eli delivery consortium

EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND
INVESTING IN YOUR FUTURE

Creating and using Extreme Light

Wolfgang Sandner
Director General and CEO
ELI Delivery Consortium International Association (AISBL)

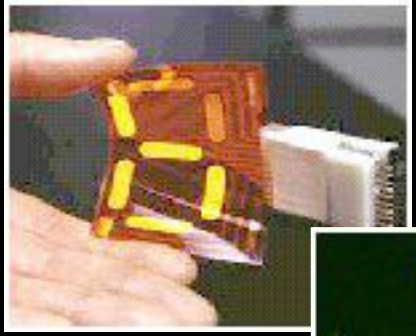
World Science Forum, November 6, 2015, Budapest, Hungary
Session on the “International Year of Light”

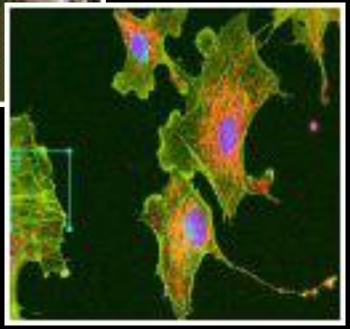
United Nations Educational, Scientific and Cultural Organization
International Year of Light 2015

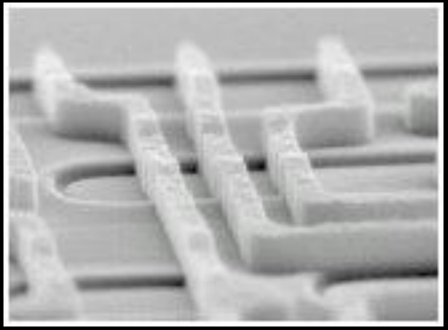
WORLD SCIENCE FORUM BUDAPEST

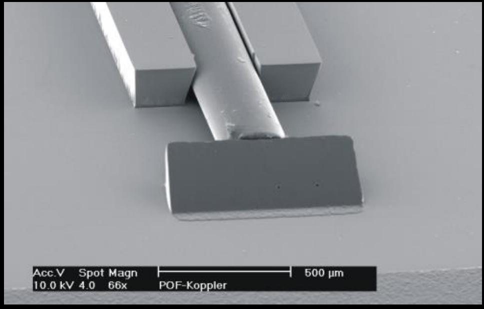
Coherent light from lasers has changed the world

Materials processing, Sensing, Metrology, Medicine, Information Technology, Entertainment …









With all this success –

What is the need for “extreme light”?

Lasers could change the world again ...

... by

W.C. Röntgen

controlling the coherence of x-rays, the light of the micro- and nano-technologies

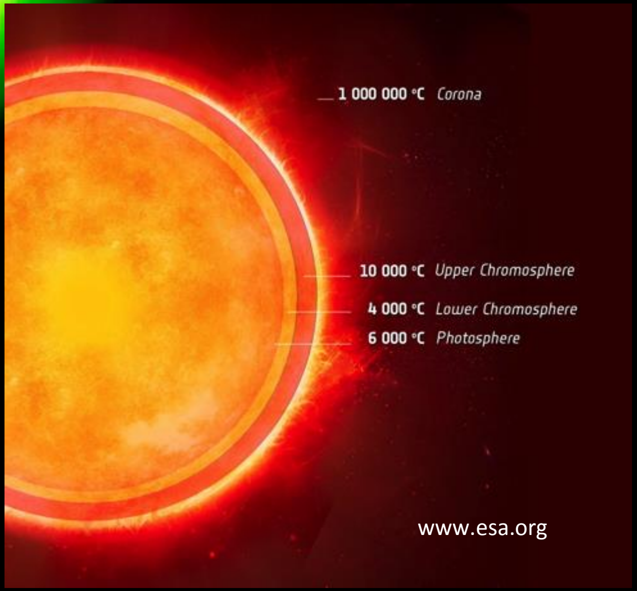
Lasers could change the world again …

… by

accelerating particles beyond the limits of established technologies, or in novel compact devices

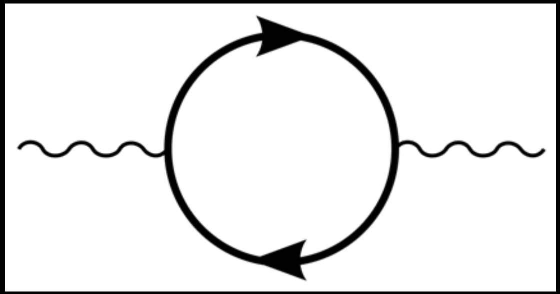
Lasers could change the world again …

… by



creating and controlling the interior of stars in the laboratory

Lasers could change the world again …



… or even by

controlling virtual particles (quantum vacuum fluctuations)

