Introduction

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ILC-JP Seasonal Physics and Detector Meeting

Oct 11, 2018, KEK

Problems with Standard Model

- No candidate for Dark Matter
- Cannot explain the origin of EW symmetry breaking
- Cannot explain the matter dominance of Universe
- Higgs mass correction: quadratic divergence fine-tuning problem – unless multiverse?
- …

All the above indicate New Physics Beyond SM

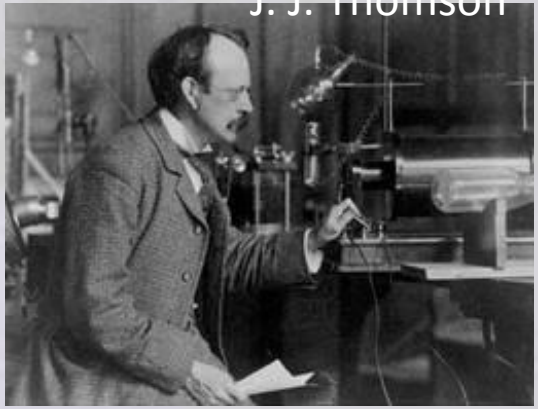
Higgs is the probe for BSM

E. Rutherford

New era of particle physics has begun!

Can be compared to the discoveries of nucleus (Ratherford) and electron (J.J. Thomson) opening new era of particle physics

J. J. Thomson



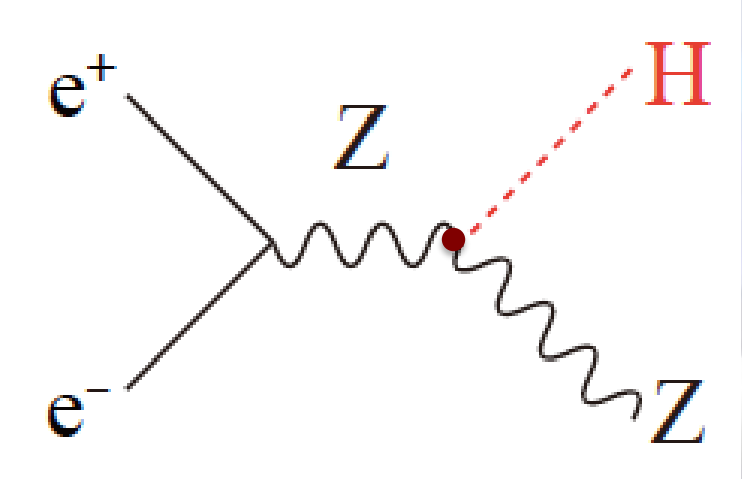
ILC has been designed to lead this new era

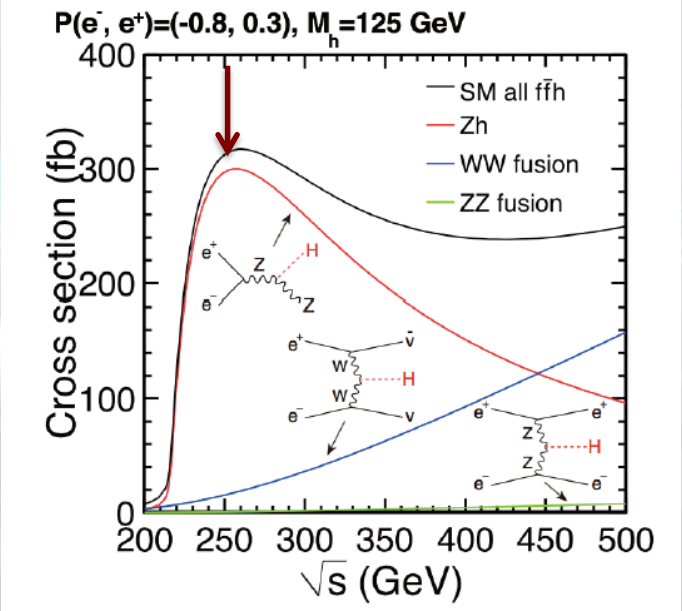
ILC 250 Higgs Factory

ILC 250 Higgs Factory

- Optimal energy to produce Higgs in a controlled environment.
- Measurements there will show which energy to go next.

Higgsstrahlung

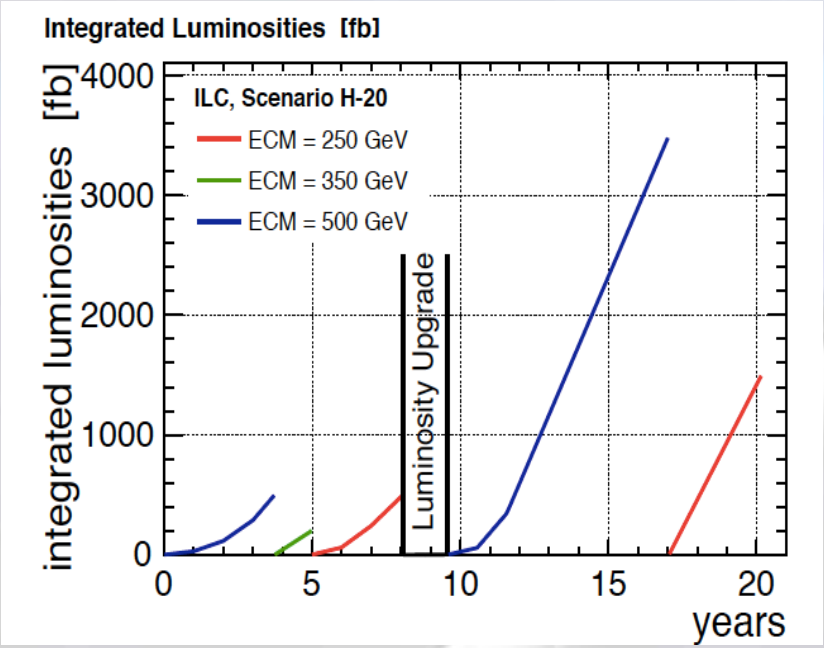




- Precise measurement of HZZ coupling by production
- Recoil mass of Z ≡ Higgs reconstruction
  - No explicit reconstruction of Higgs (Higgs tagging)
  - Powerful for invisible Higgs decays

