

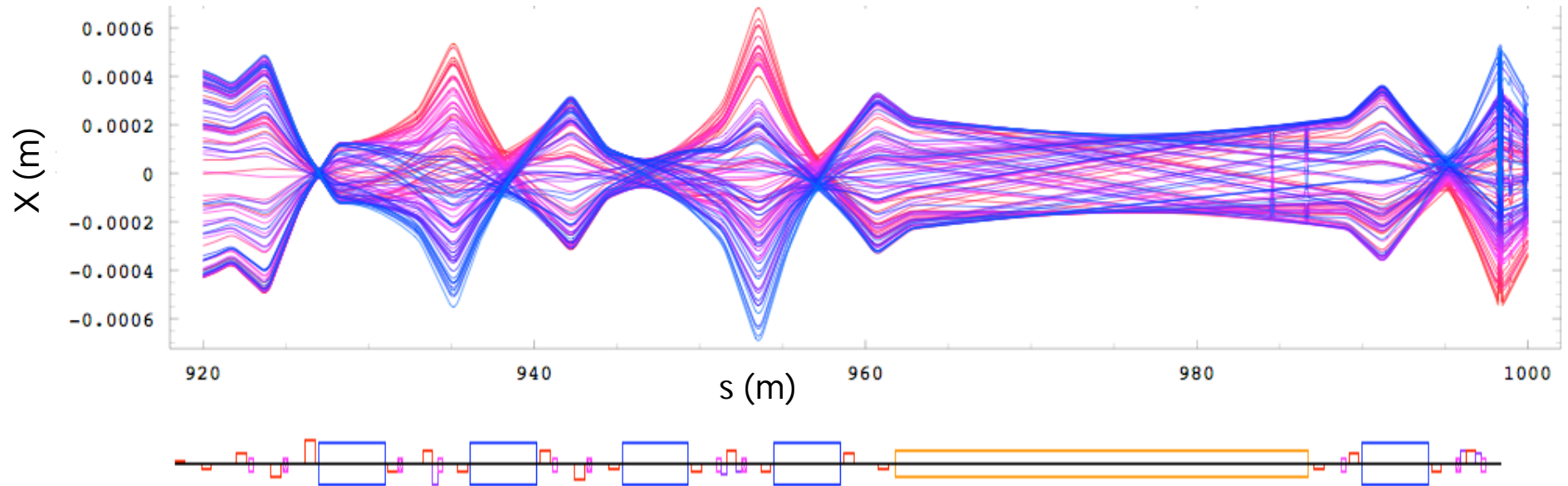
Cornell University

ERL Lattice and Layout
Coherent Synchrotron Radiation

Energy Recovery Linear Accelerator at Cornell



Optimization of ERL Optics



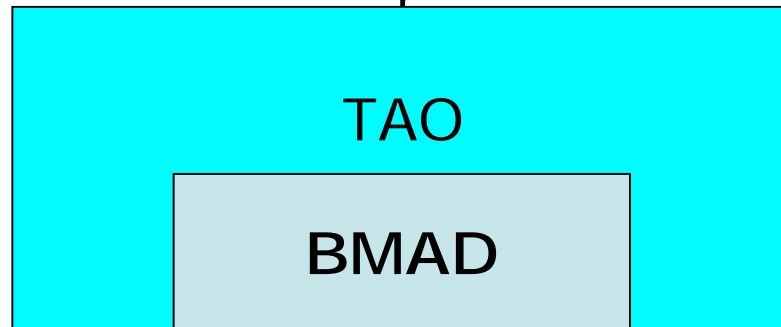
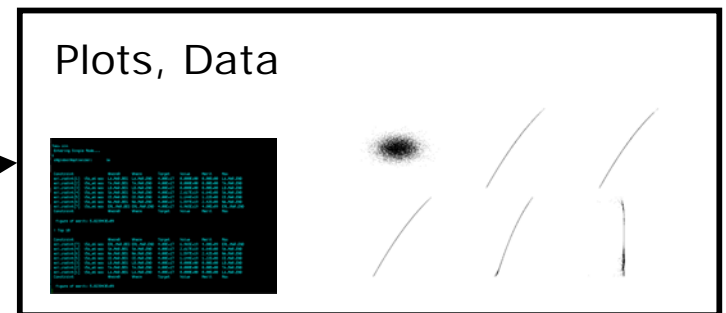
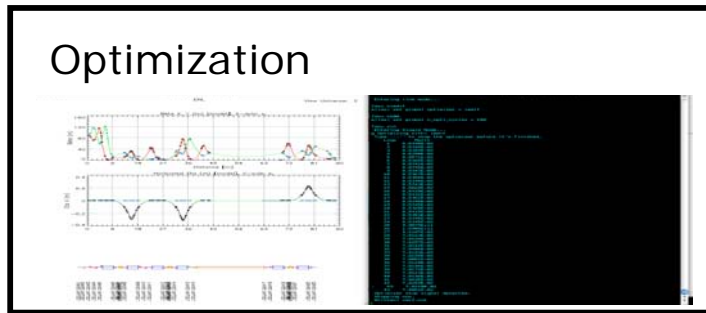
Variables

- 18 Undulators
- 535 **Quadrupole Magnets**
- 172 **Dipole Magnets**
- 64 **Sextupole Magnets**
- 400 Accelerating Cavities
- ~1300 Drifts

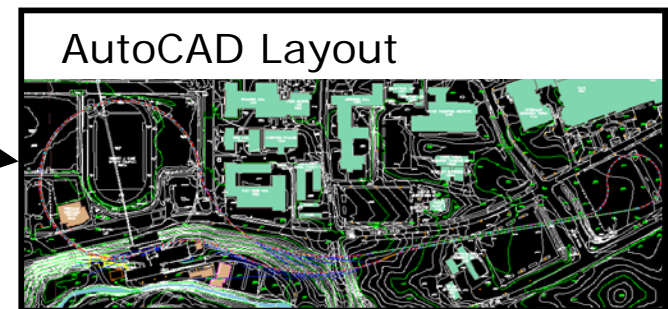
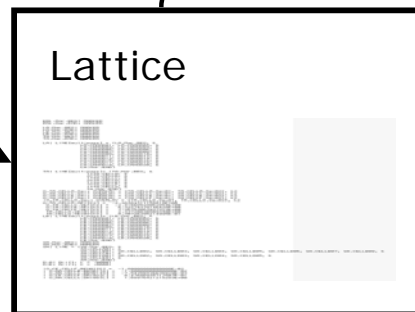
Constraints

- **Beta Functions**
- **Dispersion** (1st and 2nd order)
- **Time of Flight** (1st and 2nd order)
- **Physical Placement**
- Number of Elements
- Space for additional elements
- Emittance Growth

Tools. . .



User Input



SVN

ERL Wiki

ERLLayout < ERL/Private < LEPP TWiki

https://wiki.lepp.cornell.edu/lepp/bin/view/ERL/Private/ErlLayout

ERL

ERL/Private

Projects
Archive
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Message Board

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Home
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Topic list
Changes
Changes detailed

Projects
ERL Prototype R&D
ERL@CESR
ERL Control System
ERL RF Control
ERL Injector
Cryomodule
ERL X-ray
Development

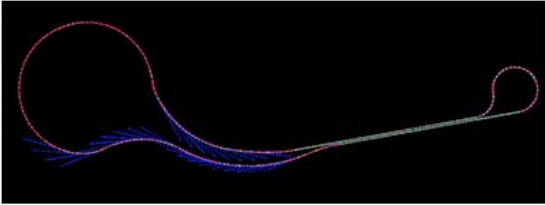
Meeting Minutes
ERL General
ERL@CESR
ERL Controls
Injector Diagnostics

General
Introduction
Register

Miscellaneous
WebLeftBar
WebNotify
WebPreferences

Outside Links
ELOG
Create personal sidebar

You are here: [LEPP TWiki](#) > [ERL/Private Web](#) > [ErlProposals](#) > [ErlAtCesr](#) > [ErlLayout](#) r13 - 29 Jul 2007 - 21:57:42 - ChrisMayes



[Edit](#) [Attach](#) [Printable](#)

Subversion Repository

All files related to the lattice and layout may now be checked out using Subversion.

The command to checkout is:

svn checkout file:///home/cem52/nfs/svnrepos/cerl

This will create the directory **cerl/**. There is a file **readme.txt** that explains its structure.

To update, type **svn update** anywhere within the **cerl/** directory

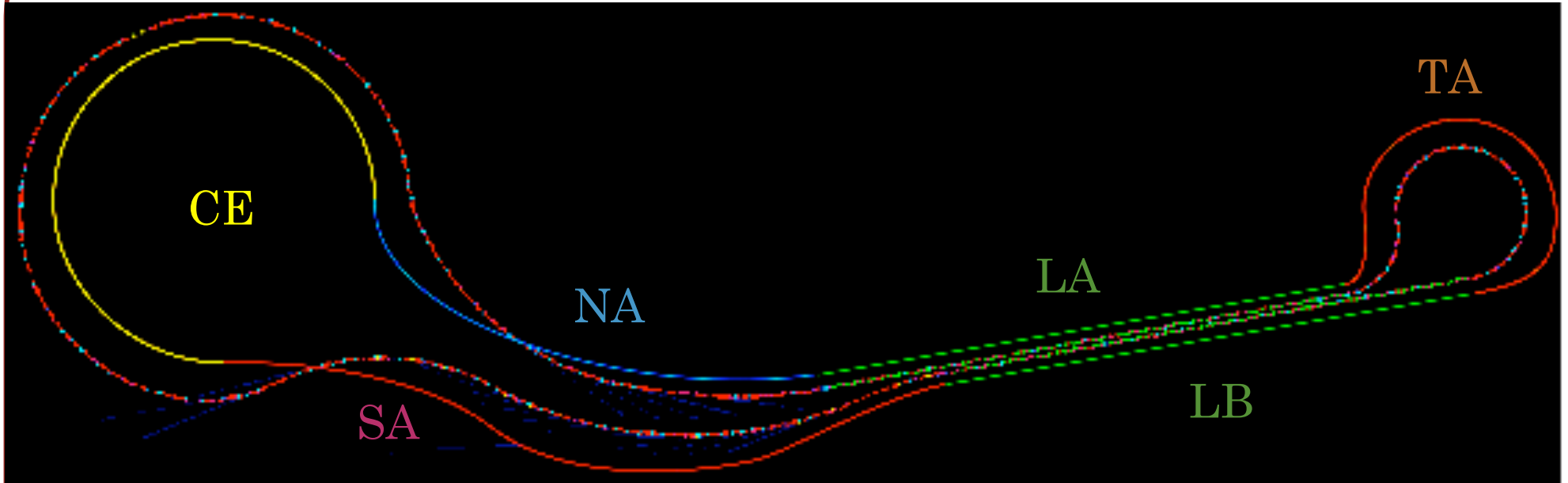
Information on Subversion can be found at <http://subversion.tigris.org/>

Lattice and Layout Drawings

Date	BMAD lattice	Twiss parameters	AutoCAD lattice	PDF Map	Comments
2006/08/04	cerl2.0.modea.bmad cerl2.0.moddec.bmad	cerl2.0.modea.twiss cerl2.0.moddec.twiss	cerl2.0.dwg cerl2.0.dwf	cerl2.0_map.pdf	cerl2.0_comments.txt
2006/08/04	cerl1.3.bmad.zip	cerl1.3.twiss	cerl1.3a.dwg cerl1.3a.dwf	cerl1.3_map.pdf	cerl1.3_comments.txt
2006/08/04	cerl1.2a.bmad.zip		cerl1.2a.dwg cerl1.2a.dwf	cerl1.2a_map.pdf	cerl1.2a_comments.txt
2006/08/04	cerl1.1a.bmad.zip				cerl1.1a_comments.txt
2006/07/31	cerl1.bmad.zip		cerl1.dwg cerl1.dwf	cerl1_map.pdf	cerl1_comments.txt

Sections and Subsections

6 Sections: Linac A, Turn Around, Linac B, South Arc, CEsr, North Arc



Subsections: SA = SA.CELLA01 + SA.CELLB01 + SA.CELLB02 + . . .

