ttH Potential in Run II

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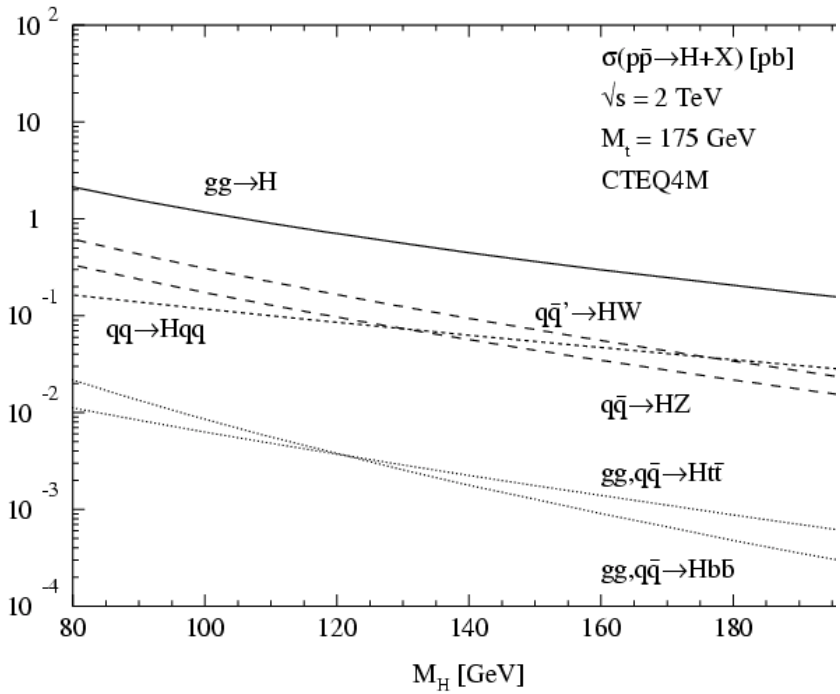
Why ttH?

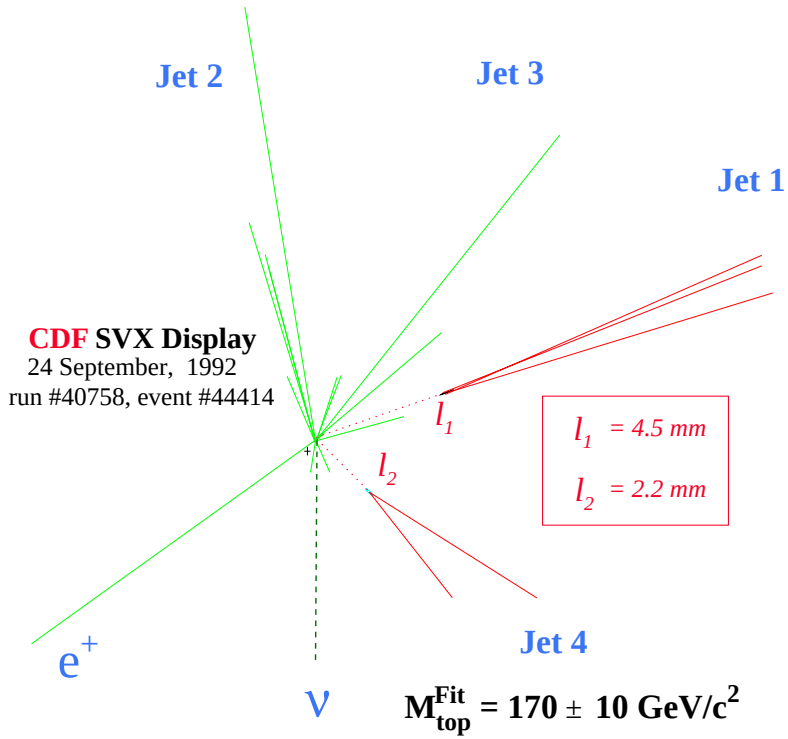
- First proposed by J.Gunion et. al., in context of SSC, LHC
  - Phys Rev Lett **71** 2699 (1993)
  - Use *top as tool* to tag Higgs
- What warrants *new* investigation at Tevatron?
  - Fermilab officially states 15 fb-1 per experiment as goal for Run II
    - For a 120 GeV Higgs, 110 very distinctive events
  - B-tagging Technology continues to improve
    - Vast improvements to experiments for Run 2A
      - **3D vertexing**
    - Run 2B upgrades even more promising
      - **70% single tag efficiency for Run2A + Run2B not impossible**



