ELI Beamlines
High-Energy Beam Pillar
• Part of the Czech Academy of Sciences

• FZU is the largest one of 53 institutes of the CAS – over 1300 employees

• More than 60 years of history

• World-leading and internationally excellent scientific results
**Science Case @ ELI Beamlines**

RP1 – Laser Development, B. Rus
Lasers generating rep-rate ultrashort pulses & multi-petawatt peak powers

RP2 – Radiation Physics and Electron Acceleration, S. Bulanov
Soft to hard x-rays, GeV electrons

RP3 – Ion Acceleration, D. Margarone
250 MeV Ions Acceleration by lasers

RP4 – Applications in MBMS S, J. Andreasson & ELIBIO, J. Hajdu

RP5 – Plasma Physics, S. Weber
Laser plasma and HED physics, astrophysics

RP6 – UHI Interactions, S. Weber
High-field physics and theory
Facility Layout - Priority Action

**Laser Building**

**Support Rooms**
First Floor

- L1 100 mJ / 1kHz
- L2 5 J >20 Hz <20 fs
- L3 PW / 30 J / 10 Hz
- L4 10 PW / 1.5 kJ

**Lasers**
Ground Floor

- E1 Material & Bio-molecular Applications
- E2 X-ray Sources
- E3 Plasma Physics
- L4c Compressor
- E4 ELIMAIA Ion Acceleration
- E5 Electron Acceleration & Laser Undulator X-ray Source
- E6

**Cryogenic systems, power supply cooling, auxiliary systems**
<table>
<thead>
<tr>
<th></th>
<th>8/2019</th>
<th>Technology</th>
<th>Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1</td>
<td>30mJ kHz 14fs</td>
<td>DPSSL, OPCPA pumped by thin disk</td>
<td>100 mJ kHz &lt;20fs</td>
</tr>
<tr>
<td>L2</td>
<td>10J 10Hz ns</td>
<td>DPSSL, OPCPA</td>
<td>5J &gt;20Hz &lt;20fs</td>
</tr>
<tr>
<td>L3</td>
<td>16J 34fs 3.3Hz</td>
<td>DPSSL, Ti:Sa</td>
<td>&gt;30J 10Hz &lt;30fs</td>
</tr>
<tr>
<td>L4</td>
<td>1.5kJ 1/5min</td>
<td>OPCPA FE, mixed Nd:glass</td>
<td>1.5kJ 1/ min 120 fs</td>
</tr>
<tr>
<td>HHG</td>
<td>5-120nm 30nJ</td>
<td></td>
<td>5-120nm, 1E10 ph</td>
</tr>
<tr>
<td>PXS</td>
<td>Comm. 4–30 keV</td>
<td></td>
<td>4–30 keV, 1E13 ph</td>
</tr>
<tr>
<td>LUIS</td>
<td>Installation</td>
<td>FEL Development</td>
<td>0.4 to 5 nm, 1E6 ph</td>
</tr>
<tr>
<td>Betatron</td>
<td>development</td>
<td></td>
<td>keV – MeV, 1E8 ph</td>
</tr>
<tr>
<td>ELIMAIA</td>
<td>commissioning</td>
<td></td>
<td>3/60-300MeV</td>
</tr>
<tr>
<td>ELBA</td>
<td>installation</td>
<td></td>
<td>10GeV</td>
</tr>
</tbody>
</table>
Our Big Laser Sources

L1 – ALLEGRA

L2 – AMOS

L3 – HALPS

L4 – ATON
**L1 ALLEGRA laser**

user experiments since June 2019

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Demonstrated 04/2019</th>
<th>Expected 12/2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broadband output energy</td>
<td>30 mJ @ 1kHz</td>
<td>50 mJ @ 1 kHz</td>
</tr>
<tr>
<td>Compressed output (to E1 beam distribution)</td>
<td>25 mJ @ 1 kHz</td>
<td>&gt;40 mJ @ 1 kHz</td>
</tr>
<tr>
<td>Pulse duration</td>
<td>14 fs</td>
<td>14 fs</td>
</tr>
<tr>
<td>Temporal contrast (pre-pulses to -5 ps)</td>
<td>&gt;10^{-10}</td>
<td>&gt;10^{-11}</td>
</tr>
</tbody>
</table>

**ALLEGRA operation hours July – Sept 2019**

<table>
<thead>
<tr>
<th></th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>DAYS</td>
<td>32</td>
</tr>
<tr>
<td>HOURS (with standby)</td>
<td>235</td>
</tr>
<tr>
<td>NET HOURS</td>
<td>184</td>
</tr>
<tr>
<td>STANDBY HOURS</td>
<td>51</td>
</tr>
</tbody>
</table>

