Advanced Accelerator Concepts I

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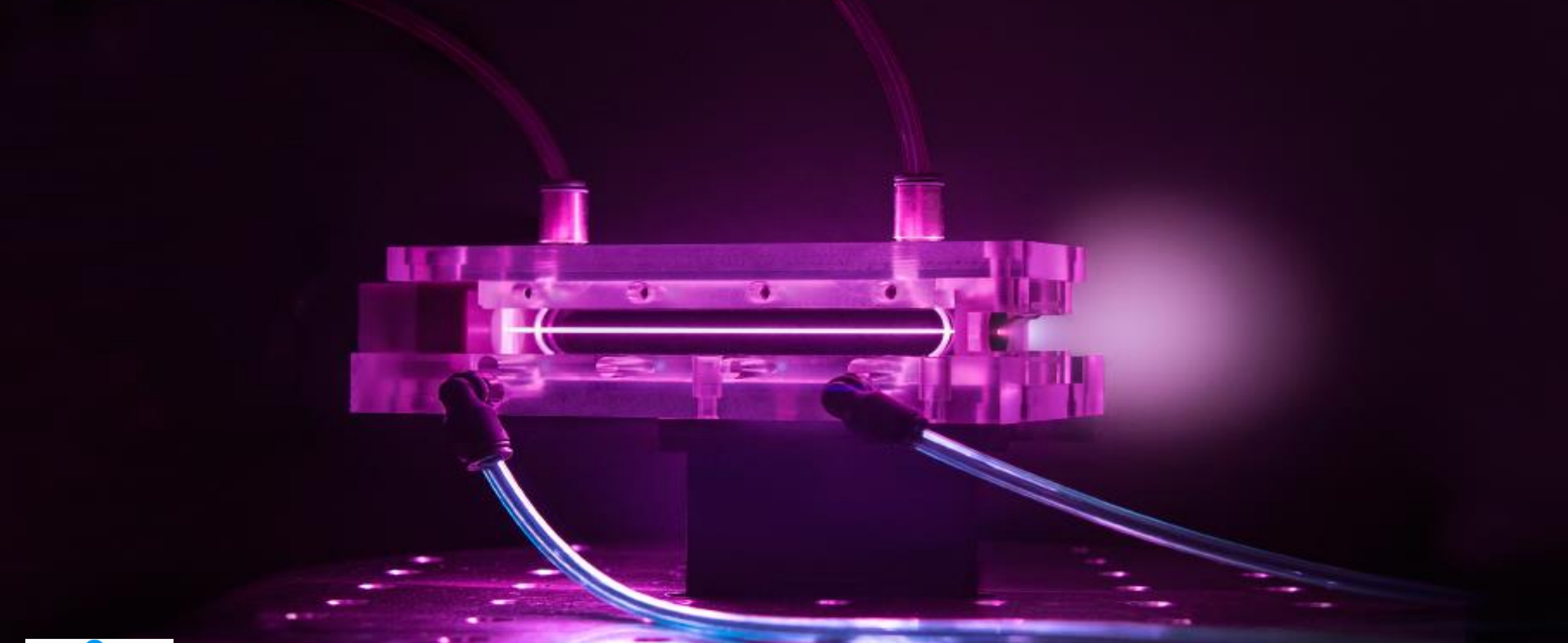


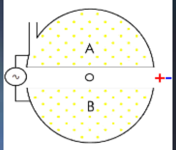
The CERN Accelerator School

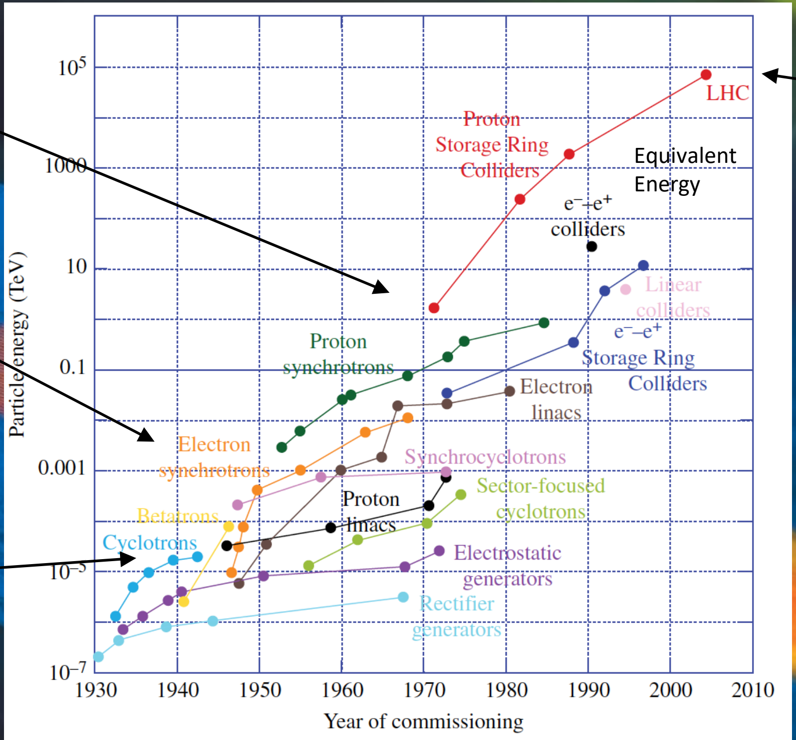
Introduction to Accelerator Physics

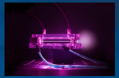
S. Susanna – 30 September 2024

Livingstone Diagram

$$\begin{cases} \omega_L = \dfrac{q B_y}{\gamma m_0} \\ p_z = q B_y R \end{cases}$$







Energy of colliders is plotted in terms of the laboratory energy of particles colliding with a proton at rest to reach the same center of mass energy.

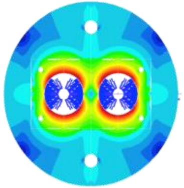
Options towards higher energies

Hadron (p) circular collider

$$p = e \cdot R \cdot B_y$$

Increase bending field
SC bend magnet work (FCC-hh)

Increase radius = size (FCC-hh)



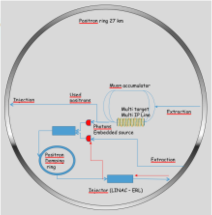
Lepton (e-,e+) circular collider

$$p \propto E_0 \cdot \sqrt[4]{\rho \cdot U_0}$$

Increase supplied RF vol
(FCC-ee)

Increase mass of acc. particle (muon)

Increase radius = size (FCC-ee)



Lepton (e-,e+) linear collider

$$p = L \cdot G_{acc}$$

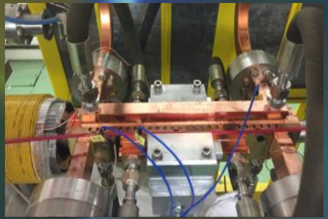
Increase length (ILC, CLIC)

Compact , Cost Effective and Improved Sustainability

High Gradient Options

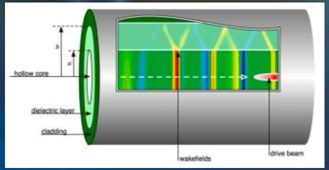
Metallic accelerating structures =>

100 MV/m < E_{acc} < 1 GV/m



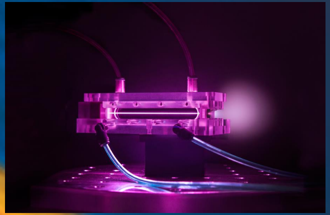
Dielectrict structures, laser or particle driven =>

E_{acc} < 10 GV/m



Plasma accelerator, laser or particle driven =>

E_{acc} < 100 GV/m



Related Issues: Power Sources and Efficiency, Stability, Reliability, Staging, Synchronization, Rep. Rate and short (fs) bunches with small (μm) spot to match high gradients

Beam Quality Requirements

Future accelerators will require also high quality beams :

==> High Luminosity & High Brightness,

==> High Energy & Low Energy Spread

$$L = \frac{N_{e+} N_{e-} f_r}{4\pi \sigma_x \sigma_y}$$

- -N of particles per pulse => 10^9
- -High rep. rate f_r=> bunch trains
- -Small spot size => low emittance

$$B_n \approx \frac{2I}{\varepsilon_n^2}$$

- -Short pulse (ps => fs)
- -Little spread in transverse momentum and angle => low emittance

VOLUME 43, NUMBER 4 PHYSICAL REVIEW LETTERS 23 JULY 1979

Laser Electron Accelerator

T. Tajima and J. M. Dawson
Department of Physics, University of California, Los Angeles, California 90024
(Received 9 March 1979)

An intense electromagnetic pulse can create a weak of plasma oscillations through the action of the nonlinear ponderomotive force. Electrons trapped in the wake can be accelerated to high energy. Existing glass lasers of power density 10^{18}W/cm^2 shone on plasmas of densities 10^{18} cm^{-3} can yield gigaelectronvolts of electron energy per centimeter of acceleration distance. This acceleration mechanism is demonstrated through computer simulation. Applications to accelerators and pulsers are examined.

VOLUME 54, NUMBER 7 PHYSICAL REVIEW LETTERS 18 FEBRUARY 1985

Acceleration of Electrons by the Interaction of a Bunched Electron Beam with a Plasma

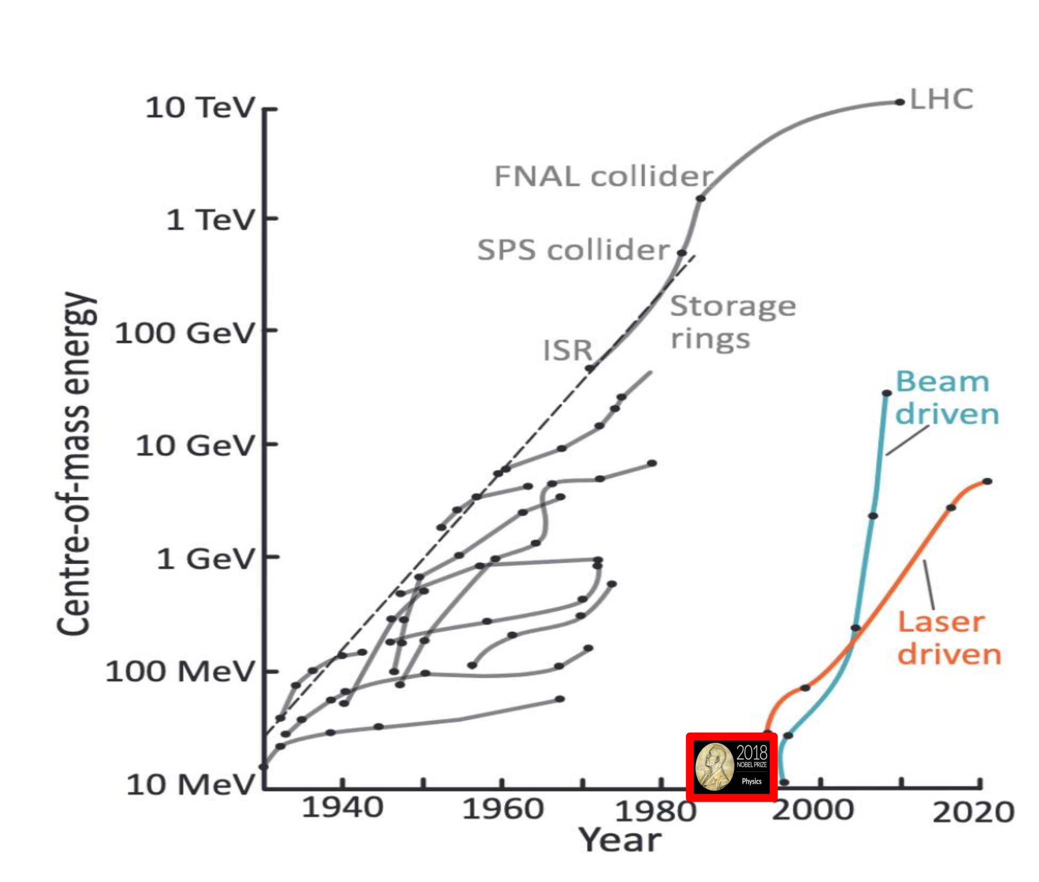
Pisin Chen[(a)]
Stanford Linear Accelerator Center, Stanford University, Stanford, California 94305

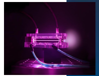
and

J. M. Dawson, Robert W. Huff, and T. Katsouleas
Department of Physics, University of California, Los Angeles, California 90024
(Received 20 December 1984)

A new scheme for accelerating electrons, employing a bunched relativistic electron beam in a cold plasma, is analyzed. We show that energy gradients can exceed 1 GeV/m and that the driven electrons can be accelerated from $\gamma_0 mc^2$ to $3\gamma_0 mc^2$ before the driving beam slows down enough to degrade the plasma wave. If the driving electrons are removed before they cause the collapse of the plasma wave, energies up to $4\gamma_0^2 mc^2$ are possible. A noncollinear injection scheme is suggested in order that the driving electrons can be removed.

Livingstone Diagram with PWFA





Principles of plasma physics

Definition of Plasma: a quasi-neutral gas of charged particles showing collective behaviour

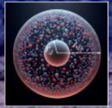
=> a plasma responds to external forces as a single entity

The Debye length is a fundamental property of nearly all plasmas of interest and depends equally on its temperature

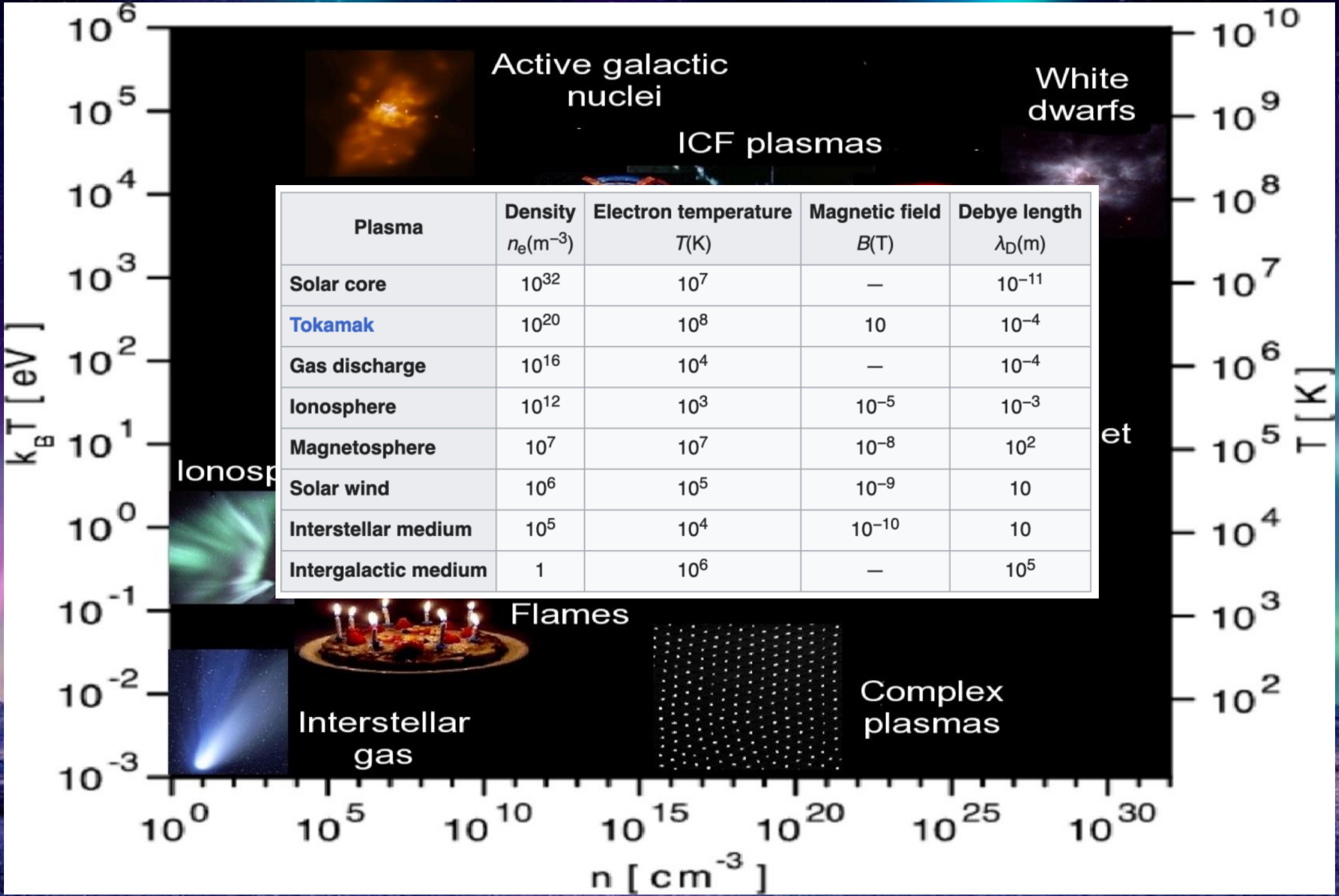
$$\lambda_D = \left(\frac{\varepsilon_0 k_B T_e}{e^2 n_e}\right)^{1/2} = 743 \left(\frac{T_e}{\mathrm{eV}}\right)^{1/2} \left(\frac{n_e}{\mathrm{cm}^{-3}}\right)^{-1/2} \mathrm{cm}.$$

