



# Computing and Engineering at CERN

## Employment and Training Opportunities for UK Students and Graduates

### 1. Introduction

As part of its commitment to CERN, STFC works to ensure that the UK profits as it should do from all the opportunities offered by CERN to its member states. In March 2012 a project was launched to improve uptake by UK students of opportunities for CERN-funded studentships and fellowships to work with CERN supervisors in all technology areas. This has been an area under-exploited by the UK in the past.

In November 2012, as part of this project, STFC facilitated a visit by two academic staff members from Brunel University to CERN. The purpose of the visit was to meet with student supervisors at CERN and learn more about selection procedures and what skills are sought in different departments. The Brunel staff members, Dr Jo Cole and Dr Roger Powell, were accompanied by Jane MacKenzie, STFC's UK Liaison Officer at CERN, and it was agreed that all findings from the visit would be made available to the wider UK University sector.

CERN recruits students for one year undergraduate industrial placements, for three year doctoral studies, and for two year graduate fellowship placements. Each CERN department has different requirements from the students it recruits, and what is needed varies greatly by subject area.

During this visit CERN Human Resources department gave an overview of opportunities, and arranged meetings with supervisors in the following departments:

a) Beams Department and Controls Group

Discussions with section leaders/representatives from the following sections within the department:

- Development & Operations
- Front Ends
- Hardware & Timing
- Infrastructure

b) Computing Department

Discussions with section leaders/representatives from the following sections within the department:

- Computing facilities
- Collaboration & Information services
- Database services
- Grid Technology
- Platform & Engineering Services

c) Beam Instrumentation and Engineering Department

Discussions with section leaders/representatives from the following sections within the department:

Industrial Controls & Electronics

Mechanics & Logistics

d) Technology Department

Discussions with section leaders/representatives from the following section within the department:

Electrical Power Converters Group

Other CERN departments also recruit students in both Computing and Engineering areas, but the above departments were selected because between them they account for a large proportion of the opportunities for undergraduates at CERN, and also have good numbers of opportunities for postgraduates. There is considerable overlap in needs, and we believe that the visit covered most key information. The selected departments are also among those whose needs are least understood in the UK, being outside the Physics subject areas most commonly engaged in by UK Universities at CERN.

It is hoped that the information provided by these supervisors will be used by UK academics and student advisors from all areas of Computing and Engineering to advise and assist students and graduates in their applications to CERN.

## 2. Overview of Opportunities by CERN Human Resources Department

CERN recruits young students and graduates for well funded positions as follows:

**Fellowships:** These are 2 year graduate contracts open to anyone who has graduated within the last four years from Bachelors, Masters or PhD studies. All departments at CERN take Fellows, but the level of previous study and experience required varies by department. For example groups working on Physics projects are likely to be looking for PhD graduates, whereas IT groups may want BSc or MSc graduates with more emphasis on industrial experience. There are currently 544 Fellows at CERN.

**Doctoral Studentships:** These are 1-3 year placements for students who are already enrolled with a member state University. The students live at CERN and work on a research project with a CERN supervisor, but return to their University to write up their thesis under the guidance of their University supervisor. The degree is awarded by the University. There are currently 163 CERN funded Doctoral students at CERN.

**Technical studentships:** These are 'industrial experience' placements for undergraduate and Masters students. Students can apply for a placement of 4 to 12 months, but those applying for the full 12 months are favoured. Undergraduates must have a minimum of 18 months' study at undergraduate level in order to be eligible. There are currently 149 Technical students at CERN.

A breakdown of the areas in which technical students are currently working shows that almost half are working in Computing, with another 20% working in Electronics, 7% in General Engineering/Science areas and 9% on Mechanics. Supervisors in Computing sections are therefore very actively seeking students in every recruitment round, and have very specific search methods and criteria which they use to select from the hundreds of applications they see. They use a keyword search facility to identify applicants with the right skills sets, and look for good references from a reliable source, favouring references from University tutors whom they know and have come to trust.

