Higgs

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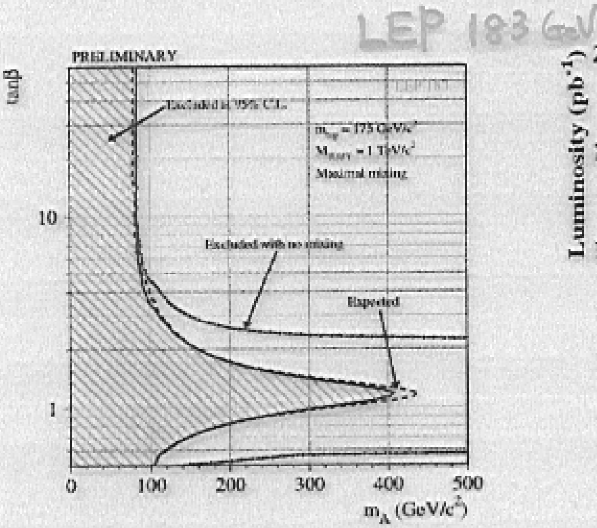
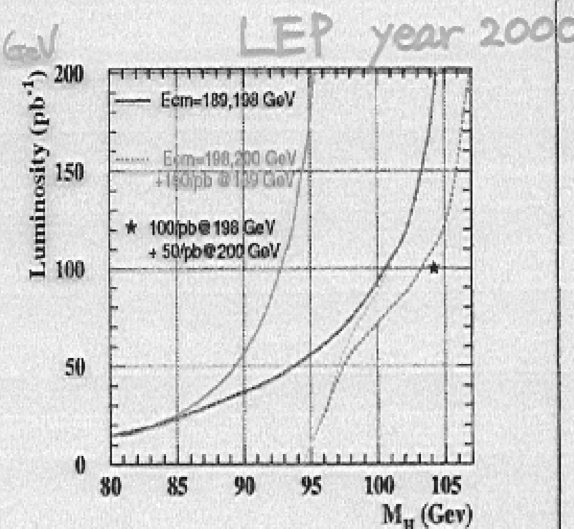
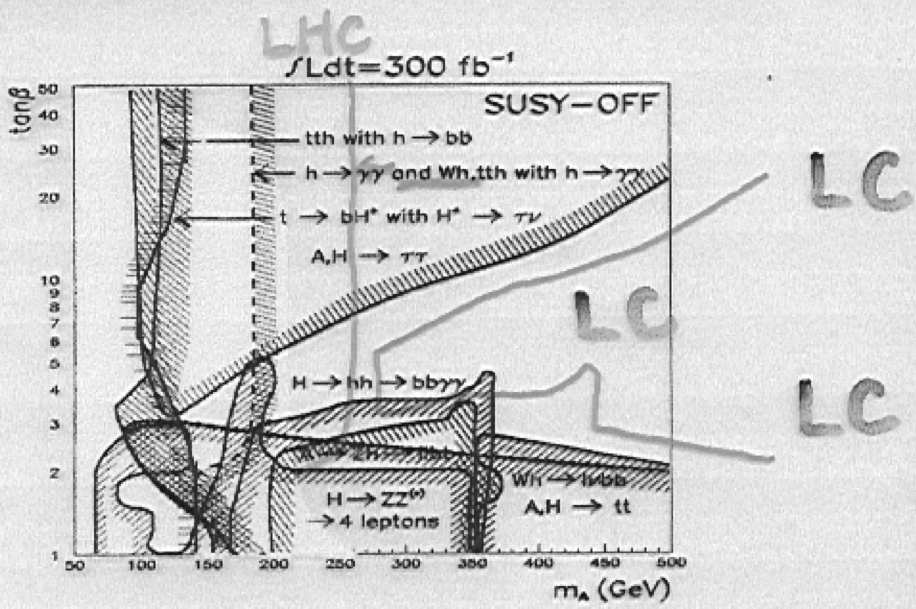
- Searches at LEP-2 are now sensitive to a SM-like Higgs boson with $M_{H^0} > M_{Z^0}$ and extensively probing the low $\tan\beta$ solutions of MSSM:



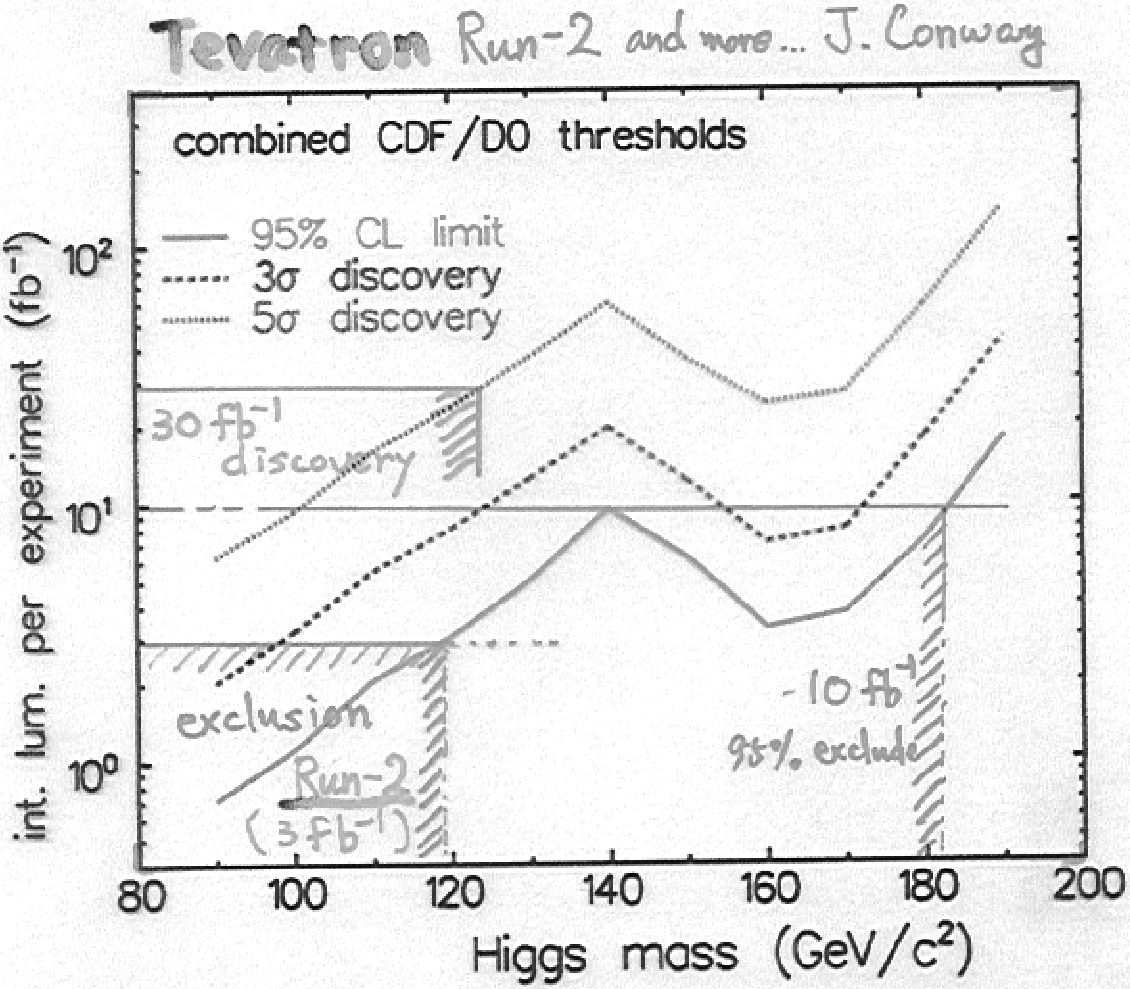


- LHC to continue Higgs search from LEP-2 kinematical limits to higher masses by combination of different decays modes:



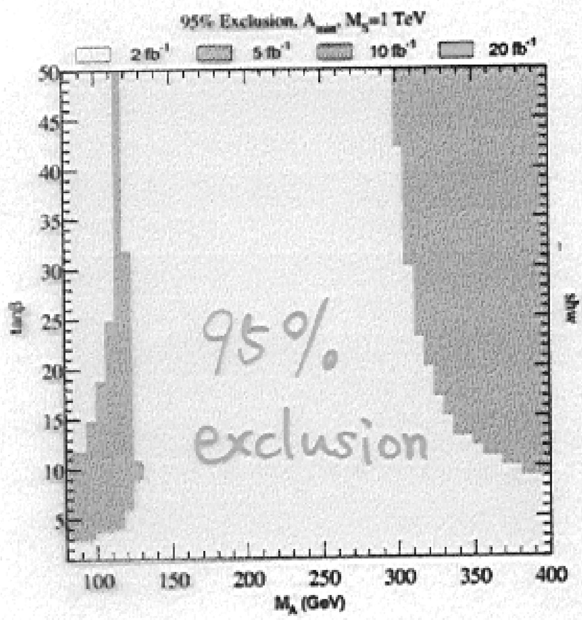
SM Higgs combined channel thresholds

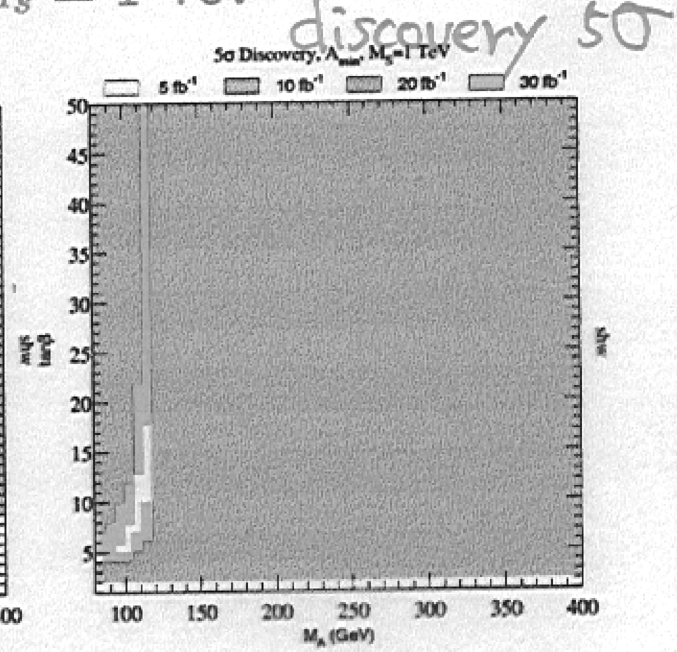
- → Bayesian combination method - two experiments
- → 30% better $m_{b\bar{b}}$ resolution than Run 1
- → SHW acceptance
- → nominal systematic errors: 10% or $1/\sqrt{LB}$



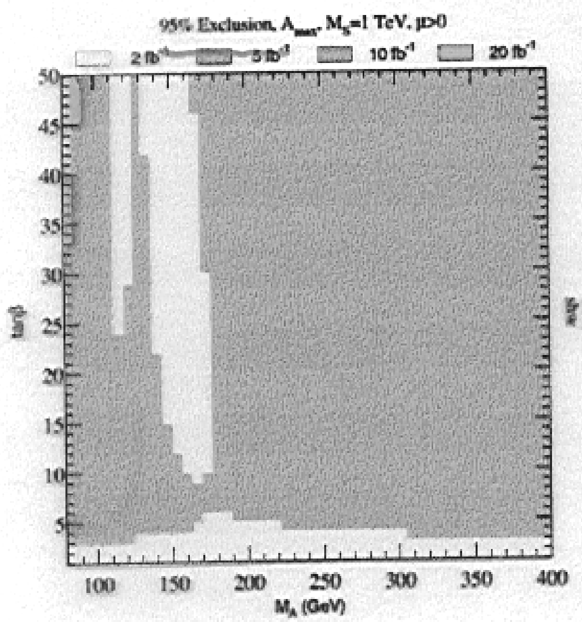
MSSM discovery/exclusion from SM Higgs channels

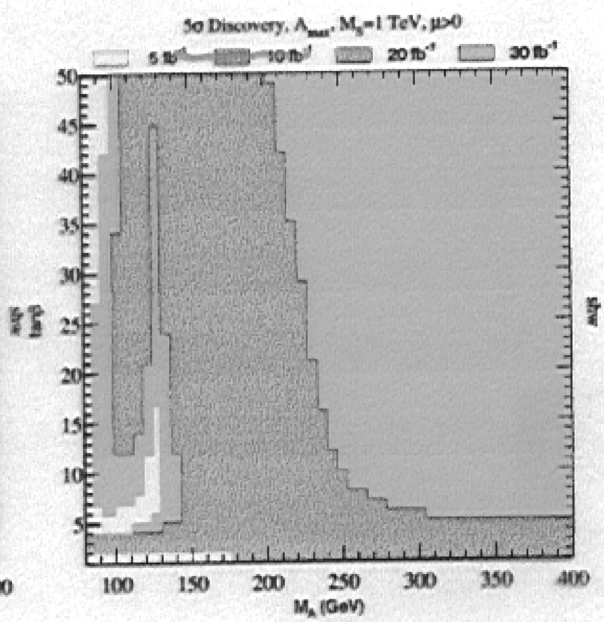
A_{min}, $M_s = 1$ TeV





A_{max}, $M_s = 1$ TeV





LC 1st phase (2007 or 2008)

M_{h^0}

LC 1st phase ($\sqrt{s} = 250 - 500$ GeV)

cover SM, MSSM, N(x)MSSM

$M_h \lesssim 280$ $\lesssim 150$ $\lesssim 150$ (~~180~~ 210)

(+self-coupling finit up to Plank scale / GUT)

Very strong discrimination power up to plank scale!

