

# RHIC Au-Au OPERATION AT 100 GeV IN RUN 25

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## Abstract

The Relativistic Heavy Ion Collider (RHIC) Run 25 operations consisted of collisions of 100 GeV/u Au beams for the STAR and sPHENIX experiments. A 6-week 100 GeV polarized proton run for sPHENIX and an additional week of fixed target for STAR at 3 energies was added. Finally, a 7-day 100 GeV/u O run was added. A magnet wiring short resulting from the Run 23 failure repair resulted in a 2-month delay to the start of the run. Machine optimizations produced the highest efficiency in the history of the complex, but the run was interrupted by a pair of two-week failure periods. This paper will discuss the progress made by each experiment and the failures and successes of the final year of operation of the RHIC accelerators.

## INTRODUCTION

The RHIC program in Run 25 called for 28 weeks of colliding beam operations with 100 GeV Au beams at two interaction points (IP), IP 6 and 8. IP 6 contains the STAR detector; the experimental plan called for a mix of high luminosity at a zero crossing angle for the first 4 hours of a store and then a 1 mrad crossing angle with luminosity levelling at 15kHz for the remainder. IP 8 contains the sPHENIX experiment with plans to run a 1.5 mrad crossing angle for stores. A mid-run Program Advisory Committee meeting resulted in a change of plans to add a 6-week 100 GeV polarized proton run for sPHENIX and a 1-week fixed target run for STAR at 3 energies. Finally, an additional six-day 100 GeV/u Oxygen run was added for the last week of operations.

## WIRING FAILURE

After the initial cryogenic cooldown of the blue ring to 4k it was found that the blue main dipole buss would not pass the required high potential test. A week of troubleshooting resulted in narrowing down a possible short location and the decision was made to warm the rings back up and start opening cryostats for investigation. Ultimately the short was found to be the result of a poorly insulated wiring splice in one side of the DX magnet that was replaced after the run-ending failure in Run 23. Cryostats, vacuum chambers and shields were all welded and the run began roughly 2 months late.

## GOLD RUN

Removal of a legacy beam collimator upstream of IP8 and a switch to triggered mode allowed the mVTX detector at sPHENIX to operate without the background problems that were discovered in Run 23 and 24 [1]. Constant and meticulous tuning of the ramp and store conditions produced the highest efficiency in RHIC's 25-year history as shown in Fig. 1. Delivered luminosity to the experiments is in Fig. 2.



Figure 1: A comparison of Au energy ramps from Run16 (dashed lines) and Run25. In Run16 blue and yellow ramp efficiencies were 92% and 95% compared to Run25 which achieved 99% and 98% at equal or greater intensities.

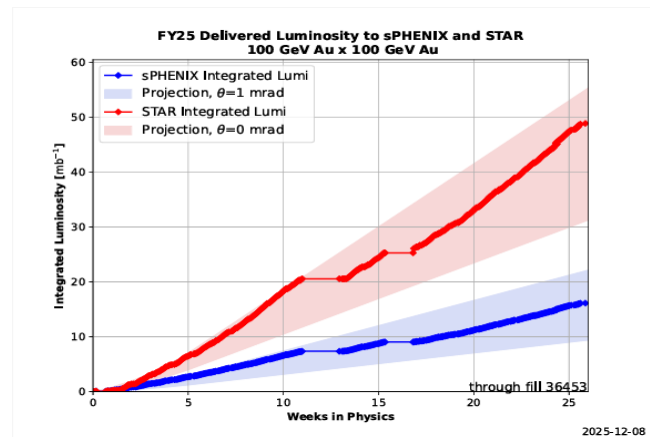


Figure 2: STAR/sPHENIX luminosity plot

Attempts were made through the early part of the run to bring the 56 MHz SRF cavity into operation. While the

effect of the cavity on bunch length was able to increase the sPHENIX luminosity by roughly 9% (higher for their 10cm vertex cut) it suffered from stability issues that aborted several stores. In week 9 an additional hardware failure occurred in one of the two fundamental power couplers. After diagnosing this fault, it was ultimately decided to run without the cavity rather than risk catastrophic failure (which would require full removal of the cavity to continue the program).

