BSM studies from the LoIs and for the ILC TDR

LCForum
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J.List (DESY)

DESY

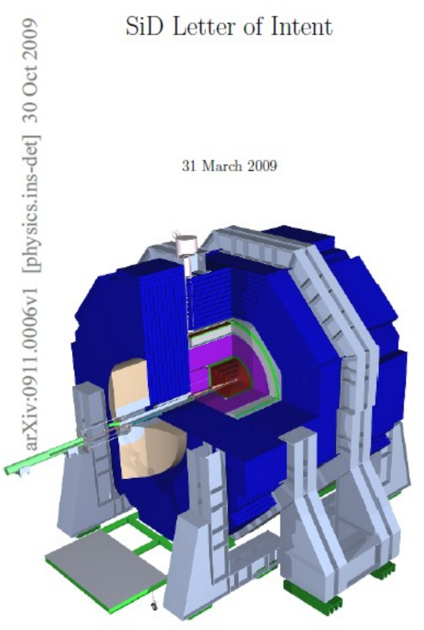
Particles, Strings,
and the Early Universe
Collaborative Research Center SFB 676

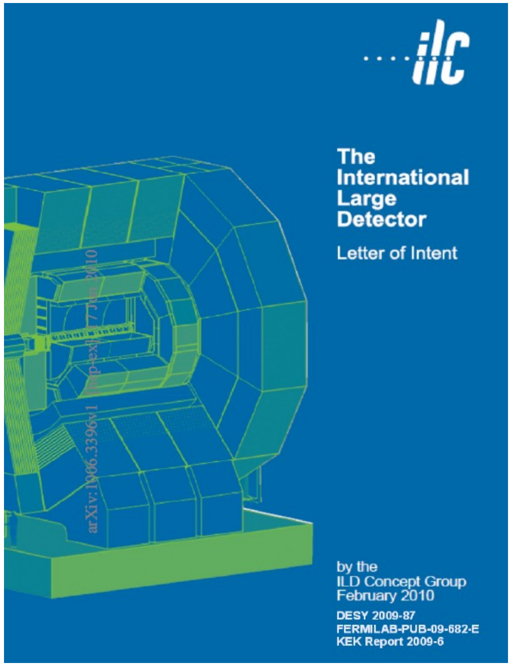
Today's Menue

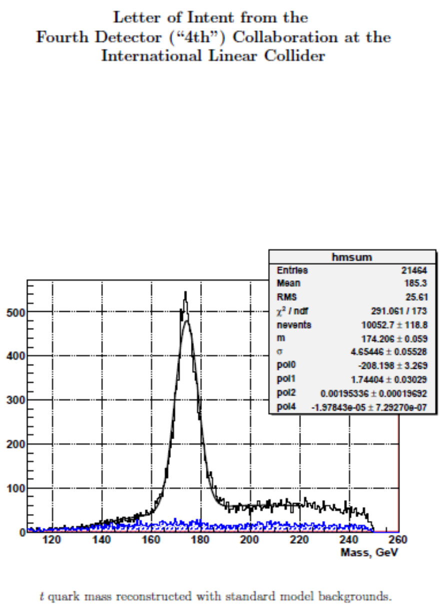
- Introduction
- Beyond SM in the ILD & SiD Letters of Intent
  - benchmark: NUHM “Point 5”
  - additional studies
  - lessons from the LoI studies
- Conclusions & Outlook

Introduction

- Letters of Intent (LoIs) for detector concepts at the ILC:
  - conceptual description of detectors, employed technologies and alternatives
  - performance studies (resolutions, efficiencies, robustness, ...)
  - benchmarks analyses: chosen to challenge the detector concepts with the experimentally most difficult final states







Introduction

- LoIs published in 2009
- reviewed by group of international experts (IDAG)
- ILD and SiD concepts were encouraged to continue their work towards a technical design (DBD), to accompany the ILC TDR due in 2012
- again, DBD will contain benchmarks to challenge detectors

