Diffuser & Analysis Requirements on Beamline

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Introduction

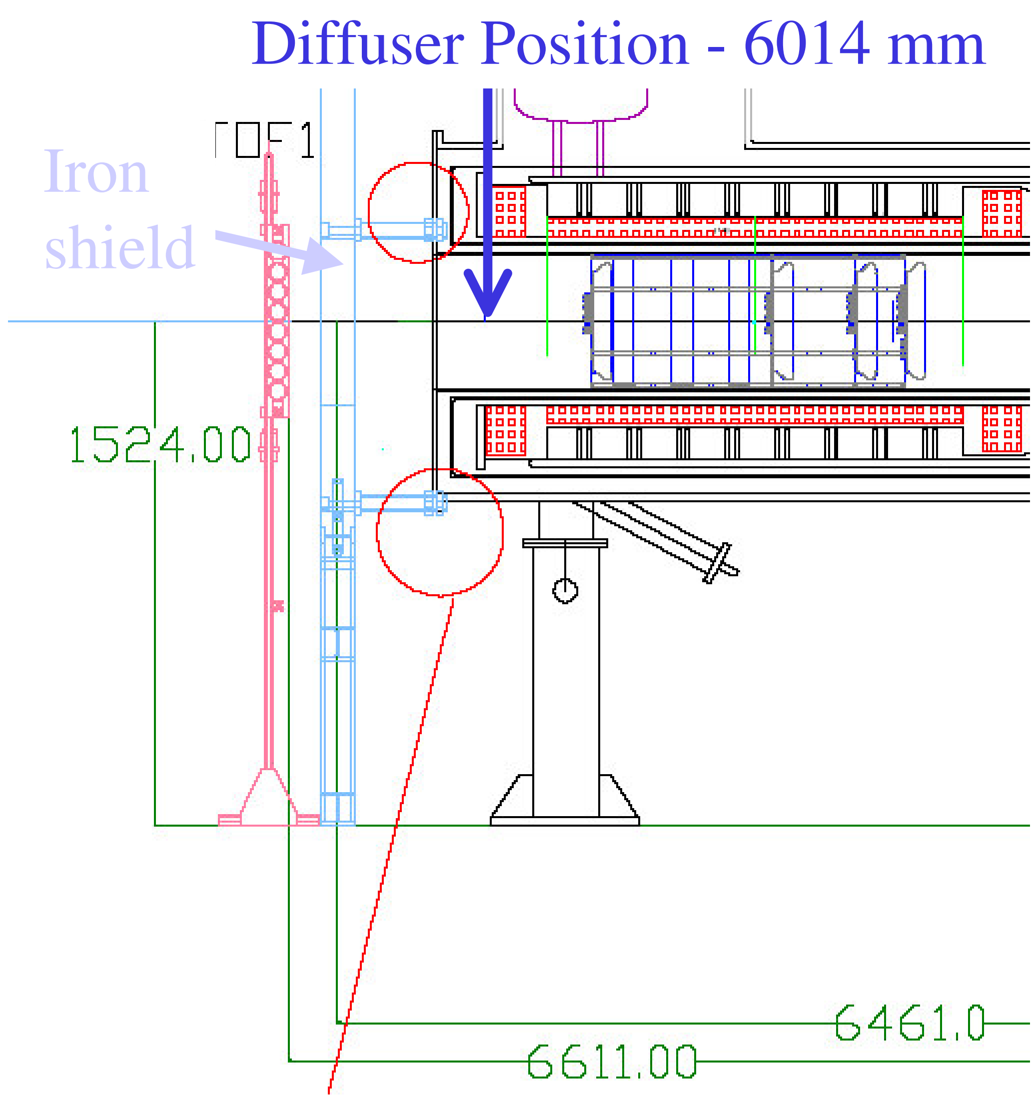
- Analysis requirements on Beamline
  - Minimum emittance
  - Or minimum statistics
- Some thoughts on the diffuser
  - Angular momentum
  - Iron plate
  - Multiple diffusers

