LEAP

Polarized electrons from LPA

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HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

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LEAP project

Laser Electron Acceleration with Polarization

<u>Aim</u>: Experimental demonstration of the generation of relativistic polarized electron beams from a laser-plasma accelerator (LPA)

- Generation of a polarized electron beam with LPA
  - ➔ This Talk
- Measuring the polarization of the generated beams
  - ➔ Jennifer Popp: "*Polarimeter Design for a LPA Electron Beam*"

Polarization of a electron beam

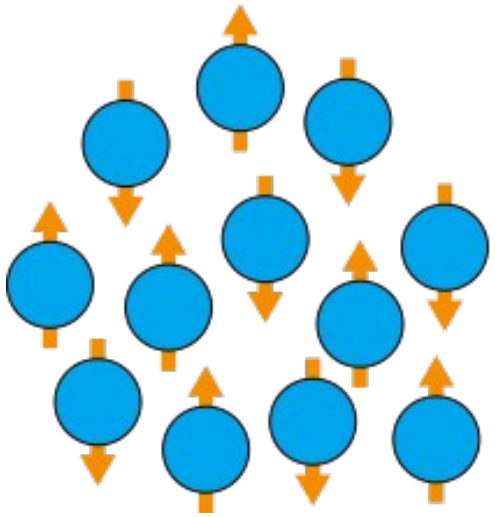
What is the polarization and why is it important ?

- The polarization P describes the spin orientation of electrons in an ensemble

$$P = \frac{N_R - N_L}{N_R + N_L}$$

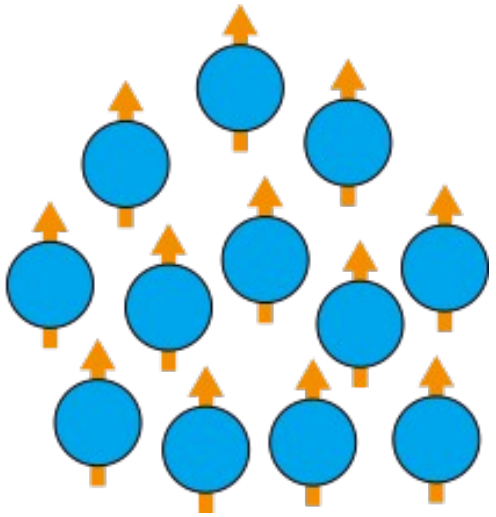
- Polarized beams are indispensable for many experiments in particle, atomic and nuclear physics

unpolarized



$P = 0$

polarized

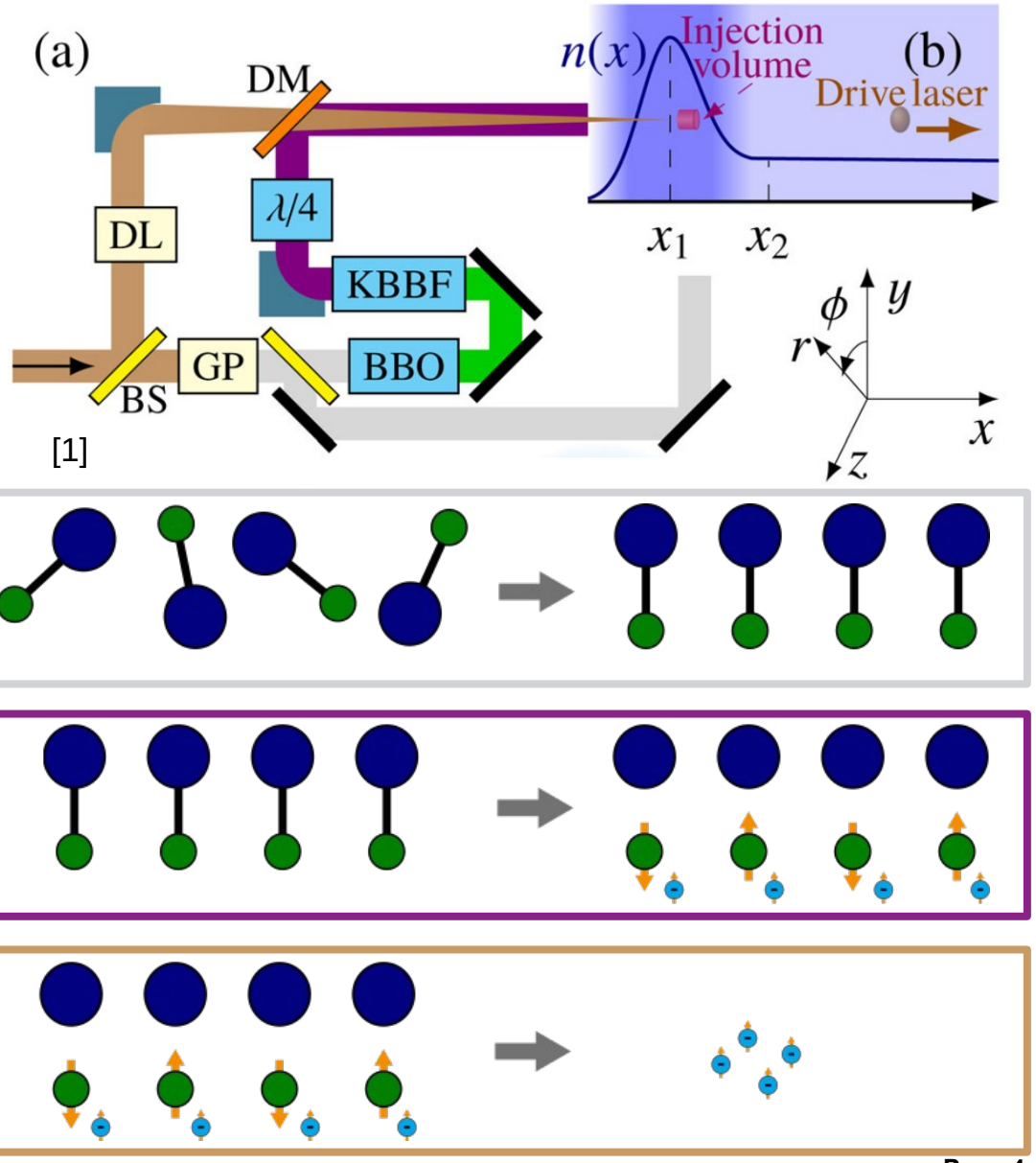


$P = 1$

How to get polarized electron beams from LPA?

Polarized beams through a pre-polarized gas jet target [1, 2]

- Alignment of **HCl** molecules with ps IR pulse
- Photodissociation of the molecules with UV pulse. Spin-orbit coupling results in polarized electrons
- Density downramp injection results in an accelerated electron beam
- Beam polarization maintained during further acceleration[3]



