UAL/ETEAPOT/SXF Presentation - Benchmark Files: E_BM_P1.0.sxf, E_BM_Z.sxf, and E_BM_M1.0.sxf

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Abstract

The benchmark, 80 bend, sxf files, E_BM_P1.0.sxf, E_BM_Z.sxf, and E_BM_M1.0.sxf, are examined. This involves assuming the elements are electric. The "m" value must also be defined. Here, I catalog electric bending configuration results for m=1 (E_BM_P1.0.sxf), m=0 (E_BM_Z.sxf), and m=-1 (E_BM_M1.0.sxf). The somewhat familiar 80 bend sxf file, E_Kepler.sxf, is overviewed with both m=1 ("Spherical"), and m=0 ("Cylindrical") to start.

1 Introduction

An electric field with index m power law dependence on radius r for y=0 is

$$\mathbf{E}(r,0) = -E_0 \frac{r_0^{1+m}}{r^{1+m}} \hat{\mathbf{r}}, \tag{1}$$

and the electric potential $V(r)$, adjusted to vanish at $r = r_0$, is

$$V(r) = -\frac{E_0 r_0}{m}\left(\frac{r_0^m}{r^m} - 1\right). \tag{2}$$

We have "exact" theoretical analysis for (m=1) inverse square propagation (Munoz [1], Boyer[2]). The methods of Munoz are used here, corrected to apply to the general m value case. The theory for this is given elsewhere. Here, after the overview, I merely catalog the 12 results (3 sxf files times 4 plots per sxf file), hopefully self-explanatory. There are actually 2 curves per plot corresponding to +/- inputs which also differ in output only by a sign.

2 E_Kepler Overview

2.1 Spherical

Figure 1 and figure 2 show the pure Kepler sxf file propagation (not "kick corrected" to cylindrical).

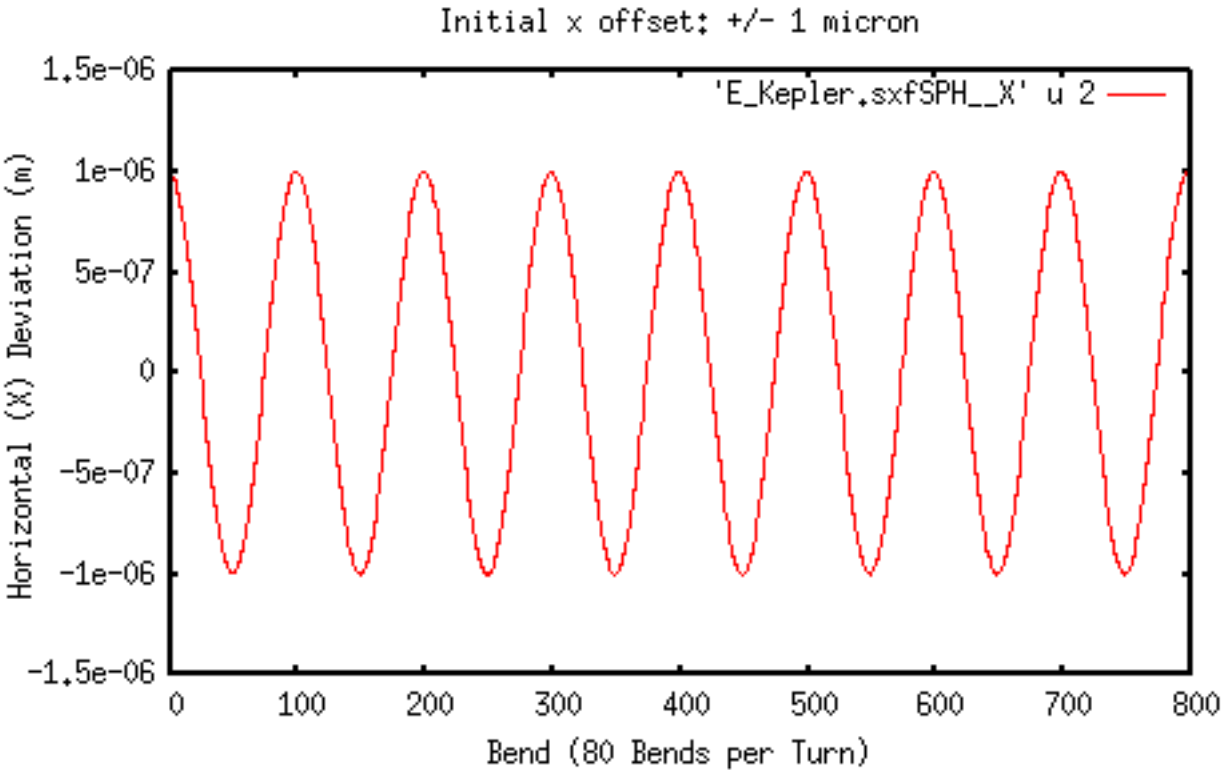

Figure 1: E_Kepler.sxf: (pure) Spherical Propagation, Horizontal Displacement. 10 turns, 1 sample per bend. $Q_x \approx 8.0$osc/800 bends*80bends/turn=0.8 osc/turn as predicted by theory

2.2 Cylindrical

Figure 3 and figure 4 show the Kepler sxf file propagation, "kick corrected" to cylindrical.

3 Results

The plots corresponding to the lattice files of Talman[4] using the syntax in the Catalog Syntax section are presented sequentially.

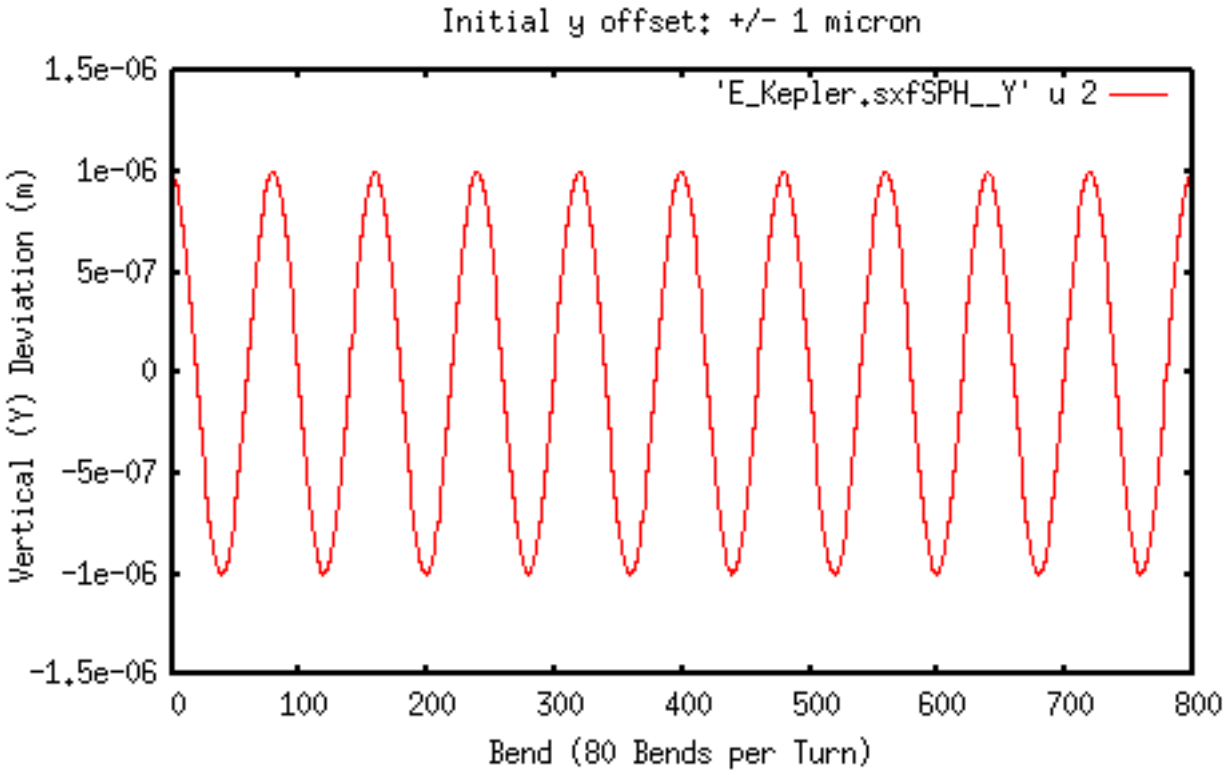

Figure 2: E_Kepler.sxf: (pure) Spherical Propagation, Vertical Displacement. 10 turns, 1 sample per bend. $Q_y \approx$ 10.0osc/800 bends*80bends/turn=1.0 osc/turn as predicted by theory

