# Higgs searches within and beyond the Standard Model

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APS Meeting, Denver, May 2009

- The Tevatron and even more the Large Hadron Collider (LHC) will test new ground and answer some of the fundamental open questions of Particle Physics:
  $\longrightarrow$ Electroweak (EW) symmetry breaking: Higgs mechanism?
  $\longrightarrow$ New Physics (NP) in the TeV range?

- The reach of the Tevatron and the incredible physics potential of the LHC rely on our ability to provide:
  $\longrightarrow$ very accurate predictions (signal/backgr, PDF, masses, couplings);
  $\longrightarrow$ broad selection of models (aiming for general properties).

- Precision becomes even more crucial for a future Linear Collider (ILC,CLIC,...).

- Higgs-boson physics: what would the theoretical and experimental precision be good for?
  $\longrightarrow$ test consistency of the Standard Model and its extensions;
  $\longrightarrow$ discover one (or more) potential Higgs boson(s);
  $\longrightarrow$ identify it (them): measure couplings, mass(es), quantum numbers.

# What are we looking for?

- Spectrum of ideas to explain EWSB: based on weakly or strongly coupled dynamics embedded into some more fundamental theory at a scale $\Lambda$ (probably $\simeq$ TeV):

  $\longrightarrow$ Elementary Higgs: SM, 2HDM, SUSY (MSSM, NMSSM,. . .), . . .

  $\longrightarrow$ Composite Higgs: technicolor, little Higgs models, . . .

  $\longrightarrow$ Extra Dimensions: flat,warped, . . .

  $\longrightarrow$ Higgsless models

- SM Higgs boson, our learning ground:

  $\longrightarrow$ $\mathcal{L}_{Higgs}^{SM} = (D^\mu\phi)^\dagger D_\mu\phi - \mu^2\phi^\dagger\phi - \lambda(\phi^\dagger\phi)^2$
  complex SU(2) doublet, reduced to one real massive scalar field upon EWSB via Higgs mechanism: $\langle\phi^\dagger\rangle = (0\ \frac{v}{\sqrt{2}})$, where $v = (-\mu^2/\lambda)^{-1/2}$;

  $\longrightarrow$ scalar particle, neutral, CP even, $m_H^2 = -2\mu^2 = 2\lambda v^2$;

  $\longrightarrow$ mass related to scale of new physics, but constrained by EW precision fits;

  $\longrightarrow$ minimally coupled to gauge bosons $\longrightarrow M_W = g\frac{v}{2}$, $M_Z = \sqrt{g^2+g'^2}\frac{v}{2}$;

  $\longrightarrow$ coupled to fermions via Yukawa interactions $\longrightarrow m_f = y_f\frac{v}{2}$;

  $\longrightarrow$ three- and four-point self couplings: testing the potential.

- Beyond SM we could have:
  - ⟶ more scalars and/or pseudoscalars particles over broad mass spectrum (elementary? composite?);
  - ⟶ physical states mixture of original fields (→ FCNC, . . .);
  - ⟶ no scalar (!);
  - ⟶ several other particles (fermions and vector gauge bosons).

  If coupled to SM particles:
  - ⟶ constraints from EW precision measurements should apply;
  - ⟶ still lots of room for unknown parameters to be adjusted: little predictivity until discoveries won't populate more the physical spectrum.

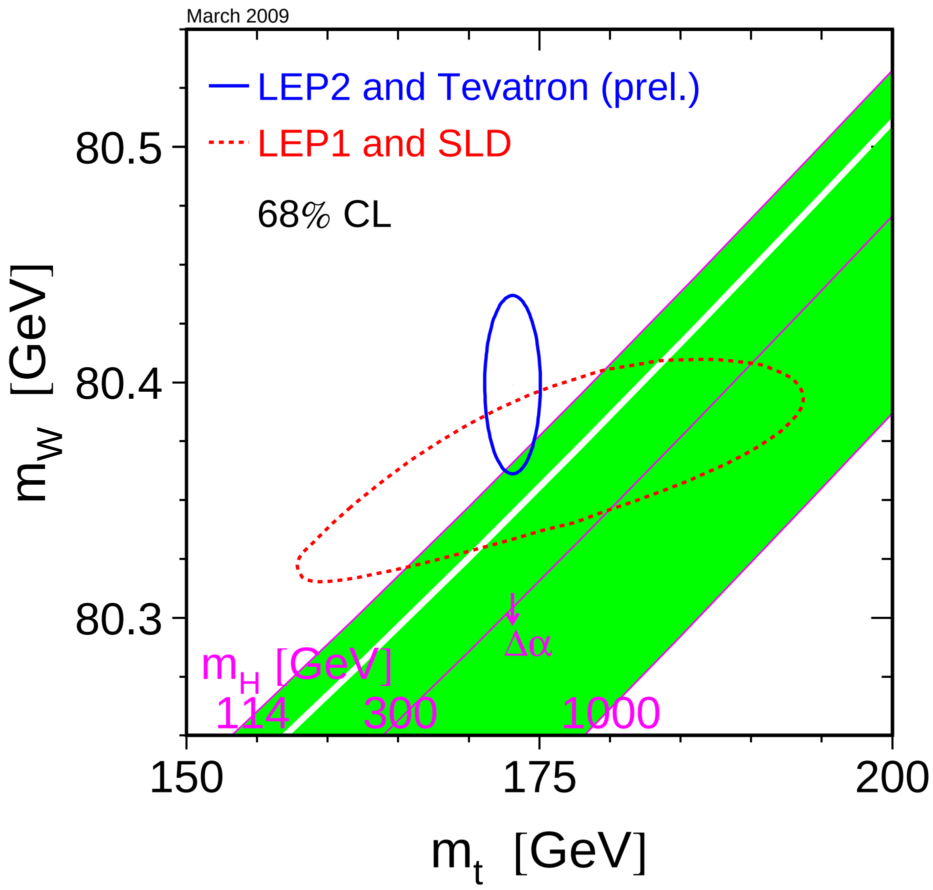
## Upon discovery:

- measure mass (first crucial discriminator!);
- measure couplings to gauge bosons and fermions;
- test the potential: measure self couplings;
- hope to see more physics.

# What we know from past and current searches

# SM Higgs boson: light mass strongly favored

Increasing precision will provide an invaluable tool to test the consistency of the SM and its extensions.



$$m_W = 80.399 \pm 0.025 \text{ GeV}$$

$$m_t = 173.1 \pm 1.3 \text{ GeV}$$

$$\Downarrow$$

$$M_H = 90^{+36}_{-27} \text{ GeV}$$

$$M_H < 163\,(191) \text{ GeV}$$

plus exclusion limits (95% c.l.):

$$M_H > 114.4 \text{ GeV (LEP)}$$

$$M_H \neq 160 - 170 \text{ GeV (Tevatron)}$$

- ▷ only SM unknown: Higgs-boson mass;
- ▷ strong correlation between $M_W$ ($\sin\theta_W^{eff}$), $m_t$ and $M_H$.

## Experimental uncertainties, estimate

| | Present | Tevatron | LHC | LC | GigaZ |
|---|---|---|---|---|---|
| $\delta(M_W)$(MeV) | 25 | 27 | 10-15 | 7-10 | 7 |
| $\delta(m_t)$ (GeV) | 1.1 | 2.7 | 1.0 | 0.2 | 0.13 |
| $\delta(M_H)/M_H$ (indirect) | 30% | 35% | 20% | 15% | 8% |

(U. Baur, LoopFest IV, August 2005)

## Intrinsic theoretical uncertainties

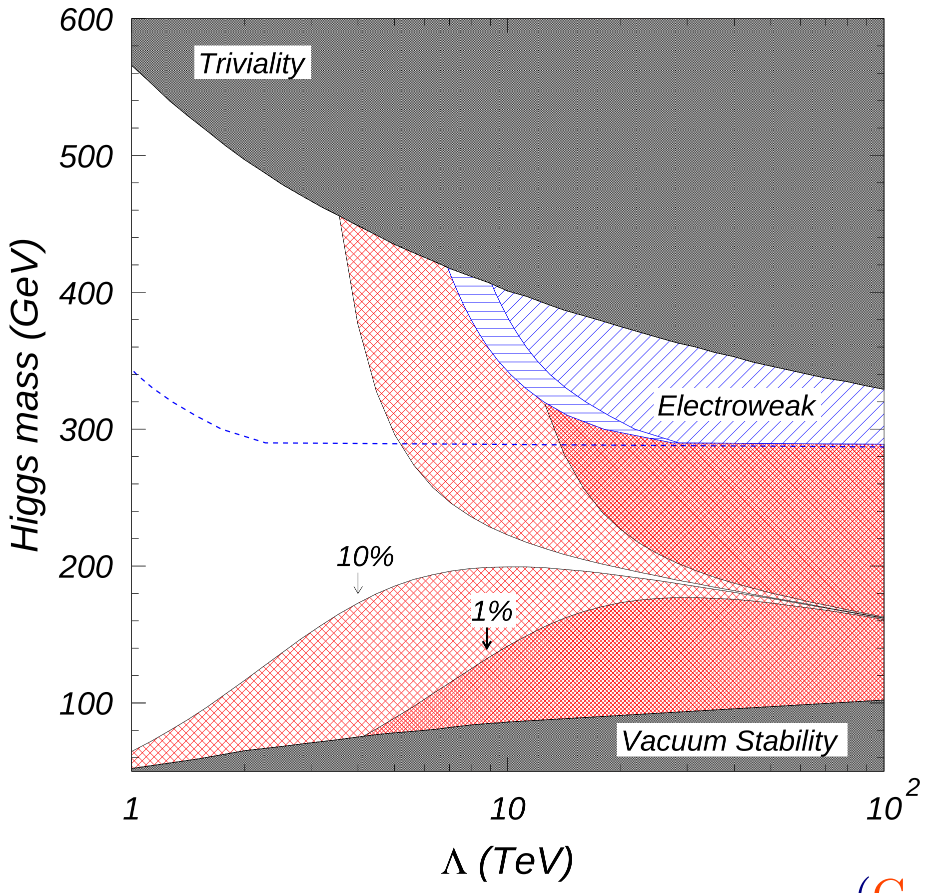
$\longrightarrow$ $\delta M_W \approx 4$ MeV: full $O(\alpha^2)$ corrections computed.

