Accelerator Studies at the Tevatron

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Tevatron's Day Job = Deliver Luminosity
Moonlighting with Accelerator Studies

T980 – Crystal Collimation

Hollow electron beam collimation

Beam-beam compensation with Gaussian electron lens

Tune Shift and Spread by Gaussian TEL-2 (antiproton-only study)
What else can be done?

- Strong interest from FNAL, CERN/LHC/LARP, BNL to participate in accelerator studies at Tevatron before it is switched off forever

- Both during collider run and a dedicated program after Run 2

- Tevatron Accelerator Studies Workshop (Jan 2010)
  - http://indico.fnal.gov/conferenceOtherViews.py?view=standard&confId=2921
  - Generated long list of studies to be considered, rough plans

- Fermilab AAC meeting (July 2010)
  - http://indico.fnal.gov/conferenceDisplay.py?confId=3475
  - Strong support for an accelerator studies program

- Since Run 2 extension denied, need to move quickly on studies planning
Guidelines for Tevatron Accelerator Studies Program

- 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
  - During/End of HEP store like T-980 crystal collimation and hollow e-beam
  - Proton-only or pbar-only studies between HEP stores
  - Desire for pbars during dedicated run (collisions and possibly pbar-only)

- Exploit existing Tevatron instrumentation
  - Need support from CDF & D0 for halo counters, luminosity measurements

- Proponents to supply written note and presentation after study
# CERN studies

<table>
<thead>
<tr>
<th>Topic</th>
<th>motivation</th>
<th>comments</th>
<th>time estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hollow e-beam</td>
<td>LHC collimator upgrades</td>
<td>in progress – mostly parasitic during HEP stores</td>
<td>as requested</td>
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<tr>
<td>Crystal Collimator</td>
<td>LHC collimator upgrades</td>
<td>T-980: in progress – end of HEP stores, some proton-only; plan for dedicated run</td>
<td>&gt;2 shifts EOS, 4 shifts dedicated colliding beams</td>
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<tr>
<td>Luminosity Leveling</td>
<td>upgrades; proof of principle</td>
<td>bunch length changes – relatively easy; dynamic beta* hard here, easier @ LHC?</td>
<td>bunch length – proton-only, end of store, then few stores?</td>
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<tr>
<td>Diffusion &amp; Halo with Beam-Beam</td>
<td>model benchmarking</td>
<td>dedicated proton-only</td>
<td>1 shift</td>
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<tr>
<td>Collimator Impedance</td>
<td>model benchmarking</td>
<td>dedicated proton-only; difficult comparison to LHC?</td>
<td>1 shift</td>
</tr>
<tr>
<td>IBS measurements</td>
<td>model benchmarking</td>
<td>dedicated proton-only; overlap with FNAL request</td>
<td>1-2 shifts</td>
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<tr>
<td>Beam-Beam &amp; AC Dipole</td>
<td>measure resonances; proof of principle</td>
<td>dedicated collisions; Ryoichi make visit?</td>
<td>&gt;1 store?</td>
</tr>
<tr>
<td>Beam-Beam Emittance Growth</td>
<td>model benchmarking</td>
<td>dedicated collisions; tickle beam(s)</td>
<td>few stores?</td>
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listed in order of CERN's priority
<table>
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<th>Topic</th>
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<th>comments</th>
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<tbody>
<tr>
<td>Lifetime Measurements (IBS, vacuum, RF noise)</td>
<td>model benchmarking</td>
<td>dedicated proton-only; overlap with CERN request</td>
<td>2 shifts</td>
</tr>
<tr>
<td>Coherent Beam-Beam Effect</td>
<td>beam-beam</td>
<td>dedicated colliding beam stores</td>
<td>3-4 shifts</td>
</tr>
<tr>
<td>Instability Studies</td>
<td>general; benchmarking</td>
<td>dedicated proton-only and colliding beams</td>
<td>2 shifts</td>
</tr>
<tr>
<td>Head-On Beam-Beam Compensation with Electron Lens</td>
<td>beam-beam</td>
<td>colliding beam stores, not necessarily dedicated; some already done; conflict with hollow e-beam</td>
<td>3 shifts</td>
</tr>
<tr>
<td>Space Charge Compensation with Electron Column</td>
<td>intensity frontier</td>
<td>dedicated proton-only</td>
<td>4-6 shifts</td>
</tr>
<tr>
<td>Electron Cloud</td>
<td>intensity frontier</td>
<td>dedicated proton-only</td>
<td>2 shifts</td>
</tr>
<tr>
<td>Phase Averaging</td>
<td>general; beam-beam</td>
<td>dedicated 1x1 colliding beam stores</td>
<td>2 shifts; 2 stores</td>
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<tr>
<td>Lifetime vs Phase Advance btw IPs</td>
<td>general; beam-beam</td>
<td>dedicated (1x1?) colliding beam stores</td>
<td>1-2 shifts</td>
</tr>
<tr>
<td>Dynamic Aperture Measurement with AC Dipole</td>
<td>general; operations</td>
<td>dedicated proton-only, possibly between HEP stores</td>
<td>1 shift</td>
</tr>
<tr>
<td>Investigate OTR TBT Profile Differences</td>
<td>instrumentation</td>
<td>dedicated proton-only</td>
<td>½ shift</td>
</tr>
<tr>
<td>Wide Tune Scans during Collisions</td>
<td>general; beam-beam</td>
<td>2 colliding beam stores, prefer dedicated</td>
<td>2 shifts; 2 stores</td>
</tr>
<tr>
<td>Lifetime vs Helix Size</td>
<td>beam-beam</td>
<td>several colliding beam stores, not necessarily dedicated</td>
<td>~few quasi-parasitic stores or 1 dedicated store</td>
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some ordering by desire and ease of completion
Eliminated Studies

