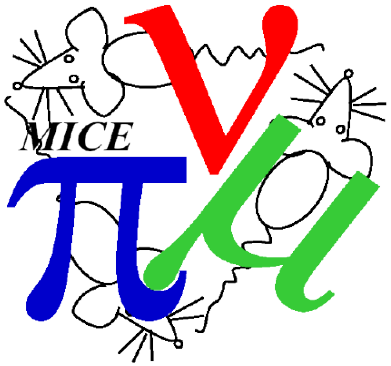
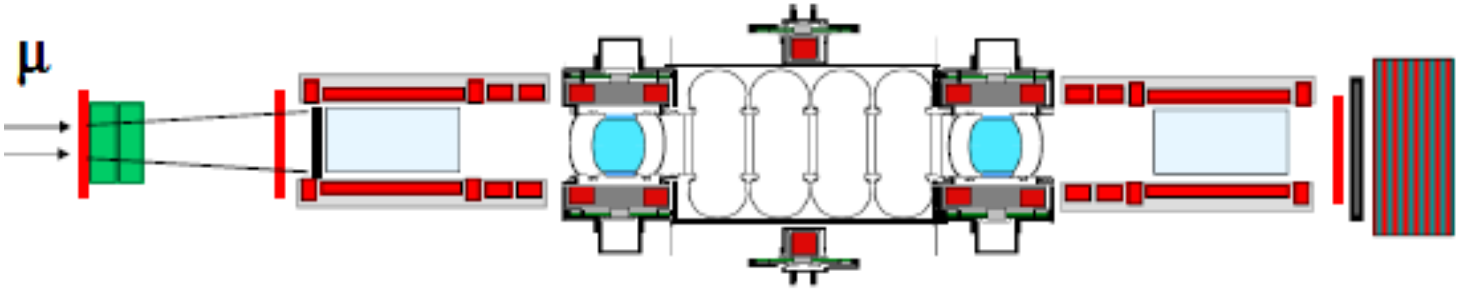
What does Step VI bring scientifically relative to Step V alone?



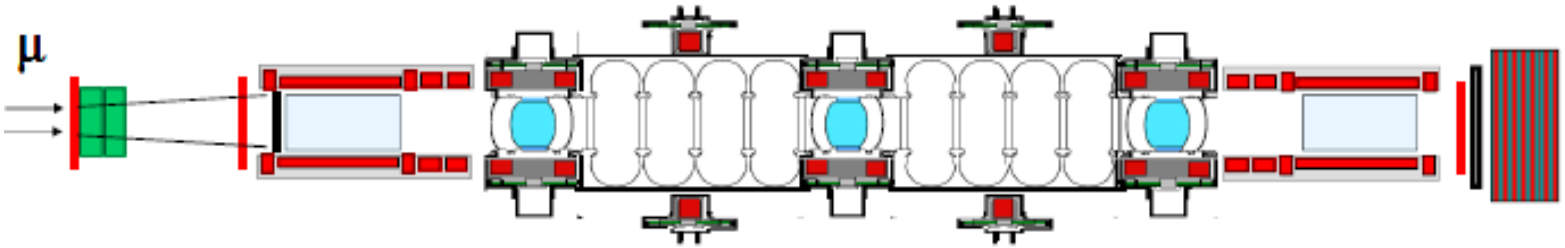
Chris Rogers,
ASTeC,
Rutherford Appleton Laboratory

MICE Step V



- Half cooling cell
  - Demonstrates energy recovery
  - Demonstrates operation of warm RF in proximity to absorbers and superconducting magnets
  - Verification of longitudinal phase space behaviour
    - No RF bucket

