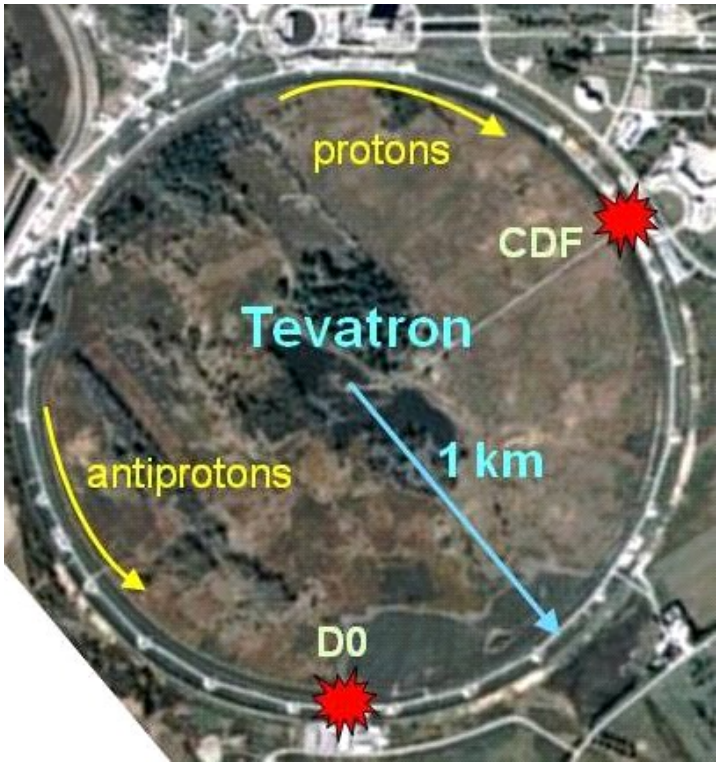
Overview of Tevatron Accelerator Studies