=> An ideal plasma has many particles per Debye sphere, a prerequisite for the collective behaviour:

$$N_D \equiv n_e \frac{4\pi}{3} \lambda_D^3 \gg 1.$$



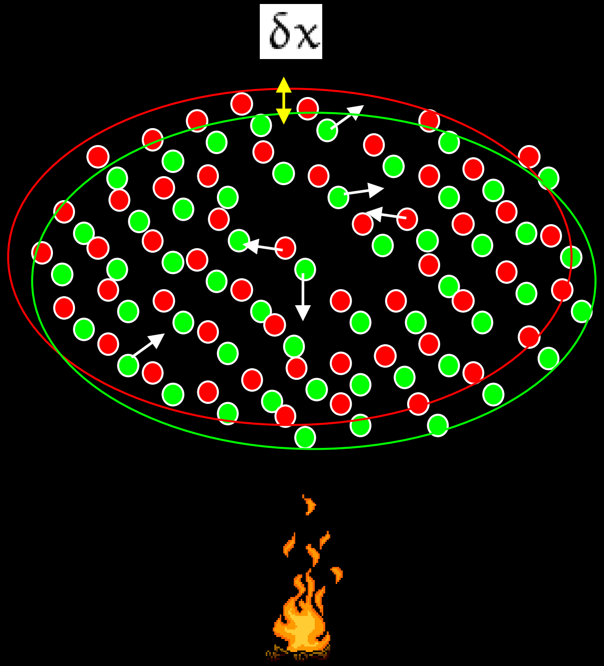
Plasma Temperature and Density



Plasma	Density $n_e(m^{-3})$	Electron temperature T(K)	Magnetic field B(T)	Debye length λ_D(m)
Solar core	10^{32}	10^{7}	—	10^{-11}
Tokamak	10^{20}	10^{8}	10	10^{-4}
Gas discharge	10^{16}	10^{4}	—	10^{-4}
Ionosphere	10^{12}	10^{3}	10^{-5}	10^{-3}
Magnetosphere	10^{7}	10^{7}	10^{-8}	10^{2}
Solar wind	10^{6}	10^{5}	10^{-9}	10
Interstellar medium	10^{5}	10^{4}	10^{-10}	10
Intergalactic medium	1	10^{6}	—	10^{5}

Surface charge density

$$\sigma = e\,n\,\delta x$$



Surface electric field

$$E_x = -\sigma/\epsilon_0 = -e\,n\,\delta x/\epsilon_0$$

Restoring force

$$m\,\frac{d^2\delta x}{dt^2} = e\,E_x = -m\,\omega_p^{\,2}\,\delta x$$

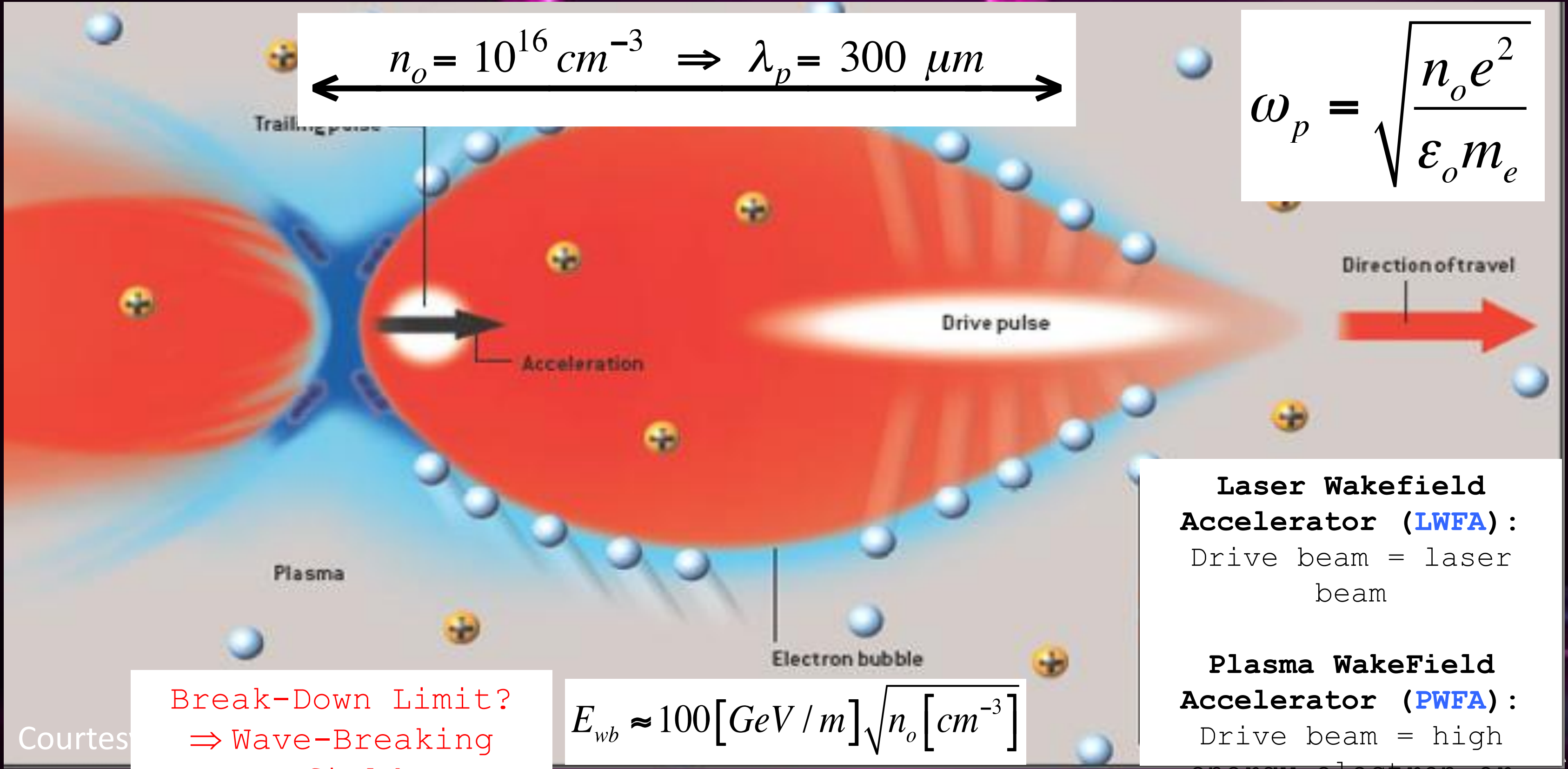
Plasma frequency

$$\omega_p^{\,2} = \frac{n\,e^2}{\epsilon_0\,m}$$

Plasma oscillations

$$\delta x = (\delta x)_0\,\cos\,(\omega_p\,t)$$

Principle of plasma acceleration



$$n_o = 10^{16}\, cm^{-3} \Rightarrow \lambda_p = 300\ \mu m$$

$$\omega_p = \sqrt{\frac{n_o e^2}{\varepsilon_o m_e}}$$

Laser Wakefield Accelerator (LWFA):
Drive beam = laser beam

Plasma WakeField Accelerator (PWFA):
Drive beam = high energy electron or proton beam

Break-Down Limit?
⇒ Wave-Breaking field:

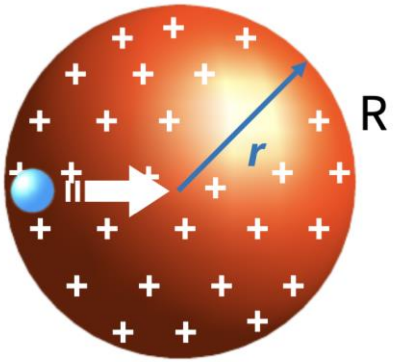
$$E_{wb} \approx 100\left[GeV/m\right]\sqrt{n_o\left[cm^{-3}\right]}$$

Courtes

Principle of plasma acceleration

From Maxwell's equations, the electric field in a (positively) charged sphere with uniform density n_i at location **r** is

$$\vec{E}(r) = \frac{q_i n_i}{3\epsilon_0} r$$



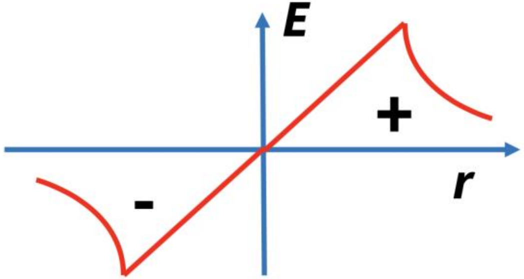
The field is **increasing** inside the sphere

Let's put some numbers

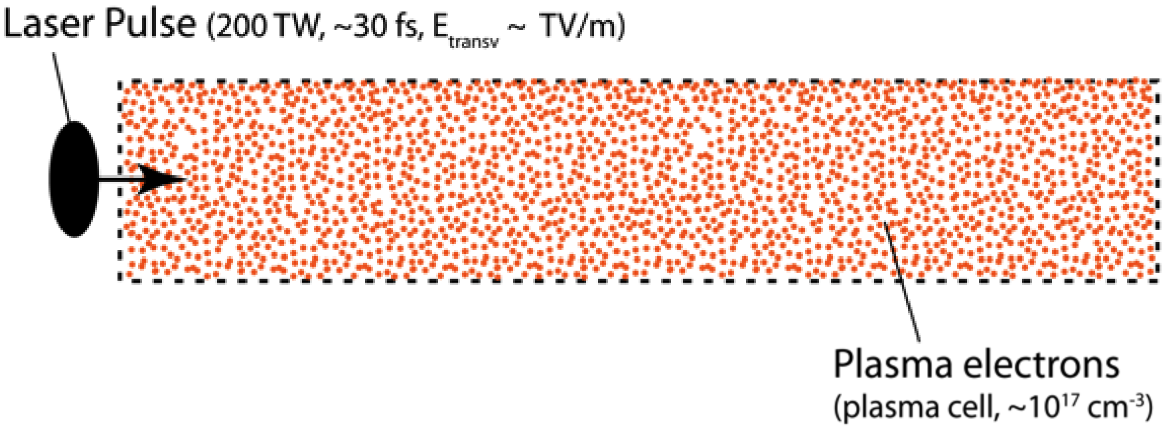
$n_i = 10^{16}\ cm^{-3}$

$R = 0.5$

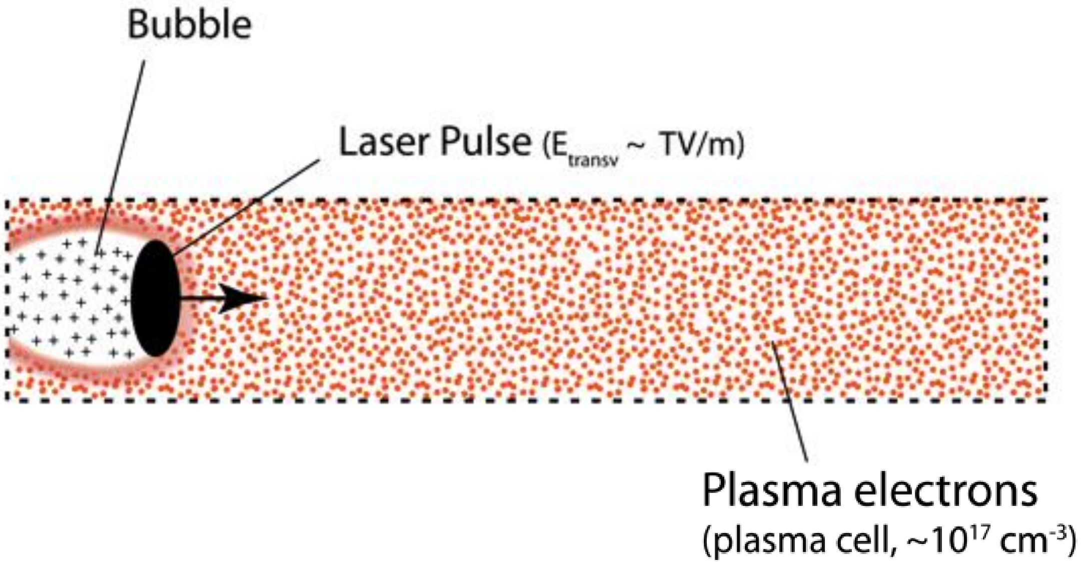
$$\Rightarrow E \approx 10 \frac{GV}{m}$$