MICE Step VI



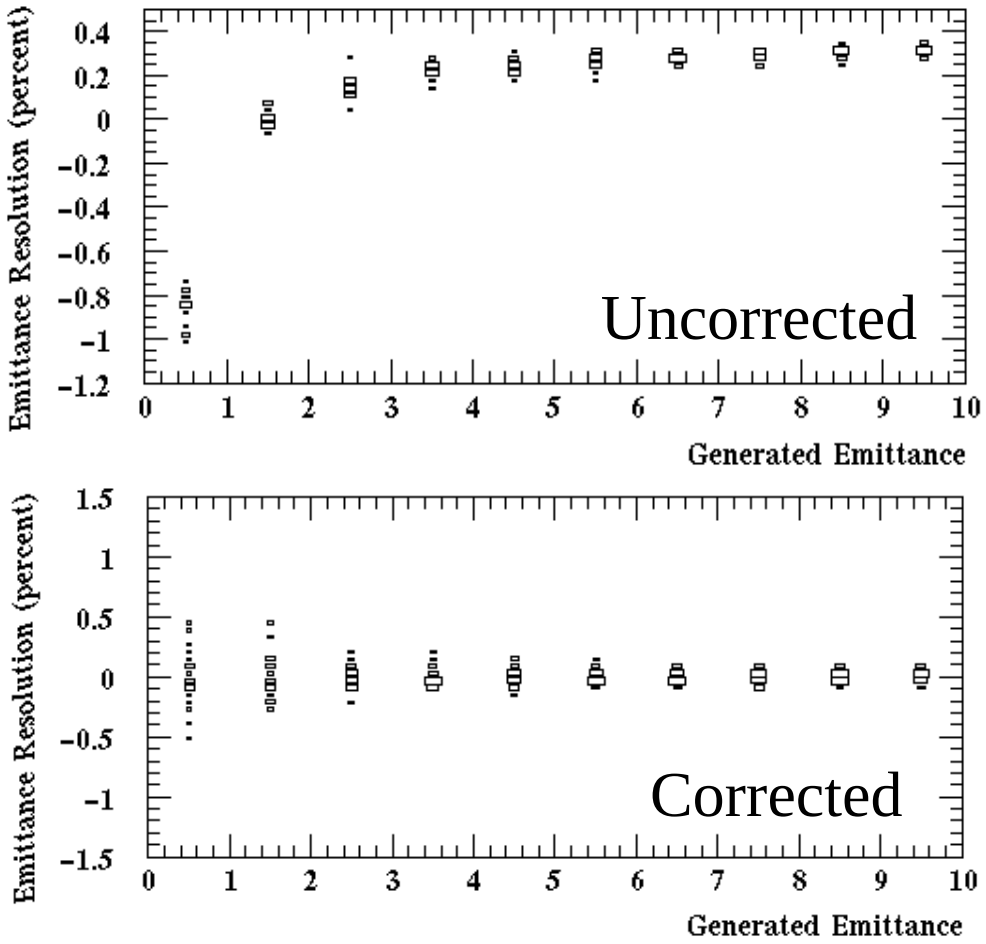
- Full cooling cell
  - Larger emittance change
    - Clearer cooling signal
    - Reduced risk of systematic effects interfering with measurement
  - Operation with all magnetic couplings
    - Demonstrate symmetry of the +ve and -ve field regions
    - Excite/observe 3 π resonance

Sources of systematic bias

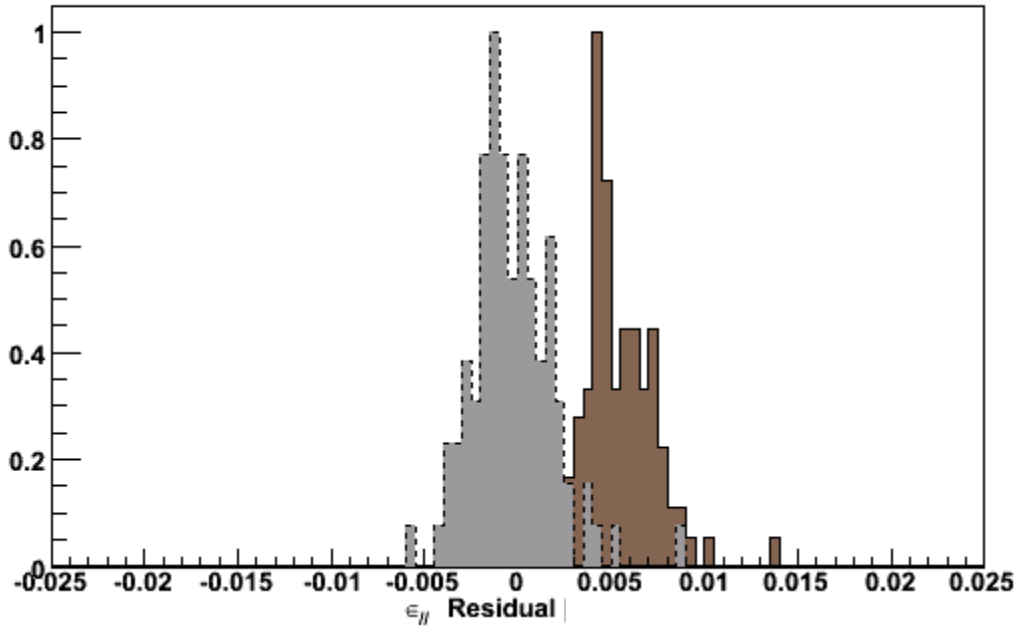
- Finite resolution of detectors and mis-id of particles
- Optical emittance growth
- Mismatch of beam line (e.g. dispersion)
- We can account for these systematic errors, and use software techniques to remove them
- Try to keep signal as strong as possible

