The RHIC Mid-Term Strategic Plan
Status as of February 2008
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The Mid-Term Plan is the roadmap for the RHIC scientific agenda, machine performance, and detector upgrades during the period leading up to the high-luminosity operation with RHIC II. The plan was formally updated in the summer of 2007, and presented at the DOE Science and Technology Review of RHIC in July. This update is appended here. The details of this plan will change, in light of the FY 2008 budget appropriation. For the current RHIC run, the planned d-Au portion has been completed, but the p-p run will be truncated to ~4 weeks of physics.

For the detector upgrades, the basic elements of cost and schedule are captured in the table of funding projections, on page 7. A detailed revision of the plan is now being prepared, based on the FY 2008 funding and the guidance we are just now receiving along with the 2009 President's request. The MIE upgrades for the PHENIX detector all are affected by these budgets. The VTX project funding is reduced in FY 2008 from $2.4M to $2.0M. This project is still planned to finish in FY 2010, and we expect to have it operational for the 2011 run. The FVTX and NCC projects will start during this fiscal year as planned, but with significantly reduced initial funding. The FVTX is now planned for completion in 2011, and the NCC in 2012.

BNL's highest priority for the STAR upgrades is to complete the DAQ1000 project this year, to be in place for the FY 2009 run. Technically, this is on track. One sector of the TPC is now instrumented with DAQ 1000, and is successfully recording data during the current run. The Forward Gem Detector (FGT) is regarded by STAR as critical for the measurement of W bosons in 500 GeV spin running. It is expected to be funded from experimental capital equipment, and our plan shows a funding profile that would allow completion in 2010. Based on our assessment of the technical readiness, following a STAR internal review in January 2008, and the projections for the capital equipment budget through 2010, we expect that this project will have a somewhat less aggressive funding profile than shown in the table, but that it can be completed in time for the FY 2011 run.

We are presently planning that the HFT project will begin construction in FY 2010, a one-year delay from the schedule shown in the Mid-Term plan. As a result of the funding constraints imposed by the FY 2007 and FY 2008 appropriations, the rate of R&D funding for this project has been slowed down. The Mid-Term plan included ~1.2M of R&D funds in FY 2007-FY 2008. Given the delayed start, this funding will be distributed over the fiscal years 2008 – 2009.

The updated budget table, taking account of the FY 2008 appropriation and the FY 2009 President's Request, is shown below.

Feb. 08 update: 06 as spent; 07 as spent; 08 approp.; 09P

	FY 2006A	FY 2007A	FY 2008A	FY 2009P	FY 2010	FY 2011	FY 2012	FY 2013	
R&D funds									
PHENIX HBD	0.10								**0.10**
PHENIX MIEs	0.30	0.45	0.16						**0.91**
PHENIX DAQ	0.10	0.05	0.26	0.40	0.40	0.20	0.25		**1.66**
STAR Tracking	0.50	0.32	0.70	0.80	0.40	0.20	0.25		**3.17**
Generic Det. R&D	0.00		0.00		0.40	0.80	1.00	1.50	**3.70**
Total R&D	1.00	0.82	1.12	1.20	1.20	1.20	1.50	1.50	**9.54**
Exp. Capital									
PHENIX HBD/TOFW	0.40	0.10							**0.50**
STAR FMS	0.20	0.20							**0.40**
STAR DAQ1000	0.90	0.35	0.65	0.00					**1.90**
STAR FGT			0.20	0.75	1.00	0.00			**1.95**
Exp. Infrastr.	0.60	0.35	0.45	0.75	1.10	1.00	0.85	0.85	**5.95**
RCF	1.30	1.70	1.70	2.00	2.50	3.00	3.00	3.00	**18.20**
Total Capital	3.40	2.70	3.00	3.50	4.60	4.00	3.85	3.85	**28.90**
MIEs									
STAR TOF	2.40	2.40							**4.80**
PHENIX VTX		1.60	2.00	1.10					**4.70**
PHENIX FVTX			0.50	2.40	1.95				**4.85**
PHENIX NCC			0.20	1.20	2.10	1.00			**4.50**
STAR HFT					2.50	5.50	5.00		**13.00**
Total MIE	2.40	4.00	2.70	4.70	6.55	6.50	5.00		**31.85**

