Higgs: Theory

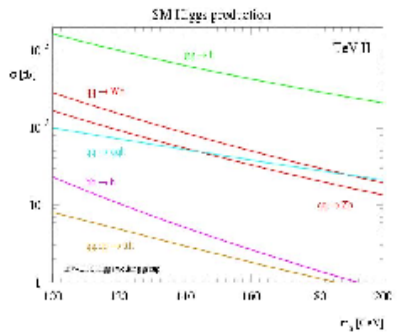
Scott Willenbrock

U. of Illinois at Urbana-Champaign

TeV4LHC@FNAL

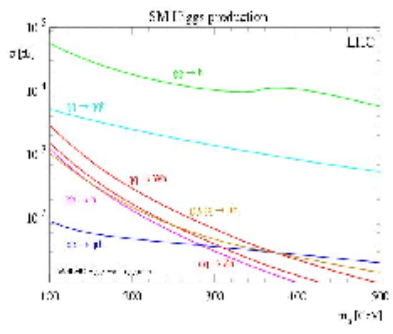
October 22, 2005

Tevatron Run II



more information

LHC



more information

Higgs Working Group

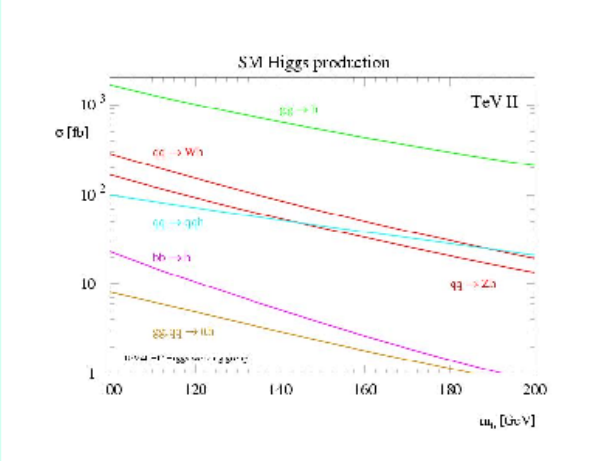
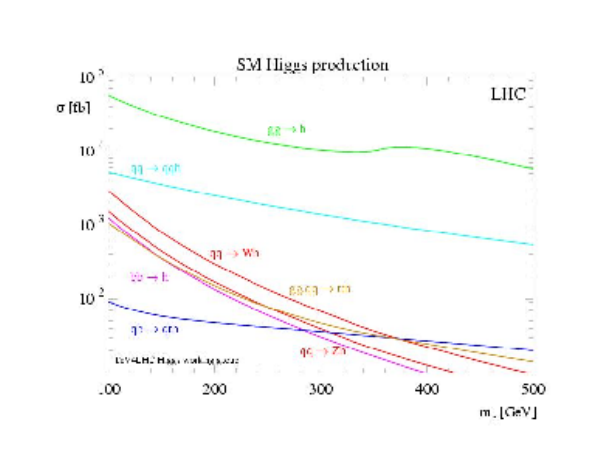
Convenors: Aaron Dominguez **(CDF)**, Ia Iashvili **(DØ)**, Scott Willenbrock **(TH)**
Send email to all three convenors

Introduction

The goal of TeV4LHC workshop is to explore how Tevatron results and experience can be used in most efficient way to impact the LHC physics program. The workshop is year-long series of meetings, with specific projects to be defined and carried out.

Standard Model Higgs cross sections at hadron colliders

Tev4LHC Higgs working group

Tevatron Run II	LHC
	
PS PDF	PS PDF

- gg → h + X: gluon fusion
  (ggh-tev.dat, ggh-lhc.dat)

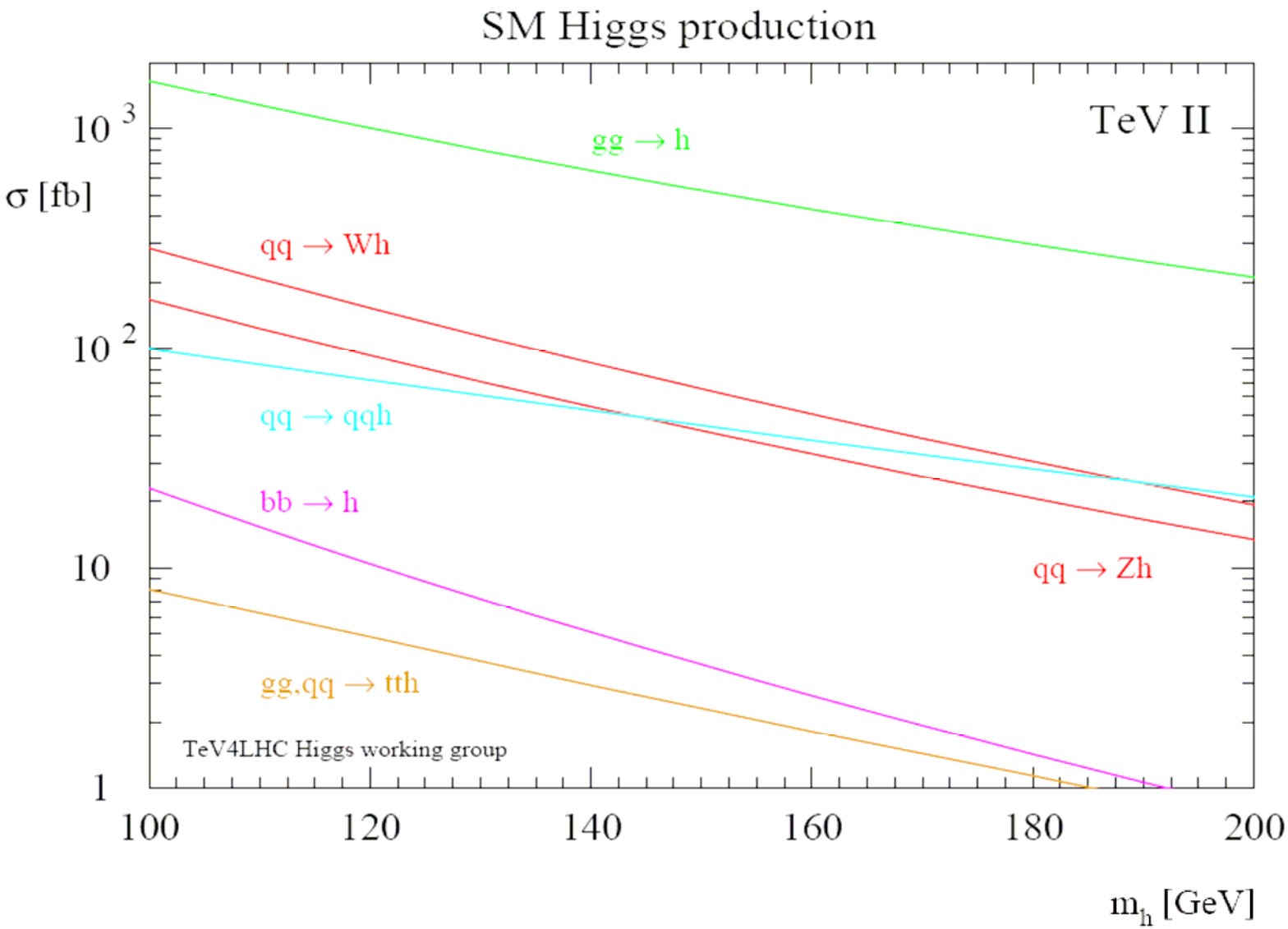
  This process is known at NNLO in QCD (in the large top-mass limit) and at NLO in QCD for arbitrary top mass (PRL 70:1372,1993). The NNLO results plotted here are from hep-ph/0306211 and include soft-gluon resummation effects at NNLL. MRST2002 at NNLO has been used, with the renormalization and factorization scales set equal to the Higgs-boson mass. The overall residual theoretical uncertainty is estimated to be around 10%. Further information on the NNLO calculations can be found in hep-ph/0201206, hep-ph/0207004 and for differential distributions at NNLO in hep-ph/0409088. NLO EW corrections are also known (for Higgs masses below 2 mW), hep-ph/0404071 and hep-ph/0407249, and range between 5% and 8% of the lowest order term (not included in the plot).

