ILC Project

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LCC/KEK

INSTR-17, Budker INP, Novosibirsk, Russia, 27 February 2017
**ILC (International Linear Collider)**

**e⁻e⁺ collider**

- 500 GeV CM with 31 km -> upgrade later to ~ 1TeV CM with 50 km
- IP beam size: 6 nm high, 500 nm wide, 300 μm long (@500 GeV CM)
- Luminosity 2 x 10^{34} /cm²s (@500 GeV CM)
- First stage: 250 GeV Higgs Factory
Why Liner Collider?

*pp collider (LHC)*

Proton proton: composite
3 quarks and gluons
(partons = quarks and gluons)

*e^- e^+ collider (ILC)*

e^- e^+: elementary particles
CMS energy = 2 x beam energy
(well defined)

Total momentum = 0 (balanced)
Why Liner Collider?

Proton-proton collision ($pp$ collider, LHC):
- Composite particles: 3 quarks and gluons
- Partons = quarks and gluons
- CMS energy = 2 x beam energy (well defined)
- Total momentum = 0 (balanced)

Electron-positron collision ($e^-e^+$ collider, ILC):
- Elementary particles

Image diagrams of collision events are shown for both types of colliders.
Why Liner Collider?

pp collider (LHC)

proton proton: composite
3 quarks and gluons
(partons = quarks and gluons)

e^{-}e^{+} collider (ILC)

e^{-}e^{+}: elementary particles
CMS energy = 2 x beam energy
(well defined)
Total momentum = 0 (balanced)
Why Liner Collider?

- **pp collider (LHC)**
  - Proton-proton collision: Composite (3 quarks and gluons, partons = quarks and gluons)

- **e^-e^+ collider (ILC)**
  - Electron-positron collision: Elementary particles
  - CMS energy = 2 x beam energy (well defined)
  - Total momentum = 0 (balanced)
  - Small background
  - Mostly full reconstruction
Why Liner Collider?

- **pp collider (LHC)**
  - proton proton: composite
  - 3 quarks and gluons
  - (partons = quarks and gluons)

- **e⁻e⁺ collider (ILC)**
  - e⁻e⁺: elementary particles
  - CMS energy = 2 x beam energy
  - (well defined)
  - Total momentum = 0 (balanced)
  - Small background
  - Mostly full reconstruction
International Linear Collider at Kitakami Hills

- Moscow
- Novosibirsk
- Kitakami
- Tokyo
- Japan
ILC Site Candidate: Kitakami

Good Access to Big/Middle-sized Cities, Ports, and Airports
Comfortable Living Environment

- Tokyo à→ Kitakami 2 hours
- Flight Narita à→ Sendai 1h

Earthquake-proof stable bedrock of granite. No faults cross the line.
Boring Exploration

Boring Core
Extremely Good Granite Geology
Physics case for ILC is very simple and strong.
Higgs, top, new physics

- Only two particles not studied precisely at $e^-e^+$ so far: Higgs & top
  - Higgs first of a kind (no spin), most important particle in today
  - top can talk to new physics, controls the fate of the Universe
- of course look for (uncolored) new physics

Hitoshi Murayama (UC Berkeley), ILC Summer Camp 2016
Spin

- every elementary particles spin forever
- electrons, photons, quarks, ....
- only Higgs boson doesn’t spin
- a new breed
- Is it the only one? (SM)
- does it have brothers? sisters? (SUSY for example)
- maybe composite? (Higgs is NOT elementary particle)

Hitoshi Murayama (UC Berkeley), ILC Summer Camp 2016
Slightly modified by TO
Higgs mass
dream case for experiments

125 GeV

Hitoshi Murayama (UC Berkeley), ILC Summer Camp 2016
Projected Higgs coupling precision (7-parameter fit)

