MSSM Higgs Bosons

MSSM Higgs sector – supersymmetry & anomaly free theory ⇒ 2 complex Higgs doublets

$\overset{\text{EWSB}}{\longrightarrow}$ neutral, CP-even h, H | neutral, CP-odd A | charged H^+, H^-

Higgs masses

$$M_h \lesssim 140 \text{ GeV}$$
$$M_{A,H,H^\pm} \sim \mathcal{O}(v)...1 \text{ TeV}$$

Ellis et al;Okada et al;Haber,Hempfling;
Hoang et al;Carena et al;Heinemeyer et al;
Zhang et al;Brignole et al;...

Decoupling limit:

$M_A \sim M_H \sim M_{H^\pm} \gg v$

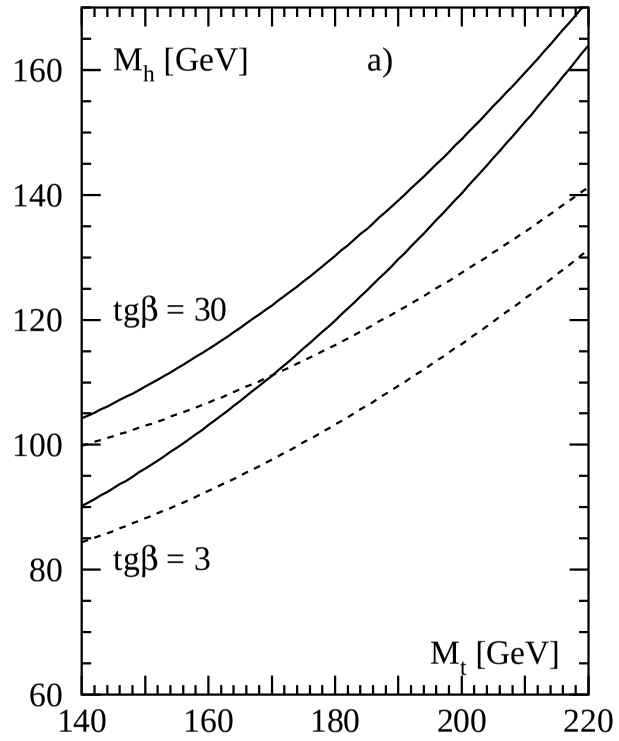
$M_h \to$ max. value, $\tan\beta$ fixed; h becomes SM-like $M_h \sim \sqrt{M_Z^2 \cos^2 2\beta + \epsilon \sin^2 \beta}$, $\alpha \sim \beta - \frac{\pi}{2}$

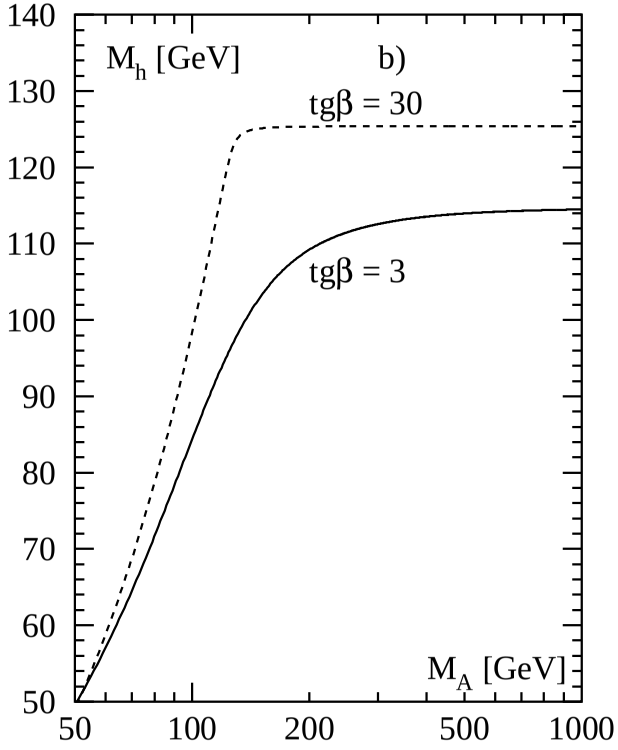
Modified couplings with respect to the SM: (decoupling limit Gunion,Haber)

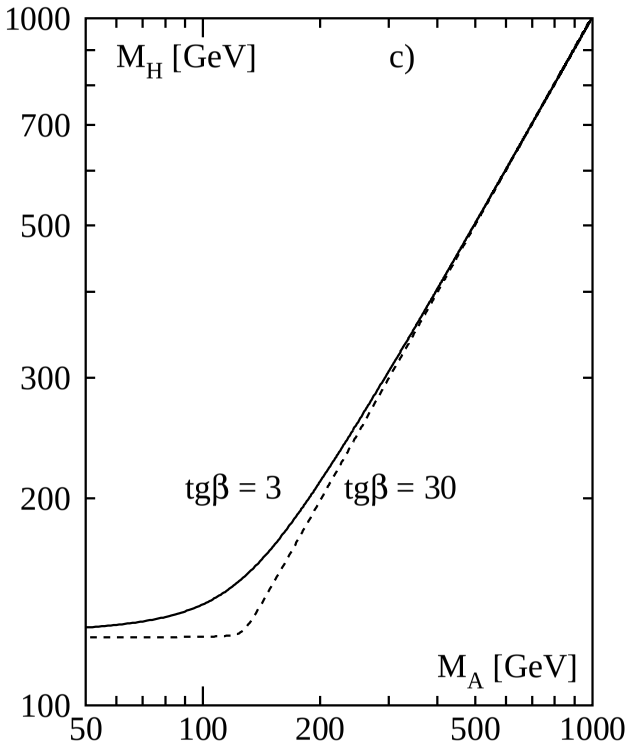
Φ	$g_{\Phi u\bar{u}}$	$g_{\phi d\bar{d}}$	$g_{\Phi VV}$
h	$c_\alpha/s_\beta \to 1$	$-s_\alpha/c_\beta \to 1$	$s_{\beta-\alpha} \to 1$
H	$s_\alpha/s_\beta \to 1/\text{tg}\beta$	$c_\alpha/c_\beta \to \text{tg}\beta$	$c_{\beta-\alpha} \to 0$
A	$1/\text{tg}\beta$	$\text{tg}\beta$	0

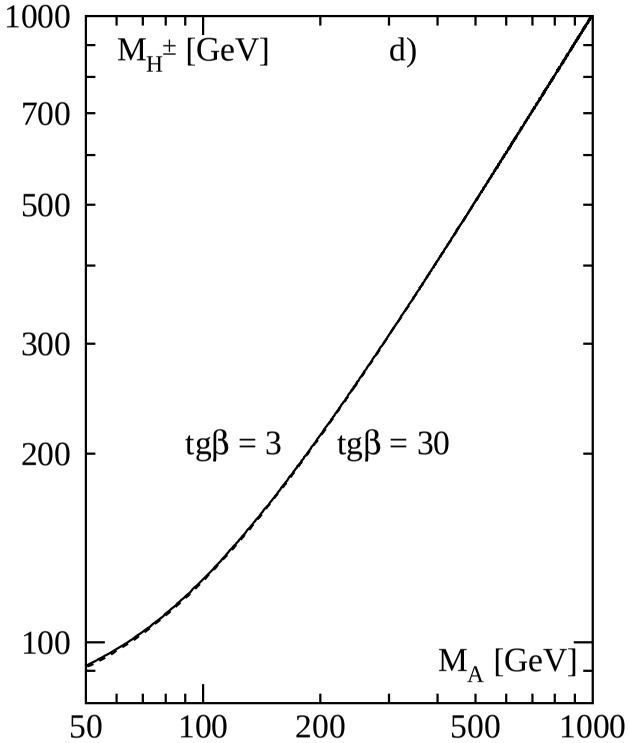
$\tan\beta \uparrow \Rightarrow g_{\Phi uu} \downarrow$, $g_{\Phi dd} \uparrow$

$g_{\Phi VV}^{MSSM} \lesssim g_{\Phi VV}^{SM}$


M_h [GeV]
a)
tgβ = 30
tgβ = 3
M_t [GeV]
160
140
120
100
80
60
140
160
180
200
220

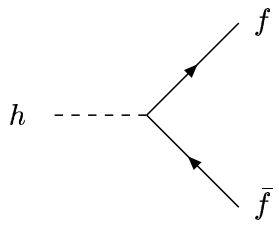

M_h [GeV]
b)
tgβ = 30
tgβ = 3
M_A [GeV]
140
130
120
110
100
90
80
70
60
50
50
100
200
500
1000


M_H [GeV]
c)
tgβ = 3
tgβ = 30
M_A [GeV]
1000
700
500
300
200
100
50
100
200
500
1000


M_H± [GeV]
d)
tgβ = 3
tgβ = 30
M_A [GeV]
1000
700
500
300
200
100
50
100
200
500
1000

Higgs decays

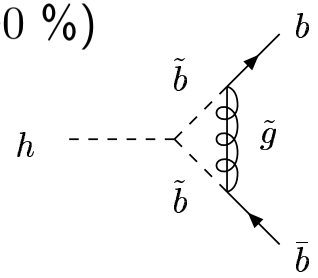
- $h \to b\bar{b}, \tau^+\tau^-, c\bar{c}$



large QCD corrections: $\sim -50... - 80$ %

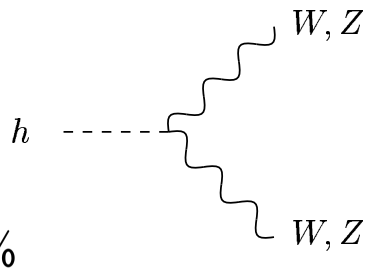
large SUSY-QCD corrections: $\mathcal{O}(10...100$ %$)$

$$\propto \frac{\alpha_s}{\pi} \frac{m_{\tilde{g}} \mu \tan\beta}{m^2_{\tilde{b}}}$$



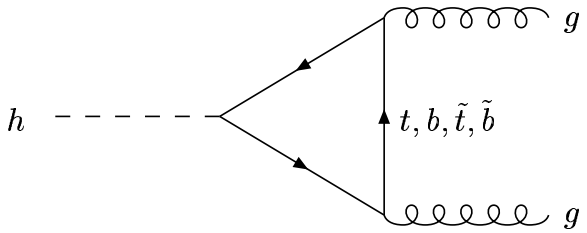
$+ \ldots$

- $h \to WW^*, ZZ^*$

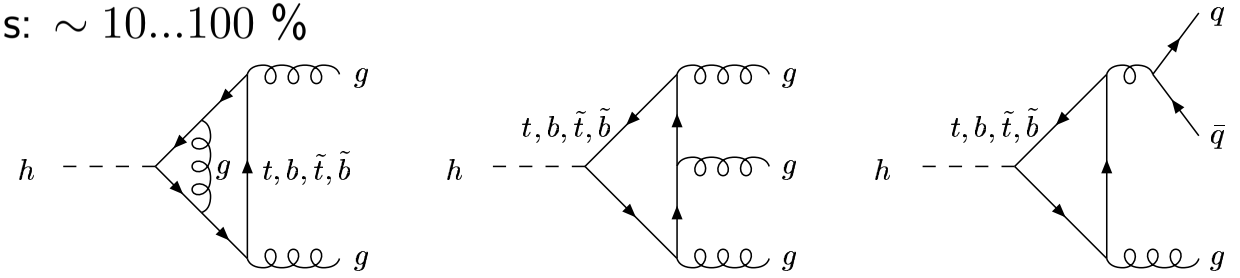


electroweak corrections: $\sim 5...10$ %

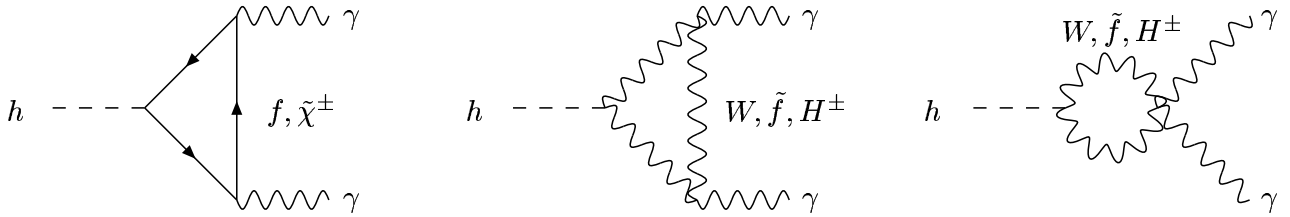
- $h \to gg$



large QCD corrections: $\sim 10...100$ %

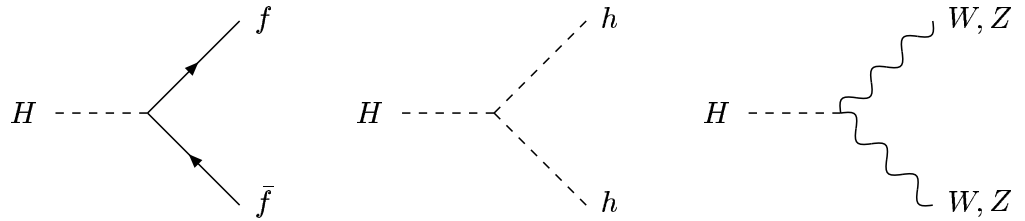


- $h \to \gamma\gamma$

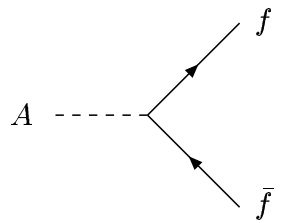


Extremely important decay channel for the LHC

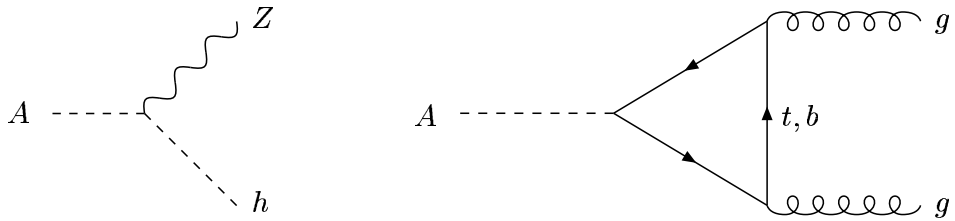
- $H \to b\bar{b}, \tau^+\tau^-$: dominant for large $\tan\beta$
- $H \to hh, WW, ZZ, t\bar{t}$



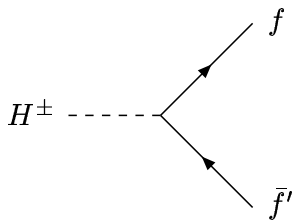
- $A \to b\bar{b}, \tau^+\tau^-$: dominant for large $\tan\beta$
- $A \to t\bar{t}$: dominant above the $t\bar{t}$ threshold for small and moderate $\tan\beta$