- qq → qqh + X: vector boson fusion
  (vbf-tev.dat, vbf-lhc.dat)

  This process is known at NLO in QCD. Results plotted here have been obtained with MCFM. The PDF used is CTEQ6M and the renormalization and factorization scales are set equal to the Higgs-boson mass. The theoretical uncertainty is rather small, less than 10%. Further information on the NLO calculations can be found in hep-ph/9206246, hep-ph/0403194, and hep-ph/0306109.

- qq → Wh + X, qq → Zh + X: W,Z associated production
  (wh-tev.dat, wh-lhc.dat, zh-tev.dat, zh-lhc.dat)

Fabio Maltoni


SM Higgs production
TeV II
gg → h
qq → Wh
qq → qqh
bb → h
qq → Zh
gg,qq → tth
TeV4LHC Higgs working group
σ [fb]
10 3
10 2
10
1
100
120
140
160
180
200
m_h [GeV]

SUSY Higgs cross sections at hadron colliders

TeV4LHC Higgs working Group

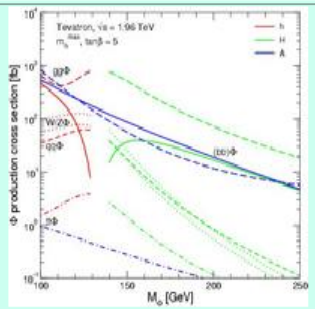
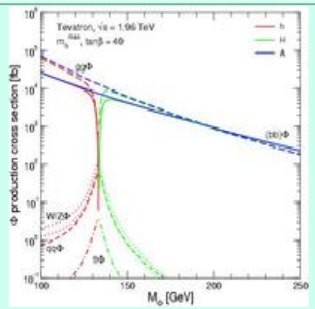
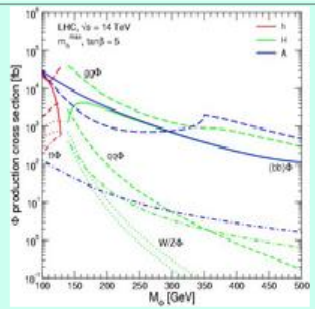
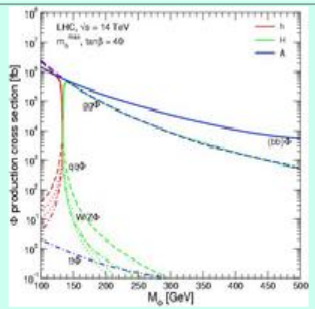
The results have been obtained with FeynHiggs2.2.10. They can be simply reproduced by using the web interface at the address above. Plots for four benchmark scenarios are provided:

- m_h^{max} (with maximum light Higgs mass values)
- no-mixing (with no mixing in the stop sector)
- small $alpha_{eff}$ (with vanishing hbb and htautau couplings for some parts of the parameter space)
- gluophobic Higgs (with small ggh coupling, especially visible for tan(beta) = 5)

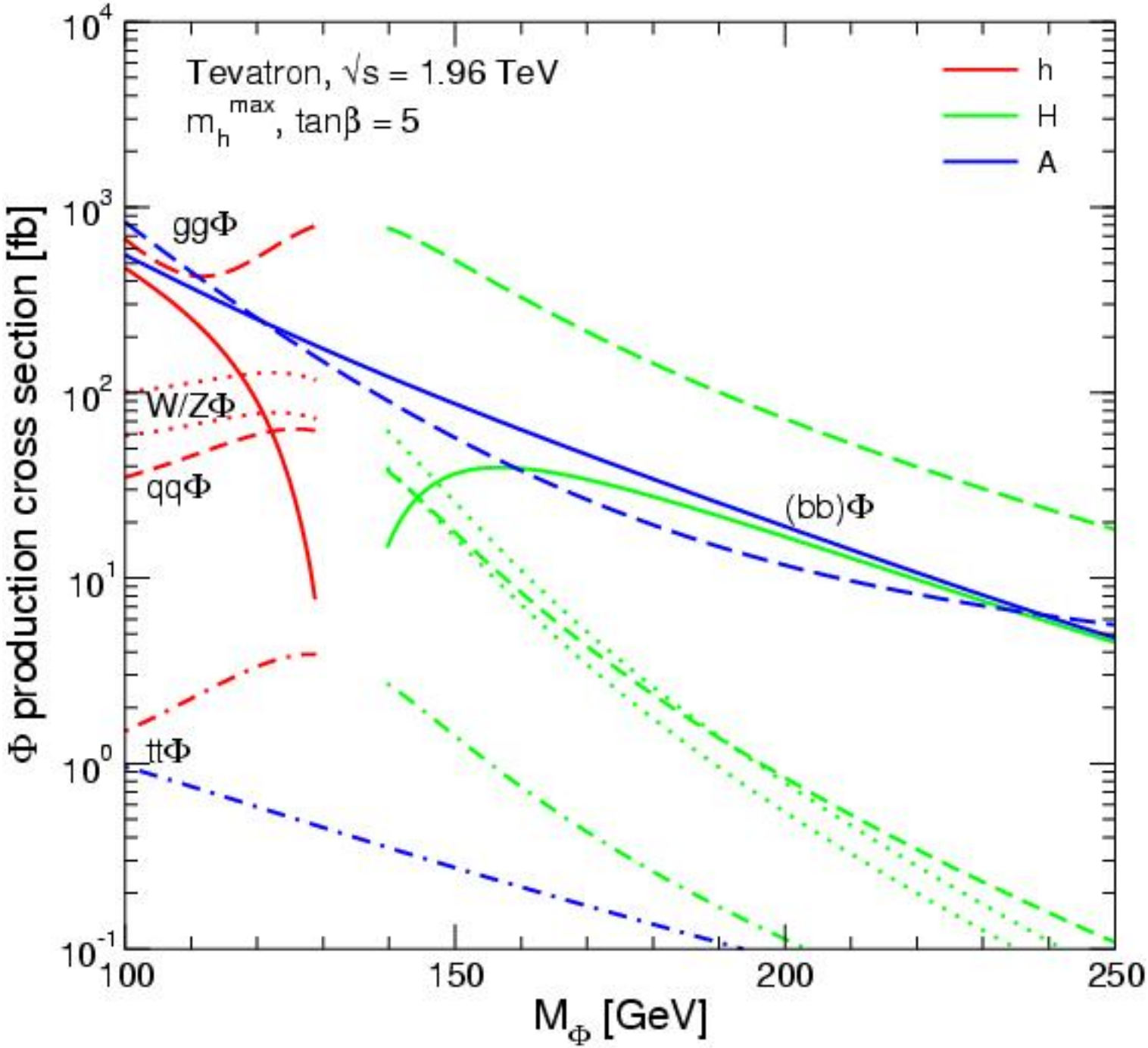
These scenarios are defined in hep-ph/0202167. For each scenario two reference values of tan(beta) (=5 and 40) are chosen, so that a total of 8 plots for each collider (Tevatron and LHC) is given.
The cross sections are obtained from those of the Standard Model by rescaling the effective couplings as included in FeynHiggs. (For literature see: hep-ph/9812320, hep-ph/9812472, hep-ph/0212020, hep-ph/0507009).
More specifically:

- gg → h+X : full one-loop with SM QCD corrections
- bb → h+X : effective couplings including Delta mb corrections
- qq → qqh+X : effective VVHiggs coupling
- qq → W/Zh+X : effective VVHiggs coupling
- gg,qq → tth : effective ttHiggs coupling (for the pseudo-scalar state A this might not be a good approximation)

"Effective coupling" means that the corrections from Higgs boson propagators that mix the Higgs bosons are included. Often these are also referred to be included via "$alpha_{eff}$" (instead of alpha), the effective angle that diagonalizes the higher-order corrected CP-even Higgs mass matrix. NLO QCD corrections to SUSY gg→H, hep-ph/0409010 are not included.

