LC NEWSLINE
THE NEWSLETTER OF THE LINEAR COLLIDER COMMUNITY

FEATURE

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by Rika Takahashi

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FEATURE

From symmetry: One Higgs is the loneliest number

Physicists discovered one type of Higgs boson in 2012. Now they're looking for more.

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DIRECTOR'S CORNER

Addressing the known unknowns

by Brian Foster

I am sure that my readers will remember that in my last Director's Corner, in April, I threatened to write at some future date about the new Project Implementation Planning (PIP) document. Those of you with an even longer memory, going back to my Director's Corner of April 2014, may even remember what it is. Just in case, however, I take this opportunity not only to honour my promise of last April to also to refresh your memory and to offer you an opportunity to peruse the final document.

IMAGE OF THE WEEK

Calorimeters don’t take holidays

by Barbara Warmbein

Summer breaks don't exist for detector prototypes. For almost three weeks in July – around the time that a new temperature record of 39.7 degrees was measured in Geneva – the team working on the technological prototype of a potential hadronic calorimeter for the ILD detector at the ILC took data at the Super Proton Synchrotron test beam at CERN.

IN THE NEWS

from *Iwate Nichi Nichi*
3 August 2015
ＩＬＣ誘致効果は　サイエンスカフェ　今年度初
一関市主催の２０１５年度第１回「いちのせきサイエンスカフエ」は２日、一関図書館で開かれた。小中学生や高校生、一般の幅広い年代から20人ほどが参加。専門家の講演を通じ、素粒子物理学の概要やＩＬＣ誘致の意義について、理解を深めた。
(“Ichinoseki Science Cafe” hosted by Ichinoseki city was held on 2 August at the Ichinoseki Library. 20 people including elementary and junior high school students listen to the lecture by the specialist improving their understandings of the significance of the ILC project)

from *Channel Sakura*
28 July 2015
超技術革命で世界最強となる日本！国際リニアコライダー編
日本の技術立国としての地位を確固たるものにする「投資」の概要を知るべく、三橋貴明がつくば市にあるエネルギー加速器機構（KEK）で取材してきた、将来技術とイノベーションの可能性をレポートしていきます。（Takaaki Mitsuhashi will report the KEK visit to investigate the Japan's possible “investment” to the ILC, to consolidate the nation’s position toward the technology-oriented country)

from *Iwate Nippo*
26 July 2015
ILC誘致へ5市町長が将来像語る　奥州・水沢でシンポ
ＩＬＣの誘致に向けたシンポジウム「ＩＬＣ実現と地域社会の展望」は２５日、奥州市水沢区の市文化会館で約４００人が参加して開かれた。大船渡、陸前高田、住田、金ケ崎、奥州の５市町長が自治体の現状と課題、地域の特色とＩＬＣ誘致を絡めた将来ビジヨンを発表。(A symposium toward the realization of the ILC was held on 25 at a community hall at Mizusawa city. Mayors from 5 cities reported their future visions considering the ILC invitation to the area)

CALENDAR

Upcoming events

Meeting of the American Physical Society Division of Particles and Fields (DPF 2015)
Ann Arbor, Michigan, USA
04- 08 August 2015

XXVII International Symposium on Lepton Photon 2015 (LP 2015)
Ljubljana Exhibition and Convention Centre, Slovania
17- 22 August 2015

10th International Positron Source Workshop (POSIPOL 2015)
Cockcroft Institute, UK
02- 04 September 2015

17th International Conference on RF Superconductivity (SRF2015)
Whistler, BC, Canada
13- 19 September 2015

Upcoming schools

15th Hellenic School and Workshops on Elementary Particle Physics and Gravity (Corfu2015)
Corfu, Greece
01- 26 September 2015

The 2015 European School of High-Energy Physics
Bansko, Bulgaria
02- 15 September 2015

View complete calendar

PREPRINTS

ARXIV PREPRINTS

1508.00706
A Radiative Linear Seesaw, Dark Matter and U(1)B−L

1507.08304
Flavour-changing Higgs decays into bottom and strange quarks in supersymmetry

1507.08190
Photoproduction of Prompt J/ψ in Association with a $c\bar{c}$ Pair within the Framework of Non-relativistic QCD at the International Linear Collider

1507.07758
Gluon saturation and Feynman scaling in leading neutron production

1507.07035
TID-Effect Compensation and Sensor-Circuit Cross-Talk Suppression in Double-SOI Device

1507.06694
Single solenoidal magnetic system for Iron-free detector

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FEATURE

Japan's expert panel for the ILC has published its summary report

Rika Takahashi | 6 August 2015

Japan's Ministry of Education, Culture, Sports, Science and Technology (MEXT) has released on 5 August its summary report of the discussions by the expert panel (ILC Advisory Panel) to investigate various issues regarding the ILC.

The panel was established in May last year, with two subcommittees: one, the ILC particle & nuclear physics subcommittee, to investigate the physics case of the ILC, and the other, the ILC TDR subcommittee, to evaluate the technical feasibility and soundness of the cost, including corresponding human resources described in the ILC Technical Design Report (TDR).