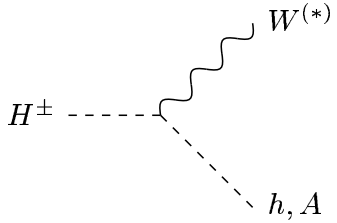
- $A \to Zh, gg$

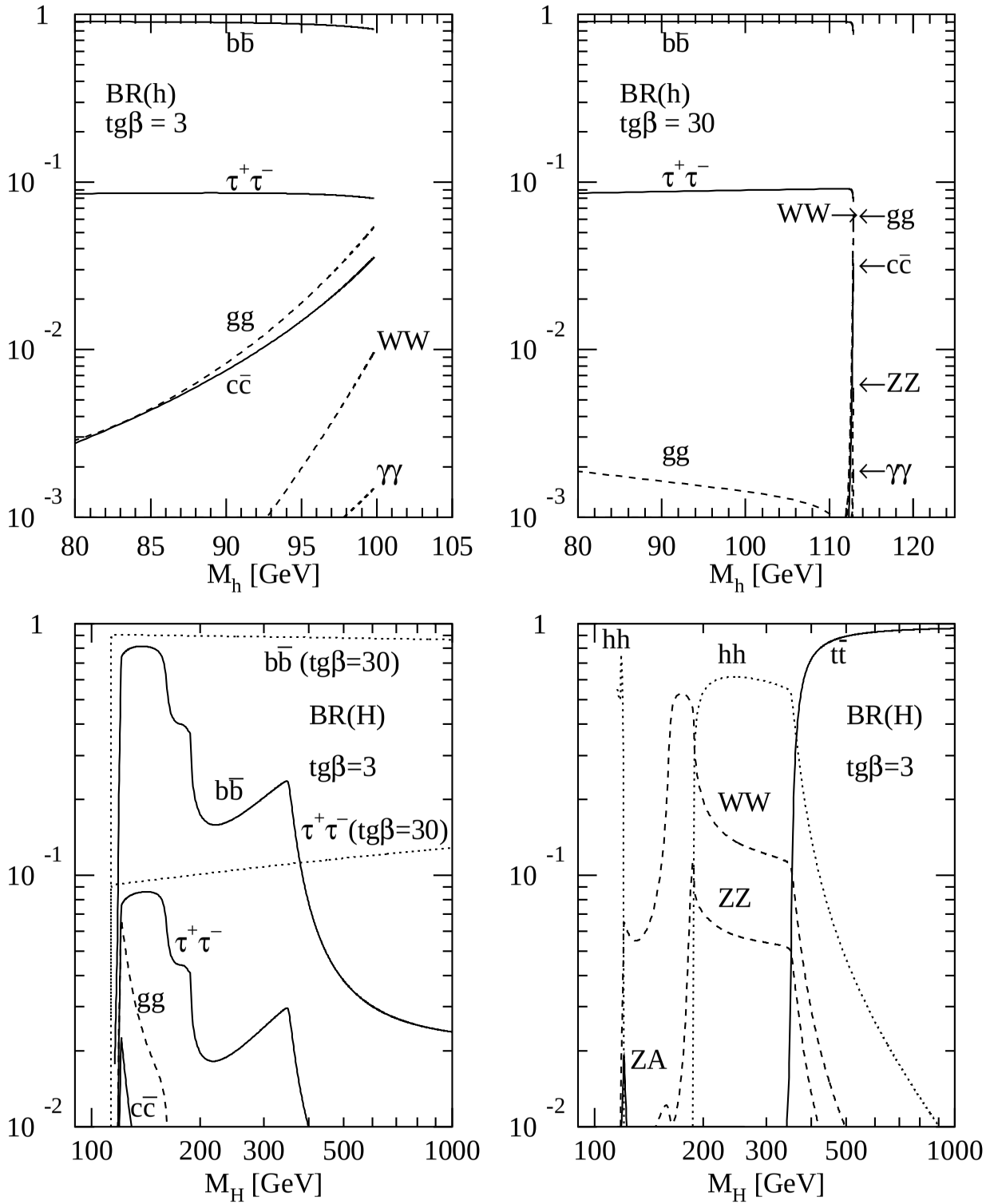


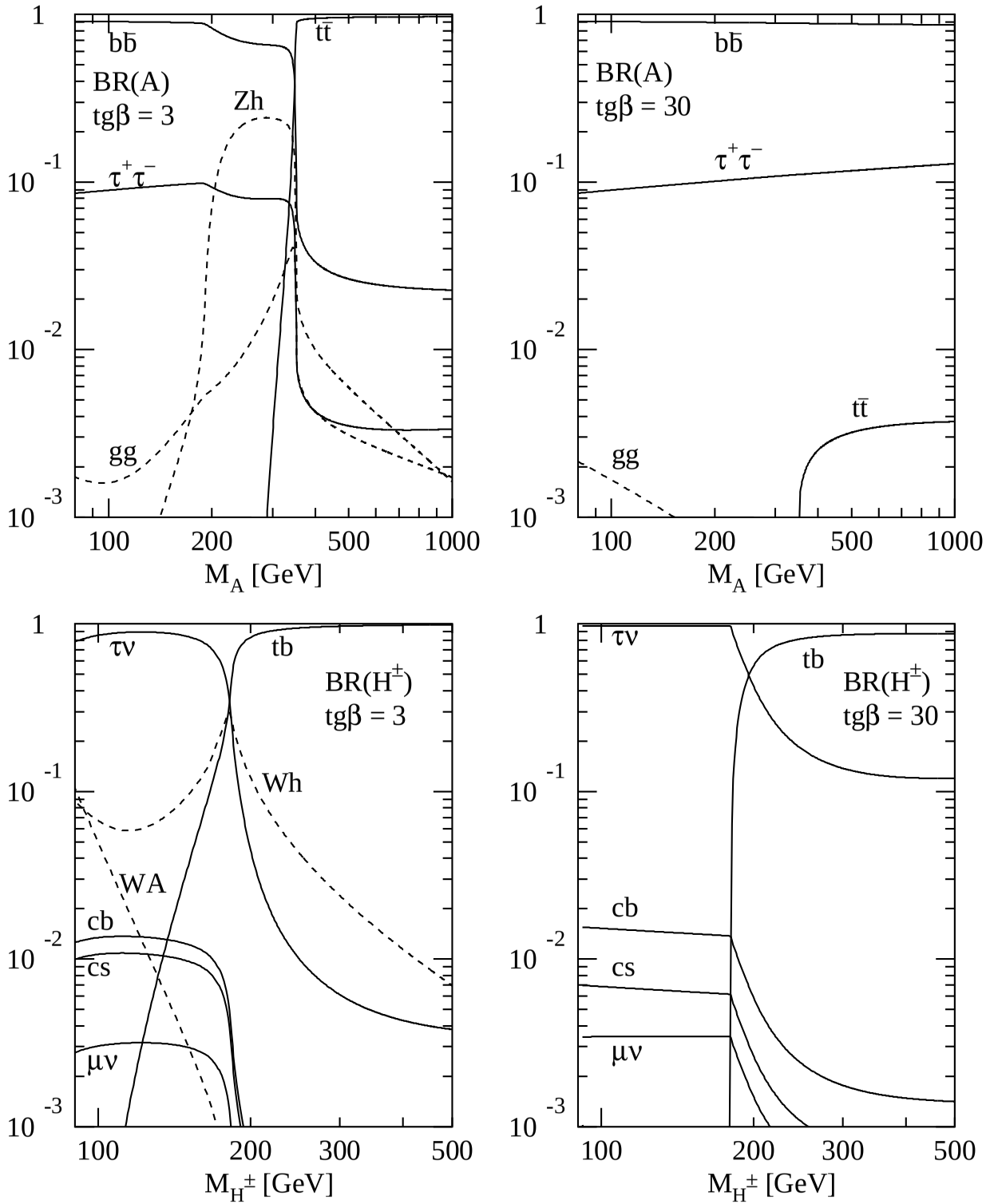
- $H^+ \to \tau^+\nu_\tau, t\bar{b}$



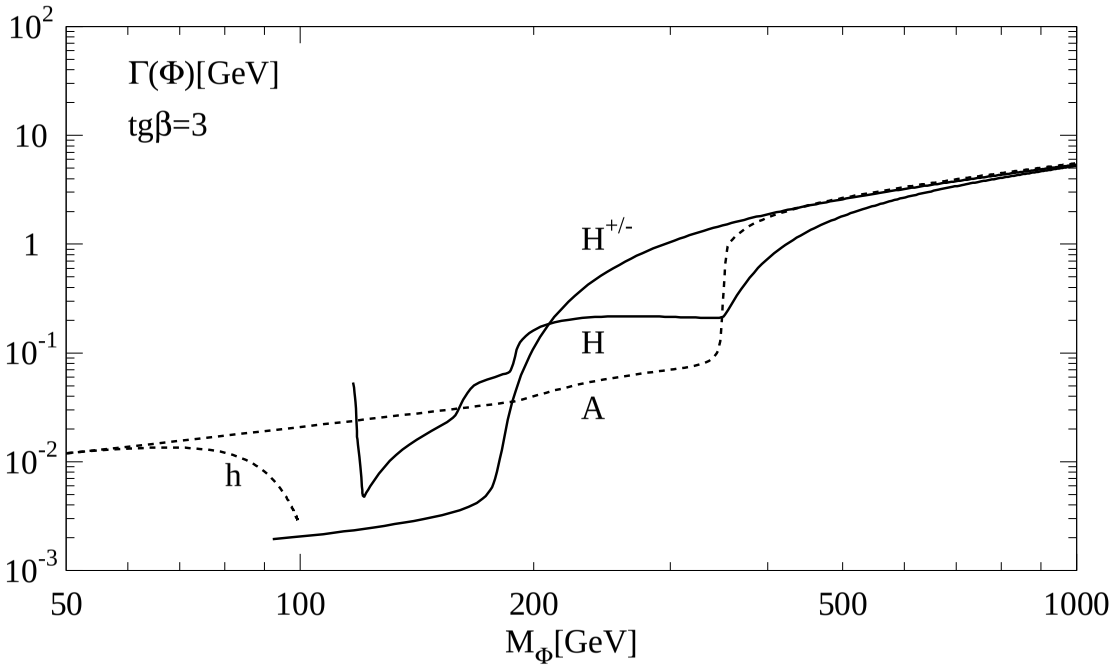
- $H^+ \to W^* A, Wh$

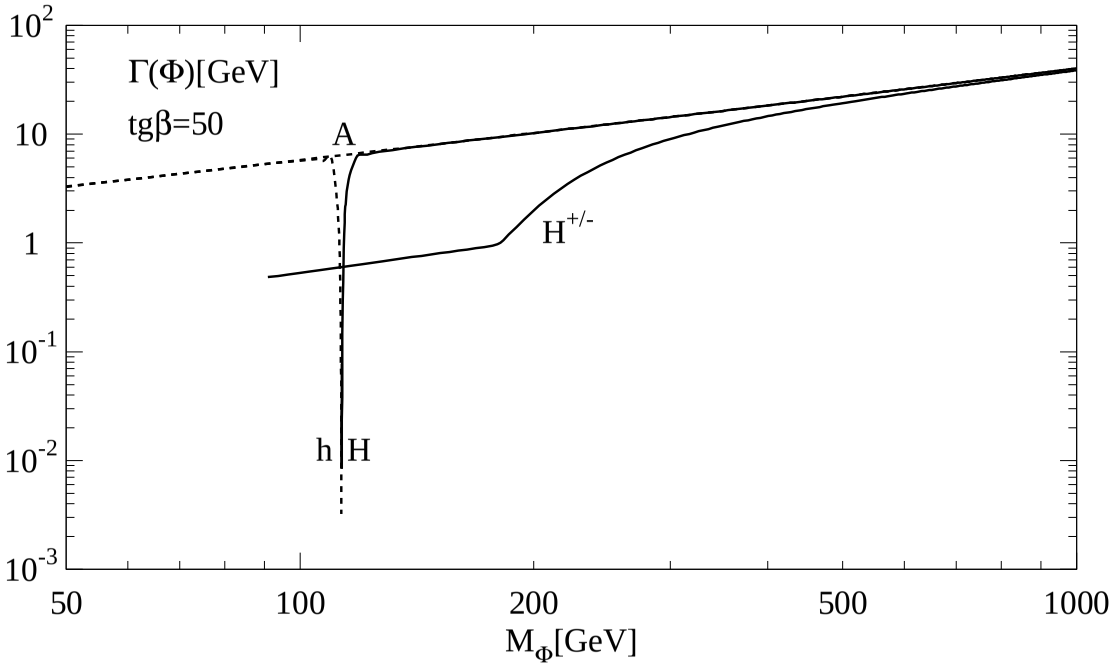



BR(h)
tgβ = 3
bb̄
τ+τ−
gg
cc̄
WW
γγ
M_h [GeV]
BR(h)
tgβ = 30
WW→
←gg
←cc̄
←ZZ
←γγ
bb̄ (tgβ=30)
BR(H)
tgβ=3
τ+τ−(tgβ=30)
M_H [GeV]
hh
tt
ZA

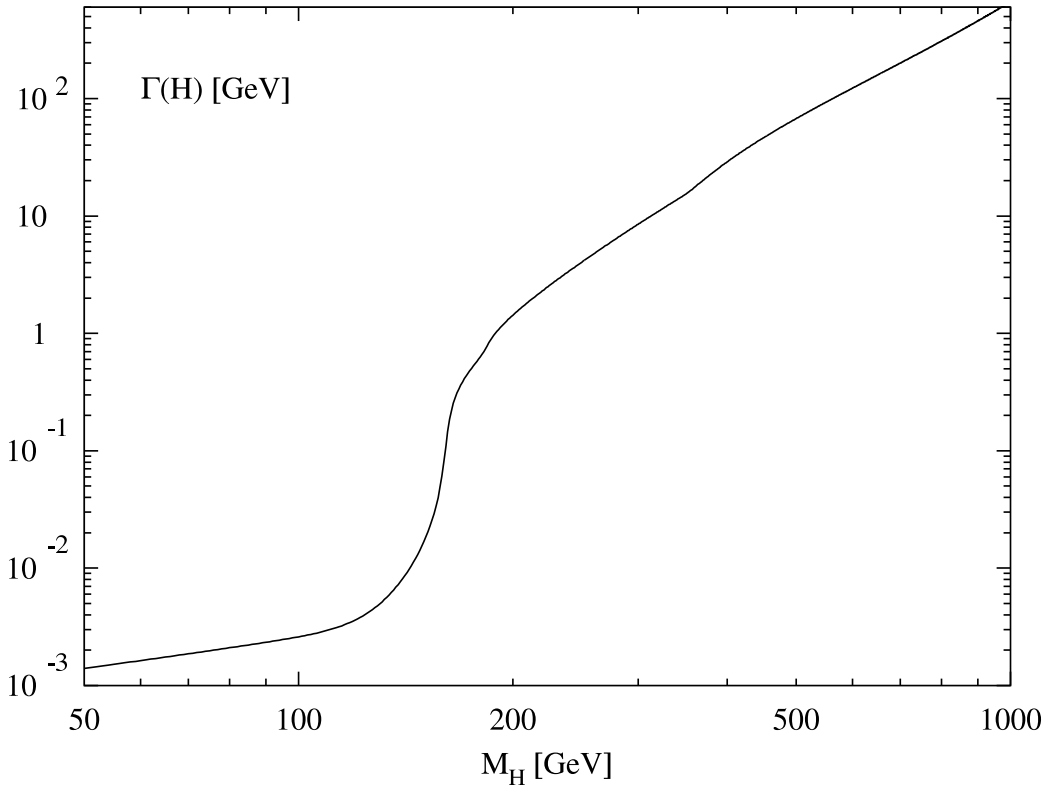

1
10^-1
10^-2
10^-3
bb̄
tt̄
BR(A)
tgβ = 3
Zh
τ+τ−
gg
100
200
500
1000
M_A [GeV]
bb̄
BR(A)
tgβ = 30
τ+τ−
tt̄
gg
100
200
500
1000
M_A [GeV]
τν
tb
BR(H±)
tgβ = 3
Wh
WA
cb
cs
μν
100
200
300
500
M_H± [GeV]
τν
tb
BR(H±)
tgβ = 30
cb
cs
μν
100
200
300
500
M_H± [GeV]

- total widths: $\Gamma_\phi \lesssim 10...30$ GeV narrow

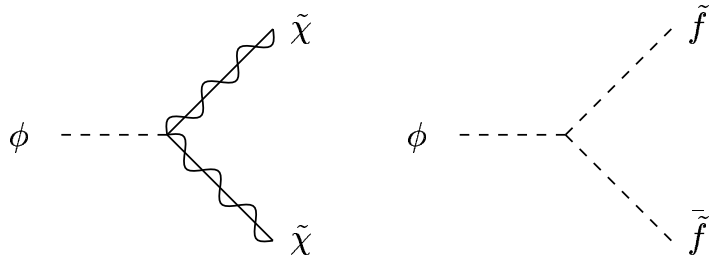


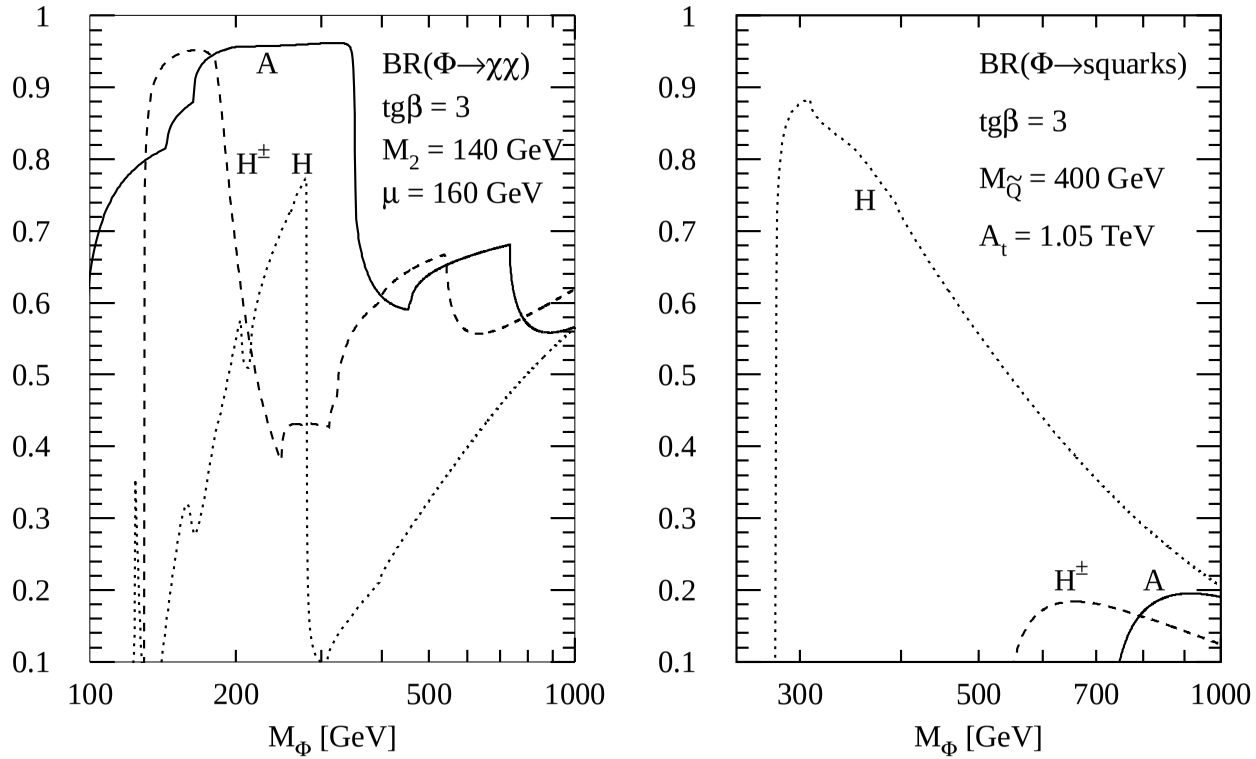


- for comparison: the total width in the SM



- Decays in gauginos and sfermions (3rd generation) important, if kinematically allowed