Scenarios	Tevatron Run II		LHC	
m_h^{max}	 tan(beta)=5 eps jpg	 tan(beta)=40 eps jpg	 tan(beta)=5 eps jpg	 tan(beta)=40 eps jpg

Sven Heinemeyer


Tevatron, √s = 1.96 TeV
m_h^{max}, tanβ = 5
h
H
A
ggΦ
W/ZΦ
qqΦ
ttΦ
(bb)Φ
Φ production cross section [fb]
M_Φ [GeV]
10^4
10^3
10^2
10^1
10^0
10^{-1}
100
150
200
250

H + 1 b jet

H + 1 b jet

Z + 1 b jet

Q = c,b

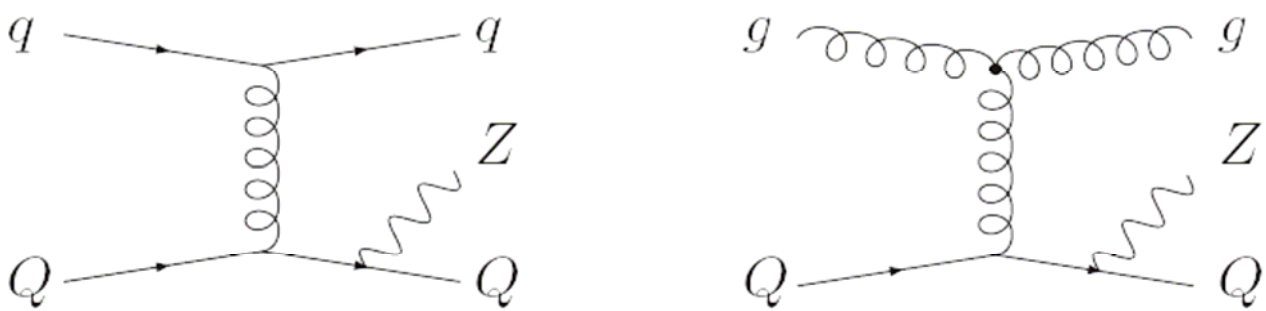
Zb / Zj

Zb / Zj = 0.023 +- 0.004 +- 0.003 D0

= 0.024 +- 0.008 +- 0.004 CDF

Agrees with NLO calculation

Z + 2 jets w/ 1 b tag



NLO calculation now available

Challenge: measure Zbj / Zjj

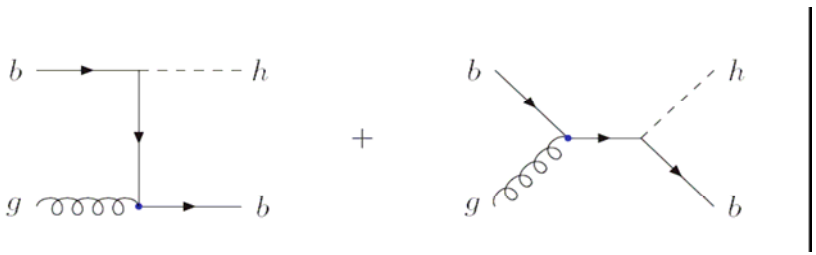
Background to Zh → Zbb w/ 1 b tag

