ELI: Scientific opportunities, perspective & challenges

delivery consortium

ELI Consultation of UK User Community
London, 11 June 2018

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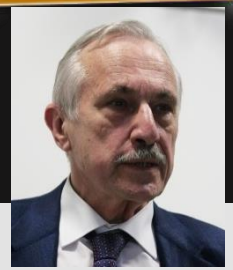
ELI's trajectory



reaching highest laser intensities & related applications

Joint Initiation → ← **Parallel Implementation** → ← **Joint Operation** →

13 Countries

40 Research Institutions

ESFRI | **ELI-PP**

ELI-Beamlines
Czech Republic

ELI-ALPS
Hungary

ELI-NP
Romania

ELI

2006 2007 2010 2011 2013 2017 2018

PP Consortium | **MoU** | **ELI-DC AISBL**
DE, IT, UK

ELI- ERIC

New science, unique research opportunities

ELI-DC

The consortium coordinating the implementation of the three pillars & the establishment of the ELI-ERIC

ELI-ALPS Szeged Hungary

Investigations of ultra-fast dynamics @ attosecond & nm spatiotemporal scales

ELI-BL Dolni Brezany Czech Republic

Applications of ultra-short pulses of high-energy particle & radiation beams

ELI-NP Magurele Romania

Ultra-intense laser & brilliant gamma/neutron beams enabling photonuclear studies

UHFS

Ultra-High-Field Science @ unprecedented laser field strength (location: to be decided later)

ELI: A prompt impact

ELI, being at forefront of present laser technology and material/optics performance, has generated so far:

- Strong involvement of Research Laboratories from UK, Germany, France, Greece, Italy, Sweden, USA… : initiating several research projects
- Strong involvement of Industries (Thales. Amplitude, Fastlite, Ekspla….), mainly in the laser market: driving investments in *R&D* laser technology

A large fraction** of ELI investment in primary and secondary sources / beamlines has been mainly addressed **to European countries and USA, boosting a tangible technology development

ELI's large impact on primary source development to serve user research

LASER SYSTEMS		Peak power	Energy in pulse	Pulse duration	Repetition rate
ELI-Beamlines	Astrella		6 & 10 mJ	20fs	1kHz
	Bio Laser		6 mJ	20fs	1kHz
	L1 (CEP stab)	>5 TW	30 (100) mJ	< 20 fs	1 kHz
	L2	100 TW	10 J		10 Hz
	L3		16 (>30) J	≤ 30 fs	10 Hz
	L4		1.5 kJ	120 fs	0.1 Hz
ELI-ALPS	HR I (CEP stab)		1 mJ	< 2 cycles (< 6 fs)	100 kHz
	HR II (CEP stab)	1 TW	5 mJ	< 2 cycles (< 6 fs)	100 kHz
	SYLOS(CEP stab)	20 TW	> 100 mJ	< 2 cycles (< 6 fs)	1 kHz
	HF	2 PW	34 J	17 fs	10 Hz
	MIR	25 GW	> 0.15 mJ	< 4 cycles	100 kHz
ELI-NP	HPLS output 1 (2x)	0.1 PW	1.5 – 2.5 J	15 - 25 fs	10 Hz
	HPLS output 3 (2x)	1 PW	15 – 25 J	15 - 25 fs	1 Hz
	HPLS output 3 (2x)	10 PW	150 - 250 J	15 - 25 fs	1 shot/ min

GAMMA SOURCE		Maximum Energy (MeV)	Bandwidth	Spectral Density (photons/s/eV).
ELI-NP	Gamma Source 1	3.5 MeV	<0.5%	$>5 \times 10^3$
	Gamma Source 2	19.5 MeV	<0.5%	$>5 \times 10^3$

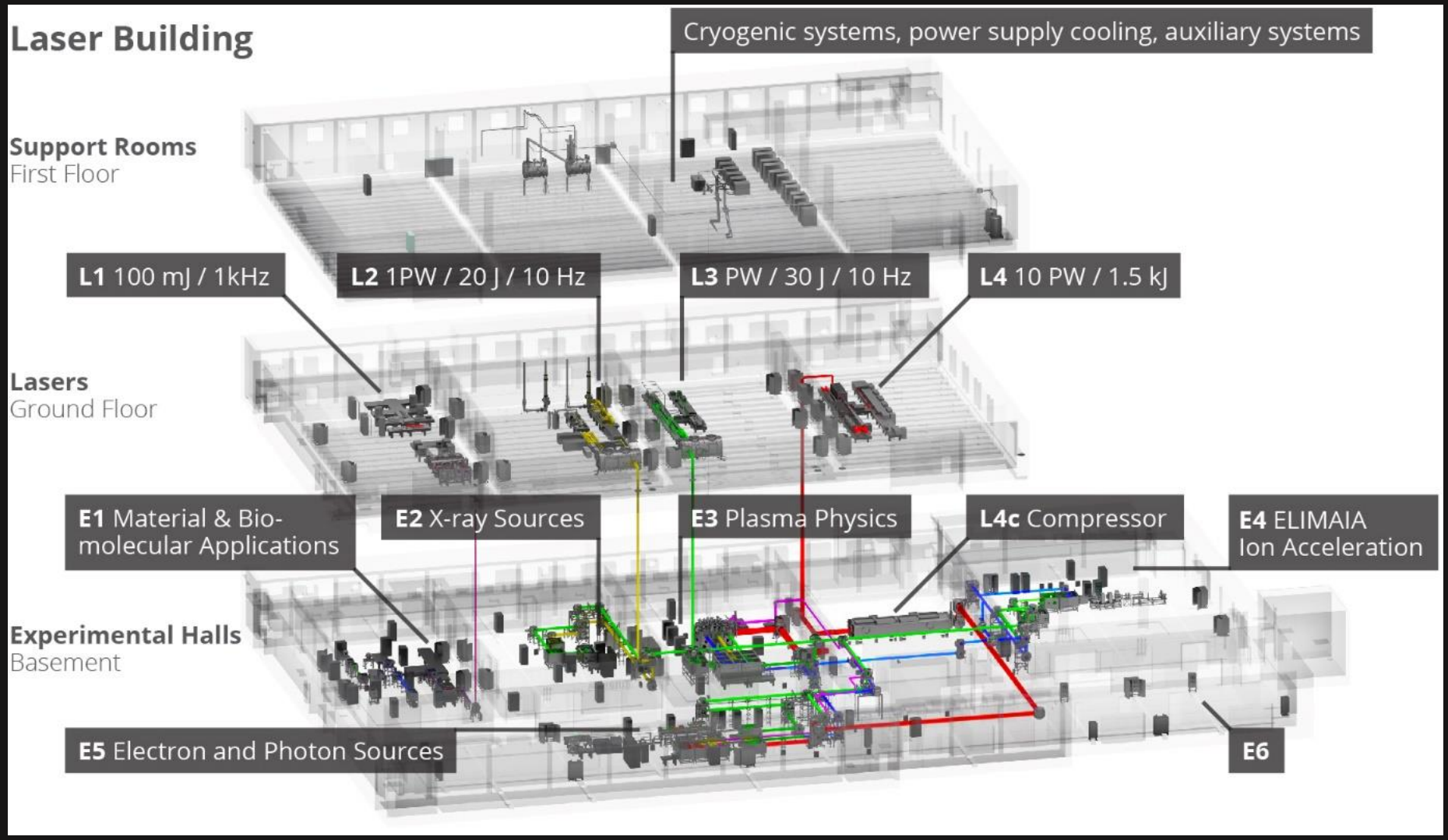
ELI's secondary sources / beamlines open to the international research community

