

Polarized proton operation for Run24

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20 week shutdown starting from sPHENIX warmup (approximate start date January 8, 2024)

26-28 cryo weeks, pending budget and PAC decision

Key dates	Event
August 14, 2023 through January 8, 2024	RHIC Shutdown
November 27 through December 4, 2023	AGS checkout
December 3, 2023	Booster off for NSRL
December 11, 2023	Start AGS setup (pending skew quads)
December 18, 2023	Start AGS setup (without skew quad)
December 18 through December 22, 2023	RHIC dry run, tentative
January 8, 2024 through July 8, 2024	RHIC run (26 cryo weeks), tentative

Run24 schedule II

26-28 cryo weeks (approved 6 week carryover from Run23), tentative

Setup p↑p↑ at $\sqrt{s_{NN}}=200$ GeV	2 weeks
p↑p↑ at $\sqrt{s_{NN}}=200$ GeV	14 weeks
Setup AuAu and p↑Au	1 week
AuAu at $\sqrt{s_{NN}}=200$ GeV	6 weeks
p↑Au at $\sqrt{s_{NN}}=200$ GeV	3-5 weeks

Run24 Schedule

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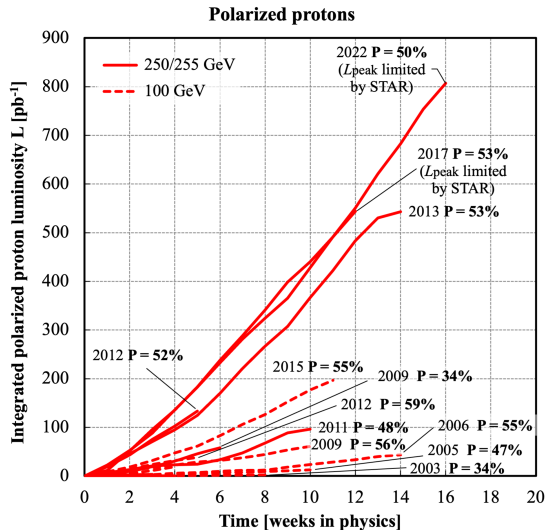
Continuation of Au+Au at 100 GeV

pAu at 100 GeV

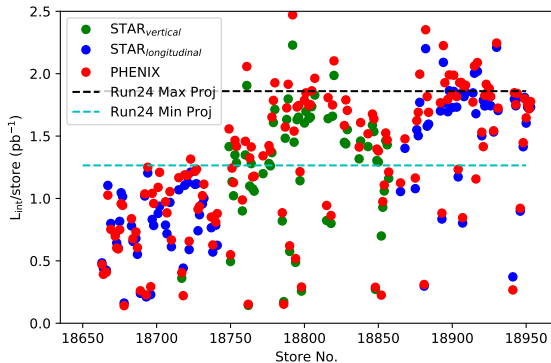
Polarization Studies and Summary

Polarized protons at 100 GeV

- Run15 is the highest luminosity run at 100 GeV and almost highest polarization run.
- Given performance from Run23, Run24 $p \uparrow$ performance expected to be equivalent to Run15.
- We will use Run15 as our performance metric.



Polarized protons at 100 GeV, Run15

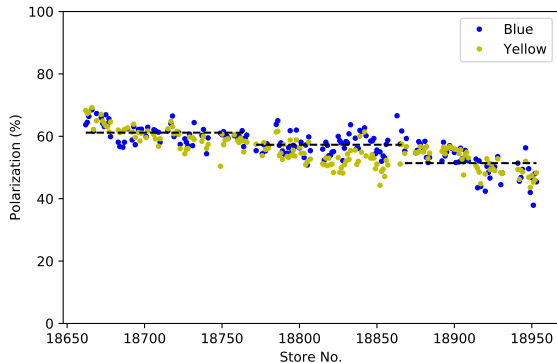


Looking at Run15 details

- Run15 started with relatively low luminosity which continued to scale up during STAR's longitudinally polarized run.
- Run15 we had a peak intensity of 2.38×10^{11} ions/bunch at ev-lumi.
- The entire run average intensity/store was 2.27×10^{11} ions/bunch.

Run24 has a target intensity of 2.5×10^{11} ions/bunch at store.

