The ATLAS Collaboration passed a major milestone during the evening of 1 August. The Central Solenoid, in its final position in the ATLAS cavern and with the final equipment, was commissioned up to 8.0 kA without quenches, exceeding its operational current of 7.73 kA for the magnetic field of 2 T. This makes the ATLAS Central Solenoid the first superconducting magnet to be fully commissioned in the underground areas of CERN’s Large Hadron Collider (LHC).

It is 12 years since the team led by Takahiko Kondo and Akira Yamamoto of the KEK laboratory in Japan proposed a thin solenoid magnet for the ATLAS experiment at the LHC. The solenoid provides a magnetic field of 2 T for momentum measurement in the inner detector part of the huge construction. Located inside the electromagnetic calorimeter, it must be thin to present as little material as possible to particles, in particular electrons and photons, produced in the proton collisions at the centre of the detector. The KEK proposal was to use specially hardened aluminium stabilizer for superconducting cables, saving about 30% in material thickness.

The solenoid also shares a common cryostat/vacuum vessel with the barrel liquid-argon (LAr) calorimeter, eliminating the need for two vacuum-vessel walls. This special configuration meant that the solenoid and LAr cryogenics teams had to collaborate perfectly from the beginning of the design stage all the way through to the commissioning that ended at the beginning of August. A highlight during construction was an exchange of final and test inner vacuum cylinders between the two projects in 2000, when the solenoid and the LAr barrel cryostat, which was the responsibility of Brookhaven National Laboratory, were being manufactured on the same Japanese island (CERN Courier 2001 May 2001 p8).

The ATLAS solenoid commissioning has not only proved that the solenoid magnet built by KEK performs well, but it has demonstrated that all the control, cryogenic, power, vacuum and safety systems worked coherently – a major accomplishment by various CERN teams. In particular, very-high-precision current generation by the digitally-controlled power supplies enables the magnetic field to be reproduced reliably to an accuracy of $10^{-5}$. Following the commissioning, the collaboration also mapped the solenoid field. Only a few days previously, a site-wide electric power failure had struck CERN for several hours, but thanks to well-designed emergency and recovery countermeasures, the solenoid was commissioned. This success with the ATLAS solenoid was a good start for commissioning even larger and more complex systems for the LHC and its experiments in the near future.
The D0 Collaboration at Fermilab has announced the first measurement of the cross-section for WZ pair production in proton–antiproton collisions. The cross-section times branching ratio for the process is the smallest ever measured at a hadron collider. The data for this result were taken from more than 1 fb\(^{-1}\) of total collision data at the Tevatron, and a sample of 1.5 thousand million events.

Making this measurement requires events in which both the W and Z boson decay to leptons, but while such events provide the cleanest signature of WZ events, they constitute only 1.4% of all WZ decays. D0 found 12 events, each containing three charged leptons with high transverse momentum together with missing transverse energy (indicating an undetected neutrino), with an expected background of 3.6±0.2 events. The probability that the background accounts for these 12 events is 4.1\(\times\)10\(^{-4}\), which constitutes 3.3\(\sigma\) evidence for WZ pair production. With these events D0 measures the WZ production cross-section to be 4.0+1.9–1.5 pb, which is consistent with the Standard Model prediction of 3.6±0.3 pb.

The coupling of the weak vector bosons is an important consequence of the non-Abelian nature of the Standard Model, and the rate for the associated production of W and Z bosons in proton–antiproton collisions allows this coupling to be probed. The kinematics of the Z boson decay can also be used to characterize the interaction between the W and Z and provide further constraints on the nature of the electroweak force. In addition, measuring the cross-section times branching ratio for Standard Model processes with such low rates is an important stepping stone in the search for the Higgs boson at the Tevatron.

Further reading
The preliminary D0 result is described at http://www-d0.fnal.gov/Run2Physics/WWW/results/prelim/EW/E15/E15.pdf.
LHC dipole installation gets to half-way mark

The installation of the 616th dipole for the Large Hadron Collider (LHC) on 12 July marked the half-way point for the machine’s 1232 dipole magnets.

Technicians and engineers continue to work day and night carefully installing 20 magnets a week. This is three times faster than originally planned, with four magnets able to be transported underground simultaneously. However, the 65 team members that are responsible for this task face daily challenges owing to the limited space inside the tunnel. Some areas leave only a few centimetres of leeway, requiring a tightly coordinated operation.

Each of the dipoles weighs 34 tonnes and is 15 m long. Once they have been lowered down the specially constructed shaft on the Meyrin site, they begin a slow progression to their final destinations in the LHC tunnel, taking about 10 hours to arrive at Point 6, the furthest point on the LHC ring. Upon arrival, each of the dipoles is aligned and interconnected to the magnets that are already installed.

