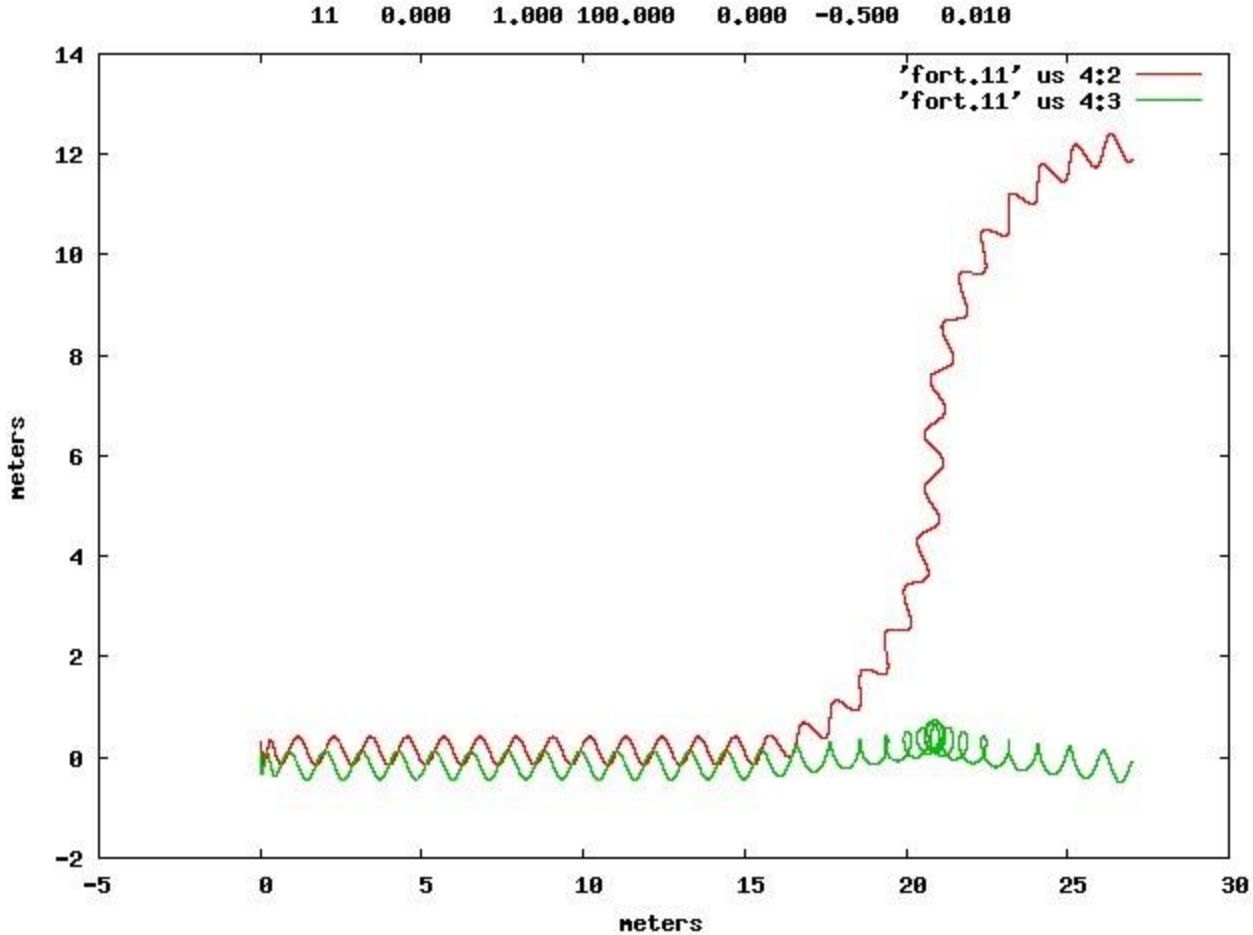
Effects of adding a B field perpendicular to the solenoid axis

Jim Miller, Boston University
Mu2e teleconference, April 16,2008



Coordinate system: y=up, z=along axis of straight solenoid in the plot:

Horizontal axis: z position of particle

Vertical axis: Green=y position, red=x position

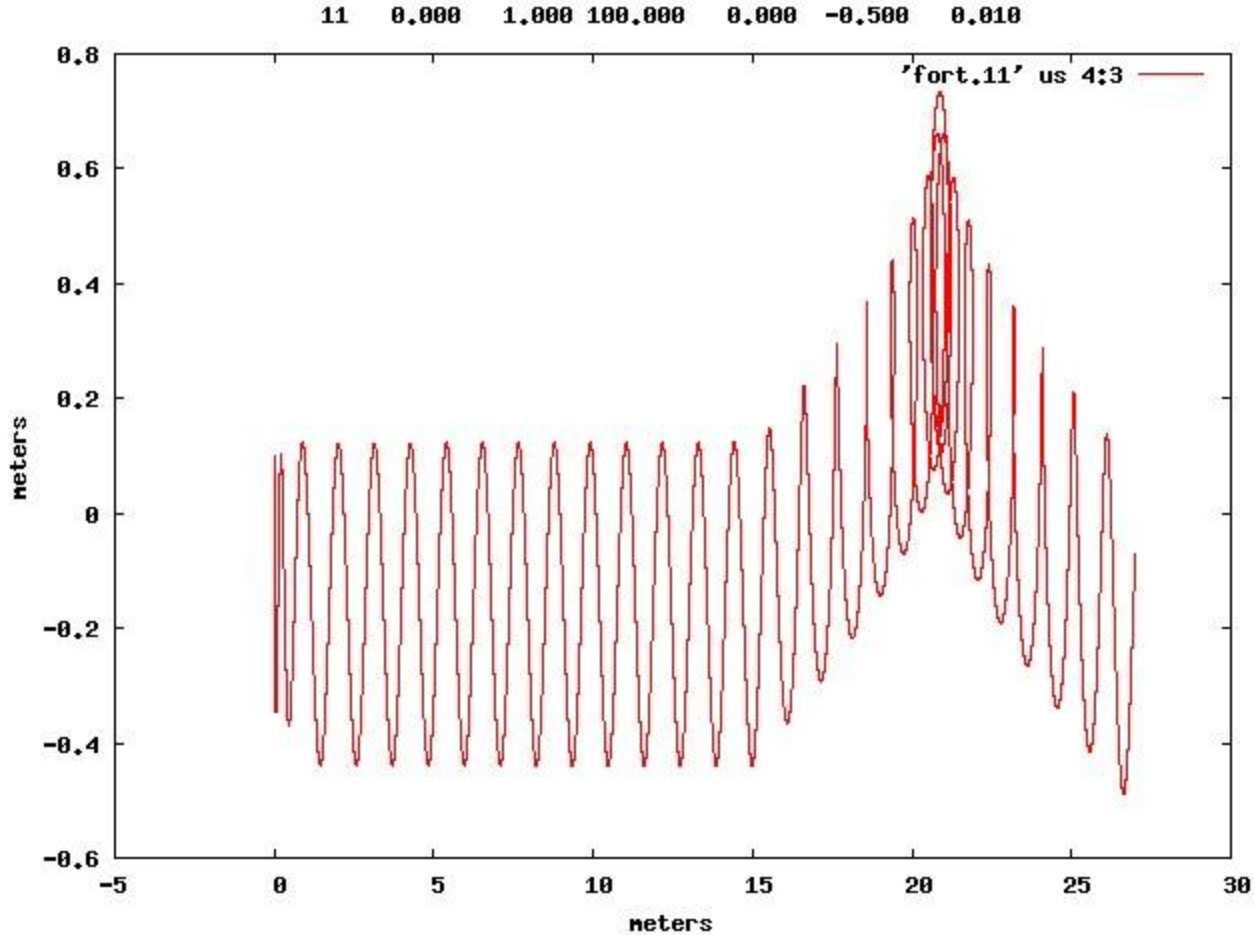
Magnet geometry: straight solenoid up to z=15 m