- Some studies already eliminated due to motivation, complexity/time, ease of completion, required work in tunnel...

<table>
<thead>
<tr>
<th>crab cavities</th>
<th>large Piwinski angle collisions</th>
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<tbody>
<tr>
<td>collisions with flat bunches</td>
<td>transverse bunch splitting by beam-beam resonances</td>
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<tr>
<td>(higher order RF cavities)</td>
<td></td>
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<tr>
<td>½ integer working point</td>
<td>120/150 GeV stretcher ring tests</td>
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<tr>
<td>crystal channeling with pbars</td>
<td>wire-based beam-beam compensation</td>
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<tr>
<td>cryogenic loss monitors</td>
<td>optical diffraction radiation (ODR) imaging</td>
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<tr>
<td>electron beam profile scanner</td>
<td>hadron-driven plasma wakefield tests</td>
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What's Next?

- Estimate 4 weeks for all studies in tables on pages 6-7
  - Padded initial estimates by factor ~2 to allow for over-optimism and operational issues, e.g. no beam from injectors, quench recovery

- Requested proponents to refine plans with help from Tevatron experts
  - Specific beam configuration, needed instrumentation, better time estimate

- Consolidate, shuffle priority based on ease to prepare & complete studies
  - Reasonable to reduce scope by eliminating low priority studies

- Studies consistent with normal collider operation can proceed now
  - End-of-store, parasitic during HEP, proton-only between stores
  - T-980, hollow e-beam, lumi leveling via bunch length, some proton-only
What's Next?

- Allowing 1 shift of studies / week or every 2 weeks would be very helpful
  - Only 33 weeks until end FY11 – the hard stop
  - Reduce duration of possible dedicated period

- Scheduling dedicated block of studies (several days?) for
  - doing studies with special configurations, e.g. 1x1 collisions
  - allowing visitors to come and participate in some studies

- 2-4 of weeks of studies until Tevatron termination would be valuable to the accelerator physics community to exploit unique opportunity
  - strong support from other labs and the AAC
  - compare to benefit of 1-2% incremental delivered luminosity over that time

- Need commitment from FNAL management to allocate time
Tevatron Collider Run 2 still scheduled to continue through Sept 2011
Few months “available” for dedicated running before 2012 shutdown
Impacts of FY11/12 budget shortfall or Run 2 extension?
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.