Session II. Operations

Chairperson: D. Schultz
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1) SPEAR Experience: J. Corbett

Jeff Corbett gave a summary of operational experience with the SPEAR ring. The ring runs continuously with ~90% uptime, being filled once a day. Repair days, followed by periods of machine physics, are scheduled at two-week intervals. The run philosophy is "Don't turn it off" – M. Donald. Recent upgrades have included; quad shunts which allow both beam based alignment of the quads with respect to the BPMs and measurement of tune shifts with individual varying quad strength, the beam orbit is steered via SVD through a feedback system about every minute, understanding and minimization of a noise source - the solar heating of a section of Al waveguide which had been exposed to the sun.

2) Damping Rings Operation and Plans: R. Pennacchi and M. Stanek

Mike Stanek spoke on Operations responsibilities for Damping Ring running. He noted that turn-on checklists had proved effective for initial hardware checkout performed by operators. A beam-on plan, comprised of a list of beam parameter goals, was also effective when used by the operators with expert help for some measurements. Communication with experts is vital in this process to highlight problems. He noted that beam turn-on can be less efficient when the initial beam requirements (for FFTB in the latest instance) are lower than what will be needed eventually (for SLC).

Stanek made the observation that operators will sometimes be creative with the tuning of the beam. This creativity can be positive when it aids in troubleshooting a problem, or when it leads to a new tuning technique or a better understanding of the system. The creativity can also be detrimental if the effect created cannot be reproduced or masks the root cause of a problem.

Roz Pennacchi spoke on operational issues. Temperature instability causes recovery problems when the ring vault is opened for access. Recovery from vacuum venting of the ring is now easier with the auto-beam-processing macro. RASKing of some magnet systems is prohibited due to the PPS logic structure, and these systems can only be tested with small lab power supplies.

3) Simultaneous Long Pulse Operation: R. Erickson

Roger Erickson gave a summary of the plan to bypass the damping rings during long-pulse ESA experiments operations, for example for the upcoming E158 run. These experiments would run interlaced with PEP2 running, with beam being taken to the PEP2 rings during ring fills, and to ESA otherwise. The current plan is to pulse the PBH and HBO magnets, sending beam to the LTRs and from the RTLs for the PEP2 cycles. PBH and HBO would be de-energized during the long-pulse ESA cycles. PBH is a laminated magnet and was originally made for pulsed operation, HBO is a solid core magnet and would have to be replaced. HBO is currently powered in series with RTL bend magnets. If it were to run on an independent power supply the regulation tolerances would be very tight. There is also an issue with the optics in sector 2, which cannot be matched both to the RTLs for the damped PEP2 beam and to sector 1 for the straight-ahead long-pulse beam. Optics matching would require either a compromise linac lattice or pulsed quadrupole magnets. Pulsed correctors would also be needed to steer the two beams independently.
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Operational Experience at SPEAR

Jeff Corbett
April 6, 1998

The SPEAR storage ring is operated as a synchrotron light source by the Stanford Synchrotron Radiation Laboratory, a division of SLAC. Formerly an e+/e- collider in the 2-8Gev CM energy range, SPEAR now operates at 3Gev and services 11 photon beam lines (7 insertion devices, 4 dipole sources). Including sidestations, 25-30 experiments can receive photon beams simultaneously. Due to the sensitivity of the experiments, a premium is placed on electron/photon beam stability both globally around the ring, and locally near the photon beam source points. Long beam lifetimes and 24-hour reliability are mandatory 9 months each year. In order to relate operational experience at SPEAR to the SLC Damping Rings, this report covers four relevant topics: (1) operational mode and run statistics, (2) quadrupole shunt circuits for beam centering, (3) slow orbit correction to combat diurnal drift and (4) recent experience with beam power coupling to the 358mHz cavity-waveguide-klystron rf system.

