

# 1<sup>st</sup> Study of Tracker Misalignments with G4MICE

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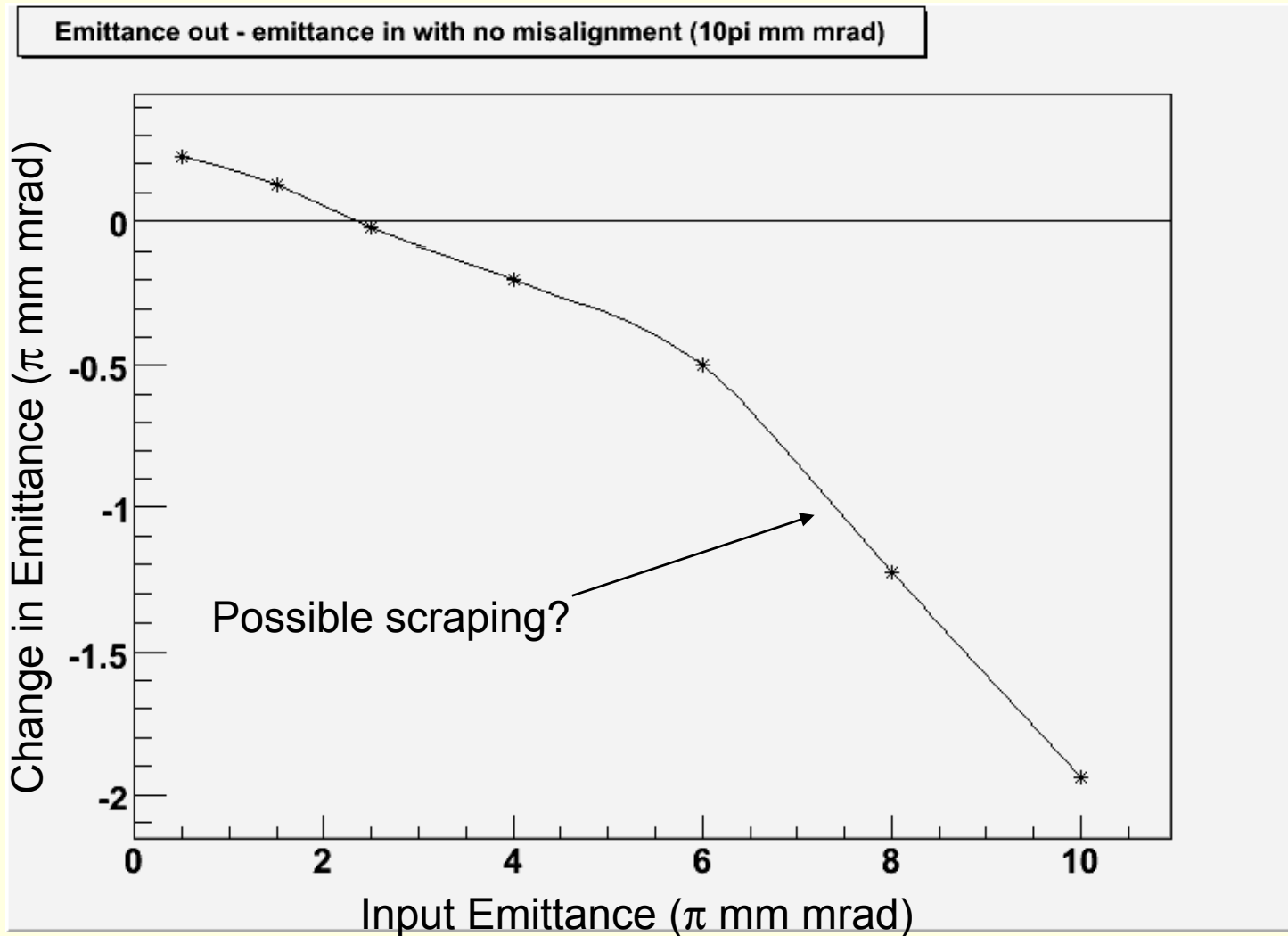
University  
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Particle Physics