Polarization From Run15

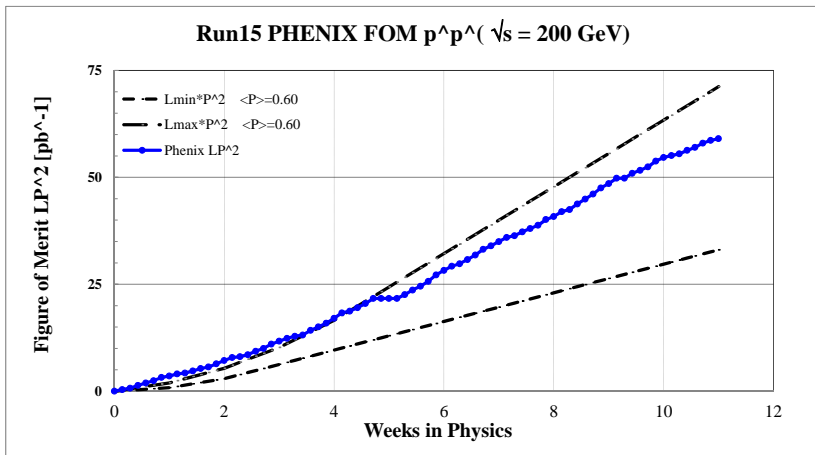


- Run15 suffered degraded polarization in the AGS due to jump quad timing shifts.
 - ▶ This has not been present since changing the timing scheme for jumps.
 - ▶ The new skew quad system a higher tolerance for timing.
- Polarization lifetime at store affected by beam-beam and tune placement between 7/10 snake resonance and 2/3 betatron resonance.

Run24 has a target of 57% polarization at store.

Run 15 Figure of Merit

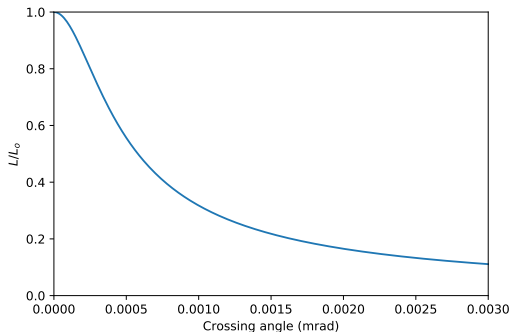
$$FOM(\text{transverse}) = LP^2 \quad FOM(\text{longitudinal}) = LP^4$$



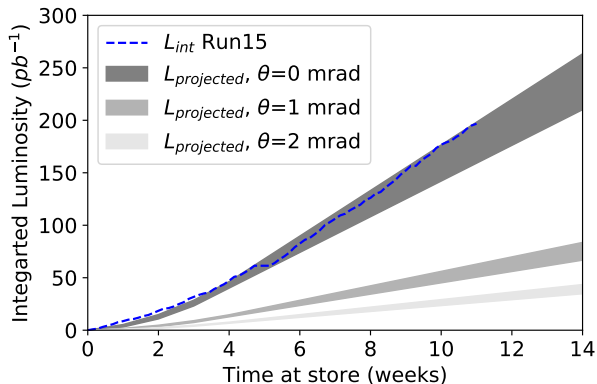
Run24 Luminosity Outlook

Crossing angles will be used at STAR and sPHENIX in part to minimize the charge in the TPC

- Crossing angles reduce the beam-beam tune shift.
- Crossing angles also reduce the maximum luminosity.
- This is not taking into account emittance growth during store.



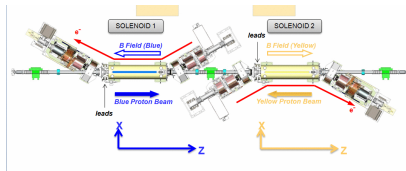
Run24 Luminosity Projections



- Projections have a ramp up in luminosity over the first four weeks proportional to that of Run15.
- Run15 had a power dip that caused 3 days of lost luminosity

electron Lenses

With two IPs, electron lenses may be required to provide beam-beam compensation.



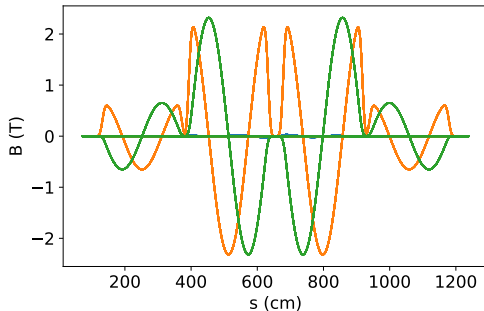
- The two electron lenses compensate beam-beam effects from one IP by colliding protons with electrons
- Crossing angles at each IP will also reduce beam-beam tune shift, which may be sufficient to not require the e-lenses.