Secondary Sources / Beam lines / Experimental areas		Delivering
ELI-Beamlines	ELIMAIA	50 (200) MeV, ions
	HELL	0,5 (3) GeV, electrons
	LUX (laser udulator x-ray source)	water window, photons
	Betatron	10-20 keV,, photons
	PXS	10-30 keV, photons
	HHG	soft x-ray, photons
	Compton	50-100 keV, photons
ELI-ALPS	HR GHHG I	≤100eV, photons, attosecond, 100kHz, for CM exp.
	HR GHHG II	≤100eV, photons, attosecond, 100kHz, for gas phase exp.
	GHHG SYLOS compact	≤100eV, photons, attosecond, energetic pulses, 1kHz
	GHHG SYLOS long	≤100eV, photons, attosecond, energetic pulses, 1kHz
	SHHG SYLOS	≤100eV, photons, attosecond, energetic pulses, 1kHz
	SHHG HF	sub-keV, photons, attosecond, energetic pulses, 10 Hz
	THz 1, THz 2	Spectroscopy, high energy
	Electron SYLOS	~50Mev electrons, 1kHz
	Ion HF	~ 100 MeV (single shot), 20 MeV (10Hz), Ions
ELI-NP	QED High Field	High Power Laser
	Nuclear Physics	Gamma beam / High Power Laser
	Positron Source	Positrons
	Electron collisions	GeV electrons

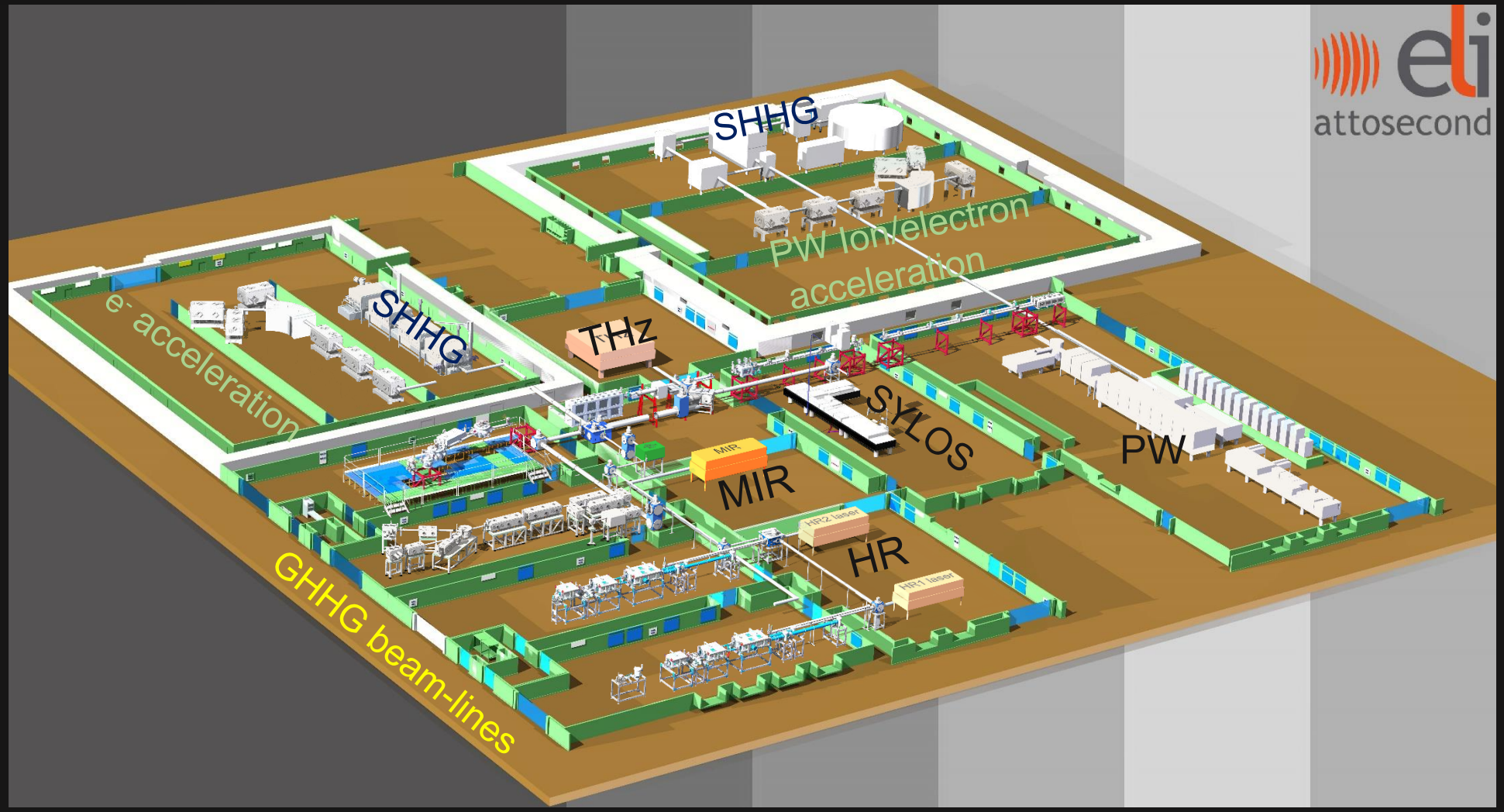
ELI's user experimental stations / areas

