Opening Comments

2015/09/05 Keisuke Fujii

WG Objectives

- On July 4, 2012, ATLAS and CMS announced the discovery of a Higgs-like boson with a mass of about 125GeV and the data that followed strongly indicates that it is a Higgs boson indeed. The world has changed since then. The discovery has vaulted the question of its properties on the top of the list of questions in HEP. The 125GeV boson is a window to BSM physics and ILC is the best machine to use it.
  The LHC has just started its Run2 at 13TeV. This will probably bring us more. It is important to stress that ILC, too, is an energy frontier machine. It will access the energy region never explored with any lepton collider. There can be a zoo of new uncolored particles or new phenomena that are difficult to find at LHC but can be discovered and studied in detail at ILC.

  We need to demonstrate that ILC will advance our understanding of particle physics qualitatively beyond the information that will be available from the results expected from the future stages of the LHC. Be prepared for LHC Run2 results!

- The ILC project preparation office has been formed in KEK and the MEXT's ILC Task Force is reviewing the project. In parallel, site-specific design started and the ILC parameter WG published a run scenario document (arXiv:1506.07830) and the ILC Physics WG published a physics case document (arXiv:1506.05992) as a byproduct of its effort to make inputs to the MEXT's physics WG. Given the interim summary from the MEXT expert panel, we now need to prepare a 3-to-4 page long summary of BSM scenario (new particle discovery potential in particular) by the end of CY2015.
  On the HEP community side, the next target for us to show our activities to the LC community is LCWS15 on Nov.2-6 in Whistler, Canada.

MEXT's ILC Review

MEXT = Japan's **M**inistry of **E**ducation, **C**ulture, **S**ports, **S**cience and **T**echnology

MEXT's ILC Review

Oct., 2013: Japanese HEP community filed a petition for the Japanese government to invite the ILC to Japan. → ILC became a project officially recognized by the government.

May 8, 2014: An Advisory Panel including external members under MEXT's ILC TF started the official review process!

MEXT's ILCTask Force

Established in May 2014

ILC Advisory Pannel (2014-5-1→2016-3-31: extensible if needed)

consisting of 13 academic experts from various fields

Research Contract on Survey of spin-off effects

Nomura Research Inst.

Particle and Nuclear Physics WG

Review ILC physics case, taking into account other HEP projects

15 from HEP(th/exp), nucl. phys., astronomy, CR research

Established in June 2014

TDR Validation WG

Evaluate ILC TDR from technical point of view (mostly on accelerator)

10 members, essentially all accelerator physicists

Established in June 2014

Particle and Nuclear Physics WG had 8 meetings and TDR validation WG had 6 meetings before producing their reports to the ILC Advisory Panel in March 2015. *The ILC advisory panel then published* ***an interim summary of discussions on Aug. 5, 2015***.

Summary of the ILC Advisory Panel's Discussions to Date

The ILC Advisory Panel

Official English version available from

http://www.mext.go.jp/component/b_menu/shingi/toushin/__icsFiles/afieldfile/2015/08/05/1360596_3.pdf

Table of Contents

3. Recommendations

Based on the investigations and reports by the working groups and discussions by the advisory panel, the panel recommends the following on the ILC project;

Recommendation 1: The ILC project requires huge investment that is so huge that a single country cannot cover, thus it is indispensable to share the cost internationally. From the viewpoint that the huge investments in new science projects must be weighed based upon the scientific merit of the project, a clear vision on the discovery potential of new particles as well as that of precision measurements of the Higgs boson and the top quark has to be shown so as to bring about novel development that goes beyond the Standard Model of the particle physics.

- The objective of the ILC project is to uncover physics beyond the Standard Model through the precision measurements of the Higgs boson and top quark and through searches for new particles. In case of new discoveries beyond the Standard Model, its scientific impact on elementary particle physics will be significant.
- As the ILC project requires huge investment, it is indispensable and essential prerequisite for the implementation to have a clear vision of participation and cost sharing by international partners including European countries and the United States while taking into account mid-term and long-term domestic economic and financial situations.
- From the viewpoint the huge investments in new science projects must be weighed based upon the scientific merit of the project, it is necessary to have a clear strategy of the discovery potential of new particles such as supersymmetry particles which are considered as a candidate of the dark matter, in addition to that of precision measurements of the Higgs boson and top quark, has to be shown so as to bring about novel development that goes beyond the Standard Model.
- It is appropriate to proceed discussion on a possible international cost sharing scheme of the ILC project by not only taking into account the scheme used by CERN but also taking into account the schemes of existing large scale international projects such as the International Thermonuclear Experimental Reactor (ITER) and International Space Station (ISS).

Recommendation 2: Since the specifications of the performance and the scientific achievements of the ILC are considered to be designed based on the results of LHC experiments, which are planned to be executed through the end of 2017, it is necessary to closely monitor, analyze and examine the development of LHC experiments . Furthermore, it is necessary to clarify how to solve technical issues and how to mitigate cost risk associated with the project.