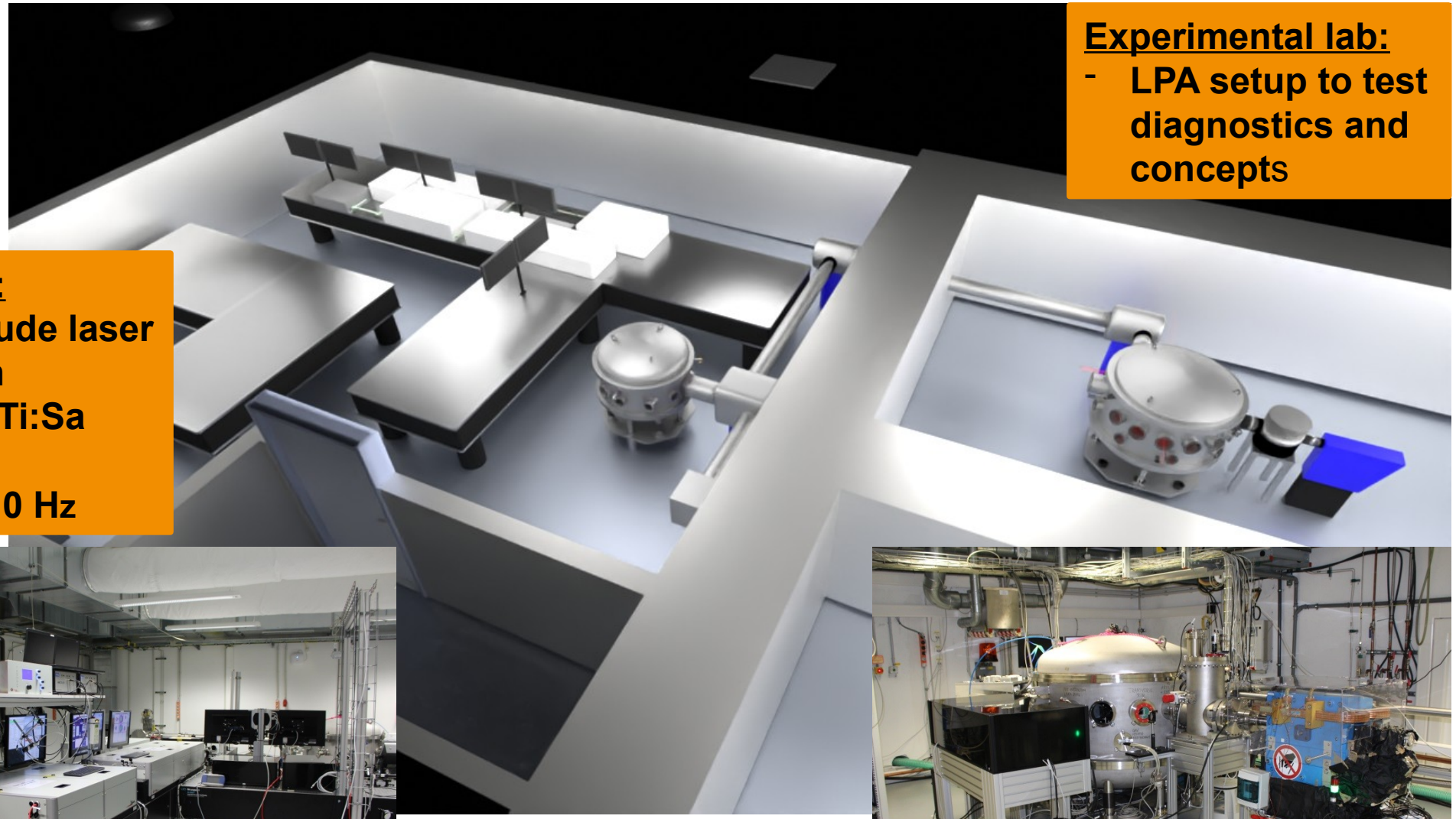
[1] M. Wen et al., Phys. Rev. Lett. **122,** 214801 (2019)

[2] D. Sofikitis et al., Phys. Rev. Lett. 21, 083001 (2018)

[3] J. Vieira et al., Phys. Rev. ST Accel. Beams 14, 099901 (2011)

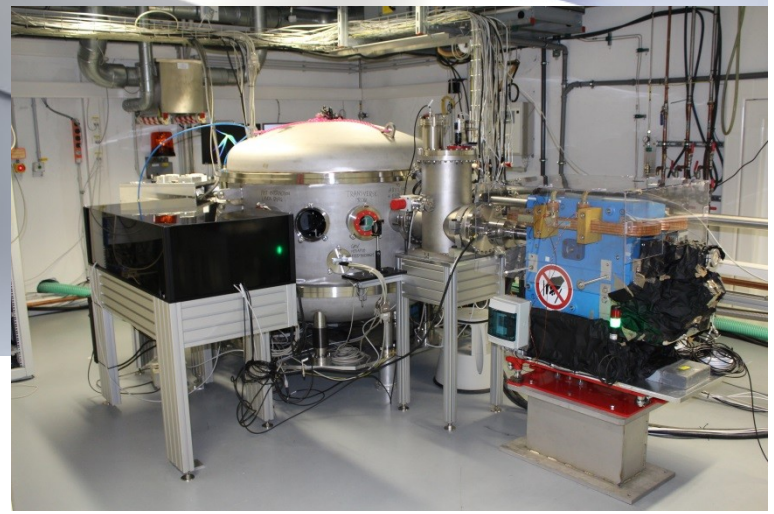
Laboratory

Lab Overview



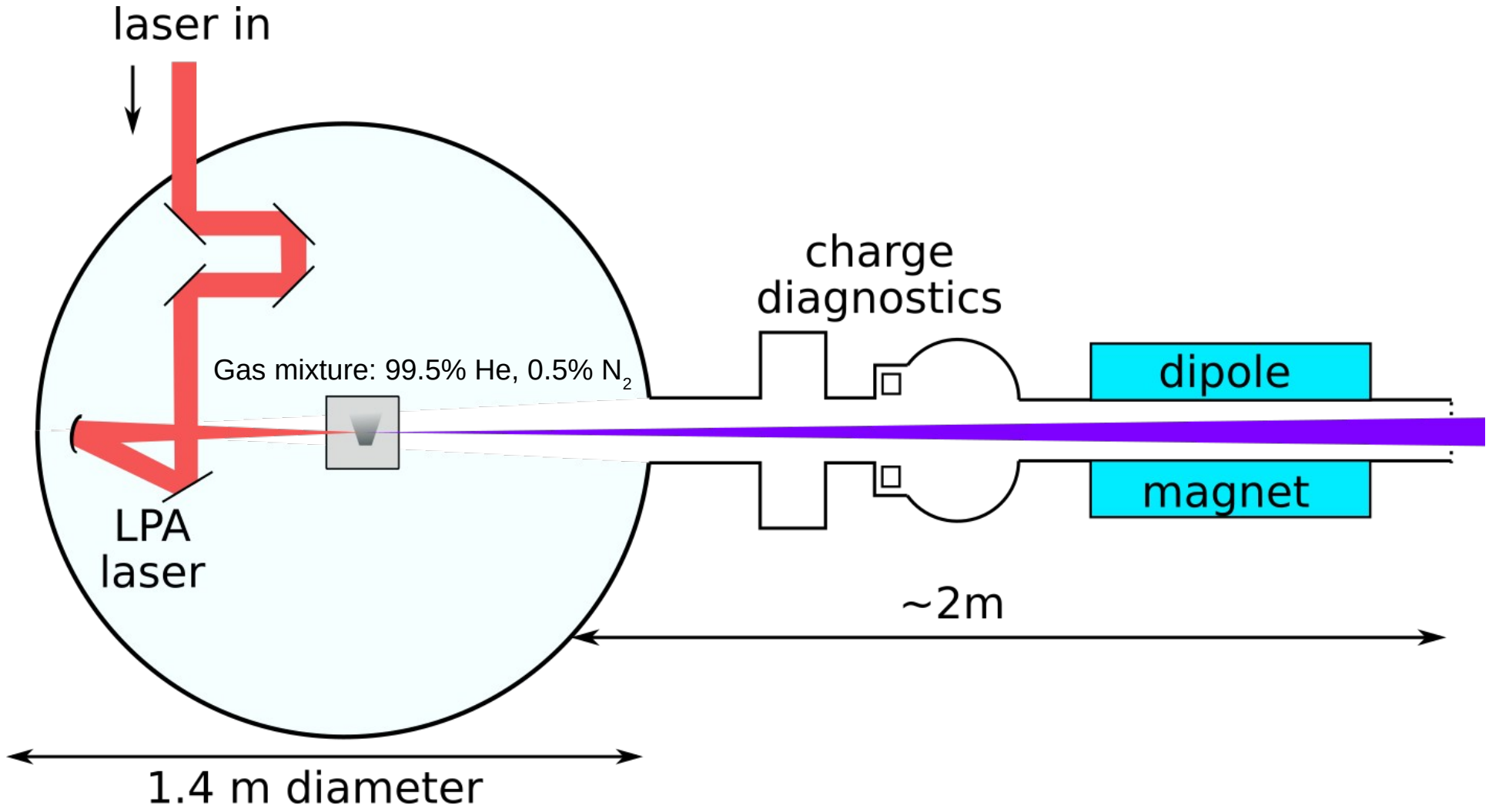
Experimental lab:
- LPA setup to test diagnostics and concepts

