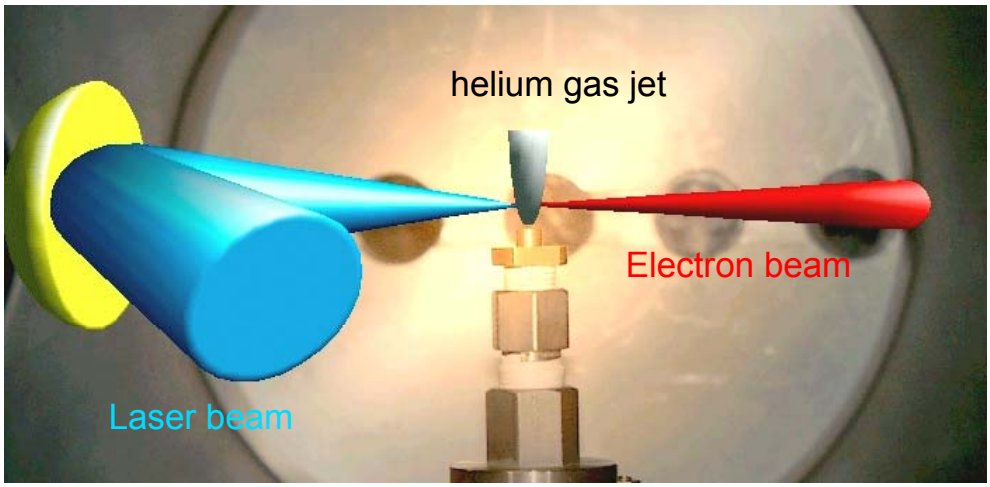
**Laser produced particle beams :**
**A new tool for science**

With a compact, powerful (30 TW) and high repetition rate (10Hz) lasers systems it is today possible to produce with plasmas energetic electron as well as proton beams. Such plasmas are created by focusing an intense laser pulse onto matter. As an ionised medium, plasmas can consequently support extremely high electric fields. In this context, their peak values have recently been demonstrated to exceed several TV/m, which is more than 4 orders of magnitude higher than those available with conventional accelerator technology. Therefore, it is not only possible to accelerate particles with these plasmas – but also to generate particle beams themselves. Electron beams are typically produced using gas jets and proton beams are commonly obtained using thin foil targets. At Laboratoire d'Optique Appliquée, LOA-ENSTA-Ecole Polytechnique-CNRS, European scientists have demonstrated that with a moderate laser energy (1 J), high repetition rate and hence low cost laser system energetic electron and proton beams can be produced.

In a new regime [1]– the "forced laser wake field" – high quality (normalized emittance less than few $\pi$mm mrad), ultra short (less than 100 fs) [2], electron beam with energies up to 200 MeV has been generated. A first application of these ultra-short electron beams, which are perfectly synchronised with the laser beam has been achieved for pump-probe experiments in ultra-fast chemistry. This experiment has permitted to study the first events in the pre-thermal regime which cannot be studied with conventional LINACs, as these provide electron bunches with a duration beyond some ps. More recently proton beams with energies up to 10 MeV have also been obtained with the same compact laser system [3]. Medical applications in protontherapy to trait the cancer tumours [4] and for the production of short lived radioisotopes for Positron Emission Thomography [3] will be an issue when improving the laser parameters.

Such particle beams produced by compact laser systems are very promising for the future, since they will certainly have an important impact in science as well as society. Bringing together researchers from different fields they will contribute to merge new and pertinent ideas. Due to their moderate cost such subjects can be developed in many universities around the world.




*The laser beam is focused on the target. During its propagation, the gas is instantaneously transformed in an under-dense plasma in which plasmas waves are excited. After breaking of these plasma waves electron beams are produced. Proton beams can be produced by replacing the gas jet with a thin foil target using the same experimental set-up. Note the very small size of the interaction zone.*

[1] Malka, V. *et al.*, Science **298**, 1596 (2002).
[2] Fritzler, S. *et al.*, Appl. Phys. Lett. 83, 19 (2003)
[3] Fritzler, S. *et al.*, Appl. Phys. Lett. 83, 15 (2003)
[4] Fourkal, E., Li, J. S., Ding, M., Tajima, T., Ma, C.-M., Medical Phys. **30**, 7 (2003).

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