

RHIC Run 10 Plan (Aug. 7, 2009)

Introduction

The RHIC/AGS Program Advisory Committee met June 15-16, 2009 to consider beam use proposals for RHIC in fiscal years 2010 and 2011. Their report is now available on the BNL NPP website:

[http://www.bnl.gov/npp/docs/pac0609/Final%20Recommendations%20\(2\).pdf](http://www.bnl.gov/npp/docs/pac0609/Final%20Recommendations%20(2).pdf)

In short, for Run 10 the PAC recommended that highest priority be given to Au+Au measurements at 200 GeV and then at 62.4 GeV, with special emphasis given to collection of dielectron spectra with good statistics before the Hadron Blind Detector is removed from PHENIX following Run 10. The PAC recommended 10 weeks of physics production time be devoted to 200 GeV and an additional 4 weeks to 62.4 GeV. Next in priority, they recommended a start on a Au+Au beam energy scan aimed at discovery of a possible critical endpoint in the QCD phase diagram. They recommended that proportionately more time be spent at the lower beam energies (especially those below RHIC transition energy), where it will take longer to accumulate a sample of several million events. Third in priority was polarized proton beam development needed for future spin runs, especially at $\sqrt{s} = 500$ GeV. For Run 11, the PAC placed a high priority on further polarized proton running at 500 GeV, and recommended that the remainder of the time be spent primarily on full-energy Au+Au and a short commissioning run for U+U collisions using the new EBIS source.

I propose detailed plans below for the RHIC FY2010 run under two different operations budget scenarios. I view these plans as consistent with the spirit, but not the letter, of the recent PAC recommendations. The differences from the PAC recommendations reflect several new pieces of information that were not available at the time of the June 15-16 PAC meeting. I describe this new information below, along with its impact on my philosophy of how to optimize the RHIC beam energy scan and polarized proton running. To help place this philosophy into a broader context, I then also include the latest version of a multi-year run plan, prepared in response to questions raised at DOE's July 22-24 Science and Technology Review of RHIC.

New Information Since the PAC Meeting

1) **Budget:** House and Senate markups of the FY10 Energy and Water Appropriations Bill both make significant cuts from the President's Request in funding for the Nuclear Physics Office, while adding a number of mandates for expenditure of the remaining funds. The impacts on RHIC operations are indirect (i.e., not mandated in the House or Senate markup language), but they make it considerably less likely that we will maintain sufficient funding for the ever-elusive 30-cryoweek run. I provide a 30-week plan below, but also one fitted to 25 weeks. If the funding is more constrained than that, the priorities below (and from the PAC) are clear. I will keep users informed of progress on the Congressional budget and its implications for RHIC operations as we learn more.

2) **PHENIX Upgrades and Optimizing the Beam Energy Scan:** I believe firmly that the impact of a RHIC beam energy scan will be enhanced if both experiments can participate fully. STAR and PHENIX tried, but failed, to work out some cooperative strategy for the beam energy scan before they submitted Beam Use Proposals for Run 10. PHENIX presently has difficulties operating usefully at energies below the RHIC transition energy, due to the combined effects of increased beam size (hence, backgrounds) and reduced collision rates (exacerbated by their presently limited acceptance) and multiplicities (hence, triggering and start time definition inefficiencies). In answers at the PAC meeting, PHENIX management left the impression that they were willing to wait until low-energy electron cooling might be implemented (possibly 2014) to address measurements at sub-transition energies. This response left the PAC a difficult decision: delay the lower energies on the beam energy scan by up to five years, or recommend significant Run 10 operation at energies where only STAR could reap benefits.

The PAC recommendation made it clearer to PHENIX management that the beam energy scan would proceed with or without their participation. PHENIX thus informed me shortly after the PAC meeting that, if sub-transition-energy running were postponed until Run 11, they would be prepared to take advantage of it. This preparation involves several changes: the planned installation of the new VTX detector before Run 11, increasing acceptance for some measurements and permitting more effective discrimination against beam-gas and beam-beampipe backgrounds; new simulation studies of possible low-energy triggering and start time definition with the existing PHENIX beam-beam counters; and, if deemed necessary, the design, construction and installation during summer 2010 of a new trigger barrel that would allow adequate start time definition at reduced multiplicities. The PAC-proposed plan included at least 7 weeks of operations during which PHENIX would be unlikely to make productive use of the collisions in their Run 10 configuration, but I think it is important to avoid such an extended period of single-experiment beam usage. I thus propose below to postpone the bulk of sub-transition Au+Au running to Run 11, while including one week of commissioning of 7.7 GeV operation in both budget scenarios.

