# Concluding Remarks

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# Black December

- UK : 11-Dec-08, STFC Delivery Plan
  - 'We will cease investment in the international linear collider'
- US : Appropriations Act, Division C
  - ITER, NOvA → 0
  - 'In the current constrained environment and without CD0',

    ILC/SCRF → about 1/4 : Already spent!

# TILC08

- More than 200 registered
  - By far the largest of the past Asian regional ILC workshops
  - More than 1/2 from Europe and Americas
- Strong political support
  - Congressman Kawamura's talk
- Realistic progress on strategy
  - Accelerator and detectors

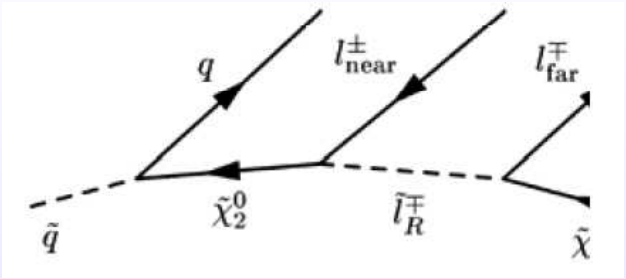
Scientific value of ILC remains valid

# LHC

- 14 TeV CM, p+p
- Run starts this summer !
- Preparation on schedule

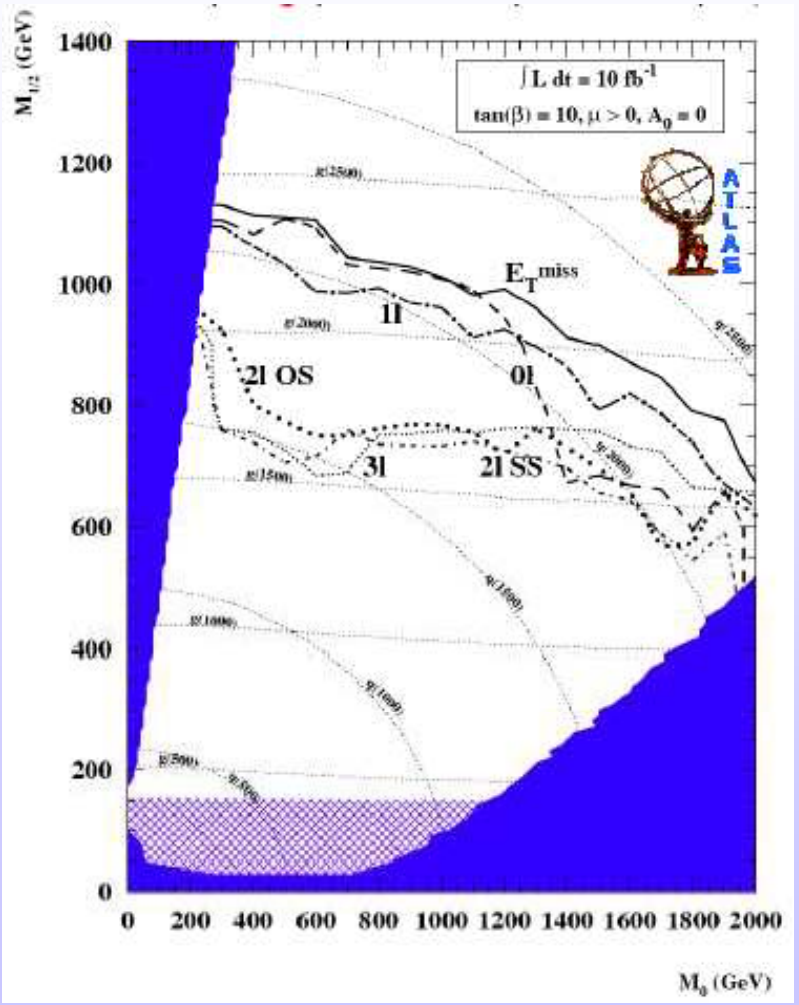
- Possible running scenario
  - 14 GeV CM
    2008 end : 1fb$^{-1}$/exp
    2009 end : 10fb$^{-1}$/exp
  - ~2025: 28 TeV CM?