Driving synchronized soft and hard-ray sources
Enables electron and ion acceleration with kHz
Surface harmonics at kHz can be tested
... proposals up to you!
## L3 HALPS laser status

**Item 6/2019**

<table>
<thead>
<tr>
<th>Item</th>
<th>Details</th>
</tr>
</thead>
</table>
| L3-HAPLS pump laser                                                 | 100 J / 3.33 Hz  
60 J / 3.33 Hz for experiments                                                                                                      |
| Pulse compressor, pulse and beam diagnostics                       | Fully integrated with the laser, energy 0.5J, output pulse duration 34 fs                                                                 |
| L3-HAPLS for TERESA experiments                                      | 1st experimental run (100 mJ), 2nd exp. campaign starting  
Output beam shape                                                  | Round beam 84-mm-in-diam. for TERESA generated                                                                                  |
| Output pulse temporal contrast                                       | Near $10^{11}$ @ 100 ps measured by Sequoia                                                                                             |

**Compressor output pulse temporal contrast**

Data from SPDP (Short Pulse Diagnostic Package) – Sequoia scan

![Compressor output pulse temporal contrast](image)

**Remnant from FE Artefacts**

Artefacts (thin beam splitters for diagnostics)
# L4 ATON laser status

## Power Amp PA1
- 18 cm clear aperture

## Power Amp PA2
- 30 cm clear aperture

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Measured value</th>
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</thead>
<tbody>
<tr>
<td>CPA pulse energy</td>
<td>1512 J, significant headroom, higher energy possible</td>
</tr>
<tr>
<td>Bandwidth FWHM</td>
<td>~14 nm Gaussian fit, compressibility 150 fs</td>
</tr>
<tr>
<td>Long pulse energy</td>
<td>1180 J, significant headroom, higher energy possible</td>
</tr>
<tr>
<td>Pulse width / temporal shaping</td>
<td>&lt;0.5-10 ns, 125 ps with 60 ps rise time</td>
</tr>
<tr>
<td>Current shot rate</td>
<td>1 per minute (&gt;1 hour sessions), 1 per 5 minutes for quality beam</td>
</tr>
</tbody>
</table>

Energy RMS shot stability <2%

[Image of laser setup]

Automated sequence 1/min PA2 output at 1 kJ
L4 10 PW optical compressor

10 PW peak power late 2020
L3 Beam Transport to P3

Main features: Versatility, Vibration stability, Cleanliness

setup with mirror inside the turning mirror box
Experimental hall E1: Applications of optical, VUV and X-ray light sources
- First open call for user assisted commissioning and early use experiments
- Published February 15, 2019, closed June 20
- 20 experiments scheduled between June to Sept. 2019
- 1200 hours supporting external experimenters
- “Users” from 7 countries (Germany, Finland, Czech Republic, Sweden, USA and Russia)
- Join us for user workshops
  - Science with coherent XUV sources, May 6 and 7, Workshop on optical spectroscopy, Sept 16 to 18,
  - Ultrafast X-ray science, Oct 24 and 25, ELIps workshop on pump-probe and VUV ellipsometry, Nov 11 and 12, 2019

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Date</th>
<th>Coordinator</th>
<th>Team Members</th>
</tr>
</thead>
<tbody>
<tr>
<td>w24</td>
<td>Jan 10 to 14</td>
<td>Luca Peletta (IT)</td>
<td>Tim Geliez (GE)</td>
</tr>
<tr>
<td>w25</td>
<td>Jan 17 to 21</td>
<td>Filipe Maia (SE)</td>
<td>松弛 Minns (UK)/Katherine Reid (UK)</td>
</tr>
<tr>
<td>w26</td>
<td>Jan 24 to 28</td>
<td></td>
<td>松弛 Minns (UK)/Katherine Reid (UK)</td>
</tr>
<tr>
<td>w27</td>
<td>Jan 31 to 5</td>
<td></td>
<td>松弛 Minns (UK)/Katherine Reid (UK)</td>
</tr>
<tr>
<td>w28</td>
<td>Feb 8 to 12</td>
<td></td>
<td>松弛 Minns (UK)/Katherine Reid (UK)</td>
</tr>
<tr>
<td>w29</td>
<td>Feb 15 to 19</td>
<td></td>
<td>松弛 Minns (UK)/Katherine Reid (UK)</td>
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<tr>
<td>w30</td>
<td>Feb 22 to 26</td>
<td></td>
<td>松弛 Minns (UK)/Katherine Reid (UK)</td>
</tr>
<tr>
<td>w31</td>
<td>Feb 29 to Aug 2</td>
<td></td>
<td>松弛 Minns (UK)/Katherine Reid (UK)</td>
</tr>
<tr>
<td>w32</td>
<td>Aug 5 to 9</td>
<td></td>
<td>松弛 Minns (UK)/Katherine Reid (UK)</td>
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<tr>
<td>w33</td>
<td>Aug 12 to 16</td>
<td></td>
<td>松弛 Minns (UK)/Katherine Reid (UK)</td>
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<tr>
<td>w34</td>
<td>Aug 19 to 23</td>
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<td>松弛 Minns (UK)/Katherine Reid (UK)</td>
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<tr>
<td>w35</td>
<td>Aug 26 to 30</td>
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<td>松弛 Minns (UK)/Katherine Reid (UK)</td>
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<tr>
<td>w36</td>
<td>Sep 2 to 6</td>
<td>Stefan Zollenn (US)/Luca Peletta (IT)*</td>
<td></td>
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<tr>
<td>w37</td>
<td>Sep 9 to 14</td>
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<td>松弛 Minns (UK)/Katherine Reid (UK)</td>
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<tr>
<td>w38</td>
<td>Sep 16 to 20</td>
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<td>松弛 Minns (UK)/Katherine Reid (UK)</td>
</tr>
<tr>
<td>w39</td>
<td>Sep 23 to 27</td>
<td></td>
<td>松弛 Minns (UK)/Katherine Reid (UK)</td>
</tr>
</tbody>
</table>

