Higgs Physics
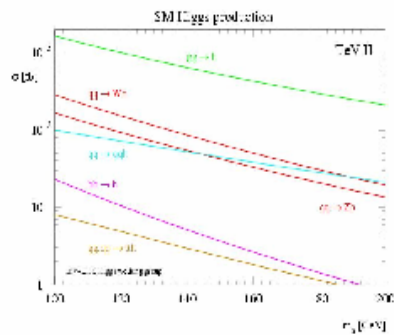
Scott Willenbrock

U. of Illinois at Urbana-Champaign

TeV4LHC@FNAL

October 20, 2005
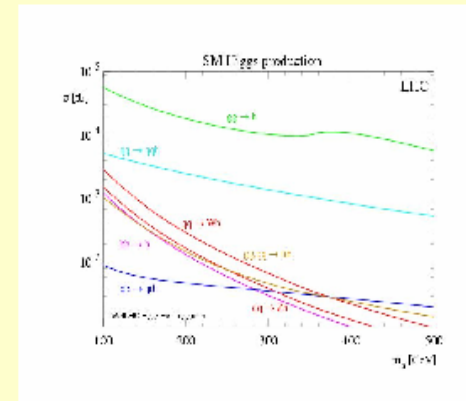
Tevatron Run II

LHC

more information

more information

Higgs Working Group

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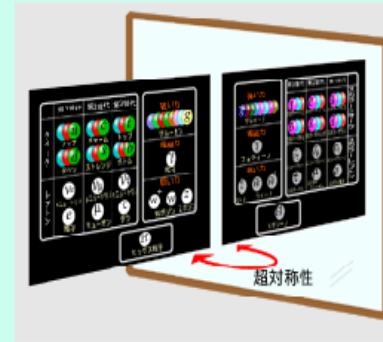
Introduction

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.

Higgs cross sections at hadron colliders
TeV4LHC Higgs working group
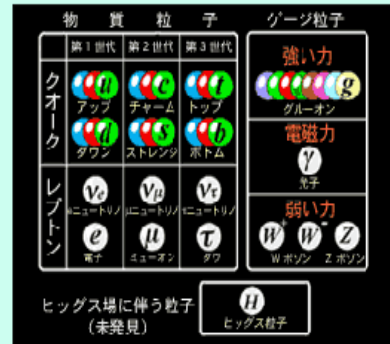
Standard Model

SUSY

We present a compilation of the most accurate theoretical results for SM and SUSY Higgs production at the Tevatron and LHC. SM cross sections used in the plots have been obtained straight from the horse's mouth, i.e., from the authors of the cited references, and are available as .dat files. MSSM cross sections in various scenarios are obtained from the SM ones by a rescaling of the couplings. The information can (and will) be easily updated as more accurate predictions become available.
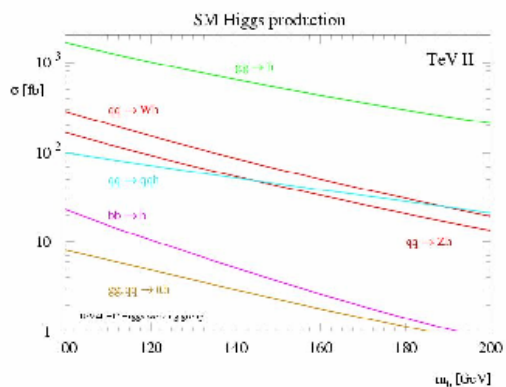
Last Update: 7 Sept 2005

Fabio Maltoni

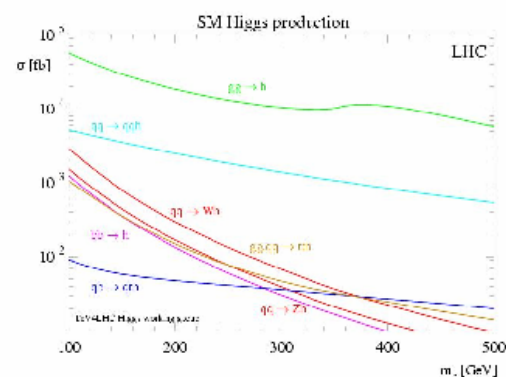# Standard Model Higgs cross sections at hadron colliders
Tev4LHC Higgs working group

