

HF0F0 Project Updates

August 28, 2026

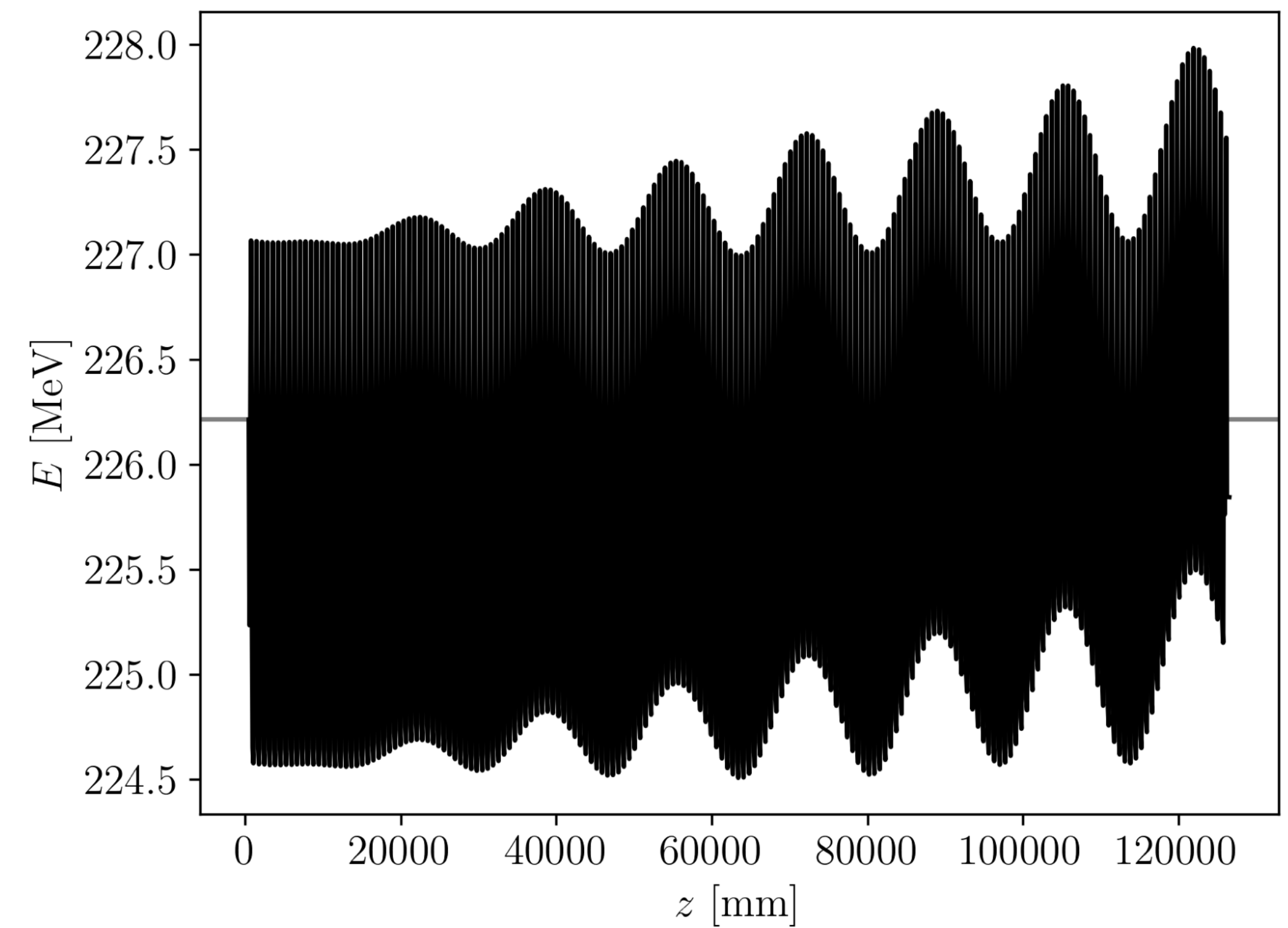
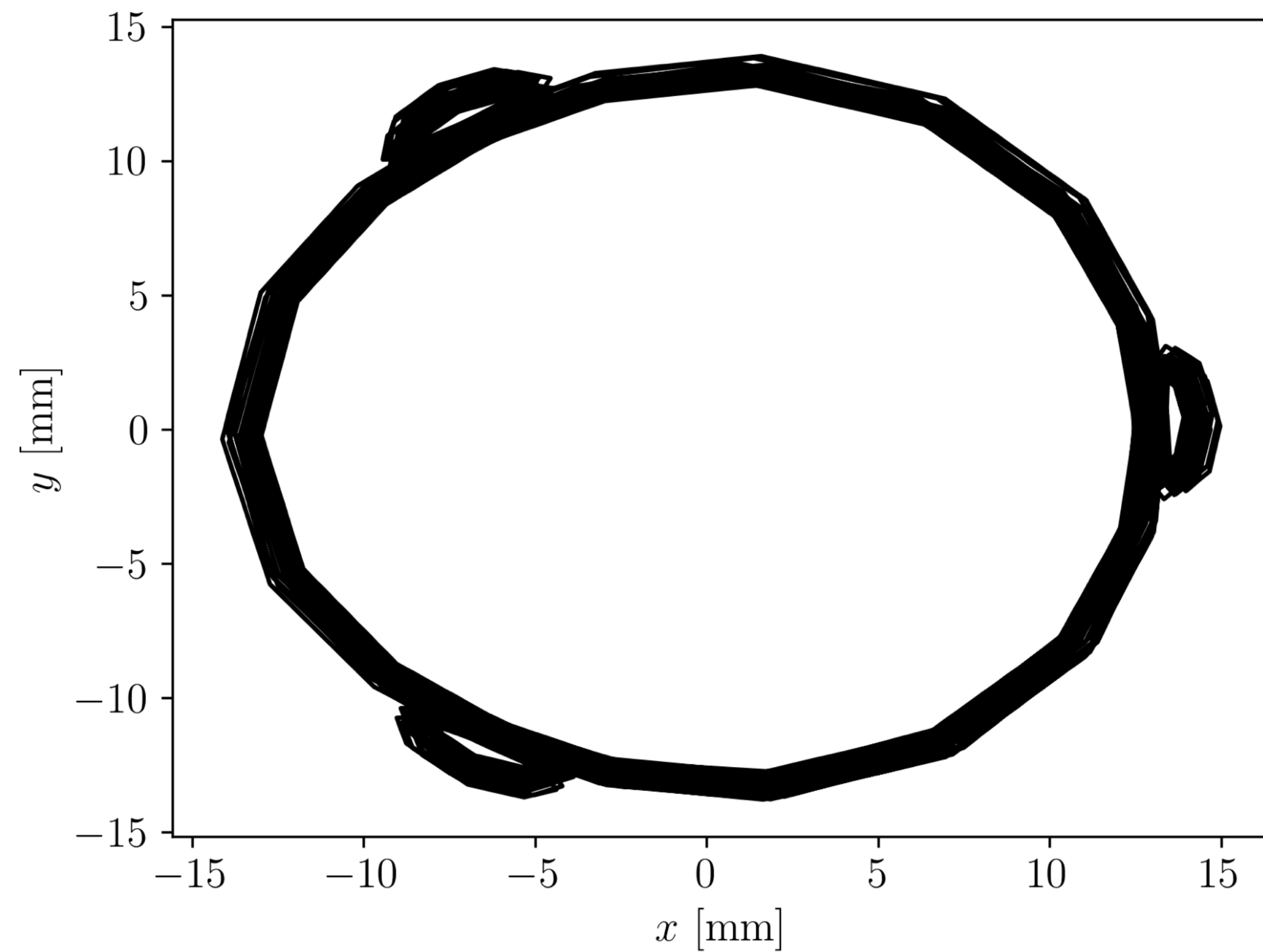
<https://github.com/criggall/muon-cooling/tree/main>

The case of the drifting orbit

A continuation of Issue #30

The facts

We observe the periodic solution drift along the channel. Why?