Mid-Term Plan funding table, updated February 2008

The RHIC Mid-Term Strategic Plan
Update and Status
July 11, 2007

Overview

The Mid-Term Strategic Plan for RHIC was submitted to DOE on February 14, 2006. The document can be found at:
http://www.bnl.gov/npp/docs/RHICplanning/RHIC_Mid-termplan_print.pdf
This plan lays out the scientific agenda for RHIC during the period 2006-2011. It details the projections for collider operation and the operation and growth of the RHIC Computing Facility (RCF) during this period. A key part of the plan is a detailed agenda for improvements in collider performance and upgrades to the RHIC accelerator facility, including the construction and commissioning of the EBIS injector and the R&D effort on electron cooling, leading to construction readiness for the RHIC II luminosity upgrade by the end of the mid-term period. A central part of the strategic plan is a sequence of upgrades to the PHENIX and STAR detectors. The planned R&D, construction, and implementation of these upgrades is coupled to the scientific priorities and the expected machine performance, including the anticipated RHIC II program.

The Mid-Term Plan is now being implemented. It remains the basis for BNL's budget priorities and operations planning for the RHIC program. In this document we outline the progress that has been made, and the status of the plan as we near the end of FY 2007. There have been some slow-downs due to the FY 2007 federal budget process, with an extended Continuing Resolution and subsequent reduction of funds from the levels anticipated in the Presidents budget. Nonetheless, the plan is proceeding and has full support of the user community. This support is reflected in the recommendation of the NSAC Long Range Plan working group, endorsing the implementation of the detector upgrades and the RHIC II luminosity upgrade.

Following discussions at the Long Range Plan meetings, BNL, in consultation with DOE, is considering the possibility that some funding might be redirected from operations in the out-years of this plan in order to advance the timeline for an electron cooling project to realize the RHIC II luminosity upgrade. The RHIC user community will be consulted and included in the final decision process. At this time it is too early to provide specific details. There are also promising new technical developments, regarding stochastic cooling of the RHIC beams, that may have a bearing on the means (and cost) of achieving the RHIC II luminosity (see below, under "Collider upgrades and development").

In the remainder of this document we provide a progress and status report on each of the major sections of the Mid-Term Plan document.

The Science Case

The scientific justification and goals presented in the Mid-Term Plan document were developed from the then-on-going discussion in the RHIC II Science Workshops, involving experimenters and theorists from across the RHIC community. In December

2006 these working groups completed the final white paper summarizing the results. This document, "Future Science at the Relativistic Heavy Ion Collider", is posted at http://www.bnl.gov/physics/rhicIIscience/
Prepared as input from the RHIC community to the Long Range Plan discussions, this white paper provides the scientific basis for the detector upgrades and the RHIC II luminosity upgrade, and describes the role of the RHIC program in the context of other future facilities, i.e. the heavy ion program at the CERN LHC and the low-energy FAIR facility at GSI.

Mid-Term Run Plan: update

In both 2006 and 2007 the RHIC runs fell short of the planned goal of 30 cryo-weeks per year as a result of budget issues. In FY 2006 the DOE funding was augmented by a $13M sponsored research grant from Renaissance Technology Corporation to provide a 20 cryo-week run that was dedicated to 200 GeV polarized proton collisions. In FY 2007 the six-month delay in the federal budget process, and final Continuing Resolution, again allowed only a 20 cryo-week run, which was devoted to 200 GeV/u gold-gold collisions.

