(Anti)Damper Simulations to Study Stabilization by the Nonlinear Lens

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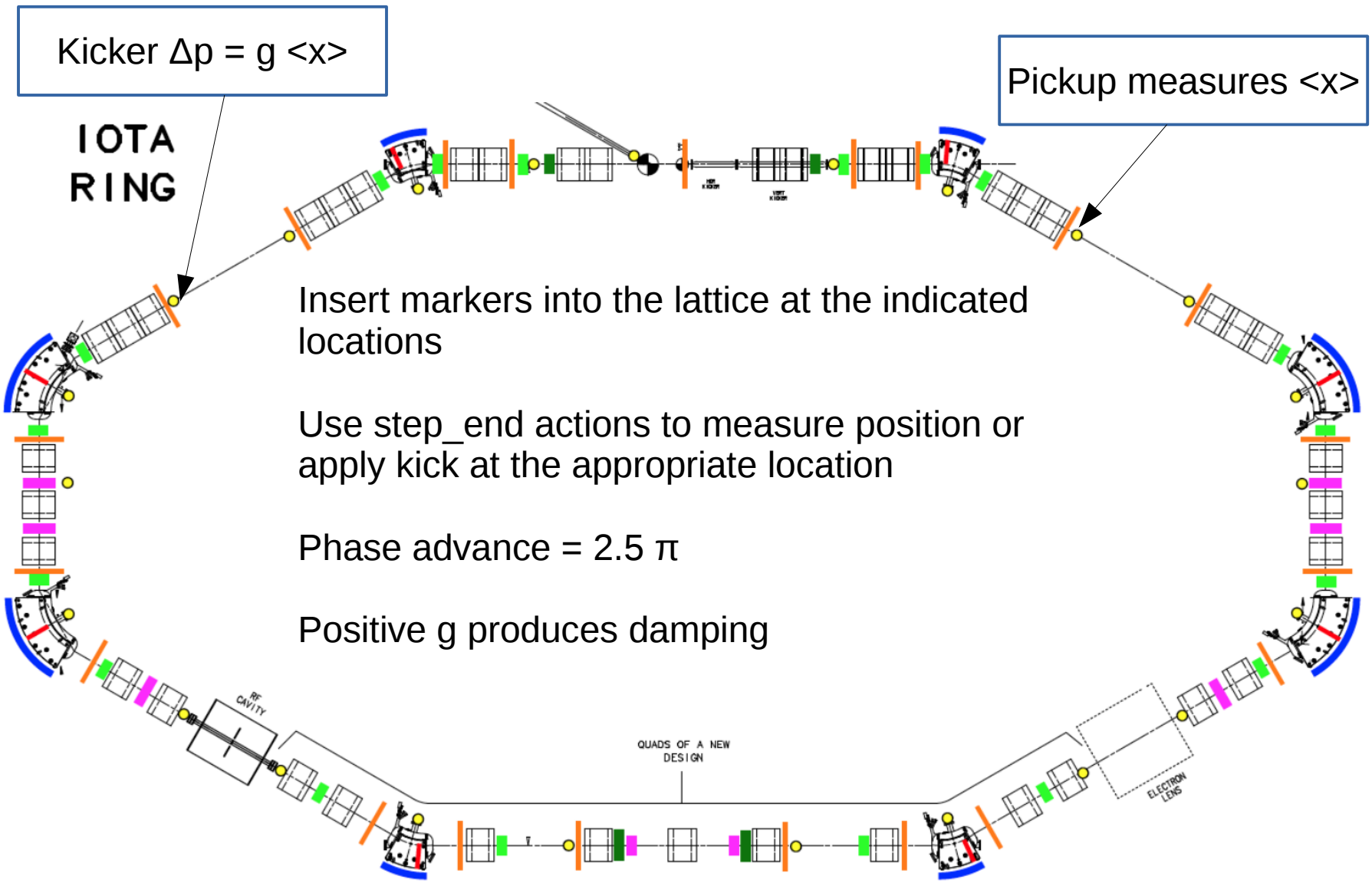
Why might we want an antidamper?

- Impedance (wake fields) in the IOTA ring are insufficient to cause instabilities.
- We want to see the see if the tune spread produced by the nonlinear insert can suppress instabilities.
- Alexey Burov suggests that an antidamper can be used to excite an instability.

