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Accelerator/Experiment Operations - FY 2004

C. Bromberg, J. Conrad, D. Denisov, S. Holmes, W. Louis,
A. Meyer, C. Moore, R. Raja, E. Ramberg, R. Roser

Edited by J. Appel

This Technical Memorandum (TM) summarizes the accelerator and experiment operations for FY 2004. It is one of a series of annual publications intended to gather information in one place. In this case, the information concerns the FY 2004 Run II at the Tevatron Collider, the MiniBooNE neutrino experiment, and SY 120 activities.

Each section was prepared by the relevant authors, and was somewhat edited for uniformity for inclusion in this summary.

Collider (Steve Holmes)

FY 2004 began with the accelerator complex in the middle of an annual, scheduled shutdown. The shutdown officially ended when coasting beam was established in the Tevatron early on the morning of November 17, 2003. This was as scheduled prior to initiation of the shutdown on September 8. All major work scheduled for the shutdown was completed with the exception of the installation of two prototype wide-aperture cavities in the Booster.

The first beam collisions were established on November 22 with a 36×12 proton-antiproton store. The first store to go on the books (36×36) was store 3043 on Sunday, November 29.

Summarized below is the final status of major activities undertaken during the shutdown aimed at improved performance. There are myriad other activities that cannot be summarized here.

Machine/Activity	**Goal**	**Status**
Linac		
New 400 MeV Lambertson	Reduce losses in 400 MeV line	Complete
Booster		
Collimators	Control losses and allow increased cycle rate to MiniBooNE.	Complete
L3 area reconfiguration	Reduce losses during Booster acceleration cycle	Complete
New (upstream) 8 GeV line dipoles	Reduce losses during Booster extraction	Complete
Prototype large-aperture rf stations (two)	Reduce losses during Booster acceleration cycle	Removed from scope of work.
Antiproton Source		
Debuncher motorized stands	Increase antiproton production yield	Complete
Debuncher filter improvements	Increase stacking rate (decrease cycle time)	Complete

Machine/Activity	Goal	Status
Main Injector		
MI-60 instrumentation rearrangement	Accommodate NuMI extraction	Complete
Longitudinal damper cavities	Improved proton longitudinal emittance	Complete
Recycler		
Heater tape replacement	Improved field quality	Complete
Vacuum bakeout	Improved vacuum (lifetime and emittance growth rate)	Complete
MI-31 breakthrough	For connection of the electron cooling beamline to the Pelletron in FY05	Complete
Tevatron		
F0 Lambertson liners	Reduce Tevatron transverse impedance	Complete
Cold mass (dumb bolt) shimming	Re-center cold masses (reduce global coupling)	Complete
New Tevatron alignment network	Establish new network that will substantially improve capabilities on future alignments.	Complete
Measure rolls on all magnets	Update knowledge of Tevatron alignment	Complete
New A-48 collimator	Reduce losses at CDF	Complete
Repair cold leaks (3 houses)	Improve operability	Complete
NuMI		
MI Lambertson magnets	NuMI extraction	Complete
Extraction line magnets	NuMI extraction	Complete
NuMI stub installation	NuMI extraction	Complete
Infrastructure Maintenance		
Electrical distribution	Preventive maintenance	Complete
LCW heat exchanger cleaning	Preventive maintenance	Complete

The FY 2004 run ended at 0400 on August 23 with the termination of store 3745. For the year, the Collider delivered a total of 342 pb^{-1} to CDF and 321 pb^{-1} to DZero. The delivered luminosity was 12% above the design curve (incorporating the investment of antiprotons for commissioning of the Recycler, the “pbar tax”). Luminosity was delivered for a total of 3704 store hours, again above the design goal by 10%. Highlights for the year included:

- A record luminosity (average of CDF and DZero) of 10.3×10^{31} on July 16 – a factor of 2.1 times the record at the end of FY 2003.
- A new “mixed-source” mode of operation in which antiprotons stored in both the Accumulator and the Recycler were utilized to create luminosity in the Tevatron. The four stores above 9×10^{31}, including the record store, all utilized this mode.
- A factor of two improvement in the beam intensity delivered to the MiniBooNE experiment, culminating in delivery of 1.0×10^{19} protons on target the week of July 12.
- The establishment of slow extracted beam from the Main Injector in support of the 120 GeV fixed-target program (in parallel with antiproton stacking for Collider operations).
- Significant improvements in operational reliability. The total of 3704 hours of stored beam represents 95.0 store hours/scheduled week of operations, a 12% improvement over the 84.7 store hours/scheduled week achieved in FY 2003.

The stage was set for these improvements during the very successful fall 2003 shutdown. We are now embarked on the fall 2004 shutdown, with beam operations in the Tevatron scheduled to recommence at the end of November, with first luminosity roughly one week later.

More detailed information is available in the weekly Accelerator Division presentations at the All Experimenters' Meeting (http://www-runii.fnal.gov/RunCoord/RunCoord.htm).

Significant configuration changes during the year included:

- New QPM (quench protection module) software ring-wide. The new software features quench detection/response time of ~2 ms, vs 16 ms in the original system design. This affords much better protection of the Tevatron against quenches originating from fast events.
- Slip-stacking as default stacking configuration on August 17. This followed an access which brought the number of Main Injector rf stations outfitted with the required beam loading compensation to 12 (out of 18). We were able to run consistently with 7×10^{12} protons on the antiproton production target, accompanied by ~95% efficiency. The Run II goal is 8×10^{12} on target. The final six stations are being outfitted during the fall 2004 shutdown. The effect on the stacking rate appeared to be about a 30% increase in yield downstream of the target, and 15% in the stacking rate.
- Mixed-source shots utilizing antiprotons from both the Accumulator and the Recycler, typically in the ratio of 2:1. The four highest luminosity stores of the year all originated from mixed-mode shots. The current antiproton stacking rate is not sufficient to support mixed-mode shots at a frequency of more than about once every five days.
- A new b_2 compensation ramp implemented for the first time on the final store, 3745. The new implementation reduces the shot setup time by eliminating the need for a dry squeeze.
- A mixed-mode stacking plus slow spill to SY120 cycle. This allowed more slow-spill beam to be delivered without compromising stacking. However, this mode of operation is not compatible with NuMI operations in the same cycle.

Simultaneous with Collider operations, total accumulated protons on target for the MiniBooNE run reached 3.6×10^{20}. Unexpectedly, the MiniBooNE horn failed on July 26. The spare horn is being installed during the current shutdown. During the period between July 26 and the end of the run, MiniBooNE operated without a horn. This data is useful for a variety of systematic checks and would have to have been accumulated at some point in any event. During the year, we also delivered 120 GeV beams to MTest for the test beam users and MCenter for the E-907/MIPP experiment.

