PEP-II Overview and Future Plans

John Seeman
SLAC Particle and Particle-Astrophysics
DOE PEP-II Operations Review
April 26, 2006
Topics

• Mission
• Operations organization, safety and planning
• Brief PEP-II collider status
• PEP-II future upgrades and status
• PEP-II luminosity projections
• Conclusions
SLAC’s Mission

• To provide a respectful and safe environment to promote research.
• To operate, maintain and upgrade all SLAC accelerator systems to maximize their high energy physics output.
• To develop the conceptual framework and technology needed for the next generation of accelerators and to advance the science of accelerator physics.
• To manage the construction and commissioning of new accelerator systems.
• To contribute to the development of the technology needed for the next generation of detectors.
• To provide Laboratory support and services in the areas of our scientific engineering and technical expertise.
• To perform the research and development necessary to accomplish our mission effectively.
Other TD Departments contributing to PEP-II

- Mechanical Design
- Mechanical Fabrication (MFD)
- Electronics and Software Engineering (CPE)
  - Power supplies, diagnostics, RF and controls
- Metrology
  - Alignment and magnetic measurements
- Site Engineering and Maintenance (CEF)
  - Power, water and buildings
- Advanced Computation (ACD)
  - Wakefield and HOM calculations
- Klystron
  - Klystron production and RF
- Accelerator Research (ARDA and ACD)
  - Accelerator theory and bunch feedback
Citizen Committees and Subject Matter Experts

- **Safety Overview**
  - Radiation Safety
  - Non-Ionizing Radiation Safety
  - Hazardous Experimental Equipment
  - ALARA
  - Electrical Safety
  - Earthquake Safety
  - Fire Protection Safety
  - Hoisting and Rigging Safety
  - Environmental Safety

- Radiation Safety Officer
- Laser Safety Officer
- Electrical Safety Officer
- Fire Marshal
- Crane Inspector
- ESH Environmental Protection Department
- ESH OSHA Experts
- ESH Industrial Hygienists
- Emergency Management Coordinator
Current Accelerator Program

• The PEP-II B-Factory provides high energy physics data to the BaBar detector running about 10 months per year.
  – Upgrade plan is to increase the peak luminosity by a factor of about 2 over the next few years.

• Linac beams are provided to other programs using linac pulses not used by PEP-II injection.
  – The linac runs at 30 Hz. PEP-II uses, on average, only about 10 to 15 Hz.
PEP-II Scheduling

- PEP-II Accelerator Run Planning is done with:
  - Laboratory Director (J. Dorfan)
  - Particle and Particle-Astrophysics Directorate (P. Drell)
  - Assistant Director of PPA for Accelerator Systems (J. Seeman)
  - PEP-II Run Coordinator (U. Wienands)
  - BaBar Spokesman (D. MacFarlane)
  - BaBar Technical Coordinator (W. Wisniewski)
  - BaBar Run Coordinators (J. McKenna, G. Bonneaud)
  - Technical staff
  - Power Manager (G. Loew)
  - Operations Group Head (R. Erickson)
  - Spokespersons of other small experiments.
DIRECTOR'S MEMORANDUM
August 1, 2005

TO: Distribution
FROM: Jonathan Dorfan
SUBJECT: Accelerator Operation Scheduling and Test Beam Scheduling

Accelerator Operation Scheduling
Effective immediately, the schedule for accelerator operations, including the coordination of down times, will be developed by the Accelerator Scheduling Committee (ASC), chaired by John Seeman of the Directorate for Particle and Partide Astrophysics (PPA). The other members of the committee will be appointed by the senior management of the laboratory. The SLAC Senior Management Group (Fermis Drell, Keith Hodgson, John Calayda, John Cornuelle, and Jonathan Dorfan) will provide guidance where needed on priorities that will be used to determine overall allocations within the schedule where time is shared among a group of experiments.

The ASC will have two functions. They will coordinate, record and publish the schedule of machine down times for all of the accelerator facilities on the site on a multi-year basis. They will also develop a proposed schedule of experiments for all of the accelerator facilities that depend on the Linac (PEP-II, E6, FFTB) as well as for NLCFA. The recommendation of the ASC will be taken to the senior lab management (Drell, Hodgson, Calayda, Cornuelle) for signoff and then to the laboratory director for approval. If unresolved conflicts arise during the scheduling process, then the ASC will develop scenarios for discussion and resolution by the SLAC senior management group.

While the overall schedule of experiments is expected to be set on a yearly basis, the ASC will meet monthly to make minor adjustments and optimizations to the schedule.