(Anti)damper model in Synergia



Simulations based on example from Radiasoft

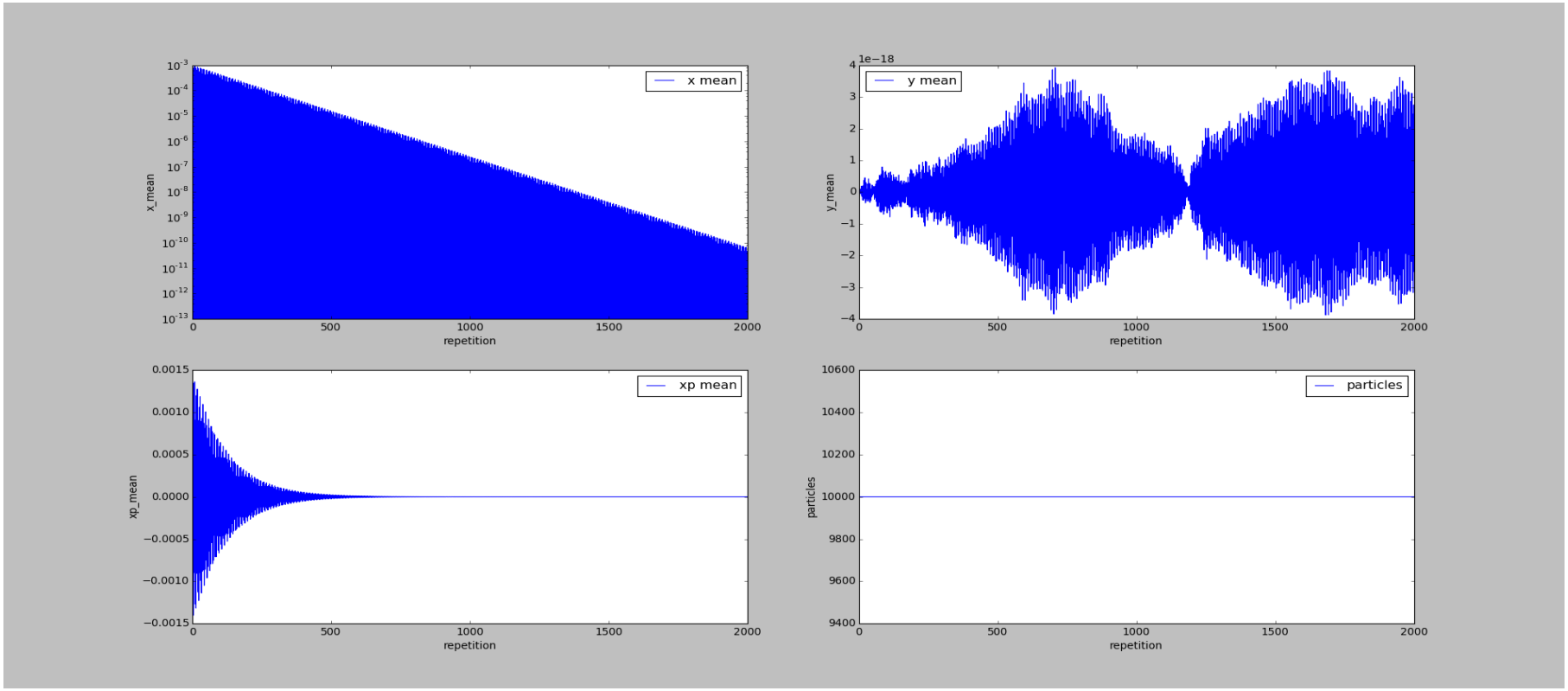
Parameters mostly unchanged from example

- Lattice file from ioptics module
  - Iota6-6/lattice_1IO_center.madx
  - Iota6-6/lattice_1IO_nll_center.madx
- Emittance 0.3e-6 (for no insert) 10.0e-6 for insert?
- Elliptical KV beam matching with insert, transverse gaussian without
- Dipedge elements are included
- Hard dipole edge vertical kicks calculated based on closed orbit angle (emittance preserving)

