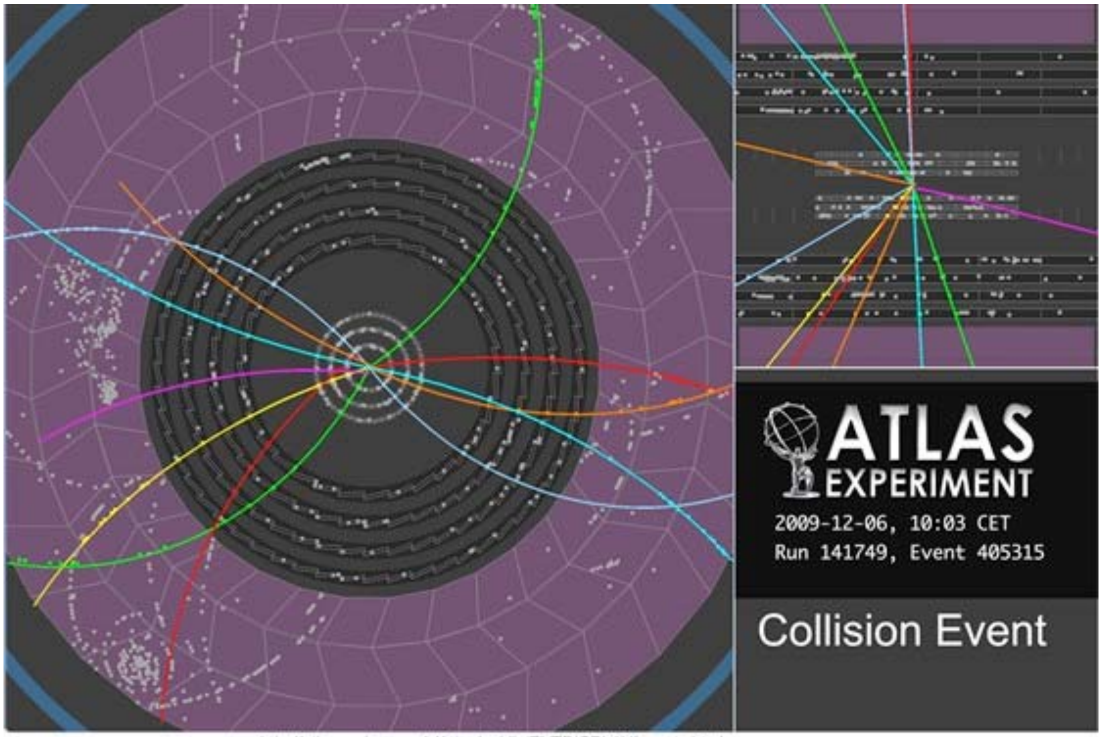
Collider Passes "Smoke Test"

by Dennis L Feucht



http://atlas.web.cern.ch/Atlas/public/EVTDISPLAY/events.html

The Europeans have been laboring patiently for decades in building at CERN the Large Hadron Collider; and what a piece of power electronics it is: an underground accelerator ring, 27 kilometers in circumference, at the Laboratory in Geneva, Switzerland. Erik Margan of IJS in Slovenia has been contributing to the detector electronics of the LHC and described the electronic circuit design earlier for En-Genius in a pair of TechNotes. Since then, the LHC has been "fired up."

The first attempt, on 19 September 2008, experienced a minor but dramatic incident. From a CERN report on 16OCT08,
"… a fault occurred in the electrical bus connection in the region between a dipole and a quadrupole, resulting in mechanical damage and release of helium from the magnet cold mass into the tunnel."

This sounds rather uneventful until details from the technical report are read (as excerpted):
"… the current was being ramped up to 9.3 kA in the main dipole circuit at the nominal rate of 10 A/s, when at a value of 8.7 kA, a resistive zone developed in the electrical bus… The first evidence was the appearance of a voltage of 300 mV detected in the circuit above the noise level… After 0.39 s, the resistive voltage had grown to 1 V and the power converter, unable to maintain the current ramp, tripped off at 0.46 s (slow discharge mode).

