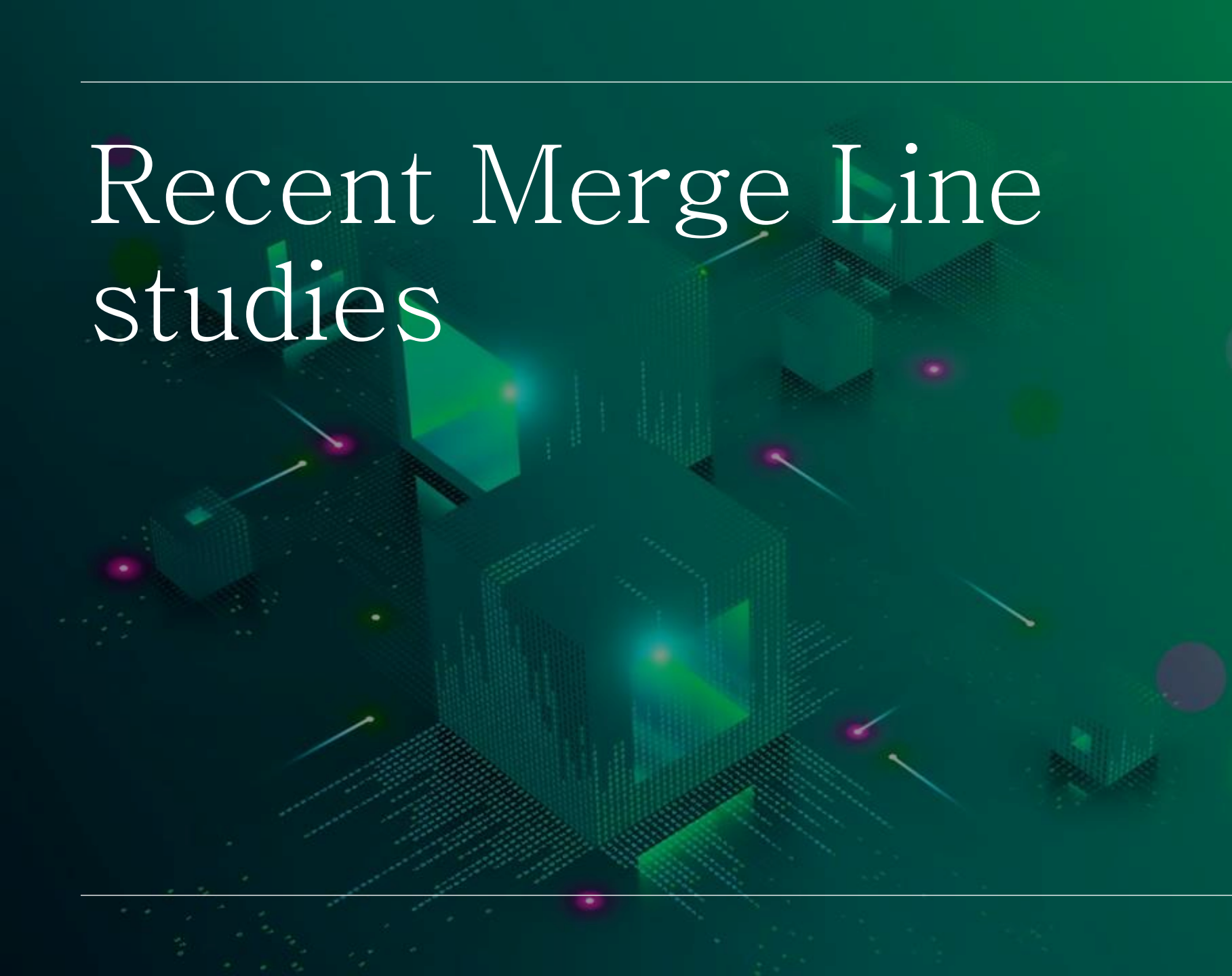
Recent Merge Line studies



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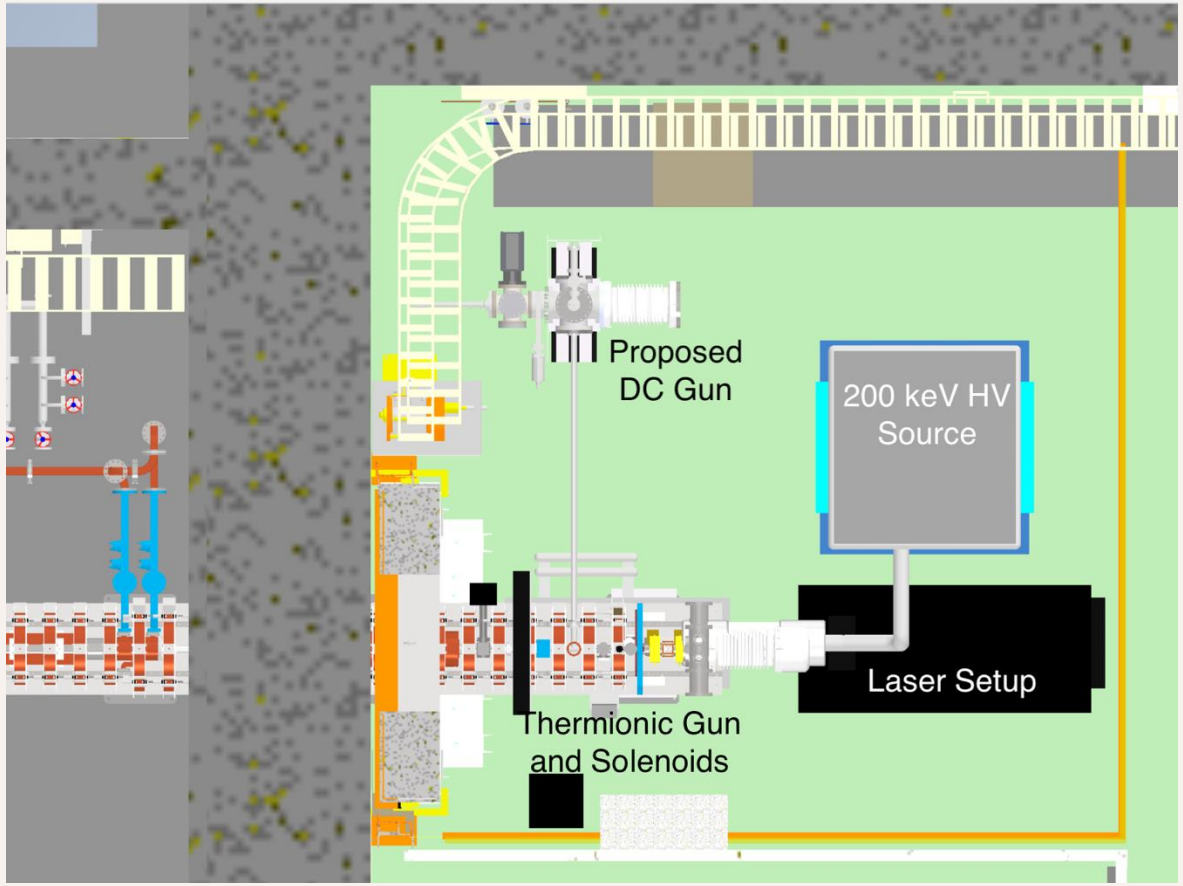
Overview

Based on the current design of the beam merger line, want to understand the beam state and optimize for injection into the 90° bend magnet.

Alex's CST simulation shows very nice beam collimation, but we should validate this and estimate the effect of space charge on a low-energy beam.



