**Low vs. lower emittance lattices**

L. Emery, M. Borland  9/18/02

<table>
<thead>
<tr>
<th>Insertion Device Source Parameters</th>
<th>“Low” Emittance Lattice</th>
<th>“Lower” Emittance Lattice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal Emittance</td>
<td>3.5 nm-rad</td>
<td>2.5 nm-rad</td>
</tr>
<tr>
<td>Effective Horizontal Emittance $\sigma_x \ast \sigma_x'$</td>
<td>3.9 nm-rad</td>
<td>3.1 nm-rad</td>
</tr>
<tr>
<td>Peak On-Axis Brightness $(x 1e19) \text{ph/s/mm}^2/\text{mrad}^2/.1%\text{BW}$</td>
<td>3.1 @ 1.0% Coupling</td>
<td>4.1 @ 1.4% Coupling*</td>
</tr>
<tr>
<td>Lifetime @ 1% Coupling (measured)</td>
<td>9.4 Hours</td>
<td>8.3 Hours</td>
</tr>
<tr>
<td>Horizontal Beam Size $\sigma_x$</td>
<td>253 microns</td>
<td>274 microns</td>
</tr>
<tr>
<td>Contribution from Energy Spread</td>
<td>117 microns</td>
<td>162 microns</td>
</tr>
<tr>
<td>Horizontal Angular Divergence $\sigma_x'$</td>
<td>15.6 µrad</td>
<td>11.3 µrad</td>
</tr>
</tbody>
</table>

*: 1.4% coupling gives same vertical beam size in low vs. lower emittance lattice
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<th>“Lower” Emittance Lattice</th>
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<tr>
<td>Vertical Beam Size $\sigma_y$ @ 1% Coupling</td>
<td>11.7 microns</td>
<td>8.5 microns</td>
</tr>
<tr>
<td>Vertical Angular Divergence $\sigma_{y'}$ @ 1% Coupling</td>
<td>3.0 µrad</td>
<td>2.9 µrad</td>
</tr>
<tr>
<td>Effect of gap closing on Horizontal emittance:</td>
<td>- 6 %</td>
<td>+- 3%</td>
</tr>
<tr>
<td>Bending Magnet Source Parameters (displaced / non-displaced)</td>
<td>“Low” Emittance Lattice</td>
<td>“Lower” Emittance Lattice</td>
</tr>
<tr>
<td>------------------------------------------------------------</td>
<td>--------------------------</td>
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<tr>
<td>Horizontal Emittance</td>
<td>3.5 nm-rad</td>
<td>2.5 nm-rad</td>
</tr>
<tr>
<td>Effective Horizontal Emittance $\sigma_x \ast \sigma_{x'}$</td>
<td>6.7 / 6.8 nm-rad</td>
<td>5.1 / 5.0 nm-rad</td>
</tr>
<tr>
<td>Horizontal Beam Size $\sigma_x$</td>
<td>106.9 / 107.5 microns</td>
<td>91.4 / 88.4 microns</td>
</tr>
<tr>
<td>Horizontal Angular Divergence $\sigma_{x'}$</td>
<td>62.3 / 63.7 $\mu$rad</td>
<td>56.1 / 56.5 $\mu$rad</td>
</tr>
<tr>
<td>Vertical Beam Size $\sigma_y$ @ 1% Coupling</td>
<td>26.9 / 27.1 microns</td>
<td>25.4 / 25.5 microns</td>
</tr>
<tr>
<td>Vertical Angular Divergence $\sigma_{y'}$ @ 1% Coupling</td>
<td>1.6 / 1.7 $\mu$rad</td>
<td>1.1 / 1.2 $\mu$rad</td>
</tr>
</tbody>
</table>
What I hate / don't hate about the legacy process variables / medm screens - G. Decker

HAngle, HPosition derived from broadband (monopulse) RF beam position monitors.
These readbacks suffer from the rogue microwave disease - resulting in hypersensitivity to small fill pattern variations, viz. what happens every two minutes during top-up. The numbers are yellow to signify suspect data. If you don’t do top-up and only observe for short periods of time, like less than an hour, these are okay for beam position. Other than that, they are crap. The problem is with the vacuum chamber internal geometry, not the electronics.

VAngle, VPosition, derived from x-ray bpm’s, _extrapolated_ back to the source point. VAngle is ok, but VPosition will enhance every little burp made by either x-bpm due to the extrapolation. I hate that.

Front-end x-ray beam position monitor raw readbacks. Our most reliable diagnostic. Unfortunately, these PV names are archaic and better ones should be used.

VAngle, VPosition derived from RF beam position monitors.
The best available, however they are susceptible to bunch pattern dependence, i.e. every 52 minutes in top-up mode (1+22 Singlets) an artificial step occurs in the readings. Orbit correction fits a smooth curve through many bpm’s (eleven per betatron wavelength), so the beam isn’t doing this - really. I promise.
Extrapolation vs. Interpolation for defining source angle

10 micron drift in BM:P1 translates to 20 microns at source point
Insertion Device X-ray Beam Position Monitors: Very high resolution, very pathological systematic effects. Non-linear outside ±0.5 mm, Feedforward required to compensate for gap dependent effects, useless for gaps larger than approx. 30 mm. My extrapolation comments also apply for the Position PV’s.

Source parameters derived from narrowband rf beam position monitors (P0’s). These are actually pretty good. These have a 20 second time constant, and are downstream of the intensity-dependence offset compensation feedforward. That’s good.
By Popular Demand, the following screen for insertion device beamlines meets most requirements that I have heard:

- InUse status (by orbit control algorithm)
- Insertion Device Gap Status
- Shutter Icon that moves when the shutter opens and closes!
- Process variables that are actually used by the orbit correction algorithm! (Background turns red if the device is hopelessly broken)
- Distance from center of ID straight!
- Equation explaining what those three numbers are!

Source code for the above plus other info available at http://www.aps.anl.gov/asd/diagnostics/xbpmDisplays/index.html
And, in addition, new screens for BM lines are also available:

- **Vertical Source Point Values**: Extrapolated from BM x-bpm’s
- **Horizontal Source Point Values**: Interpolated from RF bpm readbacks

Shutter Status

InUse pv’s make it easy to figure out what’s going on here.

Flaky vertical RF bpm readbacks, provided for completeness

Horizontal Source Point Values Interpolated from RF bpm readbacks (It’s yellow because S14B:P4:x is broken, but it is a simple matter to use B:P5 for an estimate of angle changes).

Source code for the above plus other info available at http://www.aps.anl.gov/asd/diagnostics/xbpmDisplays/index.html