Test Beam Scheduling
A test beam experiment uses the primary electron beam from the Linac and has a time duration of a week or less. The schedule of test beams is intimately linked to the overall accelerator schedule. Effective immediately, the authorization of Test Beams will be made by the Deputy Director of PPA (Steve Williams) as assembled and advised by Roger Erickson and Clive Field with concurrence from CEP on resource impacts. Scheduling of Test Beams will be made in consultation between the Accelerator Systems Department and the ASC. Any parasitic use of the test beams will also be coordinated by this mechanism.

Distribution:
John Seeman      Clive Field     Keith Hodgson     John Calayda
Roger Erickson   Fermis Drell    John Cornuelle    Steve Williams
Scheduling Committee

• Scheduling Committee members:
  • J. Seeman (chair), R. Erickson (operations), C. Field (test beams), J. Weisend (CEF), W. Wisniewski (BaBar), R. Hettel (SPEAR3), P. Pianetta (SSRL), D. Schultz (LCLS), R. M. Boyce (LCLS installation)

• Meets every few months as needed.
• Propose running schedule to the Directorate
• Provides power requirements versus month.
# Proposed SLAC Accelerator Schedule

**Fiscal Year 2005-2006**

## February 1, 2006

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<td>Run - 11/8/2005</td>
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<td>Down - 08/05/2006</td>
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<td>LINC</td>
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<td>Run - 11/1/2005</td>
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<td>Down - 07/21/2006</td>
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<td>LCLS Injector to</td>
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<td>Linac Sector 30</td>
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<td>Beam line starts</td>
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<td>12/01</td>
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<td>FTIB</td>
<td>02/01</td>
<td>02/27</td>
<td>03/20</td>
<td>04/10</td>
<td>07/03</td>
<td>07/17</td>
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<tr>
<td>SPPS</td>
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<tr>
<td>ILC</td>
<td>04/04</td>
<td>05/03</td>
<td>07/03</td>
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<td></td>
<td></td>
<td>12/01</td>
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</table>
Internal PEP-II Reviews and Meetings

- Daily (seven days) 8:00 am Program meeting
- Daily (seven days) 8:15 am BaBar/PEP-II meeting
- Five days/week Maintenance meetings (8:15 am)
- Twice/week PEP-II Group meetings
- Weekly Tech Division Construction Project reviews
- Weekly PEP-II / BaBar Strategy Meeting
- Semi-monthly PEP-II Evaluation Meeting with Upper SLAC Management
- Weekly Shut-Down Planning meetings starting three to five months before the down, continuing during the down.
- PEP-II End of Run “Lessons Learned Briefings” PEP-II
- 2e34 working committee (weekly)
External PEP-II Reviews

• Annual DOE Site Visits
• Annual DOE Program Reviews
• Semi-annual Scientific Policy Committee
• Semi-annual Experimental Physics Advisory Committee
• Semi-annual BaBar International Finance Committee
• Quarterly BaBar Collaboration meetings
• 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
  – 10) January 16-18, 2006
PEP-II Linac Accelerator Systems Department

Documentation Hierarchy

Accelerator Department Operations Directives

Administrative Documents  
*example:* Administrative Checklists  
*total number of documents:* (6)

Accelerator Operations Documents  
*Operations Linac Turn-on Checklist*  
(71)

Maintenance Documents  
*Call-in Lists*  
(4)

Documentation Documents  
*AD Documentation Archive Plan*  
(5)

Program Control Documents  
*Beam Time Requests*  
(17)

Safety Documents  
*Search Procedures*  
(41)

Training Documents  
*ASO-2 Qualification Workbook*  
(19)
Accelerator Operations BAS Key and Lock Procedures
Accelerator Operations BAS Instructions
Alarm Response Procedures
Arcs PPS Log
Beam Containment System Procedures
BSOIC Certification Checklists
BSY PPS Log
CID PPS Log
DRIP/DR PPS Log
Electrical Hazard Test Procedures
Emergency Notification Form
Entry and Exit Procedures
Equipment Checkout Log
ESA PPS Log
FFTB PPS Log
Final Focus PPS Log
Fire Alarm System Reference Manual
Guidelines for Work in SLAC Accelerator Housings
Gun Test Lab Safety Procedure
High Voltage Test Facility Safety Procedures
Hot Sheet
Incident Response Procedures
Laser Safety Procedures
Linac etc Building Emergency Plan
Linac PPS Log
Logging Requirement for Work...
MCC Building Manager Checklists
MCC Emergency Plan
MCC Key Safe Checkout
PEP PPS Log
PEP PPS Overview
PLS Keys Procedures and Log
Positron PPS Log
PPS Interlock Checklists
PPS Zone Maps
Safety Configuration Control
Safety Inspection Checklists
Search Procedures
VVS Remote Turn-on Procedure
Warning Response Procedures
ARTEMIS (Maintenance)