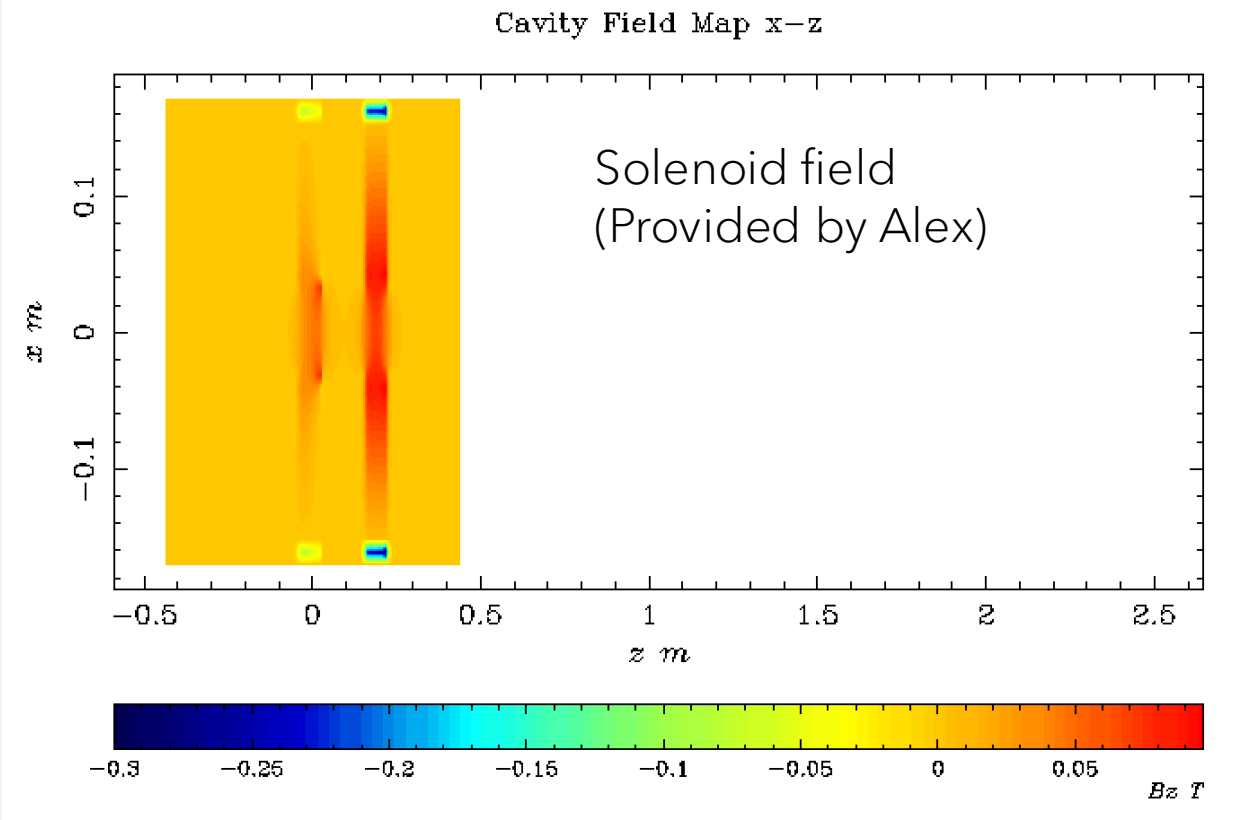
Simulation Inputs

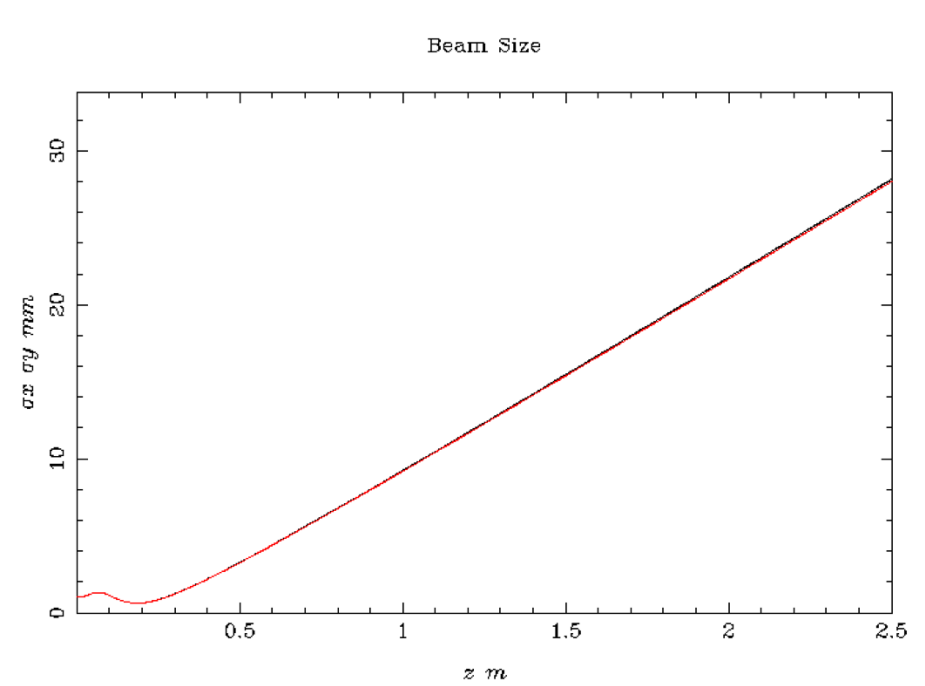
- Merge line is relatively simple:
  - 100 pC beam used in most plots shown here.
  - Assume a 200 keV energy beam (~ 0.5 MeV momentum) – not simulating the e-gun
  - Dual solenoid cavity with model provided by Alex
  - Wien filter not simulated at the moment
    - In principle, electron energy/momentum should be unaffected provided the field is set properly