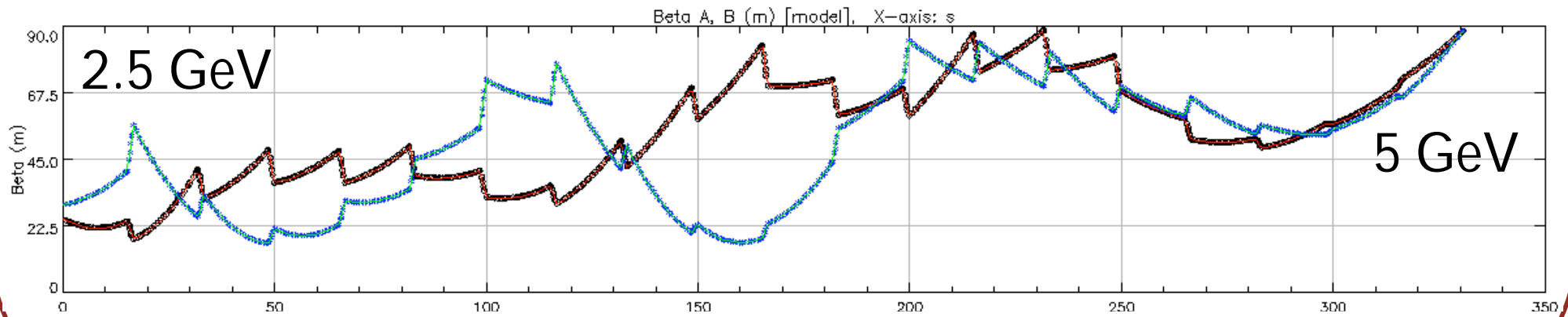
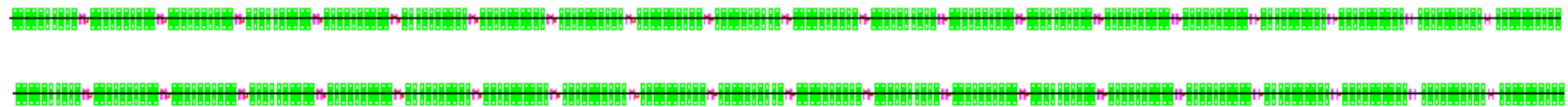
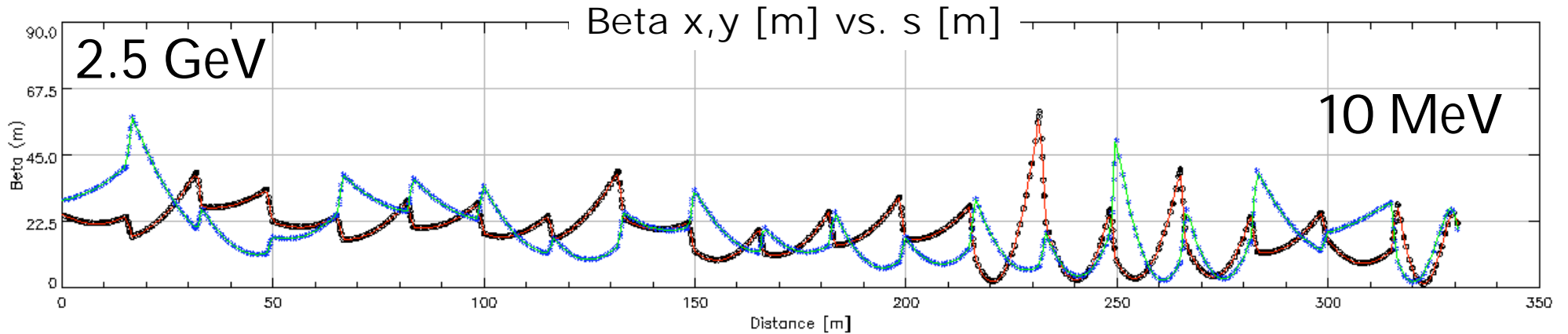
↑
matching

↙ ↘
~periodic

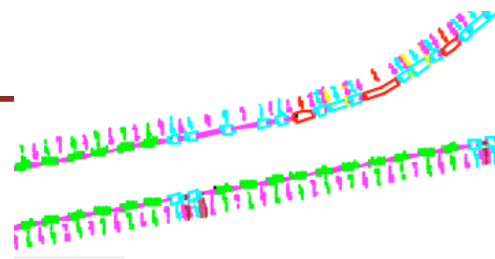
Full Naming Convention: TS.SE.SSNAM#S.DDD#DC

Example: MA.SA.CELLB05.Qua03a

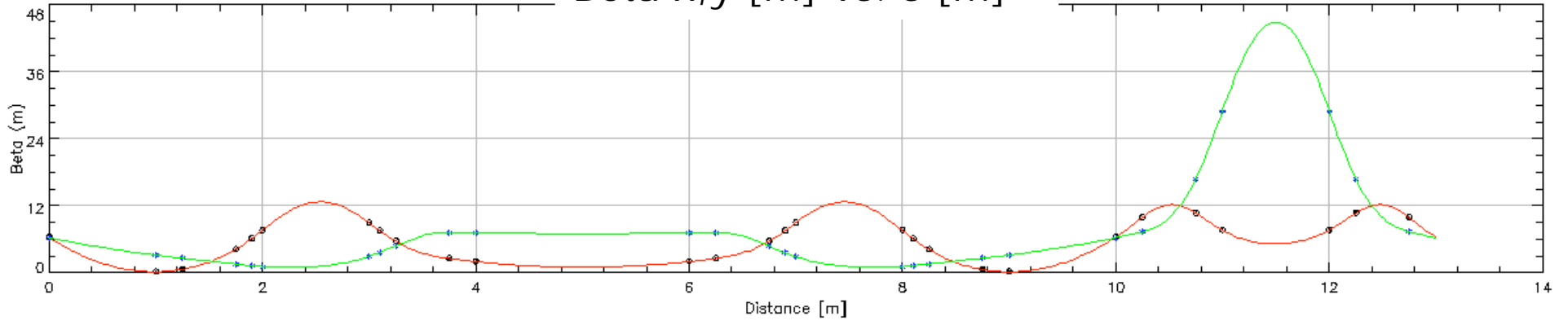
Acceleration and Deceleration



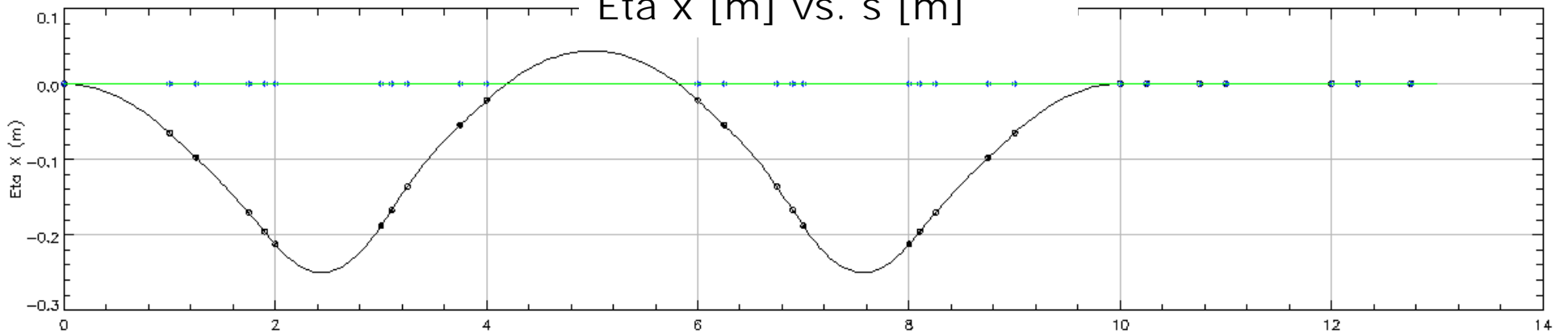
TA_CELLB



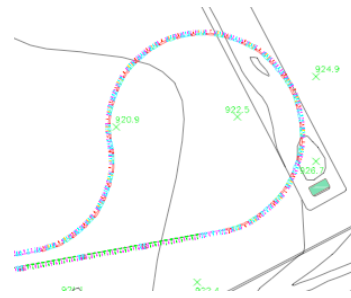
Beta x,y [m] vs. s [m]



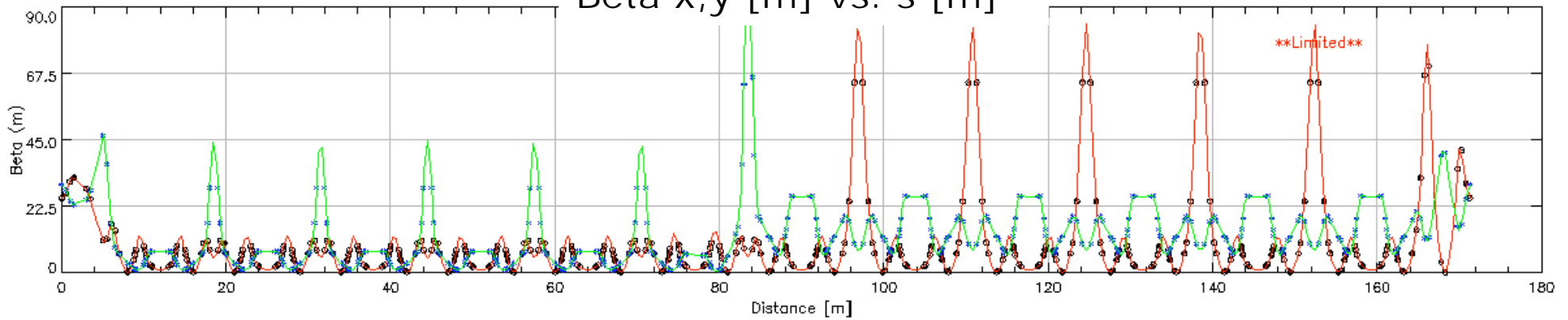
Eta x [m] vs. s [m]



