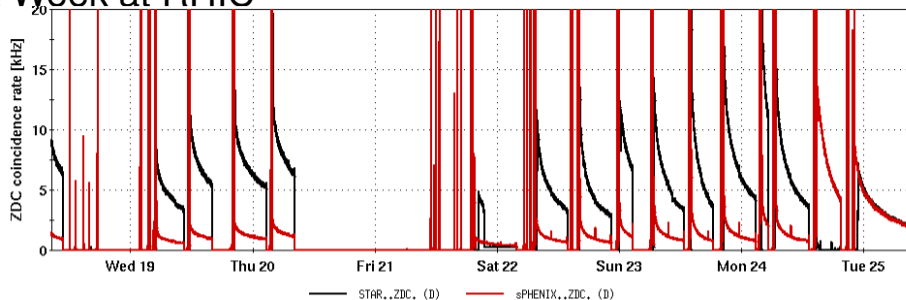


RHIC Status

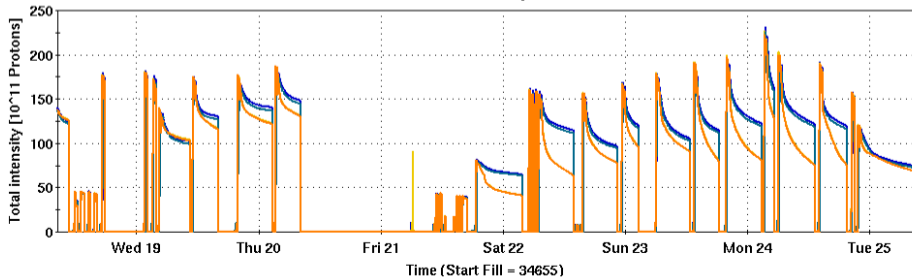
Kiel Hock

June 18, 2024

Last Week at RHIC

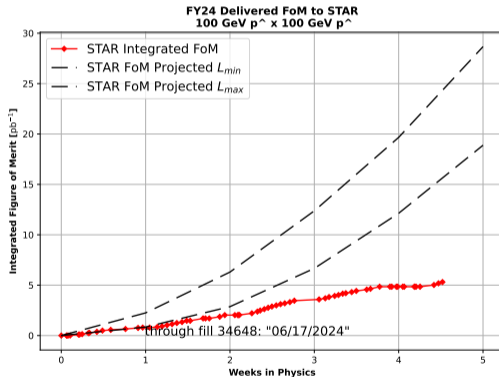
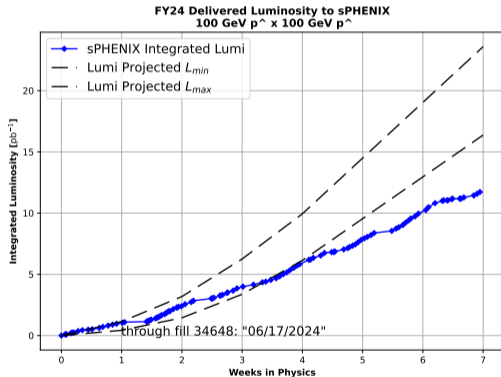


RHIC Beam Intensity



RHIC status and Lumi Projections

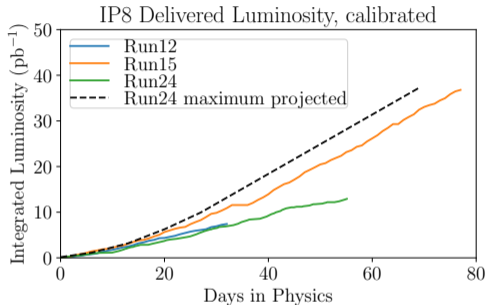
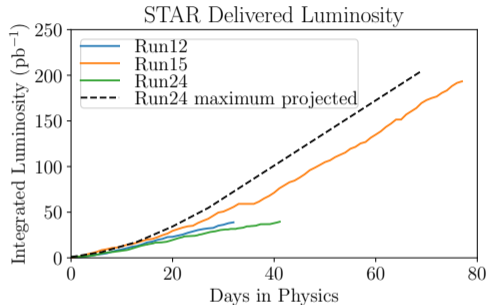
111x111 physics running since 4/30. Preliminary luminosity accounting