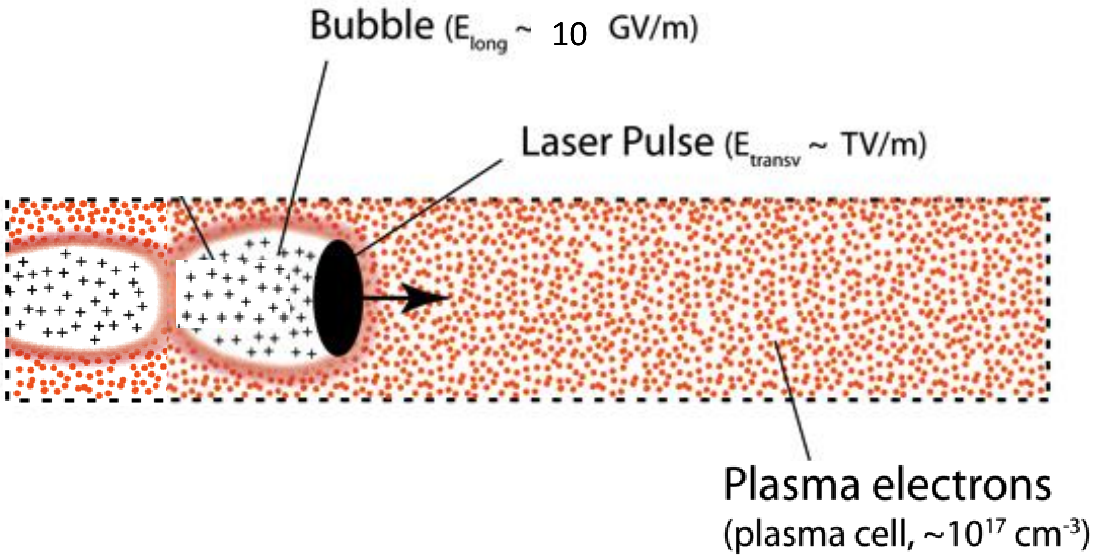
Plasma Wake-Acceleration



Plasma Wake-Acceleration

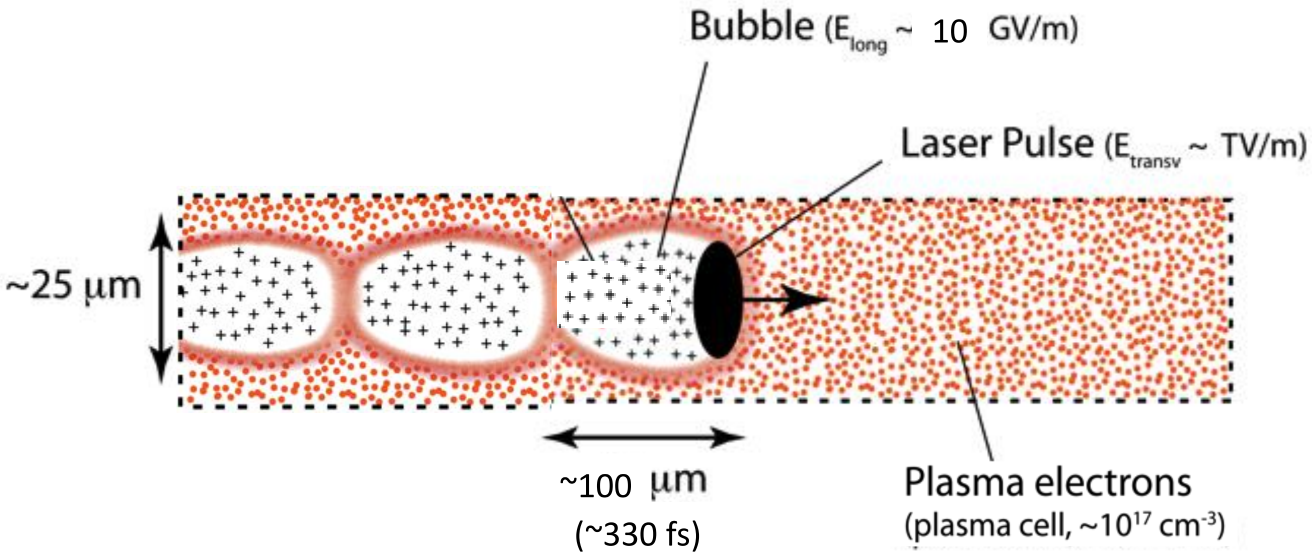


Plasma Wake-Acceleration

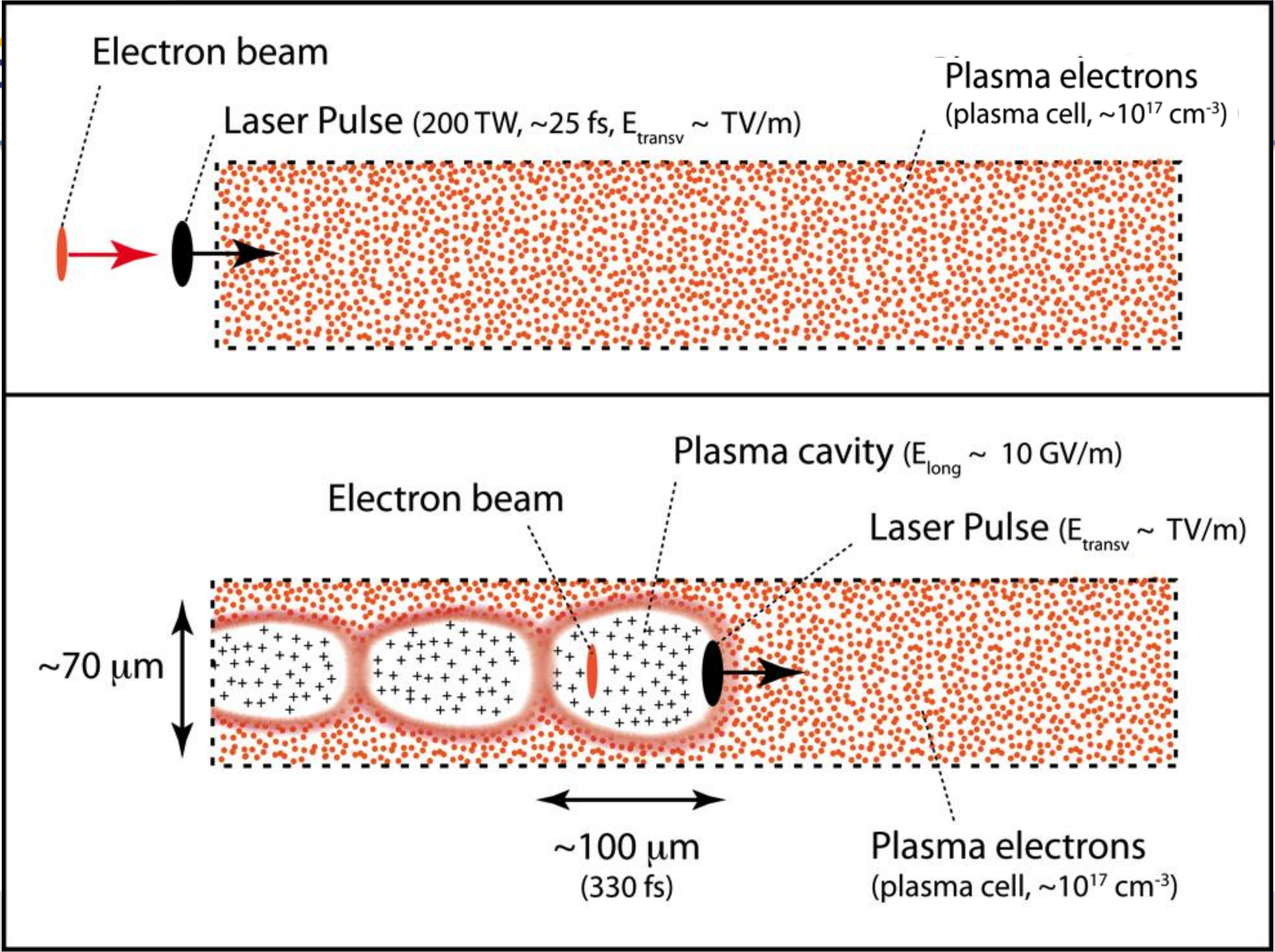


Plasma Wake-Acceleration

Horizon2020

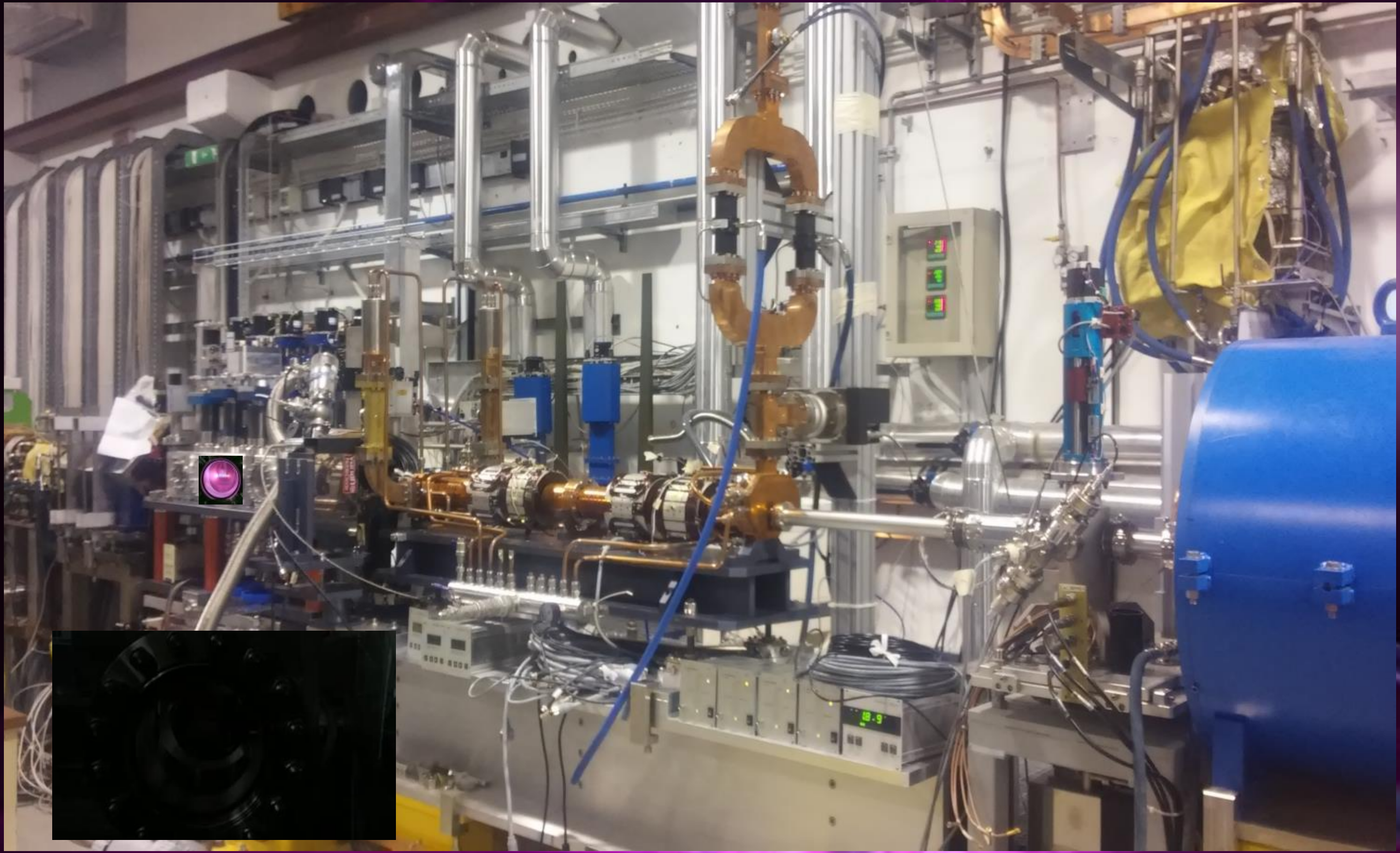


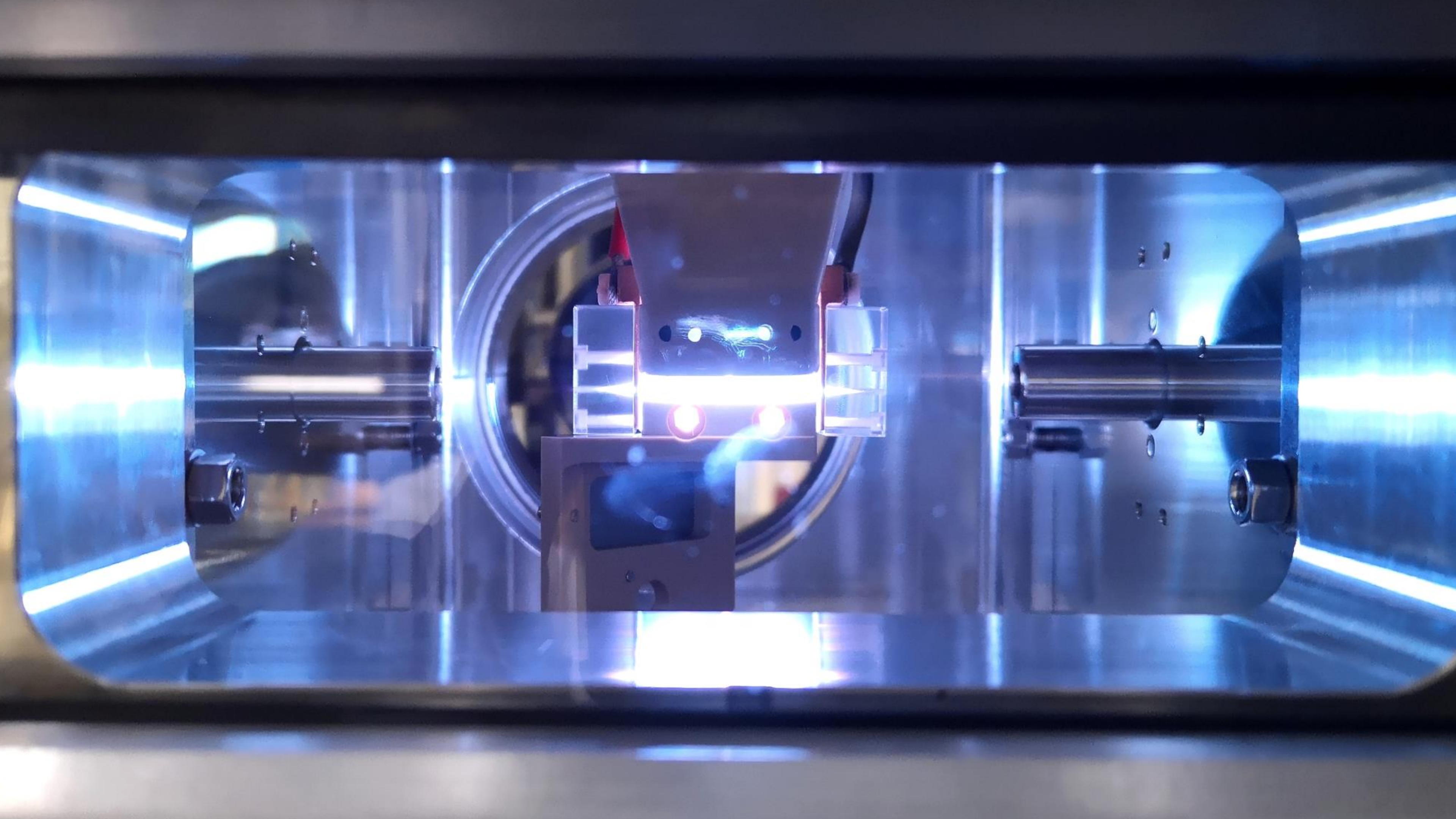
This accelerator fits into a human hair!



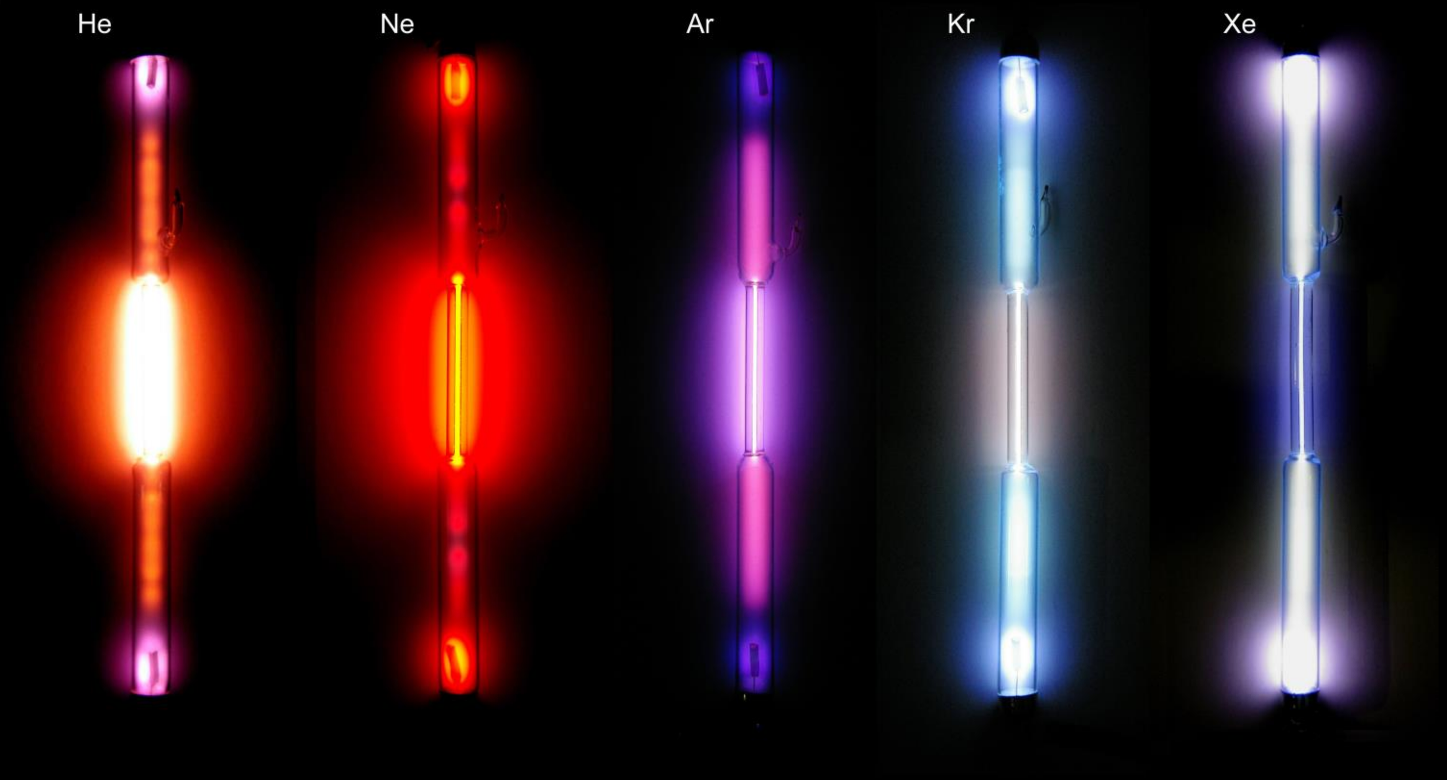
Electron beam
Laser Pulse (200 TW, ~25 fs, E_transv ~ TV/m)
Plasma electrons
(plasma cell, ~10^17 cm^-3)
Plasma cavity (E_long ~ 10 GV/m)
Electron beam
Laser Pulse (E_transv ~ TV/m)
~70 μm
~100 μm
(330 fs)
Plasma electrons
(plasma cell, ~10^17 cm^-3)

PWFA beam line at SPARC_LAB

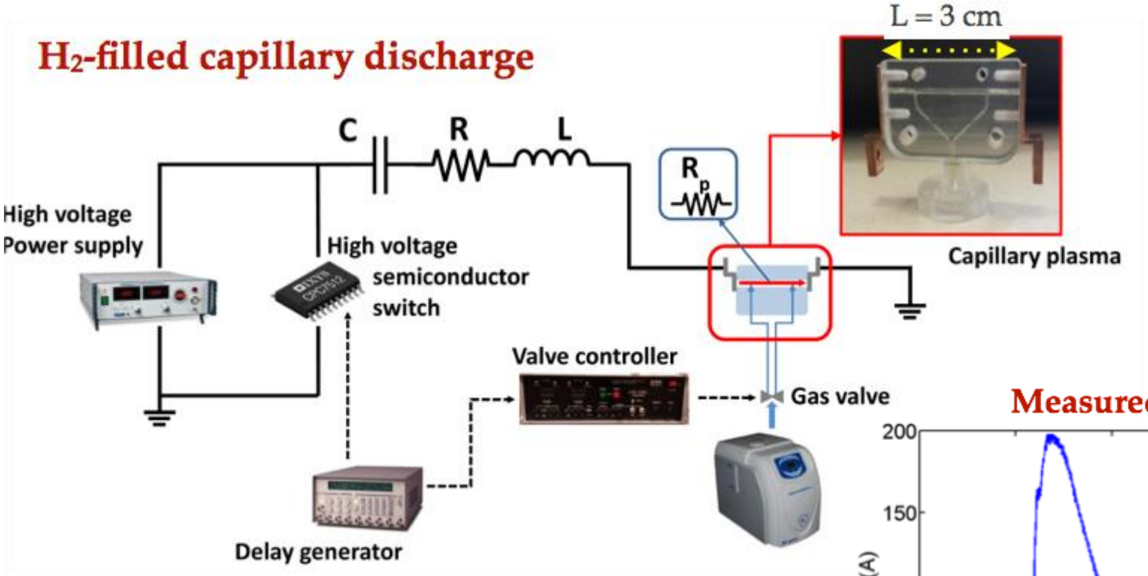


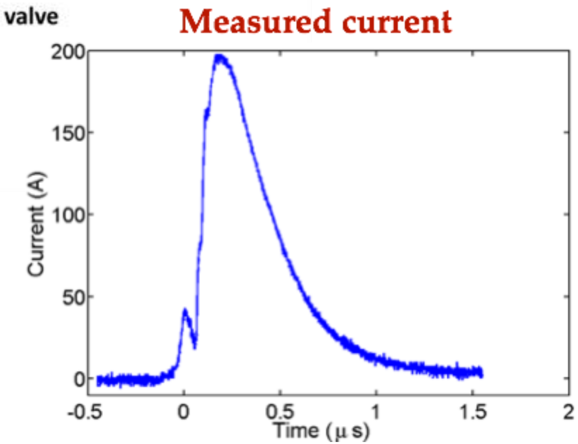


Looking for a plasma target



Plasma Source



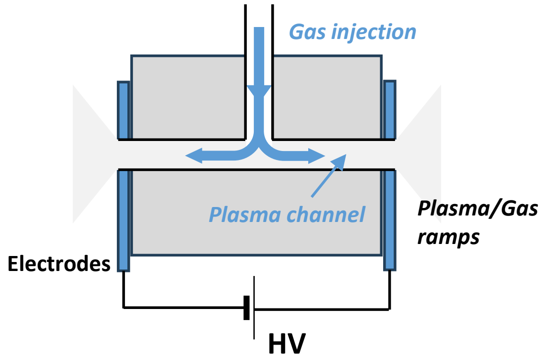


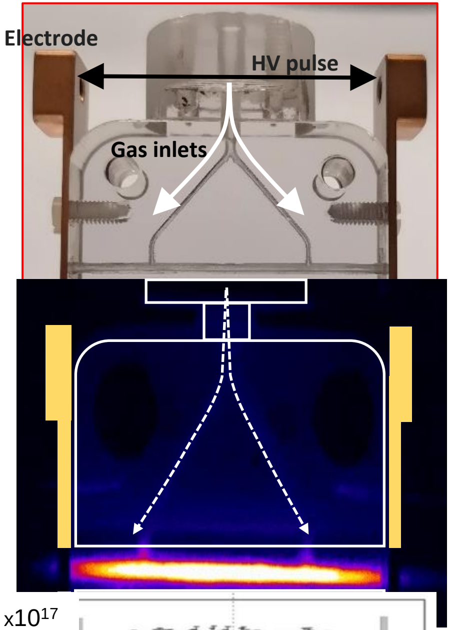
P_{H2} = 10 mbar
Total discharge duration: 800 ns
Voltage: 20 kV
Peak current: 200 A
Capacitor: 6 nF

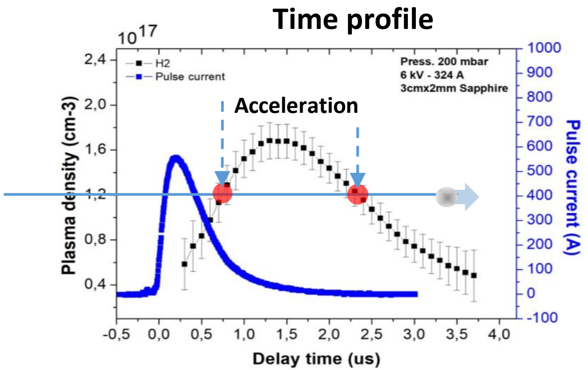
Courtesy of M. P. Anania, A. Biagioni, D. Di Giovenale, F. Filippi, S. Pella