"Summary of the International Linear Collider (ILC) Advisory Panel's Discussion to Date"
国際リニアコライダー（ILC）に関する有識者会議これまでの議論のまとめ（1）
国際リニアコライダー（ILC）に関する有識者会議これまでの議論のまとめ（2）

The LCC management will address the summary report in the next issue of *NewsLine*.

Read background stories:
Expert panel for hosting the ILC in Japan meets for the first time
Supporting political developments in Japan
ILC: What's happening in Japan

JAPAN | MEXT

signal to background

July 30, 2015

One Higgs is the loneliest number

Physicists discovered one type of Higgs boson in 2012. Now they're looking for more.

By Katie Elyce Jones

When physicists discovered the Higgs boson in 2012, they declared the Standard Model of particle physics complete; they had finally found the missing piece of the particle puzzle.

And yet, many questions remain about the basic components of the universe, including: Did we find the one and only type of Higgs boson? Or are there more?

A problem of mass

The Higgs mechanism gives mass to some fundamental particles, but not others. It interacts strongly with W and Z bosons, making them massive. But it does not interact with particles of light, leaving them massless.

These interactions don't just affect the mass of other particles, they also affect the mass of the Higgs. The Higgs can briefly fluctuate into virtual pairs of the particles with which it interacts.

Scientists calculate the mass of the Higgs by multiplying a huge number—related to the maximum energy for which the Standard Model applies—with a number related to those fluctuations. The second number is determined by starting with the effects of fluctuations to force-carrying particles like the W and Z bosons, and subtracting the effects of fluctuations to matter particles like quarks.

While the second number cannot be zero because the Higgs must have some mass, almost anything it adds up to, even at very small numbers, makes the mass of the Higgs gigantic.

But it isn't. It weighs about 125 billion electronvolts; it's not even the heaviest

fundamental particle.

“Having the Higgs boson at 125 GeV is like putting an ice cube into a hot oven and it not melting,” says Flip Tanedo, a theoretical physicist and postdoctoral researcher at the University of California, Irvine.

A lightweight Higgs, though it makes the Standard Model work, doesn’t necessarily make sense for the big picture. If there are multiple Higgses—much heavier ones—the math determining their masses becomes more flexible.

“There’s no reason to rule out multiple Higgs particles,” says Tim Tait, a theoretical physicist and professor at UCI. “There’s nothing in the theory that says there shouldn’t be more than one.”

The two primary theories that predict multiple Higgs particles are Supersymmetry and compositeness.

Supersymmetry

Popular in particle physics circles for tying together all the messy bits of the Standard Model, Supersymmetry predicts a heavier (and whimsically named) partner particle, or “sparticle,” for each of the known fundamental particles. Quarks have squarks and Higgs have Higgsinos.

“When the math is re-done, the effects of the particles and their partner particles on the mass of the Higgs cancel each other out and the improbability we see in the Standard Model shrinks and maybe even vanishes,” says Don Lincoln, a physicist at Fermi National Accelerator Laboratory.

The Minimal Supersymmetric Standard Model—the supersymmetric model that most closely aligns with the current Standard Model—predicts four new Higgs particles in addition to the Higgs sparticle, the Higgsino.

While Supersymmetry is maybe the most popular theory for exploring physics beyond the Standard Model, physicists at the LHC haven’t seen any evidence of it yet. If Supersymmetry exists, scientists will need to produce more massive particles to observe it.

“Scientists started looking for Supersymmetry five years ago in the LHC,” says Tanedo. “But we don’t really know where they will find it: 10 TeV? 100 TeV?”

Compositeness

The other popular theory that predicts multiple Higgs bosons is compositeness. The composite Higgs theory proposes that the Higgs boson is not a fundamental particle but is instead made of smaller particles that have not yet been discovered.

“You can think of this like the study of the atom,” says Bogdan Dobrescu, a theoretical physicist at Fermi National Accelerator Laboratory. “As people looked closer and closer, they found the proton and neutron. They looked closer again and found the ‘up’ and ‘down’ quarks that make up the proton and neutron.”

Composite Higgs theories predict that if there are more fundamental parts to the Higgs, it may assume a combination of masses based on the properties of these smaller particles.

The search for composite Higgs bosons has been limited by the scale at which

scientists can study given the current energy levels at the LHC.

On the lookout

Physicists will continue their Higgs search with the current run of the LHC.

At 60 percent higher energy, the LHC will produce Higgs bosons more frequently this time around. It will also produce more top quarks, the heaviest particles of the Standard Model. Top quarks interact energetically with the Higgs, making them a favored place to start picking at new physics.

Whether scientists find evidence for Supersymmetry or a composite Higgs (if they find either), that discovery would mean much more than just an additional Higgs.

“For example, finding new Higgs bosons could affect our understanding of how the fundamental forces unify at higher energy,” Tait says.

“Supersymmetry would open up a whole ‘super’ world out there to discover. And a composite Higgs might point to new rules on the fundamental level beyond what we understand today. We would have new pieces of the puzzle to look at it.”

