Centro Láseres Pulsados Ultracortos Ultraintensos

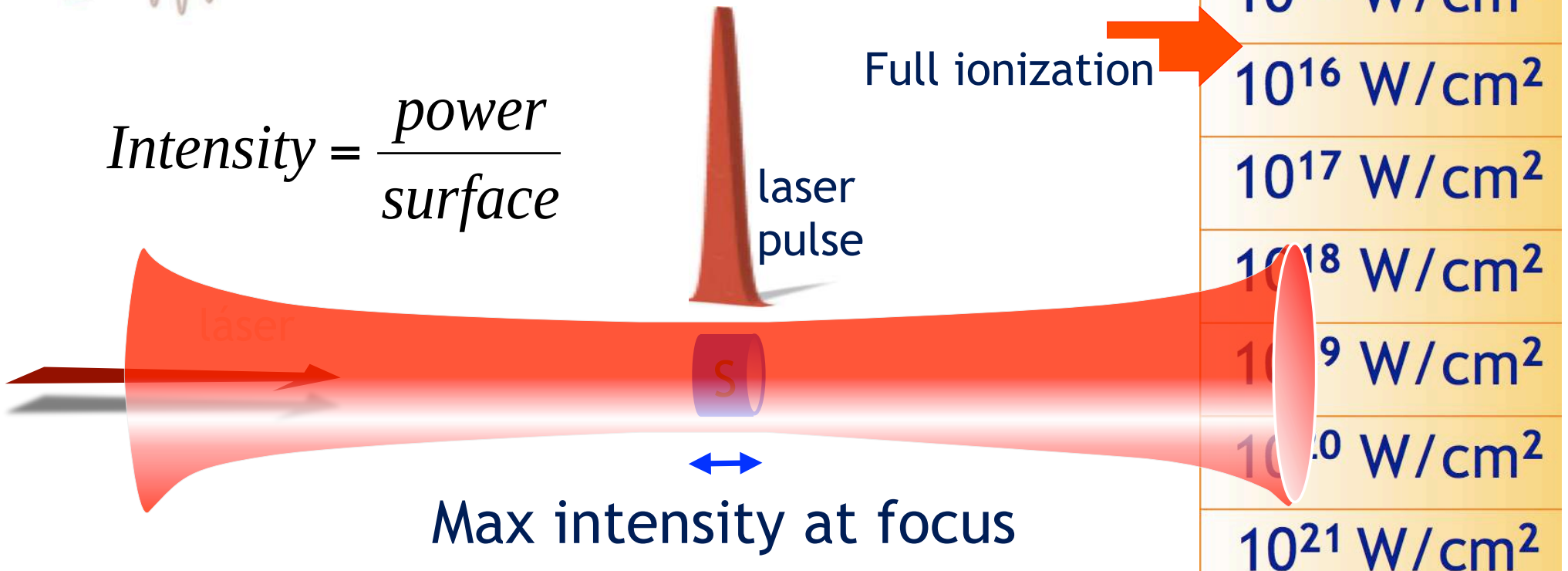
CLPU CENTRO DE LÁSERES PULSADOS

Infraestructuras Científicas y Técnicas Singulares

The VEGA laser

Intensity is the key parameter

$$Intensity = \frac{power}{surface}$$



Full ionization

Today's world record

10^{14} W/cm^2
10^{15} W/cm^2
10^{16} W/cm^2
10^{17} W/cm^2
10^{18} W/cm^2
10^{19} W/cm^2
10^{20} W/cm^2
10^{21} W/cm^2
10^{22} W/cm^2
10^{23} W/cm^2
10^{24} W/cm^2

Concentration of energy in space and time

ULTRAHIGH-INTENSITY LASERS: PHYSICS OF THE EXTREME ON A TABLETOP

By stretching, amplifying and then compressing laser pulses, one can reach petawatt powers, gigagauss magnetic fields, terabar light pressures and 10^{22} m/s^2 electron accelerations.

