eli beamlines

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Safety Challenges of Biological Applications at High Power Laser Accelerators

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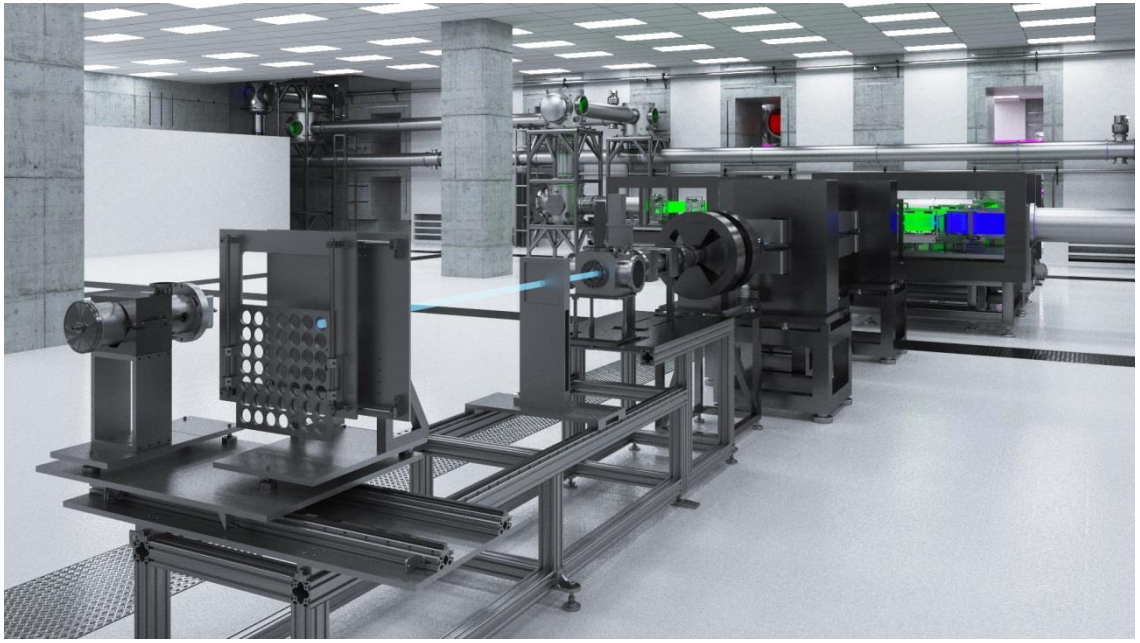
ELI Beamlines facility in Prague



- 4 major high power laser systems (up to 10PW).
- 8 main workstations under development in 5 target areas.
- Electron and ion acceleration, X-ray and plasma physics stations.
- Independently operated and driven by all laser systems via beam transport.
- Construction completed – technology to be installed – operation: end of 2018.

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Facility Layout

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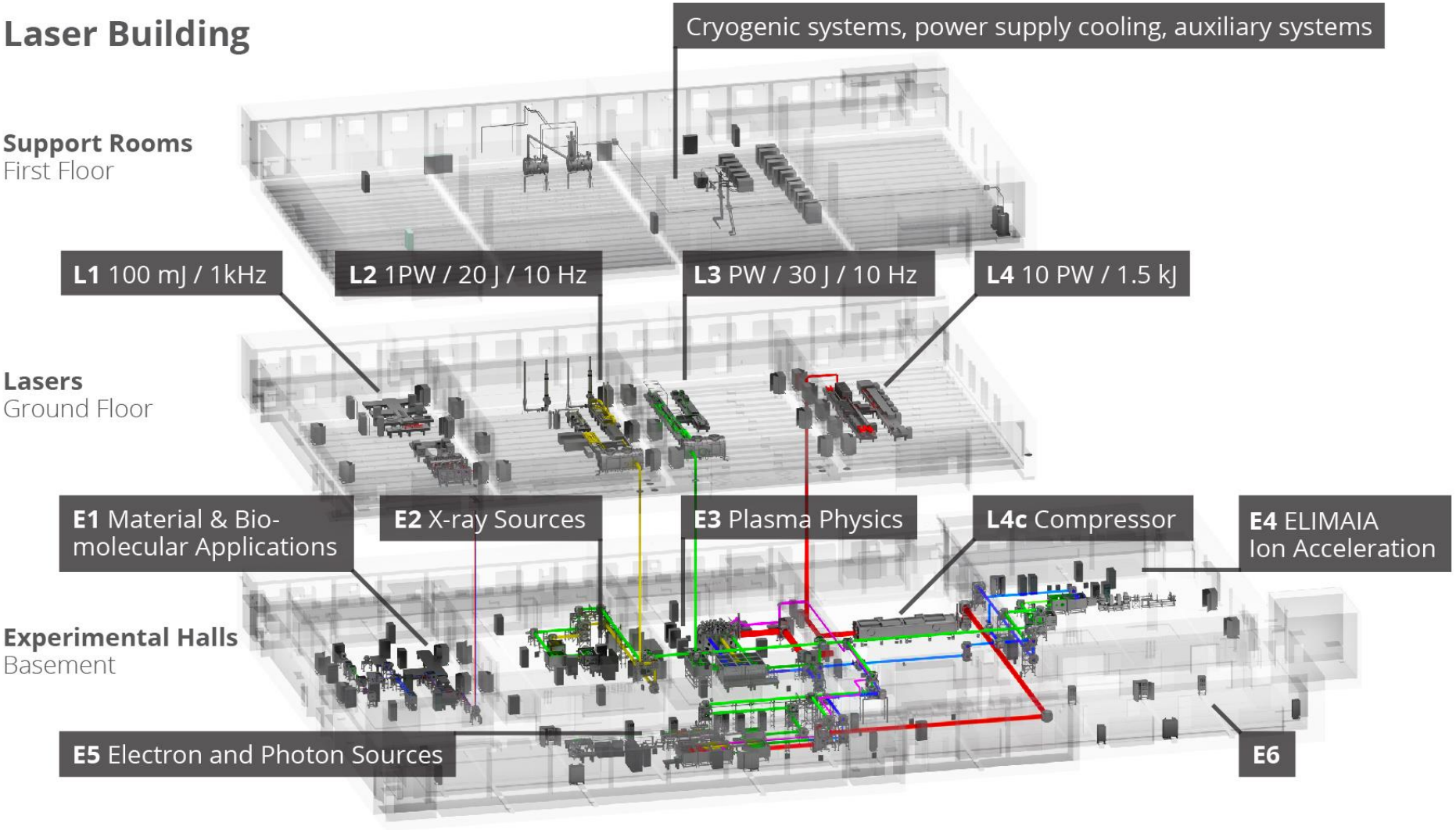
Facility Layout



