LNS Update

LABORATORY FOR NUCLEAR SCIENCE

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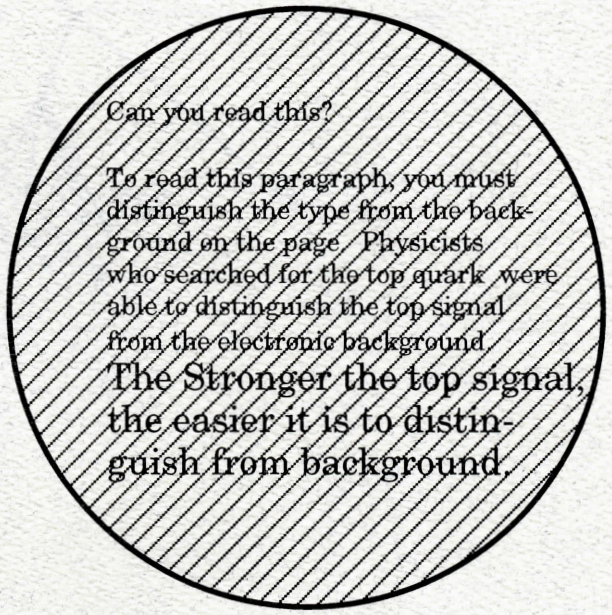
The Discovery of the Top Quark and the Participation by the MIT-CDF Collaboration

Introduction

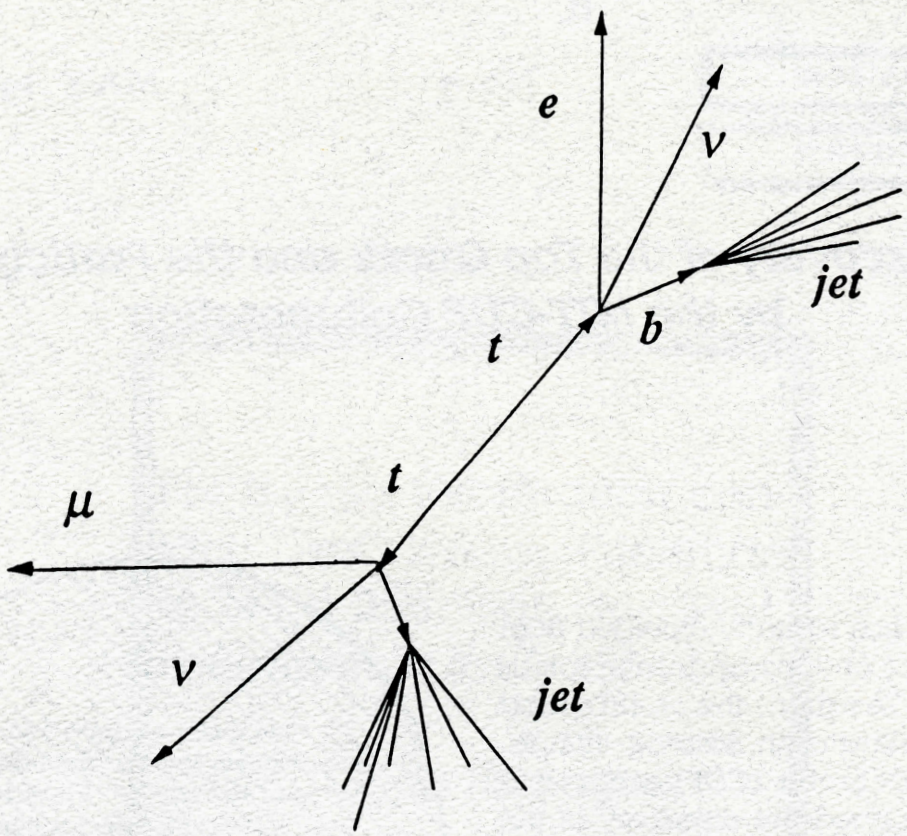
The top quark has recently emerged from the collisions of protons and anti-protons at Fermilab's Tevatron, the world's most powerful accelerator in Batavia, Illinois. The Collider Detector (CDF) group has recently announced the discovery of the top quark (t) at Fermilab. The particle has a mass of 176 GeV/c^2 which is surprisingly heavy. Subatomic particles cannot be seen, but they leave behind their electronic signature (see Figures 1 and 2). From these signatures, physicists are able to determine which particles were produced during a collision. But particles like the top quark start to decay very quickly into other particles and so it is more difficult to read their signatures. A "lego plot," shows physicists the signature pattern. The height of each lego tower shows the amount of energy detected in each section of a detector's calorimeter (see Figure 3). Recently the D-Zero Collaboration, at Fermilab, also provided evidence for the discovery of the top quark.