Commentary on Current Performance

The median luminosity over the final five weeks of the FY 2004 run was 72.1×10^{31}, exceeding the design goal of 61.9×10^{31}. The improved performance over the course of the year was derived from a number of sources, some anticipated and some not. The most significant factors included:

- Removal of significant coupling from the Tevatron. A major effort was invested in the fall 2003 shutdown in shimming Tevatron dipole cold masses that had slowly sunk within the external magnet steel over the twenty years since the Tevatron was installed. In addition a program of unrolling magnets was undertaken which fixed the worst offenders.
- Removal of coupling from the beam transfer lines. Magnets in the Main Injector to Tevatron transfer lines were rolled to provide a better optical match into the Tevatron.
- Better emittance preservation on transfers from the Accumulator to the Main Injector. Midway through the year, we retracted the secondary emission monitors between the Accumulator and Main Injector on shots. This reduced emittance dilution due to multiple scattering in the monitors. We were able to do this because the Main Injector BLT (beam line tuner) worked well.
- MI dampers, in particular longitudinal. The Main Injector longitudinal damper was implemented on both proton and antiproton shots, leading to smaller longitudinal emittances in the Tevatron. The dampers also supported shorter bunch lengths on the antiproton target, in particular with slip-stacked beam.
- 2.5 MHz transfers. The implementation of 2.5 MHz transfers from the Accumulator to the Main Injector reduced the longitudinal emittance and increased the coalescing efficiency in the Main Injector.
- Higher performance low-beta optics. Following a series of beam studies, the low-beta optics were adjusted to provide a better low beta at the B0 and D0 interaction regions, much closer to the design value of 35 cm. In December, the vertical position of the crossing beams was lowered by 4mm at B0, centering the beams in the CDF detector.
- Implementation of mixed-source shots utilizing the Recycler. This allowed us to increase the number of antiprotons available by utilizing antiprotons stored in both the Accumulator and Recycler. In addition, it provided extremely valuable experience in transferring antiprotons into and out of the Recycler. This was possible because of the dramatically improved performance of the Recycler following last year's shutdown.
- Improvements in reliability. We reaped the benefits of several improvements including replacement of old quench protection monitor (QPM) boards (reducing spurious quenches) and a change in kicker operational protocols (reducing pre-fires).

The above improvements translated into better proton beam stability, better beam lifetimes at 150 GeV, better antiproton efficiency, lower emittances, and lower beta functions in the interaction regions. The result was higher beam intensities and lower beam transverse area; i.e., higher luminosity.

The primary Collider program shortfall in FY 2004 was in the antiproton stacking rate. The design goal was 18×10^{10}/hour (zero-stack stacking rate) and we achieved 13×10^{10}/hour. This was despite implementation of a number of planned improvements to both the Debuncher and stack-tail cooling systems, and to the Debuncher aperture. Significant study time was invested in understanding the limitations. As the run ended, we believed that both the Debuncher and the Accumulator cooling systems were performing at a level sufficient to support the design goal. The shortfall is currently identified as being due to an aperture restriction in the Debuncher to Accumulator transfer. The exact restriction is not yet identified.

The most important variable determining the luminosity of any particular store remained the size of the antiproton stack. The currently configured complex can routinely achieve about 7×10^{31} luminosity from stacks of 150×10^{10}. The investment for Recycler commissioning averaged over the year is estimated at 11%. A total of 2.8×10^{13} antiprotons were devoted to the Recycler commissioning during the year. Over the last two months of the run, significant portions were subsequently used to make luminosity in the Tevatron.

In the proton source, reconfiguration of the dogleg magnets and septa in the Long 3 straight section of the Booster, along with improved alignment of rf cavities and other magnets, improved the Booster optics and opened the aperture, reducing losses and allowing more Booster beam for the MiniBooNE experiment. As noted, the record for MiniBooNE protons was 1.0×10^{19} in one week.

Following the major bake-out of the entire Recycler Ring during the fall 2003 shutdown, the vacuum in the Recycler Ring was substantially improved. The beam lifetime went from less than 60 hours to over 300 hours, and the emittance growth was reduced by a factor of five to eight. A first stand-alone shot to the Tevatron from the Recycler Ring in January, 2004, resulted in an initial luminosity of 17×10^{30} cm^{-2}sec^{-1} and a usable store for physics at CDF and DZero.

Status relative to the FY 2004 Plan

Planned and actual performance for the FY 2004 period:

	Base Profile	Design Profile	Actual	
Median Initial Luminosity	4.3×10^{31}	6.2×10^{31}	7.2×10^{31}	*
Protons/bunch	260×10^{9}	260×10^{9}	252×10^{9}	*
Pbars/bunch	25×10^{9}	31×10^{9}	29×10^{9}	*
Effective Emittance (πmm-mr)	23	20	17	*
Beta at the IP (cm)	40	40	35	*
Hourglass Factor	0.70	0.70	0.68	*
Zero Stack Stacking Rate	14	18	13	
FY 2004 integrated luminosity	229.7	305.9	342.5	pb^{-1}
FY 2004 integrated store hours	3315	3354	3704	hours
FY 2004 integrated studies hours			501	hours

*Base and Design correspond to end-of-year goals. Actual corresponds to simultaneous performance on the median store of the last four weeks of FY 2004.

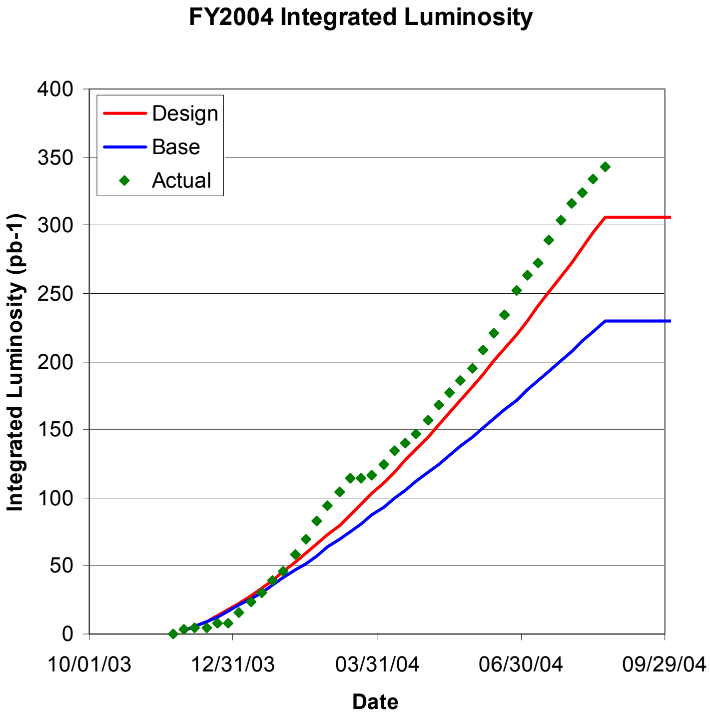


Figure 1: Actual integrated luminosity delivered compared to base and design luminosities.

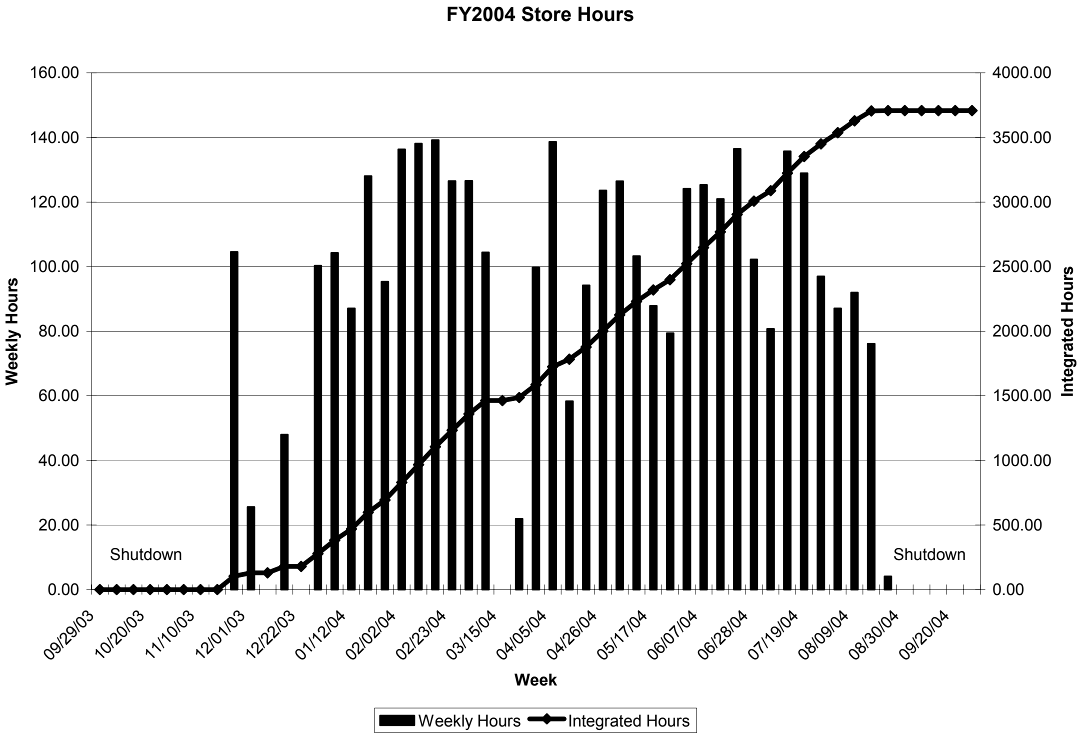


Figure 2: Hours of Tevatron Collider operation during FY 2004.

