EBPMs and Orbit Feedback
Electronics for Diamond
IWBS 2004
Guenther Rehm
Outline

• BPM locations and cross sections
• BPM response calculations
• EBPM performance examples
• SOFB plans
• FOFB plans
## Number of BPMs

<table>
<thead>
<tr>
<th>Location</th>
<th>Count</th>
<th>Type / cross section</th>
</tr>
</thead>
<tbody>
<tr>
<td>LINAC</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>LTB</td>
<td>7</td>
<td>Stripline / circular</td>
</tr>
<tr>
<td>Booster</td>
<td>22</td>
<td>Button / elliptical</td>
</tr>
<tr>
<td>BTS</td>
<td>7</td>
<td>Stripline / circular</td>
</tr>
<tr>
<td>SR</td>
<td>120+48</td>
<td>Button / octagonal+oval</td>
</tr>
<tr>
<td>Sum</td>
<td>204</td>
<td></td>
</tr>
</tbody>
</table>

All with Libera EBPM electronics
Storage ring BPMs

• Primary BPMs:
  – Increased sensitivity through smaller aperture
  – Mechanically decoupled through bellows
  – Position monitored relative to reference pillar

• Standard BPMs:
  – BPM blocks welded into vacuum vessel
  – Mounted on “anchor” stands
  – Position monitored relative to quad centre
BPM response calculation

• MATLAB based boundary element solver
  – Fast: 5.5 sec on P4/1700 for 722 boundary elements and 441 beam positions
  – Precise: results checked with finite element solver (Vector Fields OPERA)
• Geometrical manufacturing uncertainties have been modelled using Monte Carlo simulation
Calibration Factor for Primary BPM

- Offset from centre [mm]
- Calibration factor [mm]

- **Kx**
- **Ky**

![Graph showing the calibration factor for Primary BPM with curves for Kx and Ky](image)
Nonlinear 2D BPM response

Needs to be corrected before nonlinear beam dynamics studies!
RMS noise @ TBT

![Graph showing RMS noise vs. Pin (dBm) and current (mA).]
Resolution with 1 kHz BW

Plot showing the RMS (µm) against Pin (dBm) with different current levels of 30 mA and 300 mA. The graph indicates a decrease in RMS as Pin increases, with a notable difference at 0 dBm.
RMS noise with 1 kHz Bandwidth

<table>
<thead>
<tr>
<th>Beam current</th>
<th>Primary x/y in µm</th>
<th>Standard x/y in µm</th>
</tr>
</thead>
<tbody>
<tr>
<td>60-300 mA</td>
<td>0.27/0.3</td>
<td>0.65/0.45</td>
</tr>
<tr>
<td>10-60 mA</td>
<td>0.54/0.6</td>
<td>1.3/0.9</td>
</tr>
<tr>
<td>1-10 mA</td>
<td>1.35/1.5</td>
<td>3.3/2.2</td>
</tr>
</tbody>
</table>
Control and Instrumentation Areas (CIAs)

24 temperature stabilized CIAs for 19” racks
SOFB Setup

Central feedback calculation

Controls Network (EPICS)

14+8 Corrector PSUs

PSU 1

PSU N

One CIA

eBPM

eBPM

eBPM

eBPM

eBPM

eBPM

eBPM

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SOFB Details

- EPICS IOCs run inside LIBERA
- EPICS interface to PSU already available
- MatLab channel access makes application development easy
- Can be tested with “virtual accelerator”
- Expected to run at 10 Hz sampling, 0.5 Hz closed loop BW
- Will be available on day 1
Virtual Accelerator and Software Commissioning

The Virtual Accelerator is used
1) to simulate the control system environment as seen by the users
2) to provide a realistic test for AP applications

The Virtual Accelerator uses the Tracy–II code to simulate the physical behaviour of the ring

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Basic Virtual Accelerator Functionality

- Set magnet currents
- Read EBPM x/y average calculated using Tracy2 closed orbit
- Read EBPM x/y turn-by-turn buffer using Tracy2 particle tracking
“measured” Response Matrix
MatLab AT Based Feedback

Orbit Correct implemented using AT for Spear 3

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Design constraints for FOFB

• Global system, all data should be available everywhere
• Low latency from hardware, main delay should result from LP filter
• FB algorithm should be easily serviceable
• Corrector PSU interface is VME
• Robust system which continues to perform with partial faults
FOFB Setup (one CIA)

Controls Network

Event Network

VME

Processors

Event Rx

ADCs

FB Processor

PSU 1

PSU N

14+8 Corrector PSUs

Photon BPMs

pBPM

pBPM

eBPM

eBPM

eBPM

eBPM

eBPM

Cell -n

Cell +n

Cell -m

Cell +m

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FOFB Details

• FB data produced at 4-20 kSamples/s
• Dedicated FB CPU board MVME5500 running vxWorks, but no EPICS IOC, no network.
• RocketIO in Virtex2Pro to run at 2.5 Gbit/s
• PMC card with RocketIO will be board developed for timing system
• Connections inside rack can be galvanic, longer distance will be single mode fibre
• All connections between CIAs will be patched centrally
• Communication is broadcast, no routing or location information is required for any node.
FOFB Delays (simulated/estimated)

- Distribution of 168 sets of data to 168+24 locations: 30 µs
- Transfer to CPU: 10 µs
- Matrix multiplication: 30 µs (worst case)
- Write into PSU: 50 µs
- 200-400 µs delay for LP filter
  - > feedback BW >>100 Hz should be feasible
- **Detailed simulation is required!**
Acknowledgements

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• Supercomputing Systems