



# RECENT WORK ON LASER-DRIVEN RADIATION AND PARTICLE SOURCES AT FZ-JUELICH

5 OCTOBER 2020 | PAUL GIBBON, JÜLICH SUPERCOMPUTING CENTRE

# PEOPLE

- FZJ: P. Gibbon, [Z. Chitgar](#), X. Li, U. Sinha, D. Brömmel (JSC)  
M. Büscher, A. Lehrach, J. Böker, A. Hutzen, [A. Sobotta](#), ... (PGI-6, IKP)  
[I. Engin](#) (S-AA)
- Alumni: [L. Di Lucchio](#), W.-M, Wang (Renmin), B. Qiao (Peking)
- External: M. Krus, V. Horny (IPP Prague), A. Andreev (ELI-ALPS),  
J. Mikhailova (Princeton), [L. Veisz](#) (Umeå), Z. M. Sheng (STJU)

**Mission:**

- Energy
- Climate
- Transport
- Health
- Key Technologies

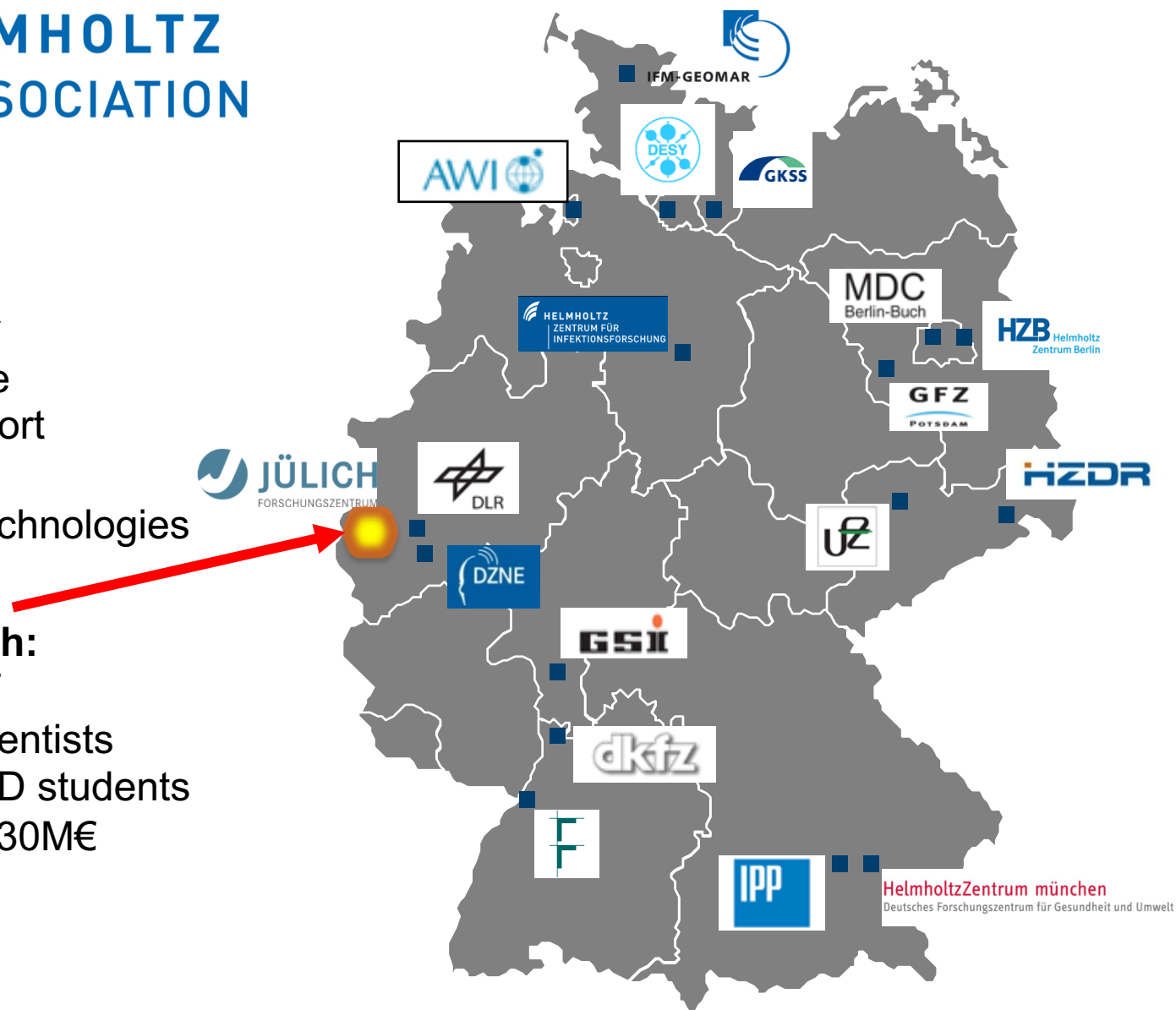
**FZ-Juelich:**

6400 staff

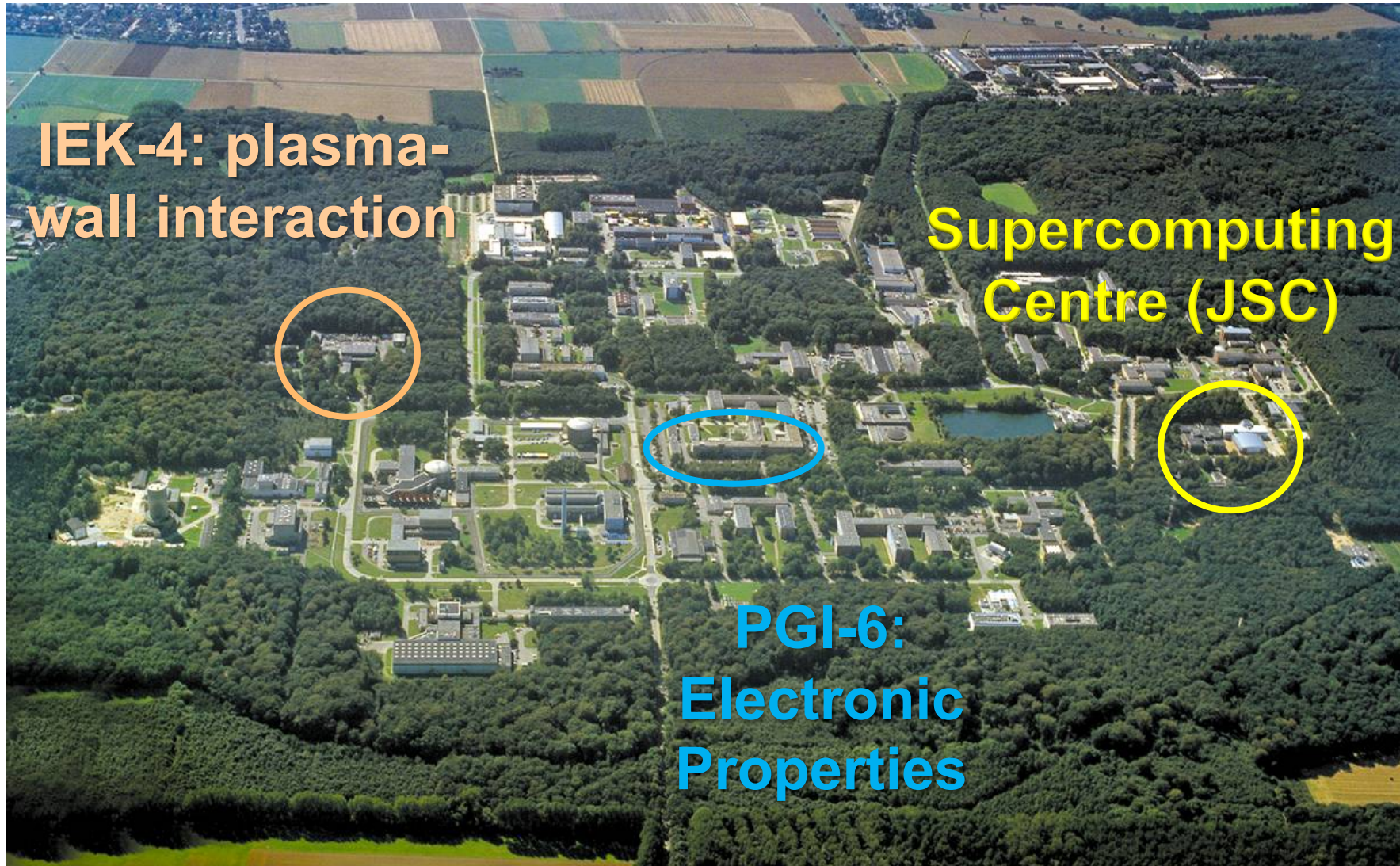
~3000 scientists

~1000 PhD students

Budget: 730M€

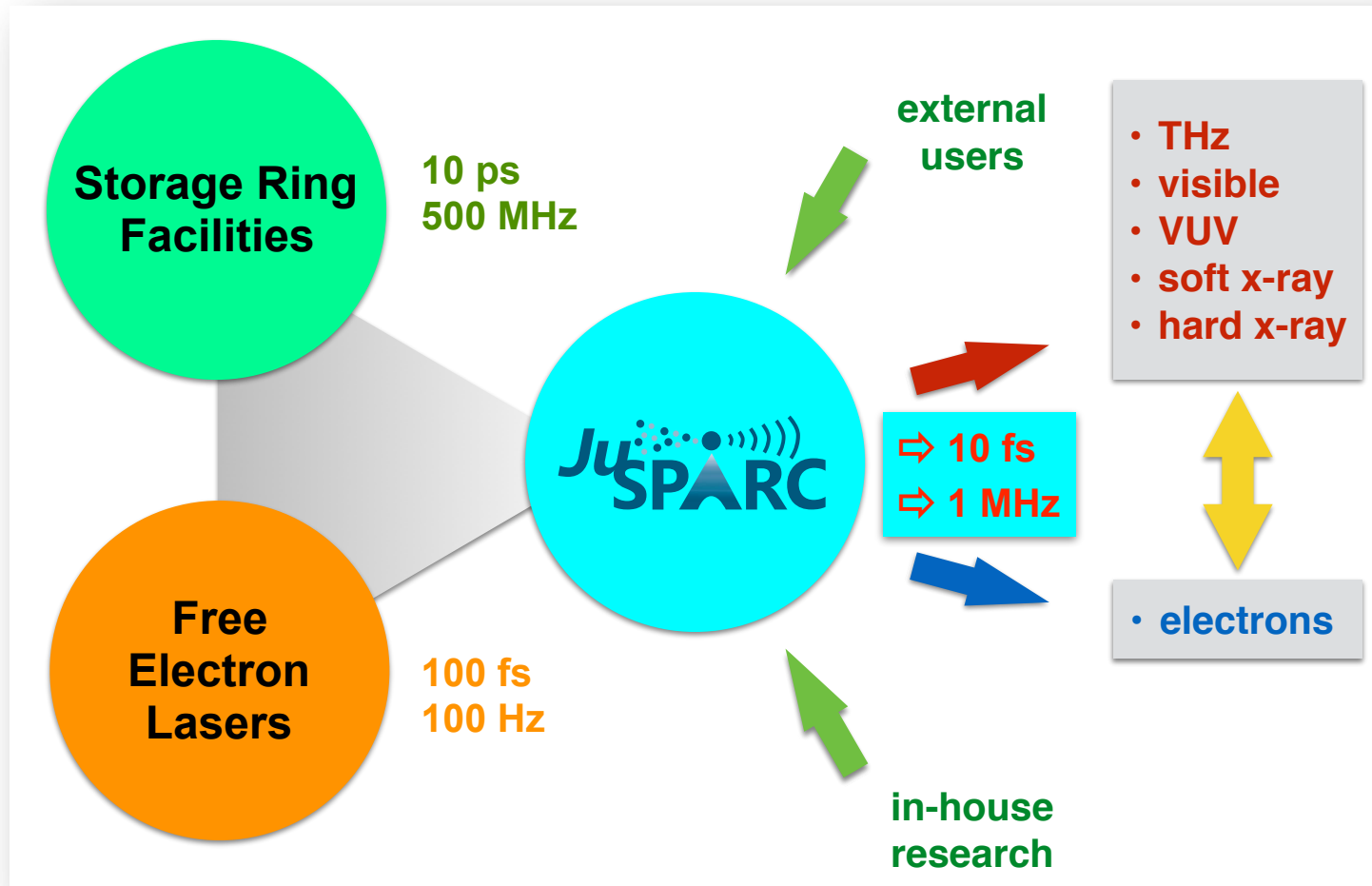


# PLASMA PHYSICS ACTIVITY IN JÜLICH

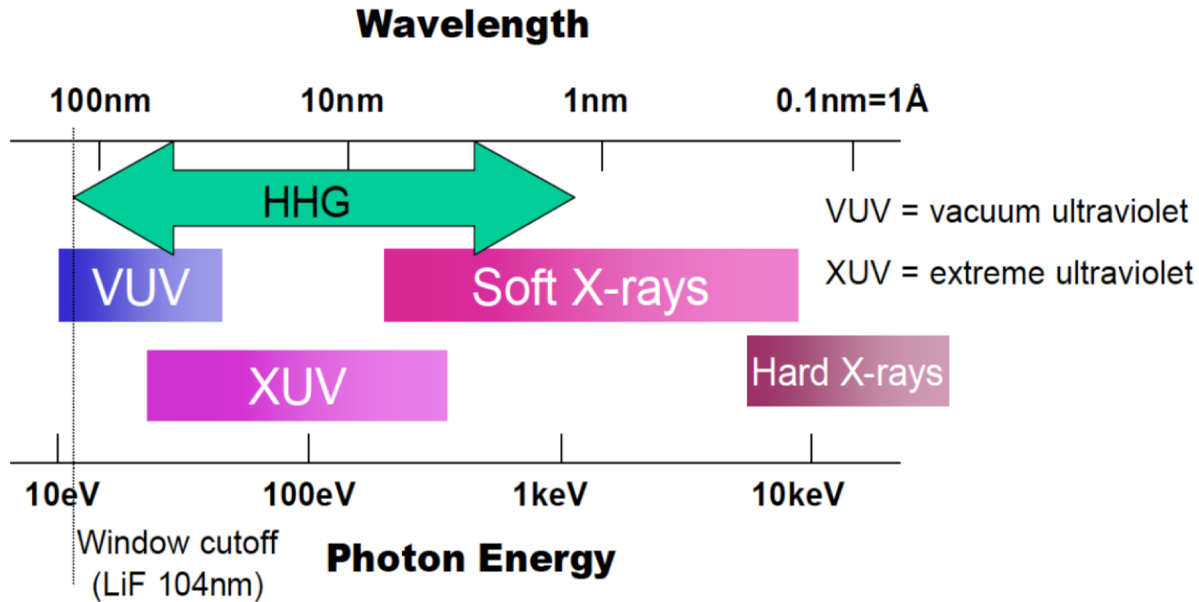


# JuSPARC

= Jülich Short-pulsed Particle and Radiation Center



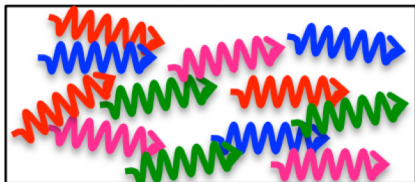
# LIGHT SOURCE PROPERTIES



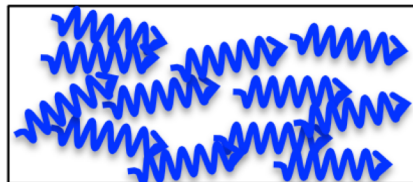
JuSPARC Vega	
Pulse energy	40 mJ
Pulse duration	25 fs
Focus $\emptyset$	10 $\mu\text{m}$
Wavelength	1 $\mu\text{m}$
Rep. Rate	1 kHz



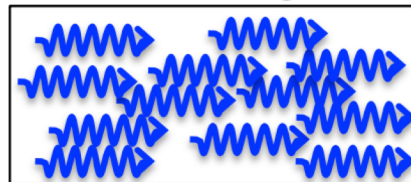
1. many photons



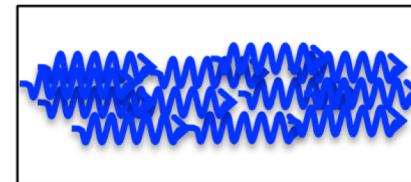
2. small bandwidth



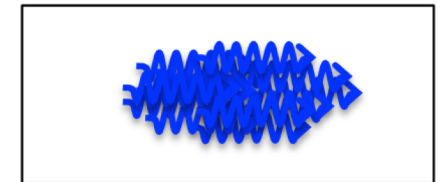
3. low divergence



4. small source



5. short duration



# 2019: JuSPARC KICK-OFF AND FIRST LIGHT

Neues Laser-Labor am FZJ eingeweiht  
**Jülich hat jetzt den Super-Laser**  
 24. JANUAR 2019 UHR 16:37 UHR | Lesedauer: 3 Minuten



Die Hygienevorschriften sind streng: Das in einem sogenannten Reinraum installiert.

**JÜLICH.** „Wenn man einen Physiker ein das nächstgrößere nach“, sagte am Doi Grünberg-Institut (PGI) am Forschungszentrum Jülich, an dem das gut acht Meter hohe und ziemlich großes Spielzeug.

