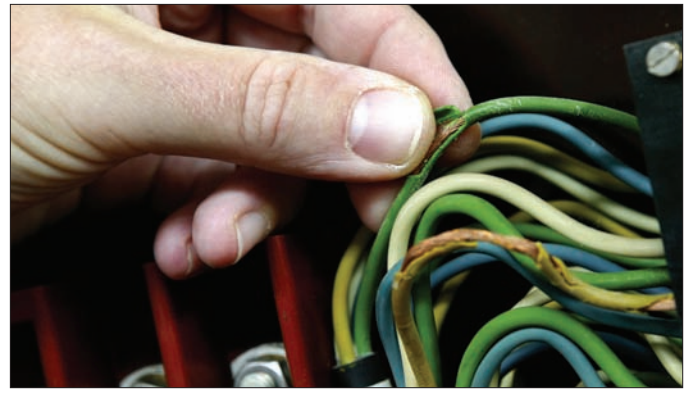
PS and SPS accelerators are back in business

After a year of renovation and construction, CERN's accelerator complex is once again beginning to deliver different beams at a variety of energies.

A 35-tonne dipole from the PS is transferred by the 45-year-old locomotive that was brought back into service for the renovations.



Aging and ionizing radiation degrades the insulation on the PS dipoles' pole-face winding. This is one reason for the renovation.

Last year was a time for rejuvenation and building at CERN as a major part of the accelerator complex was shut down while preparations for the Large Hadron Collider (LHC) took place. During the shutdown, which started in November 2004 and continued throughout 2005, the Proton Synchrotron (PS) and the Super Proton Synchrotron (SPS) began an extensive renovation programme that will continue into the next decade. The LHC will depend on the injector complex that feeds it to deliver reliable and top-performance beams when it starts up in 2007. This comprises Linac2, Linac3, the PS Booster, the Low Energy Ion Ring (LEIR) and the PS and SPS.

The programme to renovate the main magnets of the PS, which has been operating since 1959, benefited from the long shutdown. The oldest accelerator of the injector complex had shown signs of its age, going offline for two weeks in 2003 when two magnets failed. The magnets were replaced, but to ensure it is in good condition when the LHC is turned on, the PS and CERN's other accelerators in the LHC injector chain started a consolidation programme. By renovating parts that are at the end of their useful life and updating obsolete components and systems, the consolidation programme intends to identify and resolve potential problems before operations are affected.

Wear and tear in the PS, which was still equipped with many of its original components, resulted from radiation degrading the materials and mechanical fatigue from pulsed magnetic forces. During 2005, 25 of the 100 main magnets were removed, renovated and re-installed in the PS tunnel. To move the 35-tonne magnets from the tunnel to the workshop in nearby building 180, the 45-year-old PS locomotive was restored. In the workshop, teams from the Budker Institute of Nuclear Physics (BINP) in Novosibirsk, supervised by specialists from CERN, replaced the coils and pole-face windings and re-glued loose laminations. After testing, the renovated magnets were re-installed in the tunnel and re-aligned, ready for start-up in April 2006.

The SPS has also shown signs of age. In 2005, leaks appeared in the hydraulic circuits of some of the accelerator's dipoles, but after a thorough investigation, a way was found to make repairs. Those repairs and other upgrades will be completed during the 2006–07 shutdown.

New construction

The SPS is almost the last link in the chain that will supply beams to the LHC. The final connection will be made by two transfer lines, TI 2 and TI 8, that will take beams from the SPS (*CERN Courier* March 2005 p26). TI 8 was commissioned in 2004, and progress continued on TI 2 during 2005, with components installed and tested up to some 250 m before the shaft where the LHC magnets start the underground journey to their final locations (*CERN Courier* April 2005 p5). Upstream of TI 2, the beam extraction in the long straight section of the SPS has been converted into a fast extraction. Four upgraded kicker magnets have been installed to deflect the beam into the gap of existing septum magnets, which bend the beam horizontally out of the SPS ring. New extraction protection devices have also been installed to cope with the high-intensity beam for the LHC.

The recent shutdown also allowed time to work on Linac3 and LEIR. Together, they will provide heavy-ion beams to the LHC experiments in 2008. LEIR is the successor to the Low Energy Antiproton Ring and ▷

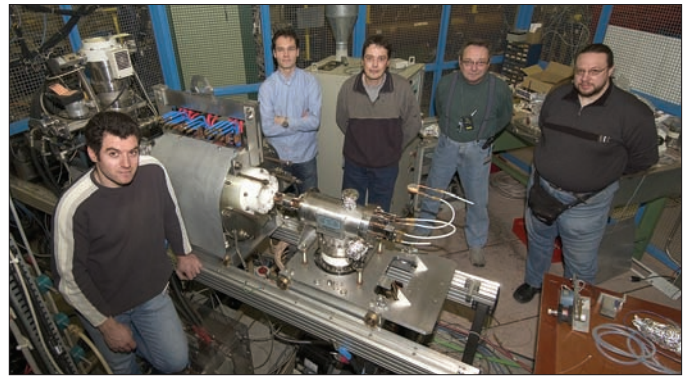
New magnet gives COMPASS wider view

The COMPASS experiment's new superconducting solenoid.

When beams are delivered from the SPS to the North Area on 15 June, the team working on the Common Muon Proton Apparatus for Structure and Spectroscopy (COMPASS) experiment expect an unprecedented number of events, thanks to a new magnet. In December 2005, the experiment received the new magnet, which will make it easier to detect particles produced at large angles from collisions in the target. COMPASS is designed to study how quarks and gluons form hadrons and what exactly contributes to the spin of the nucleon. The experiment, which started to take data in 2002, currently uses a muon beam from the SPS together with the world's largest polarized target system in a 2.5 T field.

