# Brief overview of the current status

Funded by the European Union

## ELI-Beamlines / ELI-ERIC

### PROGRESS during 2024 relevant to EuPRAXIA

- High-power laser development (L2-DUHA) aiming 100 Hz
- Laser beam transport from the L2-laser-hall to the E5-experimental-hall
- Progress with relevant technology:

  - LUIS setup (compact Laser-Plasma Accelerator)
  - Discharge plasma setup + Plasma diagnostics
  - Laser-plasma Acceleration at ELI-Beamlines
  - “Betatron” radiation at ELI-Beamlines

# ELI-Beamlines (ELI-ERIC/ Czech Republic)

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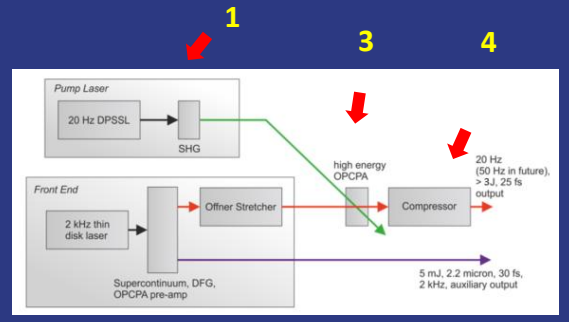
## L2-Laser (DUHA / L2-hall): dedicated to LPA-LUIS program

**Current Status / by 08.2024**

- L2-laser system would be the laser for LPA-FEL (EuPRAXIA-Phase#1 / ELI-Beamlines) setup

- **Initial target parameters:**
  **100 TW, 820nm, 25 fs, 20 Hz**
- **Direct increase of repetition rate to 50 Hz possible with current equipment.**
- **Clear path to 100 Hz available.**
- **All materials have been delivered and are ready for use (crystals, optics, optomechanics, control systems, diodes)**

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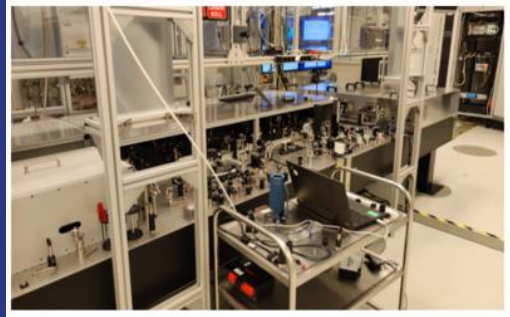
**10J Pump Laser**

- Temporally shaped pulse generator and regenerative pre-amplifier **completed**, booster pre-amplifier running at 100mJ, ramping to 0.5J.
- All components for 10J multipass are in place and **pre-aligned**, pump diodes **tested** and **installed**
- Cryo system **installed** and undergoing tests

**Broadband front end**



- 1mJ, 50fs, 2kHz **demonstrated** at 2.2µm (mid-IR development paused to focus on 100TW seed)
- Offner Stretcher **aligned** with NIR output
- **Current focus** on improving NIR seed stability and energy

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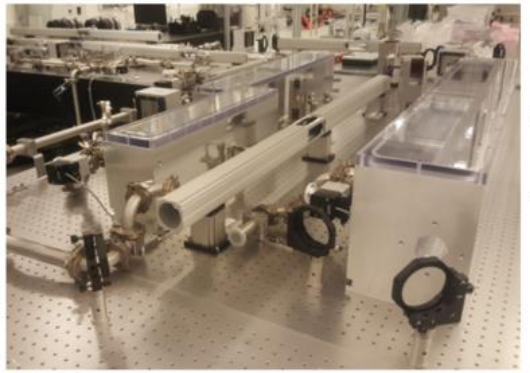
3

**High Energy OPCPA**



- All OPCPA and SHG crystals are **delivered** and ready for installation.
- Pump transport to OPCPA is **pre-aligned**

**Compressor**

- Compressor chamber **installed** along with injector chamber.
- Final optics for compressor expected to be delivered in Dec 2024.
- Compressor is **connected** to beam transport
- **First compression of OPCPA output expected 08/2025.**

