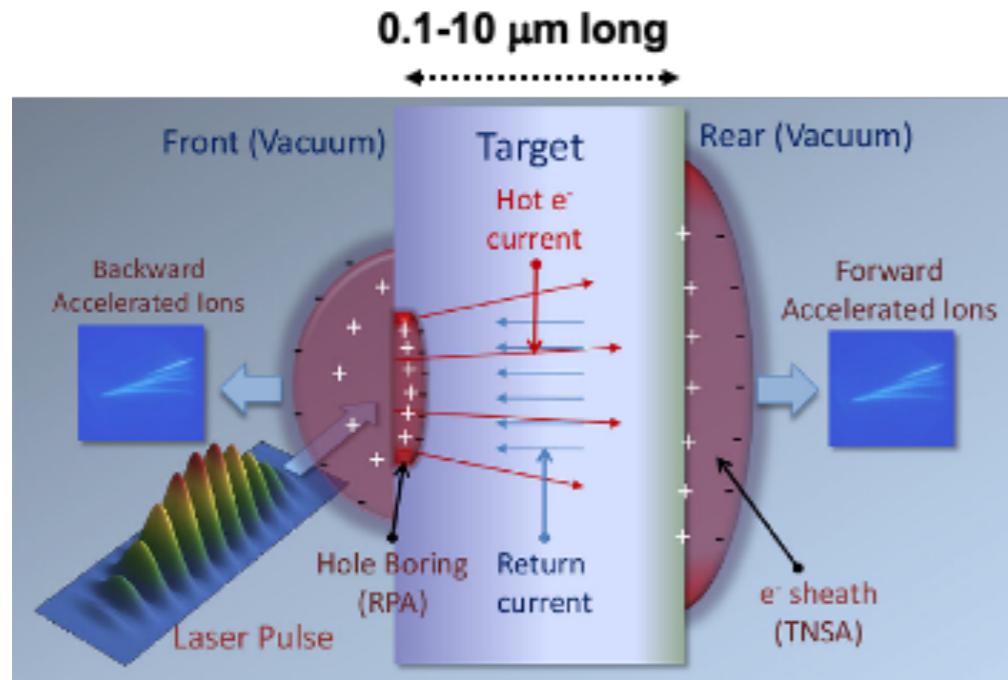
Energy Gain: 100 MeV/um (in a plasma medium)!!!

Laser plasma ion-acceleration

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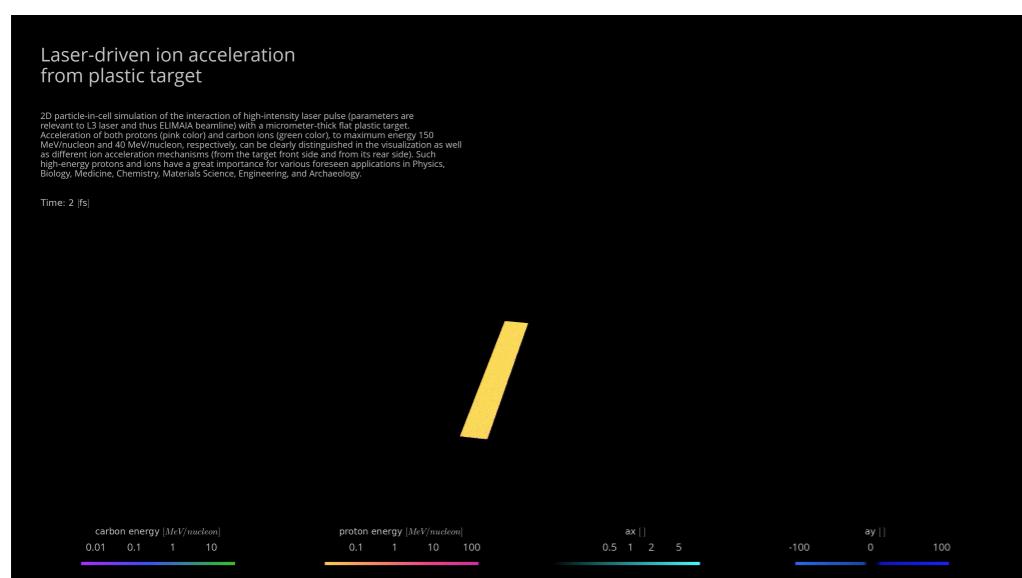
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Maximum proton energy

experimental scaling laws (TNSA)

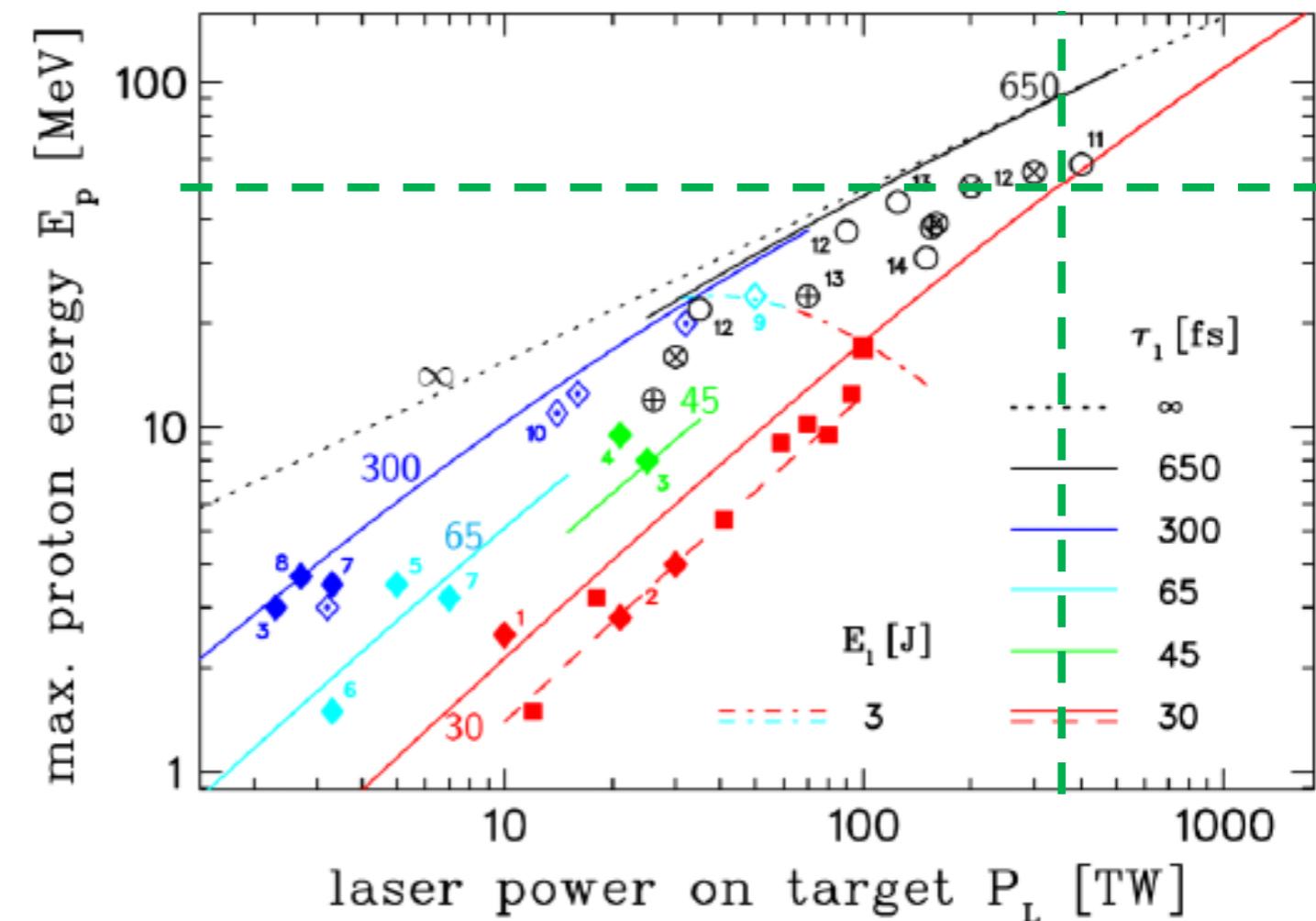
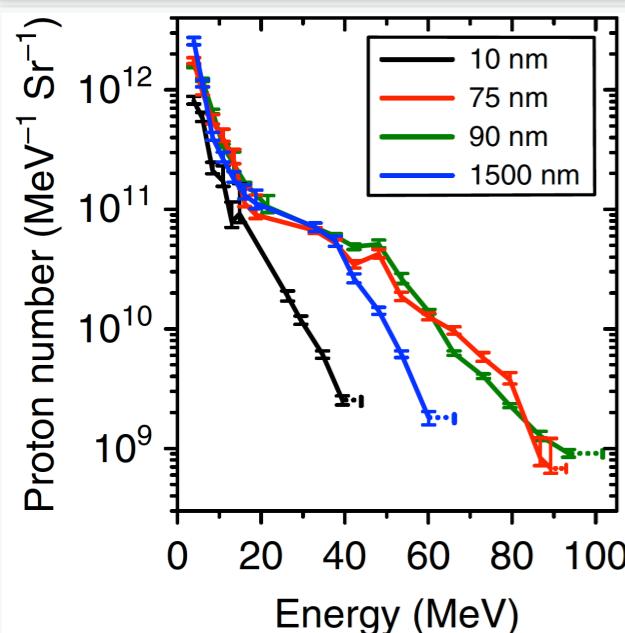
10

ARTICLE

DOI: 10.1038/s41467-018-03063-9 OPEN

Near-100 MeV protons via a laser-driven transparency-enhanced hybrid acceleration scheme

A. Higginson¹, R.J. Gray¹, M. King¹, R.J. Dance¹, S.D.R. Williamson¹, N.M.H. Butler¹, R. Wilson¹, R. Capdessus¹, C. Armstrong^{1,2}, J.S. Green², S.J. Hawkes^{1,2}, P. Martin³, W.Q. Wei⁴, S.R. Mirfayzi^{1,3}, X.H. Yuan⁴, S. Kar^{2,3}, M. Borghesi³, R.J. Clarke², D. Neely^{1,2} & P. McKenna¹



The scaling of proton energies in ultrashort pulse laser plasma acceleration

K Zeil et al 2010 New J. Phys. 12 045015

$$I \propto \frac{E_p}{\tau A}$$

Intensity W/cm^2 proton energy E_p spot surface on target τA
pulse length



I-LUCE at INFN-LNS



INFN Laser indUCEd radiation production

Goal: realisation of a new European laser facility for new beams, new physics and new Users



Roma TV, LNF, Pisa CNR, LNS
15 M€

7.9 M€ WP3 High-Power lasers

Infrastructure

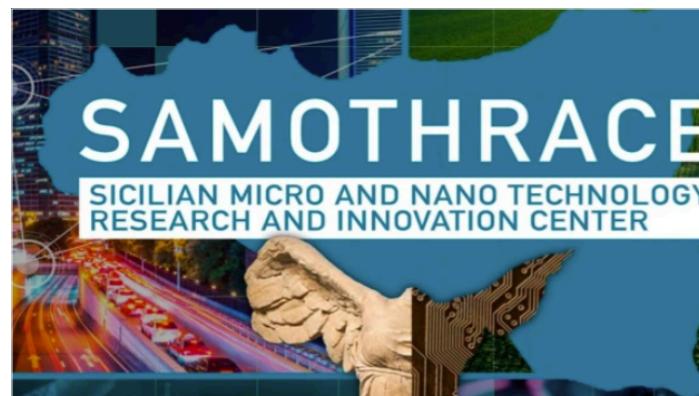
Laser system and interaction chaml



Electrons and ion acceleration

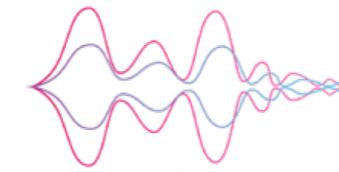


INFN Laser indUCEd radiation production



0.8 M€

Demonstration of a micro-acceleration system for
laser-driven proton beams



Advanced technologies for Human
Centred Medicine

Anthem

23 Istituti; Spoke 4: Caserta, Pavia, INFN

1.3 M€

Electron acceleration for conventional and ultra high
dose rate beams nell'accelerazione di elettroni e UHDR

