The Abdus Salam International Centre for Theoretical Physics

2443-12

Winter College on Optics: Trends in Laser Development and Multidisciplinary Applications to Science and Industry

4 - 15 February 2013

"Extreme Light Infrastructure" (ELI) - A distributed laser facility for: attoscience, laser particle acceleration and gamma sources

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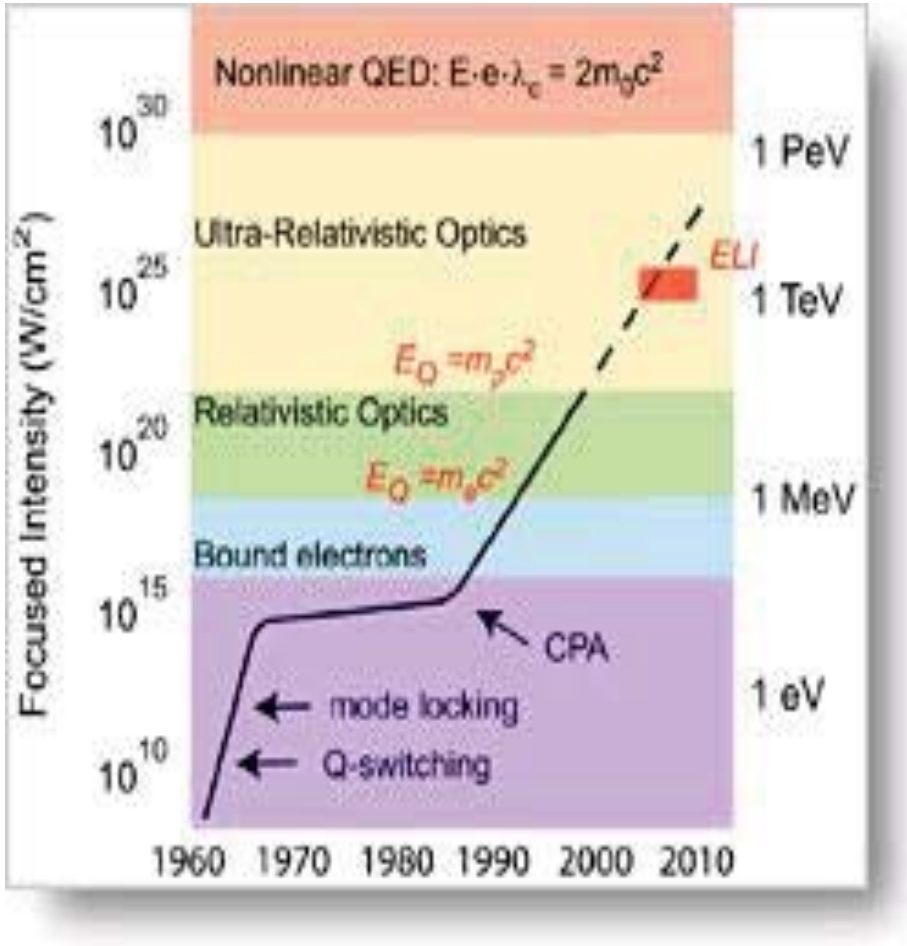
Extreme

Light

Infrastructure

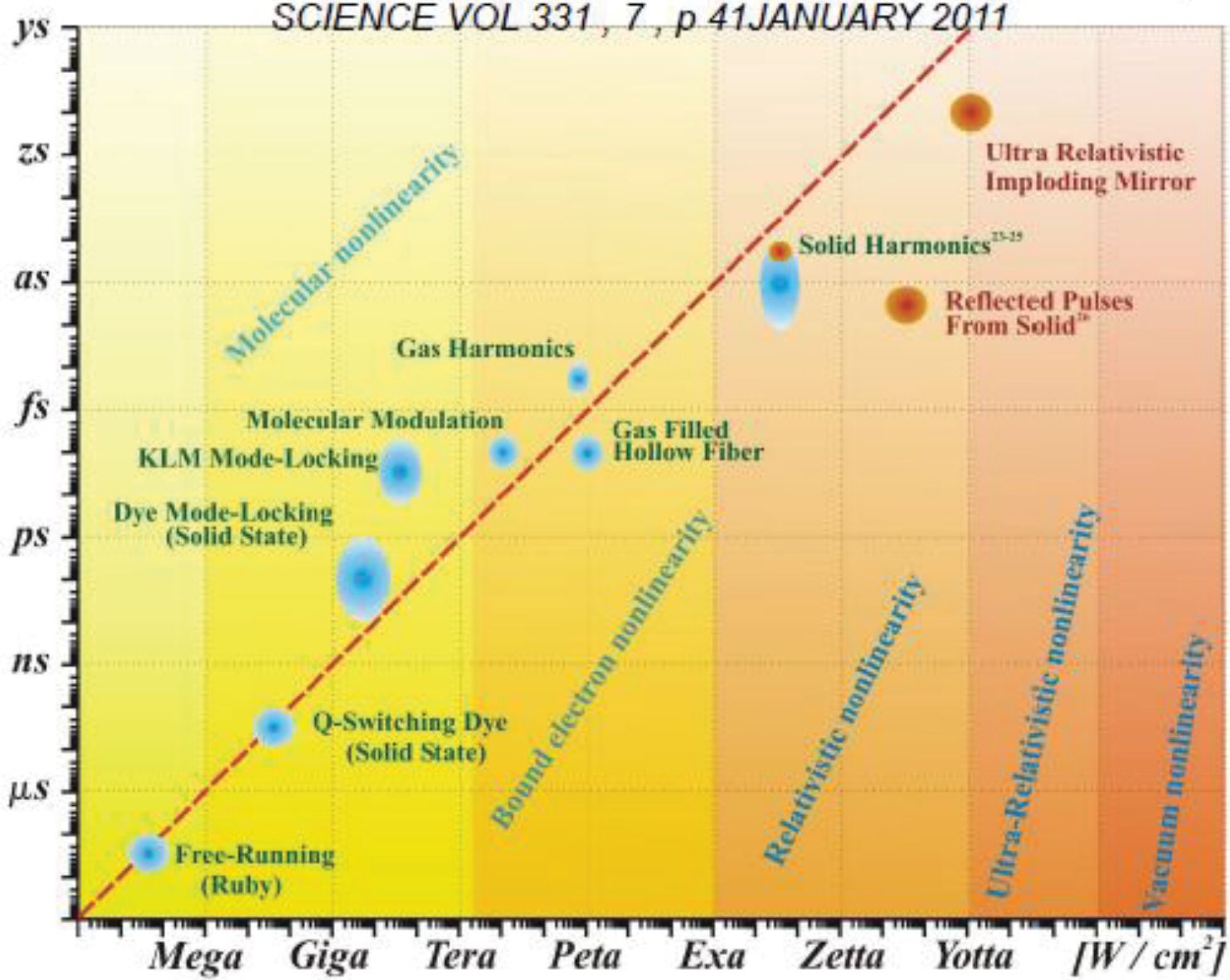
A distributed laser facility for:
Attoscience, Laser Particle Acceleration and Gamma Sources

