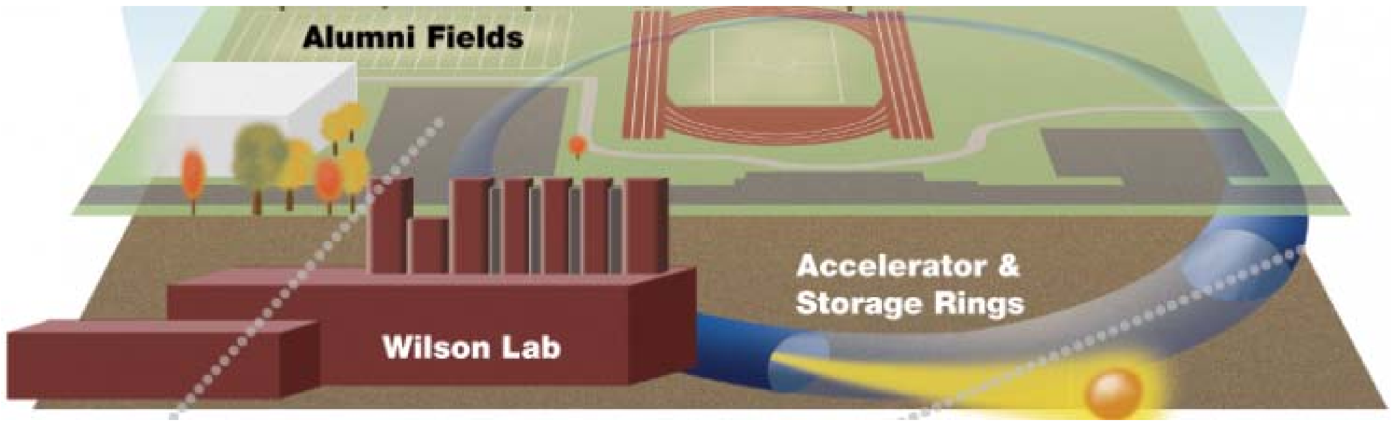
AROUND THE WORLD

Cornell makes progress on Energy Recovery Linac

by Leah Hesla



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Applying this concept, however, is seldom simple. In the case of Cornell University's Energy Recovery Linac (ERL), recycling energy to generate particle beams requires technological advancements that are born from decades of research. If scientists there fulfil their mission, they'll be able to use particle beams to accelerate particle beams, producing some of the brightest bunches to be made by an accelerator.

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Is accelerator research useful?

This story first appeared on 15 January in the ILC Tsushin, the Japanese ILC newsletter, published every month by KEK

by Rika Takahashi

There is a question almost always asked when talking about science - "OK, this is interesting. But is it useful for something?" Not too many scientists working on basic science are good at answering this question. "Dr. Masatoshi Koshiba sometimes says that the neutrino, his main research subject, is not useful at all. Well, a Nobel laureate could say that, but not us. I try to talk more about useful

DIRECTOR'S CORNER

Common goals

Today's issue features a Director's Corner from Nick Walker, Project Manager for the Global Design Effort.

by Nick Walker

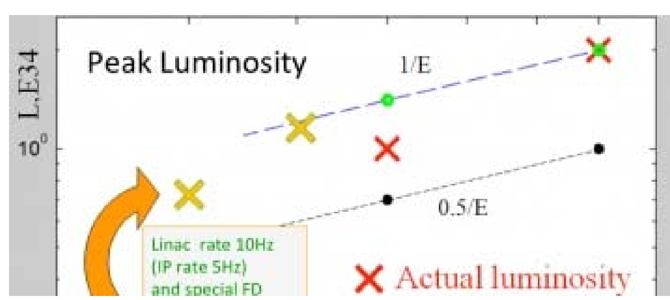

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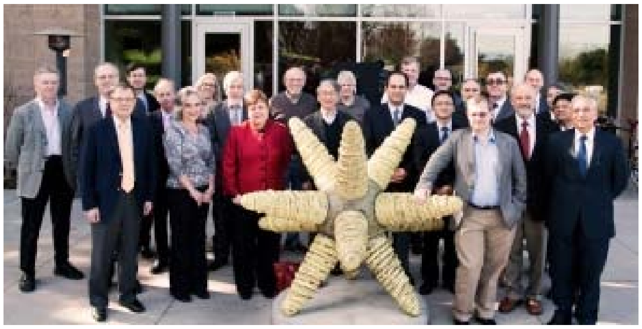
IMAGE OF THE WEEK



FALC meets at SLAC

Image: Lori Ann White

Sculpting the future: the members of the Funding Agencies for Large Colliders, or FALC, took a break from their discussions about the next-generation linear collider at SLAC last Saturday to gather around a work of art for a group picture. Read more about their meeting in SLAC Today.

