RHIC Polarized Proton Operation Run 12

RHIC/AGS Users Meeting

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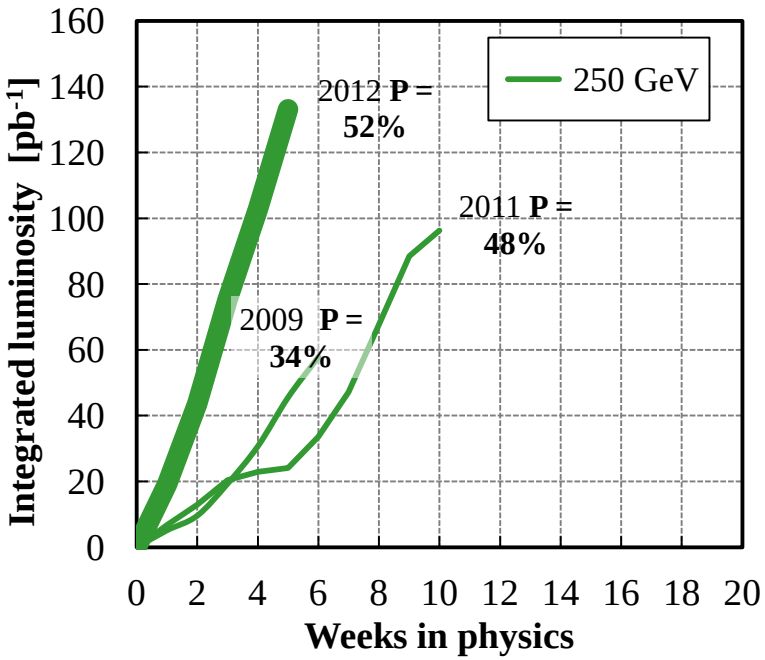
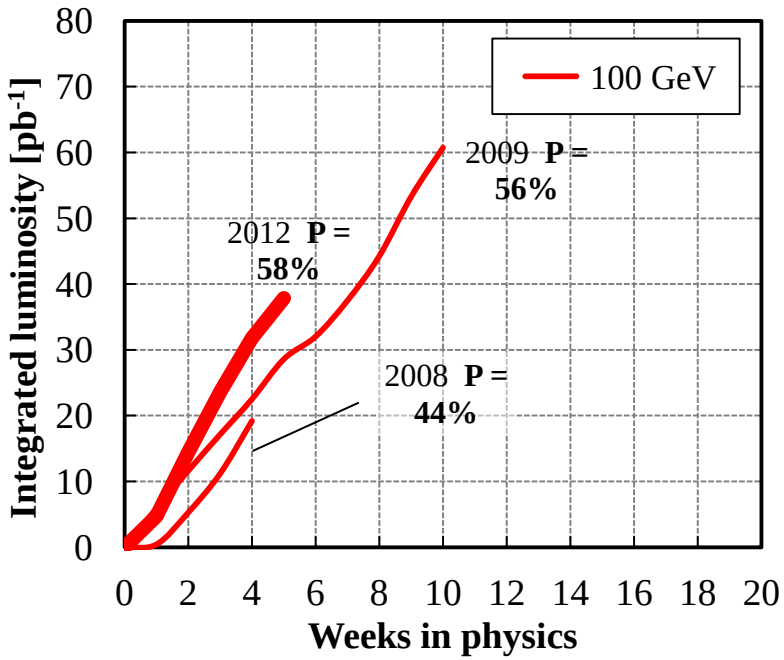
6/14/11

Overview

- Progress over the last few runs
- Run 12
  - Injector improvements
  - 100 GeV operation
  - 255 GeV operation

Recent Progress





- 9 MHz RF system
  - Longer bunches
  - Higher intensity with no e-cloud
- Polarized proton source improvements
- Feedback control of orbit, tune and coupling
  - Allows ramping near 2/3 (far from depolarizing 7/10)
- AGS Jump quad system