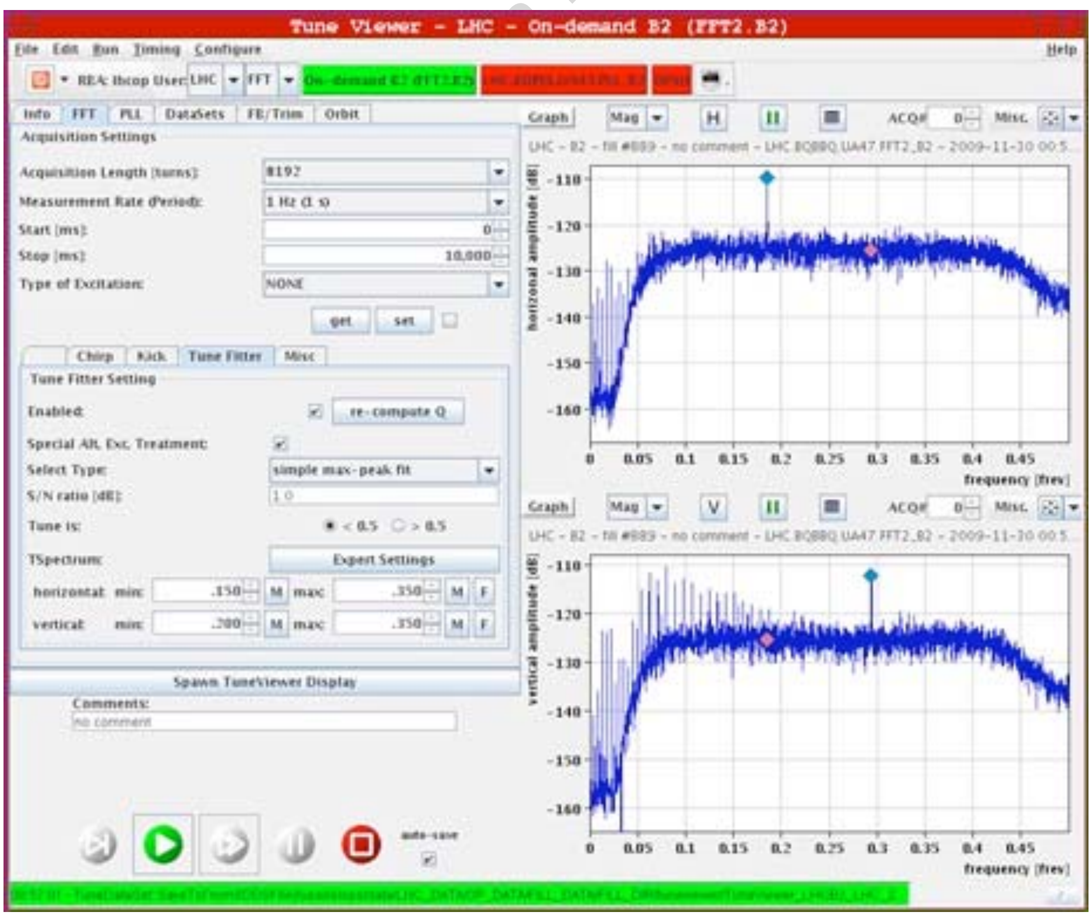
"Within the first second, an electrical arc developed and punctured the helium enclosure, leading to release of helium into the insulation vacuum of the cryostat. The additional power reaching the helium enclosure produced the onset of a pressure rise… The spring-loaded relief discs on the vacuum enclosure opened when the pressure exceeded atmospheric, thus releasing the helium to the tunnel. They were however unable to contain the pressure rise below the nominal 0.15 MPa absolute in the vacuum enclosures of subsector 23 - 25, thus resulting in large pressure forces acting on the vacuum barriers separating neighboring subsectors, which most probably damaged them. These forces displaced dipoles in the subsectors affected from their cold internal supports, and knocked the Short Straight Section cryostats housing the quadrupoles and vacuum barriers from their external support jacks… in some locations breaking their anchors in the concrete floor of the tunnel. The displacement of the Short Straight Section cryostats also damaged the *jumper* connections to the cryogenic distribution line, but without rupture of the transverse vacuum barriers equipping these jumper connections…”