Experimental station / area		Involves
ELI-BL	Trex	X-ray diffraction, spectroscopy and radiolysis
	ELIps	sub-ps VUV ellipsometer
	MAC	Multi-purpose chamber that will be used for AMO physics and CDI
	SRS	Optical spectroscopy and pump beams
	HELL user station	Electron acceleration and laser beam transport and monitoring
	LUX user station	
	ELIMED	Medical applications
	P3 - Plasma Physics	
ELI-ALPS	Surface & Condensed matter	NanoEsca, spin filter, sample preparation & diagnostics
	Reaction Microscope	Electron – Ion imaging coincidence set up
	AMO spectroscopy	VMIs, Magnetic bottles, TOFs, Optical/XUV spectrometers
	Liquid phase	Liquid jet, electron spectrometer
	Nano Science	
	High Field Plasma Physics	Ion acceleration target, Thomson parabolas, intensity diagnostics, etc.
	Radiobiology & Biology	Dosimetry, Zebra fish irradiation lab, 2D spectroscopy, THz spectr.
	Chemical physics	Semiconductor, chemical reactions & control
ELI-NP	NRF	Nuclear Resonance Fluorescence
	GANT	Gama above the Neutron Threshold
	Photo -fission	
	Industrial and medical applications	
	ELIADE array	8 segmented HPGeClover detectors with anti-Compton shields + 4 LaBr3 detectors
	CsI detectors	CsI array for angle resolved calorimetry

