BNL Responses to Homework Assignments

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RHIC Science & Technology Review

July 8, 2008

BROOKHAVEN NATIONAL LABORATORY

a passion for discovery

Office of Science
U.S. DEPARTMENT OF ENERGY

Q1: *What is funding breakdown among operations, reliability and obsolescence upgrades, machine performance upgrades and post-RHIC-II R&D? How are these decisions made?*

- **Operations:** FY08 fixed costs (salary & fringe, overhead, BNL allocations, space, fuel, deferred maint., org. burden, base power incl. building, base M&S incl. trades and replacements for failed and obsolete components) …….. $98.0 M
- **Incremental weekly operations costs:** M&S + power …….. $0.4 M/wk
- **Reliability improvements:** ~1/3 of AIP + CAP ……. ~$1.1 M
- **Replacement of failed + obsolete components done within base M&S budget of ~$7 M**
- **Machine performance upgrades:** ~2/3 (AIP+CAP) + ops. R&D … ~$3.5 M
- **RHIC operations development:** accelerator physics, etc. …….. ~$4.5 M
- **Long-term R&D:** eRHIC is #1 priority within this scope (includes ERL's, e-cooling, beam transport recirculators, polarized electron sources) ……FY08 <$0.3 M …….FY09P $3.0 M

- **How are decisions made?** Decisions made year by year in consultation with ALD, Physics Dept. and C-AD management and experiment collaboration management, with following rough priority ordering (but see separate question on run optimization for detailed FY08 example):
- **Priority #1:** Match as well as possible the number of running weeks to annual needs of scientific program, within budget constraints
- **Priority #2:** Improve machine performance and reliability
- **Priority #3:** Finance longer-term initiatives to improve performance
- **Priority #4:** R&D for eRHIC and new cooling ideas
- The priority caveat is we do not ascribe to any approaches that would impact the intellectual and technical talent of our world class accelerator team.

Q2: *Within a given run, how much time is given to accelerator studies? How is this decided?*

- Accelerator physics experiments (APEX) are scheduled for 12 hours per week once "physics production mode" is declared. This includes the time to bring the machine back into "physics mode“ after the accelerator studies.
- This division of time is result of mutual agreement among C-AD and experiments, which recognize value of APEX in often improving performance during a run, or perfecting solutions to long-term problems.
- Division of the 12 hours among APEX proposals is decided on a weekly basis via priorities determined by C-AD evaluation committee.
- AGS studies are often done behind RHIC stores, especially for polarized protons, where AGS is brought up about 3 weeks before polarized proton beam injection into RHIC.
- In consultation with experiments there is also machine development during a "physics" run until luminosity/polarization cannot be usefully improved further. Some small changes in acceleration or store parameters are sometimes made to improve the luminosity of the next store.

Q3: *To what extent do you collaborate with other institutions on accelerator R&D projects?*

- SCRF (JLab, AES)
- Stochastic cooling (FNAL, CERN)
- Electron lens (FNAL, LARP?)
- Electron cooling (Dubna, BINP, FNAL, GSI)
- Polarized e-gun (MIT, JLab)
- ERL development (JLab, DESY, AES)

Q4: *Provide summary of sources/choices that limit time in store to 60%.*

- By mutual agreement between experiments and C-AD, there is average of 20 hours/week devoted to accelerator physics experiments (12 hours, including recovery time) and maintenance (16 hours every 2nd week, including recovery time).
- Under optimal operation to date, there has been ~1 hour overhead per 5-hour store (injection, ramping, tuning, reducing backgrounds, dumping, hysteresis cycling, etc.) $\Rightarrow$ additional 24 hours lost/week.
- The remaining 124 hours/week would have to be operated with 81% availability to reach average of 60% time in store for a run. This is slightly above our annual target of 80% availability, but slightly below the 82-83% achieved in Run 8.
- 60% time in store is a typical value for large hadron colliders.

Q5: *What factors go into optimization of operations schedule (e.g., 30 vs. 24 weeks, etc.) and how are they weighted?*

In planning schedule with President's budgets, number of weeks is mostly driven by experiment requests, ALD decisions informed by PAC recommendations and various performance milestones/science impact factors, expected machine and detector performance, i.e., is necessary hardware in place to optimize physics and cost effectiveness, etc. Polarized protons are the most difficult of all accelerator physics problems. They require significantly more operating time to reach the desired performance as compared to heavy ion operations. This fact is folded into run length calculations.

