MEMORANDUM

Date: December 7, 2005

To: Distribution

From: Larry Cardman and Andrew Hutton for the Nuclear Physics Experiment Scheduling Committee

Subject: Accelerator Schedule: Through December 2006

Schedule

Attached is the draft accelerator operations schedule through December 2006. As you know, the Lab was expecting (based on this Spring's House and Senate mark-ups) FY06 Nuclear Physics funding at least equal to the FY05 level. In a move that surprised all observers, the House-Senate Conferees reverted to the Administration's Budget Request, which means an 8.4% cut for Nuclear Physics. Initial budget guidance for JLab is that we will receive the same percentage cut in our budget. This will force the Lab to curtail physics running significantly from historical levels and is the reason why this draft schedule shows substantially reduced running (down about one third). The fact that we are already two months into the new fiscal year aggravates the pressure of adjusting final plans. In addition, the Lab will implement only minimal summer running. We recognize that eliminating summer running complicates the lives of users with teaching responsibilities significantly. However, a substantial fraction of our power bill is determined by the demand charge that is "set" on the basis of the peak power used between May 12 and September 8. By minimizing power consumption during that period the Lab can save substantially on the FY06 power bill and, due to the idiosyncrasies of the power cost algorithm, save even more in FY07.

Trying to make the best of a bad situation, we will dedicate what little summer running there will be in 2006 to a very low energy run focused on obtaining a portion of the G0 experiment's backward angle data. With the exception of the first G0 backward angle run (scheduled to begin in March with an accelerator energy gain of 650 MeV per pass), the proposed G0 backward angle runs are incompatible with beam delivery to the other halls for essentially all of the approved experimental program in those halls. By running this experiment during the summer, it will be possible to use only one of the two linacs to deliver a 362 MeV beam, and the resulting operational costs are only marginally more expensive than a complete accelerator shut-down.

Please note that even this modest low-energy summer run must be considered as only tentatively scheduled at this time. We will make a final decision on our ability to carry it out when the lab's final budget for FY06 (which still depend on pending legislation on a general rescission to the federal budget) is known.

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, Rolf Ent , Kees de Jager, Lia Merminga, Will

Oren, Matt Poelker, Mike Seeley, Dennis Skopik, Mike Spata, Steve Suhring, and Karen White. 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, 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. It was particularly difficult to find running conditions during the G0 run that would be as satisfactory as usual for polarization delivery in multiple halls; this complication is due to the fact that as the linac energy is lowered the “energy spacing” between solutions that give high polarization in more than one hall grow.

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. Note also that there has been an 8 hour shift in the shutdown hour associated with major downs and holidays.

Accelerator
Increasing the energy reach of the accelerator to 6 GeV as soon as is feasible within the constraints of both budget and technical difficulties is the highest priority of the Accelerator Division. A cryomodule in the North Linac Zone will be replaced by Renascence, a new prototype high-gradient module. This module is presently under test in the SRF Institute and it will then be fully commissioned with beam. This year, we have also initiated a program of refurbishing the existing cryomodules. The first module was removed in May 2005, the second during the October down. The second module removed will reduce the overall reach of the machine, but we have chosen to remove the second cryomodule as soon as possible because the presently scheduled operations do not require higher energy and we wish to maximize progress on refurbished cavities available in 2007. The removal of cryomodules for refurbishment explains why the maximum energy of the machine is reduced from 5.78 GeV to 5.275 GeV; it will stay at this value until these cryomodules have been refurbished and reinstalled.

In addition, we have made considerable progress towards reducing the time lost to RF trips. The automatic reset software package has reduced the average time for resetting the RF from 45 seconds to about 18 seconds and further reductions are expected. We understand that this is not as attractive as reducing the number of trips but is another way to try and increase beam on target.

Beam Polarization, minimum of 80%, usually up to 85%

We are now operating routinely with the super-lattice photocathode, delivering 85% polarization for all Halls requiring polarization. Experiments may now expect that the polarization available will be up 80% with good lifetime, and usually up to 85%. The maximum current to the halls is only subject to the beam power constraints listed above. Halls A and C are receiving beam from newly acquired, commercial Ti-Sapphire lasers. These lasers have enough power to generate beam currents in excess of 100 μA (200 μA has been demonstrated during Injector tests). Their fast turn off time will eliminate polarization dilution due to beam bleed through between adjacent halls. However, we are suffering from an occasional loss of lock by the lasers. We are trying to find a short-term workaround; the longer term solution is the development of a new type of fiber laser. If the R&D proceeds smoothly, this new kind of laser might be available within a year.

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 carefully 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 3 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.

