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KURRI FFAG simulation update
- effects of multipoles -

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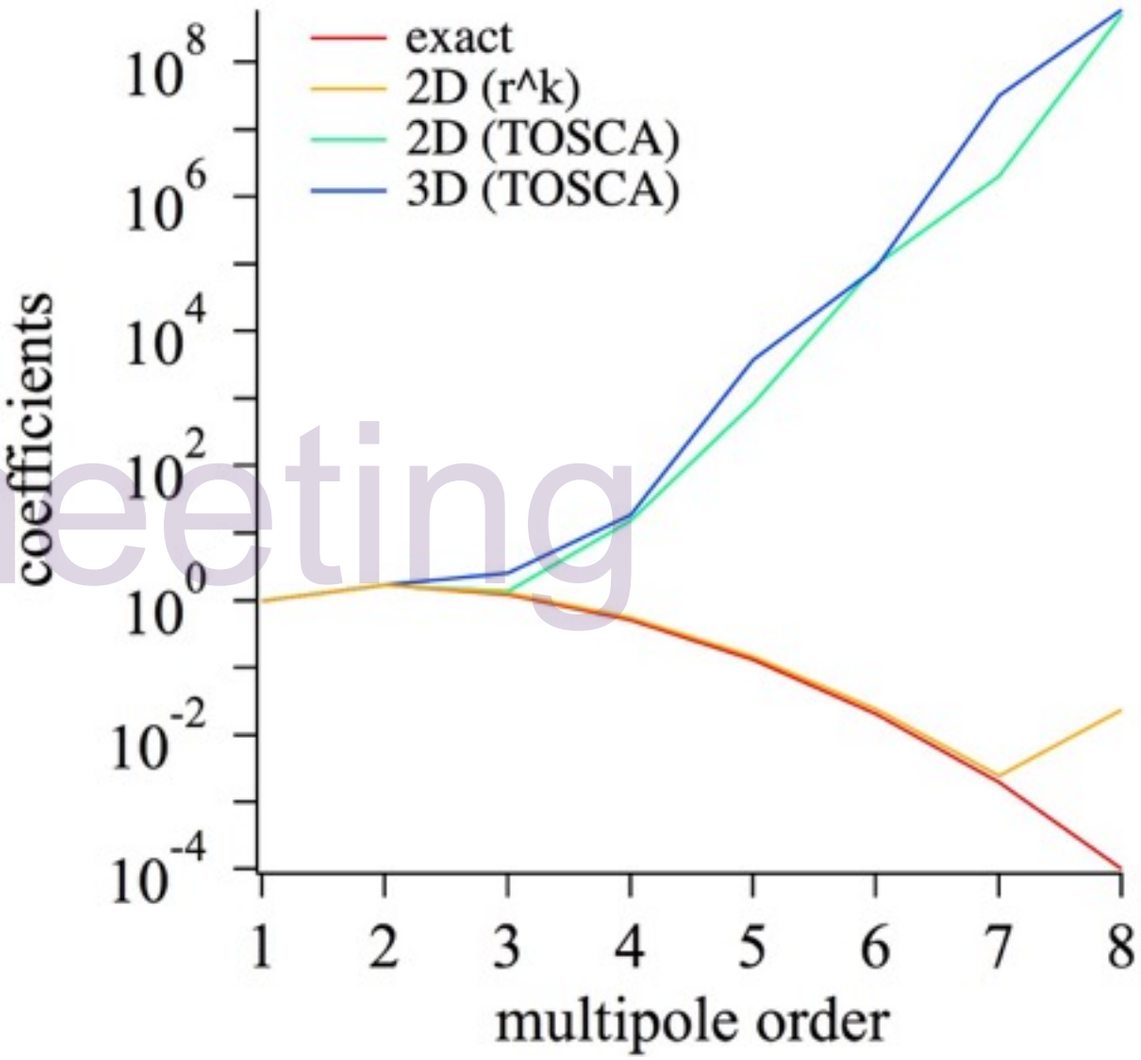
All compared

Multipoles obtained from 2D and 3D TOSCA field maps are significantly different from ideal at n=4, 5 and higher.

It depends on

1. the order of vertical coordinate z^m when extrapolating from 2D.
2. the location of “rotating coil”.