# Scope

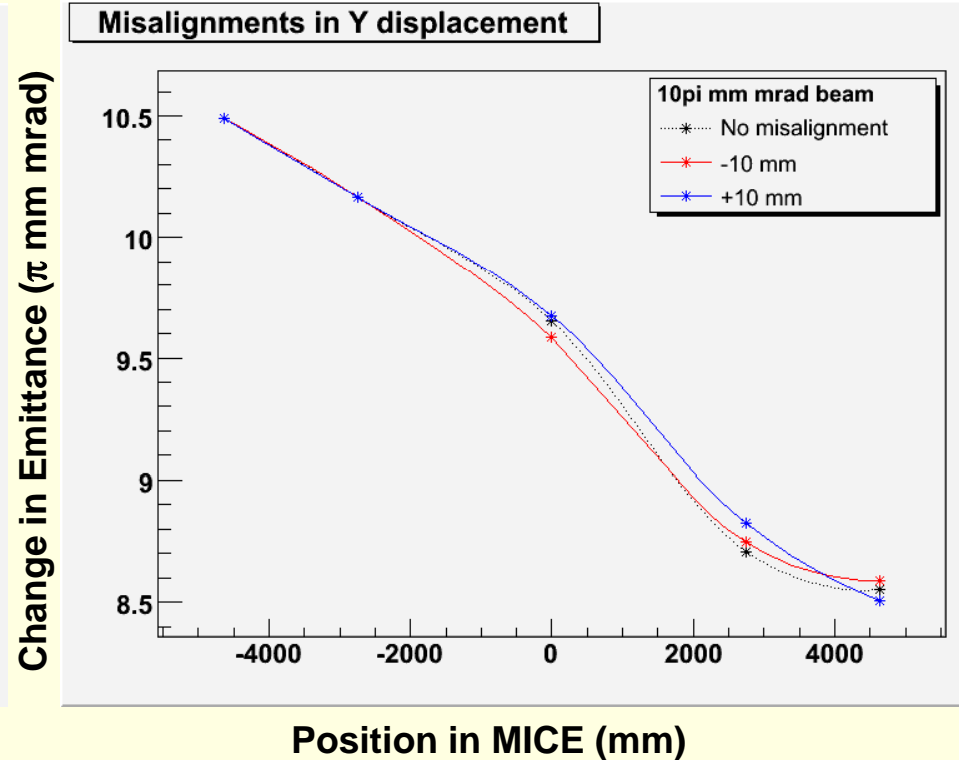
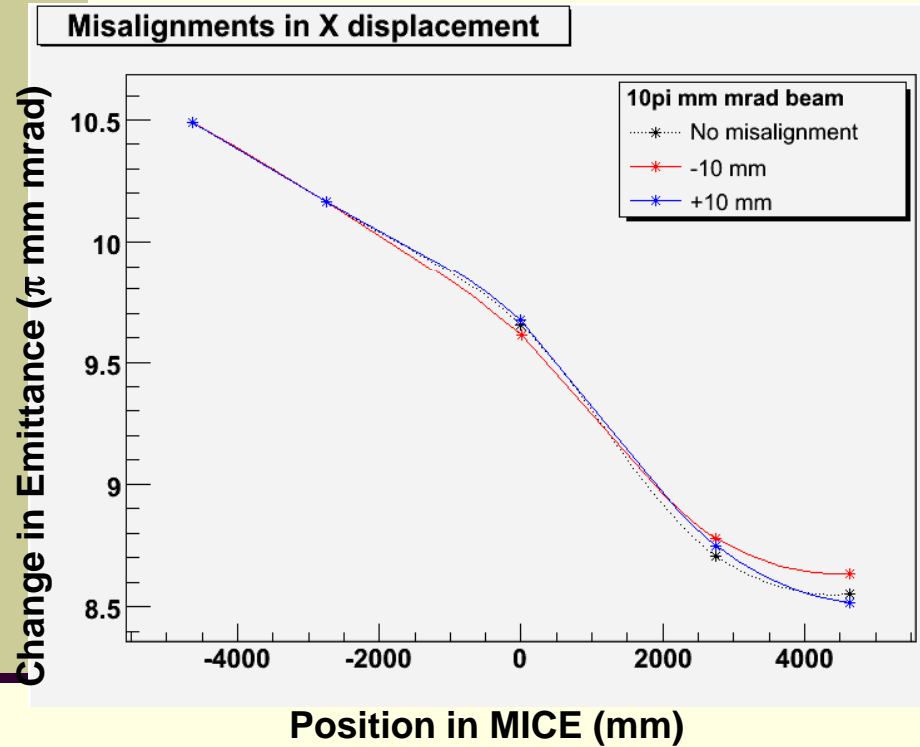
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- G4MICE Simulations (No digitisation or reconstruction - - yet!)
- Step VI, 1000 events, 7 beams: 0.5, 1.5, 2.5, 4, 6, 8, 10 pi mm mrad
- Second spectrometer (tracker+magnet) only one misaligned
- $\pm 10$  mm,  $\pm 3$  mrad,  $\pm 10$  mm &  $\pm 3$  mrad together, for x and y
- A total of 96 simulations (unfortunately the seeds were not changed for each simulation so results are probably correlated)
- Partially intended as training exercise