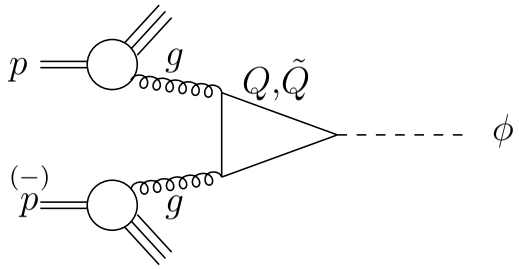




Higgs production

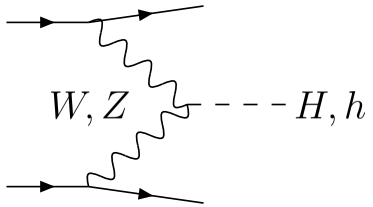
a) Hadron Collider

- Gluon fusion: $pp \to gg \to h, H, A$



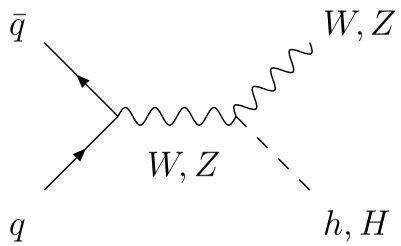
QCD corrections $\sim 10...100$ %

- W/Z fusion: $pp \to W^*W^*/Z^*Z^* \to h/H$



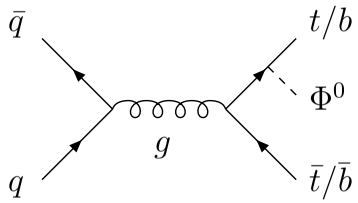
QCD corrections ~ 10 %

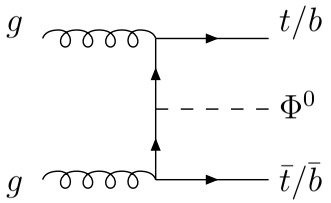
- Higgs-strahlung: $pp \to W^*/Z^* \to W/Z + h/H$



QCD corrections ~ 30 %

- Associated production with $t\bar{t}/b\bar{b}$: $pp \to t\bar{t}/b\bar{b} + h/H/A$



