Radiation Test Workshop2016

Sevilla, 31st March – 1st April 2016

Laser-driven source for space applications at the Spanish Pulsed Lasers Centre (CLPU).

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CLPU CENTRO DE LÁSERES PULSADOS

MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD

Junta de Castilla y León

VNiVERSiDAD D SALAMANCA
CAMPUS DE EXCELENCIA INTERNACIONAL

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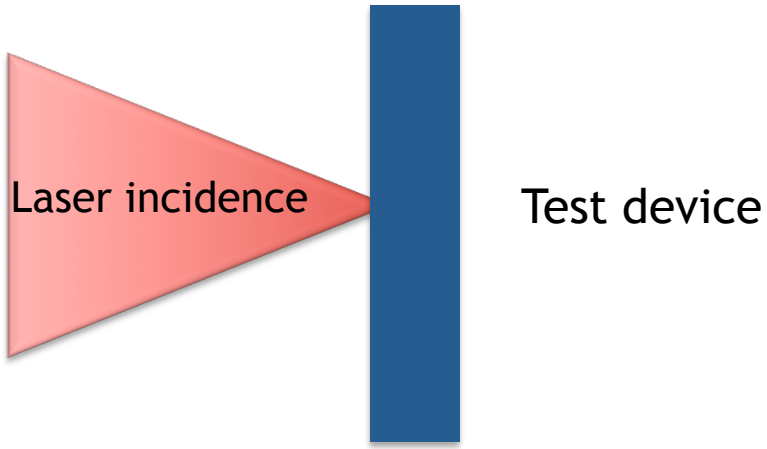
In the space radiation testing community, **laser** is automatically associated with:



Even though there are laser systems at the CLPU that can be used in this "conventional" way…

...here, we are going to speak about laser, in a very different context :

particle accelerators based on laser-produced plasmas

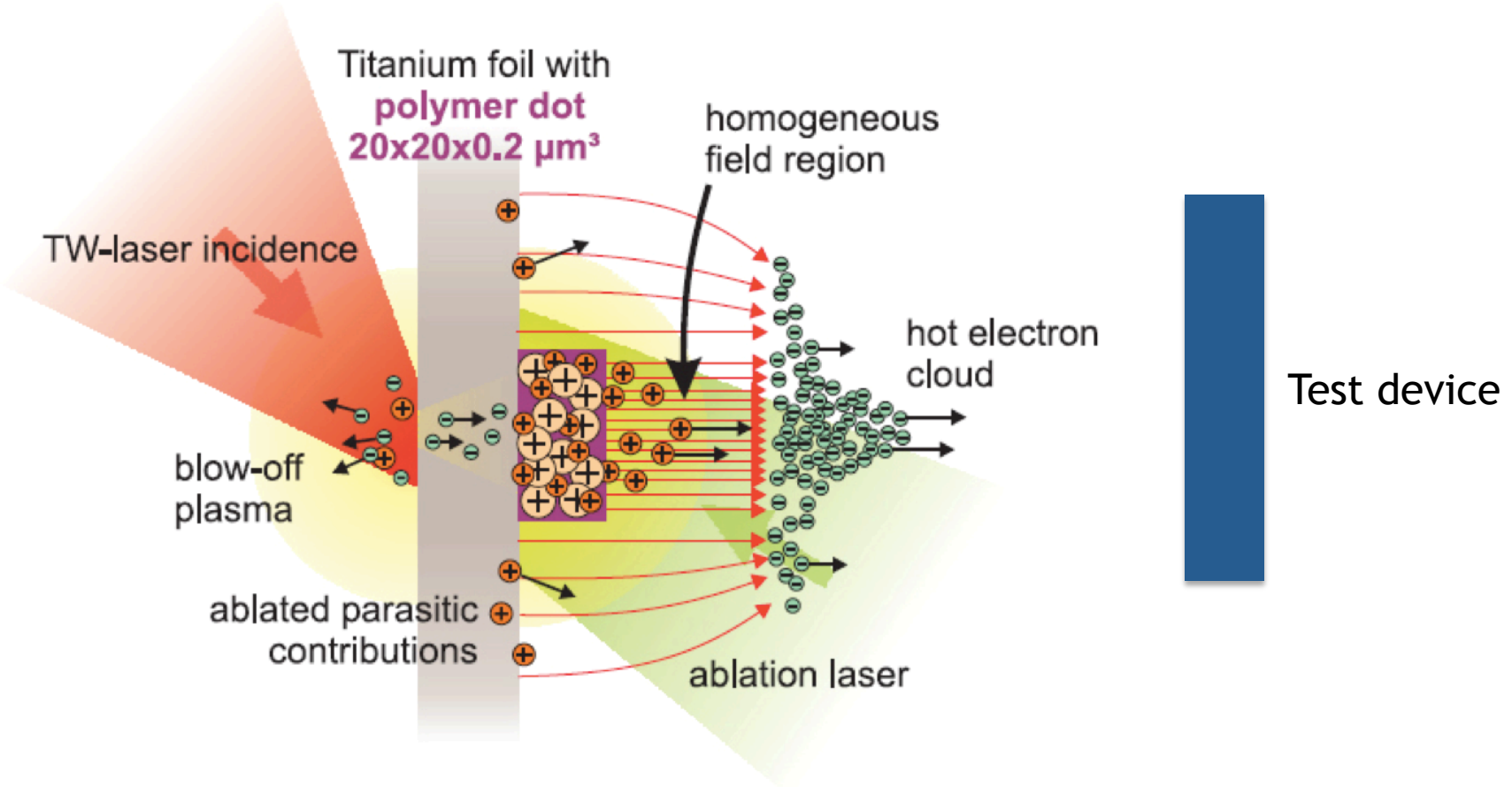
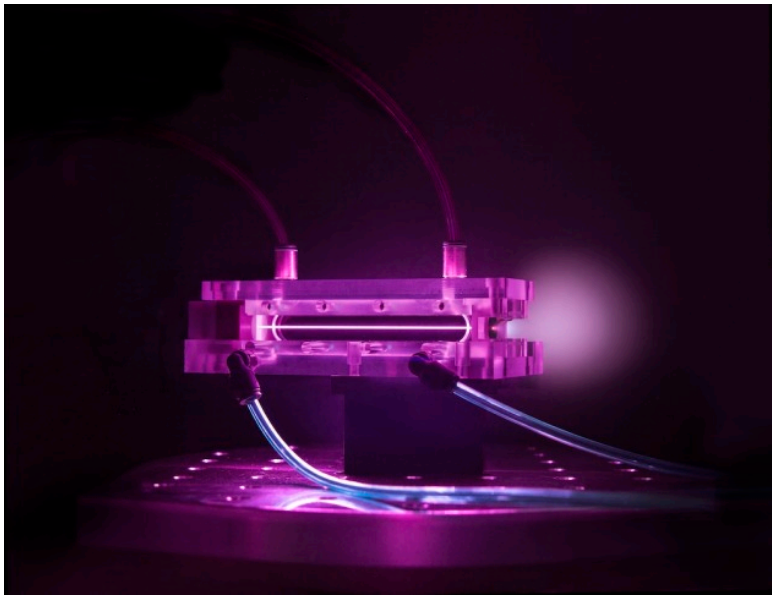


Image taken from S.M. Pfotenhauer et al, New J. Phys. (2008) 033034

- **Particle accelerators** based on laser-produced plasmas are able to stand field gradients up to 100 GV/m. This allows the production of high-energy particle beams in very short distances, making laser plasma accelerators a very attractive alternative to large-scale conventional accelerators.

