Cooling Perfomance of MICE Stage 4 With Reduced Current AFC

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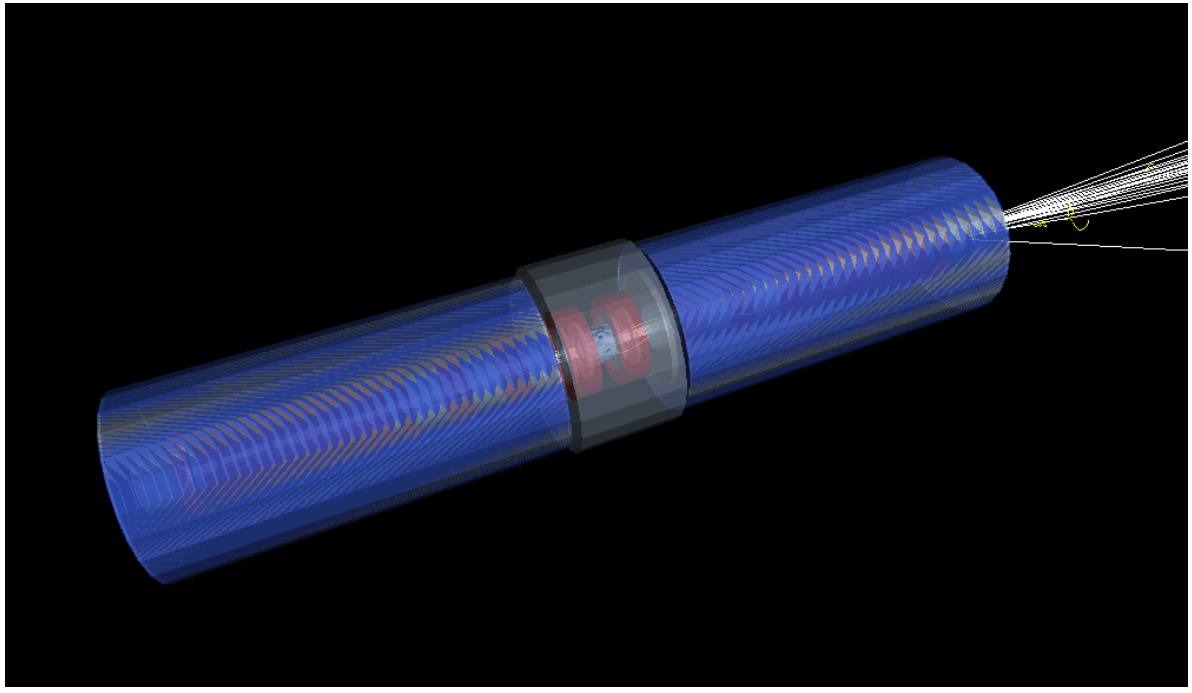
MICE Step 4

One absorber, no RF, two trackers. Step 4 in simplicity.
Geometry tweaked to values provided by Pierrick



The AFC

The Focus Coil training didn't quite go as planned. FC#2 is currently returned to sender and FC#1's training fell a little short.

- Reached full design current in solenoid mode (114A)
- Only just reached the baseline (200 MeV/c) current in flip mode (188A)

If we use it in step 4 - what could we 'safely' run at?

First estimate: assume *approximate* derrating of 11%
(thanks to John Cobb)
Approx 167A

Goals

Given the prior complications and upcoming/recent meetings we were tasked with:

1. Using our own, specific software (MAUS) to simulate the cooling channel in step 4
2. Estimating the effects of a reduced current FC on the cooling perfomance
3. Investigating the simulated and reconstructed emittance from the trackers
4. Producing a report of the findings for the April round of meetings

