Multi-fb\(^{-1}\) Predictions for the Physics Reach of the Tevatron

For the CDF and DØ Collaborations

Beate Heinemann
University of Liverpool
Tevatron Connection, 06/25/05
Standard Model

Rock solid?
Standard Model

Rock solid?

No, not really!
- Neutrino Mass
- Dark matter
- Dark energy
- not beautiful enough?
Standard Model

ATTACK!!!
Standard Model

Attack #1: flavour sector

- **B_s mixing**: $\Delta m_s/\Delta m_d$
- Rare decays: $B_s \rightarrow \mu\mu$, etc.
- $B_s$ lifetime: $\Delta \Gamma/\Gamma$
- CP violation: $B_s \rightarrow \phi\phi$
- masses and lifetimes: HQE
- $V_{tb}$ (single top)
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Attack #2: QCD
• jet cross section
• HQ production: $t, b, c$
• proton structure
• diffraction
• Underlying event
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Attack #3: electroweak sector + top
- $W$ mass and width
- Top mass
- Trilinear gauge couplings
- Higgs boson
- Top quark decay
- Top quark charge, spin
Standard Model

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Attack #4: new physics searches
- SUSY: trileptons+squarks
- gauge sector: $Z'$, $W'$
- extra dimensions
- compositeness: $b'$, $t'$, leptoquarks
- substructure
- Non SM Higgs bosons
Will we break the Standard Model?
Attack with Luminosity

\[ \sqrt{L dt} (\text{fb}^{-1}) \]

We are here

- 8.2 fb^{-1}
- 5.1 fb^{-1}
- 4.1 fb^{-1}
Attack with Luminosity

We are here

Discovery?

9.2 fb^{-1}
8.2 fb^{-1}
5.1 fb^{-1}
4.1 fb^{-1}

0 1 2 3 4 5 6 7 8 9
9/29/03 9/29/04 9/30/05 10/1/06 10/2/07 10/2/08 10/3/09

6/25/2004
Flavour Sector
**B^0_s - \overline{B^0_s} mixing: Motivation**

- Measure side of unitarity triangle: \( \Delta m_d / \Delta m_s \)
  - CKM fit: \( \Delta m_s = 18.9 \pm 1.7 \text{ ps}^{-1} \)
  - Observation will significantly shrink allowed region

- New physics:
  - 3\(\sigma\) if \( \Delta m_s > 31 \text{ ps}^{-1} \)
  - 5\(\sigma\) if \( \Delta m_s > 38 \text{ ps}^{-1} \)
$B_s^0 - \bar{B}_s^0$ mixing: Present

- First measurements in spring:
  - CDF: $\Delta m_s > 7.9$ ps$^{-1}$
  - D0: $\Delta m_s > 5.0$ ps$^{-1}$
  - World: $\Delta m_s > 14.5$ ps$^{-1}$

- New measurements expected soon

- Main challenges:
  - Flavour at production: $\epsilon D^2$
  - Vertex resolution
  - Trigger bandwidth
**B_s mixing: Future Discovery**

- **CDF assume:**
  - Flavour tagging:
    - Add same-side kaon tagger
    - $\varepsilon D^2 = 1.6% + 3%$
  - Vertex resolution:
    - Improve by 20%
  - Trigger bandwidth:
    - Utilize 50% of CDF data

- **DØ expect similar sensitivity:**
  - Install Silicon L0
    - improve vertex resolution
  - Upgrade L3 trigger bandwidth

**5\sigma Observation:**
- $L=2 \text{ fb}^{-1}$: $\Delta m_s < 15 \text{ ps}^{-1}$
- $L=8 \text{ fb}^{-1}$: $\Delta m_s < 22 \text{ ps}^{-1}$
Rare Decay: $B_s \rightarrow \mu^+ \mu^-$

- SM rate heavily suppressed:
  $$BR(B_s \rightarrow \mu^+ \mu^-) = (3.5 \pm 0.9) \times 10^{-9}$$  

- SUSY rate may be enhanced: $\propto \tan^6 \beta$
  (Babu, Kolda: hep-ph/9909476+ many more)

- Results at 90% C.L.: Healthy Competition!
  1. CDF (L=171 pb$^{-1}$): BR < 5.8 x 10$^{-7}$
  2. D0 (L=240 pb$^{-1}$): BR < 4.1 x 10$^{-7}$
  3. D0 (L=300 pb$^{-1}$): BR < 3.0 x 10$^{-7}$
  4. CDF (L=364 pb$^{-1}$): BR < 1.6 x 10$^{-7}$