In the 2006 polarized proton run, 46 pb^{-1} and 47 pb^{-1} of integrated luminosity were delivered to STAR and PHENIX respectively, at a center-of-mass energy of 200 GeV. The peak polarization reached 65%, and the average store polarization 60%.
0.35 pb^{-1} of integrated luminosity was delivered each to STAR, PHENIX, and BRAHMS at a center-of-mass energy of 62.4 GeV, with an average store polarization of 50%. For the first time ever, a polarized proton beam was accelerated to 250 GeV (c.m. energy of 500 GeV), with approximately 45% polarization at the top energy.

In the 2007 Au-Au run, 3.3 nb^{-1} in integrated luminosity was delivered to PHENIX, 3.1 nb^{-1} to STAR, and 0.6 nb^{-1} to the MonoPole test experiment. Operation at 9.2 GeV/n center-of-mass was demonstrated, with a tiny amount of luminosity delivered and some events recorded by STAR. This low-energy test run demonstrated the feasibility of an energy scan to search for the QCD critical point utilizing the STAR and PHENIX detectors from the top RHIC energy down through the energy ranges previously sampled by experiments at the CERN SPS and BNL AGS experiments.

Summary of RHIC Runs 6-7

Year	**Run Plan**	**Sample**	**Physics**
2006	pp at 200 GeV pp at 62.4 GeV pp at 250 GeV	93 pb^{-1} 60% pol 1.0 pb^{-1} 50% pol 45% pol	Long data run for spin Energy scan; reference data Test run at top pp energy
2007	Au-Au at 200 GeV/A Au-Au at 9.2 GeV/A	6.5 nb^{-1} few x1000 events	High-statistics run at top energy Au-Au Test run for Critical Pt. Search

(The Sample column shows delivered luminosity summed over PHENIX and STAR)

Runs of 30 cryo-weeks per year (approximately 22 physics weeks) are planned for the remainder of the Mid-Term period. Multi-Year Beam Use proposals for PHENIX and

STAR were last reviewed by the the Laboratory's Nuclear and Particle Physics Program Advisory Committee in March 2007. The PAC recommendations for run plans through 2010 are:

> Run 8: 10 weeks (physics) dAu at 200 GeV, plus 12-13 weeks (physics) polarized pp at 200 GeV;
> Run 9: 10 weeks (physics) of AuAu at 200 GeV, plus 12 weeks (physics) polarized pp at 200 GeV and/or 500 GeV; and
> Run 10: 14 weeks (including time for changes of beam energy) of AuAu at a variety of lower collision energies dedicated to a search for the QCD critical point, followed by 8 weeks (physics) of polarized pp at 500 GeV.
> The specific splits and collision energies suggested for Runs 9 and 10 are contingent on the performance and achievements of Runs 7 and 8 and should be revisited at the appropriate time.

Collider performance projections

In full-energy Au-Au operation some improvements over the achieved average store luminosity of $12\times10^{26}cm^{-2}s^{-1}$ are still possible. However, these will be much smaller than in the past. With no polarized proton operation in 2007, we now plan to reach the Enhanced Design luminosity for polarized protons ($60\times10^{30}cm^{-2}s^{-1}$ average per store at 100 GeV beam energy), and an average store polarization of 70% in 2009, assuming a long polarized proton run in both 2008, and 2009.

Collider upgrades and development

The Enhanced Design luminosity goal of $8\times10^{26}cm^{-2}s^{-1}$ for Au-Au operation at 100 GeV was exceeded in Run-7, with average good stores at $12\times10^{26}cm^{-2}s^{-1}$. The polarized proton luminosity in Run-6 reached $20\times10^{30}cm^{-2}s^{-1}$ (at 100 GeV beam energy, average per store), and the average store polarization 60%. The calendar time in store in both Run-6 (46%, including 1 week shut-down due to an arc flash incident) and Run-7 (48%) was lower than in Run-5 (52%), and lower than the goal of 60%.

EBIS construction has started and CD4 is scheduled for FY 2010.

The feasibility of electron cooling of the 100 GeV/n RHIC gold beams (RHIC II luminosity upgrade) has been established through benchmarked simulations, and by assessing the ability to reach the parameters needed in the critical components. We expect a CD-0 decision for the RHIC II project for early 2008 and it could be completed by 2013. The progress of the test ERL was slowed by about one year due to delayed funding.