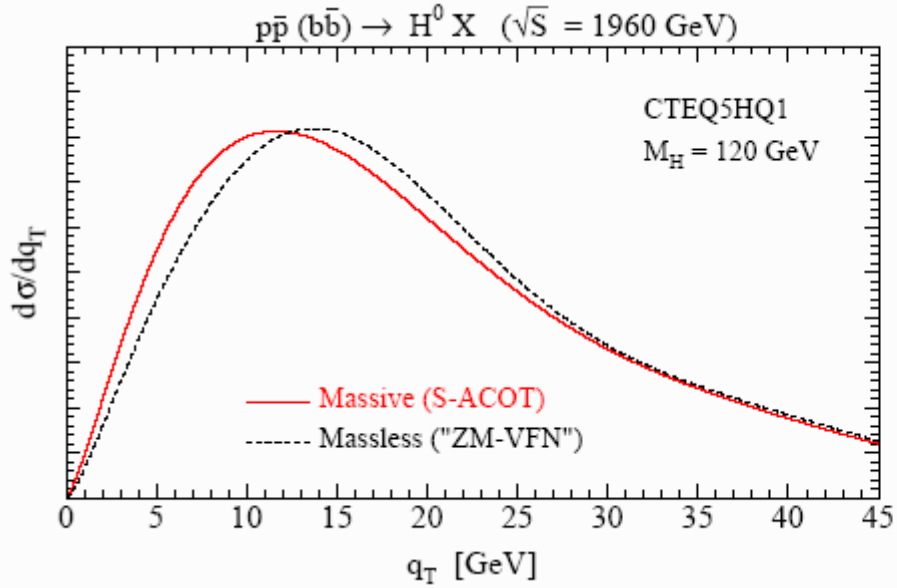
Next: Wbj

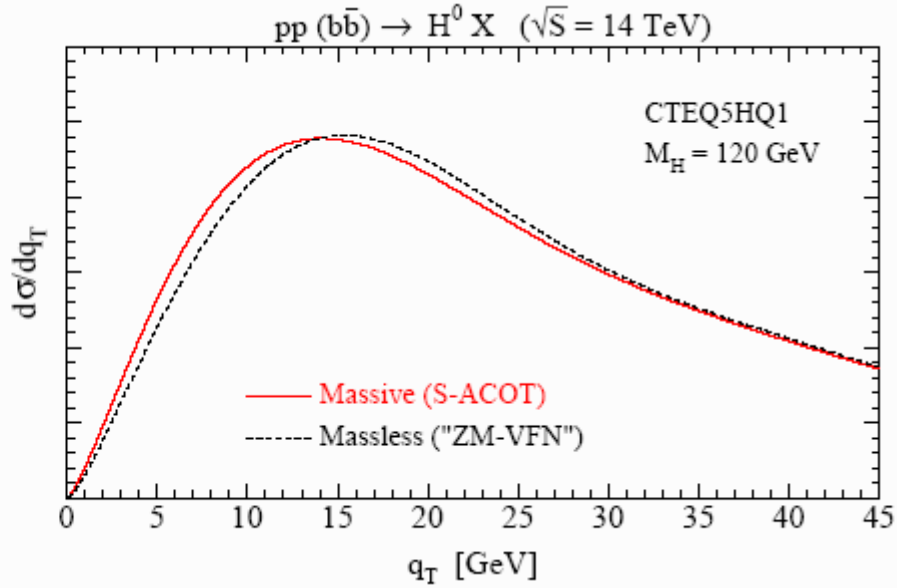
Campbell, Ellis, Maltoni, SW

Transverse momentum resummation in $b\bar{b} \to H$

Pavel Nadolsky





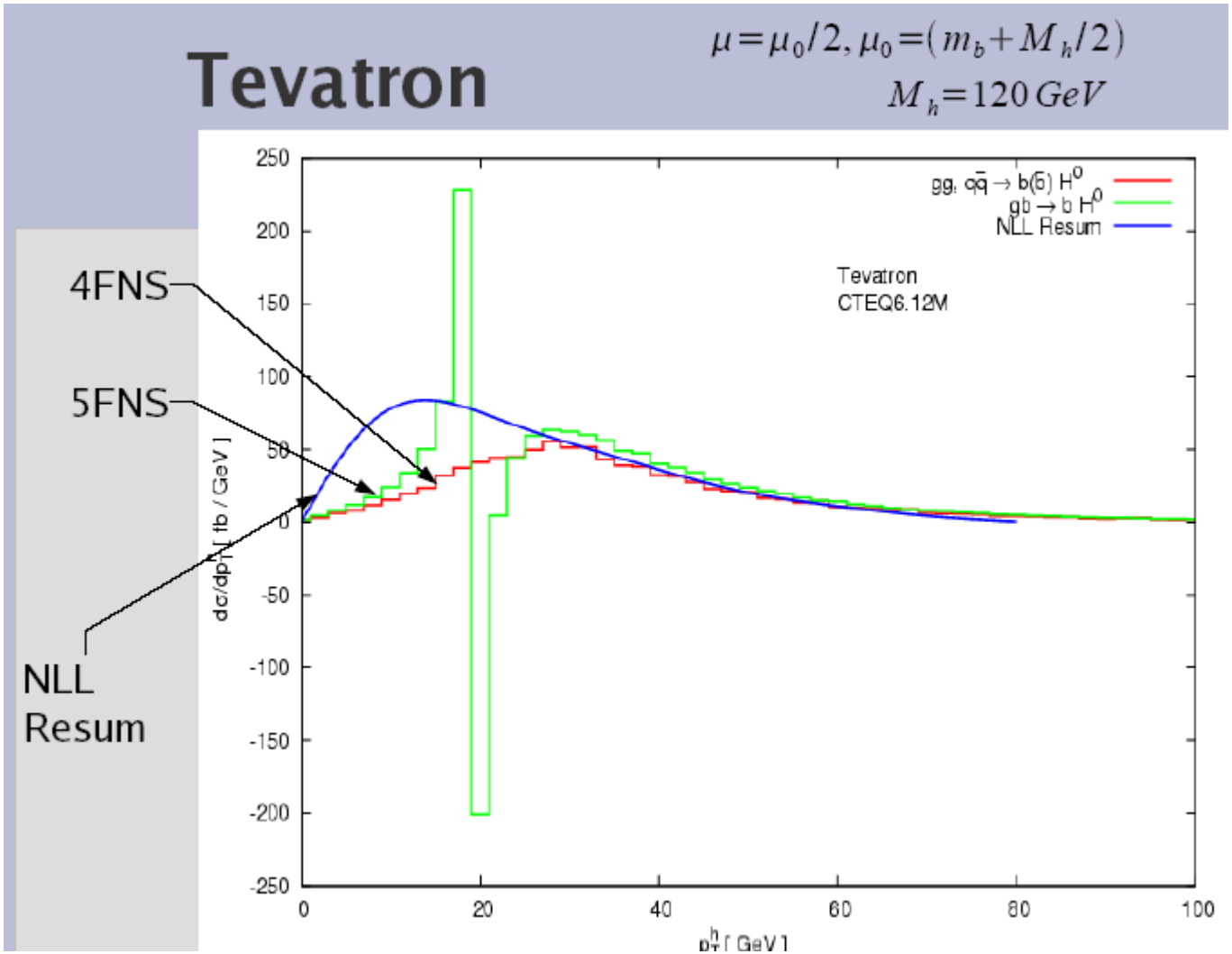


Bryan J. Field

Tevatron

$\mu = \mu_0/2, \mu_0 = (m_b + M_h/2)$

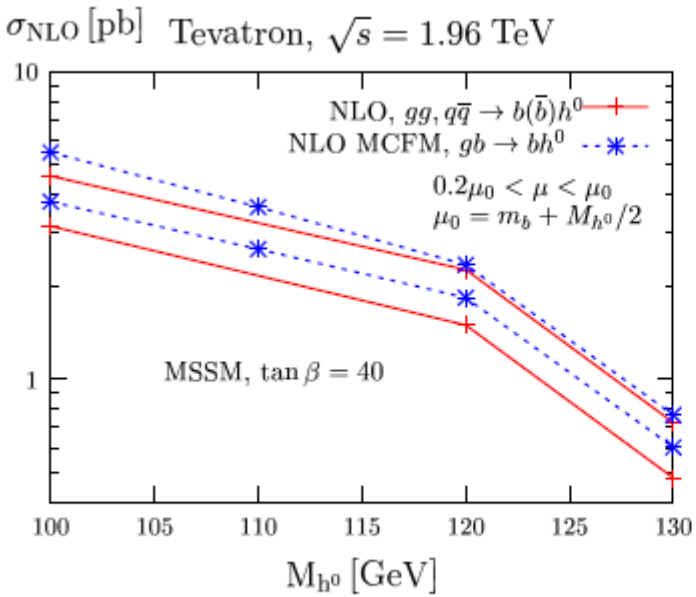
$M_h = 120\,GeV$

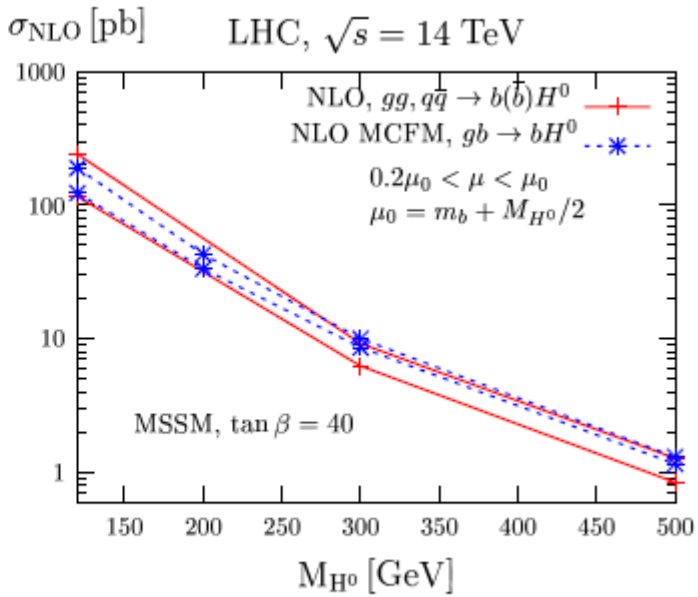


MSSM Higgs Boson Production with Bottom Quarks

Chris Jackson

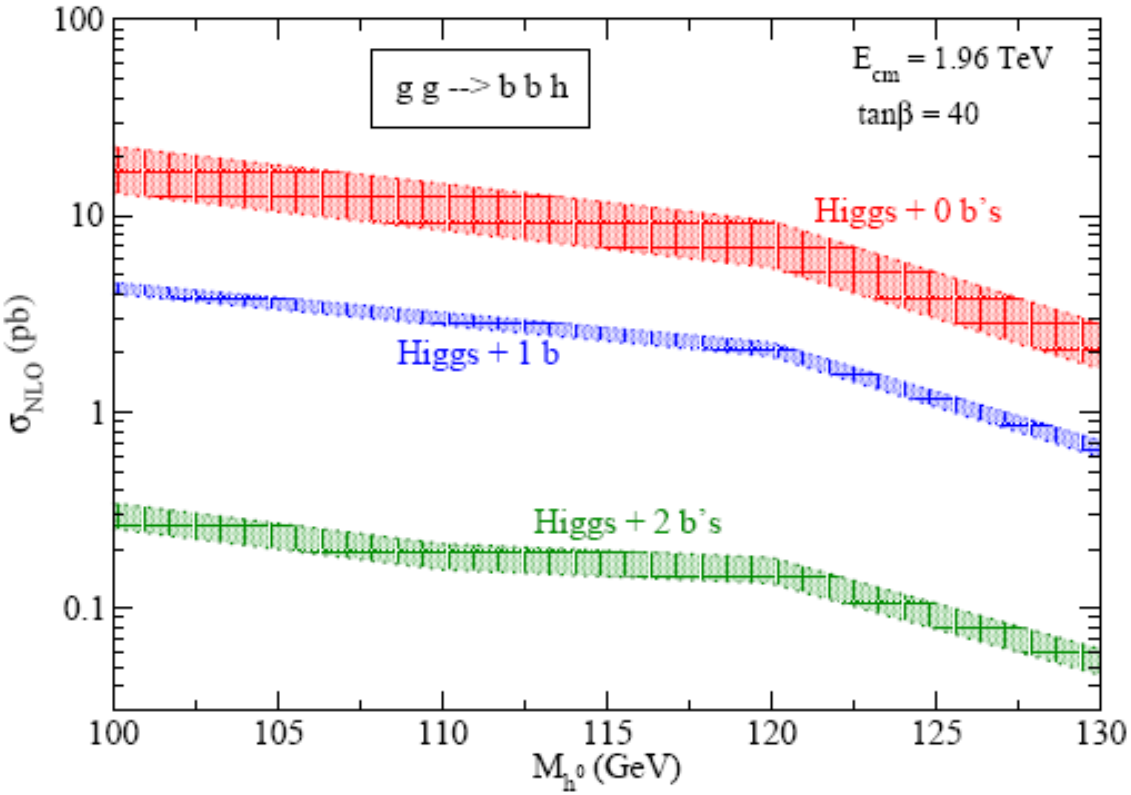
gb → hb vs. gg → bbh





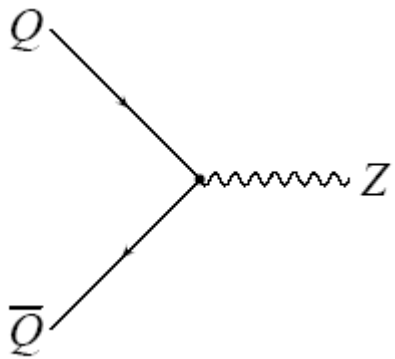
from S. Dawson, C.J., L. Reina and D. Wackeroth (hep-ph/0508293)