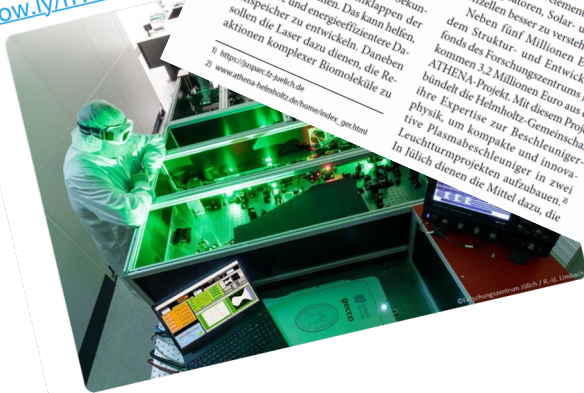
VON GUIDO JANSEN

Ganz ernst gemeint hat Büscher seine Aufgaben sind die Forscher mehr als zufrieden mit den Möglichkeiten der Materialforschung eröffnet. „Wenn man bleiben will – auf das die Forscher rund um den Tonner mit den Bauteilen vorgefahren ist u

Neues Laserlabor am @fz\_juel sind zwei Höchstleistungslaserpulse eine Leistung der Hälfte des durchschnittlichen Stromverbrauchs allerdings nur für kurze Zeit.  
[ov.ly/nYiF50kkwv/](https://www.ov.ly/nYiF50kkwv/)



<https://www.fz-juelich.de>  
[www.athena.helmholtz.de/home/index\\_ges.html](http://www.athena.helmholtz.de/home/index_ges.html)



Neue Materialien für die Informationstechnologie finden und optimieren – so lautet eines der Ziele am Forschungszentrum Jülich, das in den Bereichen Information, Energie und Bioökonomie Schwerpunkte setzt. Dafür steht den Wissenschaftlerinnen und Wissenschaftlern seit Ende Januar mit JuSPARC (Jülich Short-Pulse Particle and Radiation Center) ein neues Laserlabor zur Verfügung. Zwei Höchstleistungslaser – ein Hersteller Thales und Ampios nach den Namen – bilden das Herzstück und erzeugen ultrakurze Laserpulse mit hohen Wiederholraten und Pulsleistungen. Damit lassen sich ultraschnelle physikalische Prozesse und Spins in Halbleitern und Metallen untersuchen, beispielsweise wie sich die Spins aufzeichnen. Das kann helfen, schnellere und energieeffizientere Datenspeicher zu entwickeln. Daneben sollen die Laser dazu dienen, die Reaktionen komplexer Biomoleküle zu untersuchen und elementare Prozesse in Katalysatoren, Solar- und Brennstoffzellen besser zu verstehen. Neben fünf Millionen Euro aus dem Struktur- und Entwicklungsfonds des Forschungszentrums Jülich kommen 3,2 Millionen Euro aus dem ATHENA-Projekt. Mit diesem Projekt handelt die Helmholtz-Gemeinschaft ihre Expertise zur Beschleunigerphysik, um kompakte und innovative Plasmabeschleuniger in zwei Leuchtturmprojekten aufzubauen. In Jülich dienen die Mittel dazu, die laserbasierte Elektronenbeschleunigung zu untersuchen – als optimale Ergänzung zu den Vorhaben am DESY und am Helmholtz-Zentrum Dresden-Rossendorf. Zunächst steht das Laserlabor ausschließlich den Instituten des Forschungszentrums Jülich offen. Für die kommenden Jahre ist aber der Ausbau zu einer Nutzerplattform geplant, sodass auch Forscherinnen und Forscher anderer Einrichtungen die Infrastruktur nutzen können.  
 Kerstin Sonnabend

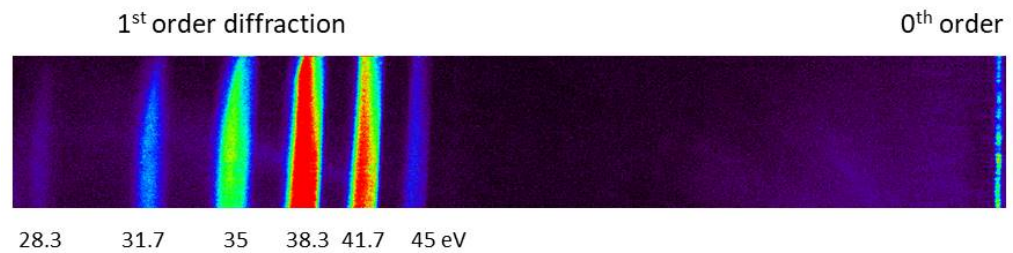
Das Forschungszentrum Jülich hat mit JuSPARC ein neues Laserlabor in Betrieb genommen.



**Laserblitze für die Materialforschung**  
 Das Forschungszentrum Jülich hat mit JuSPARC ein neues Laserlabor in Betrieb genommen.



Im Laserlabor JuSPARC des Forschungszentrums Jülich soll die Untersuchung ultraschneller Prozesse dabei helfen, neue Materialien für Datenspeicher oder Katalysatoren zu finden.

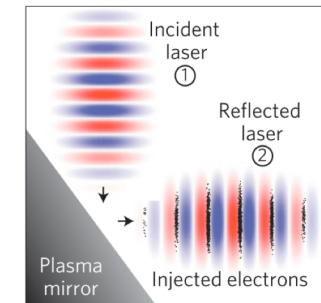
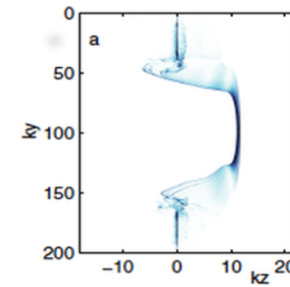
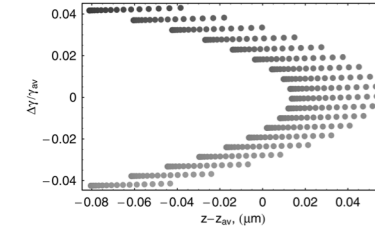


# OVERVIEW

- Attosecond electron bunches from clusters
- Tandem-bubble injection/betatron schemes
- Electron acceleration with the JuSPARC Vega (40mJ) system
- Spin-polarized ion beams from gas jets with PHELIX laser
- Circularly polarized XUV light sources

# ATTOSECOND ELECTRON NANOBUNCHES

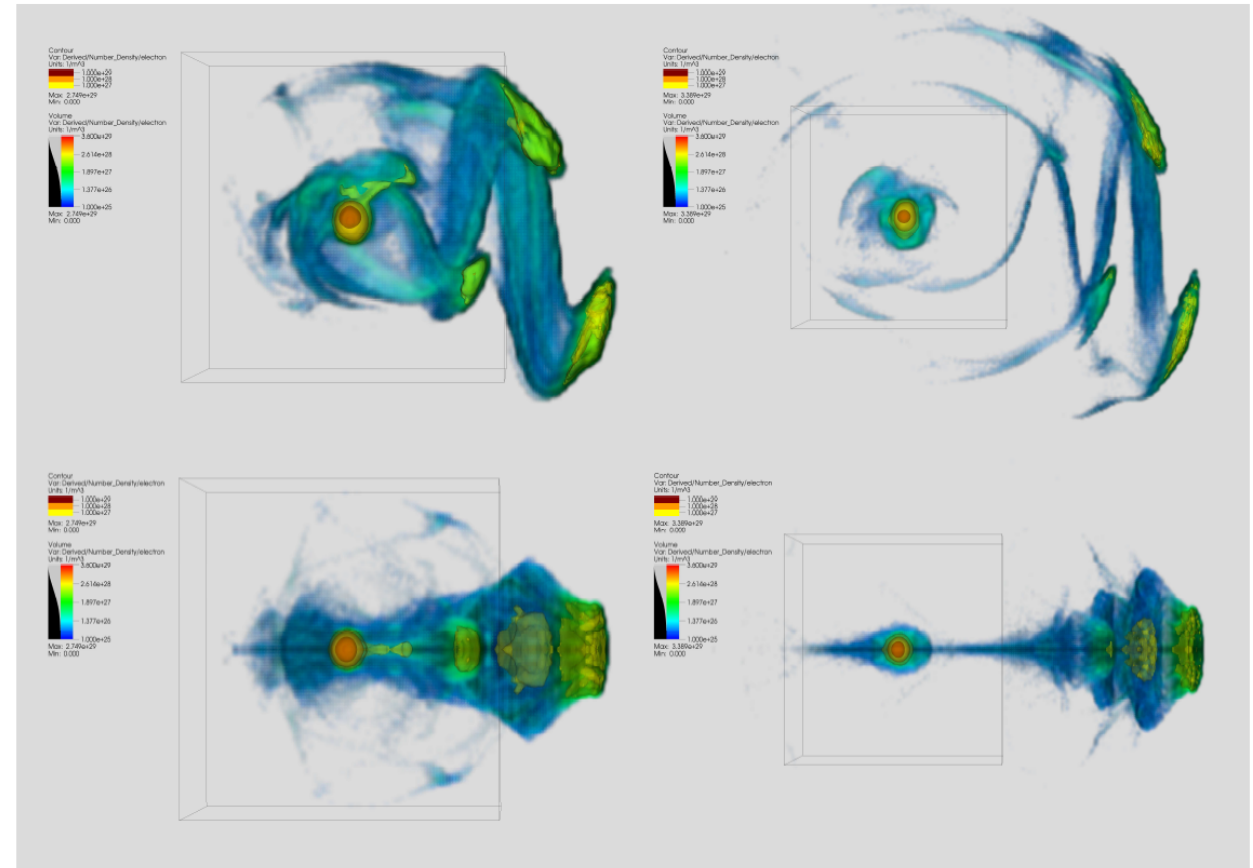
- Vacuum acceleration by radially tailored laser pulses
  - Stupakov, Zolotarev, PRL 86 (2001)
- Thin foil - relativistic electron layer
  - Kulagin et al., PRL 99 (2007)
- VLA from plasma mirrors
  - Thevenet et al., Nature Physics 12 (2015)



# ELECTRON BUNCH EMISSION FROM NANOCCLUSERS

Laura Di Lucchio

- 3D PIC simulations
- Emission mainly in polarization plane
- Bunch densities  $n_b > n_c$



# DYNAMICS OF ELECTRON BUNCHES: 1 MM DROPLET

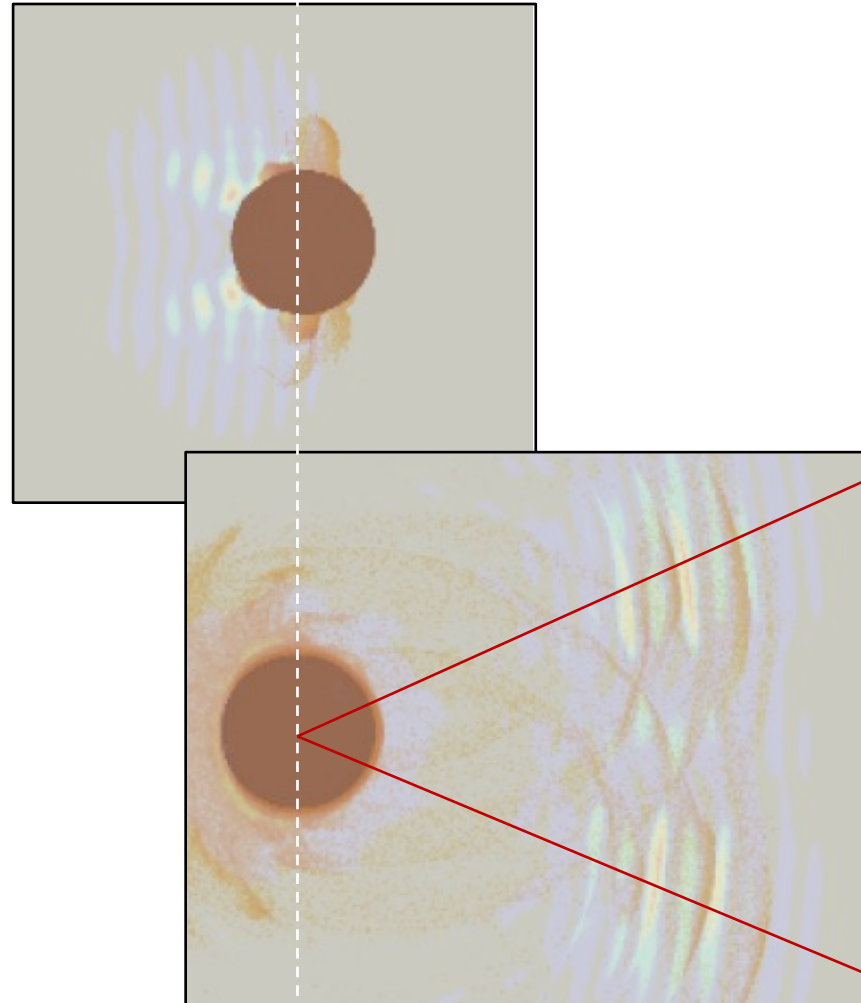
2D PIC simulations with EPOCH on JUQUEEN

Laser:

- 5fs,  $10^{20}$  Wcm<sup>-2</sup>
- 2 micron focus

Bunch properties:

- Density  $\sim n_c$
- Mie-dominated emission
- Cf: Liseykina & Bauer, PRL 104 (2010)



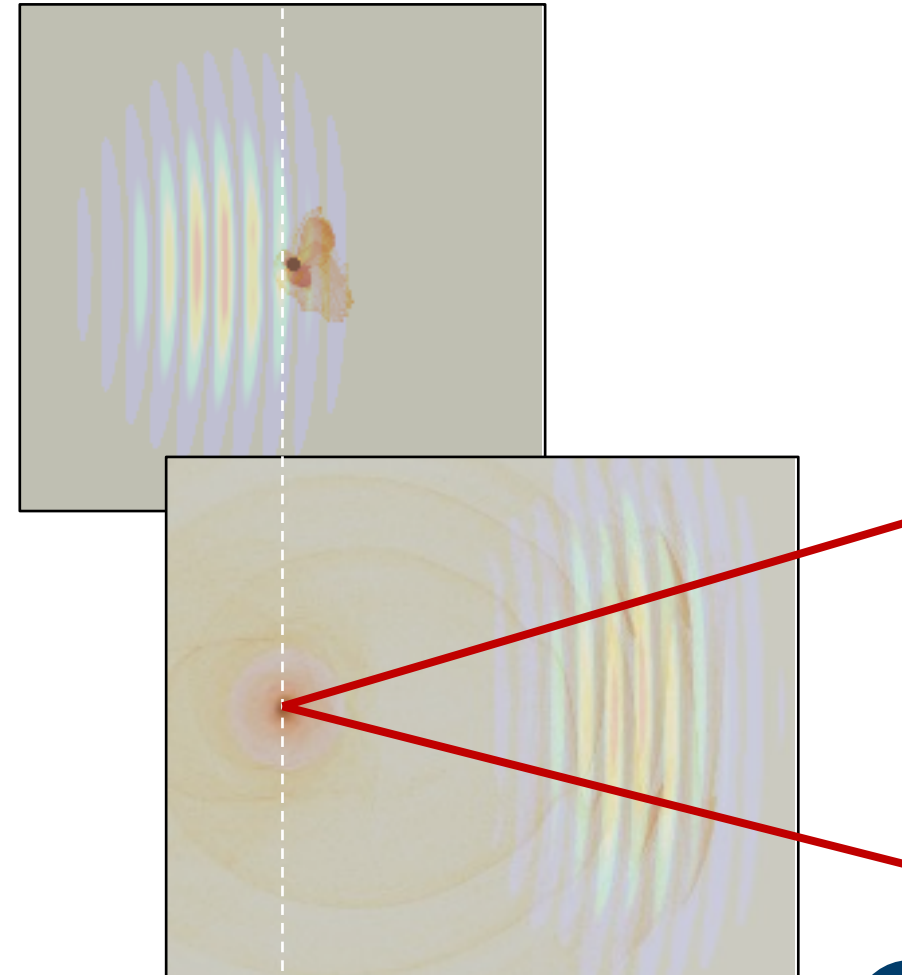
# DYNAMICS OF ELECTRON BUNCHES: 100NM DROPLET

## Laser:

- 5fs,  $10^{20} \text{ Wcm}^{-2}$
- 2 micron focus

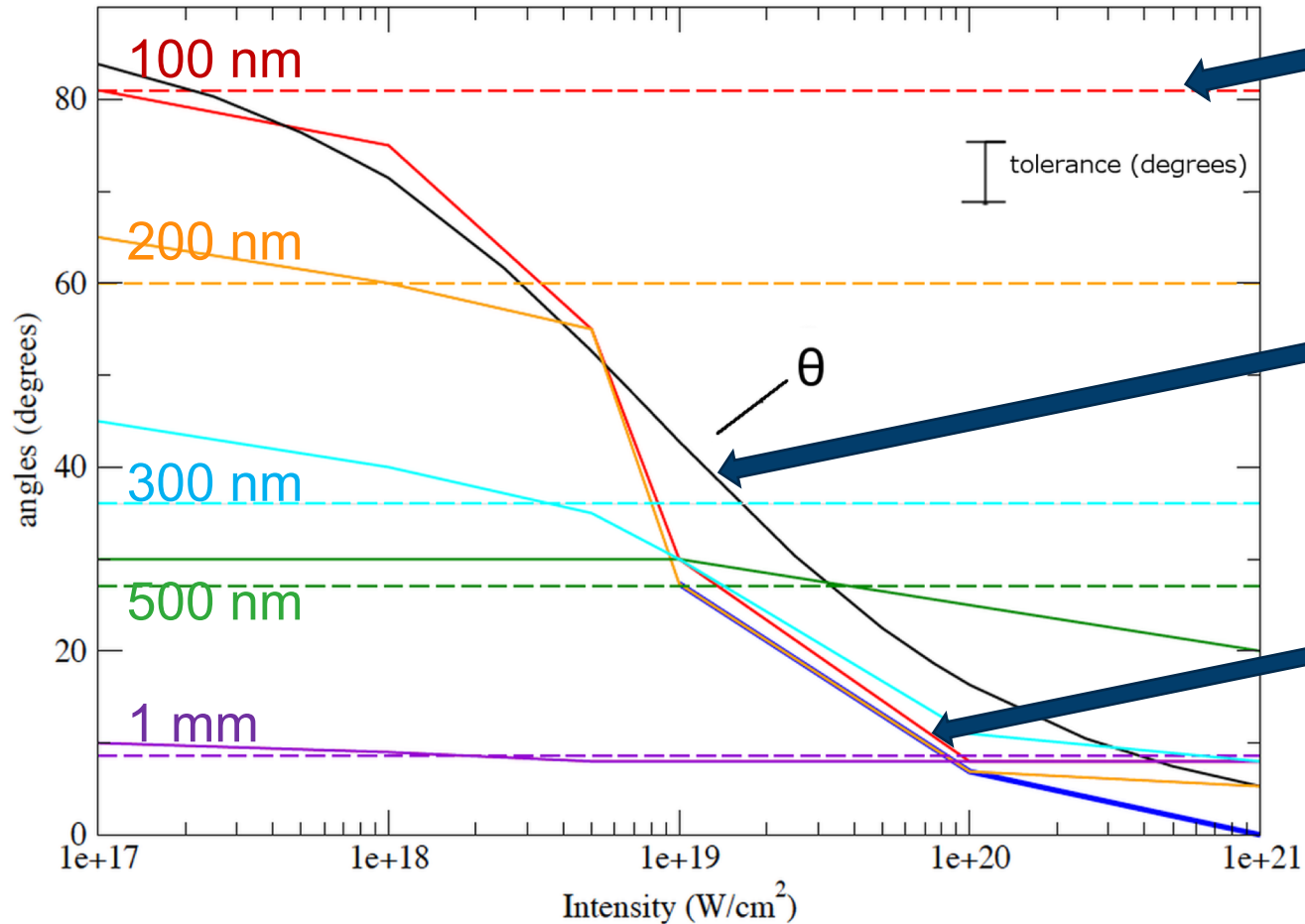
## Bunch properties:

- O(nm) thick
- Overdense ( $10x n_c$ )
- Co-propagate with pulse
- Reminiscent of VLA from plasma mirrors

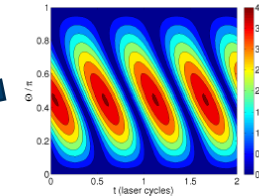


# EMISSION ANGLE INTENSITY DEPENDENCE

Non Mie-like behaviour when  $R_{cluster} < 10 \gamma^{1/2} c / \omega_p$



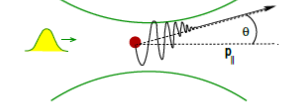
## Mie theory



$$E_{inc}(z, t) = E_0 \cos(kz - \omega t),$$

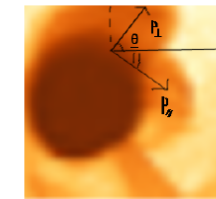
$$\lambda = 800nm, R \gg \delta$$

## Ponderomotive scattering



$$\theta_0 = \tan^{-1} \sqrt{2/(\gamma - 1)}$$

## Vacuum deflection



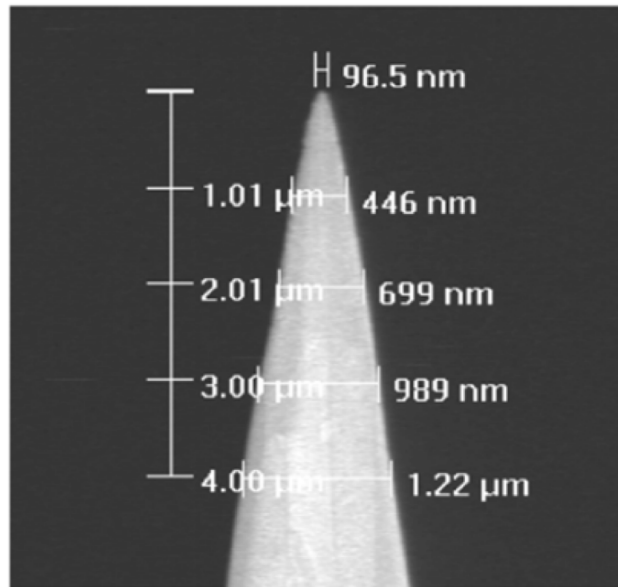
$$\theta' = \arctan \frac{p'_y}{p'_x} + \arctan \frac{p_{\perp}}{p_{\parallel}}$$

