Physics from CDF II in 2000-5

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- The CDF II Experiment
- IPP role in CDF II
- Physics Prospects for CDF II
- Schedule for Run II

IPP Planning Meeting 3 June 2000

The CDF II Experiment

CDF II gives us access to the highest-energy frontier

- Provide $p\bar{p}$ collisions at $\sqrt{s} = 2.0$ TeV
- Luminosities of $L \sim 2 \times 10^{32}$ cm^{-2}s^{-1}
- Total integrated luminosity of $5 - 10$ fb^{-1}

Canadian scientists have played a strong role in CDF instrumentation, data analysis and physics

- Run I contributions
  - DAQ systems
  - Offline software and reconstruction
  - Top and bottom quark physics
- Poised to continue pursuing this science with CDF II
- Represents a 4-5 year commitment

Run I Physics Contributions

IPP group had a focussed science agenda for Run I

- Top quark physics
  - Top quark discovery and mass
  - Single top production (talk next week!)
  - Top quark Pt distribution (talk next week!)

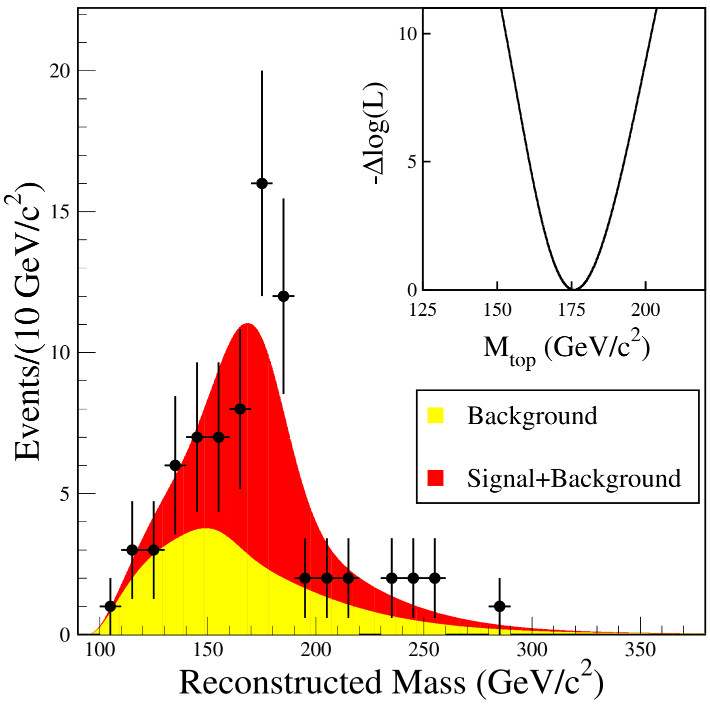
- B quark production and fragmentation
  - $b \to B^+, B^0, B_s, \Lambda_b$ rates
  - $B \to \psi(2S)$ decays
  - Charmonium polarization (talk next week!)

- High P_T Physics
  - Search for $W' \to \mu\nu_\mu$
  - Study $M(jj)$ in high mass dijet data

Top Quark Mass

Measurements now limited by statistical uncertainties

- Overall systematic uncertainty is ~ 5 GeV/c^2
  - Dominated by uncertainties in soft gluon contributions and energy scale
- Run I statistics limit systematic uncertainty

