Major Facilities (Planned) in Asia

- **China**
  - CEPC-SPPC
  - Daya Bay → JUNO
  - BEPCII-BESIII

- **Korea**
  - RENO → RENO-50

- **Japan**
  - ILC
  - SuperK → HyperK
  - SuperKEKB-BELLE II

- **India**
  - INO

- **Russia**
  - Super Tau-Charm factory

On April 5, 2016, BEPCII reached the target luminosity of $1 \times 10^{33}\text{cm}^2\text{s}^{-1}$
AsiaHEP/ACFA Statement on ILC + CEPC/SPPC

Feb., 2016

AsiaHEP and ACFA reassert their strong endorsement of the ILC, which is in a mature state of technical development. The aim of ILC is to explore physics beyond the Standard Model by unprecedented precision measurements of the Higgs boson and top quark, as well as searching for new particles which are difficult to discover at LHC. The Higgs studies at higher energies are especially important for measurement of WW fusion process, to fix the full Higgs decay width, and to measure the Higgs self-coupling. In continuation of decades of world-wide coordination, we encourage redoubled international efforts at this critical time to make the ILC a reality in Japan. The past few years have seen growing interest in a large radius circular collider, first focused as a “Higgs factory”, and ultimately for proton-proton collisions at the high energy frontier. We encourage the effort lead by China in this direction, and look forward to the completion of the technical design in a timely manner.
International Linear Collider (ILC)

Slides mainly from
Sachio Komamiya
Main Science Goals

- Precise measurement of Higgs couplings, to determine Higgs boson “elementary or composite” and to distinguish models
- Measure Higgs self-couplings to 30%, to determine EW phase transition: first or second order
- Precision Top quark measurement
- Direct search for light SUSY particles

C.M. Energy | 500 GeV
---|---
Length | 31 km
Luminosity | $1.8 \times 10^{34} \text{ cm}^{-2} \text{s}^{-1}$
Advantages of Linear Collider

- No energy loss due to synchrotron radiation
- Extendability (length ⇒ energy)
- Beam Polarization
- Energy Scanning

Power of Beam Polarization

**W^+W^- (Largest SM BG)**

\[
\begin{align*}
W^+ &\rightarrow e^+ W^0 \\
W^- &\rightarrow e^- W^- \\
\text{SU(2)_L} &\rightarrow e^- \text{SU(2)_L}
\end{align*}
\]

In the symmetry limit, \( \sigma_{WW} \rightarrow 0 \) for \( e^- \)!

**BG Suppression**

\[
\begin{align*}
e^- &\rightarrow e^- B^+ \\
U(1)_Y &\rightarrow B^+ \\
\tilde{\chi}_1^+ &\rightarrow e^+ e^- W^+ W^-
\end{align*}
\]

Chargino Pair

**Slepton Pair**

\[
\begin{align*}
e^+ &\rightarrow \tilde{\mu}^+ \\
Y &\rightarrow \tilde{\mu}^+ \\
\text{SU(1)_Y} &\rightarrow \tilde{\mu}^+ \text{SU(1)_Y}
\end{align*}
\]

In the symmetry limit, \( \sigma_R = 4 \sigma_L \)!

Decomposition

\[
\tilde{\chi}_1^+ = \circ \cdot \tilde{\chi}_1^+ + \bullet \cdot \tilde{\chi}_1^+ + \langle \tilde{\chi}_1^+ | \tilde{\chi}_1^+ \rangle
\]

Signal Enhancement

[Fujii]
Many accelerator slides are stolen from Akira Yamamoto (KEK)
SRF Facilities anticipated for ILC Hubs. and SRF Progress in 2014 – 2015

Technology globally matured to realize ILC

Amplifier Modules and Test Facility (AMTF) @ DESY/E-XFEL, CM

- 800 cavities are completed, w/ < 30 MV/m

Superconducting Triode Field-Forced Accelerator (STF2) @ KEK

- Individual cavity gradient ~ 35 MV/m

Advanced Stabilization Test Facility (ASTA) @ FNAL, TEDF @ JLab

Cryomodule test at Fermilab reached < 31.5 > MV/m, exceeding ILC specification
Local chromatic correction at final focus progress at ATF2

Average Beam Size 44 nm observed, corresponding to 7 nm at ILC
(Goal: 37 nm, corresponding to 6 nm at ILC)
ILC Detector R&D (ILD, SiD)

- **Vertex Detector**: pixel detectors & low material budget
- **(Time Projection Chamber): high resolution & low material budget, MPGD readout**
- **Calorimeters**: high granularity sensors, 5x5mm² (ECAL), 3x3cm² (HCAL)

<table>
<thead>
<tr>
<th>Sensor Size</th>
<th>ILC</th>
<th>ATLAS</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertex</td>
<td>5 × 5 mm²</td>
<td>400 × 50 mm²</td>
<td>x800</td>
</tr>
<tr>
<td>Tracker</td>
<td>1 × 6 mm²</td>
<td>13 mm²</td>
<td>x2.2</td>
</tr>
<tr>
<td>ECAL</td>
<td>5 × 5 mm² (Si)</td>
<td>39 × 39 mm²</td>
<td>x61</td>
</tr>
</tbody>
</table>

