December Study Period

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Luminosity

$$L = \frac{3\gamma f_o}{\beta^*} B N_{\bar{p}} \frac{N_p}{\varepsilon_p} \frac{F\left(\beta^*, \theta_{x,y}, \sigma^L_{p,\bar{p}}, \varepsilon_{p,\bar{p}}\right)}{\left(1 + \varepsilon_{\bar{p}} / \varepsilon_p\right)}$$

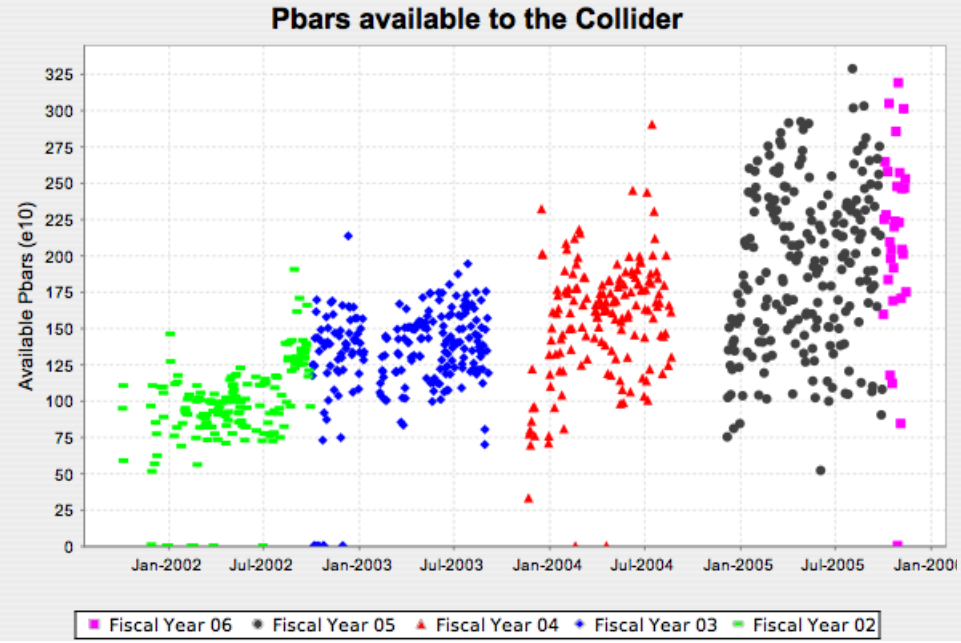
- The major luminosity limitations are
  - The number of antiprotons (BN_{pbar})
  - The proton beam brightness (N_p/ε_p)
    - Beam-Beam effects
  - Antiproton emittance
  - F<1

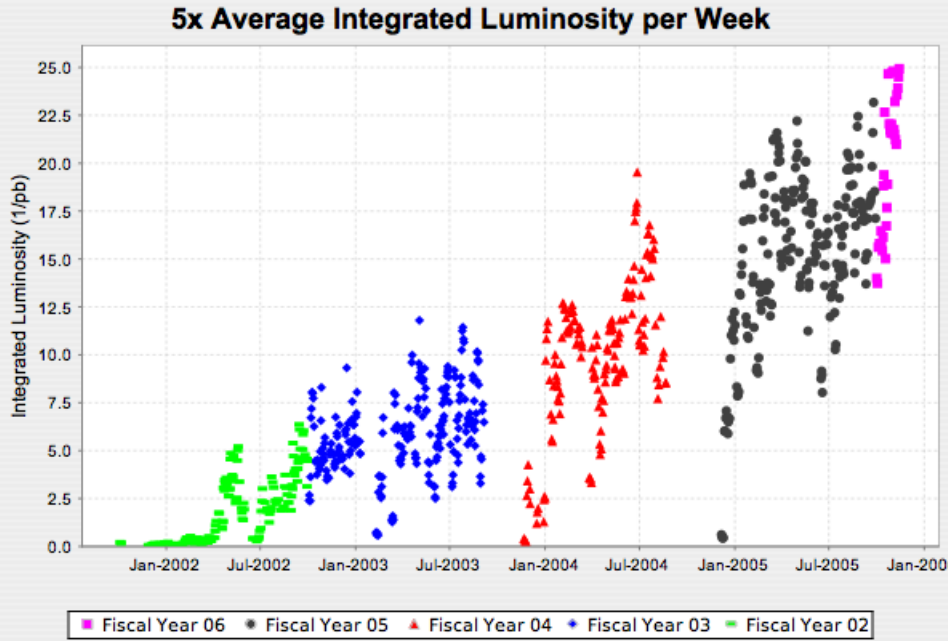
Antiproton Economics

$$\Phi_{\bar{p}}^{(\min)} = n_c \sigma_a L$$

- $n_c = 2$
- $\sigma_a = 70$ mb
- $L = 3.0 \times 10^{32}$ cm^{-2}-sec^{-1}
- $\Phi = 15 \times 10^{10}$ hr^{-1}

