Annual Progress Report for JFY 2003

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CDF Experiment

Spokespersons

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The year 2003 marked the third year for the Tevatron Run-II program and the CDF experiment. Run II officially started in March 2001. The Tevatron accelerator has been running with 36 bunches of protons and anti-protons, respectively, at an increased center-of-mass energy of 1.96 TeV. The accelerator performance improved significantly in 2003. Recently a typical peak luminosity is close to $\mathcal{L} = 6 \times 10^{31}$ cm^{-2} s^{-1}, with a record luminosity of 7.2×10^{31} cm^{-2} s^{-1} (Figure 1(top)). This is more than three times as high as the best value achieved in Run I. A weekly integrated luminosity in excess of 12 pb^{-1} has also been achieved. A total integrated luminosity in Run II amounts to roughly 450 pb^{-1} (Figure 1(bottom)).

The upgraded CDF detector has been functioning very well with high efficiency. The integrated luminosity recorded by CDF amounts to roughly 350 pb^{-1}, three times that of Run I (Figure 2). We expect to accumulate about 300 pb^{-1} of data in year 2004, and a total integrated luminosity of 2 fb^{-1} in roughly two years. After that, with further improvements to the accelerator complex, such as electron cooling in the Recycler Ring, would provide an instantaneous luminosity of 2×10^{32} cm^{-2} s^{-1} and a total integrated luminosity of 5 to 9 fb^{-1} through 2009. For operations at such a high luminosity, CDF needs further upgrades of some of the detector components. They include the replacements of the central preshower detector and upgrades to the electronics and the data acquisition system. R&D efforts for the upgrades are already under way, and the Japan group has been making significant contributions.

In the remainder of this report we summarize physics results and prospects, and detector upgrade efforts, with an emphasis on contributions from the Japan group.

1 Physics Results and Prospects in Run II

We expect a data sample corresponding to an integrated luminosity of 2 fb^{-1} in the near future. This is a twenty-fold increase in the amount of data over the previous run,

Run I. Also, the Tevatron beam energy has been increased to give a center-of-mass energy of 1.96 TeV.

We plan on carrying out a broad physics program, and preliminary results have already emerged from Run-II data. We describe some of them below, along with prospects with full 2 fb^{-1} of data.

1.1 Top quark properties

Since the top quark was discovered by CDF in 1995, tens of pair-produced top quark events were reconstructed and a various measurements of their properties were performed in a data sample of 110 pb^{-1}. However, most of the measurements were statistically limited, given the relatively small number of the reconstructed events. Therefore, all measurements are expected to improve with the increased amount of data in Run II.

The top analysis with Run-II data has produced results on measurements of the mass and production cross section using various decay channels. The production cross section has been measured using both lepton + jet and di-lepton channels. A candidate event in the lepton + jet channel is shown in Figure 3, where two b-jets are identified by secondary vertex tags. The jet multiplicity distribution of the b-tagged $W + n$-jet events is shown in Figure 4, where the excess over expected background in $n = 3$ and $n \geq 4$ bins is explained by the contributions from the top quark. The $t\bar{t}$ production cross section is measured to be $\sigma = 4.5 \pm 1.4$ (stat) $\pm$ 0.8 (syst) pb with this channel. The corresponding cross section from the di-lepton channel is $\sigma = 8.7\,^{+3.9}_{-2.6}$ (stat) $\pm$ 1.5 (syst) pb. They both are in agreement with a next-to-leading order QCD calculation of $6.7\,^{+0.71}_{-0.88}$ pb for $m_{\text{top}} = 175$ GeV/c^2. The top quark mass is extracted from the lepton + jet channel to be $m_{\text{top}} = 177.5\,^{+12.1}_{-9.4}$ (stat) $\pm$ 7.1 (syst) GeV/c^2, which is shown in Figure 5. The di-lepton mode has also yielded a mass measurement, $m_{\text{top}} = 175 \pm 17 \pm 8$ (syst) GeV/c^2. K. Sato (Tsukuba) has contributed to the analyses, in particular the calculations of event acceptance in the lepton + jet channel, while S. Tsuno (Tsukuba) has provided new Monte Carlo event generation techniques for $W + n$-jet production. K. Sato is pursuing a mass measurement using events where both b-jets are tagged.

With 2 fb^{-1} of data the mass will be measured with a precision of about 3 GeV/c^2 [1, 2], and $t\bar{t}$ production cross section with a precision of 9%. Other production and decay properties will be also measured precisely, including $t\bar{t}$ spin correlations and $W^{\pm}$ boson helicity. Y. Takeuchi (Tsukuba) has been working on spin correlations. Single top quark production should be observed, allowing a direct measurement of the partial width $\Gamma(t \to W^{+}b)$ and a determination of CKM matrix element $|V_{tb}|$ to 13%. Also, searches will be performed for new particles such as a charged Higgs boson through the top decay $t \to H^{+}b$, and new resonant states decaying into $t\bar{t}$ pairs.

1.2 Electroweak physics

Studies of single gauge boson production continue, at a new center of mass energy of 1.96 TeV. Clean signals of $W^+ \to \ell^+\nu$ and $Z^0 \to \ell^+\ell^-$ decays have been observed in Run-II data. Figure 6 shows a transverse mass distribution of the muon and missing transverse energy system for $W^\pm \to \mu^\pm\nu$ candidates, to be used for a mass measurement. Figure 7 shows an invariant mass distribution for $Z^0 \to e^+e^-$ candidates. The production cross sections are measured to be $\sigma(\bar{p}p \to W^\pm X) \cdot \mathcal{B}(W^\pm \to \ell^\pm\nu) = 2.64 \pm 0.01$ (stat) $\pm$ 0.09 (syst) $\pm$ 0.16 (lum) nb and $\sigma(\bar{p}p \to Z^0 X) \cdot \mathcal{B}(Z^0 \to \ell^+\ell^-) = 267.0 \pm 6.3$ (stat) $\pm$ 15.2 (syst) $\pm$ 16.0 (lum) pb, respectively. They are illustrated in Figure 8 as a function of the center-of-mass energy, together with earlier measurements at Tevatron and CERN. The values at 1.96 TeV are roughly 9% higher than at 1.8 TeV. Also the width of the W boson Γ_W has been extracted from those measurements.

With 2 fb^{-1} of data the $W^\pm$ boson mass will be measured with a precision of about 30 MeV/c^2. Combined with top quark mass measurements, it will provide constraints on the Higgs boson mass with a relative precision of 30%. This is illustrated in Figure 9 [1].

Another area of study concerns pair production of gauge bosons. The unified electroweak theory has a non-Abelian gauge structure, resulting in self-couplings among gauge bosons such as $W^+W^-Z^0$ and $W^+W^-\gamma$ vertices. Production of $W^\pm\gamma$ pairs is studied. 131 (128) candidates with photons above 7 GeV/c have been observed in the $W \to e\nu$ ($\mu\nu$) channel among roughly 200 pb^{-1} of data. Photon transverse momentum distribution is shown in Figure 10 for the muon channel, which is consistent with standard model predictions. N. Tanimoto (Okayama) has performed the muon channel analysis. More detailed studies of self-couplings of the electroweak gauge bosons will be performed, including radiation amplitude zero in $W^\pm\gamma$ production.

1.3 Bottom and charm physics

Traditionally CDF relied on leptons to trigger on and collect decays of B hadrons, such as $\bar{B} \to \ell^-\bar{\nu}X$ and $B \to J/\psi X \to \ell^+\ell^-X$. In Run II, CDF has introduced a device called SVT, which uses information from the silicon vertex detector at the second level of the trigger and calculates impact parameter of charged tracks with about 50 μm precision for $p_T > 2$ GeV/c. It enables us to collect decay products of long-lived particles such as B and charm hadrons. An example of signals from this new trigger system is shown in Figure 11. A huge signal of 450 k events has already been obtained in a data sample corresponding to 65 pb^{-1}, and thus charm physics has become a new area of physics investigations at CDF. An analysis on relative branching fractions $\mathcal{B}(D^0 \to K^-\pi^+)$, $\mathcal{B}(D^0 \to K^+K^-)$ and $\mathcal{B}(D^0 \to \pi^+\pi^-)$ has been performed. A search for a FCNC decay $D^0 \to \mu^+\mu^-$ has produced an upper limit $\mathcal{B}(D^0 \to \mu^+\mu^-) < 2.5 \times 10^{-6}$ (90% CL) [3], already surpassing the PDG 2002 value. Searches for lifetime differences and CP violation are planned for the $D^0\overline{D}^0$ system.