Preliminary simulation studies

Demonstrate that the damper is working

g=0.01 (damping) no nonlinear insert, starting offset 0.001m, linearized propagation. -log(1.0e-7)/2000 ~ .008



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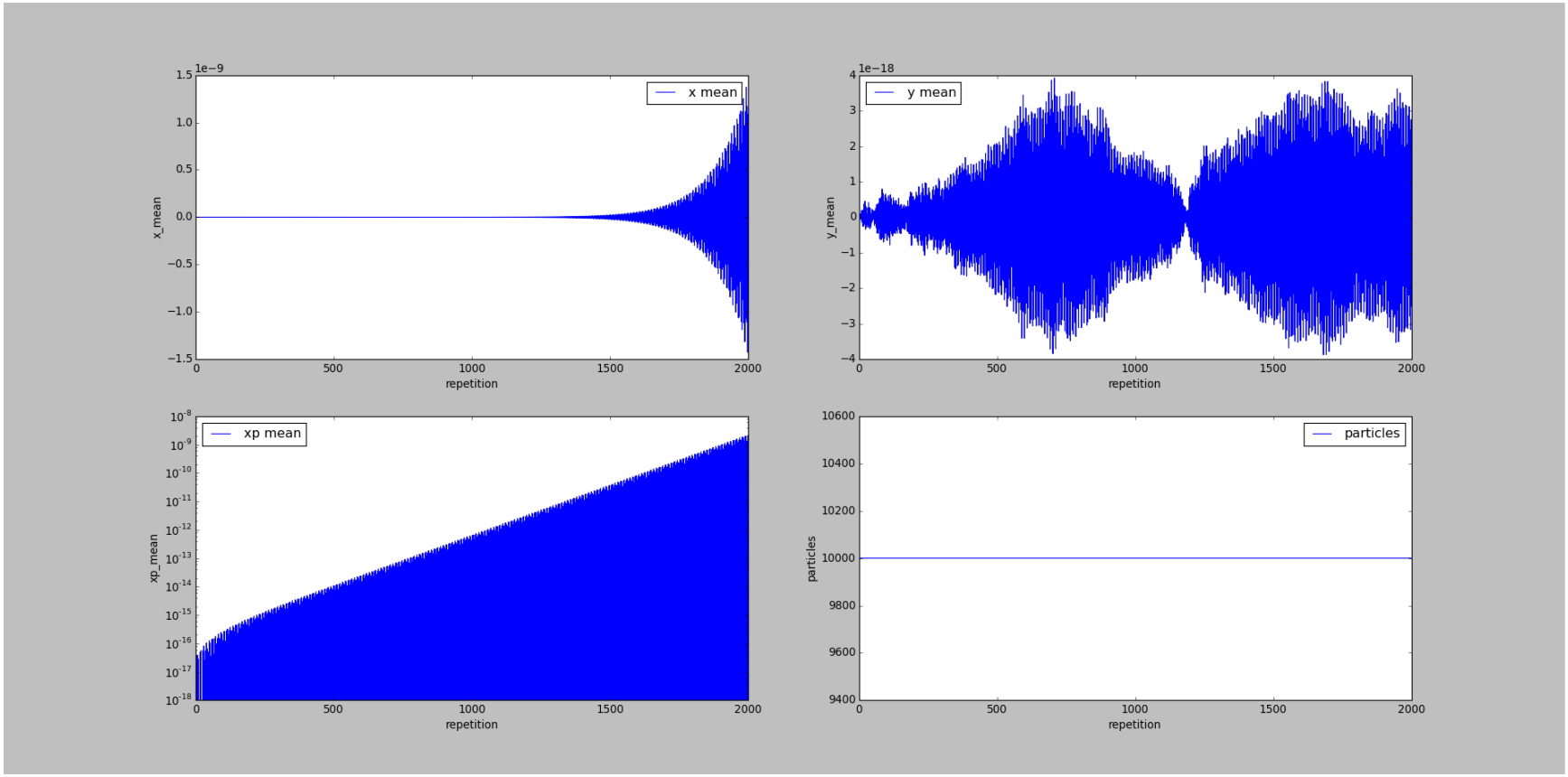
Antidamping causes instability

Gain = -0.01, no nonlinear insert, linearized propagation.