Gérard A. Mourou, Christopher P. J. Barty and Michael D. Perry

Over the past ten years, laser intensities have increased by more than four orders of magnitude[1] to reach enormous intensities of 10^{20} W/cm^2. The field strength at these intensities is on the order of a teravolt per centimeter, or a hundred times the Coulombic field binding the ground state electron in the hydrogen atom. The electrons driven by such a field are relativistic, with an oscillatory energy of 10 MeV. At these intensities, the light pressure, $P = I/c$, is extreme, on the order of giga- to terabars. The laser interacting with matter—solid, gas, plasma—generates high-order harmonics of the incident beam up to the 3 nm wavelength range, energetic ions or electrons with mega-electron-volt energies (figure 1), gigagauss magnetic fields and violent accelerations of 10^{21} g (g is Earth's gravity). Finally, the interaction of an ultraintense beam with superrelativistic

time-resolved x-ray experiments in the femtosecond range, or at the Stanford Linear Accelerator Center (SLAC) to test nonlinear quantum electrodynamics by the interaction of the high-intensity pulses with superrelativistic electrons.

Some of the new tabletop-laser principles have been implemented on existing large laser systems built for laser fusion. Lawrence Livermore National Laboratory, Los Alamos National Laboratory, the Commissariat à l'Energie Atomique (CEA) in Paris, the Rutherford Appleton Laboratory in the UK and the Institute of Laser Engineering in Osaka, Japan, have all added subpicosecond pulse capabilities to their nanosecond lasers, pushing their peak power by three orders of magnitude from 1 terawatt to 100–1000 TW.

Figure 2 presents the focused intensity of lasers as a

Extreme lasers

vs

Big Lasers

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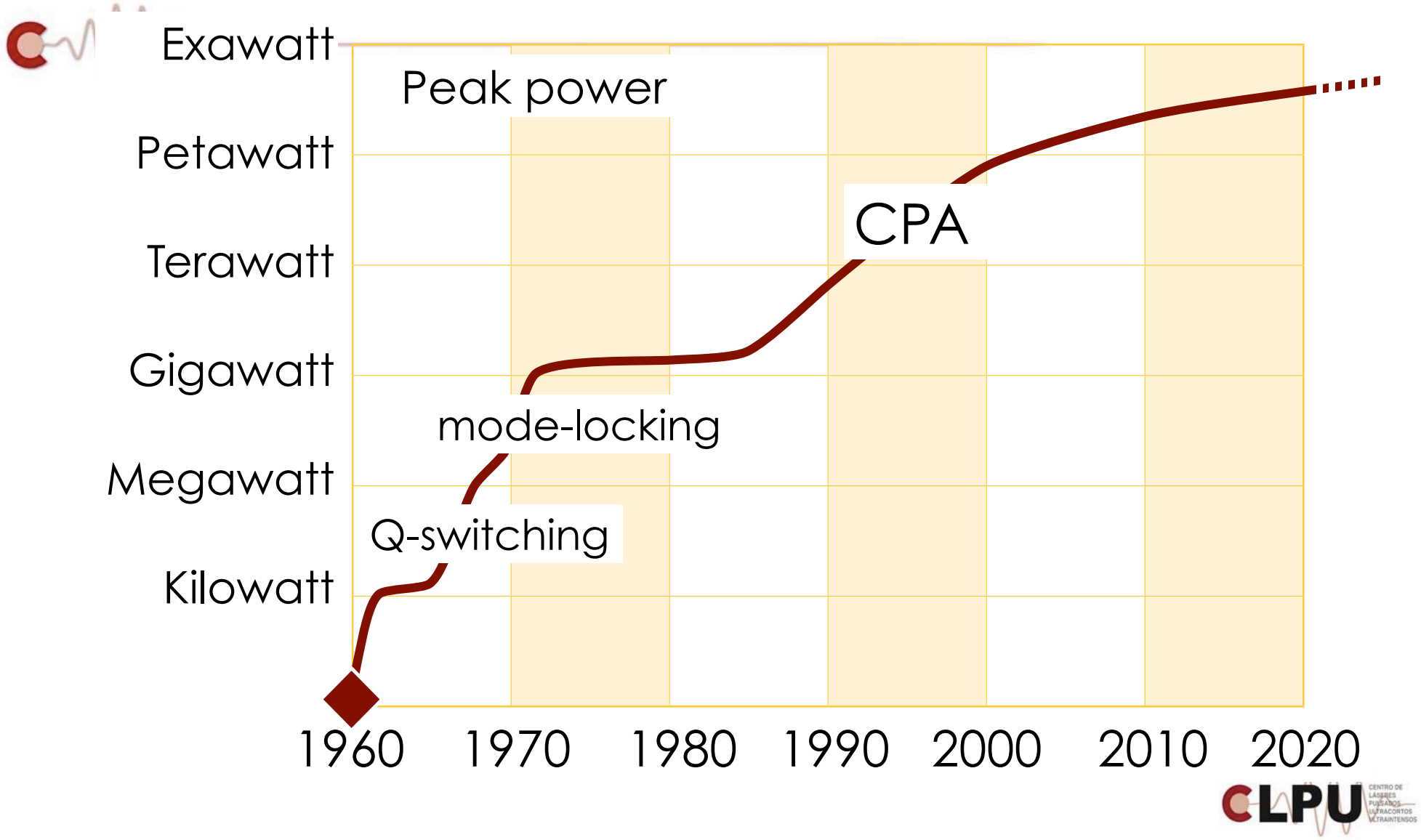
Exawatt
Petawatt
Terawatt
Gigawatt
Megawatt
Kilowatt
Peak power
CPA
mode-locking
Q-switching
1960
1970
1980
1990
2000
2010
2020
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Extreme lasers are not too big!!!

