Workshop Summary
Patrick Krejcik

This summary is intended to recap briefly the presentations of the last two days and to give us an overview of the workshop theme.

1. In the introduction (after reviewing the present performance) we began with a list of the future operating requirements for the rings:
   - relaxed requirements for PEP II injection, both in current and emittance.
   - maintain SLC capability for future collider runs and for some End Station experiments
   - Seek also to make full use of the facility
     - explore ways of using the DRs for NLC studies and prototyping.

1. Reliability
   a) Munro - designing for reliability
      - rings have good continuity now in engineering effort
      - rings have benefited from reasonable level of expenditure.
   b) McKee - reviewed history of failure modes for mechanical and vacuum systems.
      - proposed spending more money to reach our reliability goals:
• replacement spare kicker magnets
• dipole coils (get rid of butt splices)
• sextupole epoxy damage
• LIC kicker chambers ...
• totaling $1.6M

c) Ross - concerns over radiation levels and damage
• expect significantly lower levels during PEP II operation (lower rep. rate and current)

2. Operational aspects
a) Corbett - operating experience at SPEAR
• different operating schedule than DRs, but same statement is true: “don’t switch them off”
• make use of quad shunts to align magnets and BPMS
• orbit correction feedback once per minute
• machine studies scheduled every two weeks.

b) Stanek - SLC operation of Damping Rings
• commissioning of the rings at the start of the last SLC run undertaken mainly by operators, with physicists called in as necessary.
• extensive usage of web based notes, procedures and checklists
• benefits are that operators more attuned to the state of the damping rings as they put them in.
• operators can be more “creative” in dealing with operational problems
  • problem sometimes of how to ensure physicists recognize nonstandard tuning setups.
c) Pennacchi - Area Manager perspective
   • review of problems, concerns
     • RASK, temperatures, reliability...
   • enhanced role of area manager in PEP II era
     • monitoring diagnostics:
       • tunes, BPMS, scopes etc.

3. Accelerator Physics
   a) Raubenheimer - lowering the operating energy
      • emittance proportional to $E^{-3}$ while damping time
        proportional to $E^3$
      • lowering energy from 1.19 GeV to 750 MeV and
        changing to 30 Hz repetition rate gives 4 times longer
        store time and 4 times lower emittance.
      • compatible with 30 Hz PEP II injection, or even
        higher injection rates since PEP II can tolerate ~3x
        SLC emittances. Higher rep rates are also afforded by
        a NIT line kicker.
      • low emittance beams produced this way are very
        interesting for NLC studies
        • high phase space density
        • longitudinal instability thresholds
        • Intra beam scattering limit vs. energy
   b) Woodley - implementation of low energy lattice
      • although magnets, kickers, RF can all run lower, need
        more correctors to compensate saturation in bends
   c) Spencer - magnet pole modifications
• partition function altered favorably for transverse damping by adding focusing to the bends.

d) Zimmerman - frequency shift
• the partition function in this case is changed by moving the central orbit by shifting $f_{RF}$ mid-store.

e) General discussion session
• still relevant to solve some of our nagging problems:
  • model fudges
  • sextupole strengths vs. bends standardize
  • SRTL anomalous $\varepsilon_x$ growth, etc.
• lessons learnt from SPEAR
  • schedule machine studies
  • quad shunting to align quads and BPMS
    • retrieve SLC FF shunts

4. RF Systems
a) Rimmer - scale PEP II cavity for 714 MHz
• opportunity to overcome shortcomings in present cavities
• prototype NLC damping rings cavity
• when mass produced for PEP II, cost $150k ea.

b) Akre - klystron reliability review
• suggested adding interlocks to control mod anode voltage when either no beam or no RF
• klystrons will eventually become obsolete during the PEP II era
  • replace with IOT station at a cost of $350k each.
c) Hill - relocating the existing klystron
   - klystron to be housed upstairs for improved maintenance, reliability and accessibility.
   - compatible with all RF feedback and operation
   - cost is $250k for both damping rings

d) Hill - upgrading old interlock system
   - mechanical relays to be replaced with Alan Bradley logic controller, as in PEP II
   - improved reliability, standardization and trouble shooting.
   - cost is $40k for both rings.