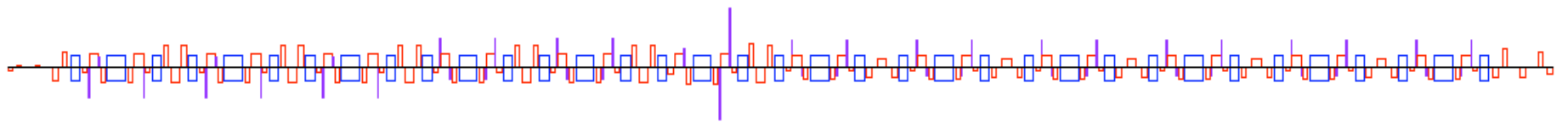
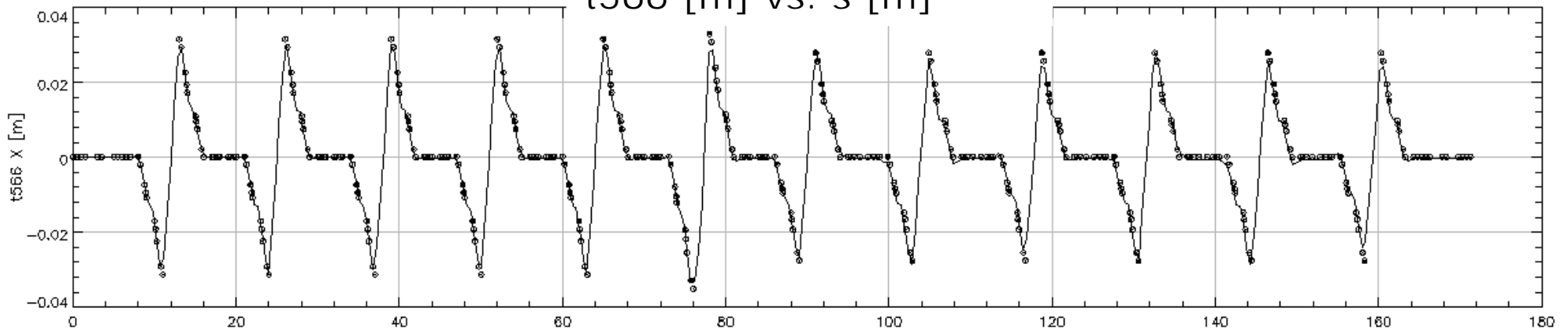
Full Turnaround



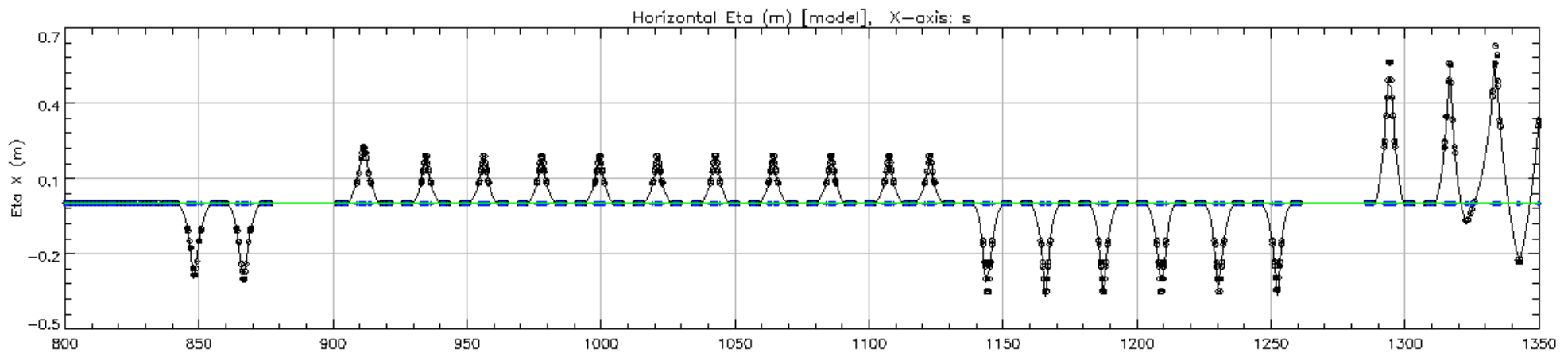
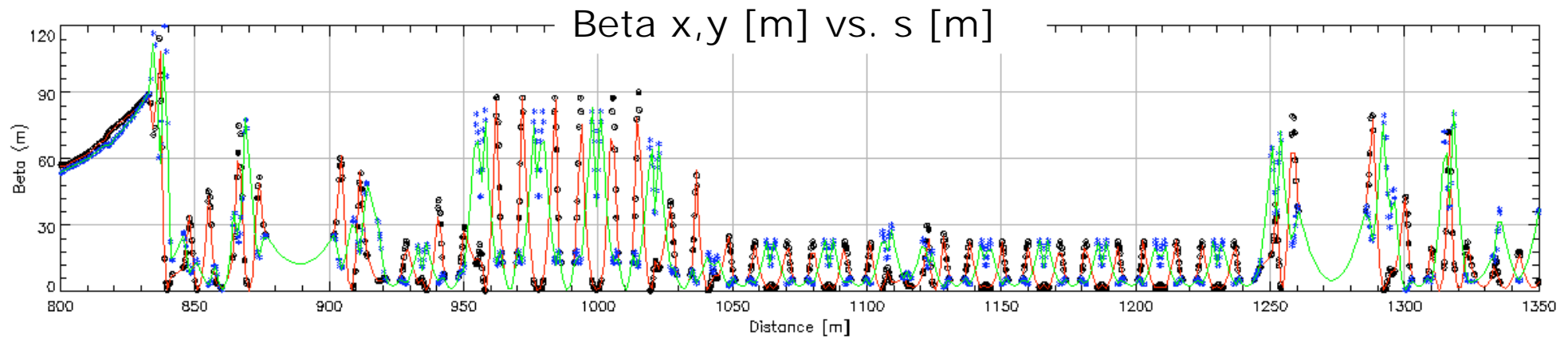
Beta x,y [m] vs. s [m]



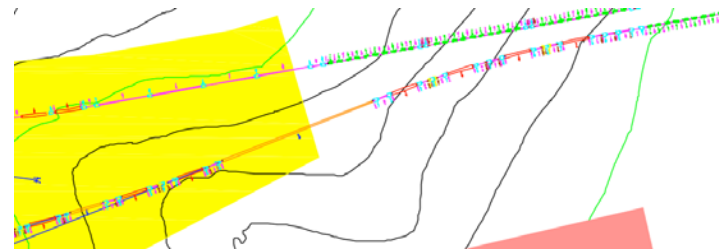
t566 [m] vs. s [m]



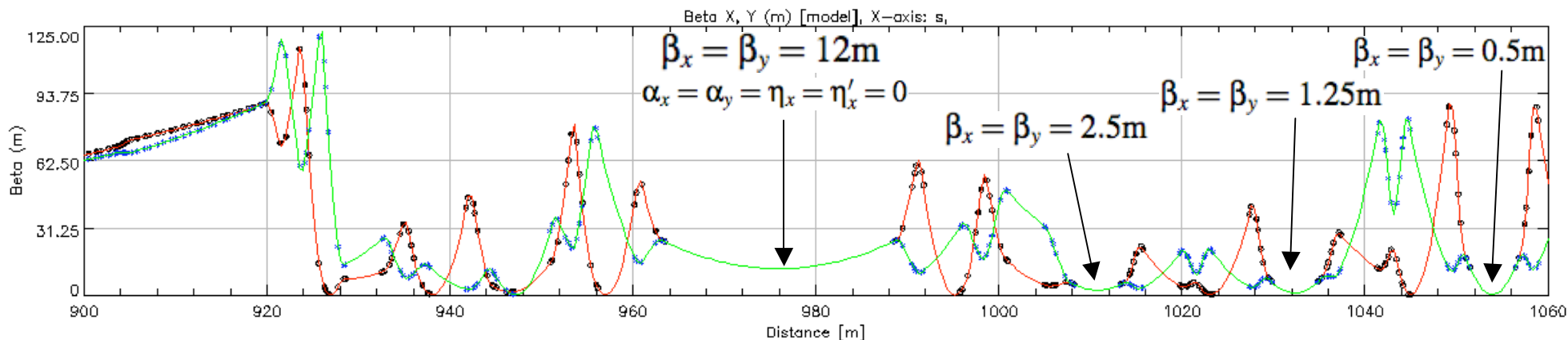
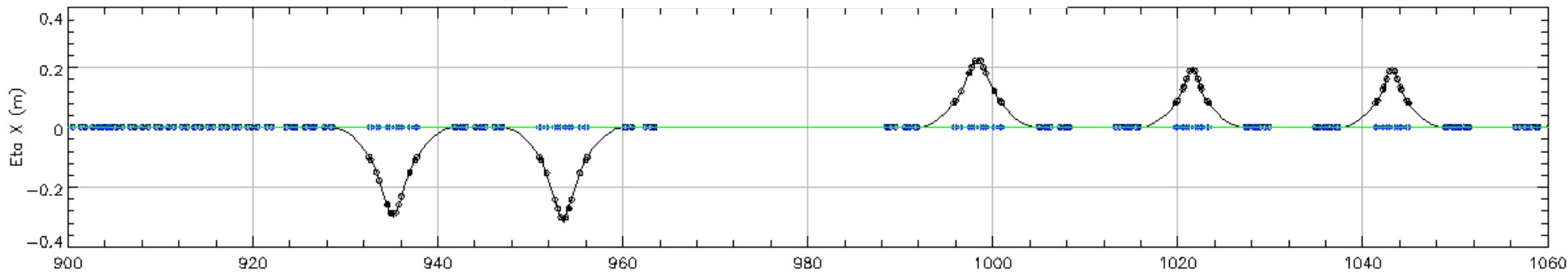
South Arc



Beginning of the South Arc



Eta x [m] vs. s [m]



