Effects of Quad Misaligments on Beam Polarization for M2M3

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The effects of quad misalignment on beam polarization

- We want to look at how the spin alignment of the particles in the beam is affected by misalignments among the quad magnets.
- Focused on the delivery system of M2, M3, DR, M4, M5

- NOTE: This is still a work in progress, and the aim here is to report what has been done so far.

Misalignments in G4BL create complications

PROBLEM

- Placing magnets with centerline coordinates want to use the center of the beam as the origin for the transverse plane.
- Though longitudinal coordinate is preserved, every misalignment caused an implied change to x,y (transverse) placement of next quad on beamline

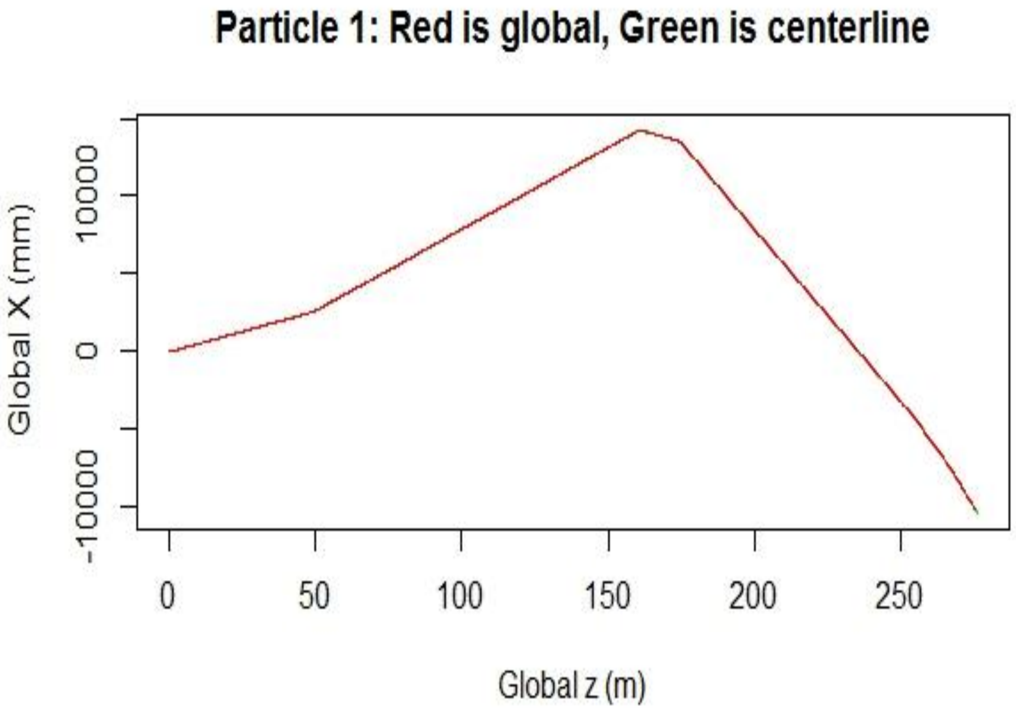
SOLUTION – Use global coordinates

- Beam elements can now be placed independent of beam position
- Increases the flexibility of our code, allowing us to explore problems like misalignments (my topic for today), injections and extraction much more easily.
- Means we can assign errors for magnets independently of each other.
- We can generate errors much more easily using parameters, which allows multiple simulations for various error sigmas.

