MEMORANDUM

Date: July 23, 2009

To: Distribution

From: Larry Cardman and Arne Freyberger for the Nuclear Physics Experiment Scheduling Committee

Subject: Accelerator Schedule: Through December 2009

Schedule

Attached are the firm accelerator operations schedule for July through December 2009 and the tentative long-range schedule for the remainder of 6 GeV running. The schedule posted is firm for the first quarter of the full 35 week program we would like to run in FY2010. The funding required to realize the full year program is a final FY2010 budget that is close to the President's budget proposal for FY2010. We are hopeful that any possible continuing resolution budget questions will be resolved in more than enough time for thoughtful decisions to be made about the running planned for Q2-Q4 of FY2010, as laid out in the tentative long range schedule. We will update the plan this Fall, and issue the firm schedule for the first half of calendar 2010 as soon as the FY2010 budget is final.

In the event we are forced to curtail running in 2010, we note (as stated with the initial release of the long range schedule) that given the realities of the scheduling conflicts anticipated in future running between now and the 12 GeV shutdown, together with likely restrictions on the total running feasible in the years before the shutdown, it is probable that experiments unable to run at the scheduled time will never be run.

The Jefferson Lab Nuclear Physics Experiment Scheduling Committee developed the schedule. Committee members are: Larry Cardman and Arne Freyberger (Co-Chairmen), Hari Areti, Volker Burkert, John Domingo, Kees de Jager, Will Oren, Matt Poelker, Joe Prebble, Chris Keith, Dennis Skopik, Mike Spata, Steve Suhring, and Steve Wood. Dave Richards provided advice. As has been the norm, a number of meetings of this committee were necessary to resolve conflicting requirements and to ensure that sufficient resources would be available at the laboratory to properly stage and carry out each of the experiments. The schedule was derived by looking at the requests for major installation work in the experimental halls and the accelerator, evaluating the number and kinds of people needed, and then scheduling to minimize overlap. The schedule request forms were useful in identifying the detailed requirements of each experiment. Information on other laboratory engineering priorities was included to ensure that the required preparatory work could be completed in time. This provided a rough overview of when each hall would be down.

The final schedule was then reached by a series of compromises in running order within each experiment and between halls to work around incompatibilities. It was reviewed and approved by the Director.

The standard section at the end of this memo on "the meaning of priority on the accelerator schedule" is included for reference but all users should read it carefully.

Supplementary Information

Accelerator

The May 1 2006 memo, "Cryomodule Refurbishment and the Maximum Energy Available from CEBAF" presented a plan to extend the energy reach of CEBAF to 6 GeV. This plan called for 10 original CEBAF cryomodules to be refurbished. As of April 2009, eight refurbished cryomodules (called *C50*s) are in operation. CEBAF delivered 5.97 GeV during the Spring09 run with a RF trip rate below expectations. Two facilities days at the end of the Spring09 run, successfully demonstrated 6.07 GeV fully beam loaded (500 μA linac current) capability. **CEBAF is now 6 GeV capable**. The remaining two C50 cryomodules will add gradient overhead which will allow for a lower trip rate and even better cryogenic heat load management.

In addition to establishing 6 GeV capability, CEBAF heat load management has made progress. Extensive effort to measure the *Q* for each of the 320 installed cavities (during the Winter09 and Spring09 runs) has been used to identify the so called *hot cavities* which have low Q values. By reducing the gradient on these low Q cavities the CEBAF load on the Central Helium Liquifier (CHL) can be optimized (with some increase in RF trip rate). CEBAF is capable of executing the published schedule in terms of beam energy and cryogenic capabilities.

During the Summer09 down a new inverted cathode load-locked gun is presently being installed and commissioned. This new gun design will support a higher gun voltage, which will help achieve parity quality beam specifications and, we hope, an improved cathode lifetime to support the upcoming high current experiments. During the Winter10 down the gun upgrade will continue with a new double Wien system to allow for slow spin flips that do not involve changing the laser spot on the cathode. This upgrade is also targeted towards the parity program.

We continue to operate with a superlattice photocathode that produces a maximum beam polarization greater than 80%, typically 85%, with good lifetime. To optimize the spin alignment in each hall requesting polarized beam, a new technique of configuring CEBAF with unbalanced linacs (which alters the amount of precession in the arcs) is being deployed. This provides another degree of freedom over the single Wien angle, at the expense of increased machine configuration complexity. The unbalanced linac technique has constraints and 100% alignment to each hall is sometimes not possible for the scheduled configuration.