There are two application deadlines each year, which in 2013/14 are in November and May, with specific deadlines advertised on [www.cern.ch/jobs](http://www.cern.ch/jobs). Successful applicants then normally start 3-6 months later. Applicants from the UK, particularly for Technical Studentships, typically aim to start in June, in which case they would apply in November. For a September start the May application deadline would work better.

For all of the above opportunities at CERN, applications need to show an understanding of what CERN offers and a clear focus on what the student/graduate wants to achieve. If the student has relevant practical experience, be it inside or outside of University, it is very important to mention it. CERN is looking for evidence of a rigorous approach to life, study and work which will ensure the student provides genuine input to CERN in response to the high level training opportunity being offered.

The application process is so crucial that STFC has prepared a separate guidance document for students and their tutors, which can be accessed on the STFC website.

### **3. Departmental Briefings**

#### **Beams Department – Controls groups (BE-CO)**

The Controls group supports all the accelerators in the CERN complex, including the Proton Synchrotron (PS), the SPS and the LHC. All the accelerators are (or soon will be) run using common systems wherever possible.

The group is involved in the development of all levels of software from embedded, real-time Front End software, up to the high-level software applications used by the accelerator operations team. They are responsible for providing and managing timing information – both beam timing and machine timing, including a lot of surveillance and machine monitoring work.

The 'lower layer' is concerned with hardware and C++ (possibly embedded) whilst the 'upper layer' is written in Java.

The group does a lot of data logging work, for which they use Oracle databases that are maintained by CERN's IT department, but it means that the CO group includes a number of database experts.

Generally, this group is looking for students with Linux skills, C, C++, Java, Oracle and COBRA, and it was also mentioned that skills in design patterns, DB design and Continuous Integration would be a plus.

- **Development & Operations Section**

This section develops operator tools, primarily using Java and/or C/C++. They provide the tools to manage the controls systems, as well as providing tools for software development (e.g. Eclipse). The tools they provide are front-line diagnostic tools for operations, providing detailed analysis of problems and early warning monitoring. As such, quality assurance is a major part of the group's work, since the tools that they provide are used for operating the accelerators, and beam loss/downtime is a major concern for both the accelerators and the experiments.

Supervisors within this section are always interested in students with system administration skills – particularly those with enough knowledge to go right into the kernel.

The section tries to promote a professional software development culture with state of the art development tools. There are a lot of highly skilled people to learn from in the group, so students need only have a basic grounding in C/C++ - the rest they can learn on the job.

- **Hardware & Timing Section**

This section provides the hardware modules for the control systems and the data acquisition (PCIe, Ethernet). They need good hardware designers who can handle both PCBs and HDL (VHDL, Verilog), who will be involved in cutting-edge design work. Part of their task is the problem of synchronising control actions to within 10 nanoseconds over many kilometres.

This also means that they develop low-level software, such as the Linux device drivers, for which they need good Linux kernel hackers. They also need good Java and C++ developers to work on the timing problems.

This section is also the main driving force behind "Open Source Hardware" (ohwr.org). The aim is to make designs and software available on an "open and commercial" basis, i.e. they are made public and can be used under license. One of the things needed for this is open source CAD software, which CERN are currently working on. They are looking for students with a strong ability and interest to work on novel hardware designs.

- **Front End Computing Section**

The key interest in this section is in embedded software engineering. The section is involved in R & D for CLIC (Future possible design for a linear electron-positron collider), and is conducting a feasibility study for the control systems required for such an accelerator.

They are looking for low-level software designers with C++, Java, XML and XSLT skills. Anyone who applies to work in such a group needs to have a strong interest in working very close to the hardware level.