  - Current beamline is simulated at an estimate of 2.5 m, but exact distance from gun to merge dipole is unclear.
    - Not aiming for exact numerical results, but rather feasibility for transporting the beam to the main beamline.

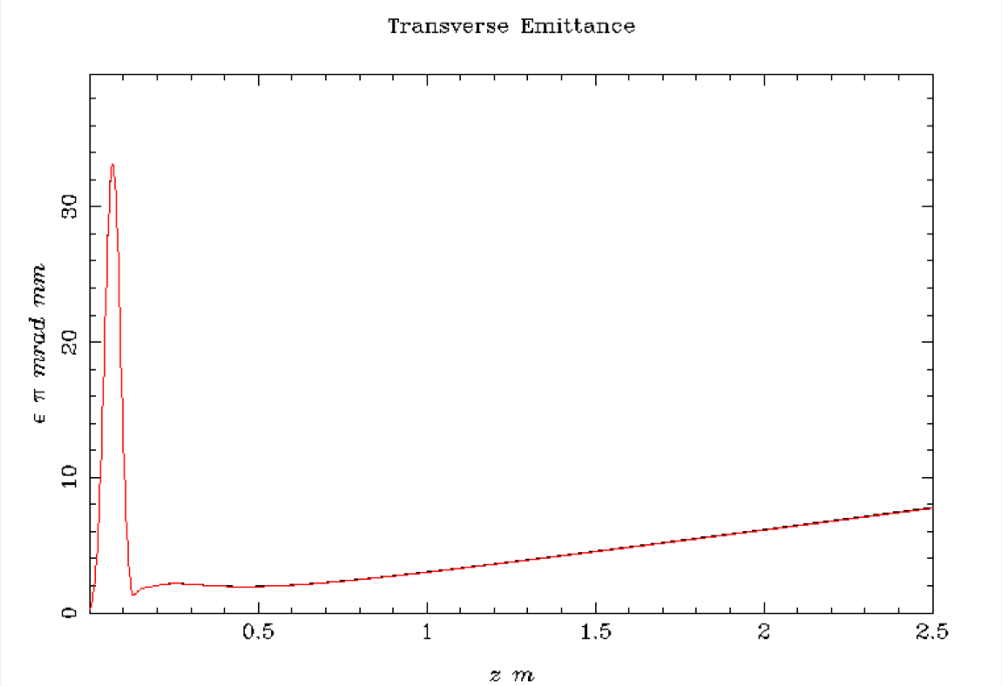
Solenoid Optimization

Use the solenoid designed in CST to optimize beam size and emittance.

Cavity fields are converted from CST outputs to a 3D cavity field to make a realistic model based directly on Alex's design.
(Fields shown at right.)