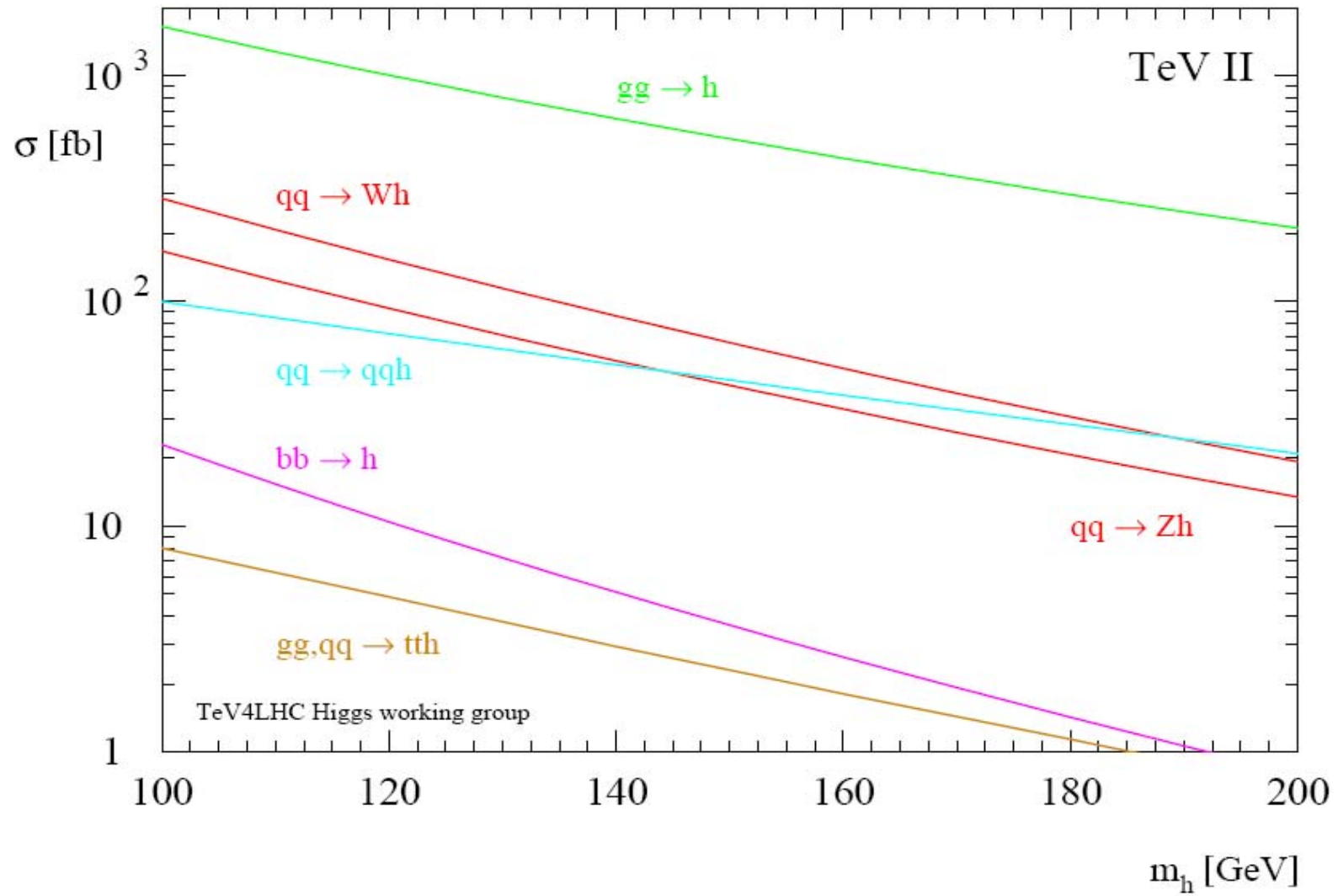| Tevatron Run II	LHC
PS PDF	PS PDF

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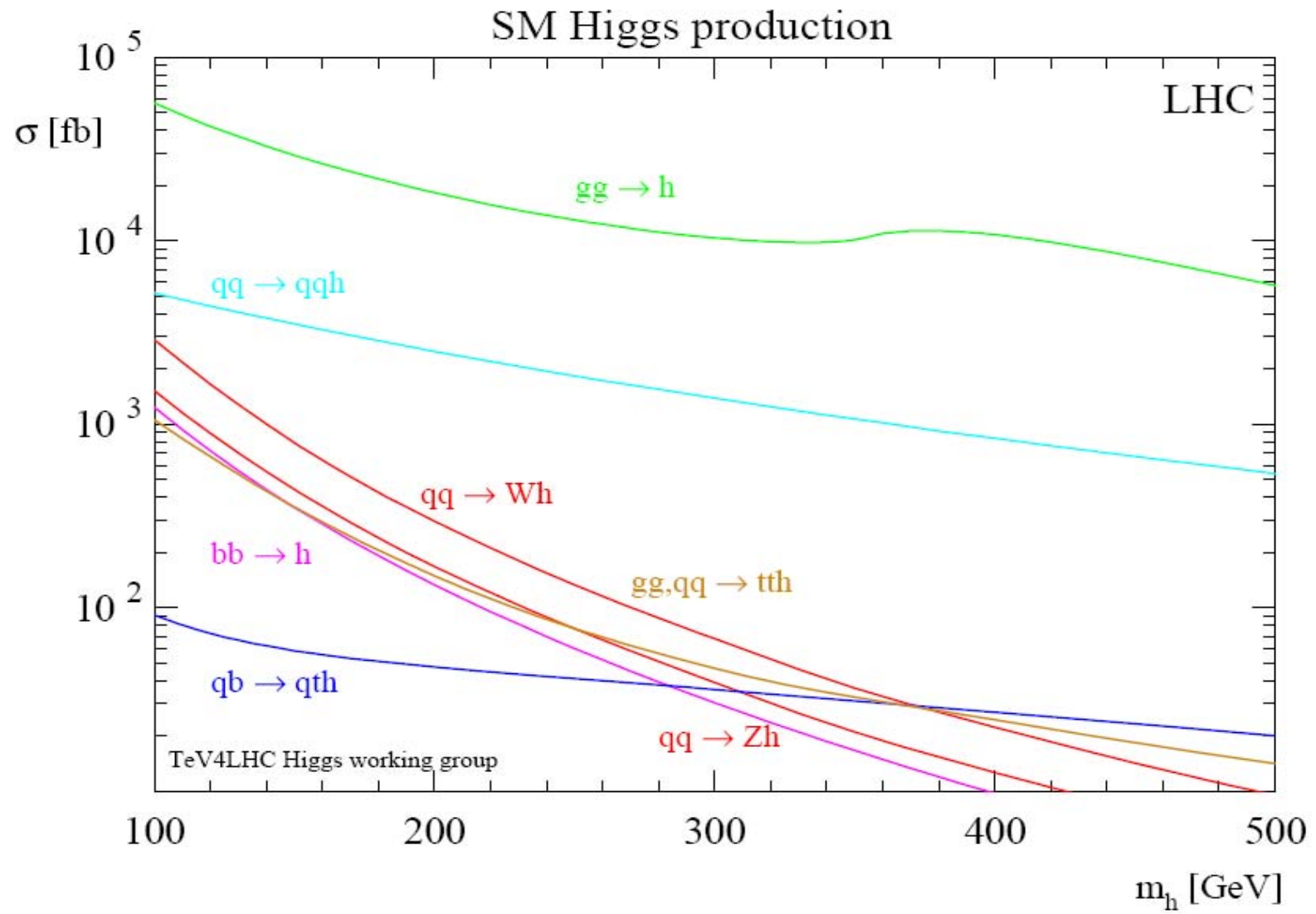
- qq → qqh + X: vector boson fusion
  (vbf-tev.dat, vbf-lhc.dat)

  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)

SM Higgs production

TeV II

σ [fb]

$gg \rightarrow h$

$qq \rightarrow Wh$

$qq \rightarrow qqh$

$bb \rightarrow h$

$qq \rightarrow Zh$

$gg, qq \rightarrow tth$

TeV4LHC Higgs working group

m_h [GeV]

SM Higgs production

LHC

σ [fb]

$gg \to h$

$qq \to qqh$

$qq \to Wh$

$bb \to h$

$gg, qq \to tth$

$qb \to qth$

$qq \to Zh$

TeV4LHC Higgs working group

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)

