Plasma and laser based particle acceleration

A short overview of activities at Wigner RCP

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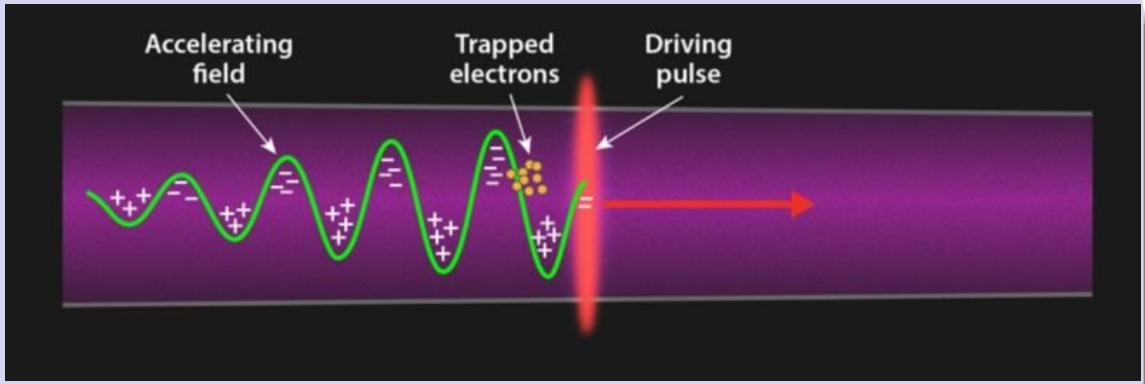
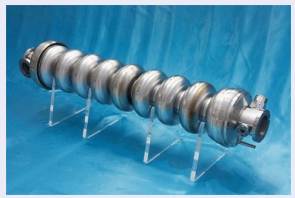
Wigner Research Center for Physics, Budapest, Hungary

High-gradient accelerator structures

Wakefield acceleration in pre-formed plasma



- Wakefields generated in plasma by driving charge separation
- Laser wakefield acceleration - laser driver
- Plasma wakefield acceleration - particle bunch driver
- Replacement for traditional RF cavity technology - 100 GV/m

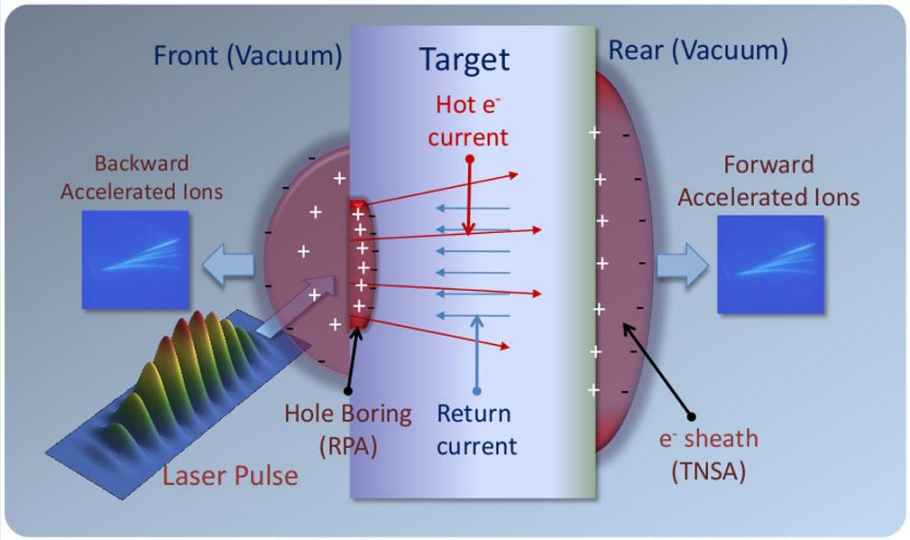


- Acceleration of light particles (e^-,e^+) - linac

High-gradient accelerator structures

„Direct” laser acceleration

- High intensity lasers (>10^{21})
- Thin foil / droplet / gas jet targets
- Acceleration of ions



