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TOP QUARK MEASUREMENTS

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Ten years after its discovery at the Tevatron collider, we still know little about the top quark. Its large mass suggests it may play a key role in the mechanism of Electroweak Symmetry Breaking (EWSB), or open a window of sensitivity to new physics related to EWSB and preferentially coupled to it. To determine whether this is the case, precision measurements of top quark properties are necessary. The high statistics samples being collected by the Tevatron experiments during Run II start to incisively probe the top quark sector. This report summarizes the experimental status of the top quark, focusing in particular on the recent measurements from the Tevatron Run II.

1 Introduction

The top quark vas discovered in 1995 by the CDF and DØ collaborations[1] during Run I of the Fermilab Tevatron collider. Like any discovery, this one caused a big excitement, although it did not really come as a surprise: the top quark existence was already required by self-consistency of the Standard Model (SM).

One of the most striking properties of the top quark is its large mass, comparable to the Electroweak Symmetry Breaking (EWSB) scale. Therefore, the top quark might be instrumental in helping resolve one of the most urgent problems in High Energy Physics: identifying the mechanism of EWSB and mass generation. In fact, the top quark may either play a key role in EWSB, or serve as a window to new physics related to EWSB and which, because of its large mass, might be preferentially coupled to it.

Ten years after its discovery, we still know little about the top quark. Existing indirect constraints on top quark properties from low-energy data, or the statistics-limited direct measurements at Tevatron Run I, are relatively poor and leave plenty of room for new physics. Precision measurements of top quark properties are crucial in order to unveil its true nature. Currently, the Tevatron collider is the world's only source of top quarks.

2 The Tevatron Accelerator

The Tevatron is a proton–antiproton collider operating at a center of mass energy of 1.96 TeV. With respect to Run I, the center of mass energy has been slightly increased (from 1.8 TeV) and the interbunch crossing reduced to 396 ns (from 3.6 μs). The latter and many other upgrades to Fermilab's accelerator complex have been made with the goal of achieving a significant increase in luminosity. Since the beginning of Run II in March 2001, the Tevatron has delivered an integrated luminosity of $L = 1$ fb^{-1}, and is currently operating at instantaneous luminosities $\mathcal{L} > 1 \times 10^{32}$ cm^{-2}s^{-1}. The goal is to reach $\mathcal{L} \sim 3 \times 10^{32}$ cm^{-2}s^{-1} by 2007, and $L \sim 4.1 - 8.2$ fb^{-1} by the end of 2009. This represents a $\times 40 - 80$ increase with respect to the Run I data set, which will allow the Tevatron experiments to make the transition from the discovery phase to a phase of precision measurements of top quark properties.

3 Top Quark Production and Decay

At the Tevatron, the dominant production mechanism for top quarks is in pairs, mediated by the strong interaction, with a predicted cross section at $\sqrt{s} = 1.96$ TeV of 6.77 ± 0.42 pb for $m_t = 175$ GeV.[2] Within the SM, top quarks can also be produced