# ACFA LCWS Summary

7th February 2007
IHEP Beijing

Sachio Komamiya
Graduate School of Science
the University of Tokyo

# 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 ⇔ 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 physic directly.
  LHC will discover new physics.

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

# Higgs Boson

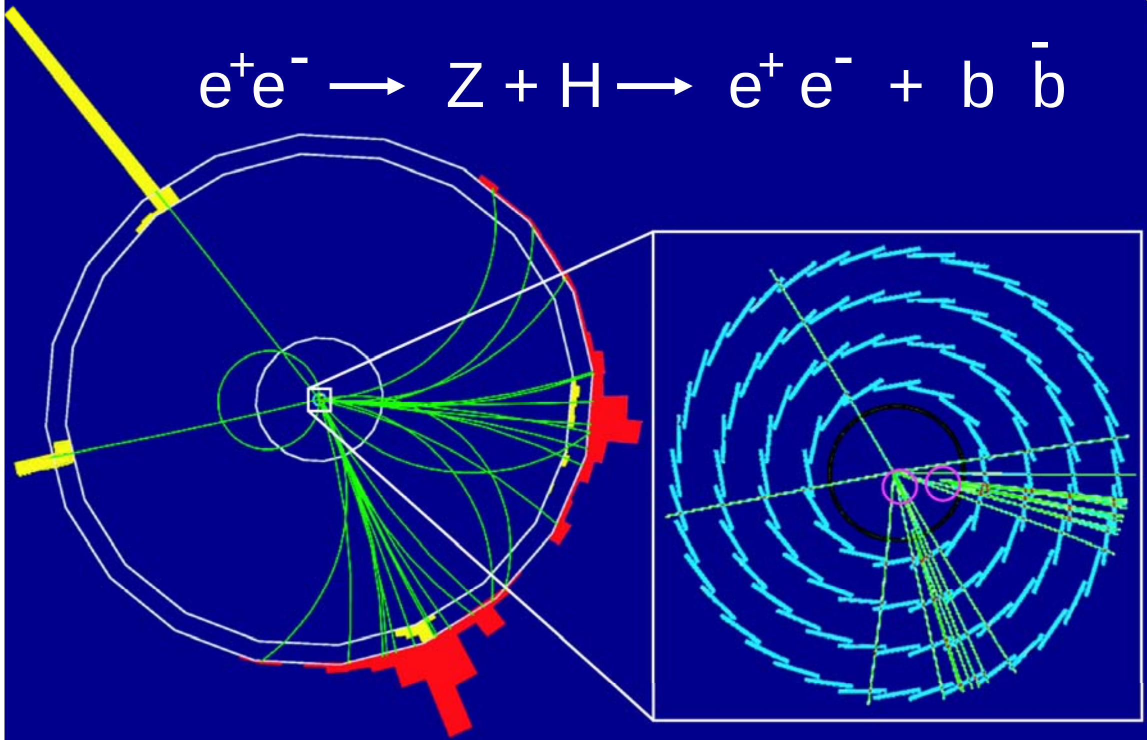
Fundamental scalar particle might be related to inflation / dark energy ?

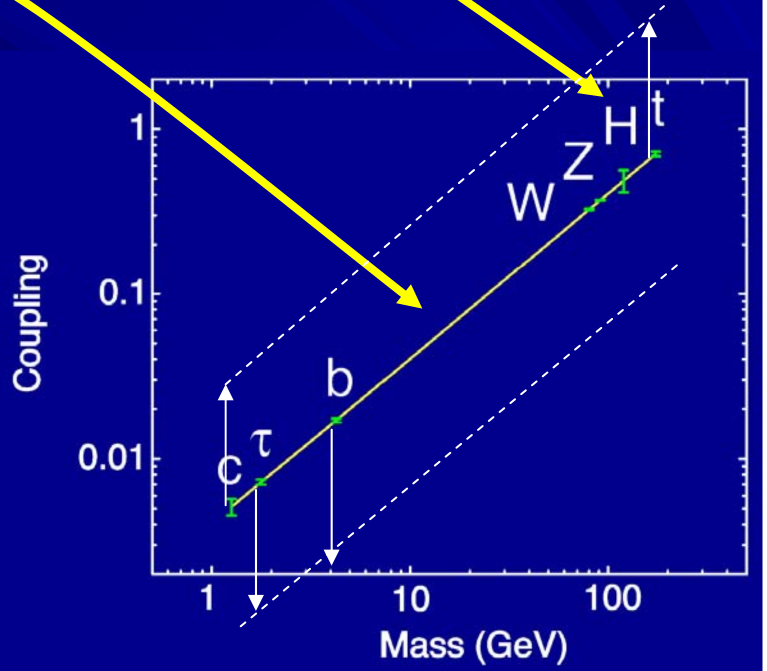
ILC is the Higgs Boson Factory

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

Origin of mass ⟷ Structure of the ‘vacuum`.

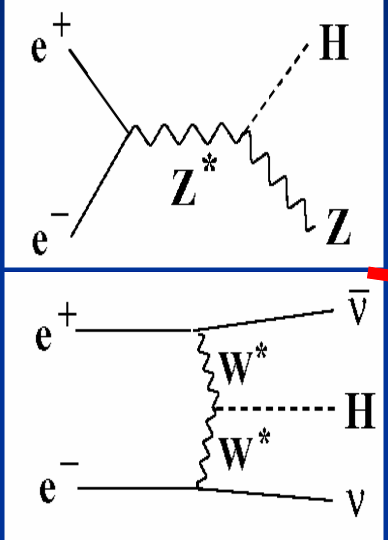
$e^+e^- \longrightarrow Z + H \longrightarrow e^+e^- + b\ \bar{b}$