$\sigma(e^+e^- \to hZ)$

$\sigma_{SM} \approx \sigma_{MSSM}$ ($\sin^2(\alpha-\beta) \sim 1$) if $M_h \gtrsim 110$ GeV.

σ can be much smaller than σ_{SM} in case of N(x)MSSM

Chance to discover Big thing!

LC should compete with LHC !!!

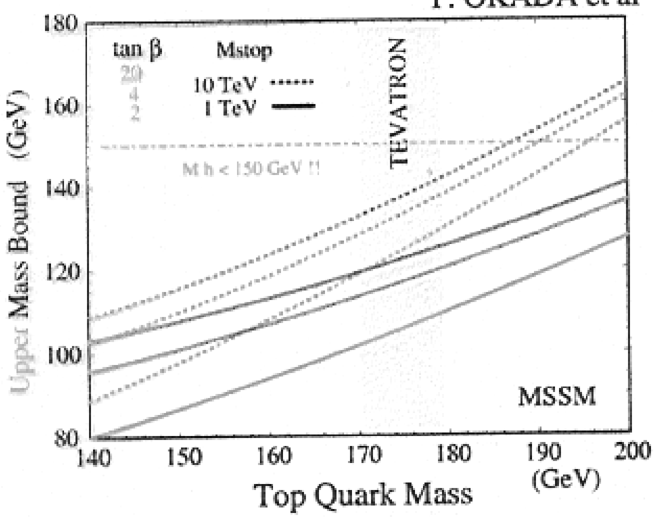
Where is Higgs ?

MSSM

At Tree Level the lightest CP-even Higgs , h, must be lighter than Z-boson

Top/Stop loop can make it larger, but limited

Y. OKADA et al

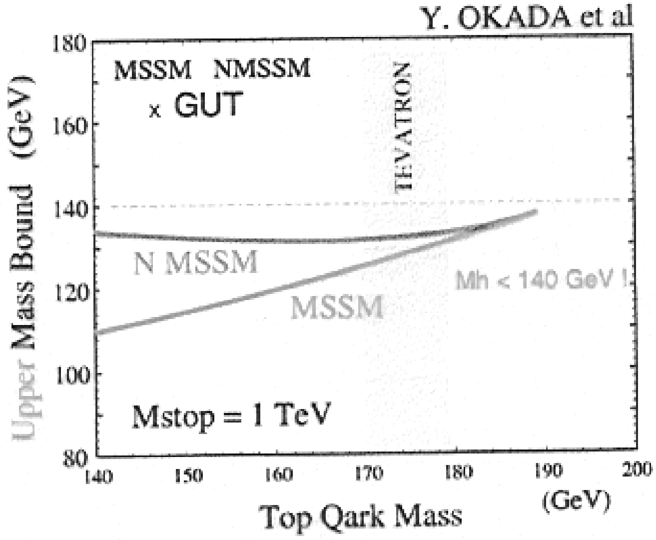


Mh < 150 GeV

NMSSM (MSSM + extra singlet)

if we assume the higgs coupling is finit upto GUT scale

Y. OKADA et al



Mh < 140 GeV!

XMSSM

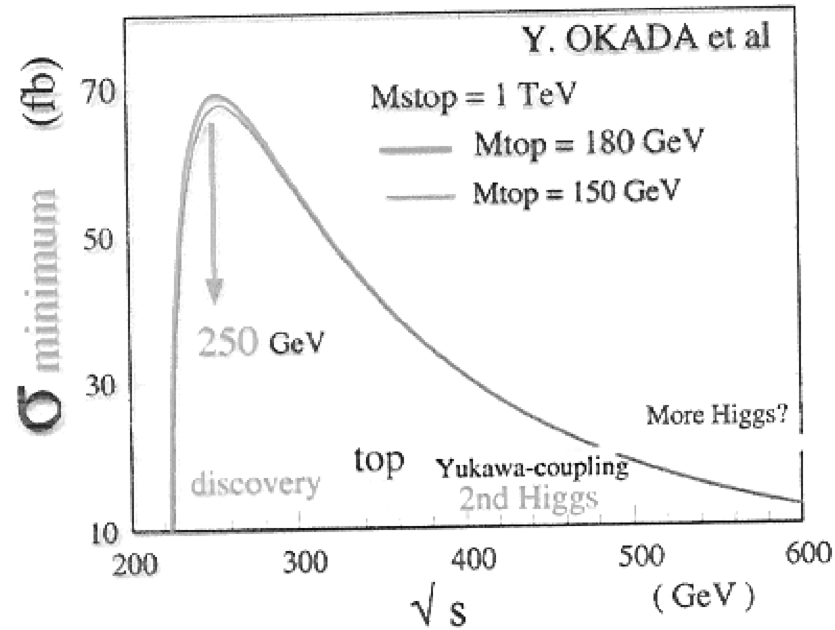
Mh < 180 GeV

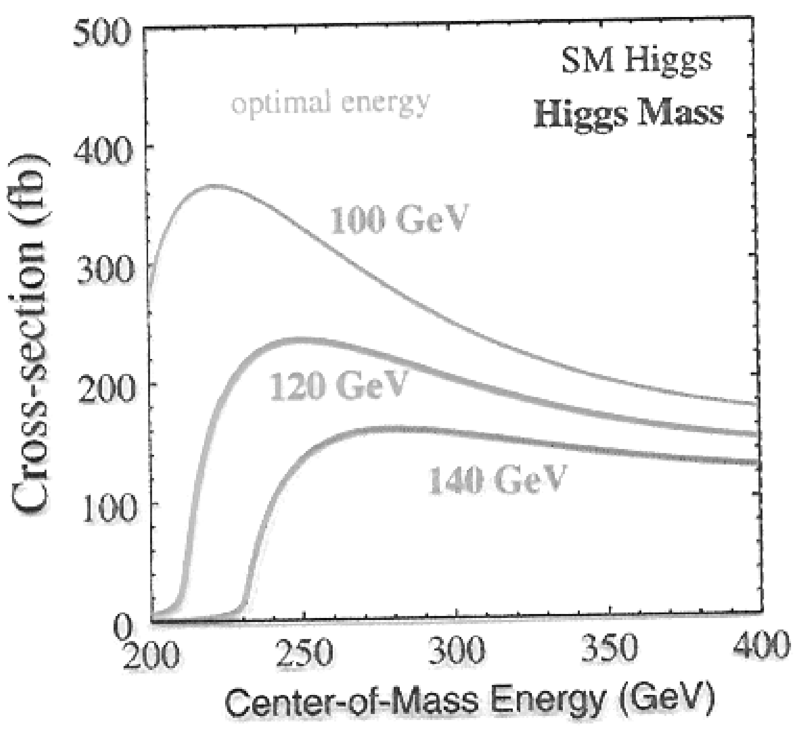
210

Espinosa et al

(observable)

Minimum Cross-section for lightest CP-even Higgs production SM, MSSM, NMSSM





$\sigma(e^+e^- \to \nu\nu H) / \sigma(e^+e^- \to ZH)$

We have to confirm $SU(2) \times U(1)$

$Br(h \to \tau\tau) / Br(h \to bb)$

Type-II (SM, MSSM..) or other?

If all observations show SM-like,
(m_A large)
let's start (very) precise measurement
to tell SM from MSSM, others.

- Indirect measurement of M_A
- Γ_{tot} from $Br(h \to WW^*)$ etc ....

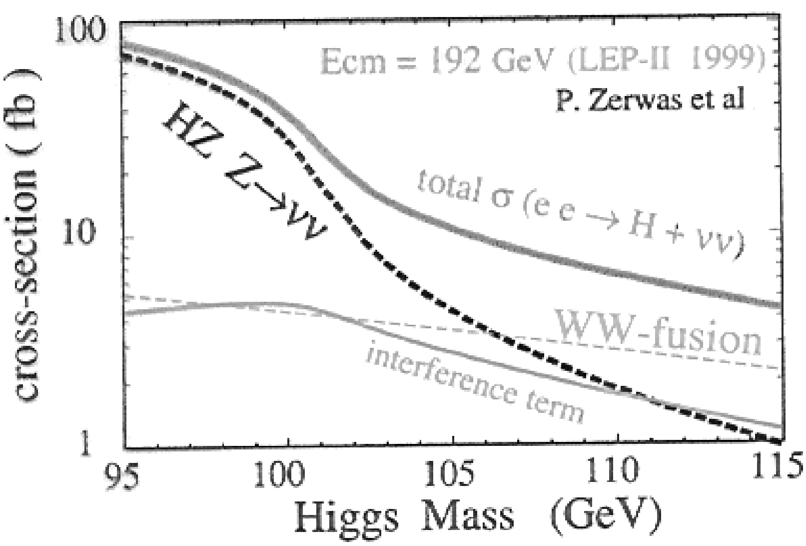
only LC can cover!!

⟹ 2nd phase of LC

Example of Higgs Measurements

WW-fusion cross-section measurement

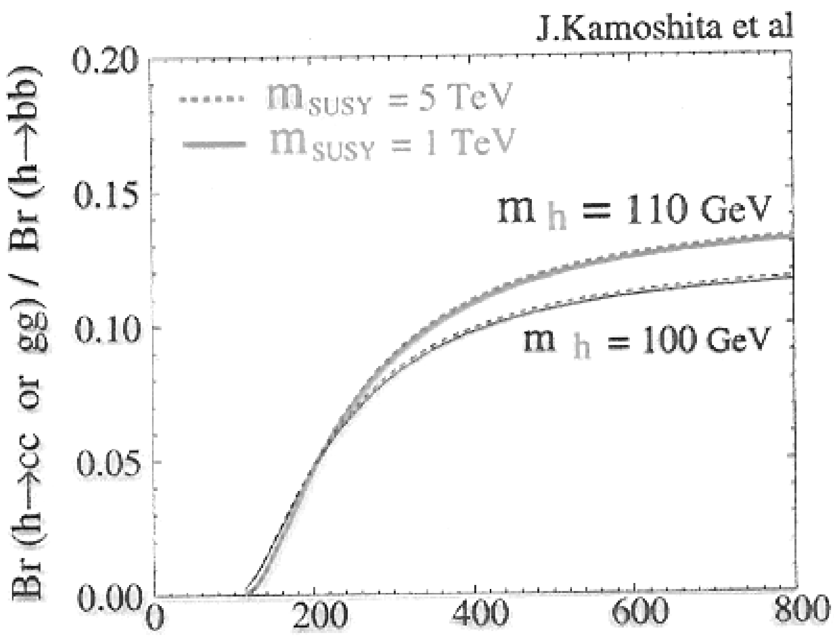
Verify Higgs Gauge Coupling



Measurement of the branching rate

SUSY parameter dependence is small for gg, cc

Know the A mass



LCWS '99 Higgs session

- Presented results were all for $\sqrt{s} = 300 \sim 500$ GeV (1st phase)
- Many talks on Br measurements.
- Various working points (person by person) $\sqrt{s}$, $\mathcal{L}$, detector performances.
- ~ Realistic simulation
- Several checks have been started in very realistic situation @ LC
- New idea, sophisticated techniques extended our sensitivities.

List of Experimental talks @ Higgs

- J. Conway "Higgs discovery potential in Run 2 at the Tevatron" — Tevatron Run-II
- W. Lohmann, P. García-Abia "Measuring the Higgs cross-section and mass with the NLC" — σ, M_H
- A. Just "M_H determination from direct reconstruction of ZH ($Z \to q\bar{q}$)"
- I. Nakamura "Higgs measurement @ JLC" σ, Br — Higgs Br measurement
- M. Battaglia "Measuring Higgs Br and telling a SM from MSSM Higgs"
- H.J. Schreiber "Measuring Br of SM Higgs $M_H = 160$ GeV"
- D. Reid "Measurement of Br($H \to \gamma\gamma$) at LC"
- A. Sopczak "A direct measurement of $\tan\beta$ $e^+e^- \to b\bar{b} \to b\bar{b}A$ at LC" — Yukawa coupling A^0
- K. Ishii "Detector acceptance ... for HZ / WW-fusion σ measurement" — Acc. detector
- I. Ueda "Effect of beam-strahlung in Higgs measurement" — beam

$\sigma(e^+e^- \to hZ)$ measurement

to determine σ independently to h decay,

use only leptonic channel.

