

DIRECTOR'S CORNER

The LHC performance and prospects

by Barry Barish



The LHC is now operating successfully at 3.5 TeV in a physics data-taking mode, and a significant amount of data has already been recorded, analysed and reported. The early results are already narrowing the available mass range for the Higgs boson and are setting limits on supersymmetric particles. Significant results can be expected from this data run, which is currently scheduled to last until the end of 2012.

AROUND THE WORLD

From Fermilab Today: Staff and users celebrated the Tevatron's last beam – Sept. 30



The Tevatron again and again did the impossible. It was the world's first superconducting synchrotron. It required the development of the world's most intense, consistent source of antiprotons. It eventually operated 300 times beyond its original design capabilities.

AROUND THE WORLD

Spanish journey to the heart of matter

François Richard speaks to Granada residents about the universe, how scientists conceive it and the role of particle colliders in illuminating it

by Perrine Royole-Degieux



With the news of superluminous neutrinos in the air, the residents of Granada, Spain were primed and ready to learn more about the strange world of particles from François Richard, who gave a public lecture during the week of this year's international workshop on linear colliders.

IMAGE OF THE WEEK



ILC squat team

Image: Nicholas Walker

Eckhard Elsen, Karsten Buesser and Klaus Sinram take a Segway tour of Granada, Spain.

IN THE NEWS

from ***symmetry breaking***

4 October 2011

International committee maps future of particle physics

This week an international organization made public their vision for the future of particle physics across the globe. The International Committee for Future Accelerators have placed on the web their report, "Beacons of Discovery".

from ***Reuters***

4 October 2011

Faster expanding universe work wins physics Nobel

The "astounding" discovery that the expansion of the universe is speeding up won the Nobel physics prize on Tuesday for three astronomers whose observations of exploding stars transformed our view of the world, and of how it may end.

from ***Reuters***

3 October 2011

Cosmic research "Dream Machine" mooted

Gathering for four days at CERN near Geneva, scientists and heads of major research centers around the globe are looking at how to combine resources and funding for the project, the International Linear Collider (ILC).

from ***The Economist***

1 October 2011

So long, and thanks for all the quarks

It already looks likely that the successor to the LHC, a device called the International Linear Collider (ILC), will be built in Japan (if it is built at all).

from **EuCARD**

July – September 2011

[To Infinity and Beyond](#)

Tasked with verifying the fabrication of CLIC components, “Infinity” is a new precision measuring machine that is now part of the CERN Metrology Service.

ANNOUNCEMENTS

Registration is now open for the [Workshop for the SiD Design Study](#), to be held at SLAC from 14-16 December 2011. Participants will review the current status of SiD detector R&D and the overall SiD design in preparation for the 2012 publication of the detailed baseline design. They will also discuss the CLIC Conceptual Design Report, future cooperation between SiD and the CLIC detector team, and SiD's future beyond the DBD.

[Register](#) for the workshop. Fee details are being worked out and will be made available on the [website](#) when they are finalised.

PREPRINTS

ARXIV PREPRINTS

[1110.0210](#)

The Epsilon Expansion of Feynman Diagrams via Hypergeometric Functions and Differential Reduction

CALENDAR

UPCOMING EVENTS

[10th ICFA Seminar on Future Perspectives in High-Energy Physics 2011](#)

CERN

03- 06 October 2011

[13th International Conference On Accelerator And Large Experimental Physics Control Systems \(ICALEPCS 2011\)](#)

Grenoble, France

10- 14 October 2011

[ILC-HiGrade 4th Scientific Workshop](#)

LAL, Orsay, France

12 October 2011

[50th ICFA Advanced Beam Dynamics Workshop On Energy Recovery Linacs \(ERL 2011\)](#)

KEK, Tsukuba, Japan

16- 21 October 2011

[2011 Low-Level Radio Frequency Workshop \(LLRF 2011\)](#)

DESY, Hamburg, Germany

17- 20 October 2011

[2011 IEEE Nuclear Science Symposium and Medical Imaging Conference](#)

