The LHC / LC Study Group: towards a first working group document

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Amsterdam, 04/2003

Worldwide Study of
the Physics and Detectors
for Future Linear
$e^+ e^-$ Colliders

1. Present status

Aim: investigate how analyses at the LHC could profit from results obtained at a LC and vice versa

- LHC / LC Study Group started one year ago (first meeting: St. Malo, April 2002)

  Truly world-wide effort

- Study Group meanwhile officially recognized by International Linear Collider Steering Committee (ILCSC)

- Currently about 185 working group members from ATLAS, CMS, LC working groups, theory + Tevatron contact person

- Working group coordination:

  R. Godbole, F. Paige, G. W.

- Web page, mailing list:

  `www.ippp.dur.ac.uk/~georg/lhclc`

  `LHC-LC@fnal.gov`

- Here at Amsterdam: discussion session

- Next meeting: May 9, CERN

Examples for ongoing studies

SUSY searches:

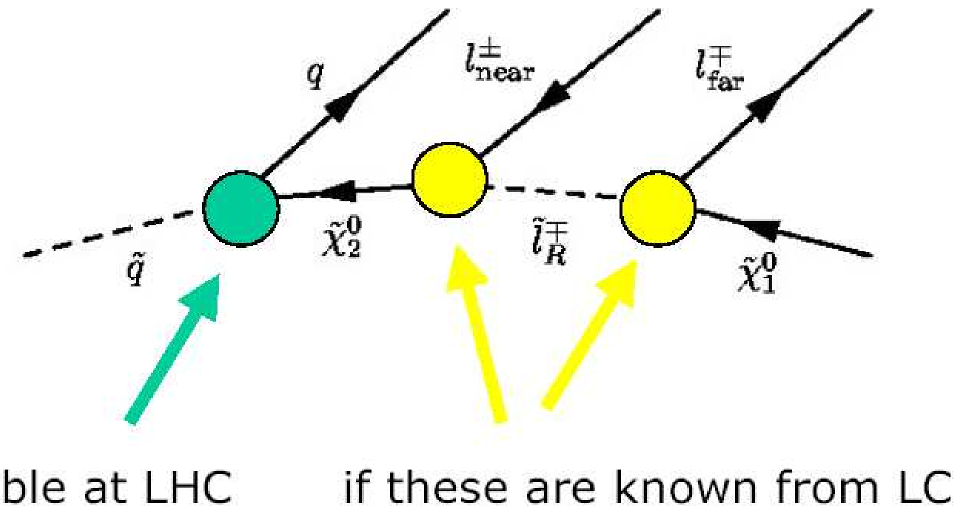
Improvement of LHC analyses (e.g. of cascade decays) by using input on masses and BR's from the LC

[*M. Chiorboli, A. Tricomi*]
[*E. Lytken, G. Polesello*]
[*J. Hisano, K. Kawagoe, M. Nojiri*]
[*B. Gjelsten, D. Miller, P. Osland*]
[*K. Desch, N. Ghodbane*]

Cascade decays of squarks at the LHC:

⇒ Measurement of squark properties using LC inputs on lower members of decay chain