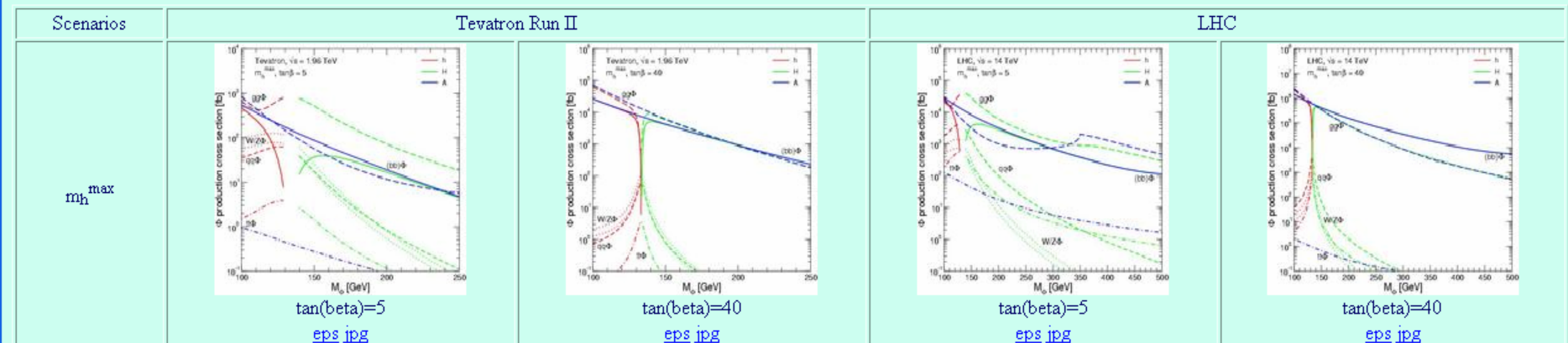These scenarios are defined in hep-ph/0202167. For each scenario two reference values of tan(beta) (=5 and 40) are chosen, so that a total of 8 plots for each collider (Tevatron and LHC) is given.
