Physics objective of ILC
DCR : Yasuhiro Okada,
ILC Physics scenarios : Tao Han, Yasunori Nomura, ⋅⋅⋅ , Honjian He
Cosmology vs ILC Physics : Jonathan Feng
The Revolutionary Epoch

- We are very lucky because we are at the entrance of the revolutionary epoch of particle physics.

- The outstanding problems of particle physics can be solved by direct measurements at the energy frontier colliders.
  - Higgs (EWSB, mass $\leftrightarrow$ structure of the vacuum)
  - SUSY (or alternative TeV scale new physics)

- In 2008 LHC starts operation with the full center of mass energy of 14 TeV, exploring TeV scale physics directly. LHC will discover new physics.

- ILC will uncover the underlying new principal of physics with the precise measurements.
Higgs Boson

ILC is the Higgs Boson Factory

$O(10^5)$ such events will be collected and studied.

Origin of mass → Structure of the ‘vacuum’

Fundamental scalar particle might be related to inflation / dark energy?

$e^+e^- \rightarrow Z + H \rightarrow e^+ e^- + b\bar{b}$
Coupling measurements at ILC

- Gauge Coupling
- Self-coupling
- Top Yukawa coupling

Yukawa coupling

Diagram showing various coupling processes and a graph plotting coupling versus mass (GeV).
Supersymmetry (SUSY)

New well motivated space-time symmetry. Stabilization of Higgs Boson Mass due to a cancellation
⇒ Numbers of Fermion and Boson fields are identical

Ordinary particles

Leptons and Quarks
- uct
d.sb
νe νμ ντ
eμτ
Gauge bosons
γ Z^0 W^± g
Higgs bosons
h H^0 A^0 H^±

SUSY partners

Scalar Fermions

Gauginos

Dark Matter Candidates

Higgsinos

Higgs and SUSY are LHC/ILC issues
Mass spectrum of SUSY particles $\Rightarrow$ SUSY breaking mechanism

LHC+ILC
Combined analysis

SUSY breaking Mechanism

Super Gravity (mSUGRA) Energy scale Gauge Mediation

G.A.Blair, W.Porod, and P.M.Zerwas
Power of electron polarization at ILC

Unpolarized

\[ W^+ W^- \]

Scalar muon production

Polarized (90% $e^-$)

Background signal

Nakanishi (Nagaoya)
Cosmology vs ILC Physics

Energy budget of the Universe

- CBR fluctuation (WMAP etc.)
- Large scale structure of galaxy cluster distribution
- Type 1a SN distribution
- Big Bang Nuclear Synthesis

\[ \Omega_B = 4 \pm 0.4 \%
\]
\[ \Omega_{DM} = 23 \pm 4 \%
\]
\[ \Omega_{\Lambda} = 73 \pm 4 \%
\]

We only know 4% of the universe \( \Rightarrow \) The other 96% must be understood by the words of particle physics
The dark matter particles are concentrated by gravitational force and probably galaxies were embedded and formed in the structure made of DM.

If LSP in SUSY (or LKP in Universal Extra Dimension models, or LTP in Little Higgs models with T-parity) is a Dark Matter, and its masses is within a reach of ILC, Mass and the couplings of the LSP will be determined at ILC.

⇒ The LSP is identified and the density of Dark Matter in the universe and in Our Galaxy can be calculated.

Large Extra-dimensions

Space-time 3+1 dim + n-dim

If the size of the extra-space is much much larger than the Planck scale, the effects can be seen at ILC.
The Detector DCR

Ties Behnke, DESY

for the editors:
T. Behnke, C. Damerell, J. Jaros, A. Miyamoto

and many colleagues who contributed text (sorry for not listing all names)

Version 1 of the Detector DCR is available on
http://www.linearcollider.org/wiki

In the clean environment of ILC state-of-the-art detectors can be designed.
The Concepts

Nevertheless:

The four concepts are the starting point and the bracket of the document.
ATLAS@LHC

- Diameter: 25 m
- Barrel toroid length: 26 m
- End-cap end-wall chamber span: 46 m
- Overall weight: 7000 Tons
- Detector sensors: 110M channels
Lots to be learned this week from the tracking review here at the ACFA workshop
Calorimeter R&D

“Dream” testbeam setup

GLD non SI ECAL concept

Very active field – watch for developments

SiD ECAL readout plance

CALICE test beam effort

Summary
Kiyotomo Kawagoe
Jet energy measurement by the particle flow algorithm

Charged particle momentum is measured by tracker
Photon energy is measured by ECAL
Neutral hadron \((K_L n)\) energy is measured by HCAL (+ECAL)

Separate these particles in the calorimeters

\[
\sigma (E_{\text{jet}})^2 = \sum \Delta E_{\text{ch}}^2 + \sum \Delta E_{\gamma}^2 + \sum \Delta E_{\text{neutral had}}^2 + \sum \Delta_{\text{confusion}}^2
\]

Due to high particle density in the core of jet and large fluctuation of HCAL energy flow, jet energy resolution is dominated by \(\Delta E_{\text{neutral had}}\) and \(\Delta_{\text{confusion}}\).

\[d = 0.15BR^2/p_t\]

Figure of merit = \(B \cdot R^2/R_m\)

Summary (Simulation)
Shaomin Chen

B = magnetic field
R = radius to EM
R_m = Moliere unit
**B-field Dependence**

- B-field dependence of the PFA performance is studied. Default B-field = 3 Tesla, 1cm x 1cm cell size.

