Prospects for Higgs Searches at CDF in Run II

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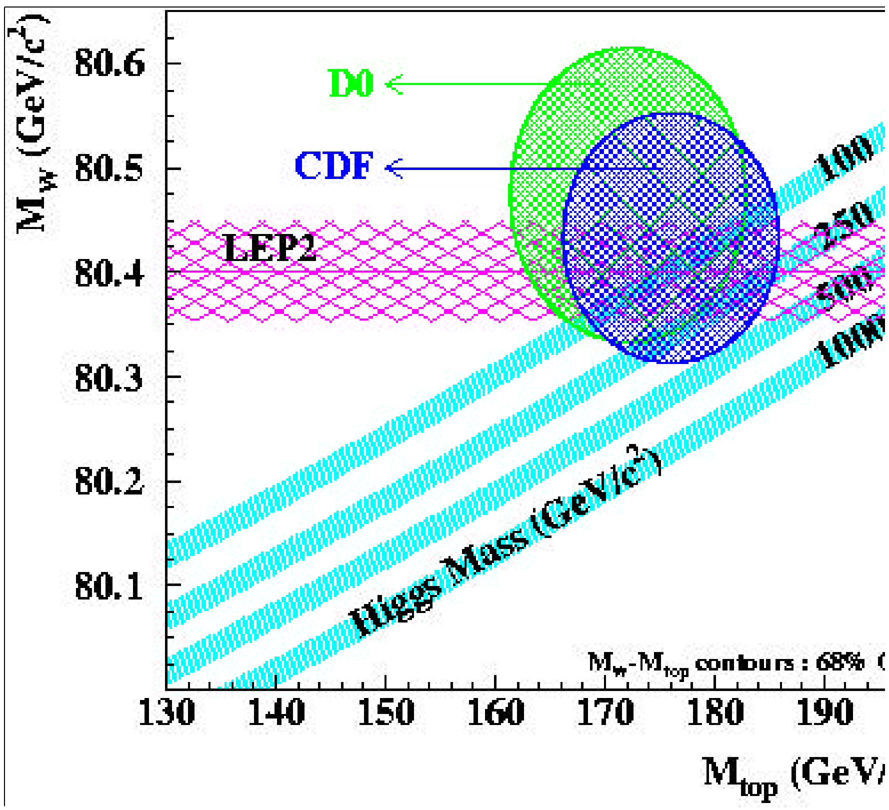
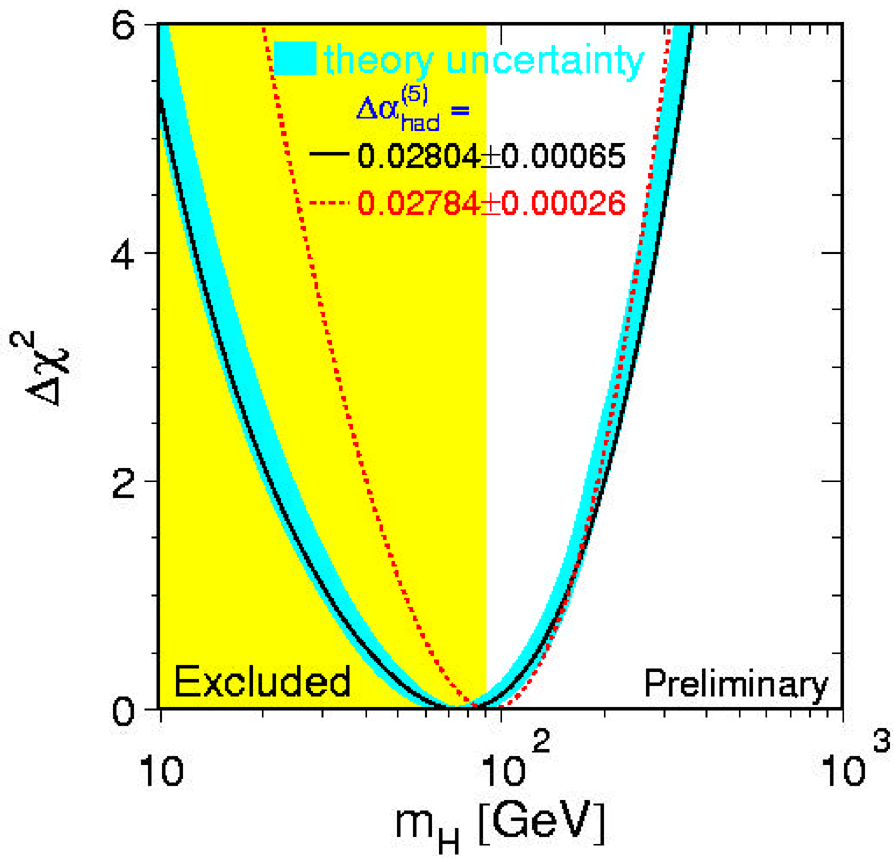
Acknowledgements: Report of the Tevatron Higgs Working Group:

http://fnth37.fnal.gov/higgs.html

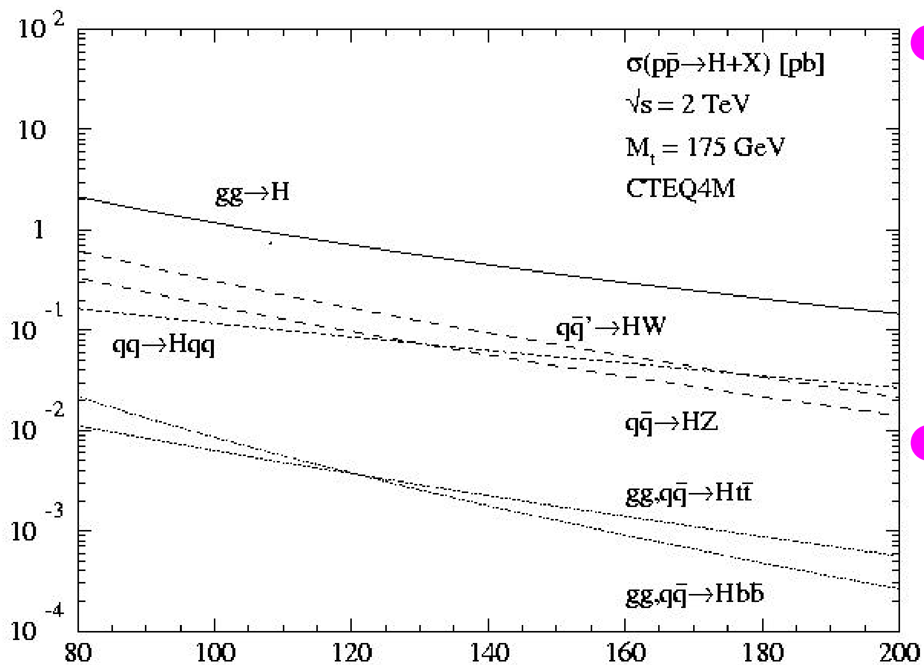
The Standard Model Higgs

- **Data seem to prefer low mass Higgs:**
  Is it within reach in Run II?





Higgs Production at the Tevatron



- **gg® H dominates over all mass ranges, but backgrounds are largest**
  - **At high masses H->WW helps**
- **WH, ZH modes provide straightforward trigger, smaller backgrounds**
- **Htt mode provides distinct signature**