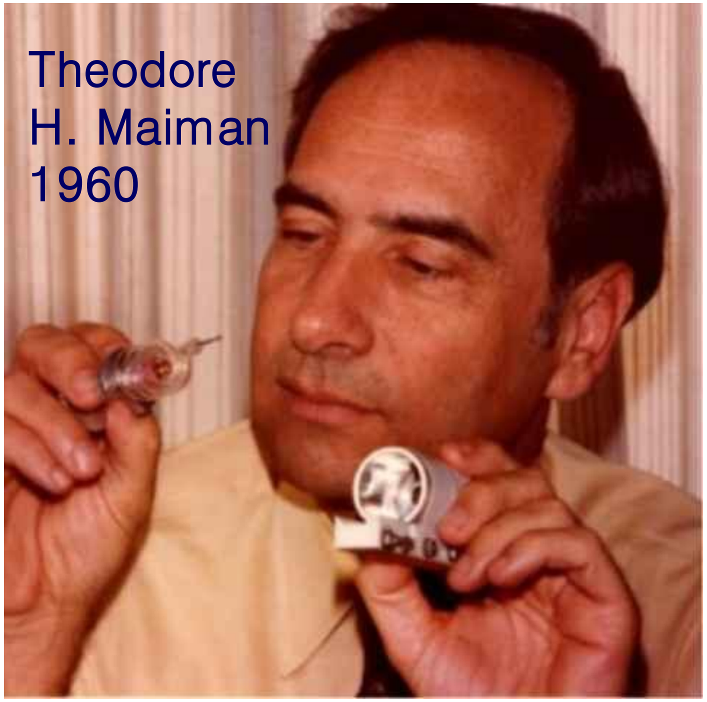
The key lies in **ultra-high intensity / ultra-high power lasers**

How?

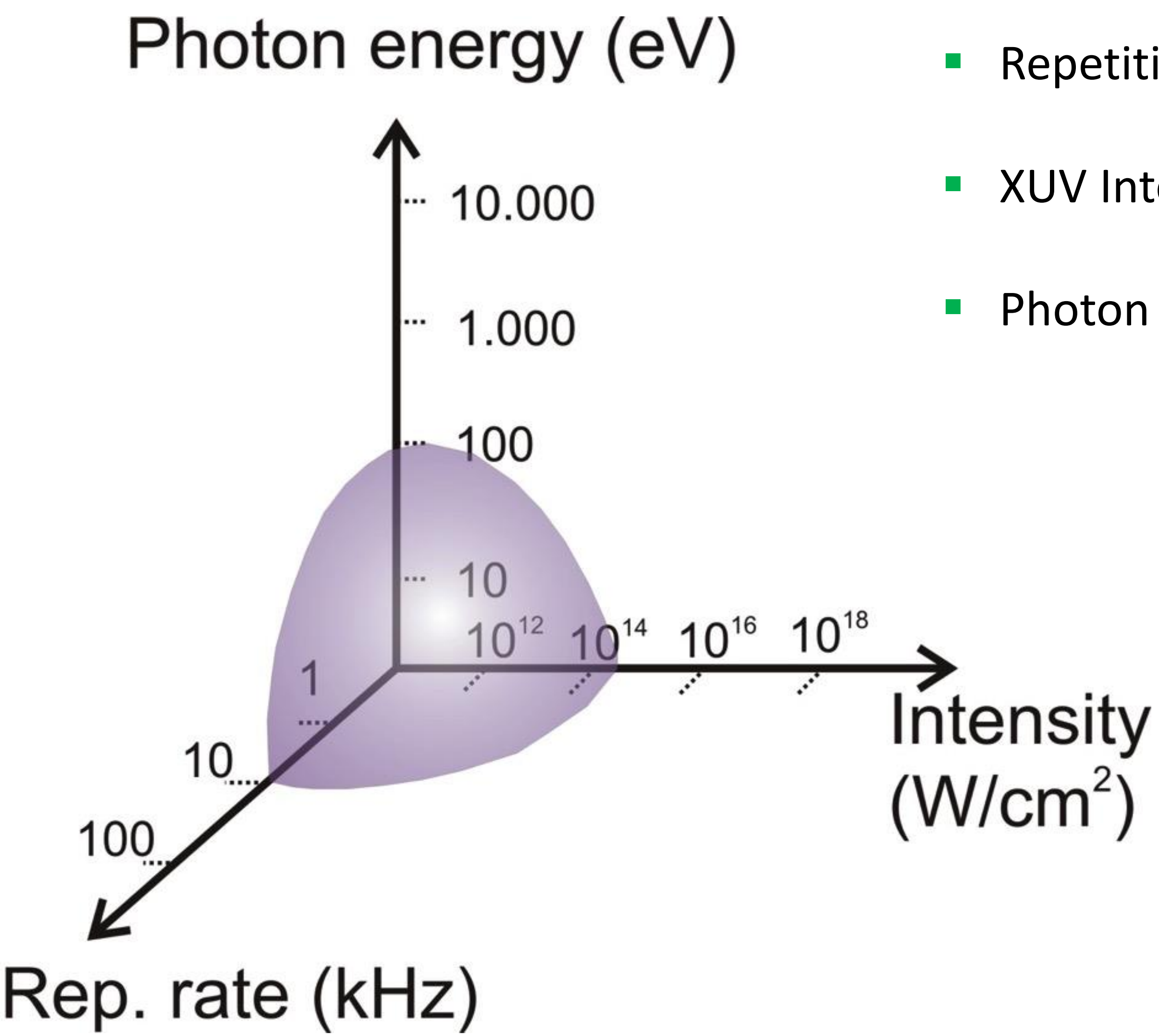
Taking Theodore Maiman‘s laser concept to the extreme - to multi-petawatt powers, attosecond pulses and broadest spectral range