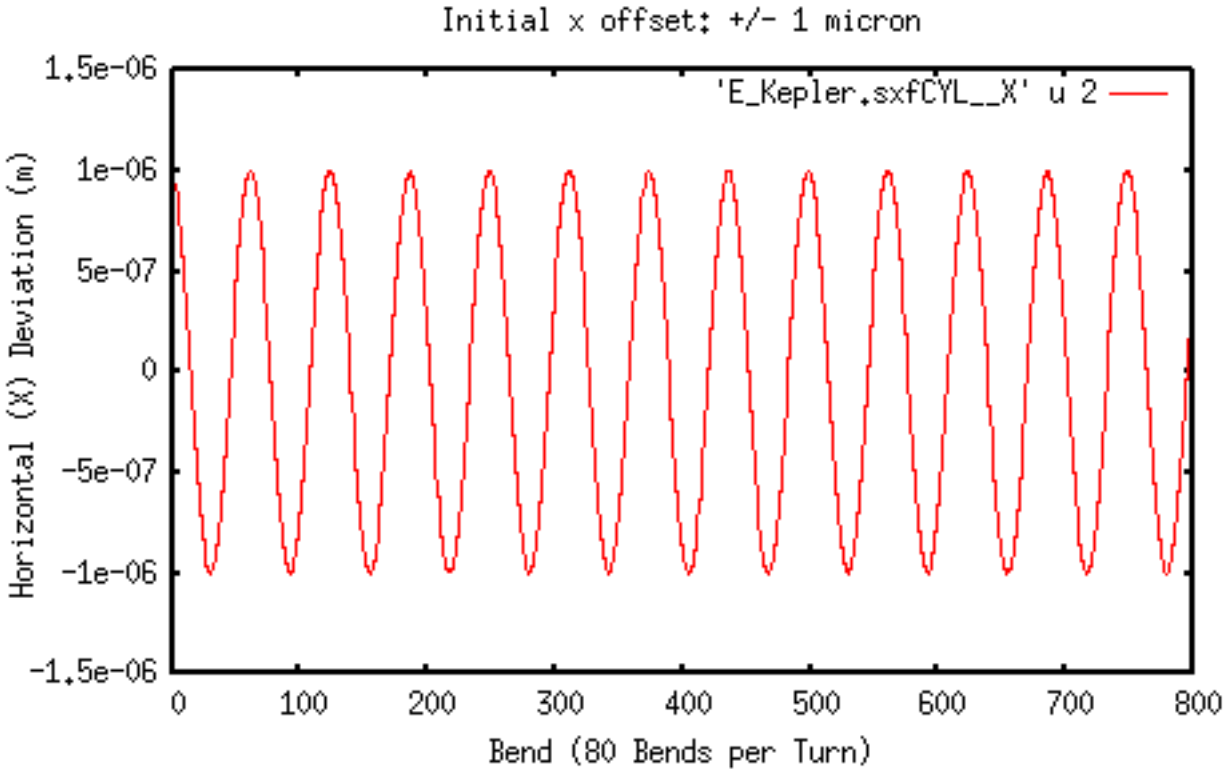

Figure 3: E_Kepler.sxf: Cylindrical Propagation, Horizontal Displacement. 10 turns, 1 sample per bend. $Q_x \approx$ 12.5osc/800 bends*80bends/turn=1.25 osc/turn as predicted by theory

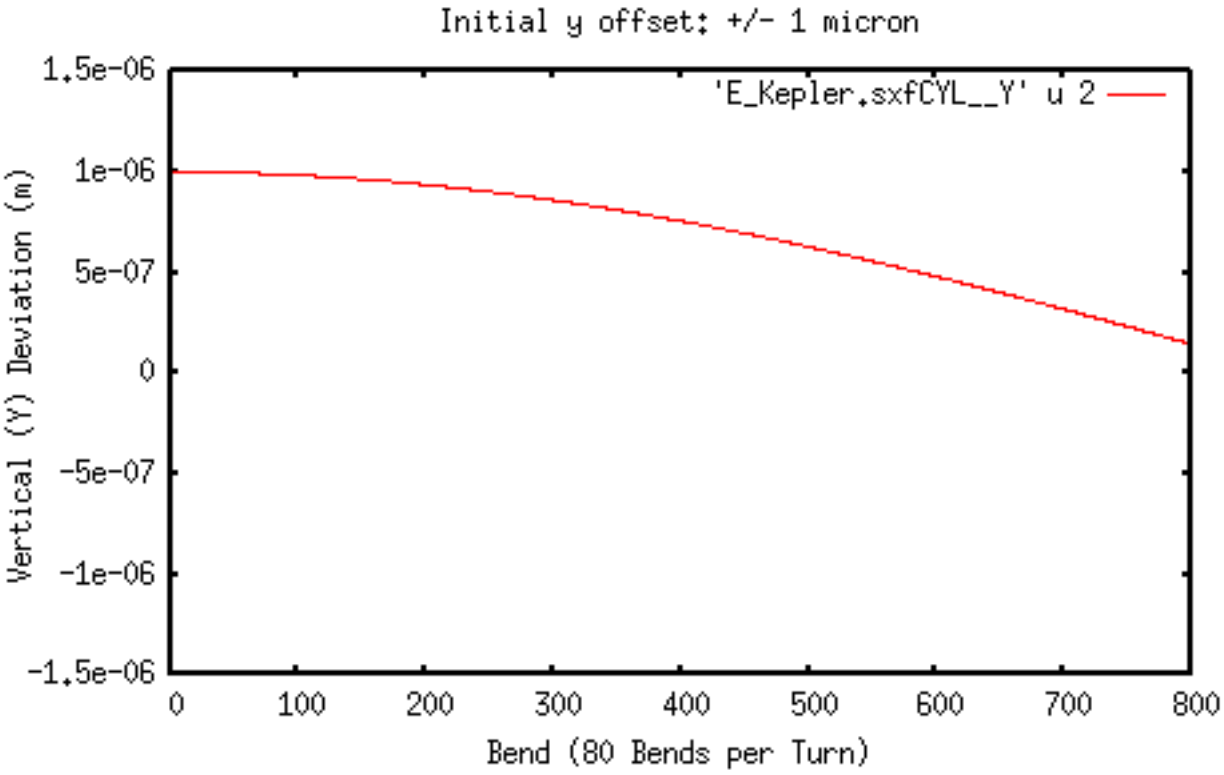

Figure 4: E_Kepler.sxf: Cylindrical Propagation, Vertical Displacement. 10 turns, 1 sample per bend. $Q_y \approx 0.2$osc/800 bends*80bends/turn=0.02 osc/turn