Finite resolution of detectors

- Finite resolution of detectors
  - Expect ~ 0.3 % systematic bias in reconstructed transverse emittance
  - “convolution” of detector error pdf and beam pdf
  - Can remove it
    - Require good understanding of the resolution
    - detector resolution << beam size

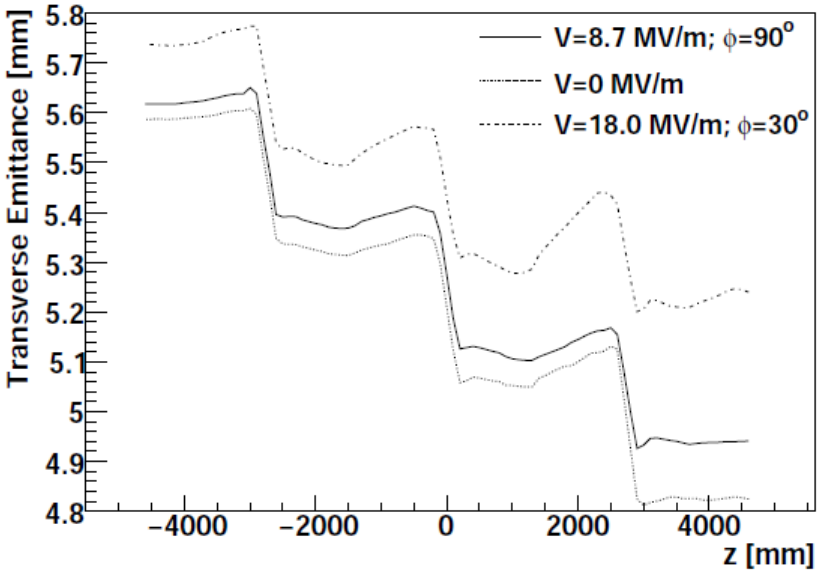


Finite resolution of detectors



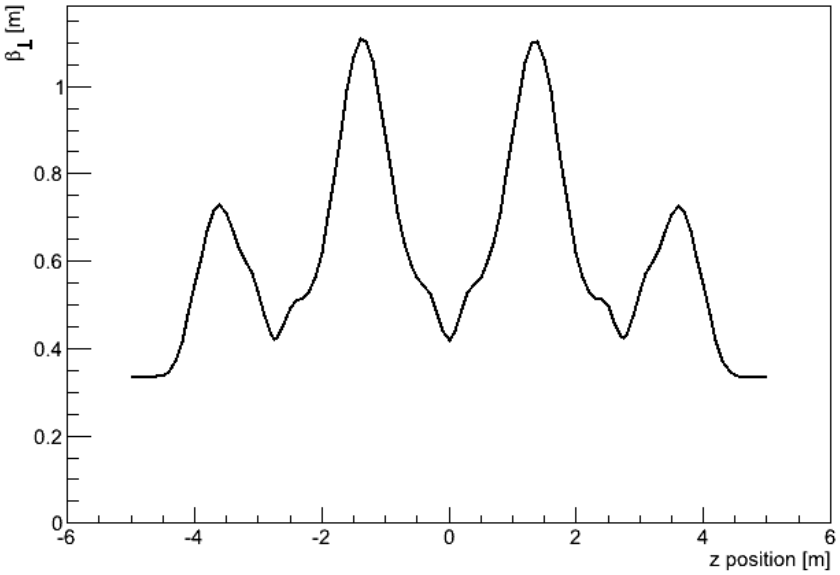
- In longitudinal phase space the bias is ~ 2% of emittance
  - Longitudinal heating ~ 6 % effect at Step V
  - Longitudinal heating ~ 10% effect at Step VI
- We hope to be able to correct the bias
  - Puts burden on Monte Carlo and analysis

