FUTURESat the TEVATRON COLLIDER

- Three Recent Results
- The Next Five Years
- Through to the LHC

Result

- run 1b data [preliminary]
  - from m_T fit

    $m_W = 80.45 \pm 0.10(stat) \pm 0.07(syst)$ GeV

  - from $p_T(e)$ fit

    $m_W = 80.49 \pm 0.11(stat) \pm 0.08(syst)$ GeV

- run 1a data [PRL 77, 3309 (1996)]
  - from m_T fit

    $m_W = 80.35 \pm 0.21(stat) \pm 0.17(syst)$ GeV

- combined m_T fit
  - common errors:

detector calibrations	36 MeV
W production, decay	34 MeV

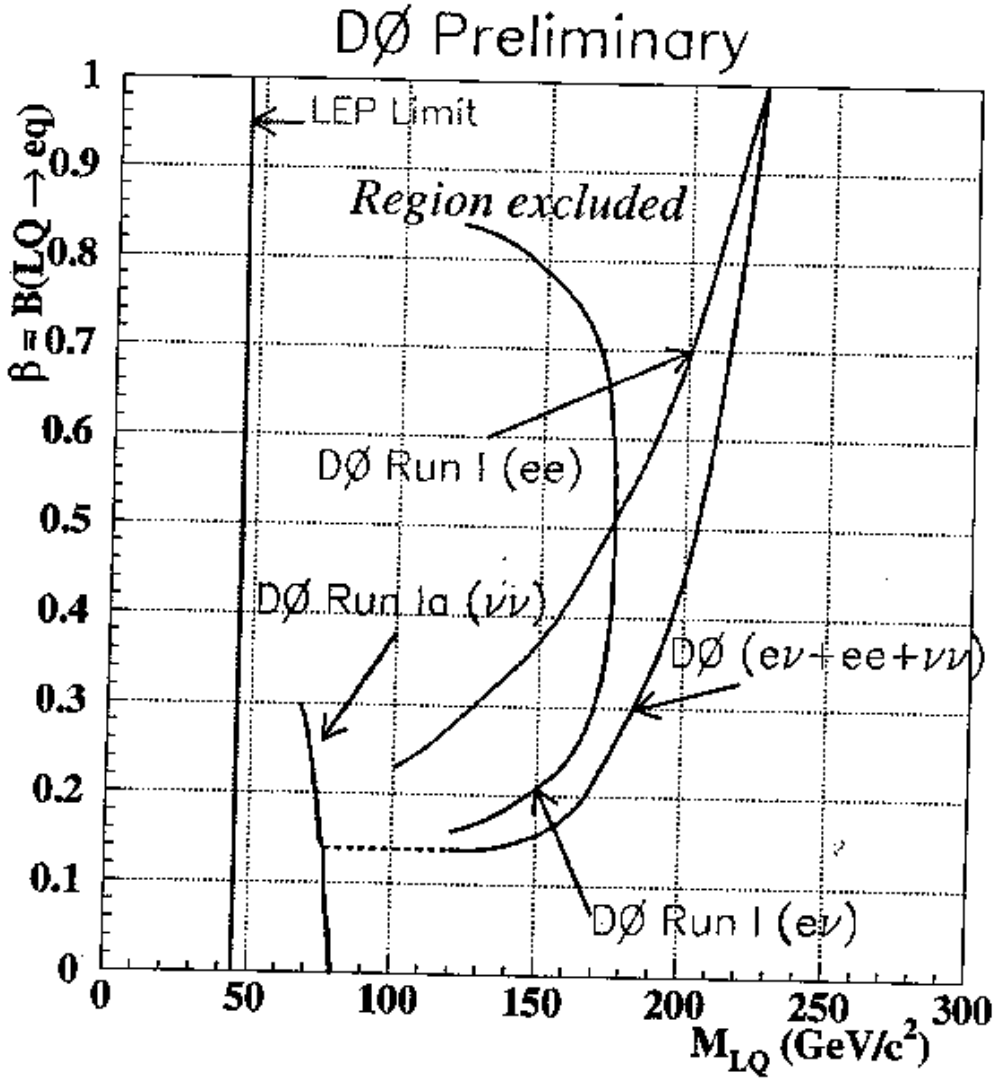
$$\boxed{m_W = 80.44 \pm 0.11 \text{ GeV}}$$

preliminary

First Generation Leptoquarks (LQ1)