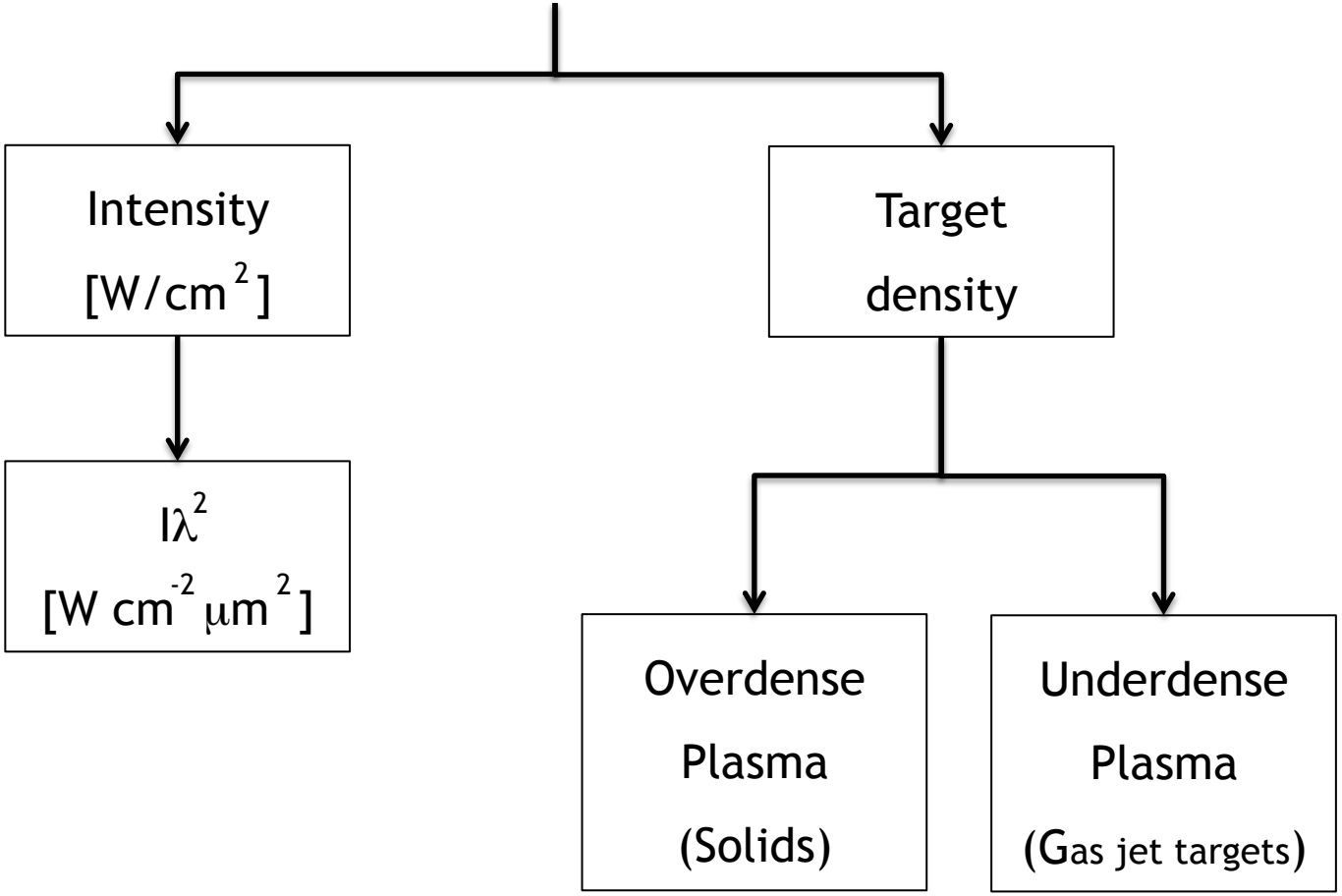


A **9 cm-long** capillary discharge waveguide used at the BELLA (laser) Center at the Lawrence Berkeley National Laboratory to produce an electron beam up to **4.25 GeV** (Leemans 2014).

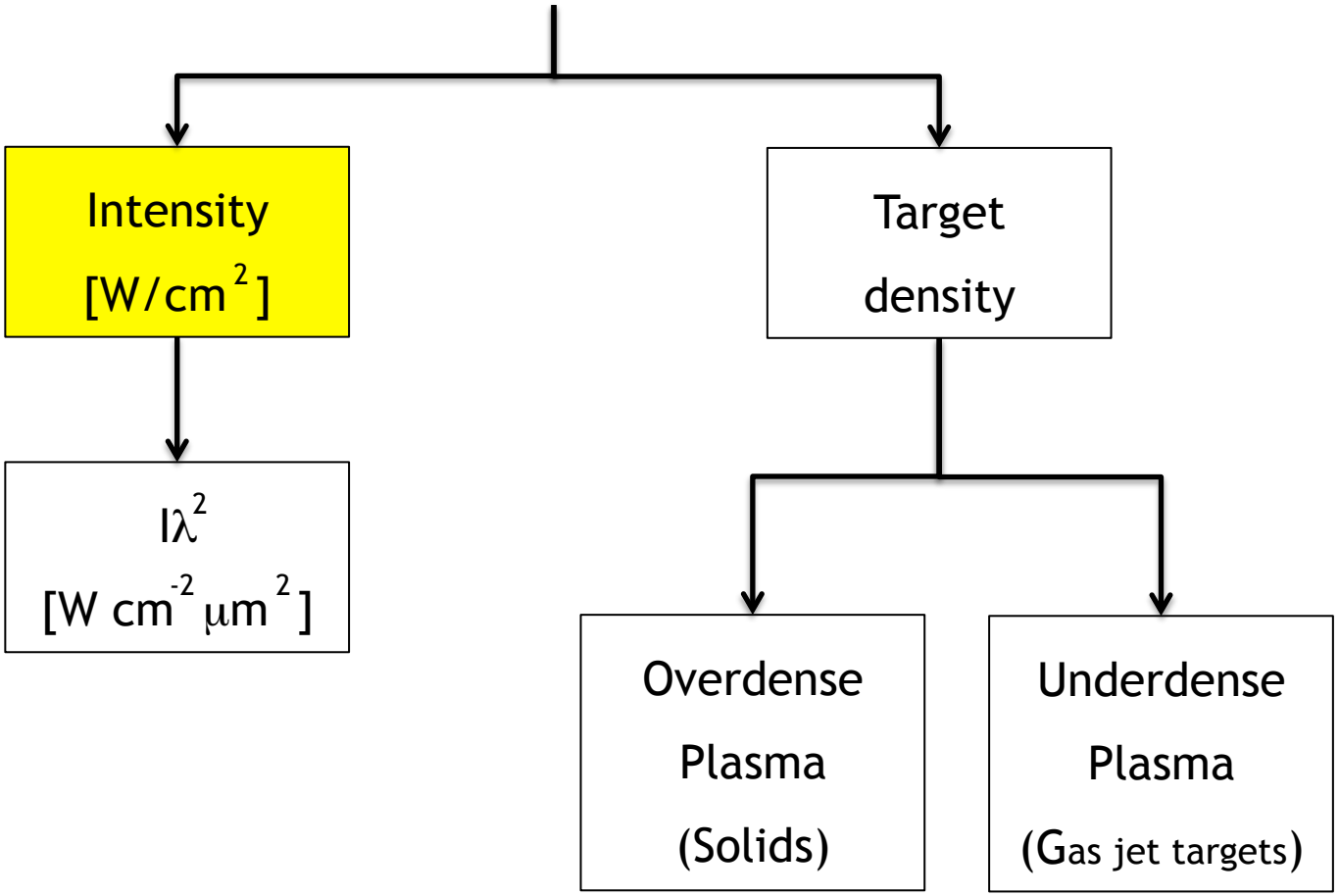
- The so-called **laser plasma accelerators** promise for innovation of affordable and compact accelerators for various applications ranging from high energy physics to medical and industrial applications among which stands the **space industry**.

- **Particle accelerators** based on laser-produced plasmas can operate in many different regimes depending upon the characteristics of the plasmas used.