One of the CDF B physics goals is to observe $B_s^0\overline{B}_s^0$ oscillations and measure its frequency Δm_s. It should provide a clean determination of the Cabibbo-Kobayashi-Maskawa matrix elements $|V_{td}/V_{ts}|$. CDF plans to use fully reconstructed decays collected by SVT so as to allow precise determination of B_s^0 meson momentum on an event-by-event basis. Such signals have also been observed, which are shown in Figure 12. In addition, two-body decays of neutral B mesons to light pseudoscalars are observed (Figure 13). The signal peak is a mixture of four decay modes: $\overline{B}_d^0 \to K^-\pi^+$, $\overline{B}_d^0 \to \pi^+\pi^-$, and $\overline{B}_s^0 \to K^+K^-$, $\overline{B}_s^0 \to K^+\pi^-$. The composition have been determined using dE/dx information from the central drift chamber, leading to the first observation of the decay $B_s^0 \to K^+K^-$. Measuring CP violation in $B_d^0/\overline{B}_d^0 \to \pi^+\pi^-$ and $B_s^0/\overline{B}_s^0 \to K^+K^-$ modes simultaneously would allow a clean determination of the CKM phase γ [4].

Lepton triggers still remain effective and useful channels for B physics. Figure 14 shows a $J/\psi \to \mu^+\mu^-$ signal from Run-II data. Thanks to a lowered p_T threshold on muons, J/ψ yield per unit amount of data is a factor of two higher than in Run I. Various B-hadron signals such as $B^+ \to J/\psi K^+$, $B^0 \to J/\psi K^{*0}$, $B^0 \to J/\psi K_S^0$, $B_s^0 \to J/\psi\,\phi$ and $\Lambda_b^0 \to J/\psi\,\Lambda^0$ have been observed and are used to measure their masses, lifetimes and relative branching fractions. T. Yamashita (Okayama) has been working on $\Lambda_b^0 \to J/\psi\Lambda^0$ measurements. M. Aoki (Tsukuba) has been working on the B_c meson reconstruction. Single leptons are a good source of semileptonic B decays. S. Uozumi (Tsukuba) has been a major contributor in this area, demonstrating signals such as $\overline{B}\to \ell^-\bar{\nu}D^0X$, $\overline{B}\to \ell^-\bar{\nu}D^{*+}X$, and $\overline{B}_s^0 \to \ell^-\bar{\nu}D_s^+X$. Their lifetimes and lifetime differences will be measured with high precision with the sample. Also, $B_s^0\overline{B}_s^0$ oscillations with a modest value of Δm_s can be looked for.

1.4 Quantum chromodynamics

A wide variety of measurements will be performed at a new center-of-mass energy of 1.96 TeV. Also, increased statistics allow measurements in a wider range of spectra, e.g. highest E_T jets, photons and other objects, and with less statistical uncertainties. They will serve as precision tests of perturbative QCD calculations.

An example is a measurement of inclusive production of jets. Figure 15 shows a measurement of inclusive jet production in various rapidity ranges. Figure 16 shows a ratio of measured jet production cross sections to theory predictions at $\sqrt{s} = 1.96$ TeV. The increased center-of-mass energy provides higher sensitivity at the high E_T end of the spectrum.

Another example is production of J/ψ's. In Run I, CDF found a surprisingly high rate of direct production of J/ψ's, fifty times higher than theory [7]. The lowered muon trigger threshold has provided a reasonable acceptance down to $p_T^{J/\psi} = 0$. The production cross section is measured as a function of $p_T^{J/\psi}$. The value integrated over p_T and rapidity $|y| < 0.6$ is $240 \pm 1\,^{+35}_{-28}$ nb. T. Yamashita has contributed to this analysis. The sample should also allow a better measurement of production polarization, which is very useful in discriminating various production mechanisms, such as gluon fragmentation and color octet models.

An investigation of decay length distributions of J/ψ's provides a discrimination of the sources of J/ψ's, namely prompt production vs. $B \to J/\psi$. The latter contribution has been determined over the nearly full kinematic range (Figure 17), and thus enabled a measurement of the (almost) total b-quark production cross section for the first time. The result is $\sigma(\bar{p}p \to bX; p_T^b > 0, |y^b| < 1.0) = 29.4 \pm 0.6 \pm 6.2\ \mu\text{b}$. This has helped understnad the long-standing puzzle of a possible excess of b-quark production rates over next-to-leading order QCD calculations.

S. Tsuno (Tsukuba) has meausred the production of jets associated with the W boson [5]. A new technique has been adopted to define jets so as to make a comparison to theory easier and reliable. Figure 18 shows the production cross section as a function of the number of jets, together with theory prediction.

1.5 New particle searches

Searches for the Higgs boson, supersymmetric particles and other new particles will be performed. The standard model Higgs boson can be searched for in a mass range up to 120 GeV/c^2 with 2 fb^{-1} of data [6]. This is shown in Figure 19. For a low mass Higgs, production in association with a gauge boson $W^\pm$ or Z^0 will be the most sensitive mode. The Higgs boson will decay predominantly to a $b\bar{b}$ pair in this mass region. At a high mass, around 150 GeV/c^2 or above, the decay to W^+W^- and Z^0Z^0 pairs will provide a very distinctive signature and our sensitivity is pretty high. In the intermediate mass region, associated production $\bar{p}p \to W^\pm HX$ followed by a Higgs decay into a virtual or real W boson pair $H \to W^{(*)+}W^{(*)-}$ provides a final state consisting of three W bosons in the event. Two of them always have the same charge, and it is also the case for their decay leptons. It is a very distinctive signature. If all three W bosons decay leptonically, it provides an even cleaner signal. Y. Ishizawa (Tsukuba) has looked for $Wb\bar{b}$ production and obtained upper limits on the cross sections as a function of the $b\bar{b}$ pair mass. A typical number is about an order of magnitude higher than the standard model values.

Many extensions of the standard model require extra U(1) gauge group and thus a new gause boson similar to Z^0. CDF has looked for such Z' bosons in their decay to $\ell^+\ell^-$. Figure 20 shows an e^+e^- invariant mass spectrum from Run-II data, which is described by contributions from known sources. A lower limit of 750 GeV/c^2 is placed assuming the standard model couplings of Z'. K. Ikado (Waseda) has performed the analysis.

Y. Miyazaki (Osaka City) performed using Run-I data a search for the pair production of scalar top quarks that subsequently decay, violating R-parity, into a tau lepton and a bottom quark [8]. The tau lepton is identified with its decay into one- and three-prong hadrons. The method is demonstrated by reconstructing the decay $Z^0 \to \tau^+\tau^-$, where one of the tau decays semileptonically into an electron or a muon, and the other taus decays hadronically. The charged multiplicity is used to identify hadronic decays of tau. The scalar quark is looked for with a final state consisting of an electron, a tau and two b-quark jets. No candidate event is found with an expected background of 1.92 ± 0.18 events. An upper limit on the production cross section has been placed, and a lower limit on the squark mass of 111 GeV/c^2 is obtained at 95% C.L. T. Ogawa (Waseda) is performing the Run-II analysis.

2 Detector Upgrades for Run II

2.1 Plug upgrade calorimeter

A new, scintillator-based plug calorimeter [9] has been constructed and installed in the CDF detector. The analysis of Run-II data is in progress, in order to evaluate overall performance of the calorimeter such as calibration of the energy scale. Also, efforts have been made to establish off-line reconstruction algorithms for the identification of electrons and photons in the plug region.

Y. Seiya, S. Uozumi and Y. Ishizawa from Tsukuba have contributed to the plug calorimeter efforts. Y. Seiya was a co-leader for the plug calorimeter project.

2.2 Silicon detectors: SVX II and ISL

The Silicon Vertex Detector (SVX II) and the Intermediate Silicon Layers (ISL) will provide precision charged particle tracking essential for detection of long-lived particles such as B hadrons. The construction of the both detectors had been complete, and they were installed inside the CDF detector in February 2001. Since then they were gradually integrated into CDF for readout, and presently more than 90% of all the channels are functioning (Figure 21).

