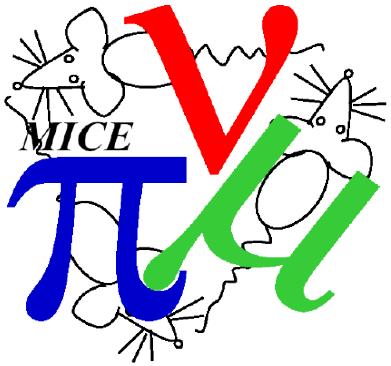
Emittance Evolution Update



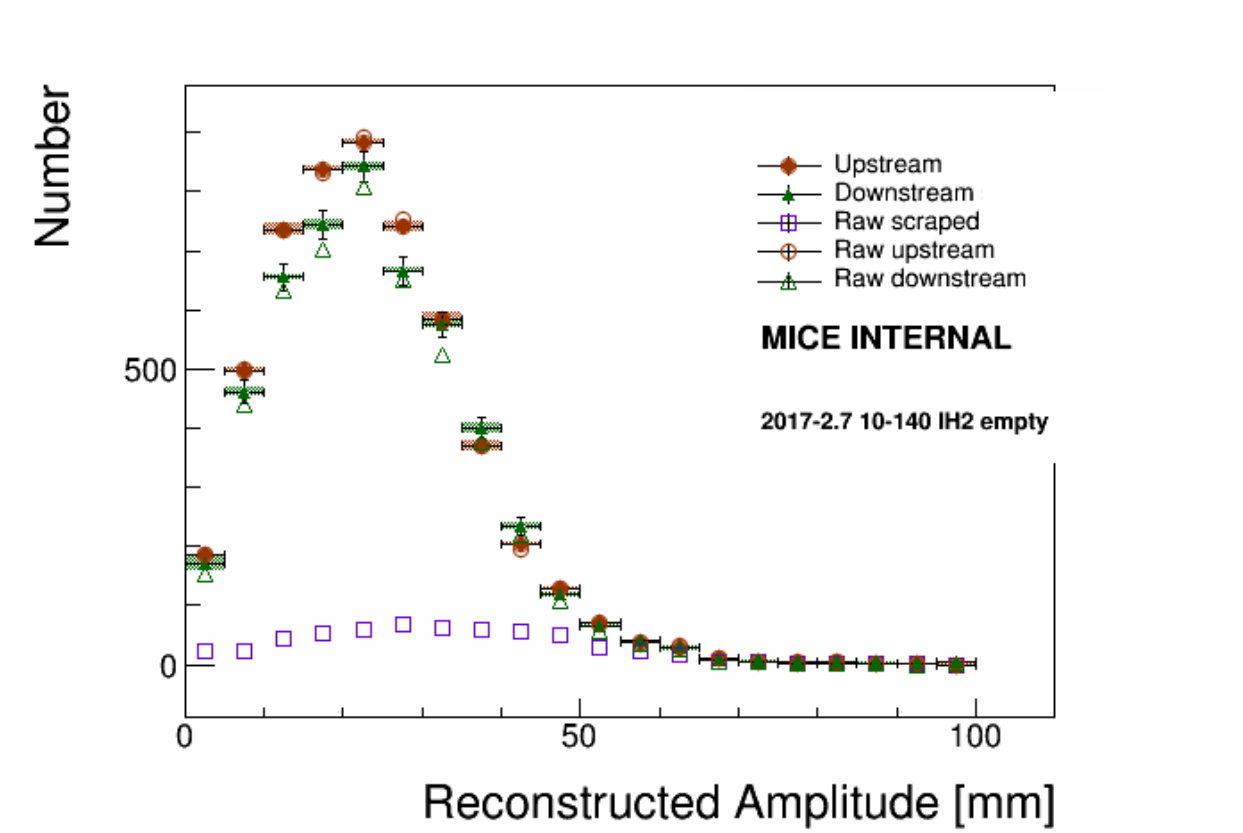
C. Rogers, ISIS Intense Beams Group
Rutherford Appleton Laboratory

Overview

- Focus is now on revisiting/tidying the amplitude calculation
  - Basic algorithm
  - Correction for detector effects
  - Systematic uncertainty on the correction

Reminder of the result

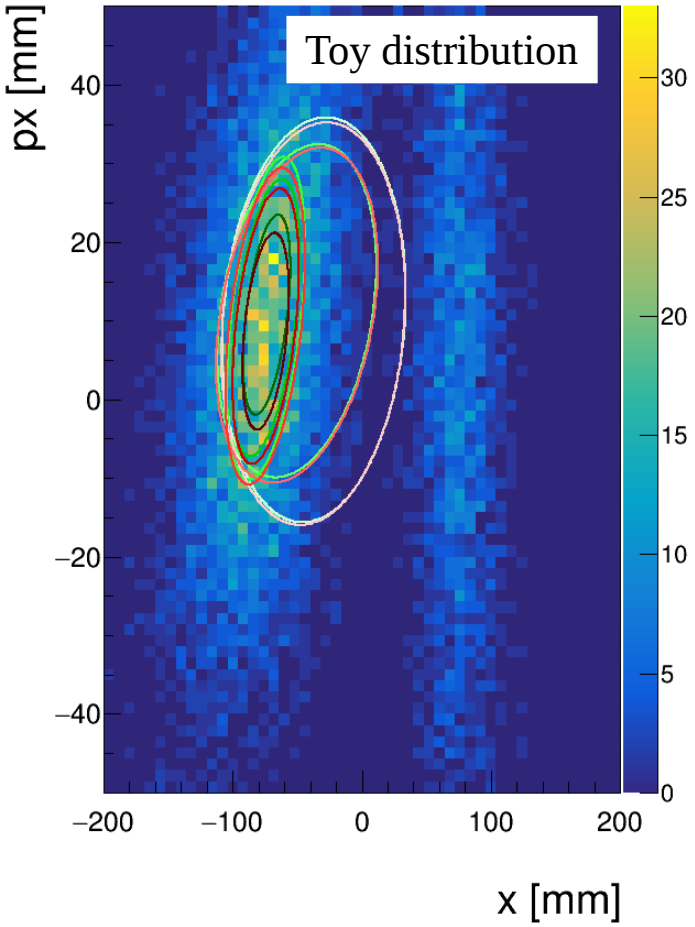
- Reminder – we are trying to measure amplitude
  - The number of muons at different “temperature”
  - Muons at low amplitude are “cooler”
  - We want to show we have more muons at low amplitude after the absorber

