

# Concluding Remarks

This is not a summary of Summary Talks

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## Global understanding in this field:

We are at the entrance of the revolutionary epoch of particle physics. (People seem to think we are always crying wolf... after 1974 there have been no real revolutions in high energy physics.)

The outstanding problems of particle physics can be solved by **direct measurements at energy frontier colliders** (examine first results at LHC and then ILC).

**Higgs (origin of mass  $\Leftrightarrow$  structure of the vacuum)**  
**SUSY (or alternative, TeV scale new physics)**

The scientific indispensability of the Linear Collider has never changed.

In the particle physics community considers that the International Linear Collider is the highest priority project after the LHC construction.

## History of Synergy between Hadron-hadron and $e^+e^-$ Collision Experiments

- Charm quark    AGS/SPEAR    (The 1974 November Revolution)
- Tau            SPEAR/DORIS/CESR/BEPC/LEP/B-Factories
- Bottom quark    Fermilab/DORIS-II/B-Factories
- Gluons            (Scaling Viol., Jet  $p_t$  Distr.) / PETRA / TRISTAN/SLC/LEP/HERA
- Weak Bosons    Sp $\bar{p}$ S/LEP(Z,W), SLC(Z)/TEVATRON
- Top quark        (LEP) / TEVATRON
- Higgs Boson     (LEP,TEVATRON) / LHC/ILC
- SUSY            LHC/ILC

Discoveries  
 $e^+e^-$  Colliders

# Story of Top Quark and Higgs Boson

From precise electro-weak measurements at **LEP**, top mass was predicted

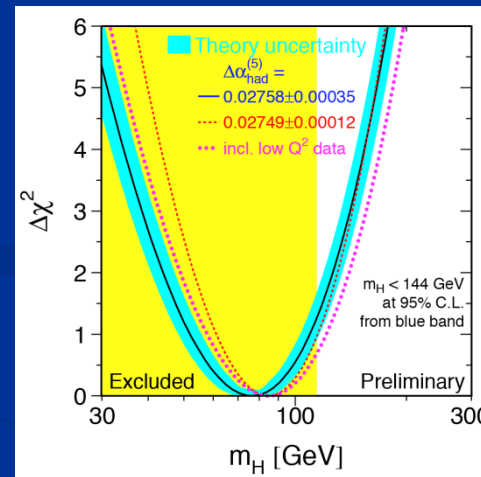
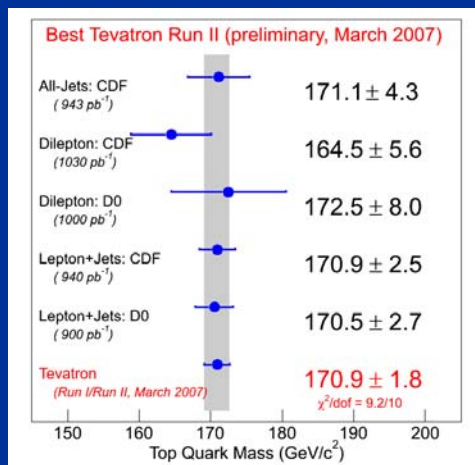
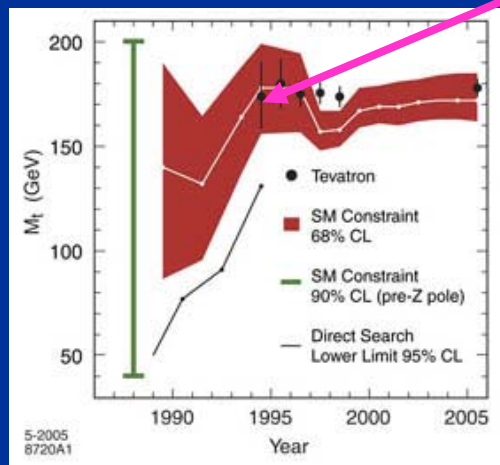


Precise Measurement of Top mass at the **TEVATRON**



Higgs mass is restricted into a narrow range using precise top mass and **LEP** electro-weak data  
 $114 \text{ GeV} < M_H < 160 \text{ GeV}$

Discovery to Top



Discovery of Higgs at **LHC**



Precise measurements of Higgs properties at **ILC**

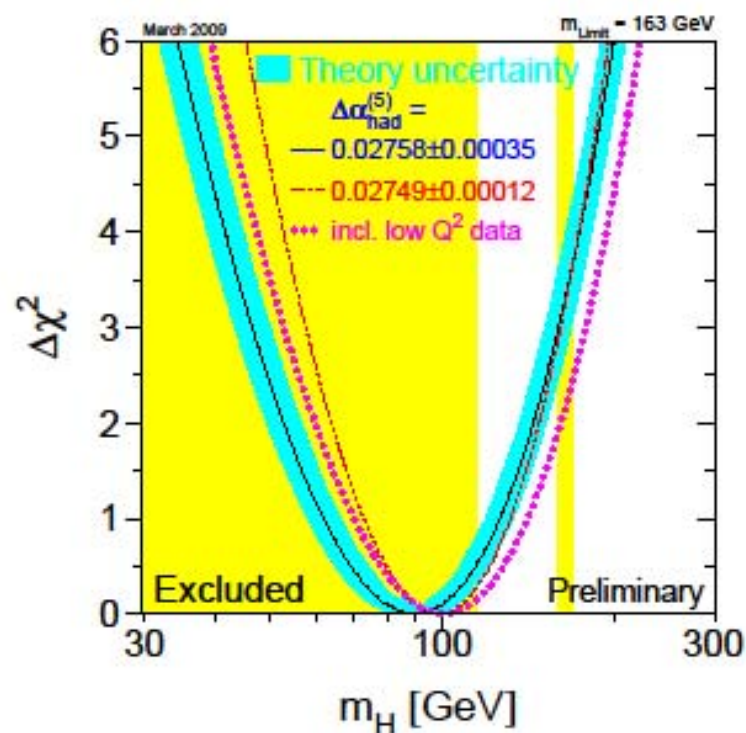




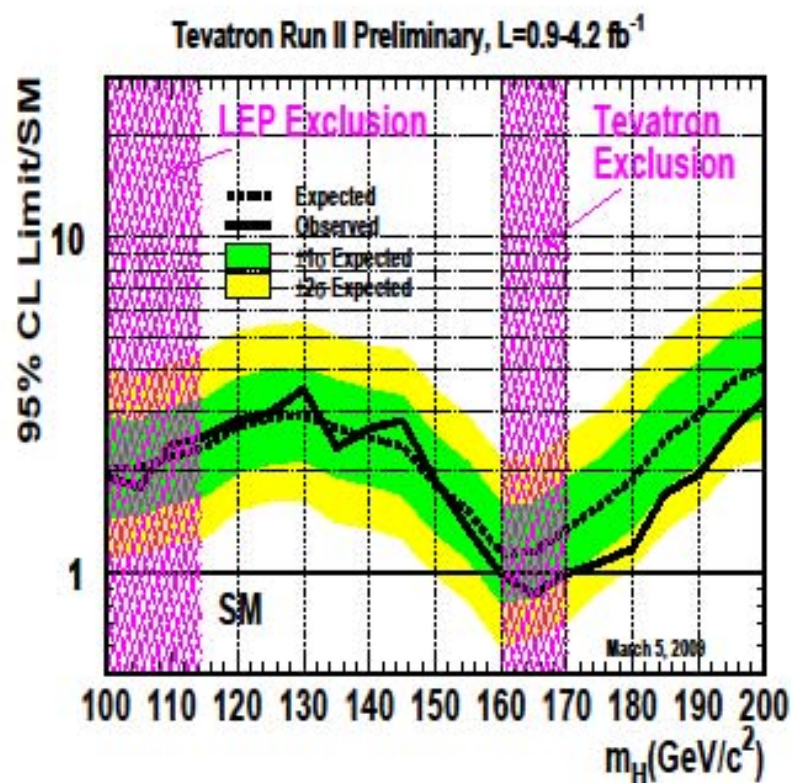
# Hints from electroweak precision data?