Higgs Decays

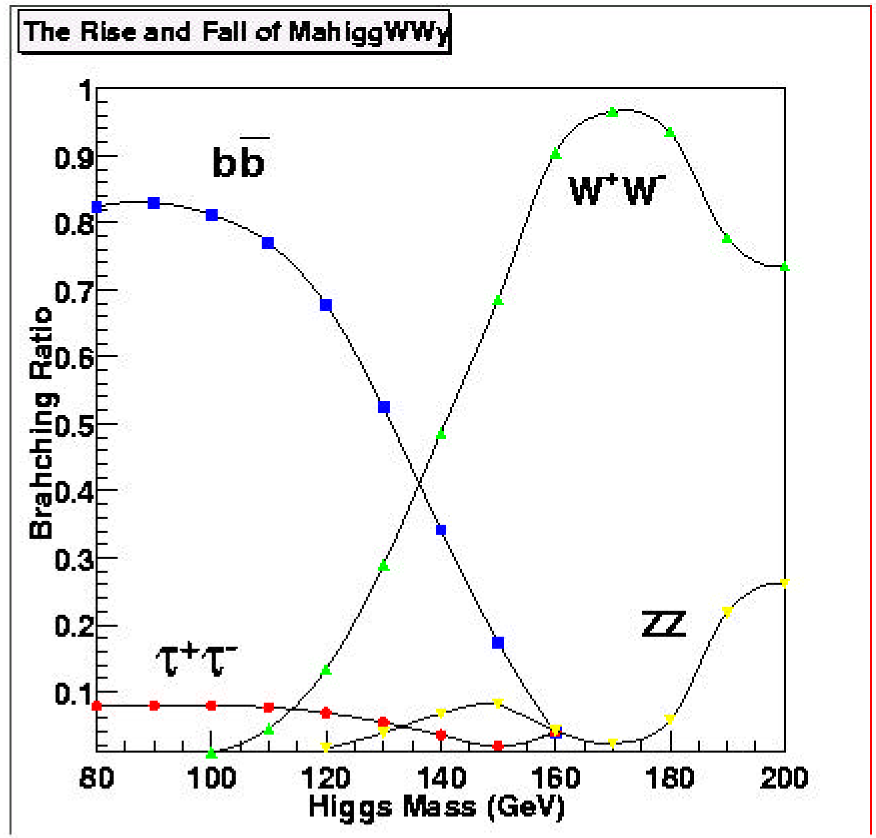
- **m(H) < 130 GeV**
  - ➢ **Most promising modes:**

$$\ell n b\bar{b},\ \ n\bar{n} b\bar{b},\ \ \ell^+\ell^- b\bar{b},\ \ q\bar{q} b\bar{b}$$

  - ➢ **B-tagging, jet resolution are the key**
- **m(H) > 130 GeV**
  - ➢ **Most promising modes:**

$$\ell^+\ell^- n\bar{n},\ \ \ell^\pm\ell^\pm jj,\ \ \ell^\pm\ell^\pm\ell^\mp$$

  - ➢ **Good lepton ID, coverage are the key**

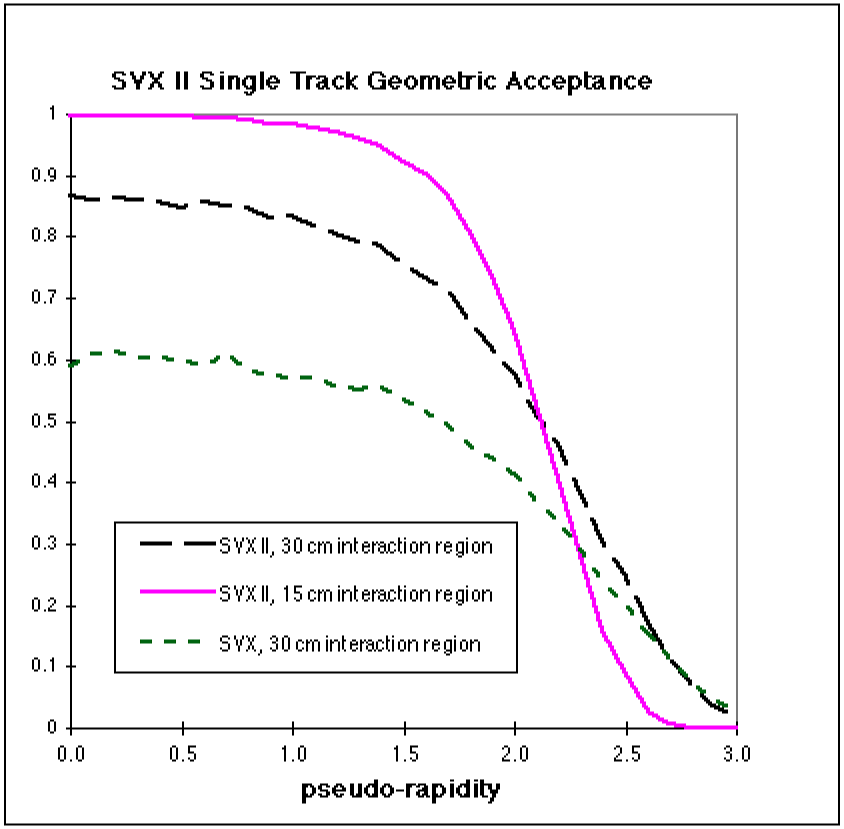


Impact of the Upgrades

- **COT**
  - ➢ **Much better stereo, faster drift: Preserves Run I capability for Run II**
- **SVXII, ISL, Layer00**
  - ➢ **Radiation hard, 3D vs 2D, much better pattern recognition**
  - ➢ **Much better Z-vertexing**
  - ➢ **Tracking and b-tagging out to larger rapidity**
- **SVT**
  - ➢ **Identification of B hadrons at Level 2: Calibration using** $Z \rightarrow b\bar{b}$
- **Muon System**
  - ➢ **Coverage nearly doubles**
- **End Plug Calorimeter**
  - ➢ **Much better Electron ID out to |h| < 2.0**