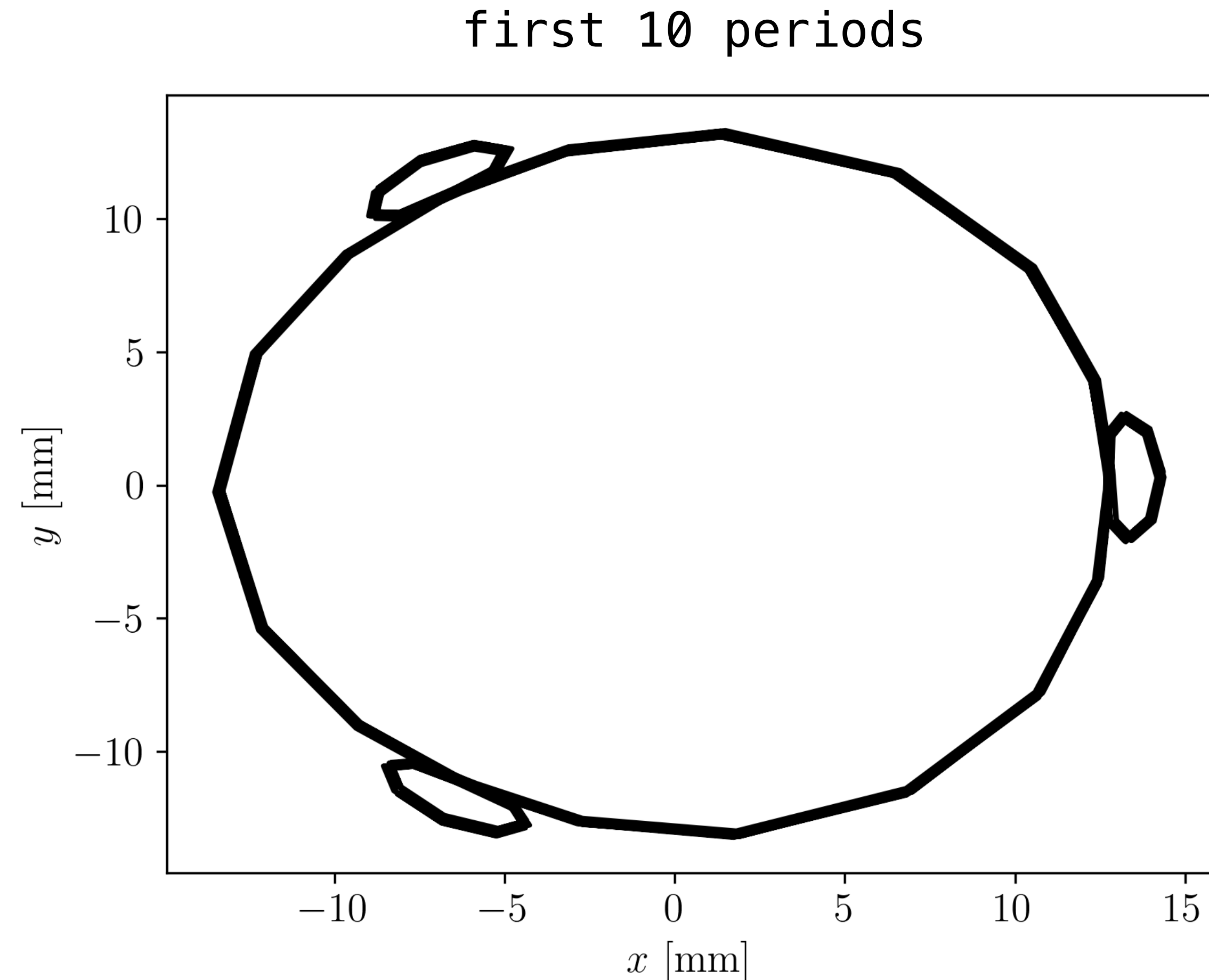


Our first suspect

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~~Possibility 1:~~
~~the solution not *fully* periodic~~

...But the behavior in the early stages of the channel is (within reasonable margin of error) truly periodic*



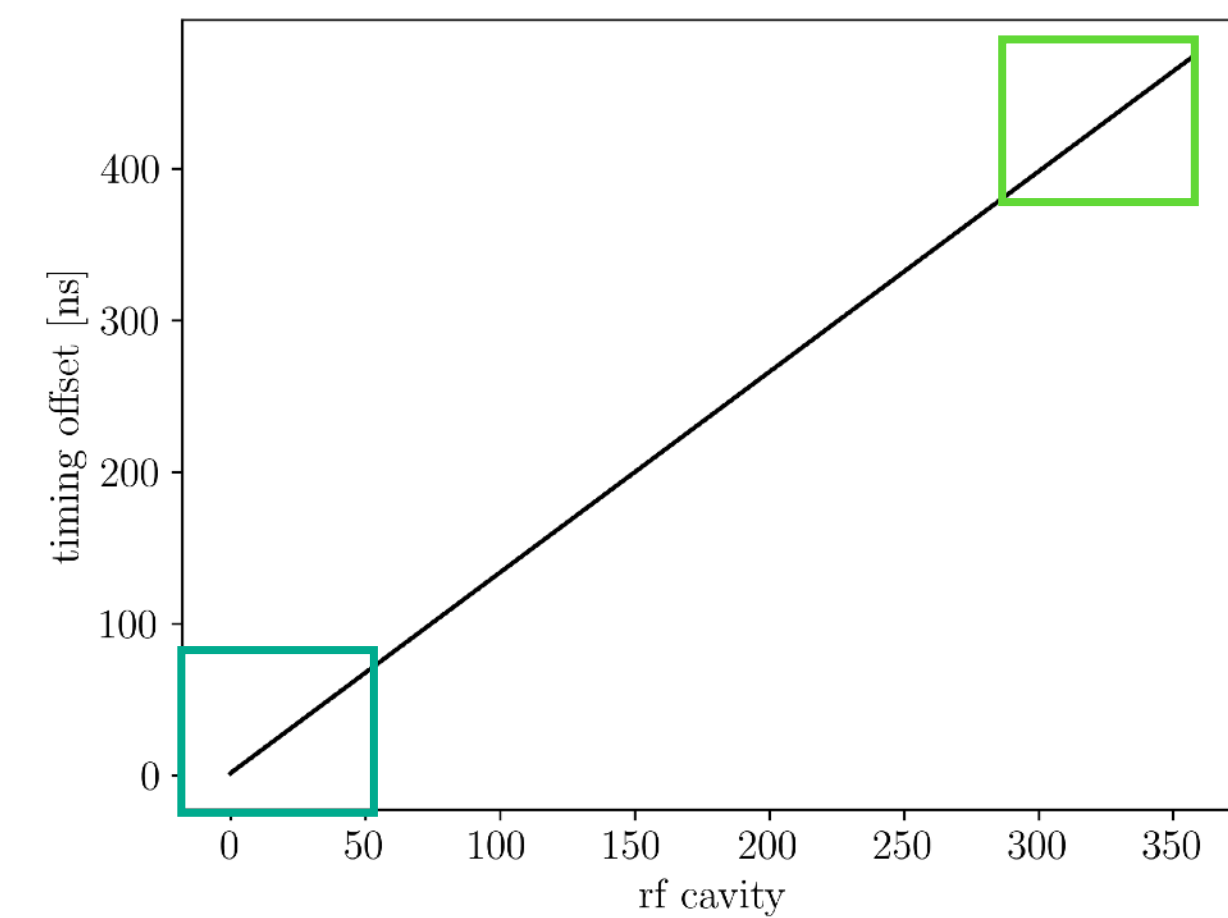
*Scott proposed a more rigorous way to approach this

