

# Opening Comments

2017/11/18

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. So far no additional new particles or new phenomena have been found in the LHC Run 2, suggesting that there seem to be no easily discoverable new particles, which enhanced the importance of the precision measurements of H125 and loophole-less searches at ILC more than ever. 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. The MEXT ILC Advisory Panel says "it is necessary to closely monitor, analyze and examine the development of LHC experiments". We did and proposed ILC250 as a JAHEP agreement on July 22, 2017.

- 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 detector optimization effort will continue. In response to the interim summary from the MEXT panel, we published a report on ILC's new particle discovery potential in last Feb. We have just published ILC physics case of ILC250. The next target for us to show our activities at ALCW2017 on May. 28 to June 1, 2018 in Kyshu.

# ***ICFA Statement***

***on November 10***

## **ICFA Statement on the ILC Operating at 250 GeV as a Higgs Boson Factory**

The discovery of a Higgs boson in 2012 at the Large Hadron Collider (LHC) at CERN is one of the most significant recent breakthroughs in science and marks a major step forward in fundamental physics. Precision studies of the Higgs boson will further deepen our understanding of the most fundamental laws of matter and its interactions.

The International Linear Collider (ILC) operating at 250 GeV center-of-mass energy will provide excellent science from precision studies of the Higgs boson. Therefore, ICFA considers the ILC a key science project complementary to the LHC and its upgrade.

ICFA welcomes the efforts by the Linear Collider Collaboration on cost reductions for the ILC, which indicate that up to 40% cost reduction relative to the 2013 Technical Design Report (500 GeV ILC) is possible for a 250 GeV collider.

ICFA emphasizes the extendibility of the ILC to higher energies and notes that there is large discovery potential with important additional measurements accessible at energies beyond 250 GeV.

ICFA thus supports the conclusions of the Linear Collider Board (LCB) in their report presented at this meeting and very strongly encourages Japan to realize the ILC in a timely fashion as a Higgs boson factory with a center-of-mass energy of 250 GeV as an international project<sup>1</sup>, led by Japanese initiative.

<sup>1</sup>In the LCB report the European XFEL and FAIR are mentioned as recent examples for international projects.

Ottawa, November 2017

# ***LCB Statement***

***on November 8***

***Conclusions on the 250 GeV ILC as a Higgs Factory  
proposed by the Japanese HEP community***

- Short Summary -

Linear Collider Board

8 November 2017, Rev 1

Physics studies by the Linear Collider Collaboration Physics and Detector Group [1], and the Japanese Association of High Energy Physicists (JAHEP) [2] show a compelling physics case for constructing an ILC at 250 GeV centre of mass energy as a Higgs factory. The cost of such a machine is estimated to be lower by up to 40% compared to the originally proposed ILC at 500 GeV [3]. The acceleration technology of the ILC is now well established thanks to the experience gained from the successful construction of the European XFEL in Hamburg. One of the unique features of a linear collider is the capability to increase the operating energy by improving the acceleration technology and/or extending the tunnel length. For these reasons, the Linear Collider Board strongly supports the JAHEP proposal [4] to construct the ILC at 250 GeV in Japan and encourages the Japanese government to give the proposal serious consideration for a timely decision.

In recent examples of similar international projects<sup>1</sup>, the host country made the majority contribution. A natural expectation would be that the cost for the civil construction and other infrastructure is the responsibility of the host country, while the accelerator construction should be shared appropriately. A clear expression of interest to host the machine under these principles would enable Japan to start negotiations with international partners. It would also allow members of the international community to initiate meaningful discussions with their own governments on possible contributions.

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<sup>1</sup>Recent examples in the field close to the ILC are European XFEL and FAIR in Germany.



## References

1. K. Fujii et. al. (Linear Collider Collaboration), “Physics Case for the 250 GeV Stage of the International Linear Collider”, DESY-17-155 / KEK Preprint 2017-31 / LAL 17-059 / SLAC-PUB-17161, arXiv:1710.07621 [hep-ex].
2. S. Asai et al, “Report by the Committee on the Scientific Case of the ILC Operating at 250 GeV as a Higgs Factory”, arXiv:1710.08639 [hep-ex].
3. L. Evans and S. Michizono (Edit.) (Linear Collider Collaboration), “The International Linear Collider Machine Staging Report 2017, Addendum to the International Linear Collider Technical Design Report published in 2013”, DESY 17-180, CERN, KEK Report 2017-3, arXiv:1711.00568 [hep-ex].
4. JAHEP, “Scientific Significance of ILC and Proposal of its Early Realization in light of the Outcomes of LHC Run 2”, <http://www.jahep.org/files/JAHEP-ILCstatement-170816-EN.pdf>.