Keywords for experts

Chirped Pulse Amplification
Coherent Combining
Parametric Amplification
Diodes for multi-kW average power

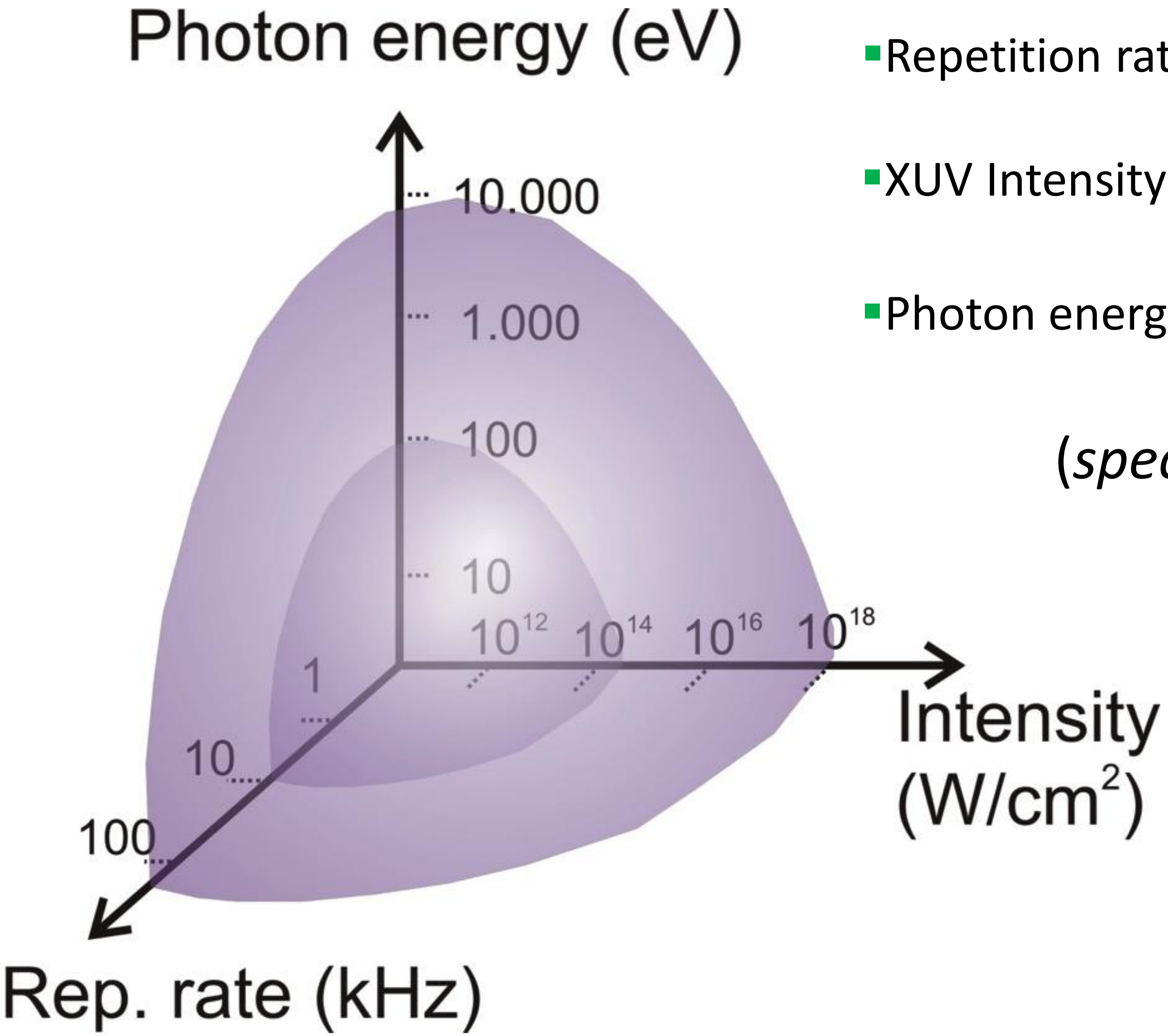


Today's spectral coverage, ultra-short intensity and repetition rate



- Repetition rate (few Hz-10 kHz)
- XUV Intensity (10^9-10^{14} W/cm^2)
- Photon energy (10-100 eV)

ELI: spectral coverage, ultra-short intensity and repetition rate



- Repetition rate (few Hz-100 kHz)
- XUV Intensity (10^9-10^{18} W/cm^2)
- Photon energy (10-10.000 eV)

(*specs from ELI-ALPS, Szeged, Hungary*)

From all this: New science and applications

Science	Application
Investigation of Vacuum Structure	
Electron Acceleration	X-rays => Materials Research
Ion sources	Medical, Materials Research
Neutron sources	Materials research
Terahertz sources	Analytics
Ultrafast-laser driven X-ray sources	Micro-, Nano-Techn.
Attophysics	Chemistry
Nuclear & Photonuclear Physics	Mat. Res., Med., Environm.
Physics of dense plasmas	X-rays, Fusion
Laboratory Astrophysics	