Results for M2 and M3 beamline

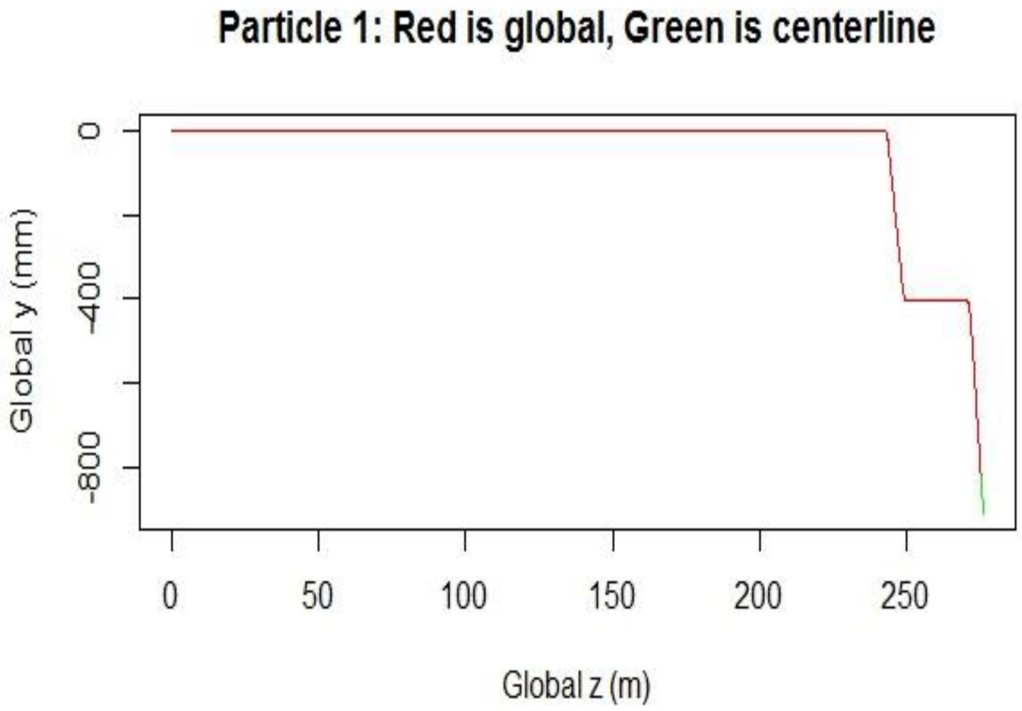
Plot of Centerline (Green) and Global (Red)

Match closely in X direction



Plot of Centerline (Green) and Global (Red)

Match closely in Y direction



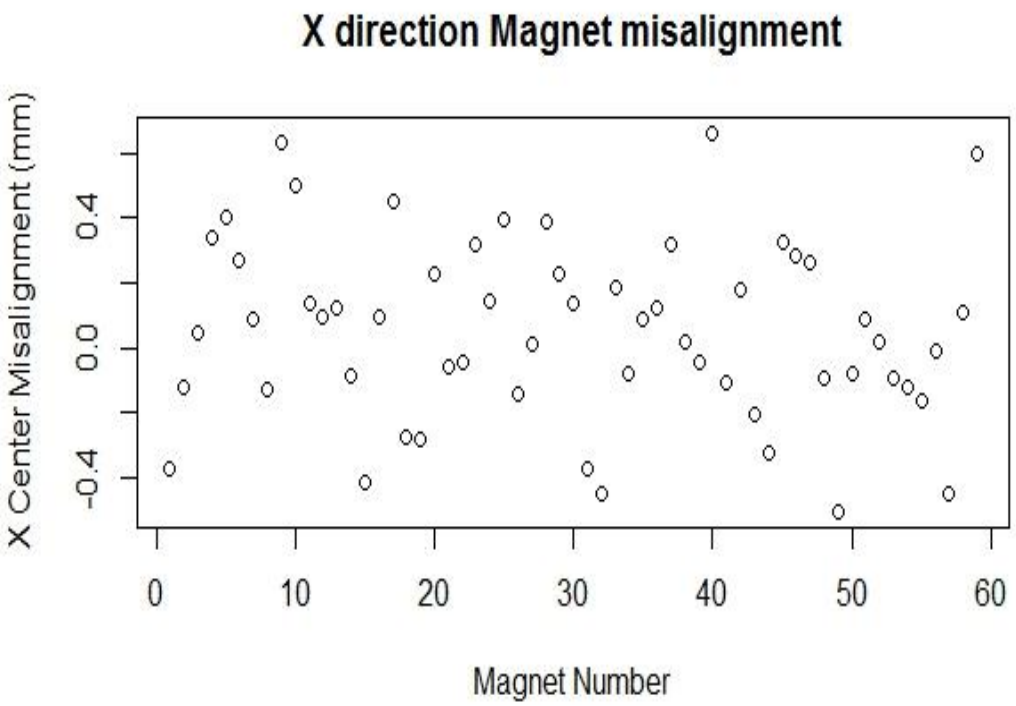
Wanted to find out what error tolerances we can handle

- Randomly generated a set of errors
- Scaled them to have a sigma of 0.25, 0.50, 0.75, and 1mm.
- Tried to see which error scale was reasonable for ensuring particles actually made it through.
- Simulated a single particle starting off on the “ideal” trajectory (x,x’)=(0,0).
- Repeated this process for 10 different random sets of errors.