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*Tyler Green (ELI-Beamlines)*

# ELI-Beamlines (ELI-ERIC/ Czech Republic)

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## L2-Laser (DUHA / L2-hall): dedicated to LPA-LUIS program

**L2-DUHA schedule**

| Pump Laser and OPCPA | Status | Expected completion |
|---|---|---|
| Cryogenic system | Defects found after initial installation repaired and full **system tests currently** underway. | 09/2024 |
| Pump laser front end | Seed laser and regenerative amplifier **complete**, booster pre-amplifier running at 100 mJ, currently ramping up to 0.5 J | 10/2024 |
| Commissioning of pump laser | Pump laser **pre-aligned**; now awaiting finalized cryo-cooling | 11/2024 |
| OPCPA pre-alignment | All components **installed**, pre-alignment of pump telescopes and signal path underway | 12/2024 |
| OPCPA amplification | Amplification possible after pump laser and BBFE complete | 03/2025 |
| **Broadband front end (BBFE)** | **Status** | **Expected completion** |
| Seed available | NIR OPCPA to be **completed** and **passed** through pre-aligned stretcher | 11/2024 |
| Mid-IR output | Work on this set aside to prioritize main amplifier seed branch. | 12/2024 |
| **Compressor** | **Status** | **Expected completion** |
| Optics | Most **delivered**, some still in production | 12/2024 |
| Alignment and first compression | Possible after OPCPA completion (03/2025) and arrival/installation of all compressor optics | 08/2025 |

