ilc newsline

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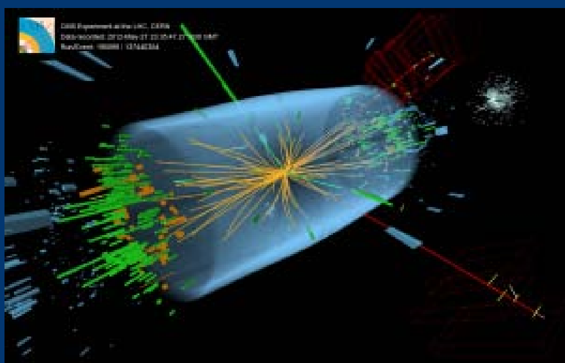
5 JULY 2012

ILC NEWSLINE SPECIAL ISSUE: THE HIGGS



The news was impossible to miss: LHC experiments ATLAS and CMS found a new particle in their data that could be the Higgs boson. Auditoriums were packed, excitement was high. The theorists who predicted the boson's existence received standing ovations. There was #Higgsteria on twitter – 4 July 2012 was Higgs day. Read CERN's press release or view the pictures and videos to relive the moment. But what does all this mean for the ILC? It's definitely good news. Find out how the ILC can help in the search and study in this special Higgs issue of *ILC NewsLine*.

FEATURE

The Higgs is Different

Theoretical physicist and ILCSC chair Jonathan Bagger explains how

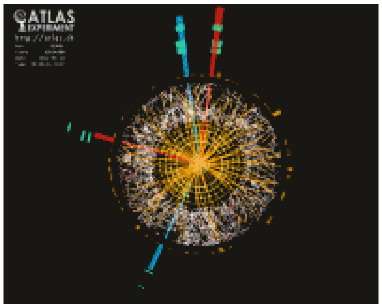
by Jonathan Bagger

The Higgs is Different, says Jonathan Bagger, a theoretical physicist and chair of the International Linear Collider Steering Committee ILCSC. It has no spin, it fills the vacuum, but most importantly, it opens the door to a new range of questions. Questions which a linear collider with its clean and controlled collisions could help answer.

RESEARCH DIRECTOR'S REPORT

Encouraging news from CERN

by Sakue Yamada

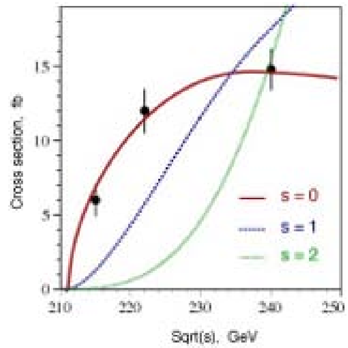


We in the ILC Research Directorate are thrilled with the announcement from CERN this week that a Higgs-like particle has been discovered. The Higgs particle has been a target of our experiments for over decades, and the affirming news from LHC finally means a great step forward. I wish to congratulate CERN and all physicists who contributed to this success.

DIRECTOR'S CORNER

The Higgs and the ILC

by Barry Barish



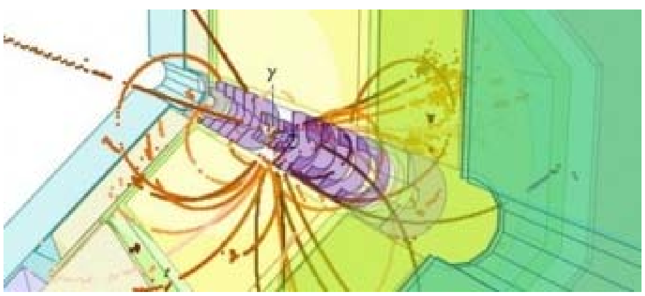
The announcements of the most recent results from the search for the Higgs boson at the LHC bring into sharper focus the new physics at the energy frontier and the potential role of the ILC. Although it is still too soon to know what will be uncovered regarding the Higgs mechanism from studies at the LHC, it is worth pointing out the long-range potential for Higgs physics at the ILC. Two examples illustrate how the ILC will be able to shed further light on the phenomena seen at the LHC.

