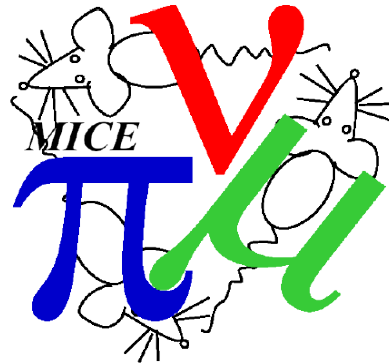


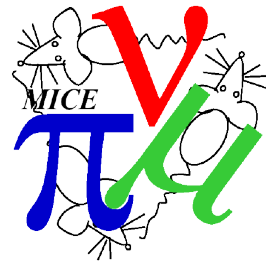
# MICE Step $3\pi/2$ Longitudinal Emittance



Chris Rogers,  
ASTeC,  
Rutherford Appleton Laboratory

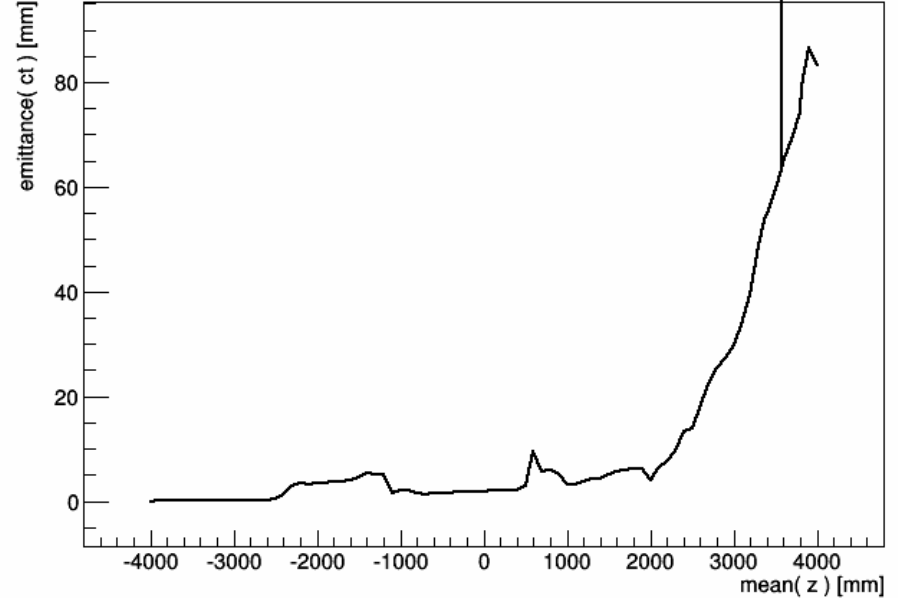
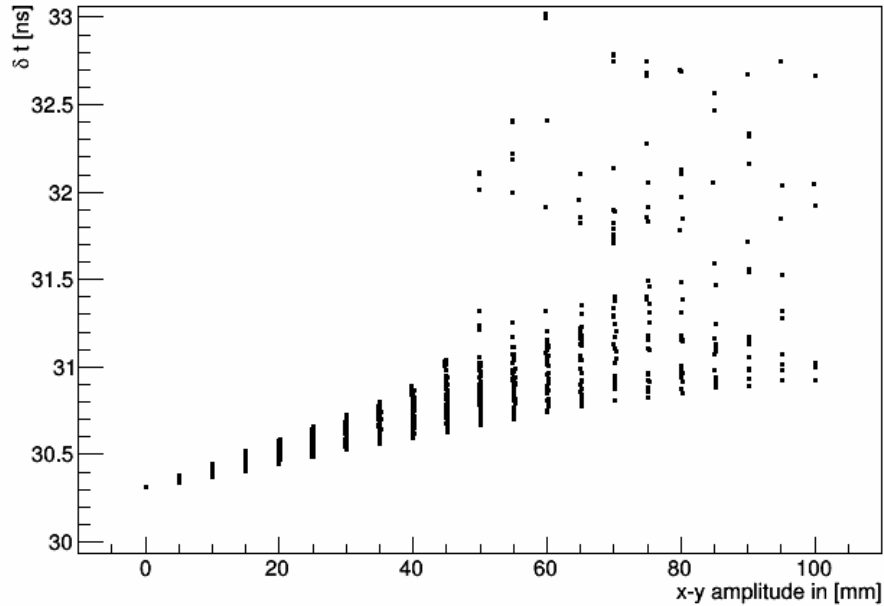
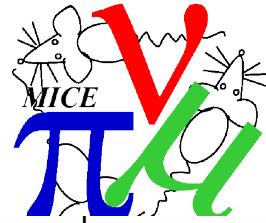