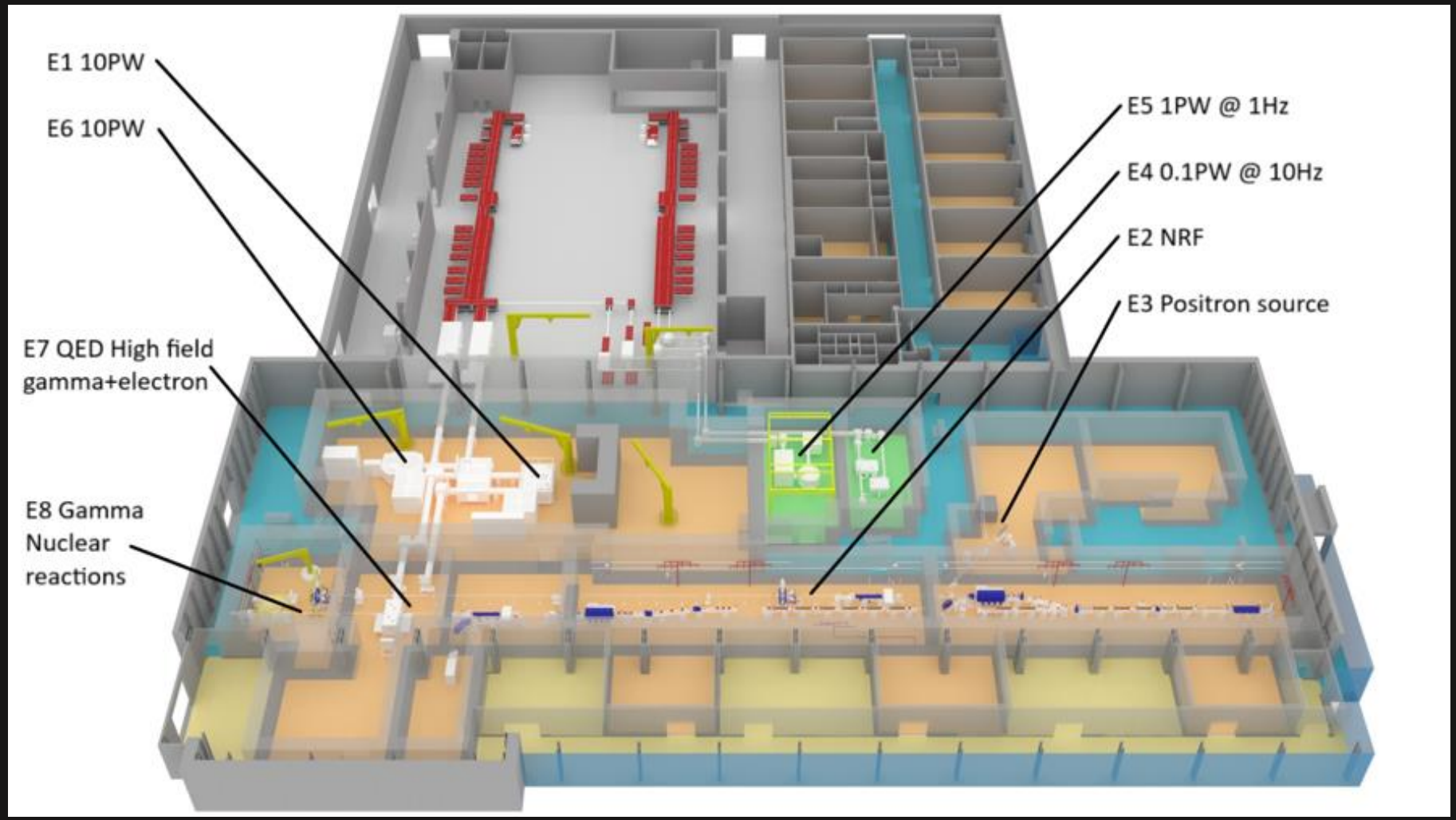
ELI BL Layout



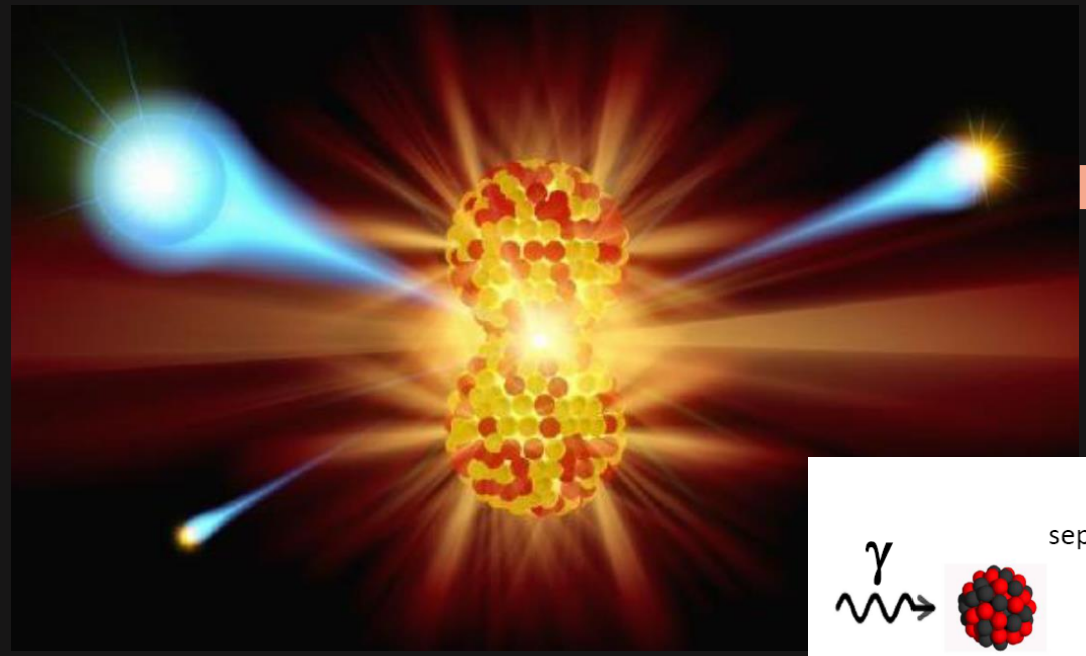
ELI ALPS Layout



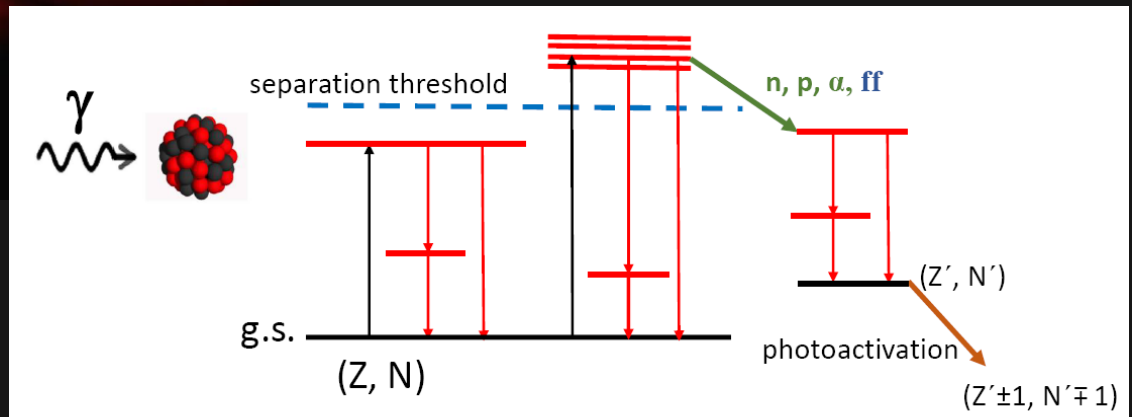
ELI NP Layout



Research @ ELI: Selected examples



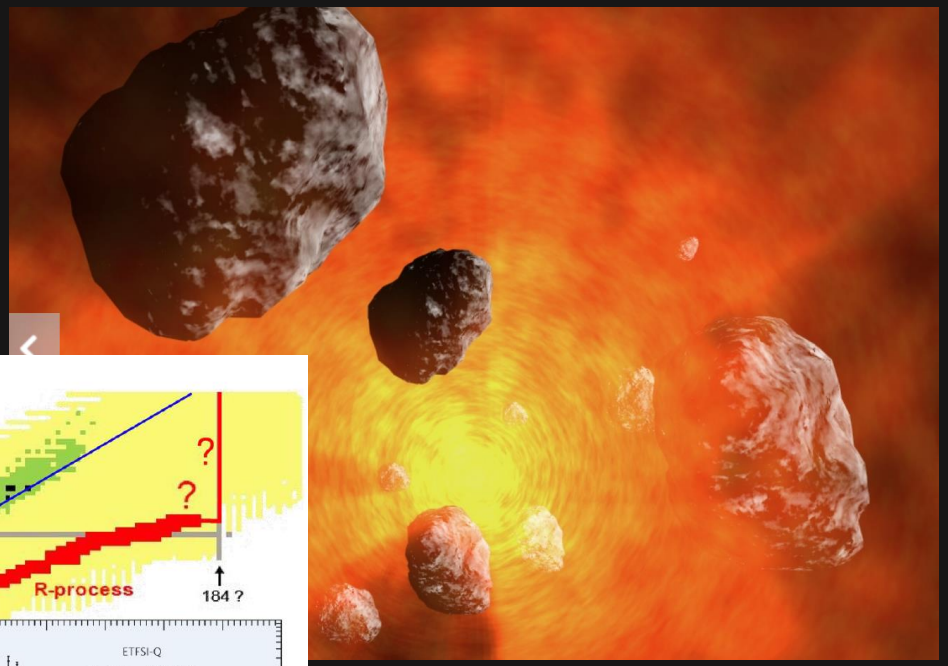
Photonuclear Physics with Gamma Beam System