- New Combined CDF + D0 result: $BR<1.2x10^{-7}$ @ 90% C.L.
Future of $B_s \rightarrow \mu^+\mu^-$

- We get smarter with time, too:
  - One year old CDF projection for $L=500 \text{ pb}^{-1}$ was
    - $\text{BR}<2.5 \times 10^{-7}$ at 90% C.L.
  - Sensitivity with new CDF analysis projection for $L=500 \text{ pb}^{-1}$:
    - $\text{BR}<1.6 \times 10^{-7}$ at 90% C.L

- Extrapolate based on current analysis (optimized for 1 $\text{ fb}^{-1}$)
  - Assume background scales linearly with luminosity
  - Will want to re-optimize the analysis for $L > 2 \text{ fb}^{-1}$

- D0 estimate similar sensitivity

Single experiment sensitivity:
- $L=2 \text{ fb}^{-1}$: $\text{BR}<6 \times 10^{-8}$ @ 90% C.L.
- $L=8 \text{ fb}^{-1}$: $\text{BR}<2 \times 10^{-8}$ @ 90% C.L.
Implications on models: $B_s \rightarrow \mu \mu$

- Sensitivity at high $\tan\beta$ and low $m_A$

R. Dermisek et al., hep-ph/0304101

Dedes, Dreiner, Nierste, Richardson, hep-ph/0207026
Implications on models: $B_s \rightarrow \mu\mu$

- BR$<2 \times 10^{-8}$ restricts allowed parameter space
- depends strongly on model parameters

R. Dermisek et al
hep-ph/0304101

(Dedes et al., hep-ph/0207026)
EWK Symmetry Breaking
W, top and Higgs

- W mass, top mass and Higgs mass related via loop corrections
- Precise knowledge of $M_W$ and $m_{top}$ allows us to constrain SM Higgs boson mass:
  - Run I Average: $m_{top} = 178.0 \pm 4.3$ GeV
    - $m_H < 280$ GeV at 95% C.L.
  - New prel. Average: $m_{top} = 174.3 \pm 3.4$ GeV
    - $m_H < 208$ GeV at 95% C.L.
- Very sensitive:
  - 4 GeV top mass shift
  - $\Rightarrow$ 72 GeV shift in Higgs mass limit
Top Quark Mass

• Using W mass constraint jets from W decay:
  – Template fit of top mass:
    • CDF Run II: $173.2^{+2.9}_{-2.8}(\text{stat.}) \pm 3.4(\text{syst.}) \text{GeV} / c^2$
  – Matrix element method:
    • D0 Run I: $180.1 \pm 3.6(\text{stat.}) \pm 3.9(\text{syst.}) \text{GeV} / c^2$

• Largest systematic uncertainty:
  – Jet energy scale
  – Will dominate even more at higher luminosity

<table>
<thead>
<tr>
<th>Source</th>
<th>CDF(GeV/c$^2$)</th>
<th>DØ(GeV/c$^2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jet Energy Scale</td>
<td>3.1</td>
<td>3.3</td>
</tr>
<tr>
<td>B-jet energy</td>
<td>0.6</td>
<td>Incl. in Jet</td>
</tr>
<tr>
<td>Background</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>MC modelling</td>
<td>0.8</td>
<td>1.1</td>
</tr>
<tr>
<td>other</td>
<td>0.5</td>
<td>1.4</td>
</tr>
<tr>
<td><strong>Total Syst. Unc.</strong></td>
<td><strong>3.4</strong></td>
<td><strong>3.9</strong></td>
</tr>
</tbody>
</table>
Top Mass: Present and Future

- New world’s best result:
  \[ m_{\text{top}} = 173.5^{+2.7}_{-2.6} \text{ (stat.)} \pm 2.5 \text{ (JES)} \pm 1.7 \text{ (syst.) GeV/c}^2 \]
  - Combined fit for \( m_{\text{top}} \) and JES
  - JES becomes statistical problem!
  - New Run II measurement is better than Run I combined CDF+D0
  - D0 will soon have result using same technique

- Projection for 2 fb\(^{-1}\)
  - Assume: JES: 1.4 GeV, other: 1.7 GeV
  - \( \Delta m(\text{top}) \approx 1.4 \oplus 1.7 \text{ GeV/c}^2 = 2.2 \text{ GeV/c}^2 \)

\[
\begin{align*}
2 \text{ fb}^{-1}: \Delta m(\text{top}) < \pm 2.5 \text{ GeV/c}^2 \text{ per experiment} \\
8 \text{ fb}^{-1}: \Delta m(\text{top}) < \pm 2.0 \text{ GeV/c}^2 \text{ per experiment}
\end{align*}
\]
**W Boson Mass: Status**

