LC NEWSLINE
THE NEWSLETTER OF THE LINEAR COLLIDER COMMUNITY

DIRECTOR'S CORNER

It's all about respect

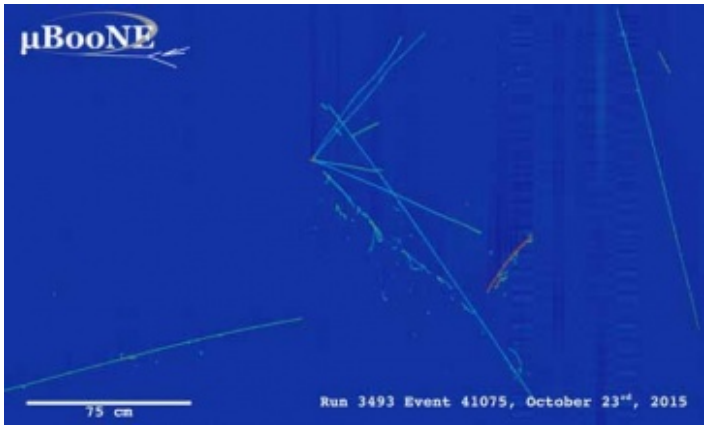
by Lyn Evans

Our particle physics community is a model of peaceful collaboration, independent of gender, race, religion or sexual orientation. In today's world, where gender discrimination and racism are becoming more and more prevalent, we should pride ourselves on our community's role model status. Let's make sure that our own high standards do not slip.

FEATURE

Pandora: opening the box for neutrino experiments

by Barbara Warmbein



Pattern recognition rules in particle physics. When particles collide, many things happen at the same time and in a very fast sequence within fractions of a second. In order to tell everyday events from rare ones, particle physicists use pattern recognition software to quickly scan and classify pictures from the collisions.

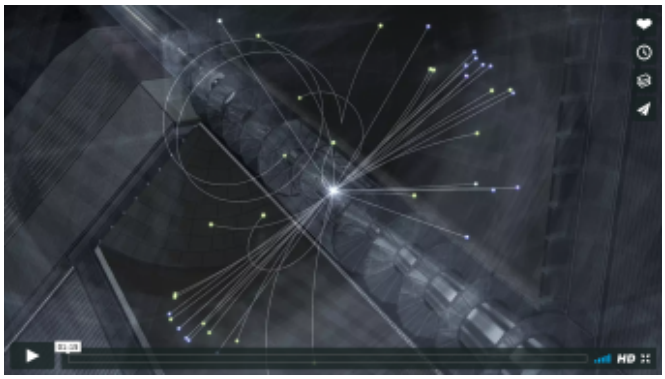
FEATURE

The Art of Linear Colliders

by Nikolai Promies, DESY

Every scientist can tell you about the beauty of his or her research. But while a small bump in a curve may delight particle physicists, most people just see a bunch of coloured lines. And the perfection of a complex theoretical model is evident only for a select few. Probably everybody would agree that science has made our world a better place. But who would say that it helps to make our lives more beautiful?

VIDEO OF THE WEEK



Let them collide!

by Barbara Warmbein

This animation, created by Rey.Hori, shows what happens when electrons and positrons collide in the ILD detector, one of the planned detectors for the future ILC. Many collisions will happen at the same time around the clock, producing a vast array of possible processes, or events. This animation shows the example of one possible collision event involving the Higgs boson. Here's a guide to what happens in the clip.

IN THE NEWS

from *CERN*
14 February 2017
How does CERN encourage women in science?
Just 20% of CERN's community are women, and CERN wants to improve on this. To encourage and attract more women to choose science, particularly physics, as a career CERN is holding events for both Gender in Physics Day (link is external) and the International Day of Women in Science (link is external).Last week, female scientists working at CERN visited local schools, to try to inspire the next generation of women in science.

from *CERN Ombuds*
14 February 2017
Do we not owe it to our daughters?
It is said that privilege is invisible to the privileged, and not only is it difficult for the majority to recognise the insidious barriers of organisational culture that minority groups face, it is sometimes equally difficult for those within the minority who have succeeded in overcoming them to grasp. (…) Indeed, a woman who walks into a meeting room surrounded by photographs of only male scientists, picks up a document that says that "the masculine gender shall be understood as referring to both genders", or works in an environment where all her superiors are male may well ask herself what would happen if the situation were reversed.

