HPFBU

Hızlandırıcı Fiziği

İleri Hızlandırma Yöntemleri

Plazma Dalgası ile Hızlandırma

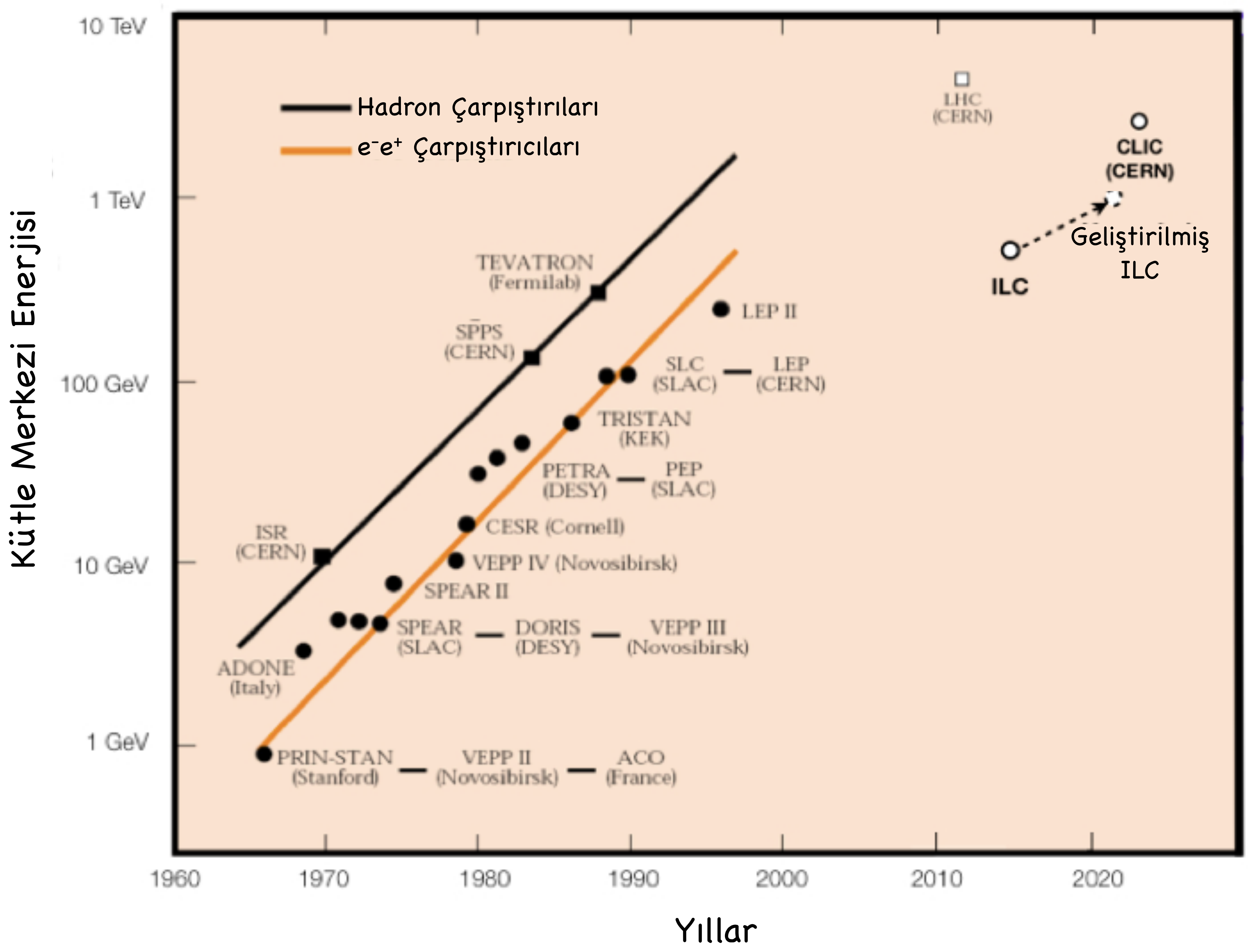
Dr. Öznur METE
University of Manchester
The Cockcroft Institute of Accelerator Science and Technology

İletişim Bilgileri
oznur.mete@cockcroft.ac.uk
oznur.mete@manchester.ac.uk
www.cern.ch/omete

Livingstone Çizelgesi

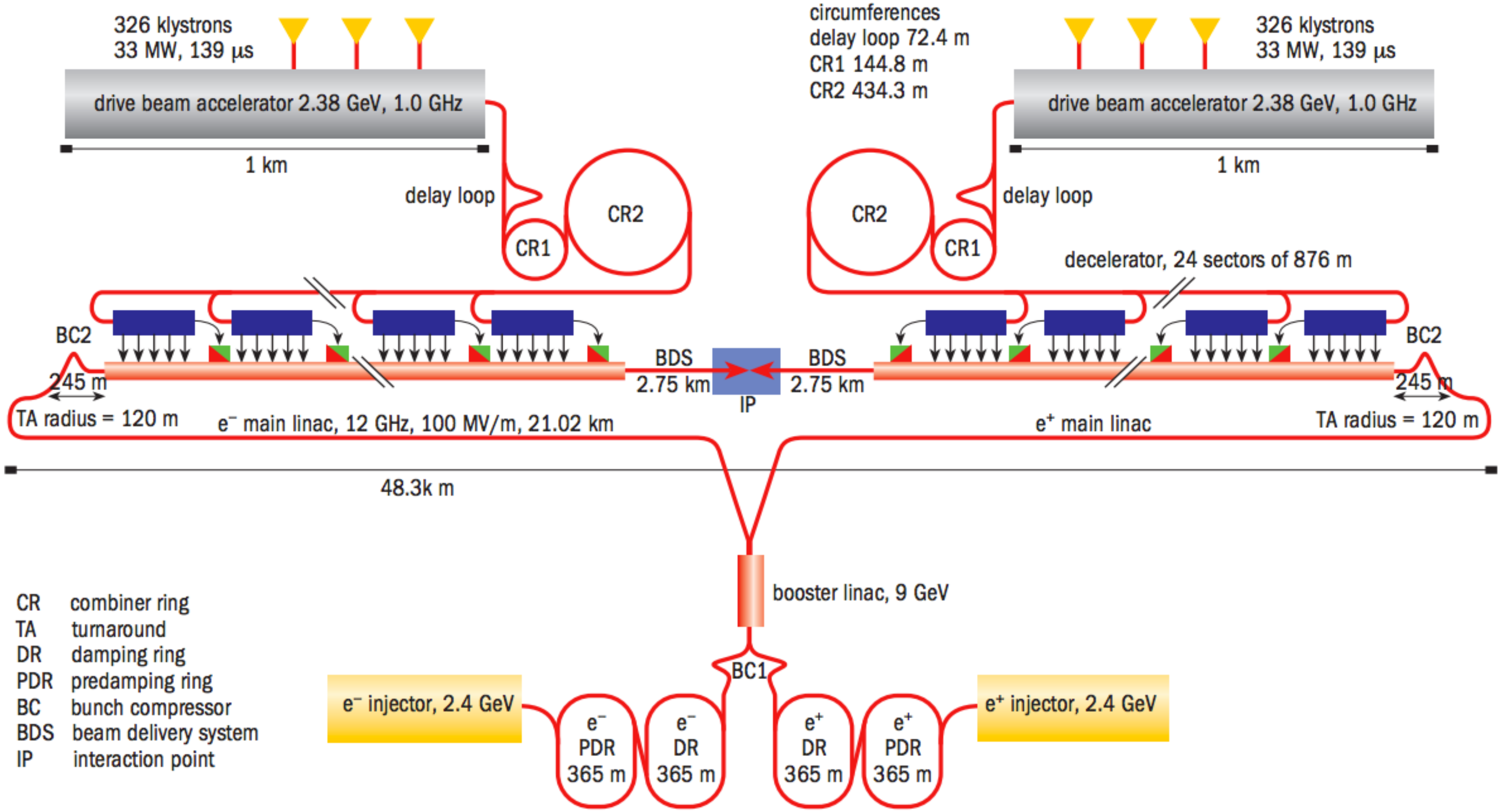
?

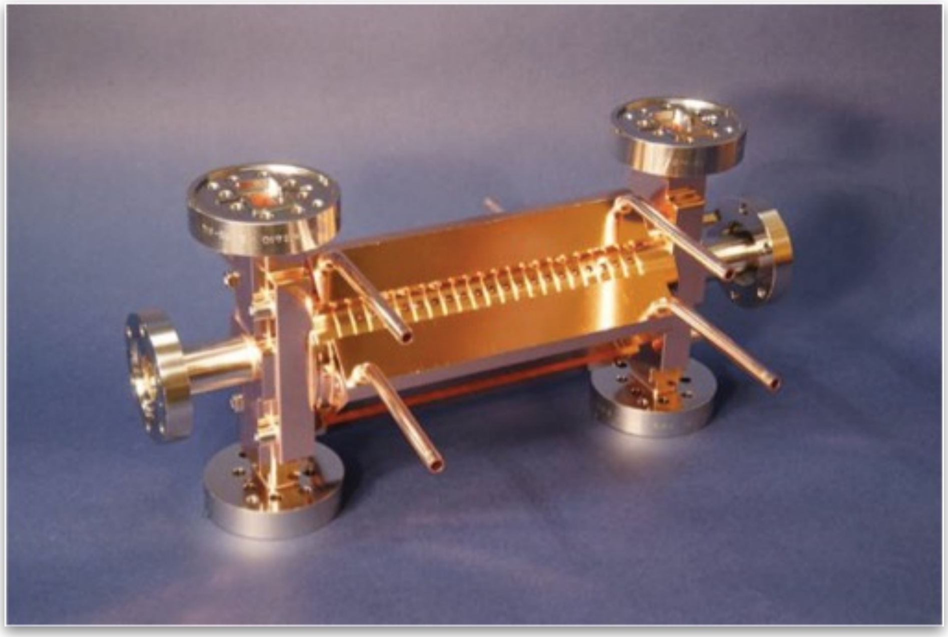
S. Livingstone'ın hazırladığı çizelgeden güncelleştirilmiştir.



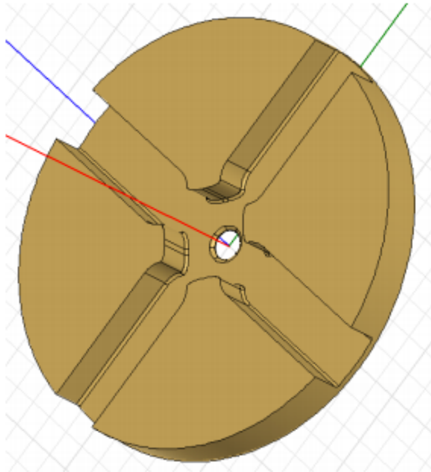
Compact Linear Collider, CLIC

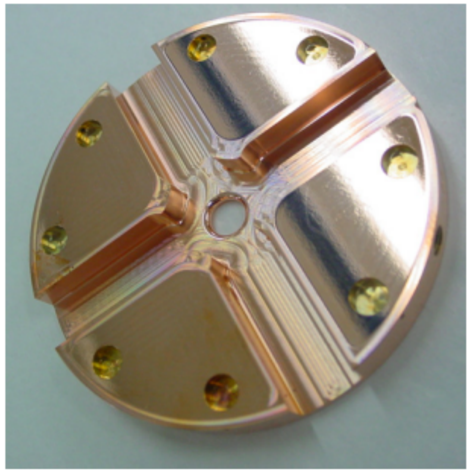
Normal iletken metalik teknolojinin limiti





100 MV/m, 12 GHz





FCC Future Circular Colliders

- CERN'de 80-100km'lik tünel içerisine kurulacak bir pp çarpıştırıcısı.
- Daha sonra e^-e^+ (TLEP) ve e^-p (VLHeC) çarpıştırıcısına dönüştürülmesi olasılığı da var.
- Kavramsal tasarımı ile ilgili bir konuşma: http://indico.cern.ch/getFile.py/access?contribId=1&sessionId=5&resId=1&materialId=slides&confId=257713
- FCC kick-off toplantısı (12-15 Şubat 2014): http://indico.cern.ch/conferenceDisplay.py?confId=282344

YEARS/ANS CERN

"ILC in Japan"

- International Workshop on Future Linear Colliders http://www.icepp.s.u-tokyo.ac.jp/lcws13/
- Japonya ILC'yi Japonya'da yapmak istiyor, kesin kararlarını birkaç yıl içinde verecekler, Ocak ayı içinde bazı açıklamalar olabilir.

INTERNATIONAL WORKSHOP ON FUTURE LINEAR COLLIDERS (LCWS13)
11-15 NOVEMBER 2013, THE UNIVERSITY OF TOKYO, JAPAN

"LHeC"

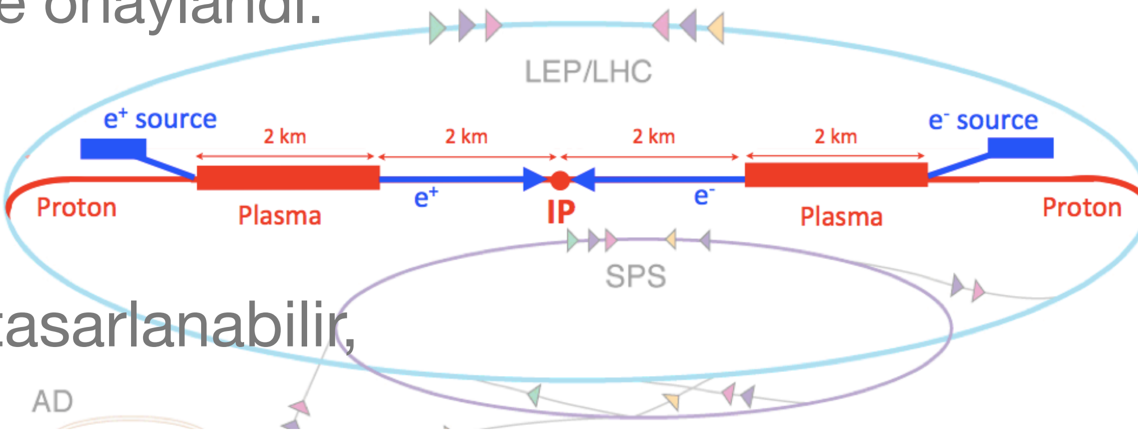
- CERN'den olur almışken ilginç bir şekilde inişe geçti.
- European Strategy for Particle Physics raporunda öncelikli projeler arasında yer almadı.