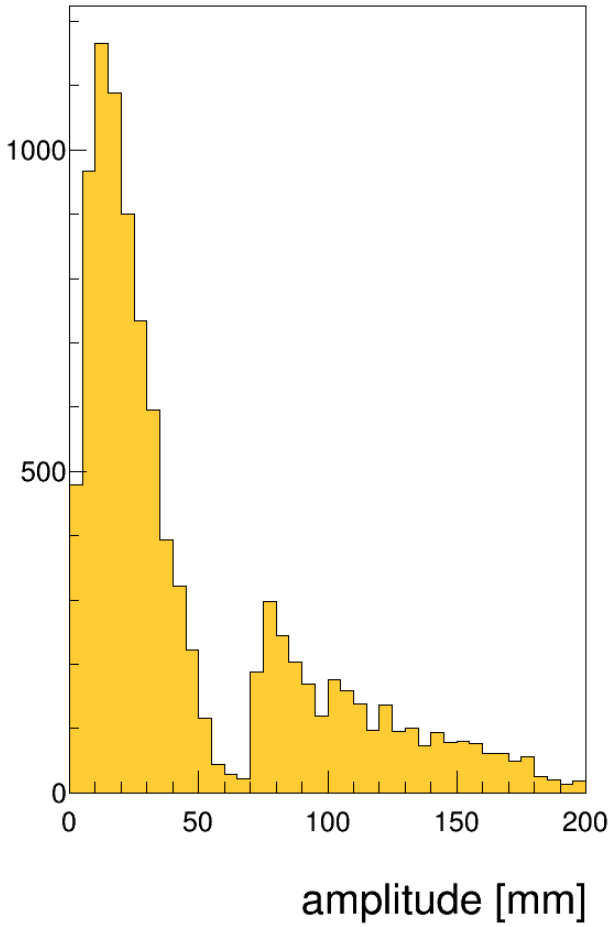


Calculation of Amplitude

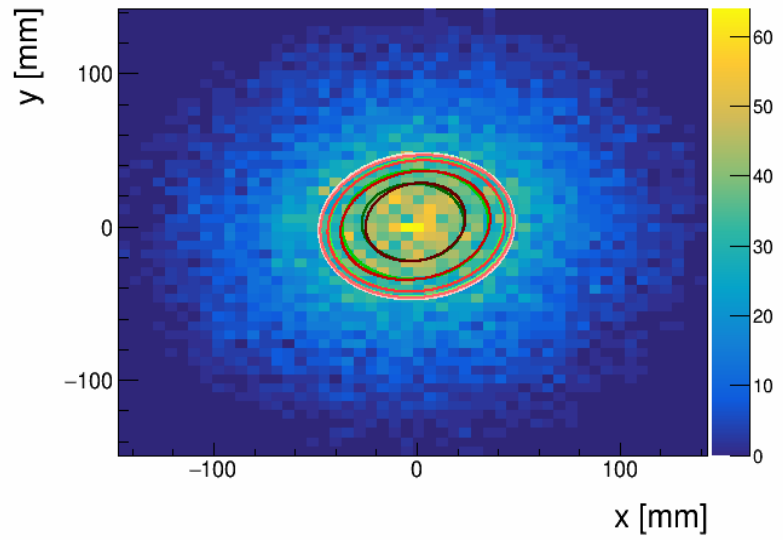
- Amplitude is area of beam ellipse enclosed by each muon
  - But beam is not elliptical in tails
- Reject tails using an iterative algorithm
  - Ignore muons with amplitude > amplitude bin
  - Recalculate ellipse; and then amplitudes
- Zoom in on beam core
- Split into “reference” and “test” samples
  - Use “reference” to calculate ellipses
  - Use “test” for actual recorded amplitudes
  - Swap samples around and recalculate to get full statistics

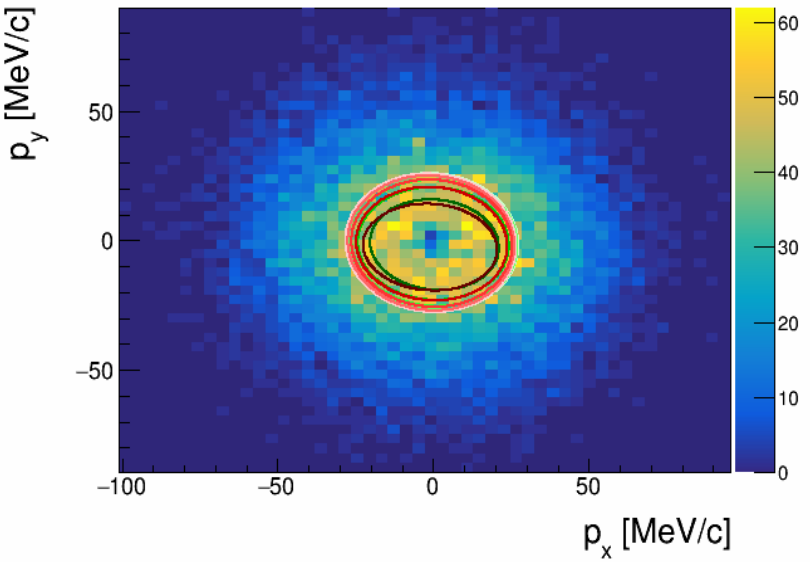
Calculation of Amplitude

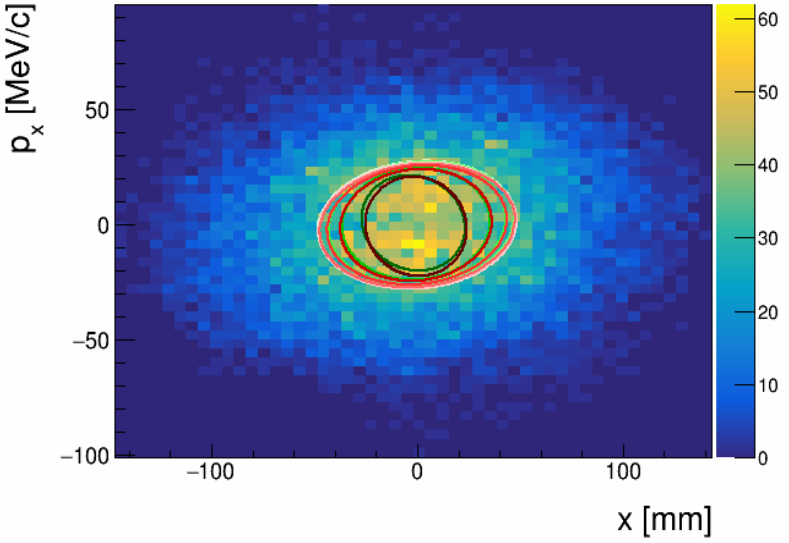


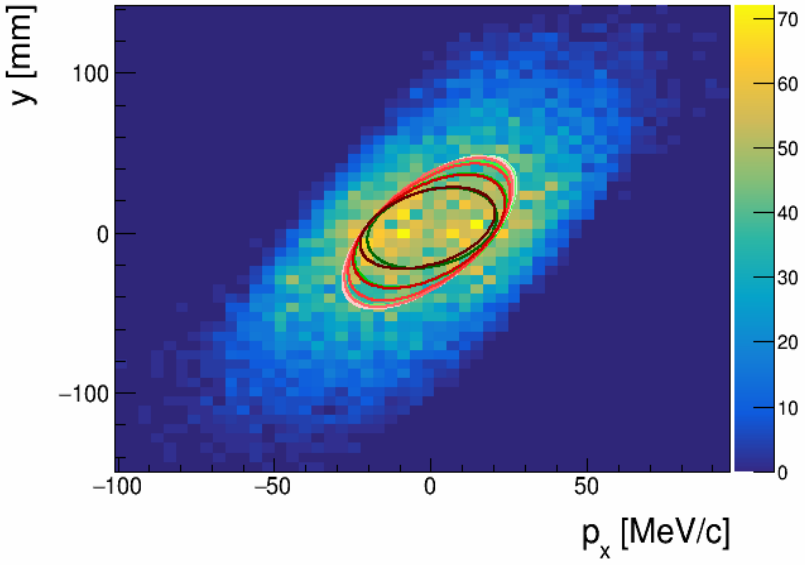


TKU (10-140 None)