Fermi News (April 15, 1994)

Top Quark Decay: Signal I

Signature I: Dilepton Channel

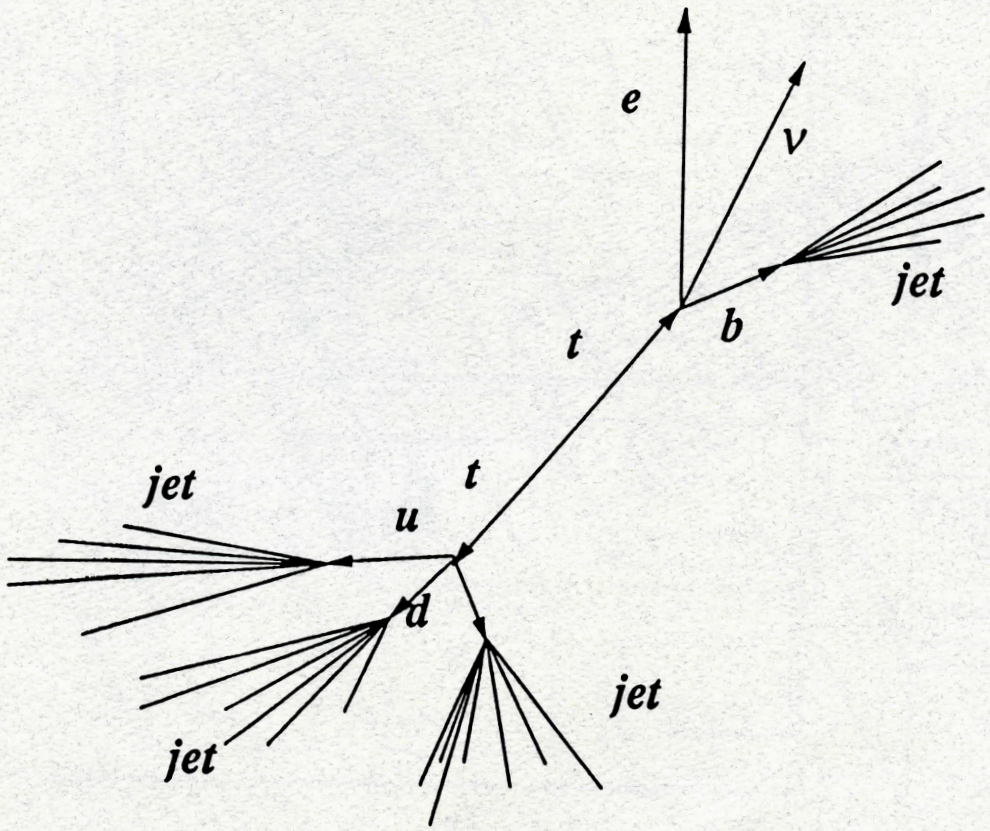


We expect:
Two high-transverse momentum leptons,
high missing transverse energy,
and 2 jets