FEATURE

Make no assumptions

A linear collider would complete the picture

by Barbara Warmbein



The LHC experiments are definitely homing in on a Higgs boson in a mass region somewhere around 126 GeV. Further studies and more data from the LHC will tell us more about what it is that they have found, but only a linear collider will be able to tell without prejudice whether it's a Standard Model Higgs (or not) and determine its mass with a precision down to about 60 MeV. Here's how.

FEATURE

#Higgs on the web

This is a small collection of interesting links to background information, facts, figures and international sites all about the Higgs. It makes no attempt to be comprehensive, but readers are encouraged to use the commenting function to add their favourite sites.

- From CERN: A big collection of background texts, videos and interviews

- Ten fun and little-known facts about

VIDEO OF THE WEEK

Singalong tutorial

Video: CERN

After all of this week's news, press releases, blog posts, backgrounders and newspaper stories here's more about the Higgs - catchy, rhythmic and full of clever lyrics. If you think you've still not grasped the Higgs mechanism this song will stick in your head! It's "The Particle Physicists' Song" (based on "The Hippopotamus Song" by Michael Flanders and Donald Swann), with lyrics by Danuta Orlowska, performed by the CERN choir in the CERN Control Room in 2010. Enjoy

the Higgs from symmetry magazine
- Peter Higgs in the spotlight: an exclusive interview by physics world
- Fermilab Higgs FAQs
- Fermilab video of Don Lincoln explaining the mechanism
- Higgs background information in German from www.weltmaschine.de
- Big questions in Japanese
- Higgs pages in French on lhc-france.fr/higgs
- Linear Collider Higgs talk at ICHEP
- Live blogging from ICHEP and an archive of blog posts from the CERN seminar on www.quantumdiaries.org

And from our own *ILC NewsLine*:

- Scientific justification for the ILC
- Articulating the physics case for the ILC
- Is the Higgs enough?
- The impact of ILC detector R&D
- Higgs makes for exotic couples

and pass the tune on to your colleagues...

IMAGE OF THE WEEK

A small part of the team that made it all happen

Image: CERN

Surrounded by cameras and showing a variety of emotions – delighted, touched, excited, shy, proud, almost overwhelmed – the central theorists, CERN management and the spokespeople of the experiments get together for a group picture after yesterday's press conference. Front row, left to right: theorist Francois Englert, theorist Peter Higgs, ATLAS spokeswoman Fabiola Gianotti, CERN director Steve Myers. Back row, left to right: CERN director Sergio Bertolucci, CERN DG Rolf Heuer, CMS spokesman Joe Incandela, theorist Carl Hagen, theorist Gerald Guralnik. Missing in the picture: Robert Brout and Tom Kibble and the rest of the ATLAS and CMS collaborations.

IN THE NEWS

from *NHK news*
5 July 2012
東北大“ヒッグス”研究誘致を
ヒッグス粒子とみられる素粒子の発見を受けて、東北大学は、ヒッグス粒子を研究する世界最先端の実験施設を岩手県に誘致するため、立地に必要な条件の調査などを行う協議会を設置することになりました。(Following the breaking news of the discovery of the new particle, the Tohoku University announced the establishment of the association that will work toward inviting a new particle physics laboratory to Iwate prefecture.)