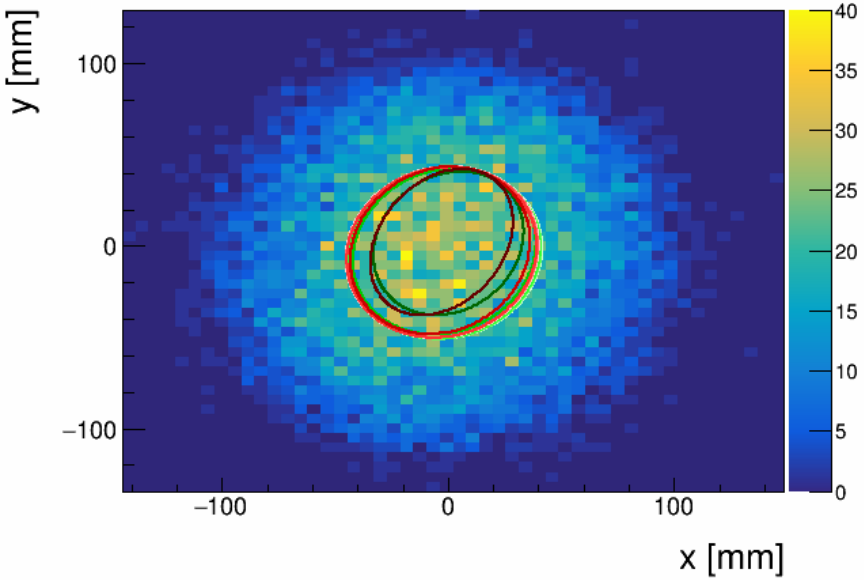


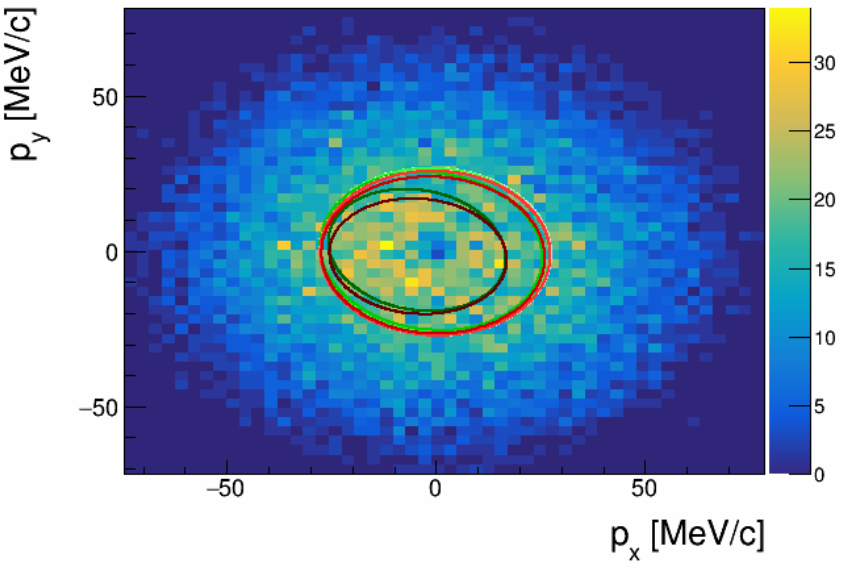


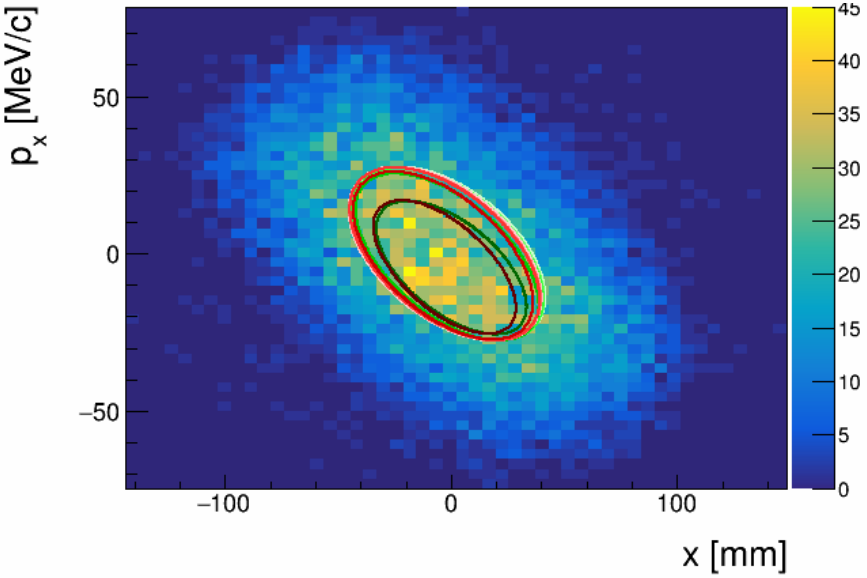


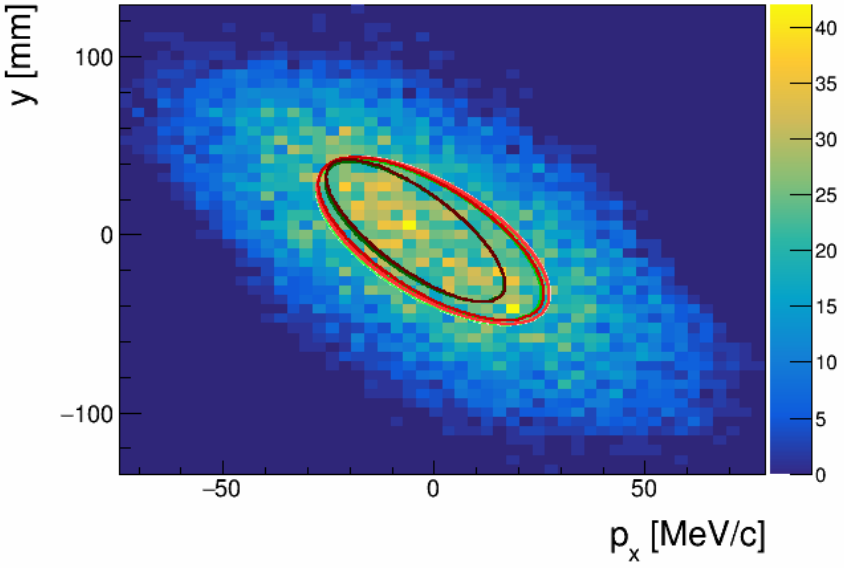


TKD (10-140 None)