In responding to final appropriations, which often come late in the fiscal year and deviate very significantly from President's requested budget, year-by-year priorities are set by ALD in close consultation with management of C-AD, Physics Dept. and experiment collaborations. On next page, we give example of detailed priorities we submitted to DOE in response to budget exercises stimulated by Dec. 2008 Omnibus funding bill.

Ordered Priorities in Addressing ONP Budget Scenarios for FY08

1) Preserve long-term future for RHIC. Implications: protect stochastic cooling R&D ($1.5M for FY08) and 56 MHz SRF AIP ($1.3M); in addition, anticipated large purchases imply that minimum funding needed to maintain viable progress on electron cooling R&D is $1.0M.
2) Get significant physics impact from ongoing run 8. Implication: minimal overall run length is 13 weeks, through 1st week in February – this would satisfy minimal needs of both STAR and PHENIX for d+Au.
3) Minimize RIFs.
4) Maintain reasonable progress on detector MIEs. Implication: protect $2.5M for PHENIX vertexing upgrades (VTX and FVTX).
5) Complete STAR DAQ1000 upgrade and associated infrastructure improvements. Implication: need $675K capital equipment funds for STAR, plus a shift of $300K from detector R&D to detector operations.
6) Extend run 8 to produce some useful p+p results. Implication: minimal pp run is 6 weeks, a compromise between PHENIX and STAR estimates, leading to overall run length of 19 weeks.
7) Maintain support for Superconducting Magnet Division (SMD) at anticipated FY08 level of $5.73M. Comment: SMD is hit hard by cessation of ILC work, and may be further impacted by other ONP and OHEP funding decisions (e.g., on LARP and FRIB R&D). Further reductions in RHIC support for SMD may be critical in making this important local and international resource no longer viable.
8) Restore detector capital equipment funding for PHENIX DAQ improvements and STAR Forward Gem Tracker start.
9) Provide carry-forward funds to FY09, that would permit a run 9 start during an FY09 Continuing Resolution.
10) Return detector R&D funding to a level above $1.0M.
11) Fill vacant positions in priority order. Comment: important vacant positions include a liaison from the RHIC-ATLAS Computing Facility to the RHIC experiments, a chief engineer for STAR, software support positions for the RHIC experiments.
12) Get a modest FY08 start on the PHENIX NoseCone Calorimeter upgrade, pending successful completion of its Science and Cost and Scheduling reviews.
13) Extend p+p running in run 8 as much as budgets will allow.
14) Reprogram operations funding to EBIS construction.

Q6: *Provide an overview of the operating costs of the experiments and the potential impact of the upgrades.*

RHIC Experimental Operations
PHENIX STAR and RCF Summary Level Detail

	FISCAL YEAR 2008		
Resource Categories	PHENIX	RCF	STAR
Salary with Overhead	4,327,783	3,370,133	4,598,256
MST (all) with Overheads	1,425,116	1,233,061	1,603,752
Space with Overheads	345,878	177,076	351,481
Other with Overheads	970,104	964,730	968,052
Grand Total	7,068,881	5,745,000	7,521,542

RCF Cap. Equip. $1.7M

Estimated increases due to upgrades:

PHENIX	$0.9M		
STAR			$0.4M
RCF Cap.		$1.3M	

Q7: *How many graduate students are currently in C-AD? What are their Ph.D. projects?*

There are 7 graduate students.

Wang, Gang: Studies of RHIC instabilities in the presence of electron cooling

Wu, Qiong: Photocathode based on secondary emission of electrons in diamond

Hammons, Lee: Single mode SRF acceleration structures for eRHIC

Webb, Stephen: Coherent electron cooling (TBD)

Kanesue, Takeshi: High-current ion beam production using laser ion source and RFQ

Tamura, Jun: Simulation study of multi-charged ion beams in linacs

Hao, Yue: Theoretical study and modeling of beam-beam simulation in eRHIC

Q8: *What fraction of their time do post-docs in C-AD spend on operations?*

- There are now 5 postdocs (1 recently arrived) [funding sources]

