Comprehensive Emittance Analysis Paper: An Update

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MICE CM53

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Current Status

- Goal is to have the full analysis chain in place by next month,
- Spent significant time understanding the shortcomings and features of the beam selection routines. They are now much more stable,
- Configured (almost) all of the MC simulations required for the direct comparisons.
- Aim to include an MC model in the IPAC poster!

Current Status

Item	MC	Data
Beamline Cuts	Done	Done
Momentum Selection	Done	Done
Beamline Comparisons	On Going	
Hybrid Monte Carlo	Done	On Going
Beam Selection Routines	Done	On Going
Standard Emittance Analysis	On Going	On Going
Sub-Emittance Analysis	To Do	To Do
Systematic Error Analysis	To Do	To Do

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Beam Selection

- We know that our cooling channel was not as it was originally designed due to magnet issues,
- We can't reproduce the originally foreseen beam settings,
- The beamline is not correctly matched into the channel.

however. . .

- Monte Carlo models did find settings that produced a measurable emittance reduction however,
- If was can select the correct initial beam parameters, we should be able to recover this performance.

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Beam Selection

1. Generate some data,
2. Find a "function"* that describes the data (the parent),
3. Find a function that describes the required distribution (the daughter),
4. Randomly select events based on the ratio of probabilities between the parent and daughter distributions.

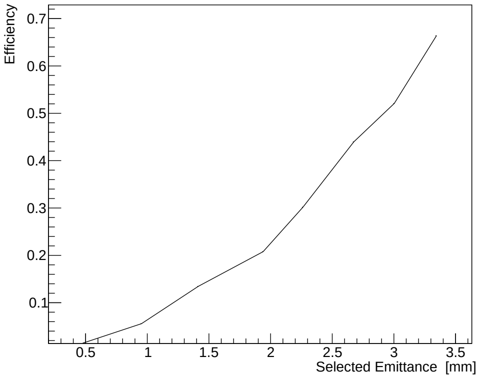
For a given event, x,

$$\text{Prob. of Selection} = \frac{\text{Daughter}(x)}{\text{Parent}(x)} \times \text{Some Normalisation}$$

*Histogram, parameterised function, fitted function, etc.

Beam Selection Testing

Selection efficiency from the same parent dist.



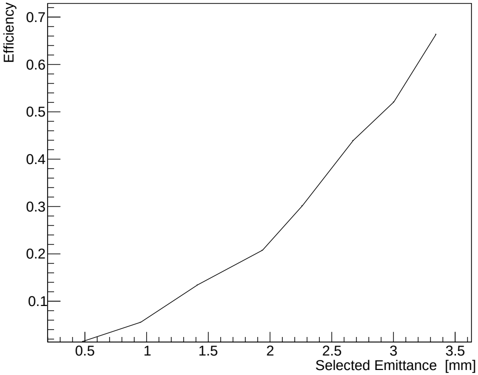
Parent Emittance = 4mm

- Perfomed series of 1D, 2D and 4D toy simulations,
- investigated how the performance changed with different settings,
- Histograms work best in one and two dimensions,
- 4D and above we need more advanced algorithms.

Beam Selection Testing

- Selected beam smaller than the parent,
- 1- 4 mm emittance,
- uncertainty is strongly related to the number of particles selected,
-

Emittance residual at different efficiencies.



Parent Emittance = 4mm

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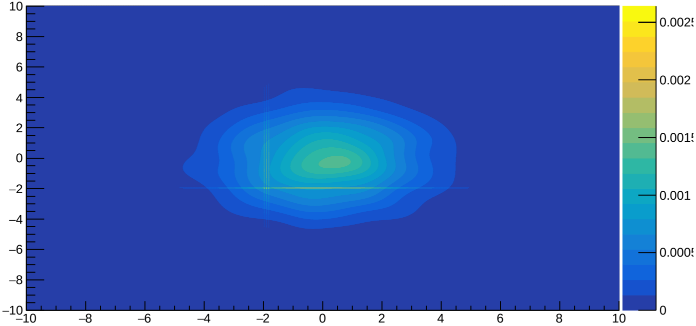
Beam Selection Testing

Found Kernel Density Estimation to be the most reliable at higher dimensions.