- ARTEMIS (Accelerator Remedy Trouble Entry and Maintenance Information System) is an Oracle database with a Remedy interface, accessible over the internet by everyone involved with SLAC accelerator maintenance.
- Operators report problems as they occur by making entries in ARTEMIS.
- Repair work is launched immediately if the problem is inhibiting the scheduled accelerator program.
- New ARTEMIS entries are reviewed at the daily maintenance meeting. Open questions are addressed and jobs are assigned.
- Jobs may be assigned to the Standby Maintenance List (SML), or to the Repair Opportunity Day (ROD) list, or marked for the next long down time.
- Jobs are tracked using ARTEMIS until they are finally closed.
ARTEMIS Example

PEP- II Linac Accelerator Systems Department

<table>
<thead>
<tr>
<th>Artemis ID</th>
<th>Urg.</th>
<th>Area</th>
<th>Subsystem</th>
<th>Nr.</th>
<th>Unit</th>
<th>Shop M.</th>
<th>Status</th>
<th>Problem Short Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>00072796</td>
<td>Soc.</td>
<td>NDR</td>
<td>TIMING</td>
<td>DR12</td>
<td>7</td>
<td>CTL</td>
<td>New</td>
<td>DR12 C7 PCU fails initialization. It supplies triggers only.</td>
</tr>
<tr>
<td>00072796</td>
<td>Soc.</td>
<td>NDR</td>
<td>BFM</td>
<td>DR12</td>
<td>CTL</td>
<td>New</td>
<td>Unable to read BPMs in NDR. Maybe due to or 7 PCU?</td>
<td></td>
</tr>
<tr>
<td>00072796</td>
<td>Soc.</td>
<td>LINAC</td>
<td>PPS</td>
<td>L104</td>
<td>CTL</td>
<td>Dc</td>
<td>VV2 breaker opened. 3 hrs DT DS 06/05/04 for PEP &amp; SPS. Th</td>
<td></td>
</tr>
<tr>
<td>00072793</td>
<td>Soc.</td>
<td>LINAC</td>
<td>ELECTRIC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>VIS circuit breaker. V1E 27 has a broken switch lever. Need</td>
</tr>
<tr>
<td>00072793</td>
<td>Soc.</td>
<td>LINAC</td>
<td>KLYSTRON/</td>
<td>L17</td>
<td>51</td>
<td>AMW</td>
<td>Rev</td>
<td>Looks like a bad PAD. please check.</td>
</tr>
<tr>
<td>00072792</td>
<td>Soc.</td>
<td>LINAC</td>
<td>KLYSTRON/</td>
<td>L13</td>
<td>31</td>
<td>KLY</td>
<td>New</td>
<td>Klystron 138 has bad vacuum.</td>
</tr>
<tr>
<td>00072792</td>
<td>Soc.</td>
<td>POSI.</td>
<td>DC MAGNET</td>
<td>EF02</td>
<td>3</td>
<td>AMW</td>
<td>Sch</td>
<td>Periodic trips on ground current.</td>
</tr>
<tr>
<td>00072795</td>
<td>Soc.</td>
<td>LER</td>
<td>BPM</td>
<td>PR02</td>
<td>CTL</td>
<td>New</td>
<td>LER BPM bad residual status in LERO feedback. Offline. Thor</td>
<td></td>
</tr>
<tr>
<td>00072795</td>
<td>Soc.</td>
<td>MCC</td>
<td>CATV</td>
<td></td>
<td></td>
<td>HDWR</td>
<td>New</td>
<td>PEP II PPS VIDEO (both consoles) is missing in MCC.</td>
</tr>
<tr>
<td>00072796</td>
<td>Soc.</td>
<td>MCC</td>
<td>MPS</td>
<td>AP52</td>
<td>CTL</td>
<td>Dc</td>
<td>MPS holding off beam with AP52 error. 4 hrs DT DS 06/08/04</td>
<td></td>
</tr>
</tbody>
</table>

Problems Since Last Meeting

Area Manager: Kathy Burrows

Problem Description
DR12 C7 PCU fails initialization. It supplies triggers only to the NDR kicker scope, so beam can be run without these triggers, but we cannot diagnose or fix NDR kicker timing problems if they occur while the triggers for this crate are down.