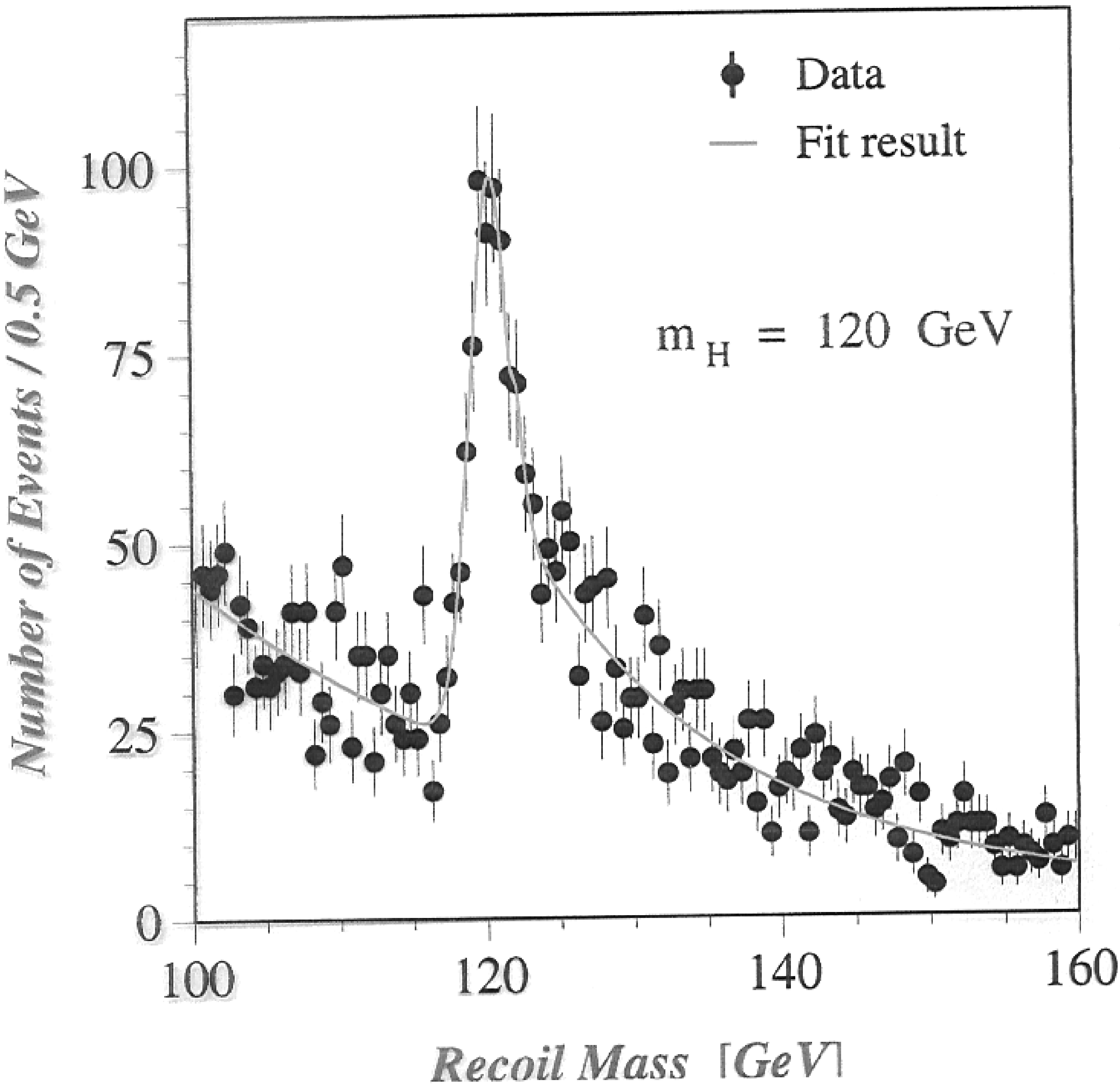
$$\left(e^+e^- \to h\, Z \quad \begin{matrix} Z \to ee \text{ or } \mu\mu \\ h \to X \end{matrix} \right)$$

Recoil Mass Fit, e^+e^-

ECFA DESY Linear Collider Workshop

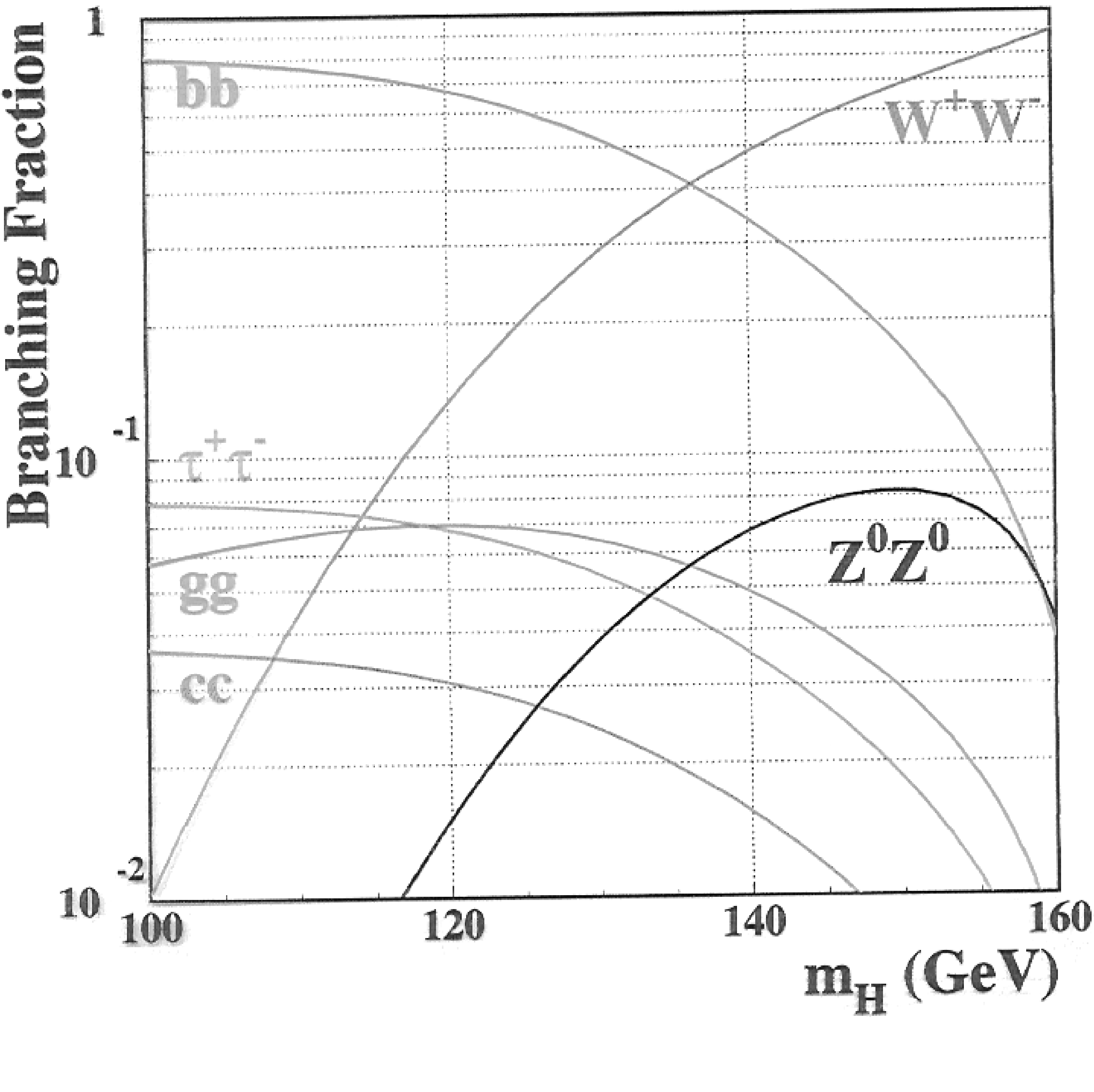
$$M_H = 120.48 \pm 0.14 \ \text{GeV}$$
$$\sigma_H = 1.48 \pm 0.11 \ \text{GeV}$$

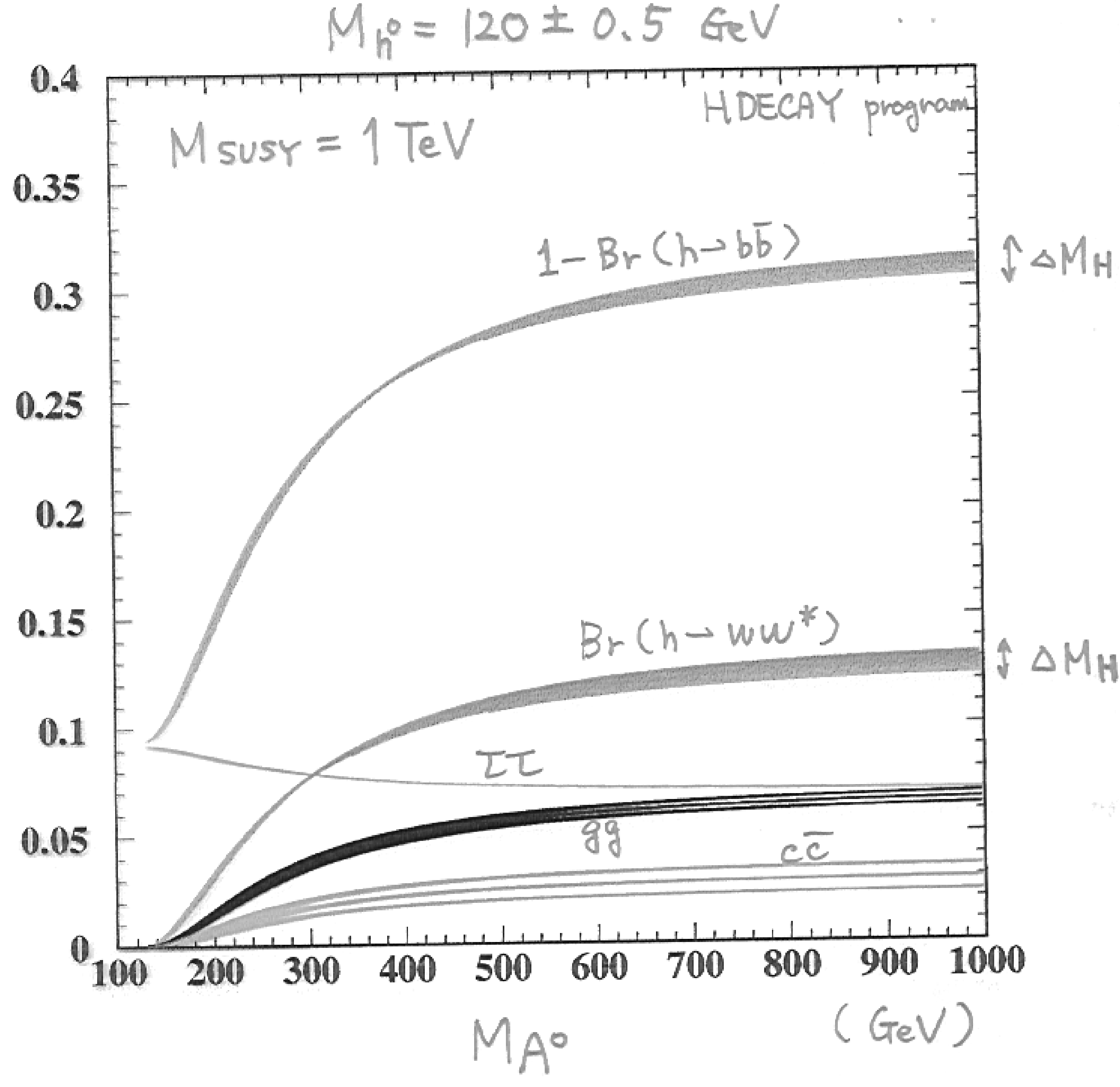
$$\sigma(ZH \to e^+e^-X) = 5.26 \pm 0.18 \pm 0.13 \ \text{fb}$$



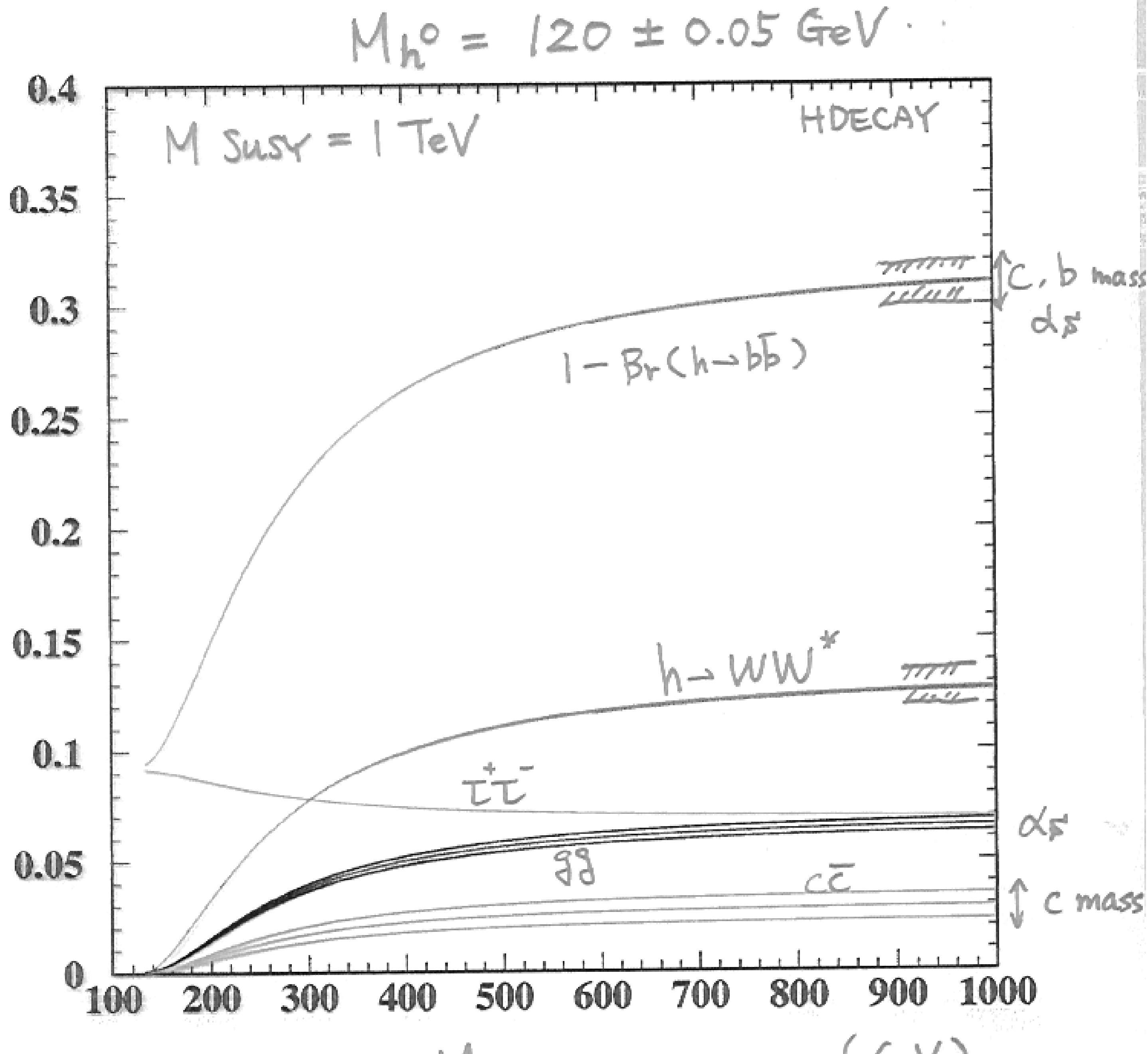
Br ratio is strong function of M_H.