ew
ew
S

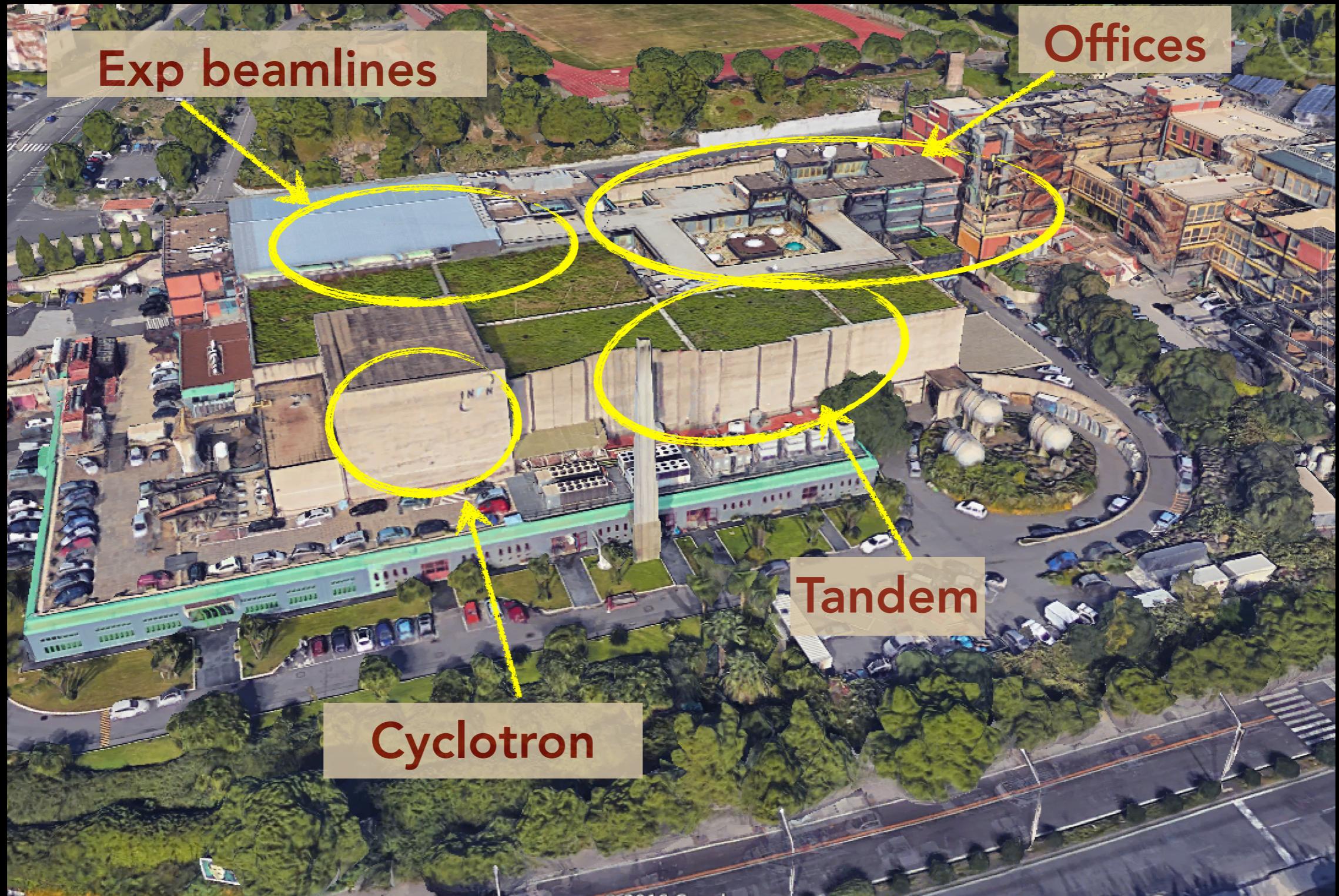
BCT

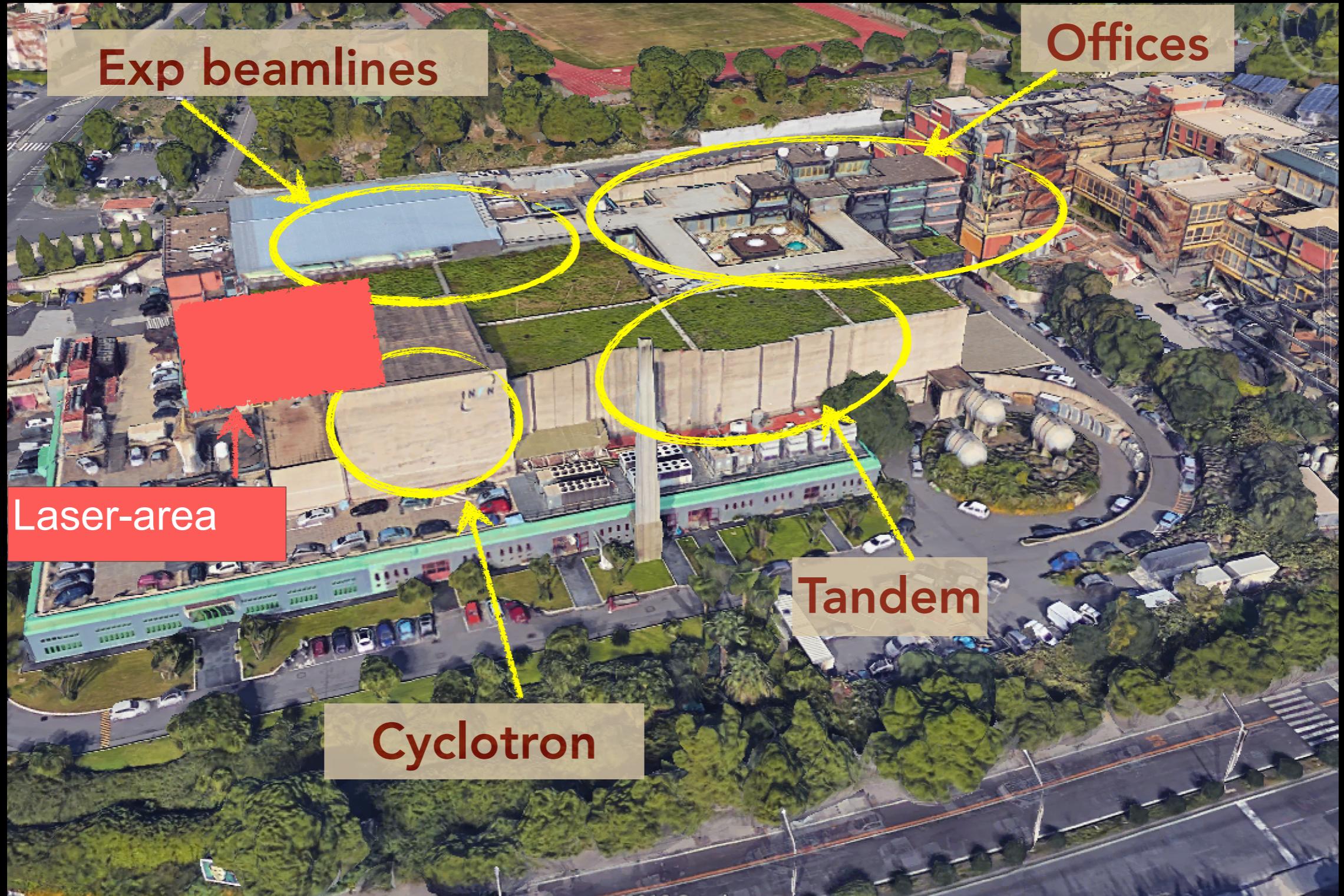
*Breast Cancer
Therapy*

2.0 M€

Ottimizzazione nella selezione di
fasci di protoni per applicazioni
mediche

EW

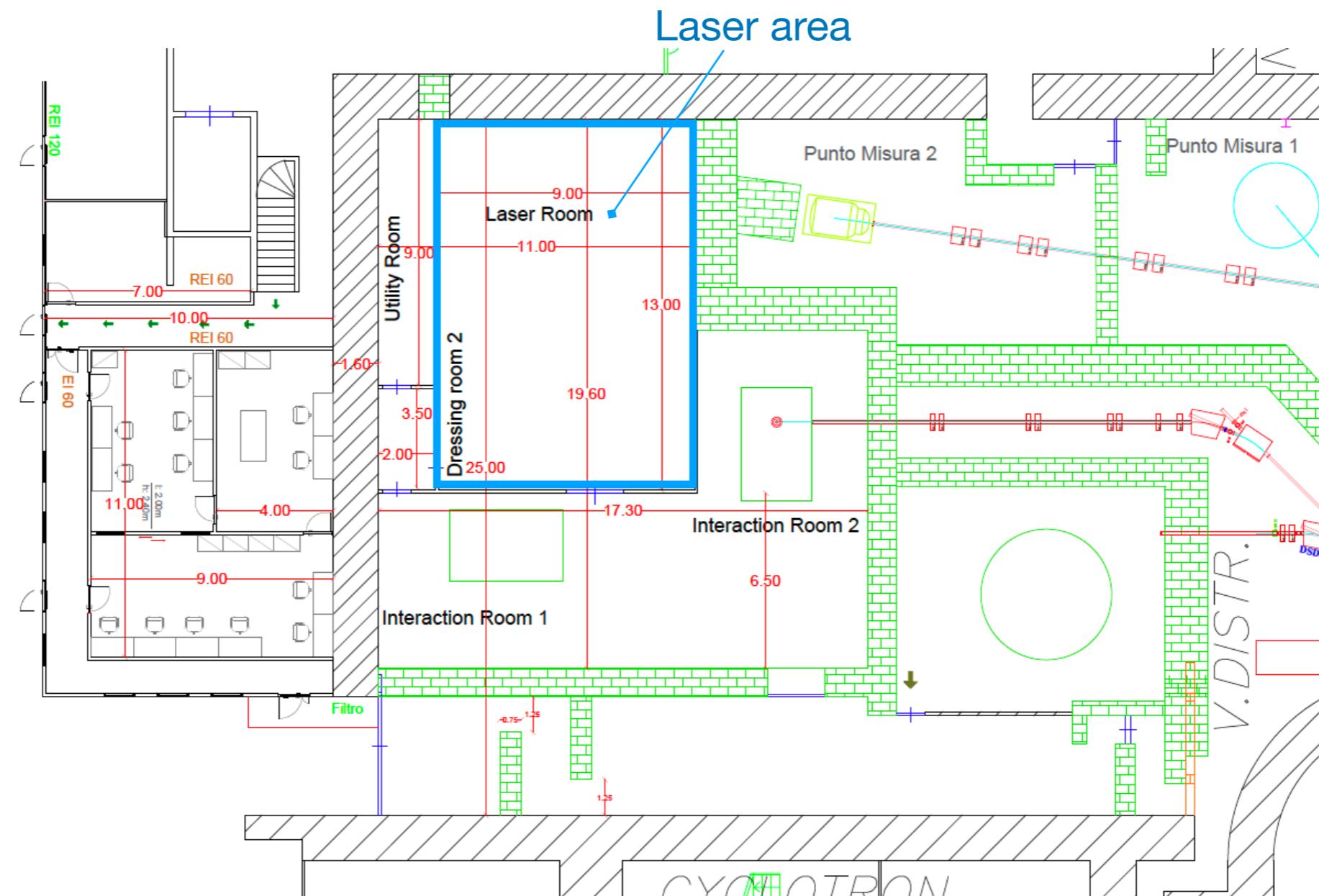




I-LUCE layout



14

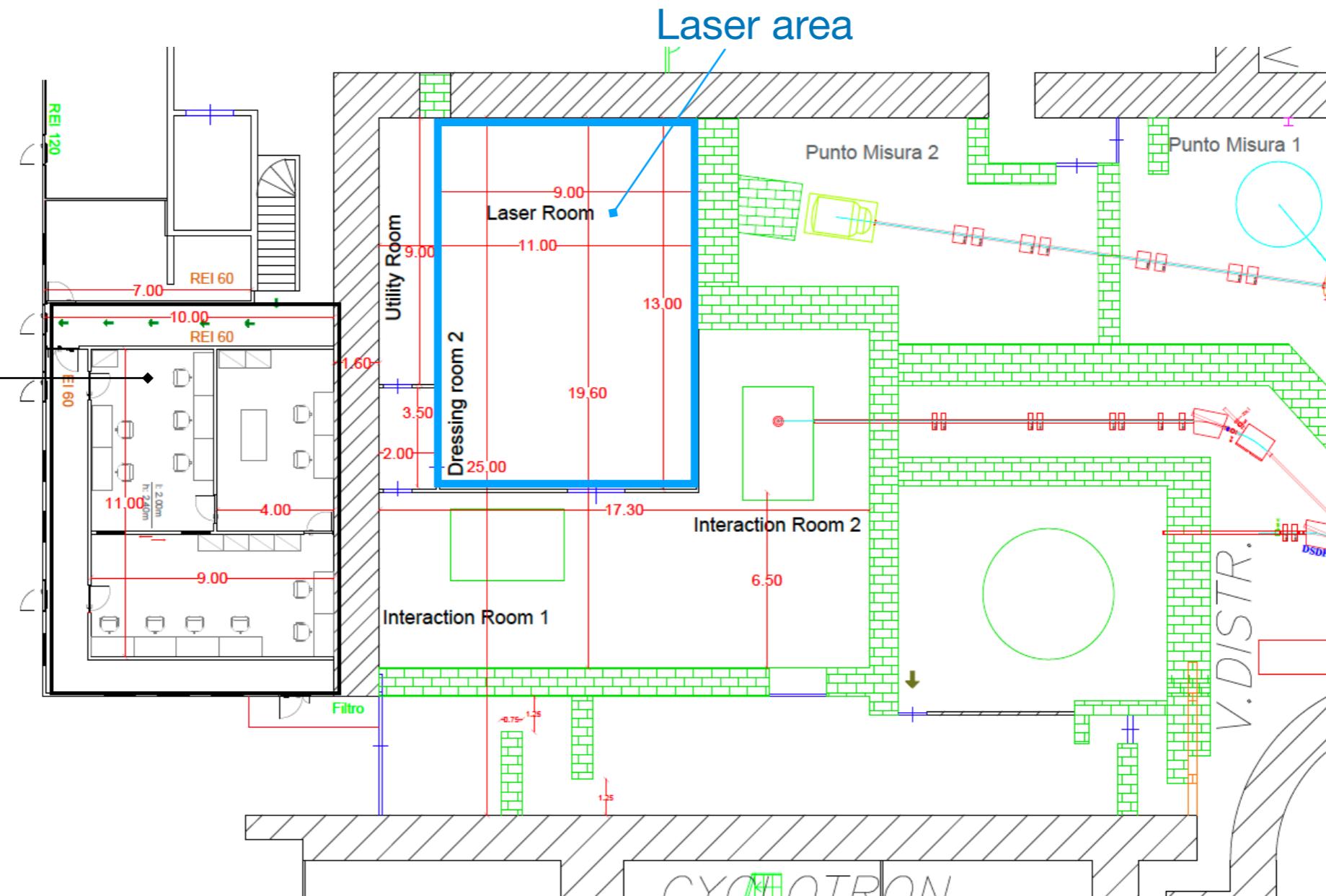


I-LUCE layout



14