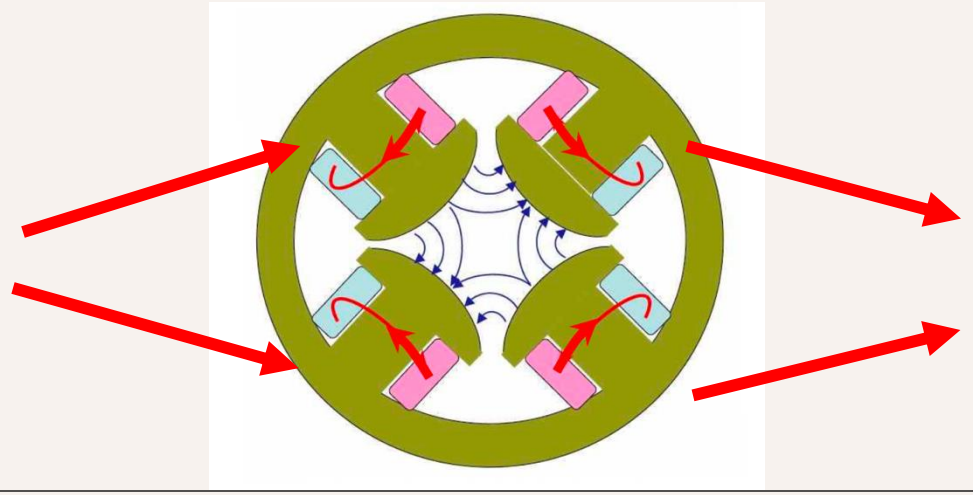


Solenoid Optimization

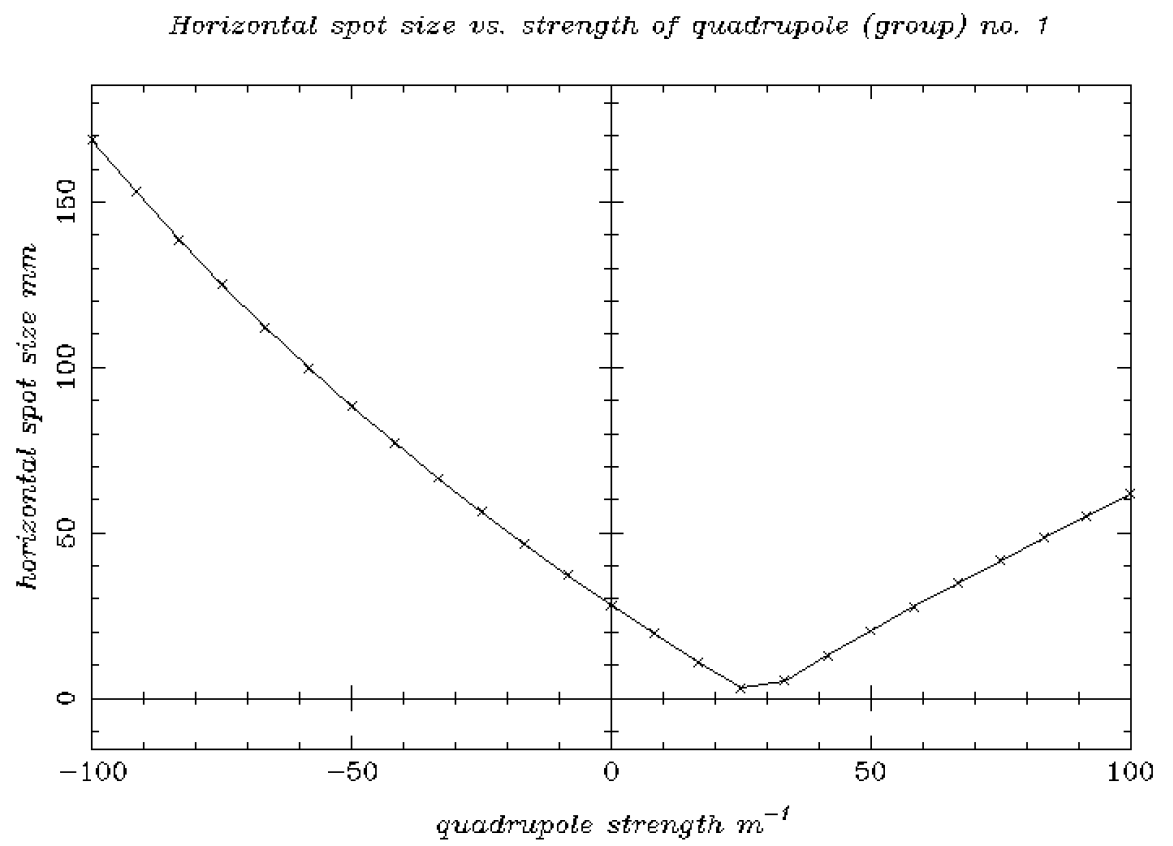
Optimizing the solenoid cavity position and strength seems to be unable to optimize the beam sizes better than a few 10s of mms.