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DIRECTOR'S CORNER

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Experience gained at the European Spallation Source currently under construction in Sweden was fed into the Project Implementation Plan. Image: ESS

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Early in 2014, Sachio Komamiya, chair of the Linear Collider Board LCB, asked me to convene a group to take another look at issues relating to ILC governance. This was not the first time I had chaired a similar activity; back in 2011, Mike Harrison and I had led the group that produced the first PIP document. Sachio asked me to look again at these issues, taking into account not only developments in major scientific infrastructures since then but also the changed situation now that Japan was exploring the possibility of hosting the ILC.

The charge I received from the LCB was the following: "*The Subcommittee is to produce recommendations on the organization and management of the proposed ILC Lab in Japan. Among the items to consider for this global project are: governance; organization; management structure; legal framework; staff composition; relationship between world HEP labs and the ILC Lab; and the role of the host nation. (…) A final report should be submitted by the Subcommittee to the LCB's 26 February 2015 meeting; an interim report can be submitted earlier if a consensus is reached on significant issues*."

The LCB also agreed the following membership:

- Brian Foster, DESY/Oxford University, Germany/UK
- Neil Calder, Vice President for Communication & Public Relations, Okinawa Institute of Science and Technology, (OIST), Japan
- Colin Carlile, Former Director of the ESS in Sweden
- Jonathan Dorfan, President and CEO, OIST, Japan
- Dean Karlen, University of Victoria, Canada
- Vera Luth, Professor (Emeritus) SLAC, USA
- Dinesh Kumar Srivastava, Director, Variable Energy Cyclotron Centre, Kolkata
- Satoru Yamashita ICEPP, University of Tokyo, Japan

Later in our deliberations, I was given permission by the LCB to co-opt a further member, Sakue Yamada from the University of Tokyo, who had been chairing a working group on related issues from the perspective of the collaborations and physicists working towards the experimental programme for the ILC.

Given the wide geographical distribution of the members as well as their busy schedules, all of our four meetings were teleconferences,

although when several of us were attending events such as LCWS, we took the opportunity to gather most of us around a table. The great majority of our work was carried out in the spring and summer of last year; we concentrated on those areas where there was new information and/or specific factors relating to Japan that needed to be included. As a result, we decided to leave unchanged several chapters of the original PIP document for which there was no important new information. These include for example that on procurement and industrialisation. I produced a draft of the new chapters at the start of the summer. This was iterated and then finalised in time for a presentation I made to the FALC meeting that took place in conjunction with the Beijing ICFA Seminar in October. A “final draft” was then presented to LCB during the notorious “snow-bound” LCB and ICFA meeting held at Jefferson Laboratory in Virginia, USA in February of this year. This resulted in several small modifications, most recently in the addition of a preface designed to emphasise yet again that the purpose of the document is not to pre-empt the role of governments and funding agencies in considering the shape of an ILC laboratory but rather to input information from the physics community on what are likely, in our experience, to be the best models for the future. This final document, merged with the unchanged chapters carried over from the 2011 PIP, has been agreed in principle by LCB and will be formally signed-off at the LCB meeting in Ljubljana in two weeks time.

What are the main changes compared to the previous PIP? The continuing development of ITER has certainly injected further information and experience that has shaped changes in the discussion of the governance model for the ILC. Also the evolution of the European X-ray Free-Electron Laser and the approval of the European Spallation Source were additional sources of useful experience. These led to more detail and clarification of what was meant by contingency and the use of the common fund. Another area that was – deliberately – not addressed in the original PIP is that of running costs for the ILC. This is a thorny question on which there are strongly held, and mutually incompatible, views across the world. The new PIP offers several models for consideration. A chapter on Intellectual Property was added, although, since none of the committee are experts in this area, it is really more of a placeholder indicating the importance of the issue than a substantial contribution to the literature. In addition to these, a large number of other modifications were made to the document, including more concrete discussion of the transition to a final ILC laboratory governance on the assumption that the accelerator complex is built in the site in Iwate, Japan.

Now that the document has been finalised and will shortly be signed off by LCB, I am happy to announce that it can be accessed at the following link . I hope you will find it a useful document; at the risk of repeating myself, it is intended to be a snapshot of information helpful to collaborating and interested governments as we progress along the road to the approval of the ILC project. At the end of my previous piece on governance I quoted Lord Curzon, a British politician. Let me conclude this one with a reference to another politician, not quite so eloquent, Donald Rumsfeld. The new PIP is intended to throw light on some of the “known unknowns” to which the former US Secretary of Defense famously and opaquely referred; the “unknown unknowns” will have to wait for the next PIP iteration!

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IMAGE OF THE WEEK

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The technological protoype currently consists of various layers equipped with scintillator tiles and strips of different geometries. "We want to build a fully equipped prototype consisting of 40 layers in the coming years, and experience from this testbeam is important input to chose one option," says Katja Krüger, test beam coordinator from DESY.

Their next beam time starts on 12 August, so stay tuned for more results and the revelation what it all has to do with German beer expertise…

CALICE | CALORIMETER | CERN | DETECTOR R&D | ILD | TEST BEAM