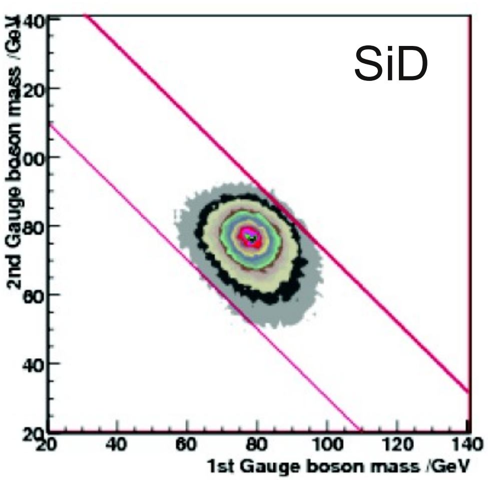
=> if performance of detailled simulation studies is similar to old fast simulation studies in the “difficult cases”, this validates the TESLA, NLC, JLC studies “a posteriori”

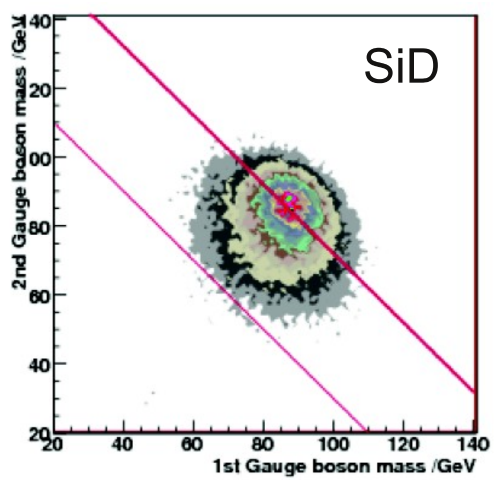
BSM in LoIs: Overview

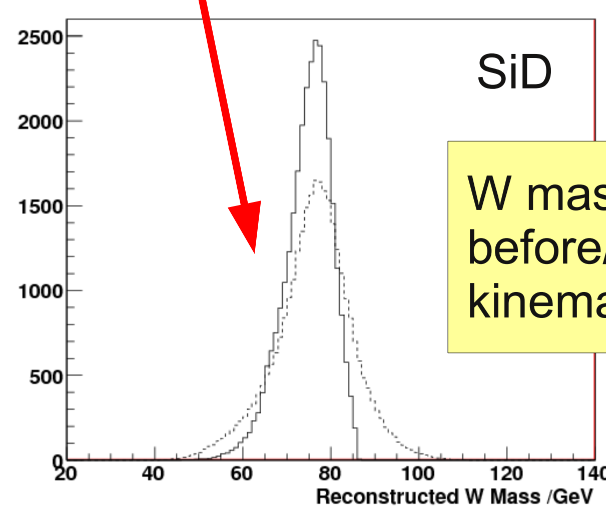
- benchmarks:
  - NUHM “Point 5”
  - strong EWSB : WW / ZZ
- beyond benchmarks:
  - $\tilde{b} \rightarrow b\ \chi^0_1$
  - non-pointing photons from $\chi^0 \rightarrow \gamma\ \tilde{G}$
  - heavy gauge bosons in Little Higgs Models
  - $\tilde{\tau}$ with small mass difference to χ^0 and $\chi^0_2 \rightarrow \mu\ \mu\ \chi^0_1$
    → *M.Berggren, Wednesday 14:30*
  - radiative WIMP production → *C.Bartels, Thursday 14:00*

"Point 5"