The production of double-sided silicon micro-strip sensors for SVX II had been completed previously. The sensors for the Layer 3 of SVX II were assembled into quarter-ladders at Hamamatsu Photonics. They were tested for electrical connections to hybrid readout electronics and for dead channels. T. Ohsugi, Y. Iwata (Hiroshima), I. Nakano, R. Tanaka, N. Tanimoto, T. Yamashita (Okayama), and R. Takashima (Kyoto University of Education) have been working on the SVX II project.

K. Hara, M. Shimojima and Y. Takeuchi from Tsukuba have worked on the silicon sensors of the ISL detector. The production of double-sided silicon micro-strip sensors was completed at Hamamatsu. Sampling probing tests were performed to assure quality, including $I-V$ characteristics, leakage current, and dead channel fraction. T. Okusawa, T. Yoshida (Osaka City) and Y. Kato (Kinki) have worked on the data acquisition system used for testing hybrids.

Y. Takeuchi, S. Tsuno (Tsukuba), N. Tanimoto and T. Yamashita have developed a system for monitoring the silicon detectors. An example is shown in Figure 22.

2.3 Data acquisition system and monitoring

M. Shimojima (Nagasaki) and H. Matsunaga (Tsukuba) have assumed responsibility for the consumer-server/logger system, which, as part of the online data acquisition system, receives events from the level-3 trigger and sends to disk and tape storage devices as well as to online monitoring programs. T. Arisawa and K. Ikado (Waseda) are responsible for the monitoring programs that check detector performance and data quality. Both of these systems have been operational smoothly in Run II. However, recent improvements in the machine luminosity call for an upgrade to increase the DAQ bandwidth to 64 MB/s. M. Shimojima has been investigating solutions.

A. Miyamoto and Y. Fujii (KEK) have contributed to the event display program, in particular the central calorimeter wedge display.

2.4 Time-of-flight detector (TOF)

The TOF detector is a set of scintillation counters that provides K/π separation up to 1.6 GeV/c in momentum. K. Sato and F. Ukegawa (Tsukuba) were in charge of production and quality control of photomultiplier tubes. The tubes have been tested at KEK for performance in a 1.4-T magnetic field, sent to FNAL, and installed in the CDF detector. The construction of the TOF detector itself was completed in 2000, and the installation of readout electronics was completed by summer 2001. All channels are read out and calibrations have been carried out using collision data [10]. K. Sato has performed a measurement and equalization of PMT gains, achieving a uniform response among different channels. He has also studied long term stability of gains using collision data. The usefulness of the detector has been demonstrated by examining mass distributions for $\phi \to K^+K^-$ candidates before and after applying kaon identification cuts using TOF information. The signal-to-noise ratio improves by a factor of 20 while keeping 82% of the signal. It demonstrates that the detector is ready for use in physics analyses, such as for B hadron flavor tagging.

F. Ukegawa was a co-leader of the TOF project.

2.5 Silicon detector upgrade

Inner layers of the SVX II detector will need to be replaced once CDF accumulates an integrated luminosity of about 5 fb^{-1} [11]. The R&D efforts for the replacement had already been started. The solution chosen by CDF is to use single-sided sensors that can be operated at higher bias voltages than present double-sided sensors. To simplify construction, all layers consists of a single, identical unit called a stave. K. Hara, M. Aoki (Tsukuba) have addressed issues such as cooling, support structure and the amount of material. I. Nakano (Okayama) has developed high density, printed-circuit flat cables for readout for Layer 0. In 2002 prototype sensors were produced and tested for characteristics such as leakage current and capacitance. Some are irradiated to neutrons and tested afterward. They have been found to satisfy our requirements. The production in large quantities started in late 2002 and continued through 2003, and they have been tested to assure quality. Unfortunately the project was terminated in September 2003.

K. Hara is a co-leader of the Run-IIb silicon project.

2.6 Central preshower detector upgrade

The central preshower detector (CPR) is located behind the CDF solenoid (about one radiation length thick) and before the central electromagnetic calorimeter CEM. It samples electromagnetic showers at their early development stage, and plays important roles in identification of electrons and photons.

The current CPR detector is a slow gas chamber with relatively coarse segmentation. This detector will suffer a serious occupancy problem once the Tevatron luminosity exceeds 10^{32} cm^{-2} s^{-1}. The solution is to replace it with a fast, finely-segmented device. CDF has adopted a device consisting of plastic scintillator with a wavelength shifting fiber for readout, similar to the preshower detector (PPR) for the upgraded plug calorimeter.

Photons through the fibers will be read out with a photomultiplier tube. A total number of channels of 3072 is required, and we use multi-anode PMTs to reduce cost and space. The model Hamamatsu H8711A-10MOD (R5900-00-M16) has been chosen. This tube has 16 pixels with a pixel size of 4 mm $\times$ 4 mm. We would need 64 channels (four tubes) per CEM wedge, with a total of about 230 tubes including spares.

In 2002 we tested 10 prototype tubes and examined the characteristics in terms of anode uniformity, pulse linearity, absolute gains, cross talk, magnetic field effects and so on. Anode uniformity of 10% is observed among different pixels within a tube. It has been decided to use a tapered base circuit so as to keep a good pulse linearity for large pulses. The design was finalized in 2002, and 30 production tubes were manufactured in late FY 2002 and tested. In 2003 additional 170 tubes were produced, bringing the total number to 200. The tests are being performed right now. The construction of other parts of the detector are also in progress, and at least partial installation is planned during a shutdown period later this year (2004).

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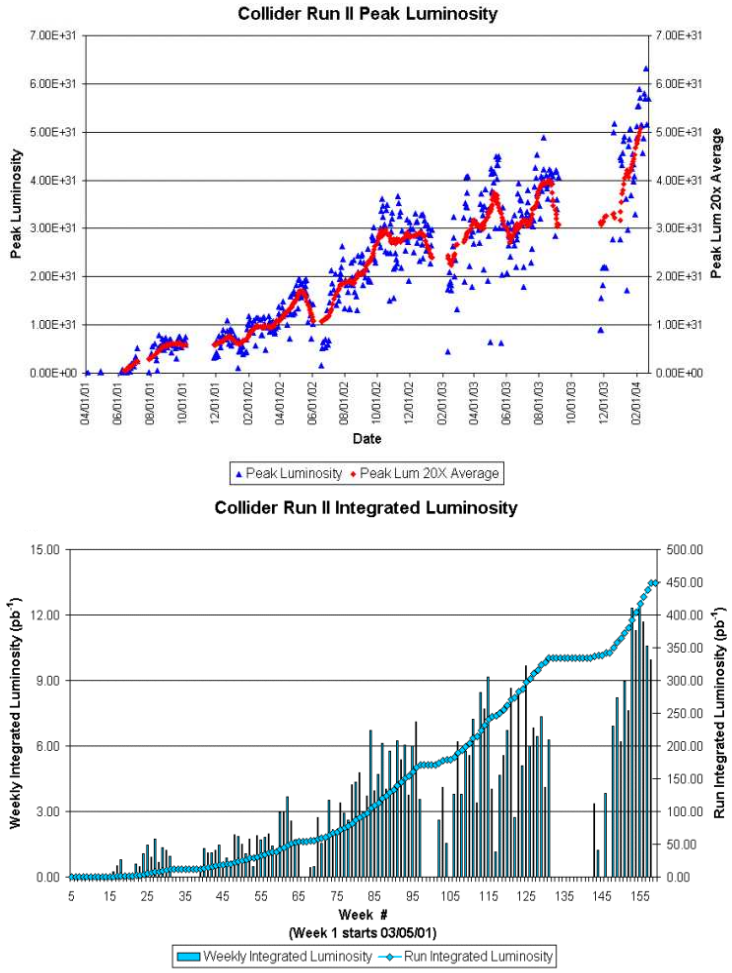

Figure 1: Tevatron performance in Run II. Top: instantaneous luminosity at the beginning of each store. Bottom: integrated luminosity delivered by week.