Requirements on Beamline

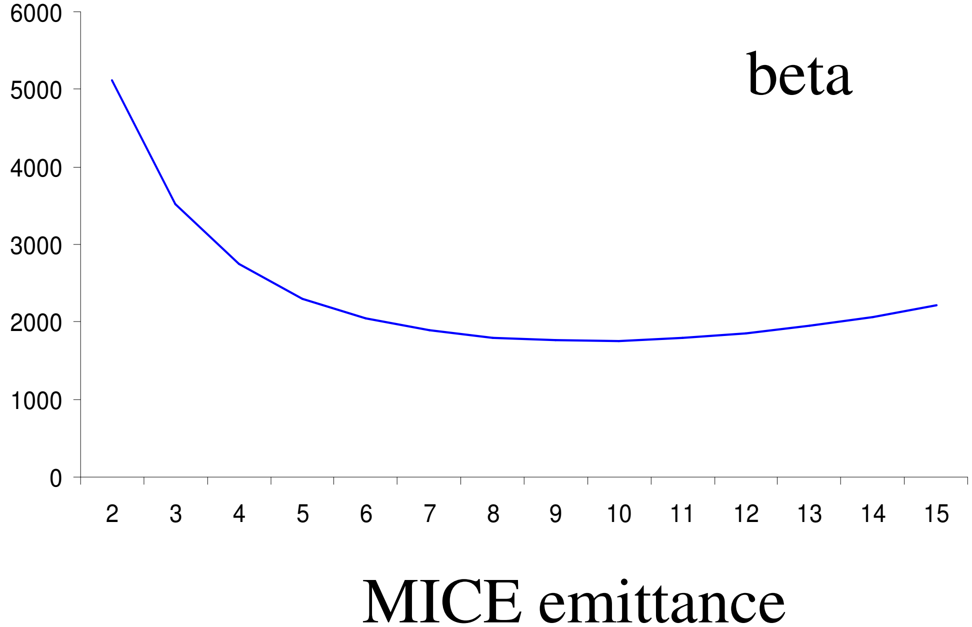
- Transverse phase space - two requirements:
  - Require that we can produce a beam that completely fills the cooling channel to scraping
  - Require that we can produce a beam at less than equilibrium emittance
  - And probably beams in between
- OR increase statistics at other emittances (e.g. > equilibrium emittance)
  - See subsequent slides
- Different beta function requirements for different optical set ups and p_z
- Need to be able to produce beams of $\langle p_z \rangle$ between 140 MeV and 240 MeV (TRD) and $\sigma(E)$ ~ 25 MeV
  - Really this means p_z between ~100 and ~270 MeV
- Need to think about timing but should be easy

