Non-standard Higgs Searches at the Tevatron

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Univ. of Wisconsin – Madison/Fermilab

(Tev4LHC, FNAL, Dec.14, 2004)

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Check every corner and turn every stone over ...

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Push the Higgs searches at Tevatron to the limit:
Check every corner and turn every stone over ...

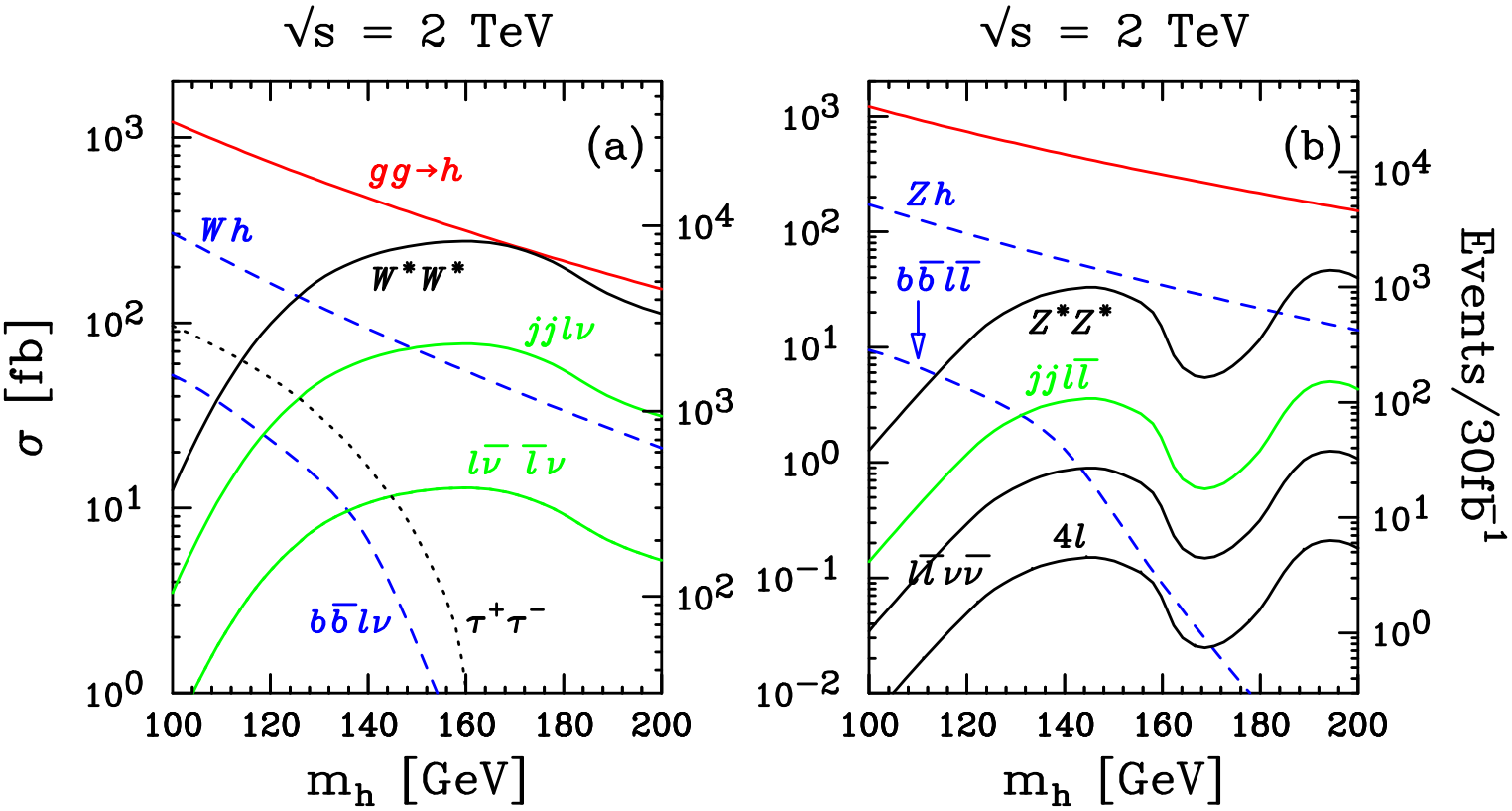
- Motivated by what we can "see" at CDF/D0:
  explore unconventional scenarios;
  search for rare (clean) modes