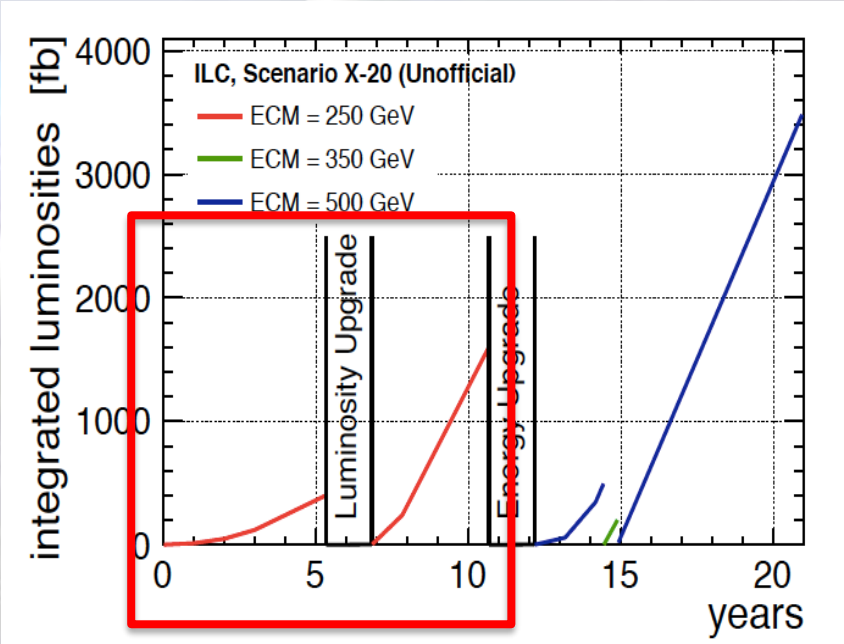
Staging : ILC250 Higgs Factory

Up to Dec. 2016 (LCWS Morioka)
500 GeV start sample scenario (H20)



ILC500 ~20 years

After Dec. 2016
Generally agreed by ILC community
To be formalized this fall

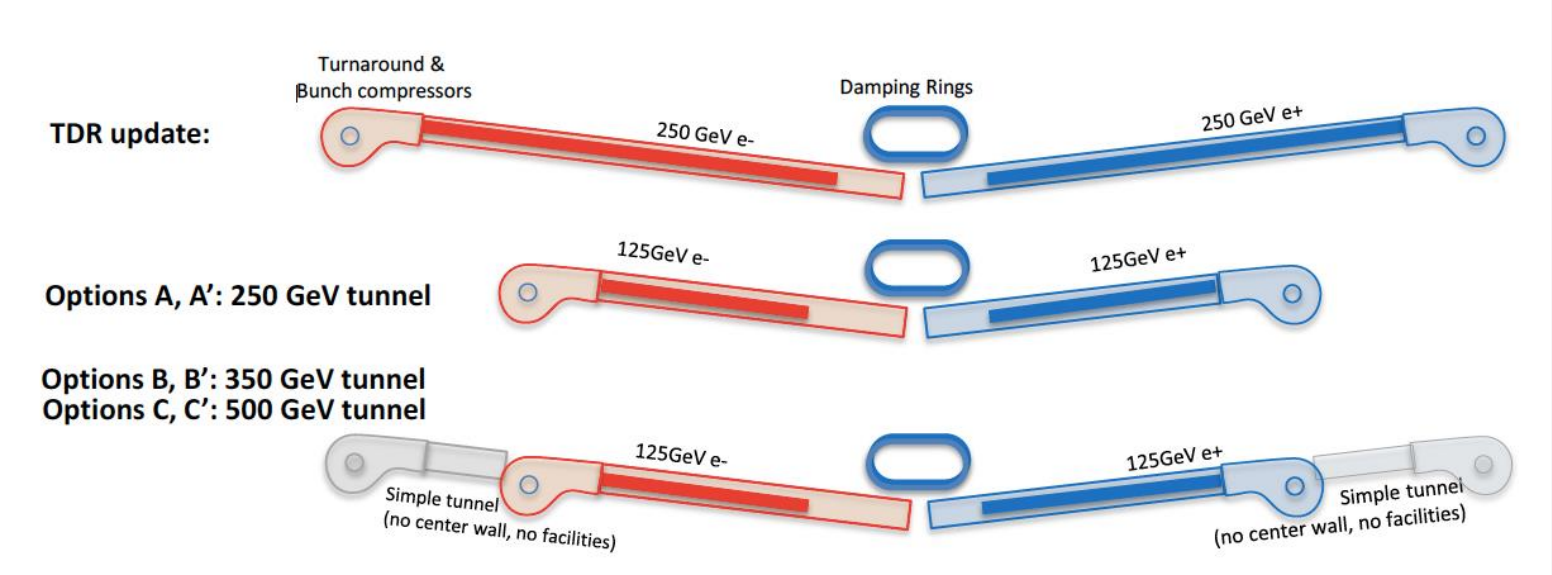


ILC250 Higgs Factory
2000 fb^{-1} in ~10 years

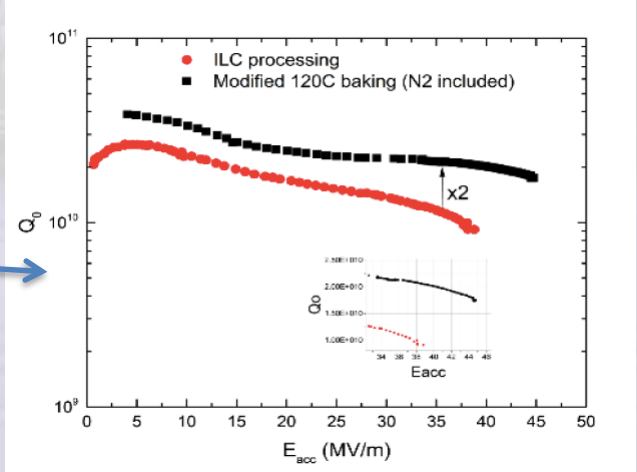
Build the ILC250 Higgs factory as the first stage 'program'