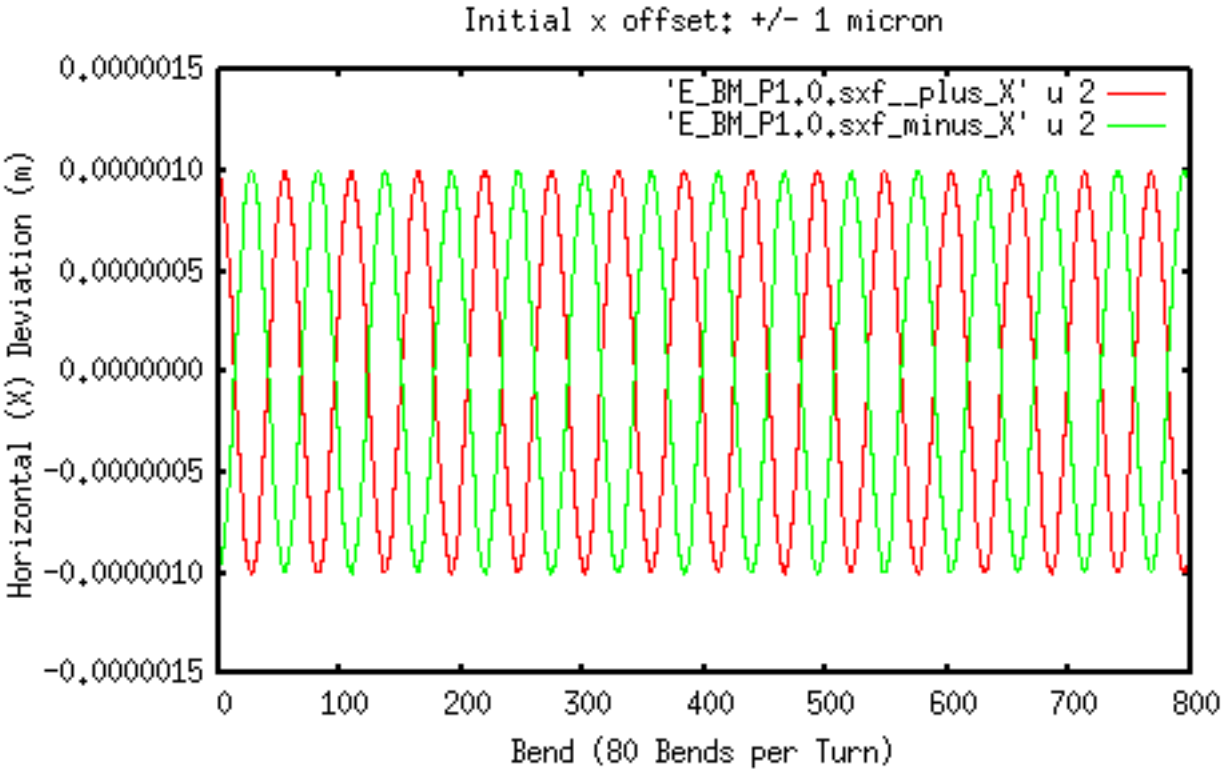

Figure 5: E_BM_P1.0.sxf: Horizontal Displacement. 10 turns, 1 sample per bend. $Q_x \approx 14.5$osc/800 bends*80bends/turn=1.45 osc/turn

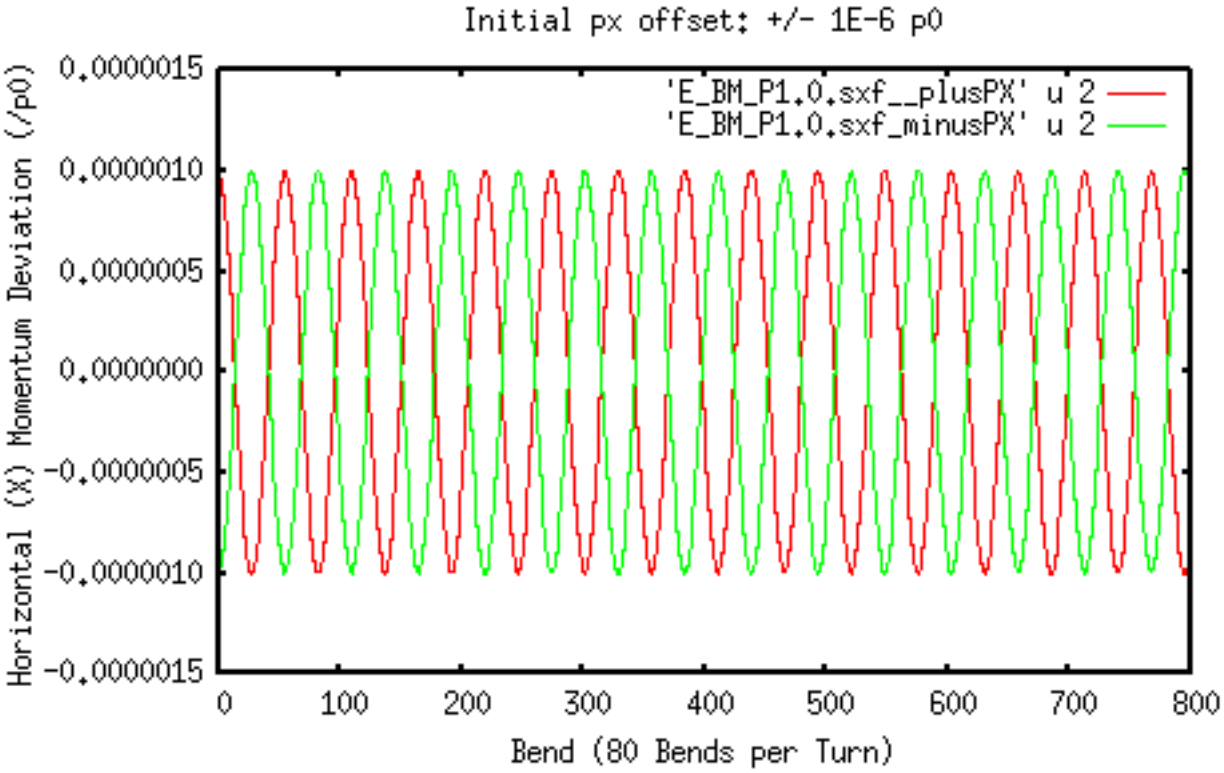

Figure 6: E_BM_P1.0.sxf: Horizontal Momentum. 10 turns, 1 sample per bend. $Q_x \approx 14.5$osc/800 bends*80bends/turn=1.45 osc/turn