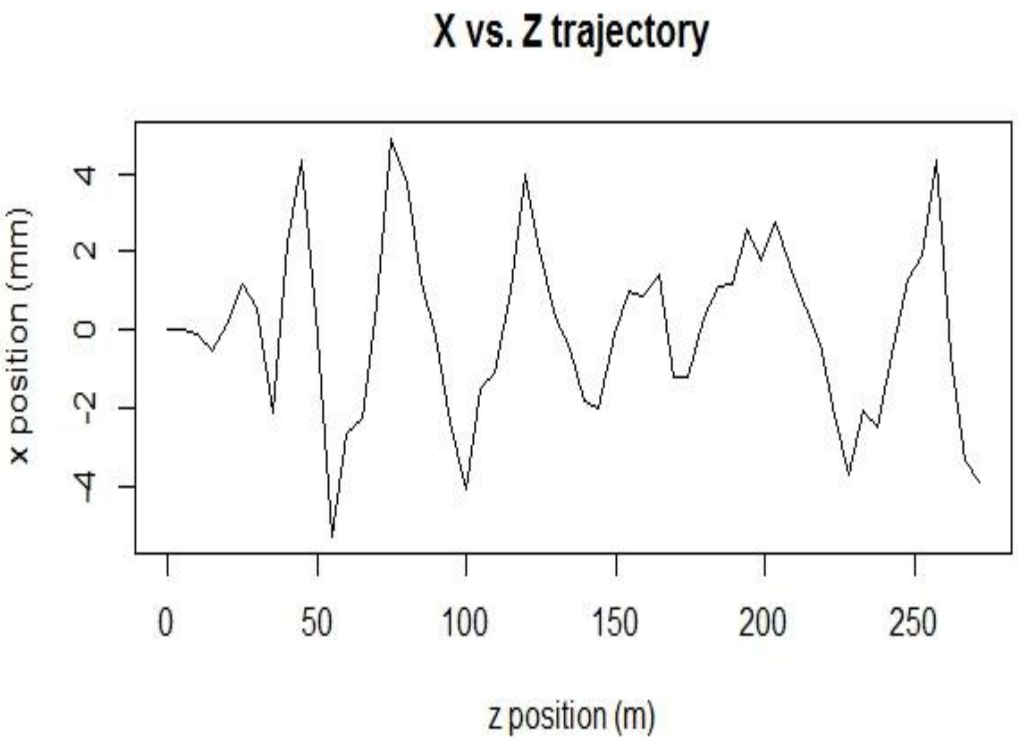
- Note: we’re not using any sort of correction magnets, so they’re omitted from analysis, for now.