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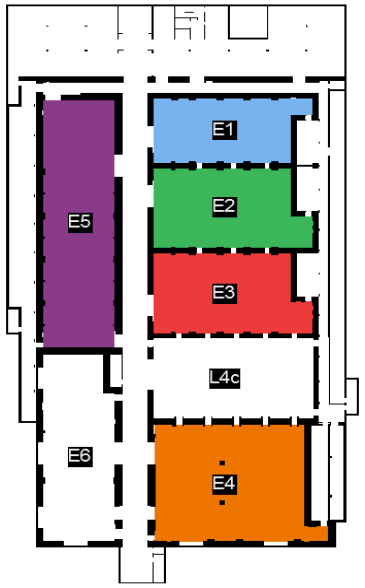

What users get

end-stations

L1

PXS 1E13 ph, 300 fs, 1 kHz, 4π sr
- X-ray phase contrast imaging
- X-ray Diffraction
- X-ray absorption spectroscopy

HHG 1E10 ph, 10 fs, 1 kHz, 5 mrad
- Coherent Diffractive Imaging
- Atomic, Molecular and Optical Science

SRS + pump, beams
- Soft X-ray Materials Science
- Pulsed Radiolysis,

L2

LUX 1E6 ph, 5 fs, 10 Hz, 5 mrad
- WW pump-probe (station development)

L3

Betatron 1E8 ph, 10 fs, 10 Hz, 20 mrad
- X-ray Phase contrast imaging
- X-ray fluorescence
- Absorption spectroscopy, WDM@10Hz,

L4

P3 Plasma Phy. Platform

ELIMAIA Ion accel.

Hell electron.

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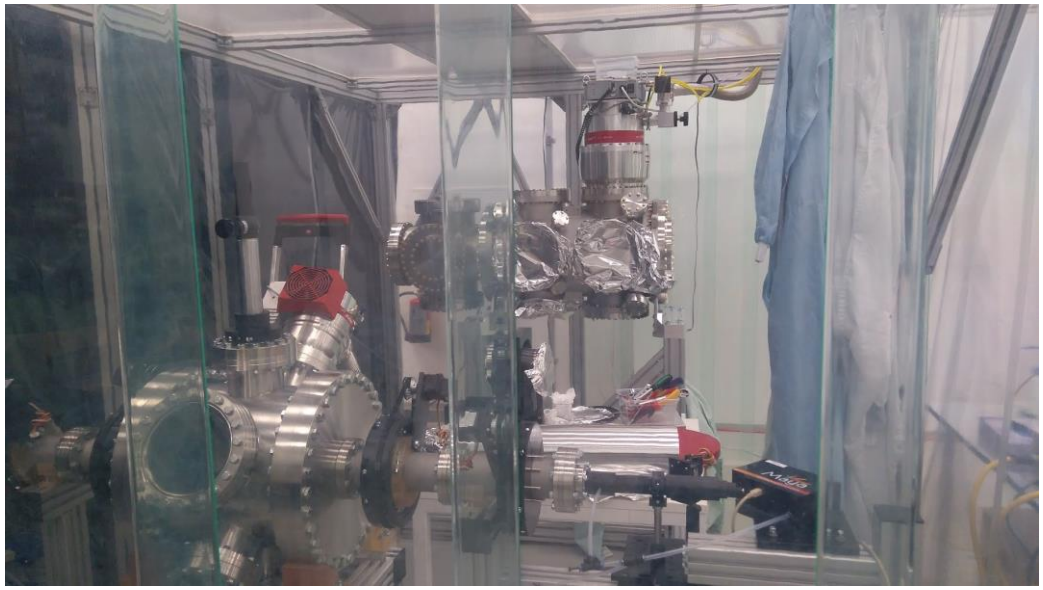
Biological Applications @ELI Beamlines



- ***Research Program 4***:
  - Coherent Diffractive Imaging (CDR)
  - Study of biochemical processes
- ***Research Program 3***:
  - ELIMAIA (p^+ and ion acceleration)
- ***ELIBIO***:
  - New project for study of processes in biological systems