(M. Awramik, M. Czakon, A. Freitas, and G. Weiglein, PRD 69:053006,2004)

$\longrightarrow$ estimated: $\Delta m_t/m_t \sim 0.2\Delta\sigma/\sigma + 0.03$ (LHC)

(R. Frederix and F. Maltoni, JHEP 0901:047,2009 )

# SM Higgs: does a light Higgs constrain new physics?



$\Lambda \rightarrow$ scale of new physics

amount of fine tuning =

$$\frac{2\Lambda^2}{M_H^2}\left|\sum_{n=0}^{n_{max}} c_n(\lambda_i)\log^n(\Lambda/M_H)\right|$$

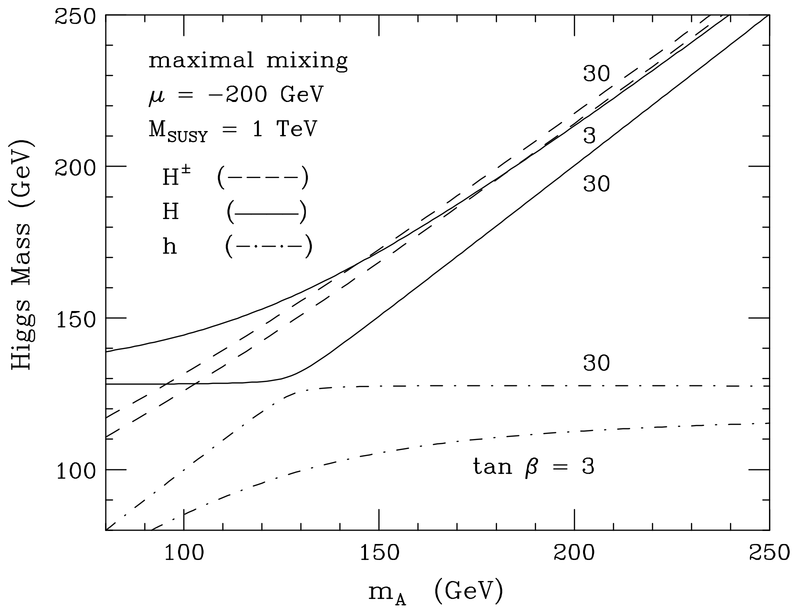
$\longleftarrow n_{max} = 1$

(C. Kolda and H. Murayama, JHEP 0007:035,2000)

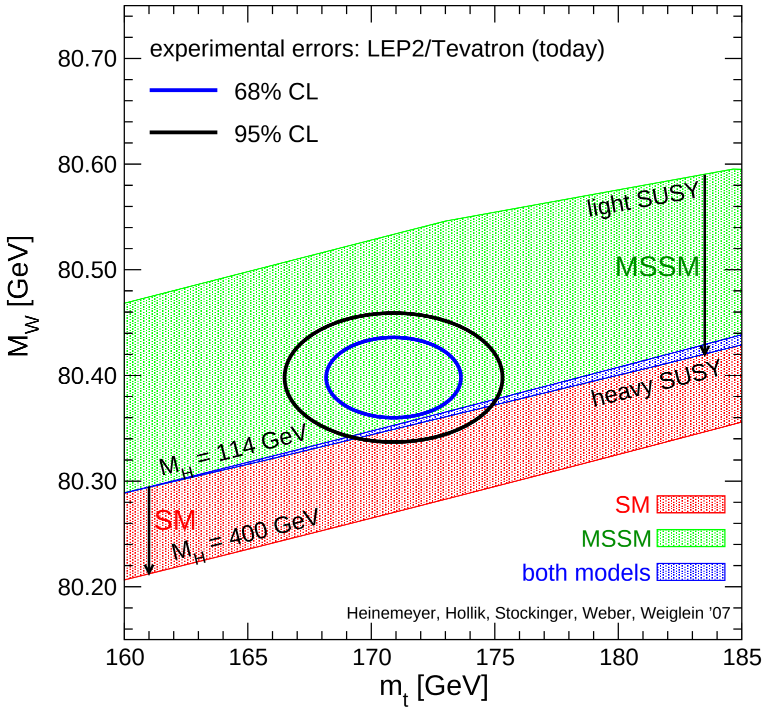
Light Higgs consistent with low Λ: new physics at the TeV scale.

# Beyond SM: new physics at the TeV scale can be a better fit

## Ex. 1: MSSM



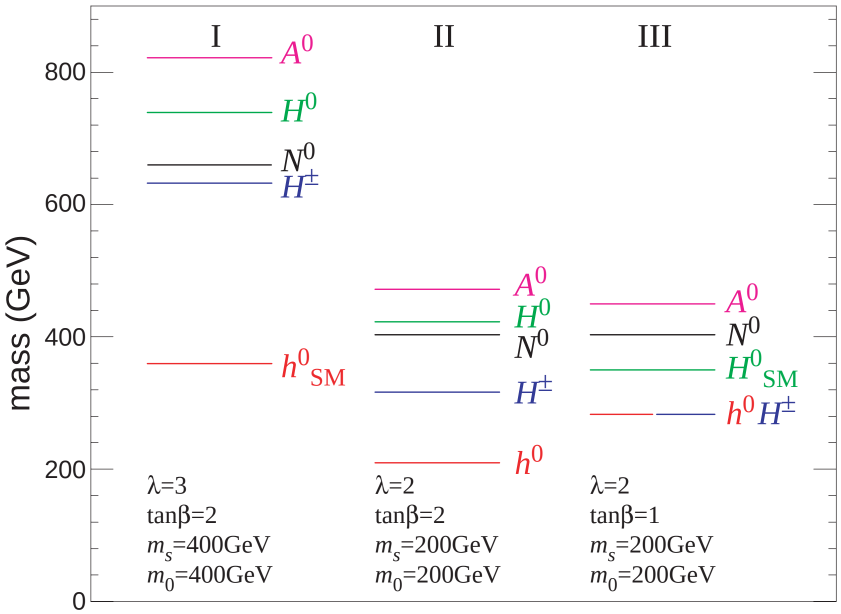
(M. Carena et al.)

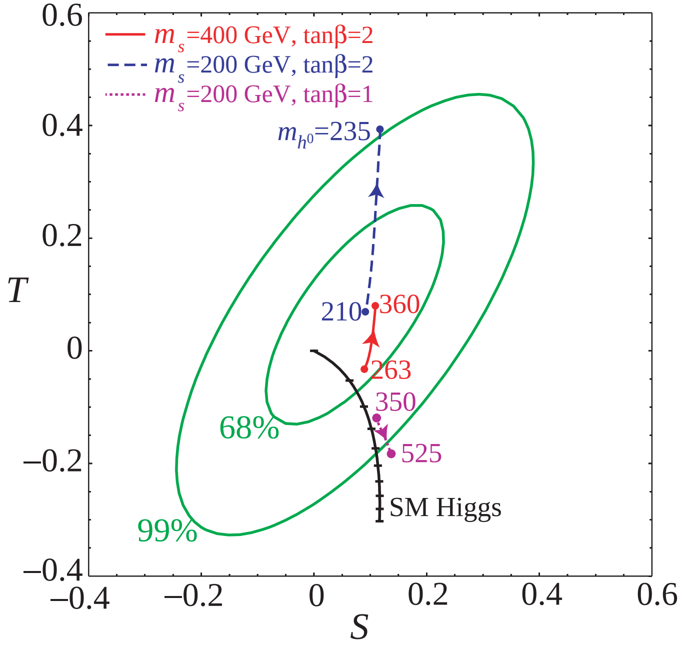


- a light scalar Higgs boson, along with a heavier scalar, a pseudoscalar and a charged scalar;
- similar although less constrained pattern in any 2HDM;
- MSSM main uncertainty: unknown masses of SUSY particles.

# Beyond SM: new physics at the TeV scale can be a better fit

## <u>Ex. 2</u>: “Fat Higgs” models

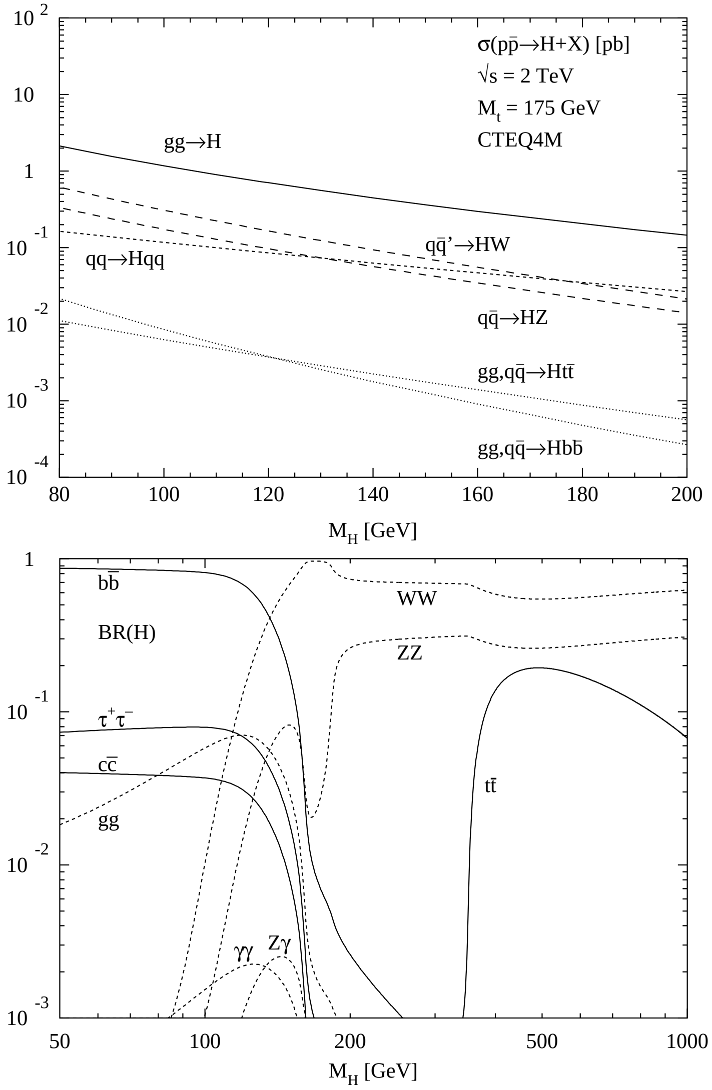




(Harnik, Kribs, Larson, and Murayama, PRD 70 (2004) 015002)

- ▷ supersymmetric theory of a composite Higgs boson;
- ▷ moderately heavy lighter scalar Higgs boson, along with a heavier scalar, a pseudoscalar and a charged scalar;
- ▷ consistent with EW precision measurements without fine tuning.

# Tevatron: great potential for a light SM-like Higgs boson



(M. Spira, Fortsch.Phys. 46 (1998) 203)

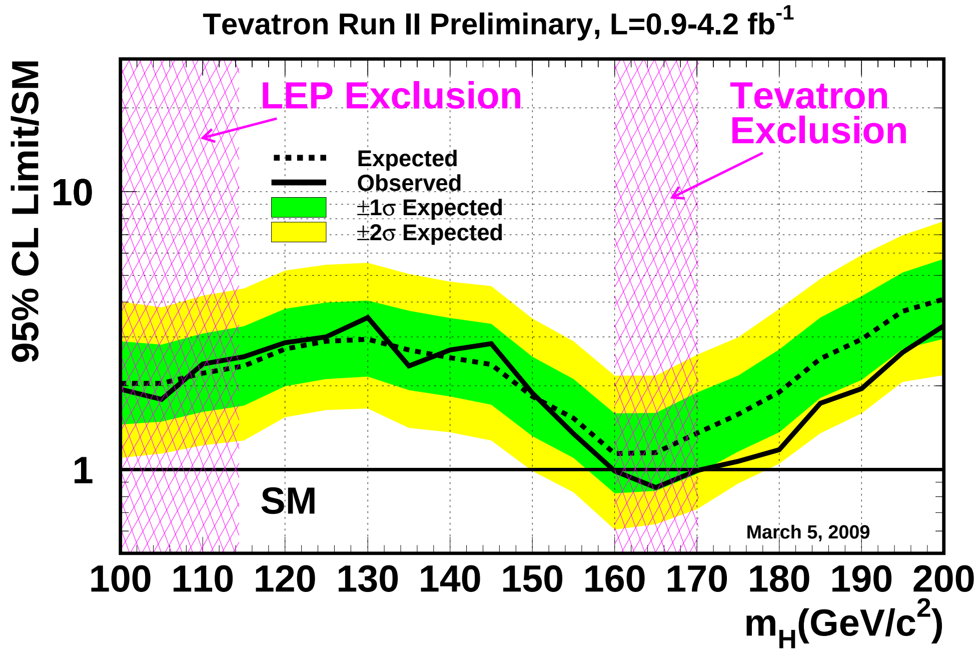
Several channels used:

$$gg \to H,\ q\bar{q} \to q'\bar{q}'H,$$

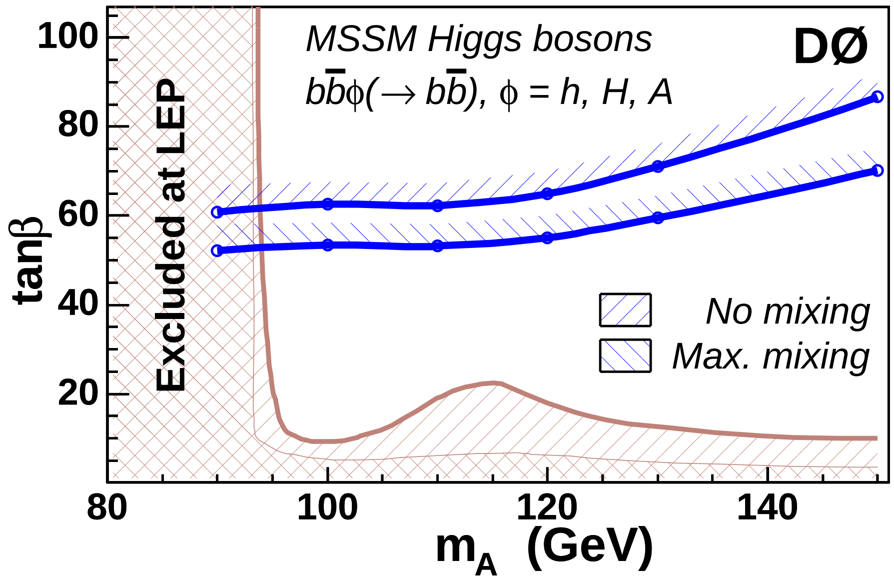
$$q\bar{q}' \to WH,\ q\bar{q}, gg \to t\bar{t}H$$

with

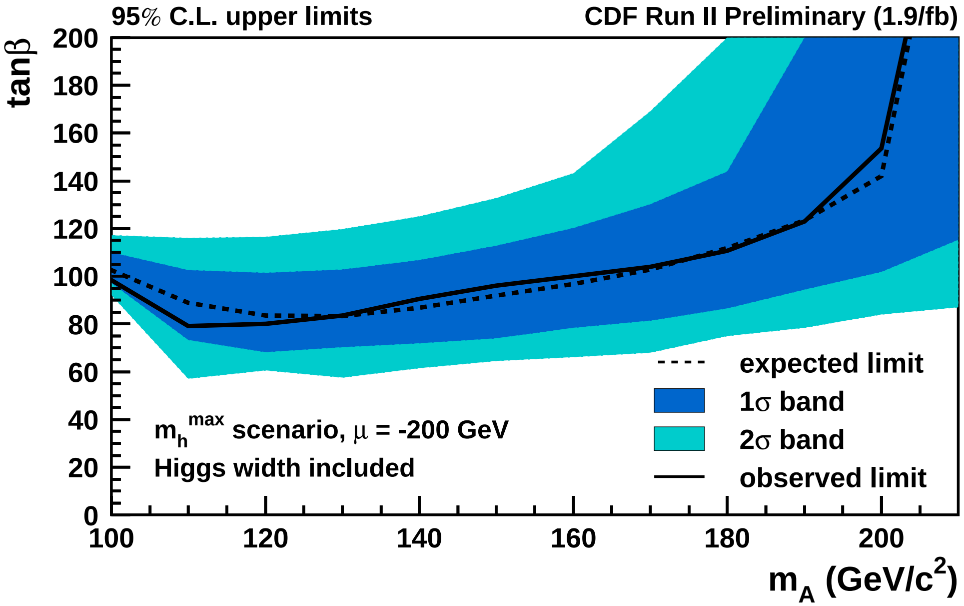
$$H \to b\bar{b}, \tau^+\tau^-, W^+W^-, \gamma\gamma$$



# . . . and first constraints on MSSM parameters from Higgs physics



(DØ, PRL 95 (2005) 151801)



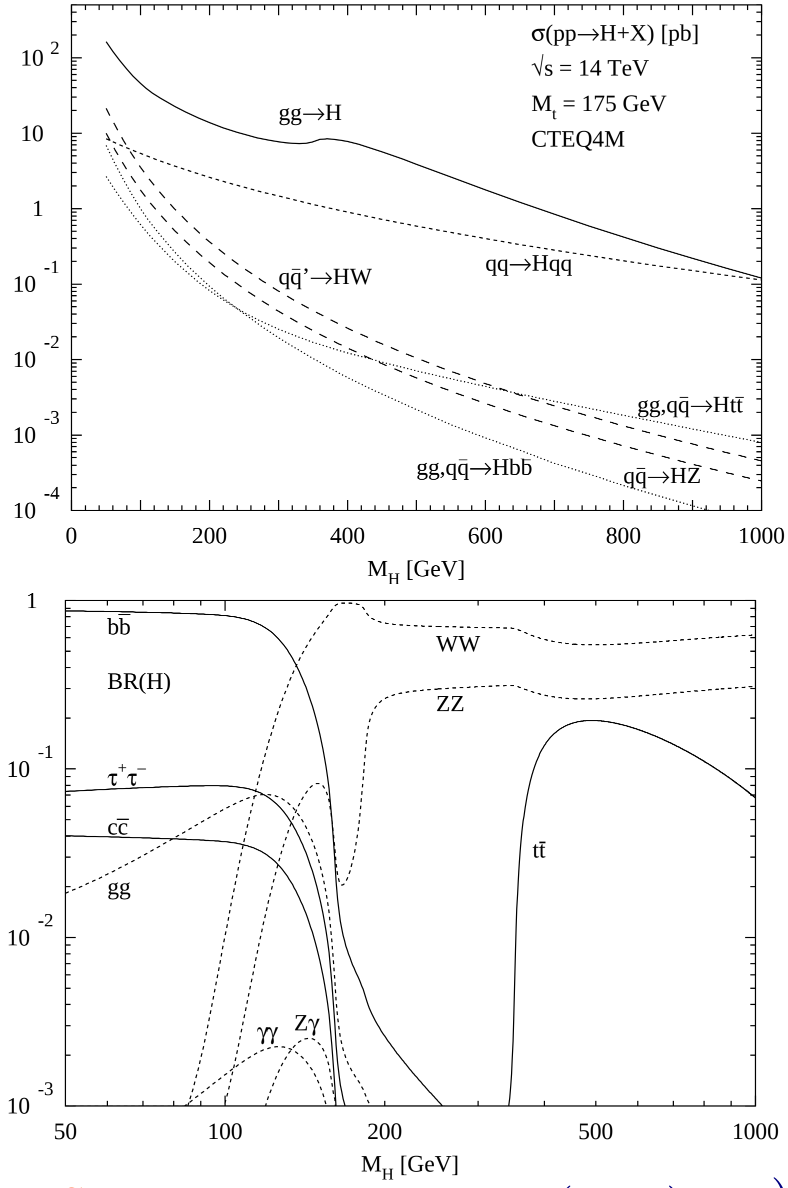
(CDF, Note 9284, 2008)

$$g^{MSSM}_{b\bar{b}h^0,H^0} = \frac{(-\sin\alpha, \cos\alpha)}{\cos\beta} g_{b\bar{b}H} \quad \text{and} \quad g^{MSSM}_{b\bar{b}A^0} = \tan\beta \; g_{b\bar{b}H}$$

where $g_{b\bar{b}H} = m_b/v \simeq 0.02$ (Standard Model) and $\tan\beta = v_1/v_2$ (MSSM).

# The LHC: unveiling the nature of EWSB

# LHC: entire SM Higgs mass range accessible



(M. Spira, Fortsch.Phys. 46 (1998) 203)

Many channels have been studied:

Below 130-140 GeV:

$gg \to H\ ,\ H \to \gamma\gamma, WW, ZZ$

$qq \to qqH\ ,\ H \to \gamma\gamma, WW, ZZ, \tau\tau$

$q\bar{q}, gg \to t\bar{t}H\ ,\ H \to \gamma\gamma, b\bar{b}, \tau\tau$

$q\bar{q}' \to WH\ ,\ H \to \gamma\gamma, b\bar{b}$

Above 130-140 GeV:

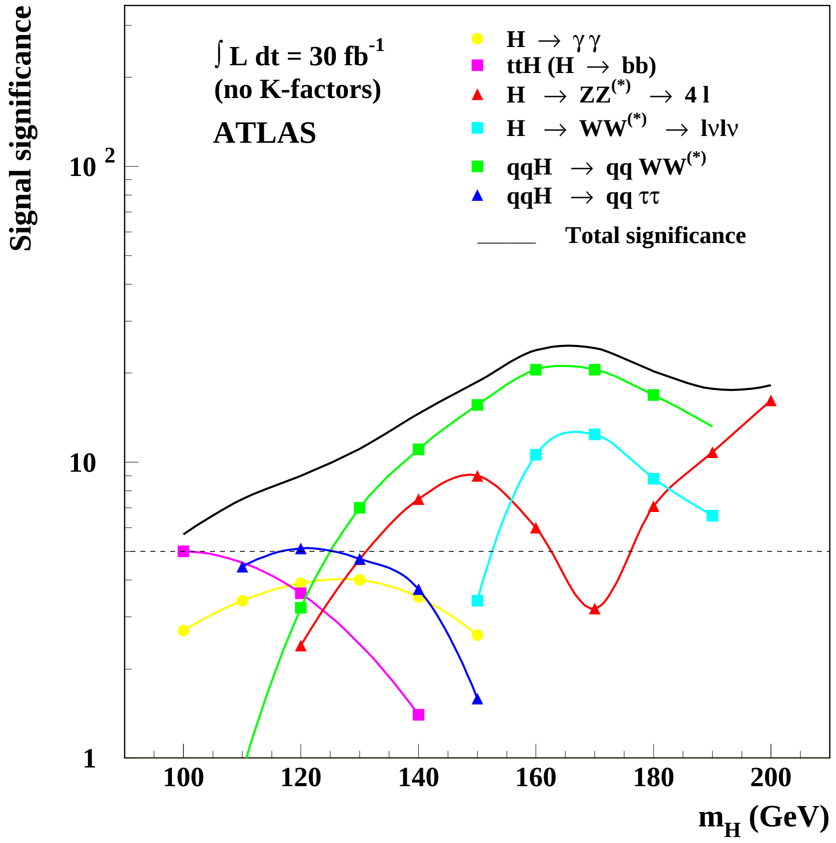
$gg \to H\ ,\ H \to WW, ZZ$

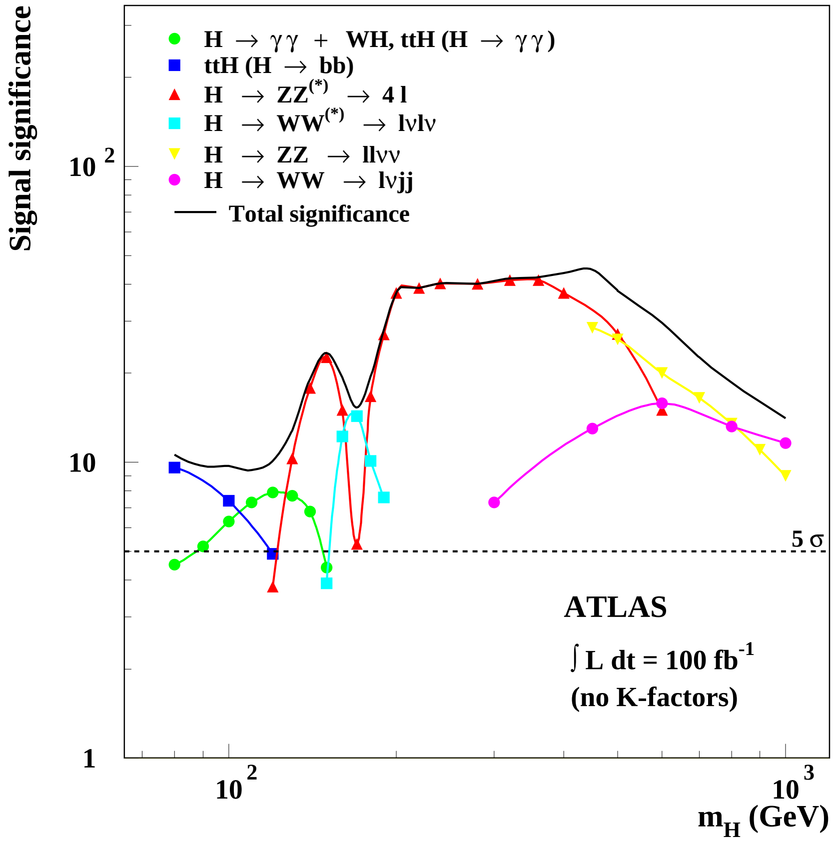
$qq \to qqH\ ,\ H \to \gamma\gamma, WW, ZZ$

