Matching and Extraction using Muon1 Response Matrix Output

Some initial studies using eRHIC Oct'14 lattice

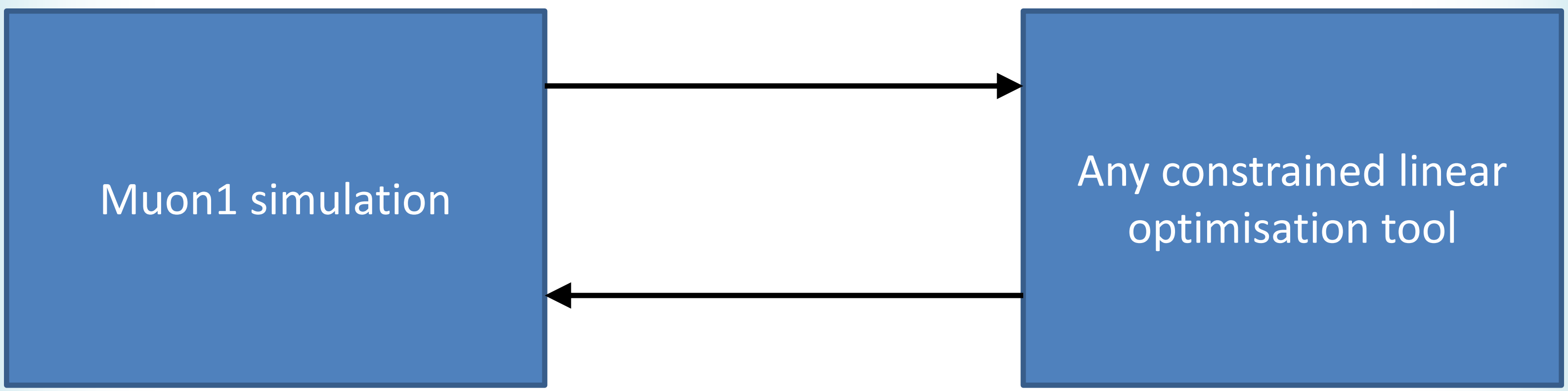
New: Muon1 Response Output

For each “ResponseBPM” j,
a CSV file containing the matrix:

$$\frac{\partial(x,x',y,y')_{Particle\ n,BPM\ j}}{\partial Corrector_i}$$

…and the uncorrected positions:

$$(x,x',y,y')_{Particle\ n,BPM\ j}$$

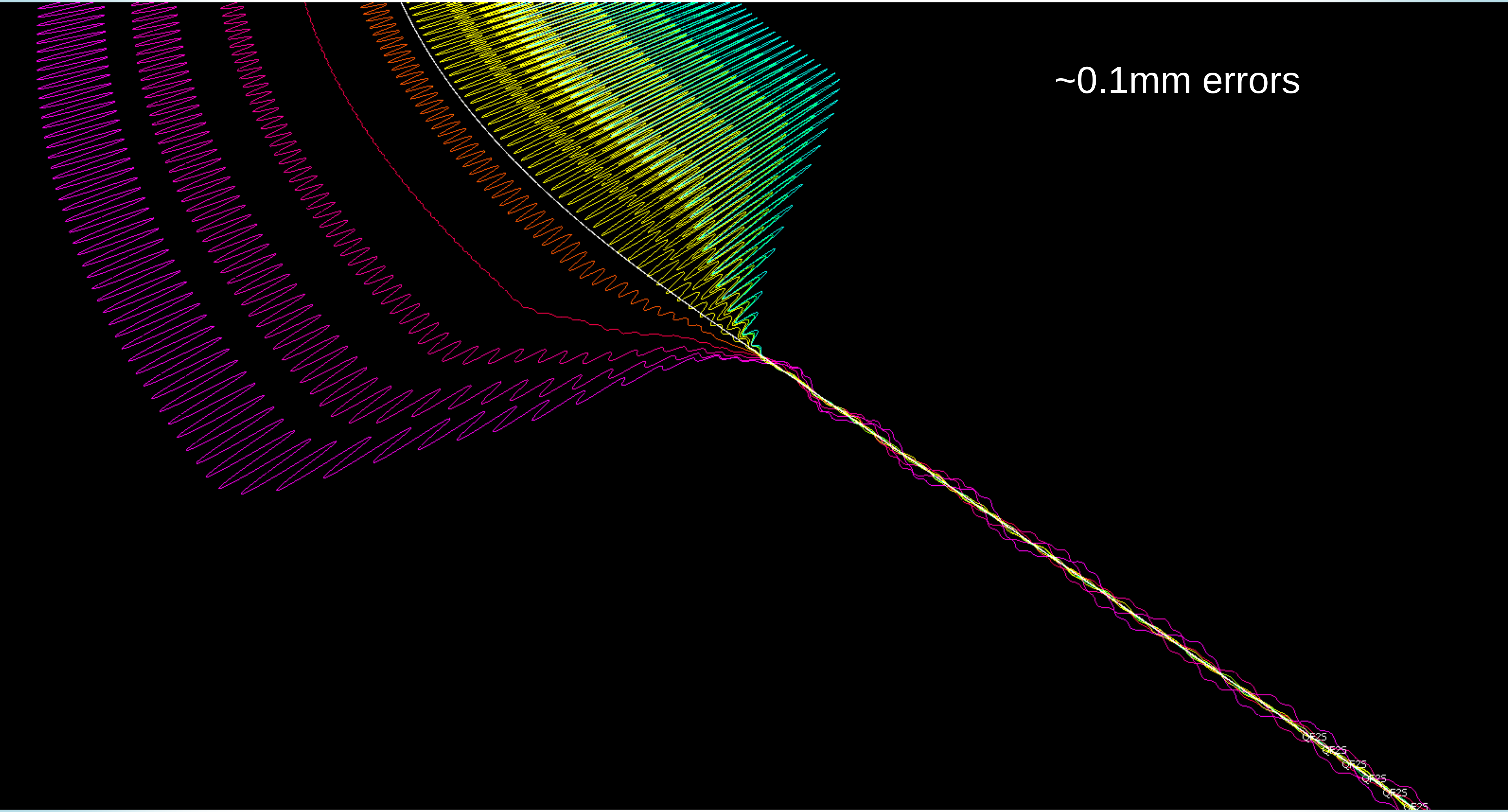


Corrector vector
as lattice input

Any attribute can become a corrector, e.g. adding a ResponseDipole=1e-6 attribute will vary that Dipole by 1e-6 Tesla in the numerical differentiation.