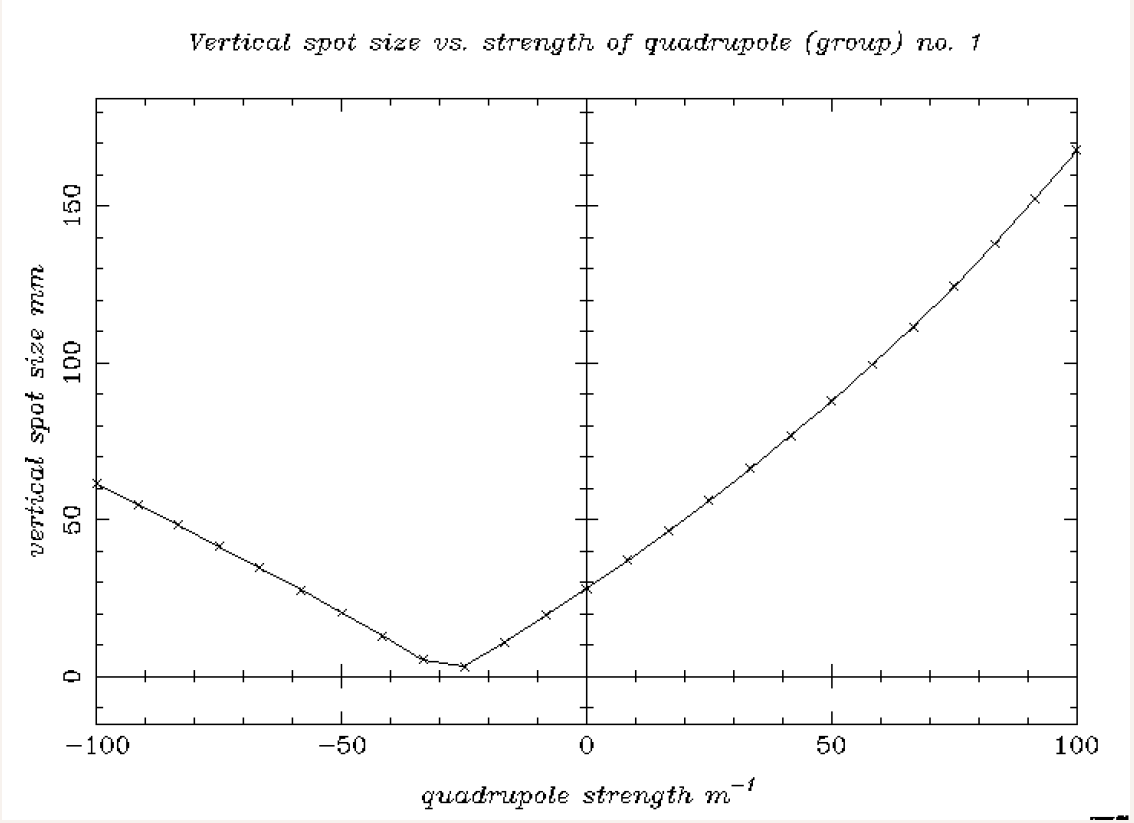
Quadrupole Focusing

- Ability to fully focus the beam far downstream with only the solenoid appears constrained
- Even though the beam is still low-energy, we can't add more solenoids downstream of the Wien filters because they will affect the polarization.
- Investigated adding a quadrupole to improve the beam size/emittance.



