Muon Cooling Project Updates

April 25, 2025

https://github.com/criggall/muon-cooling

Progress from this week

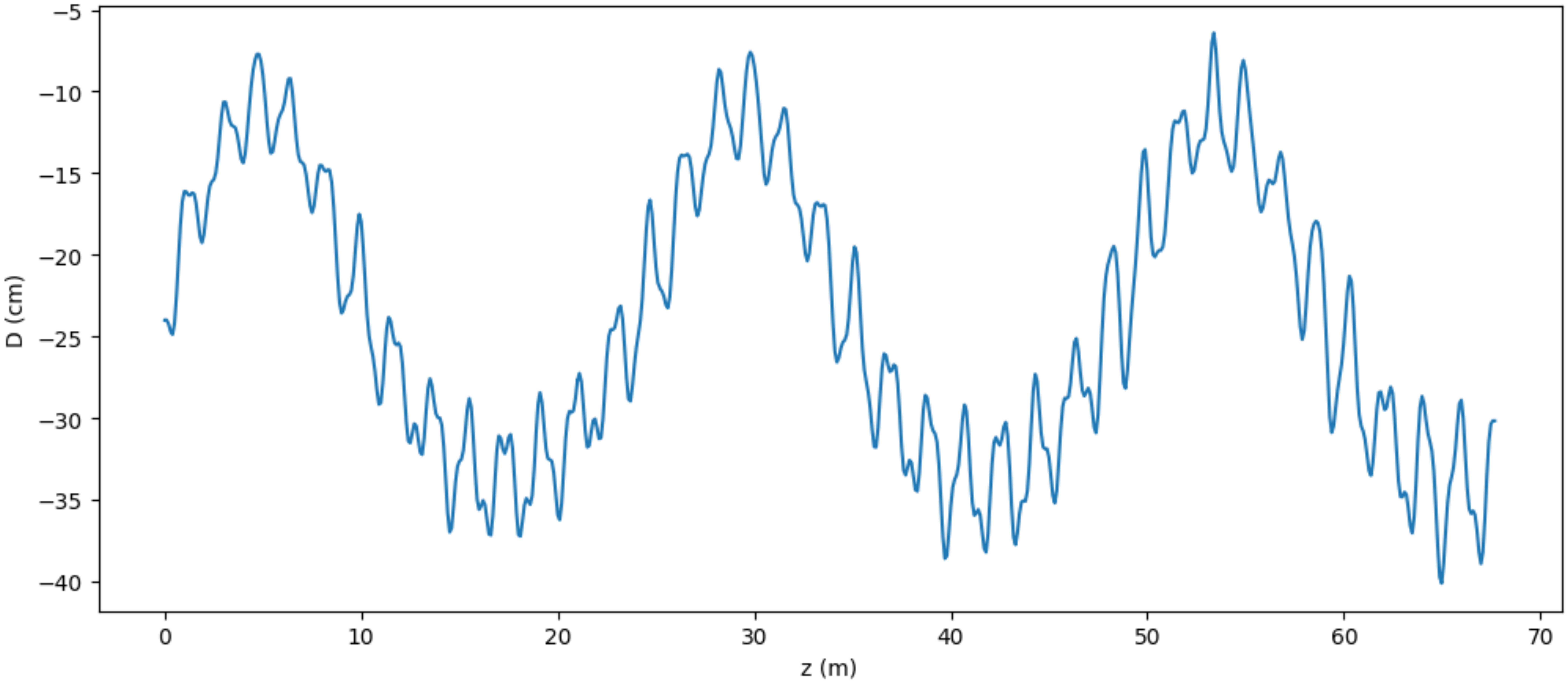
- Continued investigation of dispersion and beta function
    - Adding more terms from FFT to fit
    - Letting more parameters (namely a and k) float in fit
    - Considering larger range of values
- Downloaded ECALC9
    - Tried running on Windows machine + installing Windows Docker image to run .exe — no success
    - Using Docker image with Fortran compiler to build from source instead