- HL-LHC 14 TeV, 3000 fb⁻¹ (CMS-1, Ref. arXiv:1307.7135)
- HL-LHC 14 TeV, 3000 fb⁻¹ (CMS-2, Ref. arXiv:1307.7135)
- ILC 500 GeV, 500 fb⁻¹ ⊕ 350 GeV, 200 fb⁻¹ ⊕ 250 GeV, 500 fb⁻¹
- ILC 500 GeV, 4000 fb⁻¹ ⊕ 350 GeV, 200 fb⁻¹ ⊕ 250 GeV, 2000 fb⁻¹
- ILC ⊕ HL-LHC 3000 fb⁻¹ combination

Figure 4: Relative precisions for the various Higgs couplings extracted using the model-dependent fit used in the Snowmass 2013 study [18], applied to expected data from the High-Luminosity LHC and from the ILC. Here, $A_A$ is the ratio of the $A_A$ Ah coupling to the Standard Model expectation. The red bands show the expected errors from the initial phase of ILC running. The yellow bands show the errors expected from the full data set. The blue bands for $A_A$ show the effect of a joint analysis of High-Luminosity LHC and ILC data.
What is Higgs really?

- Only one? (SM)
- Has brothers? sisters? (2HDM)
- Not elementary? (composite)

Lumi 1920 fb-1, \(\sqrt{s} = 250\) GeV
Lumi 2670 fb-1, \(\sqrt{s} = 500\) GeV
Dark matter & the Higgs

An example: dark matter interacting via the Higgs force

Nathaniel Craig (UC Santa Barbara), LCWS2016
• Now the commissioning of XFEL is ongoing.
• XFEL Superconducting Linac: Essentially the same as ILC, Number of modules&Cavities 1/20 of ILC
• ILC will follow all experiences of the XFEL.
STF: Accelerator Cryomodule Test

8 Cavities were tuned on resonance by piezo, and vector-sum operation was done at 31MV/m.

Waveguide system
Cold box
Capture CM
CM2a
To be constructed

STF at KEK
View from upstream

07/Dec/2016
LCWS2016 @Morioka
Establish the ILC final focus method with same optics and comparable beamline tolerances

- Goal: 37 nm < - - - > ILC 6 nm  
  (ATF: 1.3 GeV    ILC: 250 GeV)
- Achieved(ATF) 41 nm (2016)
Possibility of Higher Gradient in Future
Recent Progress in FNAL

http://news.fnal.gov/2016/05/anna-grassellino-receives-2016-ieee-particle-accelerator-science-technology-award/
## Two Detector Concepts

<table>
<thead>
<tr>
<th></th>
<th>ILD</th>
<th>SiD</th>
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<tbody>
<tr>
<td><strong>Both optimized for PFA</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PFA Performance $\sim B \cdot R_{\text{ECAL,inner}}^2$ (two-track separation @ ECAL)</td>
<td></td>
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<tr>
<td><strong>B = 3.5 T</strong></td>
<td><strong>B = 5 T</strong></td>
<td></td>
</tr>
<tr>
<td>$R_{\text{ECAL,inner}} = 1.8 \text{ m}$</td>
<td>$R_{\text{ECAL,inner}} = 1.27 \text{ m}$</td>
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<tr>
<td>Si + TPC tracking</td>
<td>Tracking: Si only</td>
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**Share interaction point via push-pull**
Status of the ILC Project

Keynote by Hon. Takeo Kawamura, at LCWS 2016
a member of the House of Representatives,
President of the Federation of Diet members for ILC

Participants of LCWS2016
e) There is a strong scientific case for an electron-positron collider, complementary to the LHC, that can study the properties of the Higgs boson and other particles with unprecedented precision and whose energy can be upgraded. The Technical Design Report of the International Linear Collider (ILC) has been completed, with large European participation. The initiative from the Japanese particle physics community to host the ILC in Japan is most welcome, and European groups are eager to participate. *Europe looks forward to a proposal from Japan to discuss a possible participation.*

