Closing Remarks

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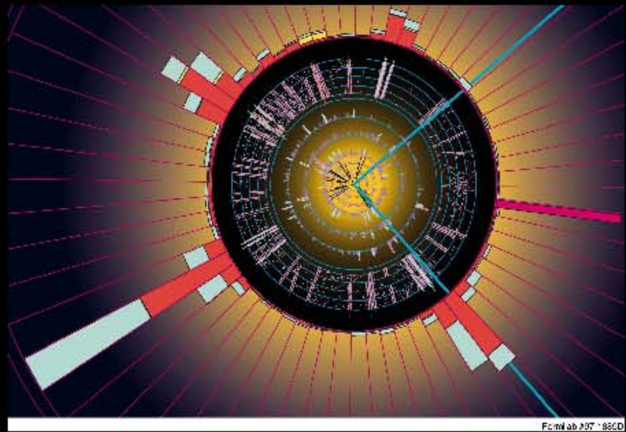
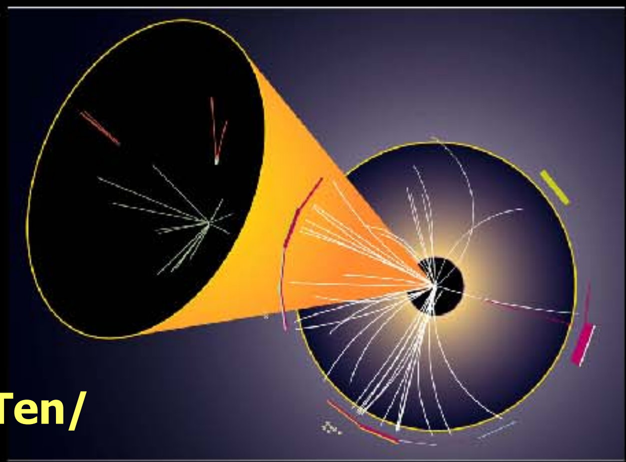
Top Turns Ten!

A symposium to celebrate the discovery of the top quark
Fermilab, March 25, 2005

Home

organizing committee
M. Narain (co-chair)
J. Womersley (co-chair)
N. Hadley
B. Klima
J. Königsberg
T. Liss
C. Quigg





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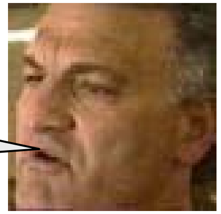
Done

Why are we here?

- The food?
- The weather?
- The scenery?
- The Long Island lifestyle?

(expletive) no



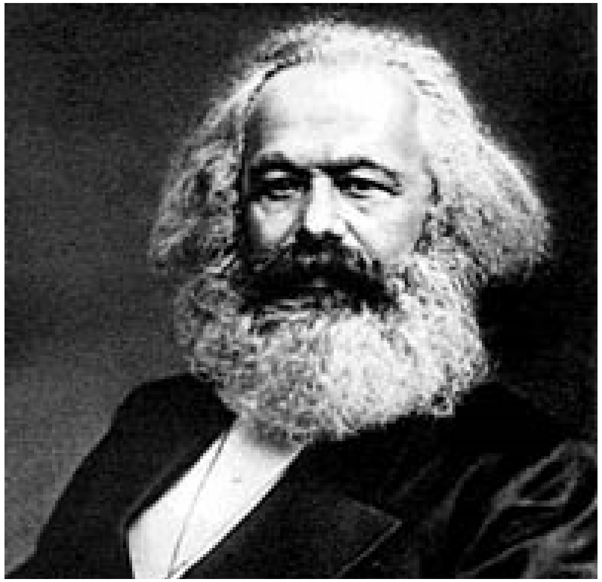
Joey Buttafuoco

- There are two reasons:

1. To understand the physics

2. To build relationships

What do these two have in common?