ELI will be the world‘s first multi-national laser project dedicated to push laser technology to the limits of ultra-high power and intensity, thus providing new research opportunities in different fields.



The Pulse Duration-Intensity Conjecture

G.A. Mourou and T. Tajima, "More intense Shorter Pulse",
SCIENCE VOL 331 , 7 , p 41JANUARY 2011



Synergies in the European Research Area

Single investigator groups	National infrastructures	*I3-Networks	Pan-European Infrastructures:
The human resources	Europe's institutional basis	The flexible instrument for new scientific challenges beyond the national scale	The flagships: mission-oriented Infrastructures of Pan-European dimension

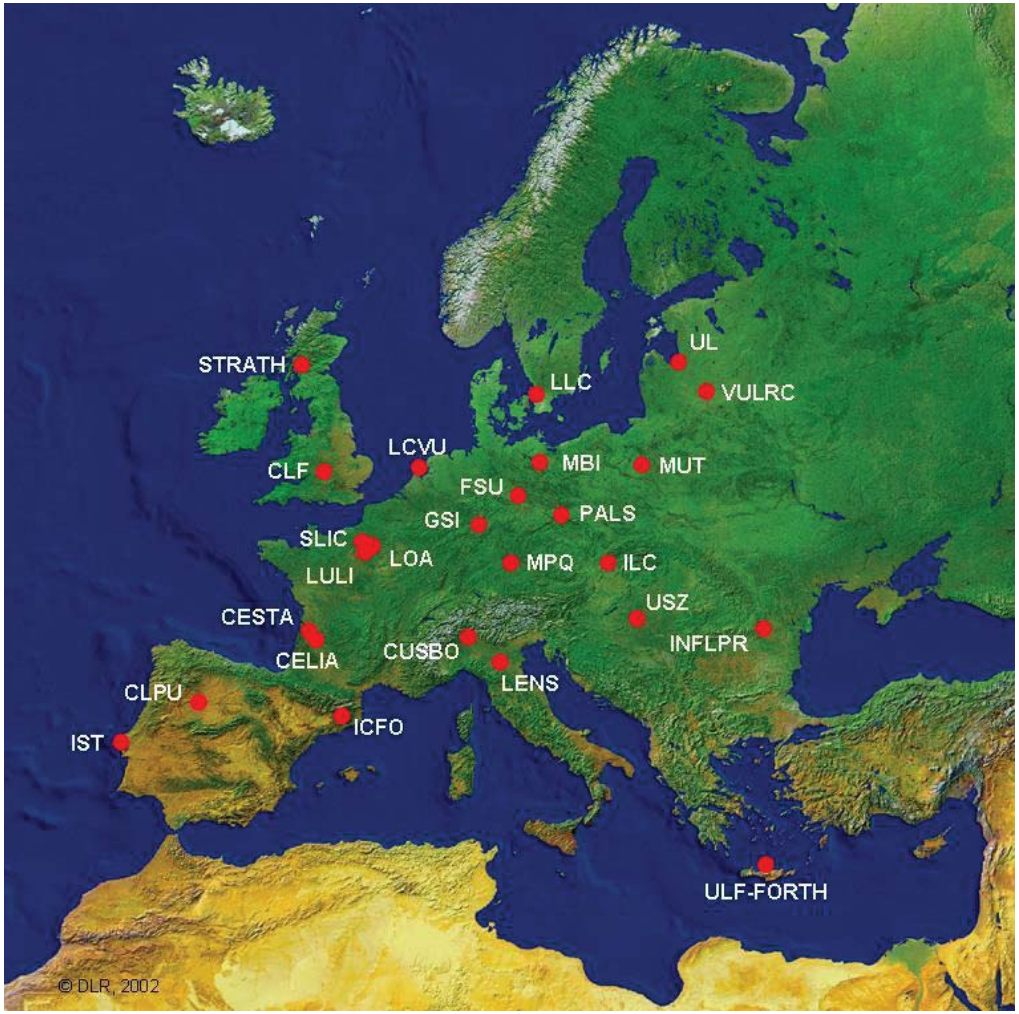
*(I3) Integrated Infrastructure Initiative

LASERLAB-Europe

Laserlab Europe

Integrated Infrastructure Initiative (I3)

- A Network of major European Laser Infrastructures (from 19 countries)
- Providing access to forefront laser instrumentation to International Users



Two large Laser Infrastructures were selected to be on the Roadmap of ESFRI (European Strategic Forum on Research Infrastructures)

- HIPER (European High Power laser Energy Research facility): for civilian laser fusion research (“fast ignition scheme”)
- ELI: reaching highest laser intensities and related applications