- Nuclear Resonance Fluorescence (NRF)
- Giant/Pigmy Resonances (GANT)
- Photodisintegration (γ,n), (γ,p), (γ,α)
- Photofission (γ,ff)

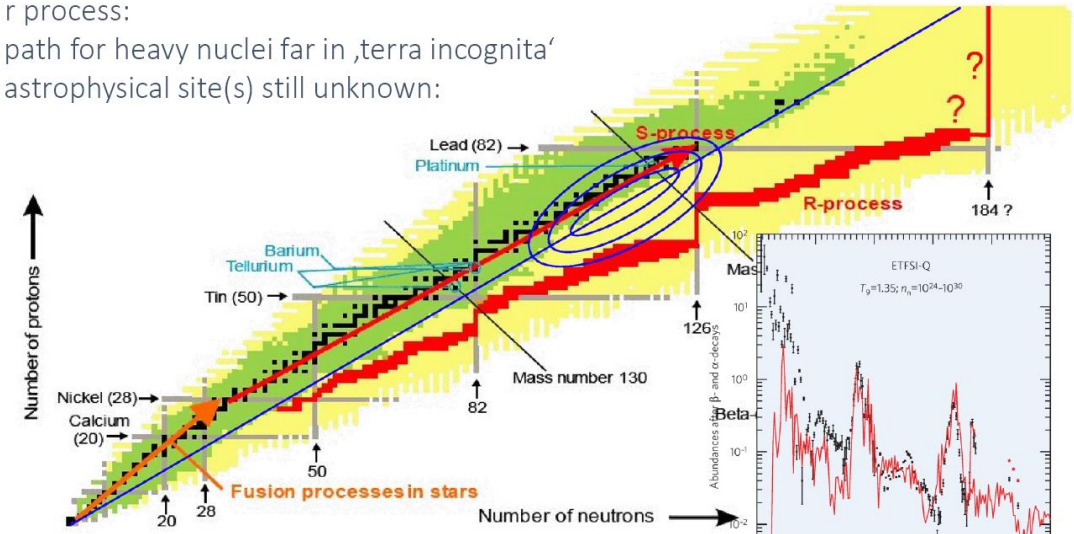
Research @ ELI: Selected examples

Astrophysical r processes - Nucleosynthesis of very heavy rare isotopes



Abundances from meteorites presosal grain and geochemical analysis

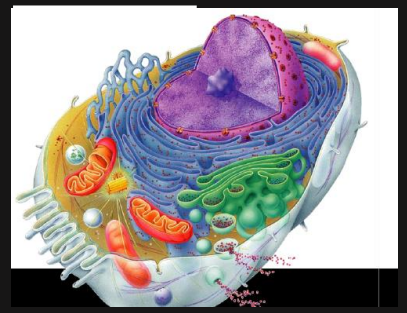
- r process:
  - path for heavy nuclei far in ‚terra incognita'
  - astrophysical site(s) still unknown:



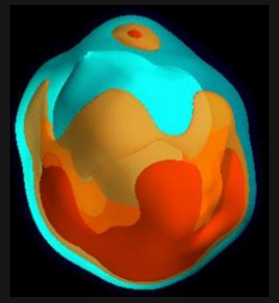
- waiting point N=126: bottleneck for nucleosynthesis of actinides
- last region of r process 'close' to stability