Scott Willenbrock **Karl Marx**

A: they both predict an imminent and inevitable revolution

Physicists of the world, unite …

Like capitalism, the Standard Model contains the seeds of its own destruction

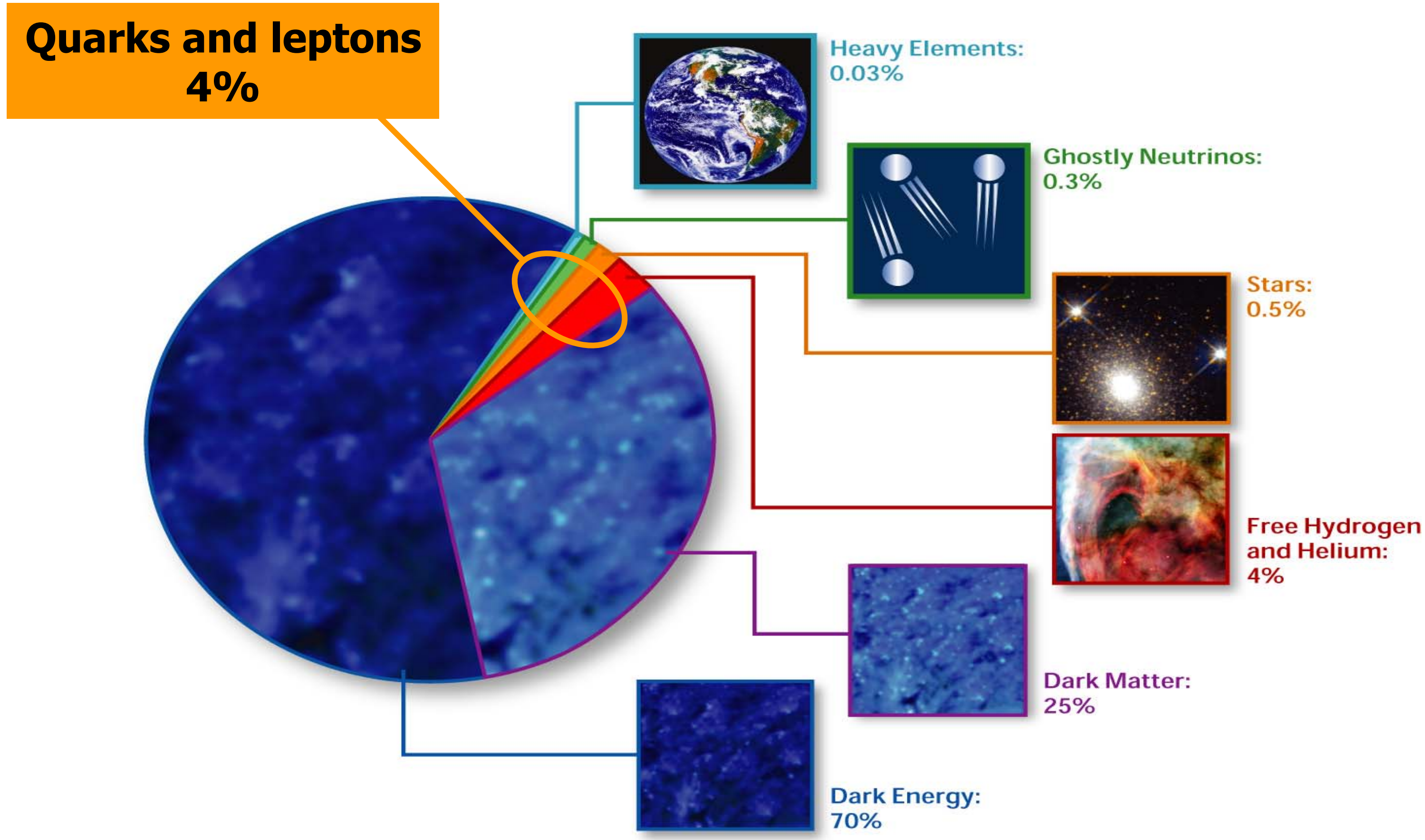
- **Its spectacular success in describing phenomena at energy scales below 1 TeV is based on**
  - At least one unobserved ingredient
    - SM Higgs
  - With a mass unstable to loop corrections
    - SUSY may fix
  - And an energy density 10^{60} times too great to exist in the universe we live in

- **These questions are amenable to experiment (and only to experiment)**
  - tantalizing – we know the answers are accessible
  - frustrating – we have known this for 20 years…