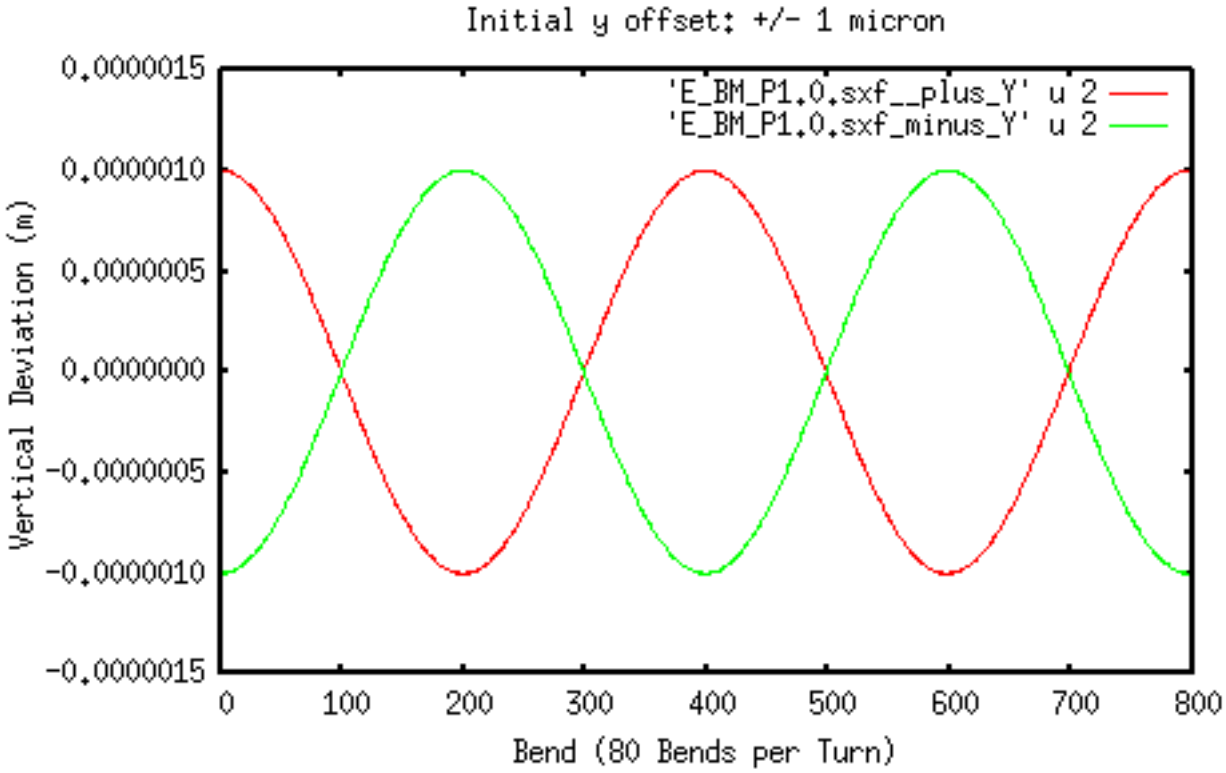

Figure 7: E_BM_P1.0.sxf: Vertical Displacement. 10 turns, 1 sample per bend. $Q_y \approx$ 2osc/800 bends*80bends/turn=0.2 osc/turn

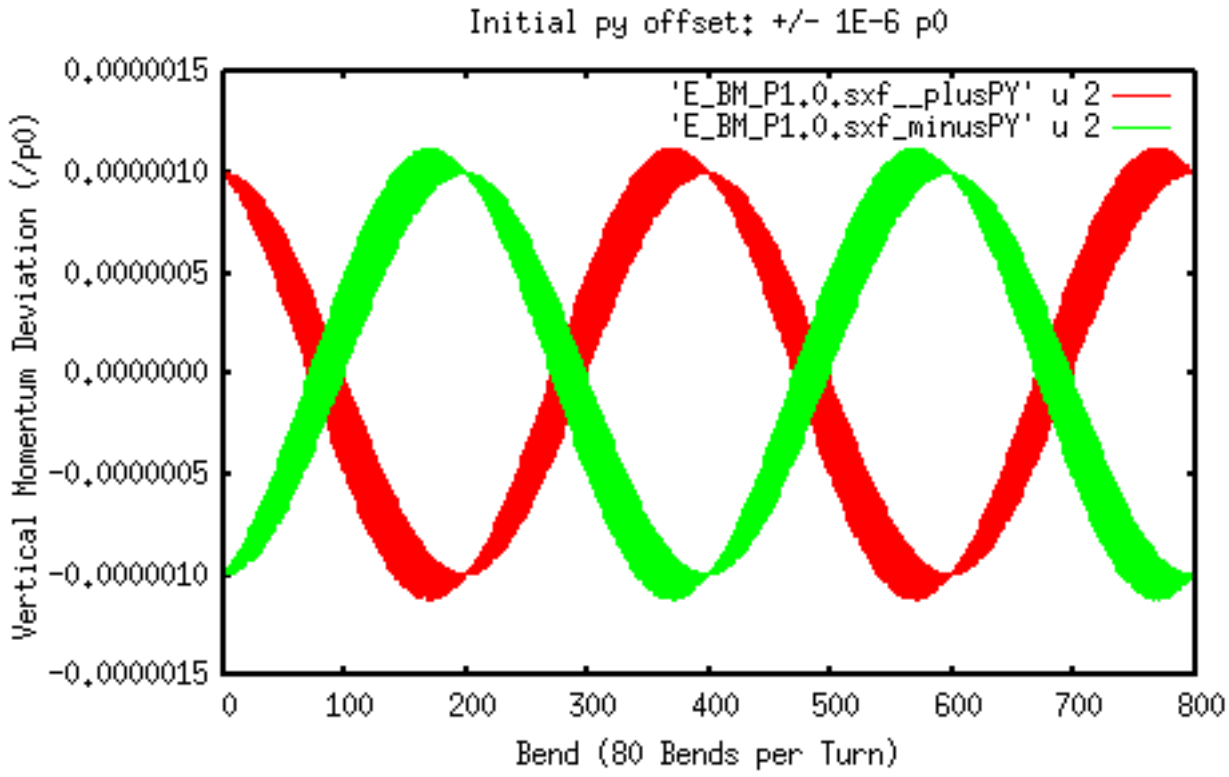

Figure 8: E_BM_P1.0.sxf: Vertical Momentum. 10 turns, 1 sample per bend. $Q_y \approx$ 2osc/800 bends*80bends/turn=0.2 osc/turn

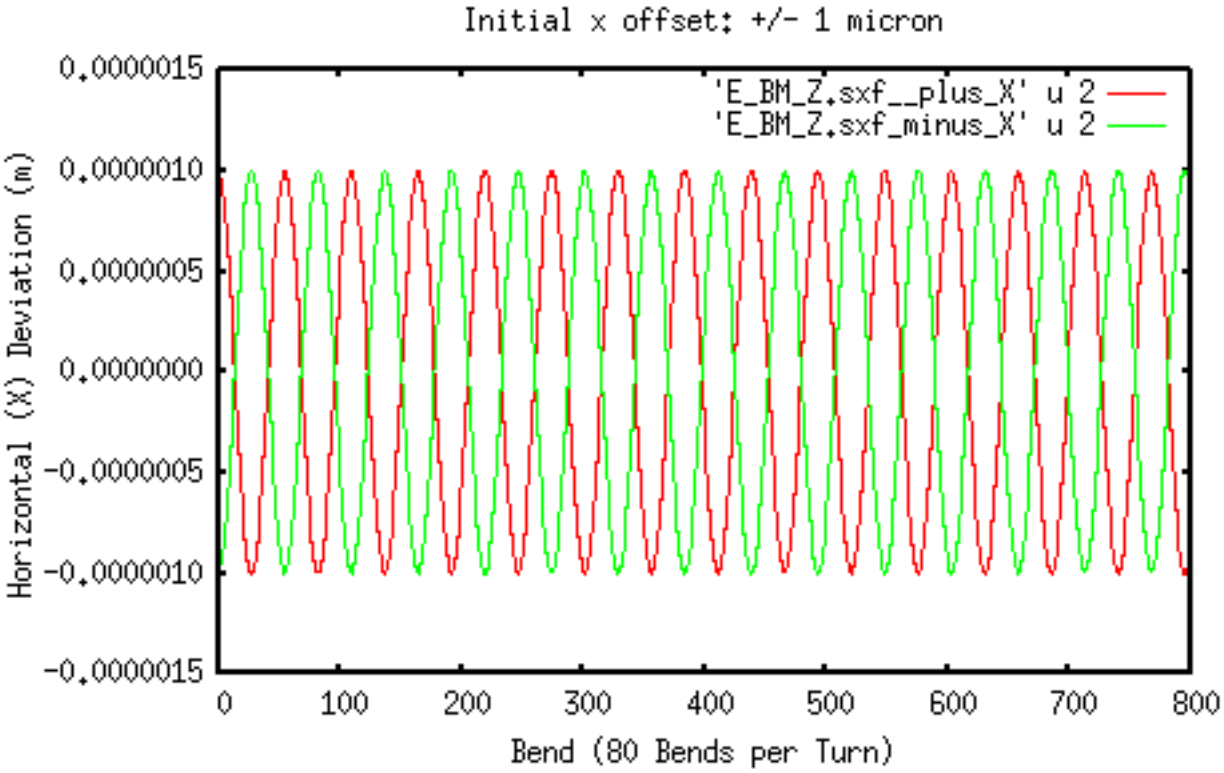

Figure 9: E_BM_Z.sxf: Horizontal Displacement. 10 turns, 1 sample per bend. $Q_x \approx 14.5$osc/800 bends*80bends/turn=1.45 osc/turn