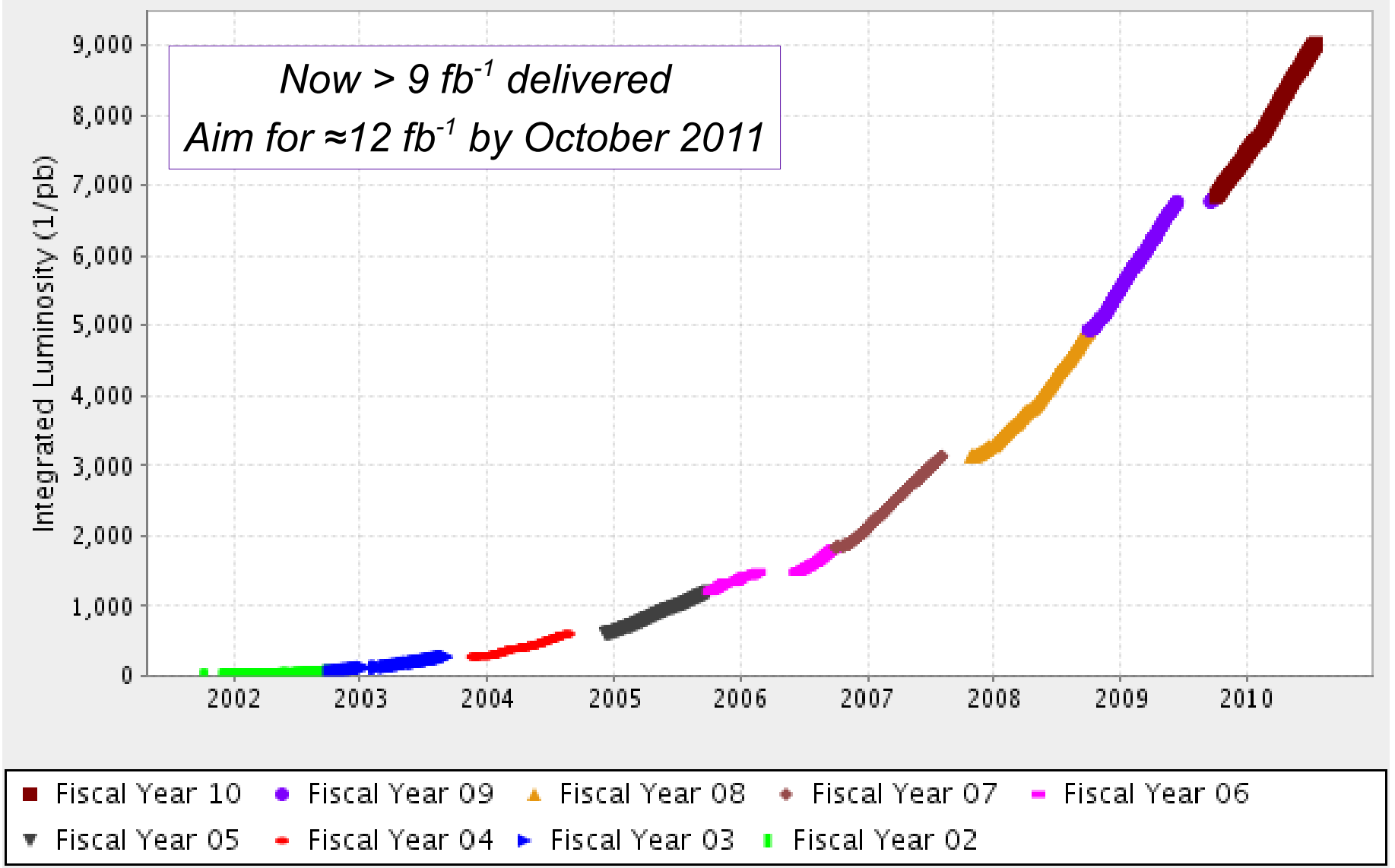


Ron Moore

Fermilab – AD / Tevatron Dept. Head

Tevatron's Day Job = Deliver Luminosity

Run 2 Integrated Luminosity



What else can be done?

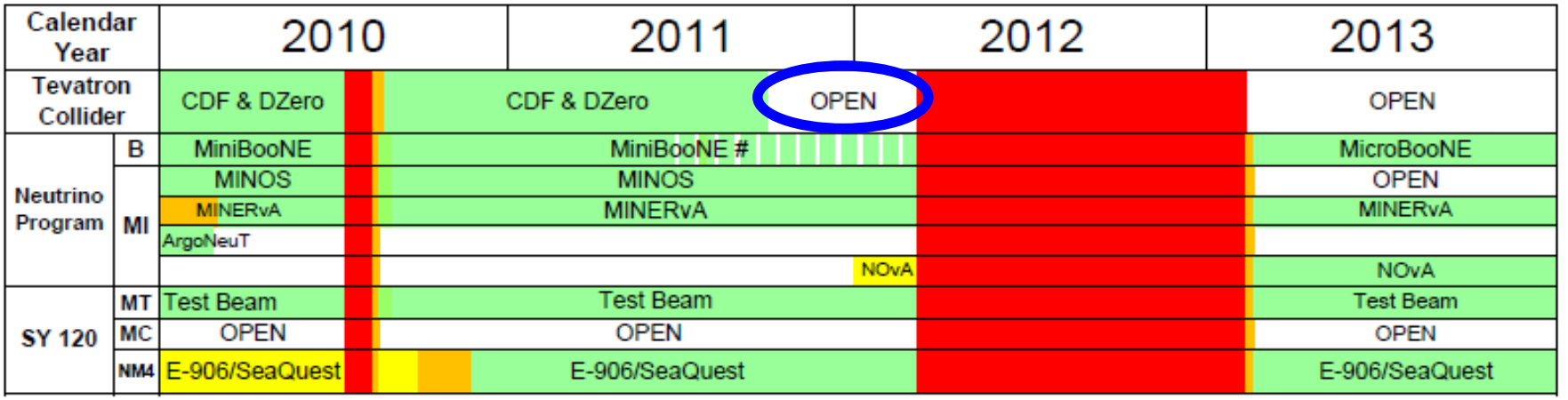
- Tevatron does some moonlighting for T-980 crystal collimator studies
  - Some beam-beam compensation with electron lenses, too