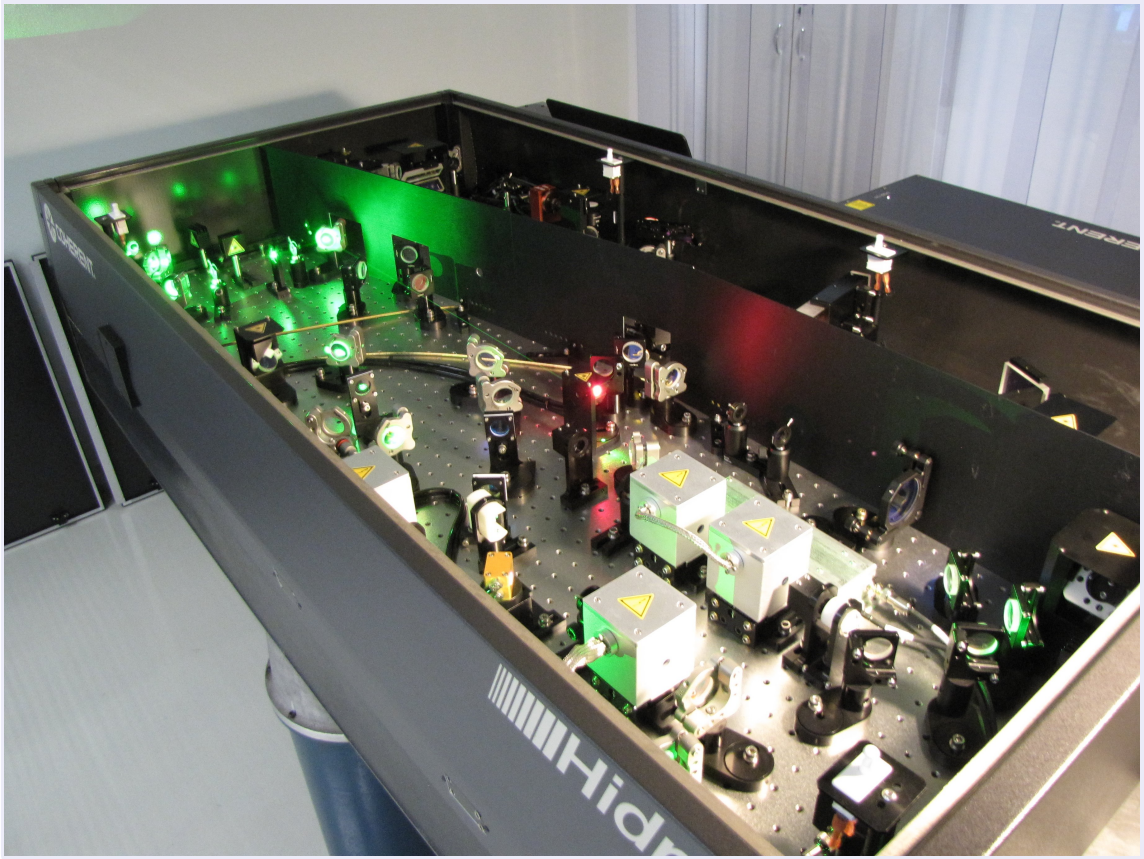
... wide range of activities worldwide, striving for

- Compactness and cost-efficiency - scientific & commercial application
- Large energy - HEP

Small scale to large international collaborations

Wigner facility: Laser lab of Dept. for HEP

Coherent Hidra: (almost) TW, Ultrafast Ti:Sapphire laser



pulse energy	32 mJ
pulse duration	40 fs
wavelength	800 nm
repetition rate	10 Hz
spatial mode	TEM00
contrast ratio	1000 / 100

in dust free, AC environment, + associated experimental equipment:

- beam expander, external compressor
- FROG, spectrometers
- vacuum technology, diode lasers, etc.