### POWER LINE FAILURE

The failure of one arm of a power pole shown in Fig. 3 resulted in two weeks of downtime (seen in Fig. 2 at the 11-week mark). The pole in question carried the main and backup 69 kV AC distribution for the RHIC facility; the repair could not be affected without disabling both lines. Repair estimates reached as high as 6 hours, jeopardizing the status of the liquid helium and the possibility of near total inventory loss should the cryogenic plant go without power for that length of time. The decision was made to move as much liquid inventory out of the rings and into storage as possible. The repair was completed in 90 minutes with minimal helium loss, and the cooldown was immediately commenced to resume the gold run. Total downtime was two weeks.



Figure 3: Power line arm failure for the main AC feed to RHIC.

### ABORT KICKER PREFIRE

To avoid spontaneous firing of a thyatron in one of the 5 modules that make up the abort kicker a hand-off is executed on the energy ramp to mechanical relays. This system has been functional since Run 22 without issue. 15 weeks into the run a never-seen failure mode occurred with the system in which two modules fired during the closing window of the mechanical relays, pulsing the 2 modules in such a way that they delivered a kick that exactly placed 2/3 of the bunch train on a 6mm wide portion of the vacuum flange between the circulating pipe and the absorber section, shown in Fig. 4. This resulted in a 1mm

hole being punched in the flange in Fig. 5, taking the warm section up to atmosphere.

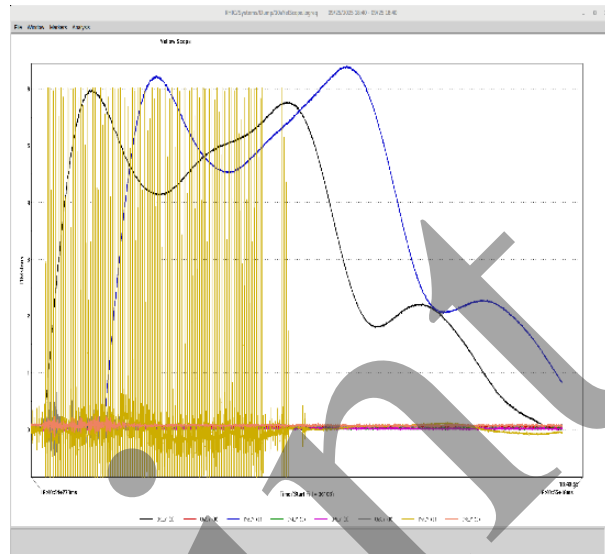


Figure 4: Two abort modules prefire during the bunch train transit.

Vacuum experts removed a large section of the piping in the area to expose the vacuum flange and allow a welder to make an incredibly precise repair. The subsequent reassembly and pump down resulted in a total of 11 days of downtime and can be seen as the second plateau in Fig. 2.



Figure 5: Pin hole breach of the vacuum flange for the beam absorber.

### POLARIZED PROTON RUN

The machine was reconfigured for proton operation on Dec 10, 2025, and reached physics production levels on Dec 12. The sPHENIX program specifically called for maximum luminosity while maintaining polarization, but no figure of merit was cited. This enabled pushing proton intensities to the highest levels of RHIC's lifetime ( $240e9/\text{bunch}$ ). On Jan 20, 2026, the polarized proton run finished, with luminosities double that of the maximum projection in Fig. 6.

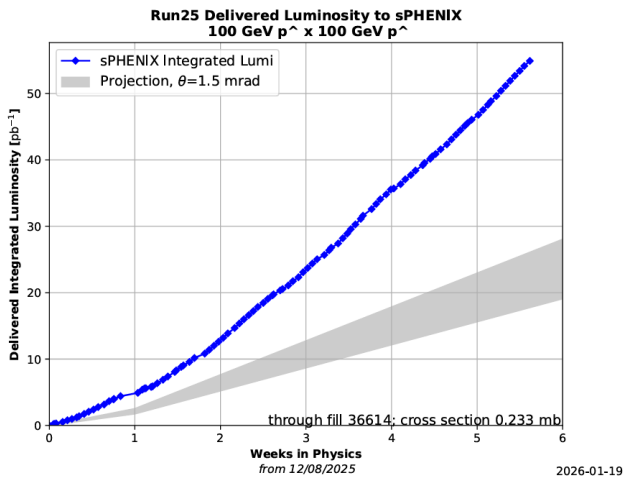


Figure 6: sPHENIX delivered luminosity for the proton run.

