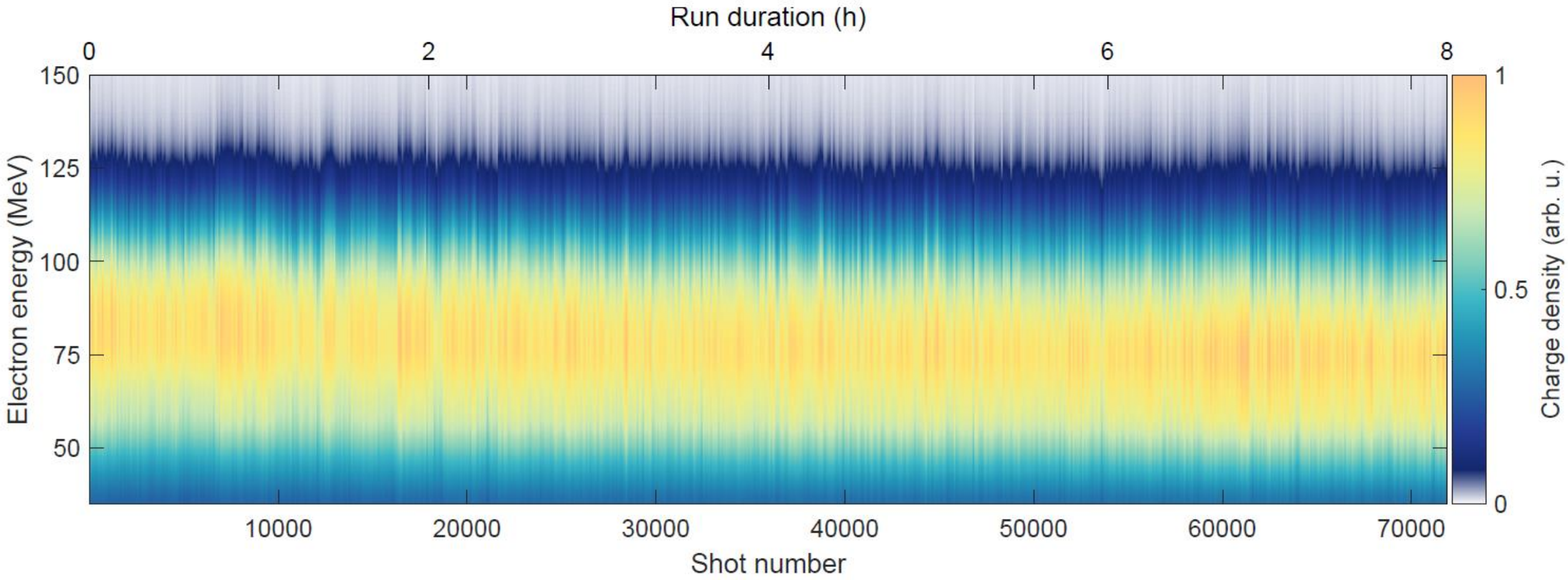
Simon Bohlen, DESY

# Stable electron beams with ionisation injection

## Electron peak energy decreases by 4.7 MeV, probably due to heating of gratings



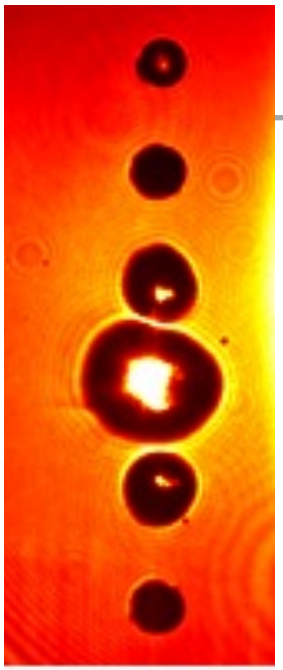

Drop of energy also at LOA
L. Rovige et al., PRAB 23, 093401 (2020)

Potential source: grating heating
S. Fourmaux et al., Opt. Express 17, 178 (2009)
V. Leroux et al., Opt. Express 26, 13061 (2018).

Stable operation at 1 Hz possible
A. Maier et al., PRX 10, 031039 (2020)

Institute of Optics &
Quantum Electronics JENA
Friedrich Schiller University

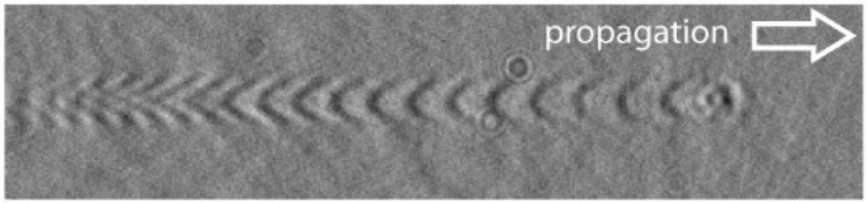
# High-Resolution Diagnostics for Plasma-Based Accelerators: a Tool for Detailed Insights into the Interaction