Wigner facility: Laser lab of Dept. for HEP

4 projects running currently:

- Two associated with fusion energy
- Two for laser/plasma based particle acceleration technology
  - Participation in the AWAKE Collaboration at CERN
  - Laser accelerated ion beam

Participants (for particle acceleration technology):

- Experiment: 2 staff, 1 postdoc, 1 engineer, 1 technician
- Theory/simulation: 2 staff + 1 former staff

Funds:

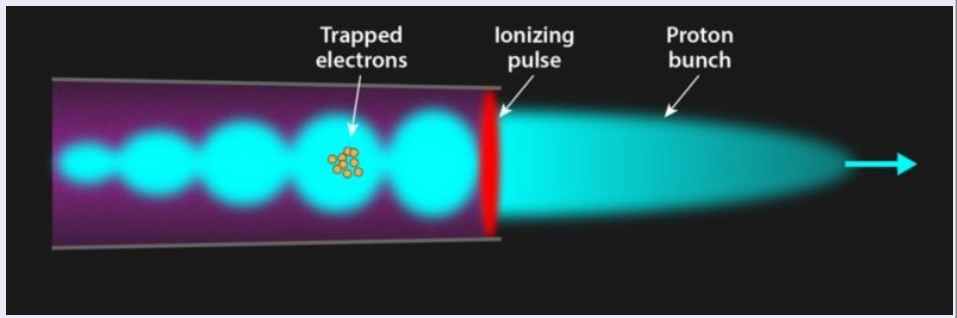
- National Excellence Program: 175 kEUR (2018-2023)
- NKFIH travel: 12.5 kEUR (2020-2022)
- ELKH Infrastructure: 30 kEUR (2020)

Challenges:

- Lab understaffed for this many projects
- Sometimes project funding is 'short term'

Advanced Proton Driven Plasma Wakefield Acceleration Experiment

- Proton bunches from SPS
- For HEP applications
- Wigner full member since 2019
- Several sattelite projects: plasma cell development, laser induced witness electron source
- Long plasma, Complex process, SMI, SSM