Accurate M_H determination is essencial





M_h° = 120 ± 0.5 GeV
M_SUSY = 1 TeV
HDECAY program
1 − Br (h → bb̄)
↕ ΔM_H
Br (h → WW*)
↕ ΔM_H
ττ
gg
cc̄
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
100
200
300
400
500
600
700
800
900
1000
M_A°
(GeV)



Mh° = 120 ± 0.05 GeV
M Susy = 1 TeV
HDECAY
c, b mass
αs
1 − Br(h → bb̄)
h → WW*
τ+τ−
αs
gg
cc̄
c mass
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
100 200 300 400 500 600 700 800 900 1000
MA°
(GeV)

M_H measurement

talk by A. Juste

New idea / technique

HZ → 4 jet : highest statistics.

but bad mass resolution in simple way

New!

Use : Beam momentum distribution

ISR effects

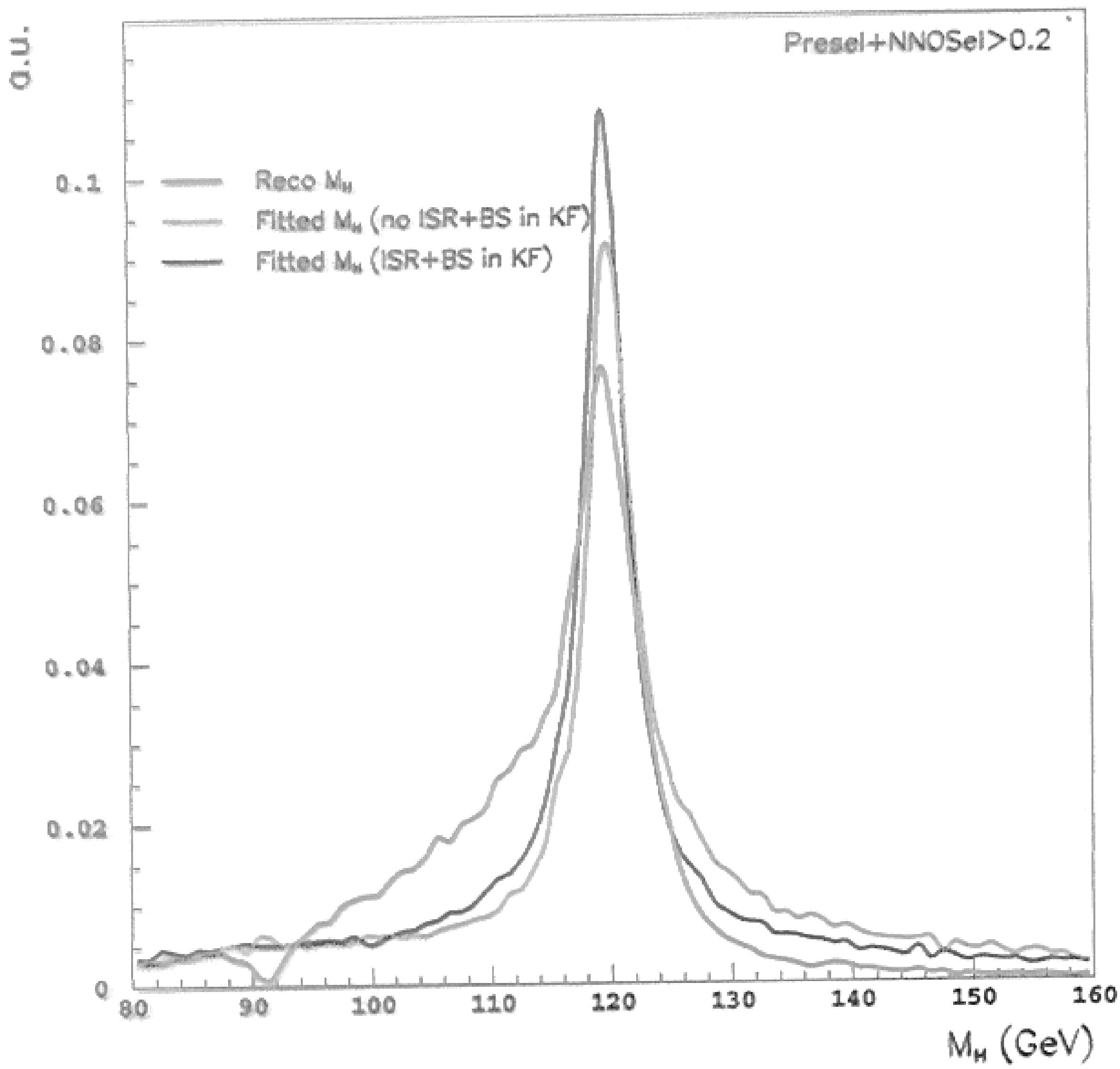
⇒ Kinematic fit of 4 jets

with the distributions.

A. Juste

$(\Delta M_H)_{stat} = 300$ MeV

$\sqrt{s} = 500$ GeV $\mathcal{L} = \underline{10\ fb^{-1}}$



a.u.
Presel+NNOSel>0.2
Reco M_H
Fitted M_H (no ISR+BS in KF)
Fitted M_H (ISR+BS in KF)
0.1
0.08
0.06
0.04
0.02
0
80
90
100
110
120
130
140
150
160
M_H (GeV)

Branching Ratio

A) $\Gamma(h \to all) = \dfrac{\Gamma(h \to W^*W)}{Br(h \to W^*W)} = \dfrac{\Gamma(H^0_{SM} \to WW)\,\sigma(hZ)}{Br(h \to WW) \cdot \sigma(H^0_{SM} Z)}$

B) $\Gamma(h \to b\bar{b}) \propto m_b^2 \dfrac{\sin^2\alpha}{\cos^2\beta}$

$\Gamma(h \to \tau\tau) \propto m_\tau^2$ "

$\dfrac{Br(h \to \tau\tau)}{Br(h \to bb)} \propto \dfrac{m_\tau^2}{m_b^2}$

$\Rightarrow$ $\underline{m_b}$

C) $\Gamma(h \to c\bar{c}) \propto m_c^2 \dfrac{\cos^2\alpha}{\sin^2\beta}$

$\Gamma(h \to gg) \propto \dfrac{\cos^2\alpha}{\sin^2\beta}$ (top loop)

$\dfrac{Br(c\bar{c}+gg)}{Br(b\bar{b})} \propto \dfrac{1}{\tan^2\alpha \tan^2\beta} \approx \left[\dfrac{M_A^2 - M_h^2}{M_A^2 - M_Z^2}\right]^2$

(large $\tan\beta$)

$\dfrac{Br(c\bar{c})}{Br(b\bar{b})} \propto$

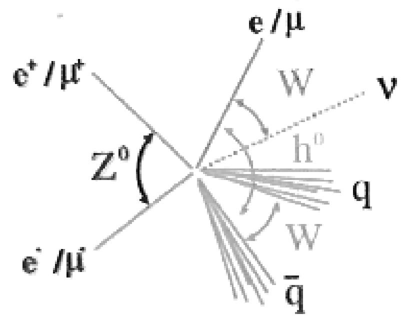
$\Rightarrow$ $\boxed{m_A}$ MSSM

$\dfrac{Br(gg)}{Br(b\bar{b})} \propto$

(m_c, α_s ambiguity large

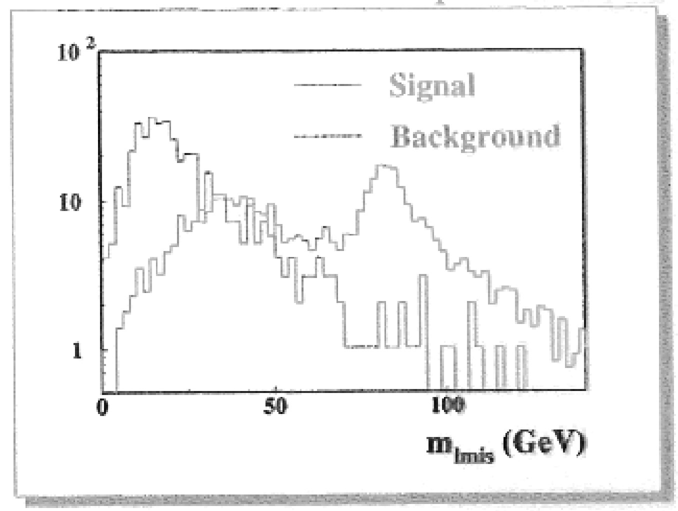
D) $\Gamma(h \to all) = \dfrac{\Gamma(h \to \gamma\gamma) \times Br(h \to b\bar{b})}{Br(h \to \gamma\gamma) \times Br(h \to b\bar{b})}$ $\Leftarrow$ from $\sigma(\gamma\gamma \to h \to b\bar{b})$

Measurement of Br($h^0 \to WW^*$)



- Use $e^+e^- \to Z^0h^0$
  $Z^0 \to q\bar{q}$ or $\ell^+\ell^-$
  $h^0 \to WW^* \to \ell\nu q\bar{q}$
- The final states are
  - $q\bar{q}\ell\nu q\bar{q}$, and
  - $\ell^+\ell^-\ell\nu q\bar{q}$
- Selecting one(three) lepton(s)
- $m_{jj}(m_{\ell\ell})$ compatible with m_{Z^0}
- Lepton Isolation
- Background from W^+W^-, Z^0Z^0

Invariant mass of 3rd Lepton and p_{mis}



	$q\bar{q}\ell\nu q\bar{q}$	$\ell^+\ell^-\ell\nu q\bar{q}$	total
Efficiency	5.8 %	17.3 %	
Signal	99.3	28.4	137.7
Higgs Bkg	8.7	8.0	16.7
Other Bkg	79.3	15.5	94.8
Total Bkg	88.0	23.5	111.5
Accuracy	13.8	25.4	11.5

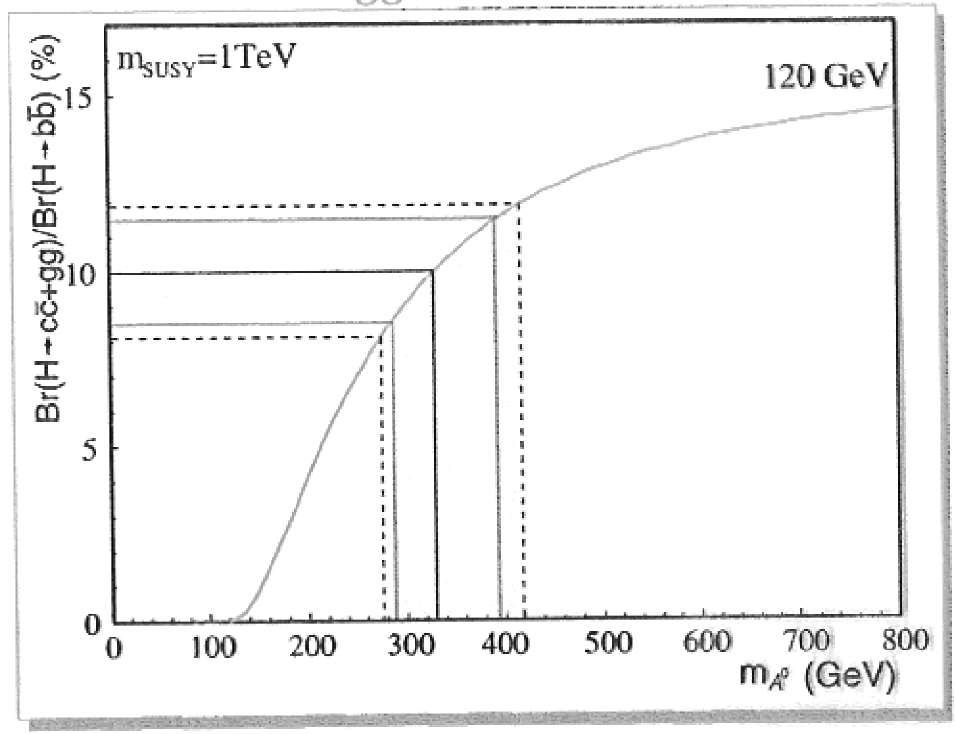
efficiency is from all $h^0 \to W^+W^-$ decay