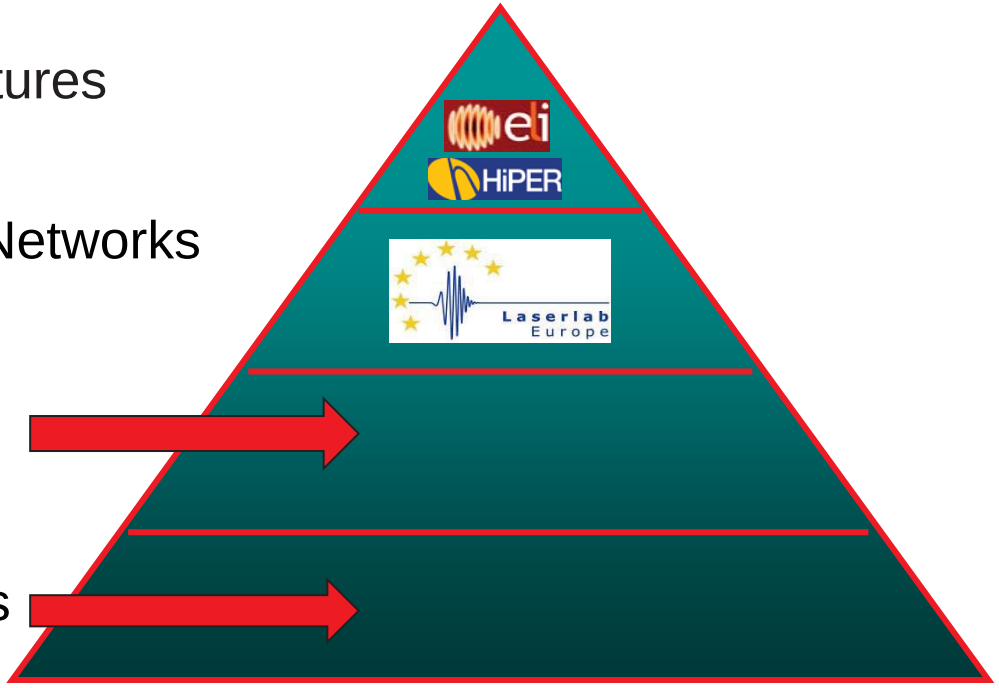
With Pan-European Reserach Infrastructures like ELI and HiPER Europe is setting a unique milestone in structuring research, after the formation of Research Infrastructure Networks (I3).

Pan-European Infrastructures

Research Infrastructure Networks

National laboratories

Single principal investigator groups



ELI: Scientific Case

“Grand Challenges”

Attosecond Laser Science: temporal investigation of electron dynamics in atoms, molecules, plasmas and solids at attosecond scale

High Energy Beam Science: development and usage of dedicated beam lines with ultra short pulses of high energy radiation and particles reaching almost the speed of light

Laser-Induced Photonuclear Physics: nuclear physics methods to study laser-target interactions, new nuclear spectroscopy, new photonuclear physics, etc.

Ultra High Field Science: investigation of laser-matter interaction in an energy range where relativistic laws could stop to be valid

ELI: Preparatory Phase (2007)

Community building

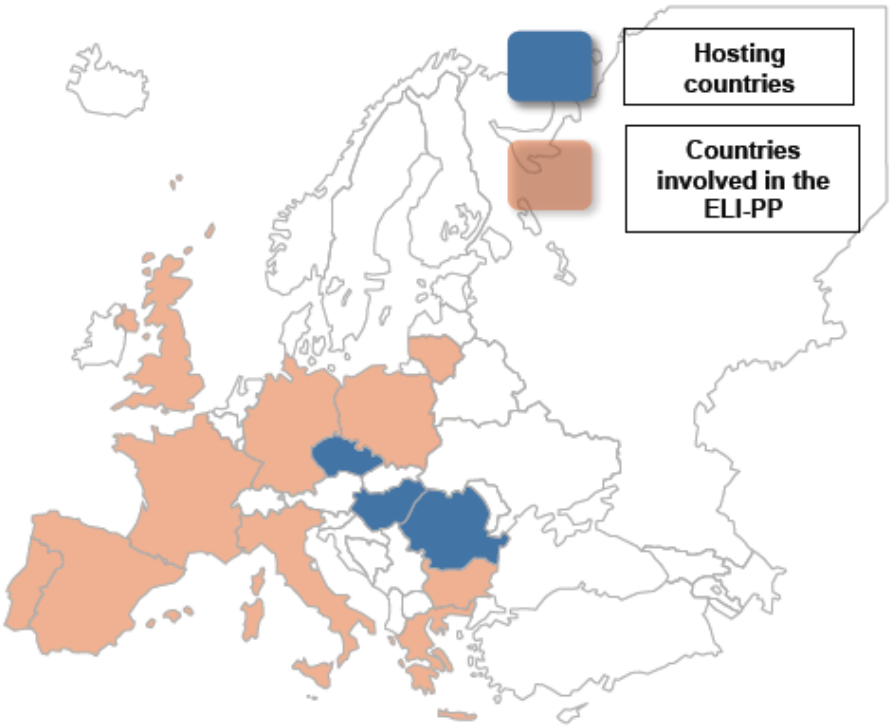
- 40 research and academic institutions from 13 EU countries

Scientific case

- Reflecting the diversity of the research opportunities foreseen within ELI

Political/financial support (structural funds)

- Decision on ELI implementation as a **distributed research infrastructure** in three new member states:
  - **Czech Republic** (Prague)
  - **Hungary** (Szeged)
  - **Romania** (Magurele)

