PEP-II Overview

M. Sullivan

for the

Machine Advisory Committee Meeting
October 9-11, 2003
Outline

• Summer 2002 hardware upgrades
• Run 3 (Nov 02 – Jun 03)
• Summer 2003 hardware upgrades
• Brief startup history and where we are now
• Plans for this run
• Summary
Summer 2002 Hardware Upgrades

♦ Worked on controlling the heating near the IP

♦ Removed the support tube and added cooling to the bellows on either side of the Be beam pipe

♦ Installed a new Q2 septum vacuum chamber

♦ Doubled the number of HOM absorbers in the bellows sections at each end of the support tube

♦ Installed 2 HER RF stations

♦ Improved SR masking for HER RF cavities

♦ Added a second abort kicker to each ring thereby cutting the abort gap in half

♦ Made the bpms near the sextupoles double view

Stan Ecklund will talk more on this

Peter McIntosh will talk more on this
New cooling at the ends of the Be beam pipe
Four new RF cavities for the HER
Luminosity records at the start of Run 3 (Nov 2002)

PEP-II Records

Peak Luminosity

\[ 4.602 \times 10^{33} \text{ cm}^{-2}\text{sec}^{-1} \]

800 bunches 1775 mA LER 1050 mA HER

March 19, 2002

Integration records of delivered luminosity

Best shift (8hrs) \[ 108.3 \text{ pb}^{-1} \] Mar 4, 2002

Best 3 shifts in a row \[ 308.8 \text{ pb}^{-1} \] Dec 22-23, 2001

Best day \[ 288.7 \text{ pb}^{-1} \] Dec 7, 2001

Best 7 days \[ 1.865 \text{ fb}^{-1} \] Oct 23-29, 2001

Best week \[ 1.836 \text{ fb}^{-1} \] Oct 21-27, 2001

(Sun 0:00 to Sat 24:00)

Best month \[ 6.66 \text{ fb}^{-1} \] May 2002

Total delivered \[ 101.16 \text{ fb}^{-1} \]
Run 3 Highlights

♦ Started a new orbit stabilizing feedback and steered the rings flat (except for IR2)

♦ The above 2 steps affected the peak luminosity. We were not able to get lumi
peaks above 3.8e33.

♦ Tried running the LER with more gap voltage (4.5MV) in order to shorten the
bunch and reduce the beam loading in the cavities, but found that the LER bellows
modules started to heat up and that the longitudinal feedback feedthroughs started
to heat up. Went back to 3.2 MV.

♦ In Feb. we discovered that introducing closed bumps into the LER at strategic
locations decreased the LEB x size and increased the peak luminosity. The lumi
peak rose to above 5.1e33 over the next couple of weeks.

♦ In the beginning of May we succeeded in moving the LEB close to the ½ integer in
x. We were able to rebalance the machine well enough to get the peak lumi up to the
present record of 6.6e33.

♦ We had four major vacuum failures

♦ There were 2 main kinds of beam aborts. RF system aborts and “dust events” –
sudden high radiation levels in the SVT causing an abort or (less often) slowly
rising radiation levels eventually leading to an abort due to integrated dose in the
SVT.

Scott DeBarger will talk more on this
Introduced closed bumps in the LER

LER vacuum valves

Power outage
Corrected Luminosity
$10^{30}/cm^2/s$ or $/ub/s$

LER x tune to $\frac{1}{2}$ integer

LER vacuum

LER vacuum

IR vacuum
LER beam current Apr-Jun 2003
The current was lowered after moving to the ½ integer

½ integer tune move

HER beam current Apr-Jun 2003
The current was gradually increased after moving the LER to the ½ integer
LER tunes

Present tune

Old tune
HER tunes

Old tune

Present tune
PEP-II Records

Peak Luminosity

\[ 6.582 \times 10^{33} \text{ cm}^{-2} \text{sec}^{-1} \]