Dispersion

$$D(s) = \frac{\Delta r(s)}{\Delta p/p}$$ ← Reference momentum

Along 16 periods

$\Delta p = -0.1$ MeV/c

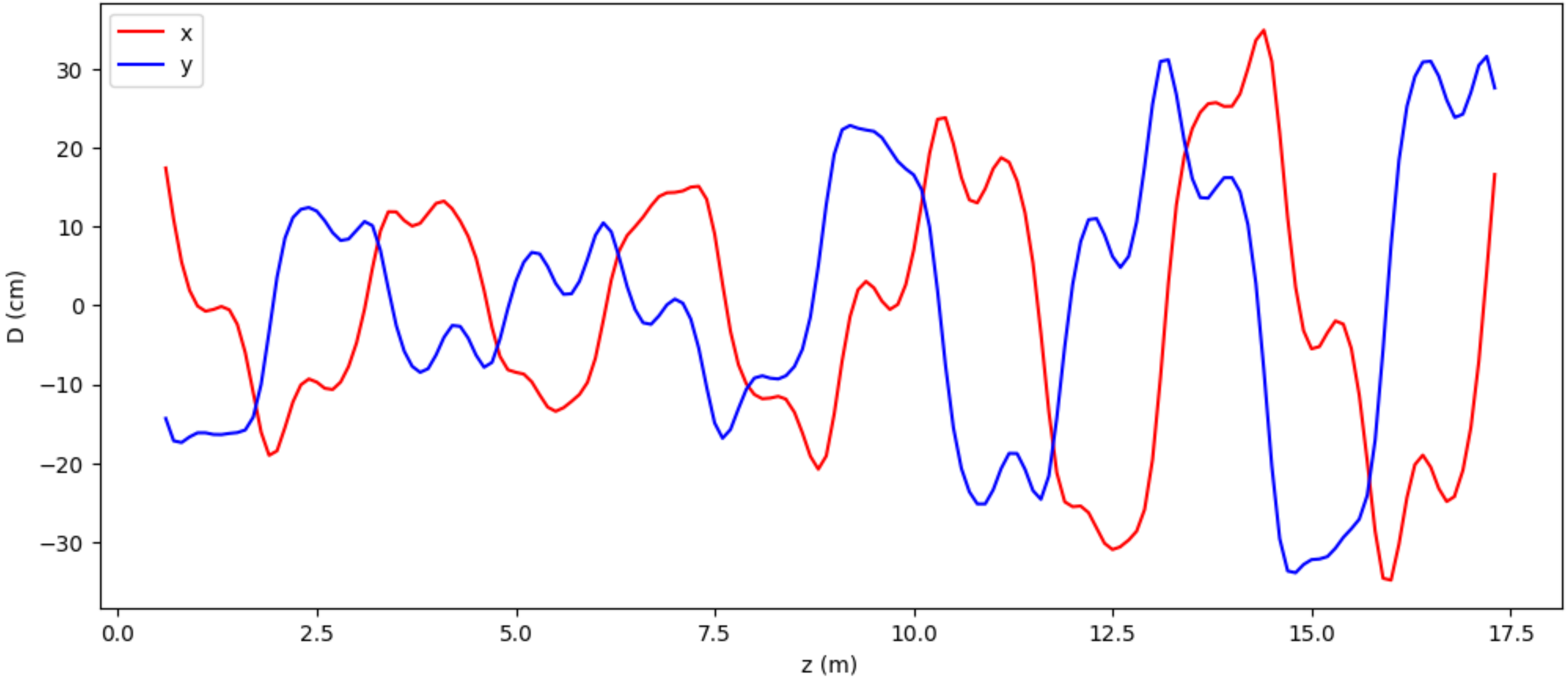


Dispersion

Along 16 periods

$$D_x(s) = \frac{\Delta x(s)}{\Delta p/p} \qquad \Delta x = x(s) - x_0(s)$$