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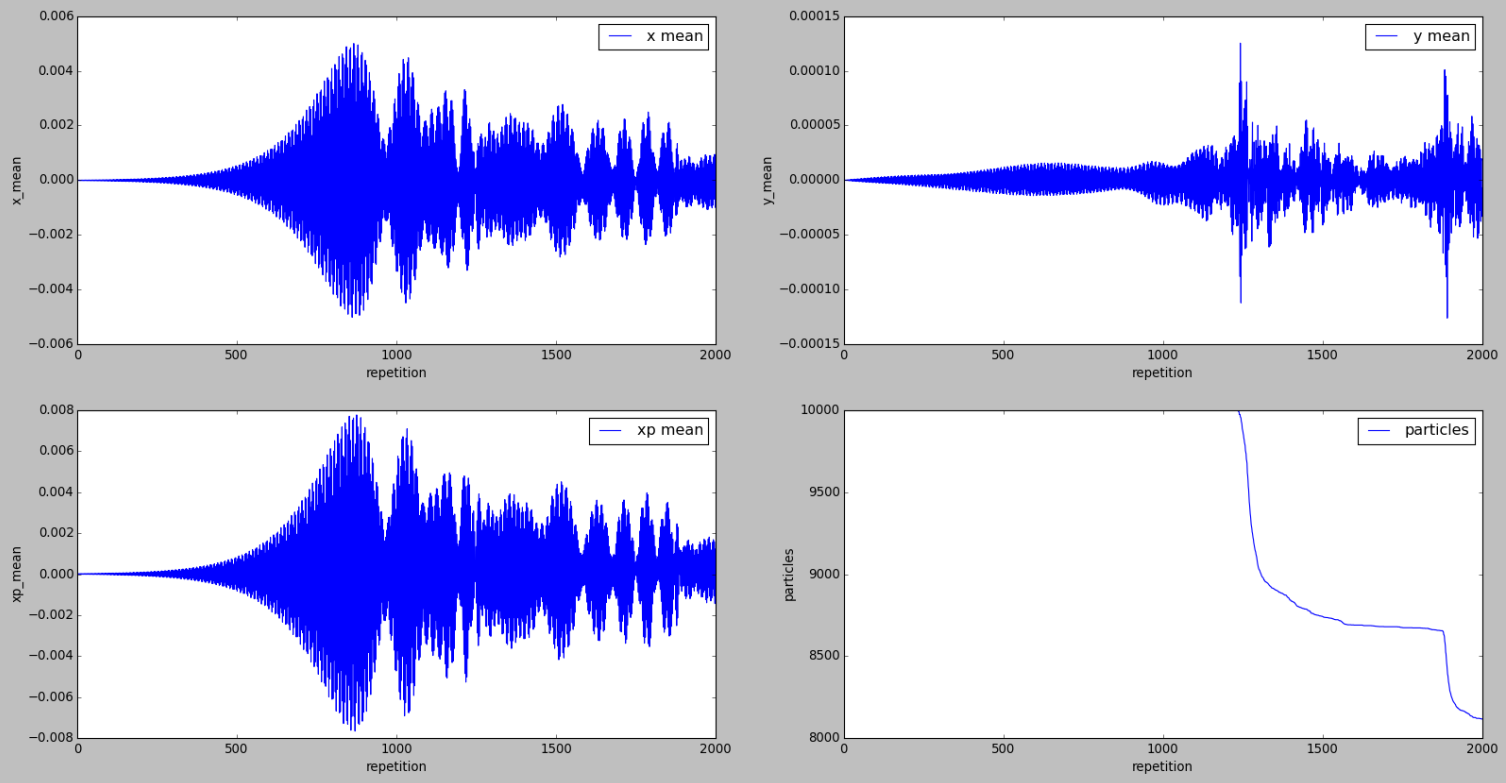
Full propagation makes things interesting