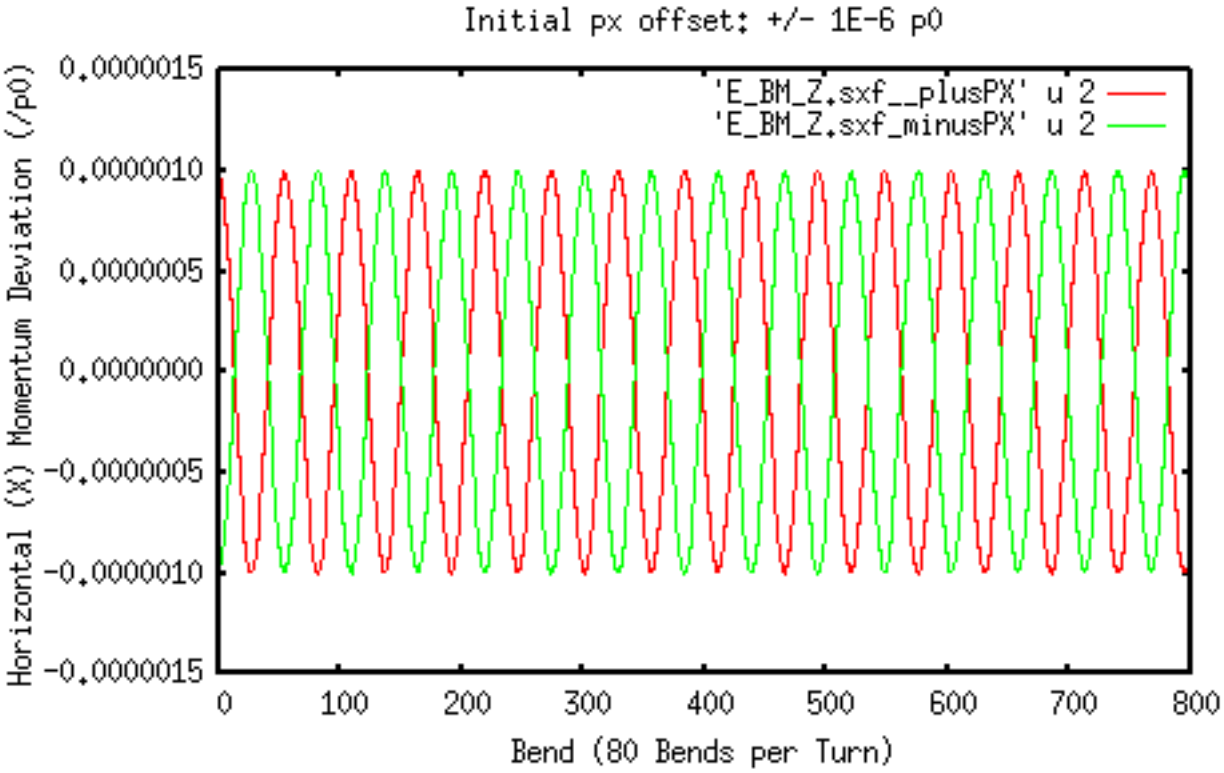

Figure 10: E_BM_Z.sxf: Horizontal Momentum. 10 turns, 1 sample per bend. $Q_x \approx 14.5$osc/800 bends*80bends/turn=1.45 osc/turn

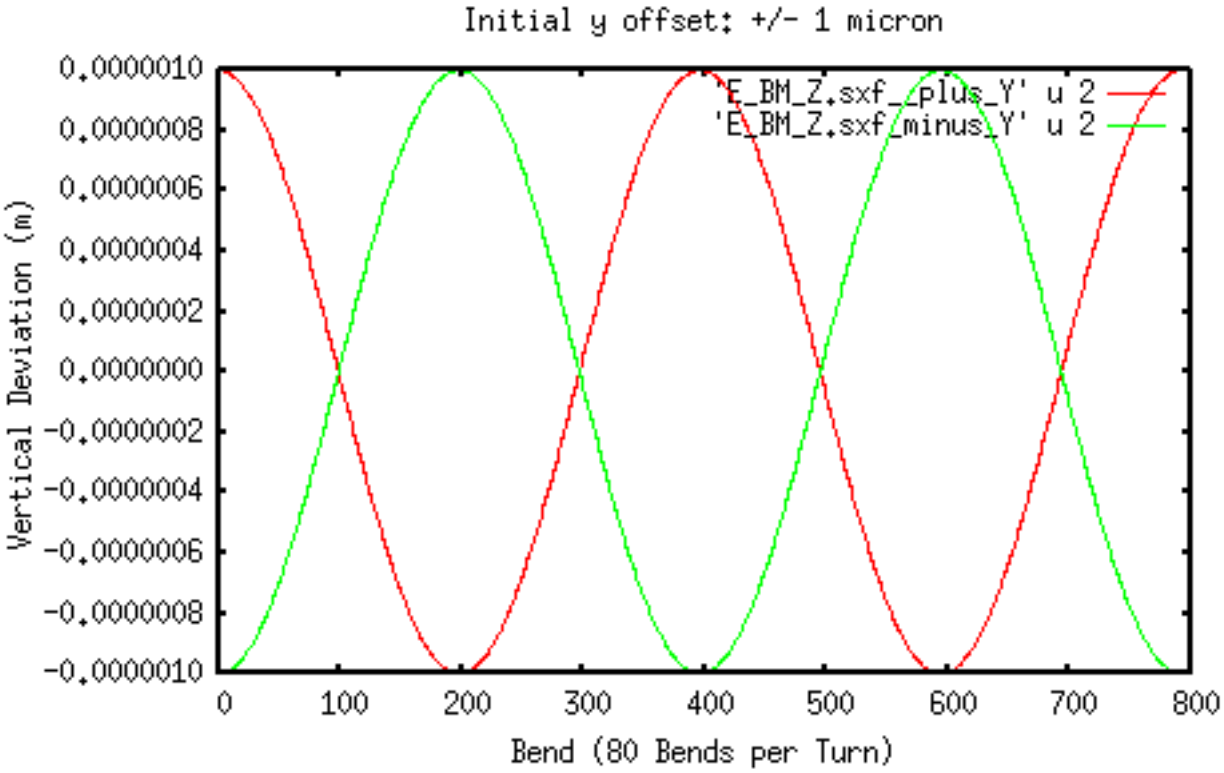

Figure 11: E_BM_Z.sxf: Vertical Displacement. 10 turns, 1 sample per bend. $Q_y \approx$ 2osc/800 bends*80bends/turn=0.2 osc/turn