➡ The cryogenic test is in progress:
Current result → 120 Kelvin on Crystal

➢ **L2-laser system readiness for the LPA-FEL (EuPRAXIA Phase#1)**

➡ **Compressed L2-beam to E5-LUIS: 1st experimental campaign 09/2025**

*Tyler Green (ELI-Beamlines)*

# ELI-Beamlines (ELI-ERIC/ Czech Republic)

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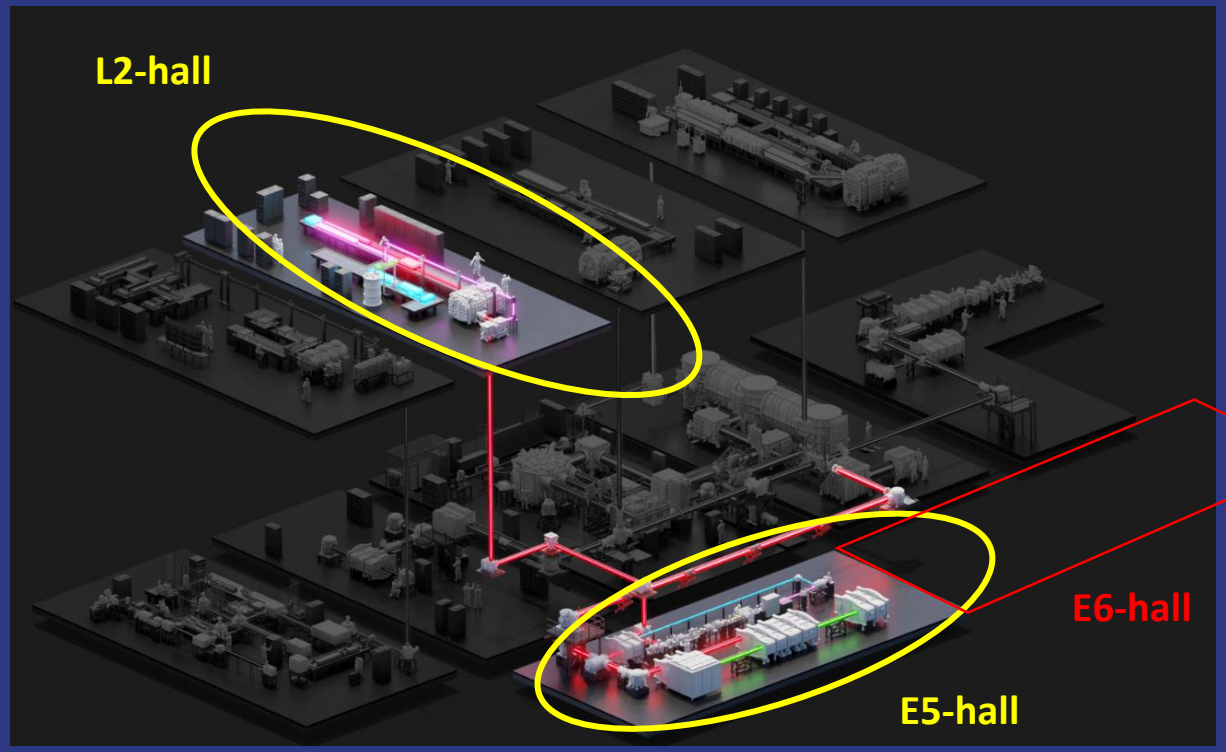
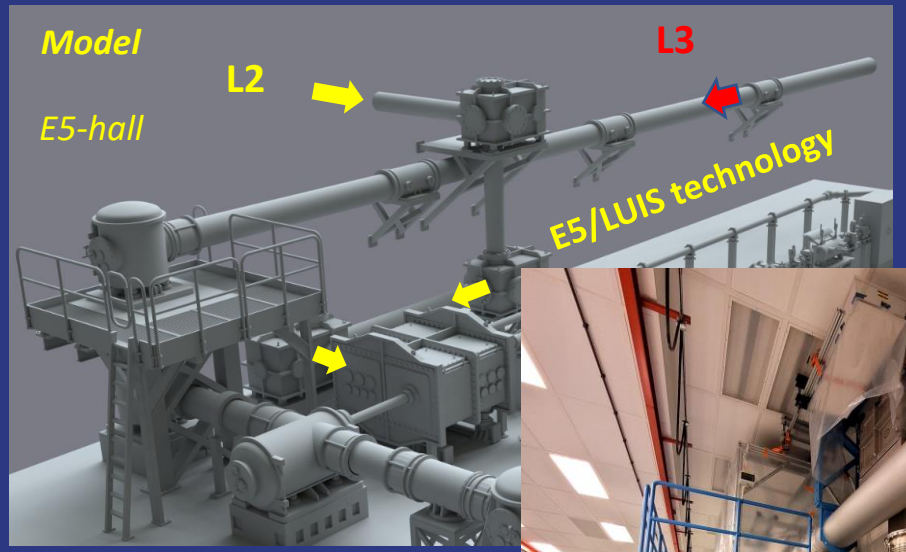
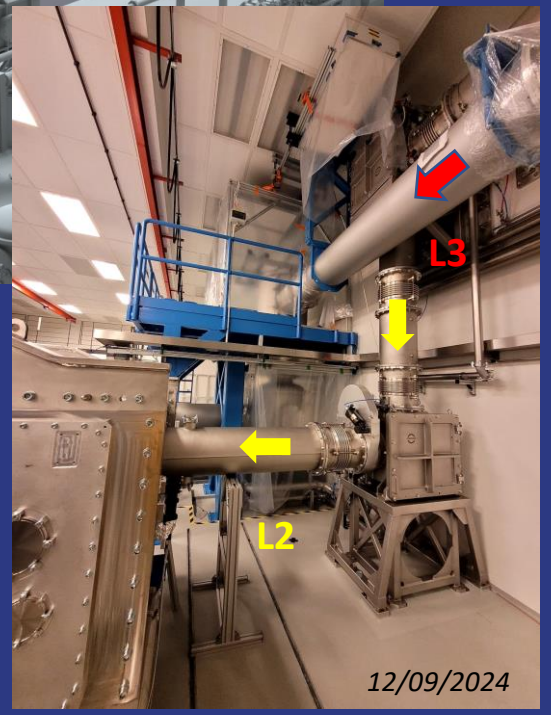
## L2-DUHA laser beam transport (L2-to-E5/LUIS) development

**2024: integration of L2 & E5 halls - DONE**




*L2-laser beam transport to E5-LUIS: installed*
*L2-to-E5 BT Vacuum system : tested*
*Optics will be placed (aligned) 2Q-2025*




