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THE DISCOVERY OF THE TOP QUARK

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1 Introduction

1.1 The Case for Top

The top quark and the Higgs boson are the heaviest elementary particles predicted by the standard model. The four lightest quark flavours, the up, down, strange and charm quarks, were well-established by the mid-1970's. The discovery in 1977 [1] of the Υ resonances, a new family of massive hadrons, required the introduction of the fifth quark flavour. Experimental and theoretical studies have indicated that this quark also has a heavier partner, the top quark.

Indirect evidence for the top quark comes from a number of sources. The most compelling data come from the observed properties of the scattering process $e^+e^- \rightarrow b\bar{b}$, where the asymmetry in the scattering of the b quark relative to the incoming electron direction implies that the b quark has weak isospin of 0.5. The most precise measurement of this comes from the LEP collider, where this asymmetry has been measured[2] to be 0.097 ± 0.004, in excellent agreement with the standard model expectation of 0.100 assuming that the b quark is a member of an $SU(2)$ doublet. The other member of that doublet would by definition be the top quark.

Additional indirect evidence comes from the study of b quark decays. It has been experimentally determined that the b quark does not decay via processes that yield zero net flavour in the final state (*e.g.*, $b \rightarrow \mu^+\mu^- X$), or where the decay results in only a quark of the same charge (*e.g.*. $b \rightarrow sX$ where X is a state with no net flavour quantum numbers) [3]. The absence of these "flavour-changing neutral currents" in the standard model imply that the b quark is a member of an $SU(2)$ doublet.

Finally, evidence for the existence of a massive fermion that couples via the electroweak force to the b quark comes from detailed measurements of the Z and W bosons performed at LEP, SLC, the CERN S$p\bar{p}$S and the Fermilab Tevatron Collider. This body of data, and in particular the radiative mass shifts of the electroweak bosons, can only be described in the standard model by introducing a top quark. A

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