**Particle Flow Algorithm**

Charged particles → Tracker, Photons → ECAL, Neutral Hadrons → HCAL

- Separate calorimeter clusters at particle level
- Use *best* energy measurement for *each* particle.
- Offers unprecedented *jet energy resolution*

State-of-the-art detectors can be designed for ILC
ILC Site Candidate Location in Japan: Kitakami

Earthquake-proof stable bedrock of granite. No faults cross the line.
The Position of MEXT and the Japanese Government towards the ILC

ILC being studied officially by the MEXT Japan

Science Council of Japan

Recommendation in 2013

MEXT

ILC Taskforce
formed in 2013

ILC Advisory Panel
in JFY 2014 ~

Commissioned Survey by NRI (in 2014, and 2015)

Particle & Nuclear Phys. Working Group
in 2014 ~ 2015

TDR Validation Working Group
in 2014 ~ 2015

Human Resources Working Group
in 2015
Necessary steps towards the approval


2. R&D and design of the machine/detectors by the international team ⇒ Technical Design Report (2013)

3. Official investigation and reviews of the ILC project by MEXT (now)

4. Clarify the scientific and technical issues in the report of the ILC Advisory Panel (done)

5. To facilitate / prepare intergovernmental discussions for sharing of cost human resources and the schedule without commitment (starting).

6. MEXT green signal

7. Endorsement of CSTP (Council of Science, Technology and Innovation; chair: Prime Minister)

8. Cabinet decision

9. International agreement with commitment ⇒ Establishment of ILC Lab
Time line for the ILC project

Years need

2  Preparation period  Continuation of high-tech  R&D  (now)

4  Preparation for the ILC construction  (with real budget)

9  Construction
   6^{th} year -  Start Installation
   7^{th} year - Start of step-by-step accelerator test

1   Beam Commissioning

~8  Physics Run  (500 GeV, 350 GeV, 250 GeV)

~  Run with Luminosity upgrade  (500 GeV, 250 GeV)

TBD Energy upgrade (~ 1TeV)
**CEPC-SPPC**

- **Electron-positron collider (90, 250 GeV)**
  - Higgs Factory: Precision study of Higgs
    - Higgs mass, width, couplings, $J^{PC}$, etc.
    - Looking for deviation from SM, new physics?
  - Z & W factory: precision test of SM
    - Deviation from SM?
  - Flavor factory: $b$, $c$, $\tau$ and QCD studies

- **Proton-proton collider (~100 TeV)**
  - Directly search for new physics beyond SM
  - Precision test of SM
    - e.g., $h^3$ & $h^4$ couplings

**Precision measurement + searches:**
Complementary with each other!
Can be downloaded from
http://cepc.ihep.ac.cn/preCDR/volume.html

CEPC-SPPC

Preliminary Conceptual Design Report

Volume I - Physics & Detector

403 pages, 480 authors

The CEPC-SPPC Study Group
March 2015

CEPC-SPPC

Preliminary Conceptual Design Report

Volume II - Accelerator

328 pages, 300 authors

The CEPC-SPPC Study Group
March 2015
CEPC Accelerator

- 3 machines in one tunnel
  - CEPC & booster
  - SppC
- Main choice of CEPC:
  - One ring machine
  - Head-on collision

Energy Ramp 10 → 120 GeV

Compatibility is the main issue

Linac

Electron

Positron

Booster

Collision ring

45/120 GeV
CEPC Design

- Beam physics: dynamic aperture, momentum acceptance, electron cloud, pretzel scheme, ...
- SRF system: High-Q cavity, power loading, HOM dumping, ...
- Total power consumption

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Value</th>
<th>Parameter</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beam energy ([E])</td>
<td>GeV</td>
<td>120</td>
<td>Circumference ([C])</td>
<td>m</td>
<td>54752</td>
</tr>
<tr>
<td>Number of IP([N_{IP}])</td>
<td></td>
<td>2</td>
<td>SR loss/turn ([U_0])</td>
<td>GeV</td>
<td>3.11</td>
</tr>
<tr>
<td>Bunch number/beam([n_B])</td>
<td></td>
<td>50</td>
<td>Energy acceptance RF ([h])</td>
<td>%</td>
<td>5.99</td>
</tr>
<tr>
<td>SR power/beam ([P])</td>
<td>MW</td>
<td>51.7</td>
<td>Beam current ([I])</td>
<td>mA</td>
<td>16.6</td>
</tr>
<tr>
<td>Emittance ((x/y))</td>
<td>nm</td>
<td>6.12/0.018</td>
<td>(\beta_{IP}(x/y))</td>
<td>mm</td>
<td>800/1.2</td>
</tr>
<tr>
<td>Transverse size ((x/y))</td>
<td>(\mu)m</td>
<td>69.97/0.15</td>
<td>Luminosity /IP([L])</td>
<td>cm(^{-2})s(^{-1})</td>
<td>2.04E+34</td>
</tr>
</tbody>
</table>
CEPC Partial Double Ring Layout

