

Error study of non-scaling FFAG

10 to 20 GeV muon ring

Shinji Machida
CCLRC/RAL/ASTeC
26 July, 2006

[http://hadron.kek.jp/~machida/doc/nufact/
ffag/machida_20060726.ppt & pdf](http://hadron.kek.jp/~machida/doc/nufact/ffag/machida_20060726.ppt&pdf)

Definition of errors

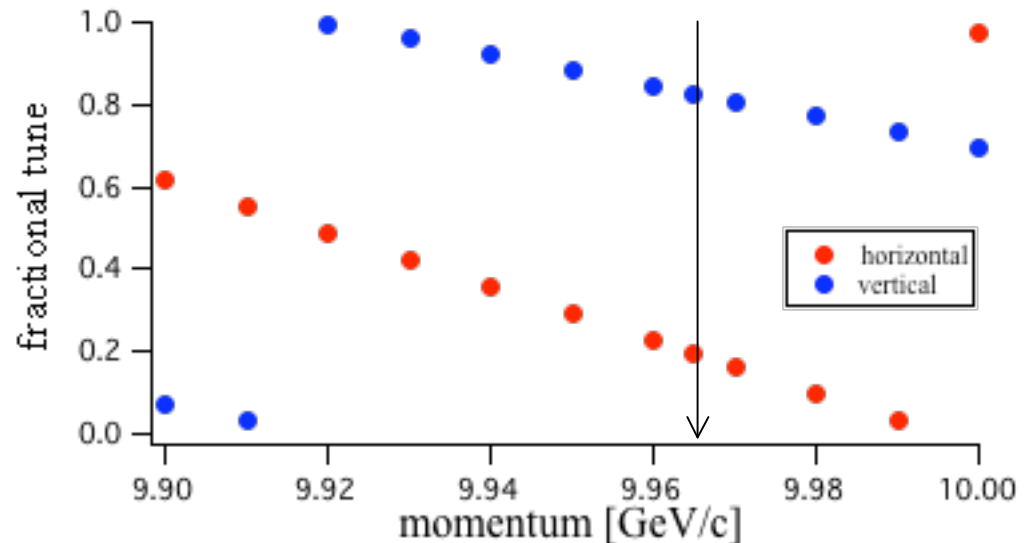
- Alignment error
 - Horizontal and vertical directions. No longitudinal or tilt.
 - Assume each QD and QF are on a single support table. QD and QF are aligned (or misaligned) together.
 - Alignment errors produce additional dipole kicks.
- Gradient error
 - Random errors of quadrupole strength.
 - Gradient errors produce additional quadrupole kicks.
- Distribution of both errors is Gaussian and there is a cut at 2 sigma.
- Use 40 seeds to see statistics.

Tracking conditions

- Constant energy gain (independent of RF phase) per turn is assumed to avoid time of flight variation due to transverse amplitude.
- 10 to 20 GeV acceleration is finished in 17 turns.
- 30 π mm emittance in horizontal and vertical (ellipsoidal in 4-D).
- Distribution of 500 macro particles is Waterbag.
- Nominal initial dp/p and phase spread are assumed.

Initial matching

- Assume the distortion of beta functions are small. Particle distribution is matched unperturbed lattice function.
- To make sure the above assumption is reasonable, choose the initial tune away from half-integer resonance.
- Initial momentum is 9.965 [GeV/c] in the present study.