from *CERN*
13 February 2017
Naturally I'm a scientist
[Manuela Cirilli] laments the fact that women are still in a minority in laboratories, especially in positions of responsibility. "There is no magic formula. We have to promote careers in science, encourage women and, most importantly, show that when women are selected, it's because they deserve it."

from *Komei Shimbun*
11 February 2017
宇宙創生の謎に迫る　国際研究拠点の建設論議に期待
宇宙創生の謎に迫る研究拠点として世界中の注目を浴びる「国際リニアコライダー」（ILC）。その建設に向けた検討が、文部科学省を中心に進んでいる。科学技術立国をめざす日本にとって大きな意義を持つだけに、議論の行方を注視したい。(International Linear Collider" (ILC) which draws attention all over the world as a research hub to approach the mystery of the universe. The examination for the construction is advanced mainly by the Ministry of Education, Culture, Sports, Science and Technology. I want to pay attention to the way of discussion just because it has great significance for Japan aiming at a science and technology nation.)

from *Kitakami Times*
10 February 2017
Iwate visits CERN, CEA Saclay, and DESY
This year will prove to be an important one for the International Linear Collider project. All signs indicate that the Japanese national government will make their decision whether or not to host the ILC sometime from the end of 2017 to 2018. It is vital for all related parties to continue to urge the government to host the project, but we also must be prepared – if and when the green light is given to the ILC, all of us must be ready to "accelerate" ILC initiatives. To that end, Shigeki Chiba, Vice-governor of Iwate travelled to Europe in January 2017 to see some of its large scientific research facilities … and to glean insights that will be helpful as Iwate prepares an environment that can receive the ILC.

from *Iwate Nippo*
9 February 2017
Ms. Takahashi of KEK teaches the citizens of Morioka about the significance and future possibilities of the ILC
She also stressed the need for increasing awareness of the ILC among young people, as today's middle and high school students may be leading ILC research by the time the facility is created.
Translation provided by *Iwate & the ILC* website. Read original article (in Japanese) here.

from *Frankfurter Allgemeine Sonntagszeitung*
5 February 2017
Die nächste Weltmaschine
Der große Teilchenbeschleuniger bei Genf läuft noch bis zum Jahr 2035 auf Hochtouren. Doch irgendwann ist alles entdeckt, was sich damit entdecken lässt. Dann brauchen die Elementarteilchenphysiker etwas Stärkeres. Die Planungen laufen bereits. (paid content)

from *Kahoku Shinpo*
26 January 2017
＜東経連＞持続可能な地域提唱　新ビジョン

東北経済連合会は２５日、２０３０年を目標年次に、新潟を含む東北７県の将来像と戦略を描く新たな長期ビジョン「わきたつ東北～結び、はぐくみ、未来をひらく」を発表した。–「国際リニアコライダー（ＩＬＣ）」と東北放射光施設の誘致実現いった方策を列挙し、数値目標＝表＝を示した。(Tohoku Economic Federation published its long-term vision toward 2030, envisioned the future picture of 7 prefectures in Tohoku area by setting a strategies. The numerical target for each visions, include inviting the ILC and Tohoku Light source, was presented in the document.)

from *IBC News*
22 January 2017
ＩＬＣ絵画コンクールに264作品
子どもたちがＩＬＣ＝国際リニアコライダーを描いた、絵画コンクールの表彰式が22日、岩手県奥州市で行われました。
このコンクールは岩手県県南広域振興局が行ったもので、２６４作品の応募がありました。 (The award ceremony for the ILC drawing competition was held on 22 January in Oshu city, Iwate Prefecture. 264 elementary school students submitted their artworks inspired by expected construction of the ILC.)