- non-universal soft SUSY-breaking contributions to the Higgs masses
- M_0 = 206 GeV, $M_{½}$ = 293 GeV, tanβ = 10, A_0 = 0, μ = 375 GeV
- => $\tilde{\chi}_1^{\pm}$ and $\tilde{\chi}_2^0$ mass degenerate (216.5 GeV), decay into $W^{\pm}\tilde{\chi}_1^0$ and $Z\tilde{\chi}_1^0$, respectively (M_{LSP} = 115.7 GeV)
- detector challenge: fully hadronic decay mode 4j + missing 4-mom.
- due to the 2 escaping LSPs, impact kinematic fitting is limited
  => this tests jet energy reconstruction in particle flow calorimetry





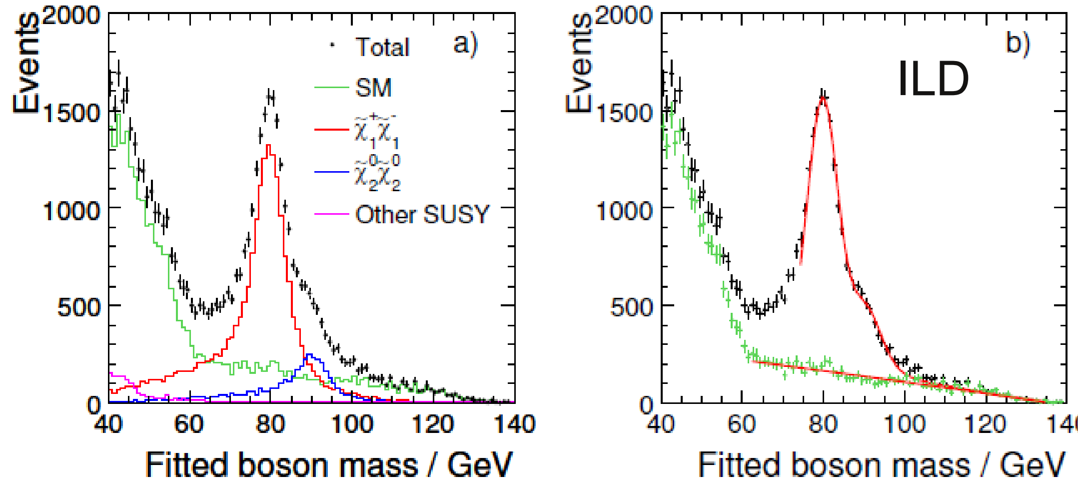


W mass before/after kinematic fit

Point 5: Cross-sections

SiD & ILD LoIs

- ...and now with backgrounds (SM + SUSY!)
- separate $\tilde{\chi}_1^{\pm}$ and $\tilde{\chi}_2^0$ according to di-jet masses
- subtract background measure cross-section
  - event counting (SiD):
    δσ = 1% ($\tilde{\chi}_1^{\pm}$)/ 4% ($\tilde{\chi}_2^0$)
  - 1D di-jet mass fitting (ILD):
    δσ = 1% ($\tilde{\chi}_1^{\pm}$)/ 3% ($\tilde{\chi}_2^0$)
  - 2D di-jet mass template fitting (ILD):
    δσ =0.6% ($\tilde{\chi}_1^{\pm}$)/ 2% ($\tilde{\chi}_2^0$)

