MULTI-GEV ELECTRON BEAMS FROM SELF-WAVEGUIDED LASER WAKEFIELD ACCELERATION IN ELBA AT ELI BEAMLINES

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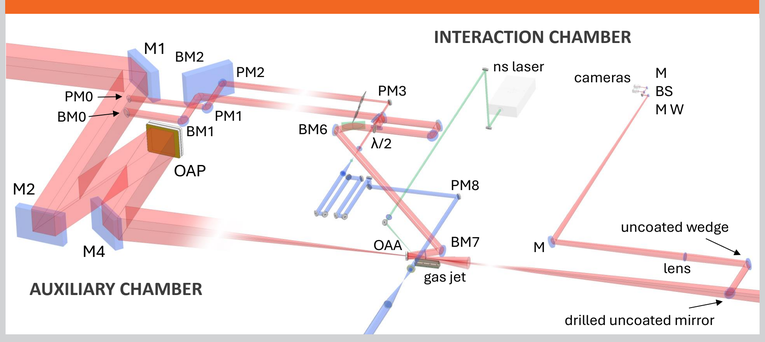
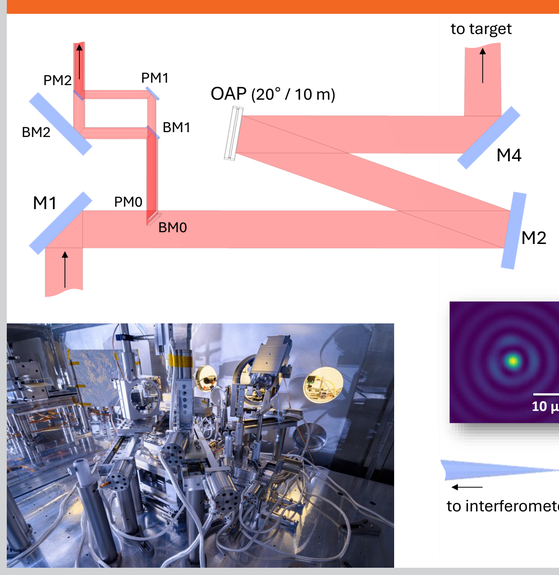
We present recent results on high-power guiding and laser wakefield acceleration (LWFA) in ELBA beamline at ELI Beamlines facility, using the L3 laser system (13 J, 30 fs, 0.2 Hz). By employing self-waveguiding in a 20 cm helium plasma channel, we achieved stable acceleration of electron beams to energies approaching 5 GeV. A novel all-reflective optical setup, incorporating an off-axis reflective axicon, enabled efficient acceleration at 0.2 Hz and guiding at repetition rates up to 3.3 Hz. This compact, single-laser, single-compressor approach establishes ELBA as a fully operational user beamline, capable of delivering multi-GeV-class electron beams for advanced laser-plasma acceleration research and secondary source development.