The continuation of the beam energy scan in Run 11 will necessarily displace some or all of the PAC-recommended full energy Au+Au operation from Run 11 to Run 12. In my opinion, this is a preferred solution, since we anticipate the full stochastic cooling upgrade, including new 56 MHz SRF rebunching system, to be in place for Run 12, providing RHIC-II era luminosities for full energy operation. As a result, we will almost certainly want to highlight full energy Au+Au in Run 12.

3) **Polarized Proton Beam Development:** PHENIX proposed, and the PAC concurred, to use several weeks of beam time in Run 10 to improve beam polarization at 250 GeV. However, a far more cost-effective way to do this was to make time available at the tail end (July 4 weekend) of Run 9, when we were already running polarized proton beams, for beam studies to explore polarization transmission to 250 GeV with a near-integer tune. The outcome of those studies is that polarization transmission in that working point region is not as good as in the original Run 9 working point region near a tune of 0.67. This result is not yet understood, and demands improvements in our spin-tracking simulations. But careful measurements of 250 GeV beam polarization as a function of tune in the vicinity of 0.67 had already been made earlier in the run, and had

demonstrated that 90% polarization transmission is possible if we can operate stably at a tune of 0.675. It was not possible during Run 9 to operate stably so close to the 2/3 resonance, due to power supply glitches, especially at the transition from accelerating ramps to flat-top. Instead, we operated at a tune of 0.68, where the influence of two Snake-induced depolarizing resonances reduces the polarization transmission to $\sim 70\%$. The transmission decreases further, to $\sim 10\%$, as one increases the vertical tune to the major Snake resonance at 0.70.

As a result of the measurements already made during Run 9, we feel that we now have in hand the most promising strategy to improve performance in 500 GeV pp collisions, and it does not require (and would not benefit especially from) dedicated pp collision running in Run 10. (I remind you that *polarized* collisions will not be possible in any case during Run 10, due to ongoing repairs to one of the Siberian Snake magnets in the Yellow ring.) We are making repairs during the ongoing summer shutdown to ameliorate power supply glitches experienced during Run 9. The stability of operation at a tune of 0.675 can then be tested with Au beams during Run 10. AGS tune jump quadrupoles intended to improve polarization transmission and polarization profiles in the AGS can be tested in parasite mode behind heavy-ion stores in RHIC. These improvements should be able to get us up to 60% beam polarization for 500 GeV collisions by Run 11, with further improvements projected from polarized source enhancements in Runs 12-13.

Run 10 Plan

Anticipated overheads during Run 10 include the usual 2.5 weeks for machine cool-down and warm-up plus 2 weeks of Au+Au collision commissioning early in the run. In addition, I would like to devote 0.5 weeks to test beam stability (with gold ions) near the tune of 0.675 that we hope to run for subsequent 500 GeV p+p operation, in the wake of improvements made over the summer to power supply stability. The PAC placed the highest science priorities for Run 10 on 10 weeks of Au+Au operation at $\sqrt{s_{NN}} = 200$ GeV, followed by 4 weeks at 62.4 GeV, especially to take full advantage of the PHENIX Hadron Blind Detector for dilepton measurements before it is permanently removed following Run 10. The above items combine to account for 19 cryoweeks, leaving 6 or 11 cryoweeks to allocate to lower-energy Au+Au collisions in 25- and 30-cryoweek scenarios, respectively.

The physics production weeks allotted to each Au+Au collision energy in the two scenarios are then as follows:

$\sqrt{s_{NN}}$ (GeV) for Au+Au	# weeks in 25-cryoweek scenario	# weeks in 30-cryoweek scenario
200	10	10
62.4	4	4
39	1.0	1.5
27	2.5	4.5
18	0	1.5
11.5	1.5	2.5
7.7	1.0	1.0

Note that 11.5 GeV is an energy where collisions can be arranged for only one experiment at a time under any conditions, and its choice provides no “extra” bias during a run when PHENIX is not prepared to exploit the lower-energy collisions. In the 25-week scenario, the 2.5 weeks devoted to 11.5 GeV and 7.7 GeV represent the only time when STAR would run without PHENIX. (The 7.7 GeV run is viewed as commissioning this energy, and PHENIX can at least make useful timing measurements during this period.) In the 30-week scenario, this single-experiment operation extends to 5 weeks at energies of 18 GeV or below (again including a 1-week commissioning run at 7.7 GeV), because PHENIX is not yet prepared to make use of energies below 20 GeV. But in this scenario, PHENIX also gets its full requested time for heavy-ion collisions. A more extended run at 7.7 GeV, as needed to accumulate a significant event sample size, would be postponed until Run 11, when PHENIX will also use these collisions. In the 25-week scenario, we may also have to revisit some other low energies in Run 11. It is important to note that each energy change is likely to involve an overhead of about 2 days to reach good conditions for physics operation, and this overhead is included in the weeks specified above at all but the starting (200 GeV) energy.

