Overview of physics RDR and the next step

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ILC Reference Design Report, Volume 2, Physics at the ILC

RDR: 4 volumes published in August 2007
vol. 1 Executive summary
vol. 2 Physics at the ILC
vol. 3 Accelerator
vol. 4 Detectors

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K. Abe, D. Marlow , J. Timmermans

Available at **arXiv:0709.1893** [hep-ph]

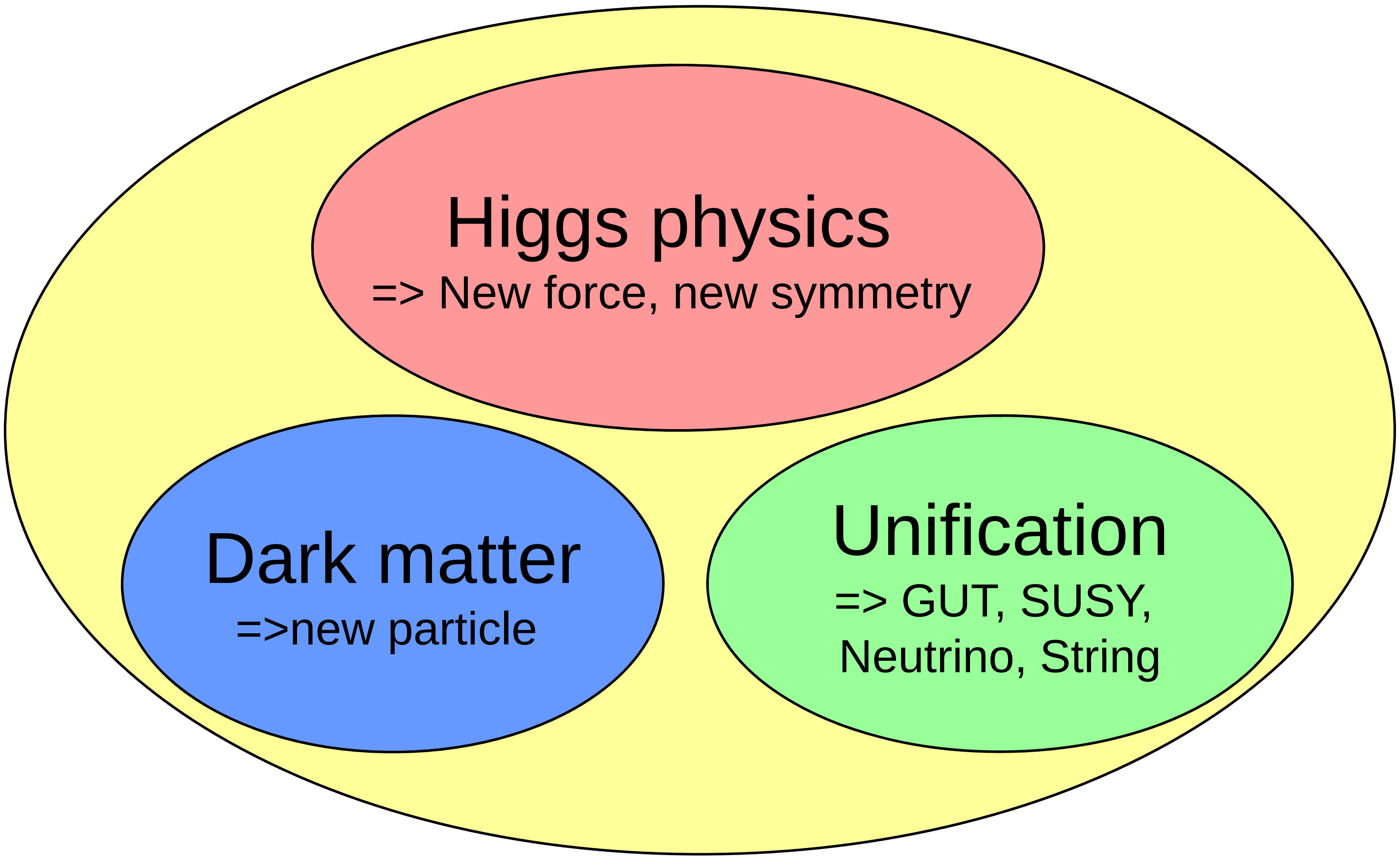
World-wide effort

- Work started around LCWS 06 (Bangalore) and ended around LCWS 07 (DESY) . Many inputs from the world-wide community at Vancouver, Valencia, and Beijing regional meetings.
- Mostly based on existing LC studies such as TESLA TDR (2001), ACFA LC report (2001) , Snowmass 2001 resource book and many updates/new studies since then.
- Mostly not based on “realistic” full-simulation studies. Physics goals are shown, but yet to be fully demonstrated.

Physics at the ILC

contents

Something new at Terascale



- LHC will have the first direct look at Terascale physics. ILC will be essential to understand new laws of nature.

Discovery of a Higgs boson at LHC.

Is this really Higgs particle?

Is the Higgs boson the SM one? If not, are there new phenomena besides the Higgs boson?

Discovery of a new gauge boson at LHC.

What are properties of new force, and its meanings in unification and cosmology?

Discovery of SUSY particles at LHC.

Is this really SUSY?

GUT? SUSY breaking? SUSY dark matter?

Requirements of ILC experiments

- Highest e^+e^- energy and variable energy: 200-500 GeV
- High luminosity: 500-1000/fb
- >80% e^- polarization (mandatory)