The operation of a longitudinal stochastic cooling system in the Yellow ring has been very successful. The Blue system is under construction. Initial simulations indicate that further significant luminosity increases are possible for heavy ions with both longitudinal and transverse stochastic cooling in RHIC. While there is still more R&D to do, it appears that such an enhancement could be accomplished with the construction of four additional transverse systems. At this early stage, we estimate the total cost of the full implementation of stochastic cooling in RHIC to be in the range of $10-20M. Stochastic cooling in RHIC will certainly complement the planned electron cooling. However, it is

too early to judge whether it could match the performance of electron cooling. The development of an ERL will continue, to ensure a path for meeting the performance requirements of RHIC II and eRHIC.

The AGS main magnet power supply transformer replacement is underway. After delays, partly due to uncertain funding in both FY2006 and FY2007, completion is now expected for 2008. Replacement of cables and cable trays in the AGS has started, with $1M of operating funds in FY2007. This needs to be increased to approximately $2M/year to finish this upgrade in about 5 years. A newly installed turbine decreased the power consumption of the liquid helium refrigerator by 1 MW. Two of the six RHIC service buildings were outfitted with air conditioning systems to reduce the impact of heat and humidity, and thus improve the reliability of equipment.

The design of the electron-ion collider eRHIC has focused on the linac-ring option, which can deliver the required luminosity performance. On a technically limited schedule eRHIC construction could start in 2013.

Status of the RHIC detector upgrades

The detector upgrades are listed here in the order shown in Table 6-1 of the Mid-Term Plan document. The costs listed here do not include expenditures prior to FY 2006. An updated summary table of costs and schedule is given below.

STAR Forward Meson Spectrometer (FMS) [$0.5M cap. equip.]

Status: Complete. Commissioned in Run 7. Ready for full operation during the d-Au run planned in Run 8.

STAR DAQ 1000 [$1.8M cap. equip.]

Status: A protracted negotiation of the agreement to purchase CERN ALTRO/PASA chips delayed the project ~1 year. This issue is resolved and the project is moving forward. A review by BNL management in March 2007 found that the plan to complete the project in time for RHIC Run 9 is technically feasible, but the project may be slowed due to budget constraints in FY 2007. A full TPC sector will be equipped with DAQ 1000 readout for Run 8.

STAR Time of Flight (TOF) [$4.8M MIE constr.]

Additional in-kind funding contribution from China.

Status: Construction began in December 2005. The project is on track for completion in FY 2010. Five of the 120 TOF modules will be installed for Run 8. It is expected that ~1/2 of the modules will be installed for Run 9, with full implementation in Run 10.

STAR Inner Tracker Upgrade [proposed MIE constr. ~$14M]

Status: Following a year of design studies by the STAR collaboration, and two reviews by BNL management, an integrated design has been developed for a

precision vertex detector using an innermost detector based on CMOS Active Pixel Sensor technology (the Heavy Flavor Tracker described in the Mid-Term Plan document) surrounded by two layers of conventional silicon strip detectors. A proposal for an MIE construction project will be submitted to DOE during the summer of 2007, aiming for a construction start (CD-3) early in FY 2009, and a completed detector in time for Run 12.

STAR Forward GEM Detctor (FGT) [$1.8M cap. equip.]

Status: A design is being finalized for an array of GEM discs forward of the collision point in STAR, subtending the aperture of the EndCap Calorimeter. The primary purpose of this array is to allow determination of the charge sign of electrons from W decays in 500 GeV polarized proton collisions. An R&D effort is underway, and it is expected that the project can be completed in FY 2010, if capital equipment budgets allow.

PHENIX Hadron Blind Detector (HBD) [$0.4M cap. equip.; $0.25M NSF]

$64K matching contribution from Stony Brook University Research Foundation

Status: The full detector was installed in December 2006. An engineering run was carried out during the subsequent Run 7. Some problems were experienced with high-voltage discharges, resulting in damage to some of the CsI-coated GEM readout foils. We expect the problems to be diagnosed and the detector to be operational for Run 8.

