A Laser-Plasma Accelerator

European Advanced Accelerator Concepts, Sept. 16th 2019


CFEL, UHH
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lux.cfel.de
operate ANGUS laser

build and operate the LUX beamline for laser-plasma driven undulator radiation

LUX is built and operated in a close collaboration of Hamburg University, DESY w/ support by ELI Beamlines

lux.cfel.de
Lux - A Laser Plasma Accelerator

Combine Plasma Acceleration with State-of-the-art Accelerator Technology


ANGUS laser

LUX group:

Undulator radiation
spontaneous emission

Plasma electrons
Few hundred MeV @ 1 Hz
Let’s build an accelerator
Let’s build an accelerator

accelerator physics

[ækˈseɪlərətər ˈfɪzɪks] =

Do whatever is necessary to get the job done.
The laser is key.

Image credits:
Sören Jalas (UHH)
lux.cfel.de
EAAC’19 talk
Two major challenges of LPA

Reproducibility and Average Power

Reproducibility

> Depends largely on the drive laser.
> We need a better understanding of the parameters affecting reproducibility.

Average Power

> No fundamental limit why high-power lasers should not be super stable.
  ➜ Requires laser engineering.

> We need to bring simulation-supported tolerance studies to laser-plasma acceleration.
  ➜ Requires super-fast PIC codes.

> High-quality LPA electron beams have been shown, but parameter space is HUGE.
  ➜ Requires a platform that continuously delivers electron beams to enable machine studies.

➤ Requires a road-map for high average power laser development.
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Reproducibility and Average Power

Reproducibility

- Depends largely on the drive laser.
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Average Power

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Our approach:
First, continuously deliver electron beams
Second, understand & tune the parameters
ANGUS Laser

- typical operation: 4J @ 35 fs 1 Hz
- complex controls system
- 169 diagnostic:
  - 62 cameras
  - 10 spectrometers
  - 17 energy/pwr sensors
  - ...

credits: H.E. Müller
Absorption of gold coating leads to heat-induced deformation of compressor gratings

Significantly distorted pulses

Know the physics to choose operation point:

There are solutions, see for example:
Better laser better life.

[Universal law]
Lux Plasma Target

> Continuous-flow target
> see also lux.cfel.de

credits: Niels Delbios and Sören Jalas (UHH)
What to do next?

Setup the electron beam.
Learn how to tune the machine

Online Tuning of Parameters

P. Messner
Monday, 19:00, Poster

in preparation
Characterization

Online Emittance Measurement

P. Winkler
Monday, 16:40, WG1

in preparation

- Compare single-shot method and quad-scan technique
- Do they provide the same results?
- Measure chromatic emittance growth
What else?

Let it run.
Day-long plasma accelerator operation

Enables Machine Studies.

A. R. Maier et al., in preparation
What else?

Energy Spread
Reproducible high beam quality

Fine tuning based on correlations and different target design

M. Kirchen

Wednesday, 18:20, WG1

in preparation
Frosty’s coming home…

demoFEL undulator

M. Trunk
Monday, 19:00, Poster

> The final aim of all our efforts is to operate a plasma driven FEL
> Using decompression scheme

> Frosty undulator (tailored design)
  > K=3
  > λ_u=15 mm

> Under Commissioning
Conclusion

> The LPA community starts building accelerators.
> Our approach
  > First, continuously deliver beams
  > Second, tune the beams
Acknowledgement

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