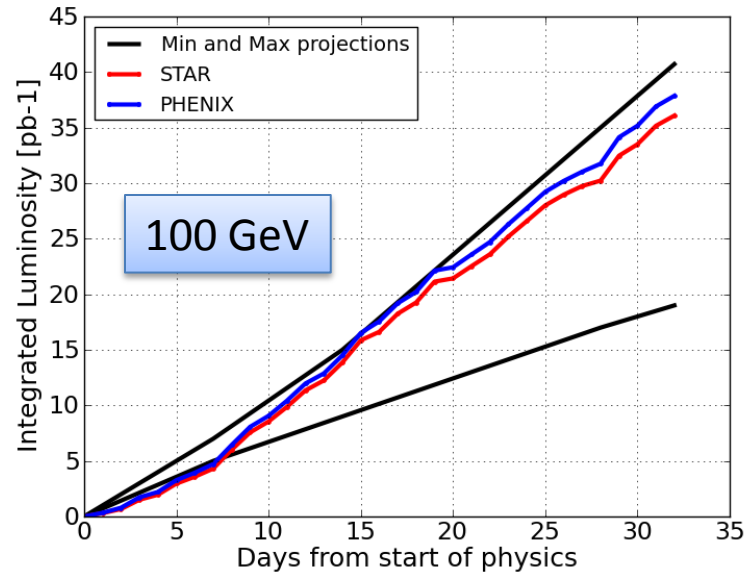
RHIC Polarized Protons: Run 12 Overview

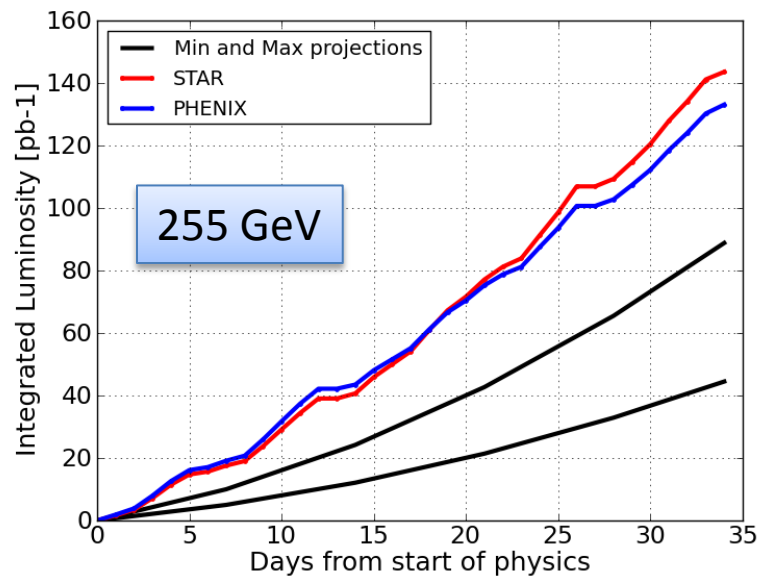
Run 12 was very successful

Operation at both 100 and 255 GeV programs

- 100 GeV: 4.5 weeks
- 255 GeV: 5 weeks

Met or exceeded all luminosity goals





Injector Improvements

Polarization at AGS extraction higher at higher intensities than in Run 11

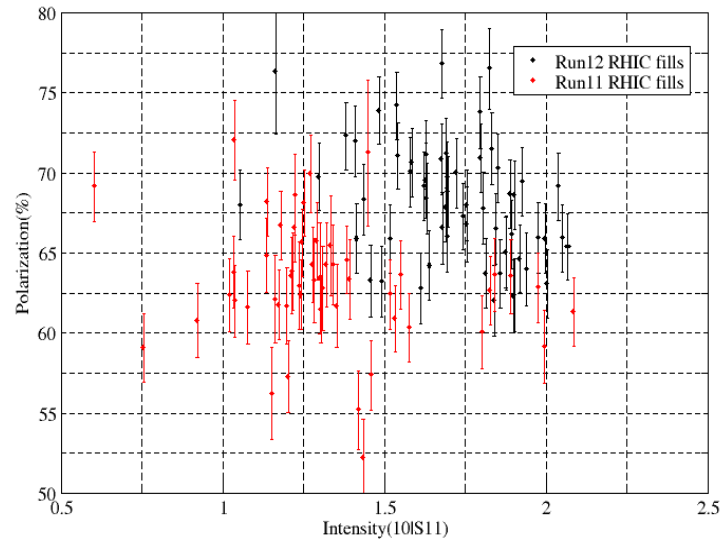
Increases from:

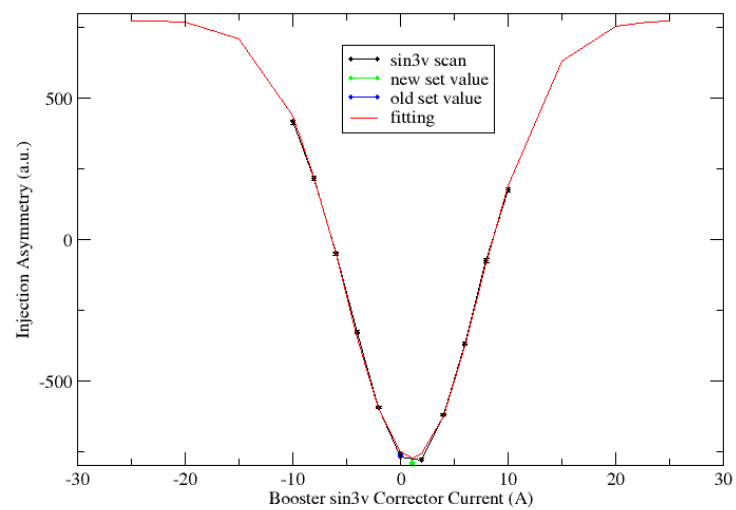
•AGS pC polarimeter modification allows routine measurement of spin asymmetry at AGS injection enabled optimization of Booster resonance compensation (+4% abs)

- Benefit eroded over time due to an orbit control software problem, corrected for future runs.

•Higher source intensity

- More scraping->10-15% smaller emittance



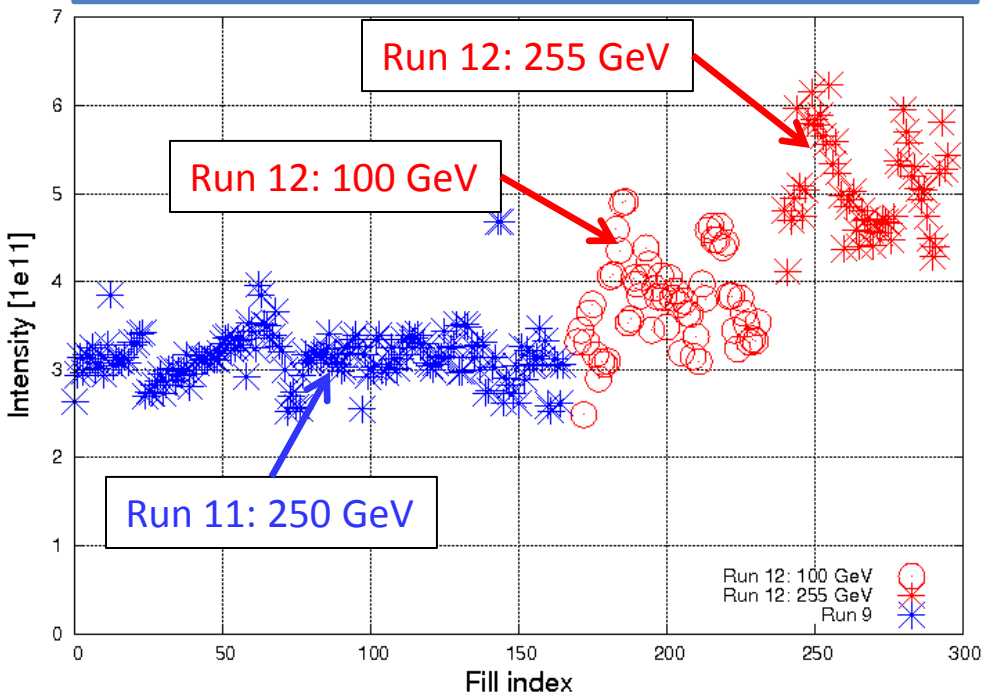


Injector Improvements: Source intensity

Source improvements yielded intensity at Booster injection as high as $6x10^{11}$, nearly double Run 11 intensities

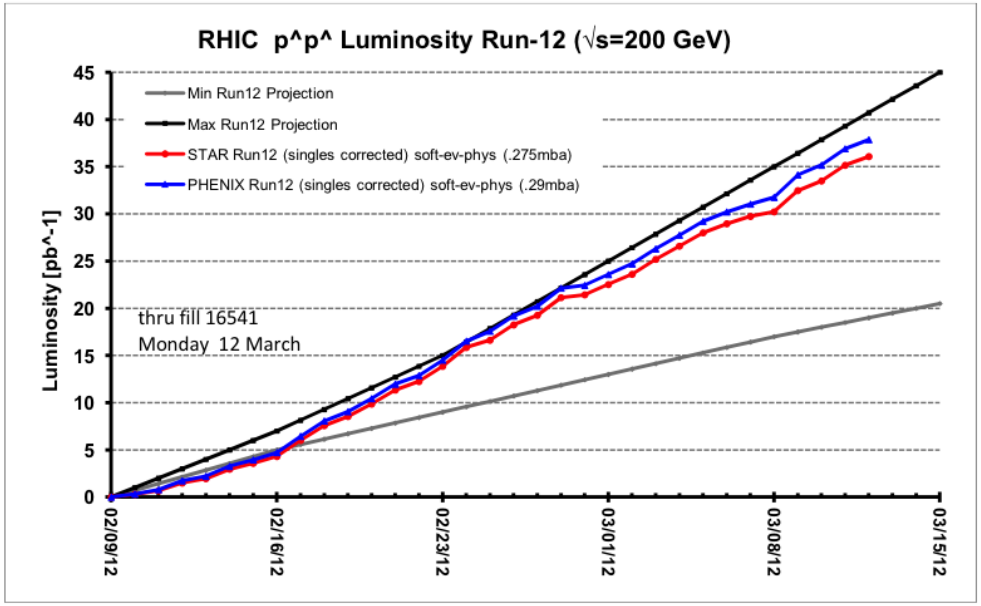
Allows additional scraping in the Booster
--- Longitudinal+vertical for 100 GeV
--- Vertical only for 255 GeV