# LHC SUSY search

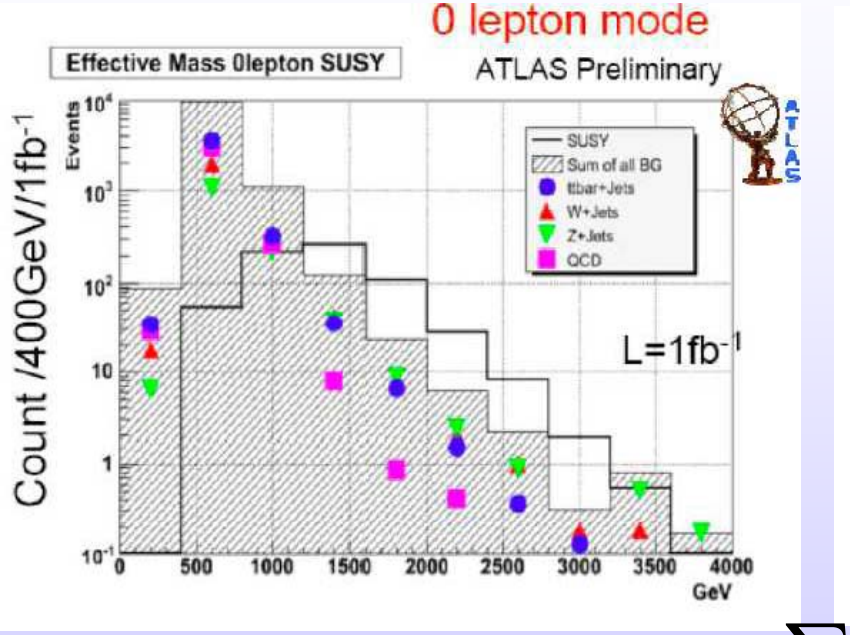


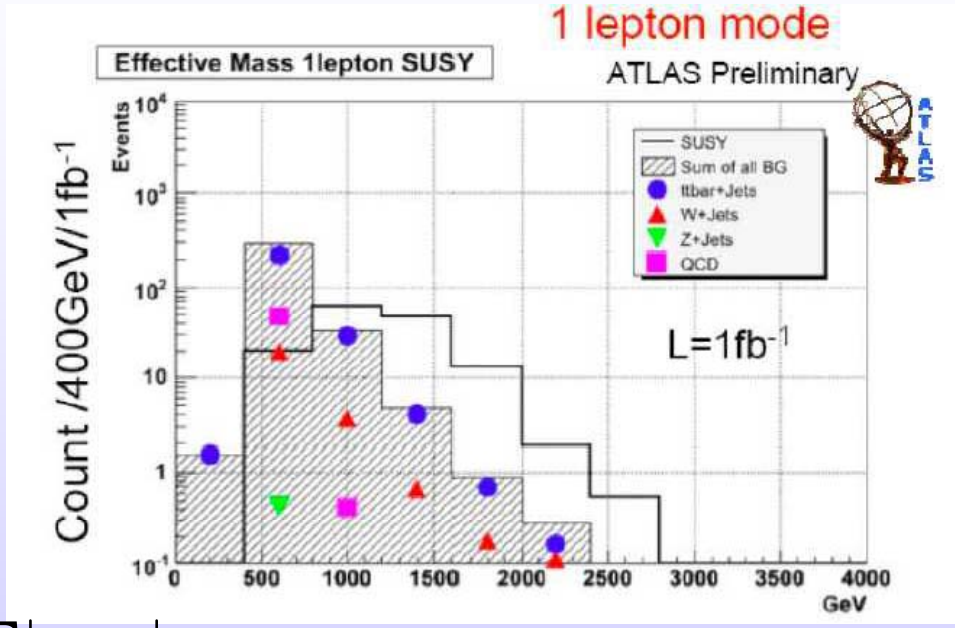

LSP

- Colored sparticles copiously created (they tend to be heavy)
- Typically a long cascade of squark or gluino decay
- Missing energy at the end (LSP)
- Leptons (e,μ,τ)
- 10fb-1 searches up to ~1.5 TeV



# LHC SUSY search




$$M_{\text{eff}} = \sum_{i=1,4} \left| \vec{p}_{\text{T}jet_i} \right| + E_{\text{Tmiss}}$$

- SUSY is detected as a global feature
- Is this really SUSY?

# LHC Mass Determination

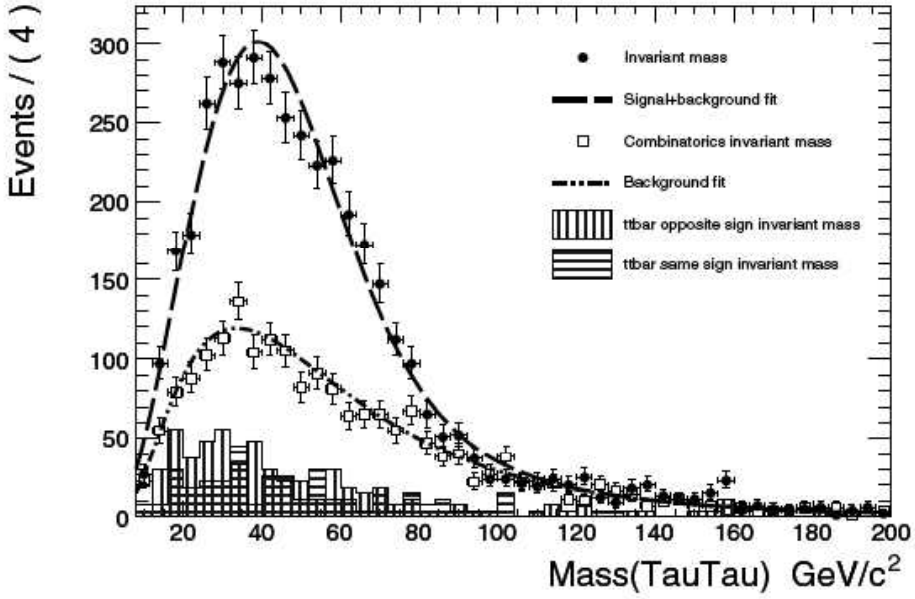
$$\tilde{q} \to q\tilde{\chi}_2^0 \to q(\tau\tilde{\tau}) \to q(\tau(\tau\chi_1^0))$$

- Signal: $\tau^+ \tau^-$ j + $E_{Tmiss}$
- Endpoints: $M\tau\tau$, $M\tau\tau j$, $M\tau_1 j$, $M\tau_2 j$, $M\tau_1 j - M\tau_2 j$
- Solve for 4 sparticle masses