# Baseline

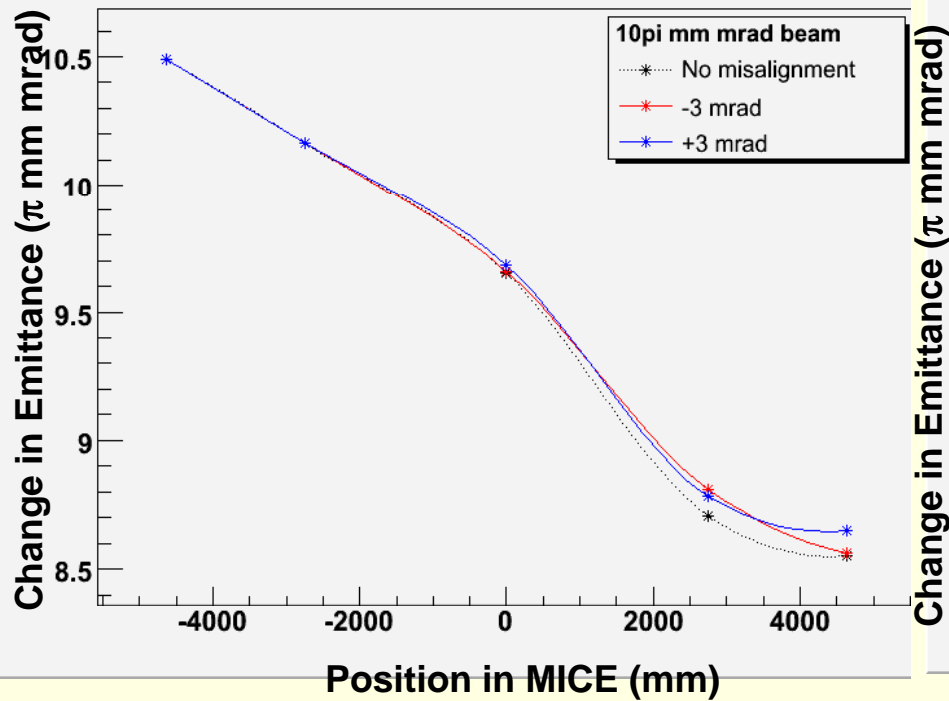


# 10 $\pi$ mm mrad (translation)

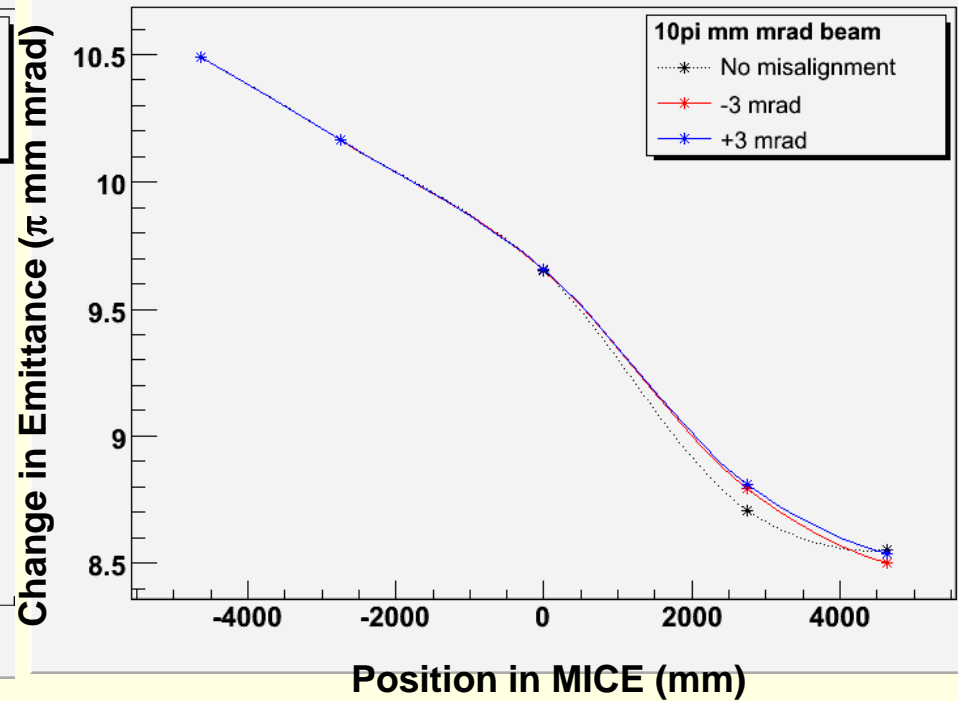


# 10 $\pi$ mm mrad (rotation)

Misalignments in X rotation