Job Priority

Submit Modification

Close
• 2005 PEP-II collider
• 2004: ‘Linac’ (includes DRs, BSY, ESA)
• 2003: GTL, GTF, HVTF, ASTA
• 2002: SPEAR
• 2001: NLCTA
• 2000: PEP II collider
• 1999: ‘Linac’
The PEP-II Team

Accelerator Systems Division
SLAC Support Groups
BaBar
LBNL
ILC
Machine Advisory Committee
Beam Lines
PEP-II e^+e^- Collider Overview

- BaBar Detector
The PEP-II e^+e^- asymmetric collider
PEP-II RF Cavities

BR_049 HER Cavities Region 12 8-19-97
PEP-II Interaction Region Components near BaBar

Collision point
How the beams enter and exit the PEP-II Interaction Region
PEP-II Long Term Run Schedule

• Run 5b: November 2005-July 2006
• Down: August-November 2006
  – (Major upgrades for PEP-II & BaBar + LCLS installation)
• Run 6: December 2006-August 2007
• Down: September-November 2007
  – (PEP-II one month + LCLS installation)
## B-Factory Overall Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>PEP-II (LER/HER)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circumference (m)</td>
<td>2200</td>
</tr>
<tr>
<td>Beam energy (GeV)</td>
<td>3.1/9.0</td>
</tr>
<tr>
<td>Number of bunches</td>
<td>1732</td>
</tr>
<tr>
<td>Beam currents (A)</td>
<td>2.9/1.7</td>
</tr>
<tr>
<td>Horizontal emittance (nm)</td>
<td>30/45</td>
</tr>
<tr>
<td>$\beta_y^*$ (mm)</td>
<td>10/11</td>
</tr>
<tr>
<td>$\xi_y$</td>
<td>0.065/0.045</td>
</tr>
<tr>
<td>IP beam sizes (microns) (x/y)</td>
<td>120/4</td>
</tr>
<tr>
<td>Luminosity ($x 10^{33}$/cm$^2$/s)</td>
<td>10.0</td>
</tr>
</tbody>
</table>
PEP-II’s best day in Run 5b April 25, 2006

<table>
<thead>
<tr>
<th>LER</th>
<th>HER</th>
<th>Luminosity</th>
<th>Spec Luminosity</th>
<th>E LER</th>
<th>E HER</th>
<th>E CM</th>
</tr>
</thead>
<tbody>
<tr>
<td>1550.23</td>
<td>2513.78</td>
<td>8225</td>
<td>3.63</td>
<td>3120</td>
<td>8885</td>
<td>10589</td>
</tr>
<tr>
<td>mA</td>
<td>mA</td>
<td>10**30/Sec</td>
<td>N*10**30 / MeV</td>
<td>MeV</td>
<td>MeV</td>
<td>MeV</td>
</tr>
</tbody>
</table>

HER N Buckets / Pattern  LER N Buckets / Pattern
1722 0:3442:2  1722 0:3442:2

Last Owl/Day/Swing/24hr 233.8 204.0 225.7 663.5 Shift: 17.42/pb
Peak Luminosities 8264 8196 8248 8345

PEP-II Luminosity and Currents

LER current
Luminosity
HER current
Total PEP-II Delivered Luminosity

Last Updated: 4/25/2006 0:03

353.9
### FY2005 Totals - PEP run

<table>
<thead>
<tr>
<th></th>
<th>BaBar</th>
<th>PEP Mach. Dev.</th>
<th>Tuning &amp; Injection</th>
<th>Unsched. Down*</th>
<th>Sched. Off</th>
<th>Total hours</th>
<th>Data delivered to BaBar (fb-1)</th>
<th>Data recorded BaBar (fb-1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1 hours</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1736</td>
<td>448</td>
<td>2184</td>
<td>0.0</td>
<td>0.0</td>
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<tr>
<td>Q2 hours</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1936</td>
<td>248</td>
<td>2184</td>
<td>0.0</td>
<td>0.0</td>
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<tr>
<td>Q3 hours</td>
<td>1000.6</td>
<td>59.3</td>
<td>466.5</td>
<td>594.6</td>
<td>62.4</td>
<td>2184</td>
<td>17.0</td>
<td>15.7</td>
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<tr>
<td>Q4 hours</td>
<td>1475</td>
<td>106.6</td>
<td>286.2</td>
<td>289.9</td>
<td>26.3</td>
<td>2184</td>
<td>36.5</td>
<td>35.4</td>
</tr>
<tr>
<td>FY2005 Total hours</td>
<td>2475.6</td>
<td>166.5</td>
<td>752.7</td>
<td>4556.5</td>
<td>784.7</td>
<td>8736</td>
<td>53.5</td>
<td>51.1</td>
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<tr>
<td>(% of total hrs.)</td>
<td>28.3%</td>
<td>1.9%</td>
<td>8.6%</td>
<td>52.2%</td>
<td>9.0%</td>
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</table>