We will continue to reserve 16 hours every week in order to recover RF cavities and perform other limited beam development activities deemed critical to successful accelerator operations. In order to finish commissioning the ninth C50 module, beam studies will be compressed to one 16 hour period per week (Tuesday) during the Fall09 run. The goal is to commission this module before the PVDIS 6.07 GeV run, which will benefit from the extra gradient. The time required for linac energy changes is now 12 hours (was 8 hours). This new value is based on the experience during the Spring 2007 run period, which had frequent energy and pass changes. We continue the effort in operator training, and procedure and tool development to minimize the time needed for accelerator configuration changes.

Hall A

In the 2008 summer down the polarized ^{3}He target was installed in Hall A to be used for a total of six experiments intended to be completed by the end of the spring of 2009. The first of those, E06-010, measuring the transverse target spin asymmetry in semi-inclusive pion production (Chen, Cisbani, Gao, Jiang, Peng), ran from early October, followed in February by E06-014, a measurement of d_2^n (Choi, Jiang, Meziani, Sawatzky). Experiment E07-013, measuring the target normal SSA in Inclusive DIS n(e,e') with a polarized ^{3}He target (Averett, Gilman, Holmstrom, Jiang), ran parasitically to E06-010. After a brief down for a month in March/April to move BigBite backwards of HRS-right, data taking started on E05-015 (Averett, Chen, Jiang), a measurement of the target SSA in quasi-elastic scattering off ^{3}He, followed in May by E05-102, measurement of the target asymmetries in the quasi-elastic ^{3}He(e,e'd) reaction (Gilad, Higinbotham, Korsch, Norum, Sirca). Experiment E08-005, measuring the target SSA in the quasi-elastic ^{3}He(e,e'n) reaction from a polarized ^{3}He target (Averett, Higinbotham, Sulkosky), ran parasitically in parallel with E05-015. All six experiments ran successfully.
In the 2009 summer down from June through mid August the polarized ^{3}He target and the BigBite detector system will be removed from the Hall and the cryo-target system will be reinstalled for the two parity-violating experiments, scheduled for the fall of 2009. The first to run will be E05-109 (Paschke, Souder), a measurement of nucleon strange form factors at high Q^2, followed in November by E08-011 (Zheng, Michaels, Reimer), e-d parity-violating deep-inelastic scattering (PVDIS) at CEBAF 6 GeV.

Hall B

After the summer shutdown in 2008 the second part of the e1-dvcs experiment E-06-003 (Burkert, Elouadrhiri, Garcon, Stepanyan) was commissioned, and production data taking started at the end of October at a beam energy of 5.9 GeV. This experiment was completed January 23, 2009, and was followed in the 2nd week of February 2009 by the eg1-dvcs run group of 2 experiments, E-05-113, (Avakian, Bosted, Crabb, Griffioen), and E-05-114, (Biselli , Elouadrhiri, Joo, Niccolai). The first part of eg1-dvcs ended March 15. Nearly one week was lost for the program due to the inability of the accelerator to deliver the required 5.9 GeV beam energy. After the spring shutdown from March 15 until late April, the eg1-dvcs run was continued, ending June 16. This run had to be conducted with a lower beam energy from what was originally scheduled which led to a reduced kinematical coverage. The summer down time was mostly used for repair work on the drift chamber system. The 3rd part of eg1-dvcs is scheduled to begin August 21 and run until September 20, at which time the changeover to the eg6 run group will occur. Eg6 consists of 2 experiments, E-07-009 (Stepanyan, Aznauryan), and E-08-024 (Egiyan, Girod, Hafidi, Luiti, Voutier) to study hybrid meson production and DVCS on ^{4}He, respectively. The eg6 run group is scheduled to take beam until December 23, 2009, with beam energies of 5.7 and 6.07 GeV.

Hall C

Since the release of the last schedule E04-108 (Brash, Jones, Perdrisat, Punjabi), which measured G_{Ep}/G_{Mp} at high Q^2 completed data-taking in June 2008. This experiment used the "BigCal" large electromagnetic calorimeter and a new Focal Plane Polarimeter (FPP) that was installed in the HMS.

During the summer 2008 down, the decommissioning of the G0 experiment was completed. The G0 superconducting magnet was removed from Hall C and placed in on site storage. The G0 detectors were also removed, freeing up the detector support ("Ferris wheel") for use by the upcoming Qweak experiment.