$$D_y(s) = \frac{\Delta y(s)}{\Delta p/p} \qquad \Delta y = y(s) - y_0(s)$$

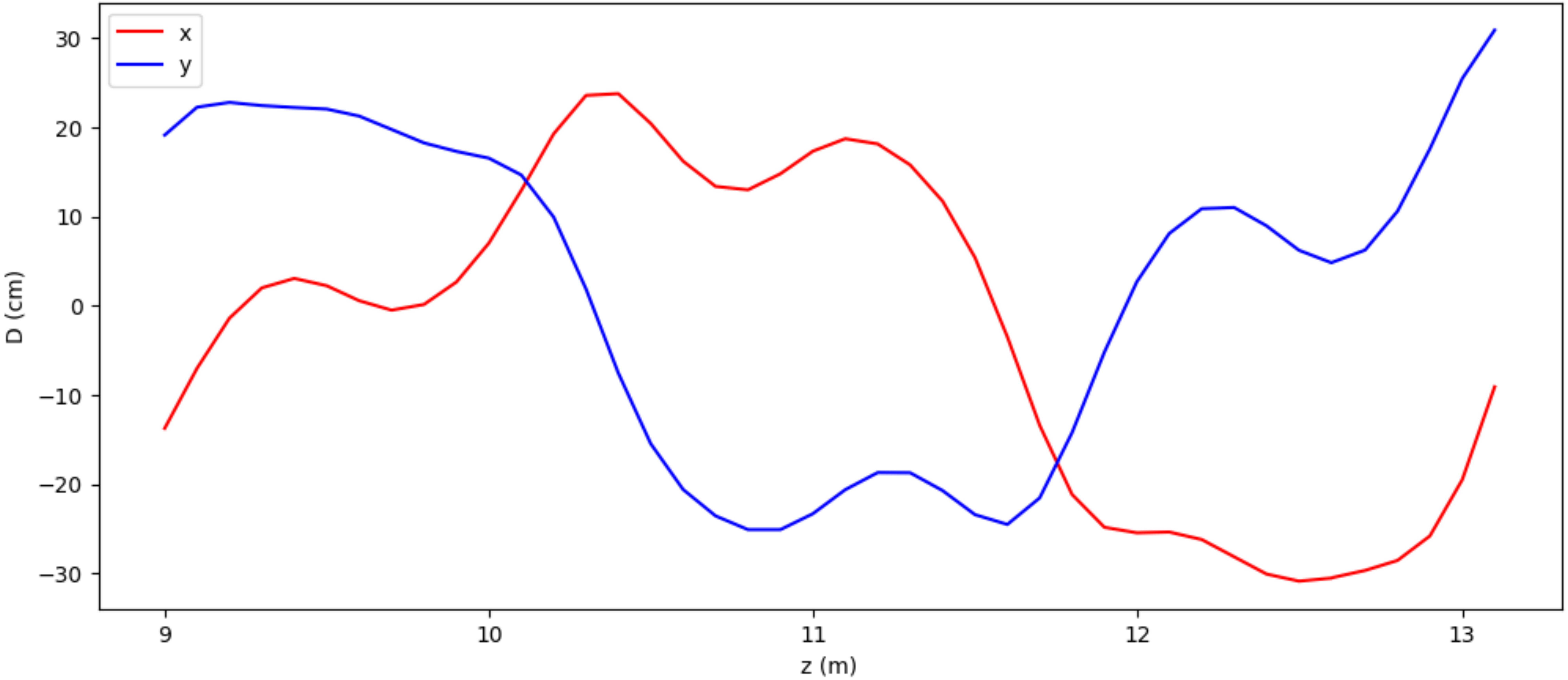


Dispersion

$$D_x(s) = \frac{\Delta x(s)}{\Delta p/p} \qquad \Delta x = x(s) - x_0(s)$$

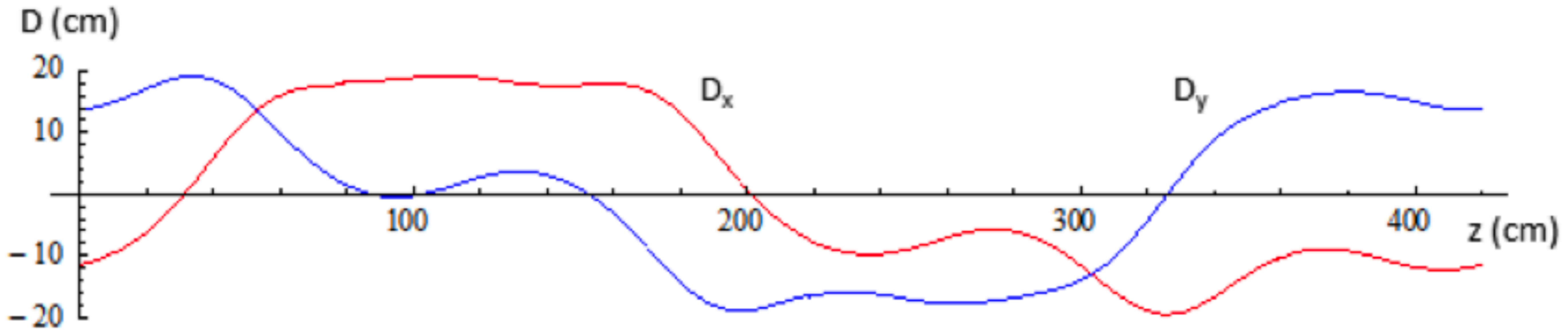
$$D_y(s) = \frac{\Delta y(s)}{\Delta p/p} \qquad \Delta y = y(s) - y_0(s)$$