[L. Di Lucchio, P. Gibbon, PRSTAB, 18, 023402 \(2015\)](#)

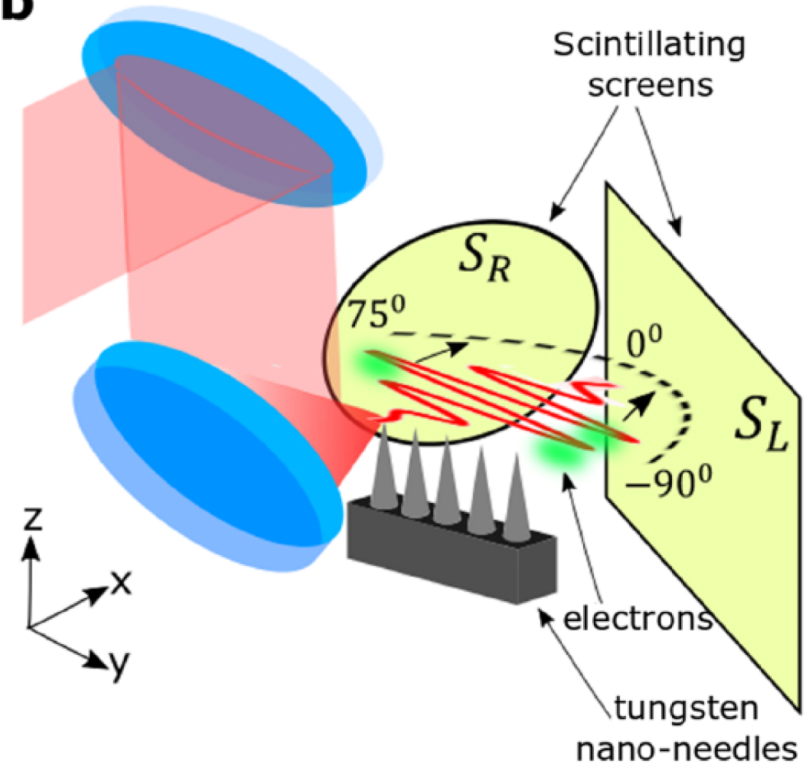
# EXPERIMENT WITH FEW-CYCLE PULSE & NANO-NEEDLES

Daniel Cardenas, Laszlo Veisz, Jörg Schreiber et al (MPQ Garching / CALA, LMU)

**a**

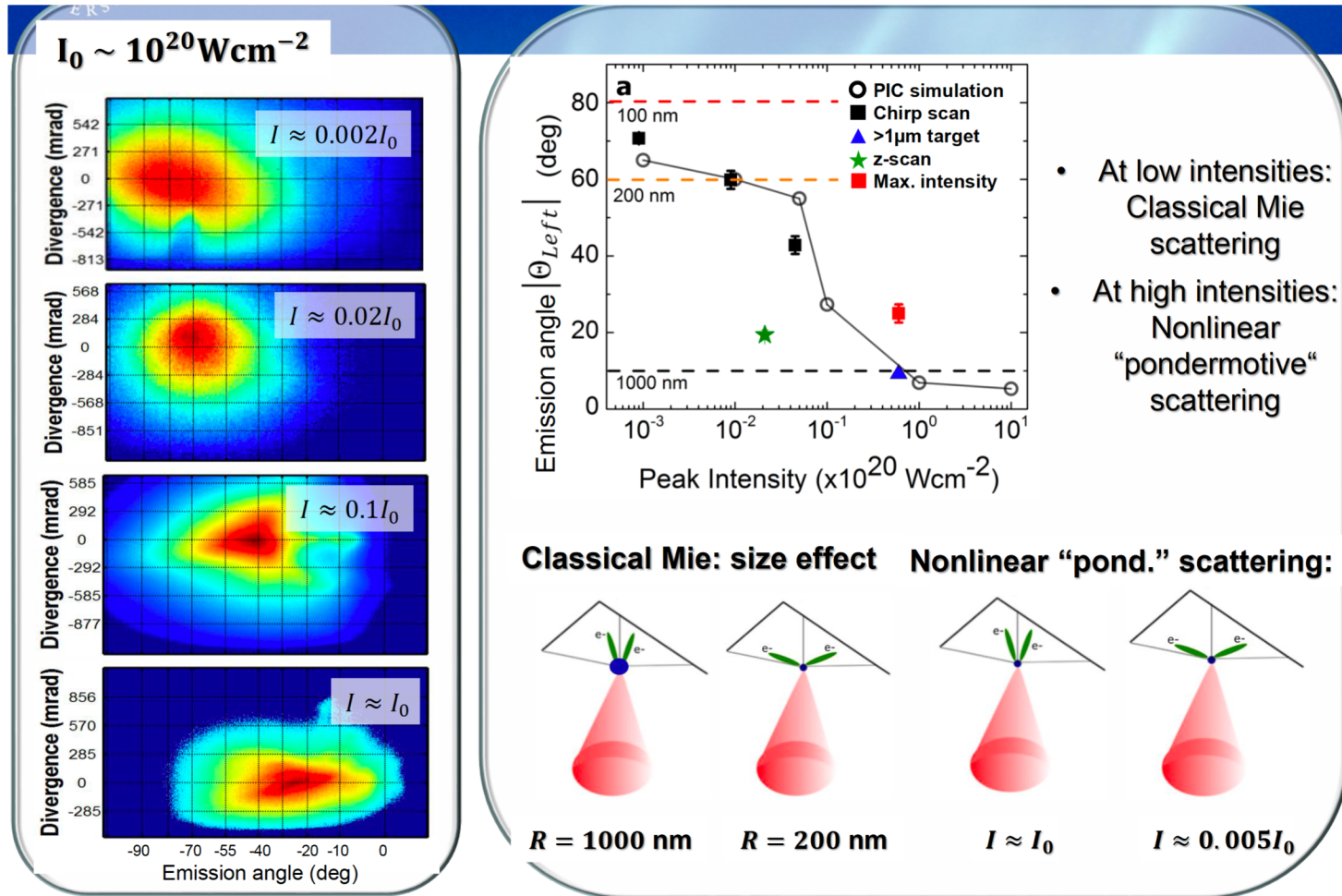


**b**



# EXPERIMENTAL RESULTS

## Intensity dependent angular electron emission



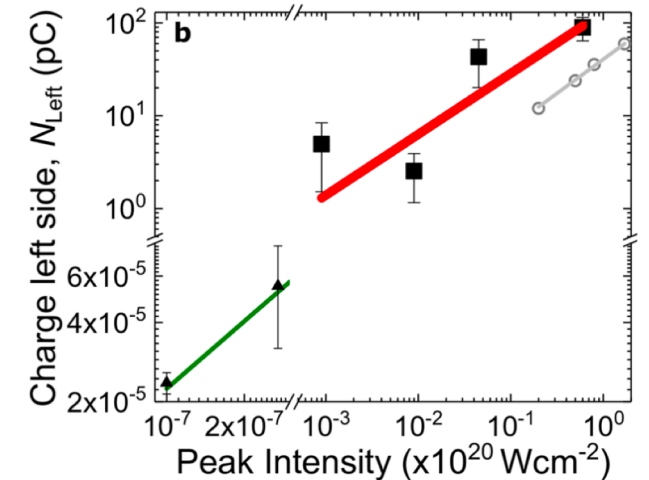
## SCIENTIFIC REPORTS

### OPEN Sub-cycle dynamics in relativistic nanoplasma acceleration

D. E. Cardenas<sup>1,2</sup>, T. M. Ostermayr<sup>1,2</sup>, L. Di Lucchio<sup>3</sup>, L. Hofmann<sup>1,2</sup>, M. F. Kling<sup>1,2</sup>, P. Gibbon<sup>3,4</sup>, J. Schreiber<sup>1,2</sup> & L. Veisz<sup>1,5</sup>

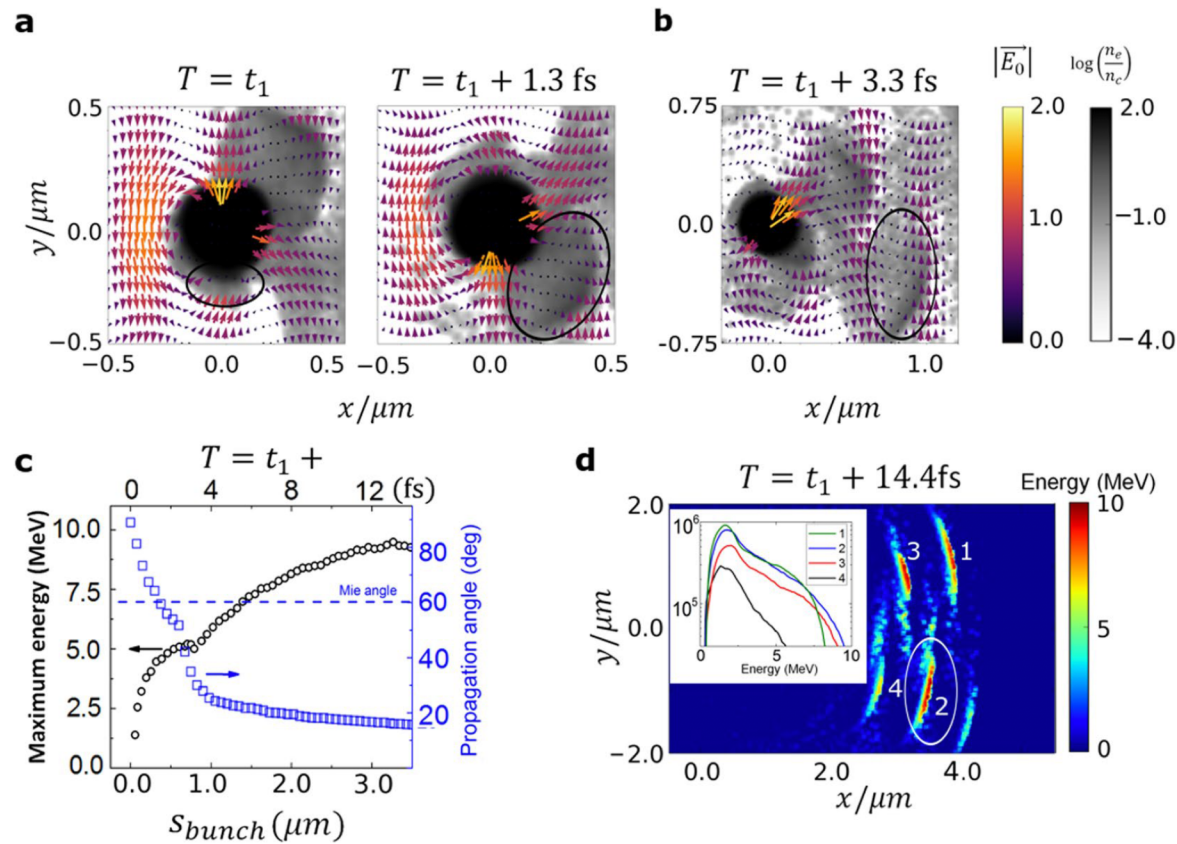
Received: 3 January 2019  
Accepted: 28 April 2019  
Published online: 13 May 2019

The interaction of light with nanometer-sized solids provides the means of focusing optical radiation to sub-wavelength spatial scales with associated electric field enhancements offering new opportunities for multifaceted applications. We utilize collective effects in nanoplasmas with sub-two-cycle light pulses of extreme intensity to extend the waveform-dependent electron acceleration regime into the relativistic realm, by using  $10^6$  times higher intensity than previous works to date. Through irradiation of nanometric tungsten needles, we obtain multi-MeV energy electron bunches, whose energy and direction can be steered by the combined effect of the induced near-field and the laser field. We identified a two-step mechanism for the electron acceleration: (i) ejection within a sub-half-optical-cycle into the near-field from the target at  $> \text{Tvm}^{-1}$  acceleration fields, and (ii) subsequent acceleration in vacuum by the intense laser field. Our observations raise the prospect of isolating and controlling

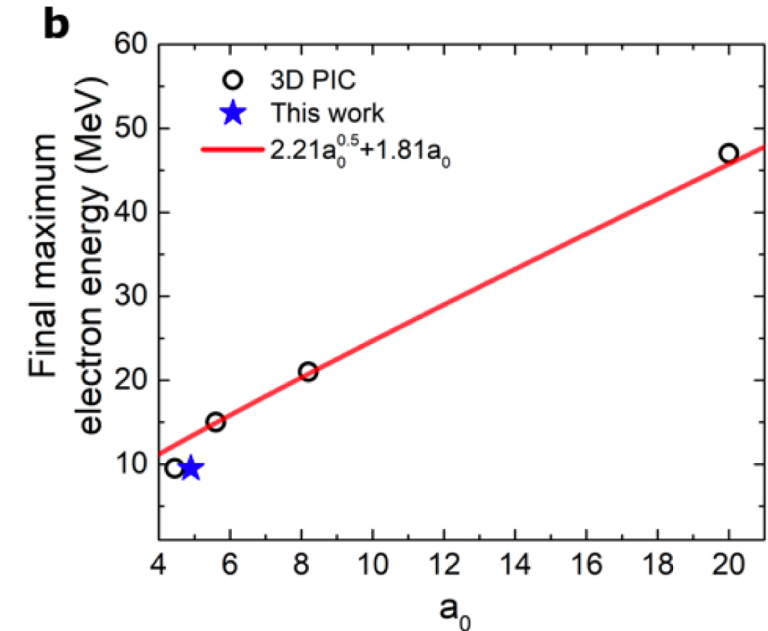


# 3D PIC SIMULATIONS

... show two distinct acceleration phases of electron bunches



[Cardenas et al, Scientific Reports \(2019\) 9:7321](#)

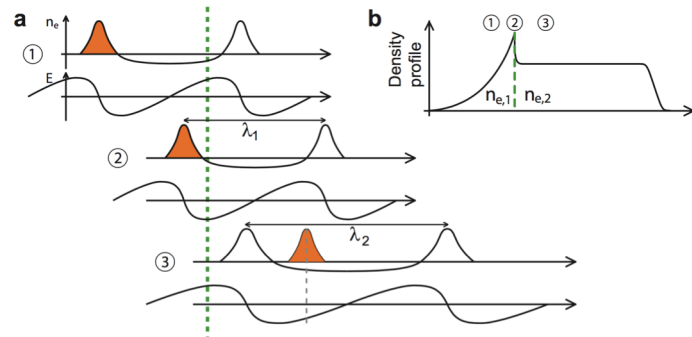
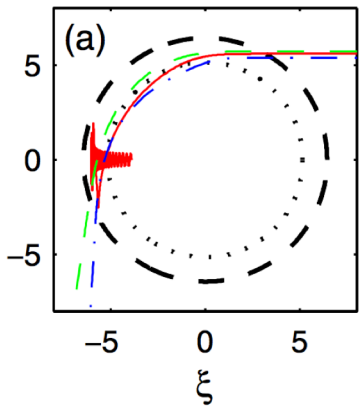


- Final bunch energy scales as  $\sim a_0$  (not  $a_0^2$ )
- Charge  $O(10s)$  pC

# ELECTRON INJECTION IN LASER WAKEFIELDS

## Evolution of Wakefield

- Wave breaking and self injection
- Density transition and shock-front injection



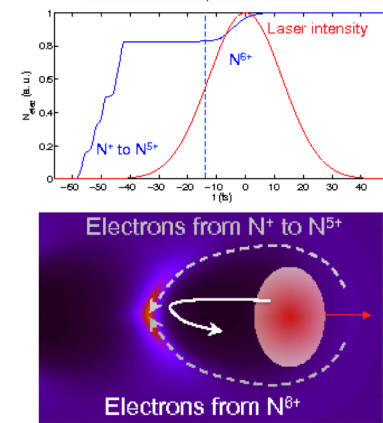
S. Kalmykov (PRL 2009)

A. Buck, PhD LMU

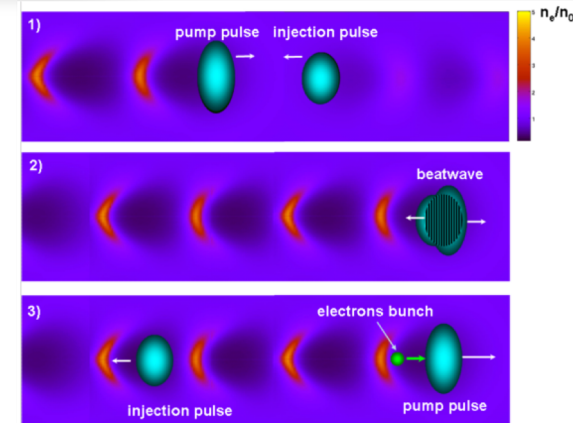
Mitglied der Helmholtz-Gemeinschaft

## Injection of Background Electrons

- Ionization injection
- Optical injection (e.g. colliding pulses)