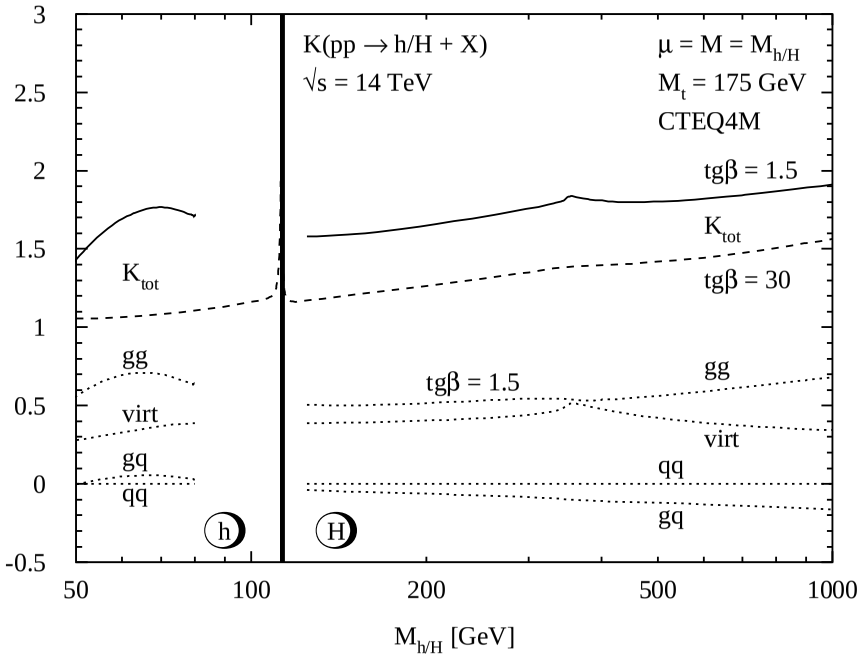


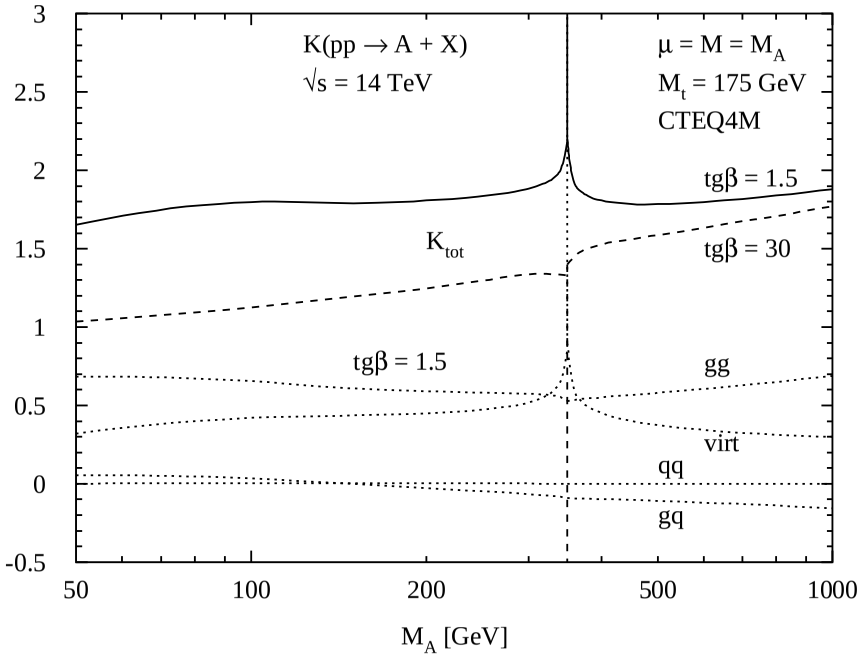
QCD corrections

$t\bar{t}\Phi^0$: $\sim \pm 20\%$

$b\bar{b}\Phi^0$: $\sim +(50 - 100)\%$

$gg \to H$ at NLO K-factor $= \sigma_{NLO}/\sigma_{LO}$

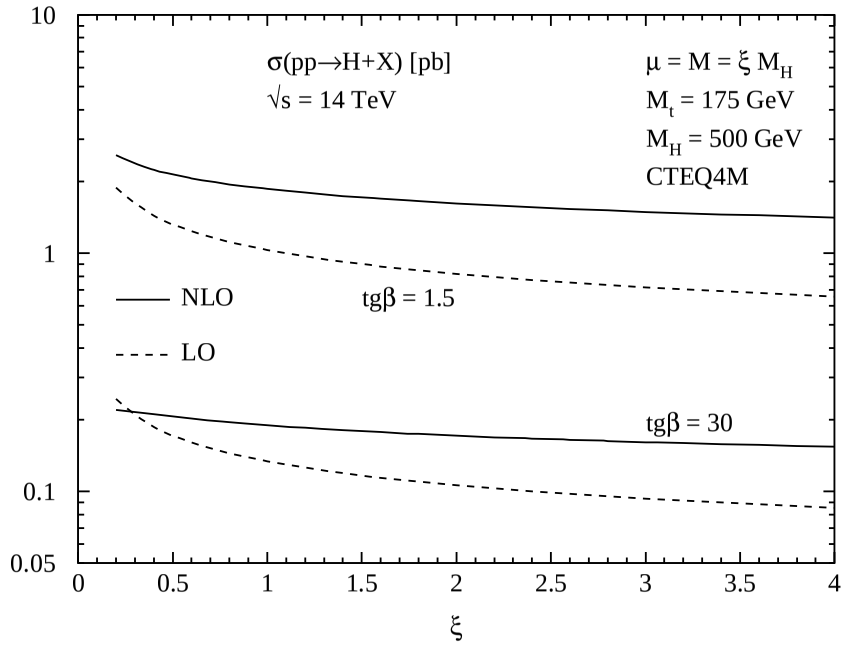


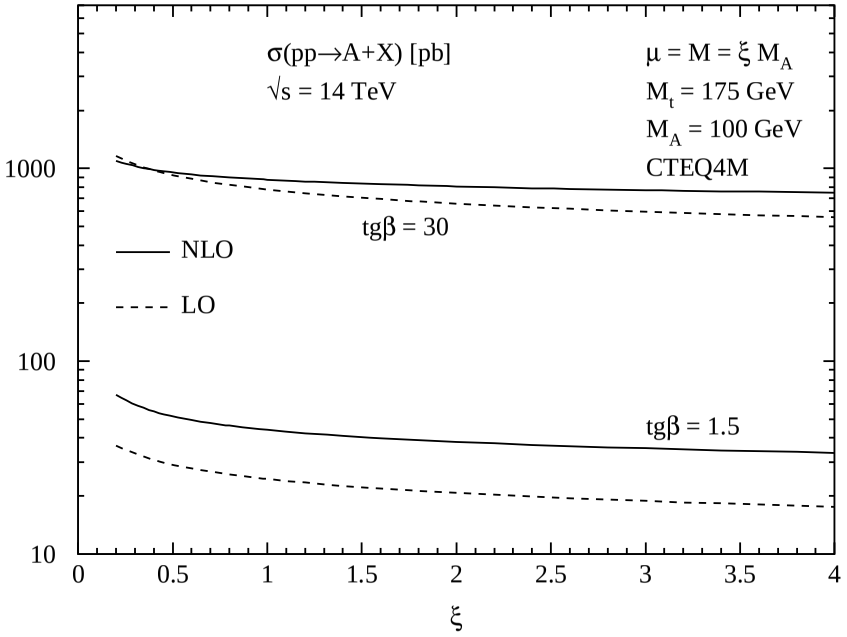


Spira eal

$gg \to H$ at NLO scale variation

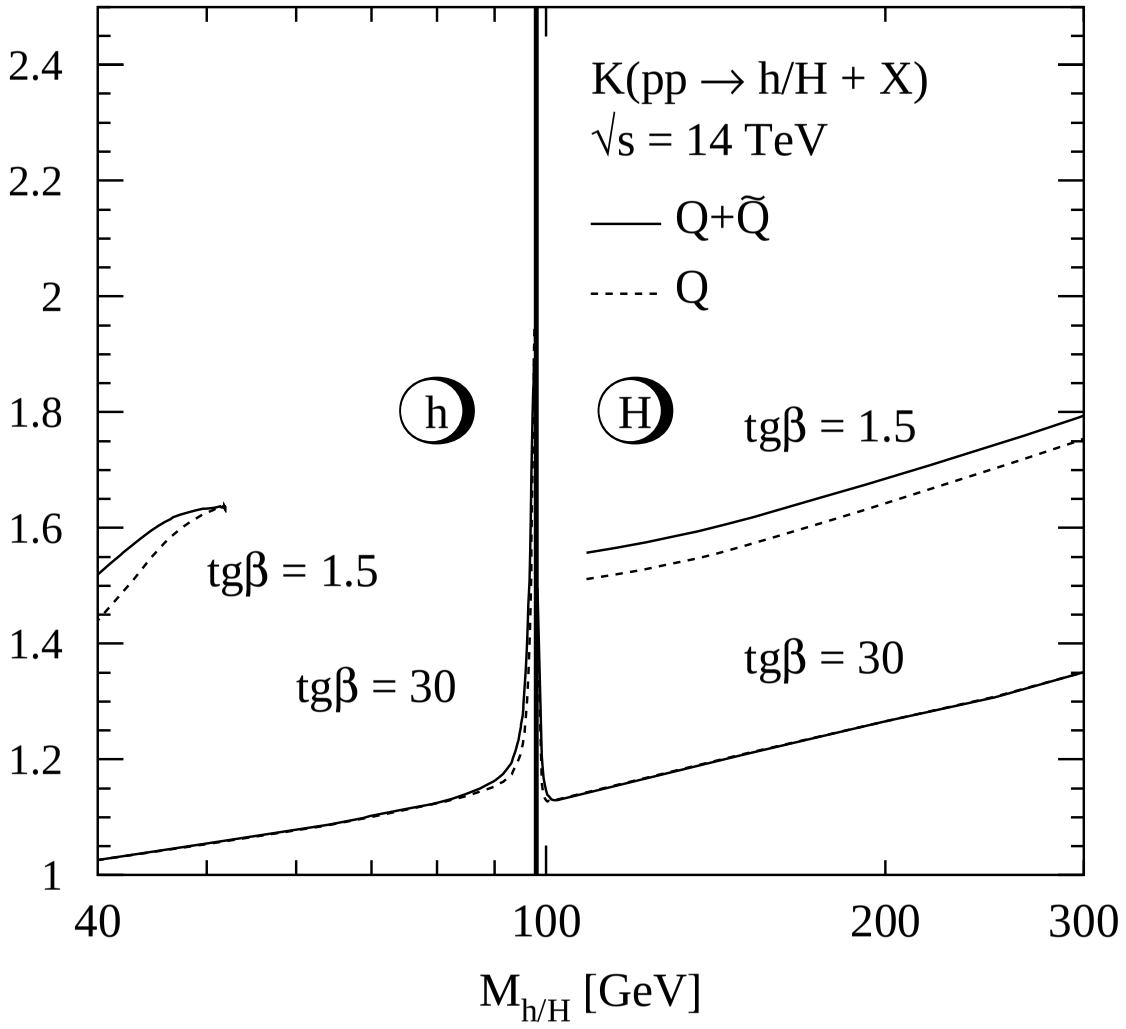
Spira eal





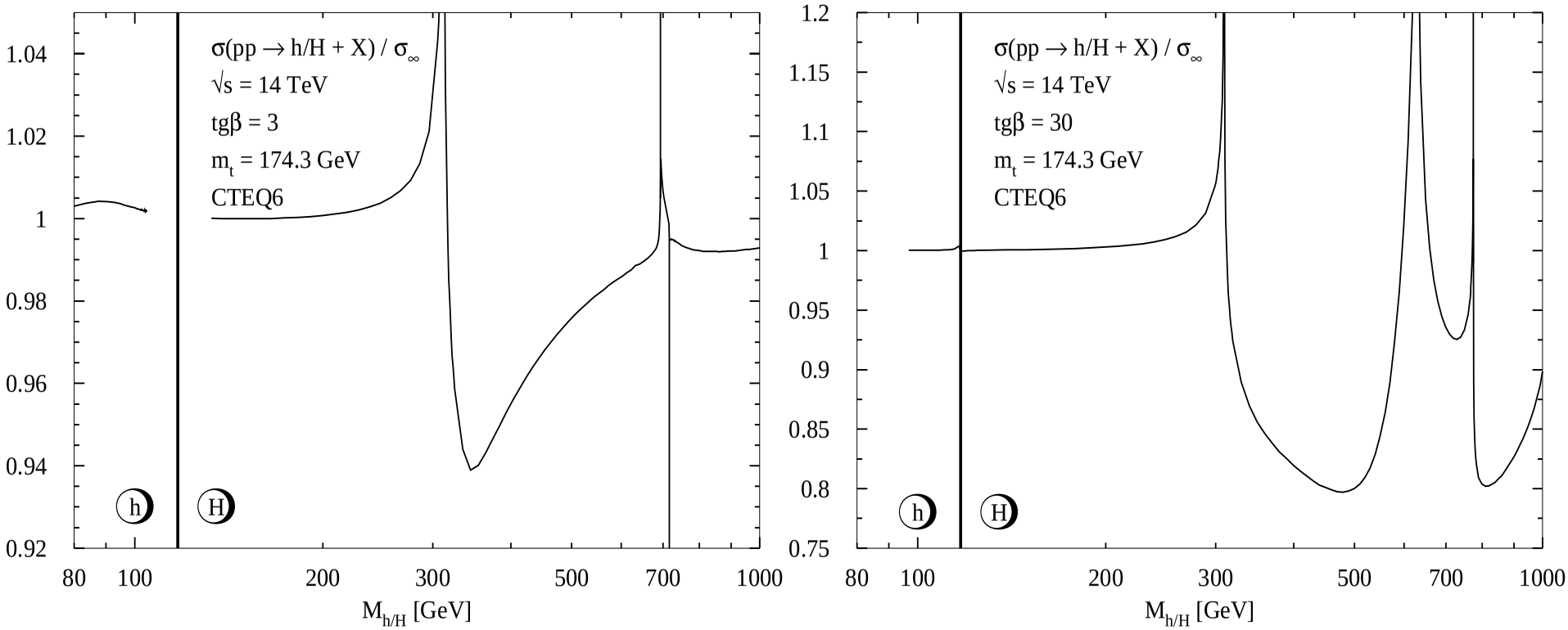
$gg \to H$ squark loop effects

Spira eal



σ_{NLO} w/ full squark mass dependence / σ_{NLO} in the heavy squark limit

MMM,Spira

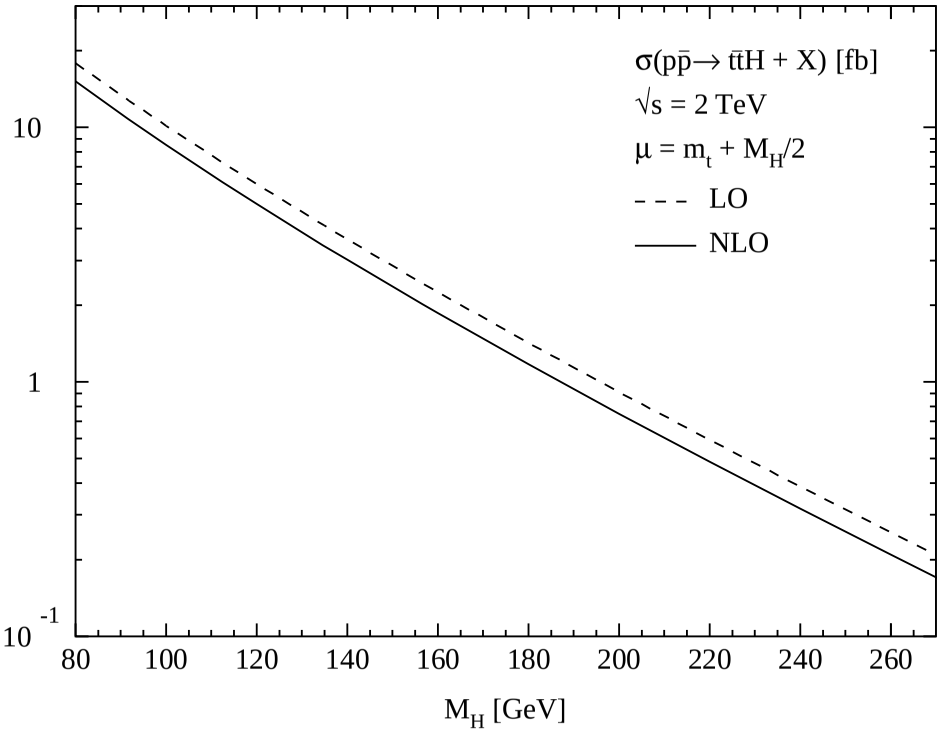


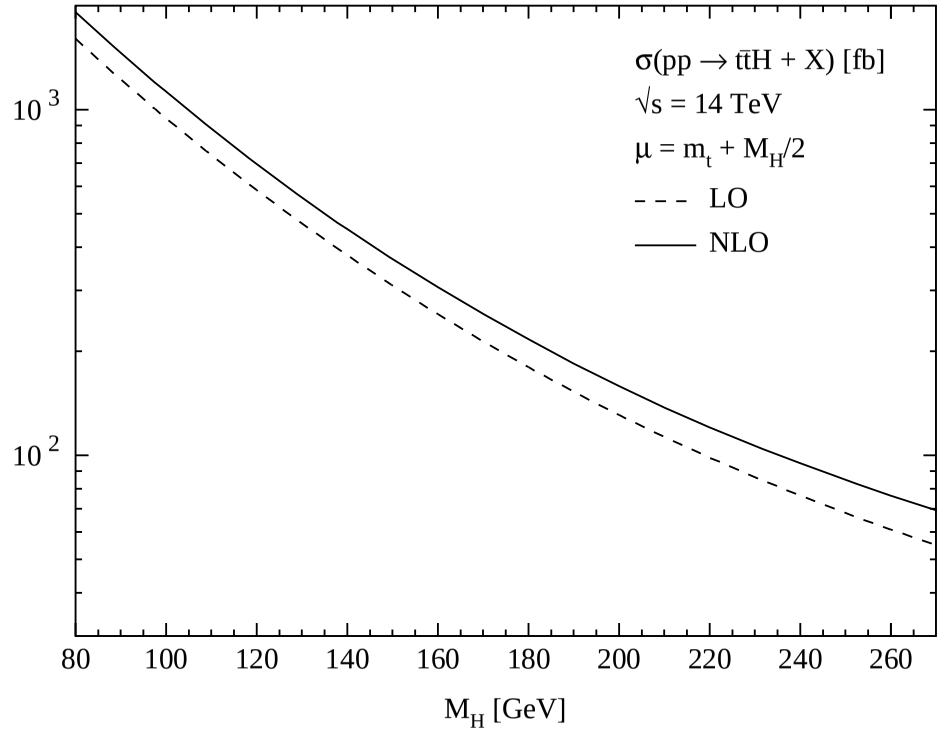
no $\tilde{g}$ loops, but bulk of expected SUSY QCD corrections

$\sigma(pp \to h/H + X)/\sigma_\infty$ up to 20%

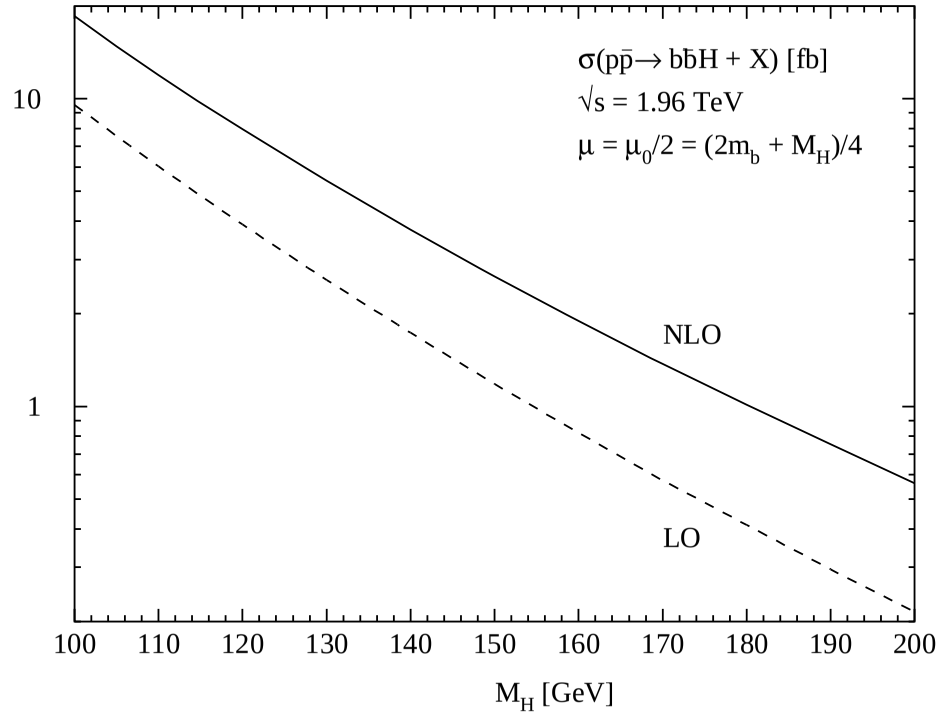
Kinks, bumps, spikes: $\tilde{t}_1\bar{\tilde{t}}_1, \tilde{b}_1\bar{\tilde{b}}_1, \tilde{b}_2\bar{\tilde{b}}_2$ thresholds in consecutive order with rising Higgs mass.

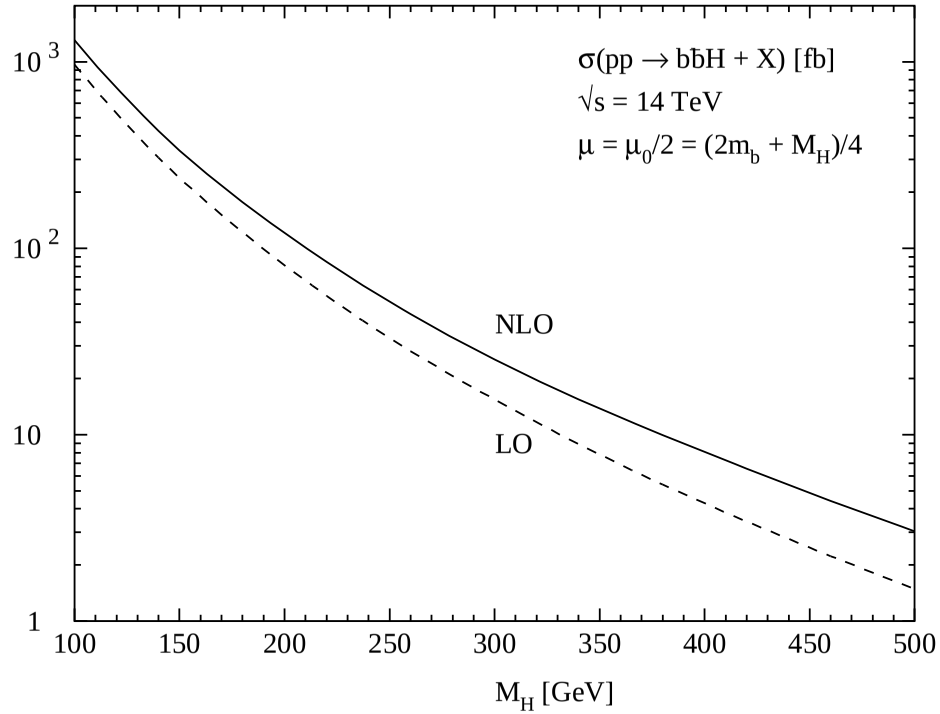
(analytically: Harlander,Kant
Anastasiou,Beerli,Bucherer,Daleo,Kunszt
Aglietti,Bonciani,Degrassi,Vicini)



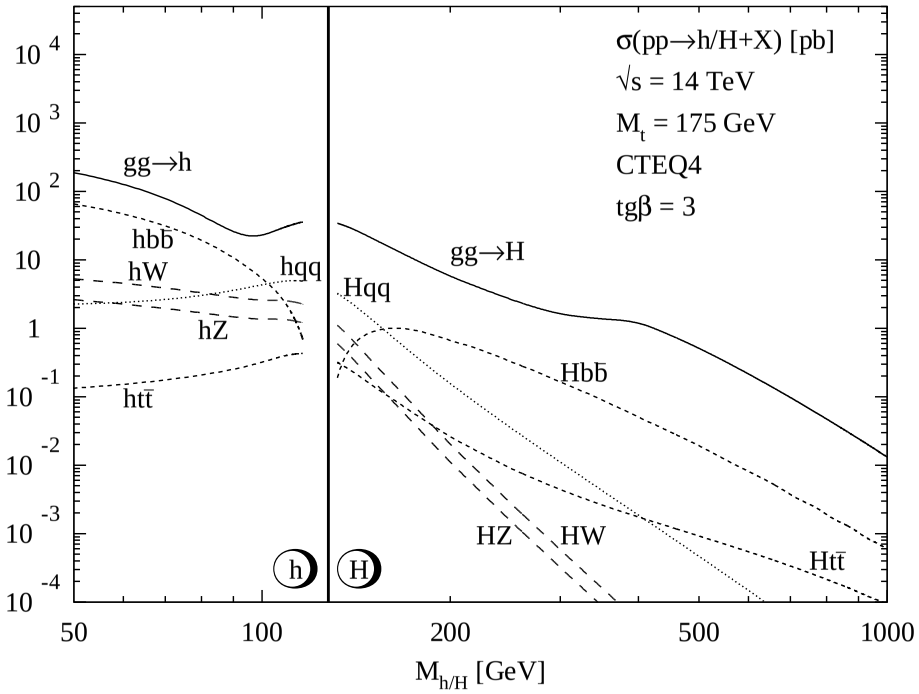


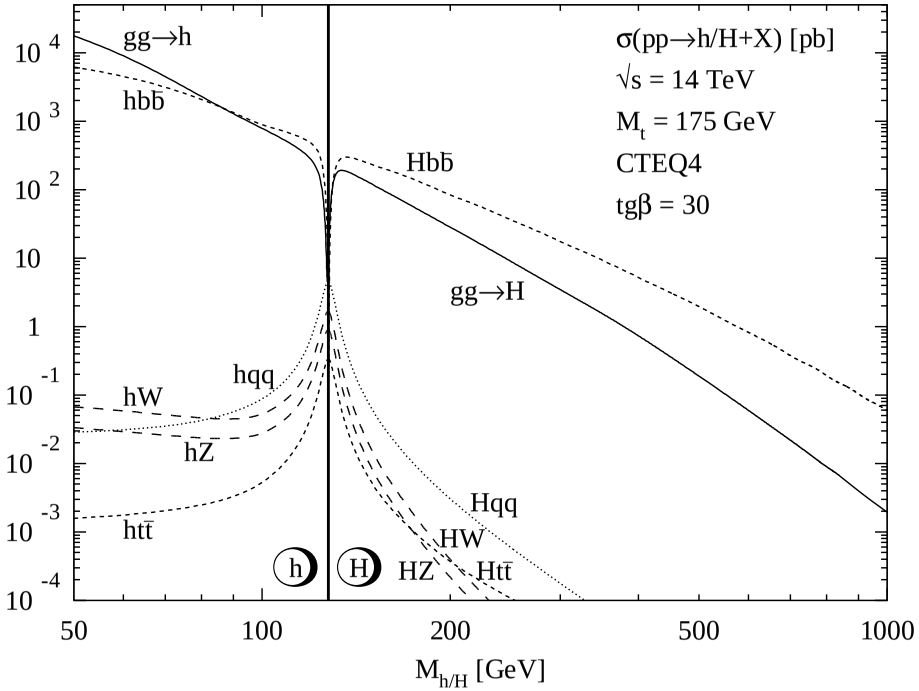
Beenakker,Dittmaier,Krämer,Plümper,Spira,Zerwas