Example of single particle X direction

This plot shows the magnitude of misalignments in x direction along z

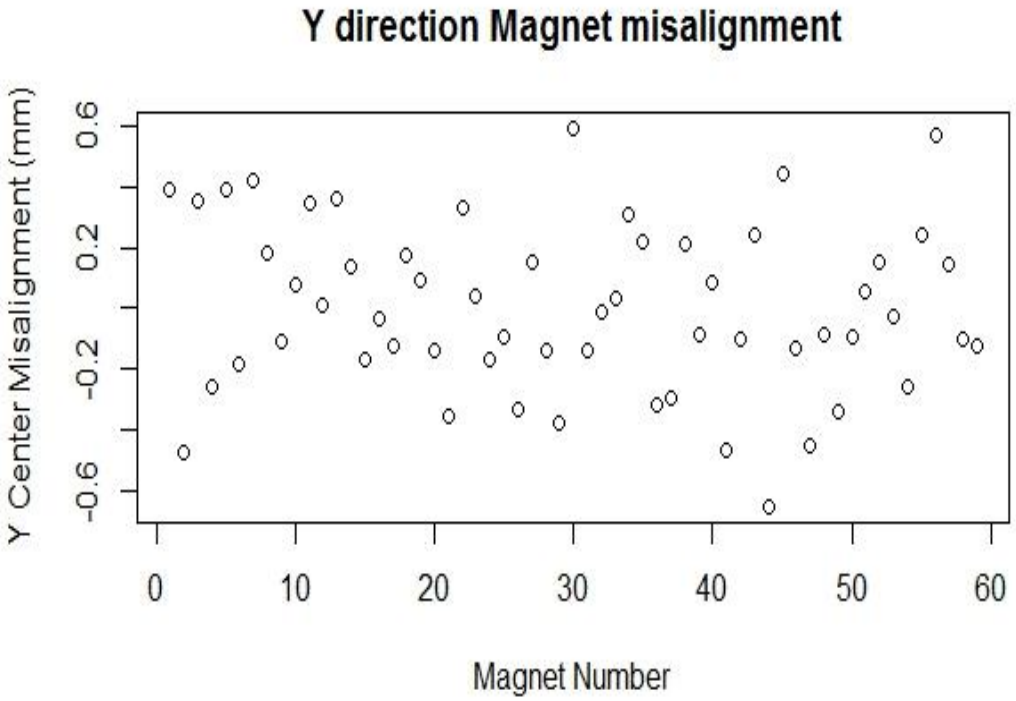


Single particle trajectory in x vs. z