IN THE NEWS

From CERN Courier
25 January 2011
Planck reveals a stellar first year
The first results from the Planck mission, released on 11 January, are already providing new insights into astrophysics and augur well for the future, with plenty more contributions to cosmology still to come.

From businessworld.in
22 January 2011
Book Review: The Big World Of Small Things
'Collider' is an extremely readable science book taking you on a scintillating journey into the enigmatic world of particle physics and the contributions of the LHC, an engineering marvel

From New York Times
21 January 2011
Editorial: The Tevatron
… Physics is an international pursuit. Fermilab is home to physicists from all over the world, and other experiments will still take place there, as will work with the Large Hadron Collider. Yet it's lamentable to see the end of an era of high-energy particle experiments in America that defined the threshold of our understanding of matter.

From The Beacon News
21 January 2011
Fermilab leader promises important work will go on
BATAVIA — While the Tevatron will close, Fermi National Accelerator Laboratory still will have its place of importance in the world of physics research, Fermilab Director Pier Oddone said Wednesday.

CALENDAR

UPCOMING EVENTS

2011 Linear Collider Workshop of the Americas (ALCPG11)
University of Oregon, Eugene, Oregon, USA
19- 23 March 2011

BLOGLINE

25 January 2011
CERN
Des valeurs partagées pour une nouvelle réalité.

2011 Particle Accelerator Conference (PAC'11)
New York Marriott Marquis Hotel, New York, NY, USA
28 March- 01 April 2011

UPCOMING SCHOOLS

US Particle Accelerator School (USPAS)
Old Dominion University, Hampton VA
17- 28 January 2011

Excellence in Detectors and Instrumentation Technologies (EDIT 2011)
CERN, Geneva, Switzerland
31 January- 10 February 2011

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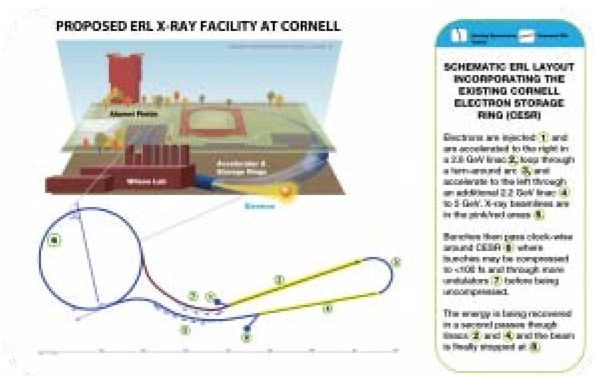
Probing lepton flavor violation signal via e^+e^-*(??)?* l_i l_j in the littlest Higgs model with T-parity at the ILC

Cornell makes progress on Energy Recovery Linac

Leah Hesla | 27 January 2011



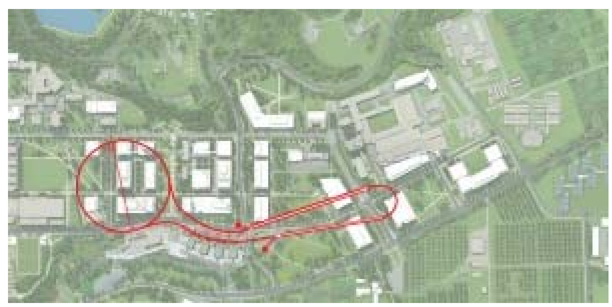
Schematic of Cornell's proposed Energy Recovery Linac. Image provided courtesy of Bruce Dunham.

The idea behind recycling is straightforward: reuse what you have to make more of the same.

Applying this concept, however, is seldom simple. In the case of Cornell University's Energy Recovery Linac (ERL), recycling energy to generate particle beams requires technological advancements that are born from decades of research. If scientists there fulfil their mission, they'll be able to use particle beams to accelerate particle beams, producing some of the brightest bunches to be made by an accelerator.