β vs m_{LQ1}

eejj+evjj+vvjj search



eejj - β^2 ; evjj - $2\beta(1-\beta)$; vvjj - $(1-\beta)^2$

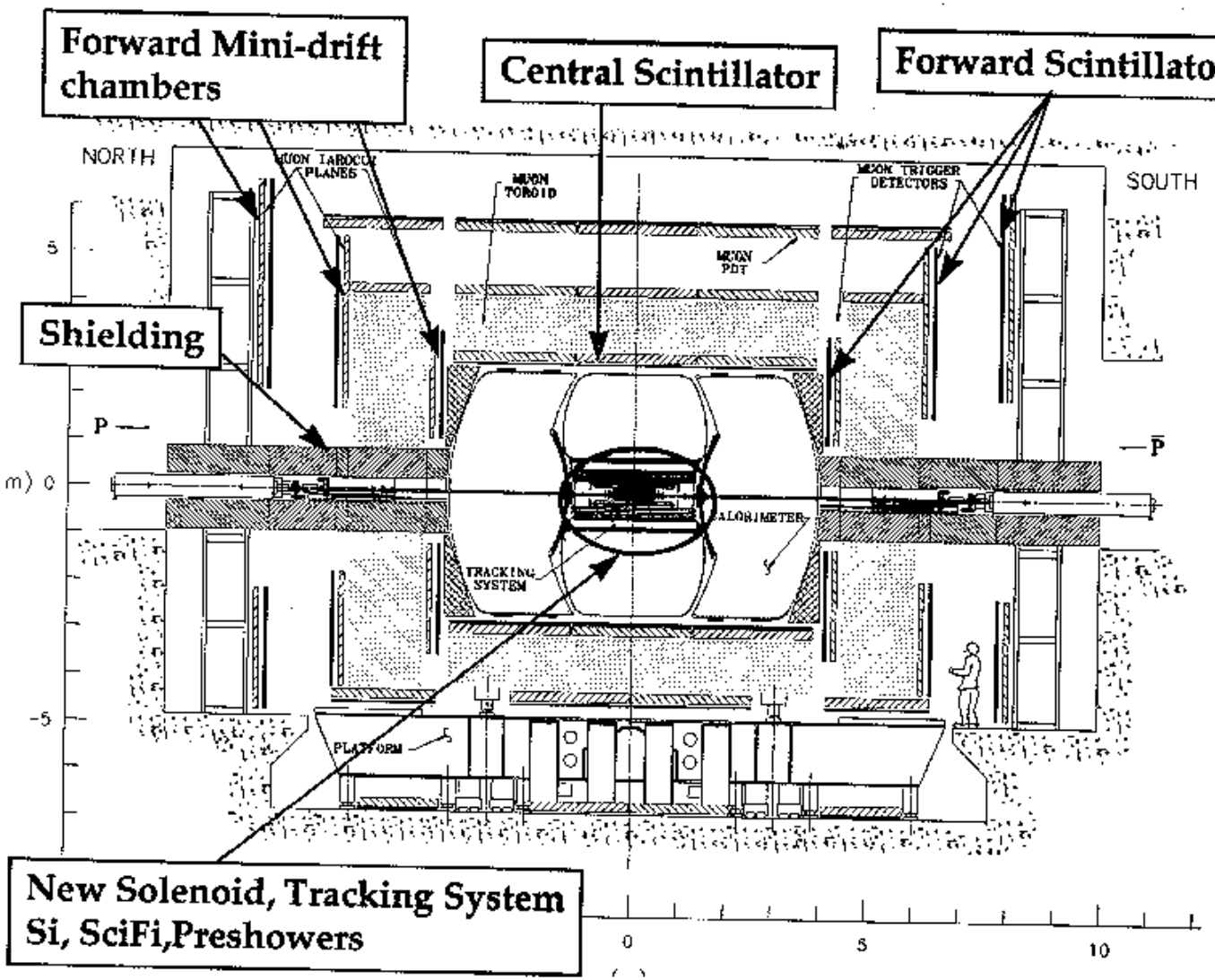
Motivation for Upgrade

- **Evolution of Tevatron**
  - Run I L_p = 1-2.5 X10^{31} (3.5 μs bunch xing time)
  - Run II (late 1999): L_p = 1-2 X10^{32}
    start with 396 ns bunch crossing time, and eventualy reach 132ns.
- **Impact on DØ**
  - Integrated $L \Rightarrow$ rad damage in tracking chambers
  - Shorter $\Delta t_b \Rightarrow$ pileup - electronics pipeline
  - Systems either Upgraded **Cal, Muon,Trig/DAQ**
    or: Replaced **Tracking System**
  - Solutions involve new Detector Technologies
    - ✻ Silicon strip detectors, SciFi, trigger processors
- **Enhanced Functionality**
  - Central Field 2T Solenoid
    - ✻ E/p for electron ID , calorimeter calibration, low p_T muons
  - b tagging

The DØ Upgrade is designed to exploit unique opportunities offered by Tevatron during Run II and beyond

Tevatron + MI — end 1998 - commissioning
DØ DETECTOR — late 1999

DØ Upgrade



+ New Electronics, Trig, DAQ

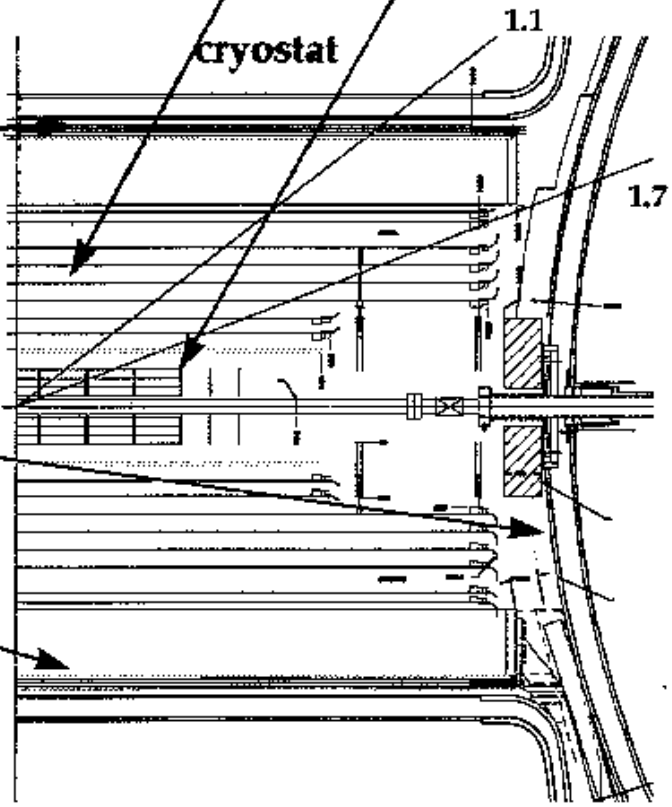
DØ Upgrade Tracking

- Silicon Tracker
  - Four layer barrels (double/single sided)
  - Interspersed double sided disks
  - **793,000 channels**
- Fiber Tracker
  - Eight layers sci-fi ribbon doublets (z-u-v, or z)
  - 74,000 830 μm fibers w/ VLPC readout
- Preshowers