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Plasma accelerators

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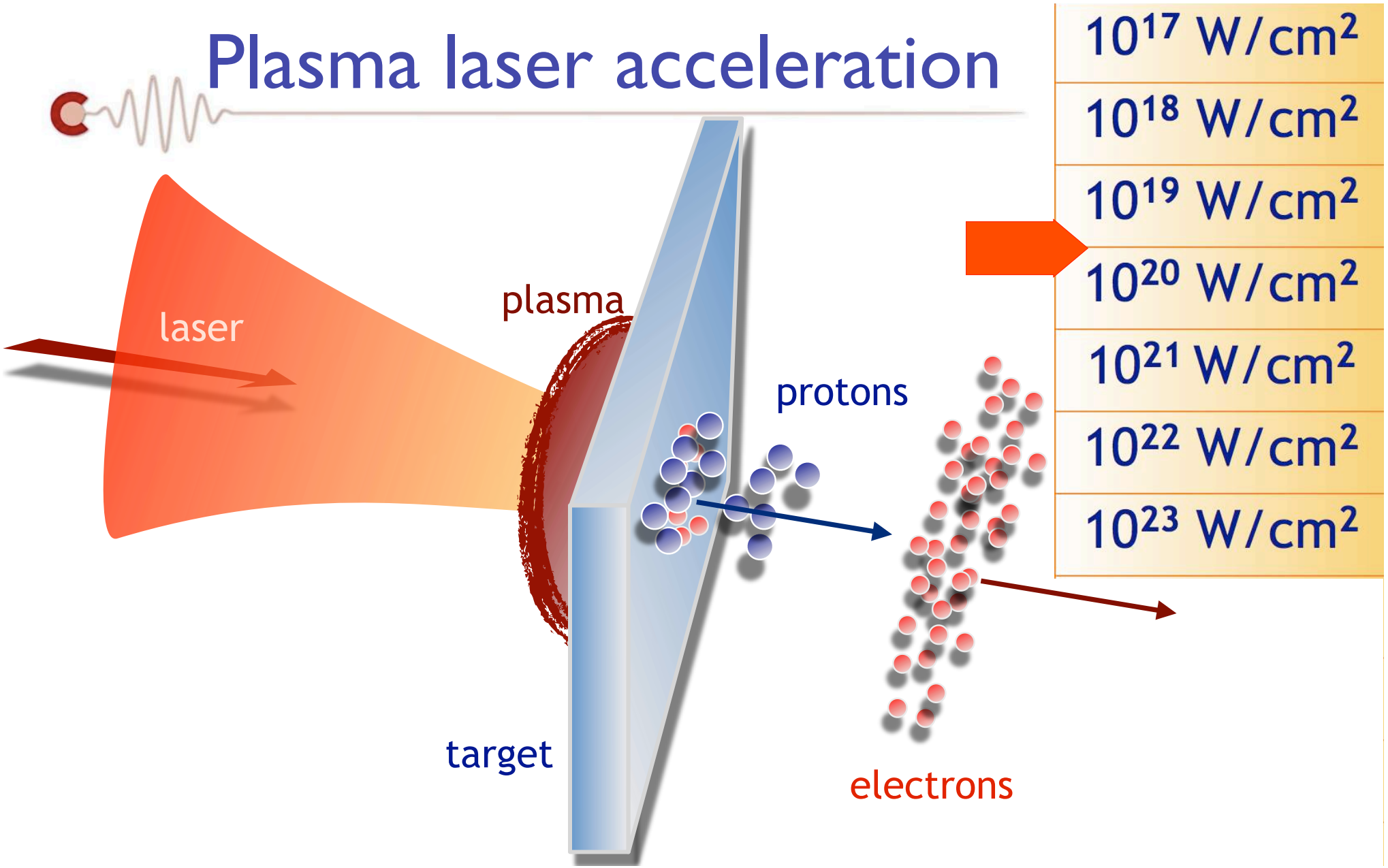
Plasma laser acceleration