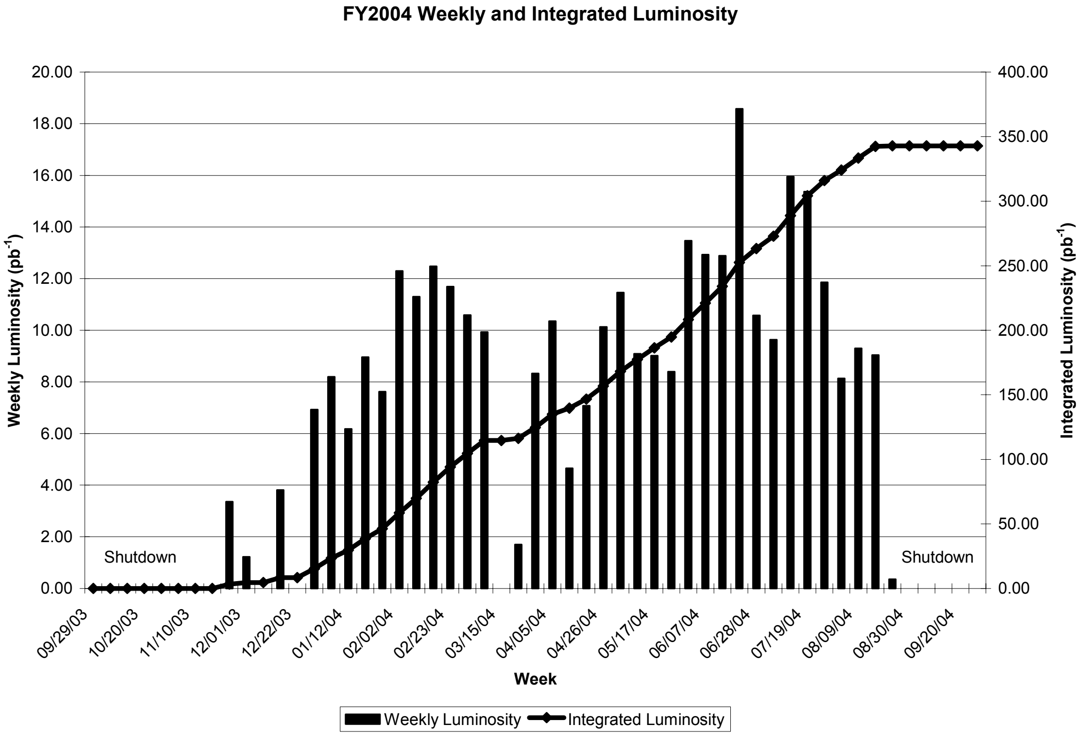


Figure 3: Tevatron Collider luminosity during FY 2004.

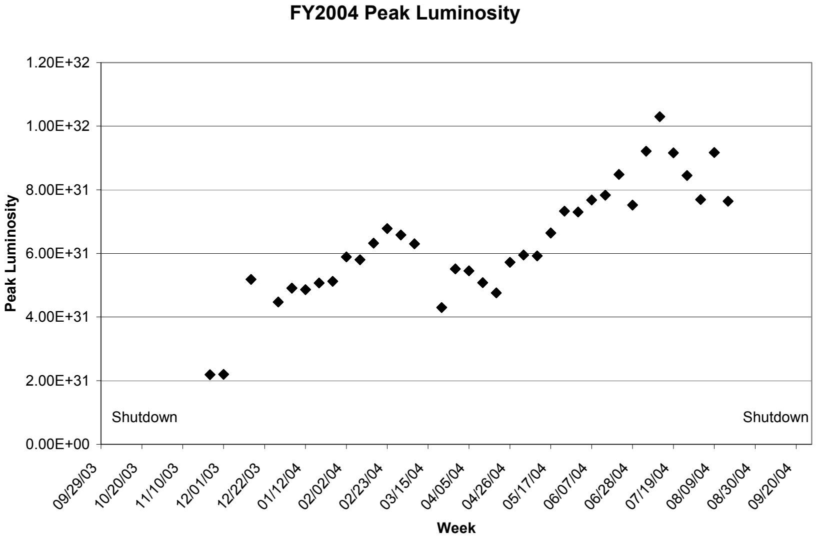


Figure 4: Peak luminosity of stores during Tevatron Collider operation in FY 2004.

Fall 2004 Shutdown Activities and Status

The first five weeks of a 13-week scheduled fall 2004 shutdown occurred in FY 2004. Electron cooling installation in the Recycler is the critical path item. Re-initiation of luminosity operations is scheduled for the week of December 6. Overall the shutdown is going well at the end of the fiscal year, with the vast majority of activities on or close to schedule.

Summarized below is the status at the end of FY 2004 of major activities undertaken in the shutdown. There are myriad other activities that cannot be summarized here. Unless otherwise stated all listed activities are on schedule.

Machine/Activity	**Goal**	**Status**
Linac		
Drift tube replacement, tank 5	Reduce losses.	Awaiting cooldown (per schedule)
Booster		
BRF19 (new large-aperture rf station)	Reduce losses during acceleration and provide added redundancy	Cavity installed and being pumped down
L13 area reconfiguration	Reduce losses during Booster acceleration cycle	Awaiting cooldown
Antiproton Source		
Debuncher motorized stands	Increase antiproton production yield	10 (of 20) installed, 8 aligned
Debuncher injection area rework.	Increase antiproton production yield	30% complete. ~1 week behind schedule but not critical path
AP1/AP2 Survey	Increase antiproton production yield	AP1 complete, starting AP2
AP30 SO cord remediation	OSHA violation	Nearly complete
Main Injector		
NuMI kicker installation	Enable NuMI operations	Kickers installed, awaiting cable connections
Beamloading compensation	Enable slip-stacking at 8×10^{12} ppp	Expect mid-October completion
Recycler		
Stochastic cooling tank repairs	Fix water leaks	40% complete.
Magnetic shielding in NuMI area	Protect Recycler from NuMI beamline stray fields.	95% complete.
Electron cooling installation	Enable another factor of >2 increase in luminosity	Pelletron installation ahead of schedule. MI bus and LCW pipe relocation complete. Cable pulls complete. Stand installation complete. Overall on track for 13 week shutdown.
Tevatron		
Install two new separators at D17	Improved helix flexibility	50% complete, ~1 week behind (but manageable)
Cold mass (dumb bolt) shimming	Re-center cold masses (reduce global coupling)	122 (of 328) magnets shimmed. Ahead of schedule. May add another 86 magnets.
Measure rolls on all magnets	Update knowledge of Tevatron alignment	Complete
Unroll misaligned magnets	Reduce global coupling	On schedule