Simulation Methods

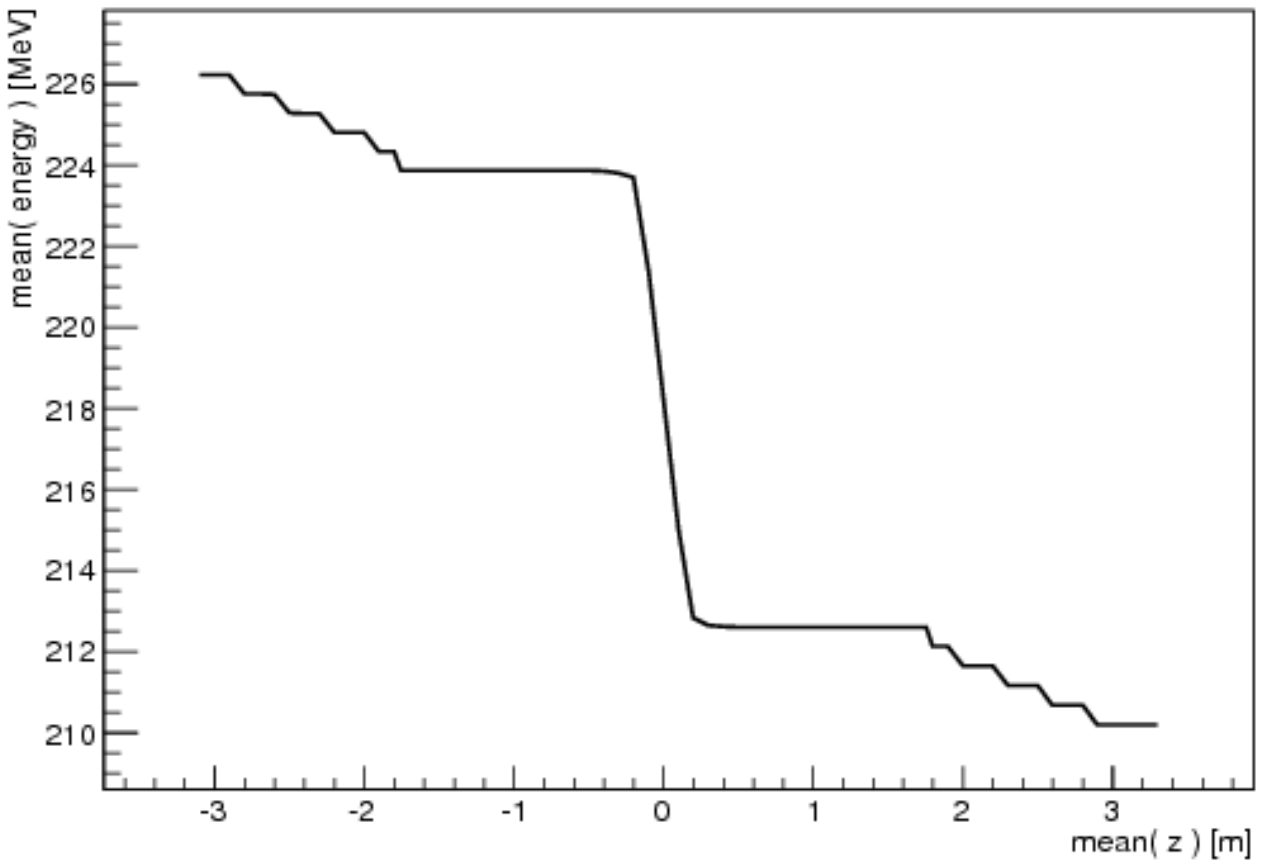
- Use standard MAUS (Version 0.8.2) to do all the simulation.
- Assumed idealised input distributions (Gaussian, 6πmm 4D emittance, 5MeV RMS longitudinal momentum spread, starting just inside solenoid)
- Python matching script used to set up currents in the Match Coils (thanks to Chris Rogers)
- Refactored downstream currents to account for energy loss through the absorber - This improves the cooling performance!