1034 bunches  1550 mA LER  1175 mA HER  

Jun 19, 2003

Integration records of delivered luminosity

Best shift (8hrs)  \( 138.4 \text{ pb}^{-1} \)  Jun 21, 2003

Best 3 shifts in a row  \( 395.1 \text{ pb}^{-1} \)  Jun 21, 2003

Best day  \( 395.1 \text{ pb}^{-1} \)  Jun 21, 2003

Best 7 days  \( 2.115 \text{ fb}^{-1} \)  May 21-27, 2003

Best week  \( 2.052 \text{ fb}^{-1} \)  Jun 15-21, 2003

(Sun 0:00 to Sat 24:00)

Best month  \( 7.395 \text{ fb}^{-1} \)  March 2003

Total delivered  \( 138 \text{ fb}^{-1} \)
Summer 2003 Hardware Upgrades

♦ Fixed the vacuum leak in IR2 septum chamber
♦ Fix vacuum problem in LER arc 1
♦ New RF station for HER in region 4 (4-1)
♦ Modified all bpm's in region 2 to be both x and y
♦ Many improvements to RF systems in both rings
♦ Added cooling to all LER bellows
♦ Added more solenoid windings for LER
Startup

♦ First stored electrons in PEP on
♦ First stored positrons in PEP on
♦ Checked out and timed in transverse and longitudinal feedbacks
♦ Gradually increased currents and luminosity
♦ BaBar reports that the ST has moved wrt DCH
♦ ROD to look at ST. Found forward raft moved 3mm in x
♦ Recover from ROD
♦ Power outage
♦ Recover from outage
♦ Machine gradually improves—still finding problems from power outage
♦ Reach 5e33 – then get browned out
♦ Recovery from brownout – reach 5.3e33
♦ 297 pb-1 in 3 shifts
♦ LINAC PPS certification
♦ BBA MD
♦ HER Beta beat MD

♦ Repair Opportunity Day (ROD)
♦ LINAC PPS certification
♦ Trickle LER beam test
Present Status

♦ Beam currents are close to where we left off in June

♦ The bunch pattern is now the same and number of bunches is slightly higher

♦ We have 6 RF stations on the HER and 3 RF stations in the LER presently operational, the same as last June

♦ The luminosity is only about 5.3e33 instead of 6.6e33. We need more steady running to be able to improve this number. The HER beta beat is worse than it was in June.

♦ Daily integration is slowly improving

♦ Injection efficiency is also slowing improving. Injection backgrounds need to improve.

♦ RF and fast feedback systems have started to stabilize
So far, this is the fastest turn on
Total PEP-II Delivered Luminosity

pb$^{-1}$

Jan-99  Jul-99  Jan-00  Jul-00  Jan-01  Jul-01  Jan-02  Jul-02  Dec-02  Jun-03  Dec-03
At the end of June 2003

PEP-II Total Delivered Luminosity for 2003

36.5 fb$^{-1}$

Grand total delivered 139 fb$^{-1}$
# Machine Parameters that are Important for the IR

<table>
<thead>
<tr>
<th></th>
<th>PEP-II</th>
<th>KEKB</th>
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<tbody>
<tr>
<td>LER energy</td>
<td>3.1</td>
<td>3.5</td>
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<tr>
<td>HER energy</td>
<td>9.0</td>
<td>8.0</td>
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<td>HER current</td>
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<td>$\beta_y^*$</td>
<td>12.5</td>
<td>6.5</td>
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<td>$\beta_x^*$</td>
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<td>60</td>
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<td>X emittance</td>
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<td>Bunch spacing</td>
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<td>Luminosity</td>
<td>$6.6\times10^{33}$</td>
<td>$10.6\times10^{33}$</td>
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### PEP-II Goal for Jul 2004

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Now</th>
<th>Jul 2004</th>
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<tbody>
<tr>
<td>LER energy</td>
<td>3.1</td>
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<td>HER energy</td>
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<td>9.0 GeV</td>
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<td>LER current</td>
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<td>2.7 A</td>
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<td>$\beta_y^*$</td>
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<td>$\beta_x^*$</td>
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<td>28 cm</td>
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<td>X emittance</td>
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<td>3.4 µm</td>
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<td>Bunch spacing</td>
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<td>1.26 m</td>
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<td>Number of bunches</td>
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<td><strong>1450</strong></td>
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<td>Collision angle</td>
<td>head-on</td>
<td>head-on</td>
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<tr>
<td>Beam pipe radius</td>
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<td>2.5 cm</td>
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<tr>
<td>Luminosity</td>
<td>$6.5 \times 10^{33}$</td>
<td>$1.2 \times 10^{34}$</td>
</tr>
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</table>