"Standard" Higgs Searches at the Tevatron

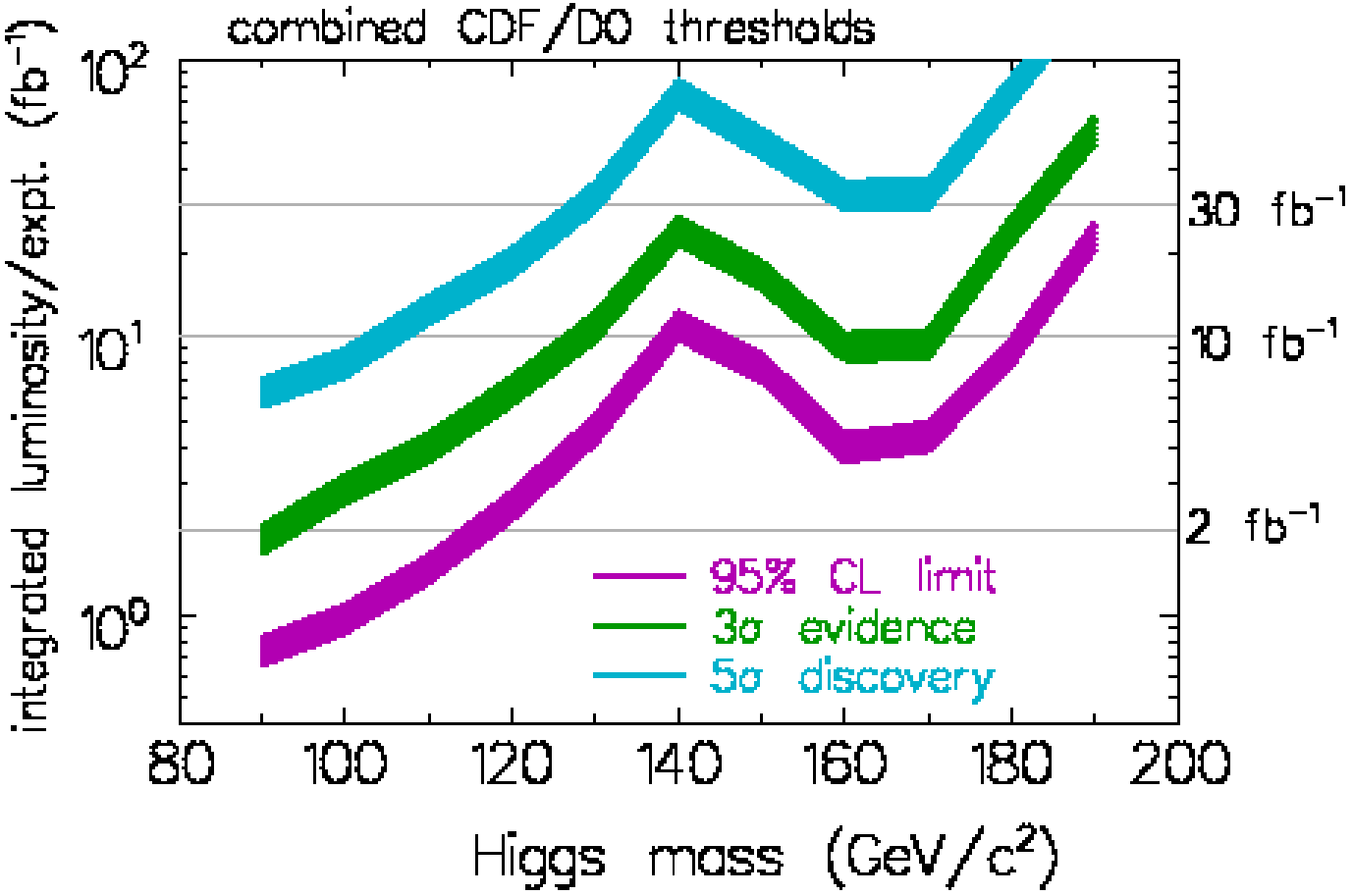
Leading production in SM:

$$q\bar{q}' \to Wh,\ Zh, \quad h \to b\bar{b}$$

$$gg \to h, \quad h \to WW^*,\ ZZ^*$$



Run-II Higgs working group report:
(M. Carena, J. Conway et al., hep-ph/0010338.)



We can "see" those (well):

- leptons: $e^{\pm}$, $\mu^{\pm}$, $\tau^{\pm}$, and thus $W^{\pm}$, Z
- photons γ
- heavy quark: b
- missing energies: $\not{E}_T$

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"Non-standard" Searches

A (partial) list of non-standard Higgs modes
— with theoretical commentaries

Leptonic decays

(1). $h/H/A \to \tau^+\tau^-$: complementary betweeen $gg \to b\bar{b}h$ and $gg \to hj$

- improve the region for large $\tan\beta$
- extend the coverage to low M_A, $\tan\beta$. *

*Belyaev, TH, Rosenfeld, hep-ph/0204201;
D. Morrissey and C. Wagner, hep-ph/0308001; Conway, Anastassov: SUSY04.