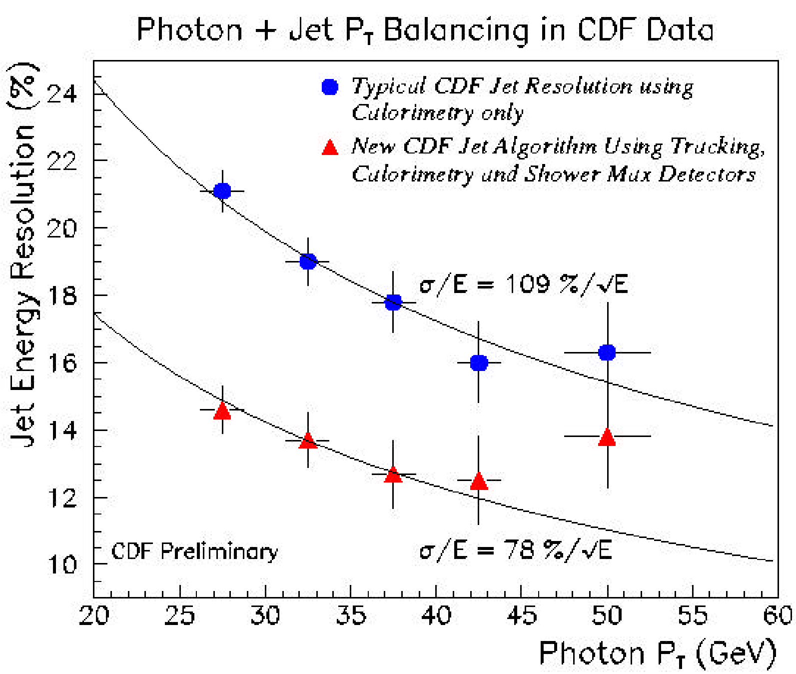
B-tagging in Run II

- **B-tagging at CDF in Run I**
  - ➢ **4 layer SVX**
  - ➢ **single tag eff (top events)**
    - **eff = 25%** **(includes geom acc ~0.5)**
  - ➢ **double tag eff (top events)**
    - **eff = 8%**
- **B-tagging at CDF in Run II**
  - ➢ **5 layer DS-SVX, ISL, Lay00**
  - ➢ **single tag eff (top events)**
    - **eff = 49%**
  - ➢ **double tag eff (top events)**
    - **eff = 25%**

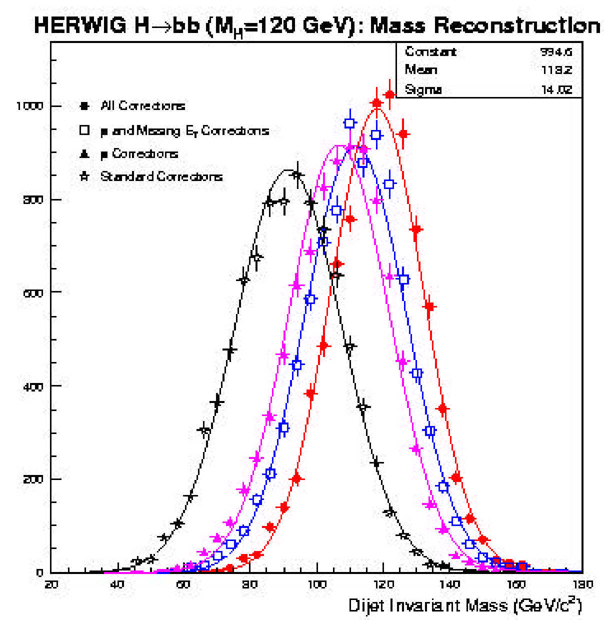


Jet-Jet Mass Resolution in Run II

- **Using more information can dramatically improve jet resolution:**
  - **Standard jet algorithm uses only calorimeter information**
  - **adding charged particle info, plus shower max detector info improves energy resolution by 30%**