Machine/Activity	Goal	Status
Vacuum upgrades at A0 and DZero	Improve operability	On schedule
NuMI		
MI extraction kickers	NuMI extraction	See MI.
Extraction line magnets shielding	Protect Recycler from NuMI stray fields	See Recycler
NuMI target hall installation	NuMI operations	~1 week behind. (Does not impact Collider schedule.)
MiniBooNE		
Horn replacement	Replace failed horn	Cooling down. Failed horn will be replaced the week of 10/18.
Infrastructure Maintenance		
Electrical distribution	Preventive maintenance	On schedule

E-830/Collider Detector at Fermilab (CDF) (Carl Bromberg and Robert Roser)

CDF began FY 2004 performing maintenance on its detectors. The Laboratory was in the middle of an accelerator shutdown necessary to perform the required maintenance as well as to upgrade selected apparatus. While CDF was running quite well just prior to this shutdown, there was a list of work to be accomplished. A few of the highlights include:

- Installation, cabling, and commissioning of the final two 30-degree sections of the CMX "miniskirt" muon chambers on the west side of the collision hall. As a reminder, these chambers now complete most of the lower gap between the North and South CMX arches – namely the region between 4 and 8 as viewed on a clock.
- Installation of 80 tons of steel shielding which surround the "B-side" low-beta quadrupole magnets. This shielding protects the detector from beam halo. The shielding for the "A-side" was installed the previous shutdown.
- Installation of timing circuitry for the entire plug EM calorimeter and for two of the 48 wedges of Central EM calorimeter.
- Addition of a special resonance detection circuit to protect the silicon detector from potentially dangerous trigger/readout conditions.

CDF completed most of its work by the end of October to allow sufficient time for checkout in preparations for the mid-November HEP startup.

After a long shutdown, accelerator startup is typically troublesome as is CDF's ability to take data efficiently. This shutdown was no different. For the first two weeks of running, the initial luminosity for stores was quite low with store luminosities in the low 20×10^{30} $\text{cm}^{-2}\text{sec}^{-1}$ region. CDF used this low luminosity time to re-commission its detector systems and revalidate its triggers with beam. During this commissioning period, CDF acquired physics quality data at 75% efficiency. This relatively low efficiency is not surprising given the number of special runs and special detector configurations that were used.

On December 1, the first of two serious beam incidents occurred which not only impacted CDF, but the operations of the entire Fermilab Collider complex. There was an unintentional Tevatron abort which quenched the machine. In this incident, the silicon received a substantial radiation dose (200 Rad). This dose resulted in permanent damage of several silicon readout chips. Then, on December 4, there was a second massive quench that damaged the Tevatron (but in this case not the silicon detector). During the two-week repair period required to fix the Tevatron, the decision was made to realign and reposition CDF's low-beta quadrupole magnets. CDF wanted the beam moved 3.8mm downward to center the beam in the silicon detector. This would not only help with the SVT trigger efficiency, but would even out the radiation dose seen on the detector, an important factor for the operation at the higher luminosities expected later in Run II. When beam returned, the luminosity quickly reached 50×10^{30} but was followed by a third heavy quench on December 20. This quench caused a helium leak in the TeV that required repair.

HEP restarted on December 31. From that point on, the accelerator operated quite stably and started a very impressive series of stores in which the luminosity continued to improve. Over the next six weeks, stores with initial luminosities regularly above 50×10^{30} were delivered and CDF was regularly recording data with better than 80% efficiency.

This regime of high luminosity was new for both the Accelerator Division and for CDF. Prior to that point, CDF had never operated its detectors with that sort of particle flux. Unfortunately, this increase in flux confirmed a problem in the Central Outer Tracker (COT) that had been suspected for some time – namely a nearly continuous gain reduction (aging), as shown in Figure 5. This aging process was most pronounced on those wires of the COT closest to the beam (superlayer 1), and almost non-existent on the outermost wires (superlayer 8). A decision was made in mid-February to turn off the inner three of eight superlayers, to reduce the gain on the next two superlayers, and to adjust the trigger requirements to maintain nearly the same trigger efficiencies, but with higher instantaneous trigger rates, while CDF tried to understand the problem. This action was not taken lightly as it severely compromised the low P_t physics program. CDF was concerned that if this aging rate were not halted quickly, the chamber gain would be reduced to such a point that the COT would no longer operate. At that point, there was very little hope that the compromised wires could be "cleaned" without heroic effort and time.

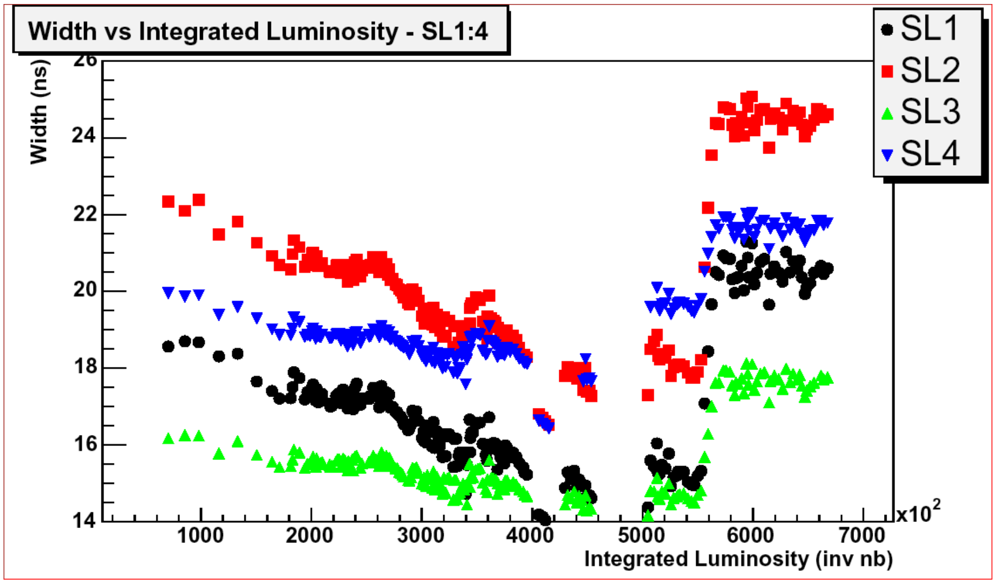


Figure 5. COT pulse widths ($\propto$ gain) for superlayers 1-4 vs. Run II integrated luminosity. Recirculation of the chamber gas at ten times the previous rate began at L=500 pb^{-1} and continuous air injection starting at L=550 pb^{-1}.

From mid-February on, CDF focused all of its available resources on this aging problem, while continuing to take data in the compromised state. Morale was certainly down, and our mid-70% efficiency reflected this. The first thing the operations group did was to form an international advisory panel to examine the evidence and help come up with ideas, and ultimately a solution. While CDF performed a number of studies and specialized tests, effort was focused on three projects:

1) A gas recirculation system that "pushed" gas through the chamber a factor of 10 faster than what had been done before in Run II;

2) Analysis of gas for possible contaminants – none were found; and

3) Removal of two wire planes for analysis. SEM analysis identified a 200 nm-thick hydrocarbon coating on the wires. No silicon was seen in the deposits.

Attempts to alter the aging included adding nitrogen, reversing the gas flow direction, and increasing the flow rate an order of magnitude via the recirculation system. Though aging effects continued, analysis showed that conditions within the chamber and not a contaminated gas system were the most likely source of the aging.