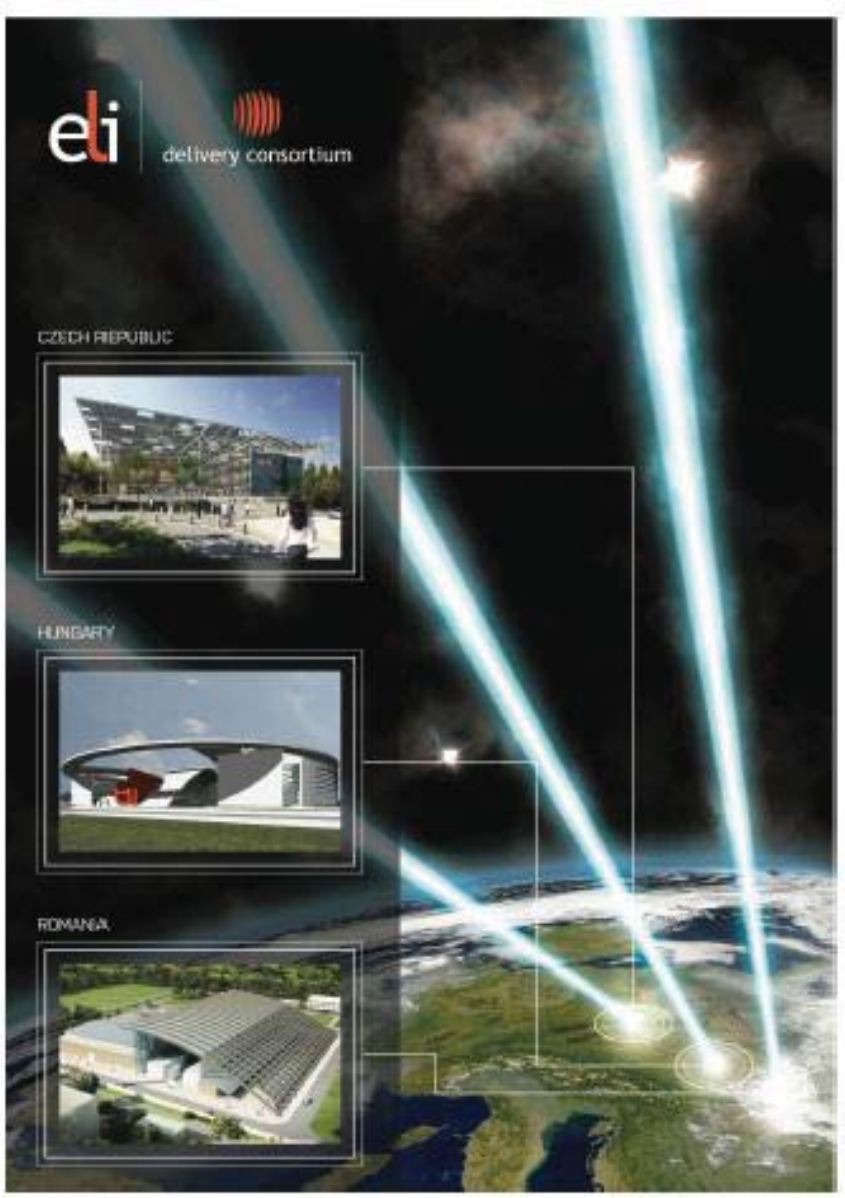


800 M€ Investment !!

ELI: Implementation Phase

Three Pillars

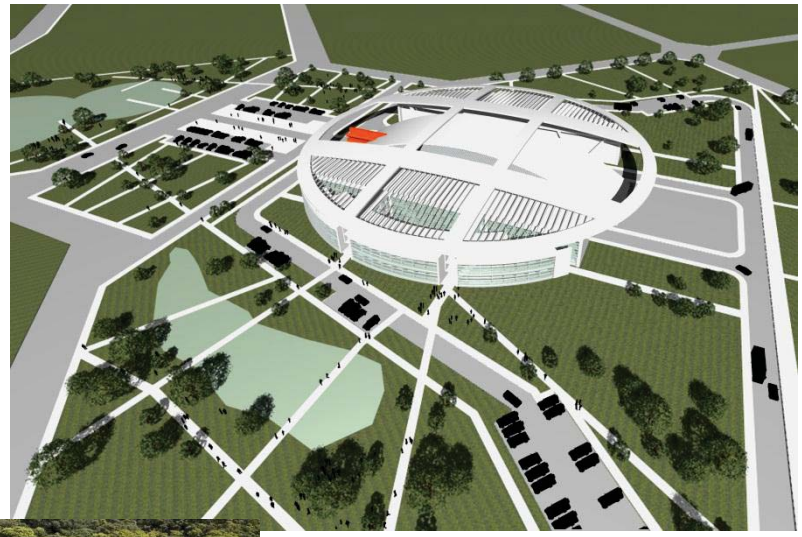
- **ELI High Energy Beam-Line Facility (ELI-Beamlines) (Czech Republic):** highly competitive source of extremely short pulse X-rays, accelerated electrons, or protons for applications (also biomedical).
- **ELI Attosecond Light Pulse Source (ELI-ALPS) (Szeged, Hungary):** ultrafast light sources (coherent XUV and X-ray radiation) including single attosecond pulses, to investigate electron dynamics in atoms, molecules, plasmas and solids.
- **ELI Nuclear Physics Facility (ELI-NP) (Magurele, Romania):** laser and gamma beams (low bandwidth, energies in the 15 MeV range) with unique characteristics to perform frontier laser, nuclear and fundamental research.



ELI: the Three Sites

- **Eli Beam-line facility in Prague (Czech Republic)**

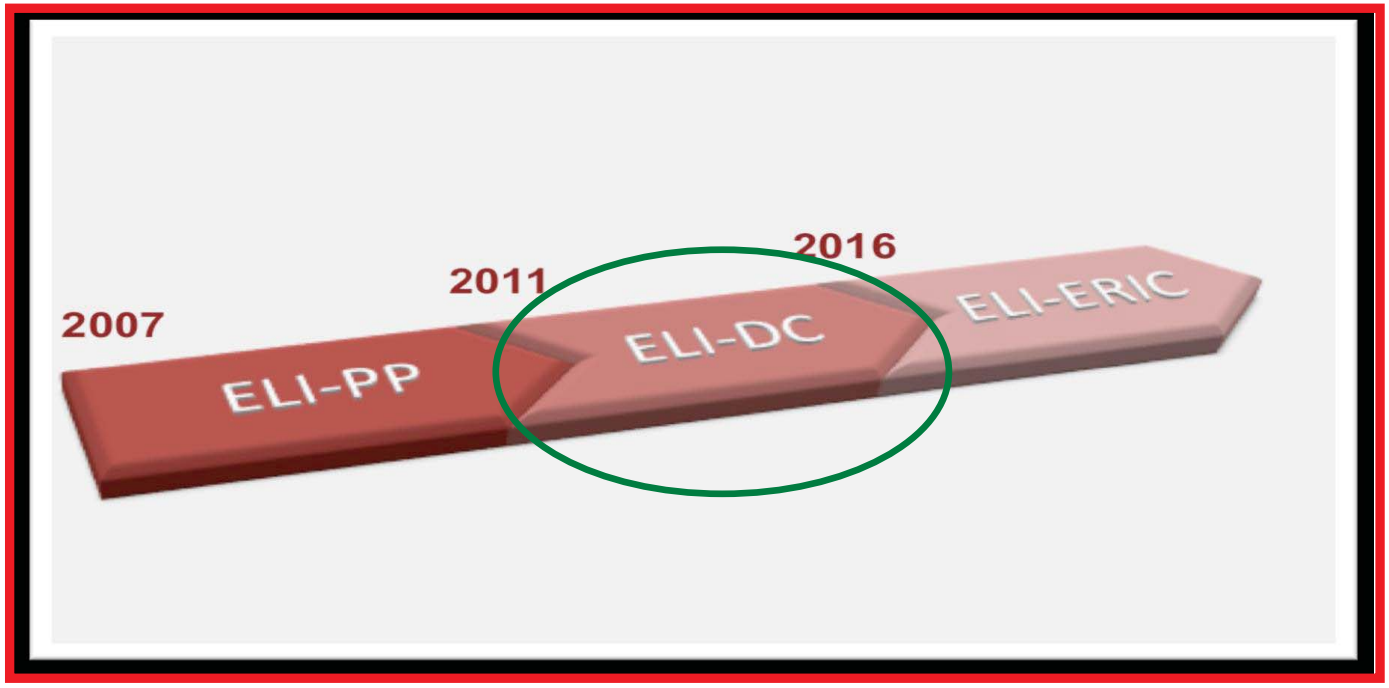
- **Eli Attosecond facility in Szeged (Hungary)**