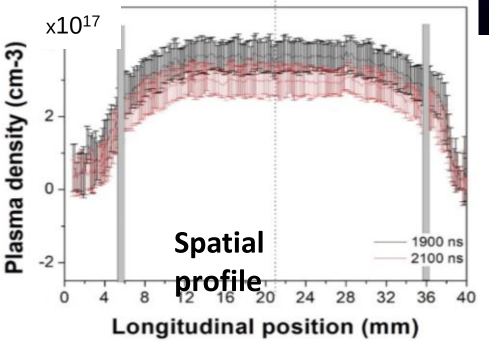
Discharge Plasma sources properties

- Region of uniform neutral gas contained by differential pumping at two input/output extremities and realized by a thin capillary
- Modulation of longitudinal gas distribution by special geometric shapes
- Small gas flow to operate in steady state regime with continuous flow ($P < 1$ bar)
- There is no movable parts
- Small dimension of the HV source to produce plasma
- Plume of gas from front and back of cell, plasma ramps to be controlled
- Density easily adjusted by controlling gas flow, geometry or voltage in the range: 10^{15} - 10^{19} cm^{-3}
- Erosion of the plasma channel due to the electrical discharges to form plasma



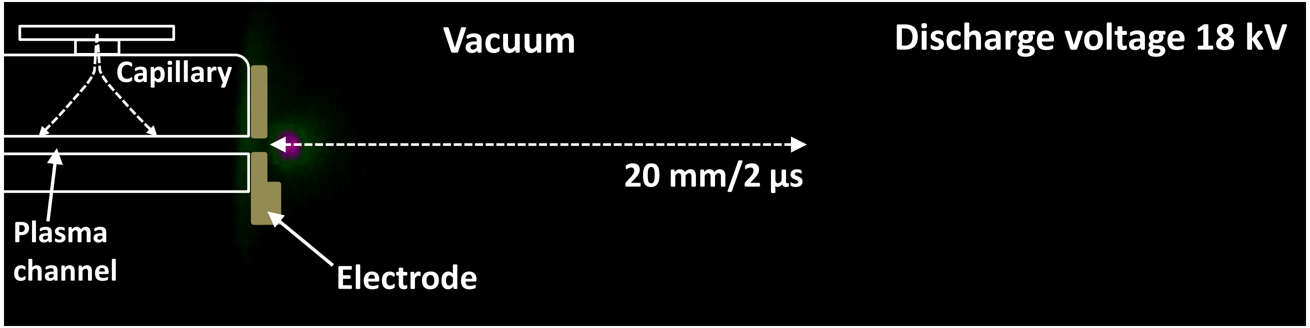






Plasma plumes

- **20 images separated by 100 ns, so 2 μs of total observation time of the plasma plumes**
- **The ICCD camera area is 1024 x 256 pixel**

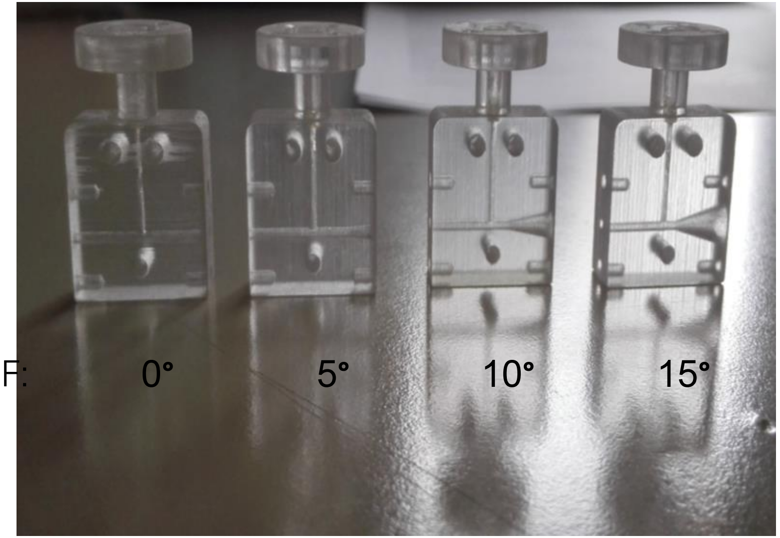


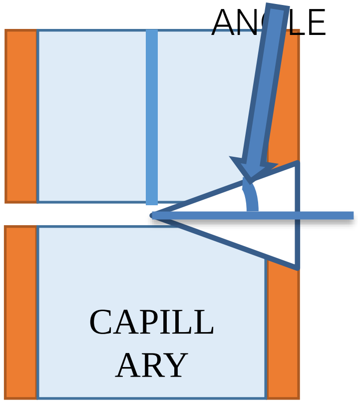
- Both plama plumes can reach a total expansion length around 40 mm (20 mm each one) that is comparable with the channel length of 30 mm, so they can strongly affect the beam properties that passes through the capillary

- Temperature, pressure and plasma density, inside and outside the gas-filled capillary plasma source, represent essential parameters that have to be investigated to understand the plasma evolution and how it can affect the electron beam.

Tapered capillaries

Local control of the plasma density is required to match the laser/electron beam into the plasma.
Tapering the capillary diameter is the easiest way to change locally the density.





Principle of plasma acceleration

Driven by Radiation Pressure

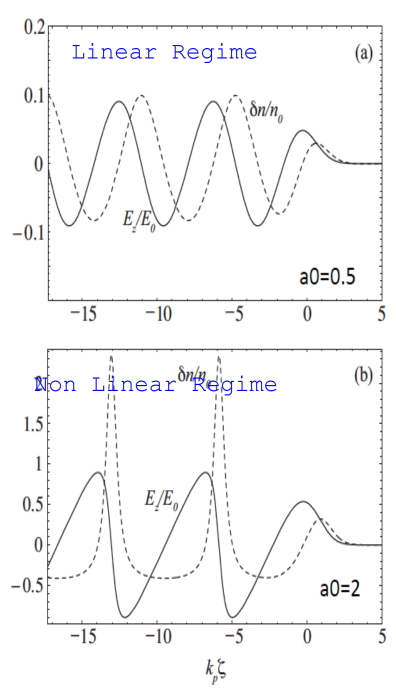
$$\left(\frac{\partial^2}{\partial t^2}+\omega_p^2\right)\frac{n}{n_o}=c^2\nabla^2\frac{a^2}{2}$$

$$a=\frac{eA}{mc^2}\propto\lambda J^{1/2}$$

Driven by Space Charge

$$\left(\frac{\partial^2}{\partial t^2}+\omega_p^2\right)\frac{n}{n_o}=-\omega_p^2\frac{n_{beam}}{n_o}$$

$$n_{beam}=\frac{N}{\sqrt{(2\pi)^3}\,\sigma_r^2\sigma_z}$$



LWFA limitations: Diffraction, Dephasing, Depletion

PWFA limitations: Head Erosion, Hose

Linear Wakefields
(R. Ruth / P. Chen 1986)

Accelerating field

Depends on radial position r

Changes between accelerating and decelerating as function of longitudinal position z

$$\mathcal{E}_z \simeq -A\left(1-\frac{r^2}{a^2}\right)\cos(k_p z-\omega_p t)$$

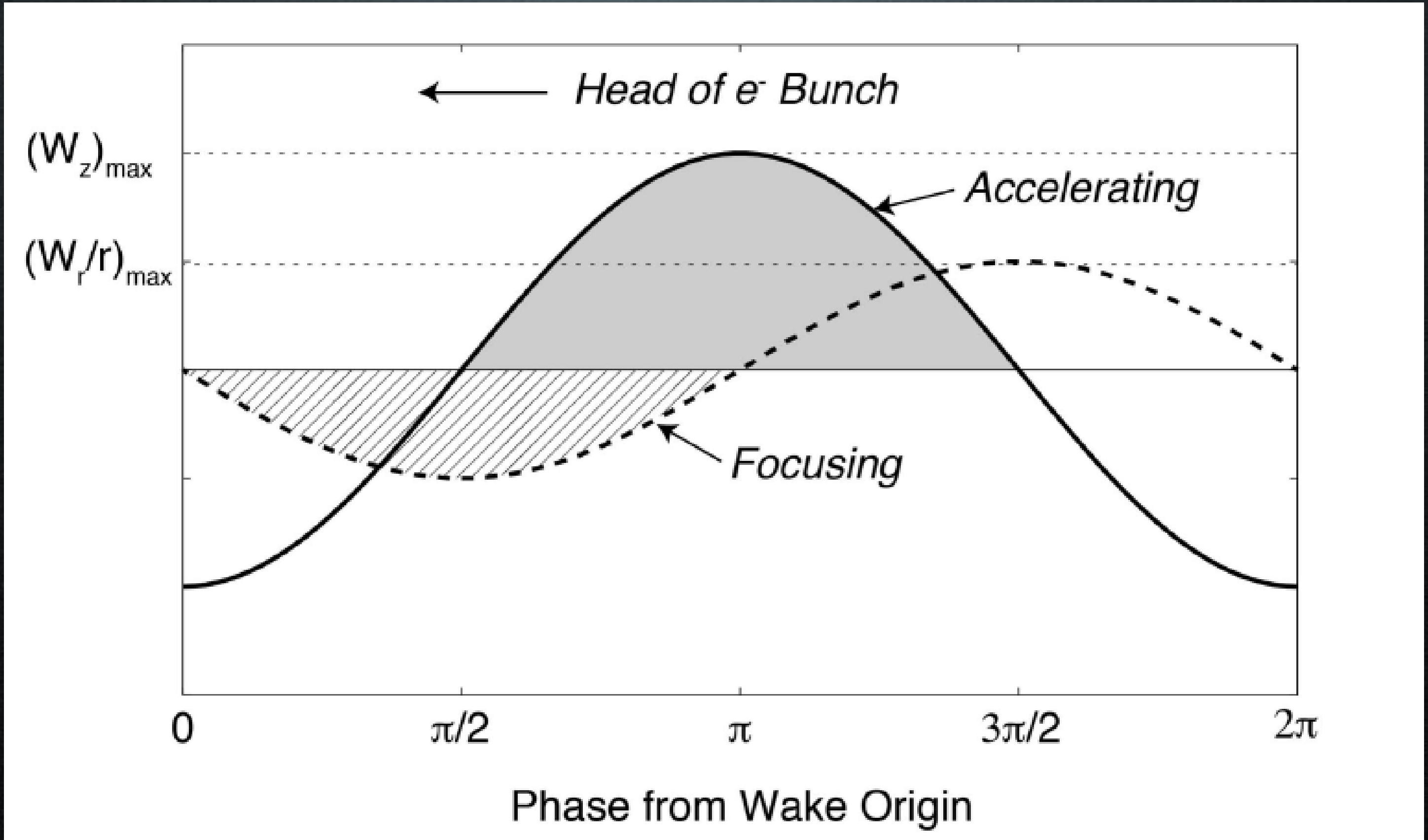
π/2 out of phase

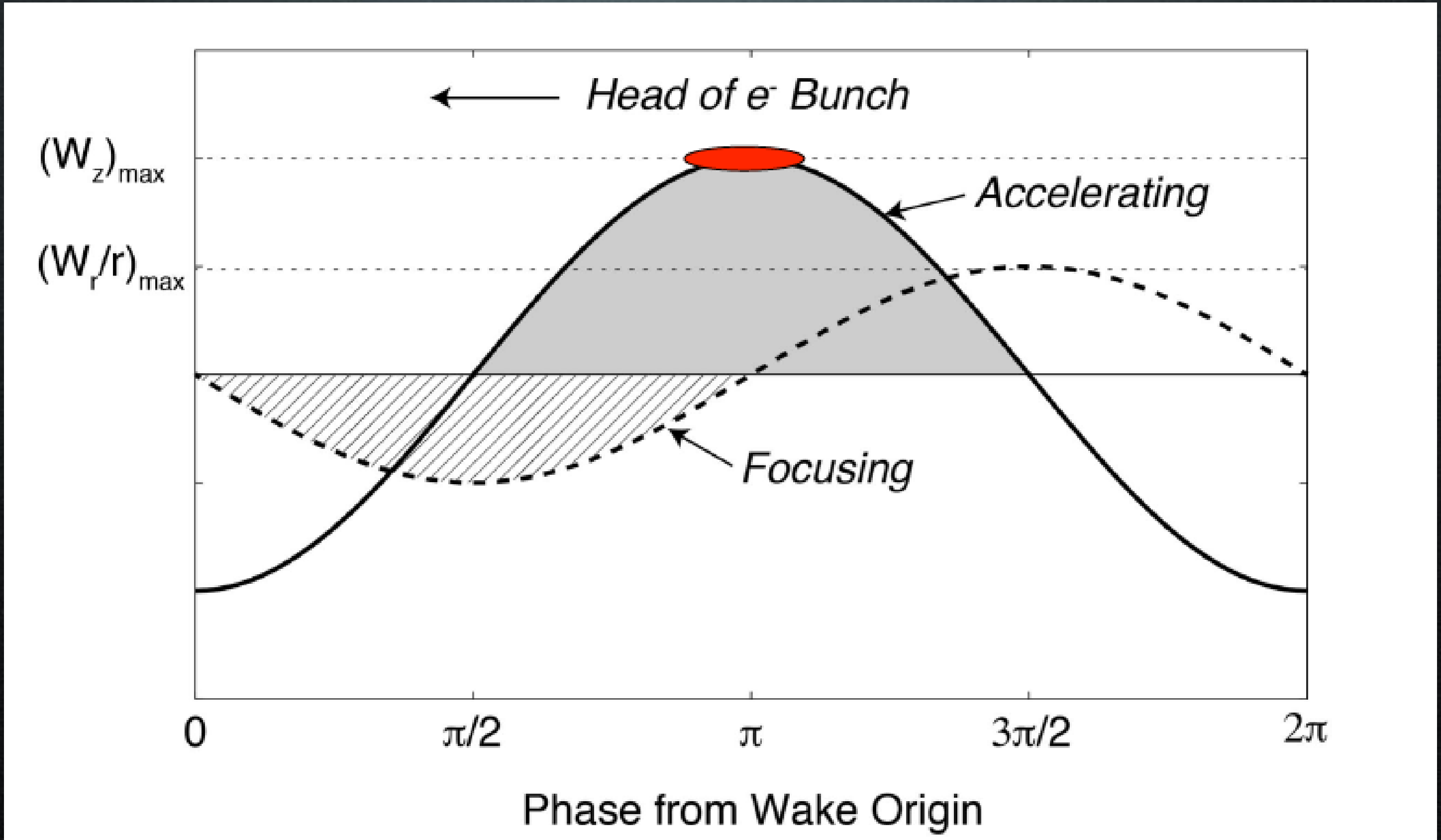
$$\mathcal{E}_r \simeq 2A\frac{r}{k_p a^2}\sin(k_p z-\omega_p t)$$

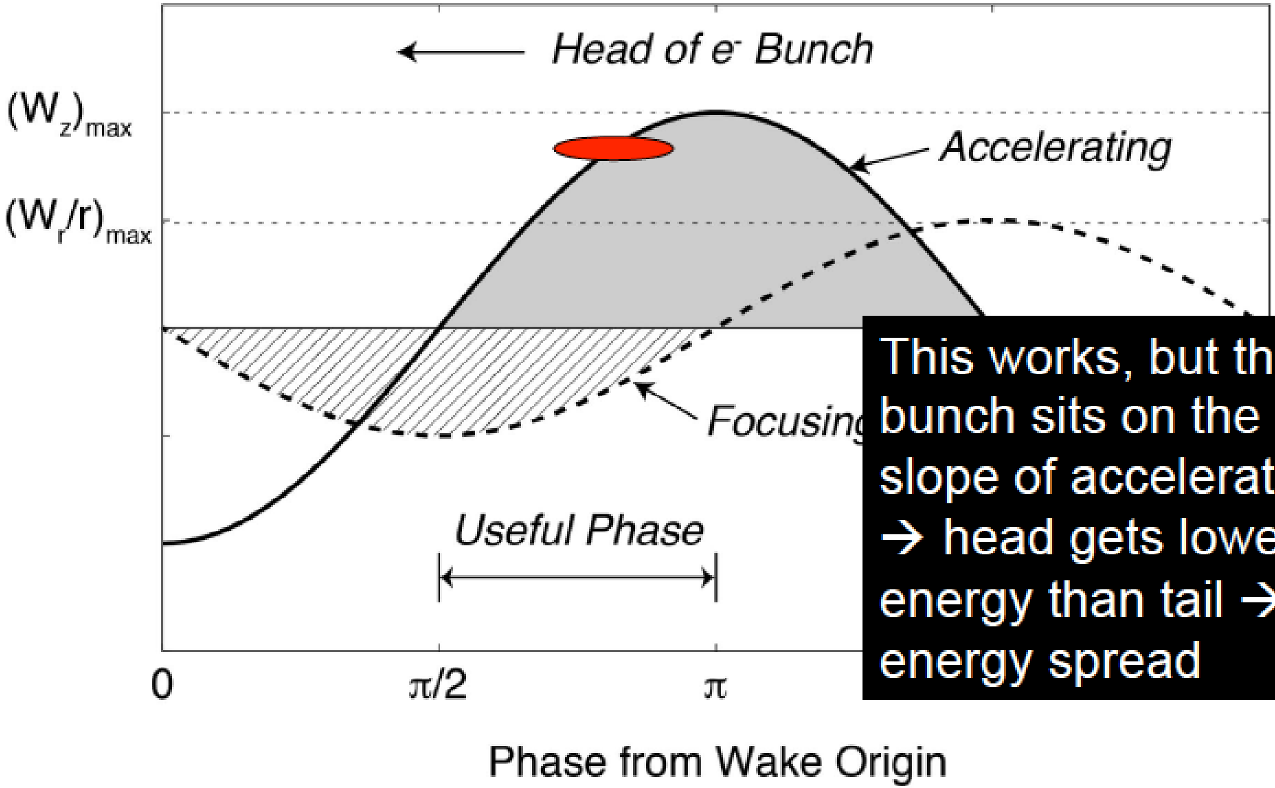
Transverse field

Depends on radial position r

Changes between focusing and defocusing as function of longitudinal position z

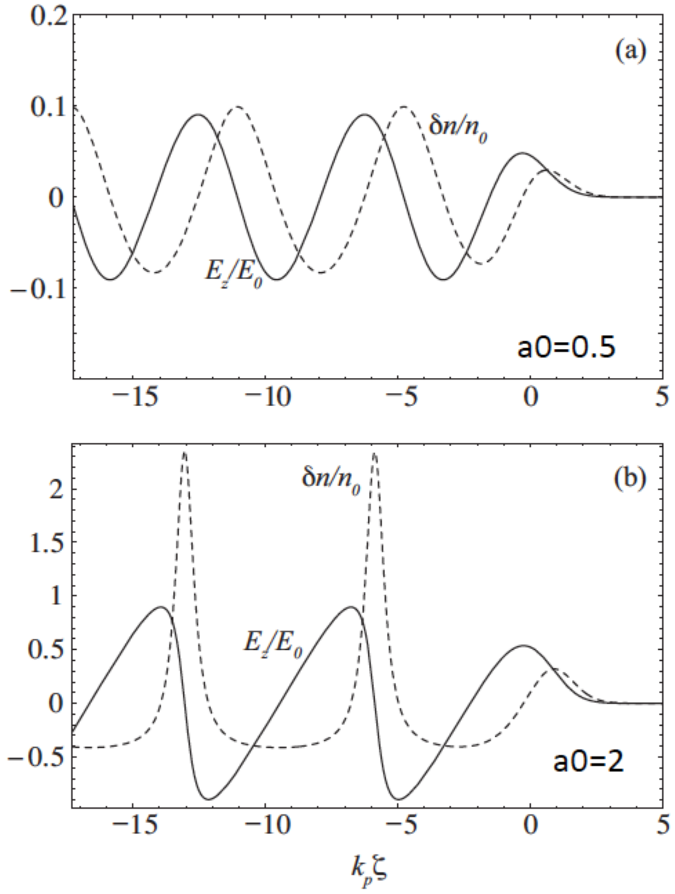

Head of e⁻ Bunch
$(W_z)_{max}$
$(W_r/r)_{max}$
Accelerating
Focusing
0
π/2
π
3π/2
2π
Phase from Wake Origin