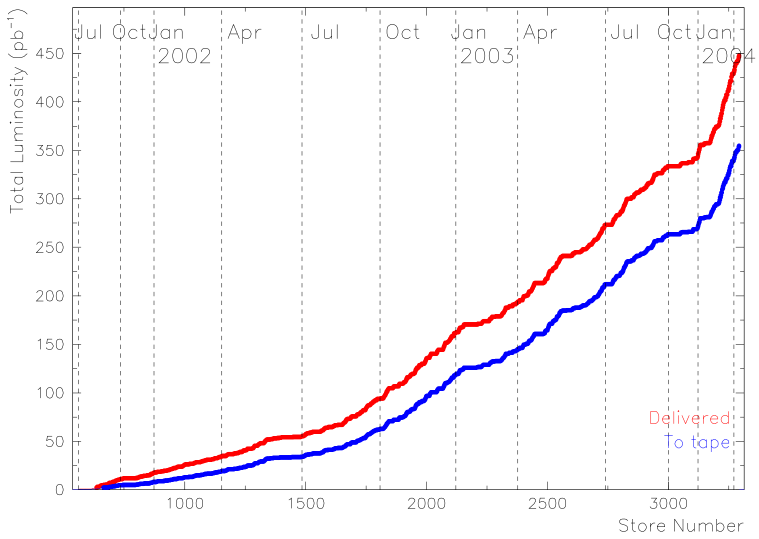

Figure 2: Integrated luminosity (top) delivered to and (bottom) recorded by CDF thus far in Run II.

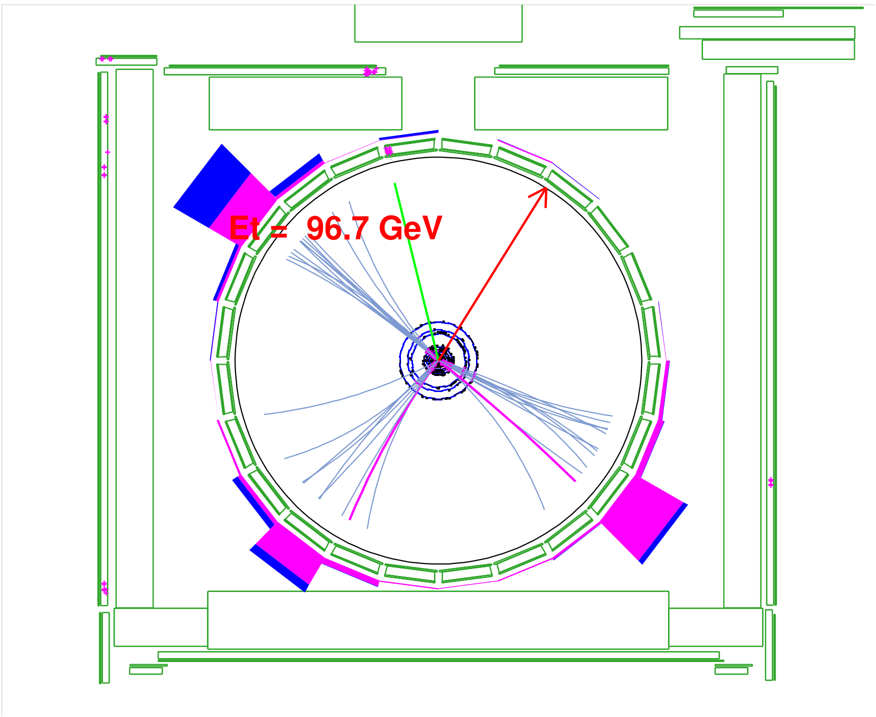

Figure 3: A top quark candidate event in the lepton + jet channel, where two b-jets are tagged by secondary vertices.

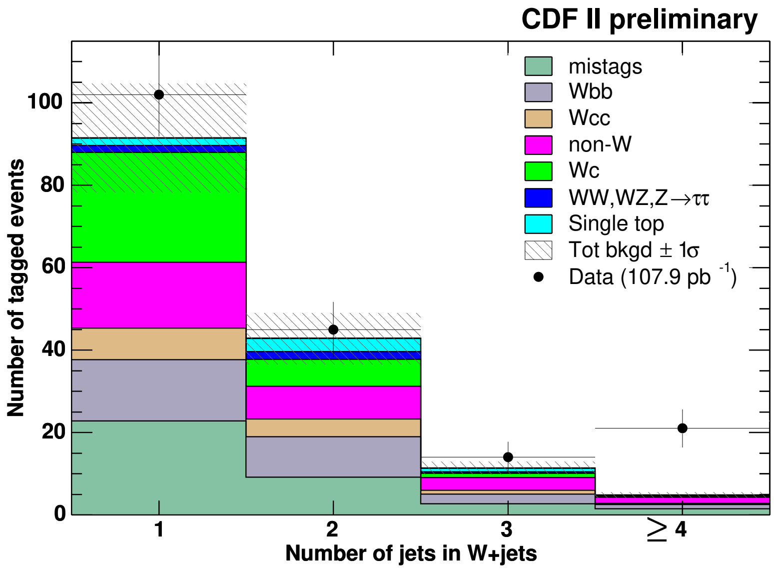

Figure 4: Multiplicity of jets in $W + n$-jet events where b-jets are tagged with secondary vertices.

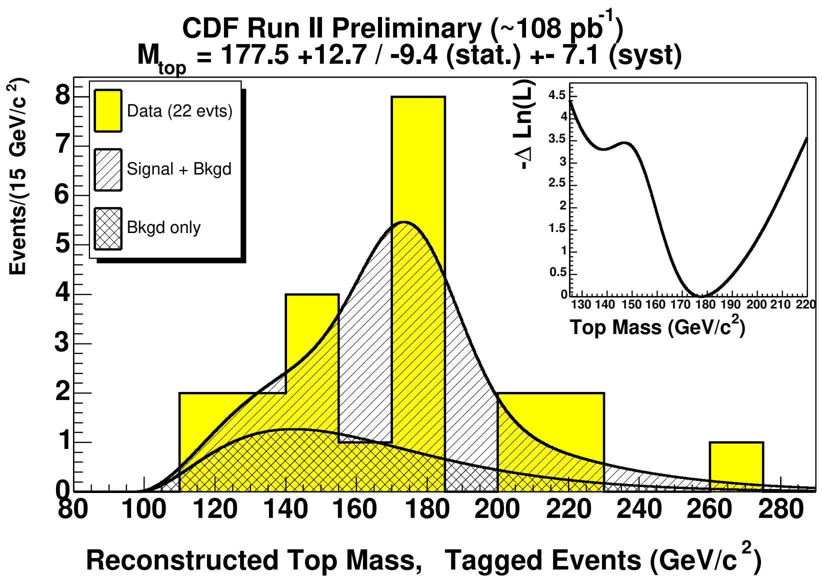

Figure 5: Top quark mass measurement from the lepton + jet channel in Run II data, where at least one of the b-jets is tagged with secondary vertices.

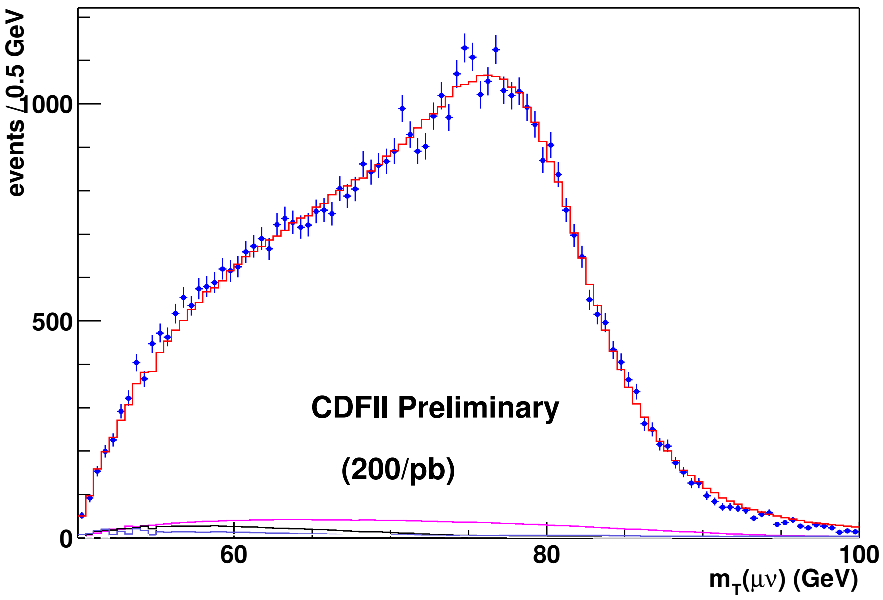

Figure 6: Transverse mass distribution of Run-II $W^{\pm} \to \mu^{\pm}\nu$ candidates.