Comparison with top in Run 1A

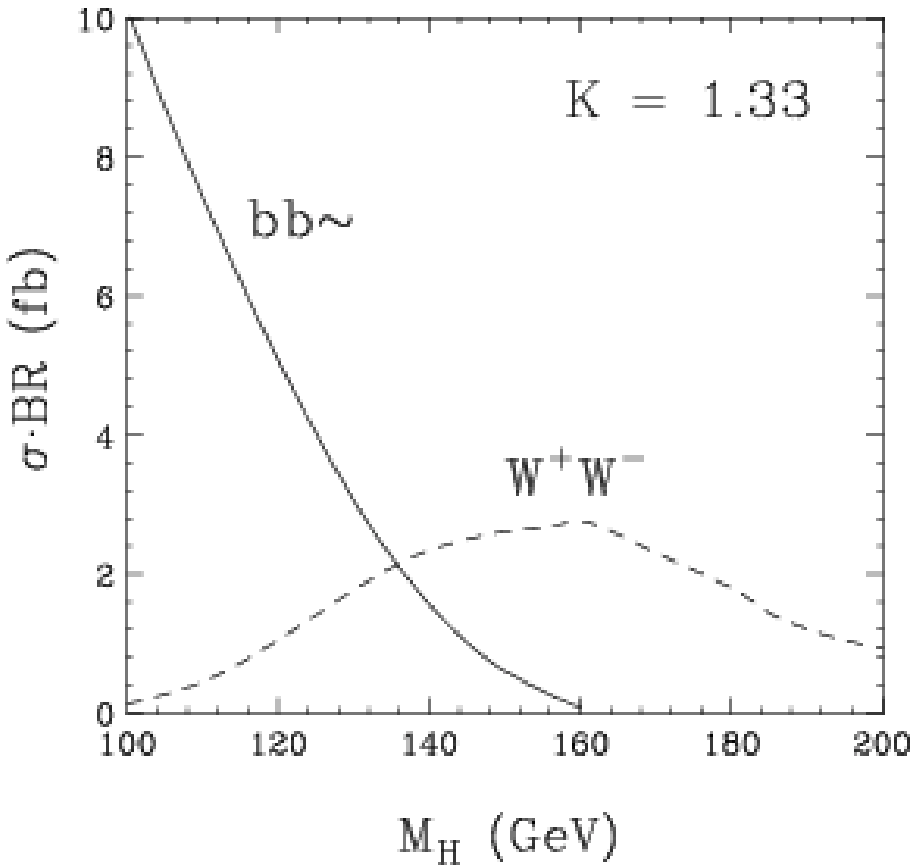
thinkshop^2
top-quark physics for Run II & beyond

- Number of Events
  - Run 1a ~ 100 ttbar
  - Run 2 ~ 110 ttH
- Backgrounds
  - Run 1a -> W+jets
  - Run 2a -> tt+jets
- Differences
  - Events more crowded
    - Mass reconstruction more difficult
  - Detector is better
    - Higher b-tag efficiency
    - b-tag higher purity



Event Topologies

- $H \rightarrow bb$ for $M_H < 140$ GeV
  - All hadronic (55%)
    - *jjjjbbbb*
  - **Lepton + jets (38%)**
    - ***ljjbbbb* + MET**
  - Dilepton (7%)
    - *llbbbb* + MET
- $H \rightarrow WW$ for $M_H > 140$ GeV
  - All hadronic (30%)
    - *8jbb*
  - Lepton + jets (42%)
    - *l6jbb* + MET
  - Dilepton (22%)
    - *lljjjj* +MET
  - Trilepton (6%)
    - *llljj* + MET