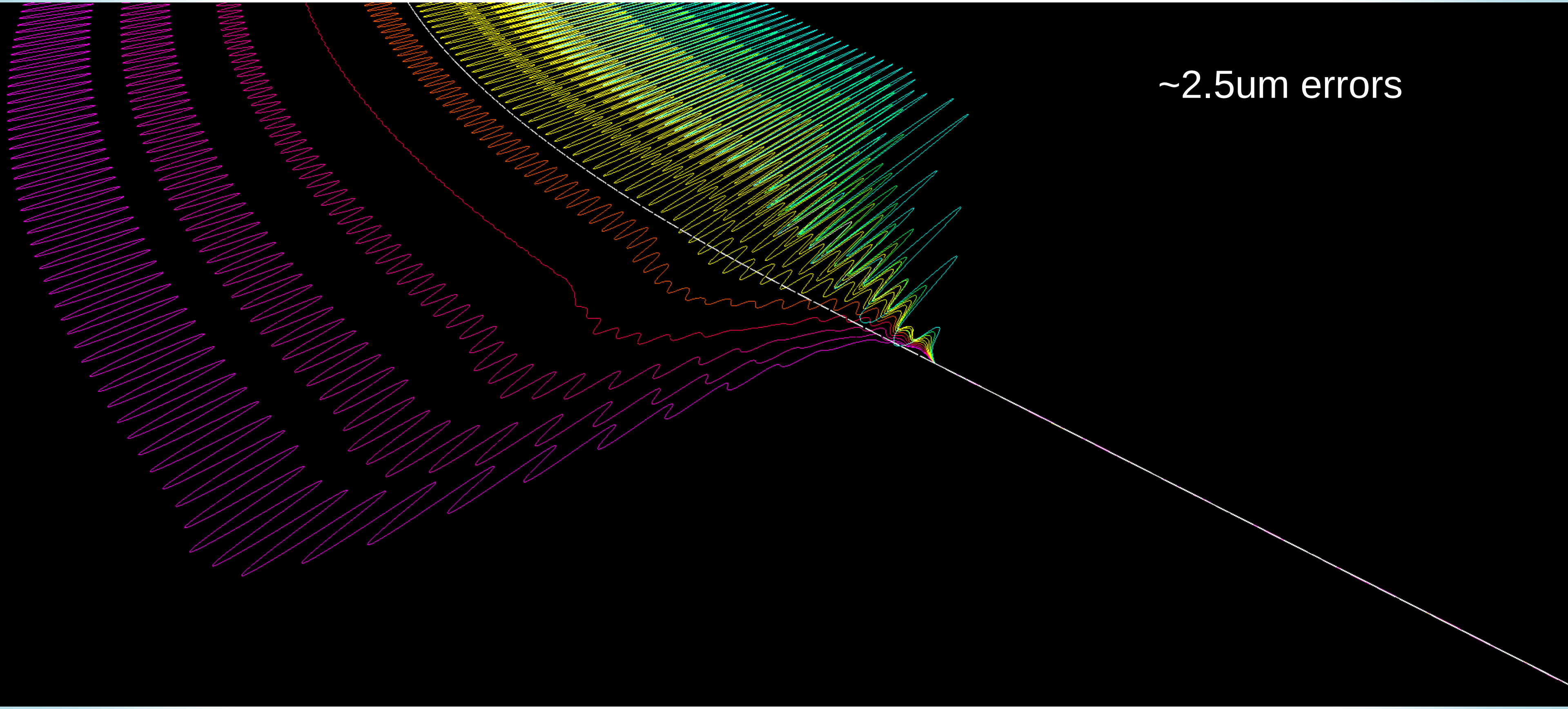
Arc-to-Straight Adiabatic Only

~0.1mm errors

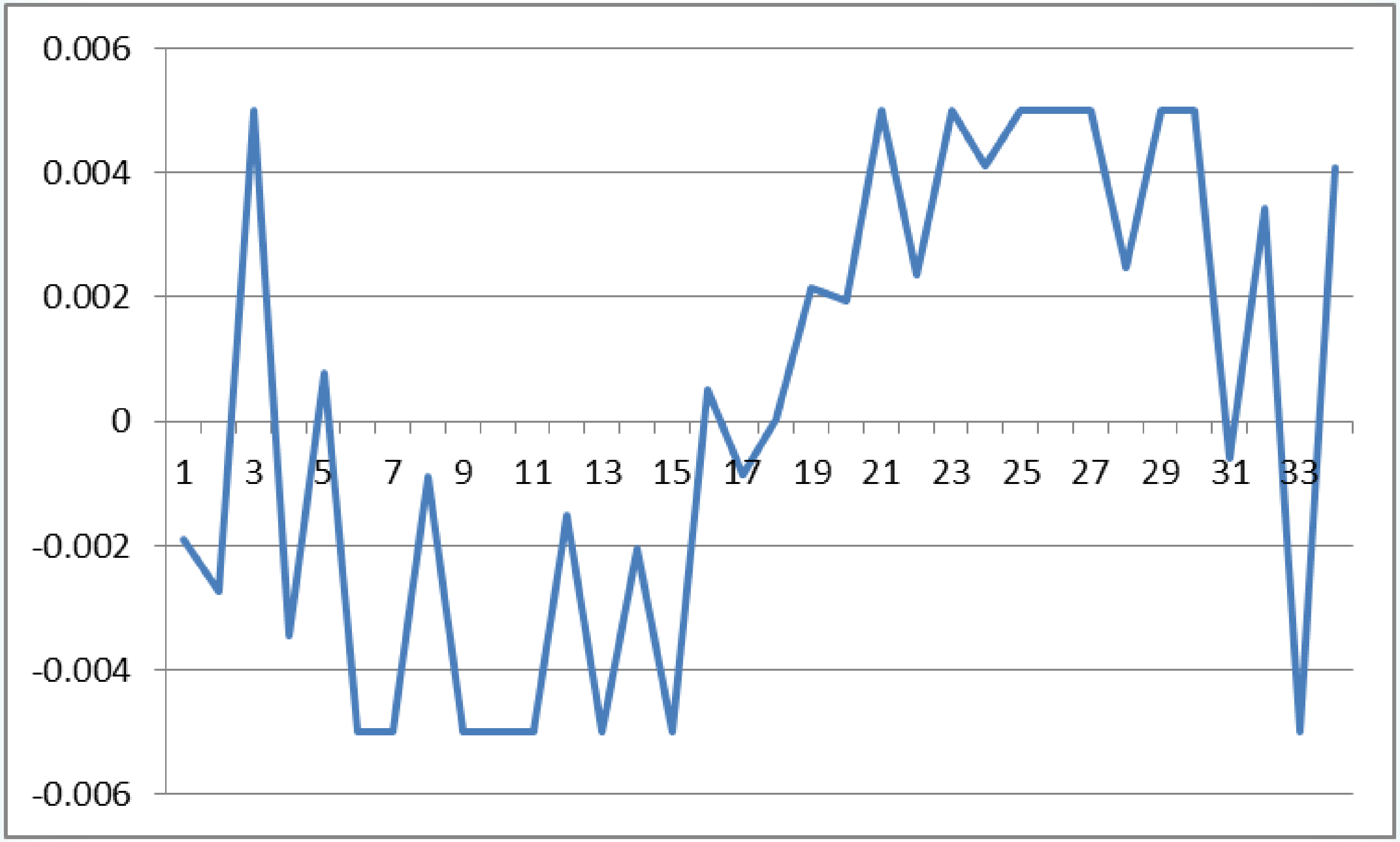


Arc-to-Straight Improved

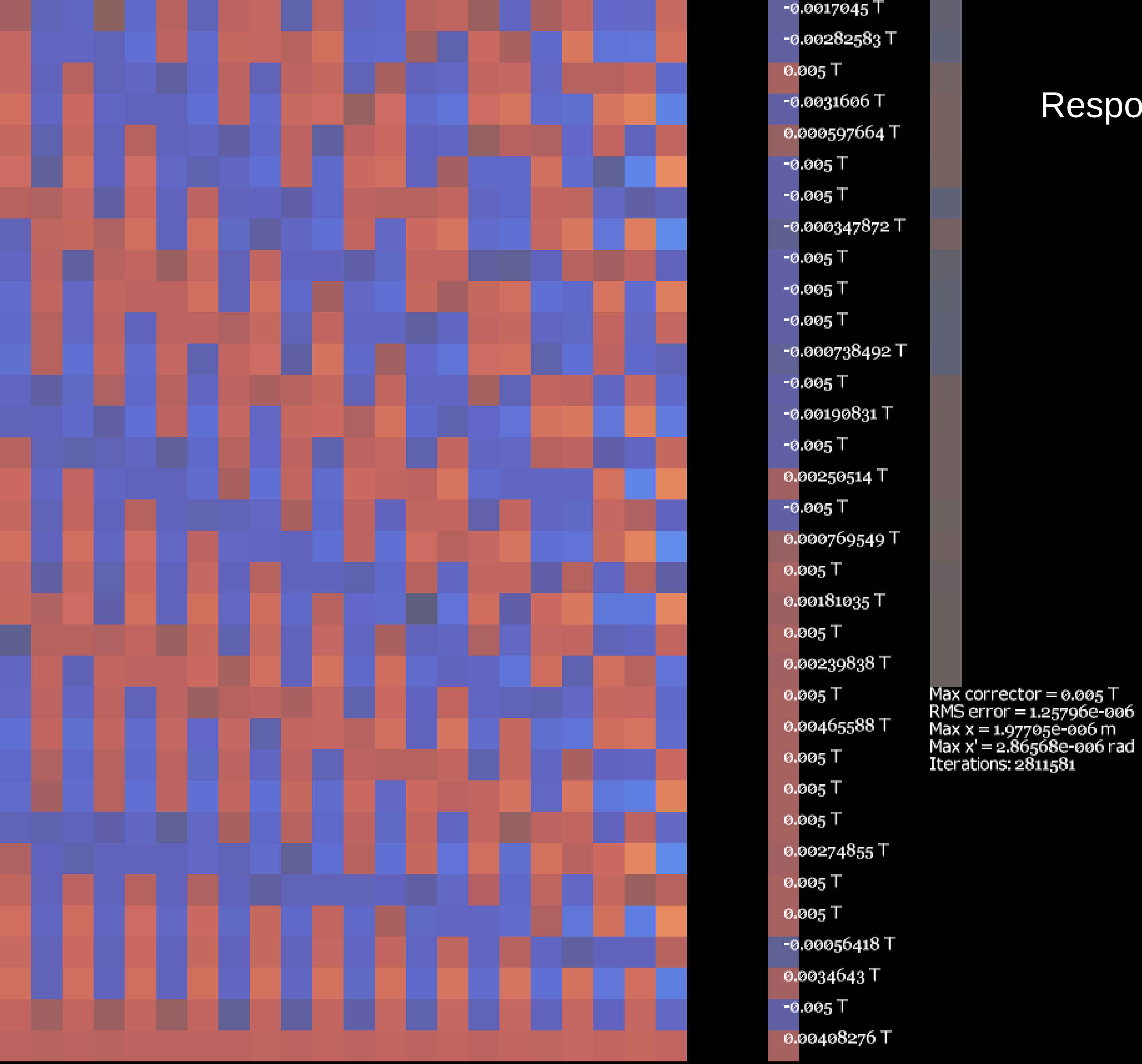
- Corrected using the 17 cells in the matcher

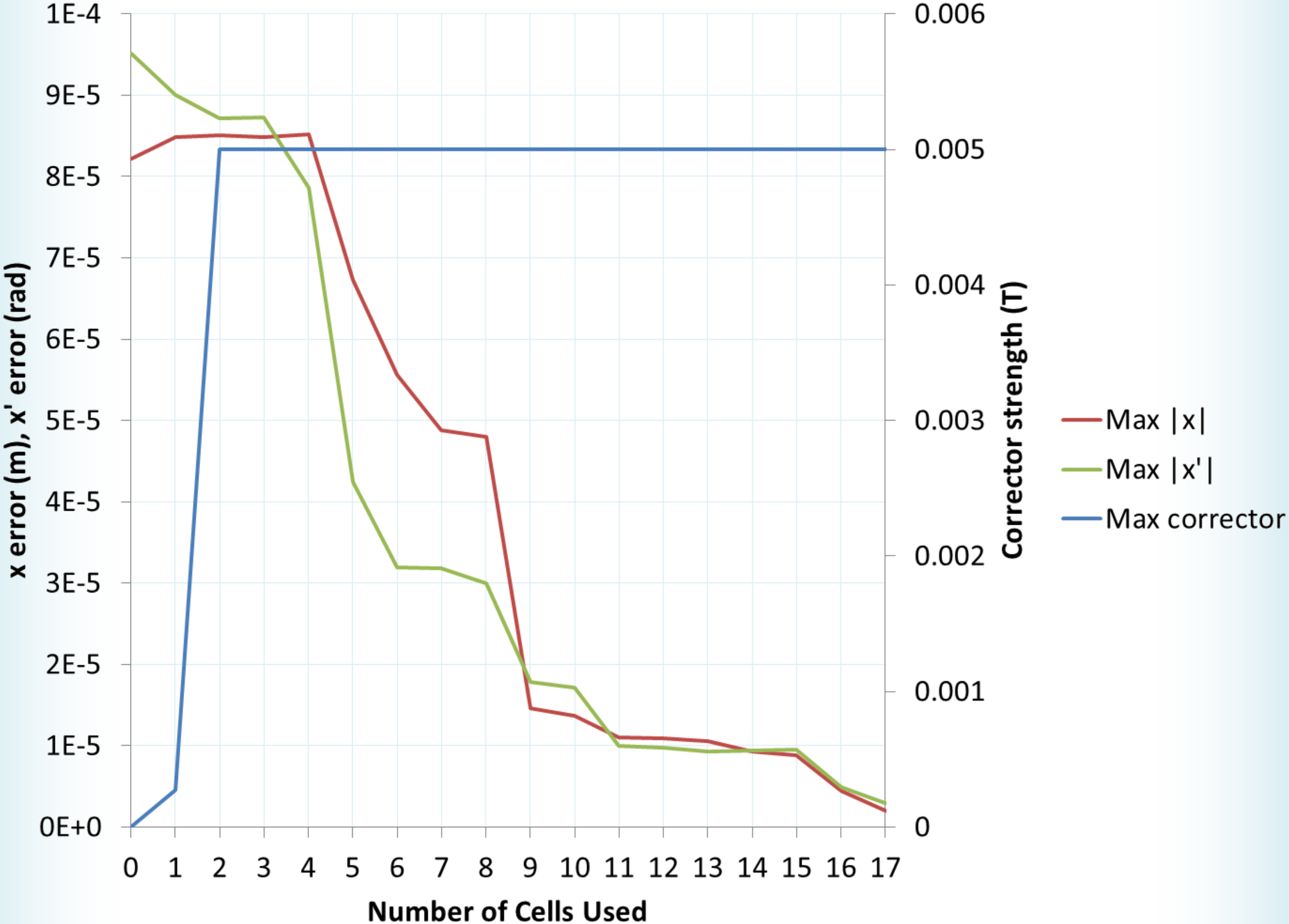


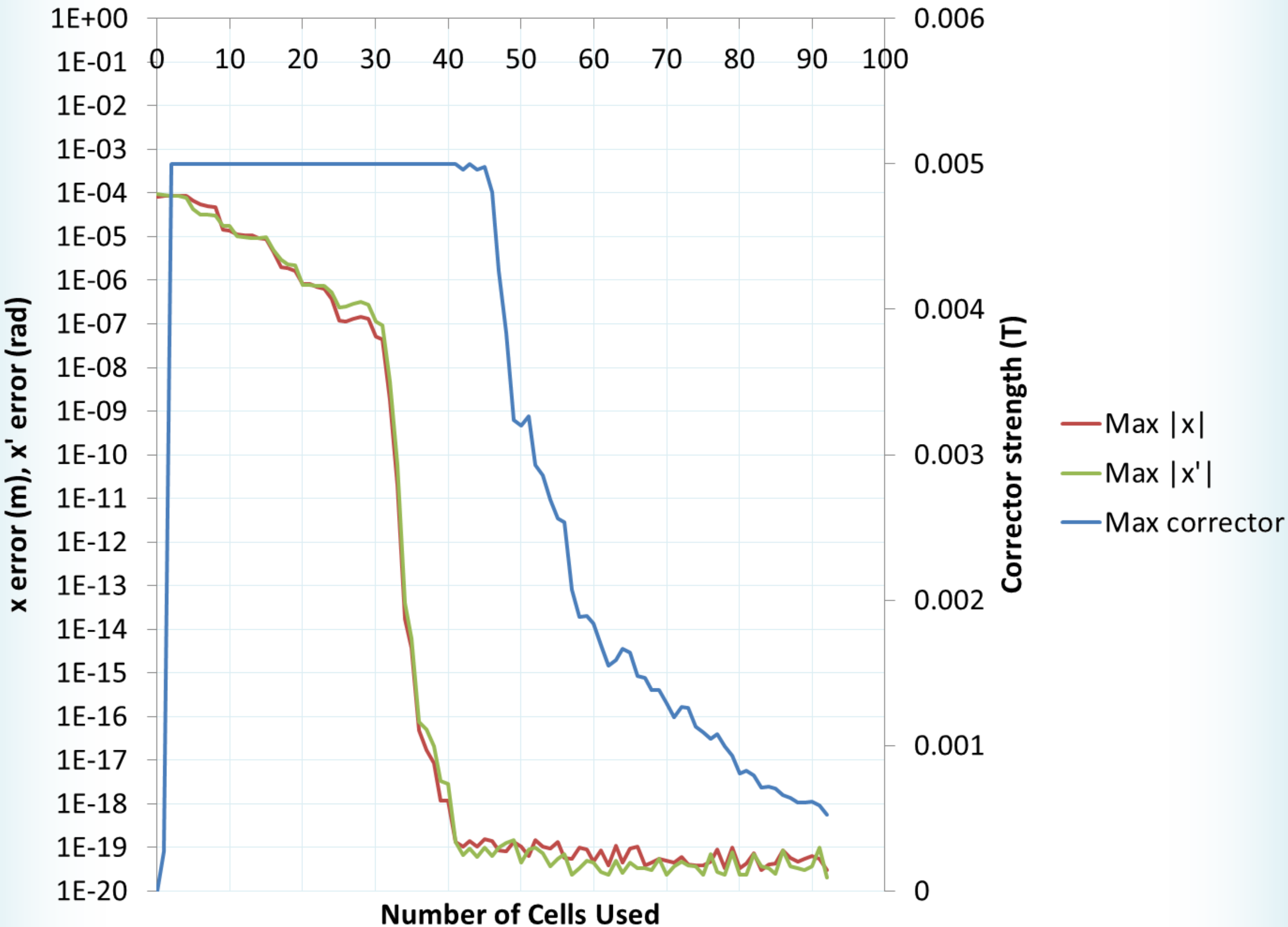
Corrector Dipole Fields (T)