SM Higgs: ew. prec. data + direct search at LEP & Tevatron

[LEPEWWG '09]

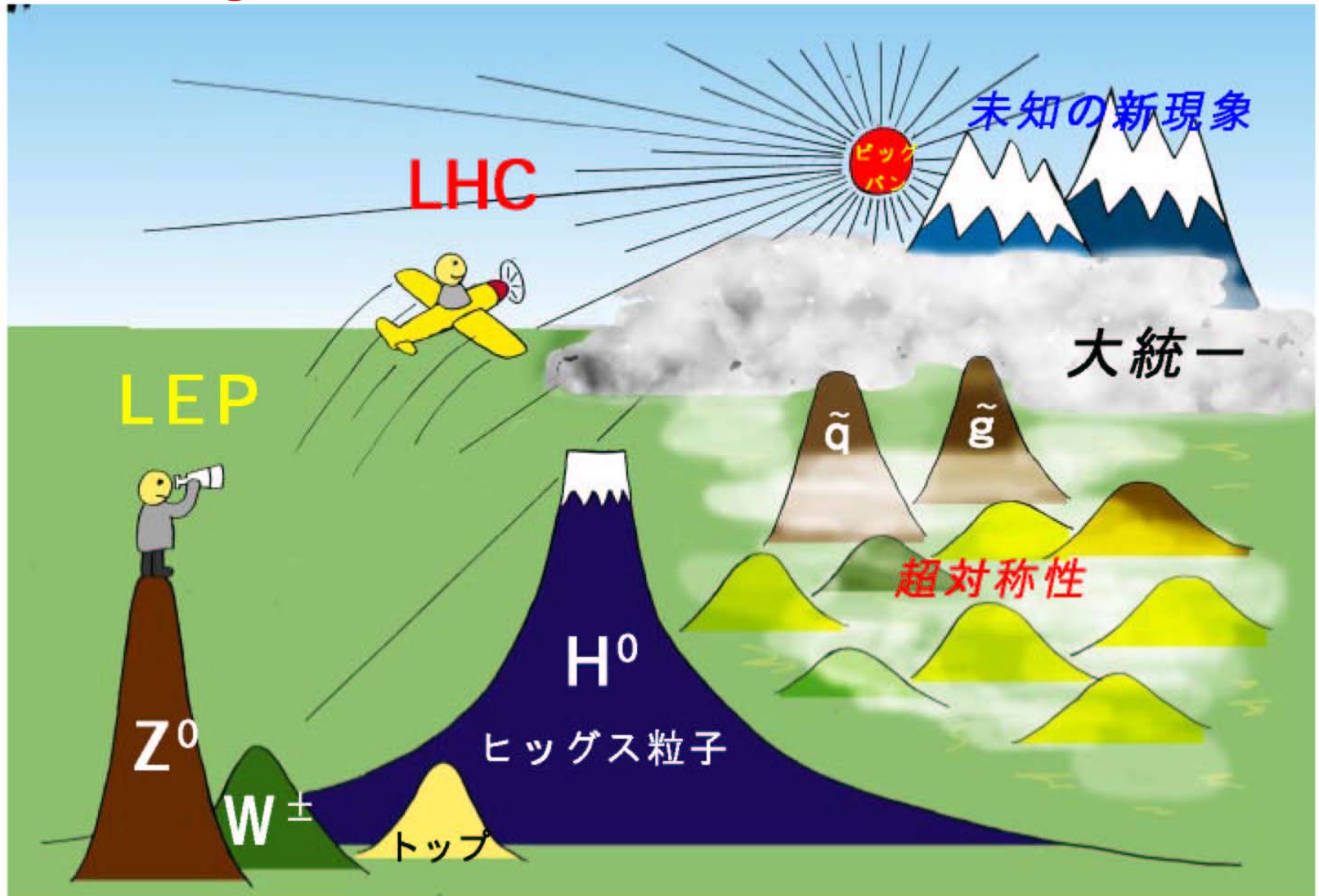


[TEVNPH Working Group '09]



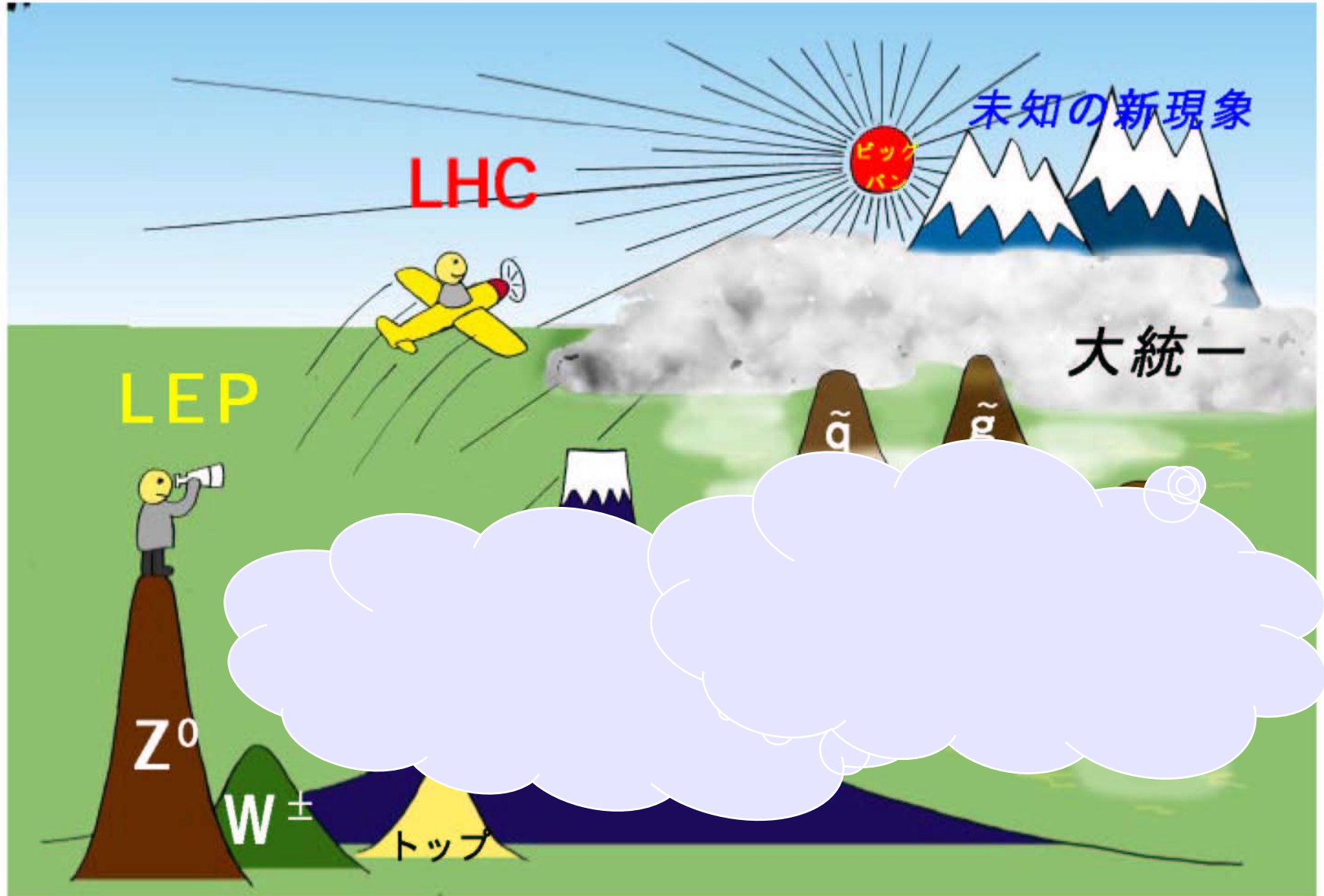
⇒ Preference for a light Higgs

# Propaganda plot of LHC for MEXT



LHC overlooks new phenomena including Higgs Boson and SUSY

Actual situation would be .....



LHC overlooks new phenomena including Higgs Boson and SUSY



# Higgs Boson

Some spin zero particle might be related to inflation / dark energy ?