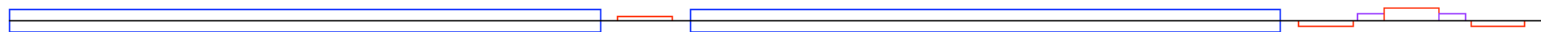
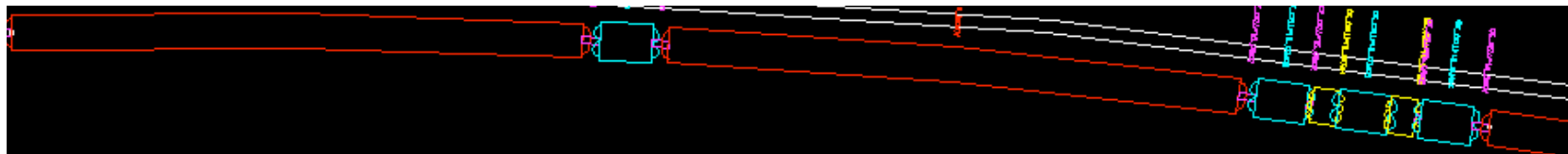
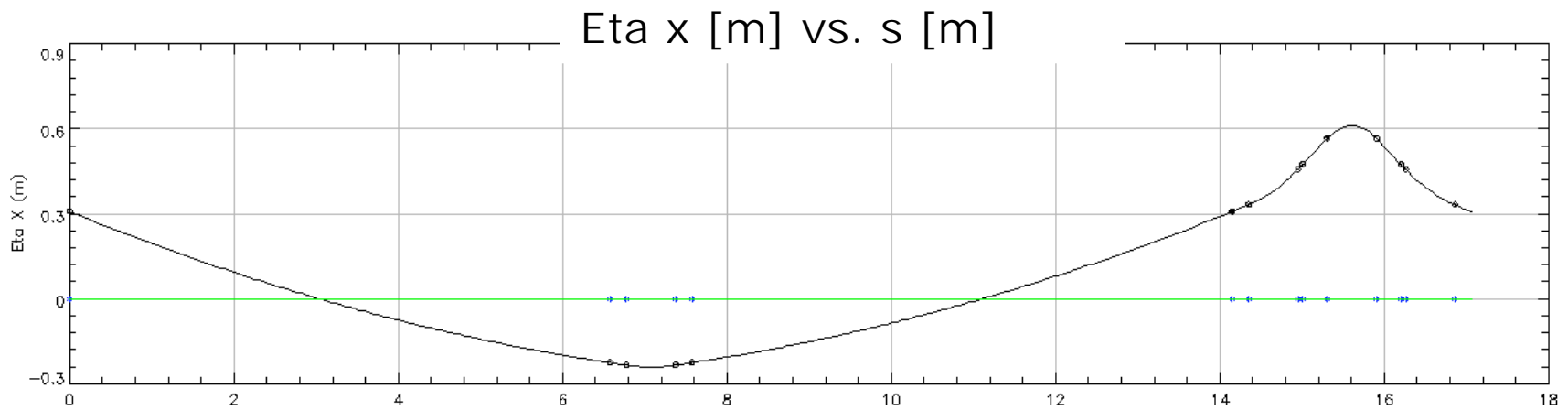
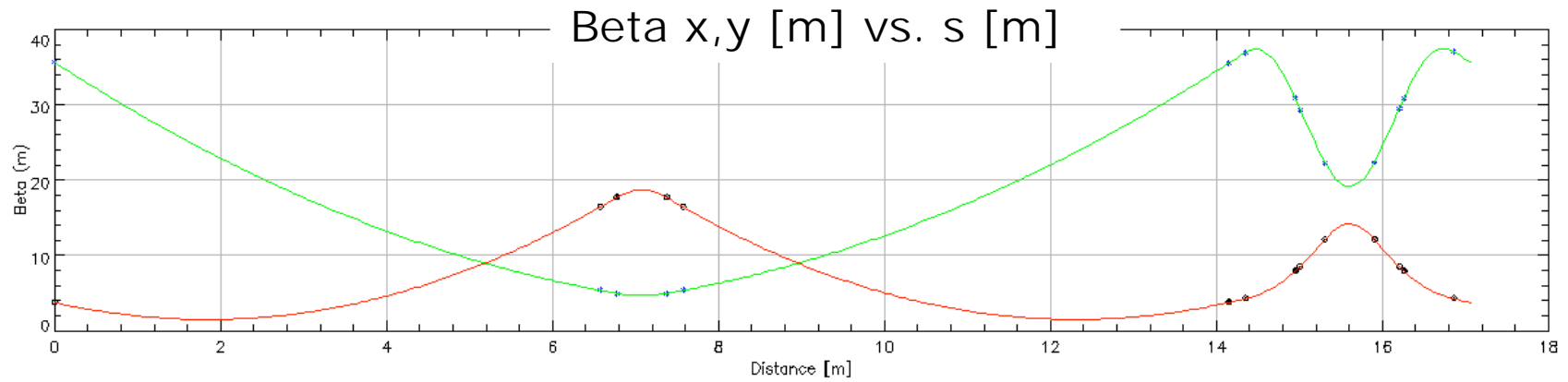
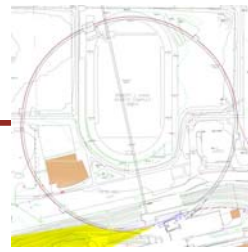
LB.CRM020

SA.CELLA01

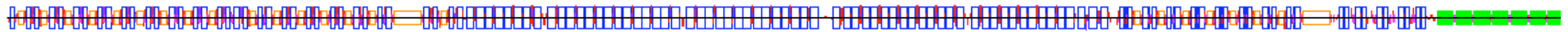
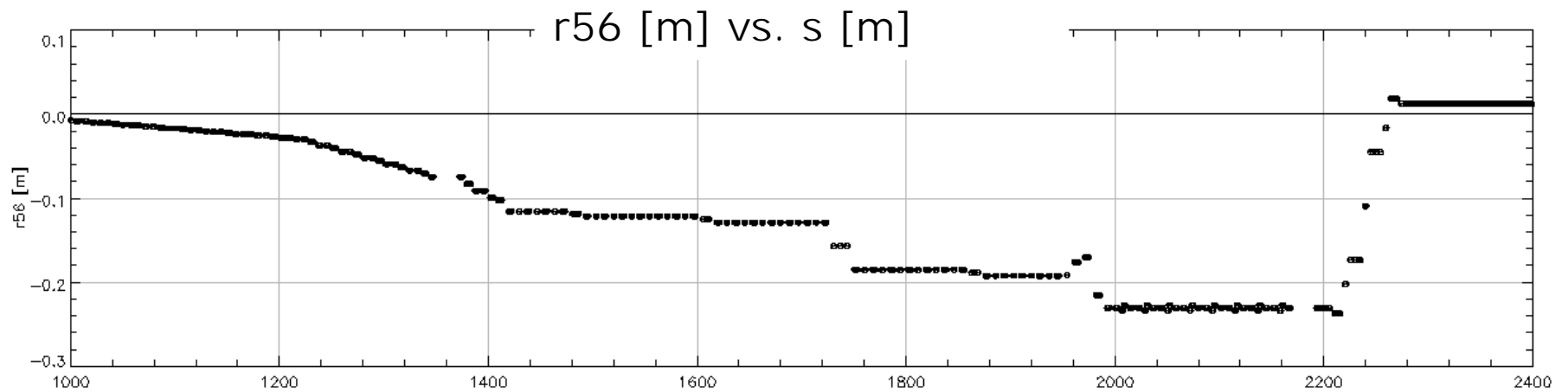
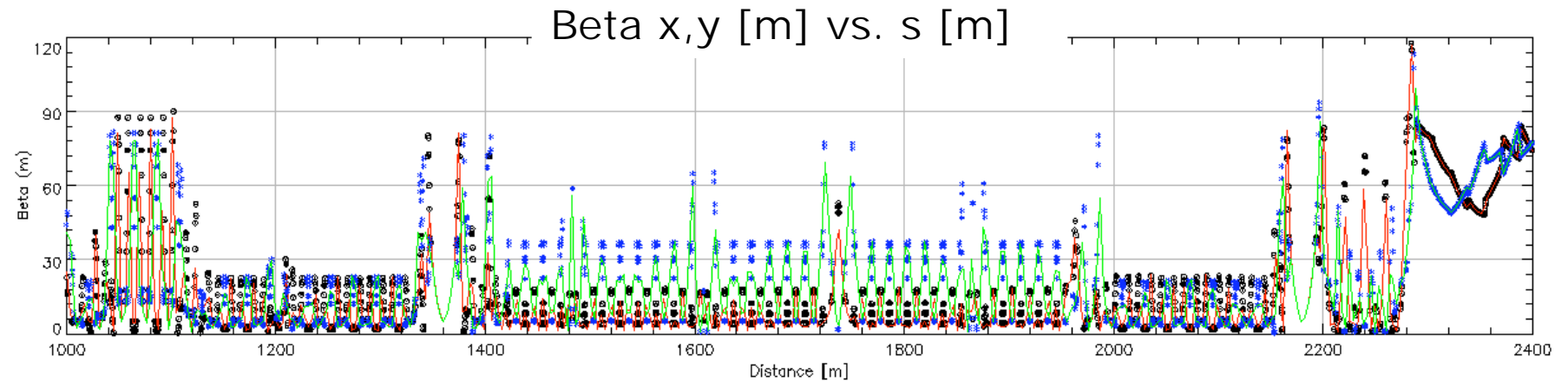
SA.CELLB01

SA.CELLB02

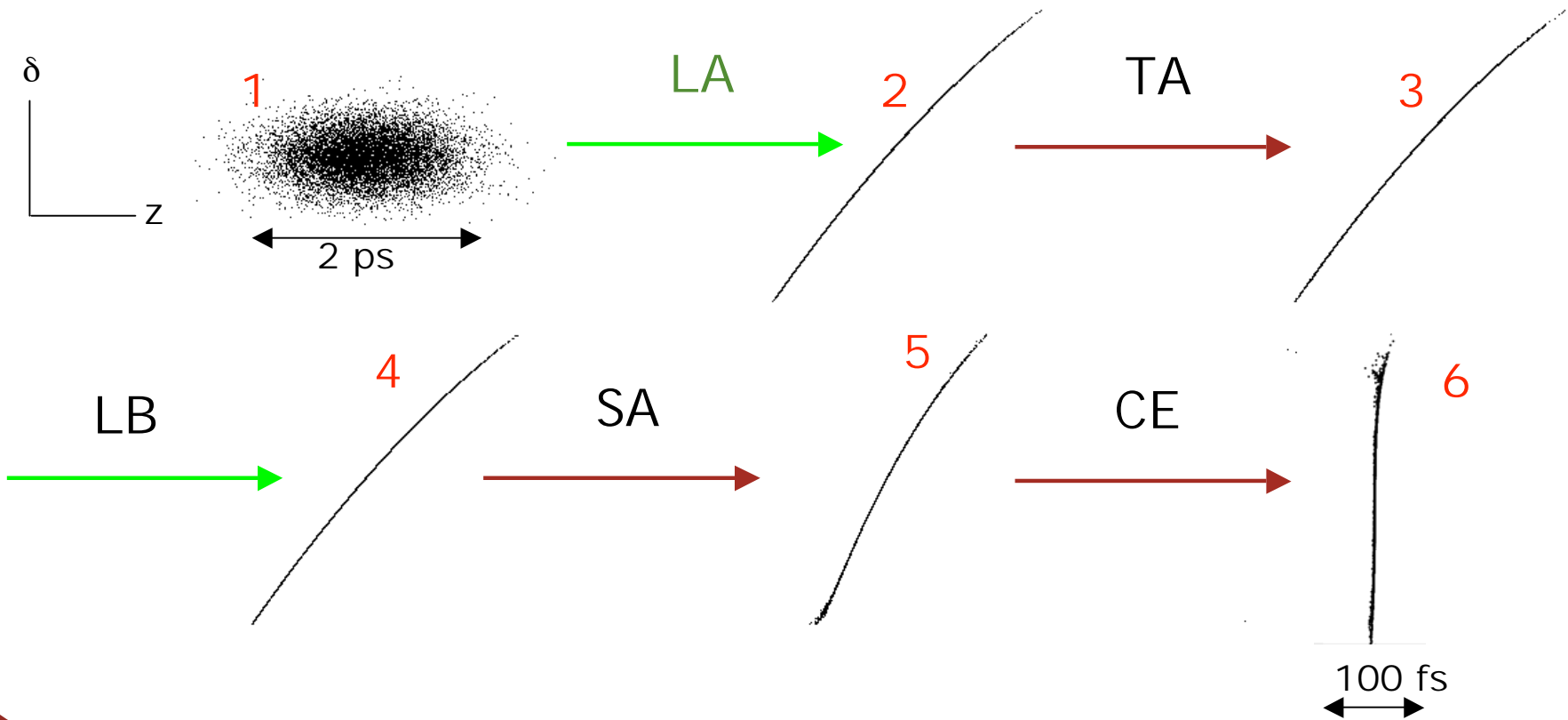
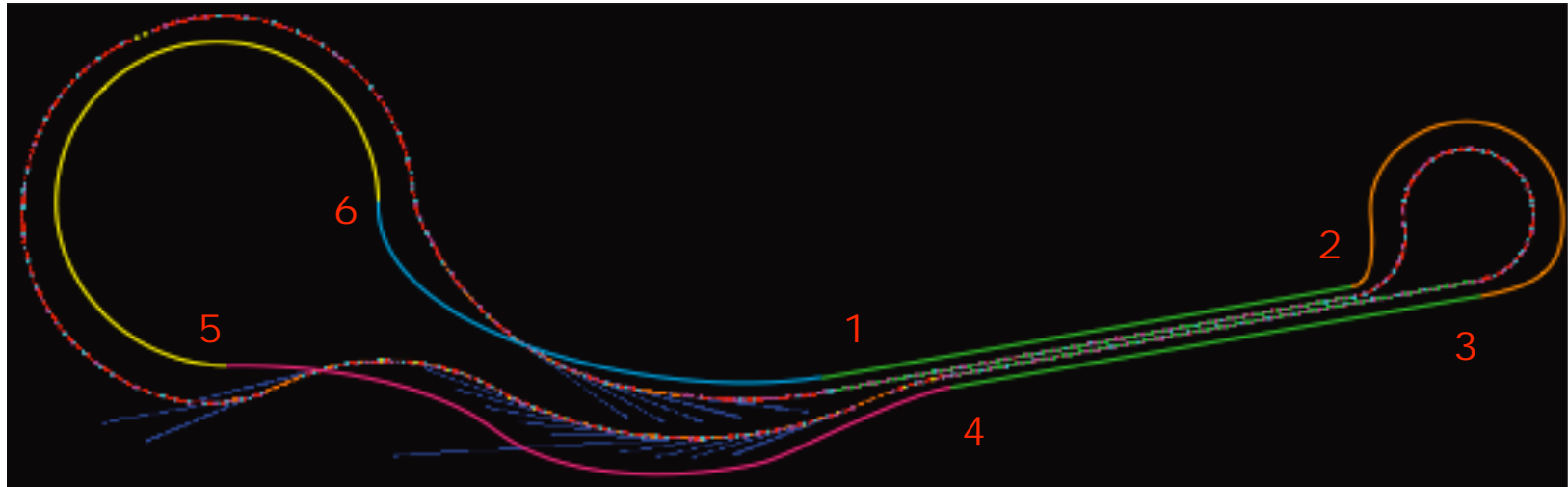
CESR Arc Cell