The new 5-tonne, 2.5-m-long superconducting magnet has a 63 cm diameter bore, much larger than the 27 cm opening of the previous magnet. To create the uniform field needed, a rather sophisticated magnet, much more complex than a simple solenoid, had to be designed and built. The number and variety of the different coils that form the magnet are the key to the high uniformity. There are two large compensator coils at either end of the magnet and sixteen correction coils throughout the volume. Finally, two "saddle" coils, one on top and one on the bottom, are used to change the orientation of the magnetic field rapidly to rotate the particles' spin into another direction. During testing at the Dapnia Laboratory of the Comissariat à l'Energie Atomique in Saclay, the team established a magnetic field homogeneity of $\pm 3 \times 10^{-5}$ over the target volume, three times better than required.

To take advantage of the magnet's larger aperture, the COMPASS collaboration is upgrading some detectors in the spectrometer. The tracker, which has 320 000 detection channels, will be enhanced to cover the new angular range. Moreover, to guarantee excellent performance in particle identification, the ring imaging Cherenkov detector is being upgraded with faster photon detectors based on multi-anode photomultipliers in the central region and with faster readout electronics for the existing photon detectors. The COMPASS experimental programme is scheduled to span the next five years.



Members of the team responsible for hadron sources and linacs with the new ECRIS mainly intended to supply ions to the LHC.

reuses much of the former machine's equipment. At the beginning of 2005, Linac3 was equipped with a new 14.5 GHz electron cyclotron resonance ion source (ECRIS) to increase the beam intensity. The configuration of the source was based on R&D done under a European Framework 5 project and the source itself was supplied by the Commissariat à l'Energie Atomique, Grenoble. In spring 2005 a beam was transported successfully from Linac3 to LEIR through the transfer line, which had been almost completely rebuilt.

LEIR itself was installed last summer and commissioning began when the first beam (of O^{4+} ions) was run in October. Preparation then began for the first studies of electron cooling, using collisions with an electron beam in a section of LEIR to reduce the dimensions of the ion beam. This focuses the beam and frees space to accumulate several pulses from Linac3 in LEIR. The cooling system, built by BINP, has been commissioned with electrons and the strong perturbations its magnetic system has on the ion beam have been corrected. The first cooling measurements took place at the end of the 2005 run, and the goal is to complete commissing in 2006.

The new control centre

While various teams worked on improvements needed for different aspects of the LHC's operation, others were working to bring control of the future accelerator complex together in one room. The new CERN Control Centre (CCC) began operating on 1 February 2006 and was officially inaugurated on 16 March in a ceremony with members of the CERN Council.

The CCC, a sleek, futuristic room filled with a multitude of monitoring screens, combines the control rooms of all the laboratory's accelerators, as well as piloting cryogenics and technical infrastructures. The new centre has 39 control consoles laid out in four zones, one dedicated to each of the technical infrastructure, the PS complex, the SPS and the LHC. The cryogenics consoles are positioned between the LHC zone and the technical infrastructure zone. During peak operation periods there could be up to 13 operators working on any one shift, not counting the many experts responsible for assisting them. Built and installed in just 15 months, the centre is the first part of the LHC project to start up. The operators for accelerator testing are already on site, as the machines spring back into life.

By bringing together all of the operators and facets of the LHC injector chain, the CCC will guarantee a high-quality beam. It will also manage the beams to other experimental facilities at CERN. Similar to a rail network that uses the same infrastructure to send

The new CERN Control Centre unites all the control rooms.

passengers towards various destinations, the accelerators of CERN can transport several beams simultaneously and adapt each one to a given facility. The PS, for example, can prepare beams for the LHC while also feeding the Antiproton Decelerator (AD) and fixed-target experiments at the SPS. This multitasking is an important feature of accelerator and beam operations at CERN.

Now the machines are all coming back to life. The Isotope Separator On Line facility (ISOLDE) already started operation in April. Serviced by the PS Booster, ISOLDE had run during 2005, when it received record numbers of protons from the booster, as the PS and SPS were not operational. The PS service to the East Hall is scheduled to recommence on 22 May, and the AD should start up on 6 June. As of 15 June the SPS will provide the beam for the North Area, where several fixed-target experiments will be ready and waiting. On 29 May however, a major new project will come to life as commissioning begins for the CERN Neutrinos to Gran Sasso project (*CERN Courier* March 2006 p6). This facility will mark a new phase in the 30 years of the SPS when it delivers protons to generate a beam of neutrinos that will travel underground 730 km to the Gran Sasso Laboratory in Italy. It will continue the tradition of neutrino beams at CERN, which began with the PS and then moved to the SPS, and will test the recent improvements to the accelerator complex as the countdown continues towards the LHC start-up.

Résumé

Accélérateurs du PS et du SPS: le retour

L'année 2005 a été une période de rénovation et de construction au CERN. En effet, une grande partie du système d'accélérateurs a été arrêtée entre novembre 2004 et fin 2005 pour faciliter l'installation du Grand collisionneur de hadrons et permettre de grandes avancées dans le programme de rénovation complète du Synchrotron à protons (PS) et du Supersynchrotron à protons (SPS). Par ailleurs, on a construit le nouveau centre de contrôle du CERN, qui rassemble les salles de contrôle des huit accélérateurs du Laboratoire, ainsi que le pilotage de la cryogénie et des infrastructures techniques. Cette longue période de fermeture a permis de rénover les expériences à cible fixe telles que COMPASS.

Kendra Snyder, *CERN, compiled from contributions to the CERN Bulletin and Annual Report.*