The PEP-II Accelerator

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Head of the Accelerator Department
SLUO Meeting
July 6, 2004
Topics

• PEP-II today
• Summer 2004 down
• Next year’s plan
• Far future plans
Beam Lines
PEP-II $e^+e^-$ Collider

- Use the SLAC linac as upgraded for the SLC for the injector.

C = 2200 m

3.1 GeV positrons x 9 GeV electrons
The PEP-II $e^+e^-$ asymmetric collider
Contributors to PEP-II

- SLAC
- LBNL
- LLNL
- With help from:
  - IHEP, Beijing, China
  - BINP, Novosibirsk, Russia
  - INFN, Frascati, Italy
  - CEA, Saclay, France
  - IN2P3, Paris, France
  - Caltech
  - BNL
  - Many people from the BaBar Collaboration
  - Visitors from CERN, DESY, Cornell, FNAL, KEK, …
PEP-II Machine Advisory Committee Reviews

- PEP-II Machine Advisory Committee
  - 1) Jan 4-6, 1995
  - 2) August 24-25, 1995
  - 3) April 11-13, 1996
  - 4) January 6-8, 1997
  - 5) November 10-13, 1997
  - 6) December 14-16, 1998
  - 7) October 9-11, 2003
  - 8) April 15-17, 2004
  - 9) December 13-15, 2004 (planned)
Improvements last year

– Peak luminosity: 6.6 $\rightarrow 9.2 \times 10^{33}$
– Number of bunches: 1050 $\rightarrow 1588$ bunches
  • by-2 pattern (24 long mini-trains) with 2% ion gap
– Parasitic collision effects seen but small (<5%)
– Electron Cloud (ECI) effects are small (<2%)
– $I^+$ current 1500 $\rightarrow 2450$ mA (3 RF stations)
– $I^-$ current 1050 $\rightarrow 1550$ mA (8 RF stations)
– $\beta_y^*$ of 12 $\rightarrow 11$ mm
– All data now taken in trickle charge mode
  • Both beams: LER in November, HER in March
Peak luminosity of $9.21 \times 10^{33}$
Daily Integration Record with Trickle Injection

<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>
</tr>
</thead>
<tbody>
<tr>
<td>1478.62</td>
<td>2419.39</td>
<td>8726</td>
<td>3.87</td>
<td>8991</td>
<td>3110</td>
<td>10591</td>
</tr>
<tr>
<td>mA</td>
<td>mA</td>
<td>10**30/Sec</td>
<td>N*10**30 /</td>
<td>MeV</td>
<td>MeV</td>
<td>MeV</td>
</tr>
<tr>
<td>mA**2/Sec</td>
<td>mA**2/Sec</td>
<td>LER N Buckets / Pattern</td>
<td>HER N Buckets / Pattern</td>
<td>LER N Buckets / Pattern</td>
<td>HER N Buckets / Pattern</td>
<td></td>
</tr>
<tr>
<td>1588</td>
<td>by2_t66_her_f</td>
<td>1588</td>
<td>by2_t66_ler_f</td>
<td>235.5</td>
<td>233.6</td>
<td>238.1</td>
</tr>
<tr>
<td>Last Owl/Day/Swing/24hr</td>
<td>Peak Luminosities</td>
<td>8940</td>
<td>8911</td>
<td>8878</td>
<td>8839</td>
<td></td>
</tr>
</tbody>
</table>

710/pb

Luminosity
LER I
HER I
PEP-II Monthly Integrated Luminosity

Last updated: 7/3/2004
Total PEP-II Delivered Luminosity

Total >240 fb⁻¹!
Near Term Goals

• In July 2004 deliver $> 16 \text{ fb}^{-1}$.  
• Reach $1 \times 10^{34}$ as soon as possible.  
• Demonstrate $850 \text{ pb}^{-1}$ per day.
Luminosity Equation

$\xi_y$ is the beam-beam parameter ($\sim 0.065$)

$I_b$ is the bunch current (1 to 3 mA)

$n$ is the number of bunches ($\sim 1600$)

$\beta_y^*$ is the IP lattice optics function (vertical beta) (10 mm)

$E$ is the beam energy (3.1 and 9 GeV)

Luminosity ($10^{33}$ cm$^{-2}$ s$^{-1}$)

\[
L = 2.17 \times 10^{34} \frac{n \xi_y E I_b}{\beta_y^*}
\]
# Overall Parameters and Goals

