MEMORANDUM

Date: November 22, 2002

To: Distribution

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

Subject: Draft Accelerator Schedule: Through December 2003

Schedule

Attached is the draft accelerator operations schedule through December 2003. We have not yet received our operating budget from DOE for FY03 and will not receive it until Congress has passed the overall DOE budget. We anticipate operating for approximately 30 weeks during Fiscal Year 2003 if the requested funding is granted.

The Jefferson Lab Nuclear Physics Experiment Scheduling Committee developed the schedule. Committee members are: Larry Cardman and Andrew Hutton (Co-Chairmen), Hari Areti, Rolf Ent, Leigh Harwood, Bernhard Mecking, Kees de Jager, Mike Seeley, Dennis Skopik, Steve Suhring, Will Oren, 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 Hall C was calculated using an estimated overall efficiency of simultaneous hall and accelerator operation of 60% in order to perform a complete set of short experiments during the break in G0 running. An efficiency of 50% was used for Hall B scheduling, even though the actual availability was higher; since most running in Hall B involves fractions of very long run groups, cutting the scheduling as tight as possible has no long-term benefit, and we take advantage of higher running efficiency (when achieved) to complete a larger fraction of a run group's program. Scheduled time for Hall A was again calculated using an estimated overall efficiency of 60%. In a number of cases the scheduled beam time 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; there were no changes in the policy this cycle. All users with running experiments should read it carefully.

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

We ran the majority of FY02 at 5.7 GeV as a compromise between the high trip rates associated with pushing the accelerator energy higher and the physics users desire for higher energy. The SL21 cryomodule, which was built mainly with FEL funding, has been installed in the accelerator for the last two years and has helped to increase the maximum energy. It is now required by the FEL for their Upgrade program and was removed from CEBAF in August 2002. A replacement cryomodule is due to be installed in February 2003 so operation above 5.0 GeV has not been scheduled until April 2003.

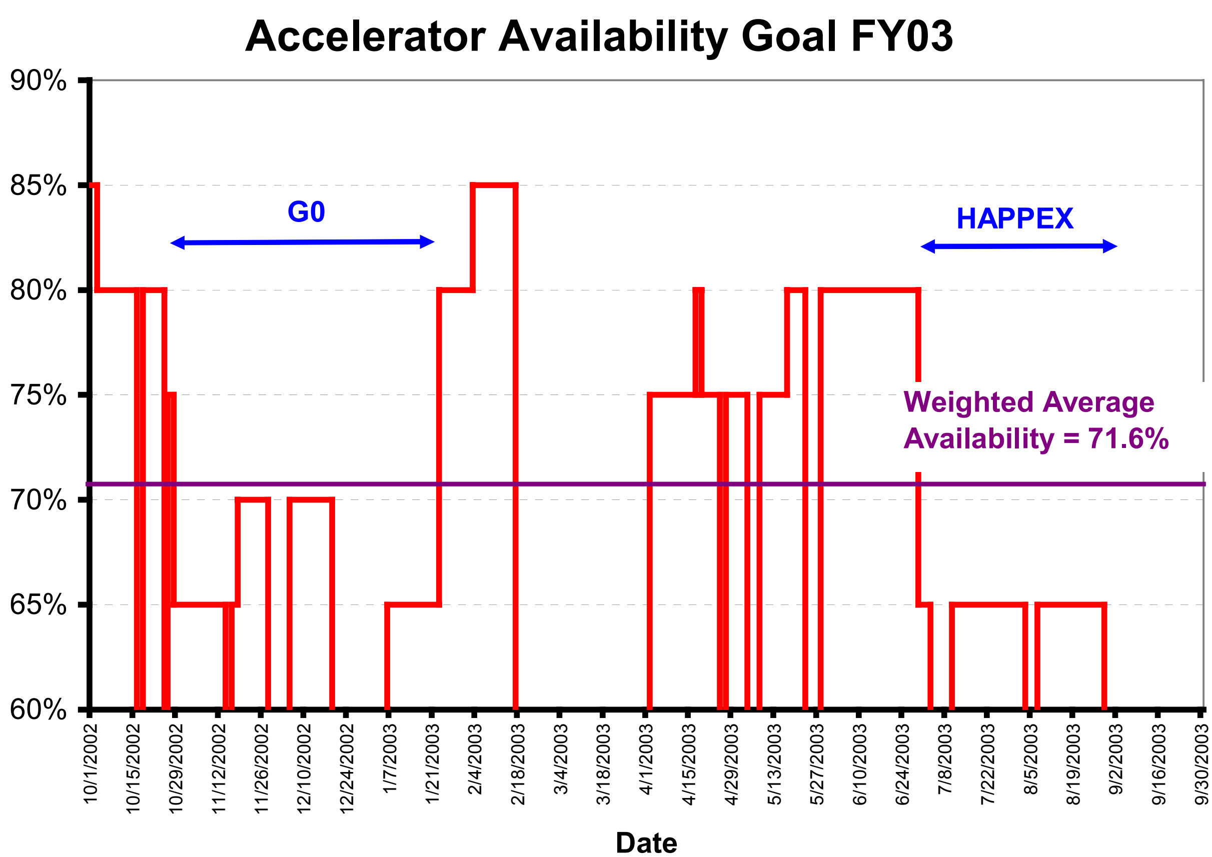
The polarized injector, with two fully operational, horizontally mounted polarized guns (one for production beam and one for a spare), continues to perform well. All beam operations, polarized or unpolarized, is conducted with high polarization cathodes. When polarized beam is not required, shorter wavelength lasers are used to take advantage of the higher quantum efficiency at these wavelengths. Typical bleed through 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. The current value is over 35,000 μA-hours or 300 Coulombs at high current. Though this long lifetime makes absolute statements difficult, our current experience is that the cathode deterioration can be completely removed by a simple heat treatment and reactivation. This cathode recovery can be accomplished during a normal maintenance period. This implies that a single cathode could be used essentially without limit. During the past year, over 280,000 μA-hours were delivered from the polarized guns with polarization between 75% and 80%.