***ELI-Beamlines teams involved:***

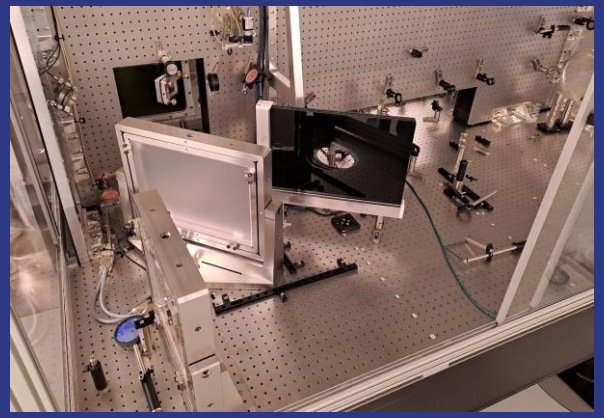
- *Optomechanics*
- *Laser beam transport*
- *Engineering support*
- *Vacuum and Control*
- *LUIS*

## LPA-LUIS technology commissioning: current status

*LUIS technology is based on the LUX (Hamburg) setup*

*Alexander Molodozhentsev (ELI-Beamlines)*

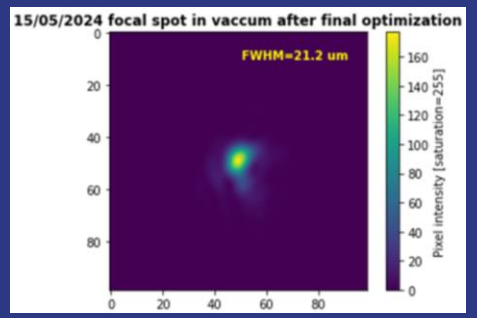
### L3-HAPLS cropped laser beam



### Sapphire capillary (gas-cell)

Precise alignment of entire setup

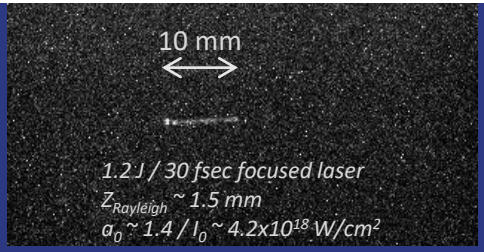

### L3-laser beam in focus

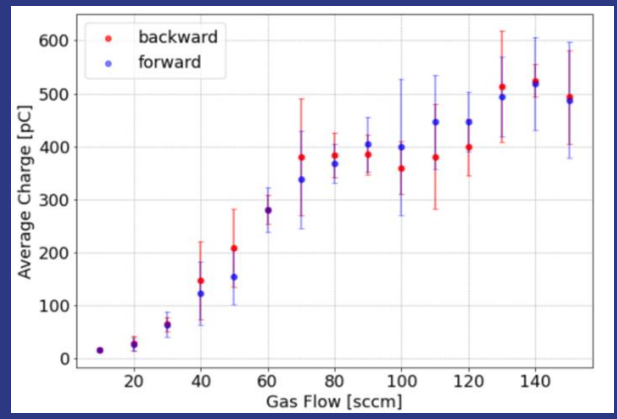



L3-laser pointing stability on OAP:
~ 1.15/0.91 mrad (H/V)

### Plasma channel formation in Capillary

| Capillary length | Capillary diameter | Gas flow in each inlet (SCCM) |
|---|---|---|
| 10 mm | 500 $\mu$m | 20-200 SCCM |
| Gas pressure (mbar) | Helium gas density in the plateau ($n_{He}$) | $N_2$ concentration ($C_N$) |
| ~ 15-50 mbar | ~ $(0.3 - 1.2) \times 10^{18}$ cm$^{-3}$ | 0.4-10 % |




1st measurements of the e-beam charge (Turbo-ICT)

**May (w19-20) 2024**
**L3-LUIS experimental campaign:**

**NO back-reflection issues**

***around 2000 high-power shots*** *were performed (1856 shots of the 10J-energy of the full beam and 90 shorts of the 12J-energy of the full beam) to make the 1st high-power measurements, dedicated to the* ***commissioning of the LUIS technology.***