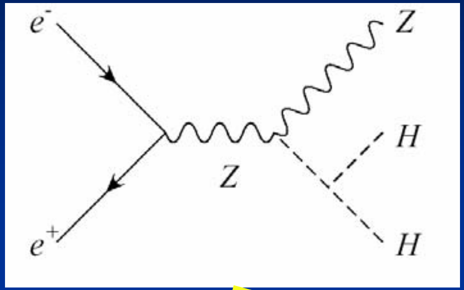


# Coupling measurements at ILC

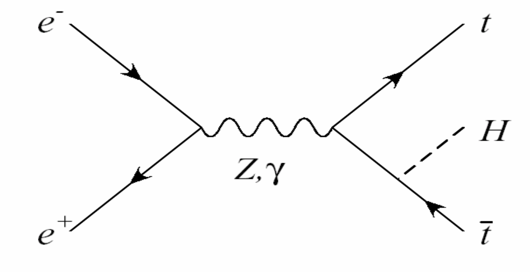
Gauge Coupling



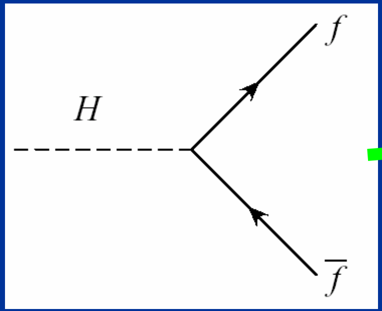
Self-coupling

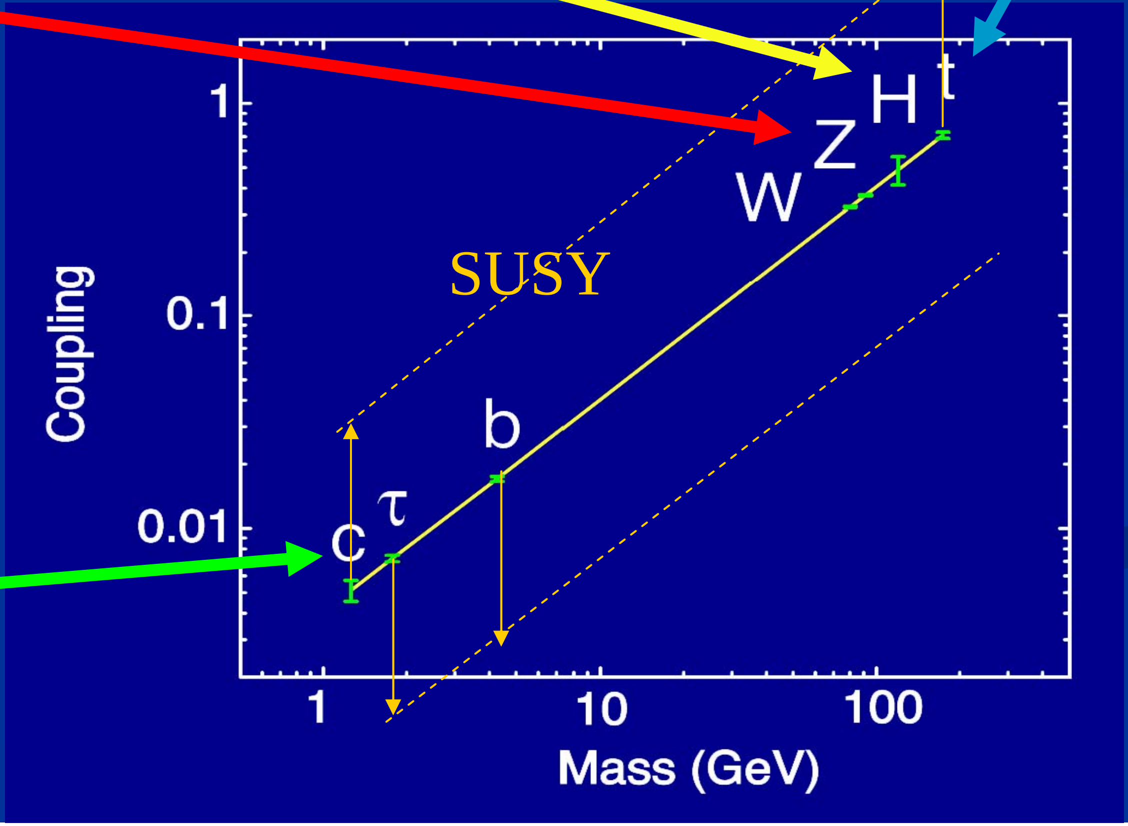


Top Yukawa coupling



Yukawa coupling



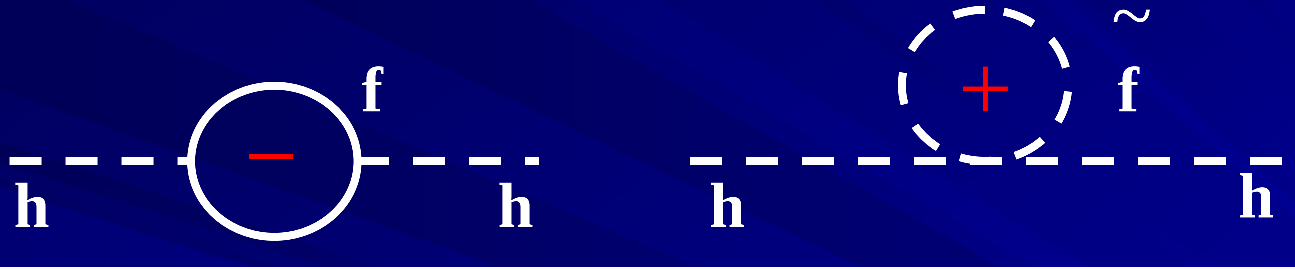


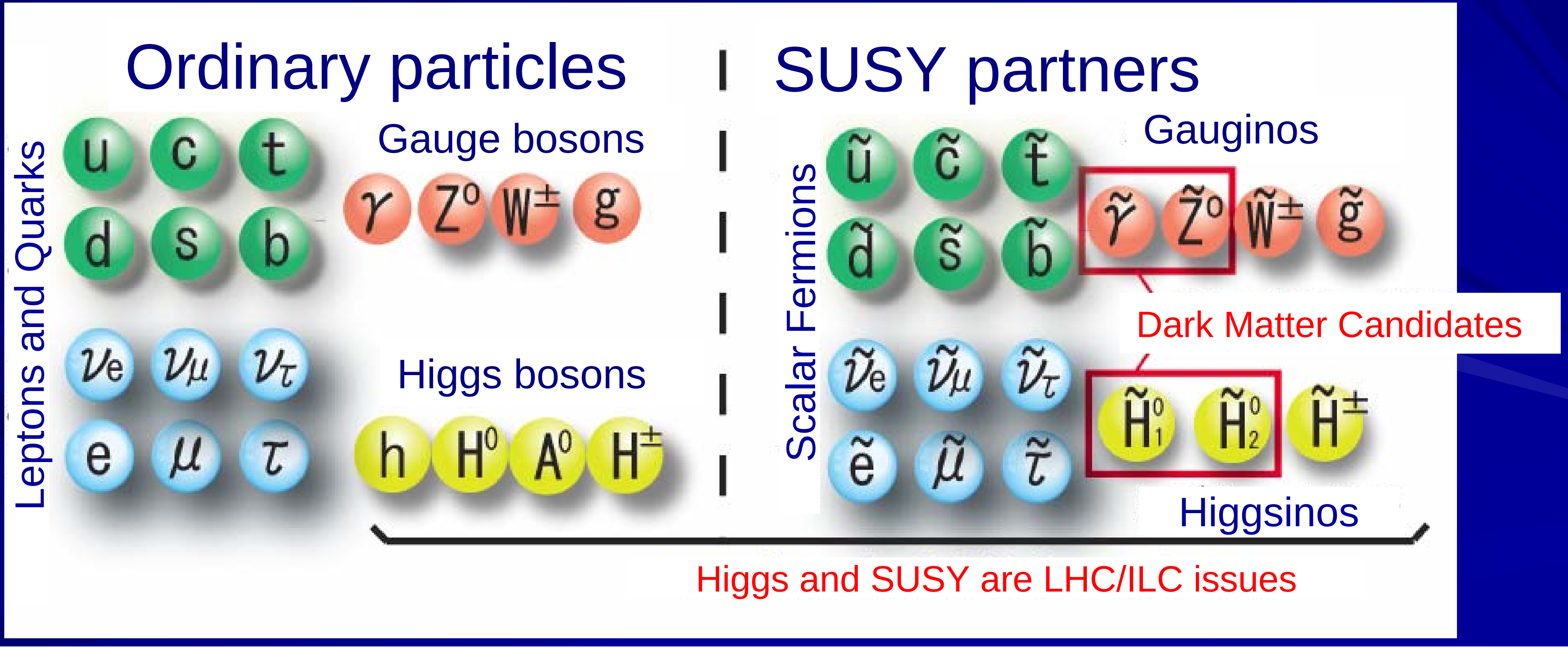
# Supersymmetry (SUSY)

New well motivated space-time symmetry.