The cross sections are obtained from those of the Standard Model by rescaling the effective couplings as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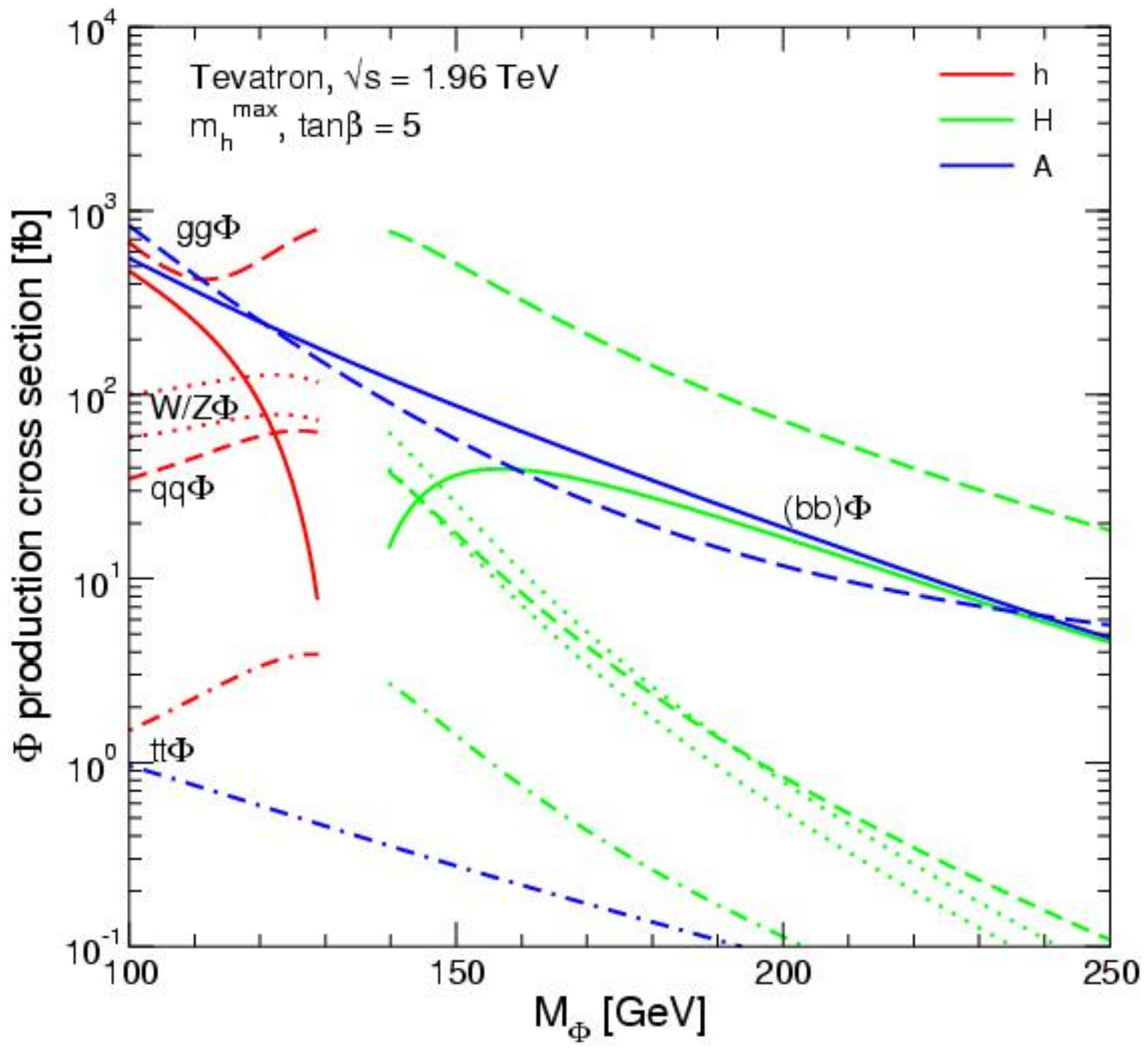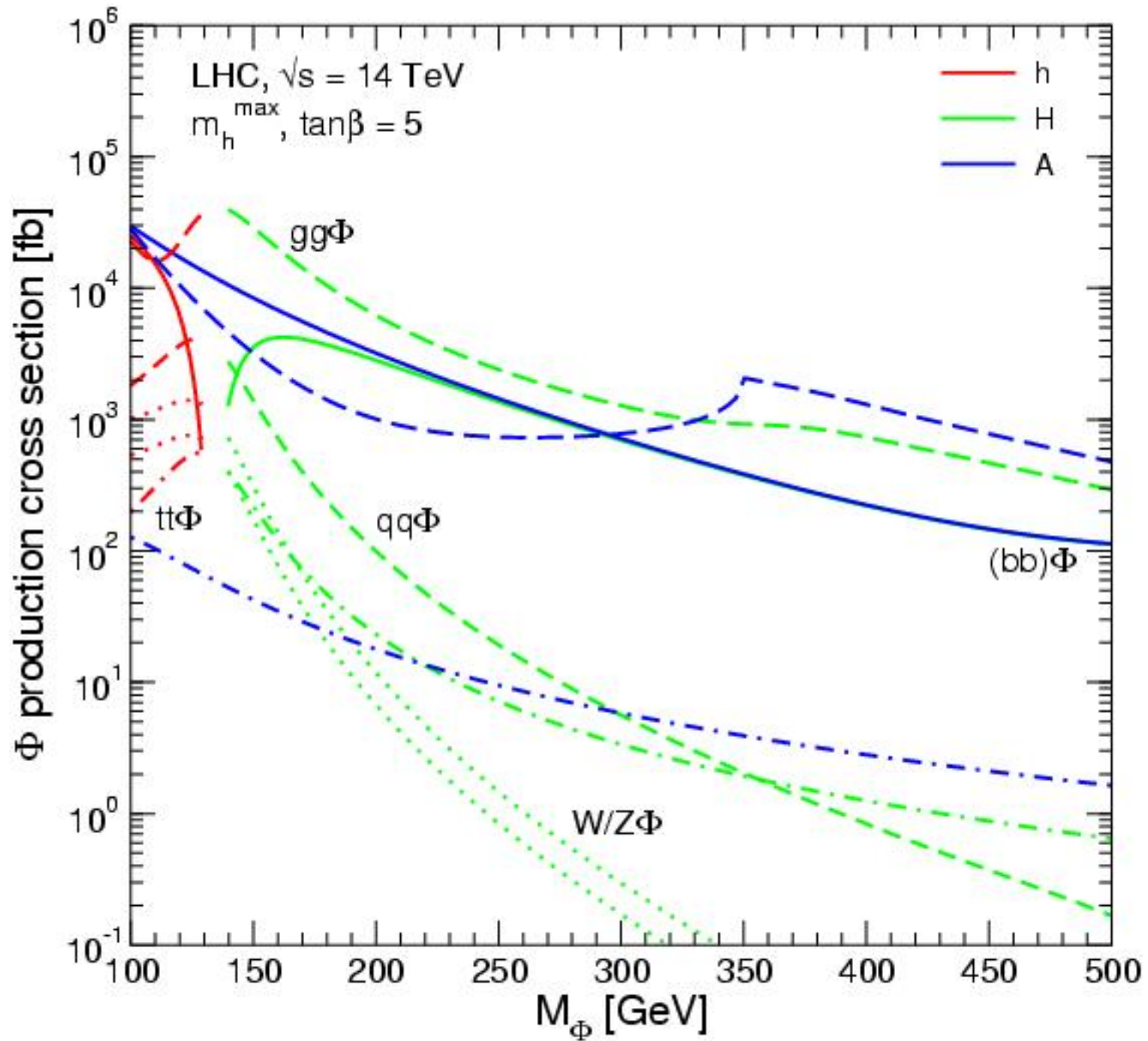More specifically:

- $gg \rightarrow h+X$: full one-loop with SM QCD corrections
- $bb \rightarrow h+X$: effective couplings including Delta mb corrections
- $qq \rightarrow qqh+X$: effective VVHiggs coupling
- $qq \rightarrow W/Zh+X$: effective VVHiggs coupling
- $gg,qq \rightarrow tth$: 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 $gg\rightarrow H$, hep-ph/0409010 are not included.
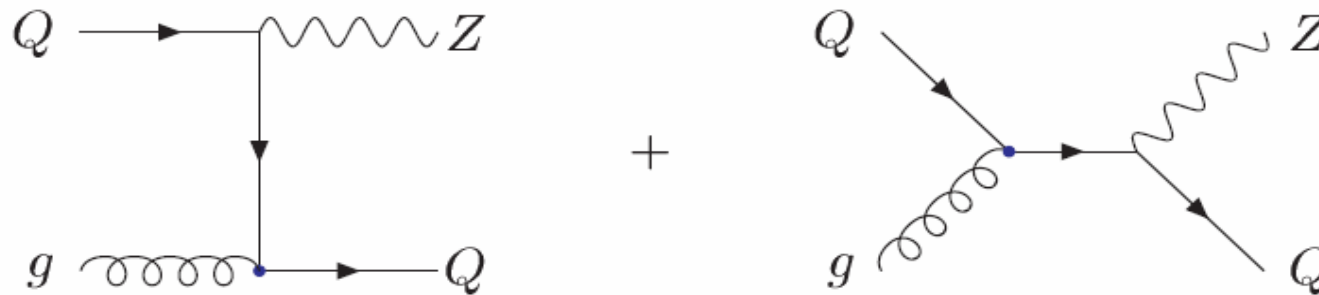
Scenarios	Tevatron Run II		LHC	
m_h^{max}				
	tan(beta)=5	tan(beta)=40	tan(beta)=5	tan(beta)=40
	eps jpg	eps jpg	eps jpg	eps jpg