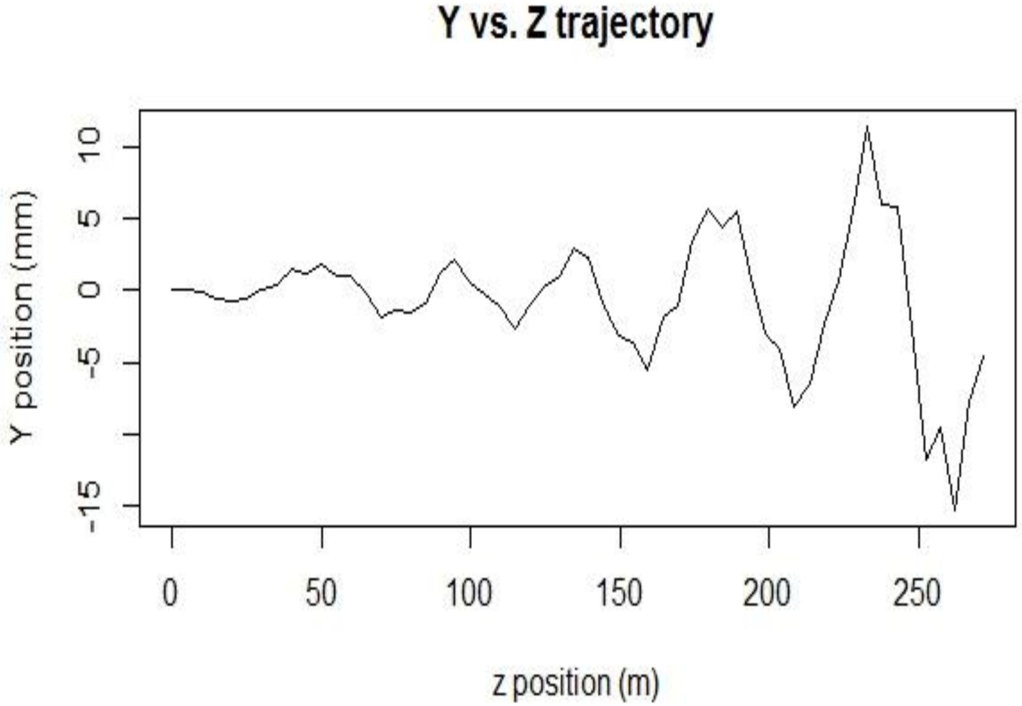


Single particle in y direction

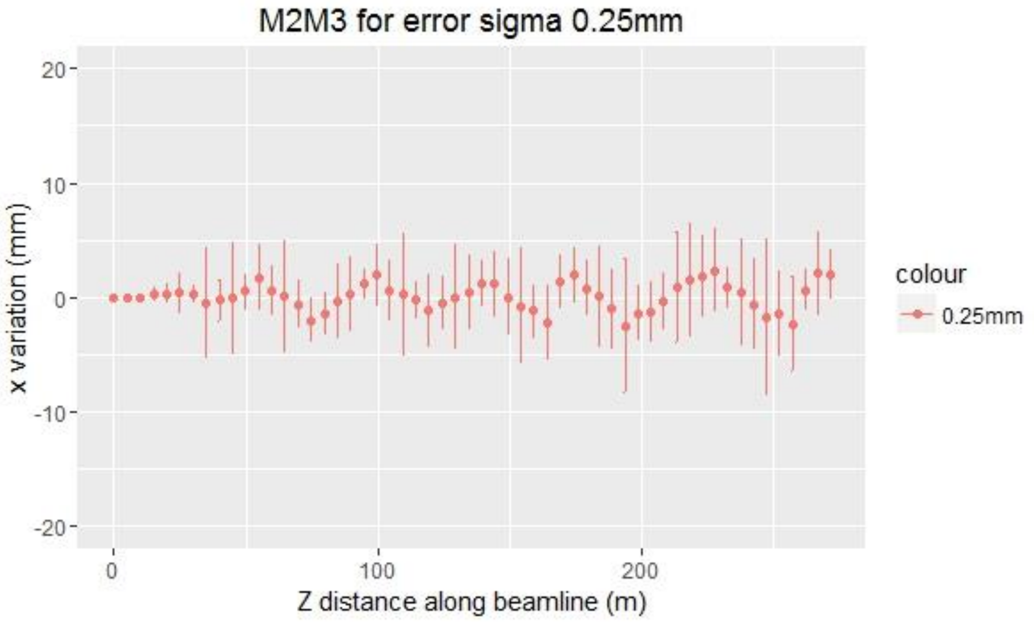
Magnet misalignment

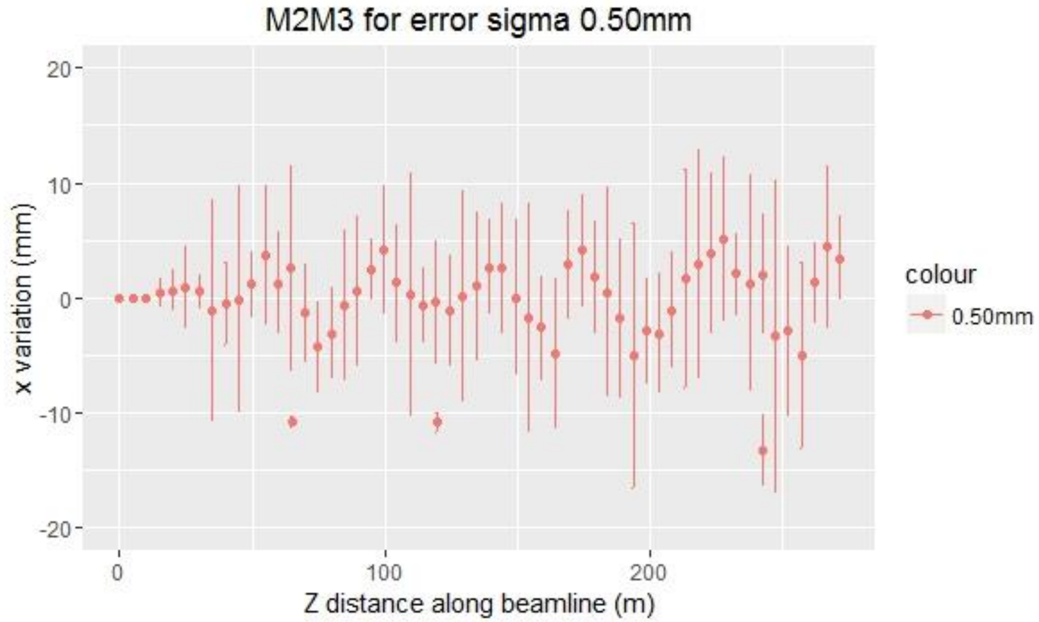


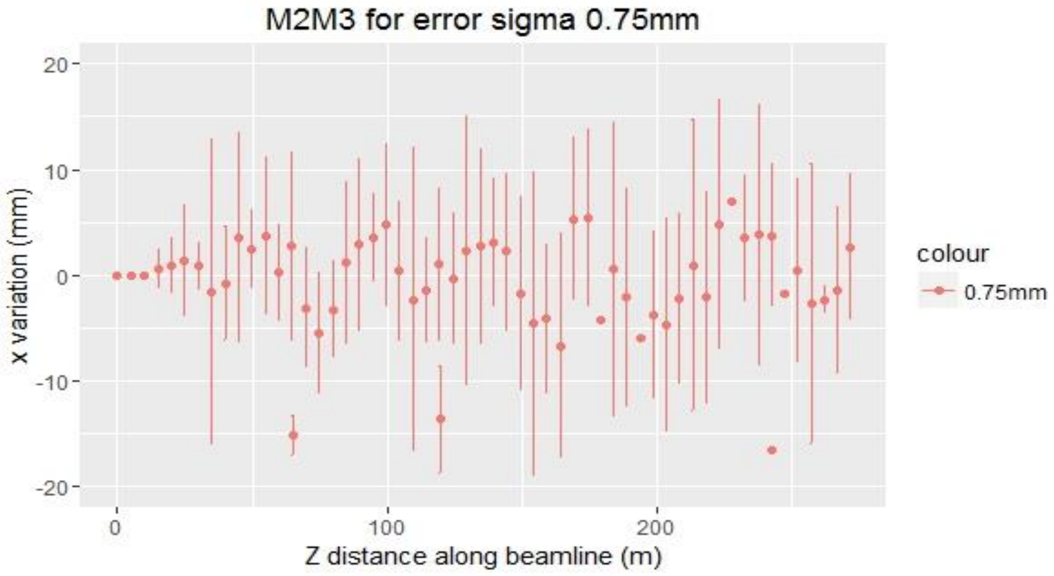