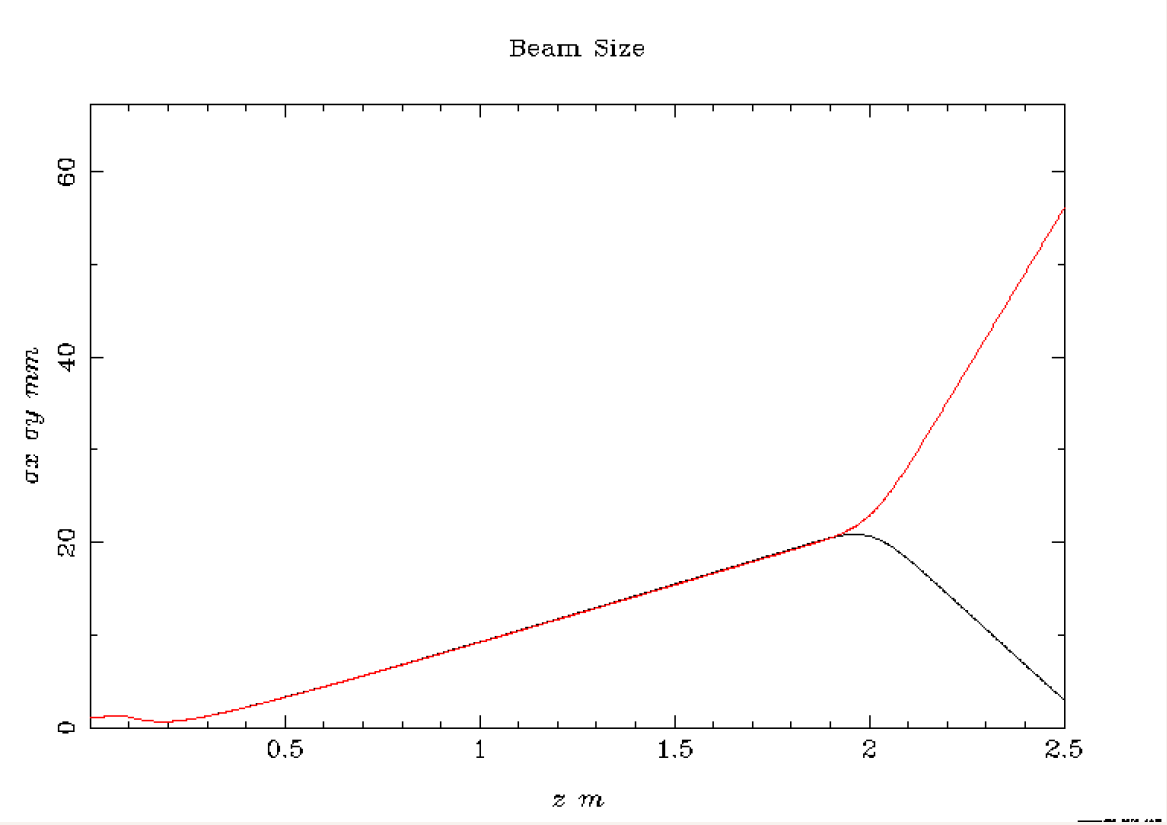
Quadrupole Optimization – Quad Singlet





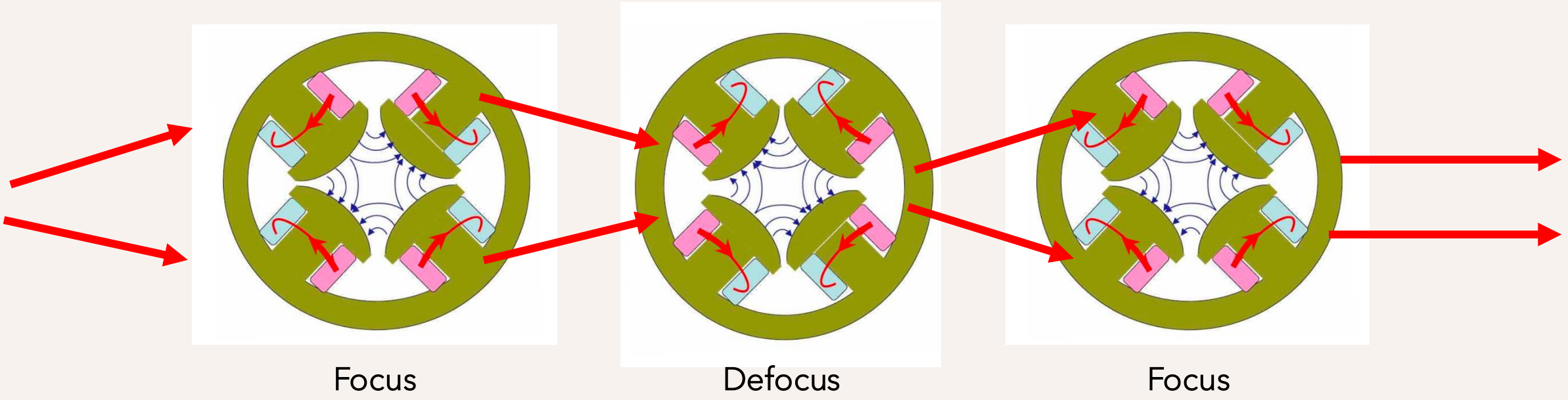
A single quadrupole can effectively focus in one direction, but with a corresponding defocus in the other.

Quadrupole Optimization – Quad Singlet



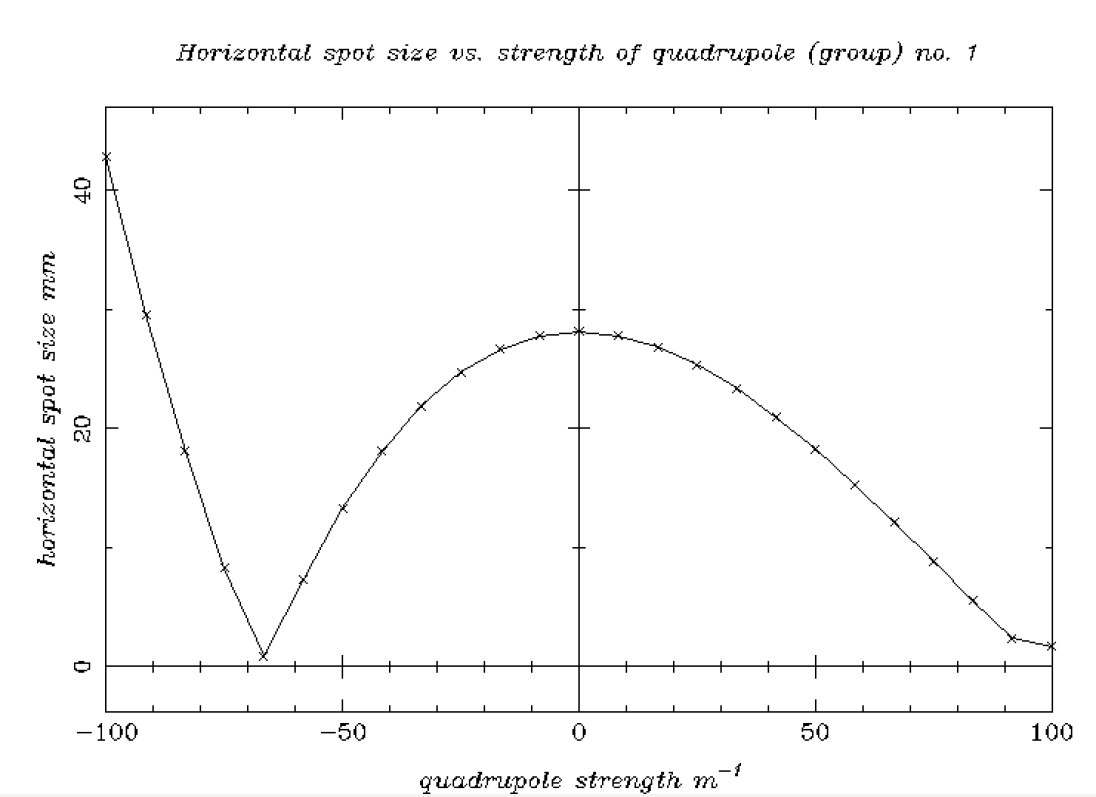
A single quadrupole can effectively focus in one direction, but with a corresponding defocus in the other. Depending on how much focusing we need, this might be acceptable, or it might be too much loss in Y.