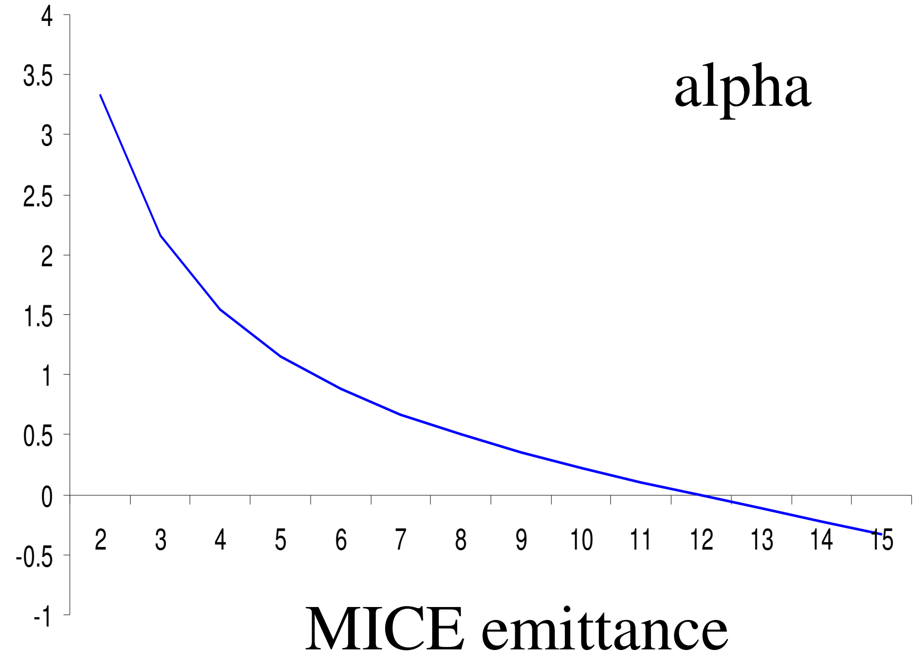
Diffuser

I will be using the setup depicted on the right



Optical functions @ Q9 vs emittance

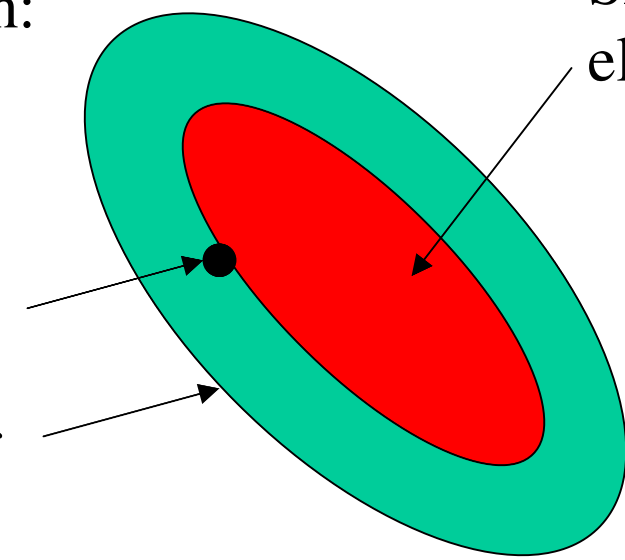




- Optical functions at Sept04 Q9 vs emittance in MICE
  - Set diffuser thickness with requirement for emittance in MICE and beamline
  - Then propagate beta backwards and read off alpha and beta
  - Input beamline emittance 2 pi mm rad
- Alternative is to increase statistics

SPE

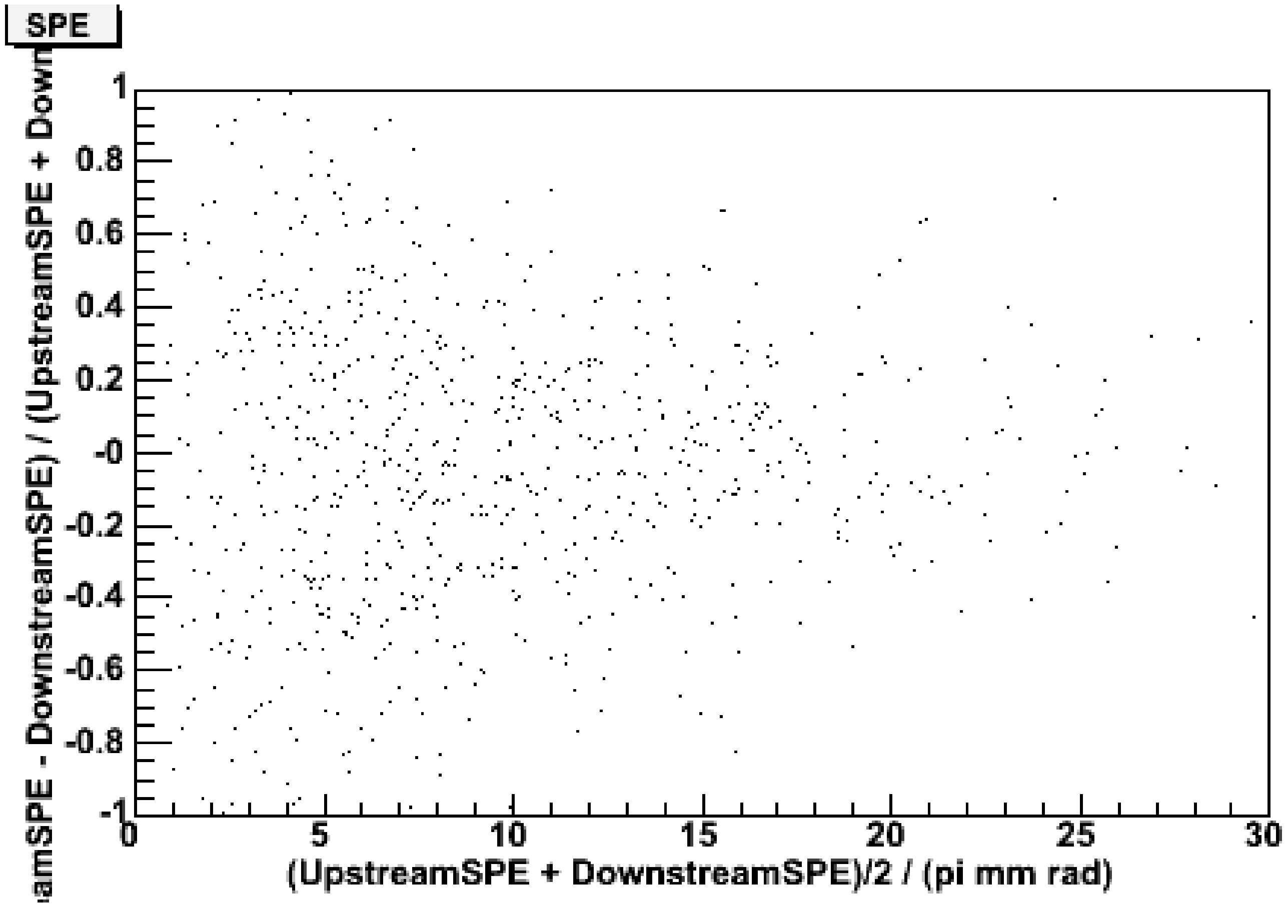
- Recall definition:



- LH_2 absorber will heat particles in the bunch centre and cool particles in the bunch wings
- There will be an equilibrium point
- Requirement for beamline is that the number of particles with SPE below this equilibrium is the same as for an ~ 10^6 muon bunch

Simulation Results

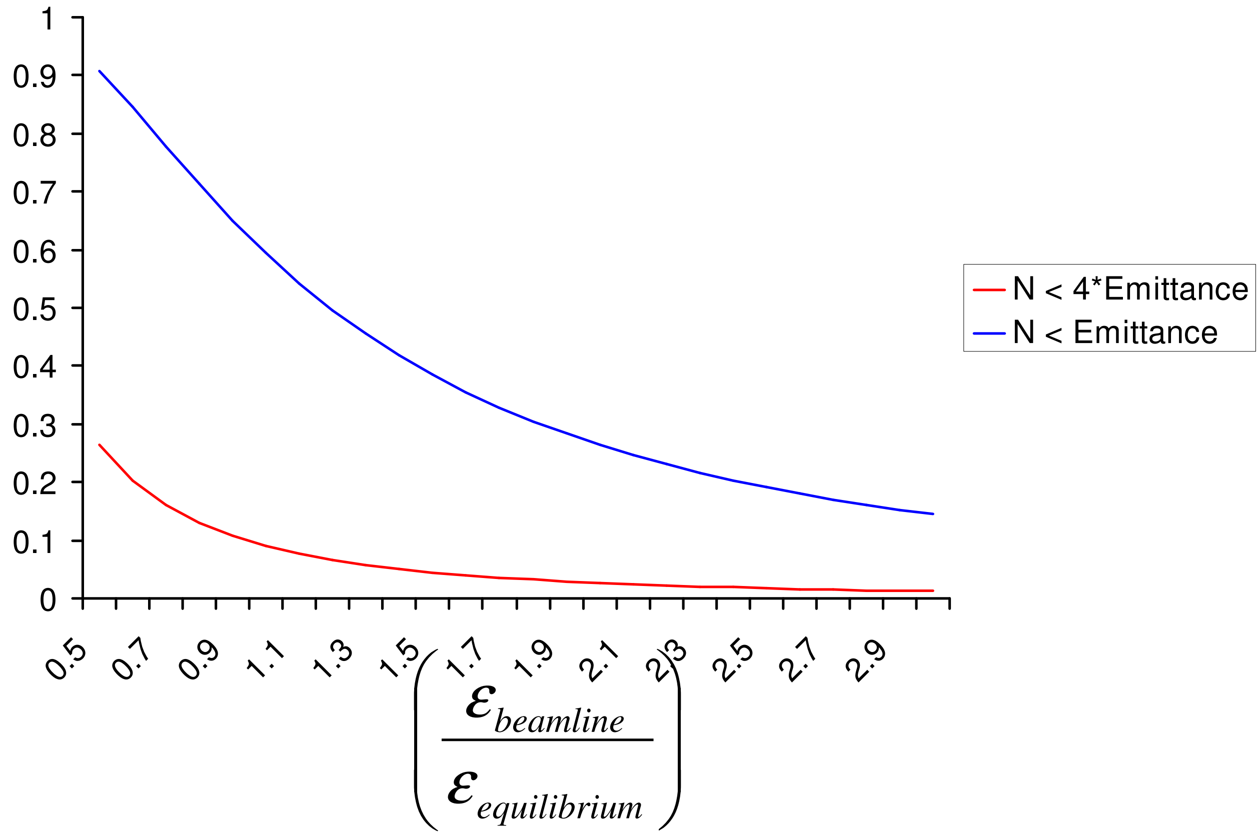