Our next suspect

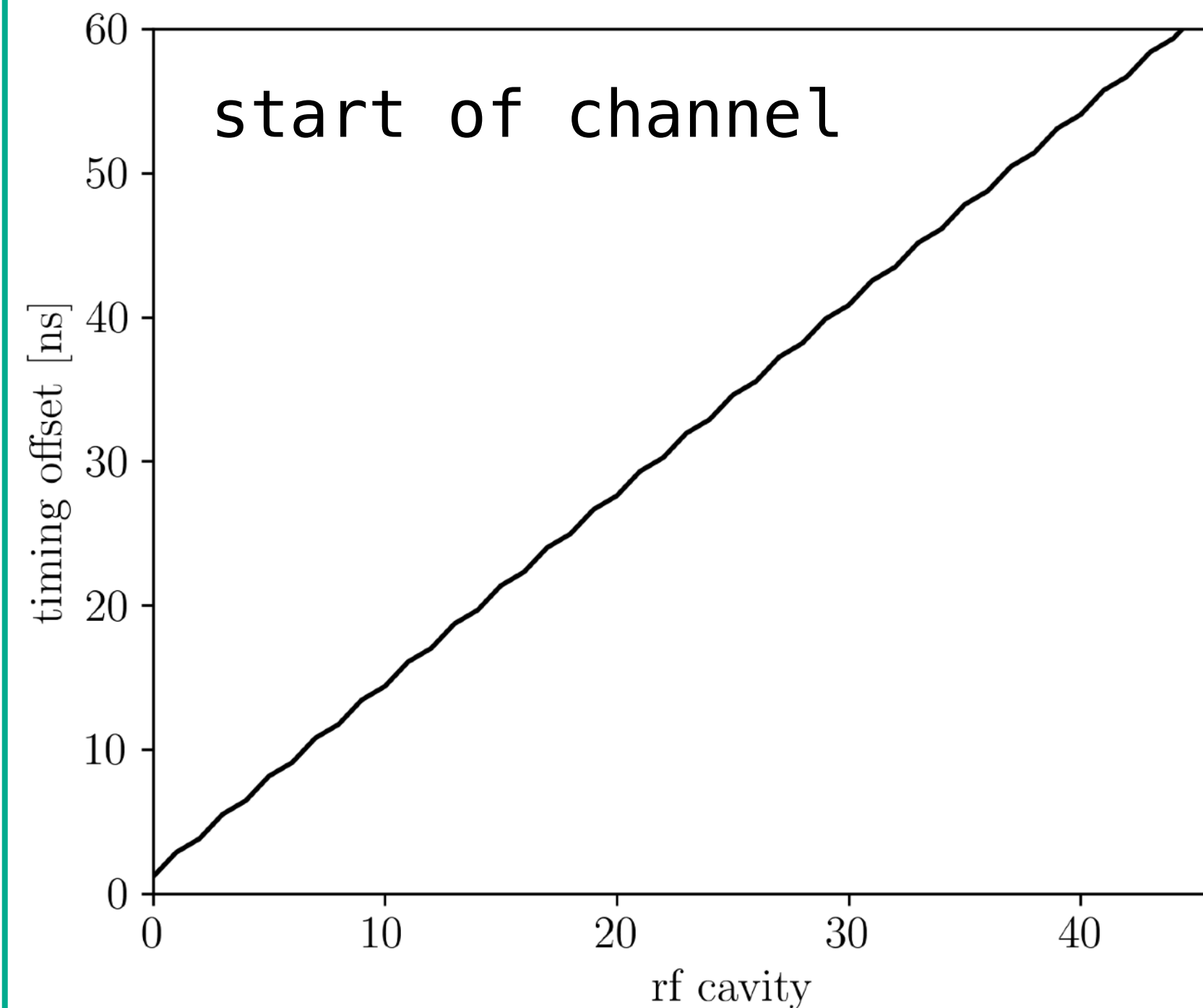
~~Possibility 2: rf phasing / time of flight issues~~