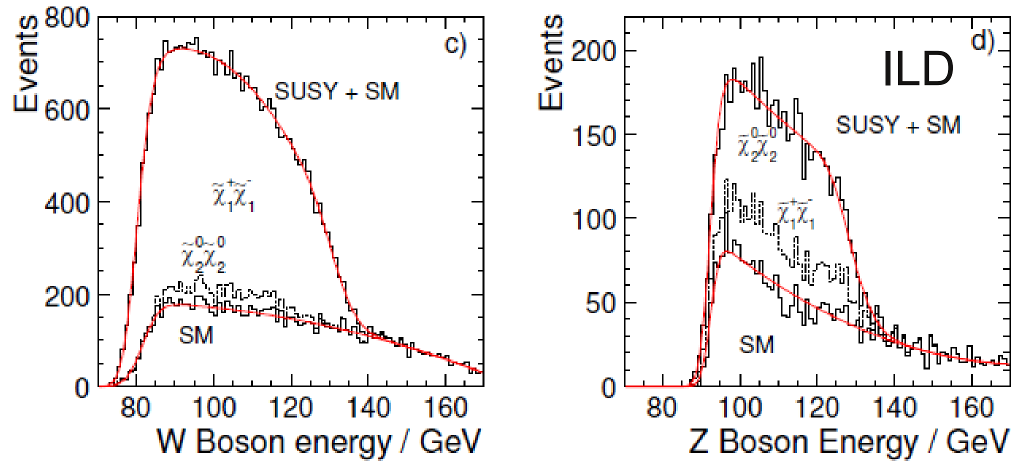


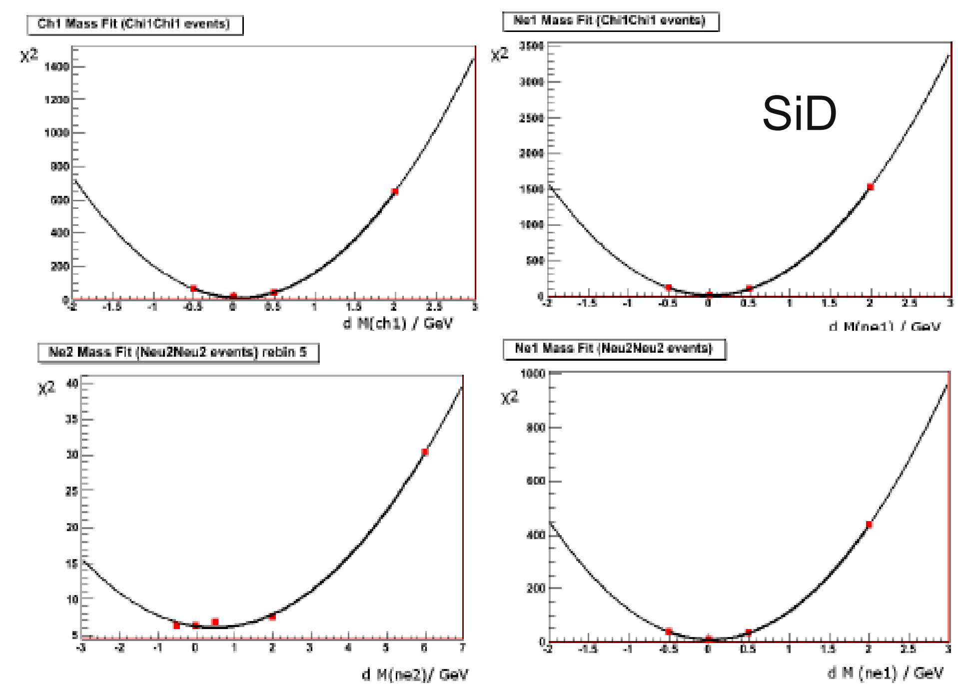
- => analysis technique matters!
- don't forget ZZ $\tilde{\chi}_1^0 \tilde{\chi}_1^0$ → qqll $\tilde{\chi}_1^0 \tilde{\chi}_1^0$: lower statistics, but
  - much less background (no chargino bkg!)
  - excellent mass/energy resolution from leptonic Z!

Point 5: Masses

SiD & ILD LoIs

- fitting the edges of the W/Z energy spectrum:
  => edge positions to 0.2....0.7 GeV
- using these to determine all three masses simultaneously (ILD):
  δM($\tilde{\chi}_1^0$) = 0.8 GeV
  δM($\tilde{\chi}_1^\pm$) = 0.9 GeV
  δM($\tilde{\chi}_2^0$) = 2.4 GeV
- correlations are substancial:
  if other 2 masses were known (SiD)
  δM($\tilde{\chi}_1^0$) = 0.2 GeV
  δM($\tilde{\chi}_1^\pm$) = 0.5 GeV
  δM($\tilde{\chi}_2^0$) = 1.0 GeV
- kinematic fitting (constraining the vector boson masses) still helps:
  w/o kin. fit, mass resolution is worse by 0.5...1.1 GeV !

