Production of
Neutral Higgs + Jet
in the MSSM

Oliver Brein

(Max-Planck-Institut für Physik, München)

in collaboration with W. Hollik

[see: hep-ph/0305321]

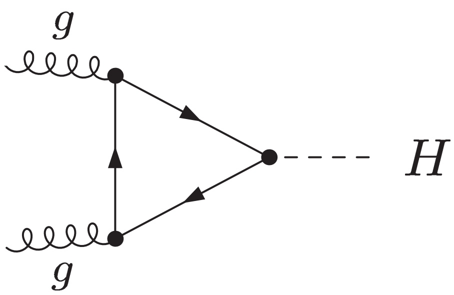
e-mail: obr@mppmu.mpg.de

outline :

- Higgs + Jet in the Standard Model
- Higgs + Jet in the MSSM
- Results

• Higgs + Jet in the Standard Model

Higgs production @ LHC mainly via gluon fusion:



Detection ($m_H \approx 100 - 140$GeV): mainly via the rare decay $H \to \gamma\gamma$.
$\to$ difficult ! huge background

– Higgs + Jet [R.K. Ellis et al. '87; Baur, Glover '89]

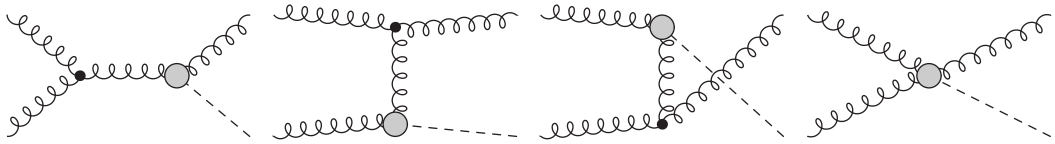
idea: study events with a high-p_T hadronic jet.

advantage:
* richer kinematical structure compared to inclusive Higgs production.
$\to$ better S/B ratio
$\to$ allows for refined cuts

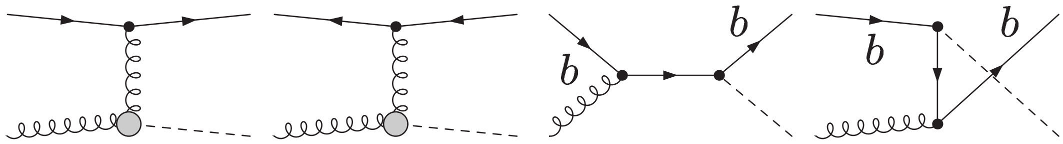
disadvantage:
* lower rate than inclusive Higgs production
* signal and background only known in LO
$\to$ large theoretical uncertainties (so far)

H+jet, partonic processes (mostly loop-induced):

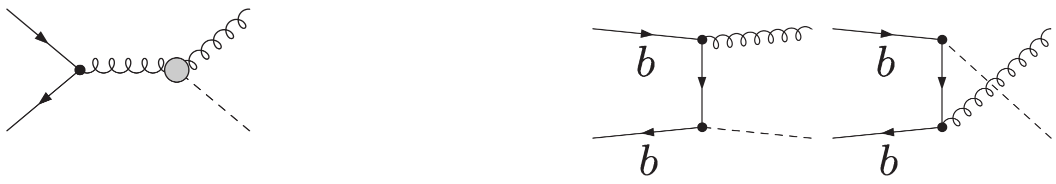
- $gg \to Hg$ (≈ 50 - 70 % of total rate)



- $qg \to Hq, \bar{q}g \to H\bar{q}$ (≈ 30 - 50 % of total rate)



- $q\bar{q} \to Hg$ (rate small)



Recently simulated: $pp \to H + \text{jet}, H \to \gamma\gamma$

[Abdullin et al. '98 & '02]

Result: H+jet production (with $p_{T,\text{jet}} \geq 30$ GeV, $|\eta_{\text{jet}}| \leq 4.5$) is a promising alternative (supplement) to the inclusive SM Higgs production for $m_H \approx 100 - 140$GeV,

but theoretical predictions need improvement.