Sven Heinemeyer

Tevatron, $\sqrt{s} = 1.96$ TeV
m_h^{max}, $\tan\beta = 5$

h
H
A

Φ production cross section [fb]

$gg\Phi$

$W/Z\Phi$

$qq\Phi$

$tt\Phi$

$(bb)\Phi$

M_Φ [GeV]

8

LHC, √s = 14 TeV

m_h^{max}, tan β = 5

h
H
A

ggΦ

ttΦ

qqΦ

(bb)Φ

W/ZΦ

M_Φ [GeV]

Φ production cross section [fb]
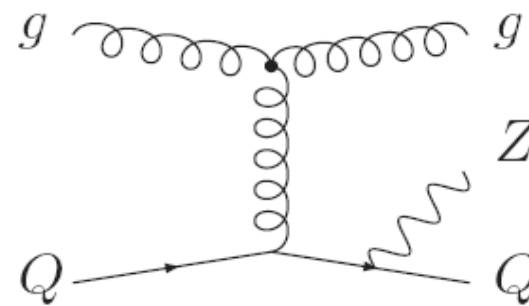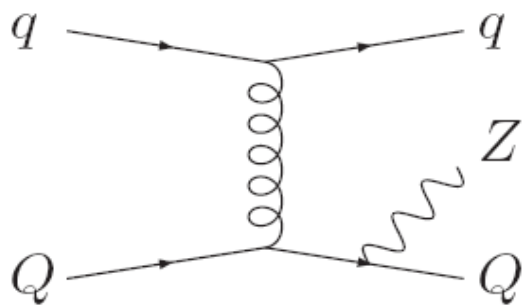
9

H + 1 b jet

H + 1 b jet

Z + 1 b jet

Q = c,b

Z + b / Z + j
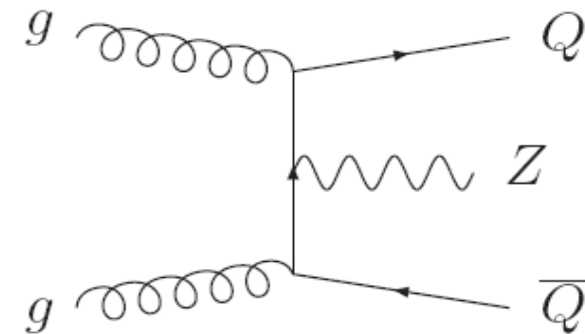
Z + b / Z + j = 0.023 +- 0.005

D0, PRL 94, 161801 (2005)

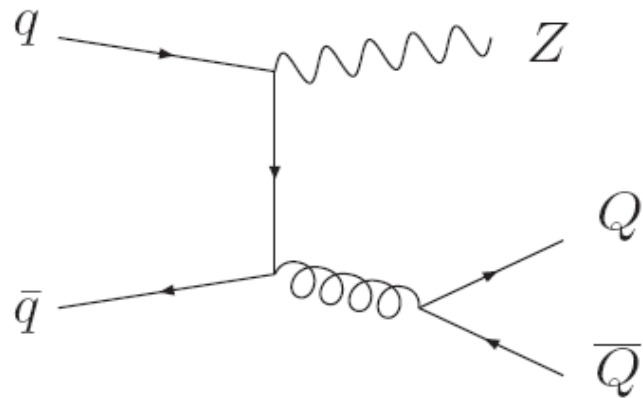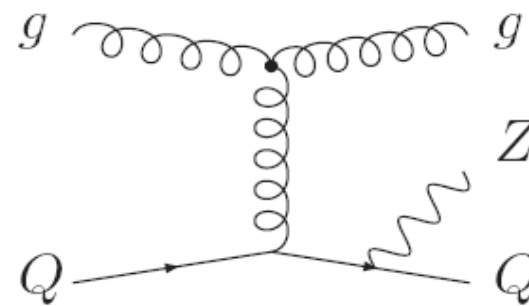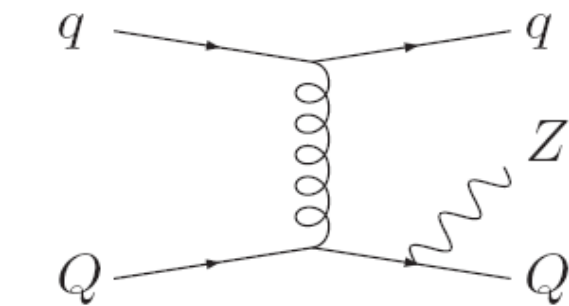## Agrees with NLO calculation

Campbell, Ellis, Maltoni, SW, PRD 69, 074021 (2004)

Z + 2 jets w/ 1 b tag

Q = c,b

Z + 2 jets w/ 1 b tag

Q = c,b

Z + 2 jets w/ 1 b tag

NLO calculation now available

Campbell, Ellis, Maltoni, SW, to appear

Challenge: measure Z + b + j / Z + j + j