from *Tanko Nichi Nichi*
6 January 2017
ＩＬＣ　膨らむ夢、好奇心（奥州市中学生科学研修、ＫＥＫなど訪問）
奥州市教育委員会が主催する「中学生科学体験研修」に参加している奥州市内の中学生３１人は、６日までの日程で学術研究施設が集積する茨城県つくば市を訪問している。５日は、高エネルギー加速器研究機構（ＫＥＫ、山内正則機構長）を訪問。北上山地が有力候補地となっている国際リニアコライダー（ＩＬＣ）とも関連性が高いさまざまな実験施設を目の当たりにし、最先端科学やＩＬＣ実現へのイメージを膨らませた。(31 Juniour high school students from Oshu city visited Tsukuba-city, a biggest science city in japan. On 5th January, they visited KEK and took a close look at the cutting -edge technologies related to ILC, filled with happy expectations)

from *Iwate Nichinichi*
2 February 2017
MEXT's Panel of Experts decides to create a new working group – Deliberations to start on research and operations structure of the ILC (研究体制、運営検討へ　ＩＬＣ誘致　有識者会議)
Director Komamiya introduced the "staging" strategy talked about at LCWS, which would take an incremental approach in increasing the ILC's capabilities. He said, "We can reduce construction costs to under 70% of the almost 1 trillion yen required by lowering the energy level of particle smashing experiments, and concentrating on precisely measuring of the Higgs particle." He showed a draft of a more minimalist ILC that would reduce the 31 kilometer accelerator found in the base plan to a compact 20 kilometers.
Translation provided by *Iwate & the ILC* website. Read original article (in Japanese) here.

PREPRINTS

ARXIV PREPRINTS

1702.03984
Scalar Production in Association with a Z Boson at LHC and ILC: the Mixed Higgs-Radion Case of Warped Models

1702.03770
CALICE Si/W ECAL: Endcap structures and cooling system

1702.03396
Discriminating leptonic Yukawa interactions with doubly charged scalar at the ILC

1702.00951
Constraining Higgs effective couplings at electron-positron colliders

1701.08751
Probing Left-Right Seesaw using Beam Polarization at an e+e− Collider

1701.08250
Constraining capability of Zγh production at the ILC

1701.08187
Analysis and Measurement of the Transfer Matrix of a 9-cell 1.3-GHz Superconducting Cavity

1701.07542
Lepton identification at particle flow oriented detector for the future e+e− Higgs factories

1701.07043
Quartified Leptonic Color, Bound States, and Future Electron-Positron Collider

1701.05124
Prospects for beyond Standard Model Higgs boson searches at future LHC runs and other machines

1701.04804
Dimension-6 Operator Analysis of the CLIC Sensitivity to New Physics

1701.02906
Second Order QED Processes in an Intense Electromagnetic Field

1701.02881
Pair production processes and flavor in gauge-invariant perturbation theory

1701.02232
Data Acquisition System for the CALICE AHCAL Calorimeter

1701.02114
Leptophilic neutral Higgs bosons in two Higgs doublet model at a linear collider

1701.01923
The design of the ILD forward region

1701.01922
Future Higgs Studies: A Theorist’s Outlook

1701.00947
Probing Lepton Flavor Violation Signal via γγ\to l_i\barl_j in the Left-Right Twin Higgs Model at the ILC

1612.09284
Exotic decays of the 125 GeV Higgs boson at future e+e− lepton colliders

1612.07476

Search for lepton flavor violation at future lepton colliders

1612.07125
Low Fine Tuning in Yukawa-deflected Gauge Mediation

1612.06840
Majorana Higgses at colliders

1612.06626
A Boost to h→Zγ: from LHC to Future e+e− Colliders

1612.06569
Heavy Higgs Boson Production at Colliders in the Singlet-Triplet Scotogenic Dark Matter Model

1612.06403
The triple Higgs coupling: A new probe of low-scale seesaw models

1612.06334
Dark Matter and Collider Studies in the Left-Right Symmetric Model with Vector-Like Leptons

1612.03888
Triple Gauge Couplings at Future Hadron and Lepton Colliders

1612.02728
Sterile neutrino searches at future e−e+, pp, and e−p colliders

1612.02718
Testing Higgs Coupling Precision and New Physics Scales at Lepton Colliders

NEWSLINE
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DIRECTOR'S CORNER

It’s all about respect

Lyn Evans | 16 February 2017

Our particle physics community is a model of peaceful collaboration, independent of gender, race, religion or sexual orientation. In today’s world, where gender discrimination and racism are becoming more and more prevalent, we should pride ourselves on our community’s role model status. In this era of deteriorating social climate, we must be extremely vigilant in making sure that our own high standards do not slip.