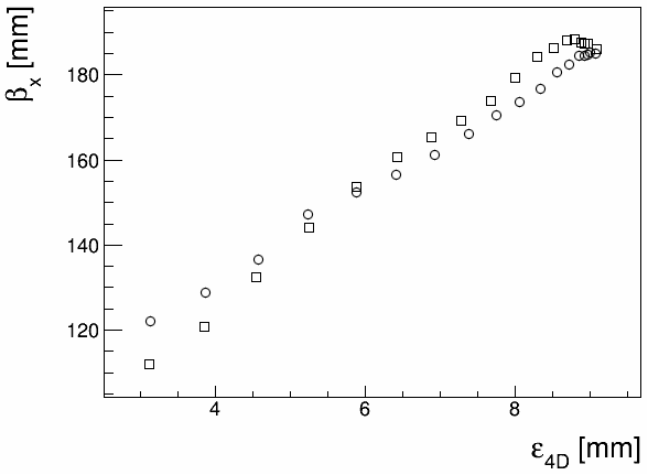


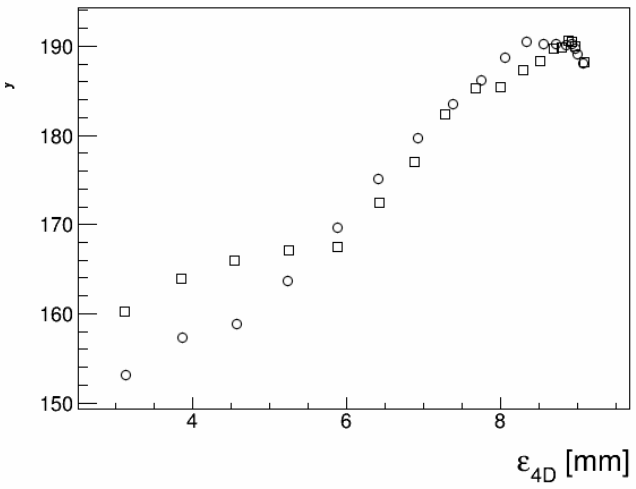


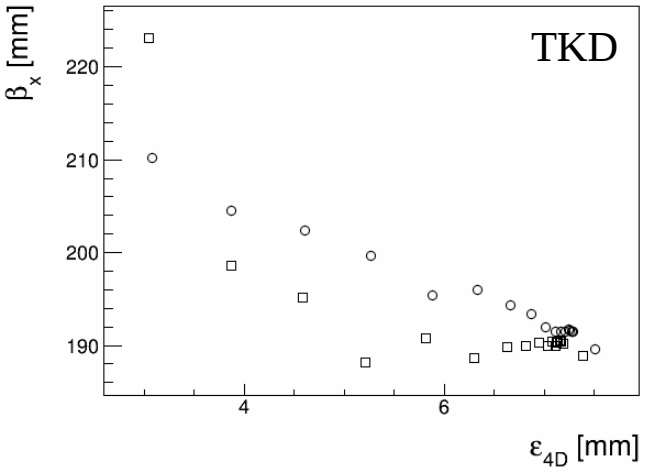


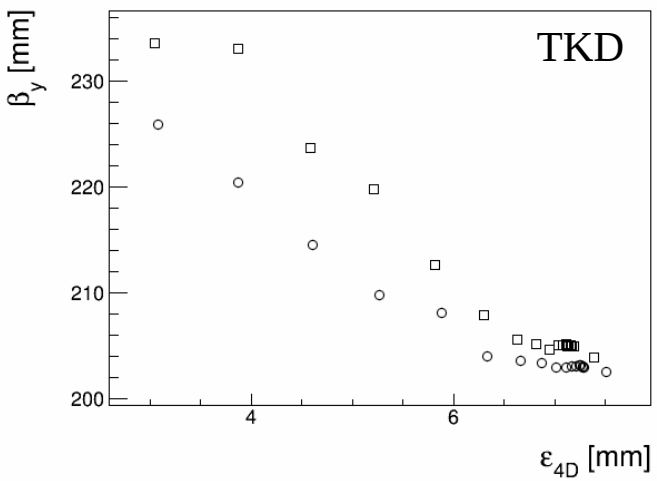


Phrase as “beta” functions

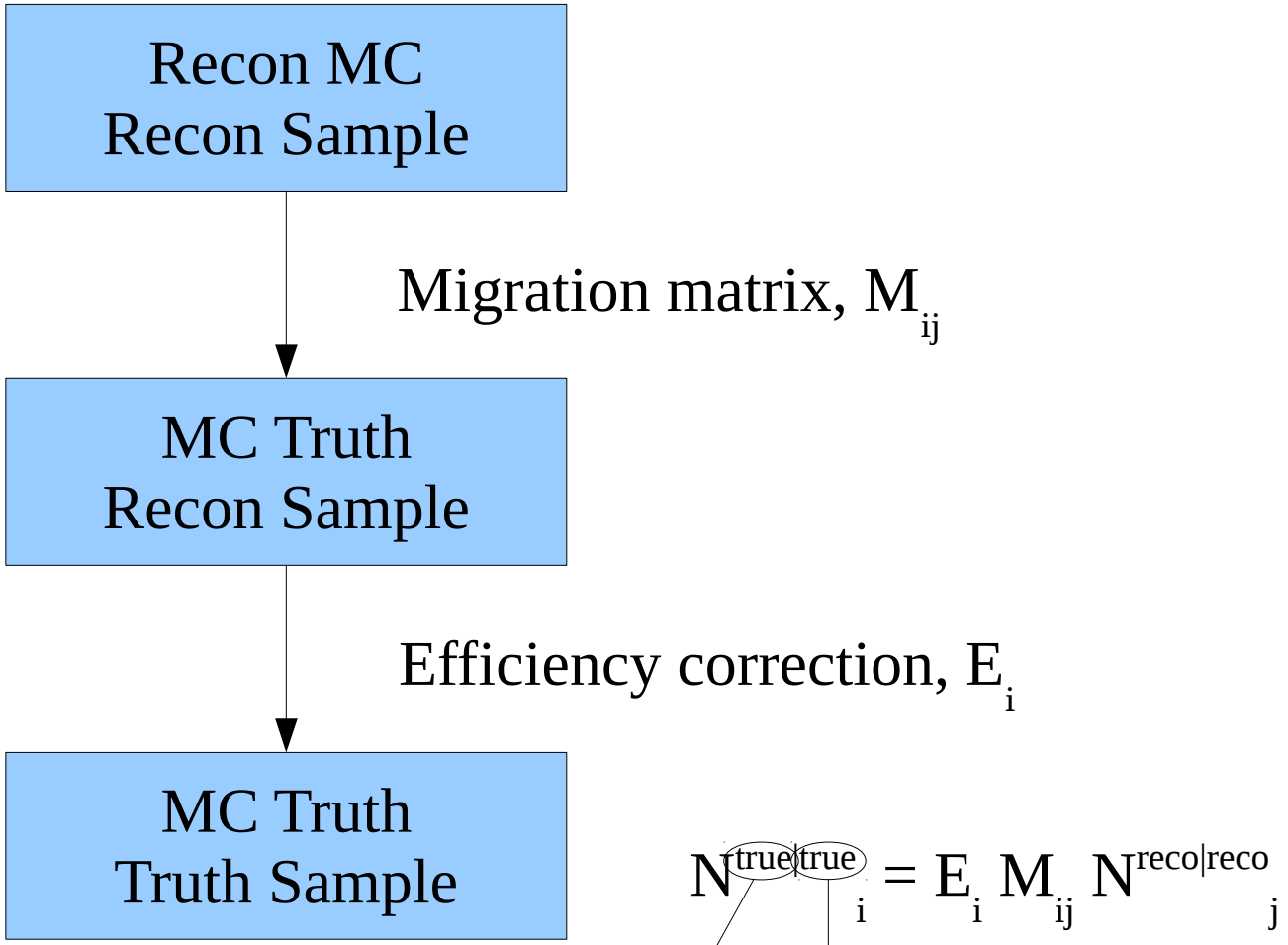








Reminder – correction routine



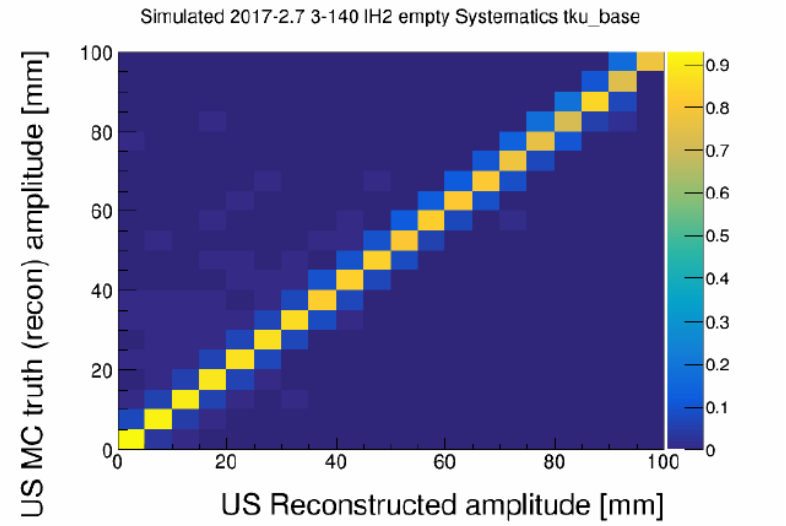
Mechanics of Calculation

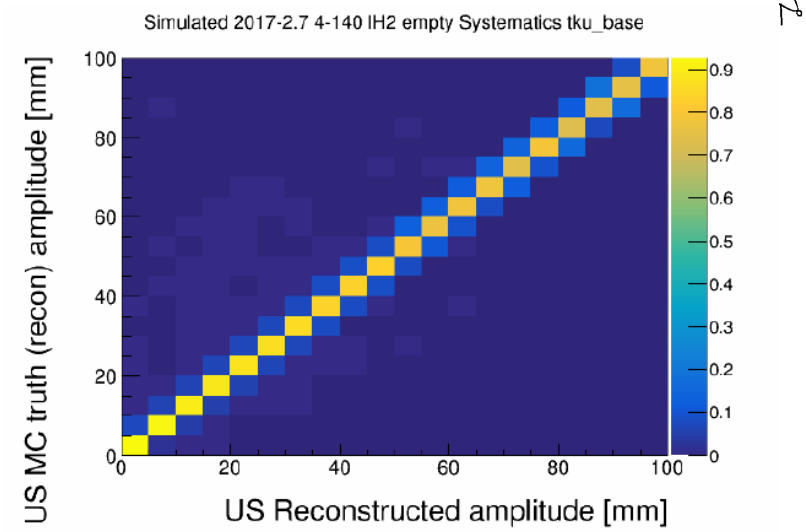
- Record the upstream sample (~1e4 events) at TKU station 5
- Smear using KDE
- Sample ~1e5 - 1e6 events from resultant distribution
- Reapply following cuts:
  - TKU chi2 cut
  - TKU max radius cut
  - TKU p cut
  - All downstream cuts
- I did a MC production for 3-140, 6-140, 10-140 lH2 empty
- Stats errors are generated by taking standard deviation of 10 subsamples / sqrt(10)