Following two inadvertent introductions of air into the COT gas, CDF noticed that there was an increase in the wire gain that persisted for many stores after purging. On June 16, CDF began injecting a small amount of air (~600 ppm) containing 120 ppm of oxygen, into the argon-ethane (50/50) gas mixture. As can be seen in Figure 5, over the next few stores the COT wire gains recovered to, and have remained at, pre-2001 values. The chamber is back to its original operating condition. CDF has since changed to injecting an argon/oxygen mixture to add 60 ppm of oxygen into the fresh gas.

About 100 pb^{-1} of integrated luminosity was delivered to CDF while the COT was in a compromised condition. Many physics topics can use this data directly, however, analyses performing precision reconstruction and normalization must treat this data separately.

One very important byproduct of having to deal with this COT aging problem is that it forced the trigger group to find ways to reduce trigger rates which resulted from a compromised detector, yet without significant loss of efficiency. Therefore, in July when mixed-mode pbar shots gave B0 an initial luminosity of 1.1×10^{32}, these earlier efforts proved to be useful. Within a few days, a trigger table was produced that allowed the full physics program to be run with <20% dead time at 0.9×10^{32}. Furthermore, dynamic prescaling of high-rate (low bias) triggers helped to keep data-taking operations efficient and the bandwidth near saturation. In the last week of beam, CDF had a successful test of parallel data logging that increased the limit for recording data from 21 to 35 MB/s.

In FY 2004 CDF recorded 275 pb^{-1} out of the 340 pb^{-1} delivered luminosity, for an average efficiency of 81%. This included periods when CDF had to turn off due to high proton or abort–gap losses. Excluding these periods, largely eliminated by July, average data-taking efficiency exceeded CDF's minimum goal of 85%.

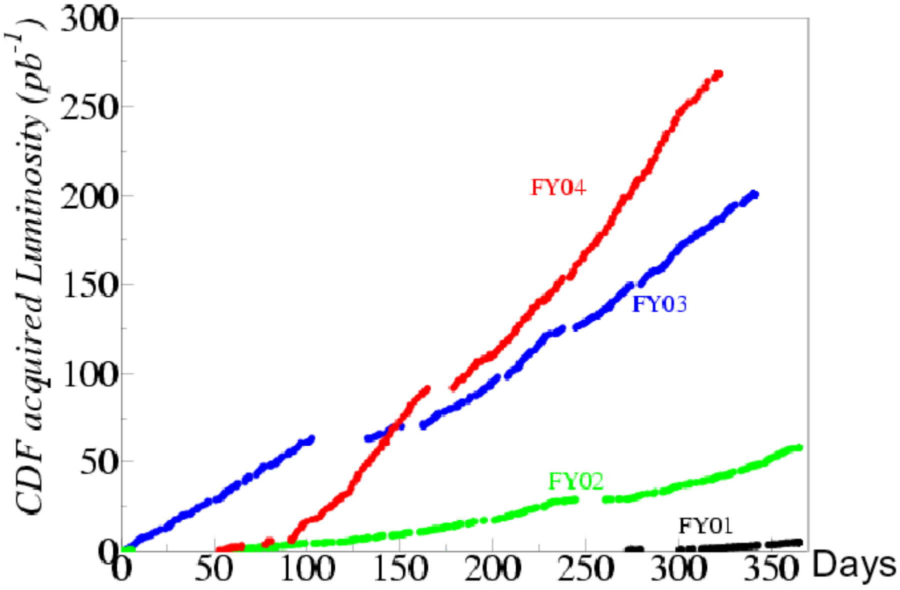


Figure 6. CDF acquired luminosity in each of the last four fiscal years.

CDF is currently in the midst of the shutdown for the installation of electron cooling and the completion of the NuMI beam line. CDF is installing new high-luminosity CPR (central pre-radiator) counters. The CPR used in FY 2004 was adequate, but will saturate with the coming year's increase in instantaneous luminosity. The new detector has finer granularity. CDF is also completing the installation of the timing electronics for all of the central EM calorimeter. Finally, CDF took the time to isolate the silicon and COT inert gas volumes so that repairs could be made on the COT without having to warm up the silicon – something that will be extremely important as the silicon sees more and more radiation damage. The low losses, high luminosities, and efficient data-taking with which CDF ended the current fiscal year bode well for a highly successful FY 2005 data run.

E-823/DZero (D0) (Dmitri Denisov and Arnd Meyer)

Operating the DZero experiment during the period covered by this report can be characterized by three distinct phases: the 10-week shutdown in September to November 2003, about nine months of data-taking, and finally the 13-week shutdown that started in August of 2004.

During the fall 2003 shutdown the main focus was on maintaining DZero's ability to continue collecting quality data for the duration of Run II. Failed readout channels in the silicon tracking system were repaired as far as possible, improving the fraction of working channels to up to 90%, depending on the detector area. For the fiber tracker, maintenance of the low-voltage power supplies and the VLPC cooling system was performed. For the calorimeter, unreliable cooling fans were replaced. In an effort to improve the calorimeter performance, several sources of "noise" were identified and eliminated, and the detector grounding was substantially improved. For the muon systems, in addition to maintenance work, additional trigger counters were installed, and a remote power-cycle system for front-end electronics was installed in order to reduce the frequency of future accesses to the collision hall. The installation of the detector and electronics for the forward proton detector were completed, and a large amount of general detector maintenance work was performed. The shutdown was completed on schedule, and stable data-taking was established within a few stores after the end of the shutdown.

From November 2003 to August 2004, the emphasis was on collecting physics-quality data with high efficiency. The target for data-taking efficiency was 90%. This was accomplished for much of this period. It should be noted that, by design, the maximum data-taking efficiency for DZero is about 94%; on average 4% are lost due to the deadtime of the tracker readout electronics, and 2% of the luminosity is needed to ramp detector high voltages, prepare for data-taking, and change prescale factors to adapt to luminosity decay. A few individual incidents impacted the average data-taking efficiency:

- Cooling leaks and water-drip-detection failures in hard-to-access silicon interface-board power supplies in January 2004;
- Collection of special runs in order to improve triggering capabilities at high luminosity, to commission ongoing upgrade projects, in particular the Silicon Track Trigger, and to improve the understanding of the luminosity measurement;
- "Noise" observed in the calorimeter and correlated with energizing the toroids in late February and early March 2004; and
- Various hardware failures: Calorimeter preamplifier power supplies, a cooling fan in a track trigger rack, and a phase shift between the 53MHz and 7.6MHz clock signals, etc.

It has to be stressed that operating and maintaining the DZero detector remains a labor-intensive task. The prospect of higher luminosity and aging equipment puts additional load on the experiment. Longevity of the silicon tracking detectors is a major concern. At the present time, the fraction of working readout channels is about 85%, and the mechanism of their failure is not well understood.

The Run II total recorded integrated luminosity for DZero is 471 pb^{-1} for the period April 19, 2002, which marks the beginning of DZero Run II physics data-taking, through September 30, 2004. With 587 pb^{-1} delivered to DZero, this corresponds to an average data-taking efficiency of 80.3%. For the period October 1, 2003 to September 30, 2004, DZero recorded 265 pb^{-1}, corresponding to a data-taking efficiency of 83.9%. The histories of data-taking efficiency and the delivered and recorded luminosities are illustrated in Figures 7 and 8.

During the fall 2004 shutdown, DZero is addressing known hardware problems, and is preparing for future upgrades to the detectors and trigger system. Failed channels in the muon systems, fiber tracker, and silicon tracker are being repaired to the extent possible. Infrastructure installations for the Level 1 calorimeter and track trigger upgrades are being completed, and clearance measurements for the Layer 0 silicon upgrade are being performed. The grounding of the experiment is being significantly improved in an effort to further enhance the performance of the calorimeter.

In summary, DZero increased its data sample by 265 pb^{-1} during the period covered by this report, bringing the Run II total to 471 pb^{-1}. The experiment is efficiently collecting physics-quality data, and is prepared for operating during the coming years of Run II.