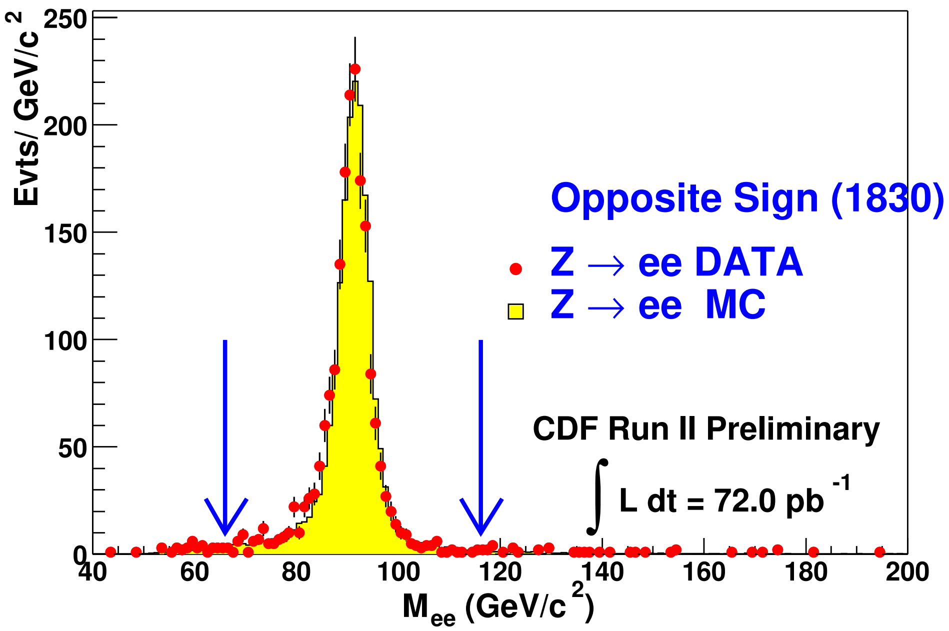

Figure 7: Invariant mass distribution of Run-II $Z^0 \to e^+e^-$ candidates.

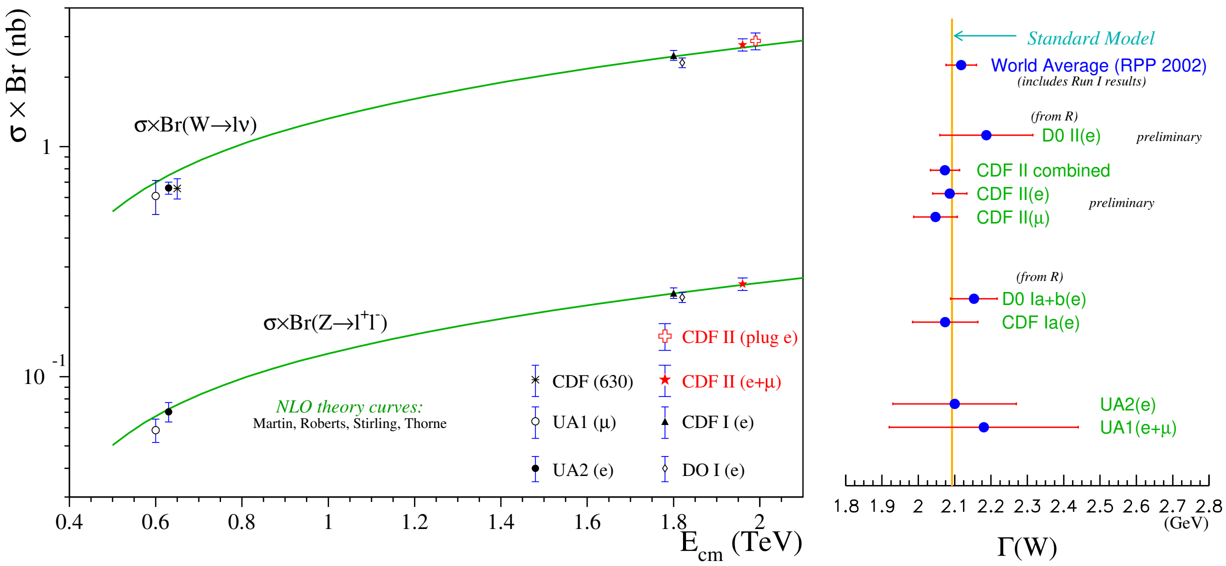

Figure 8: Left: Production cross sections of $W^\pm$ and Z^0 bosons as a function of the center-of-mass energy. Right: Measurements of the W boson width.

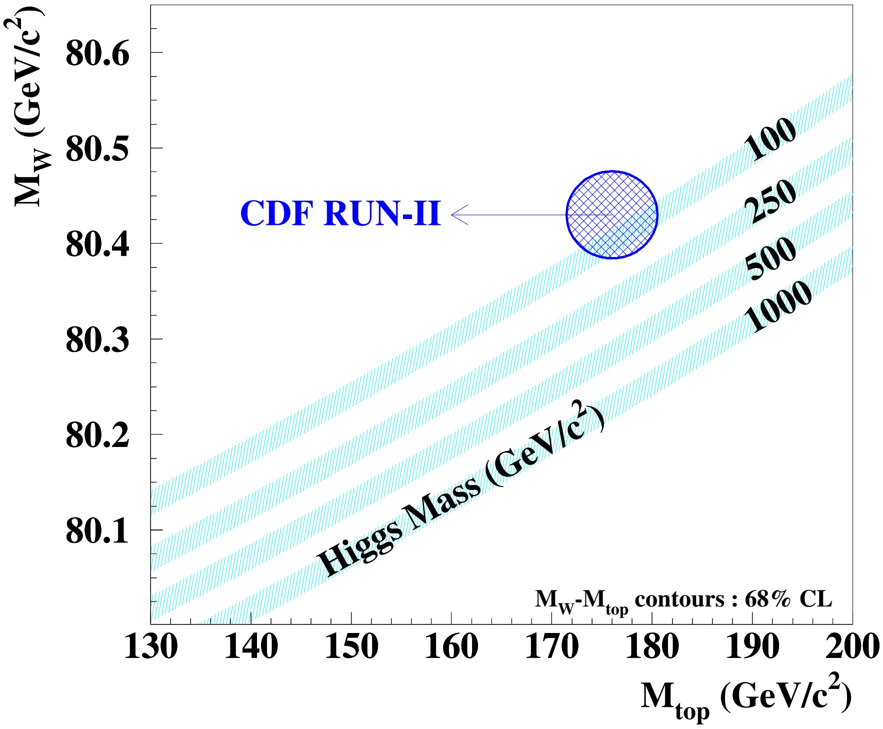

Figure 9: Expected precision in top quark and W boson mass measurements in Run II, and possible constraints on the Higgs boson mass.