# Overview



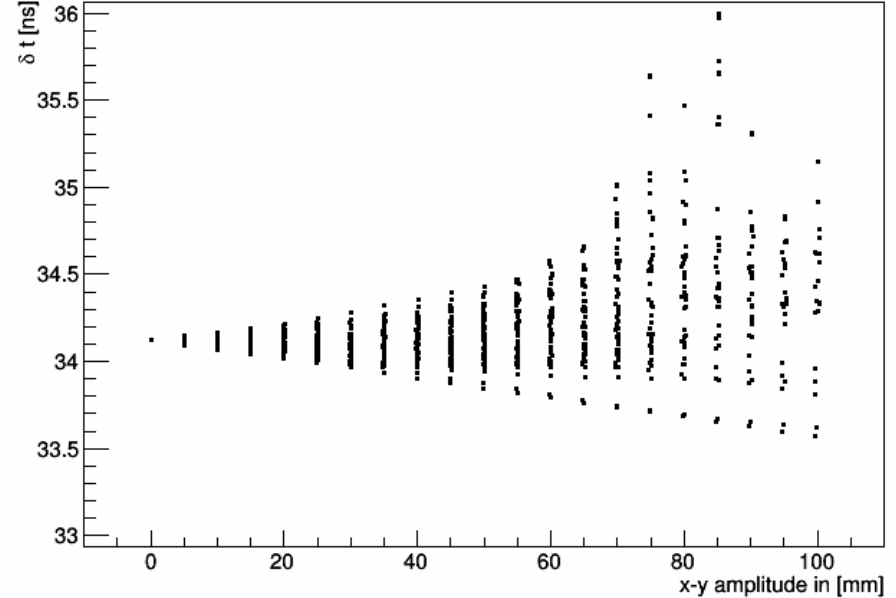
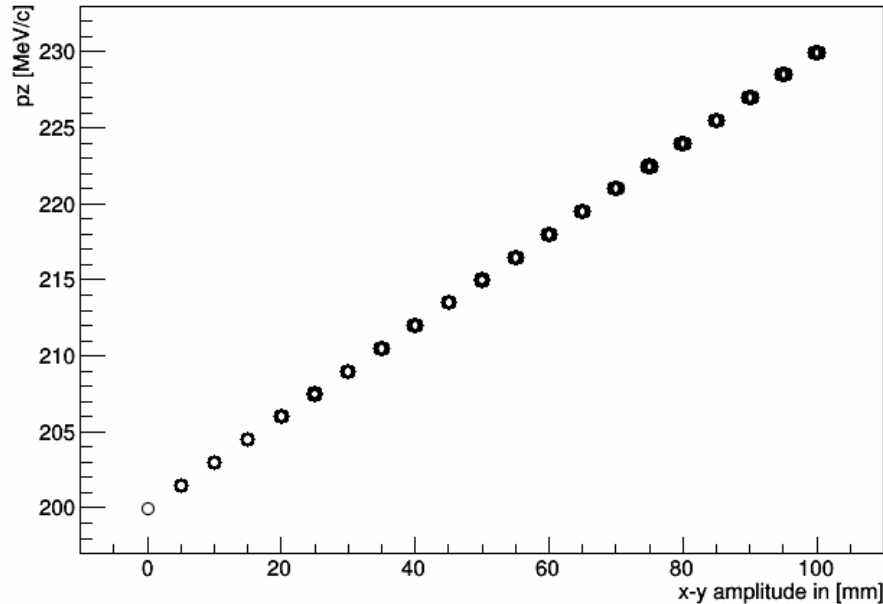
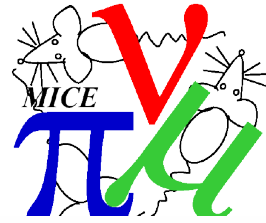
- Trying to understand longitudinal phase space in Step  $3\pi/2$ 
  - See significant longitudinal emittance growth
  - MICE no longer cools in 6D at Step  $> IV$
- Consider
  - Higher amplitude particles follow a longer path
  - Causes correlation between time of flight and amplitude
- Plan of Attack
  - Can we fix by putting higher amplitude particles at higher momentum?
- Use Step\_3pi2\_alt\_15\_1.in
  - C/o Chris Hunt, may be out of date by now
  - **With material physics processes and RF switched off**

# Toy Beam



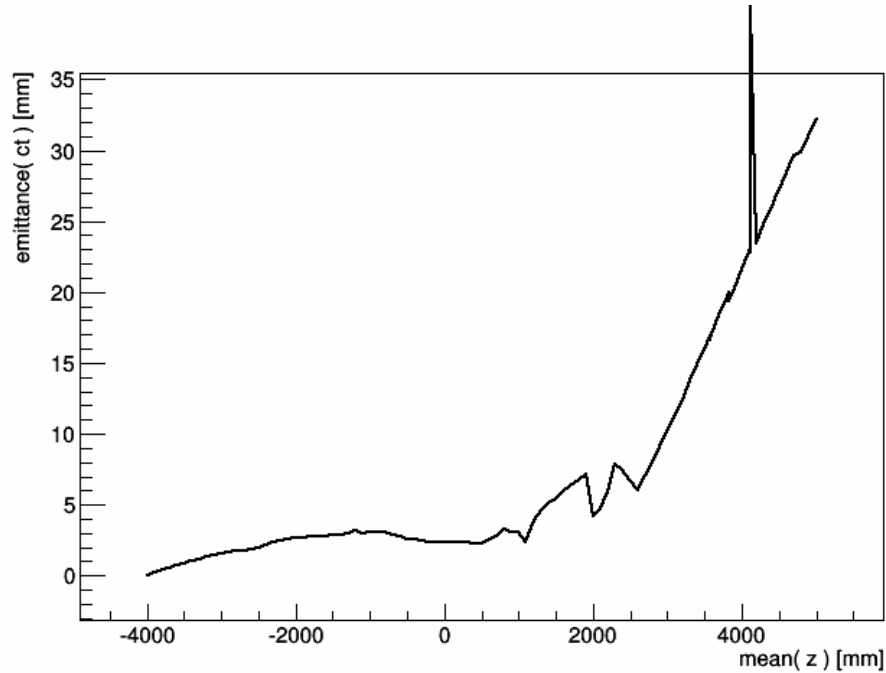
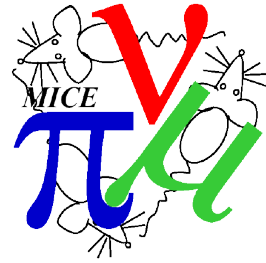
- Amplitude correlation with time of flight is quite marked
  - Initial longitudinal emittance is 0 mm (no spread in time or energy)
  - Final emittance is 80 mm

