The Accelerators

approx 4 miles around (6.3 Km)

p-pbar at 1.96 TeV

approx 27 Km around

pp at 7+ TeV

Superconducting Magnets!
Luminosities are Increasing

We owe a great debt to our colleagues in the Accelerator and Computing Divisions

Fernandez
The Detectors (Not to Scale)
The Historical SM Higgs Context – LEP excludes SM $m_H < 114.4$ GeV

Small excesses seen at $m_H = 97$ GeV and 115 GeV

Search for $e^+e^- \rightarrow ZH$

$H \rightarrow bb, \tau\tau, WW$
The Scale of the Problem

F. Margaroli

C. Ochando

Rapid progress through this plot expected.
The Tevatron – Gaining Confidence in Searches with Standard Candles

F. Margaroli

Z → b b̅ bar
Calibrates/checks
b-jet energy scale
b-tag efficiency
Techniques for separating small signals from large backgrounds using sideband data to model backgrounds

WW+WZ Diboson observation in MET+Jets
Similar, but with a much smaller cross section

σ(WW+WZ) = 20.2 + 4.5 pb

D0 Diboson with a Multivariate Discriminant – First evidence in 1.1 fb⁻¹
Single top in l+MET+(b)jets

Now measure a signal smaller than WW/WZ but with (almost) the same event selection as the HW search
- require large MET and two/three(four) jets CDF(D0)
- At least one b-tagged jet
- One charged leptons (e/μ)

Simultaneous observations at CDF and D0
Similar S and B: S=200 wrt B=4000

Likelihood
Neural networks
Bayesian NN
Evolutionary NN
Boosted decision trees
Matrix element

Good agreement!
Multivariate Analyses and Mass Measurement

$\sigma(WW+WZ) = 16.5 \pm 3.2 \text{ pb}$

SM prediction of $16.1 \pm 0.9 \text{ pb}$.

$\sigma(WW+WZ) = 18.1 \pm 4.1 \text{ pb}$

No attempt at measuring the mass, but mass peak now visible
If a SM Higgs Boson Exists (and isn’t really really heavy), The Tevatron is producing it!
**ZH → ℓℓbb**  

**Event Discriminants**

**D0** uses a Random Forest Decision Tree method:
- 20 well modeled inputs chosen
- 200 trees are trained, using a random subset of 10 inputs
- RF Output is the performance weighted result of all 200 trees

**CDF** uses a 2D NN:
- one axis is ZH vs Z+jets
- one axis is ZH vs ttbar
- A 10% slice along the ZH vs ttbar is for display (full 2D is used in limit)

More acceptance: J. Pilot’s talk
Large Multijet background – two stages of discriminants
1) Anti-QCD
2) Select H from remaining backgrounds

R. Hughes
Some of the Prominent Candidates in the Low-Mass Search at the Tevatron

ZH → ℓℓbb Event Displays

Dijet Mass = 113 GeV/c^2
Z Mass = 86.2 GeV/c^2
MET = 8.5 GeV

Dijet Mass = 116 GeV/c^2
Z Mass = 92.8 GeV/c^2
MET = 10.9 GeV

Dijet Mass = 107 GeV/c^2
Jet1 Et = 86 GeV/c^2
Jet2 Et = 62 GeV/c^2
MET = 129 GeV

R. Hughes
Backgrounds:
Wbb
Wcc
W+light flavor
ttbar
WW, WZ, ZZ
Single Top
Multijets

R. Hughes,
N. Huske
Events at $m_H = 115$ GeV

Two in WH NN, Summer 2009

CDF Run II Preliminary (4.3 fb$^{-1}$)

DATA Event: 17296825 Run: 264015 Precise: 12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88,89,90,91,92,93,94,95,96,97,98,99,100

Uncorrected: 12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88,89,90,91,92,93,94,95,96,97,98,99,100

Uncorrected: 12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88,89,90,91,92,93,94,95,96,97,98,99,100
Tevatron $H \rightarrow \gamma\gamma$