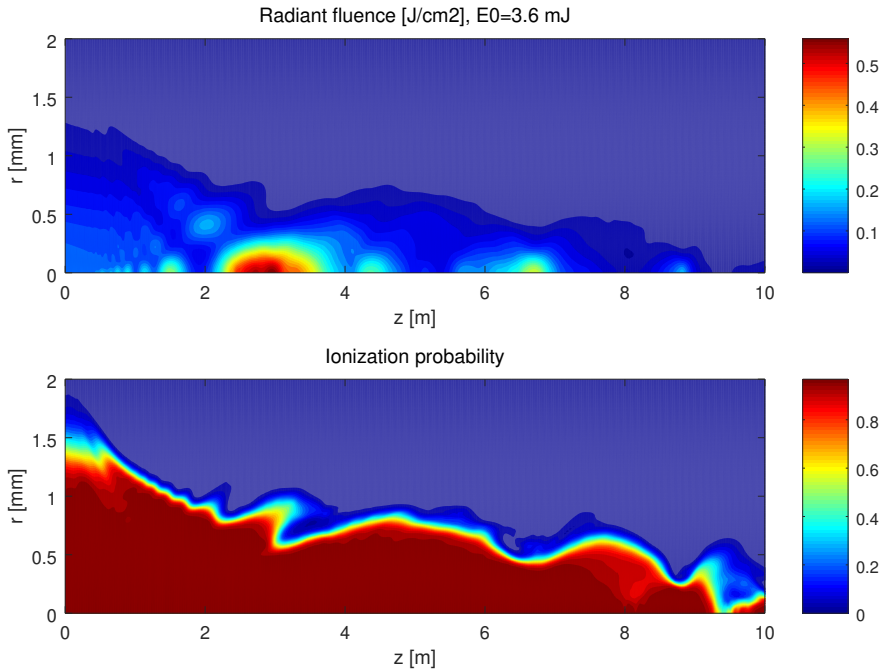


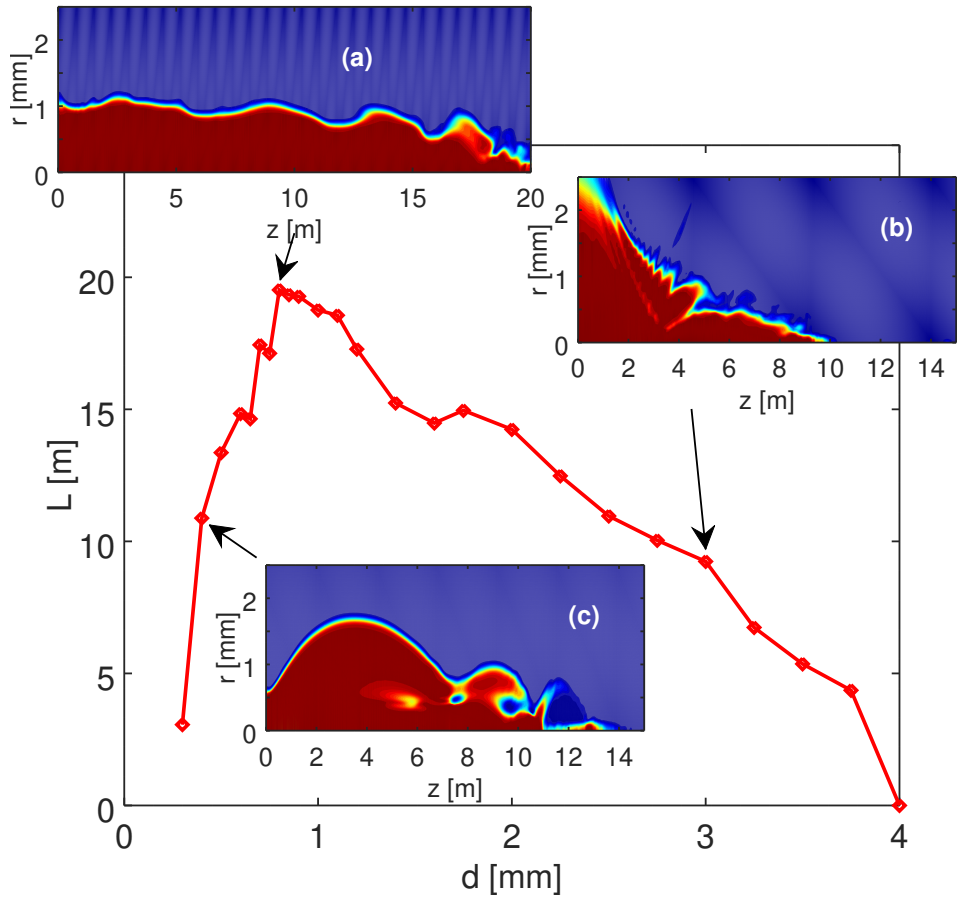
AWAKE @ Wigner - Laser ionized Rb plasma

Theory and numerical simulations

- Laser ionization
- Resonant, ionizing pulse propagation
- Resource: *Wigner Data Center*