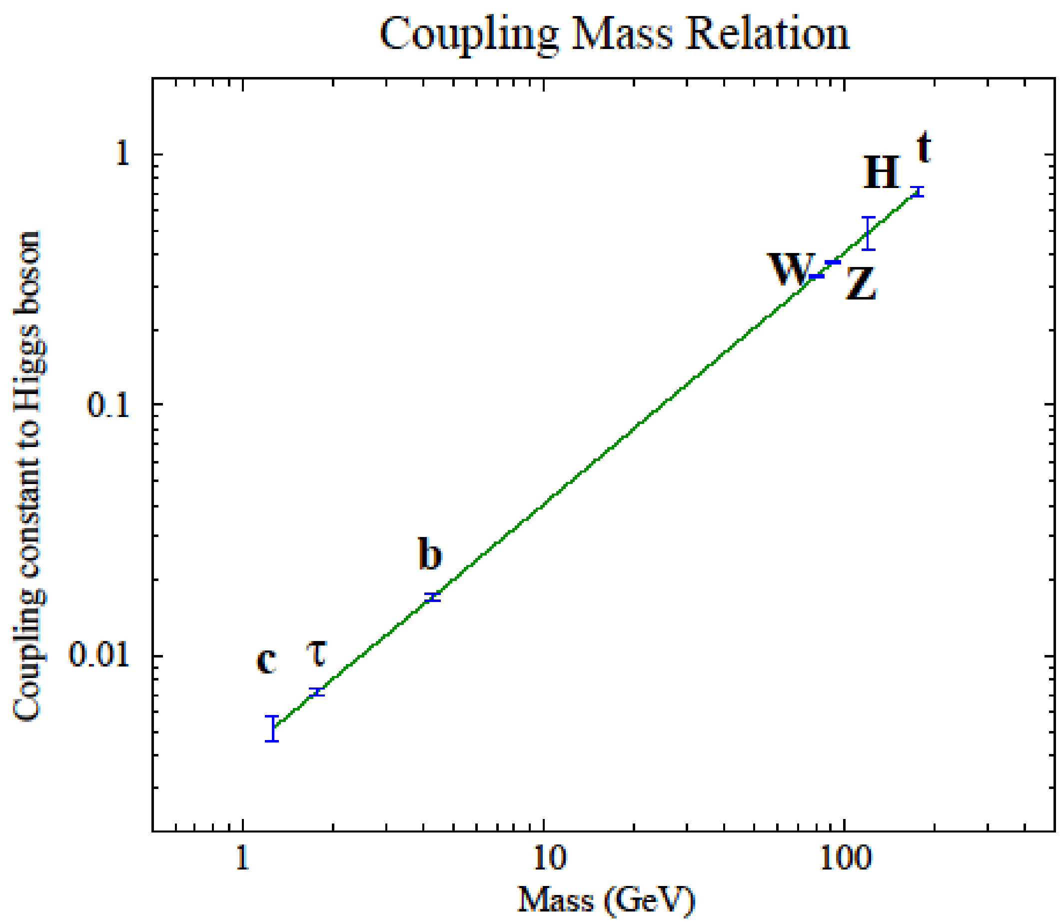
  >50% e^+ polarization
- Upgrade to ~1 TeV in the second stage.
- Possible Options: GigaZ, e^-e^-, $\gamma\gamma$, $e\gamma$
- Excellent detector performance: tracking, vertexing, jet energy resolution.

Energy scan, polarization, detector performance are all essential for physics studies at ILC.

Higgs physics

Precise determinations of mass, spin, couplings to other elementary particles.
=>
Establish the mass-generation mechanism.

Mass and coupling relation of one Higgs doublet model.

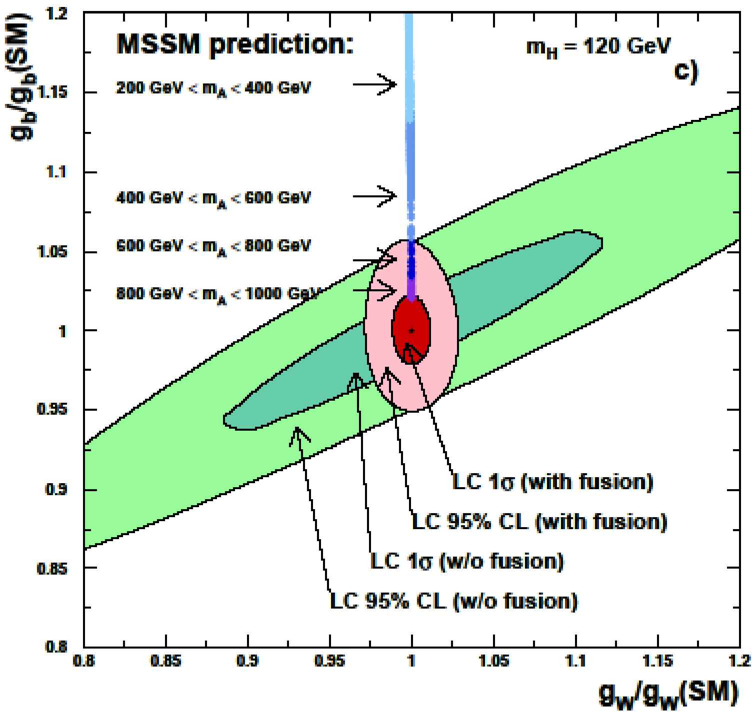


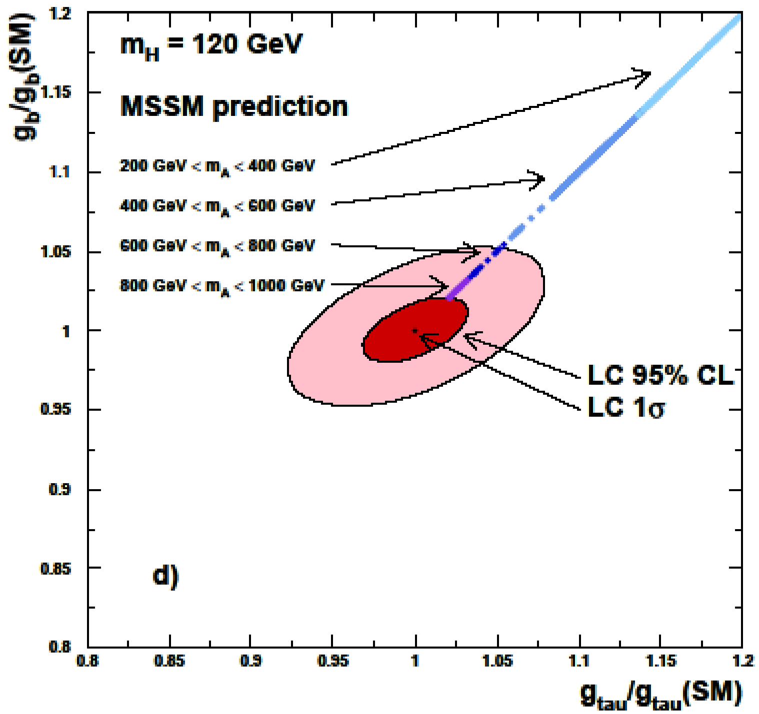
GLC project

Mh=120 GeV

Precise determination of the coupling constants => a window to non-standard Higgs sector.