Backgrounds

The Backgrounds

K-factor of 1.33 included for all backgrounds.

backgrounds to $H \to b\bar{b}$	σ (fb)
$t\bar{t} + jj \quad (\Delta R(jj) > 0.4)$	1030
$t\bar{t} + b\bar{b}$	27
$t\bar{t} + Z, Z \to b\bar{b}$	1.5
$WZ + jj, Z \to b\bar{b}, W \to e\nu, \mu\nu$	10.4

backgrounds to $H \to W^+W^-$	σ (fb)
$t\bar{t} + jj \quad (\Delta R(jj) > 0.4)$	1030
$t\bar{t} + W$	17
$t\bar{t} + Z, Z \to \ell^+\ell^-$	0.9

- While ttbar + jets is largest background, it is reducible
- ttbb is largest irreducible background
- Scale uncertainties in matrix element calculations
  - tt+jets sample in Run II large enough to calibrate the MC

Event Generation

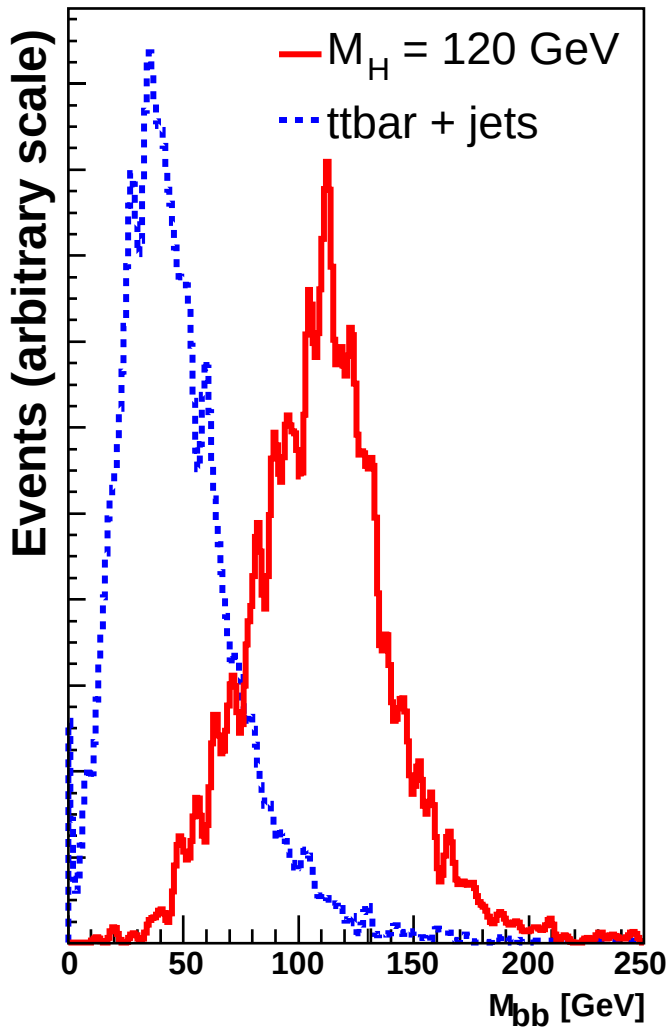
- Signal and background generated with Pythia 6.115
- Signal normalization given by exact tree-level matrix elements
  - Generated by MADGRAPH
  - COMPHEP
  - NLO corrected decay rates of Higgs via HDECAY
  - K-factor taken to be 1.33
    - NLO/LO ratio of the top cross section
    - Consistent with measured top cross section from Run I
- tt+jj parton level cross sections calculated using exact tree-level matrix elements
  - $\sigma_{ttjj} / \sigma_{tt} \approx 1/7$
  - Agree with Pythia within matrix element uncertainty