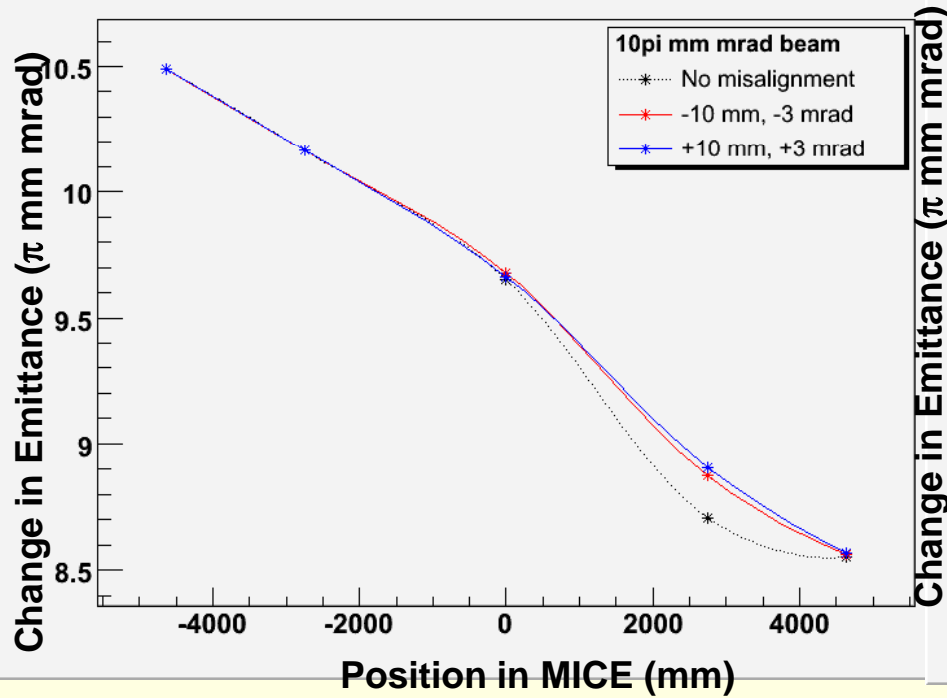


Misalignments in Y rotation

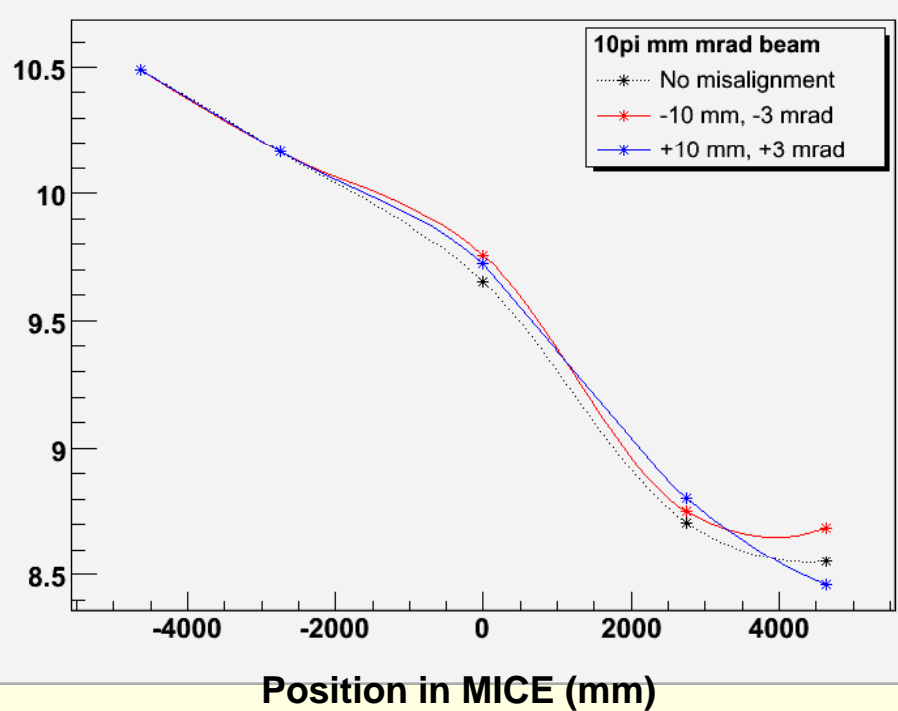


# 10 $\pi$ mm mrad (translation+rotation)

Misalignments in X rotation and displacement