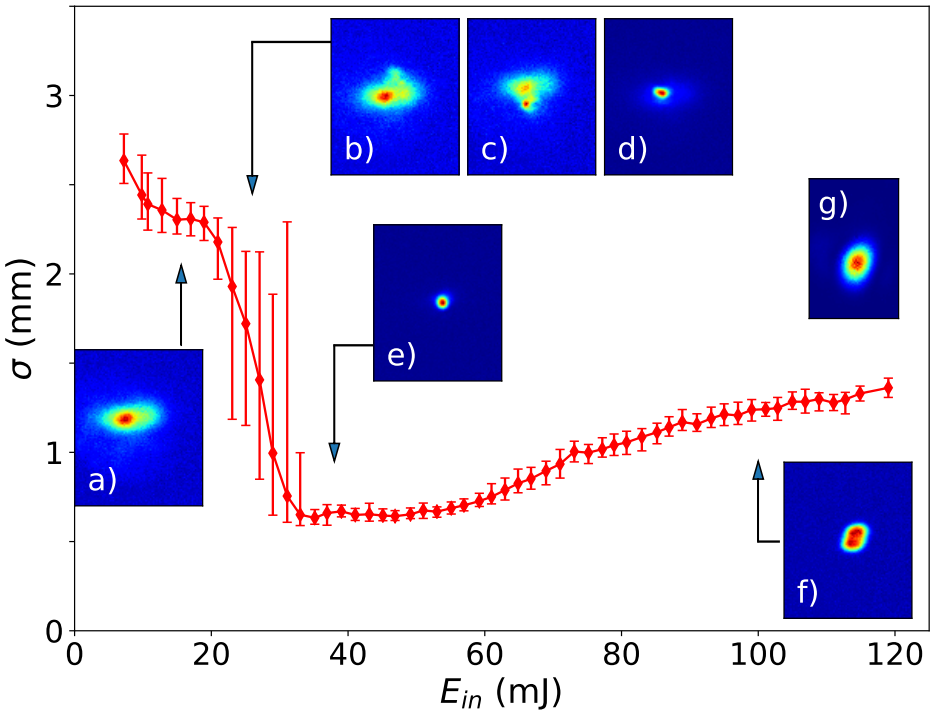
ELKH Cloud

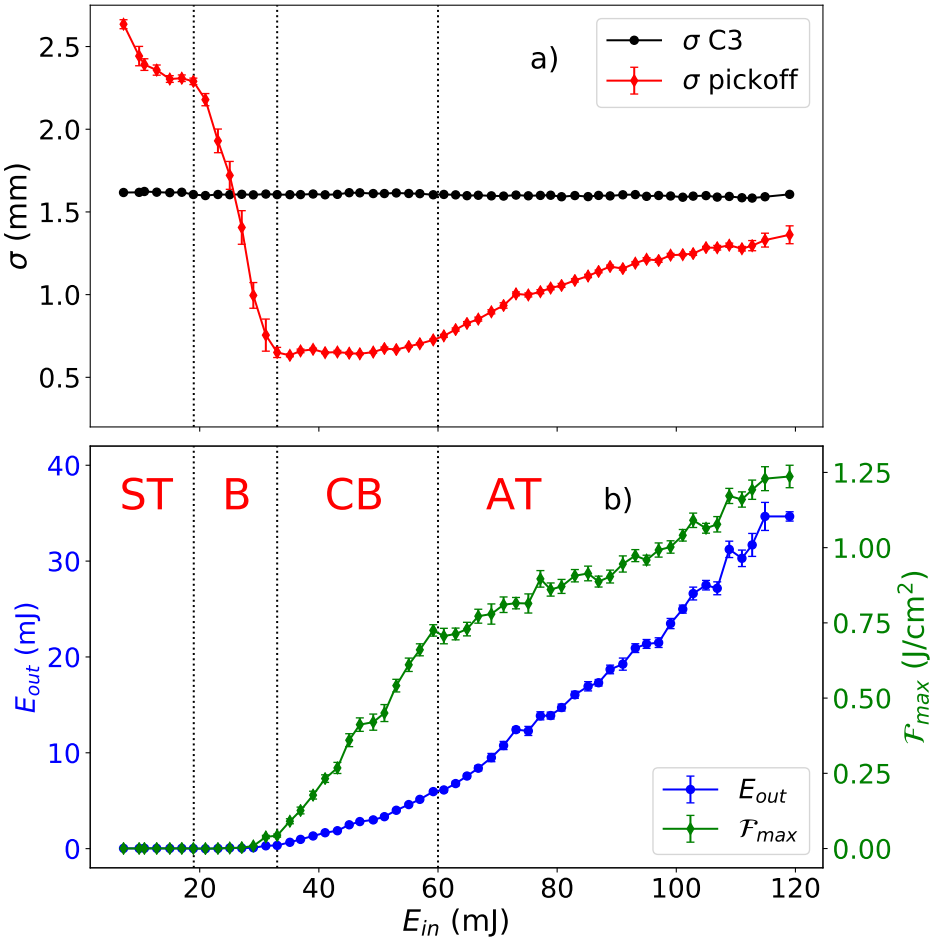




Experiment: Rubidium vapor plasma studies

- Laser ionization studies
- Laser propagation measurements