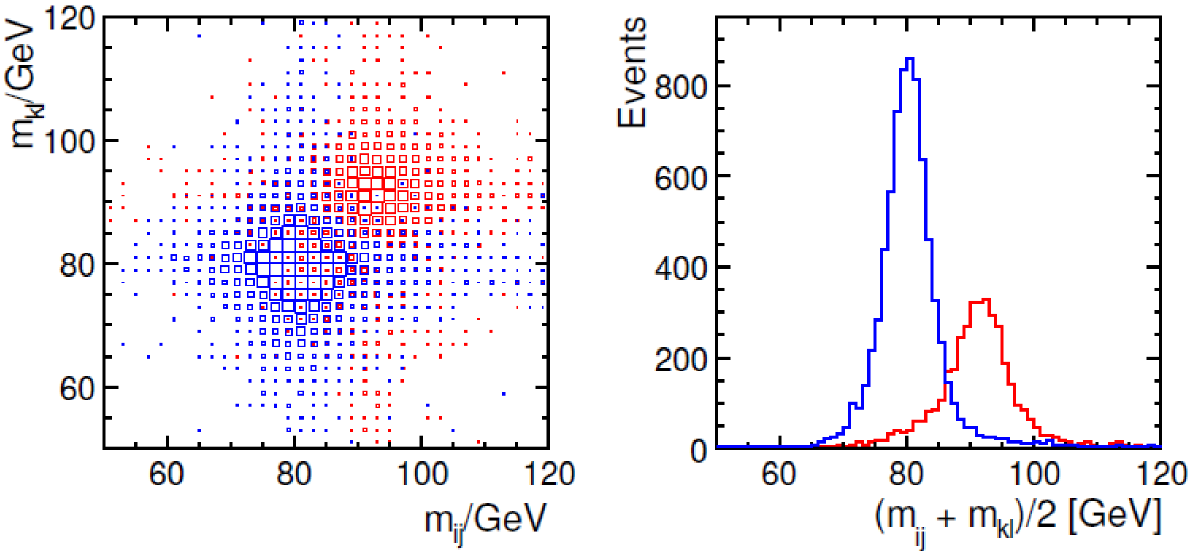




Strong EWSB

ILD LoI

- test $W^+W^- \rightarrow W^+W^-$ and $W^+W^- \rightarrow ZZ$ vertices by $e^+e^- \rightarrow \nu_e\overline{\nu}_e q\overline{q}q\overline{q}$ at 1 TeV ($1ab^{-1}$, P=(0.3,-0.8))
- di-jet mass reconstruction:

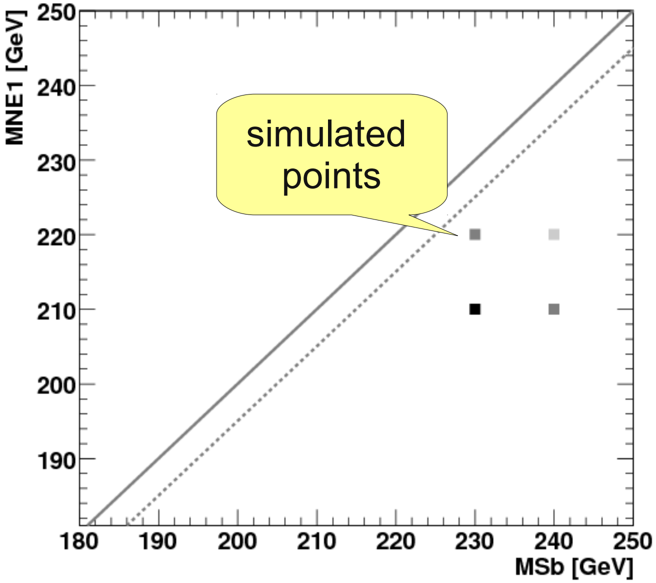


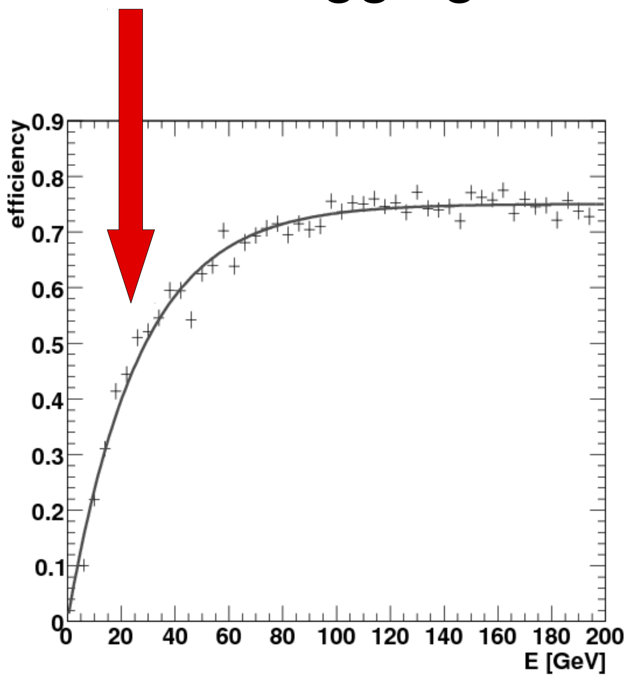
- Quartic gauge couplings (SM=0) can be limited to:

$$-1.38 < \alpha_4 < +1.10 \qquad -0.92 < \alpha_5 < +0.77$$

$\tilde{b} \rightarrow b\, \chi^0_1$

- $\tilde{b}$ is NLSP with small mass difference
- $\tilde{b}$ mass determines cross-section
- mass splitting determines jet energy
  → test b-tagging with low jet energies!

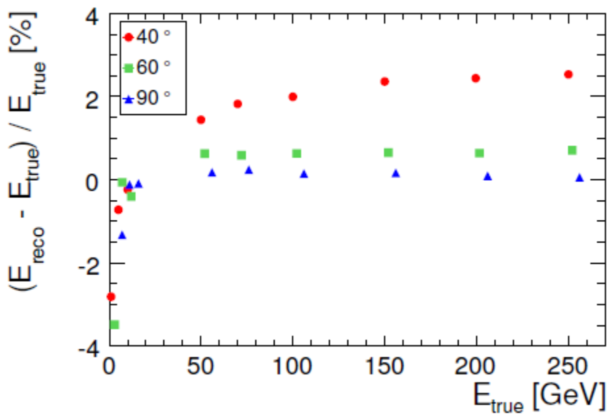




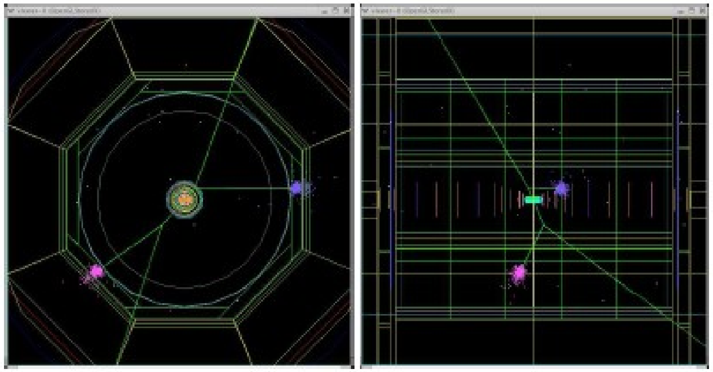
- further needs excellent coverage of forward region to veto γγ-events
- with 500fb^{-1} at 500 GeV:
  between10 and 2σ (at kinematic edge)