from *Iwate Nippo*
5 July 2012
ILC本県誘致に光 ヒッグス粒子発見
宇宙誕生の謎を解き明かす「ヒッグス粒子」の存在がほぼ確認された 日、同粒子の詳細研究に欠かせない国際リニアコライダー の誘致活動を進める県や研究者からは喜びの声が上がった。早ければ 年ごろとされる の建設地決定に向け、関係者は期待を膨らませている。(Scientists and local officials of Iwate prefecture were exicited to here the news of the discovery of the new particle consistent to Higgs particle. Iwate prefecture is woking on the activities toward invitation of the ILC, the machine which examine Higgs particle. google translation)

from *{Science[2]}, blog de Libération*
4 July 2012
Boson de Higgs: une découverte du LHC selon Michel Spiro (CERN)
Pour la suite, nous avons plusieurs idées. Construire une «usine à bosons de Higgs», les produisant en grand nombre et de manière plus propre, avec un collisionneur linéaire électrons contre électrons.(google translation)

from *Spiegel*

4 July 2012
Entdeckung des Higgs-Bosons: Neuer Blick auf unsere Welt
Die Planungen für die Mega-Maschine laufen bereits. Ein Projekt ist der International Linear Collider. (google translation)

from *CERN: Higgs a portata di mano*
4 July 2012
Punto Informatico
Nel futuro sarà necessario anche aumentare l'energia in gioco e spingersi oltre i valori attuali: CLIC (Compact Linear Collider) e ILC (International Linear Collider) sono due delle possibili evoluzioni di LHC che la ricerca già preme per vedere realizzati. (google translation)

from *AmericaRU*
4 July 2012
Новая частица может быть лишь первым из пяти бозонов Хиггса – согласно теории SUSY
В настоящее время существуют два крупных пост-БАКовских проекта. Это Международный электрон-позитронный линейный коллайдер (ILC, International Linear Collider), в создании которого уже сейчас участвуют почти 300 лабораторий и университетов по всему миру. ILC должен будет детально исследовать свойства бозона Хиггса, если последний будет открыт с помощью БАКа. (google translation)

from *Texas Tech Today*
4 July 2012
Texas Tech Researchers Announce CERN Discovery
… "If this turns out to be a real Higgs, there must be other accelerators, or perhaps an international linear collider to be built to study this particle in detail as we always imagined it would be done. …

from *Scientific American Blog*
4 July 2012
What It Means to Find "a Higgs": Lindau Nobel Laureate Meeting, Day 3
Gross said a linear collider of electrons and positrons would make it easier to test the properties of the particle, "but that is not likely for 10 to 20 years. Maybe this result gives motivation for building one." Regardless, "experimentalists, as they have proved today, are extremely clever," teasing out small signals with the instruments they have.

from *Europa Press*
28 June 2012
El IFCA acoge la Octava reunión de la Red Nacional de Futuros Aceleradores de Partículas
El ILC será un acelerador lineal electrón-positrón de 35 Km de longitud, que pretende resolver muchos de los misterios de la estructura elemental de la materia. Superará en precisión al que es en la actualidad el acelerador más grande y energético del mundo, el Large Hadron Collider (LHC), lo que permitirá responder a importantes cuestiones acerca del comportamiento del Universo. (google translation)

from *RIA Novosti*
21 June 2012
Экс-директор ЦЕРНа объединит проекты "наследников" БАКа
Российские физики полагают, что линейный коллайдер может быть построен в подмосковной Дубне, где находится крупнейший в РФ центр физики высоких энергий. В свою очередь, Япония рассчитывает разместить туннель коллайдера в горной области на острове Кюсю на юго-западе страны или в горах Китаками на севере страны, и уже готовит геологические исследования. (google translation)

CALENDAR

UPCOMING EVENTS

36th International Conference on High Energy Physics (ICHEP2012)
Melbourne, Australia
04- 11 July 2012

View complete calendar

BLOGLINE

3 July 2012
Richard Ruiz
What Comes Next?

2 July 2012
Aidan Randle-Conde
Higgsdependence Day

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FEATURE

The Higgs is Different

Theoretical physicist and ILCSC chair Jonathan Bagger explains how

Jonathan Bagger | 5 July 2012

The Higgs condenses to fill the vacuum much like steam condenses to form the sea.