Antiprotons and Luminosity





- The strategy for increasing luminosity in the Tevatron is to increase the number of antiprotons
  - Increase the antiproton production rate (Run 2 Upgrades)
  - Provide a third stage of antiproton cooling with the Recycler
  - Increase the transfer efficiency of antiprotons to low beta in the Tevatron

Stacking Rate

$$\Phi = \frac{N_p P}{T_{rep}}$$

- N_p is the number of protons on target
- P is the production ratio of the number of antiprotons produced to N_p
  - Typically about 15-20x10^{-6}
  - Mostly a function of the collection aperture
- T_{rep} is the cycle time
  - Mostly a function of the cooling rate

Run II Upgrades

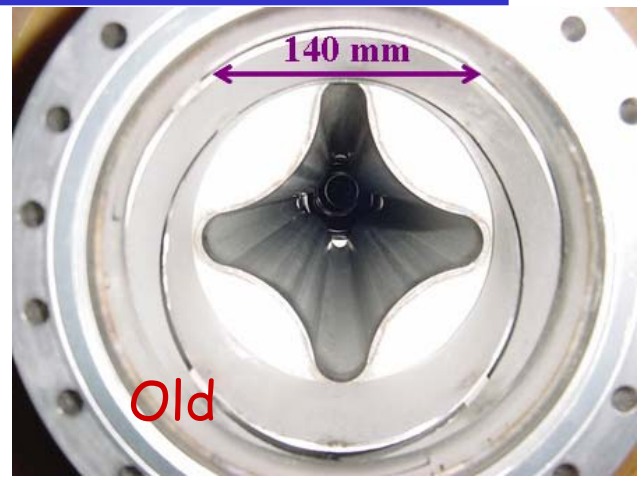
- More protons on the antiproton target
  - Slip stacking
    - MI Beam loading compensation
    - Booster Cogging
  - Intensity Goals:
    - Base: 6.5×10^{12}
    - Design: 8.0×10^{12}
- Better antiproton collection efficiency
  - Lithium lens gradient upgrade
  - AP2-Debuncher aperture increases
    - Physical aperture increases
    - Beam based alignment
  - Production Goals at a 2 second cycle time:
    - Base: 15×10^{-6}
    - Design: 21×10^{-6}
- Better cooling
  - Accumulator Stacktail
  - Electron cooling in the Recycler
  - Average Stacking Rate Goals:
    - Base: 9.7×10^{10}/hour
    - Design: 21.7×10^{10}/hour
- Rapid Antiproton Transfers
  - Transfer Time Goals
    - Base: 45 minutes
    - Design: 15 minutes

Antiproton Source November-December 2005 Focus

- Aperture increase of AP2 line and the Debuncher is the key component of the Run 2 Upgrades
- The beam based alignment of the AP2 and the Debuncher is not converging (rapidly)
  - Most of the work has to be done with reverse protons
  - Partial alignment is not compatible with operations
- Proposal – Set aside a period of 2 weeks in December 2005 to completely focus on the beam based alignment studies in AP2 and the Debuncher
  - Start Date: Monday, December 5, 2005
  - End Date: Monday, December 19, 2005

Antiproton Aperture - Pbar Production

- The measured aperture of the initial stages of the antiproton production chain is about 65% of the available physical aperture.
- An aggressive beam-based alignment program is under development to bring the measured aperture to the physical aperture.
  - Would increase the stacking rate by over a factor of 2
  - The final design goal is to achieve 77% of the physical aperture which will increase in stacking rate by 40%
- The beam based alignment scheme consists of 5 major components
  - Independent control of the quad gradients (done)
  - Beam position measurement system to measure orbit distortion due to varying quad gradients (in- progress)
  - Orbit control devices to center the beam through the quads (done)
  - Moveable control of tight apertures (stochastic cooling arrays) (in progress)
  - Loss monitor system to measure losses at tight apertures (done)
- Most of the recent focus has been to complete the instrumentation upgrade
  - Extremely small beam currents ~10μAmps
- The goal for this year is to increase the aperture for each plane from 65% to 72% of the available physical aperture which would result in a 20% increase in antiproton production rate