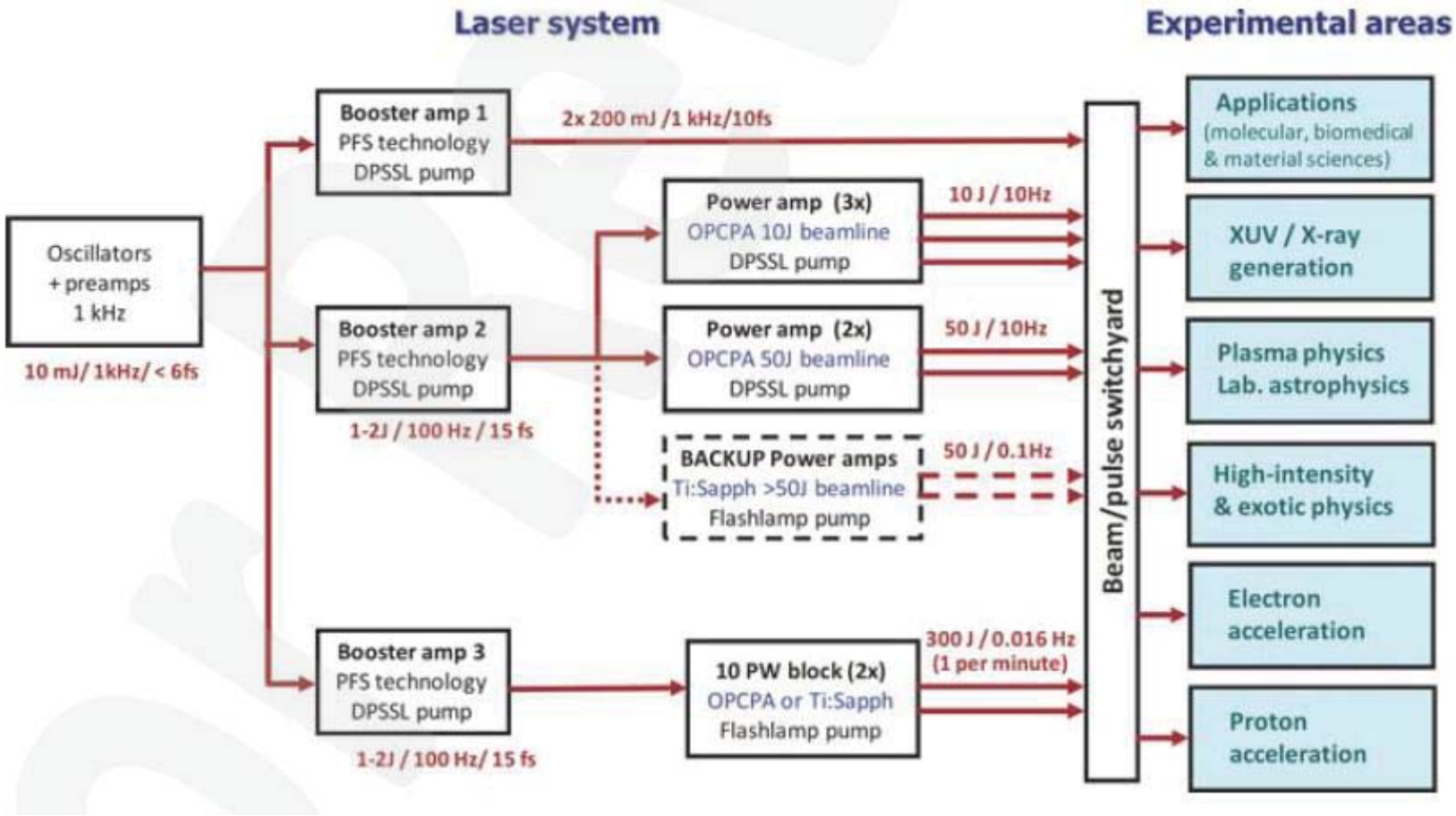
Eli Nuclear Physics facility in Magurele (Romania)