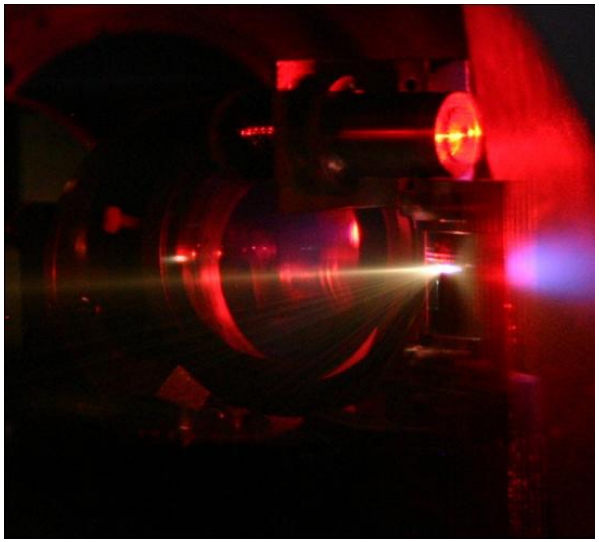


**Malte C. Kaluza**

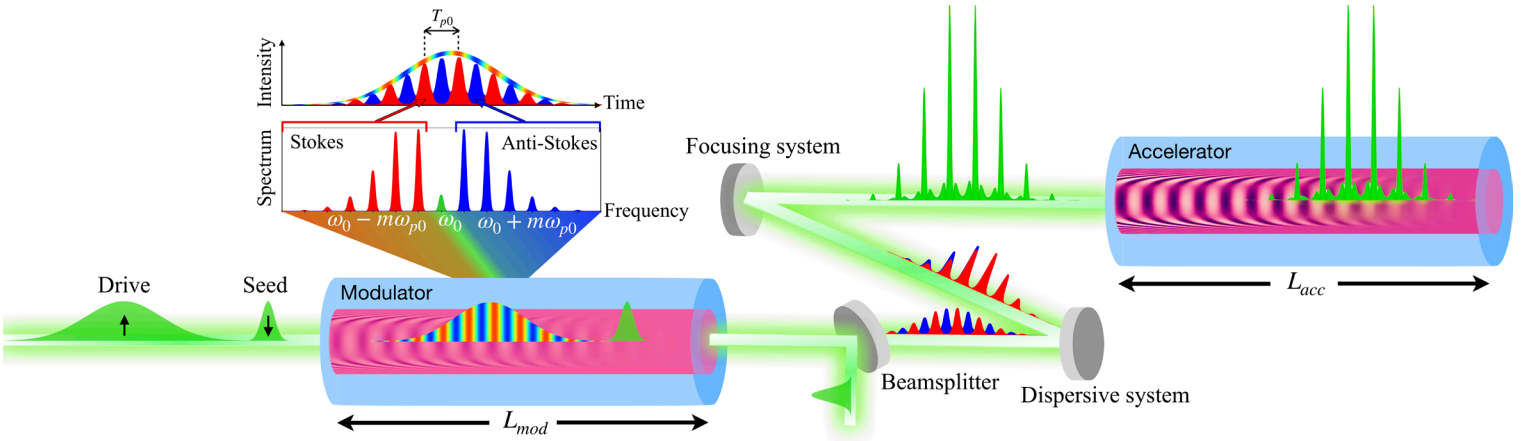
Institute of Optics and Quantum Electronics, FSU Jena, Germany

Helmholtz-Institute Jena



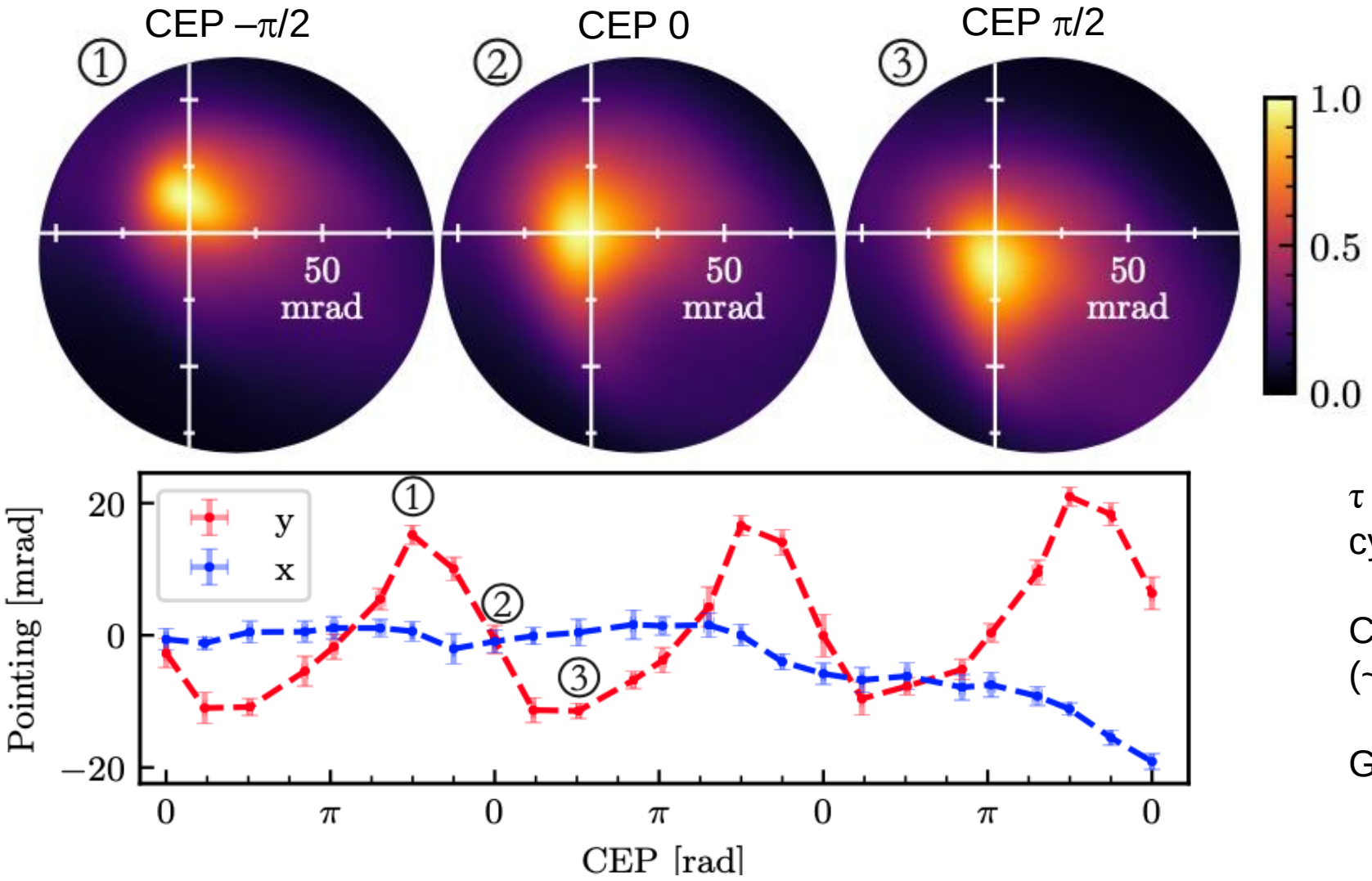



- Full scheme: Spectral-to-temporal modulation of a ps-duration pulse using low-energy seed pulse.