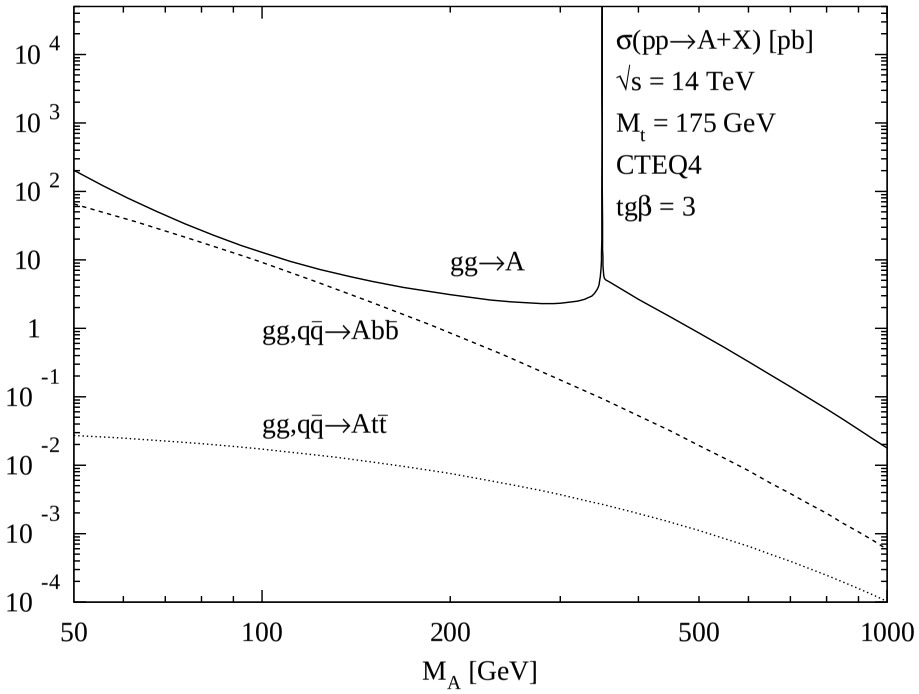


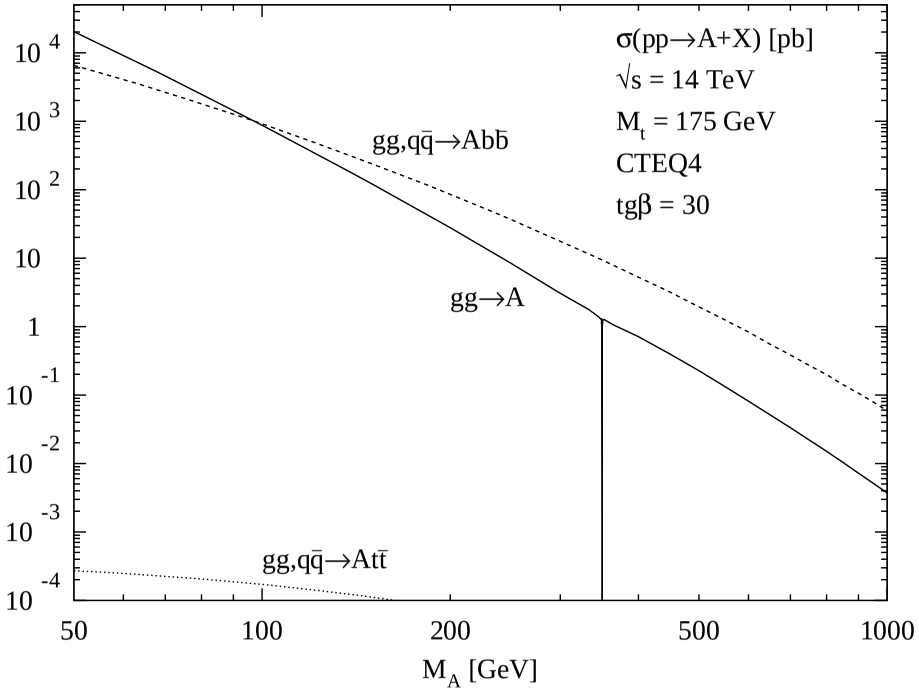


Dittmaier,Krämer,Spira


σ(pp→h/H+X) [pb]
√s = 14 TeV
M_t = 175 GeV
CTEQ4
tgβ = 3
gg→h
hbb̄
hW
hqq
hZ
htt̄
gg→H
Hqq
Hbb̄
HZ
HW
Htt̄
h
H
M_h/H [GeV]

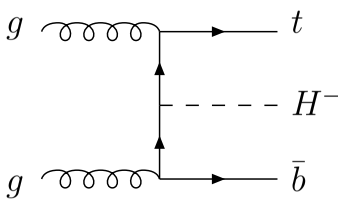

σ(pp→h/H+X) [pb]
√s = 14 TeV
M_t = 175 GeV
CTEQ4
tgβ = 30
gg→h
hbb̄
Hbb̄
gg→H
hqq
hW
hZ
htt̄
Hqq
HW
HZ
Htt̄
h
H
M_h/H [GeV]


σ(pp→A+X) [pb]
√s = 14 TeV
M_t = 175 GeV
CTEQ4
tgβ = 3
gg→A
gg,qq̄→Abb̄
gg,qq̄→Att̄
10^4
10^3
10^2
10
1
10^-1
10^-2
10^-3
10^-4
50
100
200
500
1000
M_A [GeV]


σ(pp→A+X) [pb]
√s = 14 TeV
M_t = 175 GeV
CTEQ4
tgβ = 30
gg,qq̄→Abb̄
gg→A
gg,qq̄→Att̄
10^4
10^3
10^2
10
1
10^-1
10^-2
10^-3
10^-4
50
100
200
500
1000
M_A [GeV]

Charged Higgs Production

- **Dominant: $pp \to q\bar{q}, gg \to H^- + t\bar{b}$ + c.c.**



Bawa eal;
Borzumati eal;
Belyaev eal

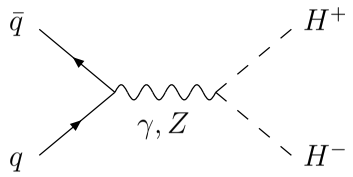
NLO QCD & SUSY QCD corrs.: $50...100$ % Peng et al.
Dittmaier et al.

scale dependence reduced: $\Delta \lesssim 15$ %

LO cxn: $gb \to H^- t$ + c.c.

NLO SUSY QCD corrs.: significant Zhu; Plehn; Berger eal;
Gao et al.

- **$H^\pm$ pair production $pp \to q\bar{q} \to H^+H^-$**



NLO QCD corrs.: ~ 30 % ($\leftarrow$ Drell-Yan)

genuine SUSY QCD corrs.: small Djouadi,Spira

- **$pp \to gg \to H^+H^-$ (LO)** Willenbrock;Krause eal;
Jiang eal;Brein,Hollik;
Barrientos eal

$pp \to b\bar{b} \to H^+H^-$ Barrientos eal;
Hong-Sheng eal

SUSY-QCD significant

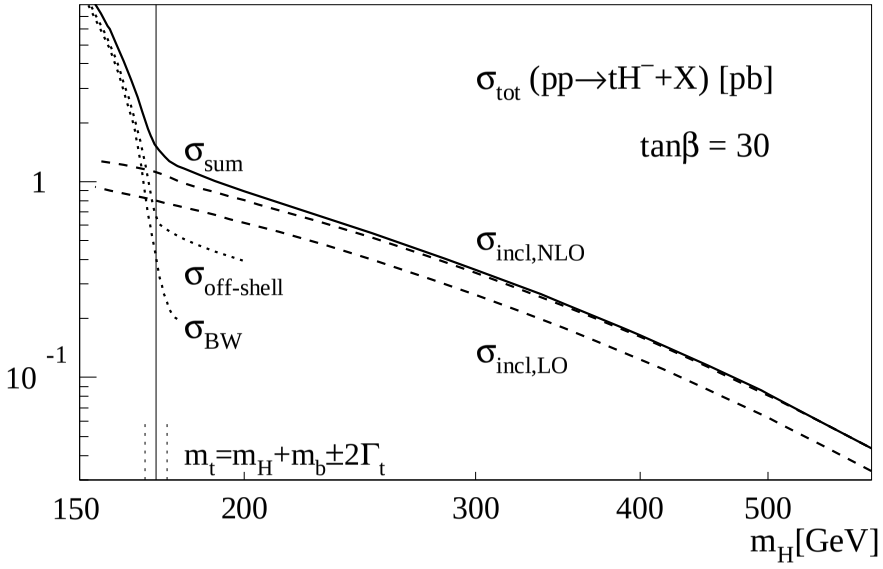
$pp \to gg \to H^+W^-$ + c.c. (LO) Barrientos et al.;
Brein et al.

$pp \to b\bar{b} \to H^+W^-$+c.c. Dicus eal;
Barrientos eal;
Brein eal;
Hollik eal;
Zhao eal

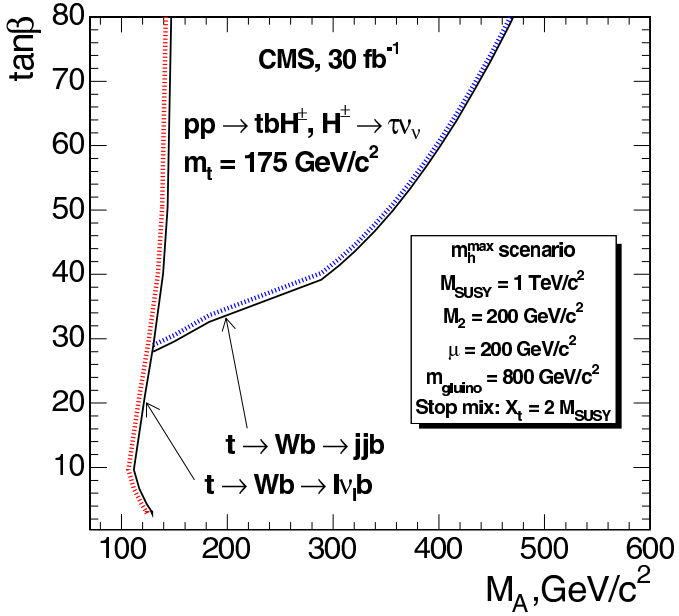
QCD corrs. moderate

Charged Higgs Boson discovery reach

Berger et al.

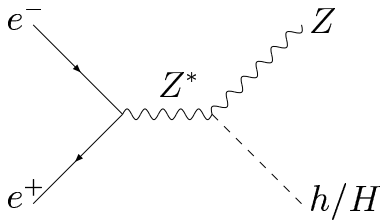


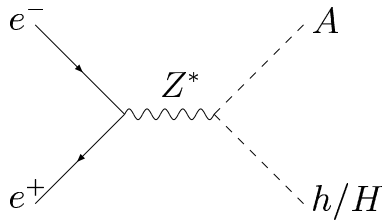
CMS

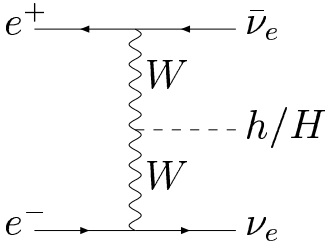


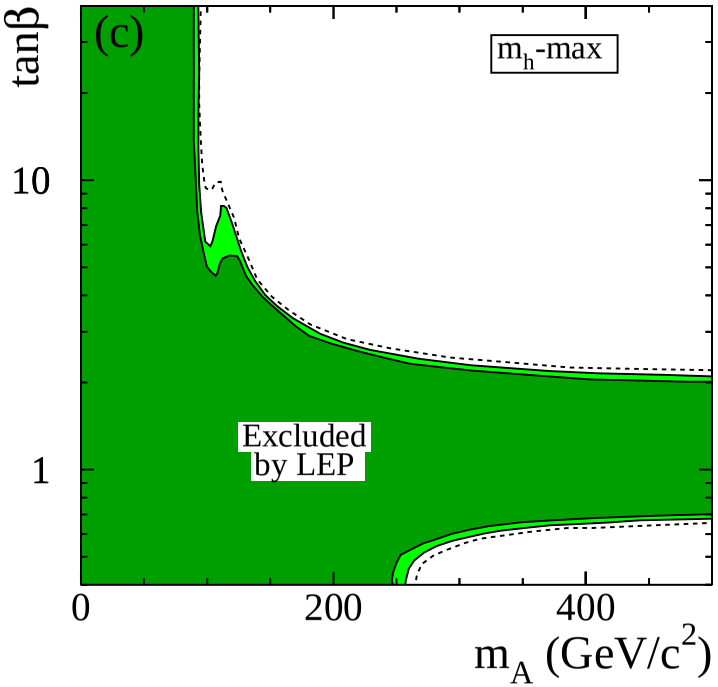
Higgs boson search: MSSM Higgs mass limits

▷ Direct Search at LEP: $e^+e^- \to Z + h/H, A + h/H, \nu_e\bar{\nu}_e + h/H$









$M_{h/H} \gtrsim 91$ GeV

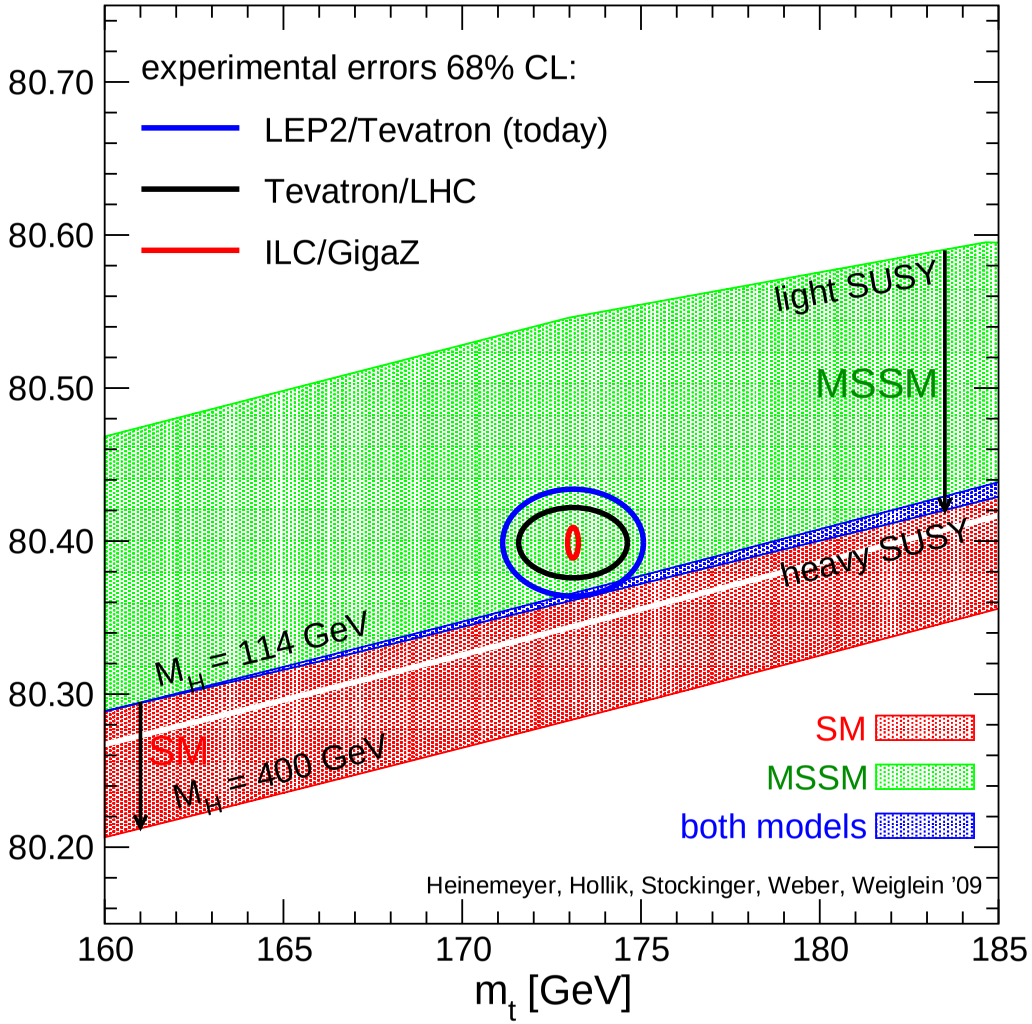
$M_A \gtrsim 91.9$ GeV

$M_{H^\pm} > 78.6$ GeV

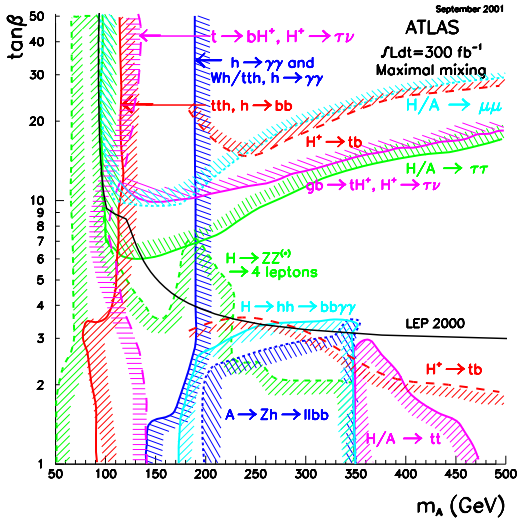
$0.5 < \tan\beta < 2.4$ excluded

(only in this scenario, $m_t = 174.3$ GeV!)