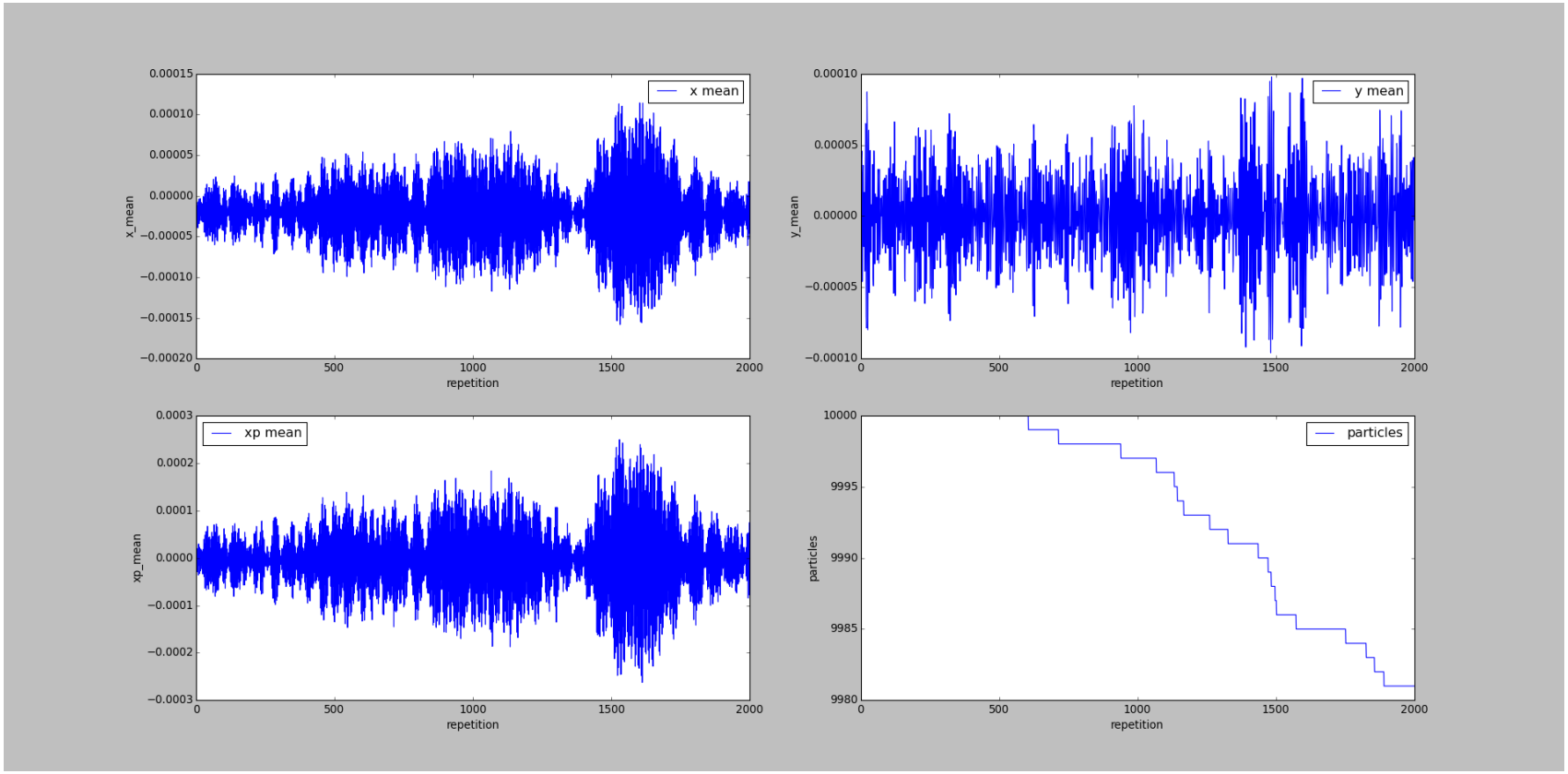
Full drift propagation: $$x_{\text{final}} = x_{\text{initial}} + \frac{p_x}{\sqrt{p^2 - p_x^2 - p_y^2}} L$$

