PHYS 5326 – Lecture #23

Monday, Apr. 21, 2003
Dr. Jae Yu

- Backgrounds to Higgs Searches
- Requirement on Experiments for Higgs Searches

Announcement

- Semester project presentation
  - 1:00 – 4:00pm, Wednesday, May 7 in room 200
  - 30 minutes each + 10 minute questions
  - Send me slides by noon, Wednesday, May 7
  - The slides will be made as UTA-HEP notes, thus we need to make the presentations electronic
  - Order of presentation: SH, VK, BS, FJ
- Project reports due at the presentation
  - Must be electronic as well so that they can be made UTA-HEP notes

Summary of Final States of Interest

- W decay:
  - $W \rightarrow qq$ channel very hard
    - depends on dijet mass resolution
  - $W \rightarrow e\nu, \mu\nu, \tau\nu$
    - Isolated lepton plus missing E_T
- Z decay
  - $Z \rightarrow qq$ same as W – difficult
  - $Z \rightarrow ee, \mu\mu$ (probably not $\tau\tau$)
    - Isolated lepton plus mass resolution
- Higgs decay:
  - Look for $b\bar{b}$ pairs
    - Impact parameter resolution
    - Silicon vertexing
    - Di-jet mass resolution

b-tagging is a MUST

Higgs Backgrounds To WH

- $WH \rightarrow l\nu\, b\, \bar{b}$ backgrounds
  - $Wb\, \bar{b}$
    - Where the W decays leptonically
    - Cross section is $2.3nb*\alpha_s^2*m_b$-threshold factor for each lepton
  - WZ:
    - W decays leptonically while Z decays to $b\, \bar{b}$
    - Cross section is $2.3nb*\alpha_{EW2}$*b final state branching ratio

Higgs Backgrounds To WH

- $t\bar{t}$: Each t decays to W and b pairs. How would this become a background?
- single t: How?

- $WH \rightarrow qq\, b\bar{b}$ overwhelmed by QCD background since it has four jets in the final state

Higgs Backgrounds to ZH

- $ZH \rightarrow l\,l\,b\,\bar{b}$ final state for signature
  - $Zb\,\bar{b}$
    - Z decays to two leptons
    - Cross section is $0.2nb*\alpha_s^2*m_b$-threshold factor for each lepton
  - ZZ
    - One Z decays to two leptons while the other decays to $b\,\bar{b}$
    - Cross section is $2*0.2nb*\alpha_{EW}$*b branching ratio
  - $t\,\bar{t}$:How does this channel become background to ZH?

Higgs Backgrounds to ZH

- $ZH \rightarrow \nu\nu\, b\, \bar{b}$
  - QCD:How would this become background to this process?
  - $Zb\, \bar{b}$: Z decays to neutrinos
  - ZZ: One Z decays to neutrinos while the other decays to $b\, \bar{b}$
  - $t\, \bar{t}$: How would this process become background?

Higgs Backgrounds to $gg \rightarrow H \rightarrow WW^*$

- WW final state is a generic, inherent and irreducible background
- 2*l*+MET final state
  - ZZ: One Z decays to two leptons while the other to two neutrinos
  - Drell-Yan ($qq \rightarrow \gamma^* \rightarrow ll$)
  - $t\bar{t}$: How this could be the background to this process?
  - WZ: Z decays to two leptons, while W decays to $l+\nu$ where l is lost
  - $\tau\tau$: Both τ's decay leptonically

