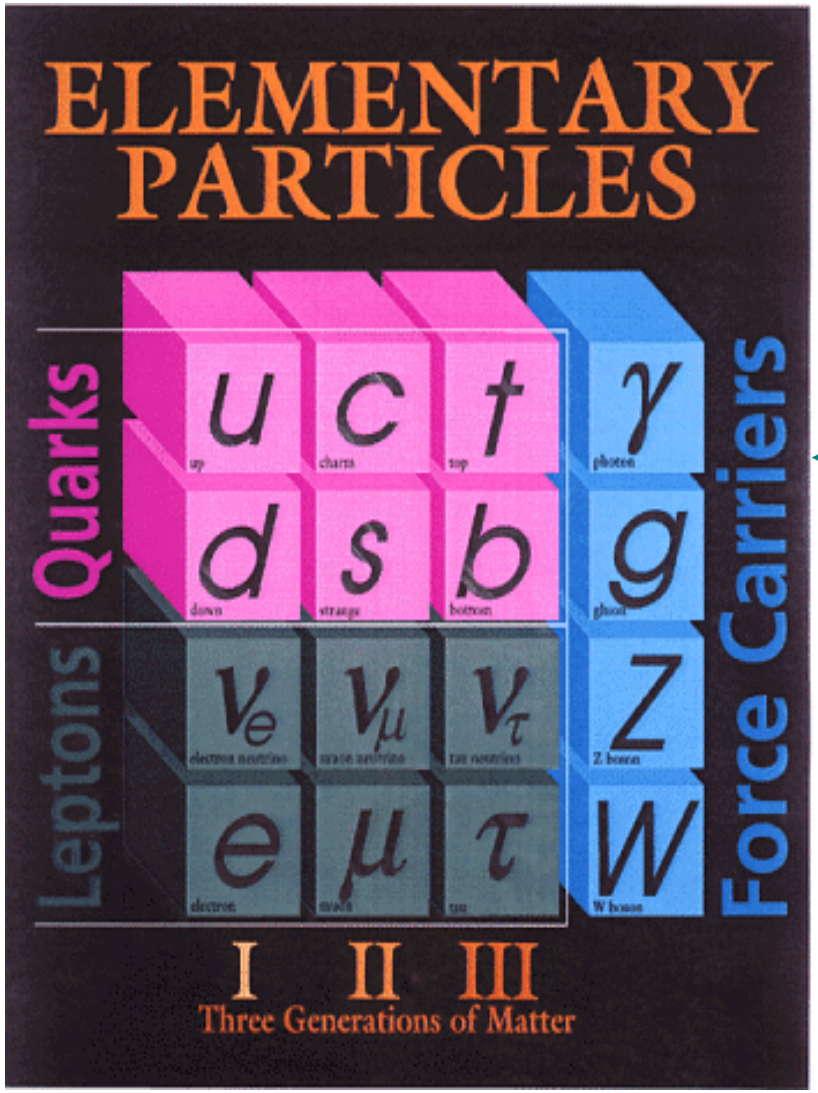
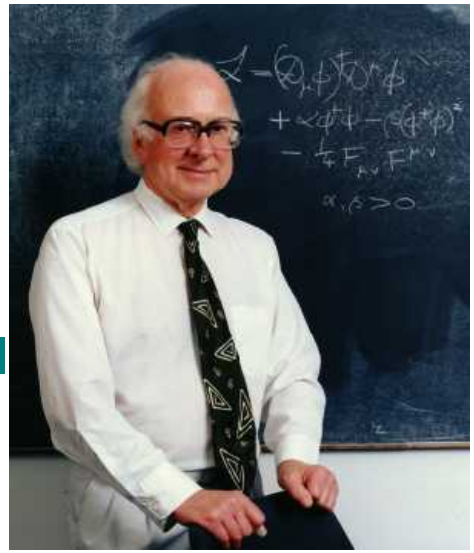
Searching for the Origin of Mass at the Tevatron