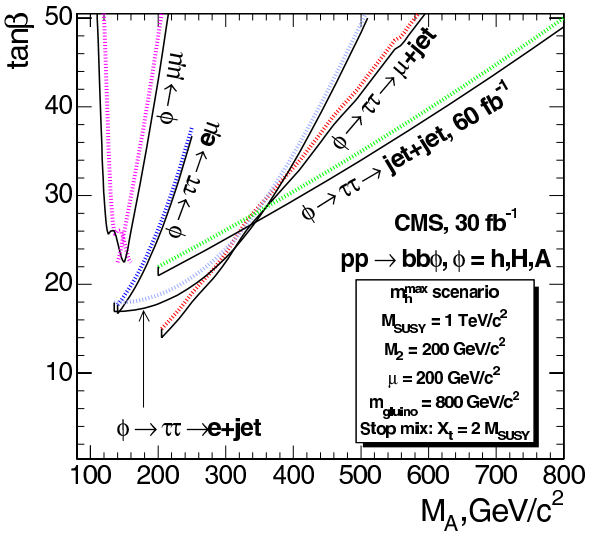
Higgs boson search: MSSM Higgs mass limits



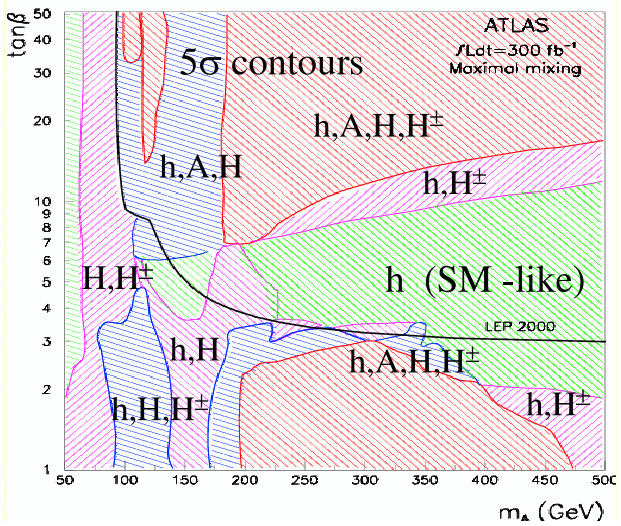
ATLAS



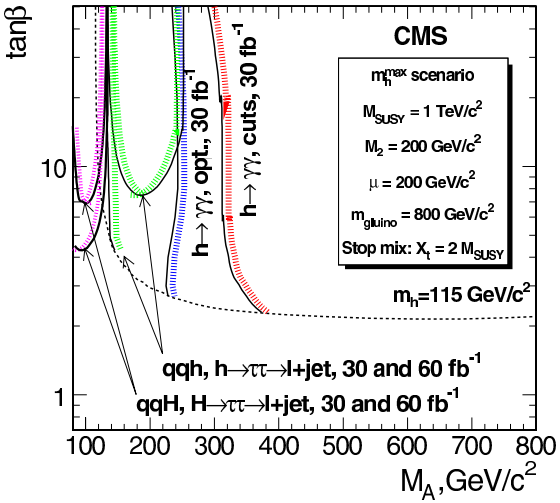
CMS



ATLAS

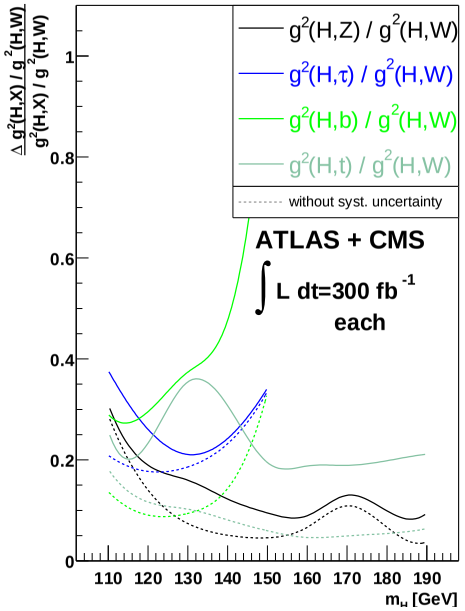


CMS



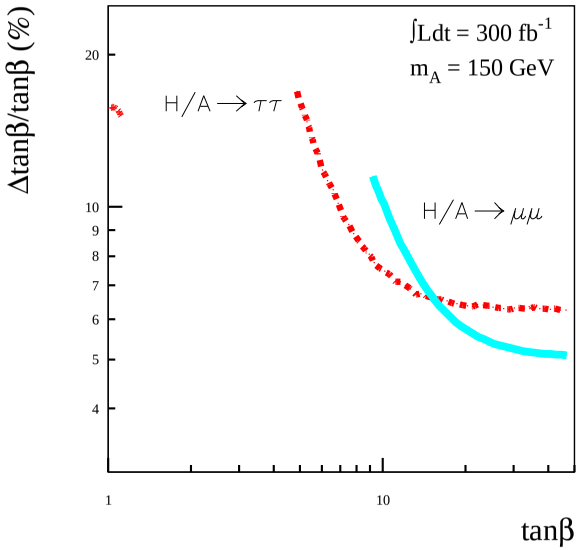
Expected Accuracies

Dührssen et al.

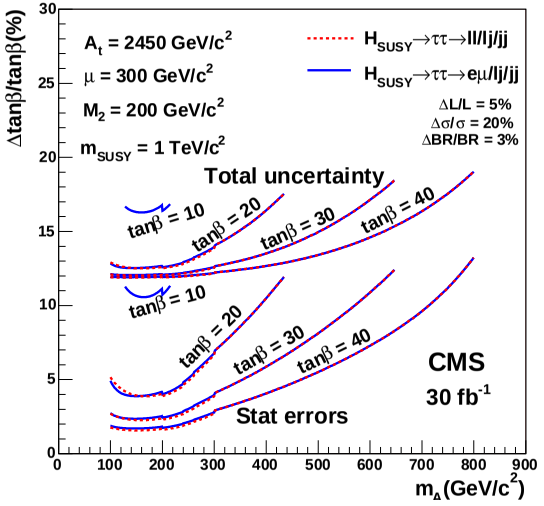


- $\frac{\delta M_H}{M_H} \sim 10^{-3}$
- $\frac{\delta \tan\beta}{\tan\beta} \sim 10 - 15$ %

ATLAS



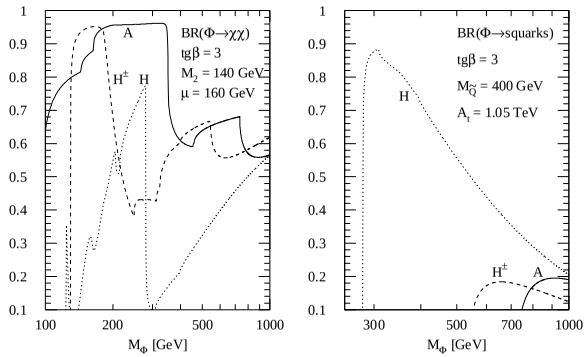
Kinnunen eal



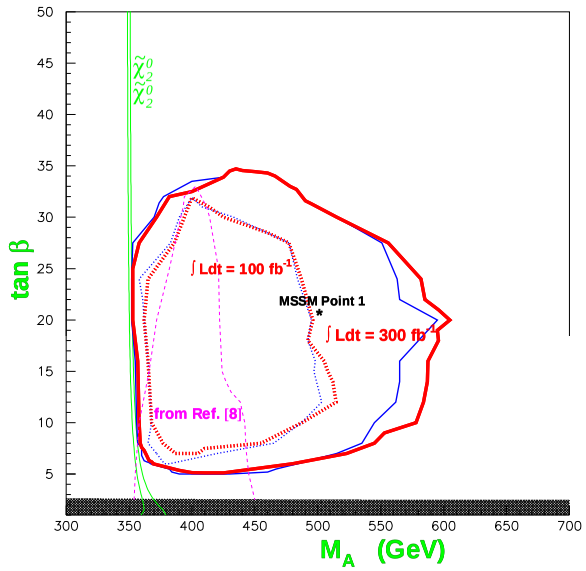
$\mathcal{H}$iggs $\mathcal{S}$earch in SUSY Particle Final States

▷ Decays in gauginos and sfermions (3rd generation) important, if kinematically allowed.

HDECAY



▷ Four-lepton LHC events from MSSM Higgs boson decays into neutralino and chargino pairs
Event-generator level simulations w/ realistic detector effects and analyses of all significant bkgs



Bisset,Li,Kersting,Moortgat,Moretti

$(\mu, M_2, M_2, m_{\tilde{l}_{soft}}, m_{\tilde{\tau}_{soft}}) =$
$(-500, 180, 90, 250, 250)$ GeV

$\Phi^0 \to \tilde{\chi}_2^0 \tilde{\chi}_2^0$ totally dominates

Part of difficult wedge region (only h discovery) can be covered

Higgs Search in SUSY cascade decays

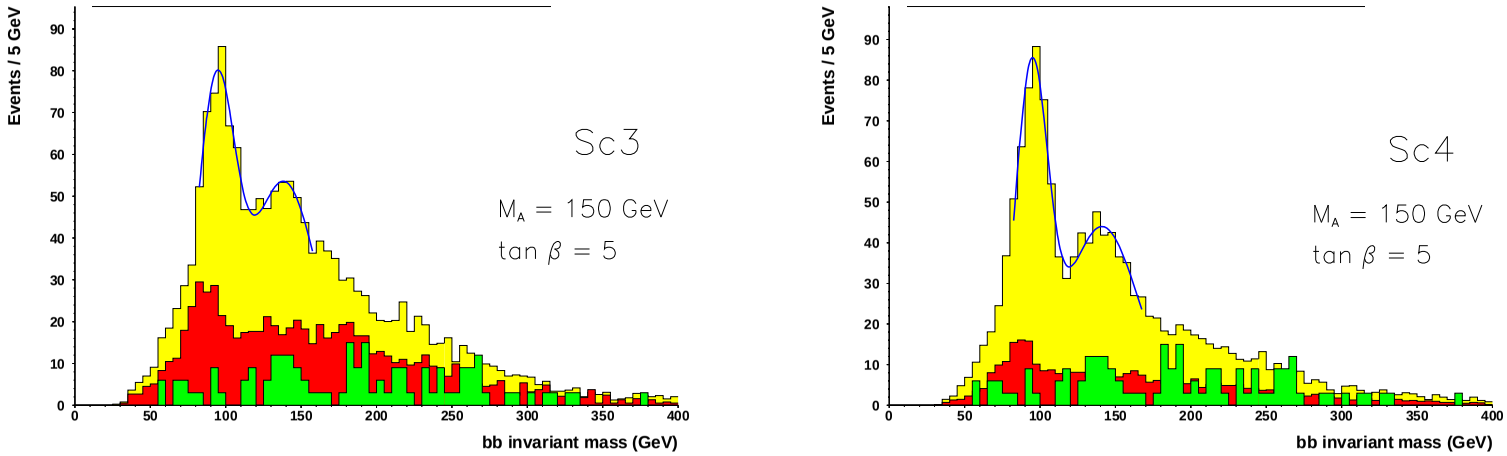
▷ Few scenarios considered Datta,Djouadi,Guchait,Moortgat

Sc3 $pp \to \tilde{g}\tilde{g}, \tilde{q}\tilde{q}, \tilde{q}\tilde{q}^*, \tilde{q}\tilde{g} \to \chi_2^\pm, \chi_3^0, \chi_4^0 + X$

$\to \chi_1^\pm, \chi_2^0, \chi_1^0 + h, H, A, H^\pm + X$

Sc4 $pp \to \tilde{g}\tilde{g}, \tilde{q}\tilde{q}, \tilde{q}\tilde{q}^*, \tilde{q}\tilde{g} \to \chi_1^\pm, \chi_2^0 + X$

$\to \chi_1^0 + H^\pm, h, H, A + X$



green - SM $t\bar{t}$ red - SUSY bkg

$\mathcal{H}$iggs $\mathcal{S}$earch in SUSY cascade decays

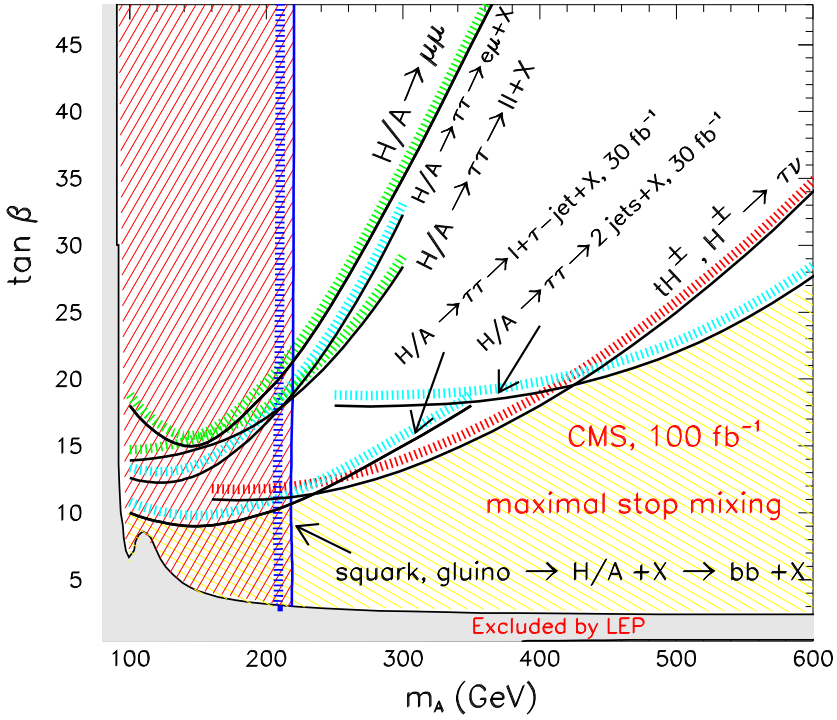
▷ Few scenarios considered Datta,Djouadi,Guchait,Moortgat

Sc3 $pp \to \tilde{g}\tilde{g}, \tilde{q}\tilde{q}, \tilde{q}\tilde{q}^*, \tilde{q}\tilde{g} \to \chi_2^\pm, \chi_3^0, \chi_4^0 + X$

$\to \chi_1^\pm, \chi_2^0, \chi_1^0 + h, H, A, H^\pm + X$

Sc4 $pp \to \tilde{g}\tilde{g}, \tilde{q}\tilde{q}, \tilde{q}\tilde{q}^*, \tilde{q}\tilde{g} \to \chi_1^\pm, \chi_2^0 + X$

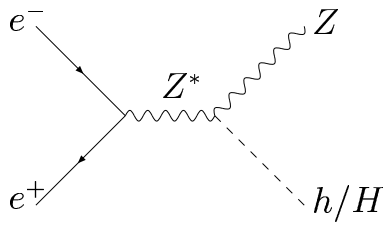
$\to \chi_1^0 + H^\pm, h, H, A + X$



Difficult region of low M_A and low $\tan\beta$ can be explored

Higgs production b) e^+e^- Collider

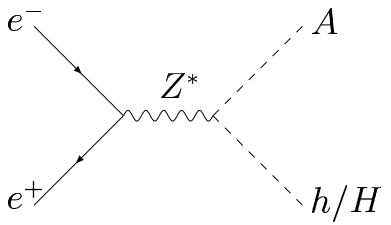
- Higgs strahlung: $e^+e^- \to Z + h/H$



$\sigma_h \sim \sin^2(\beta-\alpha)$
$\sigma_H \sim \cos^2(\beta-\alpha)$

ELW corrections $\sim -5 \ldots -10$ %

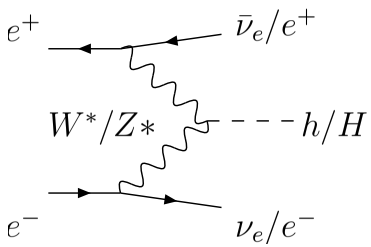
- Pair production: $e^+e^- \to A + h/H$



$\sigma_h \sim \cos^2(\beta-\alpha)$
$\sigma_H \sim \sin^2(\beta-\alpha)$

Complementarity!