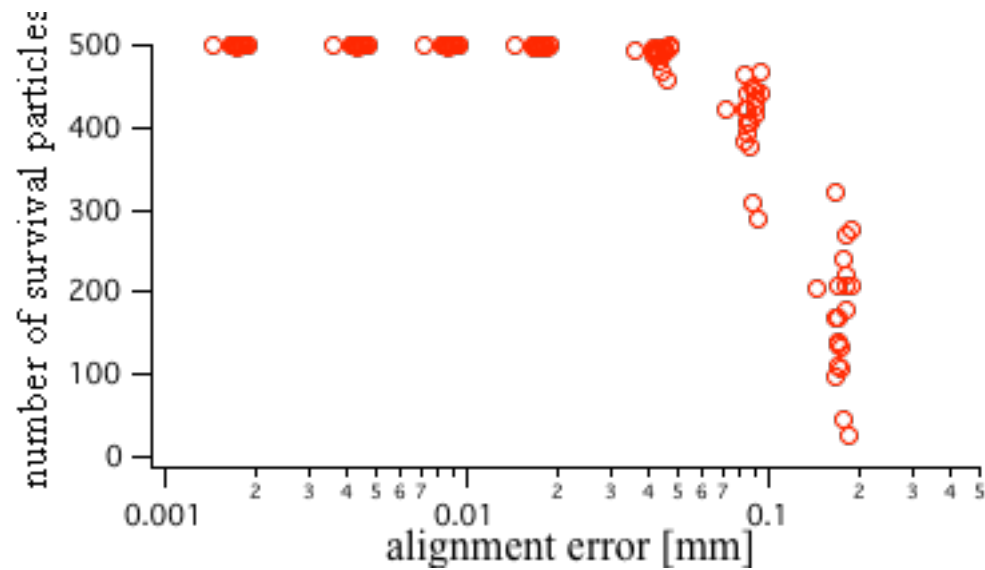
Loss criterion

- At every cell, calculate amplitude (single particle emittance) of each macro particle.
- If the amplitude is more than $45 \pi \text{ mm}$ (1.5 times of the initial emittance), the particle is regarded as lost.
- The “phase space collimation” concept was introduced by Meot.

Tracking results (1)

only alignment error

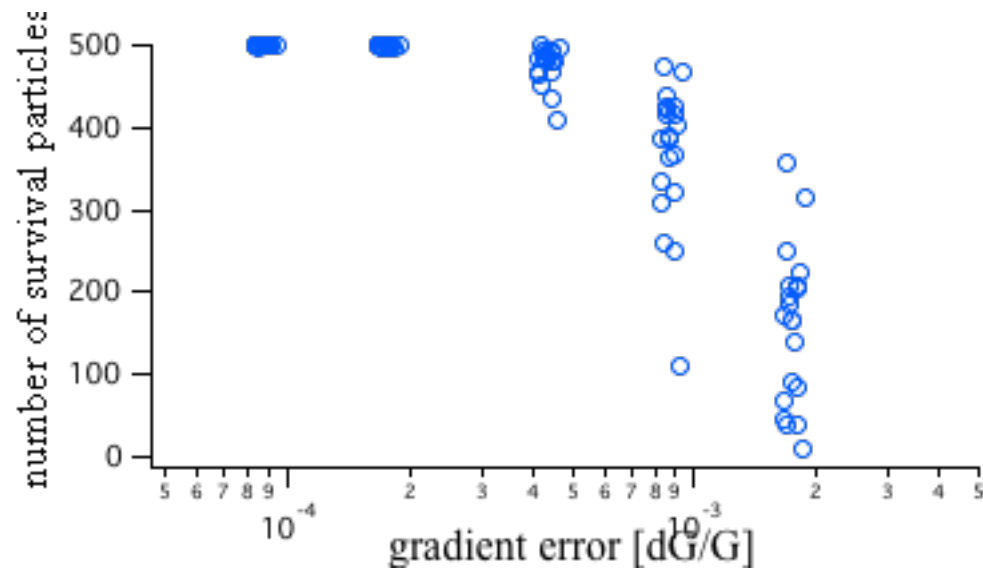
- No beam loss at 20 μm (rms) or below.
- 50 μm (rms) may be tolerable.



Tracking results (2)