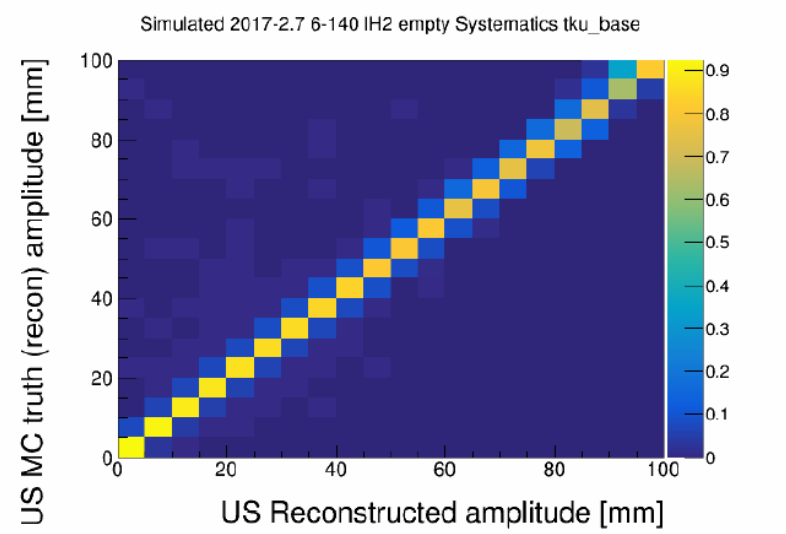
Migration matrix

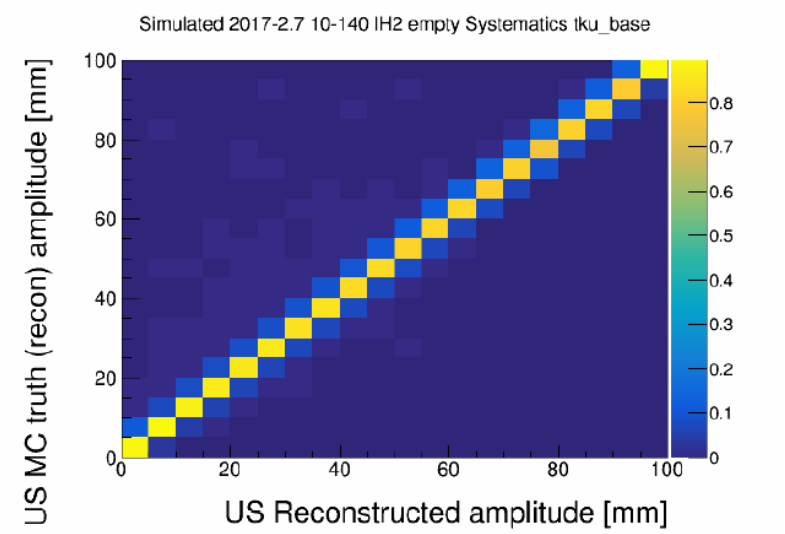
- Detector resolution causes muons to migrate between bins
- Migration matrix technique to calculate and correct migration
- N_{ij} is number of events in ith bin in truth and jth bin in recon
  - Always considering the sample of events that was reconstructed
- Then Migration matrix is
  - $M_{ij} = N_{ij}/\mathrm{Sum}_j(N_{ij})$
  - So $N^{\mathrm{true|reco}}{}_i = M_{ij} N^{\mathrm{reco|reco}}{}_j$