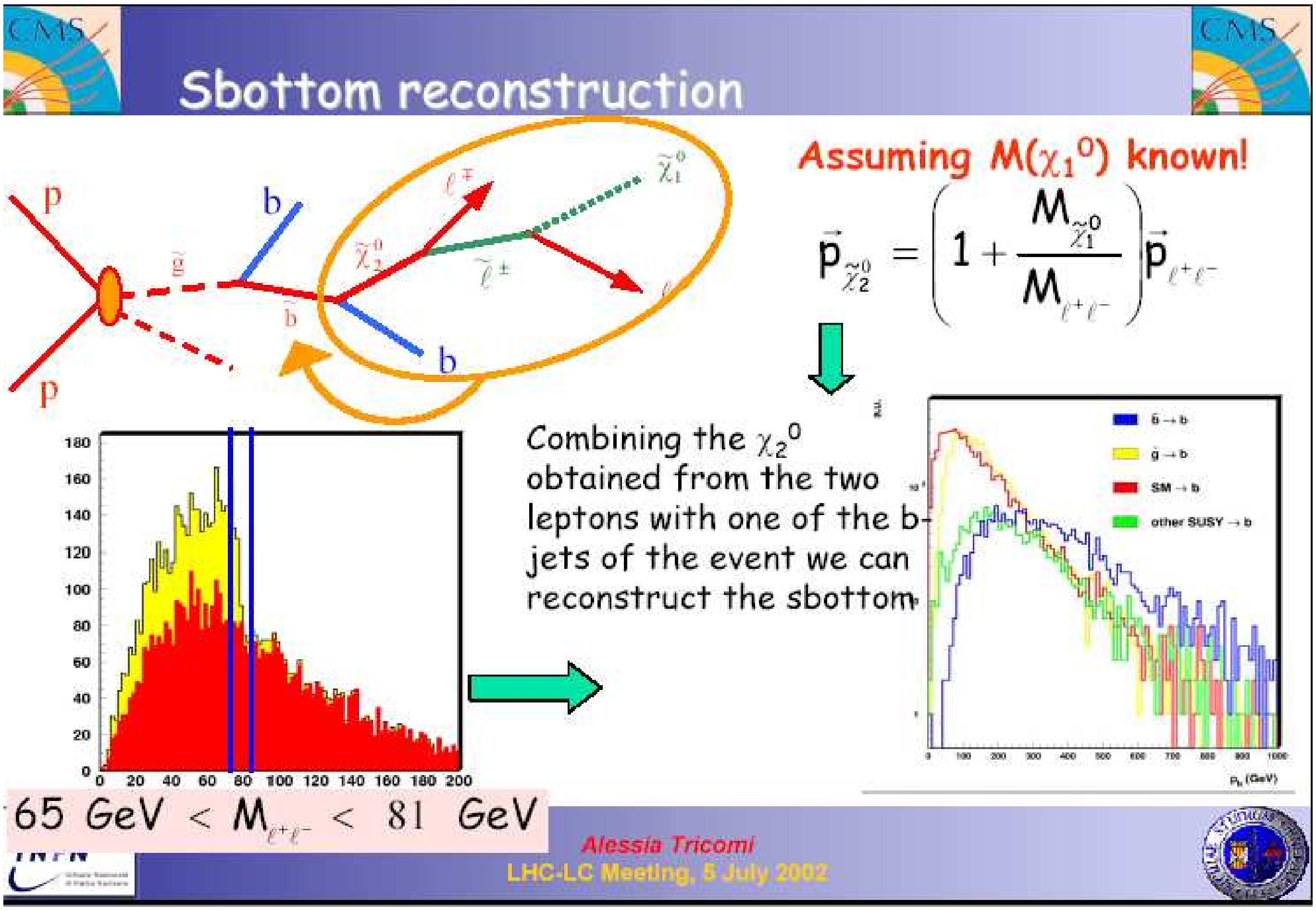
Example:



Different final states have different acceptance corrections
Can be combined if relative BR's are known

Sparticle reconstruction at the LHC using LC input on the LSP mass:

[*M. Chiorboli, A. De Roeck, A. Tricomi '02*]



Work in progress on including also LC input on BRs

[*A. De Roeck et al.*]

Stop, sbottom studies at the LHC using LC inputs

[J. Hisano, K. Kawagoe, M. Nojiri]