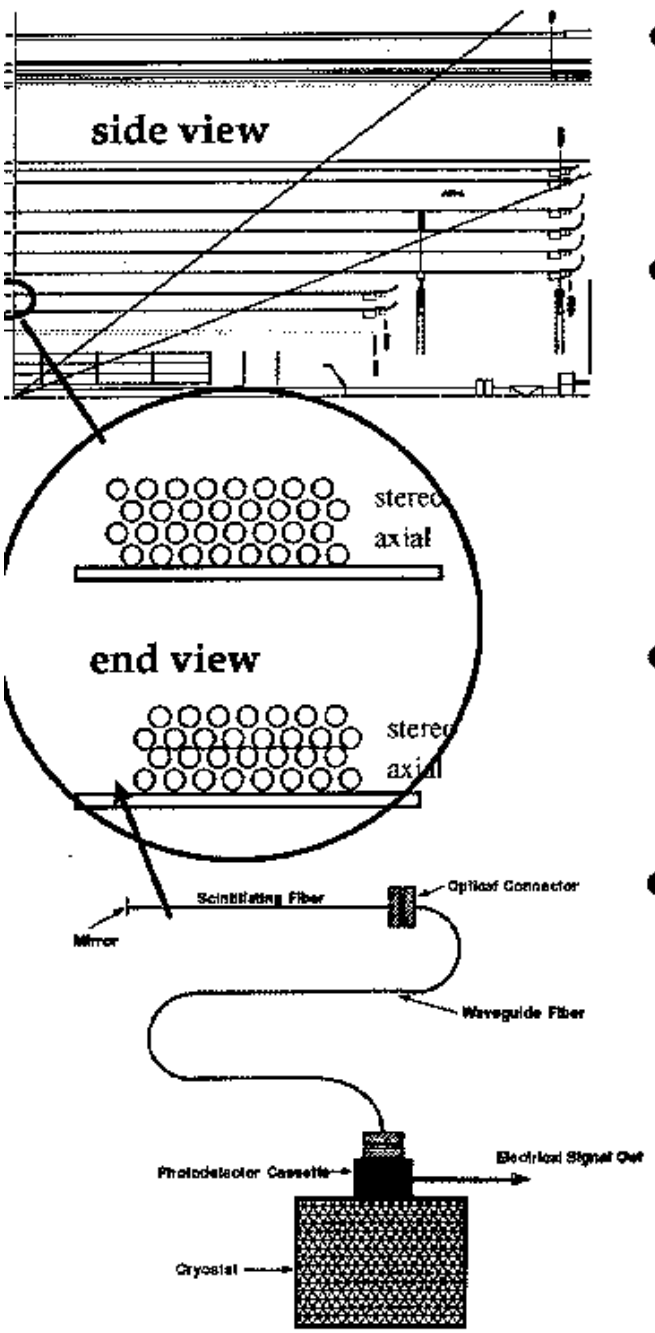
  Central
  - **Scintillator strips**
  - **6,000 channels**

  Forward
  - **Scintillator strips**
  - **16,000 channels**
- Solenoid
  - **2T superconducting**