ILC is the Higgs Boson Factory

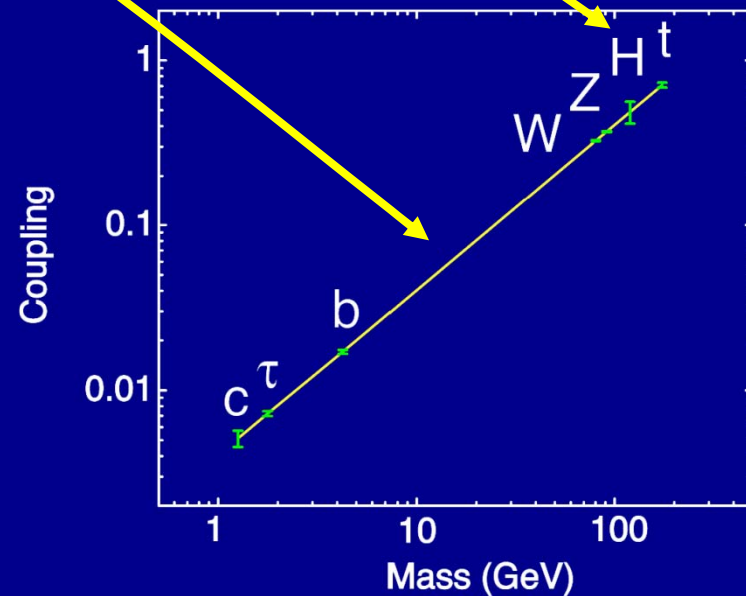
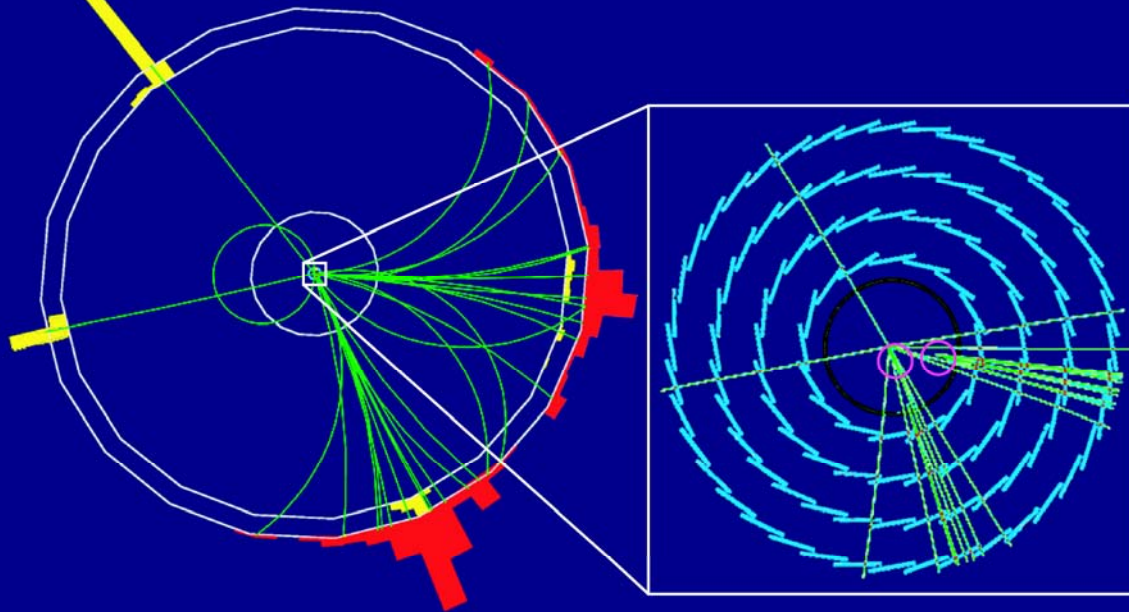
$O(10^5)$  such events will be collected and studied.

Origin of mass



Structure of the 'vacuum'

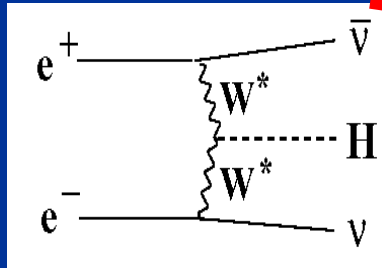
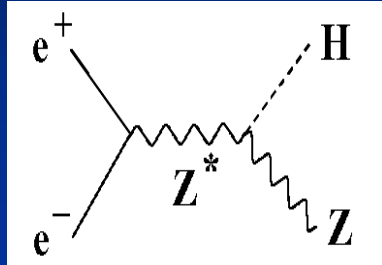
$$e^+e^- \rightarrow Z + H \rightarrow e^+e^- + b\bar{b}$$



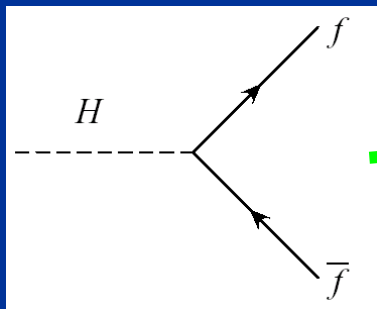


# Coupling measurements at ILC

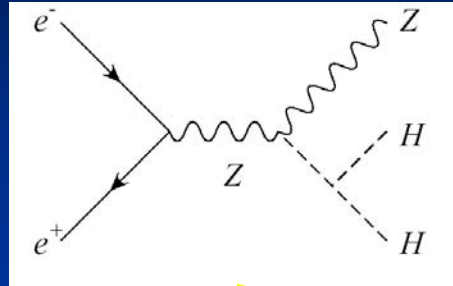
## Gauge Coupling



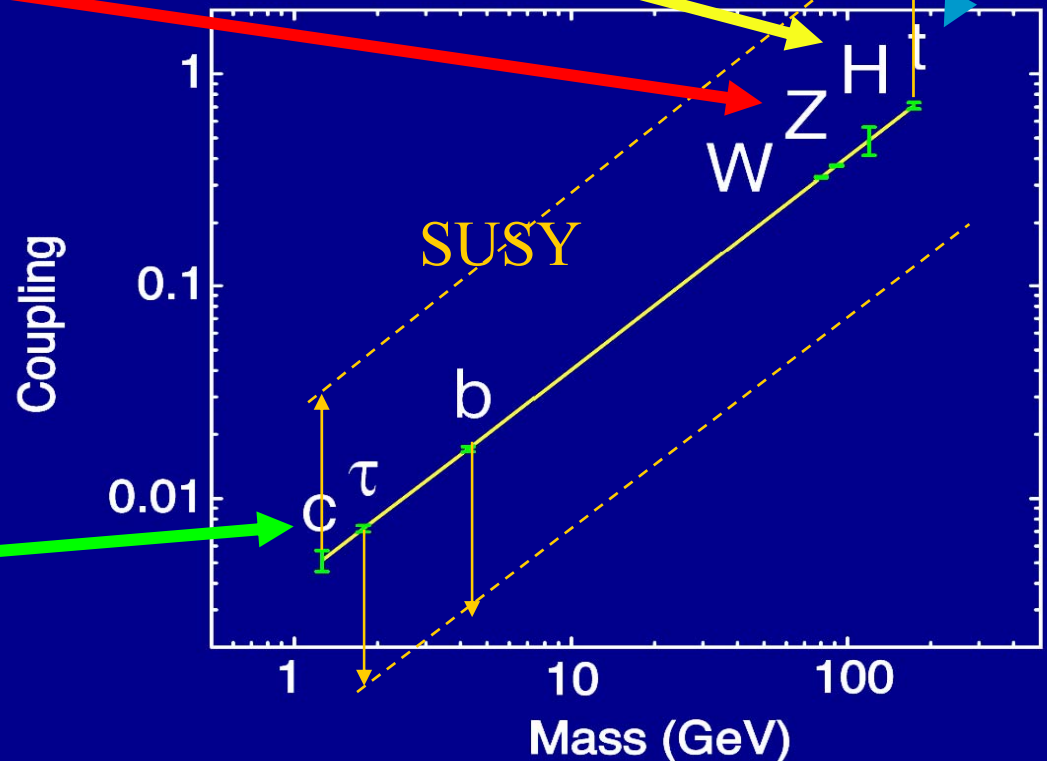
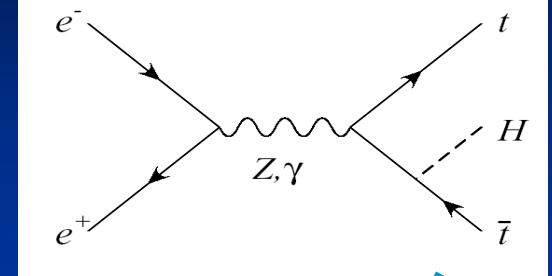
## Yukawa coupling