During this down, the hall was reconfigured to run two experiments that use the UVa polarized target. In additional to the installation of this target, the HMS was restored to the standard configuration (no FPP) and BigCal was augmented with a gas Cerenkov, lucite hodoscope and scintillator tracking detectors to convert it into the Big Electron Telescope Array (BETA). In October, operations resumed with commissioning of the detector system and polarized target for E07-003 (Choi, Rondon, Meziani, Jones), which measures inclusive parallel and perpendicular spin asymmetries in the Q^2 range of 2-6 GeV^2 and in the deep inelastic and resonance region to extract the g_1 and g_2 spin structure functions. However, very early in the run, the superconducting solenoid for the polarized target developed shorts and would not operate. The magnet was repaired in house and E07-003 resumed in late January 2009, ultimately achieving about 70% of the proposed statistics. However, because of the lost time, E07-011 (Bosted, Jiang, Wesselmann), A High Precision Measurement of the Deuteron Spin-Structure Function g_1^d/F_1^d, which was planned to run in early 2009, was cancelled.

After the completion of E07-003, the Hall will enter a long down for the installation of a beamline chicane and the HES and HKS spectrometers for E05-115 (Hashimoto, Nakamura, Reinhold, Tang), Spectroscopic investigation of the hypernuclei in the wide mass region using $(e,e'K^+)$ reaction. This experiment is scheduled to start August 21 and run through October 19. After E05-115, the Hall will start installation of Qweak (E08-016).

Footnotes to the Schedule

We summarize here the detailed footnotes to the schedule. They appear in the rightmost column of the schedule listing, and are listed at the earliest date in the schedule when they are applicable; many extend for a considerable time after they first appear. The first five footnotes apply to the entire schedule. All of the footnotes are repeated here for clarity and information.

1. When two or three halls are scheduled, the relative priority listed in the schedule (in the order listed from left to right) is the relative priority of the halls. For example, A/B/C means that Hall A is the highest priority, Hall B has second priority, and Hall C has the lowest priority. If one of the halls has an asterisk, it means that its priority is conditional, and the conditions are given in appropriate footnotes at the beginning of the running of the affected experiment. If the conditions are not met, then the remaining two halls will have priority in the order listed.

2. Energies listed in the schedule for the halls receiving polarized beam are the actual, delivered energies; they include the energy of the injector.

3. When polarized beam is delivered to all three halls, it is not, in general, possible to provide pure longitudinal polarization to all users. We have optimized the beam energies to provide the highest longitudinal polarization (generally over 90%) to all halls during extended periods of scheduled two- and three-hall operation with polarization. For two-hall operation we have occasionally used less than ideal linac energy settings when one or more of the halls has a scheduled pass change in order to optimize polarization delivery over the entire run. This avoids the loss of beamtime associated with a linac energy change, and it avoids energy shifts in the hall that has no interest in changing energy at the time of the transition in the other hall. See the note in the "polarization" subsection of the text on the meaning of priority in the schedule; the note is attached below.

4. In all cases, the orientation of the polarization at the injector will be optimized by setting the Wien angle to a value that minimizes the differences between the hall polarizations (by minimizing the dispersion) so long as this scheme does not result in a reduction of the "sum of squares" figure of merit by more than 2% compared to the optimum figure of merit as determined by summing the squares of the polarization provided to all halls scheduled to receive polarized beam. If minimizing the dispersion results in a loss of more than 2% relative to the optimum figure of merit, we will revert to our earlier algorithm of setting the Wien filter to maximize the overall figure of merit. In all cases involving polarized beam delivery the setting of the Wien Filter shall be fixed throughout the running period unless all parties scheduled to receive polarized beam agree to a different setting.

5. When polarized beam is provided at a new energy, as much time as necessary during the first shift of polarized beam operation will be used to verify polarization in the halls. This can be done by direct polarimetry in the hall(s) and/or by taking data on a reaction that is adequately sensitive to the beam polarization. By the end of the first shift of production running with polarized

beam, the run coordinator(s) for any experiment(s) receiving polarized beam must report to the Program Deputy that they have measured the beam polarization and determined it to be acceptable. Otherwise, a measurement of the beam polarization will be scheduled immediately. When the polarized beam energy is being changed in only one hall (e.g. a “pass change”) then that hall should measure beam polarization by the end of the first shift of production running. Further, if the change in settings of the Wien filter are substantial, all three halls should measure and report beam polarization by the end of the first shift of production running with the new setup.

6. Accelerator development time will be allocated 16 hours/week for the duration of this schedule.

7. Collaborative test will be performed to determine the beam quality delivered to the halls after a major down. Halls should be ready and locked at the start of the collaborative checkout. If beam conditions meet the experiment’s requirements before the scheduled time, the experiments will be able to use the beam time for production running.