Research @ ELI: Selected examples

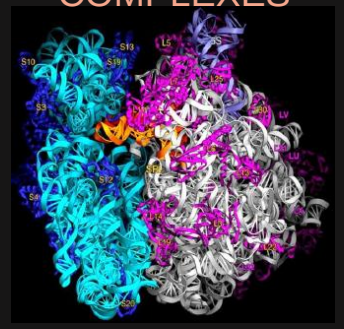
LIVING CELLS



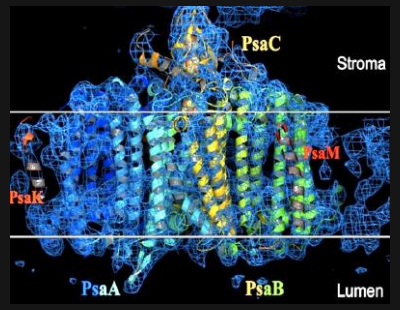
VIRUS PARTICLES



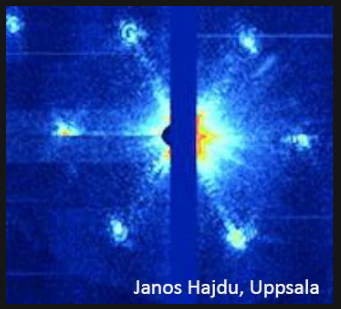
MACROMOLECULAR COMPLEXES



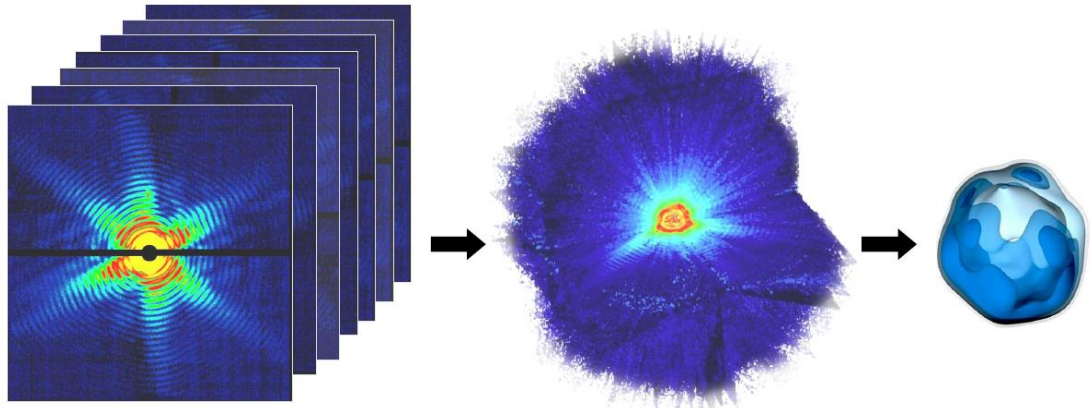
MEMRANE PROTEINS



NANOCRUSTALS



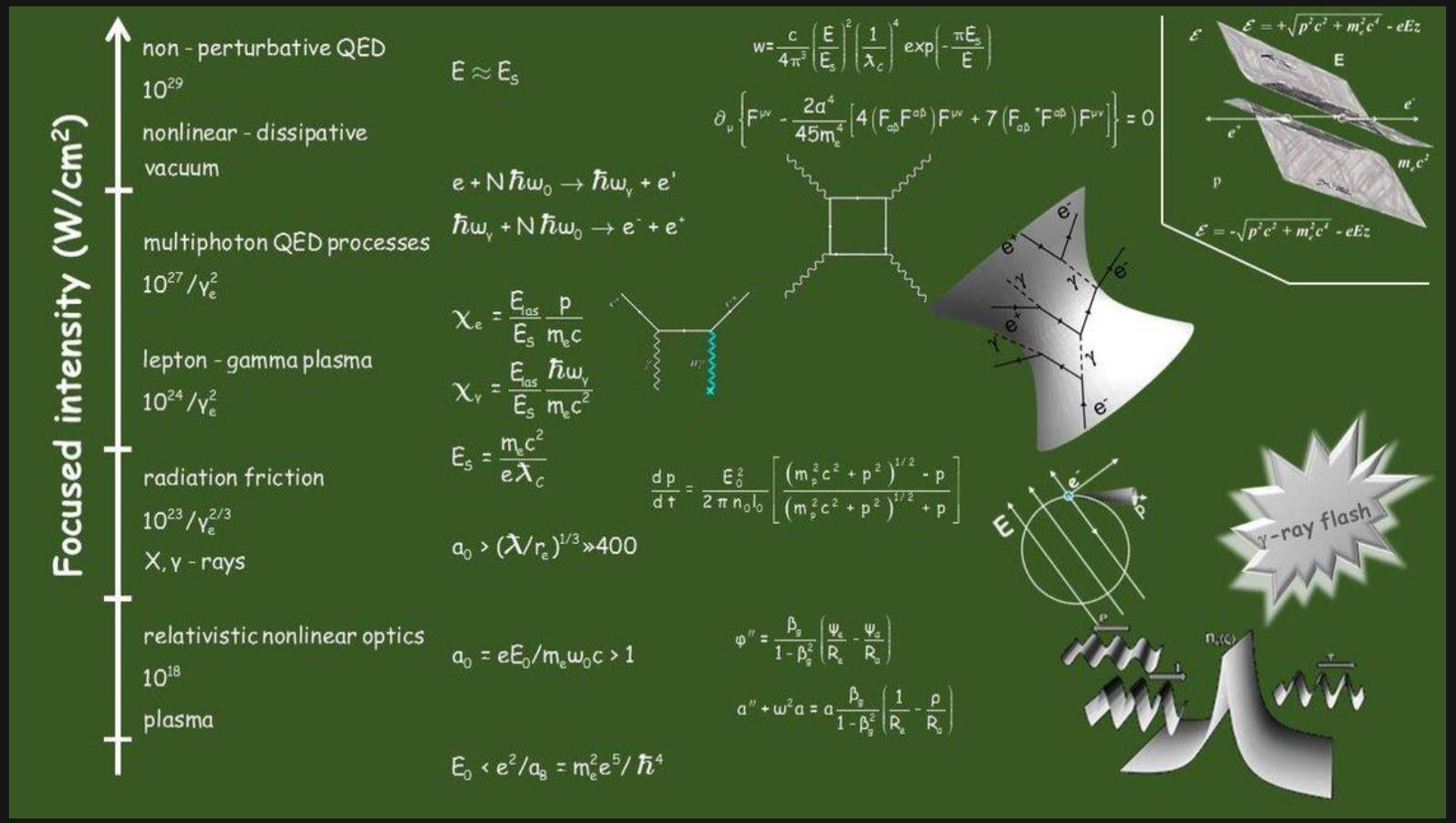
From 2D to 3D structure determination