"CLIC"

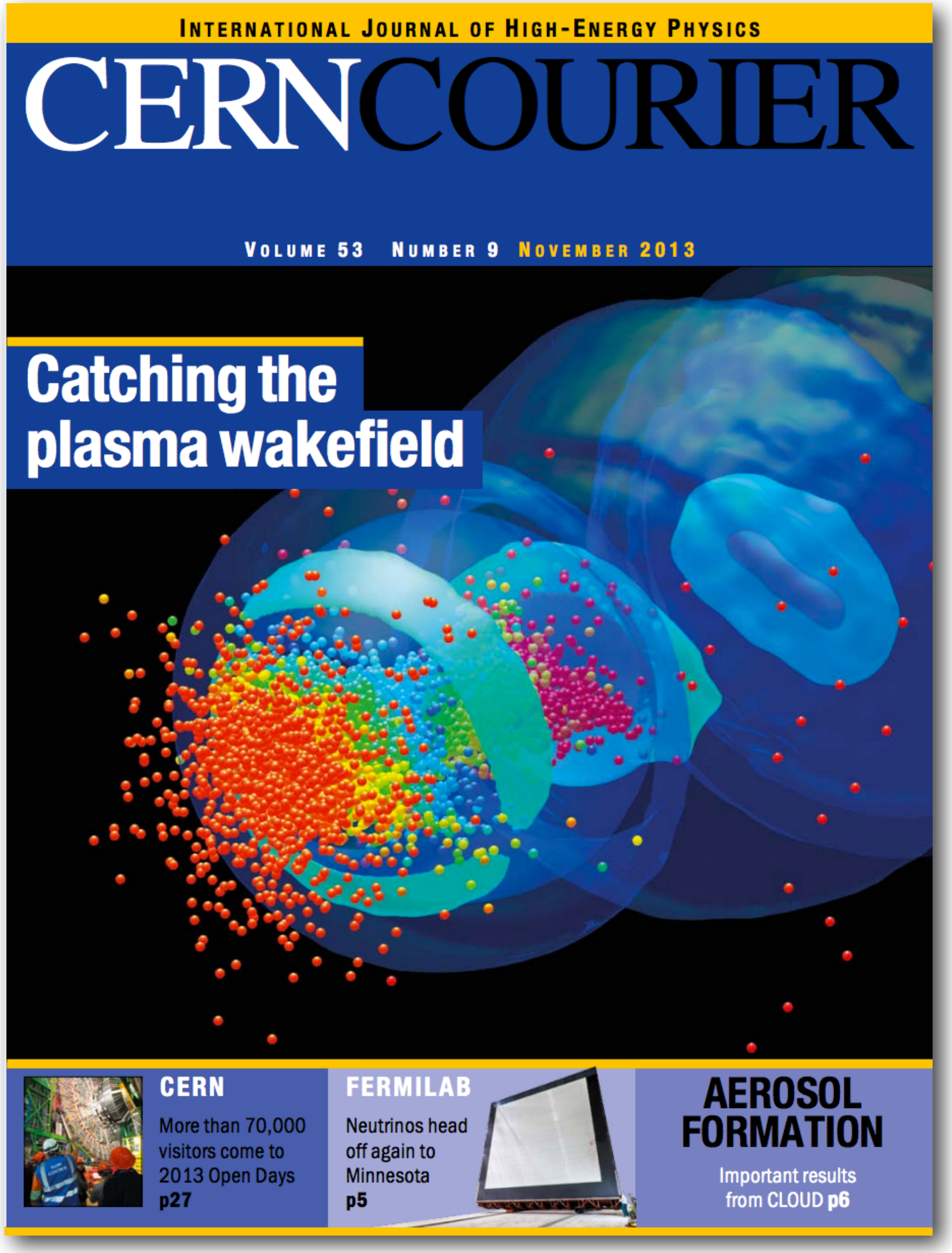
- "Compact Linear Collider" test evresi 2016'da sona eriyor…
- Yüksek gradyenli, normal iletken hızlandırma kaviteleri ve ikili demet hızlandırma gibi CLIC teknolojileri başarı ile test edildi ve onaylandı.

"Blue Sky"

- Alternatif hızlandırma teknikleri kullanılan çarpıştırıcılar,
- Proton sürümlü plazma girdabı ile hızlandırma,
- Sürücü demet LHC protonları ile sürülen çarpıştırıcılar tasarlanabilir,
- e^-e^+ ve e^-p seçenekleri sunuyor.



Plazma Dalgası ile Hızlandırma



INTERNATIONAL JOURNAL OF HIGH-ENERGY PHYSICS

CERNCOURIER

VOLUME 53 NUMBER 9 NOVEMBER 2013

Catching the plasma wakefield

CERN
More than 70,000 visitors come to 2013 Open Days
p27

FERMILAB
Neutrinos head off again to Minnesota
p5

AEROSOL FORMATION
Important results from CLOUD p6

Plazma ve lazerle hızlandırma, şiddetli lazer atmaları (ya da parçacık demeti) bir plazmada aşırı yoğunluk kipleniminleri uyarmak için kullanılabilir. Bu kiplenimler 100 GeV/m'den yüksek ve ışık hızına yakın hızlarda, dalga şeklinde, kiplenim boyunca hareket eden alan gradyenleri oluşturabilir.

3 Boyutta Plasma Dalgasının Yüklü Parçacığa Tepkisi

External Charge density $\varrho_0 = q\delta(\vec{X}-\vec{V}_b t) = q\delta(\vec{r})\delta(z-V_b t)$

dışardan uygulanan yük

$\vec{r}$, radial polar coordinate $\delta(\vec{r}) = \frac{1}{2\pi r}\delta(r)$

n_0, n_1 background and perturbed plasma density

ardalan ve rahatsız edilmiş plazma yoğunlukları

Linearised equation of motion:

Doğrusallaştırılmış hareket denklemi

$$\frac{d\vec{V}}{dt} = -e\vec{E}/m$$ Equation of motion

$$\frac{\partial n_1}{\partial t} + n_0 \vec{\nabla}\cdot\vec{V} = 0$$ Continuity **Devamlılık** $\left(\frac{\partial \varrho}{\partial t} + \nabla\cdot j = [illegible]\right)$

$\downarrow$

n_1, n_0

[illegible]:

$$\vec{\nabla}\cdot\vec{E} = -4\pi e n_1 + 4\pi\varrho_0$$

Plazma Alanının Türetimi

Maxwells equations:

Maxwell denklemleri

$$\vec{\nabla} \times \vec{E} = -\frac{1}{c}\frac{\partial \vec{B}}{\partial t}$$

$$\vec{\nabla} \times \vec{B} = (4\pi/c)\vec{j} + \frac{1}{c}\frac{\partial E}{\partial t}$$

Equation for plasma response:

Plasmanın tepkisini veren denklem

$$\frac{\partial^2 n_1}{\partial t^2} + n_0 \vec{\nabla} \cdot \left(\underbrace{\frac{\partial \vec{V}}{\partial t}}_{-e\vec{E}/m} \right) = 0$$

Plazma Alanının Türetimi

$$\frac{\partial^2 n_1}{\partial t^2} - \frac{n_0 e}{m} \underbrace{\vec{\nabla}\cdot\vec{E}} = 0$$

Continuity

$$\frac{\partial^2 n_1}{\partial t^2} - \frac{n_0 e}{m_e}\left(-4\pi e n_1 + 4\pi \varrho_0\right) = 0$$

$$\frac{\partial^2 n_1}{\partial t^2} + \frac{n_0 e^2 4\pi n_1}{m_e} - \frac{4\pi n_0 \varrho_0 e}{m_e} = 0$$

$$\frac{\partial^2 n_1}{\partial t^2} + \underbrace{\omega_p^2}_{\frac{4\pi n_0 e^2}{m_e}} n_1 = (n_0 e/m)(4\pi \varrho_0)$$

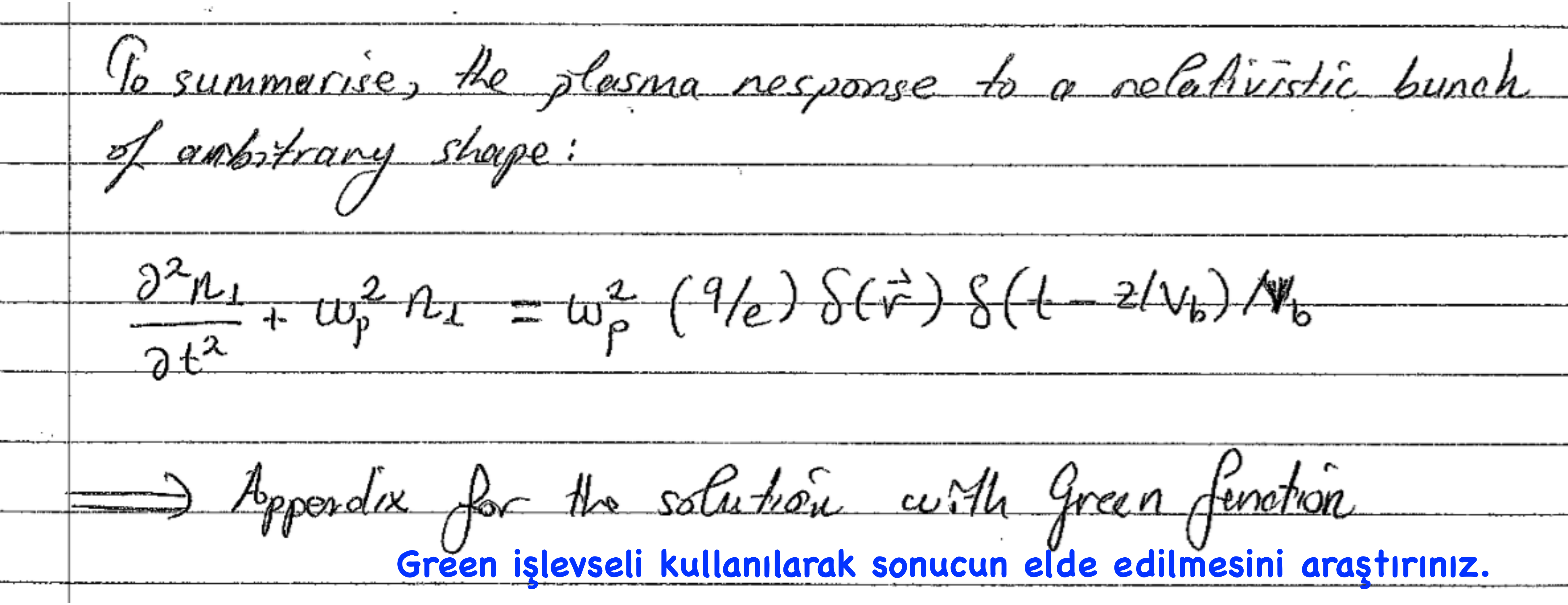
$$= (n_0 e/m)(4\pi)\, q\, \delta(\vec{r})\, \delta(z - V_b t) \quad \ldots \times\left(\frac{e}{e}\right)$$

$$= \omega_p^2 (q/e)\, \delta(\vec{r})\, \delta(z - V_b t)$$

NOTE $= \delta(z - V_b t) = \delta(t - z/V_b)/V_b$

Plazma Alanının Türetimi

Özetle, plazmanın dışardan gönderilen rastgele dağılımlı bir göreli parçacık topluluğuna tepkisi:

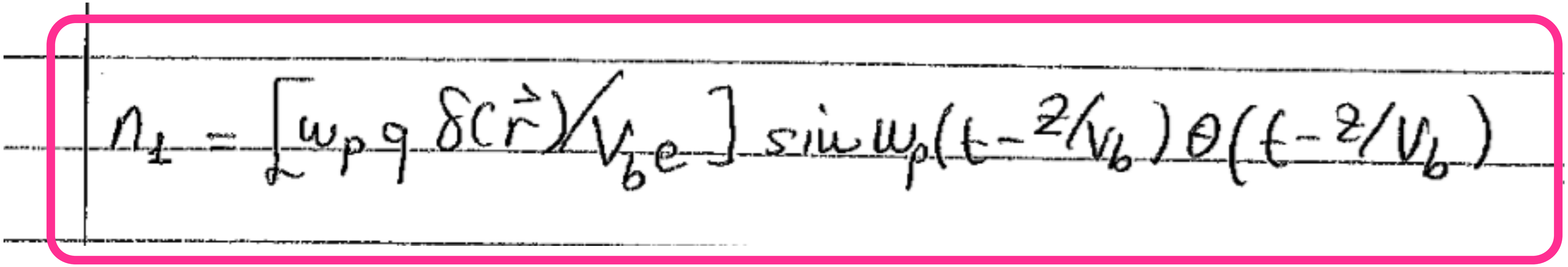


To summarise, the plasma response to a relativistic bunch of arbitrary shape:

$$\frac{\partial^2 n_1}{\partial t^2} + \omega_p^2 n_1 = \omega_p^2 (q/e)\, \delta(\vec{r})\, \delta(t - z/v_b)/v_b$$