# **Physics Case for ILC250**



Physics Case for the 250 GeV Stage  
of the International Linear Collider

LCC PHYSICS WORKING GROUP

KEISUKE FUJII<sup>1</sup>, CHRISTOPHE GROJEAN<sup>2,3</sup>, MICHAEL E. PESKIN<sup>4</sup>  
(CONVENERS); TIM BARKLOW<sup>4</sup>, YUANNING GAO<sup>5</sup>, SHINYA KANEMURA<sup>6</sup>,  
HYUNGDO KIM<sup>7</sup>, JENNY LIST<sup>2</sup>, MIHOKO NOJIRI<sup>1,8</sup>, MAXIM PERELSTEIN<sup>9</sup>,  
ROMAN PÖSCHL<sup>10</sup>, JÜRGEN REUTER<sup>2</sup>, FRANK SIMON<sup>11</sup>, TOMOHIKO TANABE<sup>12</sup>,  
JAMES D. WELLS<sup>13</sup>, JAEHOON YU<sup>14</sup>; MIKAEL BERGGREN<sup>2</sup>,  
MORITZ HABERMEHL<sup>2</sup>, SUNGHOON JUNG<sup>7</sup>, ROBERT KARL<sup>2</sup>,  
TOMOHISA OGAWA<sup>1</sup>, JUNPING TIAN<sup>12</sup>; JAMES BILAU<sup>15</sup>,  
HITOSHI MURAYAMA<sup>8,16,17</sup> (EX OFFICIO)

ABSTRACT

The International Linear Collider is now proposed with a staged machine design, with the first stage at 250 GeV with a luminosity goal of  $2 \text{ ab}^{-1}$ . In this paper, we review the physics expectations for this machine. These include precision measurements of Higgs boson couplings, searches for exotic Higgs decays, other searches for particles that decay with zero or small visible energy, and measurements of  $e^+e^-$  annihilation to  $W^+W^-$  and 2-fermion states with improved sensitivity. A summary table gives projections for the achievable levels of precision based on the latest full simulation studies.

# ***Urgent!***

*It is, however, **necessary to confirm the new beam parameters would not harm the physics performance** with full simulation; notice that*

- per bunch luminosity will be enhanced by a factor of about 1.6, which will increase 2-photon BG as well as low energy pairs (Small  $\Delta m$  processes,  $mW$ , ...),*
- longer beamstrahlung tail might affects analyses assuming a fixed  $E_{cm}$  (recoil  $M$ , ...).*

**→ Jenny's talk in the general ILD phone meeting yesterday.**

# **Plan for 250 GeV Physics Studies**

# Ongoing and Planned 250 GeV Analyses

## Higgs

- **Improve  $\sigma$  BR( $h \rightarrow WW^*$ ): Mila Pandurovic?**
- **EFT analyses: Tomohisa Ogawa**
- $e^+e^- \rightarrow \nu\nu H$ : Junping Tian
- $e^+e^- \rightarrow H\gamma$ : Yumi Aoki
- $H \rightarrow \tau\tau$ : Daniel Jeans
- $H \rightarrow$  invisible: Yu Kato
- $H \rightarrow \mu\mu$ : Shin-ichi Kawada
- $mh$ : Graham Wilson, Junping Tian
- $H \rightarrow$  exotic (new light particles, FC/LFV): ?
- $H \rightarrow Z\gamma$ : ?

*Blue: presented at LCWS 2017*

*Brown: new analyses*

## Precision EW

- $m_W$ : Robert Karl
- **2-fermion processes:  $\mu\mu$ : Hirokazu Yamashiro**
- **TGC: Robert Karl**
- $e^+e^- \rightarrow Z\gamma$  ( $A_{LR}$ ),  $\gamma\gamma$ : ?