Branching Fraction

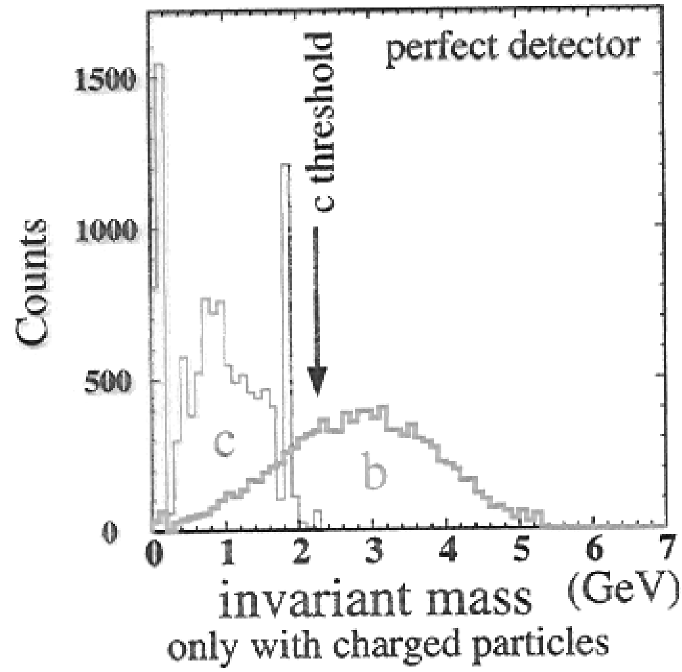
Result for $m_{h^0} = 120$ GeV with 100 fb^{-1}

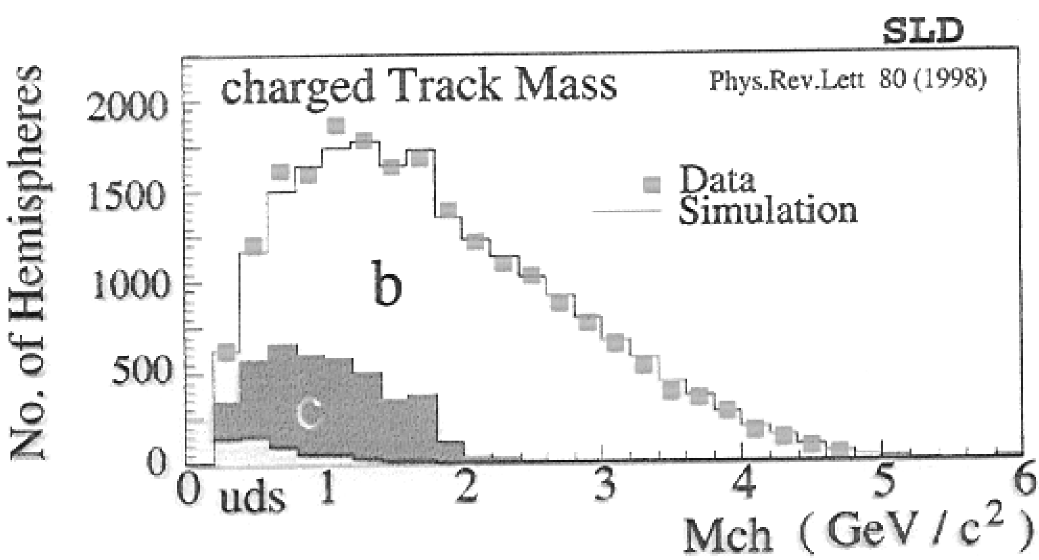
$Br(h^0 \to b\bar{b})$	2.5 %
$Br(h^0 \to c\bar{c})$	49 %
$Br(h^0 \to gg)$	23 %
$Br(h^0 \to c\bar{c}+gg)$	15 %
$\frac{Br(h^0 \to c\bar{c})}{Br(h^0 \to b\bar{b})}$	49 %
$\frac{Br(h^0 \to c\bar{c}+gg)}{Br(h^0 \to b\bar{b})}$	15 %

$Br(h^0 \to c\bar{c}+gg)/Br(h^0 \to b\bar{b})$ vs m_{A^0}



VTX mass tagging for b-c separation



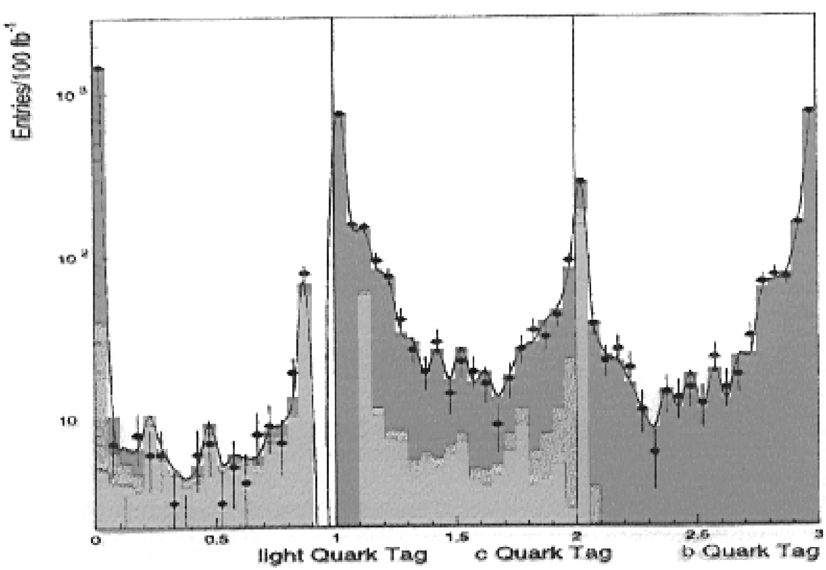


Measuring Higgs Branching Ratios

$\mathbf{BR}(H^0 \to q\bar{q})$

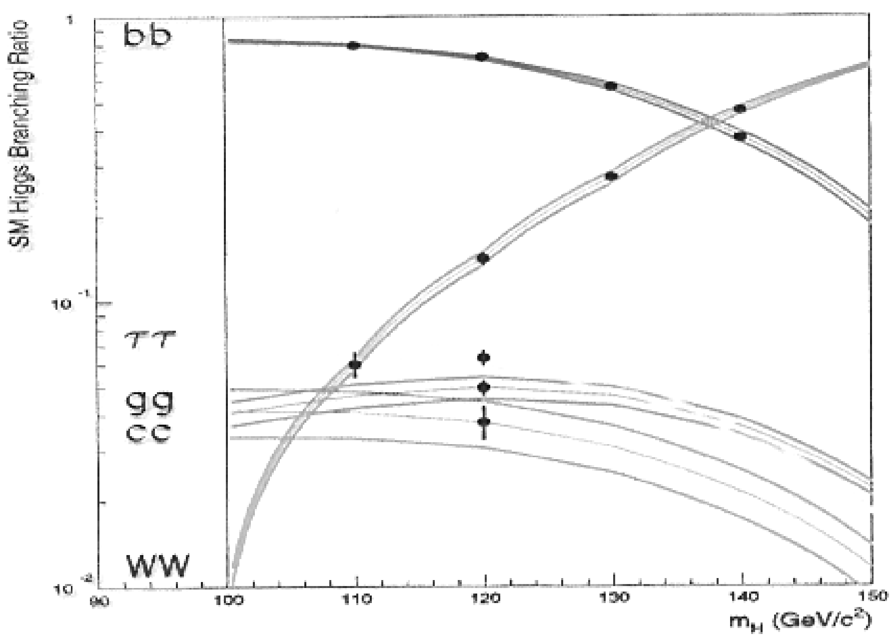
- For each candidate hadronic Higgs decay compute $u\bar{u} + d\bar{d} + s\bar{s}$, $c\bar{c}$ and $b\bar{b}$ di-jet flavour tagging probabilities;
- subtract background from H^0 peak sidebands;
- Fit:
  - BR($H \to b\bar{b}$)/BR($H \to$ hadrons),
  - BR($H \to c\bar{c}$)/BR($H \to$ hadrons) and
  - BR($H \to gg$)/BR($H \to$ hadrons) fractions
- use a binned likelihood fit to the background subtracted di-jet flavour tagging response (3 entries/evt).

$\sqrt{s} = 350$ GeV



Higgs Branching Ratio Determination for $m_H = 120$ GeV/c^2 and 500 fb^{-1}

Channel	$\delta(\frac{BR(H\to X)}{BR(H\to \text{hadrons})})/BR$		$\delta(BR(H\to X)/BR$	
$H^0/h^0 \to b\bar{b}$	± 0.011	± 0.008	± 0.024	± 0.024
$H^0/h^0 \to c\bar{c}$	± 0.134	± 0.080	± 0.135	± 0.083
$H^0/h^0 \to gg$	± 0.050	± 0.050	± 0.055	± 0.055
$H^0/h^0 \to \tau^+\tau^-$			± 0.060	
$H^0/h^0 \to WW^*$			± 0.051	



- SM BR's and uncertainties estimated from HDECAY program:
  - $m_b = (4.82 \pm 0.10)$ GeV/c^2, $m_b - m_c = (3.40 \pm 0.04)$ GeV/c^2
  - $\alpha_s(m_Z) = 0.1164 \pm 0.0025$, $m_{top} = (175 \pm 0.3)$ GeV/c^2

SCAN OF MSSM PARAMETER SPACE

- Scan of MSSM parameters:

$$2 < \tan\beta < 60$$
$$150\ \mathrm{GeV}/c^2 < M_A < 1100\ \mathrm{GeV}/c^2$$
$$500\ \mathrm{GeV}/c^2 < M_{SUSY} < 1500\ \mathrm{GeV}/c^2$$
$$-1000\ \mathrm{GeV} < \mu < 1000\ \mathrm{GeV}$$
$$0 < M^t_{LR}/M_{\tilde{q}} < \sqrt{6}$$
$$0.5 < M_{\tilde{g}}/M_{SUSY} < 1$$

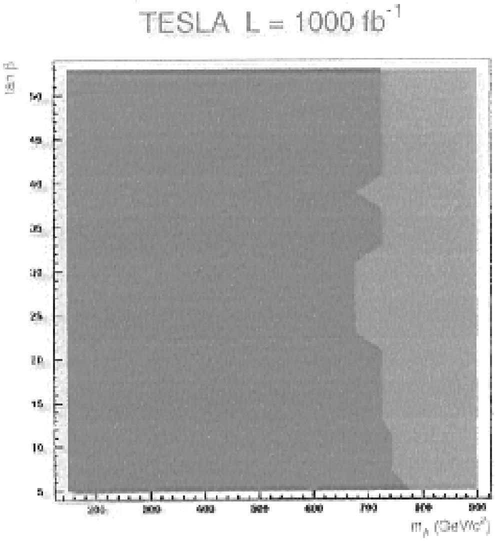
- find MSSM parameters giving $M_{h^0} = (120 \pm 2)\ \mathrm{GeV}/c^2$ using the diagrammatic two-loop result for M_h by *Heinemeyer, Hollik, Weiglen* implemented in the FEYNHIGGS program,
- compute Higgs decay branching ratios, including QCD corrections for quark and squark loops computed by *Djouadi, Kalinowski, Spira* and implemented in the HDECAY program.
- compute pulls of MSSM BR's from those predicted in SM:

$$\Delta(BR) = \frac{|BR^{MSSM} - BR^{SM}|}{\sqrt{\sigma^2_{th} + \sigma^2_{exp}}}$$

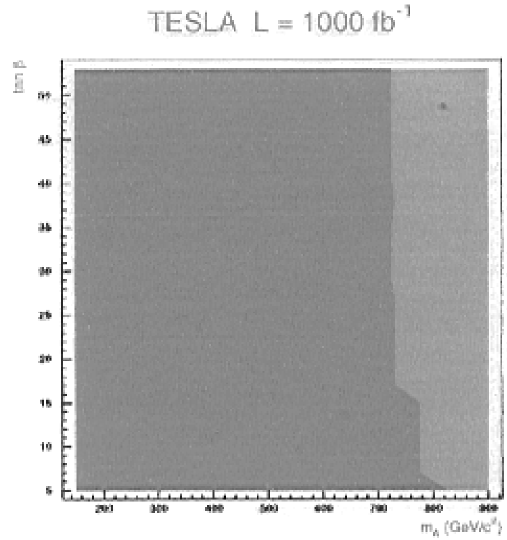
- choose as discriminating variables:
  1. BR($h \to b\bar{b}$)/BR($h \to$ hadrons)
  2. BR($h \to c\bar{c}$)/BR($h \to$ hadrons)
  3. BR($h \to g\bar{g}$)/BR($h \to$ hadrons)
  4. BR($h \to b\bar{b}$)/BR($h \to W\bar{W}^*$)

SM / MSSM Separation in M_A - $\tan\beta$ plane
$\int L = 1000$ fb^{-1}, Theory Syst. / 2.0