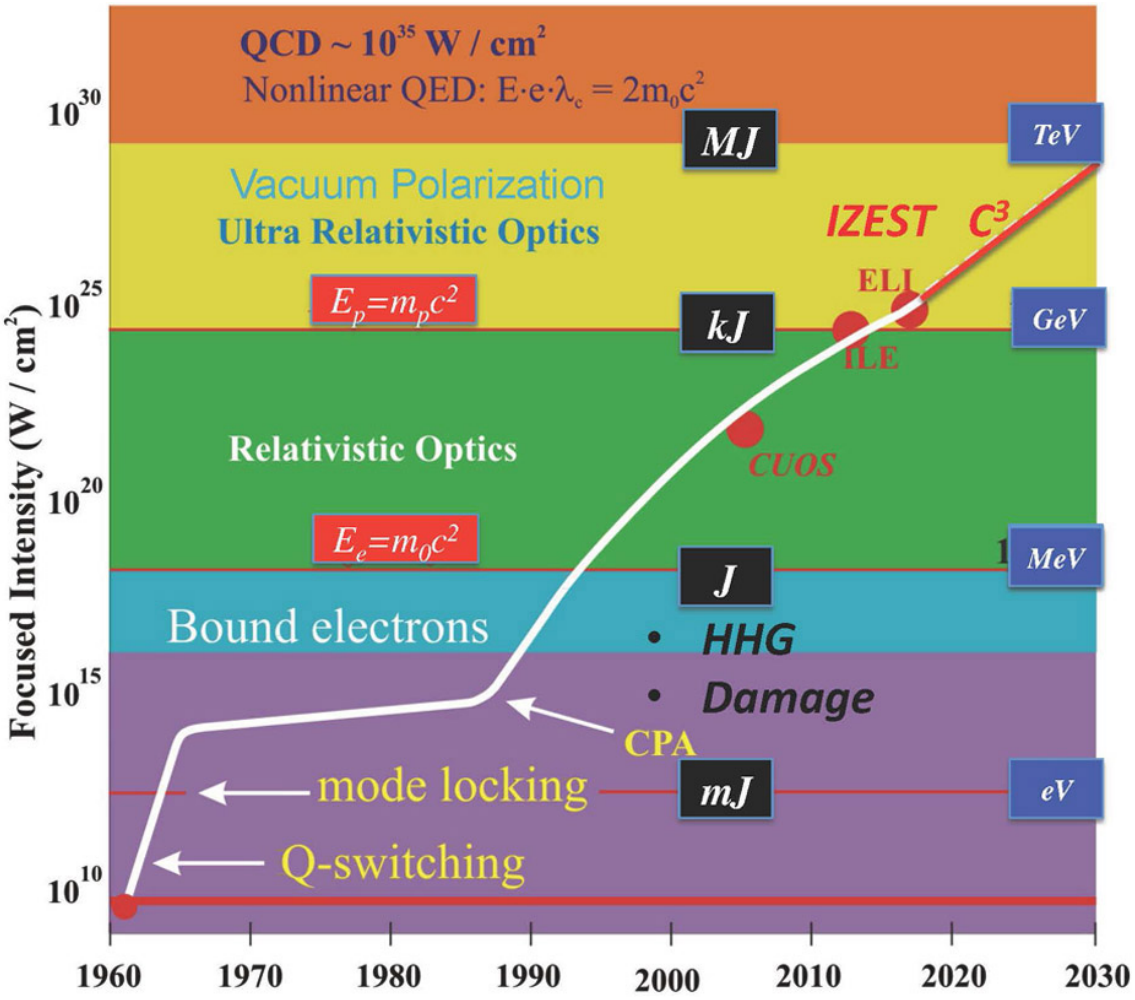
Parameters of relevance for particle acceleration

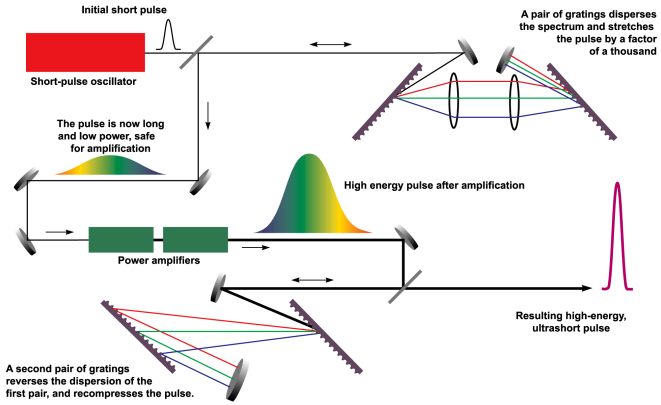


Parameters of relevance for particle acceleration



Intensity evolution since the first laser demonstration in 1960, with the different regimes of optics and electrodynamics (G.Mourou).





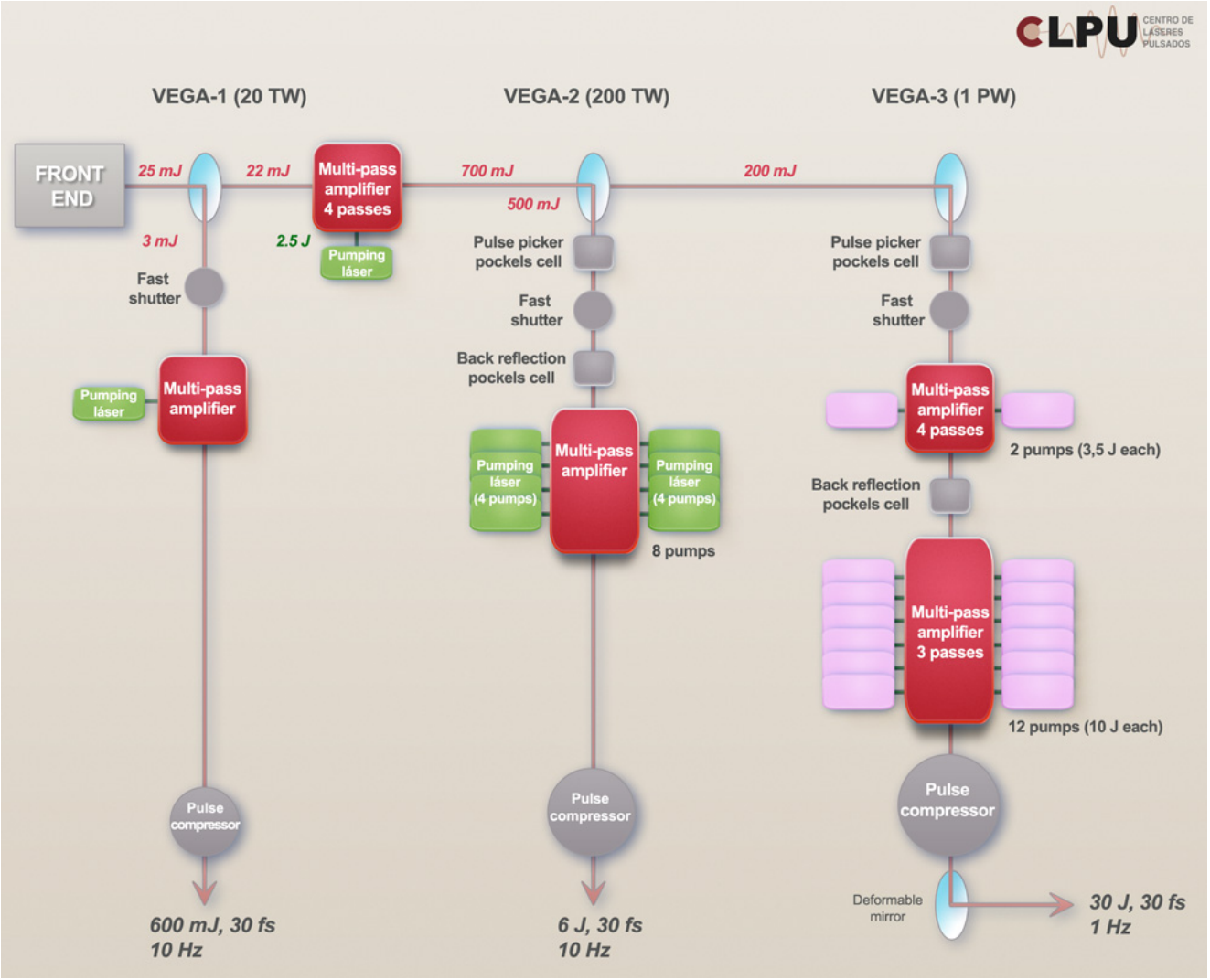
Chirped pulse amplification (CPA) (Strickland and Mourou 1985)