Particle trajectory

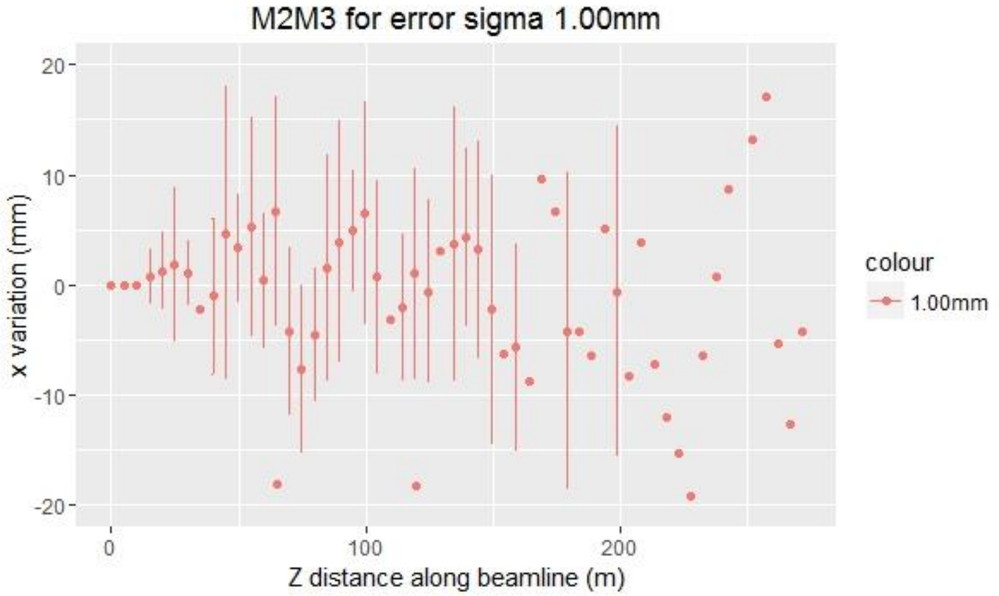


Testing for error tolerances









Looking at polarizations

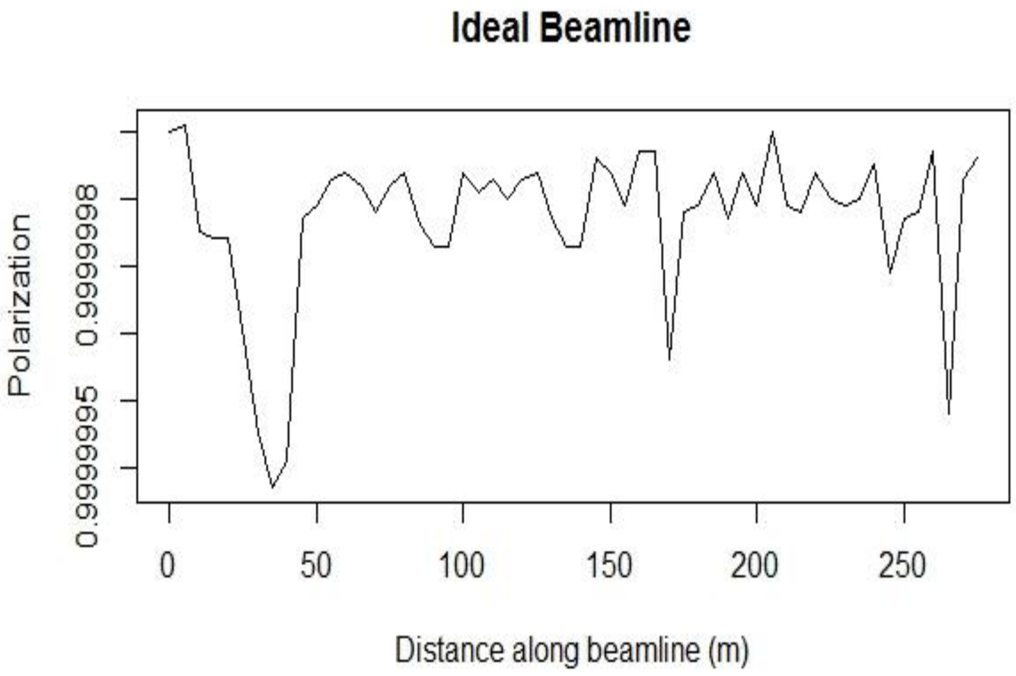
- Next, we generated a set of random errors on magnets with sigma = 0.25mm
- Ran a simulation with 500 particles
- Repeat 10x

- Want to look at the spread of the polarization of the particles at various points on the beamline.

