CENTRO DE LÁSERES PULSADOS

Laser Wakefield Acceleration Of Electron Beams

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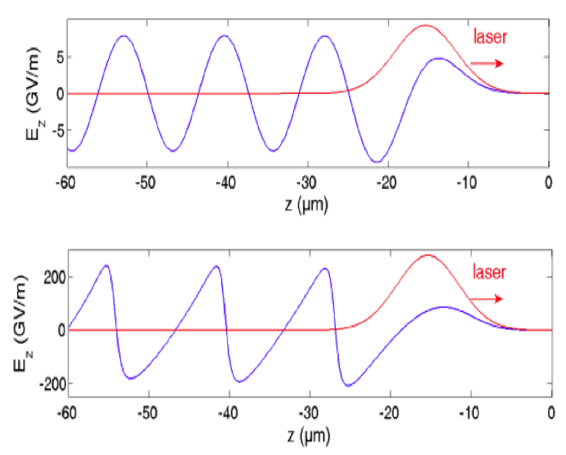
Laser driven plasma accelerators for electrons in an underdense plasma

CLPU and University of Salamanca

State of the art RF cavities can generate electric gradients up to 100MV/m which establish the length of conventional accelerators. Laser driven plasma accelerators can provide electric gradients up to 100 GV/m which could open the door to new developments in the accelerator technology.

The PW laser of CLPU will be able to provide parameters for electron acceleration both in the linear and bubble regime. Several injection techniques are being considered as well as guiding in a plasma channel for long acceleration distances.



Estimations for electron acceleration with the PW Salamanca 30 J, 30 fs.								
	N_e(cm^{-3})	L_{acc}(cm)	T(fs)	a_0	W_0(mm)	ΔE(GeV)	Q(nC)	Focale (m)
Blow Out regime	9.4x10^{17}	3	52	4.5	23.7	2.9	4.6	7
External guiding + injection	1.4x10^{17}	170	89	2	42	8.7		12.4

In the external guiding scheme δE/E can be as small as 1% but with low charge.

[1] W P Leemans et al. Nature Physics 2 699 (2006). , E Esarey et al. Rev. Mod. Phys. 81, 1229 (2009)
[2] W Lu et al. PRST-AB 10, 061301 (2007)., V Malka et al. Nature Physics 4, 447 (2008)

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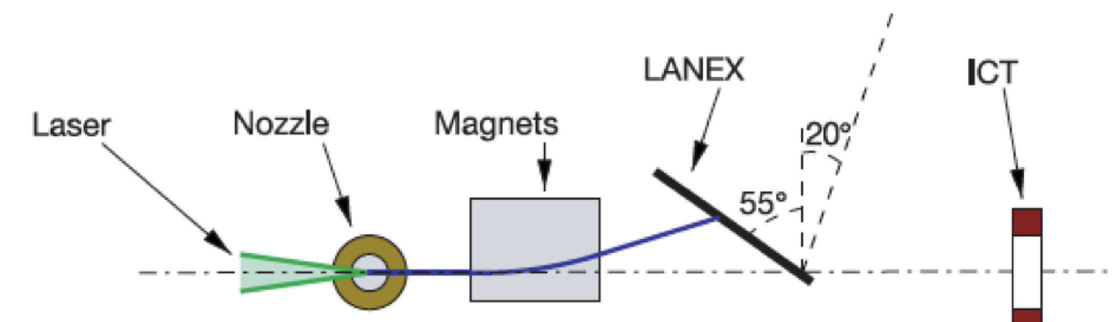
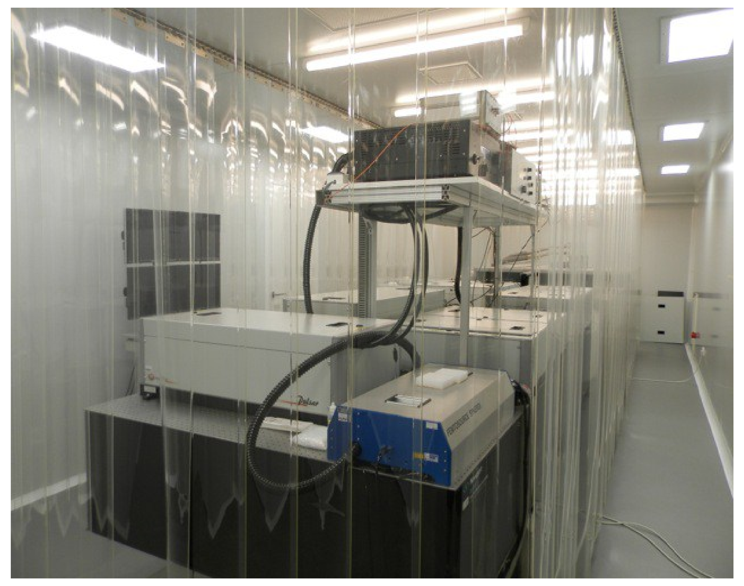
Overview