MSSM $b\bar{b}h^0$ at the Tevatron



Inclusive production of a Z boson in association with heavy quarks

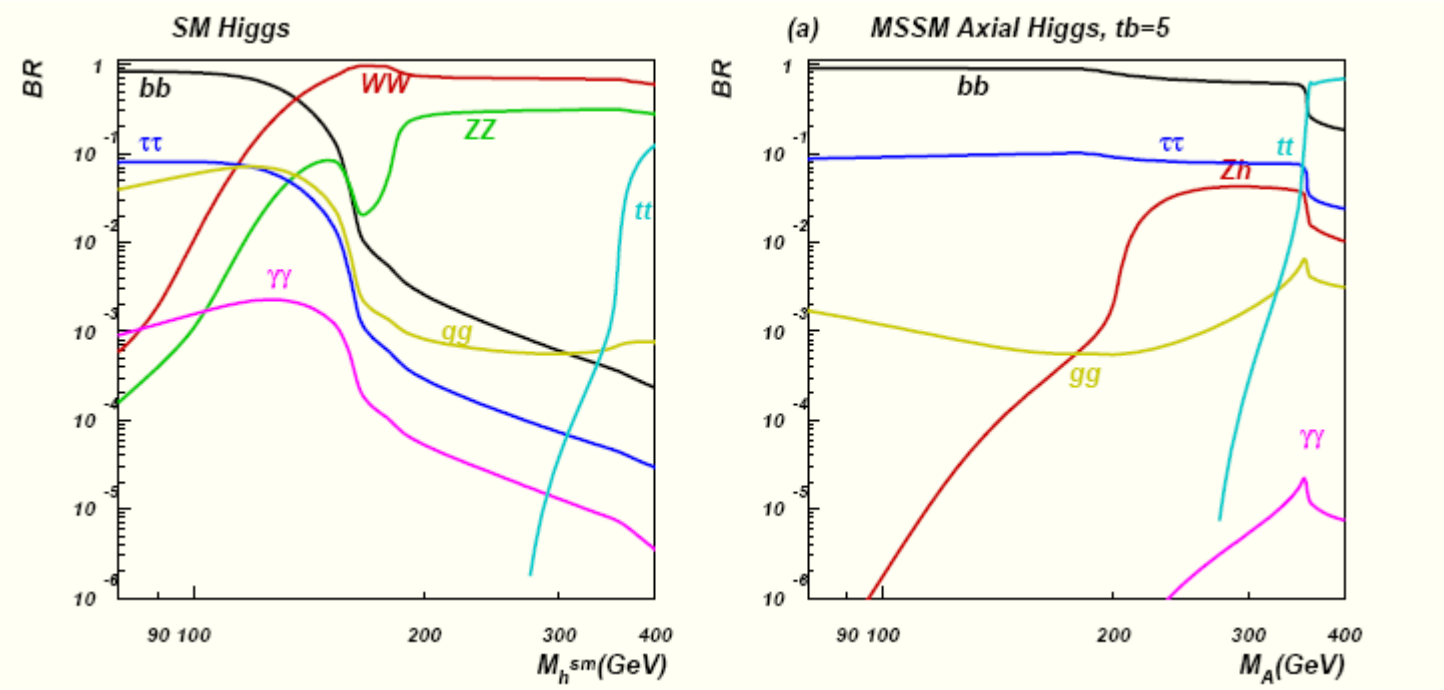
Thomas J. McElmurry

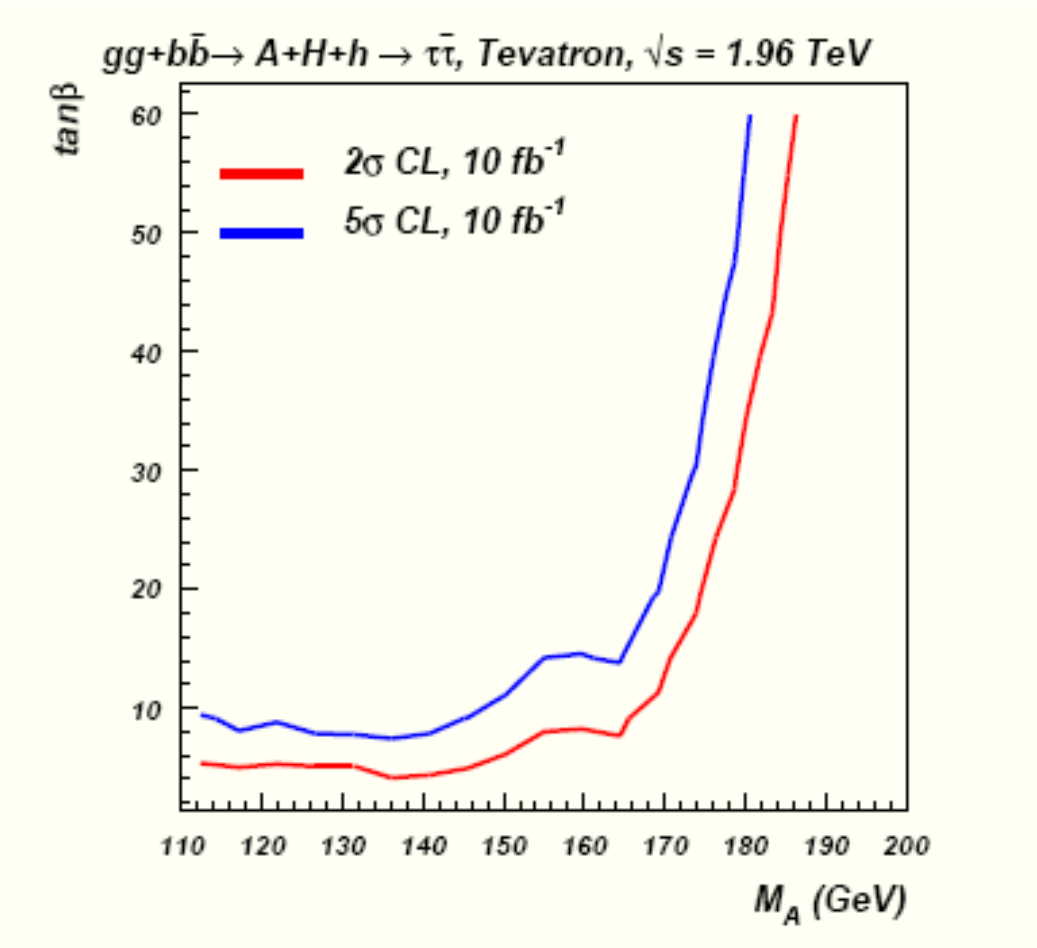


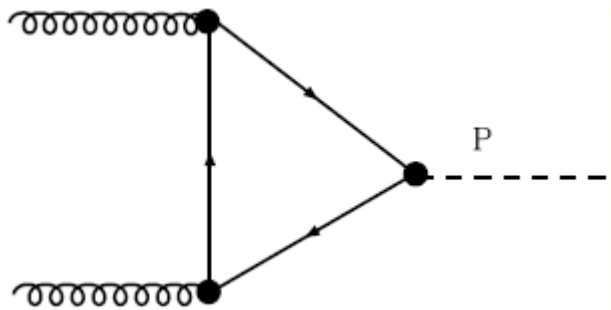
Processes involving heavy quarks account for 3% of the inclusive Z cross section at the Tevatron