Migration matrix - Upstream

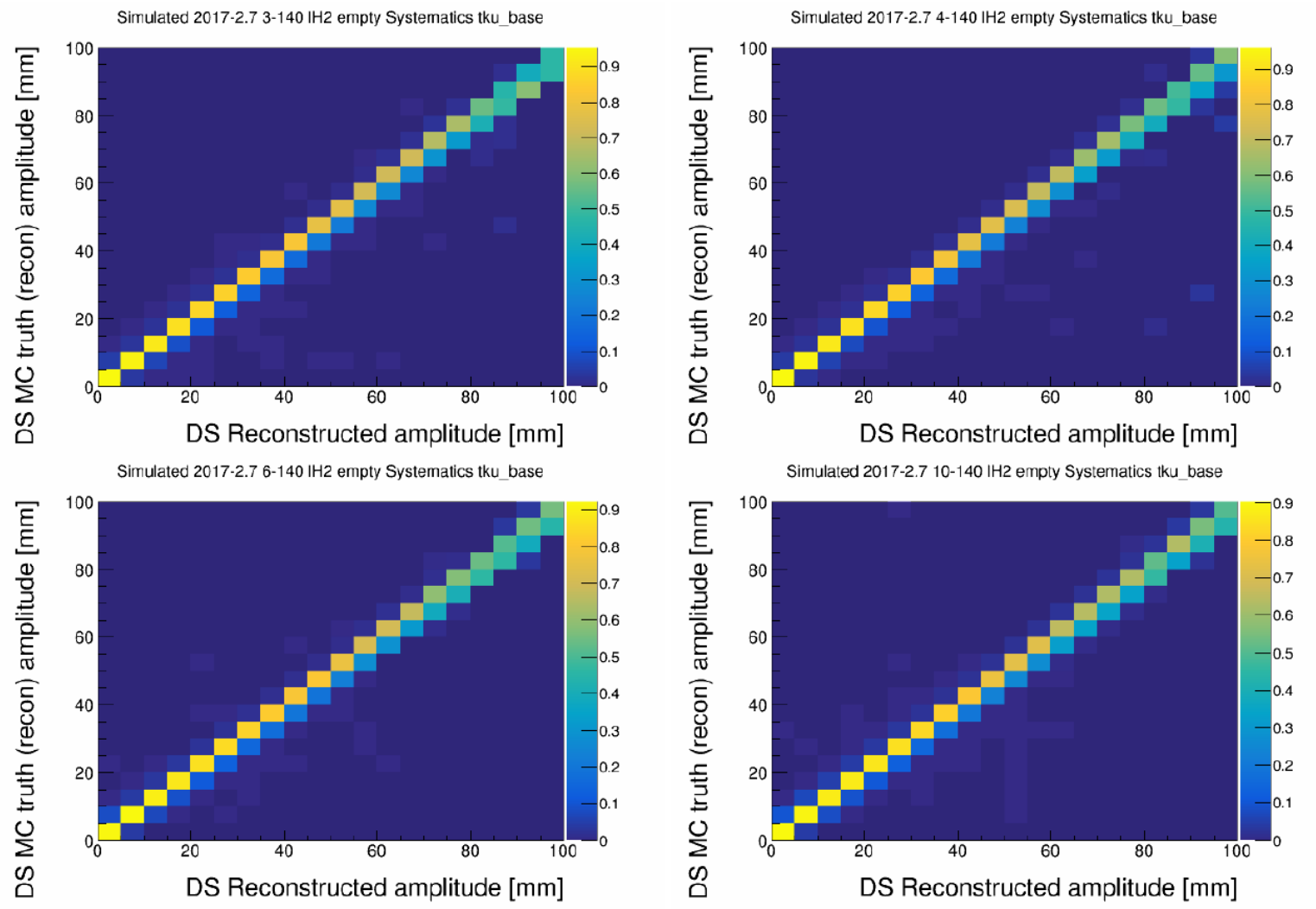








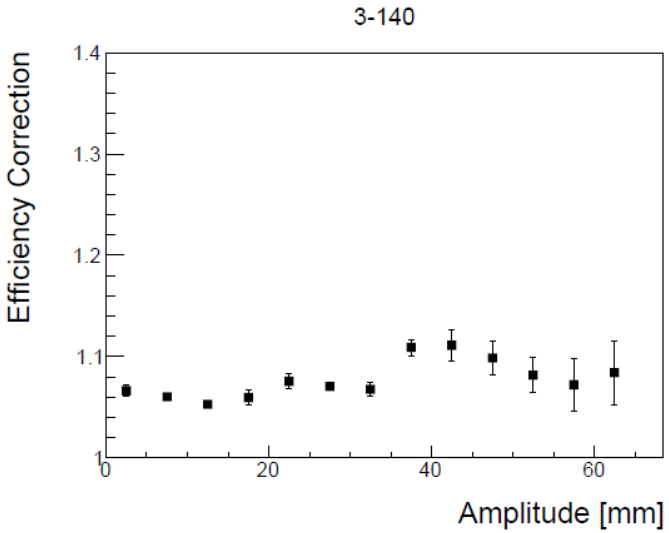
Migration matrix - Downstream

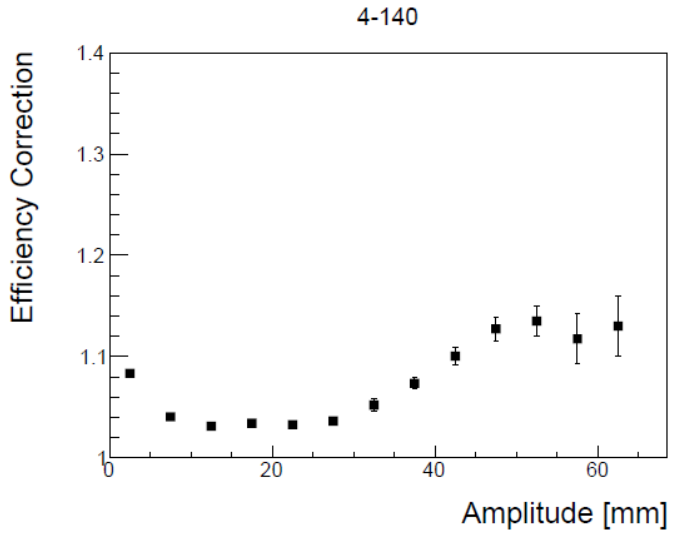


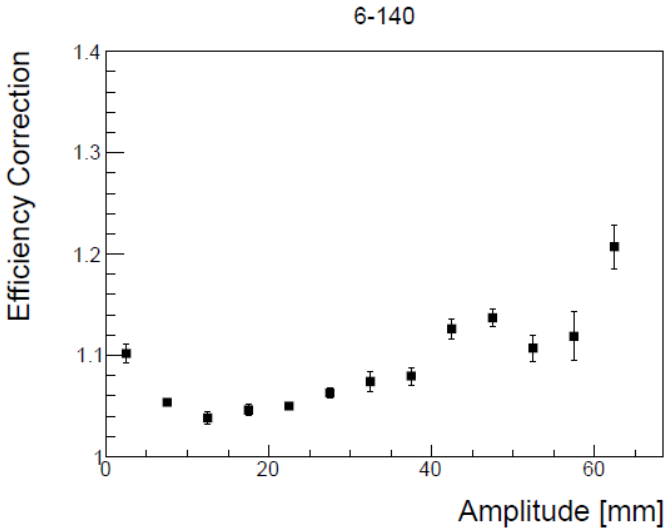
Inefficiency

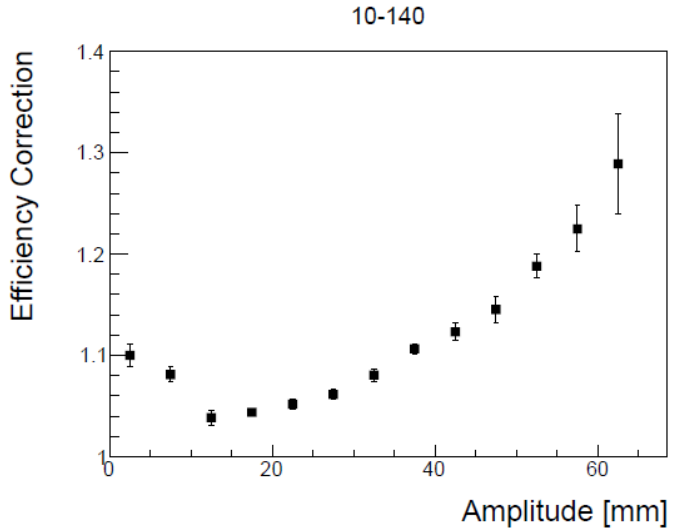
- Detector inefficiency causes muons to “disappear”
- Use MC to estimate the probability of disappearance
- $N^{true|reco}_i$ = number events in recon sample in bin i
- $N^{true|true}_i$ = number events in true sample in bin i
- Always use recon truth to calculate the amplitudes
- Efficiency correction, $E_i = N^{true|true}_i / N^{true|reco}_i$