Particle accelerators

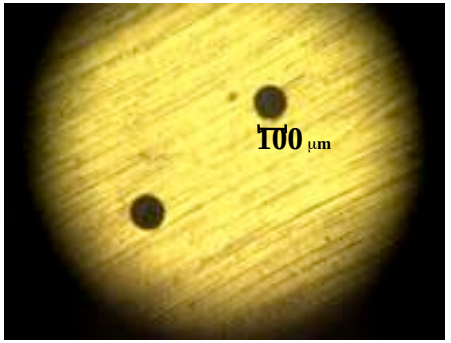
Ultracompact particle accelerators with extreme fields

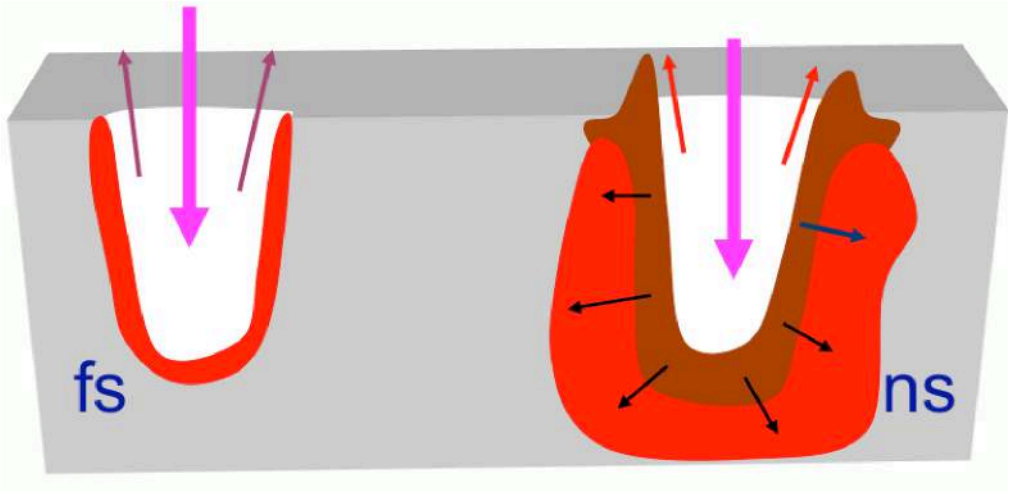
Conventional accelerator

Laser Accelerator
Wim Leemans, Berkeley

Femtosecond micromachining

Micromachining





Pulse duration is fundamental

Chichkov et al, Appl. Phys. A 63 (1996)