Laser lab:
- Amplitude laser system
- 25 TW Ti:Sa Laser
- 25 fs, 10 Hz



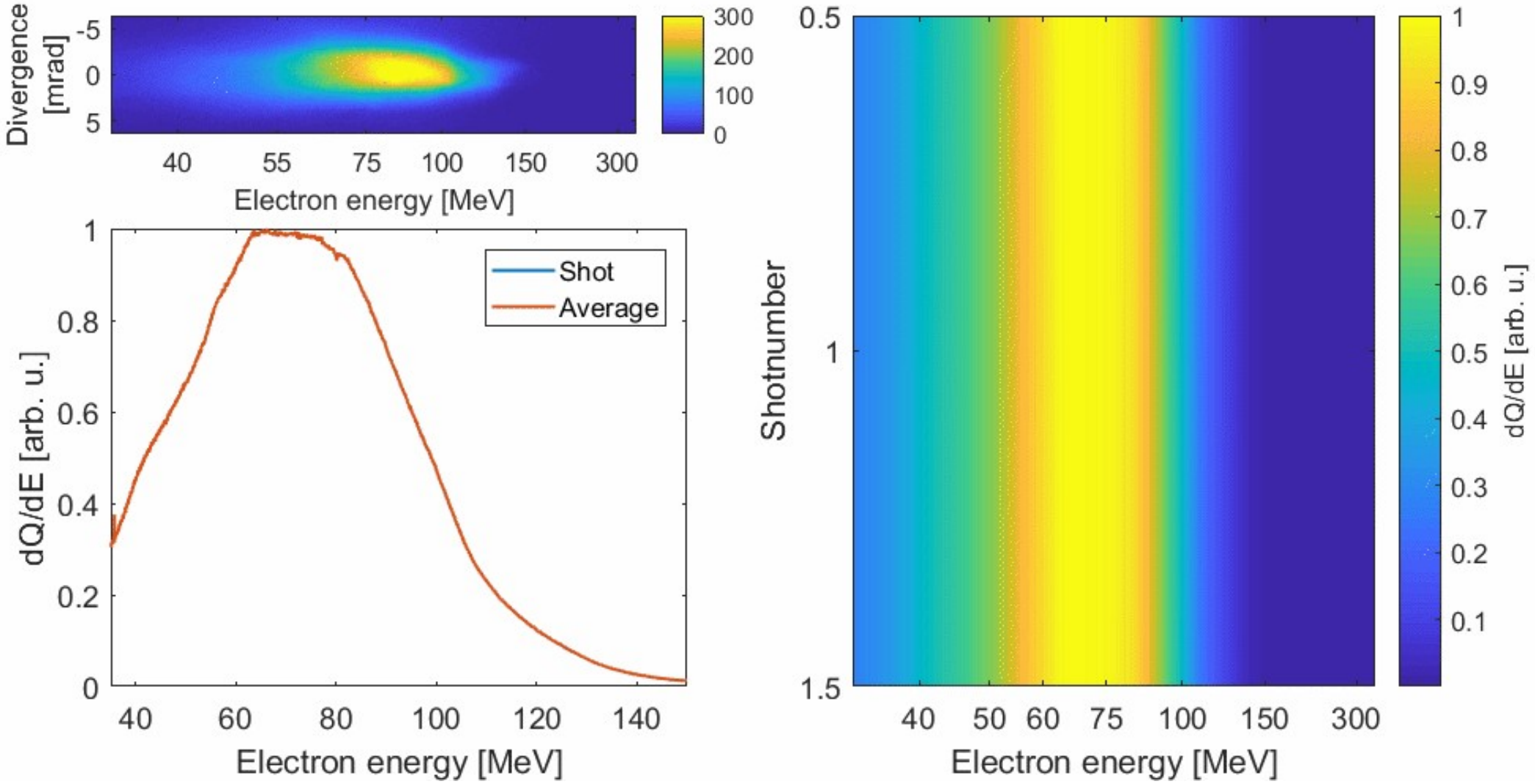
Where we are at the moment

Current setup for LPA using ionization injection



LPA long term measurements

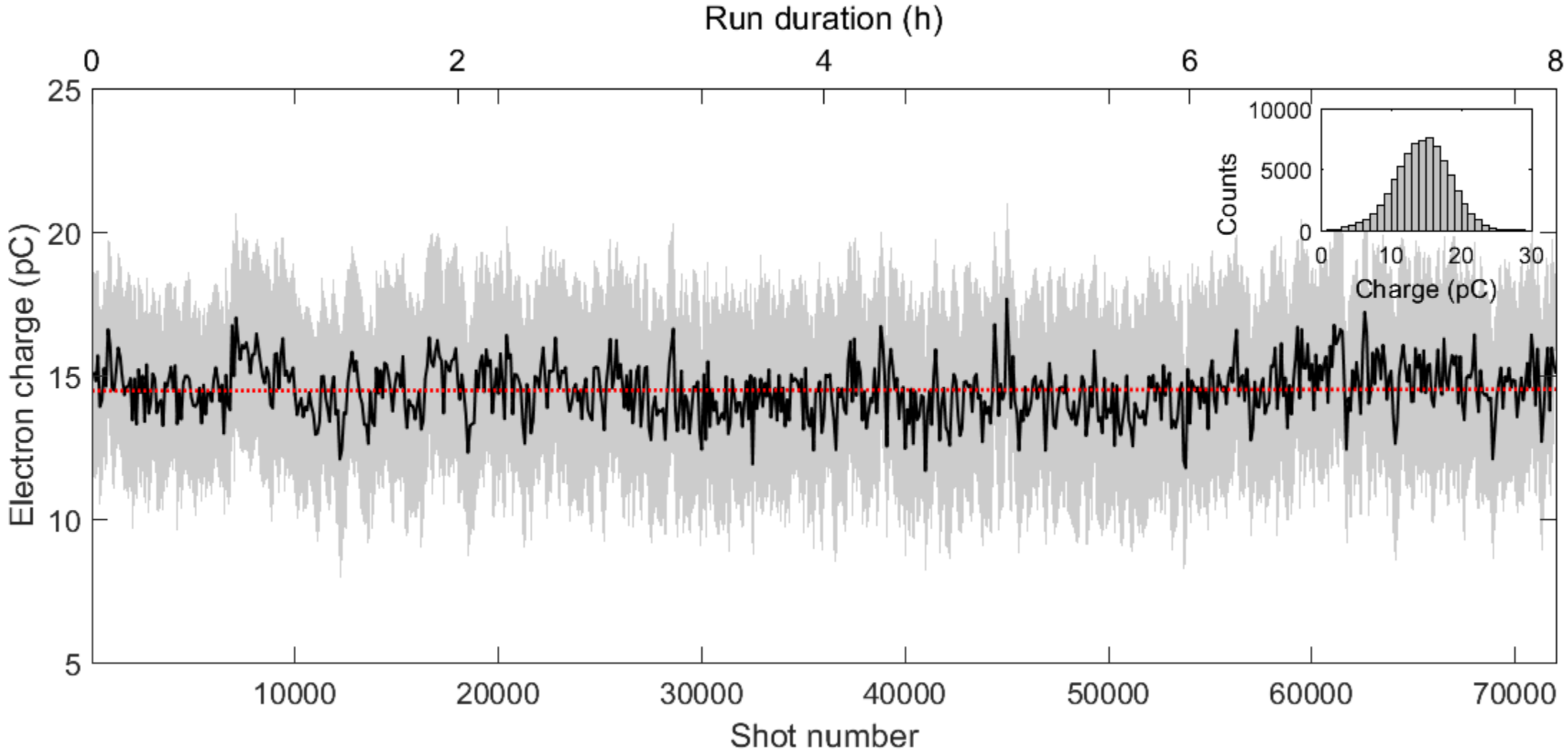
Reproducible energies at a high repetition rate (acceleration at 2.5 Hz using ionization injection)