This section sets the standards for the technologies used at CERN – they put in place major contracts and provide support to other groups at CERN. They have developed a real-time

software framework that is used widely at CERN (known as FESA). They are also developing the software that goes with the hardware that CERN are making available via the “Open Source Hardware” project. They tend to put PhD students on the CLIC studies they are involved with, whilst undergraduate placement students are more likely to be working on generic FE software using FESA.

- **Infrastructure Section**

This section is primarily involved in developing the middleware that sits between the front end and the control system tools. Their primary need is for good C++ designers, as well as for people who can design GUIs in Java. They develop tools for monitoring and diagnosis of the control infrastructure. The section leader for this particular section is also part of the team that promotes the VIA program at CERN. This is an End of Study program supported by the French government, but which was recently opened to all EU graduates. The jobs can be any discipline and CERN offers around 25 first jobs (two-year contracts) as part of the scheme. The scheme is open to anyone who has just finished studying at BSc, MSc or PhD level.

## **IT Department**

In terms of student numbers, the IT department is the largest recruiter at CERN. In particular they take large numbers each year of technical students (usually undergraduates) on one year placements (shorter periods are not favoured). Supervisors review a lot of applications therefore, and tend to skim these looking for keywords showing skills areas of interest to them. It is therefore important for students to put into their applications as many specific skills and interests as they can.

- **Platform & Engineering Services Group**

This group supports the central Linux computing system open to all CERN staff and users (lxplus). They also support some aspects of the Grid (VOMS, for example). They also provide infrastructure services such as SVN, license servers and the CERN-based twiki.

They are mainly looking for computer scientists, although they sometimes need someone with a background in electronics or mechanical engineering.

In terms of keywords, they look for specific interests like “I know Java/C++/Python”. It can also be helpful if the student mentions in their application that they know how to use particular tools. The Platform and Integration Services Group also look for people to get involved with systems integration, in which case Python or Perl would be needed.

“I am interested in X” is enough to be selected by a keyword search, ie. students do not have to have experience in a particular area to get picked up by the search – a clearly stated interest may be sufficient.

- **Grid Technology Group**

This group is involved in distributed data management and develop Grid Middleware. When looking for technical students, they rely on recommendations from people they know or the search for keywords.

They are looking for students with basic IT and programming skills. In applicants who have these skills, they then look for a specific area of interest such as “distributed computing”.

- **Computing Facilities Group**

This group is responsible for running the main Computer Centre at CERN. As such they do a lot of system admin work, operations, installation and monitoring. They are looking for applicants with software development skills and workflow development skills. They look for students with C/C++, Puppet, Openstack, code version control systems (e.g. GIT) and modern scripting language interests/experience. They also look for students with knowledge of databases. The group leader commented that MSc students are best placed for technical studentships in this area, although it was suggested that MEng students applying for a placement year after their third year of study would have an advantage as well.

They also like to rely on personal connections to get informal feedback on the quality of applicants. A track record of providing reliable references is also beneficial.

- **Collaboration and Information Services**

This group is responsible for the development of collaborative software tools (they developed the underlying software for INSPIRE in conjunction with other labs and they also developed INDICO). Their software is primarily open source. They look for people with experience in Python, databases and web design.

They collaborate with other major labs and some non-physics institutes. They also take a lot of technical students.

- **Database Services**

During this discussion it was explained that section leaders are responsible for selecting technical students, whilst the group leader signs off on the choices made by the section leaders.

This section looks for students with systems programming and integration knowledge/experience/interests. DBA experience is not essential. They look for students with Python, Perl, Java skills; some experience with MySQL would be advantageous.

When looking at student applications, they really do want to know exactly what the student is interested in. It is not a good idea for students to try to hedge their bets in their application. Writing a generic application is not recommended as the people who read them will not know what the applicant's specialist skills and interests are. They are most impressed by applicants who write from the heart about what they are genuinely interested in.