(1) Operational Mode - SPEAR is filled to 100mA in ~60 rf buckets and an ion clearing gap every 24-hours. The injection injection energy is 2.3 GeV and the fill period typically lasts 3-5 minutes (20-30mA/min). The ring is then ramped to 3.0 GeV in about 3 minutes. The record turn-around time (dump, standardize, fill, ramp, steer, deliver) is about 15 minutes. At the top of the fill (100mA), the beam lifetime is on the order of 30 hours. For both user convenience and thermal stability, fill time is 6 A.M., 7 days a week.

The SPEAR injector is combination of linac and booster synchrotron. A 1 micro sec s-band pulse train is generated by a 1.5 cell r.f. gun, "chopped" by a travelling-wave discriminator to allow passage of 3 s-band bunches, and accelerated to about 120 MeV by three standard SLAC linac sections. The 3 s-band bunches are captured in a single 353 MHz booster rf bucket at the bottom of the 10 Hz sinewave ramp cycle in the booster (White Circuit). The 120 MeV linac beam is ramped to 2.3 GeV with a 0.1 s period. The booster-SPEAR timing system is arranged to allow for arbitrary SPEAR fill patterns.

The 9 month SPEAR operation cycle begins each Fall and ends in the following Summer. This format minimizes the impact of heat waves and brown-outs. As indicated in the run integral plots, the average ring pressure (as sampled near pumps) rapidly conditions to ~1nTorr within 2-3 months of operation, even after major vacuum chamber modifications. As each run progresses, the fill period is increased from 8 to 12 hours, and finally to 24 hours.

Two attached figures show the beam current during a typical week of operation and the Run Time Distribution for operation in 1997. The beam current plot shows a series of ‘events’ where beam was lost, supporting the adage “don’t turn it off.” The run-time statistics for 1997 show a beam delivery rate on the order of >95%. (Maintenance and accelerator physics are not counted towards delivery.) Most of the down time can be attributed to photon beamline interlock faults, mysterious power supply trips and line voltage transients. Accelerator physics is scheduled for 48-hour shifts every two weeks. Once a month, 8-hours of the accelerator physics goes to routine maintenance and inspections in the tunnel.
(2) **Quadrupole shunt circuits** – Each quadrupole in SPEAR is equipped with a girder mounted, water cooled shunt circuit designed to bypass 2-3% of the main power supply current. The shunt itself is a power MOSFET, and a 1% power resistor is used to monitor the shunt current. An external control panel allows the operator to select and activate shunts under manual or computer control. The most common application is to sweep the electron beam position through the quadrupole field until activation of the shunt does not cause an orbit shift. At this point, the beam is ‘centered’ in the magnetic center of the quadrupole. Adjacent BPM readings are recorded to fiducialize the beam position. Frequently, we center the beam in adjacent quadrupoles spanning a drift space to eliminate angle errors. This method would be effective across the septum straights in the damping rings. Due to beta function modulation, horizontal and vertical centering accuracy is highest on QF/QD quadrupoles, respectively. The readback current coupled with the induced tune shift yield betafuncttion measurements which again might be useful at the QF quadrupoles flanking the septa. Radiation damage of the MOSFETs has been observed.

(3) **Orbit Correction** – At SPEAR we measure the horizontal and vertical correction-to-bpm response matrices for orbit control and feedback. A menu-driven application program allows the operator to select bpsms, correctors, and the number of SVD ‘eigenvectors’ for orbit control in each plane. (Singular Value Decomposition/SVD) is used to resolve the response matrix into matched sets of corrector pattern/orbit response eigenvectors. Typically, about half of the eigenvectors are required for global orbit control. During each fill, the orbit control program cycles once per minute to control long-term orbit drift. Analog circuits controlling local beam bumps provide ~20Hz closed-loop bandwidth for each photon beamline. In the future, we plan to convert the entire global/local orbit control system to a unified digital system that acquires orbits at a 500-1000 Hz acquisition rate. The SVD orbit control system is also used to produce closed bumps. In this application, one selects only a few correctors and moves the beam by offsetting the BPM signal(s) at the desired position(s) while holding the orbit constant elsewhere. In practice, the BPM offsets are assigned to a knob, and we ‘knob’ the beam position with the orbit control feedback active. Orbit control is not used during the fill and ramp cycle (although in principle it would work).