Response matrix



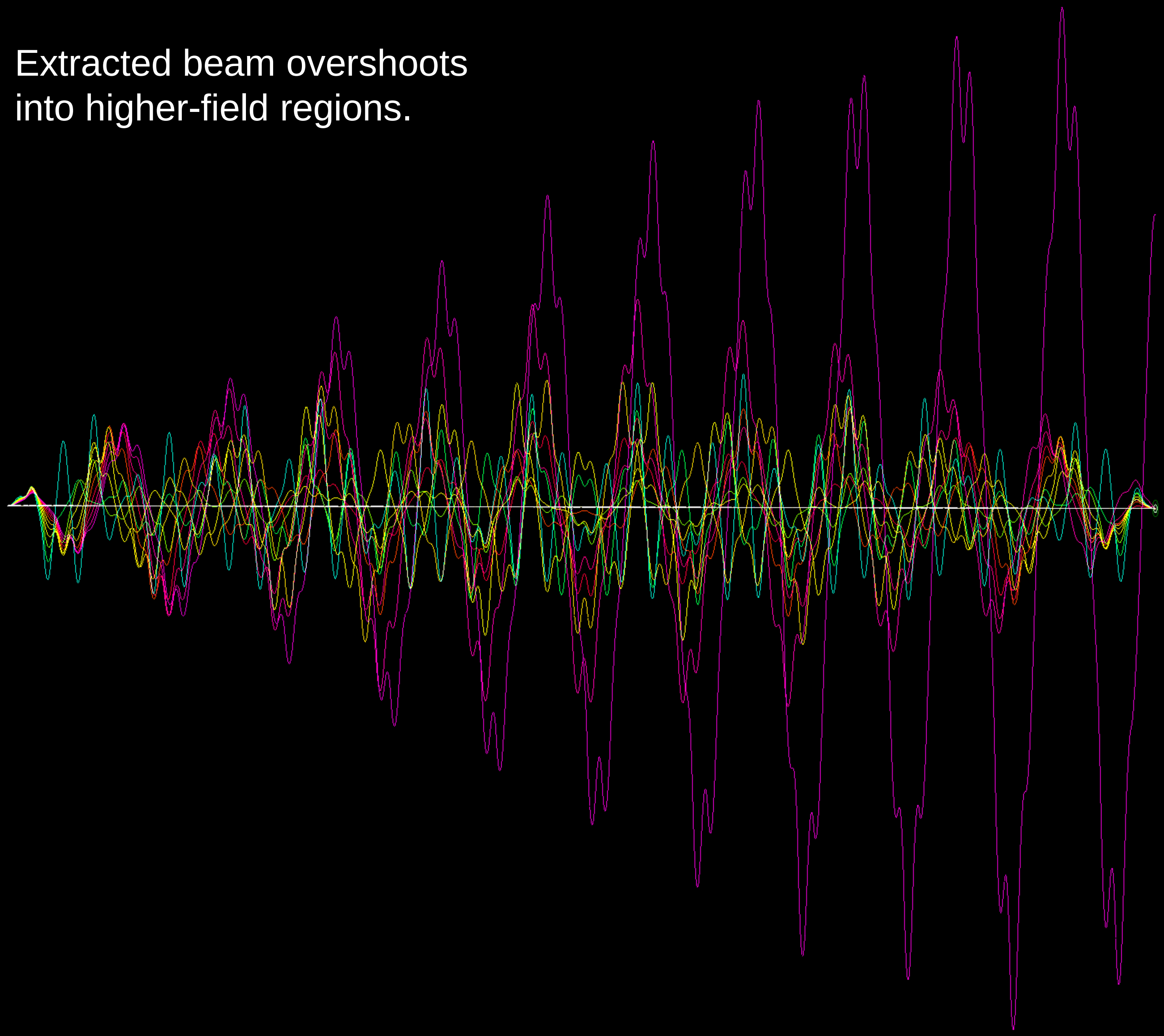

1E-4
9E-5
8E-5
7E-5
6E-5
5E-5
4E-5
3E-5
2E-5
1E-5
0E+0
x error (m), x' error (rad)
0.006
0.005
0.004
0.003
0.002
0.001
0
Corrector strength (T)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
Number of Cells Used
Max |x|
Max |x'|
Max corrector


1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
1E-08
1E-09
1E-10
1E-11
1E-12
1E-13
1E-14
1E-15
1E-16
1E-17
1E-18
1E-19
1E-20
0
10
20
30
40
50
60
70
80
90
100
0.006
0.005
0.004
0.003
0.002
0.001
0
x error (m), x' error (rad)
Corrector strength (T)
Number of Cells Used
Max |x|
Max |x'|
Max corrector

Extraction Matching x, x' Only

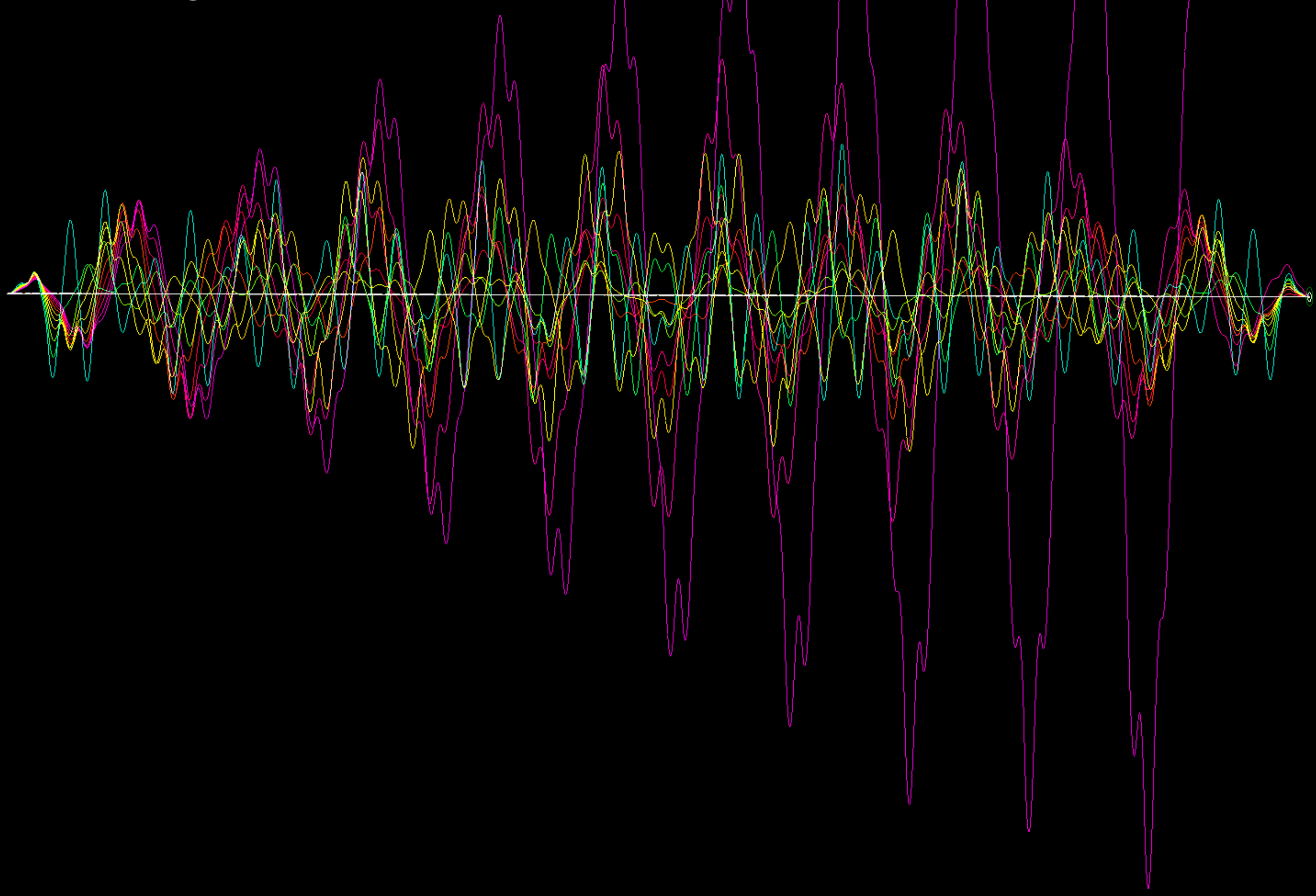
- Uses 76 cells of the FFAG2 straight section
- Goal is $x=x'=0$ except for one beam where $x>0$
- Dipole correctors limited to ±0.005T as before

Extracted beam overshoots
into higher-field regions.



Transverse exag

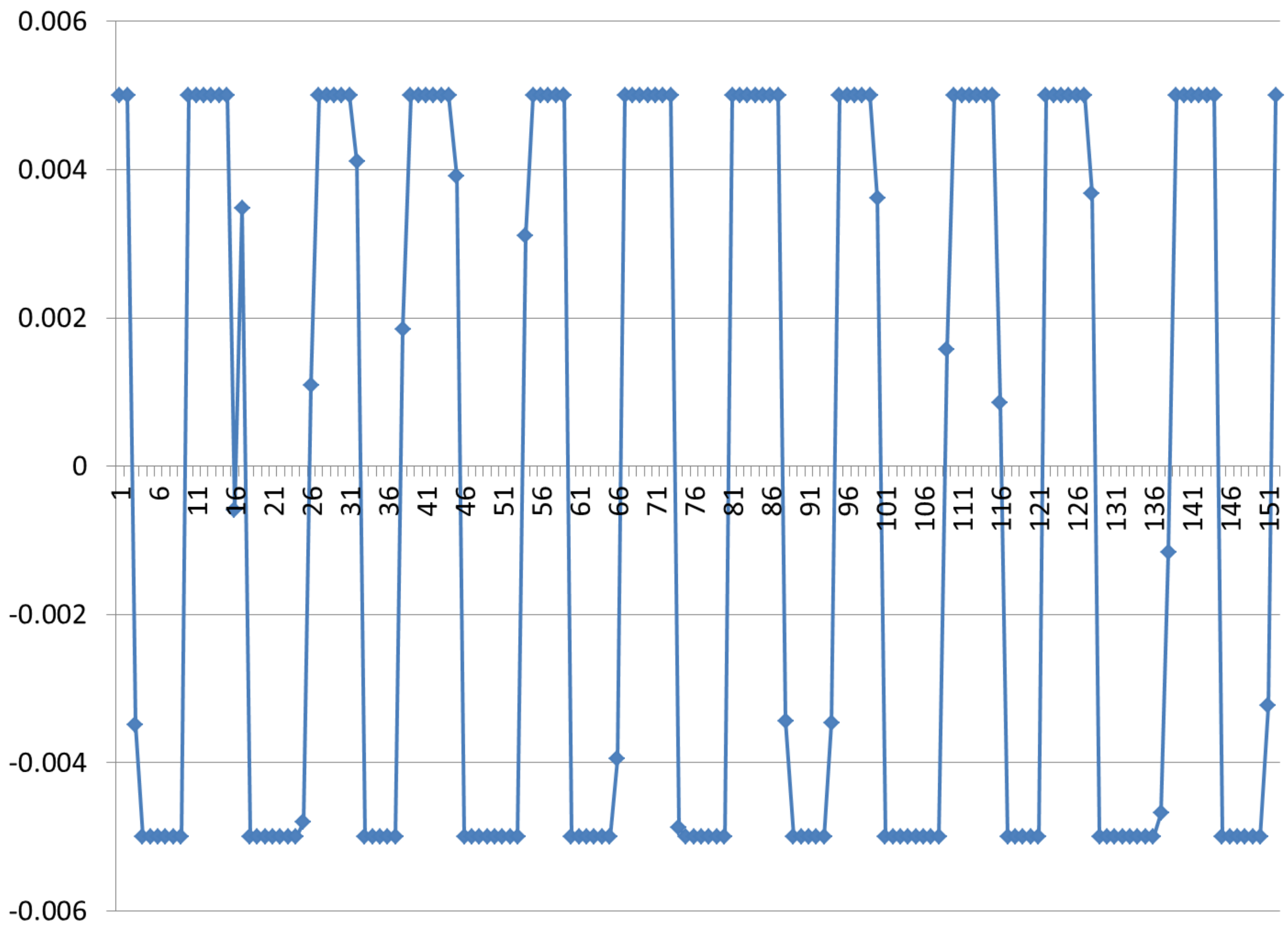
In this case, matters are improved significantly if the extraction point and re-merging point are not the same. NB: may not be true of other energies.