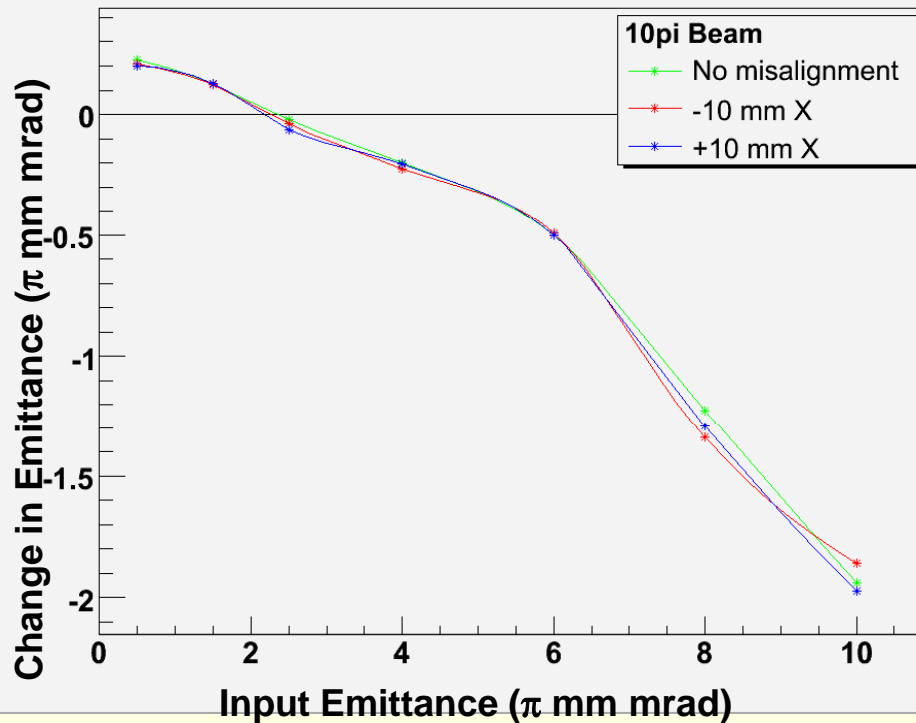


Misalignments in Y rotation and displacement

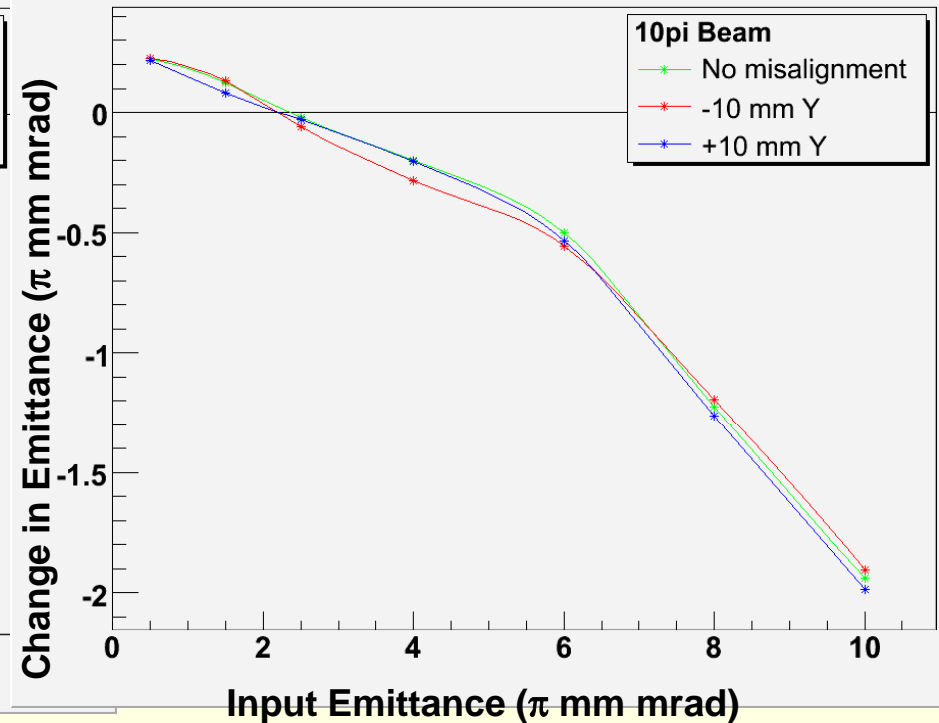


# Effect of Misalignment (translation) on