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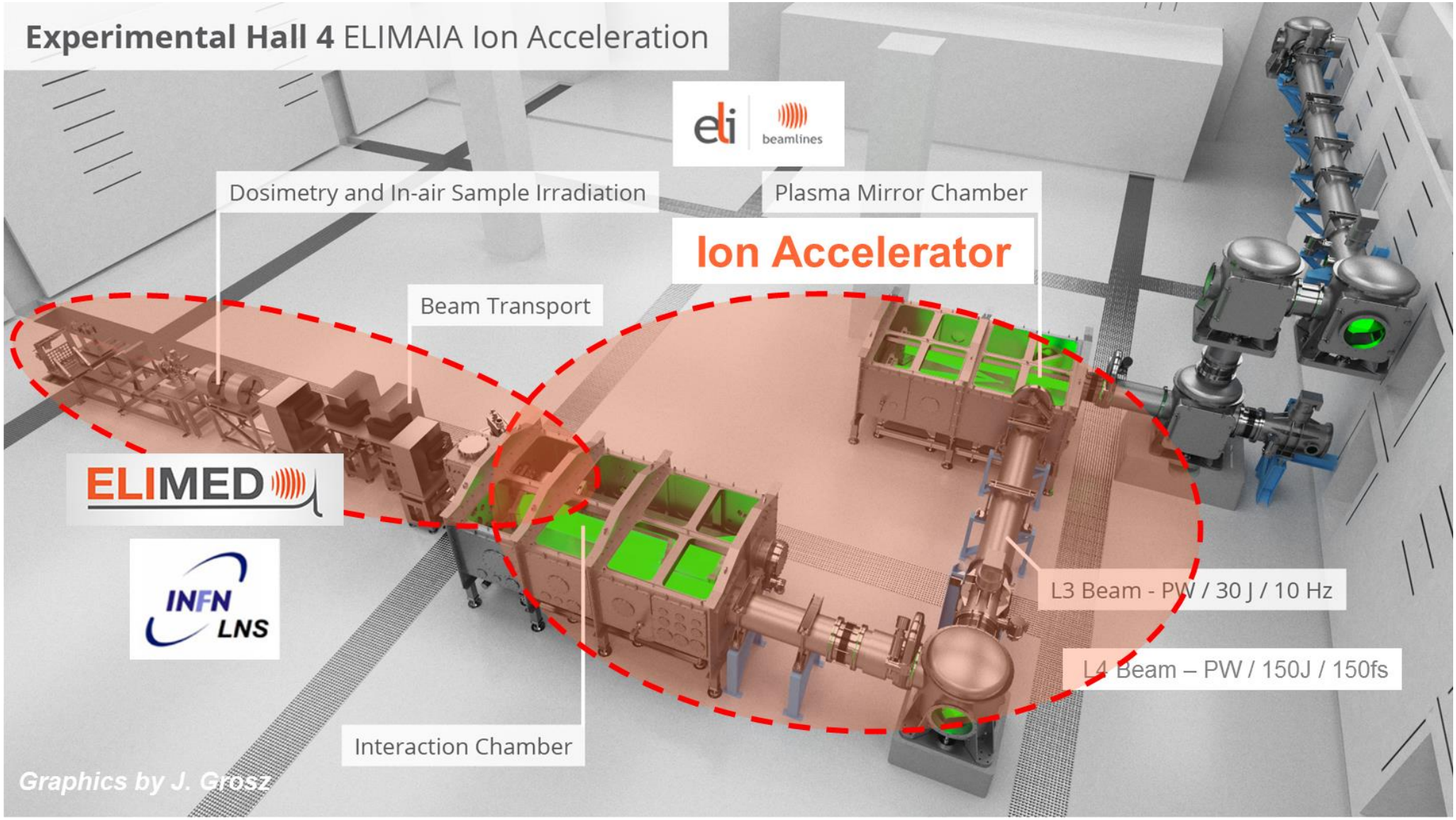
The ELIMAIA beamline

