WG 1 resume

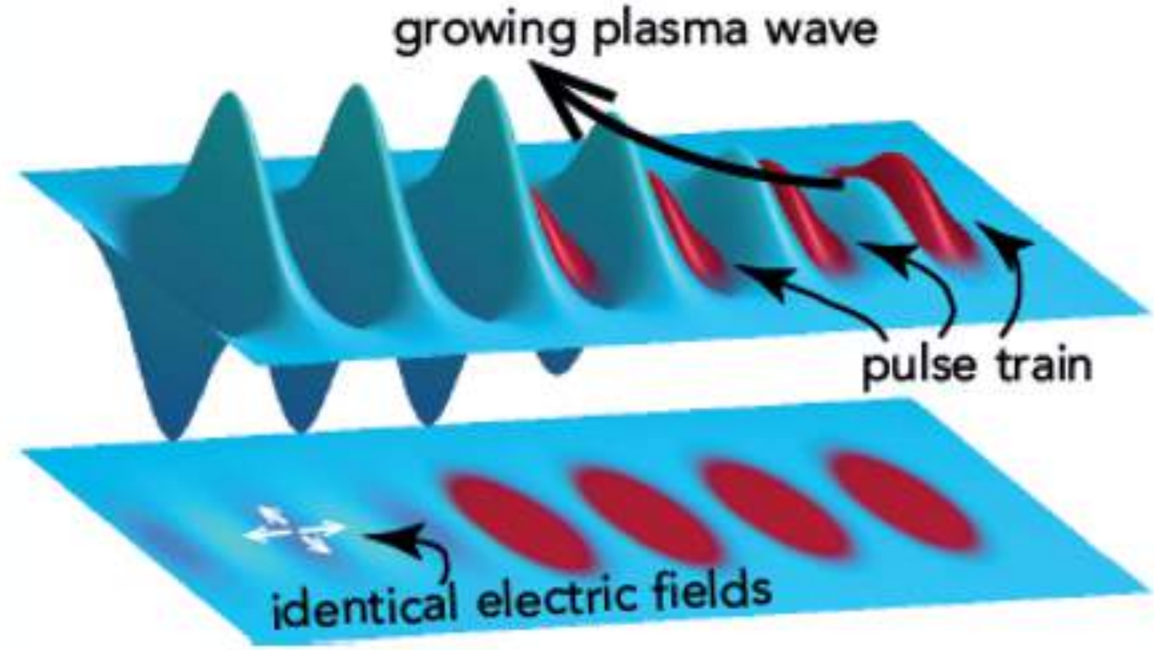
5 sessions :
26 talks-8 highlight talks-19 posters
including 3 highlight talks to PhD students

part I: Laser driven WF

MP-LWFA: Advantages

S.M. Hooker *et al.* *J. Phys. B* **47** 234003 (2013)

- Move energy storage from laser material to the plasma
- Reduce energy per laser pulse from joules to 10s mJ
  - Allows new, efficient laser technologies (thin-disk, fibre lasers, OPCPA)
- Peak intensity on optics reduced by *N*
  - Could reduce optical damage
  - Or, allow smaller diameter, shorter focal length optics
- Additional control over wake excitation
  - Vary spacing, energy, wavelength of pulses in train
- Natural architecture for "energy recovery"

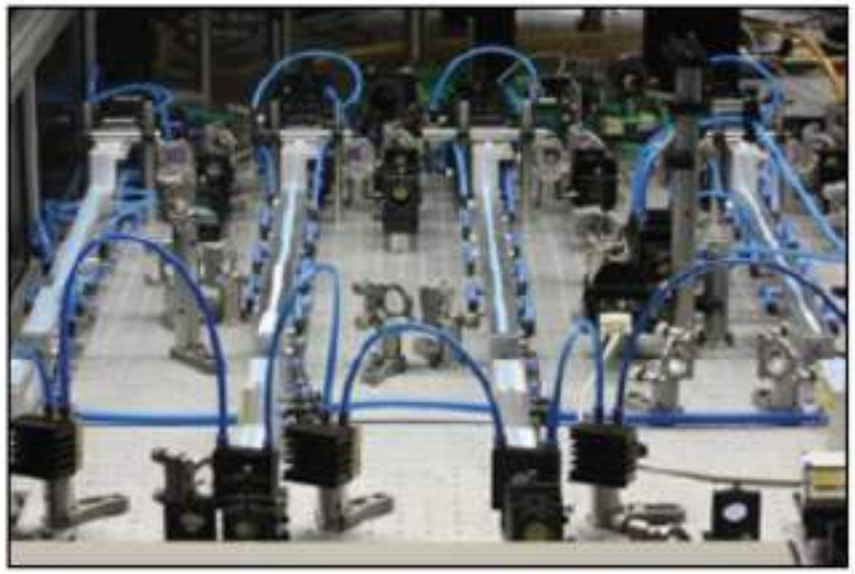


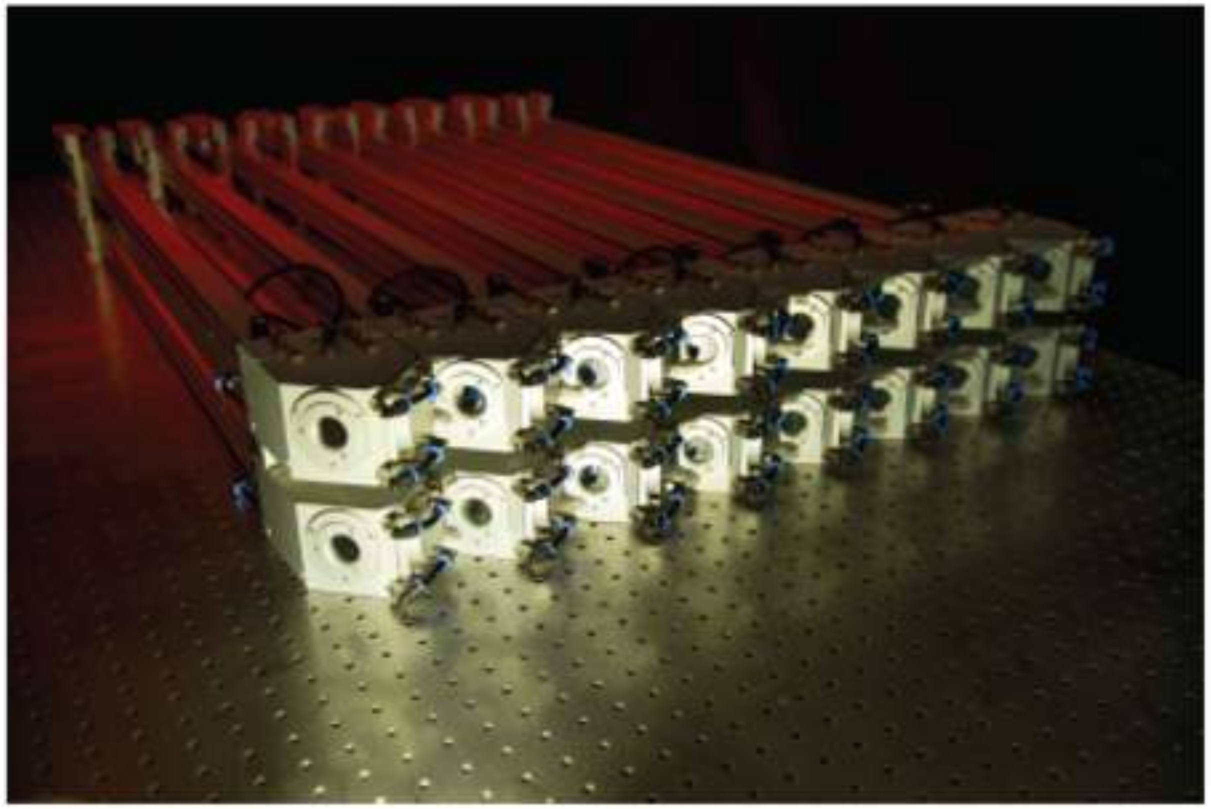
Multi-pulse LWFA
Only 4 laser pulses shown. In reality would use 10 - 100!

Coherent Addition of Ultrashort Pulses

4-channel fiber CPA system -> upgrade to 16-channel FCPA

Institute of Applied Physics
Friedrich-Schiller-Universität Jena



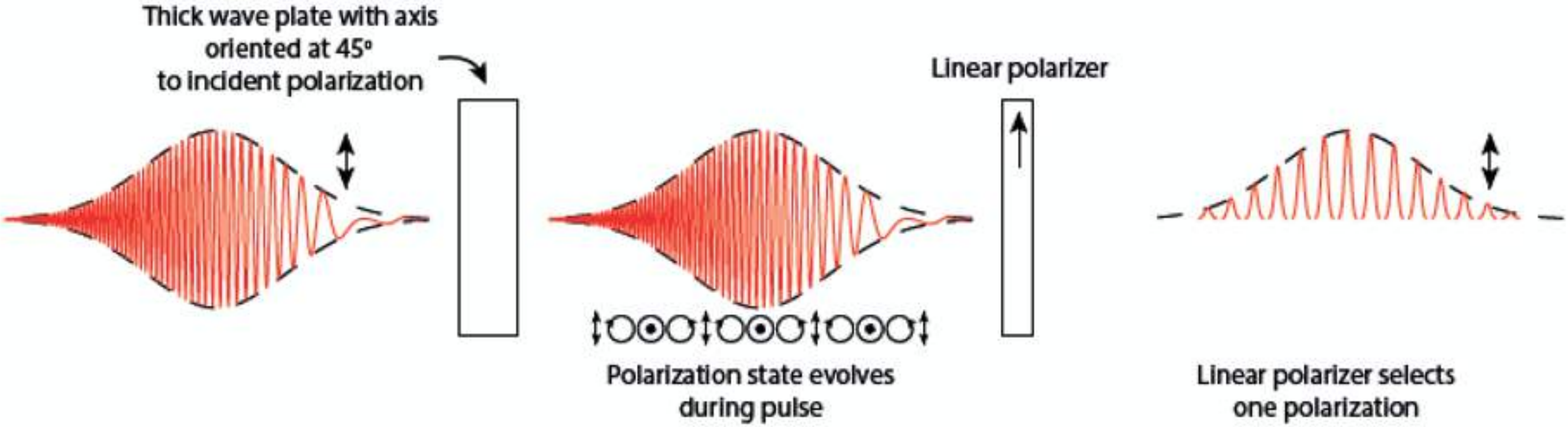


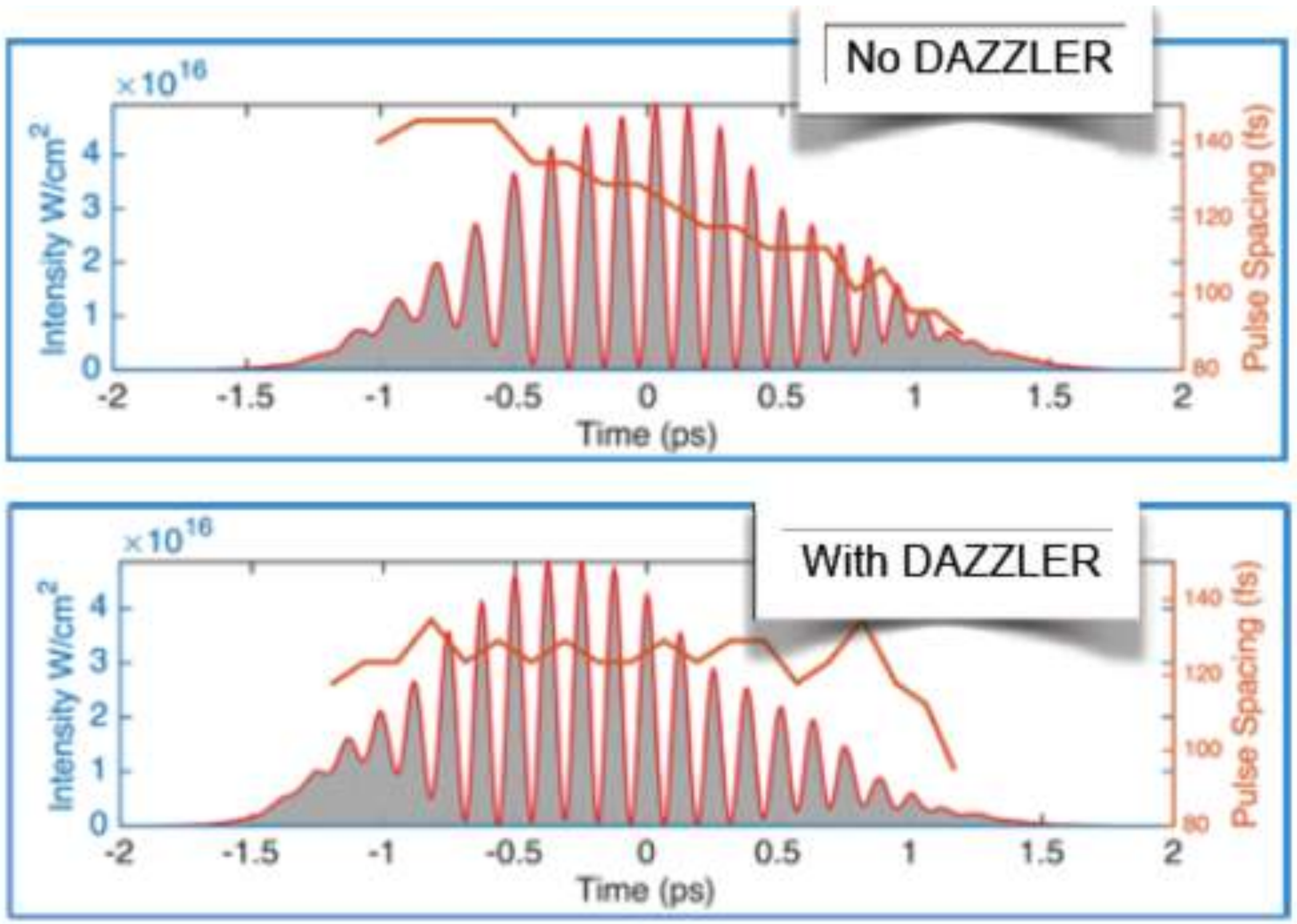
- **up to 5.7 mJ** pulse energy
- **200 fs** pulse duration
- **22 GW** peak power[1]
- **>500W** average power[2]
- **90%** combining efficiency
- **$M^2 < 1.2$**

Targeted performace:
>20mJ pulse energy and >2kW average power

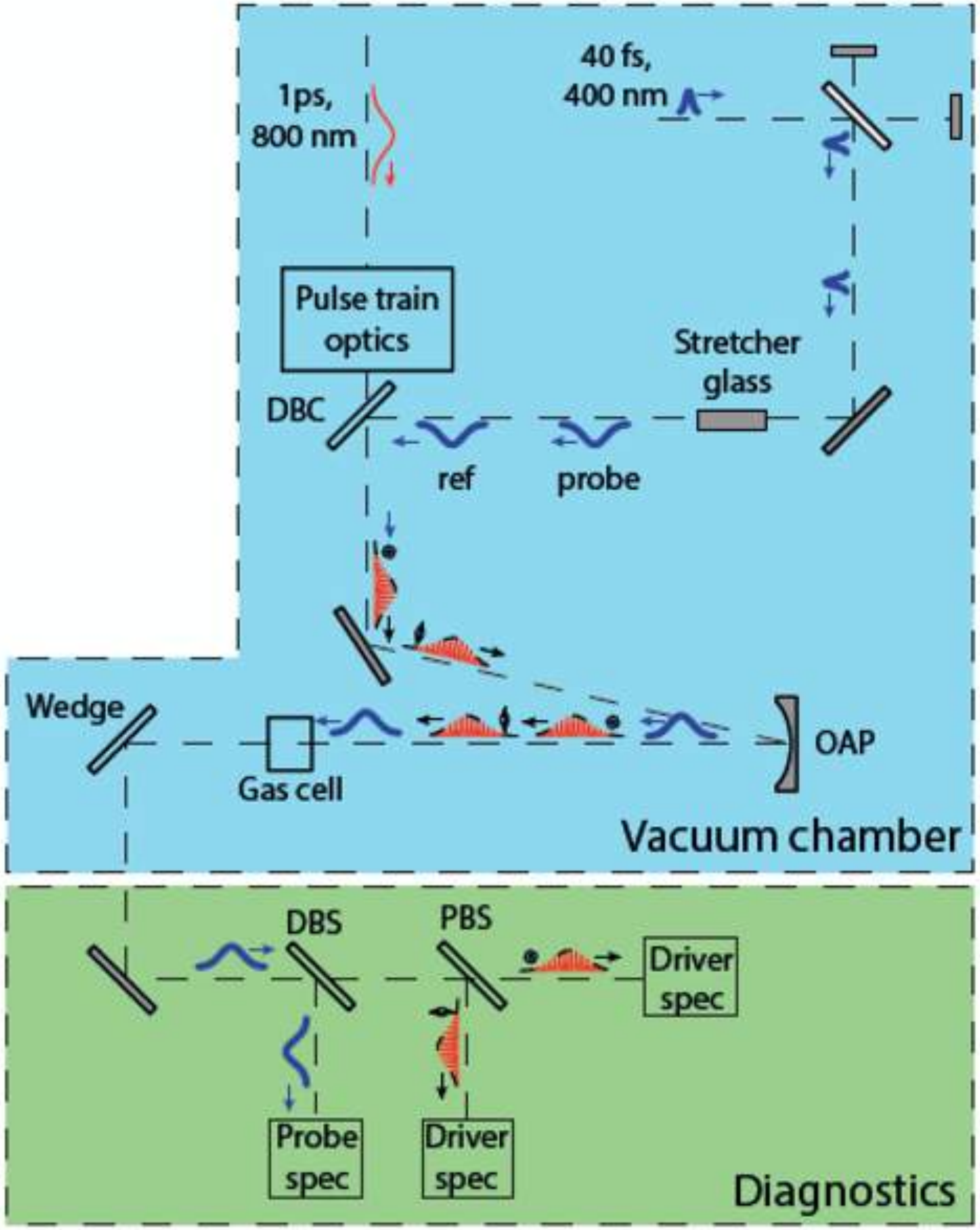
[1] A. Klenke et al. "22 GW peak-power fiber chirped-pulse-amplification system," Opt. Lett. **39**, 6875–6878 (2014).
[2] A. Klenke et al. "530 W, 1.3 mJ, four-channel coherently combined femtosecond fiber chirped-pulse [...]," Opt. Lett. **38**, 2283-2285 (2013)

Pulse train generation

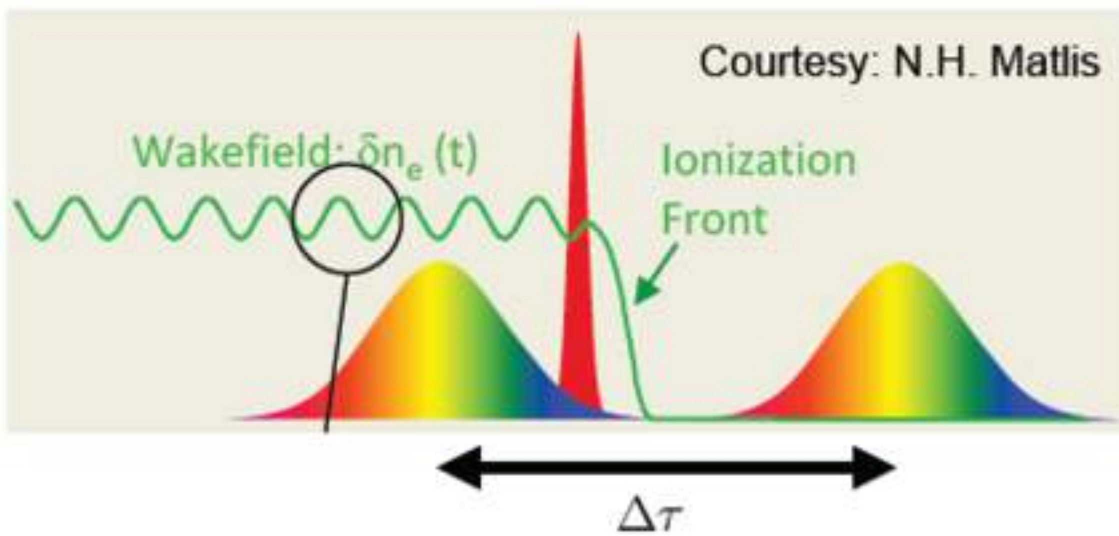




Proof-of-principle demonstration



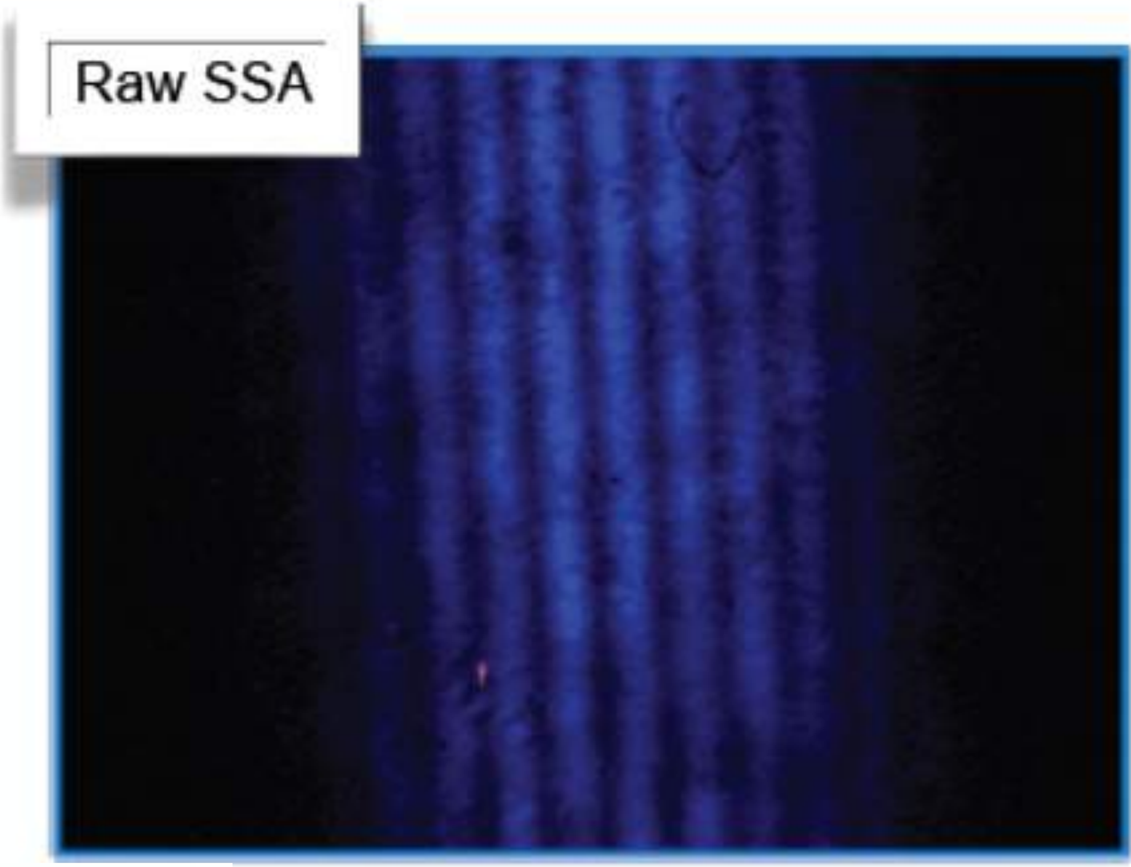
- Expts with Astra TA2 laser at RAL in progress
- Objectives:
  - Proof-of-principle demonstration
  - Study ion motion
  - Demonstrate coherent addition of wakes from two pulse trains
  - Demonstrate "energy recovery"

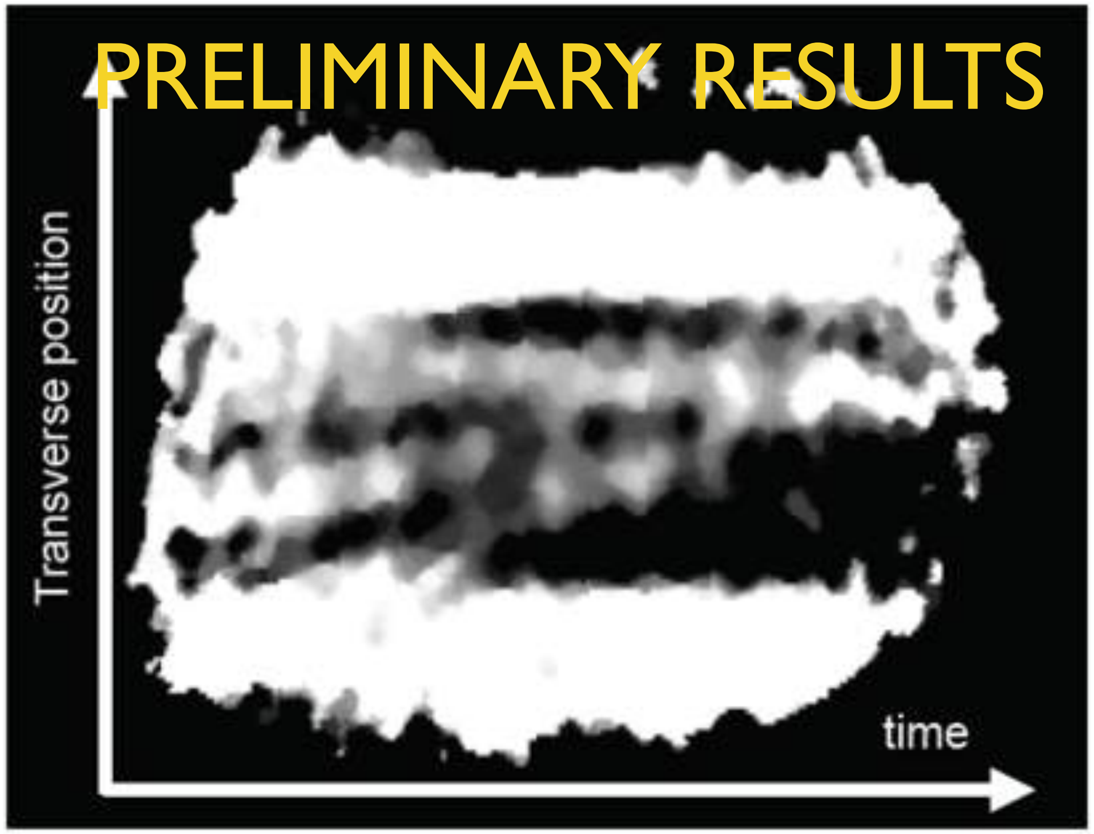


2nd European Advanced Accelerator Concepts Workshop, Elba, Italy, September 14-19 (2015)

Measured pulse trains

- Pulse trains measured by single-shot autocorrelator
- Allows third- and higher phases to be optimized by DAZZLER
- Very good agreement with theory





UNIVERSITY OF Nebraska Lincoln
Pioneering new frontiers.

HighLight: Sergei Kalmykov

Outstanding task:

GeV laser-plasma acceleration with sub-Joule (10-TW-scale) laser pulses

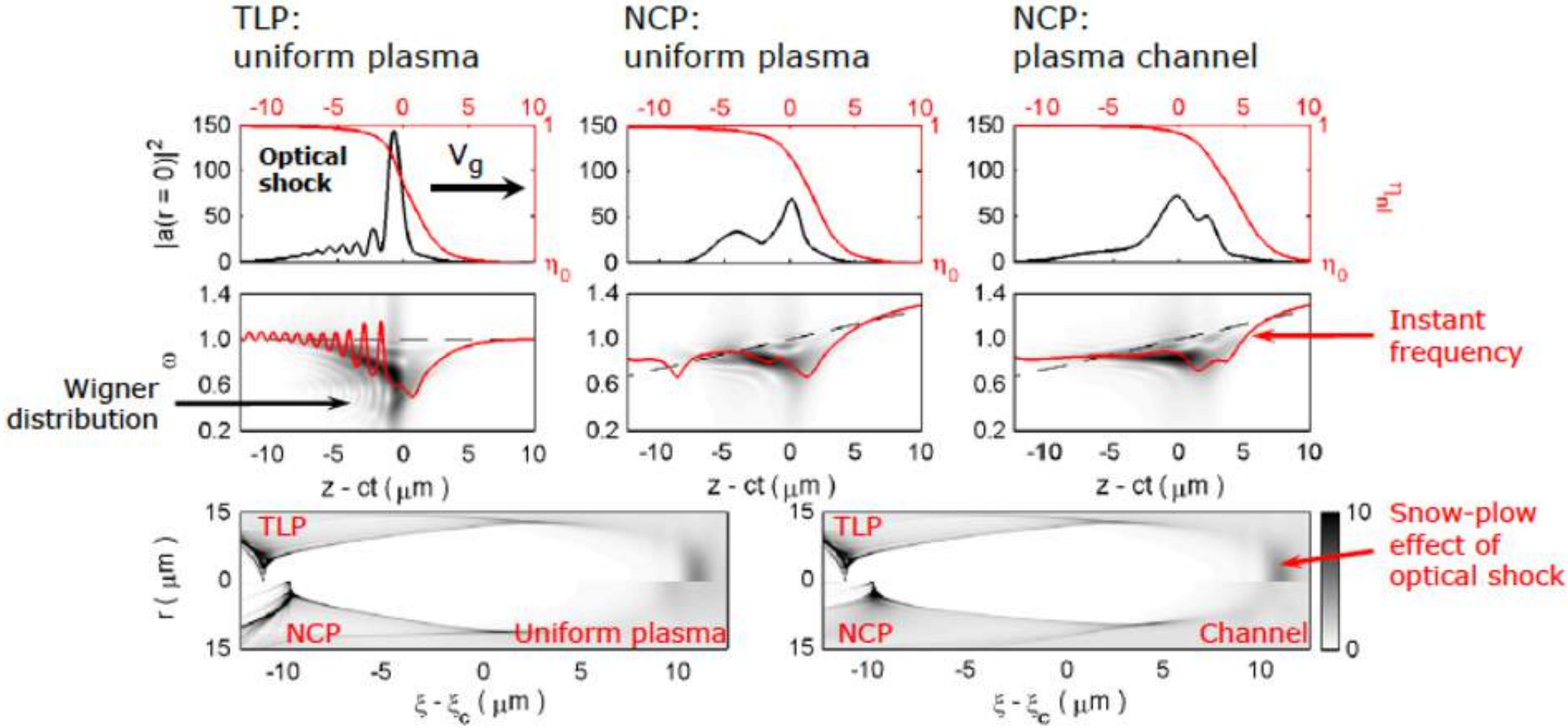
Moderate average power:

- enables *high repetition rate* needed by applications that require high dosage (medicine, nuclear fluorescence studies *etc.*)

  1J @1 kHz = 1 kW — a hard, yet manageable laser engineering problem

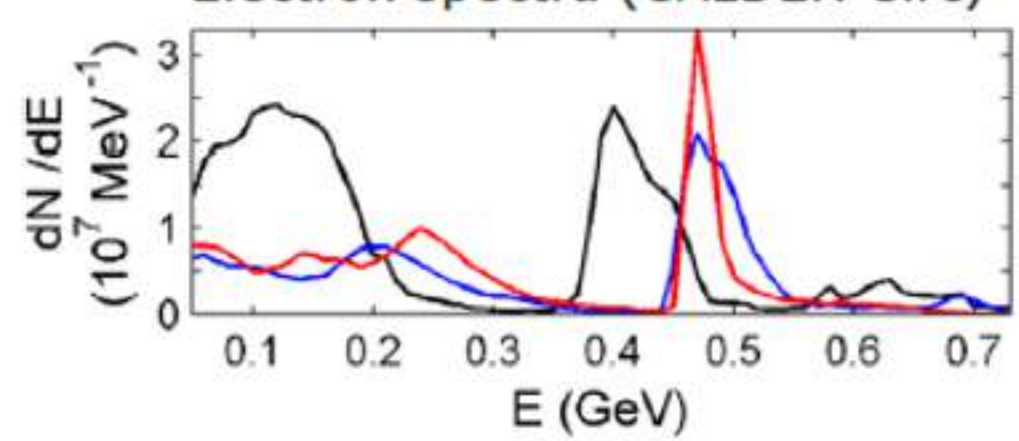
- helps *reduce the size and cost of facilities*
- *lifts the barriers for first-principle modeling*
- enables *real-time control of the laser pulse phase* (using genetic algorithms) for optimization of the acceleration process

Effect of negative chirp: Suppressing bubble expansion



z = 1.72 mm (70% of dephasing length)

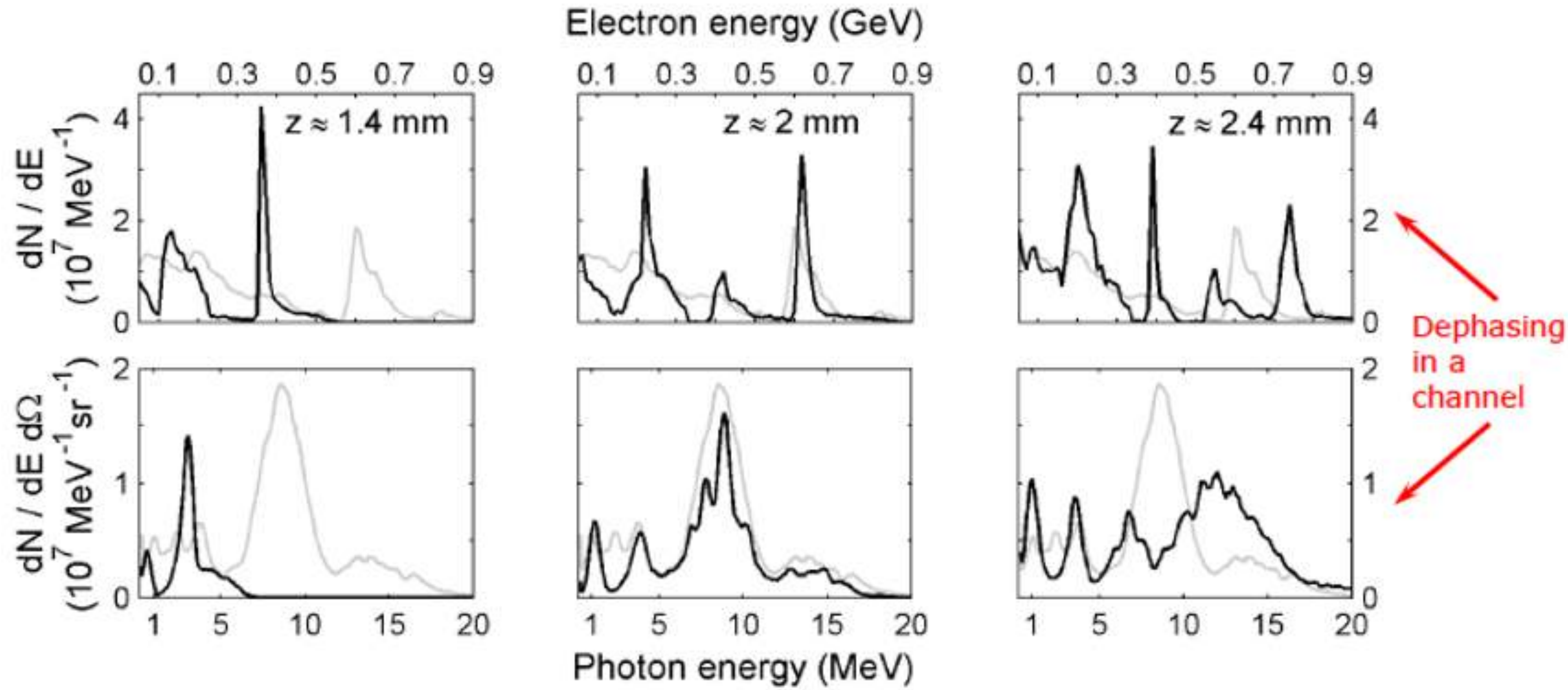
Electron spectra (CALDER-Circ)



- TLP – uniform plasma (black)
- NCP – uniform plasma (blue)
- NCP – plasma channel (red)

(WAKE simulations except the energy spectra)

Comb-like electron beams from the channel: Generating polychromatic, pulsed inverse-Thomson γ-rays



Gray: NCP in the uniform plasma (z = 2.16 mm; dephasing)

Black: NCP in the channel matched to the self-guided spot size

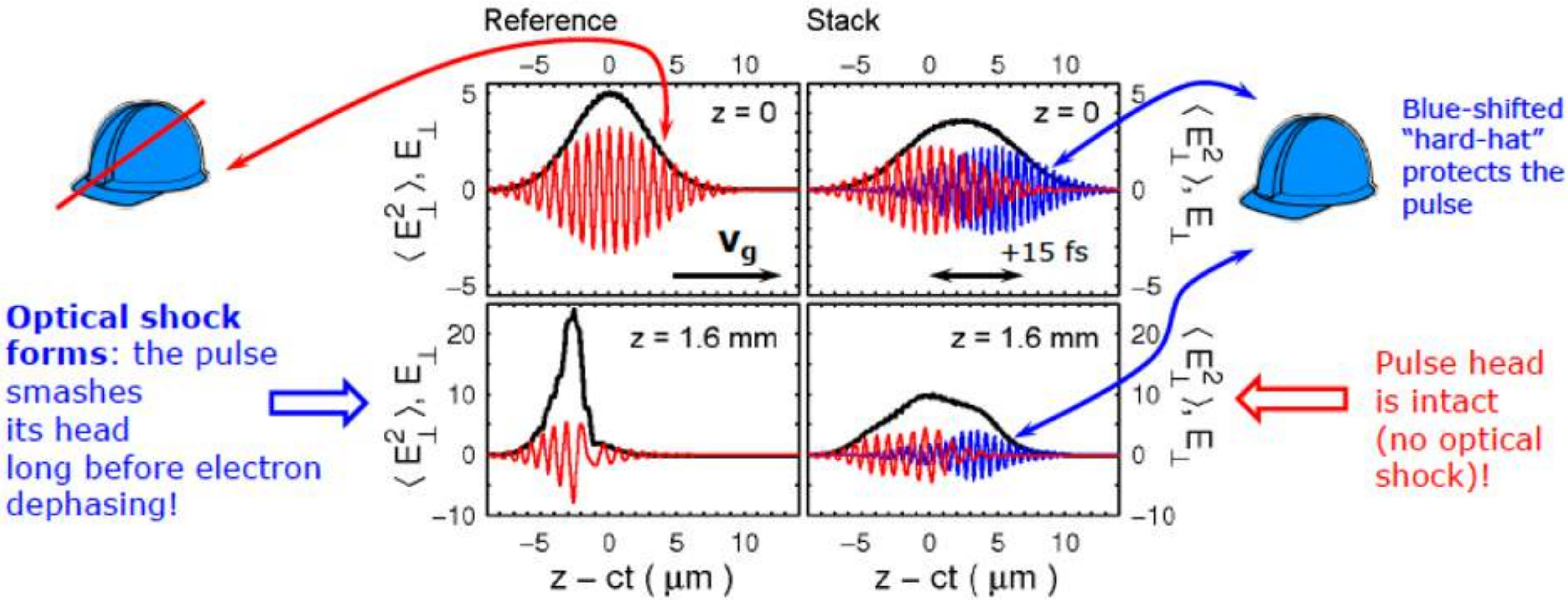
By dephasing, *four injections in the first bucket* yield four distinct, fs-length electron bunches with

$\varepsilon_{\perp}^{N} \sim 1$ mm mrad (conserved up to a third digit)

0.75 – 1.5 mrad divergence

relative energy spread 5–15%

Purpose of stacking:
Protecting the pulse from nonlinear erosion

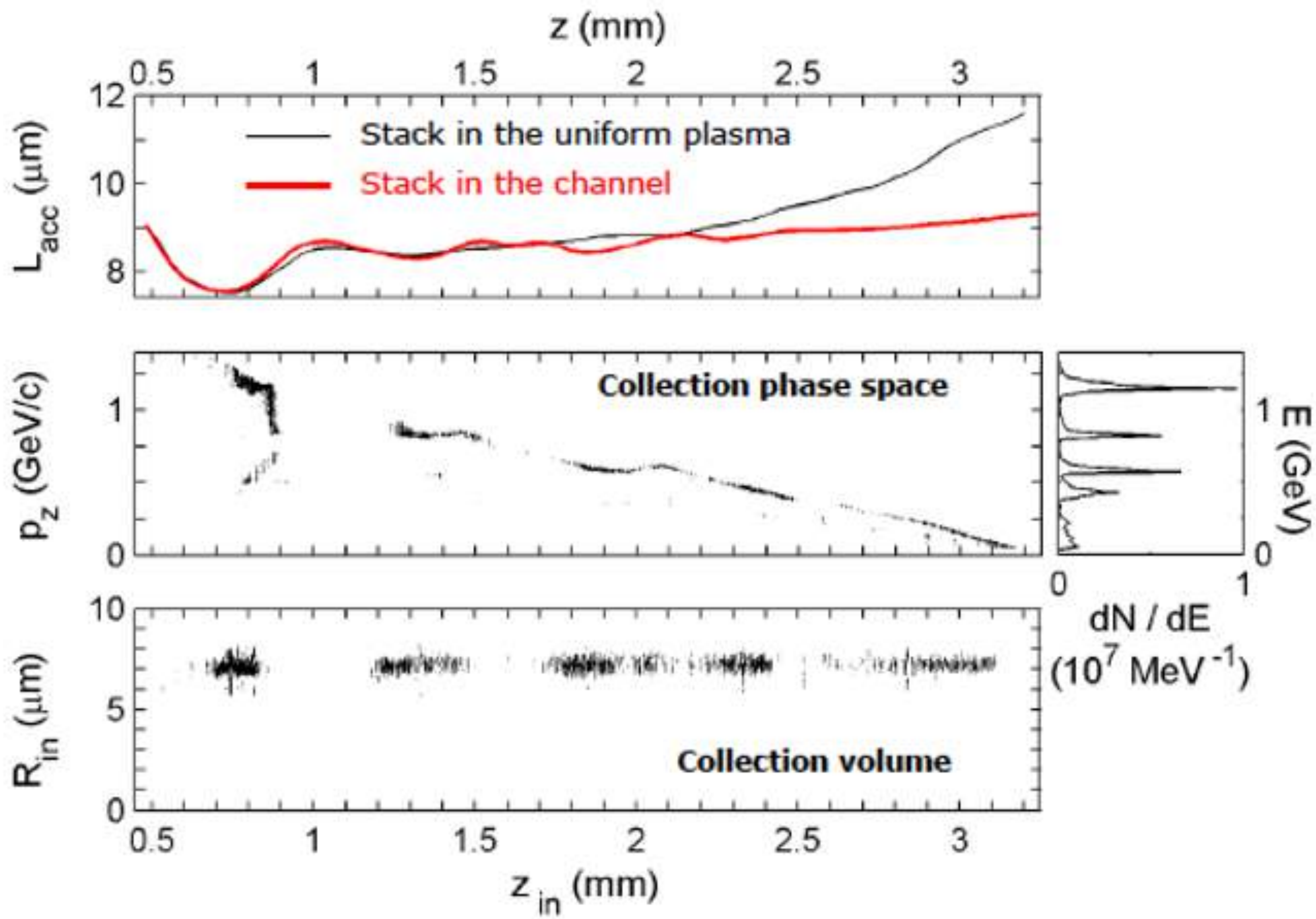


Pulse 1: 20 fs, 2.1 J, $\lambda_1 = 0.8$ µm
Pulse 2: 20 fs, 0.7 J, $\lambda_2 \approx 0.5$ µm
} orthogonally polarized (incoherent mixing)

No need in the extreme frequency up-shift: Reducing λ_2 by 20% is sufficient!

