Plugging the gap

Accelerator science plays an important part in basic science, medicine and industry, but as Carsten Welsch warns, a skills shortage threatens progress

The discovery of the Higgs boson at the CERN particle-physics lab near Geneva, which was announced in July 2012, created huge international excitement. Even those who had little interest in or understanding of physics realized that this was a major breakthrough – the final piece of the Standard Model of particle physics had finally been found. This achievement, however, could never have been made without pioneering research and development into accelerator science.

Accelerator science is one of the world's most dynamic research areas, driven by a number of developments in large-scale research infrastructures such as the X-ray Free Electron Laser (XFEL) in Hamburg, as well as an upgrade to CERN's Large Hadron Collider (LHC). While no-one can argue with the fact that basic science needs research into accelerators, there is also growing use for them in industry, from food supply and healthcare to energy production and security. For example, particle accelerators are used to produce isotopes for medical uses as well as in novel nuclear-reactor technologies and in cargo scanners for security applications.

The potential impact of accelerator science on our lives can be compared to the development of computer science back in the 1970s and 1980s. Firms raced to be first to produce a computer small enough to fit on a desk, pushing the frontiers of the technology at a faster rate than it was being taught in universities. Youngsters got their hands on early computers and started using them for gaming, building up their skills as they played. This meant that a whole generation of programmers were self-taught. Peer networks also developed, where programmers shared tips and experiences.

While you can't play with a particle accelerator in your bedroom, we are seeing a similar situation happen in accelerator science, with the demand for skilled engineers and researchers in industry outpacing academia. And just like the early computer user groups, we now have pan-European programmes such as the Optimization of Particle Accelerators (oPAC) and Laser Applications at Accelerators (LA^{3}NET) networks, which is part of the Marie Curie Initial Training Network scheme. Together, they have trained more than 40 researchers. Both programmes are co-ordinated by the Cockcroft Institute in the UK.


CERN

In demand More needs to be done to train researchers in accelerator science – a field that has many applications.

Yet despite these initiatives, there are concerns that advances in accelerator science may be delayed by a skills shortage. This shortage will be one of the key themes at the Symposium on Lasers and Accelerators for Science and Society – held in Liverpool this month – that will call for further support for training the next generation. Indeed, investment in infrastructure, such as the XFEL and at CERN, is not being reflected by a corresponding support in skills development and we will see a situation where there is fierce competition for accelerator scientists and engineers.

Impact on medical treatment

Perhaps the most worrying consequence of this is the impact that it may have on improvements in healthcare, specifically cancer therapies. Accelerators are now widely used for medical applications, for example, to generate X-rays for diagnostics, to produce isotopes as biological markers as well as to create charged-particle beams for cancer treatment. Cockcroft researchers and their collaboration partners have shown that this technology has numerous advantages over conventional treatment methods for specific cancer types. While traditional radiotherapy uses beams of high-energy X-rays to kill tumours, the way that dose is delivered to the patient means that healthy cells around the cancer are also affected. Ion therapy allows us to restrict the radiation dose almost perfectly to the 3D shape of the tumour, thus protecting healthy cells.

The UK's Clatterbridge Cancer Centre is one of only a dozen centres in the world to offer ocular proton beam therapy. Protons penetrate tissue for a short precise distance and deposit most of their energy at the end of the beam so the target cancer is destroyed but the healthy tissue is spared. It is possible to control how deep the beam goes, so it can be used to treat a tumour on the iris or one at the back of the eye. In addition, by automating the treatment process, set-up time could be dramatically reduced in the future, allowing more patients to be treated.

Other interesting work being performed at the Cockcroft Institute is around miniaturizing particle accelerators. They would use lasers in combination with dielectric microstructures to accelerate particles to high energies over just a few centimetres. This research could one day result in particle accelerators that fit in the palm of your hand. Minimizing the size and cost of particle accelerators will create more new applications and also make this technology more accessible to the international healthcare market, which can only be good for cancer patients.

The benefits of accelerator science are undisputed. Yet there is still a very dramatic lack of experts in Europe. National initiatives alone, although pushing in the right direction, are simply not sufficient and more EU-wide collaboration needs to be established and supported. Indeed, there will simply not be enough researchers to commission, operate and continuously optimize our key research facilities or to meet the quickly growing industry sector that has a high demand for accelerator experts.

International networks such as oPAC and LA^{3}NET have helped, but we need to see additional initiatives in the future to help overcome the skills shortage. We need more undergraduate and postgraduate programmes in accelerator science at universities across Europe as well as "cross-sector" schemes with relevant private sector institutions providing continual development opportunities. We also need more outreach activities to increase the number of physics and engineering students entering this exciting field. If this gap cannot be closed quickly it may have dramatic consequences.

Carsten Welsch is at the University of Liverpool and the Cockcroft Institute of Accelerator Science and Technology, UK, e-mail c.p.welsch@liverpool.ac.uk