## Self-coupling

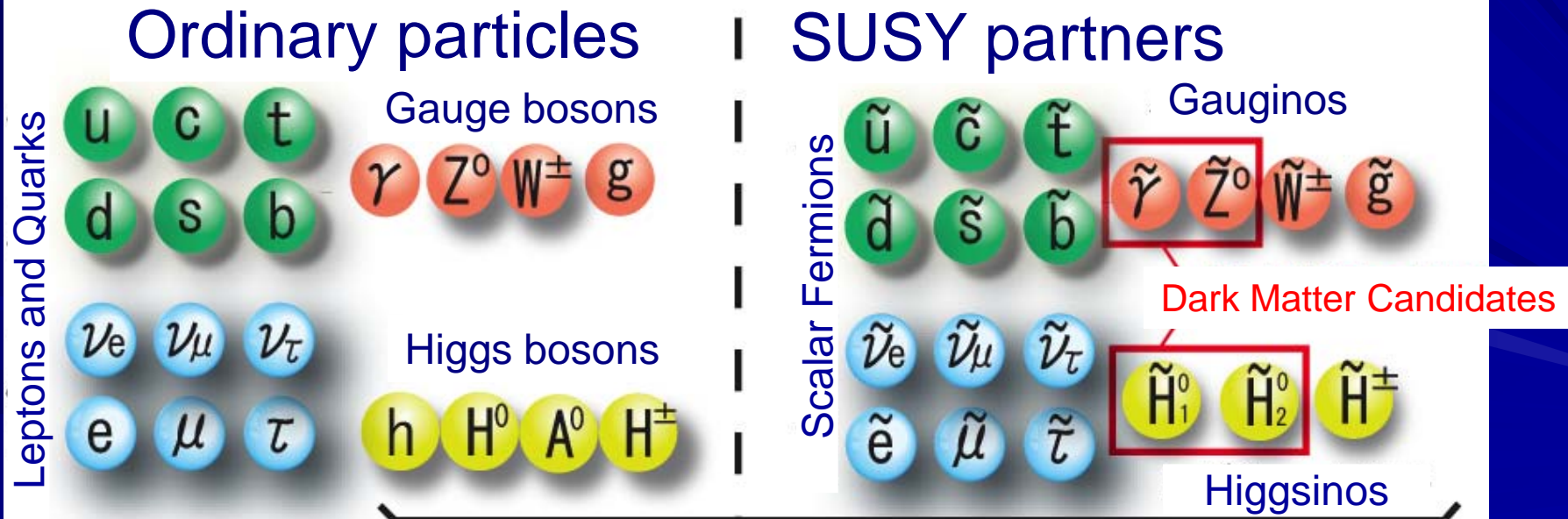
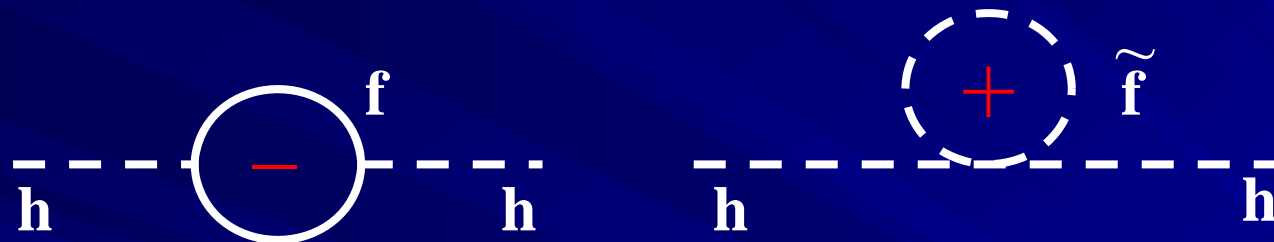


## Top Yukawa coupling



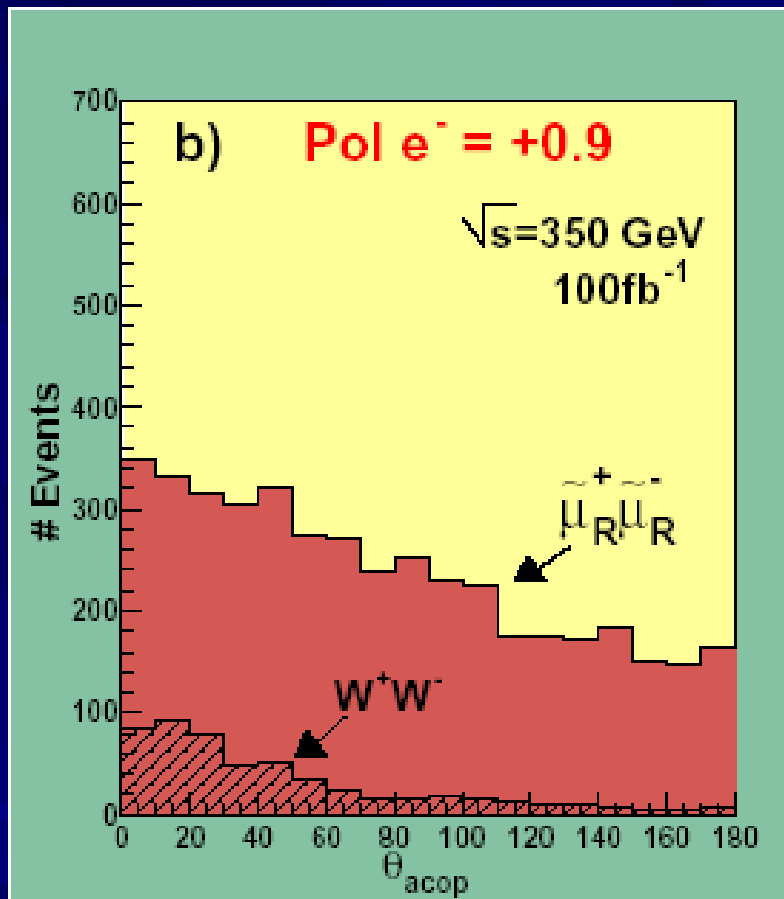
# Supersymmetry (SUSY)

Stabilization of Higgs Boson Mass due to a cancellation  
 $\Rightarrow$  Numbers of Fermion and Boson fields are identical

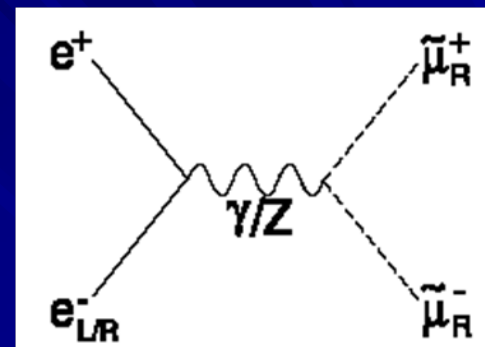
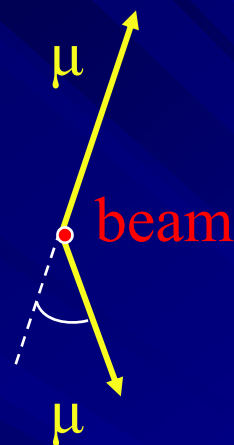


Higgs and SUSY are undiscovered

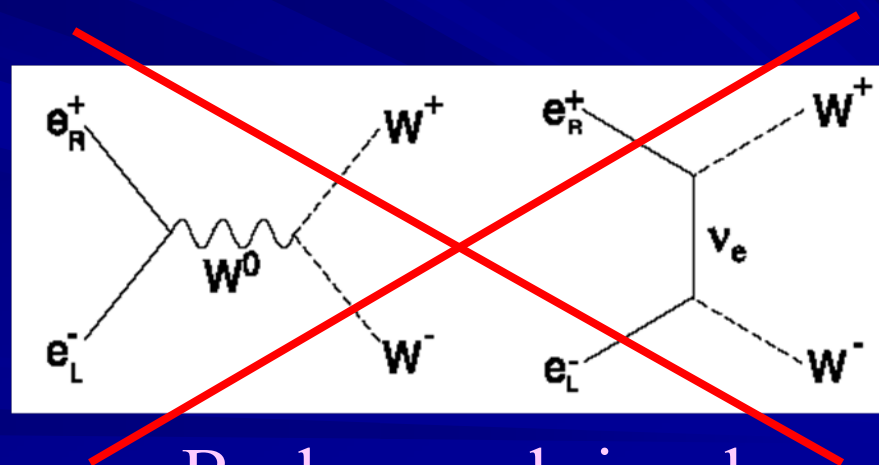
# Power of electron polarization at ILC



Polarized (90%  $e^-_R$ )



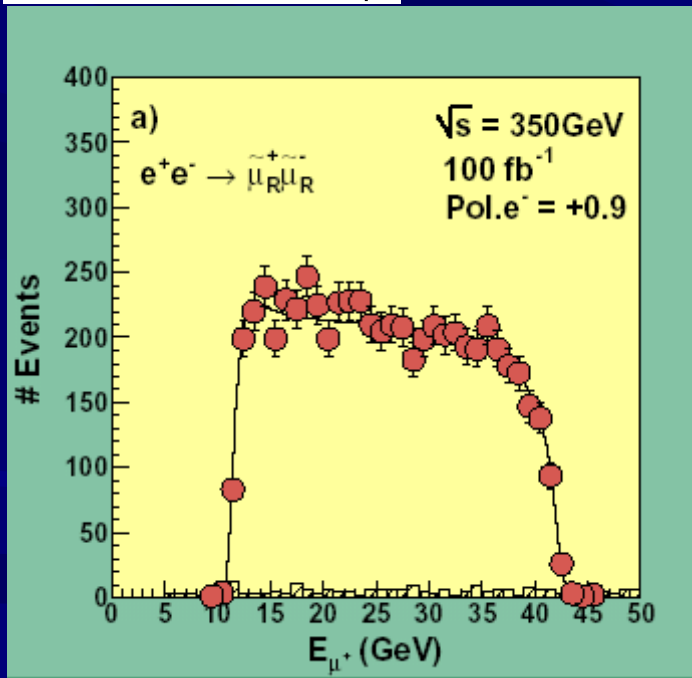
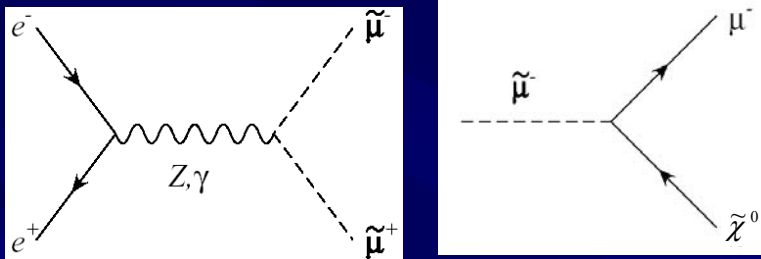
Scalar muon production