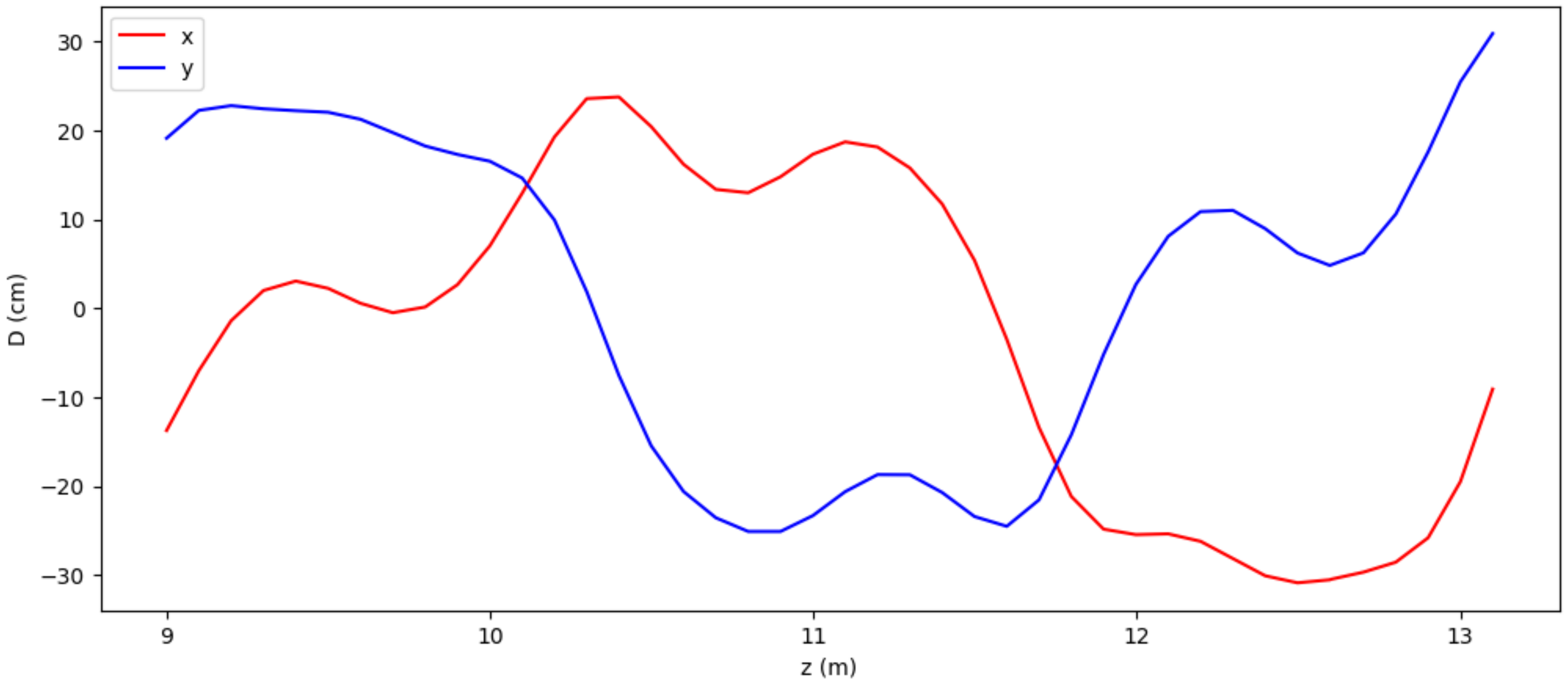
For a single period (third)



Comparing to the paper

- Order of magnitude of dispersion in agreement
- Do we expect our beam optics to be similar to Yuri's at this point?
  - Change in E along channel suggests not





Beta function

- Adding more peaks from FFT by eye yielded minimal improvement to the fit
  - Still missing some small-scale oscillations
- How to translate to actual estimate for beta function?