## LUIS plasma components: current status

*Alexander Molodozhentsev (ELI-Beamlines)*

***Electrical discharge plasma formation in Capillary***
***LUIS-Laboratory at ELI-Beamlines***
***Fully operational setup (discharge + gas distribution + control system)***

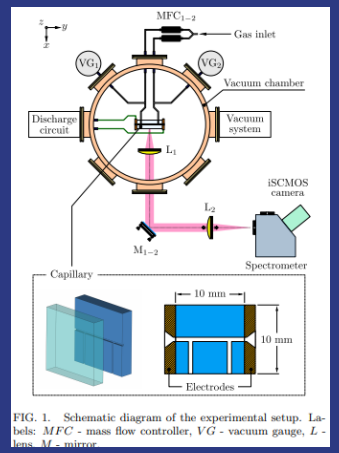
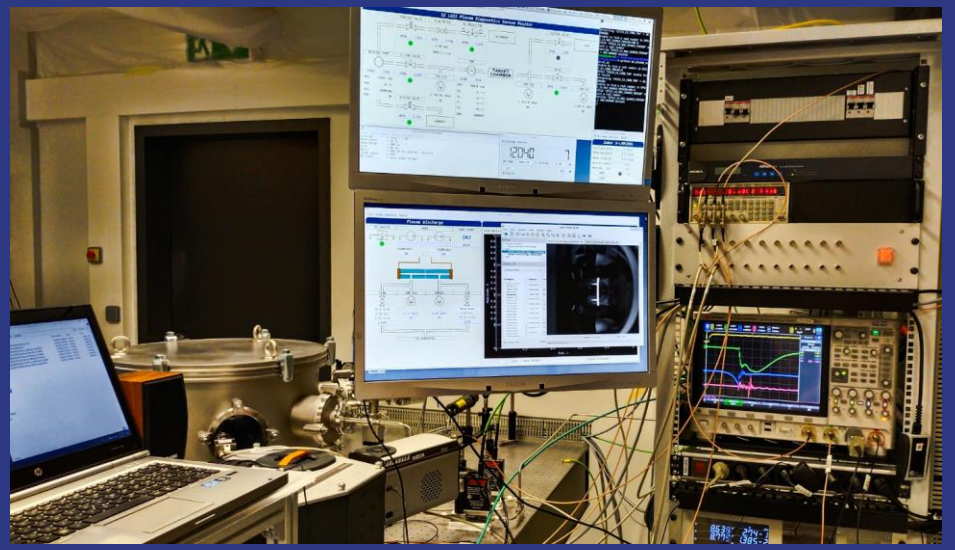
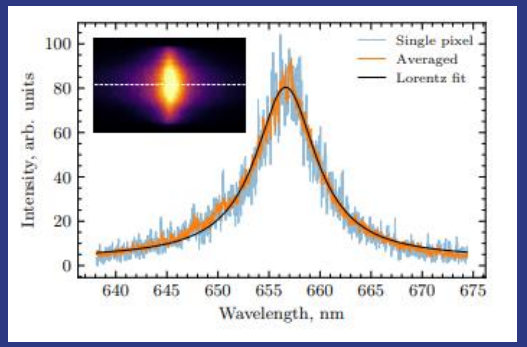



FIG. 1. Schematic diagram of the experimental setup. Labels: *MFC* - mass flow controller, *VG* - vacuum gauge, *L* - lens, *M* - mirror.