Gain = -0.01, no nonlinear insert, full propagation



Adding nonlinear insert somewhat soothing

Gain = -0.01, including nonlinear insert, full propagation



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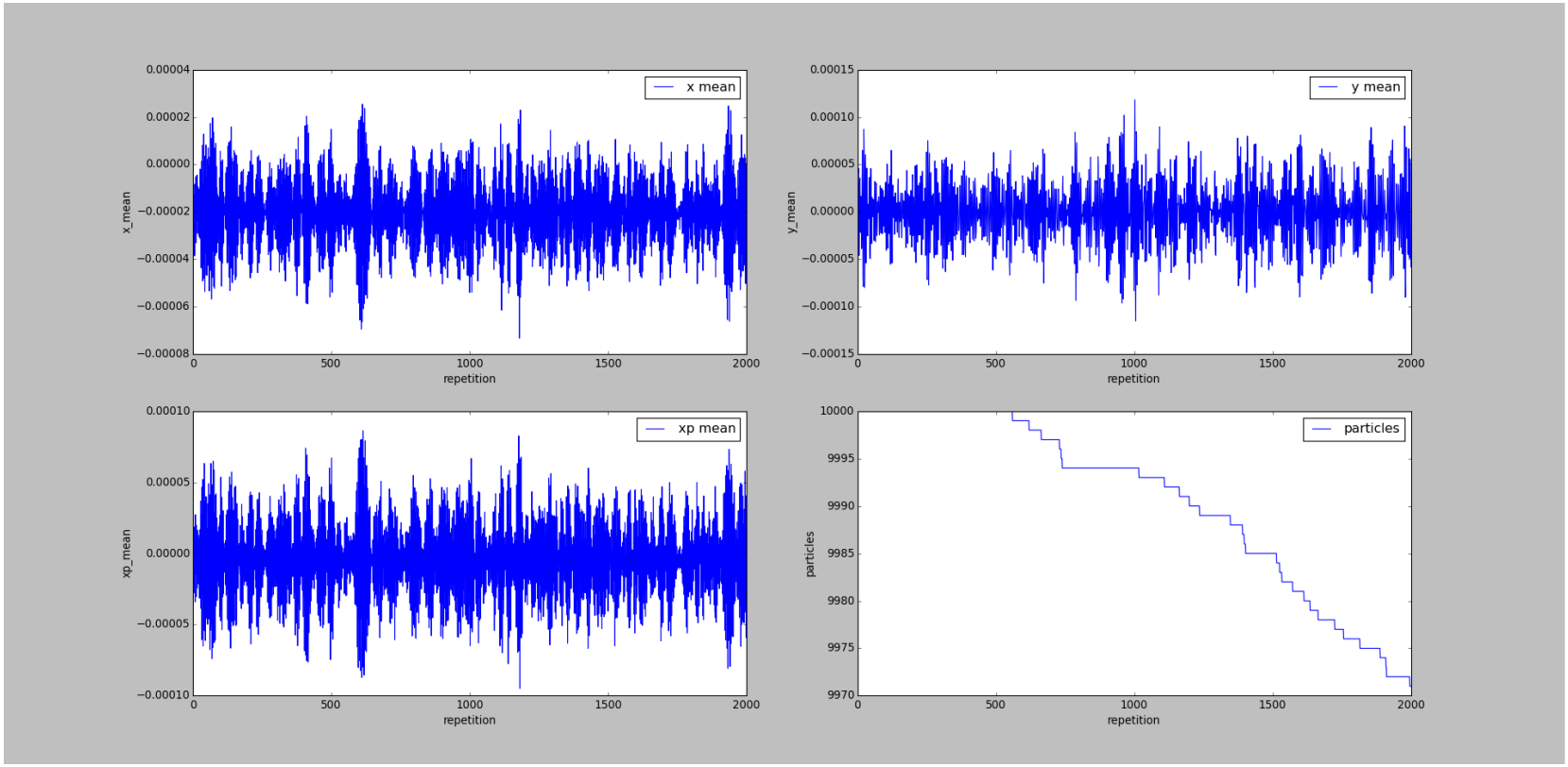
A word about particle loss

Adding the nonlinear insert combined with full propagation causes a small amount of particle loss