J. Faure (CAS 2016)

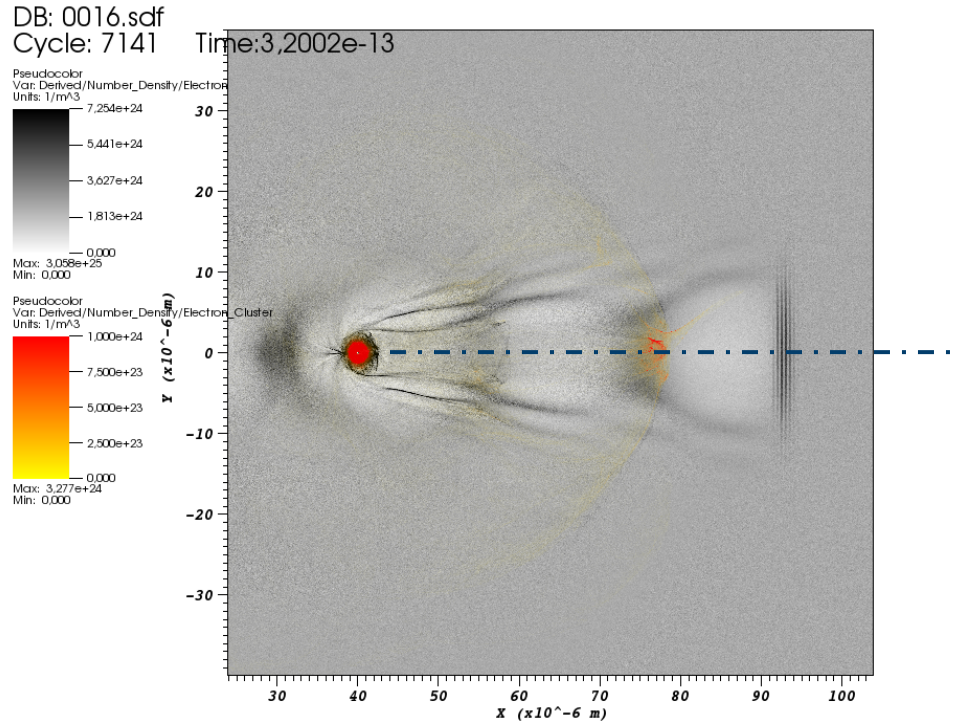


# CLUSTERS AS INJECTORS IN WAKEFIELDS

André Sobotta

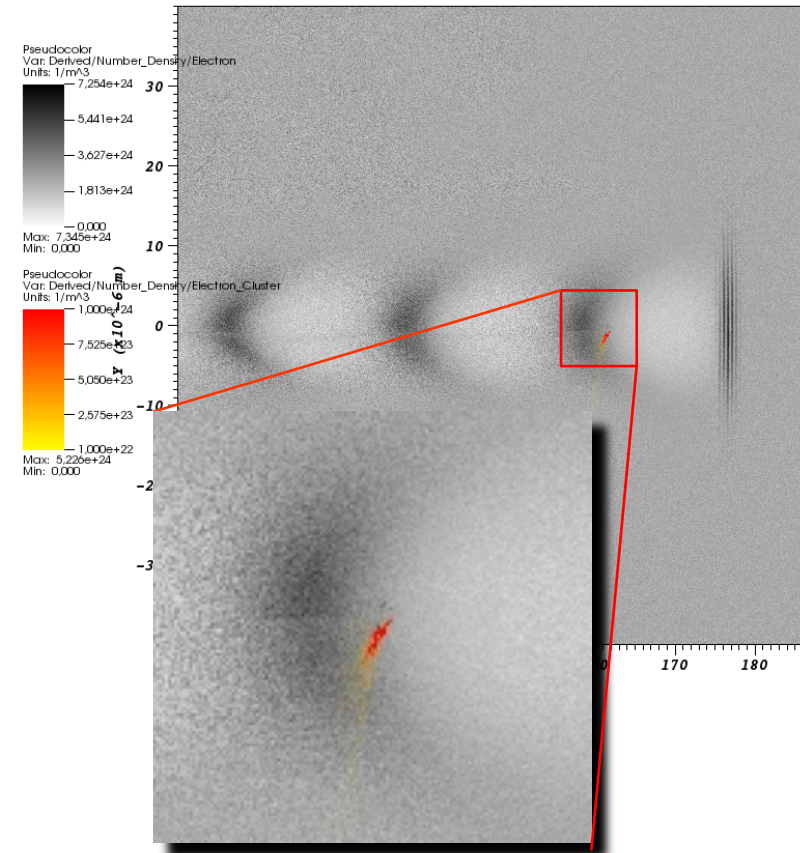
$$\epsilon \sim 0.06 \pi \text{ mm mrad (90\%, 0.2 pC)}$$

Cluster on laser axis 320 fs

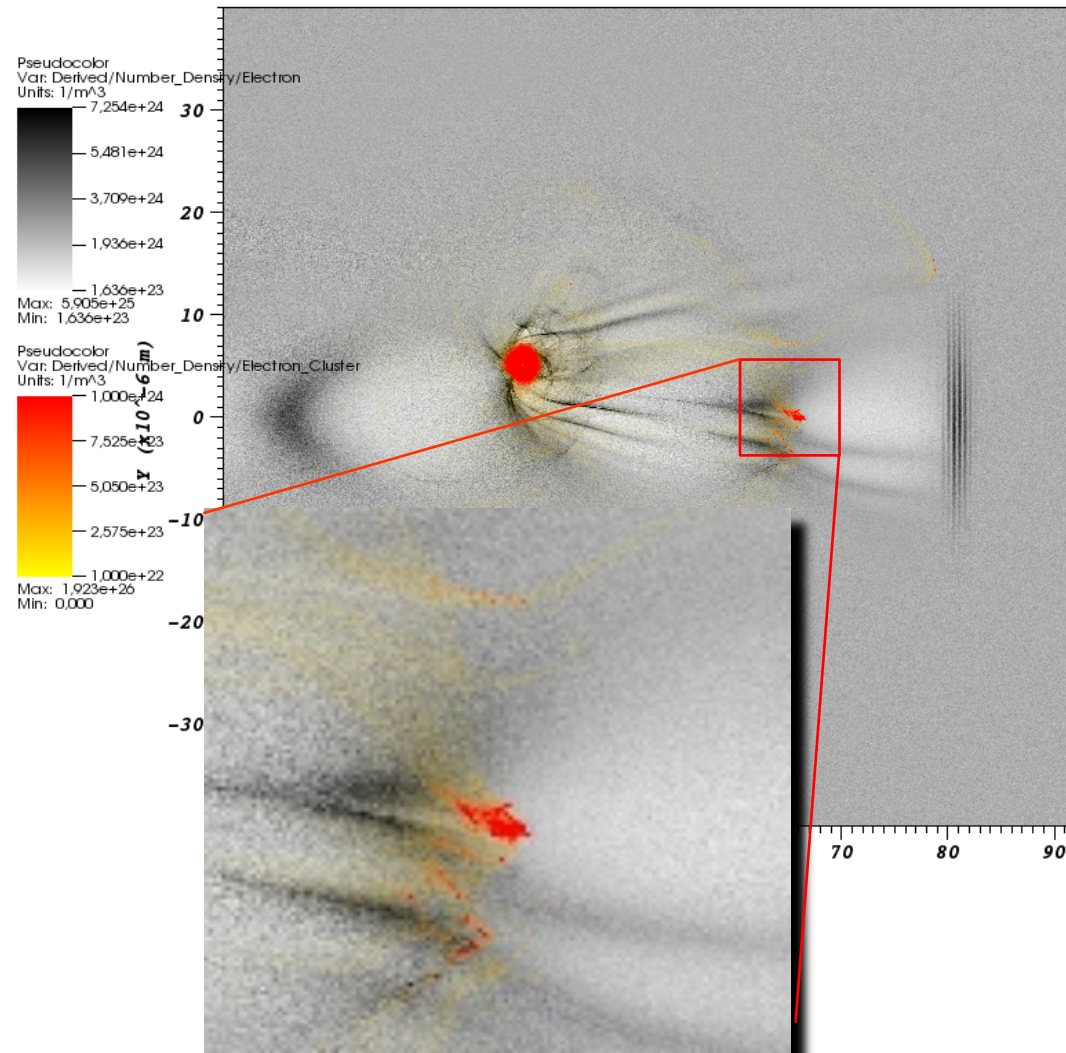


Laser intensity  $1.7 \cdot 10^{17} \text{ W/cm}^2$   
Pulse duration 20 fs  
Cluster diameter 100 nm

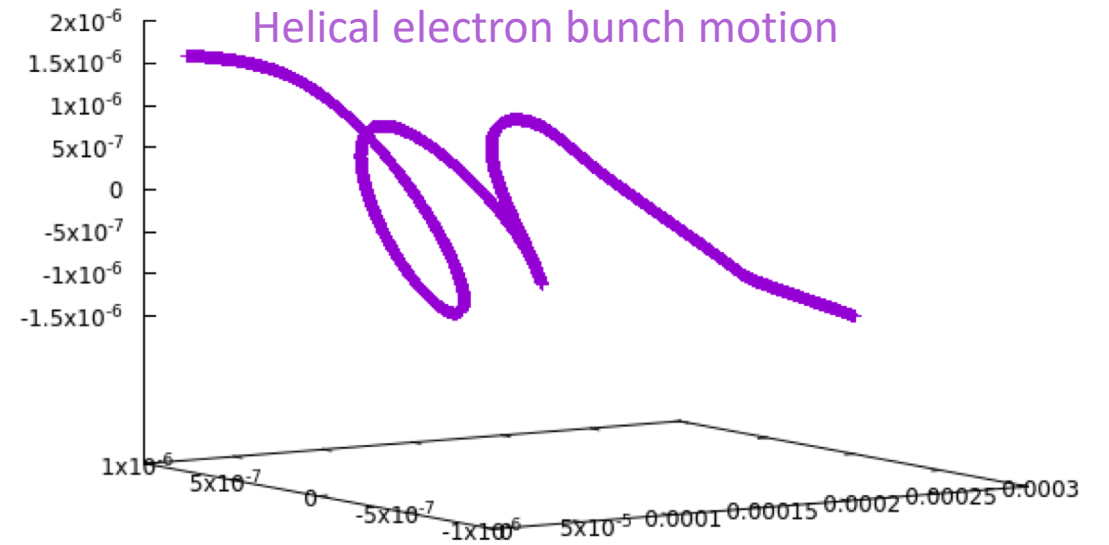
600 fs



# OFF-AXIS CLUSTER INJECTOR

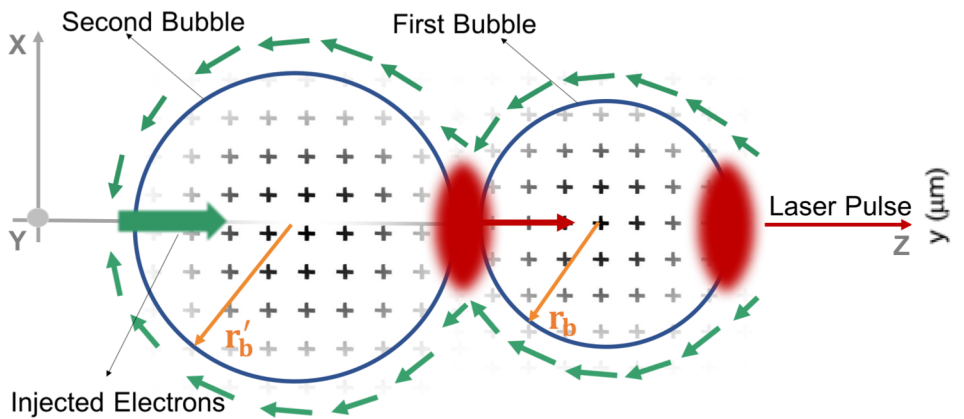


$\epsilon \sim 0.06 \pi \text{ mm mrad (90\%, 0.2 pC)}$

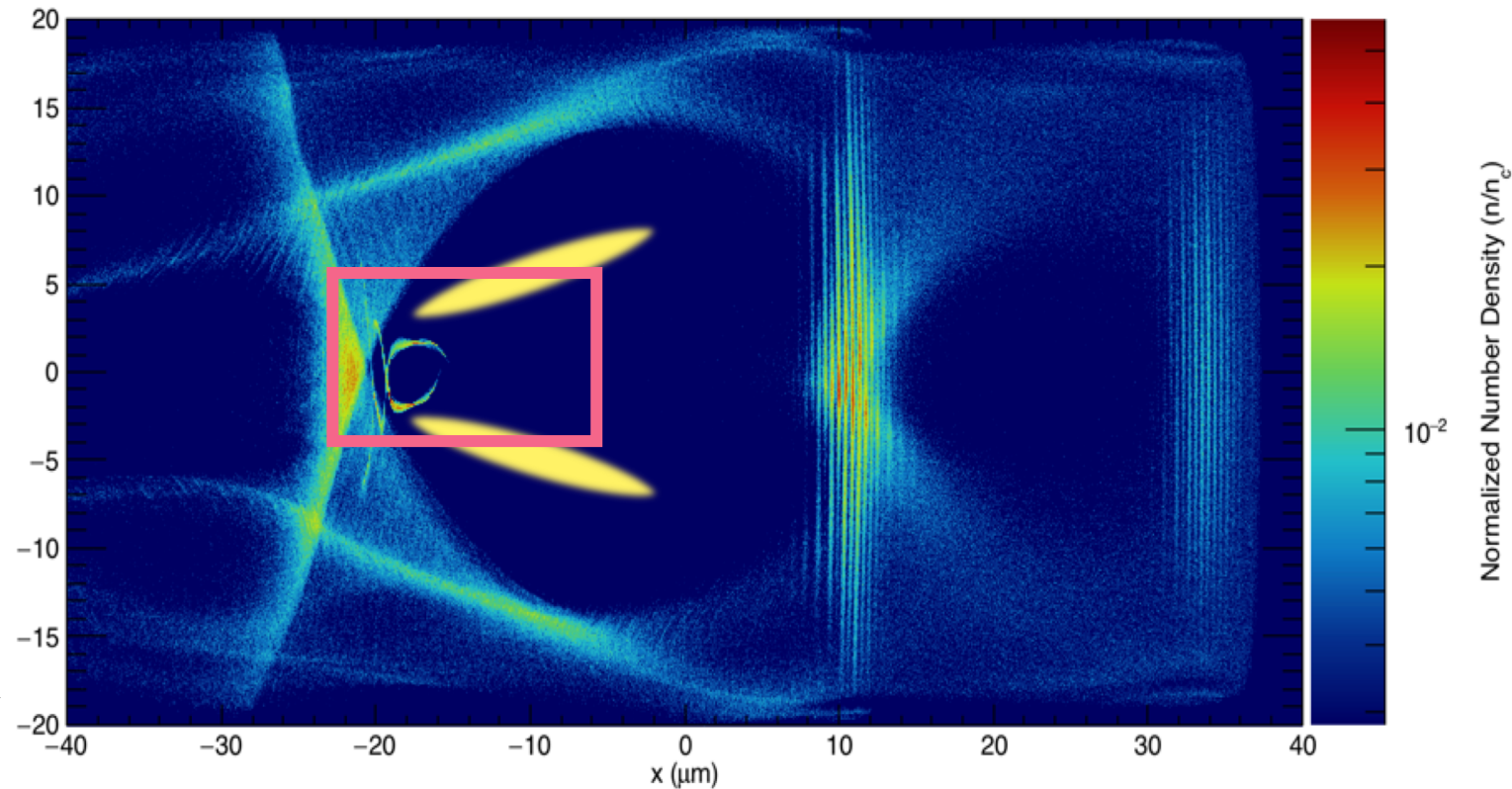


# OPTICAL INJECTION: TANDEM PULSE BETATRON

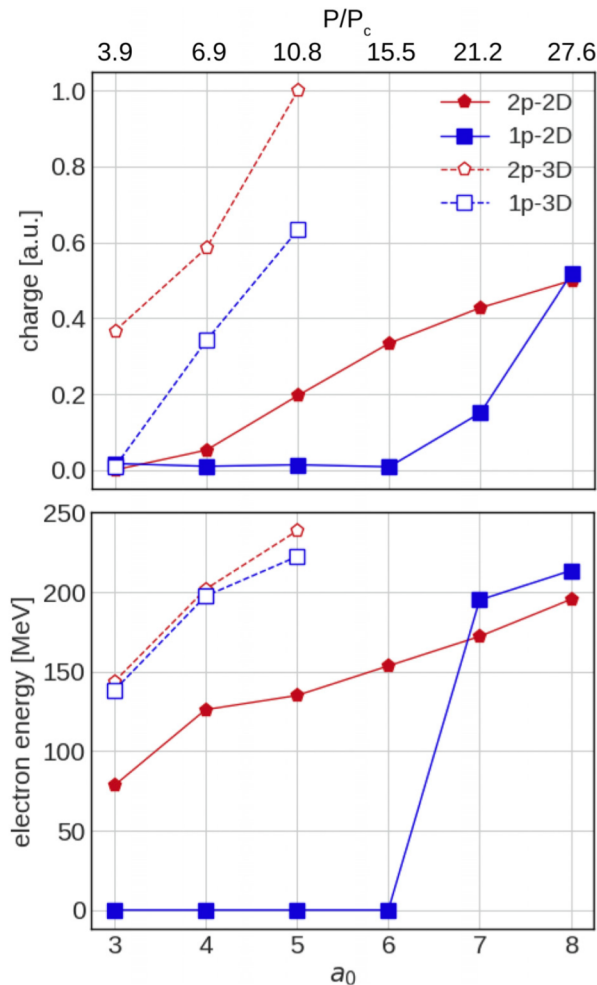
Zahra Chitgar



1st pulse acts as injector into 2nd cavity



# TANDEM SCHEME ADVANTAGES

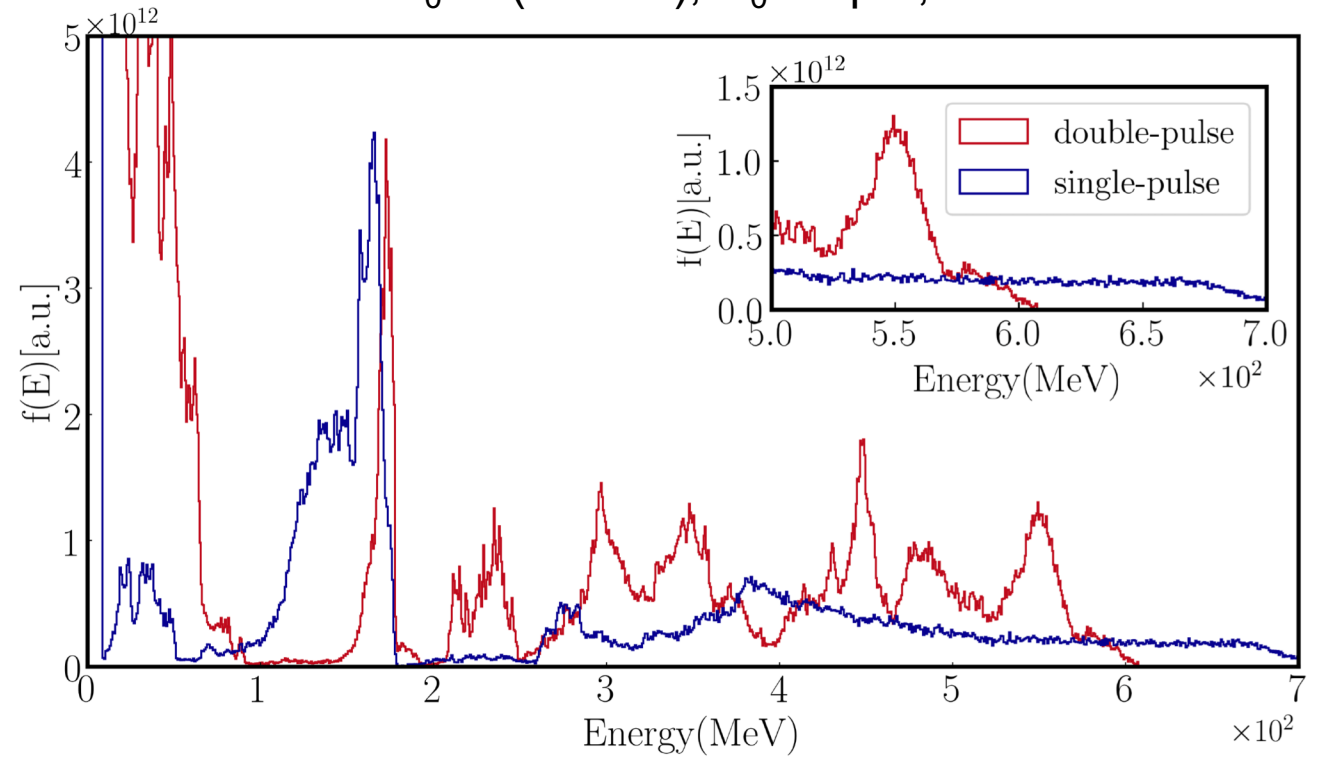
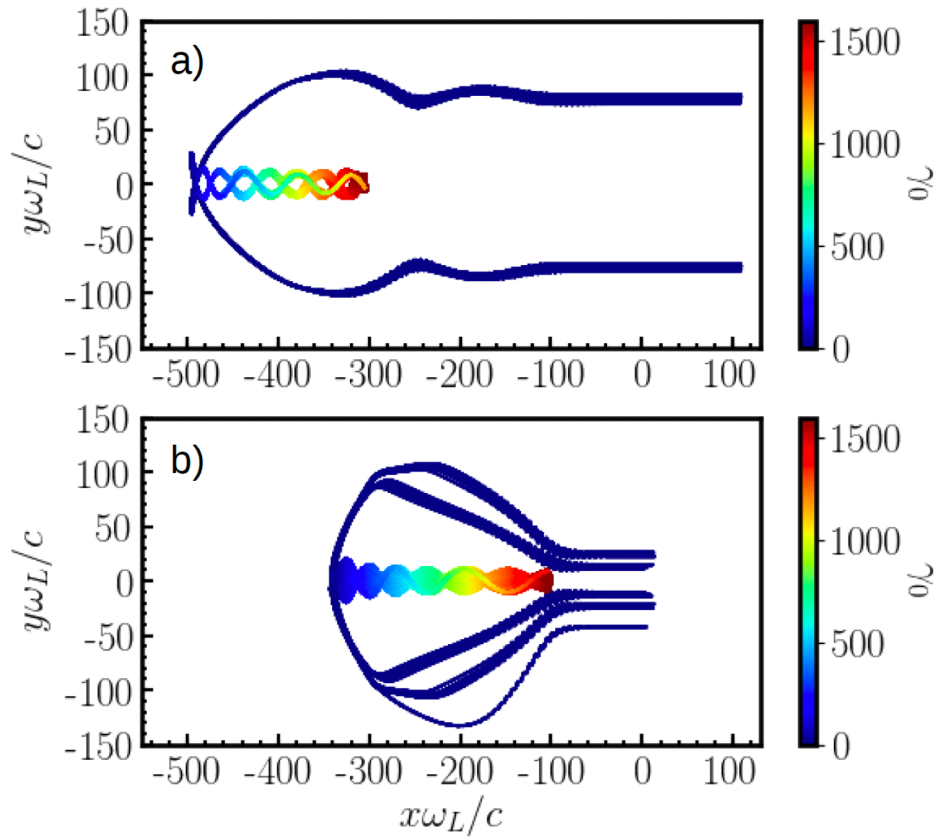