[Abdullin et al., ATLAS TDR '99]

• Higgs + Jet in the MSSM

Motivation:
* promising simulation results in the SM case
* MSSM prediction for h^0 + jet not known yet
* process loop-induced: potentially large effects from virtual particles

– partonic processes
similar to the SM:

gluon fusion	$gg \to h^0 g$,
quark-gluon scattering	$q(\bar{q})g \to h^0 q(\bar{q})$,
$q\bar{q}$ annihilation	$q\bar{q} \to h^0 g$

but:

* different Higgs Yukawa-couplings

$$g^{\text{SM}}_{q\bar{q}H} = \frac{e}{2s_W}\frac{m_q}{m_W} \longrightarrow g^{\text{MSSM}}_{q\bar{q}h^0} = \frac{e}{2s_W}\frac{m_q}{m_W} f_q(\alpha,\beta),$$

$$f_{u_I}(\alpha,\beta) = \cos\alpha / \sin\beta$$

$$f_{d_I}(\alpha,\beta) = -\sin\alpha / \cos\beta$$

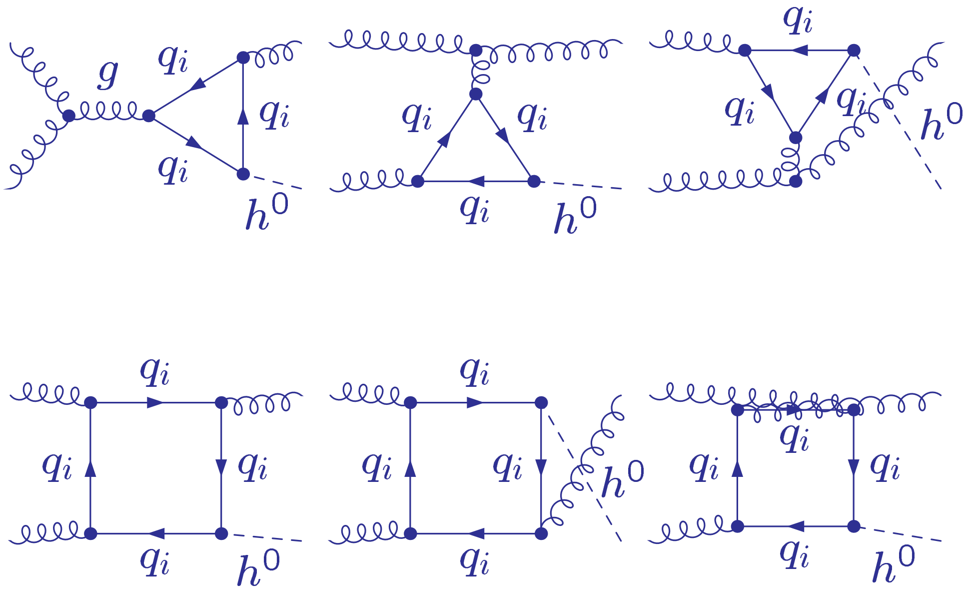
→ mainly change of overall rate

* additional superpartner-loops (even additional topologies)

