OU Physics Analysis

Why I’m Here

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Outline

- The OU group
- Current analysis in $b$-physics
  1. $CP$-violation and Mixing Flavor tagging
  2. $B_s$ mixing
- Top physics
  1. Past analysis
  2. Future prospects
- Summary and conclusions
OU Personnel

- Faculty
  - B. Abbott
  - P. Gutierrez
  - P. Skubic
  - M. Strauss

- Postdocs
  - S. Jain
  - M. Kopal
  - A. Pompoš
  - H. Severini

- Students
  - I. Hall
  - X. Zhang
Overview of Interests

- Electroweak symmetry breaking sector
  - Higgs searches
  - Mass $\neq$ Weak fermion eigenstates $\Rightarrow$ CKM matrix
    - Flavor mixing, mixing of $CP$ eigenstates, $CP$-violation
- Rare decays
- Concentrate on Heavy Flavors ($b$ and $t$ quarks)
  - $b$-quark $\Rightarrow$ Mixing and $CP$-violation
  - $t$-quark $\Rightarrow$ Mass, $\sigma(p\bar{p} \rightarrow tt)$, rare decays, CKM, …
$b$-Physics

- $CP$-violation
  - Goal: measure angles/sides of unitarity triangle
  - 6 possible triangles from unitarity constraint of CKM matrix
  - Many experiments to contribute
  - Many non-standard model sources
  - Belle & BaBar find indication of this
  - Measurement of $\sin 2\beta$

\[
B^0(\bar{B}^0) \rightarrow J/\psi K_s \quad \Rightarrow \quad \sin 2\beta = 0.73 \pm 0.06
\]

\[
B^0(\bar{B}^0) \rightarrow \phi K_s \quad \Rightarrow \quad \sin 2\beta = \begin{cases} -0.96 \pm 0.5 \\ 0.45 \pm 0.43 \end{cases}
\]
b-Physics OU Analysis

- Plan to make $\sin 2\beta$ measurement
  - Measure asymmetry in $B^0(\bar{B}^0) \to J/\psi K_s$
    
    $$A_{CP} = \sin 2\beta \sin(\Delta m_d t)$$

- Need to tag flavor at production
  - 3 common methods
    - Opposite side lepton
    - Same side jet
    - Opposite side jet (OU effort here)
      - Have measured dilution in $B^\pm \to J/\psi K^{\pm}$
      - Studying how to translate to $B^0$ sample
  - Future to consider $B^0_s(\bar{B}^0_s) \to J/\psi \phi$
Studies underway to measure $B_s$ mixing

- At present only possible at Tevatron
- Current limit $x_s > 19$ @ 95% CL
  $(x_s = \Delta m_s / \Gamma_s)$
  - Global fit of data indicates $x_s \approx 25$
- Need to measure flavor at production and decay
  - Considering $B_s^0(\bar{B}_s^0) \rightarrow D_s \ell \nu_\ell$ —a self tagged mode
    • Should be able to reach $x_s = 30$
**t-Physics**

- Least studied quark
  - ≈ 35 times heavier than $b$-quark
  - Yukawa coupling $\approx 1.4$
  - Clearest manifestation of EWSB

$m_t \ (\sigma_{m_t} \approx \pm 3 \text{ GeV}) \ & \ M_W \ (\sigma_{M_W} \approx \pm 40 \text{ MeV})$

$\Rightarrow \ \delta M_H \approx 40\% M_H$

$\sigma(\bar{p}p \rightarrow t\bar{t} + X) \ \text{expect} \approx \pm 8\%, \ \text{theory} \approx \pm 10\%$

- Deviations could be indication of new physics

- Single top production $\bar{p}p \rightarrow t + X$ direct measurement of $V_{tb}$
  - At present limits come from unitarity of CKM assuming 3 generations
Members of our group contributed to Run I $t$ analysis

Search for $t \rightarrow bH^+$

- Most straightforward extension to SM, add second Higgs doublet
- Introduces 4 new scalar particles with 2 charged
- Coupling: one doublet to weak isospin $+\frac{1}{2}$ & one to weak isospin $-\frac{1}{2}$ fermions; MMSM inspired
- Search in parameter space $M_H$ vs. $\tan \beta$
t-Physics Past Analysis

- Carried out search using two methods
  - If $\sigma(\bar{p}p \rightarrow tt)$ lower than predicted, could be due to non-SM decays
  - Search parameter space for regions where SM and $t \rightarrow H^+$ have high efficiency of being found. Regions can be excluded since SM $\sigma$ agrees with data
  - Direct search, look for excess of $\tau$’s from $H^\pm$ decays
Search for narrow resonance decay $M_x \rightarrow t\bar{t}$

- Expected in extended technicolor models
- Set limit $M_{t\bar{t}} > 560$ GeV for $\Gamma < 0.012M_{t\bar{t}}$
- Initiating new effort in single top search
  - Electroweak production
  - $s$ and $t$ channel contributions
  - Run I limits (Neural Net analysis)

\[
\sigma(\bar{p}p \rightarrow tb + X) < 17 \text{ pb} \\
\sigma(\bar{p}p \rightarrow tqb + X) < 22 \text{ pb}
\]

- Provides a direct measurement of $V_{tb}$
  - Expect a 12% error on $V_{tb}$ using Run IIa data
Summary & Conclusions

- Our primary interest is studying the EWSB sector of SM
  - Will pursue physics through study of $t$ & $b$ quarks
- All these analysis require substantial Monte Carlo samples