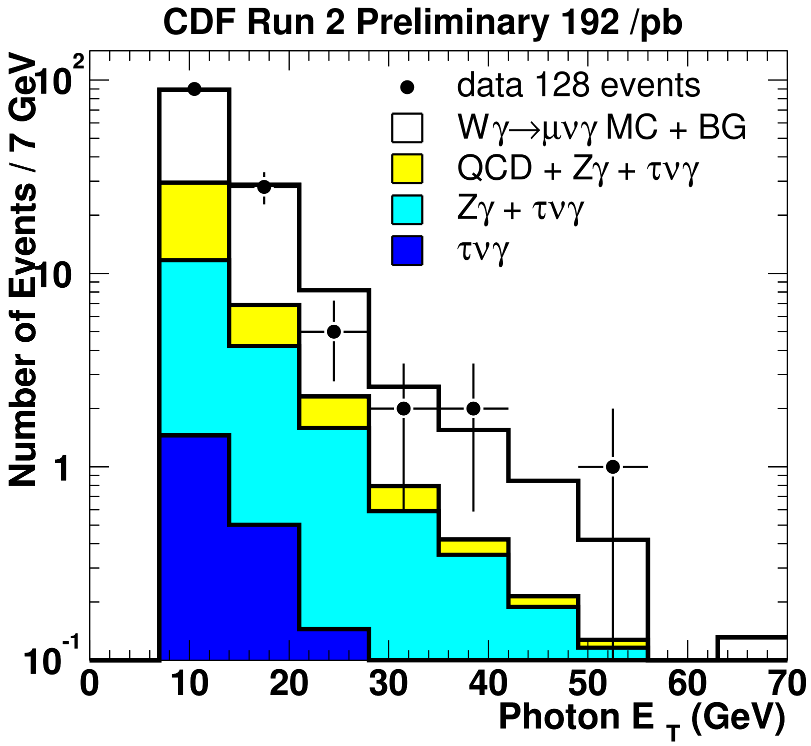

Figure 10: Photon transverse momentum distribution in $W\gamma$ pair production candidate events.

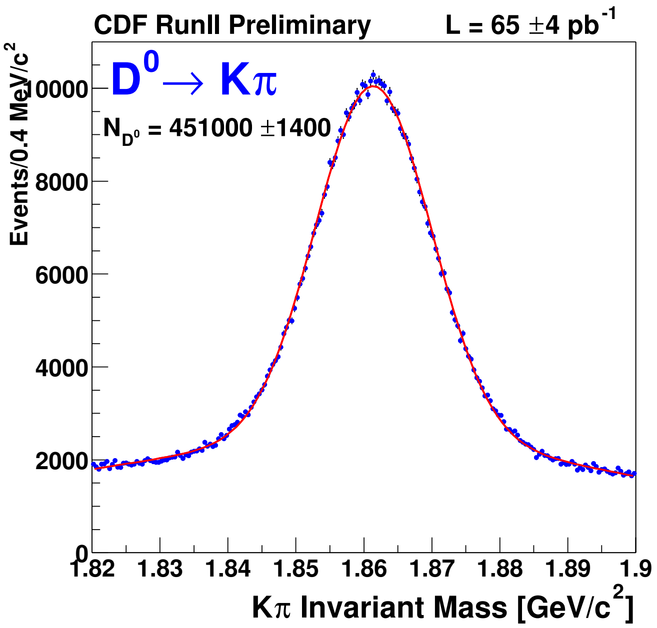

Figure 11: $D^0 \to K^-\pi^+$ signal reconstructed in a data sample collected using SVT trigger.

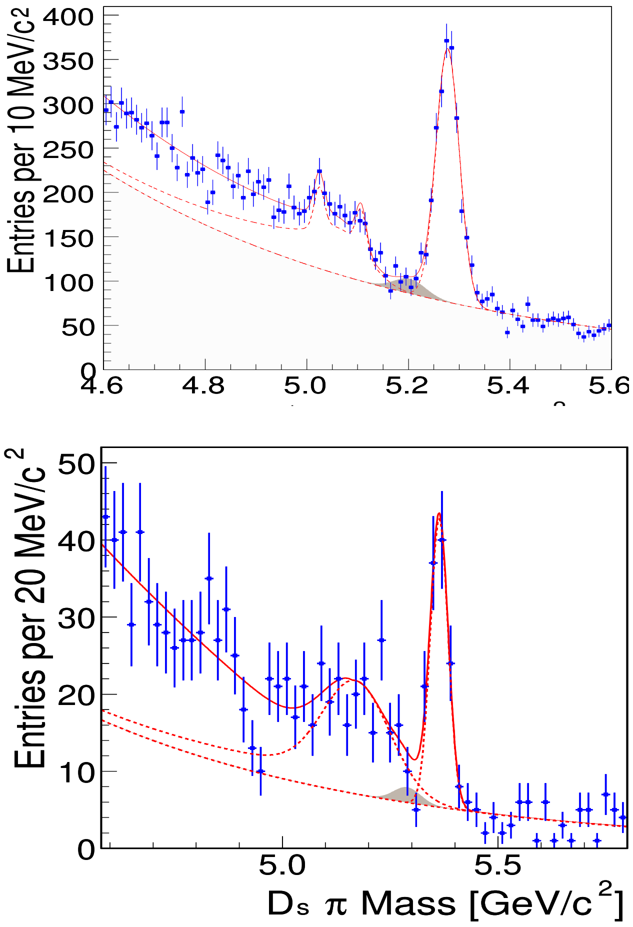

Figure 12: B meson signals from SVT trigger. Top: $\bar{B}^0 \to D^+\pi^-$, $D^+ \to K^-\pi^+\pi^+$. Bottom: $\bar{B}_s^0 \to D_s^+\pi^-$, $D_s^+ \to \phi\pi^+$.

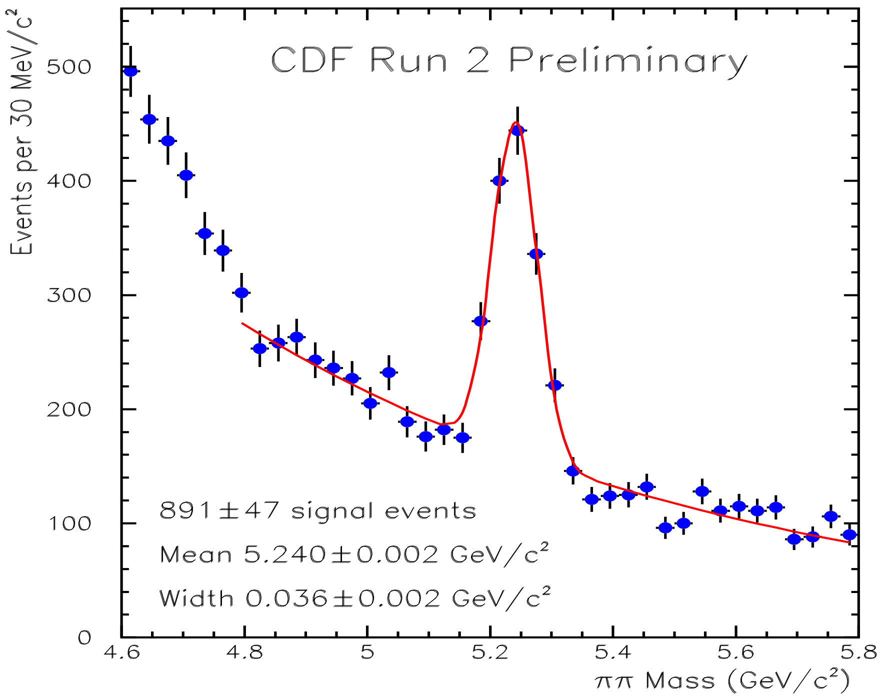

Figure 13: $B^0/B_s^0 \to h^+h^-$ signal from SVT trigger, where $h^\pm$ is either $\pi^\pm$ or $K^\pm$. Pion mass is assumed for reconstruction of two-body mass. Data sample corresponds to an integrated luminosity of about 190 pb^{-1}.