<table>
<thead>
<tr>
<th></th>
<th>CDF Run II prel. L=200 pb⁻¹</th>
<th>D0 Run I: L=82 pb⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>W→eν</td>
<td>W→μν</td>
</tr>
<tr>
<td>Statistics</td>
<td>45</td>
<td>50</td>
</tr>
<tr>
<td>Lepton scale+res.</td>
<td>70</td>
<td>30</td>
</tr>
<tr>
<td>Recoil</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>background</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Production+Decay</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>total</td>
<td>105</td>
<td>85</td>
</tr>
<tr>
<td>Comb. e+μ</td>
<td>76 MeV</td>
<td></td>
</tr>
</tbody>
</table>

- Most uncertainties scale with statistics: √L
- Production and Decay model being improved:
  - W charge asymmetry and $p_T(Z)$ spectrum constrain proton structure and $p_T(W)$
  - Decay: 2-photon radiation calculation (U. Baur)
  - Production: new improved version of ResBos
  - Expect to improve uncertainty to <20 MeV
W mass: Future

- Assume
  - constant theo. uncertainty of 20-30 MeV
  - other errors scale with $\sqrt{L}$
- Good model of data so far! Agrees with Run II TDR
- Single experiment errors:
  - $L=2 \text{ fb}^{-1}$: $\delta m_W = 25-35 \text{ MeV} \text{ (with LEP2: } \delta m_W = 21-27 \text{ MeV)}$
  - $L=8 \text{ fb}^{-1}$: $\delta m_W = 20-30 \text{ MeV} \text{ (with LEP2: } \delta m_W = 18-24 \text{ MeV)}$
Implications for Higgs and SUSY

New very preliminary top mass (D0+CDF): 174.3±3.4 GeV

- Present:
  - $\Delta m_{\text{top}} = 3.4$ GeV
  - $\Delta m_W = 34$ MeV
Implications for Higgs and SUSY

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- **Definitely:**
  - $\Delta m_{\text{top}} = 2$ GeV
  - $\Delta m_W = 30$ MeV

![Graph showing mass scales and experimental errors](image-url)
Implications for Higgs and SUSY

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Can the Standard Model work?
• Exclude $m_H<120$ GeV$/c^2$ with 2 fb$^{-1}$
• Exclude $m_H<135$ GeV$/c^2$ and $m_H=155$-175 GeV$/c^2$ with 8 fb$^{-1}$
  -- Severely constrains SUSY! => Big impact on search strategies at LHC
• $3\sigma$ evidence for $m_H<125$ GeV$/c^2$ with 8 fb$^{-1}$
Latest Results from CDF and DØ

CDF and DØ started the hunt!
Current Higgs Search Results

- **D0:**
  - $WH \rightarrow l\nu bb$
  - $ZH \rightarrow \nu \nu bb$
  - $WW \rightarrow l\nu l\nu$
- **CDF:**
  - $WH \rightarrow l\nu bb$
  - $WW \rightarrow l\nu l\nu$
  - $WWW \rightarrow l^\pm l^\pm + X$
- Cross section limits about 20 times larger than SM prediction

J. Ellis, ICHEP’04:
“Tevatron are closing in on the Higgs. So, if I were CERN director I would get LHC going asap.”
# SM Higgs: How are we doing?

## Comparison of Sensitivity: S/√B

<table>
<thead>
<tr>
<th></th>
<th>DØ Run 2</th>
<th>HSWG (w/o NN)</th>
<th>ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>WH → lνbb (L=380 pb⁻¹)</td>
<td>0.077</td>
<td>0.13</td>
<td>1.7</td>
</tr>
<tr>
<td>ZH/WH → ννbb (L=261 pb⁻¹)</td>
<td>0.055</td>
<td>0.20</td>
<td>3.6</td>
</tr>
<tr>
<td>H → WW (L≈300 pb⁻¹)</td>
<td>0.12</td>
<td>0.23</td>
<td>1.9</td>
</tr>
</tbody>
</table>

## Observations

- **m_H=115 GeV/c²:**
  - Within factor of 2-3 of HSWG prediction!
  - Improve b-tagging
  - Improve lepton acceptance
  - Improve mass resolution
  - Optimise selection
  - Use NN => x1.6