(CALDER-Circ simulation)

Optimal stack in a channel — I: Periodic injection and multi-bunching in phase space



Stack with
+15 fs delay,
$\lambda_2 = 2/3\ \lambda_1 = 0.53\ \mu m$,
$E_1 = E_2 = 0.7$ J,
in a channel matched to the incident pulse waist

The channel:

- suppresses diffraction of the pulse head, further delaying self-compression
- destabilizes the pulse tail confined within the bubble, causing periodic injection
- a comb of synchronized, kA-current bunches is produced (no tail at all!!)
- **peak energy ~ 1.2 GeV (vs ~ 420 MeV from accepted scaling)**

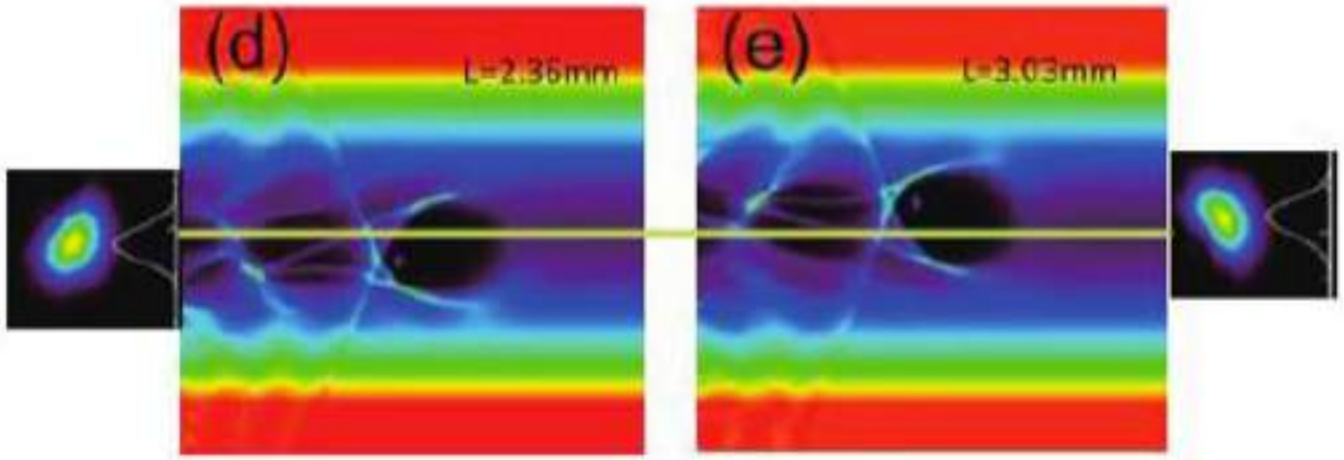
上海交通大學
SHANGHAI JIAO TONG UNIVERSITY

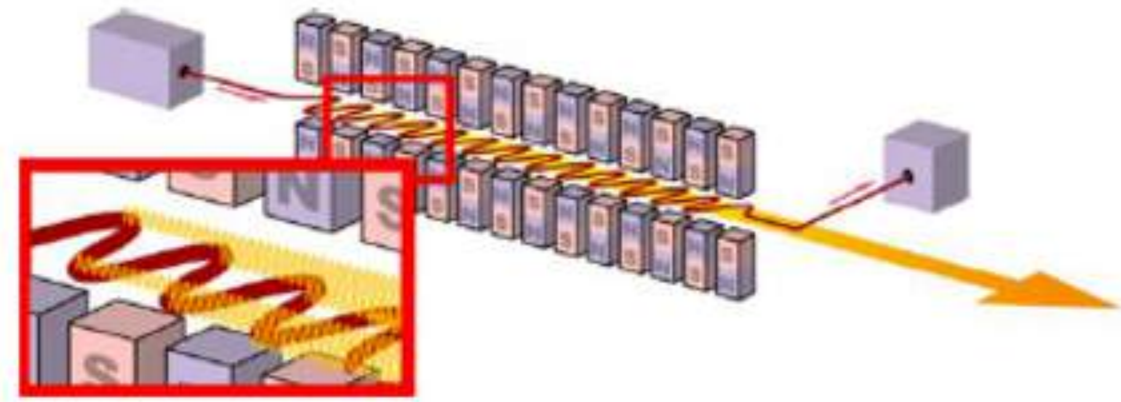
Synchrotron radiation source based on laser wakefield accelerator inside plasma channel

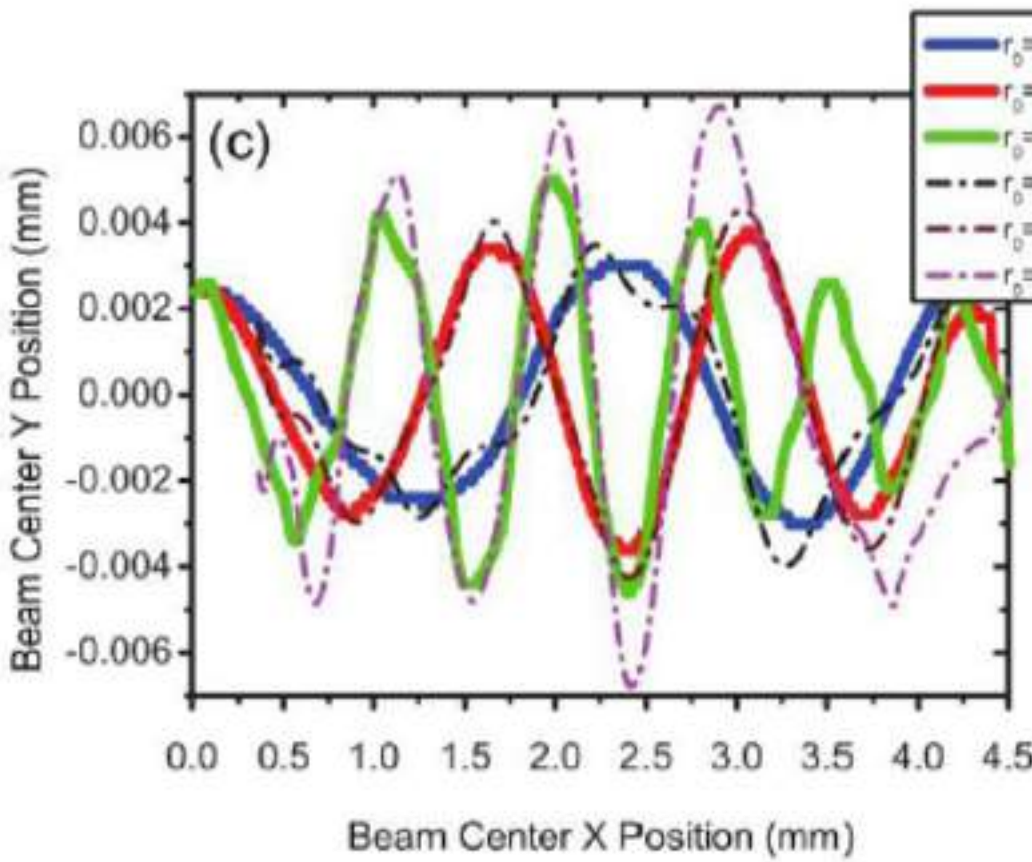
Min Chen[1,2] , Ji Luo[1,2] , Fei-Yu Li[3] , Feng Liu[1,2] ,
Zheng-Ming Sheng[1,2,3] , Jie Zhang[1,2]

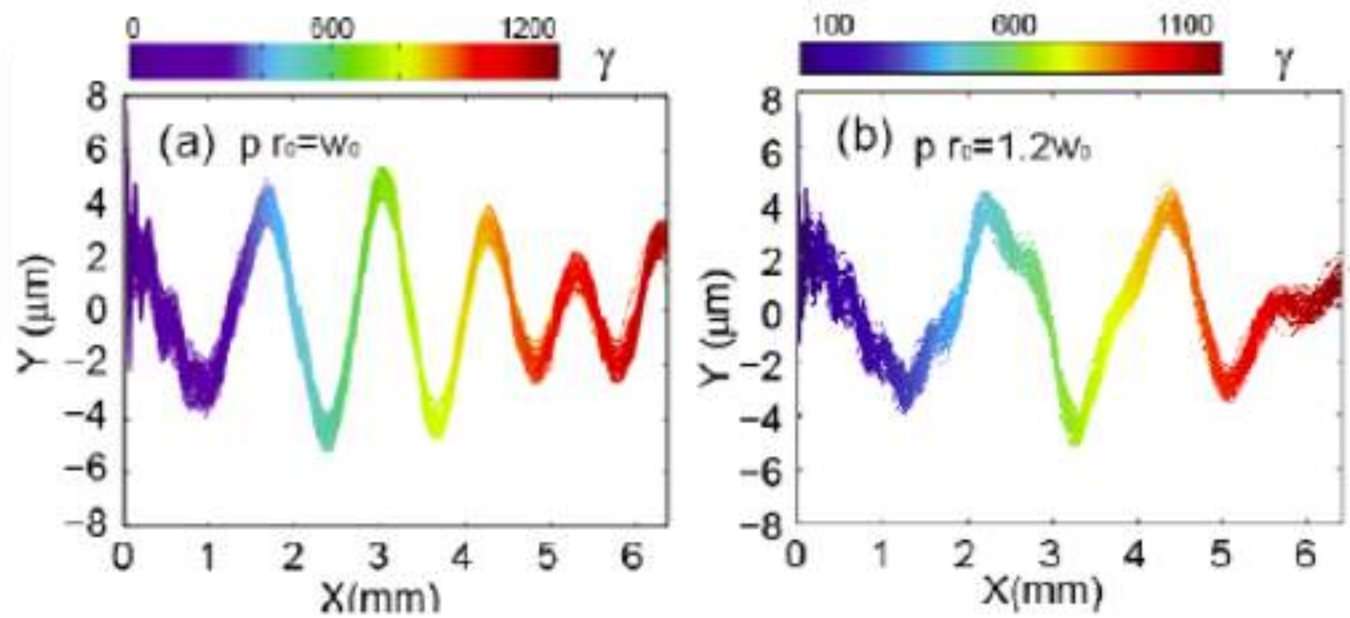
2nd European Advanced Accelerator Concepts Workshop, Elba, Italy, September 14-19 (2015)

Channel width effects on laser & e^- oscillation







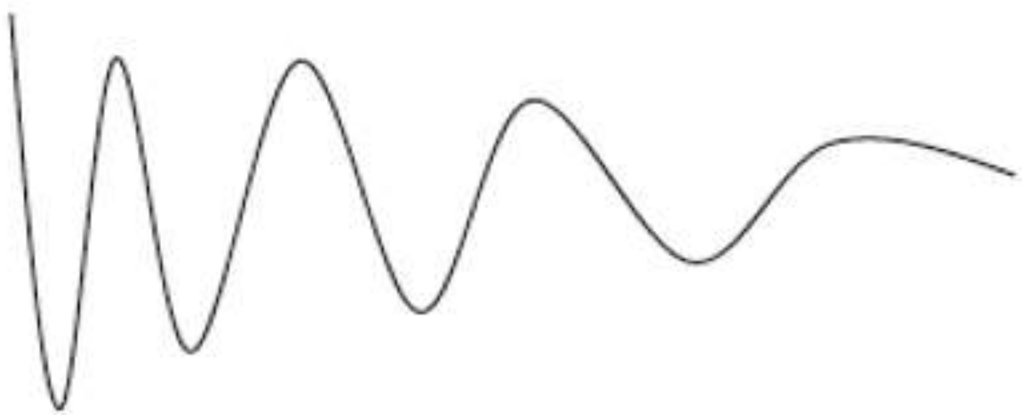


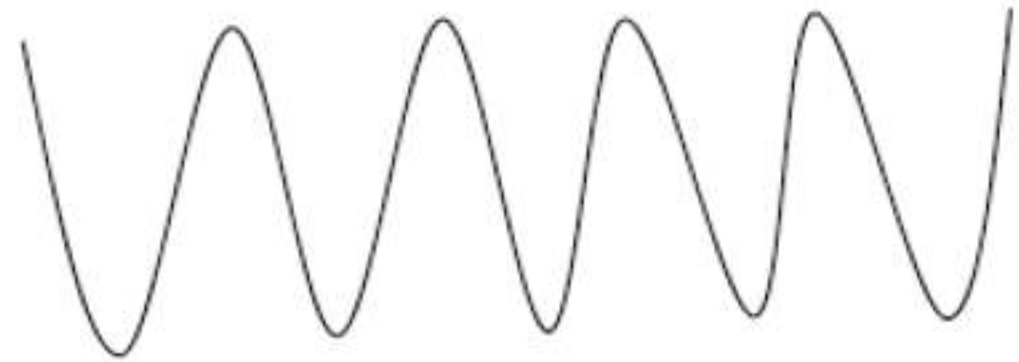
M. Chen *et al.*, arXiv:1503.08311 (2015)

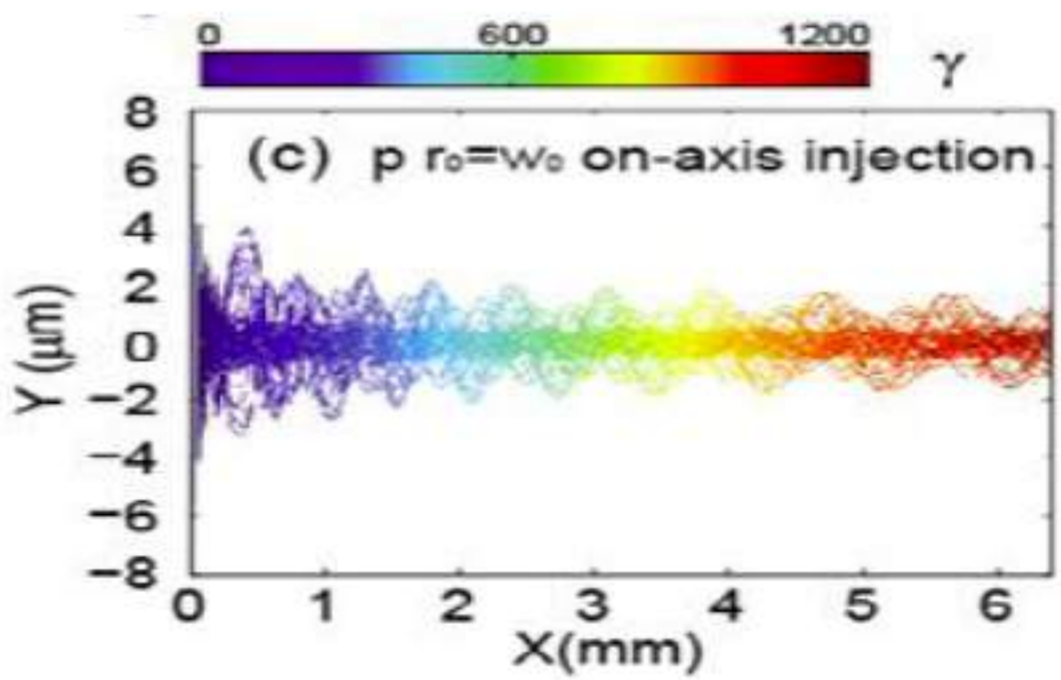
S.G. Rykovanov et al., PRL,14,145003 (2015)

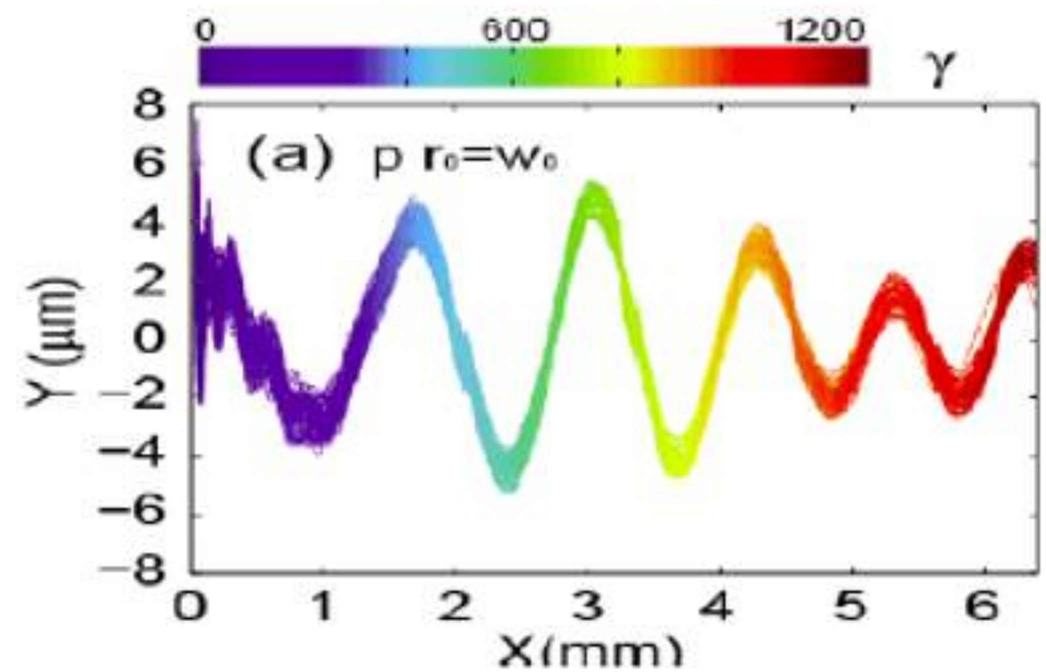
Pathak VB, Proceedings of the 41st EPS (2014)

Difference with the normal Betatron Oscillation









Both oscillation amplitude and period can be tuned in this new scheme.

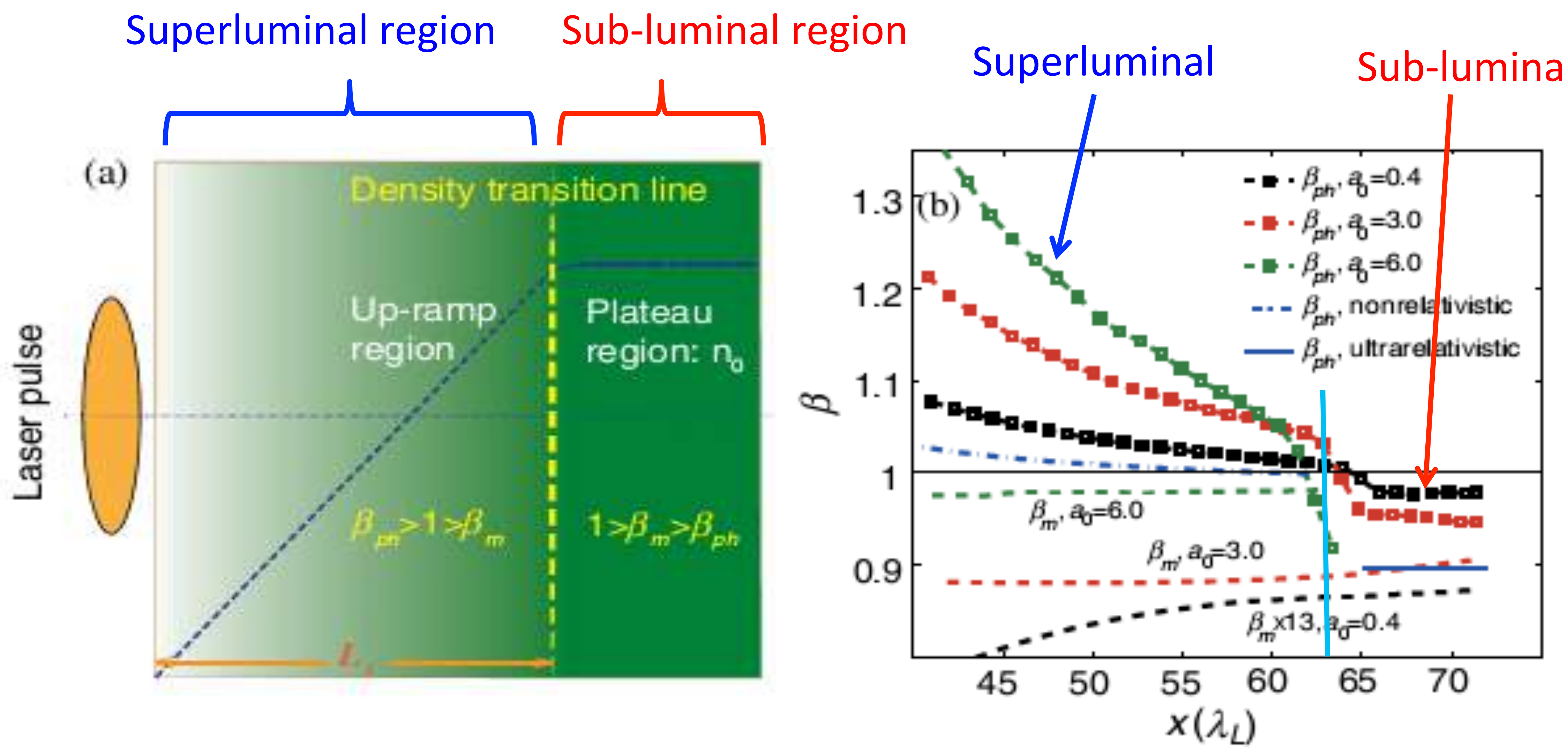
Attosecond Electron Sheets and Attosecond Light Pulses from Laser Wakefield Acceleration

Feiyu Li

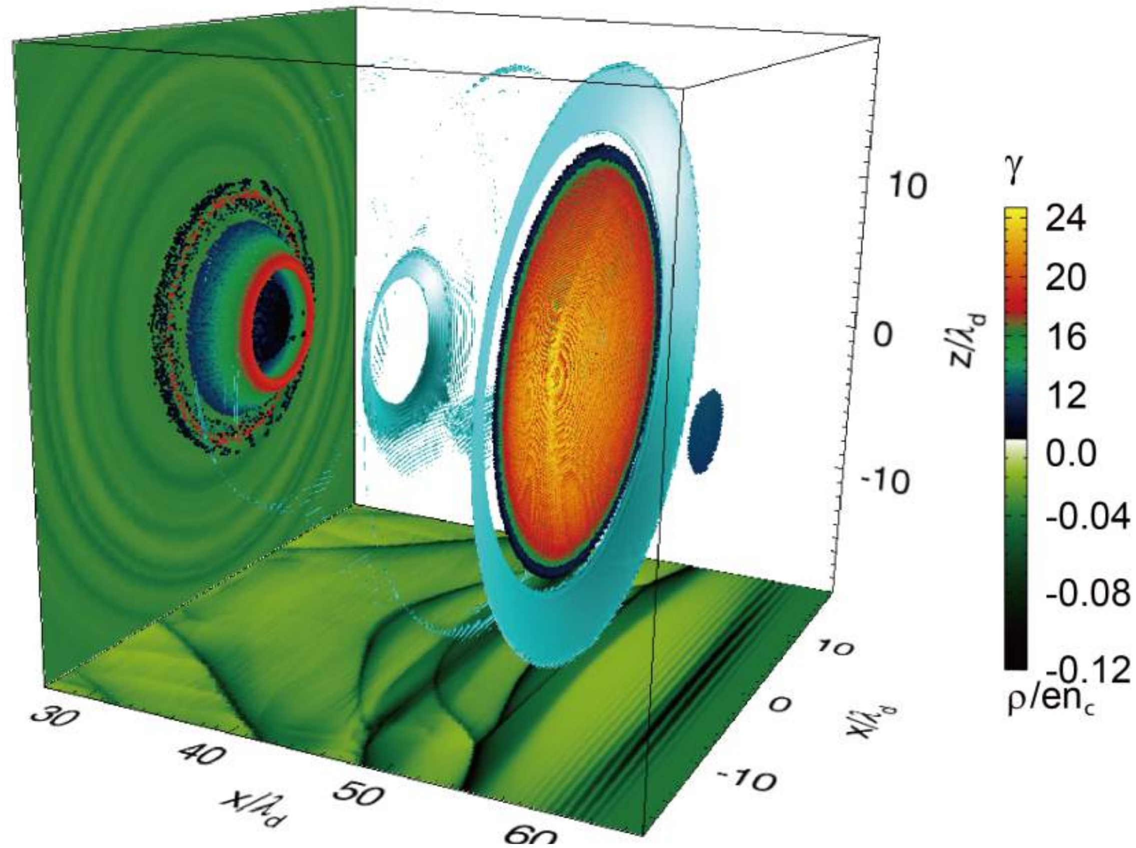
SUPA, Department of Physics, University of Strathclyde, Glasgow G4 0NG, UK

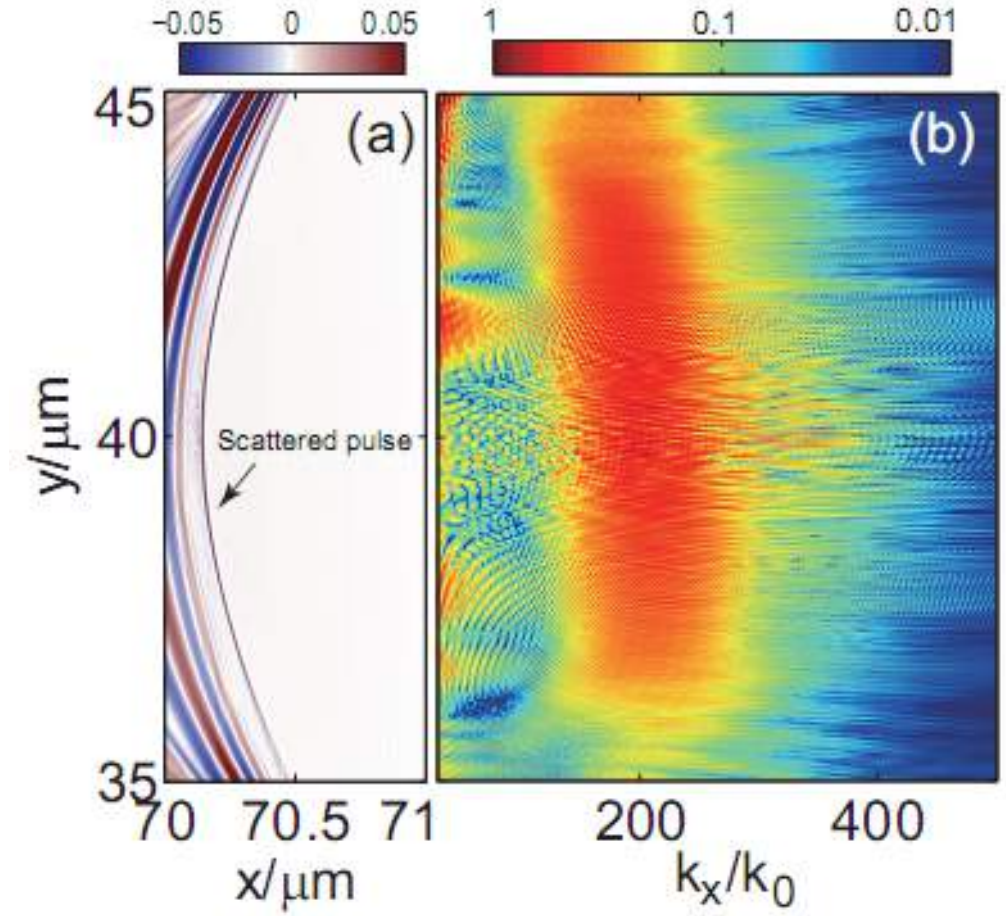
Controlled injection of attosecond electron sheets

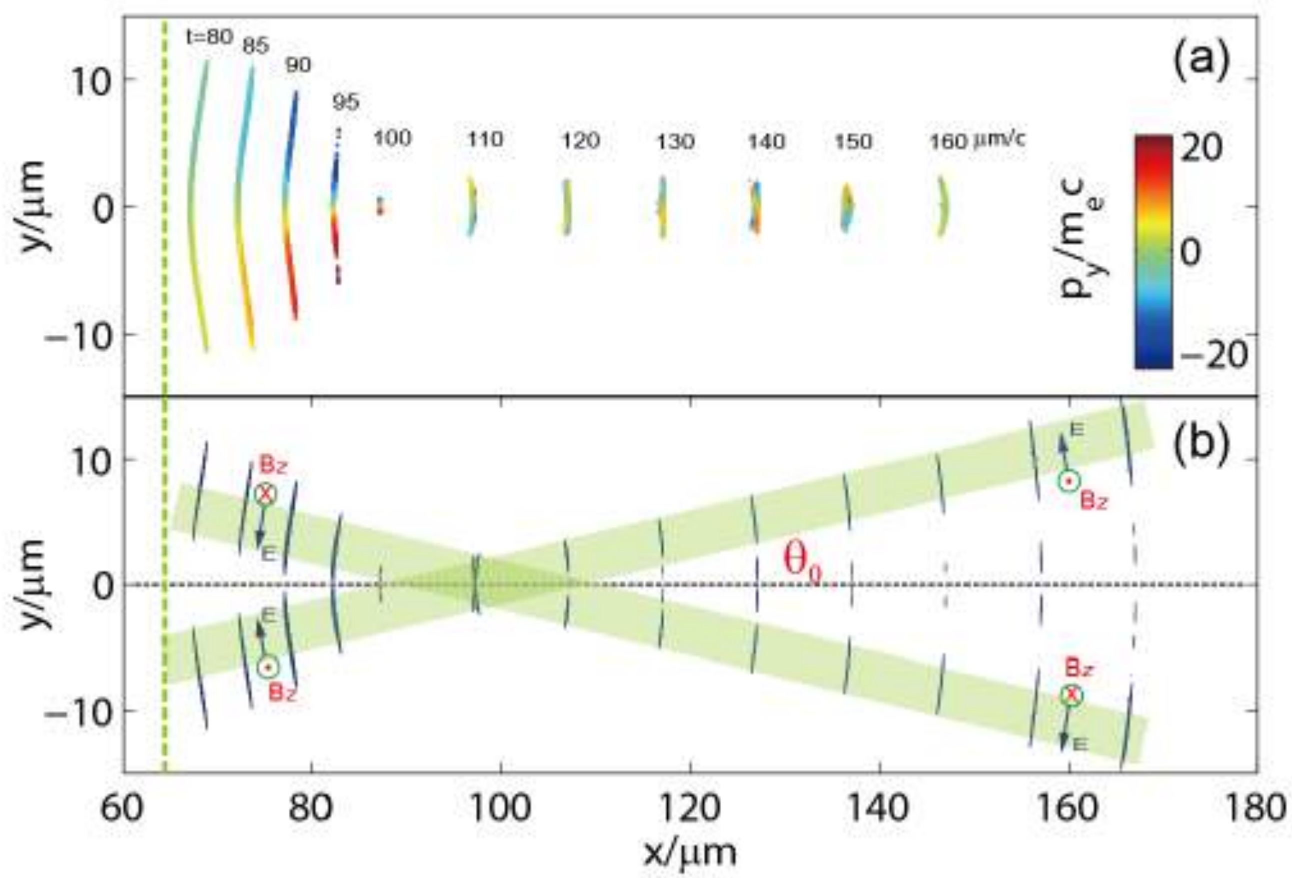
- **The ramping-up density provides the control and makes sure that the density wave crests are stably compressed without premature injection**



Li, et al. PRL 2013







Plasma:
n_e ~ 7×10^{19} cm^{-3}

Laser:
~ 7×10^{19} W/cm^2,
w_0 ~15 µm,
peak power ~300TW,
energy ~5J

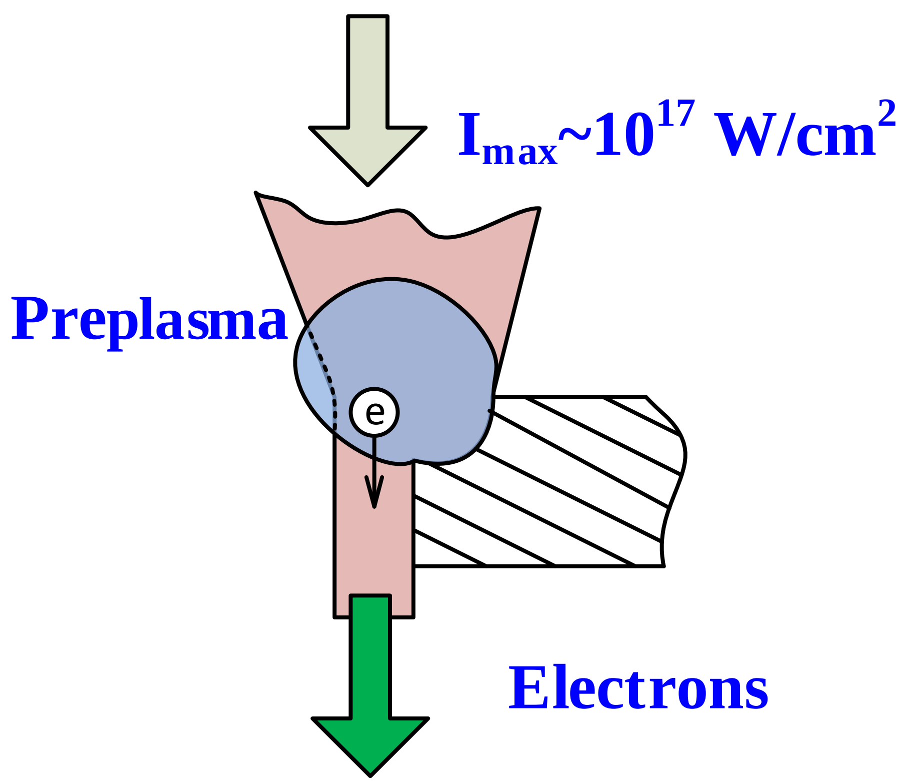
Attosecond pulse:
~10mJ,
saturated at ~ 4×10^{19} W/cm^2,
> 7×10^{20} W/cm^2 converging

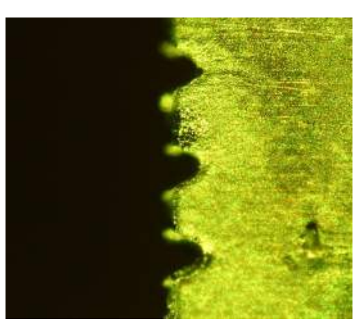
Li, et al. APL 2014

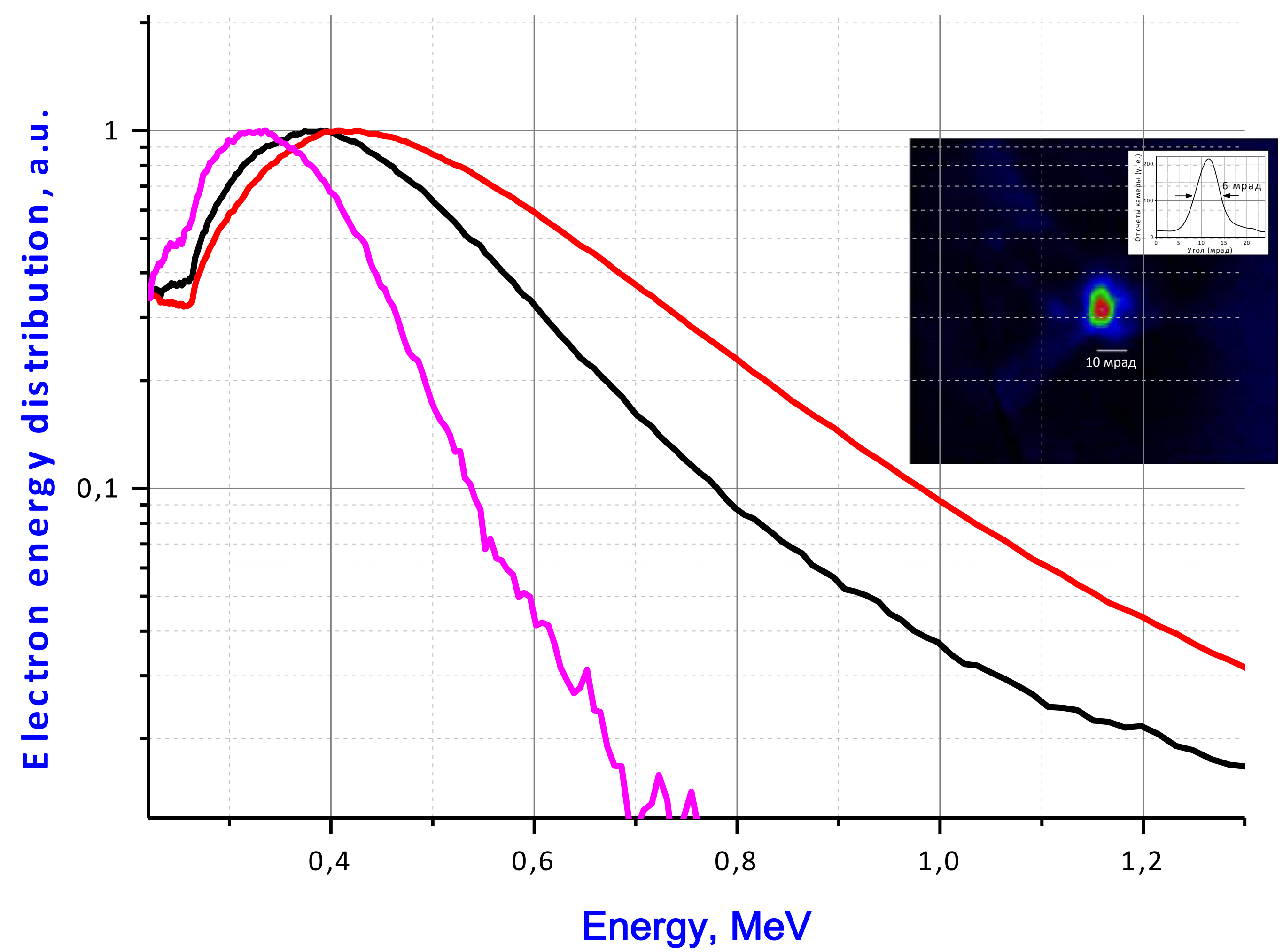
Generation of the collimated quasi-monochromatic beams of accelerated electrons in the interaction of an intense femtosecond laser pulse with an inhomogeneous plasma