Towards understanding the nature of Electroweak Symmetry Breaking at hadron colliders

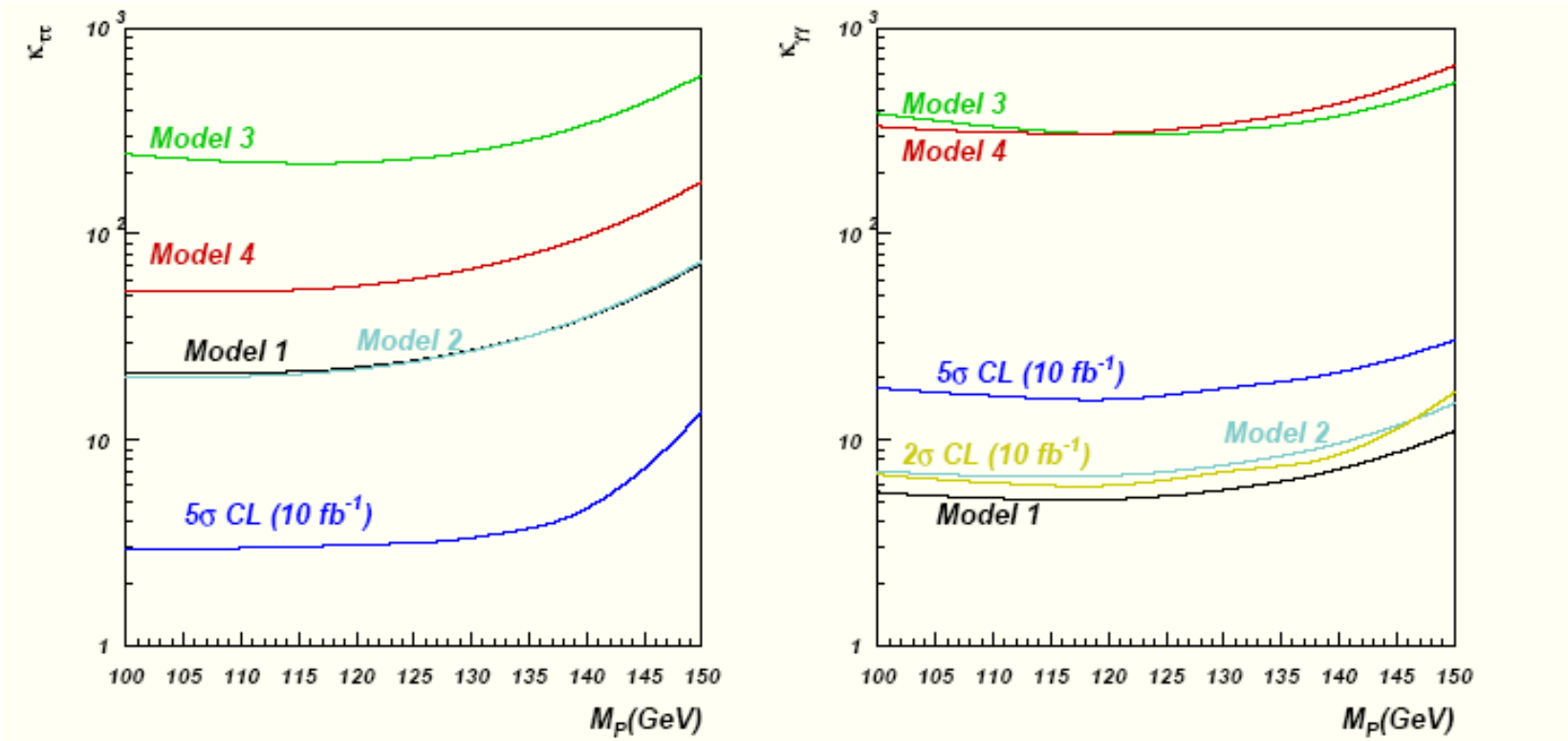
Alexander Belyaev




gg+bb̄→ A+H+h → ττ̄, Tevatron, √s = 1.96 TeV
tanβ
60
50
40
30
20
10
2σ CL, 10 fb-1
5σ CL, 10 fb-1
110
120
130
140
150
160
170
180
190
200
MA (GeV)

