

Recommendations of the Nuclear and Particle Physics Program Advisory Committee
Brookhaven National Laboratory

August 1, 2024

The Program Advisory Committee (PAC) convened online for a half day on August 1, 2024. The following is the report of the PAC at the time of the meeting. The Agenda of the Online PAC Meeting and the list of members of the BNL Nuclear and Particle Physics Program Advisory Committee are appended below the report.

At the time of the PAC meeting, C-AD had delivered 75 pb^{-1} of pp to sPHENIX, with sPHENIX collecting 45 pb^{-1} of calorimeter-triggered data within a $\sim 50 \text{ cm}$ vertex at zero crossing angle. To accomplish its pp physics goals sPHENIX has stated they need to collect 45 pb^{-1} within a 10 cm vertex, with all detectors in operation. The sPHENIX TPC was not included in the data stream due to sparking of the GEM readout and since has added isobutane as a quencher. At the meeting, sPHENIX stated it needed two weeks of commissioning with all detectors (until mid-August) prior to beginning data-taking at high rates with pp with all detectors in operation. At that point the PAC concurs with RHIC pp operation at 1.5 mrad crossing-angle and maximum luminosity, with $1\text{-}2 \text{ pb}^{-1}$ expected to be sampled per week.

A change-over to AuAu for three weeks at the end of Run 24 should allow commissioning and operation of the TPC and the MVTX for AuAu. This scenario will require close coordination with C-AD, as during the same three weeks they will be initiating operation of the RHIC 56 MHz cavities and operation of the DX magnets at full field. A minimum of three weeks AuAu operation in Run 24 is absolutely essential to ensure optimal operation of RHIC and sPHENIX in Run 25. (This statement holds regardless of the state of readiness of the sPHENIX TPC, because of the importance of the RHIC 56 MHz cavities and DX magnets and the sPHENIX MVTX for AuAu running. That said, it is certainly preferable for the sPHENIX TPC to be operational during the three weeks of AuAu operation so as to complete the commissioning of sPHENIX for AuAu operations.)

Given the above scenario (data-taking at high rates with pp with all sPHENIX detectors in operation beginning in mid-August; a minimum of three weeks AuAu operation at the end of Run 24), sPHENIX with all detectors in operation would sample the full luminosity in pp with the calorimeter trigger to reach 4.5 pb^{-1} (10% of the initial goal) for high p_T J/ψ and $Y(nS)$ production, jet substructure and high p_T charged hadrons. We were pleased to learn that utilizing the streaming readout would allow recording sufficiently many fully reconstructed open heavy flavor hadronic decays that this element of the sPHENIX pp program may be achieved even with this reduction in integrated luminosity. Unfortunately, an integrated luminosity of approximately 10% of the initial goal limits the p_T range of the quarkonium and charged hadron observables. However, in this scenario it is anticipated that analysis of those jet substructure observables that can be measured calorimetrically (without TPC data), including for jets selected via association with a photon, will

not be compromised as the total integrated luminosity for photon+jet events without and with the TPC in operation will be larger than the initial goal.

No physics goals of sPHENIX are intended to be met with the three weeks of AuAu running in Run 24; the purpose of this is commissioning sPHENIX and operating the RHIC 56 MHz cavities and DX magnets with AuAu running.

As of this PAC Meeting, STAR has sampled 67.6 pb^{-1} pp luminosity with $P^2L = 20.8 \text{ pb}^{-1}$ for cold QCD physics. STAR data taking has gone smoothly when beams are available, however a decision by the ALD to provide sPHENIX with the highest luminosity in approximately the first 40 minutes of each fill prior to start of collisions in STAR has resulted in about 20% reduced luminosity for STAR. STAR has collected 1.5 B minimum-bias and 1.5 B high-multiplicity triggered events with the lower luminosity thus far. To meet their pp physics goals, STAR has proposed to sample 170 pb^{-1} with $55 \text{ pb}^{-1} P^2L$ for cold QCD pp physics. STAR has requested an increase in the delivered pp luminosity and data collection time to STAR. If only three cryo-weeks of AuAu are available STAR expects to take 1 B minimum-bias events for physics, with anything less useless. STAR also requested pAu for 6 weeks, but the PAC does not foresee that during Run 24, unless the run is further extended.

In any scenario, the PAC recommends continued high luminosity pp running until either the integral luminosity requirements of both experiments are met or until the last three weeks of the run, at which time a switch to AuAu will be required to ensure all tests are completed in preparation for successful operation in Run 25. The PAC recommends that C-AD work to place STAR in the data stream as soon as possible during RHIC pp fills, in order to increase their data collection and sampled luminosity to meet their goals, while imposing as little impact as possible on sPHENIX data-taking.

If by mid-August (8/19) it is found that the TPC is not yet operational at high luminosity, the tracking capability of sPHENIX will be severely limited. However, data-taking with the silicon tracker at 100% streaming will still be possible although with limited track resolution. In order to complete the heavy flavor hadron component of the sPHENIX pp program and many elements of the sPHENIX jet physics program, a minimum of four weeks of high luminosity pp data-taking is necessary. In this circumstance, the best course of action as of 8/19 would likely be for sPHENIX to be given additional time to implement their full detector suite, including the TPC, before beginning the four weeks of high luminosity pp data-taking. This might require BNL to seek additional resources to extend Run 24 to allow four weeks of high luminosity p+p data taking with the full array of sPHENIX detectors as well as the three weeks of AuAu running that is absolutely essential for commissioning and preparation for Run 25.

The PAC anticipates that more information will become available on or after 8/19 with regard to the sPHENIX TPC readiness with high luminosity pp than at the time of this PAC meeting. Depending upon further developments with the sPHENIX tracking, TPC and MVTX, some of the recommendations above may require further optimization.

STAR has requested 5-6 weeks of pAu to fulfill their overall physics goals. This will need to be addressed in considerations for Run 25. Revisiting this request and considering it as a possibility for the end of Run 24 could come into play only if some exceptional and unforeseen circumstance were to preclude AuAu running at the end of Run 24, an unfortunate scenario that would compromise the ability of C-AD to prepare RHIC for Run 25.

The PAC expects to be in close communication with the ALD as the remainder of Run 24 develops.

The PAC thanks the spokespersons and collaborations for their responses to the charge and their presentations. The response to the charge of the C-AD chair and associates was important and appreciated by the PAC.

Agenda of PAC Zoom Meeting

Thursday, August 1, 2024 (10 AM – 1 PM)

10:00 Executive Session (Information and Questions) - PAC & ALD (30 m)

10:30 Report from CAD on RHIC Run 24 (25+5 m)

11:00 RHIC Run 24 Operation and Physics Update from sPHENIX (30+15 m)

11:45 RHIC Run 24 and Physics Update from STAR (20+10 m)

12:15 Executive Session Discussion - PAC & ALD (30 m)

13:00 Adjourn

Note that there is no closeout. The goal is to assess how Run 24 is progressing and its impact on this and next year's RHIC physics program. The PAC will discuss with the ALD and will be prepared to make recommendations to the ALD, if necessary, on a path forward to accomplish and complete the RHIC physics program. If needed a short document will be distributed to the ALD, CAD and Collaboration spokespersons.

2024 BNL Nuclear and Particle Physics Program Advisory Committee

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