(4) **Beam / Waveguide Coupling** - Observations of fast horizontal beam jitter on the synchrotron light monitor and photon beam position monitors indicate that the electron beam becomes unstable mornings, evenings, and under intermittent cloud cover. The source was traced to exposure of a 15 m waveguide section to direct sunlight. As the waveguide temperature increased or decreased, the rf mode volume changed and at times became resonant with horizontal betatron sidebands. The phenomenon was confirmed by hosing down the waveguide during critical periods and observing a ~20kHz ‘noise band’ sweep across the horizontal tune. Corrective measures included mounting a sprinkler system above the waveguide, installing a protective shroud to shade the waveguide, and then upgrading the dry-air pressure regulation circuit to maintain < 6" H2O over pressure.
Operational Experience at SPEAR

J. Corbett
April 9, 1998

- Facility Overview
- Operational Mode
- Orbit Feedback
- Quadrupole Shunts
- RF Waveguide Modes
End Station A

SPEAR II

120 MeV, 2856 MHz

© 10.42 (White Circuit)

4 bend magnet lines
11 ID sites

Stanford Synchrotron Radiation Laboratory
1997 Run Time Distribution

Martin Donald - "Don't turn it off!"
(PEP/circa 1990)
Week in March of Beam Current and Vacuum Quality

- DCCT
- Vacuum Quality (A-Hrs)

Electron Beam Current (mAmps)

Vacuum Quality (Amp-Hours)

AVERAGE PRESSURE AT 70 MA

- 1995
- 1996
- 1997
- 1998

~ 2 months

100 mA at top of fill
60 bunches per fill with 100 cleaning gap
LIFETIME AT 70 MA

0.5 10 15 20 25 30 35 40 45
LIFETIME (HOURS)

0 50 100 150 200 250 300 350 400
RUN INTEGRAL (AMP-HOURS)

Opto-Coupled Schmitt Trigger

Current Readback

Buffer

Isolation Amp

MOSFET + Driver

I_{shunt}

Magnet

Enable

Quadrupole Shunt Circuit
for beam centering and \beta-measurement
Beam Centering with Orbit Sweep Method
SVD for Orbit Control

\[
\Delta x = R \Delta \theta \\
\Delta x = (UWV^T) \Delta \theta
\]

See "Linear Algebra" by Gilbert Strang

\[ R = UWV^T \] (SVD)

where

\[
U = \begin{bmatrix}
\text{Orbit}
\end{bmatrix} = \begin{bmatrix}
\text{Eigen}
\end{bmatrix}
\]

orthonormal vector set spanning space

of observable orbit perturbations

\[
W = \text{eigval} \left( AA^T \right) = \text{eigval} \left( A^TA \right) \quad \text{positive definite}
\]

\[
V = \begin{bmatrix}
\text{correction vectors}
\end{bmatrix} = \begin{bmatrix}
\text{eigen- vectors}
\end{bmatrix}
\]

orthonormal set of correction patterns
(contain 'null' vectors)

\[
\text{SVDcomp}(R) \rightarrow U, W, V^T
\]

\[
R^{-1} = (UWV^T)^{-1} = VW^T U^T
\]

\[
\Delta \theta = R^{-1} \Delta x \quad \text{Apply } \approx \text{ once per minute or faster with}
\]

digital compensator
SVD Orbit Correction
10 micron bpm noise

- Residual Orbit (micron)
- Corrector Strengths (micro-radian)

Application of more eigenvectors reduces orbit amplitude but increases correctors. Do not correct below noise floor.
Week of March, 1998 at SPEAR

RMS Horizontal and Vertical error
for 1 week of operation
horizontal = 100 μm rms
vertical = 90 μm rms
Vertical orbit motion at one BPM over 4 days with and without feedback. Step changes occur after each fill and energy ramp cycle.
- Waveguide heating at sunrise causes waveguide modes coupled to Qx.
- At first we installed H2O cooling (hose) to control waveguide temperature.
- Later installed dry air pressure regulator to maintain < 6" H2O pressure.
- Waveguide is back-pressured to prevent moisture from entering system.
SIMPLE MODEL OF THE SPEAR NOISE

Cavity modes $n, m, q, \ldots$

Beam - cavity - waveguide - klystron

System only matched for fundamental.