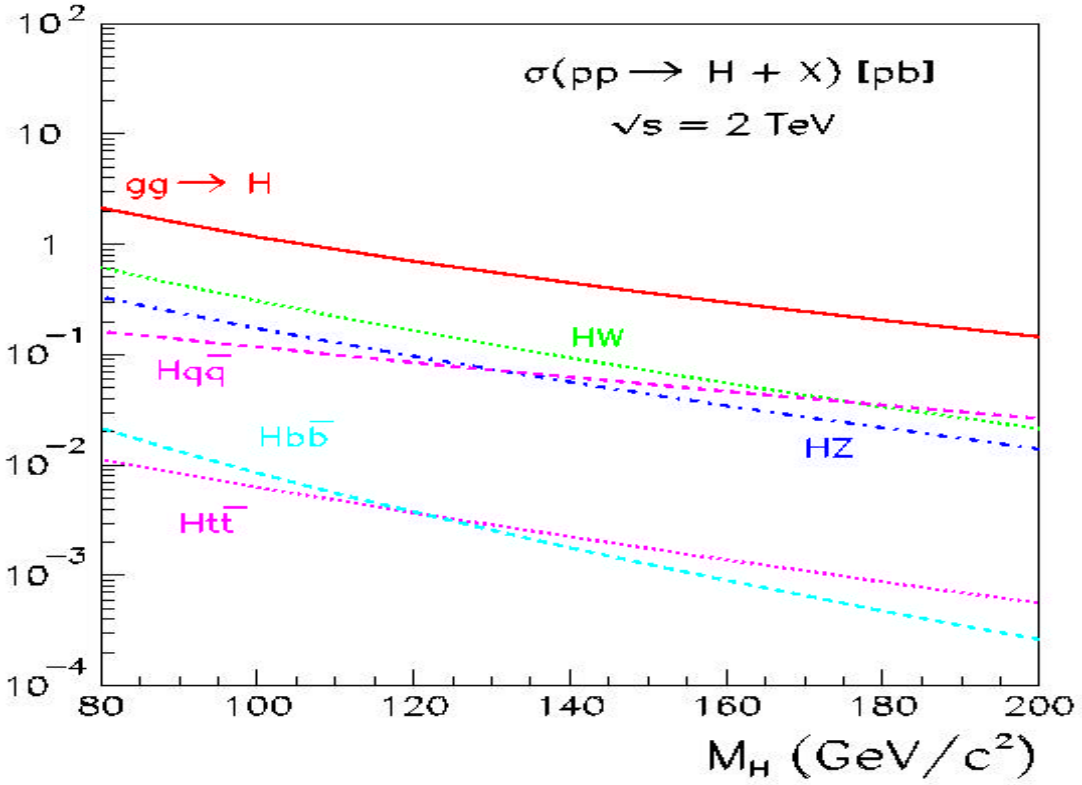
Higgs Backgrounds to $gg \rightarrow H \rightarrow WW^*$

- $1l$+MET+2jets final state
  - WZ: W decays to $l+\nu$ and Z decays to two jets
  - ZZ: One Z decays to two leptons (of which one is lost) while the other to two jets
  - $t\bar{t}$: How is this become a background to this process?
  - tW:How could this become a background to this process?

Summary of Higgs Physics Backgrounds

- The best discovery channel is with HW and HZ
- The background for $m_H < 130$ GeV are
  - $WH \rightarrow l\nu\, b\, \bar{b}$ backgrounds $Wb\, \bar{b}$, WZ, $t\, \bar{t}$, single t
  - $WH \rightarrow qq\, b\, \bar{b}$ overwhelmed by QCD background since it has four jets in the final state
  - $ZH \rightarrow llb\, \bar{b}$ backgrounds $Zb\, \bar{b}$, ZZ, $t\, \bar{t}$
  - $ZH \rightarrow \nu\nu\, b\, \bar{b}$ backgrounds QCD, $Zb\, \bar{b}$, ZZ, $t\, \bar{t}$
- The background for $m_H > 130$ GeV are
  - $gg \rightarrow H \rightarrow WW^*$ backgrounds Drell-Yan, WW, WZ, ZZ, tt, tW, $\tau\tau$

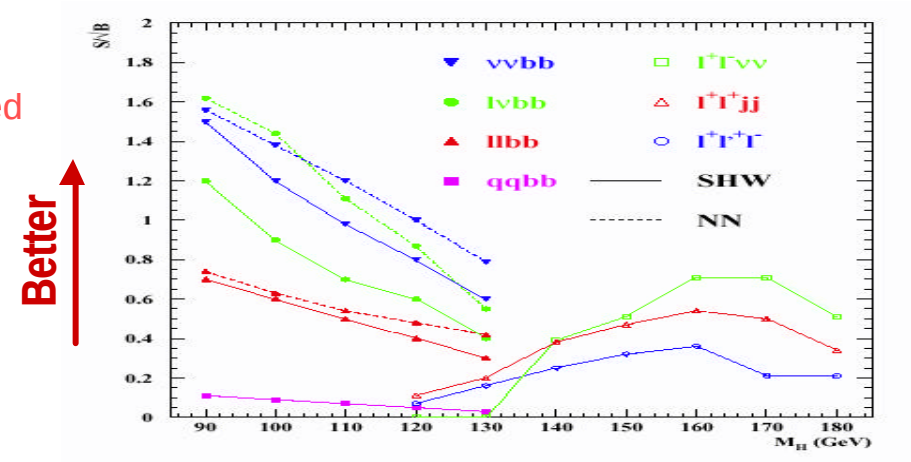
Tevatron Higgs Production σ



TeVatron Run II Higgs S/N

- $H \rightarrow b\ \bar{b}$
  - S/N drops as M_H increases
    - Run out of events….
    - Ultimately limits the experimental reach
- $H \rightarrow WW/ZZ$ (virtual)
  - Depends on di-jet mass resolution

1 fb^{-1} delivered



What do we need to do all this?