PHENIX Barrel Vertex Detector (VTX) $4.7M MIE constr.]

Additional funding contributions from Japan and France

Status: The project was funded in the President's budget for FY 2007, but, because of the 2007 Continuing Resolution, it was not started until May 2007. The funded amount for FY 2007 was reduced from the planned $2M to $1M. A revised schedule calls for completion in Q4 of FY 2010, with implementation in 2011.

PHENIX Forward Vertex Detector (FVTX) [$4.8M MIE constr.]

Status: The project is funded in the President's budget for FY 2008. Final R&D is in progress. The project is expected to be complete in FY 2011.

PHENIX Nose Cone Calorimeter (NCC) [$4.1M MIE constr.]

Status: The project is funded in the President's budget for FY 2008. Final R&D is in progress. The project is expected to be complete in FY 2011.

PHENIX Muon Trigger [~$2M NSF constr.]

Additional funding contribution from Japan

Status: Construction begun in FY 2007, with completion expected in FY 2009.

Detector upgrade costs and schedules

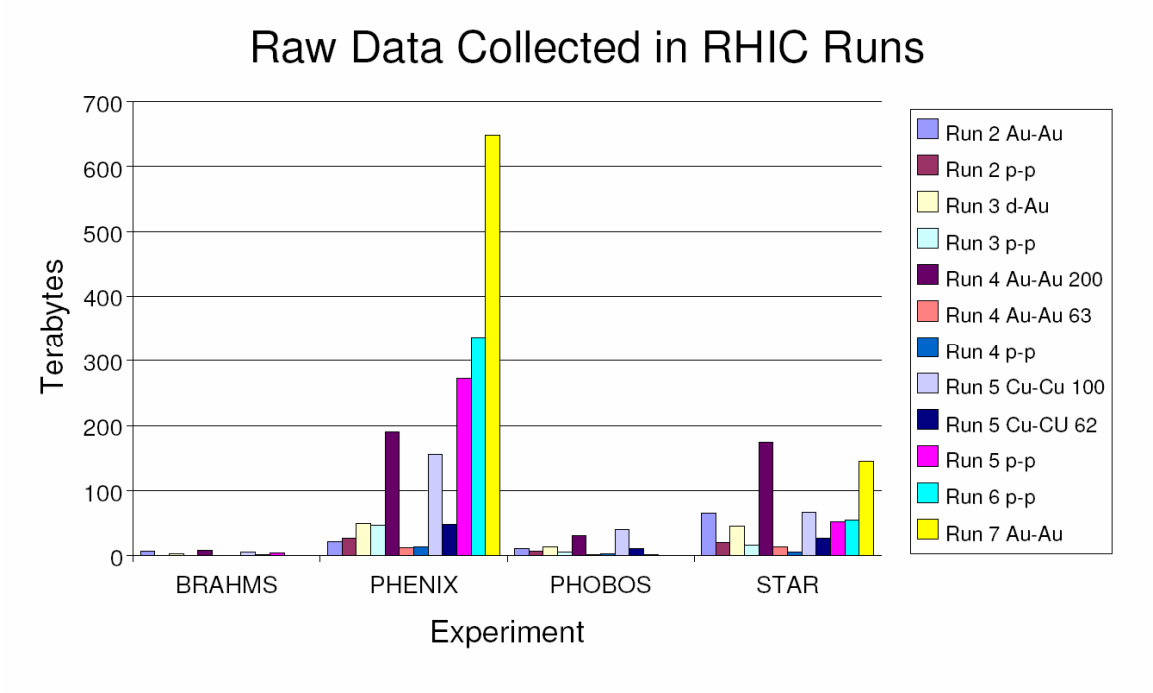
The table below updates the information in Table 6-1 of the Mid-Term Plan document. The table shows actual costs in FY 2006 and FY 2007, and the President's budget for FY 2008. It reflects a reduction in the planned R&D and capital equipment funds in FY 2007, and the new funding profile for the PHENIX VTX MIE project.