Head of e⁻ Bunch
(W_z)_max
(W_r/r)_max
Accelerating
Focusing
0
π/2
π
3π/2
2π
Phase from Wake Origin



This works, but the bunch sits on the slope of acceleration → head gets lower energy than tail → energy spread

Regimes: Linear & Non-Linear



Linear

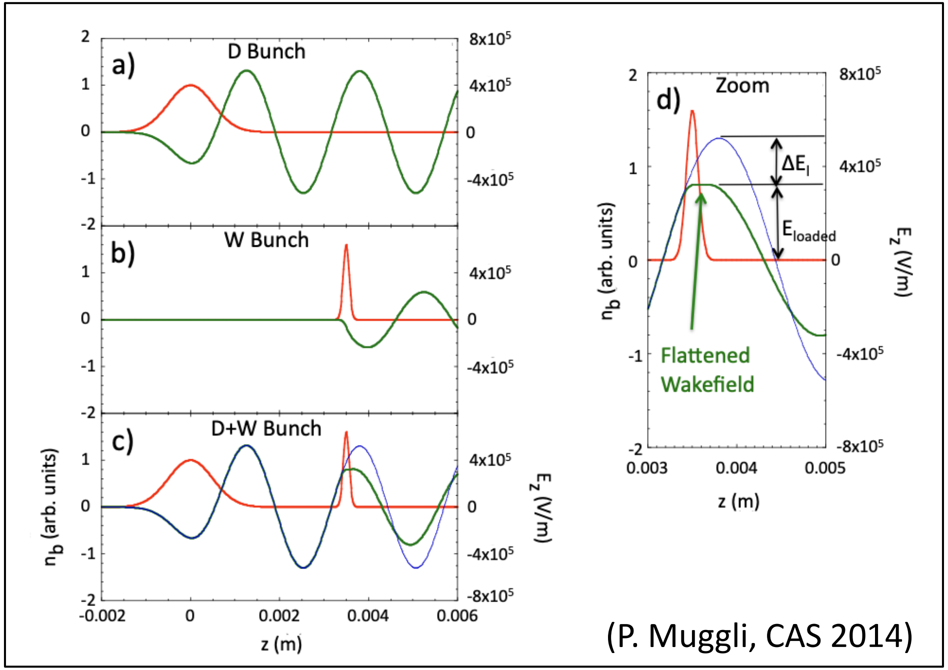
FIG. 8. Time-averaged density variation $\delta n/n_0$ (dashed curve) and axial electric field E_z/E_0 (solid curve) in an LWFA driven by a Gaussian laser pulse (pulse is moving to the right, centered at $k_p\zeta=0$ with rms intensity length $L_{\text{rms}}=k_p^{-1}$) for (a) $a_0=0.5$ and (b) $a_0=2.0$.

Non-Linear

➔ BEAM LOADING:

The presence of the witness bunch affects the wakefields

Linear regime



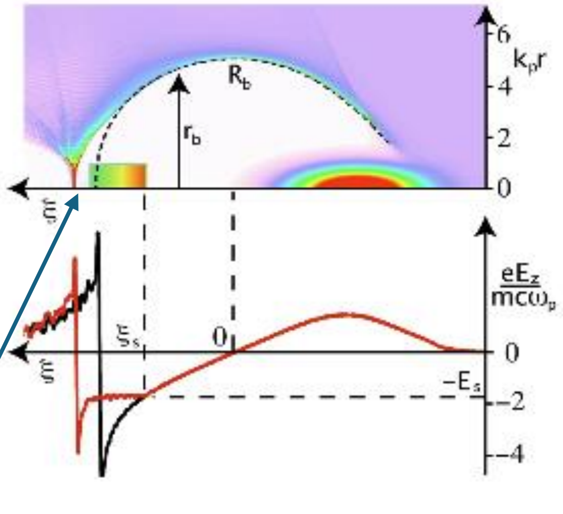
(P. Muggli, CAS 2014)

Non-linear regime


PRL 101, 145002 (2008) PHYSICAL REVIEW LETTERS week ending 3 OCTOBER 2008

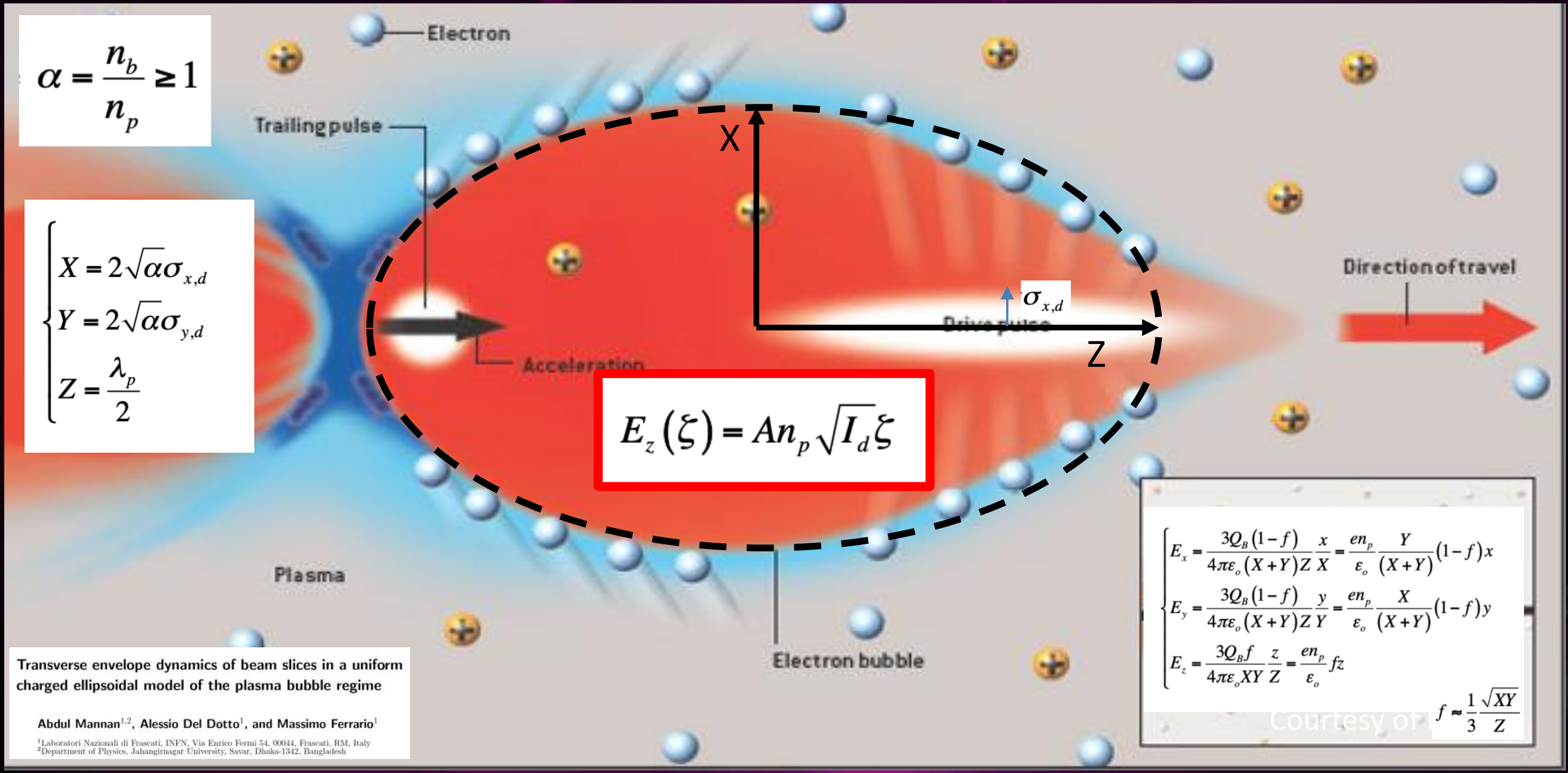
Beam Loading in the Nonlinear Regime of Plasma-Based Acceleration

M. Tzoufras,[1] W. Lu,[1] F. S. Tsung,[2] C. Huang,[2] W. B. Mori,[1,2] T. Katsouleas,[3] J. Vieira,[4] R. A. Fonseca,[4] and L. O. Silva[4]



The bubble closes later

Non Linear Regime – Ellipsoidal Bubble Model



$$\alpha = \frac{n_b}{n_p} \geq 1$$

$$\begin{cases} X = 2\sqrt{\alpha}\,\sigma_{x,d} \\ Y = 2\sqrt{\alpha}\,\sigma_{y,d} \\ Z = \dfrac{\lambda_p}{2} \end{cases}$$

$$E_z(\zeta) = A n_p \sqrt{I_d}\,\zeta$$

$$\begin{cases} E_x = \dfrac{3Q_B(1-f)}{4\pi\varepsilon_o(X+Y)Z}\dfrac{x}{X} = \dfrac{en_p}{\varepsilon_o}\dfrac{Y}{(X+Y)}(1-f)x \\ E_y = \dfrac{3Q_B(1-f)}{4\pi\varepsilon_o(X+Y)Z}\dfrac{y}{Y} = \dfrac{en_p}{\varepsilon_o}\dfrac{X}{(X+Y)}(1-f)y \\ E_z = \dfrac{3Q_B f}{4\pi\varepsilon_o XY}\dfrac{z}{Z} = \dfrac{en_p}{\varepsilon_o}fz \end{cases}$$

$$f \approx \frac{1}{3}\frac{\sqrt{XY}}{Z}$$

Transverse envelope dynamics of beam slices in a uniform charged ellipsoidal model of the plasma bubble regime

Abdul Mannan[1,2], Alessio Del Dotto[1], and Massimo Ferrario[1]

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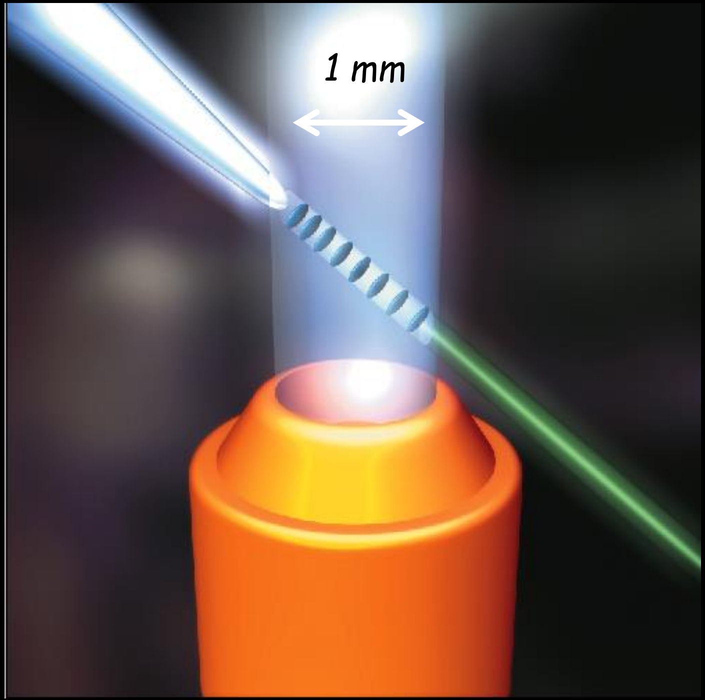
[2]Department of Physics, Jahangirnagar University, Savar, Dhaka-1342, Bangladesh