Excluding all scheduled downtime:

<table>
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<tr>
<th></th>
<th>BaBar</th>
<th>PEP Mach. Dev.</th>
<th>Tuning &amp; Injection</th>
<th>Unsched. Down*</th>
<th>Sched. Off</th>
<th>Total hours</th>
<th>Data delivered to BaBar (fb-1)</th>
<th>Data recorded BaBar (fb-1)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>31.1%</td>
<td>2.1%</td>
<td>9.5%</td>
<td>57.3%</td>
<td></td>
<td>7951.3</td>
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</table>

* FY2005 Q1 and Q2 includes directed off for lab-wide investigation, review, and remediation of safety concerns, and re-validation of all systems and procedures.
# FY2006 Run Performance (Stanek)

<table>
<thead>
<tr>
<th>FY2006 Totals - PEP run</th>
<th>BaBar</th>
<th>PEP Mach. Dev.</th>
<th>Tuning &amp; Injection</th>
<th>Unsched. Down</th>
<th>Sched. Off</th>
<th>Total hours</th>
<th>Data delivered to BaBar (fb-1)</th>
<th>Data recorded BaBar (fb-1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1 hours</td>
<td>789.9</td>
<td>46.9</td>
<td>299.5</td>
<td>155.8</td>
<td>891.9</td>
<td>2184</td>
<td>19.1</td>
<td>18.4</td>
</tr>
<tr>
<td>Q2 hours</td>
<td>1077.6</td>
<td>86.3</td>
<td>252.1</td>
<td>271.8</td>
<td>496.2</td>
<td>2184</td>
<td>16.8</td>
<td>16.6</td>
</tr>
<tr>
<td>Q3 hours</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q4 hours</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FY2006 Total hours</td>
<td>1867.5</td>
<td>133.2</td>
<td>551.6</td>
<td>427.6</td>
<td>1388.1</td>
<td>4368</td>
<td>35.9</td>
<td>35.0</td>
</tr>
<tr>
<td>(% of total hrs.)</td>
<td>42.8%</td>
<td>3.0%</td>
<td>12.6%</td>
<td>9.8%</td>
<td>31.8%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exclude All Sched. Off</td>
<td>62.7%</td>
<td>4.5%</td>
<td>18.5%</td>
<td>14.3%</td>
<td></td>
<td>2979.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(% of Sched. On hrs.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Down time:**
Scheduled down time includes prearranged outages for safety certifications, maintenance, new installations, software upgrades, RF processing, and magnet standardization. Unscheduled down time includes all periods when the scheduled program
### PEP-II Luminosity Integration and DOE Milestones

<table>
<thead>
<tr>
<th>Fiscal Year</th>
<th>DOE Milestone</th>
<th>PEP-II Delivered</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FY2002</td>
<td>35 fb-1</td>
<td>49.0 fb-1</td>
<td>140%</td>
</tr>
<tr>
<td>FY2003</td>
<td>45 fb-1</td>
<td>39.9 fb-1</td>
<td>89%</td>
</tr>
<tr>
<td>FY2004</td>
<td>45 fb-1</td>
<td>114.4 fb-1</td>
<td>253%</td>
</tr>
<tr>
<td>FY2005</td>
<td>50 fb-1</td>
<td>53.5 fb-1</td>
<td>107%</td>
</tr>
<tr>
<td>FY2006</td>
<td>100 fb-1</td>
<td>43.9 fb-1</td>
<td>so far!</td>
</tr>
</tbody>
</table>
PEP-II Records

Peak Luminosity

\[ 10.025 \times 10^{33} \text{ cm}^2\text{sec}^{-1} \]

1732 bunches, 2940 mA LER, 1740 mA HER

Integration records of delivered luminosity

- **Best shift** (8 hrs, 0:00, 08:00, 16:00)
  - \( 247.2 \text{ pb}^{-1} \) Oct 7, 2005

- **Best 3 shifts in a row**
  - \( 727.8 \text{ pb}^{-1} \) Oct 7, 2005

- **Best day**
  - \( 710.5 \text{ pb}^{-1} \) May 24, 2004

- **Best 7 days** (0:00 to 0:00)
  - 4.464 \( \text{ fb}^{-1} \) Jul 25-Jul 31, 2004

- **Best week** (Sun 0:00 to Sat 24:00)
  - 4.464 \( \text{ fb}^{-1} \) Jul 25-Jul 31, 2004