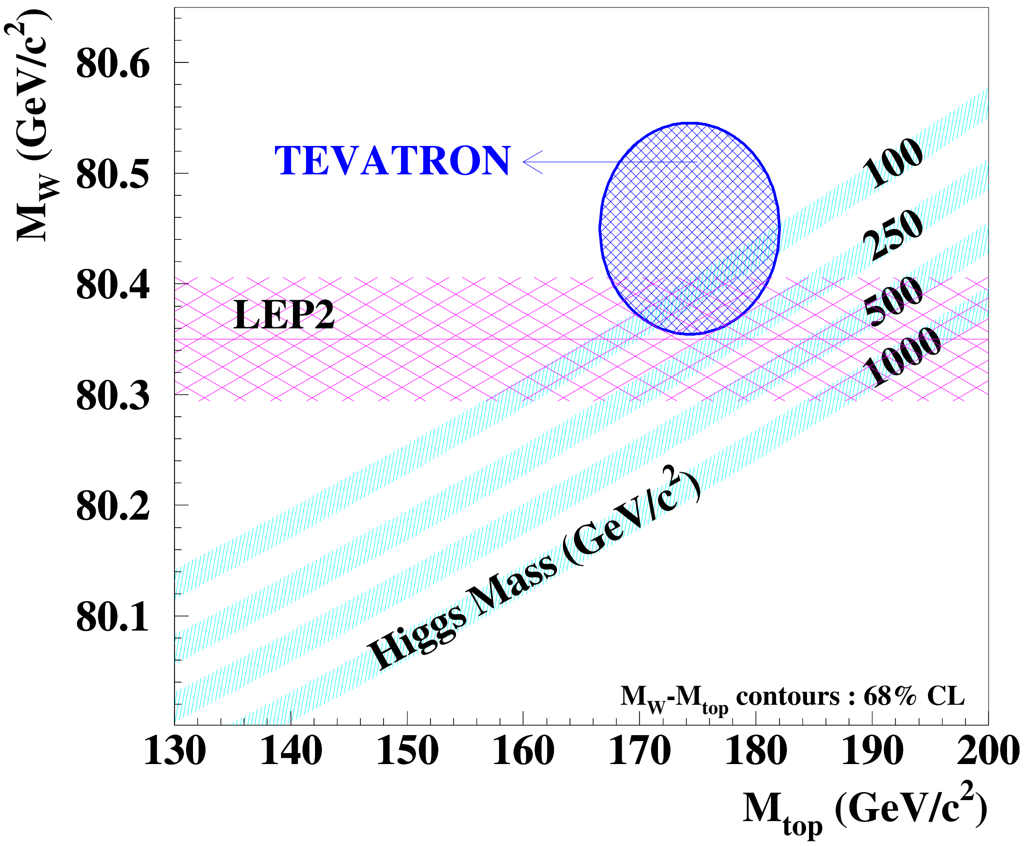


The final Run I values are

$$M_{top} = 176.0 \pm 6.5 \text{ GeV c}^2 \text{ (CDF)}$$
$$M_{top} = 172.1 \pm 7.1 \text{ GeV c}^2 \text{ (DØ)}$$
$$M_{top} = 174.3 \pm 5.1 \text{ GeV c}^2 \text{ (RunI)}$$