Intensity at Booster injection for physics fills



RHIC Performance: 100 GeV

- Luminosity
  - Relative to Run 9
    - Increased β* 0.7 -> 0.85 m
    - Increased intensity 1.4->1.6x10^{11}/bunch
    - Above two approximately cancel to get slightly higher peak lumi of ~52x10^{30} $cm^{-2}s^{-1}$ (+5% relative to Run 11)
- Lumi lifetime
    - Average ~16 hours, compared to 7 hours in Run 9 and 12 in Run 8 *(even at 1 m β*)*
    - Run 12: First 100 GeV p^ run to use tune/orbit feedback for all physics stores
    - 10 Hz feedback
    - 'Blue noise' problem solved in Run 11
- Improved integrated lumi mostly due to a combination of good uptime (>60% calendar time at store) and improved lumi lifetime



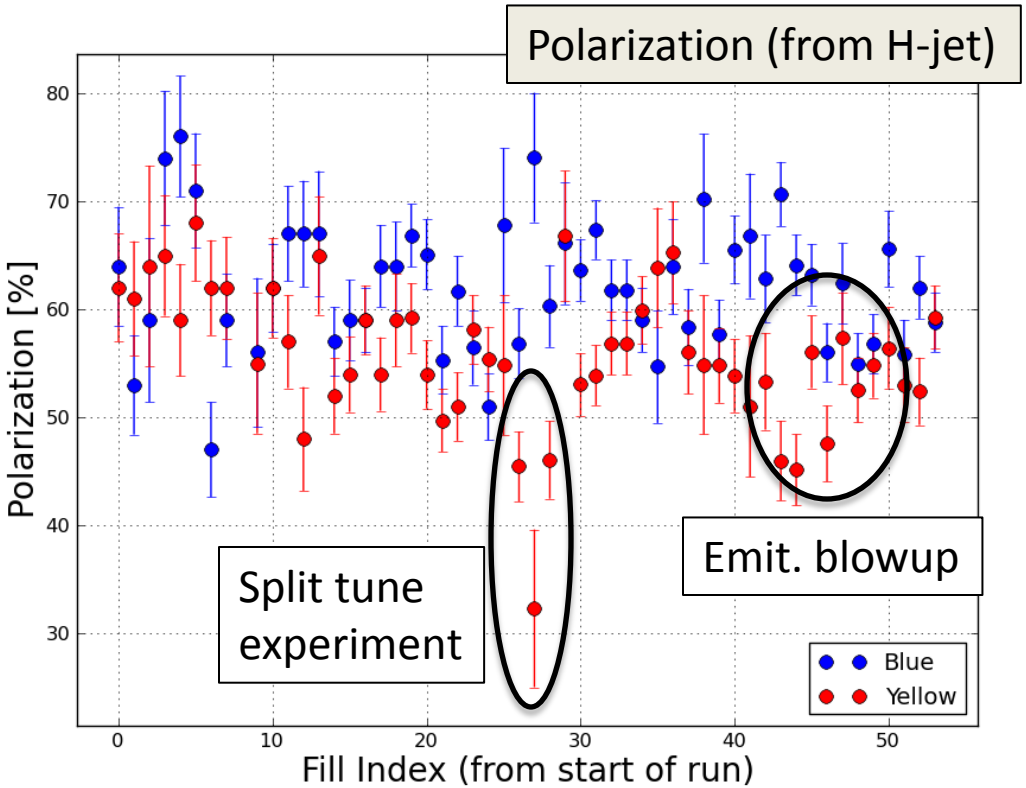
Run	β* [m]	Lumi Lifetime [h]
Run 8	1.0	12
Run 9	0.7	7
Run 12	0.85	16