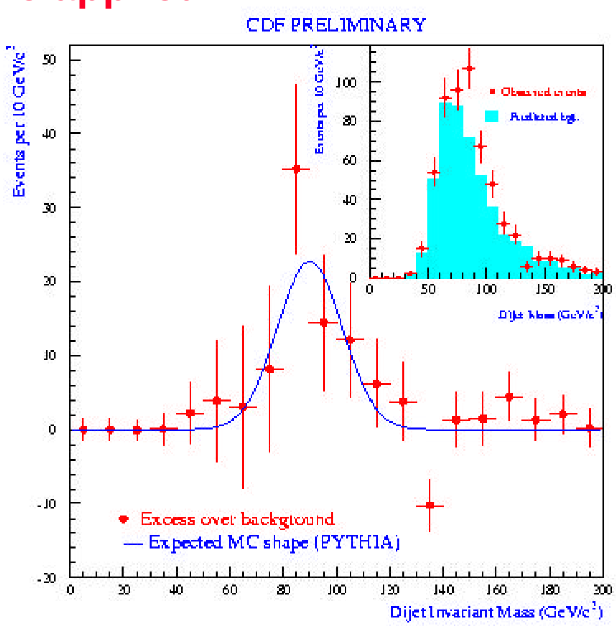


- **Monte Carlo study of dijet mass resolution in Z®bb events collected via inclusive muon trigger**
  - **adding muon momentum, missing transverse energy projection along jet axis, charged fraction improves dijet mass resolution by 50%**

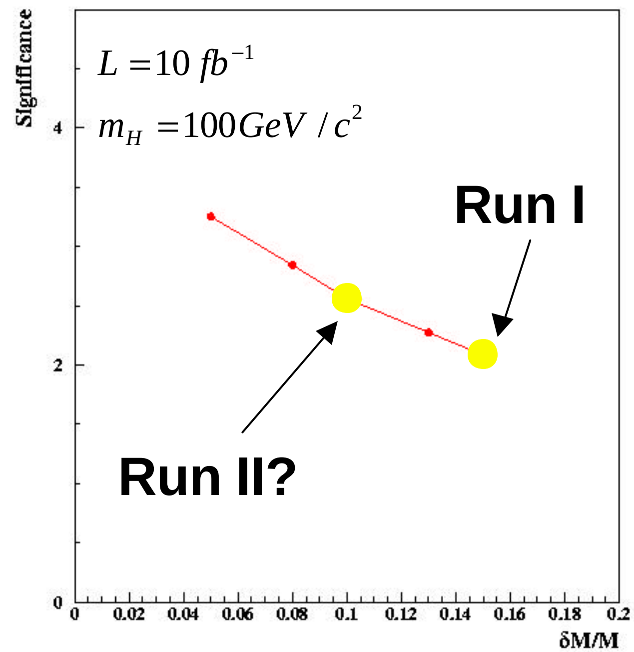


Jet-Jet Mass Resolution in Run II

- **Using these corrections in Run I data:**
  - **Real Z ® bb decays behave as expected**
  - **Average value and width agree with MC expectations after corrections are applied**



- **Impact on significance of a possible Higgs signal:**
  - **If the dijet mass resolution can improve to 10%, then an increase in significance of almost 50% is possible**



Search Strategies

- **Low mass Higgs: Example M(H)=120 GeV**
  - **Use Pythia MC for signal, most backgrounds. (Herwig for Wbb)**
  - **Use CDF Run I detector simulation**
    - **B-tagging should be better in Run II**
    - **Dijet mass resolution assumed to be 30% improved over Run I**
  - **Trigger criteria**
    - **High pt central e or mu; OR missing energy + B-tagged jet**
  - **Event selection**
    - **Lepton with P_t > 20 GeV/c**
    - **MET > 20 GeV/c**
    - **2 B-tagged jets (T/L)**
      E_t > 10 GeV/c
    - **1 tagged jet E_t > 25 GeV**
    - **No additional jets with E_t > 20 GeV**
    - **Veto events with 2 isolated high tracks**
    - **m(bb) in window 89-135 GeV**