- Tevatron Accelerator Studies Workshop held here 13-14 January 2010
  - Organizers: R. Moore, T. Markiewicz, W. Fischer, F. Schmidt
  - ~35 people attended - good mix from FNAL, BNL, CERN, LARP
  - Agenda with presentation slides are available here

- Enthusiastic presentations and discussions
  - Got initial sense of scale: interest, duration of such a program
  - Somewhat of “chicken and egg” issue
  - More planning and proposals once program approved and scheduled

Draft 2010-13 Fermilab Accelerator Experiments' Run Schedule

Typically Revised Annually - This Version from June, 2010



This draft schedule is meant to show the general outline of the Fermilab accelerator experiments schedule, including unscheduled periods.

Major components of the schedule include shutdowns:

In Calendar 2010, a 4 week shutdown for maintenance scheduled to begin July 19.

In Calendar 2011, no shutdown for maintenance is shown.

A 2012-3 11-month shutdown is shown to upgrade the proton source and change the NuMI beam to the Medium Energy (ME) config.

Duration of the MiniBooNE run will depend on preparations for MicroBooNE.

RUN/DATA

STARTUP/COMMISSIONING

INSTALLATION

M&D (SHUTDOWN)

15-Jun-10

- Tevatron Collider Run 2 scheduled to continue through Sept 2011
- Few months “available” for dedicated running before 2012 shutdown

- Impact of FY11 budget shortfall or Run 2 extension?

Program Guidelines

- Use Tevatron essentially “as-is” for collider operation
  - No major changes
  - Adding devices in warm straights possible, but difficult due to time constraints
  - But, it doesn't hurt to ask!
- Consider studies during collider operation, a dedicated run, or both
  - End of HEP store studies like T-980 crystal collimation and beam-beam compensation with electron lenses
  - Proton-only or pbar-only studies between HEP stores
  - Desire to have pbars available for dedicated run (collisions and pbar-only)
- Exploit existing Tevatron instrumentation
  - Need support from CDF & D0 for luminosity measurements

Hot Topics

- More details to be provided by other speakers
  - Frank Schmidt & Roderik Bruce for CERN
  - Wolfram Fischer for BNL
  - Nikolai Mokhov for T-980 (crystal collimation)

- Crystal collimation
  - Strong support from CERN
  - N. Mokhov outlined plan for continued T-980 studies during Run 2
  - Also expressed desire for collider and proton-only stores in dedicated run
  - D. Carrigan discussed negative-particle channeling with antiprotons

- Hollow e-beam collimation
  - Strong support from CERN
  - G. Stancari described ongoing work, plans
    - Simulation and test bench for generating hollow electron beam
    - Replace gaussian e-gun in TEL-2 with hollow beam gun (summer shutdown)
  - Request end-of-store studies throughout Run 2, dedicated run also useful

Hot Topics 2

- Beam-beam compensation
  - Interest from both CERN and BNL
- Electron lenses (head-on compensation)
  - A. Valishev described ongoing program at Tevatron (gaussian e-beam)
    - Have used both proton-only and colliding beam stores effectively
  - C. Montag outlined BNL's desires – overlap with Tevatron plans
    - Christoph has visited FNAL to participate in studies
- Wire-based BBC (long-range interactions)
  - Of interest for LHC, not RHIC
  - 1 wire unit will become available from RHIC, but likely difficult for Tevatron

Other Study Topics

- ½ integer working point *(A. Valishev)*
- AC dipole measurements *(M. Bai)*
- Generation of Flat Bunches *(C. Bhat)*
- Electron Cloud *(X. Zhang)*
- Tevatron as 120/150 GeV Stretcher Ring *(M. Syphers)*
- Space-Charge Compensation with Electron Column *(G. Stancari)*

- Luminosity leveling *(dynamic β* squeeze, bunch length control via RF voltage)*

- Exotica *(not necessarily in short study period)*
  - Plasma wakefield acceleration with hadron drivers *(W. Lu)*
    - Demonstrate self-modulation through a plasma?
  - Optical stochastic cooling