Role of LC for LHC

chargino, neutralino decay pattern

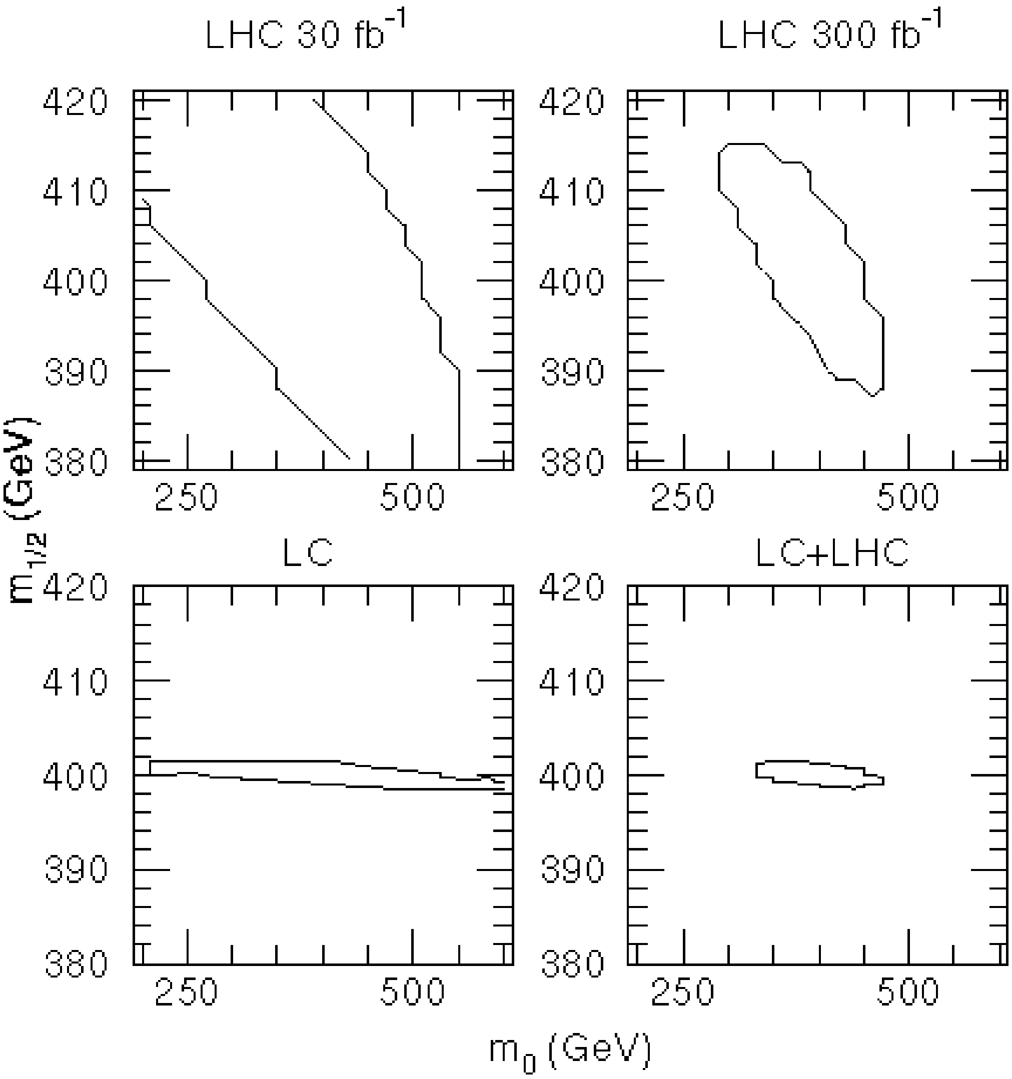
- **stop mass, sbottom mass**
  starting point, phase space of the gluino decay
  production cross section

- **N(fit) → Br(edge) or Br(edge)/Br(tb)**
  acceptance of each decay modes depends on Br(→ l X) and Br(→ W X)

- **Comparison with** $N(bbll)$ from $\tilde{g} \to \tilde{b} \to \tilde{\chi}_2^0 \to \tilde{l} \to \tilde{\chi}_1^0$
  Need Br($\tilde{\chi}_2^0 \to 2l\tilde{\chi}_1^0$)

Constraining SUSY models from LHC + LC data:

Results in the m_0–$m_{1/2}$ plane of the mSUGRA scenario for LHC alone, LC alone and LHC $\oplus$ LC
[*G. Polesello*]



LC alone ∼insensitive to m_0

$\tan\beta$ contrained to be >5

Combining LC and LHC, some gain also on m_0, as $m_{1/2}$ and m_0 correlated through squark mass measurement

Higgs physics:

Determination of the top Yukawa coupling

[*K. Desch, M. Schumacher*]

Top Yukawa coupling from LC + LHC

Idea: take absolute BR measurement from LC and cross section measurement from LHC.