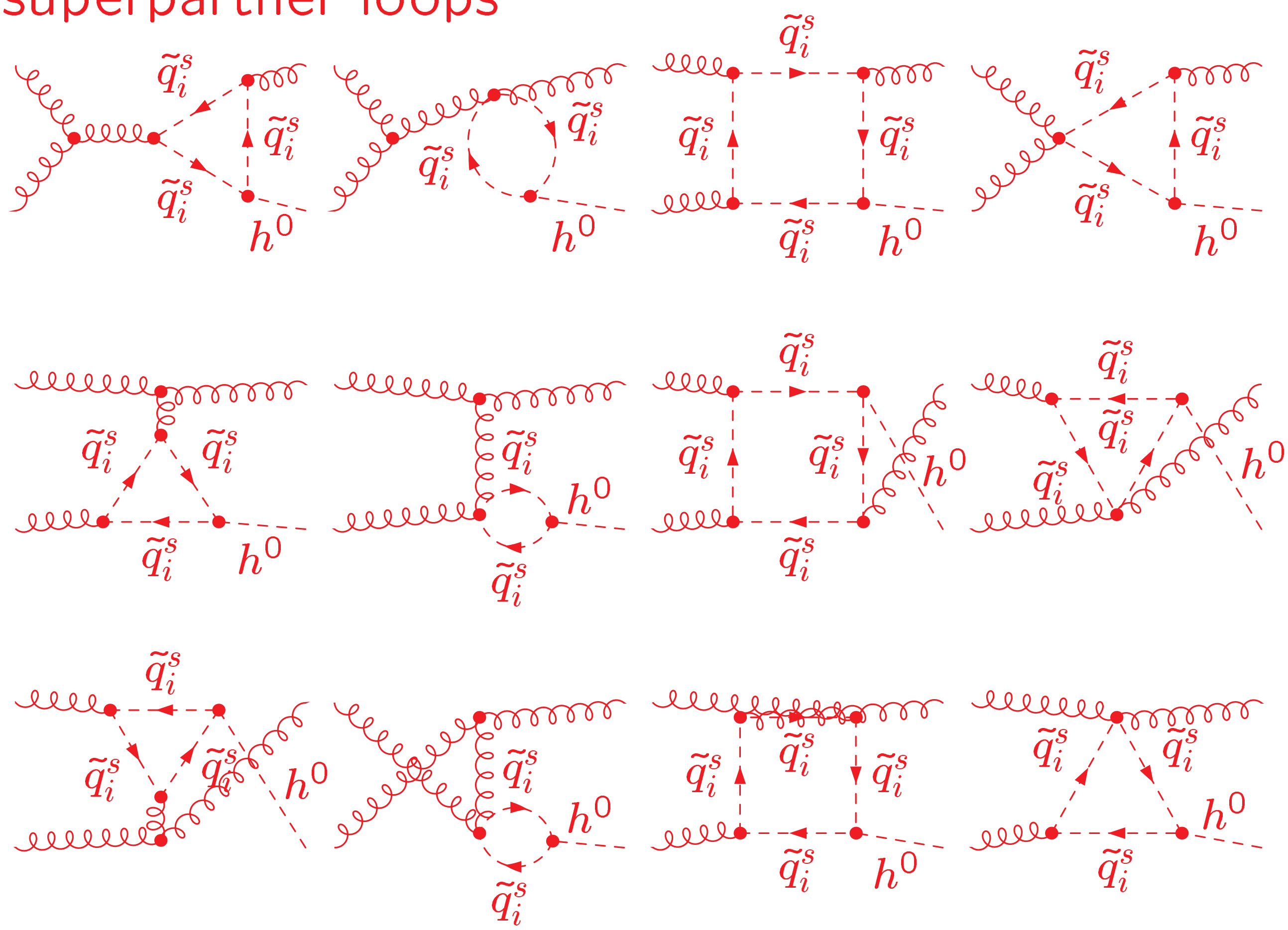
→ angular distribution changed

gluon fusion, $gg \to h^0 g$

quark loops

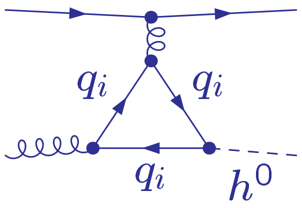


superpartner loops

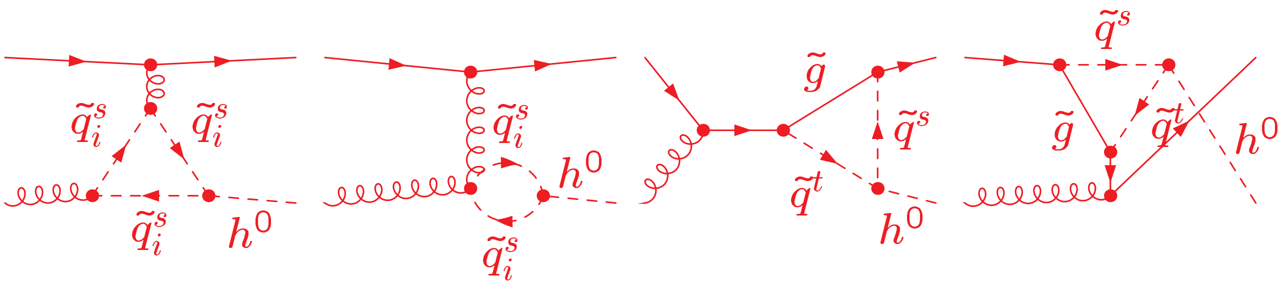


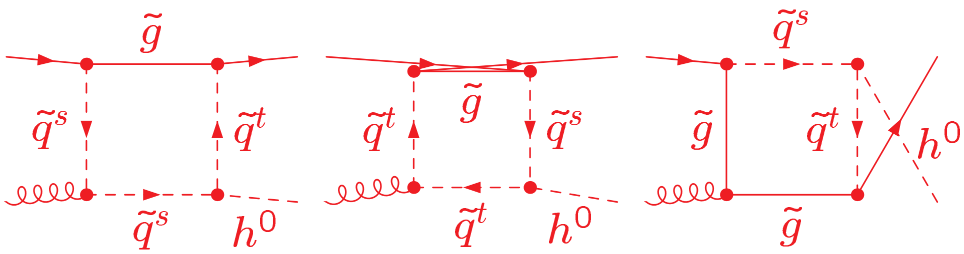
quark-gluon scattering, $qg \to h^0 q$

quark loops



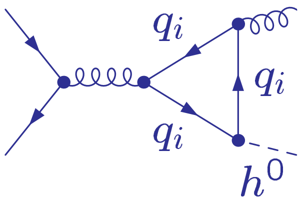
superpartner loops



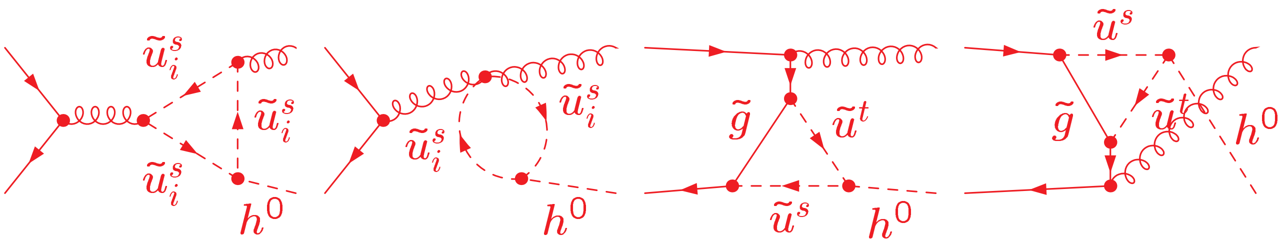


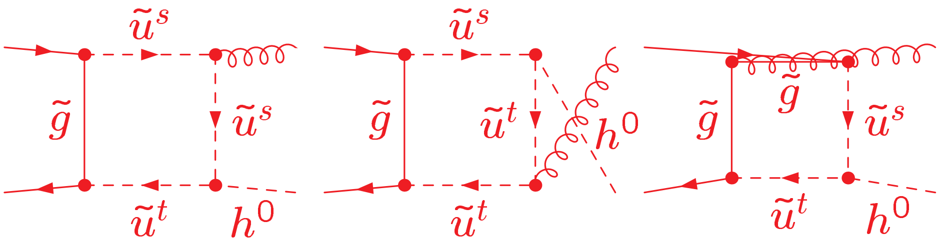
quark-antiquark annihilation, $q\bar{q} \to h^0 g$

quark loops



superpartner loops





• Results

– Hadronic cross section @ LHC ($\sqrt{S} = 14$ TeV)

$$\sigma(pp \to h^0 + \text{jet} + X) =$$

$$\int_{\tau_0}^{1} d\tau \left(\frac{d\mathcal{L}_{gg}^{pp}}{d\tau}\, \sigma_{gg\to gh^0}(\tau S) + \sum_q \frac{d\mathcal{L}_{qg}^{pp}}{d\tau}\, \sigma_{qg\to qh^0}(\tau S) \right.$$
$$\left. + \sum_q \frac{d\mathcal{L}_{q\bar{q}}^{pp}}{d\tau}\, \sigma_{q\bar{q}\to gh^0}(\tau S) \right)$$

