UK news from CERN

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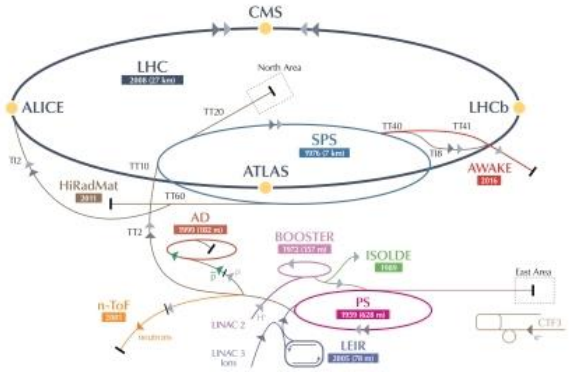
Starting up

LHC experiments are not due to start taking data until Spring 2015, but in parts of the accelerator complex, the Long Shutdown (LS1) is already over. In the first of a series of articles, we've asked some of the UK staff involved to give us an update on changes made during LS1, and how the restart is going.



Ion sources and linacs

The starting point for any particle accelerator is an ion source – a surprisingly small, but absolutely essential device for generating a stream of charged particles. At CERN, these particles gather speed as they move through a series of linear and circular accelerators until they reach the intended experiment, with some travelling at almost the speed of light in the LHC.

CERN's combination of ion sources and linacs enables its experiments to be fed with a variety of particles; protons for the majority of CERN's experiments, but also lead ions for the LHC, and argon ions to one of the fixed target experiments.

Richard Scrivens is our guide; he's an applied physicist working on CERN's three hadron linear accelerators or linacs; the first accelerators in the chain that feeds all the CERN experiments including the LHC.

"LS1 has been a combination of maintenance and standardisation for our existing linacs and getting ready to commission a new linac," explains Richard.

Linac2 (Linac1 was decommissioned in 1991) supplies protons to the Proton Synchrotron Booster (PSB). The linac is due to be replaced at the end of the next operational run so hardware changes have been kept to a minimum. LS1 activities have been focussed on a programme of standardisation that has been taking place across the accelerator complex; the most noticeable change for staff and visitors is the introduction of a new access control system with iris scanners, similar to the systems used in the LHC experiments and as part of the commitment to providing the very best quality beams to the experiments, a new beam monitoring system has also been installed, along with plenty of new controls hardware and software.

Despite relatively minor interventions with the machine, LS1 has not been completely straightforward for Linac 2. "Our biggest

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Written and edited by Stephanie Hills, UK Communications and Innovation Officer @ CERN
Stephanie.hills@stfc.ac.uk or Stephanie.hills@cern.ch

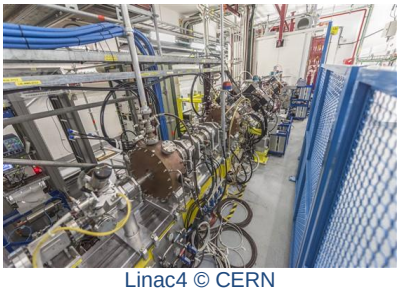
challenge was the machine's susceptibility to temperature changes," says Richard. "Even though it is located in a tunnel where controlling the temperature should be easier, large temperature variations can cause stress which could result in vacuum leaks. During LS1 we had a goal to maintain a temperature within a range of just ±1°C. With all the work taking place around Linac2, maintaining a steady 21°C was critical."

"The fact that very little accelerator hardware was changed meant that we were confident that we could get the machine working quickly," explains Richard, "but there were lots of software changes so we have been working very closely with the Beam Department's Controls group."

The way that Linac2 is designed, Richard and his colleagues were unable to test the beam acceleration section by section. The acceleration step from 0.75 to 50 MeV was made in one go, and was therefore a tense moment. "We have 140 quadrupole magnets and three high power RF systems so there is plenty of scope for technical issues. But with good preparation it worked on the first shot! There are still a few things to iron out, but the beam from Linac2 was delivered on schedule."