Diphoton mass bump-hunt

Uses all production mechanisms $ggH$, $WH$, $ZH$, $VBF$

S. Chakrabarti

T. Junk Higgs Hunting Exp. Summary 31 Jul 2010
\[ H \rightarrow \tau\tau \quad + \text{2 Jets} \]

- \( W(\rightarrow qq') H(\rightarrow \tau^+\tau^-) \)
- \( Z(\rightarrow qq) H(\rightarrow \tau^+\tau^-) \)
- \( H(\rightarrow bb) Z(\rightarrow \tau^+\tau^-) \)
- \( VBF qHq' \rightarrow q' \tau^+\tau^-q \)
- \( gg \rightarrow H \rightarrow \tau^+\tau^- + \geq 2\text{jets} \)

S. Chakrabarti
WH, ZH $\rightarrow$ qqbb

- Large signal yield as it profits from the largest cross-section x branching ratio
- Complete event information. No missing energy to infer
- Large QCD background

Signal x 1000! Large Multijet Background

Still expect to set limits ~20 x SM rate

S. Chakrabarti
High-Mass SM Tevatron Searches

$H \rightarrow WW \rightarrow l^+ \nu l^- \nu$ Signature

- leptonic $W$ decays
- opposite charge
- large missing transverse energy

- Kinematic Discriminants
  - $ll$ opening angle
  - kinematics input MVA

Really the dominant search mode above 125 GeV

M. Kirby
Analysis Strategy: Divide into jet categories (also separate out like-sign dileptons, trileptons, and taus because signals, backgrounds, and systematic uncertainties are different)
New Channels Are Always Being Added

**H → WW → ℓνjj**

- **Event selection**
  - high-$p_T$ lepton $> 15$ GeV
  - large missing $E_T > 15$ GeV
  - 2 high-$p_T$ jets

  ![Diagram](image)

- **background composition**
  - W+2 jets
  - top production
  - Diboson - WW, WZ, ZZ
  - QCD multijet events

- **utilize techniques from low mass analyses**

M. Kirby
Tevatron H→WW Projections

137—190 GeV with 10 fb⁻¹/Experiment

assumes two experiments with equal sensitivity

M. Kirby
T. Junk
Looking for a Hint of a Signal

$$-2 \ln Q = LLR = -2 \ln \left( \frac{L(\text{data} | s + b, \hat{\theta})}{L(\text{data} | b, \hat{\theta})} \right)$$

Tevatron RunII Preliminary

$$\langle L \rangle = 5.9 \text{ fb}^{-1}$$

July 19, 2010
Tevatron Observed and Expected Limits

Excluded regions:

158 < m_H < 175 GeV
100 < m_H < 109 GeV

Expected Exclusion (if no signal is present):

156 < m_H < 173 GeV
We continue to improve our analyses as well as collect more data.

Multivariate analyses are pretty much at their limit: We now seek more acceptance, looser requirements, new channels...
Algorithm improvements: b-tagging

Improved b-tagging algorithms (b vs light jet discrimination)
~10% increase in b-jet efficiency at same fake rate
New, additional algorithms
- b vs. c discrimination
- b vs. bb (merged) discrimination
Not yet in recent Higgs results

G. Bernardi
Signal Acceptance

Continue to work to maximize signal acceptance

Example: ZH channels
Electrons in inter calorimeter regions

Replace several cuts on kinematic variables by cut on discriminant

\textbf{mu+track}

Already got \sim 8\% increase in signal yields per lepton

\Rightarrow sensitivity improvement

G. Bernardi
LHC: First Data – Performance and Benchmark Processes

• Both LHC Experiments must “Rediscover the Standard Model”
  In order to back up Higgs and New Physics Searches

• Calibrations are needed for:
  • Trigger efficiency for leptons (later, high-\(E_T\) jets, MET, ....)
  • Lepton ID efficiency (electrons, muons, taus)
  • Photon ID efficiency
  • Photon Energy scale / linearity
  • Lepton energy scale / linearity
  • Jet Energy scale / linearity

Photons: M. Aurousseau, N. Chanon
Jets: J. Schaarschmidt
Muons: R. Wilken
B and \(\tau\) Tagging: M. Bluj

Lepton and Missing \(E_T\) Performance Summary: C. Ochando
**ATLAS and CMS: Calorimetry**