Deviations of hbb, hWW, and hττ couplings in the MSSM.



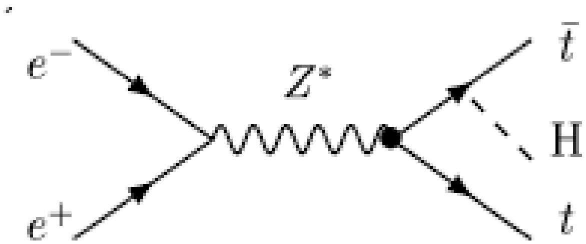


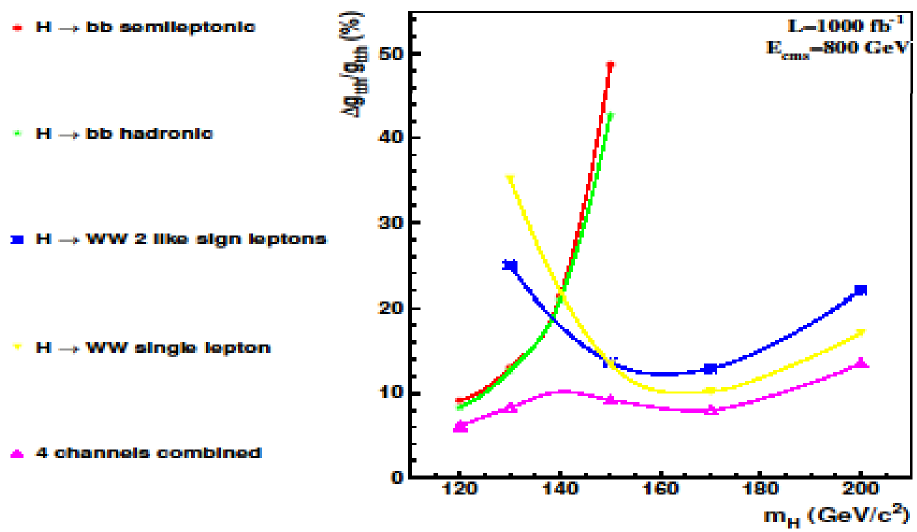
TESLA TDR

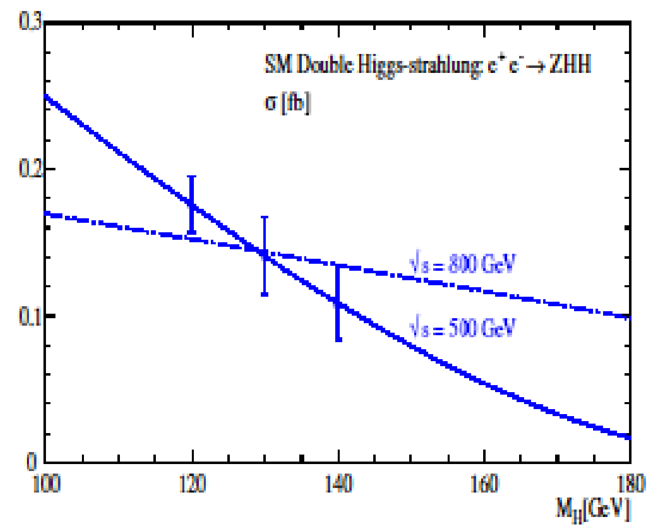
ttH and double Higgs productions

Top Yukawa coupling

Higgs self-coupling







A.Gay

Ecm =800 GeV

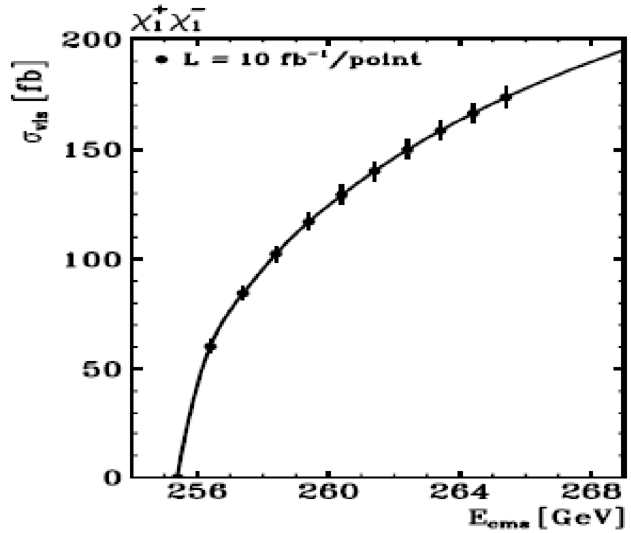
C.Castanier,P.Gay,L.Lutz,J.Orloff

Supersymmetry

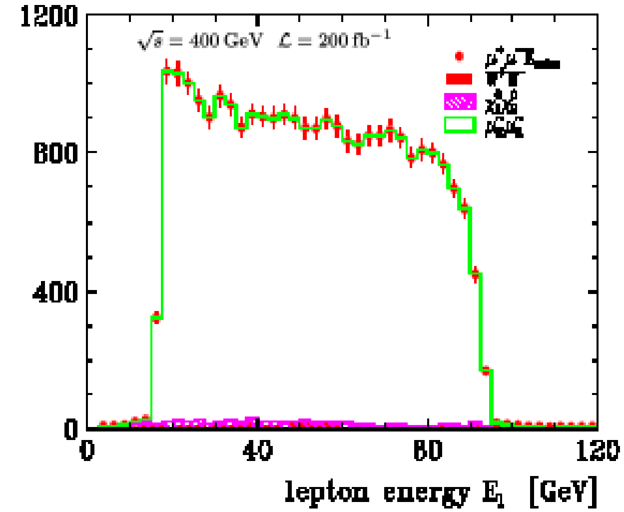
- If SUSY is realized in nature, it could provide us with a new framework to understand many fundamental questions.
  - GUT
  - Origin of the neutrino mass
  - Dark matter
  - Baryon number of Universe.