(from the “ELI White Book”)

eli delivery consortium

United Nations Educational, Scientific and Cultural Organization

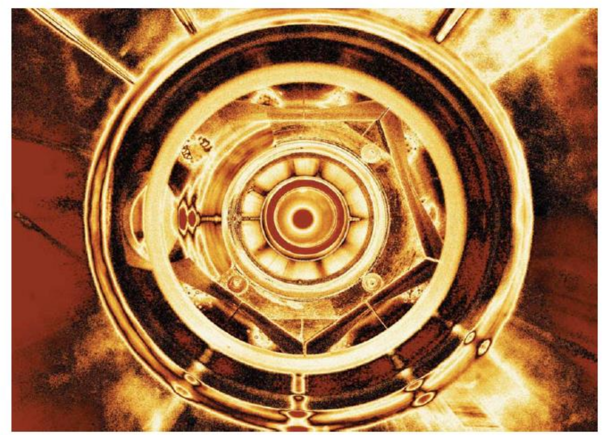
International Year of Light 2015

This is why Europe has decided 10 years ago to build ELI, the "Extreme Light Infrastructure"

ELI – Extreme Light Infrastructure

Science and Technology with Ultra-Intense Lasers

WHITEBOOK



Editors
Gérard A. Mourou
Georg Korn
Wolfgang Sandner
John L. Collier

530 pages
172 authors
10 major interdisciplinary fields

The facilities

delivery consortium

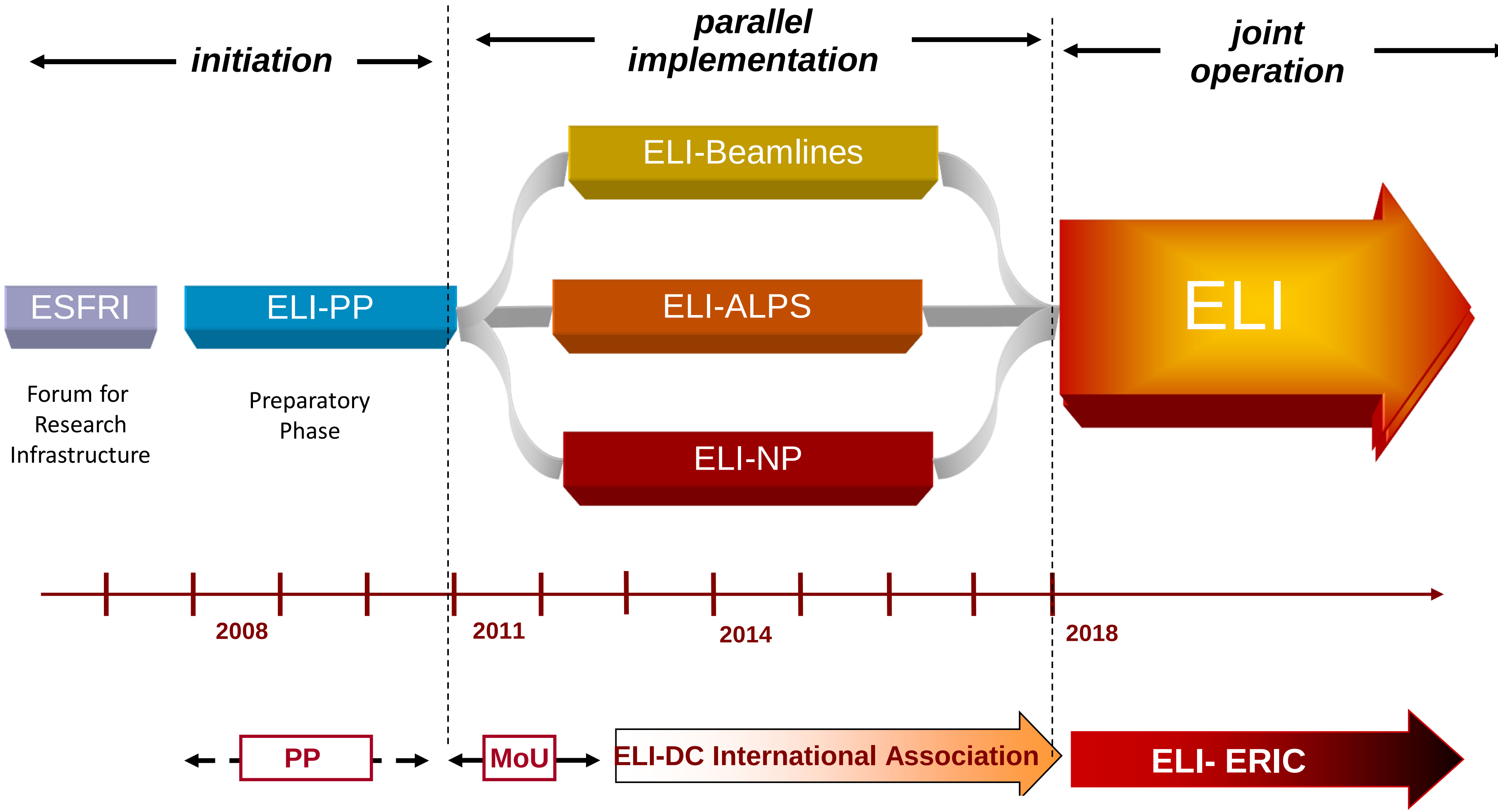
High-Energy Beam Facility (*ELI-Beamlines*, Dolni Brezany, CZ): development and application of ultra-short pulses of high-energy particles and radiation

Attosecond Light Pulse Source (*ELI-ALPS*, Szeged, HU): new regimes of time resolution