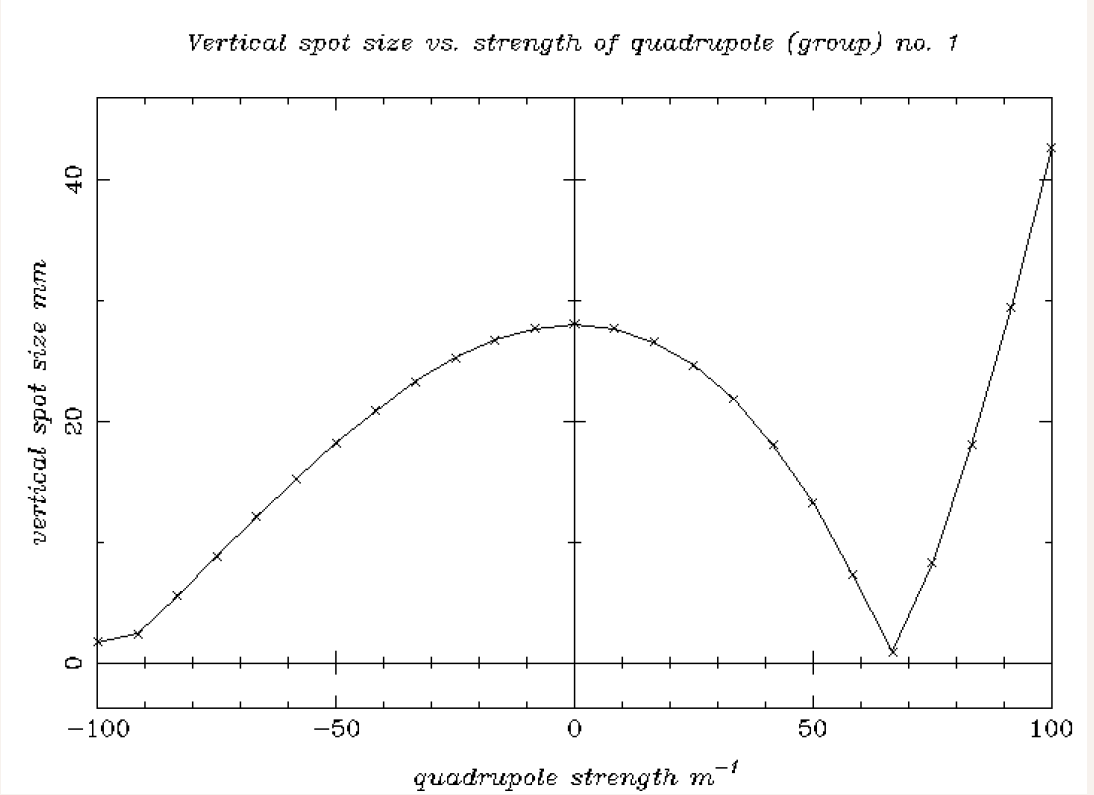
Quadrupole Optimization – Quad triplet



With the triplet, we can get small spot size in X or Y and OK spot size in the opposite dimension.
Assuming horizontal is the more important DOF, we can get sub-mm in X,