# Experiment : CEP and electron beam pointing

Lucas Rovige, LOA




First observation of CEP effects in LWFA !

$\tau$ = 4.0fs (=1.5 optical cycle at 800nm)

Controlled CEP (~300mrad RMS)

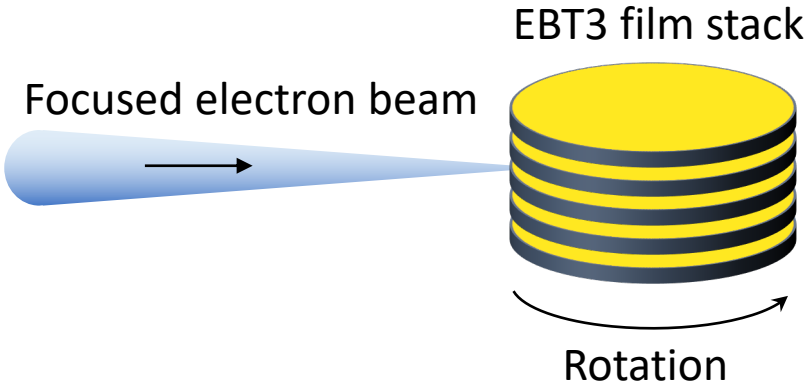
Gas : $N_2$

1 exp. point = 20 x 200 = **4000 shots**

J. Huijts, L. Rovige *et al.* Physical Review X (2022)

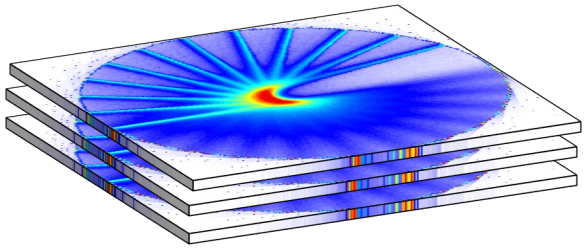
# Multiple irradiation angles

## Phantom stack




## Simulation

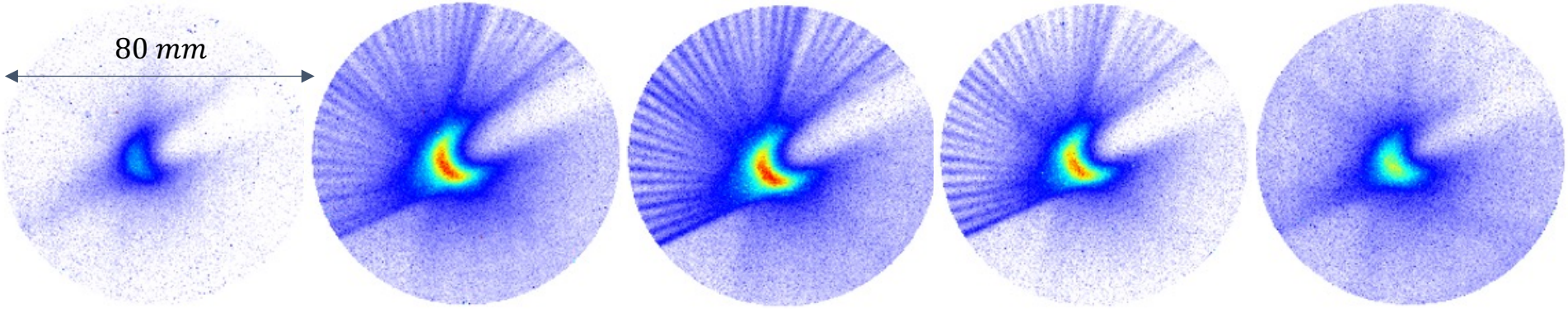
Olle Lundh, Lund



Simulation using Fluka