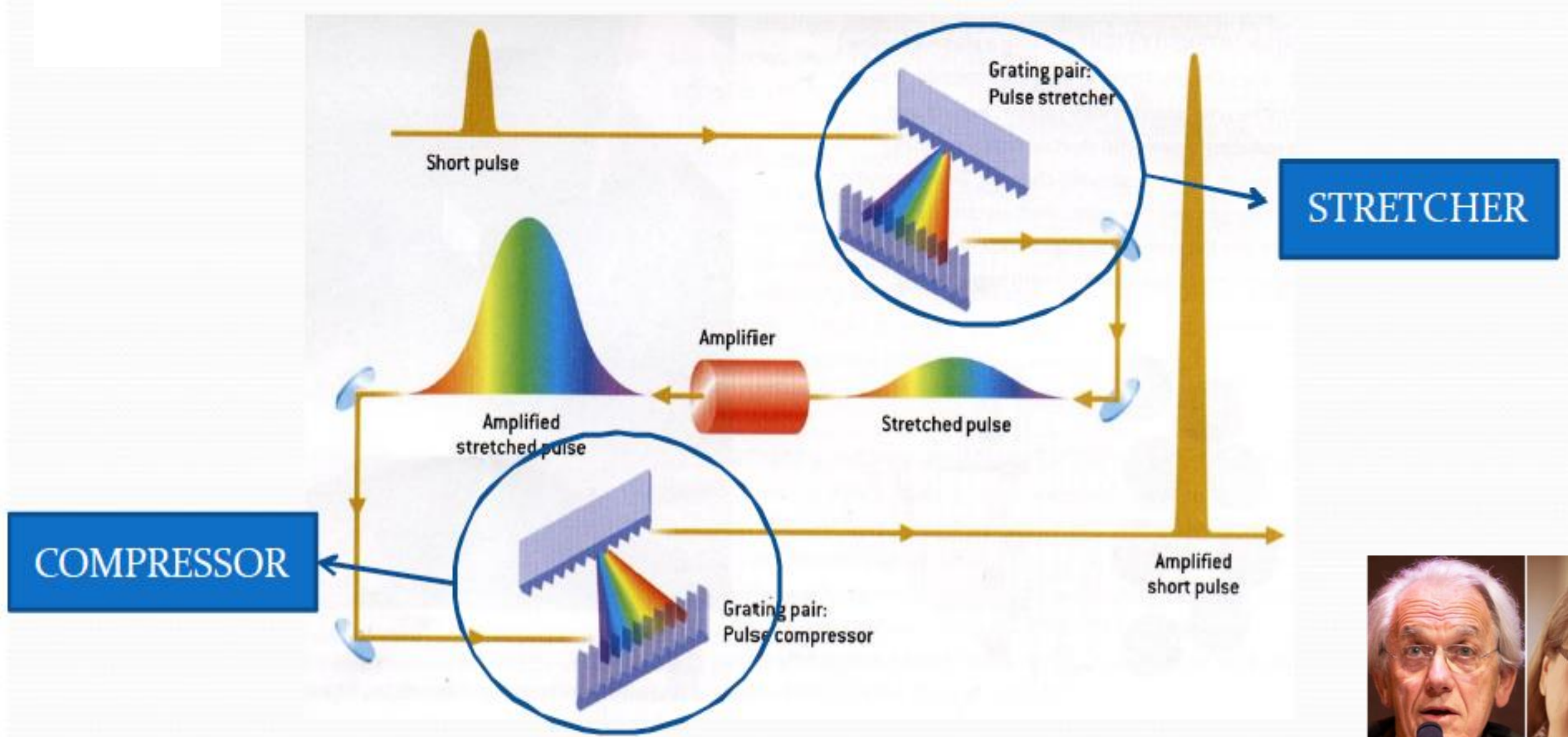
Laser Driven

LWFA

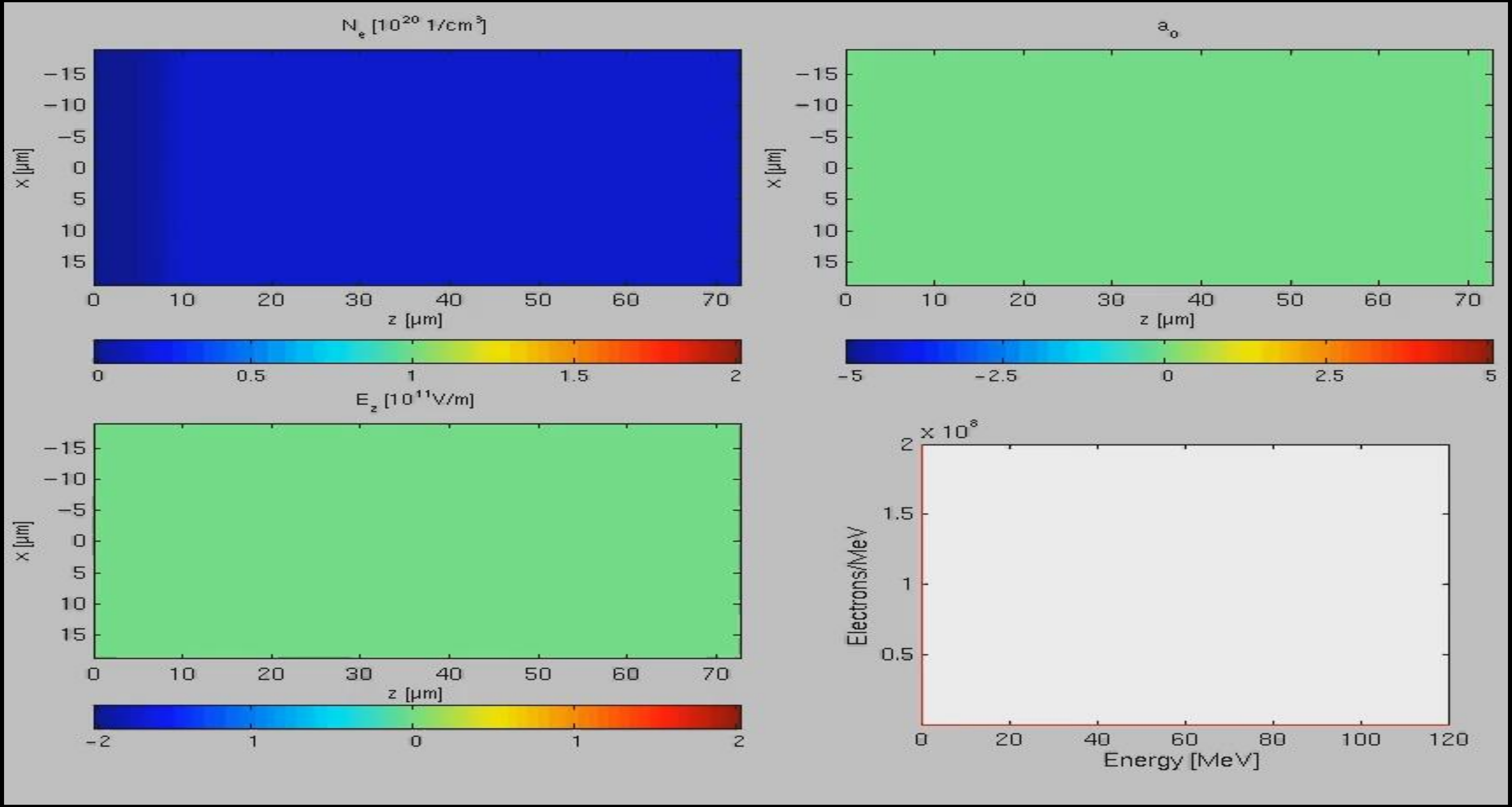
Direct production of e-beam



Chirped Pulse

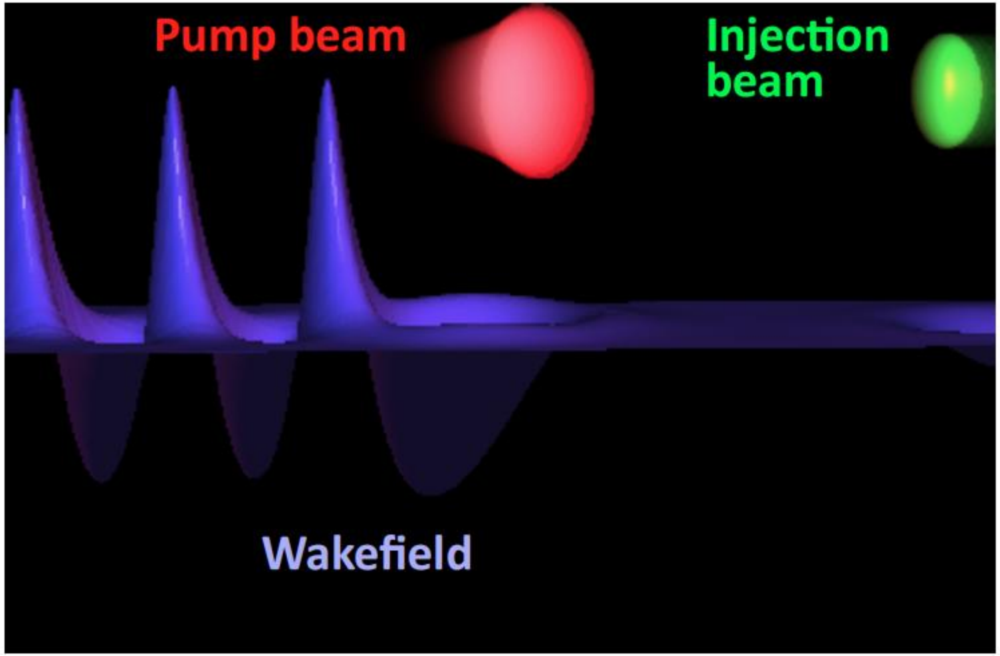


Diffraction - Self injection - Dephasing – Depletion



Colliding Laser Pulses Scheme

The first laser creates the accelerating structure, a second laser beam is used to heat electrons



Theory : E. Esarey *et al.*, PRL **79**, 2682 (1997), H. Kotaki *et al.*, PoP **11** (2004)
Experiments : J. Faure *et al.*, Nature **444**, 737 (2006)

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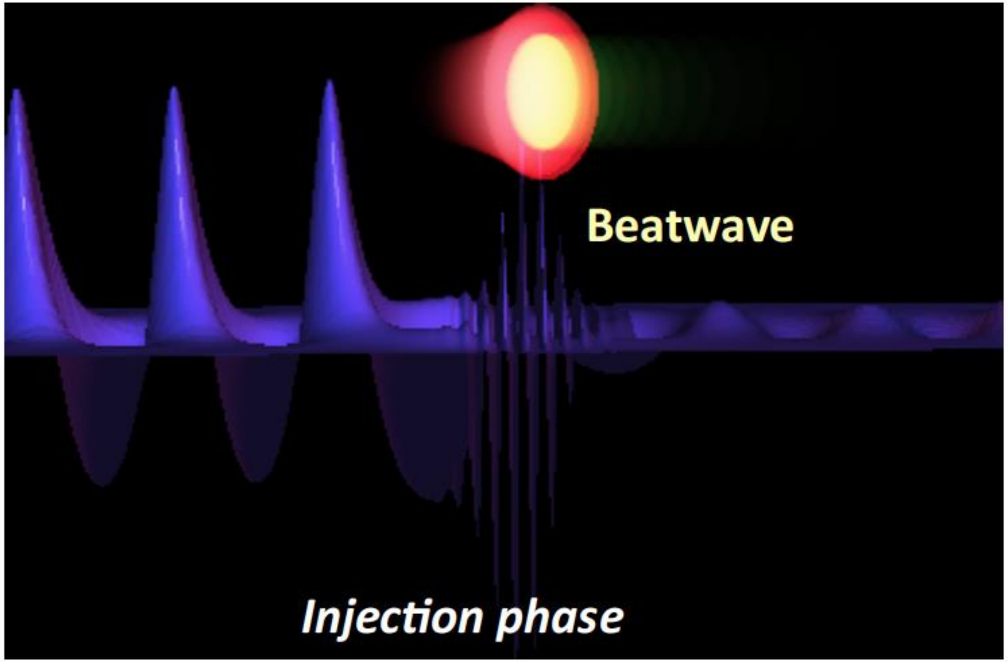

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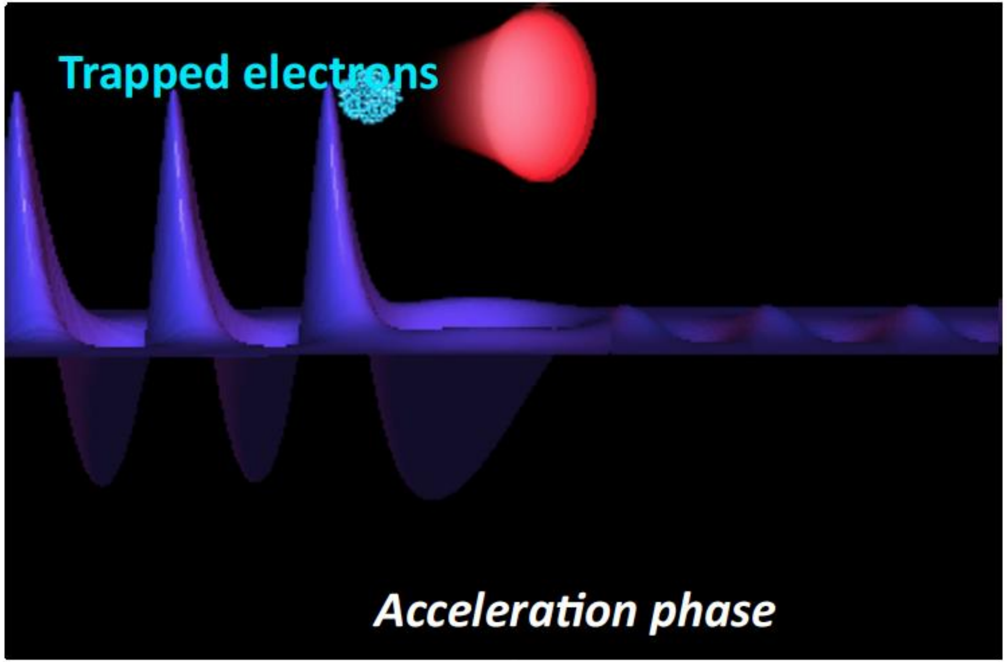
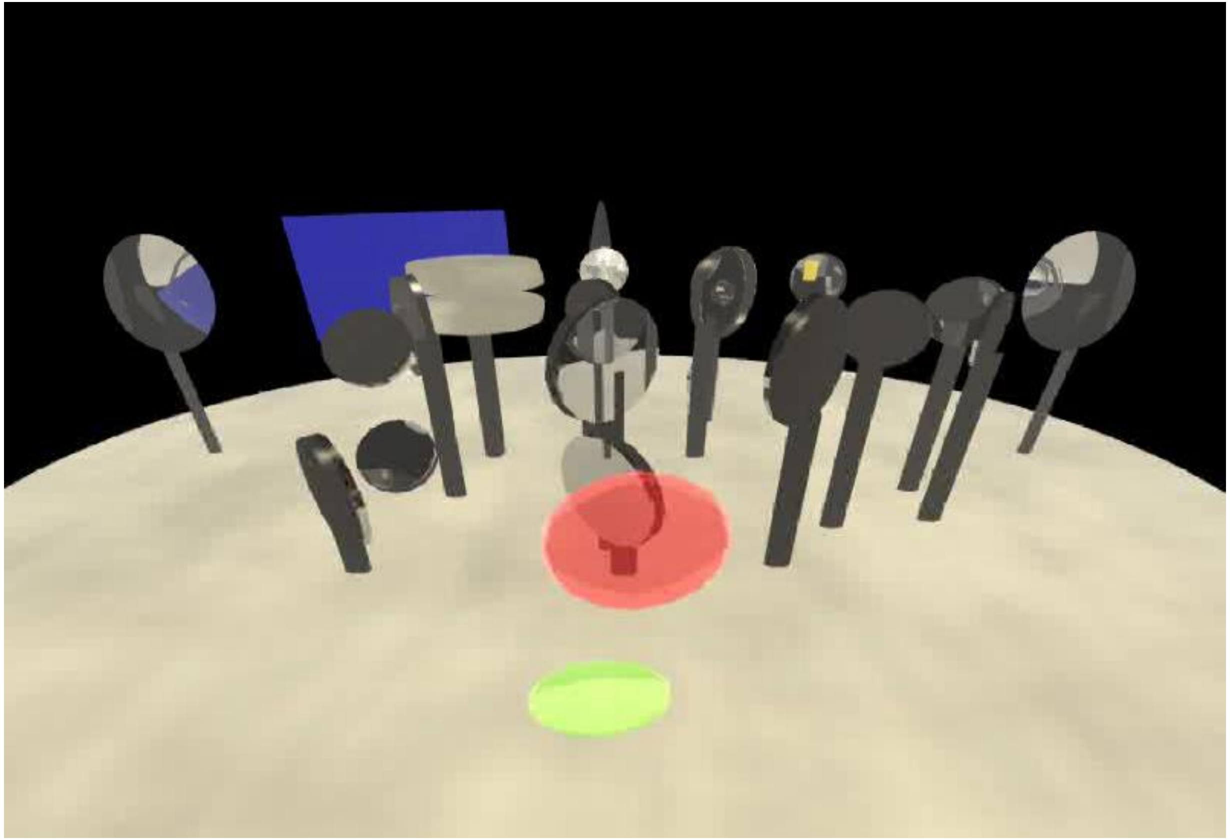
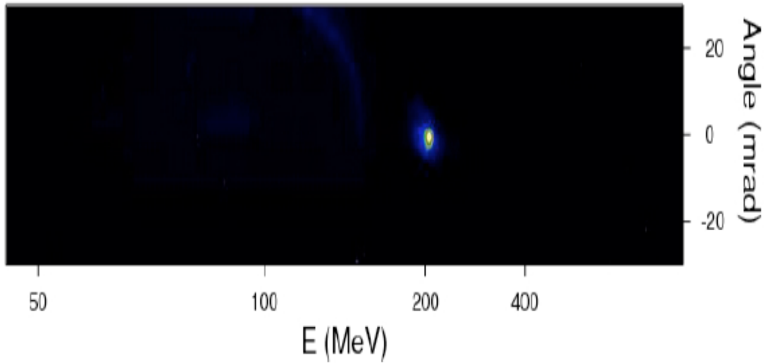
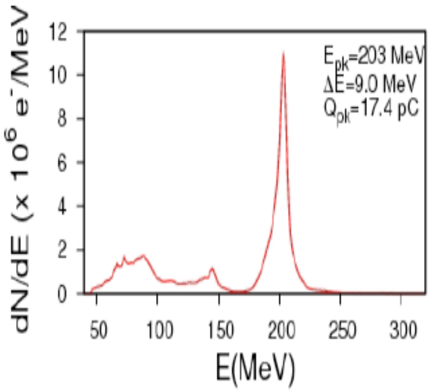


Theory : E. Esarey *et al.*, PRL **79**, 2682 (1997), H. Kotaki *et al.*, PoP **11** (2004)
Experiments : J. Faure *et al.*, Nature **444**, 737 (2006)

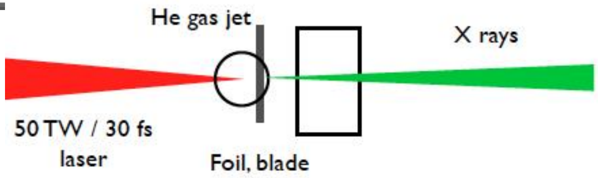
The colliding of two laser pulses




20
0
-20
Angle (mrad)
50
100
200
400
E (MeV)


E_{pk}=203 MeV
ΔE=9.0 MeV
Q_{pk}=17.4 pC
dN/dE (x 10^6 e^-/MeV
12
10
8
6
4
2
0
50
100
150
200
250
300
E(MeV)

Inverse Compton Scattering : New scheme



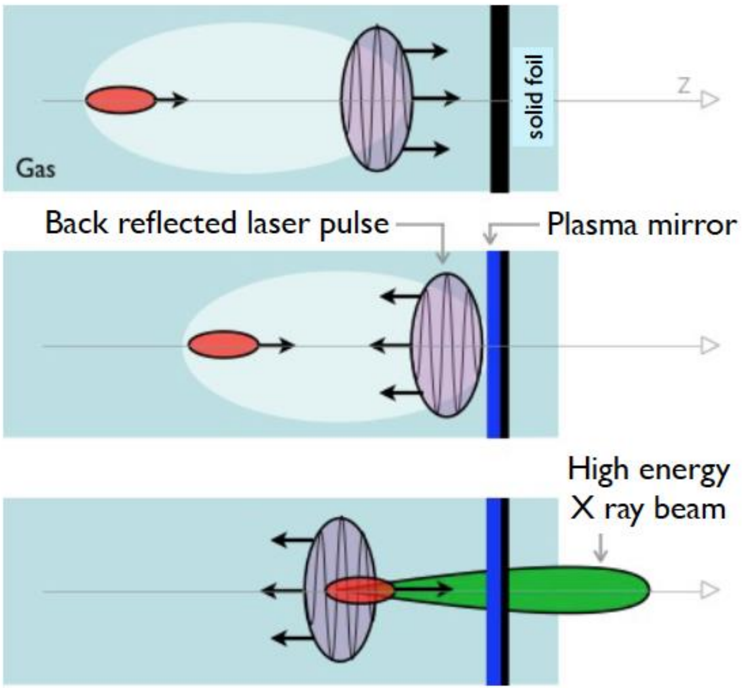
A single laser pulse

A plasma mirror reflects the laser beam

The back reflected laser collides with the accelerated electrons

No alignment : the laser and the electron beams naturally overlap

Save the laser energy !