R/O CHIPS DONE, TESTED
PRODUCTION IN MONTH



Fiber Tracker

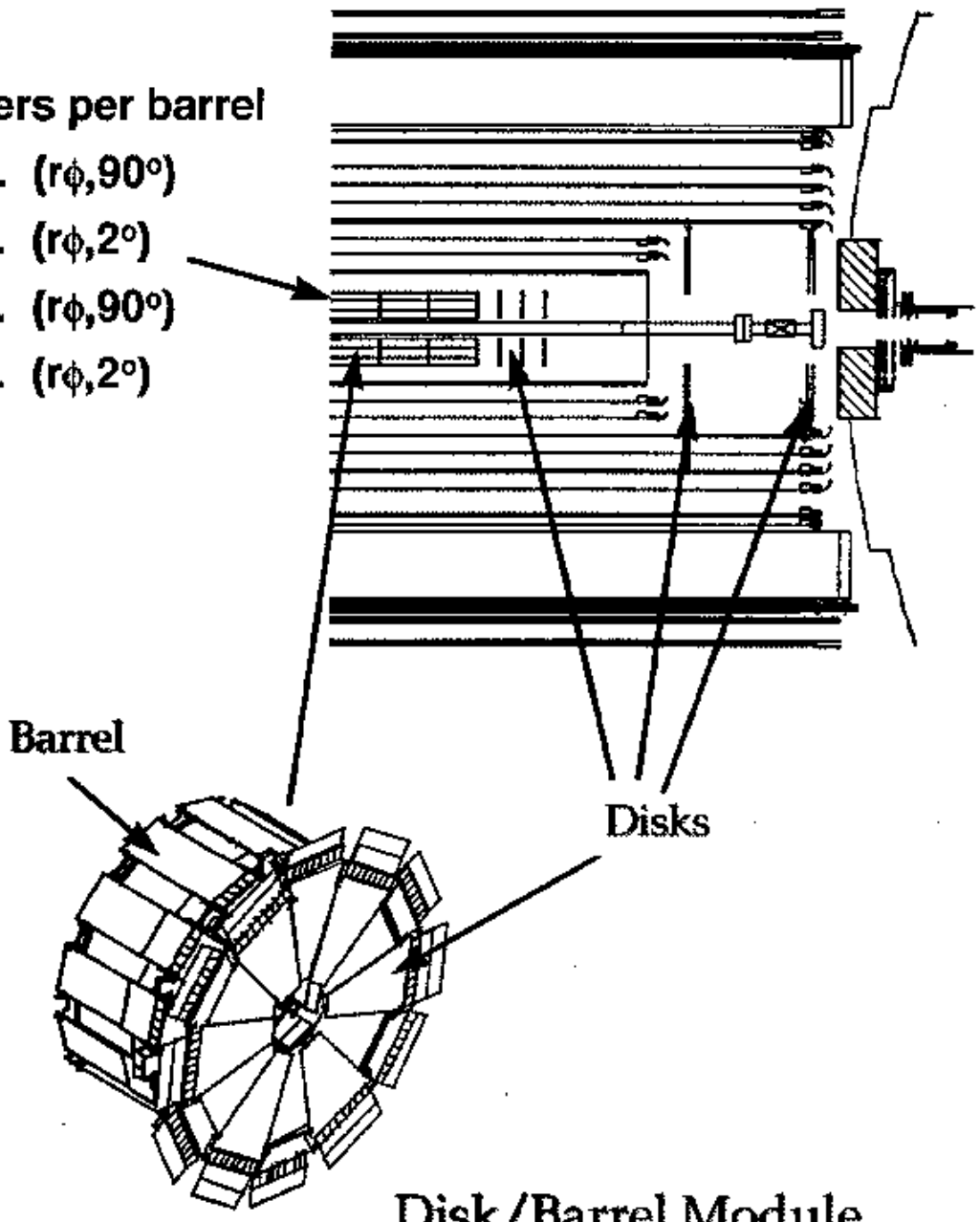


- **Barrels**
  - 8 carbon fiber barrels
  - 20<r<50cm
  - full coverage to $\eta = 1.7$
- **Scint Fibers**
  - 830μm ∅, multiclad
  - 2.6m active length
  - 10m clear waveguide to photodetector
  - rad hard (100 krad) (10yr @ 20cm @10^{32})
- **Fiber Ribbons**
  - 8 axial doublets
  - 8 stereo doublets (2° pitch)
- **Readout**
  - 77,000 channels
  - VLPC readout
  - run at low temp (9 K)
  - fast pickoff for trigger
  - SVXII readout

Silicon Vertex Detector

4 layers per barrel

1. (rϕ,90°)
2. (rϕ,2°)
3. (rϕ,90°)
4. (rϕ,2°)