- As long as pair production of SUSY particles is possible, many important measurements can be carried out. Energy scan and beam polarization are essential tools.

Chargrino



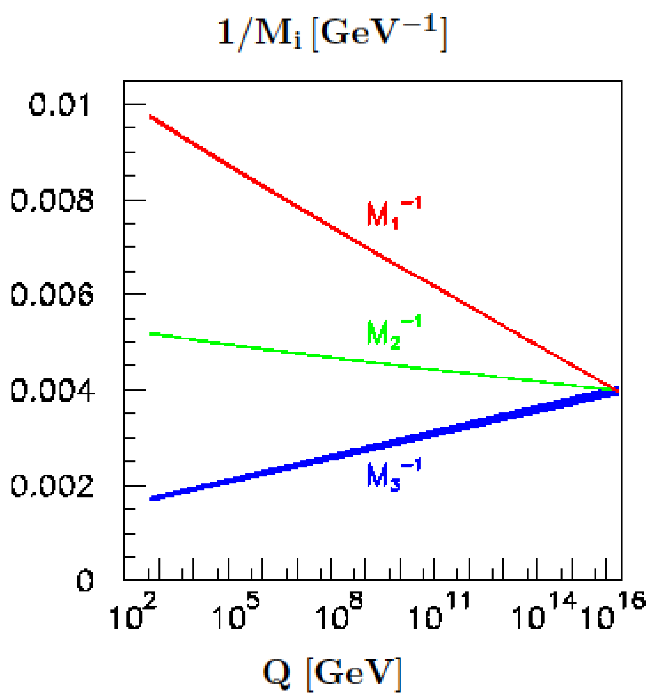
Slepton

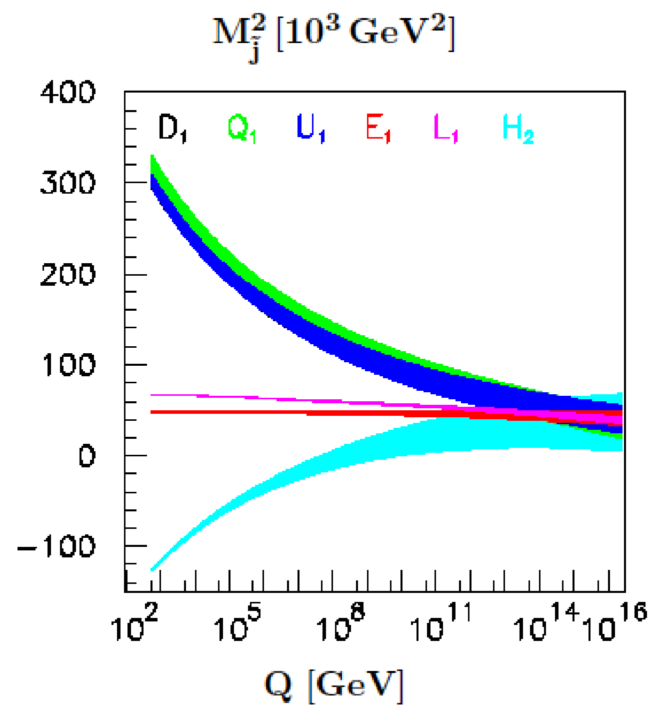


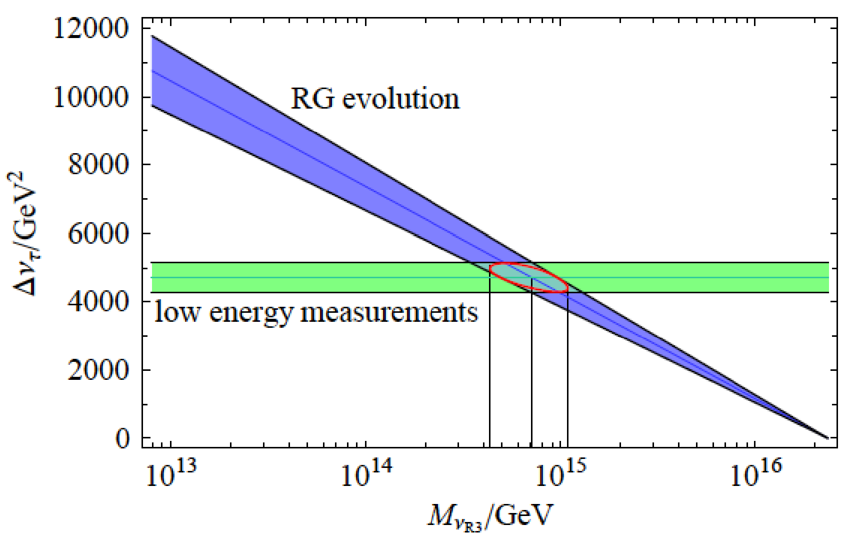
H.U.Martyn

Blair, Porod, Zerwas

Unification of SUSY breaking masses in SUSY GUT







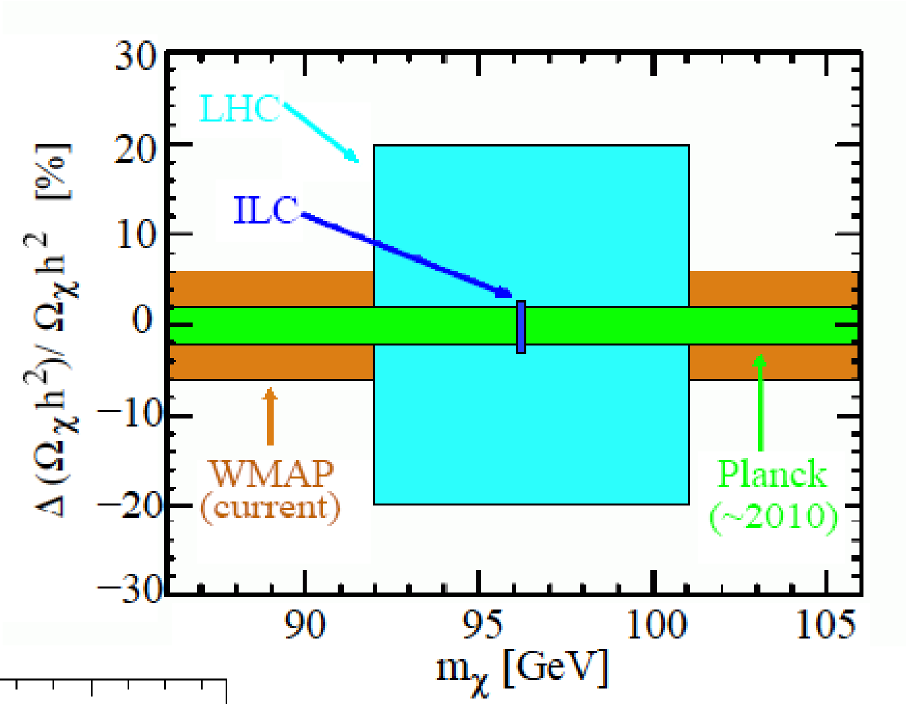
Seesaw neutrino mass scale and slepton mass difference

