Tevatron End of Run Studies


September 19 2011
Fermilab All Experimenters Meeting
Motivation and Plan

• Tevatron Accelerator Studies Workshop (*January 13-14, 2010*)
  • [https://indico.fnal.gov/conferenceOtherViews.py?view=standard&conflId=2921](https://indico.fnal.gov/conferenceOtherViews.py?view=standard&conflId=2921)
  • Generated long list of studies to be considered, rough plans

• Fermilab AAC meeting (*July 28-30, 2010*)
  • [https://indico.fnal.gov/conferenceDisplay.py?confId=3475](https://indico.fnal.gov/conferenceDisplay.py?confId=3475)
  • Strong support for an accelerator studies program

• DOE Institutional Review of Fermilab (*June 6-9, 2011*)
  • [https://indico.fnal.gov/conferenceDisplay.py?confId=4263](https://indico.fnal.gov/conferenceDisplay.py?confId=4263)
  • Support of the proposed accelerator studies

• All Experimenters’ Meeting (*August 15, 2011*)
  • [http://www.fnal.gov/directorate/program_planning/all_experimenters_meetings/special_reports/Valishev_EOR_Studies_08_15_11.pdf](http://www.fnal.gov/directorate/program_planning/all_experimenters_meetings/special_reports/Valishev_EOR_Studies_08_15_11.pdf)
List of Topics

1. AC Dipole with colliding beams
   - AC dipole is a device that adiabatically excites transverse oscillations of the beam. Turn-by-turn detection of oscillations at the excitation frequency allows to restore the beam optics.

2. Coherent Beam-Beam Modes
   - Colliding beams represent a system of coupled oscillators with their eigenfrequencies determined by beam and machine properties. Coherent instabilities may happen under certain conditions.

3. Beam-Beam Resonances vs Separation
   - Study the importance of transverse beam-beam misalignment.

4. Betatron Phase Averaging
   - Theory predicts that the magnitude of beam-beam effects is strongly affected by the ratio of transverse beta-function to the bunch length.

5. Diffusion Driven by Beam-Beam Resonances
   - Beam-beam effects interplay with other diffusion and noise sources.

9/19/2011
A.Valishev, All Experimenters Meeting
Organization and Scheduling

• We have requested 40 hours of beam time over the two week period
• RunCo team calculated that 43 hours were used
  • Actual time with beam ~35 hours
• First week was strongly affected by the ecool troubles
• Nevertheless, achieved some good results!
LHC Offset Beam-Beam Collision Studies (Ji Qiang)

- The offset collision is unavoidable due to the different bunch collision schemes at LHC
- Such offset collision might cause emittance growth that degrades luminosity lifetime and experimental conditions

Emittance Growth vs. Offset

- We have made a systematic scan of the separation in the possible range which is consistent with the simulations
- There is no emit growth which would be consistent with the worst case being at ~1.5 sigma
Separation Scan #1

- Normalized Emittance (mm mrad)
  - Time (hour)
  - Intensity Decay Rate (1/h)
  - Vertical Separation (σ)

- Graphs showing time vs. normalized emittance and intensity decay rate, with separate plots for different conditions (e.g., a, p, x, y).
Coherent Beam-Beam

- Due to lack of high intensity & low emittance for the Pbars till about this Wednesday 24th we couldn’t quite do that part (also the “driving force” Simon left on Sunday)
- However, “the other half”, i.e. the chromaticity threshold study in conjunction of BB was very conclusive:
  - Whenever BB is present any chromaticity value can be dialed in without causing an instability! Some minor Schottky activity for Q’ [0, ∼-1]
  - This remains true independent of the chosen working point.
  - In case BB is weak but the emittance is large there is also no effect.
  - For a nominal 3x0 the instability was very fast slightly above 0, causing a quench – sorry!
AC Dipole

- The goal was to excite the “weak” beam through the strong beam using the AC-dipole
- However, “without” excitation of the strong beam
- We need to record the turn-by-turn BPM data around the ring
- We had to reverse the weak-strong set-up since the BPM system operates in a turn-by-turn mode for protons only ➔ use lowest possible proton intensity against nominal low emittance pbars
- Changes to the linear lattice function due to BB can be derived from a reference measurement with protons only

- Successfully demonstrated the technique with colliding beams (3x3 bunches at LowBeta)! No instability or emittance growth after multiple excitations.
AC Dipole

Tune

y-fit [mm]

Q_{eH} Q_{PV} Q_{ac}

y amplitude [mm]

BPM

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Phase Averaging

- The goal was to collide bunches at different bunch length/beta* ratios
- This was achieved by cogging

- Produced excellent data, in qualitative agreement with expectations! Good for benchmarking future simulations.

proton (left) and pbar (right) lifetime vs beta*/sigma
Summary

• Despite numerous technical issues and machine failures, the studies were successful in many aspects:
  1. Proof-of-principle experiment with AC dipole acting on colliding bunches
  2. Demonstration of the Landau damping of coherent instability by beam-beam interaction
  3. Measurement of the “phase averaging effect” – lifetime vs. bunch length / beta*
  4. Measurement of the effect of transverse beam-beam separation on intensity and emittance
• Many thanks to the experiments for donating time
• We are indebted to the Run Coordinators and Operations personnel for making these studies happen
• A technical note summarizing the results will be published soon