Nuclear Physics Facility (*ELI-NP*, Magurele, RO): novel photonuclear studieswith ultra-intense lasers and brilliant gamma beams (up to 19 MeV)

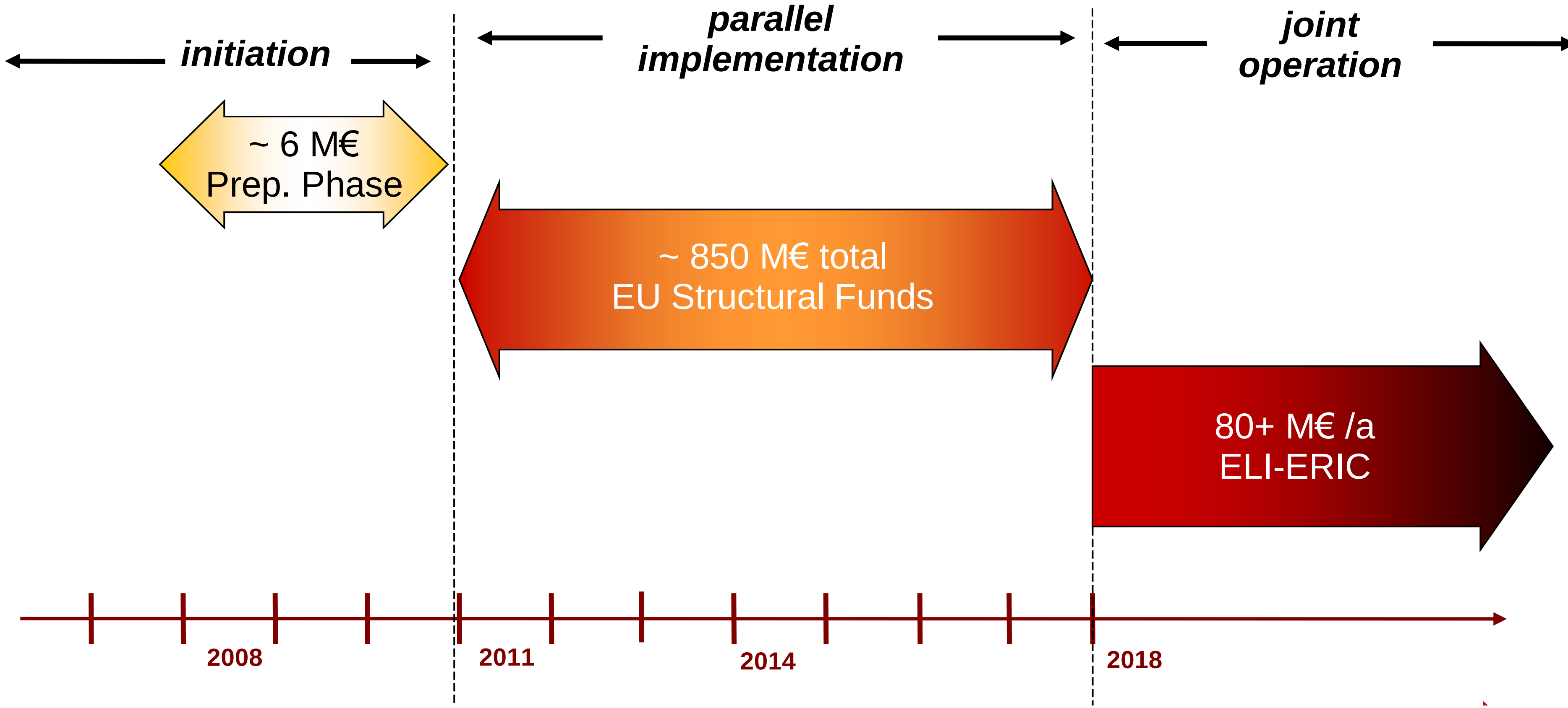
Ultra-High-Field Facility (*ELI 4*, to be decided): physics with unprecedented laser field strengths

The implementation plan



Governing bodies

The financial plan



Construction in Szeged (HU) few weeks ago

National Development Agency
www.ujszechenyiterv.gov.hu
06 40 638 638

HUNGARY'S RENEWAL

The projects are supported by the European Union and co-financed by the European Regional Development Fund.