Voronoi Tesselation for local density estimation works,
but is very sensitive to statistical fluctuations.



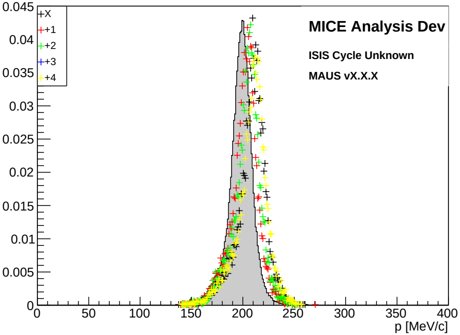
2D projection of 4D data, sampled with KDE.

Monte Carlo Model Improvements

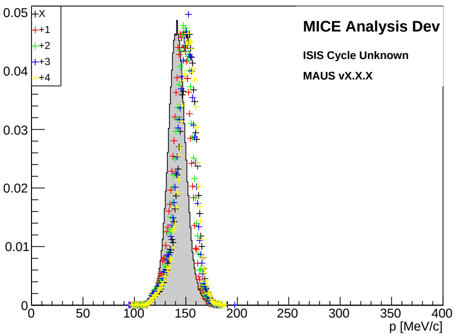
- Have MC models for all beamlines and cooling channel settings,
- All the recent channel settings have field maps (thanks Jo!),
- Now tuning the individual beamline configuration to improve comparison between MC and data,
- Thats a lot of data and a lot of individual plots to scan through, but we're getting there.

Data Shown in Histogram. Different MC Models are the points.
Variation in settings = percentage dipole current.
X = Default (around 4%).

Beamline Tuning - p



2016-02-3, 3mm, 200MeV/c.



2016-02-5, 3mm, 140MeV/c.

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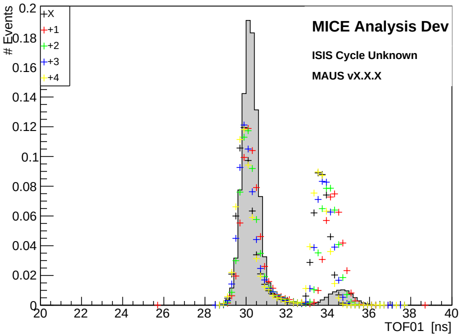
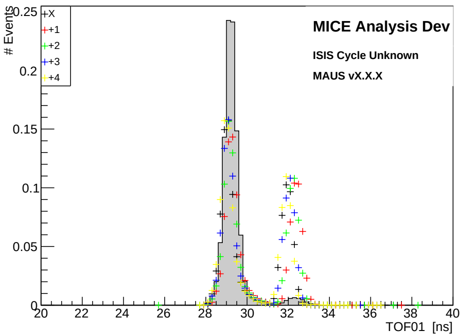
Beamline Tuning - TOF



2016-02-6, 3mm, 140MeV/c.



2016-02-8, 3mm, 170MeV/c.

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Beamline Tuning - Notes

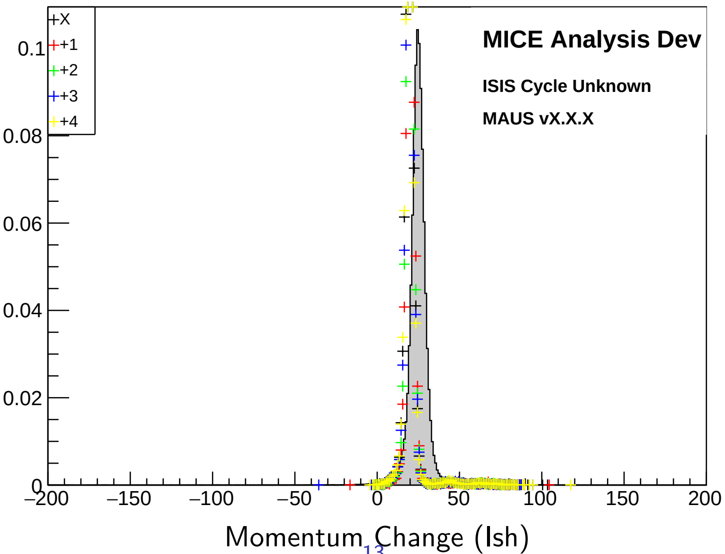
- Made a good start,
- Still need some more MC data, tuned in the opposite direction,
- Difference in number of simulated pions - as expected,

There is a difference between the energyloss/momentum measurement between data and simulation.