Femtosecond filamentation

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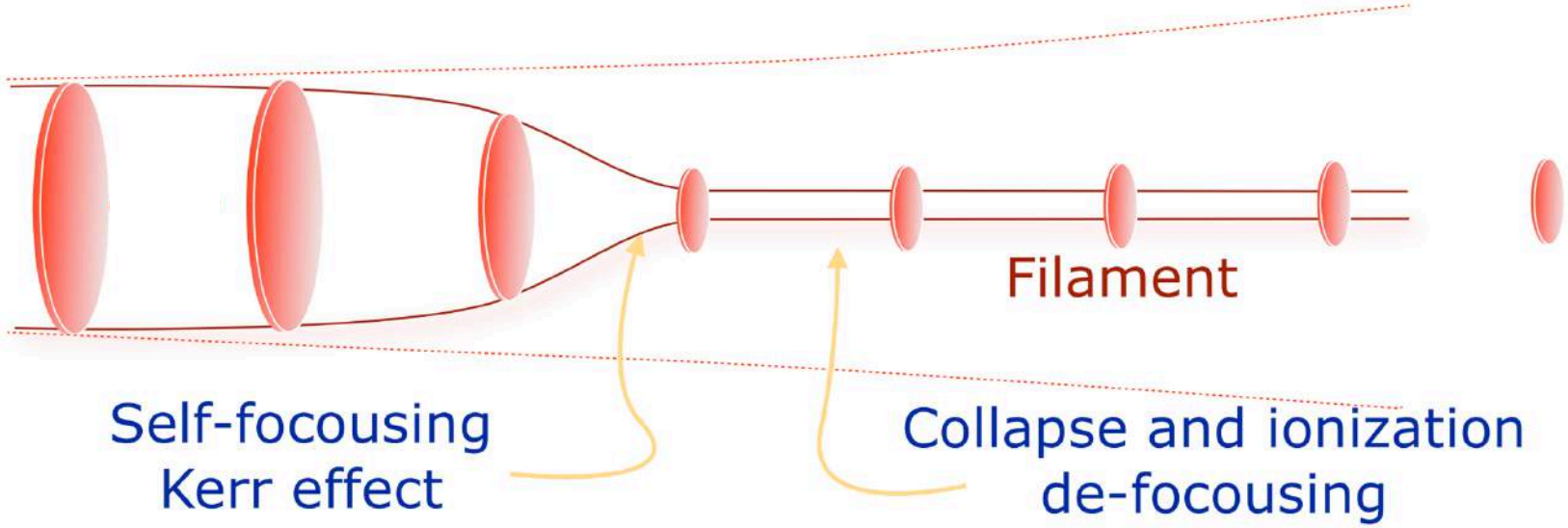
Femtosecond laser filamentation