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Design</th>
<th>Best in collision</th>
<th>Future 2007 goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>I+</td>
<td>mA</td>
<td>2140</td>
<td>2450</td>
<td>4500</td>
</tr>
<tr>
<td>I-</td>
<td>mA</td>
<td>750</td>
<td>1550</td>
<td>2200</td>
</tr>
<tr>
<td>Number bunches</td>
<td></td>
<td>1658</td>
<td>1588</td>
<td>1715</td>
</tr>
<tr>
<td>$\beta_y*$</td>
<td>cm</td>
<td>15-20</td>
<td>11</td>
<td>8</td>
</tr>
<tr>
<td>$\xi_y$</td>
<td></td>
<td>0.03</td>
<td>0.045, 0.07</td>
<td>0.055-0.08</td>
</tr>
<tr>
<td>Luminosity</td>
<td>$x10^{33}$</td>
<td>3.0</td>
<td>9.2</td>
<td>24</td>
</tr>
<tr>
<td>Integrated lumi / day</td>
<td>pb$^{-1}$</td>
<td>130</td>
<td>710</td>
<td>1800</td>
</tr>
</tbody>
</table>

- Twice design
- Over three times design
- Over five times design!
• IR2 south forward shield wall: **Backgrounds**
• Add another new LER RF station: **Higher current**
• Add a HER RF station by splitting up a current 4 cavity station into two 2 cavity stations: **Higher current**
• Two new “Frascati” longitudinal kickers in LER: **More stability**
• New electrodes for transverse kickers: **More stability**
• Add fans to all HER bellows: **Cool Higher Order Modes (HOMs)**
• Alignment work (quadrupole rolls): **Smaller vertical emittance**
• New LER synchrotron light monitor: **Smaller vertical emittance**
• IR NEG pump HOM reduction: **Better lifetime and backgrounds**
• New Support Tube Chiller: **Higher currents**
New IR2 Shield Wall for BaBar IFR

IR2 LER beamline
shield wall
S.J. Metcalfe, 14th Jan 2004
New transverse kicker electrodes
New Longitudinal Feedback Kicker Assembly
LER NEG
Test chamber
New LER Synchrotron Light Monitor

Improved resolution
Single bunch capabilities

Collimator & Drop-down Stop
PEP-II Long Range Beam Parameters Goals

- July 2004: 2.5A x 1.5 A $\beta_y^*$=11 mm 1600 bunches L=9.2E33
- June 2005: 3.3A x 1.8 A $\beta_y^*$=9 mm 1700 bunches L=15E33
- July 2006: 3.9A x 2.0 A $\beta_y^*$=8 mm 1720 bunches L=20E33
- July 2007: 4.5A x 2.2 A $\beta_y^*$=8 mm 1720 bunches L=24E33

- Overall PEP-II goals:
  - 530 fb$^{-1}$ total integrated by Fall 2006.
  - About 1.7 to 2.0 ab$^{-1}$ integrated by Fall 2010.
Summer-Fall 2005 PEP-II Shut-Down Activities

- Install LER-5 RF station
- Install HER-10 RF station
- Remove support tube for SVT work
- Increase beam separation with stronger B1 permanent magnet or small crossing angle
- Upgrade several high-power IR vacuum chambers (Be bellows, Q4, Q5, high power dump, Q2 bellows, LER abort window, radial ion pump, luminosity chamber, …)
- HER lattice upgrade for low momentum compaction
- LER quadrupole power supply upgrades for lower $\beta_y$
- New RF comb filters
- New klystron linearizer
# AIP Upgrades from SLAC Field Task Proposal April 2004

<table>
<thead>
<tr>
<th>Fiscal Year</th>
<th>PEP-II Radio-Frequency RF System</th>
<th>PEP-II Vacuum System</th>
<th>PEP-II Magnet, PS, Instruments, Feedback</th>
<th>Linac, DR, Gun, BSY, FFTB, PPS</th>
<th>Total (k$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>2234</td>
<td>300</td>
<td>766</td>
<td>0</td>
<td>3300</td>
</tr>
<tr>
<td>2004</td>
<td>2948</td>
<td>1396</td>
<td>2356</td>
<td>100</td>
<td>6800</td>
</tr>
<tr>
<td>2005</td>
<td>4900</td>
<td>2230</td>
<td>670</td>
<td>200</td>
<td>8000</td>
</tr>
<tr>
<td>2006</td>
<td>3465</td>
<td>2850</td>
<td>1585</td>
<td>100</td>
<td>8000</td>
</tr>
<tr>
<td>2007</td>
<td>1900</td>
<td>1800</td>
<td>2065</td>
<td>1235</td>
<td>7000</td>
</tr>
<tr>
<td>2008</td>
<td>1000</td>
<td>500</td>
<td>600</td>
<td>3900</td>
<td>6000</td>
</tr>
<tr>
<td>2009</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6000</td>
<td>6000</td>
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### Expected PEP-II Delivered Integrated Luminosity