"It's a new technique that hasn't been used to produce brilliant x-ray beams anywhere before," said Georg Hoffstaetter, associate chair of Cornell Laboratory for Accelerator-based Sciences and Education (CLASSE) for the ERL accelerator. "Such things don't come around so often. It's an exciting project to work on."

The aim is to produce high-brightness, focused light beams with short pulses. Linear accelerators, or linacs, are good at this, much more so than circular accelerators. Jefferson Lab in Virginia, for example, has an ERL-based free-electron laser that generates infrared and ultraviolet light for its users, using 135-megaelectronvolt electron beams to generate the light.



Cornell's Energy Recovery Linac will lie under the Cornell campus. The Cornell Electron Storage Ring, known as CESR, will be incorporated as part of the ERL. Image provided courtesy of Bruce Dunham.

However, to produce X-rays, much higher energies are needed. Cornell scientists are aiming for five-gigaelectronvolt electron-beam energy, which would then generate the linac-quality X-rays. High-brightness beams also require boatloads of current, resulting in a beam power of about half a gigawatt of power.

"That's almost a nuclear power plant's worth of electricity required to run it, if one would not use Energy Recovery" said ERL Project Director Bruce Dunham. Since that isn't the kind of electricity you can just draw out of the wall socket, the team decided to corral energy that was already at hand – the energy from the electron beam as it races through the linac.

Part of the beam diagnostics system of the Energy Recovery Linac injector prototype.

"You don't throw any energy away," said Dunham.

The electric field in the linac rises and falls many times per second, like the waves of a plucked guitar string. In the energy recovery scheme, an initial electron bunch rides the wave as it's on the rise, accelerating through superconducting cavities and accumulating energy as it zips its way around the ERL. As the bunch completes its journey, its exit is precisely timed to land on the falling side of the wave, slowing down as it departs from the linac. As it decelerates, it relinquishes its hard-earned energy to the cavities, where it's stored for the next electron bunch. That bunch will swing by to pick up the cavity's stored energy a fraction of a nanosecond after the first.

In this way each electron bunch passes its energy to the next like a baton in a relay race. The energy recovery process is over 99% efficient, so the linac would be sufficiently powered and the X-rays that come out of these accelerated bunches would be coherent and bright.

In 2005, the National Science Foundation awarded the ERL Group $18 million to develop a prototype injector for the machine. Last year the group completed construction of the injector, a device that gets the electrons going through the linac. Now in the pre-construction phase, the team is continuing its programme for producing bright beams, testing the cavities that accelerate the beams, building a cryomodule to keep cavities cold, and building a facility to test cathodes, from which the electrons originate.

Maury Tigner, now director of CLASSE, published a paper on the idea of energy recovery in 1965. But the superconducting technology needed to pull it off wasn't around.

"The ERL was always an interesting curiosity that some people have played with," said Hoffstaetter. Only in the 1990s, with progress from the TESLA project, could the concept be implemented. Now the Cornell team intends to get as much as they can out of it.

In the last year, the ERL team has made several advancements in instrumentation to get the most use out of their electrons. Their electron gun could be the highest average-power DC photocathode gun ever built. They've also developed absorbers for superconducting cavities that soak up power of unwanted frequencies that arise as a result of the ERL's high beam current. Both developments mean less waste and more useful beam for the ERL.

Cornell is drafting another proposal of the full machine, which will incorporate Wilson Laboratory on the Cornell campus and replace the existing storage ring based in the Cornell High Energy Synchrotron Source X-ray facility. The proposal will address considerations of the tunnel and buildings to house the machine and X-ray beamlines, as well technical considerations of all aspects of the machine.

It could be that in a few years' time, Cornell's ERL will provide brilliant
X-rays for use in the biological, medical and material sciences, as well as other fields of science and engineering.

Stay tuned to future issues of *NewsLine* to read more about accelerator research coming out of Cornell University.

CORNELL | ENERGY RECOVERY LINAC | ERL

AROUND THE WORLD

Is accelerator research useful?

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Rika Takahashi | 27 January 2011

Toshihide Maskawa (left) and Atsuto Suzuki at the AAA symposium held in Nagoya, Japan.