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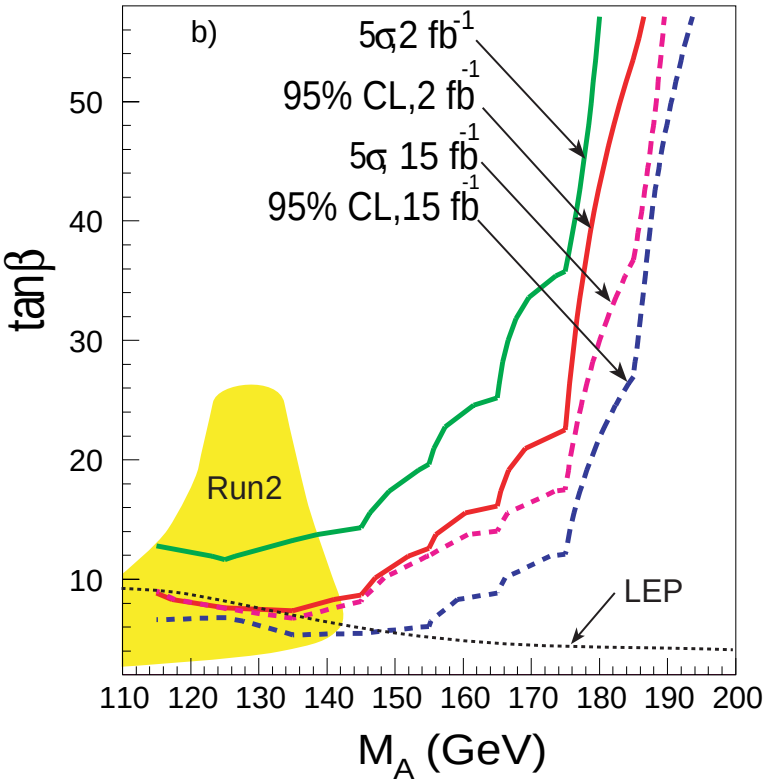

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(2). $h/H/A \to \mu^{\pm}\tau^{\mp}$ (maybe also $e^{\pm}\tau^{\mp}$, $e^{\pm}\mu^{\mp}$ *)

Very interesting since

- good experimental signatures to search for;
- motivated by $\nu_\mu - \nu_\tau$ oscillations: nearly-maximal mixing!

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If coupling scales with masses

$$\kappa\sqrt{\frac{m_\mu m_\tau}{v}}$$

like certain class of model predicted, then

$$\kappa \sim O(1)$$

can be probed at the Tevatron with 2 fb^{-1}.

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(3). $q\bar{q} \to \gamma, Z^* \to H^{++}H^{--} \to \ell^+\ell^+, \ell^-\ell^-$

Current CDF bound:[†] $M_{++} > 135$ GeV.

Consider the production $q\bar{q}' \to W^+ \to H^{++}H^-,\ H^{++}W^-$
to improve the search (kinematically favored);

Consider the decay $H^{++} \to \tau^+\tau^+,\ H^+W^+,\ W^+W^+$
to reach a larger mass-coverage.[‡]

lead to like-sign $\ell^\pm\ell^\pm X$ signatures!

[†] CDF Run-II report: hep-ex/0406073.

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(4). Fermiophobic Higgs: If the coupling $h_i b\bar{b}$ suppressed,
then $BR(h_i \to WW^*, ZZ^* \to$leptons) enhanced.
look for $q\bar{q} \to Wh,\ Zh \to$multiple leptons.

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Photons

(5). Fermiophobic Higgs (again): If the coupling $h_i b\bar{b}$ suppressed, then $BR(h_i \to \gamma\gamma)$ greatly enhanced, in particular if no large cancellation $t\bar{t}h - WWh$.

Photons

(5). Fermiophobic Higgs (again): If the coupling $h_i b\bar{b}$ suppressed, then $BR(h_i \to \gamma\gamma)$ greatly enhanced, in particular if no large cancellation $t\bar{t}h - WWh$.

Current CDF bound:[†] $M_{\gamma\gamma} > 82$ GeV.

- Can be extended to higher mass if considering

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

- Consider possible variations:[‡] down-phobic only so there is $t\bar{t}h$.

[†]CDF Run-I result: hep-ex/0105006; TeV4LHC: A. Melnitchouk (D0); S. Lee (CDF).

[‡]H. Davoudiasl, H.Logan, TH.

b's And More b's

(6). From the "top": $gg,\ q\bar{q} \to t\bar{t}$

Consider
- $t \to bH^{\pm}$ bound exists.
- $gg,\ q\bar{q} \to t\ bH^{\pm}$ production and $H^{\pm} \to t\bar{b}$ (hard). †
- $t \to ch \to b\bar{b}\ j$, or ... Coupling $\sim \kappa\sqrt{\frac{m_c m_t}{v}}$?

†Belyaev et al., hep-ph/0203031; E. Berger et al., hep-ph/0312286.