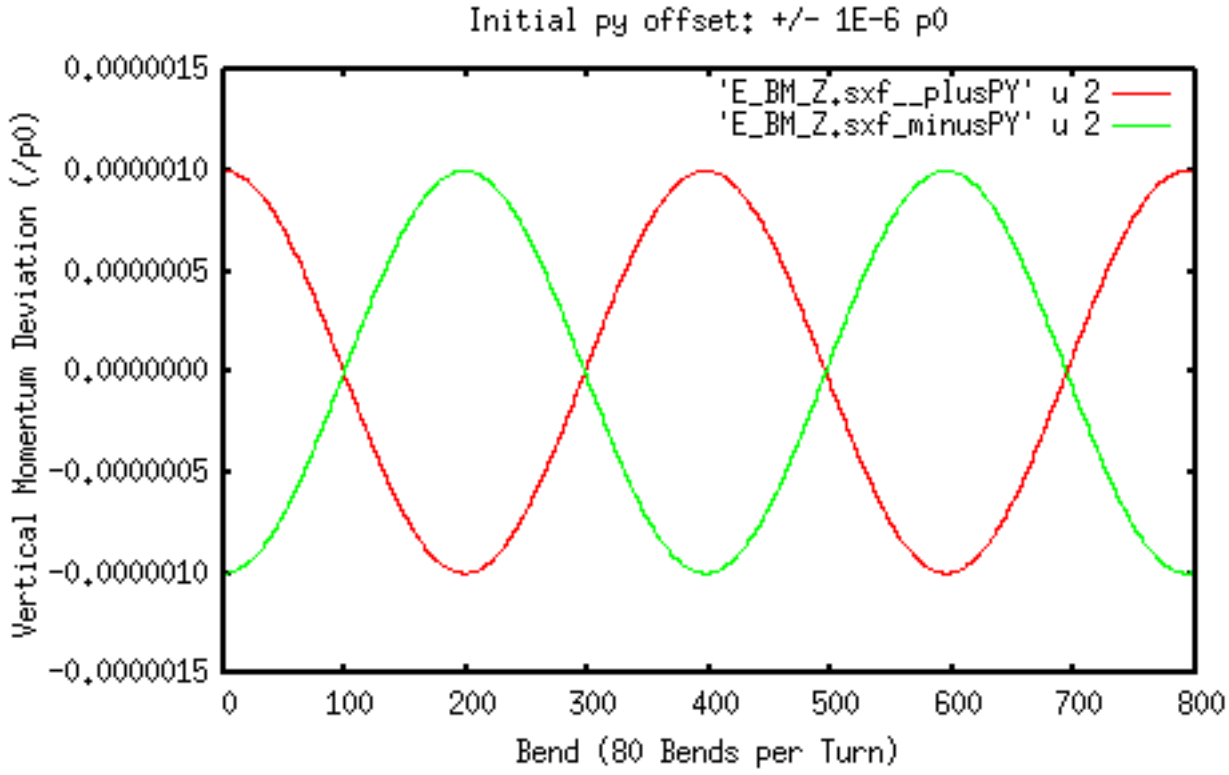

Figure 12: E_BM_Z.sxf: Vertical Momentum. 10 turns, 1 sample per bend. $Q_y \approx$ 2osc/800 bends*80bends/turn=0.2 osc/turn

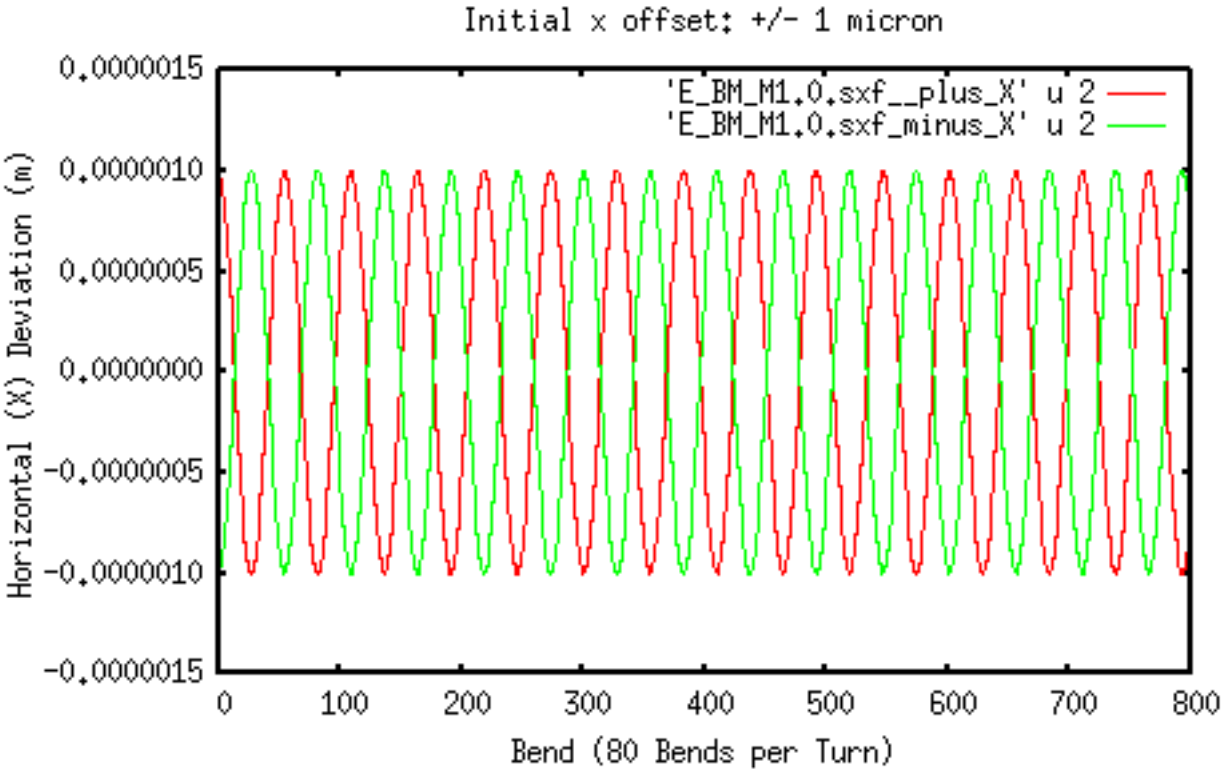

Figure 13: E_BM_M1.0.sxf: Horizontal Displacement. 10 turns, 1 sample per bend. $Q_x \approx$ 14.5osc/800 bends*80bends/turn=1.45 osc/turn

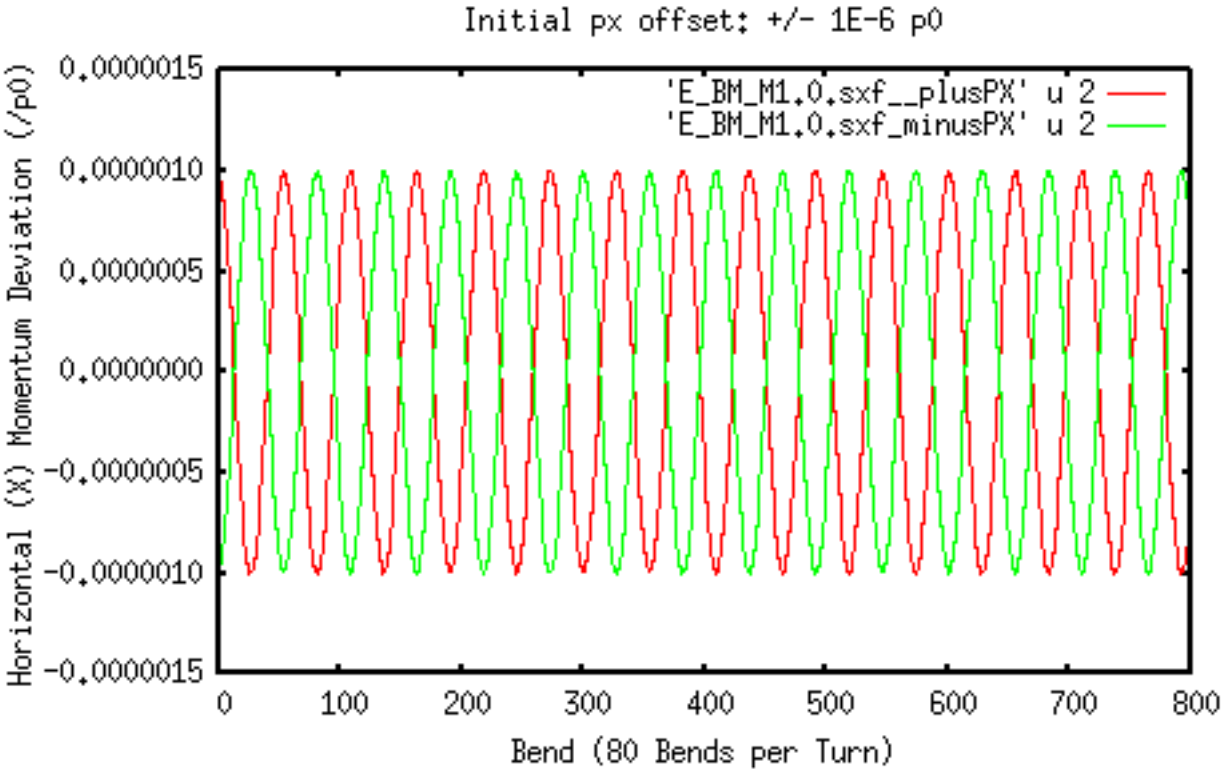

Figure 14: E_BM_M1.0.sxf: Horizontal Momentum. 10 turns, 1 sample per bend. $Q_x \approx 14.5$osc/800 bends*80bends/turn=1.45 osc/turn