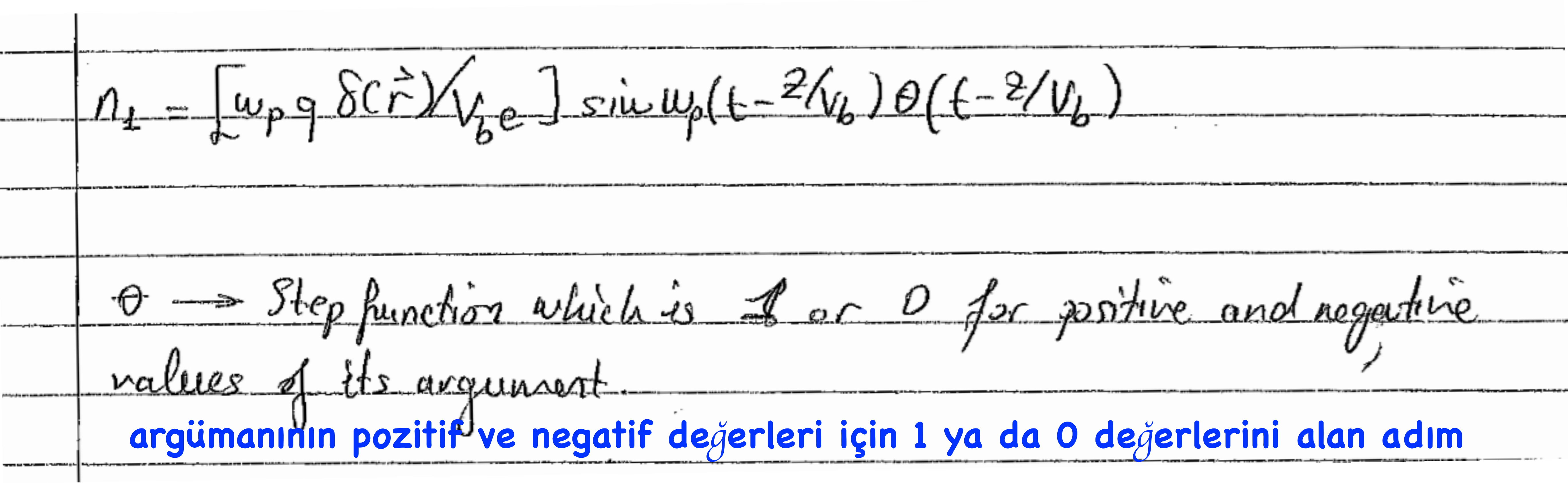
⟹ Appendix for the solution with Green function

Green işlevseli kullanılarak sonucun elde edilmesini araştırınız.



$$n_1 = \left[\omega_p q\, \delta(\vec{r})/v_b e\right] \sin \omega_p (t - z/v_b)\, \Theta(t - z/v_b)$$

Plazma Alanının Türetimi



$$n_1 = [\omega_p q\, \delta(\vec{r})/V_b e]\, \sin \omega_p (t - z/V_b)\, \theta(t - z/V_b)$$

$\theta \rightarrow$ Step function which is 1 or 0 for positive and negative, values of its argument.

argümanının pozitif ve negatif değerleri için 1 ya da 0 değerlerini alan adım işlevseli.

Plazma Alanının Türetimi

Using this expression for the plasma density in the Maxwell equations we can calculate fields.

Elde ettiğimiz plazma davranışını Maxwell denklemlerinde yerine koyarak oluşacak alanları hesaplayabiliriz.

$$\vec{\nabla}\times\vec{E} = -\frac{1}{c}\frac{\partial\vec{B}}{\partial t}$$

$$\vec{\nabla}\times\vec{B} = \left(\frac{4\pi}{c}\right)\vec{j} + \frac{1}{c}\cdot\frac{\partial\vec{E}}{\partial t}$$

Taking the curl of first one,

NOTE:

$$\nabla\times\nabla\times\vec{A} = \nabla.(\vec{\nabla}.\vec{A}) - \vec{\nabla}^2 A$$

$$\vec{\nabla}\times(\vec{\nabla}\times\vec{E}) = -\frac{1}{c}\frac{\partial}{\partial t}(\vec{\nabla}\times\vec{B})$$

$$\nabla(\vec{\nabla}.\vec{E}) - \vec{\nabla}^2 E = -\frac{1}{c}\frac{\partial}{\partial t}\left(\frac{4\pi}{c}\vec{j} + \frac{1}{c}\frac{\partial\vec{E}}{\partial t}\right)$$

Plazma Alanının Türetimi

$$\nabla(\vec{\nabla}\cdot\vec{E}) - \vec{\nabla}^2 E = -\frac{1}{c}\frac{\partial}{\partial t}\left(\frac{4\pi}{c}\vec{j} + \frac{1}{c}\frac{\partial \vec{E}}{\partial t}\right)$$

$$\nabla(\vec{\nabla}\cdot\vec{E}) - \vec{\nabla}^2\vec{E} = -\frac{4\pi}{c^2}\frac{\partial \vec{j}}{\partial t} - \frac{1}{c^2}\frac{\partial^2 \vec{E}}{\partial t^2}$$

$$\left(\frac{\partial^2}{\partial t^2} - c^2\vec{\nabla}^2\right)\vec{E} = -4\pi\frac{\partial \vec{j}}{\partial t} - c^2\,\underbrace{\nabla(\vec{\nabla}\cdot\vec{E})}$$

Maxwell denklemleri, devamlılık ilişkisi ve plazma yoğunluğunun davranışını kullanalım.

Use Maxwell equations, and continuity
~~response of~~ plasma density ~~and~~
~~continuity~~ $-4\pi e n_1$

NOTE : $j = \frac{Q\vec{r}}{t} = Q\vec{V}$ $\quad \frac{\partial \vec{j}}{\partial t} = -n_o e\frac{\partial \vec{V}}{\partial t} = n_o e^2\vec{E}/m$

Plazma Alanının Türetimi

$$\left(\frac{\partial^2}{\partial t^2} - c^2\vec{\nabla}^2\right)\vec{E} = -4\pi n_0 e^2 \vec{E}/m - c^2\vec{\nabla}\left(-4\pi e\left(\omega_p q\,\delta(\vec{r})/v_b e\right)\sin(\omega_p(t,z)\,\Theta(t,z)\right)$$

$\star$

$$= -\omega_p^2\vec{E} - c^2\nabla\left(-4\pi\omega_p q/v_b\,\delta(\vec{r})\sin\omega_p(t - z/v_b)\,\Theta(t - z/v_b)\right)$$

$$\left(\frac{\partial^2}{\partial t^2} - c^2\vec{\nabla}^2\right)\vec{E} = -\omega_p^2\vec{E} + c^2 4\pi\omega_p q/v_b\,\nabla(\cdots)$$

Plazma Alanının Türetimi

$$\rightarrow (z-V_b t)\cong(z-ct)$$

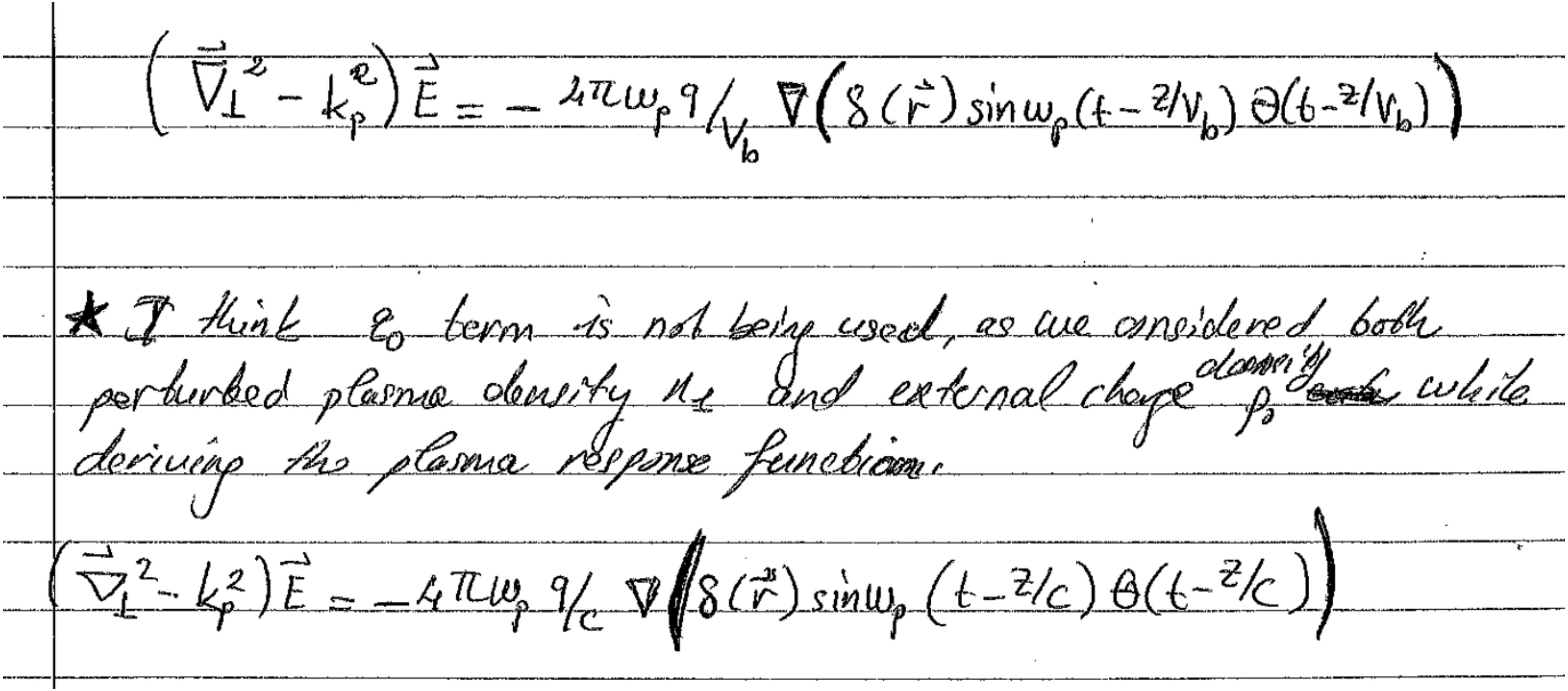
NOTE: $\vec{\nabla}^2=\vec{\nabla}_\perp^2+\frac{\partial^2}{\partial z^2}$ $\qquad \frac{\partial^2}{\partial t^2}=c^2\left(\frac{\partial^2}{\partial z^2}\right)$ $\qquad \frac{\omega_p^2}{c^2}=k_p^2$

$$\left(\cancel{c^2\frac{\partial^2}{\partial z^2}}-c^2\vec{\nabla}_\perp^2-\cancel{c^2\frac{\partial^2}{\partial z^2}}\right)\vec{E}=-\omega_p^2\vec{E}+4\pi c^2\omega_p q/V_b\,\nabla(\dots)$$

$$-\vec{\nabla}_\perp^2\vec{E}=-\frac{\omega_p^2}{c^2}\vec{E}+4\pi\omega_p q/V_b\,\nabla(\dots)$$

$$\left(\vec{\nabla}_\perp^2-k_p^2\right)\vec{E}=-4\pi\omega_p q/V_b\,\nabla\left(\delta(\vec{r})\sin\omega_p(t-z/V_b)\,\theta(t-z/V_b)\right)$$

Plazma Alanının Türetimi



$$\left(\vec{\nabla}_\perp^2 - k_p^2\right)\vec{E} = -4\pi\omega_p q/V_b \, \nabla\left(\delta(\vec{r})\sin\omega_p(t - z/V_b)\,\Theta(t - z/V_b)\right)$$

★ I think ε_0 term is not being used, as we considered both perturbed plasma density n_1 and external charge density ρ_0 while deriving the plasma response function.

$$\left(\vec{\nabla}_\perp^2 - k_p^2\right)\vec{E} = -4\pi\omega_p q/c \, \nabla\left(\delta(\vec{r})\sin\omega_p\left(t - z/c\right)\Theta\left(t - z/c\right)\right)$$

…

Plazma Alanının Türetimi

for the longitudinal wake field E_z, **Boyuna ardıl alan için:**

$$(\nabla_\perp^2 - k_p^2)\vec{E} = (-4\pi \omega_p q/c)\,\delta(\vec{r})\,\theta(t-z/c)\left(-\frac{\omega_p}{c}\right)\cos\omega_p(t-z/c)$$

$$(\nabla_\perp^2 - k_p^2)\vec{E} = 4\pi \frac{\omega_p^2}{c^2} q\,\delta(\vec{r})\,\theta(t-z/c)\cos\omega_p(t-z/c)$$

$$(\nabla_\perp^2 - k_p^2)\vec{E}_z = 4\pi k_p^2 q\,\delta(\vec{r})\,\theta(t-z/c)\cos\omega_p(t-z/c)$$

Due to the radial dependence of E_z this is the Green function response to the Kelvin-Helmholtz equation.

Appendix ←

Araştırınız.