Staging Options

Length of tunnel for ILC 250



Improvement by N2 doping



Options A, B, C : Assume 31.5 MV/m (TDR)

Options A', B', C' : Assume 35 MV/m

Now realistic, e.g.

Cost Reduction

ILC500（TDR）→ ILC250

Table 6-1: Summary of the staging cost

	e+/e- collision [GeV]	Tunnel Space for [GeV]	Value Total (MILCU)	Reduction [%]
TDR	250/250	500	7,980	0
TDR update	250/250	500	7,950	-0.4
Option A	125/125	250	5,260	-34
Option B	125/125	350	5,350	-33
Option C	125/125	500	5,470	-31.5
Option A’	125/125	250	4,780	-40
Option B’	125/125	350	4,870	-39
Option C’	125/125	500	4,990	-37.5

Up to 40% cost reduction compared to ILC500 (TDR)

ILC 250 Physics

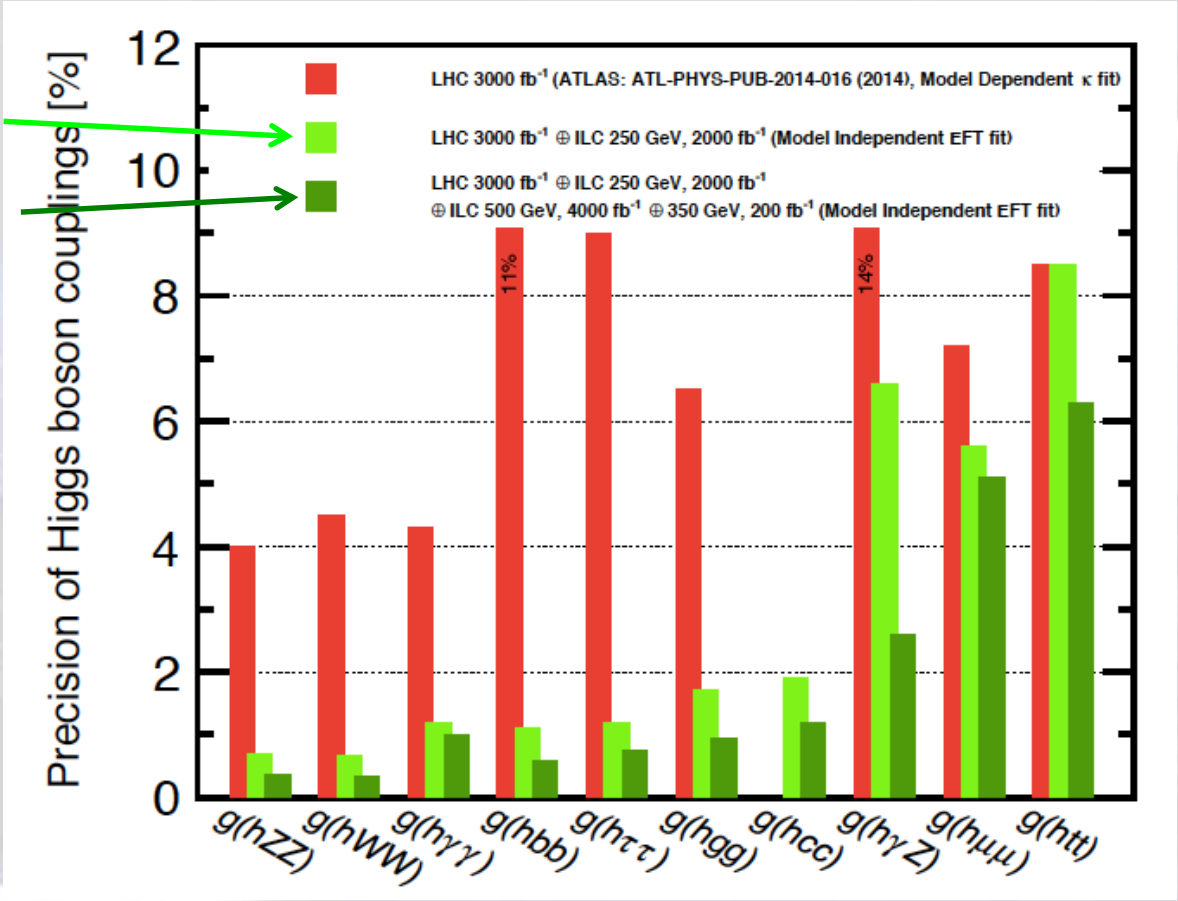
(Very briefly)

Higgs Coupling Measurement Precisions

EFT approach (SU2xU1 gauge symmetry)