Control and
Users' area



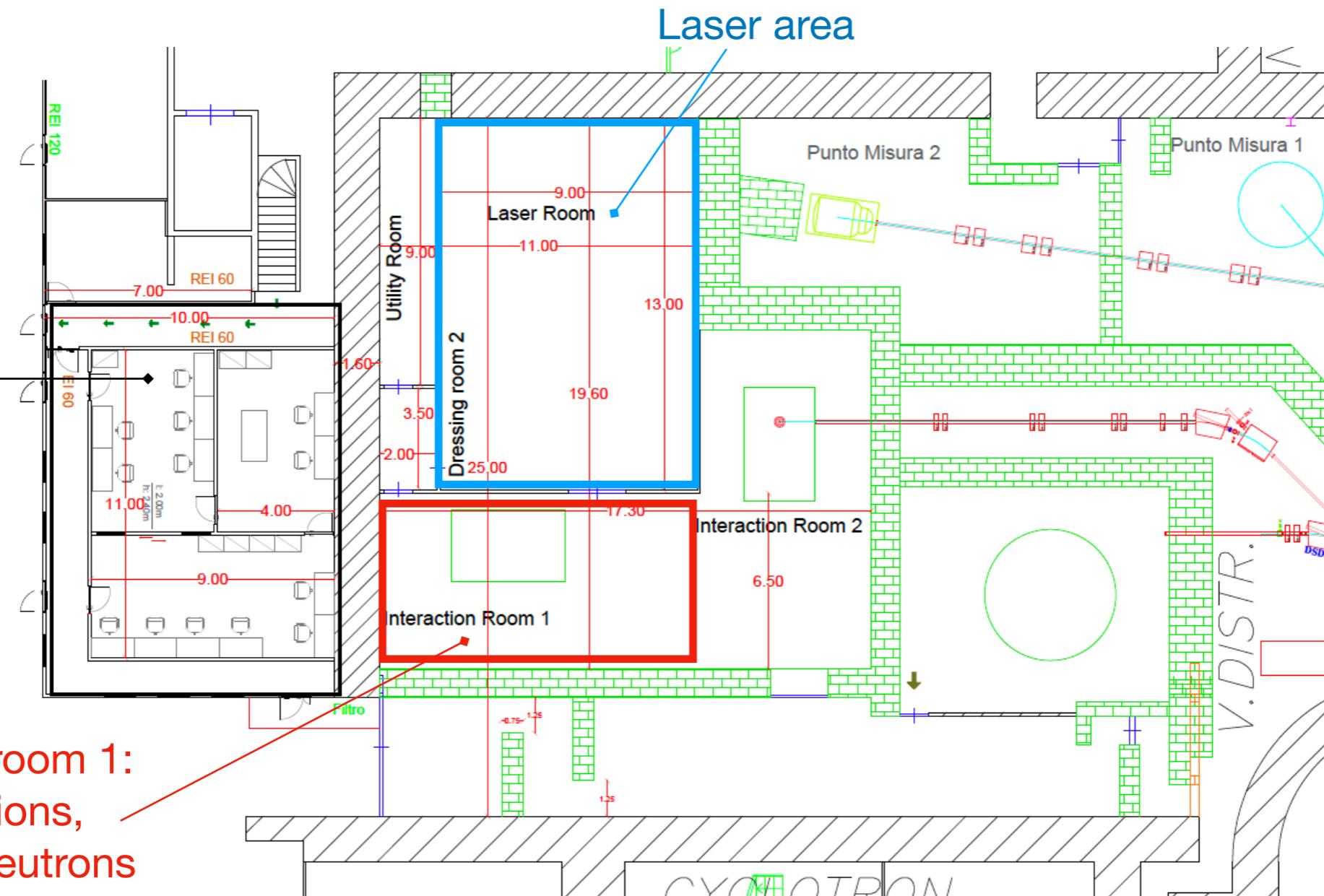
I-LUCE layout



14

Control and
Users' area

Interaction room 1:
protons, ions,
electrons, neutrons
accelerations

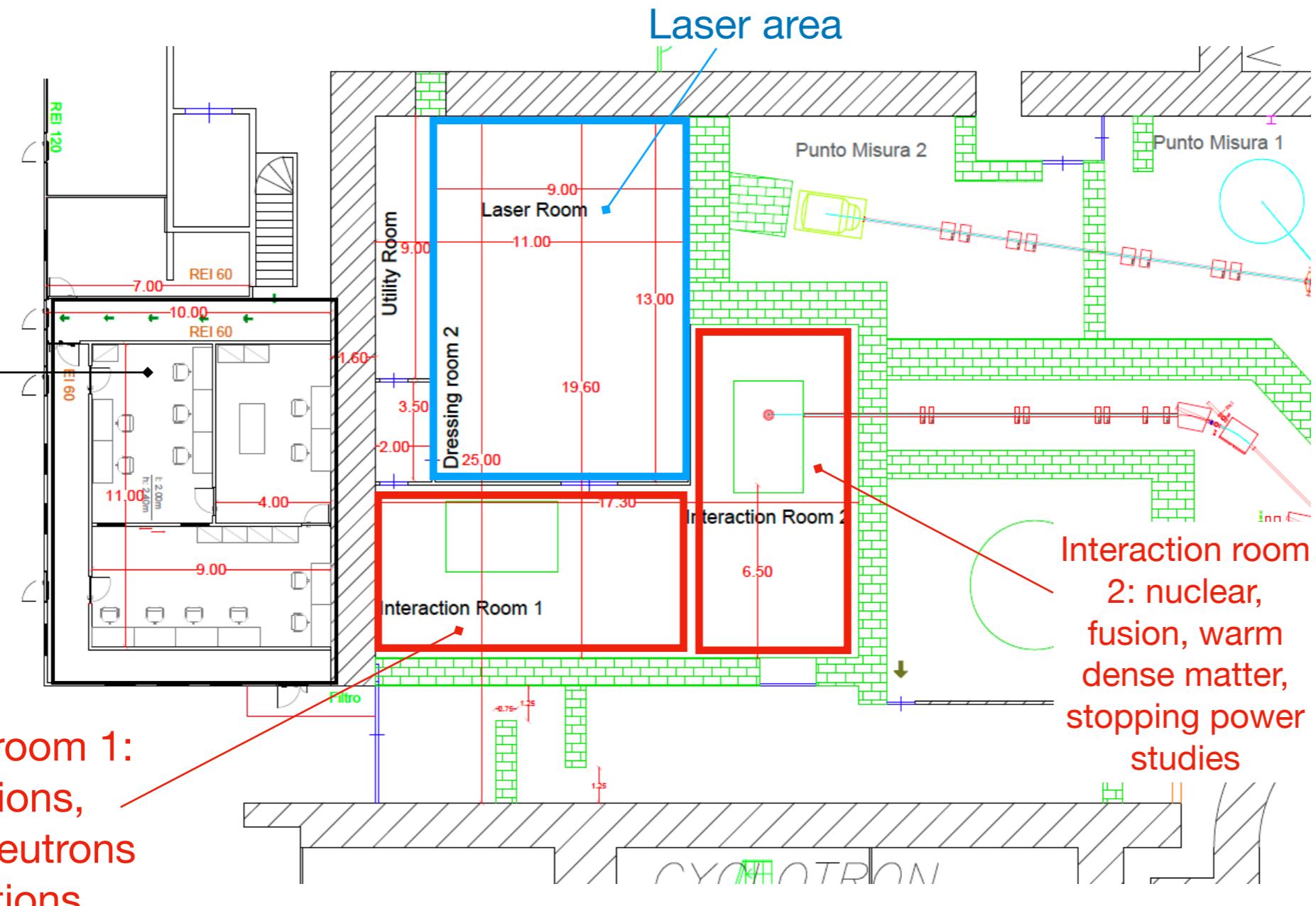


I-LUCE layout



14

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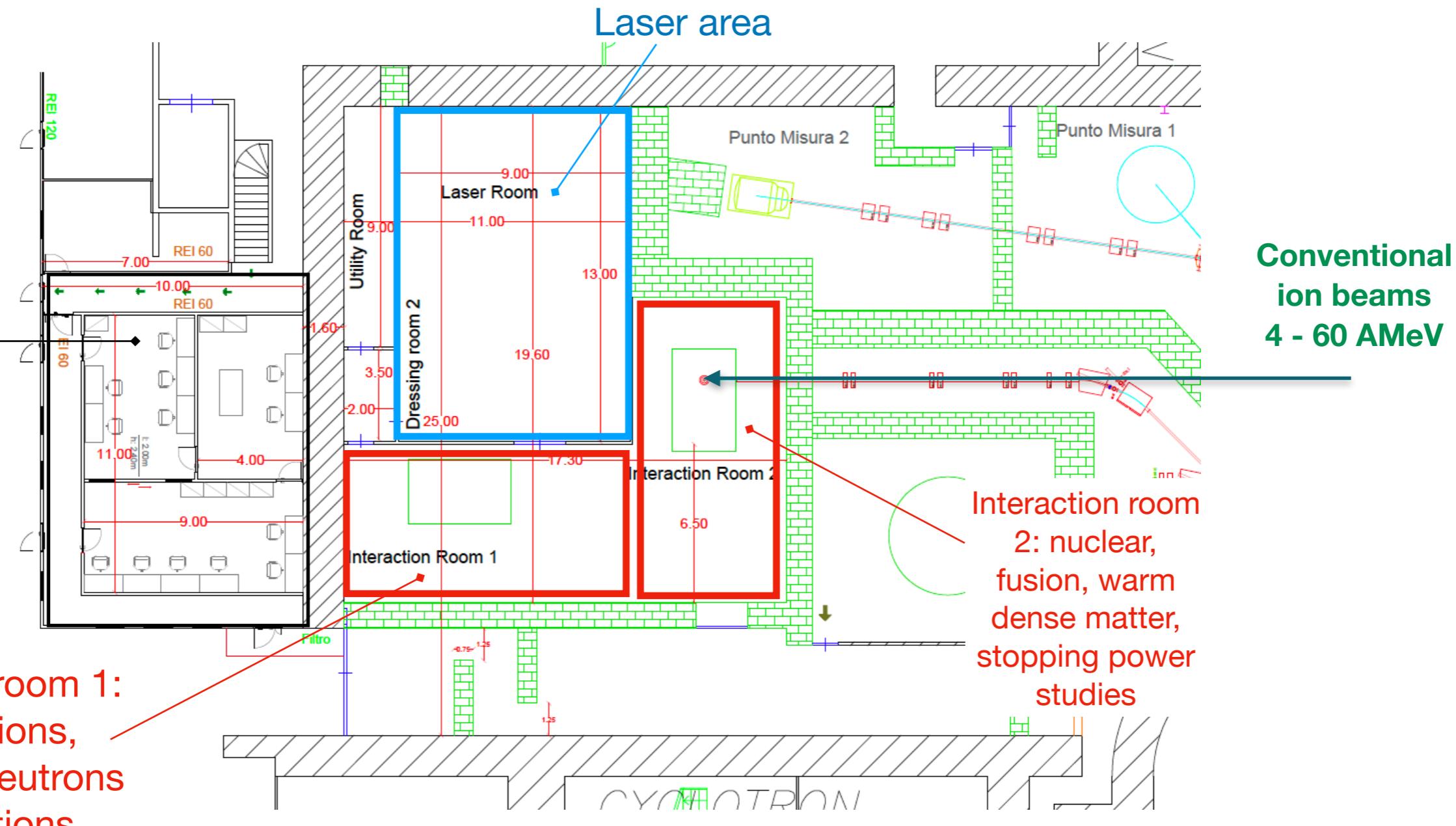