It is with this in mind that the Linear Collider Collaboration (LCC) is setting up a direct line to the LCC directorate through which any incident of gender or racial discrimination can be reported. In order to lay down guidelines for correct behaviour, I propose that we adopt the principles of the well formulated and documented CERN Code of Conduct as a reference.

If a member of our community feels that any of the principles laid down in this document, including gender discrimination, are violated, he or she should inform one of the LCC Directors. Diversity and inclusion are fundamental pillars of our community, and mutual respect is another. We will make sure that people not adhering to the Code will receive a warning and a reminder of the responsibility that comes with being a role model.

DISCRIMINATION | DIVERSITY | GENDER BALANCE | HARRASSMENT | PEACEFUL COLLABORATION | RACISM

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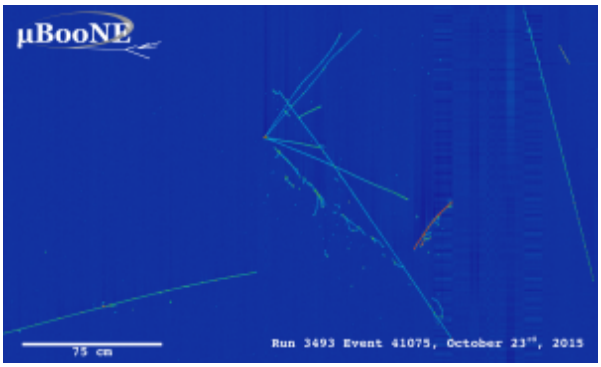
FEATURE

Pandora: opening the box for neutrino experiments

Barbara Warmbein | 16 February 2017



First neutrino event candidates identified by MicoBooNE. The image shows the raw data with some low-level processing and represent the input to the hit finding and particle flow reconstruction (i.e. pattern recognition) phases.

Pattern recognition rules in particle physics. When particles collide, many things happen at the same time and in a very fast sequence within fractions of a second. In order to tell everyday events from rare ones, particle physicists use pattern recognition software to quickly scan and classify pictures from the collisions.

A software development kit and event reconstruction system called Pandora has been helping detector developers design and run pattern recognition algorithms since 2009. Under the AIDA-2020 project Pandora has been enhanced for use in a new project: the liquid-argon time projection chamber for the MicroBooNE neutrino experiment based at Fermilab in the United States.

Pandora was originally developed for tracking particles through calorimeters being designed for the ILC and later the Compact Linear Collider (CLIC). The toolkit was the first to manage the particle flow challenge set by linear-collider physicists: to track and identify every single particle from a collision throughout the whole detector.

Pandora uses a multi-algorithm approach to pattern recognition, in which many small algorithms gradually build up a picture of events. Each algorithm specialises in a specific characteristic or event topology. For the MicroBooNE experiment, Pandora now provides a fully automated reconstruction of neutrino and cosmic-ray events in a very different detector environment to that of the linear collider.

For MicroBooNE, three separate two-dimensional images per event need to be checked by pattern recognition to finally arrive at a three-dimensional representation of the event. This can be tricky, explains John Marshall, one of the Pandora project leaders: “Features are routinely hidden in at least one view when, for example, two tracks lie on top of one another when viewed from a particular angle. Our new algorithms have a sophisticated interplay between 2D and 3D reconstruction, with iterative corrections made to the 2D reconstruction if features do not correspond between the three “views” of the event.” Pandora thus learns from its own algorithms.

In the end, the neutrino interactions can be seen in amazing detail. “They are intrinsically very complicated and frequently difficult to reconstruct,” says Marshall.

“The human brain and eye can normally do a very good job at separating the different particles in the images, but sometimes it’s not easy, even for a human!”

The MicroBooNE detector consists of a time projection chamber filled with liquid argon. When neutrinos generated from a proton beam at Fermilab pass through the dense liquid, they interact with argon nuclei and create an avalanche of secondary particles that ionise electrons in the liquid-argon volume, which then drift to three wire planes at the TPC’s anode. It’s these three planes that deliver the three different two-dimensional images that Pandora helps reconstruct.