- Choi, Eunmoi [100% RHIC] 100% 56 MHz AIP
- Naik, Damyanti [100% RHIC] 100% 56 MHz AIP
- Abreu, Natalia [50% RHIC, 50% LARP] 50 % of total time in RHIC ops
- Robert-Demolaize, Guillaume [50% RHIC, 50% LARP] 50% of total time in RHIC ops
- De Maria, Riccardo [100% LARP] 0% of total time in RHIC ops

Q9: *What are the measures taken to prepare the STAR TPC for high-luminosity running, vis-à-vis (a) space charge effects and (b) aging? What is the size of the TPC group addressing these issues?*

To be posted to S&T website:

Report of the STAR TPC Review Committee

(November 2, 2006)

Executive Summary

On October 6 – 7, 2006 a review was held at Brookhaven National Laboratory to assess the capabilities of the STAR TPC in the high luminosity era of RHIC. The review panel consisted of external reviewers and STAR collaborators. The members of the review panel were P.Seyboth (chair, STAR, Max-Planck-Institut für Physik, Munich), R.Majka (STAR, Yale University), M.Ronan (LBL), R.Settles (Max-Planck-Institut für Physik, Munich), G.Smith (BNL), B.Stringfellow (STAR, Purdue University), W.Wiedenmann (University of Wisconsin) and ex officio members C.Gagliardi, J.Lauret and H.-G.Ritter. This written report was unanimously approved. The charge to the panel is contained in Appendix I.

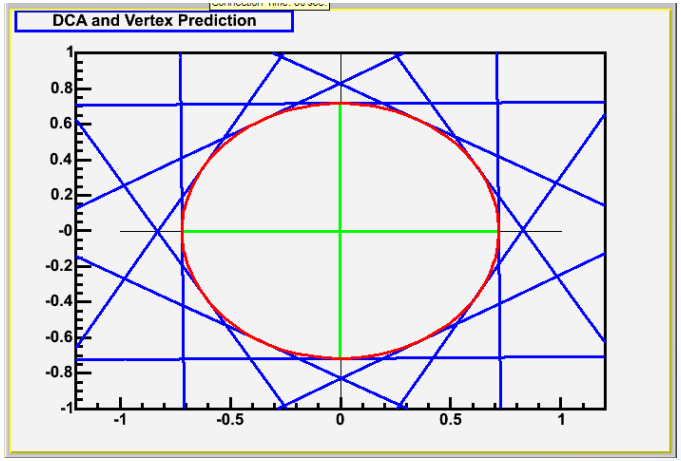
In summary, the committee believes that the TPC can be operated and produce excellent physics results at the projected higher luminosities. Solving the problems of distortions and pileup continue to pose a challenge, but there appear to be no problems in principle to prevent success.