RHIC Status

- MD on 6/18, 6/21, and 6/25
 - ▶ MD on 6/18 unsuccessful, conferred with AI for recommendations following MD
 - ▶ 6/21 developed ramp with polarity swap. Updated optics for magnet transfer functions to what was used in Run15.
 - ▶ MD today to revisit MD on 6/18
- IR8 DH0 polarity swapped on 6/20 Maintenance day to support 0→2 mrad crossing angle
 - ▶ dedicated run with sPHENIX at 0 mrad on 5/24
 - ▶ sPHENIX and STAR at 0 mrad following dedicated run
- Power dip during maintenance day resulted in a prolonged recovery
 - ▶ BA1 QEI replacement
 - ▶ YA2 QEI error, found tripped breaker to reset
 - ▶ yellow injection kicker comm error, DG645 reset
 - ▶ yi11-tq5 replaced
- yellow polarization lifetime poor due to Qv near 7/10, ongoing optimization

Comparison with previous runs



Run15 and Run12 scaled based off of emittances and calculated crossing angle
A factor of 2 improvement would put STAR at the projected Luminosity/day

A review of this run, MD findings, and solutions

RHIC Status

Run review

List of Machine Developments

MD on 4/30

MD on 5/03

MD on 5/07 and 5/09

MD on 5/13 and 5/14

MD on 5/17 and 5/20

MD on 5/29

MD on 6/07

MD on 6/13

MD on 6/18

MD on 6/21

MD on 6/25

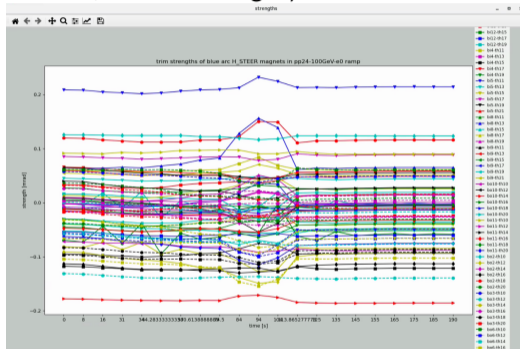
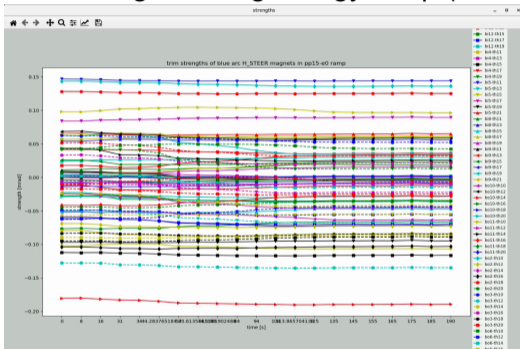
List of Machine Developments

- 4/30 Revert to design orbit to fix walk toward unstable point
- 5/03 Clean up ramp, increase octupoles, tested squeeze, vacuum limitations observed
- 5/07 Scrubbing development and scrubbing session
- 5/09 Scrubbing session
- 5/13 Ramp diagnostics
- 5/14 Emittance growth and electron clouds
- 5/17 Ramp development and rotator setup
- 5/20 Ramp development and rotator setup
- 5/29 56 MHz and ramp development
- 6/07 Blue spin tune measurement
- 6/13 Run22 ramp test and ramp development
- 6/21 IP8 Polarity Swap and updated RHIC optics
- 6/25 Commission storage ramp 2

Outcome of machine developments also summarized in Status Meeting slides

MD on 4/30 I

Trim strengths along energy ramp (run15 on left, run24 on right):



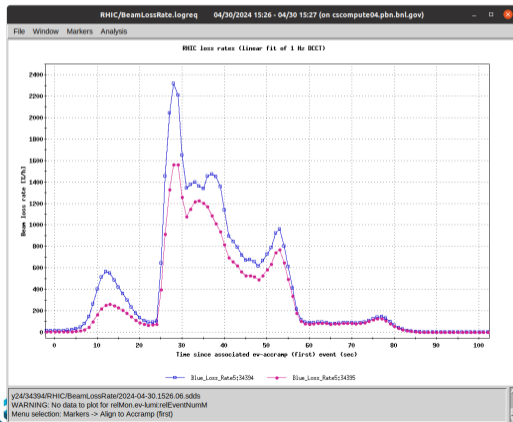
Reason: suspected feed-forward off-hysteresis at injection

Resolution: go back to design values for these supplies and feed forward on-hysteresis orbit correction.