Gain = 0.0, including nonlinear insert, full propagation



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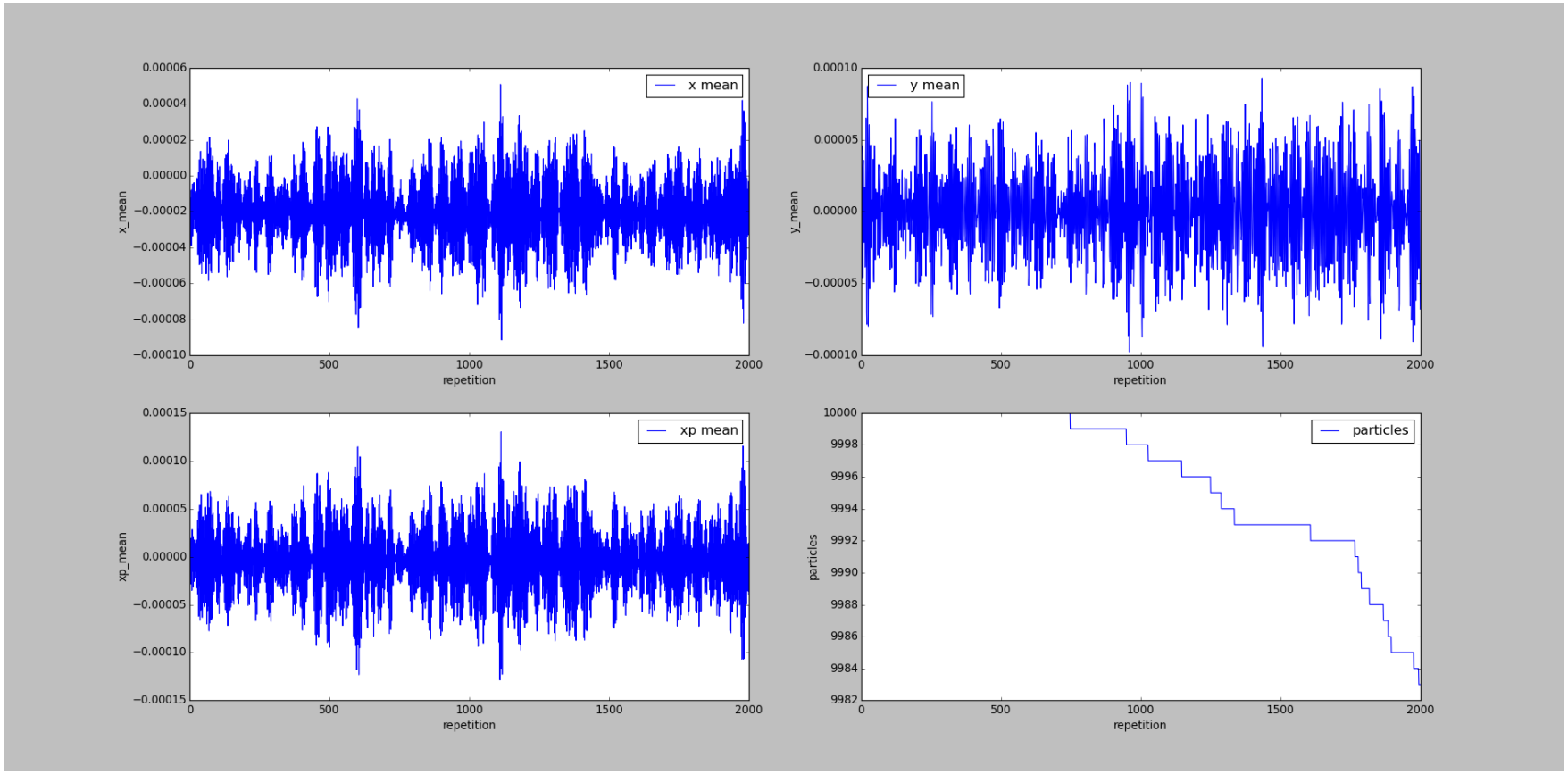
Reduced antidamper seems stable long-term