CMS : 40 fb$^{-1}$

| | |
|---|---|
| $M(\tilde{\chi}_1^0)$ (GeV) | $147 \pm 23(\text{stat}) \pm 19(\text{sys})$ |
| $M(\tilde{\chi}_2^0)$ (GeV) | $265 \pm 10(\text{stat}) \pm 25(\text{sys})$ |
| $M(\tilde{\tau})$ (GeV) | $165 \pm 10(\text{stat}) \pm 20(\text{sys})$ |
| $M(\tilde{q})$ (GeV) | $763 \pm 33(\text{stat}) \pm 58(\text{sys})$ |

Multiple solutions



# ILC running scenario

(http://www.fnal.gov/directorate/icfa/para-Nov20-final.pdf)

- 1st stage
  - Energy 200-500 GeV, scannable
  - $e^-$ polarization > 80%
  - 500 $fb^{-1}$ in first 4 years
- 2nd stage
  - Energy upgrade to ~1TeV
  - 1000 $fb^{-1}$ in 3-4 years

# ILC options

- Additional 500 $fb^{-1}$ at 500 GeV in 2~3 years
  - Depends on results from LHC, ILC phase 1.
- $e^+$ polarization 50% or more
  - 30% polarization is in the baseline
- $\gamma\gamma$, $\gamma e^-$, $e^-e^-$ colliders
  - $\gamma$ generated by inverse Compton scattering
- Giga-Z (running on Z-pole)
  - $10^9$ Z's in a few months

# Supersymmetric Particles at ILC

- ILC can pair-create SUSY particles

$$e^+e^- \to \tilde{\mu}_R^+\tilde{\mu}_R^-,\ \tilde{\mu}_R \to \mu\tilde{\chi}_1^0$$

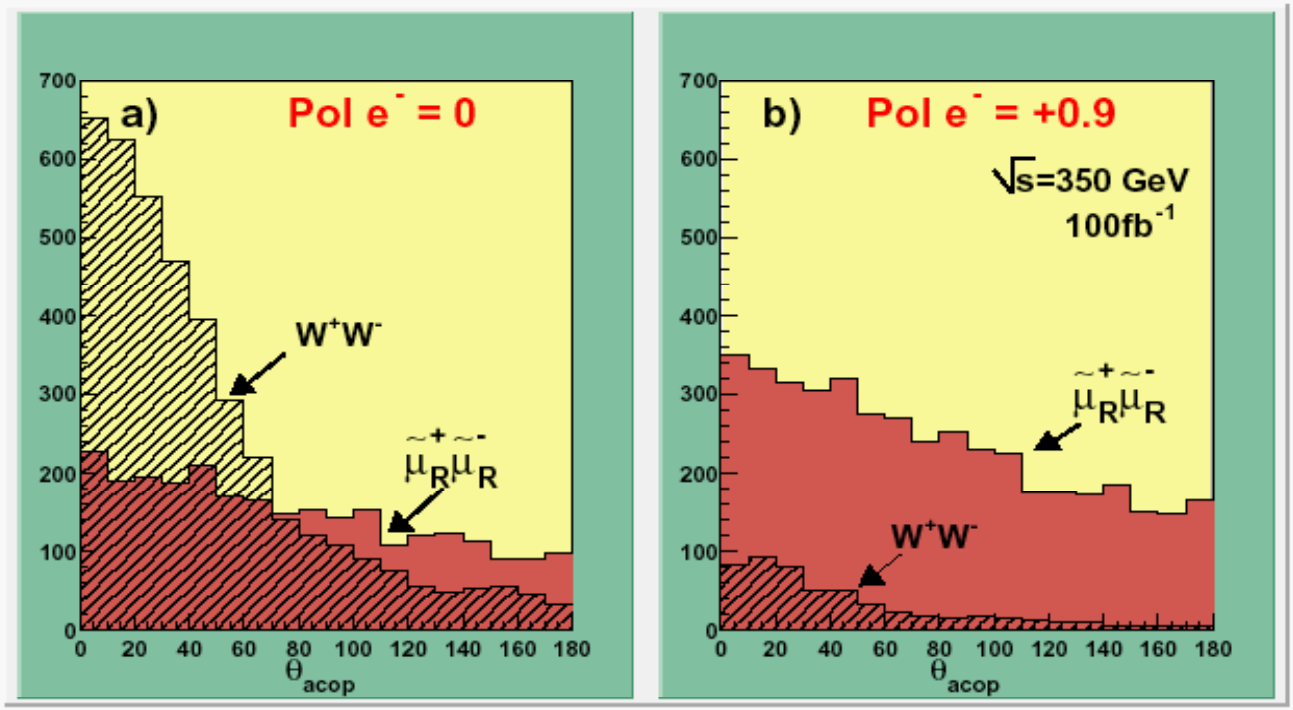
$$e^+e^- \to \tilde{\chi}_1^+\tilde{\chi}_1^-,\ \tilde{\chi}_1^+ \to W^+\tilde{\chi}_1^0$$

  etc.