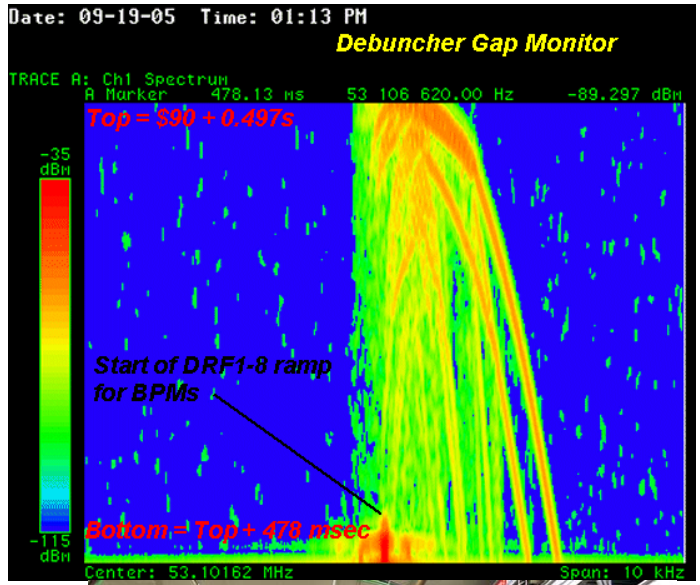


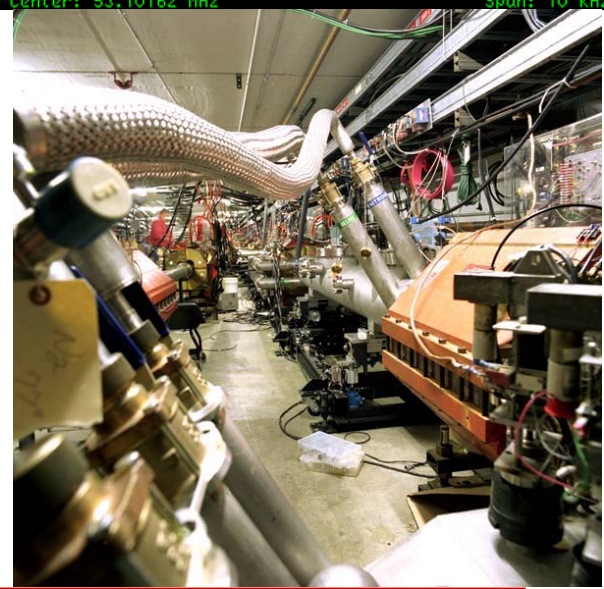
Beam Based Alignment

- For maximum aperture, we would like the beam to go through the center of the quadrupoles
- You cannot trust the absolute position of beam position monitors.
- If the beam goes off center through a quadrupole, it gets a kick. The kick is proportional to
  - strength of the quad
  - the offset of the transverse beam position with respect to the center of the quad.
- To measure how far off center the beam is in the quad
  - Measure the beam trajectory downstream of the quad with BPMs
  - Change the Quad current (strength)
  - Measure the difference in beam position
    - If the beam goes though the center of the quad, the trajectories will be the same
  - Change the position of the beam through the quad with an upstream trim magnet until the quad does not steer the beam.

Beam Based Alignment

- Necessary components
  - Beam position system
  - Individual control of quad strength
  - Trim magnets to control the orbit
- Problems in the Debuncher
  - Beam position system
    - Pbar current extremely low
    - Secondary spray
    - Reverse proton beam loading
  - Quad strength
    - Quads are on busses – had to add lots of shunts
  - Trim magnets
    - There is no space in the Debuncher to add trim magnets
    - Orbit correction is done by placing quads on remote control stands
  - Overall
    - Align with reverse protons
      - Large setup overhead
    - Stack with forward pars
    - Just isn't the same!