8. Physics production running stops at the end of the owl shift.

Additional General Information on Operations and Scheduling Constraints

As noted earlier in this memo, the operation of polarized beams in more than one hall puts severe constraints on our ability to change beam energies.

Technical support from the Accelerator Division for the firm schedule is expected to be adequate. However, experiments that require significant technical support, and are anticipated to run in the next run cycle should be carefully coordinated with the Hall and Accelerator Division engineering staff to avoid possible conflicts with the future demands of the 12 GeV upgrade.

The Meaning of Priority on the Accelerator Schedule

Generally, the assignment of priority to a hall means that the identified hall will have the primary voice in decisions on beam quality and/or changes in operating conditions. We will do our best to deliver the beam conditions identified in the schedule for the priority hall. It will not, however, mean that the priority hall can demand changes in beam energy that would affect planned running in the other halls without the consent of the other halls. Of course, final authority for decisions about unplanned changes in machine operation will rest with the laboratory management.

The operation of more than one hall at Jefferson Lab substantively complicates the interaction between the experimenters and the accelerator operations group. It is in the interests of the entire physics community that the laboratory be as productive as possible. Therefore, we require that the run coordinators for all operating halls do their best to respond flexibly to the needs of experiments running in other halls. The run coordinators for all experiments either receiving beam or scheduled to receive beam that day should meet with the Program Deputy at 7:45 AM in the MCC on weekdays, 8:30 AM on weekends.

To provide some guidance and order to the process of resolving the differing requirements of the running halls, we have assigned a "priority hall" for each day beam delivery has been scheduled. We outline here the meaning of priority and its effect on accelerator operations.

The priority hall has the right to:

- require a re-tune of the accelerator to take place immediately when beam quality is not acceptable
- insist that energy changes occur as scheduled
- obtain hall access as desired
- request beam delivery interruptions for experiment-related operations such as Mott measurements of the beam polarization or pulsed operation for current monitor calibrations, temporarily blocking normal beam delivery to all halls.

These interruptions shall be limited by a sum rule - the total time lost to the non-priority hall(s) due to such requests shall not exceed 2.5 hours in any 24-hour period. It is, of course, highly preferred that these measurements be scheduled at the morning meeting of the run coordinators whenever possible, and coordinated between halls whenever possible.

When the priority hall has requested a re-tune, if the re-tune degrades a previously acceptable beam for one of the other, lower priority running halls, then the re-tune shall continue until the beam is acceptable to both the priority hall and the other running halls that had acceptable beam at the time the re-tune began.

Non-priority halls can:

- require that a retune of the accelerator take place within 2.5 hours of the desired time (it will nominally occur at the earliest convenient break in the priority hall's schedule)
- require access to the hall within 1 hour of the desired time (again, it will nominally occur at the earliest convenient break in the priority hall's schedule)
- request Mott measurements in the injector within 2.5 hours of the desired time (it is preferred that this be scheduled at the morning meeting of the run coordinators and coordinated between the running halls whenever possible).

The ability of non-priority halls to request retunes and accesses shall be limited by a sum rule - the total time lost to the priority hall due to such requests shall not exceed 2.5 hours in any 24-hour period. (To facilitate more extended tuning associated with complex beam delivery, with the agreement of the run coordinators for all operating halls, the sum rule may be applied over a period as long as three days, so long as the average impact is less than 2.5 hours/day.) In the event that two non-priority halls are running, the 2.5 hours shall be split evenly between them in the absence of mutual agreement on a different split.

All Halls:

Can negotiate with other halls, and with the Accelerator and Physics Division for changes in scheduled energy changes (either direction).

Initial Tune-up of New Beams:

Normally one and one half shifts (12 hours) is set aside for tune-up whenever a new beam setup is being tuned (for unusual beam setups more time may be scheduled explicitly for tuning at the discretion of the scheduling committee). It is understood that beam tune-ups shall *always* be done in the order that the accelerator operations group believes will minimize the *total* time needed to tune *all* scheduled beams (i.e., the "priority hall" beam is not necessarily tuned first). In the event that obtaining the new beam setup requires more than the scheduled time, the Accelerator Program Deputy is authorized to spend up to one additional shift of tuning in an effort to deliver all scheduled beams instead of just the "priority hall" beam.