- Precision measurements of masses and mixings
- Determination of spin, hypercharge etc.
- Beam polarization useful. It can also reduce backgrounds

# Smuon detection

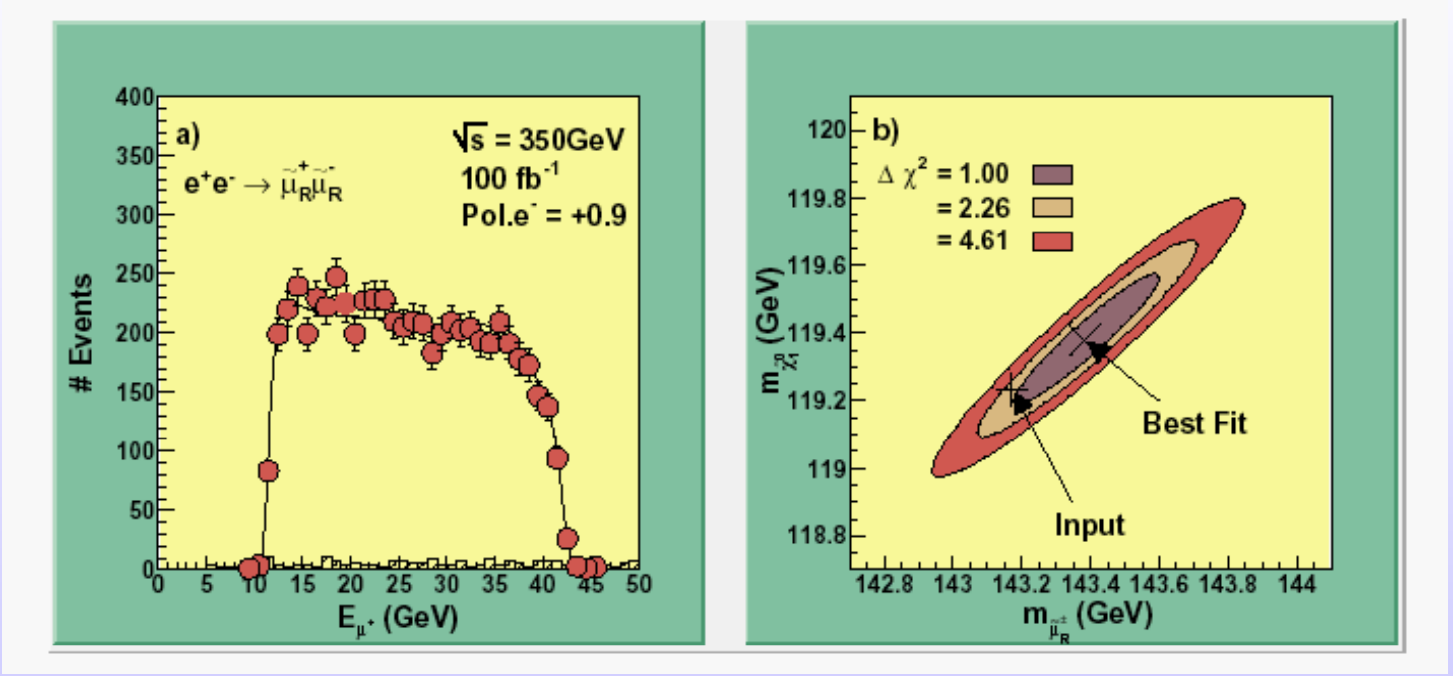
$$e^+e^- \to \tilde{\mu}_R^+\tilde{\mu}_R^-,\ \tilde{\mu}_R \to \mu\tilde{\chi}_1^0$$




- Signal : $\mu^+\mu^-$ and nothing. Plot acoplanarity of $e^+e^-\ \mu^+\mu^-$.
- Polarized $e^-$ (R) can reduce $W^+\ W^-$ background.

# Masses of smuon and LSP

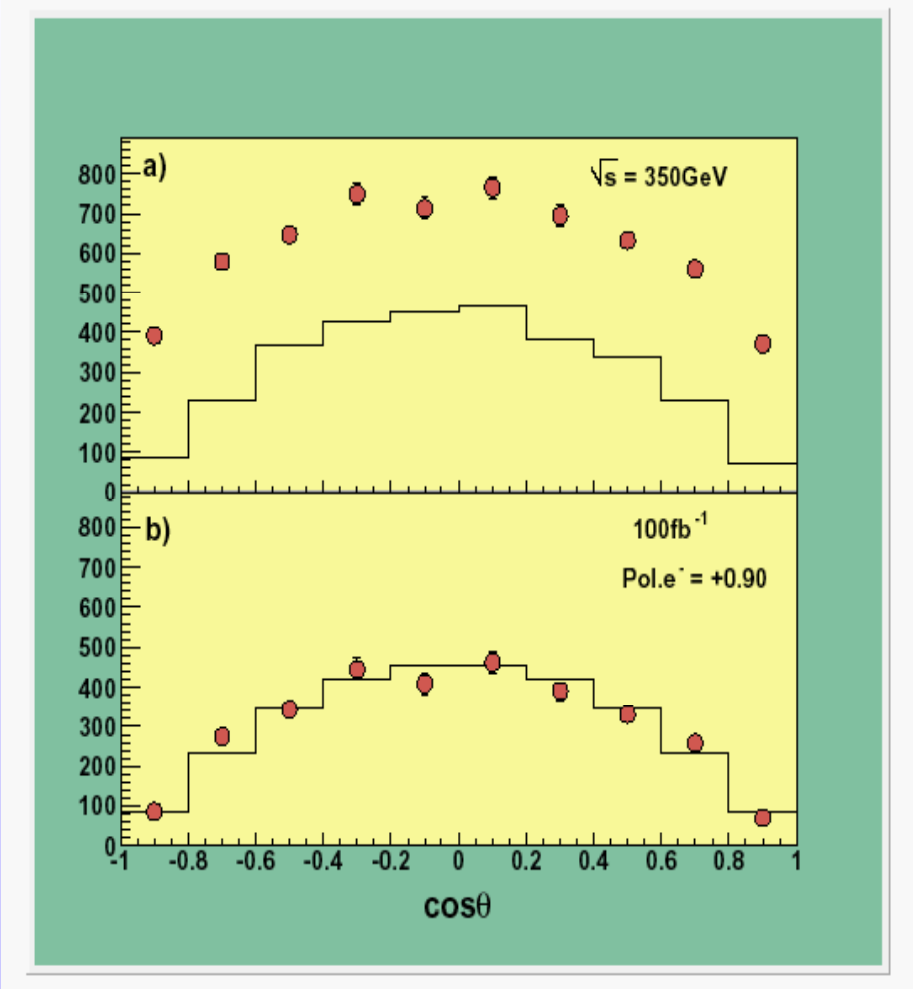
$$e^+e^- \to \tilde{\mu}_R^+\tilde{\mu}_R^-,\ \tilde{\mu}_R \to \mu\tilde{\chi}_1^0$$