Stabilization of Higgs Boson Mass due to a cancellation

⇒ Numbers of Fermion and Boson fields are identical



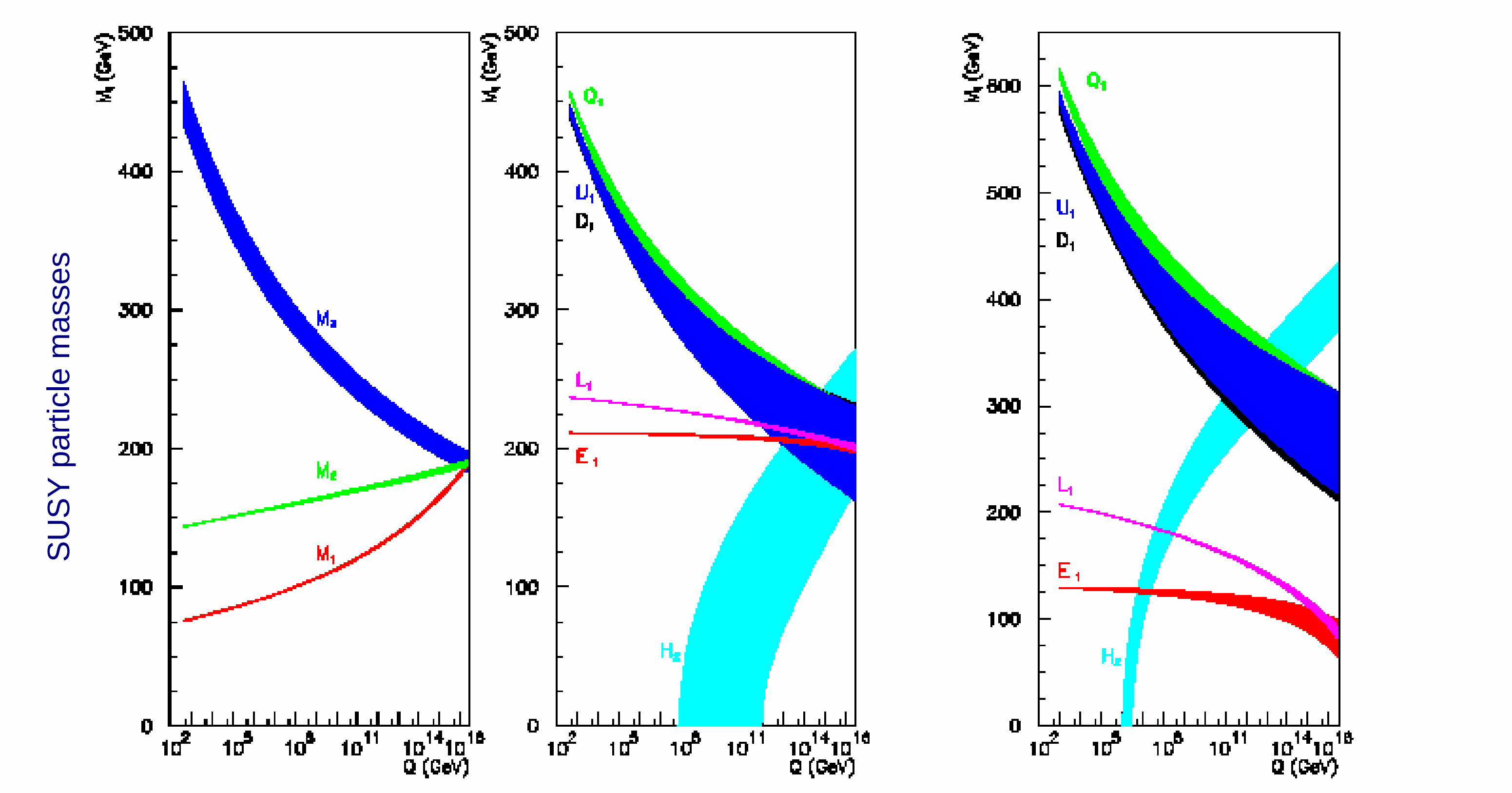


Higgs and SUSY are LHC/ILC issues

# Mass spectrum of SUSY particles ⇒ SUSY breaking mechanism

**LHC+ILC**
Combined analysis

→ **SUSY breaking Mechanism**



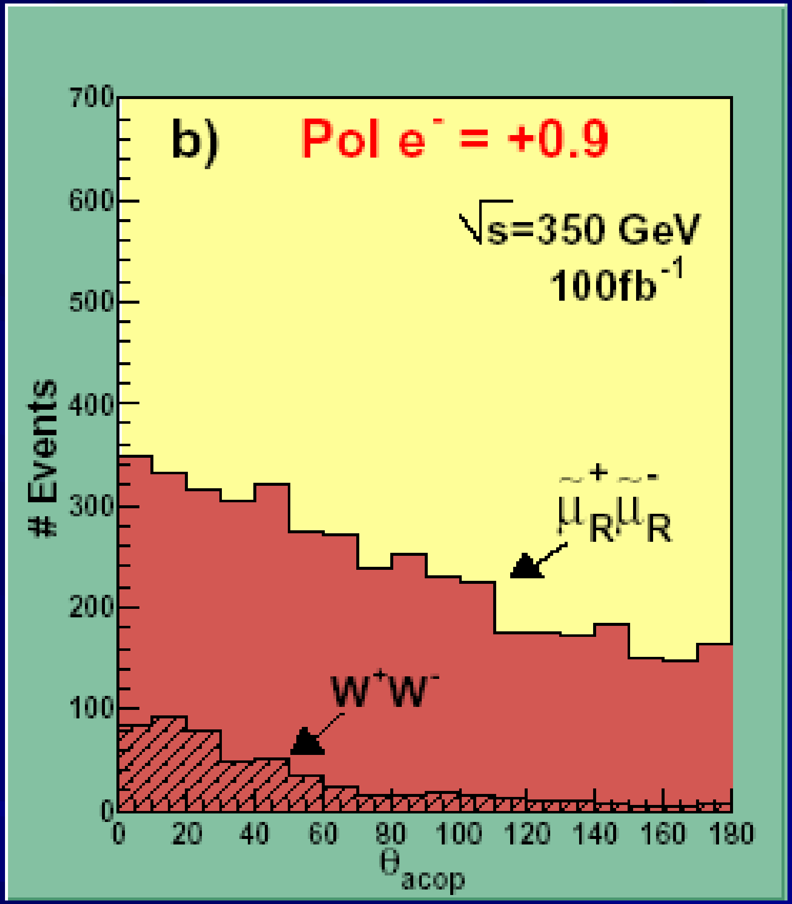
Energy scale

**Super Gravity** (mSUGRA)

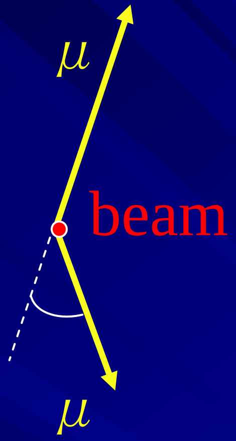
**Gauge Mediation**

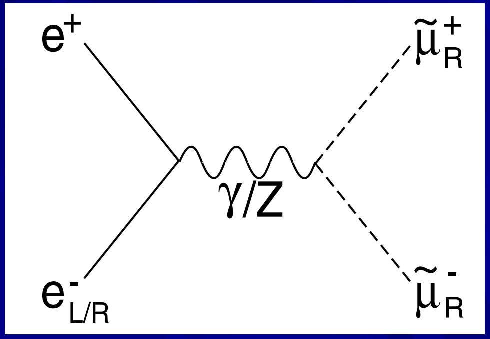
G.A.Blair, W.Porod,and P.M.Zerwas

# Power of electron polarization at ILC

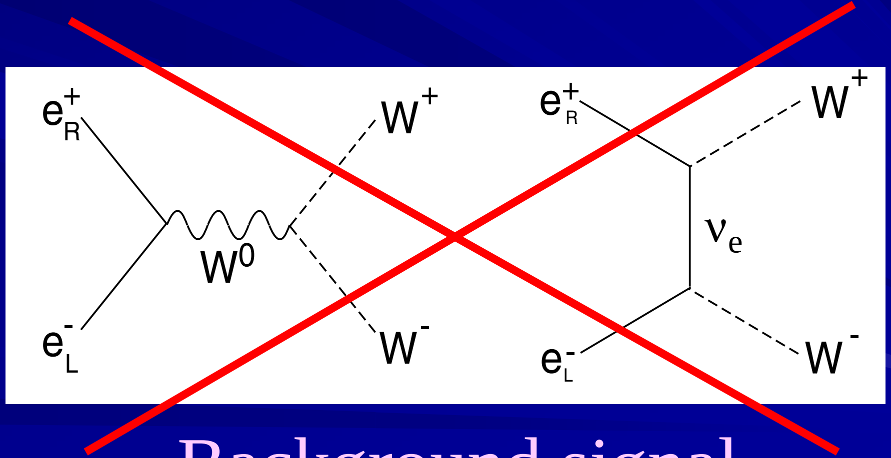


Polarized (90% $e^-_R$)





Scalar muon production



Background signal

Nakanishi (Nagaoya)