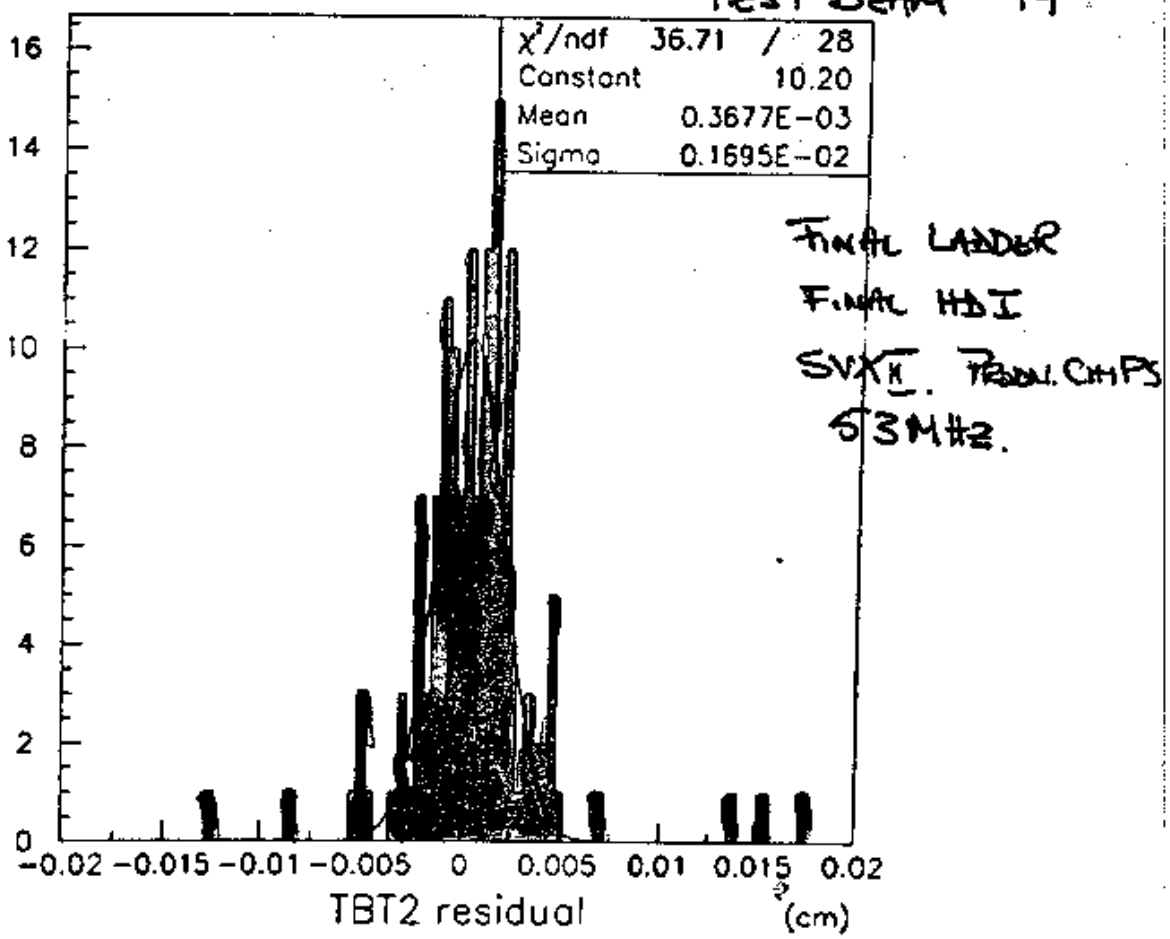


Disk/Barrel Module

Spatial Resolution

SILICON SYSTEM TESTS.

TEST BEAM '97



- from the alignment data with the magnet/table taken out, the residual is $\sim 17\ \mu m$
- subtracting the contributions from the measurement error and multiple scattering, the spatial resolution obtained is better than $10\ \mu m$

Top event Yields

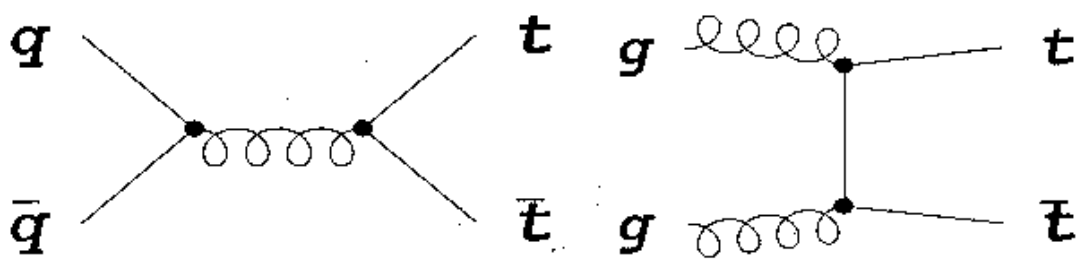
- Tevatron energy raised from 1.8 → 2 TeV

  ➔top cross section goes up ~40%

  For m_t=170 GeV :

$$\sigma(p\bar{p} \rightarrow t\bar{t} + X) = 8.0 \text{ pb}$$

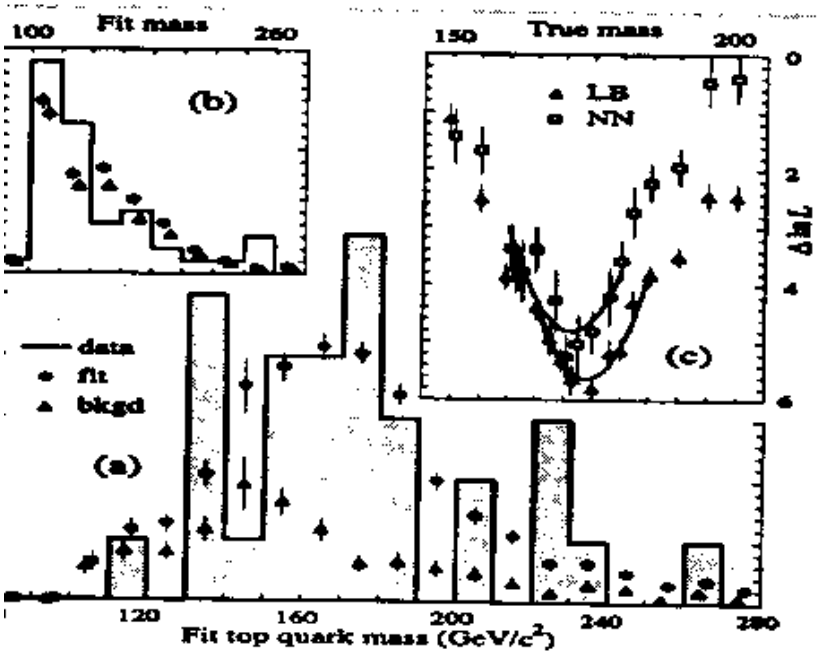
$$\sigma(p\bar{p} \rightarrow t \text{ or } \bar{t} + X) = 4.2 \text{ pb}$$



→ **expected event yields**

Channel	RunII (2 fb^{-1})	S:B
dilepton	200	5:1
lepton+≥4jets	1,800	
lepton+ ≥3jets/b-tag	1,400	3:1
lepton+ ≥4jets/b-b tags	600	12:1
Single top	330	1:2

Top Quark Mass



m_t (GeV) =
173.3
±5.6 (stat)
±6.2 (sys)

dominant systematic errors:

- Jet p_T scale ~ 4.0 GeV
- MC top modeling ~ 4.1 GeV

unII expectations:

- calibrate jet escale using data : Z+jet, γ+jet, W→ jj
- reduce combinatorics → use double b-tag events
- Constrain top production model using data

otal Uncertainty ≈ 3 GeV

statistical	1 GeV
jet energy scale	2.6 GeV
MC top modeling	2.0 GeV
backgrounds	0.5 GeV

W Mass

- Uncertanities in W Mass measurement

statistics	70 MeV
lepton scale	70 MeV
resolution/response	100 MeV
background	15 MeV
W production/decay	70 MeV