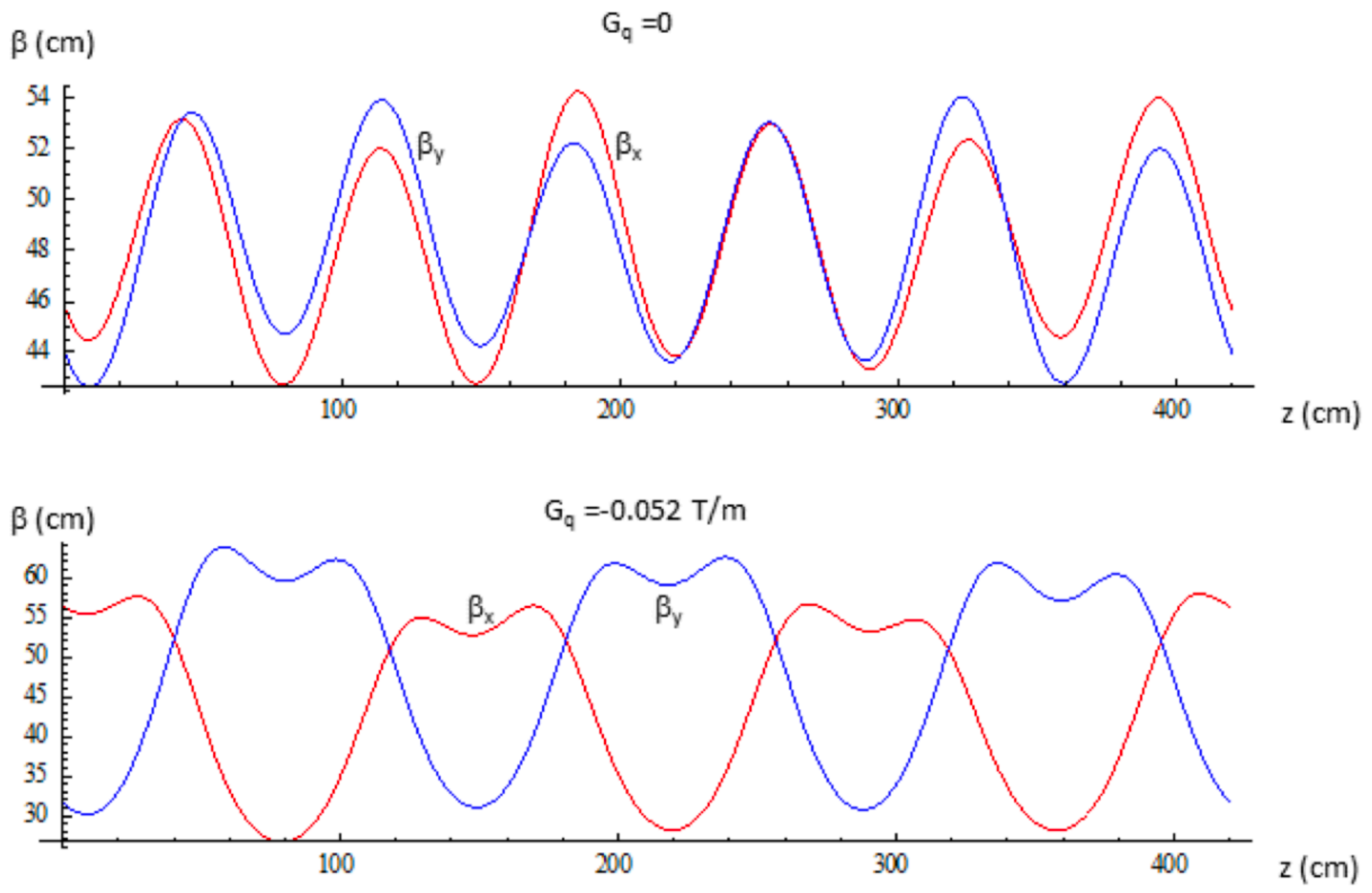
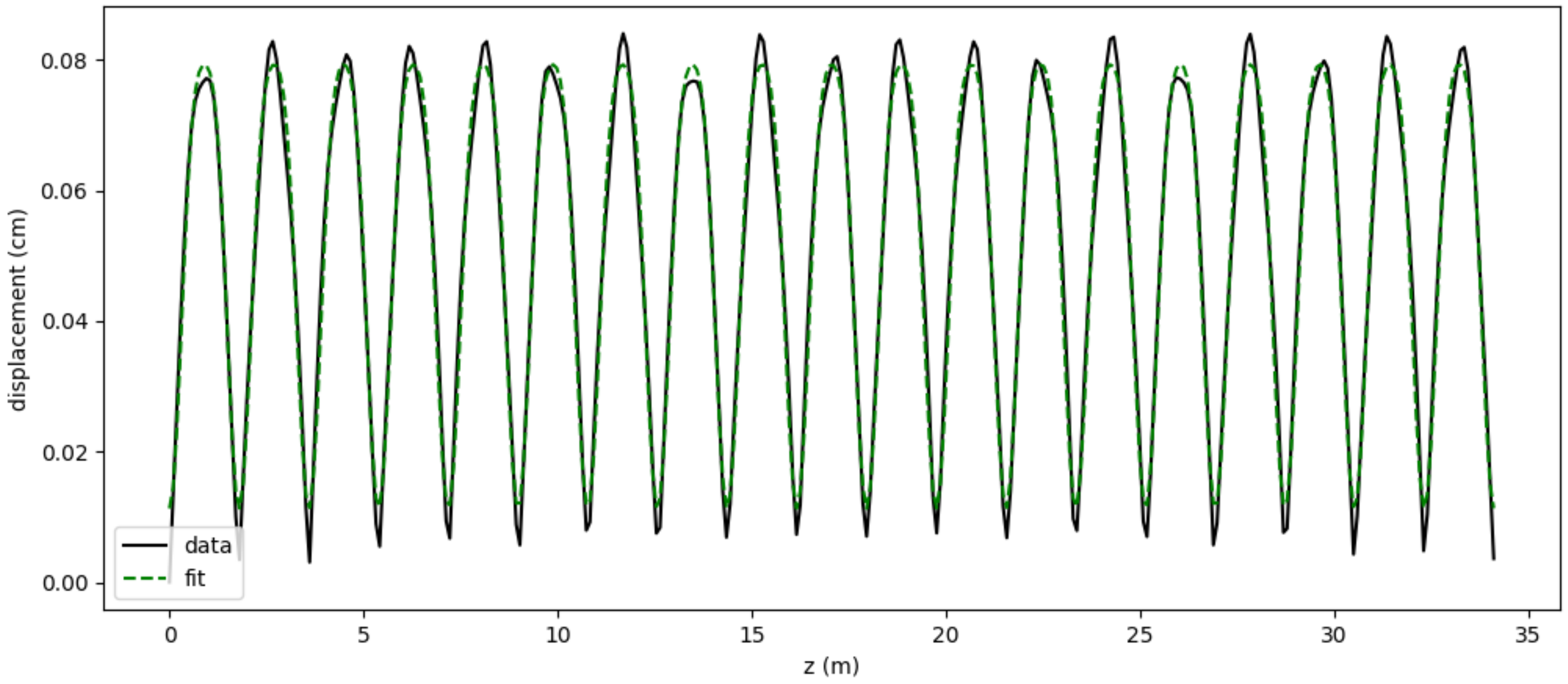


Figure 2. μ^+ transverse β-functions with no (top) and with constant quadrupole field of $G_q = -0.052\,\mathrm{T/m}$ (bottom).



Next steps

- Looking for Python function that automates sinusoid fitting process (to avoid uncertainty from picking out FFT peaks by hand)
- Further investigations into beam optics?
- Proposing to build a modernized version of ECALC9
  - Python (more user-friendly) or C++ (faster)
  - Interface with G4beamline
  - Available on GitHub for open use