A. N. Stepanov

Institute of Applied Physics, Nizhny Novgorod, Russia

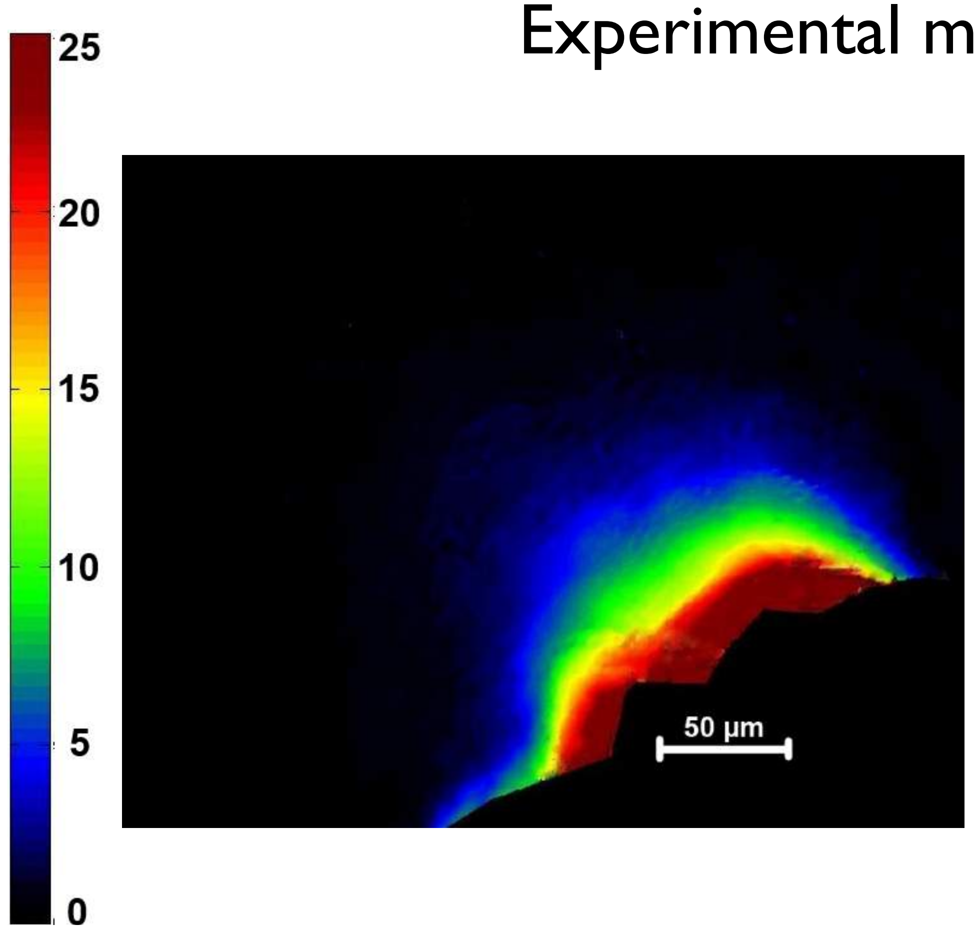


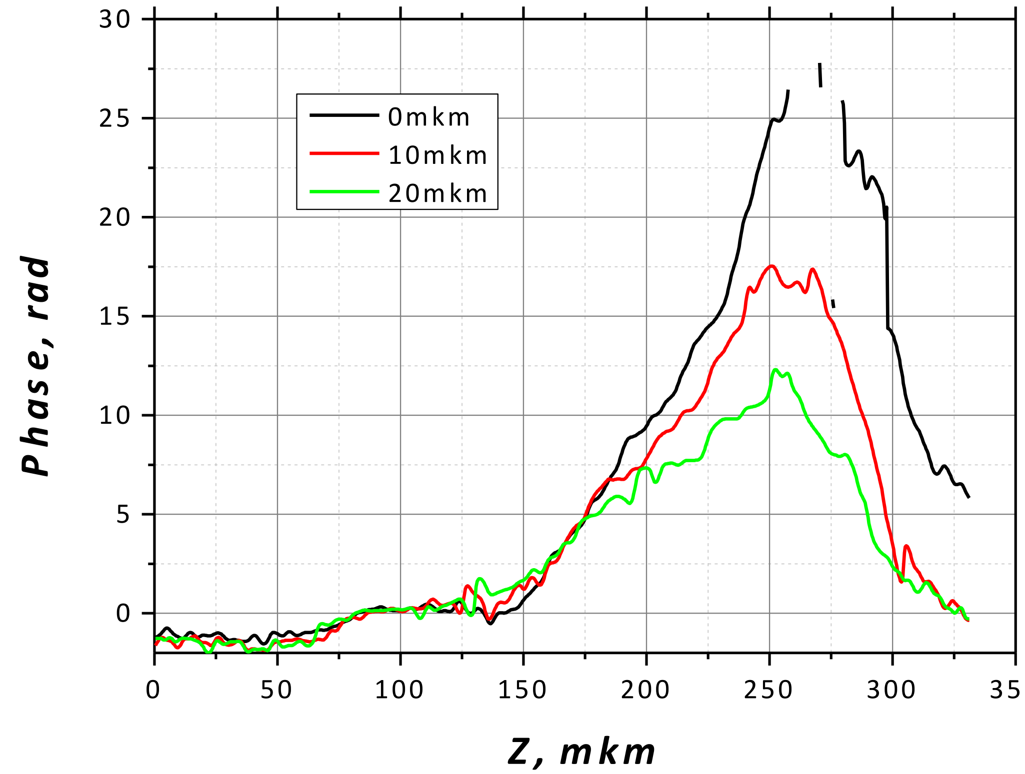




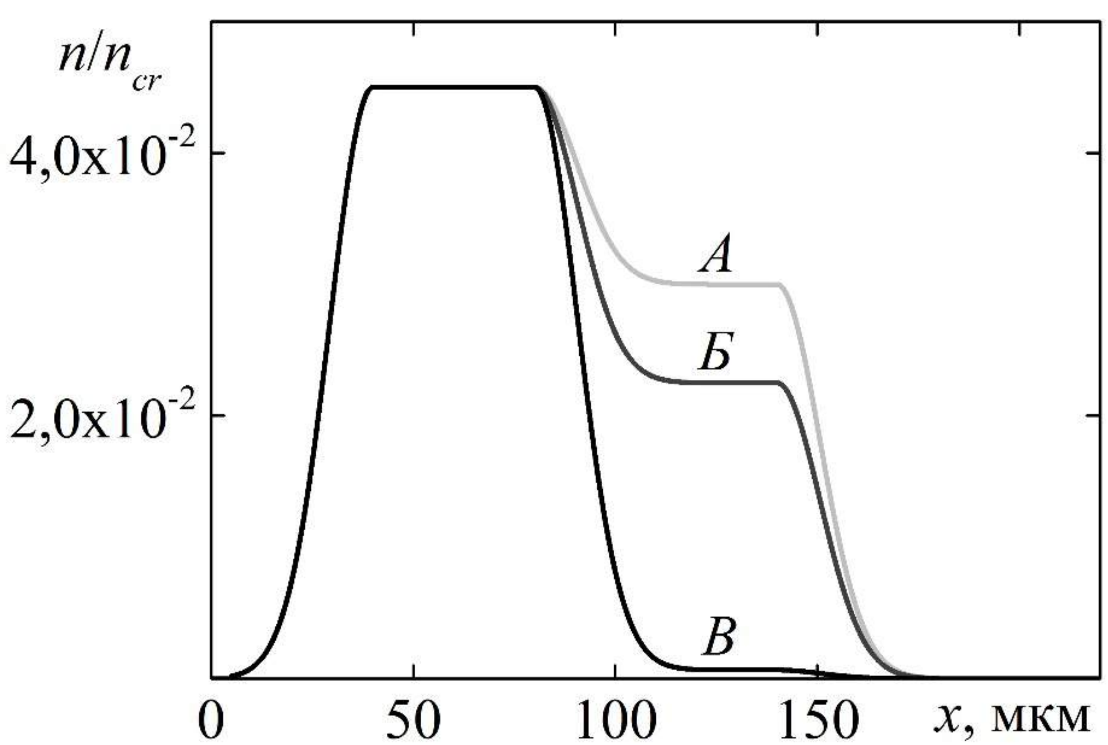
A. N. Stepanov

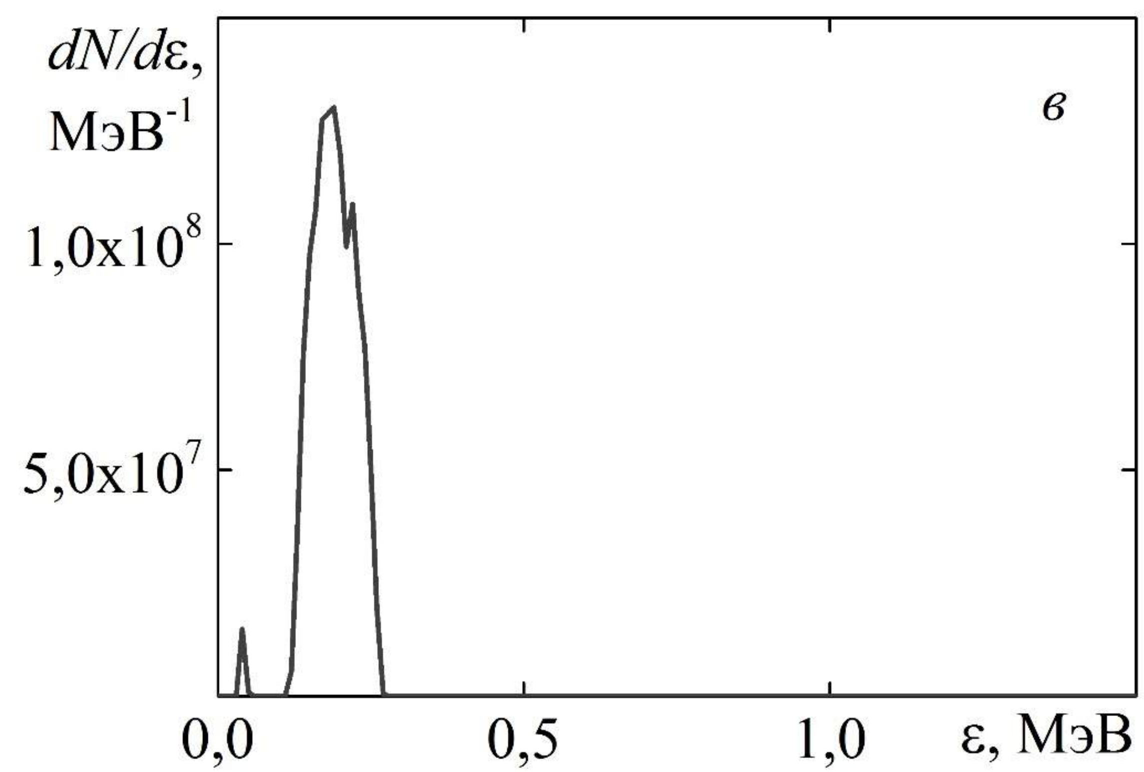
Experimental measurements of the density



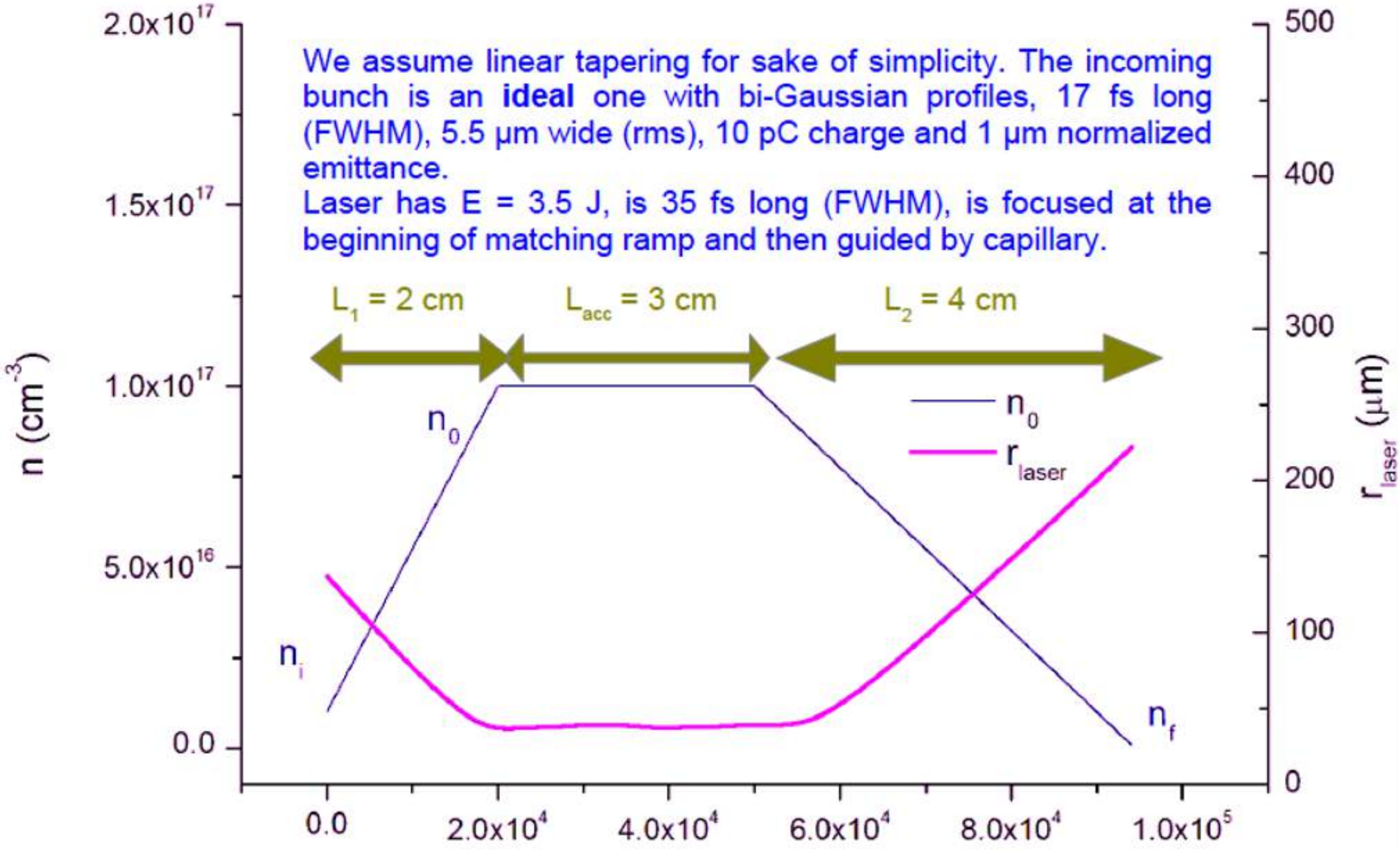


Simulated electron energy distribution

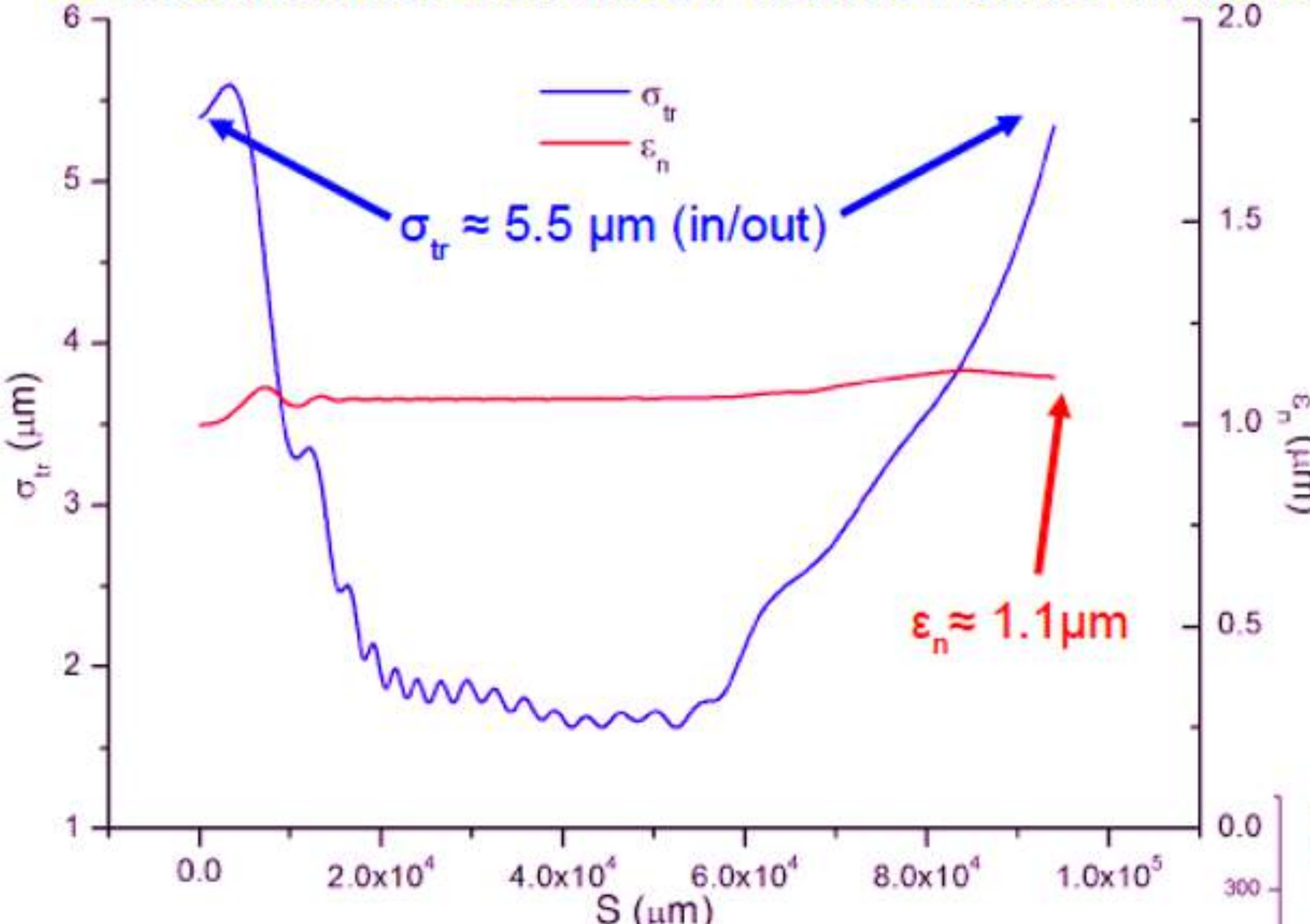




Simulation settings and matching strategy



Simulation results: transverse and longitudinal params



Energy gain is in excess of 200 MeV in a 3 cm acceleration length, which means an average electric field in excess of

7 GV/m

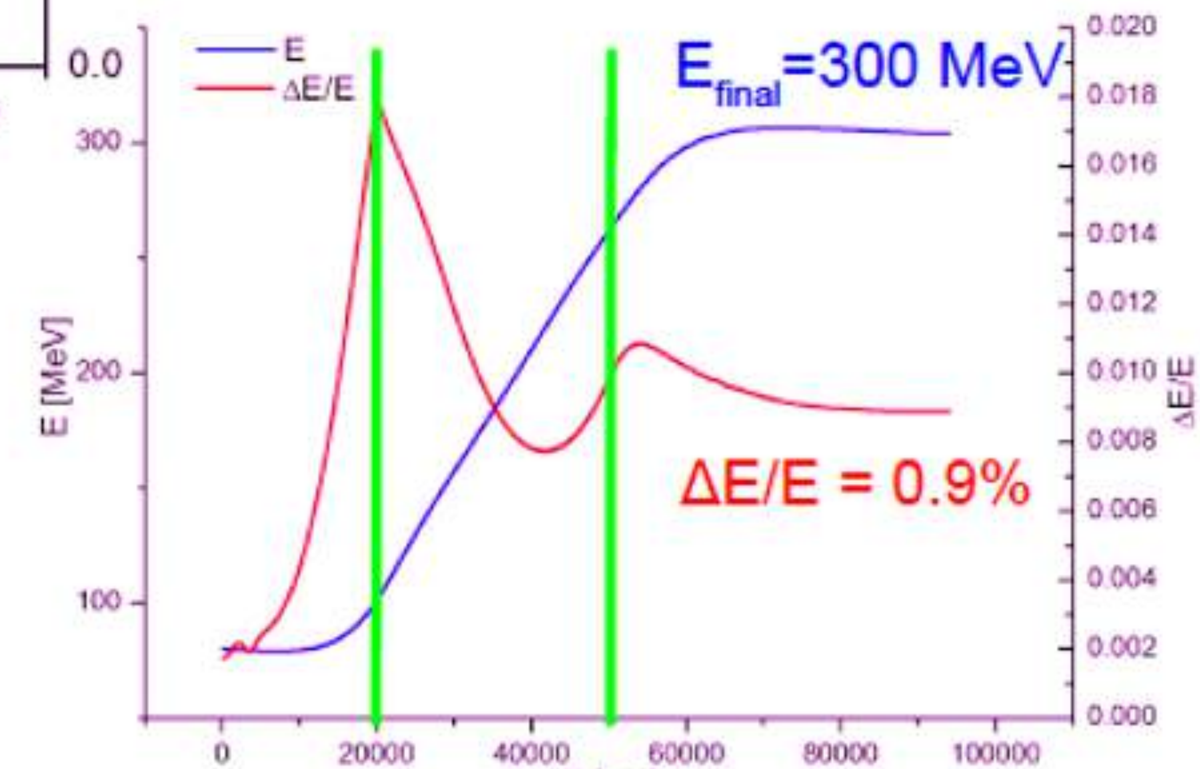
Energy spread is within 1% (a safe threshold for subsequent transport*) and REDUCED IN THE FINAL RAMP due to beam loading and plasma wavelength increase.

* P. Antici et al., J. App. Phys. 112, 044902 (2012).

A very nice matching is obtained by laser focusing method.

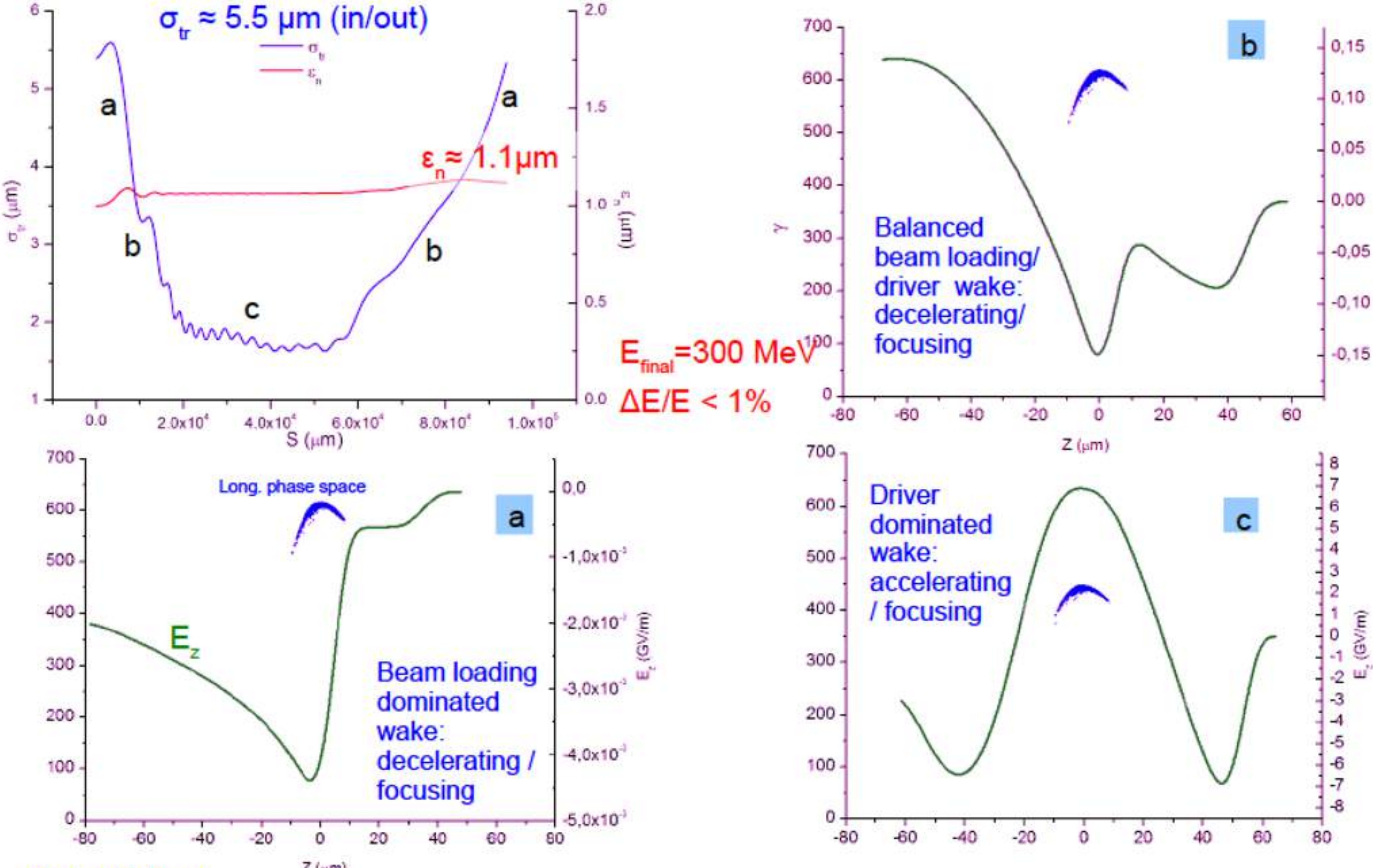
Beam size is reduced to matched size and then increased back to initial value in a quasi-adiabatic transformation.

Both initial and final sizes seems to be within manageability of permanent magnet quads.



SPARC LAB

Effects of beam loading and laser (de)focusing in ramps



Localised ionisation-induced trapping in a laser wakefield accelerator using a density down-ramp

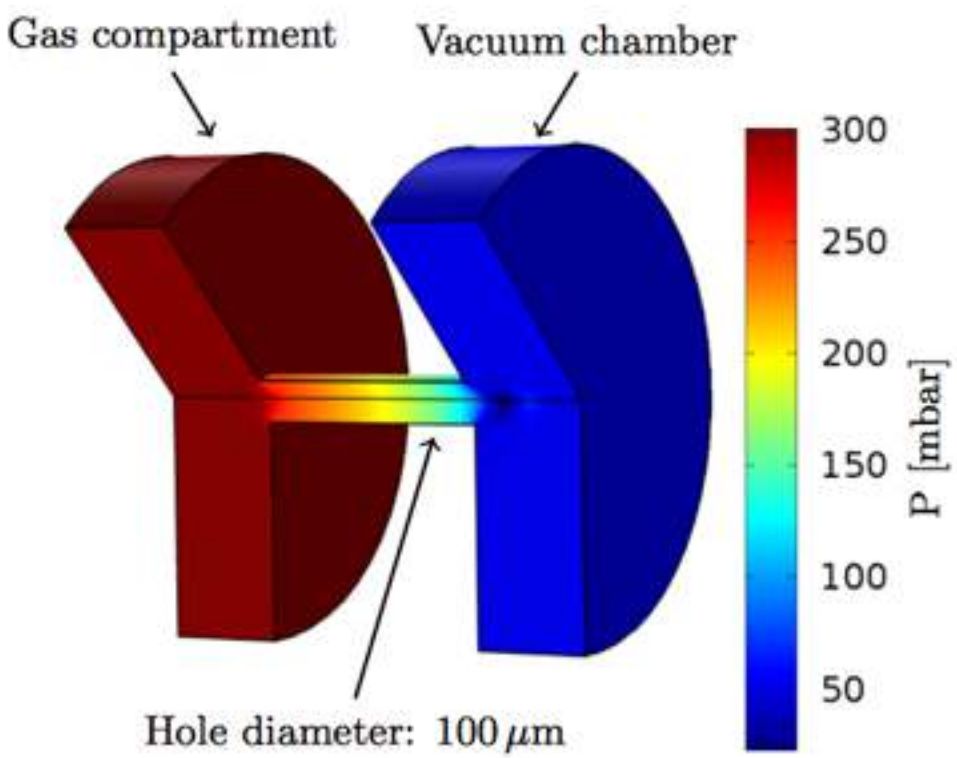
O Lundh, M Hansson, S Reymond, B Aurand, H Ekerfelt, I Gallardo, C-G Wahlström
Department of Physics, Lund Laser Centre, Lund University, Sweden

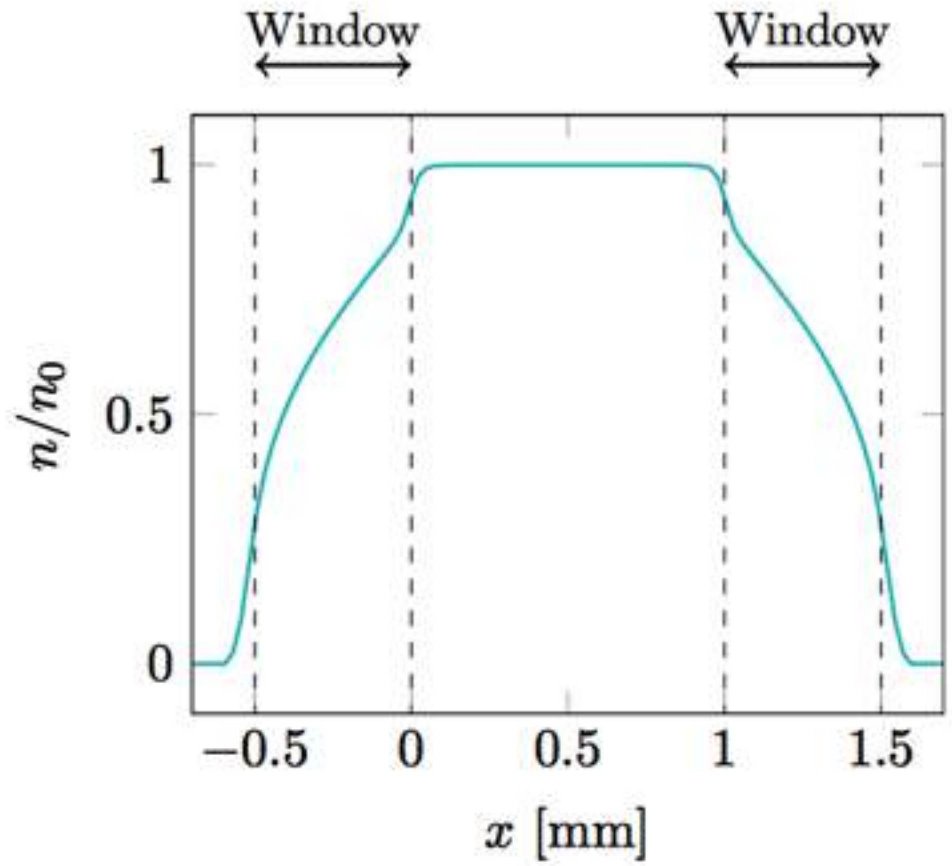
T L Audet, F G Desforges, B Cros
LPGP, CNRS-Université Paris-Sud, France

S Dobosz Dufrénoy
IRAMIS, LIdyL, CEA, Saclay, France

X Davoine
CEA-DAM-DIF, Bruyères-les-Châtel, France

European Advanced Accelerator Conference, Elba, September 13-19 2015

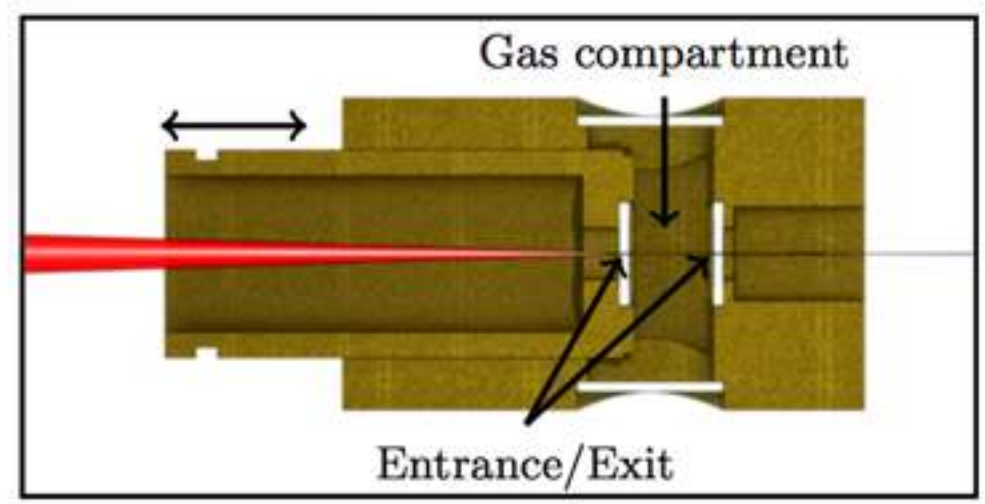




- Density gradients estimated using computational fluid dynamics
- Plateau density measured using interferometry

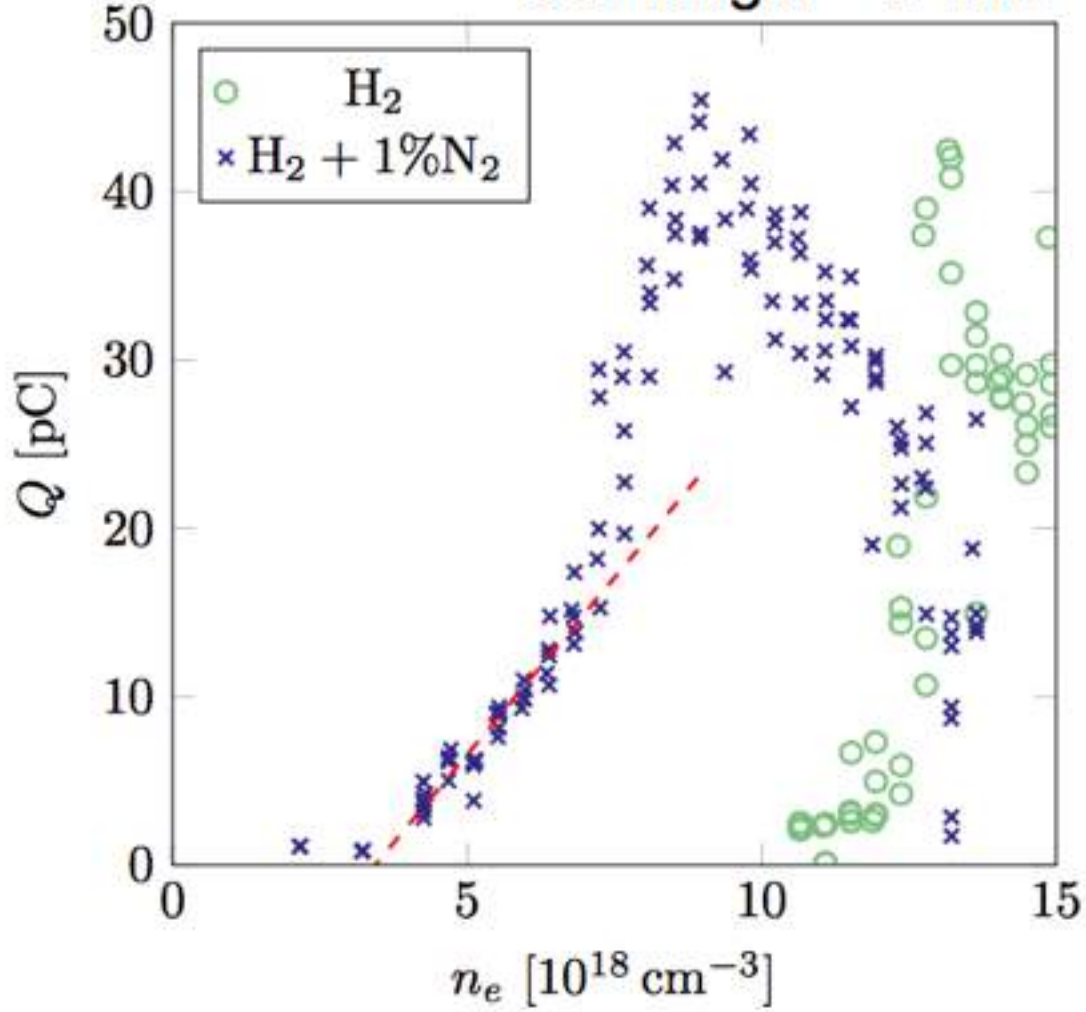
Target parameters
- L = 0.5 – 4 mm
- H_2 or H_2 + 1%N_2
- P = 100 – 300 mbar

Laser pulse parameters
- E = 600 mJ
- T_{FWHM} = 37 fs
- D_{FWHM} = 17 μm
- $I_{peak} = 4 \cdot 10^{18}$ W/cm^2
- a_0 = 1.2

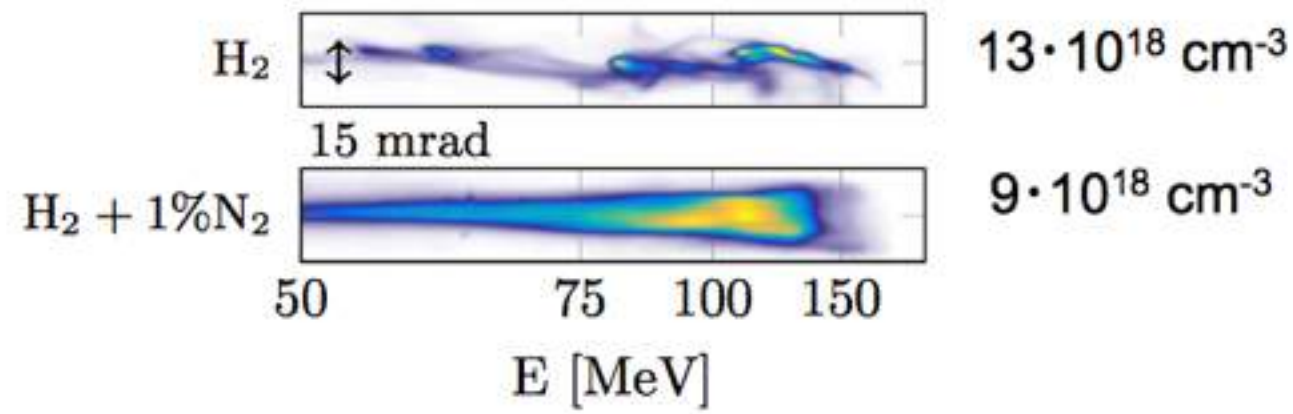


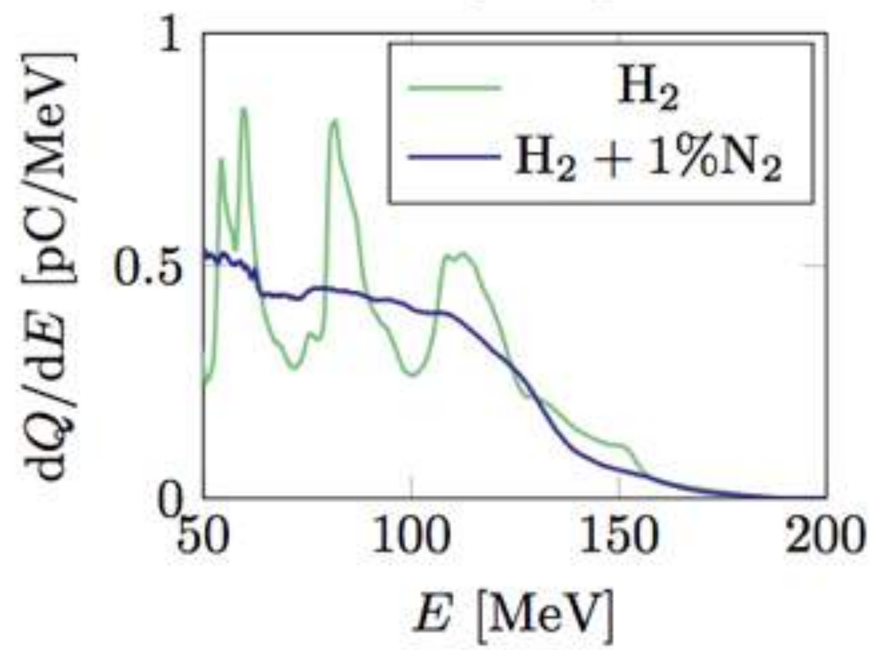
Density dependence

Cell length = 2 mm



Typical beams with Q ≈ 40 pC





Mixture H2+1%N2

- Threshold ≈ $3 \cdot 10^{18}$ cm^{-3}
- Broad energy spectrum
- Stable

Pure H2

- Threshold ≈ $1 \cdot 10^{19}$ cm^{-3}
- Narrow spectral features
- Fluctuations