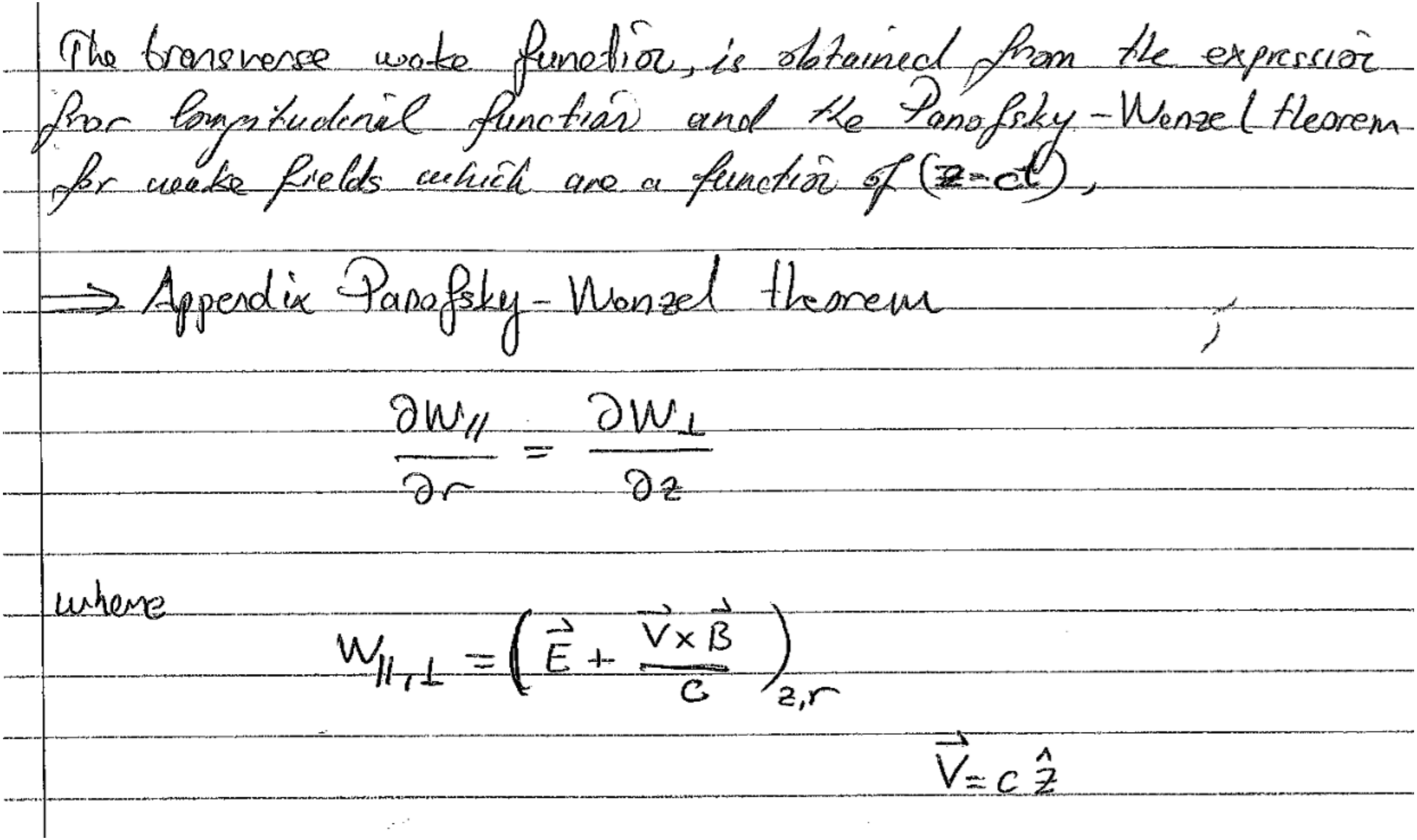
$$\boxed{\vec{E}_z = -2qk_p^2 K_0(k_p r)\,\theta(t-z/c)\cos\omega_p(t-z/c)}$$

Boyuna ardıl alanın yarıçapsal bağımlılığından dolayı Kelvin-Helmholtz denkleminde Green işlevselinin davranışı şeklinde çözülebilir.

K_0 → zeroth order modified Bessel function of the second kind.

Plazma Alanının Türetimi

Enine plazma ardıl alanı, (z-ct)'ne bağlı ardıl alanlar için Panofsky-Wenzel kuramı uyarınca, boyuna ardıl alan kullanılarak bulunur.



The transverse wake function is obtained from the expression for longitudinal function and the Panofsky-Wenzel theorem for wake fields which are a function of (z-ct),

→ Appendix Panofsky-Wenzel theorem

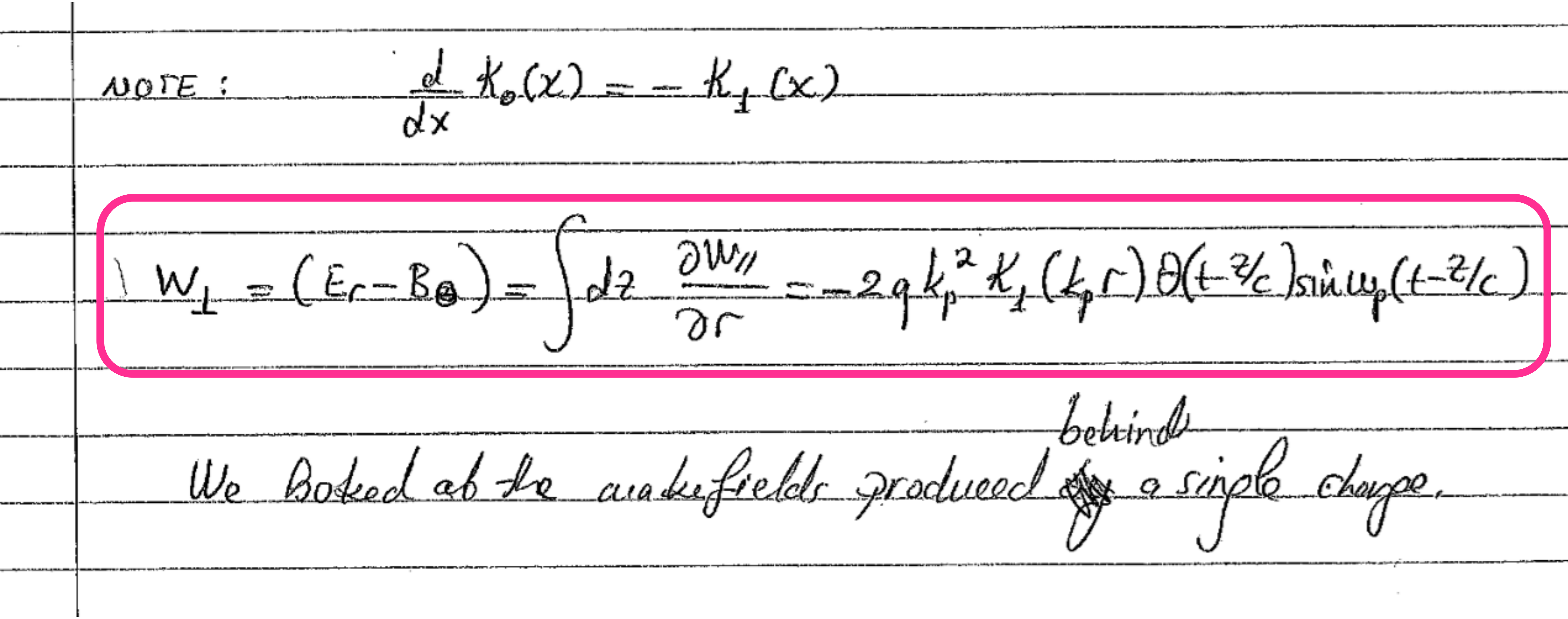
$$\frac{\partial W_{\parallel}}{\partial r} = \frac{\partial W_{\perp}}{\partial z}$$

where

$$W_{\parallel,\perp} = \left(\vec{E} + \frac{\vec{V} \times \vec{B}}{c}\right)_{z,r}$$

$$\vec{V} = c\,\hat{z}$$

Plazma Alanının Türetimi



NOTE : $\frac{d}{dx}K_0(x) = -K_1(x)$

$$\boxed{W_\perp = (E_r - B_\theta) = \int dz \, \frac{\partial W_\parallel}{\partial r} = -2qk_p^2 K_1(k_p r)\,\theta(t - z/c)\sin\omega_p(t - z/c)}$$

We looked at the wakefields produced ~~by~~ behind a single charge.

Burada delta işlevseli ile tanımladığımız bir parçacık topluluğuna karşı plazma parçacıklarının kiplenmelerinden dolayı oluşan ardıl alanları inceledik.

Plazma-Demet Etkileşmesinin farklı bölgeleri

- Bu genel çıkarımlar özel koşullara altında sadeleştirilip, kolay birimler cinsine indirgenebilir. Yalnız hangi modellerin hangi koşullar altında kullanıldığı akıldan çıkarılmamalıdır.

- Plazma dalgası altında devinim
  - Demet ölçülerinin plasma deri kalınlığına (c/ω_p) göre değerlerine (hızlandırma; öz-kipleme ve akım liflenmesi kararsızlıkları), AIP Conf. Proc. 1507, 594-599 (2012)
  - Plazma ve sürücü demet elektron yoğunluklarına (doğrusal, doğrusal olmayan), Physics of Plasmas 12, 063101 (2005)

göre değişik bölgelerde kendini gösterir.

Enerji ikiye katlama deneyi

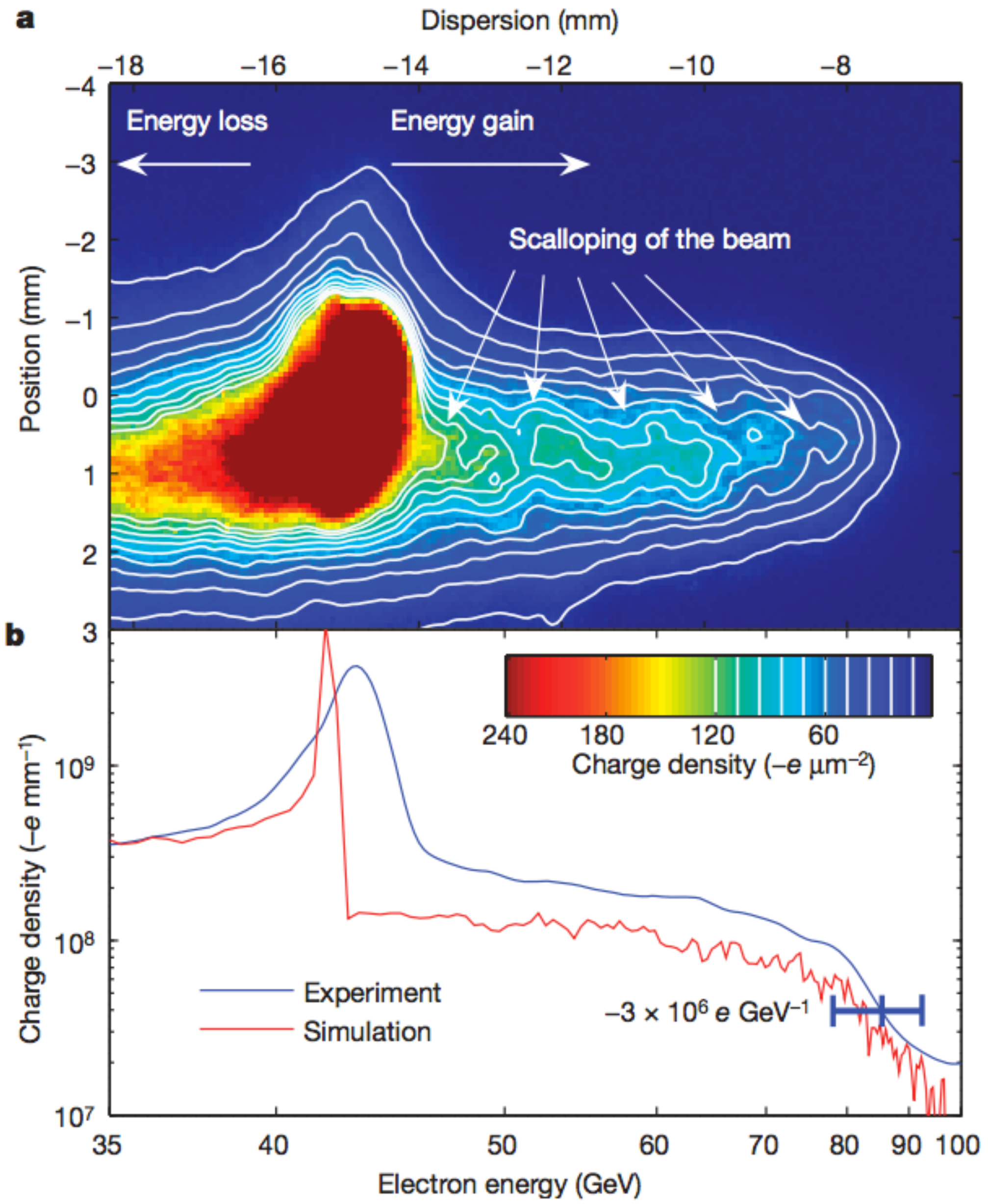
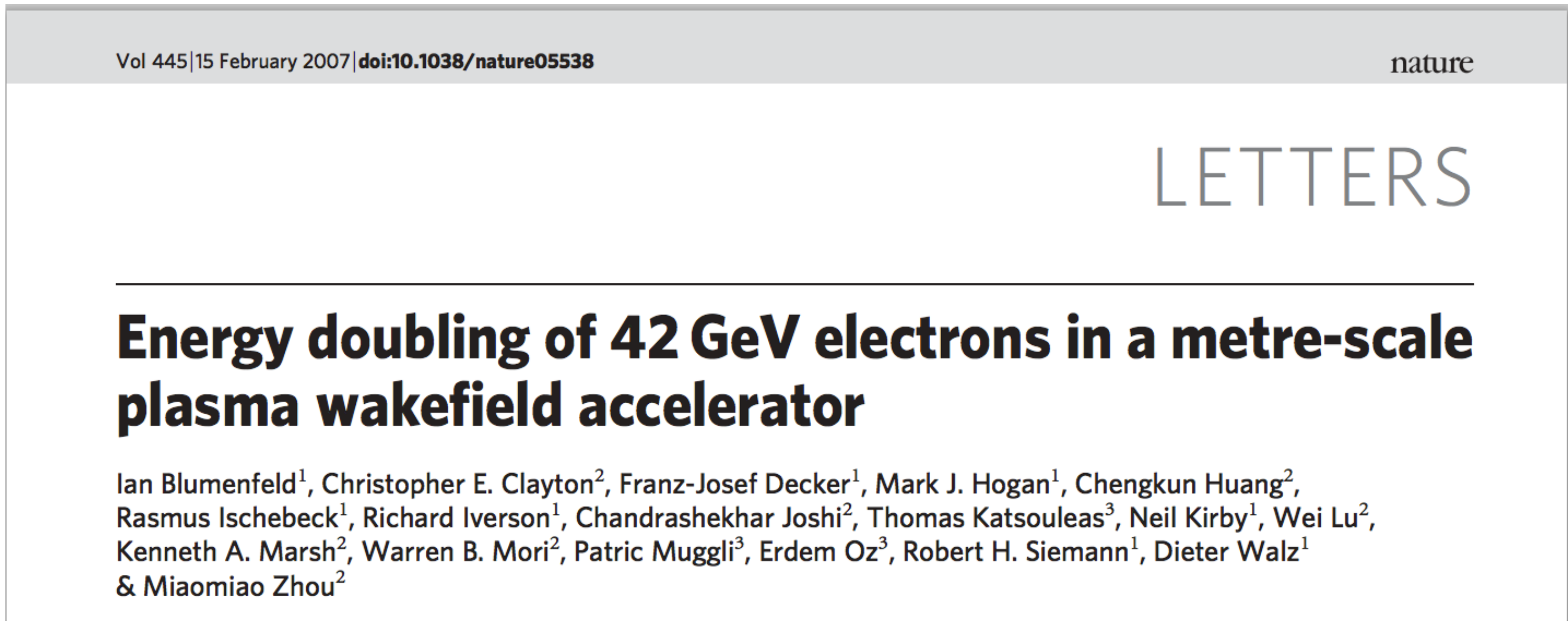