Valencia, Spain

23- 29 October 2011

[ILC Source/RTML/BDS+MDI Technical Baseline Review](#)

DESY, Hamburg, Germany

24- 27 October 2011

[View complete calendar](#)

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Barry Barish | 6 October 2011



A view of the twin aperture main superconducting magnets for the LHC

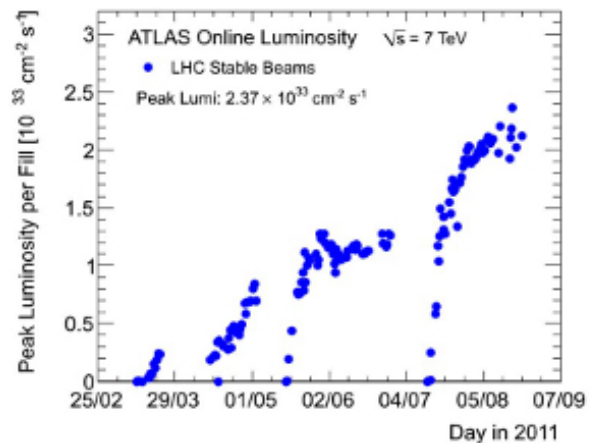
The Tevatron at Fermilab, US, was turned off last week and now the high energy frontier has officially moved across the Atlantic Ocean to CERN and its Large Hadron Collider (LHC) in Switzerland. We have great expectations for LHC physics, since historically higher energy has been our most effective probe to new discoveries in particle physics. The LHC is now operating at 3.5 teraelectronvolts (TeV) per beam and will eventually run at twice that energy. The machine is already performing quite well and is in the midst of a physics data-taking run that is scheduled to extend to the end of 2012. We anticipate significant science results will emerge from this data run.

LHC is built in the tunnel that housed LEP, a high-energy electron-positron collider that provided much of the precision data validating the Standard Model of particle physics. The LHC consists of about 8000 superconducting magnets cooled to liquid helium temperatures (1.9

kelvins). The 1232 dipole magnets are each 14.3 metres long and will operate up to 8.4 teslas. They have twin apertures, enabling acceleration and collision of protons counter-rotating (note that the Tevatron produced antiproton-proton collisions). The energy stored in the magnet system is about 10 gigajoules.

The present LHC data run at 3.5 TeV began last winter and the performance of the machine has steadily improved during the run, achieving a peak luminosity of $2.7 \times 10^{33} \text{ cm}^{-2} \text{ s}^{-1}$. As of 26 September, it achieved an integrated luminosity of 3.6 inverse femtobarns, greatly exceeding the original 2011 goal of one femtobarn. The machine is now running with 1380 bunches and scientists are now working to increase the bunch intensity to 1.55×10^{11} protons per bunch.

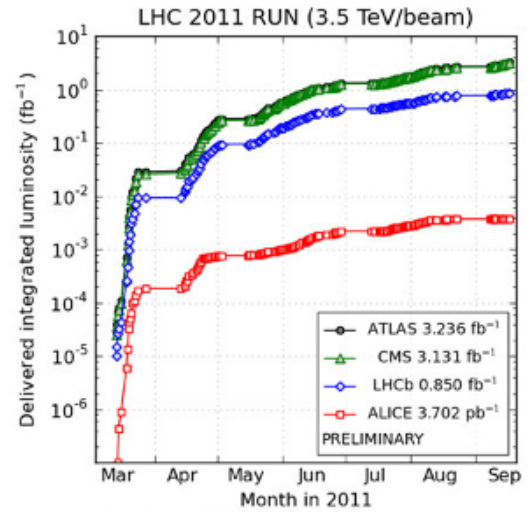
This first important LHC data run is expected to continue to the end of 2012, with a roughly five-week heavy ion (lead-lead) run inserted at the end of this year. Some continued improvements in luminosity and maybe even some increase in energy are possible for the 2012 running. The accumulated luminosity projected by the end of 2012 should enable definitive searches for the Higgs boson over the entire mass range, except for the challenging low energy (around 120 GeV) regime, where only a preliminary search will be possible.