Assumptions:

Cross section uncertainty at LHC (incl 15% from NLO+SF)

120 GeV 34% (incl 15% from NLO+SF, from bb, 100 fb^{-1})

160 GeV 23% (" , from WW, 300 fb^{-1})

200 GeV 30% (" , from WW, 300 fb^{-1})

LC uncertainties (TESLA TDR)

120 GeV: BR(bb) 2.4%, BR(WW) 5.1%, σ(HZ) 2.4%, σ(WW) 2.0%

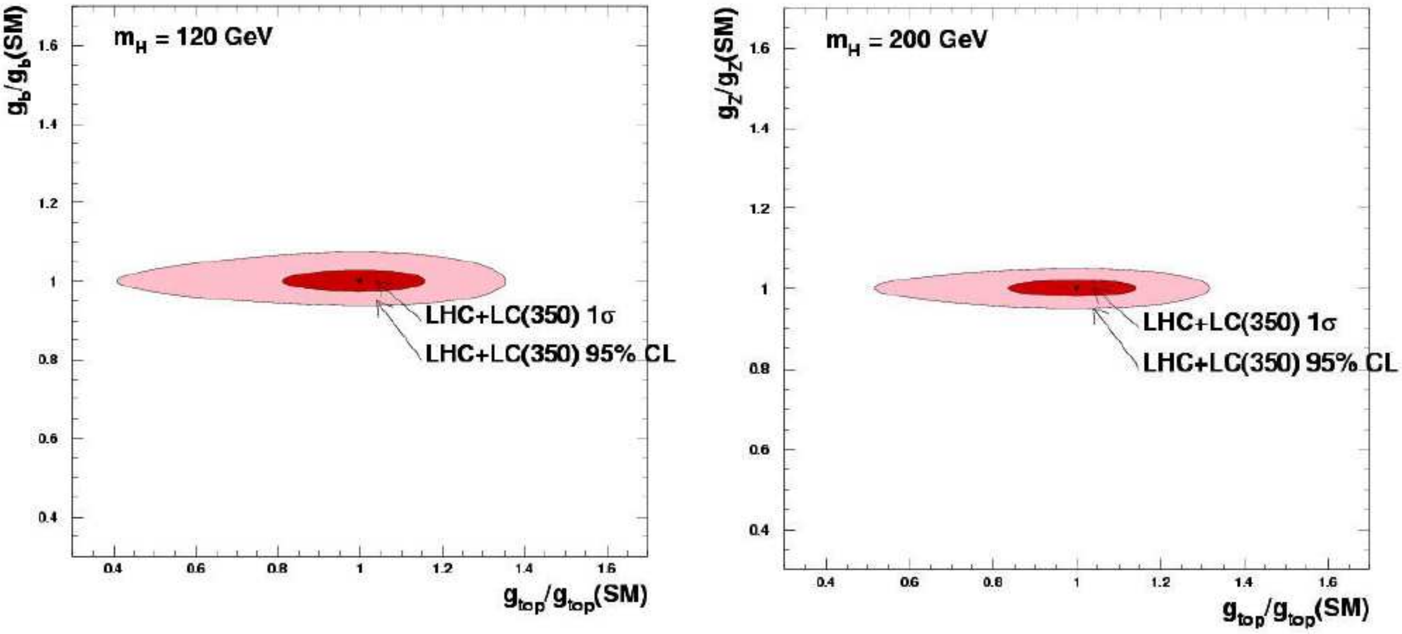
200 GeV: BR(bb) none, BR(WW) 4%, ZZ 4%, σ(HZ) 4%, σ(WW) –

(BR(cc),BR(gg) etc are not used!)

