EuPRAXIA Doctoral Network

Short-pulse laser-driven injector

Olle Lundh

Lund University

UK Research and Innovation

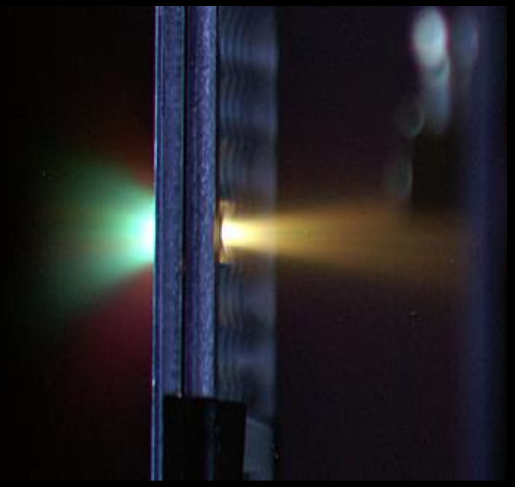
Lund Laser Centre

EuPRAXIA Doctoral Network

Members

~120 scientists, 65 PhDs

- Atomic Physics
- Chemical Physics
- Combustion Physics
- Laboratory Astrophysics
- LU Medical Laser Centre
- Laser research at MAX IV



History

- Established at Lund University in 1995
- European Large-Scale Infrastructure since 1996
- Part of Laserlab-Europe since 2003
- Coordinating Laserlab-Europe 2012-2019
- Moving to the MAX IV/ESS site 2030?

Laserlab Europe

LUND UNIVERSITY

LLC LUND LASER CENTRE

Particle accelerators in Lund

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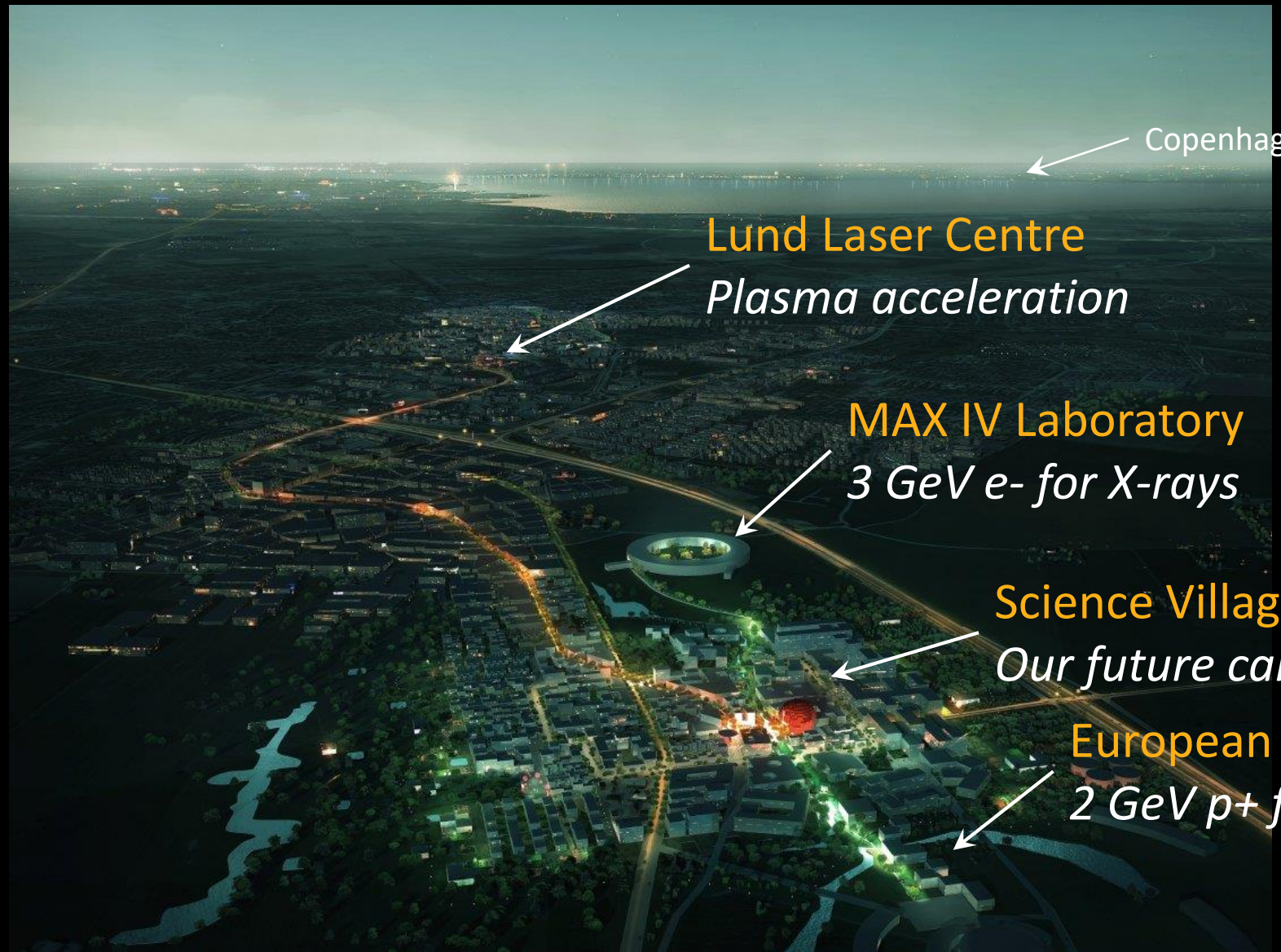

