
Stiff competition from ourselves

Early production mode a necessity

Jim Crittenden
CESR-c Lattice Design Meeting
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http://www.lepp.cornell.edu/~critten/3770_Then_and_Now.pdf
### Commissioning Milestones

- **8/2002**: First wiggler installed
- **9/2002**: Machine studies verify wiggler properties
- **10-12/2002**: Engineering run 90 mA, $1 \times 10^{31}$
- **7/2003**: New vertex chamber in CLEO
- **8/2003**: Five more wiggler magnets
- **11/2003-4/2004**: First Physics run 110 mA, $3 \times 10^{31}$, (3x world sample of $\psi(3770)$)
- **4-6/2004**: Complete installation of 12 wigglers
- **8-9/2004**: Install fast luminosity monitor
- **9/2004-3/2005**: Production run at 3770 MeV, 160 mA, $6 \times 10^{31}$, ($\psi(3770)$ X 4)
- **8-9/2005**: $D_s$ scan
- **12/2005-1/2006**: $D_s$ Production (4170 MeV)
- **1-2/2006**: Install new solenoid compensation magnets
- **3-4/2006**: $D_s$ Production (3X), 120 mA, $7 \times 10^{31}$, injection into collision
Developments since April 2005

- New IR Optics
- Electron injection into collision
- BBI included in lattice design
- Constraint on e+e- symmetry
- New diagnostic tools
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<tbody>
<tr>
<td>$\mathcal{L}$ (10$^{30}$ cm$^{-2}$ s$^{-1}$)</td>
<td>300</td>
<td>65</td>
<td>70</td>
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<tr>
<td>$I_{\text{beam}}$ (mA)</td>
<td>180</td>
<td>75</td>
<td>65</td>
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<tr>
<td>Nr Bunches</td>
<td>45</td>
<td>40</td>
<td>24</td>
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<tr>
<td>$\varepsilon_H$ (nm-rad)</td>
<td>220</td>
<td>135</td>
<td>120</td>
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<tr>
<td>$\xi_V$</td>
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<td>0.024</td>
<td>0.029</td>
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<tr>
<td>$\beta_V$ (cm)</td>
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<td>1.2</td>
<td>1.2</td>
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<tr>
<td>$\sigma_E/E$ (10$^{-4}$)</td>
<td>0.81</td>
<td>0.85</td>
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<tr>
<td>$\tau_{H,V}$ (ms)</td>
<td>55</td>
<td>50</td>
<td>55</td>
</tr>
<tr>
<td>Wiggler field (T)</td>
<td>2.1</td>
<td>2.1</td>
<td>1.9</td>
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Improved Solenoid Compensation

Ambiguous lattice design message for anti-solenoids

The Dec05 lattice for 4170 was the first to include BBI compensation and already appeared to give most of the improvement expected from the anti-solenoids.

This comparison is complicated by the fact that the Jan05 lattice was for 3770 and the Dec05 lattice for 4170.

However, improved specific luminosity from the anti-solenoids at 4170 is clear

See also Mike's plot of luminosity vs bunch current. One curious aspect of his plot is that we did not reach the luminosity predicted for 4170, while the luminosity for 3770 WAS modelled accurately.

Could this be related to not using the design pretzel?
Comparison with Measurements - Luminosity

- In simulation the operating point (betatron tunes) is determined by a tune scan.
- Assume all bunches have equal current and contribute equal luminosity.

CESR-c 1.89 GeV
12-2.1T wigglers Phase III IR

5.3 GeV Phase II IR

Tracking & plots by D. Rubin
Computer simulation shows significant gain in performance using anti-solenoids in coupling compensation scheme.

Some improvement has also been made (Dec-05) by lattice optimization.

Luminosity / bunch from W-S simulation with full lattice non-linearities

Tracking by D. Rubin, M. Forster
Ability to inject and collide in similar optics avoids fill-to-fill thermal cycling
Tune excursions from BBI much reduced (less hysteresis!)
Turn-around times reduced from 4 to less than 2 minutes.

March 26, 2005 (3770)

April 8, 2006 (4170)

Our preference for injecting into collision may be the reason we cannot inject to higher currents. (?)
"The improvements in IP optics, tune plane footprint and duty cycle re-emphasize the importance of finding a way to compensate optical distortions arising from the beam-beam interaction." (jac, EPAC'06)

In our present situation of choosing to inject into a smaller pretzel, one should expect to have to find some way to otherwise compensate the BBI.

Our BBI compensation scheme, despite some empirical success, so far has proved impractical to implement during production operations.

Our need to reach routine lumi nosity production quickly will severely limit our ability to use this approach.

Why are we painting ourselves into this particular corner??

Maybe we like it here.

If so, quit whining!
ST points out nonlinear effects in dynamic aperture calculation
(contours less “rectangular” for 3686 and more energy dependence in vertical)
Operational pretzel amplitudes

3770 8x5 (PRZ1=3137)

3686 8x3 (PRZ1=2850)

I reproduce ST's result and see current, bunch dependence: ST comment remains valid

No BBI optimization in 3770. 3686 worse despite BBI optimization. Why? Pretzel!
My Dynamic Aperture with Design Pretzel

3770 8x5 (PRZ1=3137)  06/10/11  09.22

Dynamic Aperture Calculations for Job 1428: Train 1  Energy offset 0 σ

Now with design pretzel for 3686, the effect of BBI optimization in the lattice design is clear.

The calculated DA is very tune dependent. Here I used the tunes 0.54/0.57 for 3686 and 0.54/0.59 for 3770.

3686 8x3 (PRZ1=3200)  06/10/04  12.02

Dynamic Aperture Calculations for Job 1419: Train 1  Energy offset 0 σ

Similar pretzel amplitudes
ST comment on $\eta_x$ at injection points

3770 and 3686 optics dispersion comparison

ST: Larger dispersion limits pulsed bump amplitude and lowers injection efficiency

Note: $\eta_x = 1$ m contributes 0.08% x 1 m = 0.8 mm. The total horizontal sigma is 2.5-3.5 mm.
The full injection envelope calculation shows little difference between 3770 and 3686 when the BBI effects are ignored.
BBI distortions affect 3686 (pretzel 3300) more severely than 3770 (pretzel also 3300).

The problem is further aggravated by lowering the pretzel to 2900.