**Asia**  ACFA-HEP Statement on ILC  
Chair: Mitsuaki Nozaki (KEK)  July 2013

**USA**  Particle Physics Project Prioritization Panel (P5) Report  
Chair: Steve Ritz (UC Santa Cruz), May 2014
Supports from Policy Makers and Industries in Japan

- Federation of Diet members to promote ILC

  160 Diet Members *(both the Upper and Lower Houses.)*

  - Supreme advisor: Kaoru Yosano
  - President: Takeo Kawamura
  - Secretary-general: Ryu Shionoya

- Advanced Accelerator Association, AAA
  - 100 Companies and 30 Universities

  - Honorary Chairman: Masatoshi Koshiba
  - Supreme advisor: Kaoru Yosano
  - Chairman: Takashi Nishioka
  - Vise-Chairman: Atsuto Suzuki
LCC Director Lyn Evans’ Courtesy visit to Prime Minister Shinzo Abe
March 2013, Tokyo

There is very strong interest to host ILC in Japan

Dr. Lyn Evans, LCC Director  Prime Minister Shinzo Abe

Photo: Prime Minister’s Office
http://japan.kantei.go.jp/96_abe/actions/201303/27ilc_hyokei_e.html
US-Japan dialogues

“Federation of Diet members for ILC” is successively dispatching delegations to US.

2013 Joint Symposium at Washington DC
The first visit

Hon. R. Shionoya
Secretary-general of the Federation

2016 Meeting at Hudson Institute
It was proposed to form US-Japan discussion group by both governments

It was formed soon later.

Hon. S. Suzuki
Hon. T. Otsuka
ILC Collaboration with Indian Physicists

- Representatives from 10 Indian accelerator labs and KEK had a meeting to discuss Indian involvement in ILC.
- Agreed to set up “Indo-Japan Centre for Accelerators and Detectors” in Banaras Hindu University as a base of Indian participation in ILC.

April 29, 2016, IUAC, Delhi

Jan 30th, 2017

MoU was signed by both by Banaras Hindu University and KEK
IEEE NSS/MIC Conference, Strasbourg, France
29 Oct 2016 - 6 Nov 2016

IEEE NSS/MIC Plenary
Hon. T. Shina
Federation of Diet members for ILC

Industrial Exhibition

Dr. M. Titov
Conference Chair.

Mr. T. Nishioka
AAA Chair.

Industrial Exhibition

EU-Japan VIP meeting Hon. S. Ito
Federation of Diet members for ILC
Official government-level consideration is ongoing in Japan

MEXT: Ministry of Education, Culture, Sports, Science, and Technology

Science Council of Japan → Recommendation in 2013 → MEXT

ILC Taskforce formed in 2013


Particle & Nuclear Phys. WG in 2014 - 2015
TDR Validation WG in 2014 - 2015
Human Resources WG in 2015 - 2016
Management WG (coming soon) in 2017

First meeting 8-May-2014
Keynote by Hon. Takeo Kawamura, a member of the House of Representatives, President of the Federation of Diet members for ILC

About 350 participants
LCB/LCC Organization 2017

New LCC managements Press Conference at Morioka Japan Dec 2016

S. Stapnes  J. Brau  L. Evans  H. Murayama  S. Michizono

KEK ILC Promotion Office
CLIC Collaboration
Public Relations

FALC
Chair: N.N.
Funding Agencies for Large Colliders

ICFA
Chair: J. Mnich
International Committee For Future Accelerators

LCB
Chair: T. Nakada
Linear Collider Board 2012-

LCC organized in 2013
New 3-year mandate from 2017

LCC Director
Lyn Evans

IlC
Associate Director: Shin Michizono

CLIC
Associate Director: Steinar Stapnes

Physics & Detectors
Associate Director: Jim Brau

Deputy
Hitoshi Murayama
Summary

• Physics case for ILC is very simple and strong.
  – Higgs, top, new physics.

• ILC accelerator design is ‘ready’.

• The ILC detectors are pushing the state of the art of particle detection technologies.

• There are strong supports by the international science community.

• Official government-level consideration is ongoing in Japan