If yesterday's newly discovered particle turns out to be the Higgs boson, as many think it might, it will be a landmark accomplishment for physics. Every other fundamental particle discovered to date – the quarks, leptons and gauge bosons of the standard model – has spin, an intrinsically quantum mechanical property that determines its fate. The Higgs, however, does not. It is an entirely new form of matter.

The spin of the quarks and leptons is ultimately responsible for the structure of matter, including the properties of nuclei and the electronic structures that govern all of chemistry. The spin of the gauge bosons gives rise to the forces of nature, ranging from electricity and magnetism to nuclear reactions and gravity.

The Higgs, though, is different; it has no spin. Its spinless state allows it to condense and fill the vacuum, much like steam condenses to form the sea. It is this Higgs condensate that is responsible for mass: particles travelling through the condensate experience a drag that slows their motion and gives them mass. The more the drag, the greater the mass.

But the Higgs does much more. Its discovery will mark a triumph of physics, and as with any discovery, it will open the door to a whole new range of questions.

For example, the Higgs condensate fills the vacuum, so empty space is not empty. Condensed matter physicists tell us that an analogous condensate forms inside a superconductor. Does this mean that the universe itself is a new type of superconductor? And if so, what new physics controls its properties?

Higgs-like particles are ubiquitous in theories of physics that extend beyond the standard model. They are predicted by supersymmetry and by theories of grand unification. Their condensates contribute to the dark energy that is accelerating the expansion of the universe, and they determine the geometry of the extra dimensions in string theory. Higgs-like particles might even be responsible for cosmological inflation, the change in time of dark energy, the missing dark matter, or even the puzzling properties of neutrinos.

Is yesterday's discovery that of the Higgs, or is it something else? Time will tell, but signs so far are positive. Already the LHC experiments have shown that the new particle is different – it is not a quark, a lepton, or a gauge boson. But is it the Higgs? For a particle to be the Higgs, its properties must be exquisitely balanced – and that is difficult to check.

A linear collider, with its clean and controlled electron-positron collisions, offers the perfect environment to study Higgs bosons. Experiments at a linear collider can measure Higgs properties without assumptions and with unprecedented precision. A linear collider can serve as a Higgs factory, producing Higgs particles around the clock. A linear collider can tell whether a Higgs is really the Higgs – or whether it is an impostor, sharing some of its properties and not others. Is it the first of a family? Does it provide a portal to a world beyond? We need more experiments to know for sure.

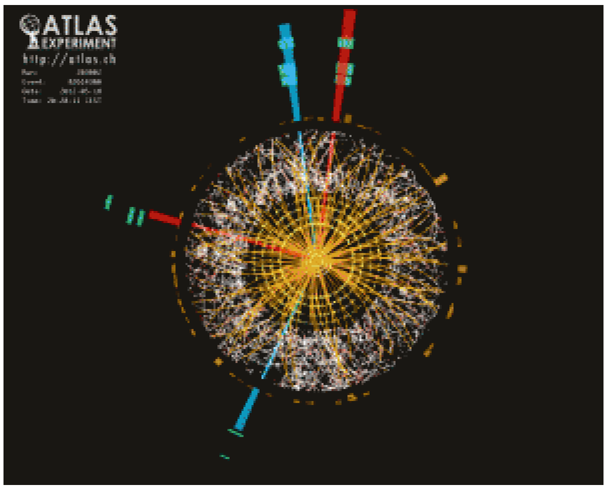
Every physicist knows Faraday's famous answer to Gladstone, when asked about the utility of electromagnetism: "Sir, I do not know what it is good for. But of one thing I am quite certain – some day you will tax it." So why study the Higgs? To a physicist, the answer is clear: because it represents a new form of matter. It is something entirely different, fundamental to the world in which we live. But will it be useful? Again invoking Faraday: "It may be a weed instead of a fish that, after all my labour, I may at last pull up." Time will tell, but I'd place my bet on the fish.