We went to Texas

… and we came back

Meanwhile, back in the universe

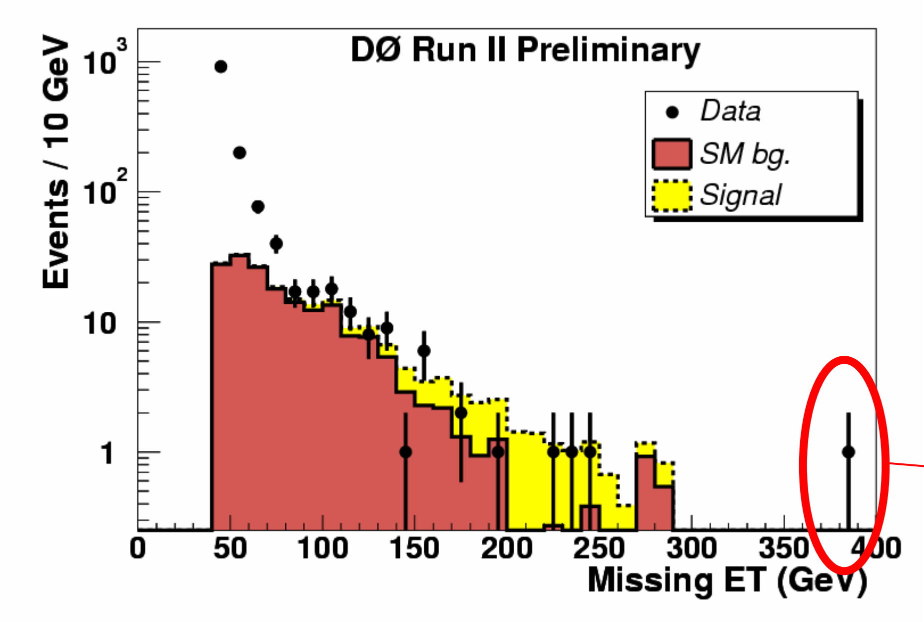


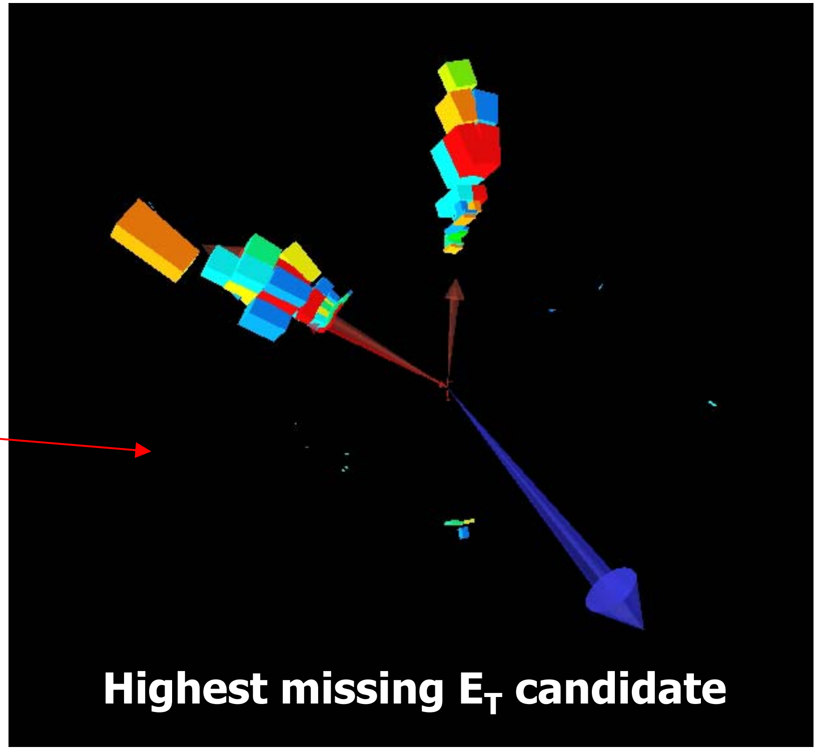
State of the standard model 2005

- **Who would have guessed, in 1990, the role that neutrinos and the cosmic microwave background would play in undermining the edifice?**