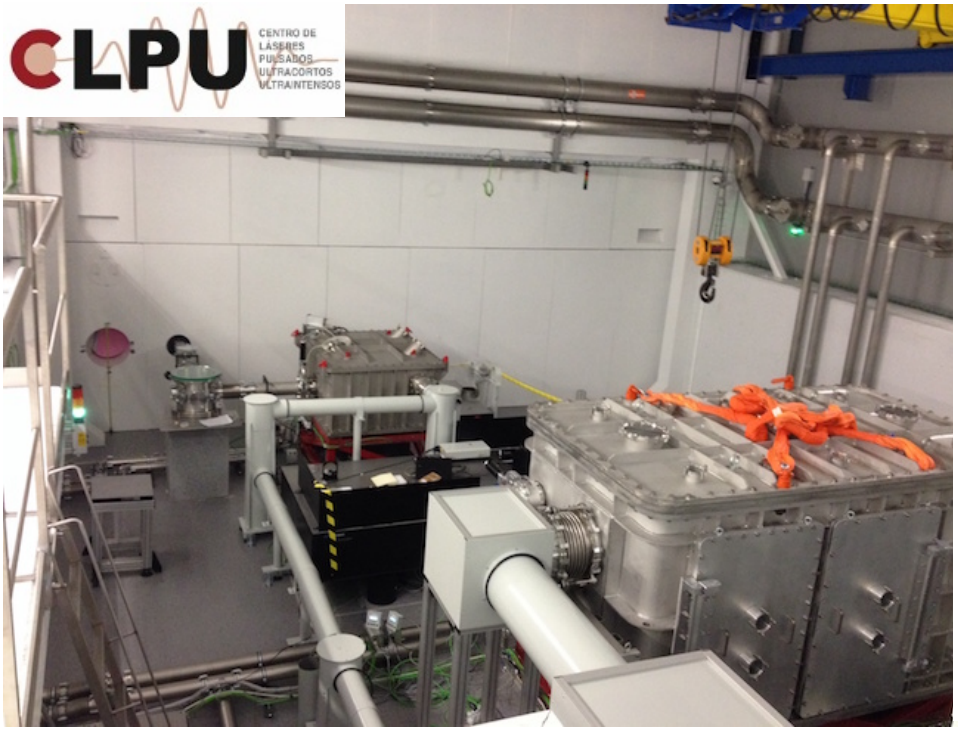
Pulsed emision

Intense Laser Labs World Wide

Taken from the "International Committee of Ultra-High Intensity Lasers" (ICUIL, www.icuil.org)

VEGA laser : a Ti:Sapphire custom made laser built by Amplitude Technologie.

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PULSADOS
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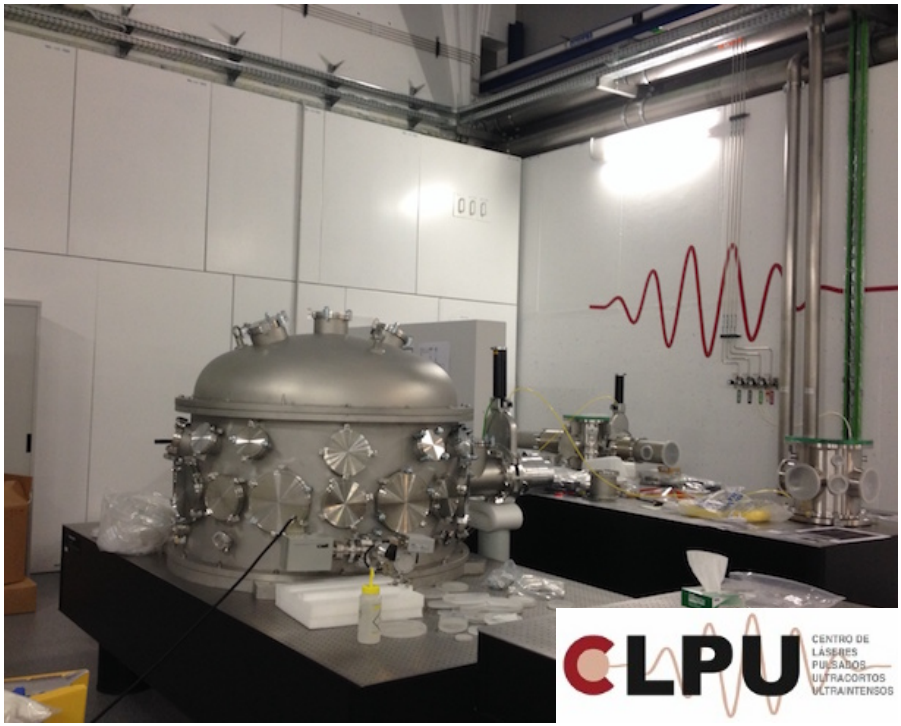
ULTRAINTENSOS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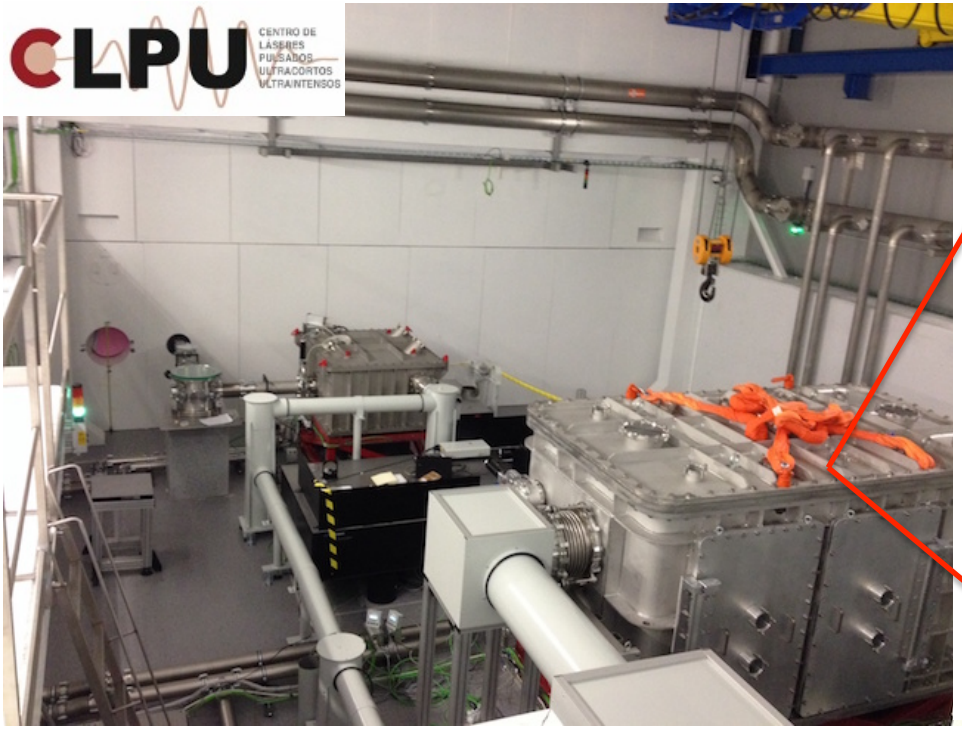
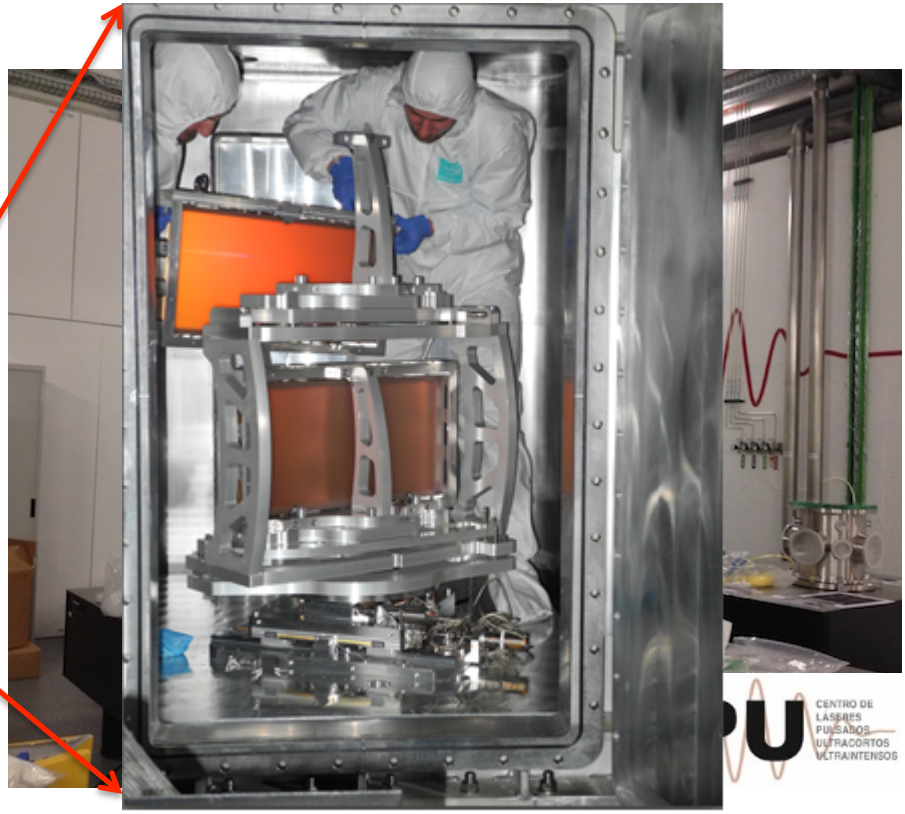
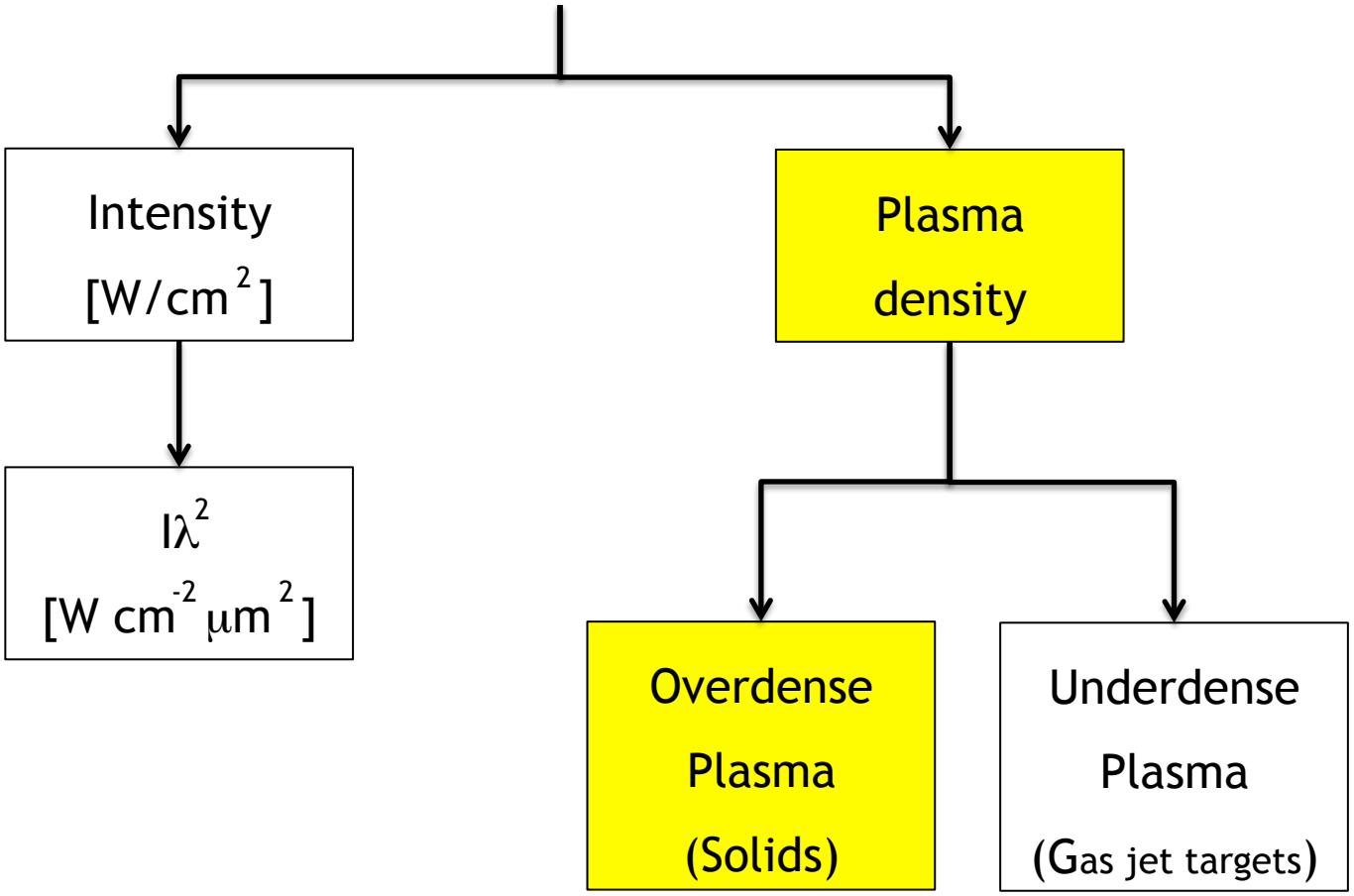