This was noticed by Chris and is seen on the next slide.
Changing the dipole currents doesn't change this disagreement.

Need to double check the fieldmaps were configured correctly for all settings, otherwise this is difficult systematic uncertainty to handle.

Beamline Tuning - Momentum Systematic



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Preliminary Results

- Combining the latest beam selection routines with the optimal runs, we can investigate the potential for observing cooling,
- Using analysis task H31c, 2017-02-6, 10-140, LH2-Full,
- Tuned the beam selection routines on MC, then applied them to data.

On the same data set perform beam selection and evaluate the evolutions of the selected tracks in the downstream tracker.

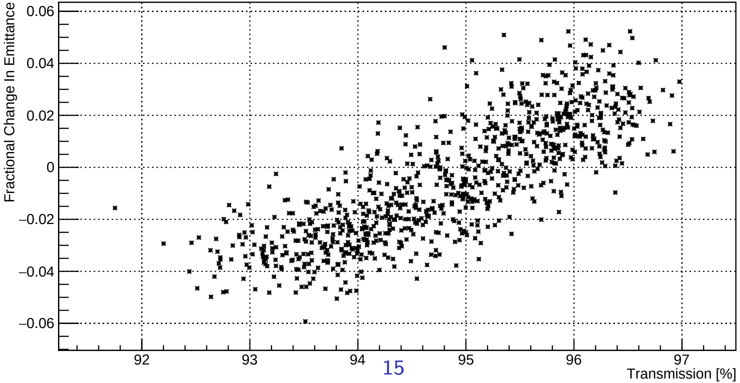
Each point is very strongly correlated with every other point, however the stability and statistical uncertainty in the selection process can be seen.

Preliminary Results

Settings: 2016-02-6, 10mm, 140MeV/c

Start with matched parameters: $\beta = 311mm, \alpha = 0.0, L = 1.0$

Parameters varied by approx 10% and resampled.



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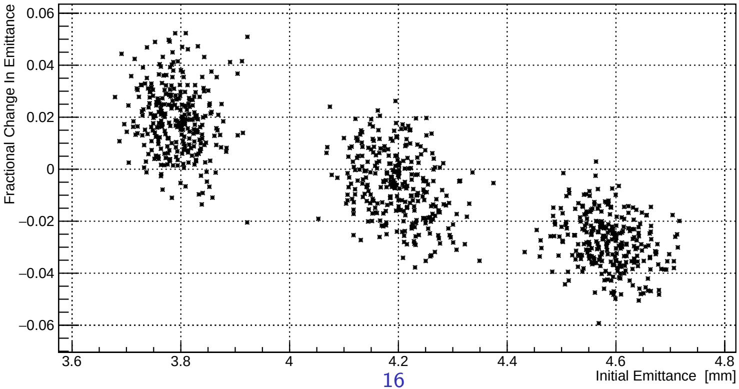
Preliminary Results

Potentially an early version of the "Money Plot"

There are plenty of points that show cooling with good transmission.
Equillibrium emittance can be easily seen.



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Conclusions - 1/2

- Beam selection routines have been finalised, only the performance needs evaluating on the actual data,
- They appear stable and generate reproducible results.

- Beamline tuning is under way,
- Expected disagreements seen and are tricky to combat - maybe just systematic corrections?
- MC data production is configured, just need a few more data sets and the optimised values to be selected.

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Conclusions - 2/2

- Preliminary results show that cooling can be seen at good transmission without amplitude analysis,
- The first pass on the total data set is being pushed through at the moment, then we can see where we are.

- Still have potential issues RE:Computational time and complexity, but those are being worked through,
- Do no expect the Systematic Uncertainties to be addressed before my contract finishes 31st May,
- Hope/Expect to have the whole chain running as smoothly/automatically as possible, but it won't be complete.

Will be discussion with Ken and Chris RE:What happens next.