There is a question almost always asked when talking about science – "OK, this is interesting. But is it useful for something?" Not too many scientists working on basic science are good at answering this question. "Dr. Masatoshi Koshiba sometimes says that the neutrino, his main research subject, is not useful at all. Well, a Nobel laureate could say that, but not us. I try to talk more about useful accelerators these days," said Atsuto Suzuki, the Director General of KEK, at a symposium held in Nagoya, Japan, in November, which was organised by the Advanced Accelerator Association promoting science and technology (AAA).

The track record shows that particle physics studies have been the source of many innovations not originally part of the research to understand the Universe. "Synchrotron radiation light emitted by electrons orbiting in a storage ring of the accelerator makes it possible to analyse structures of the smallest size, such as proteins. Neutron beams produced by accelerators enable us to see through the inner structure of devices without breaking them," Suzuki explained. He also mentioned accelerators are used for medical diagnosis or therapy. Positron emission tomography (PET) enables us to view chemical processes within live organs. Heavy-ion radiotherapy is recognised as a powerful treatment method, delivering a concentrated, targeted dose of heavy ions precisely to the site of a tumor. "In addition to those applications already in effect, accelerators are expected to work as a useful tool in astrophysics or life science," Suzuki said.

Those innovations have changed the way we live and do business. One of the most striking examples is discovery of electron. The then unknown particle has now become a necessity of our life in many ways, in many shapes. But, for scientists working on basic science research, those innovations were recognised as spin-offs, not the results from their efforts. Therefore, no proactive advertisements had been made to report what was the origin of those useful innovations.

Another factor that makes it difficult to connect innovations and basic research is the length of the lead time. Basic research can precede innovations by decades. "It is said that it takes 50 to 100 years for a result from basic research to reach back into the society," said Toshihide Maskawa, who won the 2008 Nobel Prize in physics, and also gave a talk at the AAA symposium. But he pointed out that the lead times are being 'bypassed' these days. "Some of the innovations are accomplished as quickly as within two or three years. As the experiments got bigger, technical elements for the accelerators and detectors became more complicated, requiring sophisticated and unprecedented technologies. Those technologies are benefitting the society rather than waiting for the scientific results from experiments," said Maskawa.

The World Wide Web (WWW) is one of the good examples of quick innovation. The WWW was invented in 1989 by Tim Berners-Lee, a scientist at CERN. It was originally conceived and developed to meet the demand for automatic information sharing between scientists working in different universities and institutes all over the world. The ILC is also expected to be the source of yet more technological breakthroughs. For example, the superconducting radio frequency accelerating technologies could be adapted to produce monochromatic X-rays for medical diagnoses and treatment, enabling radically new probes of biological processes and tissue protein structure, and help develop new medicines.

Even though the lead times are becoming shorter than in the past, it still is unsure where, when and how, if ever, basic research being done now would benefit us. One can easily imagine that people don't want to invest in unknown possibilities under the tough circumstances we experience now. "However, we cannot forget that the innovation happens by multiplication," said Suzuki. "When you multiply zero by any number, you always get zero. Even when you multiply zero by hundreds of thousands, you still get zero. Our job in science is to produce 'one' to multiply."

"Is it useful for something?" This might be the question answered only by scientists in the future. No one can tell if it is useful or not for sure at the time of the new discovery. But scientists are accountable for explaining what may originate from the innovations we enjoy now.

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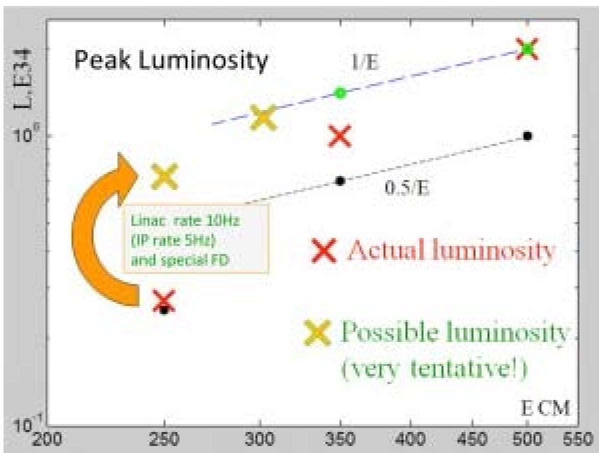
DIRECTOR'S CORNER

Common goals

Today's issue features a Director's Corner from Nick Walker, Project Manager for the Global Design Effort.