	FY 2006A	FY 2007A	FY 2008P	FY 2009	FY 2010	FY 2011	FY 2012	
R&D funds								
PHENIX HBD	0.10							**0.10**
PHENIX MIEs	0.30	0.15						**0.45**
PHENIX DAQ	0.10	0.05	0.20	0.20	0.20	0.20		**0.95**
STAR Tracking	0.50	0.40	1.30					**2.20**
Generic Det. R&D	0.00		0.00	1.00	1.00	1.00	1.50	**4.50**
Total R&D	1.00	0.60	1.50	1.20	1.20	1.20	1.50	**8.20**
Exp. Capital								
PHENIX HBD/TOFW	0.40	0.10						**0.50**
STAR FMS	0.20	0.10						**0.30**
STAR DAQ1000	0.90	0.60	0.30	0.20				**2.00**
STAR FGT			0.35	0.95	0.50	0.00		**1.80**
Exp. Infrastr.	0.60	0.20	0.55	0.75	0.75	0.75	0.60	**4.20**
RCF	1.30	1.70	2.00	3.00	2.90	3.00	3.00	**16.90**
Total Capital	3.40	2.70	3.20	4.90	4.15	3.75	3.60	**25.70**
MIEs								
STAR TOF	2.40	2.40						**4.80**
PHENIX VTX		1.00	2.40	1.20	0.10			**4.70**
PHENIX FVTX			1.40	2.75	0.80			**4.95**
PHENIX NCC			1.00	2.20	1.50			**4.70**
STAR HFT/IST				2.00	4.75	4.75		**11.50**
Total MIE	2.40	3.40	4.80	8.15	7.15	4.75	0.00	**30.65**

RHIC Computing Facility

As described in the Mid-Term Plan document, computational resource planning continues on the basis of a scalable architecture consisting of three main components – a CPU farm, central and distributed disk, and a hierarchical mass storage system (HPSS) – interconnected with a Gigabit Ethernet network. The two small experiments, BRAHMS and PHOBOS, have completed their data taking and are in the final stages of analysis. However, as planned, the overall data volume and CPU requirements will increase as a result of upgrades to PHENIX and STAR, and the increasing machine luminosity.

In the Plan, this growth in capability is accomplished through the annual replacement of ~1/4 of the installed hardware within the facility by new computing and storage components offering an improved performance to cost ratio at a capital investment level of ~$2M per year. A detailed analysis at the beginning of FY 2006, presented in the Mid-Term Plan document, showed that this investment should grow to $2.5M in FY 2008 and $3.0M in FY 2011. Performance in Run 6 and Run 7 bears this out. By way of illustration, the figure below shows the amount of raw data recorded by the four RHIC experiments during each year of operation. During the just-completed Run 7, PHENIX and STAR together collected 800 TeraBytes of data.



Although both runs 6 and 7 were shortened by budget constraints, so too was the level of investment in new equipment for RCF, which was reduced to $1.3M in FY 2006 and $1.7M in FY 2007. Nonetheless, the increased demands on RCF due to increased data rates for the experiments, despite the reduction from four to two experiments, have been clearly felt. An updated analysis of the out-year requirements, based on current projections, is now being prepared by RCF staff, working with the PHENIX and STAR collaborations.

The issue of physical infrastructure requirements, noted in the Mid-Term Plan, has also been clearly felt. The combined RHIC Computing Facility and ATLAS Computing Facility (RCF/ACF) has reached the limit of available floor space. During the past two years, additional power and cooling capability has been added to the current location, but this too has reached its limit. During the just-completed Run 7 there were instances where insufficient available cooling capacity threatened to shut down key components of the RCF facility. These problems continue to be studied at the Laboratory level. Additional floor space within the existing building is being converted for use by RCF/ACF. Plans are being made for building modifications to increase the available floor space, and the associated power and cooling, within the next two years.