filament diameter
70 microns
from S L Chin
Laval Univ

meter

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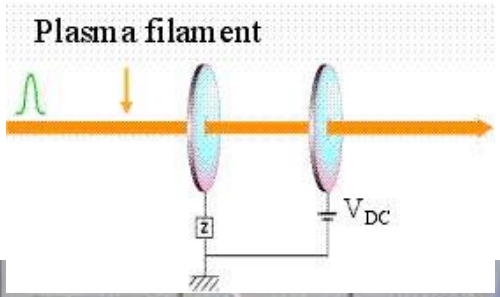
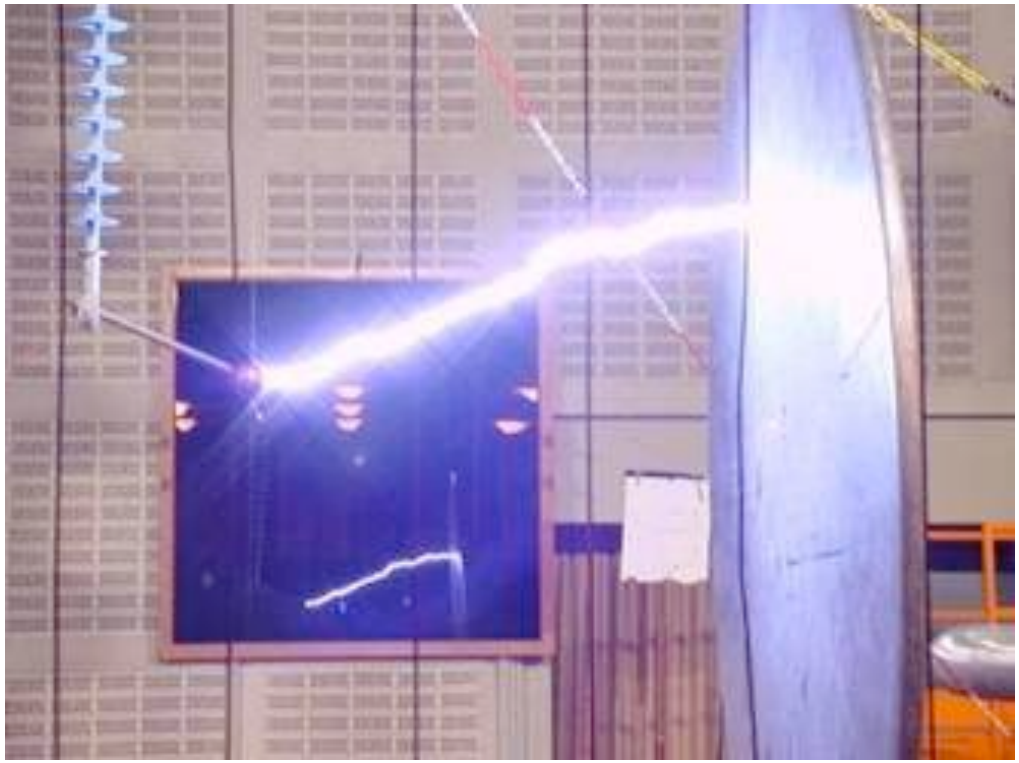
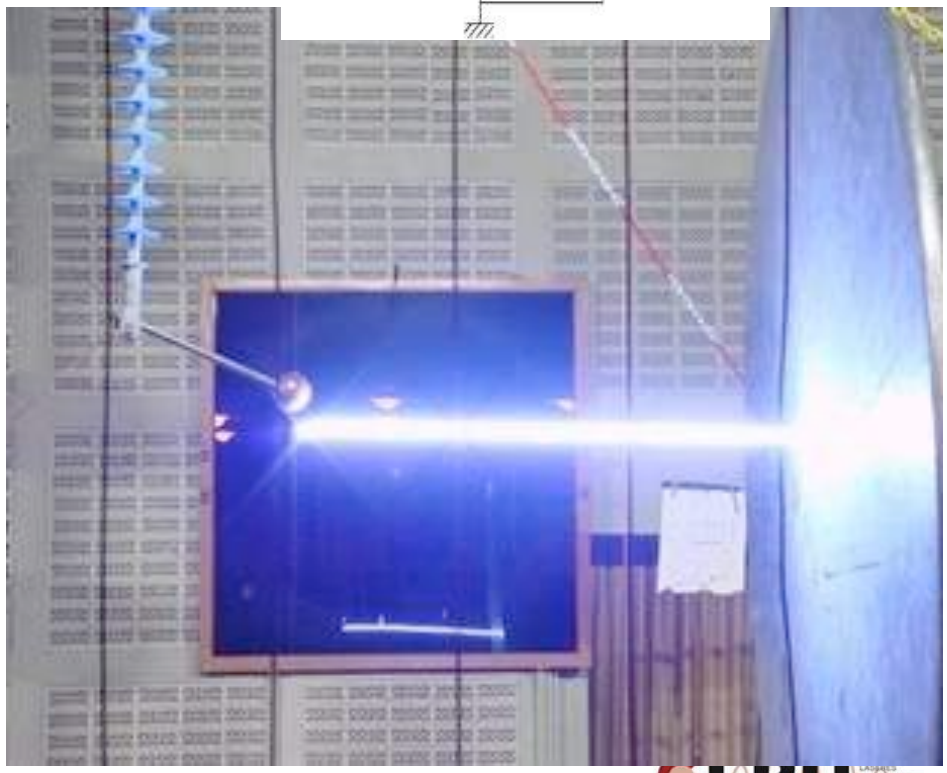
Electrical discarge guiding