Lund High-Power Laser Facility

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Ultrafast X-Ray Science

Ultra-High Intensity Laser Physics

Attosecond Science

MAX IV Femtomax

Time-Resolved Electron Difraction

Laser-Driven Electron Acceleration

Laser-Driven Proton Acceleration

Ultrafast Laser Science

Attosecond XUV Spectroscopy

Attosecond Atomic Physics

Intense XUV Attosecond Physics

Free Electron Lasers

Jörgen Larsson

Olle Lundh

Claes-Göran Wahlström

Cord Arnold

Johan Mauritsson

Anne L'Huillier

Per Johnsson

Group leaders

Electron acceleration and X-ray generation

J B Svensson *et al*, Nature Physics **17**, 639–645 (2021)
O Lundh *et al*, Nature Physics **7**, 219–222 (2011)

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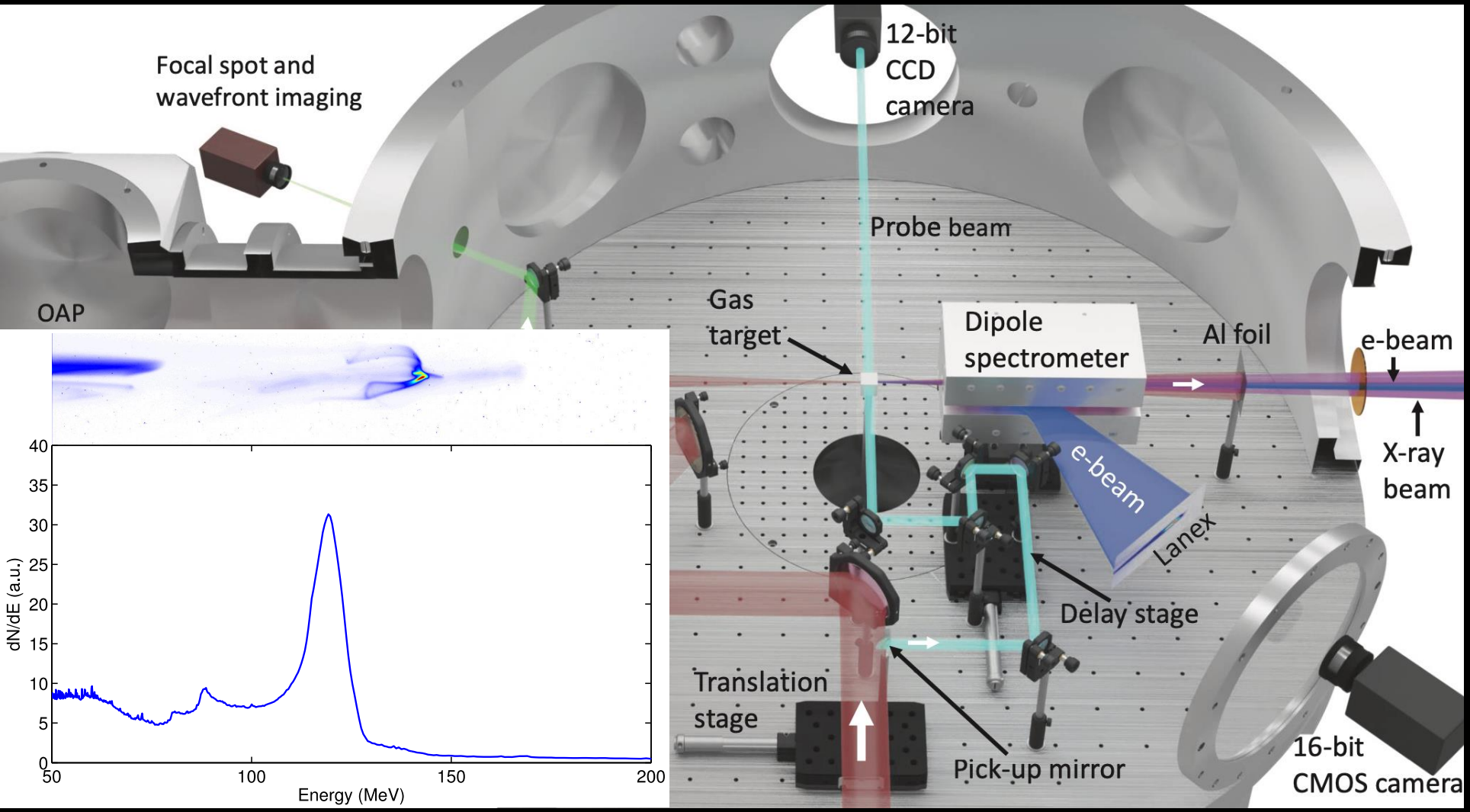