Figure 1

Top Quark Decay: Signal II

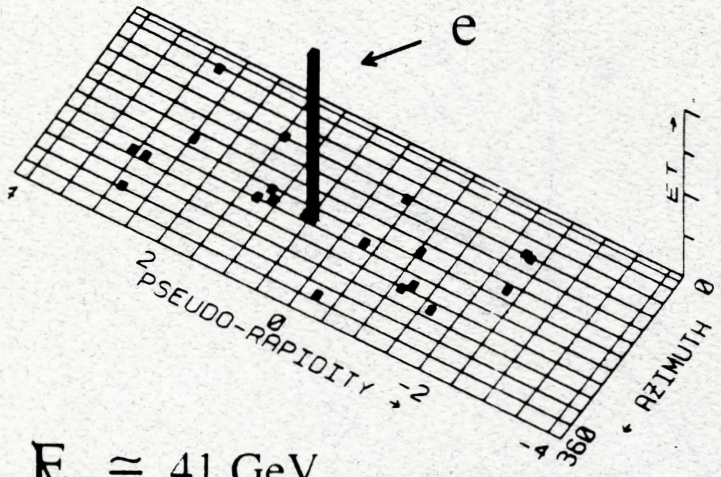
Signature II: W+jets Channel



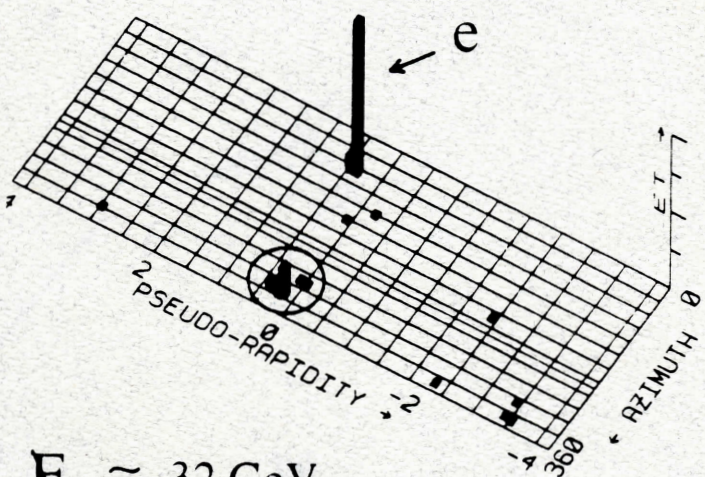
We expect:
A high-transverse momentum lepton,
high missing transverse energy,
and 4 jets