Low Mass Higgs, WH Mode

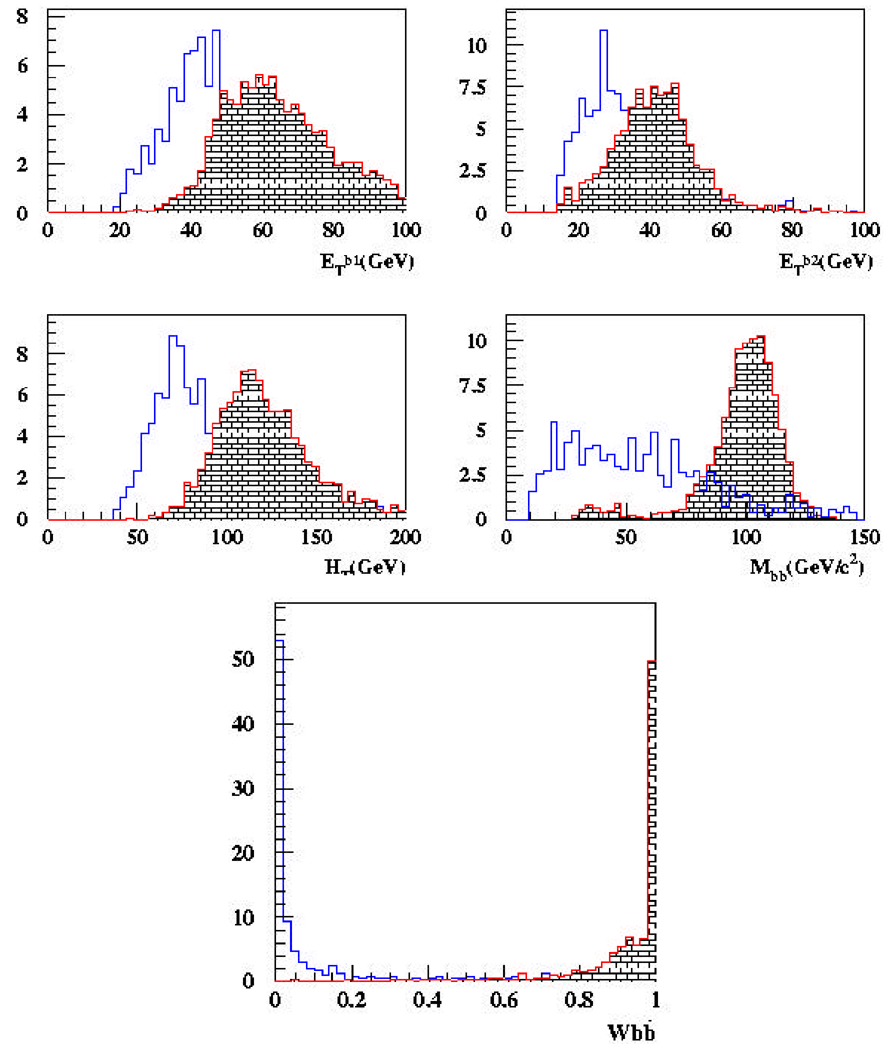
- **Assuming M(H) = 120 GeV, and a luminosity of 20 fb^{-1}**
  - **After all cuts:**
    - **74 WH events remain**
    - **986 total background events**
    - **S/ÖB=2.4 (about 99%CL)**
  - **Need L=10 fb^{-1} for 95%CL**
  - **Need L=90 fb^{-1} for 5s discovery**

Note: All event #'s shown assume L=20 fb^{-1}

	s(pb)	#events produced 20fb^{-1}	# events after cuts 20fb^{-1}
WH	0.16	3,200	74
$Wb\bar{b}$	10.6	212,000	394
$t\bar{t}$	7.5	150,000	376
t b	1.0	20,000	192
tqb	2.5	48,000	78
WZ	3.2	64,000	46