S-shaped for z>15 m, radii of toroids = 6 m

Magnetic field: gradient from z=-1 m to z=+1 m, B_z going from 2 T to 1 T

B_z=1 T from z=1 m to z=15 m

Toroid from z=15 m, bcentral=1 T



In this STANDARD plot:

Horizontal axis: z position of particle

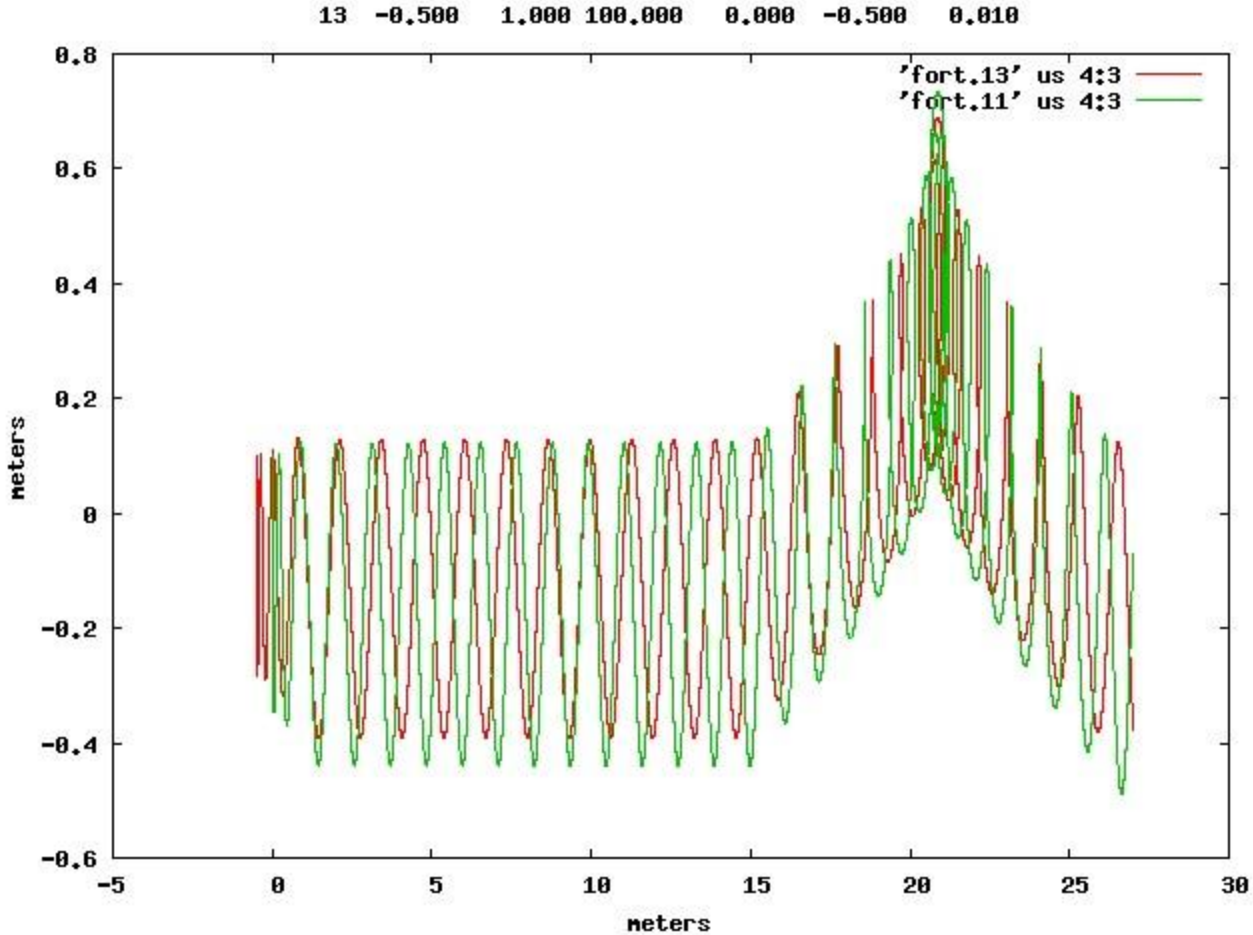
Vertical axis: red=y position of particle