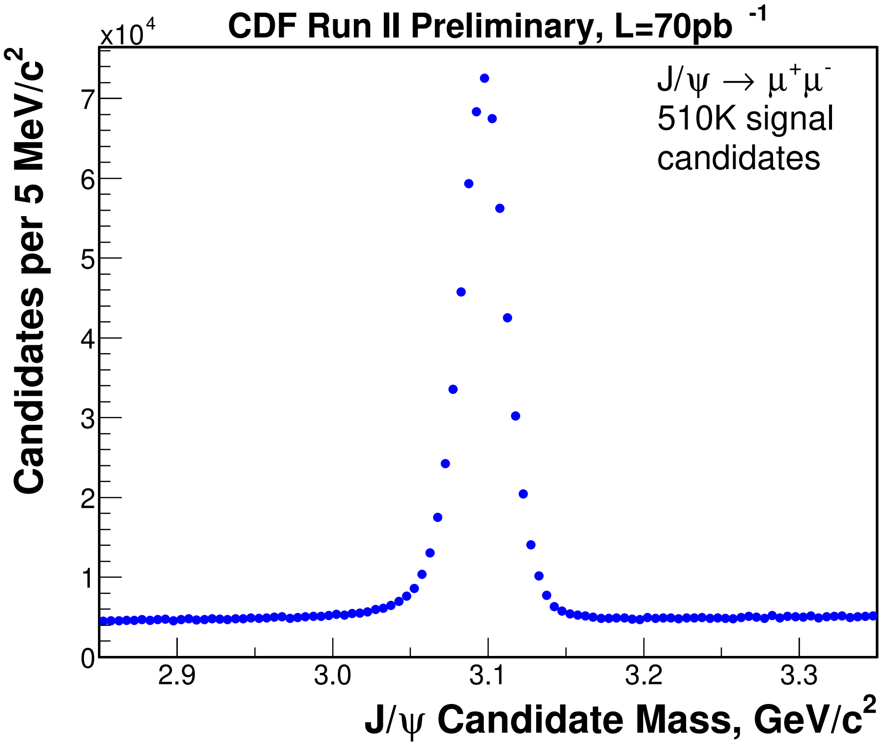

Figure 14: Run-II dimuon invariant mass distribution near J/ψ region.

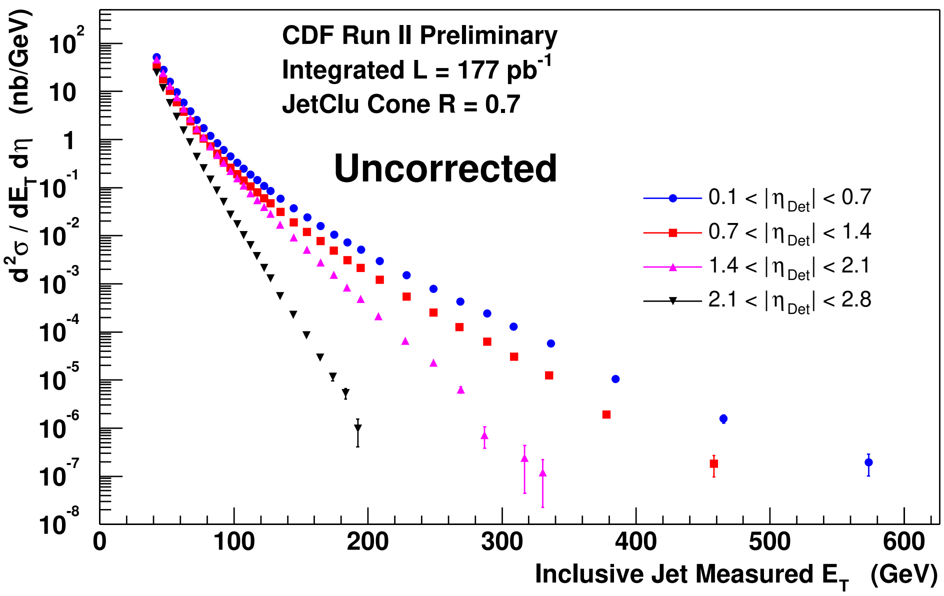

Figure 15: Run-II measurement of inclusive jet production in various rapidity ranges.

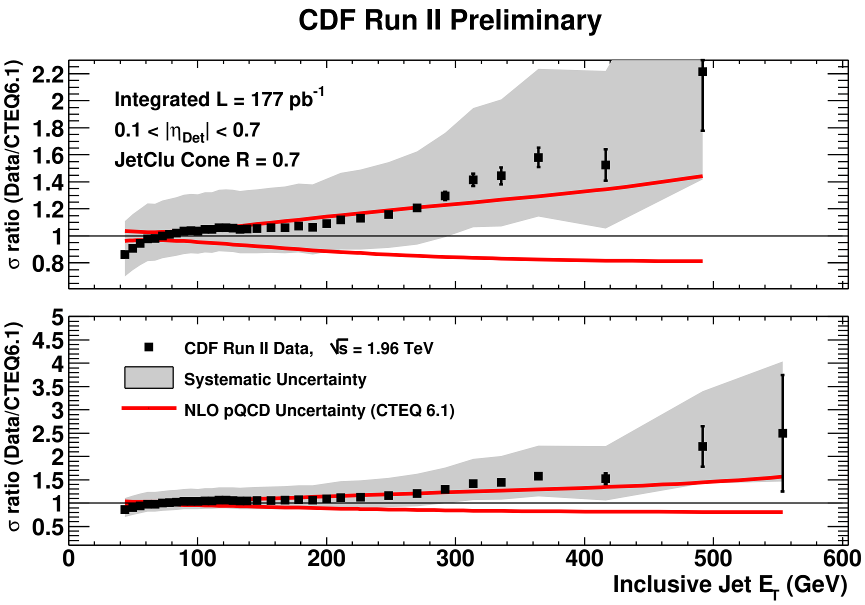

Figure 16: Ratio of measured inclusive jet production cross sections to theory at $\sqrt{s}$ = 1.96 TeV.

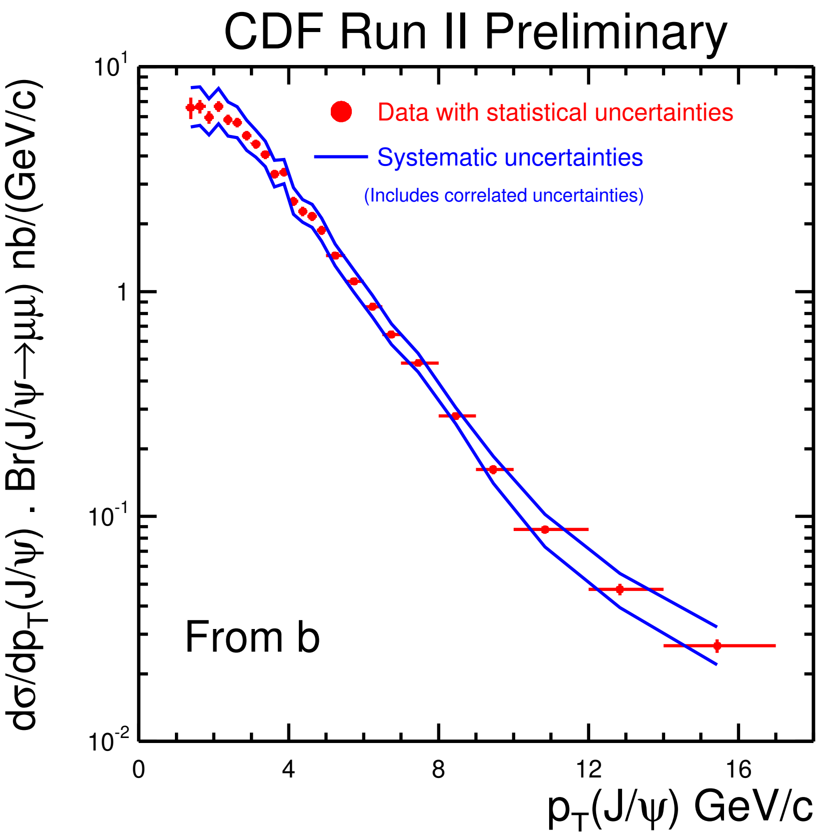

Figure 17: J/ψ production cross section from B hadrons.

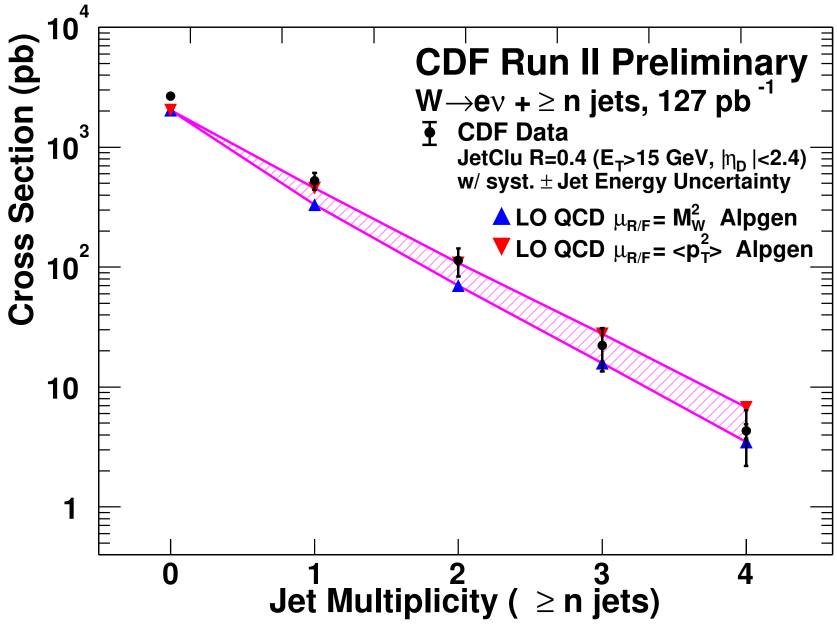

Figure 18: W+jets production cross section.