South Arc - CESR - North Arc Time of Flight

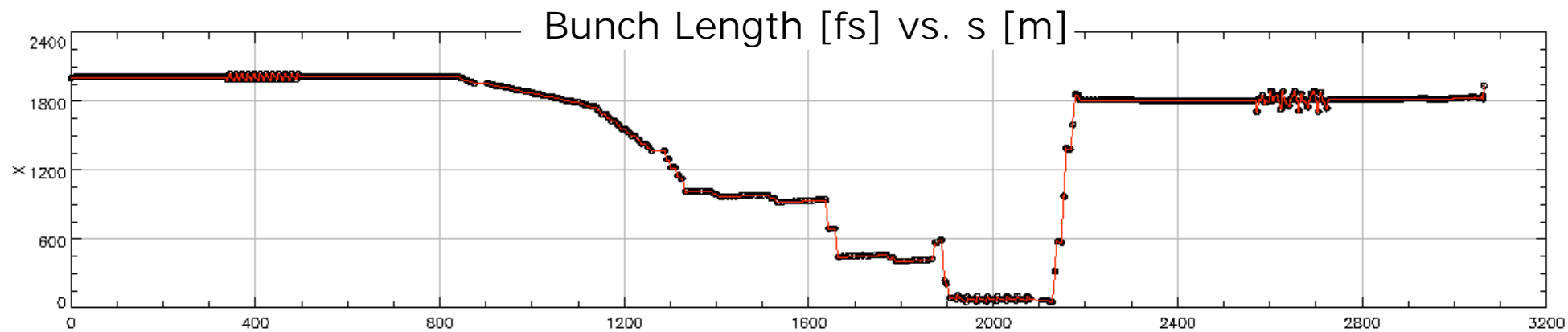


Mode C Bunch Compression

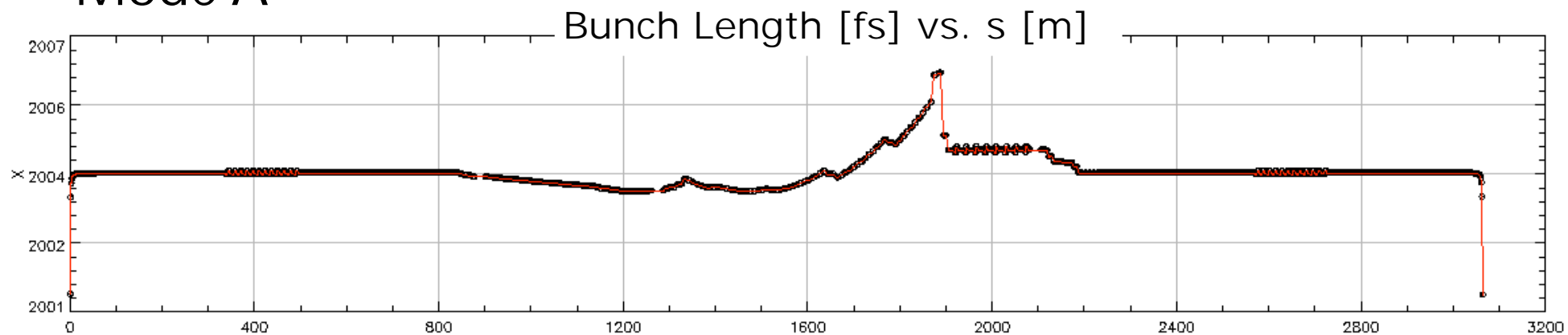


Bunch Length

Mode C

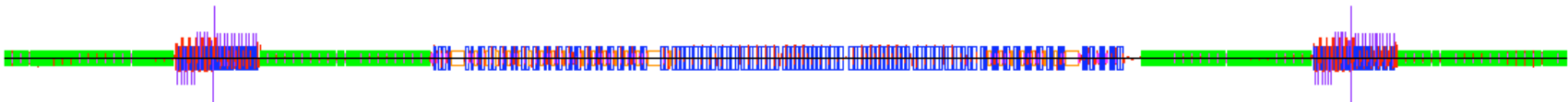
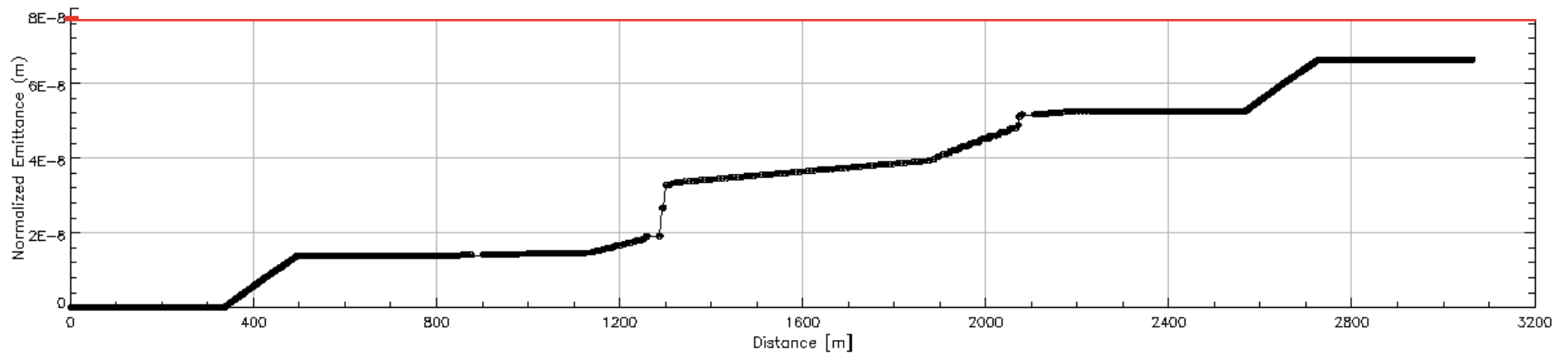
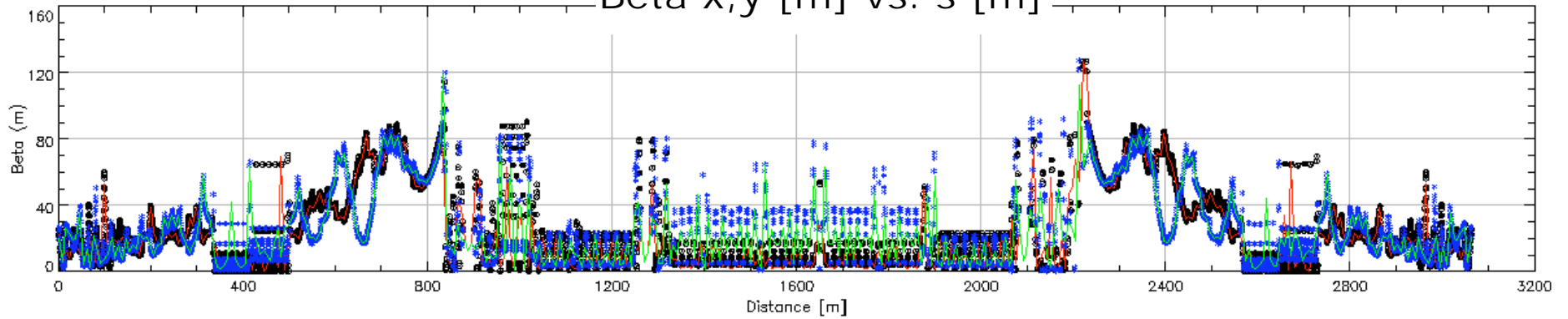


Mode A

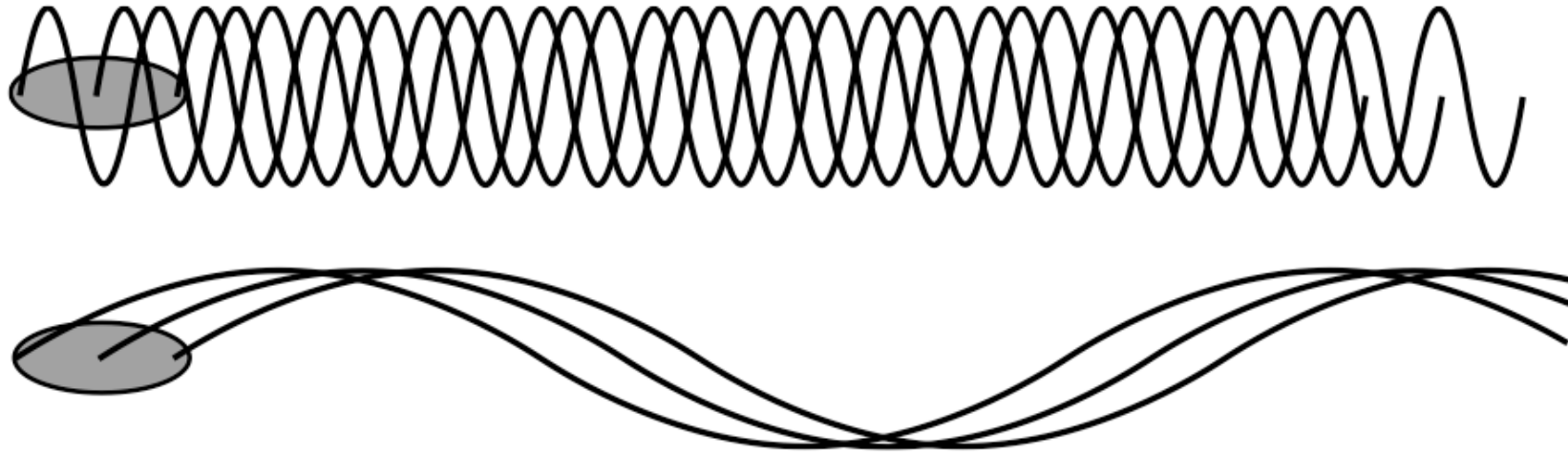


Emittance Growth in Complete ERL

Beta x,y [m] vs. s [m]