Unique Qualities

- ✓ Compact
- ✓ Ultrashort
- ✓ Tunable

Laser: 1 J, 35 fs, 10^{19} W/cm^2

Plasma: 2 mm jet, H_2 or He, 2–20·10^{18} e-/cm^3

Shock injector improves beam quality and gives some control

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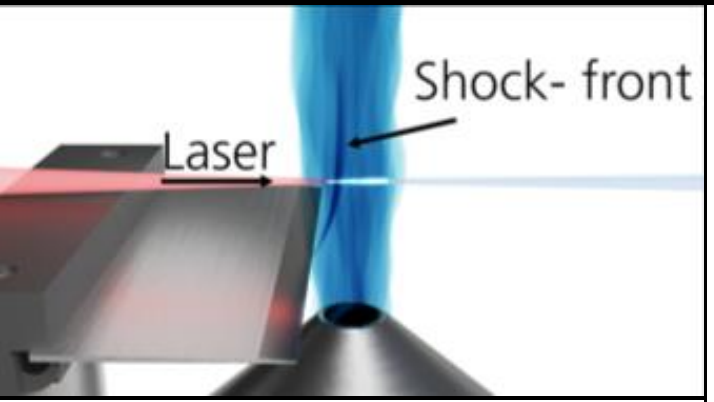