December Study Period

- The purpose of the study period is to beam-base align the AP2 line and the Debuncher.
  - Starting at 08:00:00 on December 5
  - Ending 0:00:00 on December 19.
- Pbar studies 2 shifts a day from 08:00:00 – 23:59:00
  - The first week will focus on alignment of the Debuncher
    - Requires one 5 sec. event every 60 seconds
  - The second week will focus on the AP2 line
    - Requires one 5 sec. event every 10 seconds
    - Will reduce NUMI neutrino flux by 50%
- Stack during the owl shift (00:01:00 – 08:00:00).
  - Do not have enough manpower to staff pbar study shifts around the clock
  - First week: Provide pbars for special luminosity runs for the experiments
  - Second week: Provide pbars for Recycler and Main Injector coalescing studies

December Study Period

- The Booster and Main Injector will provide beam to support pbar studies, pbar stacking, neutrino production and SY120.
  - Will attempt slip stacking of NUMI batches (Proton Plan study)
  - The flux to the neutrino experiments and SY120 may be somewhat reduced depending on the Pbar studies.
    - First week will have little impact on NUMI nuetrino flux.
    - Second week will impact NUMI neutrino flux by 50% during Pbar studies
  - Will do 2.5 MHz coalescing studies during the second week
- Recycler
  - First week: stashing pbars in support of collider operations.
  - Second week: stashing pbars in support of 2.5 MHz coalescing studies.
  - Interspersed electron cooling studies

December Study Period

- Tevatron will be providing a couple of special low luminosity runs for the experiments during the first week.
  - CDF requests a 2 shift access on December 5.
  - Dzero requests two stores with 1 proton bunch x 4 antiproton bunch at nominal bunch intensities
    - No low beta squeeze
    - No separated orbits (separators off)
      - Parasitic collisions an issue for the experiment?
      - Might have to try a couple of times because of beam-beam effects
        - » Low number of pbars permits quick turnaround
    - Stores separated by a period of time.
  - Both experiments request a 1-3x10^{30}cm^{-2}sec^{-1} store
    - Small emittances
    - Low bunch intensities
      - Proton intensity looks straight forward
      - Questions on performance of feedback loops in the Main injector for pbar acceleration

December Study Period

- Tevatron will do proton only studies during the second week.
- The low luminosity stores are higher priority than Tevatron studies
- Tevatron Studies
  - Move proton tunes above the 7/12 everywhere
    - 2 shifts
    - followed by a normal store as a reality check
  - Move IP longitudinal in CDF
    - Requires swapping trims
    - redo ramps
    - followed by a normal store as a reality check
  - Looking at new working point - Measuring nonlinear content of Tevatron ~1-2 shifts
  - Electron cloud study
  - TEL BPM calibration

December Study Period Organization

- Keith Gollwitzer is in charge of planning the Pbar Studies
- Val Lebedev and Ron Moore will define and coordinate the Tevatron Studies.
- Jim Morgan is in charge of overall machine operation and scheduling.
- We need a lot of input from the collider experiments. The usual collider coordinators will be our main points of contacts.
  - Bill Lee and Taka Yasuda from DZero
  - Patrick Lukens and Willis Sakumoto from CDF
- We are having 3 planning meetings for the December Studies period.
  - The meetings take place at 10am in the Penthouse (Booster West Towers) on Wednesdays
  - November 16, 23, 30
    - The goal for the first meeting is for everybody to voice requests.
    - The goal for the second meeting is to have a draft schedule.
    - The goal for the third meeting is to agree on a final schedule.
  - Present the final schedule at the December 2 Run 2 PMG

Spring 2006 Shutdown Planning

- The shutdown is 14 weeks in length followed by two weeks of startup
- All machines will be down for the entire 14 weeks
- Shutdown jobs are limited by available manpower
  - Accelerator Division has only 33 mechanical techs available
  - Requesting ~30 more mechanical technicians from other divisions
- Current job list under negotiation
  - Freeze date: December 15, 2005
  - Jobs can be viewed at: www-bd.fnal.gov/worklist/
    - http://www-bd.fnal.gov/worklist/

Spring 2006 Shutdown Planning

- The focus of the shutdown will be for the neutrino program
  - Booster Injection girder
  - Booster 8 GeV dump relocation
  - Main Injector Collimator
  - Main Injector Kicker
  - Main Injector Large Aperture quadrupoles
- The other focus is routine maintenance
  - Tevatron cryo work
  - Electrical power supply and feeder maintenance
- Major Collider Jobs
  - Tevatron cold lifts
  - Tev magnet rolls and alignment
  - Pbar Aperture increases
  - Misc. Recycler alignment
  - Most of the components of the Run 2 upgrades have been installed.