DARK ENERGY | **EXTRA DIMENSIONS** | **GRAND UNIFICATION** | **HIGGS** | **HIGGS FACTORY** | **ILC** | **ILCSC** | **SUPERSYMMETRY**

RESEARCH DIRECTOR'S REPORT

Encouraging news from CERN

Sakue Yamada | 5 July 2012



A Higgs candidate event in the ATLAS detector. Image: CERN

We at the ILC Research Directorate are all thrilled with the announcement from CERN this week that a Higgs-like particle has been discovered. The Higgs particle has been a target of our experiments for over decades, and the affirming news that has finally arrived from the LHC is a great step forward. I wish to congratulate CERN and all physicists who contributed to this success.

The observed mass agrees with what was estimated for Higgs particle from the combined precise data of the colliders LEP, SLC and the Tevatron. The Higgs particle is the unique building element of the universe, totally different from any particles so far known: leptons, quarks or gauge bosons. It gives masses to these particles. If confirmed to be a Higgs, the discovery can be compared with that of the electron over a century ago, which marked the start of particle physics.

Again the door opens for entirely new physics. We need to verify that the particle is really the Higgs particle by measuring its precise mass, its scalar (i.e. zero) spin, and its coupling to various fermions, to vector bosons and to itself. There are rich and challenging questions we need to answer to fully understand the particle and to clarify its role in the universe. There is agreement in the HEP community that the ILC is the best suited facility for this endeavour, and we have been preparing for it for many years. Now this R&D work is being summarised in our *Detailed Baseline Design* report describing the physics case of the ILC and the capability of the two detector designs. The report presents today's most advanced studies to demonstrate that we are ready to step into the new field with excellent tools. The big news gives us tremendous encouragement to go forward.

DBD | DETECTORS | HIGGS | LEP | LHC | SLC | TEVATRON

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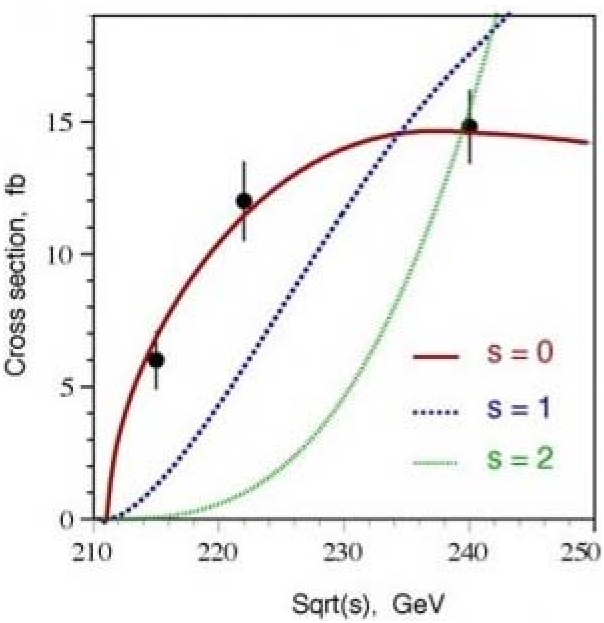
DIRECTOR'S CORNER

The Higgs and the ILC

Barry Barish | 5 July 2012



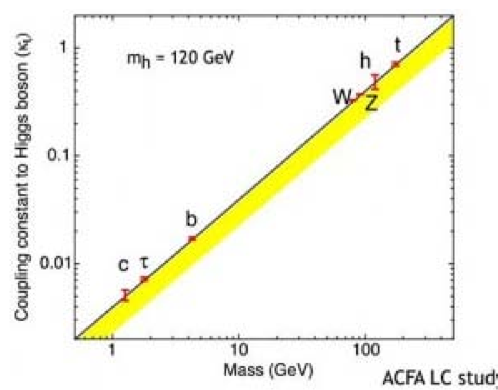
An illustration of how the Higgs spin can be determined at the ILC by studying the behaviour of the cross section from production threshold.