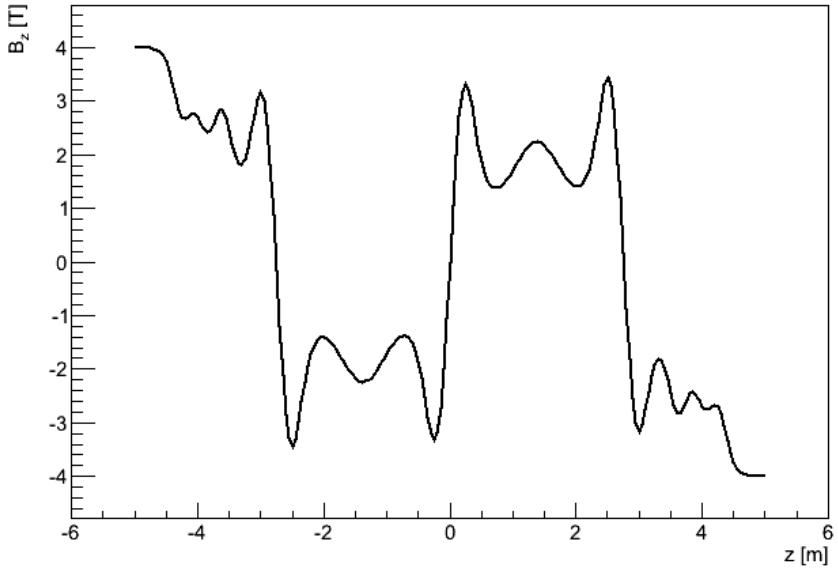
Transverse Cooling



- Emittance growth from chromatic aberrations (2nd order)
  - Spherical aberrations at 3rd order
  - Causes emittance reduction as well as emittance growth
  - Scale is ~ % level, depending on momentum spread
  - A stronger emittance reduction would give greater distinction between optical emittance changes and true cooling