- **Back** (0.05x0.025)
- **Middle** (0.025x0.025)
- **Strips** (0.0031x0.1)
- **Presampler** (0.025x0.1)

- Pb + LAr sampling calorimeter
- 3 radial layers + pre-shower
- Design energy resolution:
  \[ \frac{E}{E} \frac{10\%}{\sqrt{E}} \frac{300\,\text{MeV}}{E} = 0.7\% \]
- Outside solenoid coil

- **PbWO_{4}** scintillating crystals
- Preshower in front of EE
- Design energy resolution:
  \[ \frac{E}{E} \frac{2.9\%}{\sqrt{E}} \frac{125\,\text{MeV}}{E} = 0.3\% \]
- Inside solenoid coil

M. Aurousseau

T. Junk Higgs Hunting Exp. Summary 31 Jul 2010
Using the $\pi^0$ As a Calibration Signal

**ATLAS**

\[ L = 414.4 \text{ b}^{-1} \]

$E_T(T) > 400 \text{ MeV}$

$E_{\gamma}(\gamma) > 900 \text{ MeV}$

\[ \sigma = 14.9\% \]

**CMS**

\[ L = 123 \text{ nb}^{-1} \]

$E_T(T) > 300 \text{ MeV}$

$E_{\gamma}(\gamma) > 900 \text{ MeV}$

Using Conversions to Map Detector Material – Spectacular Moding in Very Early Running!

**ATLAS**

Pixel support shift ~ 1cm

3 pixel layers

**CMS**

Some discrepancies

Corrected from overall shift between tracker and reference frame

M. Aurousseau
**Isolation**

ATLAS

<table>
<thead>
<tr>
<th>Cone (0.4)</th>
<th>Core (5x7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EM + HAD</td>
<td>EM</td>
</tr>
</tbody>
</table>

- **Energy in ring includes:**
  - Photon leakage out of the core
    - Depends on photon pT
    - Subtracted from the ring energy
  - Pile-up / Underlying Event effects
    - Ambient energy density from low E jets
    - Subtracted from the ring energy
  - Nearby hadronic activity
    - Isolation energy

This definition of isolation is closer to theoretical parton-level isolation

---

*ATLAS Preliminary*

\[ \sqrt{s} = 7 \text{ TeV}, \int \mathcal{L} = 15.8 \text{ nb}^{-1} \]

- Data 2010
- Simulation (all γ candidates)
- Simulation (prompt γ)

Candidates already passing the loose ID cut

---

Higgs Hunting 2010
Orsay (29-31 July 2010)

Mathieu Aurousseau - LAPP
Triggering on Leptons

- Events are filtered online in 2 (CMS) or 3 (ATLAS) steps.

- **Level 1 Muon Trigger efficiency:**
  - Threshold at 6 GeV,
  - Eff. w.r.t “Stand Alone” offline Muon (reconstructed only with the Spectrometer)

- **Level 1 Electron Trigger efficiency:**
  - Threshold at 5 GeV,
  - Eff w.r.t ET of the ECAL super-cluster of the electron candidate
  - Measured on Minimum bias events with electrons from conversions.
  - Turnon gets sharper with isolated electrons from W&Z.
Lots of High s/b Samples to Calibrate Muon Efficiency and Energy Scale and Resolution

Mean from data = 3.0927±0.0005 GeV
PDG mass = 3.0969±0.000011 GeV

C. Ochando

R. Wilken
Muon Isolation

- Lepton-kinematic templates method used to calculate isolation efficiency

- Lepton-kinematic Templates use pre-defined directions from MC to estimate isolation in data

- Isolation calculated using 100 lepton-kinematic templates for each $W \rightarrow \mu \nu$ data event

- If template falls within 0.6 in eta and phi of muon then event thrown out

R. Wilken
Missing $E_T$

- Key variable for the $W \rightarrow \ell \nu$ analysis.
  (MET from escaping neutrinos).

- Very sensitive to noise, pile-up, beam-halo background.
  => Need dedicated cleaning.