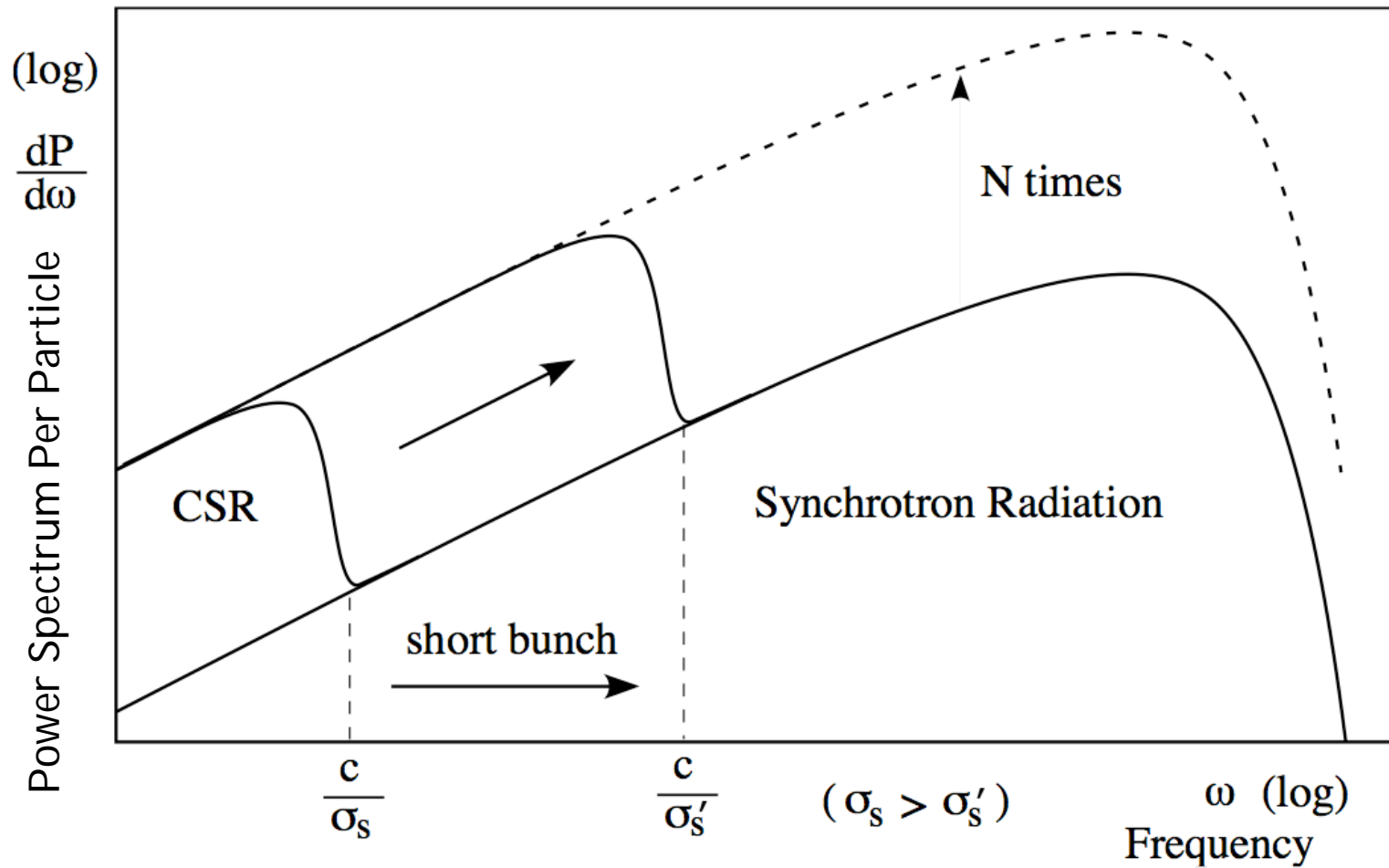


Coherent Synchrotron Radiation



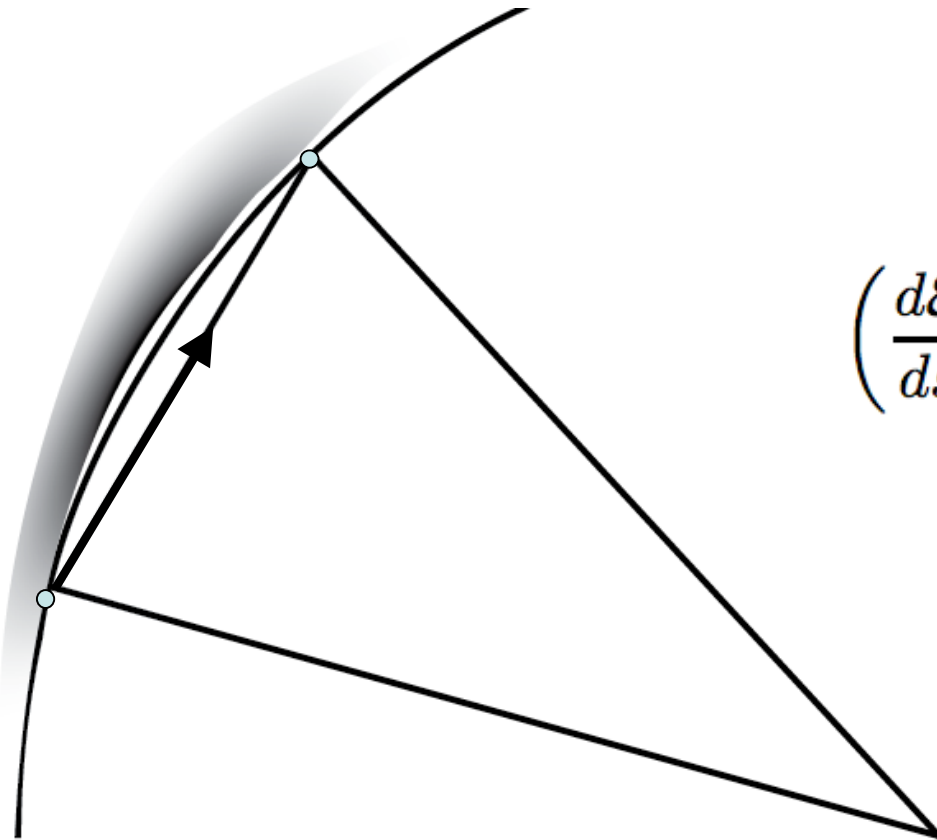
$$\begin{aligned}\frac{dP^{(N)}}{d\omega} &= \left| \sum_{j=1}^N e^{i\phi_j} \right|^2 \frac{dP^{(1)}}{d\omega} \\ &= \left(N + \sum_{j \neq k} e^{i(\phi_j - \phi_k)} \right) \frac{dP^{(1)}}{d\omega} \\ &= N \left(1 + (N-1) \left| \int \lambda(z) e^{i\omega z/c} dz \right|^2 \right) \frac{dP^{(1)}}{d\omega}\end{aligned}$$

Power Spectrum per particle



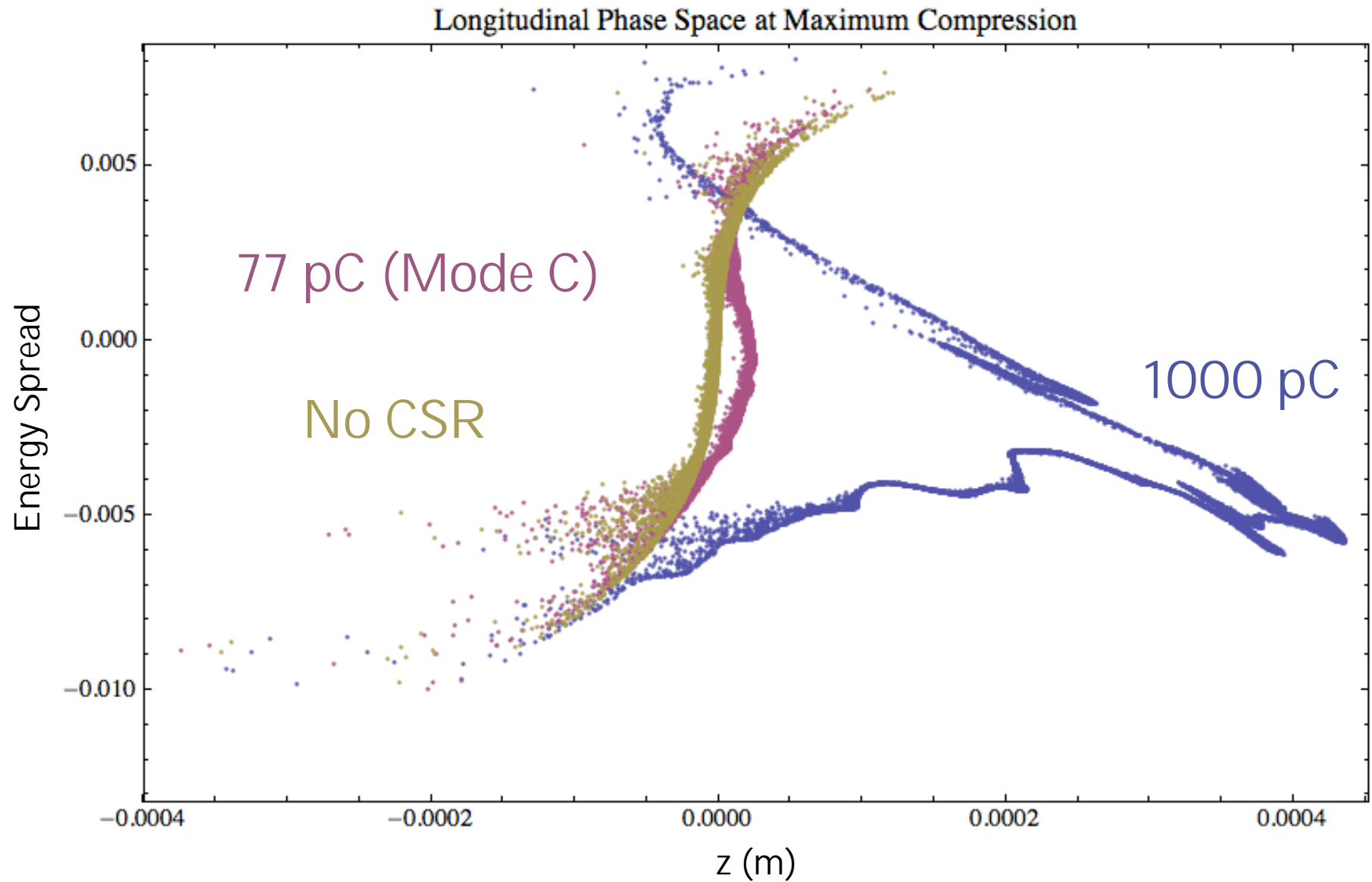
Saldin et. al. 1-D Kick (1997)