Overview

- A little bit of theory…
- The Hardware: Tevatron, DØ, Trigger
- My current analysis
- Finding the Higgs at the Tevatron
- Conclusions

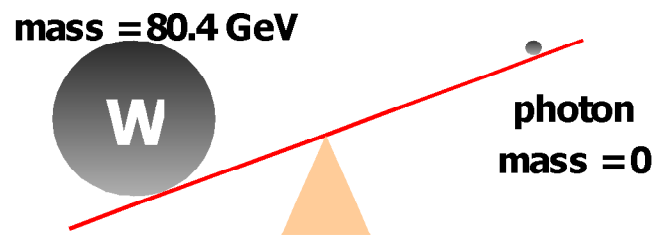
The Standard Model





What have we ordered this time?

Higgs Mechanism



- **In the Standard Model**
  - Electroweak symmetry breaking occurs through introduction of a scalar field $\Phi \rightarrow$ masses of W and Z
  - If Φ also couples to fermions $\rightarrow$ generates fermion masses

- **An appealing picture: is it correct?**
  - One clear and testable prediction: there exists a neutral scalar particle which is an excitation of the Higgs field
  - Theory predicts the production cross- sections, decay rates and couplings **but not its mass**.

Highest priority of worldwide high energy physics program: find it!

What do we know so far?

- **Over the last 10 years data from LEP II, SLD and the Tevatron has put constraints on the mass of the SM Higgs:**
  - precision measurements of parameters of the W and Z bosons, combined with Fermilab s top quark mass measurements, set an **upper limit of m_H ~ 200 GeV**
  - direct searches for Higgs production exclude **m_H < 114 GeV**

Summer and Fall 2000: Hints of a Higgs?

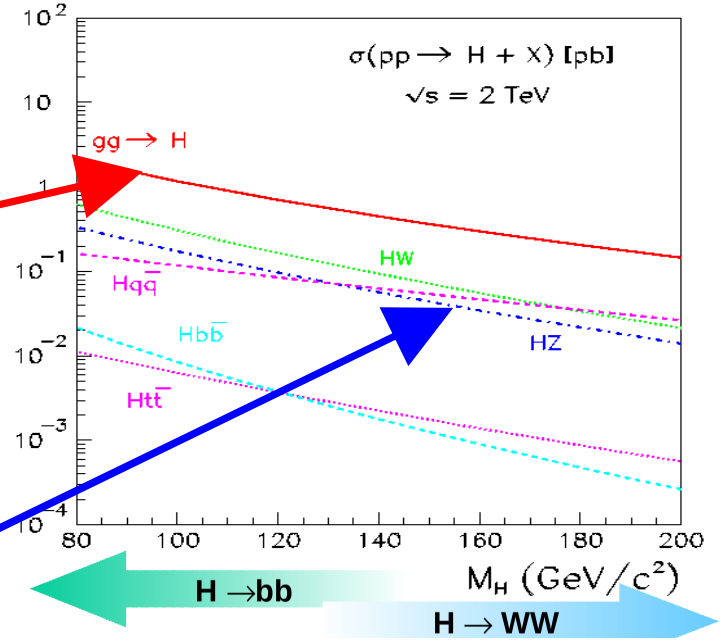
- the LEP data may have given some indication of a Higgs with mass 115 GeV (right at the limit of their sensitivity)
- despite these hints, CERN management decided to shut off LEP operations in order to expedite construction of the LHC

The resolution of this puzzle is now left to Fermilab's Tevatron and the LHC.