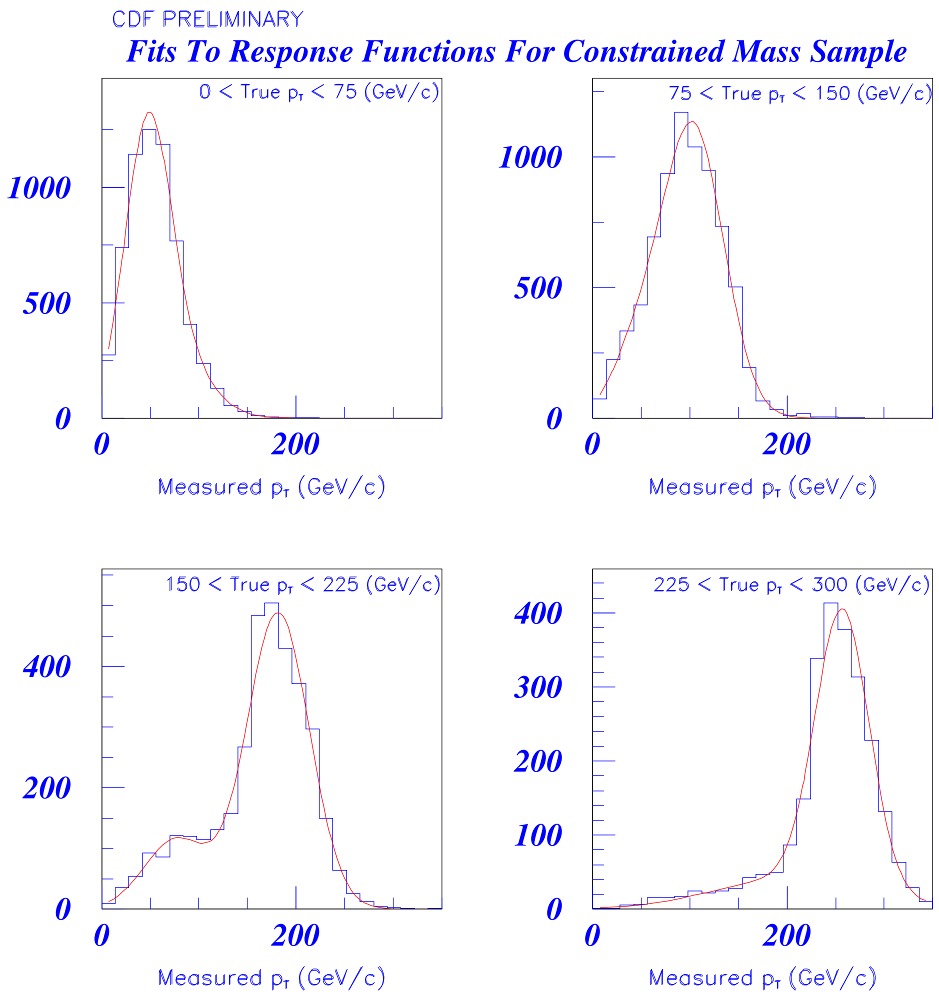
Latest W boson mass results

$$
\begin{aligned}
M_W &= 80.433 \pm 0.079 \text{ GeV c}^2 && \text{CDF} \\
M_W &= 80.474 \pm 0.093 \text{ GeV c}^2 && \text{D0} \\
M_W &= 80.350 \pm 0.056 \text{ GeV c}^2 && \text{LEP2}
\end{aligned}
$$



Top Quark Transverse Momentum

Measured P_T smearing using MC/detector simulation

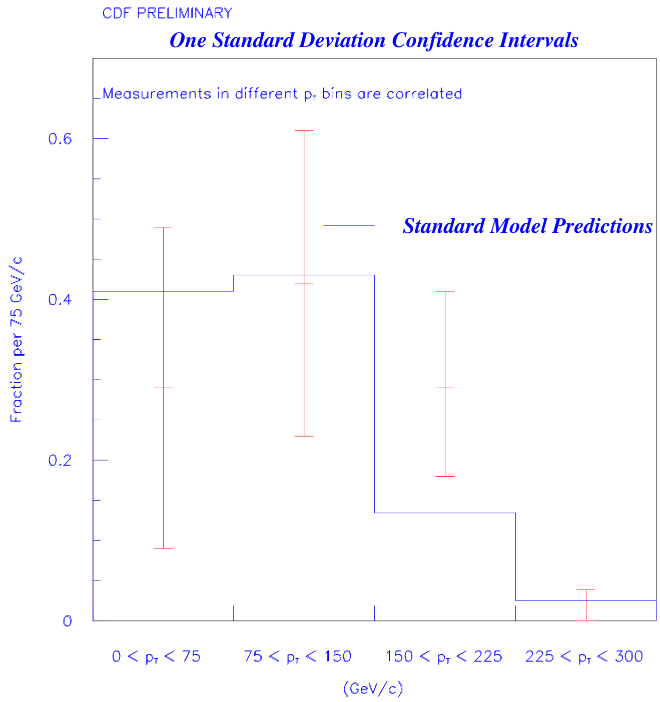


- Use standard HERWIG MC calculations
- Most smearing arises from incorrect jet assignments