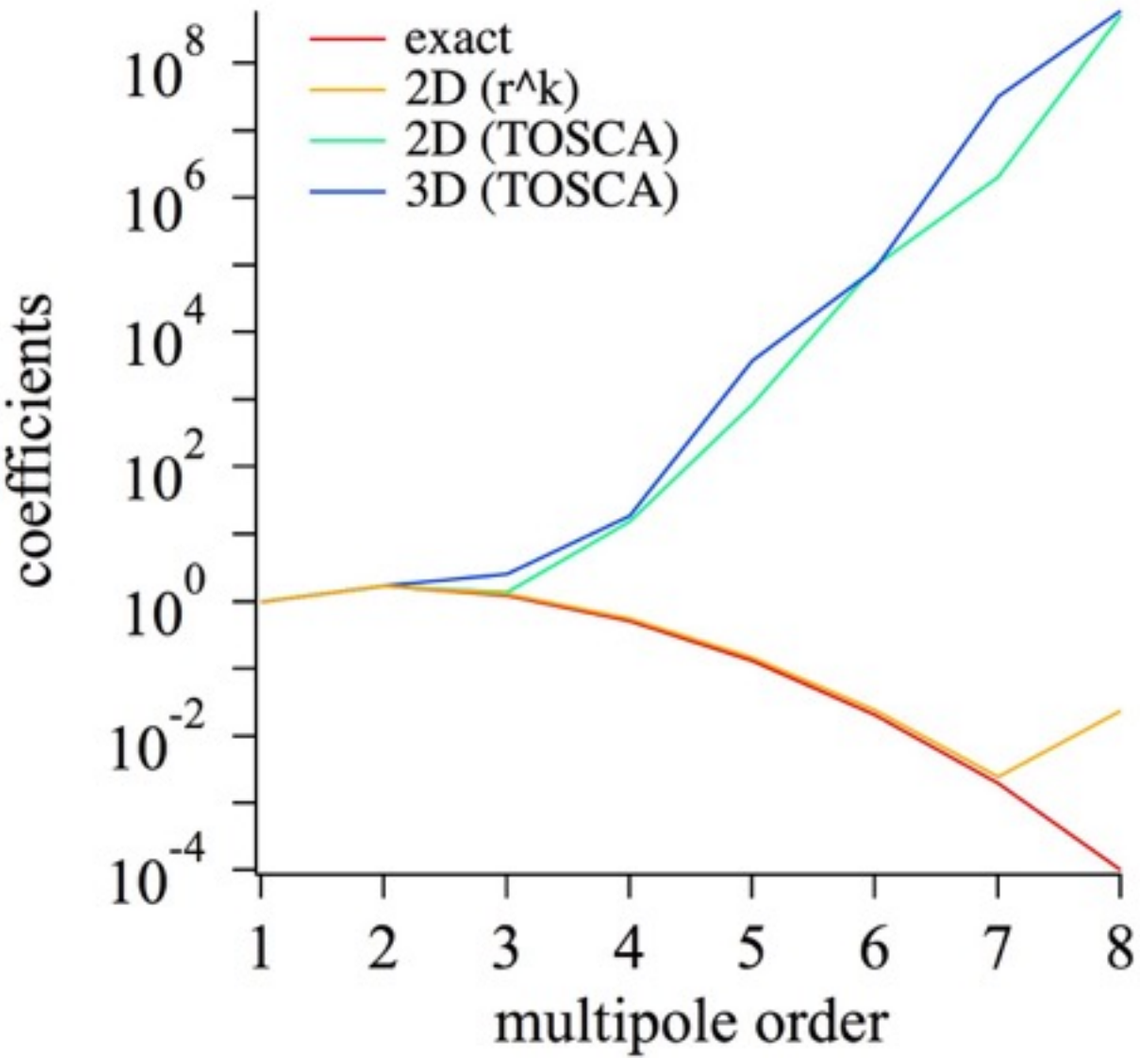
How this affects simulation?

Orbit moves in horizontal direction in FFAG and incorrect multipoles give wrong feed-down quadrupole.

(small amplitude effect).

Incorrect multipoles introduce wrong tune shift as a function of amplitude and reduce dynamics aperture.

(large amplitude effect).



Small amplitude effect

Small amplitude effect is in fact not a problem because multipoles are chosen at each radius such that tune becomes almost constant.