$q\bar{q}, gg \to t\bar{t}H\ ,\ H \to \gamma\gamma, WW$

$q\bar{q}' \to WH\ ,\ H \to WW$

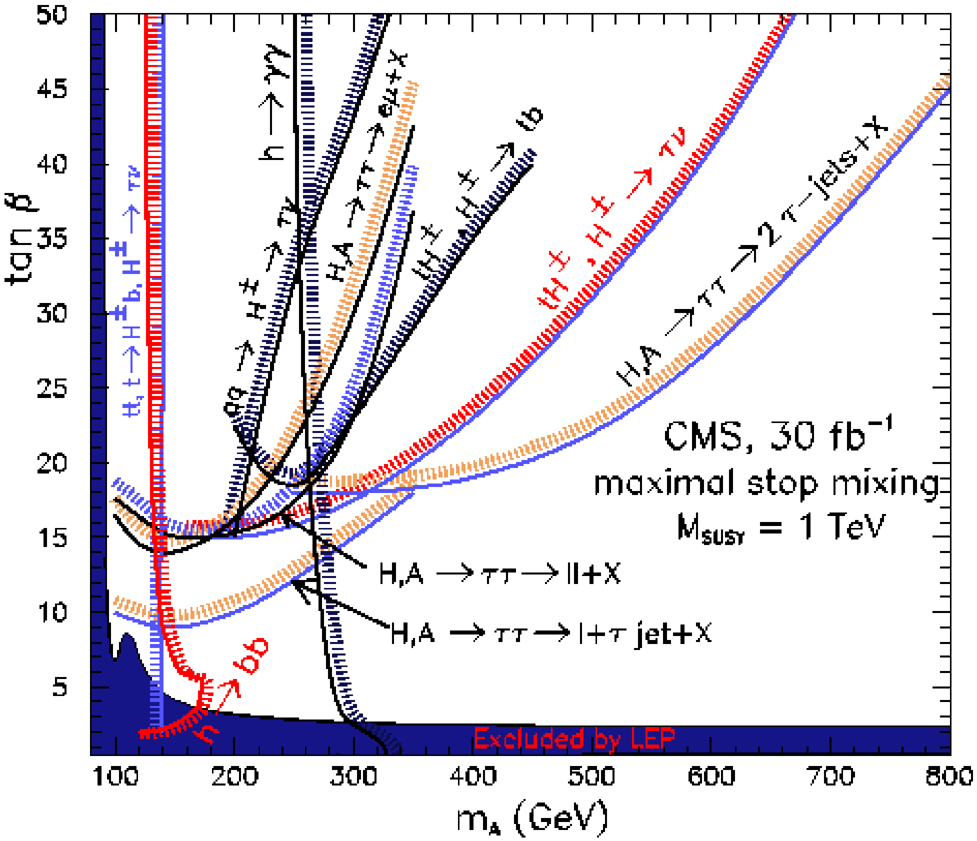
# LHC: discovery reach for a SM Higgs boson

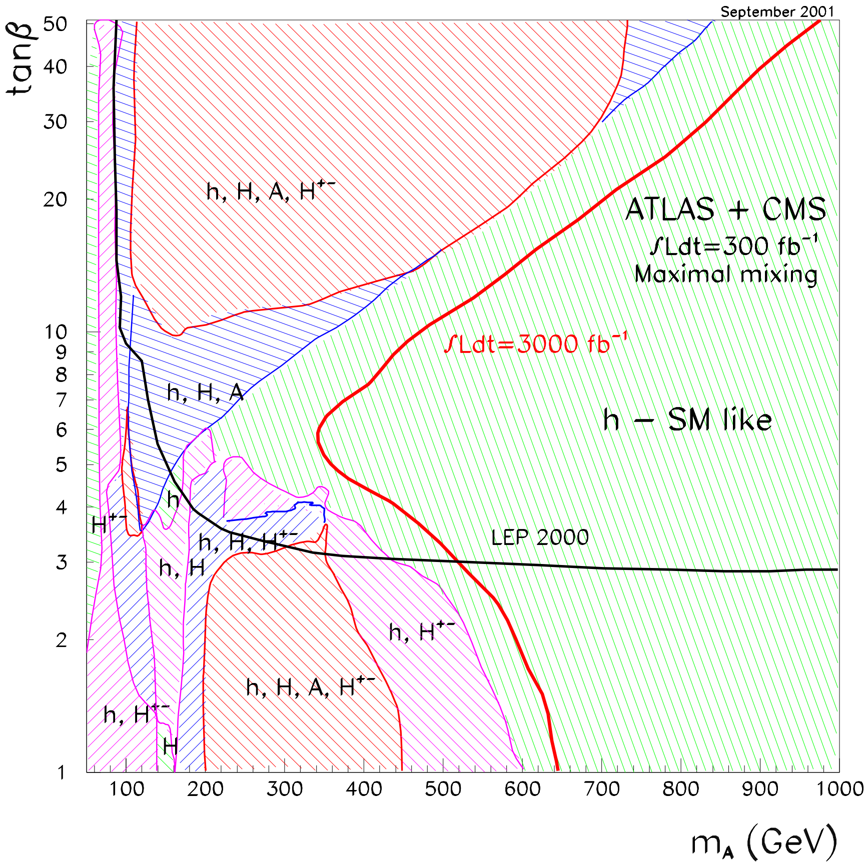




- Low mass region difficult at low luminosity: need to explore as many channels as possible. Indications from the Tevatron most valuable!
- high luminosity reach needs to be updated;
- identifying the SM Higgs boson requires high luminosity, above 100 $fb^{-1}$: very few studies exist above 300 $fb^{-1}$ (per detector).

# LHC: discovery reach in the MSSM parameter space





Low luminosity, CMS only

High luminosity, ATLAS+CMS

# SM Higgs boson: mass, width, spin and more

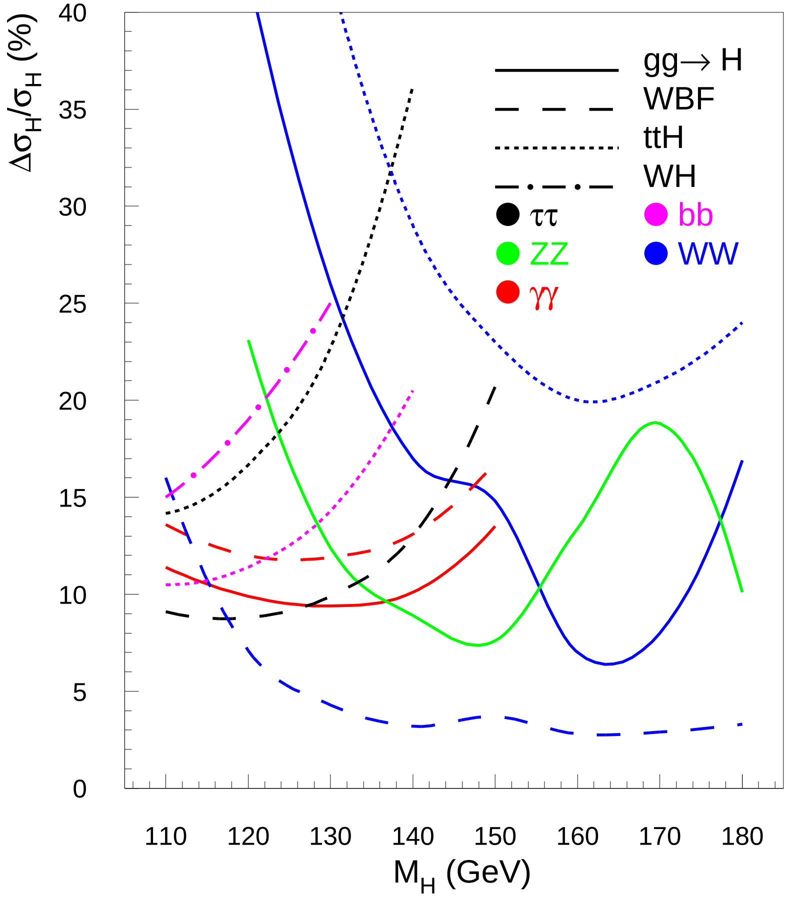
- Color and charge are given by the measurement of a given (production+decay) channel.

- The Higgs boson mass will be measured with 0.1% accuracy in $H \rightarrow ZZ^* \rightarrow 4l^\pm$, complemented by $H \rightarrow \gamma\gamma$ in the low mass region. Above $M_H \simeq 400$ GeV precision deteriorates to $\simeq 1\%$ (lower rates).

- The Higgs boson width can be measured in $H \rightarrow ZZ^* \rightarrow 4l^\pm$ above $M_H \simeq 200$ GeV. The best accuracy of $\simeq 5\%$ is reached for $M_H \simeq 400$ GeV.

- The Higgs boson spin could be measured through angular correlations between fermions in $H \rightarrow VV \rightarrow 4f$: need for really high statistics.