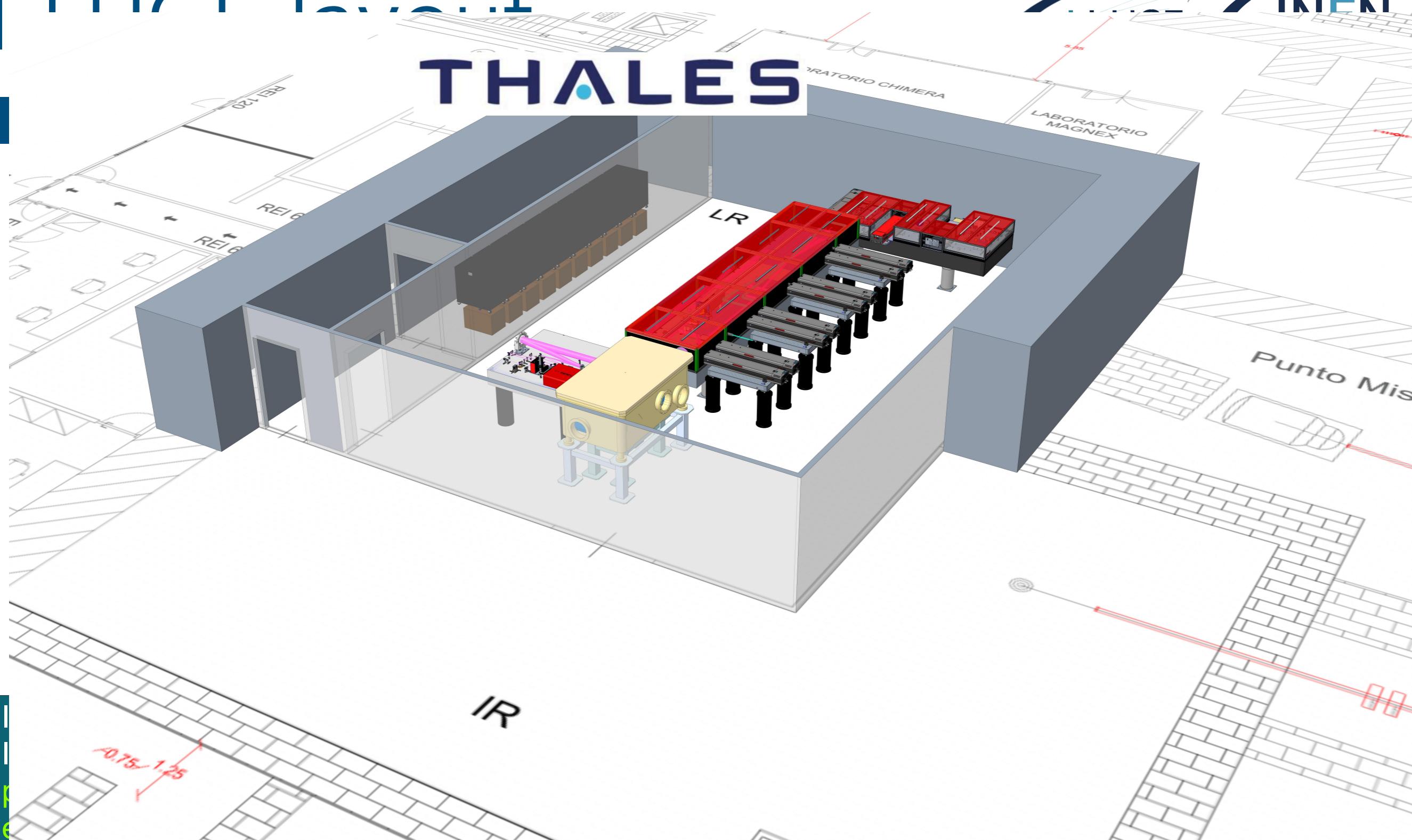
I-LUCE layout



14

Control and Users' area

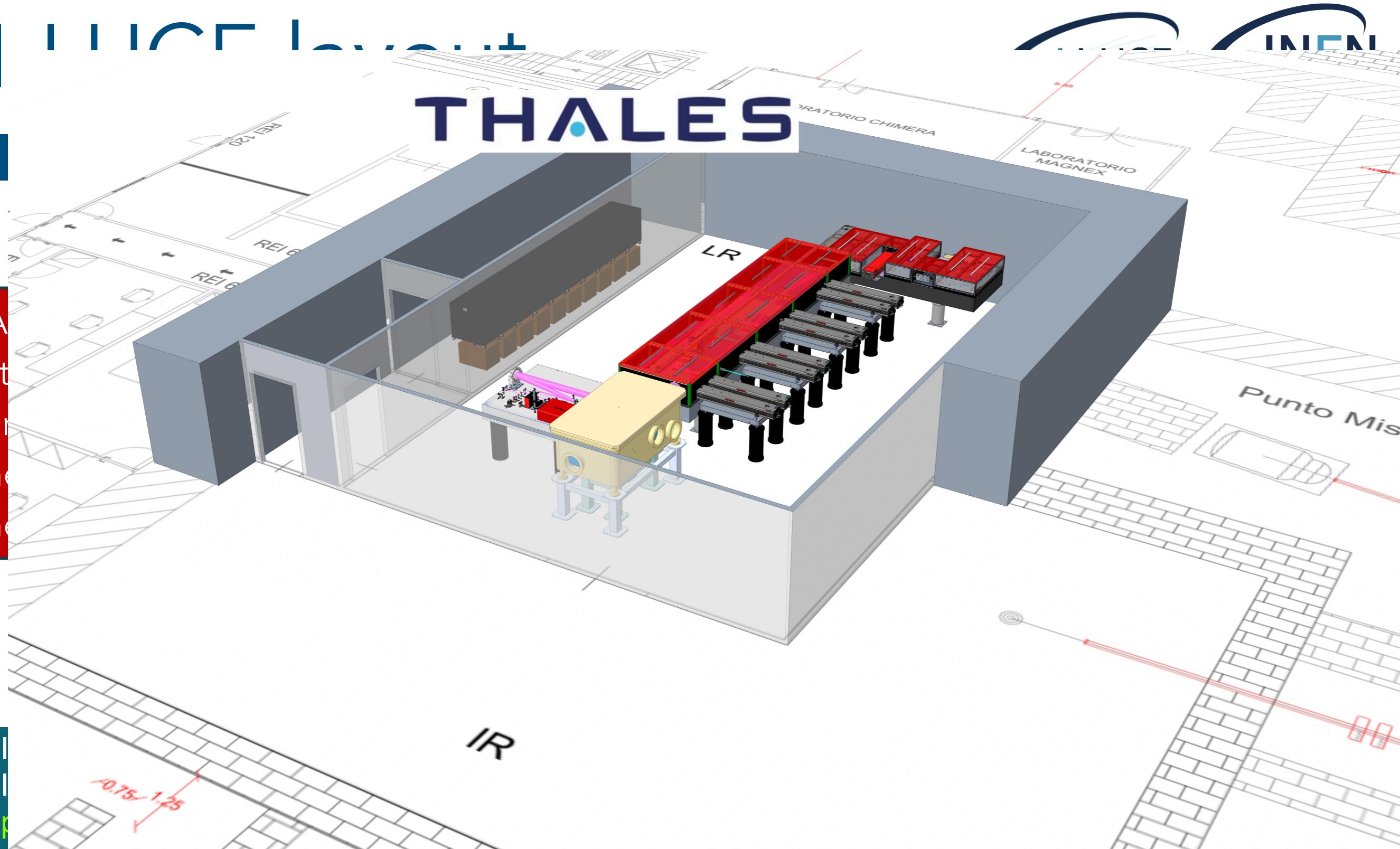


THALES

production

In-air irradiation
stationConventional ions:
from TANDEM and
Cyclotron

A
st
an
he
ne



production

In-air irradiation
station

Conventional ions:
from TANDEM and
Cyclotron

Two interaction chambers

1) **Interaction Chamber n.1:** Radiation production (protons/ions, electrons, neutrons, gamma, etc.)

- One in-air irradiation station for multidisciplinary studies

2) **Interaction Chamber n.2:** Warm Dense Matter studies (WDM)

- Nuclear physics in plasma
- Interaction of conventional ion beams with laser-generated plasma
- Nuclear physics fusion studies in plasma
-

Two working modalities

1) Low power: 50 TW/23fs/10Hz

2) High power: 350 TW/23fs/1Hz

Upgrade from 350 TW to 500 TW
(0.5 M€)

I-LUCE first phase



Istituto Nazionale di Fisica Nucleare

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EUAPS
I-LUCE @ LNS

Two interaction chambers

1) Interaction Ch

neutrons, gammas

- One in-air

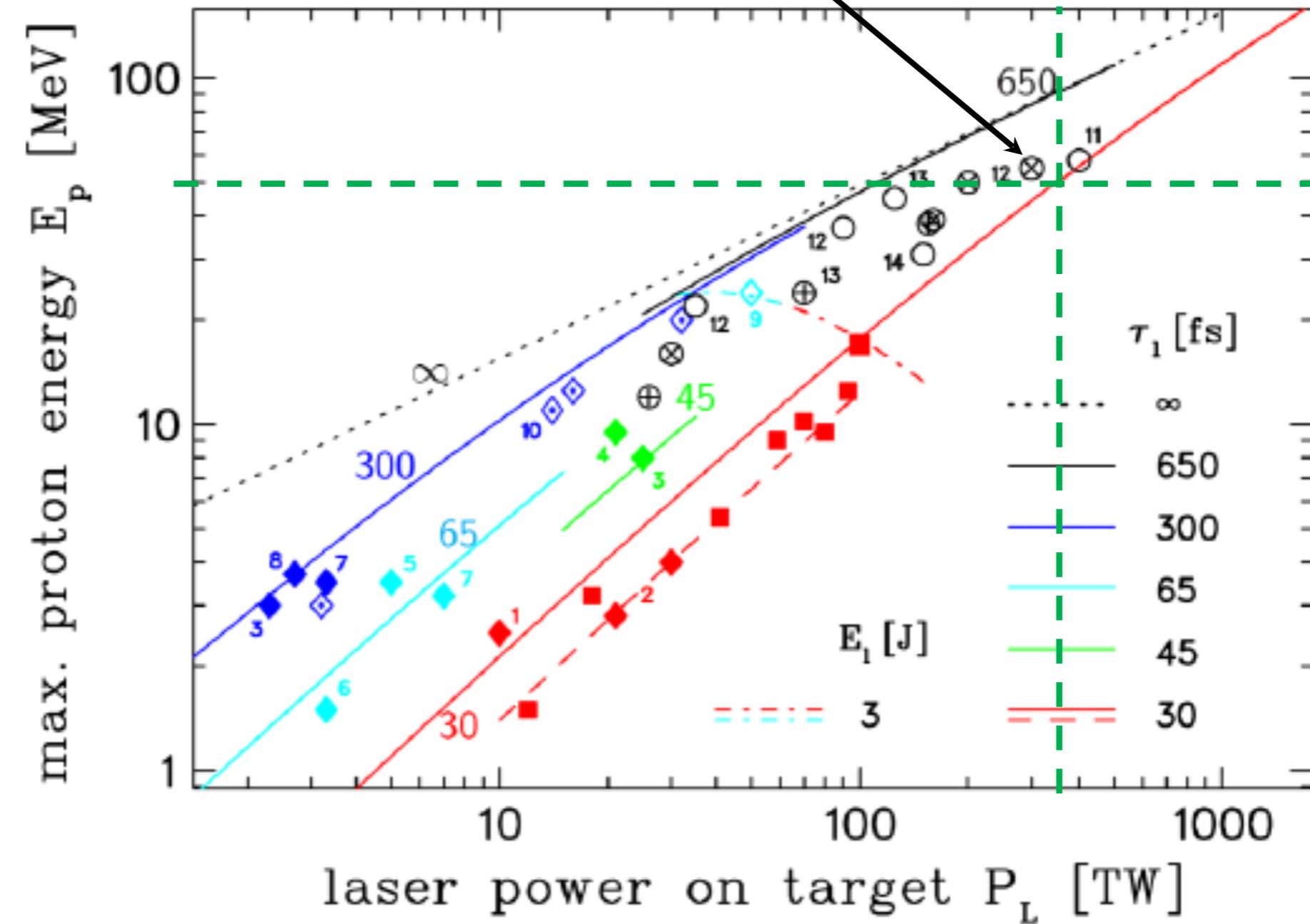
2) Interaction Ch

- Nuclear plasmas
- Interaction chamber
- Nuclear plasmas
-

Two working modes

1) Low power: 50 J

2) High power: 35 J



N

Low power modality: 50 TW

17

Laser Power	$\geq 50 \text{ TW}$
Energy per pulse	$\geq 1 \text{ J}$
Pulse duration	$\leq 23 \text{ fs}$
Focusing surface	$36 \mu\text{m}^2$
Max power density (at the target) $I^* \lambda^2$	$1.21 \cdot 10^{20}$ $7.72 \cdot 10^{19}$ $> 10^{10}$ $\geq 10 \text{ Hz}$
Contrast ratio @100 ps (ASE)	
Repetition rate	
Protons Ions	Max energy Particle per pulse (at 2 MeV) Energy spread Beam divergency (max)
Eletrons	Max energy Particles per pulse Beam divergency (max)
Neutrons	Max energy Particles per pulse Energy spread Beam divergency
Gamma X-beams	Synchrotron radiation of the electrons inside the plasma or breemsstrahlung Energy Beam divergency
	up to 20 MeV Directionality in the beam propabgation direction

*Fusion studies,
nuclear studies,
radioisotopes production,
.....*

*Acting on the compression procedure, the **pulse duration** can be increased up to 1/10 ps:*

$$\Rightarrow 2.78 \cdot 10^{18} \text{ W/cm}^2$$

$$2.78 \cdot 10^{17} \text{ W/cm}^2$$

$$\Rightarrow i\lambda^2 = 1.77 \cdot 10^{18}$$

$$i\lambda^2 = 1.77 \cdot 10^{17}$$

Longer plasma expansion times:

- Decay studies
- Stopping powers studies
- WDM characterisation

Power densities can be improved reducing the focusing spot:

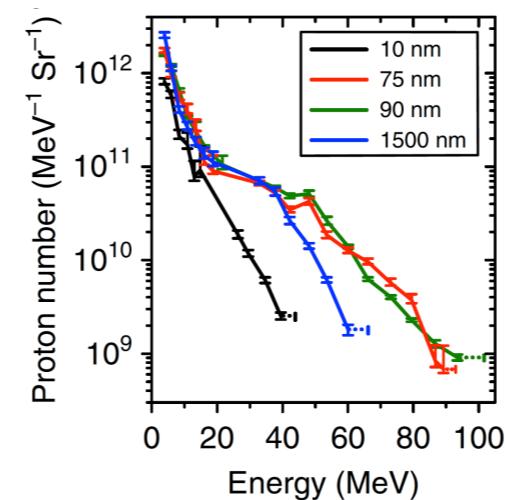
- shorter focusing parabola
- but issues related to the: target degree, back reflection, ...

High-power modality: 350 TW

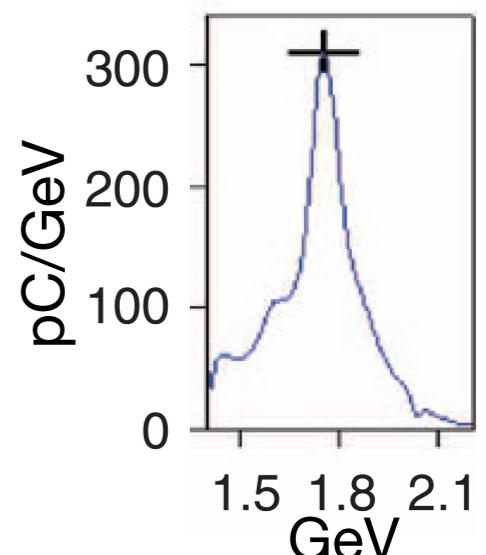
18

Laser Power	350 TW
Energy per pulse	>7 J
Pulse duration	≤ 25 fs
Focusing surface	$36 \mu\text{m}^2$ or better
Max power density (at the target)	$8.82 \cdot 10^{20}$
$I^* \lambda^2$	$5.64 \cdot 10^{20}$
Contrast ratio @100 ps (ASE)	$> 10^{10}$
Repetition rate	1 Hz
Protons	
Max energy	50 MeV
Particle per pulse (at 30 MeV)	$10^{11} \text{ MeV}^{-1} \text{ Sr}^{-1}$
Energy spread	100%
Beam divergency (max)	$\pm 20^\circ$
Electrons	
Max energy	3 GeV
Particles per pulse	10^9
Beam divergency (max)	± 20 mad
Neutrons	
Max energy	20 MeV
Particles per pulse	10^{10}
Energy spread	100
Beam divergency	Isotropic
Gamma X-beams	
Synchrotron radiation of the electrons inside the plasma or Energy	up to 80 MeV
Beam divergency	Directionality in the beam

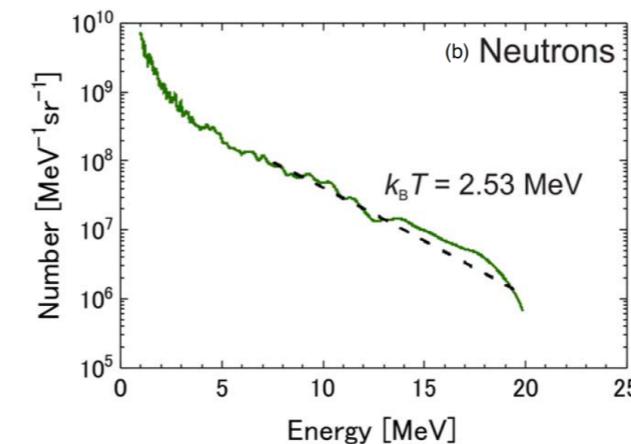
Protons spectra from A. Higginson et al. "Near-100 MeV protons via a laser-driven transparency-enhanced hybrid acceleration scheme", NATURE COMMUNICATIONS | (2018) 9:724



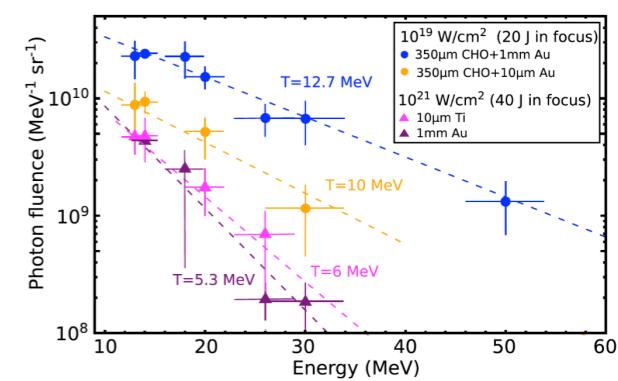
Electrons spectra from X. Wang et al. "Quasi-monoenergetic laser-plasma acceleration of electrons to 2 GeV", NATURE COMMUNICATIONS, 4:1988 2018 DOI: 10.1038/ncomms2988



Neutrons spectra from A. Yogo et al. "Single shot radiography by a bright source of laser-driven thermal neutrons and x-rays", Applied Physics Express 14, 106001 (2021)



Gamma spectra from M. M. Günther et al. "Forward-looking insights in laser-generated ultraintense γ -ray and neutron sources for nuclear application and science" NATURE COMMUNICATIONS | (2022) 13:170