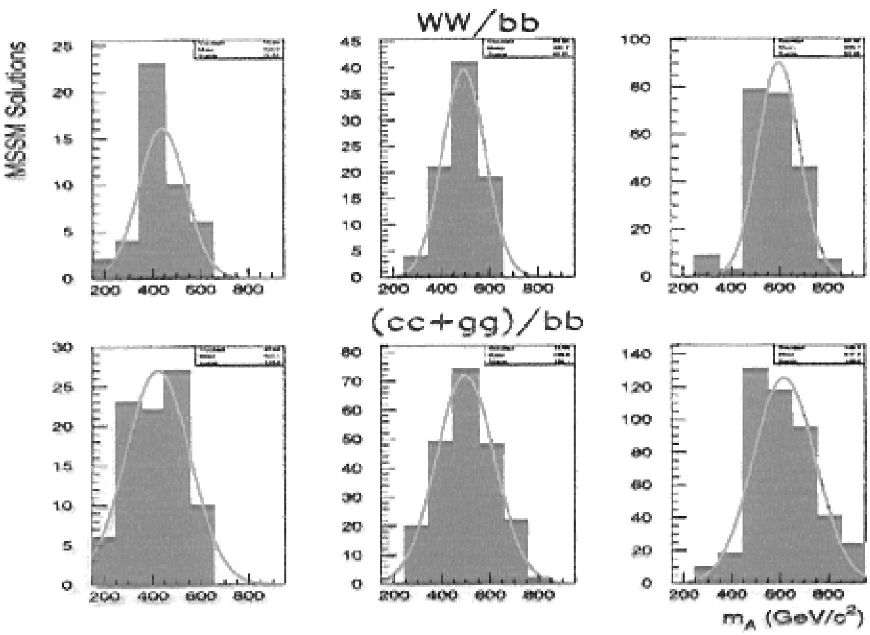
CDR Vertex Tracker



Improved Vertex Tracker



Sensitivity to M_A



$\mathcal{L} = 10\ fb^{-1},\ 100\ fb^{-1},\ 500\ fb^{-1},\ 1000\ fb^{-1}$

$\sqrt{s} = 300,\ 350,\ 400,\ 500$ GeV

Bench Mark $M_H = 120$ GeV

	$\sqrt{s}=300$	350	400	500 GeV
σ	6% $\mathcal{L}=100\ fb^{-1}$ I. Nakamura et al	< 3% $500\ fb^{-1}$ W. Lohmann et al	—	2.1% $500\ fb^{-1}$ M. Battaglia et al
ΔM_H	—	± 150 MeV (ee, μμ only) $500\ fb^{-1}$ W. Lohmann	—	± 300 MeV (4 jets) $10\ fb^{-1}$ A. Just
$\frac{\Delta Br}{Br}$ $b\bar{b}$	2.5% $100\ fb^{-1}$ I. Nakamura et al	2.4% $500\ fb^{-1}$ M. Battaglia et al	7% $50\ fb^{-1}$ M.D. Hildreth et al (1993)	2.4% $500\ fb^{-1}$ M. Battaglia et al
$c\bar{c}$	49% 〃	13.5% 〃	—	8.3% 〃
gg	23% 〃	5.5% 〃	—	5.5% 〃
WW	11.5% 〃	5.1% 〃	48% 〃	5.1% 〃
ττ	13.4% $50\ fb^{-1}$	5.7% 〃	14% 〃	5.7% 〃
cc+gg	15% 〃	—	39% 〃	—
γγ	—	14% $1000\ fb^{-1}$ D. Reid	—	—
Hνν σ × Br(bb)	2.7% $100\ fb^{-1}$ K. Ishii	—	—	—

$M_H = 120$ GeV $\mathcal{L} = 200\ fb^{-1}$ LCWS'99 compilation

	$\sqrt{s} = 300$ GeV	350 GeV	500 GeV	⇓
$\Delta\sigma/\sigma$	4.2%	4.7%	3.3%	⇒ 4%
ΔM_H	—	230 MeV (ee, μμ only)	60 MeV (4jet)	⇒ 60 MeV
$\Delta Br/Br$				
$b\bar{b}$	1.8%	3.8%	3.8%	⇒ 2%
WW^*	8%	8%	8%	⇒ 8%
$\tau\tau$	7%	9%	9%	⇒ 7%
$cc+gg$	10%	—	—	⇒ 10%
cc	35% (I.P. only)	21%	13%	⇒ 15%
gg	16% (I.P. only)	8%	8%	⇒ 8%
$\gamma\gamma$	—	14% ($L = 1000\ fb^{-1}$)	—	

Similar numbers

~ independent to $\sqrt{s}$?

Towards

real experiment @ LC

soon (2007/2008)

Need

more and more checks

considering

Real experimental situation

At Next Linear Collider (1st phase)

0. High energy Ecm = 250 - 500 GeV
1. High luminosity 2 - 3 order higher than LEP
2. Small beam size ⟶ Good Primary Vetex Resolution
3. New technologies can be used...

Discovery (if LEP/TEVATRON/LHC did not) is garanteed if Higgs exists in energy reach

We expect great Higgs "measurements" from our experiences at LEP/SLC

More consideration

Worse than LEP / SLC ?

1. Beam-beam interaction

   Energy spread, tail : depending on luminosity

   So many ee eeee creation in a train collision ⟶ SI hits

2. Short bunch spacing & high luminosity per bunch

   Events overlap !!

   two-photon process (mini-jet) + signal, bkg

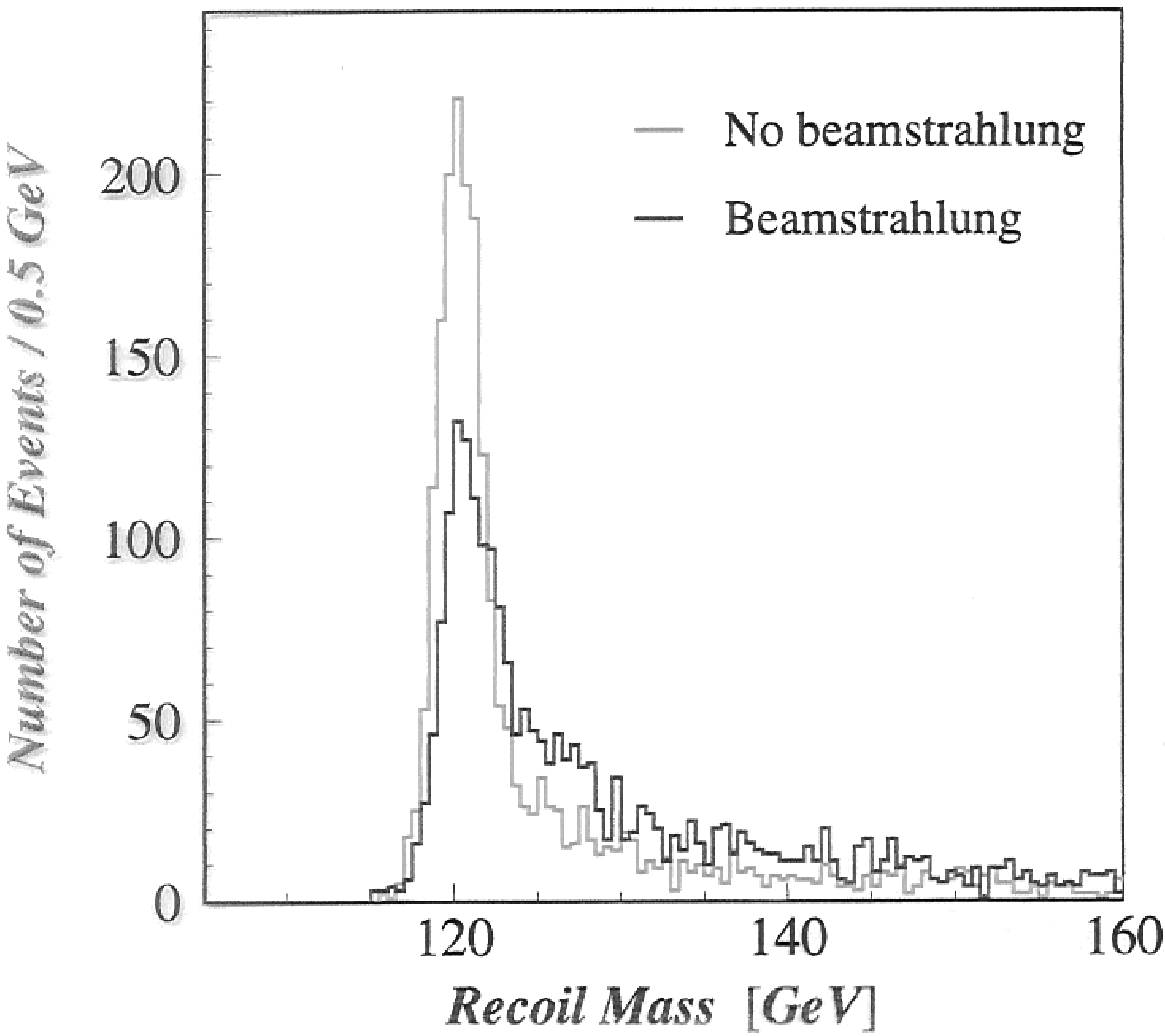
   hard event + hard event ~ hZ, Ah can happen

3. Acceptance

   can not cover very forward region ?

Impact of Beamstrahlung

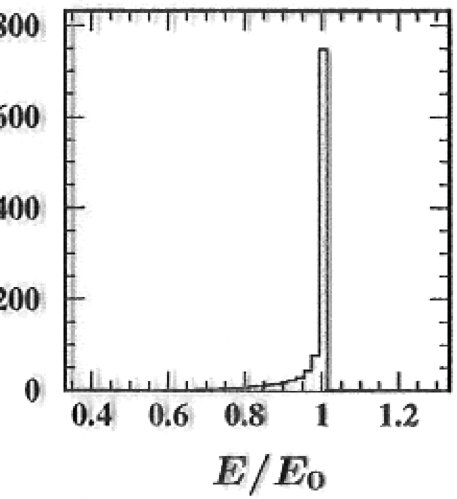
The impact of beamstrahlung on recoil mass spectra



Beamstrahlung

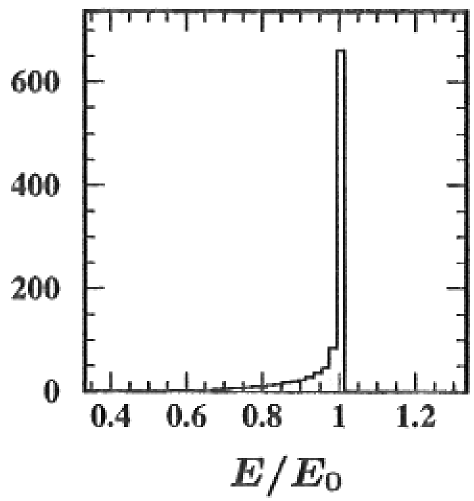
e average energy loss induced by beamstrahlung:

$$\delta_{\mathrm{BS}} = \delta_{\mathrm{BS}}\left(\frac{N_{\mathrm{b}}^2}{(\sigma_{\mathrm{x}}^* + \sigma_{\mathrm{y}}^*)^2}, \frac{E_0}{\sigma_{\mathrm{z}}}\right)$$



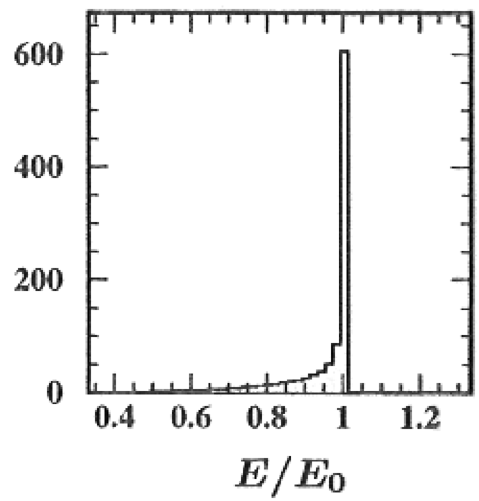
$E_0 = 150\mathrm{GeV}$
$N_{\mathrm{b}} = 0.63 \times 10^{10}$
$\sigma_{\mathrm{x}}^* = 260\mathrm{nm}$
$\sigma_{\mathrm{y}}^* = 3\mathrm{nm}$
$\sigma_{\mathrm{z}} = 90\mu\mathrm{nm}$

$\left(\frac{0.63\times10^{10}}{260\mathrm{nm}}\right)^2$ [1.0]



$E_0 = 150\mathrm{GeV}$
$N_{\mathrm{b}} = 1.26 \times 10^{10}$
$\sigma_{\mathrm{x}}^* = 368\mathrm{nm}$
$\sigma_{\mathrm{y}}^* = 3\mathrm{nm}$
$\sigma_{\mathrm{z}} = 90\mu\mathrm{nm}$

[2.0]



$E_0 = 150\mathrm{GeV}$
$N_{\mathrm{b}} = 1.89 \times 10^{10}$
$\sigma_{\mathrm{x}}^* = 450\mathrm{nm}$
$\sigma_{\mathrm{y}}^* = 3\mathrm{nm}$
$\sigma_{\mathrm{z}} = 90\mu\mathrm{nm}$