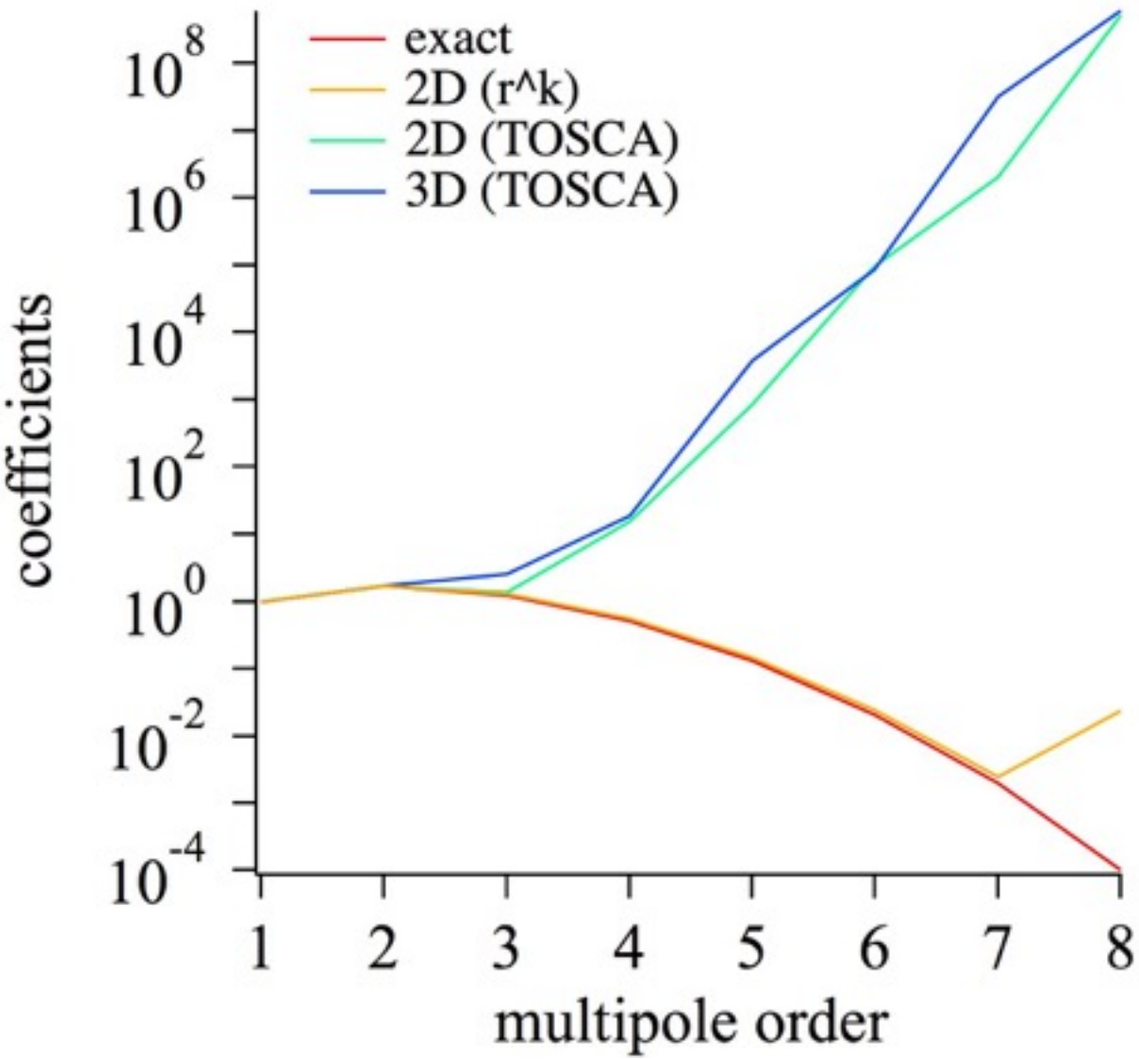
Ideally this equation is correct everywhere independent of r_0.

$$\left(\frac{r_0+x}{r_0}\right)^k = 1 + \frac{k}{1!r_0}x + \frac{k(k-1)}{2!r_0^2}x^2 + \frac{k(k-1)(k-2)}{3!r_0^3}x^3 +$$

In reality, coefficients of higher order terms, x^2, x^3, … are not constant. However, coefficients of linear term, x^1, is almost the same even thought higher order term, x^2, x^3, … varies at each r_0.