<table>
<thead>
<tr>
<th>Delivered as of end of fiscal year</th>
<th>SLAC Field Task Proposal (April)</th>
</tr>
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<tbody>
<tr>
<td>FY2004</td>
<td>253/fb</td>
</tr>
<tr>
<td>FY2005</td>
<td>392</td>
</tr>
<tr>
<td>FY2006</td>
<td>545</td>
</tr>
<tr>
<td>FY2007</td>
<td>855</td>
</tr>
<tr>
<td>FY2008</td>
<td>1216</td>
</tr>
<tr>
<td>FY2009</td>
<td>1577</td>
</tr>
<tr>
<td>FY2010</td>
<td>1939</td>
</tr>
</tbody>
</table>
Over all PEP-II Down Schedule 2004-2010

- 2004 down: August 1 to October 15 for BaBar IFR.
- 2005 down: July 1 to December 31 for BaBar IFR and PEP-II support tube.
- 2006 down: August-September.
- 2007 down: August-September.
- 2008 down: August-September.
- 2009 down: August-September.

- After FY2005 run 10 months per year.
The Roadmap Committee is studying the future of PEP-II and BaBar with a possible large upgrade at the end of the decade.

A Super-PEP-II could produce 10 ab⁻¹ per year with a peak luminosity of 7 x 10^{35}/cm²/s.

Accelerator parameter goals have been set and work towards a solid design has started.

The long range time goal is to have a new upgraded accelerator running in 2011 or 2012.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>LER</th>
<th>HER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy (GeV)</td>
<td>3.5</td>
<td>8</td>
</tr>
<tr>
<td>RF frequency (MHz)</td>
<td>952</td>
<td>952</td>
</tr>
<tr>
<td>Vertical tune</td>
<td>72.64</td>
<td>56.57</td>
</tr>
<tr>
<td>Horizontal tune</td>
<td>74.51</td>
<td>58.51</td>
</tr>
<tr>
<td>Current (A)</td>
<td>15.5</td>
<td>6.8</td>
</tr>
<tr>
<td>Number of bunches</td>
<td>6900</td>
<td>6900</td>
</tr>
<tr>
<td>Ion gap (%)</td>
<td>1.2</td>
<td>1.2</td>
</tr>
<tr>
<td>HER RF klystron/cavity</td>
<td>32/64</td>
<td>25/50</td>
</tr>
<tr>
<td>HER RF volts (MV)</td>
<td>43</td>
<td>33</td>
</tr>
<tr>
<td>βₓ* (mm)</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>βₓ* (cm)</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Emittance (x/y) (nm)</td>
<td>28/0.3</td>
<td>28/0.3</td>
</tr>
<tr>
<td>σₓ (mm)</td>
<td>1.75</td>
<td>1.75</td>
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<tr>
<td>Hourglass-X-angle factor</td>
<td>0.80</td>
<td>0.80</td>
</tr>
<tr>
<td>Crossing angle (mrad)</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>IP Horiz. size (μm)</td>
<td>65</td>
<td>65</td>
</tr>
<tr>
<td>IP Vert. size (μm)</td>
<td>0.6</td>
<td>0.6</td>
</tr>
<tr>
<td>Horizontal ξₓ</td>
<td>0.105</td>
<td>0.105</td>
</tr>
<tr>
<td>Vertical ξᵧ</td>
<td>0.107</td>
<td>0.107</td>
</tr>
<tr>
<td>Lumin. (x10^{34}/cm²/s)</td>
<td>70</td>
<td>70</td>
</tr>
</tbody>
</table>
Super B-Factory Components Under Study

IR SC magnets

New Arc magnets

New RF cavities

New IR layout
Conclusions

- PEP-II has reached a luminosity of $9.2 \times 10^{33}$/cm$^2$/s.
- PEP-II has delivered 710 pb$^{-1}$ in one day.
- PEP-II has delivered over 100 fb$^{-1}$ this run since September!
- PEP-II has delivered over 240 fb$^{-1}$ since May 1999.
- Trickle injection in both rings all of the time.
- Near term upgrades are going well.
- Planned upgrades toward $2.4 \times 10^{34}$ are on track.
- Will finalize specifications over the next few months for the 2004 and 2005 downs.
- Efforts increasing on studying a Super-B-Factory.