# Toy Beam with A-P Correlation



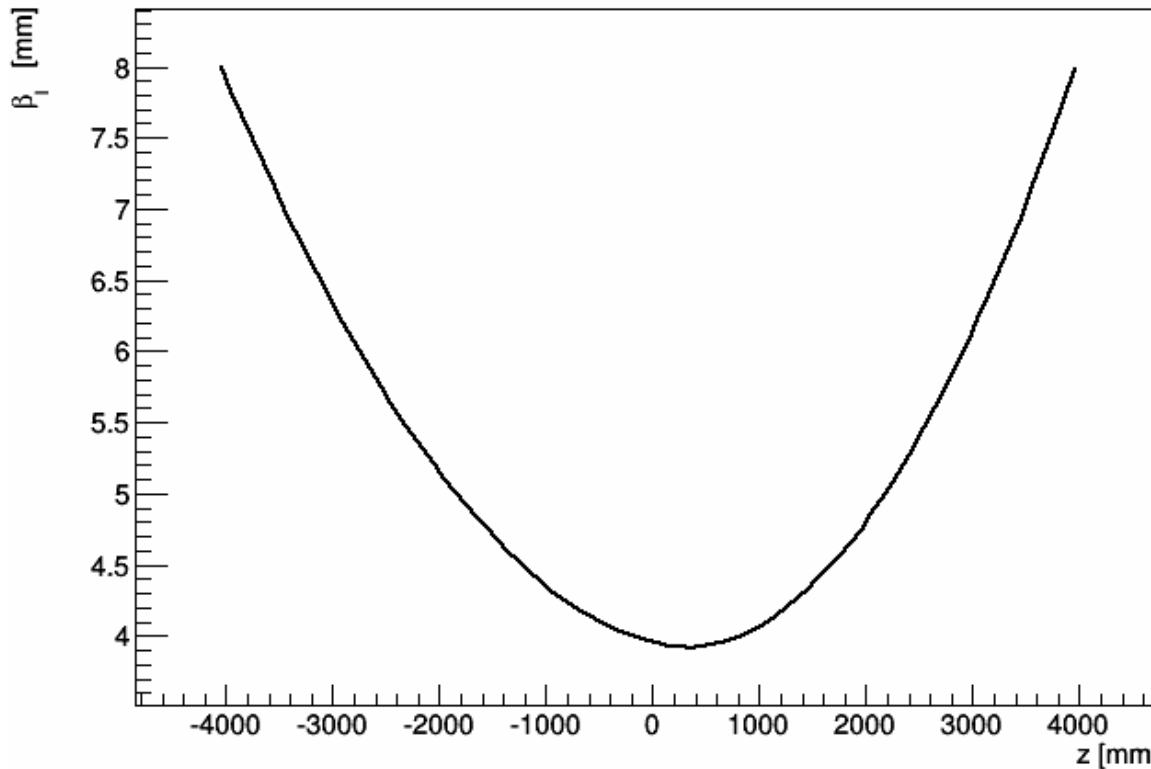
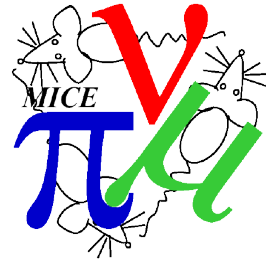
- Introduce a correlation between amplitude and momentum
  - Remove systematic correlation between amplitude and time
  - Note there is still some intrinsic emittance growth
  - i.e. High amplitude particles get a measurable spread in time

# Toy Beam with A-P Correlation



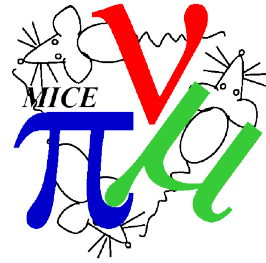
- Emittance growth is reduced but still non-zero

# Linear Optics



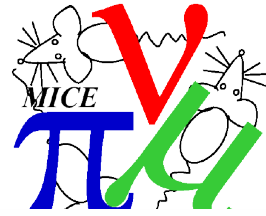
- Reasonably symmetric solution for longitudinal beta
  - (Adjusted by hand)
  - Similar to Step V
  - No longitudinal focussing as there is no RF (or it is fully accelerating)