Nick Walker | 27 January 2011



Luminosity parameters across the operational energy range (200-500 GeV centre-of-mass). Courtesy of Andrei Seryi.

As a guest columnist for the Director's Corner, it is my turn to supply this article approximately once every eleven months. Looking back I see that my last column was just before the LCWS 10 workshop held in Beijing. Interestingly enough, I now find myself on the tail end of another GDE workshop, the recent Baseline Assessment Workshop (BAW) held at SLAC last week (18 to 21 January), where over 70 scientists came together to discuss the baseline parameters and layout for the updated ILC design we will use for the *Technical Design Report* (TDR) due at the end of 2012.

The SLAC BAW was the second and last such workshop of the so-called Top Level Change Control (TLCC) process, which has been going on for the last twelve months. The first BAW was held in September at KEK, where the issues of accelerating gradient and the adoption of a single-tunnel scheme for the main linacs were the focus. Both of these proposals have since been successfully concluded and are now formally part of the TDR baseline, as reported in these columns (9 December 2010 and 16 December 2010). The SLAC BAW focused on the two remaining TLCC themes: a reduced beam-power parameter set and the location and layout of the positron source. For four solid days last week the details of the two proposals were put under the microscope; the workshop represents the culmination of almost ten months of hard work by our design team, and on behalf of my fellow project managers I would like to take this opportunity to thank them for their continued support. Having passed the initial test of the BAW itself, the project managers will now make formal written proposals to the director for his final review and decision.

I will leave the technical details of these important design modifications to a later Director's Corner (I hope after they are formally accepted as baseline). Instead I would like to spend the remainder of this column discussing the importance of the TLCC process itself from the perspective of the project managers.

Machine meets detector – over coffee.

The TLCC process was effectively 'born' from comments from two of our oversight committees: the director's Accelerator Advisory Panel (AAP) and the ILCSC PAC, which is the GDE's top-level oversight committee. When the project managers submitted their detailed proposals for baseline modifications in December 2009, first the AAP and then the PAC identified several areas that they felt required more attention. In particular, both committees noted a disconnect with the physics and detector community that needed to be addressed. While it is true that TLCC was formally put into place to deal with technical issues associated the change requests – breaking the original monolithic proposal into more manageable 'chunks' that could be dealt with individually – an important goal of the process itself was better involvement and communication with the ILC stakeholders in general, and specifically with the physics and detector groups. Research Director Sakue Yamada identified a group of five representatives from the physics and detector community to work closely with the project managers during the TLCC process, helping to organise the BAWs and to act as primary points of contact for the GDE to the broader community. These five representatives (Jim Brau, Karsten Büßer, Keisuke Fujii, Tom Markiewicz and Mark Thompson) have been an invaluable part of our 'design team' for the last ten or so months.

The results of these labours were very evident at last week's workshop. Over 30 representatives from the physics and detector community attended the workshop. Unlike the agenda for the KEK BAW, which focused entirely on machine technicalities, a section of the SLAC BAW was dedicated to presentations on the physics impact of the proposed new parameters. Indeed much of the past year's work has been focused on 'other' centre-of-mass running scenarios below 500 GeV, which have certainly been neglected up to this point. As a result, the SLAC BAW concluded a set of working parameters and operations scenarios across the energy range of 200-500 GeV, which supports the broader physics case.

These studies are an excellent example of what we can do when the machine designers get together with the physics and detector community. The project managers recognise the need to maintain these now established lines of communication into the next level of design work foreseen in part 2 of the Technical Design Phase (TDP 2). While many of these detailed design issues will have no direct relevance to the physics and detectors, it is still crucial that we maintain the open and transparent mechanisms we have established during the TLCC progress to keep the broader community informed. We intend to further establish these efforts as we begin the TDP 2 efforts at the upcoming ALCPG workshop in March.

As a final remark, I would like to thank the physics and detector representatives who have engaged and helped with the TLCC process. Without your input and hard work, we would not have been able been able to achieve the consensus on the baseline modifications now being proposed. We look forward to continued close cooperation as we work towards the Technical Design Report in 2012.

BASELINE | BAW | BEAM-POWER | POSITRON SOURCE | SLAC | TLCC | TOP LEVEL CHANGE CONTROL