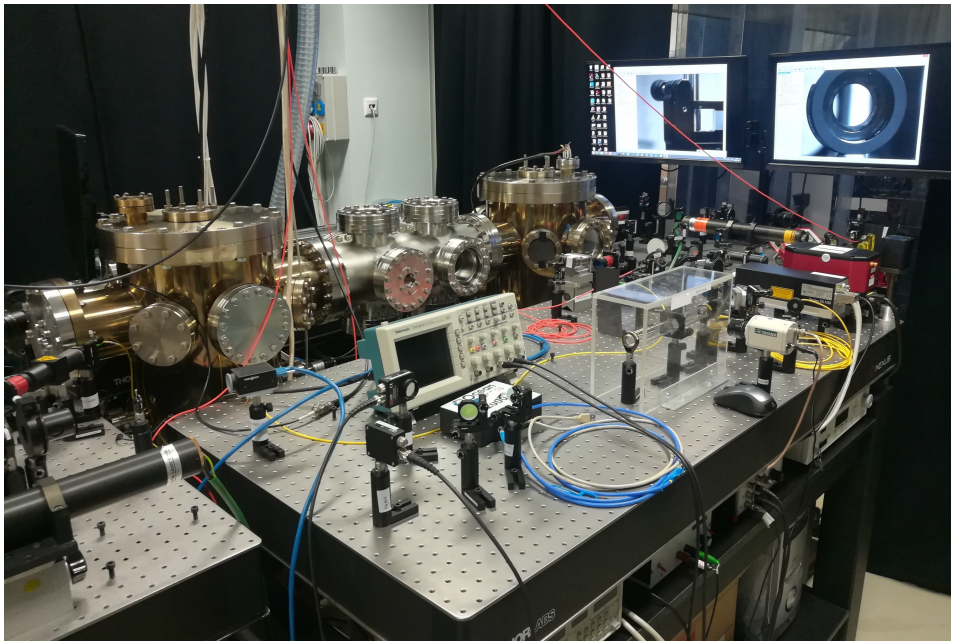


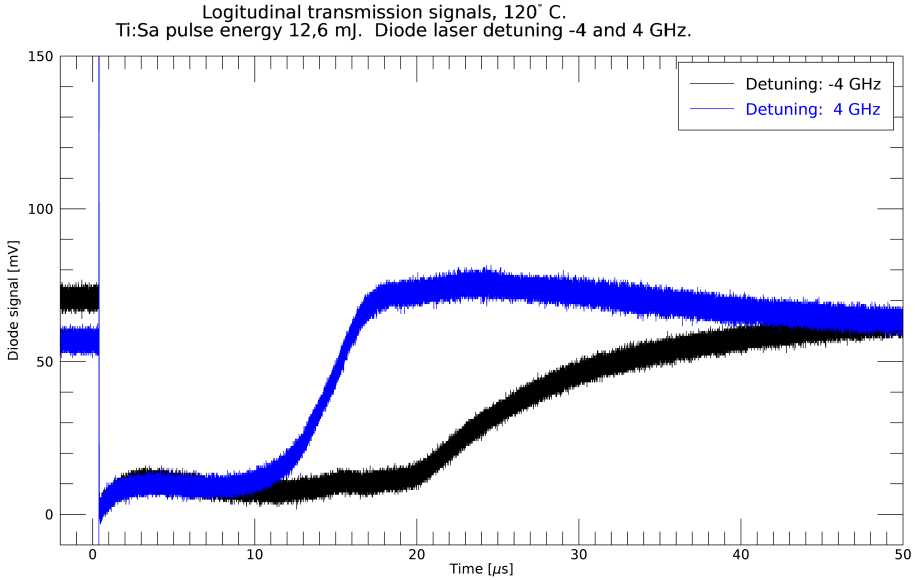


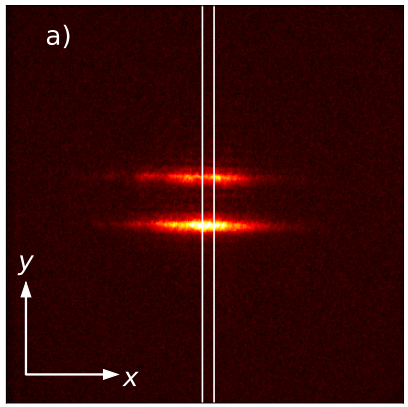
AWAKE@Wigner - Laser ionized Rb plasma

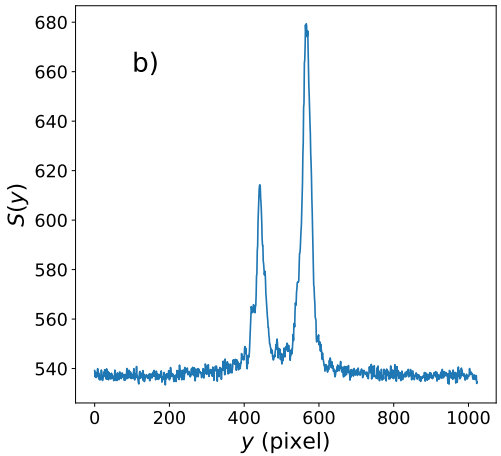
Experiment: Plasma channel diagnostic measurements

- Absorption spectroscopy
- Schlieren imaging
- Machine learning in evaluating measurements
- Resource: *Wigner Scientific Computing Laboratory*