Figure 2 | Energy spectrum of the electrons. a, Energy spectrum of the electrons in the 35–100 GeV range as observed in plane 2. The dispersion (shown on the top axis) is inversely proportional to the particle energy (shown on the bottom axis). The head of the pulse, which is unaffected by the plasma, is at 43 GeV. The core of the pulse, which has lost energy driving the plasma wake, is dispersed partly out of the field of view of the camera. Particles in the back of the bunch, which have reached energies up to 85 GeV, are visible to the right. The pulse envelope exits the plasma with an energy-dependent betatron phase advance, which is consistent with the observed scalloping of the dispersed beam. **b,** Projection of the image in **a**, shown in blue. The simulated energy spectrum is shown in red. The differences between the measured and the simulated spectrum near 42 GeV are due to an initial correlated energy spread of 1.5 GeV not included in the simulations. The horizontal error bar is due to the uncertainty in estimating the deflection angle and the spot size of the beam.



Vol 445 | 15 February 2007 | **doi:10.1038/nature05538** nature

LETTERS

Energy doubling of 42 GeV electrons in a metre-scale plasma wakefield accelerator

Ian Blumenfeld[1], Christopher E. Clayton[2], Franz-Josef Decker[1], Mark J. Hogan[1], Chengkun Huang[2], Rasmus Ischebeck[1], Richard Iverson[1], Chandrashekhar Joshi[2], Thomas Katsouleas[3], Neil Kirby[1], Wei Lu[2], Kenneth A. Marsh[2], Warren B. Mori[2], Patric Muggli[3], Erdem Oz[3], Robert H. Siemann[1], Dieter Walz[1] & Miaomiao Zhou[2]

- 2007 yılında Stanford Linear Accelerator Center (SLAC)'da yürütülen elektron sürümlü çalışmalar sonucunda,
- 85 cm uzunluğunda plazma içinde elektron bohçasının kuyruğundaki parçaçıkların enerjisi 42 GeV'den 85 GeV'ye çıkarıldı.
- Bu enerji kazanımı açısından SLAC hızlandırıcısının 3 km'de oluşturabileğl enerjinin 1 m'nin altında oluşturulması demek!
- Yaklaşık 52 GV/m'lik hızlandırma alanı oluşturuldu!

Verimin artırılmasına yönelik çalışmalar

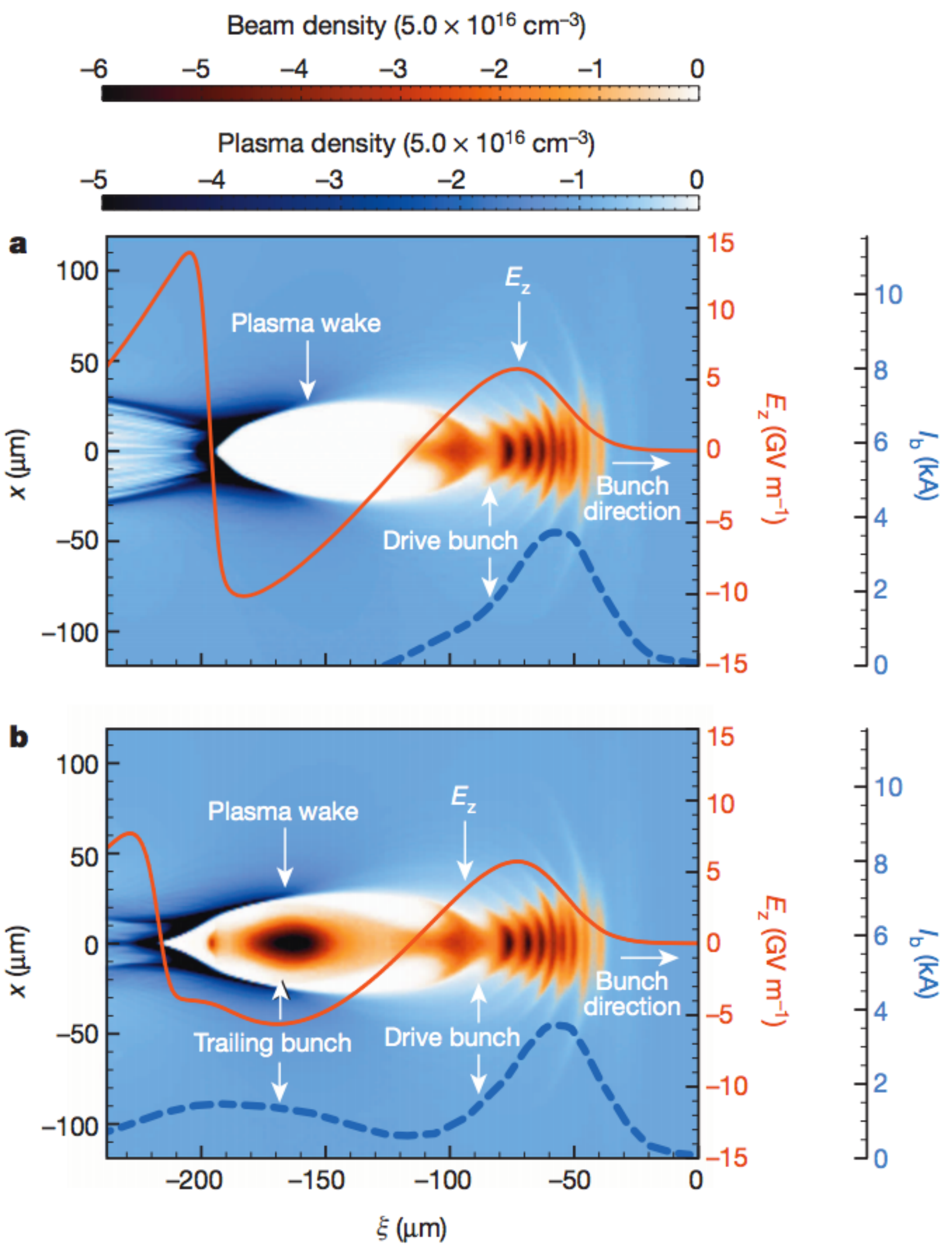


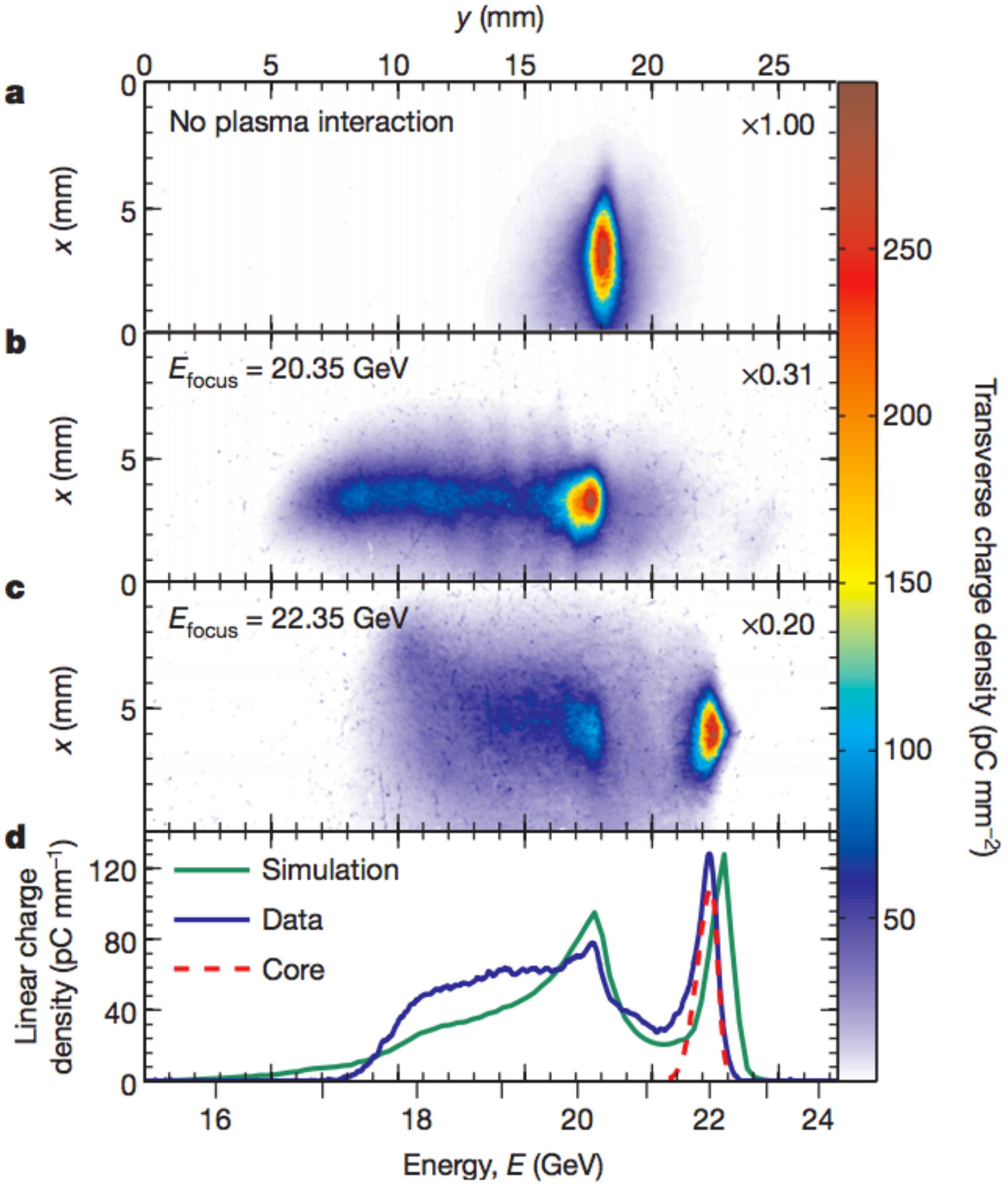
Figure 1 | Three-dimensional particle-in-cell simulation of beam-driven plasma wakefield interaction. a, A slice through the centre of an unloaded plasma wake, where x is the dimension transverse to the motion, and $\xi = z - ct$ is the dimension parallel to the motion, E_z is the on-axis longitudinal electric field (red solid line) and I_b is the current of the input beam (blue dotted line). **b,** A plasma wake generated by the same drive bunch as in **a** when loaded by a trailing bunch. The plasma electron density is represented in blue, while the beam density is represented in red. The ion density (not shown) is uniform. The particle-in-cell code QuickPIC[9,10] was used to generate this simulation of the beam–plasma interaction.