- Tail influences Head (Lienard-Wiechert)
- No Transverse Size (1-D Distribution)



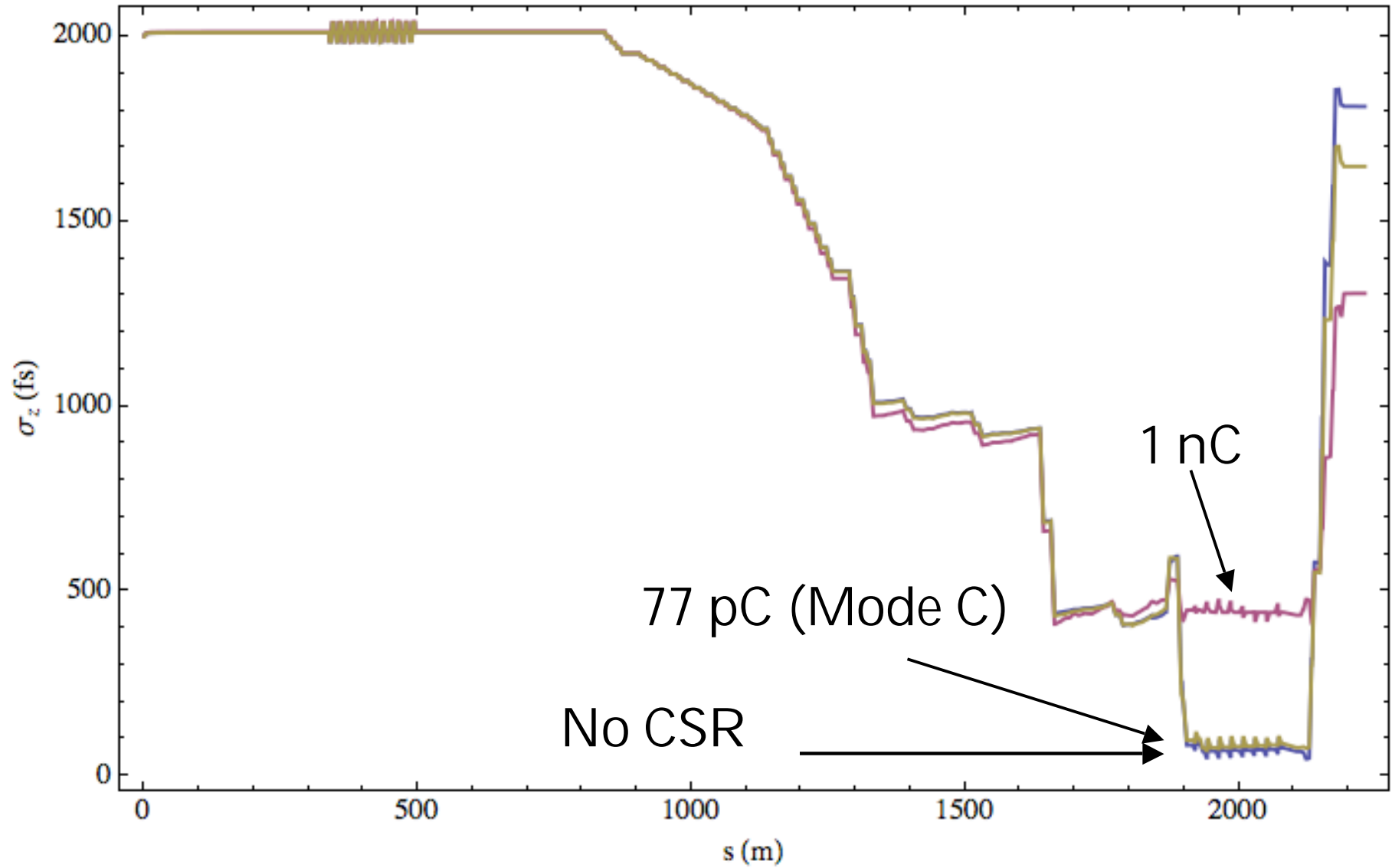
$$\left(\frac{d\mathcal{E}}{ds}\right)_{\text{CSR}} = \int_{-\infty}^{\infty} ds' \lambda(s') K_{\text{CSR}}(s - s')$$

CSR in Mode C



CSR in Mode C

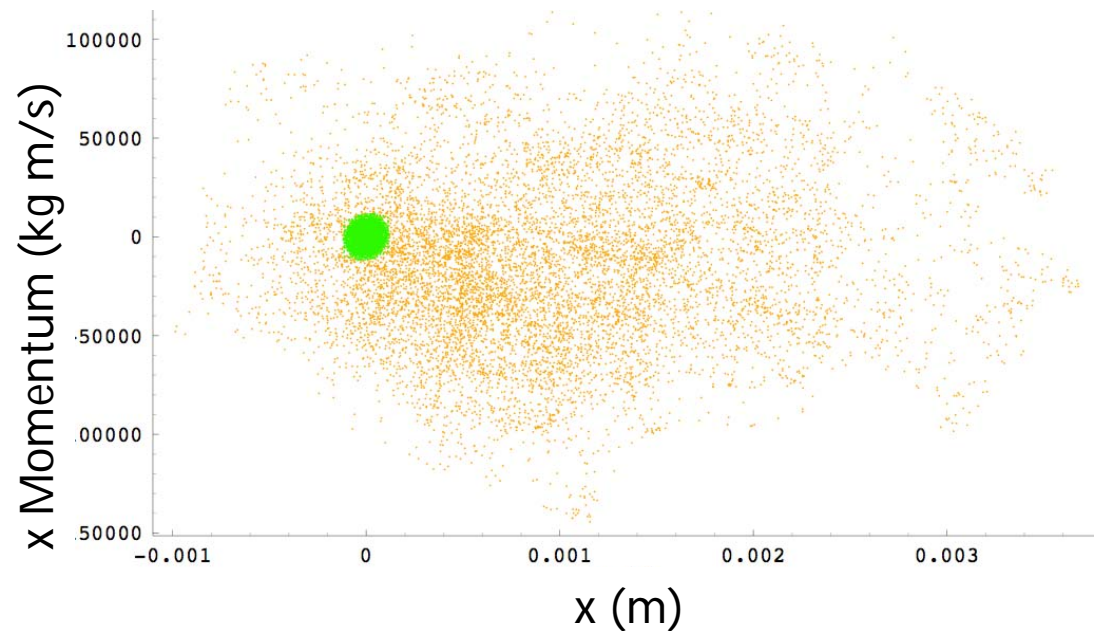
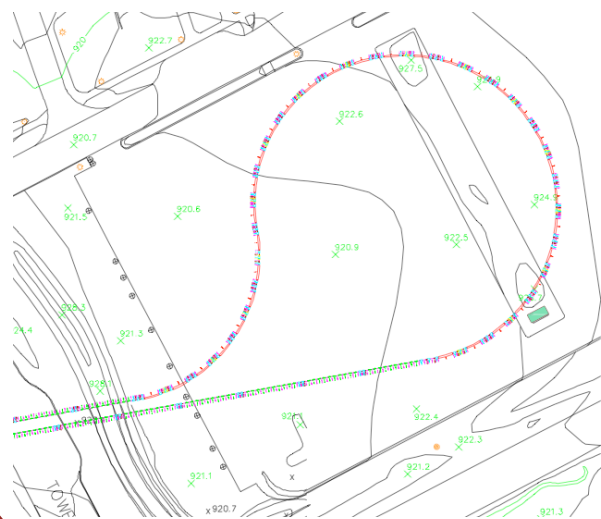
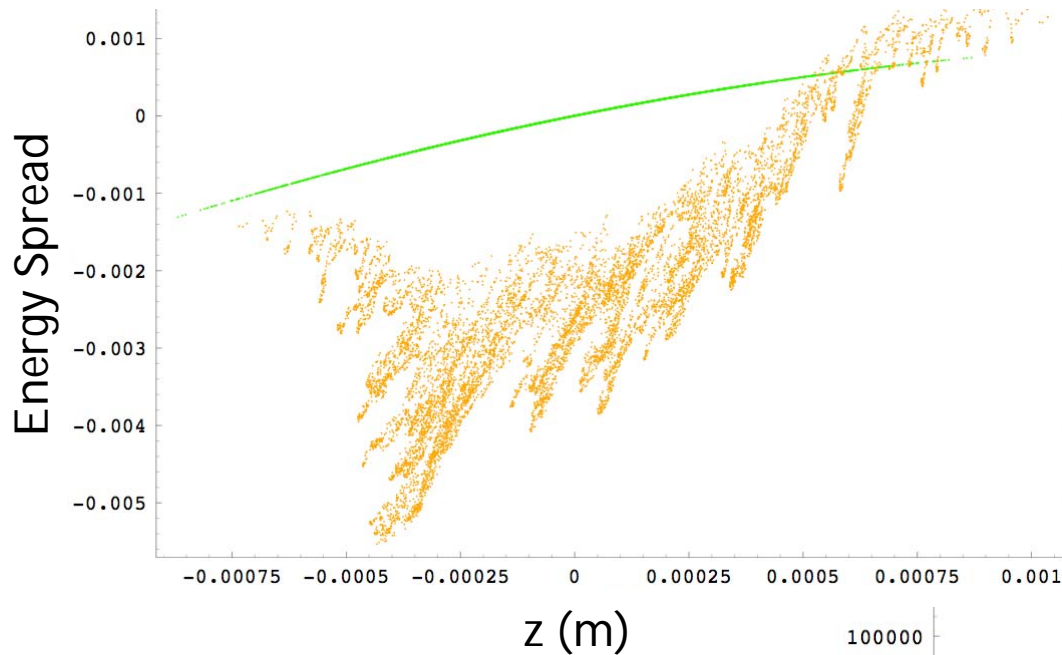
Bunch Length



