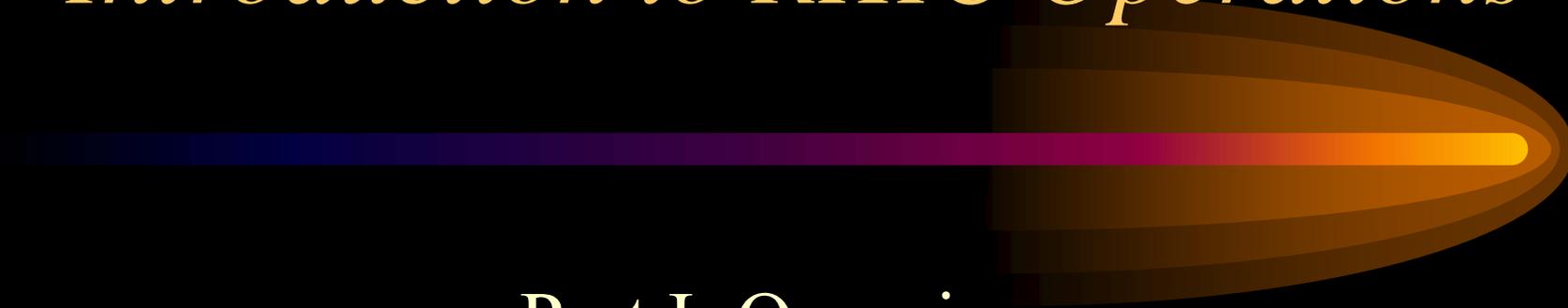


# *Did you know?*



- 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  $\equiv \mathcal{L}$**

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

$f_0 \equiv$  revolution frequency

$N_b \equiv$  number of bunches circulating

$N \equiv$  particles per bunch (assumed equal Blue/Yellow)

$\gamma \equiv$  relativistic factor

$\varepsilon \equiv$  normalized transverse emittance (assumed equal x/y, Blue/Yellow)

$\beta^* \equiv$  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,  $p\uparrow$ )
  - Beam-beam limit (resonances from tune spread)
    - $\sim 3 \times 10^9$  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
- $\beta^*$ 
  - Power supply limitations
  - Triplet aperture

# *Luminosity limitations* (cont'd)

- $\varepsilon$ 
  - 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)
- $\gamma$ 
  - Limited by design (magnet/power supply limitations)
    - Protons: increase available 100→250 GeV

# *Luminosity limitations* (cont'd)

- $\int \mathcal{L}$

- Luminosity lifetime  $\tau$

- 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  $\tau$ ,  $t_f$

- $x = t_c/\tau$  ;  $a = t_f/\tau$
- $x \approx \ln [1 + (2a)^{1/2} + a]$

# *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

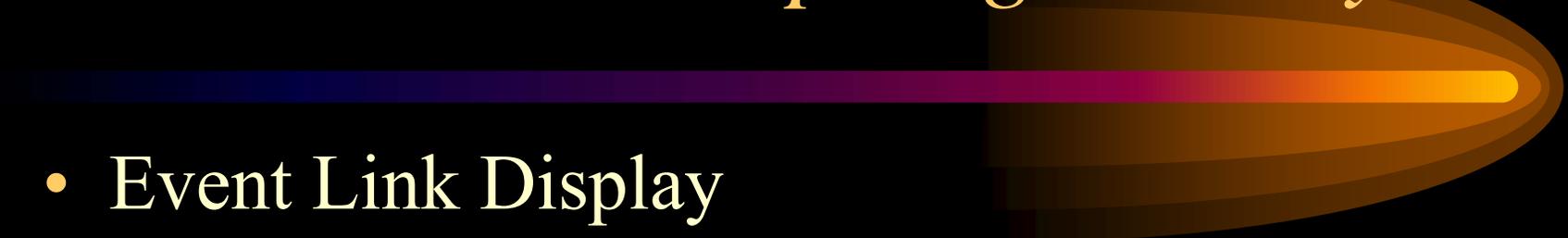
# *Go: timing, sequencing*

- 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’