- Commissioned using Minimum Bias, Dijet (and $W \rightarrow \ell \nu$) events.
W&Z measurements summary (2)

All the results are in agreement with the Standard Model expectations... let's move further!
Jet Energy Scale and Resolution

Conservative uncertainties assigned for now

- Jet Resolution Calibrated in Situ with dijet balancing – ATLAS and CMS

J. Schaarschmidt
LHC: B Tagging Performance

Impact Parameter Significance – Normally it takes years to tune these up, and they look great!

Can fit the b fraction in tagged events using the $P_T^{\text{rel}}$ distribution – calibrate the b-tag efficiency in the data

Mistags Estimated from negatively-tagged data

Mistag rate about 1% for 80 GeV jets
Tau-jet, expected performance

Efficiency of tau identification vs quark/gluon jet rejection obtained with simulation (Z→ττ and QCD di-jets samples)

- Optimized separately for 1- and 3-prongs in p_T bins

- **Expected performance** (medium working point, p_T = 25-45 GeV):
  
  efficiency $\varepsilon_{\text{sig}} \approx 45-50\%$ for rejection $r \approx 23$ ("fake rate": $\varepsilon_{\text{bkg}} \approx 4\%$)
  
  - Rejection: $r = 1/\varepsilon_{\text{bkg}} - 1$

Michał Bluja, Higgs Hunting 29-31 July 2010
Results $H \rightarrow WW^* \rightarrow 2\ell 2\nu$

**ATLAS** (Ref. ATL-PHYS-PUB-2010-005 @10TeV)
- A minimum of $\int L dt = 250pb^{-1}$ is required to be sensitive to the SM Higgs boson
- Exclusion 95%CL: $145 < m_H < 180 \text{ GeV}/c^2$

**CMS** (Reference: CMS PAS HIG-08/006 @14TeV)
- Counting above a MVA-output cut
- Exclusion 95%CL: $150 < m_H < 185 \text{ GeV}/c^2$
- Discovery sensitivity (~5$\sigma$): $160 < m_H < 170 \text{ GeV}/c^2$

---

30/07/2010

J. Fernandez

T. Junk Higgs Hunting Exp. Summary 31 Jul 2010
LHC Projections: $H \rightarrow \gamma\gamma$

**ATLAS** (Reference CERN-OPEN-2008-020 @ 14 TeV)
- Profile likelihood method is used
- Expected exclusion is set using the signal-plus-background probability only

**The SM Higgs cannot be excluded anywhere in the mass range**

**CMS** (Reference PTDR @ 14 TeV)
- Counting in a mass window
- No photon categories.

**No exclusion either.**
A fermion-phobic Higgs* with $m_h < 110$ GeV would be excluded, as for this mass range, the yield $\sigma(pp\rightarrow h_{fpn}) \times BR(h_{fpn}\rightarrow \gamma\gamma)$ is $>4$

*The limit on the anomalous production is expected to be about 4 times $\sigma(pp\rightarrow H_{SM}) \times BR(H_{SM}\rightarrow \gamma\gamma)$.

The projected exclusion reach is comparable to the current limits from LEP and Tevatron

30/07/2010  
J. Fernandez

T. Junk Higgs Hunting Exp. Summary 31 Jul 2010
LHC  SM Higgs Combination at 7 TeV

2xCMS:
Conservative and indicative projected exclusion limits assuming twice amount of data (ATLAS + CMS)

Exclusion: $140 < m_H < 200$ GeV/c$^2$
SM Higgs +4th fermion generation: $m_H < 500$ GeV/c$^2$
Minimal BSM: Fourth Generation

Theory prediction:
Anastasiou, Boughezal, and Furlan

But: A fourth Generation can make $m_H=400$ GeV consistent with precision EW!