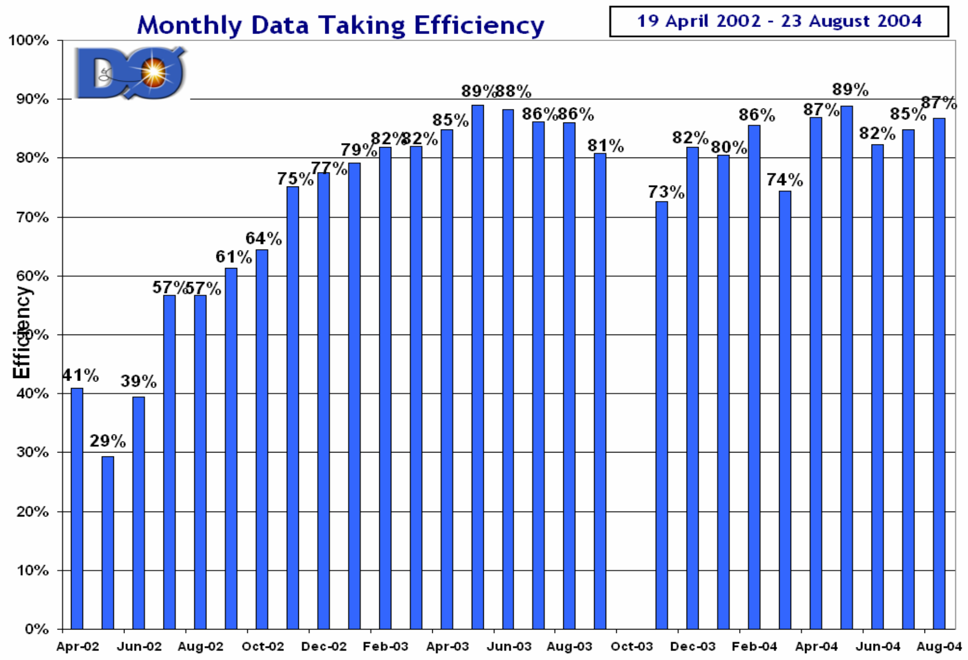


Figure 7. DZero monthly data-taking efficiency from April 2002 to August 2004.

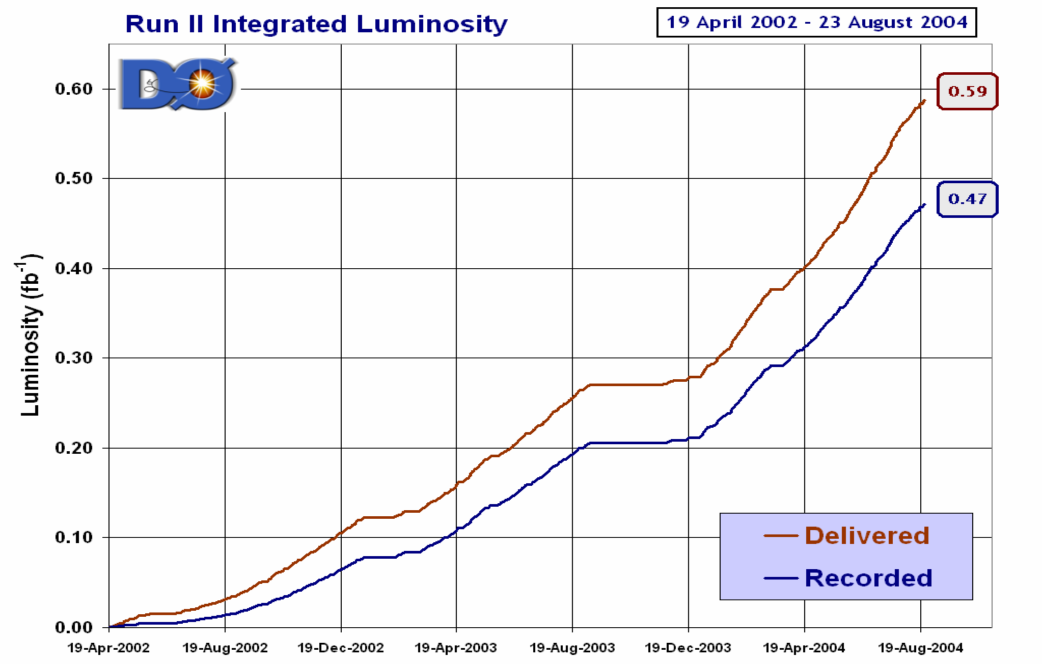


Figure 8. Delivered and integrated luminosity at DZero from April 2002 to August 2004.

E-898/MiniBooNE (Janet Conrad and William Louis)

The MiniBooNE experiment began taking data at Fermilab in late August, 2002, and has collected over 380K total neutrino events over the first two years of operation. This report summarizes the MiniBooNE data collection and analysis progress during the 2004 fiscal year, when 220K neutrino events were collected.

As shown in Figure 9, the Booster has delivered over 3.66×10^{20} protons to the MiniBooNE target during the first two years of MiniBooNE operation and about 2.15×10^{20} protons in FY 2004 alone. As the year progressed, the Booster came close to the goal of 9×10^{16} protons-on-target/hr, culminating in a record 1.016×10^{19} protons delivered in one week in July. The MiniBooNE focusing horn suffered a ground fault shortly after this record, and after careful study it was decided to turn-off the horn and replace it during the 2004 shutdown. It should be noted, however, that this first horn was pulsed a record number of 84.8M pulses (96M including test pulses) and performed admirably during almost two years of operation.

Due to the short duty factor of the Booster beam, it is very easy to identify genuine neutrino events. Figure 10 shows the time distribution of events (in a 19 micro-second time interval around the Booster beam spill) that satisfy the criteria of more than 200 tank phototube hits and less than six veto phototube hits. As can be seen in the figure, most of the events are neutrino events produced during the 1.6 micro-second beam spill and there are very few cosmic-ray induced events outside the beam spill window. The ratio of neutrino events to cosmic-ray induced events during the beam spill is about 2000 to 1. Using the above criteria to identify neutrino events, MiniBooNE has collected over 380K neutrino events during the first two years of data-taking and approximately 220K neutrino events in FY 2004 alone.

The MiniBooNE detector and beamline have also performed extremely well. In FY 2004 about 99% of the phototube channels worked well, and the data acquisition livetime averaged ~99%. Furthermore, the reconstructed time, position, energy, and angular resolutions are all in agreement with expectations, and the experiment is clearly observing charged-current quasi-elastic events, charged-current pion events, neutral-current pion events, and neutral-current elastic scattering events. As an example, Figure 11 shows the π^0 mass distribution for two Cerenkov ring events with more than 40 MeV in each ring. A clear π^0 mass peak is observed with a mass resolution of about 22 MeV.

Based on the data analysis progress to date, Figure 12 shows the updated MiniBooNE oscillation sensitivity for a total of 1×10^{21} protons on target (MiniBooNE is now about 36% of the way toward this goal). As can be seen in the figure, MiniBooNE should be able to cover almost the entire LSND region at 5 sigma. If MiniBooNE confirms the LSND signal, Figure 13 shows how well the oscillation parameters can be measured at two different points in the Δm^2 - $\sin^2(2\theta)$ parameter space.

Overall, 2004 was another outstanding year of data-taking for the MiniBooNE experiment. The detector and beamline performed well, and the Booster delivered 2.15×10^{20} protons on target (43% of the experiment's desired yearly goal). With the horn replacement and Booster improvements made during the 2004 shutdown, Booster performance in 2005 should be even better. In addition, the data analysis has made significant progress, and, assuming that a sufficient number of protons have been delivered, first oscillation results should be ready by the end of 2005.