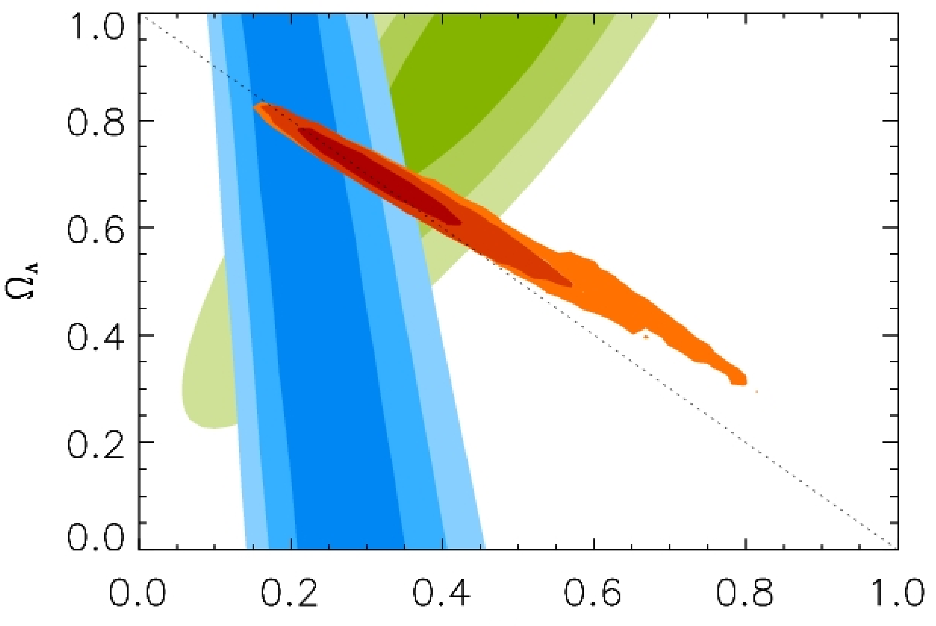
# Cosmology vs ILC Physics

## Energy budget of the Universe

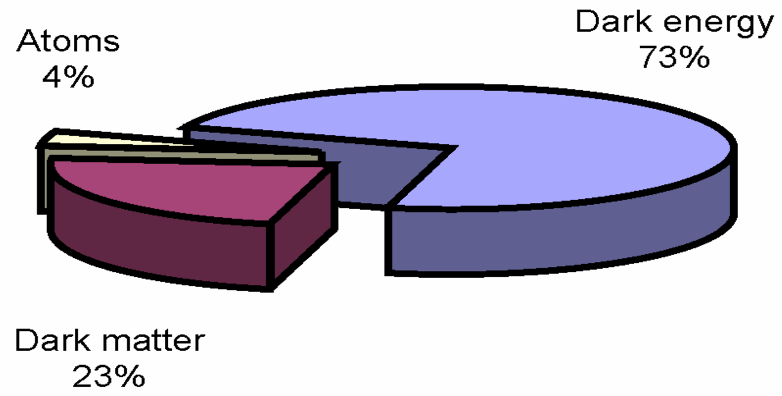
(1) CBR fluctuation (WMAP etc.)
(2) Large scale structure of galaxy cluster distribution
(3) Type 1a SN distribution
(4) Big Bang Nuclear Synthesis

$$\left.\begin{array}{l} \Omega_B = 4 \pm 0.4\ \% \\ \Omega_{DM} = 23 \pm 4\ \% \end{array}\right\} \Omega_m$$

$$\Omega_\Lambda = 73 \pm 4\ \%$$



(figure by L. Verde)



We only know 4% of the universe ⇒ The other 96% must be understood by the words of particle physics

# Dark Matter

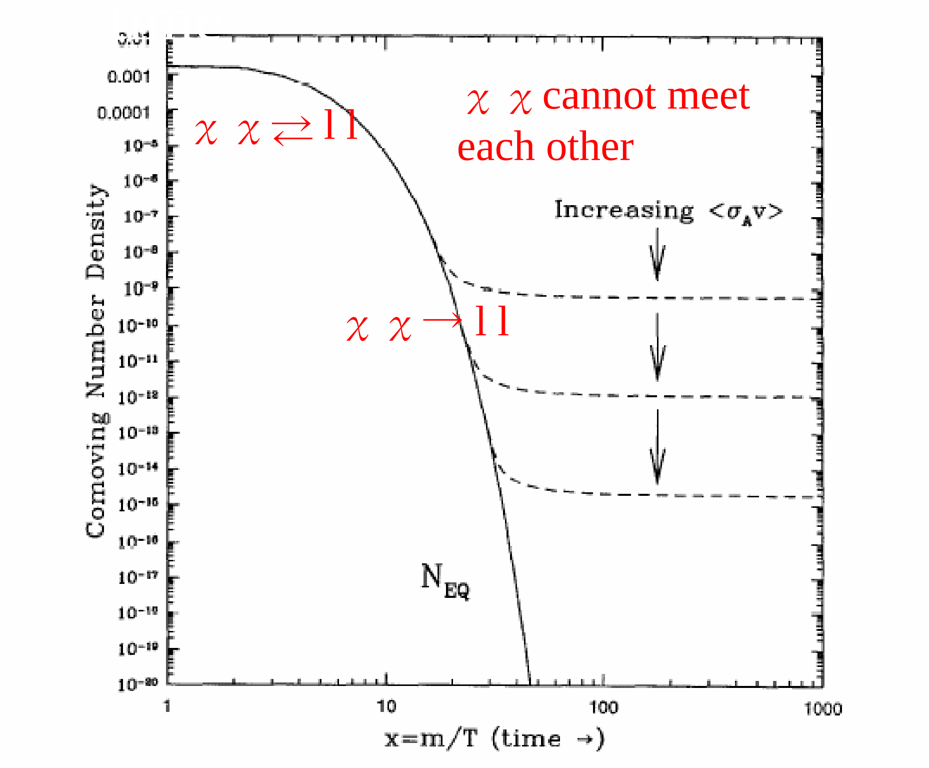
Okada, Feng, Nomura,

**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.**

$a(t)^3 \cdot \rho(t)$ vs



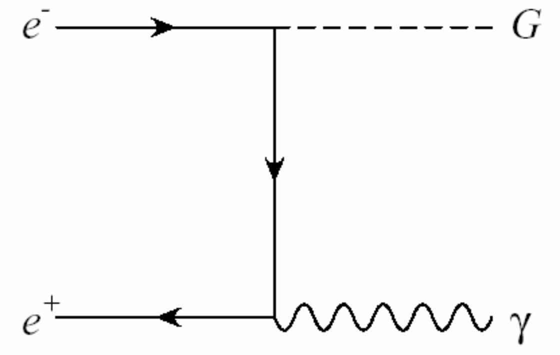
G. Jungman et al. Physics Report 267 (1996) 221