...But cavity timings follow (very nearly) linear trend consistent along channel

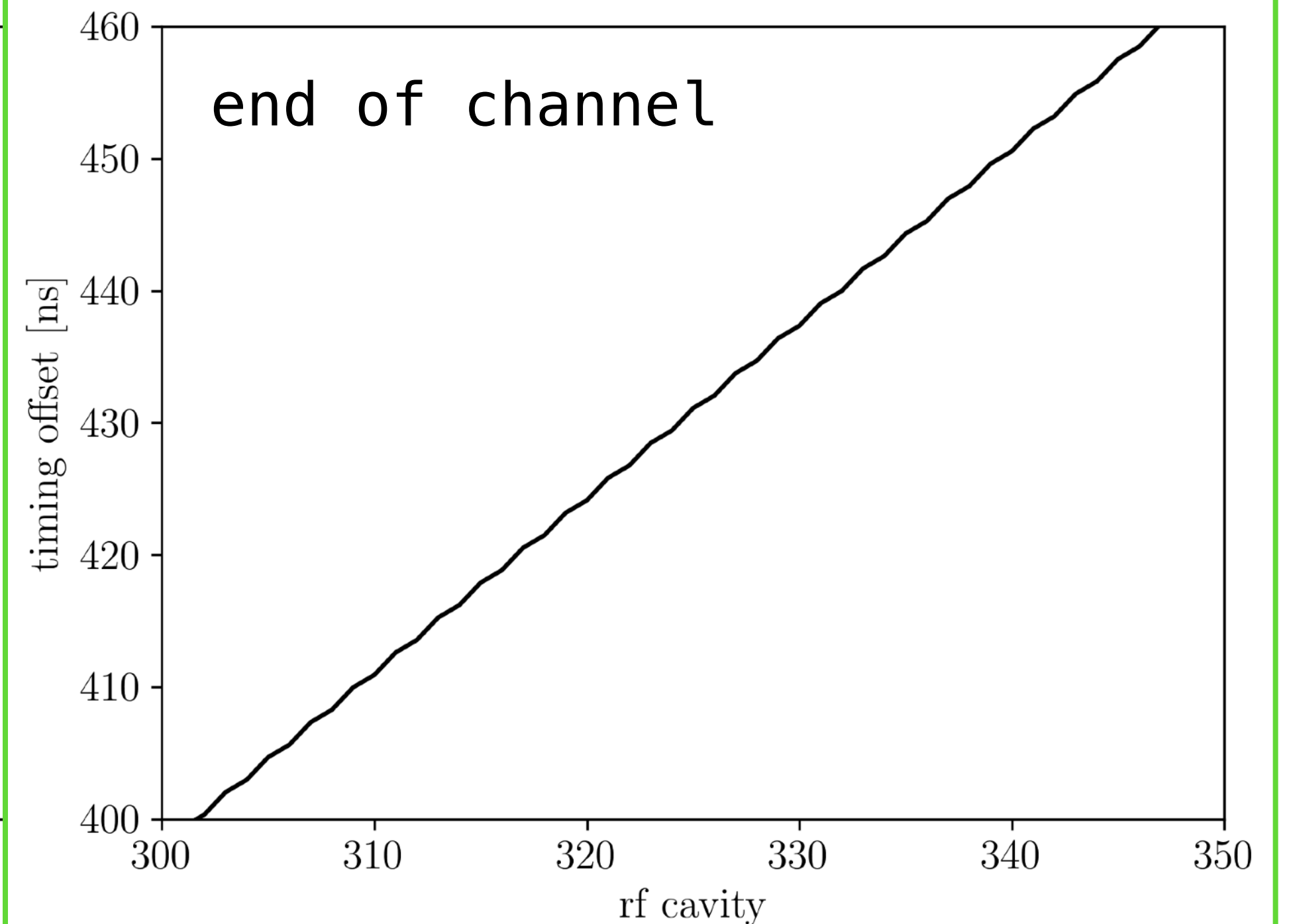
full channel



start of channel



end of channel



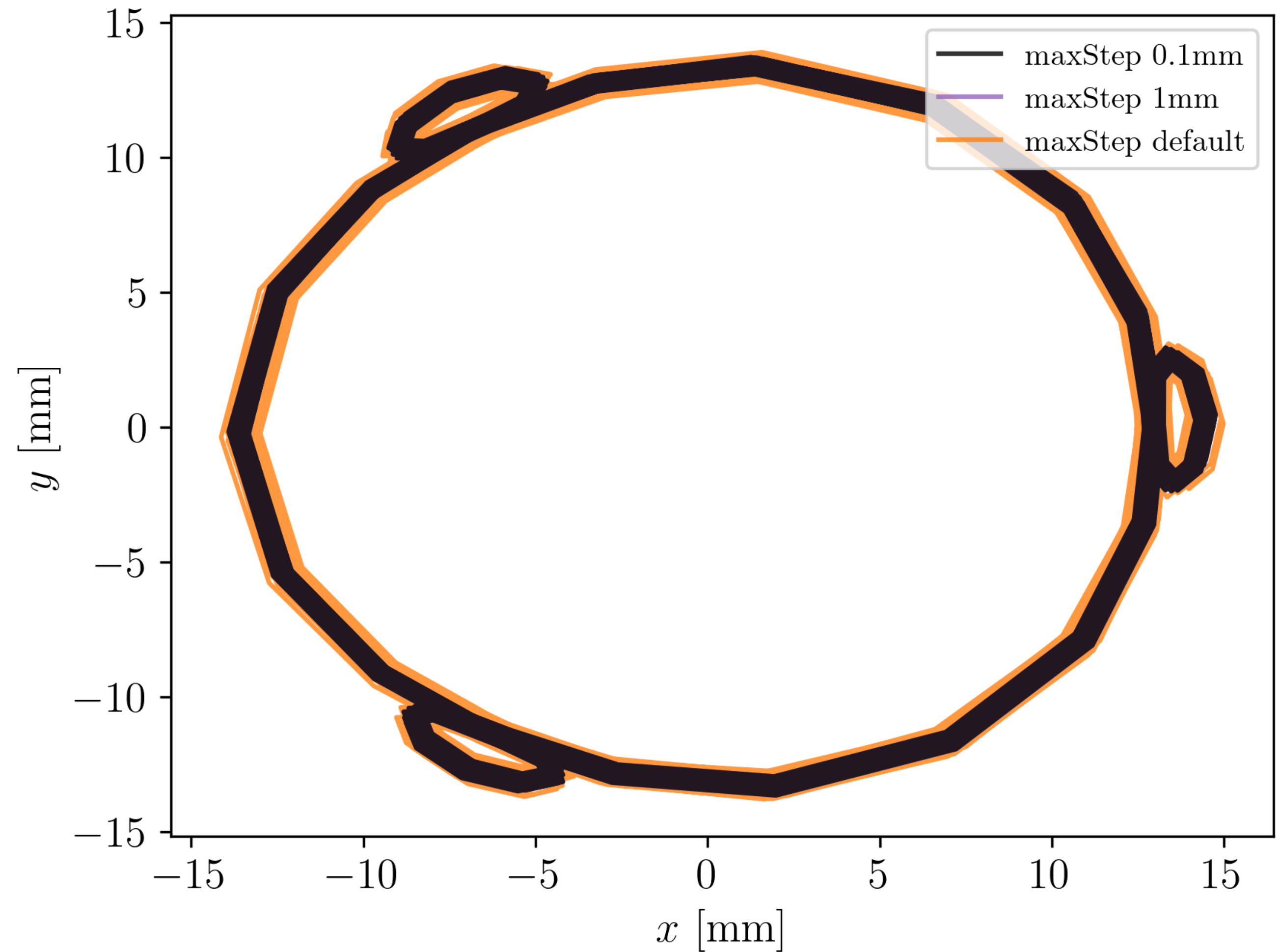
Our final suspect

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Possibility 3:
G4bl adaptive step size

Decreasing maxStep by a
couple orders of magnitude
saw a reduction in the orbit
drift along the channel!