- **m_H=160 GeV/c²:**
  - Within factor of 2 compared to HSWG
    - Improve by reducing WW background kinematically
    - NN

Not so badly compared to “ultimate performance” assumed by HSWG
Beyond the SM
Higgs: $A/H/h \rightarrow bb$ and $A/H/h \rightarrow \tau\tau$

- **Supersymmetry (MSSM):**
  - 2 Higgs doublets $\Rightarrow$ 5 Higgs bosons: $h$, $H$, $A$, $H^{\pm}$

- **High tan$\beta$:**
  - A degenerate in mass with $h$ or $H$
  - Cross sections enhanced with $\tan^{2}\beta$ due to enhanced coupling to down-type quarks
  - Decay into either $\tau\tau$ or $bb$:
    - $\text{BR}(A \rightarrow \tau\tau) \approx 10\%$, $\text{BR}(A \rightarrow bb) \approx 90\%$
    - Exact values depend on SUSY parameter space

- **Experimentally:**
  - $pp \rightarrow Ab+X \rightarrow bbb+X$
  - $pp \rightarrow A+X \rightarrow \tau\tau +X$

- **Depending on radiative corrections in SUSY different parameter space is covered**

  - C. Balazs, J.L. Diaz-Cruz, H.J. He, T. Tait and C.P. Yuan, PRD 59, 055016 (1999)
MSSM Higgs: Current Results

- $pp \rightarrow bA+X \rightarrow bbb+X$ (DØ)
  - Best sensitivity for $\mu<0$
  - Lower sensitivity for $\mu>0$
- $pp \rightarrow A+X \rightarrow \tau\tau+X$ (CDF)
  - Sensitive for $\mu>0$ and $\mu<0$, best for $\mu>0$
  - Slight excess at 130 GeV/c$^2$ “weakens limit”
- Nice complementarity of two channels
  - Interactions with theorists to probe SUSY parameter space better
  - Define scenarios suitable for hadron colliders
- Triggering for both channels challenging
MSSM Higgs Search: Future

- Sensitivity for D0 and CDF data combined
- probe values down to $\tan \beta = 20$ for $m_A \approx 140 \text{ GeV/c}^2$
- $\tan \beta = 40 \approx m_{\text{top}}/m_b$ reached for $m_A < 240 \text{ GeV/c}^2$
MSSM Higgs: Evidence/Discovery?

Discovery possible for $\tan\beta > 40$!
SUSY Trileptons

• mSUGRA:
  – SUSY broken at GUT scale
  – Neutralino $\chi^0_1$ LSP

• Trilepton Signature
  – Chargino-neutralino production
  – Low SM backgrounds

• Current DØ analysis:
  – 2 l (l=e,µ,τ) + isolated track or $\mu^±\mu^±$
  – $E_t$ + topological cuts
  – Analysis most sensitive at low tan$\beta$
  – BG expectation: 2.9±0.8 events
  – Observed: 3 events
Trileptons: Present and Future

- Current result: $\sigma x BR < 0.2-0.3$ pb
  - 3l-max scenario:
    - Sleptons light
    - Optimistic mSUGRA
  - Large $m_0$ scenario:
    - Sleptons heavy
    - Pessimistic mSUGRA
  - Current data probe optimistic scenario

- Future:
  - Cross section limit 0.05-0.01 pb
  - Probe chargino masses up to 150-240 GeV/c$^2$
    - LSP masses: 75-120 GeV/c$^2$
And so much more!!!!

Even more…but did not fit on slide
Conclusions

• Tevatron experiments **attack the Standard Model from many sides:**
  – Flavour sector
  – Strong interaction
  – Electroweak and Higgs sector
  – New physics

• New Projections from D0 and CDF are based on **full Run II analyses:**
  – More **reliable** than pre-Run II projections
  – **Competition** between CDF and D0 helps
  – We are getting **smarter** with time!