- Lower self-injection threshold
- Higher beam charge/current (cf: Horny et al, PPCF 2018)
- Lower beam emittance
- Control beam properties with intensity ratio & separation

[Z. M. Chitgar, PG et al, PoP 27, 023106 \(2020\)](#)

# INJECTION SELECTIVITY

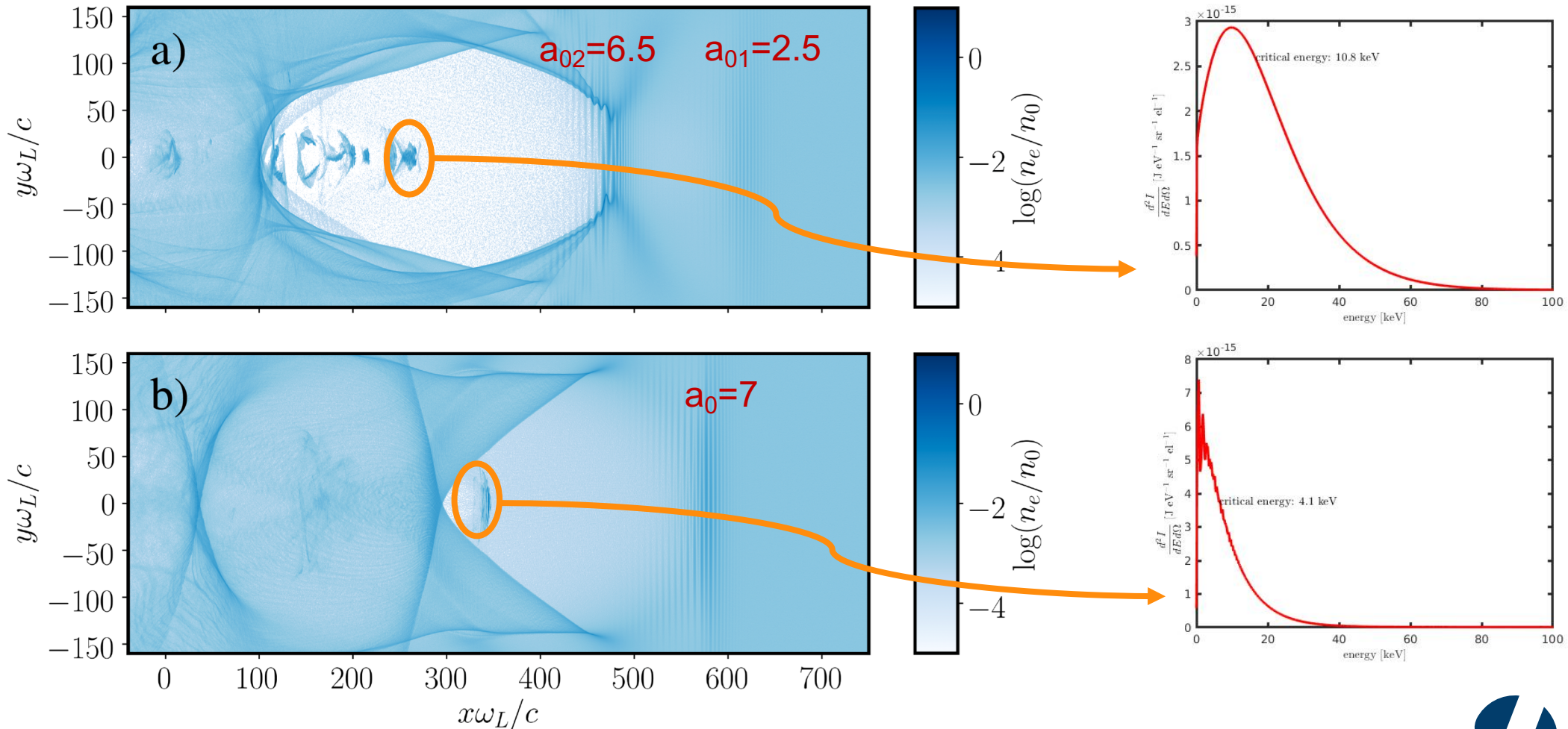
$n_e = 1.9 \times 10^{18} \text{ cm}^{-3}$   
 $a_0 = 7$  (2.5/6.5),  $w_0 = 10 \mu\text{m}$ , 20fs



# BETATRON RADIATION

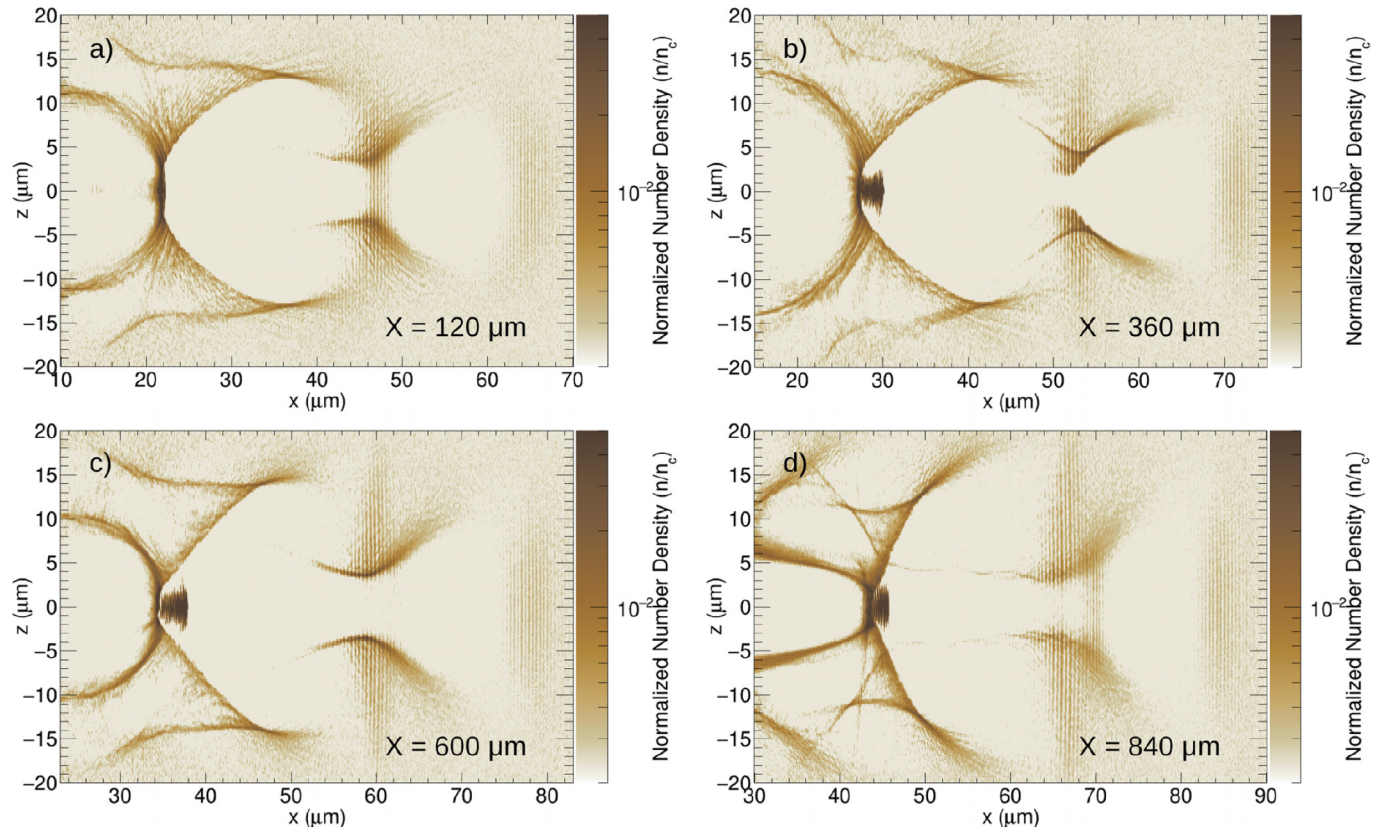
Cleaner, higher energy photon signal from leading bunch

Chitgar et al., IPAC'20



# CAVITY DYNAMICS AND CONTAMINATION

Optimal beam matching over dephasing length?



$$n_e = 1.9 \times 10^{18} \text{ cm}^{-3}$$
$$a_0 = 5, w_0 = 10 \mu\text{m}$$

Tandem:

$$Q_{\text{bunch}} = 0.3 \text{ nC}$$

$$U_{\text{peak}} = 400 \text{ MeV}$$

$$\Delta E/E = 13\%$$

Single:

$$Q_{\text{bunch}} = 0.2 \text{ nC}$$

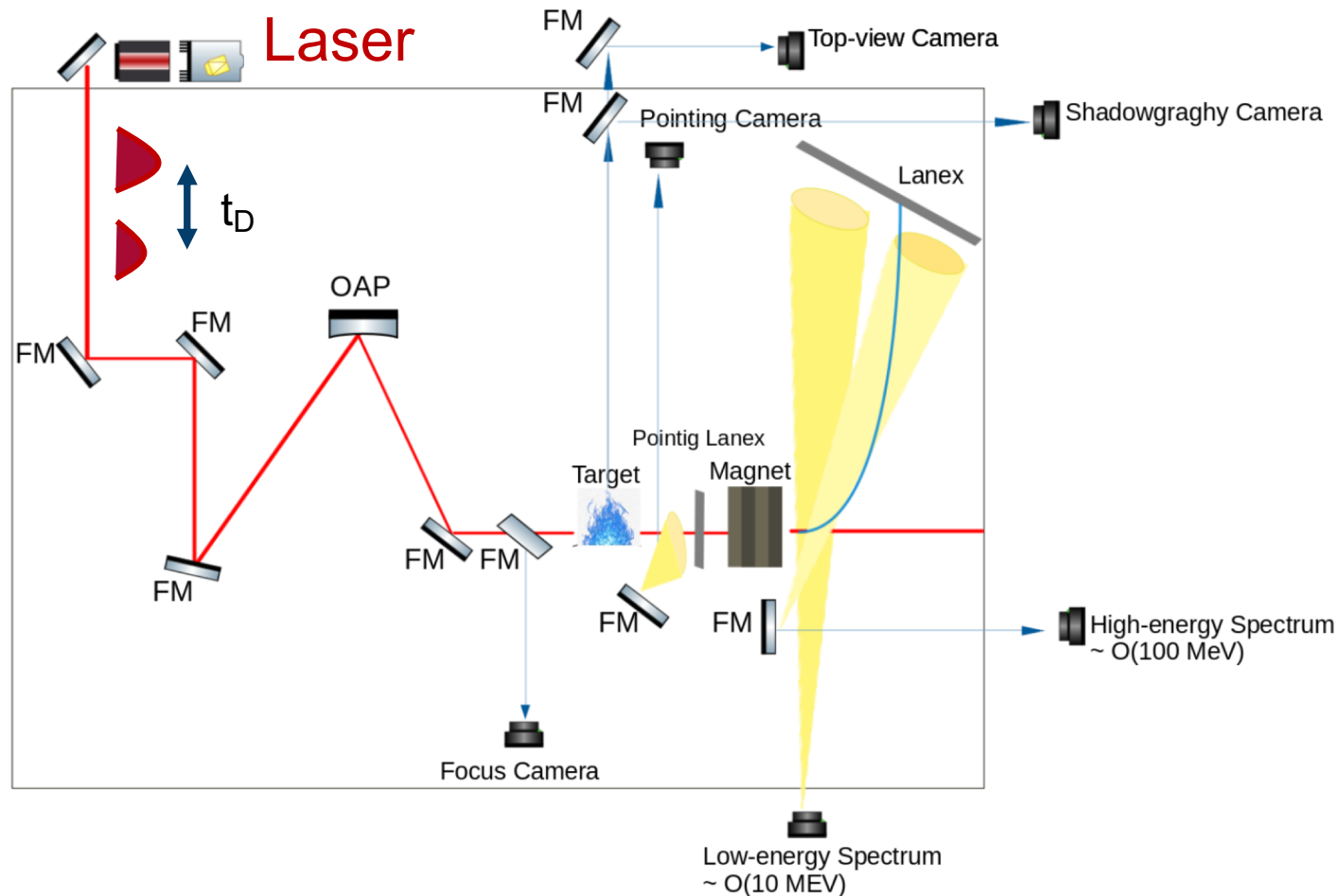
$$U_{\text{peak}} = 300 \text{ MeV}$$

$$\Delta E/E = 33\%$$

[Z. M. Chitgar, PG et al, PoP 27, 023106 \(2020\)](#)

# EXPERIMENT WITH HIGH-POWER LASER @ IPP PRAGUE

Miroslav Krus, Institute of Plasma Physics, Czech Academy of Sciences, Prague



300 mJ

25 fs

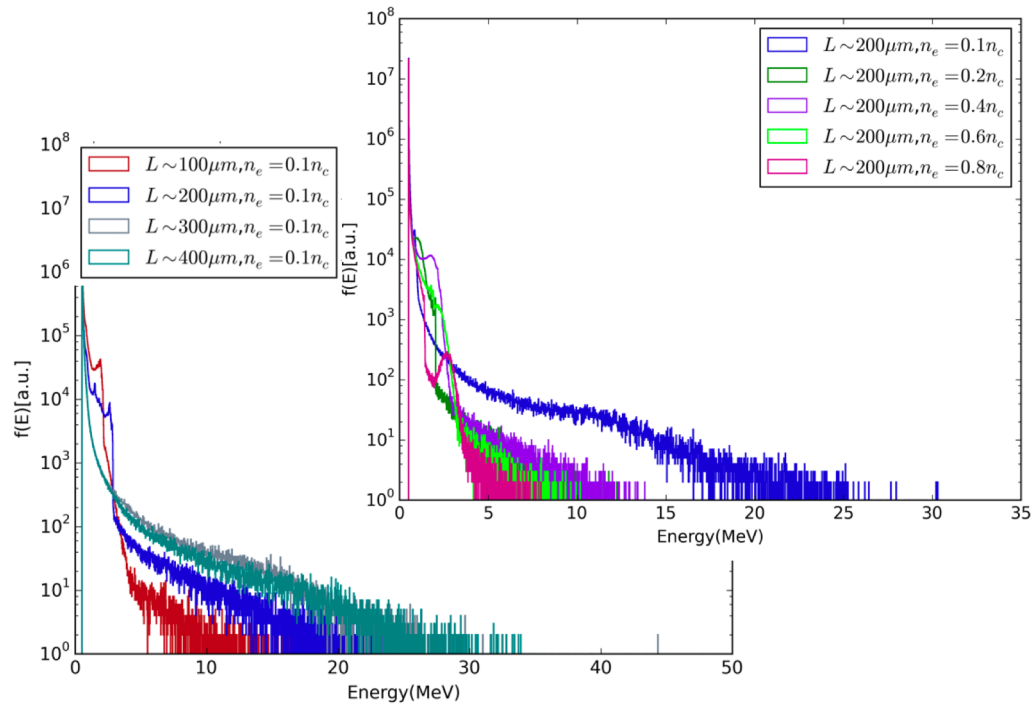
10  $\mu$ u

$t_D \sim 60-80$  fs with  $\Delta=2$ fs

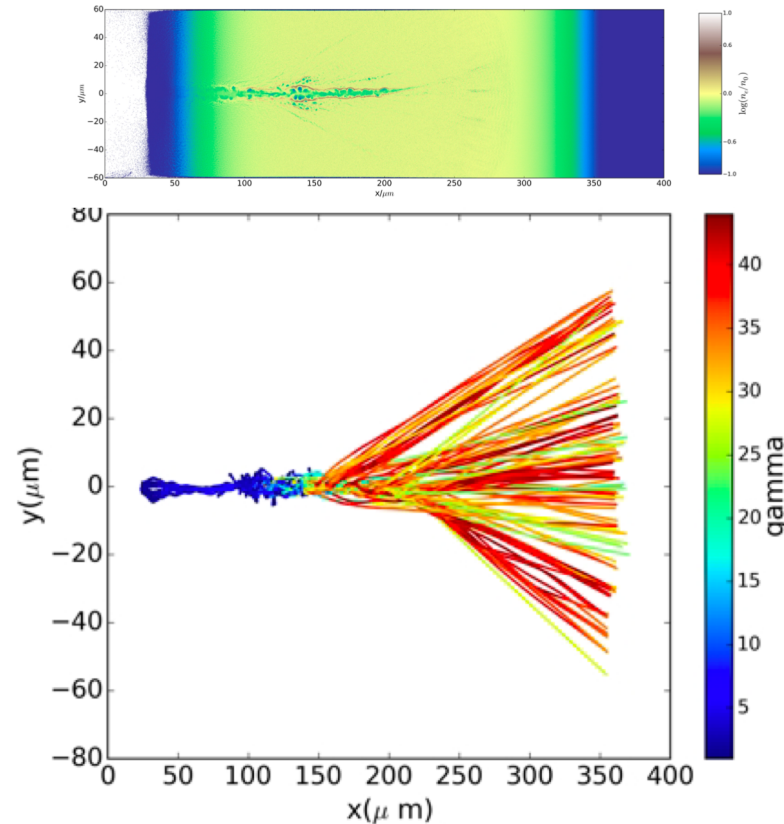
**But** pulse duration stretched to 50fs -> too much overlap to distinguish SP vs DP