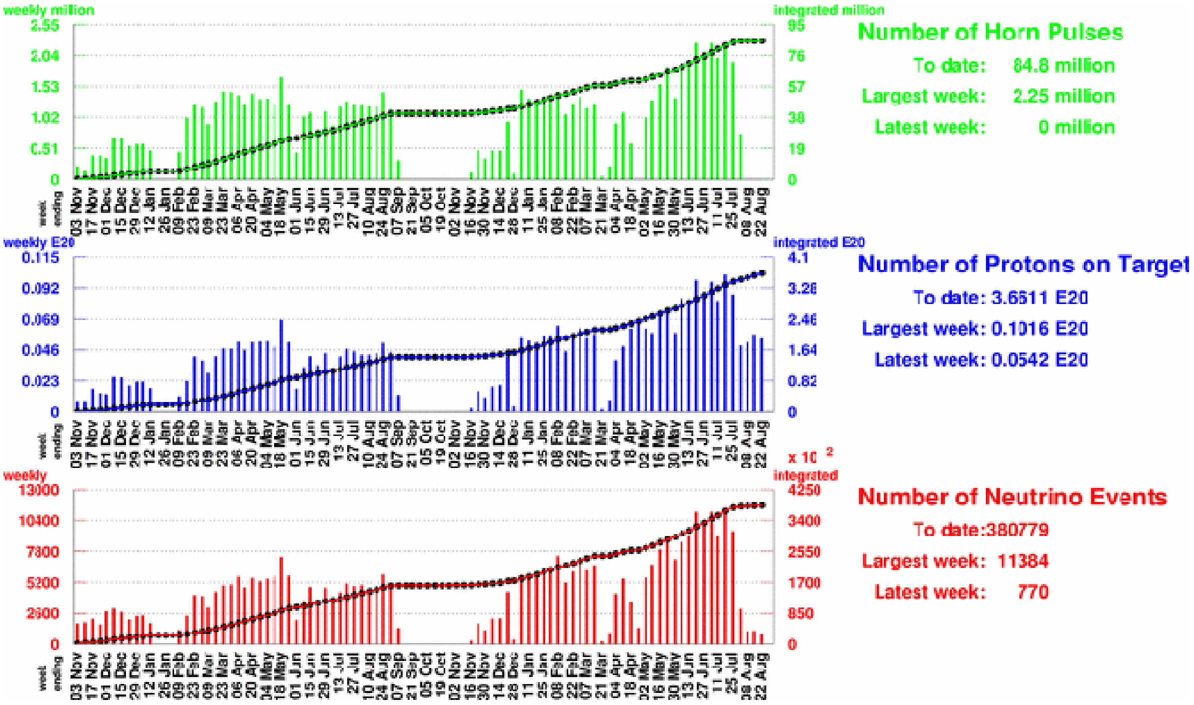


Figure 9. The progress in delivering beam to MiniBooNE during the first two years of operation.

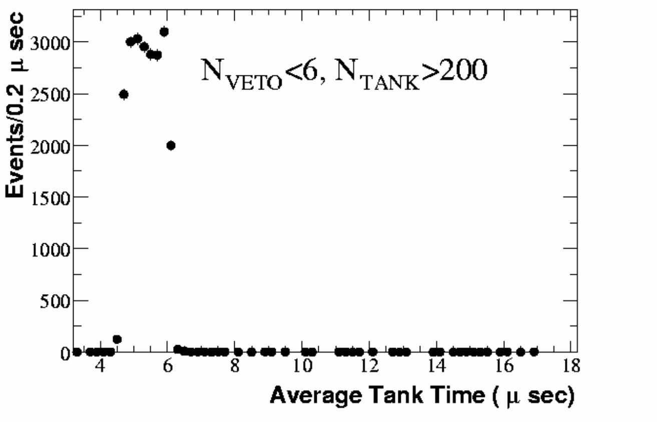


Figure 10. The time distribution of events (in a 19 micro-second time interval around the Booster beam spill) that satisfy the criteria of more than 200 tank phototube hits and less than six veto phototube hits.

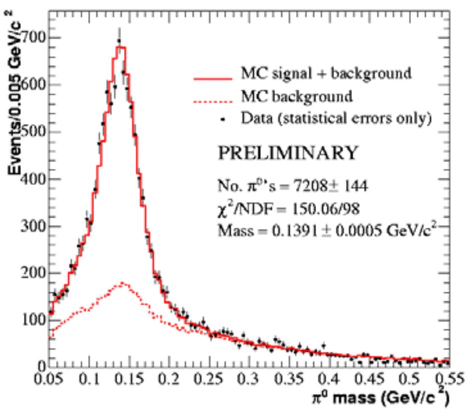


Figure 11. The π^0 mass distribution for two Cerenkov ring events with more than 40 MeV in each ring.

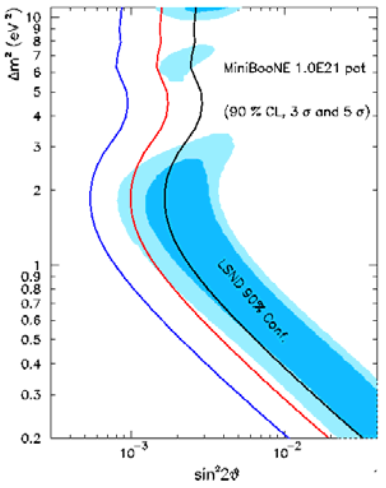


Figure 12. The updated MiniBooNE oscillation sensitivity for a total of 1×10^{21} protons on target.

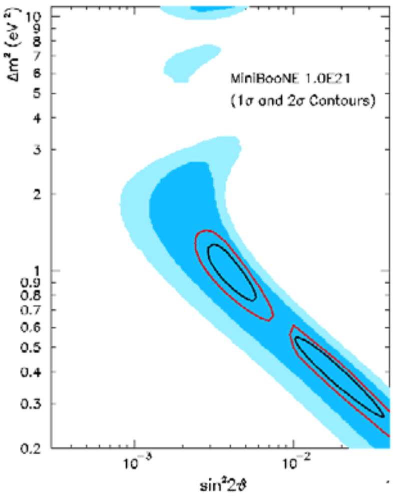


Figure 13. This figure shows how well the oscillation parameters can be measured at two different points in the Δm^2-$\sin^2(2\theta)$ parameter space.

Fixed-Target Switchyard 120 GeV (SY120) (C. Moore)

Beam was successfully extracted from the Main Injector and sent to the Switchyard Dump on February 3, 2004. Resonant extraction from the Main Injector was established in a brief test several years earlier. However, since that time, the extraction Lambertsons for the NuMI project were installed. Some tuning was required to adjust for the changed configuration. Beam to MTest was established on February 19, 2004 and beam to MCenter was established on February 28, 2004.