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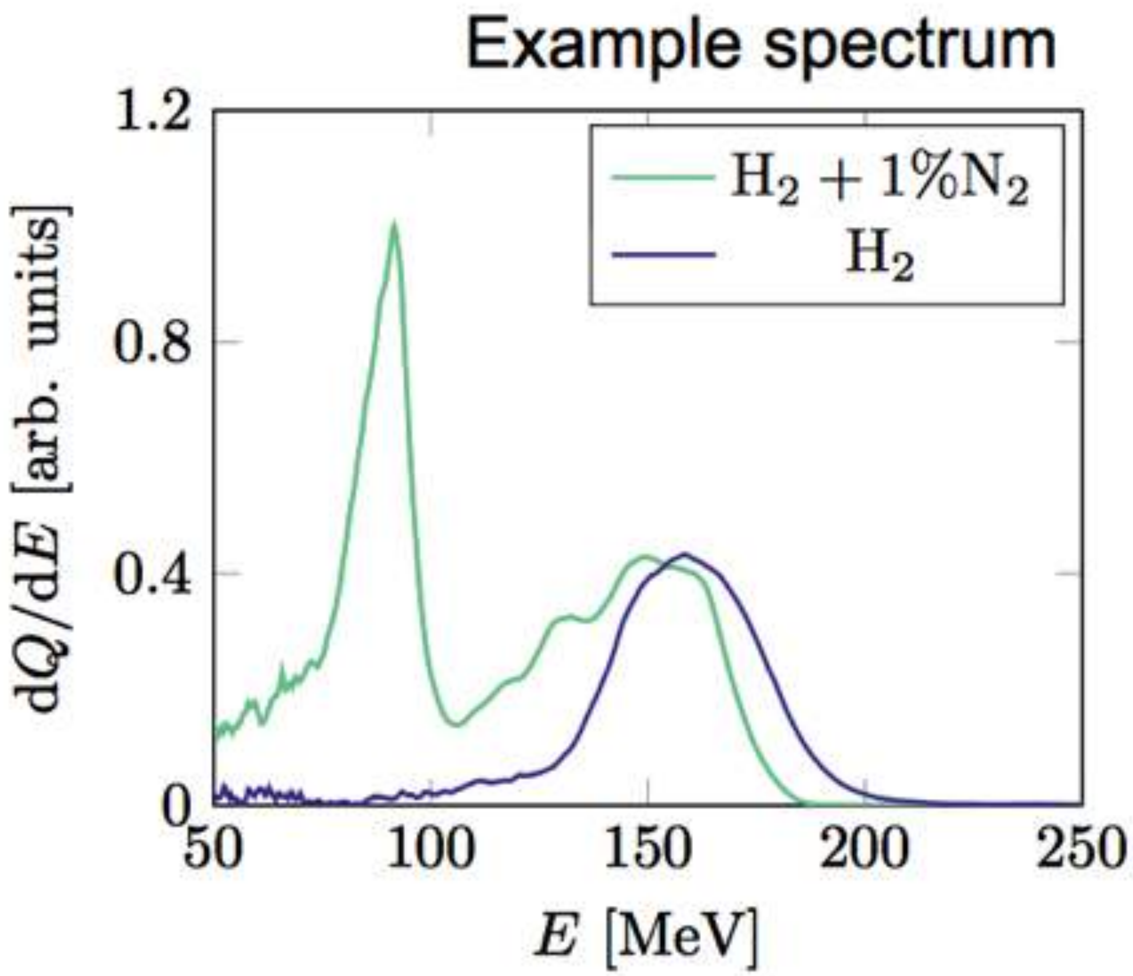
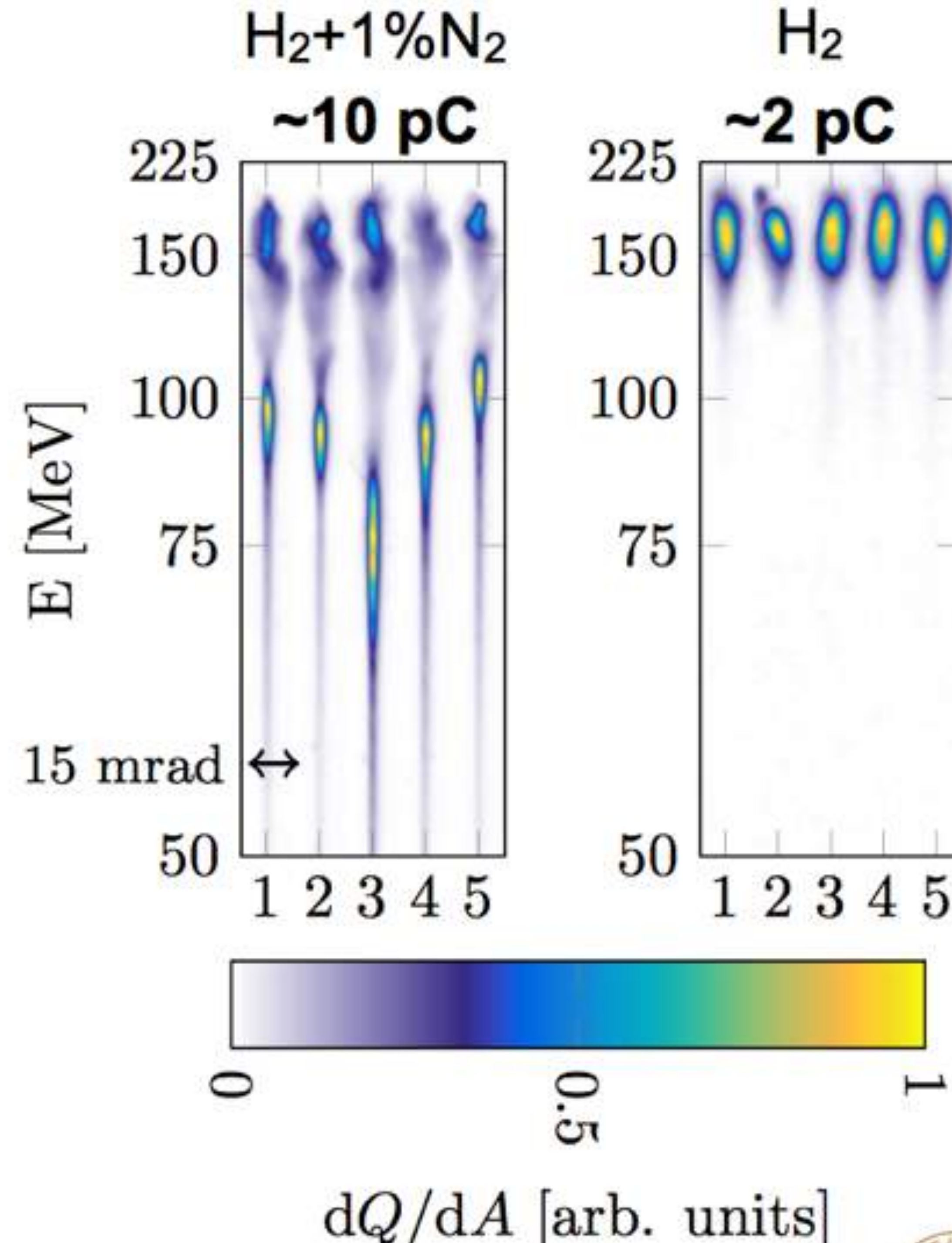
Reproducible beam characteristics





- Cell length 0.7 mm
- Pressure 250 mbar

Two spectral components — Two injection mechanisms?

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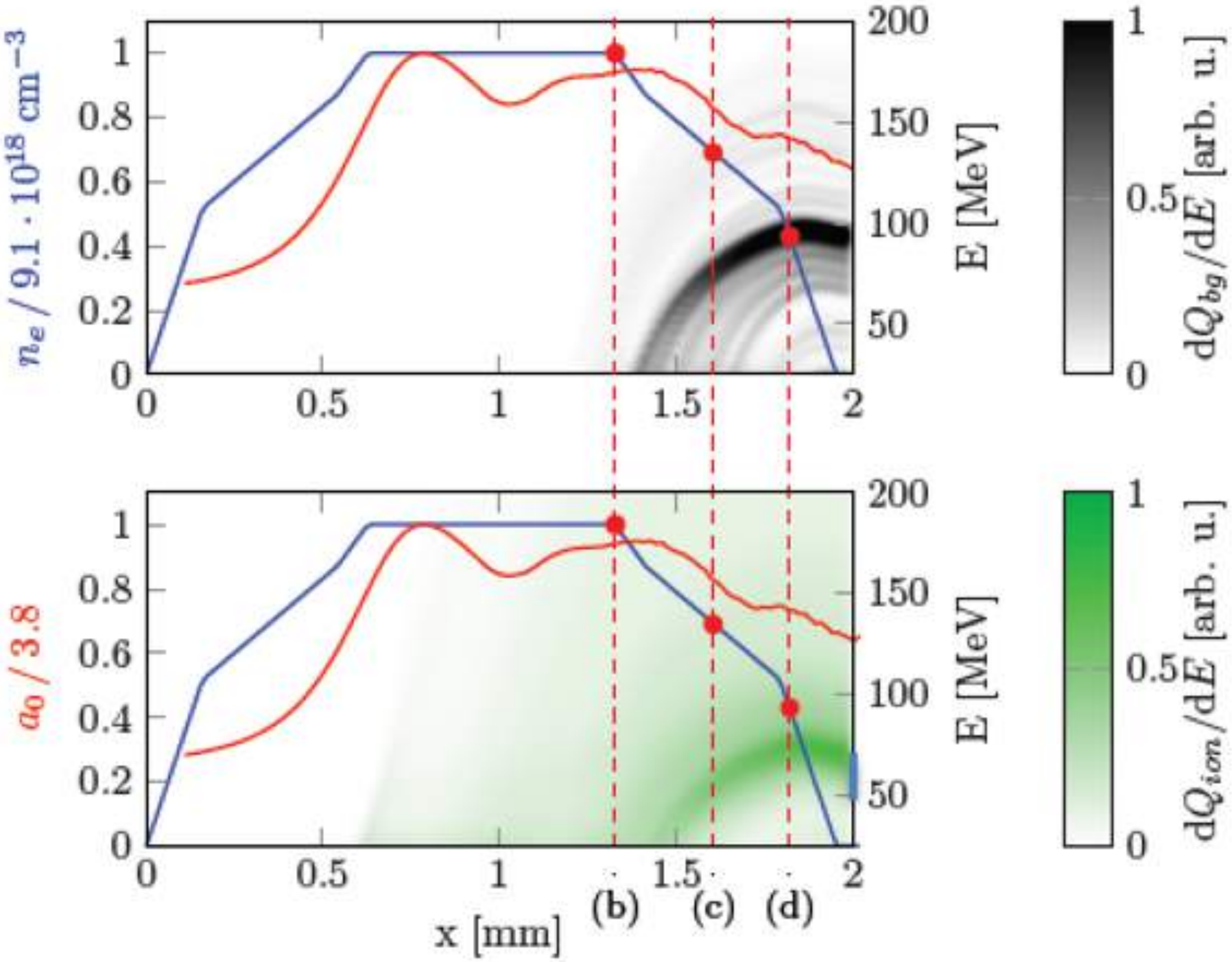
Simulations with CALDER-Circ



Background plasma

E_{peak} = 90 MeV

e- ionised from $N^{5,6+}$

E_{peak} = 75 MeV

- Increased injection from N5,6+ in the density ramp
- Longitudinal extent allows phase-space rotation
- Two separate peaks in electron energy spectrum

Controlled injection of electrons in a laser wakefield accelerator

M. Hansson[1], H. Ekerfelt[1], B. Aurand[1], K. Svensson[1], I. Gallardo Gonzalez[1], A. Persson[1], X. Davoine[2], C. -G. Wahlström[1], O. Lundh[1]

[1] Department of Physics, Lund University, P.O. Box 118, S-22100 Lund, Sweden
[2] CEA, DAM, DIF, Bruyères-le-Châtel, 91297 Arpajon, France

2nd European Advanced Accelerator Concepts Workshop
Elba, September 13-19, 2015

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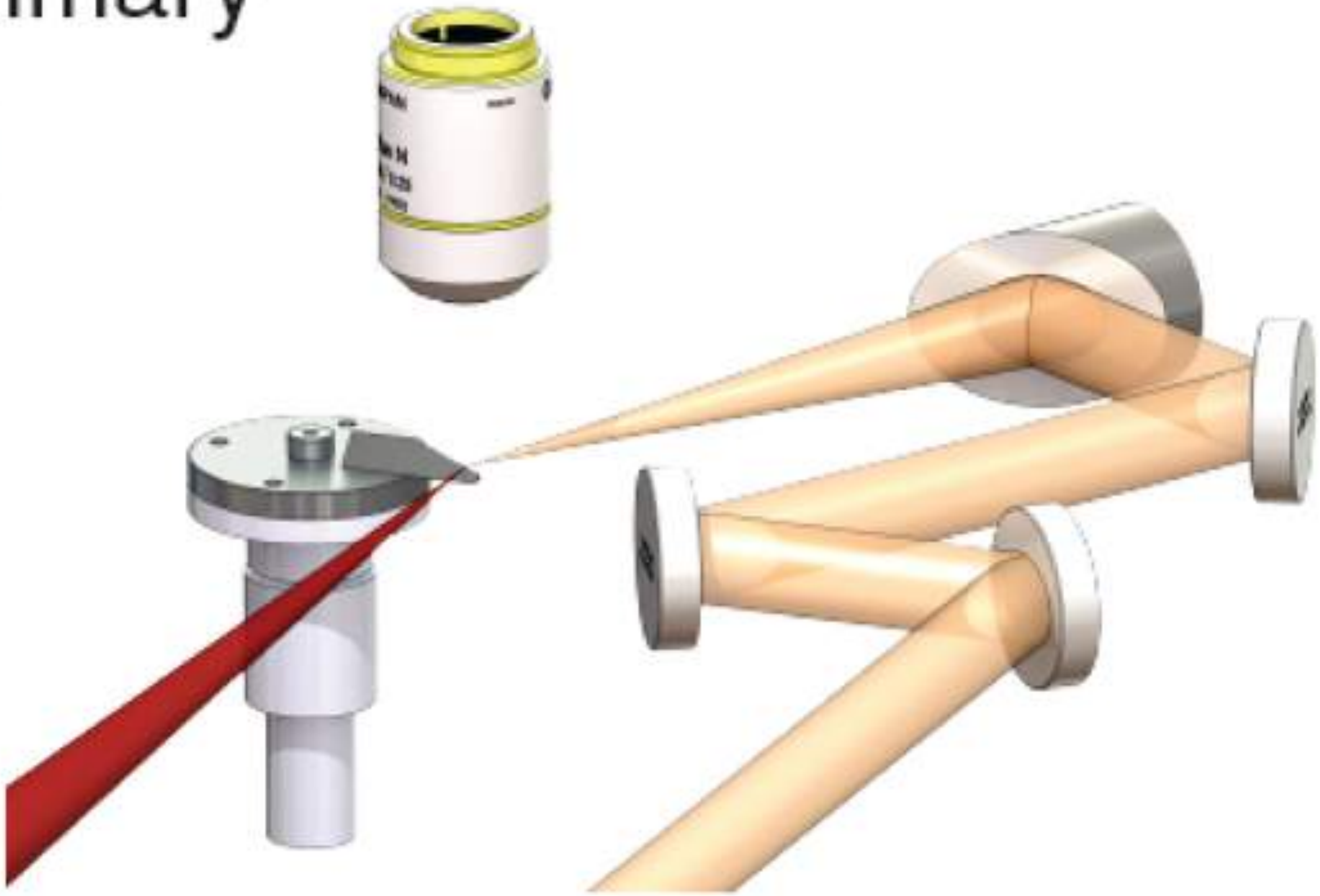
EAAC 2015

2nd European Advanced Accelerator Concepts Workshop, Elba, Italy, September 14-19 (2015)

Summary

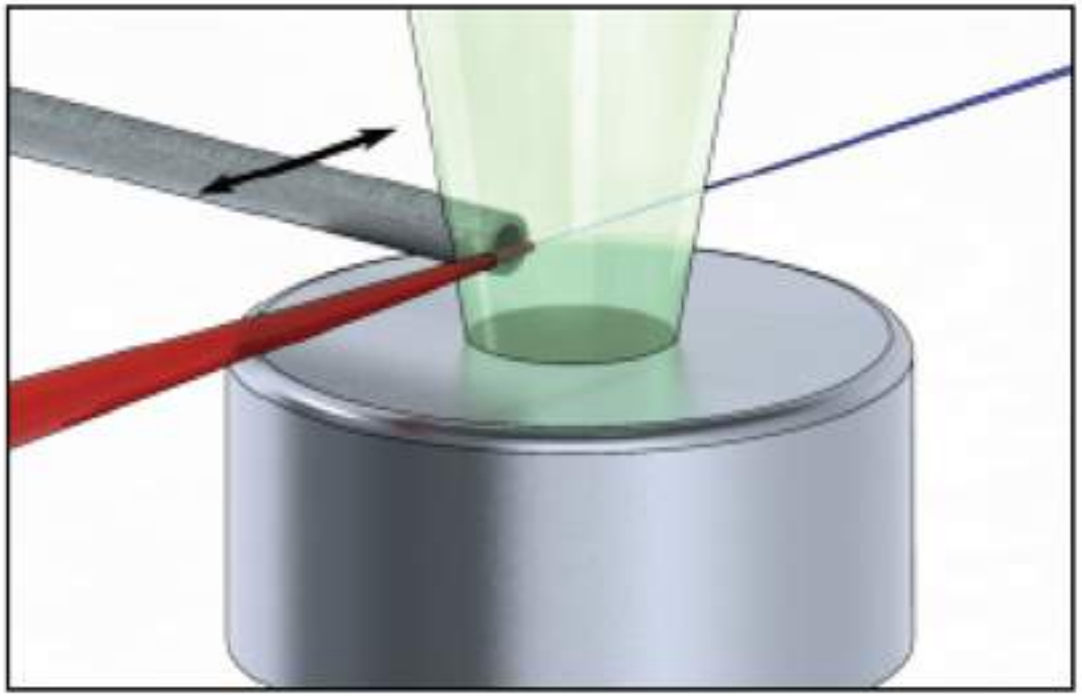
Colliding pulse injection

- Compact setup for CPI
- High quality beams generated
  - Low divergence
  - Small energy spread
- Controlled beam parameters
  - Energy by collision point
  - Charge by polarization

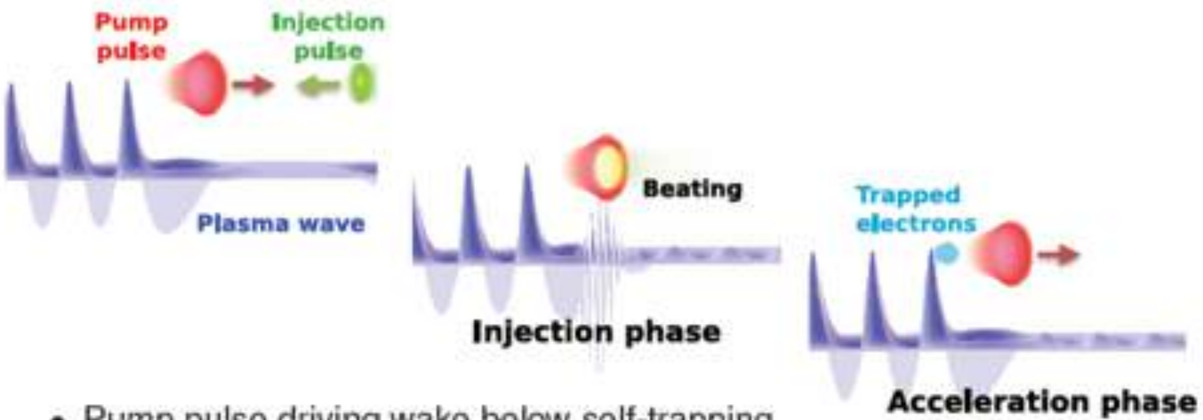


Density down-ramp injection

- Simple set-up
- Small fluctuations
- Controlled beam parameters
  - Energy by injection point
  - Energy by accelerating field
  - Charge by gradient

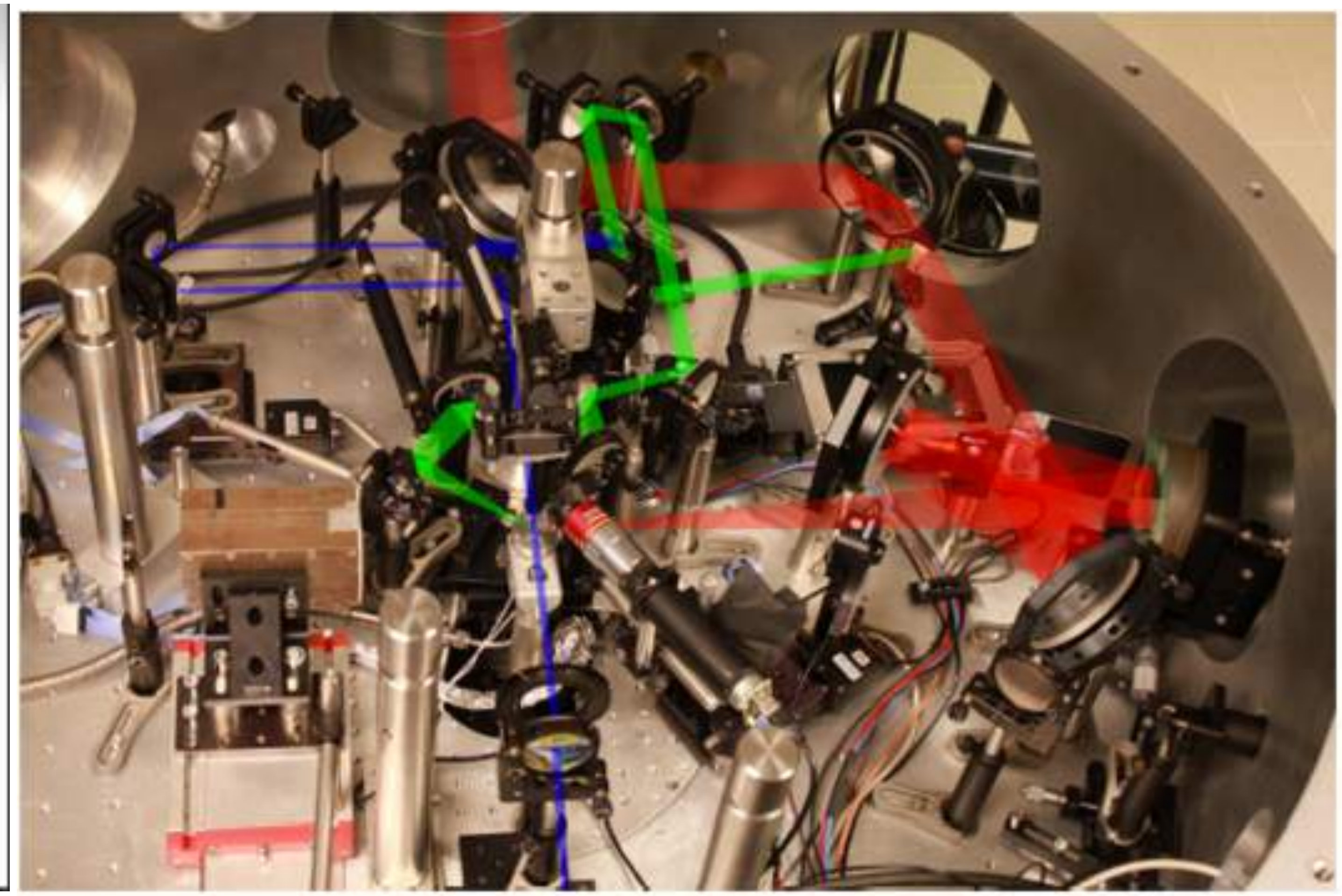


Colliding pulse injection

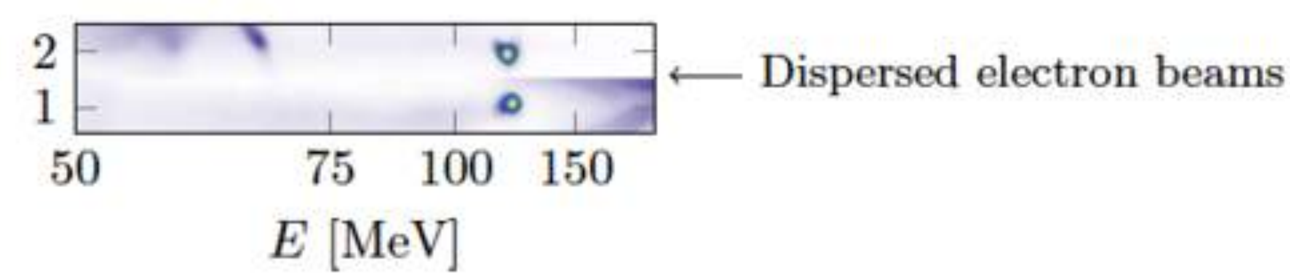


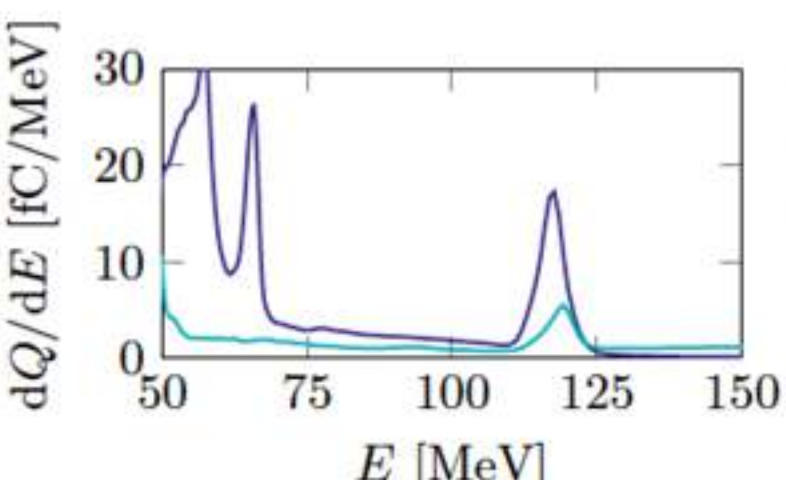
- Pump pulse driving wake below self-trapping
- Injection pulse beats with pump pulse
- Stochastic heating triggers injection

Image courtesy of Clément Rechatin

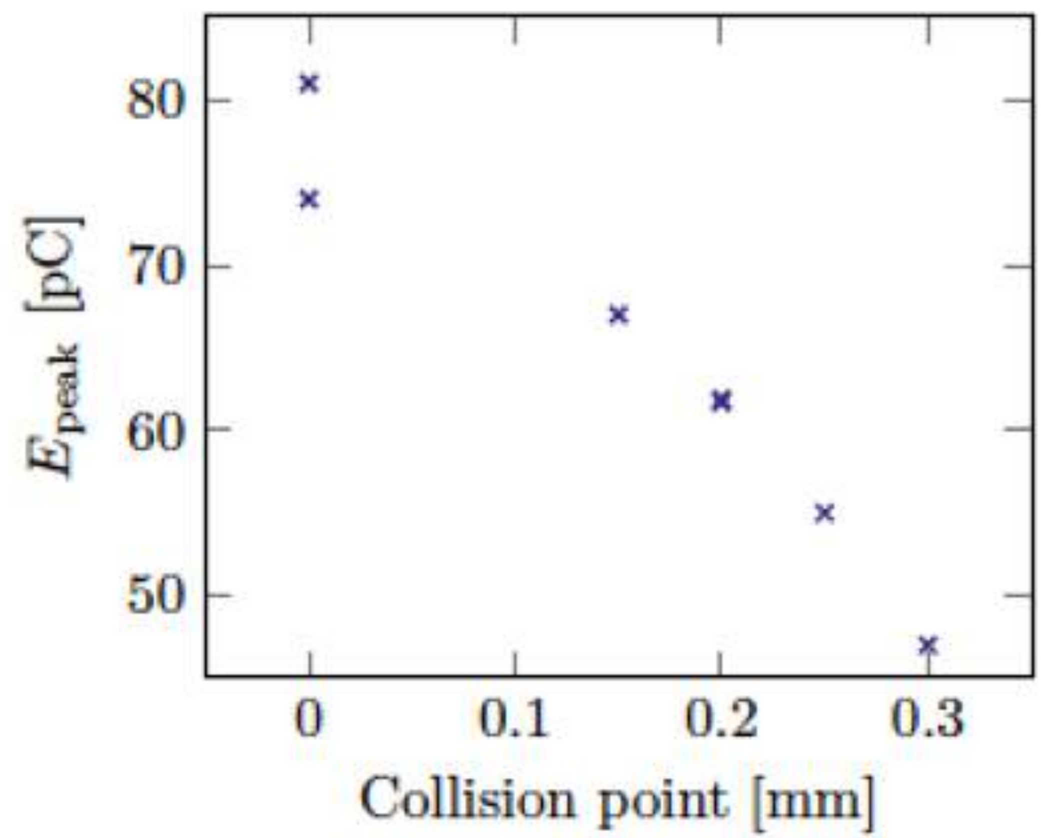


High quality beams

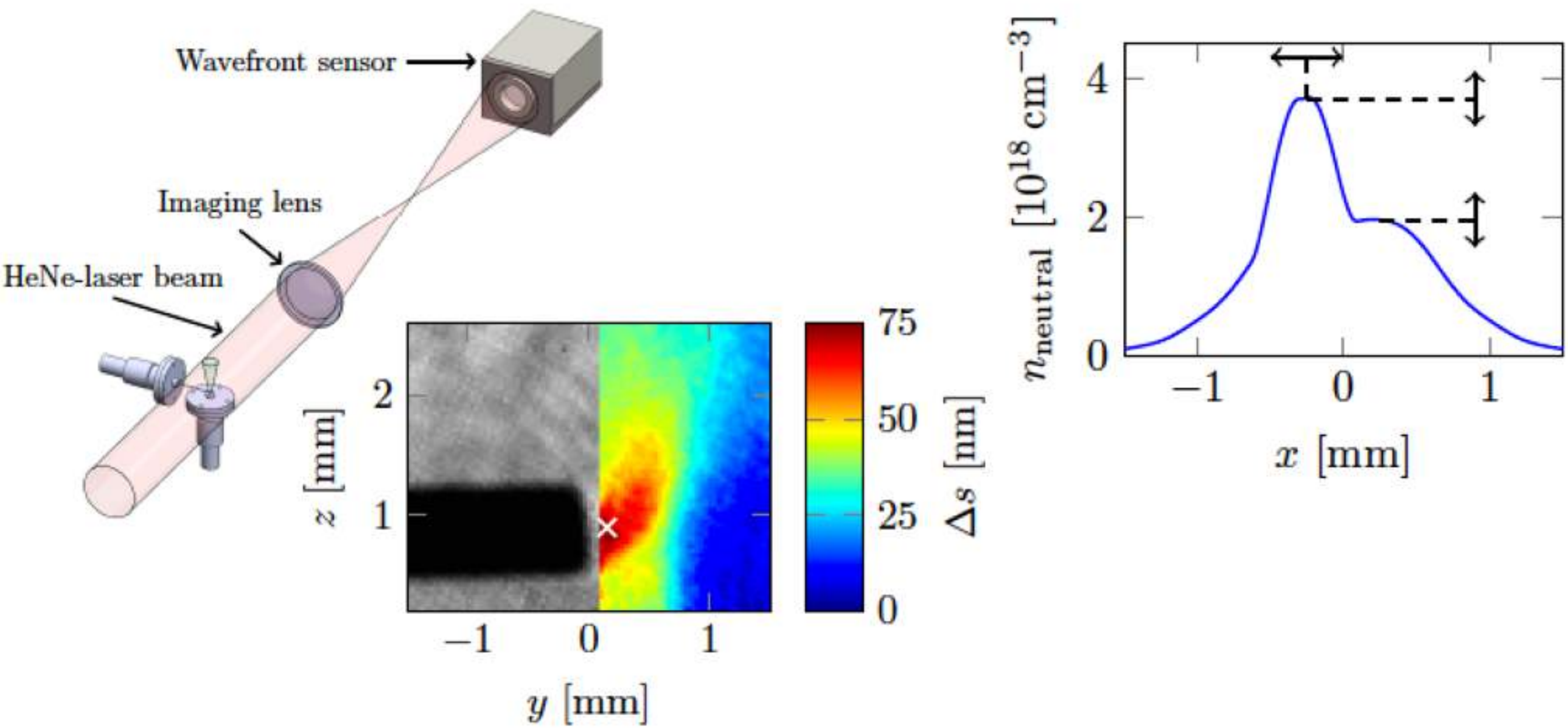




- Low divergence $\approx 3\,\mathrm{mrad}$
- Low energy spread $\approx 5\,\mathrm{MeV}$
- Charge $0.1\,\mathrm{pC} - 10\,\mathrm{pC}$

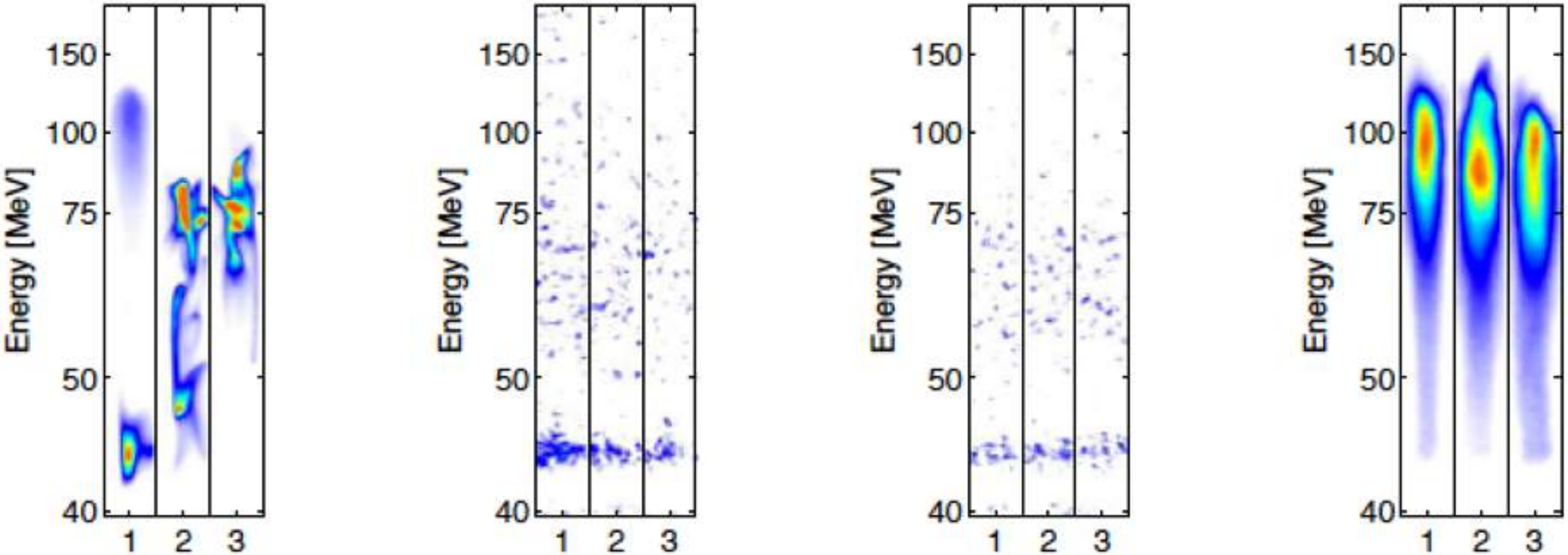


Density Gradient Injection



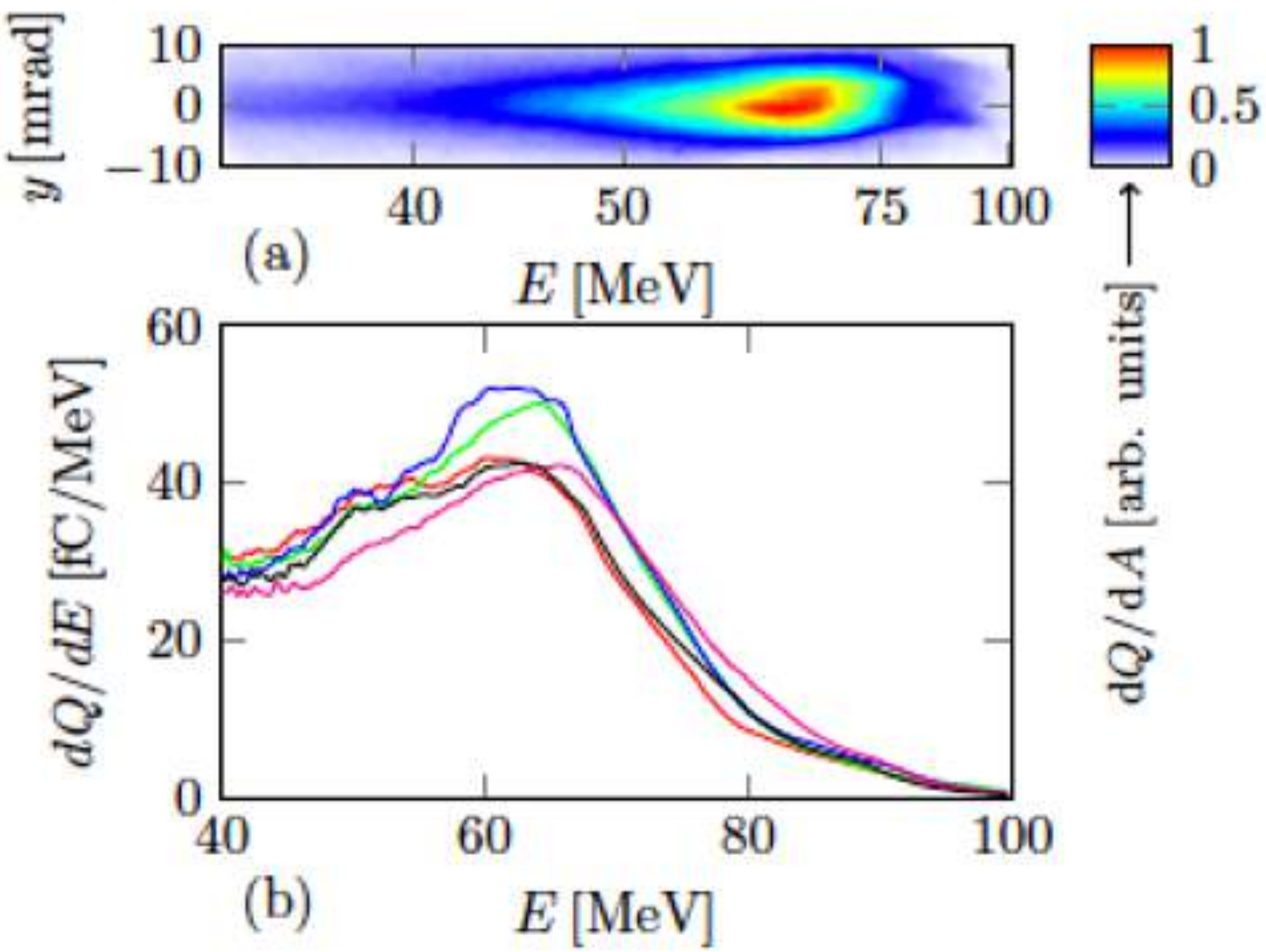
- Phase shift introduced by neutral gas measured using wavefront sensor
- Two regions of controlled density with gradient