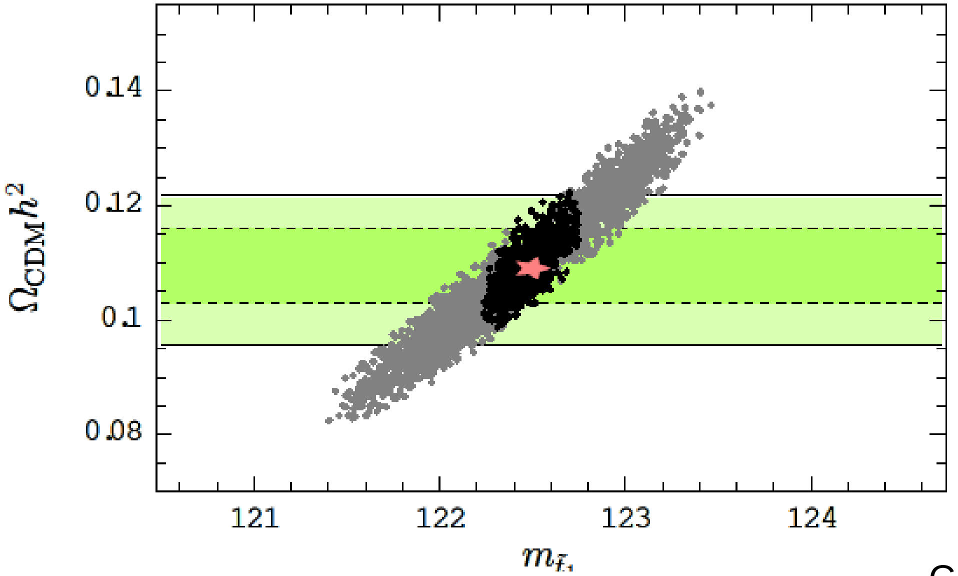
Freitas, Porod, Zerwas

Cosmological impacts

J.Feng

SUSY dark matter





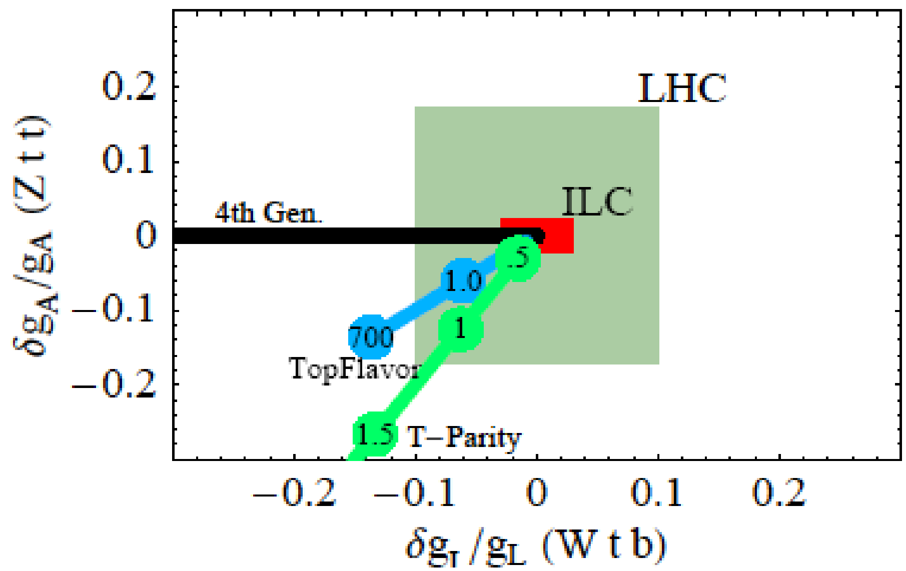
Dark matter abundance
in the electroweak baryogenesis
scenario.

Carena, Finch, Feitas, Milstene, Nowak, Sopczak

Precision studies of the SM processes

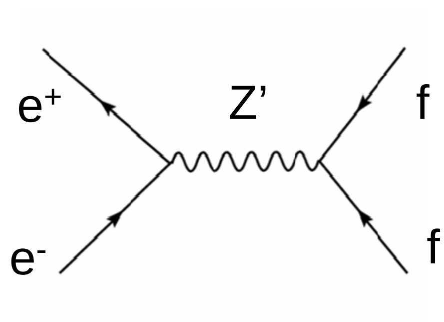
- Precise measurements of gauge boson top, and light fermion processes provide opportunities to look for new physics effects.
- If a new particle is found at LHC, these measurements are important to determine nature of a new interaction.
- Search limit by indirect processes may exceed the LHC limit.