Modes:

$i, j, k, l, \ldots$
It was usually observed that there is a certain correlation of the noise with the outside temperature (sun).

- Very nice amazing and unique experiment: Hosing the waveguide with water let the noise disappear. (first time reported at SPEAR)

But:

Temperature is not included in Maxwell’s equations!

- Only the geometrical size and dimensions are relevant
- Temperature with inhomogeneous distribution changes the waveguide form and dimensions
- Temperature changes the pressure inside the waveguides

**Observations:**

- $p < 7$ inches: **no noise**
- $p > 7$ inches: **noise possible**

This changes the eigenfrequencies of the waveguide system. The effect is relatively small:

- Frequency of the "noise-mode": $f_{\text{mode}} \approx 10^9 \text{ s}^{-1}$
- Max. horizontal tune shift: $\Delta f_x \approx 100 \times 10^3 \text{ s}^{-1}$

$$\Rightarrow \Delta f_x / f_{\text{mode}} \approx 0.0001$$
Damping Ring Operations and Plans

Roslind Pennacchi

Damping ring operational issues are examined, including temperature stability, recovery from vacuum vents and rasking of magnets in the DRIP. Various diagnostic systems are highlighted with details of extended area manager checklists and responsibilities. Future damping ring performance and improvements are also discussed.

When there is an access to the damping rings, the temperature drops by approximately 10 degrees F. Recovery from an access requires more time than the original access to return to previous beam orbits. The damping ring extraction angle is very sensitive to these temperatures and corrector strengths in the RTL track concrete temperatures in the ring. Heaters have been added and air flow restricted to minimize this affect. Even after beam is off for brief periods of time, the feedback extraction position and angle show significant changes. The planned solution is to keep full rate in the damping rings and avoid instabilities by using the 2-9 dump.

After a vacuum vent, beam is used to scrub the vacuum chamber to speed up processing. It is difficult to push the beam current close to the RF vacuum interlock threshold without tripping the station and taking time to bring it back on again. The operators wrote a macro to use Matlab to monitor a real time correlation plot and rate limit beam just below the RF trip level. Beam is restored to full rate when the vacuum reaches its lower threshold. One problem with this system is excessive CPU interrogations that can hang up the micro. The operators request improved software.

Rasking magnets in the DRIP area can be difficult. Magnet strings that cross PPS barrier gates cannot be tested with PPS interlocked power supplies on. The logic does not allow RASK access in the DRIP if the SDR is in Restricted Access. PPS logic needs to be modified to allow safe power on measurements. When possible, a small lab supply is substituted to check the polarity of magnets. This method is not always successful when checking for other problems.

Damping ring diagnostics include kicker timing with multiplexed scope setups. Standard kicker signals are easily available. RF signals are selected remotely for digital and analog scopes. The tune measuring system needs periodic attention, especially with trigger setup. The aging spectrum analyzer needs replacement.

The damping ring area manager will assume more responsibilities during the PEP II era. This will include monitoring the tunes and spectrum analyzer signals. Gold orbits will be compared with current orbits and BPM status will be checked. Ion chamber signals, envelope scopes, RF signals and the synchrotron light monitor will also be observed regularly.