Interesting events are used to develop the toolkit further. “In-Pandora visualisation tools allow relevant clusters to be displayed and colour-coded, markers can be added to indicate feature points, lines added to indicate straight-line fits, etc.” explains John Marshall. “This visual approach greatly aids algorithm development. Once an algorithm has been developed in the context of a few events, testing starts to be scaled-up to large event samples. Pandora provides a lot of internal error checking, so any mistakes in algorithm logic are normally identified and highlighted very quickly.”

Pattern recognition is likely to become even more important in the future as images of collisions become more and more detailed with improving detector technologies.

This article was first published in On Track, the newsletter for the AIDA-2020 project.

AIDA-2020 | ALGORITHMS | ILD | MICROBOONE | NEUTRINOS | PANDORA | PATTERN RECOGNITION

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FEATURE

The Art of Linear Colliders

Nikolai Promies, DESY | 16 February 2017

The exhibition poster

Every scientist can tell you about the beauty of his or her research. But while a small bump in a curve may delight particle physicists, most people just see a bunch of coloured lines. And the perfection of a complex theoretical model is evident only for a select few. Probably everybody would agree that science has made our world a better place. But who would say that it helps to make our lives more beautiful?

So arts and science don't seem to be too closely connected. But luckily there are quite a few people who try to reveal the art and beauty in science and physics in particular. CERN has been hosting so-called artists in residence programmes for many years now and a lot of spectacular projects have emerged from the cooperation of artists and scientists. The International Linear Collider also has inspired artistic work from the beginning. Some examples were the ILC-theme exhibition in Roppongi, downtown Tokyo with an ILC mock-up made from rammed earth or Science X Hello Kitty (venturing into the realm of pop art and culture). Gaining public support is one of the most important challenges on the way to make the ILC possible and exhibitions or artistic works are one way to get more support.

One of the latest highlights to connect the worlds of particle physics and arts could be examined from 29 October to 5 November at the 2016 IEEE Nuclear Science Symposium and Medical Imaging Conference (NSS/MIC) conference in Strasbourg, France. More than 2000 scientists and engineers participated in the meeting to hear about the latest developments in the fields of nuclear science, security and energy sources, particle physics and medical imaging.

Part of the 2016 IEEE NSS/MIC event was a big public exhibition at the Palais des Congrès, which was also accessible to all conference participants. "L'art et la science pour la société" (art and science for the society) showcased several artistic works that dealt with and were inspired by present and future accelerators. The exhibition was organised by the team of Arts@CMS at CERN and many of the works were taken from their permanent display at CERN and shipped to Strasbourg. But there were several new aspects in the exhibition created especially for the conference. Photographs by the artists Michael Hoch and Chris Henschke showed the beauty of future linear colliders. They took pictures of the European XFEL at DESY in Hamburg early 2016 that show what a future ILC could look like. Visitors learned about the cultural and physical impacts of accelerators and their links to today's society.

"It sometimes helps to use exciting mega-projects in particle physics to engage people with science and to receive a wider public recognition. That was one of the goals of this exhibition," explains Maxim Titov, General Chair of the 2016 IEEE NSS/MIC Symposium. "We felt social responsibility to the city of Strasbourg and wanted to give something back to the people who live here. With the exhibition, we can pass on knowledge about particle physics especially to young people. It was also the first attempt to organise a joint LHC / ILC art exhibition. Joint events can be very helpful to bridge the gap between these two important projects. Last, but not least, our goal was to address politicians and science policy makers, who came to Strasbourg to attend the opening ceremony, and emphasise the importance of our domain. After all, new instruments at large research infrastructures such as LHC and ILC can not only unravel the structure of the

Universe and the origin of its existence, but also have an impact on society by improving quality of life through technological progress and ensuring cultural exchanges between different nations.”

Thousands of people visited the congress center and saw the exhibition during the five-day conference time. “The exhibition, illustrating particle physics, accelerator technology and the human aspect of big science collaborations, was very well received. We heard many positive comments,” says Marc Winter, Chair of the Local Organising Committee and the Conference Liaison to the EU. “We don’t know in how far it may help to go ahead with the ILC, but the exhibition surely allowed many people to get in contact with the feeling of the beauty that moves and motivates particle physicists,” Marc Winter underlines.