# TOWARDS *Ju*SPARC-2: ELECTRON ACCELERATION

2D PIC simulations for *Ju*SPARC\_VEGA parameters 40 mJ / 25 fs / 5  $\mu\text{m}$  (Z. Chitgar)



First experiments planned in 2020  
- collaboration with J. Faure / LOA



Similar parameters to:

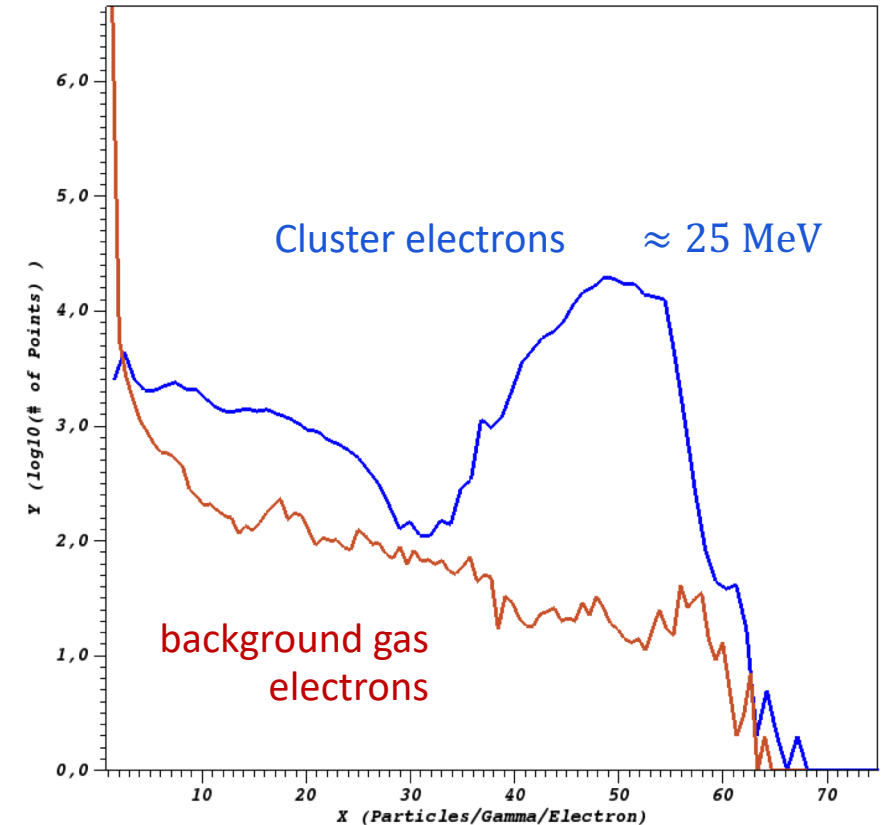
He et al., NJP 15 (2013);  
Salehi et al, Opt. Lett 42, 215  
(2017)

# ACCELERATION BOOST WITH CLUSTERS AT JuSPARC

3d PIC simulations for nano-clusters in gas jet (A. Sobotta)

Pulse energy	40 mJ
Pulse duration	25 fs
Focus $\emptyset$	10 $\mu\text{m}$
Wavelength	1 $\mu\text{m}$
Rep. Rate	1 kHz
Target material	H <sub>2</sub>
Cluster size	100 nm
Gas density	$3 \cdot 10^{19} \text{ cm}^{-3}$

Energy spectrum



# ACCELERATION OF SPIN-POLARIZED HELIUM-3 IONS

Ilhan Engin (PhD thesis)

## FZJ:

Ilhan Engin  
Pavel Fedorets  
Chuan Zheng  
Claus M Schneider  
Markus Büscher  
Laura Di Lucchio  
Paul Gibbon  
Ralf Engels  
Andreas Lehrach  
Rudolf Maier  
Dieter Prasuhn

## TUD/GSI/HIJ:

Oliver Deppert  
Simon Frydrych  
Annika Kleinschmidt  
Markus Roth  
Thomas Stöhlker

OPEN ACCESS

IOP Publishing

Plasma Phys. Control. Fusion 61 (2019) 115012 (11pp)

Plasma Physics and Controlled Fusion

<https://doi.org/10.1088/1361-6587/ab4613>

## Laser-induced acceleration of Helium ions from unpolarized gas jets

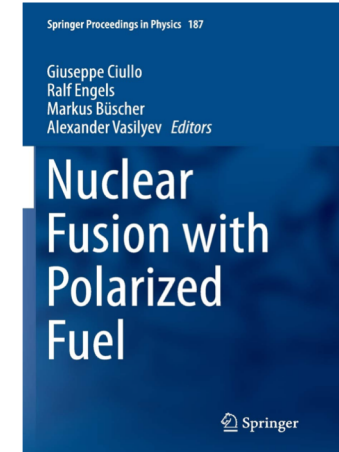
Ilhan Engin<sup>1,12,13</sup> , Zahra M Chitgar<sup>2,3</sup> , Oliver Deppert<sup>4</sup>, Laura Di Lucchio<sup>2</sup>, Ralf Engels<sup>5</sup>, Pavel Fedorets<sup>1,6</sup>, Simon Frydrych<sup>4</sup>, Paul Gibbon<sup>2</sup> , Annika Kleinschmidt<sup>4</sup>, Andreas Lehrach<sup>3,5,7</sup> , Rudolf Maier<sup>5</sup>, Dieter Prasuhn<sup>5</sup> , Markus Roth<sup>4</sup> , Friederike Schlüter<sup>1</sup>, Claus M Schneider<sup>1</sup>, Thomas Stöhlker<sup>8,9,10</sup> , Katharina Strathmann<sup>1</sup> and Markus Büscher<sup>1,11</sup> 



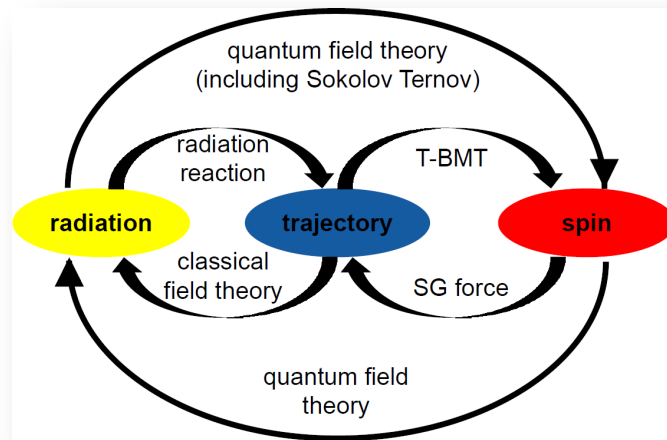
# SPIN-POLARIZED ION BEAMS

## The Why and the How (see LPA talk from Anna Hützen)

- Laser acceleration of polarized beam for fundamental physics
- Feasibility of laser-induced polarized nuclear fusion with increased energy gain



- How does the polarization change in a strong magnetic field of the laser and/or plasma medium?



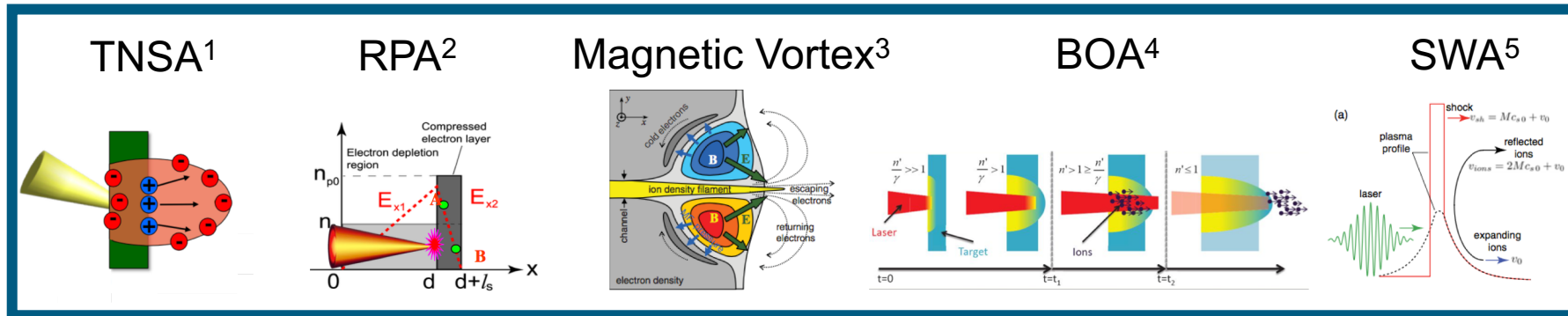
### Spin-polarized particle beams from laser-plasma accelerators

Johannes Thomas<sup>1</sup>, Anna Hützen<sup>2,3</sup>, Andreas Lehrach<sup>4,5</sup>, Alexander Pukhov<sup>1</sup>, Liangliang Ji<sup>6,8</sup>, Yitong Wu<sup>6,7</sup>, and Markus Büscher<sup>2,3</sup>

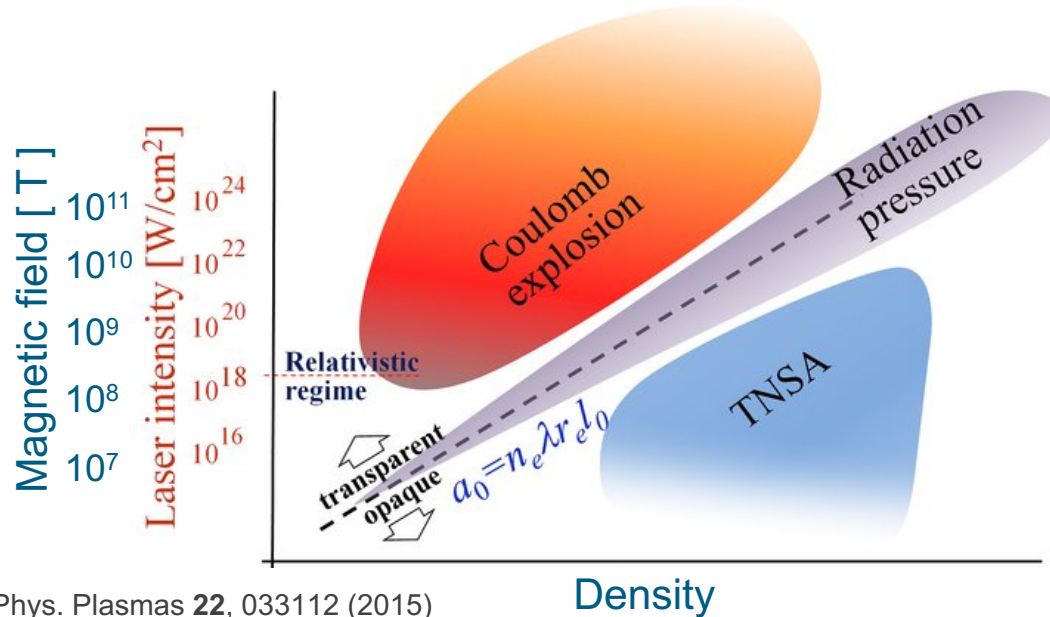
<sup>1</sup>Institut für Theoretische Physik I, Heinrich-Heine-Universität Düsseldorf, Universitätsstr. 1, 40225 Düsseldorf, Germany

<sup>2</sup>Peter Grünberg Institut (PGI-6), Forschungszentrum Jülich, Wilhelm-Johnen-Str. 1, 52425 Jülich, Germany

# LASER-DRIVEN ION ACCELERATION



1. S Hatchett, et al, PoP 7, 2076 (2000); 2. Esirkepov, et al, PRL 92, 175003 (2004); 3. SV Bulanov, et al, PRL 98, 049503 (2007); 4. L. Yin et al., Phys. Plasmas 14 056706 (2007); 5. D Haberberger, et al, Nat Phys 8, 95 (2012); F Fiuza, et al, PRL 109, 215001 (2012);

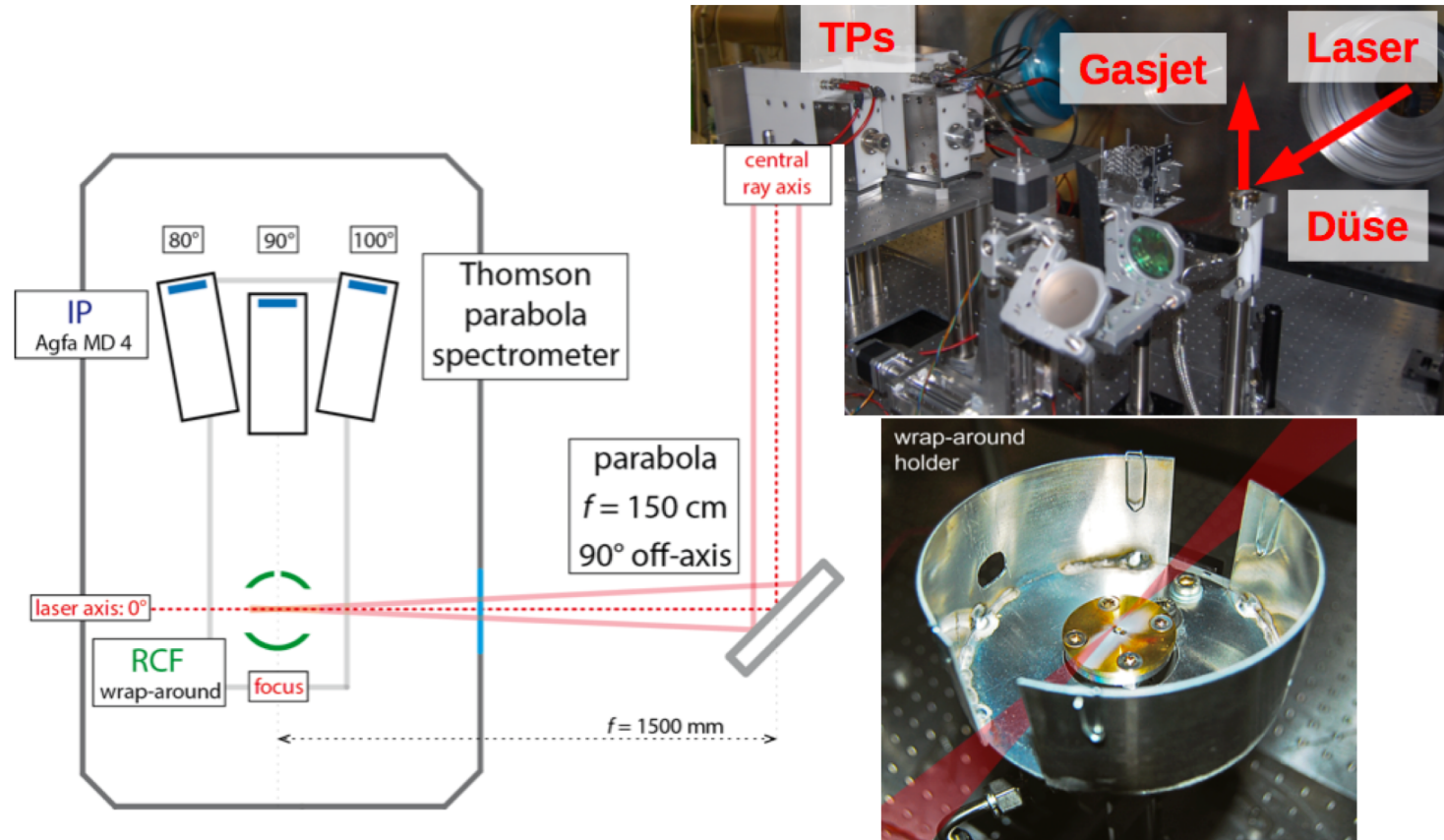


K. V. Lezhni et al. Phys. Plasmas 22, 033112 (2015)

- Polarized  $^3\text{He}$  gas only
- The driving acceleration mechanism in our case is *Coulomb explosion*:  
Wei M S et al 2004 PRL 93 155003  
Willingale L et al 2006 PRL 96 245002  
Lifschitz A, et al 2014 NJP 16 033031)

# PHELIX EXPERIMENT SETUP

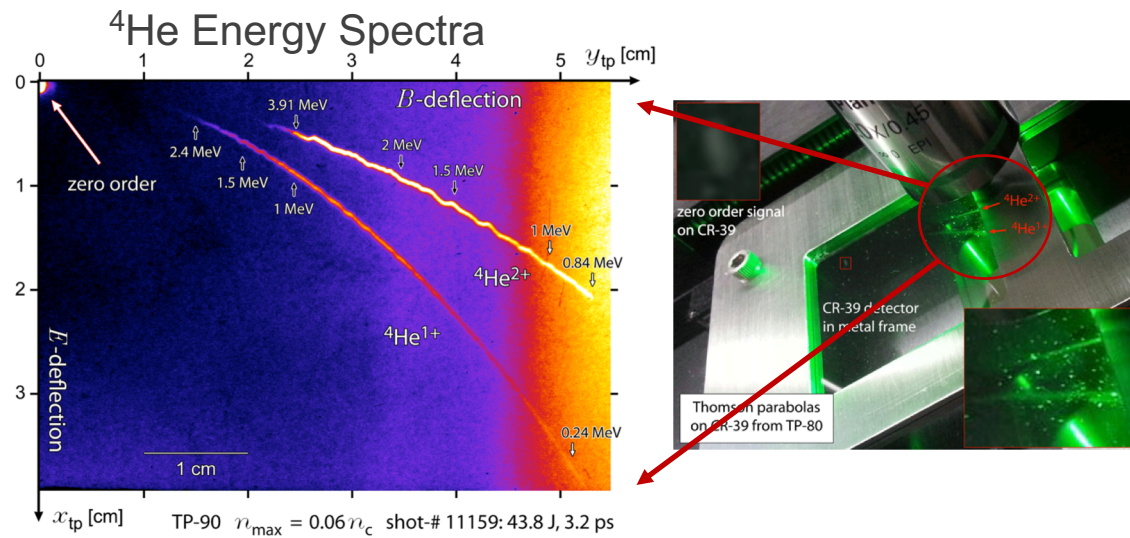
First experiment with unpolarized  $^3,4\text{He}$  gas target, January 2015



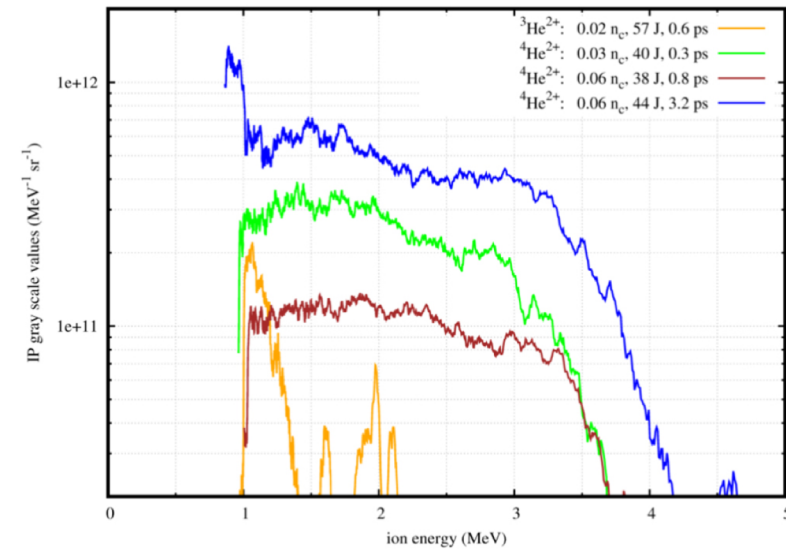
[I. Engin, Z. Chitgar et al, Plasma Phys. Control. Fusion 61 115012 \(2019\);](#)