ELI: Governance Evolution

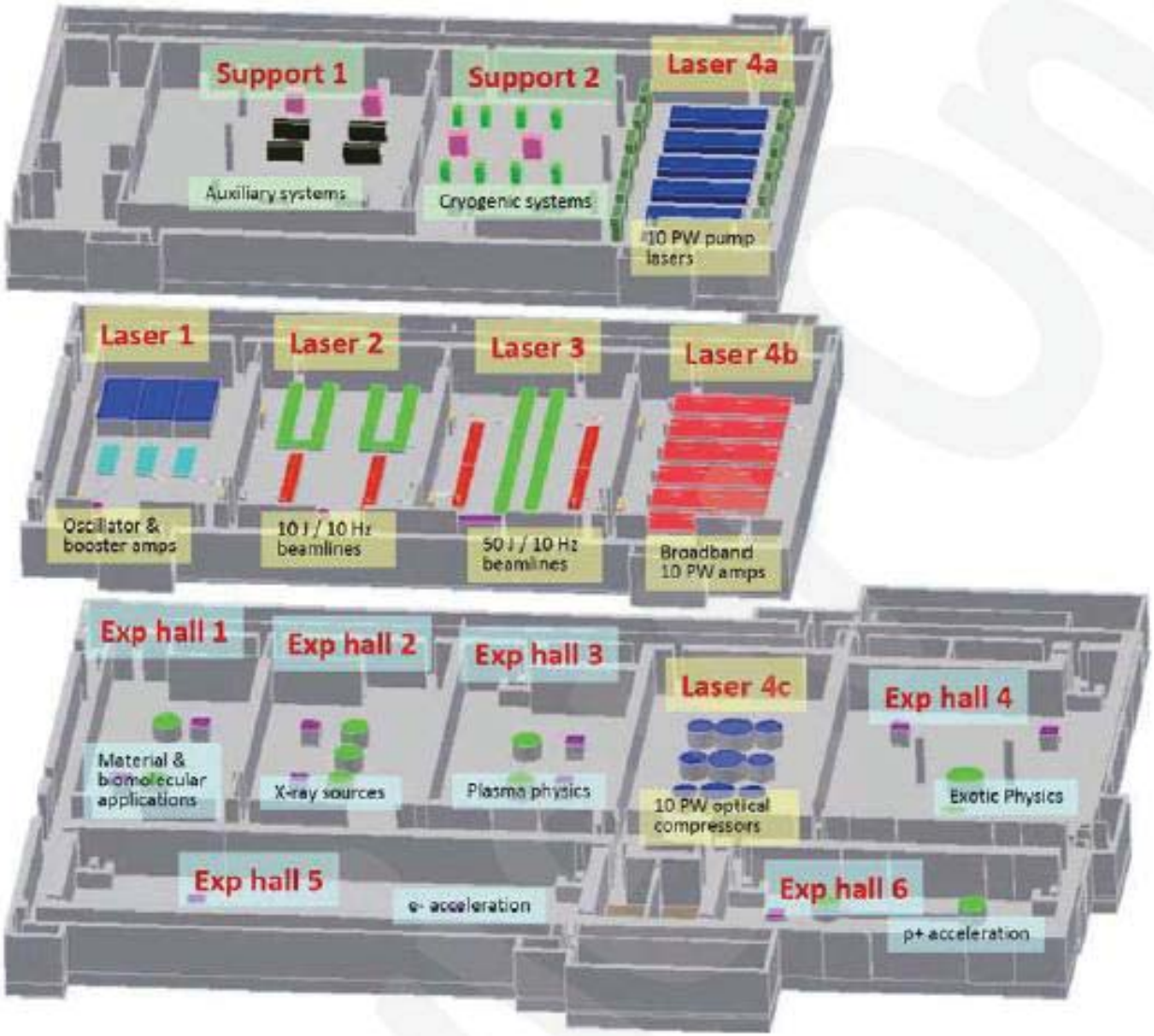
- ELI - Preparatory Phase (ELI-PP)
- ELI - Delivery Consortium (ELI-DC)
- ELI - European Research Infrastructure Consortium (ELI-ERIC)