With Linac2 due to be retired, much of the LS1 activity has been focussed on its replacement, Linac4, which will replace the aging Linac2, as well as increase the beam energy for injection into the following PSB, and changes to particle type to H- ions. When the time comes to make the switch between the two, the modifications required at the PSB will be so great that there will be no going back.

"The new ion source has been a greater challenge than anticipated," says Richard. "To start with, the negatively-charged particles that we want are extracted along with electrons. As the electrons have a higher beam power, they caused the ion source to breakdown. In addition, we didn't get the intensity of H^- ions that we were expecting." The problems required a time consuming redesign, but that has brought some advantages. "We've developed our own in-house expertise," explains Richard, "and we're now world experts in H^- ion sources and plasma diagnostics. Other labs are copying our ideas!"



Linac4 © CERN

During LS1, the Linac4 project kept up a fierce pace for installation and testing, managing to produce an H^- beam at 3MeV in a test area, and the whole installation was moved to a purpose built tunnel close to Linac2, ahead of the next installation stage.

There is also the challenge of the Linac3 restart, which supplies ions for experiments in the SPS North Area, as well as LHC. In early 2015, it will, for the first time, supply argon ions to NA61, one of CERN's fixed target experiments. To meet that goal, Linac3 had to be tested with argon ions during LS1; this added to the complexity of trying to schedule the work on CERN's cooling infrastructure while still keeping some facilities running. Later in 2015, Linac3 will supply lead ions to the LHC. Switching back to lead will require modifications to the ion source, and it takes more than a month to make the changes and get the source back up and running.

"LS1 has been a juggling act," says Richard, "we have created two new beam types in addition to all the accelerator maintenance and modifications."

There is still plenty of work to do before CERN switches from Linac2 to Linac4 but Richard and his colleagues are clear about their objective, "the beams have to be perfect for the LHC. If they're not, it shows up in the physics!"

PS Booster

The Proton Synchrotron Booster supplies much of the CERN accelerator complex. Commissioning started at the end of June following an intense programme to install low

Written and edited by Stephanie Hills, UK Communications and Innovation Officer @ CERN
Stephanie.hills@stfc.ac.uk or Stephanie.hills@cern.ch

level RF and transverse feedback systems. Alan Findlay, an engineer in CERN's RF Group and an Engineer-in-Charge for the Booster explains.

Inside the PS Booster © CERN

"The new low level RF system is rather like the engine management system in a car – it's essential to the operation of the Booster. We needed to replace obsolete electronics and make sure that the Booster can cope with the wide range of beam intensities required."

Whether it is a low intensity test beam for the LHC (5×10^9) or the highest possible intensity for the ISOLDE nuclear physics facility (1×10^{13}), the Booster has to deliver up to 20 different operational beams in pre-agreed cycles, switching seamlessly from one to another.

The new RF system has been developed in-house based on collaboration with Brookhaven National Laboratory in 2003 to develop the low level RF for LEIR.

"It's taken us years to develop," says Alan, "but the basic commissioning with beam took three weeks. We had a few hitches but these were resolved quickly and we're now commissioning each operational beam to ensure that we have all the information that we need about the cross-sectional size and length of each bunch of particles, and the time between bunches."

The new Transverse Feedback system will enable better control of undesirable horizontal and vertical oscillations of the beam in the Booster. The system has been installed in parallel with the existing system and is one of the hardware upgrades necessary to meet the higher intensities that will be possible when Linac4 starts operating. Once the existing system is fully up and running, the new hardware will be commissioned, with a permanent switch-over planned for early 2015.

Other LS1 activities have included instrumentation changes similar to those in the linacs, as well installing a new beam dump that will cope with increased beam intensities from Linac4.

