Correlated Systematic Errors on the Emittance Measurement

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MICE CM50 - RAL

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Introduction

Thank you Victoria for doing the heavy lifting thus far!

We made the measurements, analysed the cuts and beam selection, now we just need to demonstrate that we trust it.

We are concerned with: Field uniformity, scale and alignment.

Sensitive to resolution - but that is a negligible effect.

Introduction

- Make the decision that we base the calculations of systematic error on Monte Carlo,
- Need to look at emittance residuals between MC Truth and Recon MC,
- Need to decide how we change the field model to manufacture the "right" variations in reconstruction,
- Obvious suggestion is 1σ variations, but that's not always defined...

What is a 1σ variation in uniformity?

Tools At Hand

1. Tracker-Field Alignment Algorithm
   Works to high precision, but with difficult to quantify systematics.

   Luckily that doesn't matter for this study!

2. Official CDB Geometries with Comsol Field Map

   Can vary the alignments, and move things around in MC.

3. Official CDB Geometry with MAUS Field Model

   An alternative field map - no PRY effects. A significant overestimate for variations in uniformity

4. Scale Factors!

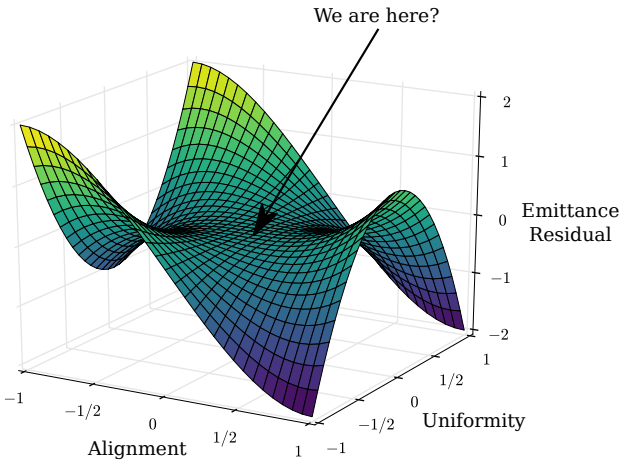
   Can arbitrariry scale fields in MC and see how the reconstruction changes.

Concept

Estimate the sytematic bias and error for a geometry that we trust

Then demonstrate that the residuals don't change across variations in the geometries.

Assert that we trust the systematic errors we estimate as they don't change within the space of reasonable geometry models.



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Job List

Type	Job	Testing	Official
Analysis	Estimate the Tracker-Field Alignment	Done	Done
Analysis	Systematic Error Estimate	Done	In Testing
MC	High-Stats CDB + Alignment	Done	In Testing
MC	CDB + 1-Sigma Misalignment	Done	Ready
MC	CDB + MAUS Fields MC	In Testing	Not Done
MC	CDB + 1-Sigma Scale Factors	Not Done	Not Done

The Analysis

Aim to distinguish two measurements from the proceedure:

1. Estimate of a Systematic Bias — *Residual from MC study*

   A fixed offset from the expected value

2. Estimate of a Systematic Error — *Chi-Square Minimisation Algorithm*

   A broadening of the measurement variance

The Analysis

With MC, we make many independent measurements of an emittance.

A true emittance sample has mean, x, and variance, σ^2.

Assume measurement introduces a bias, b, and a systematic error contribution, s^2.

So each emittance measurement is transformed by, $(x, \sigma^2) \rightarrow (x + b,\ \sigma^2 + s^2)$

Assuming normally distributed systematics.

The Analysis

1. Bias

   Difference between true mean and measured mean.

2. Systematic Error

   Minimize the expected $\chi^2 - N_{dof}$ from the measured mean.

Without Systematics

$$\chi^2 = \sum_i \frac{x_i - \hat{x}}{\sigma^2}$$

Modified For Systematics

$$\chi^2 = \sum_i \frac{x_i - \hat{x}}{\sigma^2 + s^2}$$

Prelimnary Results

Insert plots here. . .

Due to not understanding what entirely what I've done,
I don't want to present results I'm not confident in.

Till next time.

Conclusions

- Most MC geometries have been tested and some have been officially processed,
- I have a toy model of the analysis that works well and has been well tested and is very configurable,
- The concept seems to stable and practical,
- At the stage of tweaking the final analysis, but last attempt went a little wonky...
- In two weeks we hope to have all the values for the paper - not necessarily with all the official MC.

Next this is presented there will be many plots!