MEMORANDUM

Date: November 15, 2004

To: Distribution

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

Subject: Draft Accelerator Schedule: Through December 2005

Schedule

Attached is the draft accelerator operations schedule through December 2005. As of this date we still don't have a final budget for Fiscal Year 2005. If the budget is reduced from our planning budget, it may be necessary to modify the second half of this schedule to stay within our budget by reducing accelerator operations.

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. 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.

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

Operation in the first half of the FY04 included recovery from Hurricane Isabel and the associated intensive maintenance that has resulted in reduced accelerator downtime to hardware failures. This was followed by a detailed period of beam studies using the accelerator, which has resulted in an increased availability for Physics. This improved hardware availability was maintained throughout FY04. The tune time was high however as we tried successfully to provide the stringent beam conditions required by G0, the hypernuclear experiment in hall A and HAPPEx-II experiment. Overall, the availability for Physics was accurately predicted by our model: 85% for one-Hall operation, 80% for two-Hall operation, 75% for three-Hall operation, and a reduction of 10% for the first three months of delivering a new capability (hypernuclear and HAPPEx-II in FY04).

The hurricane had 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. However, we are currently successfully running the experimental program at 5.75 GeV. We are expecting delivery of a new cryomodule in July 2005 and this will allow us to run at 5.75 GeV with about 10 trips an hour – better but not comfortable. We are presently pursuing a plan to refurbish two of the old cryomodules per year, dependent on the budget for the next two years. If funded at the requested rate, this program would provide "comfortable" 6 GeV running with only a few trips per hour by July 2006.

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. There are still a few operational problems to be worked out but we are confident that within a few months use of this cathode will be routine with long lifetime (not presently the case).

We will 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

At the start of 2004 both septum magnets had been installed in order to run E94-107 (Frullani, Garidaldi, LeRose, Markowitz and Hashimoto: a study of Hypernuclear Spectroscopy). After a weeks of running at a reduced efficiency (because the left septum had to be manually re-cooled on a daily basis), a cryo-leak in Q3 of the left HRS

spectrometer (which had probably been instigated by the cryo-cycling forced by hurricane Isabelle) prohibited further running. While the cryo-leak in Q3 was repaired, the cryocan of the left septum was opened up and the cooling problem repaired. It was decided to use the long forced down to also replace the waterfall target by the cryotarget (which prohibited further hypernuclear running with the waterfall target). Production running on E94-107 was successfully resumed in early April and data taking completed on carbon and beryllium. Following E94-107, experiment (E04-012: Reimer & Wojtsekwski), a high resolution study of the 1540 exotic state, took data until early June 2004. Both HAPPEx-He (E00-114: Armstrong, Michaels) and experiment (E99-115: Kumar, Lhuillier) , HAPPEx-II, then accumulated appr. 10% of the approved data in a run until late July. 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. At the time of this memo, E00-110 has accumulated appr. 80% of the scheduled statistics and E03-106 has started production running. These experiments are to be followed by the installation and commissioning of Big Bite, a new spectrometer for Hall A.

The 2005 schedule starts with the first experiment using BigBite (E01-015: Bertozzi, Piasetzky, Watson, Wood) which is a study of the small distance structure of nuclei. Mid April 2005, the two septum magnets will be installed again in order to complete experiments E94-107 on the waterfall target and both HAPPEx experiments. This should 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.

Hall B

Since the last schedule release, Hall B completed the final portion of the G11 run group, a search for the Theta$^+$ pentaquark on a hydrogen target (E04-021: Battaglieri, De Vita, Koubarovski). During the summer shutdown the PrimEx detectors was installed (E02-103: Dale, Danagoulian, Gasparian, Miskimen), continued by commissioning and data taking which will end November 21. PrimEx is a precision measurement of the pi-zero lifetime.

From December 2004 through January 2005 the EG3 run group will conduct a search for exotic cascade baryons (E04-010: Smith, Gothe, Holtrop, Stepanyan), followed by a shutdown during which the DVCS experiment (E01-113: Burkert, Elouadrhiri, Garcon, Stepanyan) will be installed. The DVCS experiment will run from March through May 2005, followed by the G8 run group to study vector meson production with a linearly polarized photon beam (E99-013: Cole, Klein). The G8 experiment will run until the shutdown in September/October 2005.

The tentative portion of 2005 includes the installation and running of the BoNuS experiment (E03-012: Fenker, Keppel, Kuhn, Melnitchouk) until the end of 2005. BoNuS will 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 initial part of the E01-107 experiment, a measurement of pion transparency in nuclei (Dutta, Ent, Garrow), and nearly-completed the E02-019 (Arrington, Day, Filippone, Lung) experiment, a measurement of inclusive scattering on nuclei at $x>1$ and high Q^2, and a study of structure functions in light nuclei (E03-103: Arrington, Gaskell). The 2004 program continues with the E03-008 experiment to measure sub-threshold J/Psi photoproduction (Bosted, Dunne) and the completion of the E01-107 experiment.

The fixed portion of the Hall C schedule shows the installation of the HKS and Enge spectrometers for E01-011, a spectroscopic study of Lambda hypernuclei (Hashimoto, Nakamura, Reinhold, Tang). Since the installation time for this experiment was extended for scheduling compatibility reasons with other Halls, we tentatively insert a two week run to perform part of the E02-109/E04-001 experiments (Bodek, Christy, Keppel) to measure the nuclear effects on $R = \sigma_L/\sigma_T$. The E01-001 experiment will then start in June, 2005 and extend into the tentative portion of the schedule. The E02-017 experiment (Hu, Margaryan, Tang), a measurement of the hypernuclear life time in a heavy nucleus, follows the E01-011 experiment, also using the HKS apparatus.

Beyond E02-017, the tentative portion of the schedule shows a reconfiguration of Hall C in preparation for the start of the E04-115 (Beck) backward angle measurements of the G0 experiment, combined with the E04-001 parasitic measurement of parity-violating electron scattering in the Delta resonance region (Wells, Simicevic). The tentative portion of the schedule ends with a commissioning run for these experiments, with the intent to continue their physics data taking in 2006.

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

7. The time allocated to the L/T separation experiments in Hall C will be re-assessed based upon the success of the J/Psi and Transparency experiments.

8. 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.

9. E01-113 (the CLAS DVCS experiment) is listed on the fixed portion of the schedule for 6 days of commissioning and 70 days of data-taking. At the historical average data-taking efficiency of ~50% that we use for scheduling, this corresponds ~35

days or 58% of the PAC-approved 60 day run. However, because of the major installation efforts that will be taking place in Halls A and B during this period, much of the E01-113 run is in "single-hall" mode. It is easier for the accelerator to deliver a single beam because this mode of operation avoids the need to satisfy multiple requirements simultaneously, to tune beams for more than one hall, and to make configuration changes to accommodate energy changes in the halls. As a consequence, single-hall running is more efficient. Because E01-113 is scheduled for so much single hall running, we are optimistic that it will significantly exceed the expectation of the scheduled run providing 58% of the PAC-approved experiment. If actual data-taking for E01-113 (as reported by the collaboration in the shift reports) exceeds 75% of the PAC-approved "60 days of perfect running" then we will adjust the schedule.

10. The time scheduled for Cryo-Cycling may not be needed. If that is the case DVCS will begin running early.

11. The installation of experiment e8-BoNus is dependant upon a successful test demonstration of the BoNus detector that is scheduled for 6/04/05 to 6/10/05. If these tests are not successful, the schedule will be appropriately revised.

Additional General Information on Operations and Scheduling Constraints

The accompanying schedule is fixed thru June 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 July-December 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.