Injection in density down-ramp



2 mm nozzle	2 mm nozzle	400 μm tube	Combined target
Plateau density: $13 \cdot 10^{18}\,\mathrm{cm}^{-3}$	Plateau density: $4 \cdot 10^{18}\,\mathrm{cm}^{-3}$	Peak density: $8 \cdot 10^{18}\,\mathrm{cm}^{-3}$	Peak density: $12 \cdot 10^{18}\,\mathrm{cm}^{-3}$ Plateau density: $4 \cdot 10^{18}\,\mathrm{cm}^{-3}$

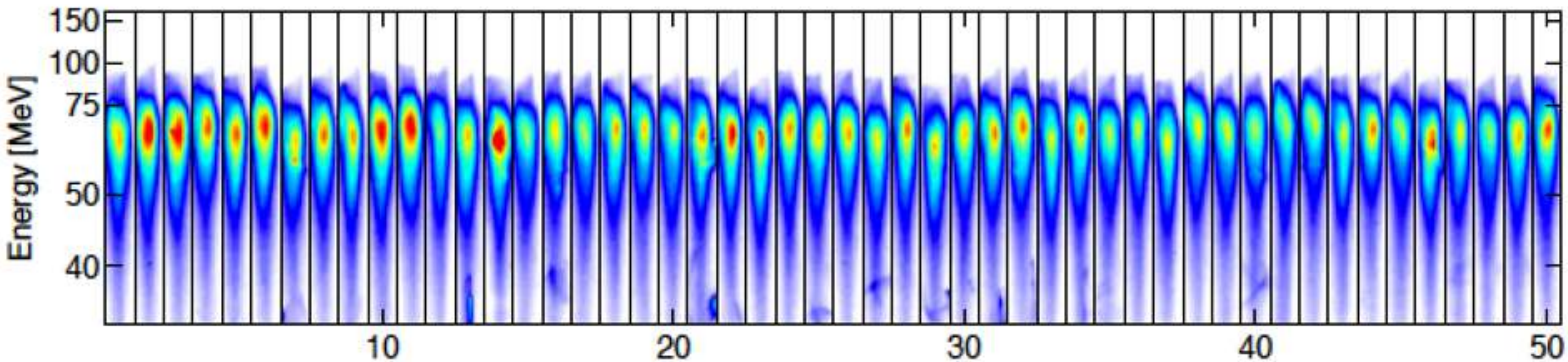
Stable beams of accelerated electrons



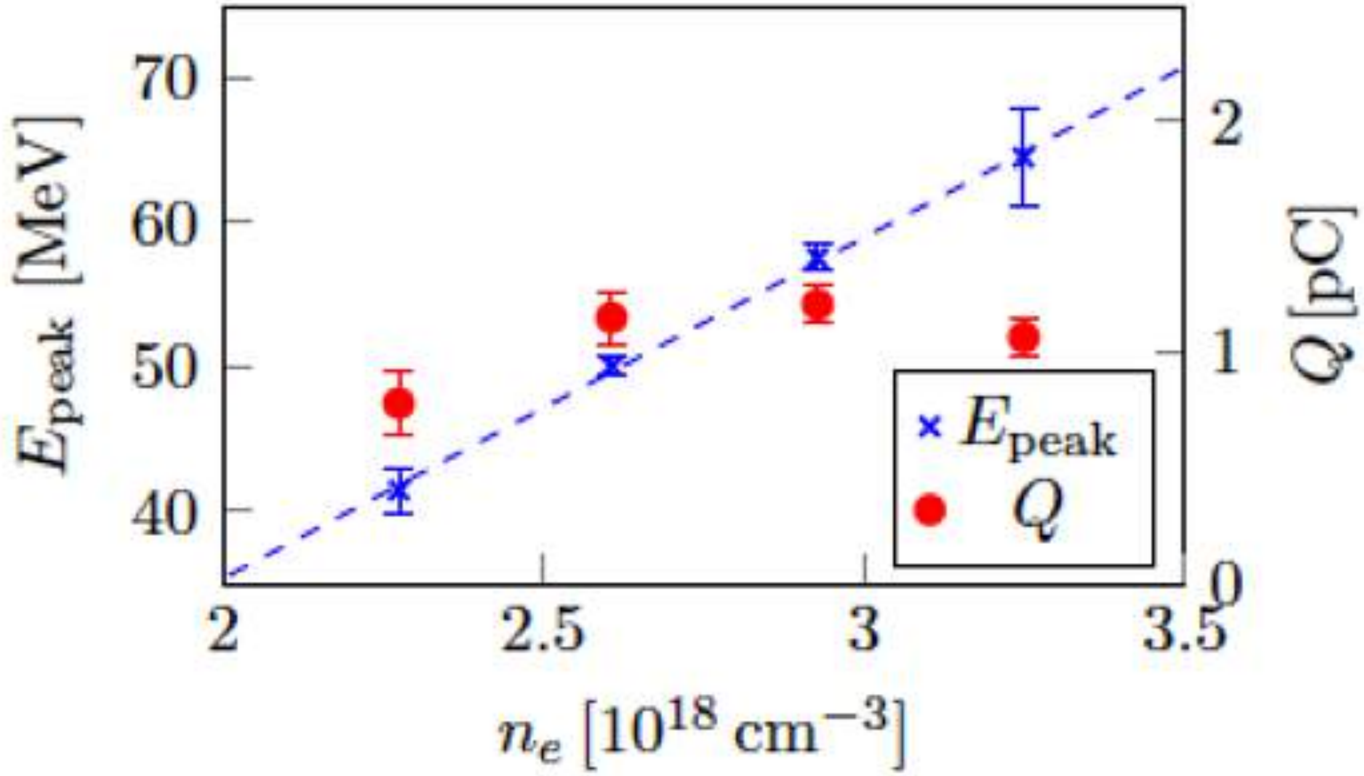
100 consecutive shots over 17 minutes

Peak density: $10 \cdot 10^{18}\,\mathrm{cm}^{-3}$
Plateau density: $3 \cdot 10^{18}\,\mathrm{cm}^{-3}$

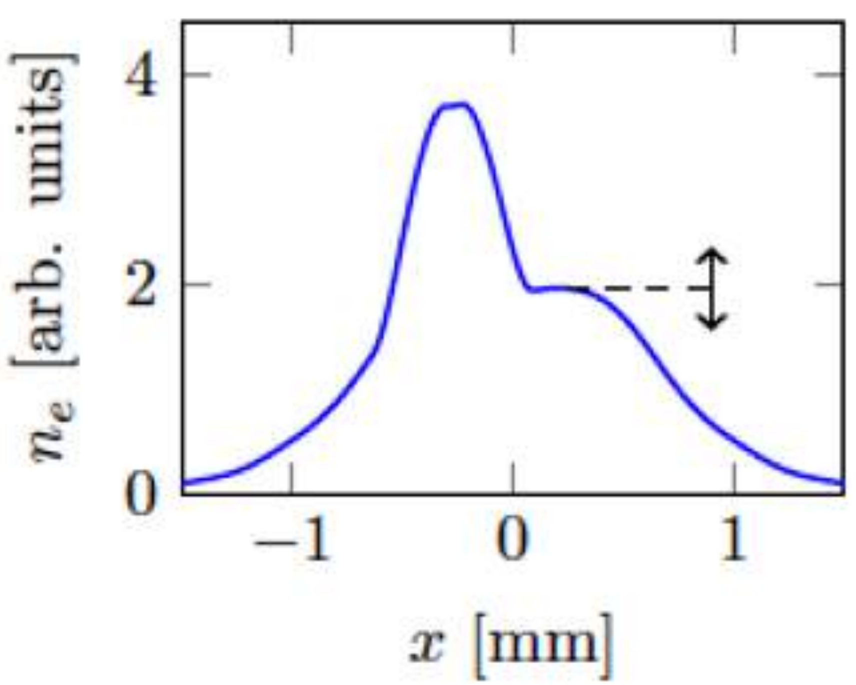
Average peak energy: $62\,\mathrm{MeV} \pm 5\%$
Average bunch charge: $1\,\mathrm{pC} \pm 13\%$



Tuning the accelerating field



Peak density: $10 \cdot 10^{18}\,\mathrm{cm}^{-3}$
10 shots for each position



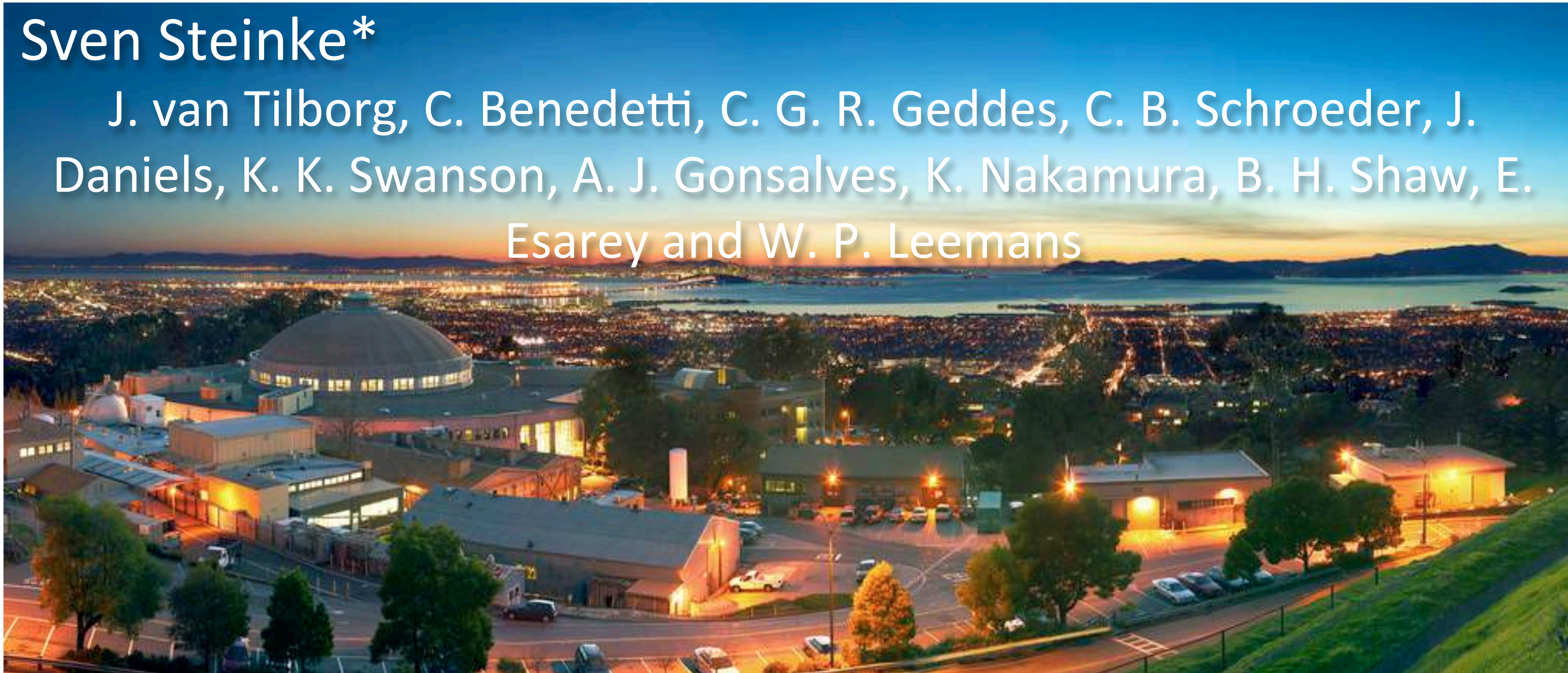
Increasing the plateau density increases electron bunch energy

Multistage Coupling of Laser Plasma Accelerators

HighLight

Sven Steinke*

J. van Tilborg, C. Benedetti, C. G. R. Geddes, C. B. Schroeder, J. Daniels, K. K. Swanson, A. J. Gonsalves, K. Nakamura, B. H. Shaw, E. Esarey and W. P. Leemans



*ssteinke@lbl.gov

BELLA Center, LBNL

Work supported by Office of Science, Office of HEP, US DOE Contract DE-AC02-05CH11231, and by NNSA DNN R&D, US DOE

BERKELEY LAB | U.S. DEPARTMENT OF ENERGY | Office of Science | High Energy Physics | NNSA National Nuclear Security Administration | DNN R&D

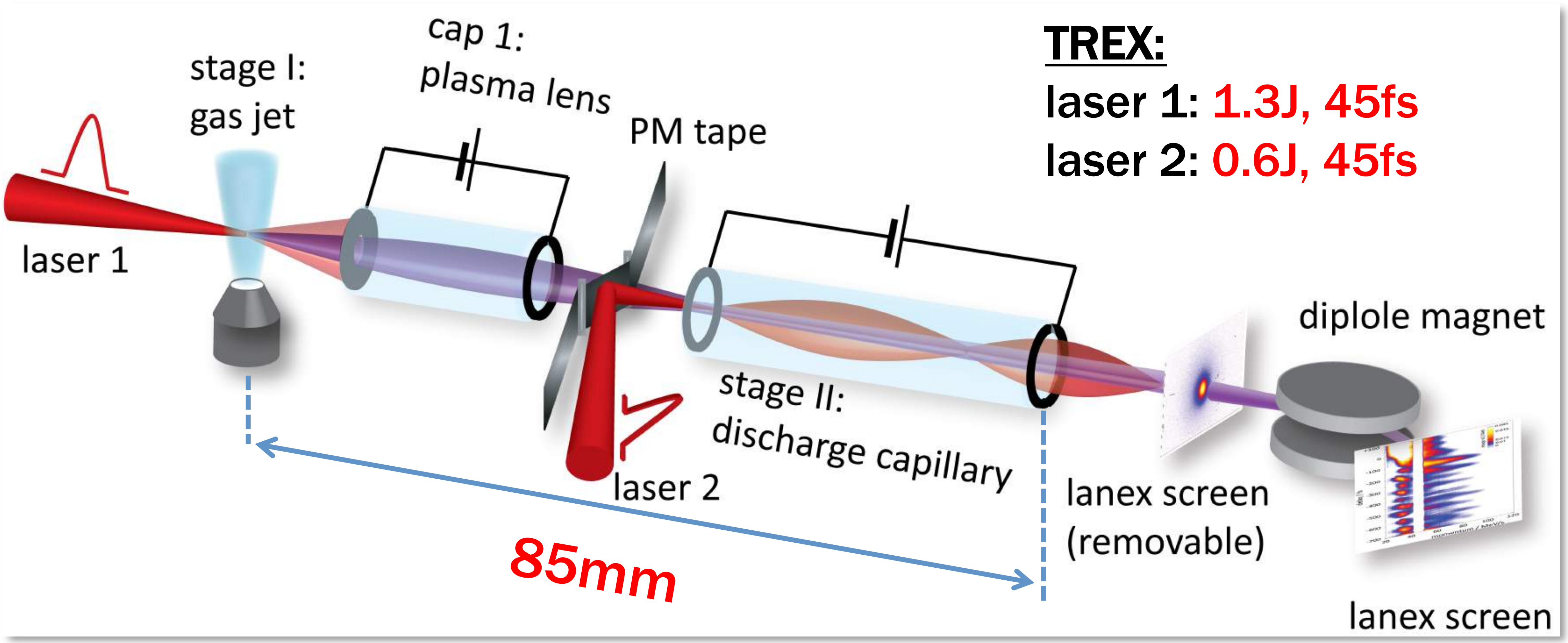
Compact setup for staging two LPAs in sequence

Stage I: gas jet - injector

Coupling II: tape-driven plasma mirror

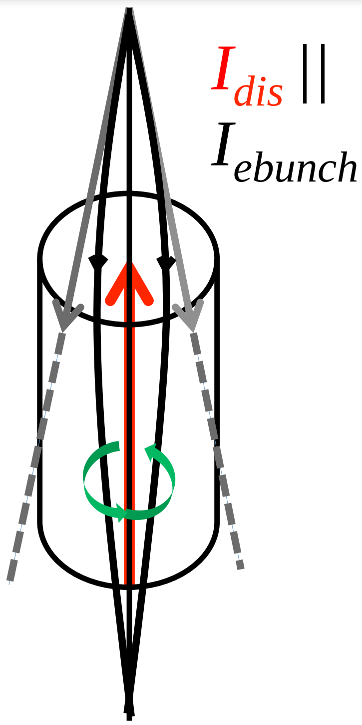
Coupling I: active plasma lens

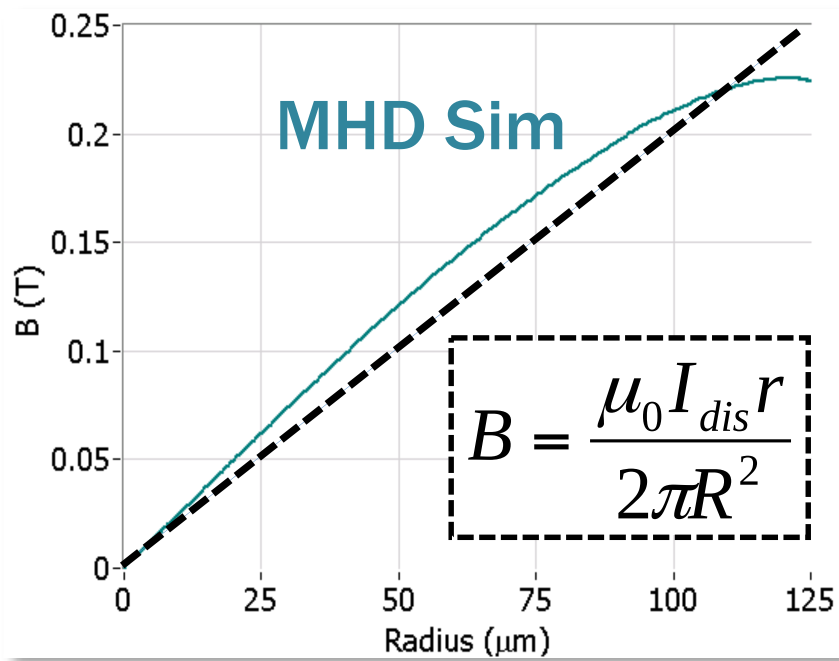
Stage II: discharge capillary- accelerator



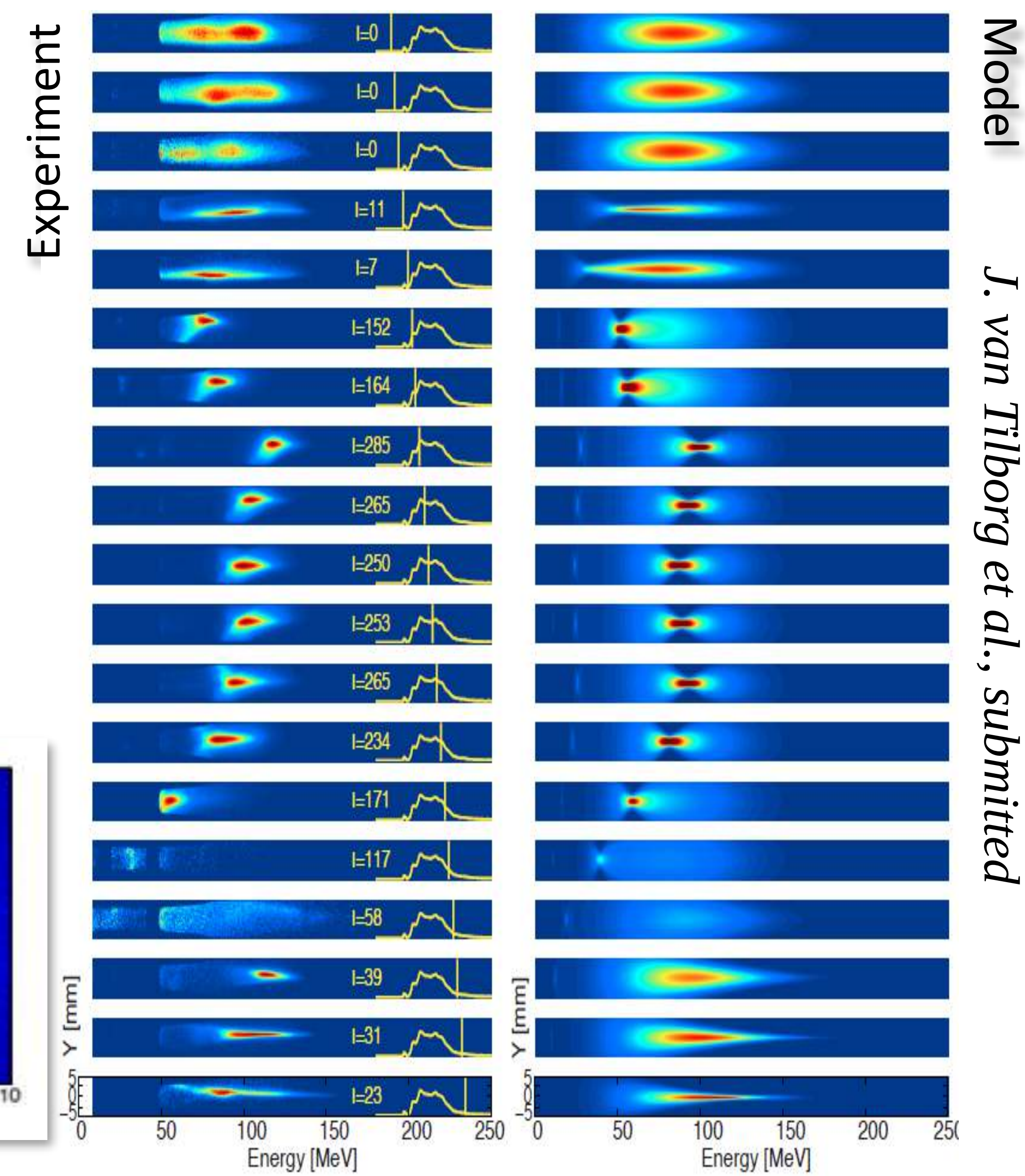
2nd European Advanced Accelerator Concepts Workshop, Elba, Italy, September 14-19 (2015)

Developed Active Plasma Lens for efficient e-beam coupling to the 2nd stage and emittance measurement

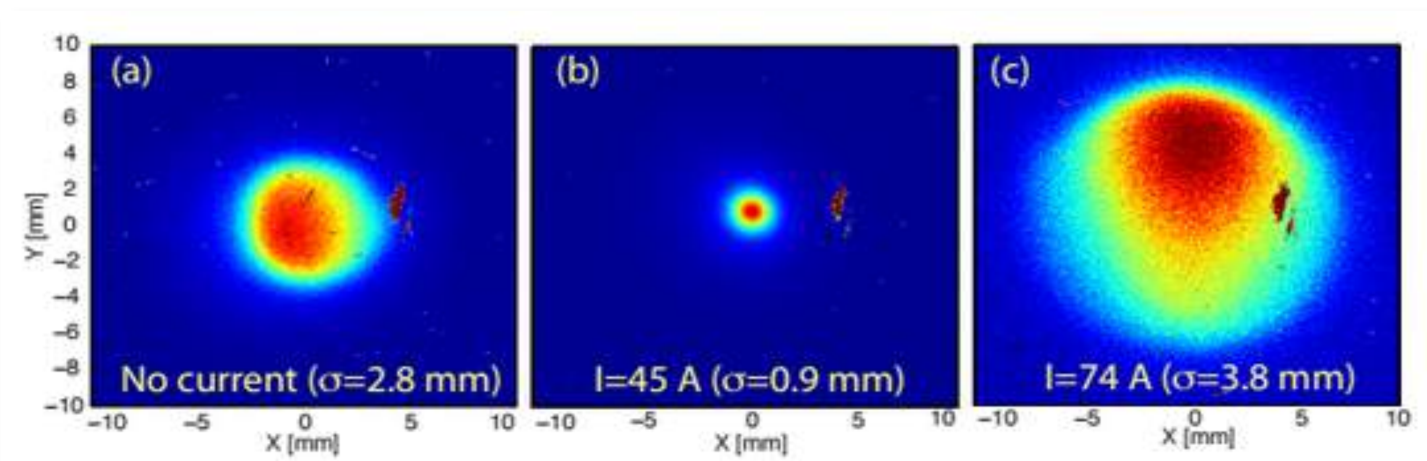




Magnetic spectrometer:

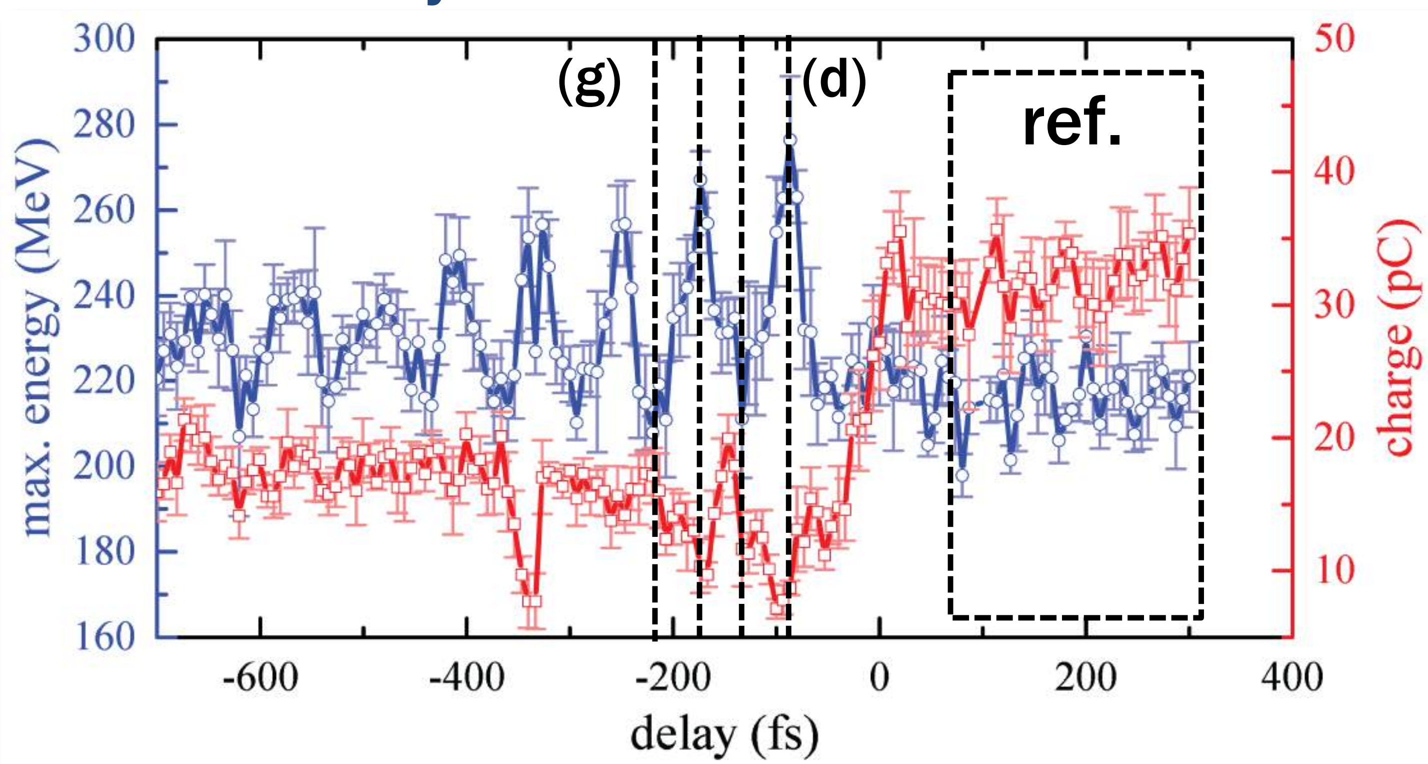


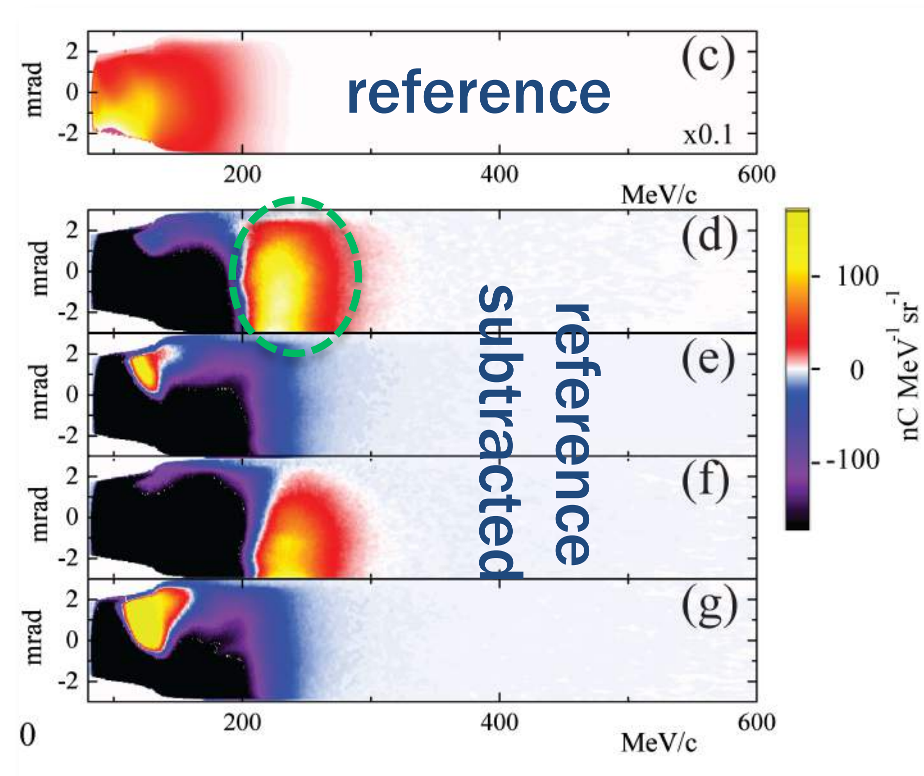
Phosphor screen:

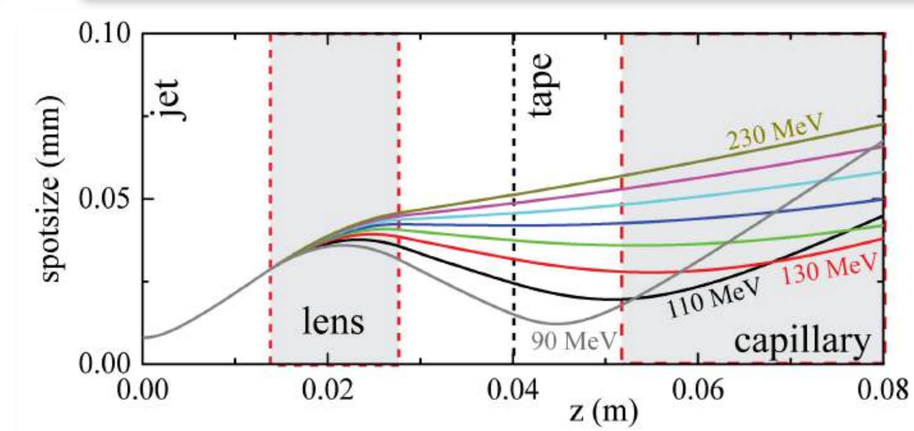


Quasi-linear wake properties probed and energy gain/loss of witness beam observed

- Modulation period of 80fs consistent with a plasma frequency at a density of $2x10^{18}cm^{-3}$







1pC of trapped charge is consistent with

- area ratio of e-beam and transverse wake radii at cap2 entrance
- energy interval of 10MeV

Controlled injection of plasma electrons into a laser-driven wakefield using a variable length gas target

O. Kononenko[1], N.C. Lopes[2], J.M. Cole[2], C. Kamperidis[2], S.P.D. Mangles[2], Z. Najmudin[2], J. Osterhoff[1], C.A.J. Palmer[1], K. Poder[2], D. Rusby[3], D.R. Symes[3], J. Warwick[4], J.C. Wood[2]

1 - Deutsche Electron-Synchrotron, Germany
2 - Imperial College London, UK
3 - Rutherford Appleton Laboratory, UK
4 - Queen's University Belfast, North Ireland

Imperial College London

Science & Technology Facilities Council
Rutherford Appleton Laboratory

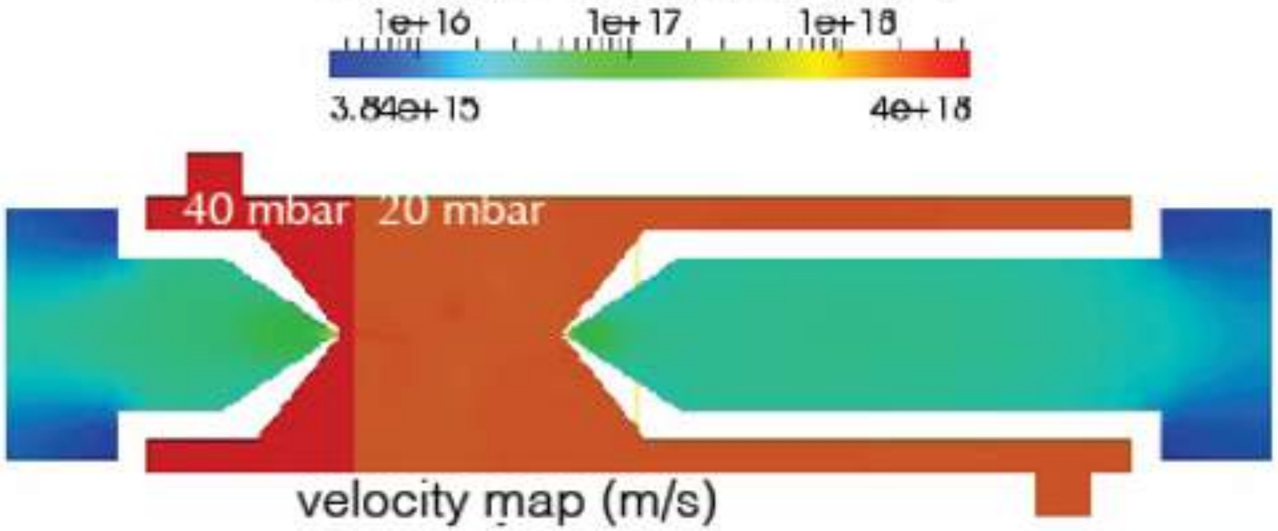
DESY
Deutsches Elektronen-Synchrotron

HELMHOLTZ ASSOCIATION

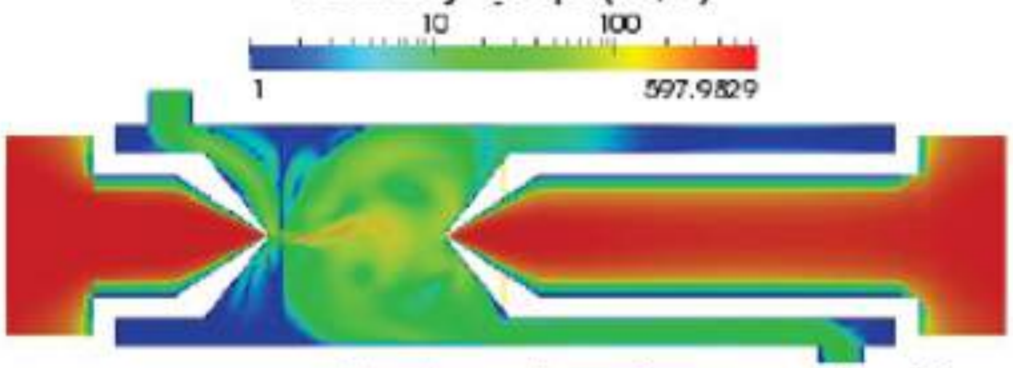
Queen's University Belfast

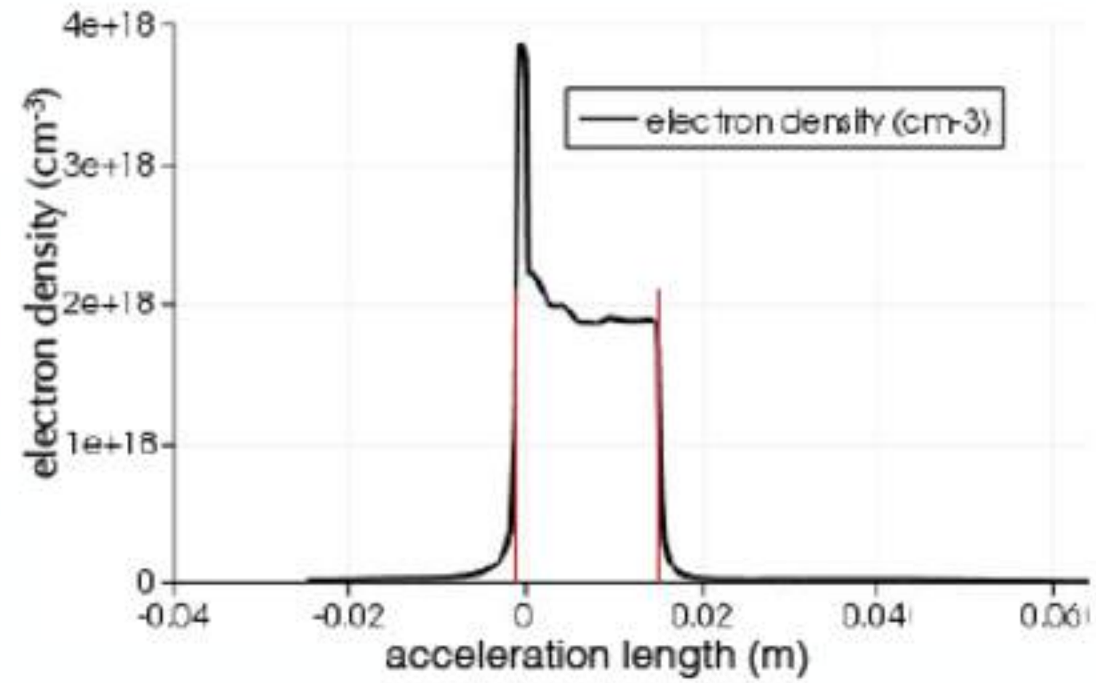
2D hydrodynamic simulations

electron density map (cm^{-3})