## Top/QCD

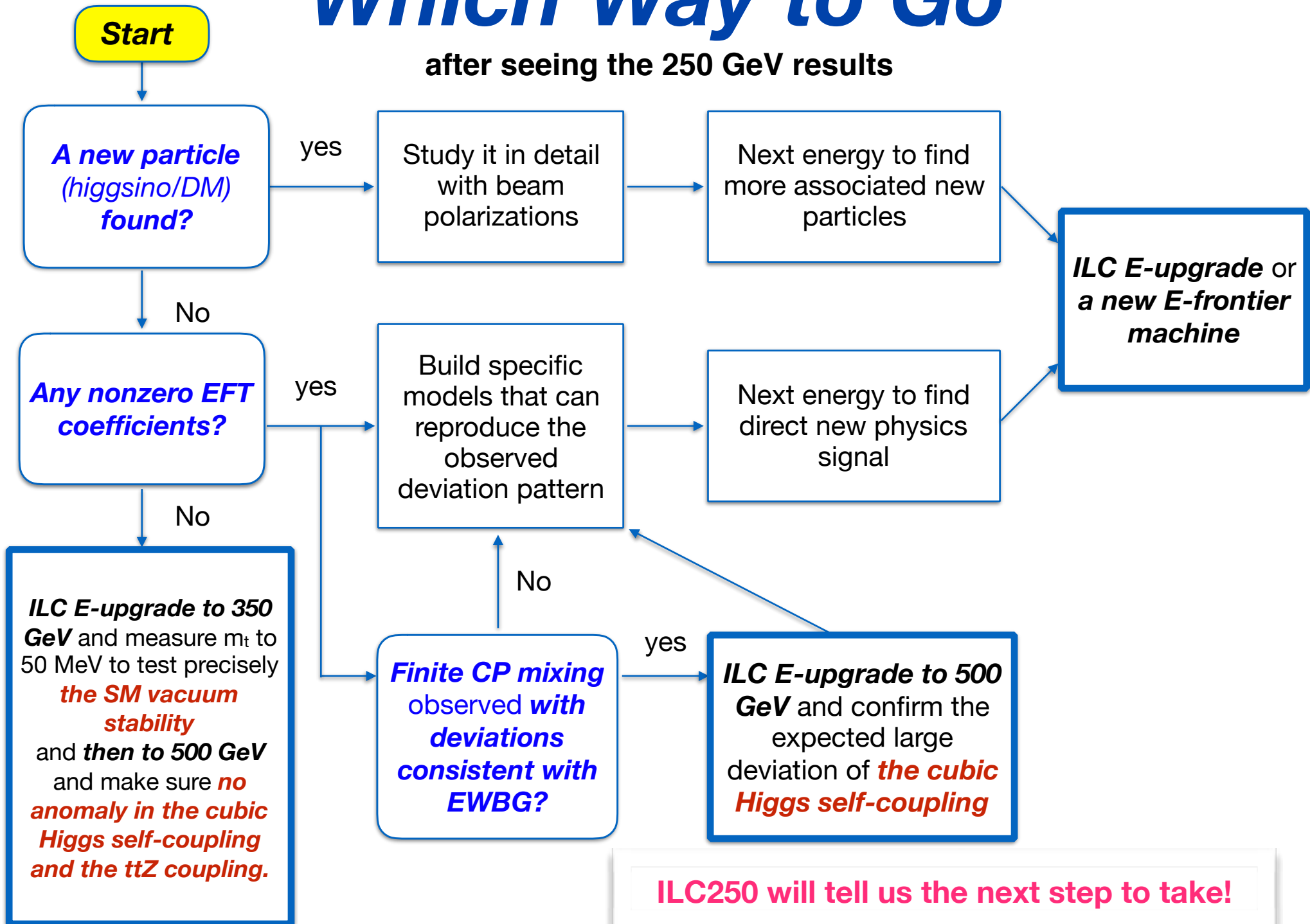
- **$bb$ : Sviatoslav Bilokin  $\rightarrow$  who to take this over**
- **Single top production: ?**

## BSM: Direct search

- **Dark Matter: Moritz**, Tomohiko, Masakazu, ..
- **Extra light states** (light extra higgses, dark photon, ..)
  - **$ZX$  ( $m_X < 125\text{GeV}$ ): Yan Wang**
- **Higgsinos: Tomohiko + Swathi (for very low  $\Delta M$ )**

# Which Way to Go

after seeing the 250 GeV results





# *Validity of EFT*

*At ILC 250, we will have enough redundancy (#observables > #unknown) to test the validity of (dim.-6) EFT. Notice, in particular that beam polarizations essentially doubles the number of usable observables in the EFT fit.*

*If we see inconsistency, it suggests  $\Lambda_{BSM} \sim E_{cm}$ .*

*(→ **need demonstration of this**)*

*We then expect to see significant deviations from the SM, or to find some new particle.*

*In this case, we forget about EFT and try to build specific models to explain the observed deviation pattern and/or the new particle and test these specific models.*