CLPU
CENTRO DE LÁSERES PULSADOS ULTRACORTOS ULTRAINTENSOS


CENTRO DE LÁSERES PULSADOS ULTRACORTOS ULTRAINTENSOS

Parameters of relevance for particle acceleration



How similar would be the particle beams to those from space?

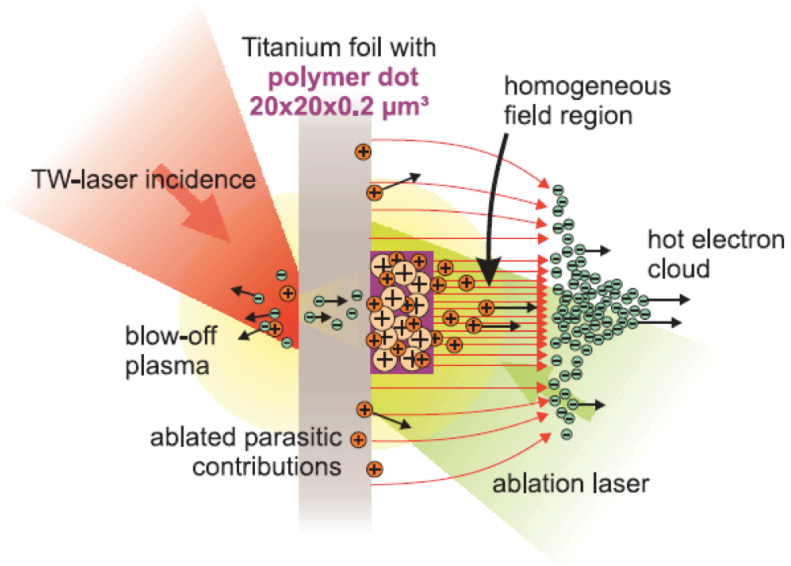
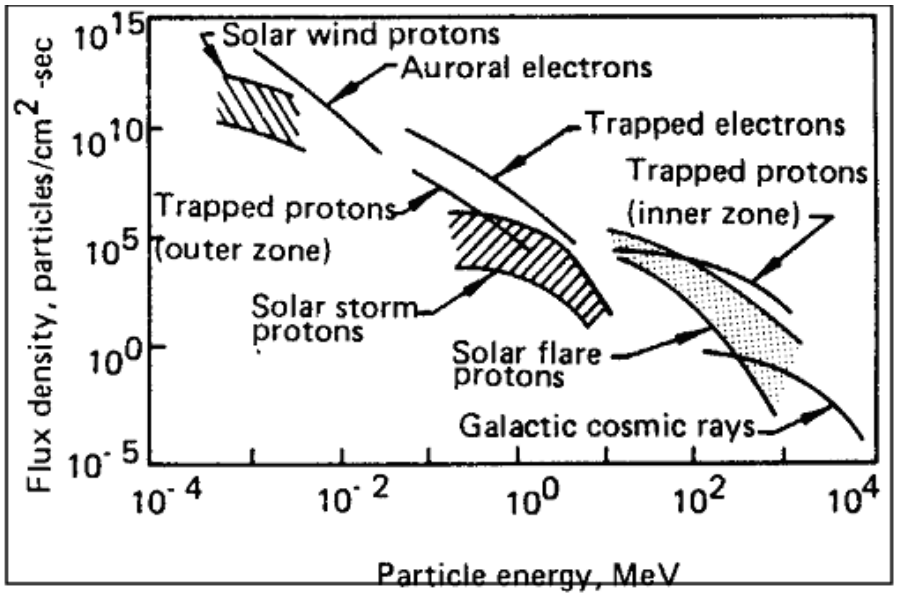