Run 2 Detector Simulation

- Parametric model of CDFII tracking
  - Uses Run 2a silicon system
  - Run I b-tag algorithm used
    - only 2D vertexing
- Run I CDF simulation used for calorimetry
- Default CDF Run1 jet clustering algorithm
  - cone size of 0.4
- Tagging Efficiencies
  - ε_b = 60%, ε_c = 25%, ε_j = 0.2%
    - This we believe is achievable in Run 2a
  - Expect Run 2b silicon replacement to be even better
    - ε_b = 70%, ε_c = 10%, ε_j = 0.02%
  - For this study (run2a + run2b) we have used
    - **ε_b = 70%, ε_c = 25%, ε_j = 0.2%**

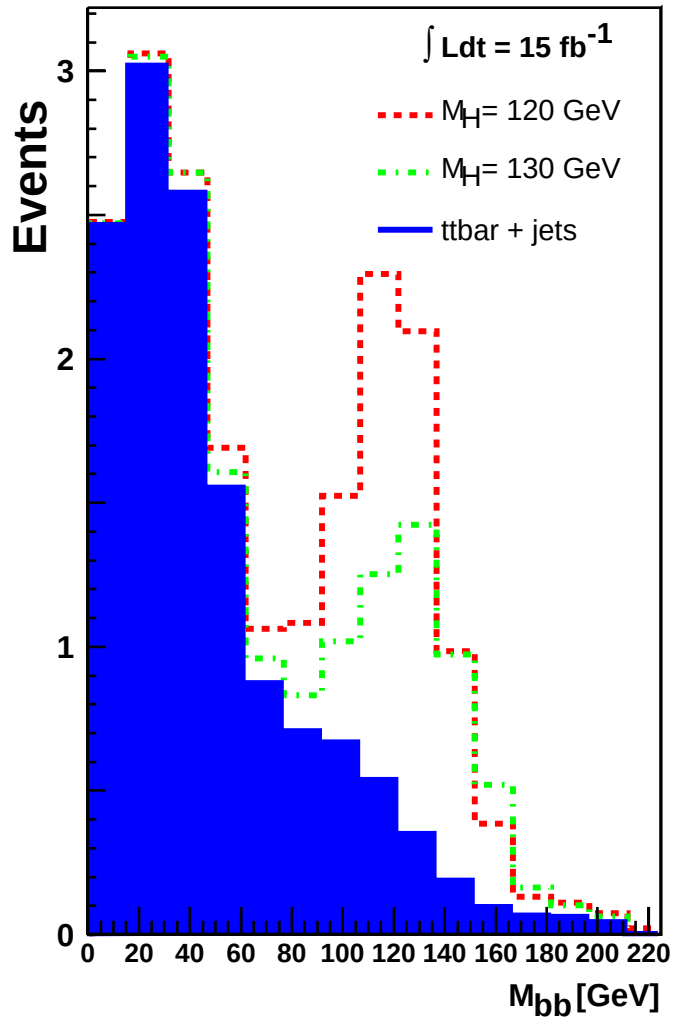
Light Higgs Analysis

- Selection Cuts
  - 1 isolated lepton > 15 GeV
  - Missing ET > 15 GeV
  - 4 jets greater than 15 GeV
  - 2 additional jets > 10 GeV
    - Required to reconstruct ttH
  - 3 b-tags
    - Reject ttjj background
  - Require invariant mass of 4th highest b-candidate pair be greater than 60 GeV
    - Exploit low invariant mass of quarks from gluon splitting



Light Higgs Analysis Results

- M_H = 120 Gev, 15fb-1
  - ~7 signal events
  - ~12 ttbb background
  - ~2 ttcc background
- Reconstruct top
  - Top reconstruction efficiency depends on
    - Number of Combinations
      - **Number of b-tags**
        - **CDF Run I, 2 tags -> 60%**
      - **Purity of b-tags**
  - ttH has more combinations than ttbar *but*
    - Don't care if reconstruct top correctly
    - 3 high purity b-tags
- 2.5σ significance for 60% efficiency
- 2.8σ significance with 70%