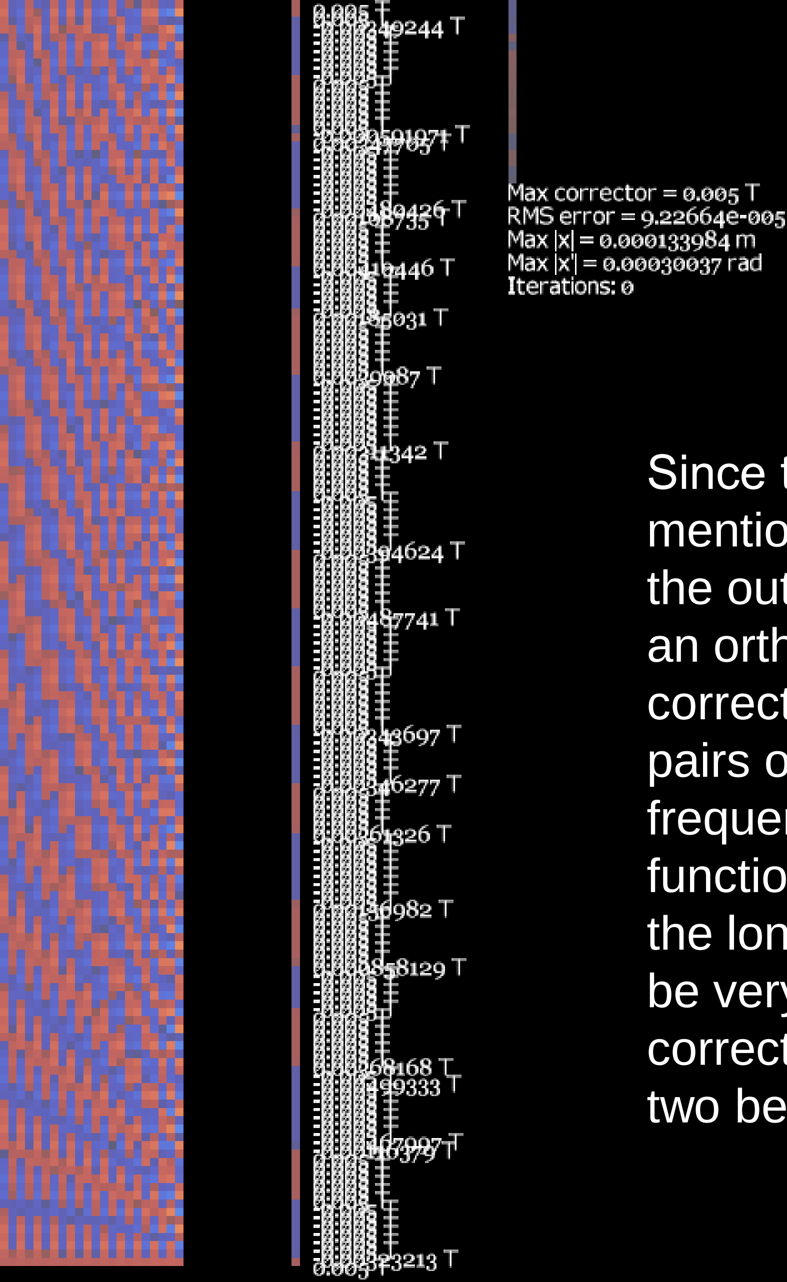


Transverse exa

11 / 20

Corrector Dipole Fields (T)

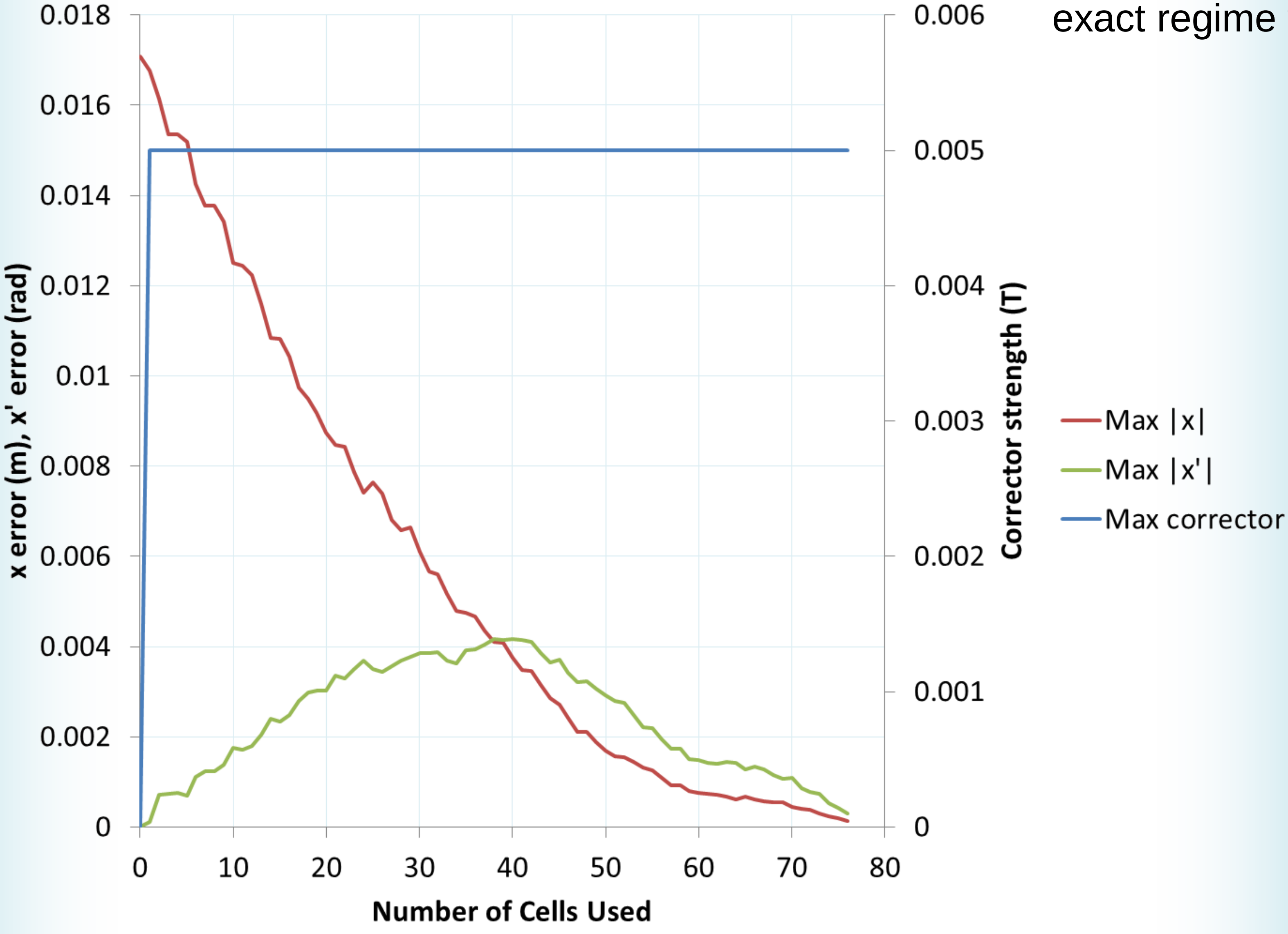




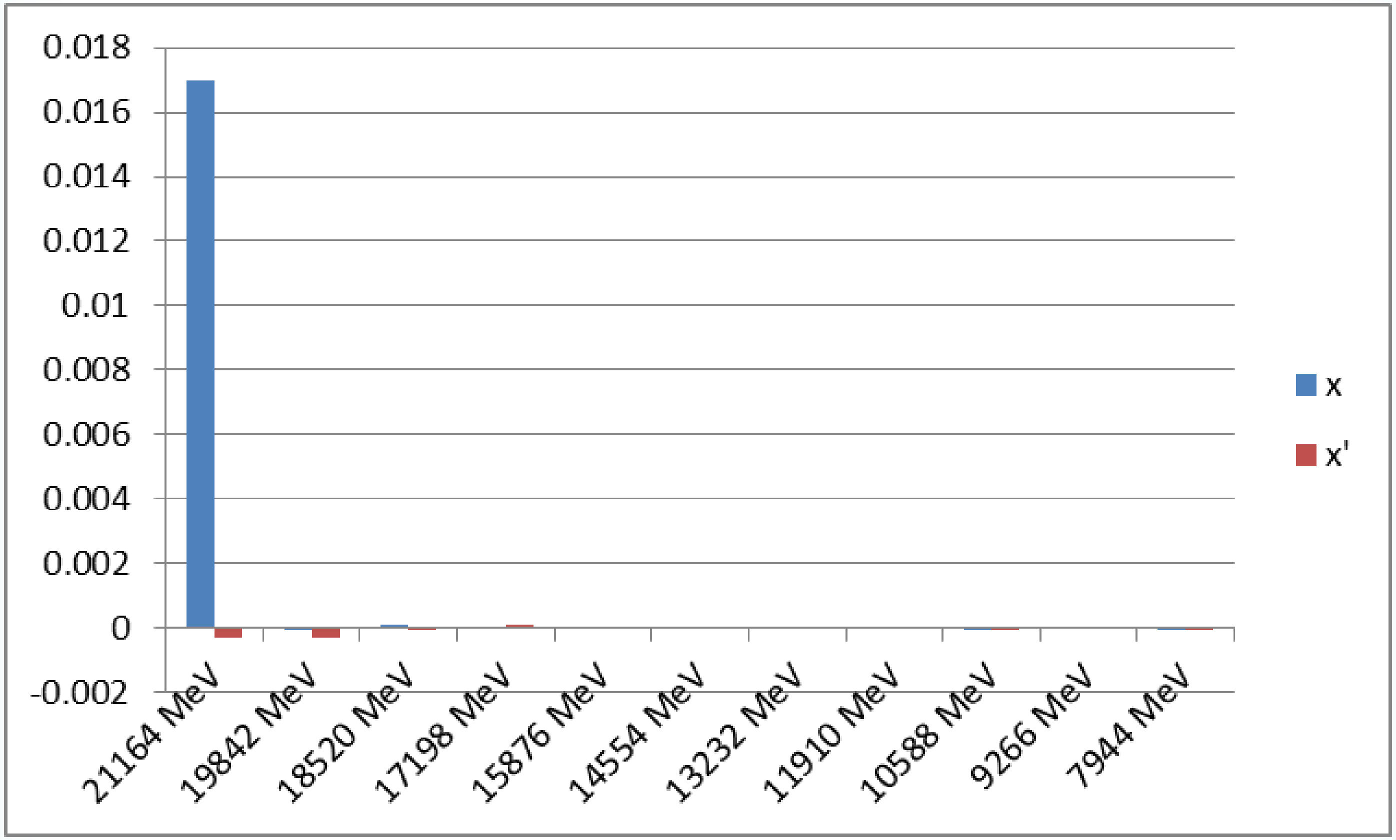
Response matrix

Since there is a blank space on this slide, I'm going to mention an interesting fact. The response vectors of the output variables (columns here) are asymptotically an orthogonal set as the number of cells used for correction tends to infinity. This is because they are pairs of sine and cosine waves with different frequencies and the inner product of two such functions tends to zero as the waves go out of phase in the long term. This linear system could be expected to be very well behaved in the case of large numbers of correctors, provided there is enough distance for the two beams with closest tunes to go out of phase.