# Tracking

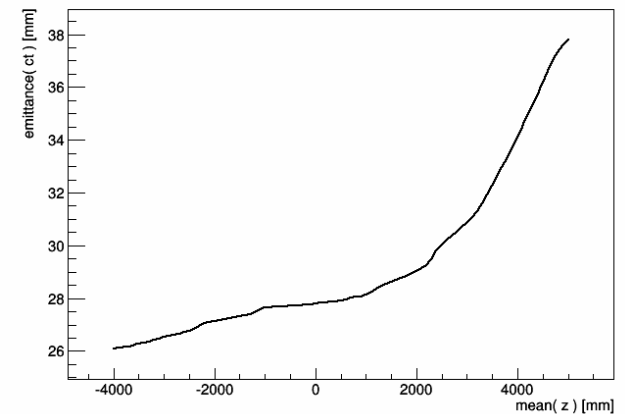
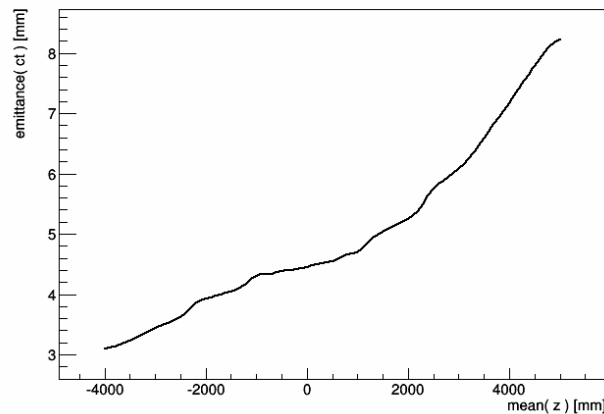
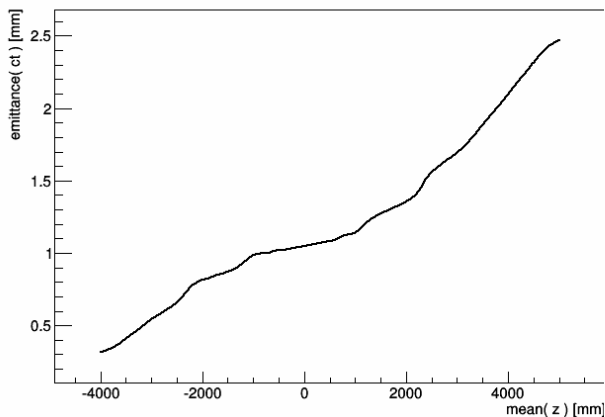
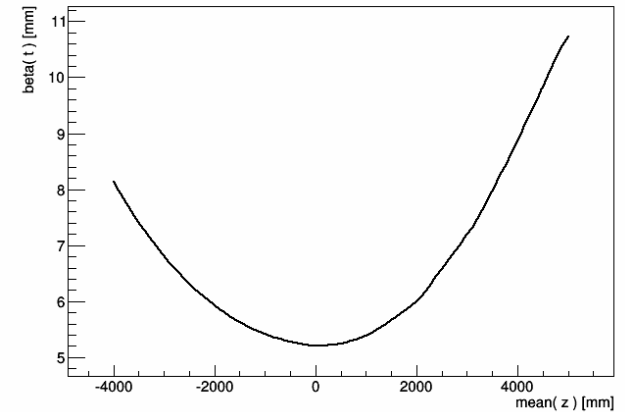
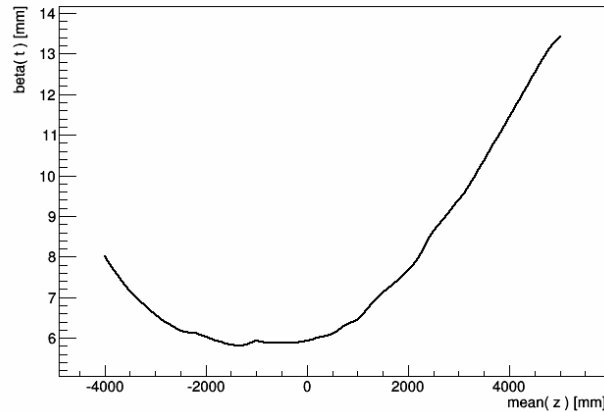
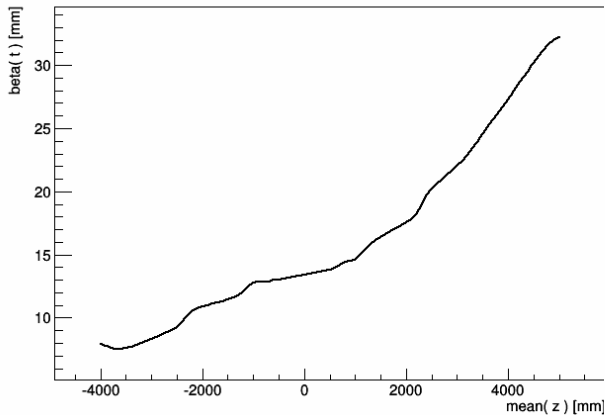


- 6 mm transverse emittance
- Magnetic fields only
  - RF off
  - Energy loss/straggling and scattering off
  - Decays off
- Barely enough statistics – 1000 muons
- Transmission cut
  - Particles which are at the start, but not at the end, are rejected
- Radial cut
  - Events which have  $r > 150$  mm at the start or end are rejected

# Tracking



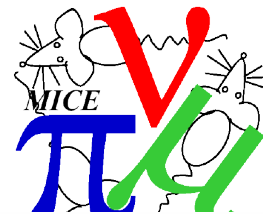
Increasing long. emittance →



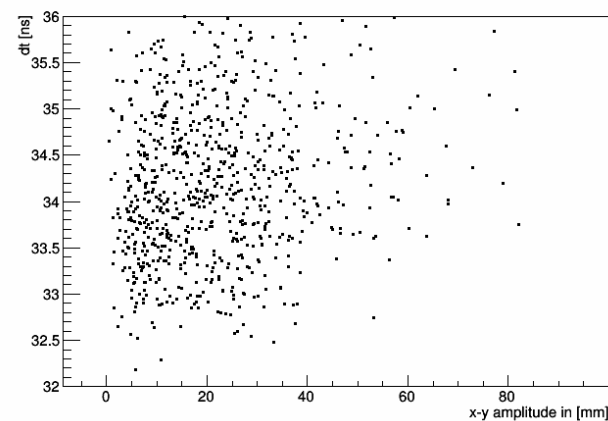
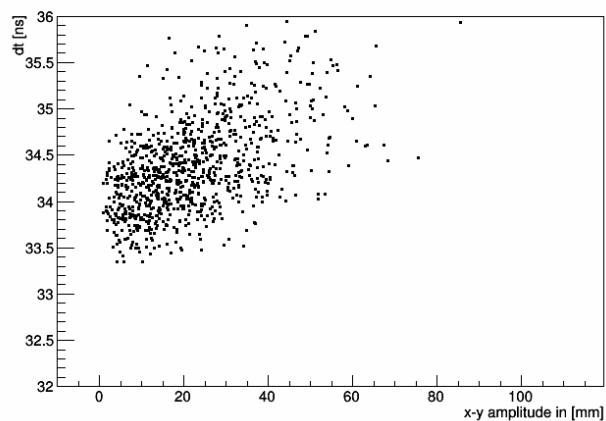
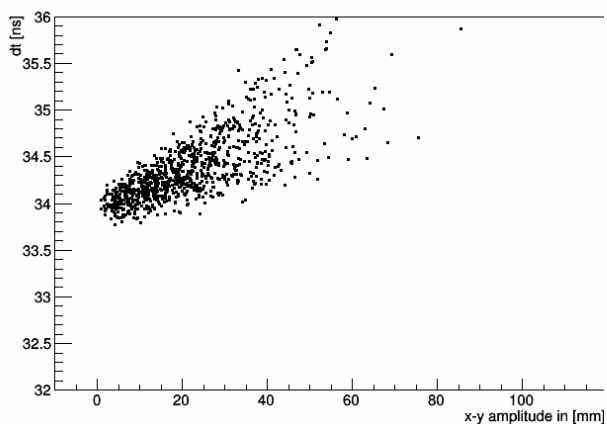
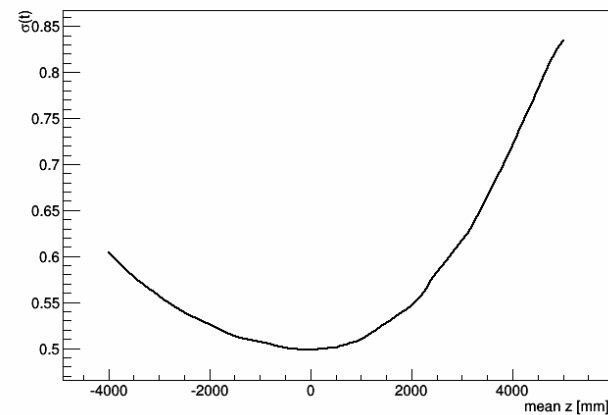
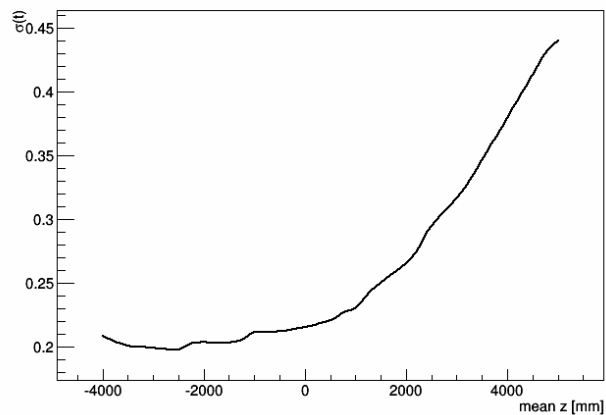
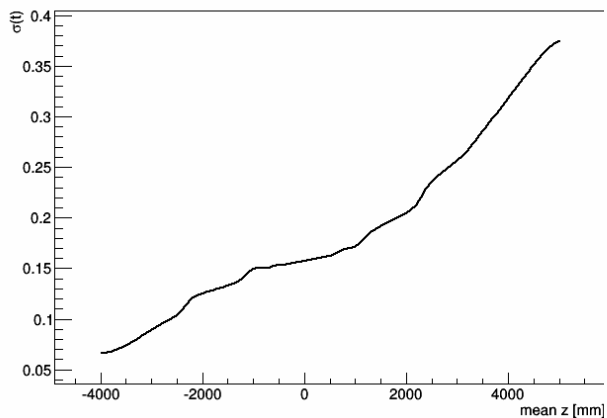
- Note non-linear stuff dominates for lower emittance beams
- ~ 50% emittance growth even at highest long. emittance



