Edge Effects in Dipole/Quadrupole Cooling Rings

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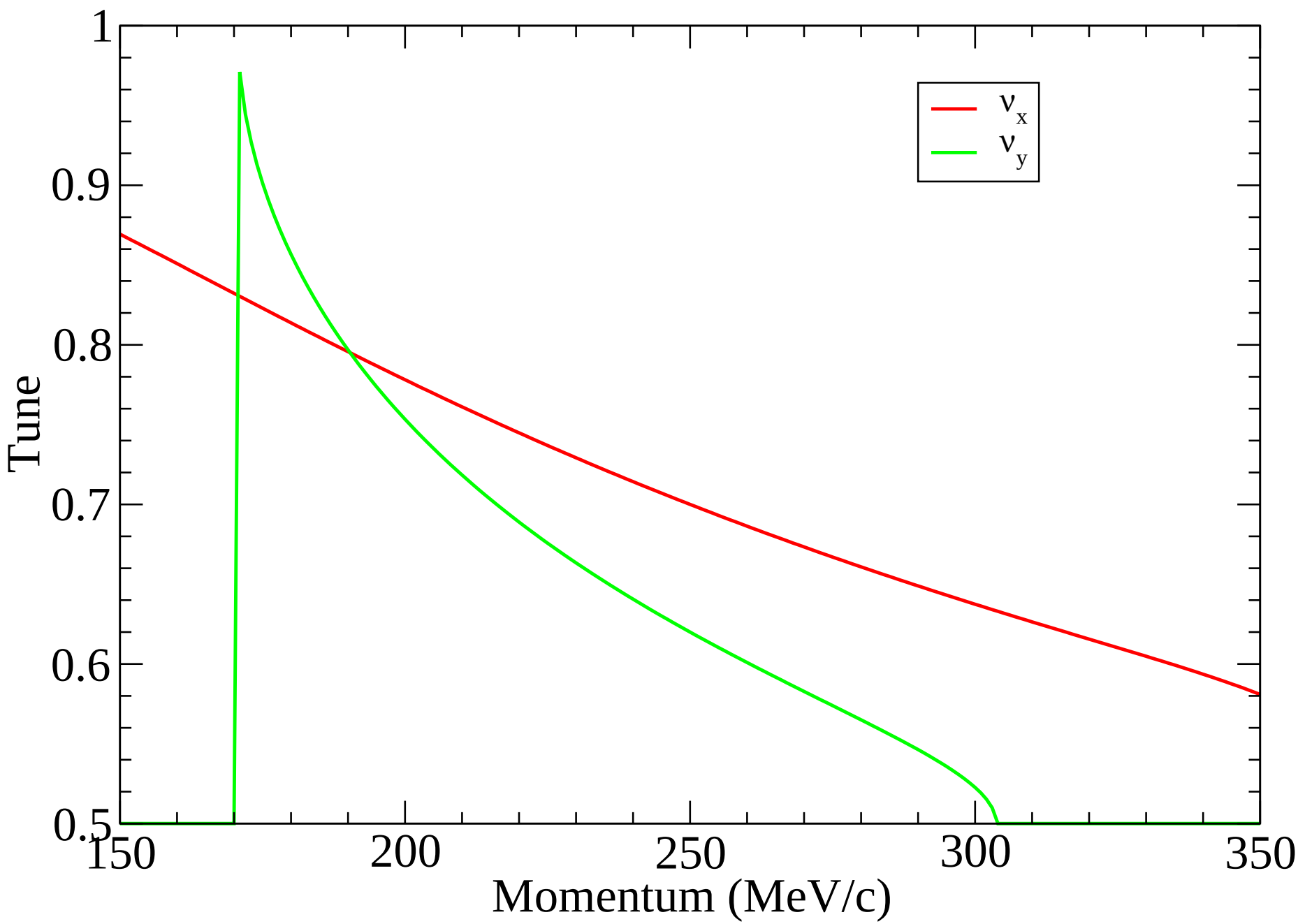
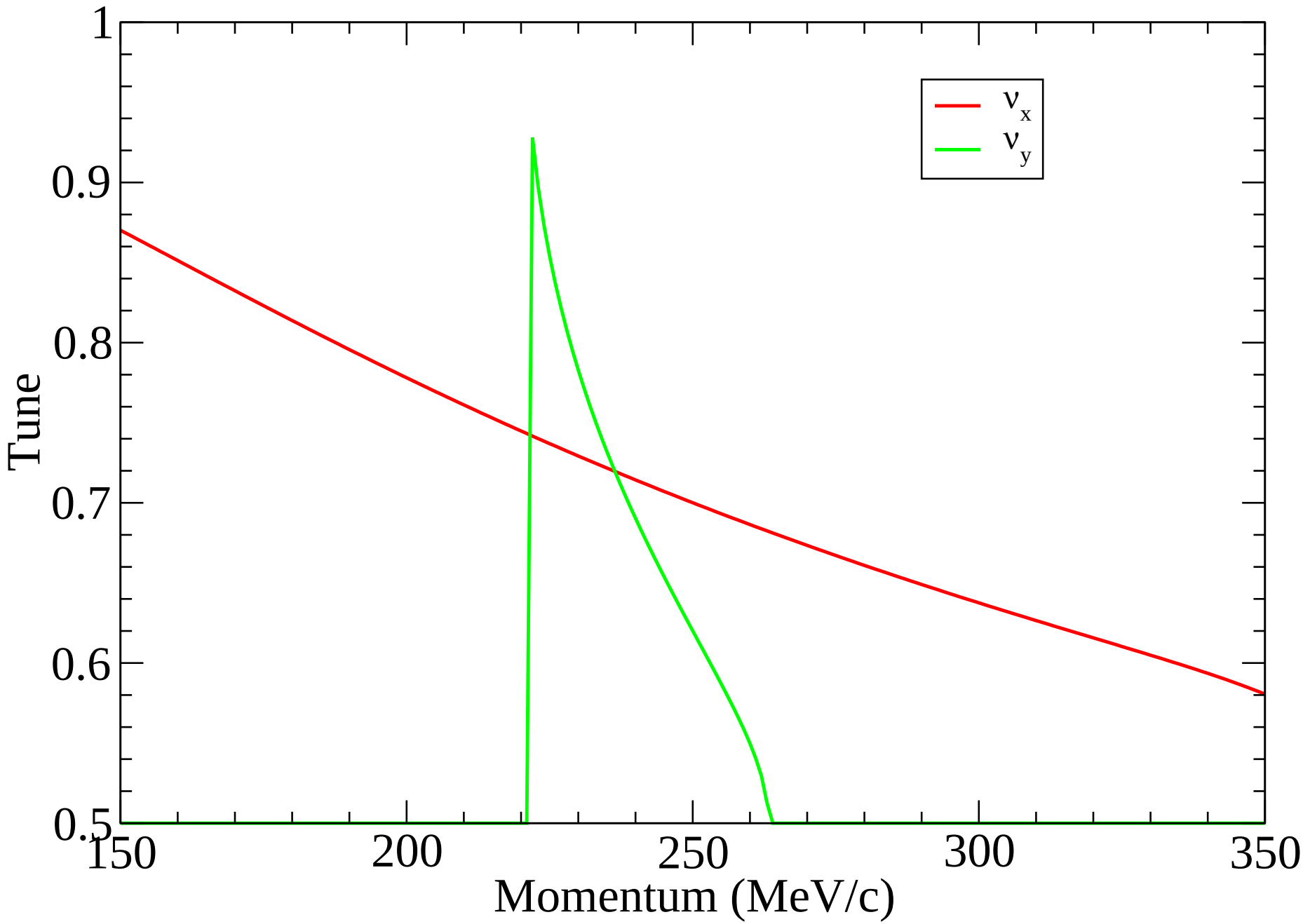
Effect of Thin Ends