# LHC: can measure most SM Higgs couplings at 10-30%



Consider all "accessible" channels:

- Below 130-140 GeV

  $gg \to H\ ,\ H \to \gamma\gamma, WW, ZZ$

  $qq \to qqH\ ,\ H \to \gamma\gamma, WW, ZZ, \tau\tau$

  $q\bar{q}, gg \to t\bar{t}H\ ,\ H \to \gamma\gamma, b\bar{b}, \tau\tau$

  $q\bar{q}' \to WH\ ,\ H \to \gamma\gamma, b\bar{b}$

- Above 130-140 GeV

  $gg \to H\ ,\ H \to WW, ZZ$

  $qq \to qqH\ ,\ H \to \gamma\gamma, WW, ZZ$

  $q\bar{q}, gg \to t\bar{t}H\ ,\ H \to \gamma\gamma, WW$

  $q\bar{q}' \to WH\ ,\ H \to WW$

Observing a given production+decay (p+d) channel gives a relation:

$$(\sigma_p(H)\mathrm{Br}(H \to dd))^{exp} = \frac{\sigma_p^{th}(H)}{\Gamma_p^{th}}\,\frac{\Gamma_d\Gamma_p}{\Gamma_H}$$

(D. Zeppenfeld, PRD 62 (2000) 013009; A. Belyaev et al., JHEP 0208 (2002) 041)

Associate to each channel $(\sigma_p(H) \times Br(H \to dd))$

$$Z_d^{(p)} = \frac{\Gamma_p \Gamma_d}{\Gamma} \qquad \begin{cases} \Gamma_p \simeq g_{Hpp}^2 = y_p^2 \to \text{production} \\ \Gamma_d \simeq g_{Hdd}^2 = y_d^2 \to \text{decay} \end{cases}$$

From LHC measurements, with given simulated accuracies and theoretical systematic errors (GF: 20%, WBF: 4%, ttH: 15%, WH: 7%):

- Determine in a model independent way ratios of couplings at the $10 - 20\%$ level, for example:

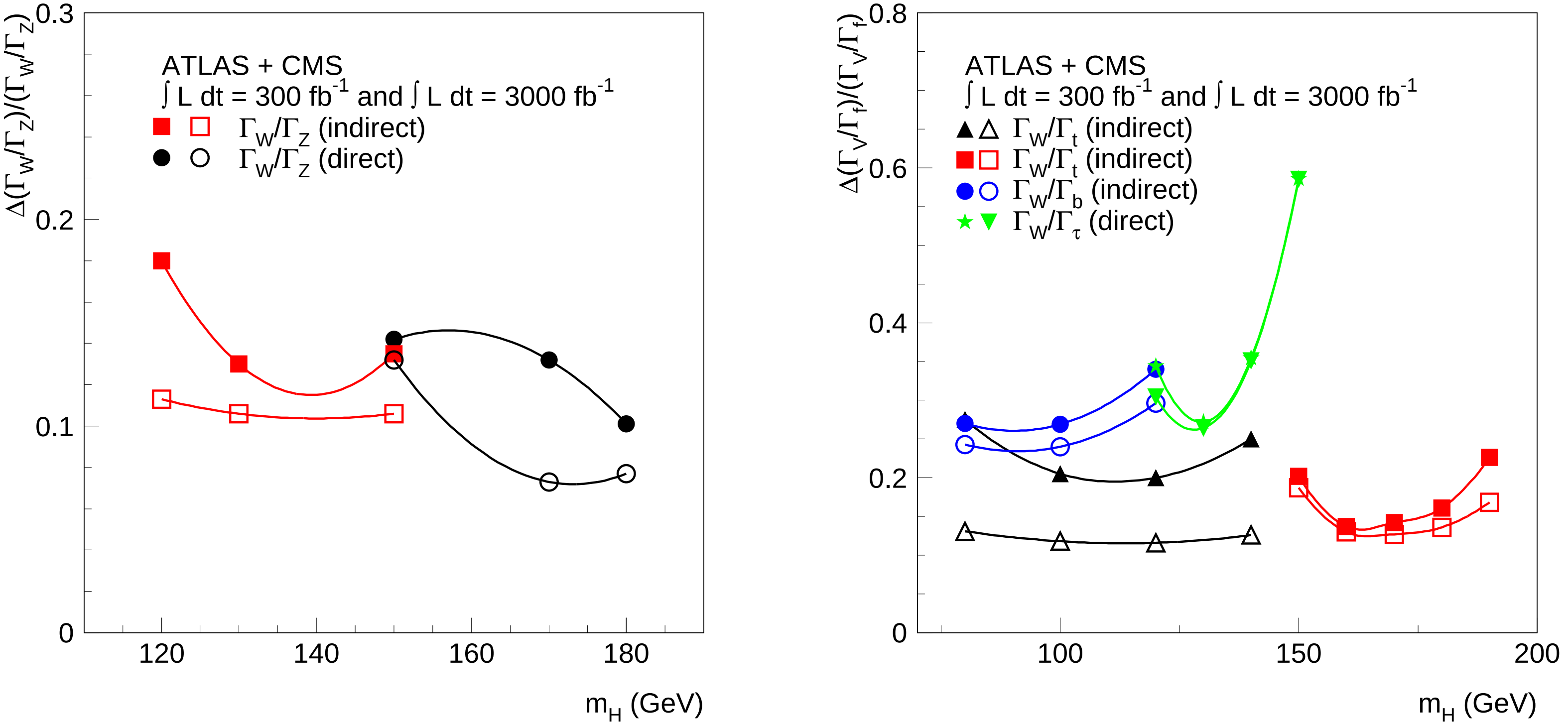
$$\frac{y_b}{y_\tau} \longleftarrow \frac{\Gamma_b}{\Gamma_\tau} = \frac{Z_b^{(t)}}{Z_\tau^{(t)}}$$

$$\frac{y_t}{y_g} \longleftarrow \frac{\Gamma_t}{\Gamma_g} = \frac{Z_\tau^{(t)} Z_\gamma^{(WBF)}}{Z_\tau^{(WBF)} Z_\gamma^{(g)}} \text{ or } \frac{Z_W^{(t)}}{Z_W^{(g)}}$$

  crucial to have many decay channels for the same production channel.

- determine individual couplings at the 10-30% level, assuming:
  $\Gamma_H \simeq \Gamma_b + \Gamma_\tau + \Gamma_W + \Gamma_Z + \Gamma_g + \Gamma_\gamma$, $\frac{\Gamma_W}{\Gamma_Z} = \left.\frac{\Gamma_W}{\Gamma_Z}\right|_{SM}$ and $\frac{\Gamma_b}{\Gamma_\tau} = \left.\frac{\Gamma_b}{\Gamma_\tau}\right|_{SM}$

# Along these lines, exploring higher luminosity:



(F. Gianotti, M. Mangano, and T. Virdee, hep-ph/02040887)

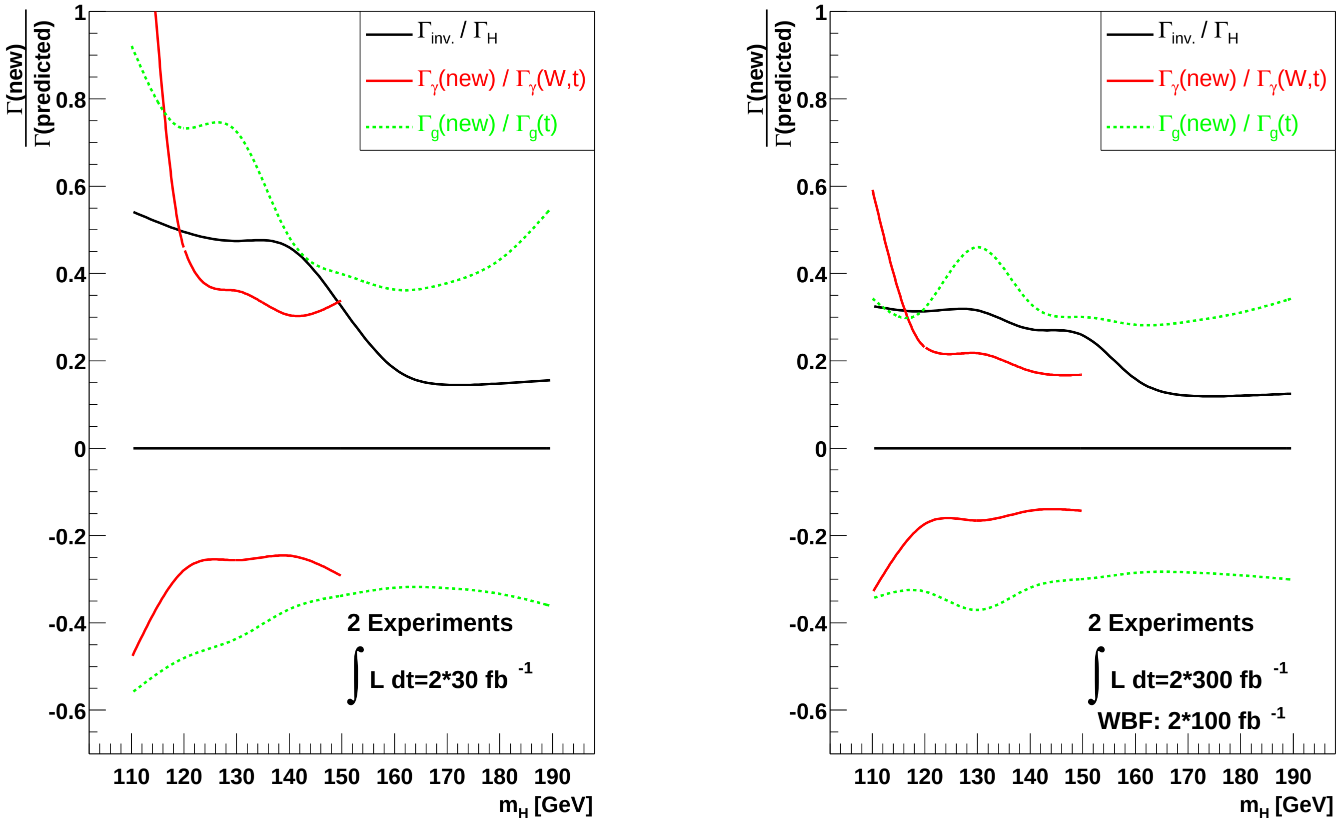
where the "indirect" ratios are obtained under some assumptions:

$$\frac{\Gamma_W}{\Gamma_Z} = \frac{Z_\gamma^{(g)}}{Z_Z^{(g)}} \;,\; \frac{\Gamma_W}{\Gamma_t} = \frac{Z_\gamma^{(WH)}}{Z_\gamma^{(g)}} \text{ or } \frac{Z_W^{(WH)}}{Z_W^{(g)}} \quad (\text{assuming } gg \to H \text{ is } t\text{-dominated})$$

$$\frac{\Gamma_W}{\Gamma_b} = \frac{Z_\gamma^{(t)}}{Z_b^{(t)}} \quad (\text{assuming } H \to \gamma\gamma \text{ is } W\text{-dominated})$$