MD on 4/30 II

MD goals:

- reset orbit feedback to start of run to clear feed forwards moving to bad point
- improve blue ramp efficiency
- investigate 10 Hz feedback



MD outcome:

- blue losses improved, note 25 s loss (post MD in red)
- orbit reverted and issue has not returned
- 10 Hz feedback found to still be problematic, off until 5/2 which used a smoothing function for the 10 Hz correction matrices

MD on 5/03

Purpose: diagnose ramp losses and emittance growth with intensity

- ramp with Run15 RF voltage (22 kV instead of 34 kV)
- ramp with no tune bridge
- ramp with stronger and zero octupoles
- optimize ramp to allow for -2 mrad at sPHENIX at collisions

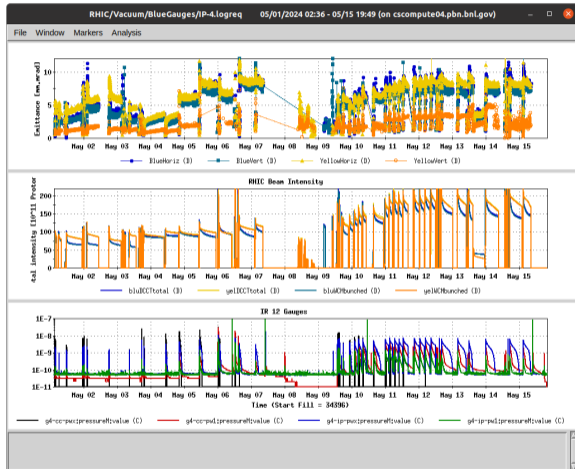
Outcome:

- Ramp with 22 kV resulted in higher losses and a beam abort during ramp. It was later noted that the landau voltage was not moved in sync with the 9 MHz voltage, resulting in peakier bunches.
- Ramp with flat tunes during energy ramp provided a factor of 2 improvement in losses through energy ramp
- Ramp with high octupole strength (8 units) provided near zero losses during the energy ramp except at snapback. Test with zero octupole strength skipped and remainder of MD was optimizing the setup to hand off for physics.

Note: first instance of vacuum response at new DX magnet which setoff the scrubbing exercises, 2 hour stores, search for electron clouds, etc.

MD on 5/07 and 5/09

Purpose: produce more efficient setup for scrubbing and then scrub

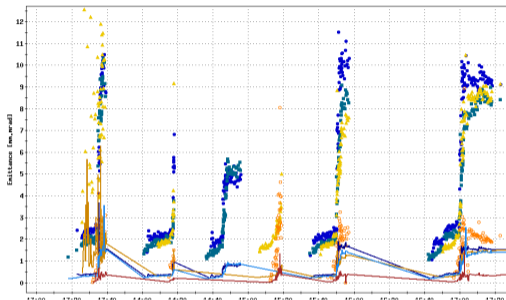


Outcome: emittance improved following scrubbing sessions. With two hour stores, vacuum scrubbing improved quickly but with emittance growth increasing with intensity.

MD on 5/13 and 5/14

Purpose: ramp diagnostics and development
Machine Development

- ramp without feedbacks showed no difference in emittance
- ramp with lower tunes showed no difference in emittance
- ramp with blue only showed less than expected emittance growth (about 1/2)
- ramp with yellow only showed significantly lower emittance growth



Try ramping with different bunch lengths as part of physics program.