$\int \mathcal{L}dt$	80 pb^{-1}	2fb^{-1} (RunII)
δ stat	70 MeV	17 MeV

→ Slower than $1/\sqrt{N}$ due to multiple interactions
trade off between stats and pileup(>1 int/xing)

δ scale, resolution, response $\propto$ δ stat
→ constrained by control data samples

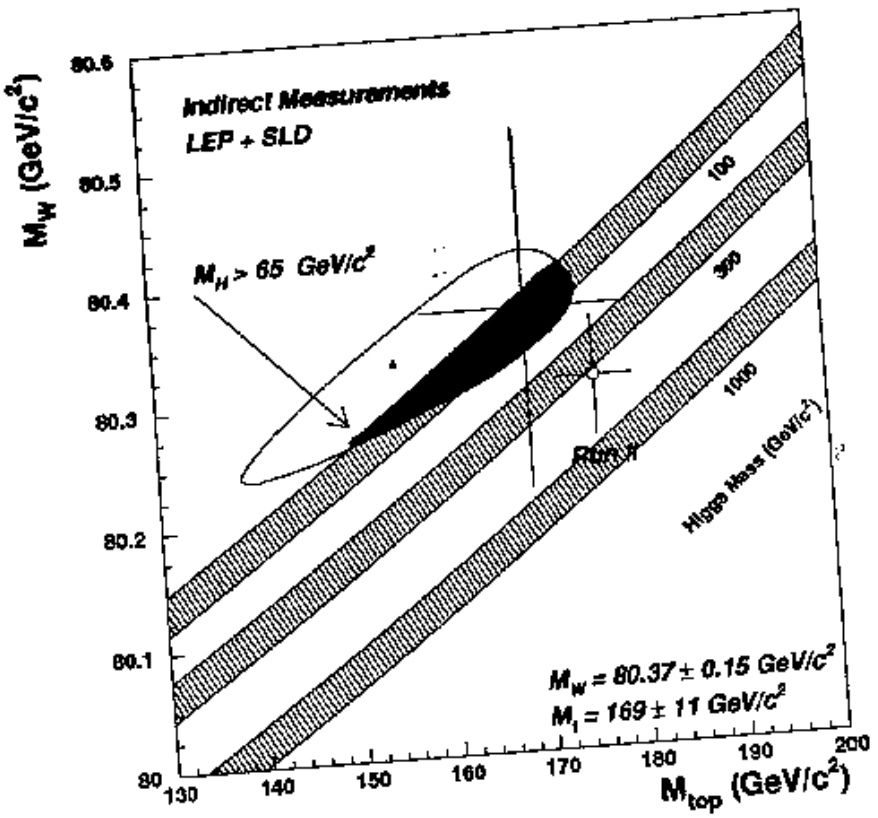
δ production, decay ➔ need better calculations (theory); proton structure functions; diff between Z and W production visible with high statistics.

Total uncertainty $\approx$ 40 MeV (RunII)

M(W) vs M(top)

ecision measurements of the SM will
ɛld constraints on the Higgs mass or
ovide a glimpse of physics beyond the
M

- plot for error on M_W=+/-50 MeV, M_t=+/-4 GeV
  → constrain Higgs mass to 80% accuracy



Compare: LEPII error on M_W is 40 MeV

Summary of Searches

- D0 discovery reach
  - using a combination of DØ and CDF estimates for both the present limits and discovery reach
  - mass reach large compared to HERA or LEP I,II

Signal	cross-section	present limit	discovery reach ($1fb^{-1}$)
right handed W	0.5-1000 pb	650 GeV	
W'	0.5-.0001xσ_W	720 GeV	1 TeV
Z'	0.1-.001xσ_Z	670 GeV	1 TeV
scalar 1st gen. leptoquarks	1-100 pb	~~143~~ 225 GeV	300 GeV
scalar 2nd gen. leptoquark	1-100 pb	140 GeV	300 GeV
squark and gluino pairs	5-1000 pb	230 GeV	390 GeV
gaugino pairs	0.5-10 pb	90 GeV	90 GeV
stop	0.1-100 pb	93 GeV	150 GeV
b'	10-1000 pb	95 GeV	?? (130 GeV)
q*	0.1-100 pb	720 GeV	800 GeV

COMPOSITENESS (JET ANG. DIST)

2 TeV

B Physics

- The upgraded DØ detector will enhance the B-Physics capabilities by the addition of magnet and precision tracking

- CP violation in B --> J/ψ Ks decays,
  $\delta\sin(2\beta)$ to ~ 0.16.
- Bs Mixing:
  - With 1 fb^{-1} , a reconstructed sample of 2000 Bs Decays (in mode Bs --> Dsπππ, Ds --> φπ) is expected, with a lifetime resolution of ~ 5%.
- Other B-Physics Topics:
  - Bc Spectroscopy
  - Rare B Decays, B --> $\mu^+ \mu^-$
  - b quark baryons
  - QCD test of production dynamics

The b quark production cross-section is large at Hadron collider (50 μb). We are studying several options including SVT to improve our B-Physics capabilities in Run-II

THE FUTURE (+PRESENT)