with the parton luminosity

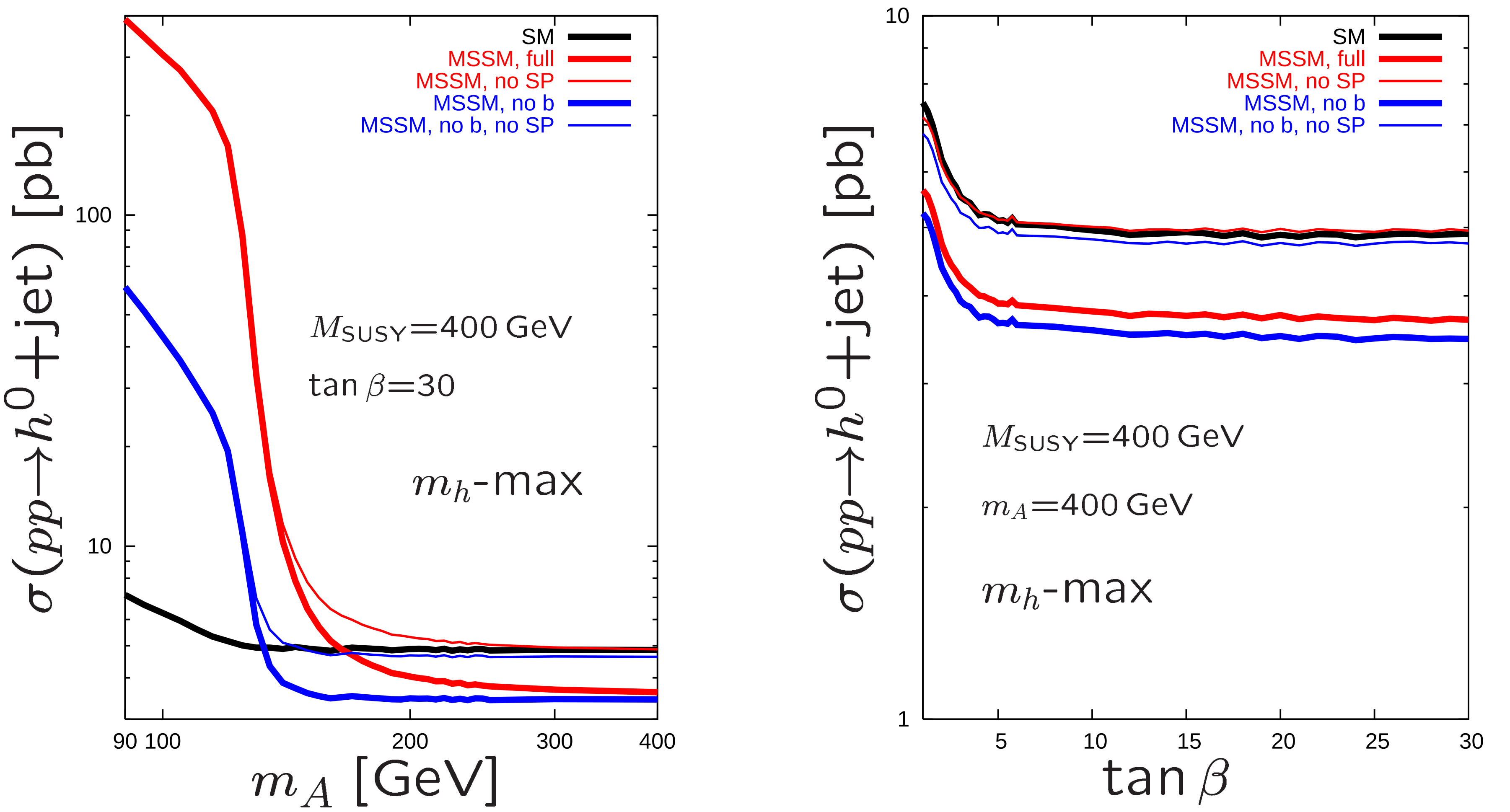
$$\frac{d\mathcal{L}_{nm}^{AB}}{d\tau} = \int_{\tau}^{1} \frac{dx}{x} \frac{1}{1+\delta_{nm}} \Big[f_{n/A}(x) f_{m/B}(\frac{\tau}{x})$$
$$+ f_{m/A}(x) f_{n/B}(\frac{\tau}{x}) \Big] .$$

The cuts $p_{T,\text{jet}} \geq 30$ GeV and $|\eta_{\text{jet}}| \leq 4.5$ determine τ_0 and the angular integration limits.

The results shown are for the MSSM m_h^{max} benchmark scenario with common squark mass scale M_{SUSY}.