p0_z/p0=.01, x0=y=.1 m, p0=100 MeV/c

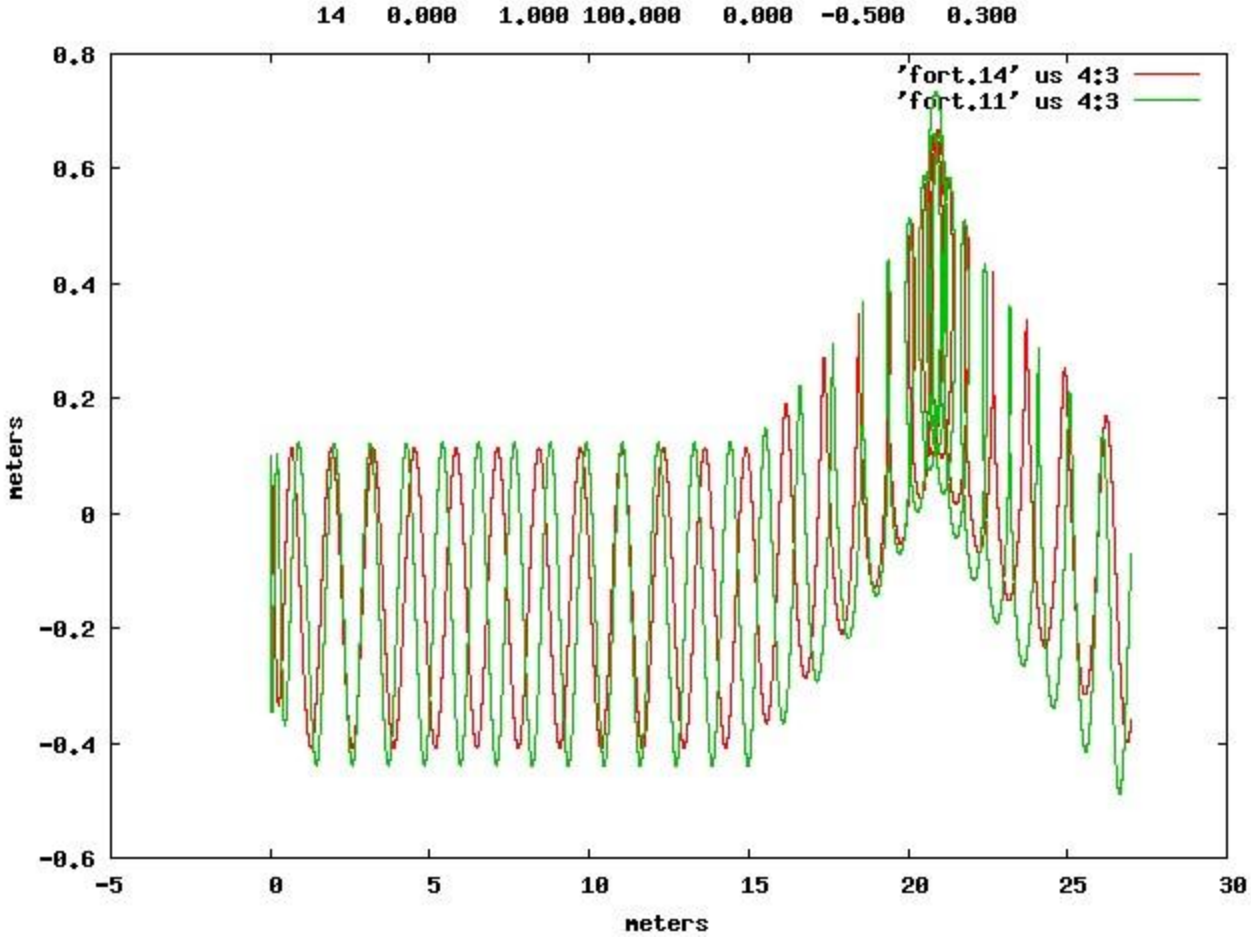
Magnet geometry:

straight solenoid up to z=15 m

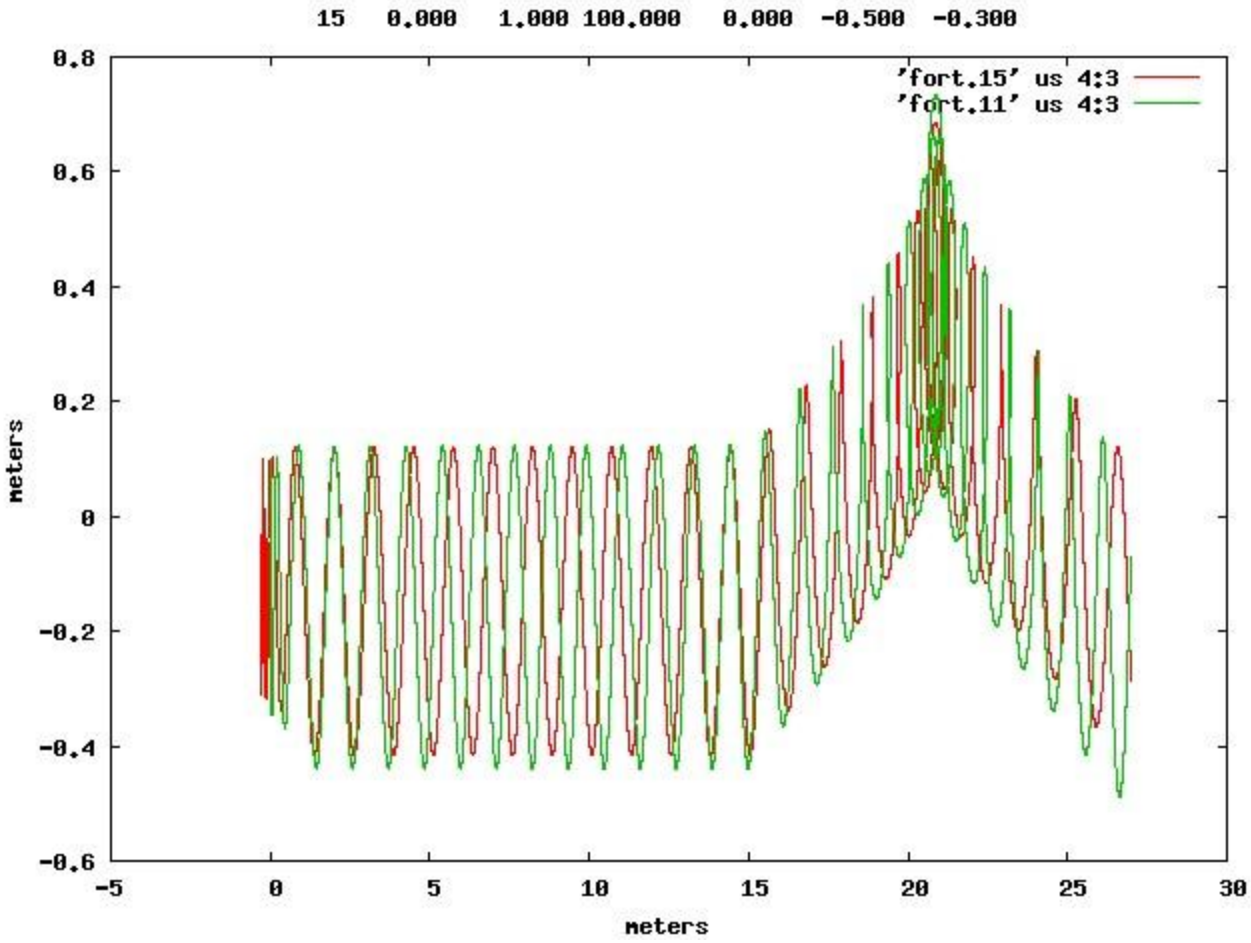
S-shaped for z>15 m, radii of toroids = 6 m



