Conceptual Design of the PETRA III Orbit Feedback

PETRA III
Conversion of PETRA II (2304 m circ.)

Conversion is going to start middle of 2007

Operation with beam should start in 2009
### PETRA III Optics old octant

<table>
<thead>
<tr>
<th>element</th>
<th>Hor. (µm)</th>
<th>Ver. (µm)</th>
<th>Roll (mrad)</th>
<th>Long. (µm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>monitors</td>
<td>200</td>
<td>200</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quad's old oct.</td>
<td>250</td>
<td>250</td>
<td>0.2</td>
<td>500</td>
</tr>
<tr>
<td>Dipoles</td>
<td>250</td>
<td>250</td>
<td>0.2</td>
<td>500</td>
</tr>
<tr>
<td>Sext.</td>
<td>250</td>
<td>250</td>
<td>0.2</td>
<td>500</td>
</tr>
</tbody>
</table>
PETRA III damping wiggler $\varepsilon_z: 4 \rightarrow 1 \text{ nmrad}$

Damping wigglers
- $B = 1.5$ T
- $\lambda = 0.2$ m
- $h = 0.025$ m
- $L_{tot} = 80$ m (2x40m)
PETRA III
Optic new octant

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Dispersion limits to achieve design emittance

<table>
<thead>
<tr>
<th></th>
<th>Hor. (mm)</th>
<th>Ver. (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wiggler section</td>
<td>18</td>
<td>5</td>
</tr>
<tr>
<td>Undulator‘s (ID‘s)</td>
<td>20</td>
<td>3</td>
</tr>
<tr>
<td>FODO arc</td>
<td></td>
<td>58</td>
</tr>
<tr>
<td>DBA</td>
<td>22</td>
<td>31</td>
</tr>
</tbody>
</table>
Orbit stability goal

\( \varepsilon_x = 1 \text{nmrad} \)  
**coupling 1\%**

<table>
<thead>
<tr>
<th>Low ( \beta ) insertion</th>
<th>High ( \beta ) insertion</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \beta(\text{m}) )</td>
<td>( \sigma(\mu\text{m}) )</td>
</tr>
<tr>
<td>Horizontal</td>
<td>1.2</td>
</tr>
<tr>
<td>Vertical</td>
<td>3.9</td>
</tr>
</tbody>
</table>

**Stab. Requirement** \( 0.1 \times \sigma \)  
\( \rightarrow \text{Sub micron orbit stability !!} \)
1. Golden Orbit

Combined orbit and dispersion correction:

\[ \alpha u + (1 - \alpha) D_u + \alpha R + (1 - \alpha) S \theta = 0 \]

- \( u \) and \( D_u \) measured orbit or dispersion
- \( R \) and \( S \) orbit or dispersion response matrix
- \( \alpha \) weighting factor

Alternative: separated orbit & dispersion correction with skew quads
Elements for orbit correction

- 206 beam position monitors
- 182 horizontal correctors (resolution ≥ 16 bit)
  - 98 backleg windings on old dipoles
  - 18 backleg windings on new dipoles
  - 66 single correctors
- 189 vertical correctors (resolution ≥ 18 bit)
  - 91 additional windings on sextupoles
  - 98 single correctors

\[ \Theta_{\text{max}} \approx 0.5 \text{ mrad} \quad \mathcal{B} = 100 \text{ Gm} \]
2. Orbit stabilization

• top-up
• slow feedback: repeated orbit correction every few seconds
  • using all monitors and correctors via SVD algorithm
• fast feedback : BW few tenth of Hz up to 100 Hz
Fast orbit distortions in PETRA II

Fast Horizontal Orbit Motion at OL90 (β_z = 21 m)

Fast Vertical Orbit Motion at OL90 (β_y = 12 m)

0.1 σ_x = 14 μm

0.1 σ_y

Fast feedback requirements: BW 100 Hz amplitude reduction faktor ≤ 5
Elements for fast orbit correction

- **41 vertical & horizontal correctors** (air coils: $\Theta_{\text{max}} \approx 5 \, \mu\text{rad} \quad B^*l = 1 \, \text{Gm}$)
  - 30 new octant (for orbit stabilisation)
  - 11 old octant (1 per short straight & 1 at the beginning and end of long straight section) to maintain small vertical emittance
- **Photon BPM‘s (?)**

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<td>148</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>New octant</td>
<td>40</td>
<td>2</td>
<td>0.5</td>
</tr>
<tr>
<td>Next to ID</td>
<td>18</td>
<td>2</td>
<td>0.2</td>
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• monitor (resolution)
Position of Monitors & Correctors in DBA cell

Monitors
QF

Dipole
V: slow ↑: fast

Horizontal Correctors

V: slow ↑: fast

Vertical Correctors
Rate of orbit measurements: $\geq 4$ kHz
Data flow on cables (fiber optics) manageable
Digital controller (SVD & PID) feasible
Power supplies: work in progress
Correctors: air coils similar to ESRF
Entrance BPM
$x_{rms} = 0.199412 \, \text{mm}
\sigma = 0.287373 \, \mu\text{m}$

Exit BPM
$x_{rms} = 0.039652 \, \text{mm}
\sigma = 0.152391 \, \mu\text{m}$

Entrance BPM
$y_{rms} = 0.012183 \, \text{mm}
\sigma = 0.271300 \, \mu\text{m}$

Exit BPM
$y_{rms} = 0.073483 \, \text{mm}
\sigma = 0.331794 \, \mu\text{m}$
Long term stability
slow orbit feedback

- Alignment of the machine every half year
- Temperature stability (new octant ± 0.1 °C, old octant ± 1 °C)
- Cooling water temperature ± 0.2 °C
- Establishing a new golden orbit ≥ 24 h

ATL law: $\Delta x^2 = A \cdot T \cdot L$

$A = 4 \times 10^{-6} \, \mu m^2/m/s ; L = 65 \, m$
$\Delta x = 15 \, \mu m$
$T = 10 \, d$

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* Special supports for monitors close to ID’s
Summary

• PETRA III is an unconventional Light Source
• Unconventional measures have to be taken to fulfill the stability requirements
• Nevertheless use can be made of the experience gained at other light sources concerning correction procedures and hardware design