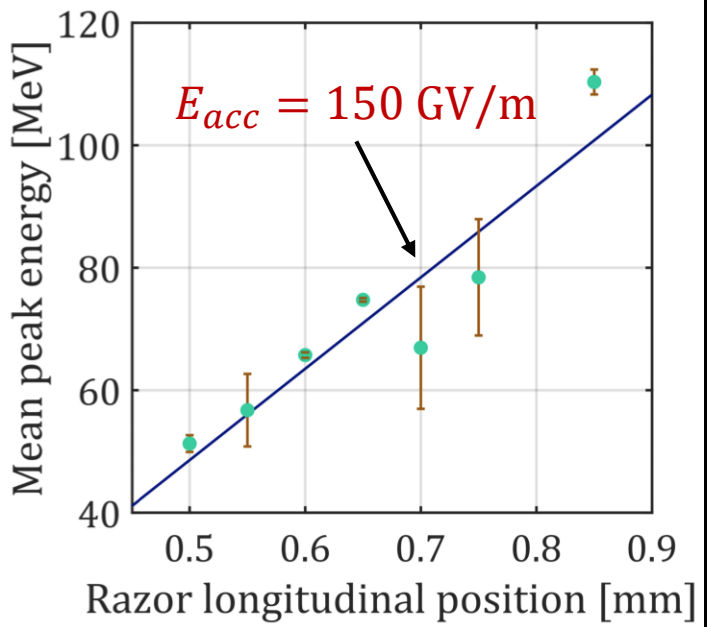

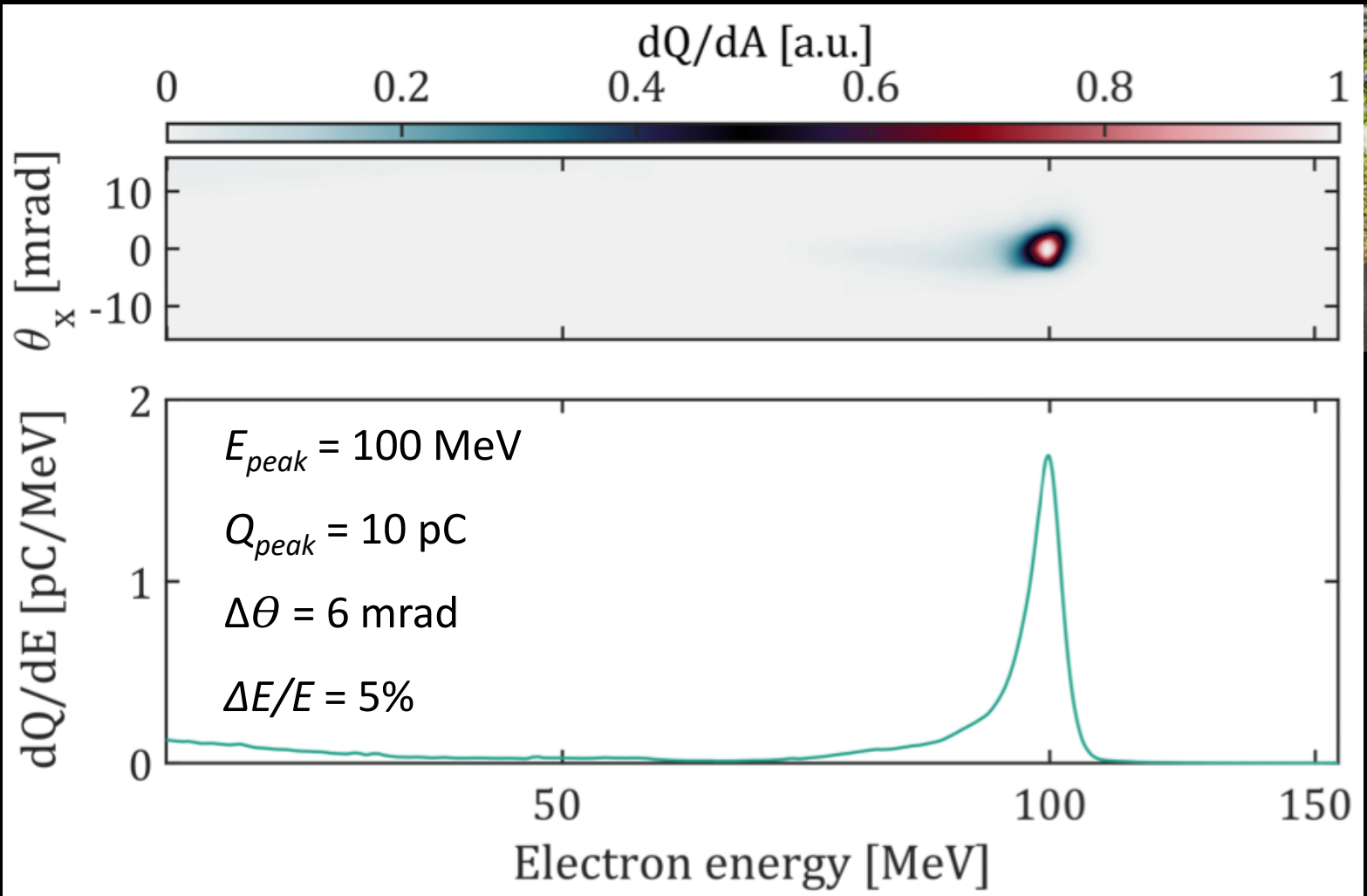

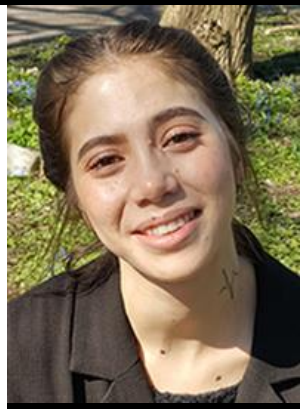

Cornelia Gustafsson Thesis

Applications