First Very Preliminary Result

Error on g_{ttH} 16.8% (@120 GeV) 14.9% (@200 GeV)

HFITTER:



Looks promising…

Next: BG uncertainties, closer look at SF uncertainties

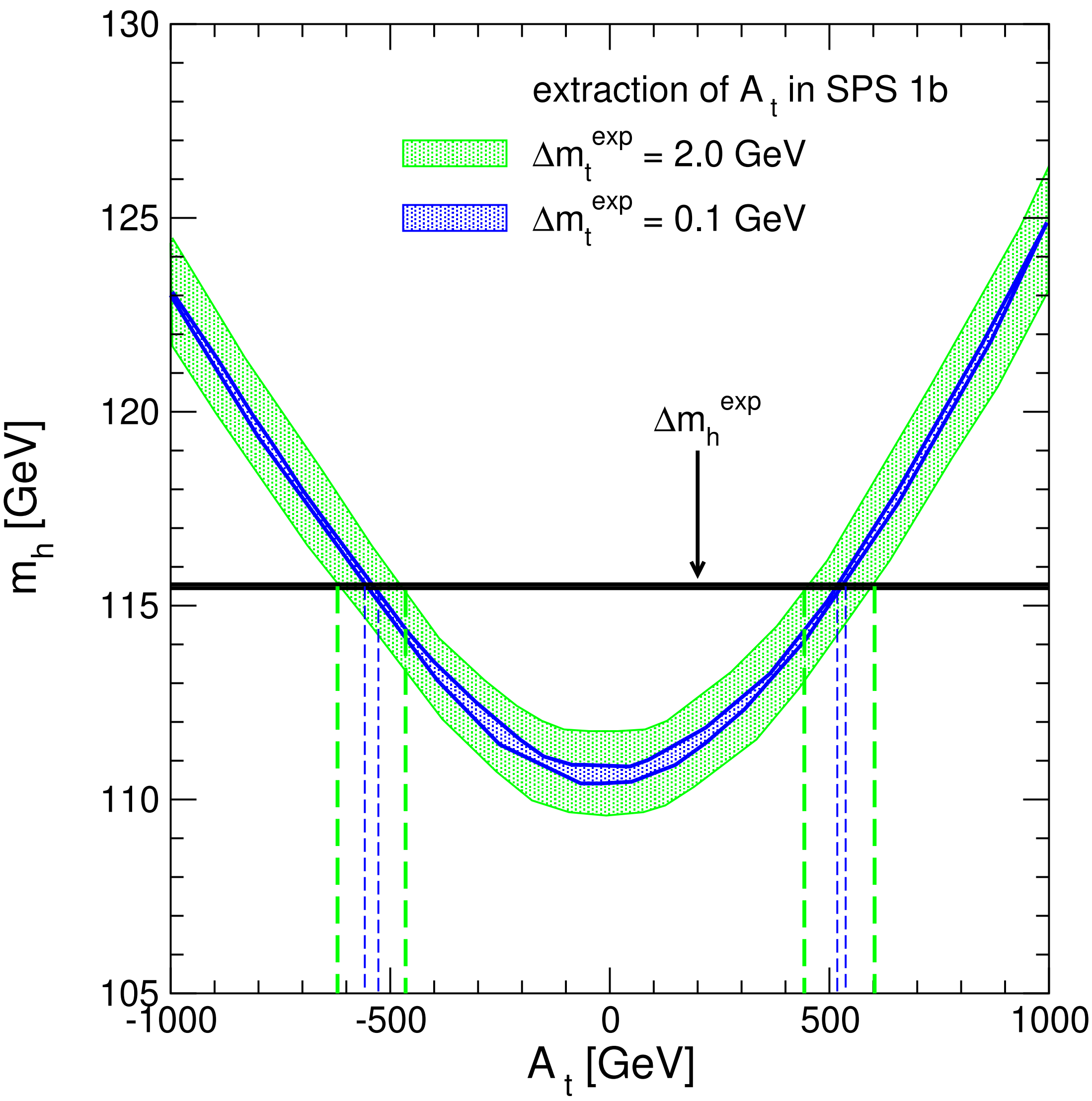
SUSY Higgs physics:

Combination of measurement of $m_{\tilde{t}_1}$, $m_{\tilde{t}_2}$, $m_{\tilde{b}_1}$, $m_{\tilde{b}_2}$ at LHC with measurement of m_h and m_t at LC

Assumed: $m_{\tilde{t}_1}, m_{\tilde{t}_2}, m_{\tilde{b}_1}, m_{\tilde{b}_2}$: 5% accuracy
M_A: 10% accuracy, $\tan\beta = 30 \pm 5$

$\Rightarrow$ Determination of A_t

[S. Kraml, S. Heinemeyer, W. Porod, G. W.]