Quadrupole Optimization – Quad triplet





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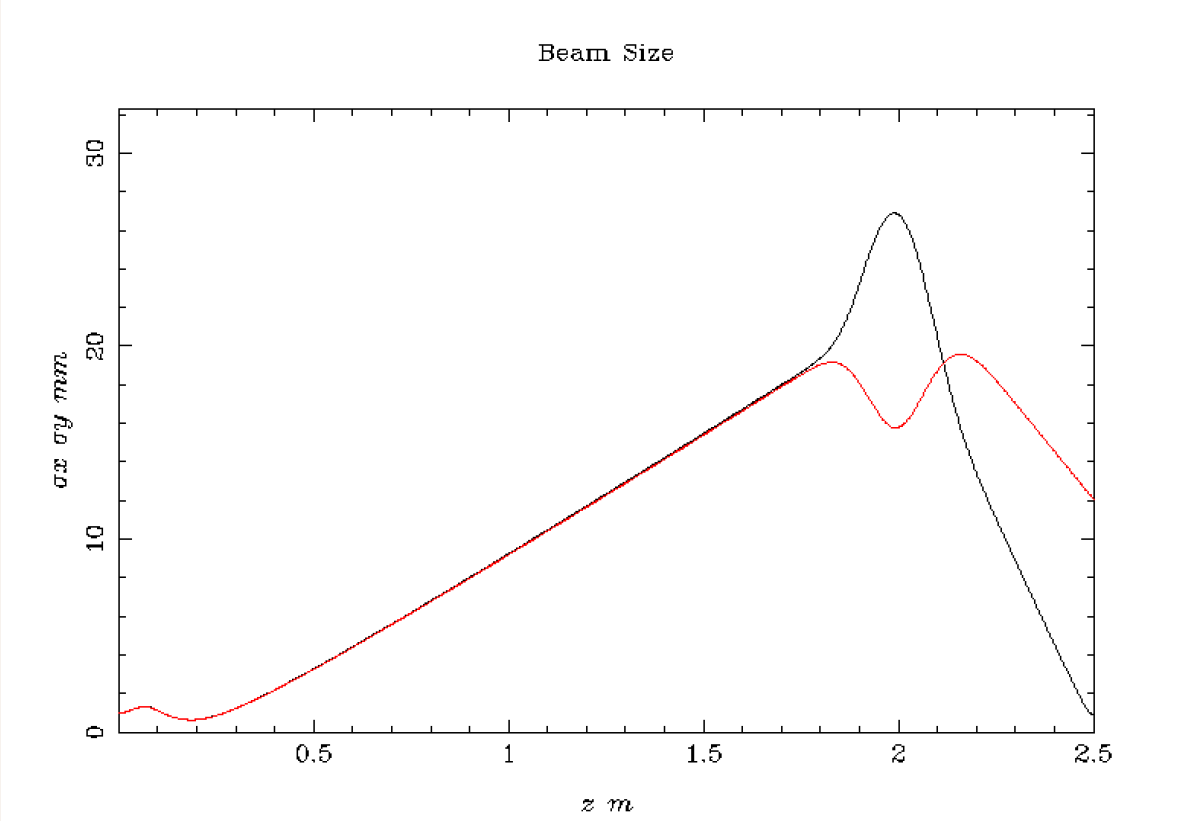
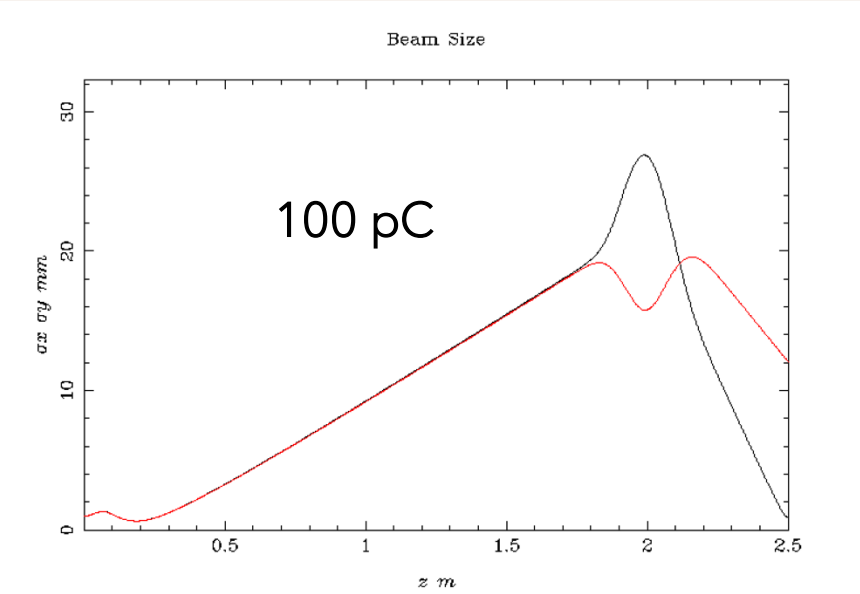
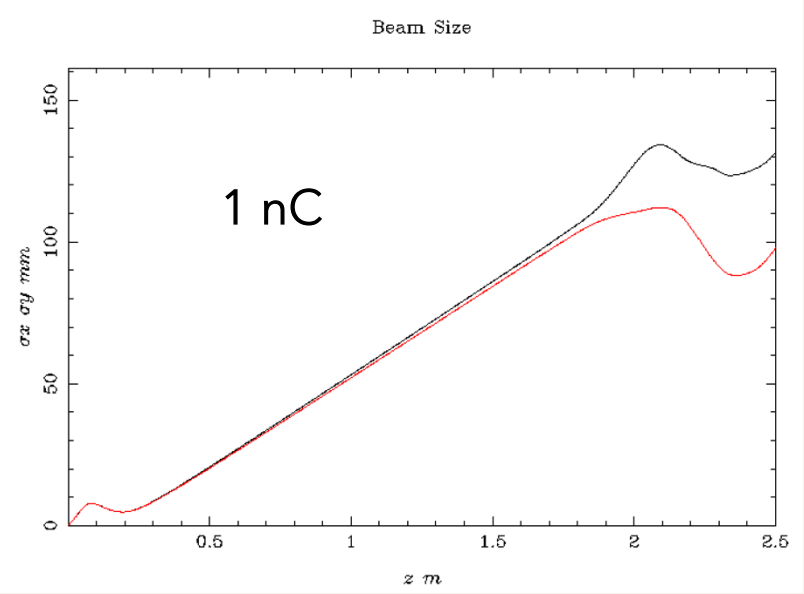
Quadrupole Optimization – Quad triplet



Assuming horizontal is the more important DOF, we can get sub-mm RMS in X and ~12 mm in Y (depending on how far the Quad is placed from the entrance)

Bunch charge effects





Focusing depends strongly on beam charge – moving from 100 pC to 1 nC causes a large blow-up – solenoid and quads will need to be adjusted based on extracted charge.

Conclusions

- Solenoid focusing with the current (?) design can focus the beam to the order of ~10s of mms at a few meters.
  - Possible to improve based on further optimization of initial solenoid?
- Adding quadrupoles before the merge point seems to be promising for reducing the beam spot size.
  - Singlet may be sufficient, but a triplet (FDF) can provide better focusing in both directions
- Beam size/spread depends strongly on the bunch charge.