$\frac{\Delta(SPE)}{SPE}$



- Not obvious where equilibrium point lies

Statistics

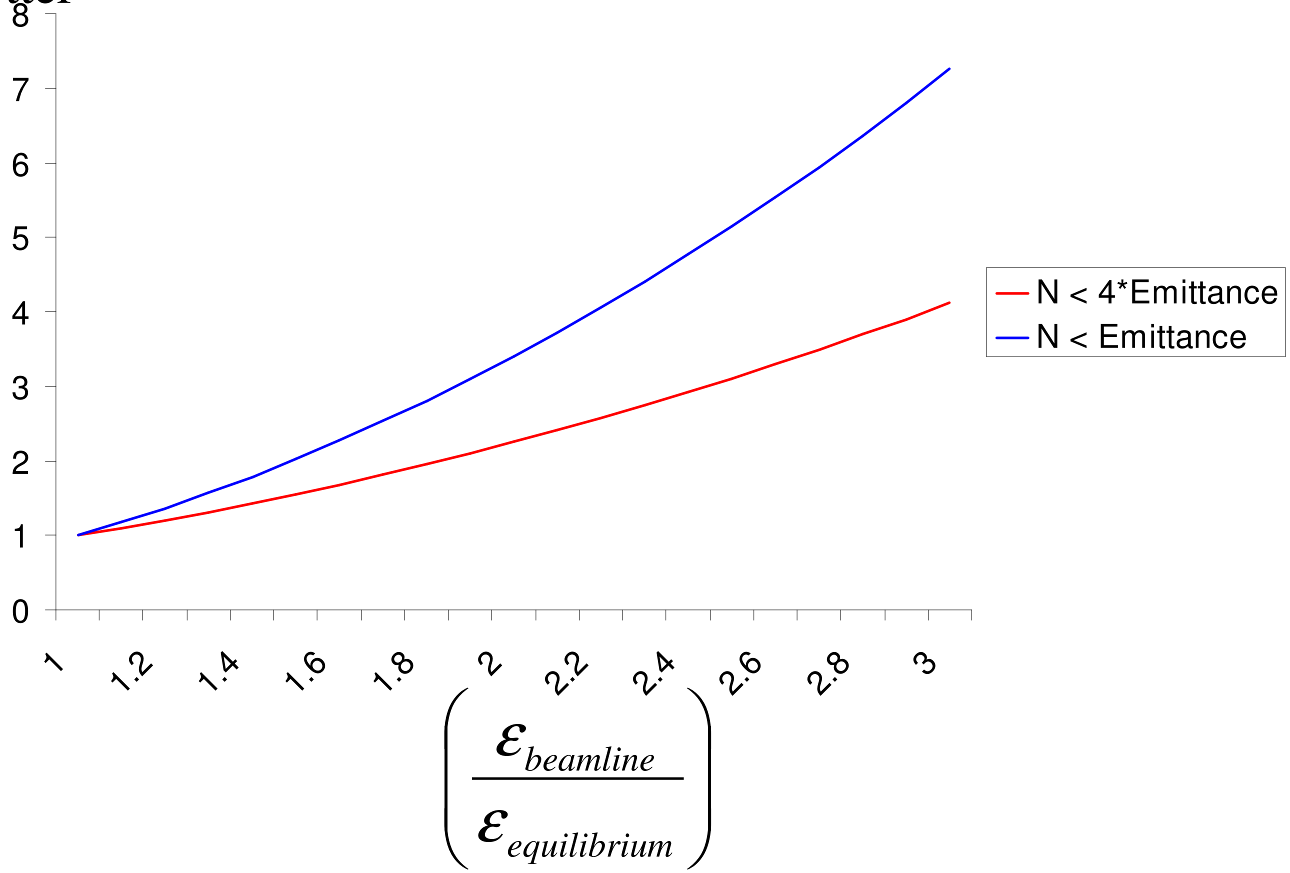
- Number of particles in central region of phase space is small
  - Phase space is a 4D hypervolume
- Guess $\varepsilon_{equilibrium} < SPE_{eqm} < 4\varepsilon_{equilibrium}$ but don't know for sure