***Emission spectroscopy***

***Test of technology applicable for laser wave-guiding and for active plasma lens***
***Development of the plasma diagnostics (Emission spectroscopy + Interferometry)***
***<u>High repetition rate regime</u> ( up to 100Hz )***
***Modelling * and measurements ****

*<u>Recent publications:</u>*
** P.Sasorov et al, Physical Review Research 6, 013290 (2024) / doi:10.1103/PhysRevResearch.6.013290*
*** K.Kruchinin et al, under review for publication*

# ELI-Beamlines (ELI-ERIC/ Czech Republic)

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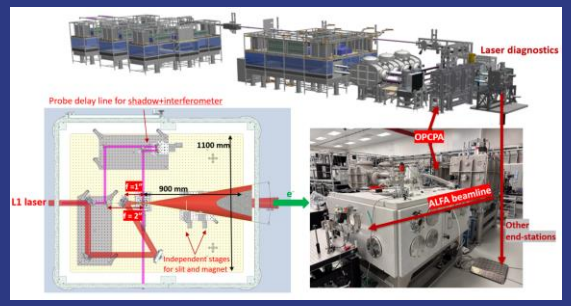
## LPA electron beam at ELI-Beamlines: current status

*Gabriele Grittani (ELI-Beamlines)*

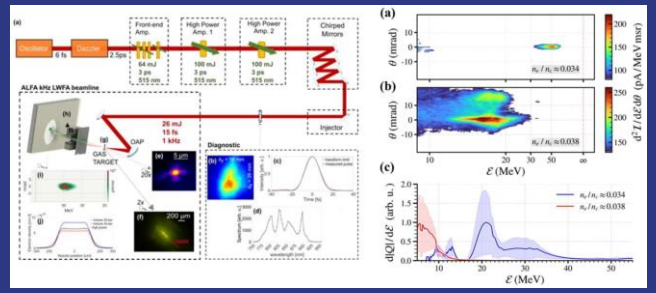
### ALFA kHz Laser-Plasma Accelerator → 50 MeV / 1 kHz

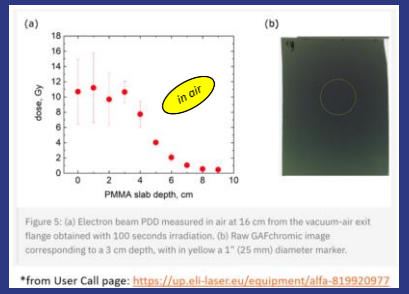
**L1-laser: 30mJ (100 mJ) / 1 kHz / 15 fs**

**2024: Installation of new bigger vacuum chamber (final version / L1-hall)**




ALFA-LPA: First demonstration of LWFA with scalable kHz laser technology (OPCPA)
ALFA-Medical: Irradiation of samples with % uniform dose distribution






*from User Call page: https://up.eli-laser.eu/equipment/alfa-819920977

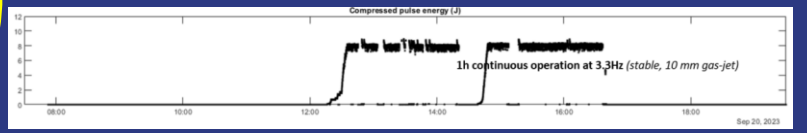
**Setup is open to users (through "USER-CALL")**

*Recent publications: Lazzarini, Phys. Plasmas 31, 030703 (2024)*

### ELBA Electron Accelerator → 800 MeV / 3.3 Hz

**Multi-GeV electron beams and PW-class photon-electron collider (3-10 Hz)**
**Based on the L3-HAPLS laser system**


**> 30k consecutive laser shots on target**
**(8J, 300TW) @3.3Hz *(< 2 hours net time)***




ELBA user assisted commissioning results (G. Sarri, G. Grittani et al.) / March 2024