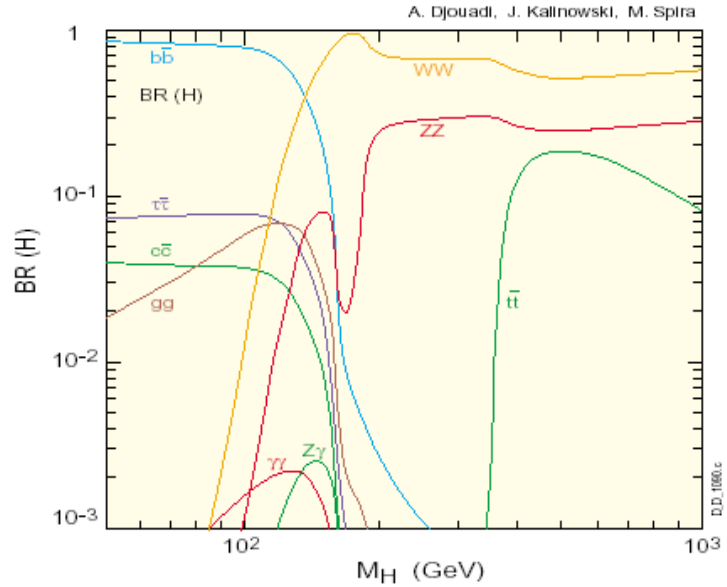
Luciano Maiani

Higgs production and decay

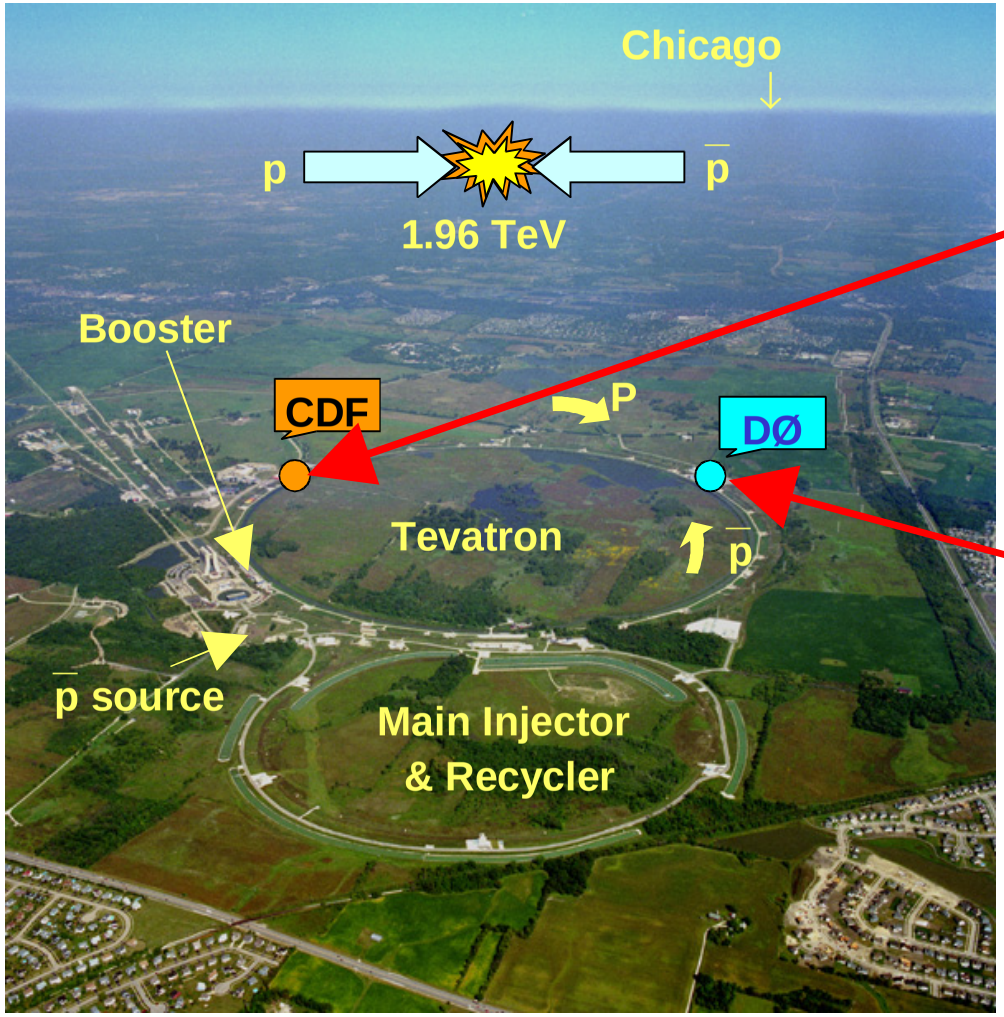
- **Inclusive Higgs cross section is quite high: ~ 1pb**
  - for masses below ~ 140 GeV, the dominant decay mode H → bb is swamped by background
  - at higher masses, can use inclusive production plus WW decays
- **The best bet below ~ 140 GeV appears to be associated production of H plus a W or Z ("Higgsstrahlung")**
  - leptonic decays of W/Z help give the needed background rejection
  - cross section ~ 0.2 pb