Rotator currents for Longitudinally and Transversely Polarized Collisions

The spin at each IP is aligned to the stable spin direction (vertical) without the use of rotators.

Calculated from field maps for 100 GeV:

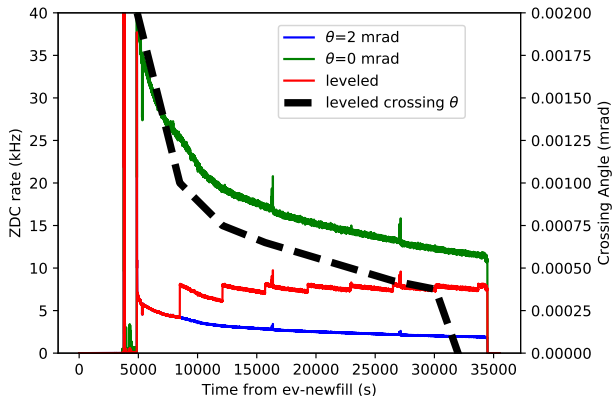
	I_{out} (A)	I_{in} (A)
Longitudinal	48.5	173.9
Radial	155.9	255



Changes and statuses

- Blue snake reinstall (see Shutdown talk)
- RHIC ramp development
 - ▶ Using Run15 lattice but model updates have caused this lattice to be reworked (in development)
- Luminosity leveling with crossing angle changes (in development)

- Example store with leveled luminosity using a DX angle ramp once per hour.
- A DX angle ramp requires changing the ramp file, inherently different than using feedbacks and correctors.
- Need to ensure the 2 mrad angle is reinstalled at end of store.



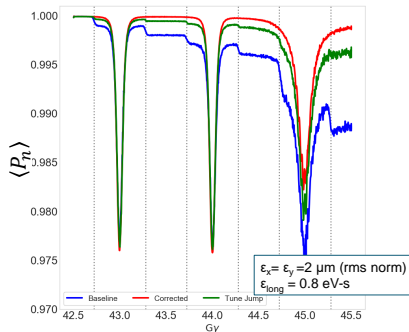
PP in the Injectors

How to get 2.5×10^{11}

- Typical RHIC ramp efficiency 98-100%
- Typical AGS to RHIC injection efficiency 92-96%
- This corresponds to a minimum of $\sim 2.8 \times 10^{11}$ /bunch at AGS extraction.

What about 57% polarization

- Typically $\sim 2.8 \times 10^{11}$ /bunch would have degraded polarization of 62% (extrapolated from $\sim 2.5 \times 10^{11}$ /bunch)
- The skew quads should provide lossless transmission (seen on right), giving this bunch 75+% polarization at AGS extraction and 65% at store in RHIC.



This system will be commissioned prior to the run, pending PS delivery.

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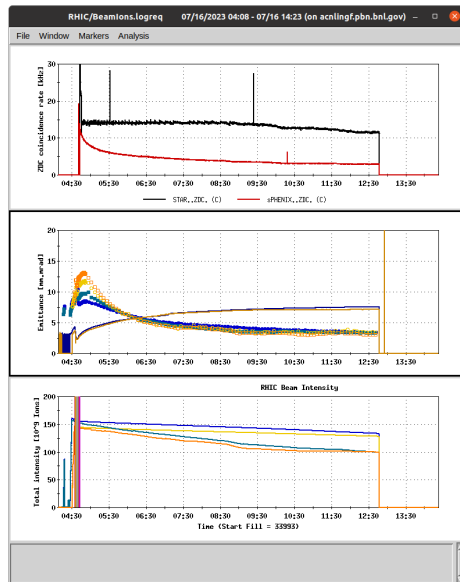
Continuation of Au+Au at 100 GeV

pAu at 100 GeV

Polarization Studies and Summary

Continuation of Au+Au at 100 GeV

- Continue to collect data and commission sPHENIX.
- Investigate cause for emittance increase on ramp.
- Commission 56 MHz cavity.
- Stochastic cooling should be able to come on in relatively short order since they had just been used.
- As intensity improves, the longer the rates can be sustained.