Background signal

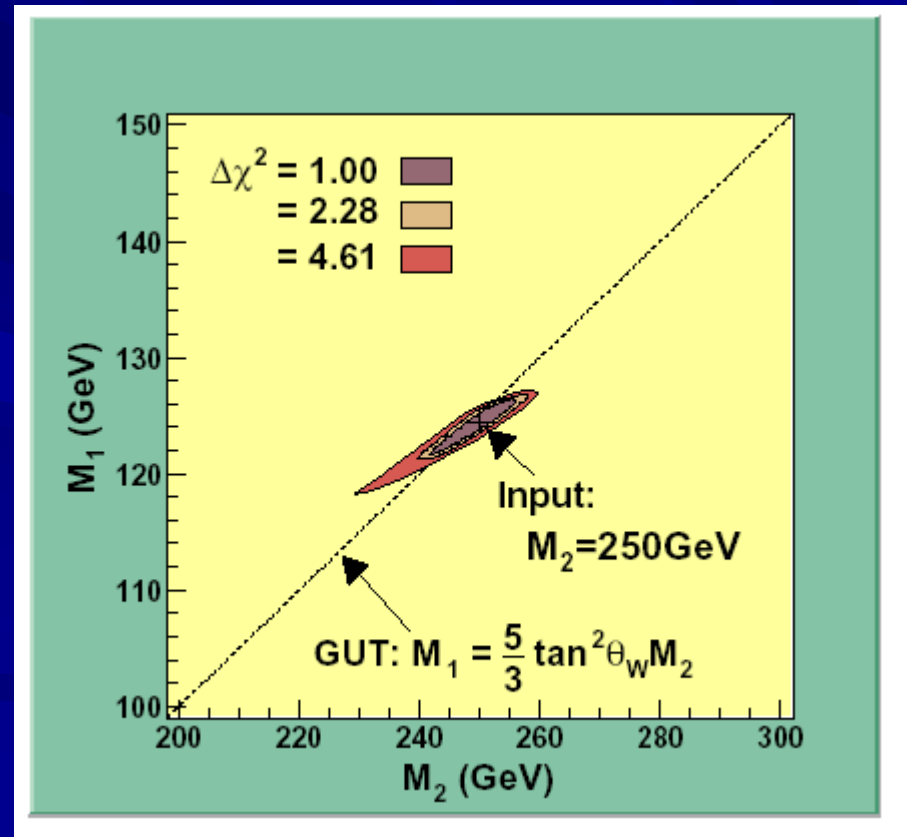
# SUSY at ILC

## Slepton/Neutralino



Spin, CP, coupling strength, etc..  
are precisely measured

Chargino/Neutralino  
Mass, Coupling, Mixing  
 $\Rightarrow$  GUT unification





# ILC vs Cosmology

Astronomical observations and theoretical works have been solving real nature of many unidentified phenomena:

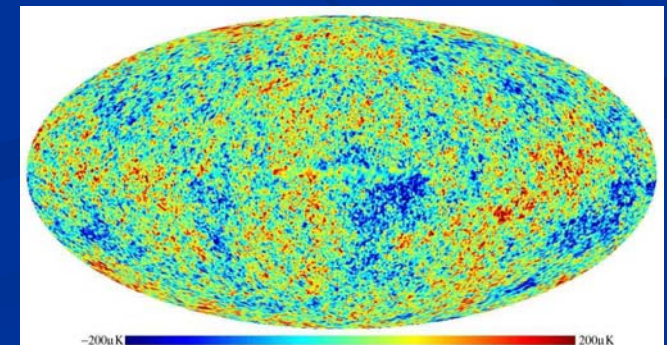
**Quasars** : merge of galaxies (merge of black holes)

**Gamma ray bursts**: Probably type Ic Supernovae

Observational Cosmology  $\Rightarrow$  the energy budget of the **dark energy** and **dark matter**. We do not know the real sources of these objects.

**Inflation** is expected from the flat and uniform universe, but we do not know how, when, how many times inflation(s) took place.

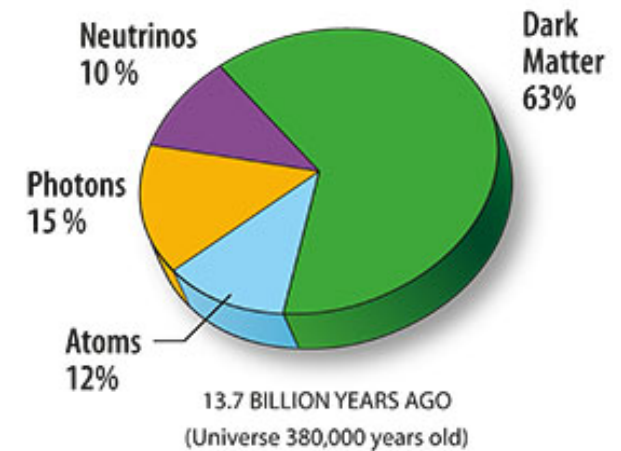
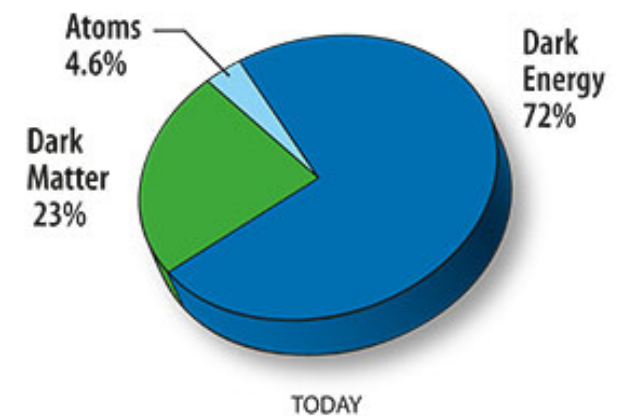
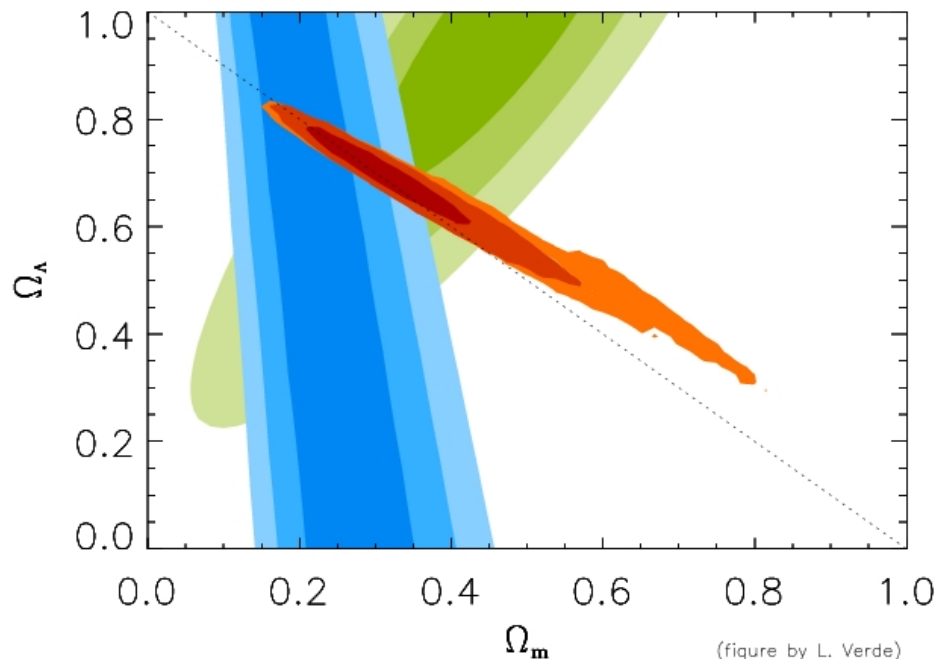
$\Rightarrow$  Synergic studies by cosmologists and particle physicists are essential to solve these questions.