# Large Extra-dimensions

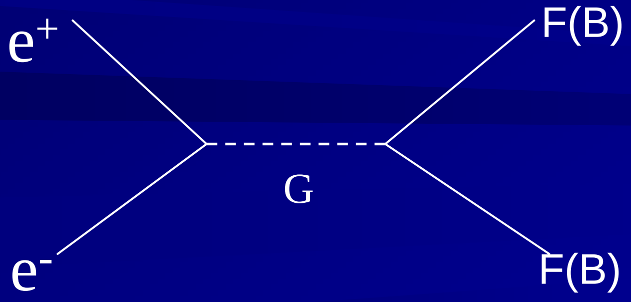
Space-time 3+1 dim + n-dim

$>>10^{-33}$ cm

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



**KK Graviton emission**



**KK Graviton exchange**

# The Detector DCR

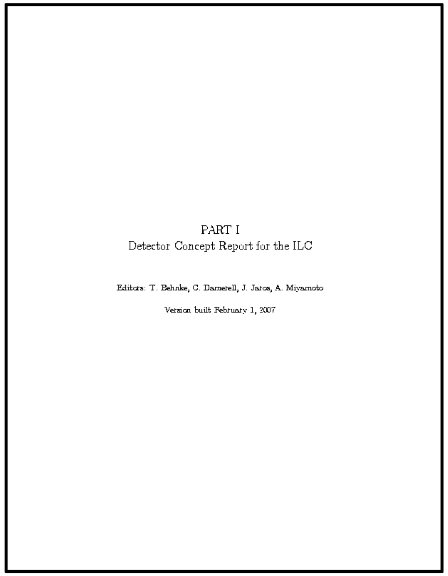
Ties Behnke, DESY

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



PART I
Detector Concept Report for the ILC

Editors: T. Behnke, C. Damerell, J. Jaros, A. Miyamoto

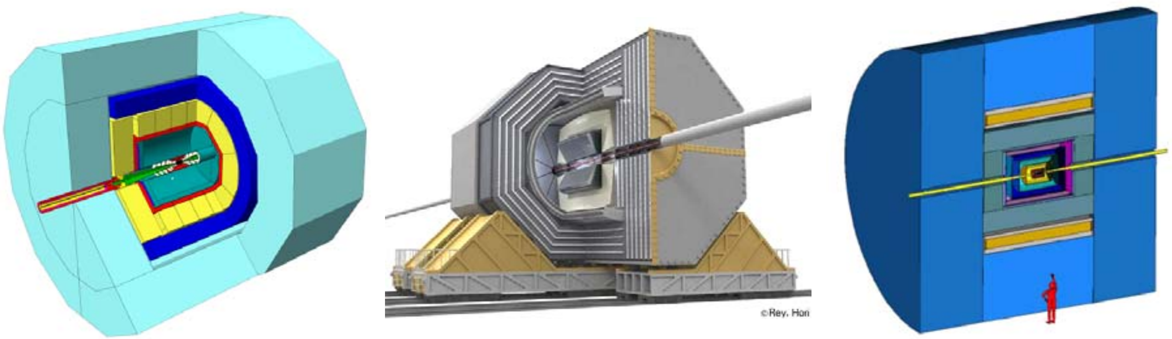
Version built February 1, 2007

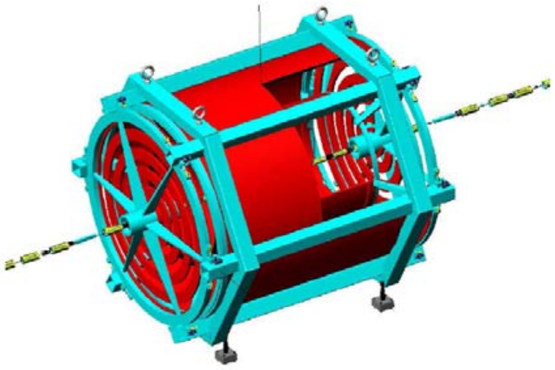
In the clean environment of ILC state-of-the-art detectors can be designed.

# The Concepts

Nevertheless:

The four concepts are the starting point and the bracket of the document



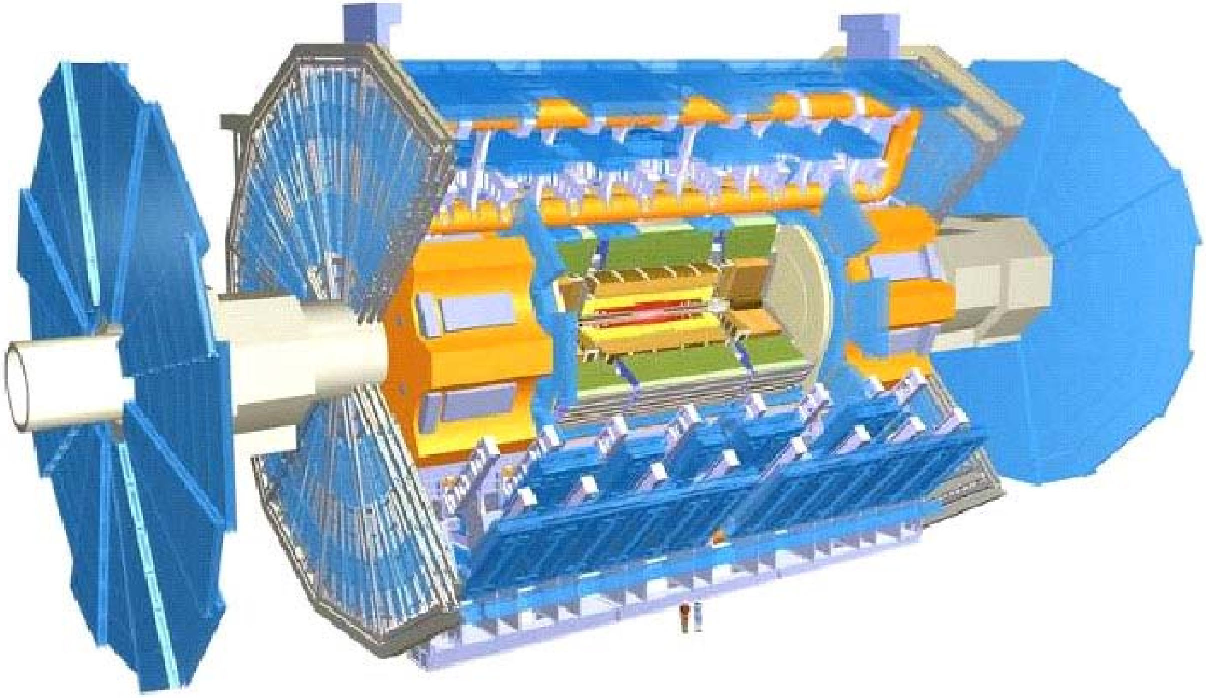


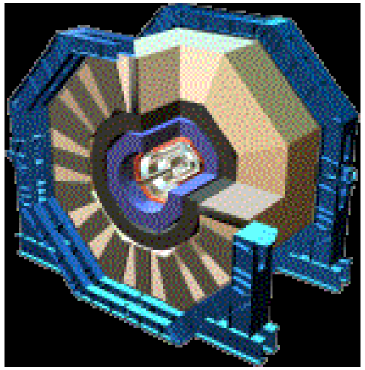
Self shielding detectors with Iron Yoke

Non-self shielding,
no classical iron
yoke

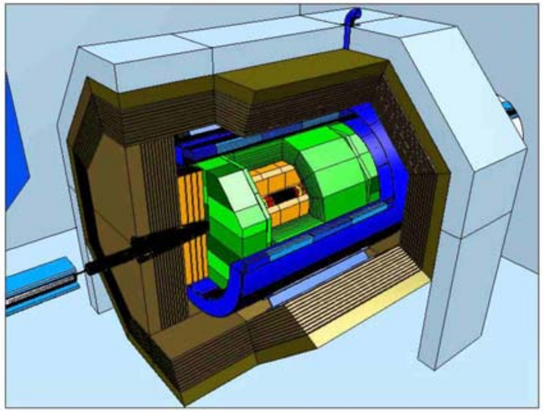
# ATLAS@LHC

| | |
|---|---|
| Diameter | 25 m |
| Barrel toroid length | 26 m |
| End-cap end-wall chamber span | 46 m |
| Overall weight | 7000 Tons |
| Detector sensors | 110M channels |

