LHCb’s extra dimension

Predictability can be both reassuring, and a bit dull. For physicists at CERN, the Standard Model of particle physics is like a jigsaw into which they are gradually fitting pieces. Some pieces seem to be fitting – measurements of the Higgs boson seem to be pointing towards a Higgs that fits beautifully. But most physicists prefer living life on the edge, and they are hoping to find pieces that just won’t fit. This would mean that the Standard Model isn’t right. And it would force a radical (and exciting) rethink; one that could lead to a theory that answers questions that the Standard Model leaves open. For example, why there is only matter in the Universe.

Jonas Rademacker (University of Bristol) is one of those hoping to shake things up a bit. But for Jonas, it is not a question of stumbling upon a new particle that overturns current thinking. He has developed a new way of analysing data from LHCb that offers an unprecedented level of detail and precision, “We’re hoping to find the jigsaw piece that looks like it should fit, but when you look very closely, the pattern isn’t quite right.”

LHCb is focussed on the matter:antimatter conundrum; if matter and antimatter were created in equal amounts at the Big Bang, what happened to all the antimatter? Tiny deviations from the Standard Model predictions in LHCb’s measurements could reveal spectacular new insights into the nature of matter, antimatter and the creation of the Universe.

Precision is key. LHCb provides the opportunity for unprecedented precision – it is a detector especially built for exploiting the vast number of b and c quarks (heavy cousins of the ‘everyday’ quarks you find inside protons and neutrons) produced at the LHC, which are ideal for these precision measurements.

The b and c quarks produced in LHCb collisions associate with other quarks to form various types of short-lived particles that decay in a number of ways; two-body, three-body or four-body, with the name relating to the number of pieces of particle debris produced in the explosion. LHCb seeks to reconstruct these decays by tracking the paths of the debris. Analysing the decays is a complex process.

One of the most precise tools to measure matter:antimatter asymmetries in these data are Dalitz plots, named after the British scientist, Richard Dalitz. These are scatter plots that beautifully represent all the weird and wonderful quantum-mechanical interference effects that go on in decays, and Jonas and his colleagues use them at LHCb as a precision tool to measure CP violation. Importantly, Jonas has added a new tool to LHCb’s toolbox that generalises these analyses to four-body decays. This requires analysing a scatter plot in five dimensions, rather than two - considerably more complicated, but worth the effort because it significantly increases the precision of the measurement. Higher precision is the key to success if you are looking for tiny deviations.
In fact, the precision expected from these measurements is so spectacular that traditional mathematical models describing the quantum mechanical interference effects are no longer sufficiently accurate. The limitations in the models produce a small measurement uncertainty that, for the high precision Jonas and his team are aiming at, is simply unacceptable.

Jonas’ project is funded by a recent €1.4M grant from the European Research Council. Once his team is complete, it will include a post-doc and three PhD students.

An holistic approach

It takes a range of skills and technologies to improve the performance of a particle accelerator but often different research areas discover that they have been working towards a common goal when it is too late to share resources, swap ideas or collaborate, simply because there has been no mechanism to bring the different activities together. A new network is taking a more holistic approach.

The oPAC network is seeking to improve the performance of current and future particle accelerators including the LHC and CLIC. Like LA³NET (featured in UKNFC 14), oPAC is a Marie Curie Initial Training Network (ITN) for young researchers. Each fellow works on their own project (normally leading to a PhD) but also participates in a number of schools and workshops to share knowledge and expertise. With a project budget of 6 M€, the network is one of the biggest of the EC-funded ITNs. oPAC has 22 fellows five of whom are based at CERN, three at the Cockcroft Institute/University of Liverpool and two at Royal Holloway University of London.

“oPAC has a very broad remit – the fellows are looking at all aspects of accelerator optimisation, including beam dynamics, beam instrumentation, control systems and numerical studies.” says coordinator Carsten Welsch (University of Liverpool). “But we also have a very practical focus and aim to implement the results of the fellows’ projects.

“For example, one of the beam instrumentation projects is to develop a beam halo monitor. The halo is the outer part of the beam and it’s difficult to measure because that part of the beam only contains a few particles. Nevertheless, it is very important to the overall performance of the accelerator. The fellow, Blaine Lomberg (University of Liverpool), is building a prototype in close collaboration with
the University of Maryland (USA), experts from Thermo Fisher Scientific (USA), ViALUX (Germany) and CERN which will be tested on the ALICE and EMMA accelerators at STFC Daresbury Laboratory.