*For new particle searches, we will work on particular models anyway.*

# Our Group's Activities



# Status & Next Step

## Symmetry Breaking & Mass Generation Physics

- ZH :  $H \rightarrow bb, cc, gg \rightarrow$  EPJ C (2013) 73:2343, now working on  $m_h=125$  GeV case: Ono+Miyamoto  
 $H \rightarrow WW^*$  anomalous coupling: analysis done  $\rightarrow$  publication: Takubo  $\rightarrow$  P.R.D88,013010(2013)  
 $\rightarrow H \rightarrow WW^*$  to be reexamined: Liao Libo  
 $H \rightarrow$  other modes: Tino (AA,  $\mu\mu$ ) + Kawada/Tanabe/Suehara/Daniel ( $\tau\tau$ )  $\rightarrow$  publication  
 $\rightarrow$  EPJC (2015) 75:617.  
 Recoil mass: Jacqueline  $\rightarrow$  P.R.D94,113002(2016), Suehara (qq), CP mixing in  $h \rightarrow \tau\tau$ :  
 Daniel  $\rightarrow$  draft being reviewed by ILD, HVV couplings: Ogawa, Yumi Aoki (Hgamma)  
 direct mH reconstruction: Junping
- ZHH : full simulation of the  $H \rightarrow bb$  &  $Z \rightarrow$  all modes, fast simulation of  $nnuHH$ : finished:  
 Junping + Takubo (Ph.D thesis: done)  $\rightarrow$  New analysis with improved analysis tools: Junping +  
 Claude + Suehara + Tanabe, Jet-clustering: Kurata, Shaofeng Ge, LCFIPlus: Suehara, Yonamine  
 New analysis: ZHH  $\rightarrow$  Zbb  $WW^*$ :  $dE/dx$ : Kurata, Systematic Error: Tim, EFT: Junping
- nnHH : full simulation @ 1TeV, done for DBD: Junping  $\rightarrow$  publication
- nnH, eeH : precision measurements of HVV couplings,  $m_h=125$  GeV: Junping  
 BR measurements: Ono, Christian
- TTH : quick simulation studies with NRQCD corrections  
 $\rightarrow$  P.R.D84,014033(2011)  $\rightarrow$  full sim. @ 0.5 & 1 TeV: (Yonamine left) Tanabe + Sudo
- TT Threshold : Top Yukawa measurement: Horiguchi + Ishikawa + Tanabe, Theory: Kiyo +  
 Sumino  $\rightarrow$  publication? (cf. a recent significant theoretical development!): Ozawa  $\rightarrow$  Eda
- W mass ( $m_W$ ) : Koya Tsuchimoto  $\rightarrow$  Kotera (controlling systematic uncertainties)  $\rightarrow$  Kotera
- AA  $\rightarrow$  HH : quick simulation studies, so far  $H \rightarrow bb$  and  $WW$  BG  
 $\rightarrow$  P.R.D85,113009(2012) : Kawada, Theory: Harada



# Status & Next Step

## Beyond the Standard Model

- SUSY : full simulation studies for LOI → publication
  - **EWkino** (Compressed Spectrum Case): Jacqueline
- Extra U(1) (Z' tail), Compositeness, Extra Dimensions, etc.
  - **TT** : full simulation studies for LOI → **New study with MELA**: Sato
  - tau tau : full simulation studies for LOI → ditto
  - **2f: full simulation study**: Yamashiro
- 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 --> Takuaki Mori (Tokyo) → ?
- **Quasi stable stau**: Yamaura (Master's thesis) + Kotera + Kasama → reactivated?
- **Higgs portal/h→Invisible**: Honda → Yamamoto → Ishikawa, Ogawa, Junping → Kato (Tokyo)
- W-H<sup>+</sup>/W-H<sup>-</sup>: (Shinzaki), Ishikawa (exp) + Kanemura, yagyu (th)
- **Generic DM search**: Tanabe
- New projects?
  - AMSB: Tanabe
  - Heavier Higgs bosons?: Yokoya, (Abhinav) → Christian Drews
  - **X(750)** : Junping → **published in PRD (Phys.Rev. D94 (2016) no.9, 095015)**
  - **Correlation btw h→gamma gamma & h→gg in mSUGRA**: Hidaka
  - m\_nu, DM, baryogenesis: Machida



# Short Term Schedule

- Weekly Meeting
  - Every Fri. at 14:00 (conf. ID: to be announced)
- General Meeting
  - 10:30 on Sat. Feb. 3, 2018 (KEK MCU2 conf. ID:XXX)
- AWLC 2018, Kyushu, May 28 - June 1