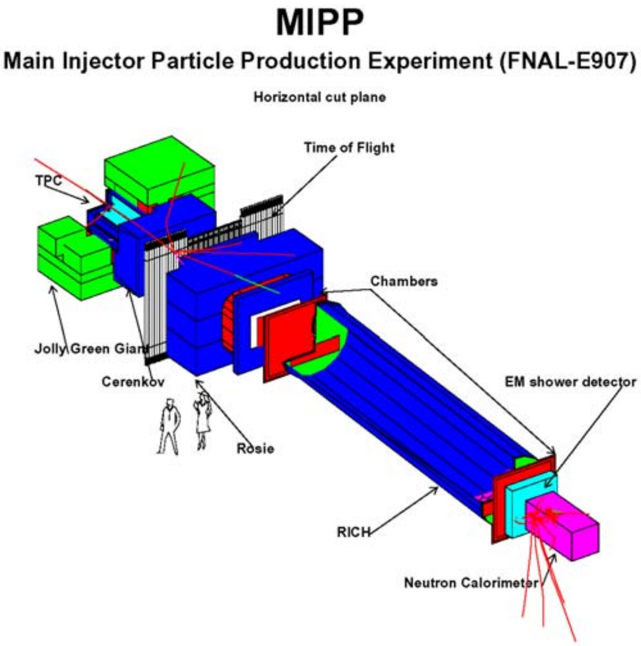
A short run for the first user of the new MTest beamline, T-926 (Radio Ice Cerenkov Experiment test), utilized (fast) single-turn extraction. All other running used (slow) resonant extraction. An example of the running for the fixed-target areas from May 1, 2004 to August 23, 2004 is given in the following table:

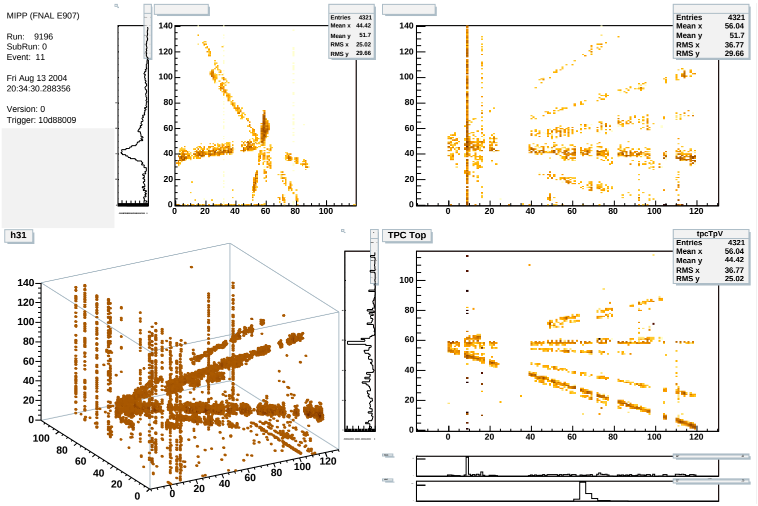
	Meson-Center	Meson-Test
Total fixed-target pulses	246649	149116
Total no beam pulses	106858	78432
Total pulses with beam	139603	70684
Total beam sum	1.24×10^{16}	1.22×10^{15}
Average beam per pulse	8.91×10^{10}	1.73×10^{10}

E-907/MIPP – Main Injector Particle Production (R. Raja)

The MIPP experiment (Fermilab E-907) is designed to measure particle production using Main Injector secondary beams ($\pi^{\pm}$, $K^{\pm}$, $p^{\pm}$ with beam momenta ranging from 5GeV/c to 90 GeV/c) over a variety of targets ranging from hydrogen to beryllium, carbon and heavy nuclei. The centerpiece of the experiment is a time projection chamber capable of detecting particles over nearly 4π acceptance. Using a combination of dE/dx, time of flight, Cerenkov and RICH detectors, MIPP will identify the charged particles in the final state. With this data, MIPP hopes to restart the study of non-perturbative QCD interactions with unprecedented accuracy as well as to measure cross sections in nuclei for the purpose of proton radiography and nuclear physics. A critical measurement MIPP will make is of particle production from the NuMI target, which will be beneficial to all neutrino experiments using the NuMI beam.

MIPP had its commissioning run in 2004, both for the secondary beamline as well as for the experimental apparatus. Slow extraction was established from the Main Injector, and the commissioning of the secondary beamline went smoothly. Beam quality has improved significantly as a function of time due to better tunes being made available. The detector commissioning went smoothly until March 14, 2004, when there was a fire in the phototube array of the RICH detector due to an electrical short in one of the phototube bases. MIPP spent a significant amount of time and resources recovering from this incident and redesigning the RICH box and safety systems to prevent recurrence of such an event. Towards the end of the run, all major components of the detector were functional, including the TPC and the RICH. MIPP plans to acquire its physics data during the period following the current shutdown.





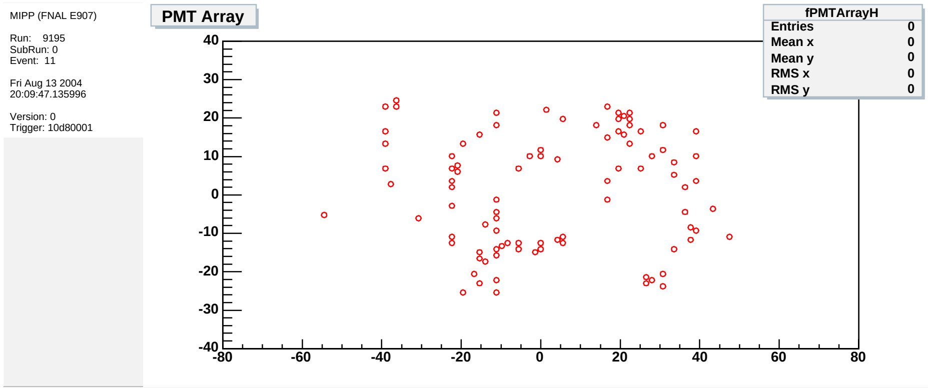
MIPP (FNAL E907)

Run: 9196
SubRun: 0
Event: 11

Fri Aug 13 2004
20:34:30.288356

Version: 0
Trigger: 10d88009

Figure 15. An event in the Time Projection Chamber.



MIPP (FNAL E907)

Run: 9195
SubRun: 0
Event: 11

Fri Aug 13 2004
20:09:47.135996

Version: 0
Trigger: 10d80001

Figure 16. An event with multiple rings in the refurbished RICH.

Meson Test Beam Facility (E. Ramberg)

FY 2004 saw the beginning of operations of the newly commissioned Meson Test Beam Facility (MTBF), located in the Meson Detector Building at the end of the MTest beamline. The beamline had been used with extracted 800 GeV Tevatron beam as late as 1999, after which the cryogenic-magnet beamline was decommissioned. It was replaced by a normal-magnet beamline that delivers 120 GeV beam to the Meson Area from the Main Injector. The 120 GeV proton beam impinges on a 4" diameter by 18" long cylinder of aluminum, and the MTest beamline can then deliver to the MTBF either the uninteracted 120 GeV protons, or a momentum-selected secondary beam below 66 GeV.

The SY120 line was commissioned late in calendar year 2003 after several difficulties with the resonant extraction tune were solved. The first test beam user was experiment T-926, or the Radio Ice Cerenkov Experiment. The requirements for this user were to have as high a number of protons per RF bunch as possible, so the normal slow-spill extraction was replaced by a single-turn extraction from the Main Injector. The experimenters ran for a total of about eight days (during two separate runs) and completed their test. The remainder of the test beam users have required a slow spill for detector tests and a standard flattop of 0.6 seconds was established. Besides T-926, there have been nine other test beam experiments approved by the Directorate. The descriptions of the experiments can be found at the MTBF web site:

http://www-ppd.fnal.gov/MTBF-w

During calendar year 2004 the operation of the test beam facility was regularized, with one primary group responsible each week for requests for beam and accesses. Most groups have requested 120 GeV beam, while one group (BTeV EMCAL) requested lower momentum beam and attempted to isolate the electron and muon components of that beam.

Currently the test beam can deliver up to approximately 0.10 MHz of 120 GeV protons during a spill, with the limit determined by losses in the Tevatron tunnel. Lower momentum tunes have lower rates, with the rate of 16 GeV beam approximately 2 KHz. The Cerenkov counters in the beamline have been used to trigger on a muon component of the beam, but so far we have not verified the presence of secondary electrons.