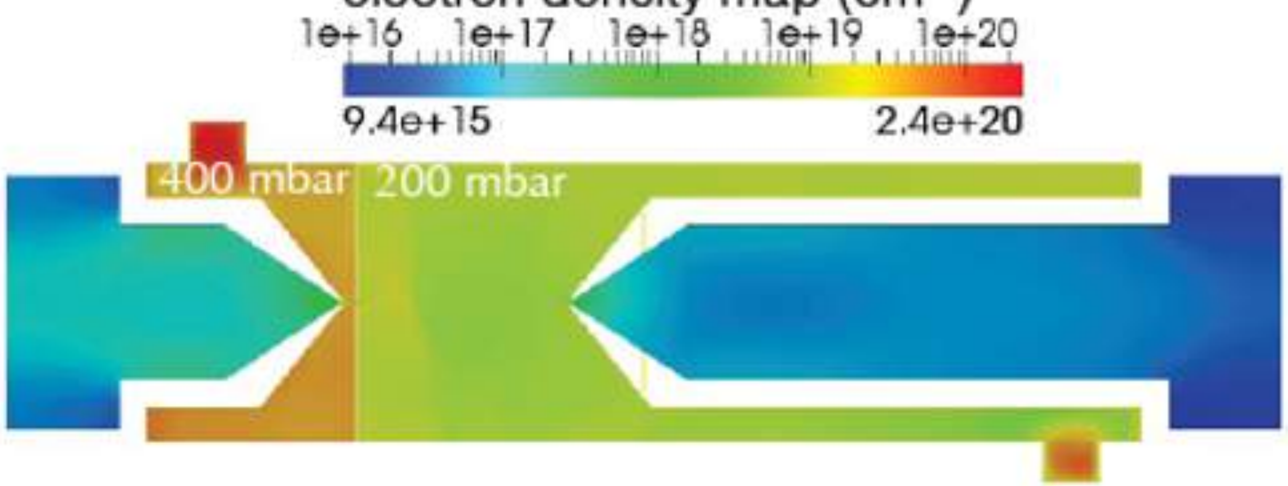
velocity map (m/s)

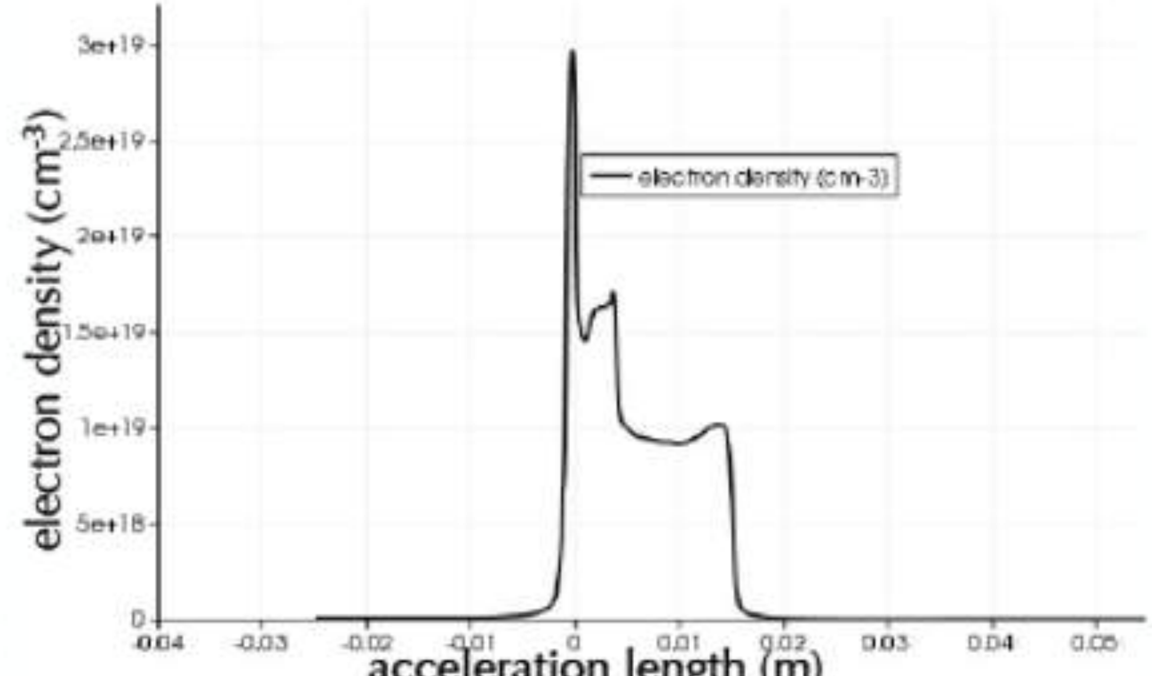




High turbulence and inhomogeneous filling for higher pressure

electron density map (cm^{-3})



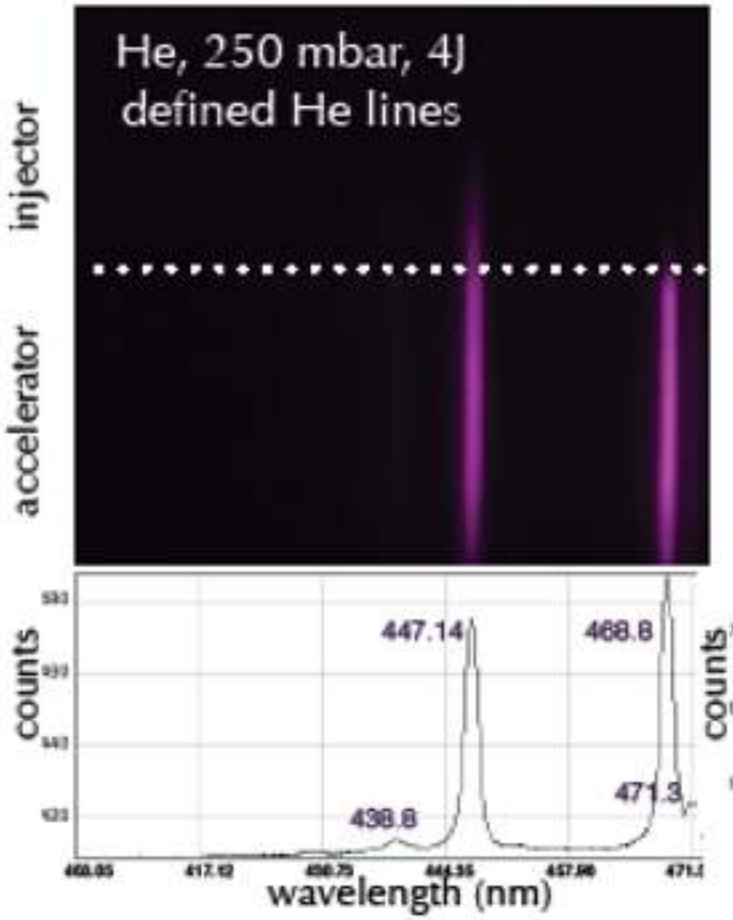


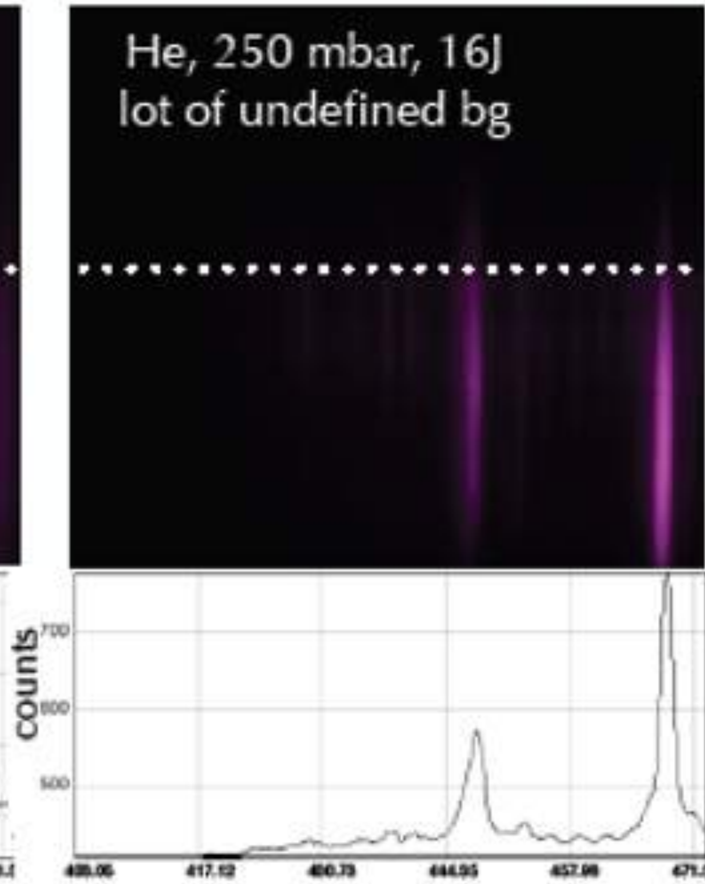
non-flat-top profile while pressuring the gas cell might lead to the high shot-to-shot fluctuations in density profile

2nd European Advanced Accelerator Concepts Workshop, Elba, Italy, September 14-19 (2015)

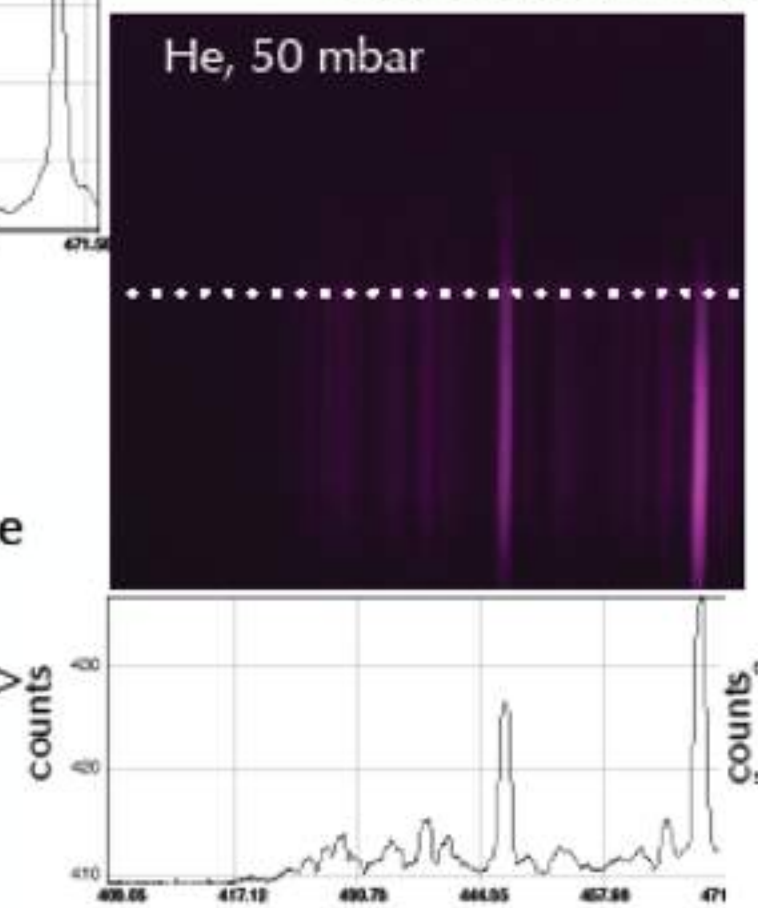
preliminary

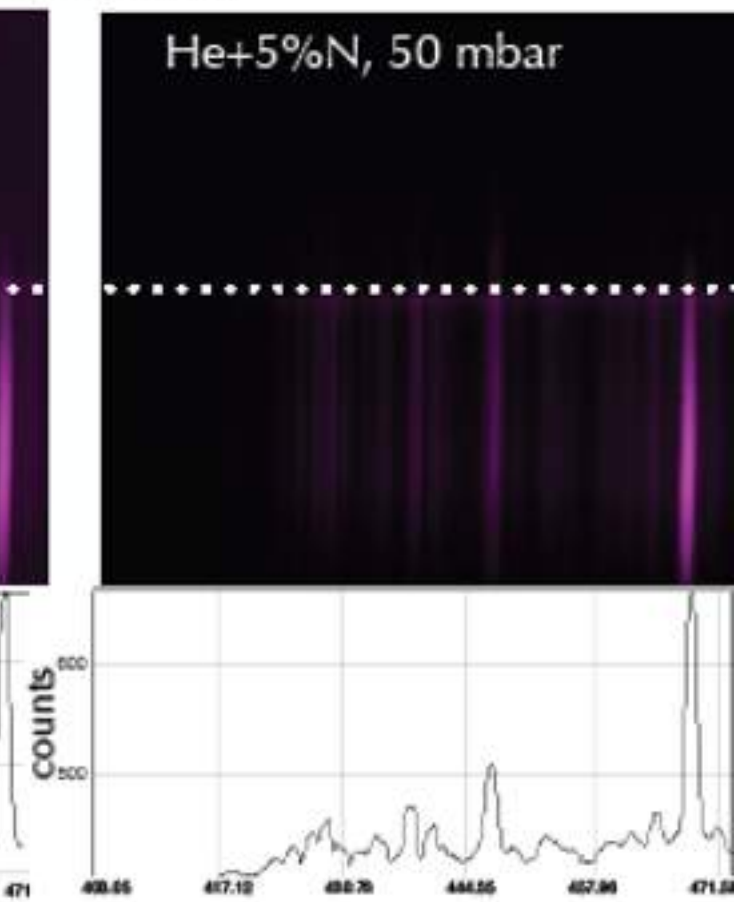
preliminary results: recombination light spectra





- Four helium lines measured at different target parameters
- high background at full energy shots (~ 12 J on target) observed
- nitrogen lines (460 - 466 nm) are not observable in integrated spectra
- data collection is ongoing





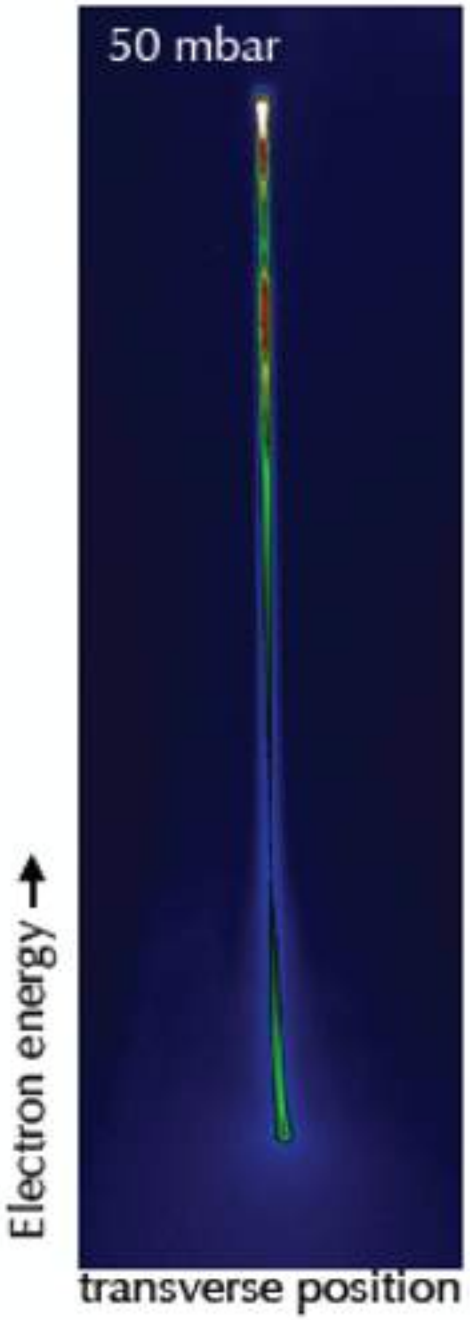
- ~~use bigger optics to collect more light~~
- ~~increase resolution by changing the grating~~
- intensity of lines scales with a density -> increase density
- measure spectra in different spectral regions -> e.g. at 567 - 587 nm [2]

[2] Pollock B B *et al* 2011 Phys. Rev. Lett. 107 045001

preliminary

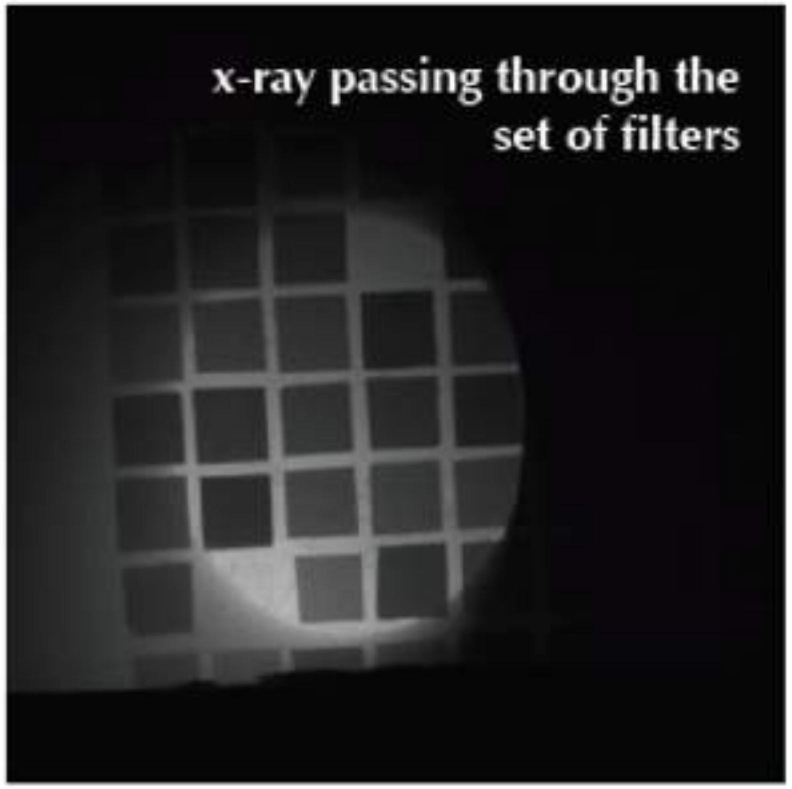
preliminary results: electrons and x-ray

Self injection
at 2 cm of He



- guiding over few Rayleigh distances observed
- Self injection and ionisation injection tested at:
  - different target length,
  - gas mixture,
  - electron densities and
  - laser energy pulse
- electron energy above 1 GeV achieved
- bright x-ray signal was measured

EXPERIMENT AND DATA ANALYSIS
ARE ONGOING



Numerical investigation on formation and stability of a hollow electron beam in the presence of a plasma wake field driven by an ultra-short electron bunch

F. Tanjia[a,b], R. Fedele[a,b], S. De Nicola[c,b], T. Akhter[a,b], and D. Jovanović[d]

[a] Dipartimento di Fisica, Università di Napoli Federico II, Napoli, Italy

[b] INFN Sezione di Napoli, Italy

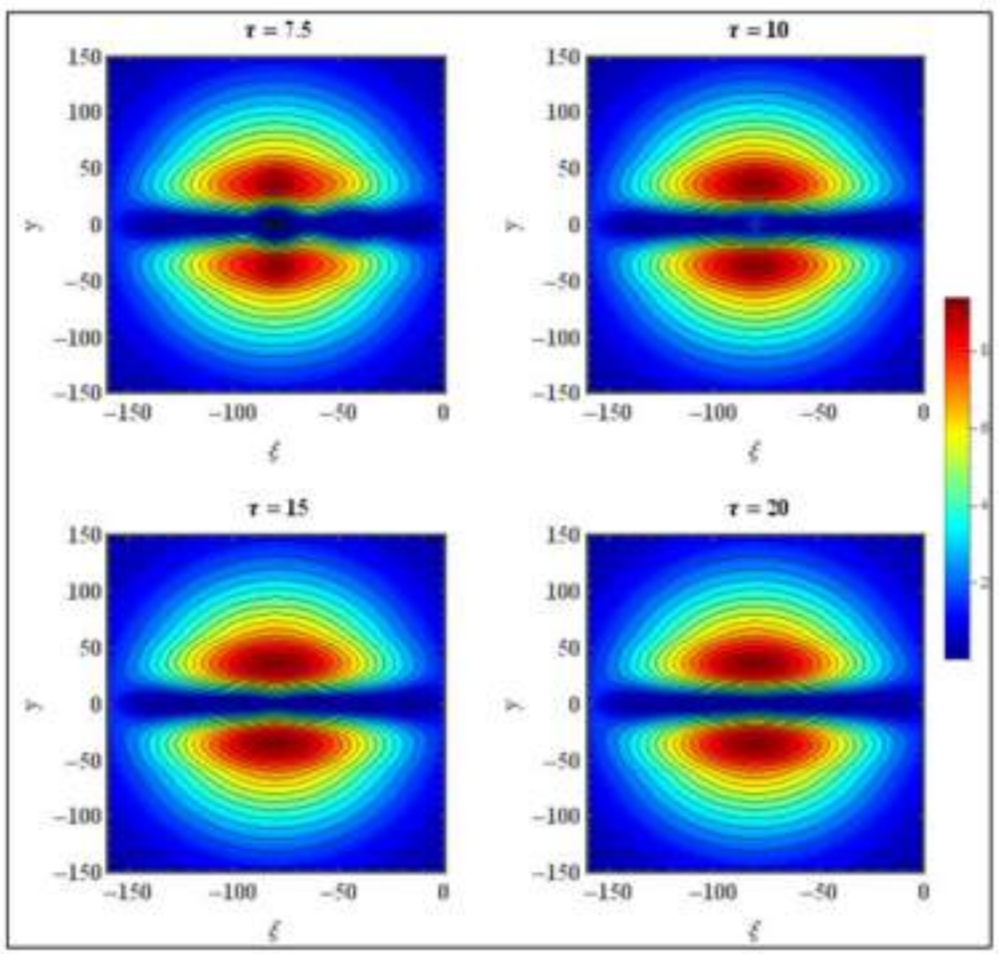
[c] CNR-SPIN, Sezione di Napoli, Napoli, Italy

[d] Institute of Physics Belgrade, Serbia

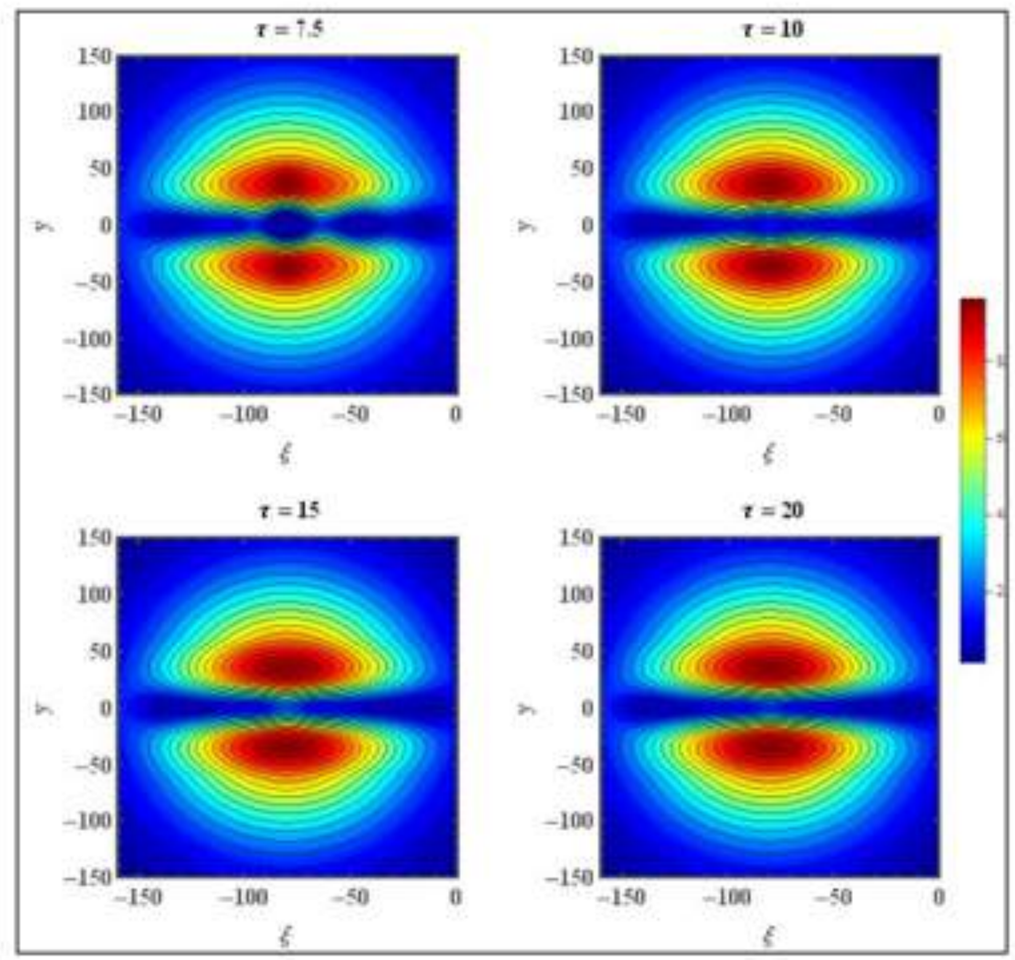
Formation of filaments and voids ($\tau' = 0 - 0.5$)
Coalescence of voids and channeling ($\tau = 0.75 - 5$)
Hollow beam formation ($\tau = 7.5 - 20$)

Hollow formation

$\rho_b'(x, y, \xi, \tau)$ at the depth $x = 0$



$\rho_b'(x, y, \xi, \tau)$ at the depth $x = 5$

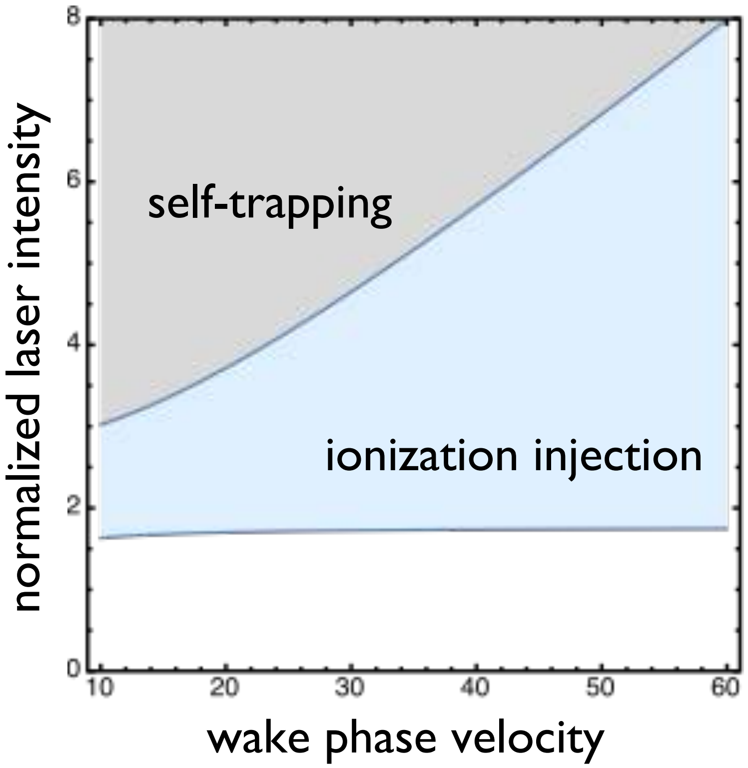


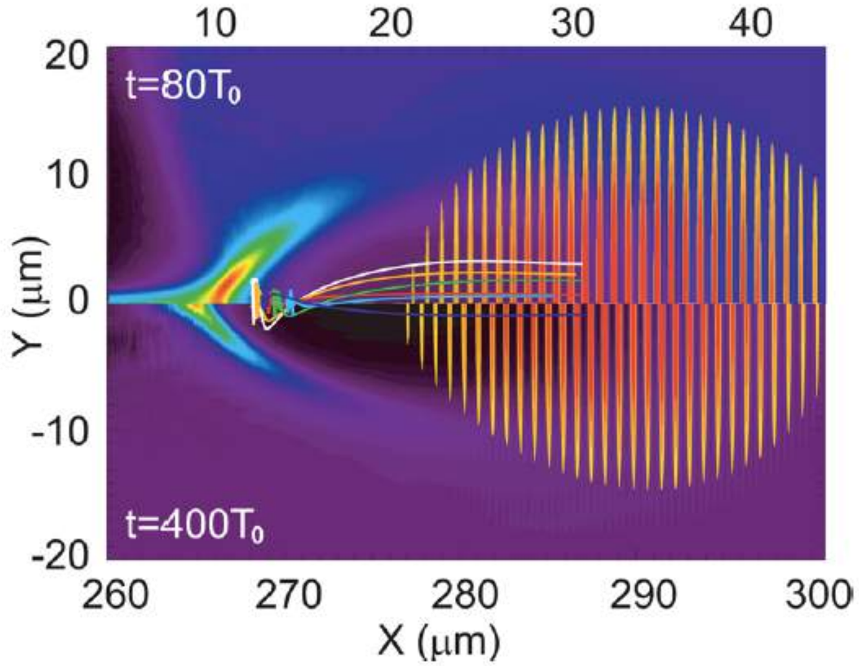
- Evolution becomes slower
- Through the process of channeling, hollow structure is created
- the evolution preserves this hollow formation

Summary

- A model of PWF theory in the overdense regime has been presented introducing the effective careful analysis of the longitudinal sharpness of the bunch compared to its high energy conditions
- A second electron beam of Gaussian profile is **externally injected** in phase locking with the plasma wake field. The longitudinal beam dynamics of driven beam has been analysed within the context of quantum formalisms (quantum-like domain) provided by the Thermal Wave Model (TWM).
- The beam density evolution has been numerically investigated by taking into account typical values for the beam and plasma parameters. We have found several interesting phenomena as time increases:
  - ❖ **Formation of filaments and voids**
  - ❖ **Coalescence of voids and channeling**
  - ❖ **Hollow beam formation**
- In conclusion-
  - ❑ The number of particles are pushed forward or backword in such a way that they are longitudinally squeezed in specific regions, thus **modulating *the longitudinal beam profile*** (the effect resembles the bucket formation due to a spatially periodic electric field structure)
  - ❑ In the transverse direction, the effect seems to be mainly due to the radial dependence of the wake potential that leads to the formation of ***hollow beam***
  - ❑ After some certain time interval the beam profile becomes stable both longitudinally and radially thus ***preserving it from being collapsed***

Transverse emittance of electron beams generated by ionization injection in laser-plasma accelerators





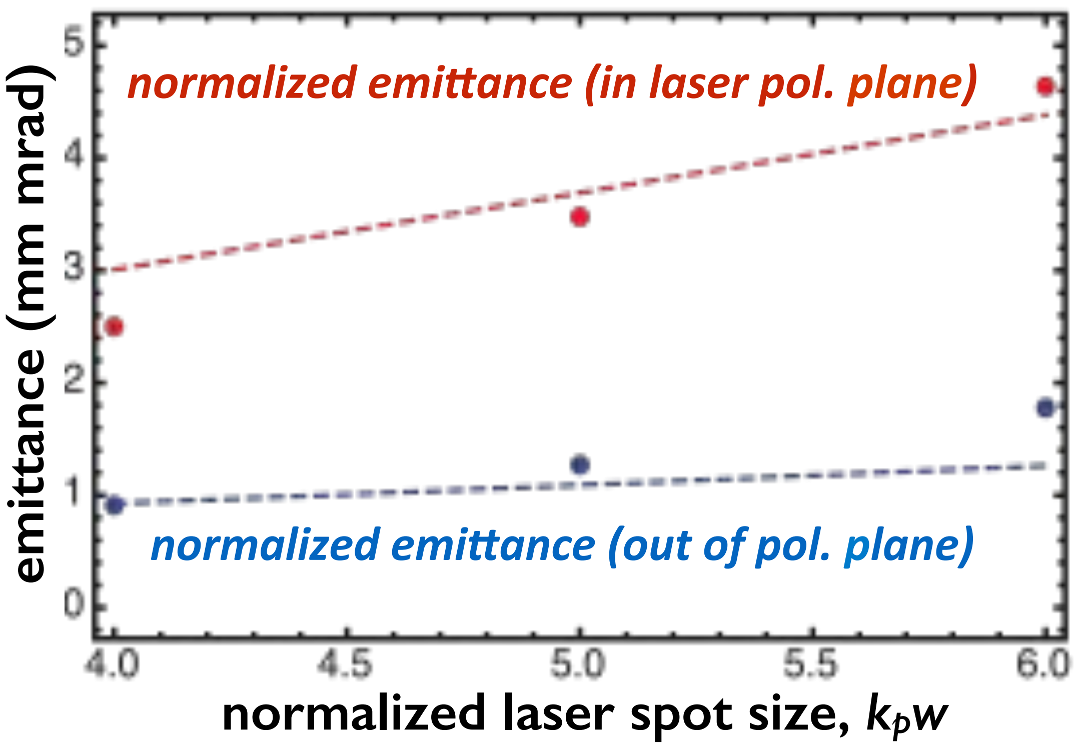
a_0=3
ω/ω_p=20
($n=4x10^{18}$ cm^{-3})
gas: $H_2 + N_2$
ionize N+6 (Ui=667 eV) trapped

- Beam generation using ionization injection in LPAs:
  - Initial transverse phase-space distribution following ionization and passage through the laser determines final saturated emittance.

C. Schroeder et al., PRST-AB 17, 101301(2014)

  - Initial transverse beam momentum dominated by quiver motion — asymmetric emittance
  - >1 micron emittance (~order-of-magnitude larger than self-trapped beam)

points = PIC (modeled using INF&RNO)
dashed curves = theoretical model

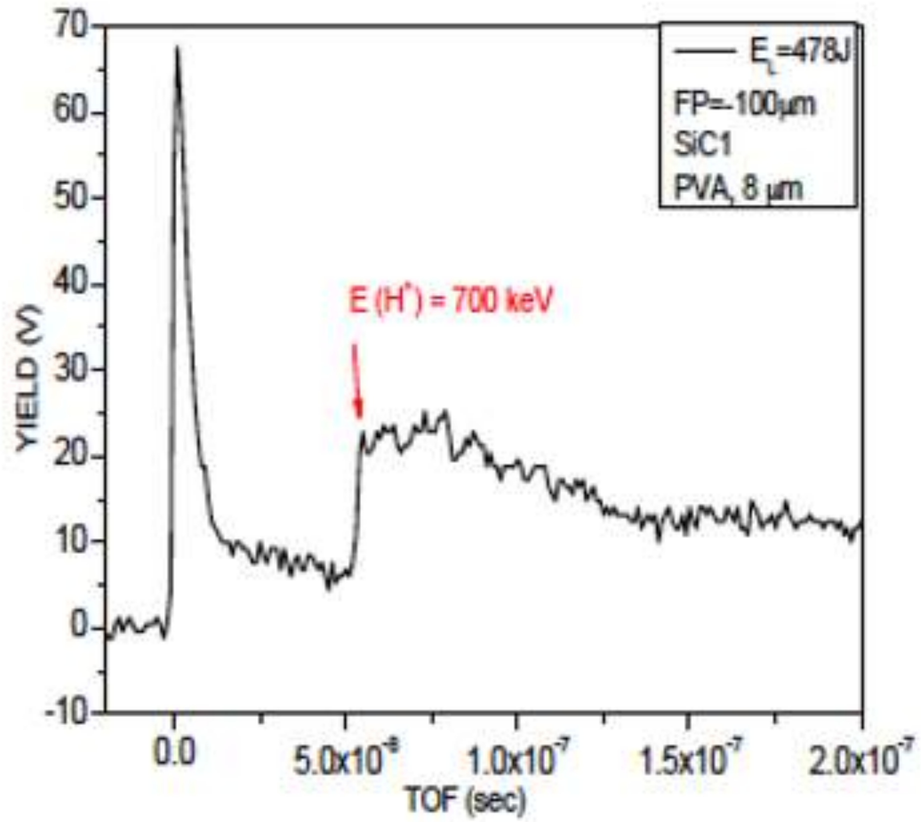


SUMMARY

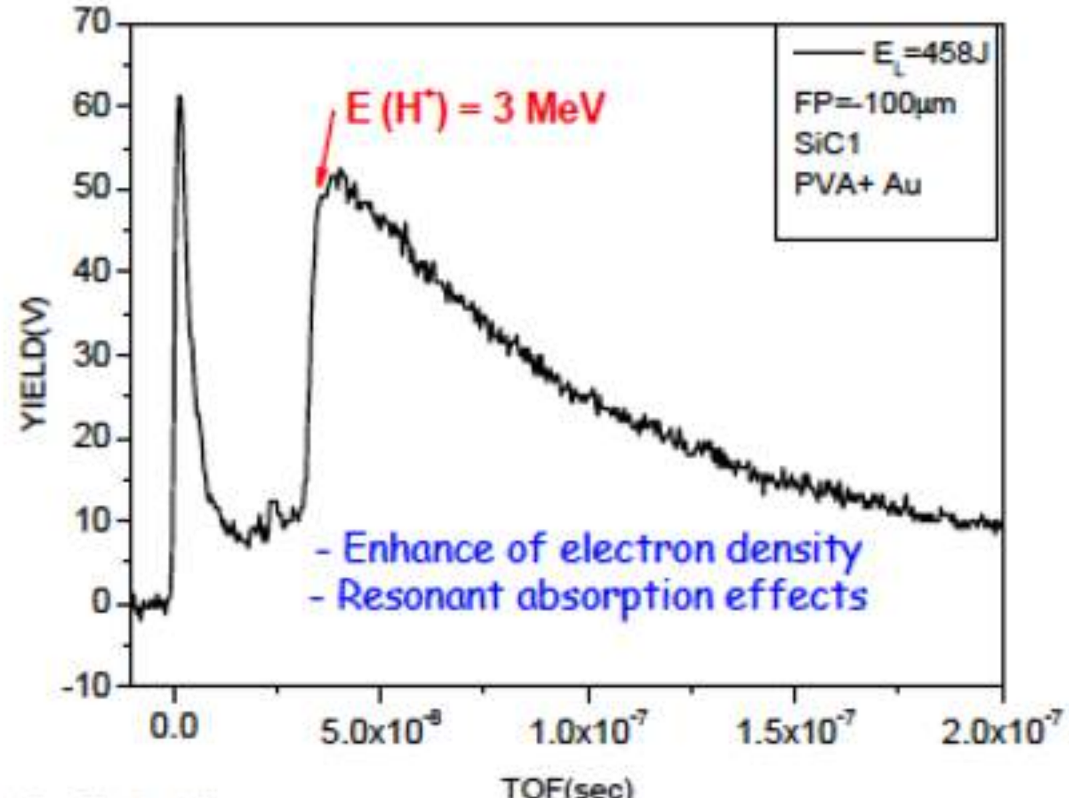
- NANOSECOND vs FEMTOSECOND LASER-MATTER INTERACTION AT HIGH INTENSITIES
- ENEA EXPERIMENT: THE ROLE OF PARAMETRIC INSTABILITIES
- PALS EXPERIMENT: THE ROLE OF THE NANOPARTICLES AND RESONANT ABSORPTION
- CONCLUSIONS AND PERSPECTIVES

TOF Spectra from SiC detectors

$D_{TOF} = 62$ cm



Pure PVA
polyvinyl alcohol, $(C_2H_4O)_x$



Au nanospheres, D ~ 50 nm,
Embedded in PVA+A.R. by Spinning
deposition (10 mg/10 ml), 10 um thick

EAAC-2015 Danilo Giulietti

Downramp-assisted underdense photocathode electron bunch generation in plasma wakefield accelerators

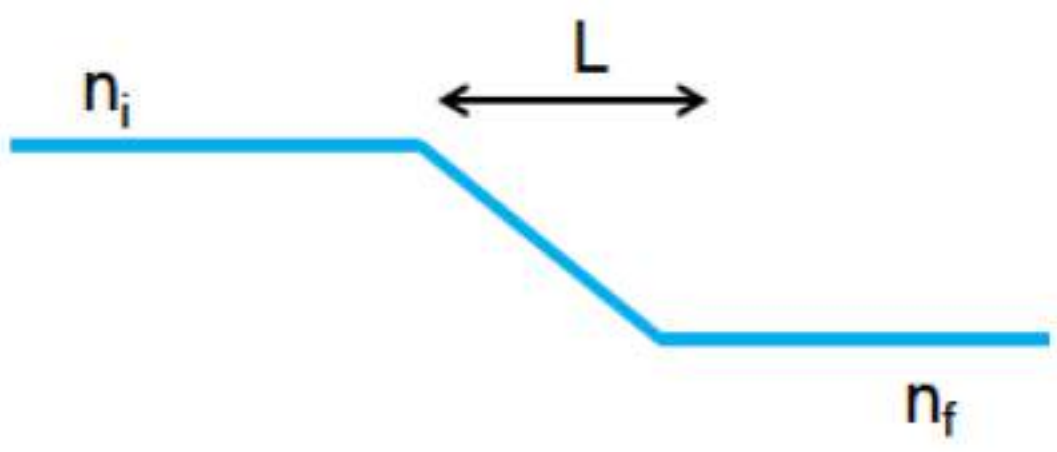
A. Knetsch [1], G. Wittig[1], O. Karger[1], H. Groth[1], G.G. Manahan[2], Y. Xi[3],
A. Deng[3], J. B. Rosenzweig[3], D.L. Bruhwiler[4], G. Andonian[2,5], G. Xia[6], D. Jaroszynski[2],
Z.M. Sheng[2], J. Smith[7], S. P. Jamison[4], B. Hidding[1,2]

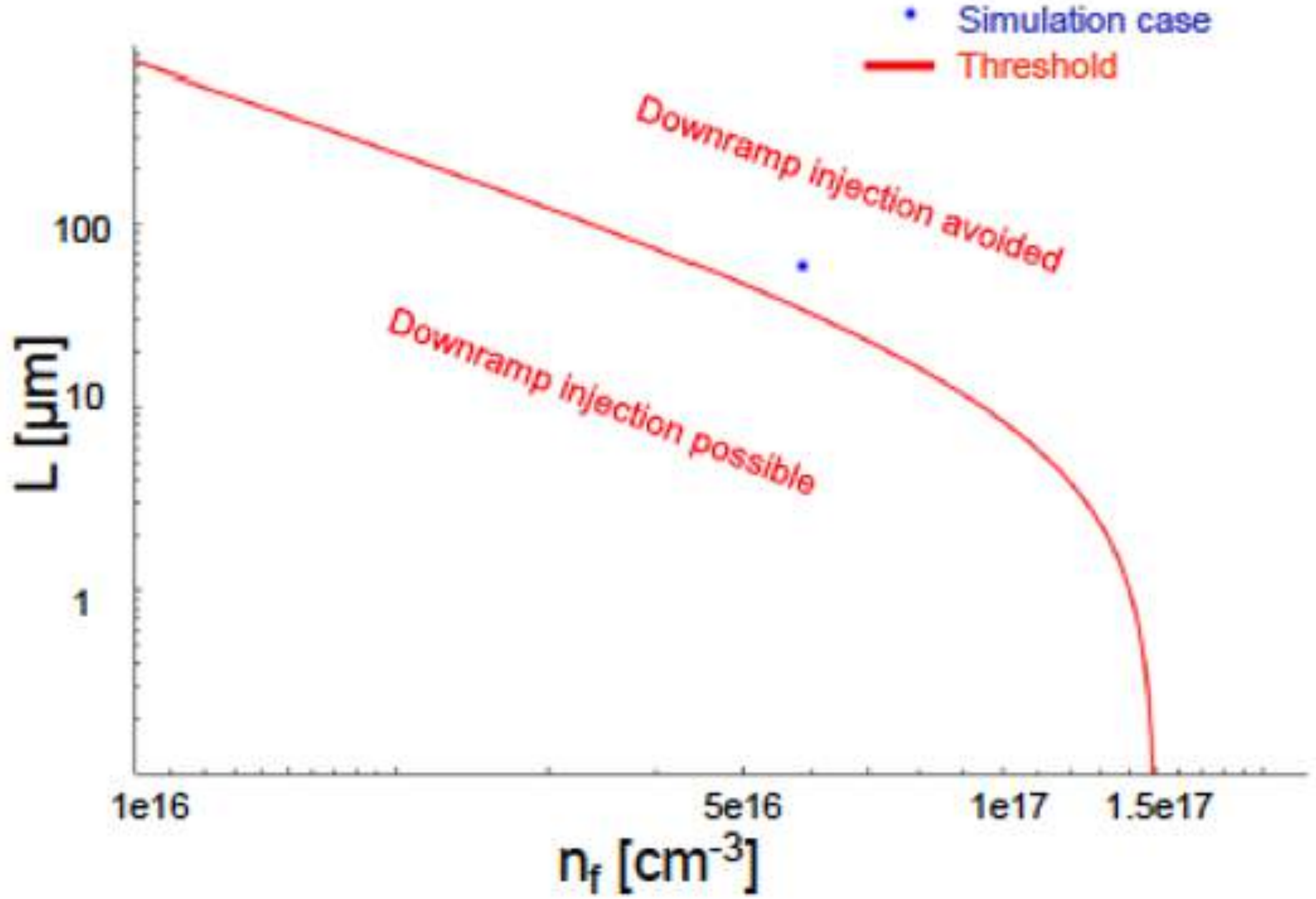
[1] Institute of Experimental Physics, University of Hamburg, [2] University of Strathclyde, SCAPA, SUPA,
[3] Particle Beam Physics Laboratory, University of California, Los Angeles, [4] RadiaSoft LLC, USA,
, [5]RadiaBeam Technologies, [6] University of Manchester, UK, [7]TechX UK Ltd [8] Cockroft Institute, Daresbury, UK.