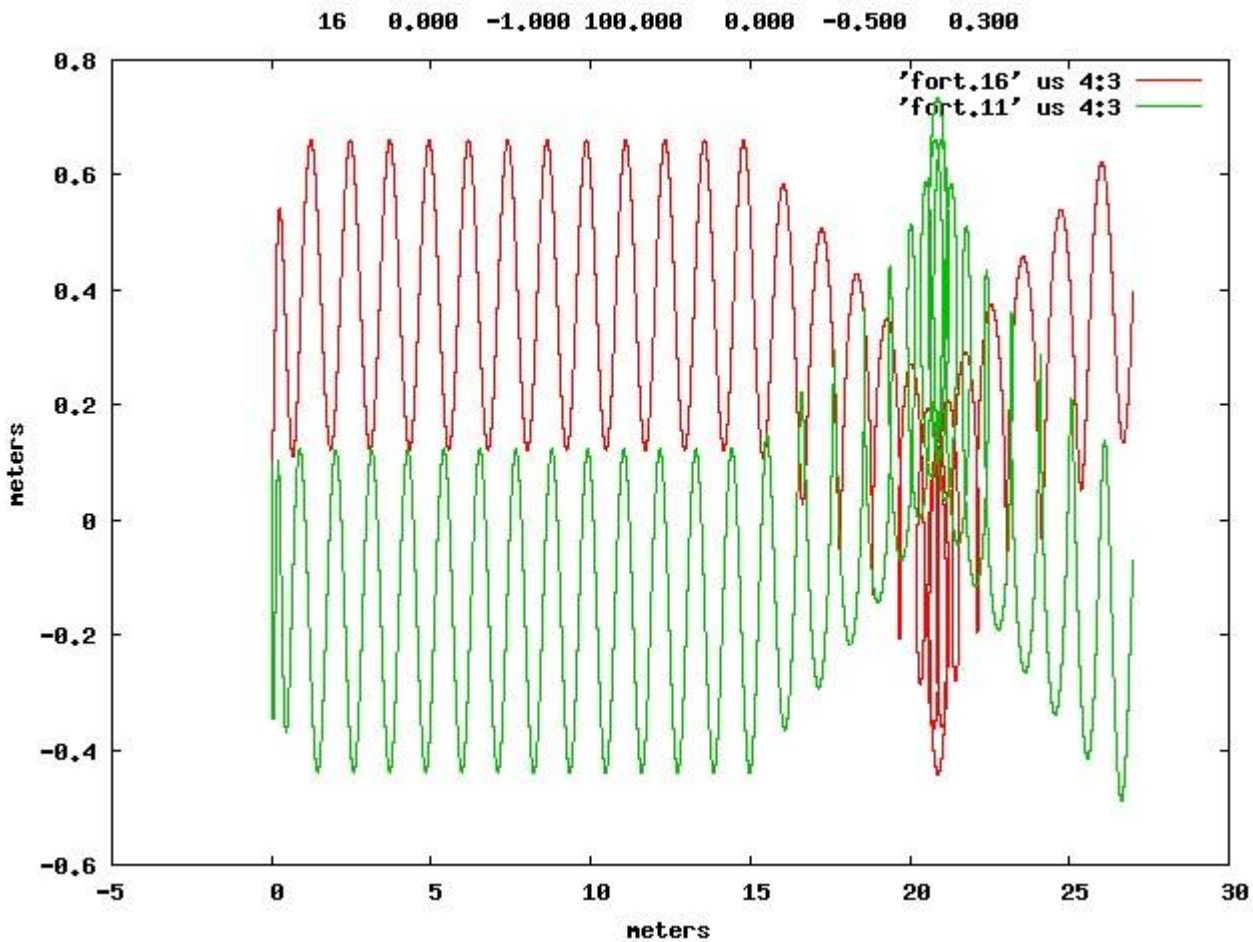
Red: STANDARD plot
Green: z0=-.5 m



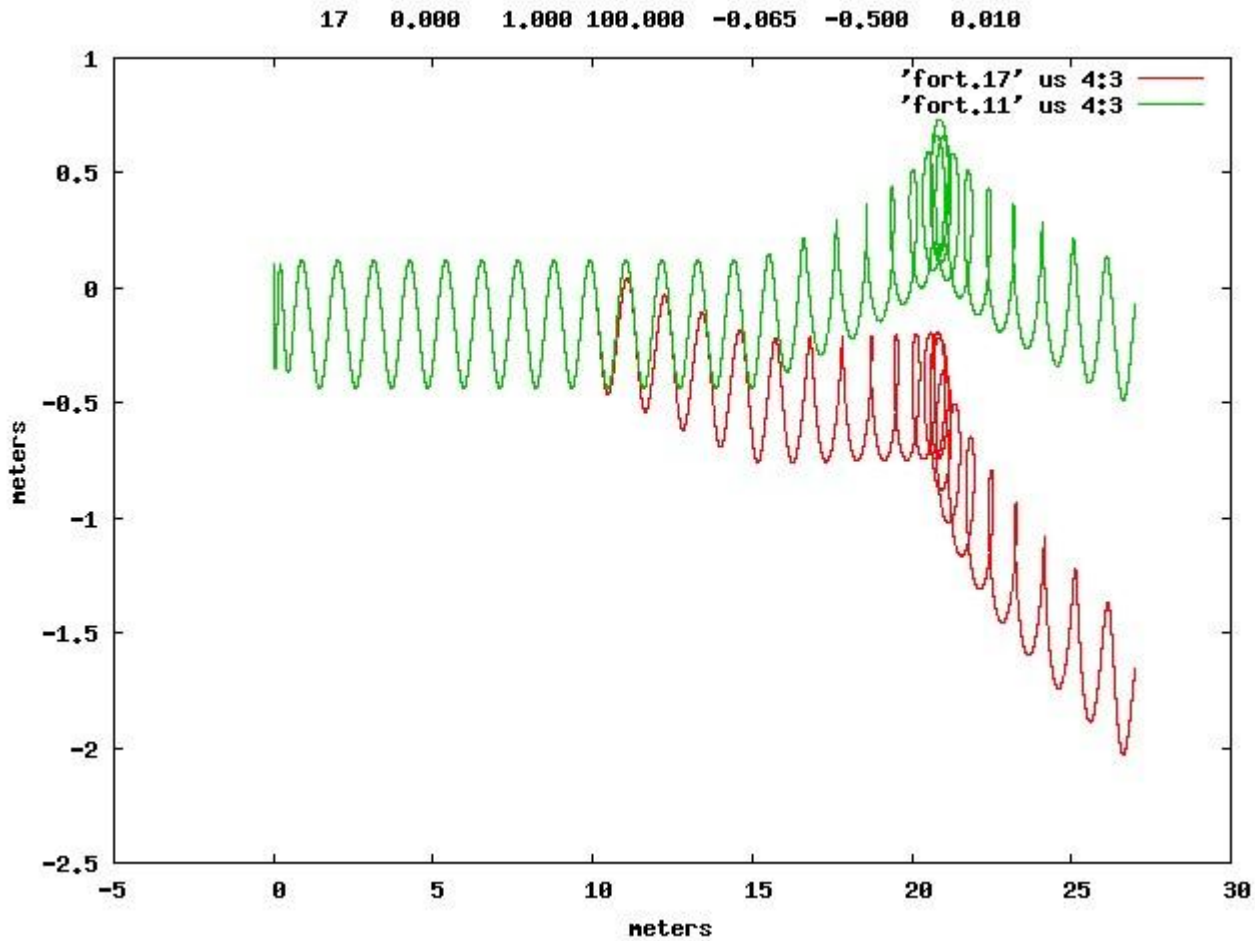
Green: Standard plot
Red: p0_z/p0=0.3