The 2016 IEEE NSS/MIC Symposium served as an international forum to discuss the importance of broadening scientific, industrial and cultural partnership between the EU and other parts of the world; with Japan being in the focus of the last year event, and exploiting long-term links between Japan and Strasbourg. The ILC was one of the central topics at the conference, especially during the Grand Opening Ceremony on Monday, where several Japanese and EU politicians, directors of major particle physics laboratories, and representatives of funding agencies were invited. Inmaculada Figueroa, Executive member of the European Strategy Forum on Research Infrastructures (ESFRI) talked about the planned update of its roadmap for the year 2018. Two Japanese Diet Members, the Honorable Shintaro Ito and the Honorable Takeshi Shina expressed their strong support for the ILC project. Last, but not least, the dedicated session on Monday afternoon concentrated on the importance of concrete next steps towards the realisation of the ILC between European countries and Japan in the coming two years, and the opportunity for the ILC to re-appear on the ESFRI roadmap.

ART AND SCIENCE | IEEE | UNIVERSITY OF STRASBOURG

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VIDEO OF THE WEEK

Let them collide!

Barbara Warmbein | 16 February 2017

ILC – The Point of Interaction (2016) from Rey.Hori on Vimeo.

This animation, created by Rey.Hori, shows what happens when electrons and positrons collide in the ILD detector, one of the planned detectors for the future ILC. Many collisions will happen at the same time around the clock, producing a vast array of possible processes, or events. This animation shows the example of one possible collision event involving the Higgs boson. Here's a guide to what happens in the clip.

After a glance at the full accelerator tunnel complex the animation zooms into the interaction point at the centre of the collider. This is where electrons smash into positrons and the detectors record what happens. At 0:17 the ILD detector comes into view. If built, it would be some 16 metres high and 14 metres long – a little smaller than the detectors at the Large Hadron Collider at CERN, but still rather impressive!

The view cuts to the inside of the detector (sliced open for better viewing) and reveals the different layers of subdetectors that all play a vital role in tracing and understanding the debris from the collision. We see an electron and a positron flying in and -ping-, they collide. What follows are three different ways of explaining what's going on in the collision, all based on simulations made by scientists for the ILD detector. In this collision, a Z boson and a Higgs boson come out of the collision and decay to a muon-antimuon pair and a pair of b and anti-b quarks, respectively.

The animation first takes stock of all the particles generated by the collisions. The top line branches out in two lines that end in two turquoise circles, representing a muon each – the decay products of the (invisible) Z boson created from the collision. It's slightly more complicated with the Higgs: it decays into a pair of b and anti-b quarks (red circles with black writing) which then form all sorts of composite particles made of quarks and gluons. The composites carry on decaying and creating new particles in the process until the products can't decay any further. The intermediate particles are grey while the end products of the collisions are marked in different colours. Muons are turquoise, kaons purple, pions green and photons are blue. These colours pop up again the next two interpretations of the collision, by the way!

This first interpretation was just a list, but from 0:37 we are treated with a full-colour 3D-reconstruction of the same collision, showing the actual positions of the particles in the detector. High-energy particles fly out of the interaction point, charged ones are deflected by the detector's magnetic field, lower-energy charged ones curl out in a spiral, and the two tell-tale muons quickly disappear out of the viewing window because they fly through the whole detector before being stopped in the outermost muon detectors. The animation zooms out from the inner detectors to the calorimeter system, and particles hitting the calorimeters can be seen forming particle showers, visible as clusters of bright spots.

The third interpretation, starting at 0:45, shows the event as it would actually happen in the ILD detector. Particle tracks aren't shown as lines but as a series of little dots, which represent the actual hits in the detector. Lines are a product of the reconstruction software. From 0:53 the view switches again to a fully colour-coded 3-D reconstruction that very clearly shows the two escaping muons from the decay of the Z boson. It finishes with side views of other collision examples.

Physicist at the ILC will use the data from their detectors in combination with the knowledge they have of the different elementary and composite particles to get a complete picture of every particle, its properties and its path through the detector to a very high precision.

These complete pictures taken of every collision – including the Higgs event shown here – will allow ILC physicists to learn finest details about many particles including the Higgs boson.