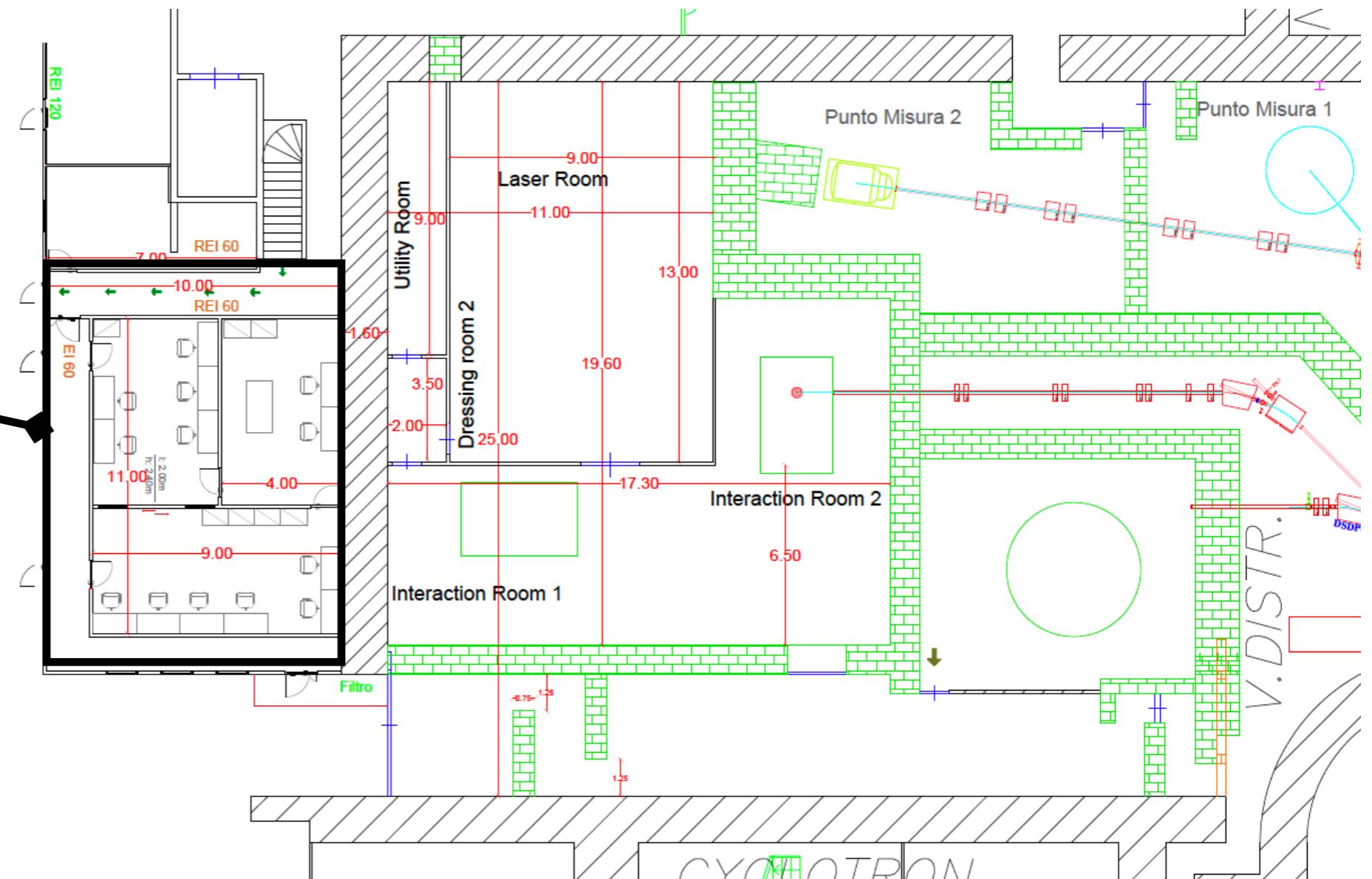


I-LUCE current status

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Control area
under
construction

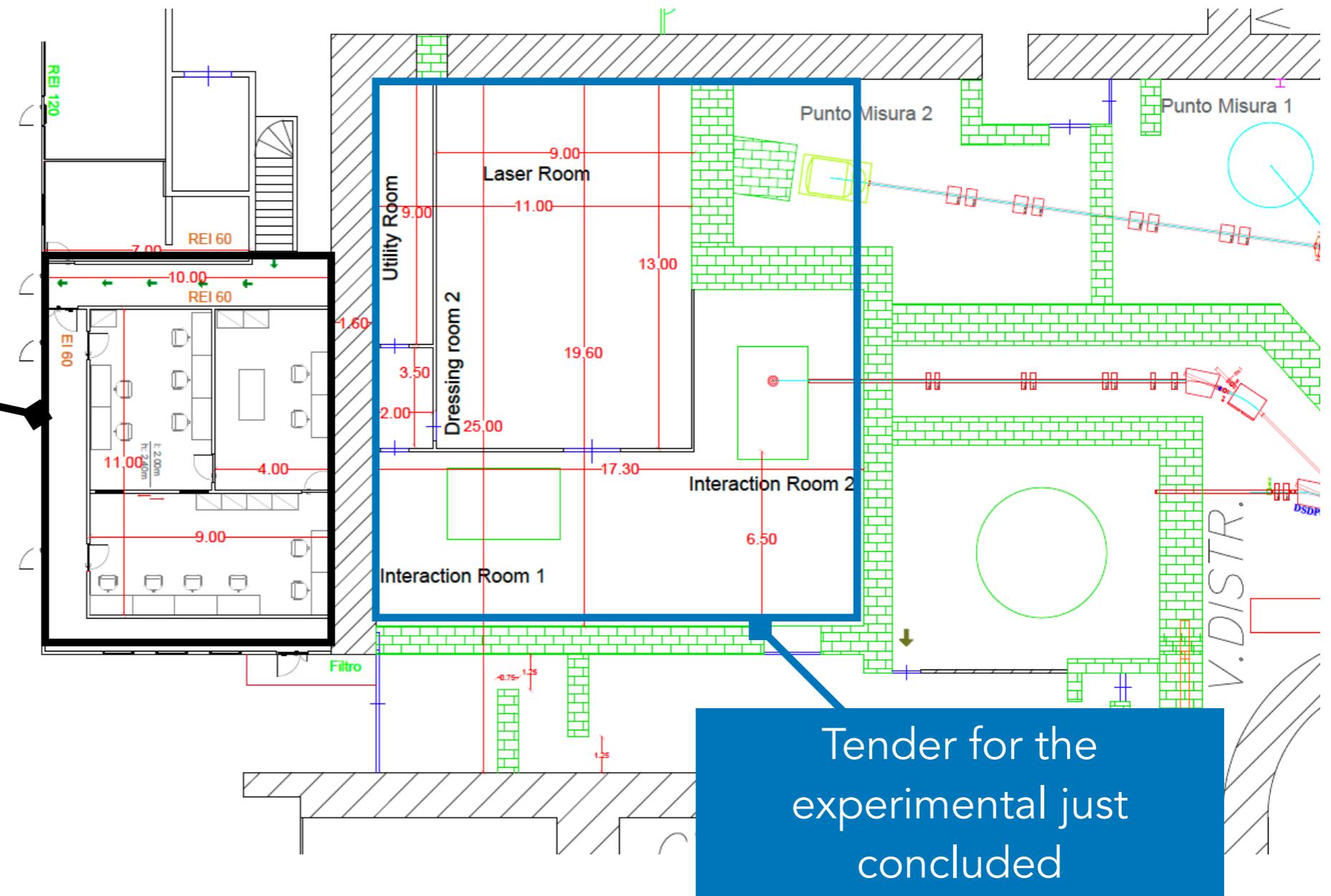


I-LUCE current status

19



Control area
under
construction



I-LUCE current status



Istituto Nazionale di Fisica Nucleare

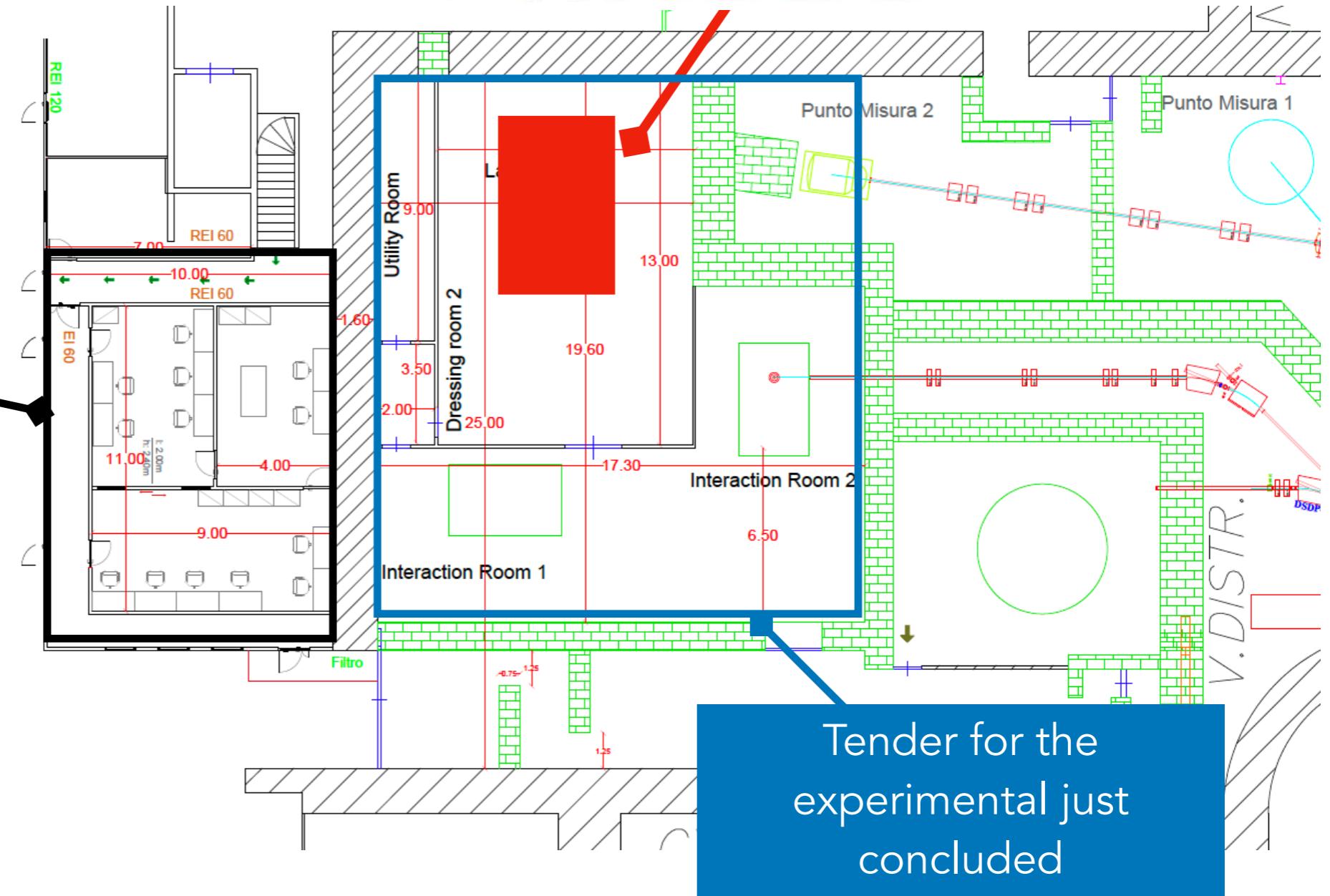
19

Laser tender concluded
Contract to be signed

THALES



Control area
under
construction



I-LUCE current status

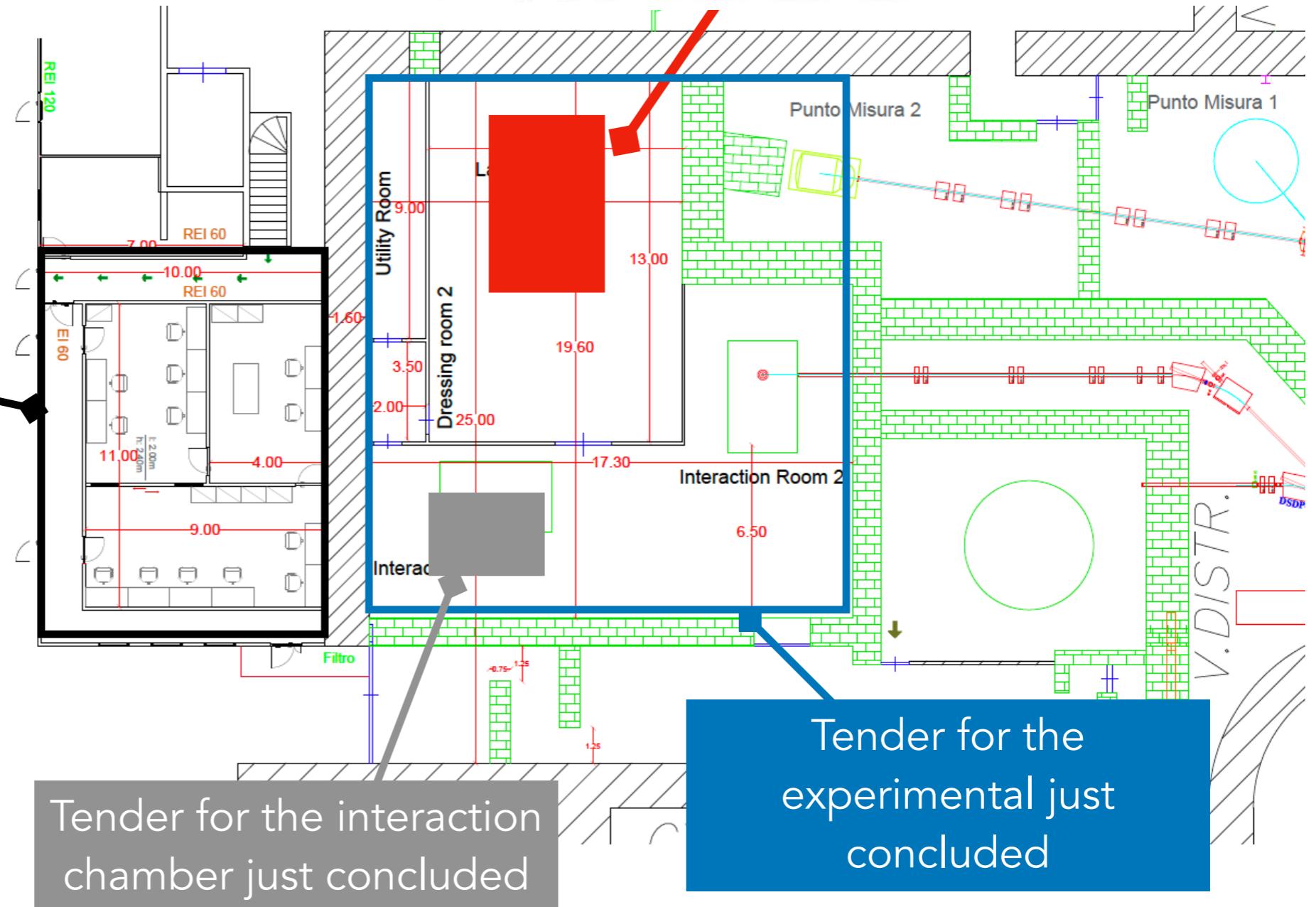
19

Laser tender concluded
Contract to be signed

THALES



Control area
under
construction





Istituto Nazionale di Fisica Nucleare



One physics cases
at I-LUCE: proton
acceleration an
transportation

21

....for radiobiology studies

....for radioisotope production

... for hydrogen production

....for cultural heritage applications

... for inertial confinement studies



ELIMED/LIMAIA beamline at ELI-Beamlines facility (CZ)