A. Hoecker
MSSM neutral Higgs: Tevatron

U.-K. Yang

3b mode analyzed by CDF and D0 but not yet combined

Inclusive $H \rightarrow \tau \tau$ Search by CDF and D0, and combination

Also: $b\tau \tau$ from D0 with a strong constraint
Light $H^\pm$ Search in Top Quark Decay

CDF: Search for a second bump in $m_{jj}$ where it peaks at $m_W$ in lepton+jets events

D0: Count events in dilepton, lepton+jets, tau+jets, lepton+tau & fit branching fractions

U.-K. Yang

T. Junk Higgs Hunting Exp. Summary 31 Jul 2010
LHC $H \rightarrow \tau\tau$ Sensitivity Projections

0 b-tag + 1 or more b-tagged channels

K. Leney

R. Tanaka
Light Charged Higgs $M_{H^\pm} < M_{top}$

\[
\begin{align*}
    t\bar{t} & \rightarrow (H^+b)(W^-b) \\
    \text{Semi-leptonic } t\bar{t}, \quad H^+ & \rightarrow c\bar{s} \\
    t\bar{t} & \rightarrow (H^+b)(W^-\bar{b}) \rightarrow (c\bar{s}b)(\ell^-\nu\bar{b}) \\
    \text{Di-lepton } t\bar{t}, \quad H^+ & \rightarrow \tau^+\nu \\
    t\bar{t} & \rightarrow (H^+b)(W^-\bar{b}) \rightarrow (\tau^+b)(\ell^-\nu\bar{b}) \rightarrow (\ell^+\nu\nu\nu b)(\ell^-\nu\bar{b})
\end{align*}
\]

$\sqrt{s}=7$ TeV, $\int L dt=1$ fb$^{-1}$

R. Tanaka
Parton Distribution Functions

MSTW 2008 NLO PDFs (68% C.L.)

Q^2 = 10 GeV^2

Q^2 = 10^4 GeV^2

R. Thorne
Parton Luminosities – Comparing 14 TeV LHC to 10 and 7 TeV LHC, and the Tevatron

Tevatron: 10 fb\(^{-1}\) analyzable/exp at 1.96 TeV by end 2011. Asking for three more years.
LHC: 1 fb\(^{-1}\) per exp by end 2011. Much more data and energy later

J. Fernandez
Different PDF sets

- **MSTW08** – fit all previous types of data. Most up-to-date Tevatron jet data. Not most recent HERA combination of data. PDFs at LO, NLO and NNLO.

- **CTEQ6.6** – very similar. Not quite as up-to-date on Tevatron data. PDFs at NLO. New – **CT10** include HERA combination and more Tevatron data. Little changes.

- **NNPDF2.0** – include all except HERA jet data (not strong constraint) and heavy flavour structure functions. Include HERA combined data. PDFs at NLO.

- **HERAPDF1.0** – based entirely on HERA inclusive structure functions, neutral and charged current. Use combined data. PDFs at LO, NLO and now NNLO.

- **ABKM09** – fit to DIS and fixed target Drell-Yan data. PDFs at NLO and NNLO.

- **GJR08** – fit to DIS, fixed target Drell-Yan and Tevatron jet data. PDFs at NLO and NNLO.

Use of HERA combined data instead of original data slight increase in quarks at low $x$ (depending on procedure).
Valence Quark PDFs and Uncertainties Largely Under Control

Uncertainties on, e.g. valence quarks not notably different to other groups at all

But variations in the predictions of small-x gluons
PDF correlation with $\alpha_S$.

Can also look at PDF changes and uncertainties at different $\alpha_S(M_Z^2)$. Latter usually only for one fixed $\alpha_S(M_Z^2)$. Can be determined from fit, e.g. $\alpha_S(M_Z^2) = 0.1202^{+0.0012}_{-0.0015}$ at NLO and $\alpha_S(M_Z^2) = 0.1171^{+0.0014}_{-0.0014}$ at NNLO from MSTW.

PDF uncertainties reduced since quality of fit already worse than best fit.

Expected gluon–$\alpha_S(M_Z^2)$ small–$x$ anti-correlation $\rightarrow$ high–$x$ correlation from sum rule.
Variations in Predictions for Different PDF Sets

Very Measurable! (but need luminosity!)
Variations in Predictions for Different PDF Sets

gg → H Production cross section depends largely on the $\alpha_s$ value associated with the PDF set.

But the Ratio of $W^+$ to $W^-$ Doesn’t seem to depend on $\alpha_s$!

PDF’s are an extrapolation from lower energies to the LHC. Surprises can still come from nucleon structure!
Summary

• Many thanks to the Organizers! Louis, Gregorio, Abdelhak, Yves, Gautier, and the whole committee

• Many thanks for the opportunity to get experimentalists and theorists together! We are making progress much more efficiently face to face

• The young scientist forum was fantastic! Keep up the good work!