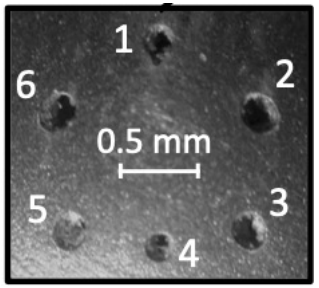
## Measurement – concave volume

*36 angles, 10 pulses/angle*

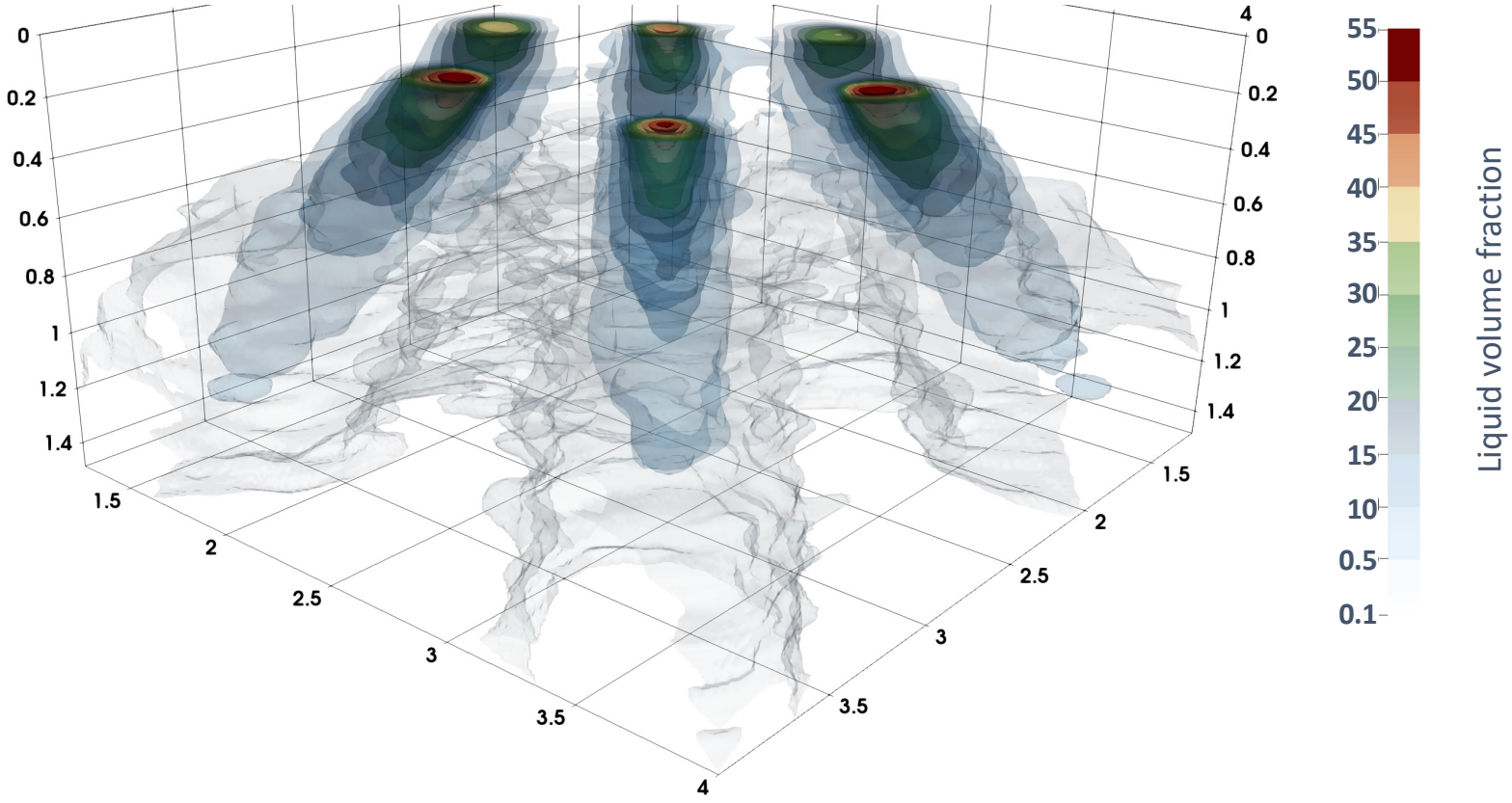



*Layers at different heights from beam center*

# Transient spray tomography

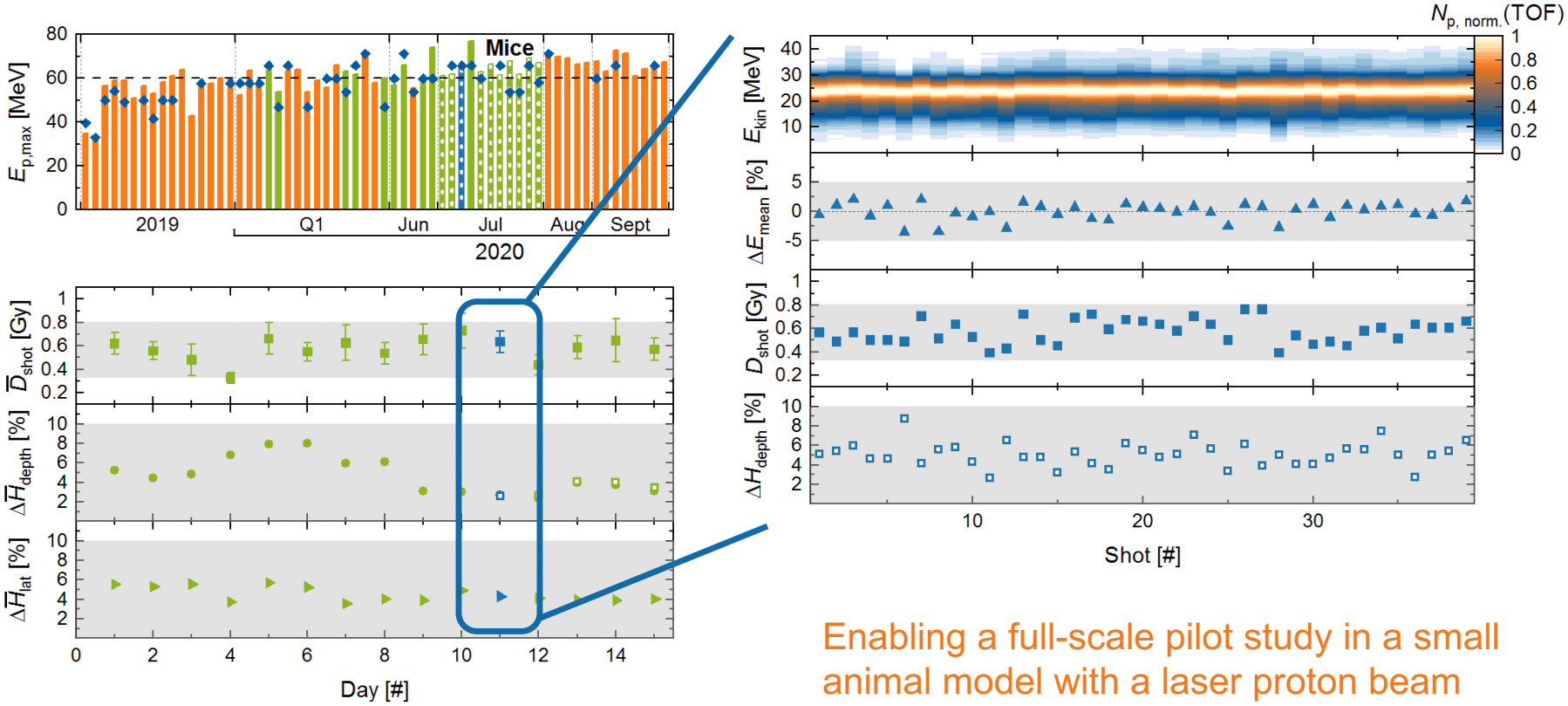



Olle Lundh, Lund



# Accelerator readiness and stability benchmarked

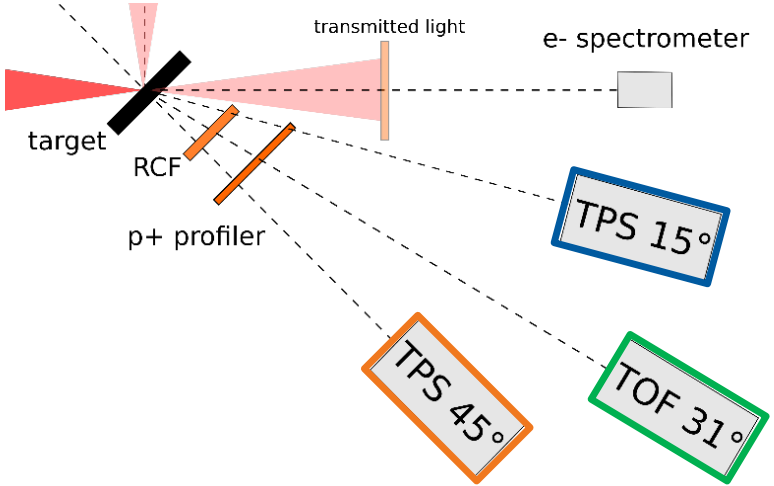
Ulrich Schramm, HZDR



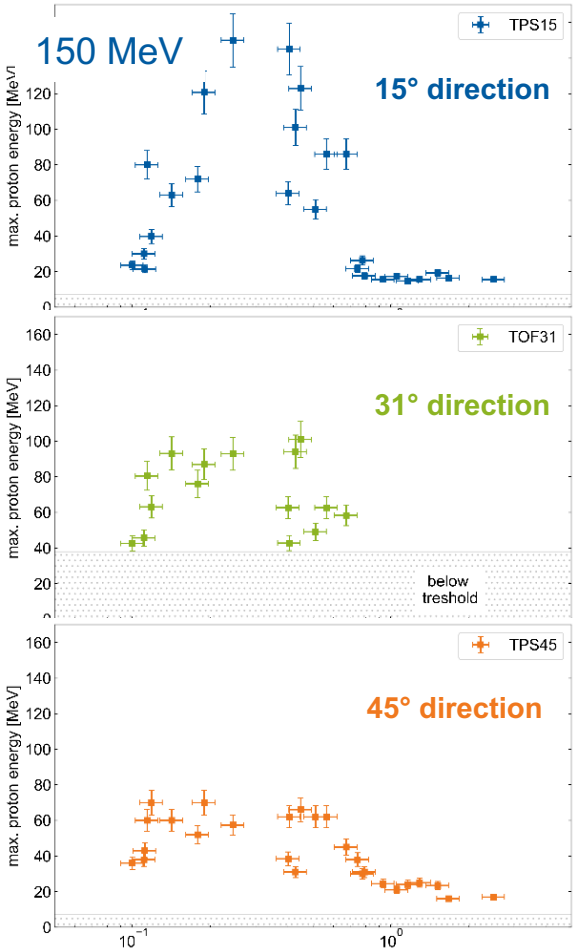

Enabling a full-scale pilot study in a small animal model with a laser proton beam