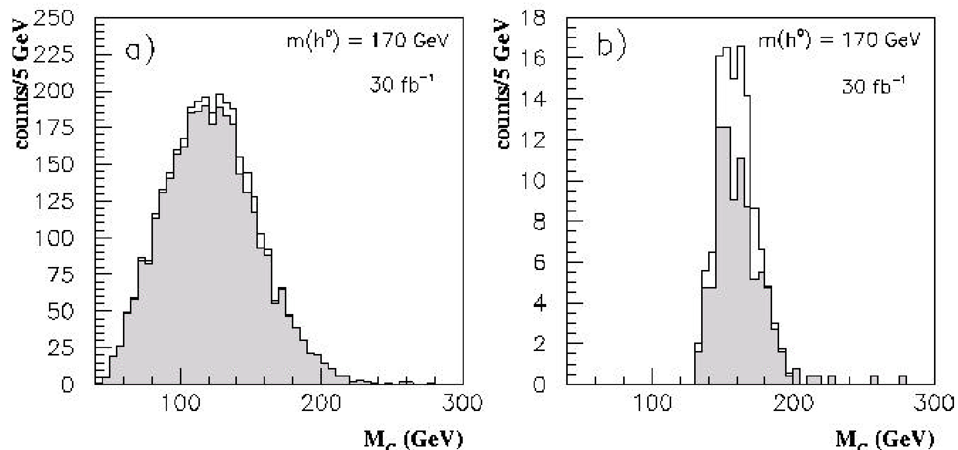
Low Mass Higgs

- **How do we improve things?**
  - **Add ZH, Z®nn,ℓℓ modes**
    - **Expect 34 signal events 166 background events in L=20fb, S/ÖB=2.6**
  - **Use more aggressive analysis techniques, such as neural networks:**
    - **For WH, H®bb:**
      - **expect 61 signal events 441 background events in L=20fb, S/ÖB=2.9**
      - **versus 2.4 traditional cuts method**



High mass Higgs: Example
M(H)=170 GeV

- **Use Pythia MC for event generation, SHW detector simulation (developed by Higgs Working Group)**
- **Focus on H® W^*W^* ® ℓ^+n ℓ^-n**
- **Trigger criteria**
  - **Two High pt central e or mu**
- **Event selection**
  - **angular cuts to remove** tt **background**
  - **Veto events with high Et jets, or B-tags**
  - **Use kinematic likelihood plus cut optimization**

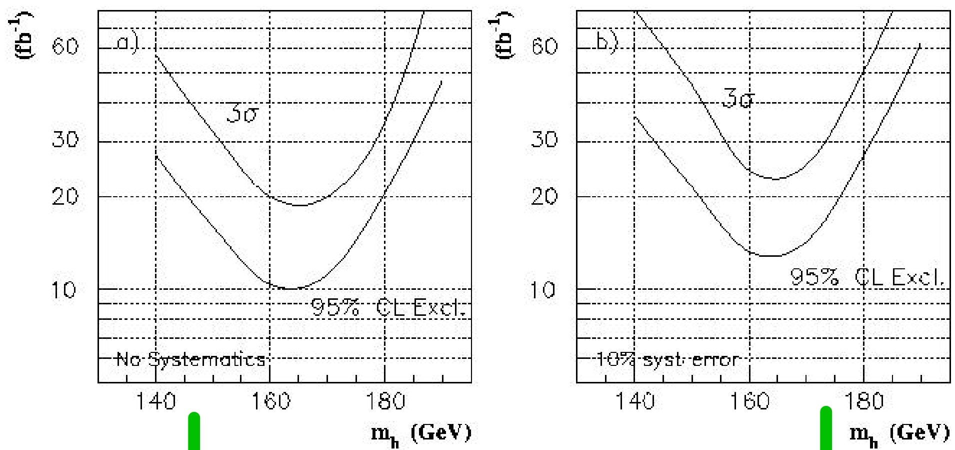


	Background Events In $20fb^{-1}$	*Signal Events In $20fb^{-1}$*
Selection	**3356**	**37**
Likelihood	**2100**	**31**
Optimized Cuts	**46**	**22**