- **Peak HER current**
  - 1745 mA Oct 10, 2005

- **Peak LER current**
  - 2995 mA Oct 10, 2005

- **Best 30 days**
  - 16.720 \( \text{ fb}^{-1} \) Jul 2 – Jul 31, 2004

- **Best month**
  - 17.036 \( \text{ fb}^{-1} \) July 2004

**Total delivered**

315 \( \text{ fb}^{-1} \)

Sullivan
PEP-II Progress since October 2005

- Installation down (Oct 10-Nov 15).
  - One new IR chamber
  - Improved IR NEG pumps
  - Position monitor upgrades
  - Abort window spoiler
  - Safety upgrades.
  - IP dither feedback coils
- Turned on November 15.
- Luminosity rose quickly and reached $0.86 \times 10^{34}/\text{cm}^2/\text{s}$ in mid-December.
- Successfully ran PEP-II through the year-end holidays
- Two vacuum issues came up in December 2005.
PEP-II Machine Advisory Committee

- Meeting: January 18-20, 2006

- Report available. Words from report:
  - Impressive progress in all areas since the last review a year before.
  - Congratulates achievement of $10^{34}$ luminosity (3.3 x design).
  - Trickle charge injection is very effective.
  - Accelerator plan is sound for optimizing the collider productivity through FY2008
  - Vacuum burst studies are being intensely investigated. [Committee made several suggests what to look for.]
  - Suggest re-examine increasing the specific luminosity.
Two Vacuum Issues in December 2005

- Two major vacuum problems developed in the month of December limiting the peak luminosity to about $\sim 0.5 \times 10^{34}/cm^2/s$:
  - Gap ring (RF seal) problem near LER RF cavity caused $e^+$ beam instability
  - Higher Order Mode absorbing bellows caused vacuum bursts in IR
- The first problem was quickly identified ($\sim 2$ weeks) and solved in late January.
- The second problem was thoroughly investigated, replacement parts manufactured, and repaired in late March with elapsed time of about three months.
LER Current in Run 5

LER Current (mA)

Fall down
Vacuum issues

2.95 A

INTerval: 180    MEAN: 1193.7    MIN: -111.4
SIGMA: 997.68    MAX: 2933.6
LAST DATA POINT: 18-APR-2006 08:47:44 MAX-MIN: 3045.0
18-APR-06 13:30:57
Location of the First Vacuum Problem

- Vacuum spike area

RF seal installation procedure problem
A Selected Event

Pressure at 3037 goes up to ~300 ntorr and is back down to <1 ntorr in ~30 sec
High LER+HER Current Causes Radiation Trips → Clear current threshold
PEP-II Task Force Structure addressed the issue

<table>
<thead>
<tr>
<th>Task-Force Number</th>
<th>Title</th>
<th>(Co-)Chairs</th>
<th>Addresses items from the task list</th>
<th>Meeting times</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Steering Committee MD planning</td>
<td>Seeman</td>
<td>Long term planning</td>
<td>As needed</td>
</tr>
<tr>
<td>2</td>
<td>PEP-II Operations</td>
<td>Wienands</td>
<td>Short term Planning</td>
<td>Mon + Thurs 3 pm MCC</td>
</tr>
<tr>
<td>3</td>
<td>2E34</td>
<td>Seeman</td>
<td>Task Force Reports</td>
<td>Wed 12 pm Sierra</td>
</tr>
<tr>
<td>4</td>
<td>RF and longitudinal feedback</td>
<td>Van Winkle, Teytelman</td>
<td>1,2,3</td>
<td>Friday 9 am Fuji</td>
</tr>
<tr>
<td>5</td>
<td>Transverse Feedback</td>
<td>Akre + Wienands</td>
<td>4</td>
<td>Friday 9 am Fuji</td>
</tr>
<tr>
<td>6</td>
<td>Optics and Steering</td>
<td>Cai, Wittmer</td>
<td>5,6,7,8</td>
<td>Wed 3 pm Fuji</td>
</tr>
<tr>
<td>7</td>
<td>Beam Beam Interaction and Beam Dynamics</td>
<td>Raimondi, Seeman</td>
<td>9,10,11</td>
<td>Thursday 11 am Bldg 280</td>
</tr>
<tr>
<td>8</td>
<td>Reliability</td>
<td>Himel, Mattison</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>BPM heating and operation</td>
<td>Ecklund, Kurita, Smith</td>
<td>13</td>
<td>As needed</td>
</tr>
<tr>
<td>10</td>
<td>Instrumentation</td>
<td>Sullivan, Fisher</td>
<td>14</td>
<td>Thurs 1 pm MCC</td>
</tr>
<tr>
<td>11</td>
<td>MDI &amp; Backgrounds</td>
<td>Weaver</td>
<td>15</td>
<td>Friday 10 am</td>
</tr>
</tbody>
</table>
IP Vacuum Issue Resources

• Help from many groups: PEP-II, BaBar, Material Science Group, Klystron Dept., High Power RF Group, Vacuum Dept., Pulsed Kicker Group, and LBNL.