ELI Multidisciplinary Applications of laser-Ion Acceleration



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ELIMAIA User Offer

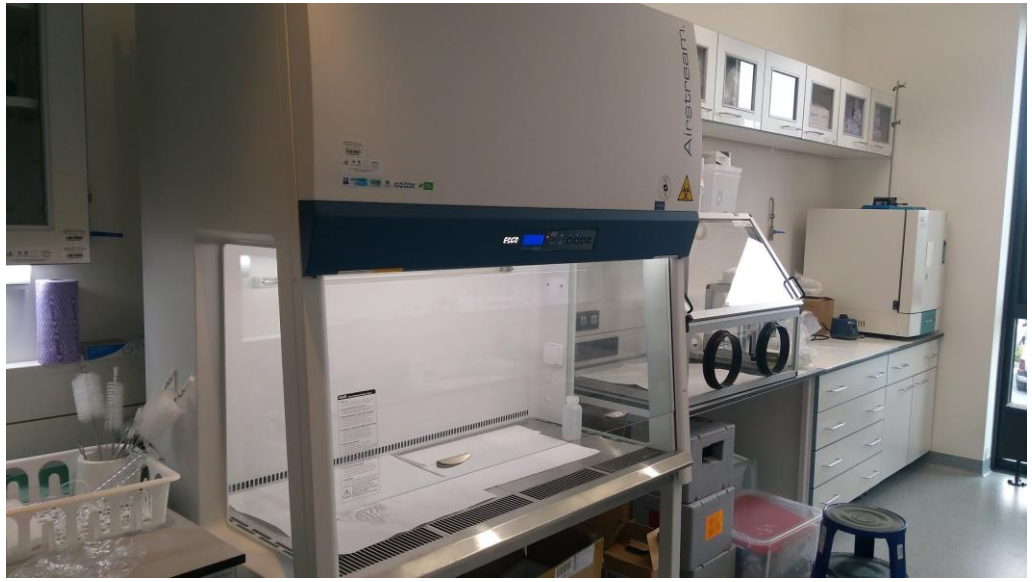
What users (will) get

Ion Beam Features (PW)	Enabling Experiments	Flagship Experiments
Energy range	3-60 MeV/u	3-300 MeV/u
Ion No. / laser shot	$>10^9$ (0.1 nC) in 10% BW	$>10^{10}$ (1 nC) in 10% BW
Bunch duration	1-10 ns	0.1-10 ns
Energy spread	±5%	±2.5%
Divergence	±0.5°	± 0.2°
Ion Spot Size	0.1-10 mm	0.1-10 mm
Repetition rate	0.01-1 Hz	0.01-10 Hz

Anticipated users at ELI-Beamlines

- **In vitro and in vivo radiation biology** with short ion bunches
- Radiation chemistry (**pulsed radiolysis** of water)
- Innovative approaches to **hadrontherapy**
- Radio-isotopes for **PET**
- Proton/Ion **Acceleration** at high rep. rate (short and long pulse)
- Pitcher-catcher nuclear reactions (e.g. **neutrons**)
- **PIXE** analysis for cultural heritage
- Time-resolved **Proton Radiography** of dense objects
- Space Radiation for testing **space-grade electronics**

Biocontainment available @ELI Beamlines



- Biochemical Laboratory (BSL1)
- Planned up to BSL3 facilities
- BSL1 and BSL2 implementation in progress – with electron microscopy capabilities
- Bio-hutches at the beamlines (mobile or solid)

- Planned up to BSL3 beamlines for liquid and aerosol handling (suspended from budgetary reasons)

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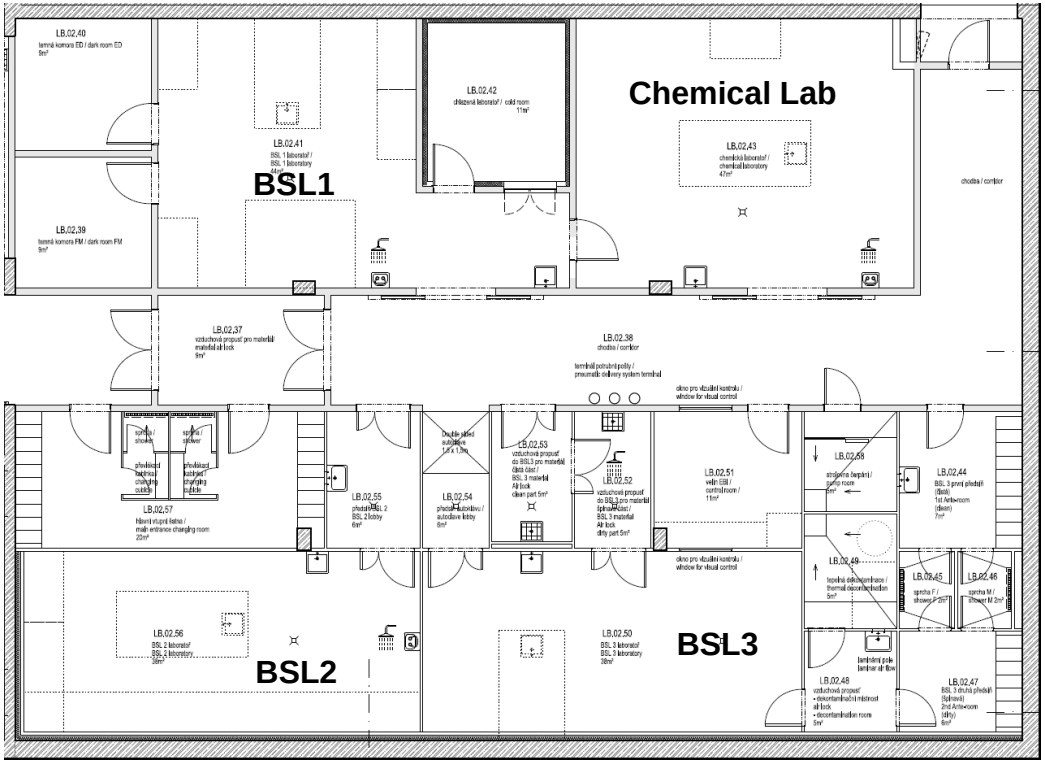
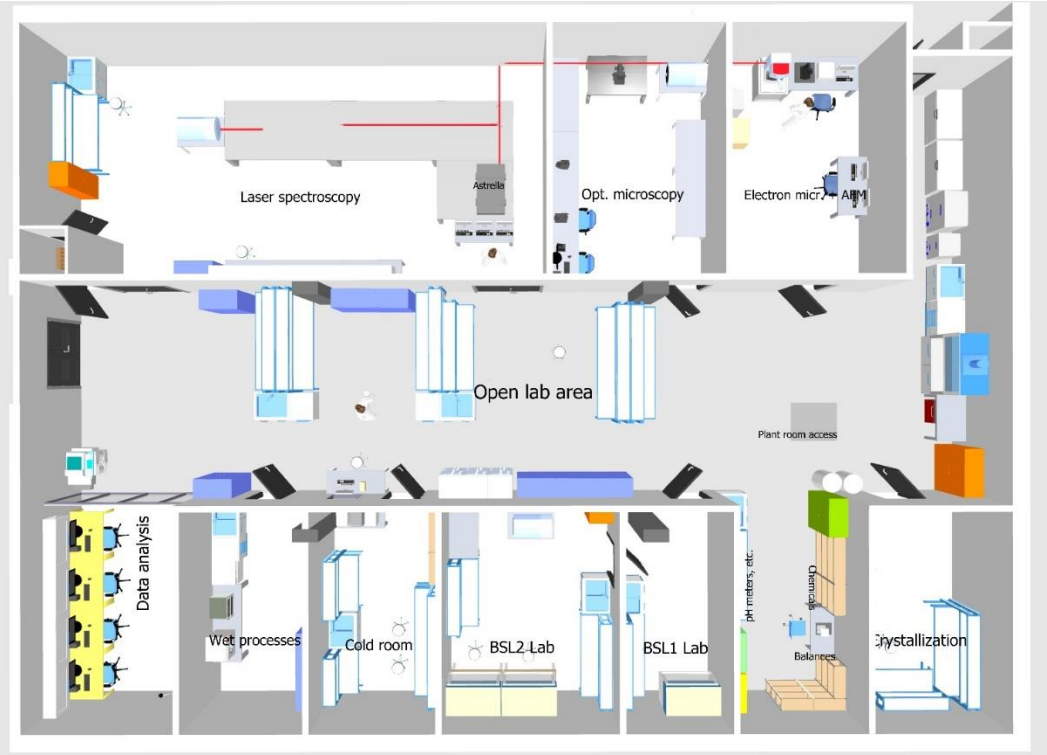
Biocontainment available @ELI Beamlines