*F. Kroll, et al., Nature Physics 18, 316 (2022)*

# Proton emission characteristics




- sorting by transmitted light



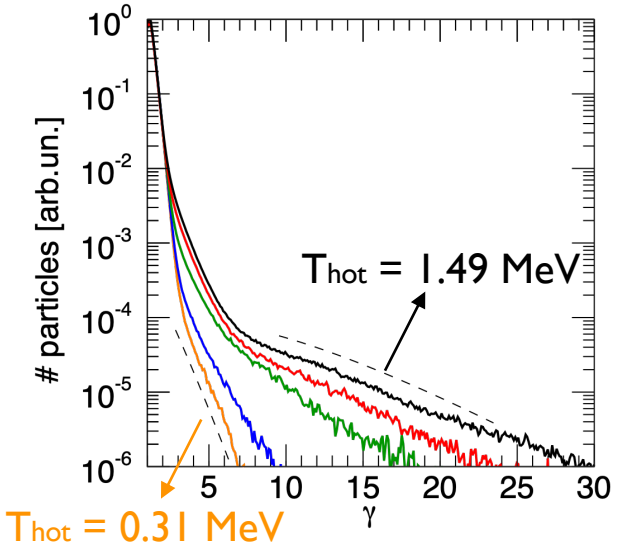

Ulrich Schramm, HZDR

T. Ziegler, et al. unpublished

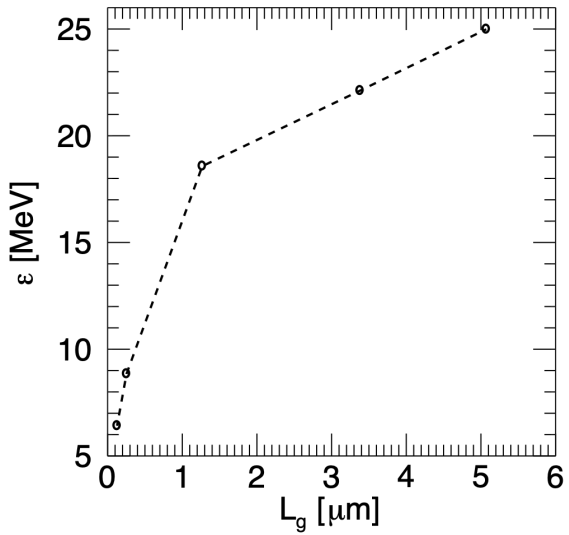
Lancaster University

# Simulation results confirm that a controlled pre-plasma enhances the cutoff energy

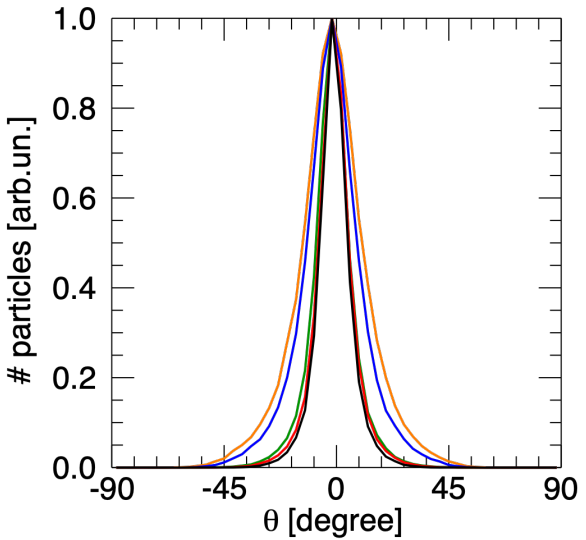
Electron distribution




Proton cut-off energy vs pre-plasma scale length



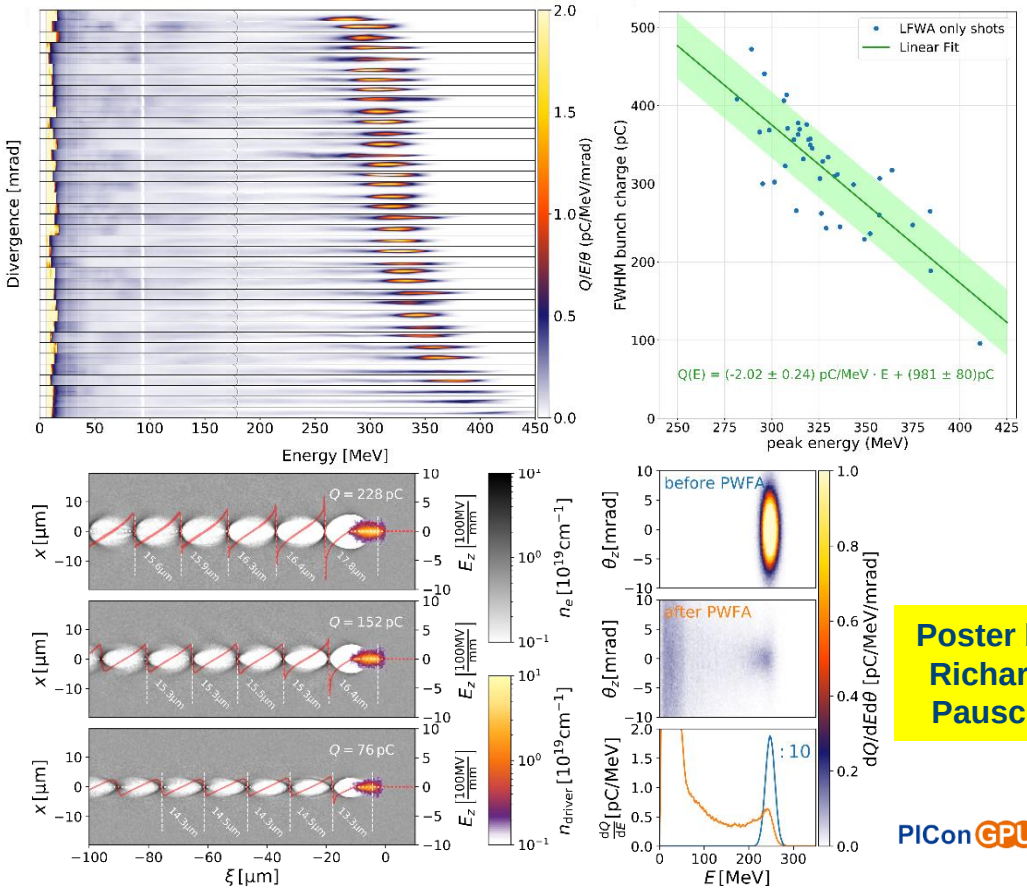

Proton angular distribution




— $L_g$ = 0.13 μm, — $L_g$ = 0.25 μm, — $L_g$ = 1.27 μm, — $L_g$ = 3.38 μm, — $L_g$ = 5.07 μm

# Cavity size vs. driver charge

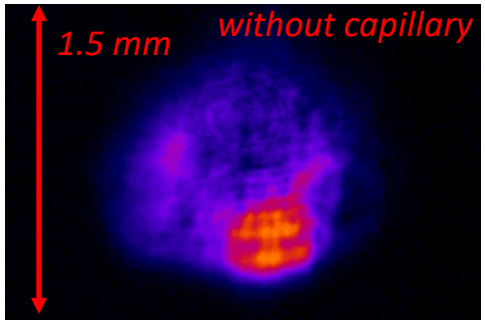