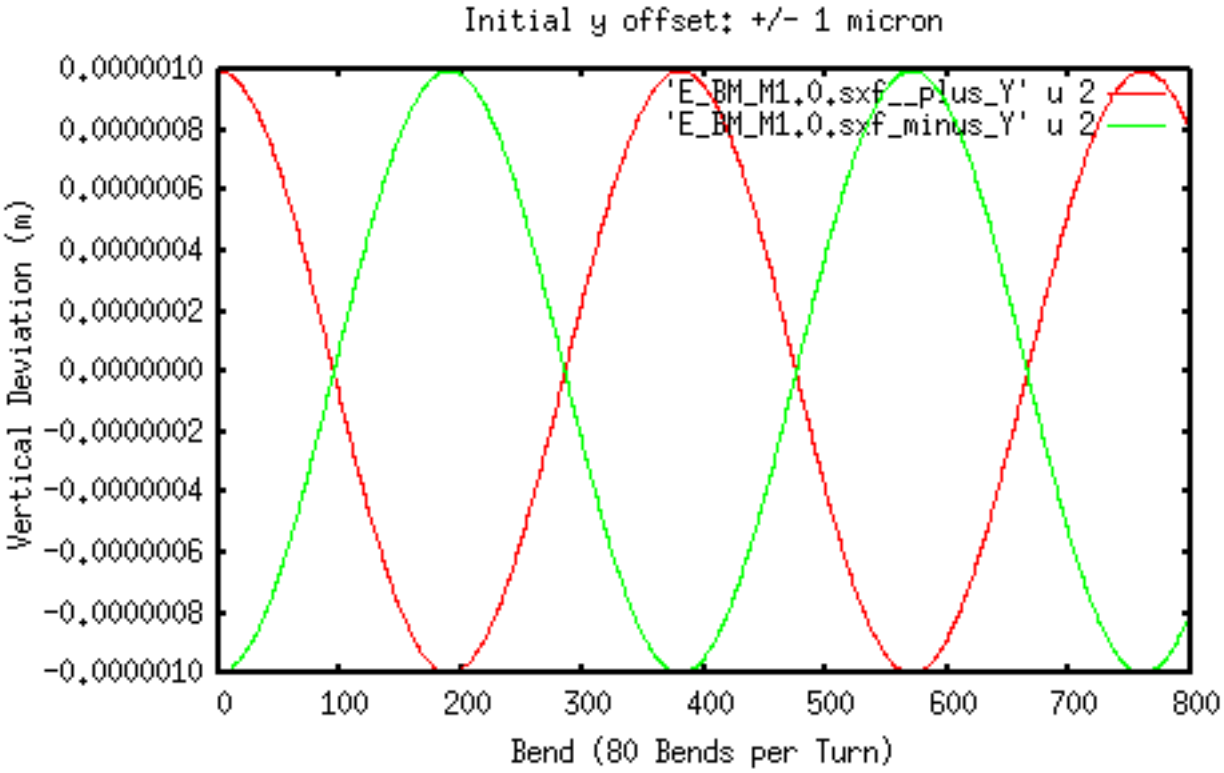

Figure 15: E_BM_M1.0.sxf: Vertical Displacement. 10 turns, 1 sample per bend. $Q_y \approx$ 2osc/800 bends*80bends/turn=0.2 osc/turn

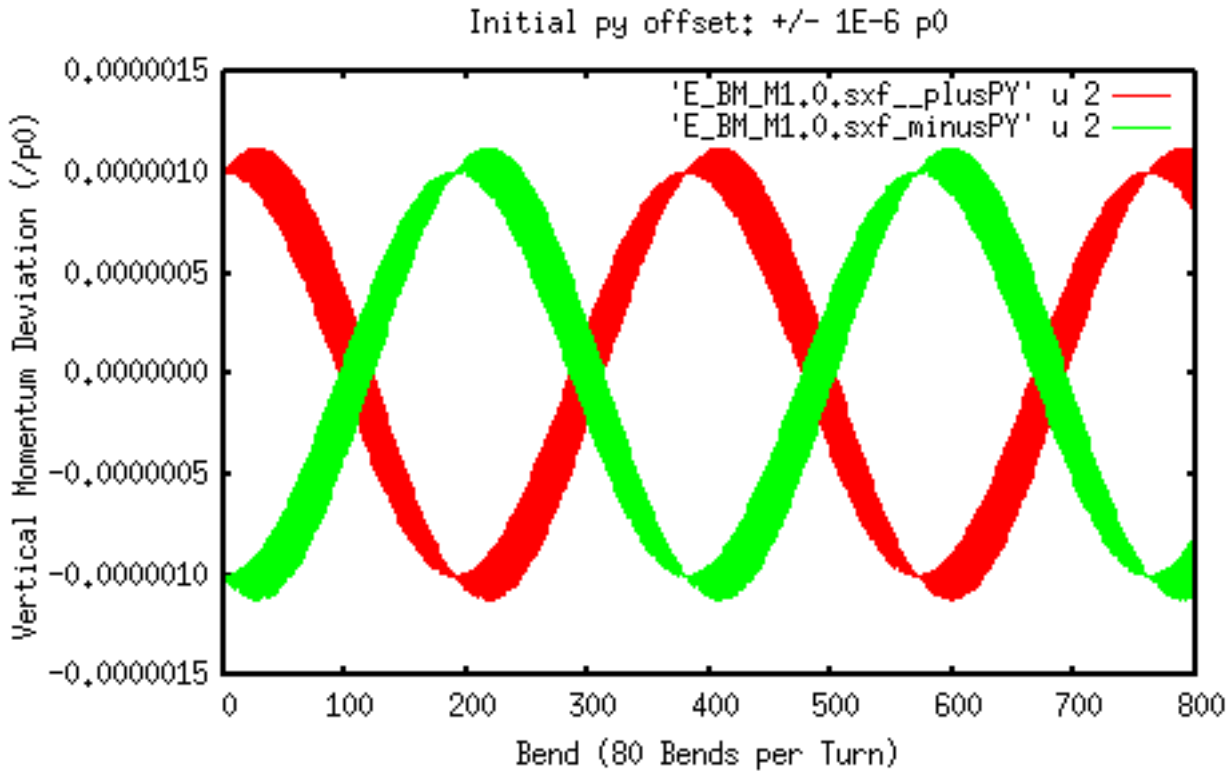

Figure 16: E_BM_M1.0.sxf: Vertical Momentum. 10 turns, 1 sample per bend. $Q_y \approx$ 2osc/800 bends*80bends/turn=0.2 osc/turn