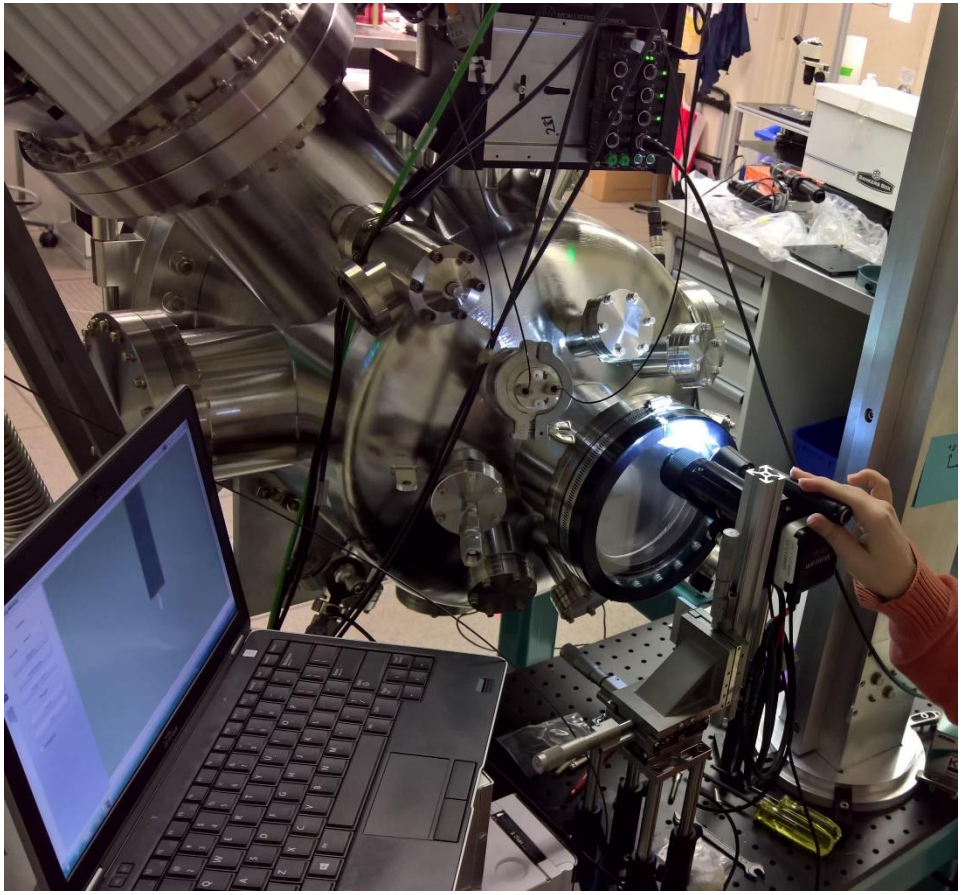
- Planned up to BSL3 beamlines for liquid and aerosol handling (suspended from budgetary reasons)
- Comprehensive BioLab support for sample preparation and testing of equipment.
- Capability of experiments with Risk Group 3 agents in liquid form (advantage for those unsuitable for crystallization – e.g. West Nile Virus)