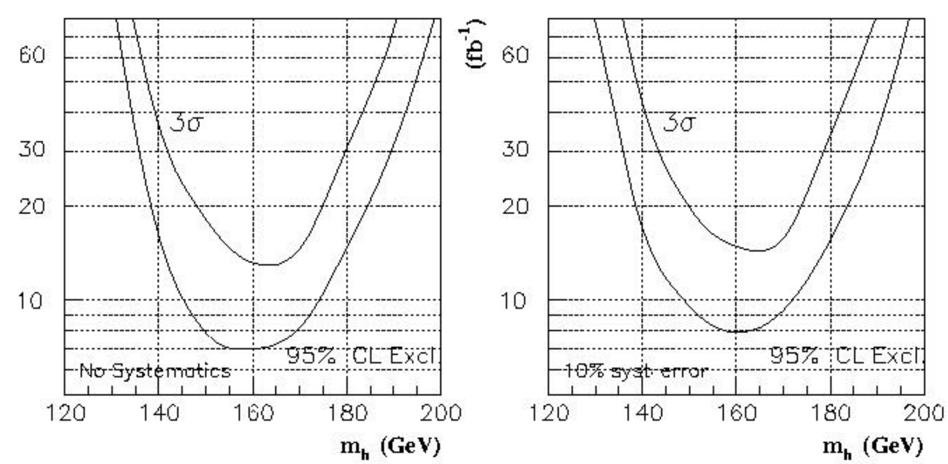
High mass Higgs: Example M(H)=170 GeV

- **How do we improve things?**
  - **Add WH®WWW mode, all 3 W's decay to e, m (trilepton)**
    - **Expect 0.7 events, 0.5 background in L=20fb, S/ÖB=1.0**
  - **Add W/ZH ® ℓℓjj mode (like sign dileptons + 2 jets)**
    - **Expect 7.6 events, 11.6 background in L=20fb, S/ÖB=2.2**

H® W*W* ® ℓ+n ℓ-n

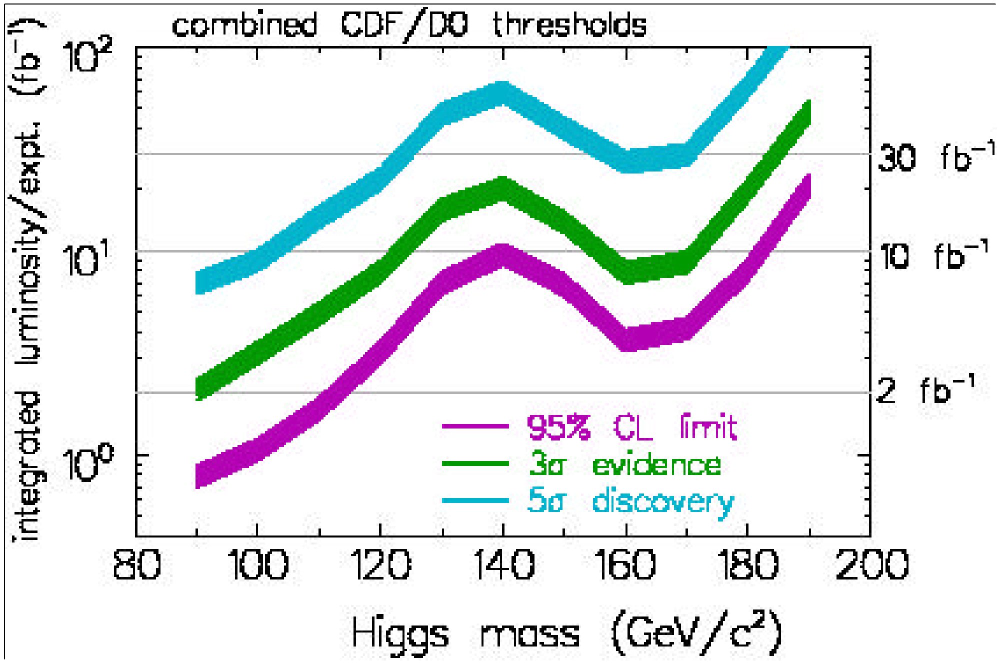


Adding W/ZH ® ℓℓjj , ℓℓℓ



Higgs Combined Channel Results

- **Determine Signal and Background for each channel**
- **Form a joint liklihood of all channels, including D0 and CDF results**
- **Integrate Likelihood to form 95%CL limit, as a function of Higgs cross section**
- **Discovery thresholds determined by ratio of maximum likelihood to likelihood at zero Higgs xsec**
- **At each mass, determine the require integrated luminosity at which 50% of future outcomes meet the desired threshold.**



Fermilab Long-Term Luminosity Goals

- **Can we get to 20fb-1 or more?**
- **The following schedule yields ~15fb-1 by 2008**