- LWFA **driver charge and energy** connected via **beam loading**: **less energy→ higher charge**
- **3D PIConGPU** Simulation: energy constant, different driver bunch charge: **elongation depends** on the **charge**
- **deceleration** of the driver: charge is hard to reconstruct from remaining bunch
- **Energy peak position is preserved** (see simulation) → via **beam loading** allows **estimation** of **charge** possible

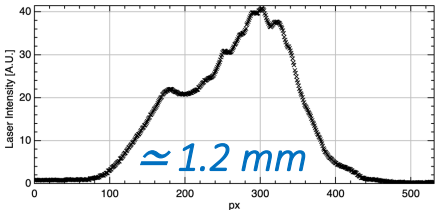


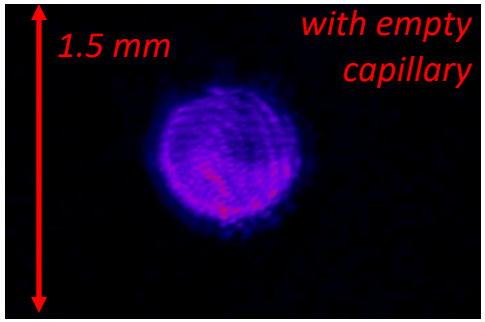

**Poster by Richard Pausch**

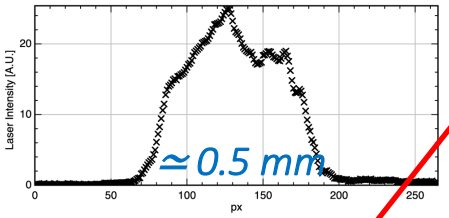
J. Couperus et al., Nature Communication **8**, Article number: 487 (2017)
J. Götzfried et al. Phys. Rev. X **10**, 041015 (2020)
M. Kirchen et al. Phys. Rev. Lett. **126**, 174801 (2021)