Besides broken concrete anchor bolts on cryostats:
“About 2 t of helium… was rapidly discharged and eventually released to the tunnel, producing a cloud which triggered the oxygen deficiency hazard detectors installed on the tunnel vault and tripped an emergency stop, thus switching off all electrical power and services from sector 3 - 4. In the subsequent leakage from the open circuits, and before restoration of electrical power enabled to actuate cryogenic valves, another 4 t of helium were lost, though at much lower flow rates. The total loss of inventory thus amounts to about 6 t, out of 15 t initially in the sector.”

The safety systems performed as expected and nobody was put at risk, the report adds.

After this starting glitch, the giant machine was put back in order and recently tried again. On 20 November 2009 at 20:53 hours, the first beam occurred. The happier news this time was the detection of *first beam*. As Erik Margan wrote in an email on 23 November 2009 to some of us, “As it looked like there were no major problems, things have been moving much ahead of schedule than previously expected. After a number of *splashes* (collisions of the beam with a fixed target), we are now expecting first true beam to beam collisions at energies of ~0.5 TeV this very morning.”

Then the next day (24 November 2009) the exciting news arrived in another email from Erik, “As expected, yesterday (Monday 23) at 14:22 CERN time we recorded the first two beam collisions at 900 GeV.



The tangible fruits of decades of labor elicited some emotional response from the physicists at CERN. As Erik put it in his email, "Please excuse the spam, but at this historical moment I want to share my emotions with you!" The official announcements, photos, and other related material can be found at CERN websites recommended by Erik:
https://public.web.cern.ch/public/
http://press.web.cern.ch/press/lhc-first-physics/
http://atlas.ch/news/
http://thecoffeedesk.com/news/index.php/2009/07/02/hadron-colliders-for-not-so-particle-physicists/

The CERN official announcement explained in summary what the excitement was about:
"Geneva, 23 November 2009. Today the LHC circulated two beams simultaneously for the first time, allowing the operators to test the synchronization of the beams and giving the experiments their first chance to look for proton-proton collisions. With just one bunch of particles circulating in each direction, the beams can be made to cross in up to two places in the ring. From early in the afternoon, the beams were made to cross at points 1 and 5, home to the ATLAS and CMS detectors, both of which were on the look out for collisions.

"Since the start-up, the operators have been circulating beams around the ring alternately in one direction and then the other at the injection energy of 450 GeV. The beam lifetime has gradually been increased to 10 hours, and today beams have been circulating simultaneously in both directions, still at the injection energy. Next on the schedule is an intense commissioning phase aimed at increasing the beam intensity and accelerating the beams. All being well, by Christmas, the LHC should reach 1.2 TeV per beam, and have provided good quantities of collision data for the experiments' calibrations.

"The first beams are used to calibrate and test beam detection instruments. For instance, the Beam Condition Monitor (BCM) was successfully tested using some dedicated splash events. The BCM abort system has been working since the BCM was tested and no spurious abort has been triggered by it."

The grand scale of this apparatus might not be appreciated until some rough calculations are done. As electronics engineers, when hearing the word *beam*, we might think of electron beams in CRTs. These LHC beams, with energies of 1.2 TeV, are in another league, comparable to the energy of a landing 747 aircraft. The latest report from CERN (as of 8 December 2009) was of 2.36 TeV collision events, setting a world record for particle accelerators.

The data acquisition capabilities of the LHC are equally big. The ATLAS detector alone could fill 100,000 CDs per second. The selective recorded data rate is equivalent to 27 CDs per minute. The detector itself is large: about half as big as the Notre Dame Cathedral in Paris, and weighs the same as the Eiffel Tower or a hundred empty 747 jets.

Another perspective on LHC activity can be attained from physics students and young particle physicists who write diaries of their experiences at CERN, such as the report on *Beams in the Tunnel* by Anadi Canepa, an Italian-born, Italian- and American-educated, Canadian research scientist, in her quantum diaries. The atmosphere at CERN is decidedly international, with most European countries involved and other major countries of the world having observer status.