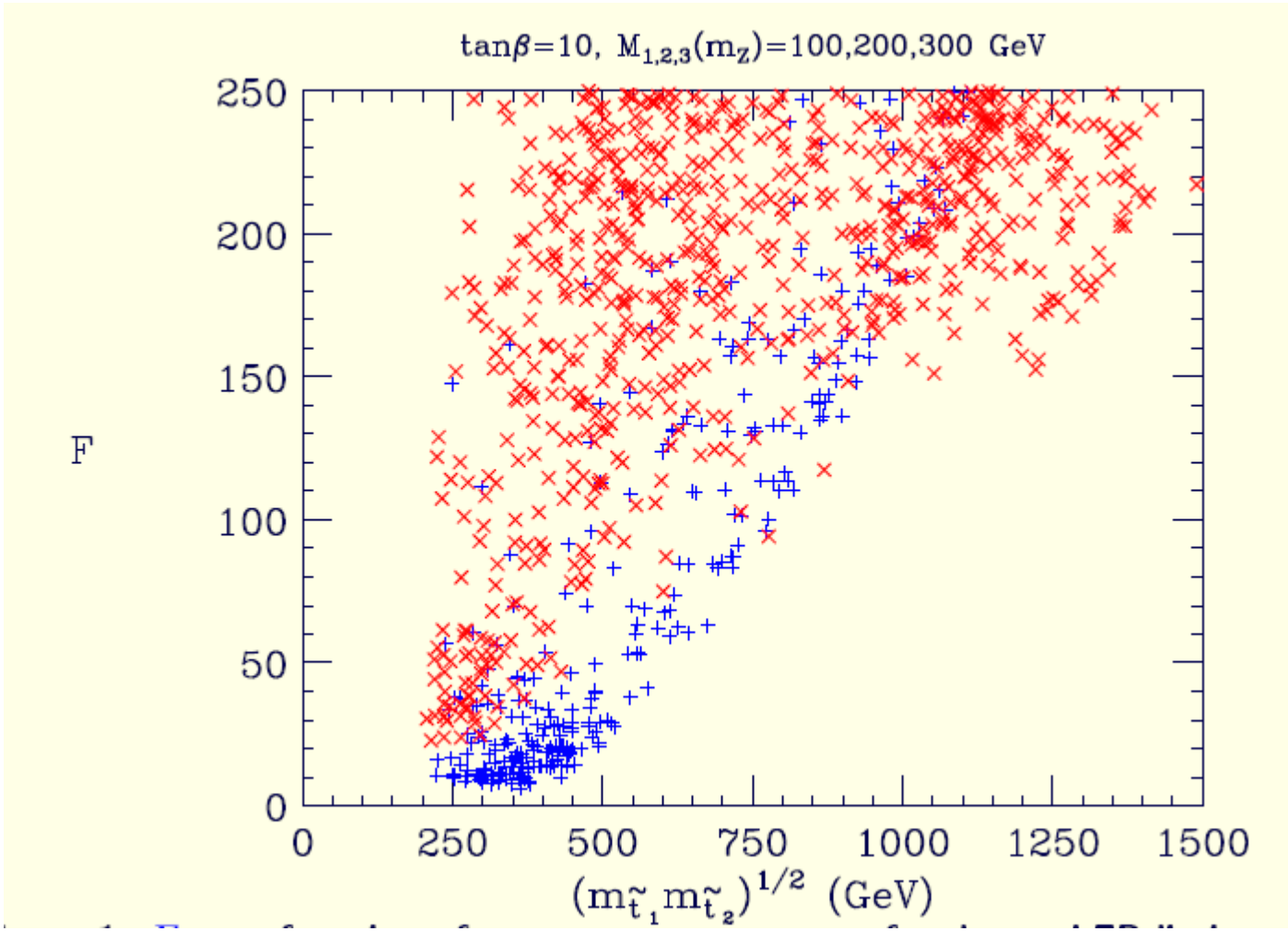

P

Technipion

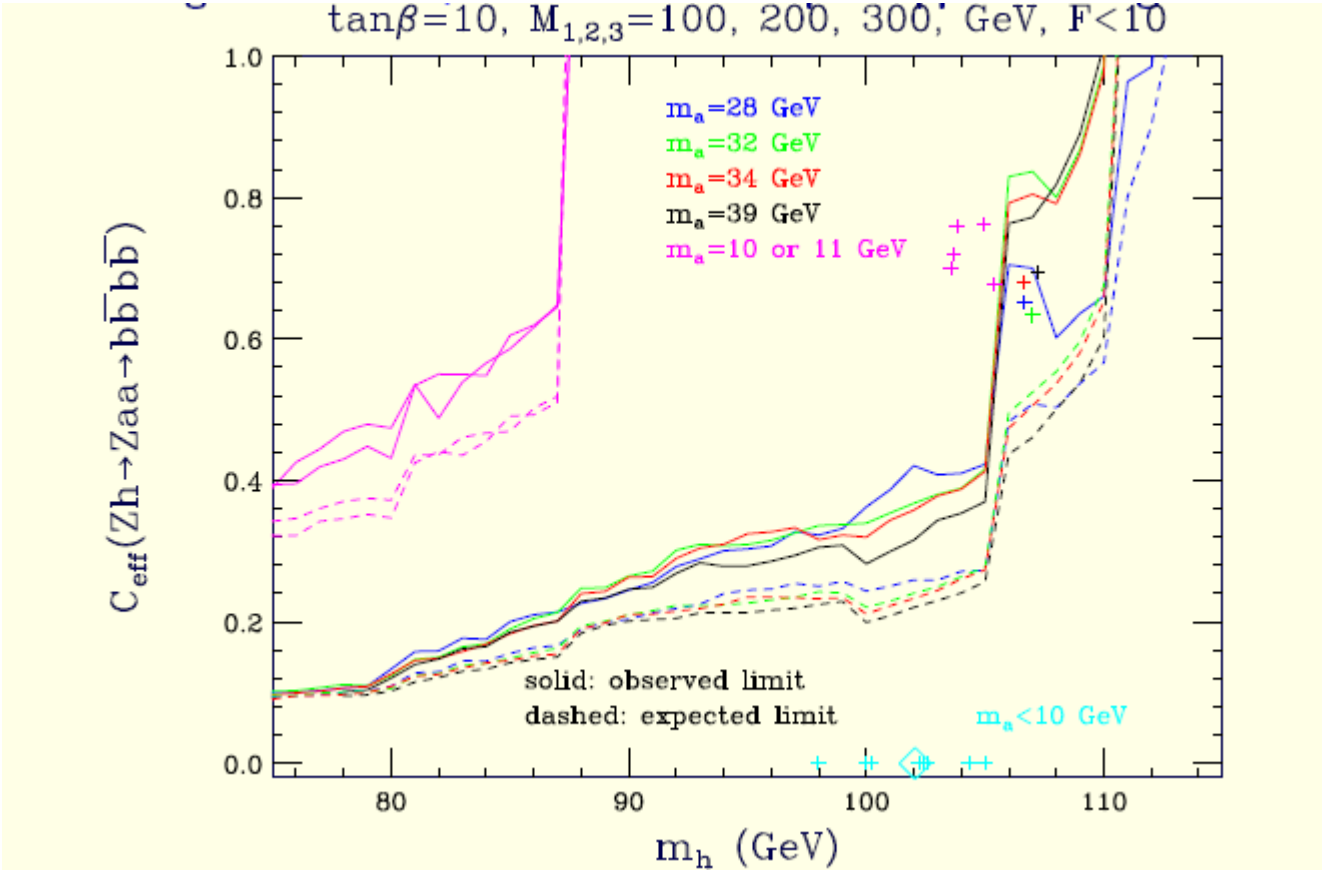

$\kappa_{\tau\tau}$
10^3
10^2
10
1
Model 3
Model 4
Model 1
Model 2
5σ CL (10 fb^{-1})
100 105 110 115 120 125 130 135 140 145 150
M_P(GeV)
$\kappa_{\gamma\gamma}$
10^3
10^2
10
1
Model 3
Model 4
5σ CL (10 fb^{-1})
2σ CL (10 fb^{-1})
Model 2
Model 1
100 105 110 115 120 125 130 135 140 145 150
M_P(GeV)

Updates on Higgs and Dark Matter in the NMSSM

Jack Gunion



h → aa

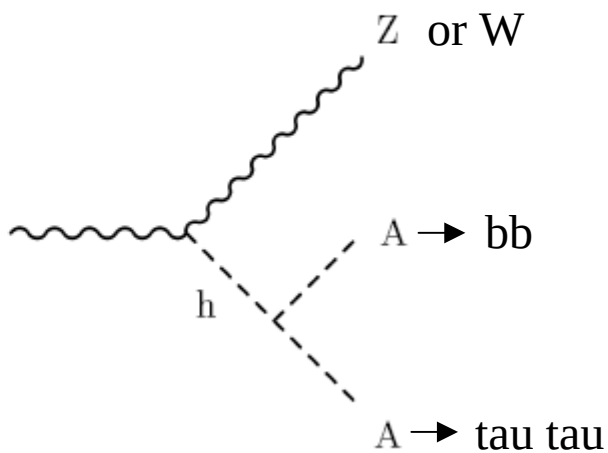

tanβ=10, M1,2,3=100, 200, 300, GeV, F<10
ma=28 GeV
ma=32 GeV
ma=34 GeV
ma=39 GeV
ma=10 or 11 GeV
solid: observed limit
dashed: expected limit
ma<10 GeV
Ceff(Zh→Zaa→bb̄bb̄)
mh (GeV)
1.0
0.8
0.6
0.4
0.2
0.0
80
90
100
110

H→AA at TEVATRON

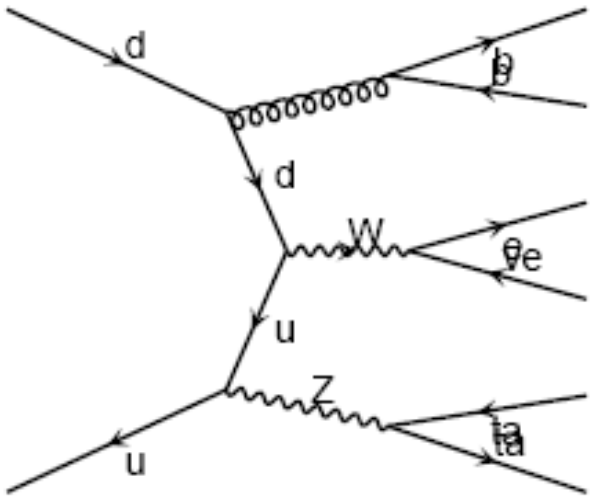
Guiyu Huang (UW-Madison)