Top quark anomalous coupling

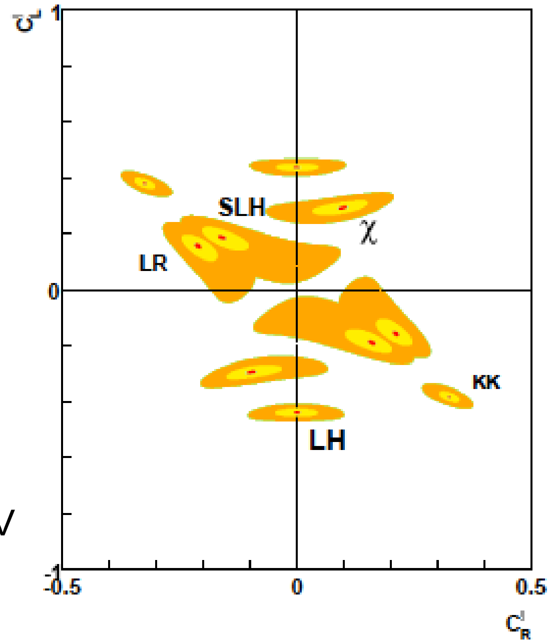


P.Bhartra and T,Tait

Distinction of various Z'modols



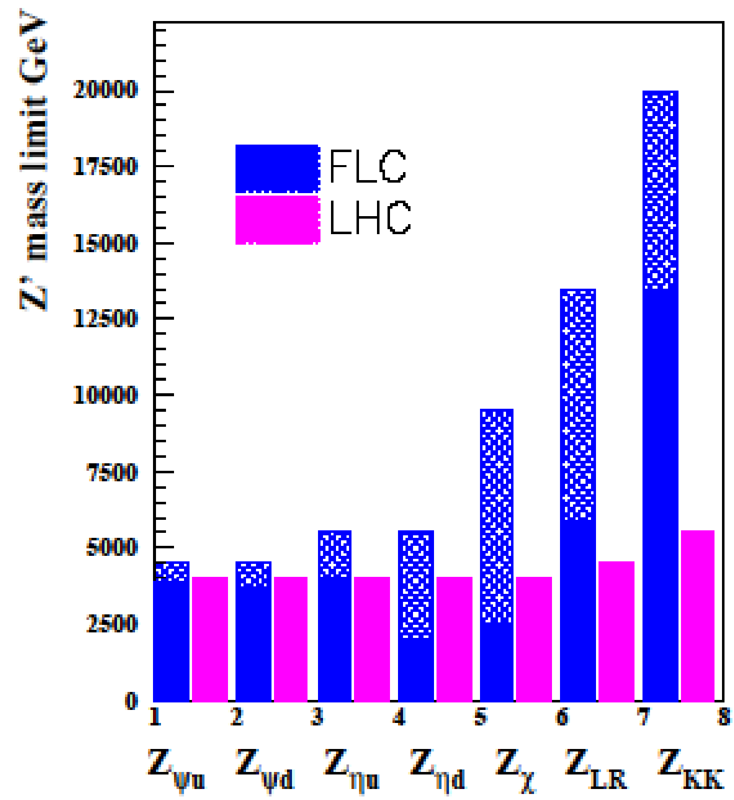
Godfrey, Kalyniak, Reuter



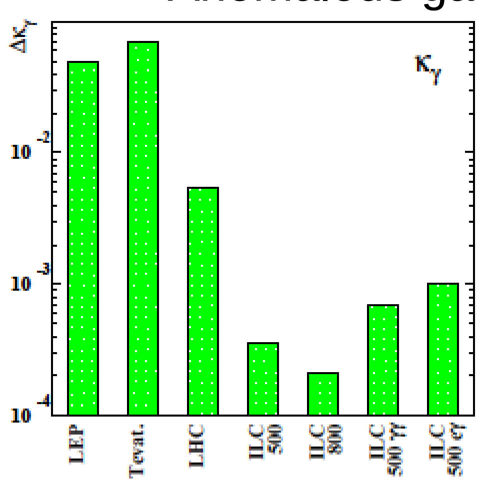
Mz'=1,2,3 TeV

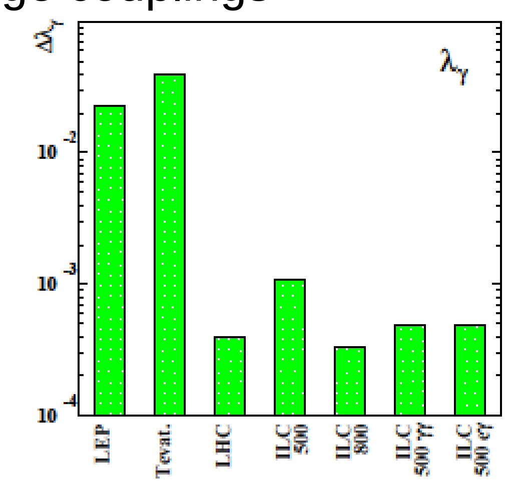
Indirect mass reach by ILC with the GigaZ option