S. Bohlen, J. Wood, T. Brümmer, F. Grüner, M. Meisel, K. Põder, T. Staufer and J. Osterhoff, in preparation

LPA long term measurements

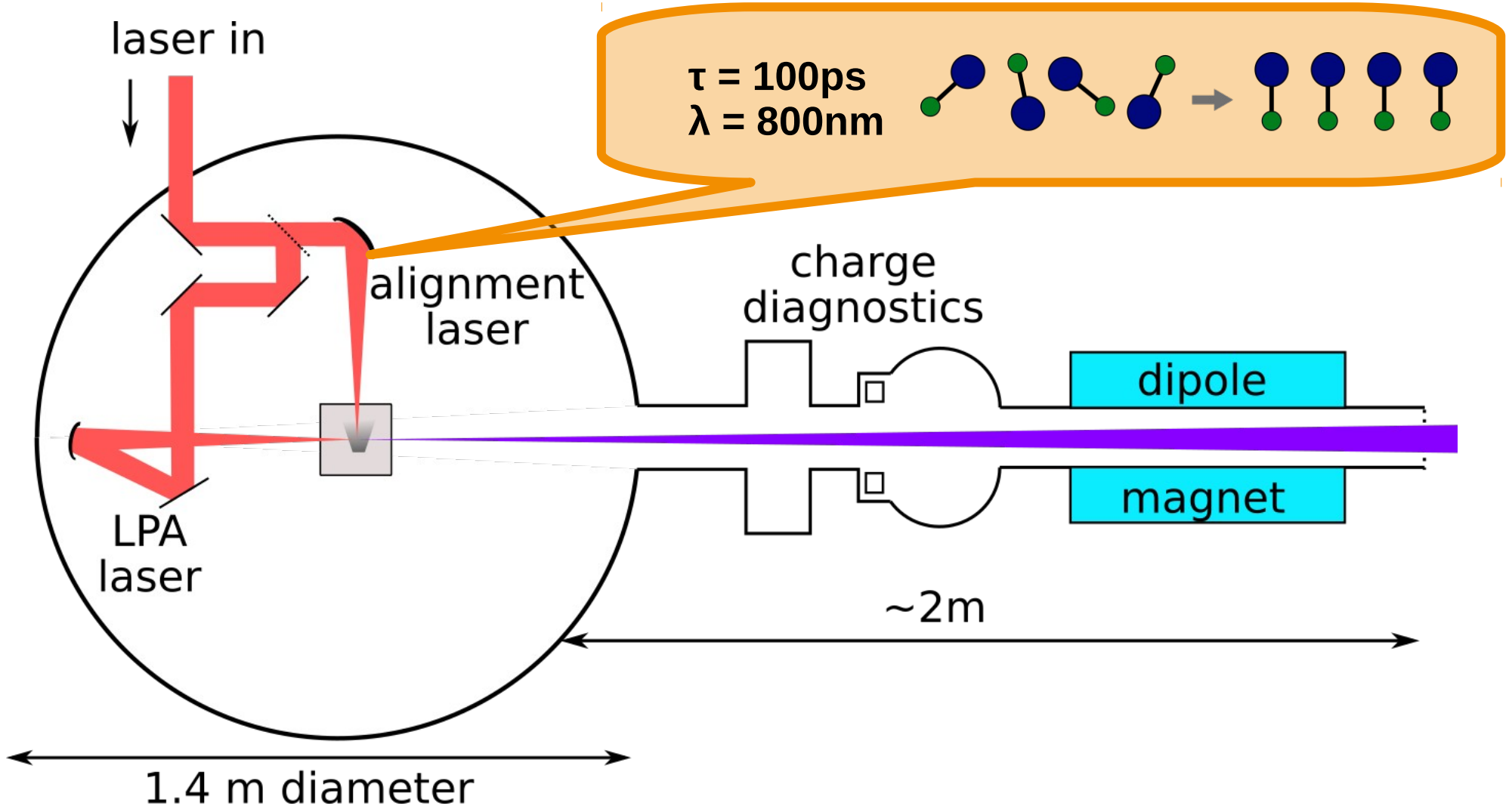
Stable acceleration over several hours in terms of beam charge