- Smaller x-sec ➔ Need higher rate
- Increase CMS energy of the accelerator
  - Increased x-sec
  - Increased kinematic reach for higher M_H
- Increased instantaneous Luminosity
  - Increased Number of protons and anti-protons, especially anti-protons
  - Increased duty factor/efficiency
  - Shorter fill time of anti-protons

Run II TeVatron Benchmarks

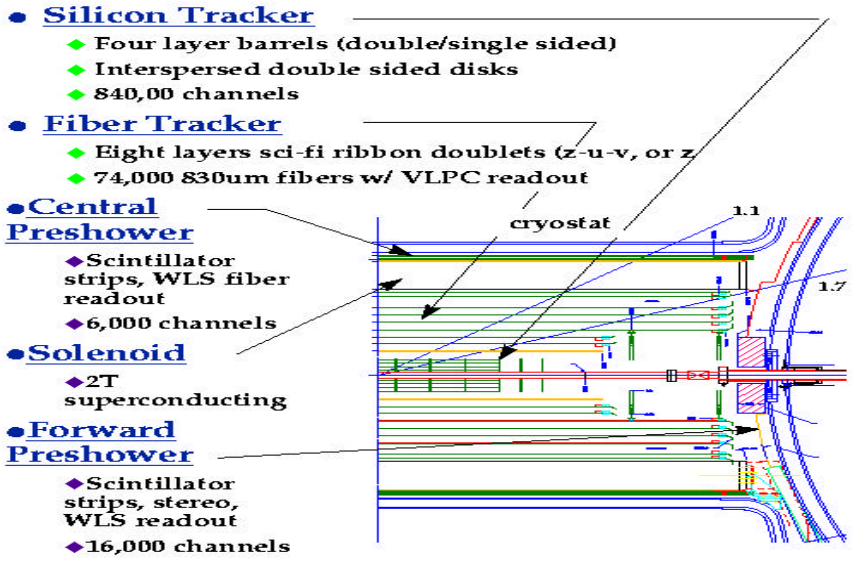
Parameters	Run I	RunIIa/b
L_{inst} (cm^{-2} sec^{-1})	~10^{31}	2x10^{32} ~10^{33}
Bunch Spacing	3.5 μsec	396 / 132 nsec
E_{CMS}(TeV)	1.8	1.98
L_{int}	~110pb^{-1}	2fb^{-1} / >6fb^{-1}

- $\sigma(tt)$ ~ 40% higher at 2 TeV
- δM_H ~ 40% per experiment
- Increase in rates
- Decrease in bunch spacing

- Detectors need to be able to:
  - Tag the b-quark jets
    - Capable of measuring vertex that are ~100μm away from the primary vertex ➔ Precision vertex detector
    - Tag and associate leptons with a jet
  - Good Track momentum measurement, charge, and P-ID
  - Good jet mass resolution
  - Faster and more efficient and targeted trigger
    - Track trigger
  - Higher data recording bandwidth