D0 Upgrade Physics Menu

- Basic goals
  - maintain and strengthen excellent high pT capabilities
  - extend reach into low pT physics as an outgrowth of the upgrade
- W physics, mass $\Delta M_W \sim 30$ MeV
- Forward-backward asymmetries, W, Z
- Top physics, with b-tagging 3-600 $t\bar{t}$ "RECON" $/(fb^{-1})$
- Di-boson physics, $W\gamma$, ...
- B spectroscopy
- Bs mixing
- B rare decays
- Approach to CP violation $\Delta \sin 2\beta \sim 0.15$
- Searches
- QCD – especially with τ, W, Z
- Improved τ identification, t to charged Higgs to τ

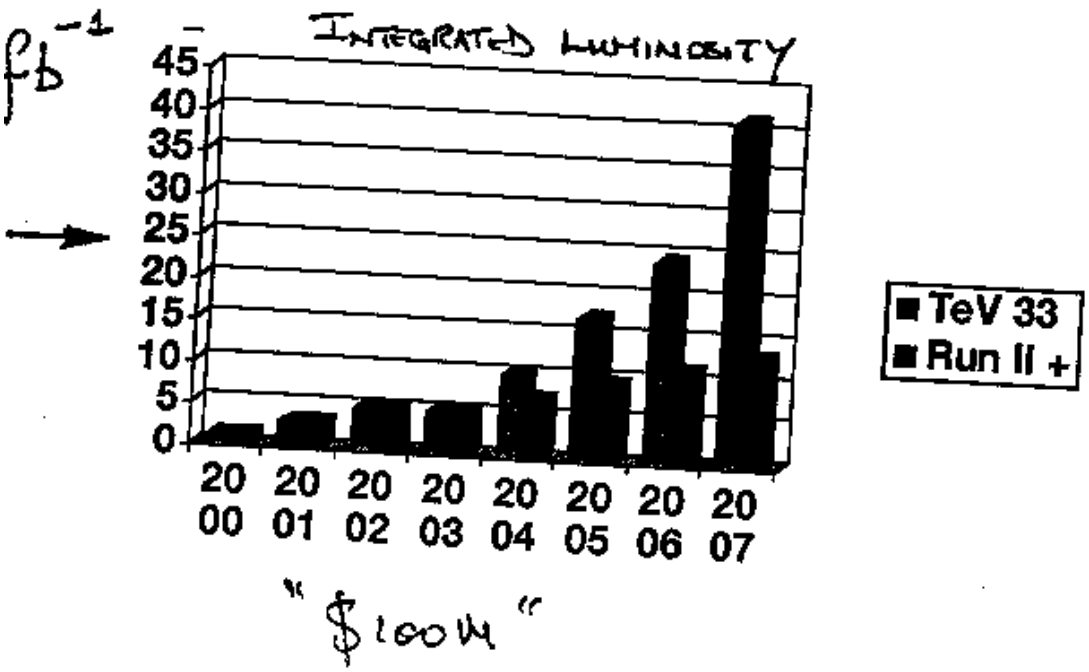
Opportunities

- **Funding Help**
  - $1-1.5M short on Base Upgrade
  - Enhancements
    - Vertex Trigger, Fwd Proton Det.
- **Technical Challenges**
  - Silicon, Fibers, Triggers, Cal. Electronics Callibrations
- **Computing**
  - New Detector- New Software
  - New Paradigm
  - New World

A Tractable TeV33 Scenario

- Tevatron becomes 1. 10^{33} cm^{-2} sec^{-1}
- Luminosity Leveling
  Detectors 5. 10^{32} cm^{-2} sec^{-1}
  Penalty 70%
- 1 Year Shutdown
  Replace Silicon +++
- 1 Real Year gives (100*AP(10^{31})) pb^{-1}
  (July 1994-95 AP~1* 10^{31})

AP ≡ "Average Peak"