quantum beam science

Review

ELIMAIA: A Laser-Driven Ion Accelerator for Multidisciplinary Applications

Daniele Margarone ^{1,*}, G. A. Pablo Cirrone ^{1,2}, Giacomo Cuttone ², Antonio Amico ², Lucio Andò ², Marco Borghesi ³, Stepan S. Bulanov ⁴, Sergei V. Bulanov ¹, Denis Chatain ⁵, Antonín Fajstavr ¹, Lorenzo Giuffrida ¹, Filip Grepl ¹, Satyabrata Kar ³, Josef Krasa ¹, Daniel Kramer ¹, Giuseppina Larosa ², Renata Leanza ², Tadzio Levato ¹, Mario Maggiore ⁶, Lorenzo Manti ⁷, Guliana Milluzzo ^{2,3}, Boris Odlozilik ¹, Veronika Olsovcova ¹, Jean-Paul Perin ⁵, Jan Pipek ², Jan Psikal ¹, Giada Petringa ², Jan Ridky ¹, Francesco Romano ^{2,8}, Bedřich Rus ¹, Antonio Russo ², Francesco Schillaci ^{1,2}, Valentina Scuderi ^{1,2}, Andriy Velyhan ¹, Roberto Versaci ¹, Tuomas Wiste ¹, Martina Zakova ¹ and Georg Korn ¹

MDPI

Can be a high power laser competitive for ion acceleration?

22

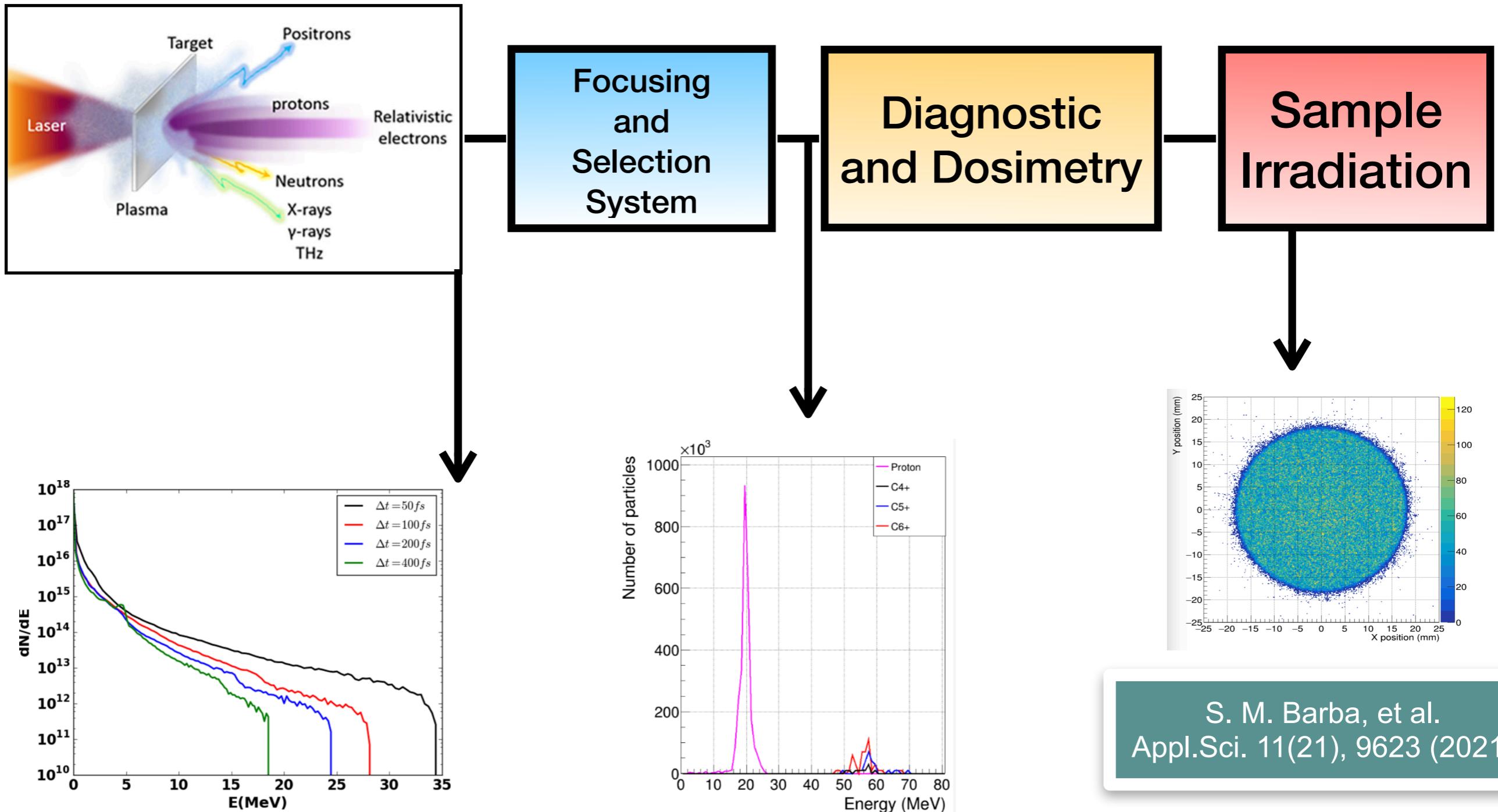
- 1. Enhancing the maximum proton energy and flux
 - 2. Reducing the beam angular divergence or improving the beam homogeneity
 - 3. Reducing the ion contamination of the beam
 - 4. Developing new technologies and strategies for diagnostics and dosimetry
- 

Transport and
selection
system

Target
optimization

A typical irradiation set-up

23



S. M. Barba, et al.
Appl.Sci. 11(21), 9623 (2021)

24

ELIMAIA experimental area

30J / 30fs

Protons are emitted from metallic/plastic foils um thickness
cut-off energy of up to ~40 MeV.

Beamline	L3 HAPLS	L4 ATON
Peak power	≥ 1 PW	10 PW
Energy in pulse	≥ 30 J	≥ 1.5 kJ
Pulse duration	≤ 30 fs	≤ 150 fs
Rep rate	10 Hz	1 per min
Supplier	LLNL	National Energetics
ELI-Beamlines	Compressor, short pulse diagnostics, controls & timing systems	Compressor design, OPCPA design, short pulse diagnostics, timing system

24

ELIMAIA experimental area

30J / 30fs

Protons are emitted from metallic/plastic foils um thickness
cut-off energy of up to ~40 MeV.

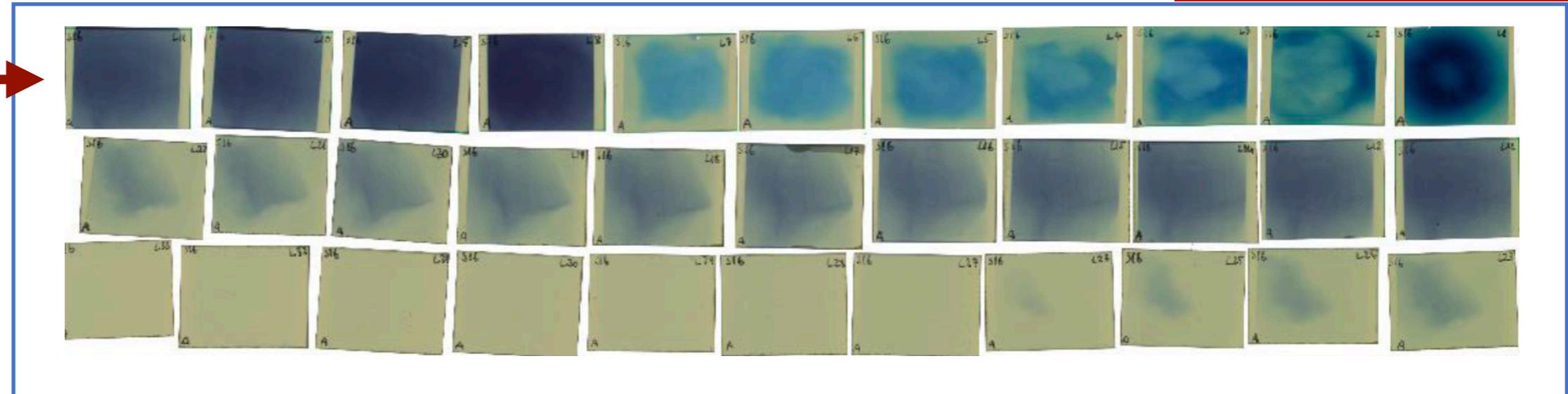
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Supplier	LLNL	National Energetics
ELI-Beamlines	Compressor, short pulse diagnostics, controls & timing systems	Compressor design, OPCPA design, short pulse diagnostics, timing system



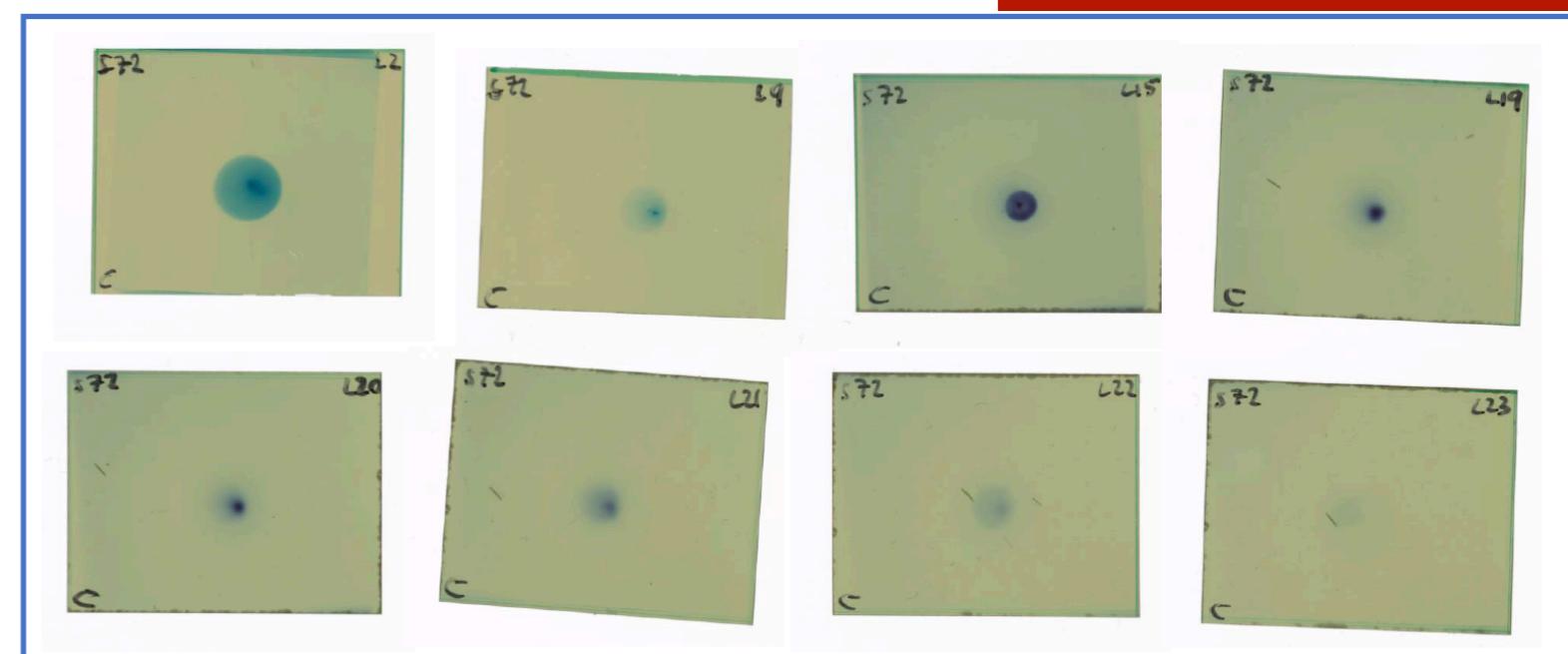
Laser-driven flash?