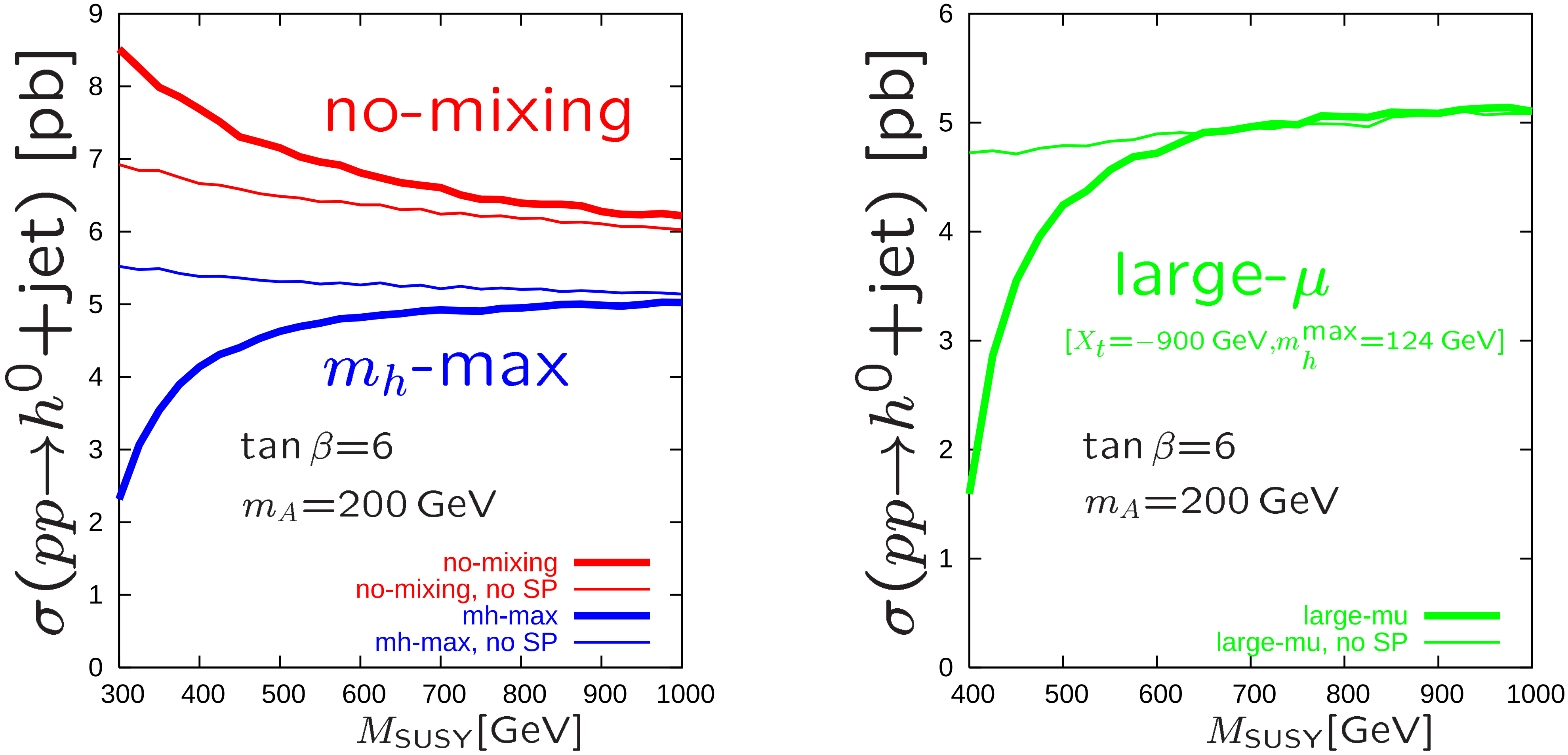
[partonic processes calculated using FeynArts/FormCalc, see : www.feynarts.de]

– m_A- and $\tan\beta$-dependence (cuts: $p_{T,\text{jet}} \geq 30$ GeV , $|\eta_{\text{jet}}| \leq 4.5$)