- The specifications of the performance and the scientific achievements of the ILC project depend on the results of LHC experiments in the 13TeV run which is currently going on through the end of 2017. Especially whether new particle(s) can be found or not, and what their mass value(s) would be in case of the discovery, will provide important viewpoint for the judgement.
- It is important to show a clear outlook to address technical and cost issues pointed out at the working group discussions.
- It is recommended to further enhance the maximum efforts to incorporate technology development that can improve the accelerator performance.

Recommendation 3: While presenting the total project plan, including not only the plan for the accelerator and related facilities but also the plan for other infrastructure as well as efforts pointed out in Recommendations 1 & 2, it is important to have general understanding on the project by the public and science communities.

5. Future prospects of the investigation

- We will set up another working group to investigate the issue of necessary human resources and their cultivation.
- We will commission another survey using an external research agency in order to understand the world trends in technology issues related to accelerator construction, and in approaches to reduce the production cost of accelerators.

Personal Comments

a) The ILC Advisory Panel is setup in the government and hence its interim summary is official and very important.

b) Based on the recommendations, ***it is expected that MEXT will start government-to-government talks.*** It is very important to make sure that the contacted governments to react positively, which would then induce a positive feedback towards a green light.

c) I would like to ask those of you who want ILC to ***contact your governments so as to extract from the governments the positive feedback towards the realization of the ILC.*** There would be no positive development without proactive bottom-up movements in the individual potential participating countries.

d) There were some unofficial contacts made by MEXT in the past 1.5 years.
The government-to-government talks mentioned above will be made based on the recommendations by the Advisory Panel and hence has much higher importance.

e) I consider the fact that the panel set ***a definite deadline (2017) for the judgement*** in their interim summary very important. It could have been the end of the full LHC program (~2035). We need to pave the way to the table for eventual international negotiations for cost sharing by the end of 2017. This needs the positive feedback from the potential participating countries during the period of the government-to-government talks as mentioned above. I would like to ask again those of you who want ILC to ***work coherently on your governments***. We have only two years or so. We need to hurry.

A Short Report on

Prospects for

New Particle Discoveries

Contents: Prospects for new particle discoveries at ILC
Target: MEXT Expert Panel (official name: MEXT ILC Advisory Panel)
Length: 3-4 pages
Deadline: End of CY2015 (complete draft should be available by LCWS15)

Plan

Report to be based on a ILC-LHC comparison table of discovery potential

Structure of the table

Typical discovery scenarios in Y-axis

- SUSY (subdivision such as Bino-, Wino-, Higgsino-LSP, as needed)
- Minimal Composite Higgs Models (subdivision as needed)
- Dark matter particles

Discovery channel/method in X-axis

- Precision Higgs measurements
- Precision top measurements
- Indirect searches (other than H and t)
- Direct searches

Each cell

Prospects at ILC (depending on 13TeV LHC results)

Key message to deliver

There are other important kinds of discovery than new particle discovery!

Classification of Parameter Space

(a) Both ILC and 13TeV LHC can access some new particle(s)
(b) Only 13TeV LHC can access some new particle(s)
(c) Ony ILC can access some new particle(s)
(d) Neither ILC nor 13TeV LHC can access any new particle

Need to decide we make a table for each of the 4 cases or combine some of the cases such as (a,b)(c,d) or (a,c)(b,d)

Key point:
- LHC-ILC synergy (in reconstructing Lagrangian in particular when some new particles are found)
- What will ILC's precision bring to us (even when the new particle is beyond the ILC's reach)

Visualization of Parameter Space

Although the measure in the parameter space is unknown a priori it may help show prospects.

We need physics studies that backup the table

→ We need some more studies to make it fully convincing.

→ Form a team for each row (=discovery scenario)

Parameter space analysis, visualization, preparation of contents in each cell

→ DM study on going led by Shigeki Matsumoto

→ Contact phenomenologists working on LHC physics and ask if they can also investigate prospects at ILC.

→ A core team collect information and make the table.

Schedule

2015/09	**1st draft**
2015/11	final draft (English version)
2015/11	approval @ LCWS2015 (Whistler)
2015/11	final version (+ its Japanese translation)
2015/12	Send it to MEXT Expert Panel
2016/08?	Full report.

What we want

- We have the 125 GeV boson that is a powerful tool to explore the symmetry breaking sector (SBS).
  We need to invent a way to make maximal use of it.
  - Is it possible to map various BSM models in ideally a single and hopefully a small number of generic parameter spaces so as to compare the physics reach of ILC with that of the future upgraded LHC.
  - If yes, explore the possibility of fingerprinting BSM models in the generic parameter space. --> partially done in the Snowmass process
- The most important Mission of ILC = bottom-up reconstruction of the SBS and clarification of its relation to other open questions of elementary particle physics.
  - Make a strategy to reconstruct the SBS
    - Shape of SBS: Multiplet Structure (a SM-like 2-let main but what about small admixtures of 1-let?, 3-let? If there, how many?, ...)
    - Dynamics behind SBS: weakly/strongly interacting = elementary/composite
  - Clarify relation to other open questions: DM, Baryogenesis, Neutrino mass, Hierarchy, ...