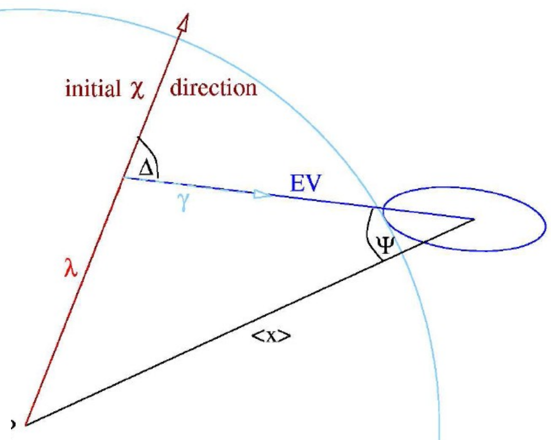
GMSB: Non-pointing photons N. Wattimena, desy-thesis-10-006

- $\chi^0 \rightarrow \gamma\ \tilde{G}$: reconstruct lifetime from photon direction → *cluster shape!*
- χ^0 mass from edge of photon energy to 2 GeV (stat), although bias due to:

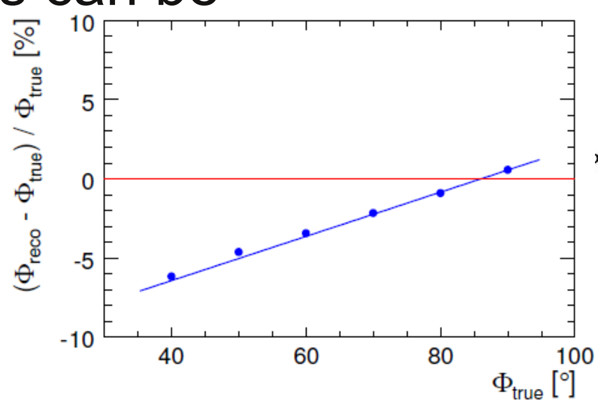


→ needs better photon reconstruction





- lifetimes between 2 and 11ns can be reconstructed to a few %
- lifetimes of O(0.1ns) again suffer reconstruction "feature"
  => repeat with better γ reco



Little Higgs with T-Parity

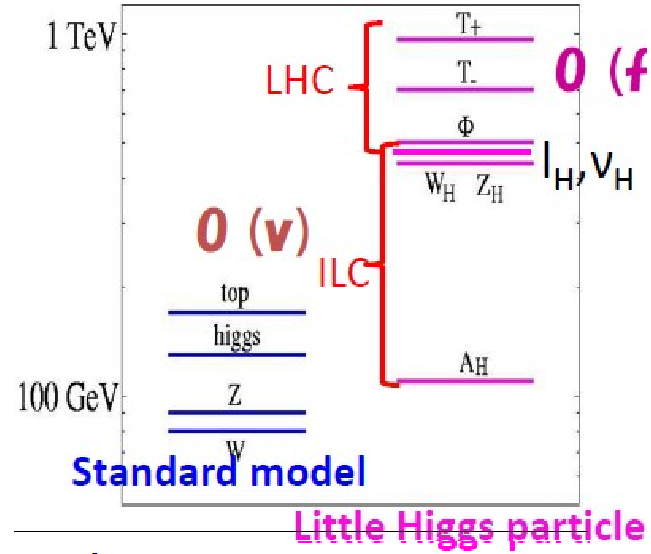
M.Asano, K.Fujii,E.Kato et al, LCWS11

E_{cm}=1TeV,
Luminocity = 500fb^{-1}

Coupling extracted from xsec

Mode	Coupling meas. Accuracy
A_HZ_H	3.90%
Z_HZ_H	0.219%
e_He_H	1.49%
$\nu_H\nu_H$	0.648%
W_HW_H	0.174%