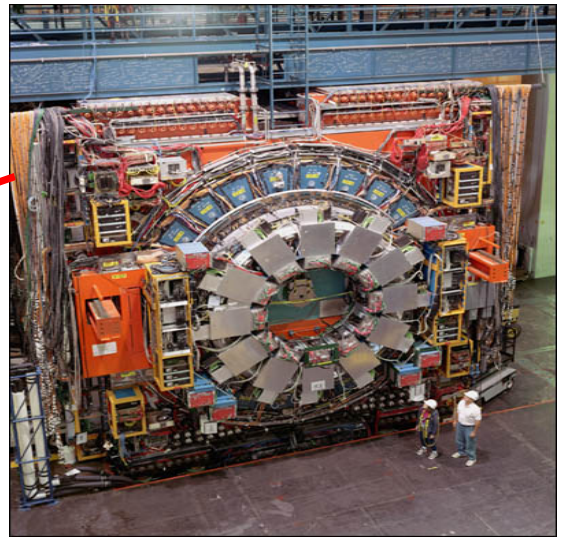


A. Djouadi, J. Kalinowski, M. Spira



The Fermilab Tevatron Collider and its detectors

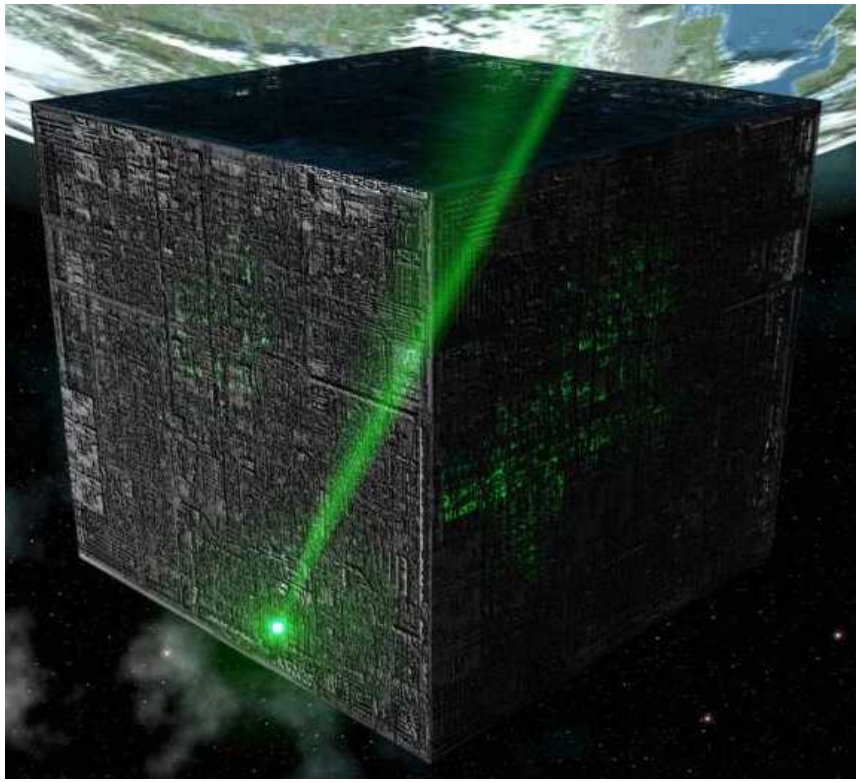




- Run I: 1992 – 1996
- Run II: started 2001

DØ vs Borg

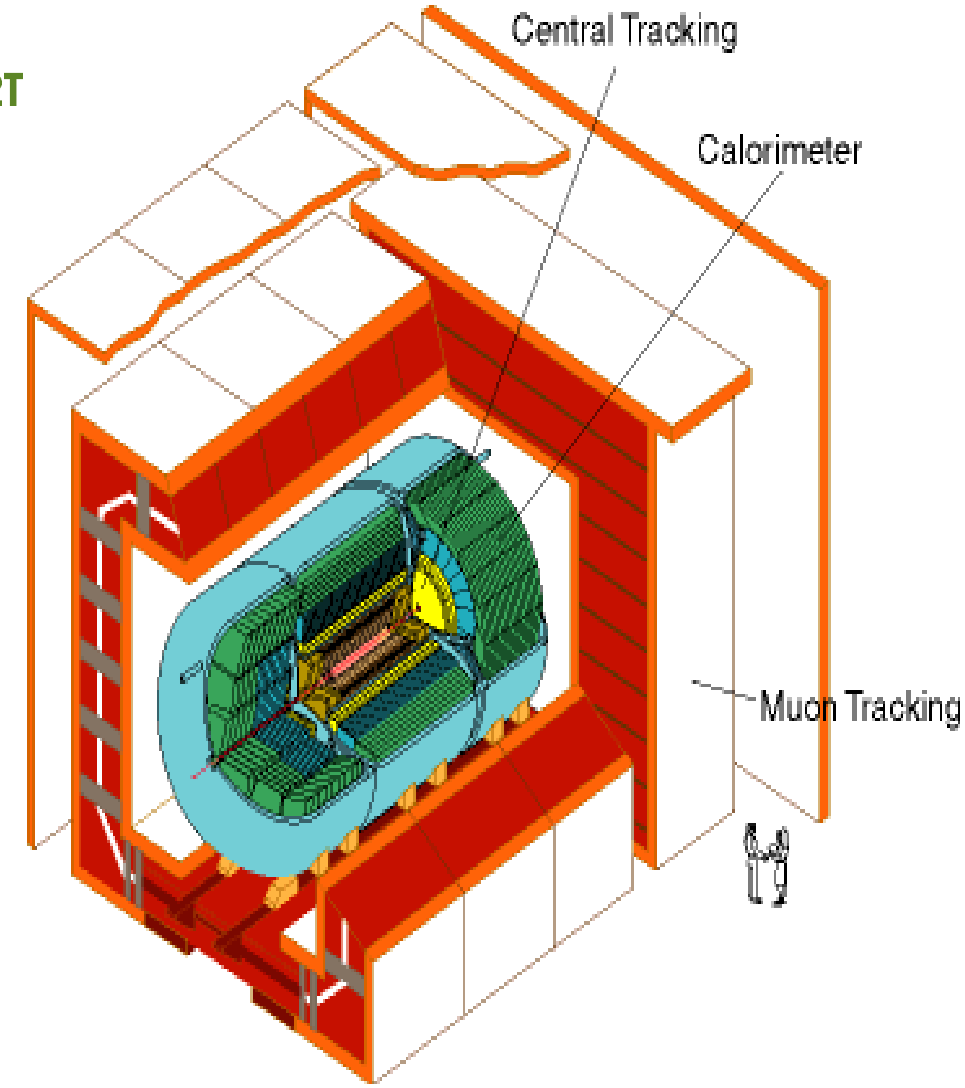
Coincidence ???