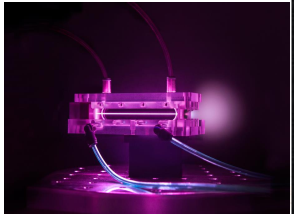


BELLA: BErkeley Lab Laser Accelerator

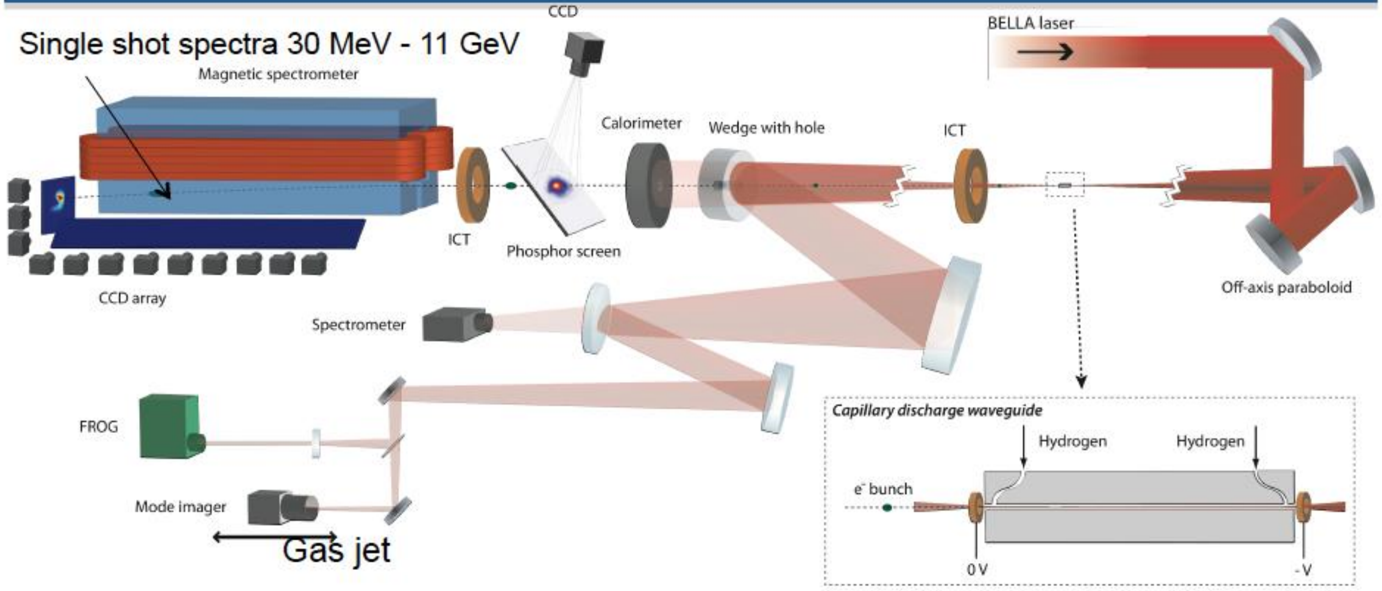
BELLA Facility: state-of-the-art 1.3 PW-laser for laser accelerator science:
>42 J in <40 fs (> 1PW) at 1 Hz laser and supporting infrastructure at LBNL

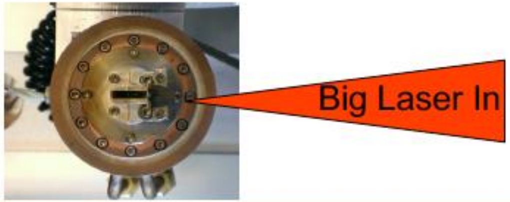
Critical HEP experiments:

- 10 GeV electron beam from <1 m LPA
- Staging LPAs
- Positron acceleration



Experiments at LBNL use the BELLA laser focused by a 14 m focal length off-axis paraboloid onto gas jet or capillary discharge targets

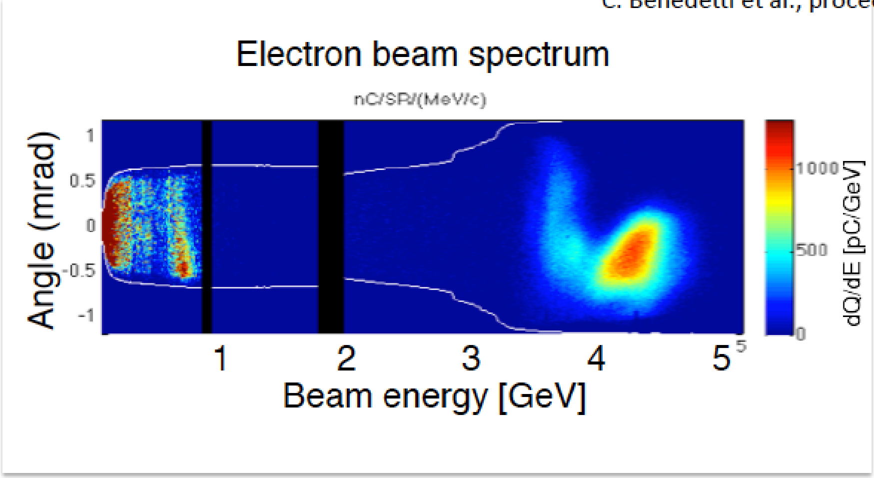


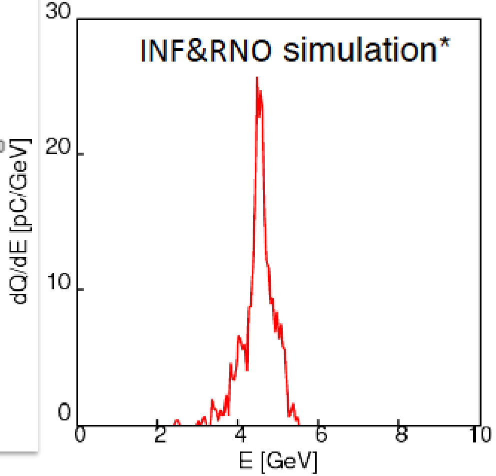


Capillary discharge

4.25 GeV beams have been obtained from 9 cm plasma channel powered by 310 TW laser pulses (15 J)

*C. Benedetti et al., proceedings of AAC2010, proceedings of ICAP2012





	Exp.	Sim.
Energy	4.25 GeV	4.5 GeV
ΔE/E	5%	3.2%
Charge	~20 pC	23 pC
Divergence	0.3 mrad	0.6 mrad

- **Laser** (E=15 J):
  - Measured) longitudinal profile (T_0= 40 fs)
  - Measured far field mode (w_0=53 μm)
- **Plasma:** parabolic plasma channel (length 9 cm, n_0~6-7x10^{17} cm^{-3})

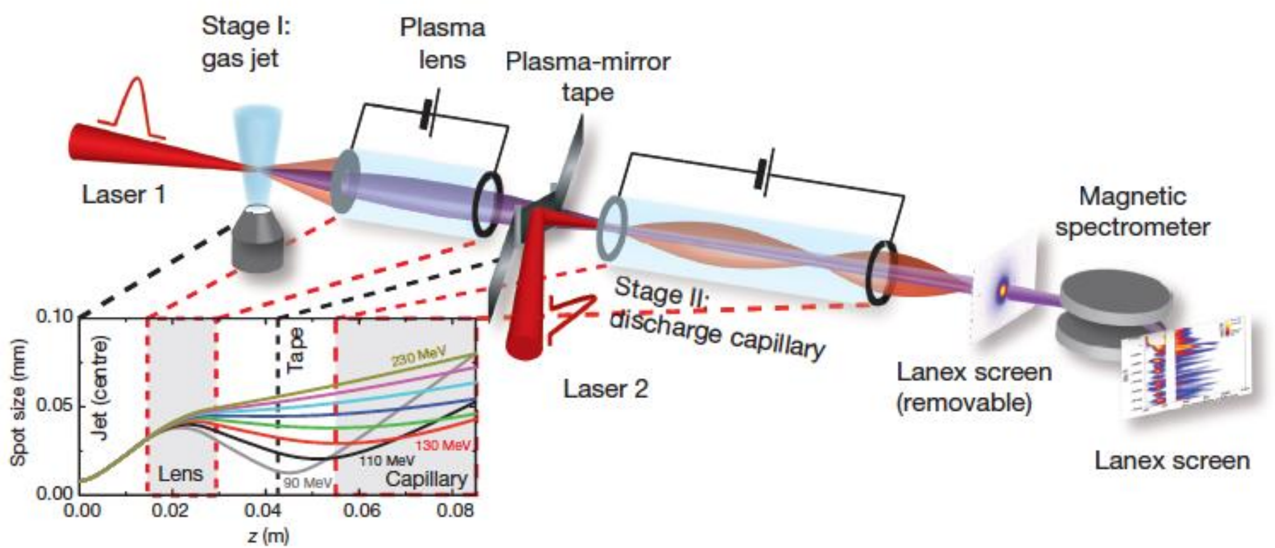
W.P. Leemans et al.,PRL 2014

LETTER

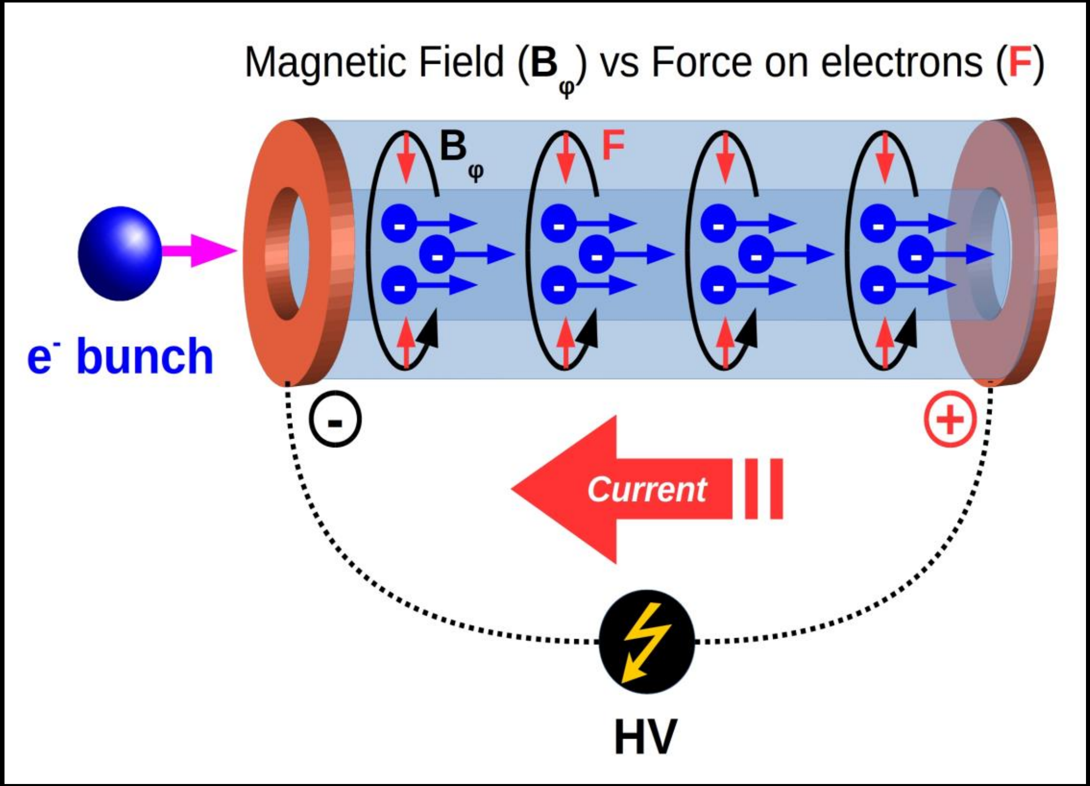
doi:10.1038/nature16525

Multistage coupling of independent laser–plasma accelerators

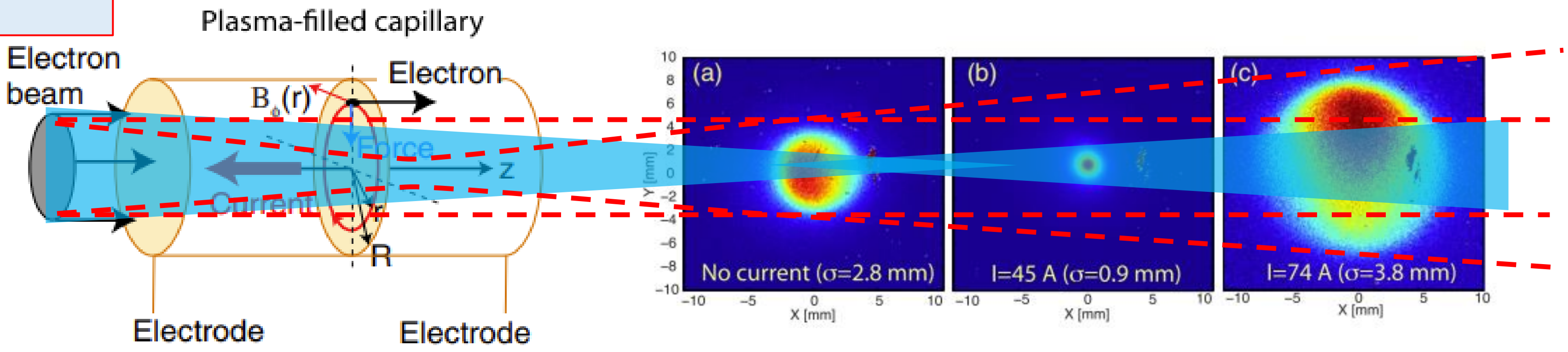
S. Steinke[1], J. van Tilborg[1], C. Benedetti[1], C. G. R. Geddes[1], C. B. Schroeder[1], J. Daniels[1,3], K. K. Swanson[1,2], A. J. Gonsalves[1], K. Nakamura[1], N. H. Matlis[1], B. H. Shaw[1,2], E. Esarey[1] & W. P. Leemans[1,2]



Active Plasma Lens



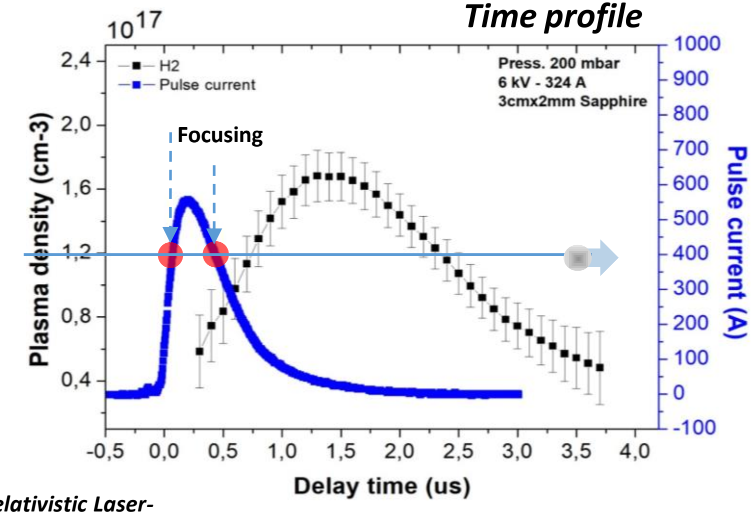
Active PlasmA alens (APL)

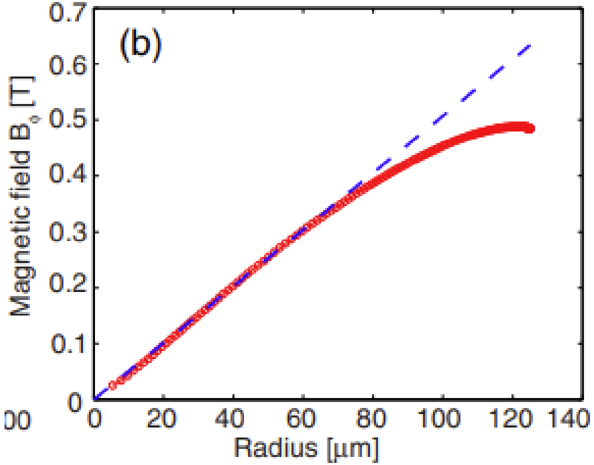


$$\partial B_\phi/\partial r = \mu_0 I_0/(2\pi R^2)$$

- ***R*** capillary radius
- ***I_0*** peak current

Time profile





J. van Tilborg et Al, ***Active Plasma Lensing for Relativistic Laser-Plasma-Accelerated Electron Beams***, **PRL 115, 184802 (2015)**

Beam Quality Preservation requires proper matching – Focusing

➔Ion column provides linear focusing force

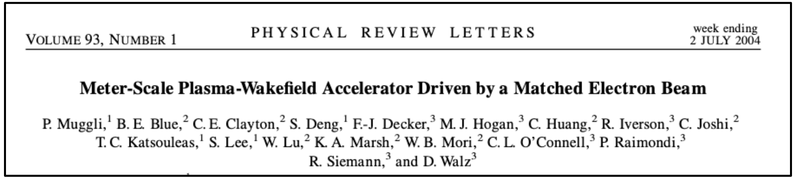
Radial electric field: $E_r(r) = \frac{e n_{pe}}{2\varepsilon_0} r$ (Gauss' law on cylinder of ions)

→ Plug it in envelope equation: $\sigma_r''(z) + \sigma_r(z) \underbrace{\left(K - \frac{\epsilon_g^2}{\sigma_r^4(z)}\right)}_{=0:} = 0$

=0:
Matching condition → Equilibrium between focusing force and emittance

- $\beta = \frac{\sigma^2(0)}{\epsilon_g} = \sqrt{\frac{2\varepsilon_0 m_e c^2 \gamma}{n_{pe} e^2}}$
- Injection at waist: $\sigma'(z=0) = 0$

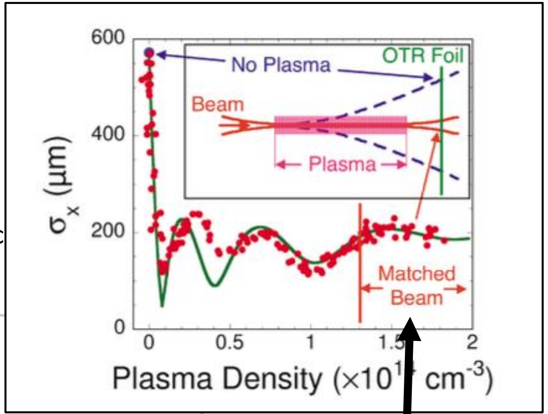
Note: the matching condition is given by β!
→ Stronger focusing required for higher density



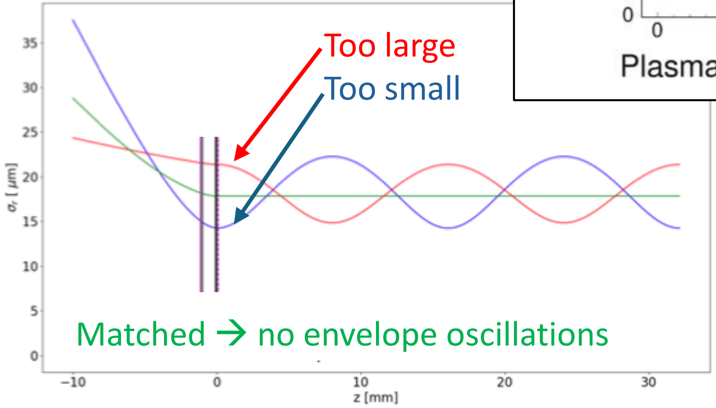
VOLUME 93, NUMBER 1 PHYSICAL REVIEW LETTERS week ending 2 JULY 2004

Meter-Scale Plasma-Wakefield Accelerator Driven by a Matched Electron Beam

P. Muggli,[1] B. E. Blue,[2] C. E. Clayton,[2] S. Deng,[1] F.-J. Decker,[3] M. J. Hogan,[3] C. Huang,[2] R. Iverson,[3] C. Joshi,[2] T. C. Katsouleas,[1] S. Lee,[1] W. Lu,[2] K. A. Marsh,[2] W. B. Mori,[2] C. L. O'Connell,[3] P. Raimondi,[3] R. Siemann,[3] and D. Walz[3]