Summary of Requirement

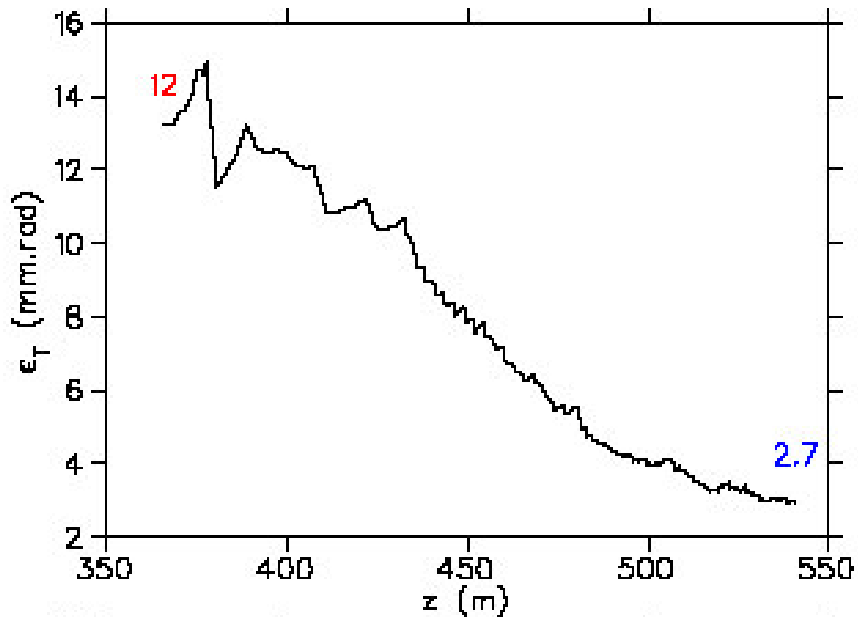
- Increasing beamline emittance puts a requirement on rate that lies somewhere between the two lines
  - If required it should be possible to nail down the requirement better

Rate increase



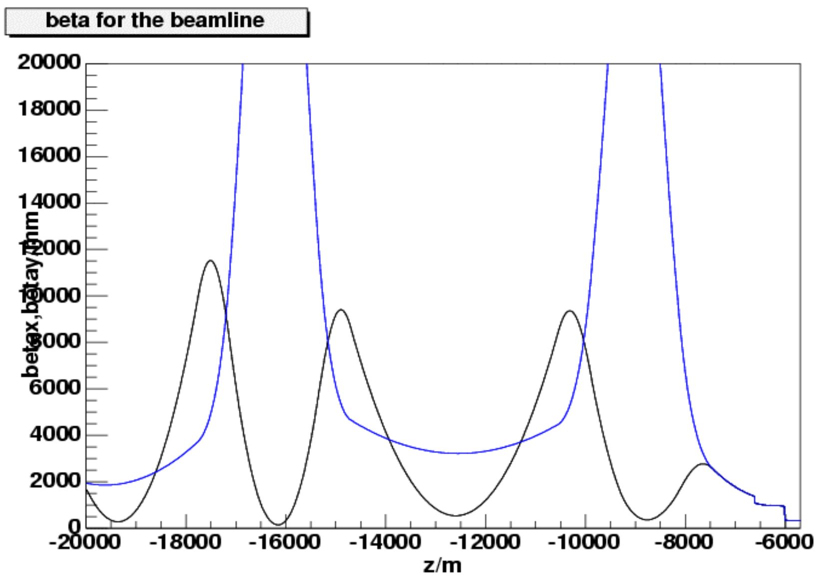
Direct Measurement Preferred

- Bad alternative is to do an indirect measurement of equilibrium emittance
  - Measure emittance at two points and extrapolate