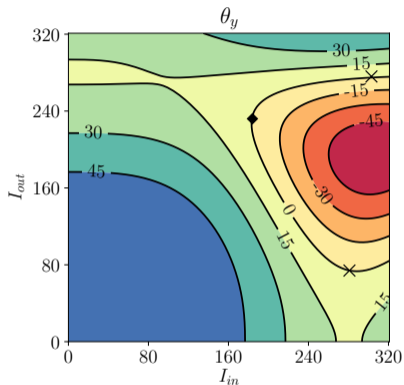
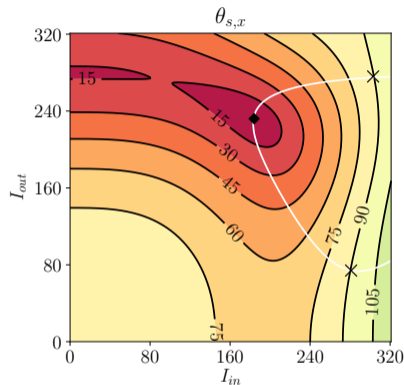
Adjust orbits at possible IPs where beams are close to try and improve separation

Outcome: investigation into electron clouds and instabilities caused by blue but driving yellow, no observed coherence, vacuum pressure, or cryo heating.

Iterated through bunch patterns, bunch intensity, and total ring intensity (as a combination of the two) and determined signatures followed e-cloud despite not seeing emittance growth.

MD on 5/17 and 5/20

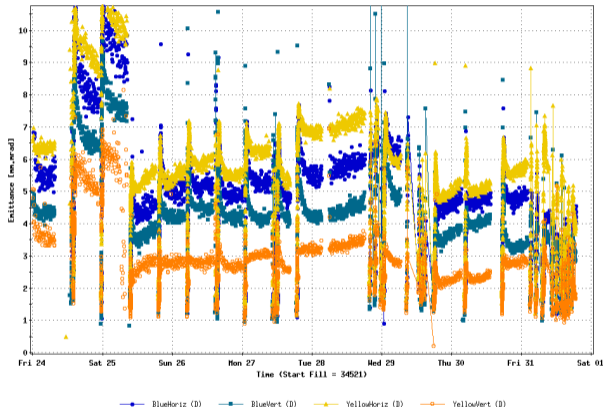
Purpose: setup and optimize rotator ramp



- Ramp efficiency nominal after 3 ramps
- Initial currents used were $I_{out}, I_{in}=273, 302$ A leading to quenches of rotator magnets
- 5/20 switched to $I_{out}, I_{in}=274, 77$ A, angle scans resulted in quenches. Final values arrived at from extrapolated longitudinal currents on 5/25.

MD on 5/29

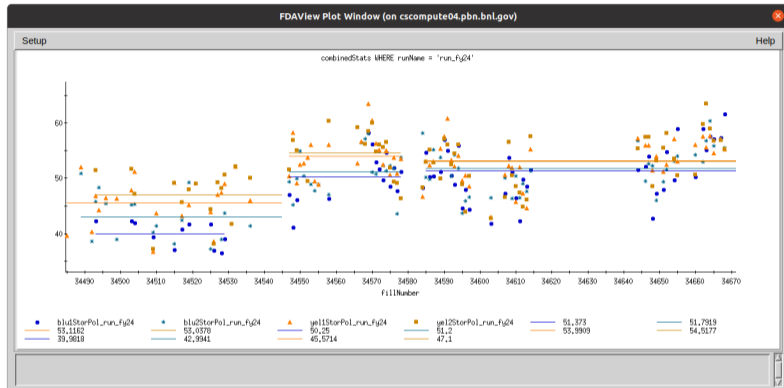
Purpose: Insert 56 MHz FPC further and optimize ramp for change in conditions



Outcome: Emittances improved following initial insertion on 5/24 and 5/25. Further improvements made during this MD with final emittances in the 2-4 μm range

MD on 6/07

Purpose: measure blue spin tune and adjust current of 9 o'clock snake to correct.