Top Quark Differential Cross Section

$$R_1 + R_2 = 0.66^{+0.17}_{-0.17}(\mathrm{stat})^{+0.06}_{-0.06}(\mathrm{syst})$$

$$R_4 < 0.16 \text{ at } 95\% \text{ C.L.}$$



P_T Bin	Measured Fraction of Top Quarks
$0 < P_T < 75$ GeV/c	$R_1 = 0.21^{+0.22}_{-0.21}(\mathrm{stat})^{+0.10}_{-0.08}(\mathrm{syst})$
$75 < P_T < 150$ GeV/c	$R_2 = 0.45^{+0.23}_{-0.23}(\mathrm{stat})^{+0.04}_{-0.07}(\mathrm{syst})$
$150 < P_T < 225$ GeV/c	$R_3 = 0.34^{+0.14}_{-0.12}(\mathrm{stat})^{+0.07}_{-0.05}(\mathrm{syst})$
$225 < P_T < 300$ GeV/c	$R_4 = 0.000^{+0.031}_{-0.000}(\mathrm{stat})^{+0.019}_{-0.000}(\mathrm{syst})$

Run I Record

9 Ph.D. students will have completed studies

- G. Sganos on B branching fractions
- A. Warburton on $B \to \psi(2S)X$ rates
- W. Taylor on B fragmentation using semileptonic decays
- H. Kim on $W' \to \mu\nu_\mu$ search
- K. Kordas on B Penguin decays
- B. Hinrichsen on high mass dijet events
- R. Cropp on J/ψ polarization
- A. Robinson on Top quark P_T distributions
- M. Popovic on B_s lifetimes (in progress)

Primary authors for 2 PRD's, 3 PRL's and 2 more in pipeline...

- Major contributions to many others

Overall scientific impact is high

Run II Forecasts

Run II will start this summer at $\sqrt{s} = 2.0$ TeV

- CDF II will begin with commissioning run (no SVX II)
- Will be completed and rolled-in by March 2001
- Physics running for first two years (IIa) $\Rightarrow$ 2 fb^{-1}
- Possible goal of 15 fb^{-1} by 2006 (IIb)

Will be worth the wait

- Begin with $\sim$ 1 fb^{-1}/year per detector
- Finish up with $\sim$ 5 fb^{-1}/year in 2005-6
- Literal "Top Factory" – in 2 years,
  - 300 dilepton events
  - 3000 tagged lepton+jet events
  - 1500 events in "mass sample"

IPP Physics Goals for Run II

Mass analysis uncertainties scale with statistics

- Can expect $\delta M_t \sim$ 3.0˜GeV/c^2
- With $\delta M_W \sim$ 40 MeV/c^2

$$\frac{\delta M_{Higgs}}{M_{Higgs}} \sim 40\%$$

- Powerful "pointer" for LHC searches

Single top production

- Measure σ_t with 10% uncertainty
- Measure V_{tb} with 12% uncertainty

CP violation studies in the B sector

- Very competitive in B^0 sector with BaBar
- Only way of directly measuring in B_s sector
  - will be able to cover up to $x_s \lesssim 60$

Planned IPP Involvement

Effective involvement in CDF II programme for 3 years

- Responsible for Si detector positioning system
  - Designed "inchworm" system and controls
  - Commitment to SVX and ISL alignment

- Lead role in offline reconstruction and simulation
  - Responsible for coordination of all calorimetry
  - Are developing
    * GEANT/GFLASH simulation
    * Calorimetry and jet reconstruction

Expect to continue these responsibilities

- Currently are commissioning inchworms

- Preparing for "Mock Data Challenge 2"

Personnel and Resources

Involvement expected to remain constant for Run IIa

- Currently Trischuk, Sinervo and Orr
  - Scope for additional involvement
- Three research associates
- 5-6 graduate students (may increase)

Expect some evolution in Run IIb

- Almost totally operational and data analysis phase
- But will remain primary training ground for next generation of experimentalists

Funding requirements will not grow significantly

- Requires $250K/annum operating support over next 4 years
- Expect to ramp down after 2005

Summary

CDF-II will be one of the most exciting particle physics project in the next 5 year period

- IPP has significant investment in exploring high-energy frontier
- IPP is well-positioned to continue lead role
- Strong team of young (relatively!) scientists

Strategically, provides IPP community with early window into LHC physics

- Top and bottom quark sectors are clear focus
- Will face technological barriers similar to ATLAS
- Fills in the "physics gap" that overwise is created by lengthy lead-in to LHC programme