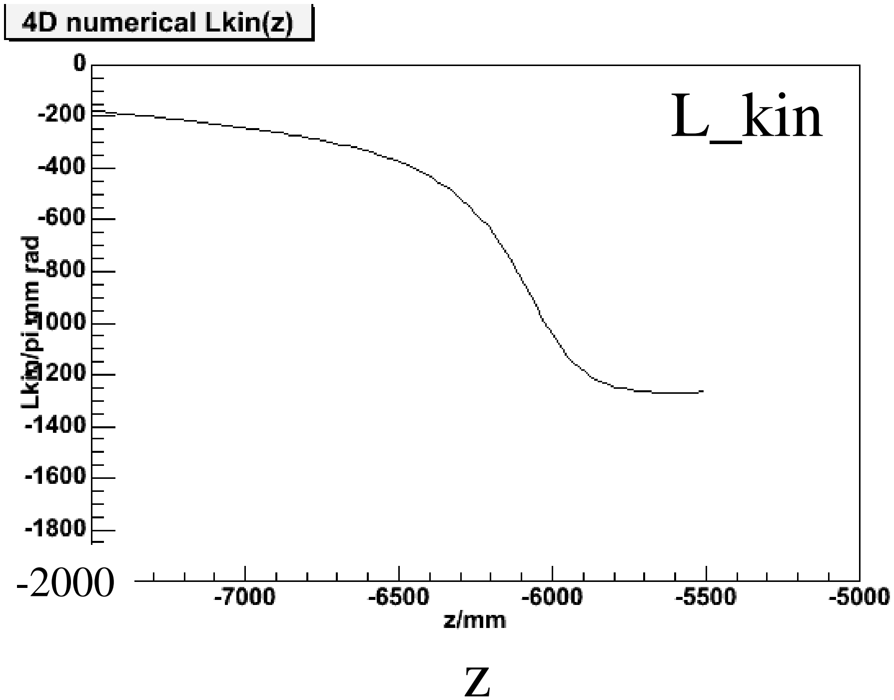
- Or just do a simulation optimisation (but also bad)

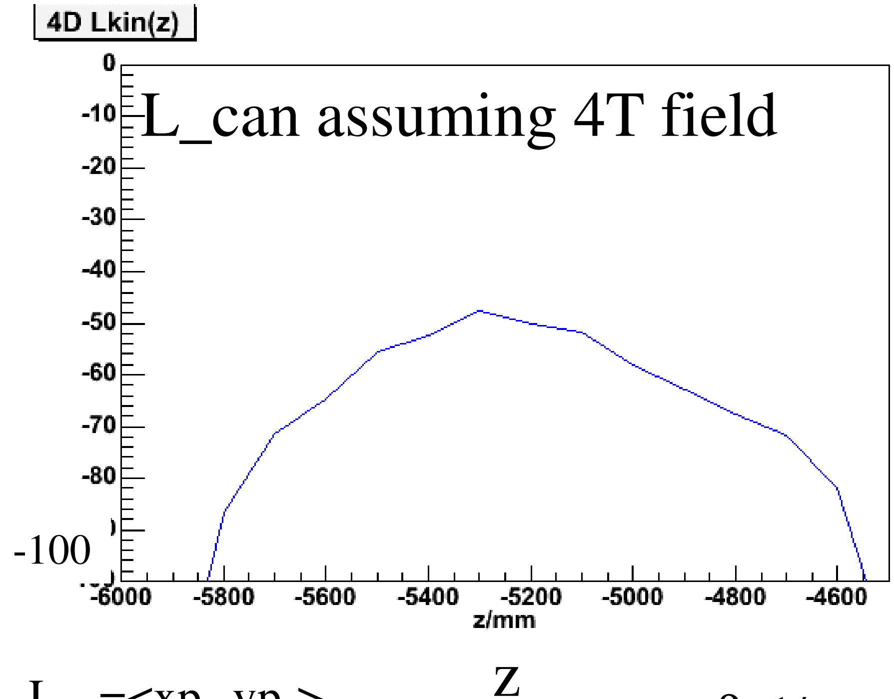
Optics Code



- G4MICE now has code that can find optical solutions for the Beamline
  - Quads, solenoids
  - Materials
- Integrated with Minuit for optimisation
  - Optimise for quad positions, quad currents, (solenoid currents)

Angular Momentum (Preliminary)