Four planes of stochastic cooling (longitudinal and vertical for each ring) will be installed for Run 10, and will be commissioned early in the run. Most of the commissioning will likely be done in parasitic mode during physics stores, but it may detract slightly from available 200 GeV days early in the run. Hopefully, this commissioning will lead to enhanced time-averaged luminosities (by at least a factor of 2 over Run 7) during the latter weeks of the 200 GeV run. Further improvements should be attained during Run 12, when the new 56 MHz SRF system and horizontal stochastic cooling planes are added. As in past runs, we will continue to devote about 12 hours per week to accelerator physics experiments. An additional constraint on the time sequence of energies during Run 10 comes from the need to get accelerator safety approval for the rapid-beam-loss conditions anticipated at the lowest energies. For this reason, the lowest energies must come late during the running period.

Multi-Year Run Plan

The multi-year strawman plan I prepared after the 2008 PAC meeting was updated for the recent RHIC S&T review, to take account of new timelines for machine and detector upgrades, including acceleration of some Accelerator Improvement Projects (horizontal stochastic cooling planes and electron lenses) by stimulus funding during FY09. The revisions also take account of the new thinking about ways to improve polarized beam performance, in the wake of experience in Run 9. The table below was shown at the S&T review, and reflects present best guesses regarding upgrade availability timelines and their meshing with a science program aimed at meeting relevant DOE performance milestones for Nuclear Physics. As always, this plan will continue to be updated at least annually, taking into account the PAC’s advice, budget situations, and upgrade progress.

Year	Likely Beam Species	Science Goals	New Detector Sub-systems	New Machine Upgrades	Gain from Machine Upgrades	Comments
FY10	Au+Au at 200, 62.4 GeV + assorted lower E	Low-mass dilepton spectrum; early collision temp.; improved jet quenching studies (especially e ⁻ from heavy quarks); begin energy scan for critical pt.	STAR TOF completed; PHENIX HBD for heavy ions	Blue ring longitudinal + yellow & blue vertical stochastic cooling; yellow longitudinal cooling (μ wave link) upgrade	Factor >2 increase in average store luminosity for full energy Au+Au	Need 4-8 weeks early in run to (re)commission all 4 stoch. cooling systems, demonstrate gain in lumi. lifetime
FY11	Subinjection Au+Au; 500 GeV p+p; short 200 GeV U+U	Continue critical pt. search; gluon pol'n at low x + antiquark pol'n from W production; 1st characterization of deformation effects in U+U centrality distrib'n's	PHENIX VTX; upgraded PHENIX trigger (t0) barrel	EBIS (tandem as backup); 9 MHz cavity ; AGS tune jump quads (comm'd in Run 10); RHIC spin flipper	U beam capability; improved pp vertex distrib'n ; improved pol'n from AGS; reduced syst. errors	9MHz requires upgrade to main PS + "bouncer" cavity for both rings + longitudinal damper or Landau cavity for each ring.
FY12	Au+Au at 200 GeV; 500 GeV p+p	RHIC-II heavy-ion goals: heavy flavor, γ -jet, quarkonium, multi-particle correlations; antiquark polarizations in proton	PHENIX FVTX and μ trigger; STAR FGT + HFT prototype	Yellow + blue horiz. stoch. cooling (installed FY11); 56 MHz SRF; e-lenses; OPPIS solenoid + "proton cannon"; RHIC collimator upgrade	Full RHIC-II heavy-ion luminosity + improved vertex & store length; improved pp luminosity + polarization	Electron lens commissioning \Rightarrow Run 12 gains possible; detailed collimator upgrade plans still to be developed

FY13	200 GeV p+p; further heavy-ion running to complement earlier runs	Continue RHIC-II heavy-ion goals; transverse spin asymmetry for γ + jet (2015 spin milestone); pp reference data for new subsystems	PHENIX FOCAL?	Catchup for ambitious FY12 upgrades plan		N.B. "Proton cannon" increases pol. source current, to allow scraping to improve polarization
FY14	200 GeV Au+Au; low-E Au+ Au dictated by Run 10+ 11 results	Continue pursuit of γ + jet, energy scan and identified heavy flavor (DM10-12) milestones.	Full STAR HFT	RHIC low-E electron cooling; R&D ERL to RHIC for coherent e-cooling test	Factor of several increase in lowest-E Au+Au luminosity	Low-E cooling relies on Pelletron from FNAL in late 2011