# Guiding in plasma density parabolic profile (mJ level)

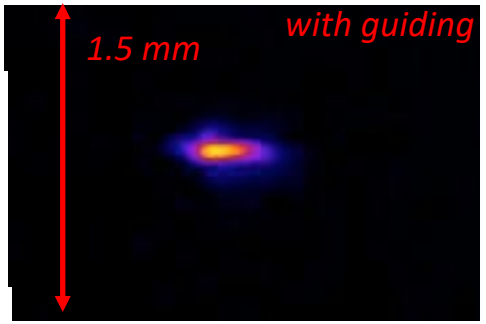


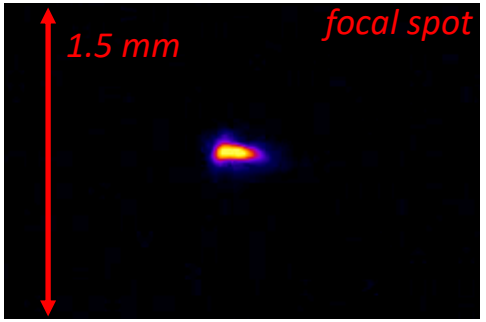



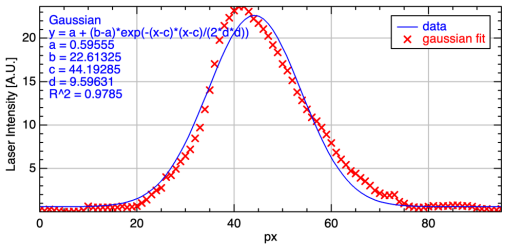



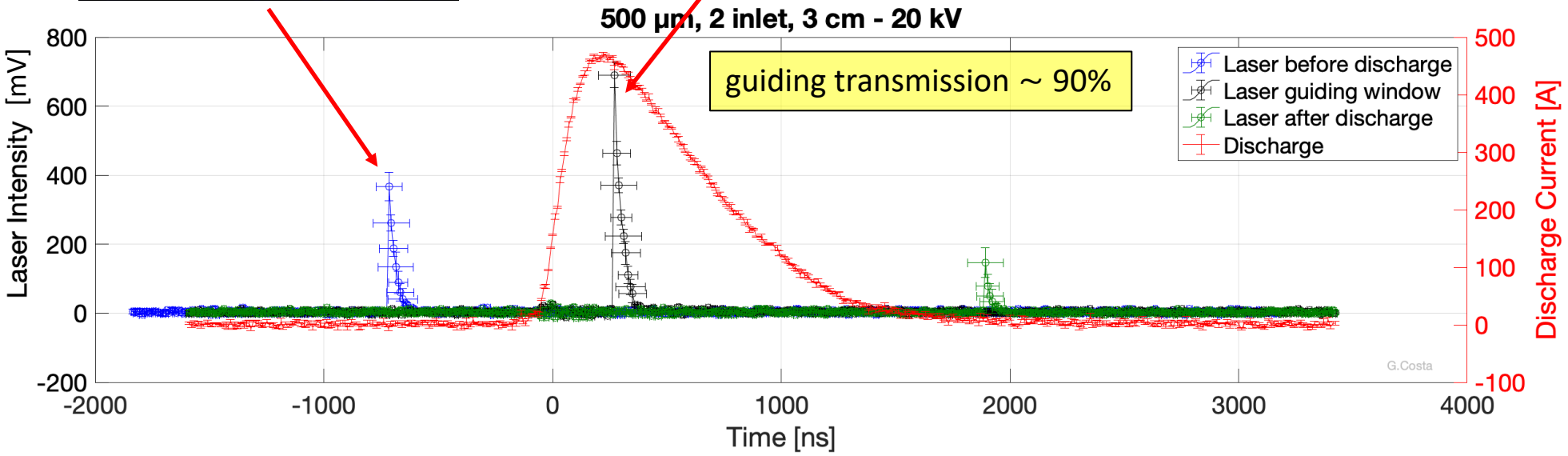

spot@focus *60 μm* FWHM




GUIDED LASER SPOT!
~ *70 μm* FWHM

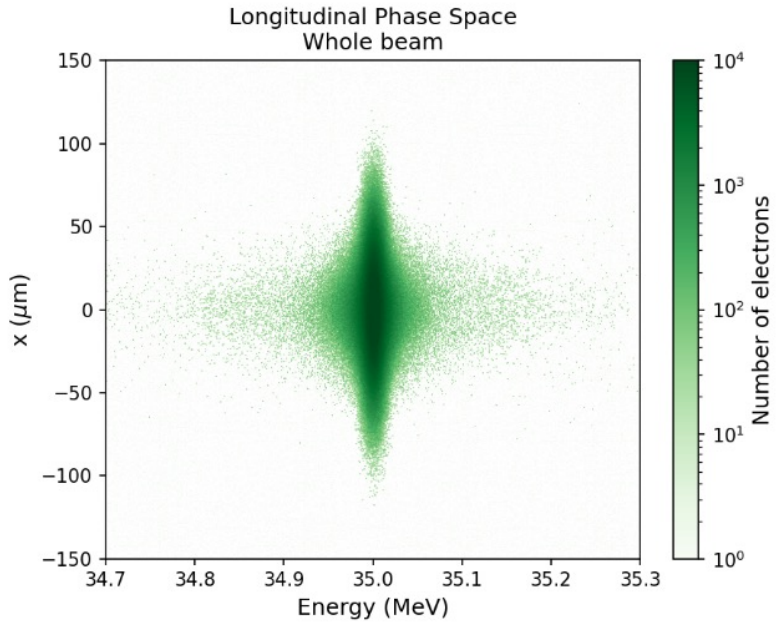


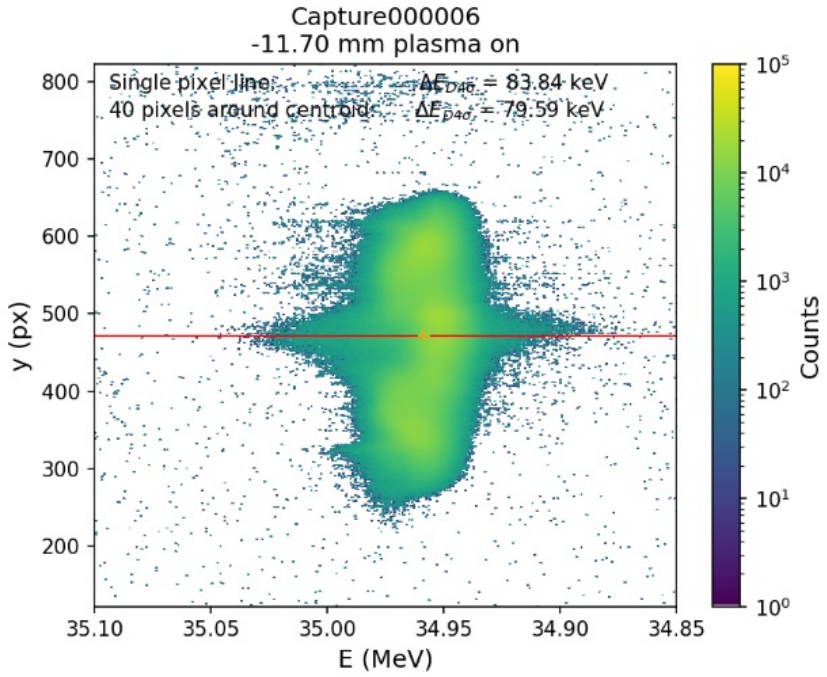

Gemma Costa, SparcLab

*G Costa, et al., submitted*

# Simulations

Laura Corner, Liverpool



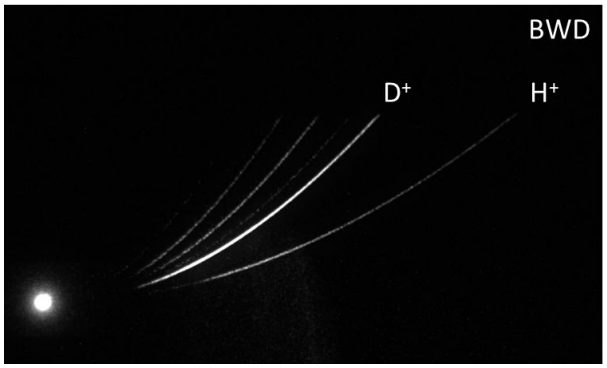

