MEMORANDUM

Date: March 1, 2004

To: Distribution

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

Subject: Draft Accelerator Schedule: Through December 2004

Schedule

Attached is the draft accelerator operations schedule through December 2004. Due to the combination of the effects of hurricane Isabel and budget constraints, the accelerator will operate for approximately 28 weeks during Fiscal Year 2004.

The Jefferson Lab Nuclear Physics Experiment Scheduling Committee developed the schedule. Committee members are: Larry Cardman and Andrew Hutton (Co-Chairmen), Hari Areti, Jay Benesch, 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. Rocco Schiavilla 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.

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The standard section at the end of this memo on “the meaning of priority on the accelerator schedule” is included for reference; there were no changes in the policy this cycle. All users with running experiments should read it carefully. There has been an 8 hour shift in the shutdown hour associated with major downs and holidays.

The schedule attached represents our best effort to optimize the physics output of the laboratory consistent with our resource constraints and the technical evolution of the accelerator and the experimental equipment. In the material that follows, we outline the technical considerations that influenced the scheduling, and outline the planned program.

Accelerator

Operation in the first half of the FY03 included a major effort to support the G0 experiment, which needed special beam conditions (one bunch every sixteen buckets). This required the acquisition of a Ti-Sapphire laser capable of delivering the required 31.2 MHz beam structure. The unusual bunch structure – the first time that CEBAF had delivered anything other than 499 MHz bunch trains – created problems both for the beam diagnostics and for bunch formation in the injector. It proved possible to create the G0 bunch conditions using strong longitudinal focusing in the injector to counter the strong space-charge forces. However, these conditions were not fully compatible with the bunch structure required for Halls A and B, which have lower space charge forces, so a compromise had to be found. Eventually, the G0 experiment got excellent results, albeit with significant impact on the availability of acceptable beam conditions for the other two Halls.

A new cryomodule was constructed, successfully tested, and installed in CEBAF in position SL21 during the long maintenance period in February 2003. This cryomodule, the first of a new type with seven-cell cavities and a reduced cold mass, initially had some teething troubles, creating fast beam instabilities that were difficult to identify and fix. Eventually, the problems were traced to the stub tuners used to optimize the impedance match. When the stub tuners were retracted, the module started to work reliably, and SL21 is currently the cryomodule in the accelerator with the highest gradients (up to 60 MV total acceleration). As this cryomodule is one of the early prototypes of the 12 GeV modules, the experience gained was invaluable.

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. When polarized beam is not required, shorter wavelength lasers are used to take advantage of the higher quantum efficiency at these wavelengths. Typical bleedthrough from high current Halls A and C to Hall B is less than 3%. The photocathode lifetime in the new horizontal guns is excellent. In fact, the lifetime is now so long, it has become difficult to measure accurately. We have received delivery of the first batch of “super-lattice” cathodes, which in the lab have demonstrated high quantum efficiency, high polarization and an improved analyzing power (change of beam parameters with helicity reversal). We are hoping to be able to translate this success into the machine for operation during calendar 2004. A spare Ti-Sapphire laser has been procured which operates at a frequency better matched to the super-lattice cathode material, which will enable us to take full advantage of the new cathode material.

Hurricane Isabel came through our area on September 18, 2003 causing only slight damage to the site, but inflicting major havoc on the electrical grid. There was no power on site for over five days and the cryomodules warmed up for the first time in their fourteen-year history. We took the opportunity to do a lot of maintenance to the infrastructure (power, water, cryogenic systems) and then initiated an extremely detailed re-commissioning of the entire accelerator complex. The cryomodules have mostly recovered, although four cavities sprung vacuum leaks that cannot be repaired so that they will be permanently off-line from now on. The detailed tuning has led to a machine set-up that is significantly better than last year and we look forward to better performance. We are also hoping that the additional maintenance will translate into higher availability.