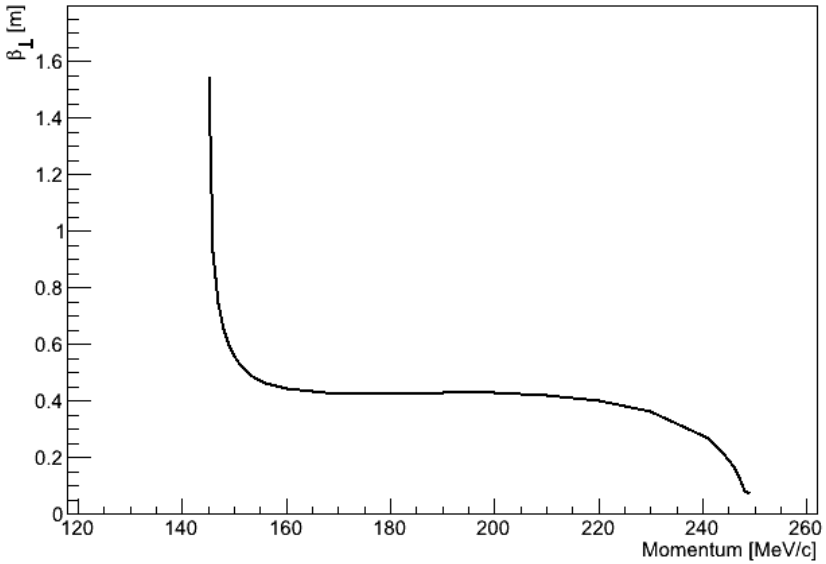
Transverse Beam optics

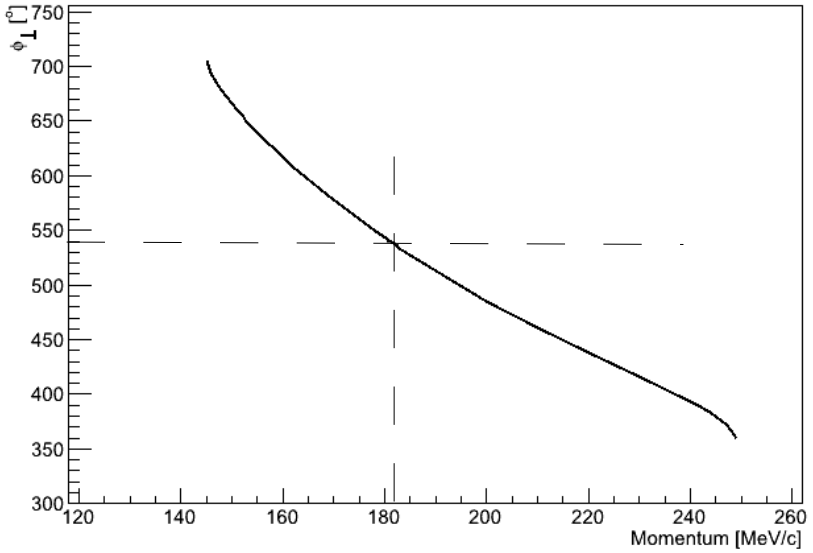




- In Step VI we have three absorbers at each of three focal points
  - Field can change sign at each absorber (as considered here)

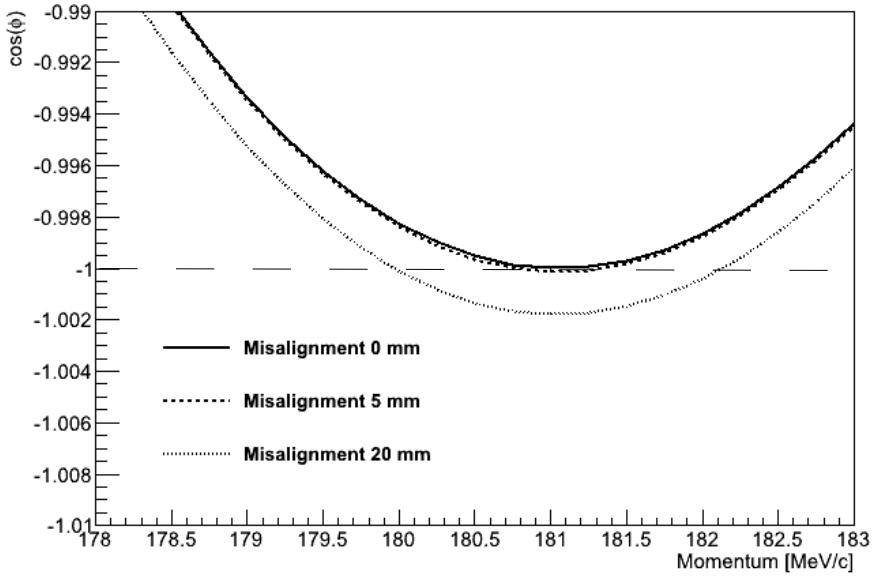
Momentum dependence of optics





- Beta function vs momentum
  - Chromatic aberration (2nd order) suppressed by harmonic composition of $B_z(z)$
  - 3π resonance suppressed by symmetry of lattice
    - Focussing goes as B_z^2
    - Beam sees two cells so long as this symmetry is obeyed

Sensitivity to CC Alignment



- Longitudinal misalignment can induce resonance
  - Systematic misalignment induced from e.g. coil forces can make an effect over multiple cells
  - Desire to measure effect on beam
- Explore experimentally by asymmetric coil excitation
  - Either directly in Coupling Coil or using e.g. Focus Coil
  - Look for abnormal emittance growth around 181 MeV/c

Conclusion

- Operation of the full MICE Step VI
- Gives a stronger cooling signal
  - Reduced risk of bias due to systematic effects
- Allows us to observe the behaviour of a full cooling cell
  - Observation of 3 π resonance