EAAC 2015

Avoid Downramp injection

Electron density profile





- Avoid downramp injection into first blowout

  $k_p \frac{n}{|dn/dz|} > 1$ [5]

- DR Injection into subsequent blowout possible

[5] H. Suk et al., PRL 2001

Summary

- Downramp-assisted trojan horse PWFA can significantly lower the requirement for the driver beam in peak current
- Emittances compareable to the straight forward trojan horse PWFA can be achieved.
- Excellent tool for dark current suppression
- Witness bunch is stretched longitudinally
- Downramp injection into subsequent blowout likely

Laboratoire d'Optique Appliquée

Palaiseau – FRANCE http://loa.ensta.fr

UMR 7639

Effect of the laser wavefront in a high repetition rate laser-plasma accelerator

B. Beaurepaire, A. Vernier, A. Lifschitz and J. Faure

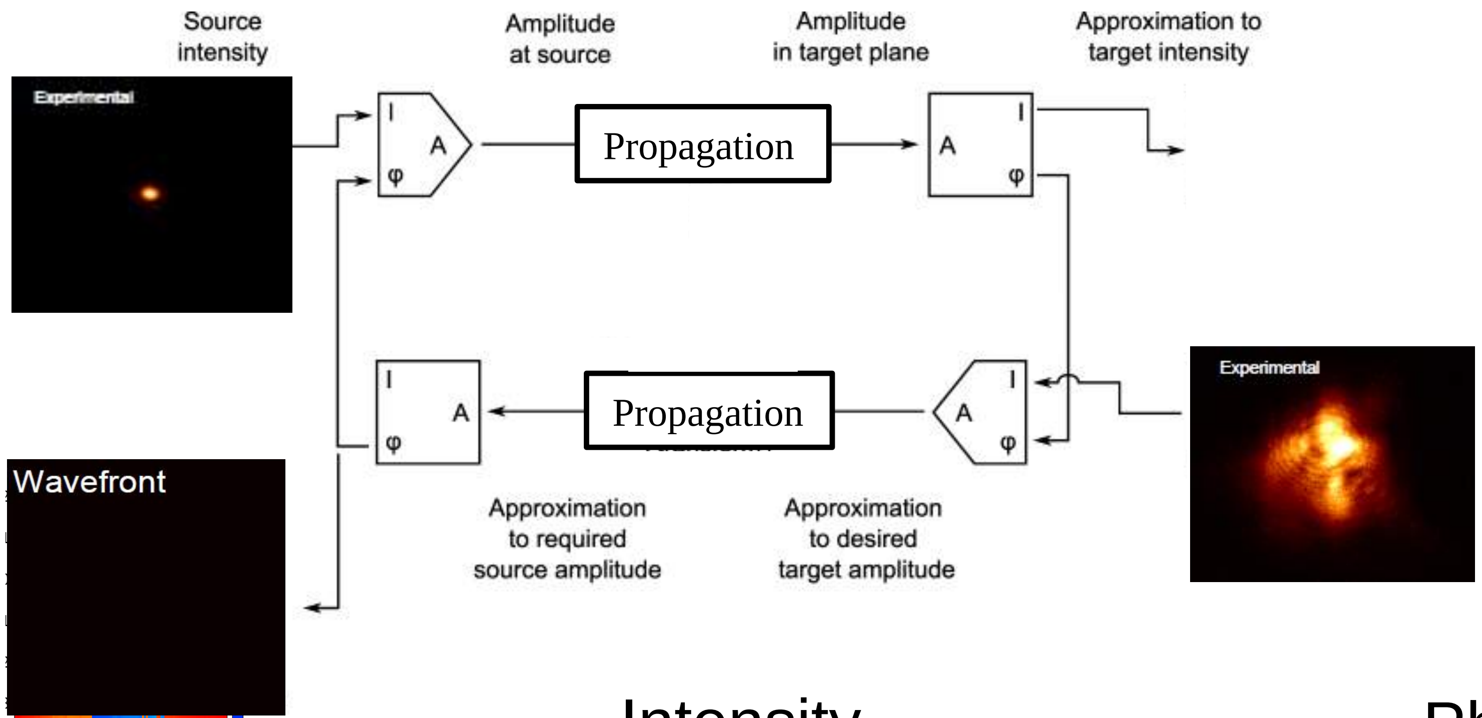
Laboratoire d'Optique Appliquée
Ecole Polytechnique, France

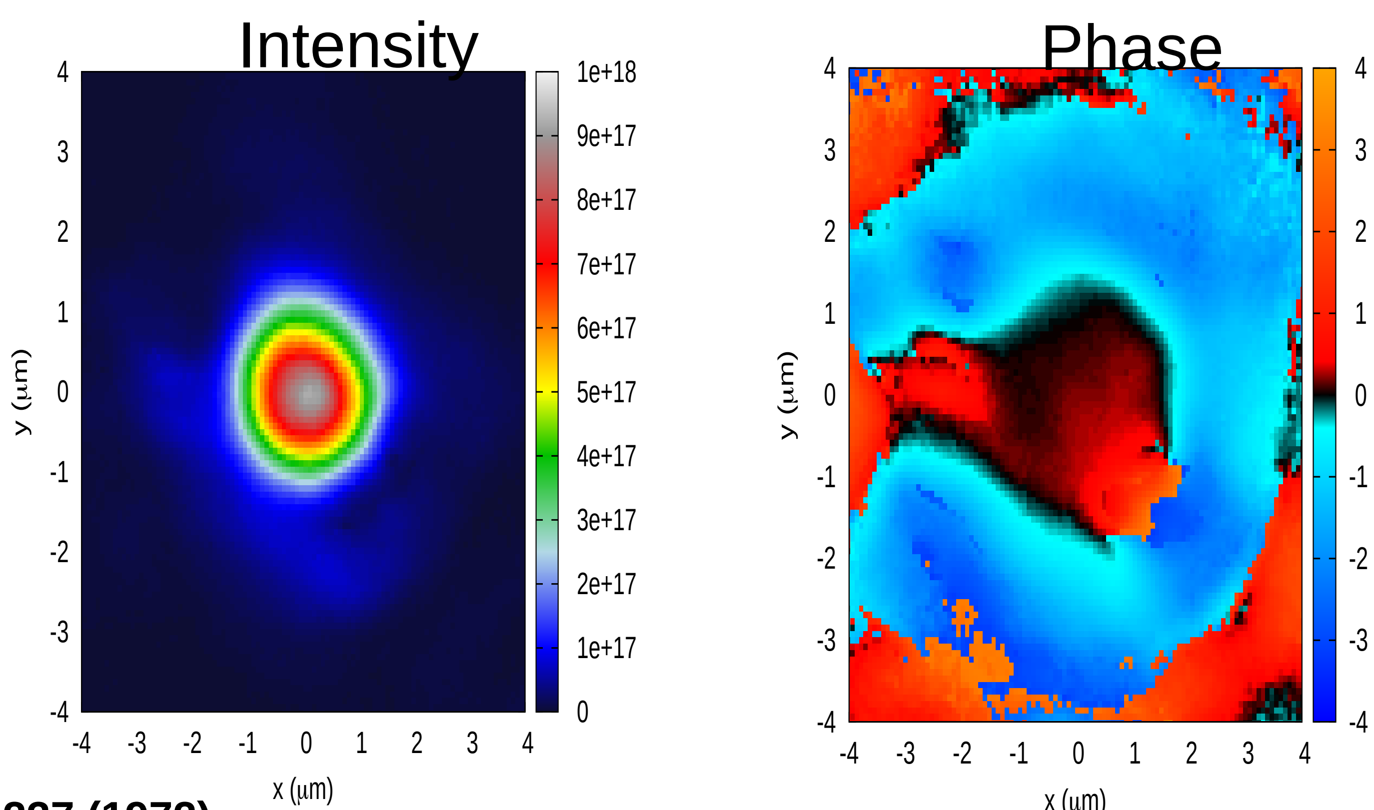
Z. He, J. Nees, B. Hou, K. Krushelnick and A. Thomas

Center for Ultrafast Optical Science
University of Michigan Ann Arbor, MI, USA

EAAC Workshop 2015

Reconstruction of the laser wavefront: The Gerchberg-Saxton algorithm





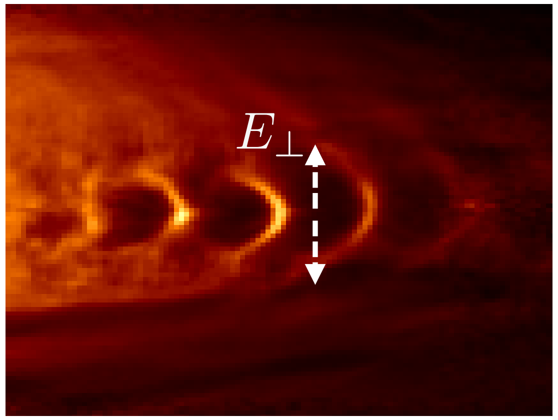
Phase reconstruction

→ input for PIC simulations

R.W. Gerchberg and W. O. Saxton, Optik **35, 237 (1972)**

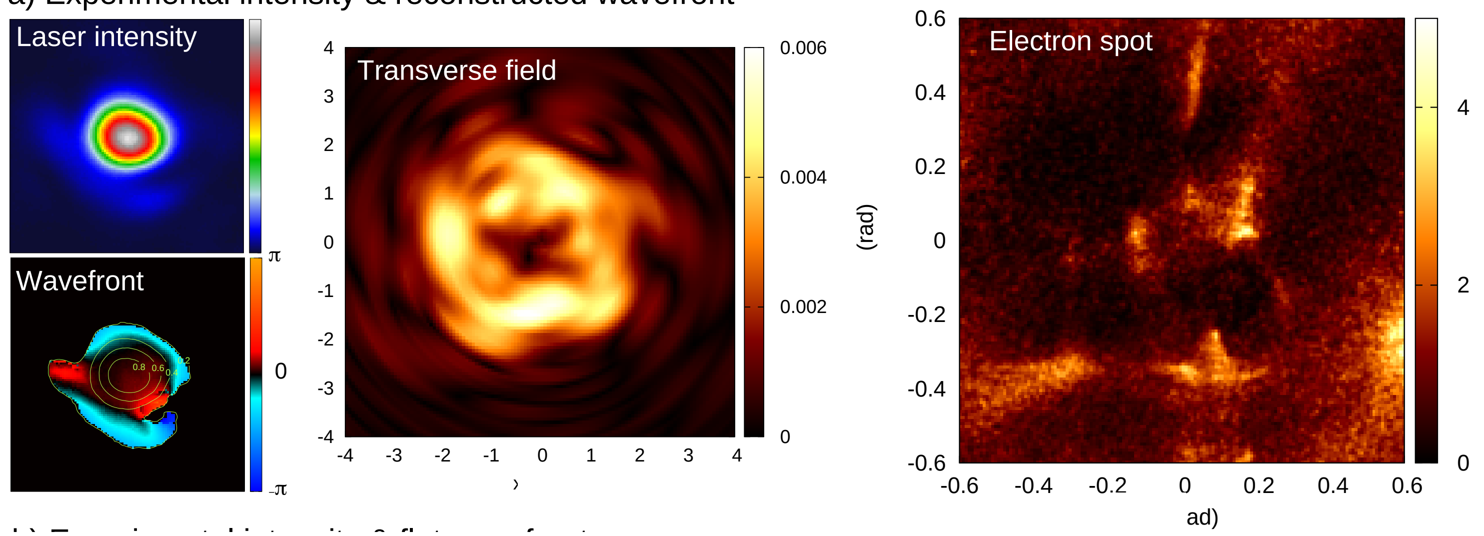
Transverse fields tailored by wavefront

Accelerating structure:
transverse fields $E_\perp$



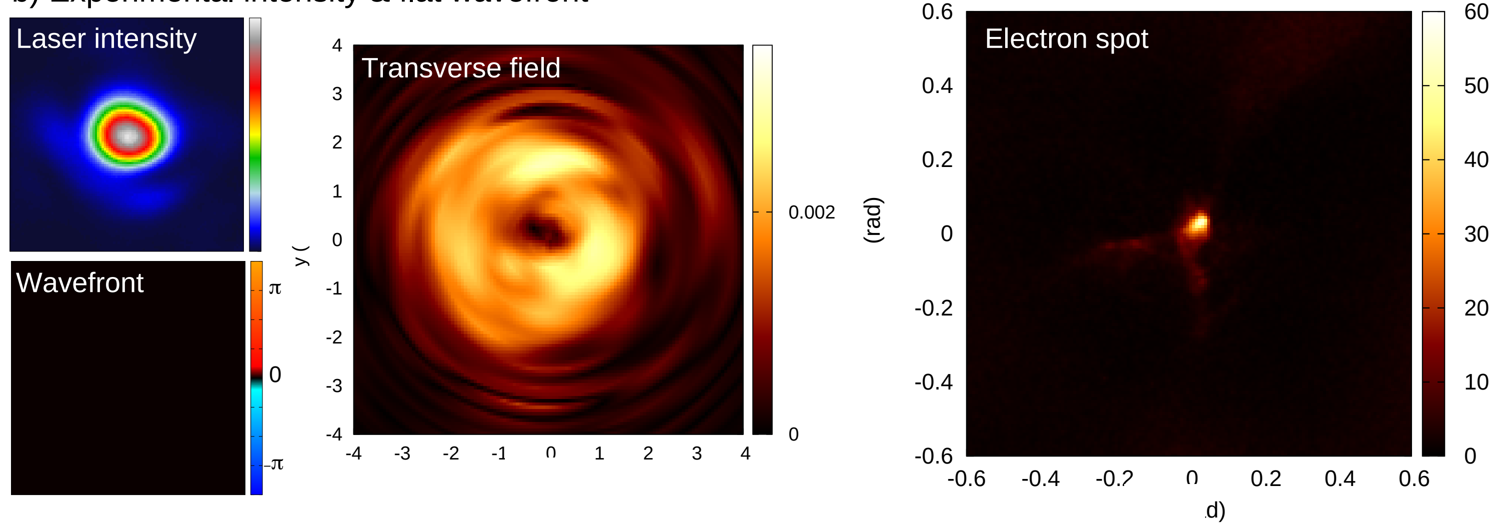
Intensity & phase $E_\perp$ e- distribution

a) Experimental intensity & reconstructed wavefront



Distorted wavefront
Distorted $E_\perp$
Low quality e-beam

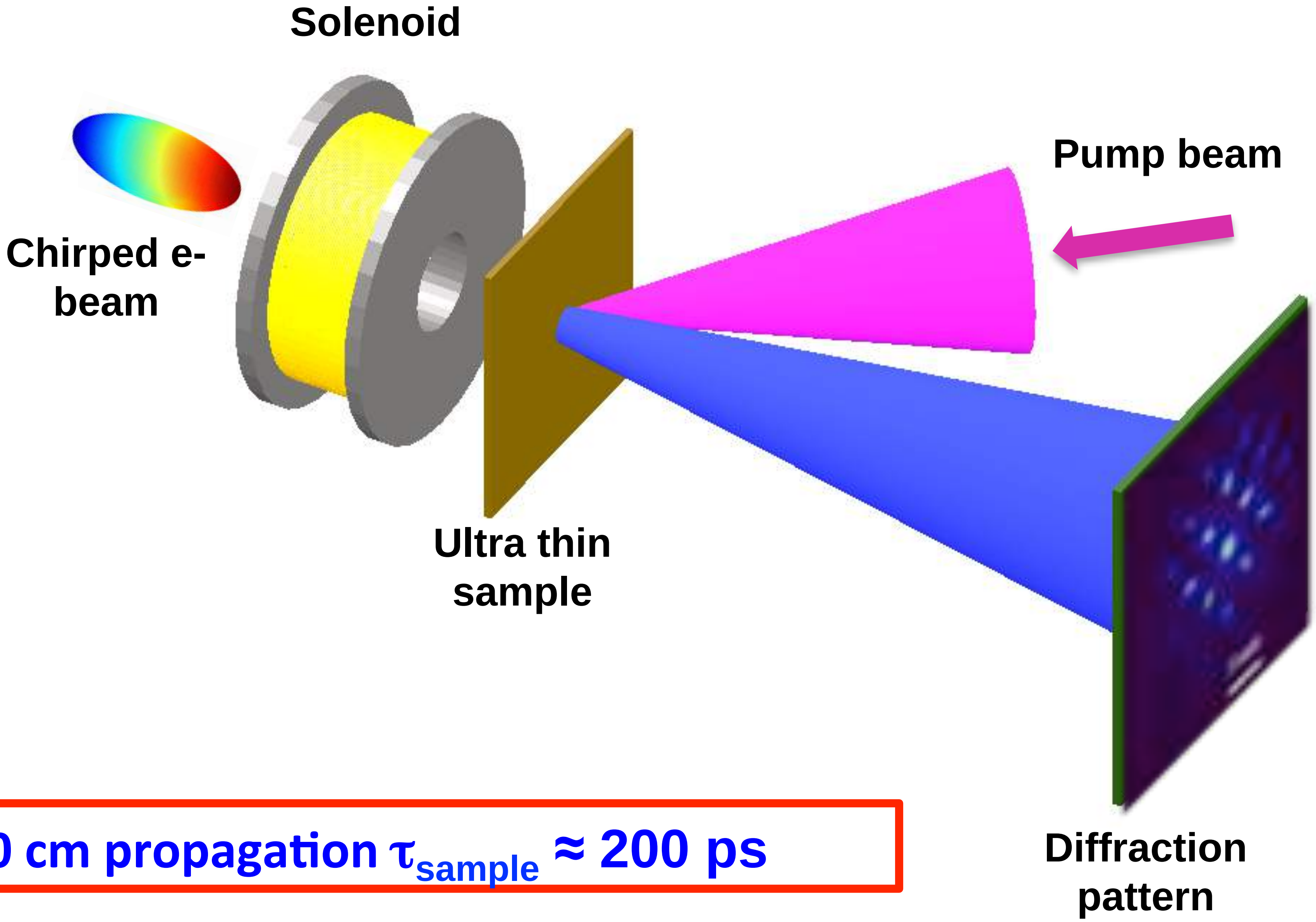
b) Experimental intensity & flat wavefront



Flat wavefront
Axi-symmetric $E_\perp$
High quality e-beam

Beaurepaire et al., PHYSICAL REVIEW X 5, 031012 (2015)

Setup for the pump-probe experiment

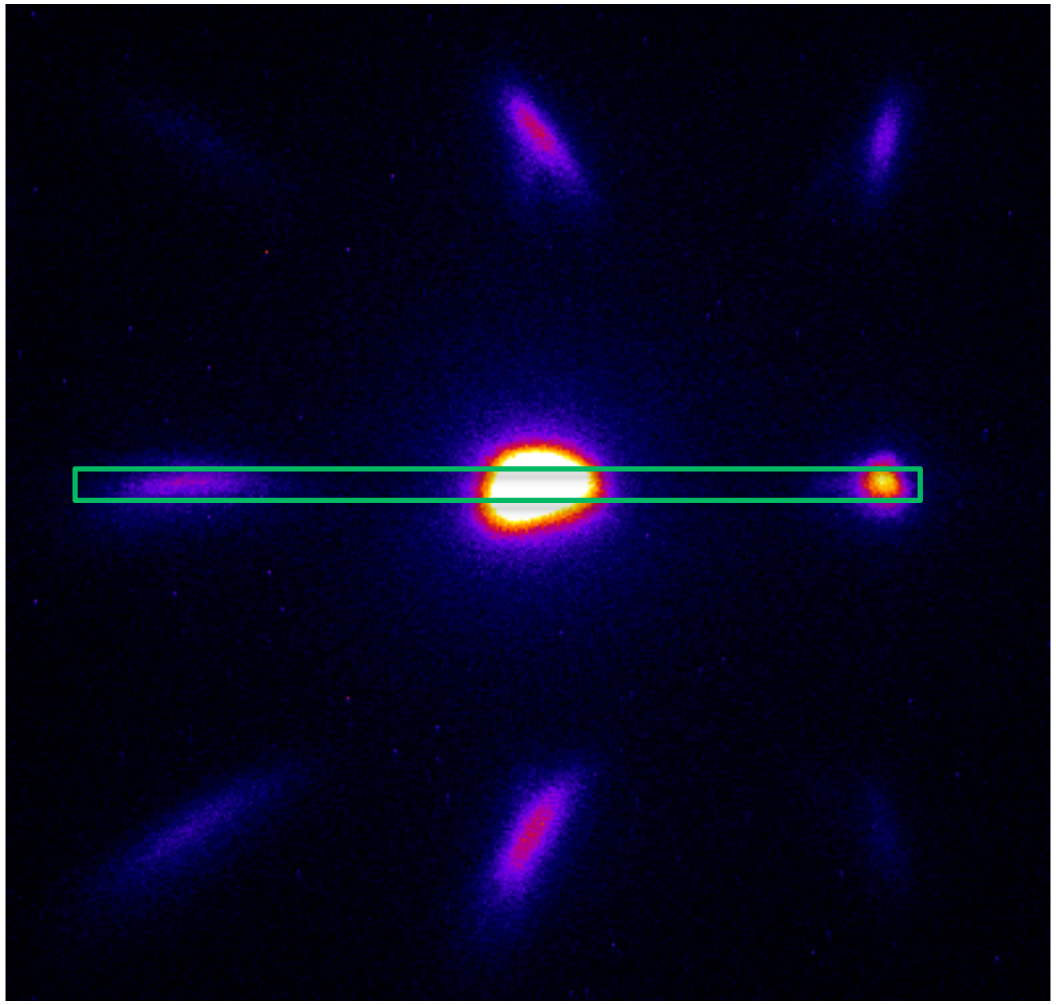


After 10 cm propagation $\tau_{sample} \approx 200$ ps

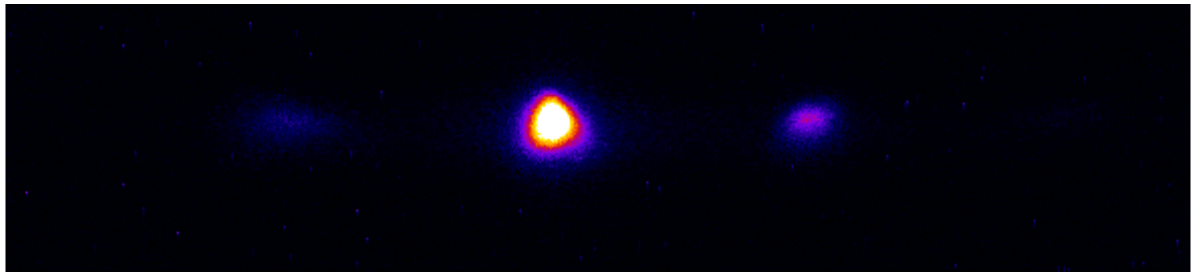
Pump-probe experiment on single crystal Si

Can we observe the 7ps peaks intensity oscillations?

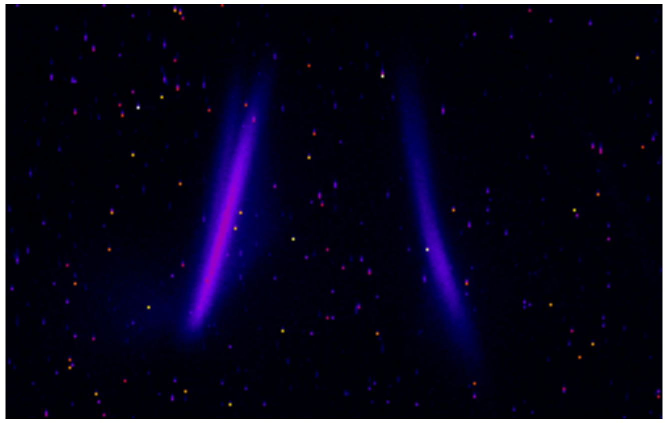
1s exposure (500 shots)



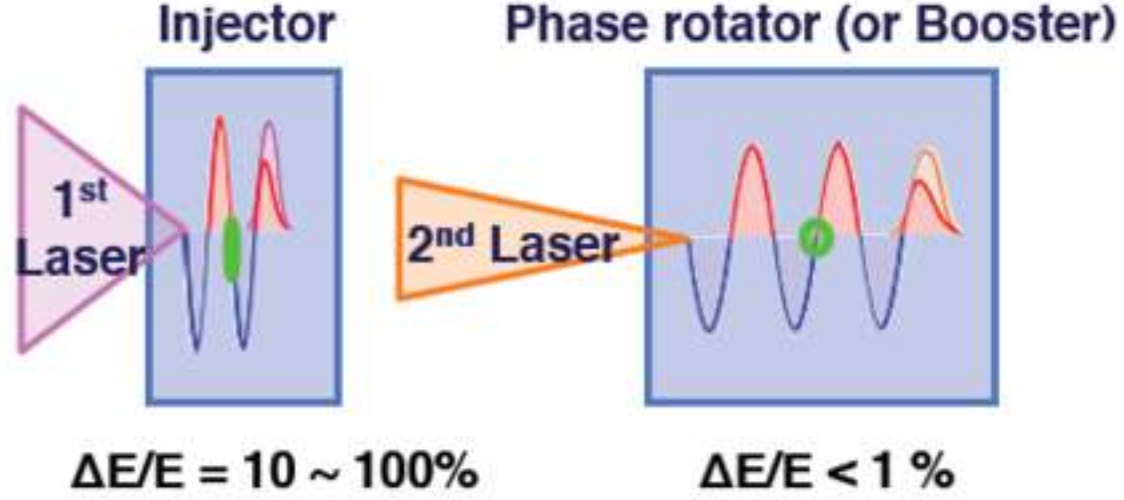
Bragg peaks and 0-order selected by a slit:



Bragg peaks streaked by the magnets:



No dynamics recorded yet: the experiment is still under progress
But it will be difficult to reach a resolution < 1ps (very long exposure)



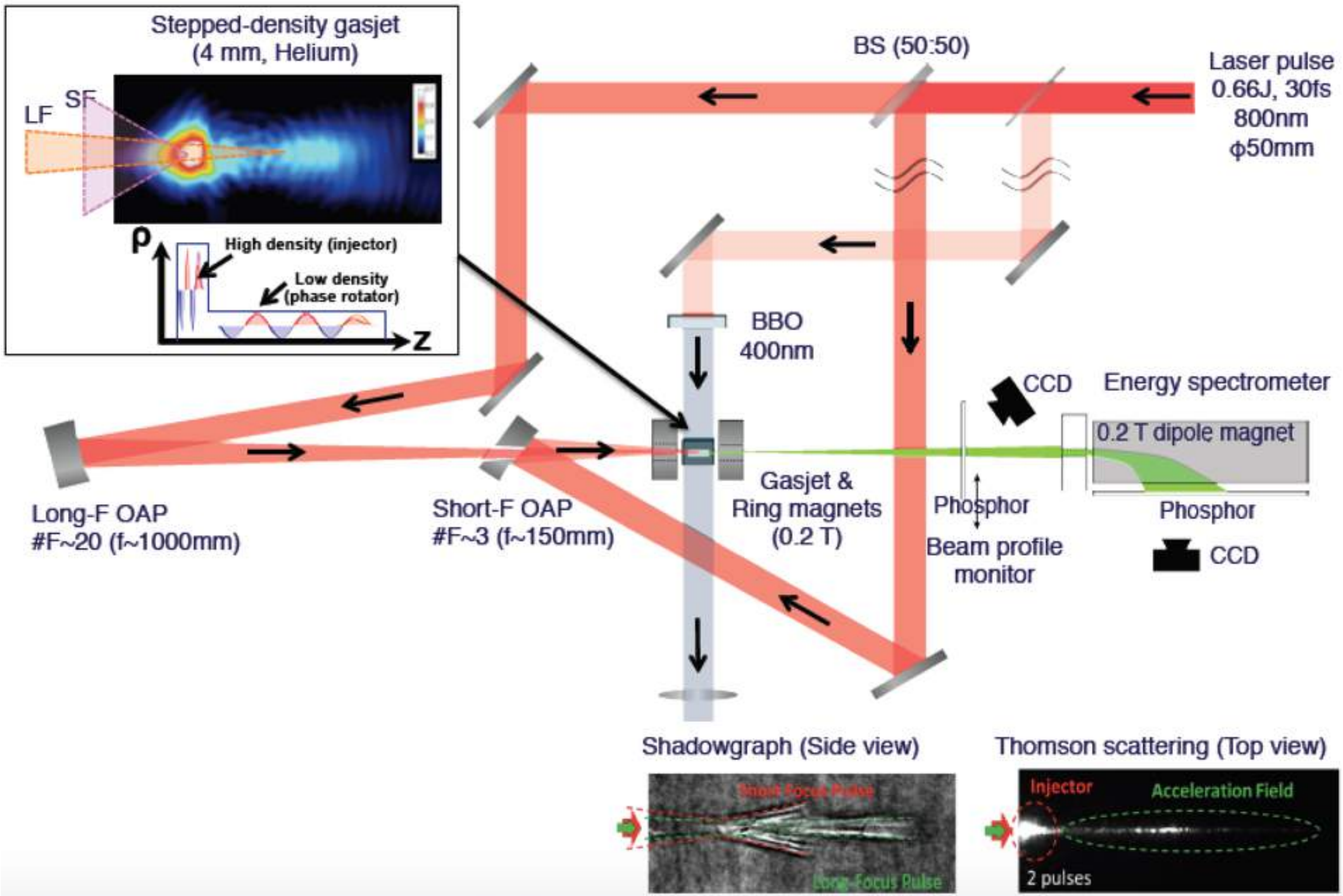
Multistage laser wakefield acceleration
driven by two laser pulses with different focal lengths

Nobuhiko Nakanii, Tomonao Hosokai, Shinichi Masuda, Alexei Zhidkov, Pathak Naveen, Takamitsu Otsuka, Kenta Iwasa, Naoki Takeguchi, Hirotaka Nakamura, Keiichi Sueda, Jumpei Ogino, Koki Osako, Yuki Taguchi, Masaki Kando, Michiaki Mori, Hideyuki Kotaki and Ryosuke Kodama

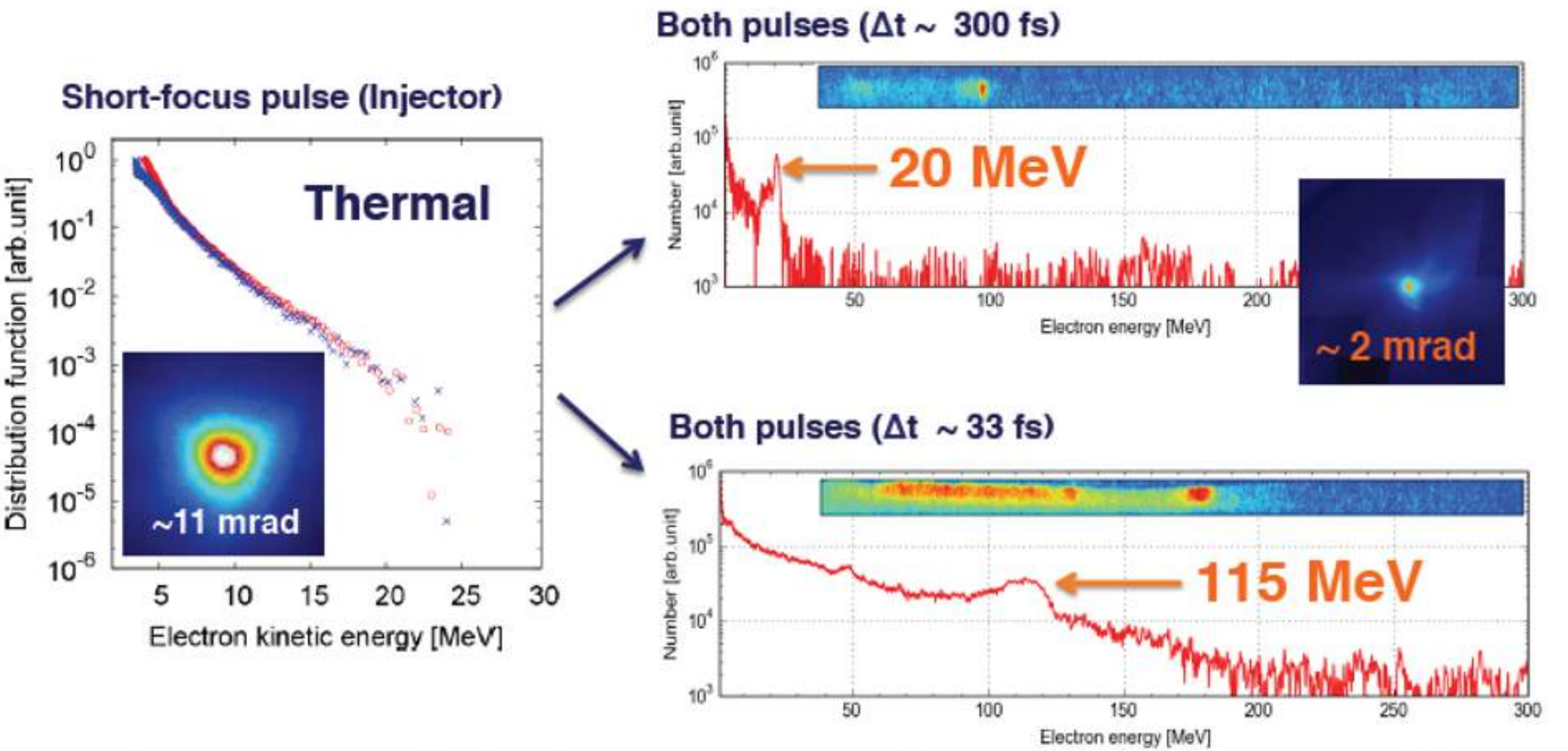
Photon Pioneers Center, Osaka University
Graduate School of Engineering, Osaka University
Kansai Photon Science Institute, Japan Atomic Energy Agency

This research was funded by ImPACT Program of Council for Science, Technology and Innovation (Cabinet Office, Government of Japan).

Multistage LWFA experimental setup



Quasi-monoenergetic electron beam with narrow energy spread is obtained by multistage LWFA



- In the 2nd wakefield, the thermal energy spectrum of injector beam is modified to quasi-monoenergetic spectrum with narrow energy spread by phase rotation.
- By changing the injection timing, the electron can be accelerated in the 2nd wakefield. We obtained quasi-monoenergetic beam with peak at 115 MeV.