### AU FIXED TARGET RUN

On Jan 23, 2026, the complex was reverted to Au operation for fixed target running at STAR, utilizing the yellow beam and a target assembly installed in 2022 in the lower portion of the interaction area beampipe. After a 3-hour setup period the program began using 9.8 GeV gold beam (nominal RHIC injection energy). Three days later the configuration was changed to 8.65 GeV by lowering the extraction energy from the injectors. Thirty hours after that the machine was changed to have a short energy ramp to 13.5 GeV. The fixed target run completed on Jan 30, 2026, with STAR meeting all their data targets. Total events are in Fig. 7.

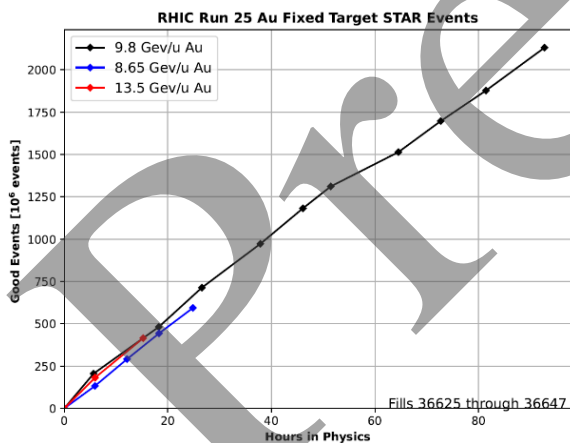


Figure 7: STAR fixed target data events for all three energies.

### OXYGEN RUN

Operations for the final RHIC run were extended roughly 1.5 months past the original planned ending date and a final week of Oxygen collisions at 100 GeV was added for both experiments. With setup completed in 24

hours and 6 planes of stochastic cooling available (the lowest Z ion ever attempted for cooling at RHIC) five days of physics resulted in the delivered luminosity of Figure 8.

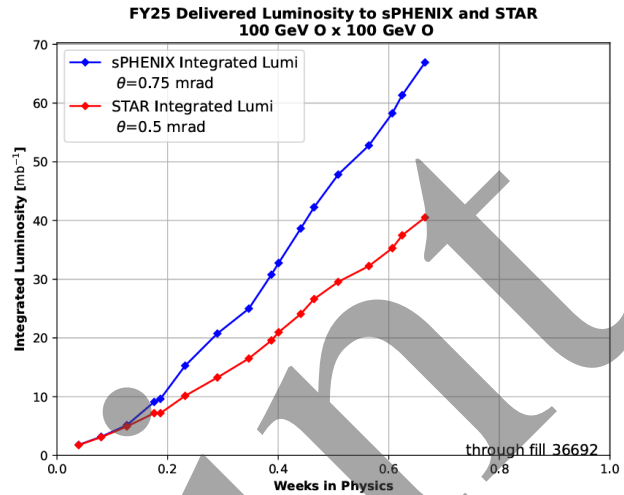


Figure 8: Delivered oxygen luminosity to STAR and sPHENIX.

### COMPLETION OF THE RHIC PHYSICS PROGRAM

At 0900 on Feb 6, 2026, the final beam was dumped, concluding 27 calendar years of beam operations at RHIC.

### ACKNOWLEDGEMENTS

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### REFERENCES

- [1] K. Hock *et al.*, "RHIC Au operation in Run24", in *Proc. IPAC'25*, Taipei, Taiwan, Jun. 2025, pp. 264-266. doi:10.18429/JACoW-IPAC2025-MOPM001