LETTER

doi:10.1038/nature13882

High-efficiency acceleration of an electron beam in a plasma wakefield accelerator

M. Litos[1], E. Adli[1,2], W. An[3], C. I. Clarke[1], C. E. Clayton[4], S. Corde[1], J. P. Delahaye[1], R. J. England[1], A. S. Fisher[1], J. Frederico[1], S. Gessner[1], S. Z. Green[1], M. J. Hogan[1], C. Joshi[4], W. Lu[5], K. A. Marsh[4], W. B. Mori[3], P. Muggli[6], N. Vafaei-Najafabadi[4], D. Walz[1], G. White[1], Z. Wu[1], V. Yakimenko[1] & G. Yocky[1]



cm ölçeğinde lazer sürümlü hızlandırma

LETTERS

GeV electron beams from a centimetre-scale accelerator

W. P. LEEMANS[1*†], B. NAGLER[1], A. J. GONSALVES[2], Cs. TÓTH[1], K. NAKAMURA[1,3], C. G. R. GEDDES[1], E. ESAREY[1*], C. B. SCHROEDER[1] AND S. M. HOOKER[2]

[1] Lawrence Berkeley National Laboratory, 1 Cyclotron Road, Berkeley, California 94720, USA
[2] University of Oxford, Clarendon Laboratory, Parks Road, Oxford OX1 3PU, UK
[3] Nuclear Professional School, University of Tokyo, 22-2 Shirane-shirakata, Tokai, Naka, Ibaraki 319-1188, Japan
*Also at: Physics Department, University of Nevada, Reno, Nevada 89557, USA
†e-mail: WPLeemans@lbl.gov

- 2006 yılında lazer sürümlü sistemde,
- 225 μm'lik tüp içinde hidrojen gazı ile gerçekleştirilen deneyde 0.5 ve 1 GeV'luk enerjilere ulaşıldı!

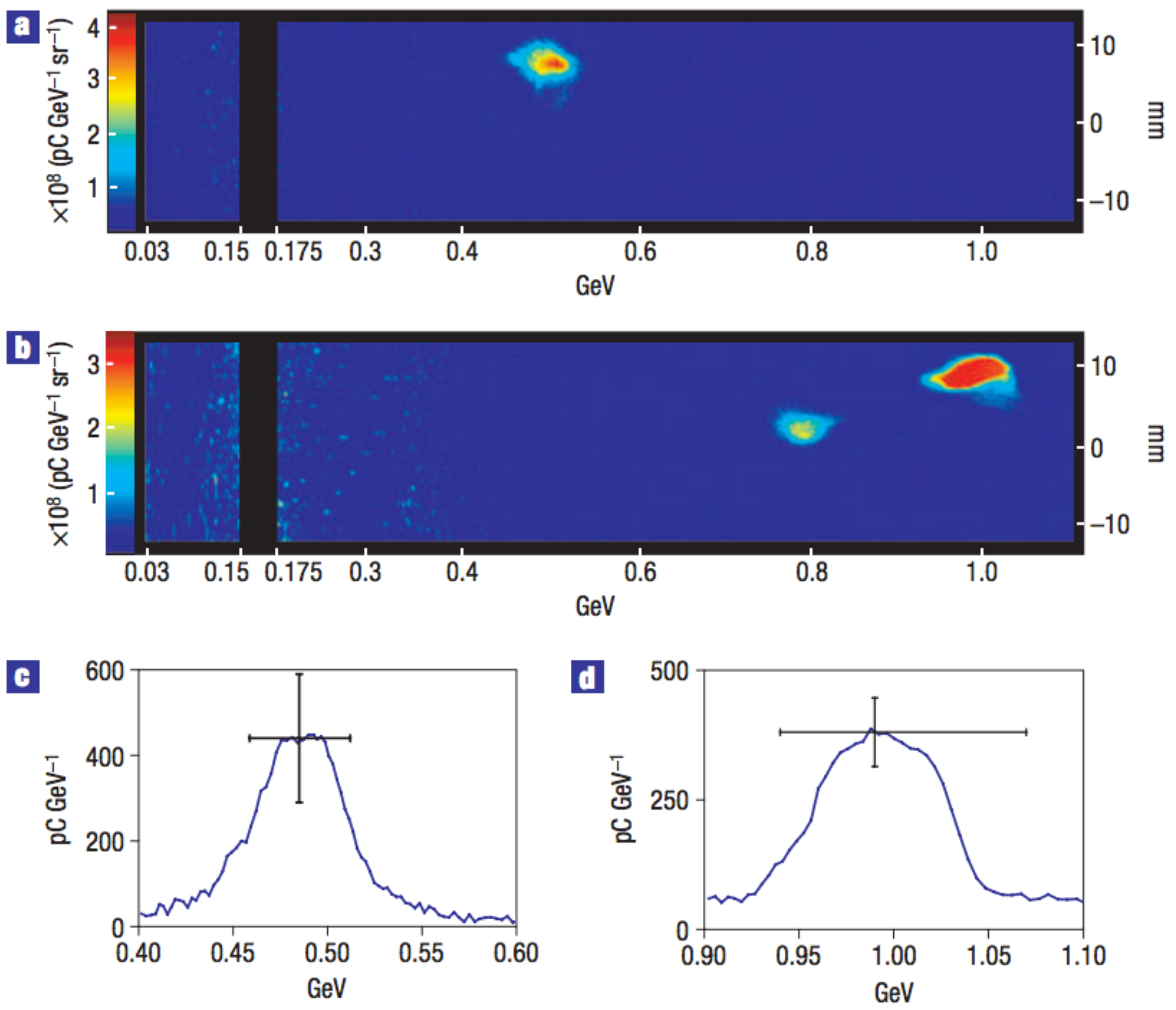


Figure 3 Single-shot e-beam spectra of the capillary-guided accelerator. a,b, Examples of bunches at $0.50^{+0.02}_{-0.015}$ GeV (5.6% r.m.s. energy spread, 2.0 mrad divergence r.m.s., ~50 pC charge) (**a**) and $1.0^{+0.08}_{-0.05}$ GeV (2.5% r.m.s. energy spread, 1.6 mrad divergence r.m.s., ~30 pC) (**b**). The horizontal axis is the beam energy and the vertical axis is the beam size in the undeflected (horizontal) plane. The colour scale denotes the bunch charge in pC $\mathrm{GeV}^{-1}\,\mathrm{sr}^{-1}$. The 0.5 GeV (1.0 GeV) beam shown was obtained in the 225 (310) μm capillary with a density of $\simeq 3.5\times10^{18}$ (4.3×10^{18}) cm^{-3} and input laser power of 12 TW (40 TW). The black stripe denotes the energy range not measured by the spectrometer. In **b**, a second beam at 0.8 GeV is also visible. Note that the energy spread and divergence are obtained after including the imaging properties of the spectrometer. The energy spread at 1 GeV may actually be less as the energy resolution is limited to 2.4% at 1 GeV and there is slight saturation of the image. **c,d**, Vertically integrated spectra for the 0.5 (**c**) and 1.0 GeV (**d**) beams. The vertical axis is the charge density in pC GeV^{-1}. The vertical error bar arises from uncertainty in calibration of the phosphor screen as a charge monitor (±17%). The horizontal error bar is due to the uncertainty in entrance angle of the e-beam resulting in an uncertainty in its energy. The spectrometer did not use an input slit, but the angular acceptance was limited by the transport beam pipe. For the 0.5 GeV (1 GeV) beam, this gives an uncertainty in central energy of +2%, −1.5% (+8%, −5%). In addition, for the 0.5 GeV beam, sufficient statistics were obtained to include the shot-to-shot fluctuation, which amounted to ±5% in mean energy and ±30% in charge. Hence, the convolution of those factors are shown in **c**, which are +5.4%, −5.2% in mean energy and ±34% in charge. The fluctuation in central energy was correlated with fluctuations in laser power.

Proton sürümlü plasma dalgası ile hızlandırma çalışmaları

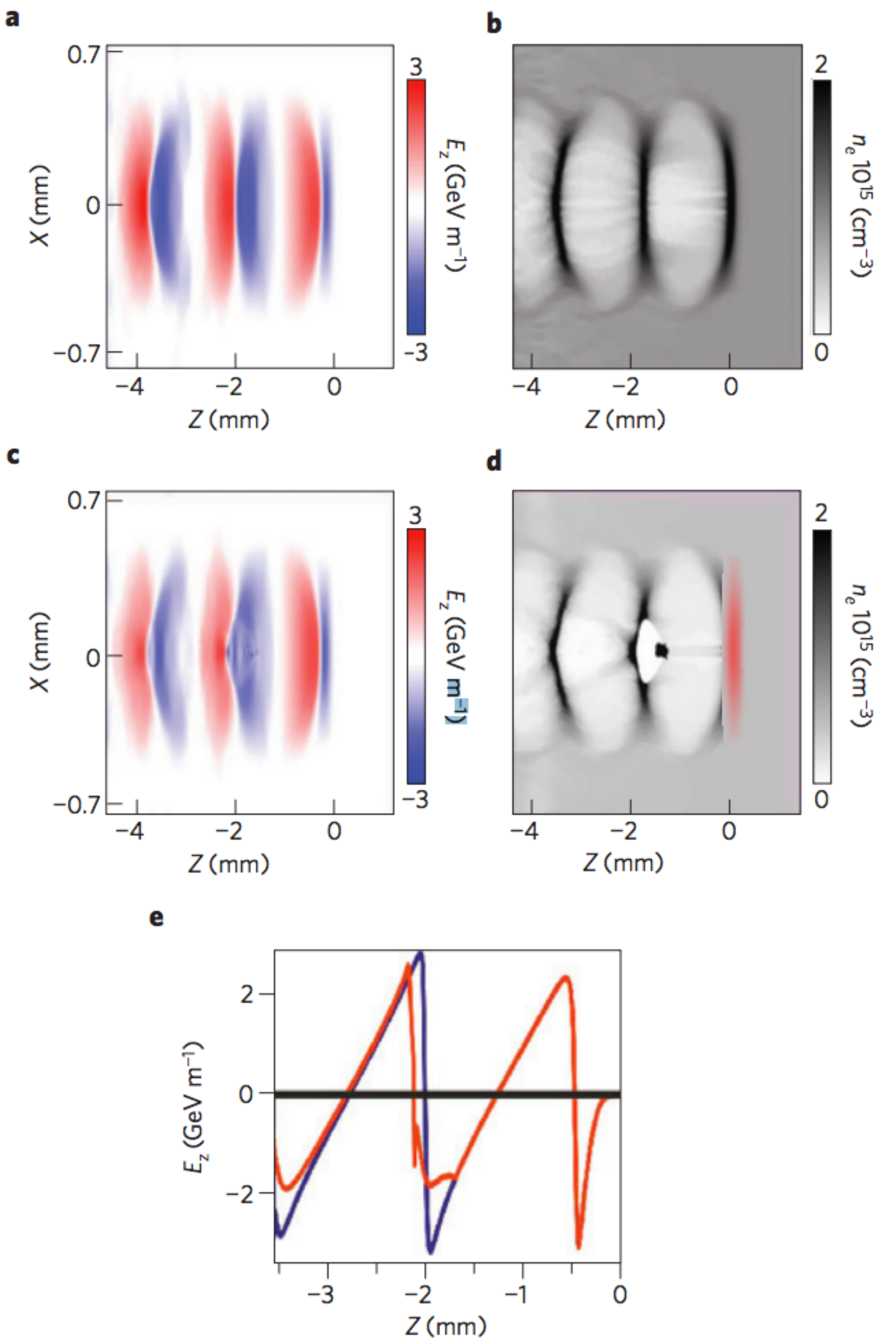
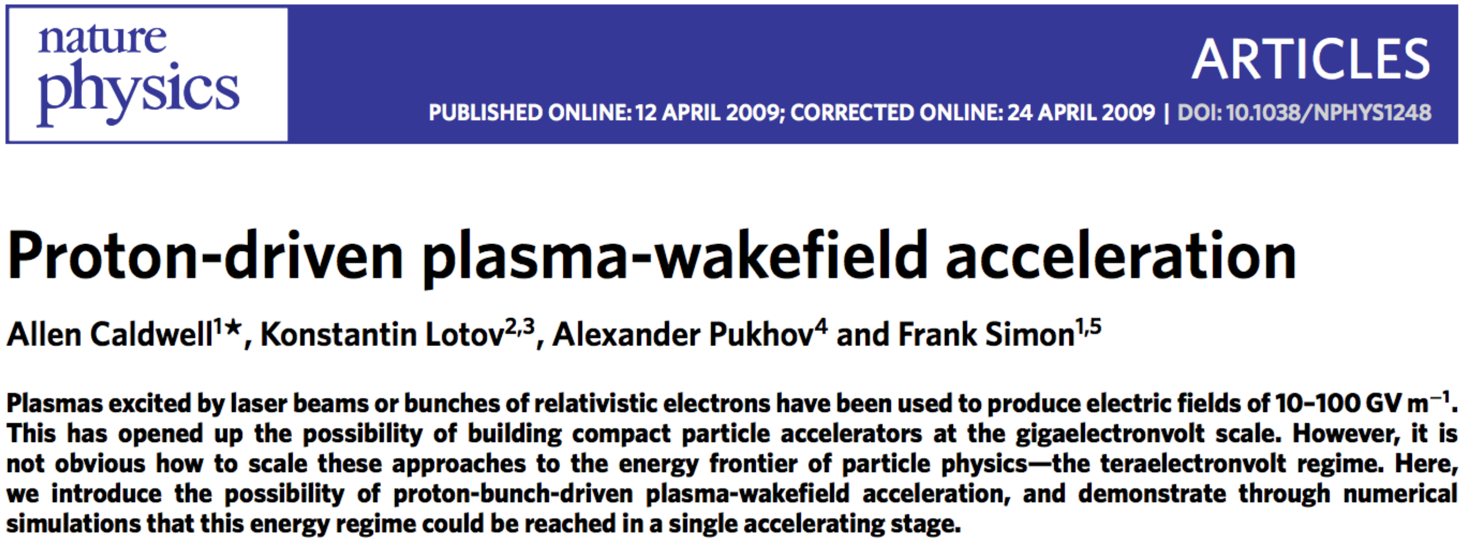


Figure 2 | The electric field strength and the electron density in the plasma. a–d, Simulation results for the unloaded (no witness bunch) case (**a**,**b**) and in the presence of a witness bunch (**c**,**d**). The witness bunch is seen as the black spot in the first wave bucket in **d**. **d** also shows the driving proton bunch at the wavefront (red). **e**, The on-axis accelerating field of the plasma wave for the unloaded (blue curve) and loaded (red curve) cases.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ARTICLES

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Proton-driven plasma-wakefield acceleration

Allen Caldwell[1]*, Konstantin Lotov[2,3], Alexander Pukhov[4] and Frank Simon[1,5]

Plasmas excited by laser beams or bunches of relativistic electrons have been used to produce electric fields of 10–100 GV m^{-1}. This has opened up the possibility of building compact particle accelerators at the gigaelectronvolt scale. However, it is not obvious how to scale these approaches to the energy frontier of particle physics—the teraelectronvolt regime. Here, we introduce the possibility of proton-bunch-driven plasma-wakefield acceleration, and demonstrate through numerical simulations that this energy regime could be reached in a single accelerating stage.

