Did you know?

- Lost the cursor?
  - Mouse sonar on Linux stations: *Ctrl-Alt*

Introduction to RHIC Operations

Part I: Overview

Objectives

- Following this presentation, operators should:
  - Be able to describe Operations' primary goal for collider operation, and relevant machine parameters to that goal.
  - Understand the differences involved in operating collider vs. accelerator programs.
  - Be familiar with the systems that coordinate a RHIC cycle, and possible interruptions to that cycle.
  - Be able to use various applications to review and compare historical data from previous ramps.

The goal: **Luminosity**

Why?

rate of interactions between two colliding beams $dN/dt = \mathcal{L} \cdot \sigma$

thus, experiments' data rate proportional to $\mathcal{L}$

Instantaneous luminosity ≡ $\mathcal{L}$

$$\mathcal{L} = 3 f_0 N_b N^2 \gamma / 2 \varepsilon \beta^*$$

f_0 ≡ revolution frequency

N_b ≡ number of bunches circulating

N ≡ particles per bunch (assumed equal Blue/Yellow)

γ ≡ relativistic factor

ε ≡ normalized transverse emittance (assumed equal x/y, Blue/Yellow)

β^* ≡ betatron function at collision point; related to transverse beam focus (assumed equal x/y, Blue/Yellow)

Machine Development concentrates on maximizing $\mathcal{L}$

Integrated luminosity = $\int \mathcal{L}\, dt$

Increasing integration period maximizes Luminosity

Operations' role involves minimizing periods without collisions

Luminosity limitations

- N - most important variable to maximize
  - Injector intensities (especially Au, p↑)
  - Beam-beam limit (resonances from tune spread)
    - ~3×10^9 for Au
    - Working point scanned for best lifetime
  - Transition instability (heavy ions)
  - Aperture losses, annihilation (small effect)
- N_b
  - Vacuum pressure rise (in combination with N)
  - Rise time of kicker (56/60, 110/120, etc.)
  - Bunch spacing, undesirable interactions at IPs
- β^*
  - Power supply limitations
  - Triplet aperture

Luminosity limitations (cont'd)

- ε
  - Injector emittances
    - At minimum, defined by space charge effects at Booster injection
    - Important to avoid blowing up emittance in injector chain
  - Intra-beam scattering (IBS)
    - 'cooling' combats emittance growth
- f_0
  - Limited by design (ring circumference)
- γ
  - Limited by design (magnet/power supply limitations)
    - Protons: increase available 100→250 GeV

Luminosity limitations (cont'd)

- $\int \mathcal{L}$
  - Luminosity lifetime τ
    - Beam-beam, IBS, etc. result in decreasing $\mathcal{L}$ over length of store
  - Fill time t_f
    - Not colliding, no luminosity
    - Run 4: 5 min/ramp = 24 hours extra store time (1%)
  - Maximum average luminosity, optimal store length t_c defined by τ, t_f
    - $x = t_c/\tau$; $a = t_f/\tau$
    - $x \approx \ln [1 + (2a)^{1/2} + a]$

Comparing injector, collider operations

- Injectors cycle ~ seconds, RHIC ~ 30 min.
  - Less reactive tuning, more planning
  - More instrumentation, logging
- Superconducting systems
  - Pre-emptive interlocks (BLMs, permit/quench links)
- Experiments in-line as opposed to end-of-the-line
  - Access, maintenance, etc. more problematic

Go: timing, sequencing

- Event link, beam sync
  - Differs from injector 'timelines'
- tape Sequencer
  - Coordinates systems in a complex series of events and delays based on state of machine

Stop: PASS, permit, quench

- PASS
  - Personnel protection only
  - Inputs to permit link, critical devices
- Permit link
  - Equipment protection
- Quench link
  - Superconducting system protection

Stop & go: analysis

- Event Link Display
- Permits
  - The fish
- Quench Event Diagnostics (QED)
- Post-mortem Viewer
- pscompare

Instrumentation: acquisition

- Beam Position Monitor (BPM)
- Beam Loss Monitor (BLM)
- Ionization Profile Monitor (IPM)
- DC Current Transformer (DCCT)
- Wall Current Monitor (WCM)
- Schottky spectrum analyzers
- Other instrumentation uses these devices for more sophisticated measurements (Artus Tune Meter, PLL/BBQ, etc.)

Instrumentation: analysis

- Individual applications
  - Artus, IPM, RhicLumi, LossMonitor, Orbit, PLL Tunemeter, WCM, etc.
- General Purpose Monitor
- LogView
- FDAView

Summary

- RHIC Operation is driven by the experiments' need for collision events. Maximizing instantaneous and integrated luminosity are the means to that end.
- Compared to the injectors, tuning the collider tends to involve a bit more historical data analysis and planning, utilizing a myriad of logged instrumentation systems.
- Coordination of various RHIC systems during beam operations is accomplished through event and beam sync links, and managed via Sequencer. Interruptions to the beam involve the quench and/or permit links as well as PASS.
- In addition to applications for individual instrumentation systems, there are a few general applications to view and compare wide ranges of information.

For more information...

- W. MacKay, "Luminosity As Calculated From Machine Parameters," C-A/AP Note #89, November 2002.
- W. MacKay et al, "Luminosity Upgrade Options for RHIC," C-A/AP Note #51, May 2001.
- K. Zeno, "A Rookie's Guide to Booster Operations," Booster Tech Note #231, September 1998.
- RMS web page
  - QLI analysis, etc. in 'RHIC Setup'