Peak luminosity in the ATLAS detector during the 2011 data run

The question for us in the ILC effort is whether this LHC data run will produce enough physics results to motivate a linear collider, and whether it will give us the guidance we seek regarding the parameters required for such a machine, such as beam energy. Answer: probably not! Although important physics results are anticipated and will give us important early guidance, it appears likely that the data run, following the anticipated long shutdown from 2013-2014, will be required to really understand what new physics is emerging in this new energy regime.

Keeping this longer timescale in mind, those of us involved in the linear collider efforts are thinking hard about how best to incorporate the LHC guidance into the ILC design as it emerges. We will complete the major milestone of producing an ILC *Technical Design Report* (TDR) by the end of 2012, and the question that faces us is how to continue and update the design during the post-TDR period. I will be addressing this important question in future columns.



Integrated luminosity as of 19 September (Image: R Heuer – LCWS11 Granada, Spain)

CERN | LHC

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Feature

Staff and users celebrated the Tevatron's last beam - Sept. 30

Thousands of Fermilab staff members and scientific collaborators flooded Fermilab and watched remotely online from across the globe Friday to see the Tevatron power down one final time. Following the shutdown, everyone joined in to celebrate nearly three decades of [scientific](#) and [technological](#) achievements that have changed the way we understand the world.

"The Tevatron exceeded every expectation ever set for it," said Fermilab Director Pier Oddone, as the 40-minute [shutdown procedure](#) began. "As of this moment, the two detectors, CDF and DZero, have recorded nearly 12 inverse femtobarns of data. The collider has reached peak luminosities of 4×10^{32} per centimeter squared per second, producing several million collisions per second. These numbers were considered totally impossible by scientists and engineers back in the eighties when the machine first came online."

The Tevatron again and again did the impossible. It was the world's first superconducting synchrotron. It required the development of the world's most intense, consistent source of antiprotons. It eventually operated 300 times beyond its original design capabilities.

The creativity and tools needed for these achievements helped enable consumer products, such as MRI machines, and a globally competitive workforce that has gone on to help design the Large Hadron Collider and countless other physics experiments as well as improve industries as diverse as finance and manufacturing.

Shutting the Tevatron down Friday was a bittersweet time for employees and users, many of whom had spent most of their careers making the Tevatron one of the most productive sources of physics research in the world. CDF and DZero will continue to churn out analyses from Tevatron data at an average rate of one scientific paper a week for at least two more years.

"We will really miss the Tevatron but we have to move on and hopefully do something even better, contributing to pushing back the frontiers of science," said Roger Dixon, head of the Accelerator Division.

Fermilab plans to build upon the pioneering spirit that built the world's largest proton-antiproton accelerator in the middle of a prairie to now build the world's most powerful linear proton accelerator, Project X. This will enable Fermilab to lead in a new era of precision physics, producing the largest number of particles to optimize the study of the rarest particle interactions.

The myriad neutrino, muon and kaon experiments operating and planned are attracting young scientists from across the globe. They will face the challenge of topping the breadth of the Tevatron's scientific [accomplishments](#).

The discovery of the tau neutrino by the Tevatron's fixed-target program has been one of the main achievements in neutrino physics worldwide.

"The Tevatron program has been remarkably successful; from the discovery of the top quark, to the precision measurement of the W boson mass, the observation of B_s mixing and the many limits set on potential new physics theories," said Rob Roser, co-spokesperson for CDF. "The Tevatron has changed the way the world views particle physics."

In the collider program, CDF and DZero improved our understanding of the building blocks in the Standard Model, the recipe for the matter that makes up everything we see and for how the rules of nature affect daily life. They observed the strongest evidence yet for an imbalance in matter and antimatter in particles. This imbalance tipped the cosmic scales in matter's favor. The discoveries made by CDF and DZero include the top quark and a whole new family of baryons.