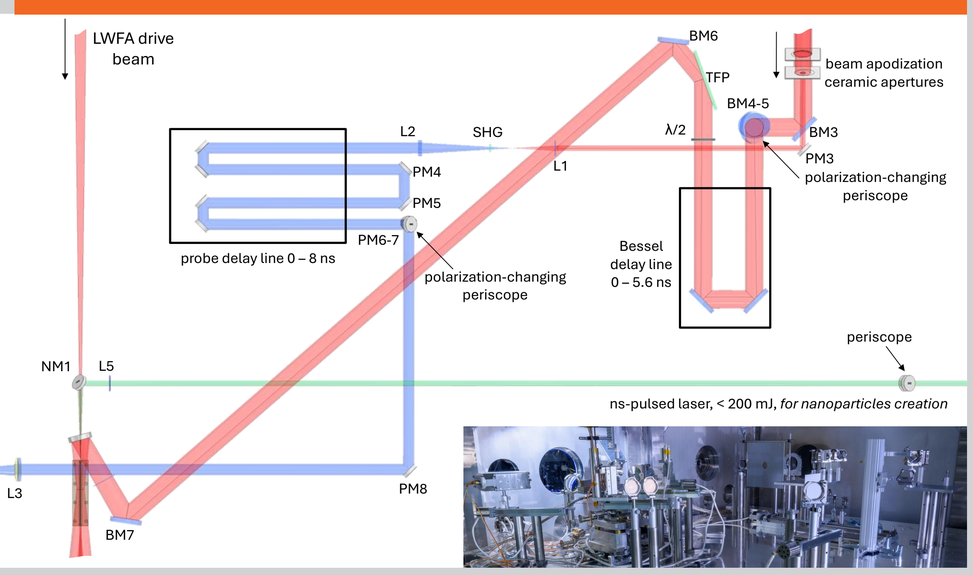
EXPERIMENTAL SETUP OVERVIEW



AUXILIARY CHAMBER

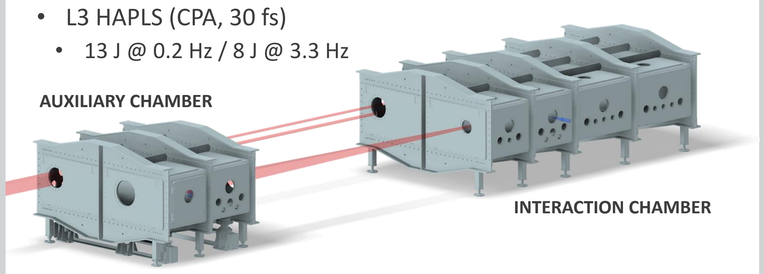


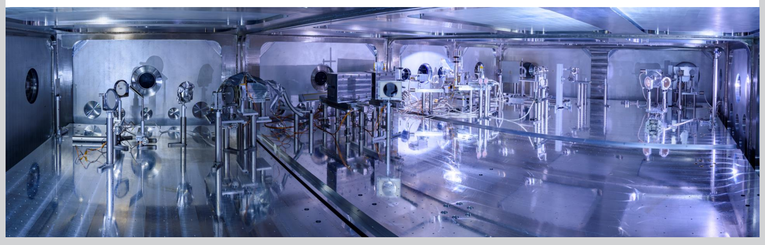
INTERACTION CHAMBER



ELBA BEAMLINE

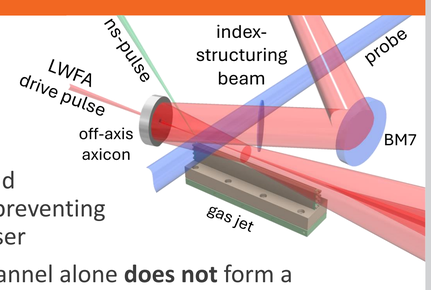
- ELBA (**EL**ectron **B**eam **A**ccelerator): all-optical collider at ELI-BL
- 50:50 wavefront splitting to enable high temporal synchronization of the LWFA beam and the CP laser
- currently the beam was split by pick-off mirrors
- L3 HAPLS (CPA, 30 fs)
  - 13 J @ 0.2 Hz / 8 J @ 3.3 Hz





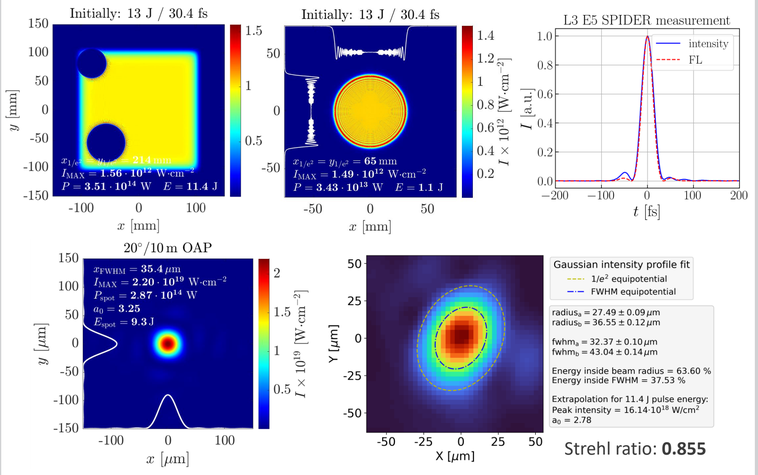
SELF-WAVEGUIDING LWFA

- LWFA energy gain limits:
  - dephasing
  - depletion
  - **diffraction**
- Plasma waveguides extend acceleration distance by preventing diffraction of the drive laser
- Expanding OFI plasma channel alone **does not** form a waveguide structure at low density
- **Self-waveguiding**: Leading wings of an injected high intensity pulse ionize neutral shock driven by expanding OFI plasma
- Control of plasma channel expansion by **delay** or **energy** – adjusting the channel size to given focal spot