- Cooling rings need large energy acceptance and dynamic aperture
- Consider effect of adding nonlinear end fields to dipole/quadrupole based lattice
- Even thin ends have a drastic effect on ring performance
- Energy acceptance greatly reduced when adding thin ends
- Dynamic aperture also reduced significantly

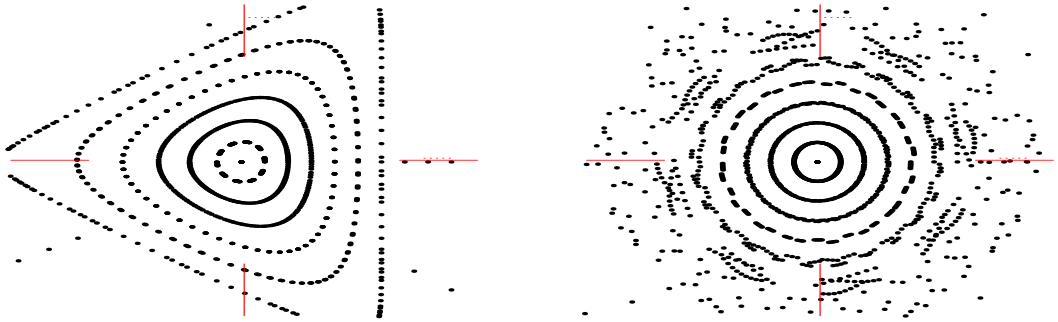
Cooling Lattice Tunes, No Ends



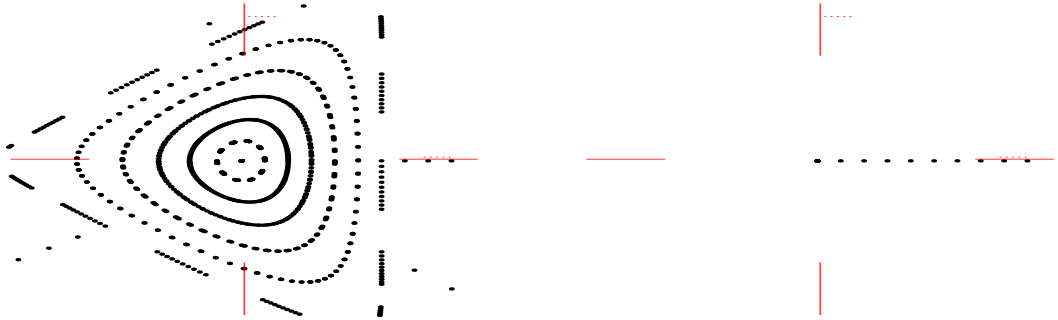
Cooling Lattice Tunes, With Thin Ends



Dynamic Aperture



Without Ends



With Thin Ends

Explanation

- For any magnet, there is a "hard-edge" end field
  - Integral is roughly independent of end length
  - In particular, integral is nonzero even if end has zero length
  - Two orders higher than magnet order
  - Sextupole-level terms in dipole!
    - Chromaticity
    - Geometric nonlinearities
    - Nonlinear coupling
- Why only affects vertical
  - Field is longitudinal, linear in y
  - Horizontal force like $p_y B_s \propto y p_y$
    - Off-energy closed orbit displaced only in horizontal, so no chromatic term
  - Vertical force like $y p_x$
    - Off-energy closed orbit turns this into $D'_x \delta y$: chromaticity

Conclusions and Commentary

- End effects in bends can have a drastic effect on cooling ring performance
- Even infinitely thin ends have this effect
- Additional effects from thick ends, particularly when using short magnets