The Higgs boson is being eagerly sought by particle physicists at the Large Hadron Collider (LHC) at CERN because it would explain how elementary particles get their mass, a process called spontaneous electroweak symmetry breaking. The discovery of a new phenomenon, maybe the Higgs boson, at the LHC at around 125 GeV could validate this concept, and open up a future focus of particle physics research to understand how the Higgs mechanism manifests itself. For example, is it a simple Higgs or is it a more complex version? Although it is too soon to know what additional information will be uncovered from the LHC experiments, the potential for exploiting Higgs physics at the ILC provides a graphic example why we will need an electron-positron collider that is complementary to the LHC's proton-proton collisions.

The Higgs mechanism is a completely new phenomenon in particle physics and its discovery will open up a totally new and very important area of research. To illustrate the potential power of the ILC to study Higgs physics, I give two examples of how the ILC can shed light on this new physics.

In order to prove that what has been observed at the LHC is actually a Higgs, it will be necessary to demonstrate that its spin is zero. The ILC has the ability to measure the particle's spin directly by tracking the behaviour of the production cross section as the collision energy is increased from the Higgs' threshold. This ability results from the fact that for electron-positron collisions the full centere-of-mass energy is transferred to the final annihilation products, the particles that are created in the collision, including the Higgs. The cross-section behaviour from threshold then depends on the spin, and particles of spin zero can thus easily be distinguished from those having spin 1 or spin 2.

A second unique feature of the Higgs boson is that the Higgs field is responsible for the particles' masses, and therefore the Higgs boson's coupling strength is proportional to mass. Measuring how the Higgs couples to different constituent particles having different masses will not only demonstrate that this coupling relationship exists, but thanks to many collisions at the ILC, quantitative measurements of the different coupling strengths will enable distinguishing between different models of the Higgs.



The Higgs coupling strengths are proportional (or nearly proportional) to mass, which can be tested at the ILC.

The potential discovery of the Higgs is a very exciting development for particle physics! As the evidence grows, we are beginning to uncover the new physics territory being opened up by the LHC. For physicists who have worked so hard and so long developing the LHC and its detectors, this is a rewarding payoff. For those of us working towards a future complementary linear collider, the Higgs

discovery will provide strong motivation to propose a machine to complement the
LHC, and we are working hard to optimise our design to exploit the results being reported from the LHC.

CERN | **HIGGS** | **ILC** | **LHC**

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FEATURE

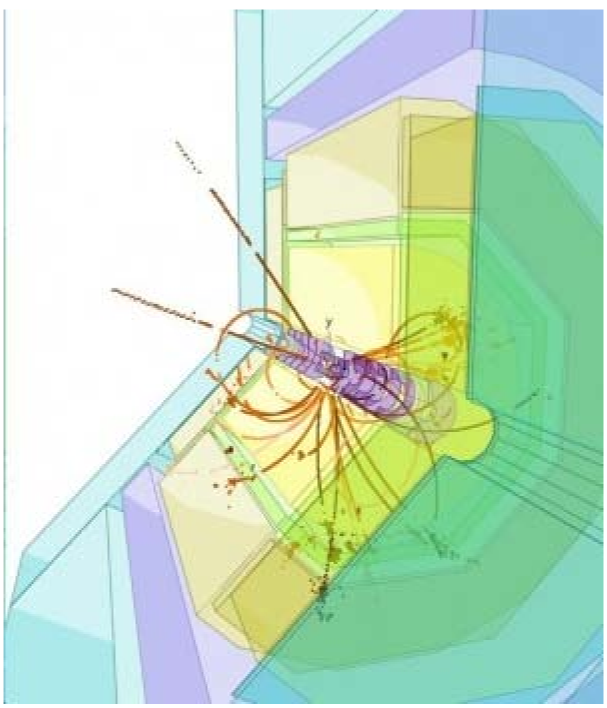
Make no assumptions

A linear collider would complete the picture

Barbara Warmbein | 5 July 2012

Collisions in the LHC are like fireworks. At energies no other particle collider has ever reached, protons smash into protons and produce such exciting particles as the Higgs boson. The catch: many, many things go on at these collisions, and filtering out the interesting ones is possible, but hard. What is more, LHC physicists can never know for sure what went into the original collision at which energy because protons consist of quarks and gluons, which all can interact and which carry a part of the total energy of the proton.