Polarization: 100 GeV

- Polarization averages
  - (B,Y) ~ (61%, 55%)
  - Yellow slightly higher (57%) when omitting 'split tune' fills and the emittance blowup period

- Polarization decay at store varies over the run, but is typically 0.5%/hr in blue and 1%/hr in yellow (absolute)

- Standard store length is 8 hours



Beam-beam Emittance Blowup

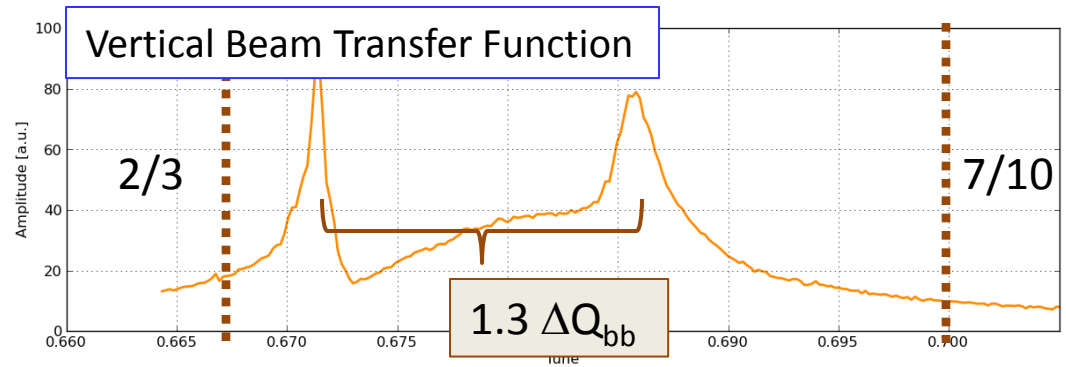
Longitudinal scraping being used to reduce beam loss during rebucketing at 100 GeV.

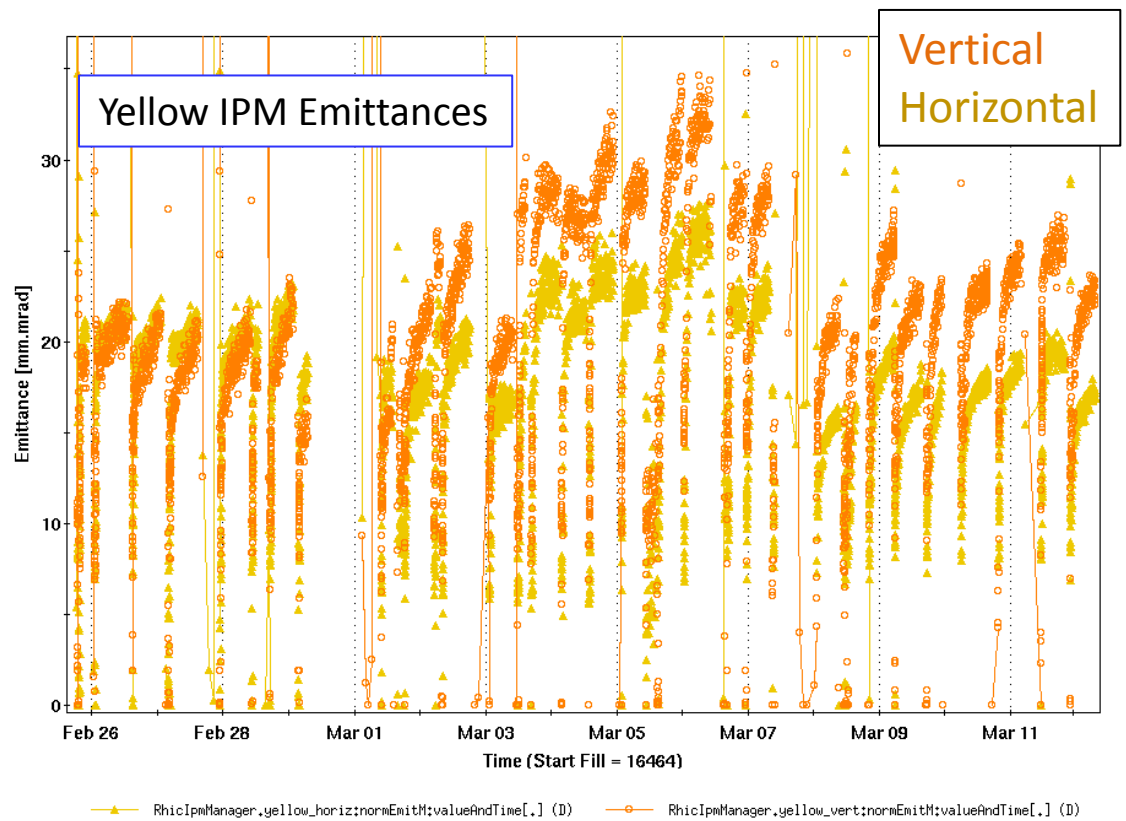
Moving to a vertical-only scraping scheme increased beam-beam tune spread, ΔQ_{bb}