Analysis Methods

- Virtual planes used to record the MC hits
- Tracker software used to record reconstructed hits
- XBOA used to calculate emittances from bunches of hits
- Some cuts were required to account for some small issues
  - MC Hit aperture cut: r $<$ 189mm
  - MC PID selection: Only Positive Muons (PID = -13)
  - Recon Transverse Momentum: Pt $<$ 150 MeV/c
  - Recon Longitudinal Momentum: Pl $<$ 300 MeV/c

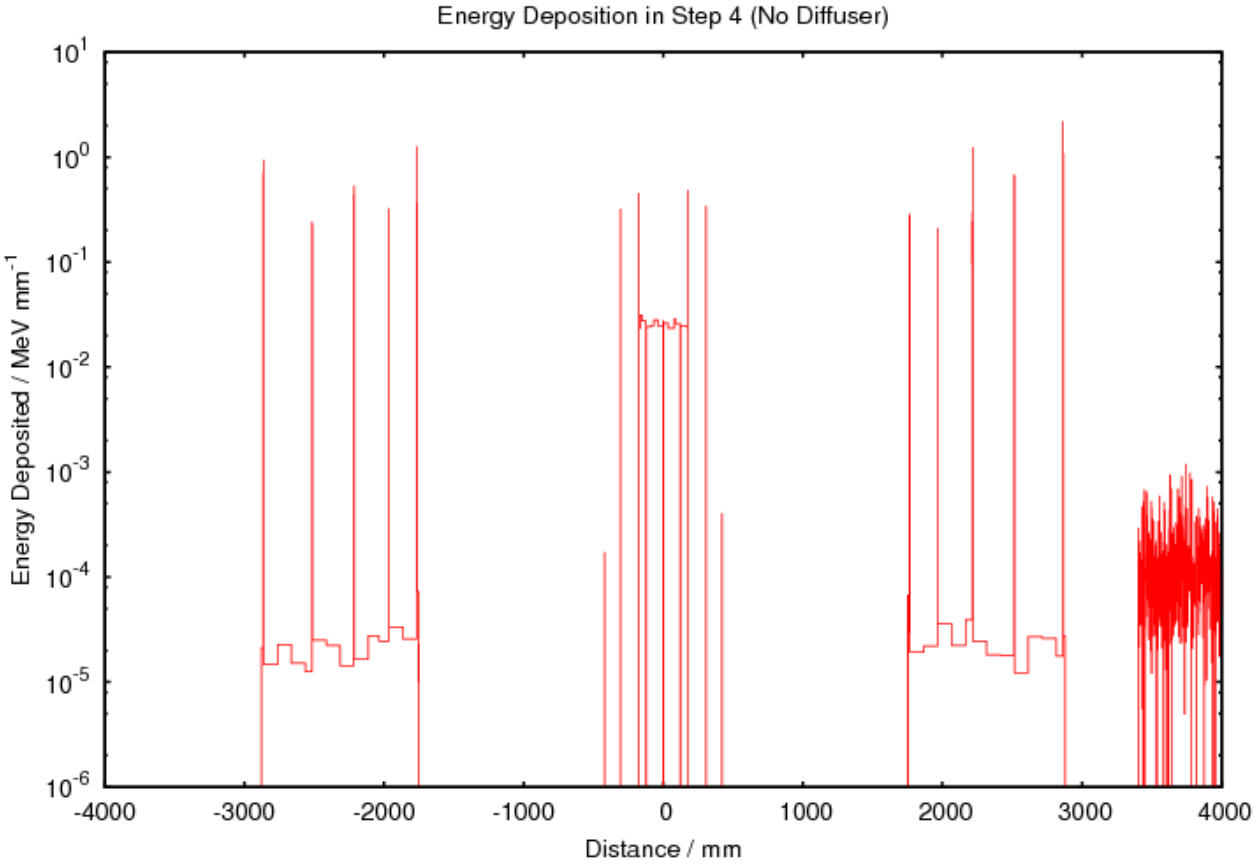
Average Energy

Can clearly see tracker planes, AFC windows and the absorber



Energy Losses

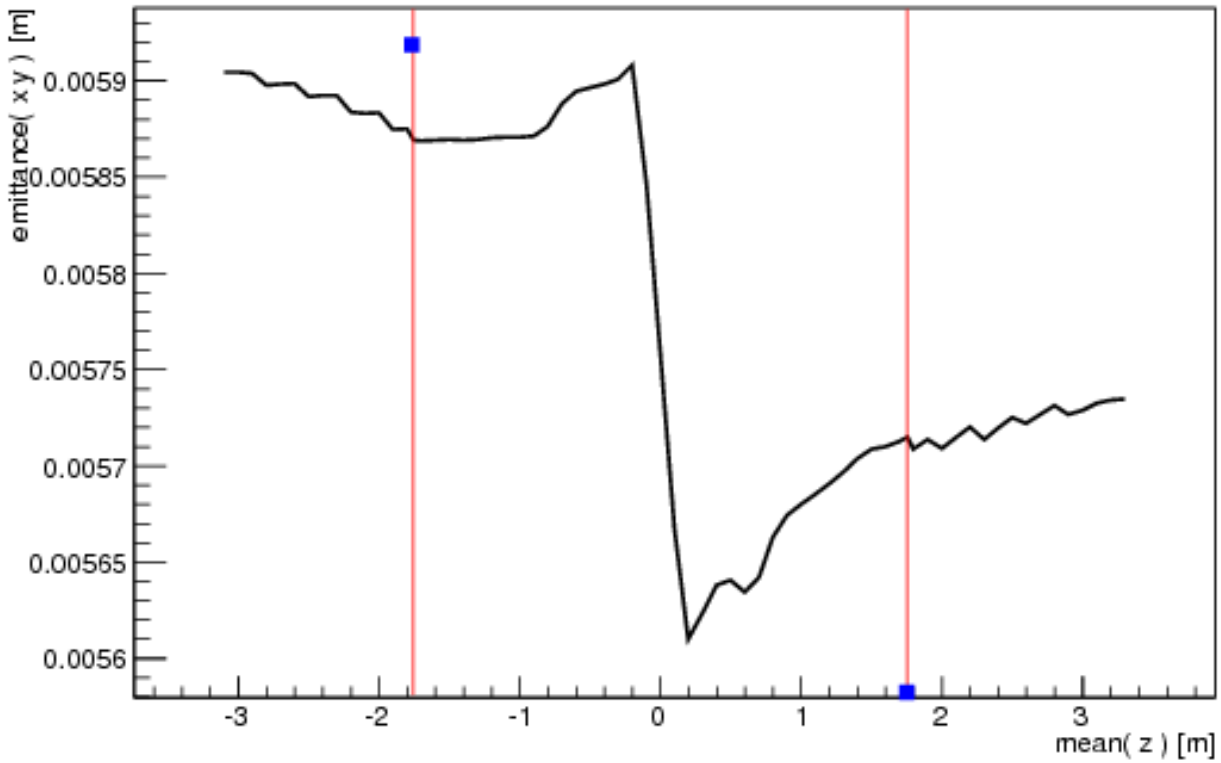
Starting to look like you would expect.



Only one recent issue - the wrong size vacuum belows
(Notice the step through air either side of the AFC)