Large amplitude effect

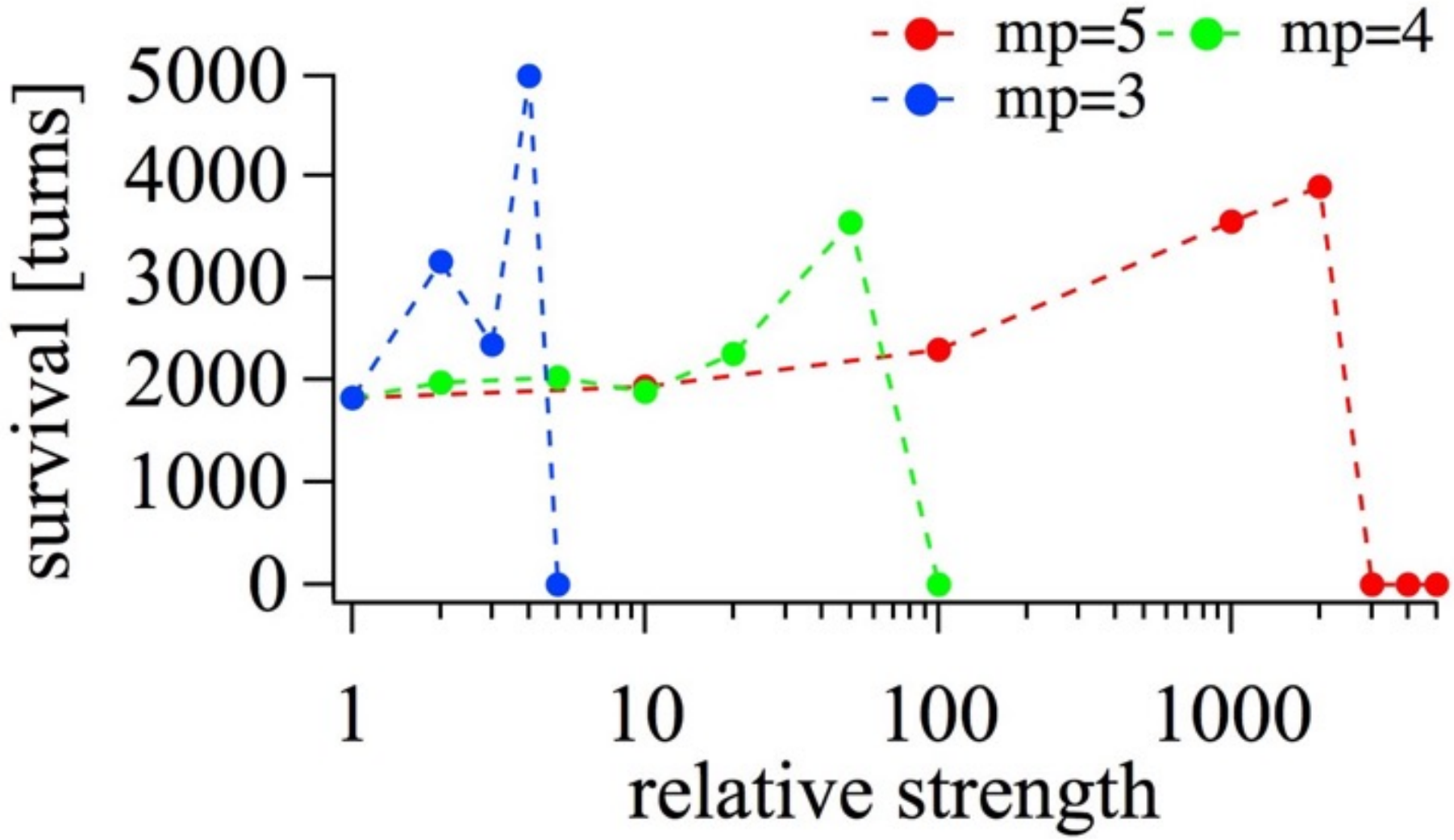
Large amplitude effect gives a wrong estimate of dynamic aperture.



Dynamic aperture

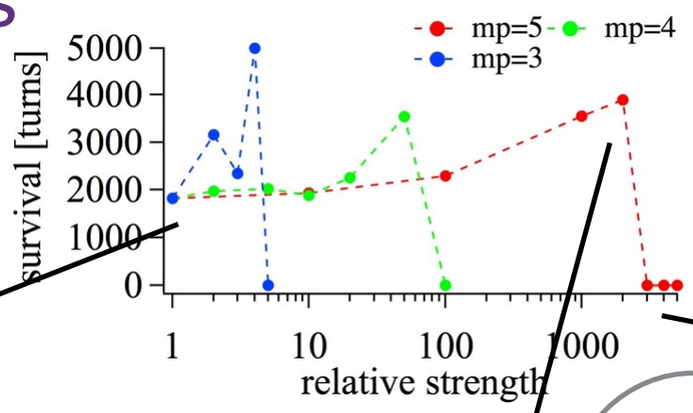
Large amplitude effect gives a wrong estimate of dynamic aperture.