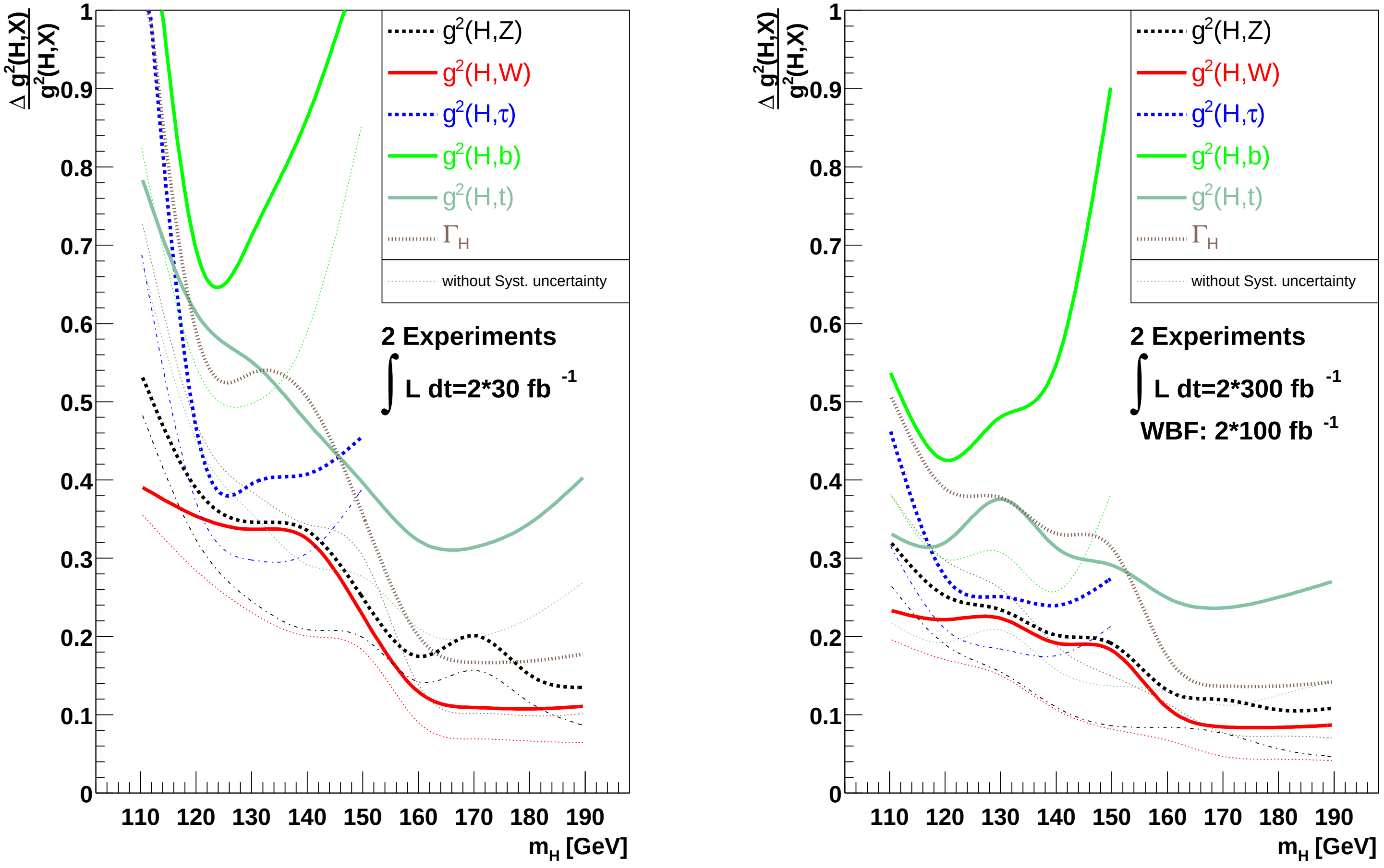
# Toward a more model independent determination of Higgs couplings and width

Consider both a $\chi^2(x)$ and a likelihood function $L(x)$ over a parameter space $(x)$ made of all partial widths plus $\Gamma_{\mathrm{inv}}$, $\Gamma_\gamma(\mathrm{new})$, and $\Gamma_g(\mathrm{new})$.



(M. Dührssen et al., PRD 70 (2004) 113009)

with the only assumption that: $g^2(H,V) < 1.05 \cdot g^2(H,V,SM) \quad (V = W, Z)$

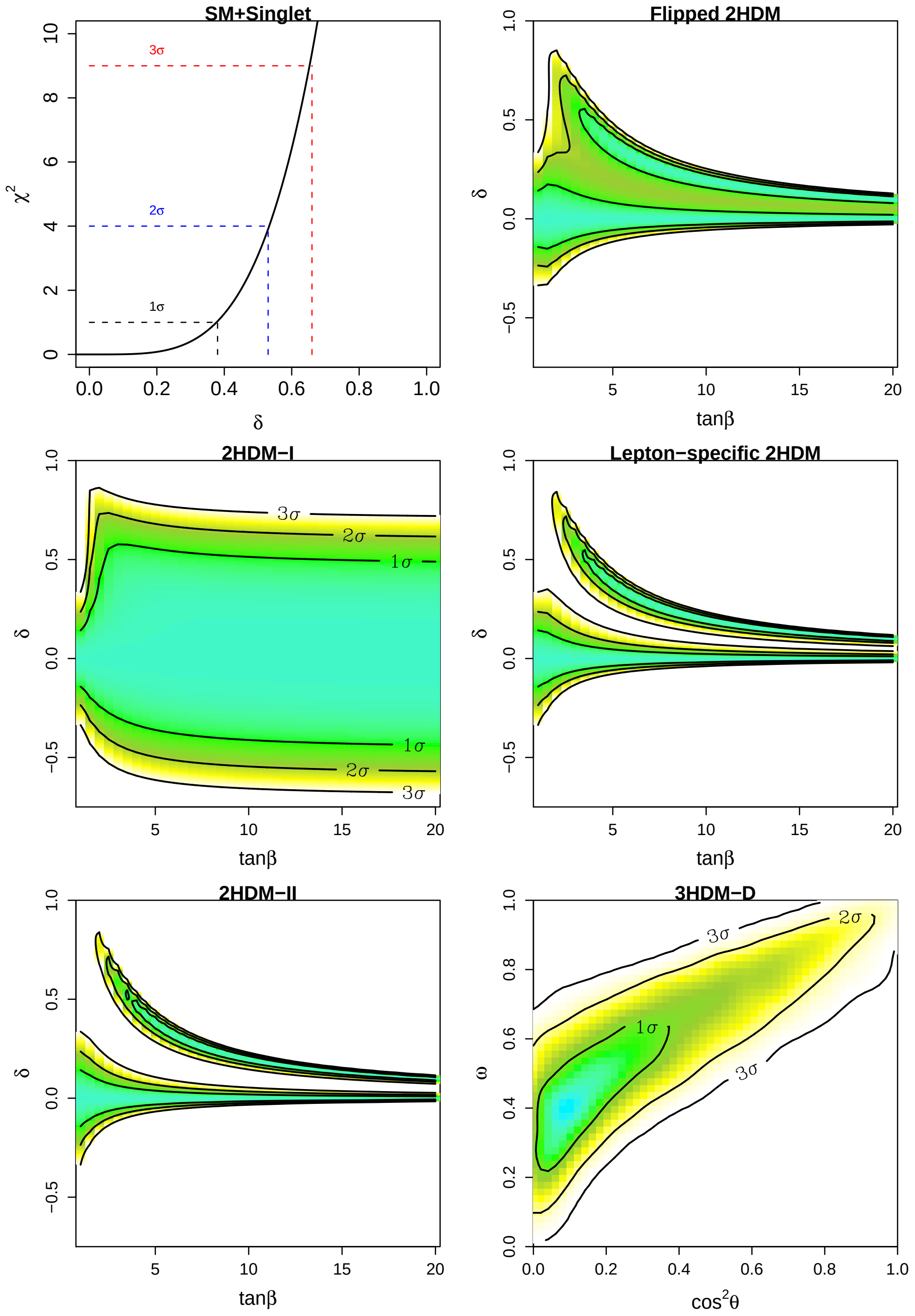


(M. Dührssen et al., PRD 70 (2004) 113009)

- ▷ Most coupling within 10-40% at high luminosity (for light $M_H$);
- ▷ notice the impact of systematic uncertainties;
- ▷ of course, adding assumptions considerably lower the errors.

⟶ New study by Lafaye, Plehn, Rauch, Zerwas, and Dührssen (arXiv:0904:3866)

# Looking for footprints of new physics:



Consider all extended Higgs sectors

- involving $SU(2)_L$ doublets and singlets;
- with natural flavor conservation;
- without CP violation.

15 models have different footprints!

$\delta \longrightarrow$ decoupling parameter
($\delta = 0$: SM)

(V. Barger, H. Logan, G. Shaughnessy,
arXiv:0902.0170)

# ILC: ultimate precision

- Higgs boson mass within $\delta M_H = 50$ MeV;
- Model independent determination of Higgs boson couplings
- All Higgs boson couplings known within few percents (but top Yukawa coupling!)
- Measure 3H coupling with high luminosity ($\mathrm{ab}^{-1}$): first direct test of Higgs boson potential, impossible at the LHC.

Ex.: SM Higgs boson, $\sqrt{s}=500$ GeV, 1 $\mathrm{ab}^{-1}$

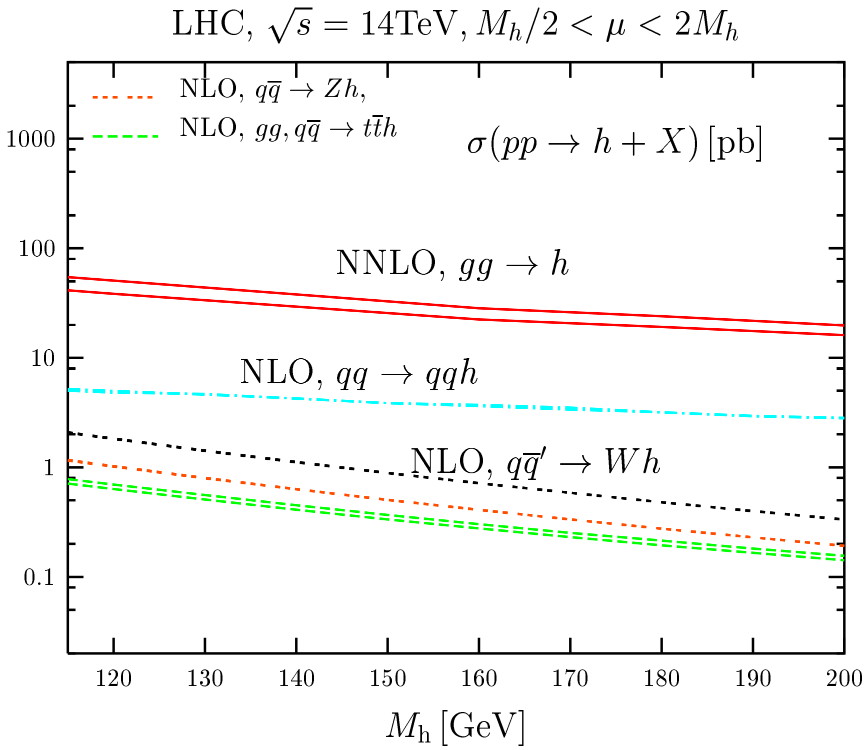
| Coupling: | $Hb\bar{b}$ | $H\tau^+\tau^-$ | $Hc\bar{c}$ | $HWW$ | $HZZ$ | $Ht\bar{t}$ | $HHH$ |
|---|---|---|---|---|---|---|---|
| ($M_H=120$ GeV) | 2.2% | 3.3% | 3.7% | 1.2% | 1.2% | 25% | 17% |
| ($M_H=140$ GeV) | 2.2% | 4.8% | 10% | 2.0% | 1.3% | | 23% |
| Theory | 1.4% | 2.3% | 23% | 2.3% | 2.3% | 5% | |

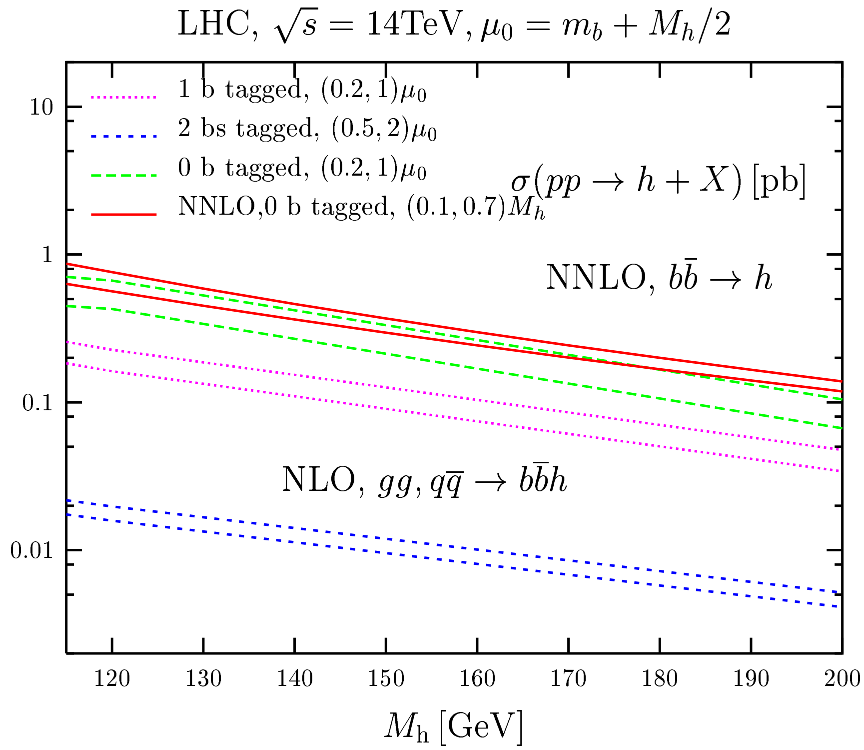
- Higgs boson quantum numbers, spin, . . .