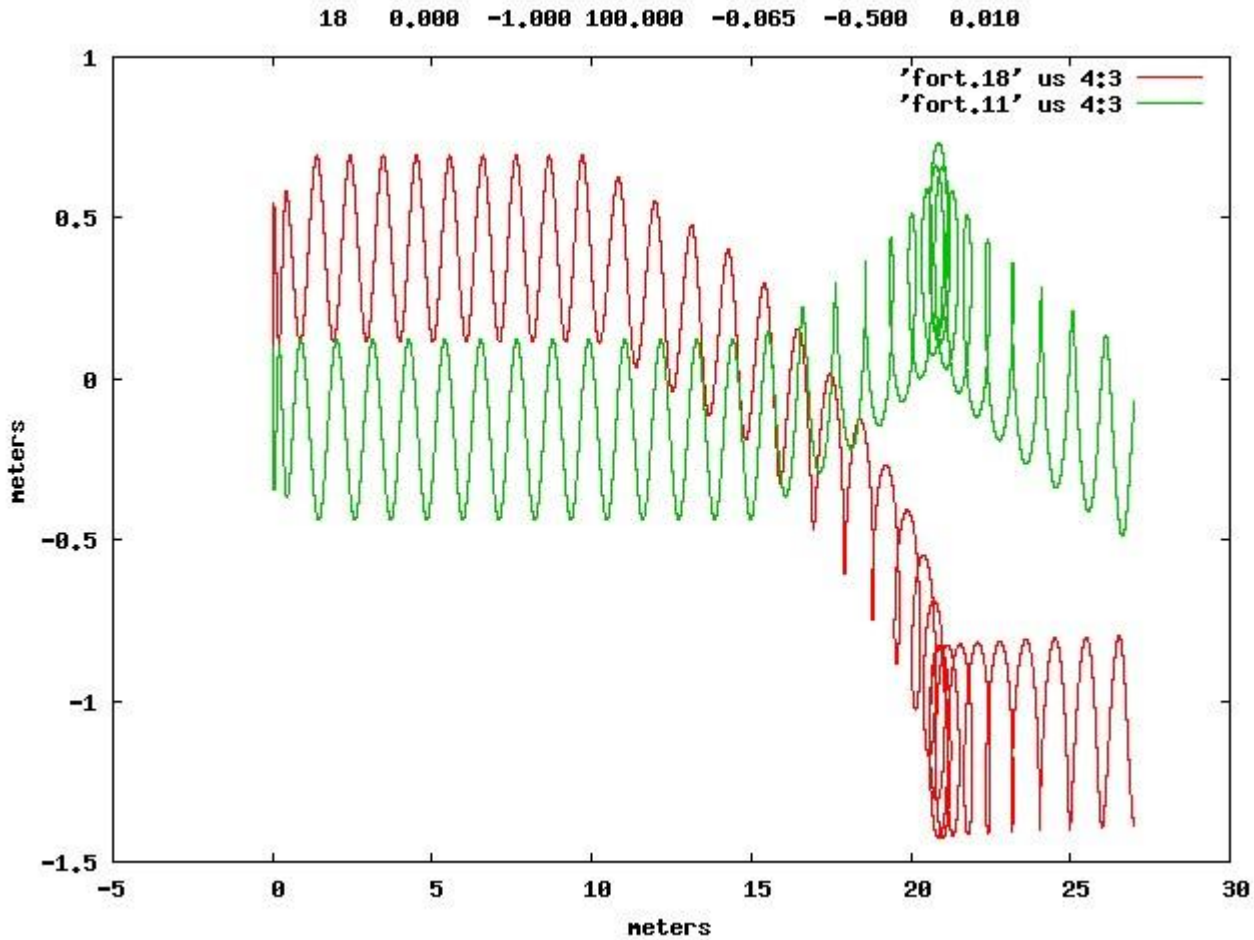
Green: Standard plot
Red: p0_z/p0=-0.3



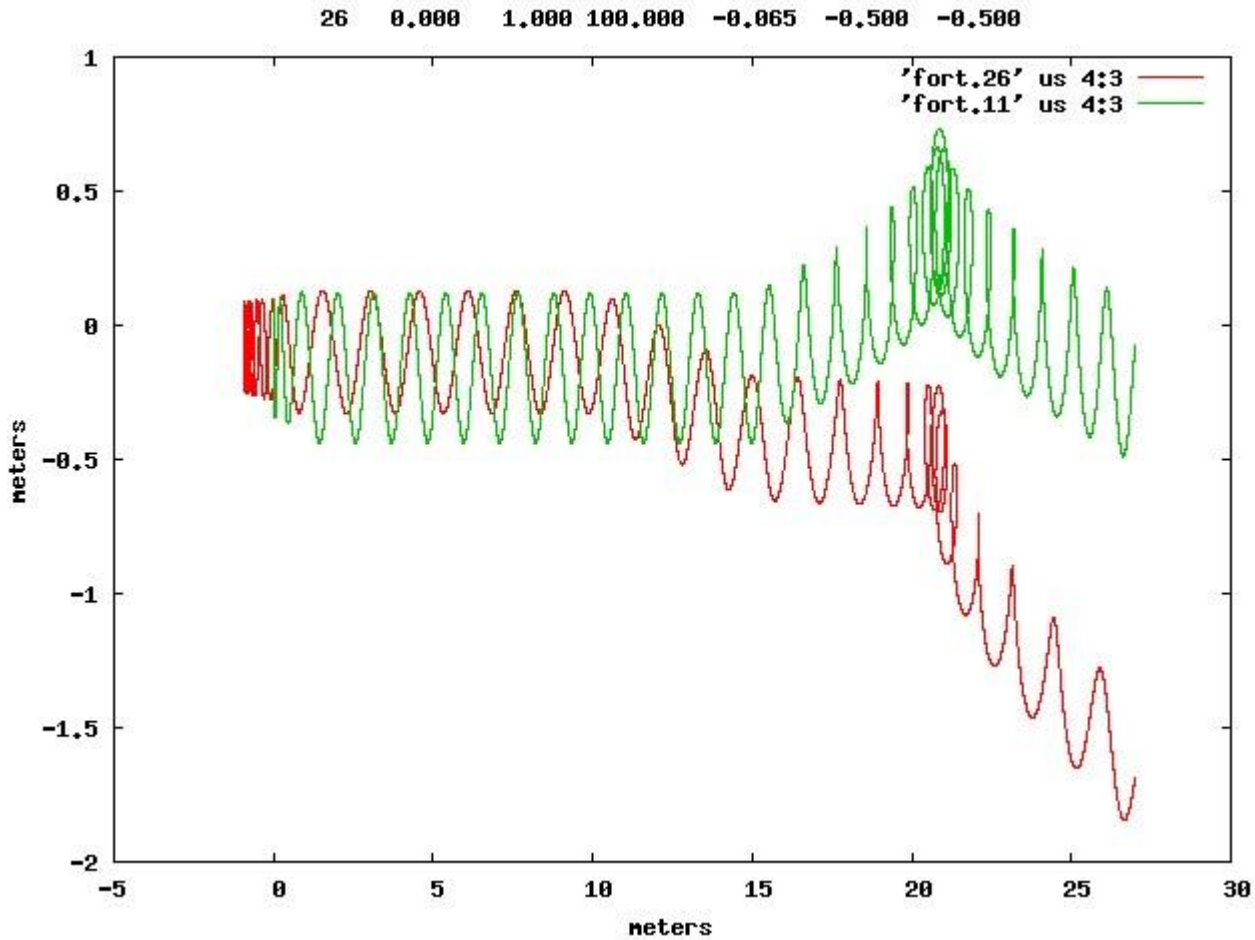
Green: Standard plot
Red: p0_z/p0=0.3, q=-1