Works with identical objects

Research @ ELI: Selected examples

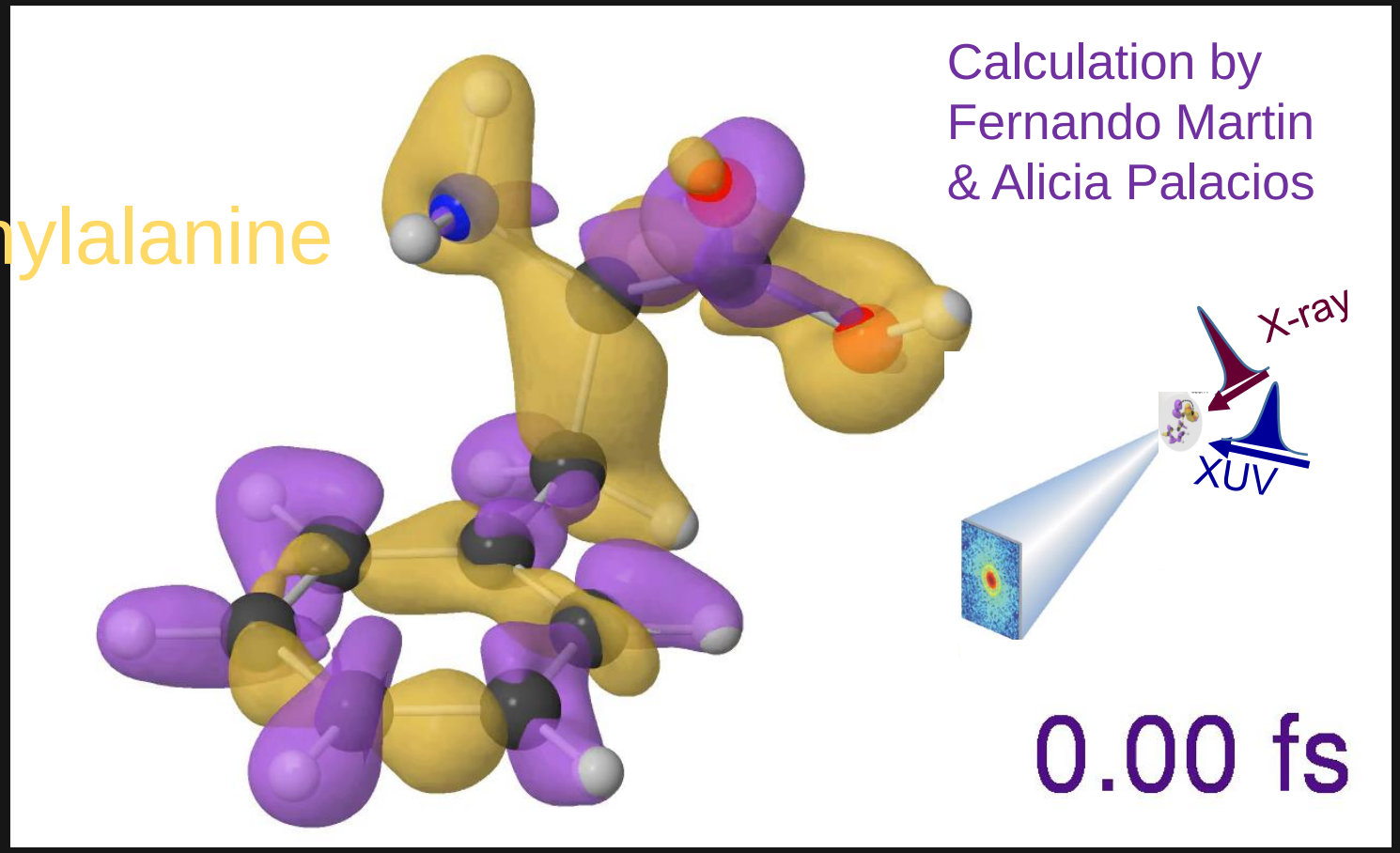
Limits of High Power Laser Interaction with Matter & Vacuum
How far can we go?



Research @ ELI: Selected examples

Visualizing ultrafast structural dynamics

Phenylalanine

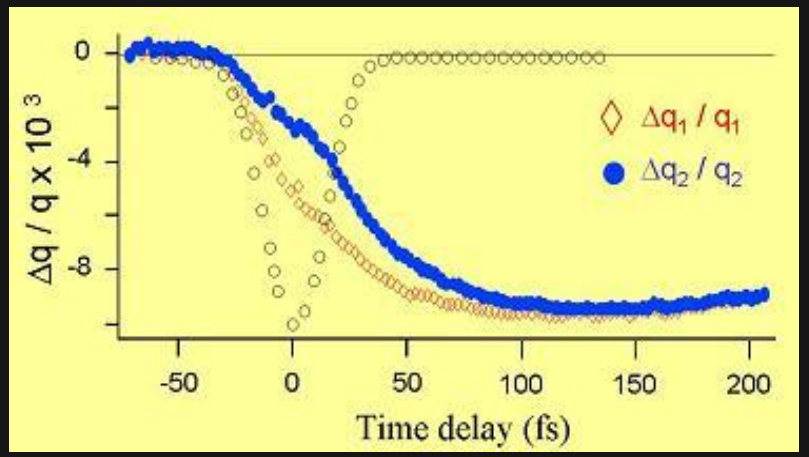


Video from: F. Calegari et al. Science **346**, 336 (2014)