Heavy Higgs

- Backgrounds swamp all hadronic and lepton + jets channels
- All leptonic mode has negligible σxBR
- Other modes have *very few events* but they are *very distinctive*
  - Trileptons
    - ~1 event after cuts
  - Like sign dileptons
    - 1-2 events after cuts
- Will be helpful in corroborating evidence seen for Higgs at this mass in other channels

Comments

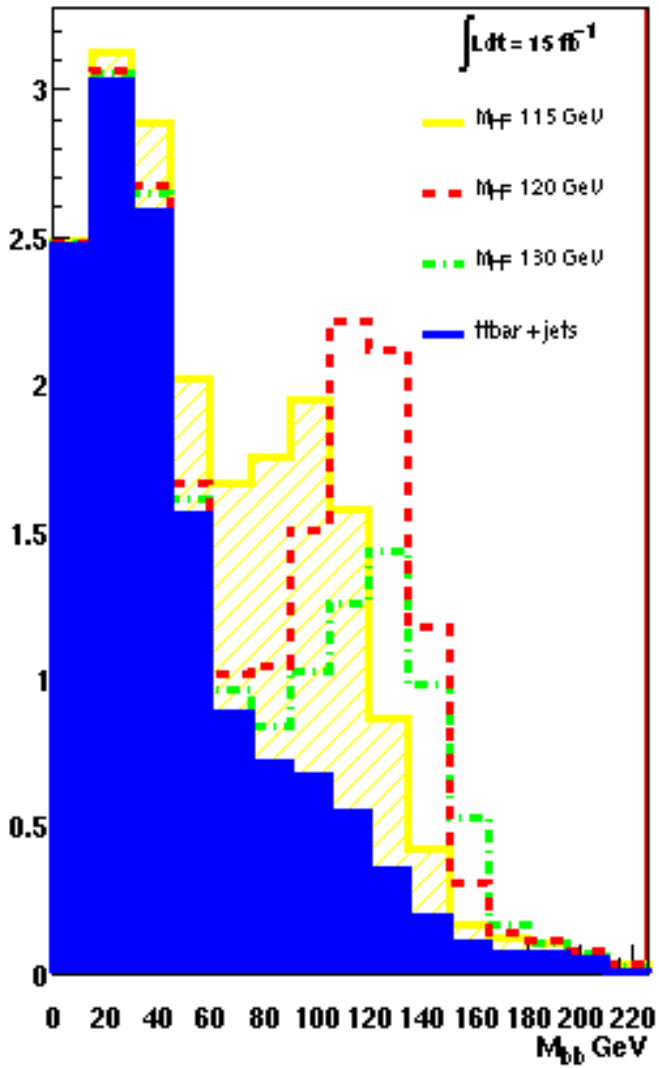
- This search is limited by machine luminosity
  - Factor of 3 pushes significance over 5σ
- Only one experiment has been considered
  - D0 needs to investigate as well
    - **Significance over 4σ with two experiments**
- Search will depend on not only capability of current silicon systems (run 2a) but their *replacements for run 2b*
  - Need to design best possible system for these and other physics needs
- Have only shown mass analysis
  - Counting experiment in the works
    - Exploit kinematic separation in dijet invariant mass

Summary

- ttH provides a ***complementary*** search to those already considered in the Run II Higgs Working Group report
- In combination with these searches, or alone, ttH will benefit from
  - Luminosity
  - Detector upgrades
- We are excited about prospects for seeing Higgs at Tevatron and strongly recommend that every effort be made to maximize the opportunity for a discovery prior to the LHC era
  - *Top may be just the tool* needed to push the Tevatron Higgs search over the … **top**

What if Higgs is say **114.9 GeV?**

- M_H = 115 Gev, 15fb-1
  - ~8 signal events
  - ~12 ttbb background
  - ~2 ttcc background
- Cuts not optimized for 115 GeV



Ordered dijet mass pairs

- 4 b quarks
  - 6 mass combinations
- 3 tags plus random guess from remaining jets
- Working on combining this separation
  - Background rejection may be sufficient to allow counting experiment