Δm_t^{LC} vs. Δm_t^{LHC}

$\Rightarrow$ Accuracy of A_t det. improved by factor 3

Radion–Higgs mixing:

[*M. Battaglia, S. De Curtis, A. De Roeck, D. Dominici, J. Gunion*]

Exercise...

- Check where the Higgs discovery at LHC gets more difficult/impossible
- Can one observe $gg \to \phi \to ZZ^*$ in those regions
- perspectives for identifying the nature of the observed scalar at a LHC & LC

Tool used
HDECAY, introducing relevant terms for radions (J. Gunion/D. Dominici)

Radion $\phi \to ZZ^* \to 4l$ 50 GeV < M_ϕ < 400 GeV
Take experimental bounds (Tevatron/LEP) into account

Higgs $H \to ZZ^* \to 4l$
$H \to \gamma\gamma$
$ttH \to ttbb$
low Higgs mass range 120-140 GeV

New gauge theories

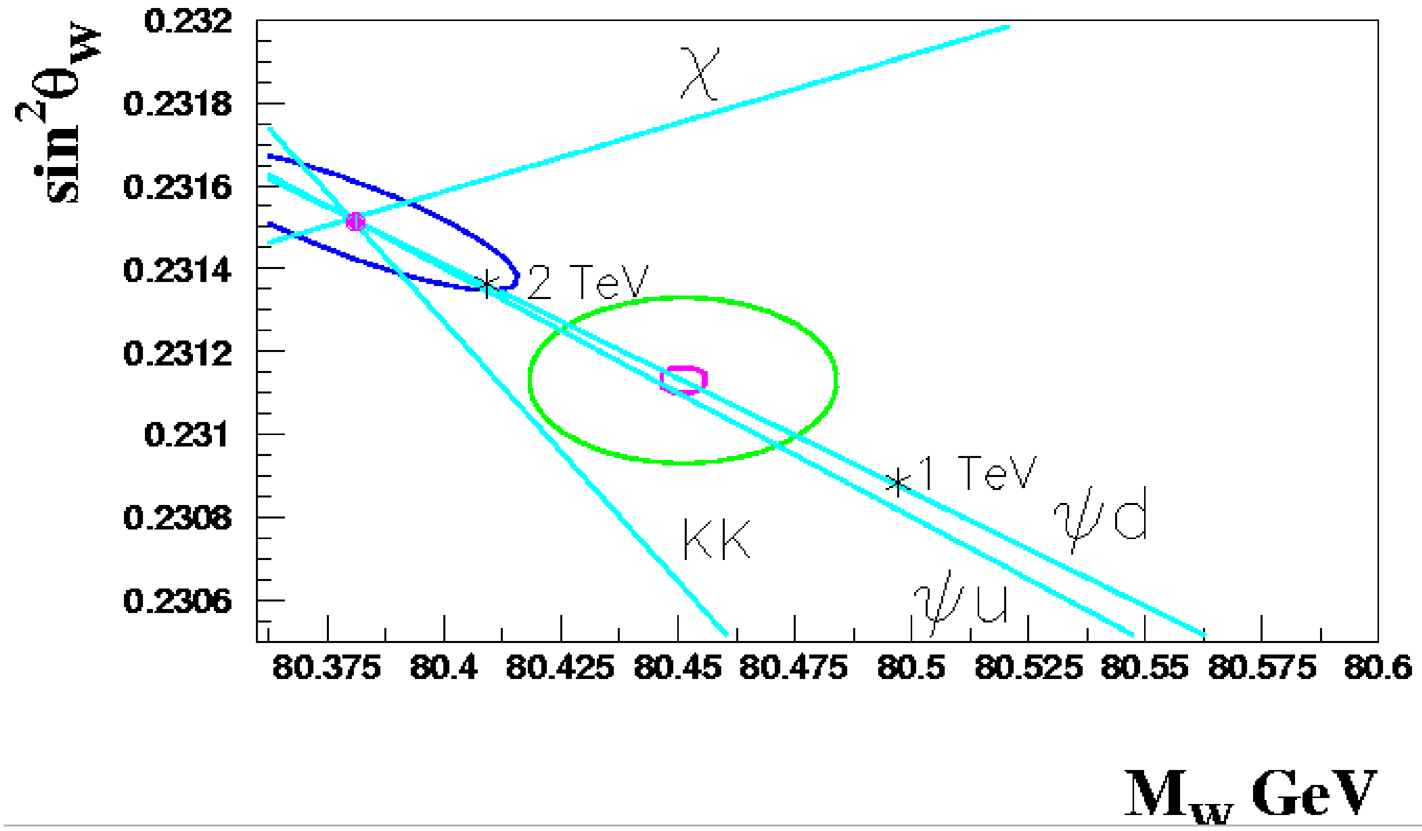
Mass measurement of Z', W' at LHC as input for determining couplings at LC