e) Corredoura - upgrade to low level RF control
   - replace point-to-point wiring and discrete modules with a PEP II style integrated unit.
   - improvements in reliability, low noise, functionality and standardization.
   - operates at base band with digital control of feedbacks and filtering. Gives flexibility of operation and enhanced diagnostics for troubleshooting.
   - prototype for NLC RF control system
   - development and installation cost ~$400k

f) Tighe - pulsed operation of RF control
   - compare pulsed 120 Hz operation of damping ring with steady state operation of storage rings like PEP II.
   - in the previously described PEP II style RF controller, software handles e.g.
• logic controls of cavity tuners for different rate changes, intensity etc.
• RF gymnastics for pulsed amplitude changes (munch), pulsed phase shifts, pulsed frequency shifts.

**g)** Neubauer - RF cavity windows
• thicker ceramic allows air side discharge to occur before puncturing of ceramic occurs.
• new windows being procured for damping rings.

**h)** Judkins - S-Band feedback loop
• main issue is minimizing noise while maximizing dynamic range
• should remeasure performance of present system
• consider digital feedback for future systems.

**i)** McKee, Schwarz - RF cavity tuners
• upgrade of mechanical design was successful
  • improved centering, alignment
• RF design of brushes ongoing
  • long conditioning period, outgassing

**j)** Schwarz - tuning outside the cavity
• adjustable stubs, or equivalent, used in external waveguide to match load to klystron.
• cavity tuners would not be continually adjusted in vacuum
• stubs and windows have to be designed with high level of reactive power in mind - might be possible over a limited range.
5. Diagnostics
   a) Kotseroglou - review of beam size monitors
      - synchrotron light detection techniques
      - light fibers and fast detectors to resolve multi-bunches and measure multi-turns
      - moveable slits to measure diffraction limited spots
   b) Turner - energy spread instrumentation in transfer lines
      - a real time energy spread measurement at ring injection would be helpful
      - multiple strip lines appear not to have adequate horizontal (energy) resolution
      - wire scanners read over many machine pulses
      - synchrotron light appears ideal
        - non-invasive
        - gated camera captures horizontal spread of single pulses
      - very large energy spread of compressed beam in RTL can be measured on BPM quadrupole mode monitor.

Thank you to all participants for the excellent quality of the presentations, which will make the proceedings a useful reference and guide for future evolution of the damping rings in the next millennium!
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## Appendix - Table of Beam Requirements for Damping Rings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>SLC</th>
<th>PEPII LER</th>
<th>PEPII HER</th>
<th>E150</th>
<th>E157</th>
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<tbody>
<tr>
<td>Linac repetition rate (Hz)</td>
<td>120</td>
<td>120 (S0-10)</td>
<td>120</td>
<td>10</td>
<td>10</td>
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<tr>
<td></td>
<td></td>
<td>60 (S11-19)</td>
<td></td>
<td></td>
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<tr>
<td>No. of $\psi$ bunches in NDR</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
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<tr>
<td>No. of $e^+$ bunches in SDR</td>
<td>2</td>
<td>1</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
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<tr>
<td>Particles/bunch ($10^{10}$)</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>1.3</td>
<td>4</td>
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<tr>
<td>*Bunchlength at end of linac (mm)</td>
<td>1.2</td>
<td></td>
<td></td>
<td>0.6</td>
<td>0.6</td>
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<tr>
<td>*Energy spread at end of linac (%)</td>
<td>0.15</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
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<tr>
<td>$\varepsilon_{n,x}$ ($10^{-5}$ m-rad)</td>
<td>3.2-3.6</td>
<td>NA</td>
<td>10</td>
<td>3</td>
<td>6</td>
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<td>$\varepsilon_{n,y}$ ($10^{-5}$ m-rad)</td>
<td>0.3-0.5</td>
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<td>10</td>
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<td>$\varepsilon^+_{n,x}$ ($10^{-5}$ m-rad)</td>
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<td>$\varepsilon^+_{n,y}$ ($10^{-5}$ m-rad)</td>
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<td>1.5</td>
<td>NA</td>
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*Primarily linac issues.*
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## DR 2000 Workshop Participants

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<th>Name</th>
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<tr>
<td>Akre, Ron</td>
<td>Klystron</td>
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