# Tracking

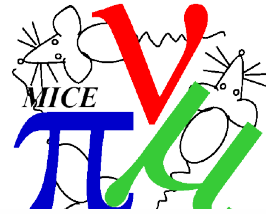


Increasing long. emittance →

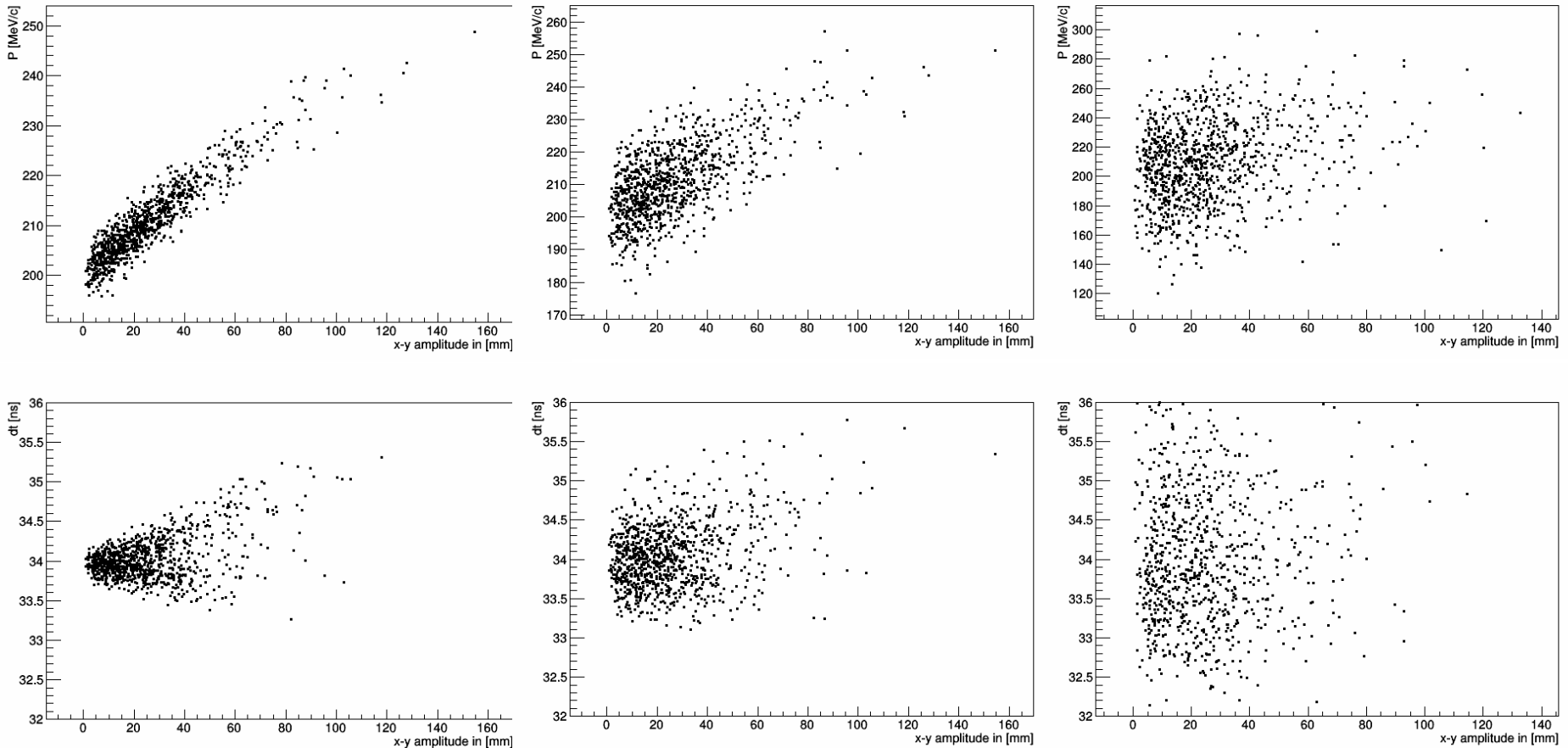


- Spread in time is of interest
  - Do we fit in the 5 ns RF period? Probably okay