Simulated (left) and experimental (right) electron spectrometer images showing electron spectral broadening.

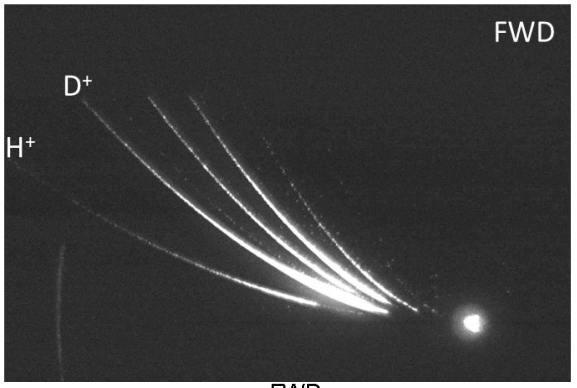
Simulations: Dr. L. Reid

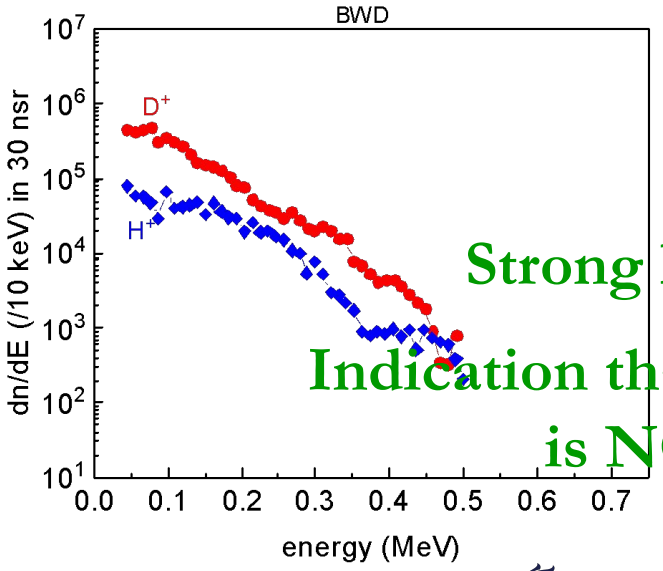
# Proton and Deuterion and acceleration at 1 Hz repetition rate

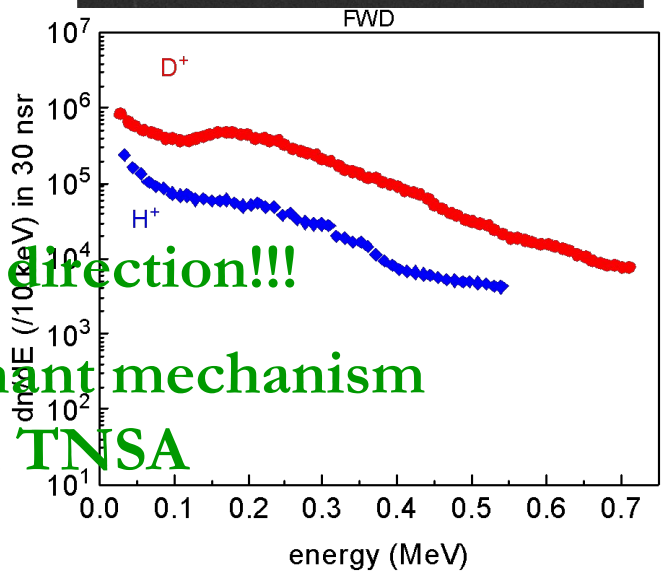
HUNGARIAN NATIONAL LABORATORY

## Each shot is recorded and stamped – example shot #976




**Strong D+ in FWD direction!!!**

**Indication that the dominant mechanism is NOT classical TNSA**

NLTL National Laser-Initiated Transmutation Laboratory University of Szeged