• Many studies done:
  – Beam current thresholds
  – Beam instability identification
  – External leak checks
  – Transient leak checks during spikes
  – Gas pressure profiles
  – Gas pressure flow rates
  – Gas injections (puffs) (He, N2, Air) (various locations)
  – Transient gas analysis during spikes
  – NEG pump heating to make H2 gas
  – Background timing with BaBar
  – Borescoped 100 m of vacuum chamber (several times)
  – Replaced RF seals and four vacuum chambers
  – SiC-AlN HOM tile lab tests and thermal calculations

• This vacuum problem was the most subtle and hard to diagnose problem PEP-II has had. However, we solved it in a timely way over two months with a strong team.

• In the end as will be shown later, the chamber at fault was anticipated to be a long term problem and was scheduled to be replaced in Fall 2006 (AIP project). (The problem came 6 months too early!)
Q2 Bellows section

Bellows are fully compressed in pictures
“Discharge” on Absorbing Tile

- SiC/AlN HOM Tile
- Arc site
- Cu heat sink
- RF seal fingers
New RF seal to correct problem:
New seat on Cu base not tile

N. Kurita
New HOM bellows design for Fall 2006

Tiles behind Fingers

N. Kurita
Novokhatski
Weathersby
April 2006
Recent Run Results

PEP-II Daily Integrated Luminosity for 2006
0:00 to 0:00

Vacuum work
Delivered luminosity matches prediction since March 1.
## PEP-II Overall Parameters and Goals

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Design</th>
<th>Present best</th>
<th>2007 goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>I+</td>
<td>mA</td>
<td>2140</td>
<td>2940</td>
<td>4000</td>
</tr>
<tr>
<td>I-</td>
<td>mA</td>
<td>750</td>
<td>1740</td>
<td>2200</td>
</tr>
<tr>
<td>Number bunches</td>
<td></td>
<td>1658</td>
<td>1732</td>
<td>1732</td>
</tr>
<tr>
<td>$\beta_y^*$</td>
<td>mm</td>
<td>15-20</td>
<td>11</td>
<td>8-8.5</td>
</tr>
<tr>
<td>Bunch length</td>
<td>mm</td>
<td>15</td>
<td>11-12</td>
<td>8.5-9</td>
</tr>
<tr>
<td>$\xi_y$</td>
<td></td>
<td>0.03</td>
<td>0.044-0.065</td>
<td>0.054-0.07</td>
</tr>
<tr>
<td>Luminosity</td>
<td>$x10^{33}$</td>
<td>3</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Int lumi / day</td>
<td>pb$^{-1}$</td>
<td>130</td>
<td>727</td>
<td>1300</td>
</tr>
</tbody>
</table>

*Over three times design*  
*Five times design*
PEP II Integrated Luminosity Projection (1/fb)

- 2006 down
- 2007 down
- Now
PEP-II Upgrades

• Goal: A factor of two in PEP-II luminosity
• \( (1 \rightarrow 2 \times 10^{34}/\text{cm}^2/\text{s}) \) will come from:
  – Increasing each beam current by 40%.
  – Lowering \( \beta_y^* \) from 11 to 8.5 mm giving 30%.
  – Increasing the beam-beam parameters by 10%.
  – Keeping detector backgrounds at the predicted levels.
  – Maintaining (and improving) accelerator reliability.
The items to upgrade PEP-II have been identified by the PEP-II Task Forces. Engineering has been done on most items and these items are in manufacturing. A few items are in final design review to start manufacturing in about one month. Funding is in place for all PEP-II items. Detailed time planning for the fall down has started with every task being identified with loading for the various shops. Interferences with BaBar and LCLS are being worked out months in advance to minimize problems.
Many of the new vacuum chambers for higher current are near the IP.

Dots show new vacuum chamber locations.