Image taken from S.M. Pfotenhauer et al, New J. Phys. (2008) 033034

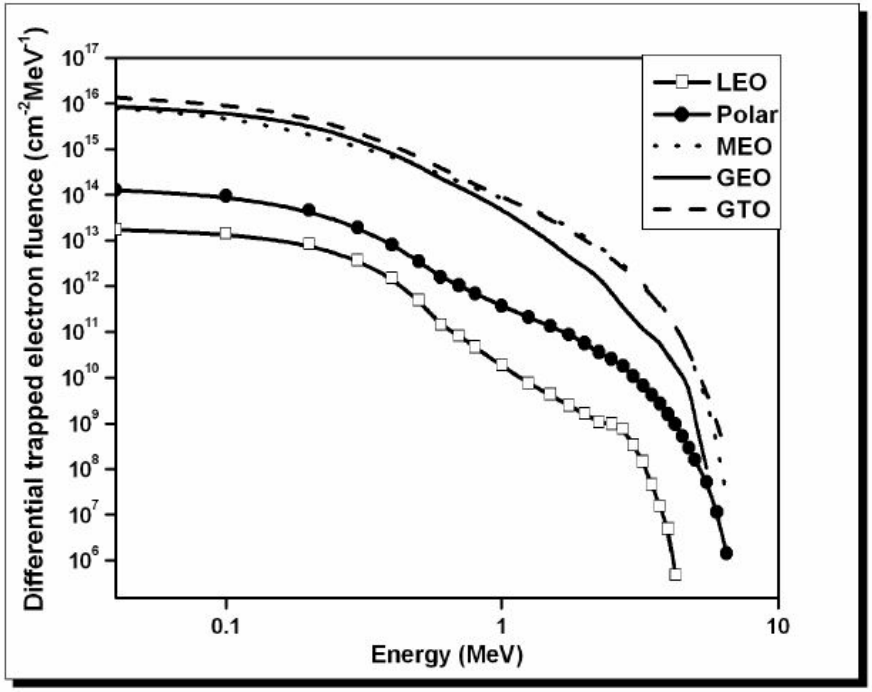


Schimmerling,.W and Curtis, S.B, NASA

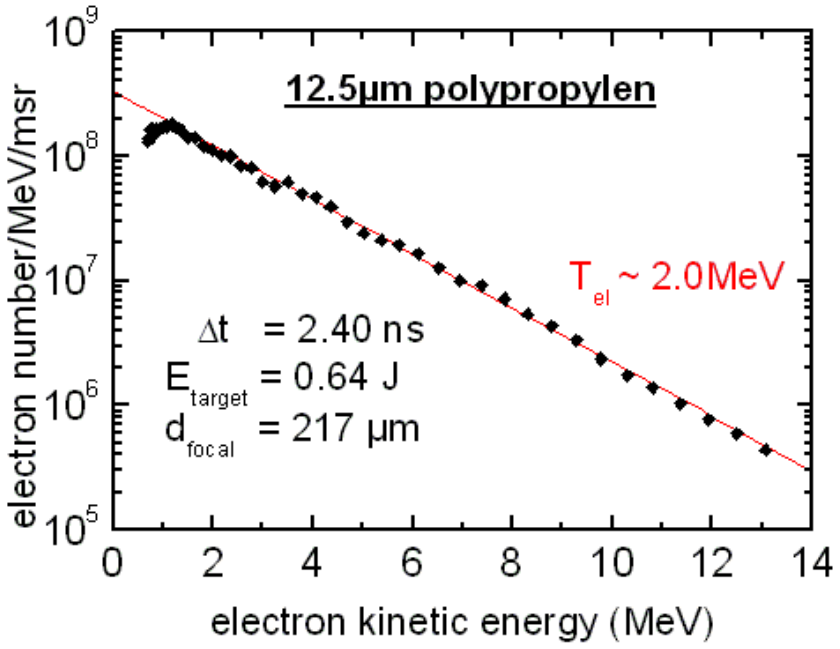
- Mixed radiation fields: electron, proton/ion, photons and neutrons.

Today, we are going to speak about trapped particles environment.