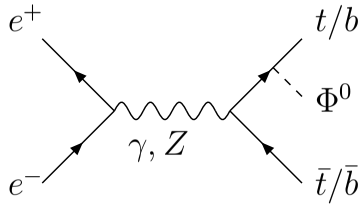
- W/Z fusion: $e^+e^- \to \nu_e\bar{\nu}_e / e^+e^- + h/H$



important at high energies

ELW corrections: $\sim -2 \ldots -10$ %

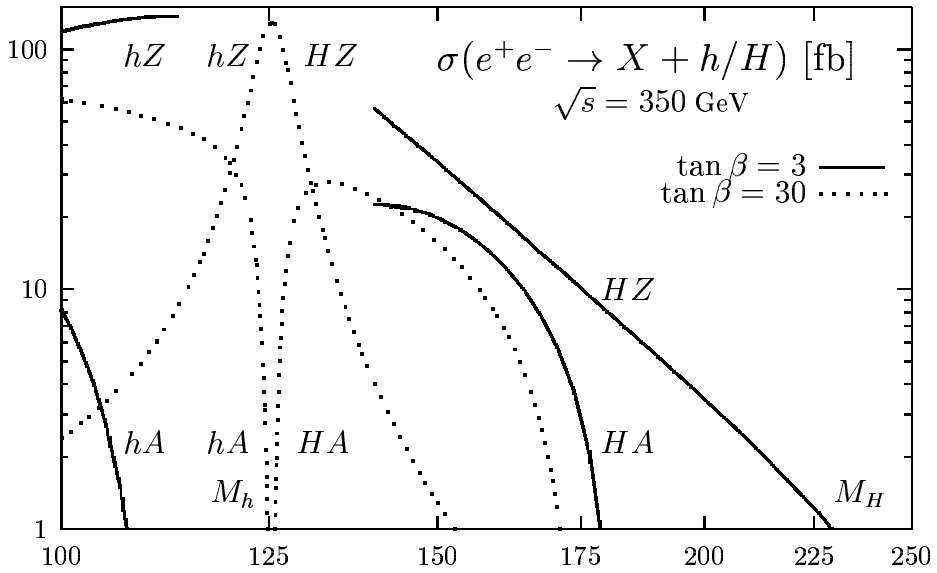
- Assoc prod w/ $q\bar{q}$: $e^+e^- \to t\bar{t}/b\bar{b} + h/H/A$

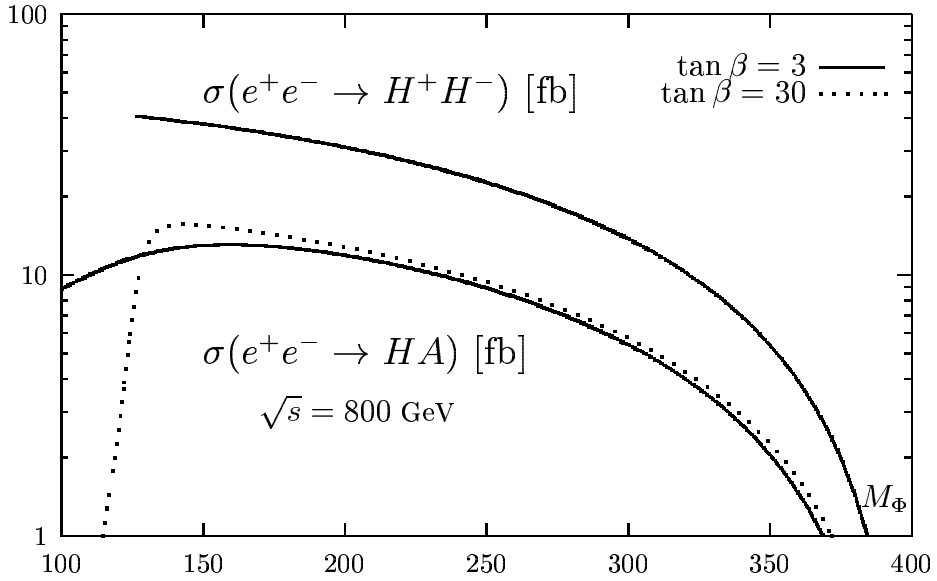


measurement of the Yukawa couplings

QCD corrections: $\sim -10 \ldots +50$ %

ELW corrections: $\sim +10$ %





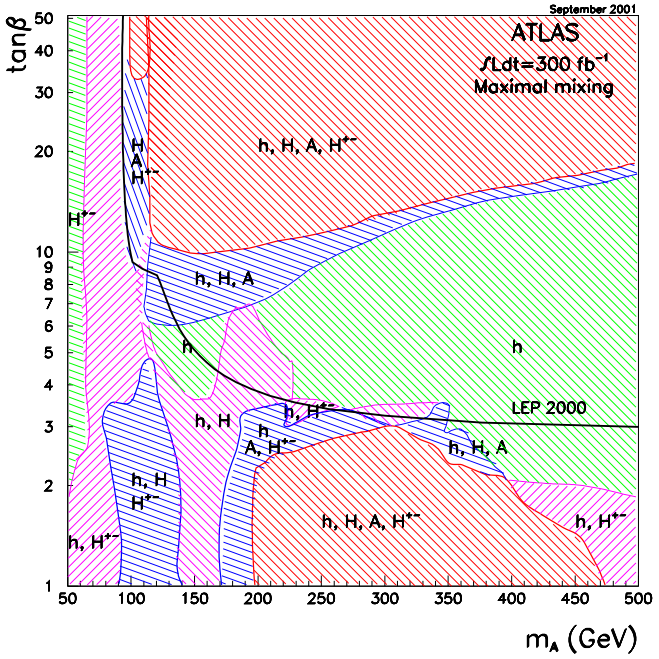
Djouadi, Kalinowski, Zerwas

* h can be discovered in the entire MSSM parameter range: Zh or Ah
* All SUSY Higgs bosons can be discovered @ 500 GeV if $M_A, M_H, M_{H^\pm} \lesssim 230$ GeV
* If decay modes are very complicated $\rightsquigarrow$ missing mass tech. $\rightsquigarrow$ detection

MSSM Higgs Boson Production in $\gamma\gamma$ Collisions

Krämer,MM,Spira,Zerwas, Phys.Lett.B508(2001)311-316

▷ Search for H, A at the **LHC**:



Higgs particles H, A with masses $M_{H/A} \gtrsim 200$ GeV and centered around $\tan\beta \sim 7$ may escape discovery at the LHC

MSSM Higgs Boson Production in $\gamma\gamma$ Collisions

Krämer,MM,Spira,Zerwas, Phys.Lett.B508(2001)311-316

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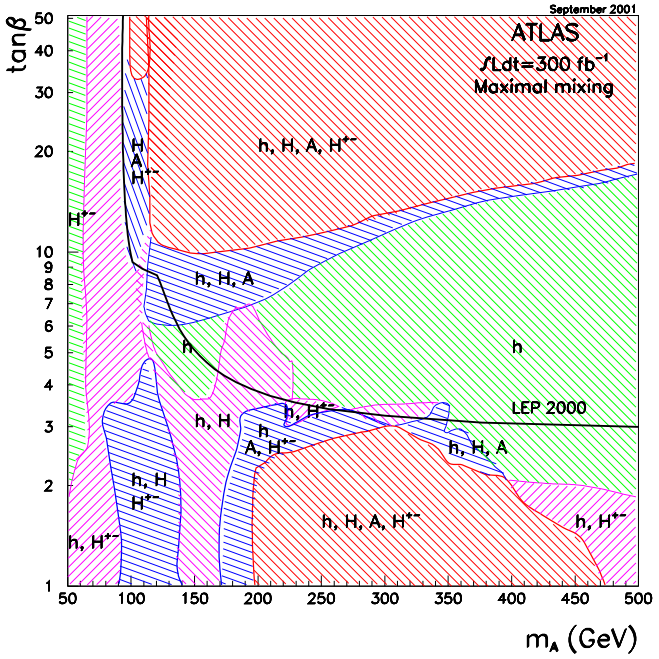

Higgs particles H, A with masses $M_{H/A} \gtrsim 200$ GeV and centered around $\tan\beta \sim 7$ may escape discovery at the LHC

▷ At e^+e^- **linear colliders:** Production of H, A with masses $M_{H,A} \lesssim 0.5\sqrt{s_{ee}}$

MSSM Higgs Boson Production in $\gamma\gamma$ Collisions

Krämer,MM,Spira,Zerwas, Phys.Lett.B508(2001)311-316

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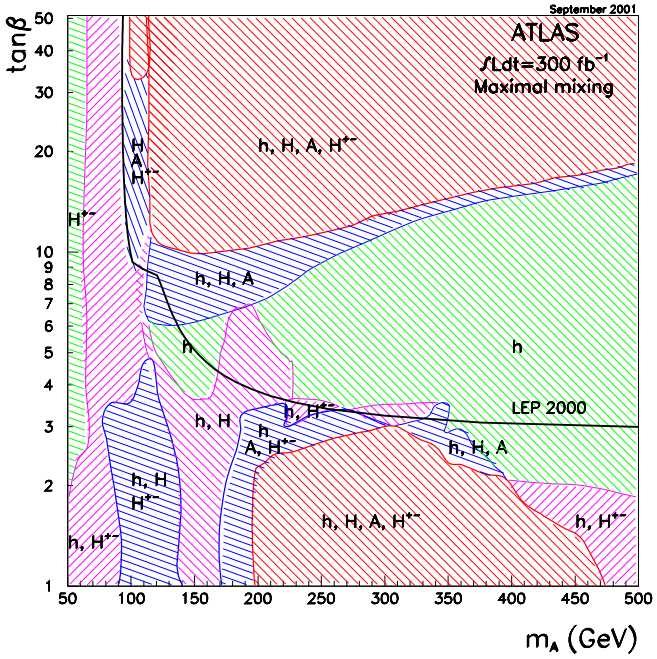


Higgs particles H, A with masses $M_{H/A} \gtrsim 200$ GeV and centered around $\tan\beta \sim 7$ may escape discovery at the LHC

▷ At e^+e^- **linear colliders:** Production of H, A with masses $M_{H,A} \lesssim 0.5\sqrt{s_{ee}}$

▷ Alternative: Search for H, A at **future $\gamma\gamma$ colliders**

Ginzburg,Kotkin,Panfil, Serbo,Telnov

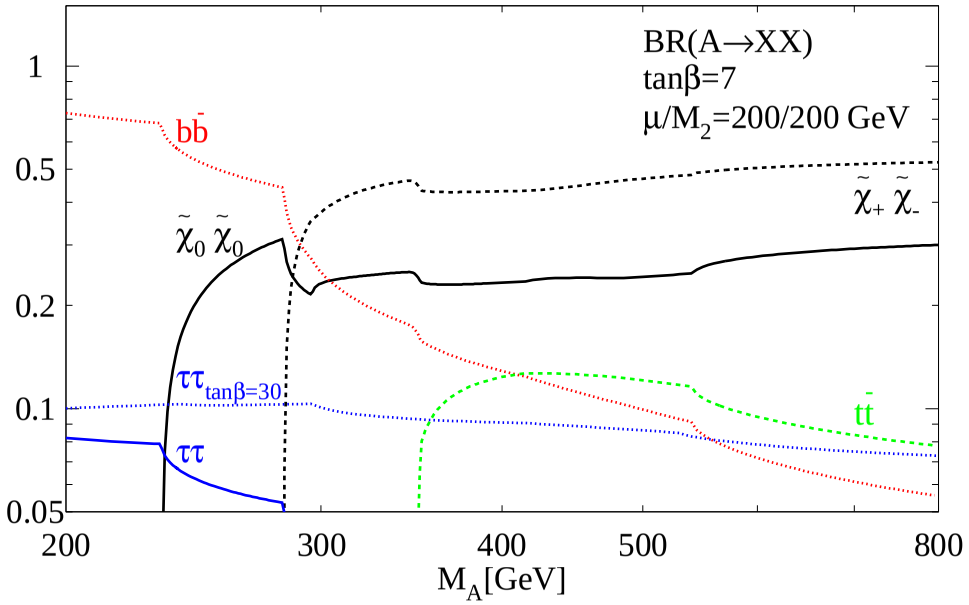
high luminosity ($\int \mathcal{L} = 300$ fb^{-1} in 2 years)

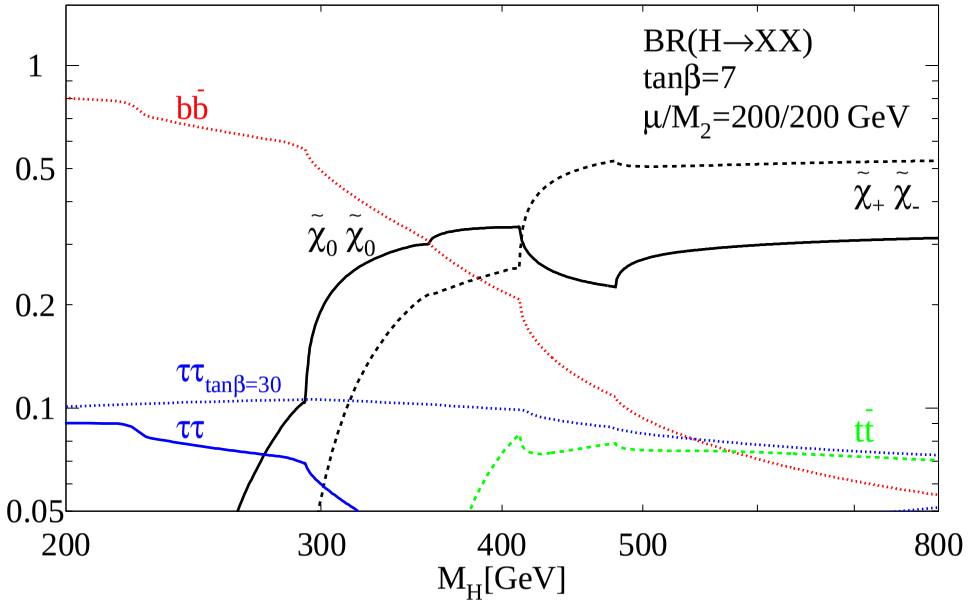
high energy, high degree of polarisation

H, A can be produced with masses up to $M_{H,A} \lesssim 0.8\sqrt{s_{ee}}$

Decay Modes

HDECAY

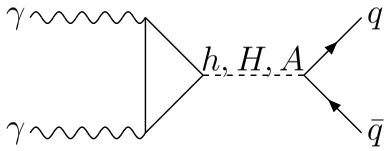




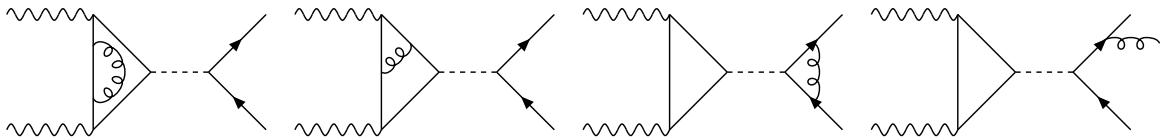
Process $\gamma\gamma \to q\bar{q}$ – signal

Signal process

LO



NLO



Spira,Djouadi,Graudenz,Zerwas
Melnikov,Yakovlev
Inoue et al.
Braaten,Leveille
Drees,Hikasa;...

$$\frac{d\sigma_{\rm LO}^{++/--}}{d\cos\theta} = \frac{N_c G_F^2 \alpha^2 \beta m_q^2}{128\pi^3}\left[g_{hqq}^2\beta^2|\mathcal{G}_h|^2 + g_{Hqq}^2\beta^2|\mathcal{G}_H|^2 + g_{Aqq}^2|\mathcal{G}_A|^2 + 2g_{hqq}g_{Hqq}\beta^2{\rm Re}(\mathcal{G}_h\mathcal{G}_H)\right]$$

$$\frac{d\sigma_{\rm LO}^{+-/-+}}{d\cos\theta} = 0$$

$$\mathcal{G}_\Phi = \mathcal{M}_\Phi/(1 - m_\Phi^2/s + i m_\Phi\Gamma_\Phi/s) \qquad \Phi = h, H, A \qquad \mathcal{M}_\Phi: \ \gamma\gamma\Phi - \text{form factor}$$

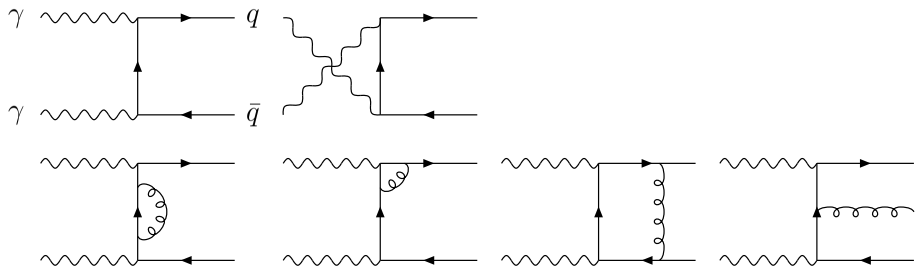
$$\beta = (1 - 4m_q^2/s)^{1/2}$$

Process $\gamma\gamma \to q\bar{q}$ – bkg & interference

Background process

LO

NLO



Jikia, Tkabladze
Kamal, Merebashvili, Conogouris

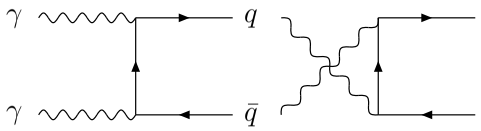
$$\frac{d\sigma_{\rm LO}^{++/--}}{d\cos\theta} = \frac{N_c\alpha^2 Q_q^4 16\pi\beta(1+\beta^2)}{s}\frac{m_q^2}{s}\frac{1}{(1-\beta^2\cos^2\theta)^2}$$

$$\frac{d\sigma_{\rm LO}^{+-/-+}}{d\cos\theta} = \frac{N_c\alpha^2 Q_q^4 4\pi\beta^3}{s}\frac{\sin^2\theta(2-\beta^2\sin^2\theta)}{(1-\beta^2\cos^2\theta)^2}$$

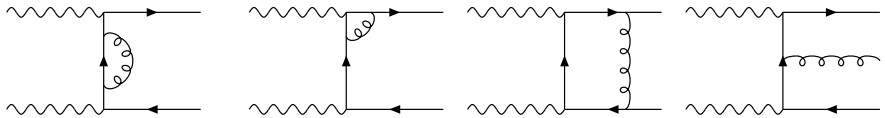
Process $\gamma\gamma \to q\bar{q}$ – bkg & interference

Background process

LO



NLO



Jikia, Tkabladze
Kamal, Merebashvili, Conogouris

$$\frac{d\sigma_{\rm LO}^{++/--}}{d\cos\theta} = \frac{N_c\alpha^2 Q_q^4 16\pi\beta(1+\beta^2)}{s}\frac{m_q^2}{s}\frac{1}{(1-\beta^2\cos^2\theta)^2}$$

$$\frac{d\sigma_{\rm LO}^{+-/-+}}{d\cos\theta} = \frac{N_c\alpha^2 Q_q^4 4\pi\beta^3}{s}\frac{\sin^2\theta(2-\beta^2\sin^2\theta)}{(1-\beta^2\cos^2\theta)^2}$$