1st results


**Setup is open to users (through "USER-CALL")**
**Coming user-oriented campaign (November 2024)**

**Next USER-CALL (Sep.25/2024):** *https://eli-laser.eu/news/5th-eli-user-call-set-to-launch-on-25-september/*

# ELI-Beamlines (ELI-ERIC/ Czech Republic)

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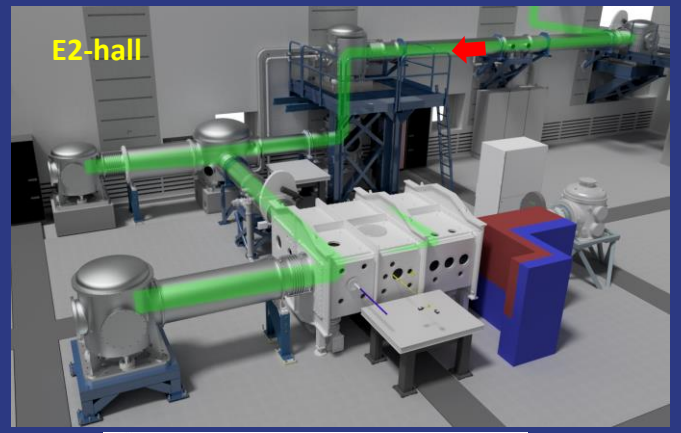
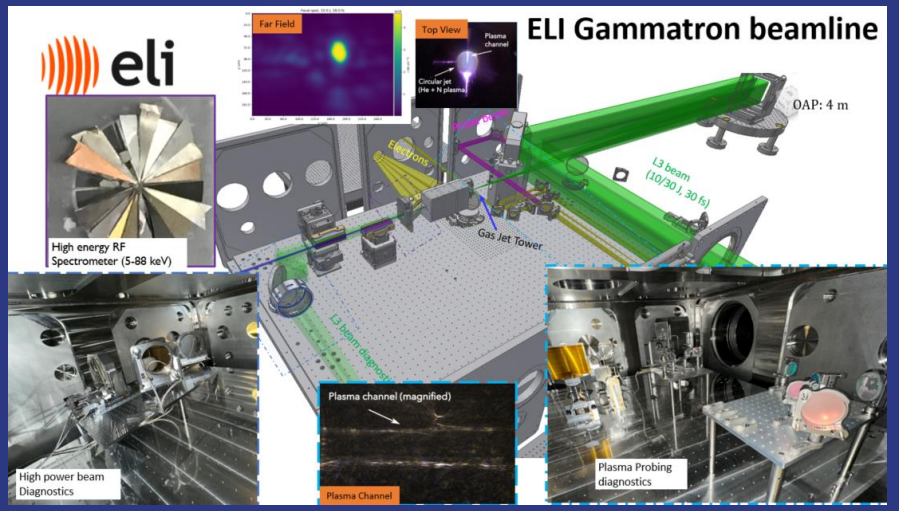
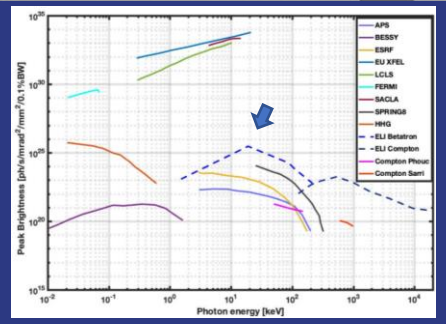
## Betatron radiation at ELI-Beamlines: current status

*Udhabb Chaulagain (ELI-Beamlines)*

**L3-HAPLS laser**



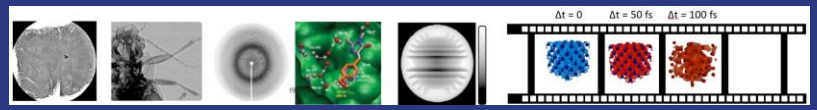




**Commissioning of the technology was performed successfully in April 2024:**

- *Plasma channel formation (gas-jet)*
- *1st electron beam and betatron radiation*

- ✓ **Compact synchrotron-like X-ray source (1-50 keV)**
  - ✓ *~10 fs, micron source size, collimated*
  - ✓ *Expected photon flux $10^{11}$ photons/shot*
  - ✓ *10% flux variation & 10% energy variation*
  - ✓ *Energy tunable and Partially Polarised X-ray source !*
- ✓ **Equipped with electron and X-ray diagnostics**
- ✓ **Pump beam** (800 nm, 400 nm or 266 nm)
- ✓ **Open to users from Q3-2024 (USER-CALL: September 25, 2024)**




*Chaulagain et al., Photonics 2022, 9(11), 853 (2022)*

**User assisted commissioning campaign - now: w38-w39 / 2024**

# ELI-Beamlines (ELI-ERIC/ Czech Republic)

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## THANK YOU for YOUR ATTENTION

***ELI-Beamlines TEAM / ELI-ERIC***