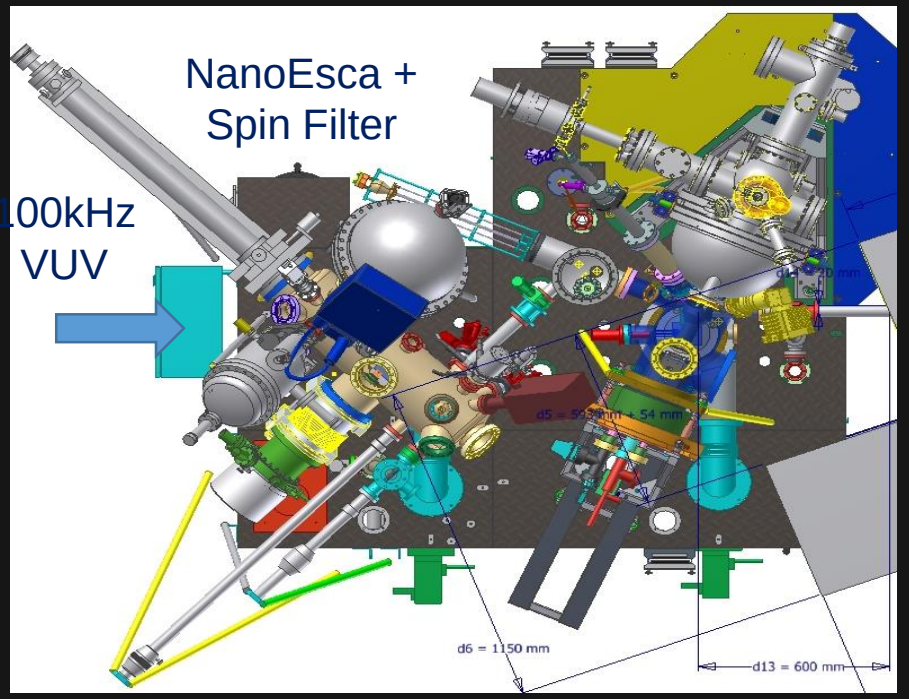
Research @ ELI: Selected examples

Condensed Mater & Surface Ultrafast Dynamics

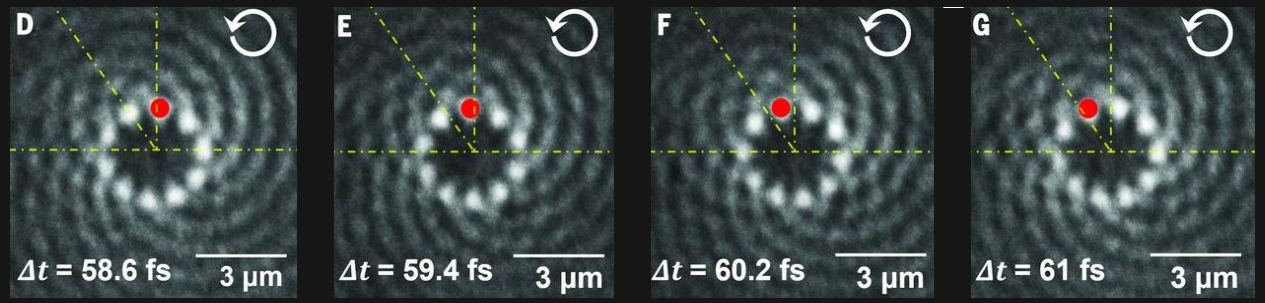
Femtomagnetism



J.Y. Bigot *et al.* (1998)



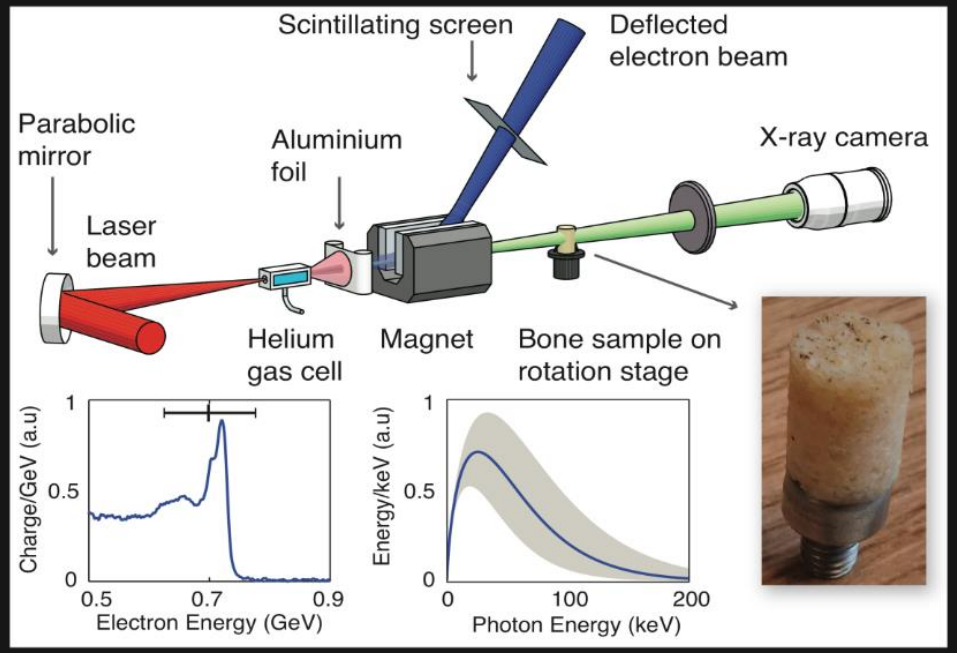
Sub-fs dynamics in nanoplasmonic vortices



Science 355, 1187 (2017)

Research @ ELI: Selected examples

Betatron radiation tomography



Cole et al. *Scientific Reports* 5, 13244 (2015)

ELI-ERIC Access

ELI Access in a nutshell

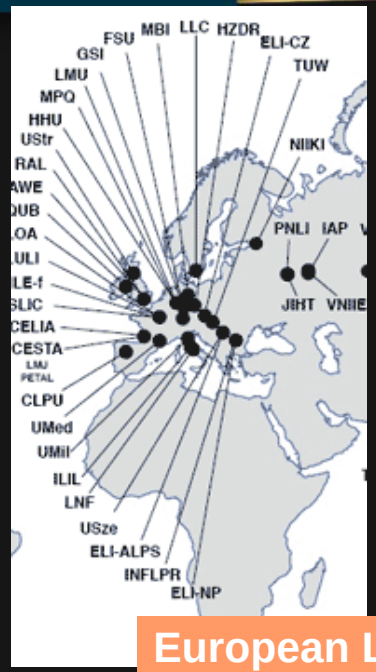
Open Access through a **Common entry point**

Selection based on **international peer-review**

Evaluation solely based on the **S&T quality** of the expected outcome

Proprietary Access and **Access for Training** acceptable **if not conflicting** with Open Access

ELI: Borne by the International Laser Scientific Community, blessed by the EU & challenging its Optimal Integration within the Landscape of Laser RIs in Europe



European Laser Community

- **National scale**
- **National interest**

A consolidated Laser Infrastructure Network: Laserlab-Europe

Flexible instrument to perform and initiate new science **beyond the national scale**

Multiple & multi-disciplinary mission

An ESFRI pan-European Laser Infrastructure: ELI (evolving to an ERIC)

International integrated Laser user Facilities

Mission oriented

Scientific & political challenge: how to make all these tools available, operating and effective for the benefit of the widest user community?

Thanks for your attention!