**Director’s challenge to deliver another 100 fb-1 by Jul 2004**
How do we achieve this?

- We need to further improve the HER and LER beta beats and move closer to the $\frac{1}{2}$ integer in $x$.

- Increase the beam currents and the number of colliding bunches. This means going to a by2 colliding bunch pattern and learning to work with the tune shifts induced by the parasitic crossings.

- Understand and control the coupling in the IR

- Trickle injection for the LER

- Lower the $\beta_y^*$ in both rings. We were somewhat successful with this in the HER but the bunch length of the HER is so long that we did not see much (if any) improvement in luminosity. This also means the bunch length will have to be smaller.

- Improve injection – better efficiency, less detector background, faster turnaround after a beam abort. If we can get the HER injection backgrounds low enough we will be able to try HER trickle injection.

- Minimize the number of beam aborts. Biggest effort is in the RF system. We want to reduce the number of beam aborts to less than one a day.
A fairly good “typical” day unfortunately has 10 beam aborts

<table>
<thead>
<tr>
<th>HER</th>
<th>LER</th>
<th>Luminosity</th>
<th>Spec Lum</th>
<th>HER</th>
<th>LER</th>
<th>CM</th>
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<td>10592</td>
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<td>mA</td>
<td>mA</td>
<td>10**30/Sec</td>
<td>N*10<strong>30 / mA</strong>2/Sec</td>
<td>MeV</td>
<td>MeV</td>
<td>MeV</td>
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<tr>
<td>HER N Buckets / Pattern</td>
<td>LER N Buckets / Pattern</td>
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<tr>
<td>Last Owl/Day/Swing/24hr</td>
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<td>90.5</td>
<td>87.8</td>
<td>280.2</td>
<td>Shift: 72.64 /pb</td>
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<td>Peak Luminosities</td>
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<td>5043</td>
<td>5019</td>
<td>5184</td>
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</table>

![PEP-II Luminosity and Currents](image)

10/05/2003 14:50:16
We want all days to look this good

<table>
<thead>
<tr>
<th>I HER</th>
<th>I LER</th>
<th>Luminosity</th>
<th>Spec Lum</th>
<th>E HER</th>
<th>E LER</th>
<th>E CM</th>
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<tbody>
<tr>
<td>1027.12</td>
<td>1327.68</td>
<td>4253</td>
<td>3.51</td>
<td>8995</td>
<td>3118</td>
<td>10592</td>
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<tr>
<td>mA</td>
<td>mA</td>
<td>10**30/Sec</td>
<td>N*10**30</td>
<td>mA**2/Sec</td>
<td>MeV</td>
<td>MeV</td>
</tr>
</tbody>
</table>

HER N Buckets / Pattern | LER N Buckets / Pattern
| 1126 | 0:3378:3 | 1126 | 0:3378:3 |

Last Owl/Day/Swing/24hr | 99.2 | 89.0 | 109.8 | 298.0 |
| Shift: | 80.31 | pb |

Peak Luminosities | 5232 | 5184 | 5259 | 5076 |

PEP-II Luminosity and Currents

10/06/2003 14:00:27
Summary

In spite of the vacuum leak near the IR of last June, PEP-II has started up fairly quickly.

We initially had some trouble with magnet misalignments in IR2 (fixed after Sept 9).

We reached a luminosity of 5e33 10 days after the power outage of Sept 12. We again reached 5e33 after the brownout that occurred on Sept 24.

We are planning to test LER trickle running soon and also hope to soon fix the beta beating in the HER that prevents us from lowering the HER x tune.

We have a long way to go to meet the director’s goals, but the overall startup has been encouraging.