

## MEMORANDUM

Date: July 16, 2007  
To: Distribution  
From: Larry Cardman and Andrew Hutton for the Nuclear Physics Experiment  
Scheduling Committee  
Subject: Draft Accelerator Schedule: Through June 2008

### Schedule

Attached is the draft accelerator operations schedule through June 2008. The schedule is firm through December 2007 and tentative through June 2008. This schedule release completes the schedule that would normally have been released in the Spring, but was delayed this year until issues associated with planning for both the cleanup of the 2K cold box and the installation and re-commissioning of refurbished cryomodules (aimed at ultimately raising the machine energy to a full 6 GeV) could be resolved.

The Jefferson Lab Nuclear Physics Experiment Scheduling Committee developed the schedule. Committee members are: Larry Cardman and Andrew Hutton (Co-Chairmen), Hari Areti, Volker Burkert, John Domingo, Kees de Jager, Lia Merminga, Will Oren, Matt Poelker, Joe Prebble, Mike Seeley, Dennis Skopik, Mike Spata, Steve Suhring, and Steve Wood. Dave Richards and Tony Thomas 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.

Each hall leader took the requests for running time submitted by the experiment spokespersons and developed a tentative plan for their hall's program by considering the scientific priority of each experiment, together with the long-term goals of the research program, the accelerator's ability to deliver the beams desired reliably, the availability and reliability of the necessary experimental apparatus, the time necessary to mount each major experiment, and other constraints as appropriate. An effort is made to schedule complete experiments whenever this is deemed technically feasible.

The Scheduling Committee then folds the plans for the three halls together and tries to develop a run plan that optimizes the scientific productivity of the laboratory as a whole. Scheduled time for all three halls was done using an estimated overall efficiency of simultaneous hall and accelerator operation of 50%; this value is consistent with last year's experience. In a number of cases the scheduled beamtime has been adjusted to reflect significant changes in facility capabilities since the time of PAC approval of the

experiment; the most obvious of these is the availability of high polarization beams with significantly higher current than was the case a few years ago. The final schedule was then reached by a series of compromises in running order within each experiment and between halls to work around incompatibilities.

As is always the case, the second half of the schedule is tentative, and may have to be re-evaluated depending on the laboratory's budget for FY2008, which won't be known until late this year or early 2008.

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.

### **Accelerator**

Increasing the energy reach of the accelerator to 6 GeV as soon as is feasible within the constraints of both budget and technical challenges is the highest priority of the Accelerator Division. The broad outlines of the plan to reach 6 GeV were provided in the May 1 memo from Swapan Chattopadhyay and Larry Cardman titled "Cryomodule Refurbishment and the Maximum Energy Available from CEBAF." We have initiated a program of refurbishing the existing cryomodules. The first module was removed in May 2005, the second during the October down. The refurbishment project is progressing well, and the first of the refurbished cryomodules, C50-1, was installed in January 2007, and the bulk of the commissioning took place between 2/26/07 and 3/1/07 with additional opportunistic commissioning occurring during March. The cryomodule is presently delivering close to 40 MeV, with one of the 8 cavities turned off due to interlock problems. As part of the program to reach 6 GeV beam energies we will also replace a cryomodule in the North Linac by Renascence, a new prototype high-gradient module. The problems with Renascence are now solved and the cryomodule will be installed and commissioned during the July-Sept 2007 shutdown period. In addition, during this same down period, we will install and commission two more refurbished cryomodules (C 50-2 and C50-3). C50-4 is expected during the last week in November.

A notable accelerator achievement is the delivery of parity quality 362 MeV beam for G0 and beam of the same energy simultaneously to Hall A.

### **Beam Polarization, minimum of 80%, usually better than 85%**

We are now operating routinely with the superlattice photocathode, delivering better than 85% polarization for all Halls requiring polarization. Experiments may now expect that the polarization available will be at least 80% with good lifetime. The maximum current to the halls is only subject to the beam power constraints listed above. All three halls now receive beam from fiber-based lasers capable of providing current in excess of 100  $\mu$ A. These lasers operate reliably without loss of phase lock, a problem that frequently plagued operations when mode-locked Ti-Sapphire lasers were used.

A new load locked polarized electron source has been commissioned at the Injector Test Cave at building 58. This new gun functions very well, providing exceptional charge

lifetime with both bulk and superlattice photocathodes. The load locked gun will enhance the operating lifetime of the CEBAF photoinjector, speeding replacement of photocathode material and providing more opportunities for photocathode research using the 5 MeV Mott polarimeter. It is being installed at CEBAF during the July-September 2007 shutdown. A 500 keV Mott Polarimeter will also be installed during this down period.

### **Helicity-correlated effects.**

It was predicted that the helicity dependent current fluctuations from the super-lattice cathode would be smaller than with the strained GaAs cathodes, and this has proven to be true. In addition, careful work by the HAPPEX group to align and focus the laser in the Pockels cell has also reduced the spot motion on the cathode during helicity flipping. There has also been progress on reducing the coupling in the Injector which has improved the adiabatic damping. The helicity-correlated effects during the latest HAPPEX run were the smallest ever recorded.

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. We have recently been choosing to take this time in 2 periods each week, which has had the advantage of reducing the number of recoveries and we may well continue this cycle, which integrates well with short accesses by the Halls. We have also increased the time for linac energy changes from 8 hours to 12 hours to provide the opportunity for increased operator training in this essential effort.