Recent problem bellows

Done March 2006

Done October 2005

Forward (HEB Direct.) ← Backward (LEB Direct.)
Accelerator Improvement Projects on track for Fall 2006

<table>
<thead>
<tr>
<th>Project Description</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>X-Y BPM upgrades</td>
<td>2005-2006</td>
</tr>
<tr>
<td>New HER Q5 vacuum chambers</td>
<td>2005-2006</td>
</tr>
<tr>
<td>New HER/LER Q2 chambers</td>
<td>2006</td>
</tr>
<tr>
<td>HER-10 RF station</td>
<td>2006</td>
</tr>
<tr>
<td>HER-11 RF station</td>
<td>2006</td>
</tr>
<tr>
<td>HER power supply upgrade for higher tunes</td>
<td>2006</td>
</tr>
<tr>
<td>New HER Q4 vacuum chambers</td>
<td>2006</td>
</tr>
<tr>
<td>New IR2 Q2 bellows</td>
<td>2006</td>
</tr>
<tr>
<td>LER IR HOM absorber</td>
<td>2006</td>
</tr>
<tr>
<td>HER IR HOM absorber</td>
<td>2006</td>
</tr>
<tr>
<td>LER BPM monitor upgrade</td>
<td>2006</td>
</tr>
<tr>
<td>LER new high power bellows</td>
<td>2006</td>
</tr>
<tr>
<td>LER NEG vacuum chamber upgrade</td>
<td>2006</td>
</tr>
<tr>
<td>New Longitudinal feedback processor</td>
<td>2006</td>
</tr>
</tbody>
</table>

Cost of AIP projects is about 7 M$ spread over FY2006 and FY2007. PEP-II AIP expenditures from 1999-2005 averaged about 5 M$ each year.
B-Factory RF Klystrons (1.2 MW) under construction
RF Cavity Production

- Cavity bowls welded together
- Ports to be welded
- Finished cavity
Example: HER QF5R Chamber (Fall 2006)

**Specifications**

- HER beam current: 2.2 A
- No LER fans.
- No SR heating during normal operation.
- HOM and I3R power: 1kw/m, 8 cooling channels required.
- BSC: 12 x 8.7 (Q2R still limiting aperture)
- SR misaligning envelope through Q4R-Bellow-Q5R-Prangible Link:
  - x offset: -2 mm / +7 mm, x angular: -0.5 mrad / +0.5 mrad
  - y offset: -3 mm / +3 mm, y angular: -1 mrad / +1 mrad
- Vacuum load 14.7 psi.
- Q2R Chamber remains. Aperture is a constraint.
- Chamber-to-magnet clearance: 0.080" (2 mm) to the pole and 0.120" (3 mm)
- to the coil.
- 1:10 tapers (5.7 degree)
- < 0.5mm (0.02") transverse steps.
- Improve BPM stability
- Improve mechanical reliability.
  - Reliability
  - Load on Q2

**Construction**

Design

R. Pope
LER/HER Q2 IR Vacuum Chamber (Fall 2006 → March 2006)

Thermal analysis of synchrotron radiation power (~100 W/cm)

S. Metcalfe

High power separation chamber
PEP-II Accelerator Technology for Future Accelerators

- **High beam currents**
  - World record $e^+$ current (2.95 A)
  - World record $e^-$ current (1.75 A)
  - High power vacuum chamber design

- **Large number of bunches**
  - World record number of colliding bunches (1732)
  - Very fast and strong bunch-by-bunch feedbacks (4 nsec)
  - Electron Cloud Instability (ECI) cures (solenoids, antechambers)

- **High power RF systems**
  - >1.2 MW CW klystrons 476 MHz
  - High power Cu cavities (600 kW)

- **Complex interaction region design with two rings**

- **PEP-II provides continued strong input into new accelerator designs:**
  - ILC damping rings, low emittance light sources (PETRA-3), Super-B Factories, LHC ECI, BEPC-II, …
PEP-II Conclusions

- PEP-II achieved a new luminosity level ($1 \times 10^{34}$) in October 2005 and set several integrated luminosity records.
- Run 5b started well but two serious vacuum problems occurred keeping the luminosity peak to about half the former peak.
- Both vacuum problems have been identified with the help of many people and experiments and have been solved in a timely way.
- Over past two weeks, the luminosity has risen steadily to $>0.84 \times 10^{34}$ with several 600+ pb$^{-1}$ days. (663 pb$^{-1}$ yesterday)
- Planned upgrades towards $\sim 2 \times 10^{34}$ are on track.
- Run plans are in place with a target of $\sim 1$ ab$^{-1}$ in 2008.
- We strongly believe that the combined performance of PEP-II and BaBar will remain competitive through 2008.

- We work daily to make SLAC and PEP-II safer and better.
- We have internal and external reviews of our program.
- We set yearly performance goals and track them daily-weekly-monthly-yearly.
- We perform regular in-depth safety reviews of all our accelerators.
- We are actively working to make our accelerator more reliable.