Crossing Angle: 30 mrad

Advantage:
- Avoid pretzel orbit
- Cost less than whole double-ring
- More bunches for high luminosity Z, W
- High luminosity with crab waist collision

One ~3 km (10 μs) macro-bunch

IP1_ee/IP3_ee, 3Km
IP2_pp/IP4_pp, 1132.8m
4Straights, 849.6m
4Long ARC, 120*FODO, 5852.8m
4Short ARC, 100*FODO, 4908.8m

SU Feng
2015.10.12
Partial Double Ring Lattice

Seperator

FFS orbit

DIS Dipole

15 mrad

Full crossing angle 30 mrad

Begin FFS e-

30 mrad

End FFS e+

11.558964 m

Su Feng
CEPC PDR Luminosity vs circumference

Many Remaining Issues

- Single ring or partial double are clearly more difficult
- Beam physics: Dynamic aperture, …
- SRF: total & transient beam loading, RF-to-beam efficiency,…

Arc sextupole: 2 groups
Crab sextupoles - off

After chromaticity correction
- DA (on-momentum): $27 \sigma_x \times 57 \sigma_y$
- DA ($\pm 0.5\%$): $2\sigma_x \times 2\sigma_y$
Site Selection

• Continue to work on site selection
• A new possibility, invited by the local government
Civil Construction

- Accelerator: 63%
- Civil: 26%
- Detector: 10%
- Synch rad ext: 10%
International Collaboration

• Limited international participation for the pre-CDR
  – An excise for us
  – Build confidence for the Chinese HEP community

• Chinese government welcomes international collaboration
  – to integrate China better into the international community
  – to modernize China’s research system (“open door” policy)
  – to obtain needed help on funding, technology, etc.

• This machine will be built and owned by the international community, but a new scheme of collaboration and management need to be explored

• An international advisory board is formed last Sep. to consult on this issue, in addition to scientific and technological discussions
Timeline (dream)

- **CPEC**
  - Pre-study, R&D and preparation work
    - Pre-study: 2013-15
      - **Pre-CDR for R&D funding request**
    - R&D: 2016-2020
    - Engineering Design: 2015-2020
  - Construction: 2022-2028
  - Data taking: 2029-2035

- **SppC**
  - Pre-study, R&D and preparation work
    - Pre-study: 2013-2020
    - R&D: 2020-2030
    - Engineering Design: 2030-2035
  - Construction: 2035-2042
  - Data taking: 2042 -
China plans world's most powerful particle collider

By Cheng Yingqi (China Daily)
Updated: 2015-10-20 07:49

The first phase of the project's construction is scheduled to begin between 2020 and 2025.

Five-year plan boosts basic research funding

By Hao Xin, in Beijing

A windfall for basic science. Cosmic evolution, the structure of matter, the origins of life, and understanding how the brain works all deserve strengthened support, according to China's latest 5-year development plan, which could triple funding for basic research by 2020.

An outline of the plan, which covers 2016 through 2020, received pro forma approval by the National People's Congress (NPC) on 16 March at its closing session. The plan signals that top leaders are looking to researchers, even those doing fundamental work, for innovations that will drive the economy as it transitions away from being powered by manufacturing and exports.

The most important of the new funding is expected to come from the Ministry of Science and Technology (MOST), which funds most of China's basic research. MOST is holding expert meetings to help it decide which programs to support, according to its website. MOST has already called for proposals in nine areas, including precision medicine, reproductive health, biomedical materials, global change, and cloud computing and big data mining.

New big science projects, too, are vying for a share of the increased funding. After the U.S.-based Advanced Laser Interferometer Gravitational-Wave Observatory at the South Pole and made a premature detection claim 2 years ago. Some in the Chinese scientific community have suggested that the Ngari project should enlist international collaborators.

For one high-profile project the news is not as good. China plans to hold off on construction of the Circular Electron Positron Collider (CEPC), intended to generate large numbers of Higgs bosons to precisely measure the particle's mass. The project would cost somewhere between $3.8 billion and $5.4 billion, depending on its circumference. Wang Yifang, director of CAS's Institute of High Energy Physics in Beijing, the chief sponsor of the CEPC, says the project continues to get R&D funding.
Current Status and the Plan

- Pre-CDR completed
  - No show-stoppers
  - Technical challenges identified → R&D issues
  - Preliminary cost estimate

- Working towards CDR
  - A working machine on paper
  - Ready to be reviewed by government

- R&D issues identified and funding request underway
  - Seed money from IHEP available: 12 M RMB/3 years
  - MOST: ~45 M + 45 M / 5 yr, proposal submitted, approval this year?
  - NCDR: ~1 B RMB / 5 yr, process may start this year

- Start international collaboration once funding is available
Summary

• Asia is catching up on Science, thanks to its economic growth. New initiatives from Asia are opportunities to the community

• ILC is now under review by the Japanese government, while CEPC is still in its early stage

• Given the importance of Higgs, we hope that at least one of them, FCC-ee, ILC, or CEPC, can be realized.