# Tracking (A-P correlation)

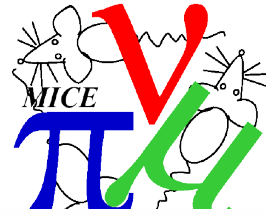


Increasing long. emittance →

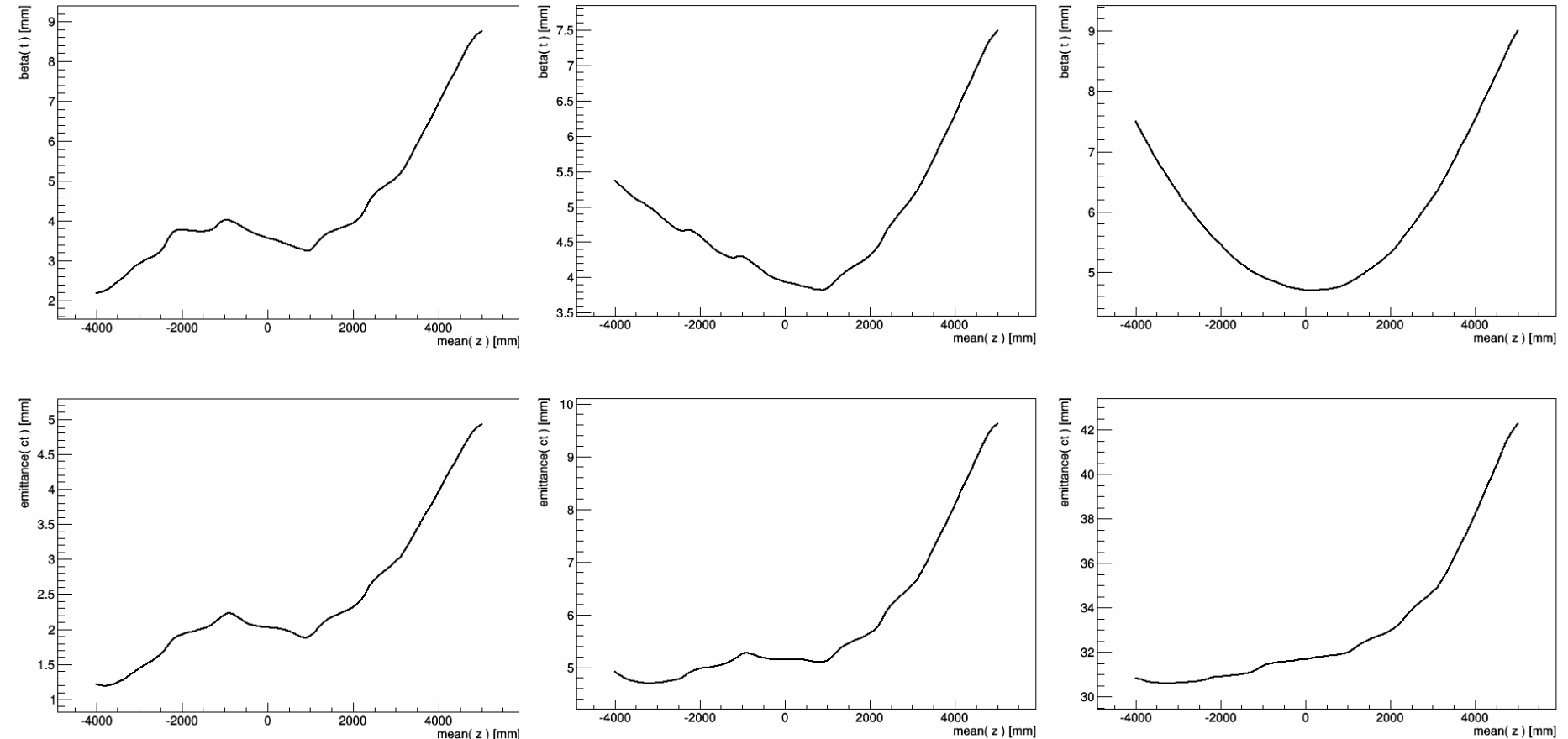


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# Tracking (A-P correlation)