As with the other ITNs, industry involvement is very important, and Carsten and his colleagues on the steering group consulted industry representatives when they were developing plans for the network. “The training that we provide must be relevant, so we asked industry what skills graduate recruits are missing when they leave university, and what companies have to spend time and money teaching them. The list included project management, presentation and communication skills.” So, alongside their individual research projects and regular technical workshops, the fellows also get together for skills training.

This focus on producing highly-skilled young researchers undoubtedly pays off. All the fellows from Ditanet (oPAC’s predecessor network, also coordinated by Carsten) are still working in R&D, mostly in industry, but some in academia.

“Our approach is to make sure that the skills training is directly relevant. We don’t use fictitious scenarios in the training courses – for example, project management training is focussed on the requirements of the fellows’ own PhDs and they leave the course with a plan that they can implement immediately.”

Carsten is convinced that the Marie Curie ITNs provide the best research and training conditions for young researchers, and certainly hundreds of young researchers applied for positions with oPAC, “to me, there is no better way of doing a PhD than through a Marie Curie ITN.”

The network organises a number of events that are open for the wider scientific community. The next oPAC topical workshop will be held at CERN 27-28 June. Focussed on the grand challenges in accelerator optimisation, leading experts will cover everything from the machine, through the detector to the control room. The workshop is free and anyone can participate in the discussions or the poster session. More information is available on the oPAC web site.

Educating the united nations

Uprooting your family from the UK to take up a job at CERN is a big decision, particularly if your children are already at school. The obvious advantages are the opportunity to become proficient, or even fluent, in a second language and to broaden their horizons. But making sure that this is not at the cost of their overall education is vital.

When CERN extended across the Franco-Swiss border some 40 years ago, the laboratory worked with the French authorities to ensure that good local schooling that also recognised the cultural diversity of the region, would be available for the children of international personnel. This led to the creation of the International Collège and Lycée in Ferney Voltaire, with an associated International Primary Programme. Today, the school has more than 2000 students from 70 different countries. Within the school, there are six national sections, one of which is the English National Programme (ENP) with over 800 students enrolled.

Managed by the Association de Langue Anglaise - English Language Programme (ALA-ELP), the ENP provides 6-8 hours of teaching per week in English at Collège and Lycée, in the key subjects of English, English literature, history-geography and maths, for students whose English is already very good or is of mother-tongue standard. All other subjects are taught in French and the aim is to provide a bilingual, but equally importantly, a bicultural education. English and maths courses are largely based on the English national curriculum, with students being prepared for UK exams including GCSE and IGCSE as well as French qualifications including the international Baccalaureat.

ALA-ELP governs and finances the ENP. Elected committee members manage resources, recruit and employ teachers, and are involved in all aspects of governance. James
Gillies, Head of Communications at CERN, is the Vice President of ALA-ELP, “The brilliance of the international system in Ferney is that it’s not just bilingual, it’s bicultural, and that really broadens the students’ horizons. Things are taught differently in French and English, so the programme also allows the students to experience different ways of being taught, and benefit from the best of both.”

One of the practical ways in which CERN continues to help the school is through work experience placements for its students. Oliver Chard, 14, has just spent a week working with the Communications team. “The highlight was definitely helping a film crew from the BBC. It has been really interesting to see how hard the communications team works to tell people about CERN’s research and I’d definitely like to work in science communication.”

The school is academically successful, and there is a wide range of extra-curricular activities. One of the highest profile clubs is the Ferney Modern United Nations (FerMUN). Intended to get students to engage with international issues, hone their debating skills and learn how to write resolutions, the club was started by ENP teaching staff, who still play an important role in the annual FerMUN conference.

The FerMUN conference is entirely run by the students and simulates a UN general assembly on geopolitical topics. Every member of the club takes part, with roles including a secretary-general, delegates, press officers, journalists and photographers. It’s a bilingual club and, just like the real UN, the members provide a simultaneous English/French translation service for delegates.

“The international system in Ferney Voltaire is important because people working at CERN need to know that their children are getting the best start in life,” says James.

More information is available on-line about the International Lycée and ENP.

Northern Ireland Assembly visit

Ahead of the LHC’s visit to Northern Ireland in May, members of the Northern Ireland Assembly Committee for Employment and Learning have been to CERN.

Accompanied by colleagues from organisations including Institute of Physics Ireland and Colleges NI, five Members of the Legislative Assembly enjoyed a full day at CERN. With the Long Shutdown just getting underway, the group was privileged to see not just the LHCb experiment, but also inside the LHC tunnel.

In the afternoon, the group visited the iconic Globe of Science and Innovation, home to the Universe of Particles exhibition before discussing CERN’s highly successful outreach and education programmes.

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Diary dates

LHC on Tour in Belfast – 6-10 May
CERN public open day – 29 September

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