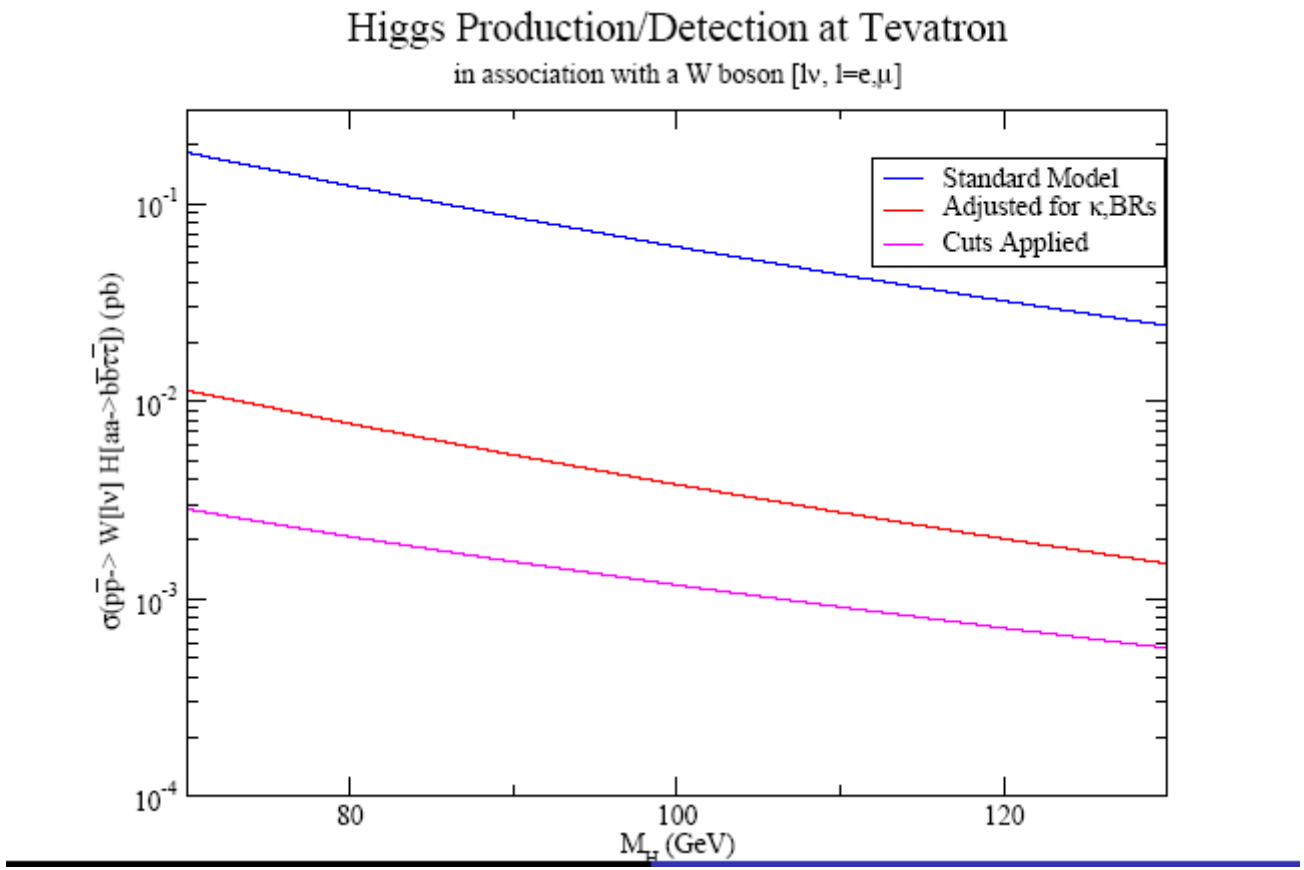
W/Z: Leptonic, H: (pseudo)scalar pair ($M_H > 2M_A$)

- $W/Z \to l\nu_l/l^+l^-$
  lepton (e, μ) signature
- Higgs to scalar pair AA
- $A, A \to b\bar{b}, \tau\bar{\tau}$ respectively



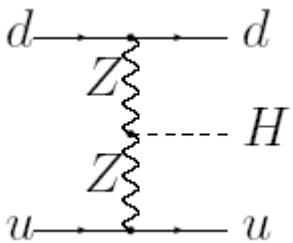
Background - negligible



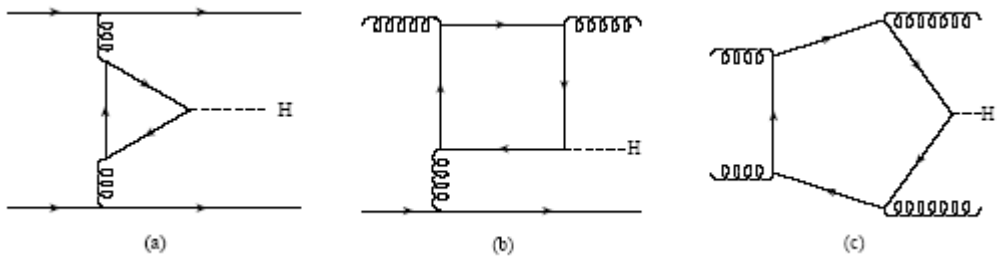

Higgs Production/Detection at Tevatron
in association with a W boson [lν, l=e,μ]
Standard Model
Adjusted for κ,BRs
Cuts Applied
σ(pp̄ -> W[lν] H[aa->bb̄τ⁺τ⁻]) (pb)
10^-1
10^-2
10^-3
10^-4
80
100
120
M_H (GeV)

Higgs production through WBF and gluon fusion at the LHC

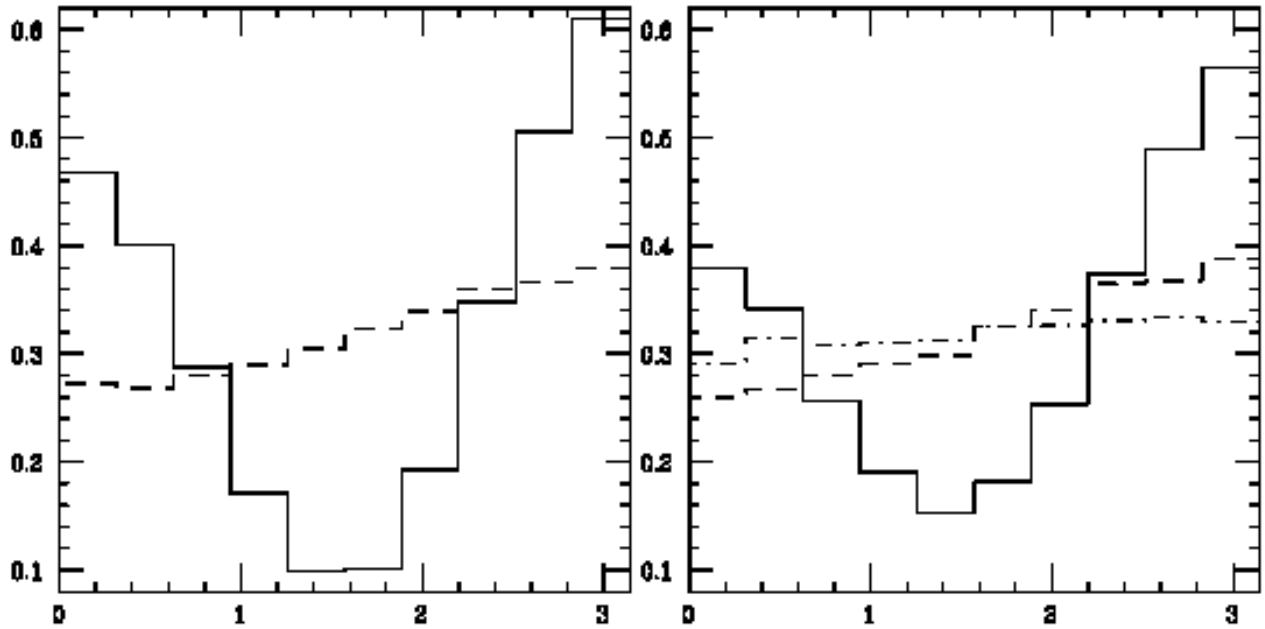
Fulvio Piccinini



vs.



Azimuthal correlation between the tagging jets



Left: $\frac{1}{\sigma} d\sigma/d\phi_{jj}$ distribution at LO partonic level for the process $pp \to H + 2$ jets. Solid line: QCD Higgs production; dashed line: WBF

Right: $\frac{1}{\sigma} d\sigma/d\phi_{j_1 j_2}$ distribution with Parton Shower (j_1 and j_2 are the leading p_T jets) on top of $pp \to H + 2$ jets generated events

Right: Dot-dashed line has been obtained generating $gg \to H$ with `HERWIG` and taking all jets from shower

Conclusion

Steady progress on Higgs theory

Our efforts will pay off