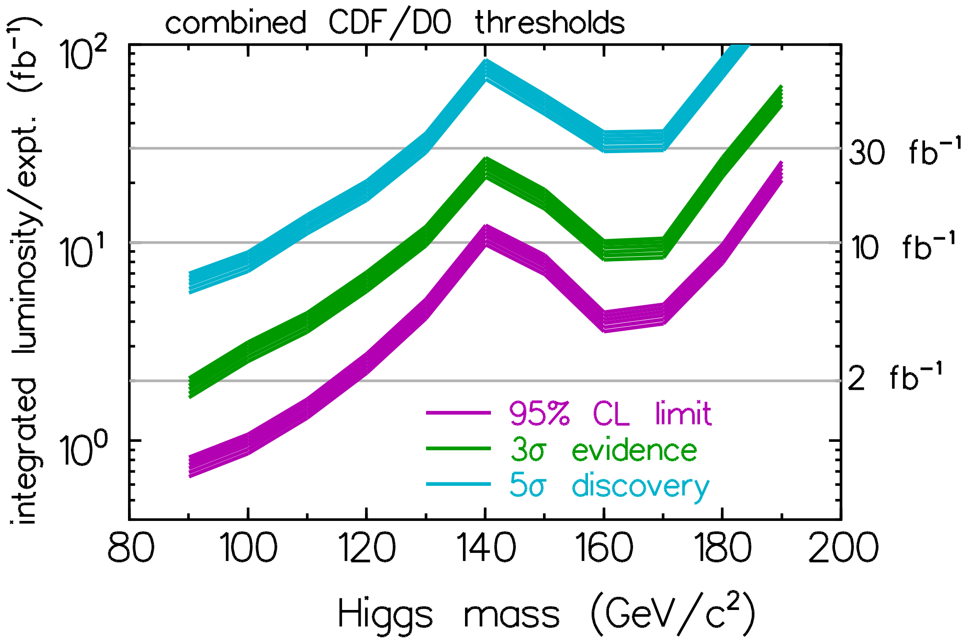

Figure 19: Tevatron reach for the standard model Higgs boson. Three bands show, as a function of the Higgs mass, the amount of data that are necessary (a) to exclude at 95% CL if the Higgs does not exist at that mass (bottom band), (b) to provide 3σ evidence for existence (middle), and (c) to discover with 5σ significance (top).

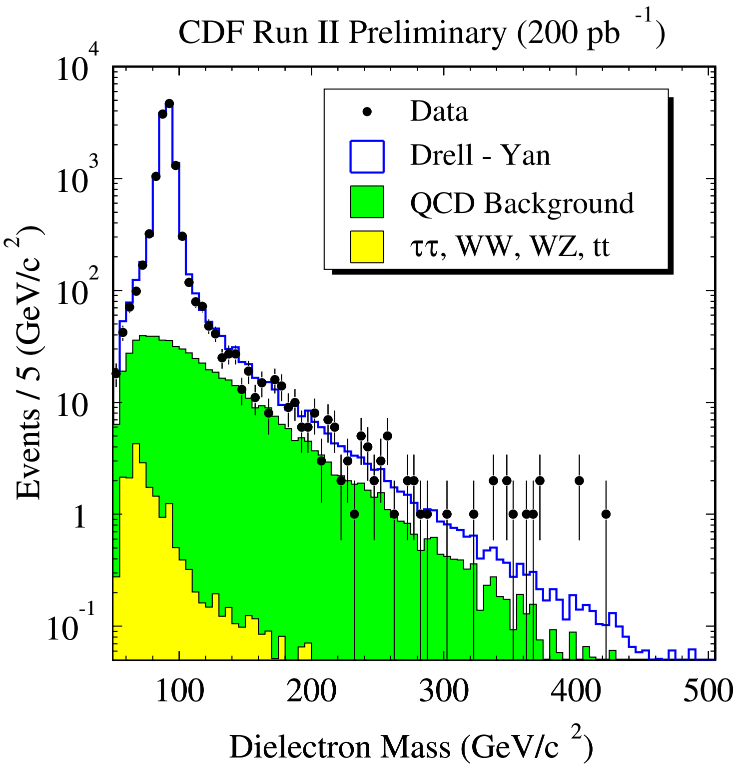

Figure 20: Invariant mass spectrum of e^+e^- pairs at high mass region.

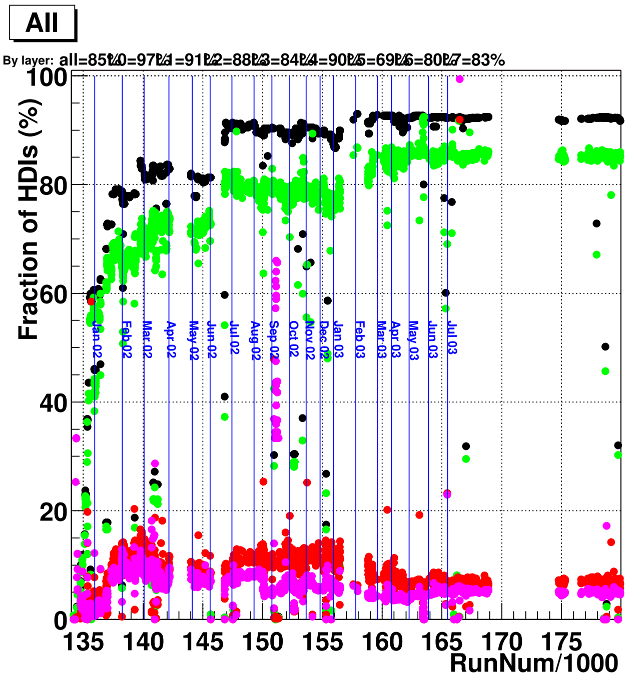

Figure 21: CDF-II silicon detector status. Fractions of channels read out are shown for combined Layer 00, SVXII and ISL detectors as a function of time (run number).

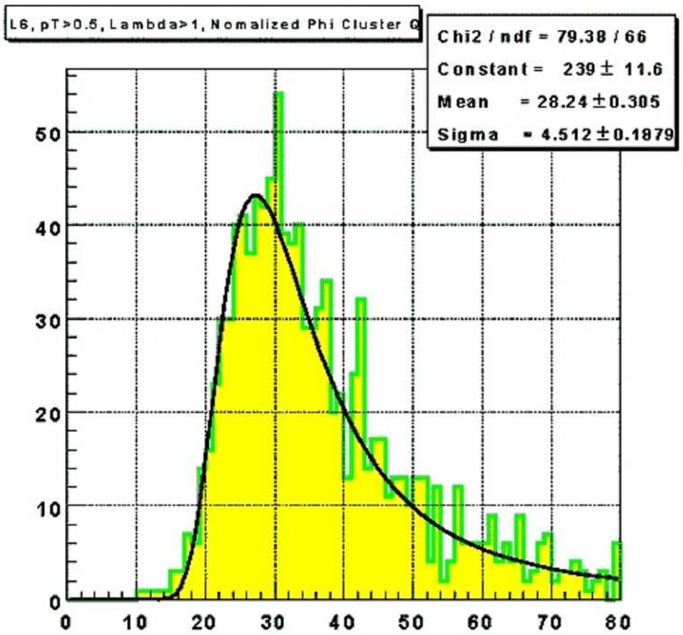

Figure 22: Pulse height distribution observed on ISL. A typical signal-to-noise ratio of 12 has been achieved.