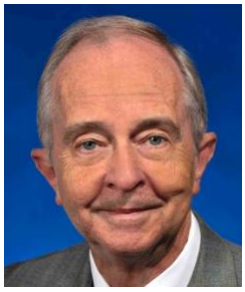
From the ALD's Desk
RHIC News Bulletin Update

October 2020



Much has happened in the twelve months since the last edition of the RHIC Bulletin. On the positive side, the Electron-Ion Collider received Critical Decision 0 (Mission Need) by the U.S. Department of Energy, and Brookhaven National Laboratory was selected as the site of the future EIC. The second run of the three-year precision beam energy scan (BES-II) of RHIC was successfully completed thanks to flawless performance of the new low-energy RHIC electron cooling (LEReC) system. The upgrade of the STAR detector and the construction of the new sPHENIX detector are making excellent progress. On the negative side, the world had to grapple with the impact of the COVID-19 pandemic, which is still with us and has deeply changed how we work and live. In the second half of March 2020, the Lab transitioned for to a "min-safe" status in which only mission critical activities were maintained. Although on-site operations were stepwise resumed starting in mid-June, still only approximately one-half of the Lab's staff works on site on any given date, and access to BNL for guests and users remains severely curtailed.

On a personal note, I will be stepping down from my role as Associate Laboratory Director for Nuclear and Particle Physics after eight years at the end of 2020. We can all be proud of what has been accomplished during this period: The RHIC program is secure until its final planned run with sPHENIX in 2025. The past few years have seen one record achievement of the RHIC facility after another. The isobar comparison run and the ongoing precision beam energy scan are just two examples. RHIC's versatility and its ability to address novel questions as they arise are unprecedented and unsurpassed for any collider. The next few years will witness another set of targeted studies that will illuminate fundamental aspects of QCD, such as: Is there a critical point in the QCD phase diagram? What is the dynamics of spinning partons? At what scale does the "perfect fluidity" of the quark-gluon plasma arise? We all are looking forward to answers to these exciting questions. RHIC will provide them.

RHIC: Run-20 was the second run in the three-year Beam Energy Scan II (BES-II). Following the 2019 PAC recommendations, the plans for Run-20 were:

- Collider runs of Au+Au at $\sqrt{s_{NN}}$ = 11.5 GeV.
- Collider runs of Au+Au at $\sqrt{s_{NN}}$ = 9.1 GeV with electron cooling (LEReC).
- Fixed-target Au+Au collisions with $\sqrt{s_{NN}}$ = 3.5, 3.9, 4,5, 5.2, 6.2, 7.1 and 7.7 GeV (the 7.1 GeV run is parasitic to the CeC experiment).
- Eight days of running for the Coherent Electron Cooling (CeC) experiment.

All the goals for the run were achieved and, in several cases, exceeded.

This year, electron cooling with RF accelerated electron beams was used to cool beams transversely and longitudinally in both RHIC accelerators and then successfully applied during colliding beam operations at $\sqrt{s_{NN}}$ = 9.2 GeV. All Ultimate Performance Parameters (UPPs) for the LEReC project were achieved including demonstration of a factor of four increase in luminosity compared to luminosity delivered during the Beam-Energy Scan Phase-I Physics program (BES-I).

Run-20 was particularly challenging due to the COVID-19 pandemic and operation of the accelerators over the summer. Despite challenges, the collider supported 10 operating modes in total consisting of 2 colliding modes, 6 fixed target modes (+1 parasitic to CeC) and interspersed Coherent Electron Cooling experiments. At the very end of Run-20, optimization of RHIC operating parameters with electron cooling of Au+Au at $\sqrt{s_{NN}}$ = 7.2 GeV demonstrated a 50% improvement in integrated luminosity compared to commissioning results from Run-19.

For Run-21 the highest priority is completion of the BES-II program with Au+Au at $\sqrt{s_{NN}}$ = 7.2 GeV. The CeC experiment will also continue. Under consideration as well are Au+Au at $\sqrt{s_{NN}}$ = 17.1 GeV and O+O at $\sqrt{s_{NN}}$ = 200 GeV. These additional run components will be subject to funding and speed of completion of the lowest energy BES-II collider run.