ELI-ALPS building in Szeged (HU) when finished in 2016

National Development Agency
www.ujszechenyiterv.gov.hu
06 40 638 638

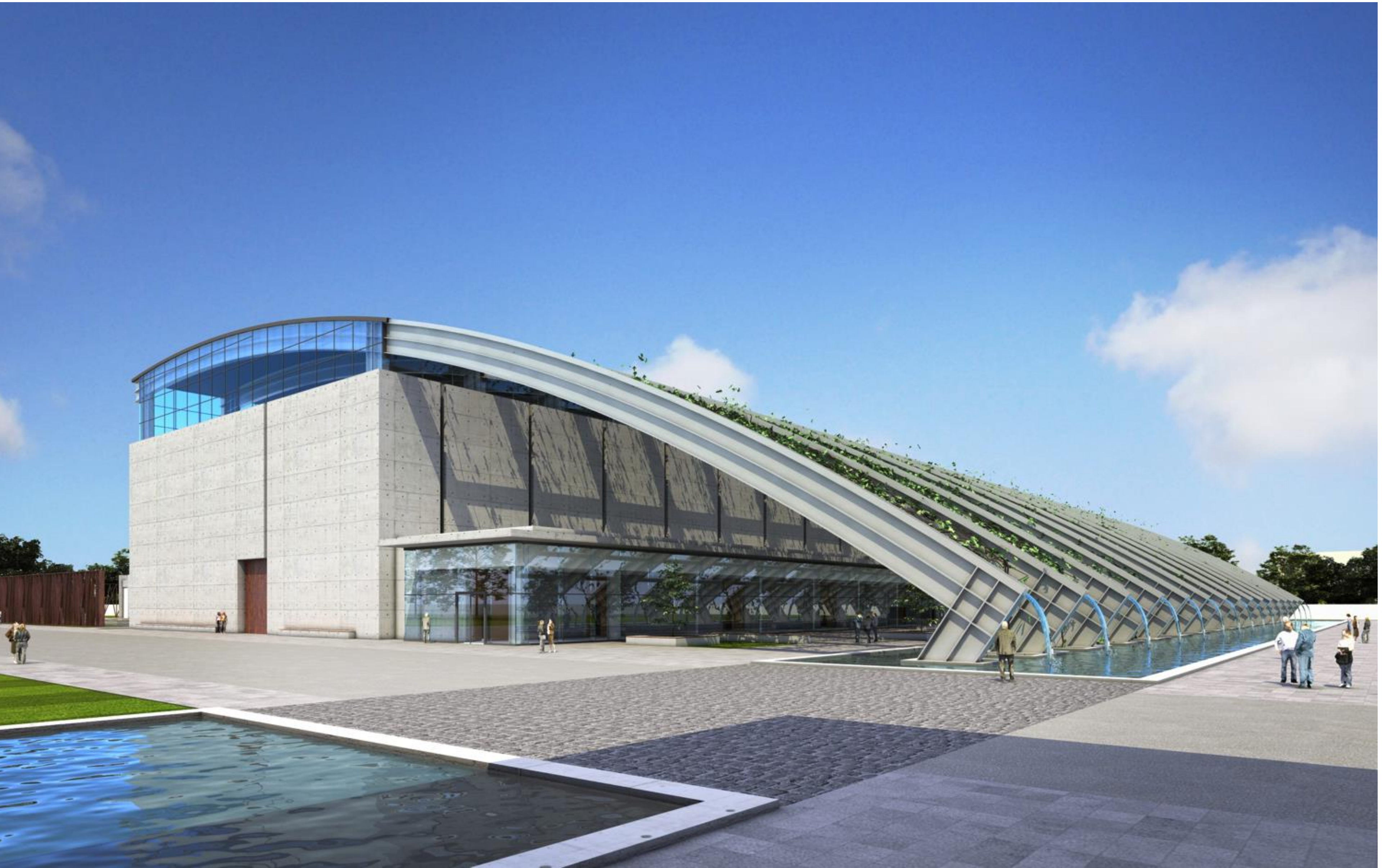
HUNGARY'S RENEWAL

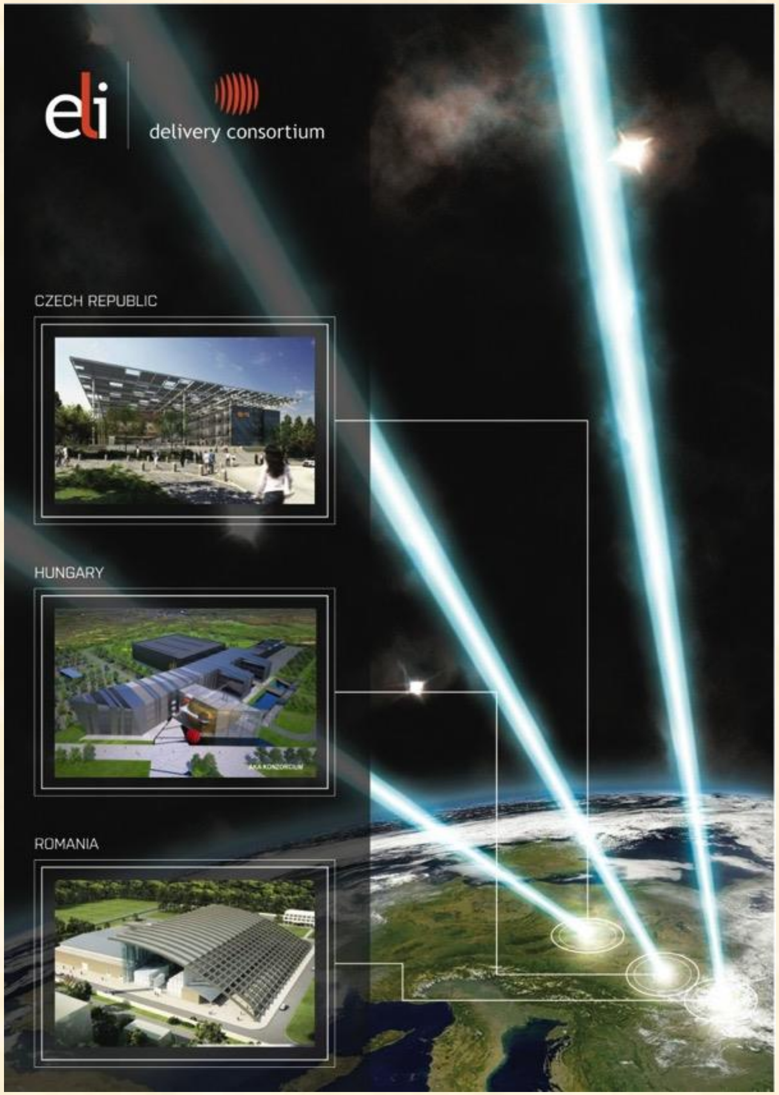
The projects are supported by the European Union and co-financed by the European Regional Development Fund.

