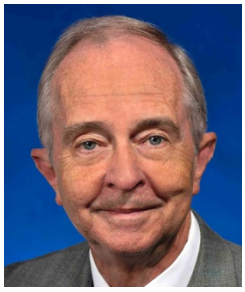
From the ALD's Desk
RHIC News Bulletin Update

October 2019



A few days before the *Quark Matter 2019* conference in Wuhan (China) it is a good moment to look back at the 2019 RHIC run and forward to next year's run. Run-19 was again one marked by "firsts" and superlatives: RHIC operated smoothly in 11 different modes, far exceeding last year's record of 6 modes, an achievement unparelleled in any collider. The low-energy RHIC electon cooling facility was successfully commissioned at two energies and demonstrated simultaneous cooling of all bunches of both store ion beams, also world's first. The leaders of the STAR iTPC upgrade (Flemming Videbaek) and the LEReC project (Alexei Fedotv) were awarded DOE Appreciation certificates, honoring both teams for their outstanding performance. All the while, the eRHIC design team worked feverishly on completing an update of the BNL EIC pre-conceptual design report, successfully passed an external cost and schedule review, prepared for the Independent Cost Review that was held in May/June in preparation for CD-0 and formulated a response to the six criteria DOE had established for the assessment of possible sites of the EIC. The outstanding performance of RHIC, now entering its twentieth year of operations with vastly enhanced capabilities, helps to underpin Brookhaven's EIC proposal.

<u>RHIC:</u> Run-19 was the first run in the three-year Beam Energy Scan II (BES-II). Following the 2018 PAC recommendations, the plans for Run-19 were:

- Commissioning of LEReC for Au+Au collisions with $\sqrt{s_{NN}}$ = 7.7 GeV and 9.1 GeV.
- Collider runs of Au+Au at $\sqrt{s_{NN}}$ = 19.6 and 14.5 GeV.
- Fixed-target Au+Au collisions with $\sqrt{s_{NN}}$ = 3.9, 4.5, 7.7 GeV.

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

In Run-19 the collider increased the number of operating modes to an unprecedented 11 total, demonstrating the unmatched flexibility of the machine. The 11 modes, all with Au beams, consisted of five colliding modes, four fixed target modes, and two modes for the commissioning of bunched electron beam cooling. Modes were frequently run interleaved with up to two mode changes per day.

Also in Run-19, electron cooling with RF accelerated electron beams was demonstrated by the Low Energy RHIC electron Cooling (LEReC) team – the first such demonstration in the world. Cooling with RF accelerated electron beams is novel and opens the possibility of electron cooling at much higher beam energies. Previous electron coolers used DC beams accelerated electro-statically. The achievable electrostatic voltage limit sets a limit for the beam energies that can be cooled with DC beams; RF accelerated, bunched beams do not face such a limit.

For Run-20 we anticipate again up to ten different modes, with two colliding and six fixed target modes for the BES-II. Most notable we are planning to operate with the commissioned LEReC at one of the two colliding energies in physics.

PHENIX: The PHENIX collaboration continues to publish new results. Since the last March, six papers including two *Physical Review Letters* were published. One of these reported a scaling behavior for the yield $dN/d\eta$ of direct photons with low transverse momentum over a variety A+A collision systems for all centralities and wide range of collision energies. The yield of direct photons in A+A collisions is enhanced by an order of magnitude compared with the yield scaled from p+p. collisions. This enhancement is considered to be caused by thermal emission from the hot quark-gluon plasma formed in A+A collisions. The scaling behavior suggest that the most photons are emitted at the phase boundary. The other PRL reported suppression of the transverse single spin asymmetry (TSSA) A_N in p+Au collisions. This is a very surprising result since the data clearly disfavor the A-dependent hypothesis of the origin of single spin asymmetries.

STAR: Run-19, which initiated the BES-II, was very successful for STAR, with data at $\sqrt{s_{NN}}$ = 19.6 GeV and 14.6 GeV in collider mode and 3.2 GeV and 3.0 GeV in fixed target mode collected, as well as several other smaller datasets. In Run-20 we will continue the BES-II with the goal of recording data at 8 additional energies. These 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 recently heard that the NSF has approved funding for the FCS, and during the summer shutdown the first forward upgrade detector, the EM Calorimeter was installed. Platform modifications, critical prior to the HCAL installation next summer, were also completed. All this means we are on track for first data taking in FY22. The summer also saw STAR collaborators continuing their strong tradition of training students, including undergraduates, via hands-on research. While many worked on projects at their home institutes others, including some majoring in engineering, had the opportunity to visit BNL, visit STAR, and work directly on hardware related to the Forward Upgrade.

So far in 2019 STAR has published 15 papers with 6 others in journal review. These include publication of the first inclusive and di-jets measurements at 500 GeV providing important constraints on ΔG, especially at in the previously largely unconstrained region of $x < 0.05$. Others reported the observation of polarization of the Lambda hyperon along the beam direction, of directed flow of charmed mesons with the HFT, and of J/ψ from photoproduction in non-central heavy-ion collisions. Results on the J/ψ, our first MTD publication, extended the reported kinematic reach at RHIC and suggest that at high p_T the observed strong suppression is the result of color screening in the medium with little to no c-cbar recombination.

Finally, congratulations go to Bernd Surrow (Temple) and Saskia Mioduszewski (Texas A&M) for being elected APS Fellows, and Isaac Upsal (BNL) for being awarded the DNP Thesis prize for his PhD work at OSU on vorticity in the QGP.

sPHENIX: The sPHENIX project received Project Decision-2/3 approval by BNL in September 2019. The PD-2/3 approval sets the cost and schedule baseline for sPHENIX and officially authorizes the start of construction.