ILC250

ILC500



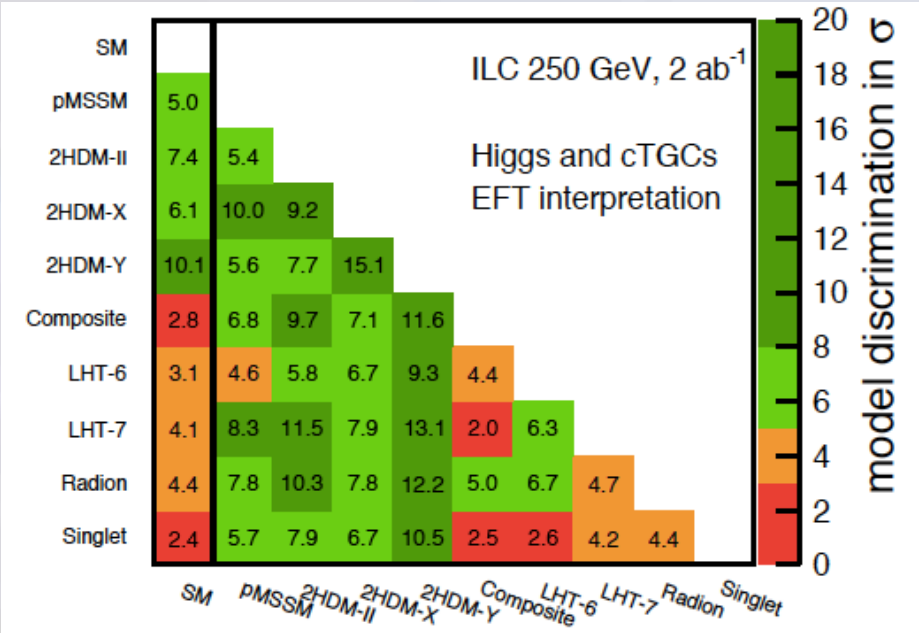
Polarization:
(-+, +-, ++, --) =
(45%, 45%, 5%, 5%)

HL-LHC will be there. What are the improvements by ILC?

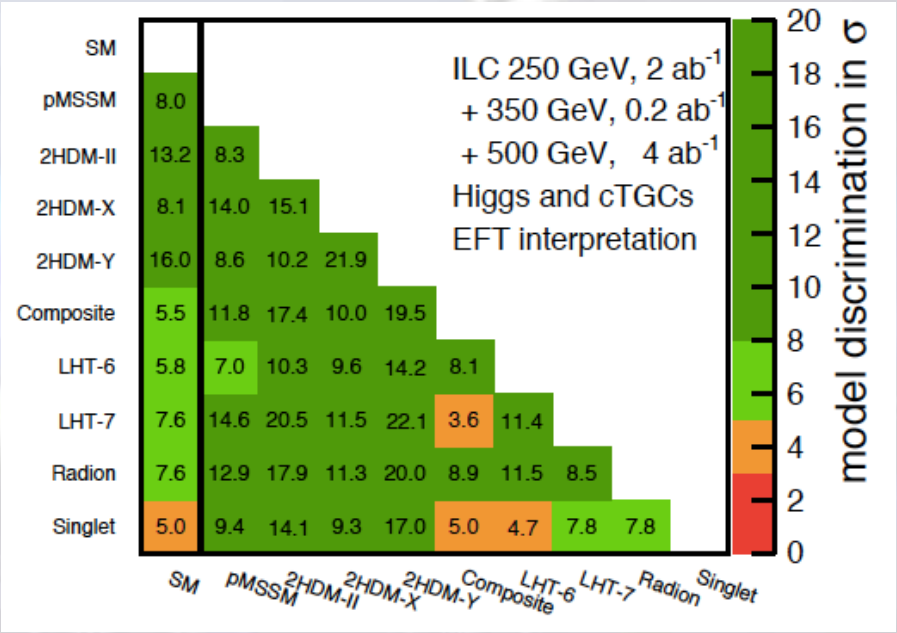
ILC 250 (~10 yrs) is nearly as effective as ILC500 (~20 yrs).

Model Discrimination

ILC250



ILC500 (~H20)



Separations among models in #sigma
(9 models unlikely to be rejected by HL-LHC)

ILC500 (~H20) has better separations among models that are beyond HL-LHC.
ILC250 has less sensitivities, but still quite effective in model separations.
(ILC500 takes twice as long running time)