## Beam Instrumentation & Engineering Department

- **Industrial Controls & Electronics Group (EN-ICE)**

This group tends to buy in commercial hardware and then develop it for their specific needs. They work for the accelerators, the experiments and the CERN infrastructure. They deal with large industrial control systems and lab control systems such as the Cryogenics, the interlock systems, power converter controls and the vacuum controls systems.

When looking for technical students the kinds of keywords they look for are things like “process control”, “safety control”, “monitoring” and “interlocks”. They need software engineers, control engineers and people with experience in data acquisition systems for monitoring things like electricity distribution etc.

They are also interested in networking technologies such as Profibus and Profinet, “white rabbit” and CAN (Control Area Network).

When looking for technical students, they look for C/C++ skills, as well as software management skills and design experience. They made the point that the number of years’ study is less important to them than useful skills and experience. Proper software engineering skills are especially important.

This group commented that Doctoral students are also a possibility in this area. They are interested in advanced control and automation, as well as data analytics.

For this group, they felt that knowing the tools was less important than having the right skills, such as problem solving, team skills etc. They also like to see people who have relevant practical experience in the lab or in industry.

- **Mechanics & Logistics Section**

This section includes Mechanical Engineers, Physicists and Electronic Engineers and is responsible for monitoring and measuring all aspects of the beams. When looking for technical students, they look for low-level software skills (C++/Java), as well as Linux engineering skills.

In the Mechanics area, they do a lot of finite element analysis and a lot of project work. The instruments they design all interact with the beam somehow and it is therefore essential that they study the effect the instrument will have on the beam. This means they are involved in the design and construction of compensators and collimators, as well as wire scanners (there is currently a project ongoing to understand why wire scanners tend to break so easily and hence to find a new way to build them).

In the area of Applied Physics, they look at the physics processes behind the issues that are being faced by the Mechanics group. As such, they do work on optical transmission, radiation monitors, Synchrotron radiation telescopes, APDs. They work for all the accelerators, plus CLIC (they put quite a few students on CLIC).

They also develop analogue electronics (low power, high frequency electronics), including simulating the impact of the beam on the electronics. They study the effects of the RF fields on the instrumentation. They also do pure electronics, including the design, layout and fabrication of FE devices, both analogue and digital.

The section leader is a Mechanical Engineer by training and he commented that the Technical Department also do a lot of Engineering. The EN group also need engineers for the vacuum, the magnet systems (standard and superconducting) and the cryogenics. Here, because they are looking for specific skills that are relatively rare, Technical Students and Fellows who show good potential are often kept on long term.

### **Technology Department – Electrical Power Converters Group**

The TE-EPC group is in charge of the design, development, procurement, construction, installation, operation and maintenance of electrical power systems for all accelerators, transfer lines, experimental areas and tests facilities at CERN.

When looking for technical students, they look for C/C++ skills, as well as software management skills and design experience. They made the point that the number of years' study is less important to them than useful skills and experience. Proper software engineering skills are especially important.

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## **4. Conclusions**

CERN offers tremendous opportunities for the right students to develop their skills and understanding through some of the most exciting and cutting edge projects in engineering, computing and physics.

CERN also offers the opportunity to work on a truly international campus, and provides the opportunities to work in collaboration with scientists and engineers from all over the world, and particularly from Europe. This broadening of the students' cultural and professional development will be immensely useful in whatever career the students choose.

Understanding the detailed needs of the supervisors at CERN who select candidates will help to make applications more focused and relevant. In a recent case a UK candidate with an Electrical and Electronic Engineering background missed a place at CERN solely because he believed he should stress the Electrical side of his experience, and neglected to mention his extensive Electronics experience and programming knowledge. This paper has aimed to give initial information which advisers can use to guide students and recent graduates.



Any of the CERN departments described above would be pleased to engage in more depth with UK University departments and tutors, employers, trainers and careers advisers. Visits to CERN can be facilitated by STFC, and the first point of contact for this is Stephanie Hills – [stephanie.hills@stfc.ac.uk](mailto:stephanie.hills@stfc.ac.uk)