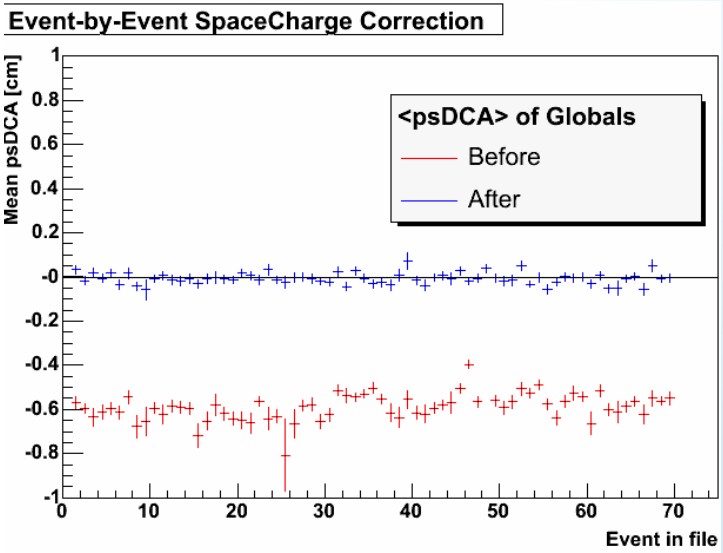
Wire Aging in the TPC

- From max measured wire currents in pp operation (0.07 nA/cm inner most wire)
  - A gate closed component – depends on L and background
  - A gate open component – depends on L and background times gating rate
  - 260 yr before reach aging onset of 0.1 coul/cm at current rate
  - 29 yr before reach 0.1 coul/cm with L of 80×10^{30} $cm^{-2}Hz^{-1}$ + 1kHz gating rate
  - 6 yr with RHIC II 400×10^{30} cm^{-2} Hz^{-1}
- From max wire currents in AuAu operation (also 0.07 nA/cm innermost wire), central trigger
  - Assume large interaction track density dominates over background and pileup, so wire current scales as gate frequency, independent of L, bkgd.
  - 320 yr before reach 0.1 coul/cm at 2004 gate frequency, 75 Hz
  - 24 yr before reach 0.1 coul/cm at 1 kHz gate frequency
- Additional details
  - http://rnc.lbl.gov/~wieman/WireAgingLimits2006Estimate.htm
- Mitigation of aging effects
  - We keep the voltage off the anodes except when necessary
  - We keep a clean environment inside the TPC – constantly under P10 or N_2

Space Charge

- Space Charge isn't the largest distortion in the TPC
  - A shorted ring has the largest effect (at 2008 Luminosities)
  - Due to the wonderful geometric precision of the TPC, the shorted ring distortion can be removed from the data with mathematical precision
- We monitor space-charge second by second based on beam diagnostic monitors and the total charge accumulated in the TPC from the previous 10 (or 20) events
  - Poisson's Equation is solved for the accumulated charge in the TPC and corrections applied to the data
  - This can be done to 2% accuracy, or better





- Depends on an accurate model for the shape of the charge distribution in the TPC (e.g. $1/R^2$)
- The model for the charge distribution requires work every year (e.g. d-Au)

The TPC Calibrations Team

- Patricia Fachini
- Yuri Fisyak
- Alexei Lebedev
- Hao Qiu
- Andrew Rose
- Jim Thomas
- Gene Van Buren (calibration coor.)
- Richard Witt (Chair)
- & others on an as-needed basis

dE/dx Experts:
Patricia and Yuri

Laser Expert: Alexei

Alignment Experts:
Hao and Andrew

Space Charge Experts:
Gene, Hao, Howard and Jim

Shorted Ring Experts:
Gene, Alexei, Wieman and Jim

- Calibration activities is part of S&C lead by Jerome Lauret

Weekly meeting: Monday at 3:30 PM

TPC Operation Team (post B. Stringfellow retirement)

Alexei Lebedev normal operation 24/7

A committee of people with the knowledge of TPC including B. Christie, Jim Thomas, Alexei Lebedev, ...
In case of unusual condition, the committee will be consulted before any action.

Operation workshop will be in mid-Sept. to discuss the plan.

Q10: *Are there any longevity concerns for elements of the detectors in light of anticipated luminosities?*

- STAR response:

PHENIX detector longevity concerns?

- *Yes, in the long term, and also electronics & DAQ, but not affected by luminosity upgrades*
- Wire chambers:
  - Drift Chamber (the closest) is 1.8m from beam
  - Initiated alcohol bubbling in DC in ~2003
  - Same in Pad Chambers in 2007
  - Will consider for other chambers, but they are rather far away and not in serious jeopardy.
  - After 2014, the central arm wire chambers are 15+ years and we will have to evaluate
- Do not anticipate any problems with phototubes
- All electronics are in repair mode
  - We actively maintain them.
  - Remanufacture not possible, would need new design
  - Are looking at replacement of EMCAL Front End
  - Additional benefit: significantly improved triggering
- Regular maintenance of ancillary equipment is crucial

Spin Questions/Responses

Q11: In the discussion of the capability of W measurements of Delta q-bar, the sensitivity has been given in comparing measured single spin asymmetries A_W to various model predictions. Previously, the expected results were given in terms of measured values of the helicity distributions, which are more transparent. Are the older presentations in terms of measured Delta q-bar uncertainties still valid, and what is the effective resolution of the measurements in x_Bjorken?

R: The earlier figure showing q and anti-q polarizations vs. x_Bj is leading order, assumes no W p_T, and treats the data as if the q and qbar separation in parity-violating contributions is complete. The latter is, I believe, the largest issue with the x_Bj presentation. This can be seen in Fig. 7 and 8 in the W appendix of the spin plan.

Response, cont.