Emittance

Effect of 10 mm X misalignments on emittance

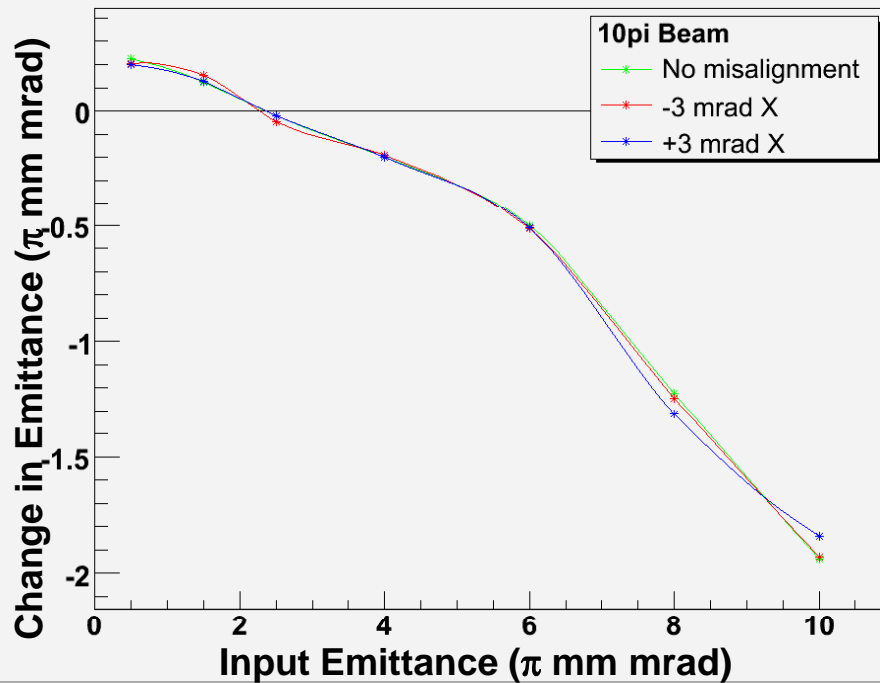


Effect of 10 mm y misalignments on emittance

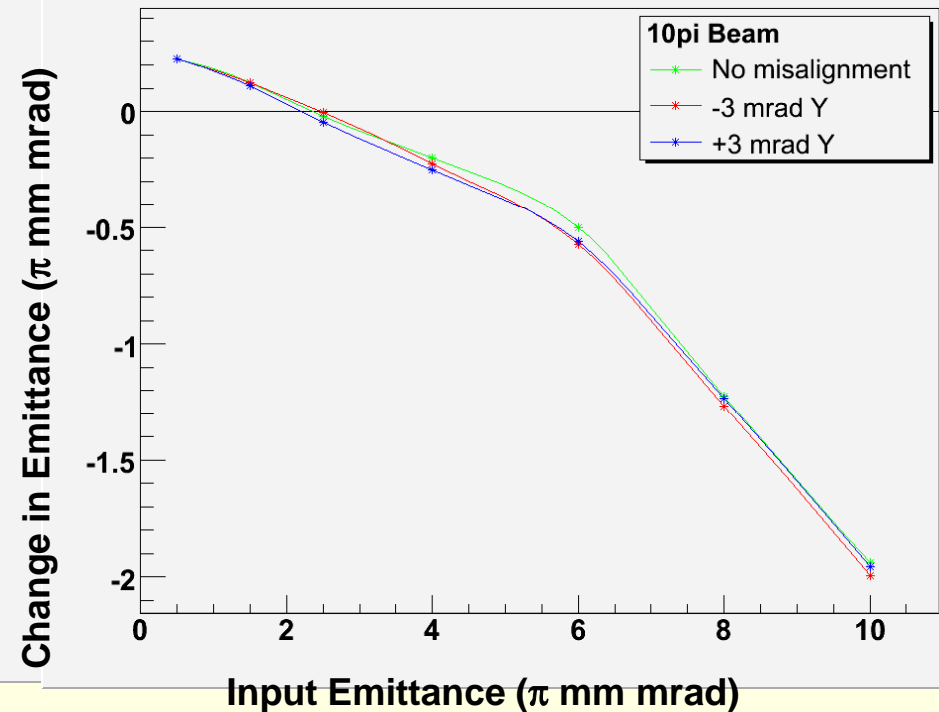