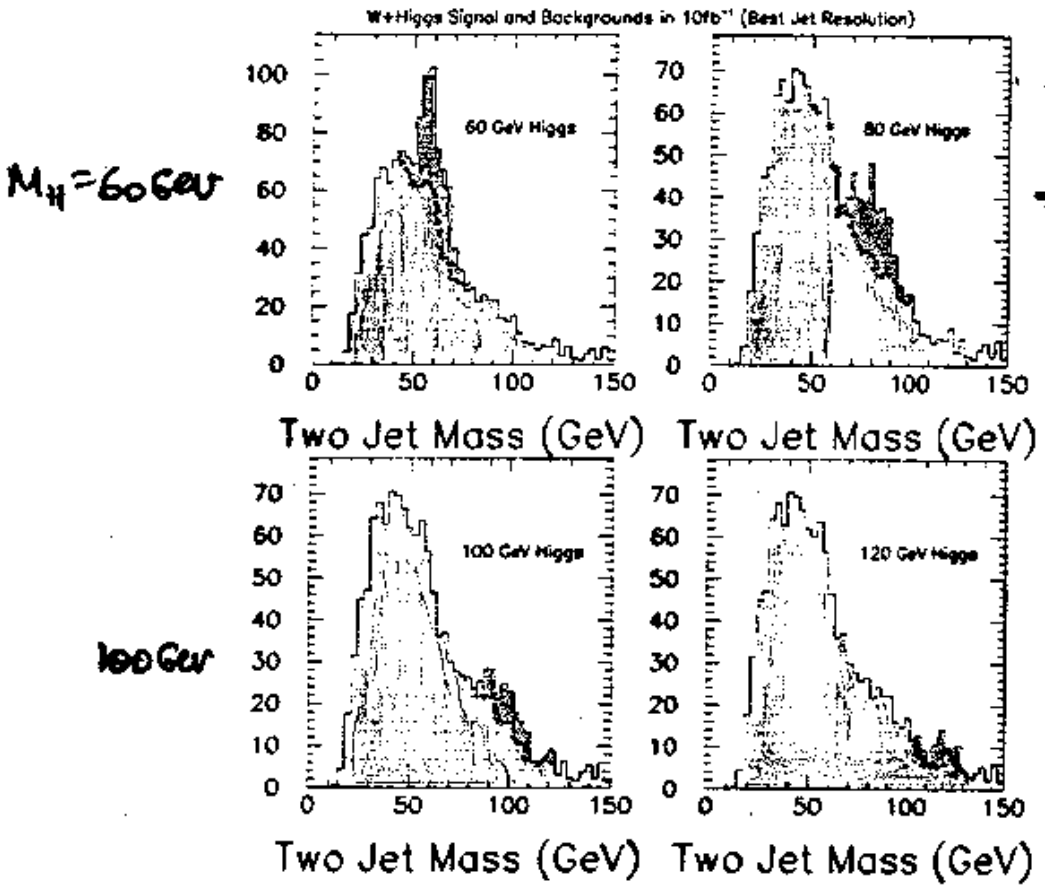


Run II DØ → DØ33: Tracker

- Silicon
  - * Replace the Run II detector
  - * Inner radii ($r < 10$ cm)
    - ▷ **Pixels**
    - ▷ **Rad hard strips**
  - * Outer radii (10 cm $< r <$ 30 cm)
    - ▷ **Silicon strips**
- Technology choice will depend on
  - * Progress in R&D and lab support
  - * Optimization of tracker performance
- Geometry needs a detailed design study, we have considered a tracker with
  - * 3 layers of pixels
  - * 2 layers of Si strips
  - * Re-optimized CFT

$q\bar{q} \rightarrow W H$

$H \rightarrow b\bar{b}$



$M_H = 60$ GeV

80 GeV

100 GeV

120 GeV.

Figure 5.15: The signal+background mass distributions for 10 fb^{-1} of data, but with a better jet resolution compared to the nominal.

S. KUHLMANN

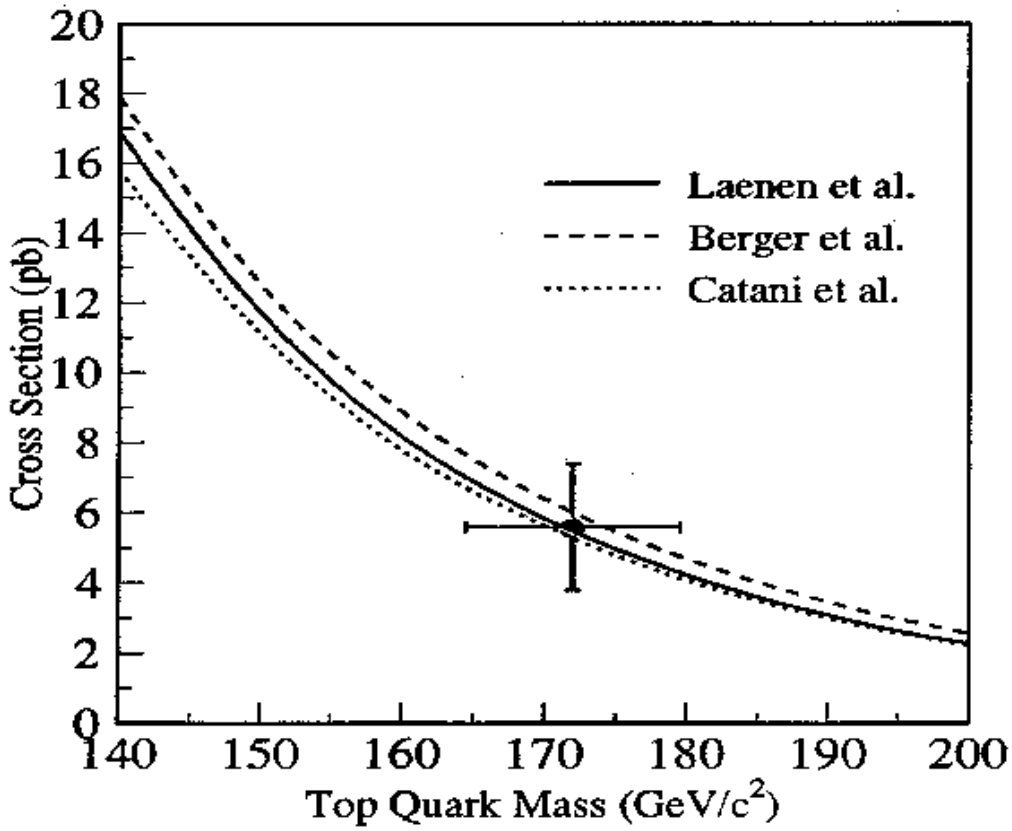
$5-10\ fb^{-1}$

– depends on b tagging, jet mass resolution.

CONCLUSIONS

- Program is
  - at the Frontier
  - will stay their through to LHC Startup
- Clear Opportunities
  - Run II Detector
  - Computing/Analysis
  - Physics
  - Future Apparatus
  - Physics

III. Summary

- lj: $m_t = 173.3 \pm 5.6(\text{stat.}) \pm 6.2(\text{syst.})$ GeV/c^2.
- ll: $m_t = 168.4 \pm 12.3(\text{stat.}) \pm 3.7(\text{syst.})$ GeV/c^2.
- Combined:

$m_t = 172.0 \pm 5.1(\text{stat.}) \pm 5.5(\text{syst.})$ GeV/c^2