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(7). $gg \to h/H_2 \to AA\ or\ H_1H_1 \to 4b's$

CP-odd A, or CP-violating Higgs‡ H_1 may be lighter...
needed for e.w. baryogenesis.

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(8). $q\bar{q} \to ZH_2,\ WH_2 \to\ VH_1H_1 \to \ell, 4\ b's$

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$\not{E}_T$

Invisible decays: $h \to \tilde{\chi}_0\tilde{\chi}_0,\ SS$, etc.

may be substantial or even dominant.
Test Higgs coupling to dark matter![‡]

(9). $q\bar{q} \to ZH \to \ell^+\ell^- \not{E}_T$.

(10). $qq \to qq\ V^*V^* \to qqH \to 2j,\ \not{E}_T$.

[‡]H. Davoudiasl, H. Logan, TH.

Recap

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"top-ten" list

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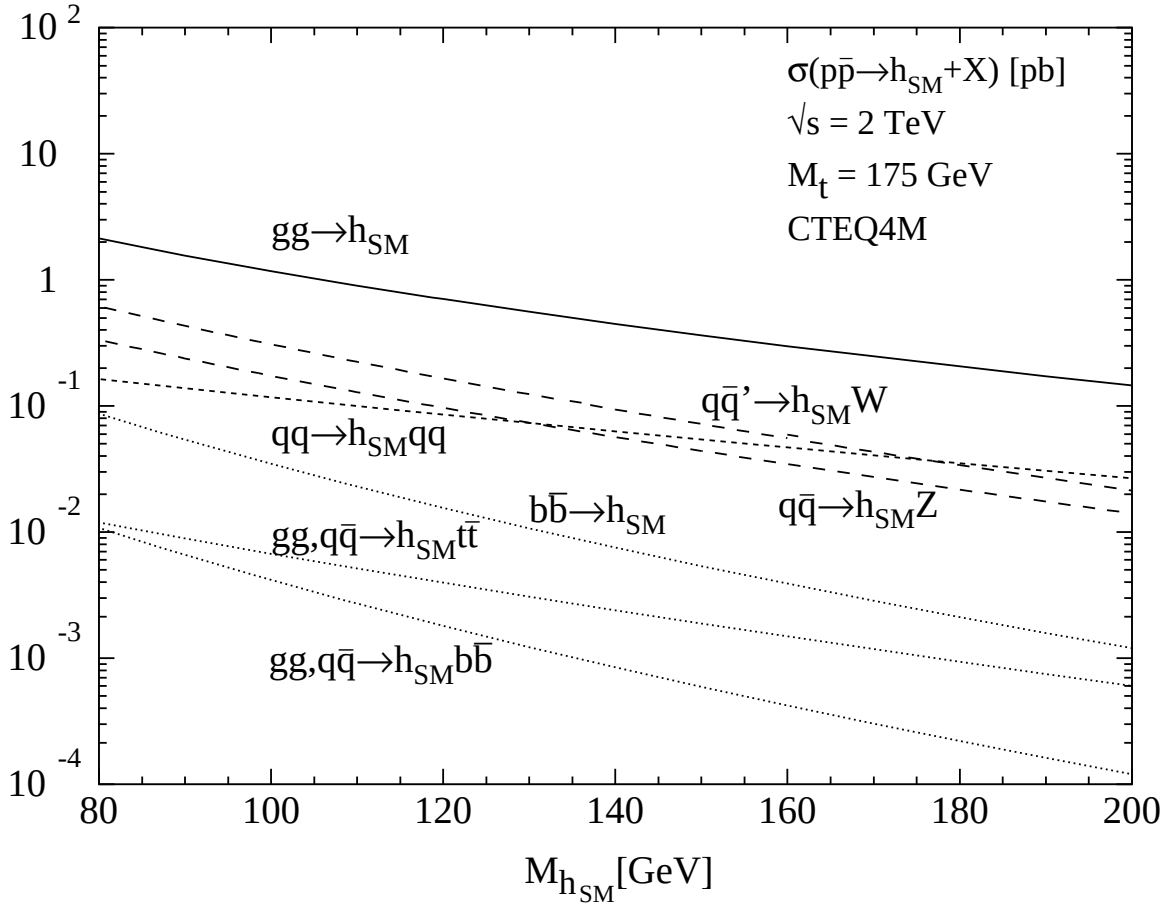
Each with motivations from underlining new physics.
Let's hope the best!


σ(pp̄→h_SM+X) [pb]
√s = 2 TeV
M_t = 175 GeV
CTEQ4M
gg→h_SM
qq̄'→h_SMW
qq→h_SMqq
bb̄→h_SM
qq̄→h_SMZ
gg,qq̄→h_SMtt̄
gg,qq̄→h_SMbb̄
10 2
10
1
10 -1
10 -2
10 -3
10 -4
80
100
120
140
160
180
200
M_h_SM[GeV]