Figure 2

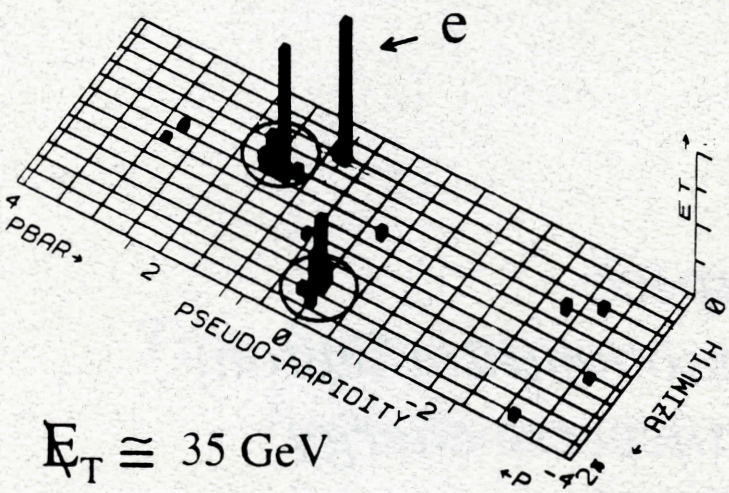
CDF:
W + 0,1,2,3 jet(s) Events



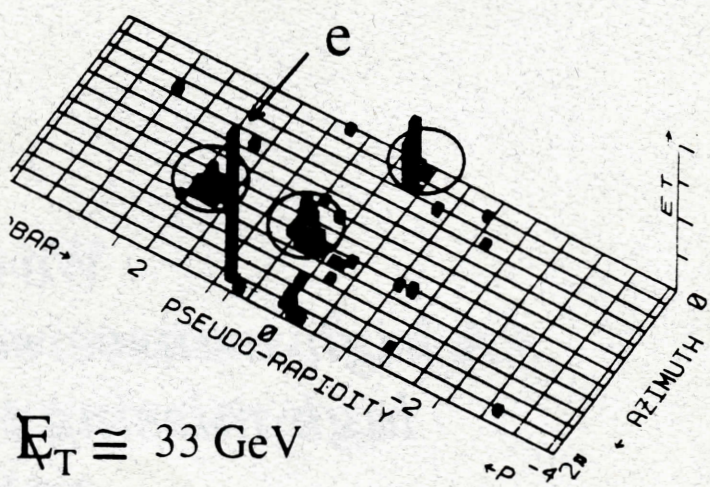
$\not{E}_T \cong$ 41 GeV



$\not{E}_T \cong$ 32 GeV



$\not{E}_T \cong$ 35 GeV



$\not{E}_T \cong$ 33 GeV

Figure 3

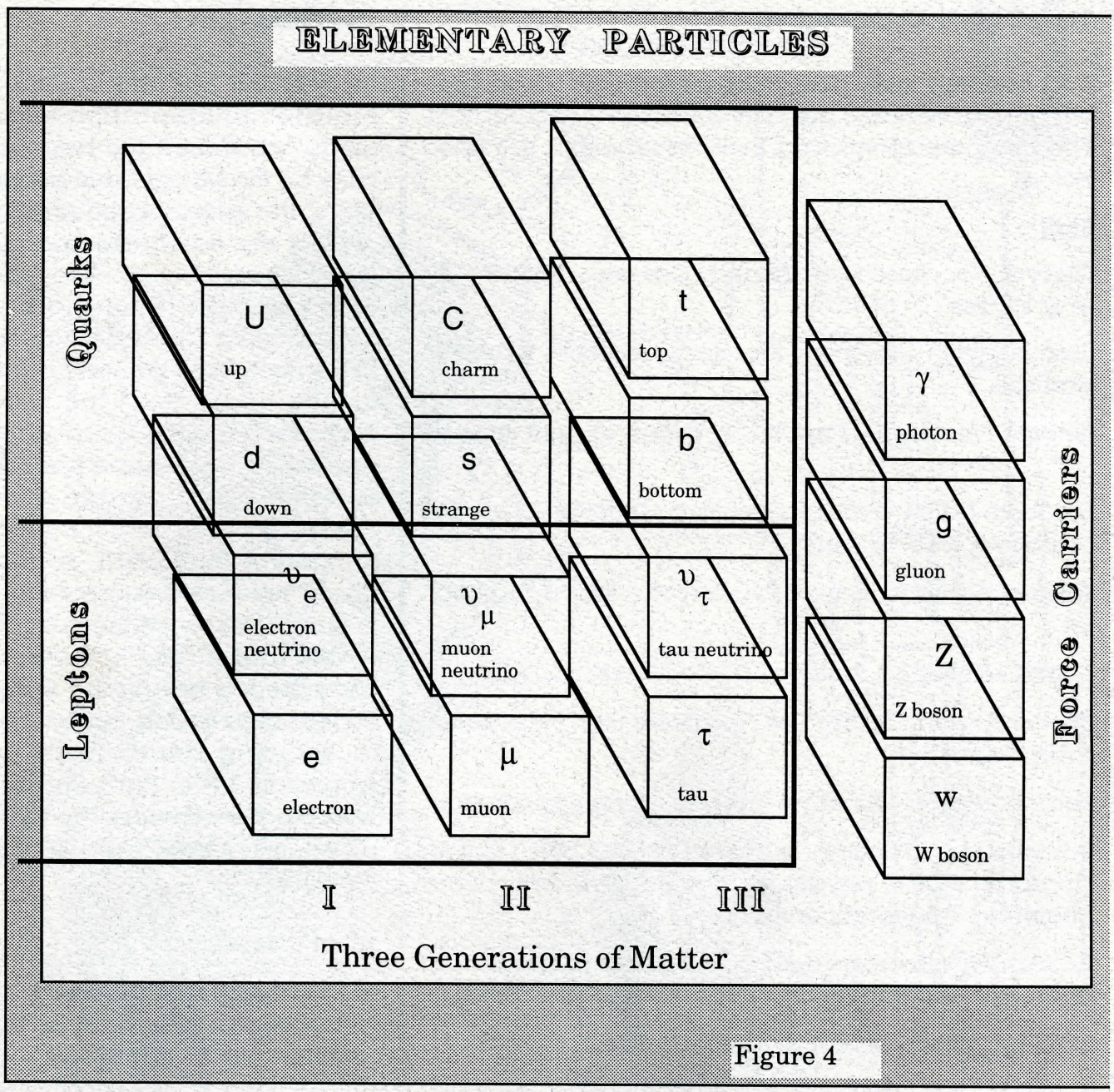


Figure 4

Quarks and leptons are the building blocks of the universe, and bosons are the quanta of the force fields with which the building blocks interact. The discovery of top quark provided support for the validity of the Standard Model. The Standard Model includes 6 quarks: up, down, charm, strange, top and bottom (see Figure 4 above). Top quarks are produced in pairs when a light quark in the proton and a light antiquark in the antiproton annihilate to form a top-antitop pair. Top quark pairs are also produced by gluon-gluon interactions.

The MIT-CDF Collaboration

Four hundred thirty nine collaborators from 35 universities and laboratories are part of the CDF Collaboration. The MIT participants and their contributions are listed below.

Staff

Gerry Bauer - Research Scientist - Gas gain; PHA; B -> ψ' studies

José Benlloch - Postdoc - Gas gain; Searches for exotic particles

Jerome Friedman - Faculty - Analysis; student supervisor*

Elizabeth Hafen - Principal Research Scientist - Joined in March 94. CDF Tracking

Andrey Korytov - Research Scientist - Joined in March 94.

Robert Mattingly - Postdoc - DAQ: B Physics

Steven Pavlon - Spons. Res. Technical Staff - Electronics & Simulation