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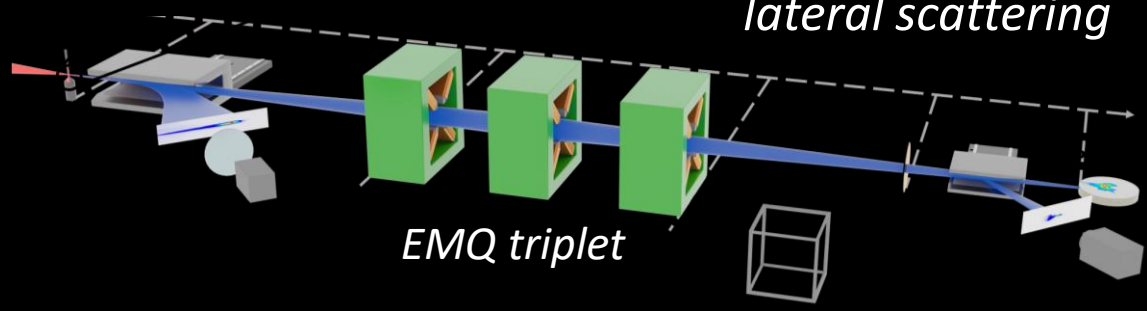
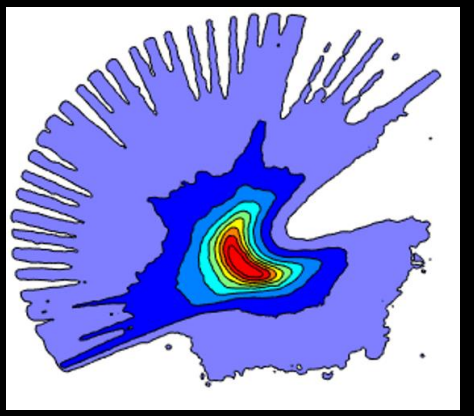
High Energy Electron Radiotherapy