PHENIX: Four years after PHENIX completed data taking the collaboration continues to present and publish new results from the large datasets accumulated during the last years of operation. This year, four new papers came out and another four manuscripts were submitted for peer review. One of the published papers gives a comprehensive overview of J/Ψ production in small systems probing cold nuclear matter effects. At QM2019 in November 2019, PHENIX introduced new preliminary data on low-p_T direct photon emission from Au+Au data taken in 2014. The data show large direct photon yields that scale universally with the event multiplicity, confirming previously published PHENIX results. In addition, the collaboration is now fully engaged in a data analysis and data preservation effort through a publicly accessible webpage to retain current data analysis knowledge for possible future analyses.

STAR: Run-20, which continued the BES-II, was very successful for STAR, with data at $\sqrt{s_{NN}}$ = 11.5 GeV and 9.2 GeV in collider mode and 3.5, 3.9, 4.5, 5.2, 6.2, and 7.7 GeV in fixed target mode collected. In Run-21 we plan to complete the BES-II program with the goal of recording data at 7.7 GeV in collider mode. The BES-II data are the first to utilize the increased acceptance and momentum resolution resulting from the upgraded TPC and the newly installed EPD and eTOF.

Many important steps have been completed in preparation for our forward physics program. We completely reorganized the Forward Calorimeter System (FCS) production chain due to COVID-19. All parts required to assemble and instrument the FCS are now in hand. More engineers were hired at Shandong University to speed up sTGC module production process. Plans to streamline production the Forward Silicon Tracker (FST) are in place in order to create more schedule float. Recently we had a successful ALD's review of the STAR forward upgrade. All this means we are on track for first data taking in Run-22. What was missing this year is the opportunity to train our undergraduate students via

hands-on research even though we tried our best to get some local graduate students trained.

So far, in 2020 STAR has published 13 papers with 9 others in journal review. These include publication of the first quantitative s-sbar symmetry test using hypertriton and antihypertriton. No deviation from expected exact matter-antimatter binding energy symmetry is observed. We experimentally discovered the Breit-Wheeler process and vacuum birefringence using electron-positron pairs produced from linearly polarized quasi-real photons. We reported the first nuclear modification measurement of inclusive charged jet production in Au+Au collisions at top energy and the first jet substructure measurements in p+p collisions at 200 GeV. Our first measurement of charmed baryons in Au+Au collisions suggests hadronization via coalescence for charmed hadron production. For the critical point search, the measurement of net-proton high moments from the BES-I data shows non-monotonic variation as a function of collision energy.

Finally, congratulations go to Bedanga Mohanty (NISER, India) for being elected an APS Fellow and James Daniel Brandenburg (BNL) for being awarded the Nuclear Physics A Young Scientist Award at QM2019.

sPHENIX: sPHENIX has progressed enormously since the last news Bulletin. Just prior to QM'19 in Wuhan, the collaboration held its second "sPHENIX in Asia" meeting, this time at Fudan University in Shanghai, China, including a tour of their impressive sPHENIX EMCal factory. Tungsten/scintillating fiber blocks from the Fudan production are being shipped to the production center at UIUC and have been successfully tested there. The collaboration was well represented at QM'19, with a talk on heavy flavor by Yuanjing Ji (LBNL/USTC) and 20 posters on sPHENIX physics and technology.

The collaboration now comprises 80 institutions and more than 300 collaborators, with a significant rise in the number of students and postdocs. More than 50 collaborators took part in an intensive week-long software and computing “workfest" in January 2020 with the goal of improveing the software for track reconstruction and detector calibration. The sPHENIX participants were joined for the week by five guests from the ALICE and ATLAS collaborations, who shared their expertise.

The collaboration has continued to make progress in spite of the limitations imposed by the COVID-19 pandemic. sPHENIX detector components are being produced and delivered to BNL from collaborating universities, national labs and commercial vendors. Sectors of the Electromagnetic and Hadronic Calorimeters are coming off the production lines and undergoing their final tests at BNL. Major components of the TPC, Silicon Pixel and Silicon Strip detectors are being assembled at various international sites. Components and boards for production electronics are in test at many collaborating institutions. Cryogenics is being installed in the 1008 experimental hall at RHIC in preparation for the operation of the sPHENIX superconducting solenoid. All this work is in anticipation of the start of sPHENIX assembly in the spring of 2021, and first RHIC collisions in sPHENIX in early 2023.

CeC Experiment: The goal of the Coherent electron Cooling experiment in Run-20 was to demonstrate that (a) the mechanism of plasma cascade amplification in the Terahertz

frequency regime works as predicted for the newly designed electron beam transport system, (b) that the noise level in the electron beam is sufficiently low to permit a demonstration of amplification of an imprinted signal, and (c) that a co-propagated ion beam leaves an observable imprint on the electron beam. All three objectives were accomplished during the run. The CeC setup is now poised to demonstrate longitudinal cooling of the ion beam during Run-21.