Polarization:

Note that the setting of the Wien filter, which determines the polarization orientation in all halls, is NOT affected by the hall priority assignment. For two-hall operation we will always optimize the figure of merit for the two running experiments by setting the Wien filter to a value that results in identical longitudinal polarization components for the two halls. For three-hall operation we set the Wien angle to a value that minimizes the differences between the hall polarizations (by minimizing the dispersion) so long as this scheme does not result in a reduction of the “sum of squares” figure-of-merit by more than 2% compared to the optimum figure of merit as determined by summing the squares of the polarization provided to all halls scheduled to receive polarized beam. If minimizing the dispersion results in a loss of more than 2% relative to the optimum figure of merit, we will revert to our earlier algorithm of setting the Wien filter to maximize the overall figure of merit. In all cases involving polarized beam delivery the setting of the Wien Filter shall be fixed throughout the running period unless all parties scheduled to receive polarized beam agree to a different setting.

Finally, any change in the accelerator schedule that has implications for running beyond one week and/or is not agreed to by the run coordinators for all affected experiments and the accelerator program deputy must be discussed and confirmed at meetings to be held (as required) each Tuesday and Friday afternoon at 4:00 in the office of the AD for Physics.

Maintenance/Development The twelve hours per week allotment for both maintenance and beam studies in previous memos proved insufficient for preparation for recent experiments. Beginning in Jan. 2005, the Accelerator Division has asked instead that sixteen hours per week be explicitly assigned for RF recovery, cathode work, operability improvement studies and beam studies in support of PAC approved experiments. Users will be consulted in deciding how these sixteen hours per week are placed on the calendar, i.e. five shorter or three long blocks of time.

Holidays For holidays shown on the schedule as down when we plan to run beam just up to the holiday, the beam will be shut down at ~8 AM on the last day shown as beam delivery.

Energy Constraints on Multiple Hall Operations The standard constraints for the different energies in the three halls during multiple hall operation are reiterated here for your information. The RF separators are able to extract one beam after each pass or, alternatively, to deliver beam to all three halls after five passes. Therefore, it is always the case that: 1. All three beams can have the same energy only on the fifth pass. 2. No two halls can have the same energy, except on the fifth pass. 3. Unusual beam energies in one hall will sometimes preclude multiple beam operation and impose shutdowns on the other halls, unless one or more of the other halls can also use a commensurate, unusual energy.

Polarization Constraints on Multiple-Hall Operations There are only two beam energies (2.115 and 4.230 GeV) at which purely longitudinal spin can be delivered simultaneously to all three halls when the halls have the same energy. There are, however, many combinations of passes and linac energies at which it is possible to deliver beams with precisely longitudinal polarization to two halls simultaneously, and many combinations at which it is possible to deliver nearly longitudinal polarization to three halls. A technical note covering all combinations of 2-hall polarized beam running is available (TN 97-021). Tables of ideal energies for two-hall operation and optimal energies for three-hall operation are available at the url: http://clasweb jlab.org/spin_rotation/

You can also determine the dependence of the polarization in all three halls on the Wien filter angle for the actual settings of the accelerator. Experimenters scheduled for periods involving multiple-hall polarized beam delivery should consider the possible impact of a transverse polarization component on their measurements, and provide the laboratory with a maximum allowable transverse component if appropriate. Because of the limitations on beam energies associated with the different combinations of linac settings and numbers of passes delivered to the different halls, we have a great deal less flexibility for changing energies in the different halls during polarized beam running. This is because there are many instances where the nominal linac energy and number of recirculations for the running halls provide reasonable polarization, but where changing the number of recirculations for one of the running halls results in nearly transverse polarization.

In an effort to optimize polarized beam running, we schedule many weeks of operation at energies that are consistent with good polarization in multiple halls. The details vary from run period to run period and hall by hall. In the worst case, the effective polarization delivered to a hall is typically reduced to no less than ~90% of the nominal maximum available from the cathode. This reduction is due to the angle at which the polarization vector will be set relative to the beam direction in the hall in a compromise that will optimize delivery to all halls. For two-hall operation we can optimize the figure of merit for both running experiments by simply setting the Wien filter to a value that results in identical longitudinal polarization components for the two halls. For three-hall operation we have previously used an algorithm that set the Wien filter to a value that maximized the overall figure of merit (the sum of the squares of the polarization provided to all halls scheduled to receive polarized beam). It has been noted that this sometimes results in situations where the delivered polarization is significantly different for the three halls. To "equalize the pain" for three-hall operation, we are adopting a refinement to this algorithm. The Wien angle for three-hall operation will now be set to minimize the differences between the hall polarizations (by minimizing the dispersion) *so long as this scheme does not result in a reduction of the "sum of squares" figure of merit by more than 2% compared to the optimum figure of merit.* In all cases involving polarized beam delivery the setting of the Wien Filter shall be fixed throughout the running period unless all parties scheduled to receive polarized beam agree to a different setting.