Trapped Particles Environment : Electron

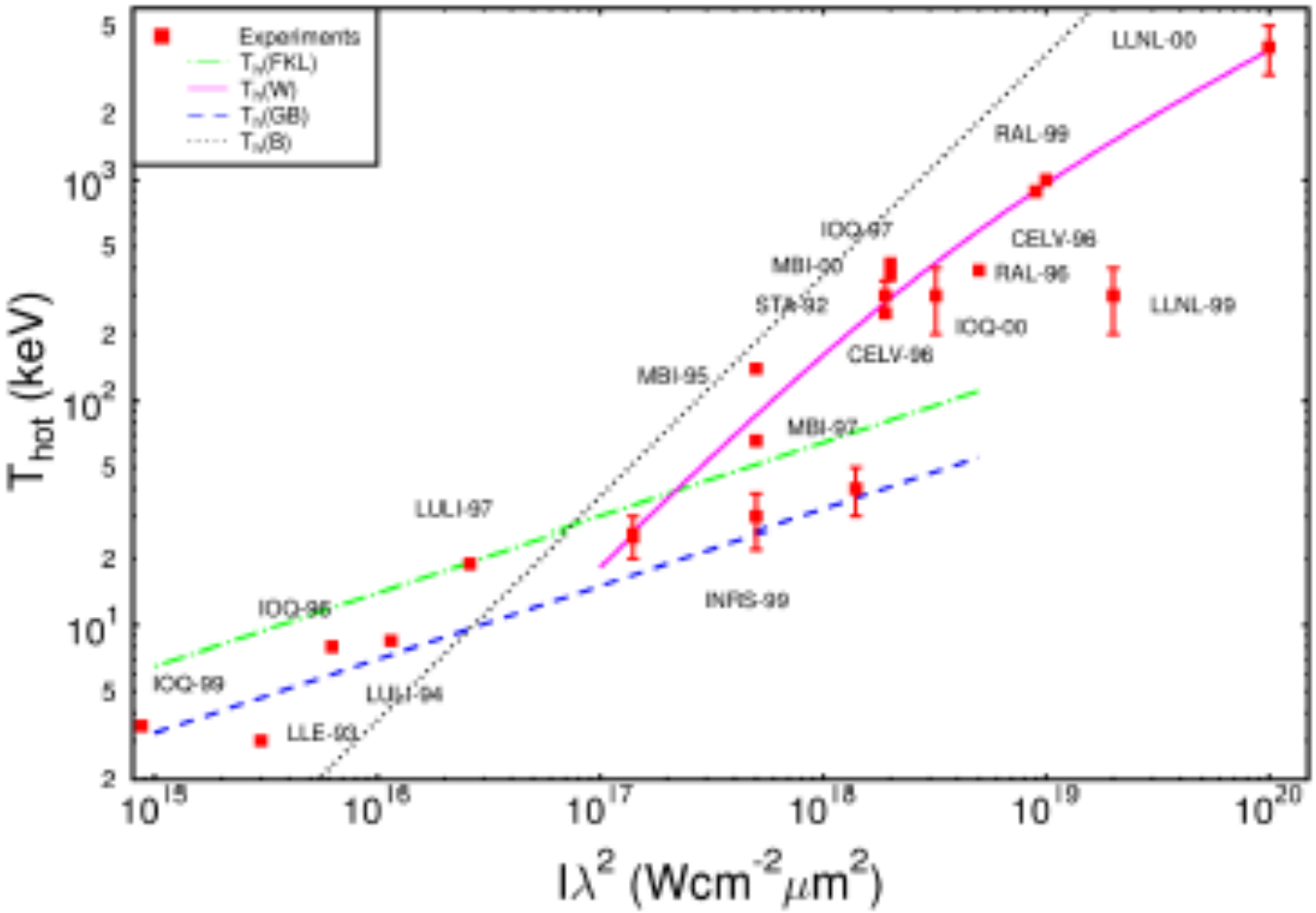


S. Samwel et al.,International Journal of Astronomy and Astrophysics 01, 2006.



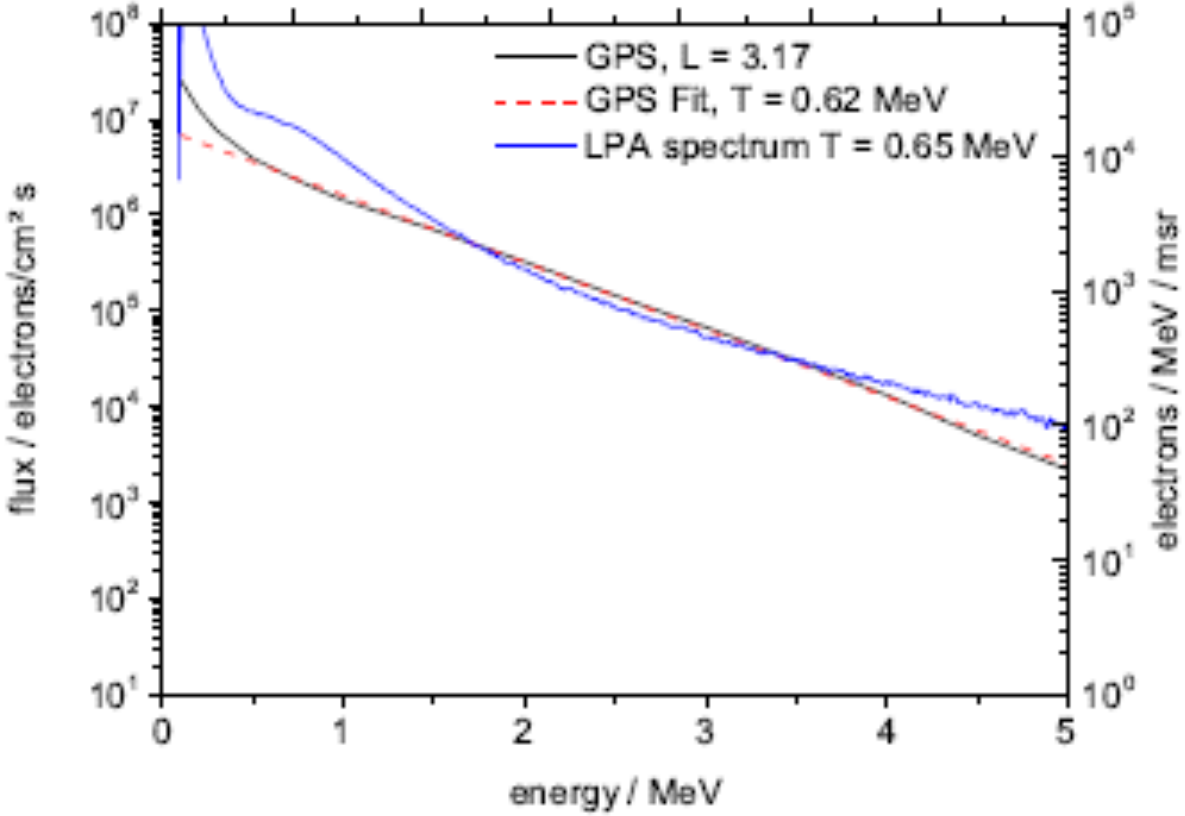
ATLAS-Laser system (mpq.mpg.de)

- Large energy broadband.
- Low energy electron might be relevant for studies of surface charging.



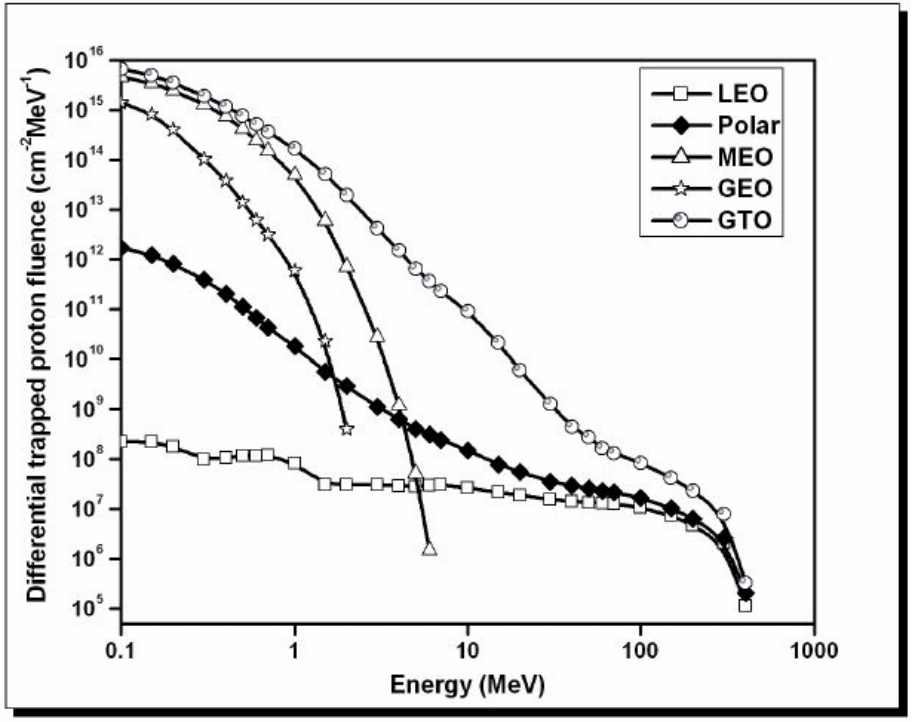
Hot electron temperature as a function of irradiance from experiments of sub-ps laser-solid interaction. The lines give **scaling laws** derived from different models [FKL: Forslund et al. (1977), W: Wilks et al. (1992), GB: Gibbon and Bell (1992), B: Brunel (1987)]. Gibbon (2005)

How similar would be the electron beam to those from space?

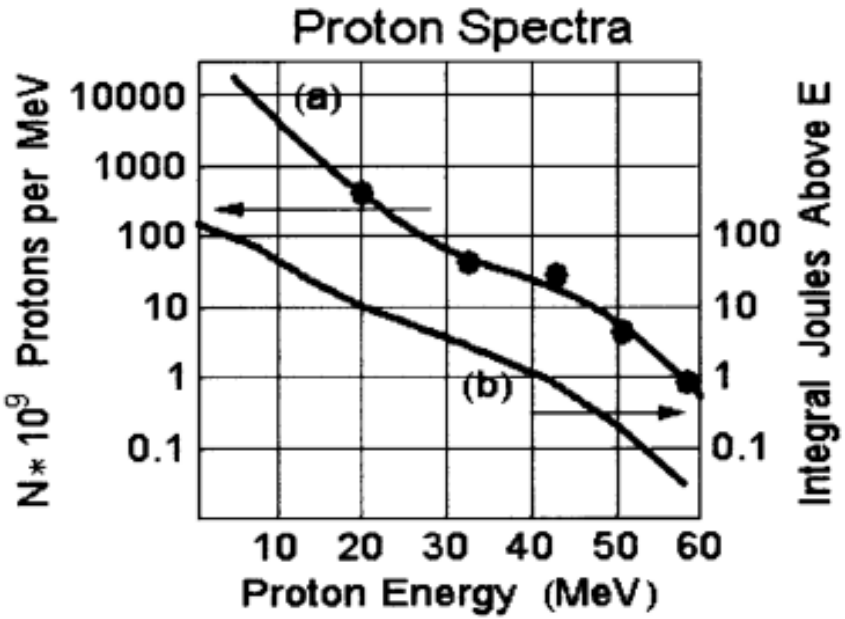


Reproduction of electron fluxes in the GPS orbit with laser-plasma-generated electron flux with Teff=0.65MeV. Hidding et al. (2013), ESA NPI Activity 4000102854