- Known smuon pair 4-momentum
- Use the endpoints of $\mu^\pm$ for simultaneous determination of $m(\tilde{\mu}_R)$ and $m(\tilde{\chi}_1^0)$

# Smuon spin determination

$$e^+e^- \to \tilde{\mu}_R^+\tilde{\mu}_R^-,\ \tilde{\mu}_R \to \mu\tilde{\chi}_1^0$$




- Smuon production angle
  - Quadratic solutions
  - Wrong solution ~ flat
  - $\sin^2\theta \to$spin0
- Similarly for

$$e^+e^- \to \tilde{\chi}_1^+\tilde{\chi}_1^-$$

# SUSY parameter determination

- Charginos are mix of Wino and Higgsino with mass terms :

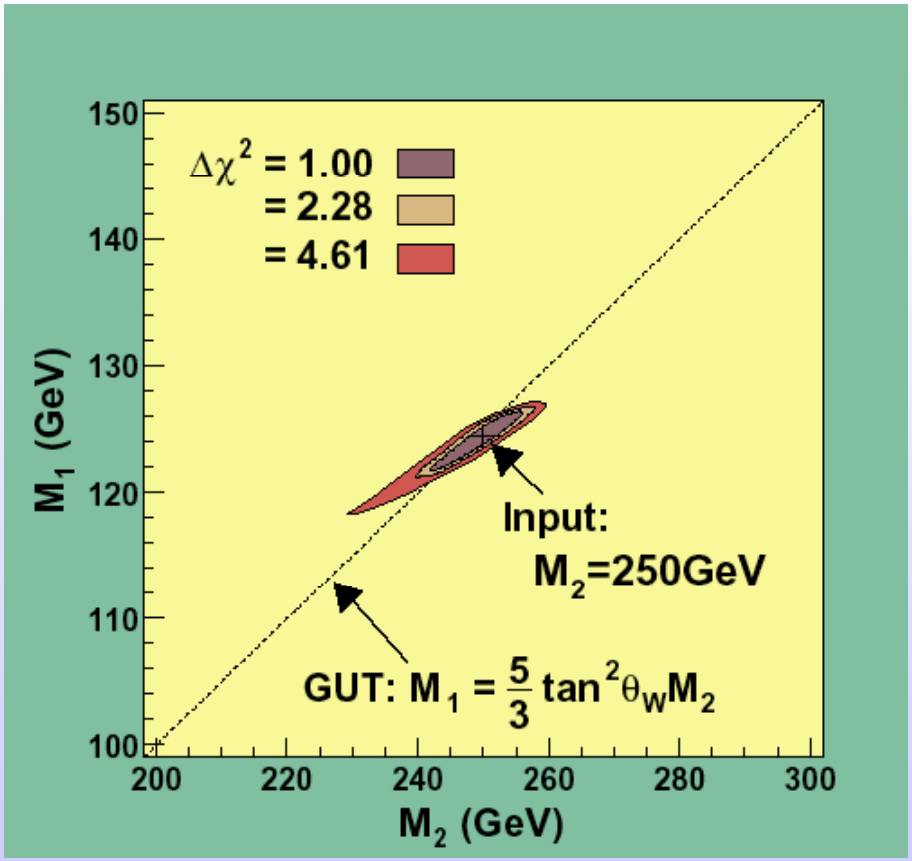
$$(\tilde{W}^+, \tilde{H}_u^+)\begin{pmatrix} M_2 & \sqrt{2}m_W \cos\beta \\ \sqrt{2}m_W \sin\beta & \mu \end{pmatrix}\begin{pmatrix} \tilde{W}^- \\ \tilde{H}_d^- \end{pmatrix}$$