Ran into the beam-beam limit:

- Transverse emittance blowup
- Increase in polarization decay
  - >2%/hr, compared to ~1%/hr nominal

Diminishing tune spread from beam-beam is exactly the goal of the electron lens





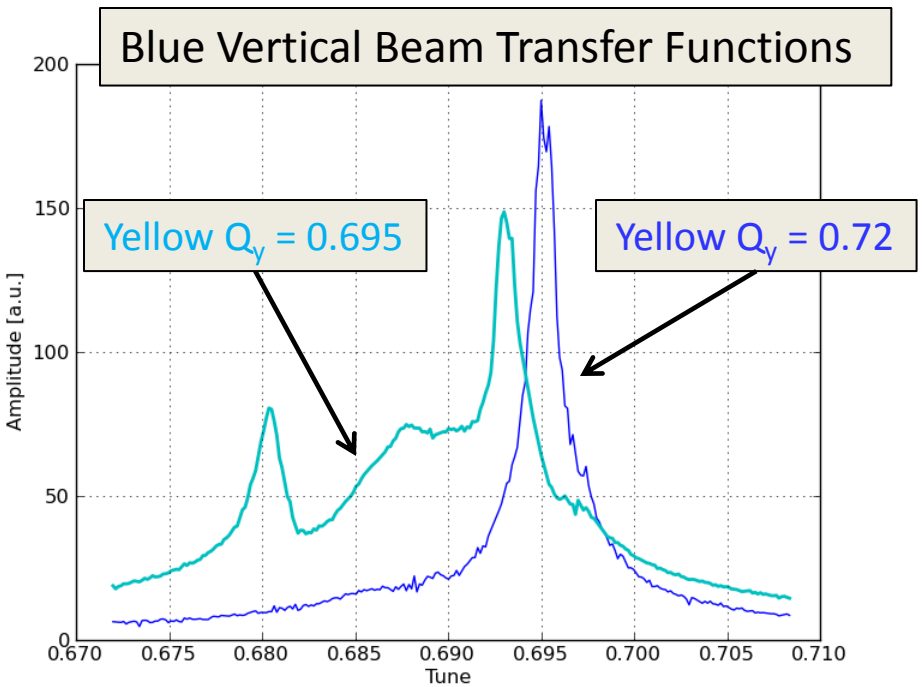
‘Split tune’ Experiment

Move the yellow horizontal and vertical tunes above 0.7, away from blue at Qx, Qy = (0.695, 0.685) in order to suppress coherent modes and reduce tune spread

Coherent modes are successfully suppressed but

•Yellow polarization decay increases to over 2%/hr (abs)

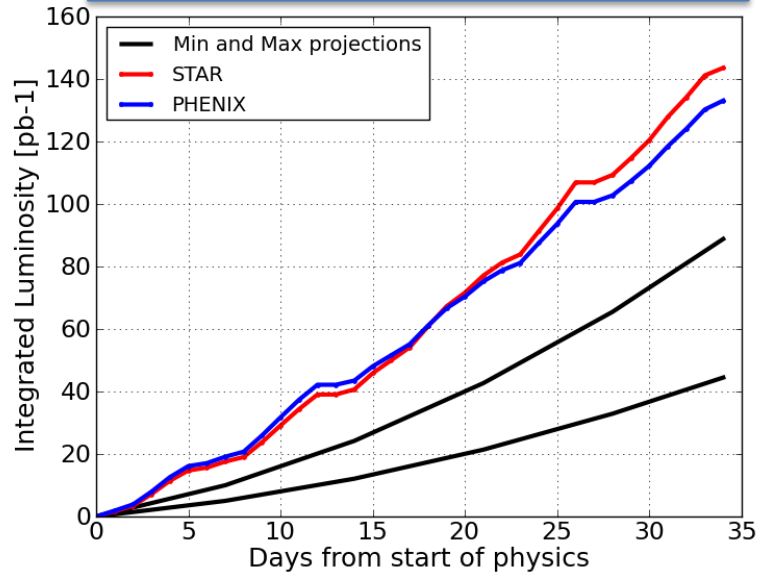
•New mechanisms for emittance growth are excited