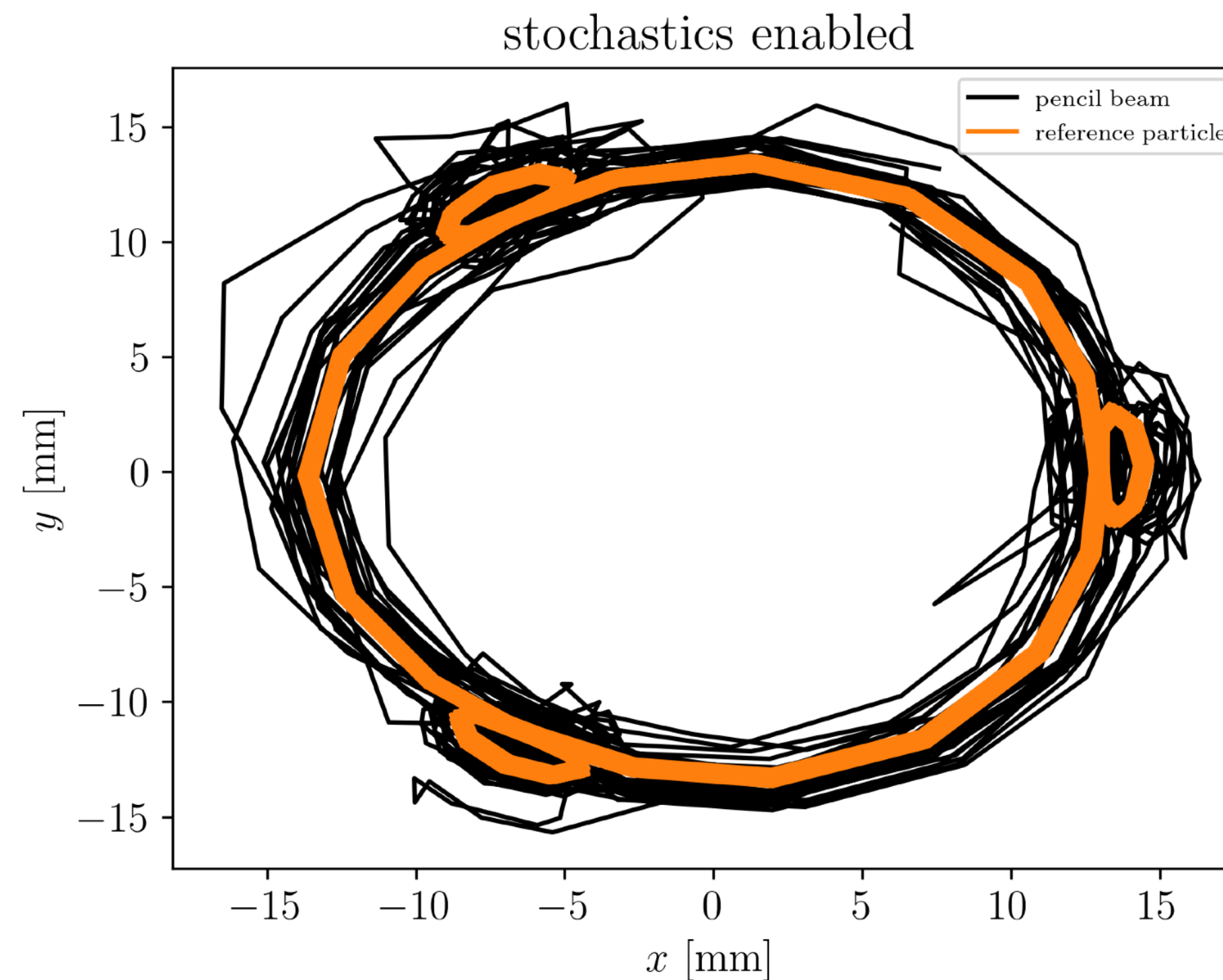
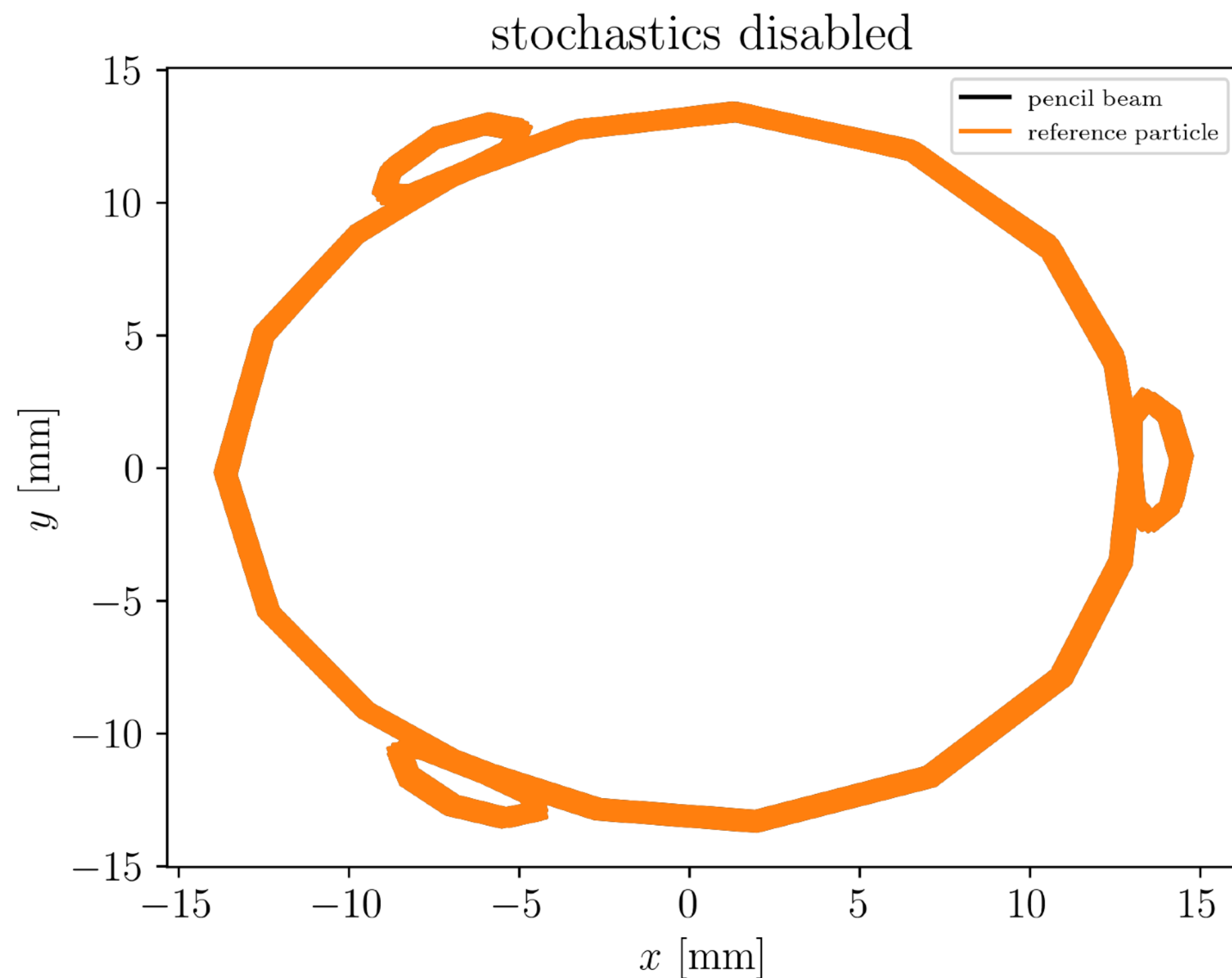
==> Case closed?