# Effect of Misalignment (rotation) on Emittance

Effect of 3 mrad X misalignments on emittance



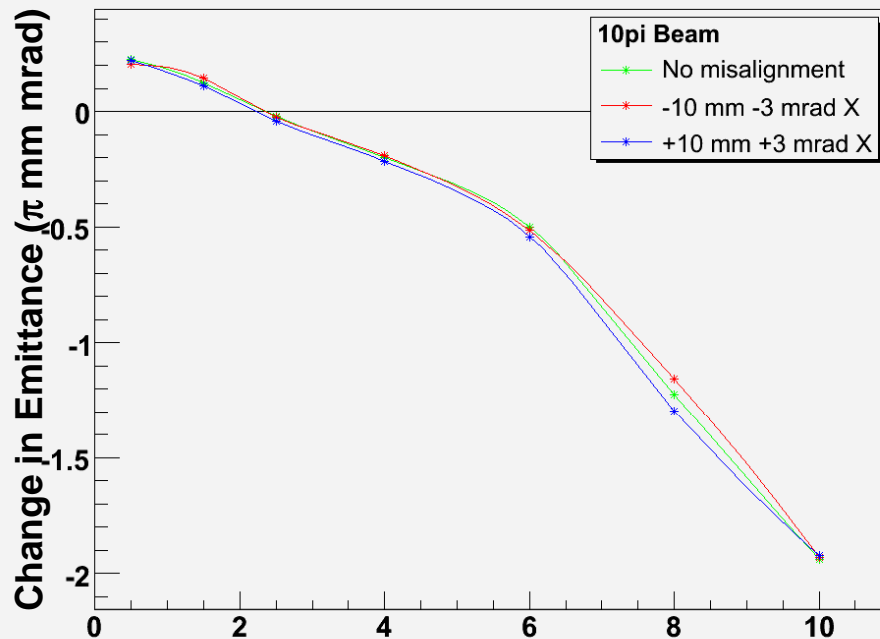
Effect of 3 mrad Y misalignments on emittance