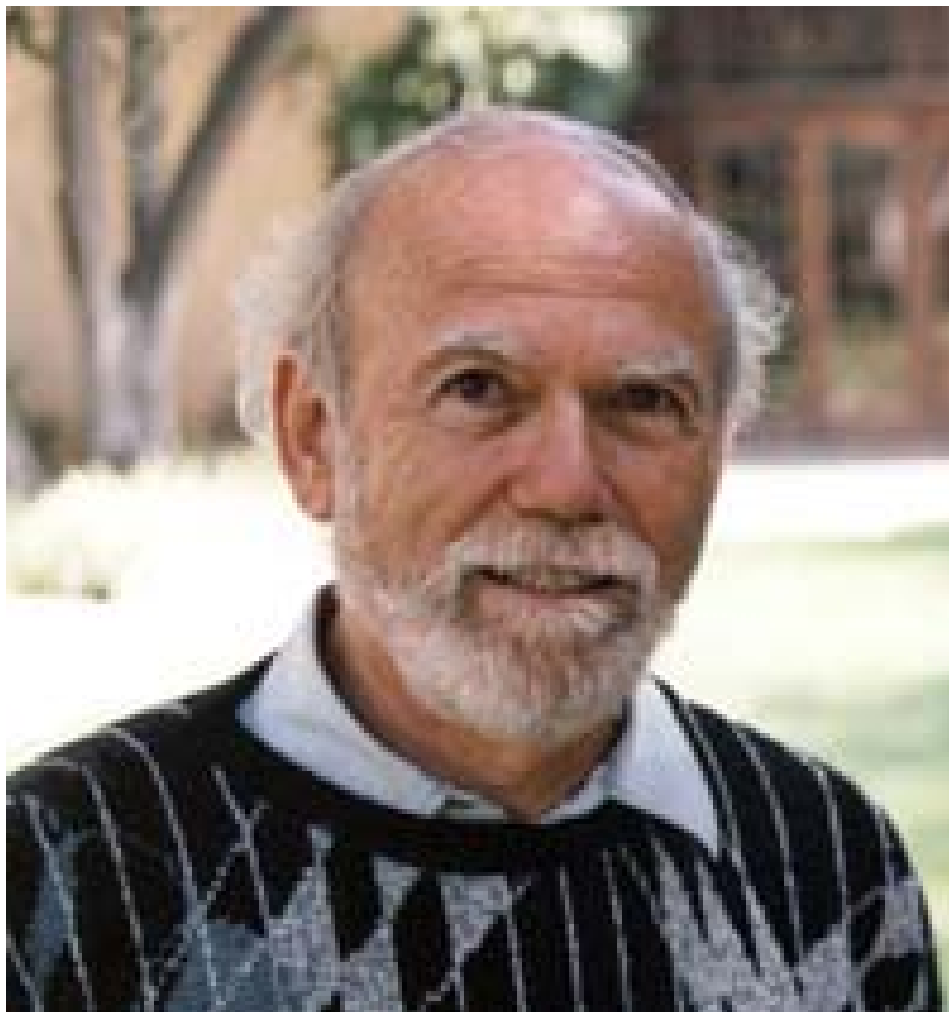
# Cosmology vs Particle Physics

## Energy budget of the Universe

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



**We only know 5% of the universe.**  
**Dark Matter:** LSP ?  $\tilde{\chi}, \tilde{G}$   
**Dark Energy/Inflation:** Scalar particle???  
**Discovery of Higgs = first step to understand DE**





# What are we doing?

- Updated version R&D Plan: Plug Compatibility concept fleshed-out; SCRF test facilities;
- R&D Demonstrations – Progress on CsrTA (electron cloud); ATF-2 (final focus); and SCRF cavity gradient
- We are beginning the process of a cost-performance optimization of the design leading toward “re-baselining”
- Developing a Project Implementation Plan
  - Governance study; Siting activity & strategy





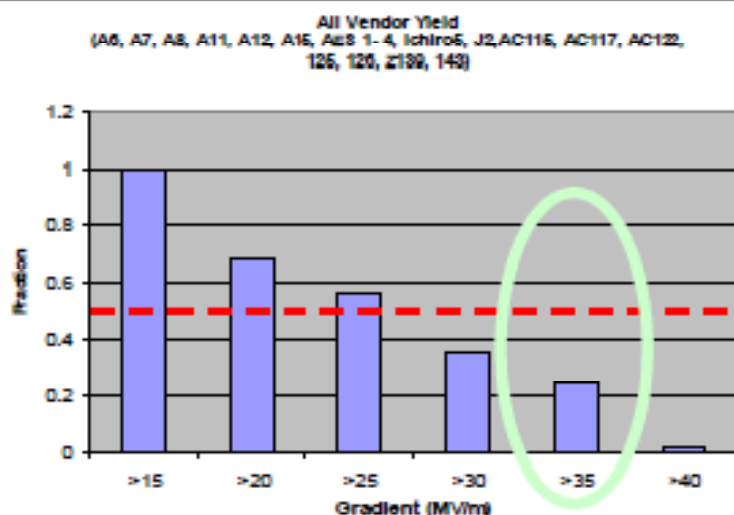
# Status of 9-Cell Cavity R&D

48 Tests, 19 cavities

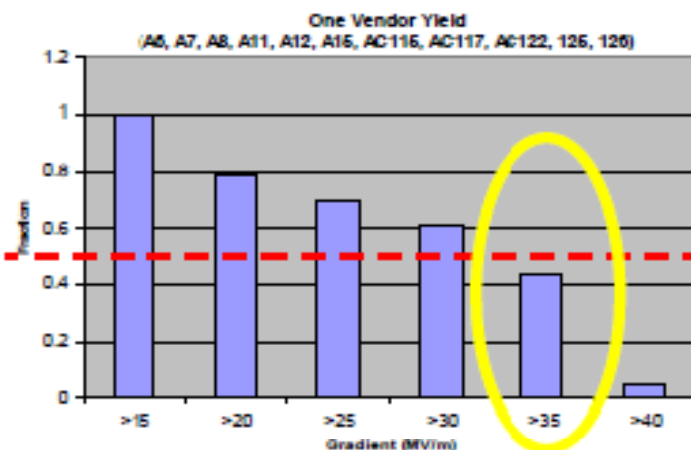
ACCEL, AES, Zanon, Ichiro, Jlab

23 tests, 11 cavities

One Vendor

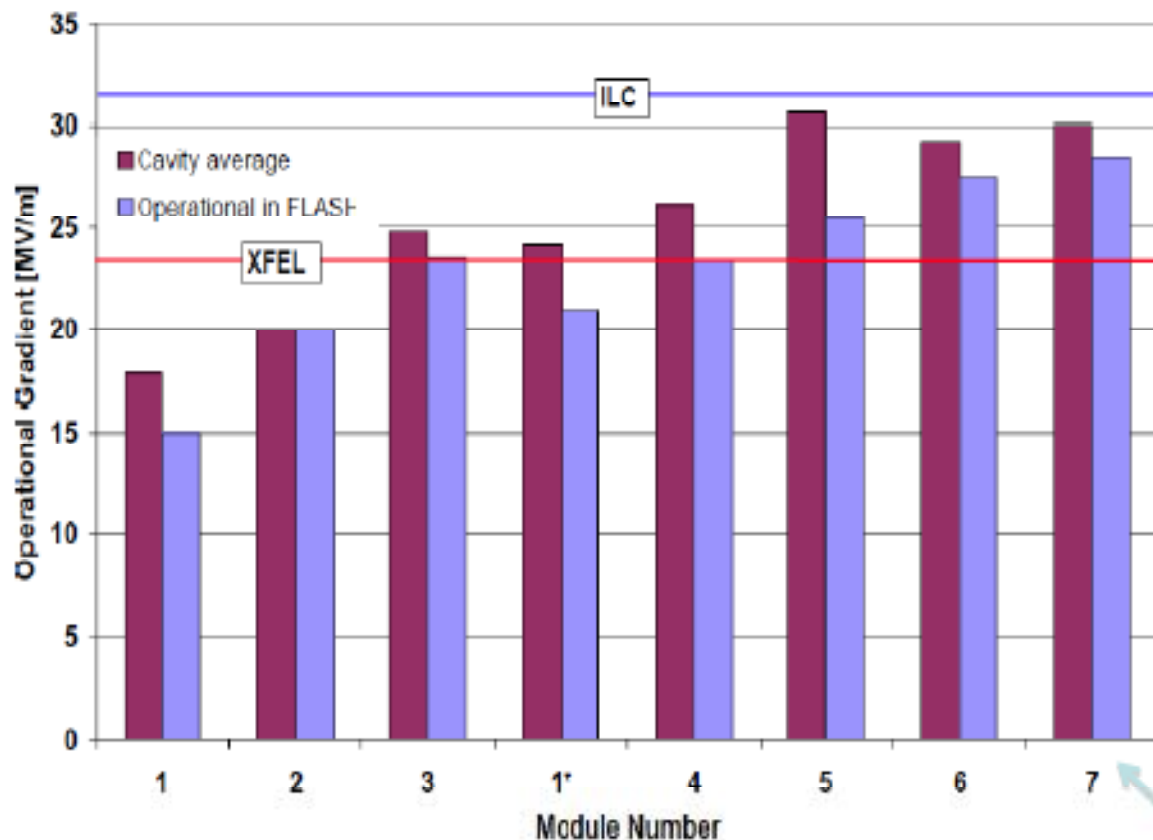


50%



Yield **45 %** at **35 MV/m** being achieved  
by cavities with a qualified vendor !!