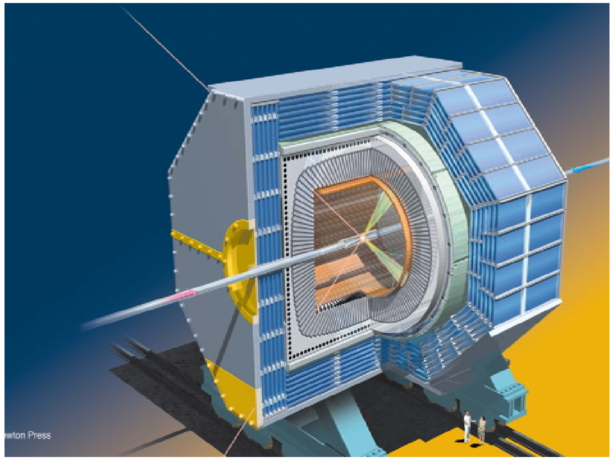




**SiD**



**LDC**



**GLD**

Summary
Akiya Sugiyama R&D
Chris Damarelle Review

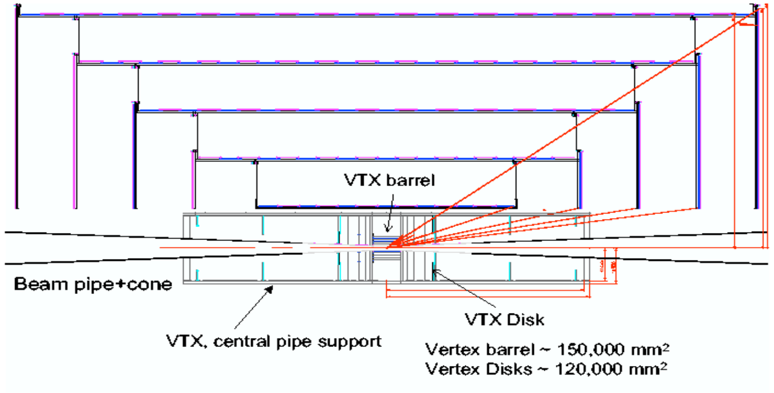
# Tracker

Material, speed

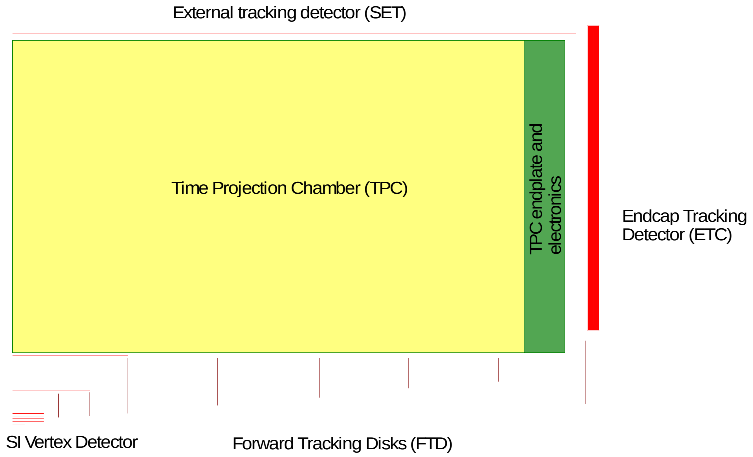
Endplate design?

Resolutions

All Silicon tracker



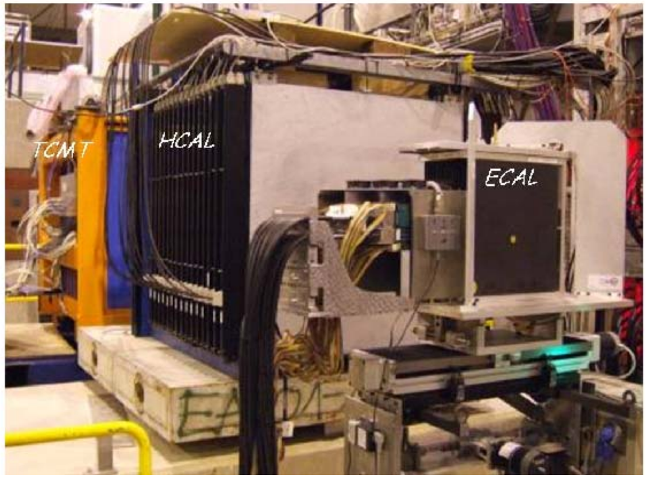
Gaseous / mixed tracker

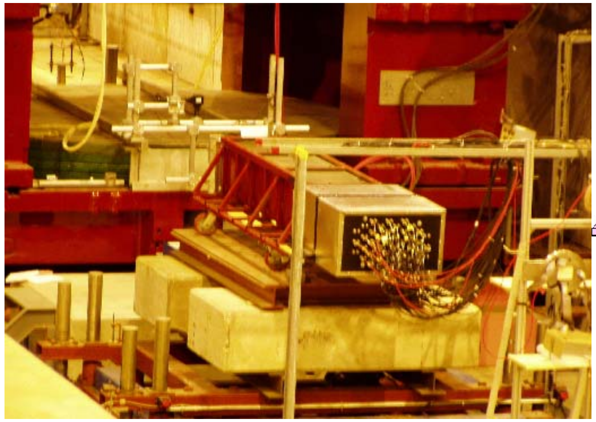


Lots to be learned this week from the tracking review here at the ACFA workshop

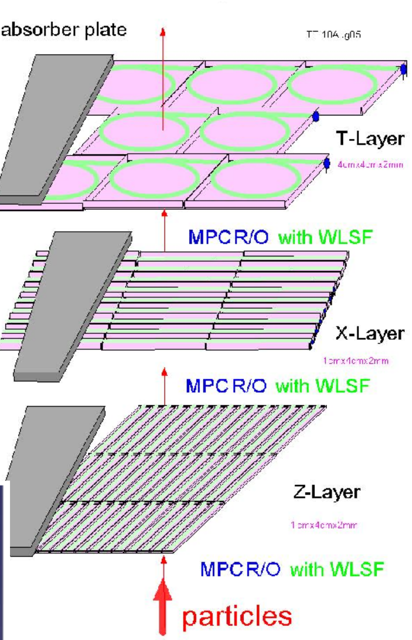
Summary
Kiyotomo Kawagoe

# Calorimeter R&D

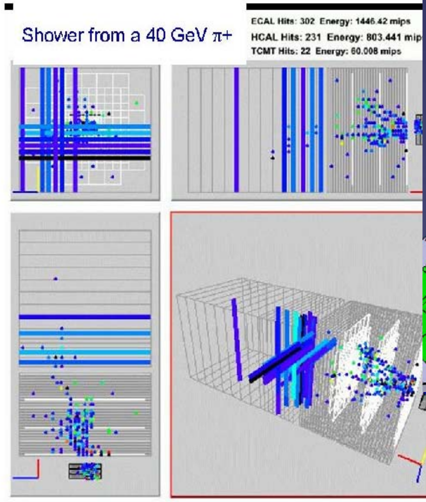




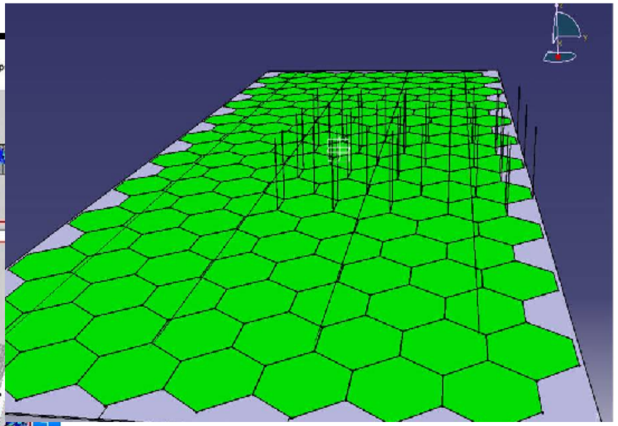
“Dream” testbeam setup



GLD non SI
ECAL concept



CALICE
test beam
effort



SiD ECAL
readout plance

Very active
field – watch
for developments

# 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

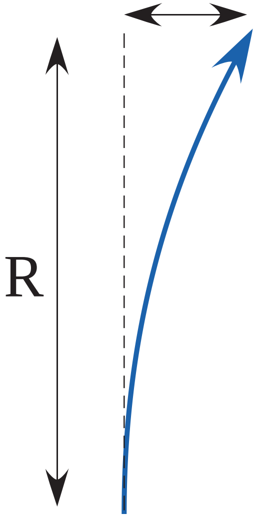
$$\sigma\,(E_{jet})^2 = \Sigma\,\Delta E_{ch}{}^2 + \Sigma\,\Delta E_{\gamma}{}^2 + \Sigma\,\Delta E_{neutral\ had}{}^2 + \Sigma\,\Delta_{confusion}{}^2$$