# How good are our theoretical predictions?

# SM Higgs-boson production: theoretical precision at a glance.

QCD predictions for total hadronic cross sections of Higgs-boson production processes are under good theoretical control:



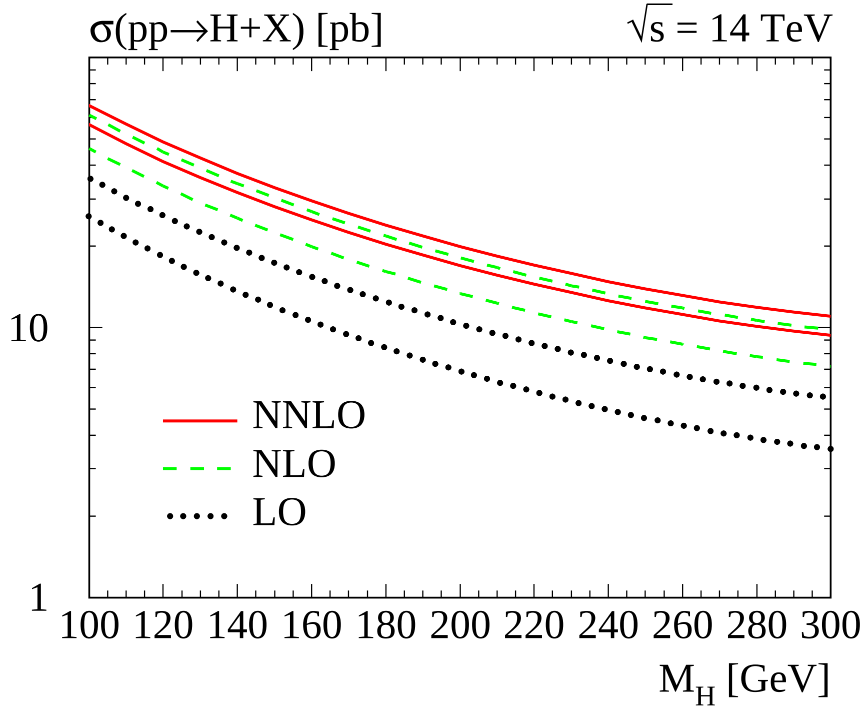


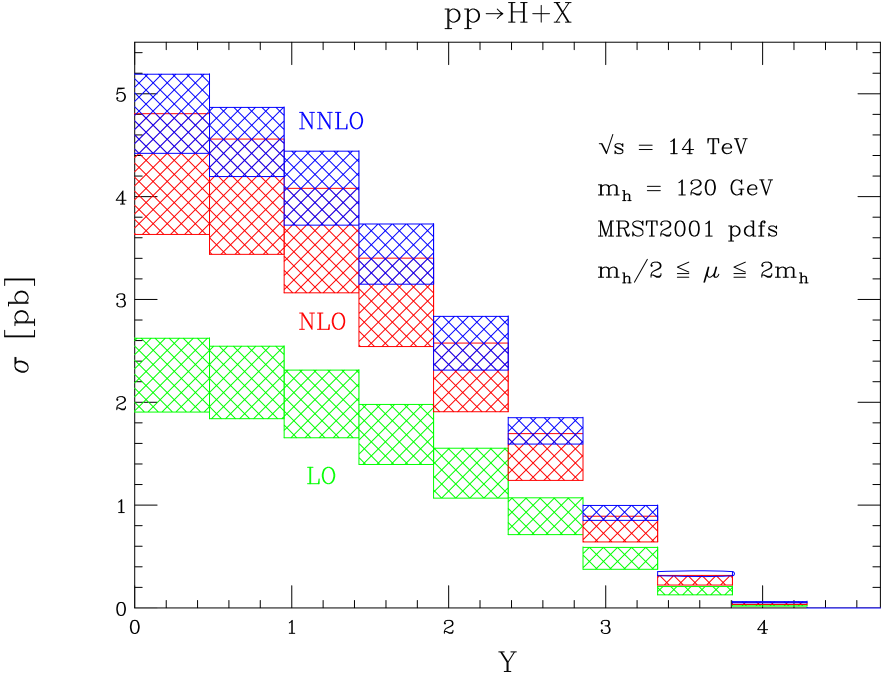
Caution: in these plots uncertainties only include $\mu_R/\mu_F$ scale dependence, PDF's uncertainties are not included.

# Ex. 1: $gg \to H$, the main production mode

Harlander,Kilgore (03); Anastasiou,Melnikov,Petriello (03)

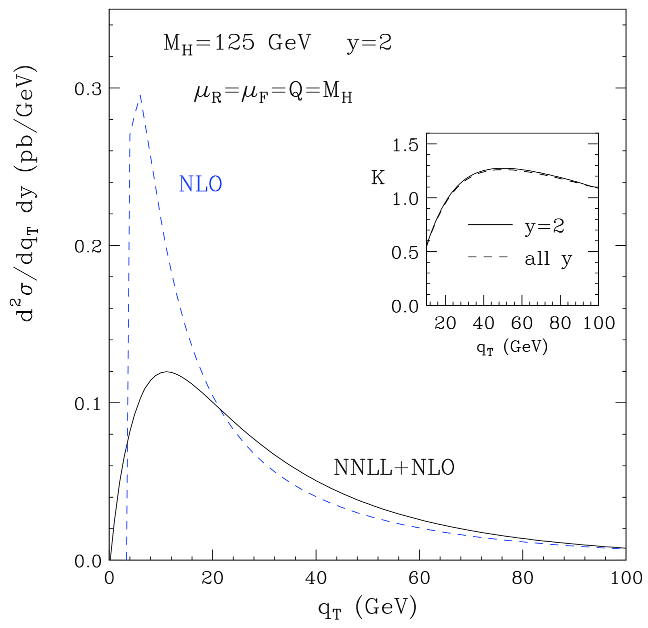
Ravindran,Smith,van Neerven (04)





- dominant production mode in association with $H \to \gamma\gamma$ or $H \to WW$ or $H \to ZZ$;
- dominated by soft dynamics: effective $ggH$ vertex can be used ($3 \to 2$-loop);
- perturbative convergence LO → NLO (70%) → NNLO (30%): residual 15% theoretical uncertainty.

Inclusive cross section, resum effects of soft radiation:



large $q_T$ $\xrightarrow{q_T > M_H}$

perturbative expansion in $\alpha_s(\mu)$

small $q_T$ $\xrightarrow{q_T \ll M_H}$

need to resum large $\ln(M_H^2/q_T^2)$

Bozzi,Catani,De Florian,Grazzini (04-08)

Update: Going from MRST2002 to MSTW2008 greatly affects the Tevatron/LHC cross section: from 9%/30% ($M_H = 115$ GeV) to -9%/+9% ($M_H = 200/300$ GeV) !

De Florian,Grazzini (09)

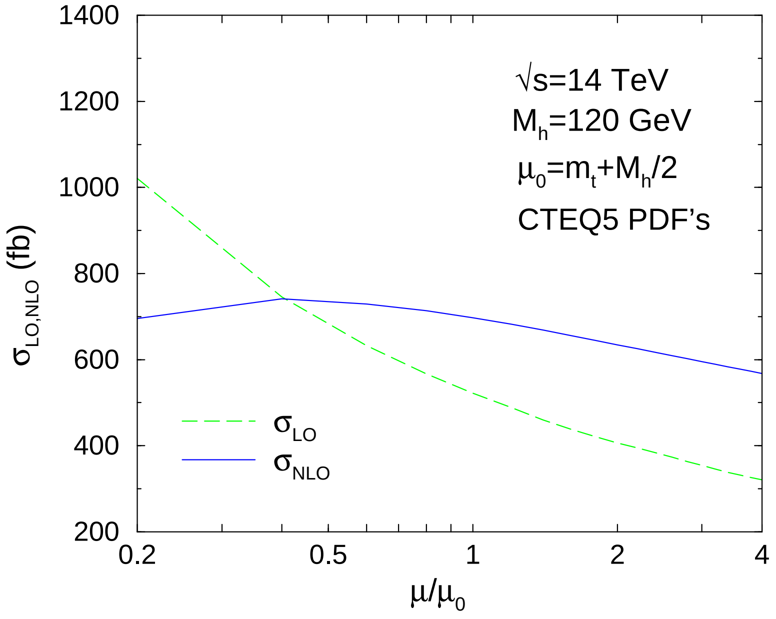
Exclusive NNLO results: e.g. $gg \to H \to \gamma\gamma, WW, ZZ$

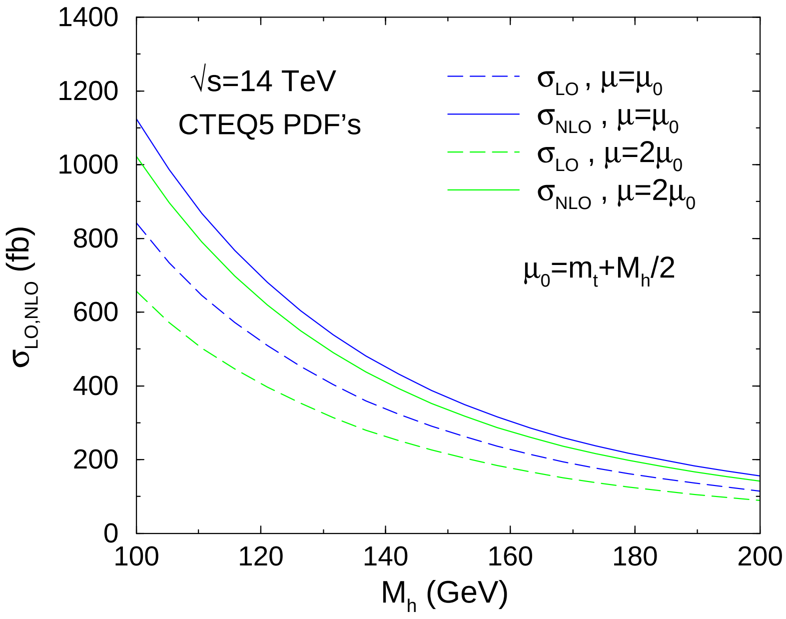
Extension of (IR safe) subtraction method to NNLO:

$\longrightarrow$ HNNLO (Catani,Grazzini)

$\longrightarrow$ FEHiP (Anastasiou,Melnikov,Petriello)

