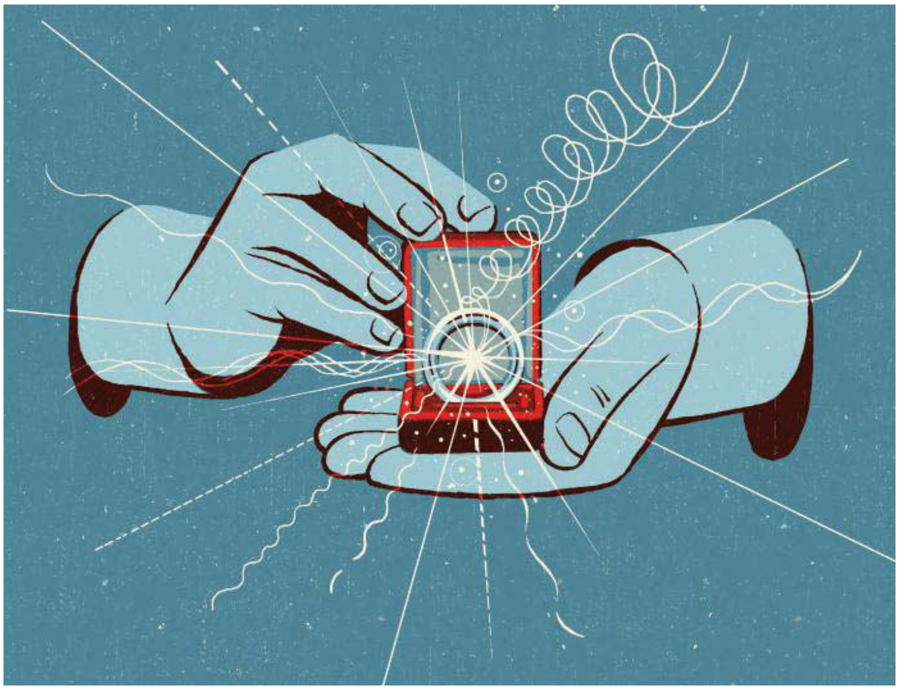

HIGH SPEED

*by Massimo Ferrario**

Particle accelerators use is not limited to research. They can treat tumors, reduce pollution and improve our lives. Do they have limits? Costs and dimensions. But a new tabletop generation is coming.

PARTICLE ACCELERATORS can revolutionize our future, helping us discover the origin of the universe, treating tumors and keeping pollution under control. There is just one problem: they are huge and very expensive. But teams of physicists, including many Italians, are miniaturizing them in order to make their extraordinary benefits available to everybody. The most famous particle accelerator is the Large Hadron Collider (LHC) at Cern, Geneva. In 2011, when it was powered up, it became the protagonist of every newspaper cover for its ability to accelerate particles up to 99.9999991% of the light speed, in a 27 kilometers ring located 100 meters underground, and costing more than 5 billion euros.

Just one year later, in July 2012, this accelerator was able to detect a particle whose existence had never been proved before: the Higgs Boson, **the source of the mass of all bodies**. And it doesn't stop there, more questions await an answer: why is the Universe expanding faster than we thought? Why is it made up for 95% of something we do not see, the dark matter, but that influences the motion of galaxies?

Enrico Fermi asked similar questions back in 1954, but the technology of the time did not help him: to accelerate particles at the needed energy, he could only imagine an accelerator whose circumference was as long as the equator or, even better, an accelerator orbiting around Earth, that he called Globatron. However, just seven years later, the scientific horizon was revolutionized by a new idea, thanks to an Austrian physicists, Bruno Touschek, and a **young Italian team** from the National Laboratory of Frascati of the National Institute for Nuclear Physics (INFN).

The idea was as brilliant as it was simple: making two particle beams circulating at equal speeds in opposite directions within the same accelerator collide, rather than shooting the particle at a fix target, as it had always been done up to that moment. That way, the energy available during the collision is extremely higher and offers a wider discovery potential.

ILLUSTRATION: ANGELO MONNE

RADIATION FOR EVERYBODY

Only 1% of all accelerators is currently devoted to particle physics. The rest of them is applied to a number of different fields, such as medical science, art, industry.

1 ONCHOLOGY About 40% of tumor patients undergo therapy based on X-rays, generated by particle accelerators. New generations accelerators allow to focus the radiation more precisely, avoiding damage to surrounding tissue. These machines are very expensive; one of them can be found at the Pavia National Centre of Hadrontherapy.

2 ENVIRONMENT AND NUTRITION Cutting down air pollution, managing waste water, sterilizing food bacteria can be achieved irradiating materials with particle beams that alter their chemistry.

3 NEW MATERIALS Exposition to electron beams can result in new materials such as those providing the «memory effect», like «memory foam» mattresses, that are able to change their shape according to temperature and pressure, eventually getting back to their original state.

4 CULTURAL HERITAGE Reading ancient papyrus charred at Herculaneum avoiding damage; identifying coloring materials used by middle ages miniaturists; dating artwork verifying its authenticity. These are just a few of the possible applications of accelerators in the field of cultural heritage preservation.

5 DIAGNOSTICS There are also several medical applications. Strong X-ray beams (generated themselves by particle accelerators) can trace DNA and single proteins' structures, develop new drugs and study our biological cycle.

The new frontier is the tabletop accelerator, small and cheap. Every hospital could have access to revolutionary therapies and diagnostic methods

And it is thanks to this idea that today the Large Hadron Collider is able to reach five times the energy Fermi wished for Globatron.

But the dimensions of these machines are still huge, if they were smaller and cheaper **they could be used in hospitals**, universities and industrial labs. The number of patients that could benefit from new oncologic therapies based on particle radiation would increase enormously. Microelectronic industry could use these machines to produce even smaller components, the greatest calculators could be the size of mobile phones, knowledge would face new horizons.

The new frontier is the tabletop accelerator, as long as a pencil, with the same performances of big accelerators. A worldwide effort is ongoing to reaching this goal, also because of the possible economic benefits. Following this line of research the European project called EuPraxia (eupraxia-project.eu) was recently approved, featuring the participation of many Italian research centers, from the INFN Laboratory of Frascati to CNR and Enea. The tabletop accelerator **is as thin as a glass straw**: its hole has a 1 millimeter diameter, called capillary. A particle beam and a strong laser beam, meant to accelerate the particles, are injected at the same time in the capillary. There are still lots of obstacles to overcome, but researchers hope to reach their goal in no more than ten years, thanks to a "combination of hard work, intelligence, and a pinch of luck," as Fermi would have said.

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