The main challenge in FY04 will be the second G0 experimental run scheduled to run partially concurrently with the extremely demanding hypernuclear experiment in Hall A, which requires a very small energy spread ($<2.5 \times 10^{-5}$). There is another major capability upgrade in FY04, the -II experiment that requires that the precision in helicity-correlated errors in energy, position, and current that were achieved by HAPPEx-I using a bulk photocathode now be achieved using a high-polarization photocathode. This will require further development of feedback schemes and this is likely to adversely affect operations.

A second challenge will be the delivery of the higher energy beams called for in the second half of this schedule. As you know, due to the warm-up of CEBAF resulting from the extended power outage following hurricane Isabel, the performance limits on each and every cavity must be re-established. This information can only be obtained after an extended period of running (we must determine the trip rate for each cavity as a function of gradient). We believe an adequate information base will be accumulated by February 1, and on that date we will meet to evaluate the maximum energy that can be delivered. We are optimistic that we will be able to deliver beams of at least 5.7 GeV, and the present schedule assumes that we can deliver these beams. However, it may need to be adjusted if the data accumulated between now and February 1 indicate that the accelerator will not be able to deliver the higher energy beams reliably.

We will continue to reserve a 12-hour period every Tuesday (7am-7pm) 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-hour periods every day up to a total of 12 hours per week. This has had the advantage of reducing the recovery time and we may well continue this cycle, which integrates well with short accesses by the Halls.

The DOE, through negotiations with JLab, defines the accelerator availability goal. The long-term availability goal has been defined for many years to be 80% at a multiplicity of 2.0. Since we usually run a considerably higher multiplicity, we have analyzed the running data for the last five years to evaluate the impact of multiple Hall operation on availability. The results show that the availability for single Hall operation should be 5% higher, while the availability for three-Hall operation should be 5% lower. In addition, for many years it has been agreed that the accelerator availability for the first three months of commissioning a major capability upgrade will be 10% lower. This year there are two major capability upgrades: G0 and -II. Putting all this together with the proposed running schedule leads to an accelerator availability goal that varies through the year depending on the difficulty of the program.

Hall A

The experimental schedule for FY03 had to be readjusted several times to allow for a delay in the delivery of the septum magnets. Following the delivery of the first septum magnet, the polarized ^{3}He target was moved to the septum interaction point, and E97-110 (Chen, Deur, Garibaldi) Forward-angle GDH, began running in May. There were problems with the septum magnet with both the connection of the windings and the cooling. When these were corrected E97-110 was run to completion.

The second septum magnet was received this fall, and its modification to correct for design flaws and its installation are nearly complete. The present schedule will begin with E94-107 (Frullani, Garidaldi, LeRose, Markowitz, Hashimoto), A Study of Hypernuclear Spectroscopy; it has been scheduled to run in January and February. Following that experiment, the waterfall target will be replaced by the cryotarget (in March and the first half of April) and then we will run E99-115 HAPPEx II (Kumar, Lhuillier), together with a week-long test run for E00-114 (HAPPEx-He: Armstrong, Michaels). On completion of E99-115 the septa will be removed.

The tentative portion of the schedule begins with the installation and running of the two Hall A DVCS experiments (E00-110 – DVCS from the proton: Bertin, Hyde-Wright, Ransome, Sabatie, and E03-106 – DVCS from the neutron: Bertin, Hyde-Wright, Sabatie, Voutier). These are to be followed by the installation and commissioning of Big Bite, and the start of running of the first experiment using it (E01-015 – a study of the small distance structure of nuclei: Bertozzi, Piasetzky, Watson, Wood).

Hall B

Since the last schedule release, Hall B completed final portion (e1e) of the e1 run group (polarized electrons on a hydrogen target, mainly to study N* excitations, 14 experiments). This was followed by the start of the eg2 run group (2 experiments on quark propagation in the nuclear medium). During the Isabel-imposed downtime, the Hall B group carried out extensive maintenance on the drift chambers, which were showing signs of serious aging problems.