Biocontainment available @ELI Beamlines

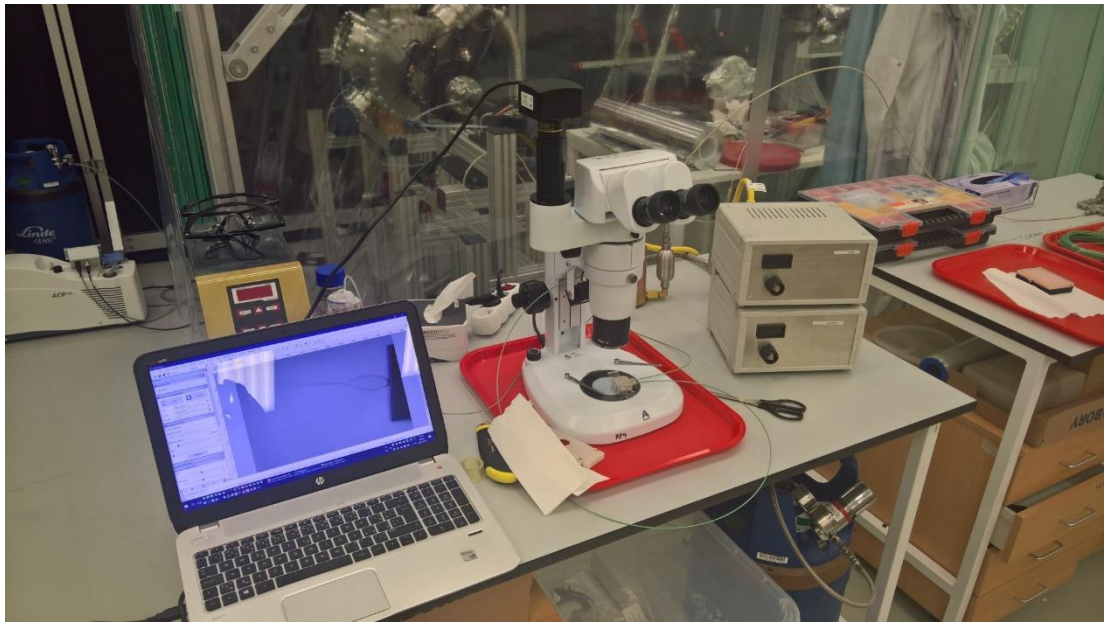


- New facilities within ELIBIO project.
- Up to BSL2 capabilities.
- Utilization of Class 4 lasers in the biological laboratories.
- Electron microscopy available.
- Joint project with BIOCEV institute.

Liquid jet for CDR



Testing @SLAC Feb 2017
©Photo Martin Přeček



Available @ELI Jul 2017
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Biosafety Challenges: Containment

- BSL1:
  - no special requirement
- BSL2:
  - requirements on disinfection, arrangement, and regime
- BSL2+, BSL3:
  - For works with aerosolized RG2 agents
  - Requirements on sealing, negative pressure, respiratory protection, decontamination etc.

- Arrangement of experiment in the target area.
- Solid bio-hutch (construction requirements)
- Mobile bio-hutch (e.g. BioBUBBLE)
- HEPA filters on vacuum pumps exhaust

Biosafety Challenges: Disinfection

- Typically disinfected with bleach (not applicable to sensitive optics).
- **Isopropanol** and **ethanol** are efficient for inactivation of agents.
- Necessity to test the optics on disinfectant resistance and sustainability.
- Inactivation efficiency testing of used disinfectants (not broad spectrum disinfectants).
- Probably do not need to be changed in time (biological agents turnover is relatively high due to different experimental campaigns).

- ***Vacuum chamber decontamination:***
  - All agents are oxidizers (H_2O_2, ClO_2, O_3 etc..)
  - Sensitive optics can be destroyed
  - A procedure for manual cleaning need to be developed
  - Usage of volatile cleaning agents can be used

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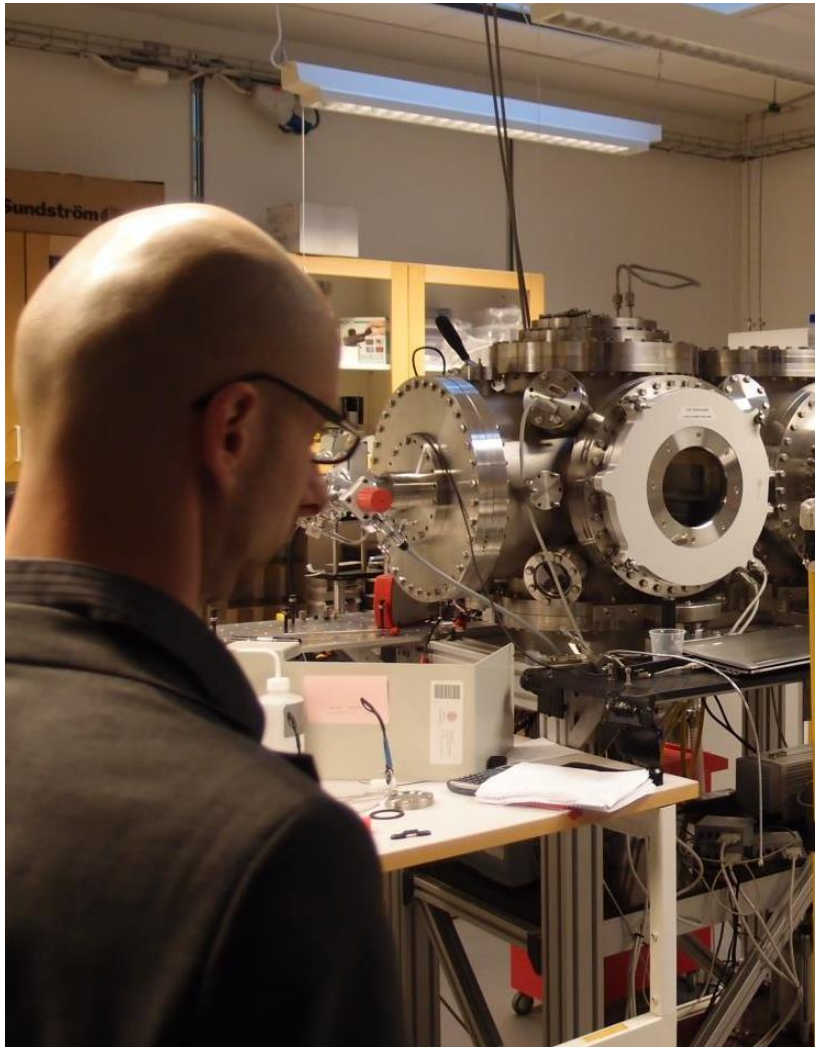
Conclusions