- Higher magnetic field gives better PFA performance as expected.
- 5 Tesla case does not improve PFA performance very much. → Due to low momentum tracks?

<table>
<thead>
<tr>
<th>Ecm</th>
<th>3 Tesla</th>
<th>4 Tesla</th>
<th>5 Tesla</th>
</tr>
</thead>
<tbody>
<tr>
<td>91.2</td>
<td>29.8 ± 0.4</td>
<td>28.4 ± 0.3</td>
<td>28.6 ± 0.3</td>
</tr>
<tr>
<td>350</td>
<td>68.7 ± 1.1</td>
<td>58.5 ± 1.0</td>
<td>55.5 ± 0.9</td>
</tr>
</tbody>
</table>

\[
\Delta E/E = a/\sqrt{E}
\]

Tamaki Yoshioka
Particle Flow Performance

Performance of particle Flow at different energies (Pandora PFA)

ILC goal: 30%/√E

Lots of progress,

but for high energies still no good enough performance demonstrated
The main problem

There are many performance studies done for technical systems
There are only very few full analyses available which are reliable

The DCR therefore will be sketchy on final results, and will only be a snapshot. It will not and can not be a comprehensive review of the analyses, as they are not available yet.
February 4, 07

Global Design Effort

The concept is evolving and details being worked out

Platform for electronic and services (~10*8*8m). Shielded (~0.5m of concrete) from five sides. Moves with detector. Also provide vibration isolation.

Andrei Seryi

Concept of IR hall with two detectors

may be accessible during run

accessible during run
GDE management’s idea of push-pull

Surely, you jest…

BILC07
We need to:

- Finalize DCR
  - Time scale: as soon as possible
  - Perform further studies
- Work toward EDRs
  - Strengthen concept studies
  - Strengthen horizontal efforts
  - Form consensus on how to converge to two detectors
- Establish better communications with the accelerator camp
  - Including the push-pull study
- Prepare (brace..) for physics results from LHC
- Involve more people and countries

Hitoshi Yamamoto
Charge of this workshop
How to merge the detector concepts?

Science
First of all, we need to understand the jet-energy measurement before talking about the choice of concepts. (The cost driver is the calorimeter).

Putting all the efforts into a single state-of-the-art and truly-international detector concept might be ideal, since we can spend a little more budget on it to add some redundancy. (Just adequate detector is normally not adequate enough).

However, in order to cross-check the results at least two detectors are needed (statistics/detector $\leq \frac{1}{2}$ for the push-pull scheme). “ILCSC parameter committee”

Sociology
The ILC physics/detector community is large enough to have two detectors. We need some competition. ATLAS/CMS, H1/ZEUS, BaBar/Belle, ...
How to merge the detector concepts?

- **Methodology**
  Spontaneously forming detector collaboration might be ideal and this was the usual method in the past HEP experiments. (..........., at LEP, at LHC)

  If a new methodology is needed, the procedure has to be extensively discussed and carefully designed not only within WWS but also among the ILC physics/detector community.

  More scientific studies are needed to have consistent overall concept of detectors.

  Two equally good detectors, two complementary detectors, ...

  We have to be fair to all the parties. We should not make losers in the community.

- **Timing for the merge**
  - too early detector concept will not be optimal
  - too late miss the accelerator commissioning

  We should not be too hectic. We need to see the accelerator R&D development and development of international consensus.

- *(One collaboration with two detector concepts might be the ideal case.*)
GDE made heroic efforts in the RDR phase. Starting from the determination of the Baseline Configuration, building up the methodology of cost evaluation, now Reference Design with Cost (with 30% systematic error) is waiting for the forthcoming reviews.

Cost reduction within ½ years since the Vancouver meeting is magic.

The figure of the ILC machine looks quite different from the one at Snowmass. They cut out unnecessary fat and rearrange the DR and BD system. (2nd IR's is unnecessary fat???

"2IRs" should be kept as an option)

The main linac is almost as it was, but more R&D for superconducting cavities, modules, couplers, ... is absolutely necessary (S0, S1, ...).
After RDR = EDR phase

- We cannot directly go to the political era. We need a solid EDR.

- EDR should be based on extensive and systematic hardware R&D. Cost reduction has to be based on technological breakthrough in R&D.

- Industrialization
  The cost drivers (components of the main linac) have to be fabricated in the three regions.
  ⇒ R&D workpackages for superconducting cavity/modules have to be subdivided into three regions.

- Organization of EDR era (ILCSC issue)
Beyond EDR issue

This project has to be succeeded. We share a common destiny.

- Some moment we need to do a risky gambling. Obviously, however, we cannot gamble away this project, since future of HEP and a large international scientific (and some industrial) communities depend heavily on this project.
- The project need to be armed itself by several layers of insurances.
  1) Detector and machine design has to be flexible to various physics scenarios. We do not exactly know what will happen at the energy frontier. Some physics depends on LHC findings.
  2) Cost/human resources sharing must be agreeable to all the parties in order not to allow any major dropouts. >1 host candidates are necessary. Competition is an insurance.
  3) Industrialization must be done in the three regions for the main linac (SCs, Cryomodules,...).
      ....... .......
- Buy insurances before the gamble, then the gamble would be not a gamble any more.
We thank very much for the great hospitality of IHEP and our Chinese Colleagues.

Cheer for the truly international unification (for ILC)!
Looking forward to seeing you in DESY Hamburg

LCWS07 + 3rd ILCWS

30th May - 5th June 2007

I would like to dedicate this to

Bjorn Wiik, Shuji Orito, M