# Cryomodule Gradient Progress



## ILC operation :

- $<31.5>$  MV/m spec
- (27 MV/m achieved at DESY/FLASH)
- (29 MV/m achieved DESY test stand)

• 20 % improvement required for ILC



- Beam delivery system studies
  - Demonstrate ~ 50 nm beam spot by 2010
  - Stabilize final focus by 2012
- Broad international collaboration (mini-ILC) for equipment, commissioning and R&D program



ATF2 Beam Line vacuum pipe connected in October

**Commissioning underway**

# Final Remarks

- We are on track to be able to propose the ILC on a time scale of ~2012 (or before!)
  - GDE R&D demonstrations
  - Cost/risk/performance optimized technical design
  - Project Implementation Plan
  - Detector LOIs → Technical designs
  - LHC results
  - Outreach to generate support from science community, funding agencies, etc
- **Welcome! This meeting should be particularly interesting: first following LOIs; and first AAP review (or experiment)**



# ILC cost (Germany version) ( for a host country/region )

Euro  
per citizen  
per year

**Bier vom Fass**

eine Wurst mit  
Sauerkraut

~7 years



# Research Director



# LOIs

- They contain much information for IDAG to study for validation.
- While the length was limited by ILCSC, all groups overrun the given limit to some extent.  
(We agreed on certain excesses.)
- The groups provided more detailed information with support documents. These are also available from their web pages.

**They reflect tremendous amount of work carried out by the groups in preparing for the LOIs.**

- Many authors signed the LOI. They included many university people.

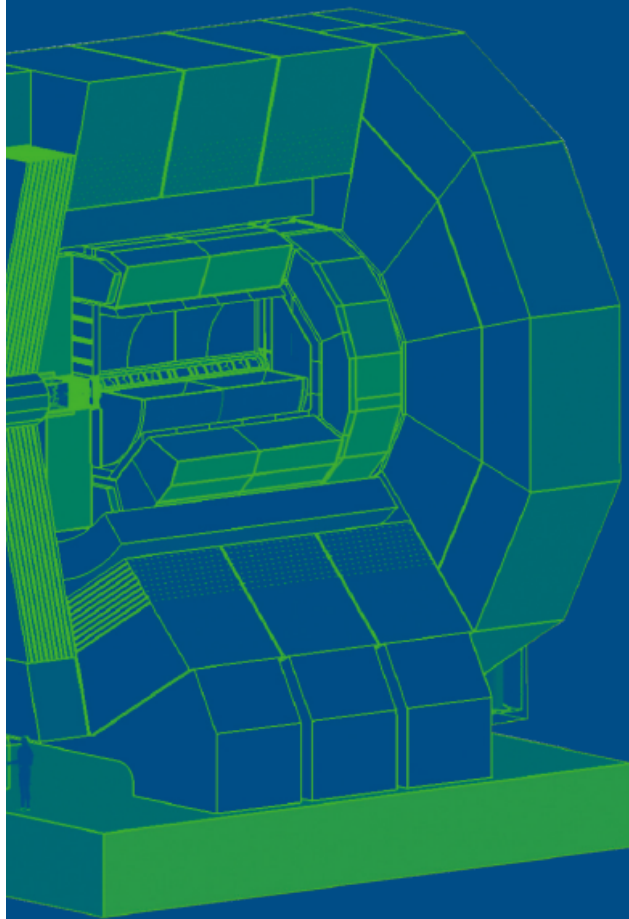
ILD (148 Inst.), SiD(77 Inst.), the 4<sup>th</sup>(32 Inst.)

- It is encouraging and important in the view that ILC will be a research facility for yet-young students.
- Also there will be many topics for universities to study regarding R&D for detector technologies and physics simulations.



## The International Large Detector

Letter of Intent



by the  
ILD Concept Group  
March 2009

## The ILD group

Location of LOI and  
supporting documents

[http://www.ilcild.org/doc  
uments/ild-letter-of-intent](http://www.ilcild.org/documents/ild-letter-of-intent)

**Introduction**

**Detector Optimization**

**Physics performance**

**Sub-detector system**

**DAQ and computing**

**Detector integration and**

**MDI**

**Costing**

**The group**

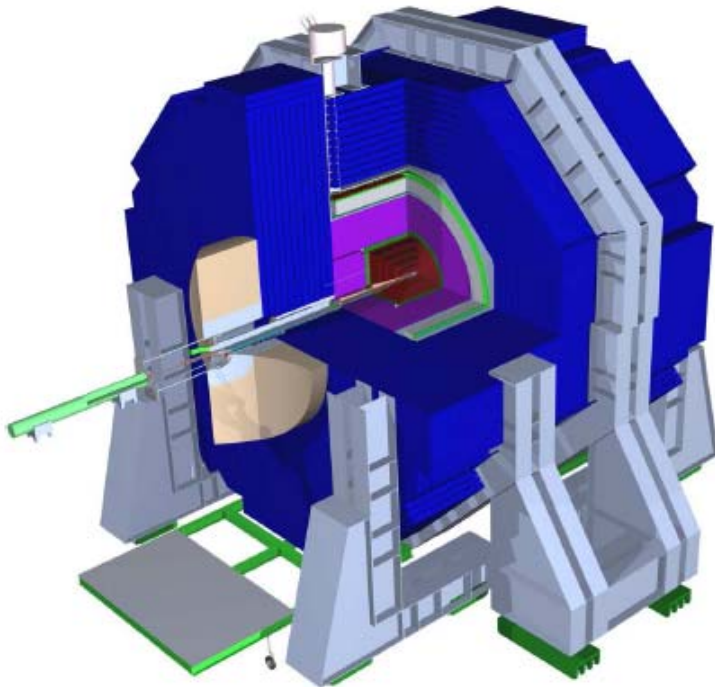
**R&D plan**

**Conclusion**



## SiD Letter of Intent

31 March 2009



## The SiD group

Location of LOI and  
supporting documents

<http://silicondetector.org/display/SiD/LOI>

**Introduction**

**Subsystem**

**MDI and global issues**

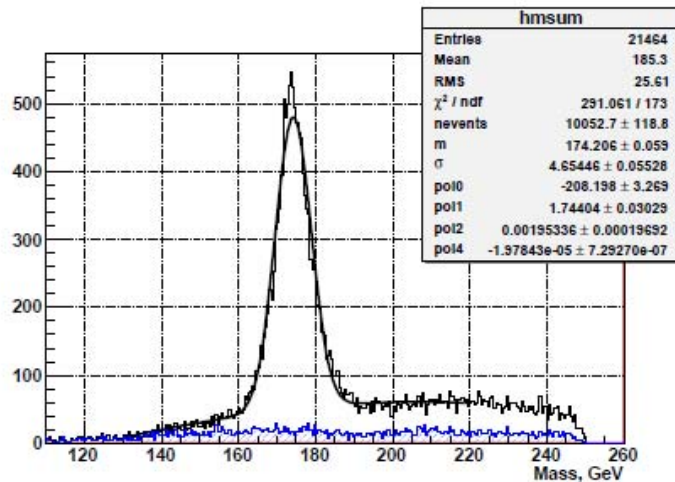
**Physics performance and**

**Benchmarking**

**Cost estimate**

**SiD R&D**

Letter of Intent from the  
Fourth Detector ("4th") Collaboration at the  
International Linear Collider



*t* quark mass reconstructed with standard model backgrounds.

## The 4<sup>th</sup> group

The LOI location

<http://www.4thconcept.org/4LoI.pdf>

Supporting documents

<http://www.4thconcept.org>

**Introduction**

**Description of the detector**

**The performance of the  
detector**

**Physics Studies of the  
Benchmark processes**

**MDI**

**Status of realistic detector  
model and R&D**

**Structure and capability**

# IDAG

- **IDAG organized itself in Chicago to be ready for the validation process, as was reported by its Chair at LCWS08.**
  1. Each member will examine one of the three LOIs and also one of the four categories (Tracking, CAL, MDI, Benchmarks) through all the LOIs.
  2. IDAG listed more questions to be answered in LOIs.
- **IDAG had internal meetings after LCWS08 to become ready for LOIs.**
- **IDAG will listen to presentations this afternoon and interview each group tomorrow.**
- **There will be an IDAG-proper meeting on June 22/23 in Paris.**
- I expect and request IDAG to give a validation report at **the ALCPG meeting in New Mexico, during Sep.29-Oct.3, this Autumn.**

# Review Organization

- 'vertical' reviews by subject with one convener (all projects studied)
- 'horizontal' reviews by project with one referee (all aspects included)



Michel  
Davier

	Benchmarking		Tracking	Calorimetry	MDI
ILD	<u>Hewett</u>	Li	<u>Nickerson</u>	<u>Green</u>	Himel
SiD	Grosjean	<u>Palestini</u>	Danilov	Karlen	<u>Toge</u>
4 <sup>th</sup>	Godbole	<u>Grannis</u>	Elsen	<u>Kobayashi</u>	Kim



# Validation Schedule

- LOIs received March 31
- IDAG phone meeting on April 14
- 5-6 questions asked to each concept for fast feedback in Tsukuba
- Open presentations on April 17
- Separate interviews on April 18 (1.5 hr each)
- Common interview on benchmarking (1.5h)
- More questions/clarifications asked
- Follow-on interviews on June 19 (+20?)
- Decision in September

# Benchmark analysis

In the Monte Carlo analyses we can often reach the correct answer, simply because we know the ‘answer’ as well as input background distributions/cross sections.