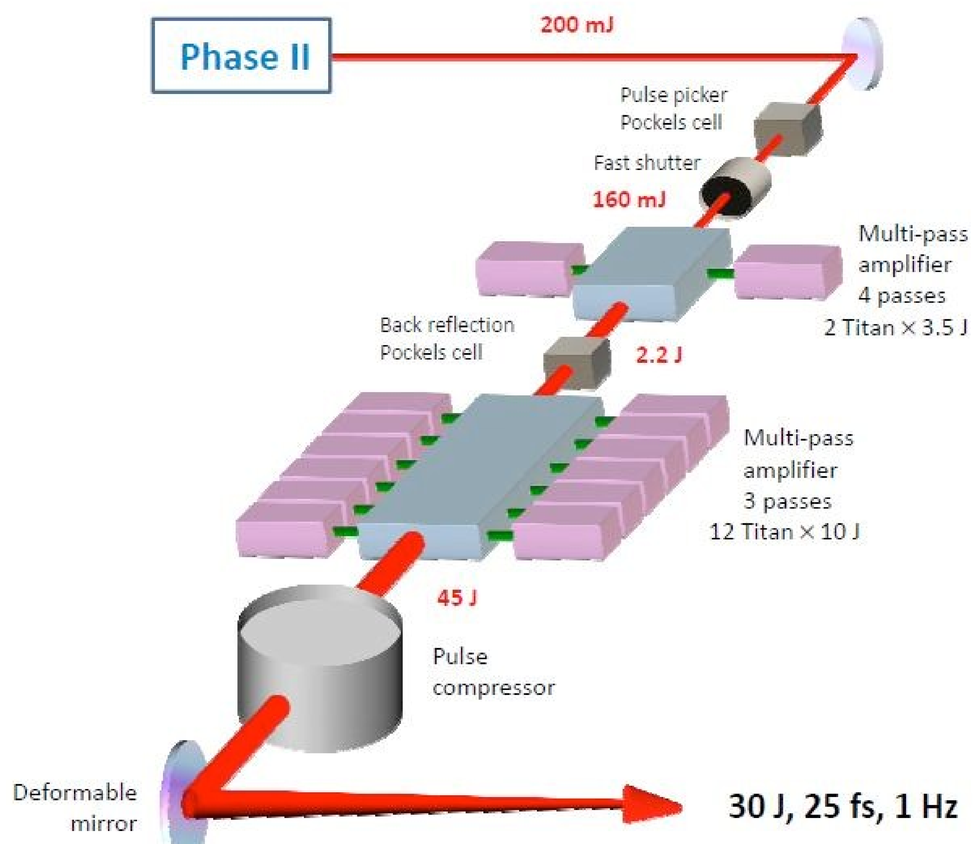
The fast development of laser technology over the last two decades has allowed to obtain very high laser intensities. With these high intensities, it is possible to create plasmas, which can later be used as electron accelerators driven by the laser pulse. In these plasmas a longitudinal accelerating electric field is generated by the ponderomotive force of the laser pulse removing the electrons in the underdense plasma. The accelerating gradient can reach some ~100 GV/m which can produce electron beams with high energy over very small distances [1--3].
Demonstrations of the production of monochromatic electron beams have been reported in the literature, with energies reaching 1 GeV for a laser pulse of 40 TW [2]. The use of electric discharges in a gas cell to generate a plasma waveguide has been proposed to increase the acceleration length. Techniques of electron injection by ionization have also been proposed to optimize and control the parameters of the electron beam.