4 Computer Syntax

```
svn co http://ual.googlecode.com/svn/trunk/ ual1
cd ual1
tcsh
setenv UAL ‘pwd‘
source setup-linux-ual
make clean
make >&! make.log

cd examples/ETEAPOT
make clean
make >&! make.log
./tracker ./data/E_Kepler.sxf 30 1 | grep pOf0 | grep ONE   >! E_Kepler.sxfSPH__X
./tracker ./data/E_Kepler.sxf 30 1 | grep pOf1 | grep THREE >! E_Kepler.sxfSPH_PX
./tracker ./data/E_Kepler.sxf 30 1 | grep pOf2 | grep FIVE  >! E_Kepler.sxfSPH__Y
./tracker ./data/E_Kepler.sxf 30 1 | grep pOf3 | grep SEVEN >! E_Kepler.sxfSPH_PY

./tracker ./data/E_Kepler.sxf 30 0 | grep pOf0 | grep ONE   >! E_Kepler.sxfCYL__X
./tracker ./data/E_Kepler.sxf 30 0 | grep pOf1 | grep THREE >! E_Kepler.sxfCYL_PX
./tracker ./data/E_Kepler.sxf 30 0 | grep pOf2 | grep FIVE  >! E_Kepler.sxfCYL__Y
./tracker ./data/E_Kepler.sxf 30 0 | grep pOf3 | grep SEVEN >! E_Kepler.sxfCYL_PY
...
(TWO, FOUR, SIX, EIGHT are the minus inputs results)

gnuplot
unset mouse
set terminal x11 size 470,300 0

set  title ’Initial x offset: +/- 1 micron’
or
set  title ’Initial y offset: +/- 1 micron’
...

set xlabel ’Bend (80 Bends per Turn)’

set ylabel ’Horizontal (X) Deviation (m)’
or
set ylabel ’Vertical (Y) Deviation (m)’
...

set yrange [-1.5E-6:+1.5E-06]
p ’E_Kepler.sxfCYL__X’ u 2 w l

(different terminal)
xwd>E_Kepler.sxfCYL__X
```

```
convert E_Kepler.sxfCYL__X E_Kepler.sxfCYL__X.eps
(include in latex file)
...
```

5 Catalog Syntax

```
E_BM_P1.0.sxf:
   ./tracker ./data/E_BM_P1.0.sxf 30 1 | grep pOf0 | grep ONE   >! E_BM_P1.0.sxf__plus_X
   ./tracker ./data/E_BM_P1.0.sxf 30 1 | grep pOf0 | grep TWO   >! E_BM_P1.0.sxf_minus_X
   (gnuplot)
      p 'E_BM_P1.0.sxf__plus_X' u 2 w l, 'E_BM_P1.0.sxf_minus_X' u 2 w l

   ./tracker ./data/E_BM_P1.0.sxf 30 1 | grep pOf1 | grep THREE >! E_BM_P1.0.sxf__plusPX
   ./tracker ./data/E_BM_P1.0.sxf 30 1 | grep pOf1 | grep FOUR  >! E_BM_P1.0.sxf_minusPX
   (gnuplot)
      p 'E_BM_P1.0.sxf__plusPX' u 2 w l, 'E_BM_P1.0.sxf_minusPX' u 2 w l

   ./tracker ./data/E_BM_P1.0.sxf 30 1 | grep pOf2 | grep FIVE  >! E_BM_P1.0.sxf__plus_Y
   ./tracker ./data/E_BM_P1.0.sxf 30 1 | grep pOf2 | grep SIX   >! E_BM_P1.0.sxf_minus_Y
   (gnuplot)
      p 'E_BM_P1.0.sxf__plus_Y' u 2 w l, 'E_BM_P1.0.sxf_minus_Y' u 2 w l

   ./tracker ./data/E_BM_P1.0.sxf 30 1 | grep pOf3 | grep SEVEN >! E_BM_P1.0.sxf__plusPY
   ./tracker ./data/E_BM_P1.0.sxf 30 1 | grep pOf3 | grep EIGHT >! E_BM_P1.0.sxf_minusPY
   (gnuplot)
      p 'E_BM_P1.0.sxf__plusPY' u 2 w l, 'E_BM_P1.0.sxf_minusPY' u 2 w l

E_BM_Z.sxf:
   ./tracker ./data/E_BM_Z.sxf 30 0 | grep pOf0 | grep ONE   >! E_BM_Z.sxf__plus_X
   ./tracker ./data/E_BM_Z.sxf 30 0 | grep pOf0 | grep TWO   >! E_BM_Z.sxf_minus_X
   (gnuplot)
      p 'E_BM_Z.sxf__plus_X' u 2 w l, 'E_BM_Z.sxf_minus_X' u 2 w l

   ./tracker ./data/E_BM_Z.sxf 30 0 | grep pOf1 | grep THREE >! E_BM_Z.sxf__plusPX
   ./tracker ./data/E_BM_Z.sxf 30 0 | grep pOf1 | grep FOUR  >! E_BM_Z.sxf_minusPX
   (gnuplot)
      p 'E_BM_Z.sxf__plusPX' u 2 w l, 'E_BM_Z.sxf_minusPX' u 2 w l

   ./tracker ./data/E_BM_Z.sxf 30 0 | grep pOf2 | grep FIVE  >! E_BM_Z.sxf__plus_Y
   ./tracker ./data/E_BM_Z.sxf 30 0 | grep pOf2 | grep SIX   >! E_BM_Z.sxf_minus_Y
   (gnuplot)
      p 'E_BM_Z.sxf__plus_Y' u 2 w l, 'E_BM_Z.sxf_minus_Y' u 2 w l

   ./tracker ./data/E_BM_Z.sxf 30 0 | grep pOf3 | grep SEVEN >! E_BM_Z.sxf__plusPY
   ./tracker ./data/E_BM_Z.sxf 30 0 | grep pOf3 | grep EIGHT >! E_BM_Z.sxf_minusPY
```

```
   (gnuplot)
     p 'E_BM_Z.sxf__plusPY' u 2 w l, 'E_BM_Z.sxf_minusPY' u 2 w l

E_BM_M1.0.sxf:
   ./tracker ./data/E_BM_M1.0.sxf 30 -1 | grep pOf0 | grep ONE   >! E_BM_M1.0.sxf__plus_X
   ./tracker ./data/E_BM_M1.0.sxf 30 -1 | grep pOf0 | grep TWO   >! E_BM_M1.0.sxf_minus_X
   (gnuplot)
     p 'E_BM_M1.0.sxf__plus_X' u 2 w l, 'E_BM_M1.0.sxf_minus_X' u 2 w l

   ./tracker ./data/E_BM_M1.0.sxf 30 -1 | grep pOf1 | grep THREE >! E_BM_M1.0.sxf__plusPX
   ./tracker ./data/E_BM_M1.0.sxf 30 -1 | grep pOf1 | grep FOUR  >! E_BM_M1.0.sxf_minusPX
   (gnuplot)
     p 'E_BM_M1.0.sxf__plusPX' u 2 w l, 'E_BM_M1.0.sxf_minusPX' u 2 w l

   ./tracker ./data/E_BM_M1.0.sxf 30 -1 | grep pOf2 | grep FIVE  >! E_BM_M1.0.sxf__plus_Y
   ./tracker ./data/E_BM_M1.0.sxf 30 -1 | grep pOf2 | grep SIX   >! E_BM_M1.0.sxf_minus_Y
   (gnuplot)
     p 'E_BM_M1.0.sxf__plus_Y' u 2 w l, 'E_BM_M1.0.sxf_minus_Y' u 2 w l

   ./tracker ./data/E_BM_M1.0.sxf 30 -1 | grep pOf3 | grep SEVEN >! E_BM_M1.0.sxf__plusPY
   ./tracker ./data/E_BM_M1.0.sxf 30 -1 | grep pOf3 | grep EIGHT >! E_BM_M1.0.sxf_minusPY
   (gnuplot)
     p 'E_BM_M1.0.sxf__plusPY' u 2 w l, 'E_BM_M1.0.sxf_minusPY' u 2 w l
```

6 References

References

[1] Munoz, G., Pavic, I. A Hamilton-like vector for the special-relativistic Coulomb problem European Journal of Physics 27(2006) 1007-1018

[2] Boyer, T. Unfamiliar trajectories for a relativistic particle in a Kepler or Coulomb potential American Journal of Physics 72(2004) 992-997

[3] Malitsky, N., Talman, J., and Talman, R. Appendix UALcode: Development of the UAL/ETEAPOT Code for the Proton EDM Experiment Personal Communication Feb. 9, 2012

[4] Talman, R. All-Electric Proton EDM Lattices for Benchmarking Simulation Codes Personal Communication Mar. 12, 2012