S. Bohlen, J. Wood, T. Brümmer, F. Grüner, M. Meisel, K. Põder, T. Staufer and J. Osterhoff, in preparation

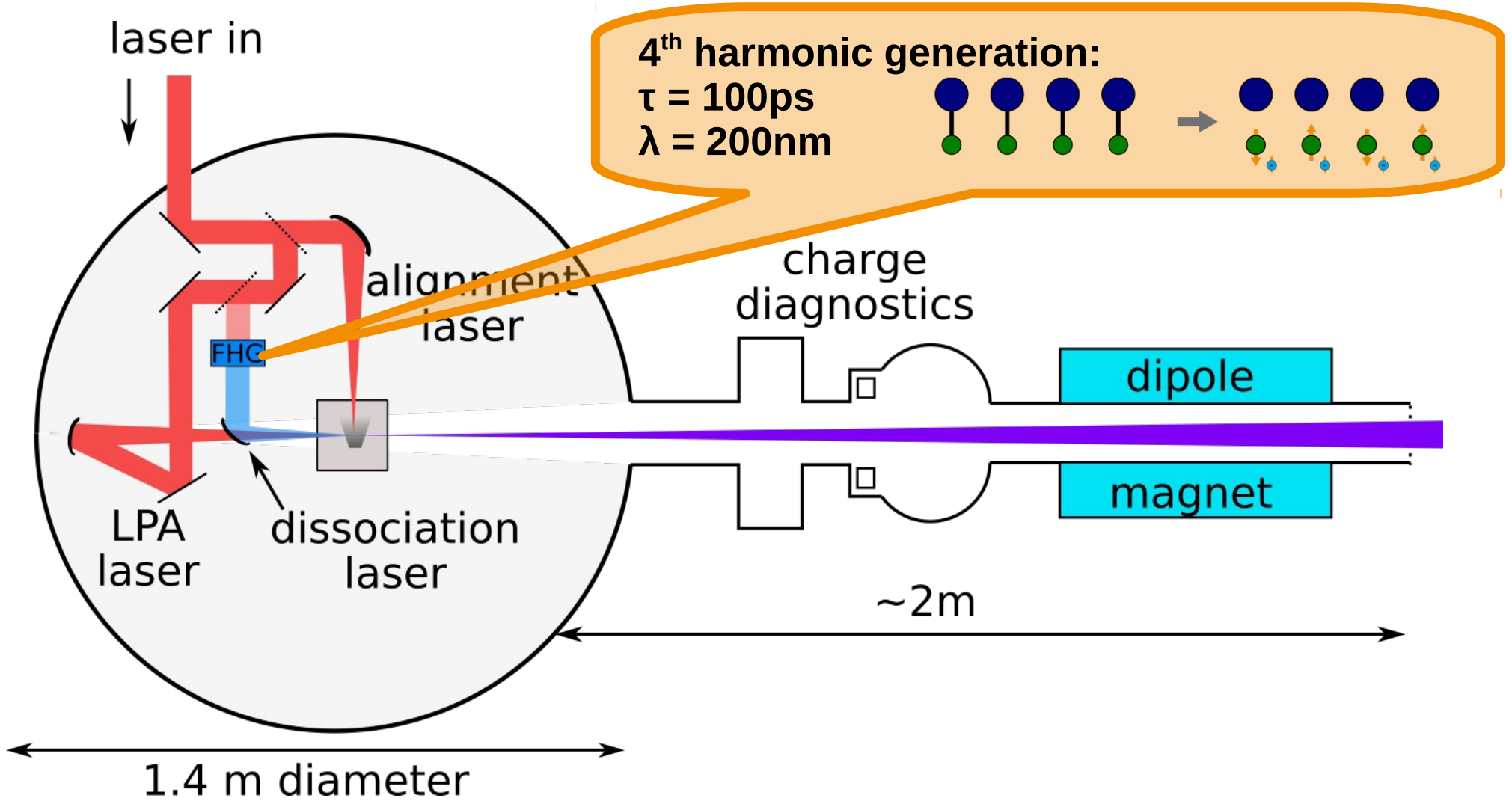
Next updates to the existing LPA setup

Add a laser beam to align the HCl molecules



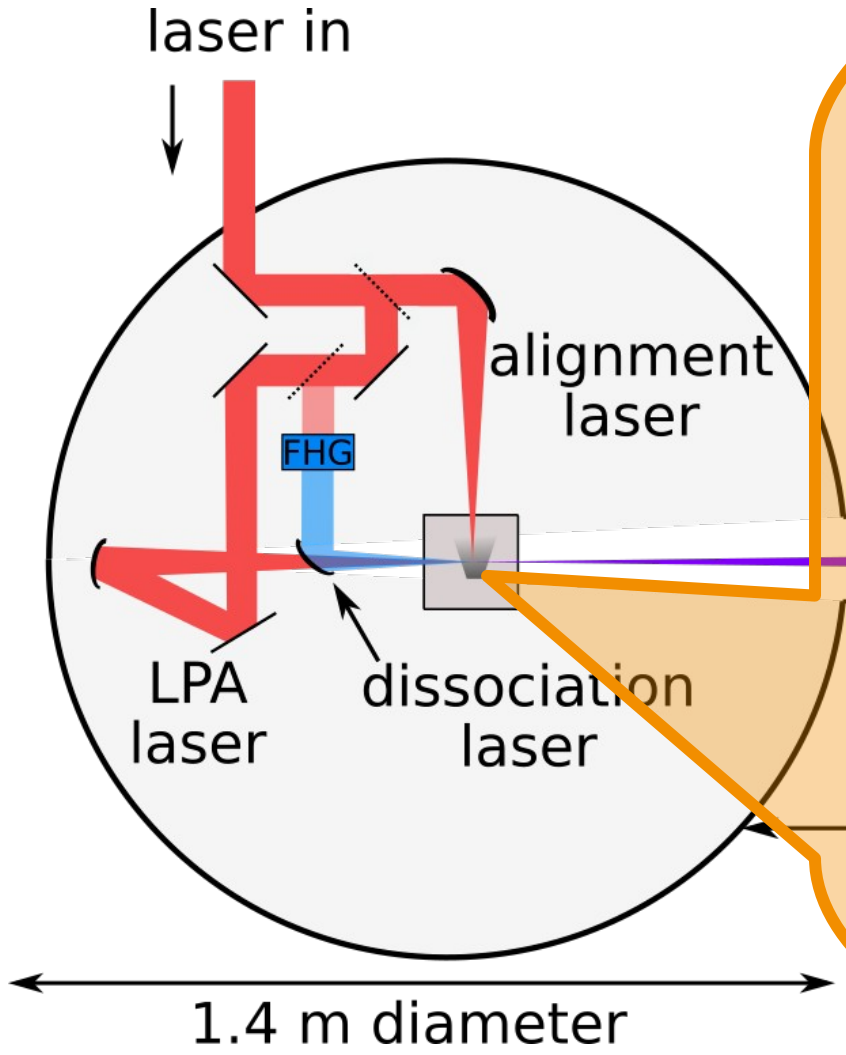
Next updates to the existing LPA setup

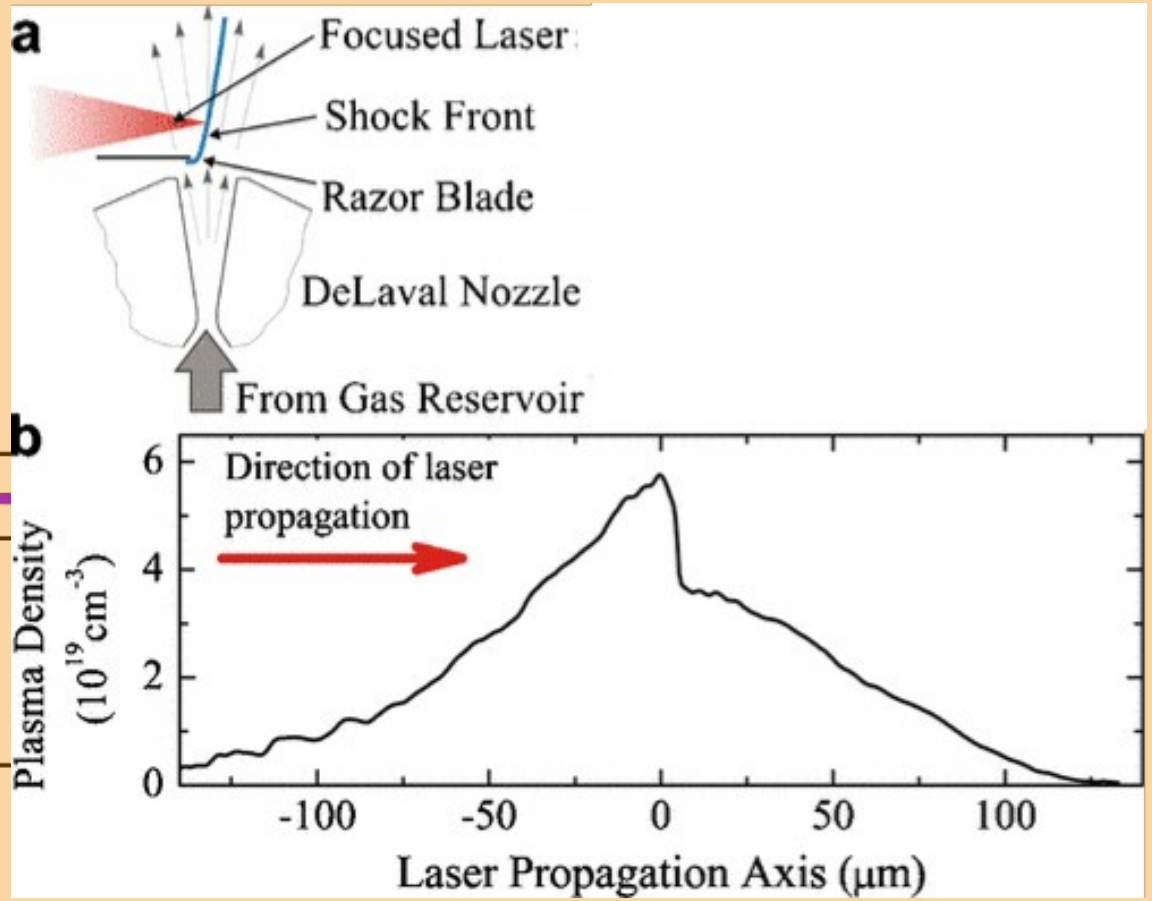
Add a UV laser beam to dissociate HCl molecules