Future damping ring performance will be enhanced by the following upgrades: Changes in rate limiting states will be implemented to improve the temperature stability of the rings. Software will be improved for vacuum processing with beam. Monitoring of existing diagnostics will be shared by operators and the area manager.
Damping Ring Operations
and Plans

Roslind Pennacchi
Damping Ring Area Manager

April 6, 1998
Operational Issues

- Temperature Stability
- Recovery from Vacuum Vents
- Rasking of Magnets in the DRIP
- Diagnostics
- Area Manager Checklist
- Future Damping Ring Performance
Temperature Stability

- Damping Ring Extraction Angle very sensitive to Temperature
- After Beam is off for brief periods of time, feedback extraction position and angle show significant change
- Recovery from a Ring access requires more time than the original access to return to the original orbit
- Heaters added to compensate, but concrete temperatures track corrector strength changes in RTL
- Keep full rate in Damping Rings to avoid instabilities by using 2-9 dump
Recovery from Vacuum Vents

- Beam is used to scrub vacuum chamber
- Difficult to push beam close to RF vacuum interlock threshold without tripping stations
- Operators wrote macro to use Matlab to monitor real time correlation plot and rate limit beam just below RF trip level
- Beam is restored to full rate when at lower vacuum threshold
- This macro uses excessive CPU interrogations and can hang up micro need improved software
Rasking Magnets in the DRIP

- Magnet strings which cross PPS barrier gates cannot be tested with PPS interlocked power supply on
- Logic does not allow RASK access in DRIP if SDR is in Restricted Access
- Need modification of PPS logic to allow safe power on measurements
- When unable to RASK a small lab supply is used if possible
Diagnostics

- Kicker Timing Diagnostics have multiplexed scope setups with standard signals easily available
- RF Signals are selected remotely for digital and analog scopes
- Tune Measuring System needs periodic attention especially trigger setup
- Aging Spectrum Analyzer Needs Replacement
Area Manager
Checklists

- Tune Monitor and Spectrum Analyzer
- Orbits and BPM Status
- Ion Chamber Signals
- Envelope Scopes
- RF Signals
- Synchrotron Light Monitor

Damping Ring Operations / RP
April 6, 1998
Future Damping Ring Performance

- Implement changes in the rate limiting states to improve temperature stability
- Improve software for vacuum processing with beam
- Existing diagnostics with shared responsibility of OPS and AM
- Performance Goals & Milestones
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Damping Rings Operational Issues

M. Stanek

Summary

For the April 1997 SLC turn on, the Operations Section staff was responsible for the initial Damping Ring turn on and commissioning plan. This increased involvement in the generation and execution of the turn on plan was generally successful, and should be continued for future runs.

The final checkout of hardware systems is done by the operators, using formal Turn-On Checklists, starting a few weeks before turn on. Coordination and scheduling of checkout is done with input from the Area Manager. This process is effective for finding standard, simple problems with power supplies and control system hardware. CATERs are generated for the support groups to address.

The Turn-on plan was developed by the Operations supervisors with input, review and approval by the Accelerator Physics group. The EOIC's and Operators then carried out the turn-on and beam tuning steps, using standard procedures. Special checkout (e.g. DR RF feedback setups) was carried out by the RF experts and Accelerator physicists. This process worked well for establishing stored beam in the Damping Rings, checking out standard diagnostic tools, and characterizing the system performance. More subtle problems and unusual performance needed much heavier interaction with the system physicists to plan and carry out further measurements. The process of diagnosing and addressing these more difficult problems was an ongoing effort for many weeks during the 1997 turn on. A Web page was developed by Patrick Krejcik to summarize and track these problems and the associated machine studies needed. This proved a very effective tool for communicating with the Operations staff.

Attached are examples of Turn-On Checklists, Commissioning goals and plans, and summary progress reports. An example of the Damping Ring Web page is also shown.

For standard day-to-day operation, the operators typically tune to maintain beam parameters at the run goals. They work without much interaction with or assistance from the accelerator physicists, except when subtle instabilities or serious hardware failures occur. Operators are encouraged to understand the Damping Ring systems, rather than memorize procedures. This leads to some "creative" solutions and work-arounds. This approach has both positives and negatives, as shown on the attachment. In general, this has resulted in more independent troubleshooting, and quicker diagnosis of problems.
Damping Ring Operation

Operations Staff responsibilities

Turn On/Start-up

- Final checkout of hardware systems,
  - Use Damping Rings Turn-on Checklist (formal document).
  - Checklist generated by operators, approved by EOIC supervisor.
  - Checklist completed by operators, approved by an EOIC.
  - CATER reports generated to address problems.
  - Scheduling of checkout by Operations supervisors, after consultation with Area Manager.