Trapped Particles Environment : Proton

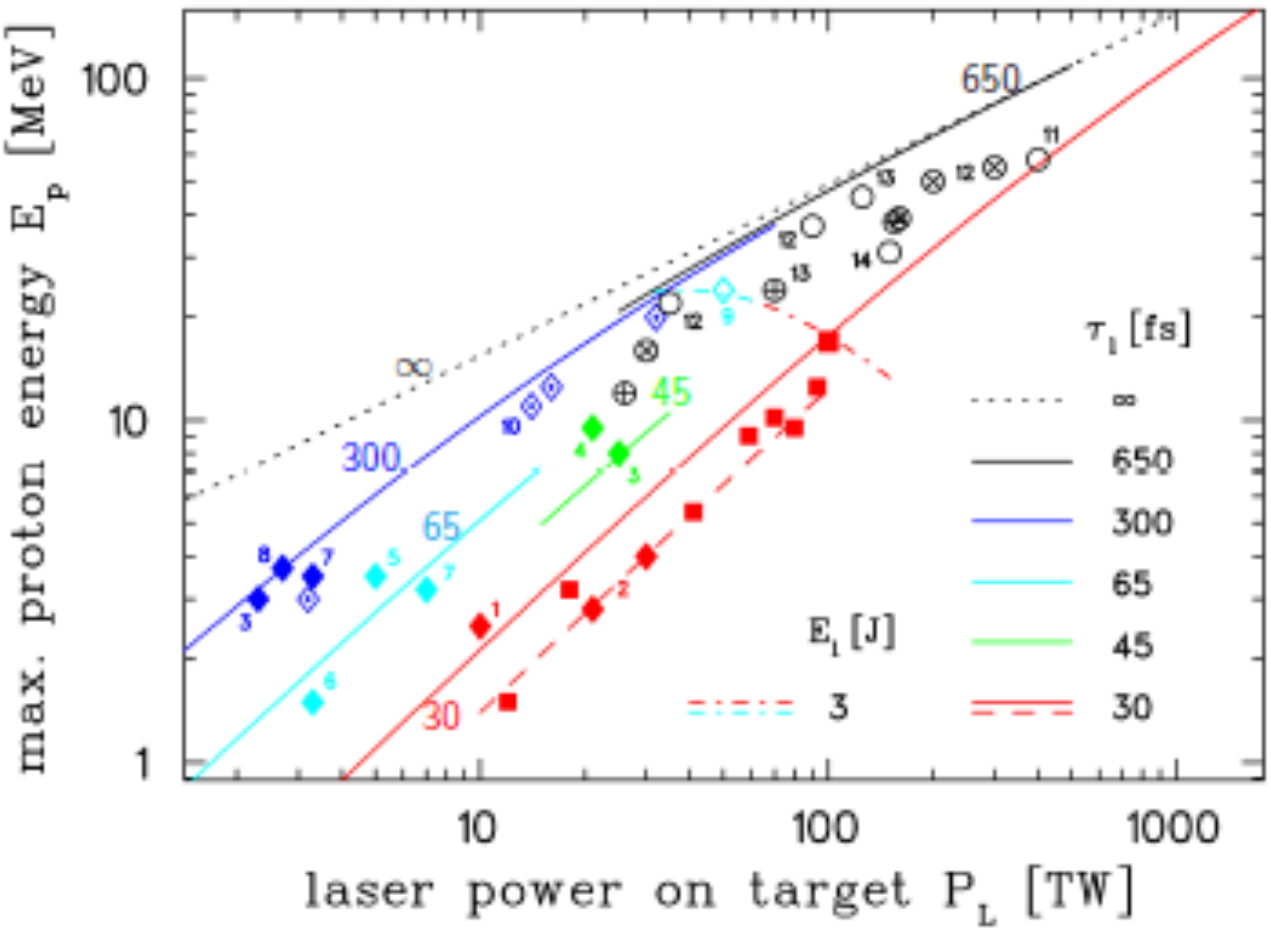


S. Samwel et al.,International Journal of Astronomy and Astrophysics 01, (2006).



Snavely et al. (2000)

❖ Large energy broadband



Experimental scaling of proton energy cut-off with laser power and pulse duration.
Zeil et al. (2010), New J. Phys. 12, 045015.

How different would be the particle beams to those from space?

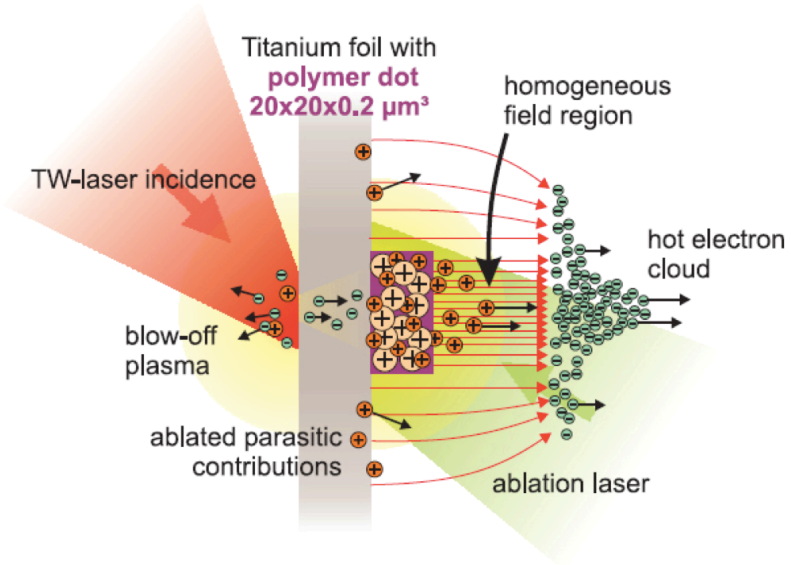
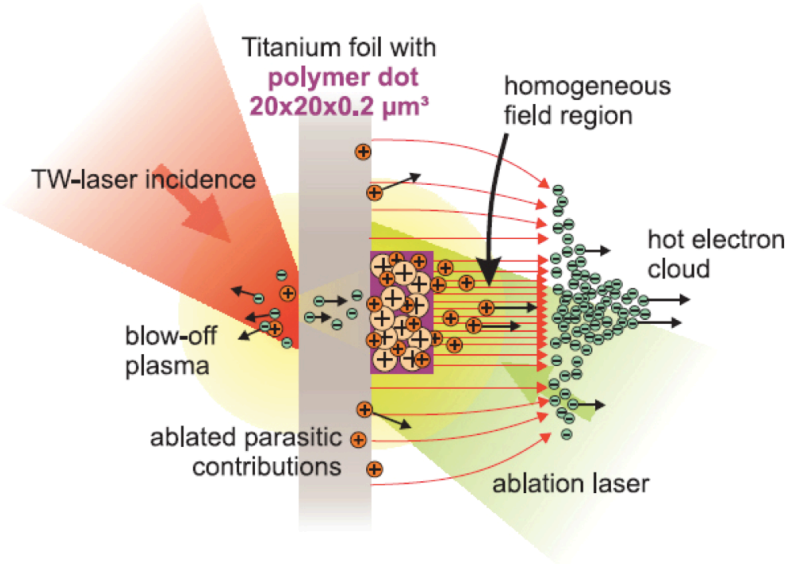


Image taken from S.M. Pfotenhauer et al, New J. Phys. (2008) 033034

- The radiation field is pulsed, since it is generated during the laser pulse interaction.
- Bunch of particles (scale of 10-100fs).
- Very high particle flux.

Is this (+) or (-) ?

How different would be the particle beams to those from space?



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- The radiation field is pulsed, since it is generated during the laser pulse interaction.
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Is this (+) or (-) ?

- (+) We will have enough particle flux to reproduce an space exposition in a short time.
- (-) Nonlinear effects might occur at very high fluxes (the flux can be lowered easily but with the penalty of increasing the exposition time).
- (-) The experimental characterization of the radiation beam is not trivial.

Conclusion

- Laser-driven source might cover the need of affordable and compact accelerators for applications in the space industry.
- First studies are very promising (Hidding et al. 2013).
- There is a lack of knowledge about the effects that a bunch of particles in the time scale of the laser pulse might produce.
- Further studies are needed in order to validate that laser-driven source meets the criteria required in this field.
- The Spanish Laser Center (CLPU) is a high intensity laser facility with capability to contribute in this field together with the space radiation testing community.


Thank you
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