Next updates to the existing LPA setup

Install a knife-edge into the gas jet to create a density downramp

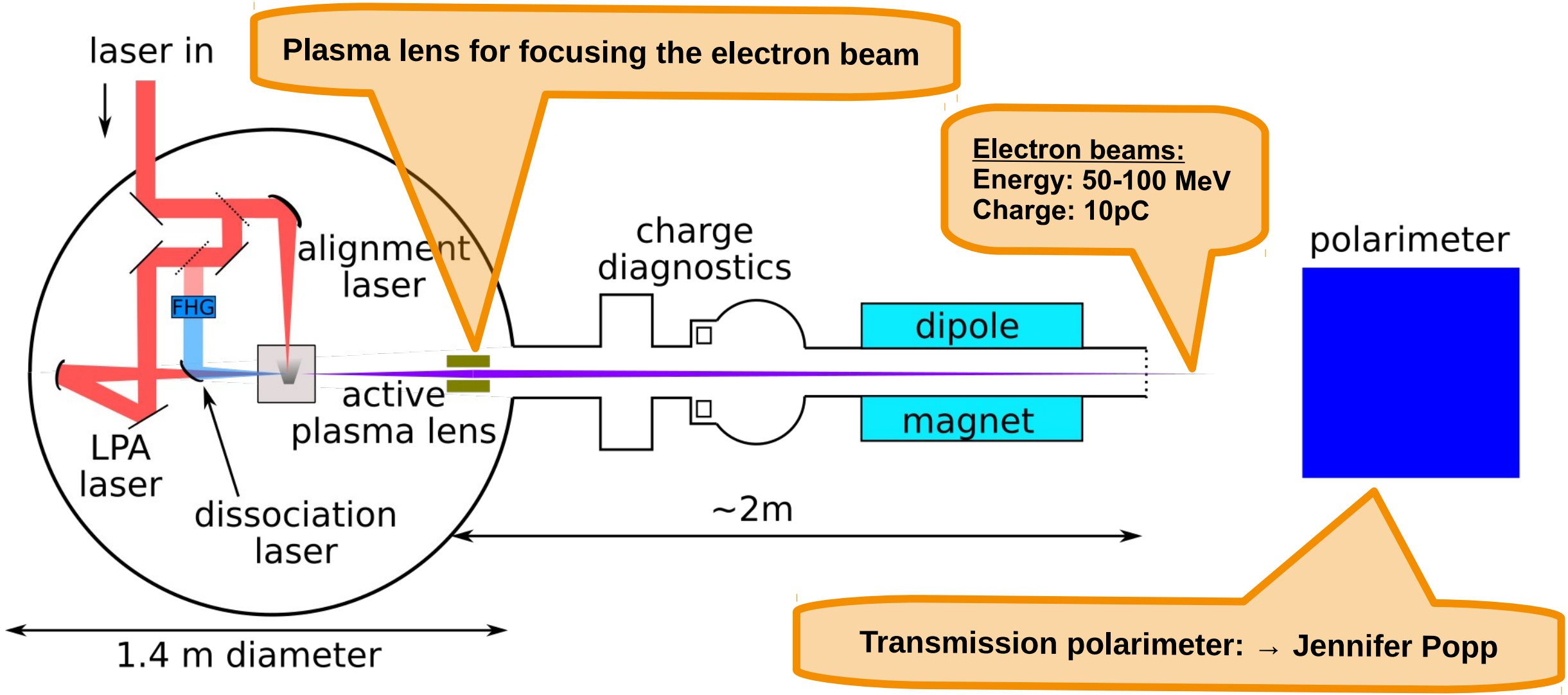




K. Schmid et al., Phys. Rev. ST. Accel. Beams 13, 091301 (2010)

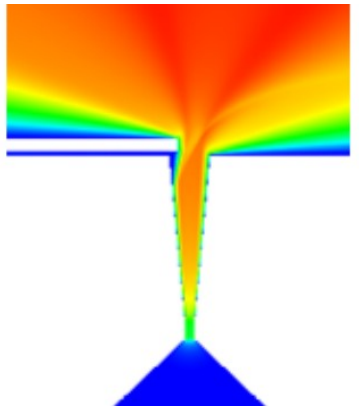
Whole LEAP setup

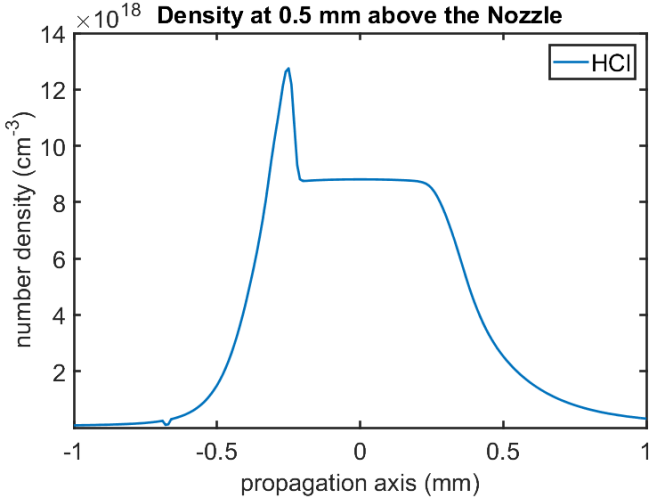
Schematic sketch of LPA and polarimeter

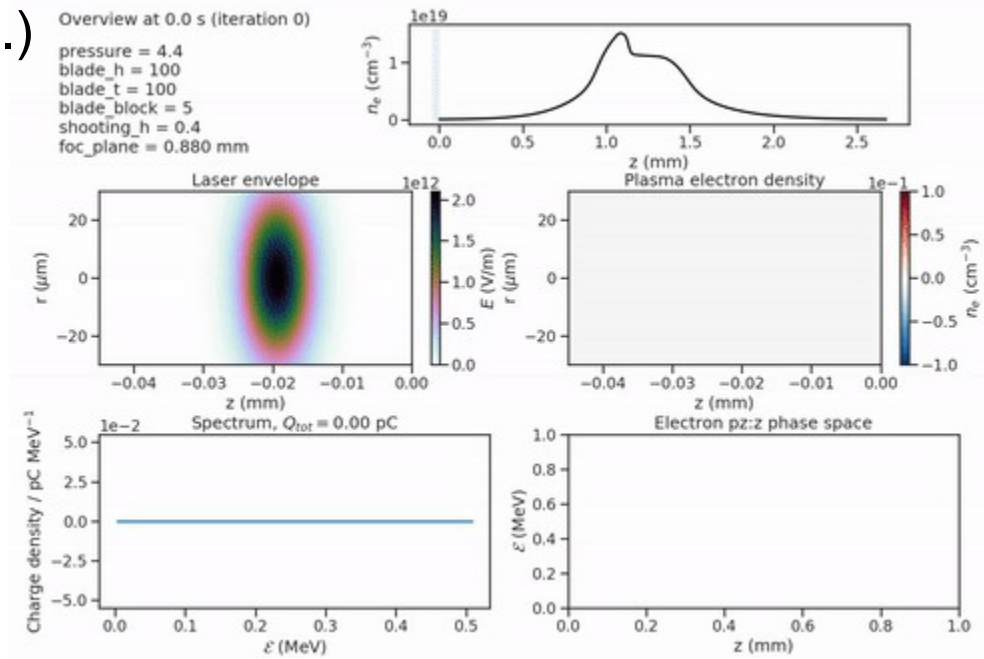


Work in progress

- Flow simulations using ANSYS:
  - ➔ Find suitable parameters for density ramp with HCl
- LPA simulations using FBPIC including spin tracking[1] :
  - ➔ Optimise laser parameters (energy, focus position, etc.) and plasma density using ANSYS density profiles for LPA in HCl
- Geant4 simulations:
  - ➔ Adjust the polarimeter and detector design to a wide range of parameters
- Still no lab-work at the moment due to COVID-19







[1] Matteo Tamburini and Michael Quin
MPIK Heidelberg

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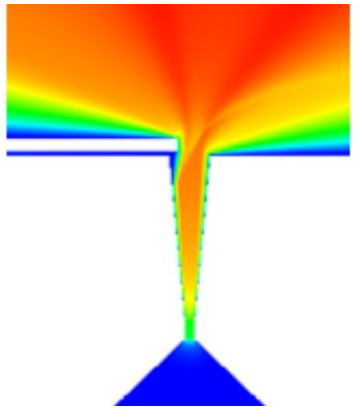