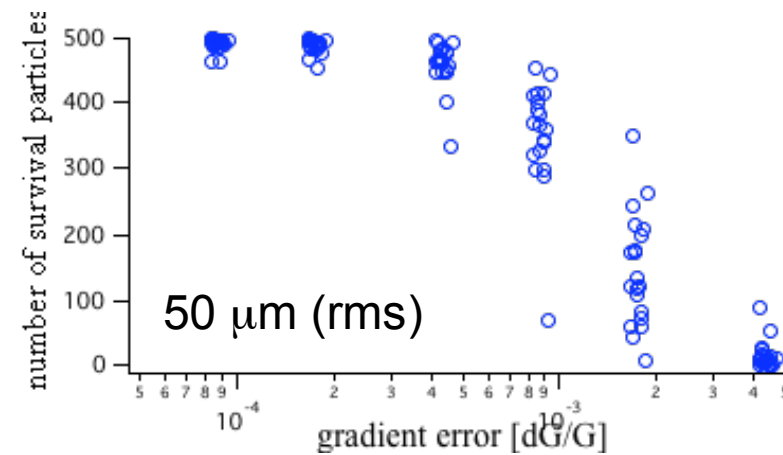
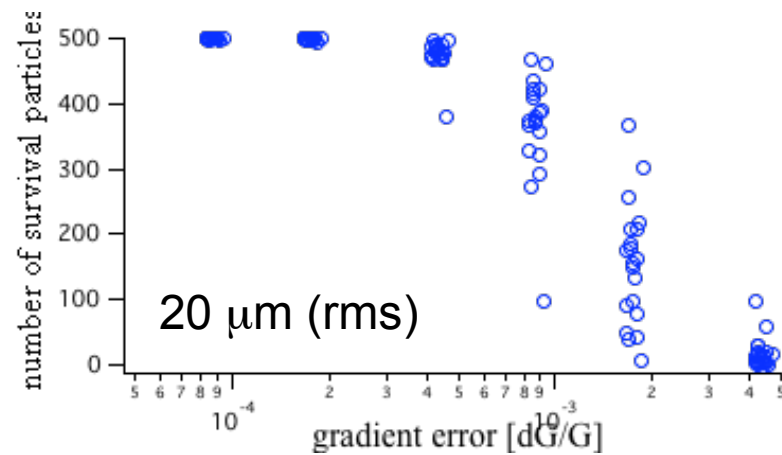
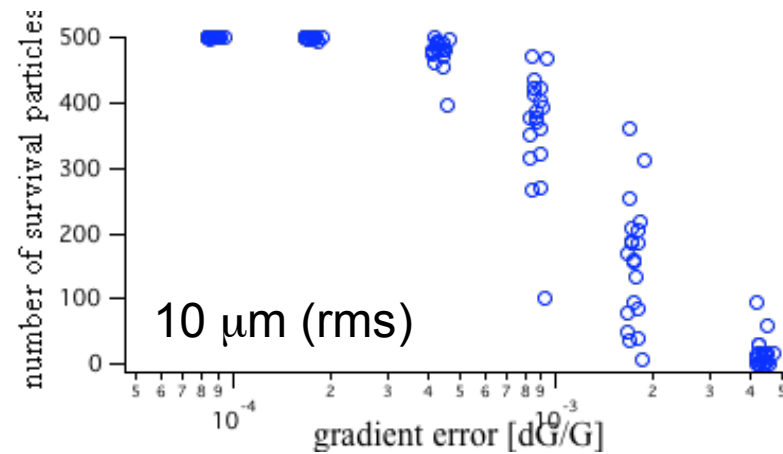
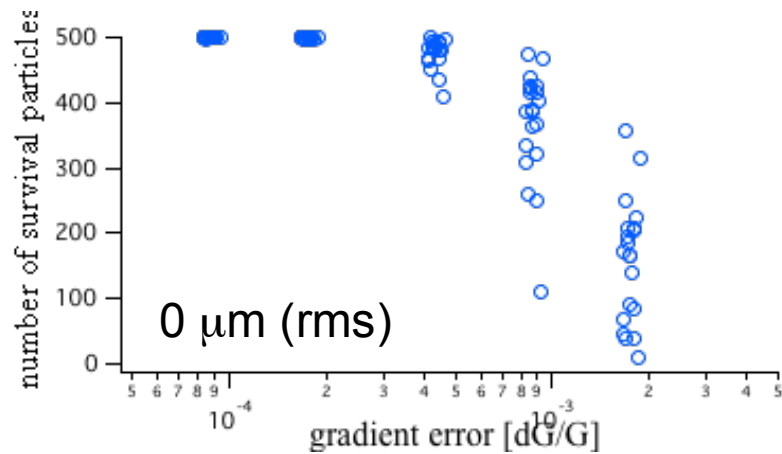
only gradient error

- No beam loss at $dG/G=2 \times 10^{-4}$ (rms) or below.
- $dG/G=5 \times 10^{-4}$ (rms) may be tolerable.



Tracking results (3)

gradient error with some alignment error



- Two kinds of errors seem to be added, not multiplied.

Summary

- In 10 to 20 GeV/c muon ring,
 - Alignment error should be 20 to 50 μm (rms) .
 - Gradient error should be $dG/G = 2$ to 5×10^{-4} (rms)
- Requirement of gradient error may be a bit hard.