The x_Bj representation gives the reader a more intuitive understanding of the physics behind the measurement, but a global fit using the (eta, pT) of each A_L measurement will actually be used to obtain the anti-quark (and quark) polarizations. We do not have a plot showing the x_Bj range for each A_L(eta, p_T) data point.

One more remark: the x_Bj representation was misleading in one way—it suggests that there is little value in the mid-rapidity measurements, where the q and qbar contributions to the parity violation signal are evidently mixed. However, when we prepared this spin plan, we found that for W^+, the u and dbar contributions were also mixed forward/backward, and that the best sensitivity for anti-d polarization was for mid-rapidity (Figs. 14 and 17 vs. Figs. 13 and 16 of the Spin Plan).

Response to Hal Jackson's question:

Q: Is there a mistake in Fig. 22 of the W appendix to the Spin Plan?

R: It sure looked like it. However, we checked the uncertainties, and it is ok. We find about 1000 W^+ events for 70 pb^-1, giving a Delta A_L = 4.5% (with P=.7), and this corresponds to the uncertainty in Fig. 23. There are about 3K W^+ events for 300 pb^-1 at mid-rapidity for PHENIX.

Q12: *What steps are being pursued by the laboratory to ensure that a broad and compelling physics case for the EIC/eRHIC is developed in a timely manner?*

1) *e-A group centered at BNL (Ullrich, Lamont, Morrison, Venugopalan) leading efforts to deepen/flesh out program studying universal properties of dense gluonic matter. Several others involved in White Paper preparation for 2007 LRP. See T. Ullrich talk.*
2) *Discussing growth in e-A group fueled by BNL Program Development funds.*
3) *SV emphasized need to deepen/broaden science case at EIC Collaboration meetings. This led, e.g., to initial ideas of EW exp'ts at May 2008 Hampton Workshop: R. Holt e+D PV DIS at high Q^2, to explore running of weak coupling below the Z; A.W. Thomas CC $e^{\pm}$ comparison to measure CSV quark distributions. Also anticipated involvement of M. Ramsey-Musolf & K. Kumar in future workshops.*
4) *SV working with EIC planners for next (LBNL Dec. '08) workshop to focus discussions on set of 4 key experiments that span/illustrate science case and technical requirements: e.g., F_{2L} measurements in e+A to determine gluon densities at low x; e+A diffraction cross sections to search for predicted effects of dense gluon field; polarized e+p DVCS to map GPD's, low-x nucleon structure; DIS PV.*
5) *Aronson & Leeman jointly set up EIC Internat'l Advisory Committee to provide sounding board on science case and technical issues.*
6) *Initiated discussions with Hugh Montgomery on paths to approach consensus on machine issues at first.*
7) *Stimulated initial thinking about eRHIC staging, to be followed up by detailed discussions of achievable science program stages.*

Q13: *What is membership and funding sources of the BNL Lattice Gauge Theory group for FY08 and envisioned for FY09?*

	Projected New (BA) $k Funding		
	FY 08	FY 09	FY 10
Lattice Gauge Theory Funding Support			
DOE Program Support	100	600 *	600
Physics Department Support	293	132	309
RIKEN Center Support	118		
LDRD - QCD Thrmdynmcs at Non-Zero Tmp	408	200	
LDRD - Lattice QCD Smltn on BlueGen/L	189	50	
Total Lattice Gauge Theory Support	**1108**	**982**	**909**

			FTE's		
Staffing	**Appoint. Type**	**Appointment End**	**FY 08**	**FY 09**	**FY 10**
Karsch,Frithjof	Sr Scientist/Tenure		1	0.5	0.5
Petreczky,Peter	Assoc/Scientist/Term	9/30/2009	1	1	1
Ejiri,Shinji	Asst Scientist/Term	9/30/2008	1	1	1
Huebner,Kay A	Research Assoc	11/30/2008	1		
Pica,Claudio*	Research Assoc	11/1/2008	1	1	1
Schmidt,Christian**	Research Assoc	3/31/2008	1	1	1
Soldner,Wolfgang**	Research Assoc	9/4/2008	1	1	1
Total Scientific Staffing			**7**	**5.5**	**5.5**

*Assumes $500k increase over FY 08 New BA Funding

**staffing includes out year replacement for Research Associate