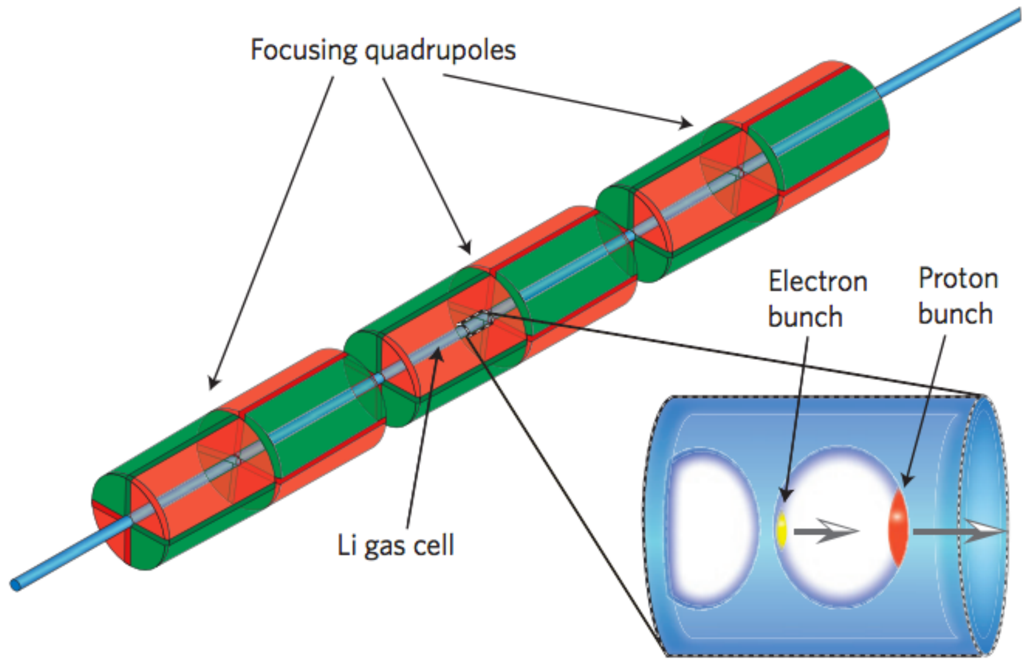
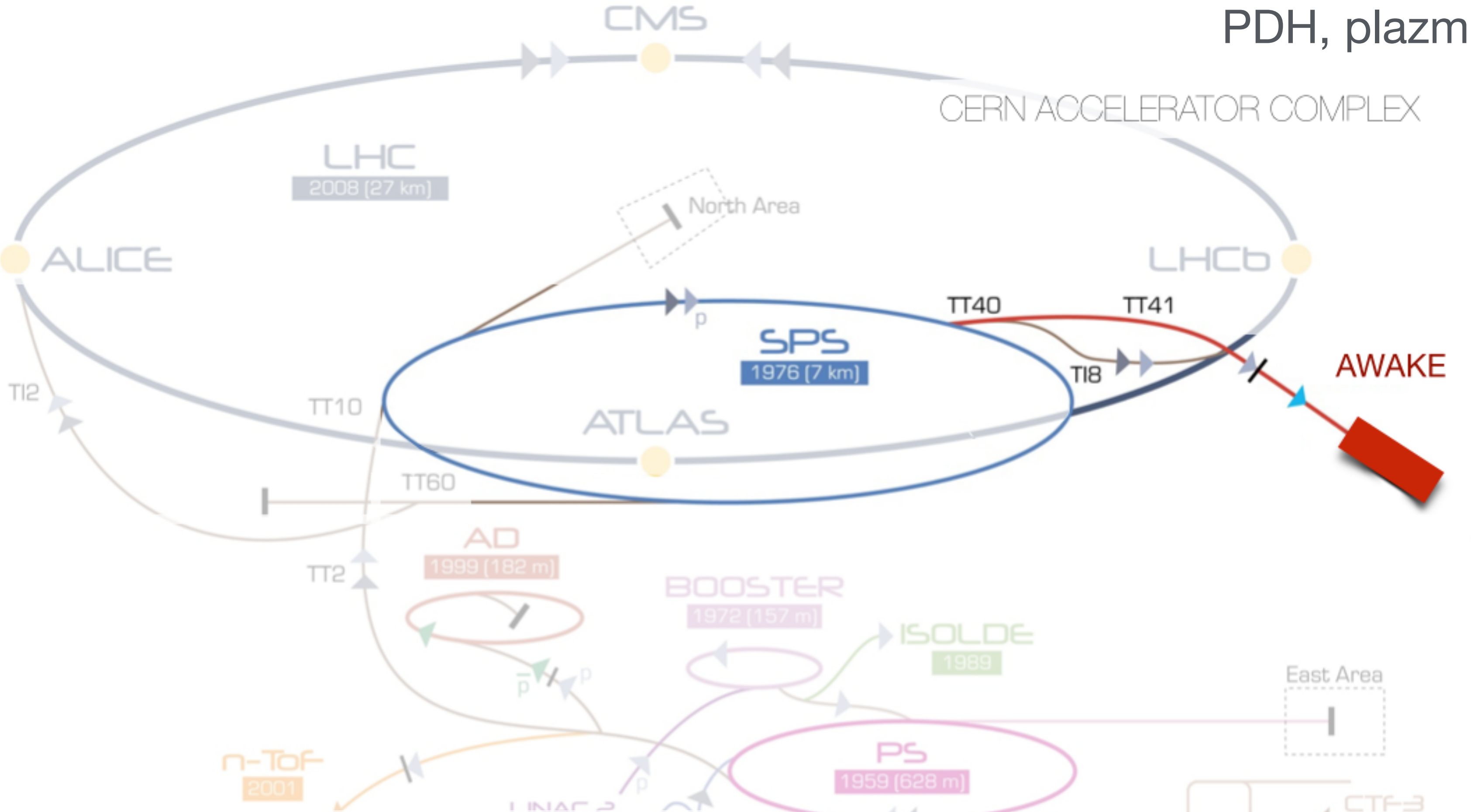
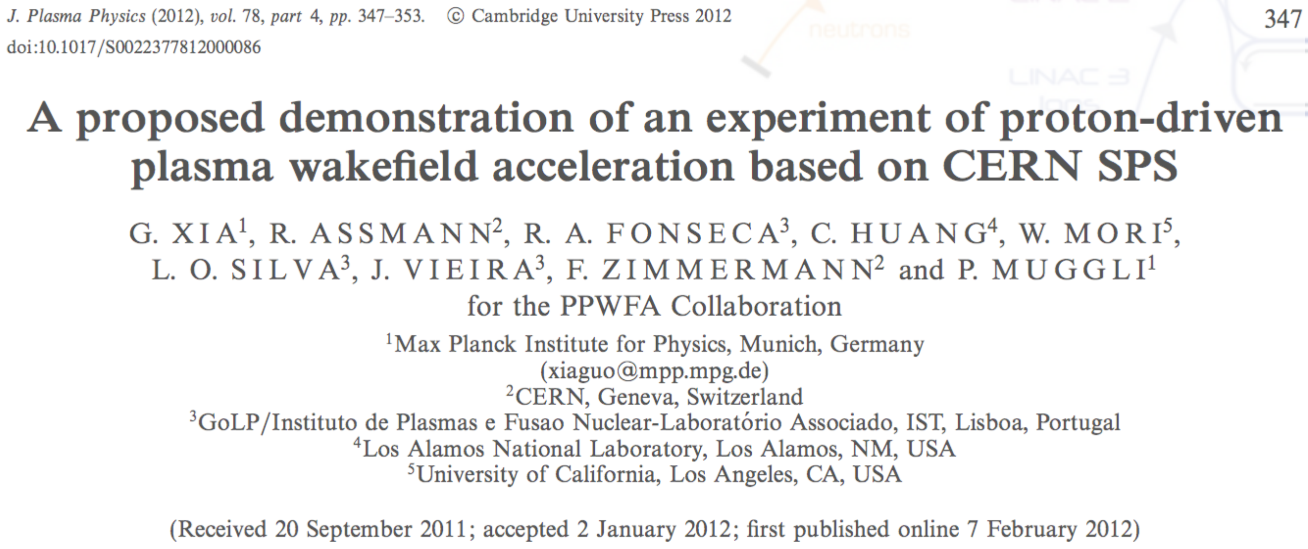


Figure 1 | A schematic description of a section of the plasma-wakefield-accelerating structure. A thin tube containing Li gas is surrounded by quadrupole magnets with alternating polarity. The magnification shows the plasma bubble created by the proton bunch (red). The electron bunch (yellow) undergoing acceleration is located at the back of the bubble. Note that the dimensions are not to scale.

AWAKE, Dünya'nın ilk ve tek proton sürümlü PDH deneyi

PDH, plazma dalgasıyla hızlandırma.





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A proposed demonstration of an experiment of proton-driven plasma wakefield acceleration based on CERN SPS

G. XIA[1], R. ASSMANN[2], R. A. FONSECA[3], C. HUANG[4], W. MORI[5], L. O. SILVA[3], J. VIEIRA[3], F. ZIMMERMANN[2] and P. MUGGLI[1]
for the PPWFA Collaboration
[1]Max Planck Institute for Physics, Munich, Germany
(xiaguo@mpp.mpg.de)
[2]CERN, Geneva, Switzerland
[3]GoLP/Instituto de Plasmas e Fusao Nuclear-Laboratório Associado, IST, Lisboa, Portugal
[4]Los Alamos National Laboratory, Los Alamos, NM, USA
[5]University of California, Los Angeles, CA, USA

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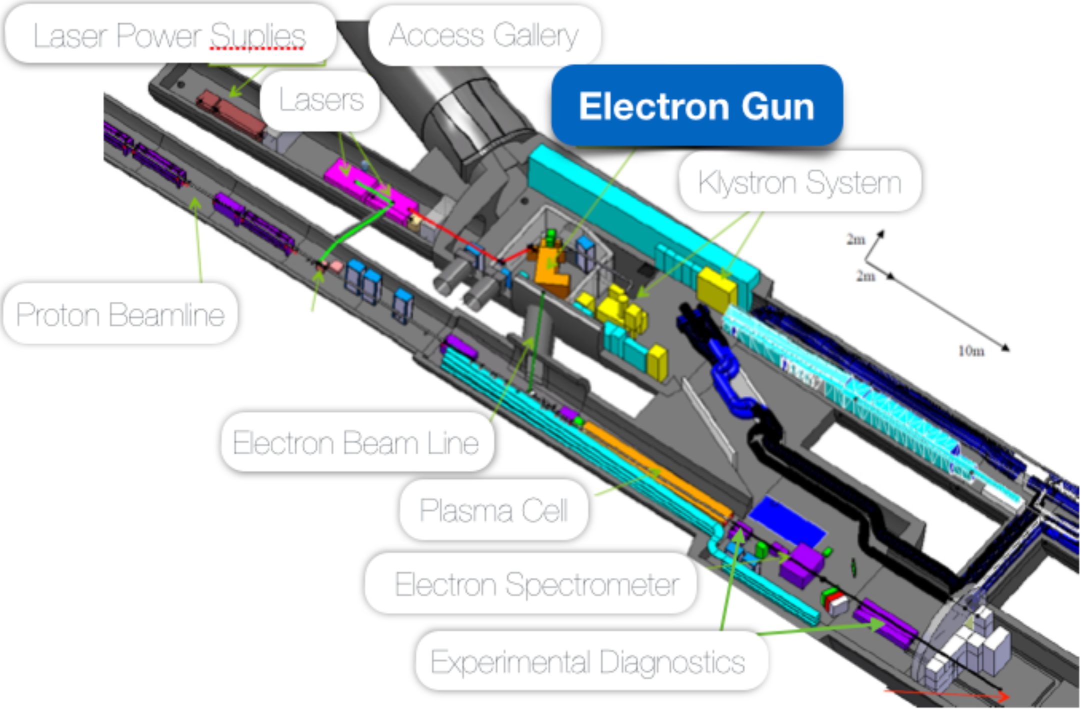

AWAKE Design Report
A Proton-Driven Plasma Wakefield Acceleration Experiment at CERN

CERN-SPSC-2013-013 ; SPSC-TDR-003

PARS@CLARA, bu okulda inceleyeceğimiz PDH deneyi örneğimiz

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A plasma wakefield acceleration experiment using CLARA beam

G. Xia [a,b,*], D. Angal-Kalinin [c], J. Clarke [c], J. Smith [d], E. Cormier-Michel [e], J. Jones [c], P.H. Williams [c], J.W. Mckenzie [c], B.L. Militsyn [c], K. Hanahoe [a,b], O. Mete [a,b], A. Aimidula [b,f], C.P. Welsch [b,f]