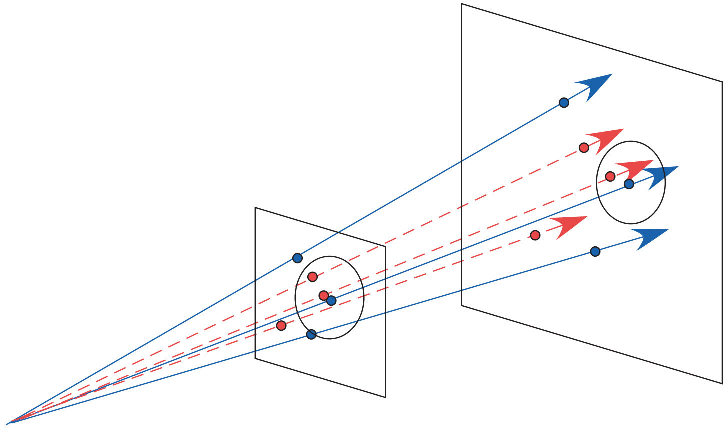
Due to high particle density in the core of jet and large fluctuation of HCAL energy flow, jet energy resolution is dominated by $\Delta E_{neutral\ had}$ and $\Delta_{confusion}$

$d=0.15BR^2/p_t$

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

Summary (Simulation)
Shaomin Chen





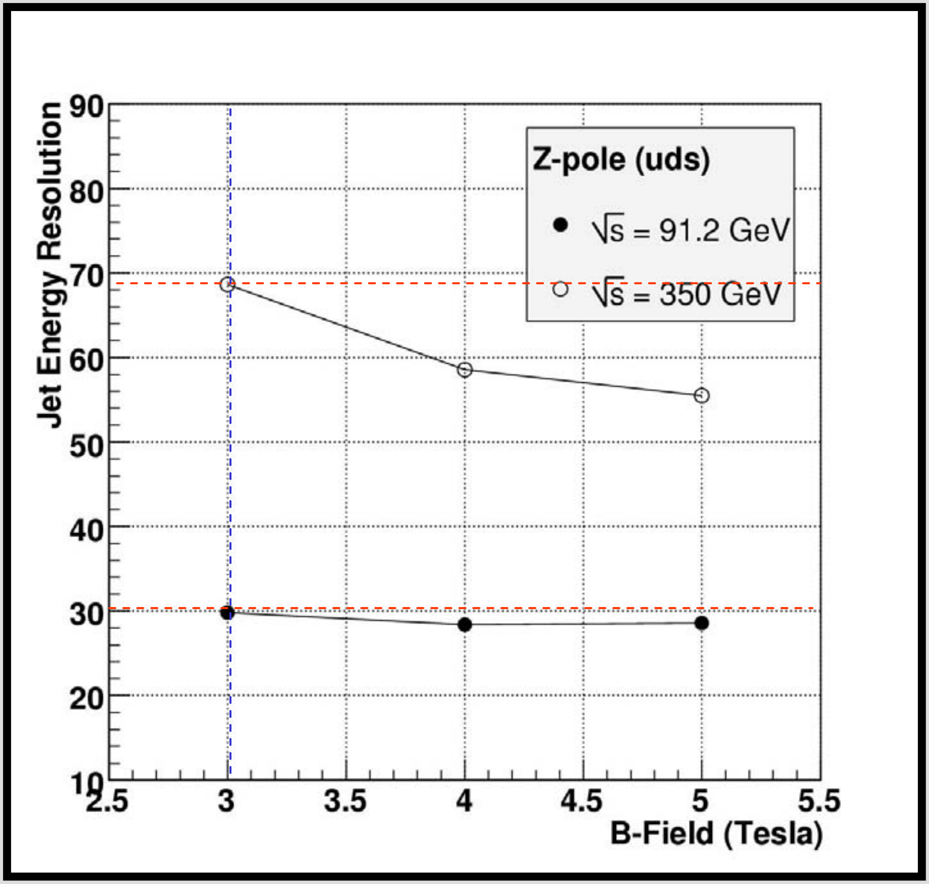
B=magnetic field

R=radius to EM

Rm=Moliere unit

# *B-field Dependence*

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



$\Delta E/E=a/\sqrt{E}$

- Higher magnetic field gives better PFA performance as expected.
- 5 Tesla case does not improve PFA performance very much.

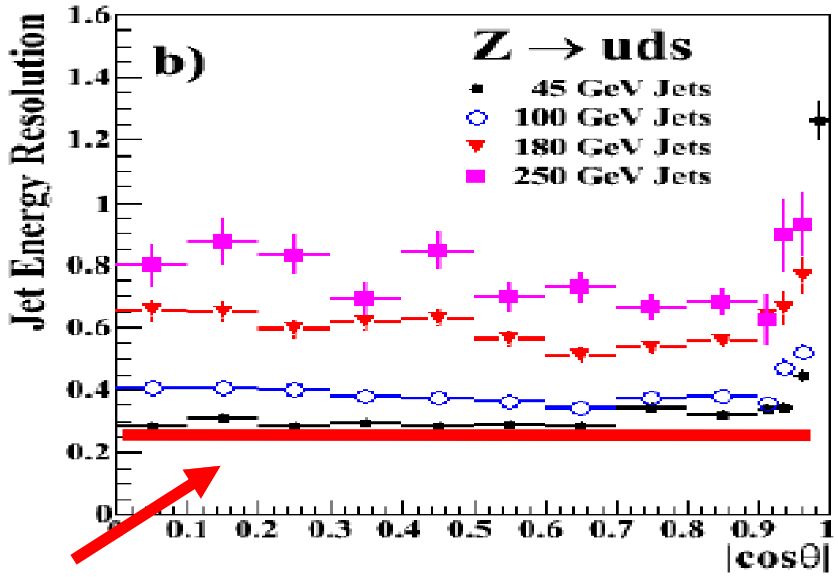
→ Due to low momentum tracks?

| Ecm | 3 Tesla | 4 Tesla | 5 Tesla |
|---|---|---|---|
| 91.2 | 29.8±0.4 | 28.4±0.3 | 28.6±0.3 |
| 350 | 68.7±1.1 | 58.5±1.0 | 55.5±0.9 |