From left: Leon Lederman, Nobel Laureate (1988 Physics) and former Director of Fermilab; Robert Mau, the former head of Fermilab Accelerator Operations; and Helen Edwards, the former head of the Accelerator Division, aborting colliding beams in the Tevatron for the last time. Photo: Marty Murphy, AD

The subsequent precision measurements of the top quark as well as those of the W boson mass have laid the groundwork for the search for the Higgs boson. Without the mass the Higgs bosons imparts to fundamental particles, the world as we know it would not exist. Because the Higgs lives for less than the blink of an eye, physicists at the Tevatron and LHC would not be able to hunt it down without the guiding measurements of the particles it decays into.

"To make discoveries you need to understand the Standard Model," said Dmitri Denisov, DZero co-spokesman. "To understand, you need to do calculations. And to do calculations, you need to be able to study particles to high precision. The data from the Tevatron enables us to excel at that."

To share your own memories of the Tevatron, or to read those of others, please visit the Tevatron [online guestbook](#).

—Tona Kunz

AROUND THE WORLD

Spanish journey to the heart of matter

François Richard speaks to Granada residents about the universe, how scientists conceive it and the role of particle colliders in illuminating it

Perrine Royole-Degieux | 6 October 2011



*Francois Richard makes the case for a linear collider.
Image: Perrine Royole-Degieux*

While the linear collider scientific community was discussing the next steps to propose a future machine for particle physics at the [LCWS11](#) conference, a crowded audience gathered to listen to a public lecture entitled “Journey to the heart of matter,” given by François Richard on 27 September in Granada, Spain at the Parque de la Ciencias, one of the major science museums in Spain. Audience members enjoyed asking him diverse questions on matter, the vacuum, the universe, and of course the International Linear Collider during the question-and-answer session that followed.

Richard posed his own questions to the audience during his talk: Why are there three families of leptons when we observe stable objects that are only made of the first one? Why are there fourteen orders of magnitude of difference between the neutrino and the top quark masses? Are these numbers just random or deterministic? Could there

be other parallel universes where nature made other choices?

Using such questions as motivators for high-energy physics research, François Richard, French CNRS researcher at LAL, Orsay and former European contact for the ILC research director and co-chair of the Worldwide Study, emphasised that these mysteries are exceedingly puzzling, prompting thinkers to suggest that our universe is a result of a Darwinian-like selection, better known as the anthropic principle. But if such notions are not acceptable to us, Richard said, we must look for fundamental laws that govern nature, and answer these questions by looking to the universe's smallest constituents. Quoting Averroes, a famous Andalusian Muslim philosopher from the 12th century who mastered theology, law, mathematics, physics and other sciences, he noted that “In nature, nothing is superfluous.”

In lay Spanish language, he also explained the purpose of the Large Hadron Collider and why, complementary to the LHC, a linear collider is necessary to accurately observe and understand new particles such as the Higgs boson, and maybe, to answer one of the deep questions of science, the origin of particle masses.

After Richard made his case for a linear collider, the enthusiastic audience members followed up with a variety of questions from the place of string theory in physics to how we would know when we've finally reached the search-ending most-fundamental particle. They also asked very concrete questions about how much a future linear collider would cost and what would be applications of particle physics research to society, even if no major discoveries were made.

To a question about when there would be a final ILC design, Richard responded that it had to be the result of a global effort, and that it would depend on what the LHC discovers. Referring to the LCWS11 workshop, Richard concluded: "Let's hope that the marvelous city of Granada will inspire us to define the next steps of our exploration of matter."

During the LCWS11 concluding talk, Jonathan Bagger, chair of the ILC Steering Committee, advised physicists to meet and convince the outside community of the importance of particle physics. "Good science is not enough," he said, "we need to engage the public." That night in Granada, Richard demonstrated the effectiveness of that advice.



12th-century thinker Averroes as depicted by 14th-century painter Andrea da Firenze

GRANADA | LCWS11 | PUBLIC EVENT | PUBLIC LECTURE | SPAIN

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