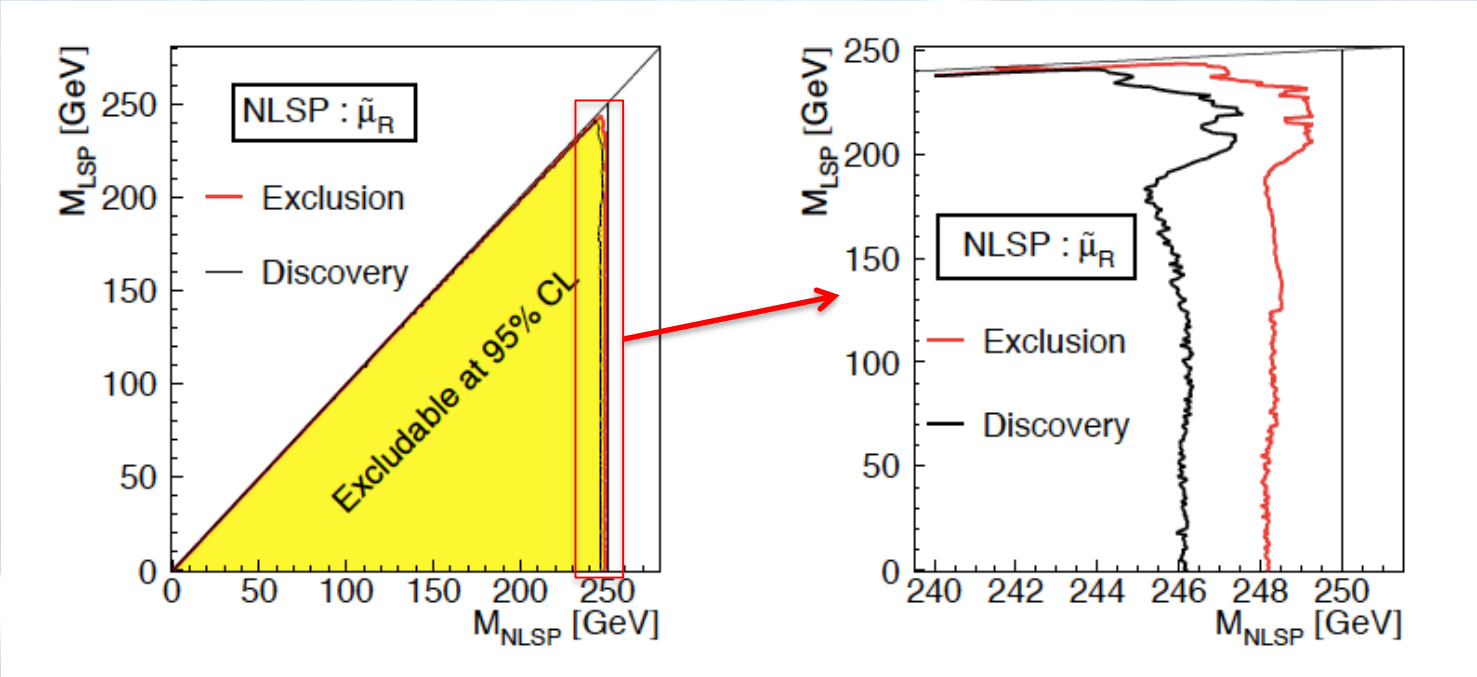
NLSP Pair Production

'Smuon' pair prodution

$$e^+e^- \to \tilde{\mu}^+\tilde{\mu}^- \qquad \tilde{\mu} \to \mu\chi$$

Signal: soft muon pair

M. Berggren



Sensitivity nearly up to the kinematic limit

Possibility to find a new particle at ILC 250

ILC 250 Political Status

MEXT ILC Advisory Panel on ILC250

Final Report: July 4, 2018

Based on the lack of new physics found at LHC,

. . .

'The strongest advantage of experiments at the 250 GeV ILC is their capability to precisely measure the couplings of the Higgs boson. If any coupling(s) is measured to be different from the Standard Model prediction, a particle-by-particle pattern of the deviation will elucidate the nature of new physics, suggesting a future direction of elementary particle physics. Mysteries in the Standard-Model such as the nature of dark matter and compositeness of the Higgs boson may also be clarified with this measurement.'

. . .

It also stated that going from 500 GeV to 250 GeV reduced the chance to find new particles and precluded precision top physics.

Also commented on cost estimation, technical feasibility, human resources, organization/management, and international cooperation.

Science Council of Japan (SCJ)

Committee on the Revised ILC

- Five years ago, the SCJ committee on ILC issued a report:

… the government of Japan should

(1) secure the budget required for the investigation of various issues to determine the possibility of hosting the ILC, and

(2) conduct intensive studies and discussions among stakeholders, including authorities from outside high-energy physics as well as the government bodies involved for the next two to three years.

… Upon completion of the above investigations, SCJ is prepared to contribute to the government's decision by presenting scientific and academic perspectives.

Now that MEXT experts' committee finished its report

- SCJ committee was re-Established on Jul 26, 2018
  - Final Report by ~ end of 2018
  - European Strategy sets the deadline

Ruling Party（LDP）'s Coordination Council for Realization of ILC

- Established Sep 18,2018
  - Goal: realize ILC as a national project addressing cross-policy issues
  - Takeo Kawamura (chair)
  - + Chairs of committees related to science and technologies, desaster recovery:
    - Toshihiro Nikai (chair: national resiliency)
    - Akira Amari (chair: intellectual Property)
    - + …
  - + Industry organizations
    - Advanced Acceerator Assoc.
    - Tohoku ILC promotion council
  - + 'experts'
    - Hiroya Masuda
    - Satoshi Fujii
    - + …

Abe: prime minister

Amari: election

Nikai: general secretary

LDP Leadership

Resolution by the Coordination Council for Realization of ILC

September 18, 2018

(unofficial translation)

We, requesting that ILC be realized as a national project, thereby propose as follows:

1. To position ILC as a cross-policy ”national project", covering not only science, technology and innovation but also many challenges faced by the national government;