• It is a great time to hunt for the Higgs boson.
  • The Tevatron is performing very very well and is testing for the presence of the SM Higgs boson
  • The LHC Detectors are working very very well on the first data
  • The LHC is running at 3.5 times the Tevatron energy and will accumulate soon enough data to test for the SM Higgs boson and hopefully find something new.
  • The Tevatron and the LHC will be able to answer different questions on the near timescale. 165? Same question. Low mass? Very high mass?
So let’s go find the Higgs Boson(s) already!
Backup Material
Tevatron Run II Preliminary

\[ \langle L \rangle = 5.9 \text{ fb}^{-1} \]

1-CL_s Observed

1-CL_s Expected

Expected ±1\( \sigma \)

Expected ±2\( \sigma \)

95% C.L.
CDF Run II Preliminary, $\langle L \rangle = 5.6-5.9$ fb$^{-1}$

LEP Exclusion

- Dotted line: Expected
- Solid line: Observed
- Green region: ±1σ Expected
- Yellow region: ±2σ Expected

95% CL Limit/SM

$m_H$(GeV/c$^2$)

SM=1

July 19, 2010
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<th>$m_H$ (GeV/c^2)</th>
<th>$\sigma_{gg-H}$ (fb)</th>
<th>$\sigma_{WH}$ (fb)</th>
<th>$\sigma_{ZH}$ (fb)</th>
<th>$\sigma_{VBF}$ (fb)</th>
<th>$\sigma_{t\bar{t}H}$ (fb)</th>
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<th>$B(H \rightarrow c\bar{c})$ (%)</th>
<th>$B(H \rightarrow \tau^+\tau^-)$ (%)</th>
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The CDF Detector

Lepton coverage:

- $|\eta| < 1.5$ (muons)
- $|\eta| < 2.0$ (electrons)

b-tagging with

- $|\eta| < \sim 1.4$

Jets to

- $|\eta| < 2.8$

Higgs analyses restrict to

- $|\eta| < 2.0$

Dijet mass resolution: $\sim 16\%$
The **DO** Detector

**Lepton coverage:**
- $|\eta| < 2$ (muons)
- $|\eta| < 2.6$ (electrons)

**b-tagging with**
- $|\eta| < \sim 2$

**Jets to**
- $|\eta| < 3$

Similar dijet mass resolution to CDF

New Innermost Silicon Layer added between Run IIa and Run IIb
Lepton Acceptance Gains

10% gain in CDF electron acceptance

30% gain in CDF single-muon acceptance

Inter-calorimeter electrons
-- 10% gain in D0 electron acceptance

These Leptons don’t all trigger!
Use another lepton, or MET+Jets triggers.
WW Cross Section Measurement

Checks Matrix
Element discriminant shape of dominant background in the signal sample

Same as Higgs search but reverse roles of signal and background

\[ \sigma(p\bar{p} \rightarrow W^+W^-) = 12.1 \pm 0.9 \text{ (stat)} ^{+1.6}_{-1.4} \text{ (syst)} \text{ [pb]} \]

SM: 12.4 \pm 0.7 \text{ pb (MCFM)}
ATLAS’s Projections

Standard Model Higgs Boson Decay Branching Fractions

HDECA by
M. Spira

114.4 < m_H < 135 GeV: H→bb dominates.

gg→H→bb drowned by gg→bb. Use WH, ZH.

135 < m_H < 200 GeV
H→W⁺W⁻ dominates

gg→H, WH, ZH, VBF all can be used
SM Higgs Boson Production Mechanisms

Studies of Injecting a Signal at $m_H=115$ GeV

- $lvbb$, MET$bb$, and $llbb$ channels included
- Inject SM*1.0 signal at $m_H=115$ GeV on top of SM backgrounds, and generate pseudoexperiments with that.
- Analyze 115 signal+background pseudoexperiments at other test masses – 100 GeV to 150 GeV
- Find the median expected limit assuming signal is there (compute it just as you would without the signal) and compare with the distribution of limits assuming the signal is completely absent.

![Graph showing expected limits for different masses](image)