- Use polarized beam ($e^-_R$)
  - Only Higgsino component of chargino contribute to chargino pair creation
  - Right-handed selectron pair production depends on Bino in S channel only
- Perform global fit of $(M_1, \tan\beta, M_2, \mu)$ to

$$\sigma(e^+e^-_R \to \tilde{e}^+_R\tilde{e}^-_R) \qquad \sigma(e^+e^-_R \to \tilde{\chi}^+_1\tilde{\chi}^-_1)$$

$$m(\tilde{\chi}^+_1) \qquad m(\tilde{\chi}^0_1)$$

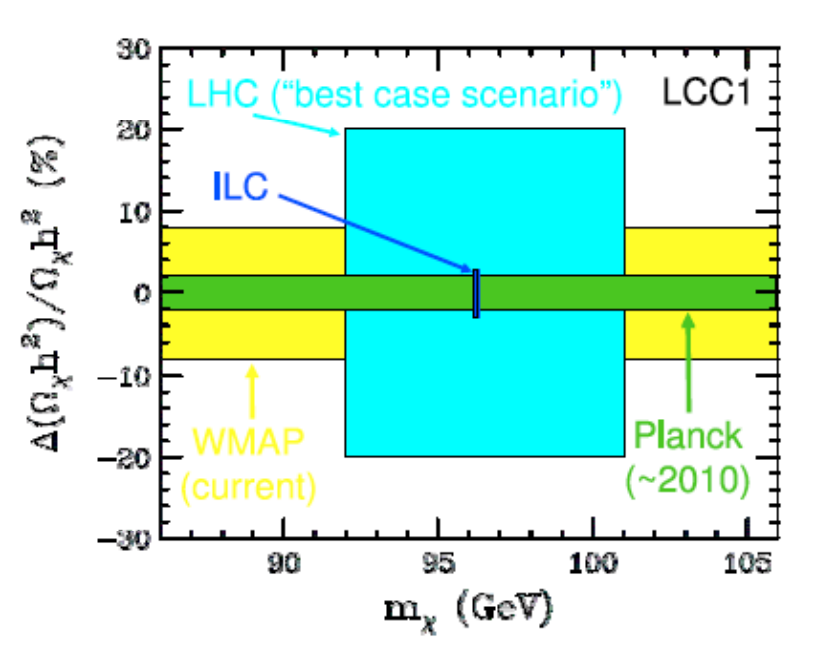
# SUSY parameters (cont'd)




- $E_{cm}$ = 500 GeV, 50 $fb^{-1}$
- Serves as a test of GUT relation (or other mechanism)
- Lagrangian reconstruction

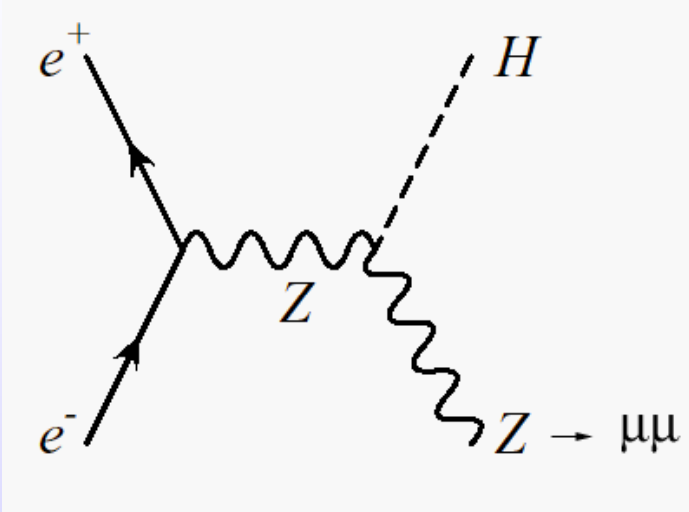
# Dark Matter

- Key question: can it explain the '23%'? (relic density)
- Production + annihilation rate → relic density
- Need to know all interactions contributing to LSP annihilation




Relic density estimation by LHC and ILC (mSUGRA SPS1a)