Investigating the effect of stochastics

Does this drift issue constitute a significant problem in our simulations?

Consider the deviations induced by stochastics alone:



==> No!

A test of cooling performance

Issue #15

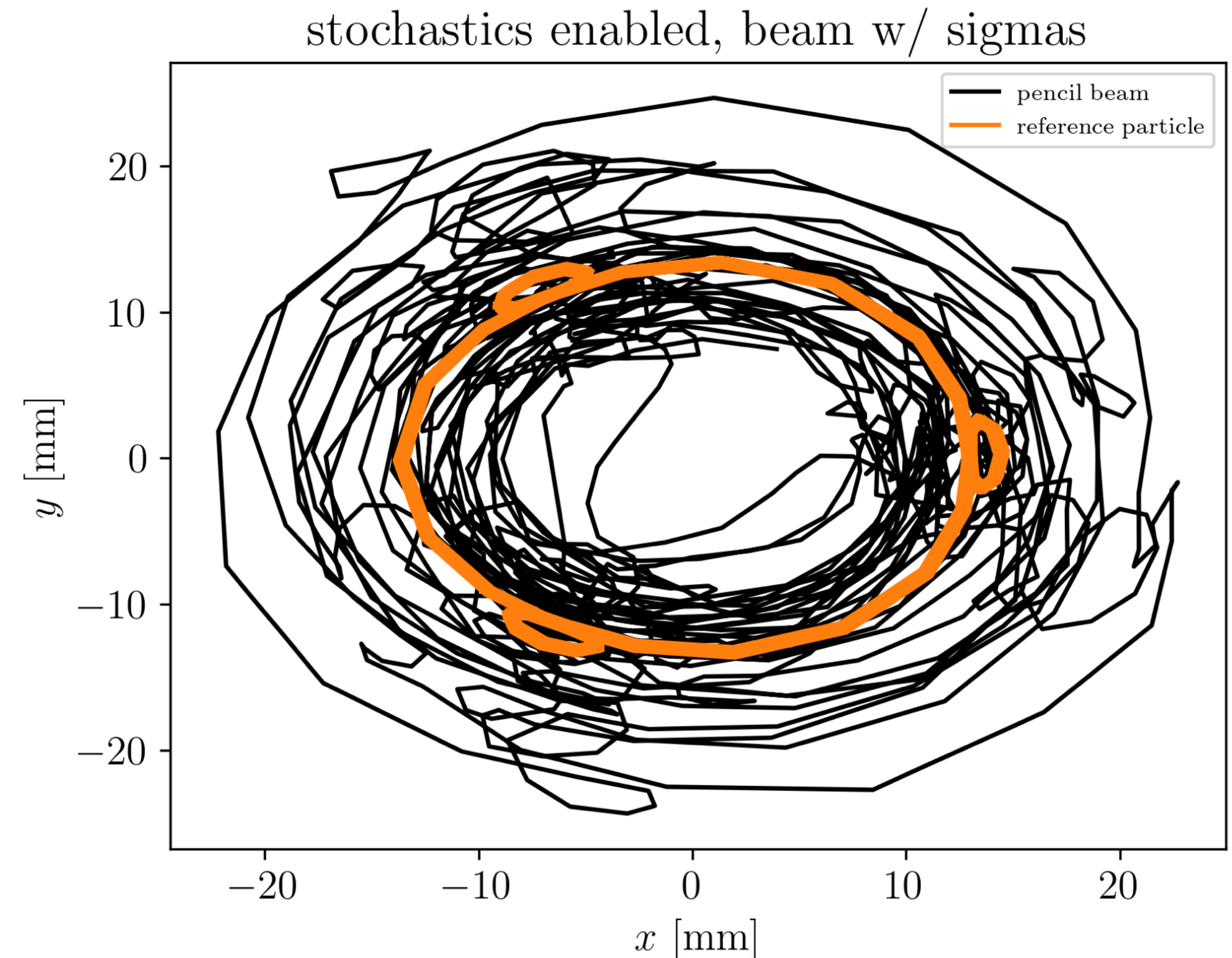
Inputting a beam distributed in phase space

So, we now have our fully 6D periodic 200 MeV/c HFOFO lattice!