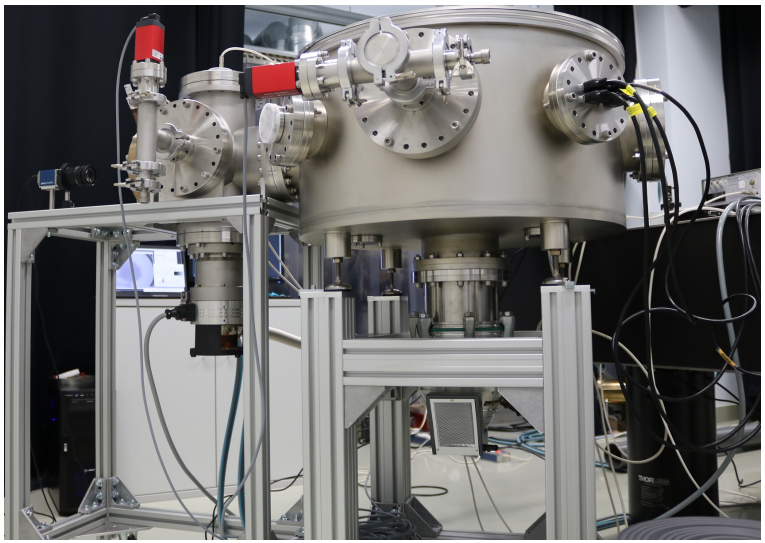


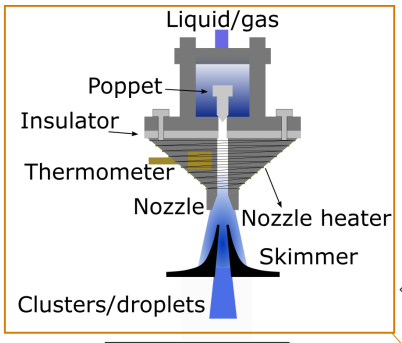


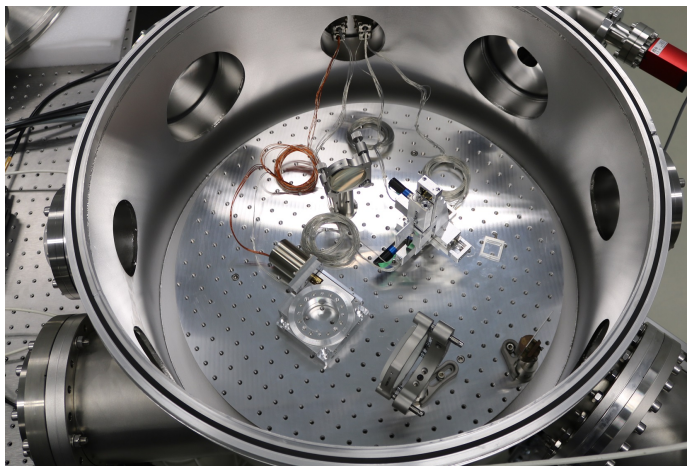
Laser accelerated ions

Developing a flexible experimental platform

- Thomson parabola spectrometer
- Various thin foil targets (e.g. carbon nanotubes)
- Liquid droplets and clusters



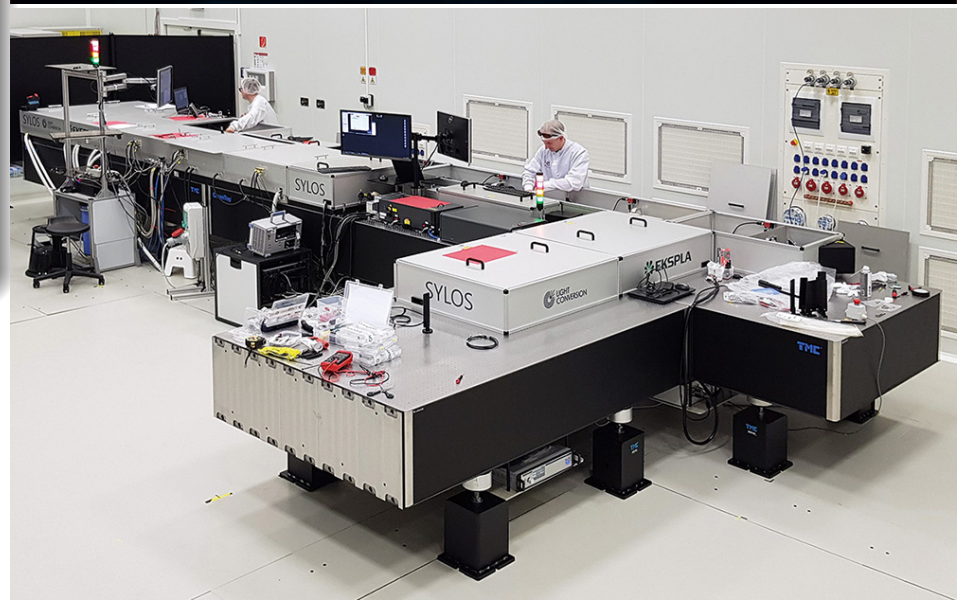




Laser accelerated ions

Sylos alingment laser

pulse energy	> 40 mJ
pulse duration	< 12 fs
wavelength	850 nm
repetition rate	10 Hz



Future plans: European Plasma Research Accelerator with eXcellence In Applications

„The worldwide first 5 GeV plasma-based accelerator with industrial beam quality and user areas.”

Wigner RCP is associated partner. Proposed contributions:

- Detector R & D
- Data storage and processing facilities (Data Center)
- Numerical simulations of electron dynamics in THz fields (with University of Pécs)

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Thank you for your attention!