### **Hall A**

During the low-energy running for  $G^0$  a short run was successfully completed in Hall A to measure the elastic form factors of Li and B (Higinbotham, Gilman). Next, in March E06-007, proton knock-out from  $^{208}\text{Pb}$  (Saha, Aniol, Udias, Urciuoli), was run to completion in parallel with the approved running time extension of  $G^0$ , after which E04-018, measuring the elastic form factors of  $^{3,4}\text{He}$  up to large  $Q^2$  values (Camsonne, Gomez, Katramatou, Petratos), resumed data taking to completion in June. This was followed by E03-101, hard photodisintegration of a proton pair (Gilman, Piasetzky). During the three-month summer down a NaI calorimeter will be installed in the focal plane of HRS-right. This will be used during the running of the Coulomb Sum Rule experiment E05-110 (Chen, Choi, Meziani) in October through December. In February and March the Big Bite spectrometer will be installed in Hall A which will be used first in E04-007, a study of  $\pi^0$  electroproduction on the deuteron near threshold (Annand, Higinbotham, Lindgren, Nelyubin, Norum), scheduled to run in March and April. Following that, the polarized  $^3\text{He}$  target will be installed for a total of five experiments intended to be completed in 2008. The first of those, E06-011, measuring the transverse target spin asymmetry in semi-inclusive pion production (Chen, Cisbani, Gao, Jiang, Peng), is tentatively scheduled to start running in late July.

## **Hall B**

Since the last schedule release, Hall B has completed the g13 run (E-06-103: Berman, Ireland, Nadel-Turonski, Tkabladze), a search for new baryon states in hyperon production from neutrons (deuterium), using polarized photons scattered off liquid deuterium. The first part (g13a) used only circularly polarized real photons. Hall B was down after the holiday break in December until the middle of March 2007 due to low energy running for the G0 experiment. The g13a run group was followed by the second portion of the same run group (g13b) using linearly polarized photons generated by coherent bremsstrahlung of high energy electrons on an appropriately oriented diamond crystal. The same liquid deuterium target was used also for this part. G13 was followed by a two test runs, one using a low energy real photon beam to study background conditions for a possible experiment to measure the pion polarizability with CLAS. The second test run was aimed at studying the feasibility of operating a fission fragment detector in CLAS to measure lifetimes of hypernuclei. Both test were successfully completed.

The extended summer shutdown will be used for the installation of FROST, the upgrade of the large angle time-of-flight detectors in CLAS, and maintenance and repair work on the drift chamber system.

The schedule after the summer down shows the commissioning and execution of the first part of the g9-FROST program with a longitudinally polarized target and using a variety of different beam energies and combinations of photon beam polarizations (circular and linear). This experiment will begin in October 2007 and run until mid January 2008.

After the winter shutdown from January to March the g12 run group, "A search for new forms of hadronic matter" (E-04-005, E-04-017; P. Eugenio, D. Weygand) will take data until the end of May. This run is tentatively planned to be followed by the second part of the e1-dvcs run group (V. Burkert, L. Elouadrhiri, M. Garcon, R. Niyazov, S. Stepanyan).

## **Hall C**

Since the release of the last schedule, a merged program of L/T separations of elastic electron-proton scattering, E05-017 (Arrington), and of resonance region measurements for both deuterium, E06-009 (Christy, Keppel) and heavier nuclei, E04-001 (Bodek, Keppel) was completed on July 12th. E04-001 is a continuation of experiments with phase-I already completed, in close collaboration with the neutrino community.

At present, the Hall is being reconfigured for the "GeP" experiments. The newly-constructed "BigCal" large EM calorimeter and the new Focal Plane Polarimeter for HMS will be installed to prepare for the polarization-transfer program of elastic electron-proton scattering experiments: E04-108 (Brash, Jones, Perdrisat, Punjabi) and E04-019 (Gilman, Pentchev, Perdrisat, Suleiman). These experiments will start in October and continue into 2008.

E07-002 (Wojtsekhowski, Nathan, Gilman), a measurement of polarization transfer in Wide Angle Compton Scattering, is provisionally scheduled for January. While it is

approved for only 3 “PAC days” and uses the same equipment as the “GeP” experiments, it does require the addition of a sweeping magnet and Bremsstrahlung radiator, and has different beam energy requirements. It is scheduled for 5 calendar days, subject to the availability of the magnet and radiator, and the status of higher rated E04-019 measurements.

After the high  $Q^2$  part of E04-108 finishes at the end of May 2008, the Hall will be open for a 10 week installation of the polarized target and the addition of gas Cerenkov, lucite hodoscope and scintillator tracking detectors to the BigCal to convert it into the Big Electron Telescope Array (BETA). The BETA will first be used in E07-003 (Choi, Rondon, Meziani) which will measure inclusive parallel and perpendicular spin asymmetries in the  $Q^2$  range of 2-6  $\text{GeV}^2$  and in the deep inelastic and resonance region to extract the  $g_1$  and  $g_2$  spin structure functions.

### **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. Physics production running stops at the end of the owl shift.
8. The exact energy for this portion of the run will be determined based on an evaluation of the installed and commissioned “C-50” cryomodules. We have listed the energy as 5.71 GeV but are hopeful that a slightly higher energy may be feasible.

### **Additional General Information on Operations and Scheduling Constraints**

The accompanying schedule is fixed thru June 2008. 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/](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.