A new Ti-Sapphire laser was purchased for the G0 experiment that provides the required laser pulse rate (31 MHz versus 499 MHz). It has functioned well and we have been able to demonstrate the successful achievement of most of the required beam specifications. This has required a major upgrade of many parts of the accelerator and we are still learning how to maintain the specifications over time.

There is another major capability upgrade in FY03, the HAPPEX-II experiment that requires unprecedented precision in helicity-correlated errors in energy, position, and current. This will require further development of feedback schemes and this is likely to adversely affect operations.

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 that integrates well with short accesses by the Halls. Since there are two long periods(5 weeks) of continuous operations scheduled in January and June, we will also claim, if required, one half of our normal maintenance time(12 shifts in a 3-4 week period) for performing machine maintenance during these two periods.

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 HAPPEX-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. This is shown in the graph, together with the estimated weighted average for the year of 71.6%.



Hall A

The experimental schedule for FY02 had to be readjusted several times to allow for a delay in the delivery of the septum magnets. In FY02, Hall A used the December/January shut down to remove the waterfall target system and install the cryogenic target system, the Focal Plane Polarimeter (FPP) and the leadglass calorimeter with its associated charged-particle sweep magnet required by experiment E99-114 (Hyde-Wright/Nathan/Wojtsekhowski) . E99-114 carried out precise measurements of Real Compton Scattering at high luminosity. Following E99-114, E98-108 (Baker, Chang, Frullani, Iodice, Markowitz), electro-production of kaons up to $Q^2=3\ (GeV/c)^2$, was completed in February.

Experiment E01-001 (Arrington/Segel) ran in May. E01-001 performed a new measurement of G_E/G_M for the proton, using an improved version of the Rosenbluth separation technique. In June the first half of E01-020 (Boeglin, Jones, Klein, Ulmer, Voutier), Electro-disintegration of the Deuteron, was completed. Then, when it became clear that the septum magnets would not be delivered during the summer down, experiments E00-107 and E00-007 (Gilman, Holt, Meziani for both) were scheduled for September. Because of a second crash of the cryotarget, E00-107 could not run, but E00-007 was completed successfully. In October/November E01-020 was successfully completed.