ELI-Beamlines building in Dolni Brezhany near Prague, CZ (opened recently)

Construction in Magurele (RO) few months ago

ELI-NP building when finished in 2016





With all this, ELI will be the world‘s first international laser user facility, providing unique research opportunities for science and innovation and socio-economic impact for Europe

“*The CERN of laser research*”

It requires new "disruptive technologies"

- **Chirped pulse amplification (1986)**: overcoming the B-Integral barrier (self-focusing).The basis of today's PW-lasers.
- **Optical parametric amplification**: potentially overcoming intermediate energy storage, contrast-, bandwidth- & thermal problems
- **Coherent beam superposition:** potentially overcoming size limitations in optical components
- **Others?** Damage-resistant surfaces, crystals, gratings, new amplifier concepts (e.g. Raman) or compressor concepts
- **Diode pumping**: overcoming the average power problem ("*the next challenge after multi-PW is multi-kW*")

delivery consortium

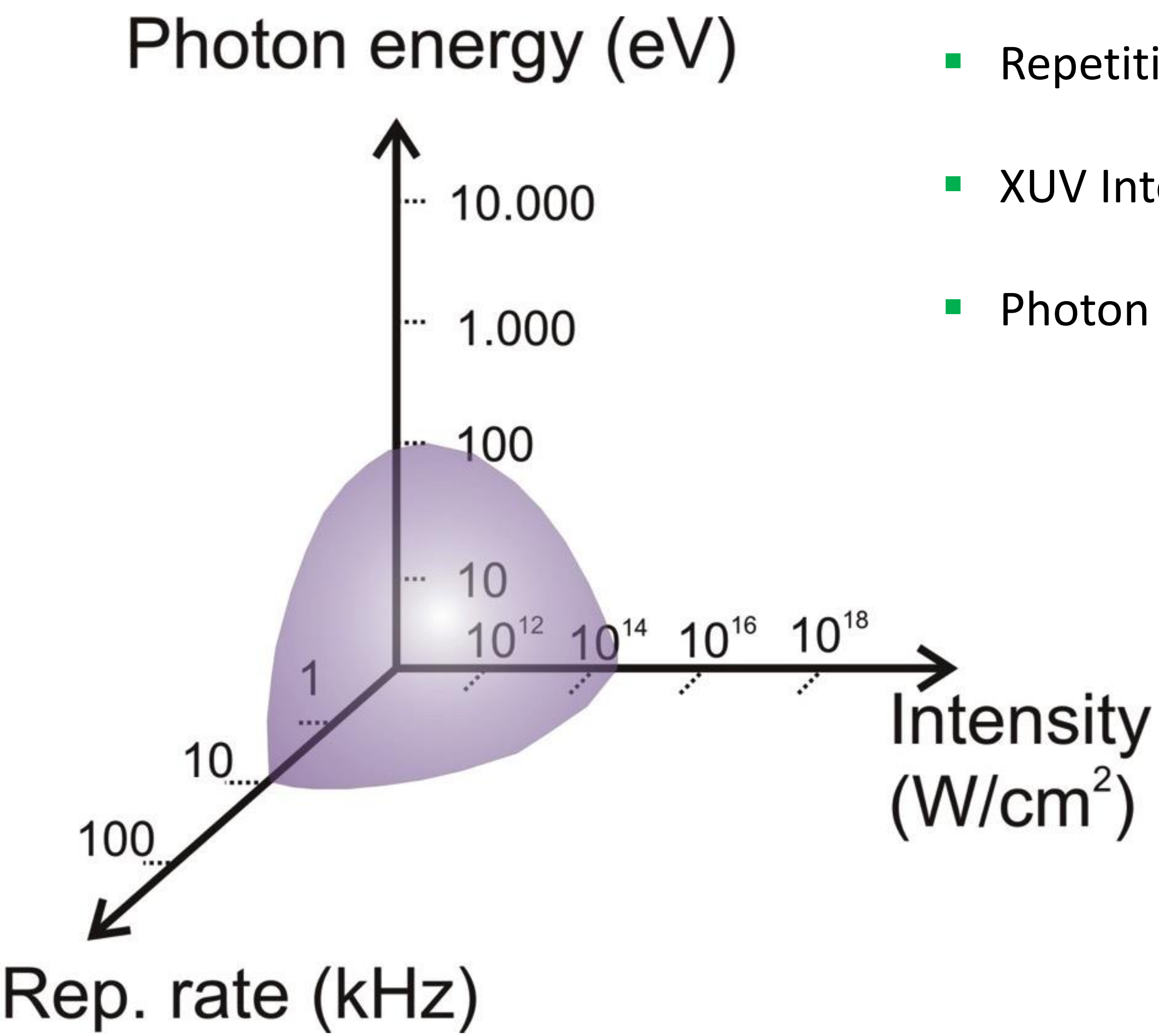
Extreme peak power @ ELI

- Today's most powerful lasers achieve max. few PW @ max. 1Hz (typically << 1Hz).
- There exist about a dozen PW lasers world-wide, more are planned