Injection, Acceleration and Collimation of Electrons in Laser-Plasma Accelerators

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K. Ta Phuoc[1], A. Lifschitz[1], L. Veisz[2], S. W. Chou[2],
M. Hansson[3], O. Lundh[3], V. Malka[1,4]

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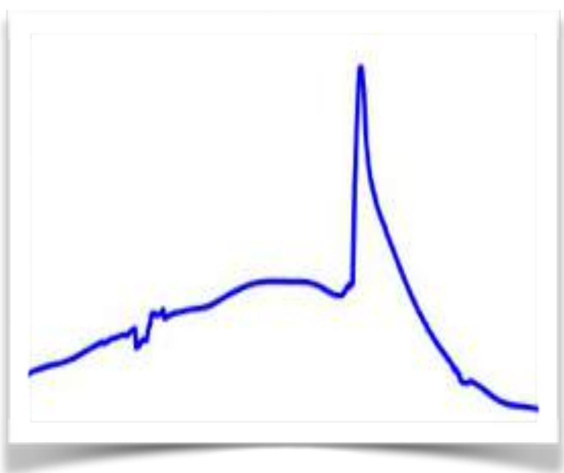
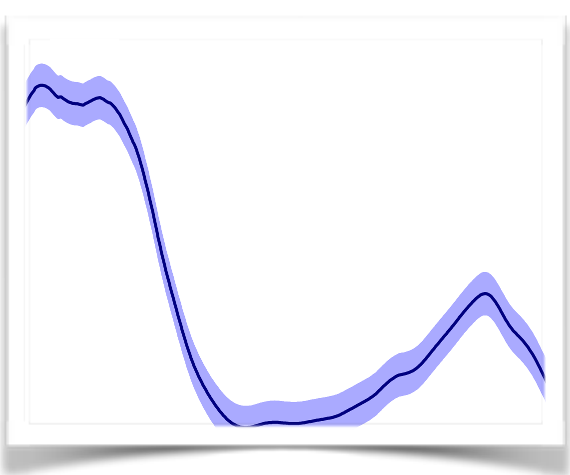
[2]MPQ, Garching, Germany
[3]Lund Laser Center, Lund University, Lund, Sweden
[4]Weizmann Institute of Science, Rehovot, Israel

Outline

I. Injection in a shock front w/wo ionization assistance

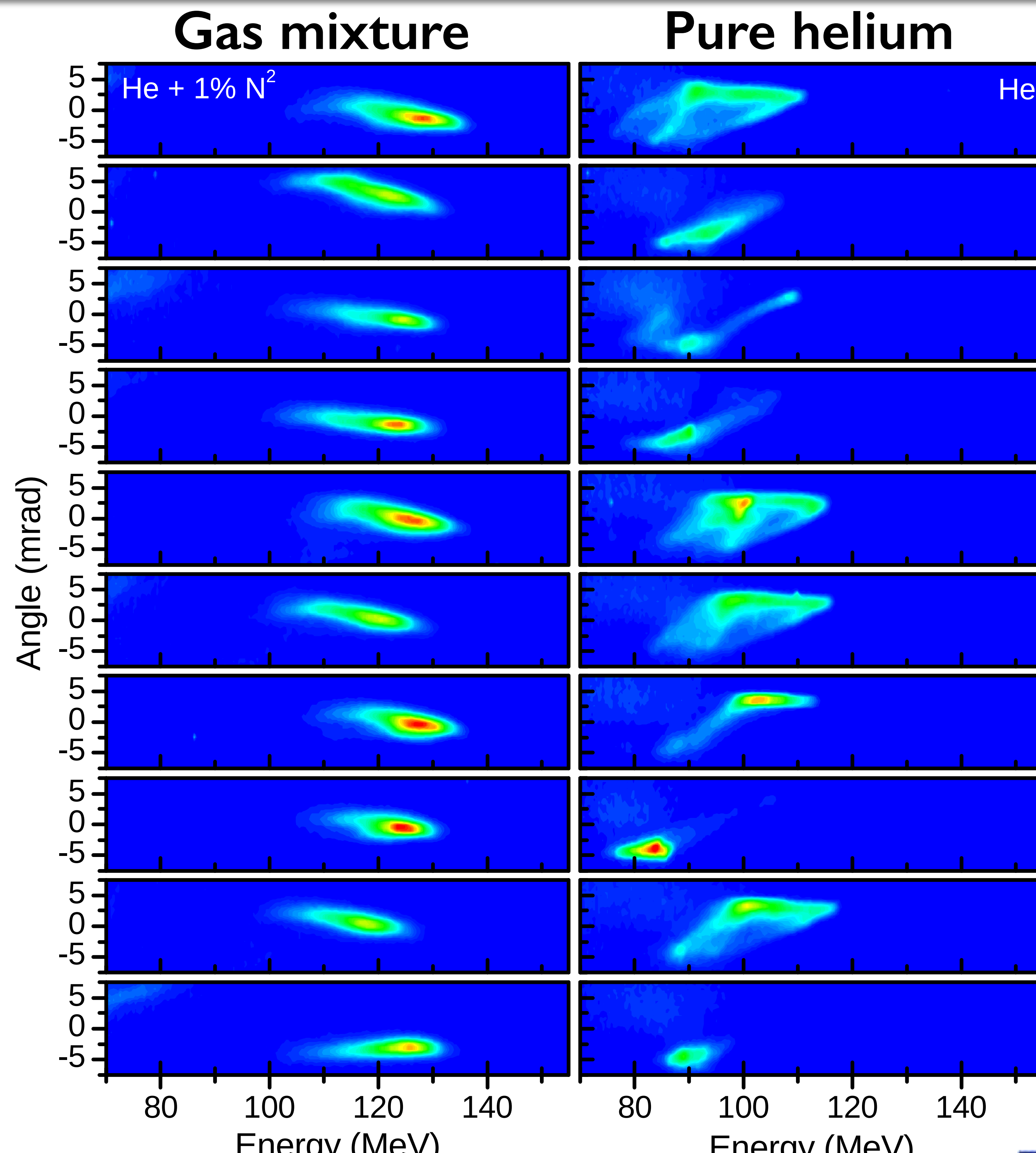


II. Electron beam rephasing



III. Laser plasma lens

Experimental Results : Pure helium vs gas mixture (1% N_2)



Gas mixture	Pure helium
RMS Stability δE/E = 2.5% δQ/Q = 12%	**RMS Stability** δE/E = 7% δQ/Q = 24%
Pointing 1.5 mrad RMS (down to 0.7)	**Pointing** 3.2 mrad RMS
Divergence 2.6 x 5 $mrad^2$	**Divergence** 3.2 ± 0.7 mrad
Energy spread 14 ± 2 MeV	**Energy spread** 20 ± 10 MeV

Electron rephasing in laser-wakefield accelerators

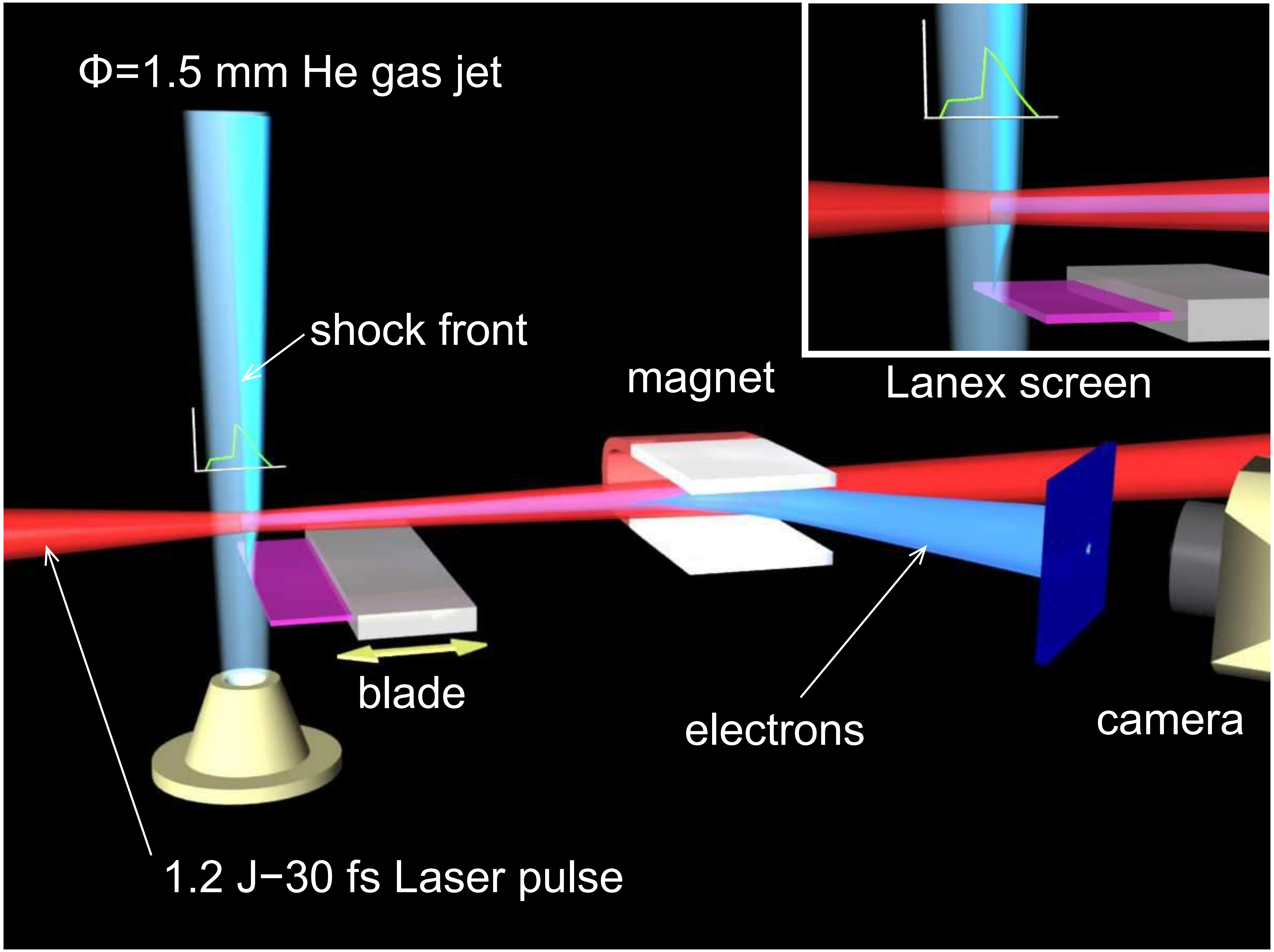
EAAC 2015

La Biodola, Italy, 14-18 September 2015

A. Döpp,[1,2] E. Guillaume,[1] C. Thaury,[1] K. Ta Phuoc,[1] A. Lifschitz,[1] J-P. Goddet,[1] A. Tafzi,[1] D. Douillet,[1] G. Rey,[1] S.W. Chou,[3] L. Veisz,[3] and V. Malka[1]

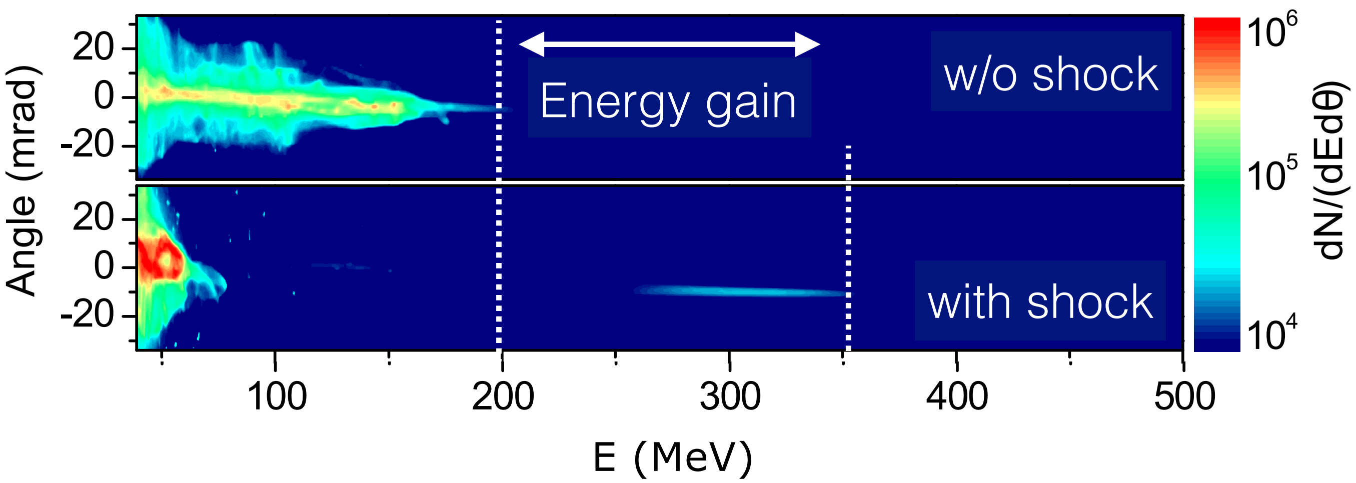
[1]Laboratoire d'Optique Appliquée, Palaiseau, France
[2]Centro de Láseres Pulsados, Salamanca, Spain
[3]Max Planck Institute for Quantum Optics, Garching, Germany

Experimental set-up

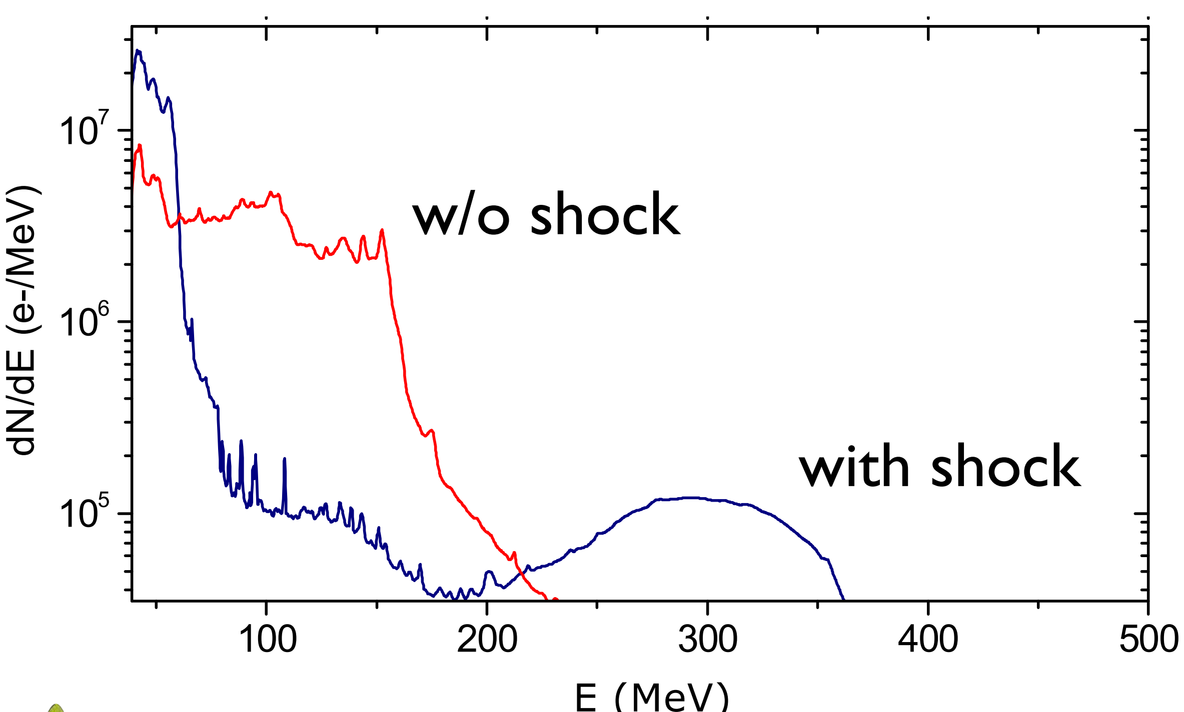


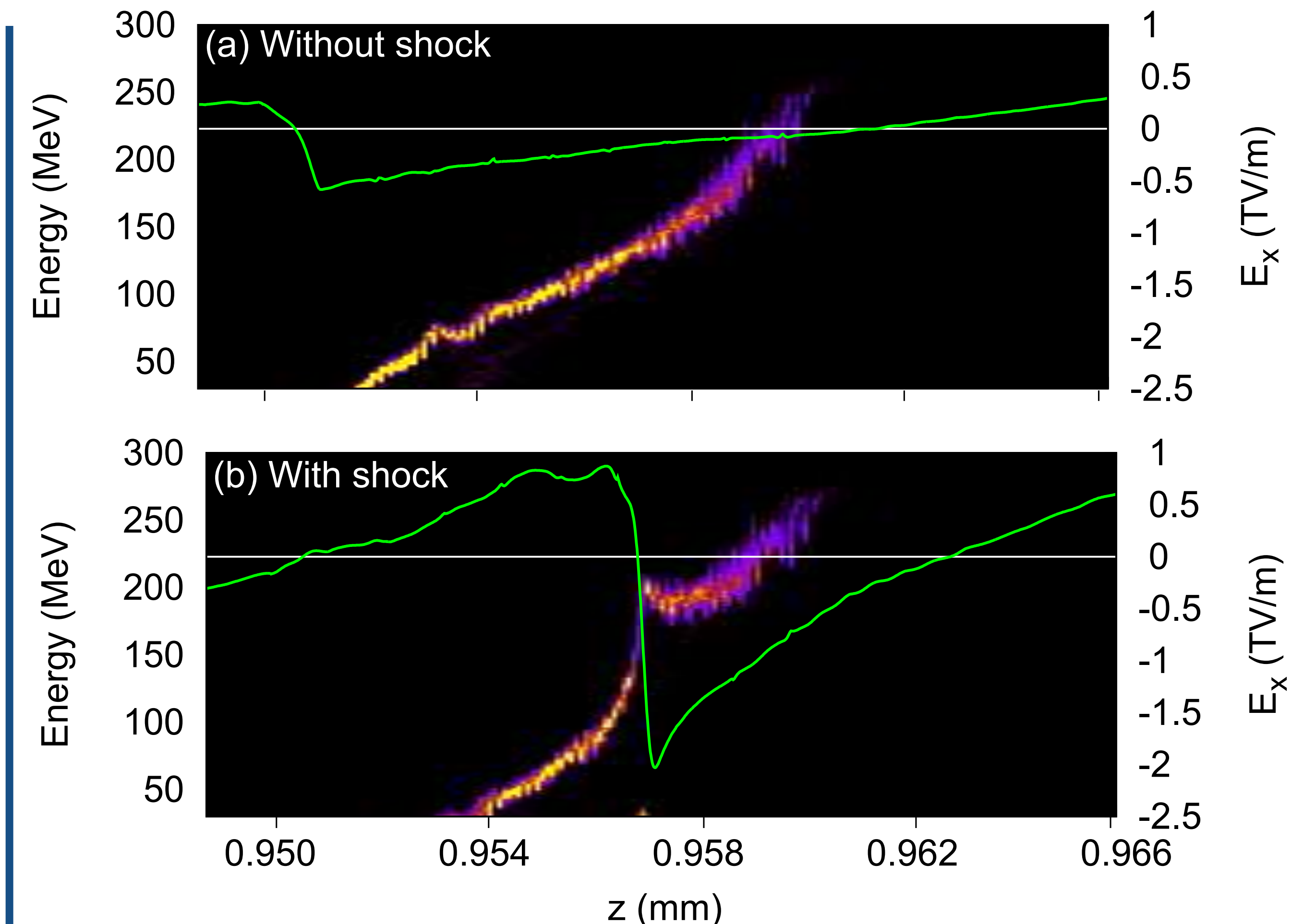
Rephasing AND Energy Boost: exp./PIC CalderCirc Sim.

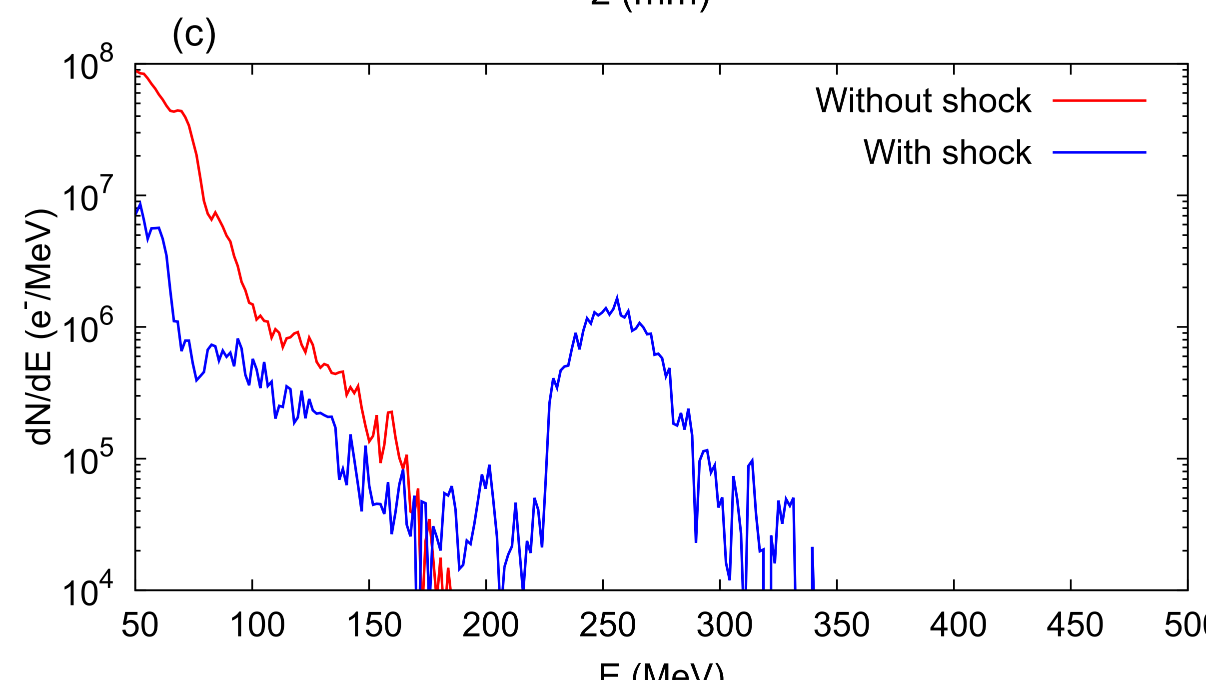
2D dispersion corrected spectra



Angularly integrated spectra



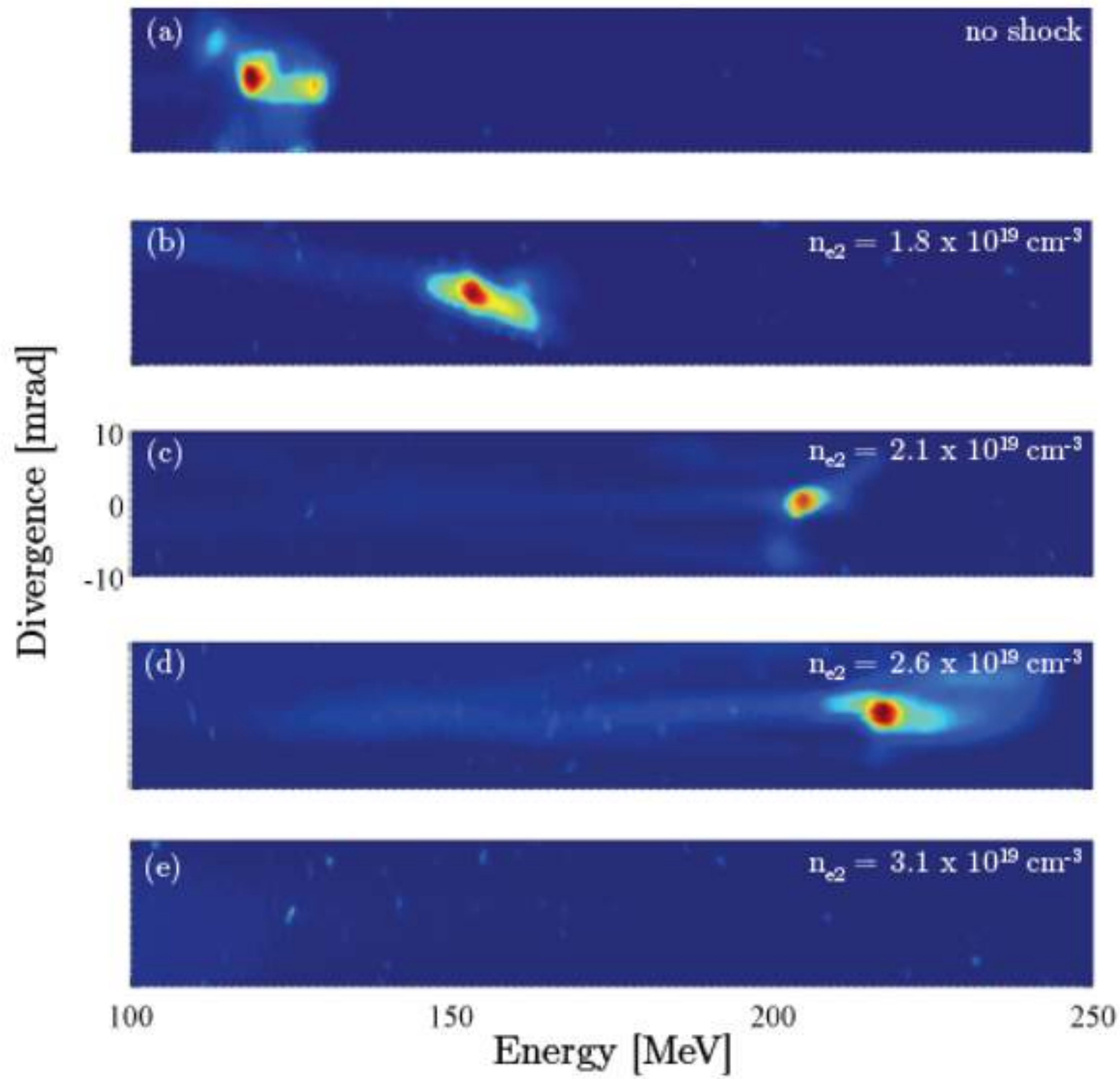




Experimental results

Energy gain of monoenergetic beams

- Electrons injected via shock front injection
- Energy increases with backing pressure of second jet
- At high pressure electrons are entirely defocused



Experimental setup

Acceleration stage

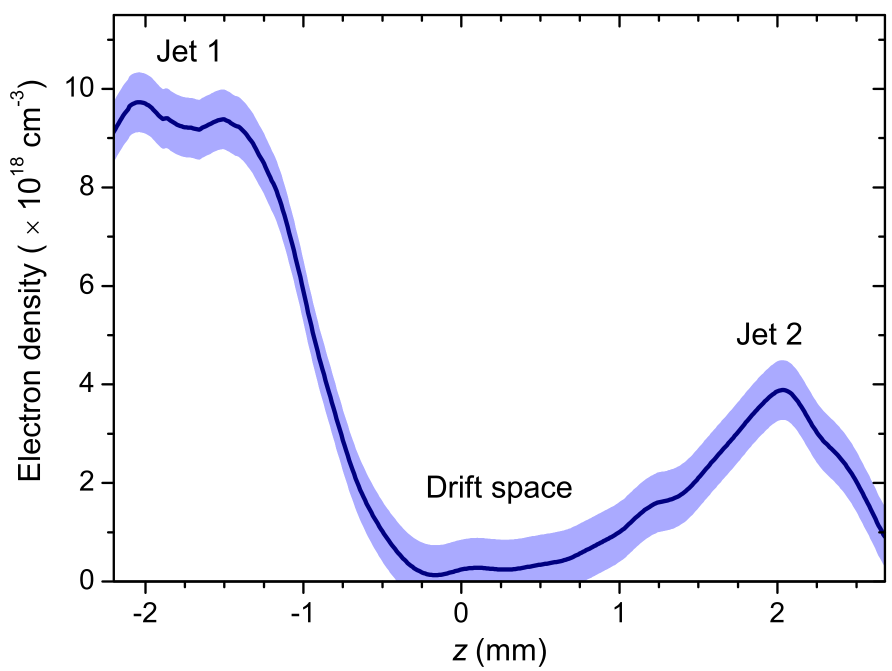
Laser beam
0.9 J, 28 fs, 12 microns FWHM

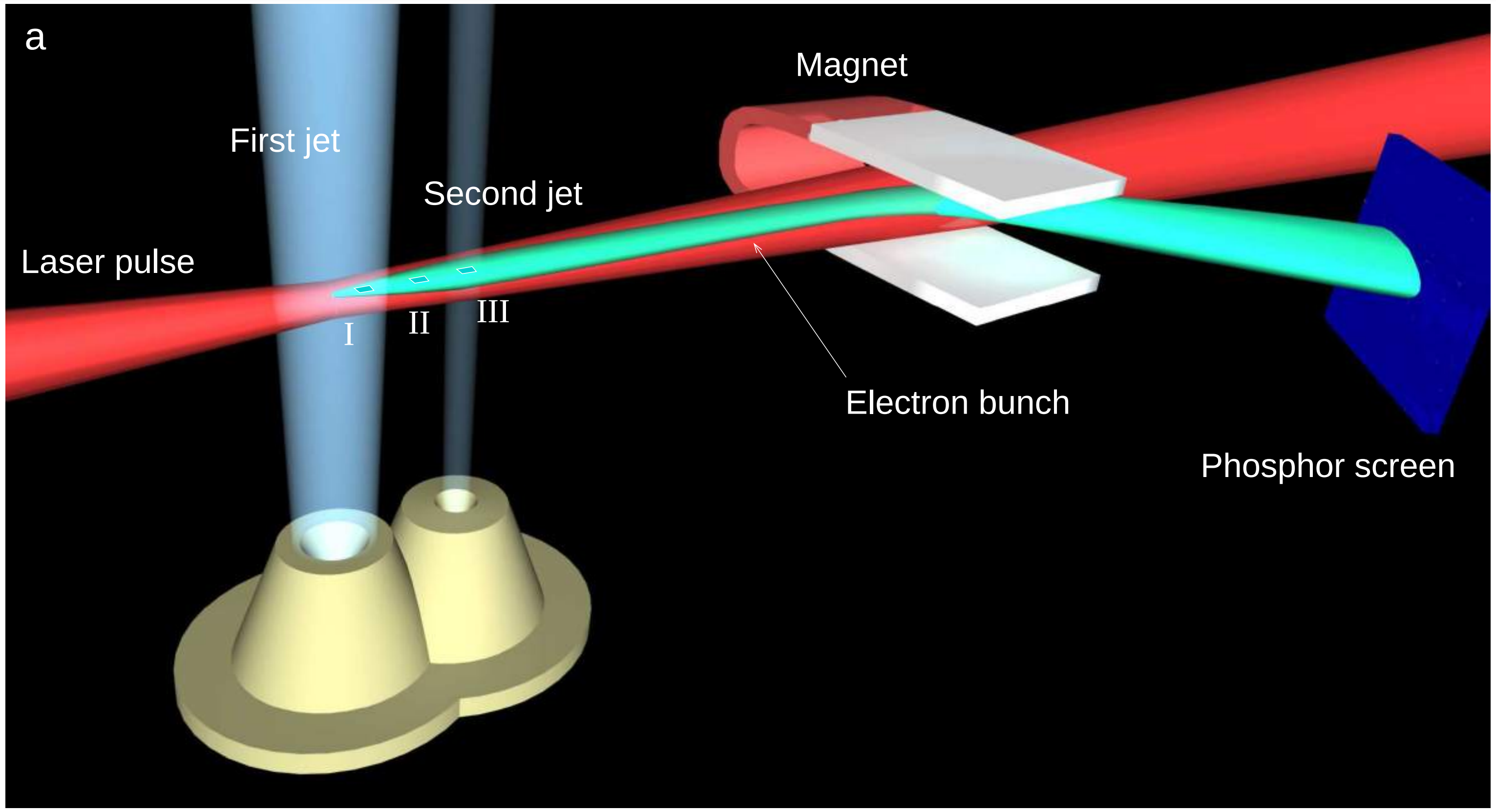
Focused with a 1 m OAP at the entrance of a 3 mm gas jet

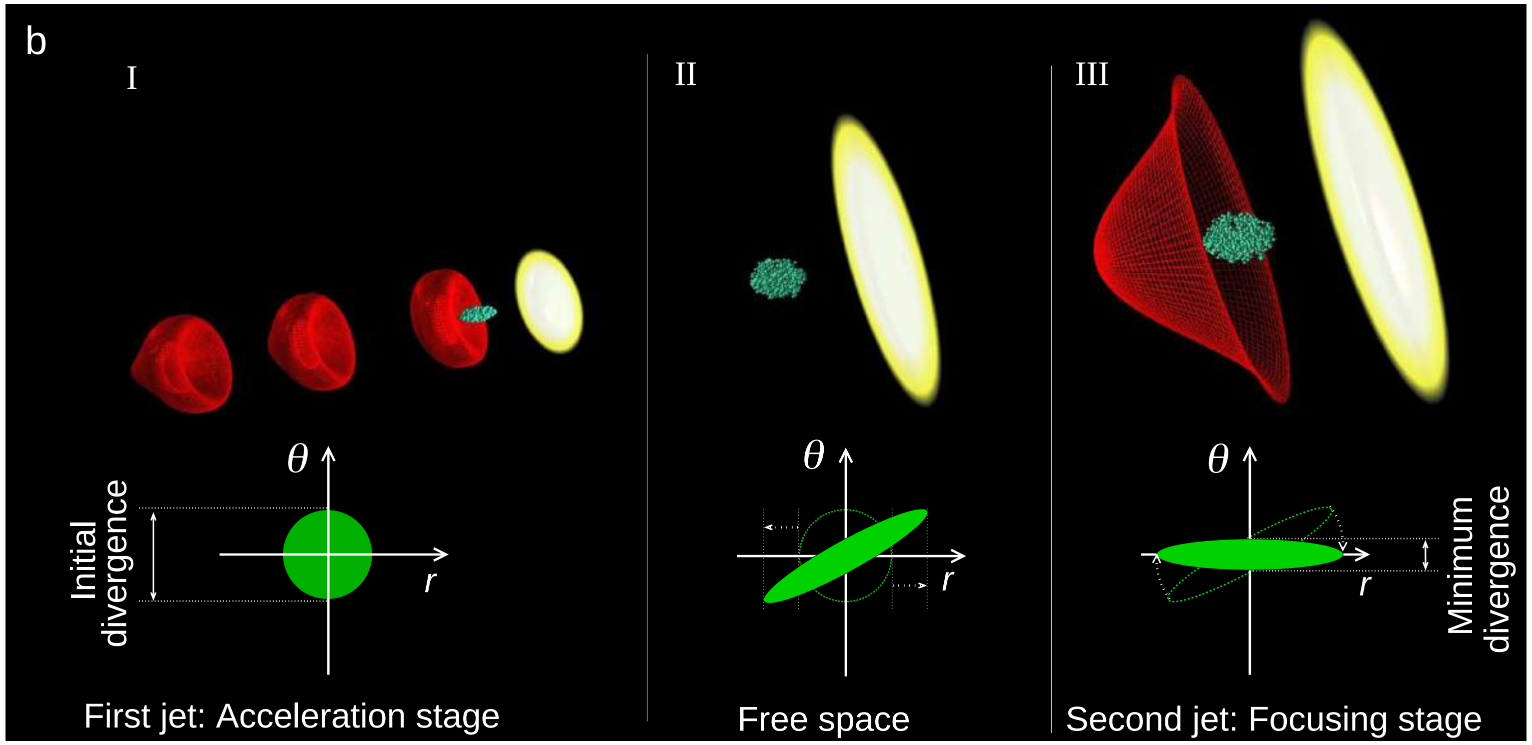
$$n_1 = 9.2 \times 10^{18}\ \mathrm{cm}^{-3}$$

Focusing stage

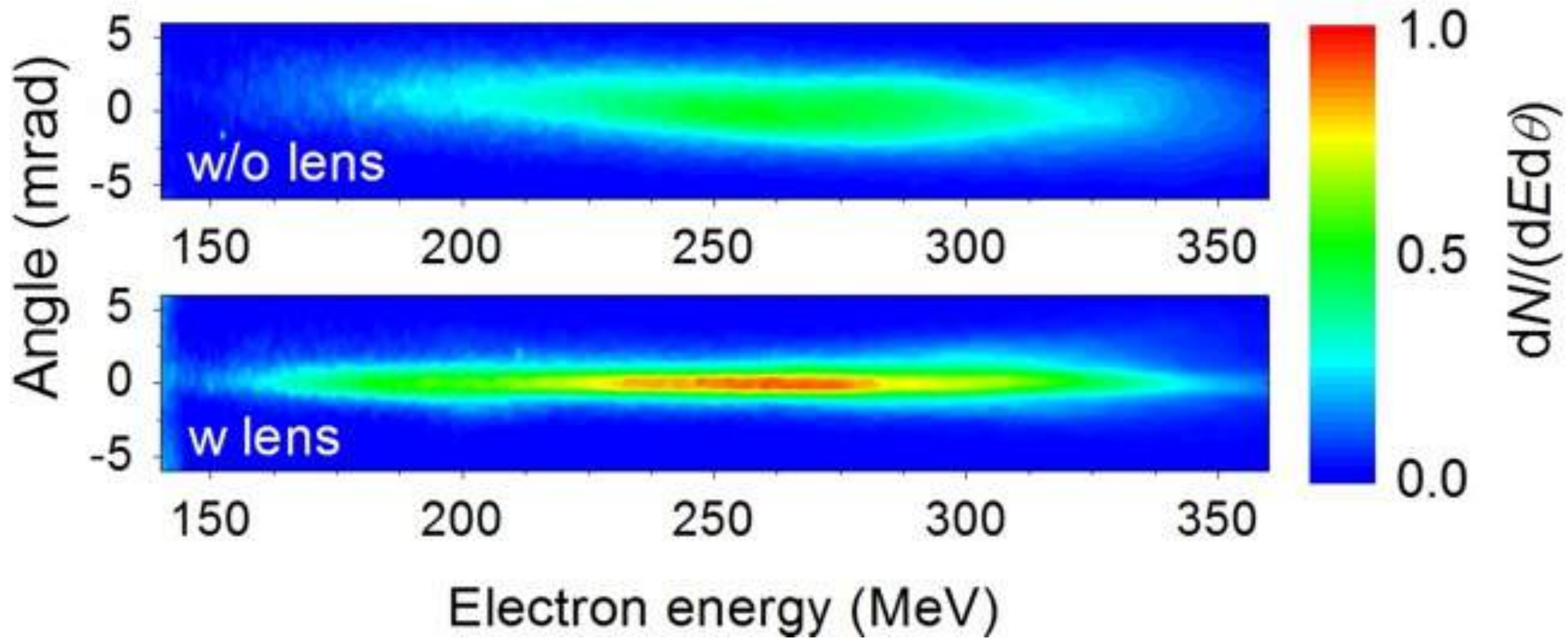
1 mm nozzle with variable n_2
Variable L_d

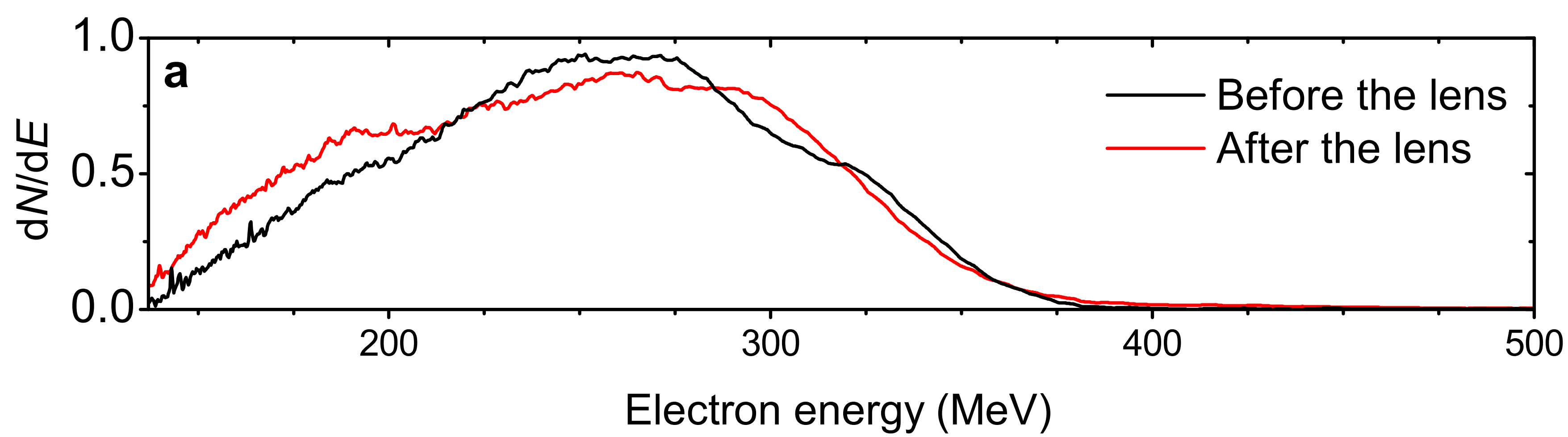






Demonstration of beam focusing





Focusing stage parameters :

L_d = 1.8 mm

n_2 = 3.9 x 10^{18} cm^{-3}

Divergence after the lens (FWHM)

$$\sigma_\theta = 1.6 \pm 0.2 \text{ mrad}$$

Divergence reduction ~ 2.6 ± 0. 7

C. Thaury *et al.*, Nature Comm. 6, 6860 (2015)