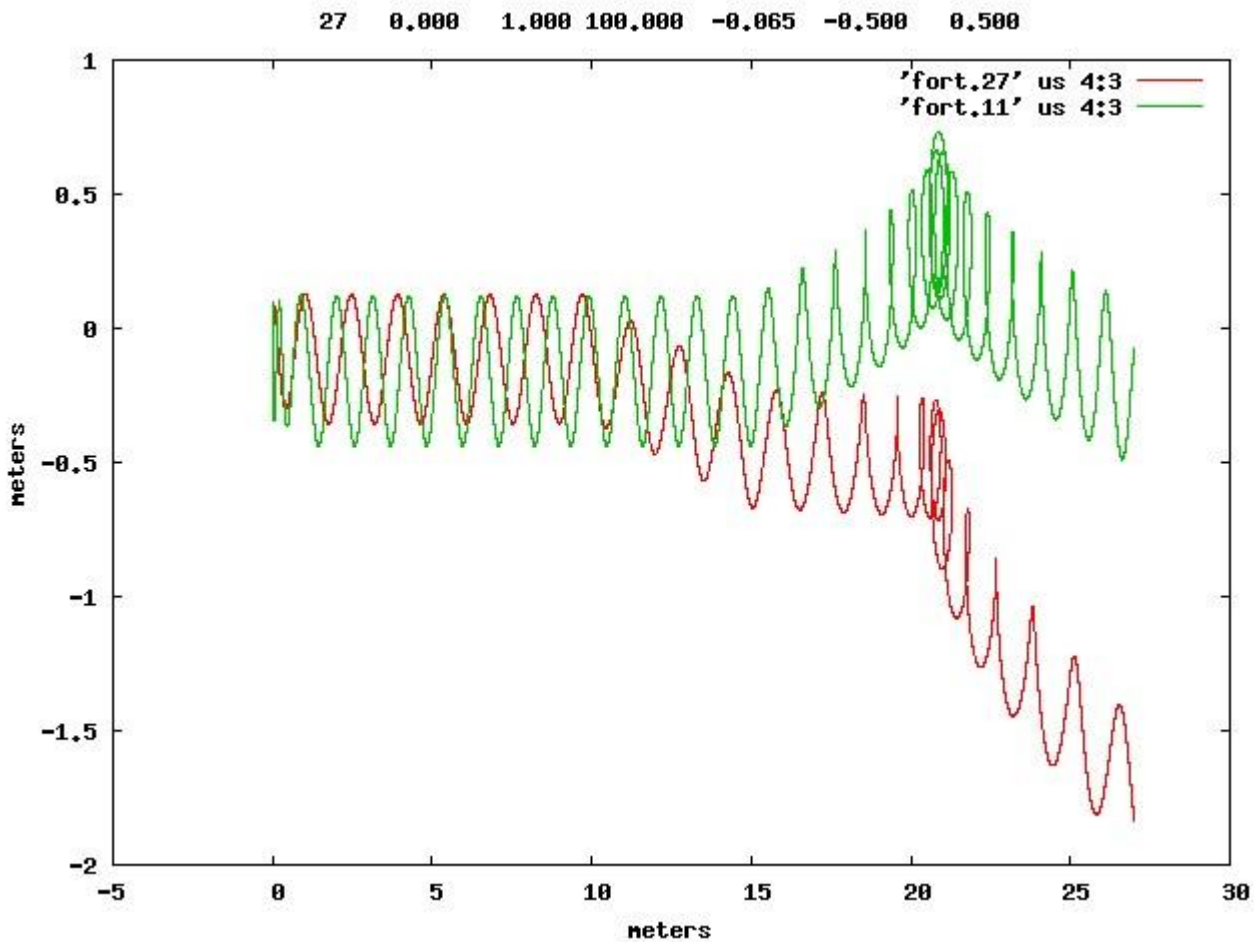
Green: Standard plot
Red: B_y=-.065 T for z>10 m
Leads to constant vertical displacement rate for 10<z<15 (straight solenoid)
Vertical displacement due to B_y and toroid gradient *cancel* in first toroid section and add in the second toroid section



Green: Standard plot
Red: q=-1, B_y=-.065 T for z>10 m
Vertical displacement rate for 10<z<15 is the same as for q=+1
Vertical displacement due to B_y and toroid gradient add together in first toroid section and cancel in the second toroid section, just the opposite from q=1 case