In November/December the polarized ^{3}He target will be installed at the standard interaction point to allow E01-012 (Chen, Choi, Liyanage), A Study of Spin Duality in ^{3}He, to run. One septum magnet is expected to be ready for installation during the February/March shutdown, when also the polarized ^{3}He target will be moved 80 cm upstream to the septum interaction point This will allow to run E97-110 (Chen, Deur, Garibaldi). Forward-angle GDH, in April/May. The second septum magnet will then be installed, together with the cryotarget, in May/June, followed by running E00-114 (Armstrong, Michaels) for a week and E99-115 (Kumar, Lhuillier), HAPPEX-II, to completion in July-September. After replacing the cryo-target by the waterfall target E94-107 (Frullani, Garibaldi, LeRose, Markowitz), A Study of Hypernuclear Spectroscopy, has been scheduled to run November/December. On completion of E94-107 the septa will be removed and Big Bite will be installed for commissioning and running of the first experiment.

Hall B

Since the last schedule release, Hall B completed the second half of the e2 run (polarized electrons on a helium-3 and other nuclear targets to study nuclear phenomena - eight experiments). This was followed by a short test run for the Primex experiment.

After the maintenance period in July/August 2002, the g7 experiment (search for medium modifications in the mass spectrum of electron-positron pairs) took data and was completed. This was followed by the beginning of the e1e run (polarized electrons on a hydrogen target, mainly to study N* excitations, 14 experiments). The e1e run will complete the presently approved e1 program. It will occupy the entire first half of 2003 and the beginning of the second half of 2003.

The tentative part of the schedule in the second half of 2003 shows the completion of the eg2 run (high energy electrons on a variety of nuclear targets to study quark propagation and vector meson production in nuclei, experiments E02-104 and E02-110).

Hall C

Since the last schedule was released, Hall C has run a single experiment, E01-006 (Rondon/Jones), accessing the spin structure in the nucleon resonance region. This experiment used the polarized target system already installed for the previous E93-026 experiment accessing the neutron charge form factor. Mid March 2002 Hall C started a seven-month period of installation of the G0 apparatus, in preparation of the first engineering run for E00-006 (Beck), the G0 forward angle measurements. During this period several beam and apparatus commissioning periods were scheduled. This first G0 engineering run will end January 2003, at which time the Hall will be reconfigured for a series of HMS and SOS base equipment experiments. The scheduled base equipment experiments all use 4 cm hydrogen and/or deuterium targets. Experiment E00-002 (Niculescu/Keppel) measures the F_2 structure function in the unmeasured low-Q^2 region. Experiments E01-002 (Frolov/Koubarovky/Price/Stoler) and E01-004 (Blok/Huber/Mack) are higher Q^2 extensions of the N-Δ transition and pion form factor experiments, respectively. Experiment E00-116 (Keppel) is a small experiment finalizing Hall C's quark-hadron duality studies at the highest Q^2 achievable at a 6-GeV JLab. Experiment E00-108 (Mkrtchyan/Niculescu) will run at a best-effort basis and addresses quark-hadron duality in meson electroproduction. The tentative part of the Hall C schedule shows the installation of the G0 apparatus for the 2nd E00-006 (Beck) engineering run.

Information about the Schedule

The accompanying revised schedule is fixed through June 2003, and tentative for the following six months. 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. In the "Accelerator" column, a "low" under Polarization) indicates planned use of either a bulk or a thin (but unstrained) GaAs cathode, implying that medium (~40%) polarization can be expected. A "high" under Polarization) indicates planned use of a strained GaAs cathode, implying high (~75%) polarization can be anticipated.

4. 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 beam time 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.

5. 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.

6. 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.

7. The PAC sanctioned Energy Recover Demonstration at High Energy will be performed during this down.

Additional General Information on Operations and Scheduling Constraints

The accompanying schedule is fixed for the nine-month period October 2002 thru June 2003 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 2003 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 (such as Thanksgiving) the beam will be shut down at ~noon on the last day shown as beam delivery (e.g. Wednesday noon before the Thursday Thanksgiving holiday).

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.