- ILC is an energy frontier machine. We need to re-examine the possibilities given the existence of the 125GeV boson and their relations to the open questions.

More Exercises Needed

- For theorists:
  - ILC can measure various quantities such as mh, gamma_h, ghxx, mt, etc. far better than LHC. But how accurately do we really need to measure them?
  - What will be the ultimate theoretical uncertainties in various predictions for LHC and ILC, respectively?
  - Update various ILC physics plots to accommodate LHC constraints, etc.
- For Experimentalists:
  - Update all the old analyses with mh=120 GeV to mh=125GeV: urgent!
  - Complete the analyses such as rare Higgs decays: urgent!
  - Improve the analyses such as self-coupling, H->gamma gamma, recoil mass (jets?), where the results are not yet satisfactory.
  - Studies at Ecm = 350 GeV : requests from the ILC parameter WG.
  - With the projected running scenarios described in DBD, the most measurements are still statistically limited and should improve by a luminosity upgrade or by running longer. Nevertheless, ILC, too, will hit systematics limits, eventually. It is probably the right time to start more serious studies of expected systematic errors.
    - Identify possible sources of systematic errors
    - Estimate to what degree we can control them (partially done in the Snowmass process)

Our Group's Activities

Status & Next Step

Symmetry Breaking & Mass Generation Physics

- ZH : H->bb,cc,gg -> EPJ C (2013) 73:2343, now working on mh=125 GeV case: Ono+Miyamoto
  H -> WW* anomalous coupling: analysis done -> publication: Takubo (revision done, resubmitted to P.R.D.) -> P.R.D88,013010(2013)
  H->other modes: Tino (AA,mu+mu-) + Kawada/Tanabe/Suehara/Daniel (tau+tau-)->publication
  Recoil mass: Jacqueline -> draft-1, Suehara (qq), CP mixing in h->tau+tau-: Yokoyama, Ogawa (HVV couplings)
- ZHH : full simulation of the H->bb&Z->all modes, fast simulation of nunuHH: finished: Junping + Takubo (Ph.D thesis: done) -> New analysis with improved analysis tools: Junping + Claude + Suehara + Tanabe, Jet-clustering: Shaofeng Ge, LCFIPlus: Suehara
  New analysis: ZHH->ZbbWW*: Kurata (high level reconstruction)
- nnHH : full simulation @ 1TeV, done for DBD: Junping -> publication
- nnH, eeH : precision measurements of HVV couplingsm, mh=125GeV: Junping
  BR measurements: Ono, Christian
- TTH : quick simulation studies with NRQCD corrections
  -> P.R.D84,014033(2011) -> full sim. @ 0.5 & 1 TeV: (Yonamine left) Tanabe + Sudo
- TT Threshold : Top Yukawa measurement: Horiguchi + Ishikawa + Tanabe, Theory: Kiyo + Sumino -> publication? (cf. a recent significant theoretical development!)
- New analysis (enW) : Koya Tsuchimoto
- AA->HH : quick simulation studies, so far H->bb and WW BG
  -> P.R.D85,113009(2012) : Kawada, Theory: Harada

Status & Next Step

Beyond the Standard Model

- SUSY : full simulation studies for LOI -> publication
  - EWkino scan: Tanabe
- Extra U(1), etc. -> Z' tail
  - TT : full simulation studies for LOI -> publication in conjunction with tau tau
  - tau tau : full simulation studies for LOI -> ditto
- Hidden Sector / XD : P.R.D78, 015008 (2008)
- LHT : P.R.D79, 075013 (2009)
- Model discrimination: Saito + Suehara .. : P.R.D84, 115003 (2011)
- R-handed neutrinos: Saito : P.R.D82, 093004 (2010)
- LHT: Kato (exp) + Harigaya (th): ZHZH finished, working on eHeH, nHnH, ..: Draft (n-1)?
- Very light gravitino: Katayama (Master's thesis), Tanabe (exp) + Matsumoto (th)
  --> 1st Draft --> New student: Takuaki Mori (Tokyo)
- Quasi stable stau: Yamaura (Master's thesis) + Kotera + Kasama —> reactivated
- Higgs portal/h->Invisible: Honda -> Yamamoto -> Ishikawa, Ogawa, Junping
- W-H+/W+H-: (Shinzaki), Ishikawa (exp) + Kanemura, yagyu (th)
- New projects?
  - AMSB: Tanabe
  - Single photon (DM search): Tanabe
  - Heavier Higgs bosons?: Yokoya, (Abhinav) -> Ishikawa?
  - Radiative correction to Higgs couplings in 2HDM: Kikuchi
  - H125->ccbar: Hidaka
  - m_nu, DM, baryogenesis: Machida

Short Term Schedule

- Weekly Meeting
  - Every Fri. at 13:30 (conf. ID: to be announced)
- General Meeting
  - 10:30 on Sat. Oct.24?, 2015 (KEK MCU2 conf. ID:XXX)
- LCWS 2015, Whistler (Vancouver), Nov. 2-6, 2015