Tevatron

- **Can we discover TeV-scale physics at the Tevatron?**





- **A squark candidate from the first 200pb^{-1} – will we find more?**

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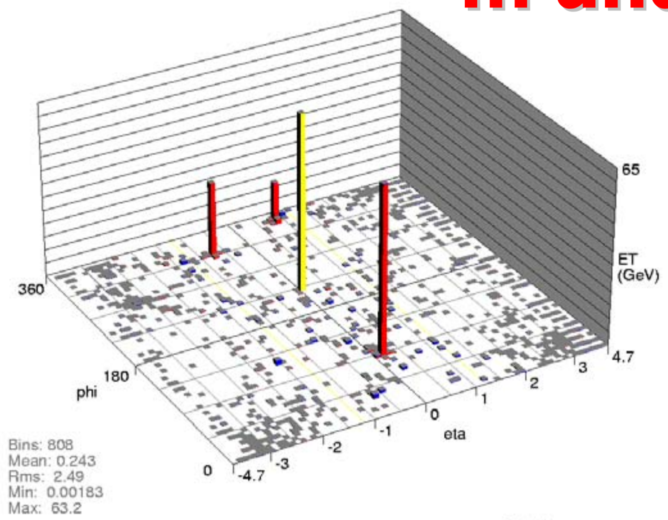
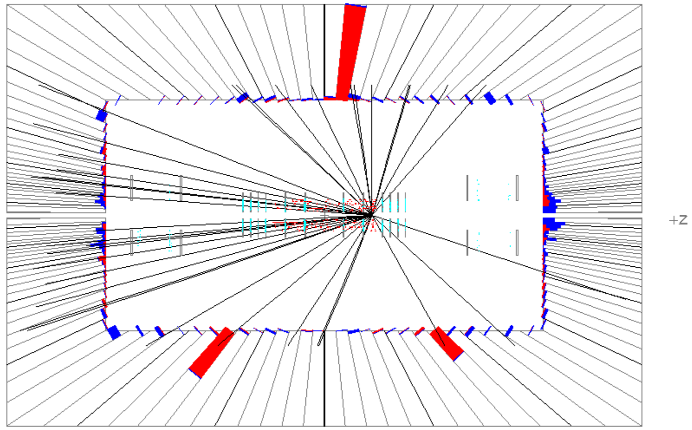
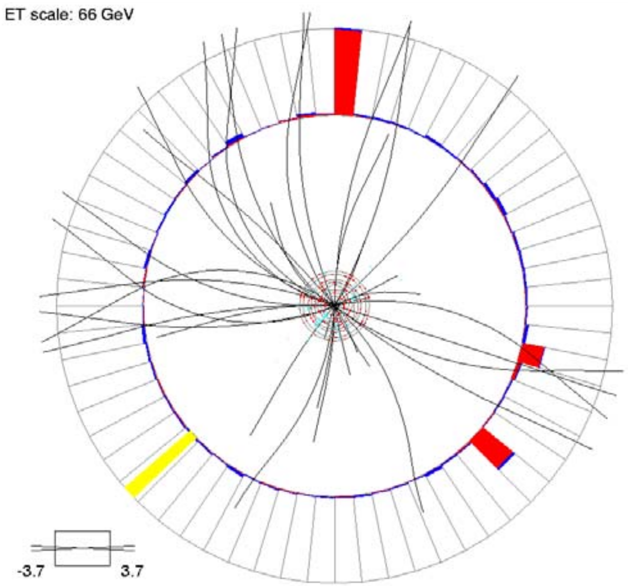
... and more fun







- **Search for gauge mediated SUSY found this intriguing $e\gamma\gamma+ME_T$ event**
  - **Transverse mass of e and ME_T = 68 GeV**
    - **Consistent with a W – but what is the expected rate of $W\gamma\gamma$ production?**

Recall CDF Run I $ee\gamma\gamma+ME_T$ event

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Relationships

What is the biggest challenge to doing physics analysis at the LHC?