Inefficiency





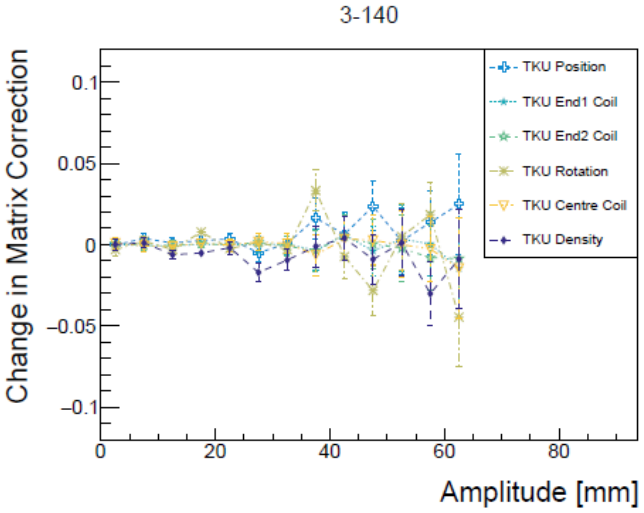


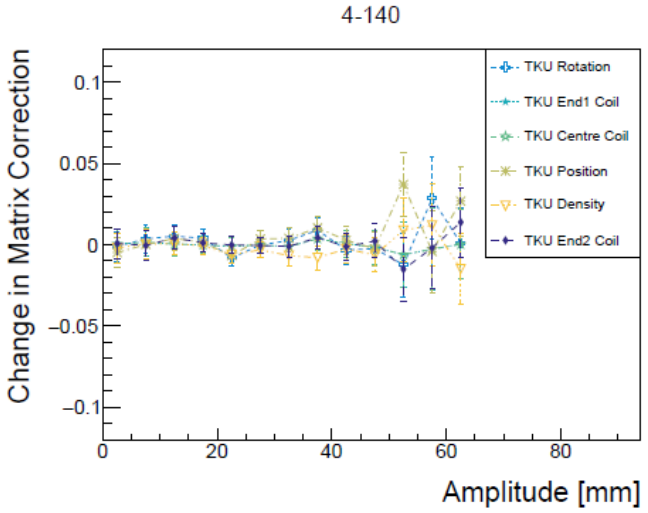


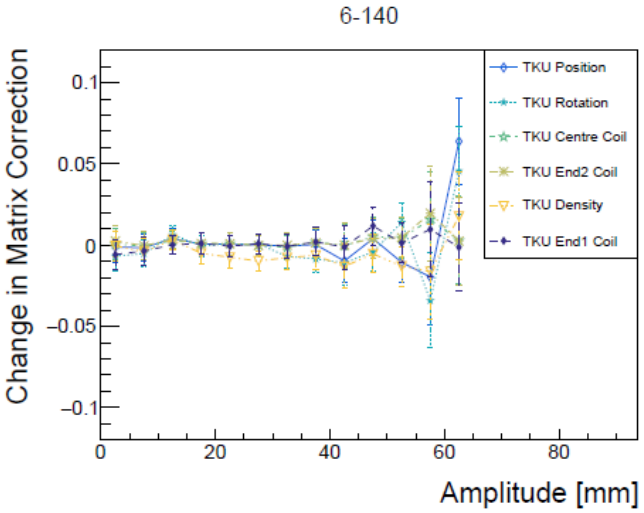
Systematic uncertainty in correction

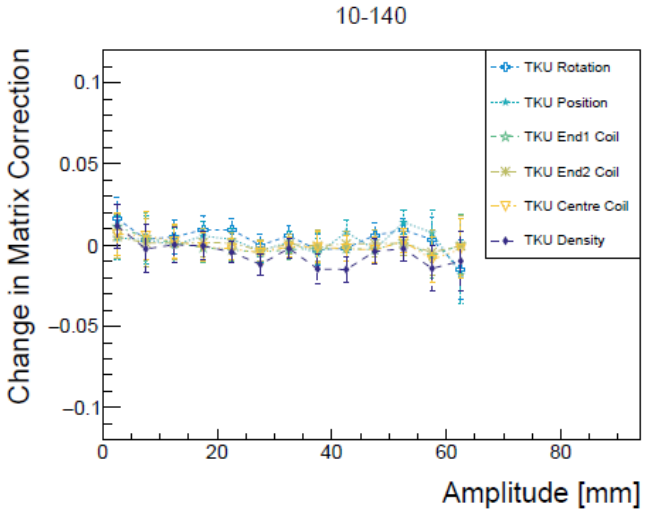
- Some systematic uncertainties arise because we don't quite know what was really installed in the hall
- Consider sources of systematic uncertainty (TKU and TKD)
  - Tracker position (1 mm)
  - Tracker tilt (1 mrad)
  - E1 scale (5 %)
  - E2 scale (5 %)
  - CC scale (1 %)
  - Tracker glue density (0.5 g/cm^3 ~ 25 %)
- Change each parameter; recalculate correction
  - How sensitive is the correction to different uncertainties?
  - Plot “modified correction” - “baseline correction” vs uncertainty
- Quoted uncertainties
  - Apply each correction in turn; calculate $N^{true|true}$
  - Calculate the difference between $N^{true|true}$ compared to the baseline
  - Add in quadrature

TKU – migration matrix



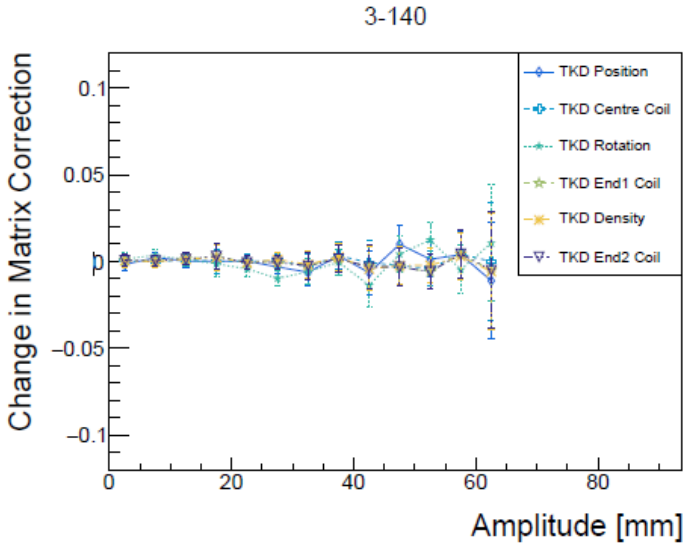


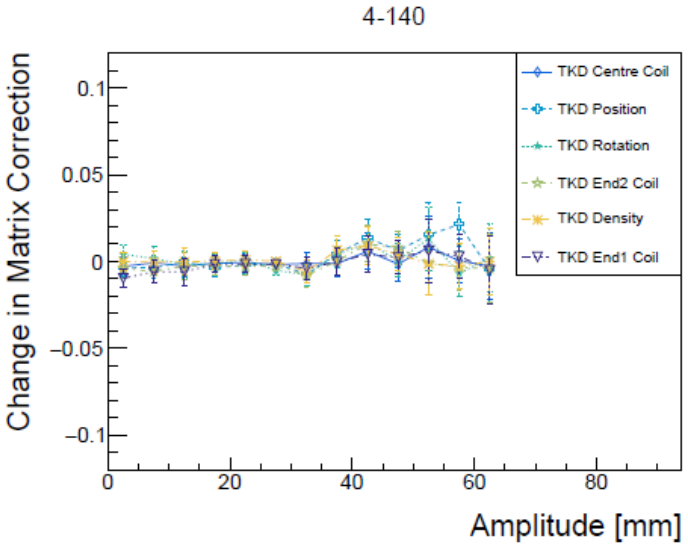


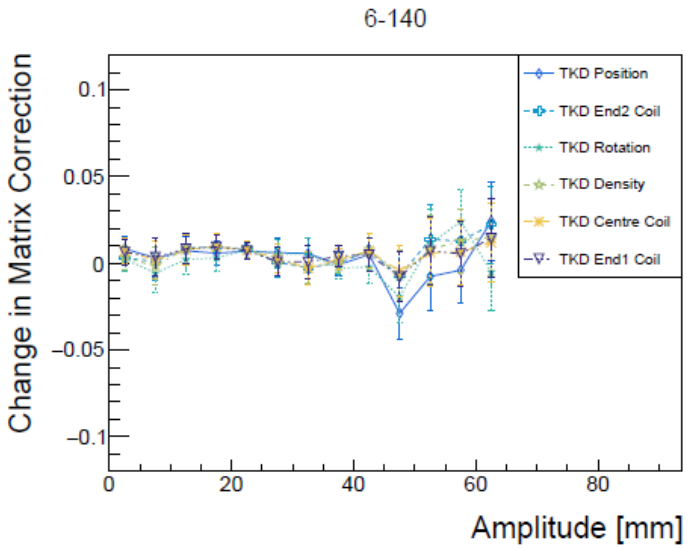


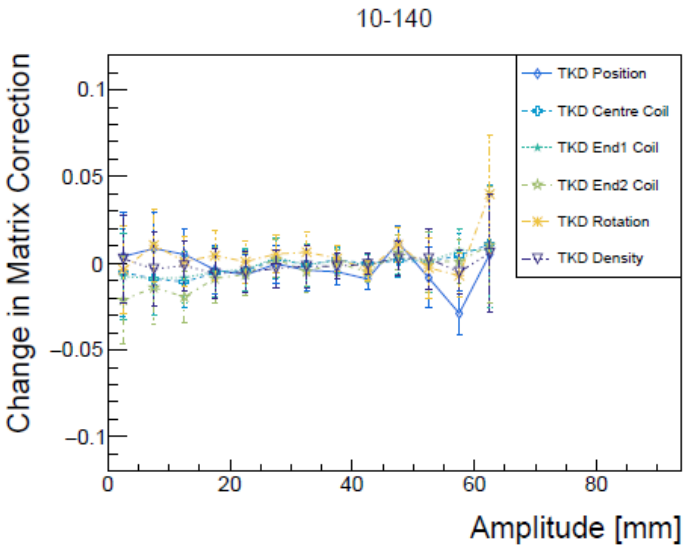
- Change in diagonal terms of migration matrix