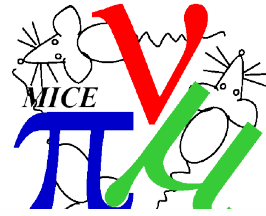
Increasing long. emittance →



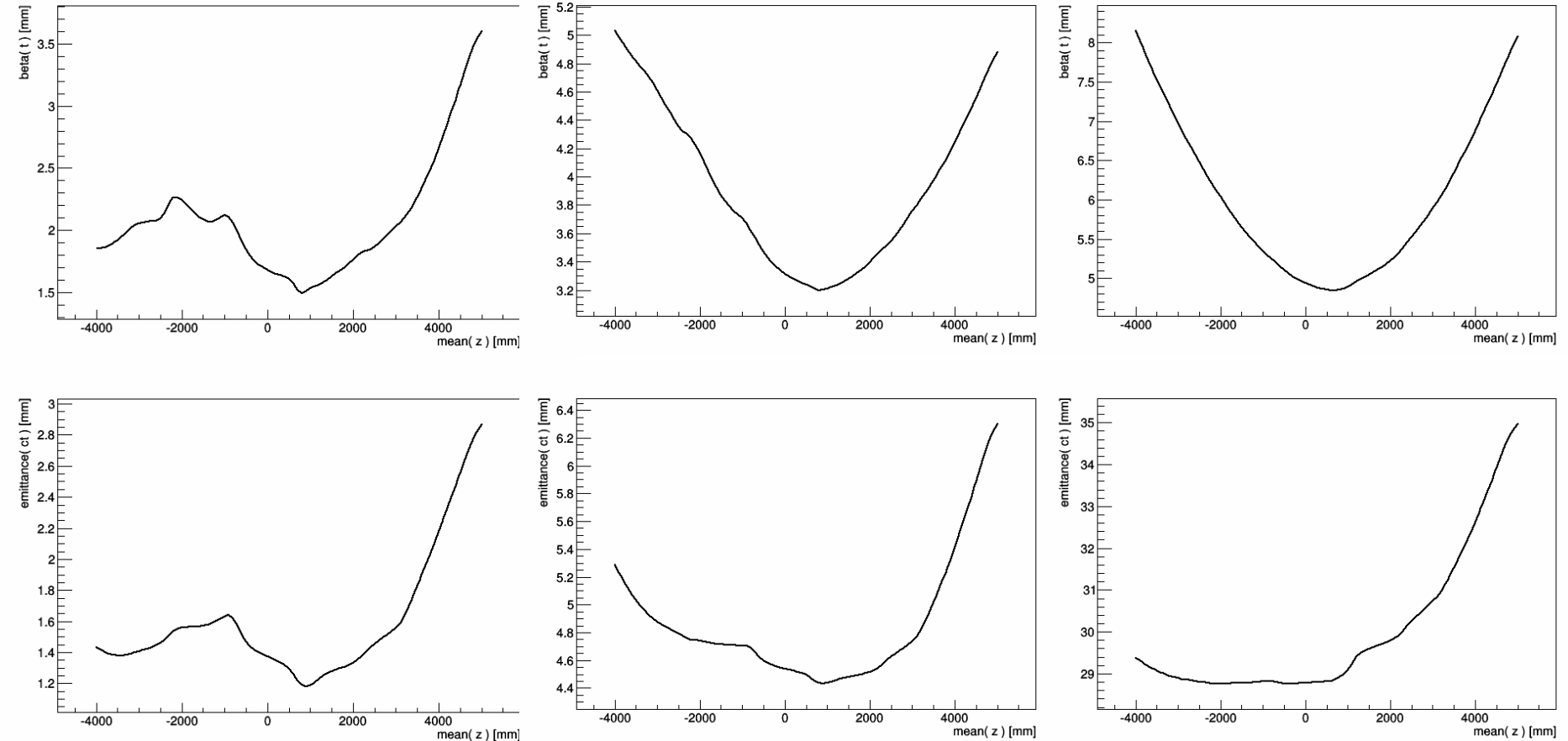
■ Longitudinal emittance growth is reduced

- But still significant  $\sim 30\%$
- $\gg$  transverse emittance reduction

# Tracking (A-P correlation)

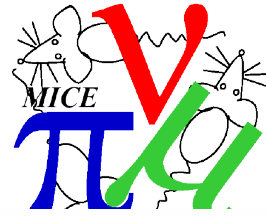


Increasing long. emittance →

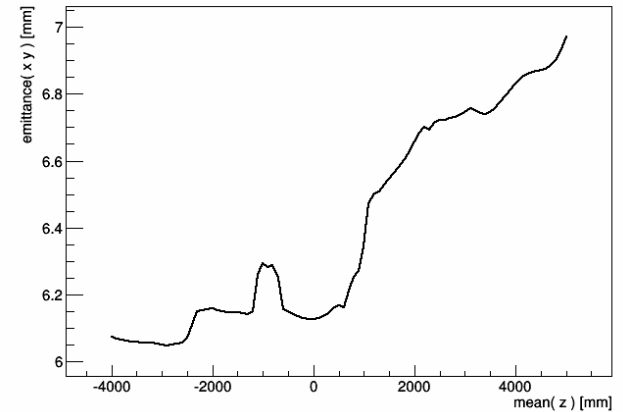
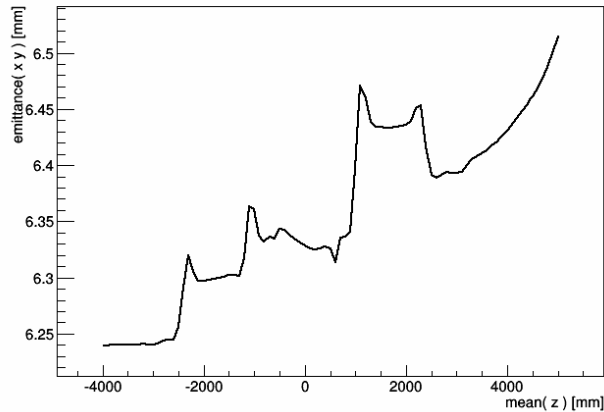
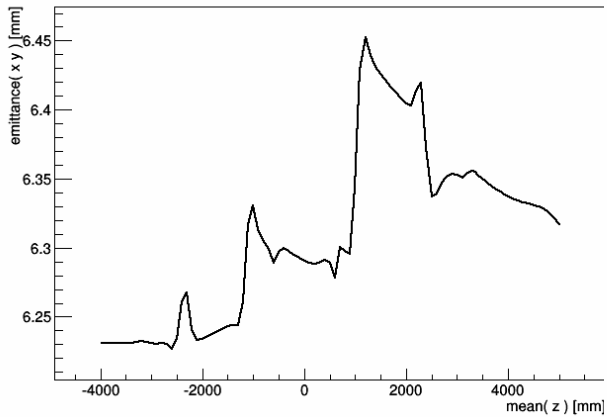


- Longitudinal emittance growth is reduced
  - But still significant  $\sim 20\%$
  - $\gg$  transverse emittance reduction