# Higgs at ILC



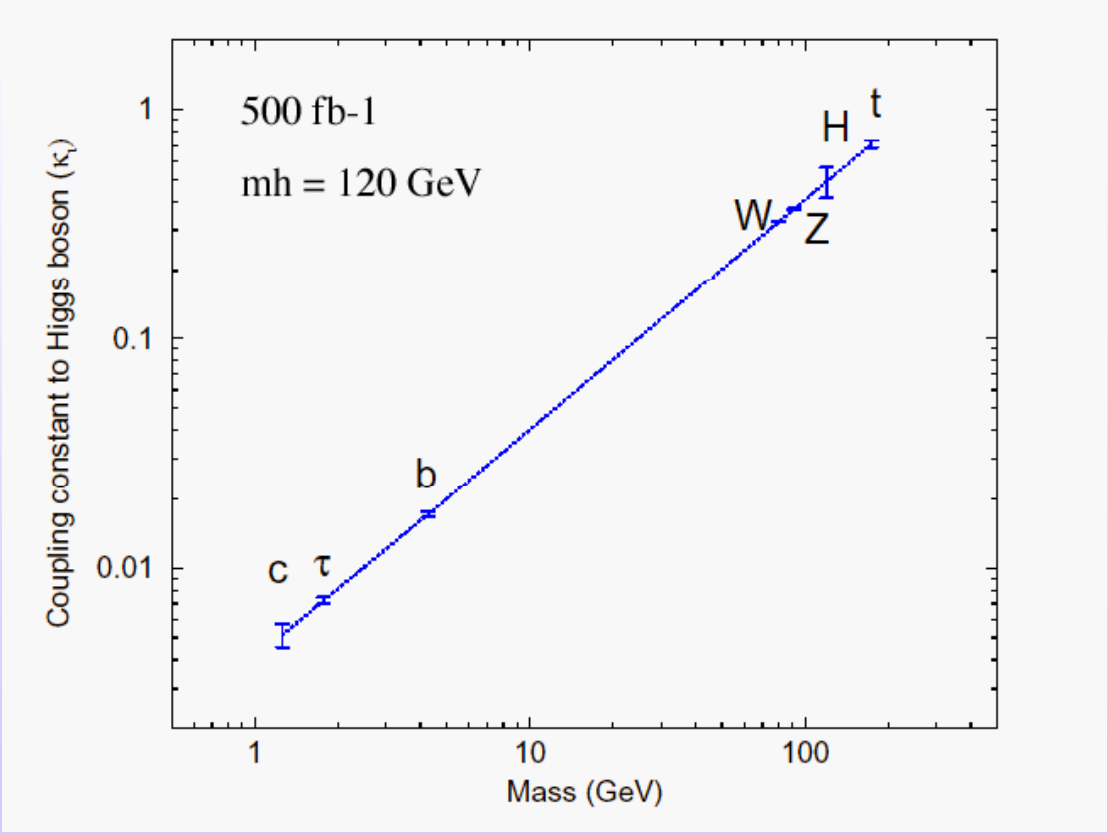

Golden channel :

'Higgs-straulung'

$$e^+e^- \to Zh,\ Z \to \mu\mu, ee$$

- Measurement of Higgs mass and production rate - independent of Higgs decay modes
- Then detect Higgs decays - absolute Brs (including invisible mode)
- **Tagged Higgs Factory!**

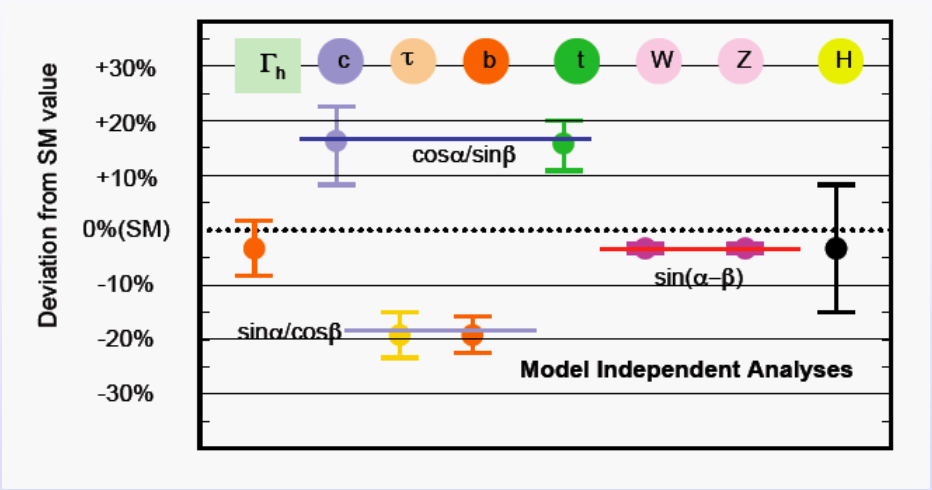
# Higgs coupling measurements

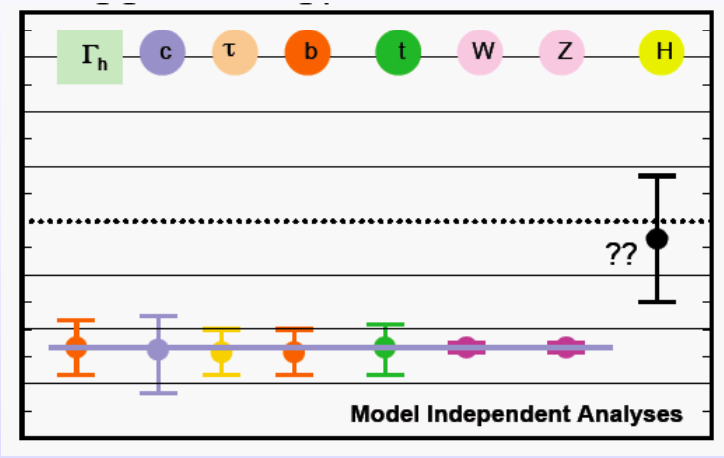



SM Higgs : coupling ∝mass

# Deviations from SM

(By S. Yamashita)