RHIC@20 Celebration: On June 12, 2020 a celebratory session commemorating the 20th anniversary of the first Au+Au collisions at RHIC was webcast on the BlueJeans platform. After an introduction by ALD Berndt Mueller, Thomas Roser reviewed two decades of RHIC machine operations; Abhay Deshpande summarized the achievements of the RHIC Spin program; and John Harris gave an overview of the insights from 20 years of RHIC heavy ion collisions. The presentations can be found at *https://indico.bnl.gov/event/8575/.*

RHIC/AGS Users Meeting: The annual RHIC/AGS Users Meeting will be held remotely on October 22-23, 2020; see the meeting Website *https://www.bnl.gov/aum2020/* for details. As customary, the Thesis and Poster awards will be presented during the plenary session on Friday afternoon.

PAC Meeting: The annual RHIC/AGS Program Advisory Committee Meeting was held remotely on September 10-11, 2020. The PAC made the following recommendations for Run-21:

1. Accumulating the required data at $\sqrt{s_{NN}}$ = 7.7 GeV (~100M events) needed to complete the BES-II program is the highest priority for Run 21. The PAC commends C-AD for successfully improving the beam performance to enable the collection of the $\sqrt{s_{NN}}$ = 7.7 GeV data within 15-20 weeks.
2. The PAC concurs with the STAR prioritization that the second priority for Run 21 is to undertake fixed-target measurements at four energies for one week in total.
3. The PAC considers the proposed one-week O+O run at $\sqrt{s_{NN}}$ = 200 GeV (aiming to record 200M central events) and the proposed 2.5-week Au+Au run at $\sqrt{s_{NN}}$ = 17.1 GeV (for 250M events) both to be important to the RHIC scientific program.

The PAC also endorses the opportunity to collect important transversely polarized pp data at $\sqrt{s}$ = 510 GeV in Run 22.

The PAC further confirmed that the commissioning of the sPHENIX detector, and data-taking with sPHENIX are highest priority for Runs 23 – 25. It also endorsed STAR running in Runs 23 and 24.

RHIC One-Day Site Visit: The DOE Office of Nuclear Physics held a virtual One-Day Site Visit to BNL on September 15, 2020. In its close out notes the DOE team noted that "RHIC has delivered an impressive record of achievements of meeting or exceeding challenging physics goals. This has continued in 2020 with electron cooled beams and difficult running conditions due to COVID-19 and operations during the summer months. Congratulations on another successful year."

The DOE team also thanked BNL as well as STAR and sPHENIX for skillfully navigating the many and varied challenges through the COVID-19 pandemic. Last but not least the DOE team positively acknowledged the establishment of the peer counselor program as it can provide a conduit for airing concerns and finding solutions.

EIC News: Following a very positive evaluation of the BNL proposal for an Electron-Ion Collider facility, DOE selected Brookhaven in January 2020 as the future site of the EIC. The site selection was preceded by Critical Decision Zero (CD-0) establishing Mission Need. The cost range for the new facility was estimated as $1.6 – 2.6 billion. In communicating the decision, DOE expressed the strong desire that the facility will be constructed and, in the future, operated in close partnership between Brookhaven and the Jefferson Lab. The two laboratories codified their intent in a partnership agreement signed by the two Laboratory Directors.

In order to facilitate an efficient management of the EIC project, BNL formed a new directorate with Project Director Jim Yeck as the Associate Laboratory Director effective April 1, 2020. A number of C-AD staff members transferred to the new directorate and are now working intensely, together with experts from the Jefferson Lab, on preparations for Critical Decision 1 (CD-1), which will approve the conceptual design of the facility. A CD-1 review is planned for January 2021 with CD-1 expected in the third quarter of FY 2021. A review assessing various design concept alternatives was held in August 2020; it concluded with the selection of strong hadron cooling as the preferred option for achieving high luminosity.

The EIC Users Group is engaged in a community wide "Yellow Report" process that aims to identify technical requirements for EIC detectors and technical approaches that can satisfy them. In parallel, the EIC project has called for "Expressions of Interest" by institutions interested in contributing to the construction of EIC detectors. While the EIC project only comprises plans for a single detector, discussions about the complementarity and scientific value of a possible second detector, which would not be part of the project, are ongoing. A call for detector proposals by the EIC project is expected to be issued in Spring 2021.