PLASMA ACCELERATION

Conventional accelerators employ oscillating radio radiofrequency (RF) fields to accelerate charged particles. The accelerating rate in these devices is restricted by electrical breakdown in the accelerating tube. This limits the amount of acceleration over any given space, requiring very long accelerators to reach high energies.

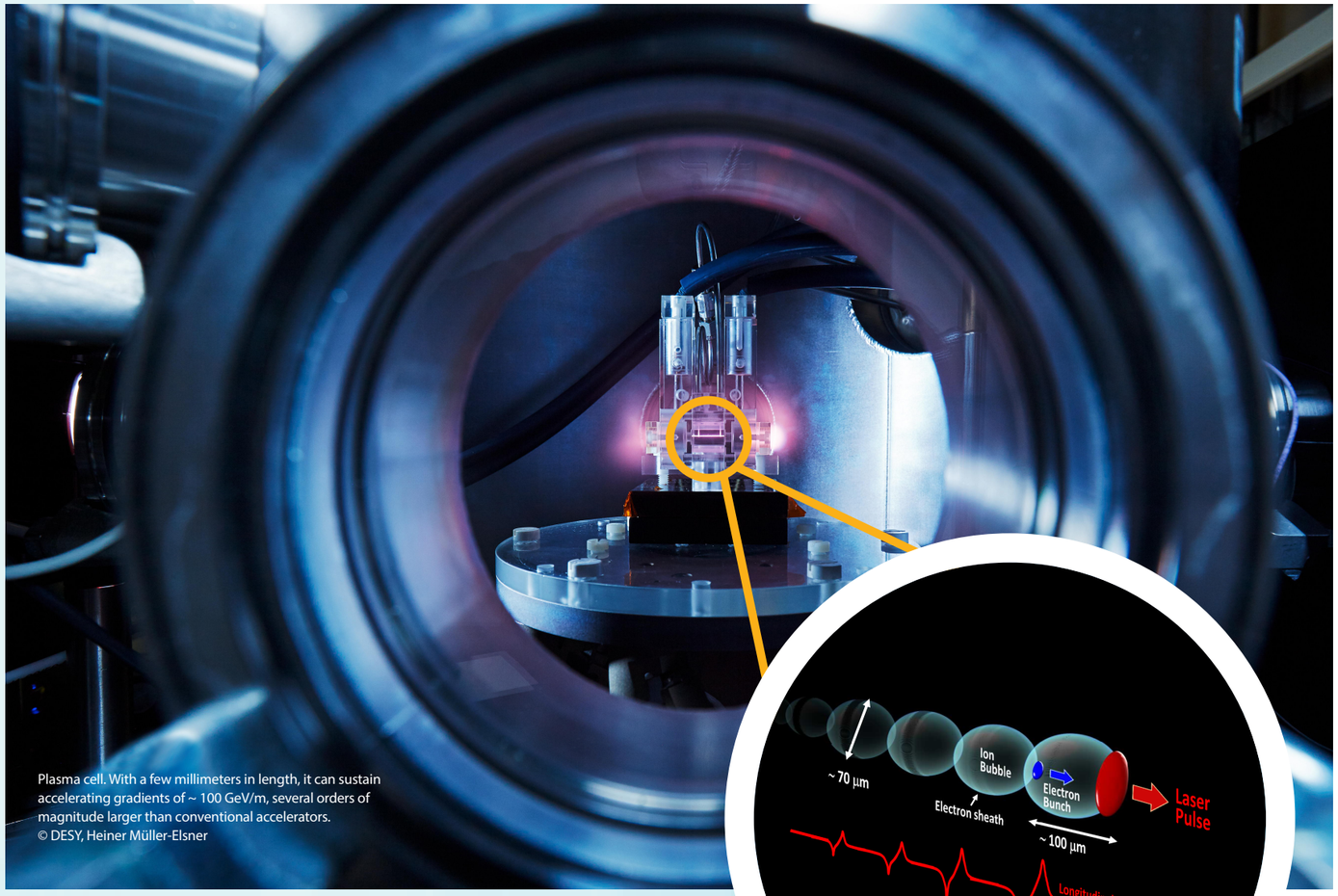
Electrons are accelerated in the plasma like surfers riding a wave.

A new paradigm in particle acceleration

In plasma accelerators the electric fields are created by driving a laser pulse or particle beam through a gas or a pre-ionized plasma. The local imbalance between positive and negative charges in the wake of the driving beam creates electric fields of the order of 100 GV/m. Any electrons trapped in between the middle and the back of the wake will be accelerated forward.

When the plasma wave is formed by an electron or proton bunch the technique is called plasma wakefield acceleration (PWFA); if a laser pulse is used instead it is called laser wakefield acceleration (LWFA).

In external injection schemes, electrons are strategically injected after the driver beam to arrive at the wake at the time of maximum expulsion of the plasma electrons.



Plasma cell. With a few millimeters in length, it can sustain accelerating gradients of ~ 100 GeV/m, several orders of magnitude larger than conventional accelerators.
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Illustration of the Laser Wakefield Acceleration concept. If the laser is strong enough, all of the ionized plasma electrons can be removed from the center of the wake: this is known as the "blowout regime". It appears that a "bubble" of charge is moving through the plasma at close to the speed of light.

1 electron-volt (eV) is the energy acquired by an electron when it is accelerated by an electric potential of 1 volt.
1 keV = 1,000 eV
1 MeV = 1,000 keV = 1,000,000 eV
1 GeV = 1,000 MeV = 1,000,000,000 eV
1 TeV = 1,000 GeV = 1,000,000,000,000 eV
1 TeV is approximately the energy of a flying mosquito.

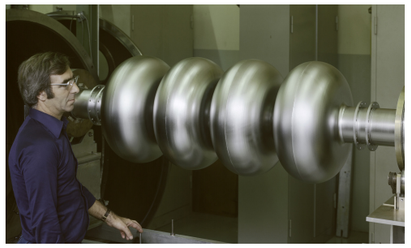
Advantages of plasma accelerators

- Acceleration rates 2 – 3 orders of magnitude higher than RF accelerators.
- Acceleration length 100 to 1000 times shorter than conventional accelerators.
- Ultrashort electron bunches.

Current limitations

- Lower beam energy and lower beam quality than conventional accelerators.
- Poor shot-to-shot stability.
- Operation limited to working hours and days.

EuPRAXIA addresses specifically these limitations by an extensive program of research.



RF cavity. Typically a few meters long, it sustains accelerating rates of ~ 0.1 GeV/m. © CERN.

A plasma is an ionized gas, that is, a state of matter in which electrons are detached from their atoms, which hence become ions. Familiar forms of plasma are lightning and neon lights. Although not so common on Earth, plasma is the most abundant form of ordinary matter in the Universe.

EuPRAXIA

www.eupraxia-project.eu

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