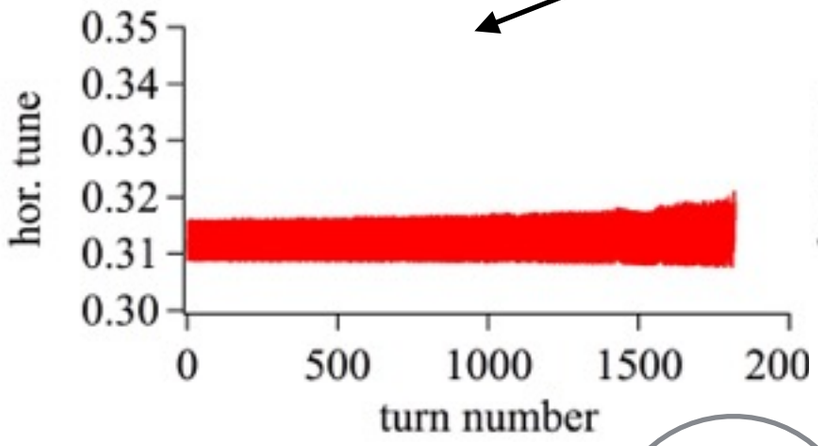
$$\left(\frac{r_0+x}{r_0}\right)^k = 1 + \frac{k}{1!r_0}x + \frac{k(k-1)}{2!r_0^2}x^2 + \frac{k(k-1)(k-2)}{3!r_0^3}x^3 +$$

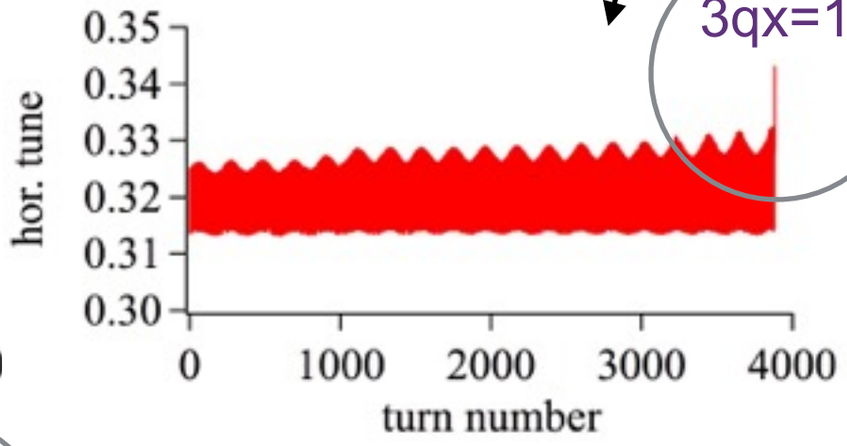


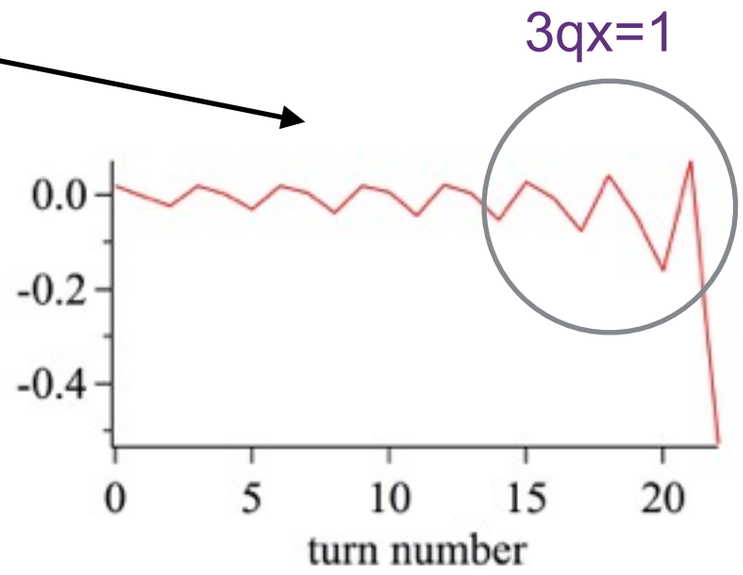
What limits dynamic aperture?