Gain = -0.005, with nonlinear insert, full propagation



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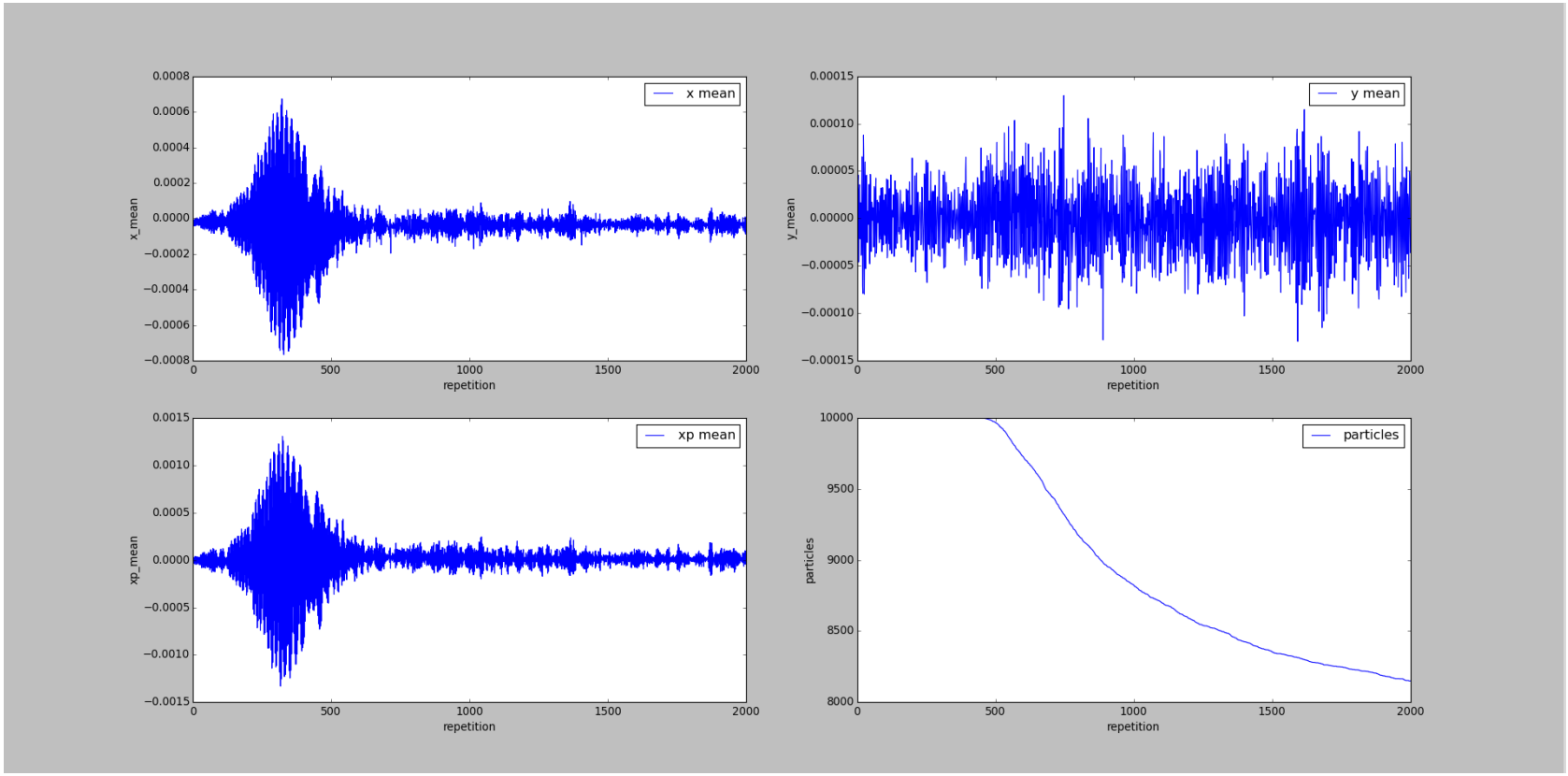
Larger antidamper overcomes nonlinear lens

Gain = -0.05, with nonlinear insert, full propagation



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Conclusions

- The (anti)damper model in Synergia is working.
- The antidamper simulation can be used to excite instabilities.
- The nonlinear lens appears to stabilize instabilities for ranges of antidamper strength.

The antidamper simulation will be provided to Radiasoft for general usage.

Future work includes parameter surveys including more detailed mapping of antidamper strength, nonlinear element strength, etc.

The antidamper would be useful to implement in the actual machine.

Sector bends are nonlinear: a geometric motivation

- In a constant magnetic volume, planar trajectories are circular arcs.
- The exit point for a particle is the intersection of the circular arc of the trajectory with the linear edge of the exit face.
- Mathematically, this is a quadratic equation.

Propagation through IOTA 60 degree sbend (agrees with PTC tracking)

Input x	Output x
-0.01	-0.005054
0.0	0.0
0.01	0.004946