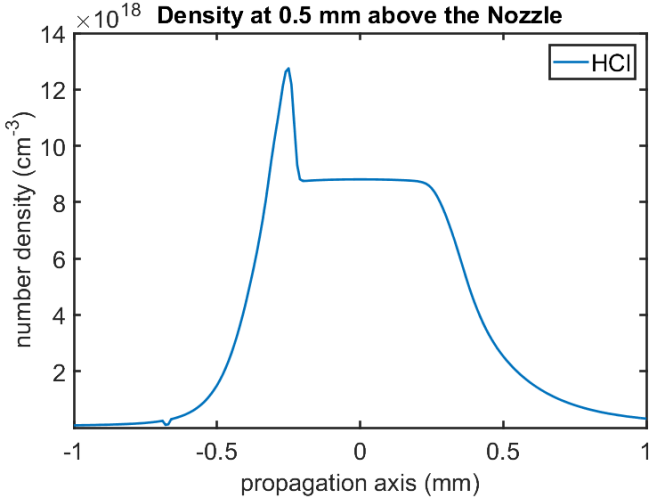

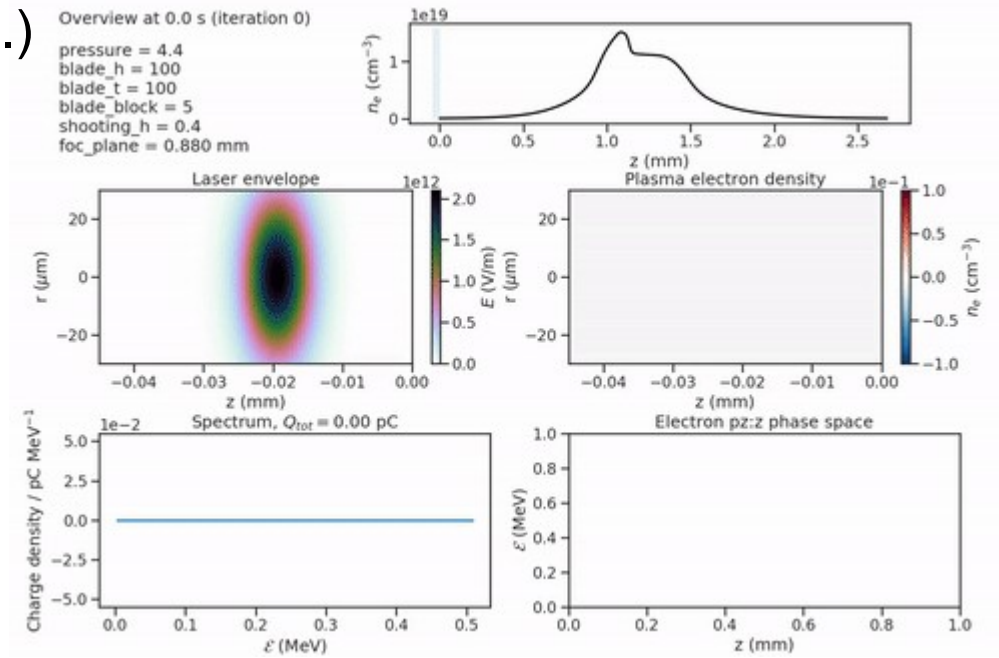

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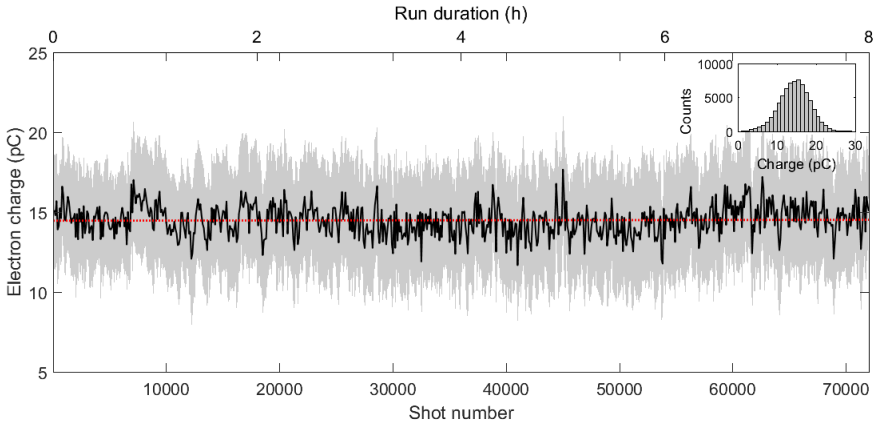
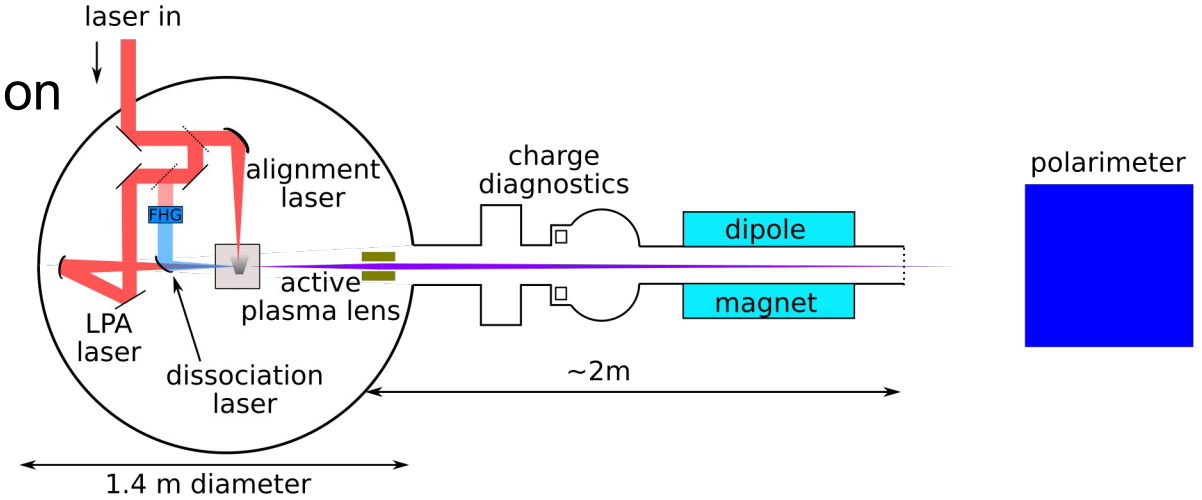
Summary

- LEAP: demonstrate the production of a polarized electron beam from LPA
- Existing setup for unpolarized beams:
  - 10Hz gas jet laser electron source
  - Demonstration of long term stability
- Change of the setup required:
  - Modify the target for density downramp injection
  - Additional laser beams to align and dissociate HCl molecules
- PIC and Geant4 simulations ongoing