# Ex. 2: $pp \to t\bar{t}H$, crucial to explore Higgs couplings.

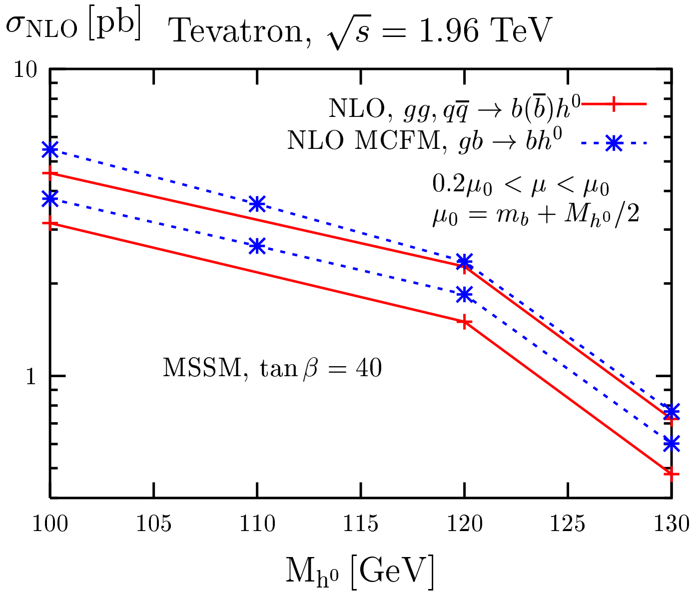


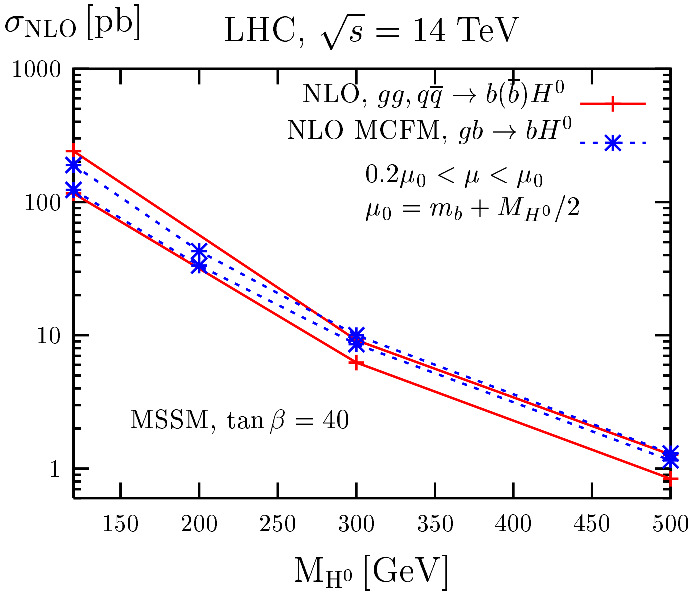


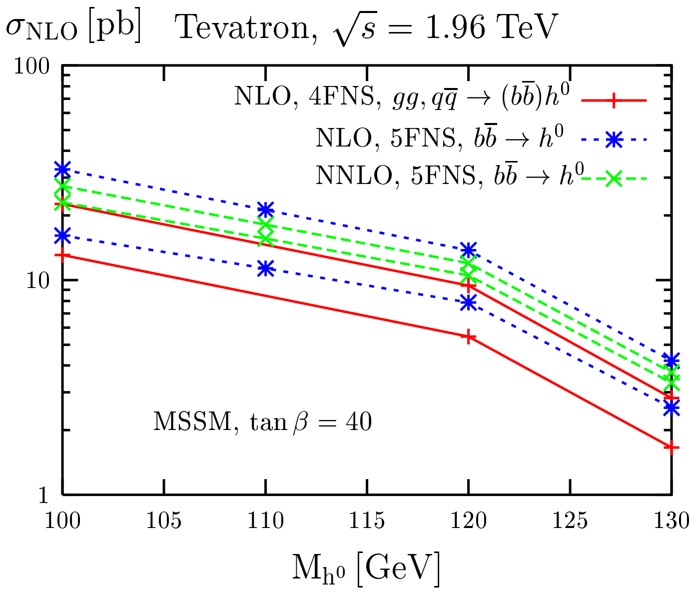
Dawson, Jackson, Orr, L.R., Wackeroth (01-03)

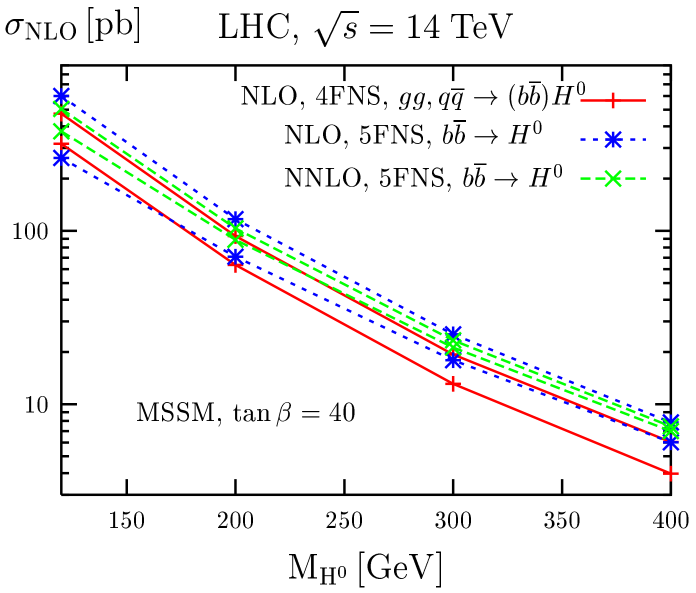
- Fully massive 2 → 3 calculation: testing the limit of FD's approach (pentagon diagrams with massive particles).
- Independent calculation: Beenakker et al., full agreement.
- Theoretical uncertainty reduced to about 15%
- Several crucial backgrounds: $t\bar{t}+j$ (NLO, Dittmaier,Uwer,Weinzierl), $t\bar{t}b\bar{b}$, $t\bar{t}+2j$, $VV+b\bar{b}$.

# Ex. 3: $pp \to b\bar{b}H$, hint of enhanced b-quark Yukawa coupling









Dawson, Jackson, L.R., Wackeroth (05)

## Ex. 4: $pp \to b\bar{b}W/Z$, crucial but not well-understood background.

$\longrightarrow$ $V \longrightarrow$ 4 partons (1-loop massless amplitudes) (Bern, Dixon, Kosower (97))

$\longrightarrow$ $p\bar{p}, pp \to Vb\bar{b}$ (at NLO, 4FNS, $m_b = 0$) (Campbell, Ellis (99))

$\longrightarrow$ $p\bar{p}, pp \to Vb + j$ (at NLO, 5FNS) (Campbell, Ellis, Maltoni, Willenbrock (05,07))

$\longrightarrow$ $p\bar{p}, pp \to Wb\bar{b}$ (at NLO, 4FNS, $m_b \neq 0$) (Febres Cordero, L.R., Wackeroth (06))

$\longrightarrow$ $p\bar{p}, pp \to Zb\bar{b}$ (at NLO, 4FNS, $m_b \neq 0$) (Febres Cordero, L.R., Wackeroth (08))

$\longrightarrow$ $p\bar{p}, pp \to W + 1\,b$-jet (at NLO, 5FNS+4FNS with $m_b \neq 0$) (Campbell, Ellis, Febres Cordero, Maltoni, L.R., Wackeroth, Willenbrock (08))

# NLO: Recently completed calculations (since Les Houches 2005): all relevant to Higgs-boson physics!

| Process ($V \in \{Z, W, \gamma\}$) | Comments |
|---|---|
| $pp \to V$+2 jets($b$) | Campbell,Ellis,Maltoni,Willenbrock (06) |
| $pp \to Vb\bar{b}$ | Febres Cordero,Reina,Wackeroth (07-08) |
| $pp \to VV$+jet | Dittmaier,Kallweit,Uwer ($WW$+jet) (07) |
| | Campbell,Ellis,Zanderighi ($WW$+jet+decay) (07) |
| | Binoth,Karg,Kauer,Sanguinetti (in progress) |
| $pp \to VV$+2 jets | Bozzi,Jäger,Oleari,Zeppenfeld (via WBF) (06-07) |
| $pp \to VVV$ | Lazopoulos,Melnikov,Petriello ($ZZZ$) (07) |
| | Binoth,Ossola,Papadopoulos,Pittau ($WWZ$,$WZZ$,$WWW$) (08) |
| | Hankele,Zeppenfeld ($WWZ \to 6$ leptons, full spin correlation) (07) |
| $pp \to H$+2 jets | Campbell,Ellis,Zanderighi (NLO QCD to $gg$ channel)(06) |
| | Ciccolini,Denner,Dittmaier (NLO QCD+EW to WBF channel) (07) |
| $pp \to H$+3 jets | Figy,Hankele,Zeppenfeld (large $N_c$) (07) |
| $pp \to t\bar{t}$+jet | Dittmaier,Uwer,Weinzierl (07) |
| | Ellis,Giele,Kunszt (in progress) |
| $pp \to t\bar{t}Z$ | Lazopoulos,Melnikov,Petriello (08) |
| $gg \to WW$ | Binoth,Ciccolini,Kauer,Kramer (06) |
| $gg \to HH, HHH$ | Binoth,Karg,Kauer,Rückl (06) |

| Process<br>($V \in \{Z, W, \gamma\}$) | Comments |
|---|---|
| NLO calculations remaining at Les Houches 2007 | |
| $pp \longrightarrow t\bar{t}\, b\bar{b}$ | relevant for $t\bar{t}H$ (1) |
| $pp \longrightarrow t\bar{t}$+2jets | relevant for $t\bar{t}H$ |
| $pp \longrightarrow VV\, b\bar{b}$, | relevant for WBF $\rightarrow H \rightarrow VV$, $t\bar{t}H$ |
| $pp \longrightarrow VV$+2jets | relevant for WBF $\rightarrow H \rightarrow VV$ (2) |
| $pp \longrightarrow V$+3jets | various new physics signatures (3) |
| $pp \longrightarrow b\bar{b}b\bar{b}$ | Higgs and new physics signatures (4) |
| Calculations beyond NLO added at Les Houches 2007 | |
| $gg \longrightarrow W^*W^*$ $\mathcal{O}(\alpha^2\alpha_s^3)$ | backgrounds to Higgs (5) |
| NNLO $pp \longrightarrow t\bar{t}$ | normalization of a benchmark process (6) |
| NNLO to WBF and $Z/\gamma$+jet | Higgs couplings and SM benchmark (7) |

(1) $q\bar{q} \rightarrow t\bar{t}b\bar{b}$ calculated by A. Bredenstein, A. Denner, S. Dittmaier, and S. Pozzorini (08).

(2) WBF contributions calculated by G. Bozzi, B. Jäger, C. Oleari, and D. Zeppenfeld (06-07).

(3) leading-color contributions calculated by: R. K. Ellis, et al. (08-09); Z. Bern et al. (08-09).

(4) T. Binoth et al., in progress.

(5) $q\bar{q} \rightarrow WW$ calculated by G. Chachamis, M. Czakon, and D. Eiras (08) (small $M_W$).

(6) M. Czakon, A. Mitov, and S. Moch (06-08) (analytical for $m_Q^2 \ll s$, exact numerical estimate).

(7) A. Gehrmann-De Ridder, T. Gehrmann, et al., work in progress.

# Conclusions and Outlook

- The Tevatron is breaking new ground and meeting new challenges: exploring the Higgs low mass region, possible $2\sigma - 3\sigma$ evidence.
- The LHC will cover the whole Higgs mass range and with high luminosity will have access to Higgs-boson precision physics.
- Using the SM as a "template", we can test our ability to pinpoint the properties of to-be-discovered scalar and pseudoscalar particles:
  - ▷ revisit existing studies;
  - ▷ identify main sources of systematic uncertainty;
  - ▷ work at reducing them, both theoretically and experimentally.
- Building on solid SM ground, start exploring beyond SM scenarios in as much generality as possible, looking for most distinctive patterns and signatures of various realizations of EWSB.