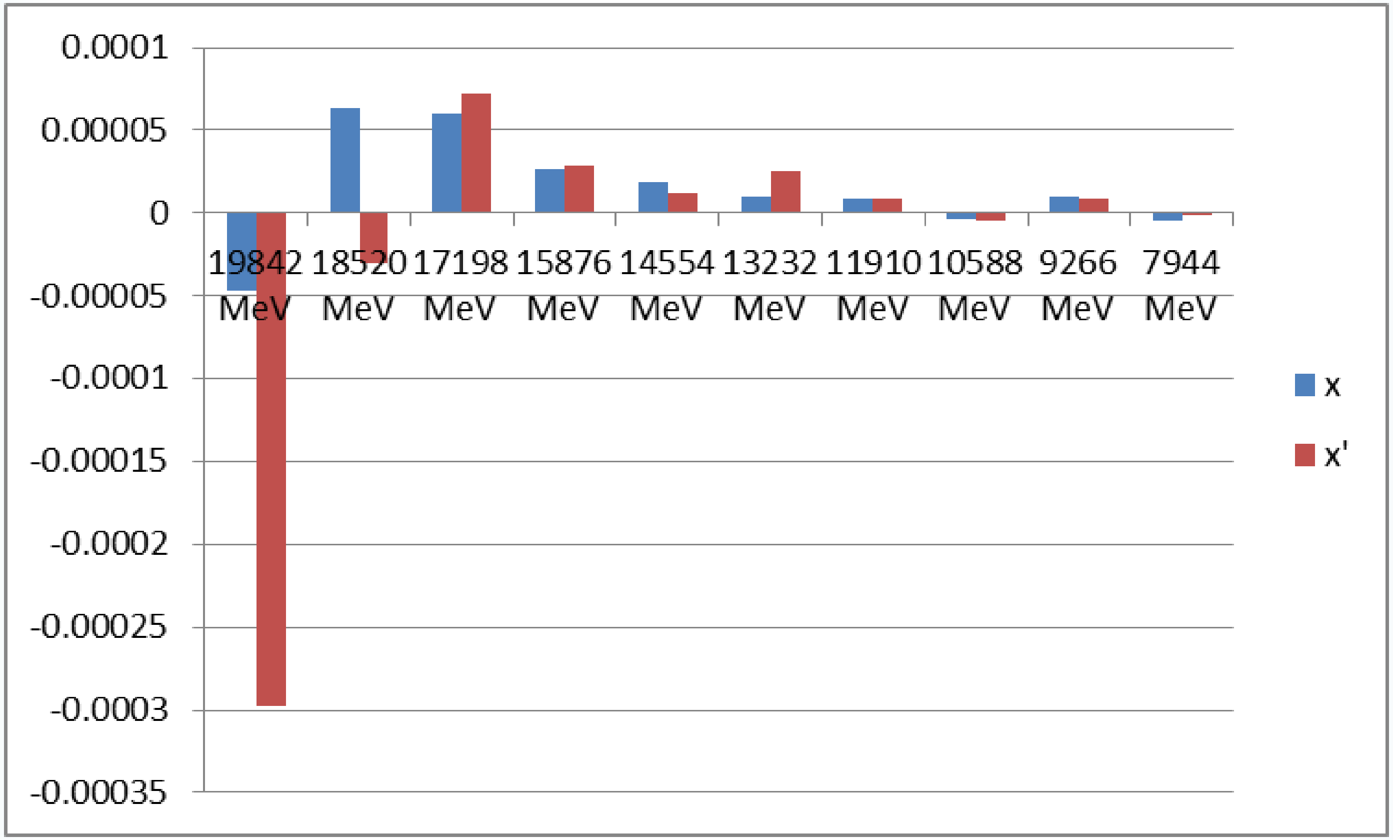
Haven't reached exact regime yet



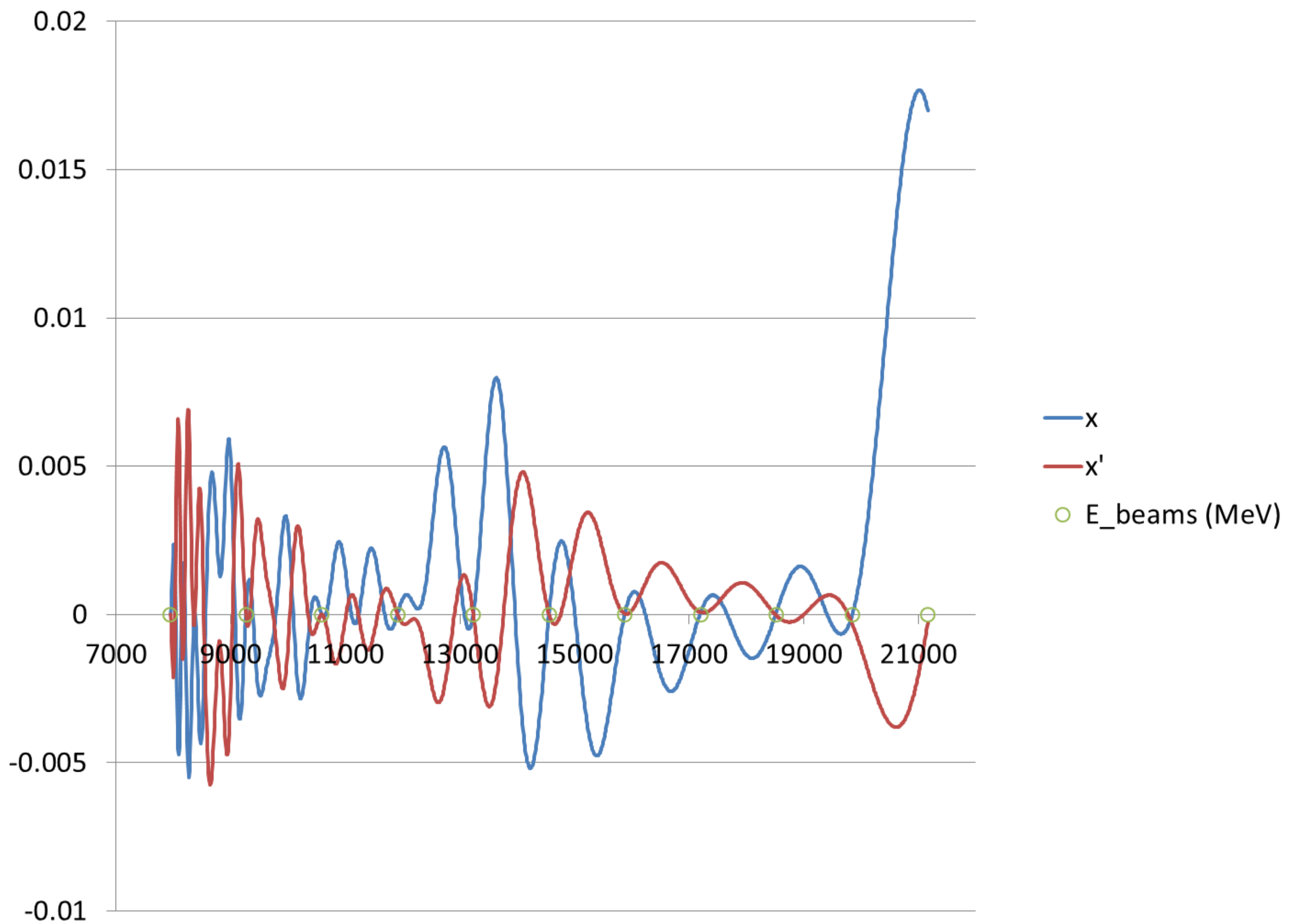
x and x’ for Beam Energies



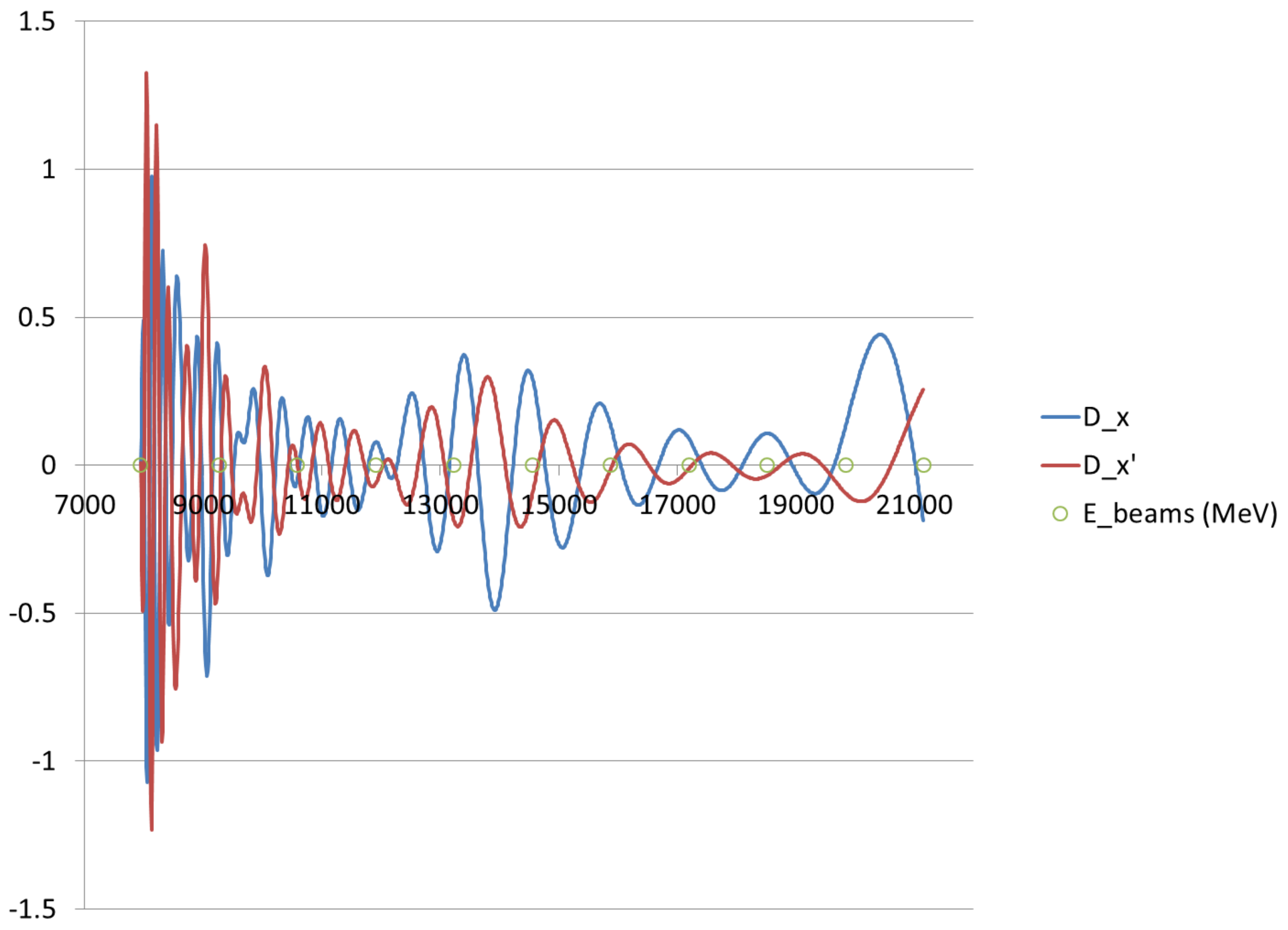
x and x’ for Beam Energies (zoom)