• Pursuing **many analyses** since we don’t know what is there to be **discovered!**
Standard Model after Tevatron Attack?
## Summary I

<table>
<thead>
<tr>
<th></th>
<th>$\int L dt = 2 \text{ fb}^{-1}$</th>
<th>$\int L dt = 8 \text{ fb}^{-1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$B_s$ mixing: 95% C.L. excl.</td>
<td>$\Delta m_s &gt; 27 \text{ ps}^{-1}$</td>
<td>$\Delta m_s &gt; 35 \text{ ps}^{-1}$</td>
</tr>
<tr>
<td>$B_s$ mixing: 5$\sigma$ obs.</td>
<td>$\Delta m_s &lt; 15 \text{ ps}^{-1}$</td>
<td>$\Delta m_s &lt; 23 \text{ ps}^{-1}$</td>
</tr>
<tr>
<td>$B_s \rightarrow \mu\mu$: 95% C.L. excl. / expt.</td>
<td>BR $&lt; 6 \times 10^{-8}$</td>
<td>BR $&lt; 2 \times 10^{-8}$</td>
</tr>
<tr>
<td>W mass uncertainty / expt.</td>
<td>25-35 MeV</td>
<td>20-30 MeV</td>
</tr>
<tr>
<td>Top mass uncertainty / expt.</td>
<td>1.7-2.2 GeV</td>
<td>1.2-1.8 GeV</td>
</tr>
<tr>
<td>$m_H$: 95% C.L. excl.</td>
<td>$&gt; 120 \text{ GeV/c}^2$</td>
<td>$&gt; 135 \text{ GeV/c}^2$</td>
</tr>
<tr>
<td>$m_H$: 3$\sigma$ obs.</td>
<td>-</td>
<td>$&lt; 125 \text{ GeV/c}^2$</td>
</tr>
<tr>
<td>MSSM A: $\mu&lt;0$: 95% C.L. excl.</td>
<td>$\tan\beta &lt; 40$</td>
<td>$\tan\beta &lt; 30$</td>
</tr>
<tr>
<td>MSSM A: $\mu&gt;0$: 95% C.L. excl.</td>
<td>$\tan\beta &lt; 25$</td>
<td>$\tan\beta &lt; 20$</td>
</tr>
<tr>
<td>MSSM A: $\mu&gt;0$: 5$\sigma$ obs.</td>
<td>$\tan\beta &lt; 60$</td>
<td>$\tan\beta &lt; 40$</td>
</tr>
<tr>
<td>Trileptons: $m(\chi^{\pm})$ excl. @95% C.L.</td>
<td>120-210 GeV/c$^2$</td>
<td>150-250 GeV/c$^2$</td>
</tr>
</tbody>
</table>
Implications for Higgs and SUSY

New top mass (D0+CDF): 174.3 ± 3.4 GeV

- **Present:**
  - $\Delta m_{\text{top}} = 3.4$ GeV
  - $\Delta m_W = 34$ MeV

- **Definitely:**
  - $\Delta m_{\text{top}} = 2$ GeV
  - $\Delta m_W = 30$ MeV

- **LHC:**
  - $\Delta m_{\text{top}} = 1$ GeV
  - $\Delta m_W = 20$ MeV

- **ILC:**
  - $\Delta m_{\text{top}} = 0.1$ GeV
  - $\Delta m_W = 10$ MeV
Run I Combination / Sensitivities

<table>
<thead>
<tr>
<th>Channel</th>
<th>Measured (expected)</th>
<th>upper limits (pb)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M_H = 90$</td>
<td>$M_H = 110$</td>
</tr>
<tr>
<td>$\ell^+\ell^- bb$</td>
<td>55.6 (36)</td>
<td>31.8 (24)</td>
</tr>
<tr>
<td>$\nu\bar{\nu} bb$ (ST)</td>
<td>20.8 (30)</td>
<td>20.8 (21)</td>
</tr>
<tr>
<td>$\nu\bar{\nu} bb$ (DT)</td>
<td>10.4 (17)</td>
<td>9.2 (14)</td>
</tr>
<tr>
<td>$\nu\bar{\nu} bb$ (ST+DT)</td>
<td>7.6 (13)</td>
<td>7.8 (11)</td>
</tr>
<tr>
<td>$l\nu bb$ (ST)</td>
<td>30.0 (18)</td>
<td>29.4 (15)</td>
</tr>
<tr>
<td>$l\nu bb$ (DT)</td>
<td>31.0 (24)</td>
<td>26.6 (19)</td>
</tr>
<tr>
<td>$l\nu bb$ (ST+DT)</td>
<td>23.2 (13)</td>
<td>22.6 (11)</td>
</tr>
<tr>
<td>$qq^* bb$</td>
<td>38.2 (77)</td>
<td>21.2 (43)</td>
</tr>
<tr>
<td>All combined</td>
<td>7.8 (7.1)</td>
<td>7.2 (5.7)</td>
</tr>
</tbody>
</table>