Although there are many indirect hints for the new physics at TeV energy scale, we are not sure if there is a light Higgs or TeV scale SUSY. SUSY breaking mechanism is unknown:

Anomaly mediated, Gravity mediated, Gauge mediated,...

Probability that Nature chooses **SPS1a** or **LCC1** point is  $1/\infty = 0$ .

**Nature can be far beyond the imagination of theorists.**

Then, what we can learn from the benchmark studies ?

We need to study several very different event topologies to study performance of subdetectors and the optimization of overall detector concept.

Young physicists and students have done tremendous amount of simulation analyses for LoIs under some pressure of your supervisors within a limited time.

Not to be discouraged, when your results are not so good as others. Please find out the reason....

To judge the maturity of detector technologies is not easy. Many detector options may be kept open until the approval of the project.

We need to attract hardware oriented physicists worked on LHC detectors ....

# $\geq$ Two Detectors

Balance between

The highest physics outcome :

To put all the budget into one state-of-the-art detector with a truly international collaboration might be ideal.

Systematic errors cannot be simply cancelled between two detectors.

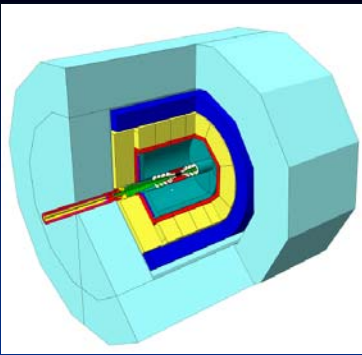
In order to cross-check the results at least two detectors are needed (parameter committee ILCSC).

The sociology of the community:

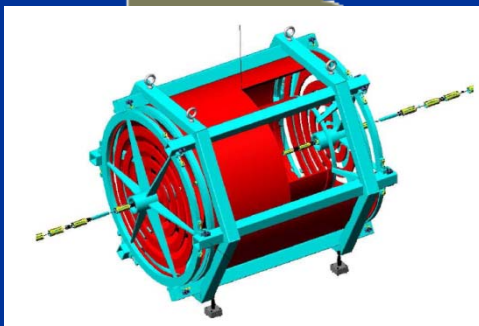
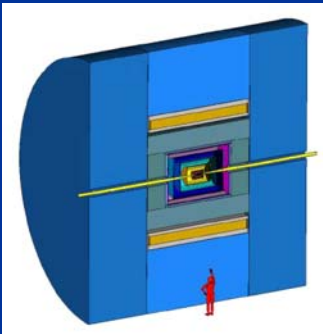
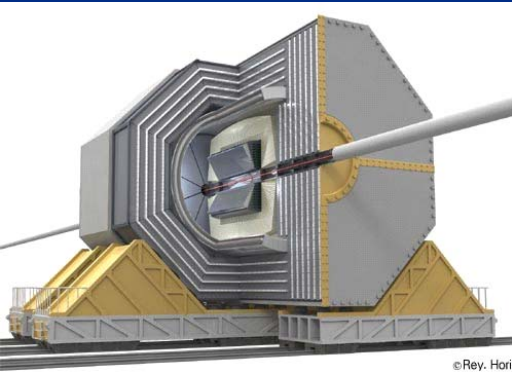
The ILC physics/detector community is large enough to have two detectors. Competition is a driving force.

ATLAS/CMS, H1/ZEUS, BaBar/Belle, ...





ILD

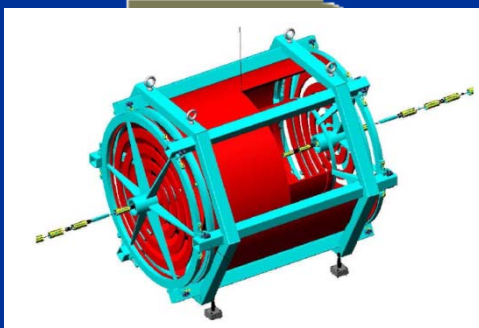
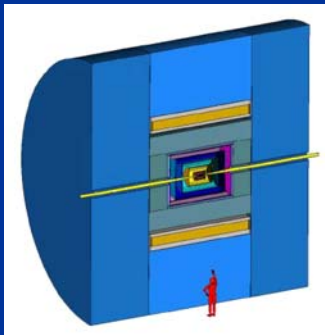
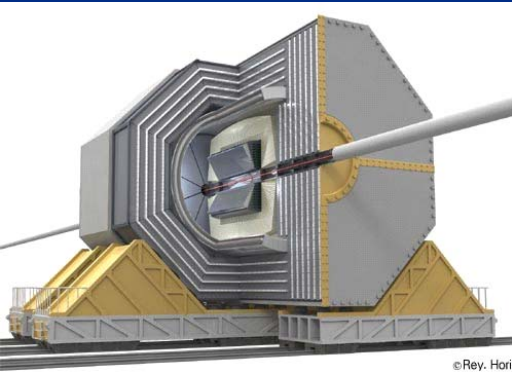
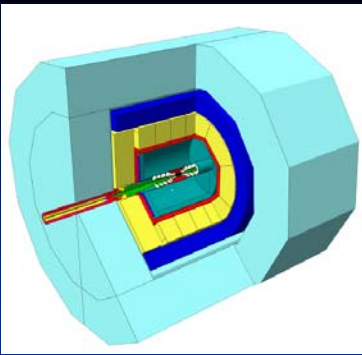


We do not know what will happen  
after IDAG recommendations



# Grand Unification

Imagine all the physicists  
living in a team



ILD

??

???



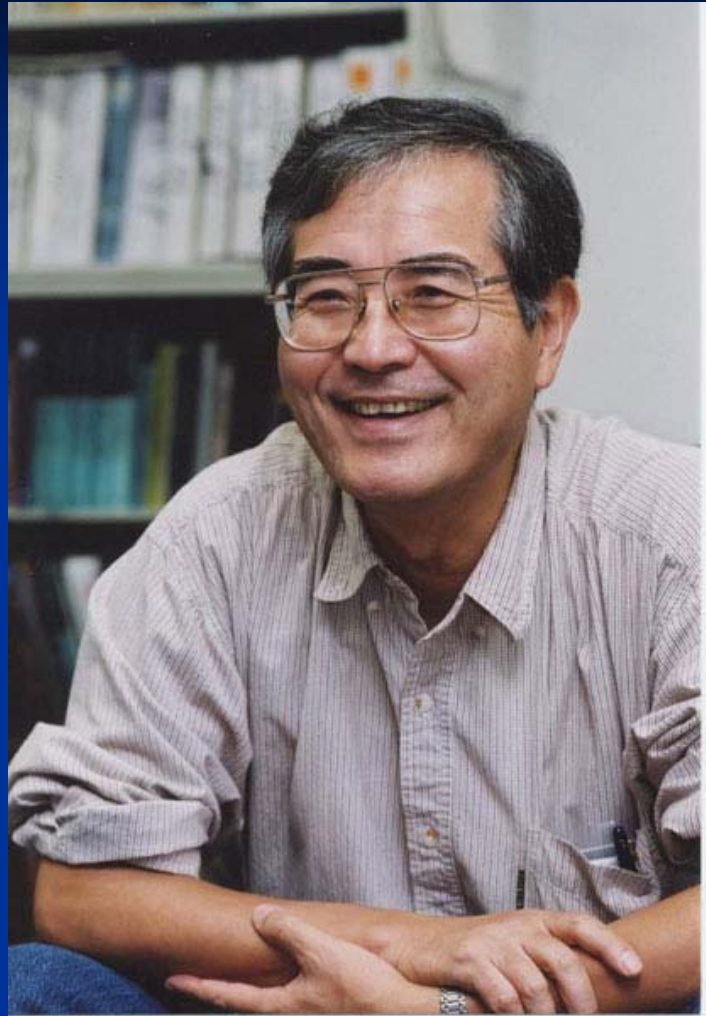
# Conclusions

- We need to have an overall project proposal of ILC by 2012.
- The proposal should be based on a realistic accelerator design supported by R&D results of hardware (specially the main linac devices are developed towards industrialization) .
- The detector design(s) should be done in parallel with the accelerator design.
- We need to be well prepared for upcoming first results (hints) of new physics from LHC.



I am always  
in your side

This talk is dedicated to ...



Yoji Totsuka



Takakyuki Matsui

# Thank you !

- We would like to thank all the participants of this workshop including specially IDAG members and AAP members from the outside of LC community.
- The success of this workshop depends very much on the local organizers, secretaries, staff members of the workshop.
- We will see one another again in the ALCWS Albuquerque, New Mexico on September 29<sup>th</sup>.