MEMORANDUM

Date: August 3, 2005

To: Distribution

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

Subject: Draft Accelerator Schedule: Through June 2006

Schedule

Attached is the draft accelerator operations schedule through June 2006. As of this date we still don't have a budget for Fiscal Year 2006. If we receive the budget implied by the laboratory's tentative allocation from the President's proposed budget for DOE/NP, we will be forced to curtail physics running significantly from historical levels, and a run schedule that is somewhat reduced from the one posted will result. If the budget is reduced from our planning budget, it will be necessary to modify the second half of this schedule to stay within our budget for the year. The posted schedule has no accelerator operations in the summer of 2006. 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 increased demand charge that is "set" on the basis of the peak power used between May 12 and September 8. By turning the accelerator off during that period and raising the cryomodule temperature from 2 to 4 K we estimate we can save a substantial amount on the power bill in FY06; there would be additional savings of order $0.4M (raising the total annual savings to over $1M) in the following year from the quirks of the "demand charge" portion of the billing formula. In the event that the budget is significantly restored toward FY05 levels (as would be the case if the version of the DOE budget passed by the House recently were adopted), we are investigating the possibility of adding a long, dedicated, low-energy run to obtain a major portion of the G0 experiment's backward angle data during the summer of 2006. This very low energy running would be done without beam delivery to the other halls, and is relatively less expensive because only one of the two linacs would be operated and cryo operations costs would be shared with the FEL. A final decision on this possibility will be made following PAC and laboratory review of the details.

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 prioritized them based on the PAC recommendations and other considerations as outlined in the scheduling committee charter. 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

Hurricane Isabel continues to have an adverse effect on the energy reach of the accelerator, and the trip rate at 5.75 GeV is currently about 15 per hour, beyond what we feel are comfortable operating conditions, either for the accelerator operators or the Users. Nevertheless, we are currently successfully running the experimental program at 5.75 GeV. We also lost another cryomodule during a warm-up, when a small leak became a much larger leak. This module has been removed from the machine and is being prepared for refurbishment. Fortunately, a detailed, continuous study of the individual cavity trips has enabled us to weather this further erosion of our installed accelerating gradient. We are presently pursuing a plan to refurbish two of the old cryomodules per year, dependent on the budget for the next two years. A new cryomodule, a 12 GeV prototype, is being completed and will be commissioned in the FEL before being transferred to CEBAF in time for the next high-energy running. All of our efforts are now aimed at ensuring that we have a comfortable margin for 6 GeV running, currently planned for January 2007.

The polarized injector, with two fully operational, horizontally mounted polarized guns (one for production beam and one for a spare), continues to perform well. All beam operations, polarized or unpolarized, are conducted with high polarization cathodes. The photocathode lifetime in the new horizontal guns is excellent. We have recently installed one of the first "super-lattice" cathodes, which have demonstrated the highest polarization ever measured at the lab (85%) and an improved analyzing power (change of beam parameters with helicity reversal). The HAPPEx-He experiment had beams with outstanding parity quality from this cathode. The remaining operational problems are being worked out and this cathode will be used routinely from now on. The last remaining problems are with locking the laser to the RF frequency, a problem that has previously been solved and should be fixed fairly soon.

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 July of 2004 HAPPEx-II accumulated approximately 10% of the approved data. The current on the right septum was limited to appr. 30 µA because of a remaining cooling problem. The septa were then removed in order to install and run the two Hall A DVCS experiments (E00-110: Bertin, Hyde-Wright, Ransome, Sabatie), DVCS from the proton and (E03-106: Bertin, Hyde-Wright, Sabatie, Voutier), DVCS from the neutron. Both E00-110 and E03-106 ran successfully until early December. In 2005 the schedule started with the first experiment using BigBite (E01-015: Bertozzi, Piasetzky, Watson, Wood) which is a study of the small distance structure of nuclei. This experiment ran very successfully, with two unshielded detectors (the BigBite detector and the neutron scintillator array) at a luminosity of 2.10^{37} $cm^{-2}s^{-1}$.

At the time this memo is written the two septum magnets are being installed again in order to complete experiments E94-107 on the waterfall target and both HAPPEx experiments. This is scheduled to take us to the end of November 2005, after which installation of the polarized ^{3}He target and BigBite for the G_E^n experiment will start. The GEn xperiment (E02-013: Cates, McCormick, Reitz, Wojtsekhowski) will then run until the start of the scheduled summer down.

Hall B

Since the last schedule release, Hall B completed data taking for PrimEx (E02-103: Dale, Danagoulian, Gasparian, Miskimen), a precision measurement of the pi-zero lifetime.

From December 2004 through the end of January 2005 the EG3 run group conducted a search for exotic cascade baryons (E04-010: Smith, Gothe, Holtrop, Stepanyan), which was followed by a shutdown during which the DVCS experiment (E01-113: Burkert, Elouadrhiri, Garcon, Stepanyan) was installed. The DVCS experiment included two new hardware components, a superconducting solenoid, and a fine granularity lead-tungstate calorimeter. Commissioning started March 11, and the experiment is currently taking production data. The first part of the experiment is scheduled to be completed May 27. DVCS will be followed by a short test run for the BoNuS detector and a test of a silicon micro strip detector that is planned for use in future experiments in Hall B. This test run will be followed by the G8b run group to study vector meson production with a linearly polarized photon beam (E99-013: Cole, Klein). The G8 experiment will run until the summer shutdown.

During the summer down the BoNuS experiment (E03-012: Fenker, Keppel, Kuhn, Melnitchouk) will be installed. BoNuS will run until the end of CY2005. It plans to measure 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

Hall C

Since the last schedule was released, Hall C completed the E02-019 (Arrington, Day, Filippone, Lung) experiment, a measurement of inclusive scattering on nuclei at x>1 and high Q^2, the E03-103 (Arrington, Gaskell) experiment, a study of structure functions in light nuclei, the E03-008 experiment to measure sub-threshold J/Psi photoproduction (Bosted, Dunne) and the second part of the E01-107 experiment, a measurement of pion transparency in nuclei (Dutta, Ent, Garrow). In addition, a two-week run was inserted to measure $R = \sigma_L/\sigma_T$ on deuterium (E02-109: Christy, Keppel) and heavier nuclei (E04-001: Bodek, Keppel), to accumulate high-priority data for the neutrino community. The Hall was then reconfigured to install the HKS and Enge spectrometers for E01-011, a spectroscopic study of Lambda hypernuclei (Hashimoto, Nakamura, Reinhold, Tang).

The fixed portion of the Hall C schedule starts with the E01-011 experiment, followed by the E02-017 experiment (Hu, Margaryan, Tang). The latter is a measurement of the hypernuclear life time in a heavy nucleus, also using the HKS apparatus. The Hall will then be reconfigured again to allow for the E04-115 (Beck) backward angle measurements of the G0 experiment, 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 the commissioning of these experiments.

The tentative portion of the schedule shows the physics data taking runs for the E04-115 (Beck) and E04-001 (Wells, Simicevic) experiments at a beam energy of roughly 800 MeV, their highest momentum transfer kinematics.

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.

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.