During the summer, the installation of Sector 7-8 of the LHC, comprising the first continuous chain of magnets and cryostats, along with their cryogenic distribution line, will be completed, in readiness for cool-down and testing before the end of the year.

CMS gets ready for its descent underground

July saw some major manoeuvres for the CMS detector, as the collaboration prepares to lower it into its final position on the Large Hadron Collider (LHC) at CERN. The two Forward Hadronic Calorimeters (HFs) were transported from CERN’s Meyrin site to the surface assembly hall at LHC Point 5 in Cessy, France, during the first part of the month. Then, on 24 July, the CMS magnet yoke was fully closed and locked for the first time.

Transporting the two HFs, which each weigh about 300 tonnes, involved constructing a 65 m trailer around them, which was simultaneously pushed and pulled by trucks at either end. The main road between St Genis, close to CERN, and Cessy was closed during each operation and the police escorted the trucks during each five-hour long journey. The HFs will be the first major elements to be lowered into the underground experimental cavern by gantry crane near the middle of September. In the meantime, the 11 large elements (six endcap disks and five barrel wheels mounted with muon chambers) that form the magnet return yoke were closed together for the first time on 24 July, to allow the tests of the giant solenoid to begin (CERN Courier July/August 2006 p28). During this process all the yoke elements were precisely aligned with respect to the magnetic axis. The closing procedure was initially quite time-consuming, but progress became quicker with about one working day required to close and lock each element. This is close to the design goal of half a day for each element.

Les physiciens des particules du monde entier sont invités à apporter leurs contributions aux CERN Courier, en français ou en anglais. Les articles retenus seront publiés dans la langue d’origine. Si vous souhaitez proposer un article, faites part de vos suggestions à la rédaction à l’adresse cern.courier@cern.ch.

CERN Courier welcomes contributions from the international particle-physics community. These can be written in English or French, and will be published in the same language. If you have a suggestion for an article, please send your proposal to the editor at cern.courier@cern.ch.
**SPACE**

**PAMELA looks for dark matter and antimatter**

On 15 June, at midday Moscow time, the Bajkonur Cosmodrome in Kazakhstan launched a Soyuz-TM2 rocket carrying the Russian satellite Resurs DK-1. This carried the Payload for Antimatter Matter Exploration and Light-nuclei Astrophysics (PAMELA), which will investigate antimatter and dark matter (CERN Courier October 2002 p24). A week later, the first scientific data were received, and after a series of tests on the satellite and all the on-board instruments, PAMELA entered continuous data-taking mode on 11 July.

PAMELA will stay in space for at least three years, on a 70° elliptic orbit at an altitude of 300–600 km. Its instruments will measure the flux, energy and characteristics of extragalactic, galactic, solar and interplanetary cosmic rays; it will also investigate dark matter and antimatter in cosmic radiation. More specifically, it will measure cosmic-ray antiproton and positron spectra over the largest energy range ever achieved and will search for antinuclei with unprecedented sensitivity. It will also measure the light nuclear component of cosmic rays and explore phenomena connected with solar and terrestrial physics.

The payload, which is 1.3 m high and weighs 470 kg, consists of a magnetic spectrometer comprising a silicon tracker in a 0.48 T field produced by a permanent magnet, together with a time-of-flight system, an electromagnetic silicon tungsten calorimeter, a “shower-tail catcher” scintillator and a neutron detector, all of which are shielded by an anticoincidence system. Transmission of data takes place several times a day (one complete orbit lasts about 90 minutes) through a telemetry system connected to a main ground station in Moscow. Data are then forwarded to the participating institutes through high-speed connections: an average of 10–20 GB a day (both engineering and scientific information) are collected and transmitted when PAMELA is fully operating.

PAMELA is the result of a collaboration between the Italian National Institute of Nuclear Physics and the Russian Space Agency and research institutes, with the contribution of the Italian Space Agency, and participation in particular of the Swedish Space Agency, the Royal Institute of Technology in Stockholm, the German Space Agency and the University of Siegen, as well as institutes in India and the US. PAMELA is also a recognized experiment, RE2B, at CERN. Tests were conducted in beams at CERN and elsewhere on prototypes, as well as on the detectors in the final flight configuration.

For further information see http://wizard.roma2.infn.it/pamela.

**FELS**

**Japanese source starts lasing at 49 nm wavelength in VUV**

On 20 June, the SPring-8 Compact SASE Source (SCSS) prototype accelerator generated its first pulses at a wavelength of 49 nm in the vacuum ultraviolet (VUV) region. This was achieved using an ultra-low emittance beam provided by an electron gun with a newly developed single-crystal CeB₆ thermionic cathode.