Contact

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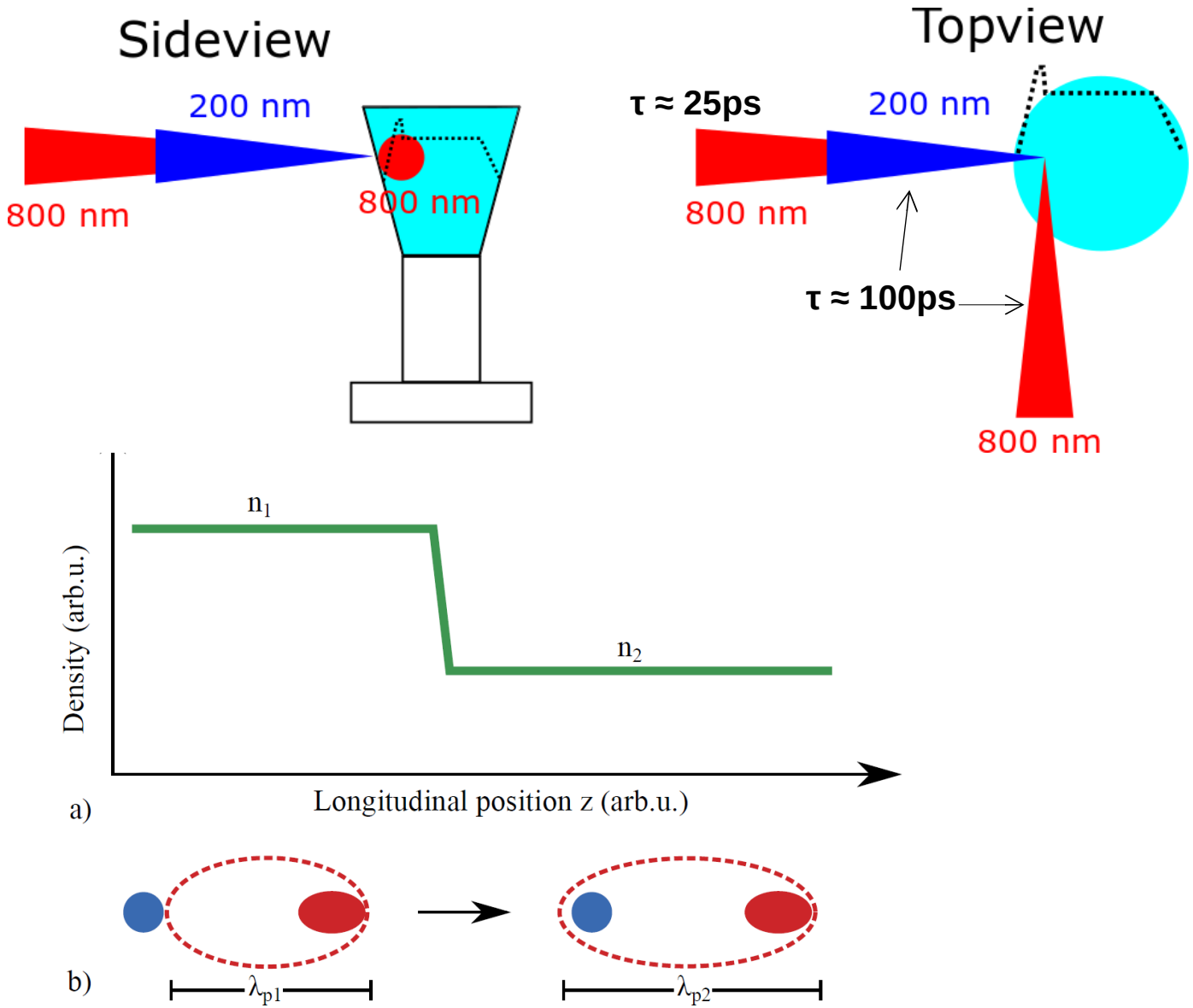
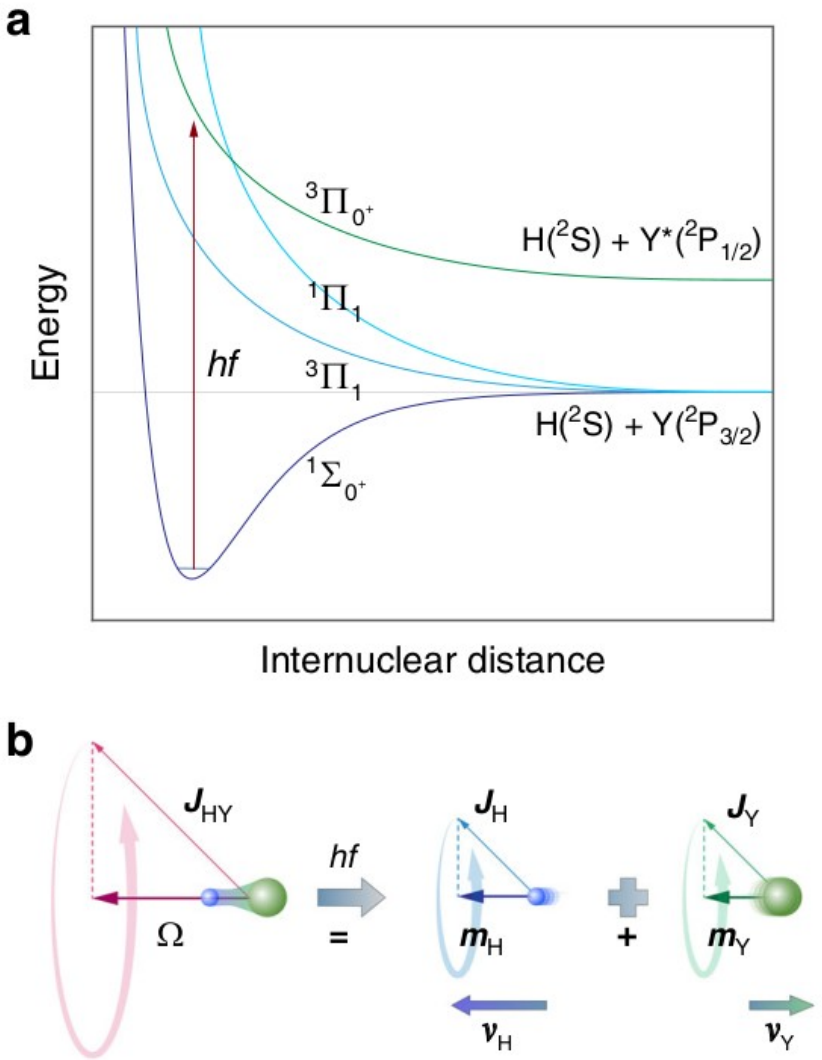
Injection of an electron beam

Injection for LEAP



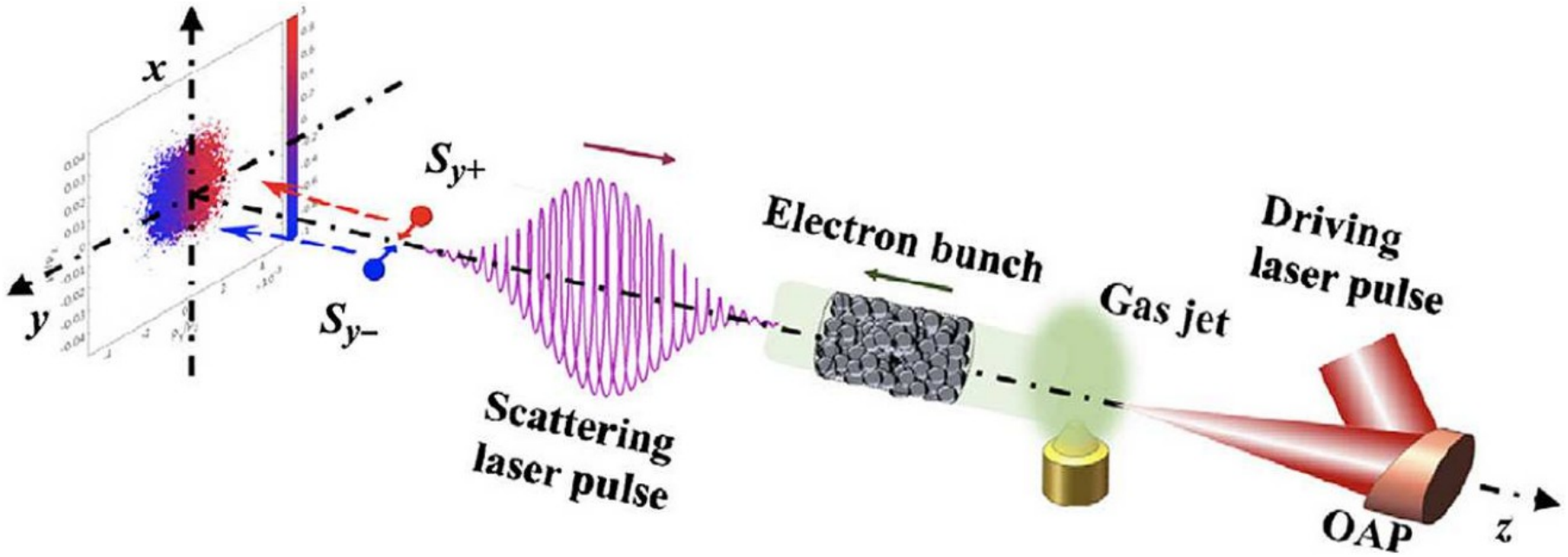
Photodissociation of hydrogen halides



A. K. Spiliotis et al., Light: Science & Application 10, Article number: 35 (2021)

How to get polarized electron beams from LPA?

Spin-polarized electron beams via nonlinear Compton scattering



Y.-F. Li, R. Shaisultanov, K. Z. Hatsagortsyan, et al., Phys. Rev. Lett. 122, 154801 (2019)