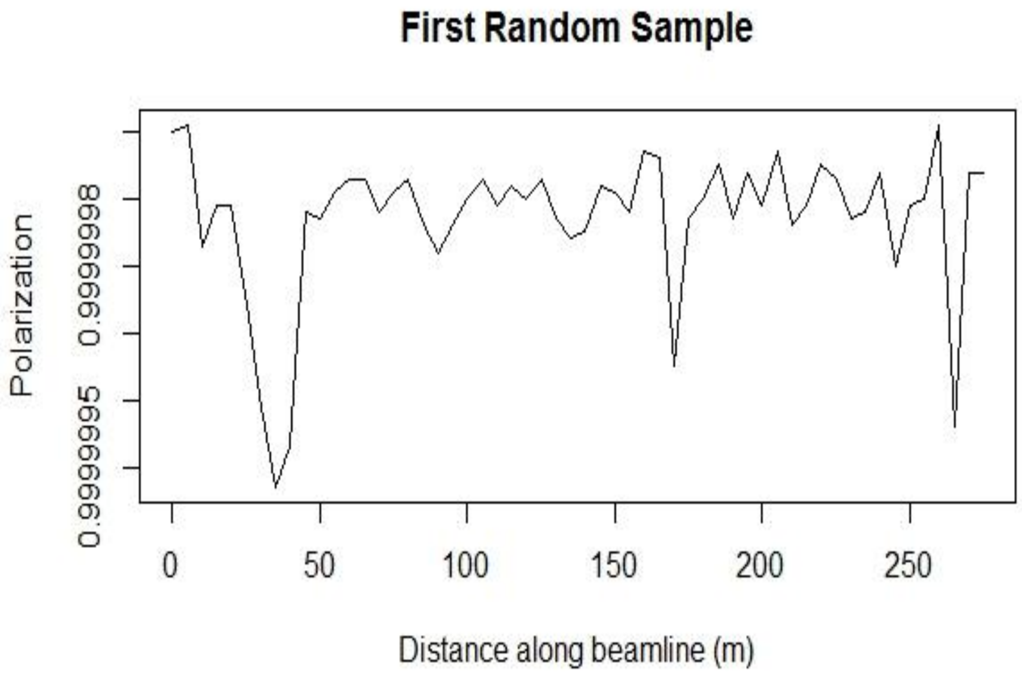
Now, we examine polarization

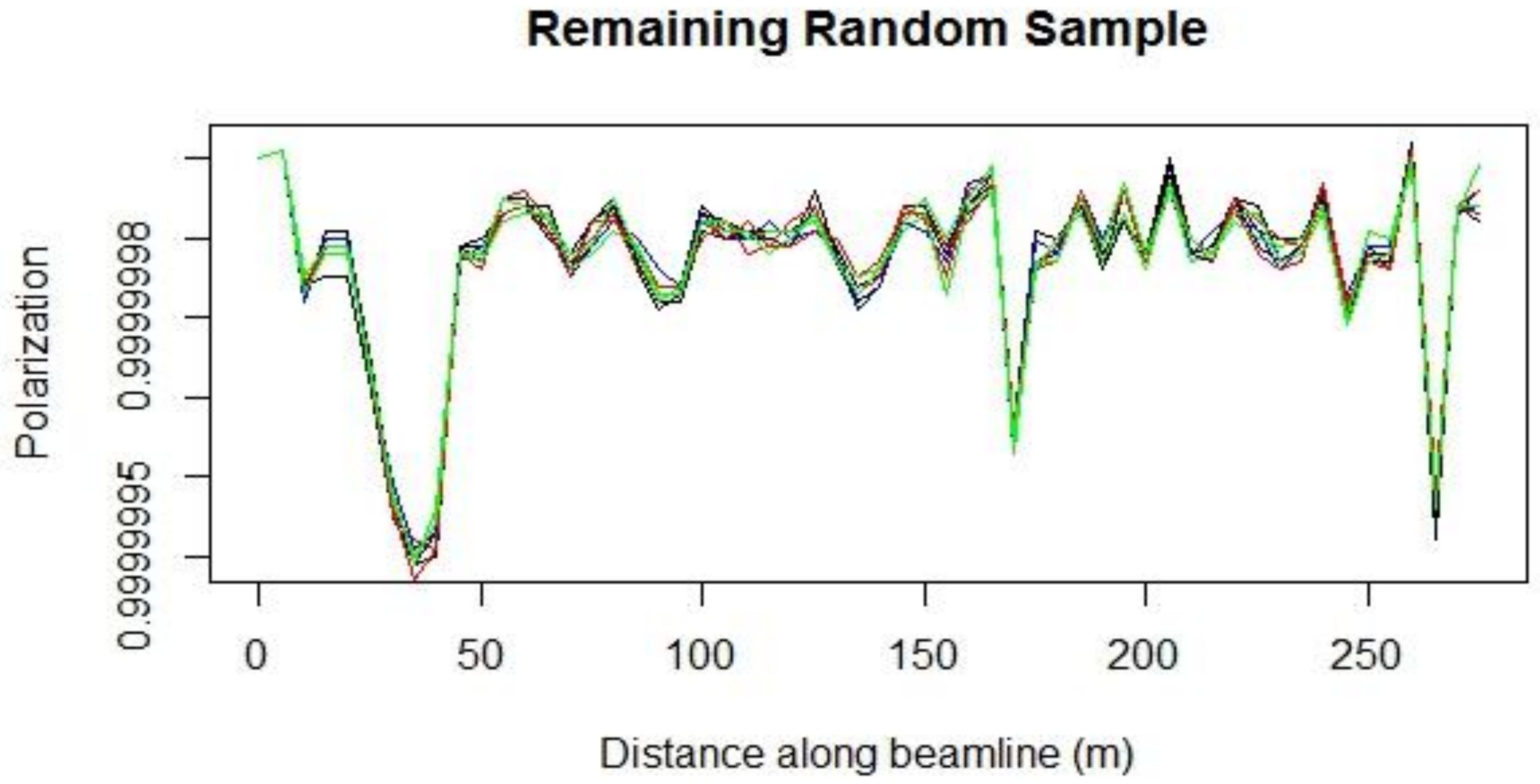
Define polarization as $p = \sqrt{P_{x(avg)}^2 + P_{y(avg)}^2 + P_{z(avg)}^2}$

Here's the distribution along ideal beamline (no magnet misalignment)



Here's distribution after magnets misaligned





Remaining Random Sample
Polarization
0.9999995
0.9999998
Distance along beamline (m)
0
50
100
150
200
250

Findings

- Errors greater than 1.00 mm can cause problems with beam making it through the entire beamline (only 1 particle survived past 200m)
- Steering correctors will help in this regard. Here, we have worst case scenario.

Future considerations

- Want to continue to look at polarization effects
- Extend to look at larger statistics (10^11 particles), adding momentum spread, particle decay in G4BL.
- Extend analysis to DR, and M4/M5
- How do alignment errors affect the polarization spread upon delivery to storage ring?