The SCSS prototype accelerator is a self-amplified spontaneous emission (SASE) free-electron laser (FEL), similar to the FLASH laser at the TESLA Test Facility (CERN Courier June 2006 p7). Built during 2004–2005 at the SPring-8 synchrotron radiation facility in Japan, the SCSS has recently been commissioned. Its main purpose is to test components developed at the RIKEN/SPring-8 centre in R&D for an X-ray FEL to generate wavelengths of 0.1 nm (1 ångstrom) using an 8 GeV electron beam. Funded by the Japanese Ministry of Education, Culture, Sports, Science and Technology, construction of this X-ray FEL is scheduled for 2006–2010.

One of the most challenging features of the SCSS is the use of the CeB₆ single-crystal cathode to generate an ultra-low emittance beam. The 500 kV electron gun produces a beam current of 1 A, which feeds an injector system of RF cavities and magnetic lenses that have been carefully designed to perform velocity bunching without allowing the emittance to deteriorate. Here the bunch length is compressed several hundred times to produce a beam of a few hundred amps. Then after four C-band accelerating stages, the beam energy reaches 250 MeV.

During beam commissioning, an emittance of 2.9 π mm mrad normalized was measured in the injector, for a bunch charge of 0.25 nC and a bunch length of 1 ps at 50 MeV. Then the SCSS team closed the upstream undulator, and after an hour of tuning observed a narrow spectrum peaked at 49 nm in the VUV. This was totally different to the natural undulator radiation (spontaneous mode). After further careful measurements, first lasing was announced on 20 June.

For more information see http://www-xfel.spring8.or.jp/.
A team at Harvard University has made a new precise measurement of the electron magnetic moment, which in turns allows the fine structure constant to be determined with an uncertainty 10 times smaller than previously attained.

Gerald Gabrielse and colleagues have measured the value of the constant g of the electron, which relates its magnetic moment to the Bohr magneton, \( \frac{e\hbar}{2m} \), where \( e \) is the size of the charge on the electron, and \( m \) is the electron’s mass. For a Dirac point particle of spin 1/2, \( g \) should have a value of 2, but quantum electrodynamics (QED) predicts a value slightly higher, owing to vacuum fluctuations and polarizations effects.

To measure \( g \) more precisely than before, the Harvard team has resolved the cyclotron and spin energy levels of an electron confined for several months in a cylindrical Penning trap cooled to 100 mK (Odum et al. 2006). The value they obtained is

\[
g/2 = 1.00115965218085(76);\]

the uncertainty of 0.76 ppt is nearly six times lower than the most recent accepted value, measured nearly 20 years ago (Van Dyck et al. 1987).

Working with Cornell University and RIKEN in Japan, Gabrielse and colleagues have used this new value of \( g \) with a prediction from QED involving 891 eighth-order Feynman diagrams, to determine a new value for the fine structure constant, \( \alpha \). They obtain

\[
\alpha^{-1} = 137.035999710(96),\]

that is, with an uncertainty of 0.70 ppb – an uncertainty that is about 10 times smaller than for any rival method to determine \( \alpha \) (Gabrielse et al. 2006).

Further reading
Once again, Dr. Novac doesn't stand a chance. Sealed up vacuum-tight by Captain Vacuum's turbopump plasma Whoosh-O-Matic and banished to a parallel universe, he vegetates in a state of failed villainy.

To be continued …

Hasta la vista, Doc …

Calling Captain Vacuum! Your home planet needs you! Dr. Novac won't give up. He wants to destroy every vacuum system on Earth and subjugate the blue planet. You've got to foil his plans!

Pfeiffer Vacuum speeds out on his mission at warp 7: in a flash, he's repaired the pumps Dr. Novac so thoroughly sabotaged – the vacuum has been saved! And now it's time to deal with you, doc …

Then comes the showdown.

Ughhh… vacuum?! Anything but that …

I've finally got you check-vacuum-mated, you scoundrel. My turbopump plasma Whoosh-O-Matic is so ingenious and reliable that you'll never get any air again.

Once again, Dr. Novac doesn't stand a chance. Sealed up vacuum-tight by Captain Vacuum's turbopump plasma Whoosh-O-Matic and banished to a parallel universe, he vegetates in a state of failed villainy.

To be continued …

The experts for perfect vacuum.

Over the course of the company's more than 100-year history of innovation, we have been driven by a quest to transform nothing into perfection. Custom-tailored solutions for your processes and the durability of our products make for secure investments. Pfeiffer Vacuum, the inventor of the turbomolecular pump – your strong partner for all applications.

As a leading manufacturer of components and systems for generating, measuring and analyzing vacuum, Pfeiffer Vacuum is your guarantee of quality, reliability and service. Our worldwide 24/7 service organization is unrivaled in being able to perform bearing changes right on site. Short downtimes – an unbeatable advantage when it comes to efficiency and cost-effectiveness.

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www.pfeiffer-vacuum.net

Vacuum is nothing, but everything to us!