TKD – migration matrix

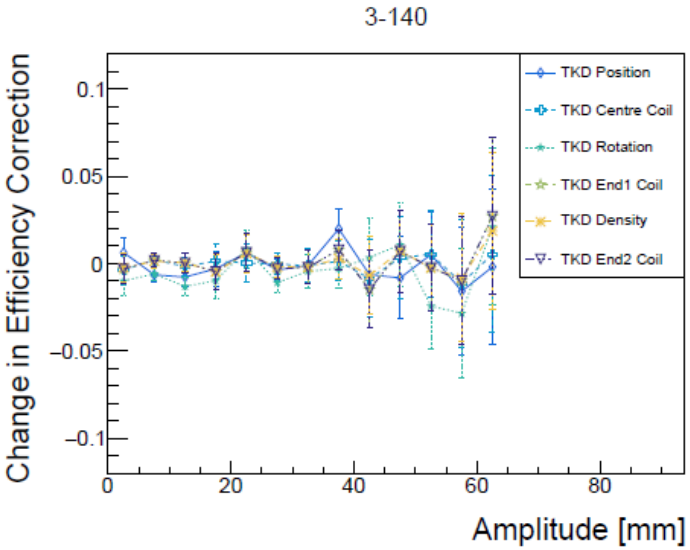


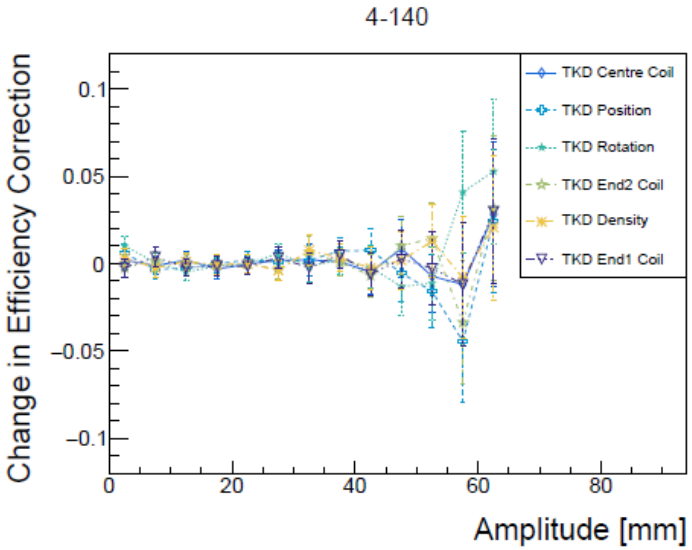


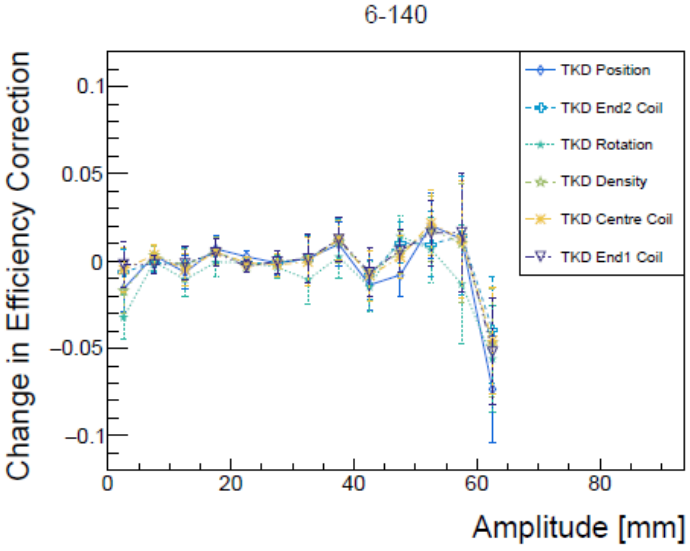


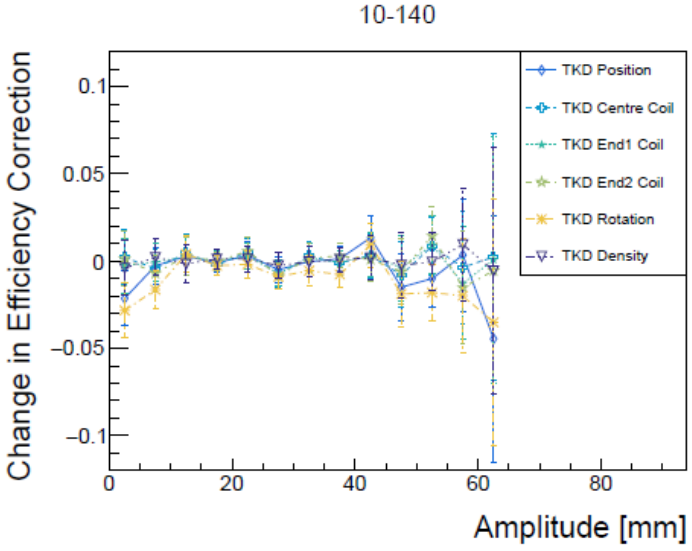


TKD – efficiency

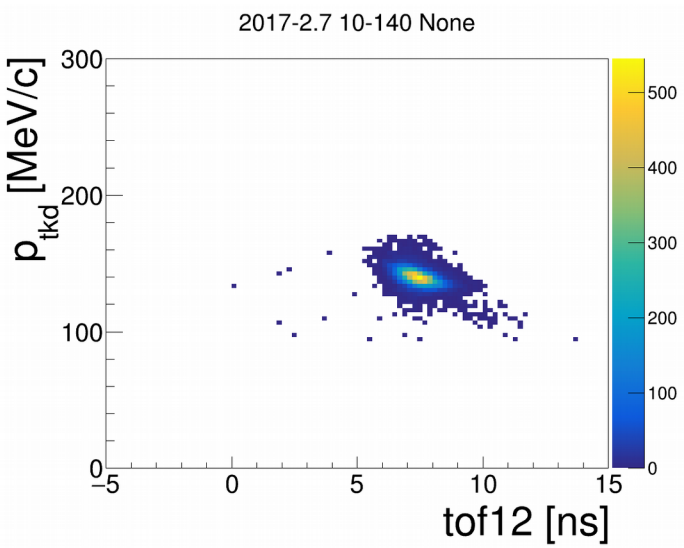


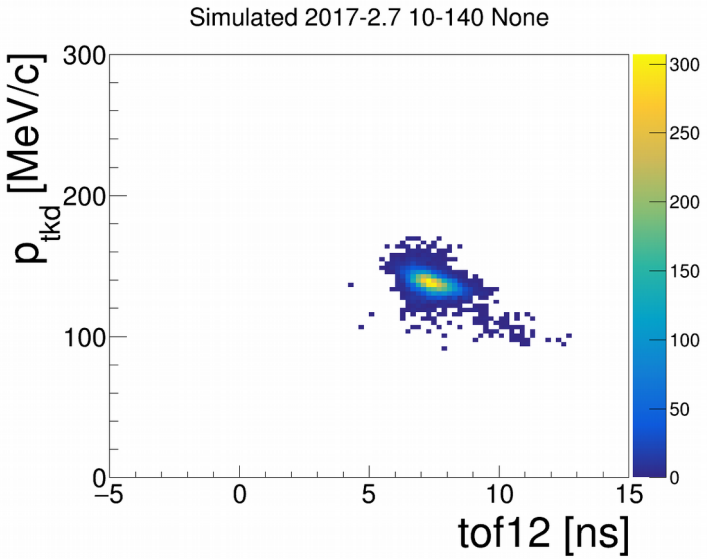






Systematic – mis-PID





- A few candidates for decay electrons in data
  - ~1e-3 level impurity
- No decay electrons appear in MC
- No apparent pion impurity either in data or MC
- No uncertainty assigned yet
  - Expect 1e-3 level uncertainty i.e. small

Job List

- ~~Diffuser geometry~~
- ~~Max Radius Cut~~
- ~~TOF relative to e- peak~~
- ~~4 mm beam – processing in progress~~
- Understand Delta TOF01 issue
- **More statistics in data & MC**
- **Systematic due to mis-PID**
- **Systematic due to downstream cuts**
- **Go over errors again**
- *Reprocess data with low pt fix in*
- Finish writing note
  - Target CM51