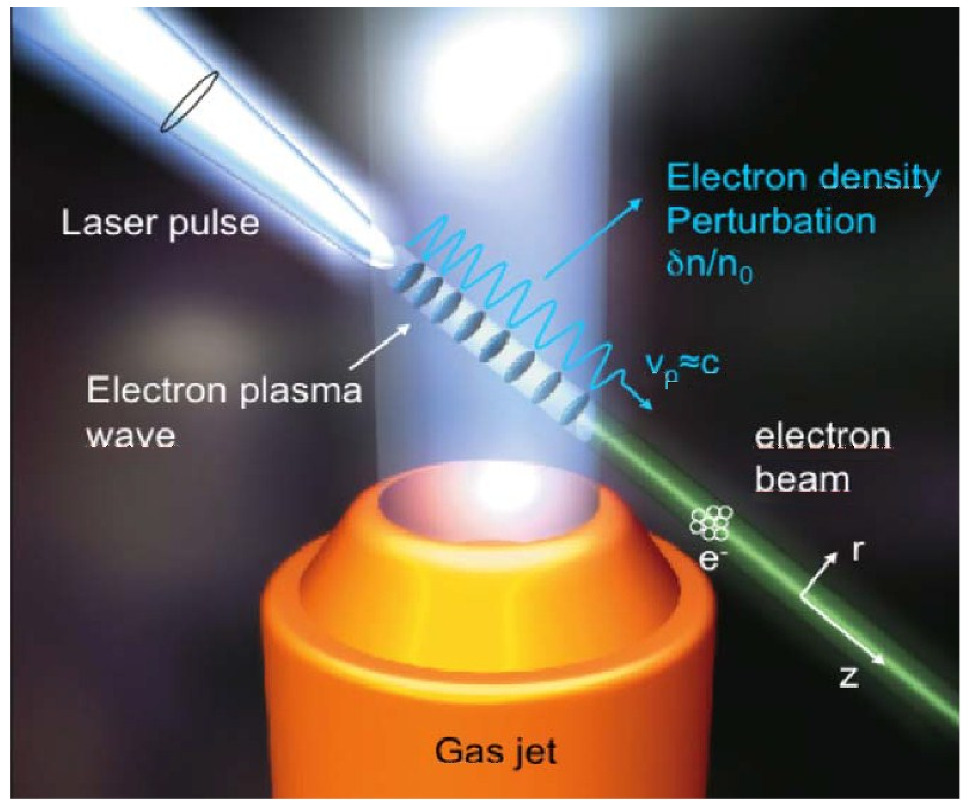
Accelerator concept @ Salamanca



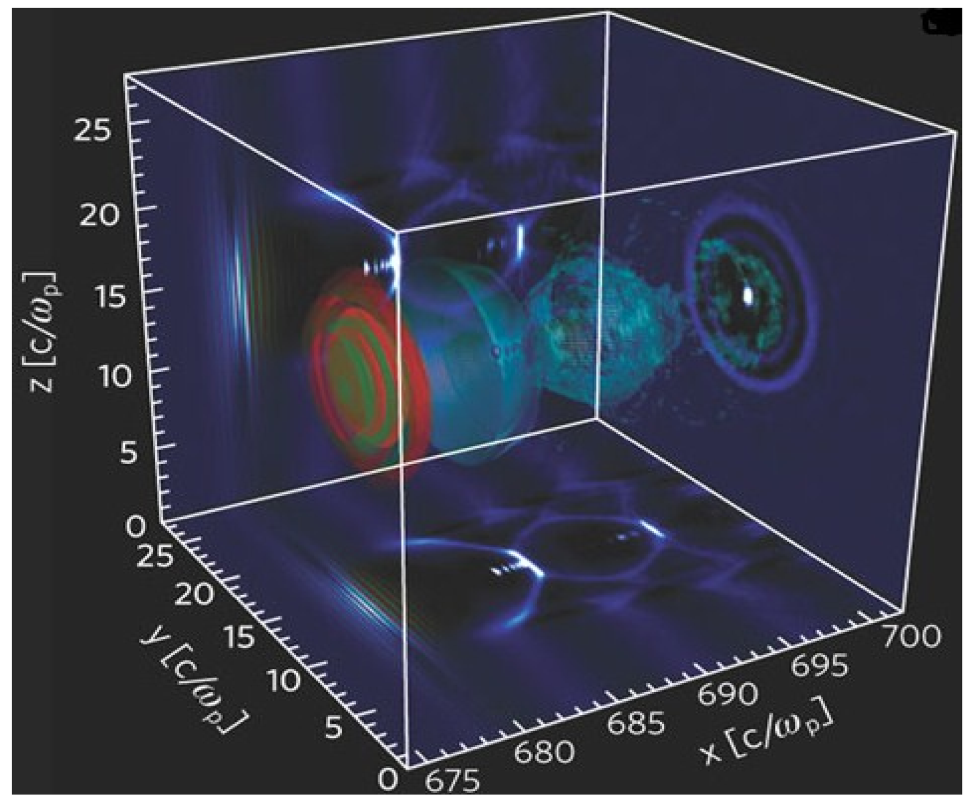
200 TW system VEGA II



PW system VEGA III



Laser plasma accelerator from a gas jet
Mutation Research/Rev. in Mutation Research **704** (1–3), 142 (2010)



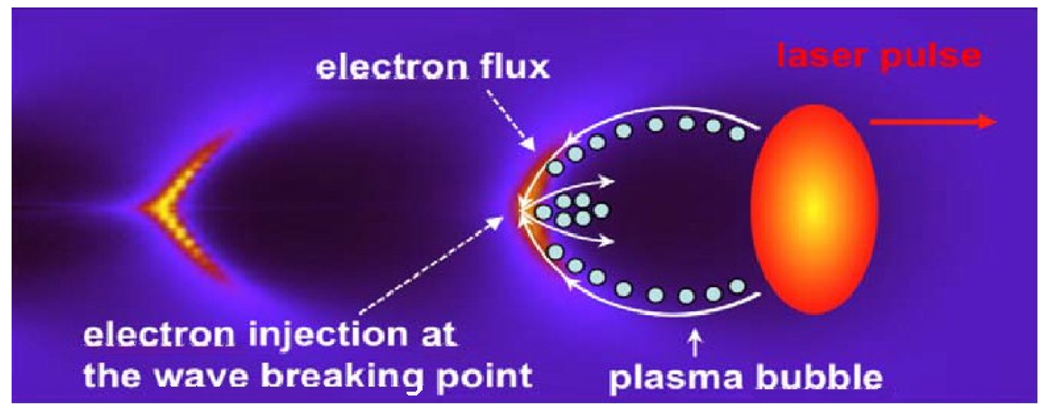
3D PIC simulation of the bubble regime
Nature Photonics **3**, 423 - 425 (2009)

Objectives at the CLPU :

- Development of an in house PIC code .
- Design and implementation of the experimental station for electron acceleration in underdense target.

Applications[4] :

- Production of intense X-ray beams (Free electron laser).
- Cancer therapy
- Ion implantation
- Electron cutting and melting
- Probing of ultra fast phenomena (biology , dense matter)



Schematic of electron injection in the bubble regime
Mutation Research/Rev. in Mutation Research **704** (1–3), 142 (2010)

References
[1] Clayton C., Ralph J., Albert F., Fonseca R., Glenzer S., Joshi C. *et al.* (2010).
"Self-Guided Laser Wakefield Acceleration beyond 1 GeV Using Ionization-Induced Injection", Phys. Rev. Lett. **105**(10).

[2] Leemans W. P., Nagler B., Gonsalves A. J., Tóth C., Nakamura K., Geddes C. G. R. *et al.* (2006).
"GeV electron beams from a centimetre-scale accelerator", Nat. Phys, **2**(10), 696–699.

[3] Hafz N. A. M., Jeong T. M., Choi I. W., Lee S. K., Pae K. H., Kulagin V. V. et al. (2008).
"Stable generation of GeV-class electron beams from self-guided laser-plasma channels", Nat. Photon. **2**(9), 571–577.

[4] Malka V. (2012).
"Laser plasma accelerators", Phys. Plasmas **19**, 055501.

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