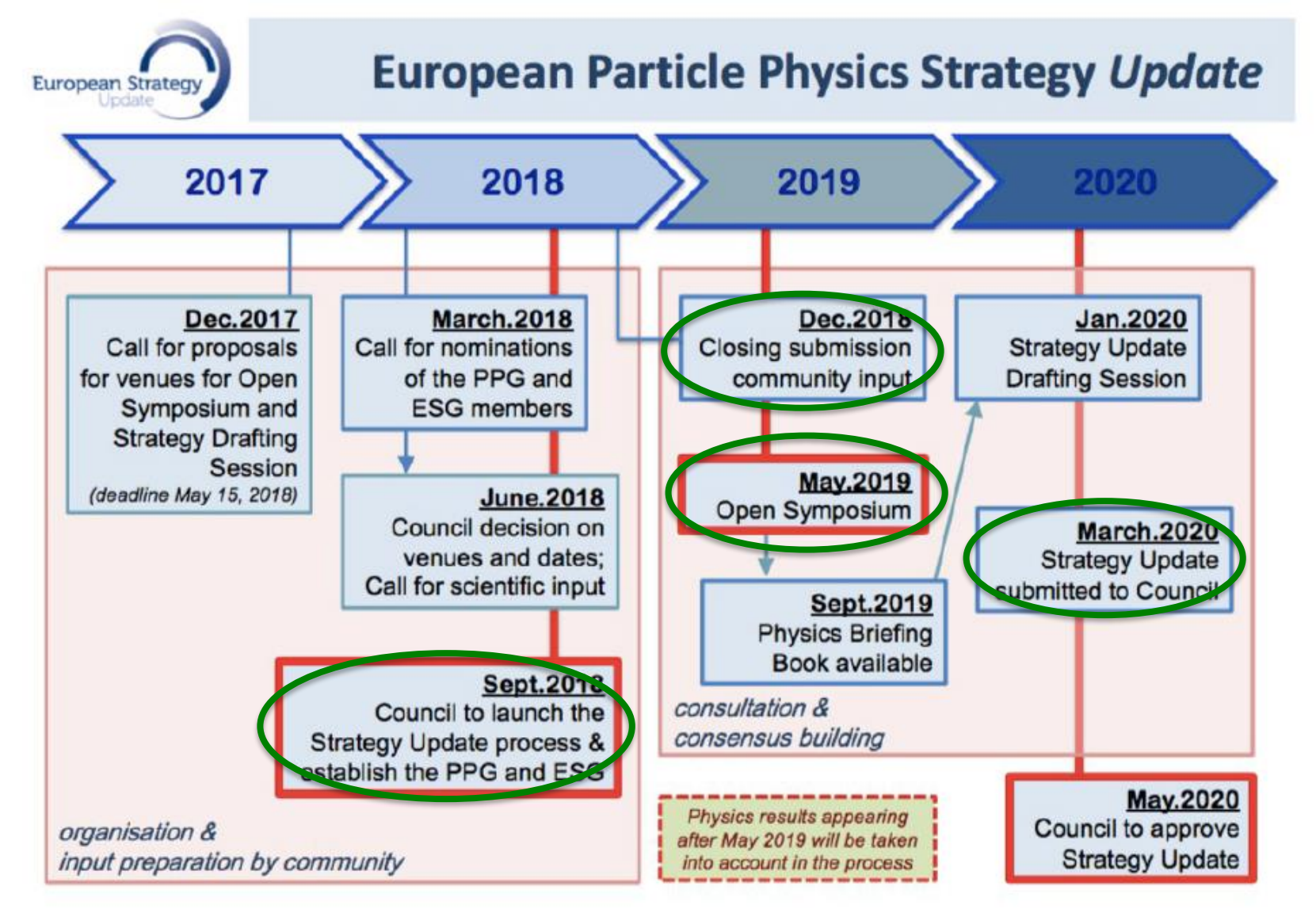
2. To secure the financial resources for the realization of ILC (beyond the Olympic Games) outside of the ordinary science and technology, academic or university budgets; and in addition,

3. To make sure that, as for the international agreement of ILC, certain critical decisions (CD’s), such as the share of investments from overseas be roughly half, be satisfied before the international agreement necessary for the start of construction of ILC is reached.

European Particle Physics Strategy Update (EPPSU 2020)

- Defines which projects for Europe to promote in the field of particle physics.
- Organized by CERN.
  - EPPSU reports to the CERN council
- Last update was in 2013, next is 2020.
- Largely defines participation of each member states (France, Germany, Italy, etc.) in key projects (including ILC)
- Preparations started this year.
  - Establish PPG (Physics Preparatory Group) : produces physics briefing book
  - Establish ESG (European Strategy Group) : drafts strategy update
  - Deadline of inputs to PPG: Dec 18, 2018.

It is critical that ILC be on the agenda!



Japanese government's positive 'expression of interest' is critical for ILC to be included in this process.

Japanese Delegation to Europe

- Jan. 8 - 11, 2018: Paris and Berlin
- 18 from Japan

  Diet members: Reps Shionoya, Ito, Otsuka +
  Administration: Itakura (MEXT vice mnister) +
  Industry: Nishioka (AAA chiar) +
  Researchers
- Met with

(France)

Olivier Becht (France national assembly, Council of Europe vice chair for France)
Silvain Waserman (Vice chair of French national assembly)
Georg Shutte (Undersecretary of ministry of education and research)

(Germany)

Stefan Kauffman (German Bundestag, committee on education,technology..)
Alain Beretz (Head of MESRI research and innovation office)

Established the contact points for discussions on ILC (resource sharing etc.) at government, parliament, academy, and industry levels.

Reps Becht and Kauffman: separate visits to Japan (past and future)

Ready for initiate official negotiations once a ‘green sign’ comes from Japan.

US: P5 Report

P5: Particle Physics Project Prioritization Panel (DOE)
23 May 2014

- On the scientific case for the ILC
  - 'we emphasize most strongly that the scientific justification for the project is compelling'.
- On the US participation
  - 'As the physics case is extremely strong, all Scenarios include ILC support at some level through a decision point within the next 5 years'.
  - If scenario C : 'Play a world-leading role in the ILC experimental program and provide critical expertise and components to the accelerator, should this exciting scientific opportunity be realized in Japan.'

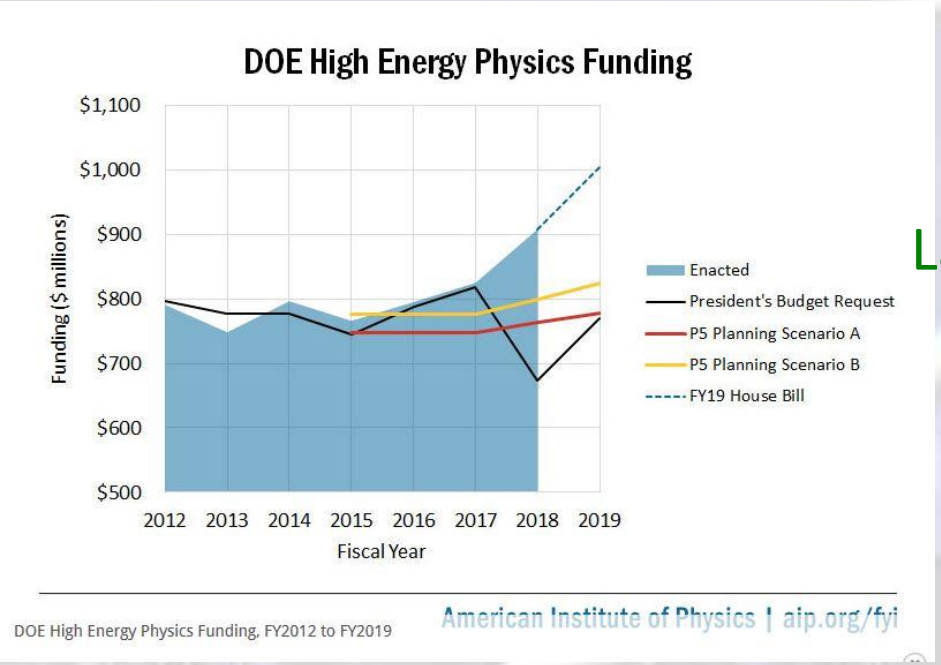
Scenario A : constant for three years, followed by increases of 2%/year wrt the FY2013 budget. (constrained and pessimistic)