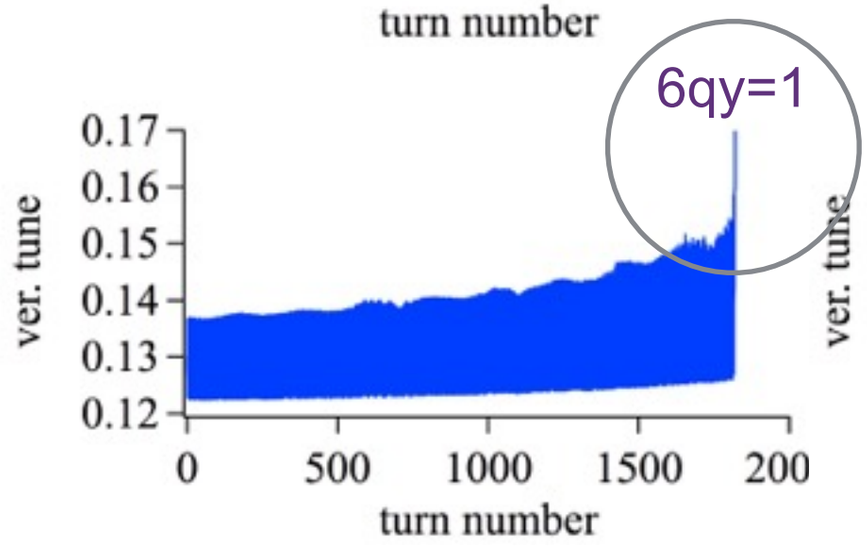
Depending of the multipole strength, beam loss occurs with different mechanism.

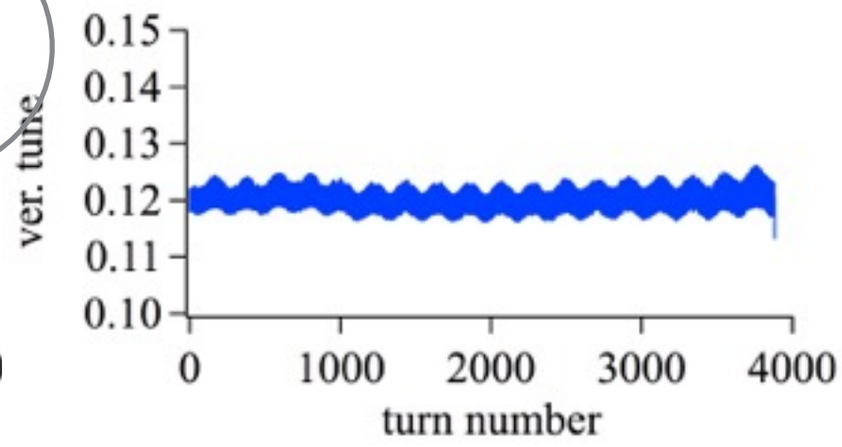


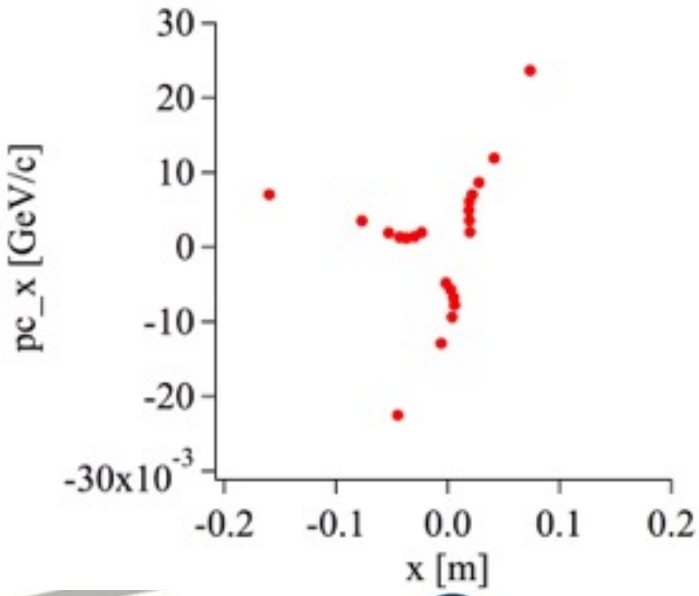












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Summary

Dynamic aperture depends on the strength of higher order multipoles.

The higher the order is, the less sensitive the relative strength of multipoles.

Inaccurate modelling of TOSCA field map (both 2D and 3D) give a wrong estimate of dynamic aperture.

However, how do we know multipoles which are so much different from the ideal field is due to inaccurate modelling or the real field itself differs from the ideal field?

TOSCA field with smaller mesh size.