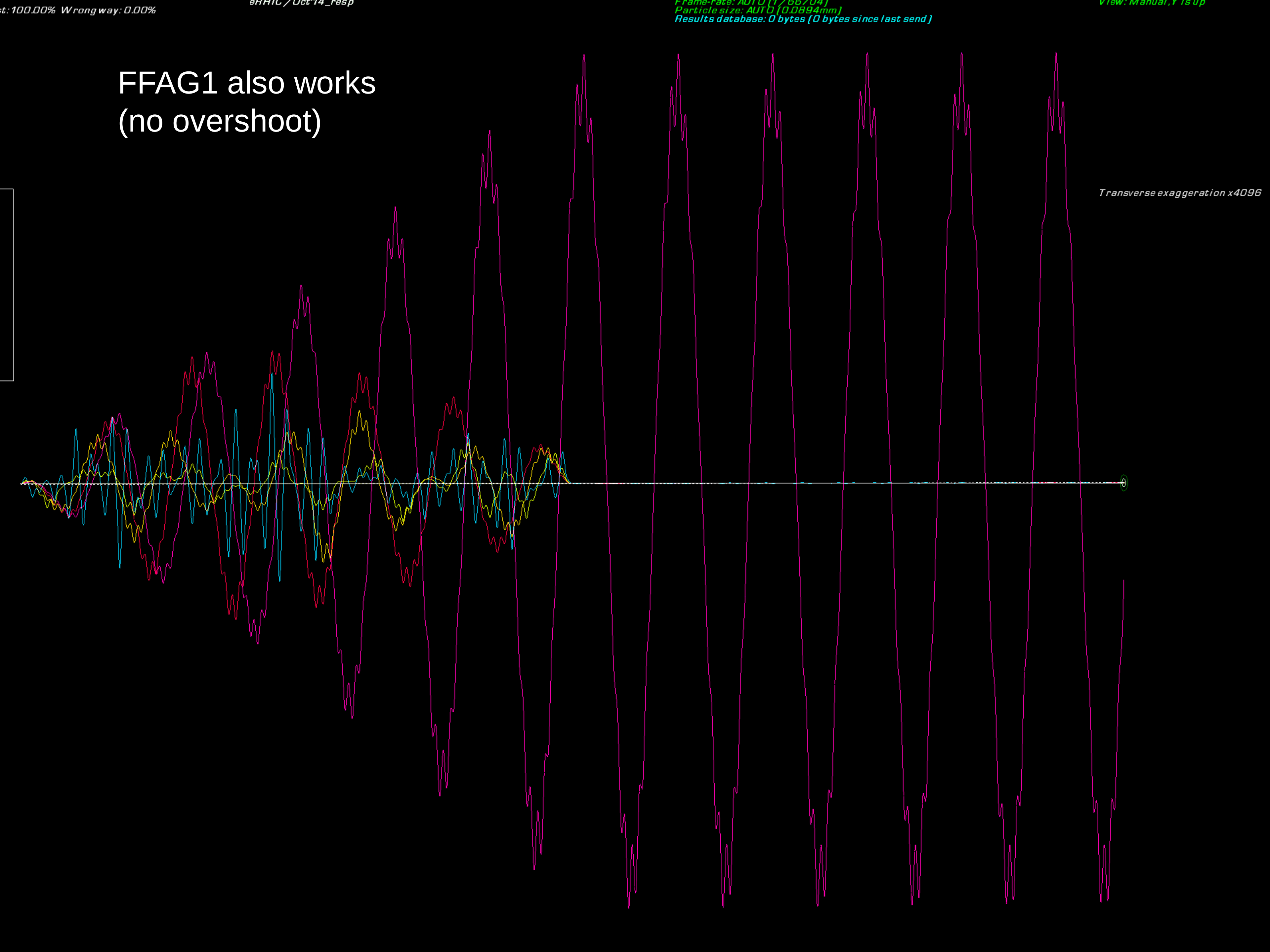
x and x' as a Function of Energy



D_x and $D_{x'}$ as a Function of Energy



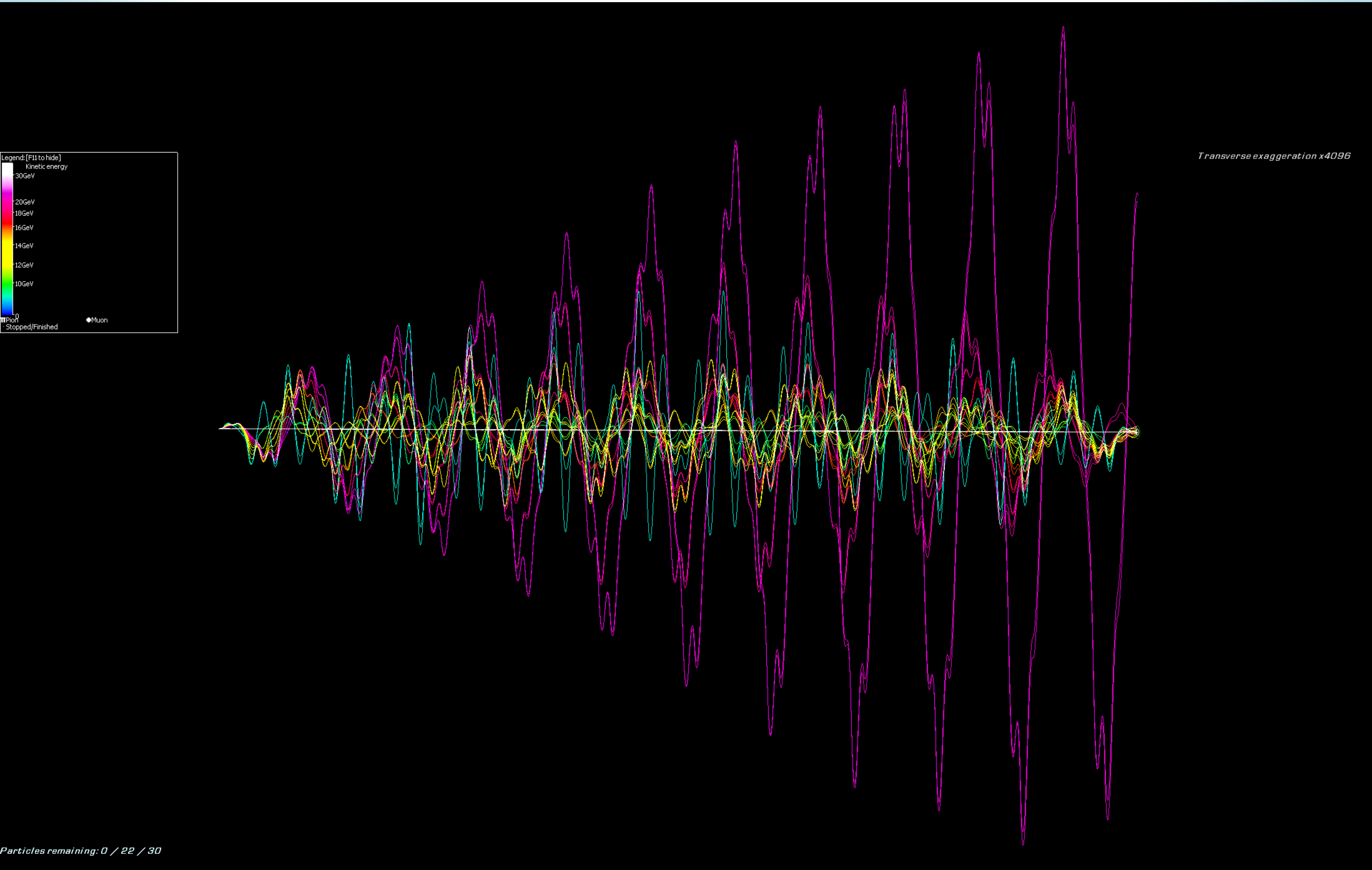
FFAG1 also works
(no overshoot)



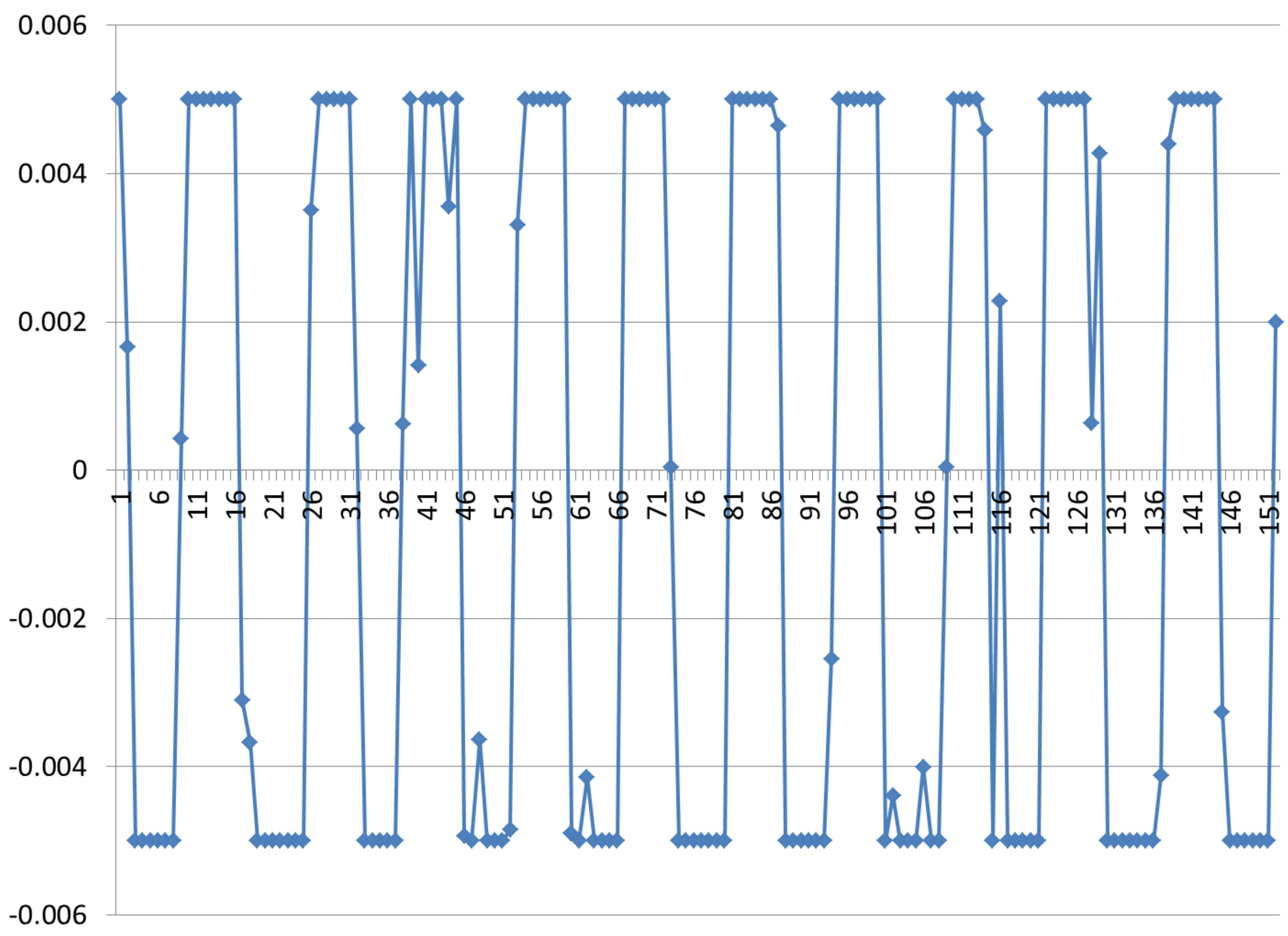
Extraction Including Dispersion

- Want gradient of $x(E)$, $x'(E)$ approximately zero around the beam points
- Add another set of beams 50MeV above the original 11
  - With the same goal x, x'
- "Double root" should force $x(E)$, $x'(E)$ to vary quadratically rather than linearly near the beam energies (D_x, $D_{x'}$ approximately zero)

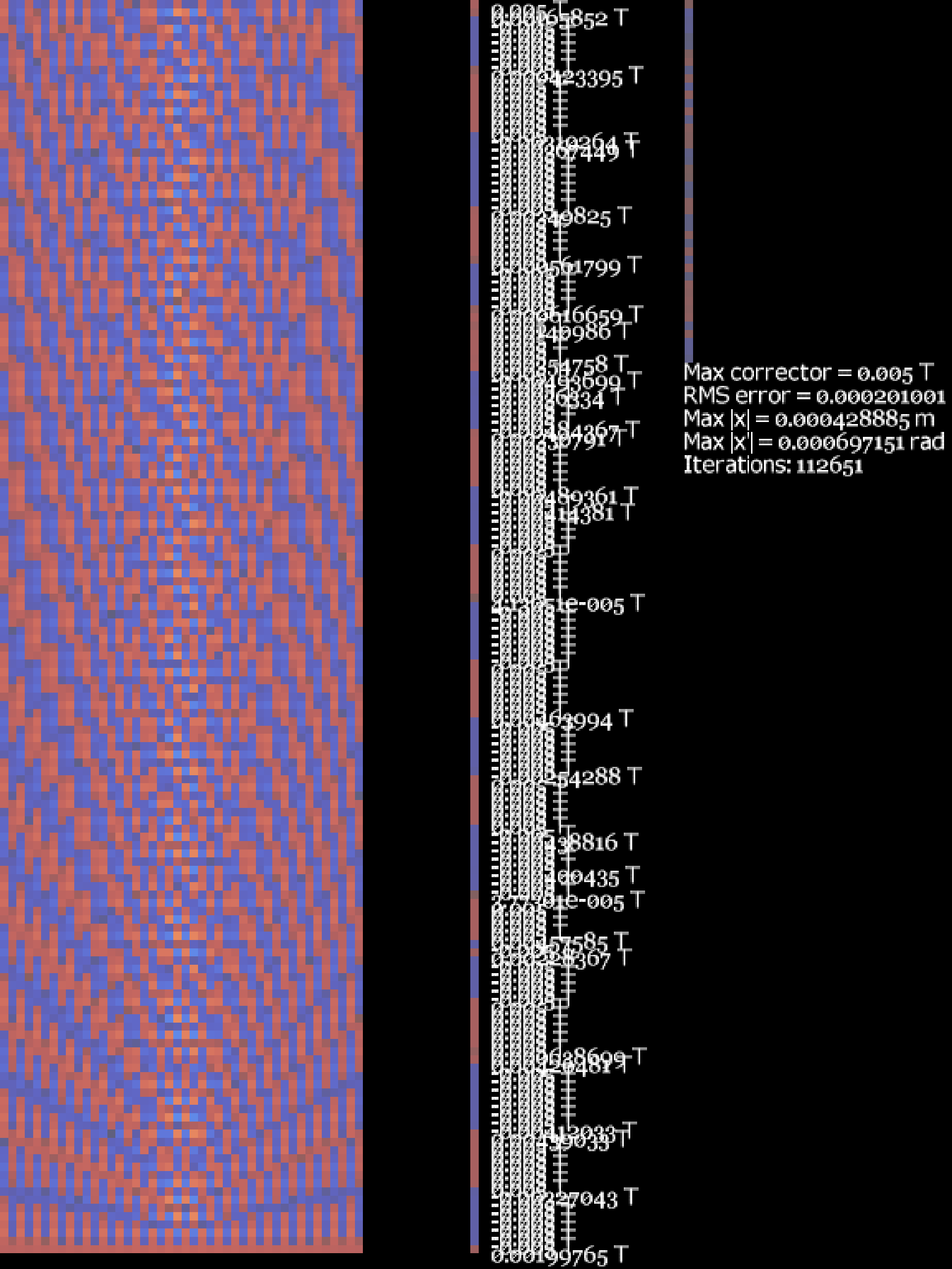
22 Beams Extraction (not 11)