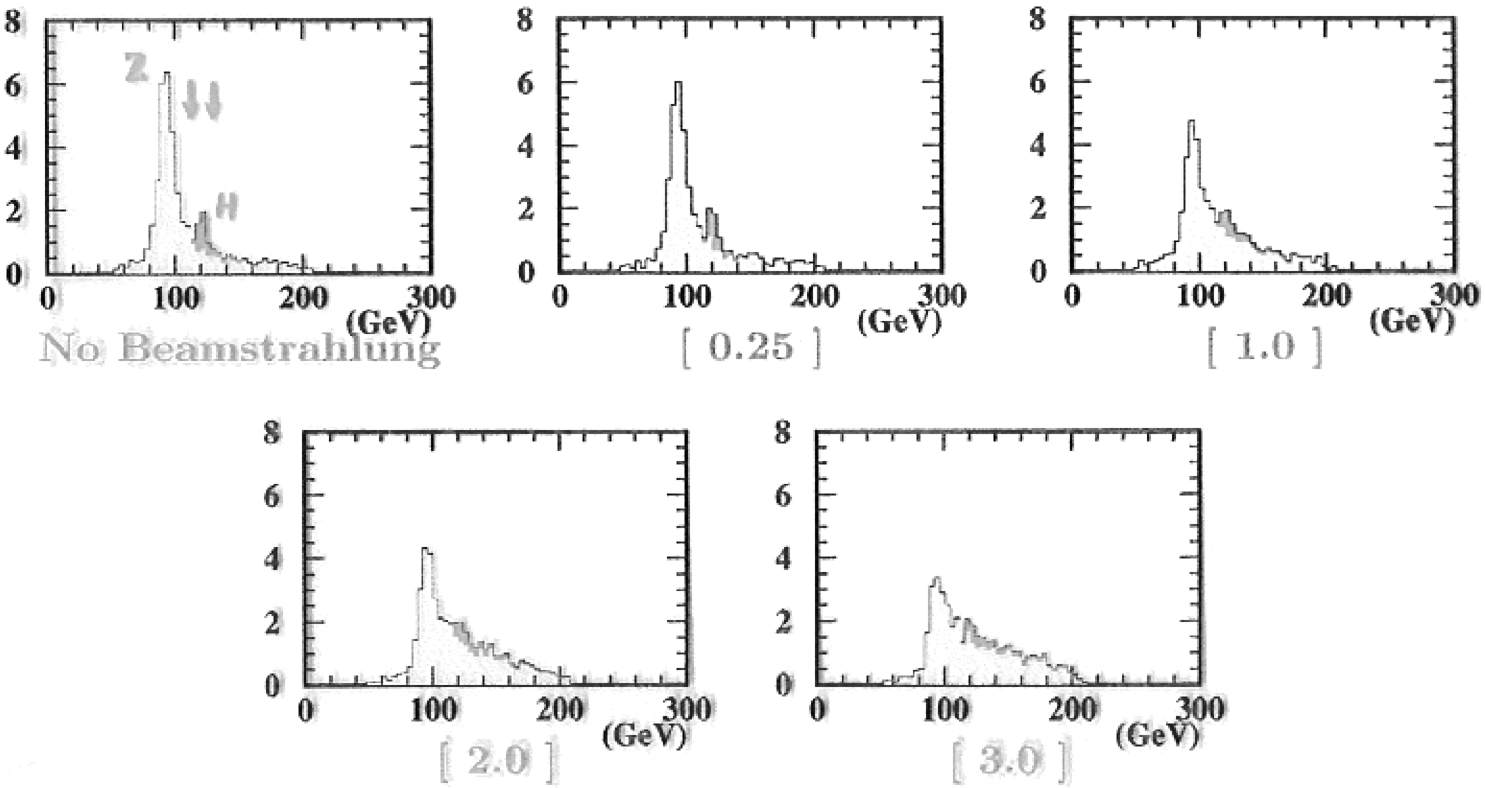
[3.0]

Effect on Recoil Mass

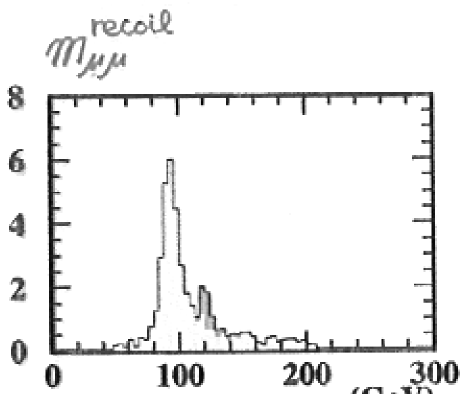
For leptonic channel,

$$m_{\ell\ell} \sim m_Z$$

$$m_{\text{recoil}} = ((\sqrt{s} - E_{\ell\ell})^2 - p_{\ell\ell}^2)^{1/2}$$

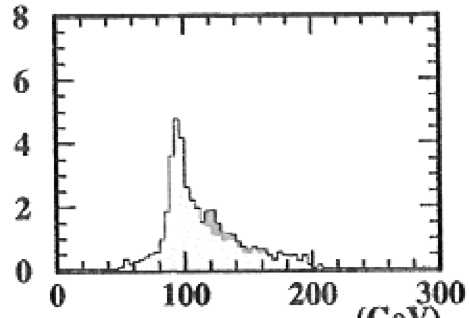


Summary and Conclusion



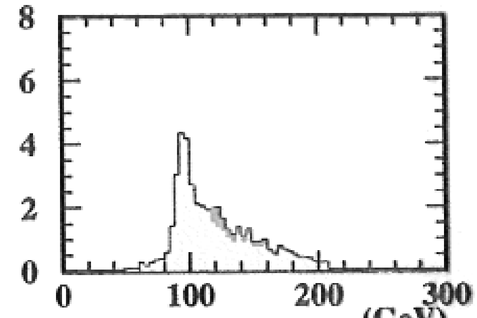
[0.25]

$E_0 = 150\text{GeV}$
$N_b =$ ~~0.63~~ 0.315 $\times 10^{10}$
$\sigma_x^* = 260\text{nm}$
$\sigma_y^* = 3\text{nm}$
$\sigma_z = 90\mu\text{nm}$



[1.0]

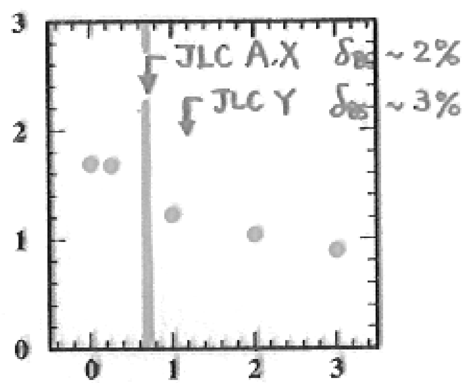
$E_0 = 150\text{GeV}$
$N_b = 0.63 \times 10^{10}$
$\sigma_x^* = 260\text{nm}$
$\sigma_y^* = 3\text{nm}$
$\sigma_z = 90\mu\text{nm}$



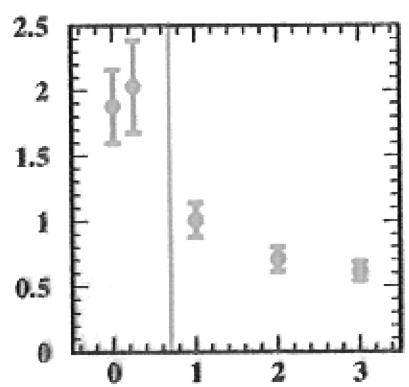
[2.0]

$E_0 = 150\text{GeV}$
$N_b =$ ~~0.63~~ 1.26 $\times 10^{10}$
$\sigma_x^* =$ ~~260~~ 368nm
$\sigma_y^* = 3\text{nm}$
$\sigma_z = 90\mu\text{nm}$

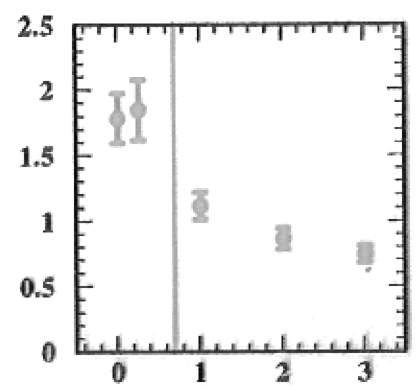
# of sig. evts / fb^{-1}



S/N



$S/\sqrt{N}$ at 1fb^{-1}



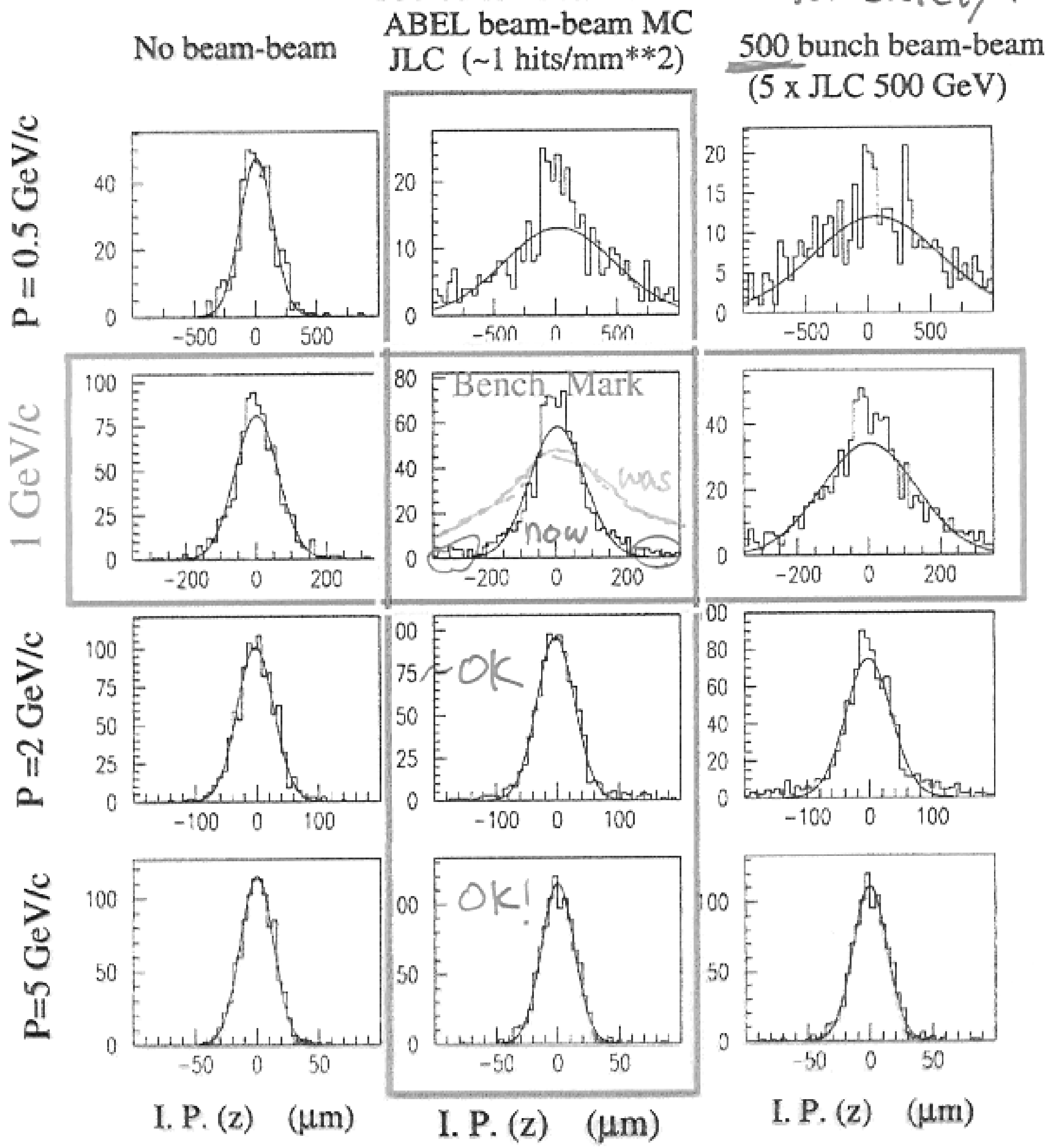
Single track muon p = 0.5-10 GeV cosθ ~ 0.8

beam-beam interaction : ABEL program

T.Tauchi, K.Yokoya, P.Chen Pair creation from beam-beam interaction in linear collider Particle Accerelators 1993 Vol 41 pp29-39.

FULL DETECTOR SIMULATION (JIM)

But using σ_{Si} = 7 μm (instead of 3 μm) for safety!



§2.

Two photon (mini-jet) background

1. Two-photon events and signal event can overlap even in Single Bunch with siginificant rate, due to Huge "Luminosity per Bunch" (L_B)

LEP-II ~ 10^{-6} nb^{-1} / bunch
SLC ~ 10^{-5} nb^{-1} / bunch

JLC-C band / JLC-X / NLC / TESLA(low/high lumi)
Next LCs $L_B = 0.5 - 2 \times 10^{-3}$ nb^{-1} / bunch
(@ 500 GeV parameter)

3 order of magnitude higher than LEP !