Works well to catch standard, simple problems like power supply interlocks and calibration, control system hardware.

- Initial "beam on" tuning and set-up.

  - Operators carry out Turn-On Commissioning Plan, using standard procedures.
  - Turn-On Commissioning Plan developed by Operations Supervisors, with review/approval from Accelerator Physics group. (e.g., Plan from April 1997)
  - Establish stored and extracted beam, checkout standard diagnostic hardware.
  - Characterize system performance compared to goals. (e.g. Commissioning Progress report, April 1997)

- Iteration / Communication with experts.

  - Bring problems and unusual performance to the attention of System physicists. Call in system physicists for assistance as needed.
  - Set-up of special systems & diagnostics done by experts (e.g., RF feedbacks), scheduled into Commissioning Plan.
  - Carry out diagnostic measurement programs, specified by system experts.

WWW page commissioning summaries maintained by Krejcik during June 1997.
2.2 Performance Test Checks

Note: Check the history buffers (HB) at least 48 hours after trim (Trim).

2.2.1 Magnet Power Supply Checks

2.2.1.1 Miscellaneous LGPS Checks

Perform the tests specified in the following list:

Date Started: 22 May 97

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April 14, 1997 SLAC-I-040-20400-002-R003 2.6
**North Damping Ring**

Goal: 3.5 e10 per bunch, in Sector 2, 3.0 x 0.3 e-5 emittance (16 ms store), jitter ~1 %, NDR transmission >95 %

(3 shifts)
- 1 e10 to NDR
- LTR, DR steering
- throughput 90%, optimize multiple turns
- RF capture/store
- Extract to RTL stopper
- Commission diagnostics - tune measurements, wires, SLM)

(3 shifts)
- Scrub NDR vacuum
- RF standard setup (Minty, Akre) feedbacks, tuners
- Increase current, rep. rate as vacuum allows.

(3 shifts)
- 1-2 e10 NRTL
- chromaticity measurement
- dispersion measurement
- e- to 2-9 - steering, RF phase
- feedbacks on
- find wire scan ranges
- emittance in LI02
- Increase current

(2-3 shifts)
- RTL skew - extraction tuning
- RTL optics tuning, Beta match
- compressor on.
- 2nd bunch on.

(2-3 shifts)
- re-optimize for 2 bunches - throughput, kicker timing, pi-mode
- measure emittance 1 bunch vs. 2 bunch
- Increase current up to 4 e10/bunch to 2-9

(1 shift)
- More RF checkout with beam (Minty, Akre) feedback dynamic range, noise

**Total 14-16 shifts**
Example from 5/97 Start-up

NDR Commissioning Summary Day Shift (Sun 5/4/97)

- Extraction kicker fixed by replacing pulser.
  (Kraszewski)

- Beam easily extracted to NRDL stopper. WSN 164 α ~ 324 μm
  δy ~ 152 μm

- Restored NDR Bend (and Slet'sd) to startup configuration
  value.

- Two Bunches Extracted. RF work (Akre, Misty) to
  setup π mode cavity interlocks.

- Difficulty monitoring B tunes, Krejick reports:
  - Use MATHLAB program to get new
    tune update. Data in MATHLAB
    looks N.F.A.
  - Then use SP "update tunes" to
    see data.

- Throughout time ~50% two bunch, ~70% one bunch.
  Sensitive to extraction septum horizontal orbit.
  Difficulty extracting cleanly past septum (septum
  bump waxed, kicker raised 59 kV ~ 60 kV).

- Synchrotron Light Monitor Commissioning (Wehhobbu)
NDR Commissioning Summary
as of 5/7/97

Primary Goals: 3.5 e10 per bunch to 2-9 dump
3.0 X 0.3 e-5 emittance (16 ms store) - NOT YET
TMIT jitter ~1%
NDR transmission > 95% 

Secondary:
Commission diagnostics - Tune measurements, Synch light monitor, wire scanners, BPMs, Prof monitors, PLIC

RF feedbacks on - S-band phase, direct feedback, Gap Voltage control

Energy and Trajectory feedbacks on - NDR launch, LTR Energy, RTL launch, RTL-LI02 launch.