25

proton beam

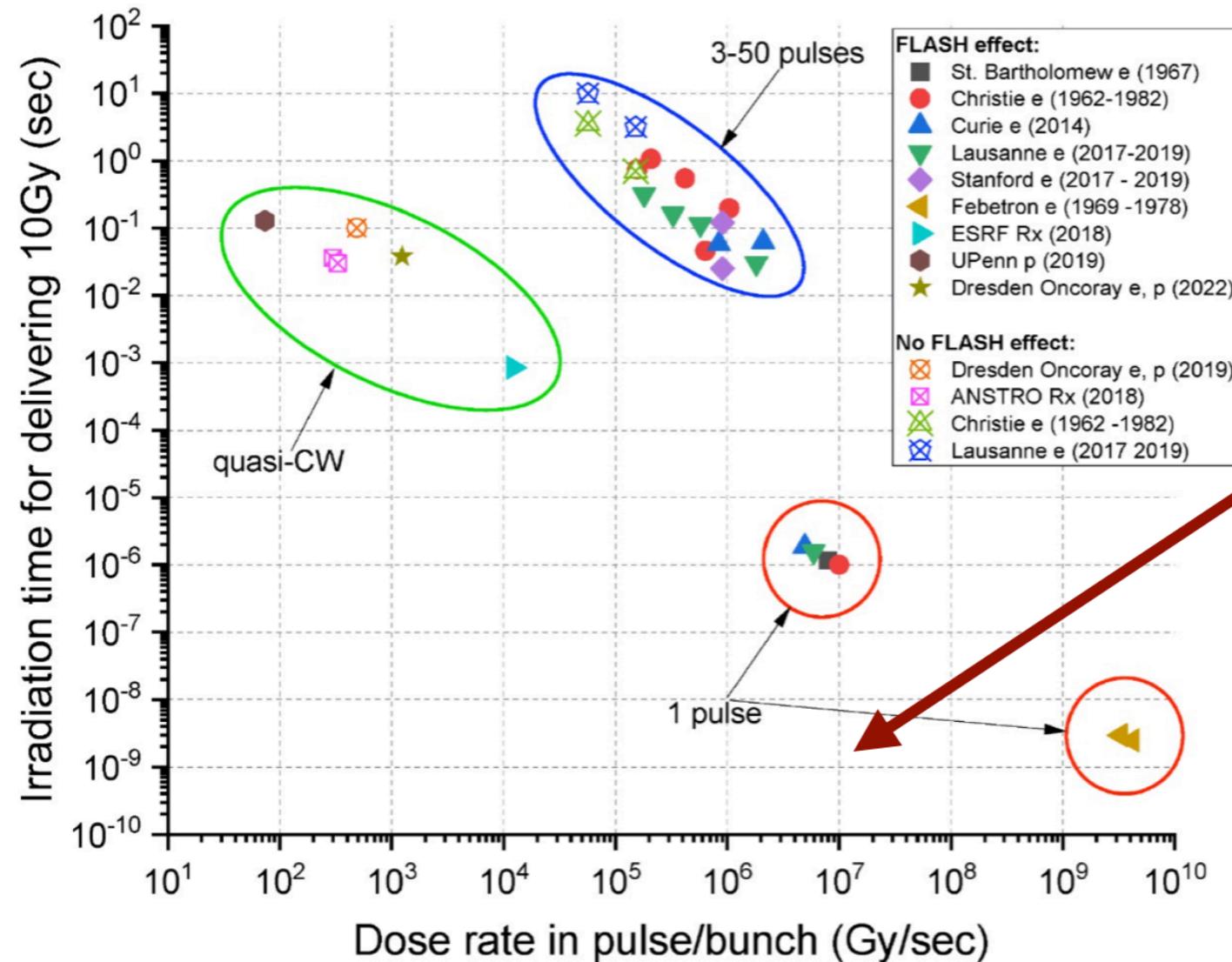


Not published data



Coil target

Energy: 10 J - Target: 2um Cu

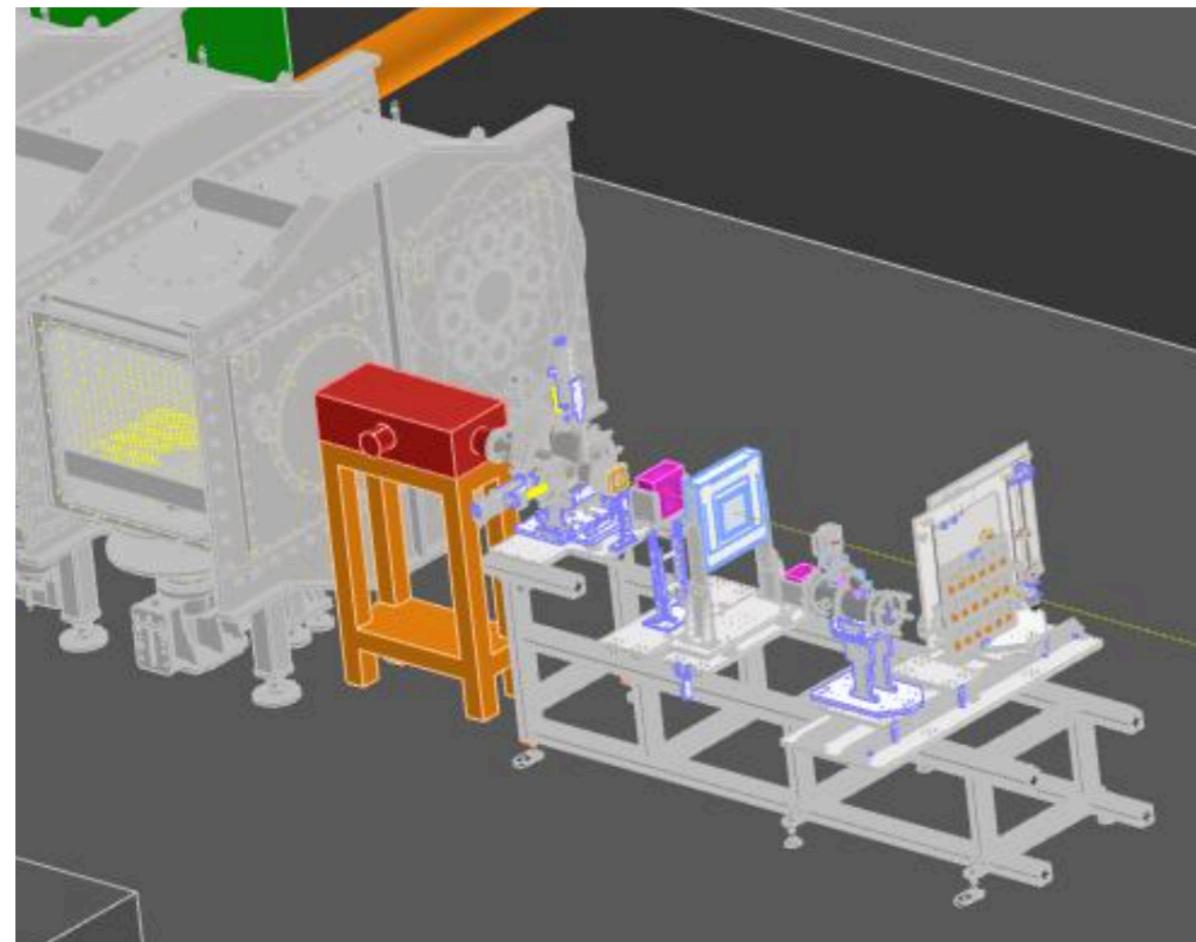


Dose [Gy]	Energy [MeV]
69,47	16,9
28	17,8
12	19,3
10,53	21,4
9,35	23,3
11,85	25,1
10,8	27
13,5	28,8
11,08	30,7
10,69	32,6
8,74	34,5

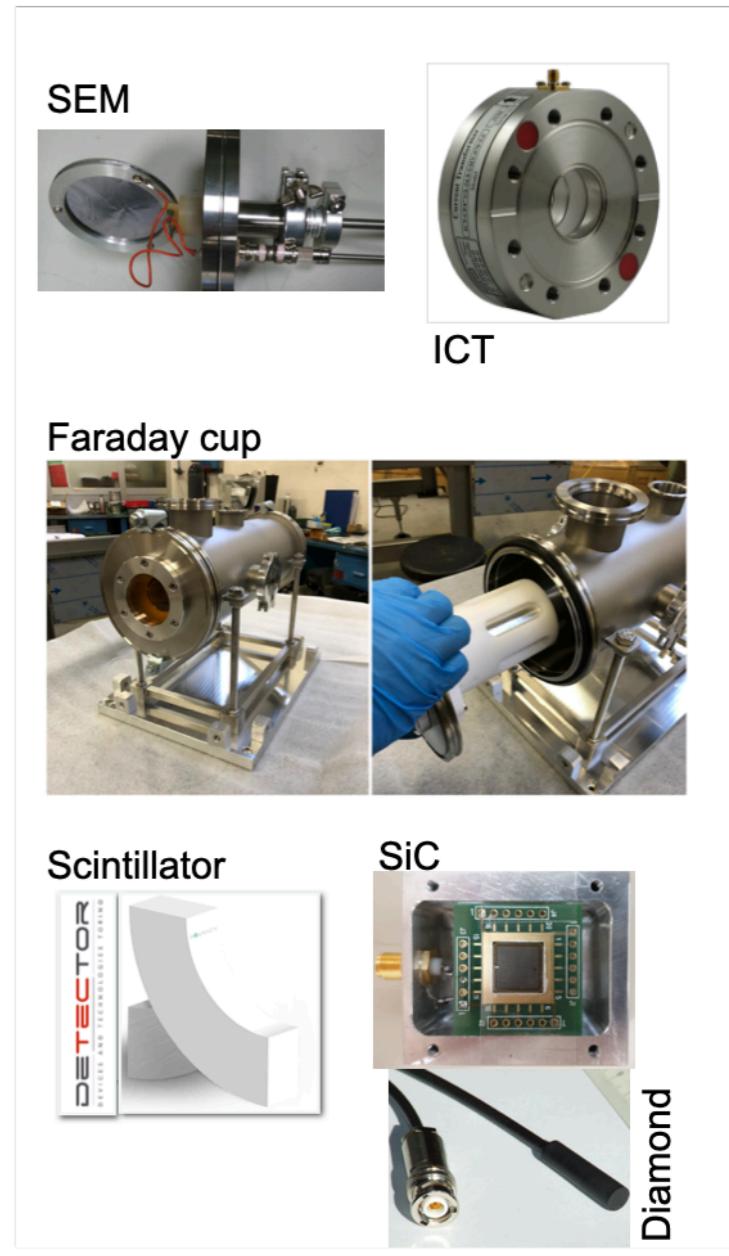
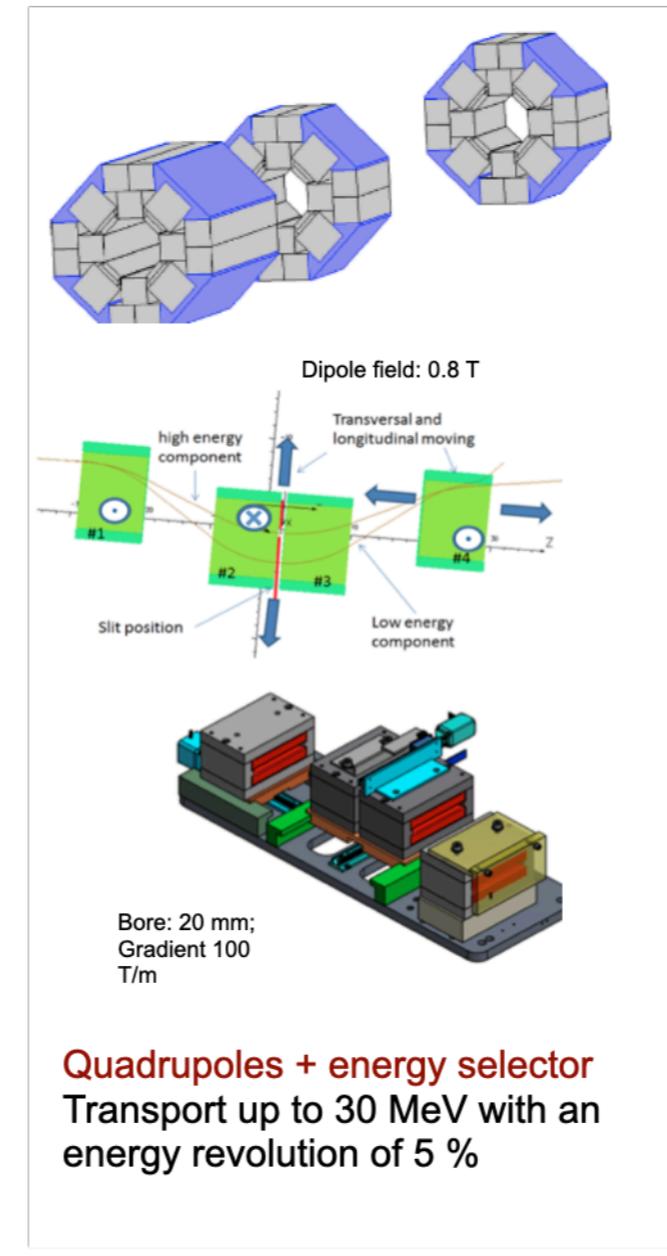
Preliminary results

Samples irradiation and radiobiology

27



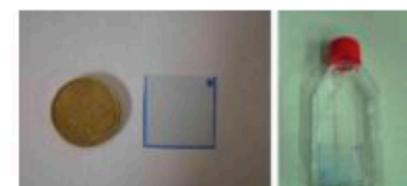
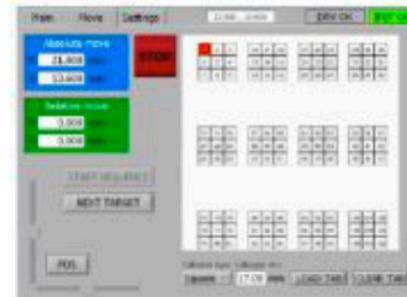
Protons / Ions	Max energy	50 MeV
	Particle per pulse (at 30 MeV)	$10^{11} \text{ MeV}^{-1} \text{ Sr}^{-1}$
Eletrons	Max energy	3 GeV
	Particles per pulse	10^9



Samples irradiation and radiobiology

28

In-vitro
positioning
system



Analysis pre
and post
irradiation



In-vivo positioning system



Types of equipment into the Bio-Lab:

- ✓ Laboratory Hood
- ✓ Inverted microscopy
- ✓ Centrifuge
- ✓ Incubator
- ✓ -80°C for storage of biological samples
- ✓ Dewar for long term storage of different cellular batch

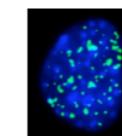
Fluorescence Microscopy



16.25 megapixel CMOS image sensors for microscopy

High sensitivity
Excellent linearity
High – frame rate
Low Noise

Integration with imaging SF



Small animals storage



What we will have at disposal at I-LUCE?