Two photon "cross-section" $\sigma_{\gamma\gamma}$ ~ 10 - 100 nb order
(in detector region : hadronic+leptonic)

example : 66 nb @ Ecm=500 GeV (Hadronic: DG1 simulator)
(T.Tauchi LCWS'93: JLC-I '93, minimum Pt 2 GeV/c)

Two-photon overlap rate on "any" signal or bkg

$$\text{Probability} = \sigma_{\gamma\gamma} \times L_B \qquad 1\,\% \sim 20\,\%$$

Can be higher..... depending on Detector acceptance
Machine parameters etc.

1. Event topology, Evis, Acop, Higgs Mass... can be distorted.

2. Track(s) from overlapping two-photon event comes from different production point in beam spot size. Use only r-ϕ ?

c-meson rate is not negligible.

Flavour tagging can be affected.

Selection efficiency, S/N should be affected. Systematic error ?

Can be difficult to control the systematic error.

because

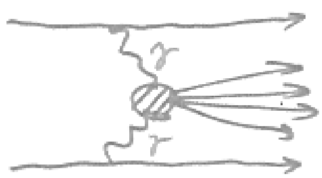
A) it depends on the luminosity bunch by bunch.

Question to experts : How well can we monitor this ?
How stable it is ? Can we use average ?

B) Two-photon cross-section depends on beam dinamics

Two sources of mini-jet

1. normal two-photon (virtual photon + virtual photon)



Machine/beam independent

2. beam-shtrahlung (real) photon + virtual photon

Machine/beam condition dependent

Same level of contribution from 1. and 2. (T. Tauchi JLC-I)

BUT we want to MEASURE Higgs property PRECISELY.

Monte Carlo Study

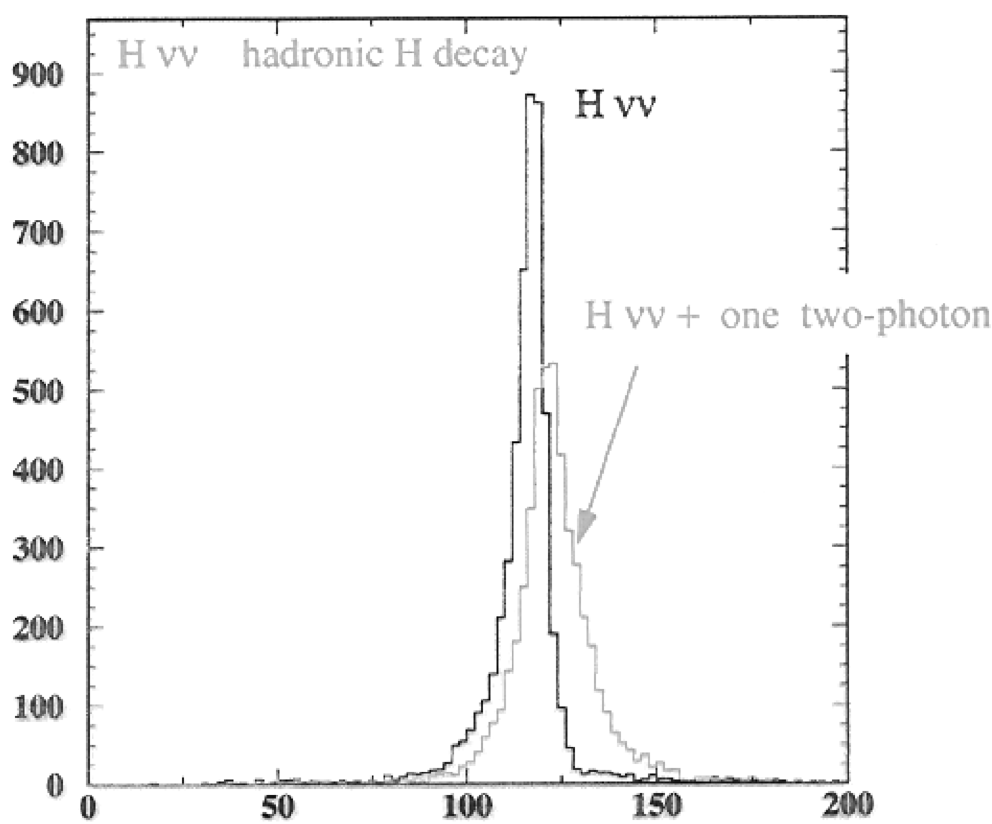
Higgs signal / bkg events (ff, WW, ZZ, Weν, Zee with Pythia)
with beam-strahlung Ecm smearing/tail

+ Two-photon sample : PHOJET (thanks to S.Soldner-Rembold)
$M_{\gamma\gamma} > 2$ GeV Ecm=300 GeV

Use JSF Quick simulator , No beam-beam hits overlaied.

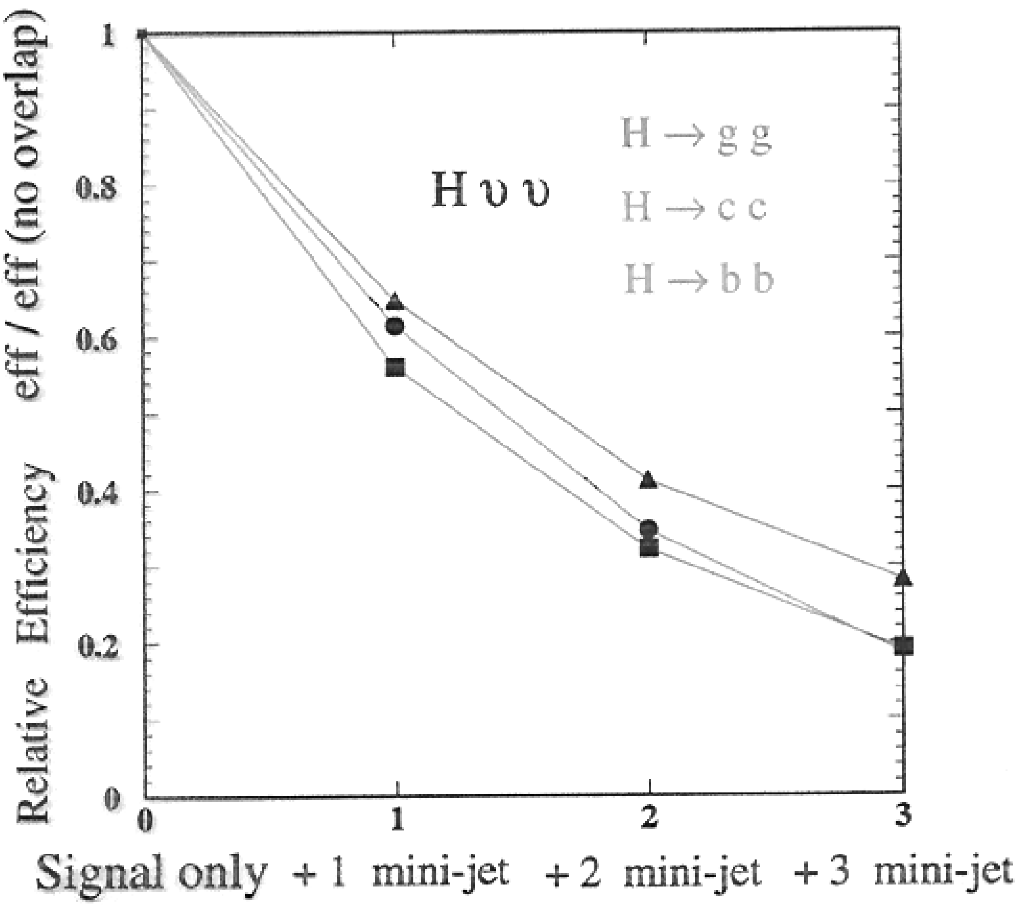
Effects on Higgs Mass reconstruction

Higgs Mass (visible mass) distribution



Effect on kinematic selection efficiency

Just applying selection optimised for no-overlap (I. Nakamura's talk)



Background level is almost same.

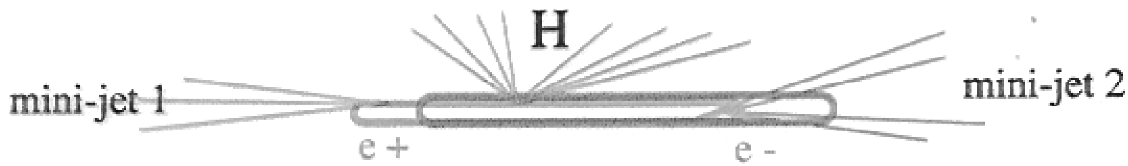
Wev increased rapidly, but still small.

Effect on the flavour tagging

Example for extreme case

Higgs (ννH) + 2 x mini-jet events

Check for different beam z-width (80 and 400 μm)

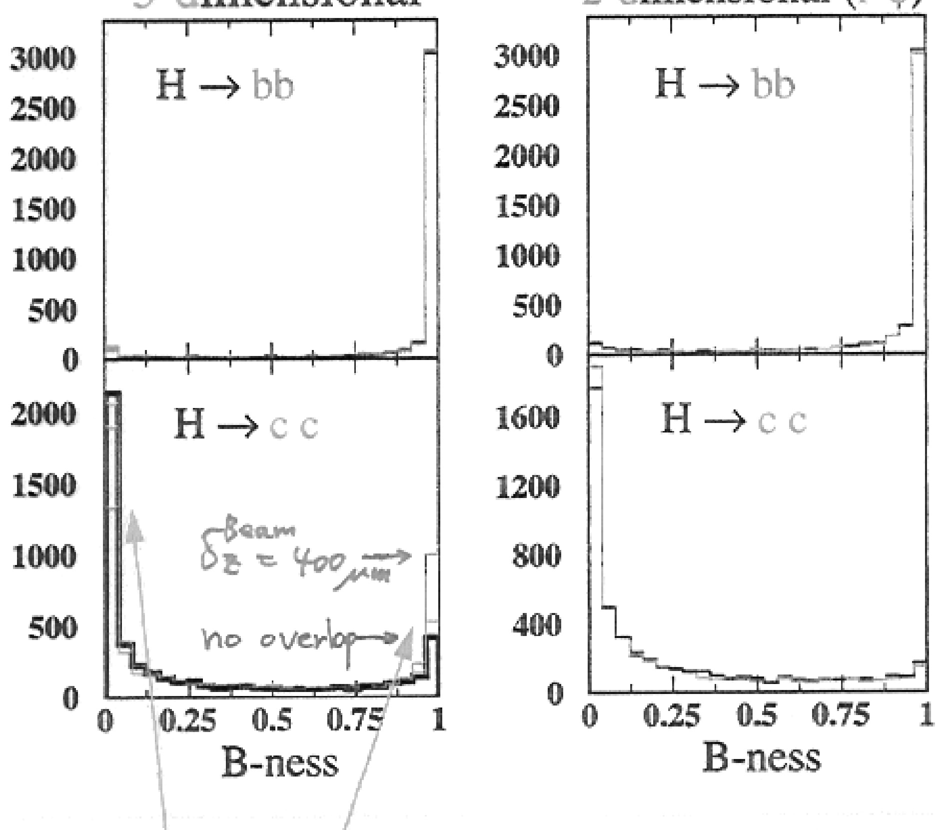


— overlap (σz beam = 0 : same pos)

— Higgs only — overlap (σz beam = 80 μm)

— overlap (σz beam = 400 μm)

3-dimensional 2-dimensional (r-φ)



b-c decay separation is sensitive to overlap rate.

No problem if overlap rate < 20 %

Insensitive to overlap rate

For very high luminosity. Sensitivity is lower than 3-d

Note : Using only tracks in |cosθ| < 0.9

Conclusion

1. Next Linear Collider is a unique machine to deeply investigate Higgs sector.

   We have big opportunity to discover big things from measurements of M_H, σ, Br.

2. Measurements accuracy does not strongly depend on $\sqrt{s}$ ($\sqrt{s}$ = 300 – 500 GeV)

   Stat error with $\mathcal{L}$ = 200 fb^{-1}, M_H = 120 GeV

   $\Delta\sigma/\sigma \sim 4\%$, $\Delta M \sim 60$ MeV

   $\Delta Br/Br$ $b\bar{b} \sim 2\%$, $WW \sim 8\%$
   $\tau\tau \sim 7\%$, $cc + gg \sim 10\%$
   $cc \sim 15\%$, $gg \sim 8\%$

   - already systematic error can dominate (experimental & theoretical)
   - to evaluate M_{A^0} (c-mass, α_s, Ebeam, η_{eff})

   If everything are controled well (theory sys → ½)
   we can discriminate MSSM from SM
   up to $M_A \lesssim 600 - 700$ GeV
   (500 fb^{-1})

Conclusion (cont')

The experimental environment at Next LC is very much different from LEP/SLC.

- Beam strahlung → Ebeam spread
- incoherent e^+e^- pair bkg → difficult tracking
- 3 order higher Luminosity / bunch → two photon overlap. double events overlap.

All affects systematic error as well as nominal sensitivity.

realistic investigation has been started.

These are still problematic. But getting better.

Detector requirements / Accelerator requirements

- ⊙ $\Delta T_0 < 1$ nsec, $\Delta T < 1$ nsec for tracker & CAL (JLC/NLC-type)
- ⊙ $\Delta E/E < 10\%/\sqrt{E}$ for $\gamma\gamma$
- ⊙ Acceptance $|\cos\theta|$ down to 0.98 for CAL
- ⊙ $\mathcal{L}$/bunch $\lesssim 2\times10^{-3}$ nb^{-1}
- → ⊙ Start experiment(s) in 2007 or 2008 as scheduled.