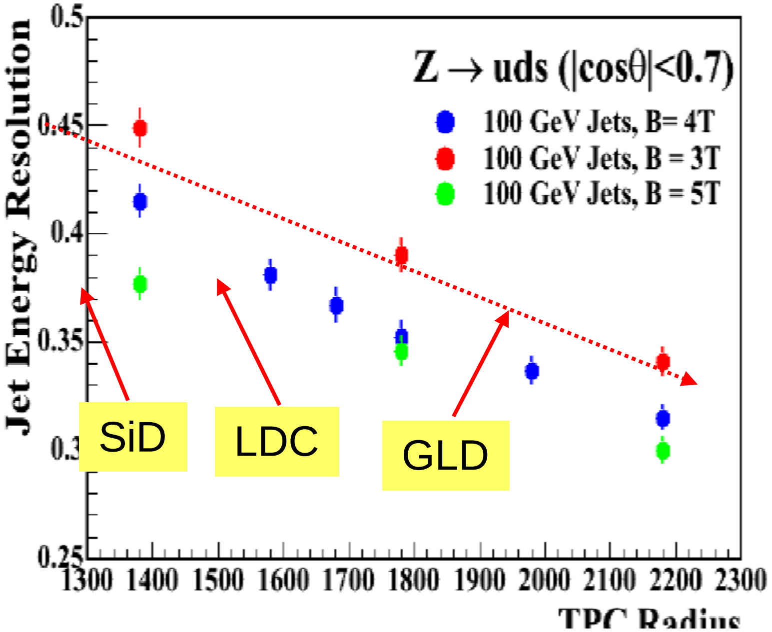
Tamaki Yoshioka

# 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

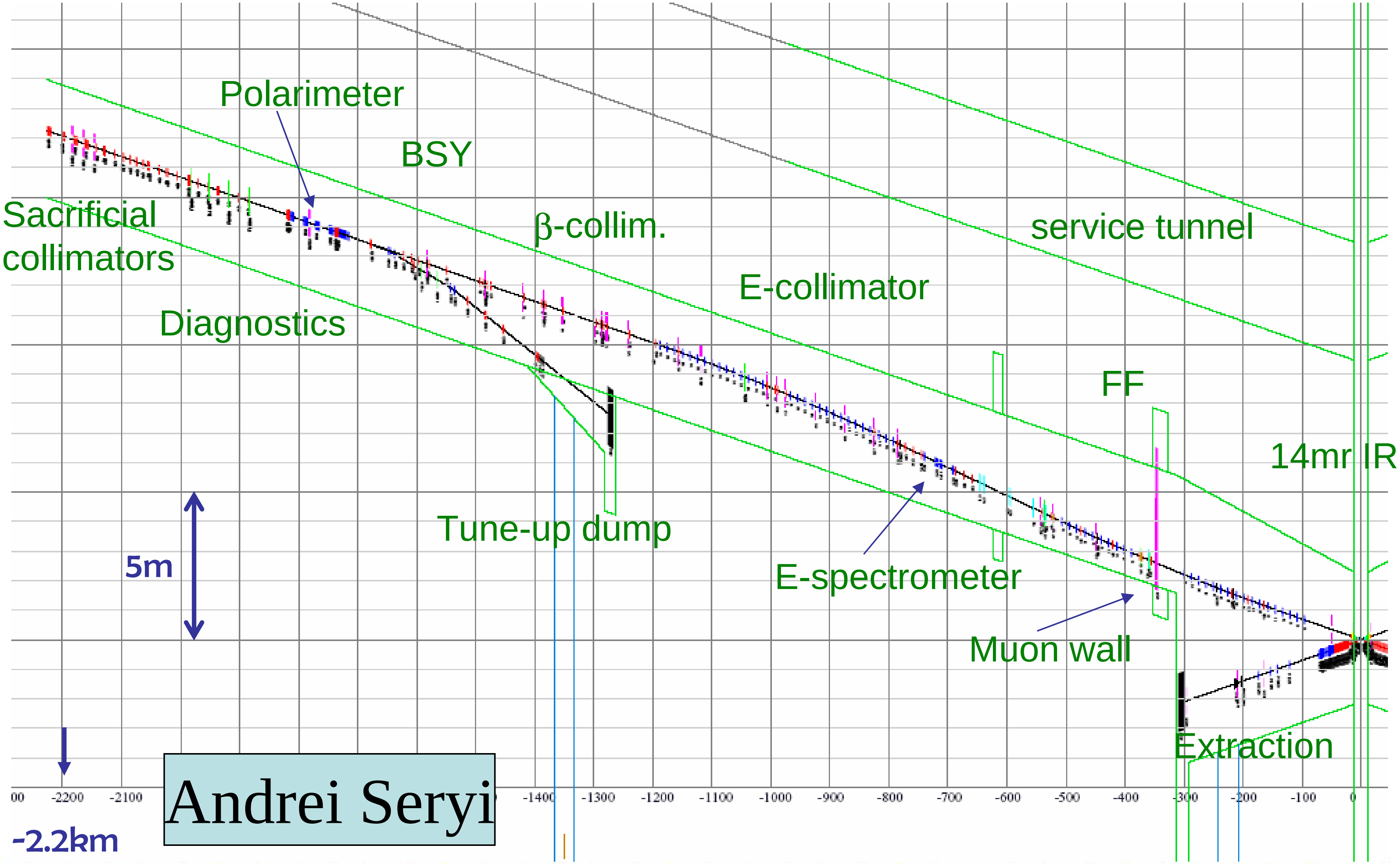
There are many performance studies done for technical systems

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.

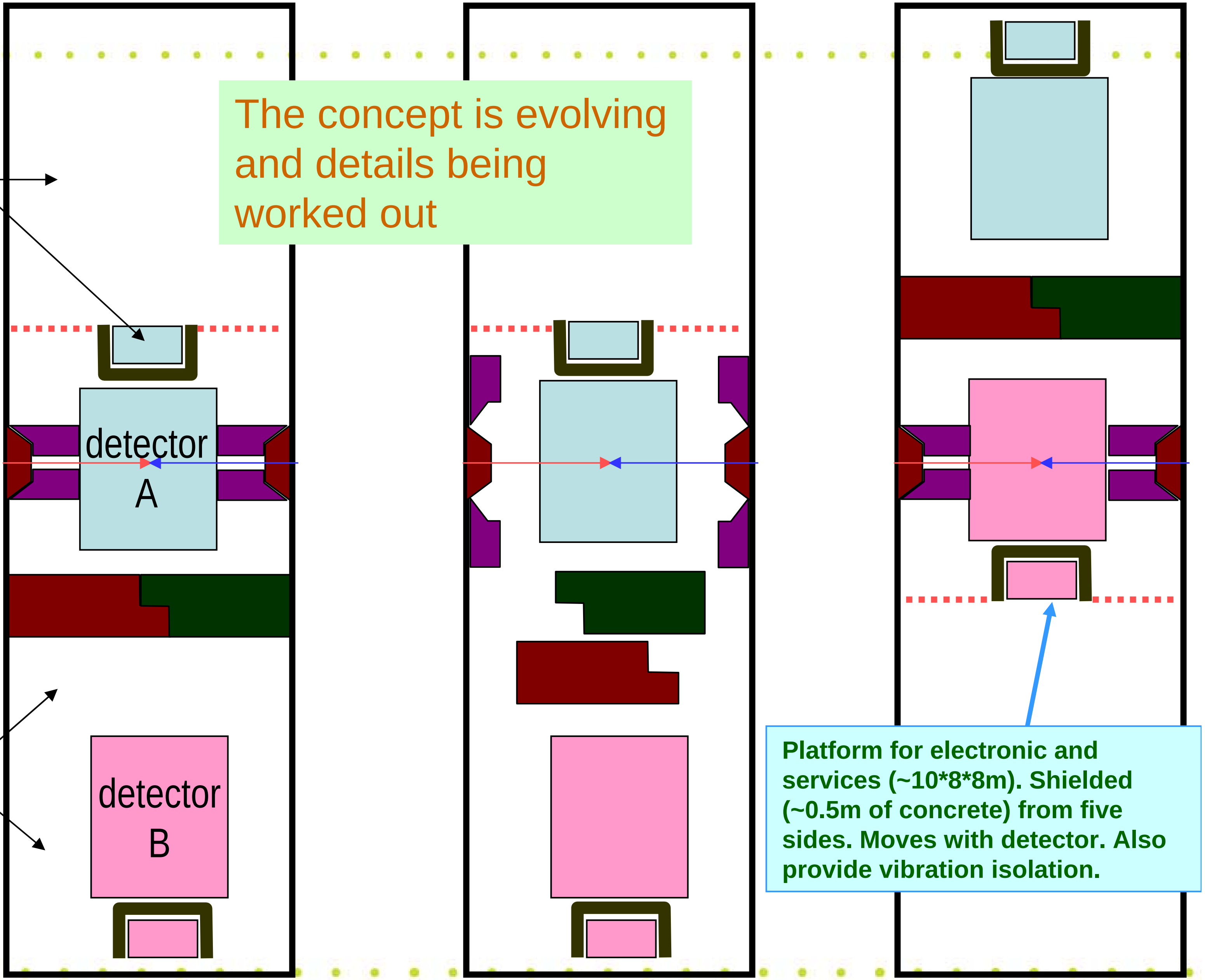
Summary MDI-BDS
Toshiaki Tauchi

# BDS beam-line layout



Andrei Seryi

# Concept of IR hall with two detectors



The concept is evolving and details being worked out

**may be accessible during run**

**accessible during run**

**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

# GDE management's idea of push-pull

Surely, you jest…

# We need to:

Hitoshi Yamamoto
Charge of this workshop

- 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

# 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. )

# RDR phase (a view from an experimentalist)

- GDE made heroic efforts in the RDR phase .
  Staring 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 forth coming 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 the 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 de 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 thi
Bjorn Wiik, Shuji Orito, M