29

An high power laser: 8J/23fs/1Hz

A plasma generated by the laser:

Temperature: 2 eV - 200 eV

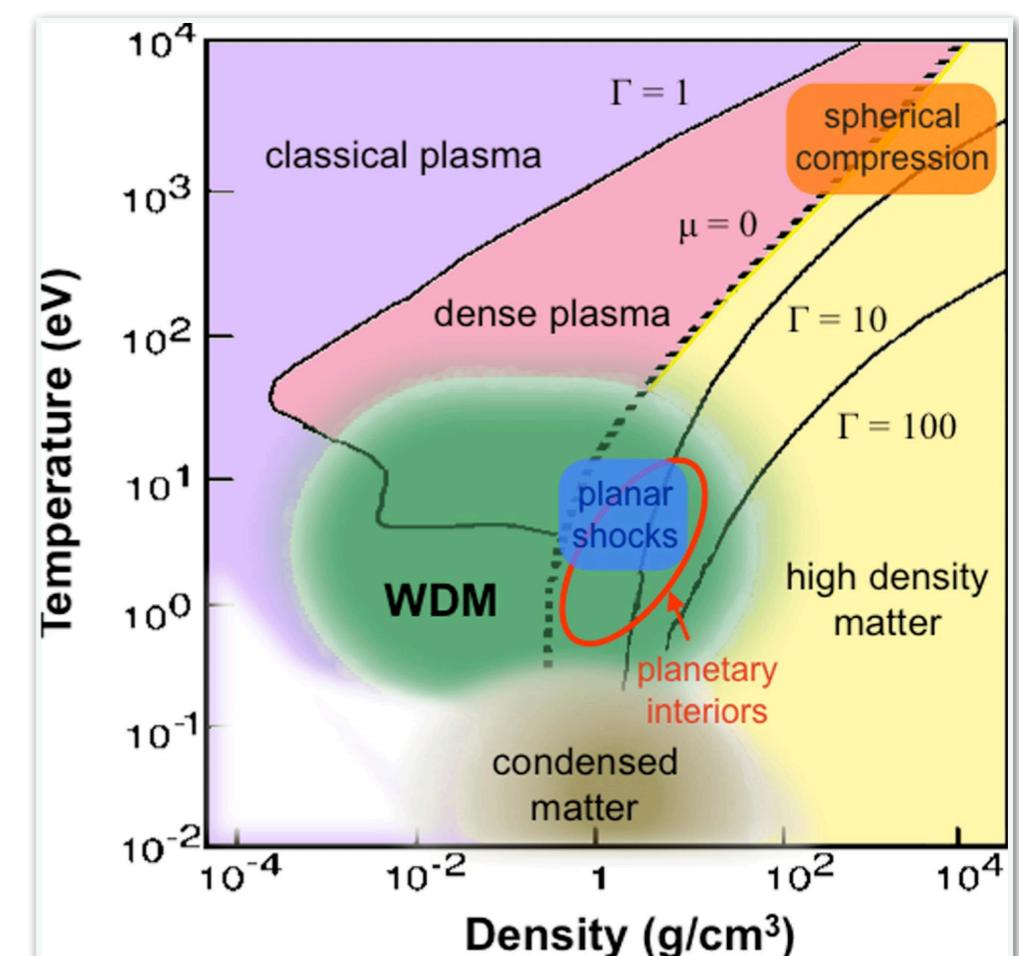
$$T \approx \left(\frac{I}{1.37 \times 10^{16} \text{ W/cm}^2} \right)^{1/2}$$

Density: 10^{25} m^{-3}

$$n \approx \frac{I}{e^2 T}$$

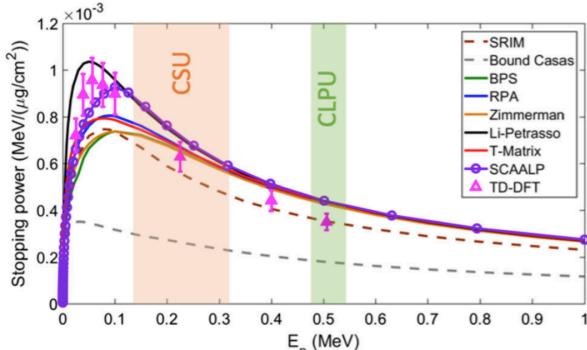
$$n \approx \frac{\epsilon_0 m_e \omega_p^2}{e^2}$$

Ion beams in a wide Z range and energy
up to 70 AMeV

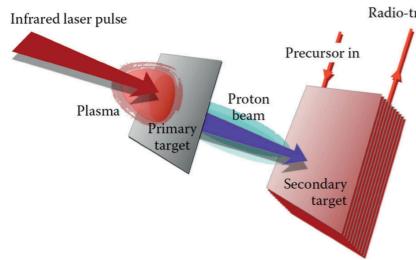


Nuclear physics mid-term plan

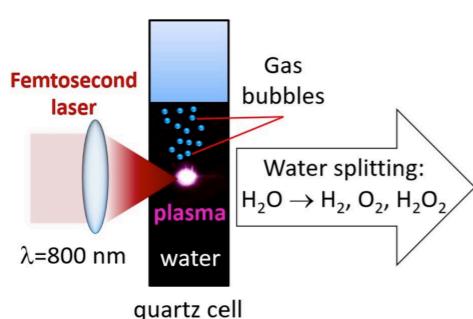
30



Stopping power in plasma



Radioisotopes



Hydrogen generation

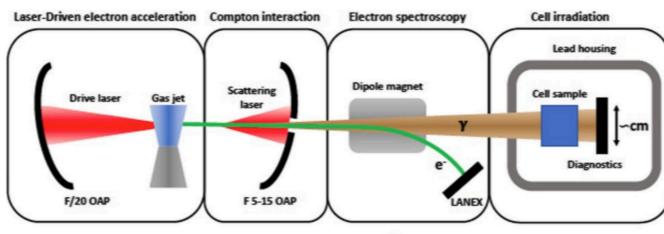
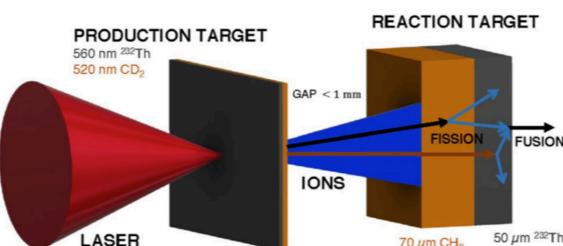
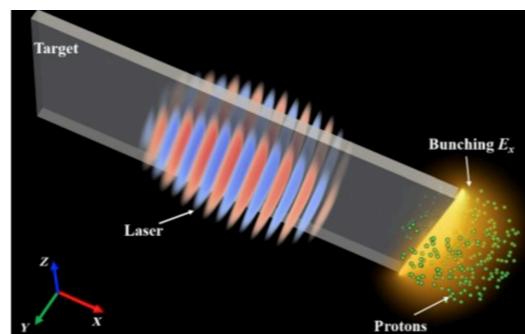


Fig. 48 Setup for the high-brilliance γ production via inverse Compton-scattering (from Sarri et al. [371])

Positrons generation



Nuclear reaction schemes



Protons and electrons generation

Chapter 6.2 Laser applications

Eur. Phys. J. Plus (2023) 138:1038
https://doi.org/10.1140/epjp/s13360-023-04358-7

THE EUROPEAN PHYSICAL JOURNAL PLUS

Regular Article



Nuclear physics midterm plan at LNS

C. Agodi¹, F. Cappuzzello^{1,2}, G. Cardella³, G. A. P. Cirrone¹, E. De Filippo³, A. Di Pietro¹, A. Gargano⁴, M. La Cognata^{1,a}, D. Mascali¹, G. Milluzzo¹, R. Nania⁵, G. Petringa¹, A. Pidatella¹, S. Pirrone³, R. G. Pizzone¹, G. G. Rapisarda^{1,2,b}, M. L. Sergi^{1,2}, S. Tudisco¹, J. J. Valiente-Dobón⁶, E. Vardaci^{4,8}, H. Abramczyk⁹, L. Acosta¹⁰, P. Adsley¹¹, S. Amaducci¹¹, T. Banerjee⁴, D. Batani¹², J. Bellone^{1,2}, C. Bertulani^{11,13}, S. Biri¹⁴, A. Bogachev¹⁵, A. Bonanno^{1,16}, A. Bonasera^{1,11}, C. Borcea¹⁷, M. Borghezzi¹⁸, S. Bortolussi^{19,20}, D. Boscolo¹⁴, G. A. Brischetto¹², S. Burrello^{21,22}, M. Busso^{23,24}, S. Calabrese¹, S. Calinescu¹⁷, D. Calvo²⁵, V. Capirossi^{25,26}, D. Carbone¹, A. Cardinali²⁷, G. Casini²⁸, R. Catalano¹, M. Cavallaro¹, S. Ceccuzzi²⁹, L. Celona¹, S. Cherubini^{1,2}, A. Chieffi^{24,30}, I. Ciraldo^{1,2}, G. Ciullo^{31,32}, M. Colonna¹, L. Cosentino¹, G. Cuttone¹, G. D'Agata^{1,7}, G. De Gregorio^{4,33}, S. Degl'Innocenti³⁴, F. Delaunay^{1,2,35}, L. Di Donato^{1,36}, A. Di Nitto^{4,8}, T. Dickey^{37,38}, D. Doria^{17,39}, J. E. Ducret⁴⁰, M. Durante¹⁴, J. Esposito⁷, F. Farrokhi¹, J. P. Fernandez Garcia²¹, P. Figuera¹, M. Fisichella¹, Z. Fulop¹⁴, A. Galata⁶, D. Galaviz Redondo⁴¹, D. Gambacurta¹, S. Gammino¹, E. Geraci^{2,3}, L. Gizzo⁴², B. Gnoffo^{2,3}, F. Groppi^{26,27}, G. L. Guardo¹, M. Guarnera¹, S. Hayakawa⁴³, F. Horst¹⁴, S. Q. Hou⁴⁴, A. Jarota⁸, J. Jose⁴⁵, S. Kar^{18,46}, A. Karpov¹⁵, H. Kierzkowska-Pawlak⁹, G. G. Kis¹⁴, G. Knyazheva¹⁵, H. Koivisto⁴⁷, B. Koop⁷², E. Kozulin¹⁴, D. Kumar^{37,38}, A. Kurmanova¹, G. La Rana^{4,8}, L. Labate⁴², L. Lamia¹², E. G. Lanza³, J. A. Lay^{48,49}, D. Lattuada¹⁶, H. Lenske⁵⁰, M. Limongi^{24,30,51}, M. Lipoglavsek⁵², I. Lombardo^{2,3}, A. Mairani⁷², S. Manetti^{26,27}, M. Marafini⁷¹, L. Marcucci³⁴, D. Margarone⁵³, N. S. Martorana^{1,3}, L. Maunoury⁴⁰, G. S. Mauro¹, M. Mazzaglia¹, S. Mein⁷², A. Mengoni^{5,54}, M. Milin⁵⁵, B. Mishra¹, L. Mou⁷, J. Mrazek⁵⁶, P. Nadtochy⁵⁷, E. Naselli¹, P. Nicolai², K. Novikov¹⁵, A. A. Oliva¹, A. Pagano³, E. V. Pagano¹, S. Palmerini^{23,24}, M. Papa³, K. Parodi⁷³, V. Patera⁵⁸, J. Pellumaj^{7,31}, C. Petrone²⁴, S. Piantelli²⁸, D. Pierroutsakou⁴, F. Pinna²⁵, G. Polit^{2,3}, I. Postuma^{19,20}, P. Prajapati⁵⁹, P. G. Prada Moroni³⁵, G. Pupillo⁷, D. Raffestin¹², R. Racz¹⁴, C.-A. Reidel¹⁴, D. Rifuggiato¹, F. Risitano^{3,60}, F. Rizzo^{2,3}, X. Rocca Mazza^{61,62}, D. Romano¹², L. Roso⁶³, F. Rotaru¹⁷, A. D. Russo¹, P. Russotto¹, V. Saiko¹⁵, D. Santonocito¹, E. Santopinto⁶⁴, G. Sarri⁴⁶, D. Sartirana²⁵, C. Schuy¹⁴, O. Sgouros¹, S. Simonucci⁶⁵, G. Sorbello^{1,36}, V. Soukeras¹, R. Sparta¹, A. Spatasfora^{1,2}, M. Stanoi¹⁷, S. Taioli^{66,67,68}, T. Tessonner⁷², P. Thirolf⁷³, E. Tognelli³⁴, D. Torrisi¹, G. Torrisi¹, L. Trache¹⁷, G. Traini⁷⁰, M. Trimarchi^{3,60}, S. Tsikata⁶⁹, A. Tumino^{1,6}, J. Tyczkowski⁹, H. Yamaguchi⁴³, V. Vercesi^{19,20}, I. Vidana³, L. Volpe⁶³, U. Weber¹⁴

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Future

31

ELI-Beamlines MoU

ELI-NP MoU

First official experiments at ELI-beamlines (ongoing)

Next ELI-Beamlines call: proof of principle for a neutron source with laser-driven electron and proton beams

Paper ongoing

Future

31

ELI-Beamlines MoU

ELI-NP MoU

First official experiments

Next ELI-Beamlines call source with laser-drive

Paper ongoing

PARTICIPANT NUMBER & NAME		EU	TYPE	ROLE
1. (Coo) – CNRS (Centre National de la Recherche Scientifique)		FR	RTO	Coordinator
2. CELIA (Université de Bordeaux CELIA)		FR	UNI	Affiliated entity to CNRS - Participation to WP3, WP5, WP7
3. LULI (Ecole Polytechnique)		FR	UNI	Affiliated entity to CNRS -
4. UPM (Universidad Politécnica de Madrid)	ES	UNI		
5. ETSI-ETSIAE (Higher Technical School of Aeronautical and Space Engineering)	ES	UNI		Affiliated entity to UPM -
6. IFN (Instituto Fusion Nucleare)	ES	RTO		Affiliated entity to UPM -
7. CLPU (Centro de Láseres Pulsados Ultracortos Ultraintensos)	ES	RTO		
8. ENEA (Italian National Agency for New Technologies, Energy and Sustainable Economic Development)	IT	RTO		
9. INFN-LNS (Istituto Nazionale di Fisica Nucleare – Laboratori Nazionali del Sud)	IT	RTO		Affiliated entity to ENEA -
10. CNR (Consiglio Nazionale Delle Ricerche)	IT	RTO		
11. GSI-JENA (Helmholtz Institute Jena)	DE	RTO		
12. HZDR (Helmholtz Zentrum)	DE	RTO		Participation WP 4 and WP5
13. STFC (UK Research and Innovation: Science and Technology Facilities Council)	UK	RTO		
14. HMU (Hellenic Mediterranean University)	GR	UNI		
15. FZU-PALS (Academy of Science of CZ)	CZ	ORG		
16. ELI-ERIC (Extreme Light Infrastructure - European Research Infrastructure Consortium)	CZ	RTO		Participation in WP2, WP5, and WP7
17. ULisboa (Instituto Superior Técnico)	PT	RTO		
18. IPPiLM (Institute of Plasma Physics and Laser Microfusion)	PL	RTO		Participation in WP3, WP5, and WP7

HIPER+ Initiative on Inertial Confinement Fusion as “affiliated” of ENEA

Future

31

ELI-Beamlines MoU

ELI-NP MoU

First official experiment

Next ELI-Beamline
source with laser-

Paper ongoing



High Power Lasers and Applications Workshop (next edition
in November 2024 with an international Geant4 school)

Thanks to everyone



December 18, 2023