# Tracking (A-P correlation)

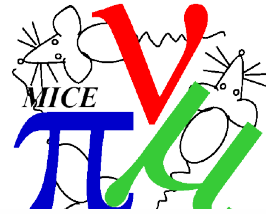


Increasing long. emittance →

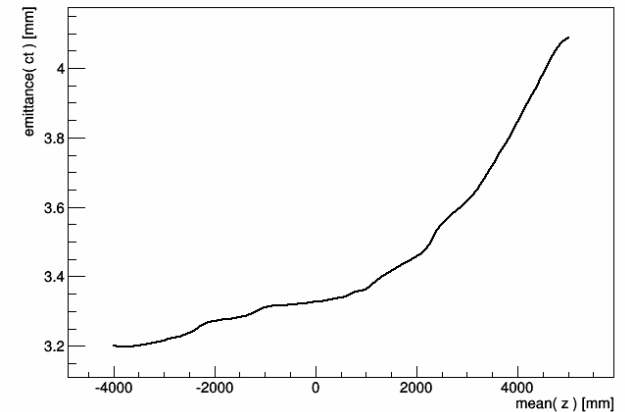
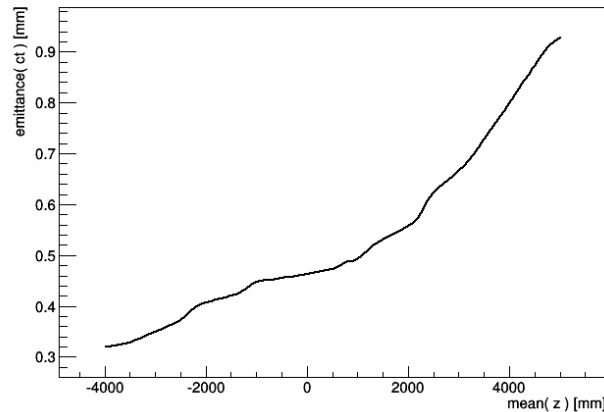
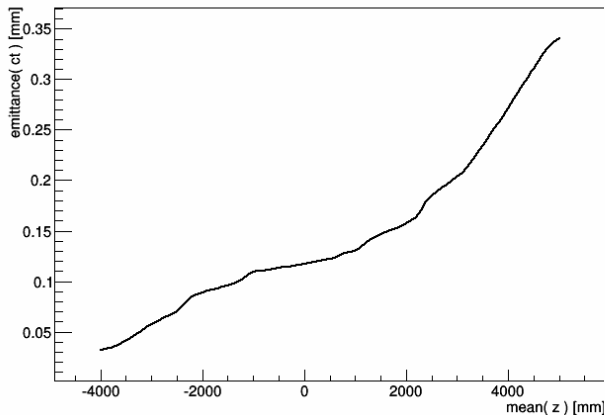
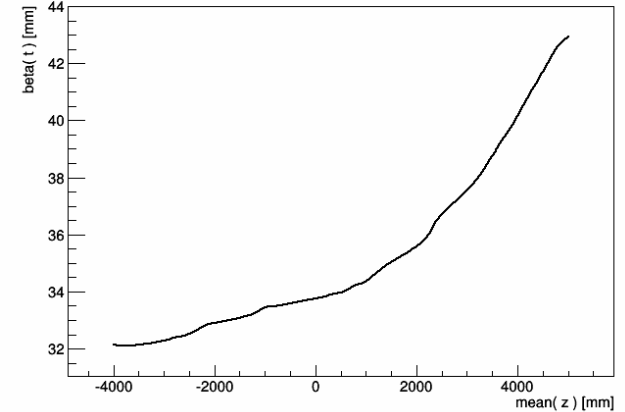
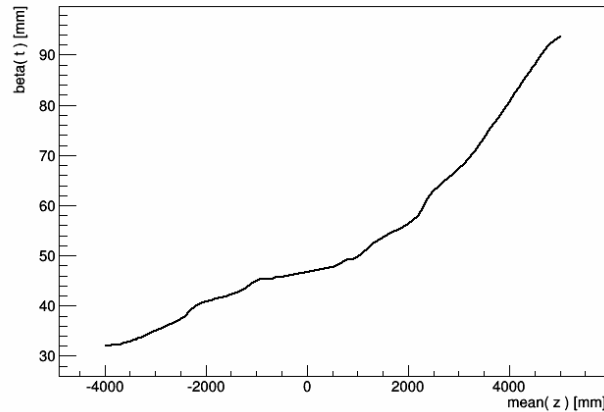
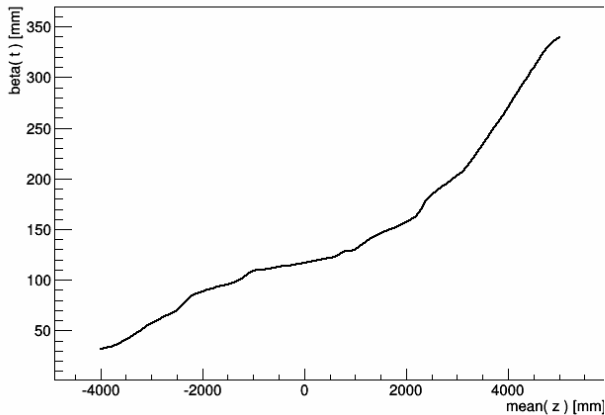


- Note transverse phase space can't cope with any more energy spread

# Tracking (Different aspect ratio)

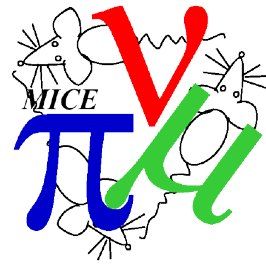


Increasing long. emittance →



- Changing the aspect ratio looks pretty hopeless
  - Decreased energy spread to reduce chromaticity
  - Still lots of longitudinal emittance growth

# Tracking (A-P correlation)



- Could not defeat longitudinal emittance growth using A-p correlation in this lattice
  - A more up-to-date lattice may yield better performance