ELI - Beamlines

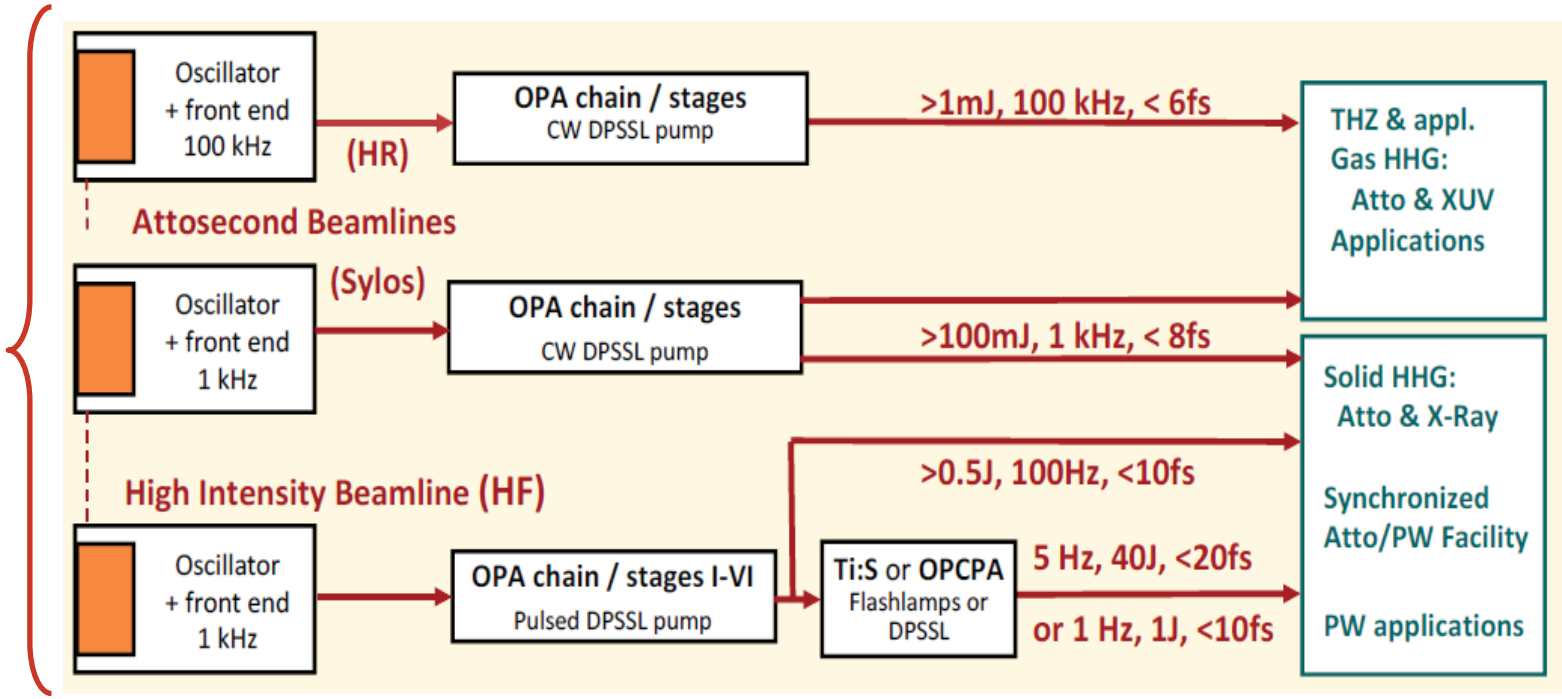


ELI - Beamlines layout

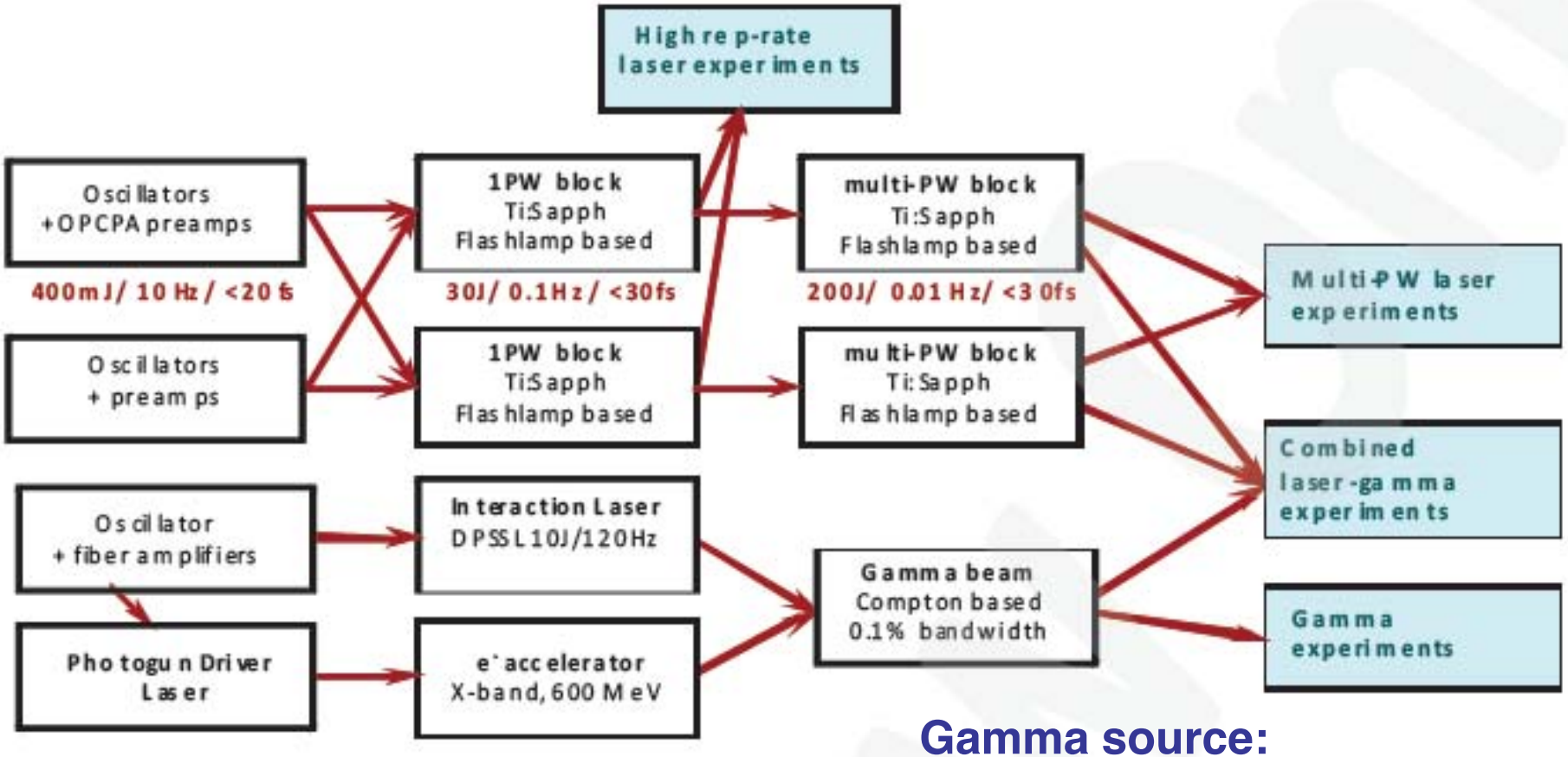


ELI - ALPS: Attosecond science

Laser chain structure



ELI - NP: Gamma ray source



Gamma source:

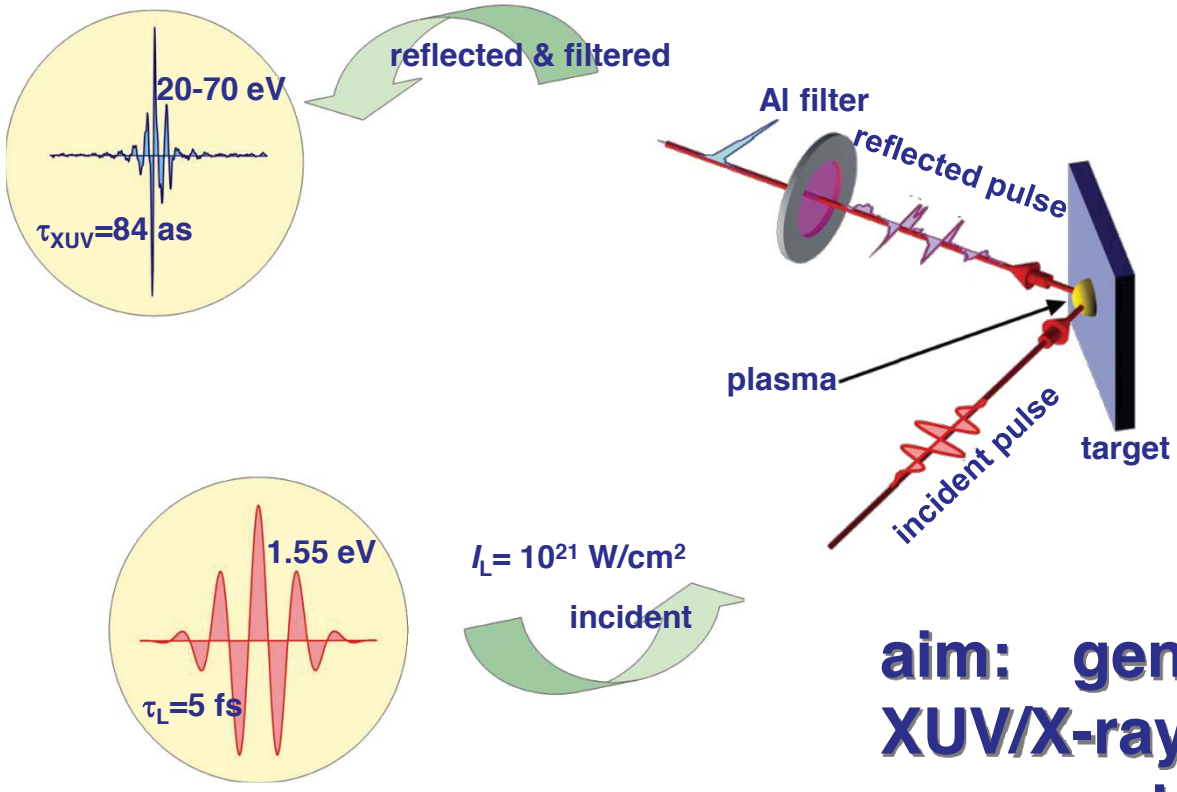
Energy up to 19 Mev

Brilliance > 10^{21}

10^{-3} bandwidth

ELI – Science: example

Ultra-intense attosecond pulses



Concept:
exposure of a solid surface to ultra-intense few-cycle light → anharmonic plasma oscillations efficiently create harmonics in the reflected pulse

aim: generation of attosecond XUV/X-ray pulses with unprecedented energy

ELI - Science: example

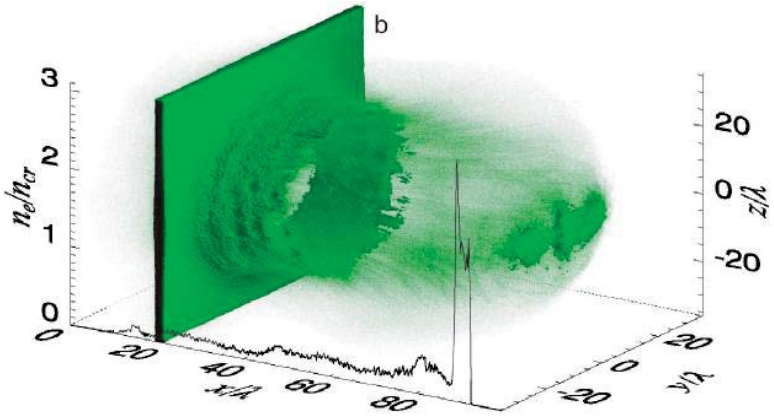
Plasma accelerators

Ions:

Ion beams for cancer treatment with ELI: 250 MeV protons

Electrons:

Ultradense, ultrashort multi-GeV electron bunches with ELI

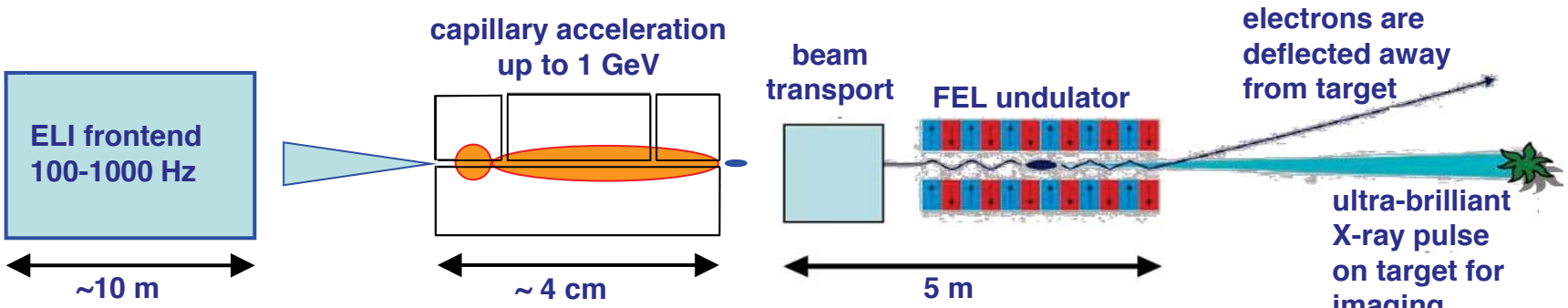


Vision:

- compact accelerators for particle physics and midical imaging

ELI - Science: example

X-ray sources: X-ray Free-Electron Laser (X-FEL)



Schlenvoigt *et al.*, Nature Physics 4, 130 (2008)

ELI: Which are the Needs?

- **ELI is at forefront of present laser technology, material and optics performance**
  - Coordinated efforts from European Laboratories and Industries are required
- **Qualified personnel**
  - Setting-up training programs

ELI: Technical Development/Design

- Series of experiments performed on “a reduced scale” helping to identify critical elements for ELI project
- Design and construction of specific instrumentations and beam-lines for ELI infrastructures
- Radioprotection design studies

ELI: Education Initiatives

- **Training Engineers and Researchers in**
  - ultrashort pulse lasers
  - secondary sources (handling and detection)
  - attosecond science
  - XUV optics and vacuum technology
  - Radioprotection
- **Stimulate university education programs** on ELI related subjects in optics and atomic/molecular physics

Conclusions

- **The Laser Scientific Community is strongly involved** in research activities related to ELI infrastructures
- **Contributions to ELI can come in different ways:** design, technical development, training, etc…
- **A large "User Community" is present,** which can perform at ELI