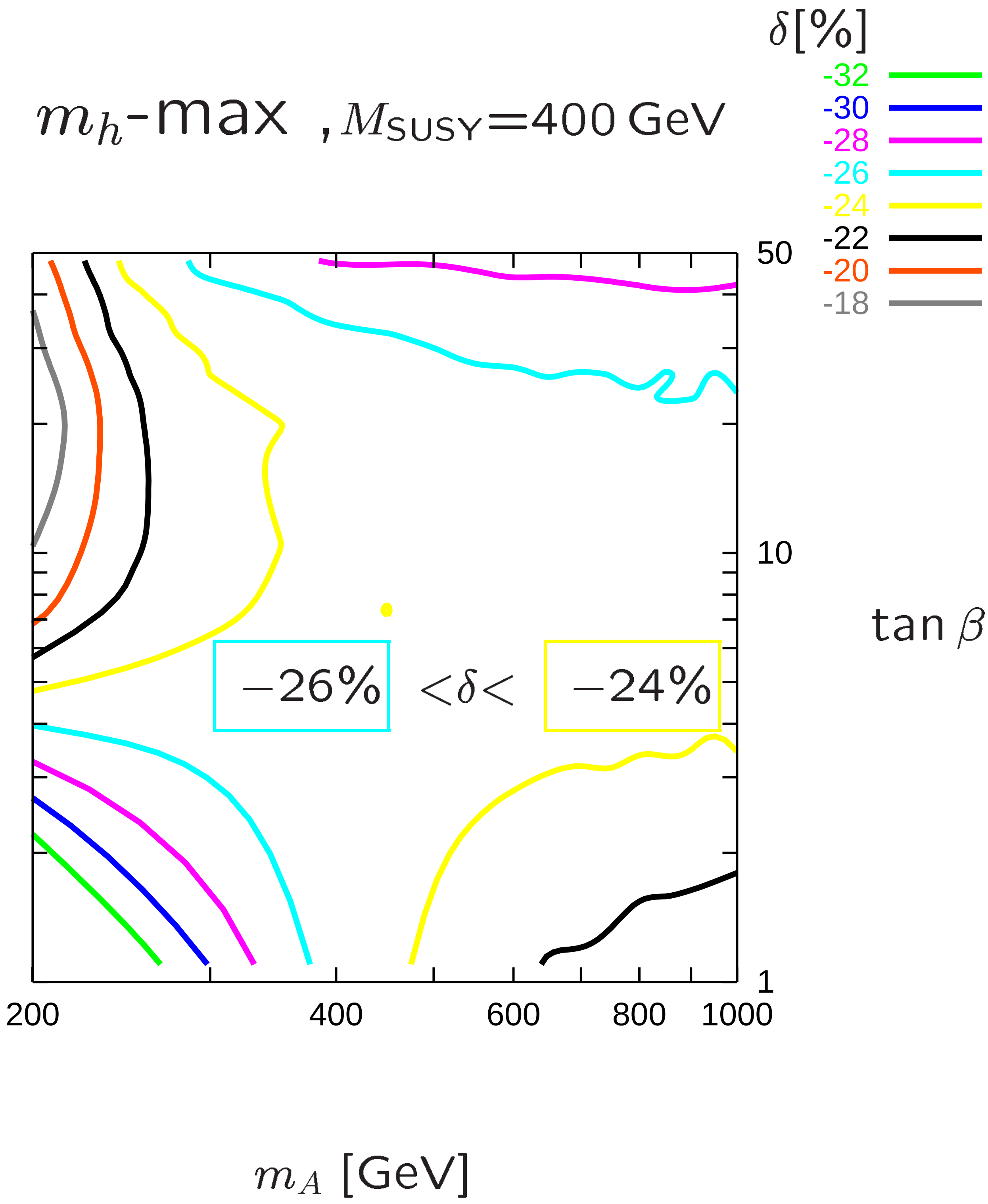


– M_{SUSY} -dependence

(cuts: $p_{T,\text{jet}} \geq 30$ GeV , $|\eta_{\text{jet}}| \leq 4.5$)



– Relative Difference $\delta = (\sigma^{\mathrm{MSSM}} - \sigma^{\mathrm{SM}})/\sigma^{\mathrm{SM}}$



summary

- The main channel to produce the lightest Higgs @ the LHC is gluon fusion.

- SM simulations show: Higgs + high-p_T jet production is a promising alternative to the inclusive production.

- LO MSSM prediction shows large effects due to virtual squarks. (processes loop-induced) Sizeable differences between SM and MSSM expectations can occur.

- NLO predictions for signal *and* background are needed in order to be useful for experimental analyses.

[see hep-ph/0305321 for more information]

By the way:

fortran code available on request

$\rightarrow$ obr@mppmu.mpg.de