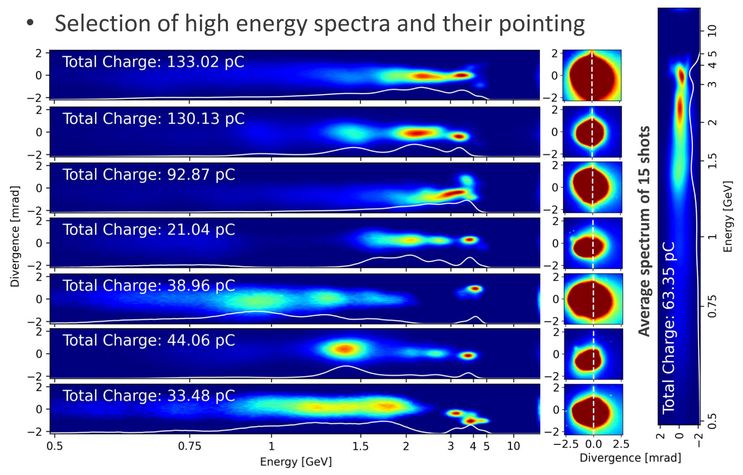
LASER BEAM PARAMETERS

L3 parameters: **13 J** (**11.4 J** LWFA drive beam, **1.1 J** Bessel beam)
7.3 J on target in focal spot radius
30.4 fs measured, **402 TW**, rectangular SG, **214 x 214 mm**



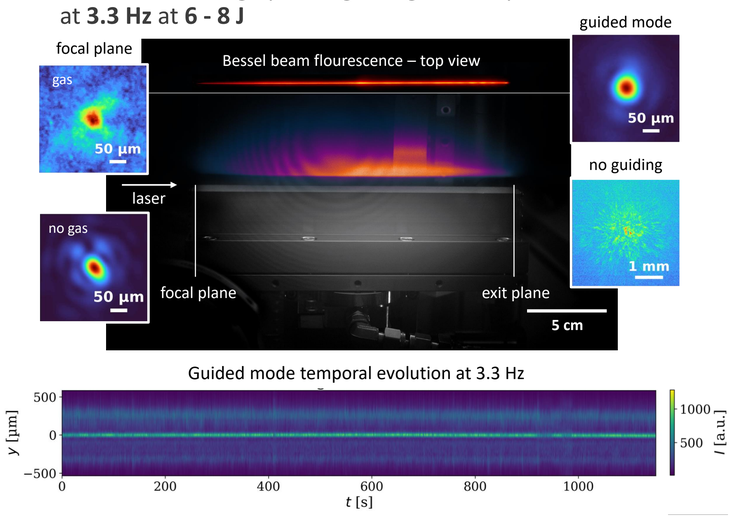
ELECTRON SPECTRA

- ELI designed slit supersonic 20-cm nozzle working with one SmartShell valve, **5 % Ar** in **He** and **10 % N_2** in **He** mixtures
- Backing pressure 20 – 42 bar, 10 ms opening time
- **Electromagnet** outside the chamber **0.6 T**, **50 cm** (4 meters away from waveguide exit)
- **Tungsten** slit **1 mm**, block length **6 cm**
- Selection of high energy spectra and their pointing



GUIDING RESULTS

- High power guiding mode diagnostic for monitoring **pointing** (entrance to waveguide) and **exit mode** (single lens imaging)
- Demonstrated high power guiding in **20 cm** plasma channel at **0.2 Hz** at **6 - 10 J**
- Demonstrated high power guiding in **3 cm** plasma channel at **3.3 Hz** at **6 - 8 J**



CONCLUSION

- **Off-Axis Reflective Axicon** – all **reflective** setup
- **Single** – **compressor** beamline
- **Helium** as a working gas
- **New injection** mechanisms tested
- Energy up to **5 GeV** (7.3 J on target)

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