Expected "sensitivity" similar for WH and ZH channels (@ $m_H=110$ GeV $\Rightarrow$ limit of 11 pb for 106 pb$^{-1}$ e+mu, SingleTag+DoubleTag)

Combination of all channels allows to go from 19 pb in a single channel (WH-DT) down to 6 pb

Run II vs Run I: expected limit 12 pb@ D0-RunII for WH-DT instead of 19 pb @CDF-Run I, with equivalent lumi (174 pb$^{-1}$ e-chan. vs. 106 pb$^{-1}$ e+mu-chan.)
- For WH-ST, expected limit 8 pb@ CDF-Run II vs. 15 pb@ CDF-Run I $\Rightarrow$ PROGRESS

PRL - hep-ex/0503039
from G. Bernardi

6/25/2004
## SM Higgs: Detailed Comparison

### WH → evbb: L=380 pb⁻¹

<table>
<thead>
<tr>
<th></th>
<th>D0 Run 2</th>
<th>HSWG</th>
<th>ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>0.12</td>
<td>0.33</td>
<td>0.36</td>
</tr>
<tr>
<td>B</td>
<td>2.37</td>
<td>5.76</td>
<td>0.41</td>
</tr>
<tr>
<td>S/√B</td>
<td>0.077</td>
<td>0.13</td>
<td>0.56</td>
</tr>
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### WW → lνlν: L=300 pb⁻¹

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<tbody>
<tr>
<td>S</td>
<td>0.55</td>
<td>0.5</td>
<td>1.1</td>
</tr>
<tr>
<td>B</td>
<td>17.7</td>
<td>4.4</td>
<td>4.0</td>
</tr>
<tr>
<td>S/√B</td>
<td>0.12</td>
<td>0.23</td>
<td>0.5</td>
</tr>
</tbody>
</table>

### vvbb (ZH): L=280 pb⁻¹

<table>
<thead>
<tr>
<th></th>
<th>D0 Run 2</th>
<th>HSWG</th>
<th>ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>0.082</td>
<td>1.0</td>
<td>0.08</td>
</tr>
<tr>
<td>B</td>
<td>2.19</td>
<td>24</td>
<td>0.09</td>
</tr>
<tr>
<td>S/√B</td>
<td>0.055</td>
<td>0.20</td>
<td>0.275</td>
</tr>
</tbody>
</table>

**Low mass Higgs**
- Need to increase signal and background

**High mass Higgs**
- Need to reduce background
Assumptions for MSSM Higgs

\[ bA+X \rightarrow bbb+X \]
- Systematic error reduced from 21% to 10%
- B-tagging efficiency increased from 30% to 40%

\[ A+X \rightarrow \tau\tau+X \]
- 30% sensitivity improvement due to
  - addition of more channels
  - Improved mass reconstruction
- Tau momentum scale error reduced
- Gluon parton density function:
  - Improved knowledge when 4 fb\(^{-1}\) are collected
Light Stop Quark

- Baryogenesis prefers stop quark and Higgs boson to be light
  - \( m(H) < 117 \text{ GeV/c}^2 \)
  - \( m(t) < 165 \text{ GeV/c}^2 \)
- Good discovery reach at the Tevatron:
  - \( \tilde{t} \rightarrow \tilde{\chi}^0 c \)
  - \( \tilde{t} \rightarrow l \bar{\nu} b \)
  - \( \tilde{t} \rightarrow \tilde{\chi}^\pm b \rightarrow l \bar{\nu} b \)
- Depends on masses of \( \tilde{\chi}^0, \tilde{\chi}^\pm, \tilde{t} \) and \( \tilde{\nu} \)

[Carena, Quiros, Wagner, 1998]
Light stop: Results

- Current analysis:
  - $E_T > 55$ GeV
  - charm tagging (jet probability)
  - Background: $8.3 + 2.3 - 1.7$
  - Observed: 11

- Assumptions:
  - BG scales with lumi
  - Reduce syst. unc. by about a factor of 2:
    - Charm tagging
    - jet energy scale
    - background
    - ISR/FSR
  - No reoptimisation

6/25/2004
Light stop: Projections

- E.g. at $m(\chi^0_1)=80$ GeV/c$^2$:
  - New projection: $m(t)=130-165$ GeV/c$^2$ excluded
  - SUSY2000 Workshop: $m(t)=110-165$ GeV/c$^2$ excluded
- Stop mass a little worse than SUSY 2000 workshop projection:
  - Further improvements when lowering $E_T$ cut
  - Reoptimise selection cuts at high lumi

6/25/2004