“Leftover” Run 2 Study Topics

- Smorgasbord of leftover Run 2 topics + others *(V. Shiltsev)*
  - Beam-beam effects
    - Lifetime vs tunes (for benchmarking simulations)
    - Lifetime vs helix size (separation)
    - Test effect of phase advance between IPs, phase averaging (σ_s/β^*)
    - Look for coherent beam-beam modes by exciting single bunch, observe others
  - Instabilities
    - Try to run at zero chromaticity; need stronger dampers
    - What is origin of longitudinal instabilities?
  - Instrumentation
    - Understand turn-by-turn OTR profile differences
    - Try to observe optical/infrared diffractive radiation for beam imaging
    - Design, install, test electron beam profile scanner
  - Other
    - Measure beam lifetime contributions: IBS, vacuum, noise (for simulations)
    - Apertures (transverse, momentum) at high energy (for future ideas)

Summary

- Strong interest in experimental accelerator program using the Tevatron
  - During ongoing Run 2 and a dedicated program
  - CERN+LARP, BNL, FNAL all interested
  - Inter-laboratory cooperation is a strong motivation
- Plenty of ideas discussed at Tevatron Accelerator Studies Workshop
- Crystal collimation and beam-beam compensation studies already in progress, expected to continue for rest of Run 2
- Several weeks – 2 months seems to be right scale for dedicated run
  - Certainly not just 1 week, not 1 year
  - Like a gas fills its container, confident all provided study time would be used
  - Need continued pbar production, luminosity measurements for duration

Tevatron Overview

- Injection energy = 150 GeV, Top energy = 980 GeV
- 1 km radius, 21.1 μs revolution time
- RF = 53.1 MHz, 8 Cu cavities, 1113 buckets around the ring
- Collider = 36 × 36 proton × antiproton bunches in single pipe
  - 3 trains of 12 bunches each, 396 ns (7 bucket) bunch separation
  - 2 collision points with 28 cm β* (CDF & D0 detectors)
- Typical collider bunch intensities for good running
  - Protons: 310 ×109 injected, 280 ×109 start of HEP
  - Pbars: 90 ×109 injected, 83 ×109 start of HEP
- Quench recovery ≈ 3 hours

Devices and Instrumentation

- Flying wires
- Sync-light monitor
- BPMs, BLMs (both can do turn-by-turn)
- AC Dipole
- 21 MHz and 1.7 GHz Schottky systems
- Ionization Profile Monitor
- Intensity pickups (DCCT, Resistive Wall Monitor)
- SBD (Sampled Bunch Display) for intensity, bunch lengths
- FBI (Fast Bunch Integrator) for intensities
- Tune and chromaticity trackers
- Couple of stripline pickups (used for dampers, noise sources)

CERN Support (letter from Steve Myers)

We are strongly interested in, or would like to propose, the following experiments and tests with Tevatron beam:

- Tests of hollow e-beam scraping of proton beams for improved LHC collimation.
- Tests of crystal-based halo cleaning for improved LHC collimation.
- Tests of cryogenic beam loss monitors for improvements of present LHC IR's and future IR upgrades.
- Tests of luminosity leveling with dynamic beta squeeze or dynamic crossing angle variation for future LHC performance upgrades.
- Measurements of equilibrium proton beam distribution for improved benchmarking of diffusion and halo models.
- Measurements of transverse resistive impedance from collimators for improved benchmarking of impedance models.
- Measurements of intra-beam scattering (IBS) with various intensities for improved benchmarking of IBS theory and models.
- Measurements of beam-beam resonances using an AC dipole.
- Measurements of beam-beam effects with various harmonic transverse perturbations for improved benchmarking of emittance growth models.
- Measurements of beam-beam effects for different schemes of transverse bunch splitting.
- Collisions with large Piwinski angle, and possibly with longitudinally flat bunches.
- Study of noise effects in collision, in view of future LHC crab cavities.

Proposals for additional experiments and measurements will likely originate from LHC beam experience in 2010. We estimate that the above-mentioned studies require about 25 shifts of 8 hours, which should be distributed over a period of 6-8 weeks.