Efforts are ramping up on various aspects of sPHENIX R&D, prototyping and the beginning of construction. Work is proceeding both at BNL and collaborating institutions all over the world. The BNL team completed the fabrication of a number of preproduction components of sPHENIX over the last few months. The preproduction fabrication includes a full size 384-tower Electromagnetic Calorimeter (EMCal) sector and six full-size Outer Hadronic Calorimeter sectors. Much work is also under way at collaborating institutions:

- The construction of a full-size Time Projection Chamber (TPC) prototype for sPHENIX is ongoing in the Stony Brook University Physics Department.
- The University of Illinois group has started building EMCal towers for the final detector.
- Columbia University is working on a large quantity preproduction build of calorimeter electronics.
- Final preparation is underway at the University of Sao Paulo (Brazil) for the manufacture of custom electronics chips to be used by the TPC.
- The TPC electronics chips will be tested at the University of Lund (Sweden) before coming to BNL for assembly onto the electronics boards.
- Scientists and students at the University of Michigan and Debrecen University (Hungary) have started testing the tens of thousands of Silicon Photomultipliers being manufactured in Japan for sPHENIX.
- Collaborators from Georgia State University, Wayne State University and Vanderbilt University are building and testing various sPHENIX detector components.
- RIKEN is building layers of a silicon strip detector in Japan.
- R&D is ongoing at MIT, LBNL and LANL on a silicon pixel detector that would enhance the sPHENIX science mission.

CeC Experiment: The Coherent electron Cooling experiment used Run-19 to identify the source of the unexpectedly large noise in the electron beam that thwarted the attempt to demonstrate cooling in Run-18. The CeC team showed that the noise results from the amplification of intrinsic noise during the transport in the electron beam line due to plasma instabilities. The team managed to reduce the noise by a large factor by adjusting the optics of the beam line. This opens the path for another attempt to demonstrate the principle of coherent electron cooling, this time using a microbunching amplification scheme. The CeC results from Run-19 and the plans for Runs 20 and 21 were reviewed by an outside panel of experts in September. The panel recommended to proceed with the plans while carefully monitoring the progress.

RHIC/AGS Users Meeting: The annual RHIC/AGS Users Meeting was held June 4-7, 2019 at BNL. As customary, the plenary session featured presentations from representatives of the funding agencies and high-level overview of the ongoing RHIC physics program and future plans, including Discovery Park and the Electron-Ion Collider. The 2019 Thesis Prize was awarded jointly to Jonah Bernhard (Duke U.) and Javier Orjuela Koop (U. Colorado).

PAC Meeting: The annual RHIC/AGS Program Advisory Committee Meeting was held on June 10-11, 2019. The PAC made the following recommendations for Run-20:

1. The PAC recommends a run with Au+Au collisions at $\sqrt{s_{NN}}$ = 7.7 GeV that employs LEReC cooling and yields at least 100M min bias collisions. We reiterate the assessment of the PAC from its previous two meetings that this run is the highest priority among the planned BES-II runs. This should be second in the RHIC run sequence. [If by the end of this summer the preference of the C-AD has changed such that they prefer to run $\sqrt{s_{NN}}$ = 9.1 GeV collisions with LEReC cooling in Run 20, this run -- yielding at least 160M min bias collisions, would be the first priority recommendation of the PAC, but second in the sequence, for Run-20. This is, indeed what happened: The current plan is to run $\sqrt{s_{NN}}$ = 9.1 GeV collisions with LEReC cooling.]
2. The PAC recommends a run with Au+Au collisions at $\sqrt{s_{NN}}$ = 11.5 GeV (with no LEReC cooling at this energy) that yields at least 230M min bias events. This should be placed first in the RHIC run sequence with LEReC commissioning interspersed during this run.
3. The PAC recommends 2-day runs of fixed target collisions at each of the five energies that complete the fixed target component of the BES-II program, namely $\sqrt{s_{NN}}$ = 3.5, 4.5, 5.2, 6.2 and 7.7 GeV.
4. 8 days of running for the Coherent electron Cooling (CeC) experiment, for the purpose of demonstrating the amplification of the imprint that the ion beam leaves on the electron beam.

RHIC S&T Review: The biennial RHIC Science & Technology Review by DOE was held on September 17-19, 2019. The panel was very complimentary on the scientific, technical, and operational accomplishments since the past full review, which was held in 2016. As usual, the panel made a number of recommendations. These include the requests to develop an analysis of the cost and benefits of updating versus replacing the existing cryo-system to reduce helium losses, to develop a resource loaded schedule, milestones, and risk assessment for the CeC experiment, and to consider establishing a named fellowship for underrepresented minorities.

EIC News: The past six months witnessed intense developments as DOE is proceeding with the decision process towards construction of an electron-ion collider. The President's budget request, released in March 2019, assigns $1M for an initial investment into the EIC project; the Congressional budget marks earmark additional funds for EIC R&D activities. In May/June 2019 DOE conducted an independent cost review of the proposals from Brookhaven and Jefferson Lab. This was followed by a request by DOE for responses from both labs to a set of six criteria that will be used to help assess the value of each of the two proposals to the taxpayer. These criteria are: Scientific merit, technical maturity, schedule, costs including major risks, project delivery, and value added for each site. The two labs had the opportunity to present their responses and answer questions to an eight-member site assessment panel on October 8, 2019. These events represent important milestones on the path towards CD-0 for the EIC. The funding agency has expressed the strong desire that an eventual siting decision will represent a win-win scenario for both laboratories.