Larry Rosenson - Faculty - Analysis; student supervisor

Paris Sphicas - Faculty - In charge of DAQ Event Builder Upgrade; CDF B physics convener; DAQ Inst. board chairman; student supervisor

Konstanty Sumorok - Principal Research Scientist - In charge of Gas gain monitoring; QCD analysis; DAQ

Stephen Tether - Research Scientist - DAQ

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*Spokesman CDF group

At FNAL:

Wasiq Bokhari
Troy Daniels
Ken Kelley
Petar Maksimovic
Dejan Vucinic

At MIT:

Paul Ngan
Vincenzo Lia
Tushar Shah

The Background

In 1991 the MIT group joined the CDF collaboration. The group has shared the responsibility for the Monte-Carlo generators, the detector simulation, and for the databases and off-line code distribution. They are also responsible for the gas gain monitor (see Figure 5) for the entire gas calorimetry and for the upgrade of the Data Acquisition (DAQ), which is the new event builder and scanner system. The upgrade from Fastbus to VME and the introduction of ULTRANET, a hub-based network was necessary in order to increase the reliability and rate of data acquisition. The system is being used in the current data-taking period and is reducing dead time. In August of 1994, Paris Sphicas became the convener for the B physics experiments at Fermilab.

What's Next?

More data are needed to increase the precision of the measurements of the mass of the top quark and its production cross-section. Currently the Fermilab Tevatron is taking data that could provide a factor of 4 more top events.