Enter the linear collider: with the electron and positron being fundamental particles, the energy of the interaction is precisely known, and can be traced back to the last electronvolt. Particles flying through the detectors have nowhere to hide, and if they do, they're flagged right away as energy that went missing. There isn't as much going on as between proton and proton, the collisions are 'cleaner', which opens the door to yet another unique opportunity: an analysis free of prior assumptions.



Fully simulated and reconstructed Higgs event in the ILD detector. The Higgs is produced together with a Z boson that subsequently decays into a muon pair. Image: Frank Gaede, DESY

Say, for example, a collision between an electron and its antiparticle, the positron, produces (a virtual Z boson that decays into) a Z and a Higgs boson. From previous experiments physicists know that the Z can, for example, decay into two electrons or two muons. "You can trigger on these two particles without any prejudice on what else is happening in your detector," says Marcel Demarteau, detector expert from Argonne National Lab in the US. With the reconstruction of the Z boson in these events where electron-positron collisions produce a Z and a Higgs and with the knowledge of the full event energy, the ILC can precisely measure the mass of the system that balances the Z, the so-called 'recoil mass', independent of the Higgs decay mode. Thus, even if the Higgs decays to invisible particles, it can still be identified and its mass measured directly.

One of the hallmarks of the Standard Model Higgs boson is that the coupling strength is proportional to the mass of the particle it decays into. At the ILC, the Higgs couplings and decay branching ratios can be measured by simply measuring the event rates directly without any prior assumptions. Although the LHC can also measure the event rates of the Higgs boson in various decay channels, one cannot avoid the need to normalise the total event rate to a theoretical prediction.

That's where the ILC has a unique advantage. Without prejudice, all the properties of the Higgs boson can be studied and it can be uniquely determined if it conforms to our expectations within the standard model or if it points to the existence of new symmetries. This assumption-free and unbiased look at everything that happens is desirable as it can shed light on the full range on possible interactions – including those that might not have been predicted by theory. At the ILC, no assumptions are needed and that is just one of the advantages.

The ILC detectors ILD and SiD are being designed to squeeze the largest possible amount of information out of the electron-positron collisions, just like ATLAS and CMS at the LHC are optimised for the phenomenal 40 million collisions per second they face with the proton-proton collisions. Precision is a key quality of all the various sub-parts of the ILC detectors; the trackers will have an unprecedented momentum resolution that will enable the most accurate measurement of the mass of the Higgs boson. To enable flavour identification and distinguish, say, a charm quark from a bottom quark, which is key to measuring the Higgs coupling constants, ultra-thin pixel detectors are being designed as close as possible to the interaction point. The calorimeters are being designed based on the concept of particle flow, which enables hadronic jet energy measurements with a precision not achieved to date. The design of the ILC detectors takes particle physics to a next level where all sub-detectors function as a single unit to allow for true precision measurements of the expected and unexpected.

"The results from the LHC are absolutely spectacular, and the machine and detectors are true marvels of technology. It is amazing how sensitive the detectors are and how much they are able to get out of their data so quickly. But, right now, we cannot really say if what they see at the LHC is really a Higgs. Is it a Standard Model Higgs? How does it couple to other particles, what are its branching ratios? " says Demarteau. "Now we have to measure all the properties to know for sure and the journey is just about to start."

DECAY MODE | **HIGGS** | **ILC** | **ILD** | **LHC** | **PARTICLE FLOW** | **SID**