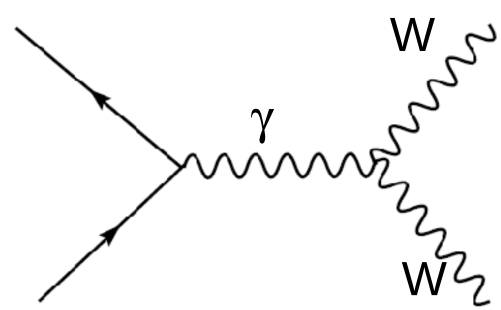
F.Richard



Anomalous gauge couplings





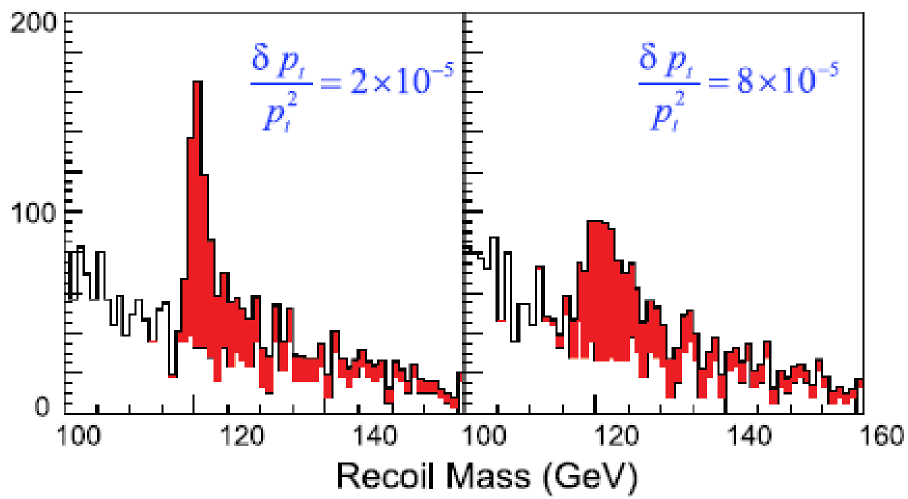


K.Moenig ,J.Sekaric

What is missing? The next step

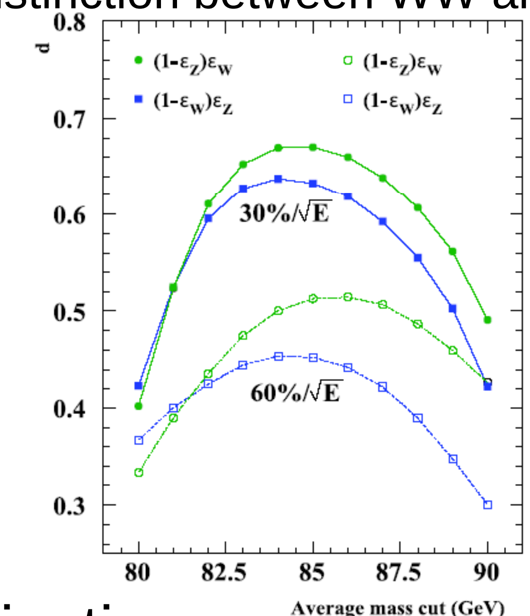
- RDR is mostly based on old studies. We need to justify them by realistic detector simulation.

Tracking resolution: ee-> HZ->μμX



T.Barklow

Jet energy resolution:
Distinction between WW and ZZ



TESLA TDR

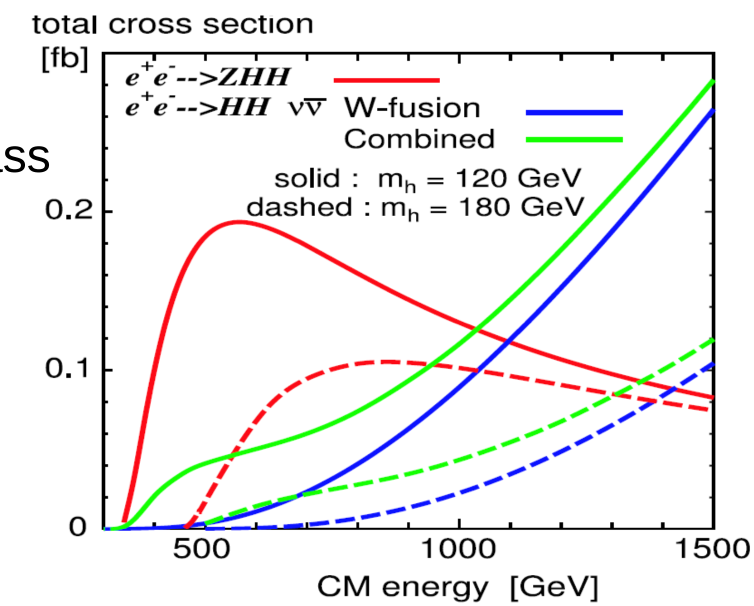
This will be done in detector optimization.

- Decision on the ILC will be made based on early discovery of LHC. We will need a detail project plan including energy, luminosity and options for the initial stage and possible upgrade. We need to fully prepare for the decision.

New particle threshold is clearly important.
The Higgs boson mass is a crucial parameter.

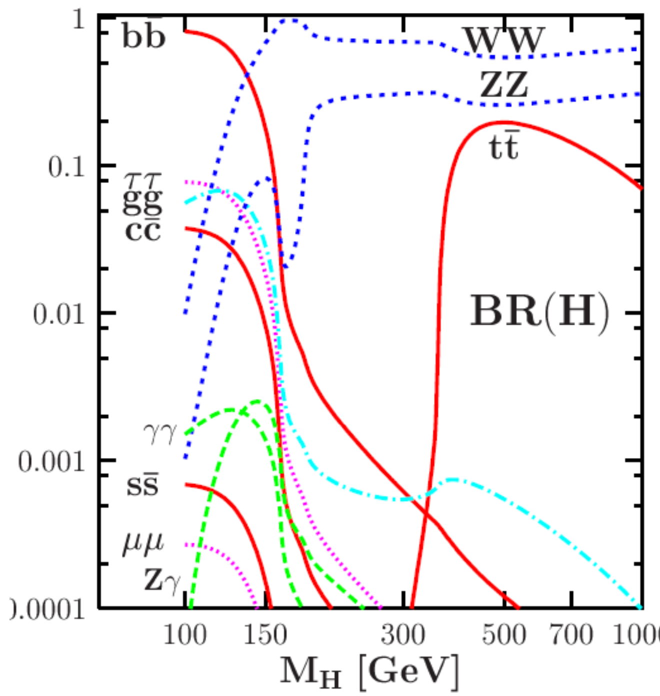
Higgs studies have been performed for limited values of mass and CM energy, especially for the topYukawa and Higgs self-coupling measurements.