*Not a full week of experiments
**Users assisting with experiment preparations (No laser)
***Follow up experiments
E3 hall layout - HEDP

- **L4n Beam**: 1.5 kJ (ns pulse shaping) - Commissioning end 2020
- **L4f Beam**: 10 PW / 1.5 kJ / 150 fs - Commissioning mid 2021
- **L3 Beam**: PW / 30 J / 10 Hz - Commissioning end 2019

**Experimental Hall 3** Plasma Physics Platform (P3)
E4 Experimental hall: ELIMAIA

Acceleration, Collimation & Diagnostics

Selection, Transport & Diagnostics

Dosimetry & Sample Irradiation

TERESA testbed
first acceleration experiments with L3-HAPLS

1 J on target, 8.2 MeV protons
Collaboration between ELI-Beamlines (FZU CAS, Czech Republic), BELLA Center (LBNL, CA, USA), Keldysh Institute of Applied Mathematics (RAS, Moscow, Russia) has resulted in the world highest charged particle energy (7.8 GeV) achieved with high power laser-plasma interaction in the LWFA regime.

Plasma channel’s electron density profile (blue) formed by discharge inside a capillary (gray) with an 8-nanosecond laser pulse heater (red, orange, and yellow). The plasma channel was used to guide femtoseconds-long “driver” laser pulses from the BELLA petawatt laser system, which generated plasma wake waves accelerating electrons to 8 GeV over the distance of 20 centimeters.

### User Calls Schedule

<table>
<thead>
<tr>
<th>Call</th>
<th>Q1/2019</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
<th>Q1/2020</th>
<th>Q2</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1 Commissioning</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>E1 Peer Reviewed</td>
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<tr>
<td>E3 Commissioning</td>
<td></td>
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</tr>
<tr>
<td>E4 Commissioning</td>
<td></td>
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</tbody>
</table>

*Note: Before ERIC establishment, calls shall be opened and administrated by IoP*
ELI BL Staff

STAFF PROFILE FTE

2/3 dedicated for user support operations

Technician
Engineer
Research Assistant
PhD Student
Postdoctoral Fellow
Associated Scientist
Scientist
Senior Scientist

FTE
headcount

Jan-10 Jan-11 Jan-12 Jan-13 Jan-14 Jan-15 Jan-16 Jan-17 Jan-18 Jan-19

Female
Male

0% 20% 40% 60% 80% 100%

Australia
France
Italy
South Korea
Moldavia
Portugal
USA
Ukraine
Bulgaria
Croatia
Japan
Costa Rica
Czech
India
South Africa
Nepal
Russia
Sweden
China
Ireland
Columbia
Hungary
Poland
Slovakia
Turkey

0% 10% 20% 30% 40% 50% 60% 70%
2017 Installation and commissioning, first experiments

2018 Facility completion, Start of biolab operation, First users

2019 First user call - E1, Availability of L1 and L3 laser sources, User calls - E1, E3, E4. Performance ramp-up

2020 User operations and performance ramp-up, L4 10 PW, L4n commissioning

2021-2 Completion of upgrades, L2 laser source, ELBA and LUIS/FEL beamline and Gammatron source

R&D and Upgrade projects – additional 100 mi. EUR
ELISus – core support for the R&D activities
ELIBIO – Biolab facility, new technology, R&D activities
HIFI – High-field science and computing capabilities
ADONIS – Multiple-enhancements for parallel operation
ELI
a world class laser research infrastructure with high impact for society