- ELI Beamlines capabilities:
  - Performing X-Ray imaging experiments with liquids and aerosols
  - Performing radiobiological experiments on tissues using accelerated protons and ions
- Technology:
  - containment for performing BSL1 experiments
  - Easy extension to BSL2 experiments
  - Future capabilities for higher containment level
- Support:
  - Complex of biological laboratories with BSL1 and BSL2 containment



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Acknowledgement

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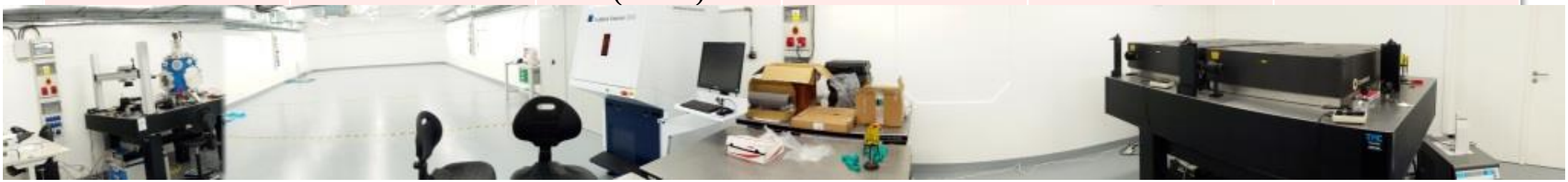
Questions?