Focusing electrons at depth mitigates lateral scattering



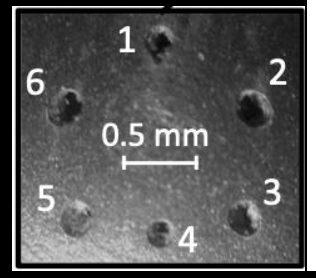
EMQ triplet

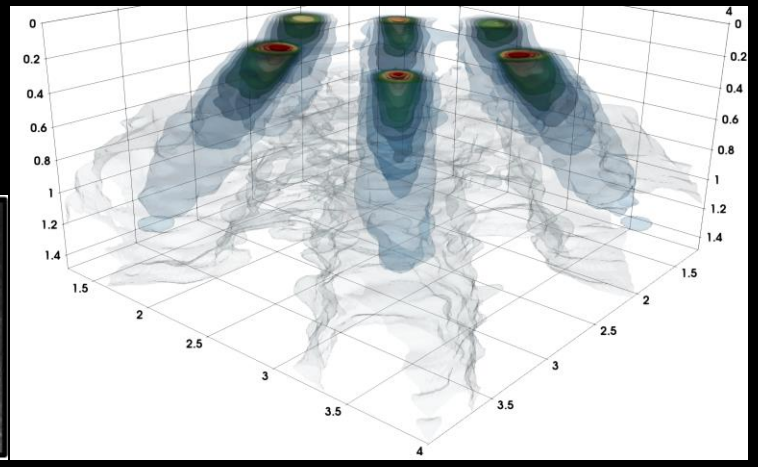


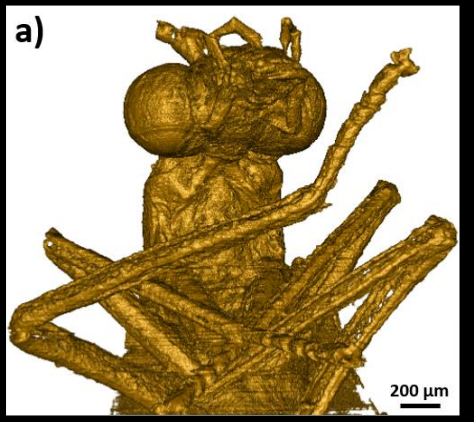
Dose distribution

X-ray imaging and tomography

Gasoline Direct Injector nozzle from a car engine







Phase-contrast tomography

New multi-terawatt laser

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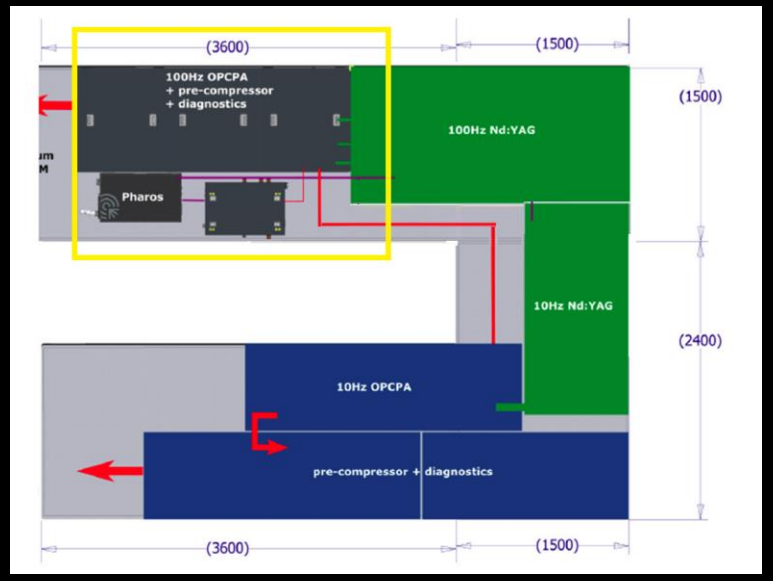

Based on OPCPA

10 fs CEP stable

100 nm bandwidth @ 800 nm

1:10^{12} contrast ratio

Scheduled delivery: May 2023

Two arms operating simultaneously

- 5 TW; 50 mJ; 10 fs; 100 Hz
- 25 TW; 250 mJ; 10 fs; 10 Hz

Experimental stations:

- High-harmonic and attosecond generation
- Laser wakefield acceleration and X-ray generation

Project

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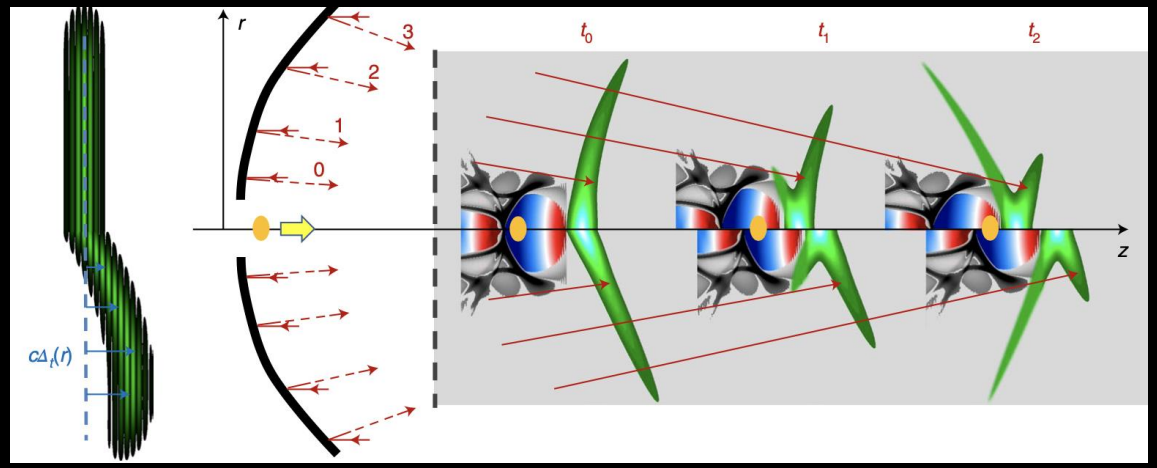
Short-pulse Laser-driven Injector

- Develop and test new laser-driven electron injector concepts
- Study the parameter range for matched acceleration using sub-10 fs laser pulses
- Demonstrate high repetition-rate acceleration at 100 Hz
- Explore spatio-temporal pulse shaping for control and optimization



C. Caizargues et al, Nature Photonics, 2020

Training

EuPRAXIA Doctoral Network

- Lund Laser Centre PhD course
- Laserlab Sweden PhD course in Experimental Laser Physics
- Lund University International MSc “Photonics”
- ERASMUS Lascala MSc “Large Scale Accelerators and Lasers”

Laboratory exercise in Laser Wakefield Acceleration

Deliverables

- Theory and simulation study that demonstrates how a parameter space to unlock pulse shaping and acceleration can be accessed (month 24)
  - Consider parameters of the new laser (bandwidth, pulse duration and CEP stability)
  - Explore methods to generate a flying focus
- Experiments that show how spatio-temporal pulse shape can be tailored for optimum acceleration (month 45)
  - Implement diagnostics for spatio-temporal couplings
  - Develop a methods for tuning spatio-temporal couplings
  - Explore acceleration with tailored pulses

Secondment at IST

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LUNDS UNIVERSITET

Experiments

Theory

Training

Secondment

IST

2 months/year

TÉCNICO LISBOA

Theory & simulation

Doctoral Network