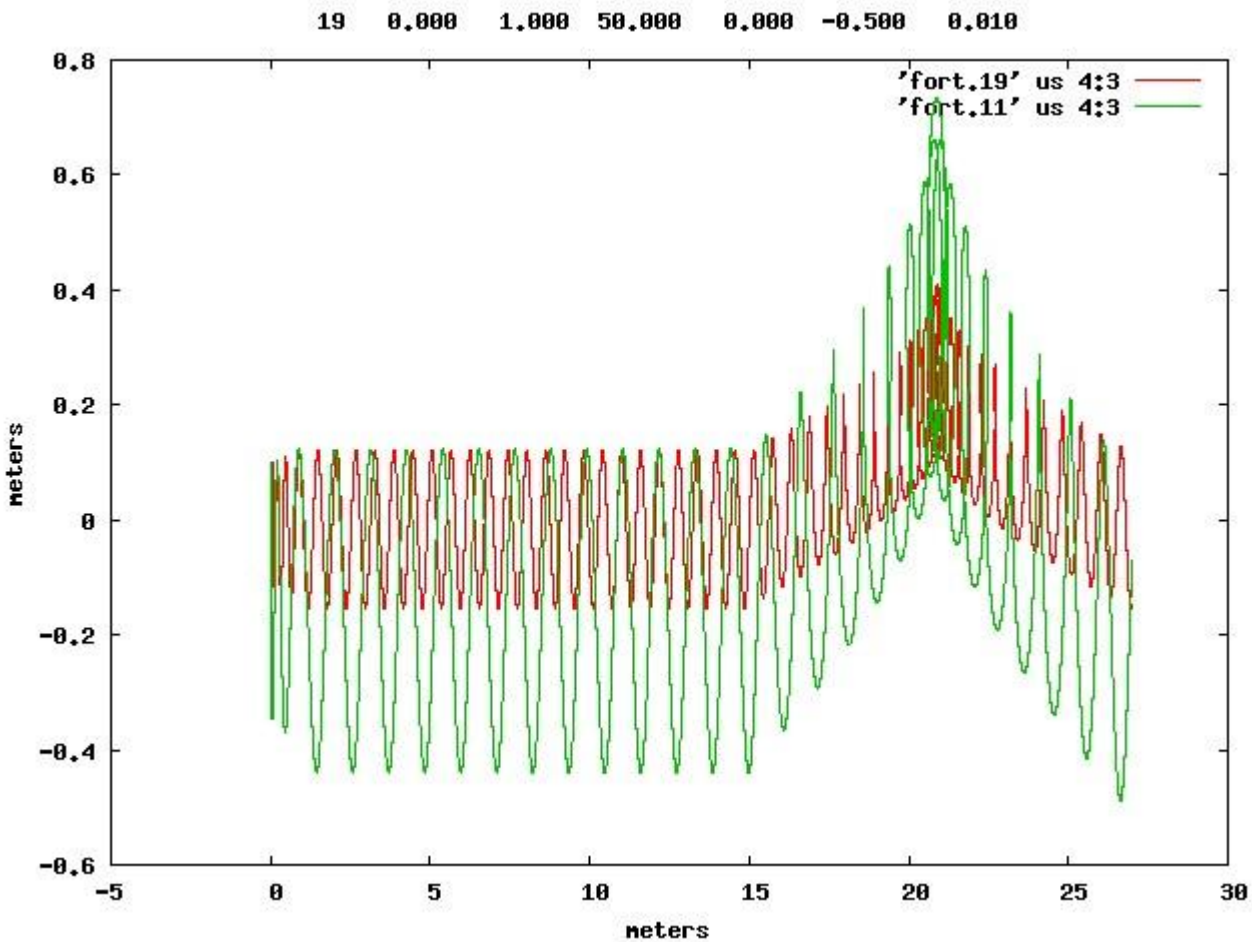
Green: Standard plot
Red: p0_z/p0=-0.5
B_y=-.065 for z>10 m