Beam leaves the plasma at waist
→ matched ➔constant size



(L. Verra et al 2020 J. Phys.: Conf. Ser. **1596** 012007)

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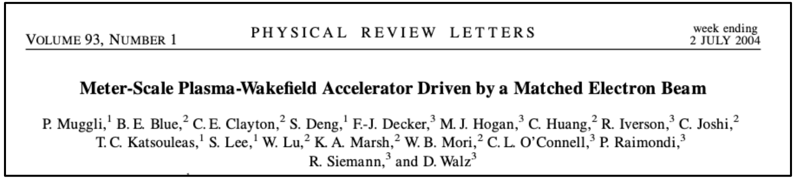
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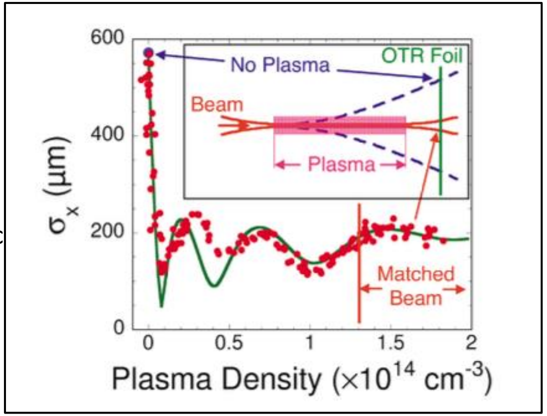
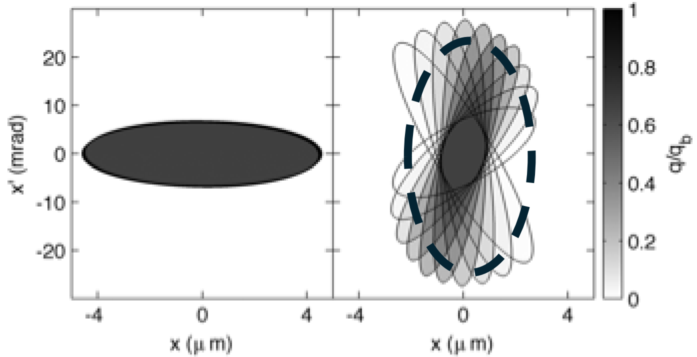


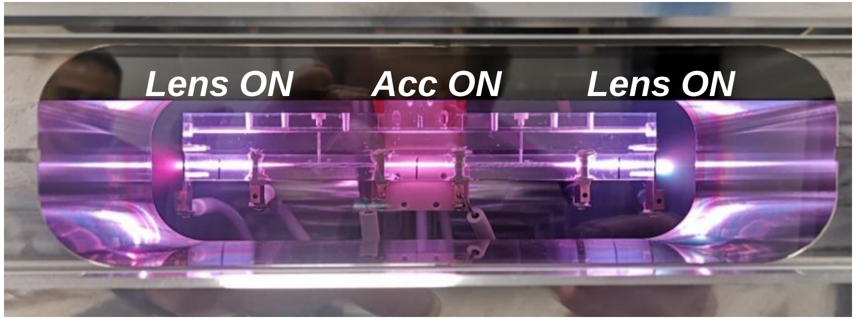
Q: WHY IS IMPORTANT TO MATCH THE BEAM ENVELOPE?

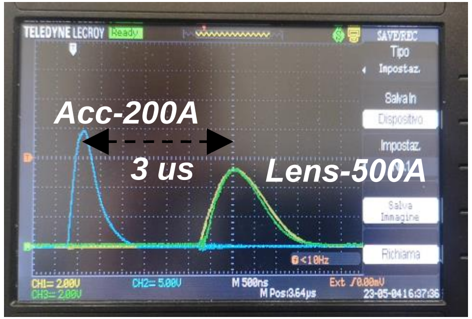


- Finite energy spread:
  → different energy slices rotate at different rates in transverse phase space
  → slice emittance preserved (linear focusing)
  → projected (i.e., overall) emittance grows!

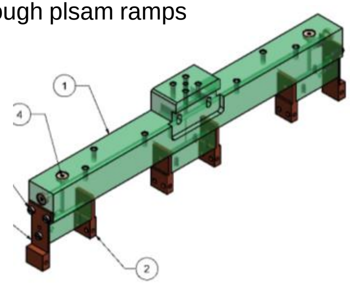
(C.A. Lindstrøm and M. Thévenet 2022 JINST 17 P05016)

Integrated capillary

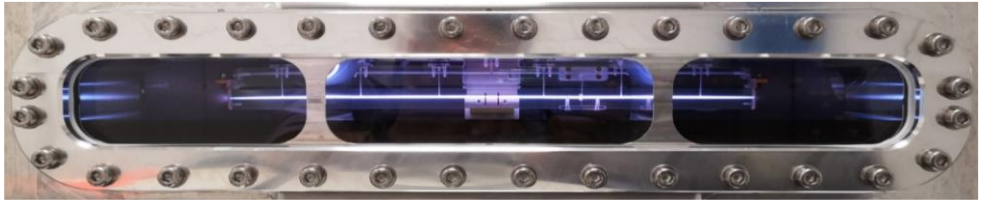




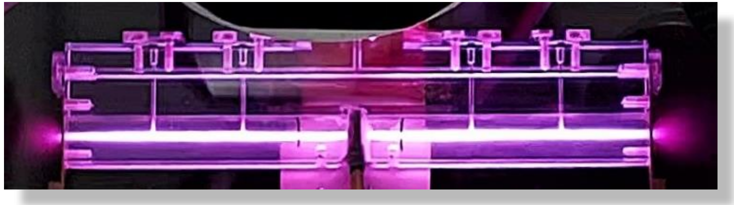
Studies on cross-talk effects:
Design of electrodes and HV-circuits to reduce the interaction among discharges through plsam ramps



Very long capillary

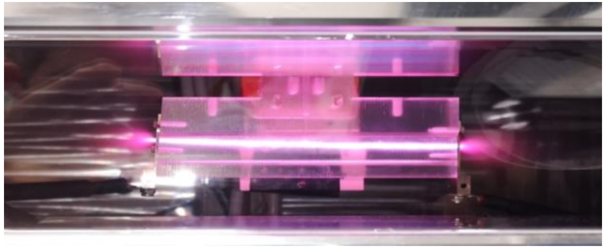


Design of m-scale capillaries for EuPRAXIA project by using segmented capillaries: design of HV-voltage circuits and discharge synchronization



Segmented capillary

Curved capillary for APD

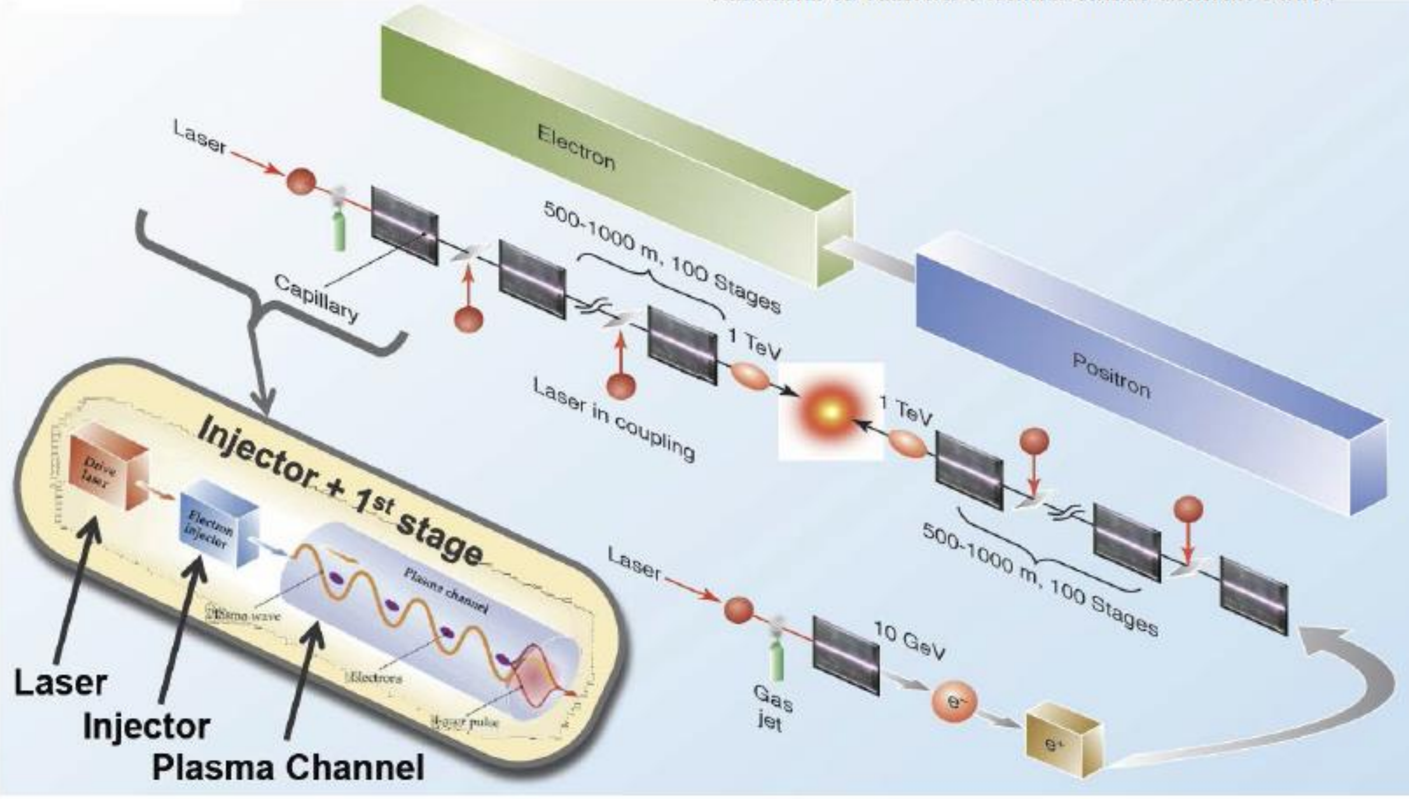


Design of new geometries for curved channels: HV-circuits to allow high current pulses

Pompili, Riccardo, et Al, Guiding of charged particle beams in curved capillary-discharge waveguides, AIP Advances 8.1 (2018)

Laser-Plasma-Accelerator LC

Leemans & Esarey, Physics Today (March 2009)



Parameter Set for LPWA LC

Case: CoM Energy (Plasma density)	**1 TeV** (10^{17} cm^{-3})	**1 TeV** (2×10^{15} cm^{-3})	**10 TeV** (10^{17} cm^{-3})	**10 TeV** (2×10^{15} cm^{-3})
Energy per beam (TeV)	0.5	0.5	5	5
Luminosity (10^{34} cm^{-2}s^{-1})	2	2	200	200
Electrons per bunch ($\times10^{10}$)	0.4	2.8	0.4	2.8
Bunch repetition rate (kHz)	15	0.3	15	0.3
Horizontal emittance $\gamma\varepsilon_x$ (nm-rad)	100	100	50	50
Vertical emittance $\gamma\varepsilon_y$ (nm-rad)	100	100	50	50
β* (mm)	1	1	0.2	0.2
Horizontal beam size at IP σ^*_x (nm)	10	10	1	1
Vertical beam size at IP σ^*_y (nm)	10	10	1	1
Disruption parameter	0.12	5.6	1.2	56
Bunch length σ_z (μm)	1	7	1	7
Beamstrahlung parameter ϒ	180	180	18,000	18,000
Beamstrahlung photons per e, n_γ	1.4	10	3.2	22
Beamstrahlung energy loss δ_E (%)	42	100	95	100
Accelerating gradient (GV/m)	10	1.4	10	1.4
Average beam power (MW)	5	0.7	50	7
Wall plug to beam efficiency (%)	6	6	10	10
One linac length (km)	0.1	0.5	1.0	5

×2+FF

Plasma collider challenges

Beam delivery system

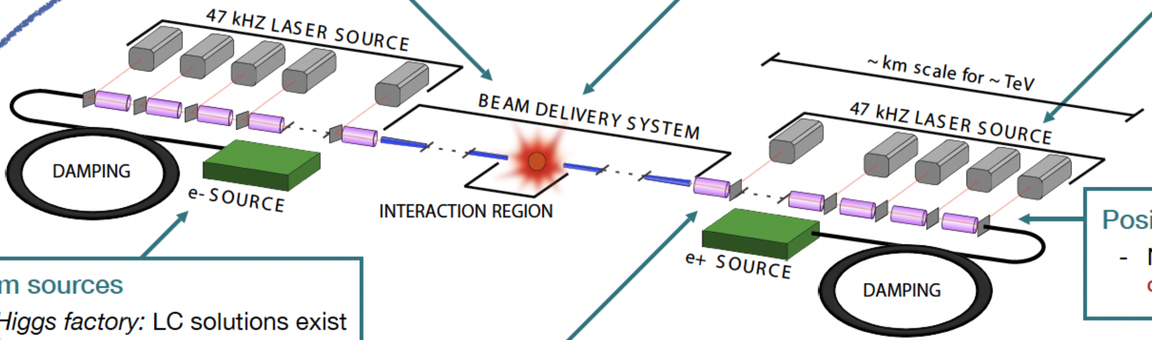
- *Higgs factory:* optimized LC designs exist
  optimizations for plasmas needed/possible?
- *10 TeV collider:* no design exists
  critical - HF designs scale poorly with energy (geo. gradient) → 20 (CLIC) to 90 (ILC) km

Interaction region

- *Higgs factory:* designed for other LCs
- *10 TeV collider:* studies critical to define collider type and machine parameters
  critical - valid codes for beam/beam studies

Driver technology

- *Beams:* technology exists in principle
  cost, gradient, efficiency, distribution optimization
- *Lasers:* do not exist, R&D paths identified
  critical - rep. rate & power, efficiency, robustness, cost
  opportunity - simple energy recovery (photovoltaics)



Positron acceleration

- No concept exists (yet) that fulfills needs
  critical - beam quality, efficiency, resilience

Beam sources

- *Higgs factory:* LC solutions exist
  opportunity - compact (cheaper) sources from plasmas
- *10 TeV collider:* undefined, potentially a key issue

Plasma stages + coupling

- Focus and key charge for our field, no roadblocks known
  critical - beam quality (incl. polarization), efficiency, stability, longevity, resilience to jitter (in time, space, and momentum), resilience to catastrophic errors (one bad shot)
- *Plasma stage:* requires demonstration of collider parameters
  + critical - rep. rates & bunch structure (CW vs. burst), power handling
- *Staging:* requires detailed concepts, additional test facilities
  + critical - driver in-/out-coupling, geometric gradient

Full system integration

- Turn components into self-consistent machine
- Optimization of the system for cost, efficiency, environmental impact, physics performance, resiliency (jitter budget)

BERKELEY LAB

Courtesy J. Osterhoff

n. 20 POST-DOCTORAL SENIOR LEVEL 3 RESEARCH GRANT IN EXPERIMENTAL PHYSICS at INFN

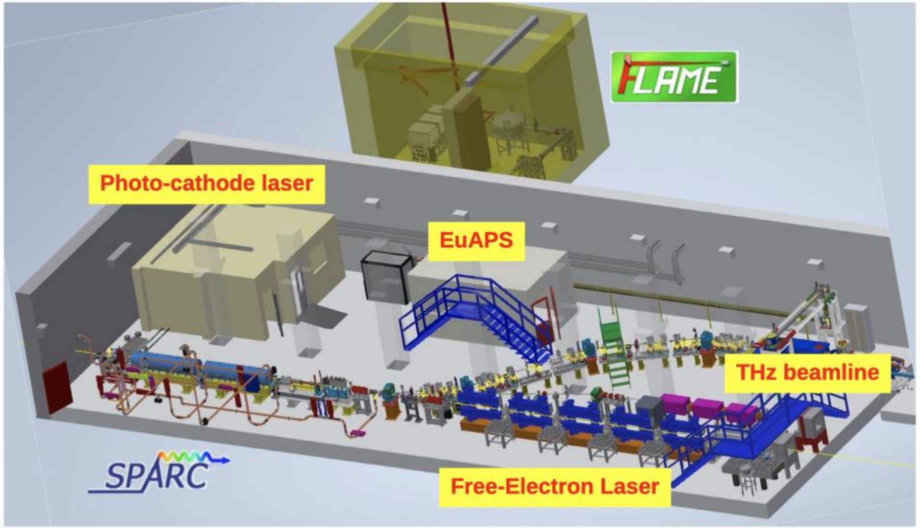
Funded by the European Union

https://jobs.dsi.infn.it/dettagli_job.php?id=4180

DETTAGLIO DEL BANDO	
Numero :	27077
Anno :	2024
Titolo:	n. 20 POST-DOCTORAL SENIOR LEVEL 3 RESEARCH GRANT IN EXPERIMENTAL PHYSICS
Numero Posti:	20
Tipo:	Assegno di ricerca
Data bando:	12-09-2024
Data scadenza:	15-11-2024
Bando:	27077.pdf

Dead line: November 15

INFN
Istituto Nazionale di Fisica Nucleare



LPAW 2025 – Ischia Island

Funded by the European Union

LPAW 2025

Laser and Plasma Accelerators Workshop 2025

14-18 April 2025, Ischia Island, Italy

https://agenda.infn.it/event/42311/

The **Laser and Plasma Accelerators Workshop 2025 (LPAW 2025) will be held at Hotel Continental Ischia, in the Ischia Island (Campania, Italy), from Monday 14 to Friday 18 April 2025.**

The Laser and Plasma Accelerators Workshop (LPAW) series is one of the leading workshops in the field of plasma-based acceleration and radiation generation.

The following scientific topics will be the main focus of the conference:

- Plasma-based lepton acceleration (experiments, simulations, theory, diagnostics...).
- Plasma-based ion acceleration (experiments, simulations, theory, diagnostics...).
- Secondary radiation generation and applications (experiments, simulations, theory, diagnostics...).

John Dawson Thesis Prize

“John Dawson Thesis Prize” is awarded on a biannual basis to the best PhD thesis in the area of plasma accelerators driven by laser or particle beams. The prize will be awarded for fundamental (theoretical or experimental) or applied aspects.

Each prize winner will receive a certificate of merit, up to 500 Euros, and financial support to attend the “Laser and Plasma Accelerators Workshop,” where the prize will be awarded.

Beam Driven

PWFA