[I. Engin, Towards Polarization Measurements of Laser-accelerated Helium-3 Ions, PhD Thesis: U. Düsseldorf, 2015](#)

# 3,4He ION ENERGY SPECTRA



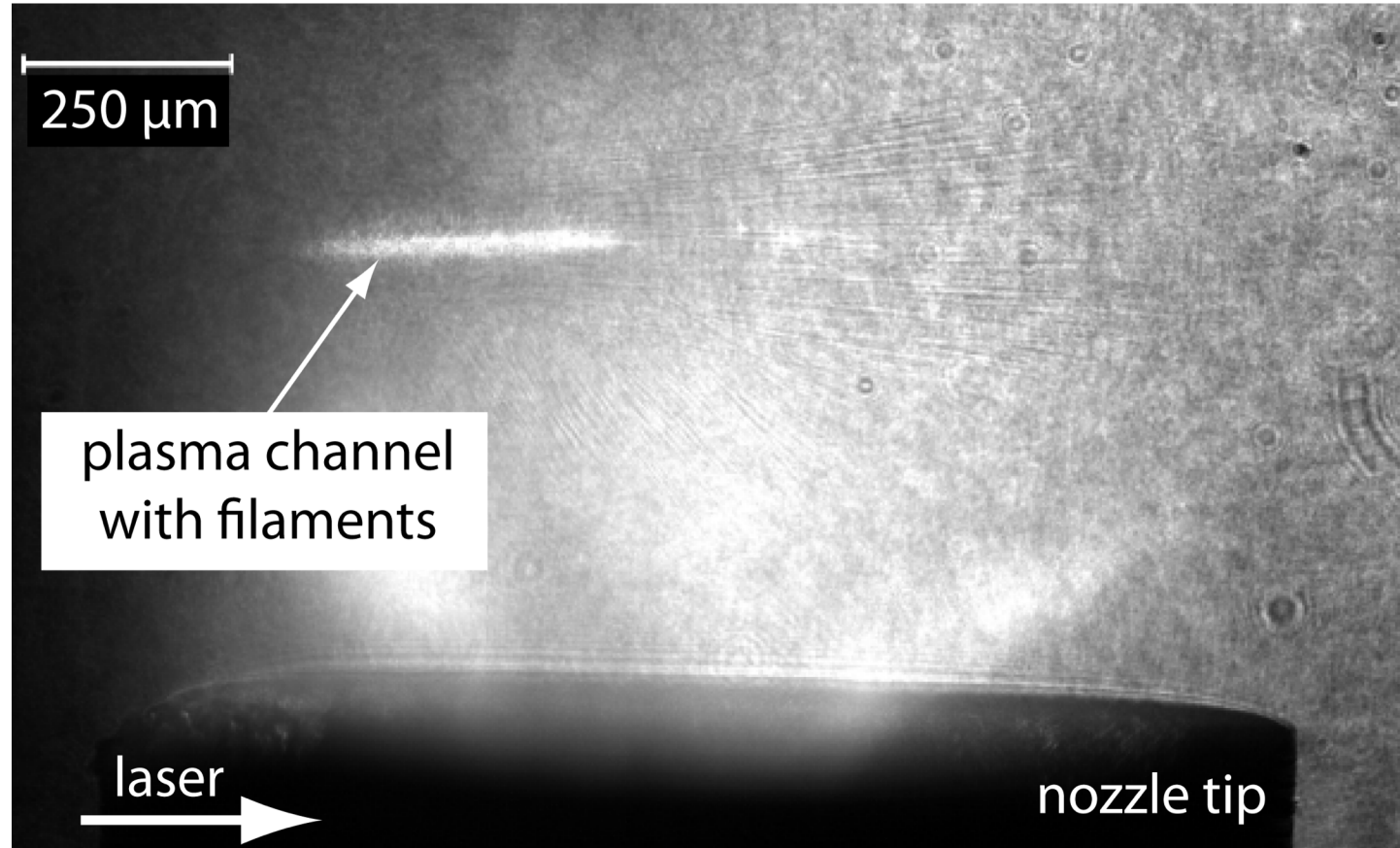
3,4He Energy Spectra



- Large variation with density and pulse duration
- Lower intensity/longer pulse seems to produce more MeV ions

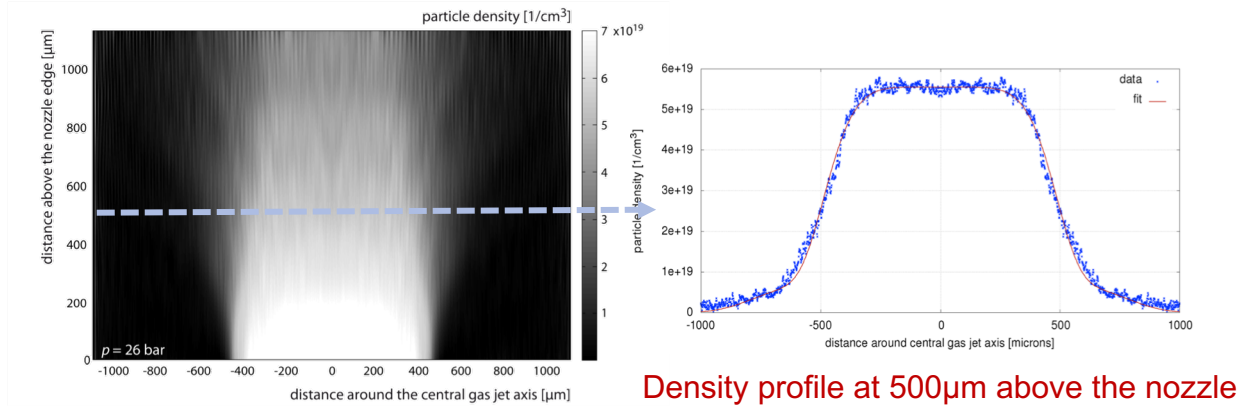
# PLASMA CHANNEL SHOWS FILAMENTATION

⇒ Hints at complex pulse propagation dynamics



# ANALYSIS USING PIC SIMULATIONS (EPOCH 2D)

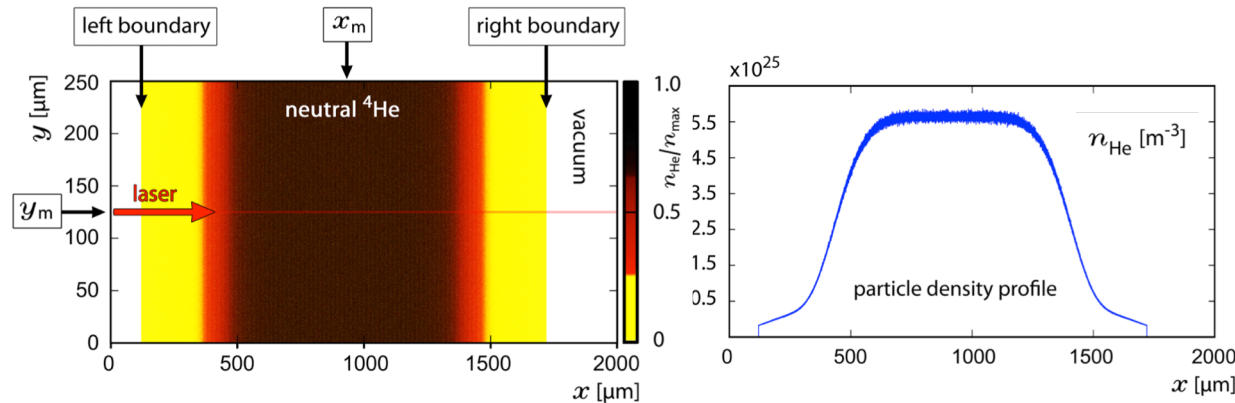
- Experiment



### PHELIX parameters:

intensity  $I_L \sim 1.4 \times 10^{19} \text{ Wcm}^{-2}$   
 wavelength  $\lambda_L = 1.053 \mu\text{m}$   
 pulse duration  $\tau_L = 0.8 \text{ ps}$   
 FWHM = 25.7  $\mu\text{m}$   
 critical density  $n_c = 1.0 \times 10^{21} \text{ cm}^{-3}$   
 normalized vector potential  $a_0 \sim 3.3$

- Model



### <sup>4</sup>He Target

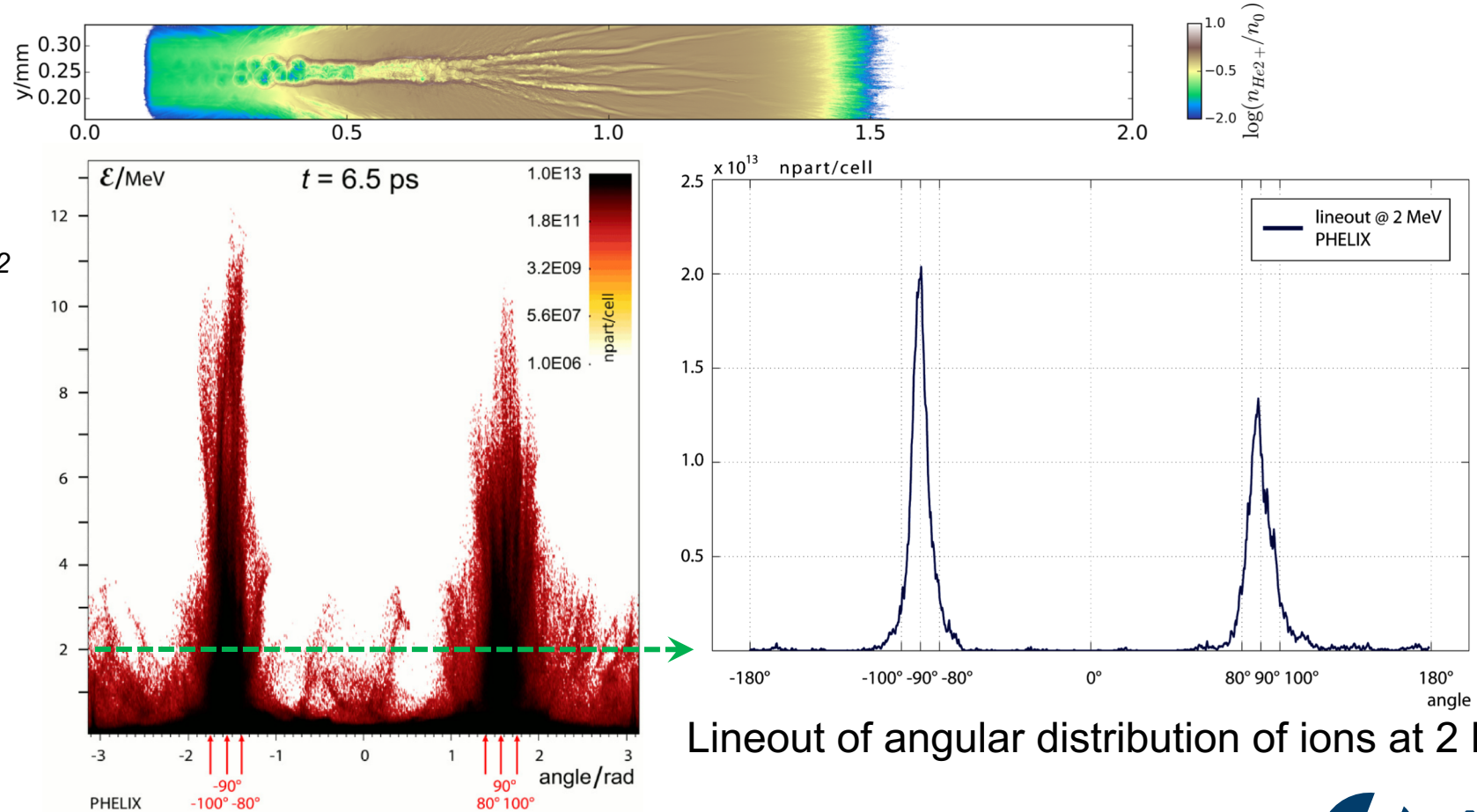
2000 × 250  $\mu\text{m}^2$   
 Resolution 40 nm  $\sim 26$  grid per  $\lambda$   
 6<sup>th</sup> order semi Gaussian distribution  
 $2.3 \times 10^8$  particles  $\sim 1.5$  ppc

# ANGULAR DISTRIBUTION OF HE ION EMISSION

## Particle-in-Cell Simulations (Zahra Chitgar)

- Parameters:

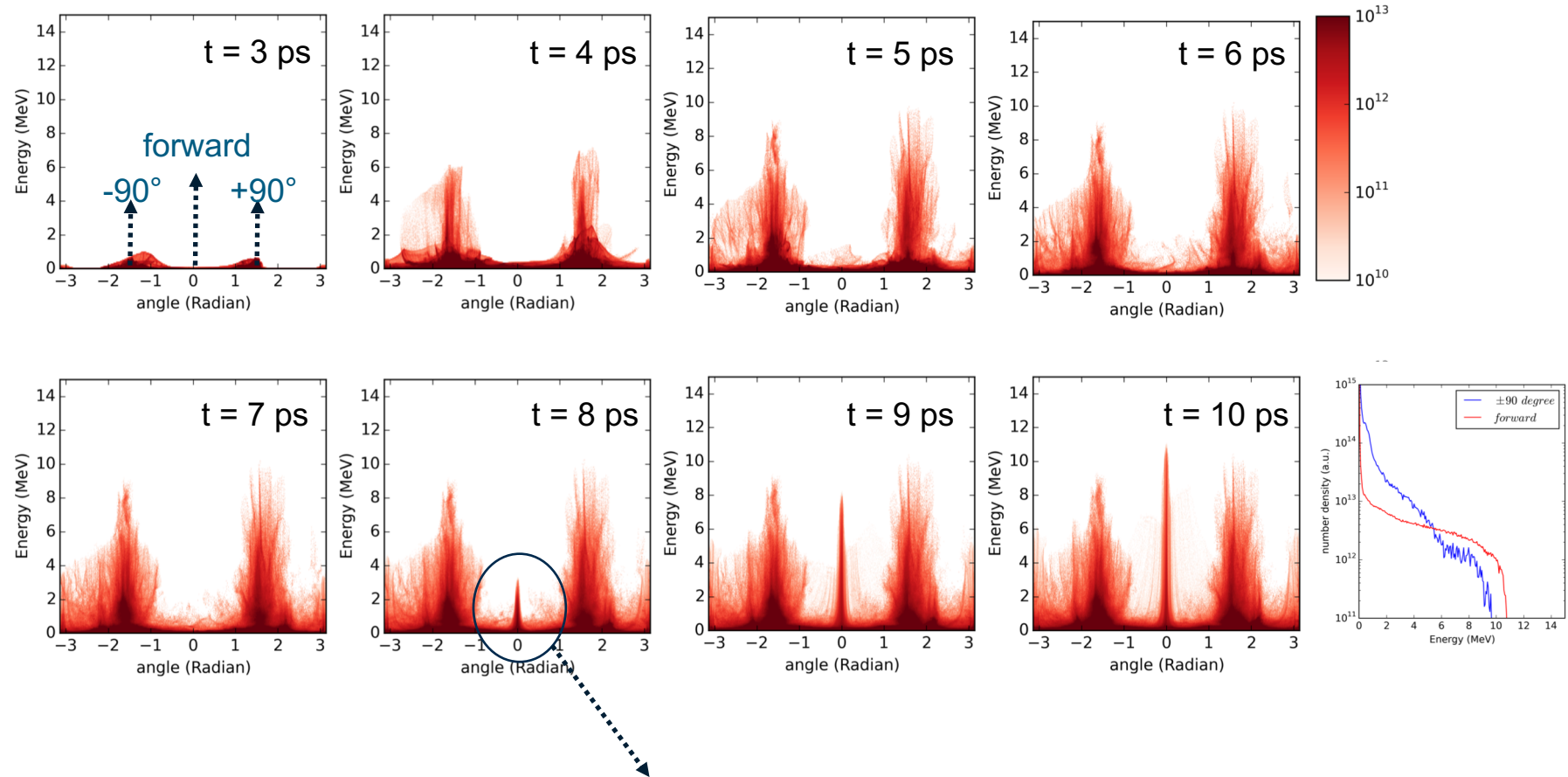
- $n_{\text{He}} = 0.06 n_c$
- $\tau = 0.8 \text{ ps}$
- $I_L = 1.4 \times 10^{19} \text{ Wcm}^{-2}$
- $\lambda = 1 \text{ }\mu\text{m}$



Lineout of angular distribution of ions at 2 MeV

# EVOLUTION OF ANGULAR DISTRIBUTION

$n_{\text{He}} = 0.06 n_c$   
 $\tau = 0.8 \text{ ps}$   
 $I_L = 1.4 \times 10^{19} \text{ Wcm}^{-2}$