Scenario B : constant for three years, followed by increases of 3/yr wrt the FY2014 President's budget request. (constrained and optimistic)

Scenario C : 'unconstrained'

Still valid now (as of Oct 2018)

US HEP Budget



Large increase!

- 2018 DOE HEP budget: $908M
- 2019 projected: $1B (somewhere between scenarios B and C)

DOE is now eager to contribute to the ILC (Office of HEP)

Paul M. Dabber undersecretary of science said (Oct 10 in Japan) that US would participate in ILC supporting the construction management and technical aspects, and that he would work with members of US congress so that agreement can be reached.

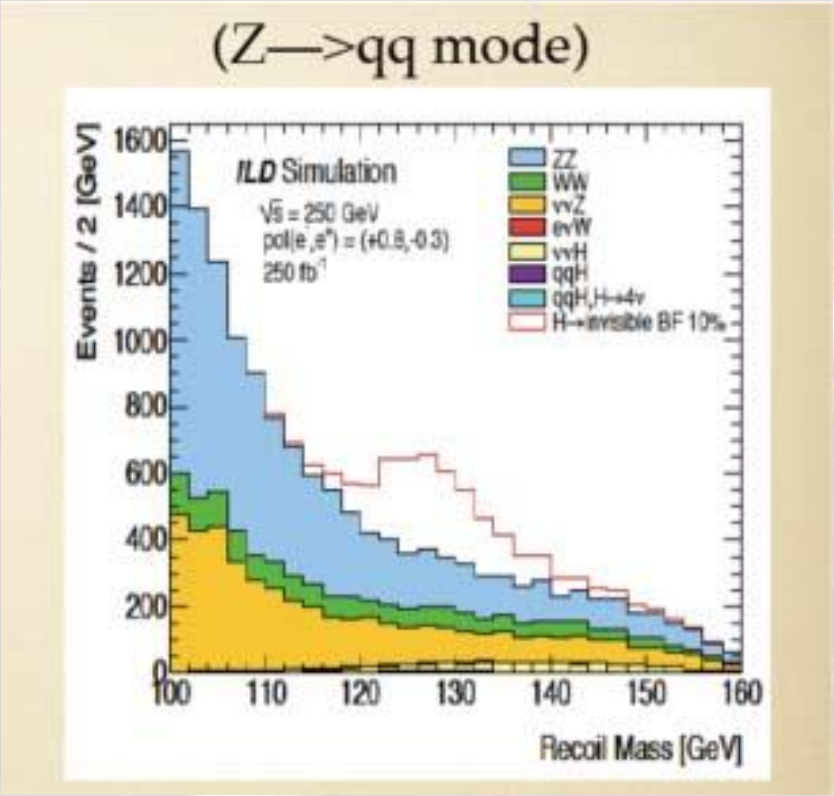
Main Points

- ILC has been designed to lead the new era of particle physics opened up by the discovery of Higgs.
- ILC250 Higgs Factory reduces the cost by (up to) 40%.
- For precision Higgs measurements, ILC ~ several tens of HL-LHC running simultaneously.
- New particles: new particle(s) would be found if they are within energy reach of ILC.
- Japanese government is about to finish evaluating the case for ILC (ILC 250 Higgs Factory).
- The ruling party is ‘ready to go’.
- The deadline for inputs to the European Strategy Discussion is the end of this year – important that a positive statement comes from Japanese government in that time scale.

Backups

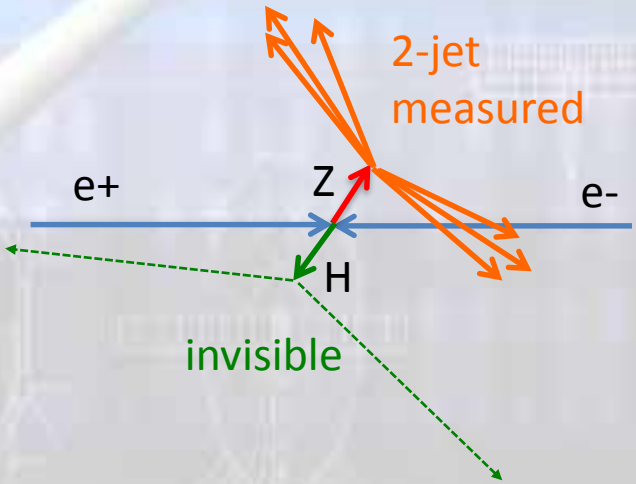
Exotic Higgs Decays by Higgs tagging

e+e- → ZH, H → invisible



250 fb-1 at Ecm = 250 GeV

Recoil mass reconstruction



Including Z → l+l- and scaling to 1500 fb-1

Br (H → invisible) < 0.4%

MEXT ILC Advisory Panel on ILC250

Established in May 2014. ‘Re-activated’ to evaluate the ILC 250 GeV ‘Higgs factory’.