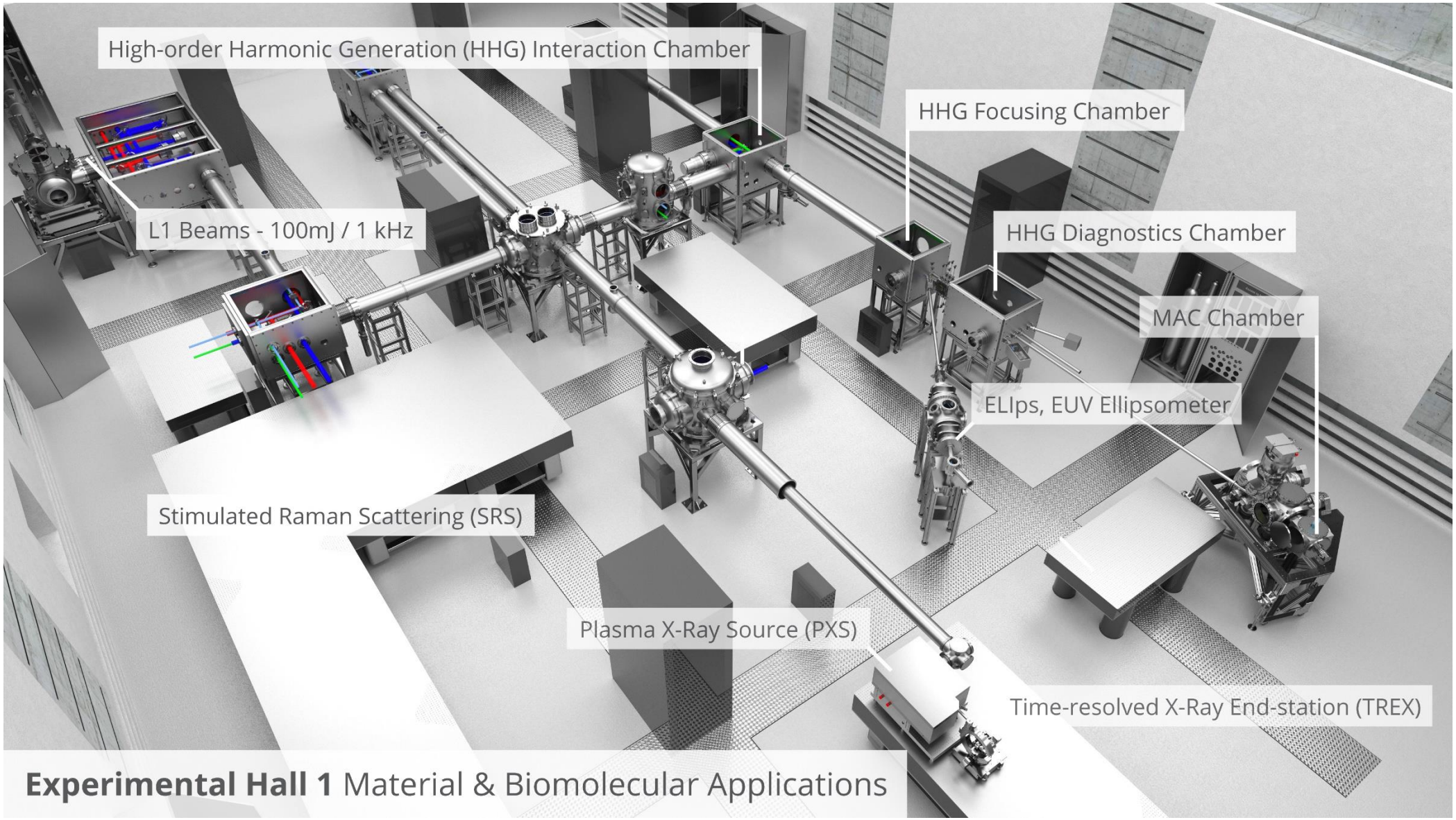
Back up slides

Laser Systems

Laser System	L1	L2	L3	L4	Astrella
Peak power	>5 TW	1 PW	≥1 PW	10 PW	TW
Energy in pulse	100 mJ	≥15 J	≥30 J	≥1.5 kJ	15 mJ
Pulse duration	<20 fs	≤15 fs	≤30 fs	≤150 fs	<40 fs
Rep rate	1 kHz	10 Hz, >10 Hz	10 Hz	1 per min	1 kHz
Wavelength	850 nm	850 nm	820 nm	1050 nm	700-900 nm
Produced	In-house	In House and Purchased (STFC)	LLNL	National Energetics, EKSPLA	Coherent



E1 with stations and MAC Chamber



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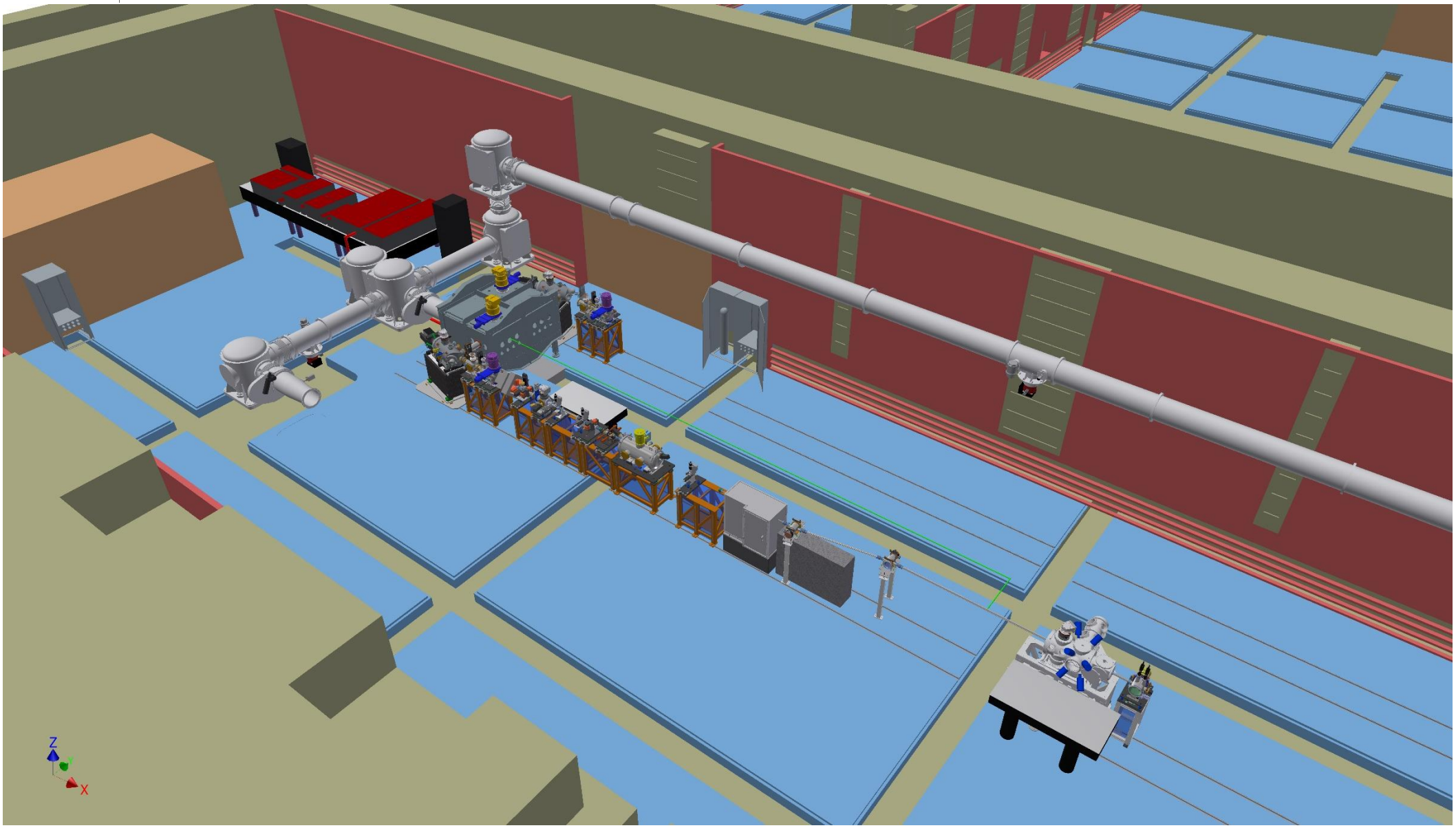
LUX with MAC Chamber



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