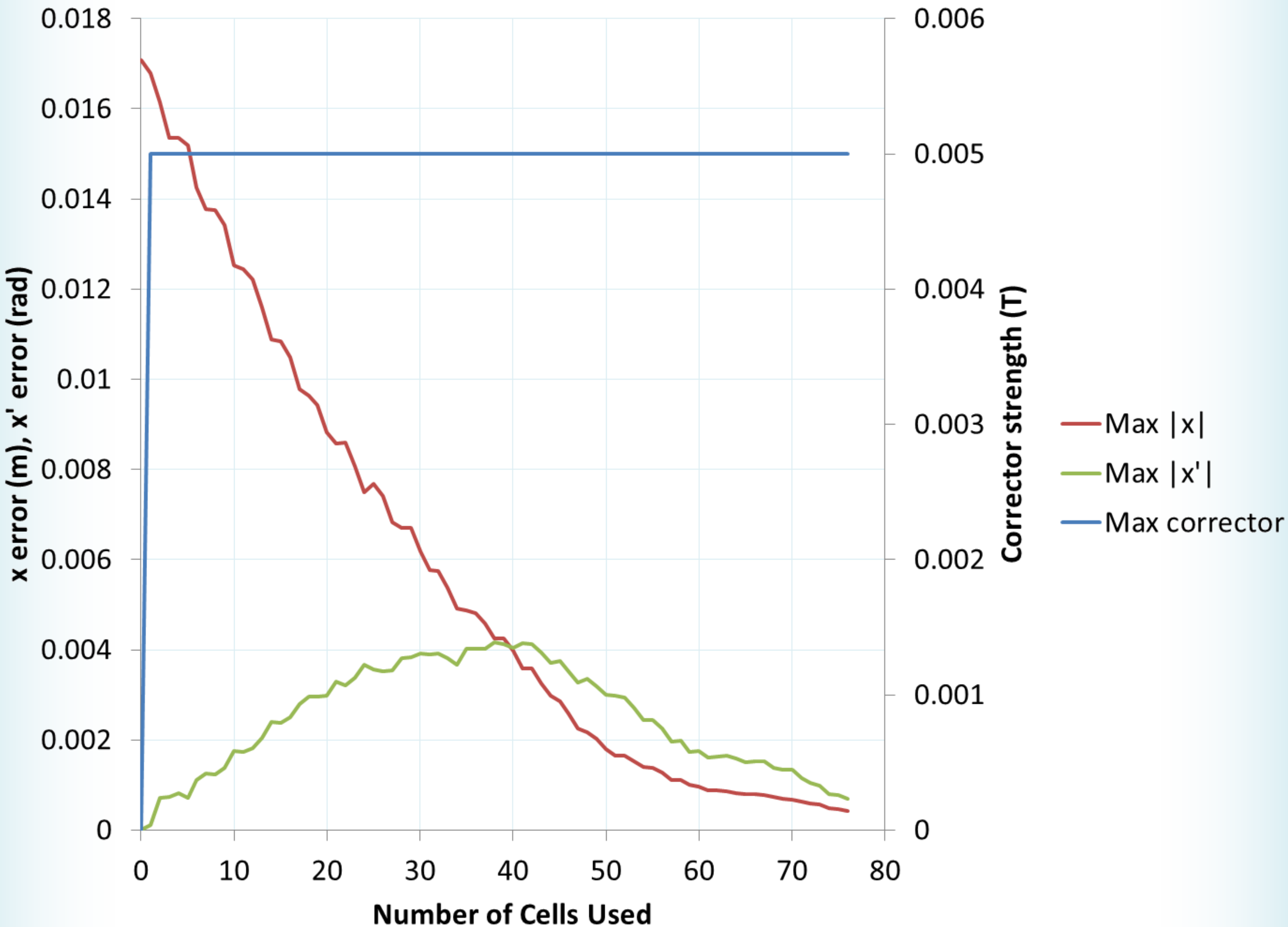


Corrector Dipole Fields (T)



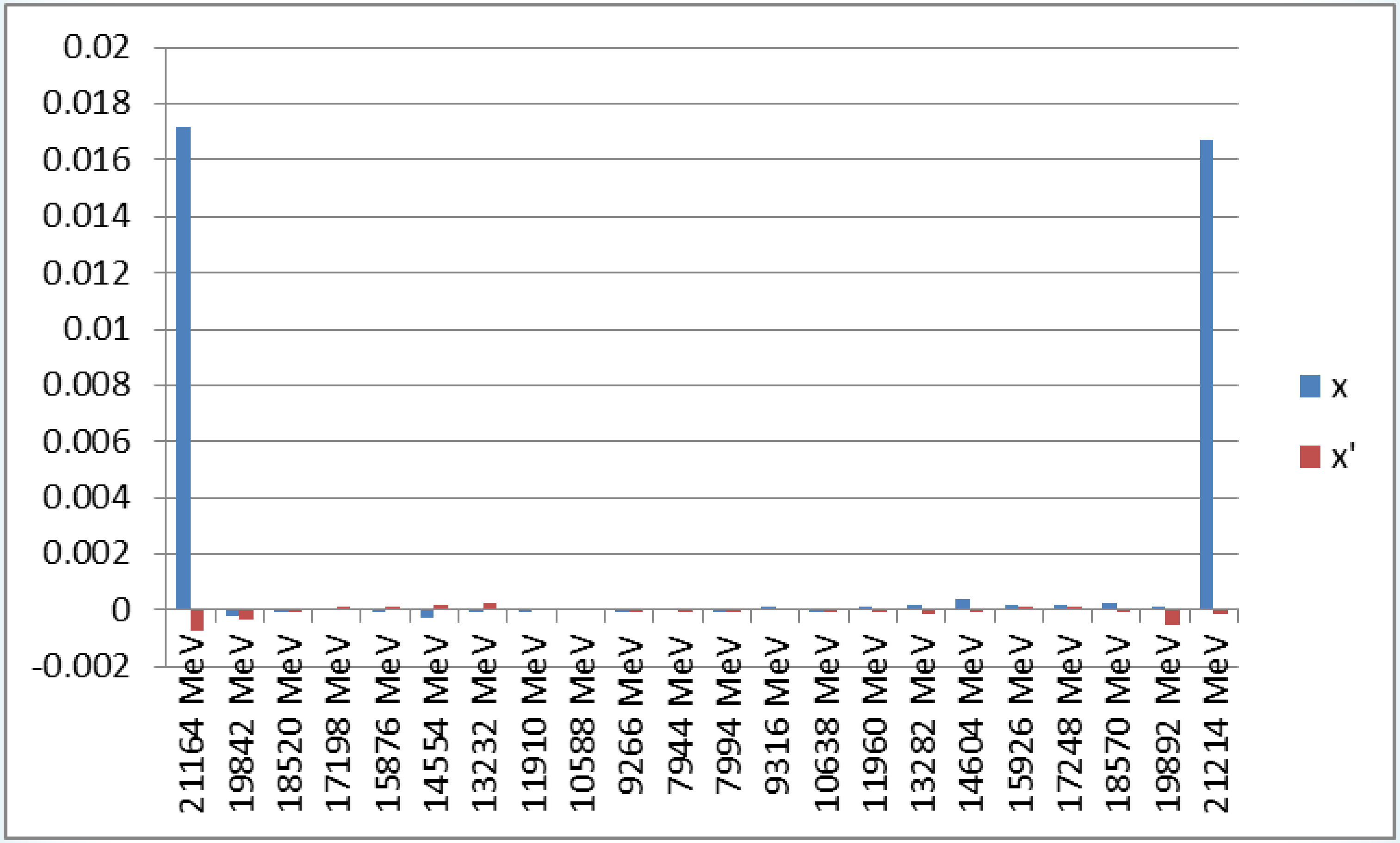
Response matrix



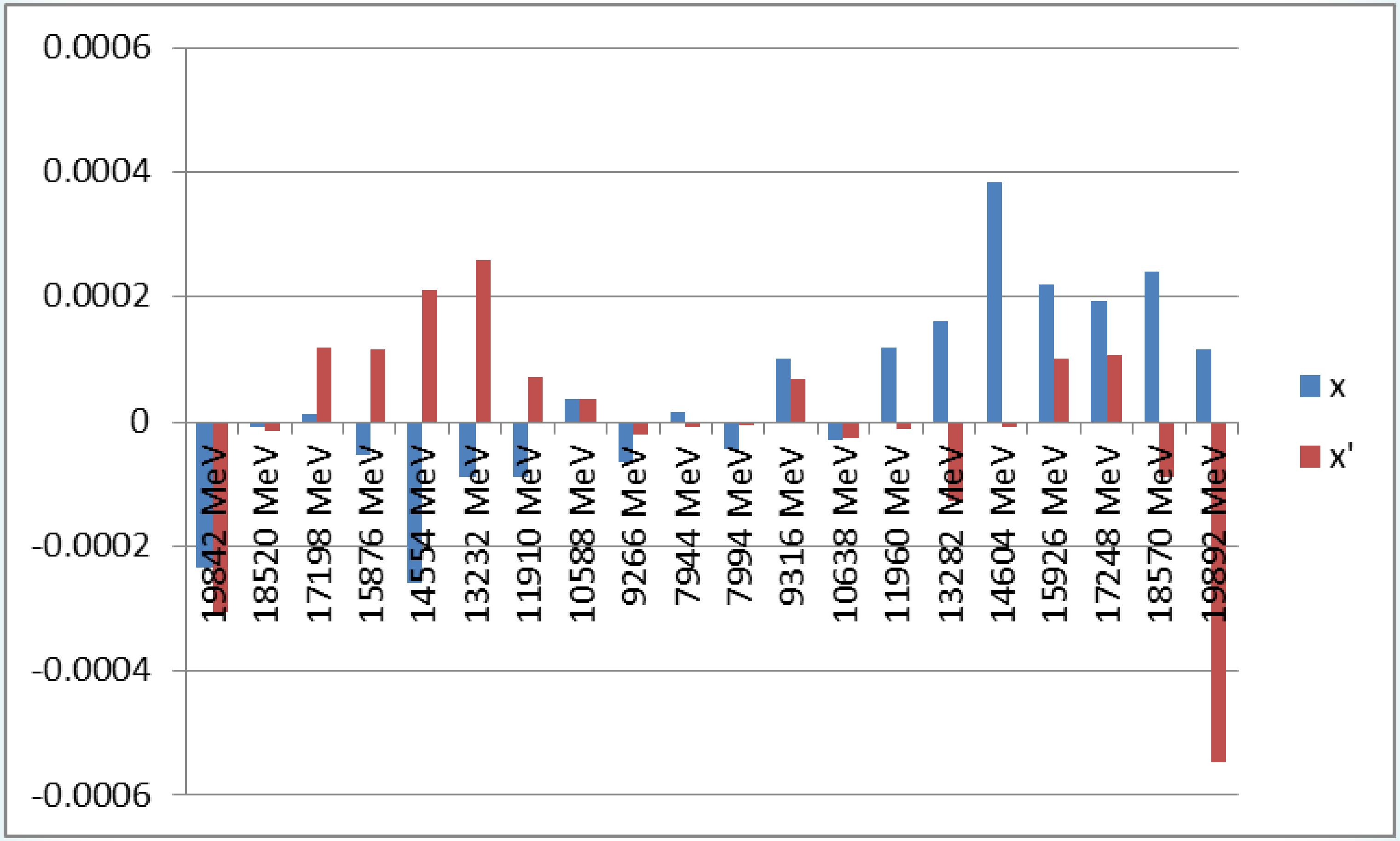


0.018
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
x error (m), x' error (rad)
0.006
0.005
0.004
0.003
0.002
0.001
0
Corrector strength (T)
0
10
20
30
40
50
60
70
80
Number of Cells Used
Max |x|
Max |x'|
Max corrector