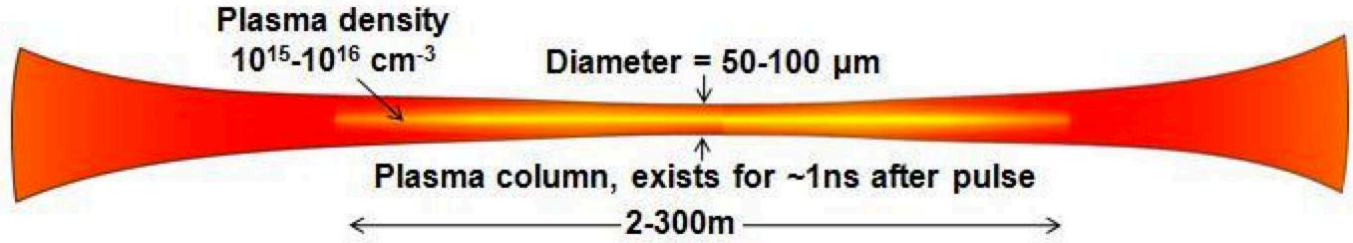
Laser plasma

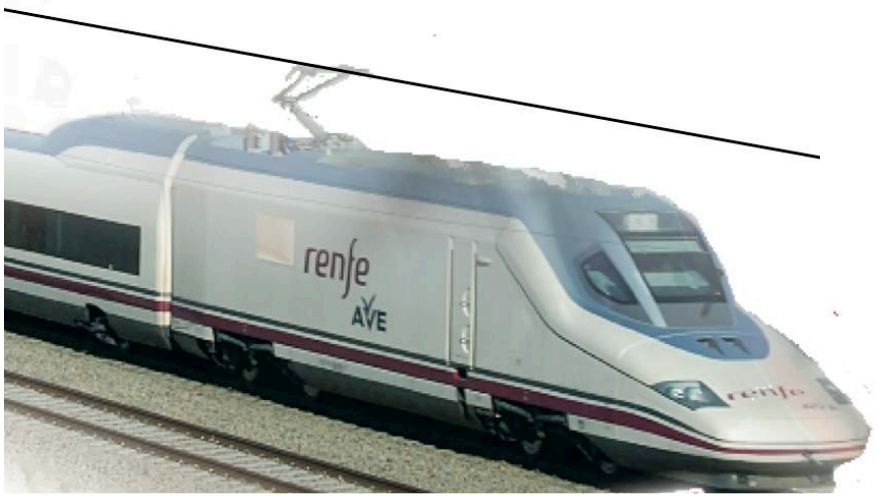






Train power supply ...