[a] *School of Physics and Astronomy, University of Manchester, Manchester, United Kingdom*
[b] *The Cockcroft Institute, Sci-Tech Daresbury, Daresbury, Warrington, United Kingdom*
[c] *STFC/ASTeC, Daresbury, Warrington, United Kingdom*
[d] *Tech-X UK Corporation, Daresbury Innovation Centre, Warrington, United Kingdom*
[e] *Tech-X Corporation, Boulder, CO, USA*
[f] *The University of Liverpool, Liverpool, United Kingdom*

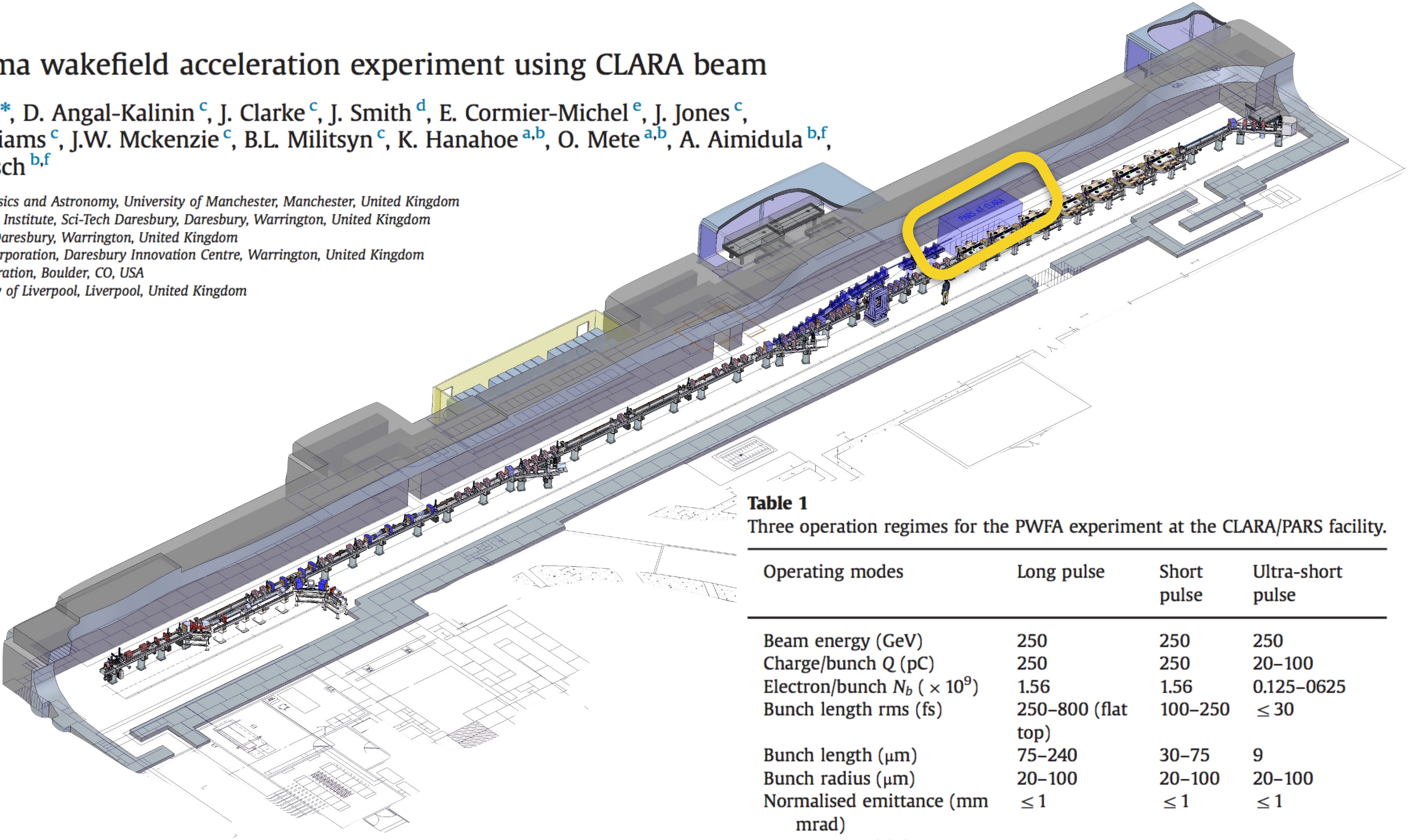


Table 1
Three operation regimes for the PWFA experiment at the CLARA/PARS facility.

Operating modes	Long pulse	Short pulse	Ultra-short pulse
Beam energy (GeV)	250	250	250
Charge/bunch Q (pC)	250	250	20–100
Electron/bunch N_b ($\times 10^9$)	1.56	1.56	0.125–0625
Bunch length rms (fs)	250–800 (flat top)	100–250	≤ 30
Bunch length (μm)	75–240	30–75	9
Bunch radius (μm)	20–100	20–100	20–100
Normalised emittance (mm mrad)	≤ 1	≤ 1	≤ 1
Energy spread (%)	1	1	1

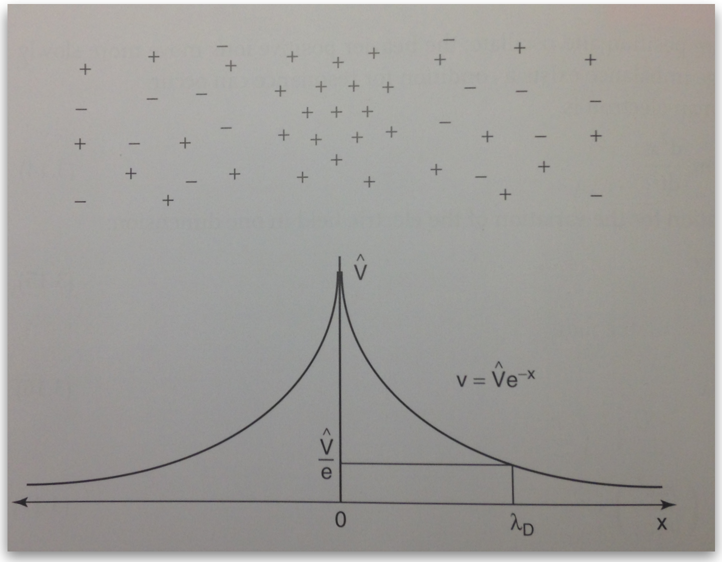
Kolay birimler türünden bazı devinim değişkenleri

- Yoğun bir parçacık demetini plazma içinden geçmesi ile plazma elektronları denge noktası çevresinde ω_p frekansında salınım yaparlar.

$$\omega_p = \sqrt{\frac{n_p e^2}{\epsilon_0 m}}$$

- Debye uzunluğu

$$\lambda_d = \sqrt{\frac{\epsilon_0 k_b T_e}{n_e e^2}}$$



- Doğrusal kuram için ($n_b > n_p$) elde edilebilecek en yüksek elektrik alan:

$$E = 240(MV/m)(\frac{N}{4 \times 10^{10}})(\frac{0.6}{\sigma_z(mm)})^2$$

- Dönüşüm oranı, sürücü demetten tanık demete aktarılabilecek en büyük enerji:

$$R = \frac{E_{max}^{witness}}{E_{min}^{drive}} \leq 2 - \frac{N_{witness}}{N_{drive}}$$

Benzetim Yazılımları ve Örnek Çalışma

- LCODE
- VORPAL,
- OSIRIS,
- VPLC,
- WARP,
- QuickPIC
- …

LCODE

http://www.inp.nsk.su/~lotov/lcode/

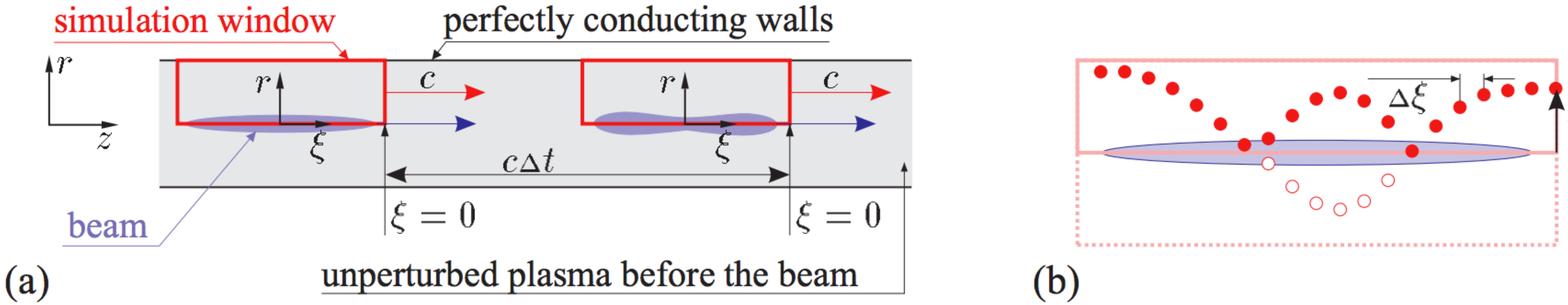


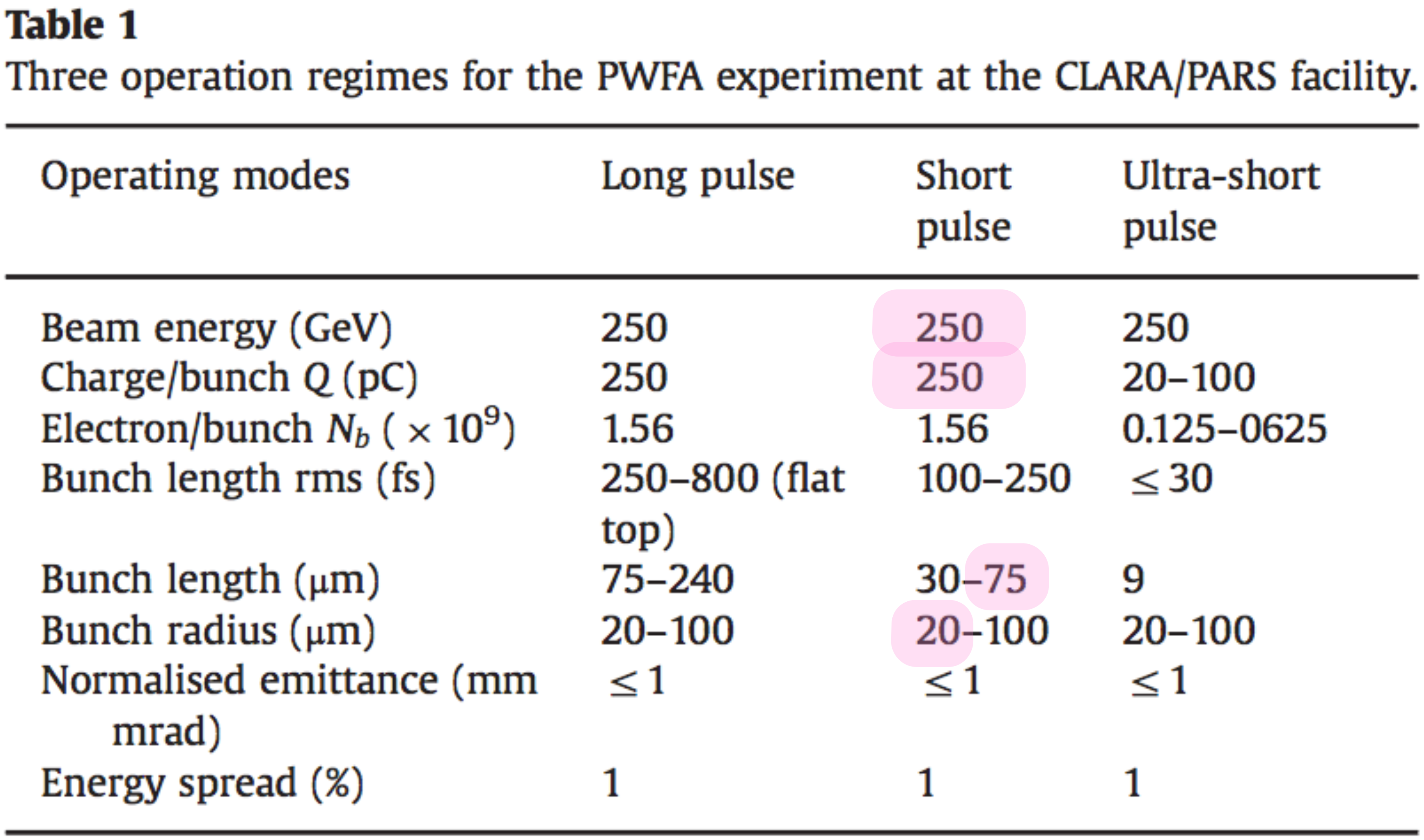
Figure 1: Geometry of the problem (a), and trajectory of a plasma particle in the simulation window (b).

Program girdileri:

- Benzetim penceresi (resim),
- Birimler plazma frekansı ve Debye uzunluğu cinsinden veriliyor,
- Benzetimde yer alacak demetler tanımlanıyor,
- Son olarak isteğe göre devinimin gözlenebilir nicelikleri çıktı olarak belirleniyor.
- Kullanım kılavuzu:
  http://www.inp.nsk.su/~lotov/autobuilds-lcode/lcode-stable/manual-r406/manual.pdf

LCODE

- CLARA demet özelliklerini kullanarak oluşturulabilecek plasma dalgası alanını hem LCODE hem de doğrusal kuram ile elde edip karşılaştıralım.



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