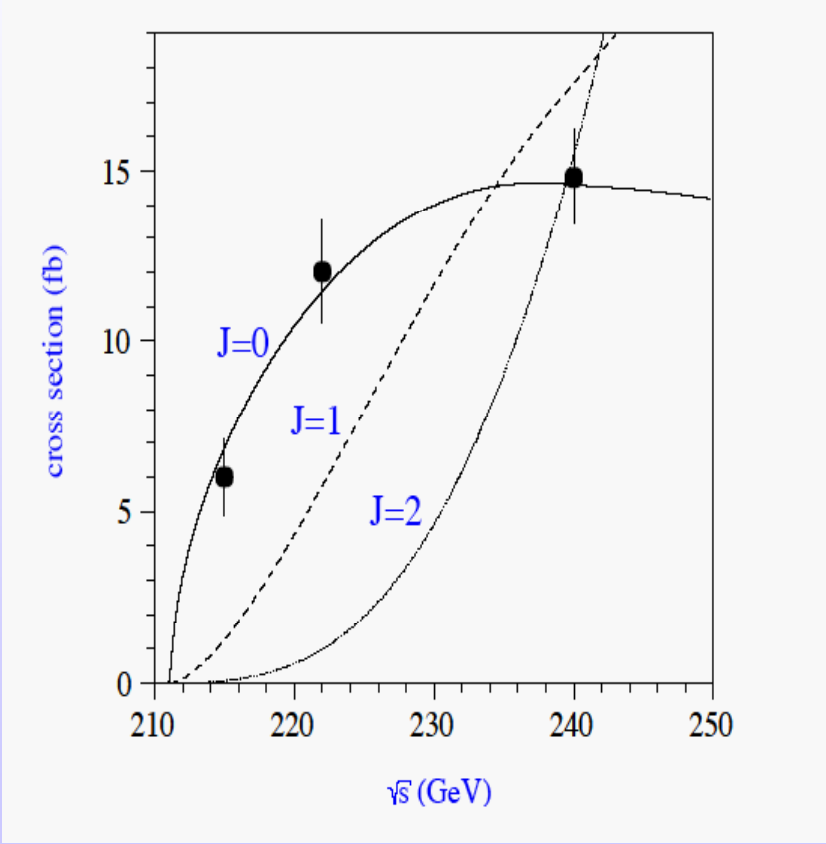




SUSY
(2 Higgs Doulet Model)

Extra dimension
(Higgs-radion mixing)

# Measurement of Higgs parameters

$$e^+e^- \to Zh,\ Z \to \mu\mu, ee$$




- Higgs mass

  $\sigma(m_h)$ = 40 MeV

- Higgs spin
  - Threshold scan
  - Higgs decay distribution
  - Zh angular dist.

    ~ $\sin^2\theta$ if J=0+

# Strategy

- Maintain momentum
- Focus on critical R&Ds
- Get all the help we can get
- Prepare for LHC results

# GDE Timeline

- TDP I : 2010
  - Technical risk reduction
  - Cost risk reduction
  - Global design
- TDP II : 2012
  - RD unit test (KEK)
  - Complete necessary technical designs (exceptions)
  - Project plan by consensus
- Detailed engineering will follow before construction

# Collaborations

- XFEL, US generic SCRF, Project-X
  - SCRF
- CLIC
  - Components (Sources, DR, BDS, etc.)
  - Detector
  - CERN expertise → ILC
  - ILC experience (costing) → CLIC
  - Enhances credibility of each (broader community)

# Detector Timeline

- Detector Design Phase I : 2010
  - Focus on critical R&Ds
  - LOI validation by IDAG
    (March 31 09 LOI deadline)
  - Update physics performance
  - MDI
- Detector Design Phase II : 2012
  - React to LHC results
  - Confirm physics performance
  - Complete necessary R&Ds
  - Complete technical designs
  - Cost (reliable)

PAC

ILCSC

FALC

IDAG

Executive Board

RD

Regional Contacts

GDE

WWS organizers

LoI-representative

Common task representative

Phys.&Exp.Board

MDI-D

IR Integration

Engineering Tools

R&D panel

R&D Collab.

LOI C

LOI B

LOI A

Software panel

Th's

Physics Panel

Outreach Panel

# Responding to LHC

- Systematic studies needed
  - When are we likely to know what from LHC?
    - Possible LHC discovery scenarios
  - For each scenario
    - What physics modes to study at ILC
    - What kind of machine to build
    - What kind of detector to build
    - Priorities and timescale
  - Cost and political realities to be included

# Responding to LHC

- Rethinking of the machine parameter will be needed.
  - Energy (250 GeV, 360 GeV, 500 GeV, 800 GeV…)
  - Luminosity
  - Upgrade path
- Accelerator and physics/detector community should have close and intensive discussions
  - Cost and politics
  - GDE + the RD structure (we need name)

# Coming workshops

- GDE meeting - ILC conventional facilities and siting workshop
  - Dubna, June 4-6, 2008
- ECFA workshop
  - Warsaw, June 6-9, 2008
- CLIC08 workshop
  - CERN, Oct 14-17, 2008
- LCWS workshop
  - Chicago, Nov 16-20, 2008

# Summary

- Black december: No domino effects seen.
- We need to focus R&Ds in accelerator and detectors
- Open collaborations with CLIC and other projects
- Establish organizational mechanism to respond to LHC results, and start systematic preparation.
  - Accelerator + Physics/Detector

- Administrative support
  - Otsuka, Toyomura, Shirakata, Miura
- Technical support
  - Takayama, Nakajima, Hanada
- Students
  - Horii, Ito, Kusano, Sasaki,
  - Itagaki, Okamoto, Sato, Suzuki, Yoshida
- Faculty/Staff
  - Sanuki, Nagamine, Tamae, Takubo
- Communicators/public relations
  - Takahashi, Kobayashi, Barbara, Perrine

- Vishnu Zutsi  G.P.Yeh, Marcel  Demarteau
  - Please see the registration desk before you leave.