No need of mechanical contact pantograph-catenary

One application: Laser-induced X-ray sources

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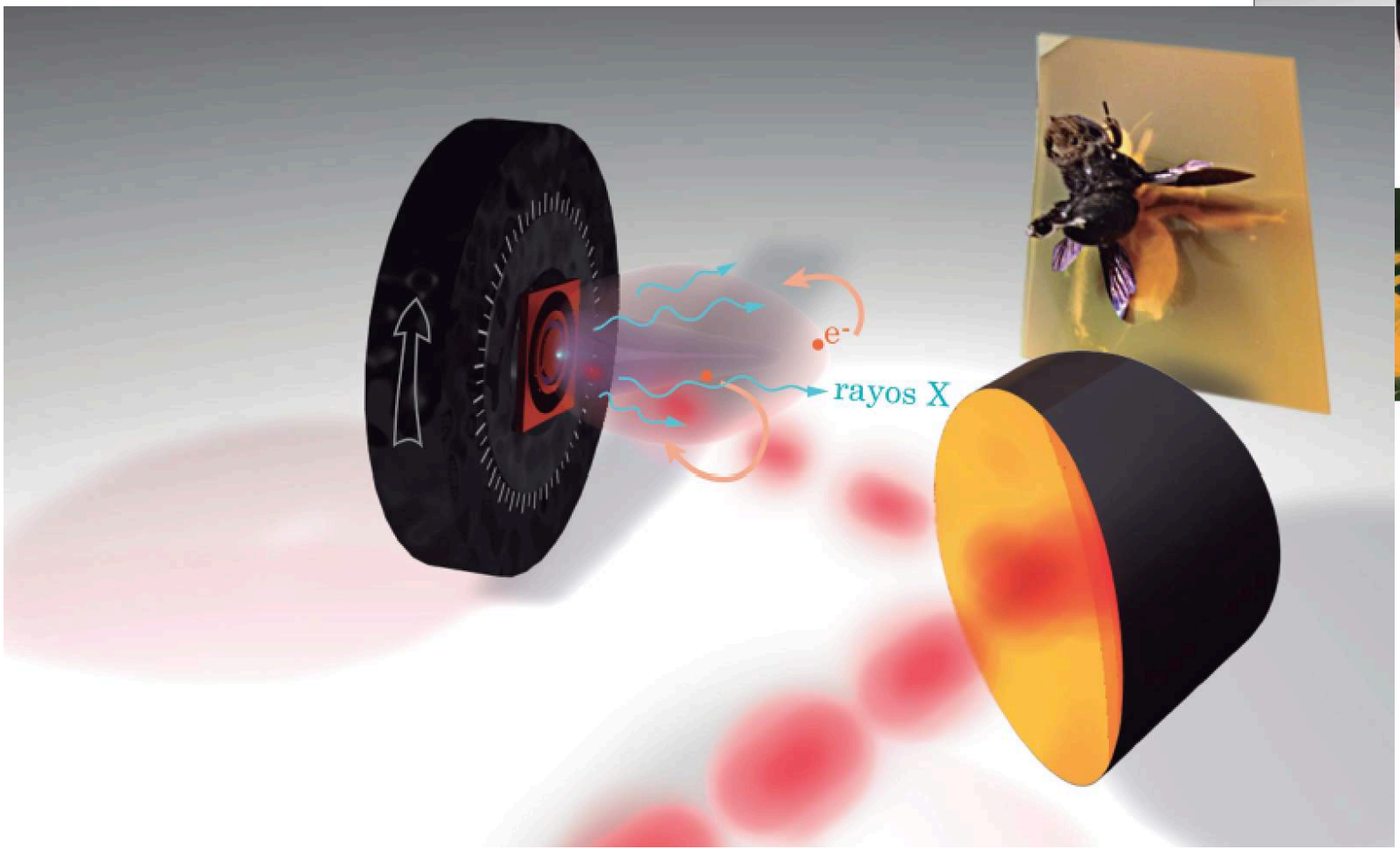
Fran Valle

X-ray source



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	peak power	energy	duration	repetition rate	operation
VEGA 1	20 TW	600 mJ	30 fs	10 / sec	2007
VEGA 2	200 TW	6 J	30 fs	10 / sec	2013
VEGA 3	1 PW	30 J	30 fs	1 /sec	2016
	10 GW	5 mJ	120 fs	1000/seg	2013
	10 GW	< mJ	6 fs	1000/seg	2013

Proyectos actuales

Seguridad vial
Faros coche
Materiales
Laser industrial
Security, inspeccién de mercancias
Redes eléctricas alta tensión
Vacío y ultraalto vacío
Cirugía de precisión
Radioterapia X
Radioterapia protones
Diagnostico PET
Detectores de radiactividad

+ pulsos rayos X
+ attosegundos

+ desarrollo tecnología láser (Mauricio Rico)

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The VEGA laser

Junta de Castilla y León

MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD

UNIÓN EUROPEA
FONDO EUROPEO DE DESARROLLO REGIONAL
"Una manera de hacer Europa"

Gracias !!!

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