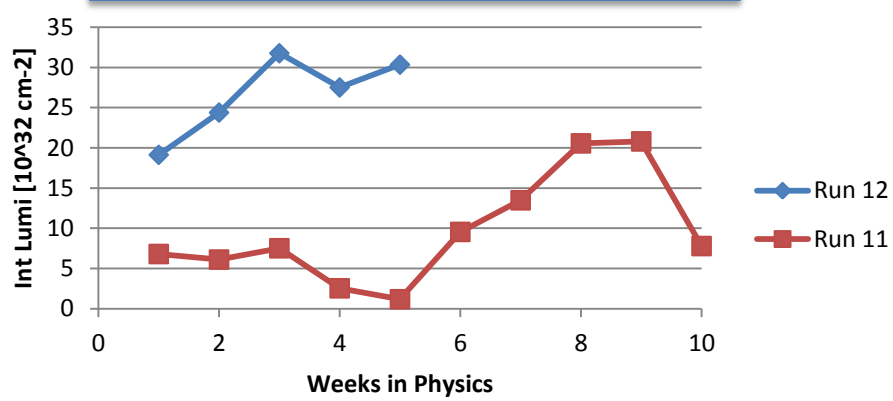
RHIC Performance: 255 GeV

- Luminosity
  - Peak
    - ~25% higher than Run 11
    - Smaller emittance
      - Source intensity + scraping
      - Less growth in AGS
  - Integrated
    - Same in first week of Run 12 as best weeks (8,9) of Run 11
    - 9 MHz RF commissioned in Run 11, operational day 1 in Run 12
    - No 'big' (multi-day) failures
    - Changeover from 100 GeV, 3.5 days, (with maintenance)
      - Enabled largely by tune/orbit feedback

Integrated Luminosity: 255 GeV



Integrated Luminosity by Week

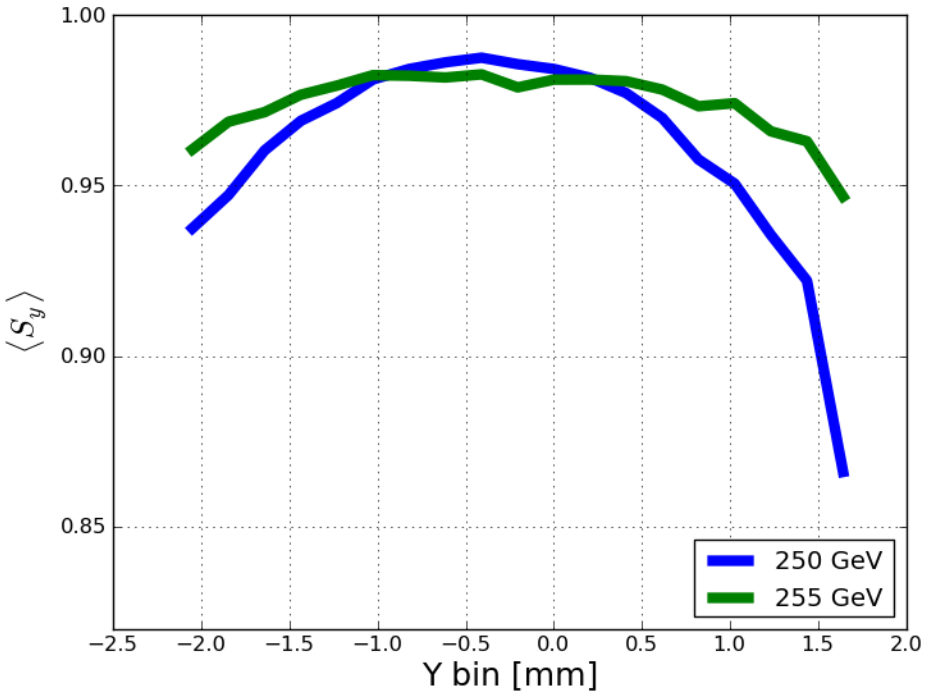


RHIC Polarization: Why 255 GeV?

A tilt of the stable spin direction with respect to the vertical axis indicates depolarizing resonance

Simulation (right) indicated that the projection of the spin of high vertical amplitude particles was less at 255 GeV than at 250 GeV

This was a possible source of polarization decay during the course of a store.