Planned running begins with the continuation of the eg2 run group, to be followed by the investigation of exotic baryons (the pentaquark) formed in photoproduction (E03-113: Hicks). We have left a portion of the Hall B schedule “to be determined” – this time will be used either for additional PAC-approved running aimed at resolving the pentaquark situation, or for further running of eg2.

The tentative portion of the Hall B schedule begins with a transition to the Primex experiment (E02-103: Dale, Danagoulian, Gasparian, Miskimen). This will be followed by the installation and start of running on the Hall B DVCS experiment (E01-113: Burkert, Elouadrhiri, Garcon, Stepanyan)

Hall C

Since the last schedule was released, Hall C completed the G0 engineering run. By the end of that run, both the apparatus and the beam were successfully commissioned. Following G0 the Hall was reconfigured for a series of HMS and SOS base equipment experiments, including: Experiment E00-002 (Niculescu/Keppel), which measured the F_2 structure function in the unmeasured low-Q^2 region; E01-002 (Frolov/Koubarovky/Price/Stoler), which is a higher-Q^2 extension of the N-Δ transition form factor measurement; E01-004 (Blok/Huber/Mack), which extended the pion form factor data to higher Q^2; and E00-108 (Mkrtchyan/Niculescu) which addresses quark-hadron duality in meson electroproduction.

The fixed portion of the schedule begins with the reinstallation of G0, followed by its engineering run (roughly ¼ of the final data sample, which is to be used to demonstrate that G0 can complete its planned run successfully). If this engineering run is successful, G0 will remain on the beamline and complete the forward angle measurements. This will be followed by a transition back to the base equipment and the running of an experiment on x>1 data extended to higher Q^2 (E02-019: Arrington, Day, Filippone, Lung).

The tentative portion of the Hall C schedule begins with the completion of E02-109This will be followed by a study of structure functions in light nuclei (E03-103: Arrington), work to install the HKS spectrometer in preparation for running E01-111 early in 1995, and the running of E01-107, a measurement of pion transparency in nuclei (Dutta, Ent, Garrow).

Information about the Schedule

The accompanying revised schedule is fixed through June 2003, and tentative for the following six months. Because of the complex couplings between the hall operations during polarized beam running, all halls must continue to run in "calendar-driven" mode. The firm schedule for the second half of 2003 (and the tentative schedule for the first half of 2004) will be released following the meetings of the next cycle of the scheduling committee.

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. This initial period will be used for tests of the G0 beam; Hall C and the G0 beamline and detector and target apparatus must be ready to carry out the necessary tests at this time.

7. Formal certification for G0 to start its production run will be based on a Jlab management review of written material provided by the collaboration.

8. Physics production running will start at the beginning of the swing shift.

9. Hall A will lock up on swing and owl shifts for beamline tests if repairs to the septum and Q3 are successful.

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

Additional General Information on Operations and Scheduling Constraints

The accompanying schedule is fixed for the eleven-month period November 2003 thru June 2004 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 July-December 2004 period will be reviewed in April, 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.

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.

During operations in which a single, 1500 MHz laser is being used to drive the electron source for all 3 halls, when a non-priority hall needs changes to the accelerator state (re-tuning, access, etc.), then all halls currently receiving beam need to agree on the timing of the change, and the shift leader for the priority hall should contact the crew chief to make the formal request. The upgrades to the PSS and MPS system, together with the development of the three-laser drive system eliminate the need for this constraint during 3-laser operation of the source. However, it is necessary to reinstate this constraint whenever, for reasons of source performance in service to the running experiments, a single drive laser is used. It is also necessary to reinstate the constraint on a temporary basis in situations such as a laser failure in which we are forced to operate the polarized source in a non-standard manner.)

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 maintenance cycle that was started last year has proven to be a considerable improvement. In the present running cycle we will continue to extend the time between full (12 shift) maintenance periods even further. During a typical 4-week cycle period the maintenance/development cycle remains the same, but the weekly, non-invasive maintenance periods will be extended from 4 to 12 hours every Tuesday (7am - 7pm). This cycle offers improved opportunity for accelerator and injector related maintenance, and should result in even higher availability for physics.

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.