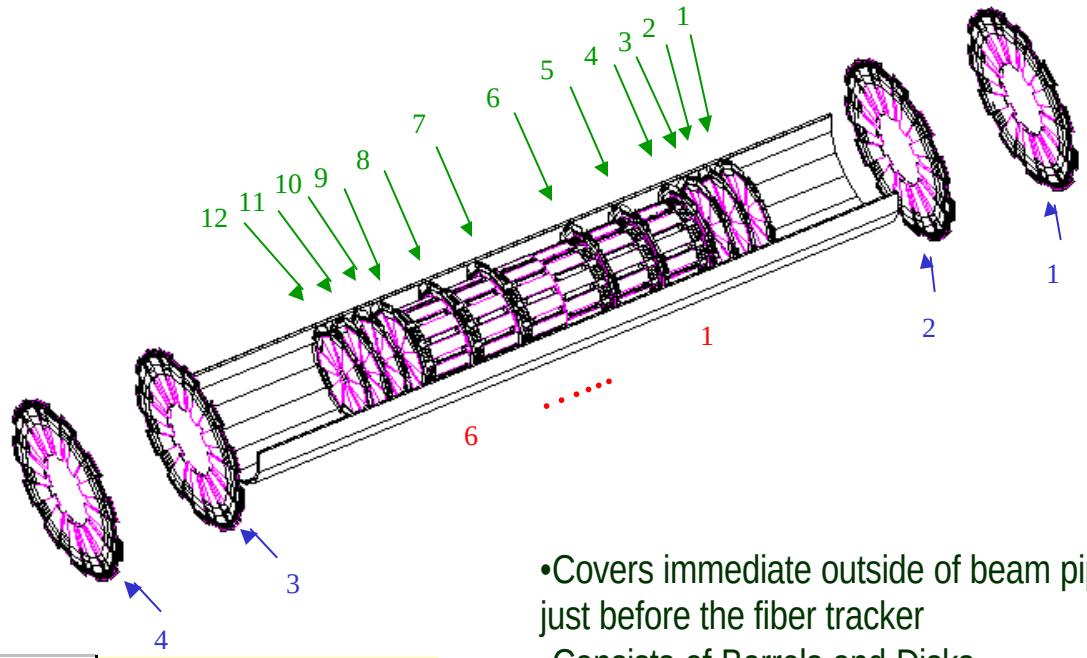
Upgraded DØ Tracking System

- Ability to trigger on tracks for quick dicision
- Measure momentum and identify charge
- Upgrade tracking & Trigger systems



Charged Particle Momentum Resolution
$\Delta p_T/p_T$ ~ 5% @ p_T = 10 GeV/c

DØ Silicon Microstrip Detector

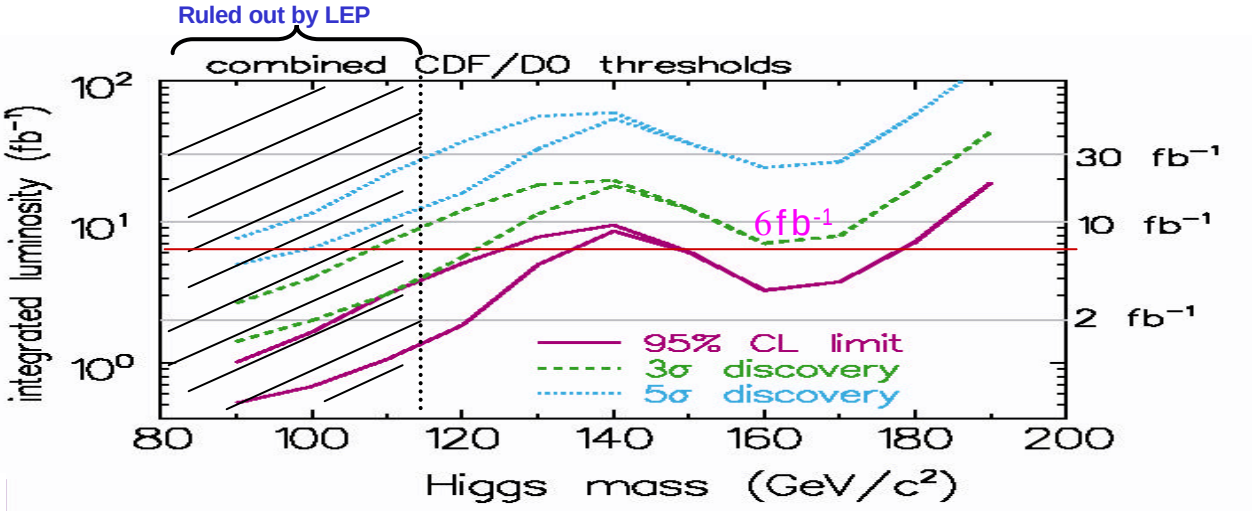


	Barrels	F-Disks	H-Disks
Channels	387072	258048	147456
Modules	432	144	96
Inner R	2.7 cm	2.6 cm	9.5 cm
Outer R	9.4 cm	10.5 cm	26 cm

- Covers immediate outside of beam pipe to just before the fiber tracker
- Consists of Barrels and Disks
- Total number of readout channels are 800k
- Expected Position resolution 10~20μm

Tevatron Run II Expectation

- LEP limit M_H>115 GeV
- Can have up to 6 fb^{-1}/exp by 2010➔ Good to reach 95% CL limit up to M_H ~ 180GeV



Homework Assignment

- Compute the following quantities for WH and ZH final states with leptons for M_H=115 GeV and L=15fb^{-1}.
  - Expected percentage of various final states
  - Number of signal events for the final states
- Due: Wednesday, Apr. 23
- Suggestion: Make a table of the above quantities