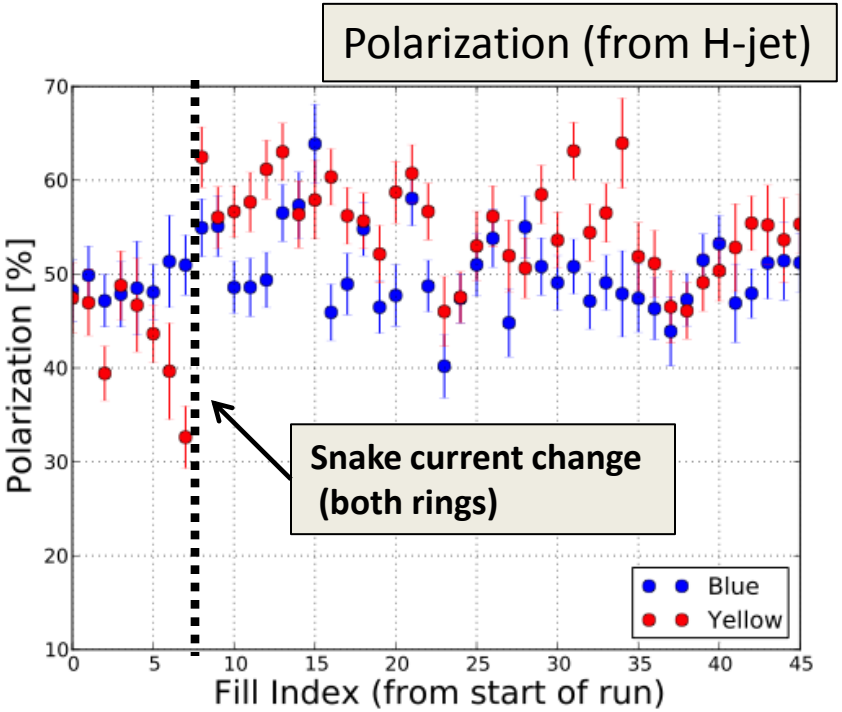
RHIC Polarization: 255 GeV

- Run 11 48% +/- 0.5 (Jet, both rings)
- Run 12 Blue 50%, Yellow 55% (each +/- 0.5)

- Adjusted snake current during ramp between 100 and 255 GeV
    - Yellow +5% (abs), blue no change.

- Further (large) scans of snake currents show polarization is largely insensitive to changes around this configuration

- No obvious improvement in polarization decay from increasing energy to 255 GeV
    - 0.7%/hr, consistent with Run 11



Longitudinal Emittance

- Longitudinal emittance puts a limit on peak lumi at both 100 and 255 GeV
  - 100 GeV: Momentum aperture at store (rebucketing)
  - 255 GeV: Acceleration losses at max acceleration rate (minimum longitudinal acceptance
  - In both cases, reduces collisions in narrow vertex cuts
- Attempts at cure:
  - Decrease the emittance
    - Shorten AGS cycle: less time at injection, smaller growth
    - Landau phase loops: minimize jitter of bunch relative to 197 MHz cavity while injecting/ramping
    - Bunch-by-bunch damping: minimize/eliminate Landau voltage at injection
  - Increase the acceptance
    - Landau cavity (197 MHz) voltage on the ramp to increase bucket area
- This may be further improved by OPPIS source intensity upgrade

A war on all fronts…..

Orbit and Optics

Local decoupling
Vertical dispersion correction
Beam-based alignment
Resonance driving term correction
Precision instrumentation calibration

RF

Landau phase loops
Bunch-by-bunch damping
LLRF commissioning
AC coupled phase loops

RHIC Polarization

Near-integer working point
Coherent mode suppression
Imperfection resonance knobs
High-precision spin tracking

Injectors

AGS Jump quad optimization
AGS magnet realignment
Model calibration
Spin tracking in a realistic AGS
Source upgrade
Polarimeter development
Transfer line optics

Conclusions

- Run 12 polarized proton operation was very successful
  - Luminosity expectations were all exceeded
  - Polarization increase due to incremental improvements throughout the accelerator chain
  - Records set in both peak and average luminosity and polarization
  - Recent major commissioning items all fully operational
- Efficient mode changes: Peak luminosities reached very quickly
- Well-positioned to take advantage of planned upgrades:
  - Beam-beam effect: electron lens
  - Longitudinal emittance: source upgrade and RF improvements
  - Polarization and transverse emittance: source upgrade

Thanks to my experimental counterpart coordinators:

Xiaochun He, John Koster and Bill Christie

…and to *Elke Caroline-Aschenauer* and the *polarimetry group*

…and to you for your attention!