The DØ Detector

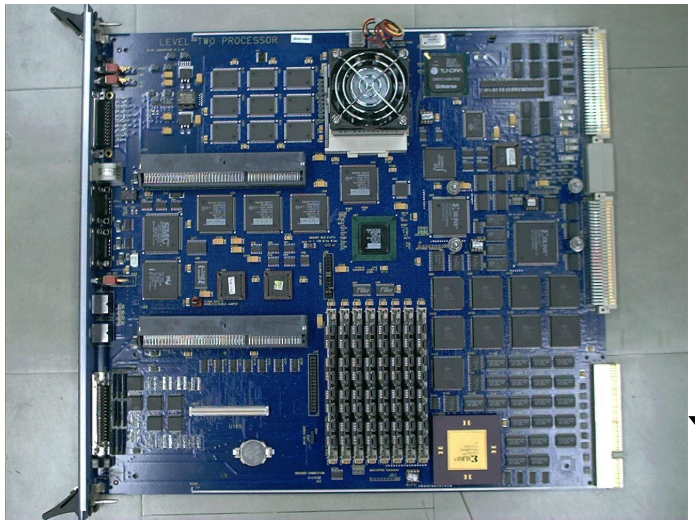
- Significant upgrades for Run II:
  - New silicon and fiber trackers in a 2T magnetic field
  - Preshower detectors in front of calorimeter
  - Improved muon system
  - New DAQ and trigger systems

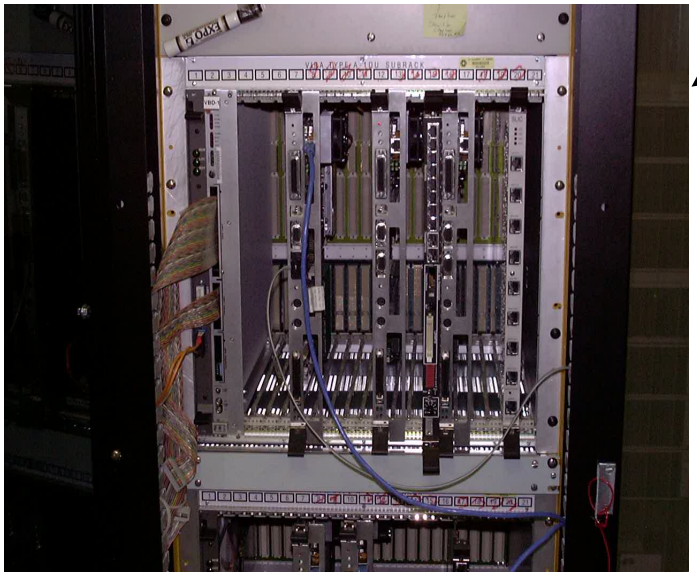
- Data rate at DØ:
  - Can inspect 5 million collisions per second
  - Records 50 collisions per second (10MB/s)
  - Will record 10^{15} bytes in Run II (1 PetaByte)