pAu at 100 GeV

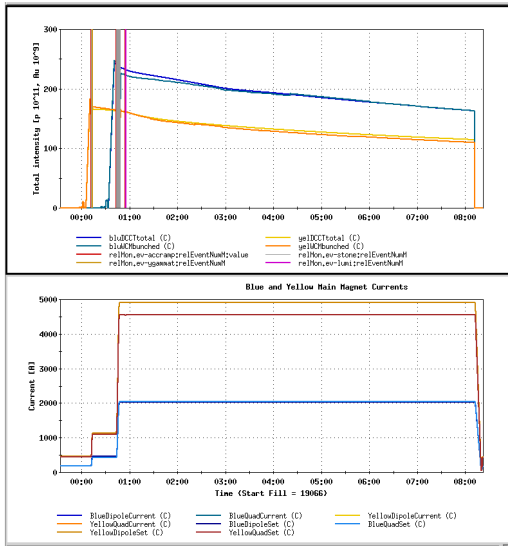
Operating pAu at 100 GeV

The pAu process:

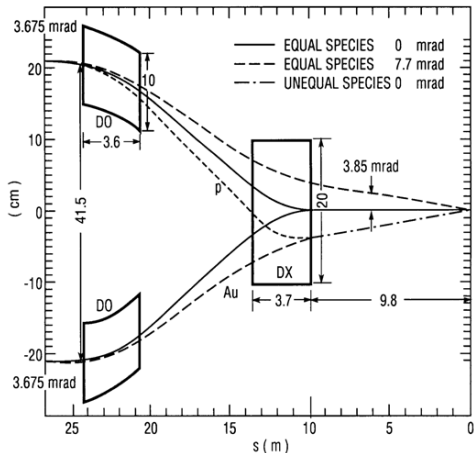
1. Yellow ring is filled with Au
2. Yellow and blue are ramped up to the proton injection porch
3. Blue is filled with protons
4. Both rings are ramped to their store setting

Colliding $B\rho$ for protons and Au are 346.50 Tm and 831.76 Tm

This is a complicated setup



Colliding beams of different rigidity



- Image from the RHIC design manual
- Unequal rigidity species go off-center through DXs
- DX magnets must be moved to accommodate shifted orbit

Dx Moves

From Chuyu on Run15 moves:

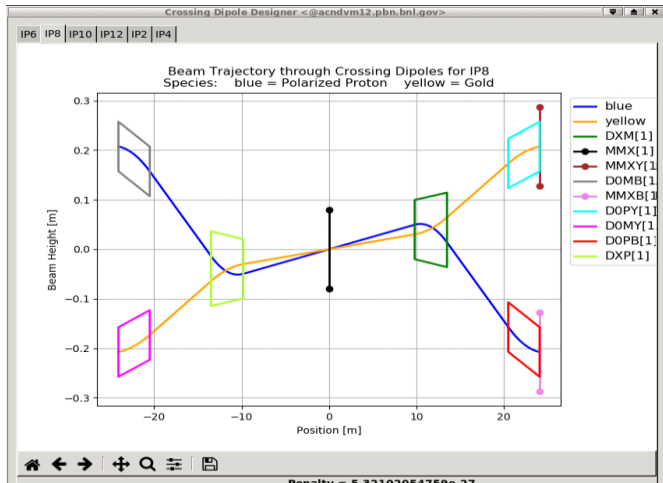
Device	Sector	DX Move	When
DX	1	+20 mm	before run
DX	2	-20 mm	
DX	3	-20 mm	
DX	4	+20 mm	
DX, ZDCs	5	+25 mm	after run
DX, ZDCs	6	-25 mm	
DX, RAD shield, ZDCs	7	-25 mm	
DX, RAD shield, ZDCs	8	+25 mm	
DX	9	+20 mm	
DX	10	-20 mm	
DX	11	-20 mm	
DX	12	+20 mm	

- The 8 DX magnets moved during the run was done on a single maintenance day.
- IR4 DX magnets could only be moved ± 17.5 mm during Run15 due to common 9 MHz cavity.
- A spool piece is being specified to replace the common 9 MHz cavity.

Crossing angles for pAu

To support a crossing angle of -2 mrad, the IR8 DO power supply needs to be upgraded to support 656 A, instead of the current 550 A.

From Chuyu:



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Polarization studies

- HSR simulations and studies
 - ▶ Accelerate with HSR working point ($Q_x, Q_y=0.228, 0.21$).
 - ▶ Check beam in 28 MHz buckets.
- Measure spin tilt at 255 GeV using full blue snake.
- Operate the spin flipper at 100 GeV to measure the spin-tune.
- More to come!

Summary

- Polarized proton runs are always exciting.
- Run15 exceeded the maximum projected luminosity, we hope to do it again.
- This is a short shutdown with several major jobs
 - ▶ Blue snake install (~13 weeks)
 - ▶ 1004 valve box repair (tbd)
- pAu is one of the more complicated setups we have run at RHIC.

Thank you

Thank you and questions.