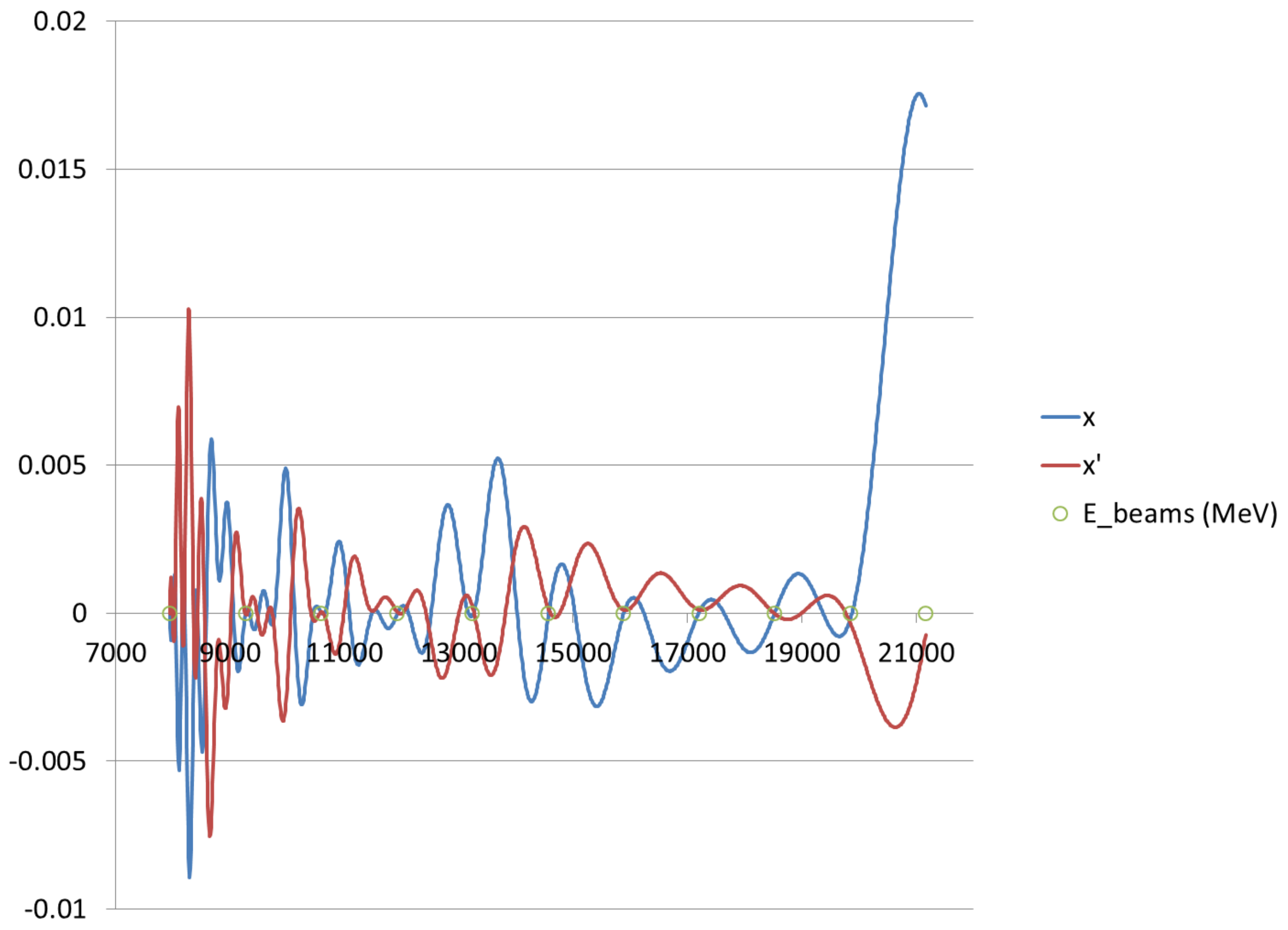
x and x' for Beam Energies



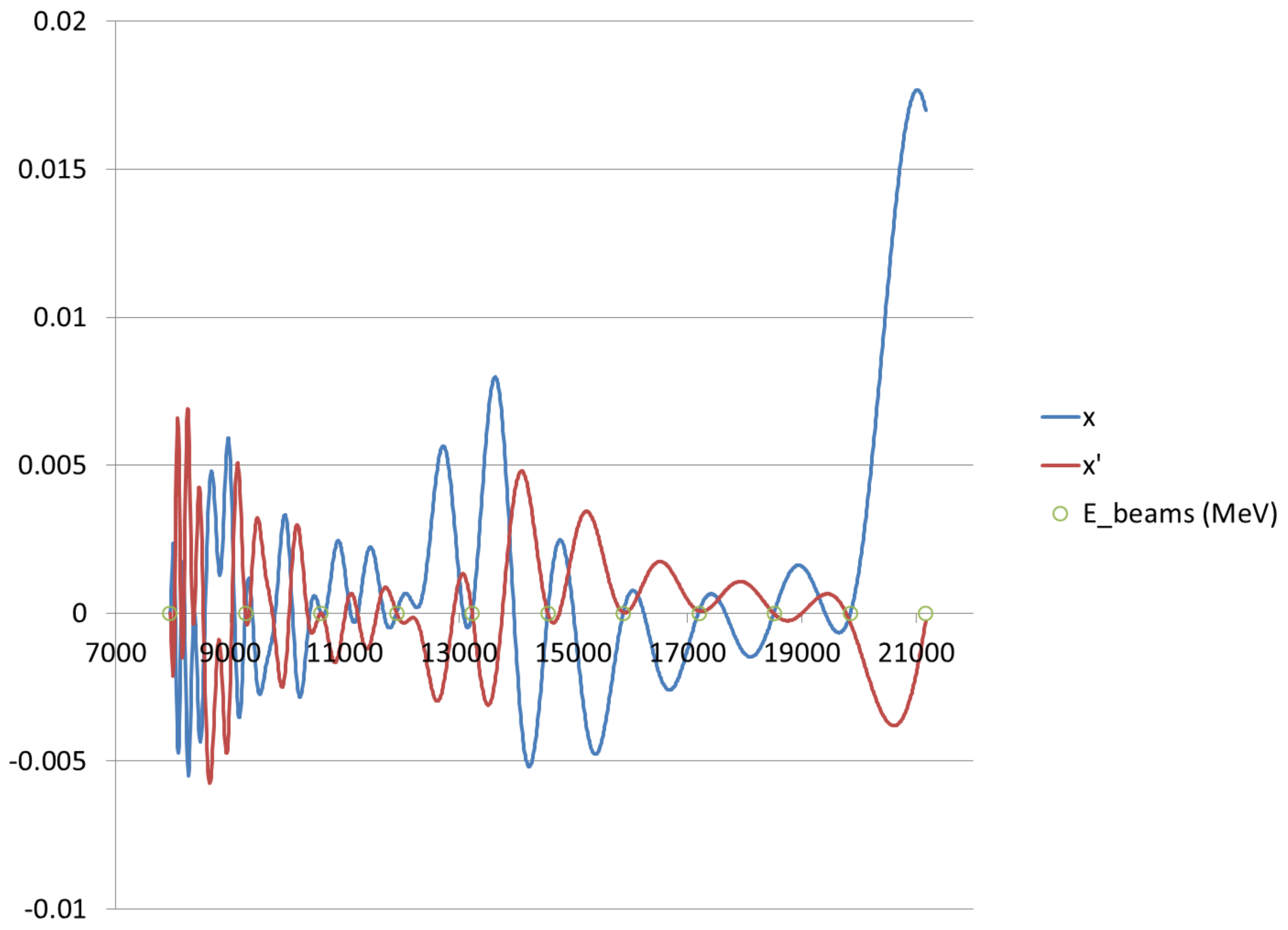
x and x’ for Beam Energies (zoom)



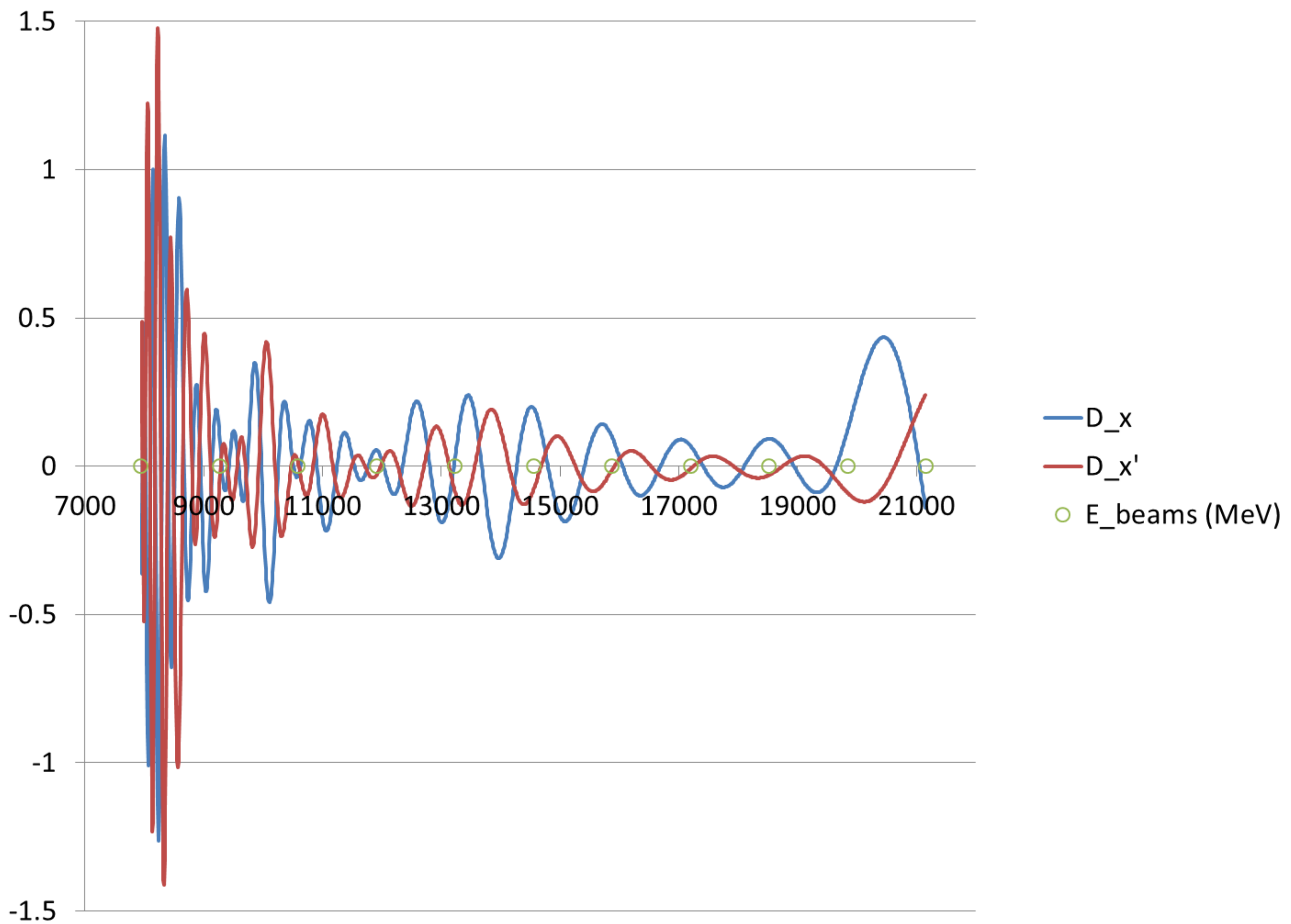
x and x' as a Function of Energy



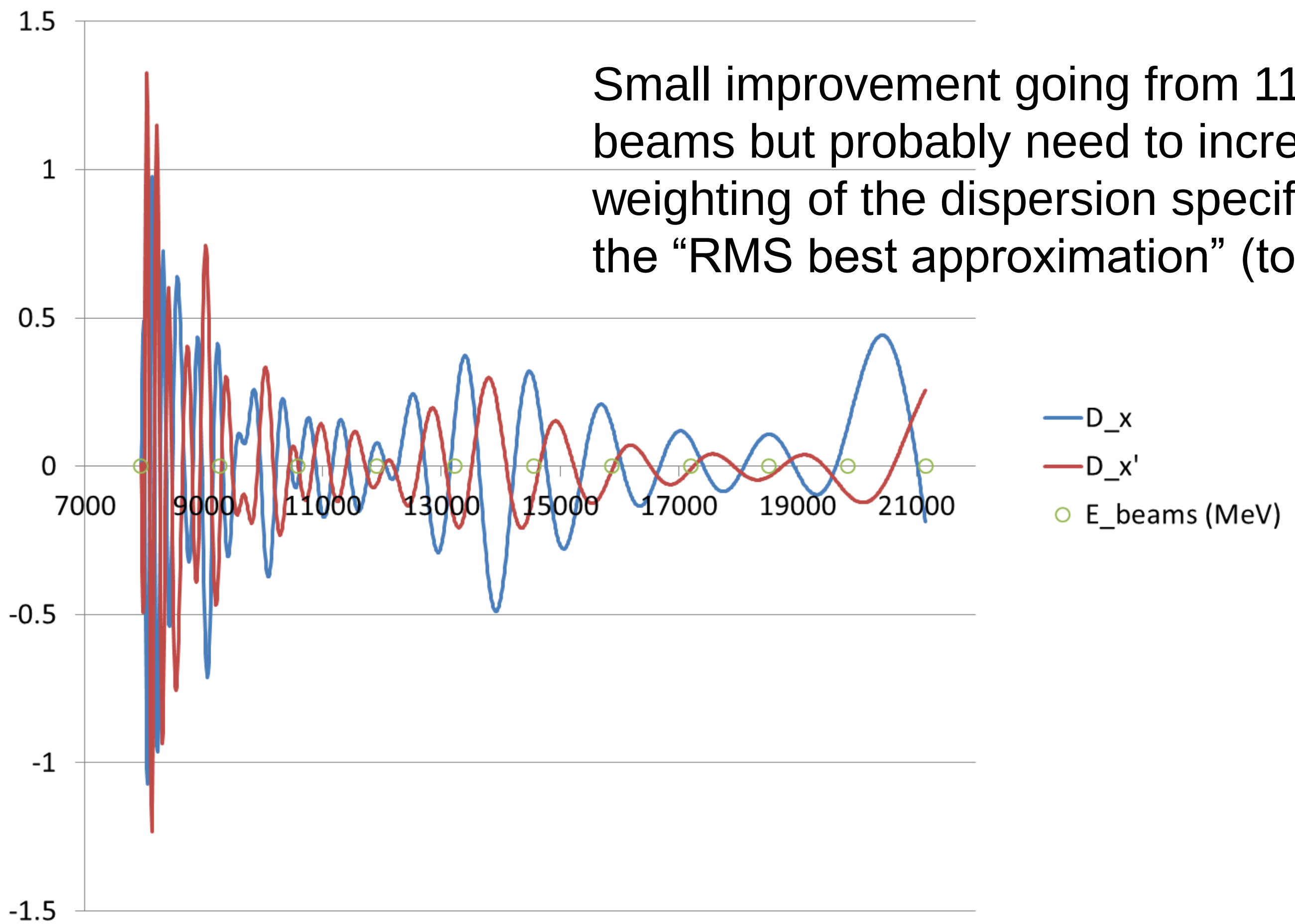
x and x' (11 beams only)



D_x and $D_{x'}$ as a Function of Energy



D_x and $D_{x'}$ (11 beams only)



Small improvement going from 11 → 22 beams but probably need to increase the weighting of the dispersion specifically in the “RMS best approximation” (to-do)

Explicit Dispersion Response

- If dx/dc(n) response at momentum p is

  $\sin(2\pi Q_x(p)\ n)$

- Then $dD_x/dc(z)$ response should be:

  $(p\ d/dp) \sin(2\pi Q_x(p)\ n)$

  $= 2\pi\ n\ (p\ d/dp) Q_x(p) \cos(2\pi Q_x(p)\ n)$

  $= n\ 2\pi C_x(p) \cos(2\pi Q_x(p)\ n)$

- So as well as sin(n), cos(n) type terms, there are n sin(n) and n cos(n)