Double Higgs production

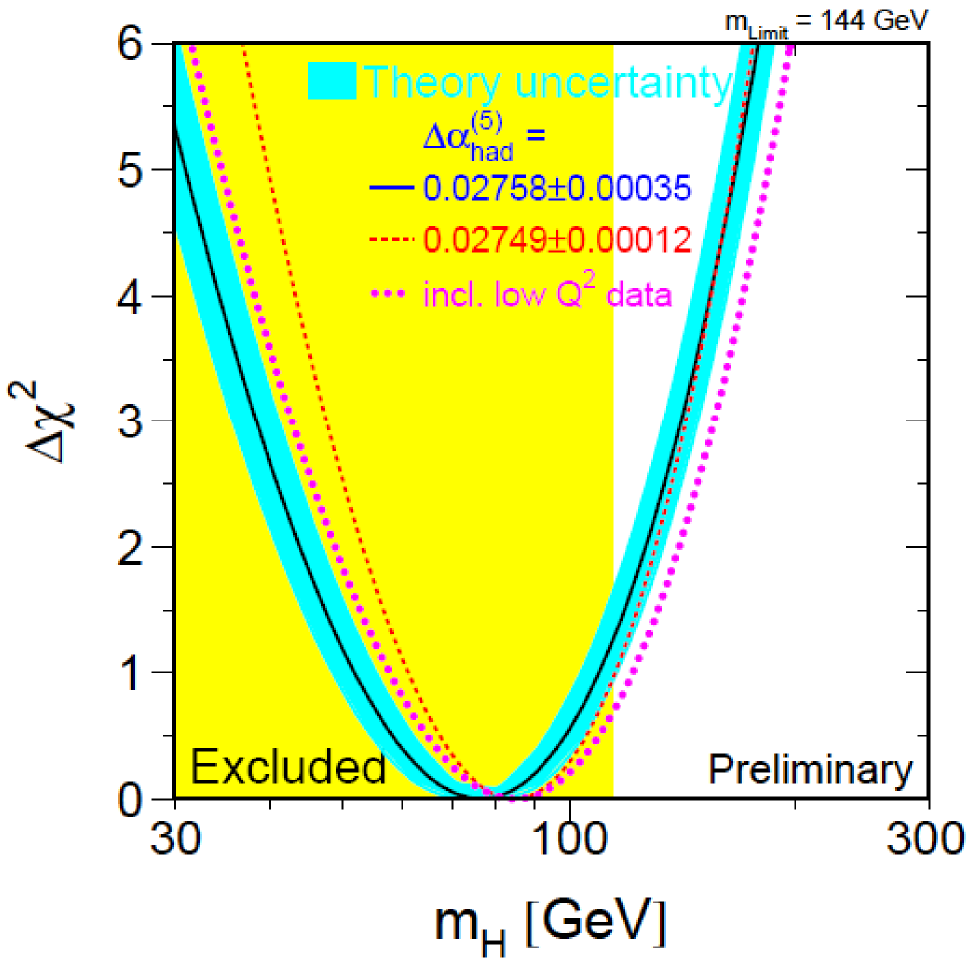


Y.Yasui,et.al.

SM Higgs branching ratio



A.Djouadi, J.Kalinowski, M.Spira



LEP EW working group

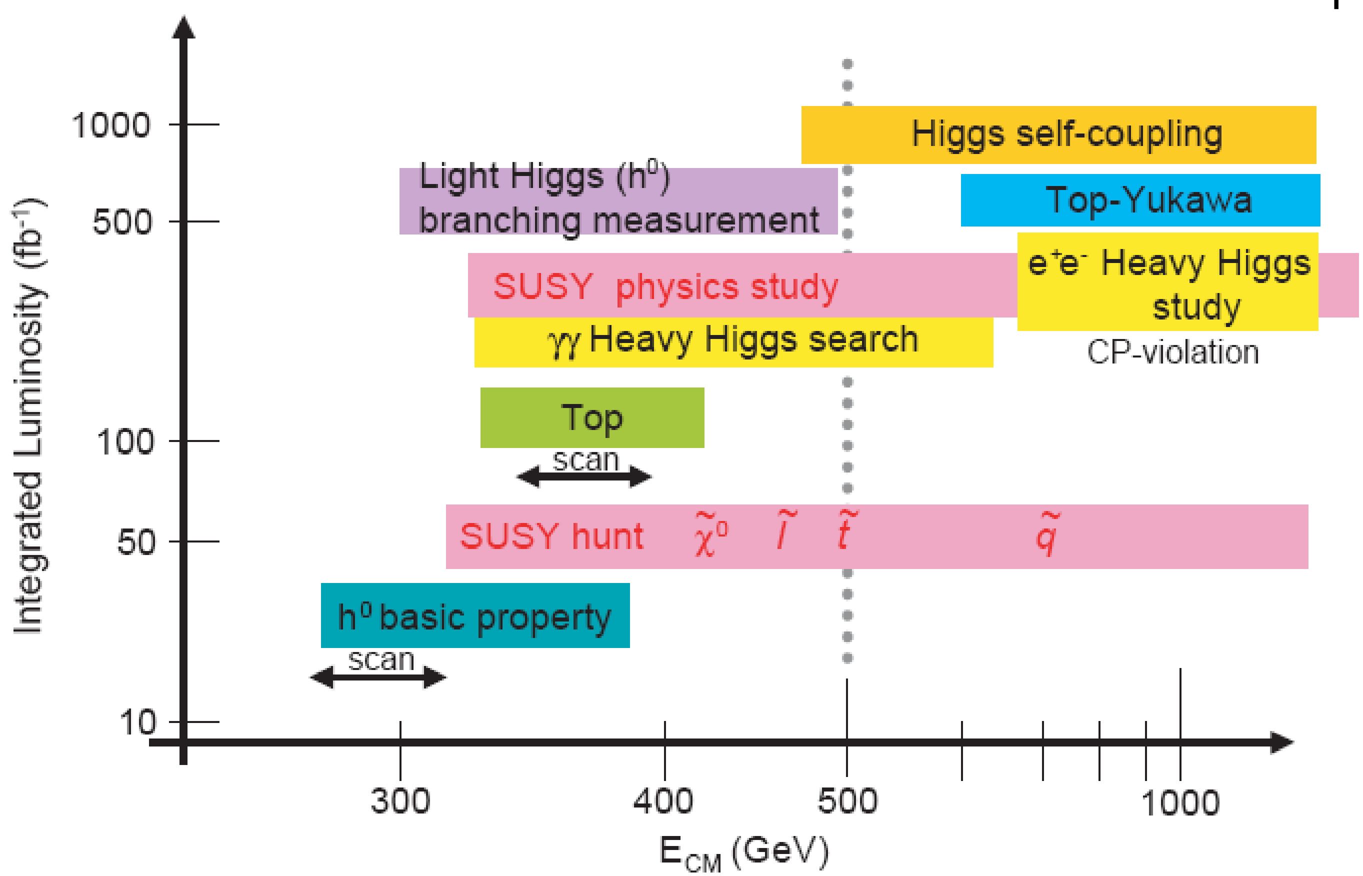
The SM Higgs mass bound

There are many examples of new physics models which include the SM like Higgs boson heavier than 200 GeV.

If the Higgs boson is heavy, it is likely that Higgs/Gauge/Top sectors are non-standard.

Energy-luminosity map

GLC project 2003



We need to have this kind of diagram based on LHC early discovery.

Conclusions

- Physics RDR is the first comprehensive report on Physics at the ILC prepared in the world-wide framework.
- Physics potentials presented in this report have to be demonstrated by detector design works.
- We should be ready to draw an energy-luminosity map for the ILC program by the time when early discovery of the LHC experiment is known.