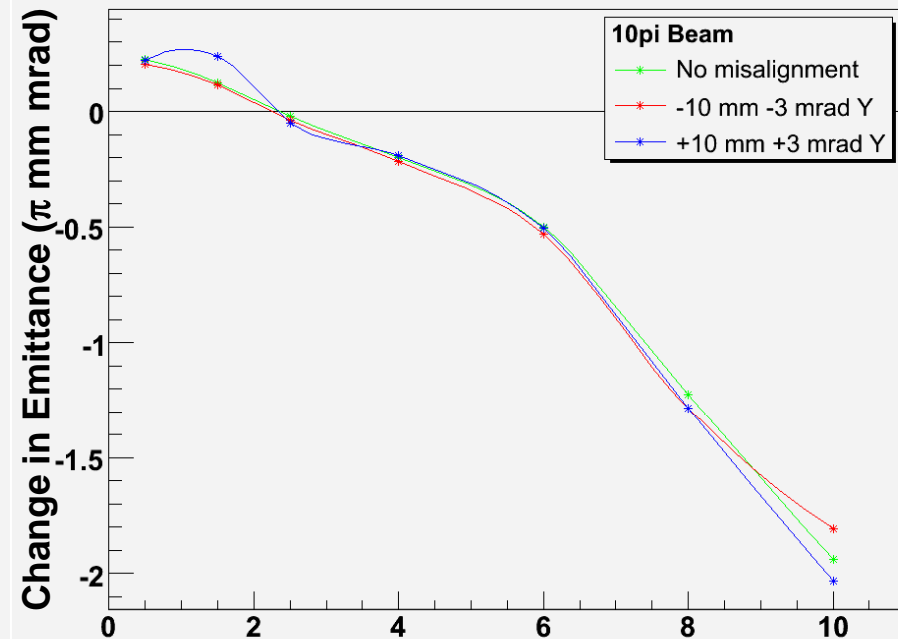
# Effect of Misalignment (translation & rotation) on Emittance

Effect of 3 mrad and 10 mm X misalignments on emittance



Input Emittance ( $\pi$  mm mrad)

Effect of 3 mrad and 10 mm Y misalignments on emittance



Input Emittance ( $\pi$  mm mrad)

# Percentage Changes

Percentage Changes in emittance due to misalignments for different input beams ( $\pi$ mm mrad)							
	0.5	1.5	2.5	4	6	8	10
X							
10mm	3.44	0.21	0.69	0.61	0.11	1.45	0.83
3mrad	4.15	1.87	0.99	0.22	0.27	0.24	0.10
10mm 3mrad	4.15	1.45	0.06	0.16	0.28	0.84	0.10
Y							
10mm	0.19	0.35	1.53	2.12	0.93	0.40	0.36
3mrad	0.14	0.19	0.77	0.61	1.22	0.50	0.52
10mm 3mrad	4.50	0.67	0.69	0.43	0.56	0.74	1.34

# Discussion

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- We are clearly dominated by poor statistics. The effect is less than the uncertainty.
- Error of emittance not implemented yet. John Cobb produced note (not yet public) to suggest:

$$\sigma\left(\frac{\Delta\mathcal{E}}{\mathcal{E}}\right) = 2 \left| \frac{\Delta p}{p} \right| \left( \frac{\mathcal{E}_{eq}}{\mathcal{E}} \right)^2 \frac{1}{\sqrt{N}}$$

- $10^4$  muons  $\rightarrow \sigma\left(\frac{\Delta\mathcal{E}}{\mathcal{E}}\right) = 0.01$  for  $\frac{\Delta\mathcal{E}}{\mathcal{E}} = -0.1$
- Need to increase number of events to at least  $10^4$  muons
- Need to implement G4MICE tool for calculating error in emittance

# Discussion

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- We need the alignment to be a negligible error in the total emittance measurement
- If the goal is to measure emittance with 1% precision then the error in the alignment needs to contribute  $\ll 1\%$  (maybe  $\sim 0.3\%$ ?) for it to be negligible.
- So, goal of alignment study is to achieve 0.3% precision, therefore we should generate  $>10^4$  events per beam  $\rightarrow$  we need the Grid!
- Have already started to set things up on Grid with Malcolm's help but have not been able to run yet.

# Future Work

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- Early work, seek to augment in the following ways:
  - Ensure seeds are changed for each run
  - Eliminate scraping by choosing good muons
  - Statistics (implementation: G4MICE on GRID)
  - Include emittance errors
  - Reconstruction of particles (rather than Monte Carlo truth)
- Next steps after this: Change **B** field of spectrometers and study effect in change in emittance