- **ELI will have by 2018**
  - Two coupled 10PW Ti:Sa lasers (ELI-NP)
  - One 1-2PW, diode-pumped laser @ >10Hz (ELI-BL)
  - One 1PW OPCPA laser, <20fs, 10Hz (ELI-BL)
  - One 10PW mixed-glass laser (1.5kJ, 150fs) (ELI BL)
  - One multi-PW Ti:Sa laser @ few Hz (ELI-ALPS)

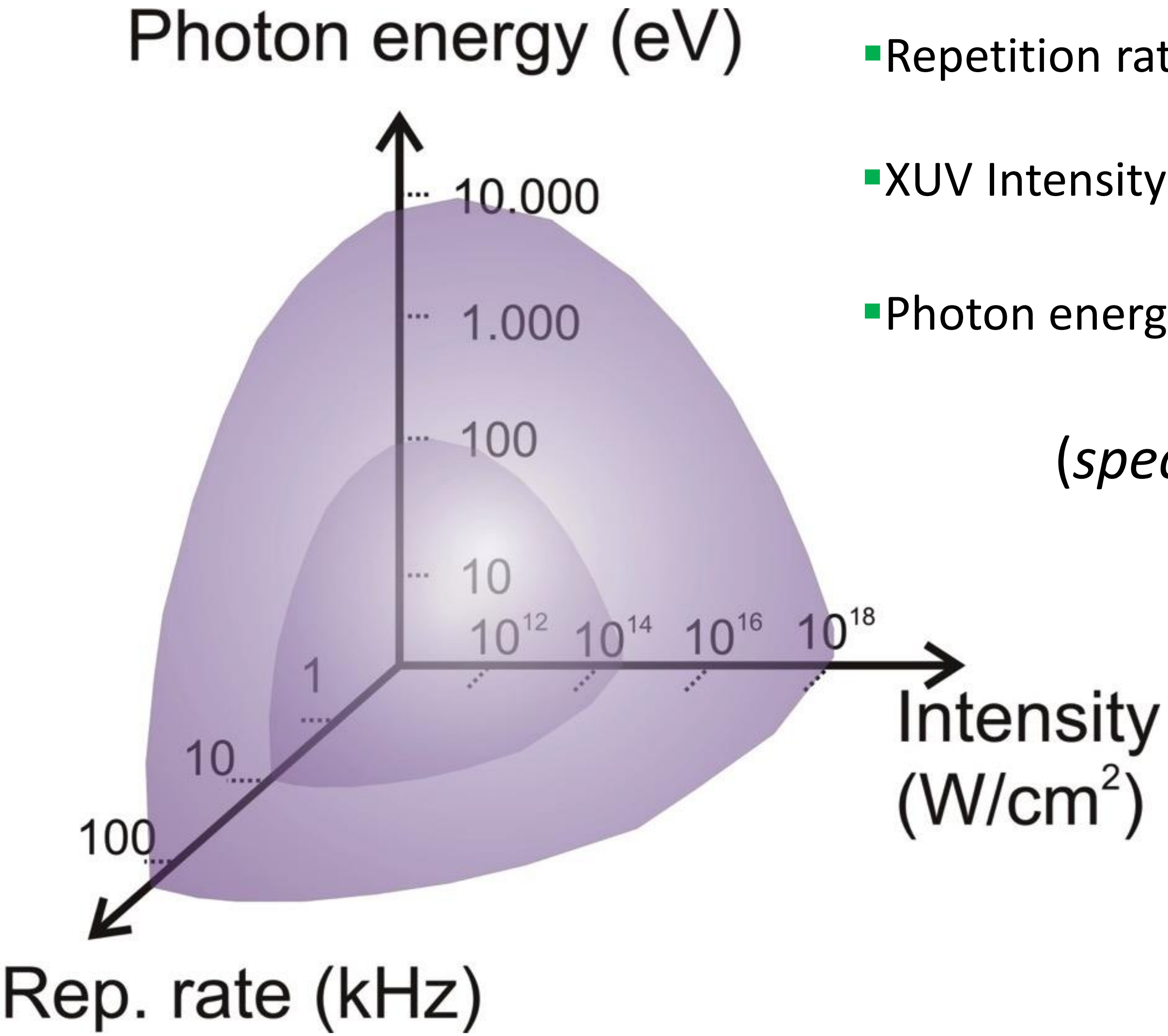
Each of these exceeds today's state-of-the-art (power and/or repetition rate) by a factor of ~10

Today's spectral coverage, ultra-short intensity and repetition rate



- Repetition rate (few Hz-10 kHz)
- XUV Intensity (10^9-10^{14} W/cm^2)
- Photon energy (10-100 eV)

ELI: spectral coverage, ultra-short intensity and repetition rate



- Repetition rate (few Hz-100 kHz)
- XUV Intensity (10^9-10^{18} W/cm^2)
- Photon energy (10-10.000 eV)

(*specs from ELI-ALPS, Szeged, Hungary*)

Example: What users will get (ELI-Beamlines in CZ)