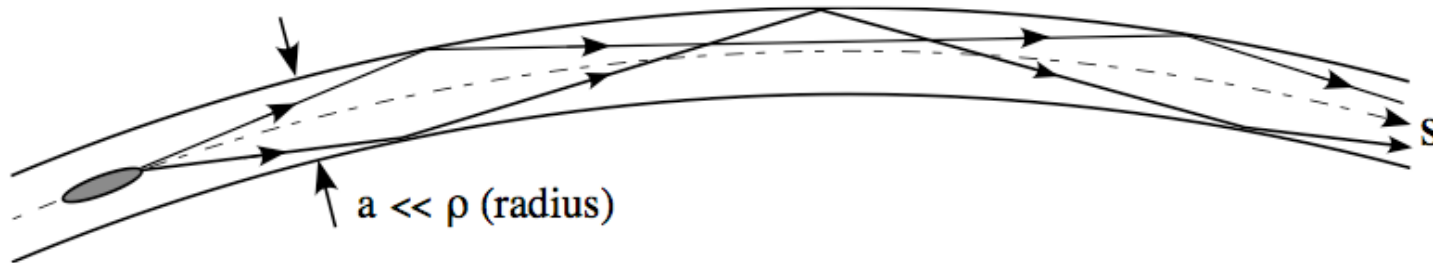
Short Pulses in the Turnaround

ERL Turnaround

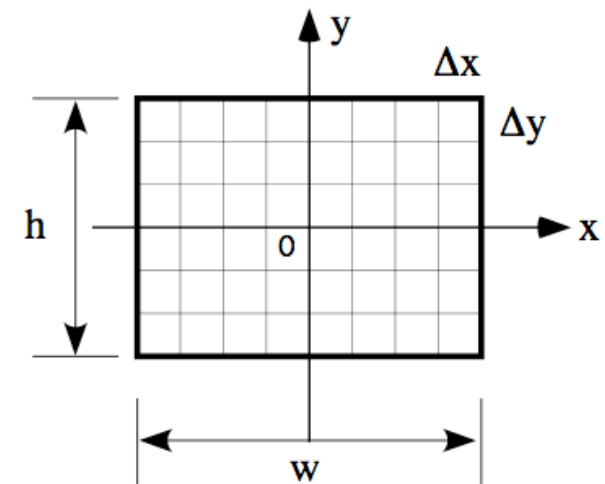
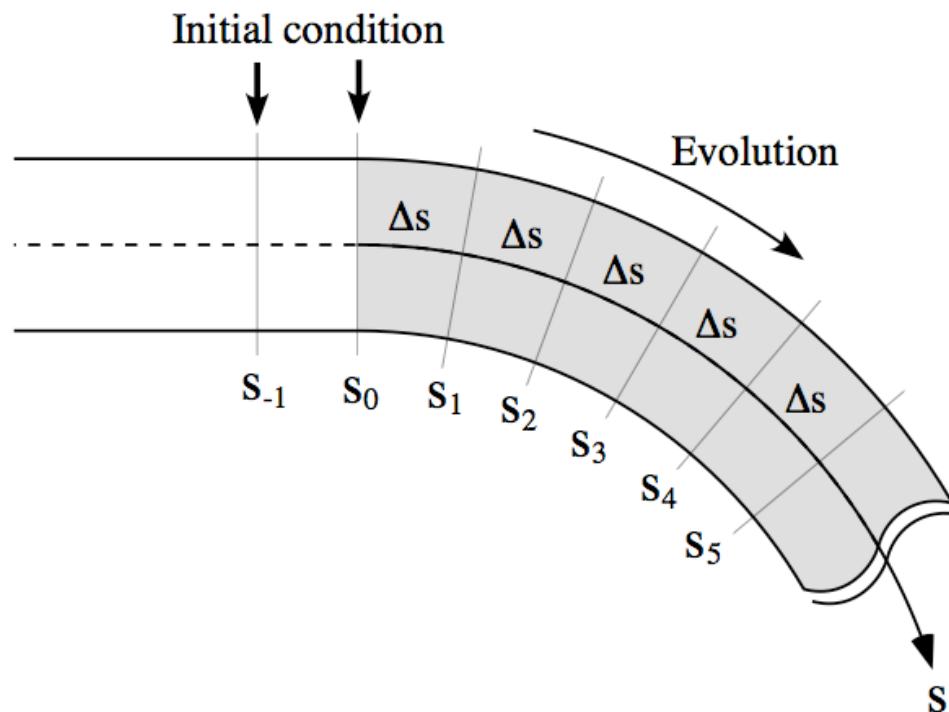
- 1ps long bunch
- 1nC charge
- 0.3 mm-mrad normalized emittance



Agoh/Yakoya Mesh (2004)

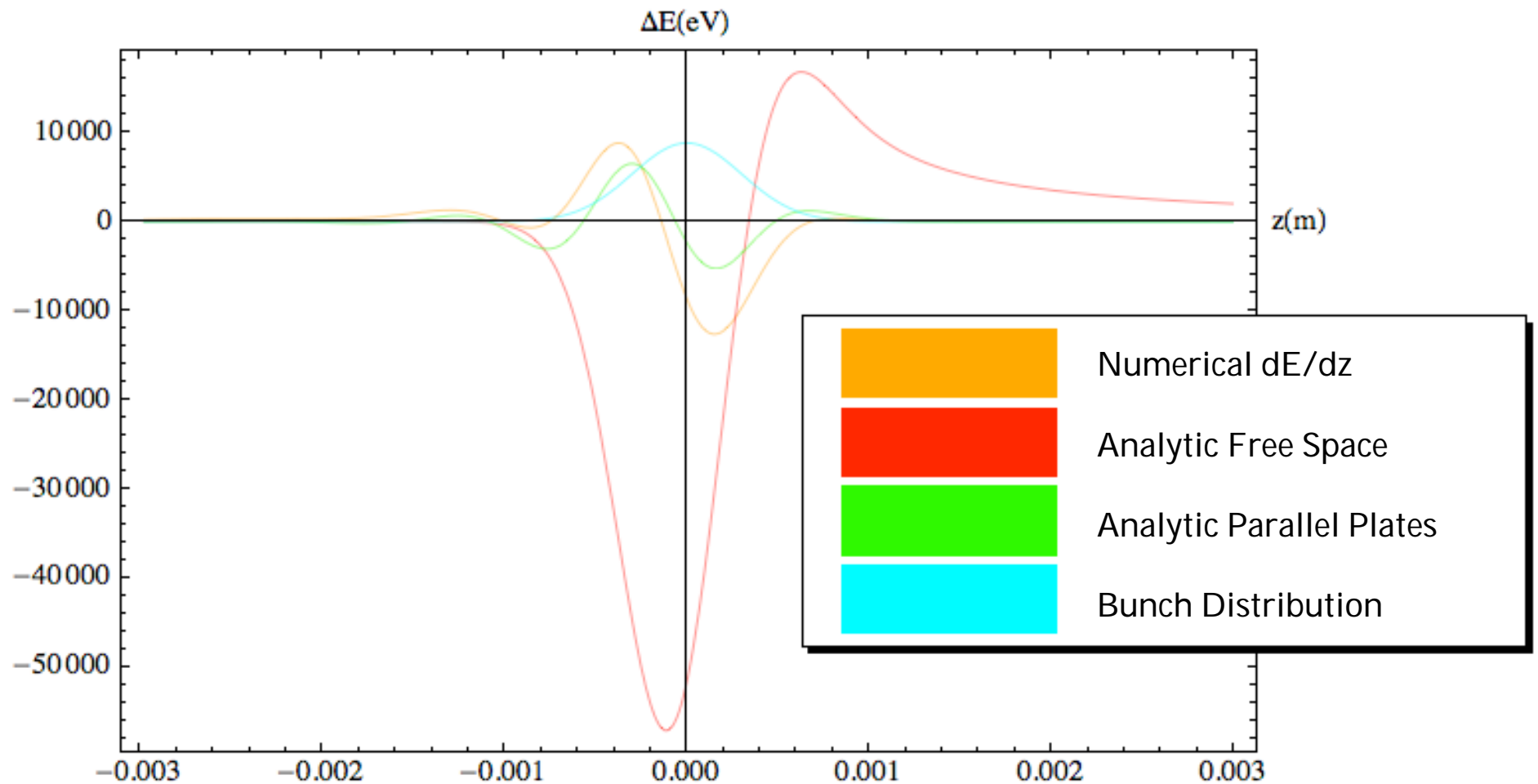


- Approximate Maxwell's Equations
- Discretize Space, Fourier Transform Time
- Propagate Fields, Construct CSR Wake



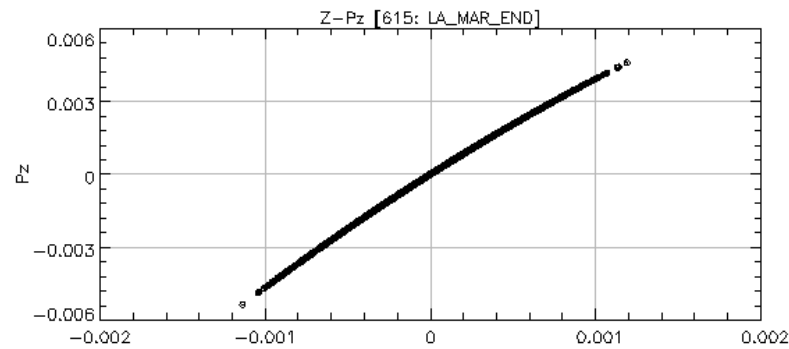
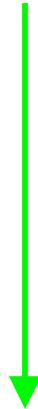
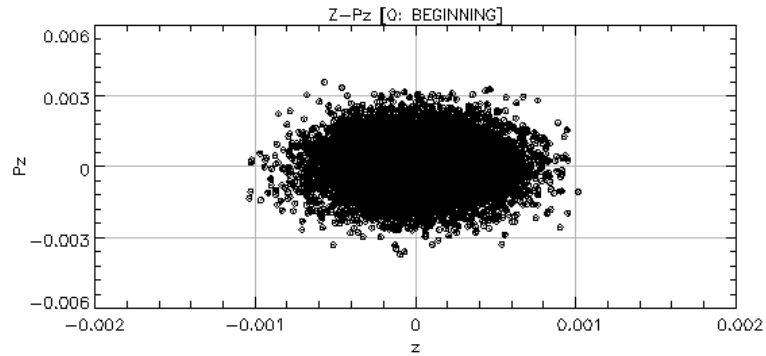
rectangular cross section
(boundary condition)

Shielding Wake Fields

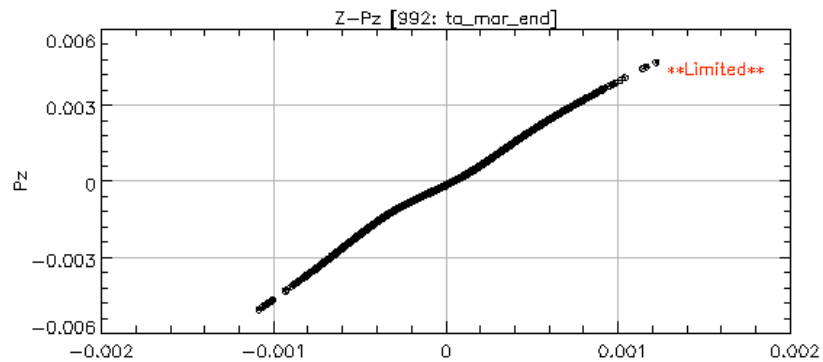


800 pC
1 ps
5cm x 1cm beam chamber
Magnet L = 1m, rho ~ 7m

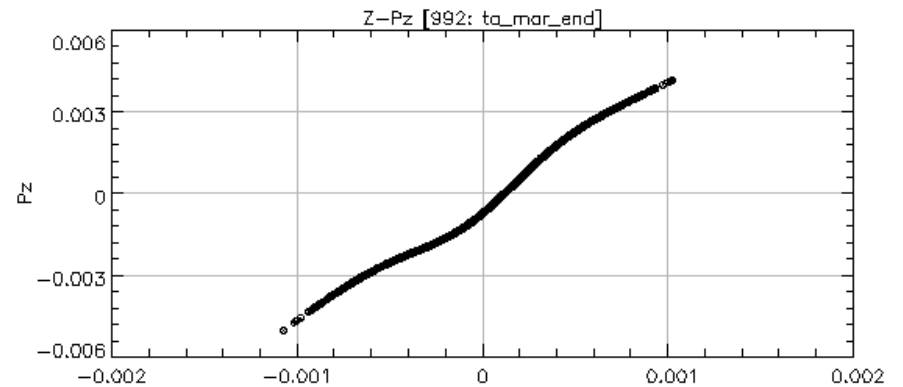
Shielding in the Turnaround



$h = 1\text{cm}$



$h = 5\text{cm}$



Some Conclusions

- CSR is not a problem for our current operating modes
- 5 GeV high charge short pulses have problems
- The CSR shielding effect may alleviate these issues

End

Energy Spread after Energy Recovery with CSR