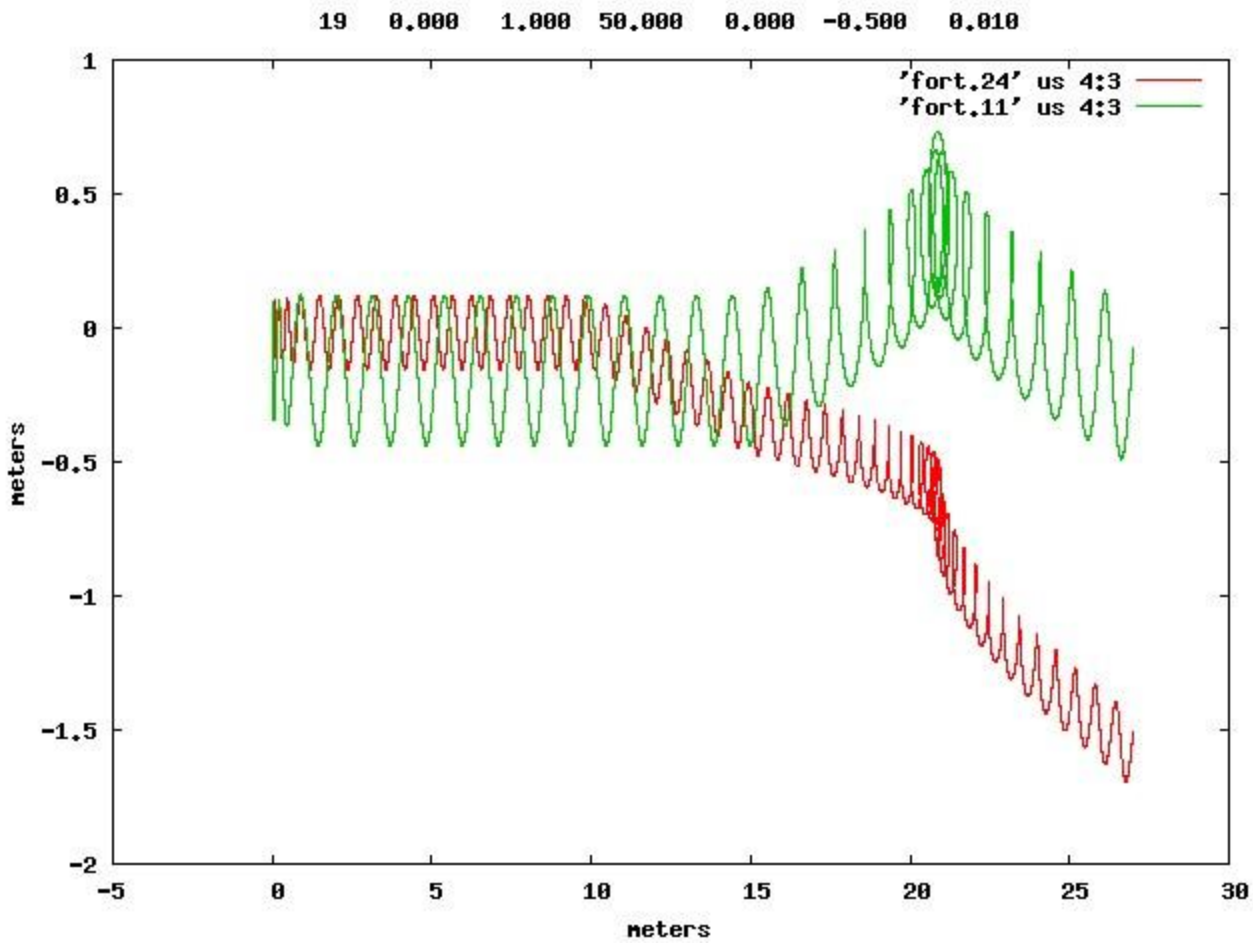
Green: Standard plot

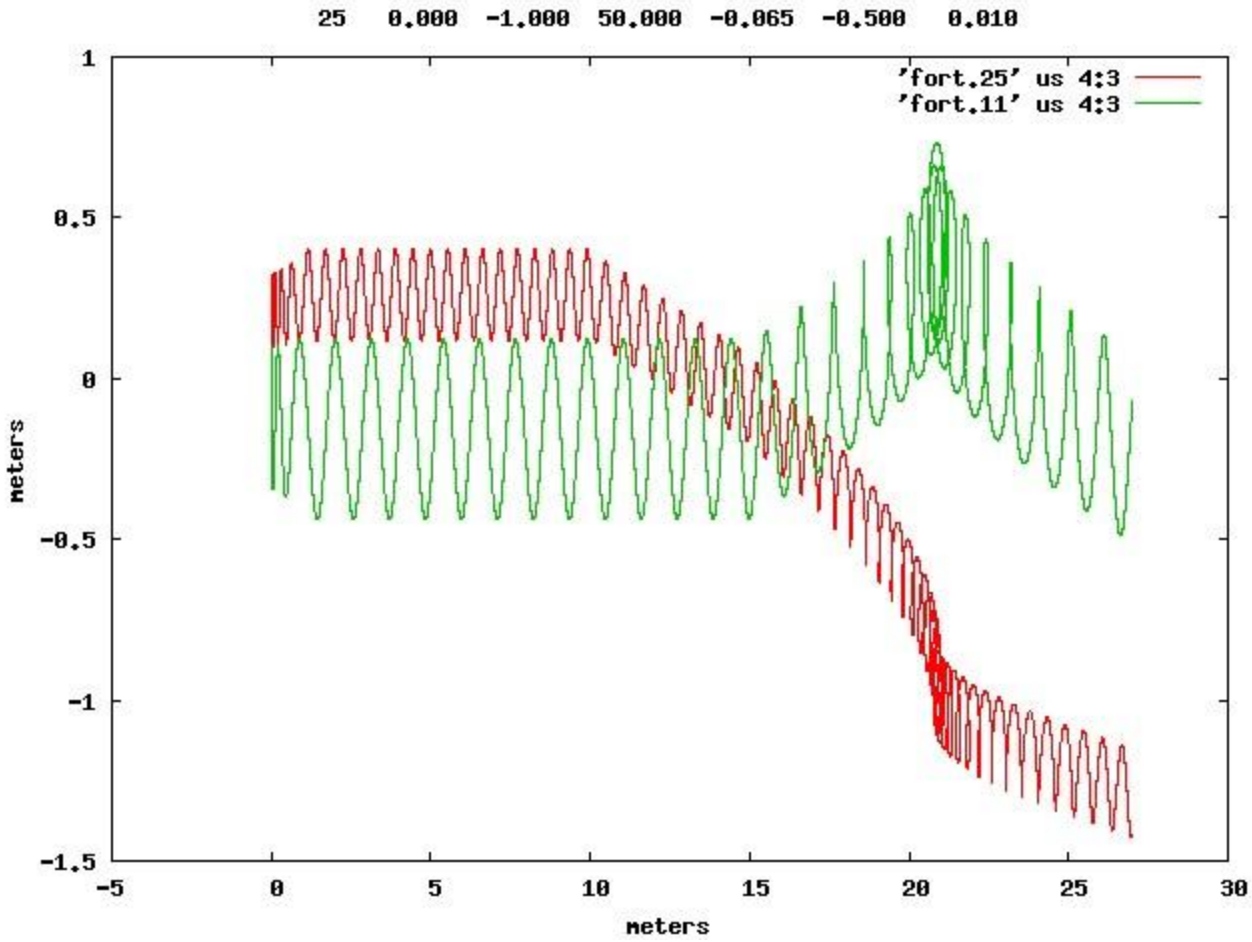
Red: p0_z/p0=+0.5

B_y=-.065 for z>10 m



Red: Standard Plot (100 MeV)
Green: 50 MeV


19 0.000 1.000 50.000 0.000 -0.500 0.010
'fort.24' us 4:3
'fort.11' us 4:3
1
0.5
0
-0.5
-1
-1.5
-2
meters
-5
0
5
10
15
20
25
30
meters


25 0.000 -1.000 50.000 -0.065 -0.500 0.010
'fort.25' us 4:3
'fort.11' us 4:3
1
0.5
0
-0.5
-1
-1.5
meters
-5
0
5
10
15
20
25
30
meters

Summary

- A uniform field perpendicular to the axis of a solenoidal magnet simply changes the direction of the field; all particles, +, -, any momentum, follow a spiraling path along the new field direction.
- Such a field can be used to adjust the position of the beam along the solenoid.
- Particles drift vertically in the toroidal portion; the amount depends on their momentum and charge.
- A uniform field added to a toroidal field just adds these two effects together; it can be used to separate electrons from protons, among other things.

Conclusions/Suggestions

- Put variable, uniform B_x and B_y at the end of TS to control the xy position of the beam entering the stopping target region.
- Use 70 MeV positrons from $\pi^+ \rightarrow e^+\nu_e$ (BR~10^{-4}) to calibrate the energy response of the detectors. (r=23.3 cm for 70 MeV, 35 cm for 105 MeV)
  - In order for the positrons to intersect the detectors at large radius, drive the incoming beam off of the center of the solenoid in several different directions onto a target of appropriate geometry. This is easier than reducing the fields of the solenoids. It may be necessary to move the downstream TS collimator to accomplish this. (Alternative: perhaps a target in the shape of a washer would work?)
  - In order to get π+ we either need to reverse the fields, or rotate the collimator in the middle of the TS (preferred).
  - Needed: a simulation of the distribution of π+ going into DS, and of the production of e+, along with a target design which gives the right multiple scattering, etc. One thing which must be different is the direction of rotation of the helix.
  - Another option for energy calibration is to use the high-E edge (near 53 MeV) of either $\mu+$ or $\mu-$ decays. In this case, at such a low energy, we would certainly have to offset the beam in several directions to calibrate different portions of the detector. (How well do we know the μ- spectrum for bound muons in this region?)
  - We can also use the upper edge of the $\mu-$ spectrum (near 105 MeV) for calibration, but here there is some uncertainty in the cross section as a function of energy, and we do not know the shape of the detector response function.
- Use a fast-pulsed (or RF) B_x or B_y in the TS to drive off particles which would otherwise arrive at the stopping target late. (Can we do such a thing inside a superconducting solenoid? Use a cosθ magnet?)