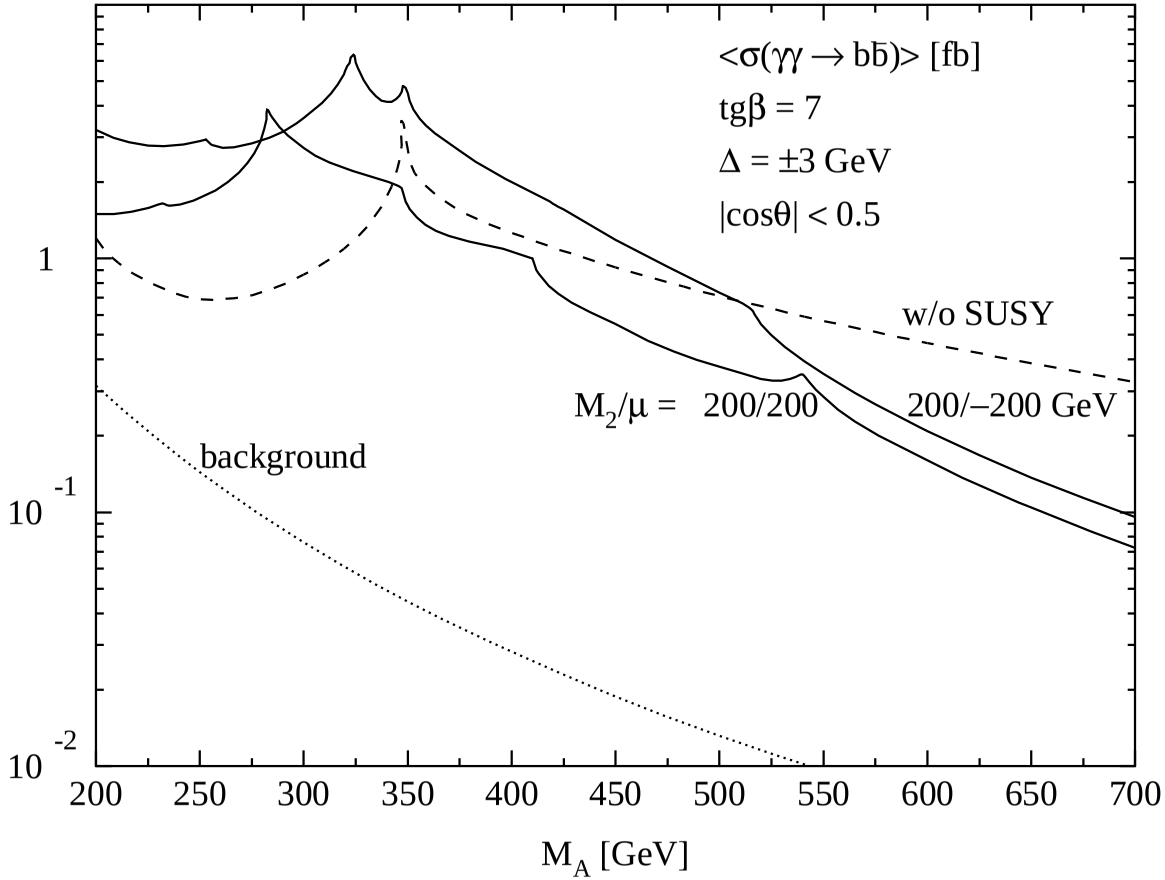
Interference process

$$\frac{d\sigma_{\rm LO}^{++/--}}{d\cos\theta} = \frac{N_c G_F\alpha^2 Q_q^2\beta}{\sqrt{2}\pi}\frac{m_q^2}{s}\frac{1}{1-\beta^2\cos^2\theta}\left[g_{hqq}\beta^2{\rm Re}(\mathcal{G}_h)+g_{Hqq}\beta^2{\rm Re}(\mathcal{G}_H)-g_{Aqq}{\rm Re}(\mathcal{G}_A)\right]$$

$$\frac{d\sigma_{\rm LO}^{+-/-+}}{d\cos\theta} = 0$$

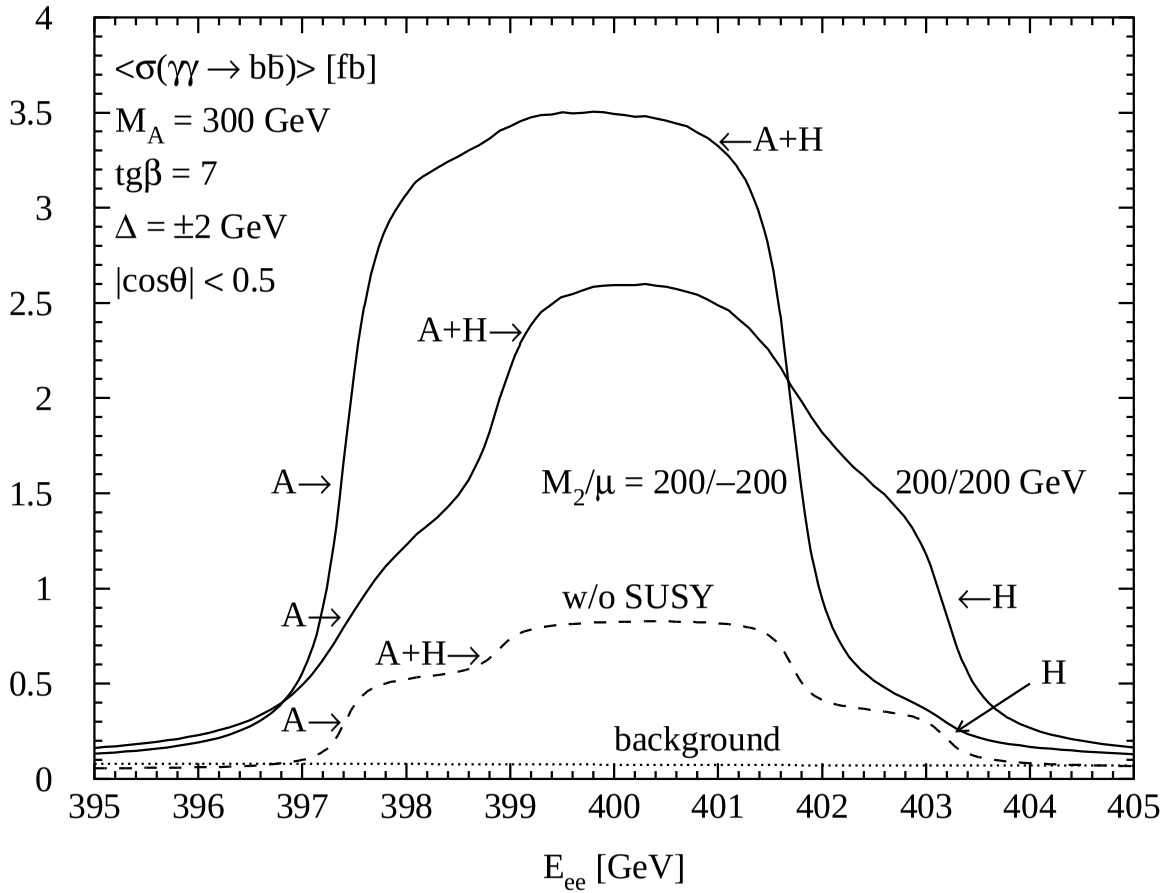
NLO corrections have been calculated

Result $e^+e^- \to \gamma\gamma \to b\bar{b}$



- ▷ Cut in $\cos\theta$ enhances S/B
- ▷ $\sigma_{\text{bkg}} \lesssim 0.3$ fb; $\sigma_{\text{signal}} \gtrsim 0.1$ fb for $M_A \lesssim 600$ GeV
- ▷ Peaks/kinks: behaviour of $\gamma\gamma A$ form factor/BR($H/A \to b\bar{b}$) at the gaugino/$t\bar{t}$ thresholds

Separation of H and A



- ▷ $M_A = 300$ GeV, $M_H = 301.37$ GeV for large SUSY particle masses
- ▷ Change of cross section at the H, A production thresholds ⇒ separation of H and A via threshold scan of the H, A production cross section

$\tau\tau$ Fusion to $\mathcal{SUSY}$ Higgs Bosons at a Photon Collider

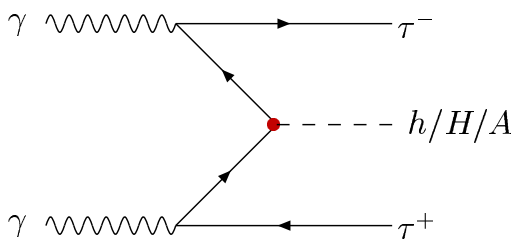
Choi,Kalinowski,Lee,MM,Spira,Zerwas, Phys.Lett.B606(2005)164

- **Motivation:** $\delta \tan\beta / \tan\beta \sim 10$ % at e^+e^-/pp colliders Choi et al.;Boos et al.;Gunion et al.;Kinnunen et al. Nieżurawski et al.;Velasco et al.

$\tau\tau$ Fusion to $\mathcal{SUSY}$ Higgs Bosons at a Photon Collider

Choi,Kalinowski,Lee,MM,Spira,Zerwas, Phys.Lett.B606(2005)164

- **$\tau\tau$ Fusion to h, H, A at a $\gamma\gamma$ Collider: Signal**



Couplings: for large $\tan\beta$

$A\tau\tau = \tan\beta$, $H\tau\tau \approx \tan\beta$	heavy H/A
$h\tau\tau \approx \tan\beta$	light A

Higgs decays: $h/H/A \to b\bar{b}$ at 90% (SPS1b)

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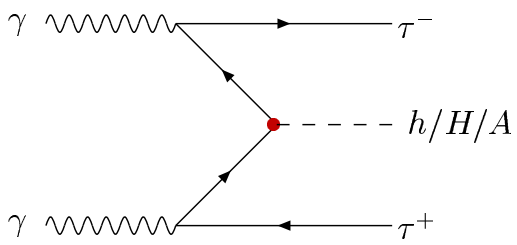

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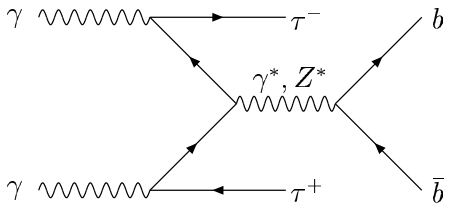

suppressed $\sim g^2$ except for $M_{bb} \sim M_Z$, $M_{\tau\tau} \sim M_Z$

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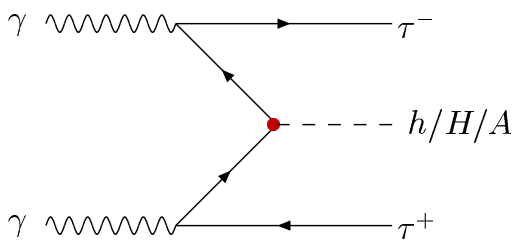

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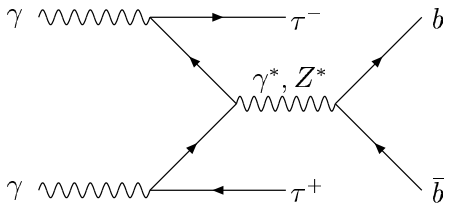

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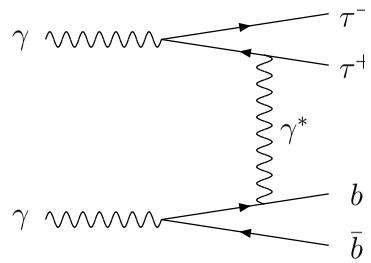
- **Bkg - diffractive: $\gamma\gamma \to (\tau\tau)(bb)$**



suppressed by event topology:

$\tau\tau$ small invariant mass/same direction

bb dito/close to γ axes

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Analysis: Full set of signal and bkg diagrams ($\rightarrow$ CompHEP Boos,Pukhov,...)

Cuts: $M_{bb} = M_\Phi \pm \Delta$ with $\Delta = \max[\Gamma_\phi/2, \Delta_{\rm ex}] \rightarrow \Delta_{\rm ex} = 0.05 M_\Phi$

τ polar angle	≥ 130 mrad [shielding: dead mask]
τ energy	≥ 5 GeV
τ^+ and τ^-	assumed in opposite directions

Efficiencies: $\epsilon_{bb} \sim 0.7$ and $\epsilon_{\tau\tau} \sim 0.5 \rightsquigarrow \epsilon \sim 0.35$

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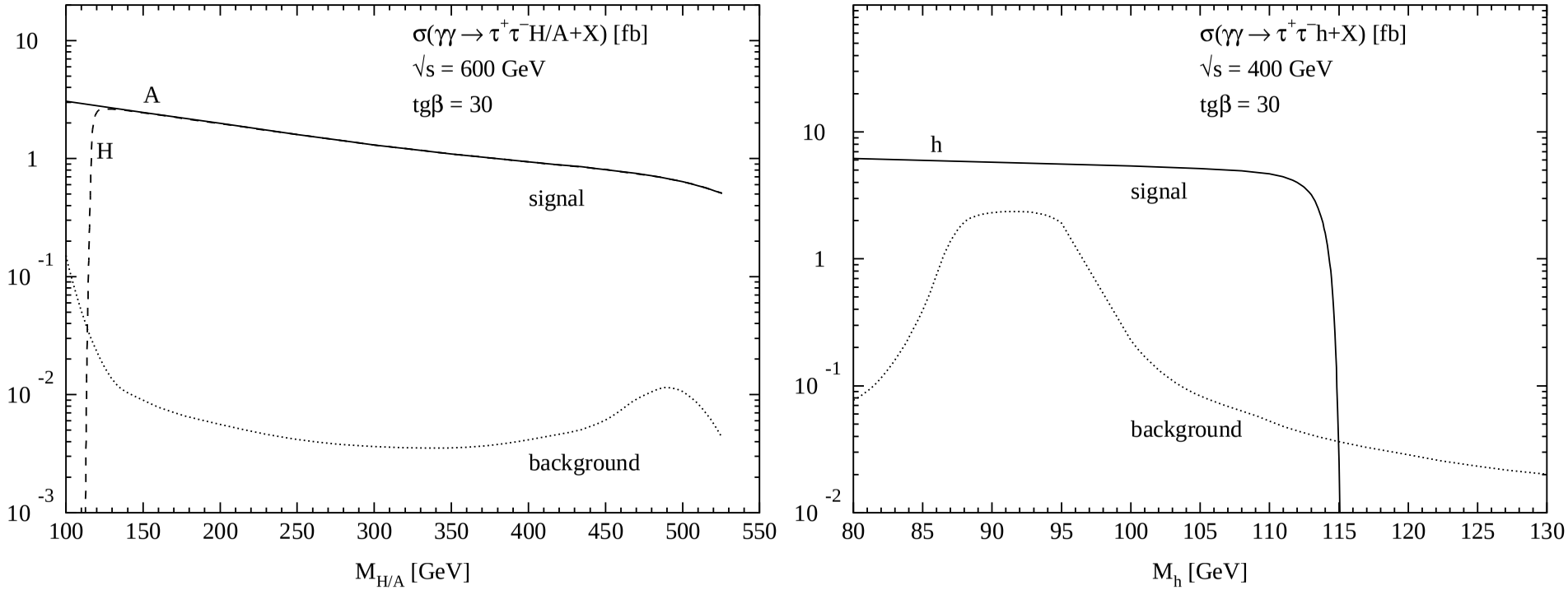
$E_{e^\pm e^-} = 800/500$ GeV $\Rightarrow E_{\gamma\gamma} = 600/400$ GeV, $\mathcal{L} = 200/100$ fb^{-1}



- $\sigma(H/A) = 3$ to 1 fb for $M_{A/H} = 100...500$ GeV and $\tan\beta = 30$
- $\sigma(h) = 5$ fb for $M_h = 110$ GeV and $\tan\beta = 30$
- $\Delta\tan\beta \approx 0.9$-1.3 uniformly for $\tan\beta \gtrsim 10$

Process $\gamma\gamma \to b\bar{b}$ - technical details

- $b\bar{b}$ final state most promising
- Restriction to 2-jet final states $\rightsquigarrow$ enhance S/B
- Higher order corrections (in 2-jet) are accounted for by resummation Fadin,Khoze,Martin Melles,Stirling
- Polarisation of $e^{\pm}$ and laser beams $\rightsquigarrow$ enhance S/B

  [For leading order with realistic photon spectra see also Gunion et al.]

$\gamma\gamma$ luminosity $d\mathcal{L}^{\gamma\gamma}/dz$ Ginzburg et al. Kühn et al.

"P": pol.; $\sqrt{s_{ee}} = 500$ GeV

For this helicity combination:
$d\mathcal{L}^{\gamma\gamma}/dz$ max. for $J_z = 0$
peaked towards high energies