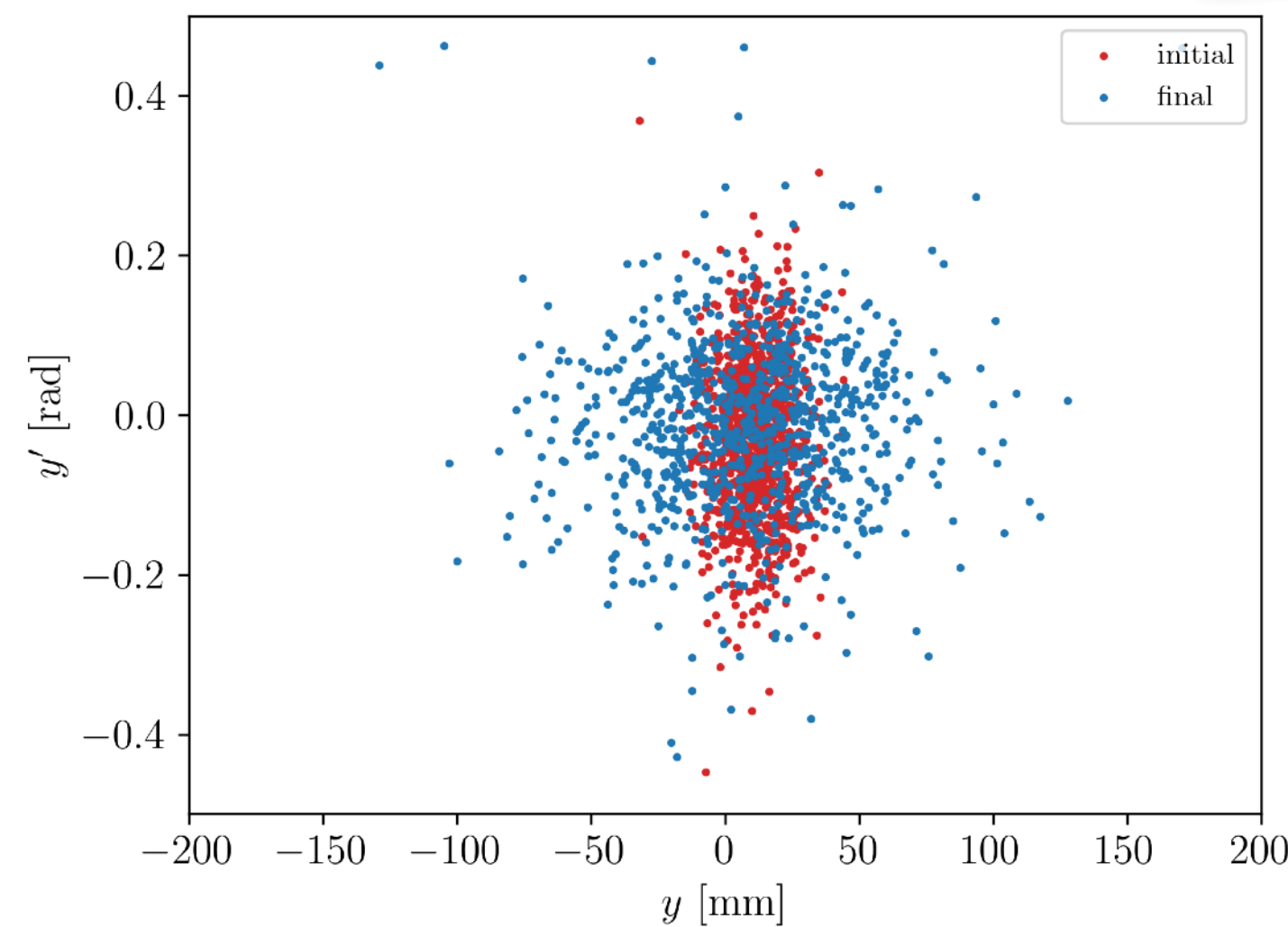
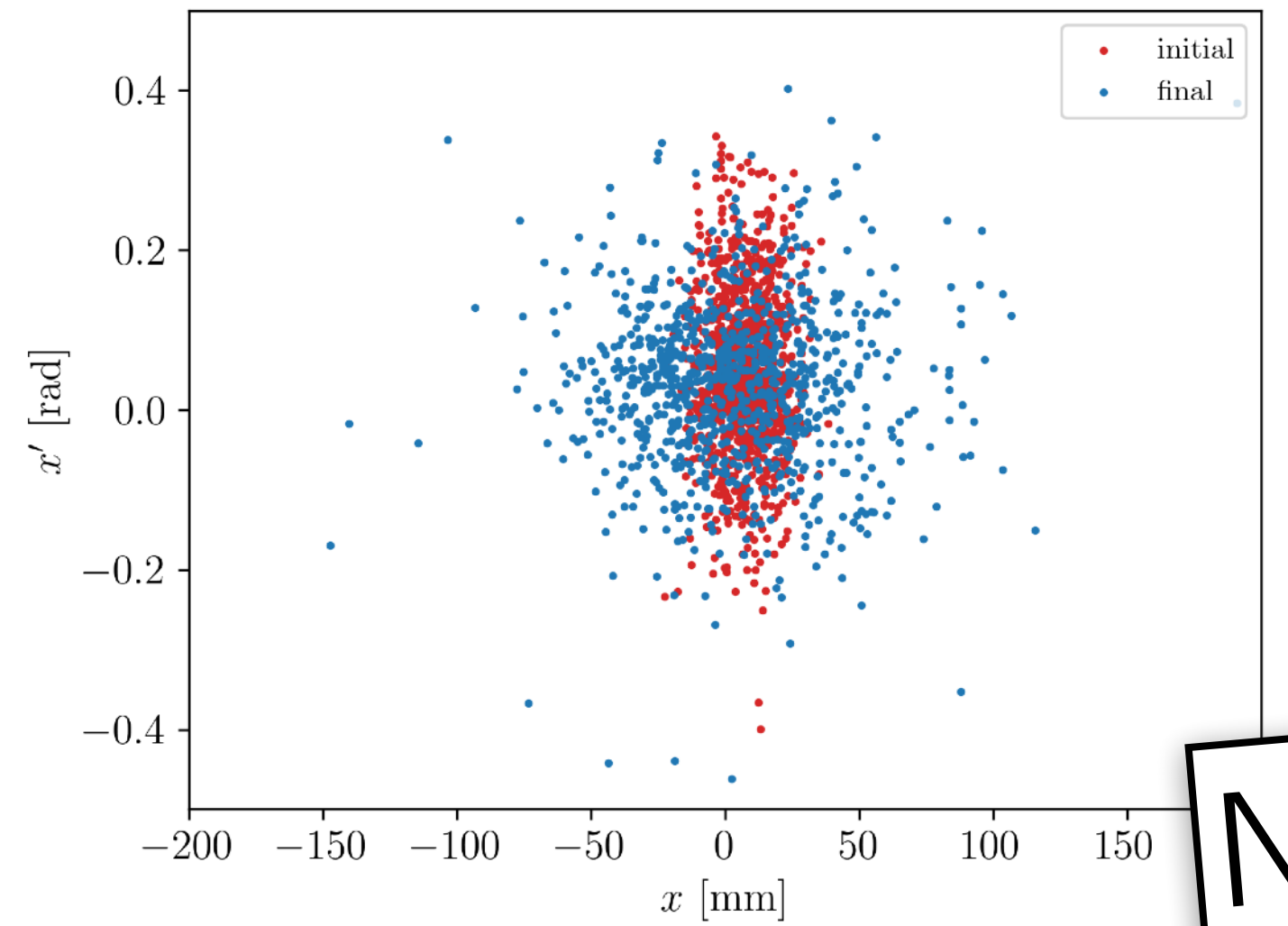
...But does it work?

Try inputting a beam with a distribution around the reference particle:

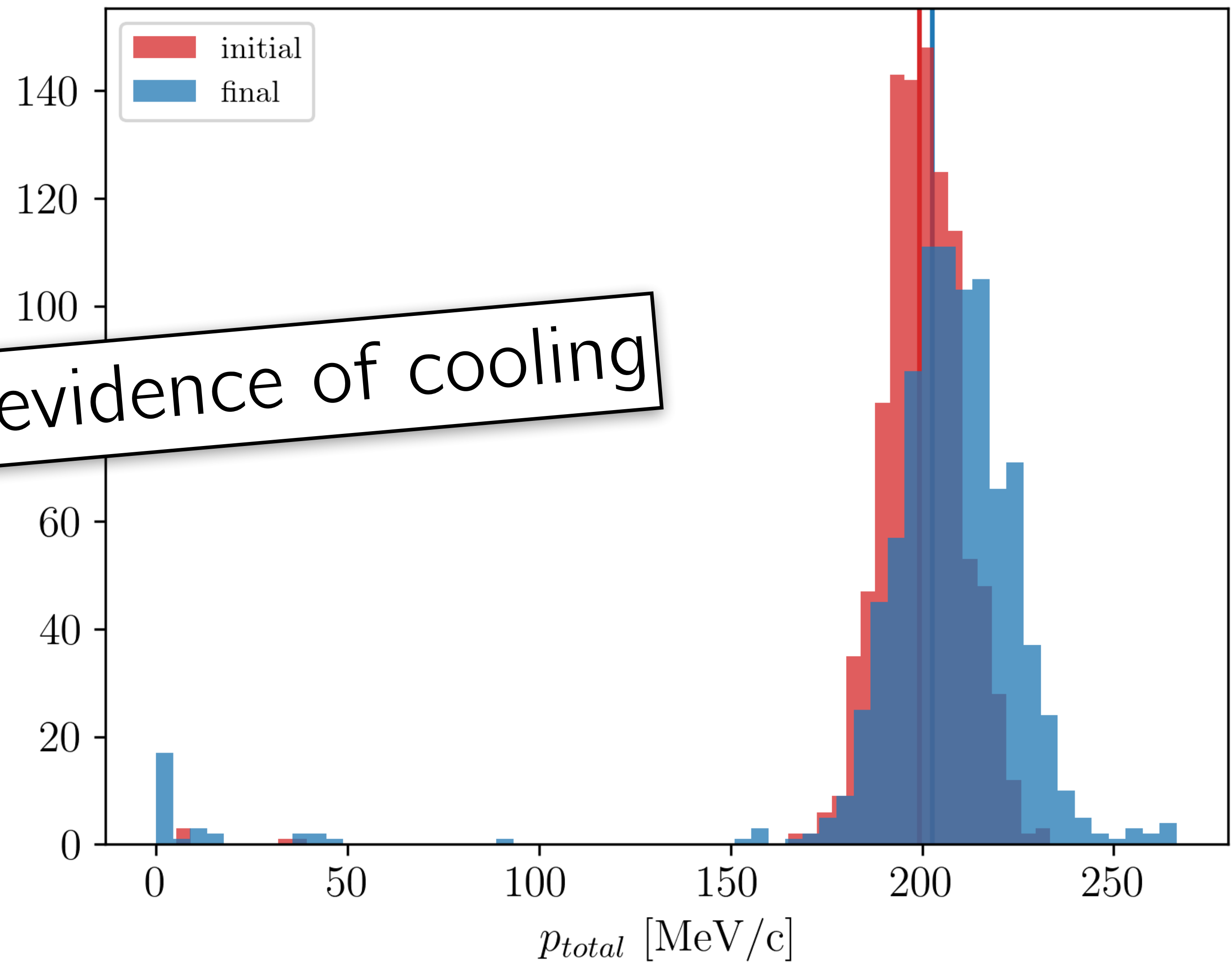
```
beam gaussian particle=mu+ nEvents=1000 \  
beamZ=500.0 beamX=$X beamY=$Y beamXp=$Xp beamYp=$Yp \  
sigmaX=10.0 sigmaY=10.0 sigmaXp=0.1 sigmaYp=0.1 \  
meanMomentum=$p sigmaP=10.0
```



Are we seeing cooling?



No evidence of cooling



Why are we not seeing cooling?

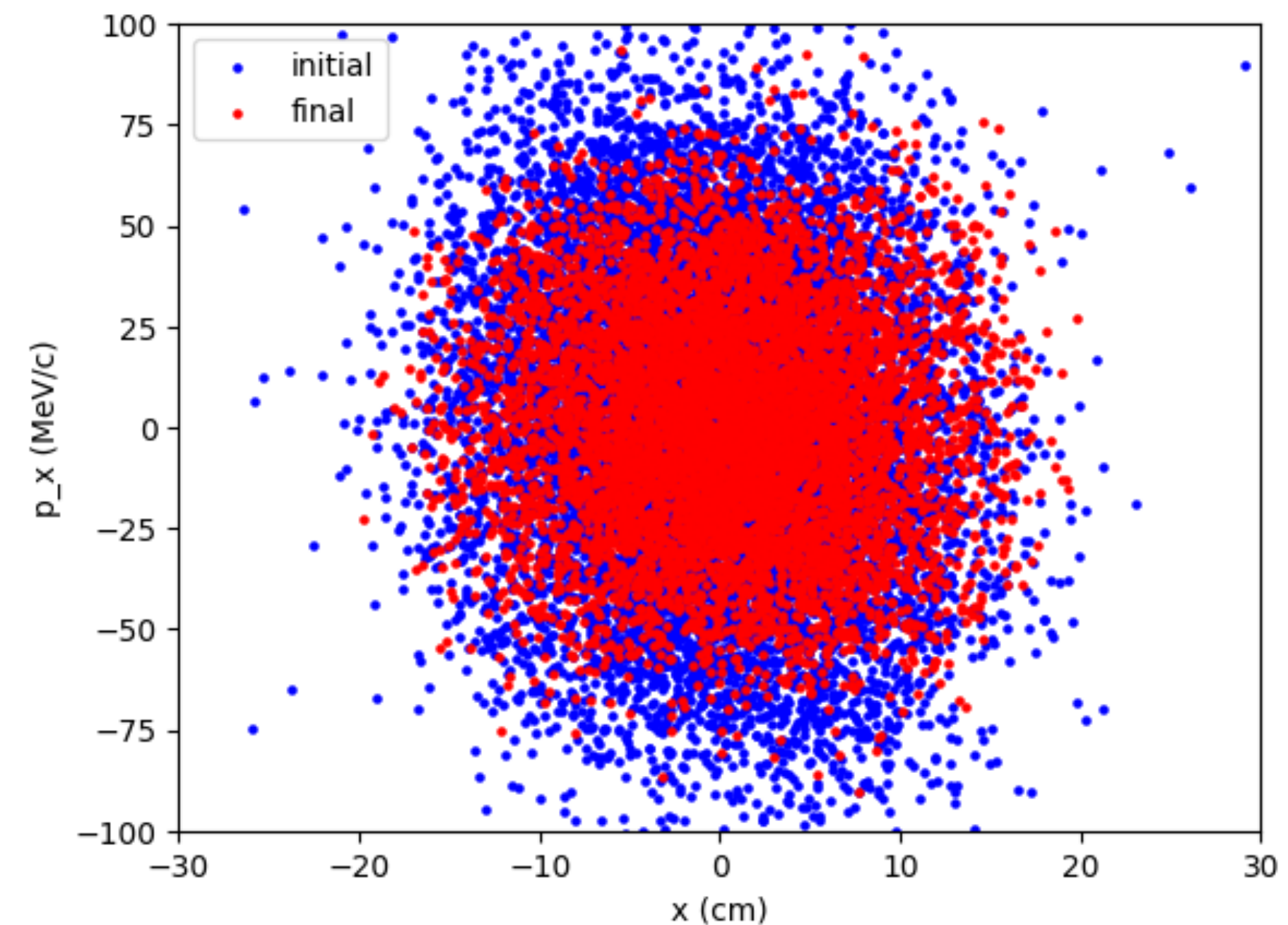
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Recall that the **absorbers** are only 10mm in length, which is realistic for HFOFO but **very thin** compared to e.g. the rectilinear design.

Hypothesis: the **gas** is the primary cooling agent in HFOFO.

Recall the result of a very old study in which I removed the gas from the design:

(No longer saw cooling when gas was removed!
Or at least, it was severely diminished)



Next steps

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Two potential next steps:

1. Increase the absorber thickness

2. Add gas back into the design

—> *Likely undesirable as we want to move to a vacuum design anyway*

Both will adjust the periodic orbit and require re-tuning