‘Re-activated’ two working groups:

- Particle and nuclear physics working group
  - evaluate the scientific case for ILC250
  - First mtg: Jan 18, 2018
- TDR working group
  - evaluate design maturity and costing
  - First mtg: Jan 30

The ILC advisory panel has produced its final report on July 4, 2018.

Scientific Significance of ILC and Proposal of its Early Realization in light of the Outcomes of LHC Run 2

Japan Association of High Energy Physicists, July 22, 2017

- …As discussed above, the scientific significance and importance of ILC has been further clarified considering the current LHC outcomes. ILC250 should play an essential role in precision measurement of the Higgs boson and, with HL-LHC and SuperKEKB, in determining the future path of new physics. Based on ILC250's outcomes, a future plan of energy upgrade will be determined so that the facility can provide the optimum experimental environment by considering requirements in particle physics and by taking advantage of the advancement of accelerator technologies. It is expected that ILC will lead particle physics well into the 22nd century.

- To conclude, in light of the recent outcomes of LHC Run 2, JAHEP proposes to promptly construct ILC as a Higgs factory with the center-of-mass energy of 250 GeV in Japan.

International Committee for Future Accelerators (ICFA)

Statement on the ILC Operating at 250 GeV as a Higgs Boson Factory
Nov 2017

…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, led by Japanese initiative.

Linear Collider Board (LCB)

Conclusions on the 250 GeV ILC as a Higgs Factory proposed
by the Japanese HEP community
8 Nov 2017

…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…

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….

LCWS2017 Strasburg

Remote speeches by Japanese diet members (Oct 27)

- Speeches were to be in person, but the general election made them remote.
- Rep. Kawamura and Rep. Shionoya : from Tokyo
- Rep. Hirano : from Tohoku U.
- Strassburg: Rep. Olivier Becht (France), Rep. Stefan Kauffman (Germany)

LCWS2017 Strasburg

Mr. Becht (France):

…I was talking on Wednesday with my colleagues in the French parliament – colleagues from the French-Japan friendship group in the assembly national, and I am very happy to tell you that we consider this cooperation as a major subject of interest for two countries and for Europe-Japan relationship. …

Mr. Kaufman (Germany):

… And everybody here is convinced that the money for the ILC is a very good investment, to understand fundamental principles of physics which can help us to make the world better….

…I think the planned ILC is shortly named in the ESFRI roadmap as you know, but more important will be the new strategy which will be soundly established in 2019, 20, wherein Europe, therefore Germany, will state their concrete position to ILC and also possibility of cooperation and support. …

European Strategy Update

Coodination Council for Realization of ILC

Unified HQ for Implementing Regional Revitalization

Head: Hon. Takeo KAWAMURA

HQ for Promoting National Resilience

Head: Hon. Toshihiro NIKAI

Research Council for Strategy on Science, Technology and Innovation

Chair: Hon. Kisaburo TOKAI

HQ for Accelerating Reconstruction from Great East Japan Earthquake

Head: Hon. Fukushiro NUKAGA

Research Council for Strategy on Intellectual Property

Chair: Hon. Akira AMARI

Coordination Council for Realization of ILC

(Representative: Hon. Takeo KAWAMURA)

(Across-party group) Science and Technology Group

Chair: Hon. Hiroyuki HOSODA

(Across-party group) Federation of Diet Members in Support of ILC

Chair: Hon. Takeo KAWAMURA
Secretary General: Hon. Ryu SHIONOYA

Advanced Accelerator Assoc. Promoting Science and Technology

Chair: Mr. Takashi NISHIOKA

Knowledgeable Advisors

Hon. Hiroya MASUDA (former Minister for Internal Affairs)
Prof. Satoshi FUJII (Counselor, Cabinet Secretariat)
Prof. Atsushi SUNAMI (Vice President, GRIPS)

Tohoku ILC Promotion Council

Representative: Mr. Hiroaki TAKAHASHI, Prof. Hideo OHNO

ILC 100 People Committee

ILC Supporters

Outreach

- ‘ILC supporters’（Apr 16, 2018 ~）
  - Promoter: Mamoru Oshii

    ‘First and last activity for the society for me’
  - Members: 20000 and increasing

- ‘Committee of 100 for iLC’（June 29, 2018~）
  - Chair: Hiroya Masuda (ex Minister of Internal Affairs)
  - 129 influential opinion leaders

    Kengo Kuma (architect), Robert Campbell (Japanology) etc.
  - Actively promoting ILC

Search Frequency Rating: ‘ILC’

- Lectures, seminars, classes…
  - Countless
  - But still not enough for outside Iwate prefecture (ILC site)

Outreach

Japan Visits by Two Nobel Laureates for ILC

- Barry Barish

  Nobel: Gravitational Wave Detection

  ILC GDE director 2005-2013, finish ILC TDR

- Sheldon Glashow

  Nobel: One of fathers of SM

- Aug 5,6,7,2018
  - 5th: Symposium (Ocha-dai)
  - 6th: Individual media interviews
  - 7th: Visit Minister of Science and Tech.

    Press Conference (FCCJ)

Barry Barish: answering a questions at FCCJ

'ILC cost per researcher is about the same as other average facilities: ½ salary, ½ equipments'

WE NEED THE ILC NOW!

Sheldon Lee Glashow
Metcalf Professor of Science & Mathematics
Boston University, Emeritus
Higgins Professor of Physics, Harvard University, Emeritus
Honorary Einstein Professor of the Sciences,
Academy Sinica, Beijing

5 August, 2018

At my own initiative, I have traveled over 10,000 km solely to attend these meetings, with the hope that the Science Council of Japan promptly issue a positive assessment of the ILC, whose construction is essential to the Global Scientific Endeavor.

ILC Symposium, Tokyo