- **I have been thinking about this at a personal level – if I were to get into LHC analysis, based in the US, what would be the challenge?**
- **Would it be**
  - **The huge amount of data**
  - **C++, Computing, the Grid, Tier N centers**
  - **Understanding pp interactions at 14 TeV**
    - **Obviously all of the above, at some level…**
  - **but the key (in my opinion) is**
    - **How to establish and maintain the relationships needed across 5000 miles of ocean and 6 timezones**

What is he talking about?

- Big collaborations are founded on mutual trust and understanding, built on a shared sense of purpose and a common experience base.
  - In the past, geographic proximity has always been a part of this
- Mutual trust and understanding is essential:
  - I need to call on other people's time to solve my problems
  - I need to use other people's work, they need to use mine
  - My results need to be believed, accepted, published, not duplicated
- Why does this matter
  - Obviously a prime concern for people who will be based in a different continent than the detector
  - But also important for the CERN-based component of the experiment
    - The collaboration that can best marshall all of its worldwide resources will come out ahead

- **Workshops like this one play a key role in the relationship-building process**
  - **Personal example:**

  - **Aside**
    consider this an official encouragement from the DOE to have a few drinks and make friends with the other workshop attendees.

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TOP QUARK PHYSICS*

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1. INTRODUCTION

The top quark, when it was finally discovered at Fermilab in 1995 [1, 2, 3], completed the three-generation structure of the Standard Model (SM) and opened up the new field of top quark physics. Viewed as just another SM quark, the top quark appears to be a rather uninteresting species. Produced predominantly, in hadron-hadron collisions, through strong interactions, it decays rapidly without forming hadrons, and almost exclusively through the single mode $t \to Wb$. The relevant CKM coupling V_{tb} is already determined by the (three-generation) unitarity of the CKM matrix. Rare decays and CP violation are unmeasurably small in the SM.

Yet the top quark is distinguished by its large mass, about 35 times larger than the mass of the next heavy quark, and intriguingly close to the scale of electroweak (EW) symmetry breaking. This unique property raises a number of interesting questions. Is the top quark mass generated by the Higgs mechanism as the SM predicts and is its mass related to the top-Higgs-Yukawa coupling? Or does it play an even more fundamental role in the EW symmetry breaking mechanism? If there are new particles lighter than the top quark, does the top quark decay into them? Could non-SM physics first manifest itself in non-standard couplings of the top quark which show up as anomalies in top quark production and decays? Top quark physics tries to answer these questions.

Several properties of the top quark have already been examined at the Tevatron. These include studies of the kinematical properties of top production [4], the measurements of the top mass [5, 6], of the top production cross-section [7, 8], the reconstruction of $t\bar{t}$ pairs in the fully hadronic final states [9, 10], the study of τ decays of the top quark [11], the reconstruction of hadronic decays of the W boson from top decays [12], the search for flavour changing neutral current decays [13], the measurement of the W helicity in top decays [14], and bounds on $t\bar{t}$ spin correlations [15]. Most of these measurements are limited by the small sample of top quarks collected at the Tevatron up to now. The LHC is, in comparison, a top factory, producing about 8 million $t\bar{t}$ pairs per experiment per year at low luminosity (10 fb^{-1}/year), and another few million (anti-)tops in EW single (anti-)top quark production. We therefore expect that top quark properties can be examined with significant precision at the LHC. Entirely new measurements can be contemplated on the basis of the large available statistics.

In this chapter we summarize the top physics potential of the LHC experiments. An important aspect of this chapter is to document SM model properties of the top quark against which anomalous behaviour has to be compared. In each section (with the exception of the one devoted to anomalous couplings) we begin by summarizing SM expectations and review the current theoretical status on a particular topic. This is followed by a detailed description of experimental analysis strategies in the

* To appear in the Report of the "1999 CERN Workshop on SM physics (and more) at the LHC".

So, on to CERN …

Talking together is good
Working together is better

→ **A challenge to this workshop:**

- **The working groups started out reviewing work**
  Can we shift mode to generating new results?

  Good to see this starting to happen
  Some groups are further along in this process than others…

… Physics

- **Producing something new will not just advance the physics but also give a feeling of joint accomplishment and make this workshop a clear success**

…Relationships

See you at the CERN meeting, April 28-30