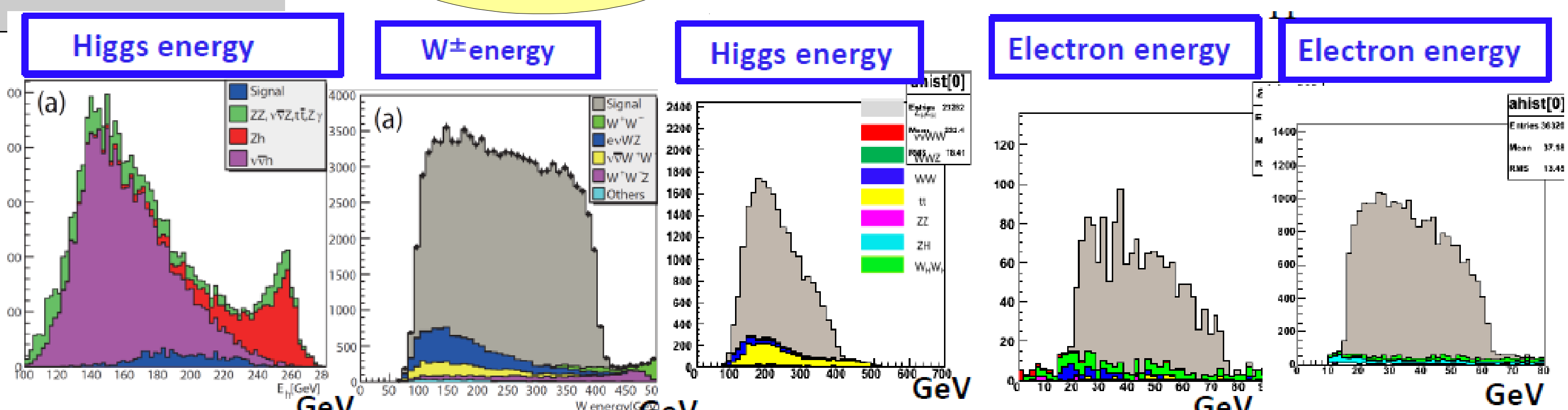
particle	mass	sensitivity
A_H	81.9(GeV)	1.3%
W_H	369(GeV)	0.20%
Z_H	368(GeV)	0.56%
e_H	410(GeV)	0.46%
ν_H	400(GeV)	0.10%



VEV of global SB

Lepton Yukawa coupling

parameter	True value	Measurement accuracy
f	580(GeV)	0.16%
K	0.5	0.01%



Conclusions of LoI studies

- in nearly all studied cases, the physics performance from full simulation is very similar to older results obtained by fast simulation
  => *this validates a posteriori the assumptions made on the detector capabilities!*
- between ILD and SiD, most differences in physics performance were tracked down to the reconstruction algorithms and the analyses
  => *if you keep it too simple, you get a too pessimistic answer*
- systematic uncertainties: accelerator properties often play a role (beam energy spectrum, polarisation uncertainty...)
  => *watch not only the detector, but mind also the machine!*
- *decay channels chosen to be experimentally difficult: often only looked at fully hadronic cases, (semi-) leptonic ignored!*

Outlook: towards TDR / DBD

- DBD: few detector specific benchmarks at 1TeV
- TDR physics volume:
  - **http://newsline.linearcollider.org/2011/11/17/articulating-the-physics-case-for-the-ilc/**
  - review the ILC physics case in view of LHC
  - no differentiation between detector concepts
  - not necessarily full simulation results:
    fast simulation and cross-section level studies
    equally welcome!
    => publicly available fast simulation of ILD based on SGV → talk by M.Berggren Thu 14:20
  - TDR physics volume has restricted length
  - the notes and the review paper resulting of this workshop
    could be important input and references!