Gold Orbits, Magnet Configs, Timing Configs, RF Configs - Not Yet
Damping Ring Program Update June 25 '97

Revised June 27 '97

Overview

Performance and procedures

We have been quite successful in tuning low-current, flat beam emittances to Sector 2.

Compressor on e- emittances in Li02 are 2.8x0.2 and for e+ 3.7x0.15. (The RTL quad emittance scans suggest that the x emittances could be as low as 2.3).

These have been achieved with the following procedure:

1. aligning and steering through the matching quads, so that they don't steer. This step has been a key, since we no longer tweak septum bumps to control emittance! Any septum bump tweak must be followed by an orbit check in the QMs!!

2. verifying that the dispersion generated by the matching quads is minimized, using bump scans, see procedure, 2. NRTL OM Dispersion bump scans.

2. Beta matching, starting with putting the waists at the RTL wire, followed by small adjustments of the QMs to reduce the BMAG at Li02 to 1.0

3. Setup of the 2 beam launch into Li02 (Now frozen!)

4. Steering the RTLs orbits for minimum PLIC

5. Dispersion and chromaticity tuning with compressor on.
Standard Day-to-Day Operation

- Operators tune to maintain beam parameter goals - Intensity, Intensity jitter, minimized emittance, minimized beam loss.

- Use standard tuning tools and diagnostics
  (e.g. Betatron tune measurements with quadrupole multi-knobs.
   BPM orbits with closed bumps or steering package.
   Energy spread with LTR wires, Ring throughput and Inj. phases.)

- Report and Prioritize Hardware problems, - CATER and work around problems, or call-in support.

- Log unusual tuning, observations.

- Escalate tuning problems to system physicists.
Observations:

Some Operators will attempt "creative solutions" and work-arounds. They don't all follow "cook book" procedures. There are trade-offs to this approach:

+ Can solve many problems on their own without calling experts.
+ Encourages understanding of the systems, better able to troubleshoot.
+ May discover better methods or performance.
+ Take more "pride of ownership" of system.

- May mask root problems with work-arounds.
- May improve one parameter at the cost of another, without realizing it.
- Can be hard to maintain reproducible conditions.
- Can get too caught up in complicated work-around solution, lose "big picture" analysis - reluctant to back-out.

We attempt to maintain a framework where the operators are able to try new approaches and exercise their judgment, as long as they can explain their actions and document the process. There is frequent review of their actions by EOICs, Operations Supervisors, and System Physicists.
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Simultaneous Long Pulse Operation

Roger Erickson
Simultaneous Long-Pulse Operation

Acknowledgments:
F.J. Decker, T. Fieguth, H. Smith, C. Spencer, M. Woodley

Experiment E-158, "A Precision Measurement of the Weak Mixing Angle in Møller Scattering", has received preliminary approval, subject to successful achievement of machine performance milestones.


E-158 requires:

- High energy (48.6 GeV).
- High integrated beam charge (4x10^{11} \text{ e}^{-}/\text{pulse}, 120 \text{ Hz}, for 5 months).
- Long pulse (> DR circumference).

Schedule?
Time early is spring 2000.
DRIP Bypass

- Required if E-158 and PEP-II are to run concurrently.

- Magnet PBH (aka PB0) is laminated and was originally run pulsed, but has run DC in recent years.

- Need new pulsed magnet to replace HB0.

- Need new pulsed power supplies for HB0 and PBH.

Other Issues

- Sector 2 optics are not the same for SLC and straight-through operation (four quadrupoles are set differently).
  Can compromise optics be found?
  Are pulsed quadrupoles required?

- Timing issues (13 μsec delay of Sectors 0 and 1 w.r.t. the rest of the linac when making positrons), including BCS implications.
Figure 6.3.4 Extraction and Re-Injection at Girder 1-9