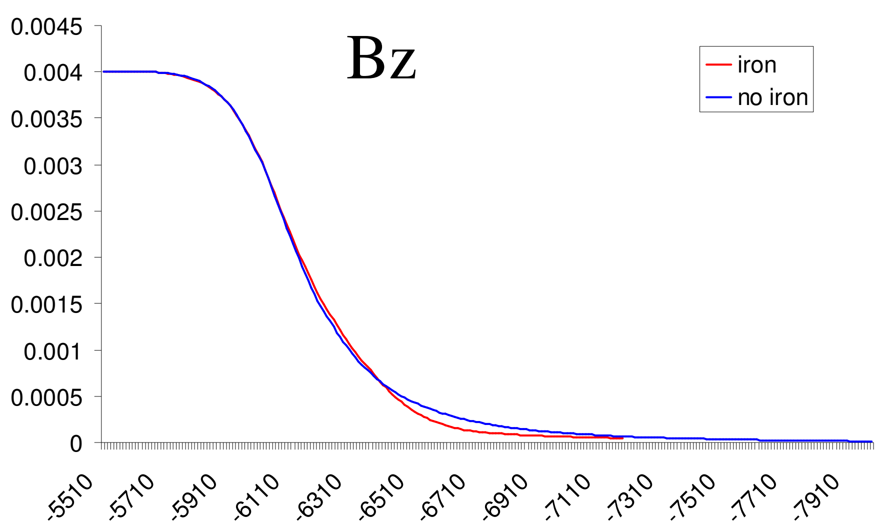


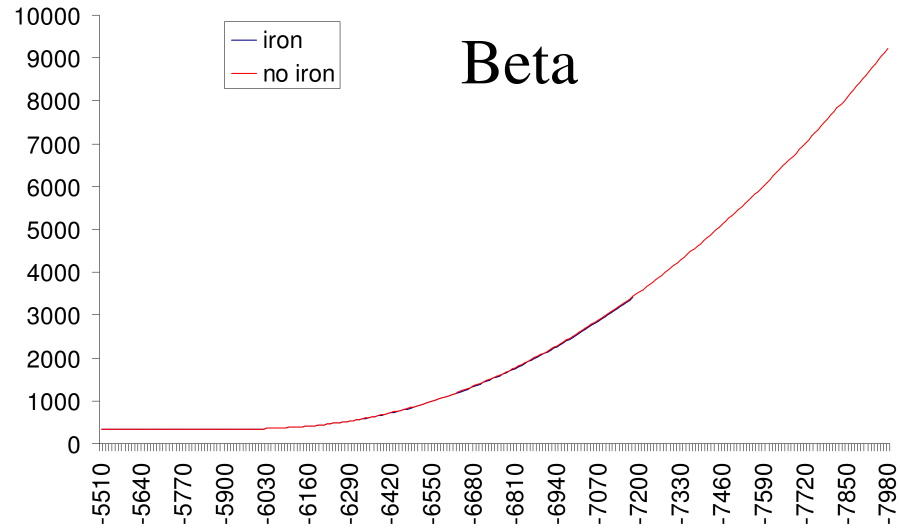
$L_{kin} = \langle xp_y - yp_x \rangle$

$\beta \sim 1/\varepsilon$

- Apologies for poor plots
  - Canonical angular momentum $L_{can} = L_{kin} - 2 m_{\mu} \varepsilon_n \beta K$
  - For the plot I assumed 4 T field
  - Should be conserved i.e. 0
  - Looks to be L_{can}~10% L_{kin} in the 4 T region so should be ok
  - But very preliminary result (Analysis needs to see field map)

Effect of iron plate





- B_z coming out of solenoid only changed in fringe
  - Barely noticeable effect on β
  - Note no diffuser in this plot

Multiple diffusers etc

- Try exotic solutions to getting the diffuser out of the solenoid bore
  - Moving diffuser puts tough requirements on quads
  - Multiple diffusers helps quite a lot

	Approximate change in Beta at Q9	Approximate change in Alpha at Q9
Diffuser to solenoid end, 3-12 pi beams	*4	*3
Diffuser to solenoid end, fixed 3pi diffuser, 6 pi beam	*1.5	*1.25

  - There is now a solution for a diffuser in the solenoid bore and optical solutions for the beamline so I don’t plan to pursue further

Conclusions

- If a low emittance beam cannot be successfully matched into MICE, an increase in the number of events at higher emittance is possible
- The iron shielding doesn't really have any effect on beam optics
- The introduction of a diffuser does not interfere with the beam angular momentum
- It might be possible to do something clever with multiple diffusers if the current diffuser solution fails