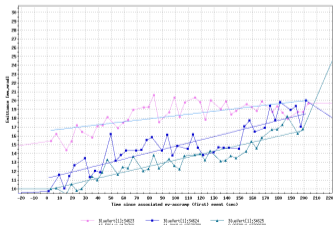
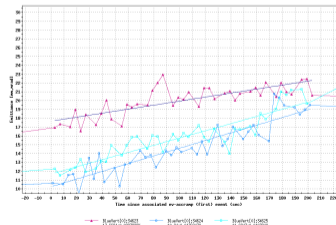
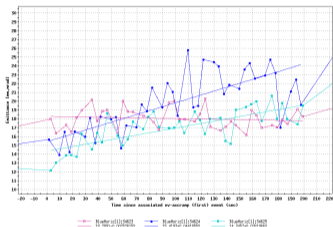
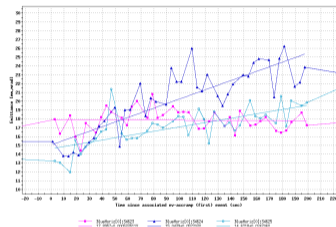
Outcome: blue spin tune adjusted 0.015 for $\nu_s=[0.5, 0.5025]$ by adjusting $I_{out}+15$ A. polarization performance in blue similar to yellow following change.

Three sets of fit lines, large emittance pre change (left), smaller emittances pre change (middle), post current change (right).

MD on 6/13

Purpose: test Run22 ramp, better optimize rotator ramp

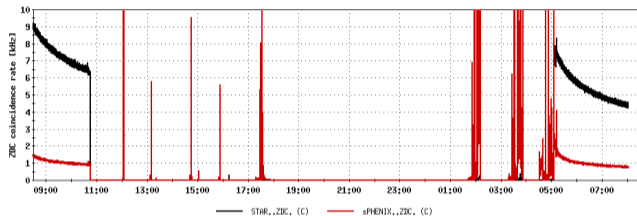
Outcome: Run22 test in red, Run24 comparison in blue



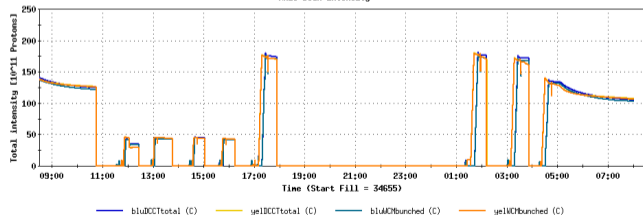
- Zero horizontal emittance growth along ramp (top plots)
- less vertical emittance growth (bottom plots)
- sparked taking a closer look at our current optics

MD on 6/18

Purpose: commission second storage ramp to provide capabilities to collapse IP6 and IP8 separately in time

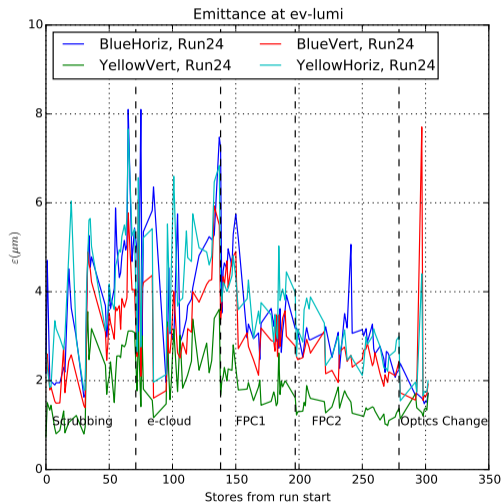


RHIC Beam Intensity



Outcome: MD unsuccessful due to errors on handoff from rotator to storage ramps.

MD on 6/21



Purpose:

- setup collisions sPHENIX following D0 polarity swap
- ramp with 0 and +2 mrad at sPHENIX
- check beampipe aperture at +2 mrad

Outcome:

- unsuccessful ramp with 0 mrad
- optics measurements at store and injection verified previous results received on 6/17
- optics updated by making magnet transfer functions closer to what was used in Run15
- Improved ZDC rates/intensity due to corrected β^* and improved emittance following optics update.

MD on 6/25

Purpose: commission second storage ramp for independent control (in time) of when STAR and sPHENIX bumps collapse. Study contribution of collapsing bumps at separate times.

Outcome: TBD.

Current Status

- sPHENIX DH0 polarity swapped to nominal configuration to allow for head-on and 2 mrad crossing angle
- With both experiments at head-on, in a position to increase intensity (1.6e11/bunch max from run 15 during physics running, 1.9e11/bunch max during run 15 APEX session)
- With optics change, in a better position to deliver higher luminosity with equivalent intensity
- This is a new setup so need to iterate on tunes to optimize beam lifetime and polarization lifetime at store