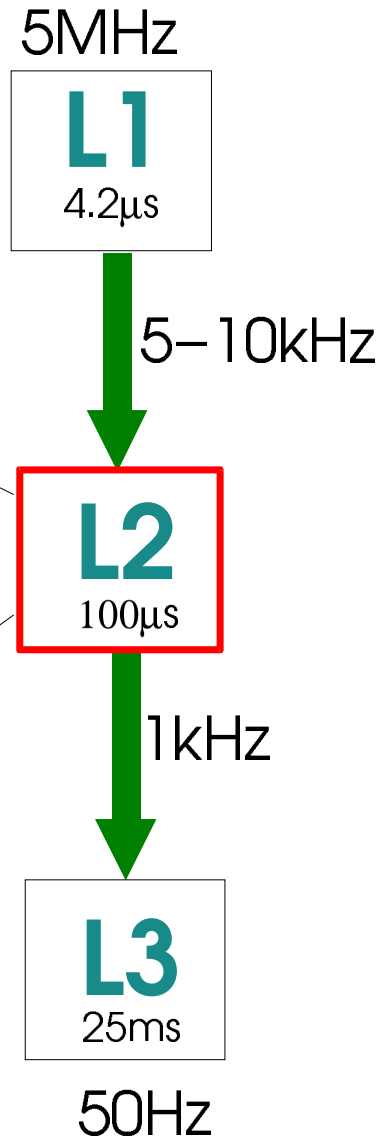


The Level2 Trigger System

- Hardware:
  - 500 MHz Alpha CPU
  - Linux OS (remote debugging!)
- Software:
  - Software algorithms make trigger decisions
  - Algorithms for Calorimeter 'Electron' and Jet triggering (C++)

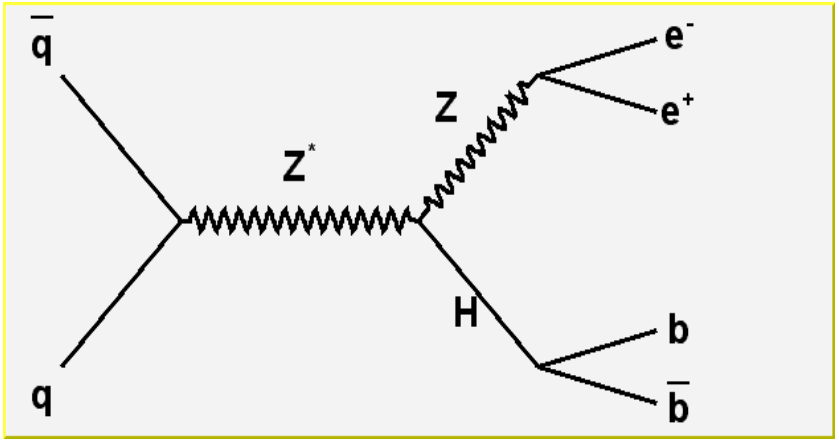


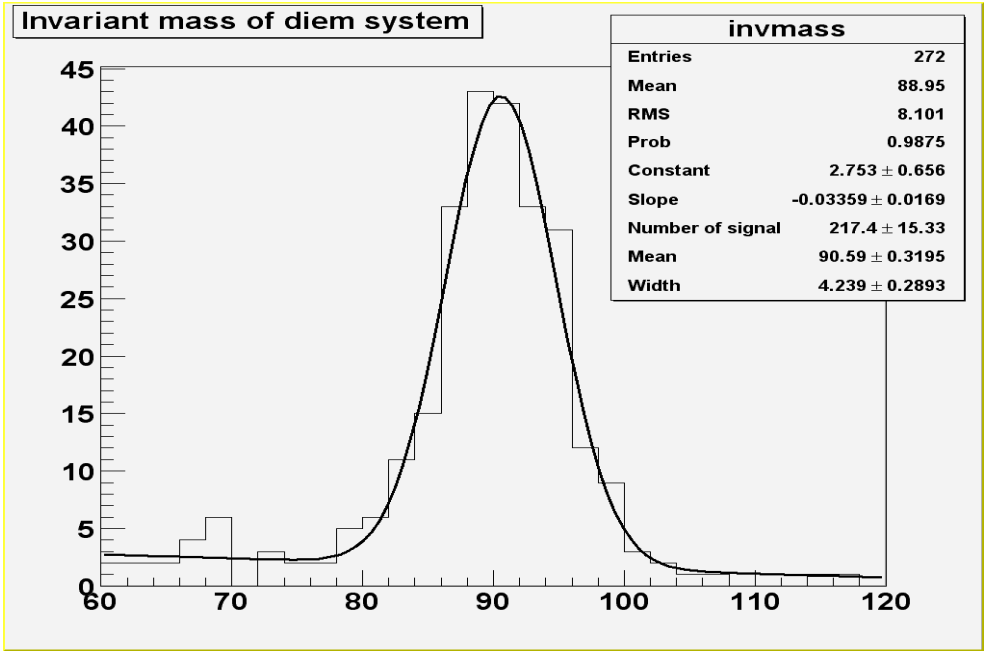




My data analysis: ZH → e^+e^-bb channel

- Has lower cs than other channels
- BUT nice to trigger on electron–positron pair from Z decay
- Using the tracker to select b–jets ('b–tagging') crucial