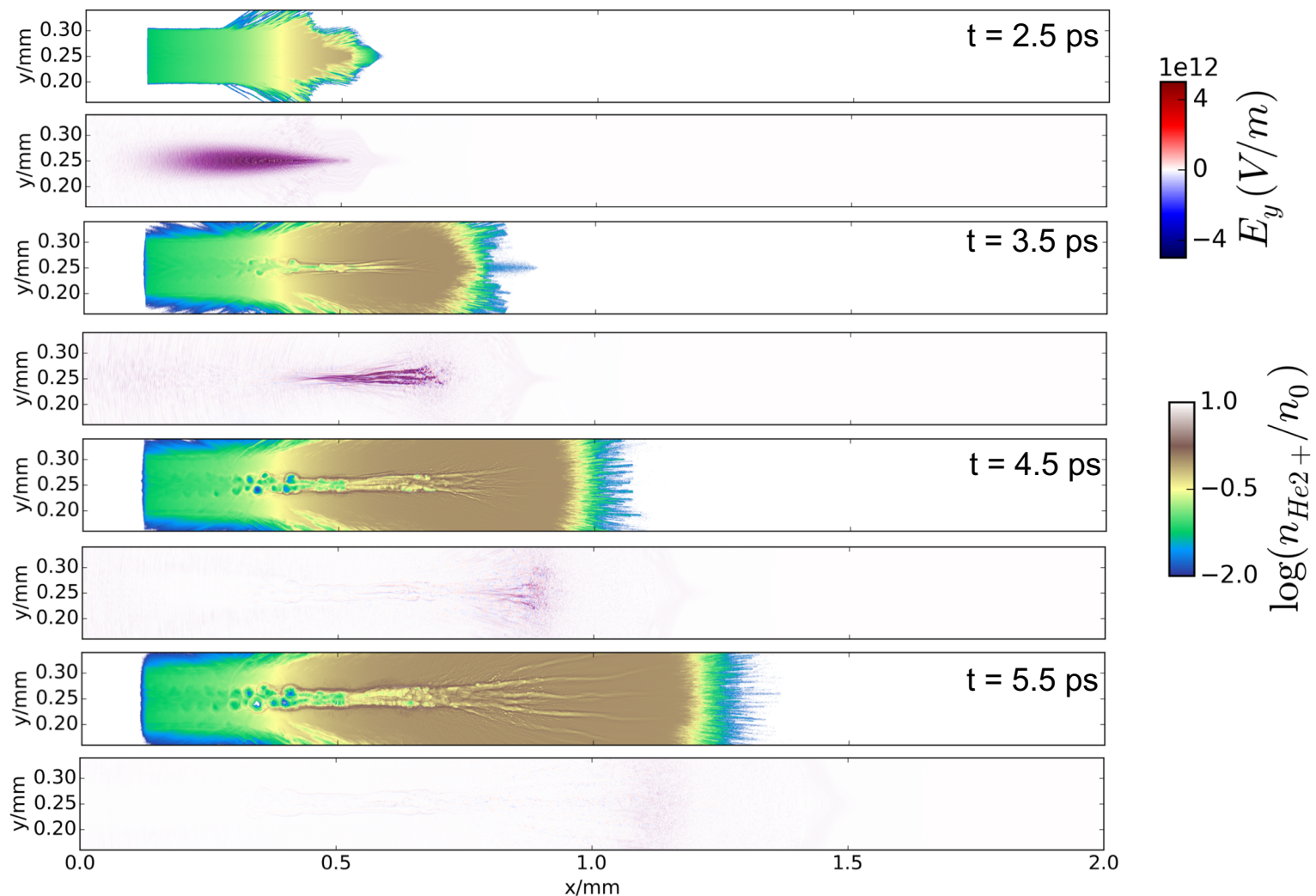


Onset of forward acceleration

# CHANNEL EVOLUTION AT HIGH DENSITY (0.06 NC)

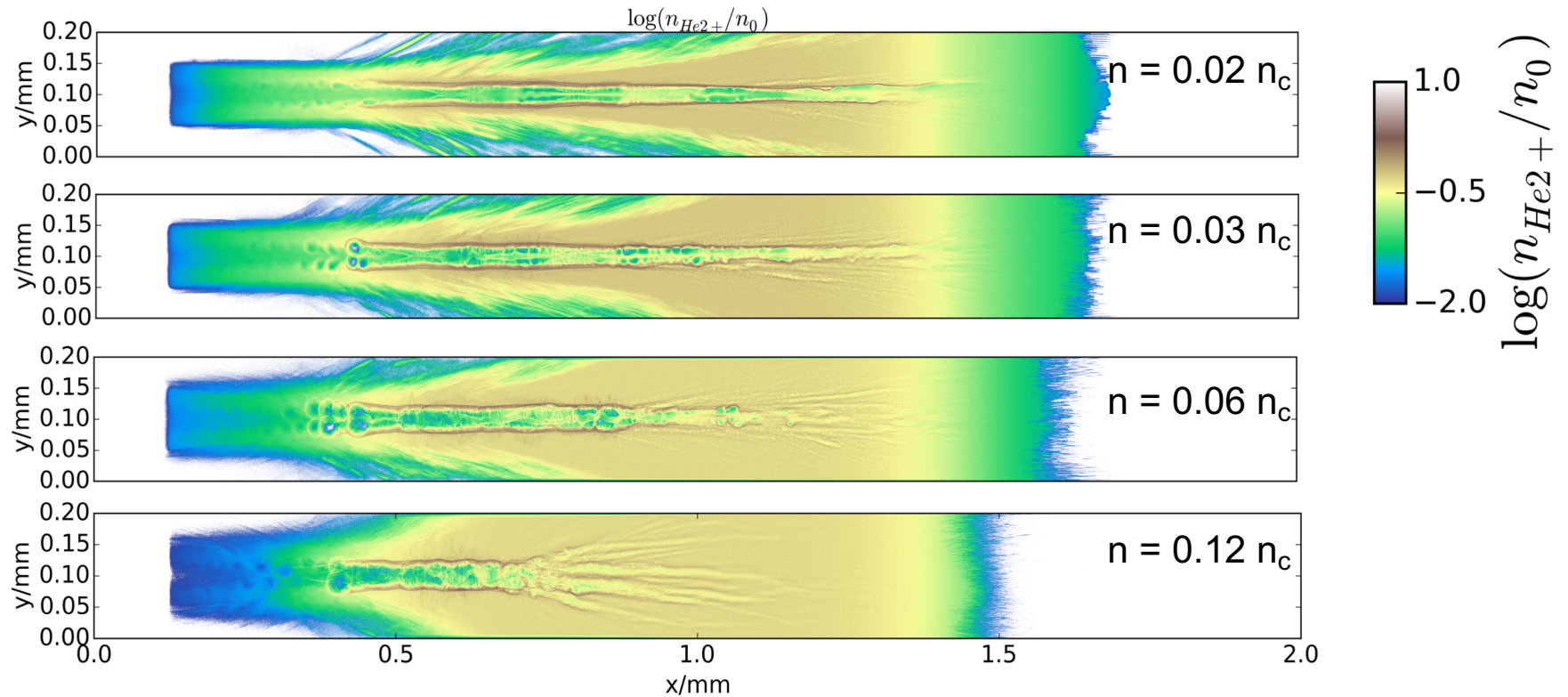
Filamentation prevents laser propagation through whole target

$n_{\text{He}} = 0.06 n_c$   
 $\tau = 0.8 \text{ ps}$   
 $I_L = 1.4 \times 10^{19} \text{ Wcm}^{-2}$



# CHANNEL LENGTH DEPENDENCE (I)

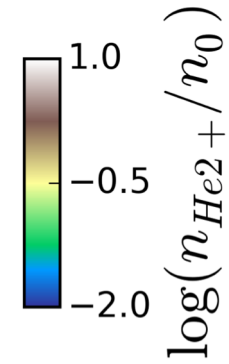
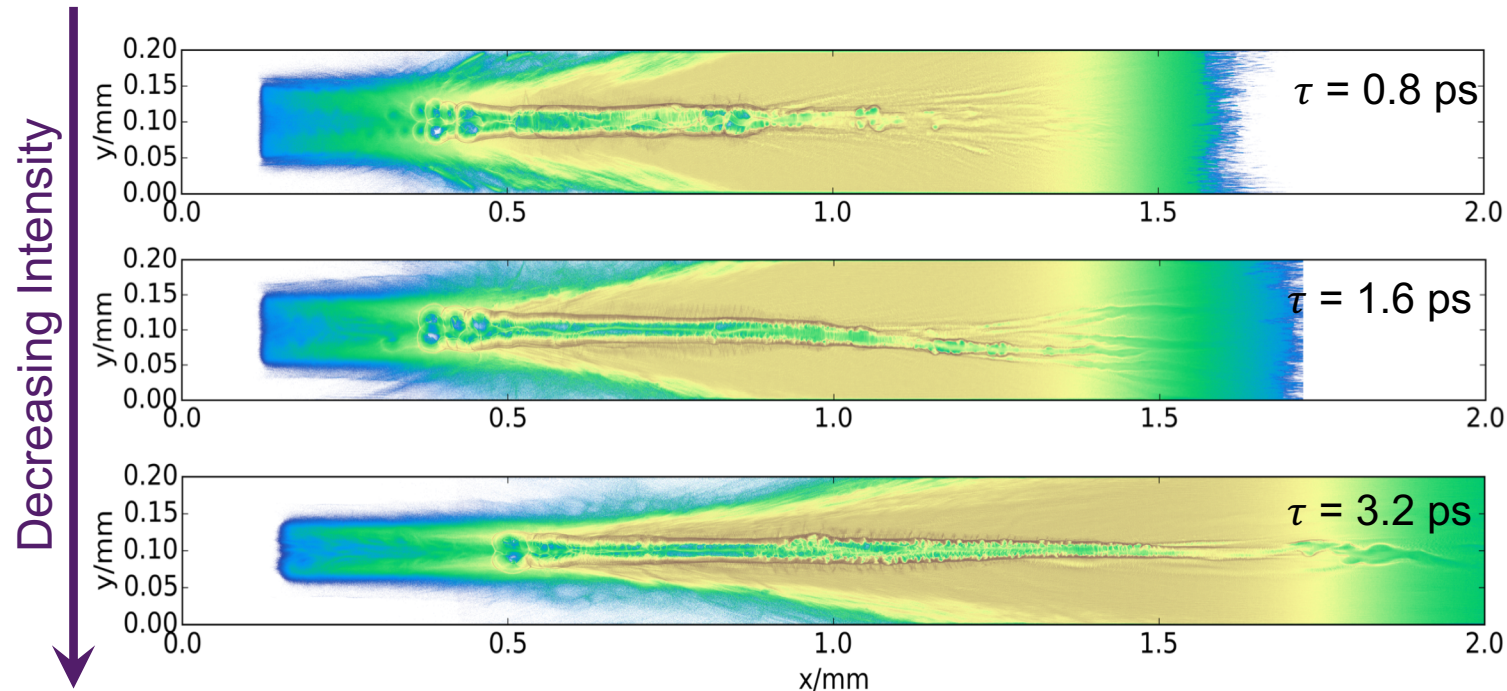
Decreases with Target Density



- Same laser pulse parameters, i.e. duration  $\tau = 0.8$  ps, energy  $U = 57$  J

# CHANNEL LENGTH DEPENDENCE (II)

Increases with lower intensity

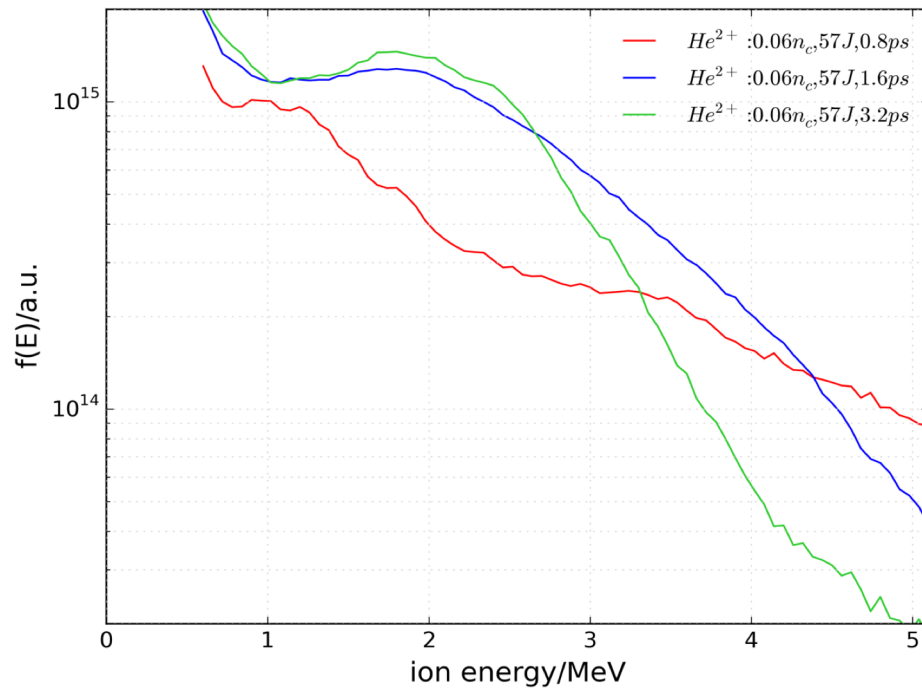


- **Fixed target density  $n = 0.06 n_c$  and laser energy  $U = 57 \text{ J}$**

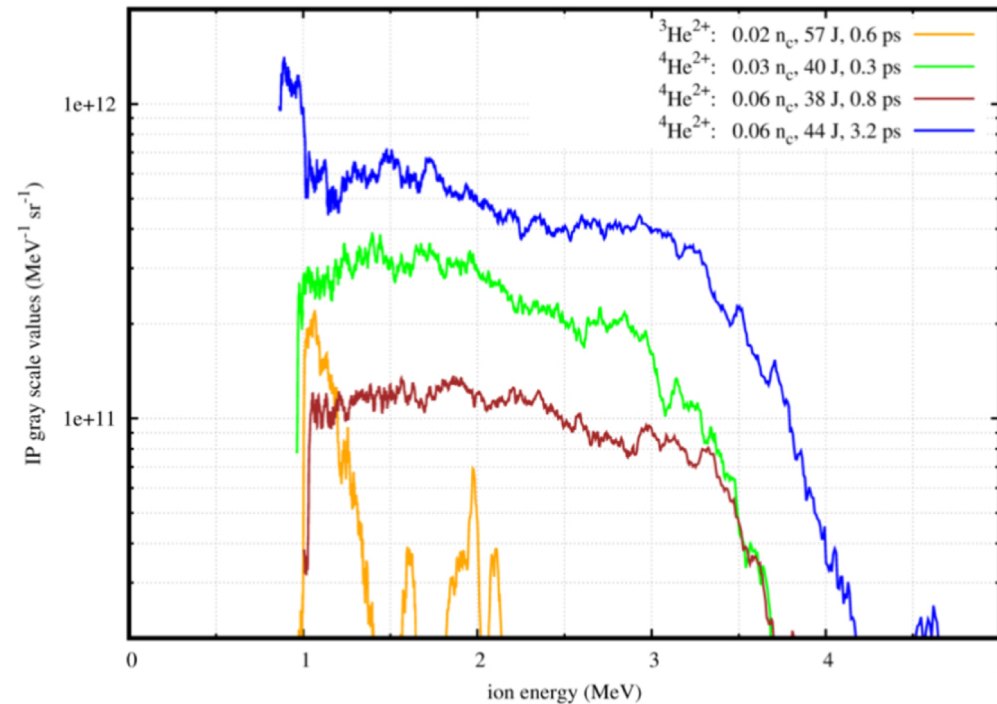
# ENERGY SPECTRA OF $^4\text{He}$ IONS

Longer, lower intensity pulse leads to higher radial ion flux in the 1-4 MeV range

Simulation results @  $t = 6.5$  ps



Experimental results



# SUMMARY OF ION ACCELERATION STUDY

## Experiment Results

- Acceleration of  ${}^3,4\text{He}^{1+,2+}$  in the radial direction
- Maximum Energy:  $\sim 5$  MeV
- Flux  $\sim 10^9$  MeV $^{-1}$  Sr $^{-1}$

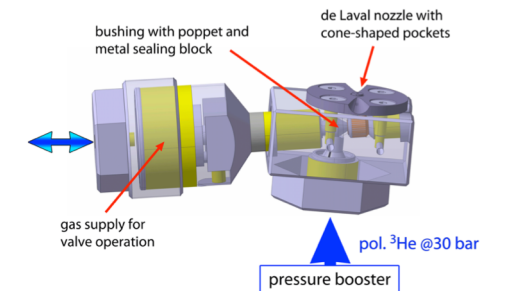
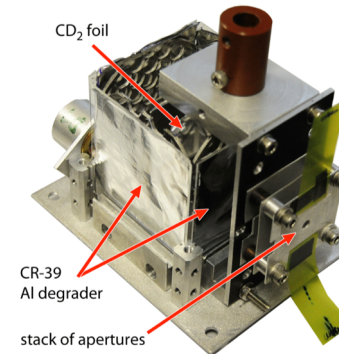
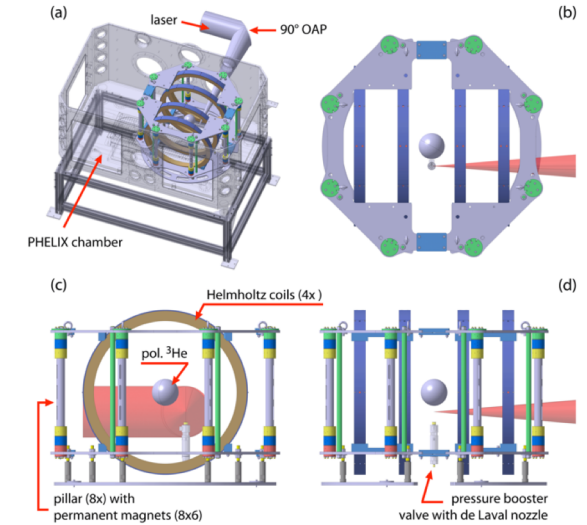
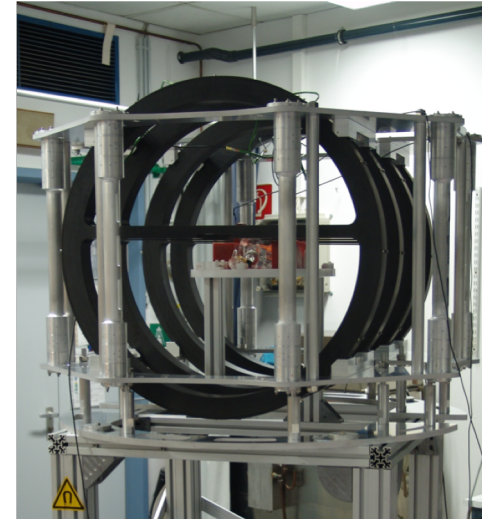
## Simulation Results

- Ion Acceleration at  $\pm 90$  degrees
- Maximum energy:  $\sim 10$  MeV
- Appearance of TNSA-like forward acceleration target rear at lower densities
  - (cf. Willingale2006, Lifschitz2014)
- Channel length dependent on both density and intensity (hosing, filamentation, other instabilities ...?)

# NEXT EXPERIMENT @ PHELIX

November 2020 ... ?

- Test measurement with unpolarized helium-3 beams @ Jülich Tandetron
- Preparation and calibration of the Polarimeter
- Preparation of polarized  $^3\text{He}$  Target
- The main experimental run with a polarized target, scheduled at **PHELIX** for **November 2020**



# FURTHER READING

- L. Di Lucchio and P. Gibbon, *Relativistic attosecond electron bunch emission from few-cycle laser irradiated nanoscale droplets*, Phys. Rev. Special Topics Accel. & Beams 18, 023402 (2015). <https://doi.org/10.1103/PhysRevSTAB.18.023402>
- Cardenas, D. E., Ostermayr, T. M., Lucchio, L. Di, Hofmann, L., Kling, M. F., Gibbon, P., Schreiber, J., Veisz, L., *Sub-cycle dynamics in relativistic nanoplasma acceleration*. Scientific Reports 1–8 (2019). <http://dx.doi.org/10.1038/s41598-019-43635-3>
- Chitgar, Z. M., Gibbon, P., Böker, J., Lehrach A. and Büscher, M., *Electron self-injection threshold for the tandem-pulse laser wakefield accelerator*, Physics of Plasmas **27**, 023106, (2020). <https://doi.org/10.1063/1.5117503>
- Engin, I. Chitgar, Z., Deppert, O., Di Lucchio, L., Engels, R. W., Fedorets, P., Frydrych, S., Gibbon, P., Kleinschmidt, A., Lehrach, A., Maier, R., Prasuhn, D., Roth, M., Schlüter, F., Schneider, C. M., Stöhlker, T., Strathmann, K. and Büscher, M., *Laser-induced acceleration of Helium ions from unpolarized gas jets*, Plasma Physics and Controlled Fusion 61, 115012 (2019) <https://doi.org/10.1088/1361-6587/ab4613>

# COMING UP SOON ...

- Polarized proton beams from HCl targets (Anna Hützen)
- Pulsed X-rays from LPAs (Claus M Schneider)
  
- Circularly polarized harmonics from plasmas (Zahra Chitgar)
- Positron acceleration (Xiaofeng Li)

25 November 2020

8 January 2021