Hall A

In April and May of 2004 both septum magnets were installed again in order to complete experiments E94-107 on the waterfall target and both HAPPEx experiments. New optics data taken resulted in an intrinsic momentum resolution for the combination of a septum and one HRS spectrometer of 1.10^{-4}. The hypernuclear experiment was successfully completed on ^{16}O using the waterfall target. Following this, first E00-114, HAPPEx-He was completed with the current limited by the left septum to 35 µA and next E99-115, HAPPEx-II, was completed with a current of 58 µA. The increase in the current relative to 2004 was due to the installation of a small sweeper magnet between the cryotarget and the septa. After Thanksgiving the installation of the polarized ^3He target and BigBite for the G_E^n experiment will start. The G_E^n xperiment (E02-013: Cates, Reitz, Wojtsekhowski) will then run until the start of the scheduled low-power running during the summer. On completion of the G_E^n experiment, Hall A will be reconfigured to its standard configuration, with both HRS spectrometers (including the Focal Plane Polarimeter in HRS-left) and the cryotarget. During the summer E05-103, deuteron photo-disintegration at low energy, and part of E05-004, measurement of the deuteron charge form factor at low Q^2, are scheduled to run, conditional to successfully extracting one-pass beam to both Halls A and C. For the fall of 2005 three experiments have been tentatively scheduled, completion of E05-004, E03-104, polarization transfer in $^4He(e,e'p)$, and the start of E04-018, measurement of the elastic form factors of ^3He and ^4He.

Hall B

Since the last schedule release, Hall B completed the first part (40%) of data taking for DVCS experiment (E01-113: Burkert, Elouadrhiri, Garcon, Stepanyan). The DVCS experiment included two new hardware components, a superconducting solenoid, and a fine granularity lead-tungstate calorimeter. This was followed by a short test run for the BoNuS detector. This test run was followed by the G8b run group of 3 experiments to study vector meson production with a linearly polarized photon beam (E94-109, E98-109, E99-013: Cole, Livingston, Klein, Tedeschi). The G8 experiment finished data taking end of August.

During the 2005 summer down the BoNuS experiment (E03-012: Fenker, Keppel, Kuhn, Melnitchouk) was installed. The BoNuS run began in early October, and is scheduled to finish end of CY2005. BoNuS measures the free neutron structure function using a novel method that tags electron scattering off the neutron by detecting the spectator proton at very low momentum at large angles. The scheduled shutdown in January 2006 will be used to install a new Cerenkov counter for CLAS as well as the polarized solid state target. This equipment is needed for experiment group eg4 (E03-006: M. Ripani, M. Battaglieri, R. De Vita, A. Deur) which will measure the Gerasimov-Drell-Hearn sum rule at very low Q^2, close to the real photon point, to test the low energy QCD evolution. The eg4 run will begin early February and continue until early May 2006. Hall B will be down during the summer months for installation, maintenance and repair work on the CLAS drift chambers and other detector systems.

The tentative portion of the CY2006 schedule sees operation in the fall of 2006 for the first portion of the "Frozen Spin Target" program g9-FROST, a search for "missing" N* resonances using linearly and circularly polarized photons and a longitudinally polarized hydrogen (alcohol) target.

Hall C

At the release of the last schedule, the HKS and Enge spectrometers were installed for experiment E01-011, a spectroscopic study of Lambda Hypernuclei (Hashimoto, Nakamura, Reinhold, Tang). The startup of this experiment was more difficult than usual, due to the unforeseen complexity of the beam line chicane, which (with the benefit of 20-20 hindsight) we now understand was exacerbated by insufficient beam line diagnostics. This resulted in the experiment being well behind its goals at the nominal completion date. Because of the tremendous effort that was required to complete the installation (and the very large effort that would have been necessary to re-install it to complete the data-taking at a later date), we took the unusual step of extending the experiment by one month. The E02-017 experiment (Hu, Margaryan, Tang), a measurement of the hypernuclear life time in a heavy nucleus, also using the HKS apparatus, followed the E01-011 experiment

Subsequently, we started the reconfiguration of the Hall to the backward-angle phase of the E04-115 (Beck) G0 experiment. The installation times for this experiment had to be increased from three to five months, both because we were running behind in the preparations for this installation due to manpower shortage, and because the shielding configuration turned out to be more time-consuming than originally thought. Hence, the fixed portion of the schedule shows the extended G0 installation time followed by a short engineering run and the first phase of E04-115 measurements (at a beam energy of 687 MeV), with the E04-001 measurement of parity-violating electron scattering in the Delta resonance region (Wells, Simicevic) running parasitically. The fixed portion of the Hall C schedule ends with a Summer down.

The tentative portion of the schedule shows the first phase of the physics data taking run for the E05-108 experiment (Beck), the lowest-energy phase of the G0 backward angle measurements, scheduled to run at a beam energy of 362 MeV. This phase of the experiment has been tentatively scheduled pending final concurrence of PAC-29. Unfortunately, the constraints on the overall laboratory budget only permit us to schedule about half of the originally-planned run at this time.The tentative schedule furthermore shows the continuation (to completion) of the E04-115 (Beck) and E04-001 (Wells, Simicevic) experiments at a beam energy of 687 MeV.

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. Collaborative checkout 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.
7. Physics production running stops at the end of the owl shift.
8. Dedicated accelerator time for 12 GeV tests and preliminary studies of simultaneous two-beam extraction at first pass.
9. Two-beam extraction studies will determine the feasibility of the planned low energy running in Halls A and C.
10. Polarization will be optimized for Hall C.

Additional General Information on Operations and Scheduling Constraints

The accompanying schedule is fixed thru December 2005 and tentative for the following six months. Priorities have been assigned as "firm" for the period of the schedule that is fixed; the tentative priorities set for the January-June period will be reviewed when the schedule for that period becomes fixed. 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 both the firm and tentative schedules 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 shift 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 (such as Christmas in 2004) 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 (e.g. Thursday at 8 AM before the Friday Christmas holiday in 2004).

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.