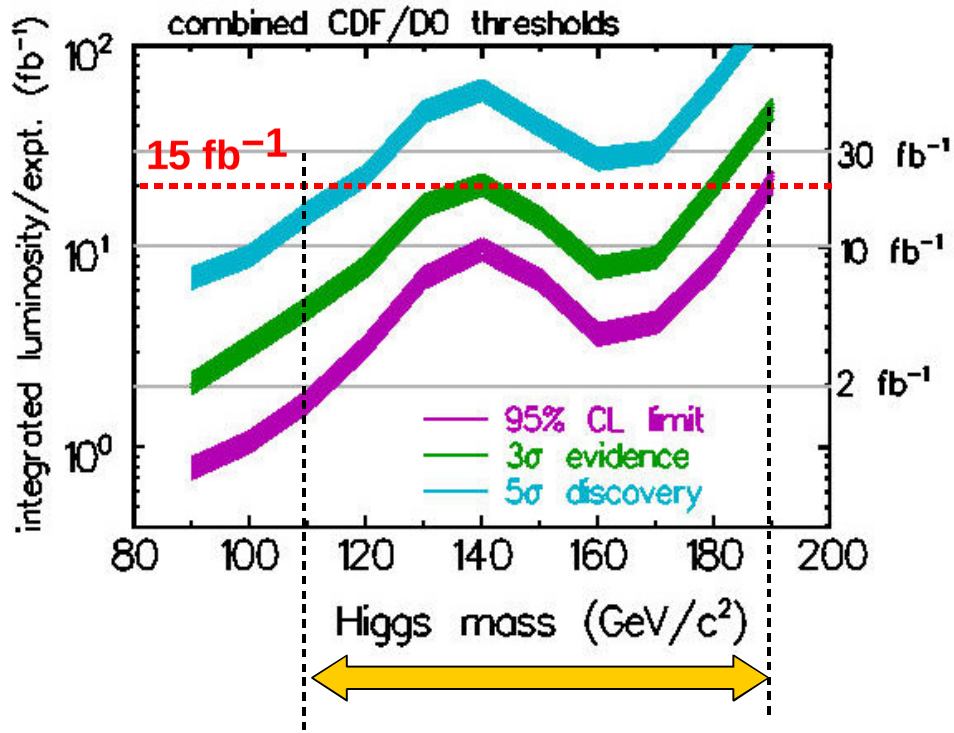




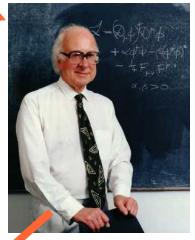
- Currently focusing on 'Z + Jets' analysis since b–tagging is still under development
- Firtst results ready for Spring 03 conferences

Tevatron discovery range

- The Higgs discovery potential for the Run II Tevatron has been evaluated (hep-ph/0010338).
- A joint effort of theorists and both Tevatron experiments, using a parametrized detector simulation.
- Main conclusions:
  - Discovery cannot be made in a single channel alone; data from all channels must be combined.
  - Must also combine the data from both experiments.
  - Must improve understanding of the background and signal processes and detector characteristics.
  - Advanced multivariate analysis techniques are vital



No guarantee of success – but certainly a very exciting possibility!

Conclusions

- Good time to join DØ: Run II in full swing...
- Exciting discoveries ahead
- What's behind the curtain???