It's also important to remember that CERN's accelerator complex is an experiment in its own right. The Booster may have started operations in 1972, but constant technology development enables it to stay at the forefront of accelerator science. One of the latest projects is to replace the RF cavities that accelerate, shape and split the beam. The aim of the collaboration with J-PARC is to develop a smaller, more compact and more efficient RF system using Finemet cells driven by solid state power amplifiers. Five cells were installed and tested in 2012 and another five have been added during LS1.

"We need the prototype to compare and prove the technology," says Alan, "It's a very interesting project for our group as it would offer us the chance to operate different groups of Finemet cells in different ways, depending on the beam cycle requirements. We're using the project to decide which technology to use in the long term – and not just in the Booster."

So far, the restart process is going well but there is still a lot of commissioning to be done and the operations team is working seven days a week in shifts, with the equipment specialists on call, to meet the schedule, "The first beams were delivered on schedule to the PS but we've got a long way to go before we're back to regular operations."

Higgs Prize visit

The inaugural winners of the Higgs Prize for physics have been enjoying a visit to CERN. Lucy Willets-White and Peter Rhodes joined undergraduates from around the world for the start of the CERN Summer Student programme

The Higgs Prize was established by the First Minister of the Scottish Parliament in recognition

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Stephanie.hills@stfc.ac.uk or Stephanie.hills@cern.ch

of the impact that Peter Higgs' theoretical work has had on modern day particle physics and is intended to reward and inspire Scotland's best young school physicists. It is awarded on merit to two pupils from a publicly-funded school who have shown outstanding performance in the Advanced Higher Physics exam.

Lucy and Peter visiting CMS © L Willets-White

Both prize winners found their expectations of CERN were challenged. "CERN is much bigger than I expected – it's huge," says Lucy. "And the aboveground parts are older than I expected," adds Peter.

Alongside the student lecture programme, both rated an underground visit to CMS as a highlight of their week at CERN. "Even though everyone tells you how big the detector will be," says Lucy, "it's really impressive – I was amazed by all the wiring!"

"CMS is undoubtedly visually impressive, but I was also fascinated by the CERN Control Centre and the way that the accelerators feed into each other," explains Peter.

The visit certainly inspired both students, and Lucy hopes that she will have the opportunity to return; she has just completed her first year studying physics at Imperial College London. Peter is enjoying the end of his gap year before studying medicine, also at Imperial.

During their time at CERN, Lucy and Peter met Nobel Laureate, Jack Steinberger. His advice to the pair? "Be incredibly lucky!"

Cosmic duets

CERN has been back at the Montreux Jazz Festival, by popular demand! 'The Music of Physics and the Physics of Music' was on the bill alongside the likes of Stevie Wonder, Pharrell Williams and Paloma Faith. This year's line-up included the Donald Sinta Quartet performing 'LHC', an original composition by Roger Dare based on the discovery of the Higgs boson.

Domenico Vicinanza (Cambridge) presented his own composition based on data from the four LHC experiments and the Voyager missions to the outer reaches of the solar system. Domenico has converted the parameters of the data into sound and then transposed them into music. The result is inspirational, beautiful and informative.

And finally, the Cosmic Piano – a musical instrument created from components used in the ALICE experiment to measure cosmic rays - made a solo performance before dueting with jazz pianist, Al Blatter. The results were out of this world!

And finally… Monty Python does physics

There's a Pythonesque flavour to the latest series of BBC Radio 4's The Infinite Monkey Cage presented by Brian Cox (Manchester and ATLAS) and comedian Robin Ince; Eric Idle has recorded the new theme tune. With several references to CERN and the LHC, there's something for every flavour of physicist

They say that the pictures are always better on the radio, but in this case there's a great video to go with the song!

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Diary dates

Collider in Manchester - until 28 September
CERN Council – 15-19 September
A world a particle in Liverpool - until 8 January

Written and edited by Stephanie Hills, UK Communications and Innovation Officer @ CERN
Stephanie.hills@stfc.ac.uk or Stephanie.hills@cern.ch