Distinction between extended gauge group and KK excitation, . . .

Sensitivity of precision measurements of M_{W}, $\sin^2\theta_{\mathrm{eff}}$ to predictions of different models: E6 vs. KK

GigaZ vs. current accuracy

[*F. Richard*]



Other example: 'Little Higgs' scenario

[*F. Richard*]

LH Scenario at LHC/FLC

- 'A Higgs with mH> 300 GeV has been seen at LHC and nothing else' (Bh and Zh too heavy)

- 'LEP/SLD inconsistent with SM'

- MSSM or standard Z' cannot help

7. Within LH, *GigaZ* can predict the mass of Bh and tell if it can be reached at LHC with increased Luminosity

$\Rightarrow$ Synergy LHC-LC

F. Richard Feb 2003

Predictions from FLC

With $m_{Bh} \sim f\,(0.1/x)$

-> Close to the LHC limit ~4 TeV

5. GigaZ would give adequate precision on Bh $\Delta M/M \sim (M/7\ \mathrm{TeV})^2$

7. Interference at FLC can tell if Zh within LHC reach $\sim (M/6\ \mathrm{TeV})^4$

-> FLC can tell if these masses within the LHC range

2. Plans for working group document

Summary of activities of LHC / LC Study Group and other available information

exploratory study, this can only be a first step

suggestions for future work

Individual contributions to be merged into a common document, detailed "synopsis" at the beginning

Report should appear on hep-ph / hep-ex,
'hybrid' CERN/DESY/Fermilab/... report?

Deadline for individual contributions:

May 5

Plan to have complete draft by end of May
(⇒ could serve as input for Les Houches workshop)

Editors for different parts of the document:

See www.ippp.dur.ac.uk/∼georg/lhclc/document.html

1. Introduction:

Physics case for LHC and LC, experimental aspects, interplay of particle physics and cosmology
Daniel Denegri, Fabiola Gianotti, Francois Richard, Heidi Schellman

Aim of Study Group, summary of main results
All

2. Electroweak Symmetry Breaking (Weakly)
Albert De Roeck, Howie Haber, Rohini Godbole, G. W.

3. Strong Electroweak Symmetry Breaking
Tim Barklow, Klaus Mönig

4. Supersymmetric Models
Klaus Desch, Kiyotomo Kawagoe, Frank Paige

5. New Gauge Theories

Francois Richard

6. Models with Extra Dimensions

JoAnne Hewett

7. Exotics

Jack Gunion (t.b.c.)

8. Electroweak and QCD Precision Physics

Edward Boos, Sven Heinemeyer, James Stirling

Please get in touch now!