Emittance

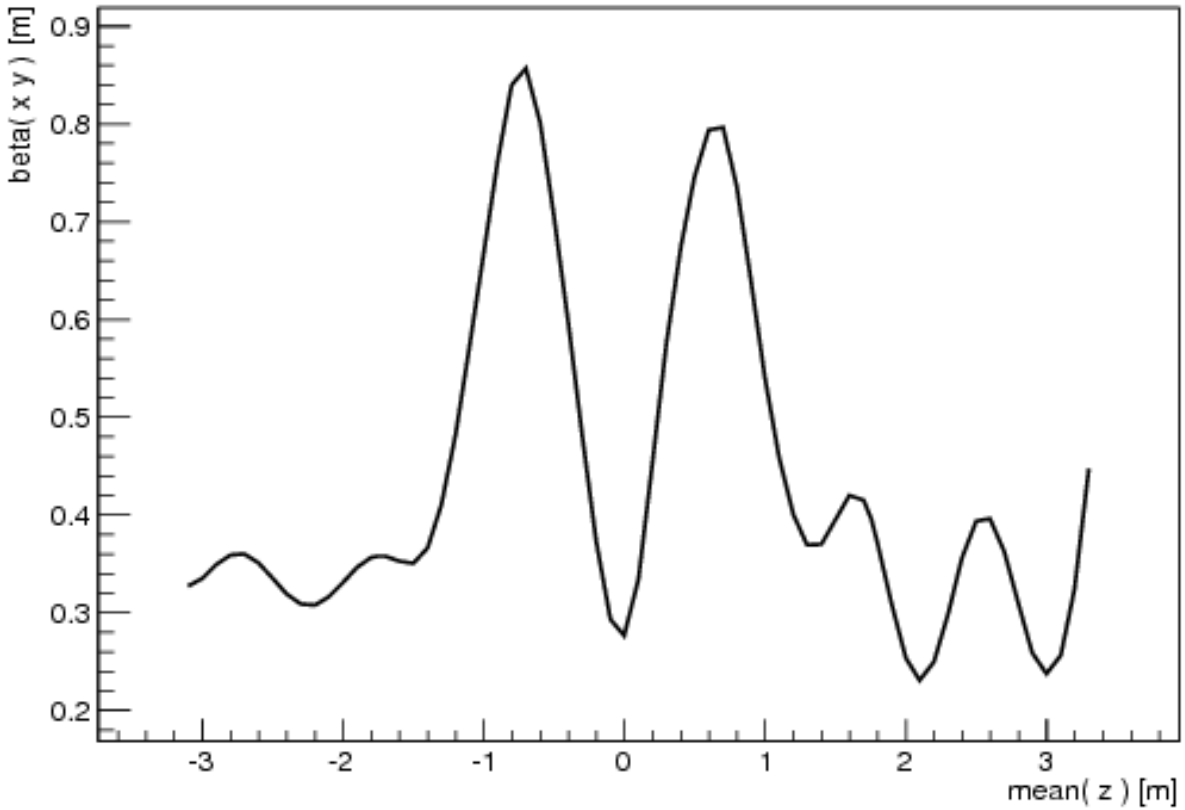
Peak-to-peak cooling through the absorber approx 5%.
Reasonable behaviour
Some issues downstream - possibly the Beta Function...



Red lines mark the Tracker Reference Plane Location.
Blue Squares Mark the Tracker Reconstruction Values

Beta Function

Looks like the Beta Function could be improved downstream.
Currently on the todo list!



Some Numbers

Using the MC Data at the Tracker Reference Planes $\pm$ 1755 mm

Parameter	Symmetric	Asymmetric
Emittance Upstream	5.877 mm	5.869 mm
Emittance Downstream	5.792 mm	5.715 mm
Beta Upstream	356.1 mm	357.5 mm
Beta DownStream	476.6 mm	359.2 mm
Number Upstream	29177	29184
Number Downstream	29088	29087

For the symmetric case:
1.4% Cooling

For the asymmetric Case:
2.6% Cooling

Some More Numbers

Using the Tracker Reconstruction at the Reference Plane

Parameter	Symmetric	Asymmetric
Emittance Upstream	5.916 mm	5.914 mm
Emittance Downstream	5.647 mm	5.554 mm
Beta Upstream	352.9 mm	353.9 mm
Beta DownStream	467.2 mm	386.5 mm
Number Upstream	28122	28052
Number Downstream	27236	27282

For the symmetric case
4.5% Cooling

Foir the asymmetric case
6.1% Cooling

Reconstruction-Vs-MC

Error in tracker measurements for asymmetric case:

Upstream Emittance	0.77%
Downstream Emittance	-2.82%

Initally a little worrying - overestimating our performance. However,

- Kalman fitting has a known systematic correction $\approx$ 1-2%, which is not yet calculated or applied.
- The trackers cannot measure every track - order of 6% not reconstructed.
- Issues with momentum reconstruction involve cutting non-realistic tracks.

These issues are all now known and are under investigation.
We don't think there are any more...

Conclusions

A good effort, if a little quick. Still some improvements to come:

Clean up the analysis:

- Implement the full tracker reconstruction
- Tune the MC to record the same set of hits as the trackers
- Discussion with Adam & Ed regarding the tracker recon
- Provide a full error analysis

Improve Current Matching technique - actually match through all the absorbing materials. Difficult due to stochastic effects

Write up the full results into a MICE note - Coming Soon!