Analysis Status

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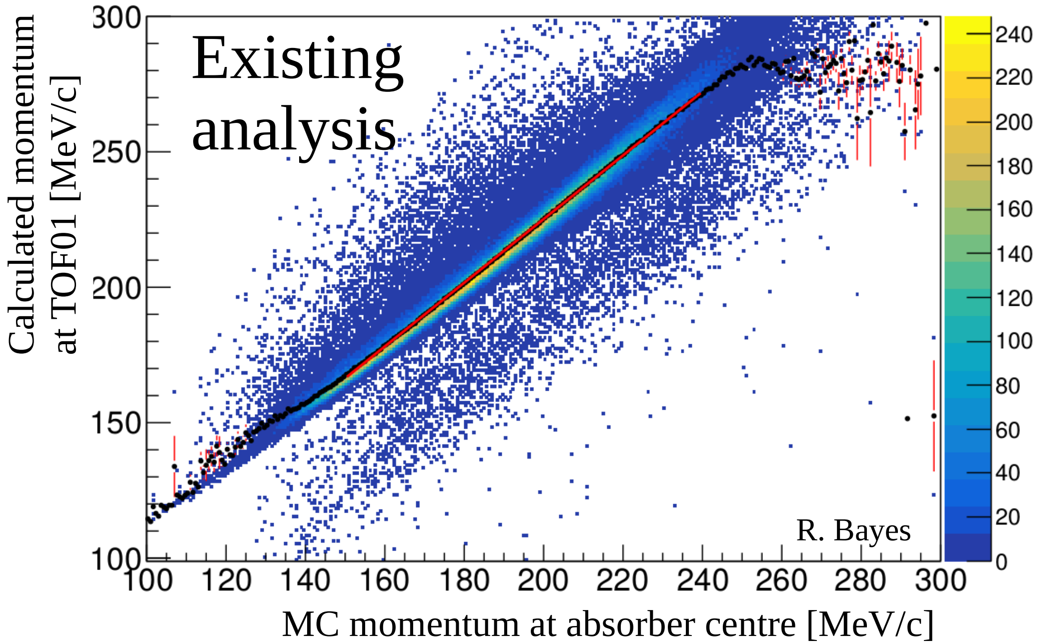
Status of Papers

- 1 slide each on:
  - Field-off scattering paper (J. Nugent)
  - Emittance measurement paper (V. Blackmore)
- Detailed update on:
  - Emittance evolution paper (C. Rogers)

Field-off scattering (J. Nugent)



- Since CM48 focus has been on momentum calculation
  - Momentum calculation used mapping between MC TOF01 and momentum at absorber
  - This was applied to the data
- Seek to validate with a-priori calculation of TOF01 and momentum at absorber
  - Complicated by intervening materials
  - Investigating analytical calculation and simple integration

Emittance Measurement (V. Blackmore)

- Studying resolution effects
  - Effect of magnetic field magnitude
  - Effect of field misalignment
- Studying systematic effects associated with selections
- Extending studies shown at CM48

Emittance Evolution

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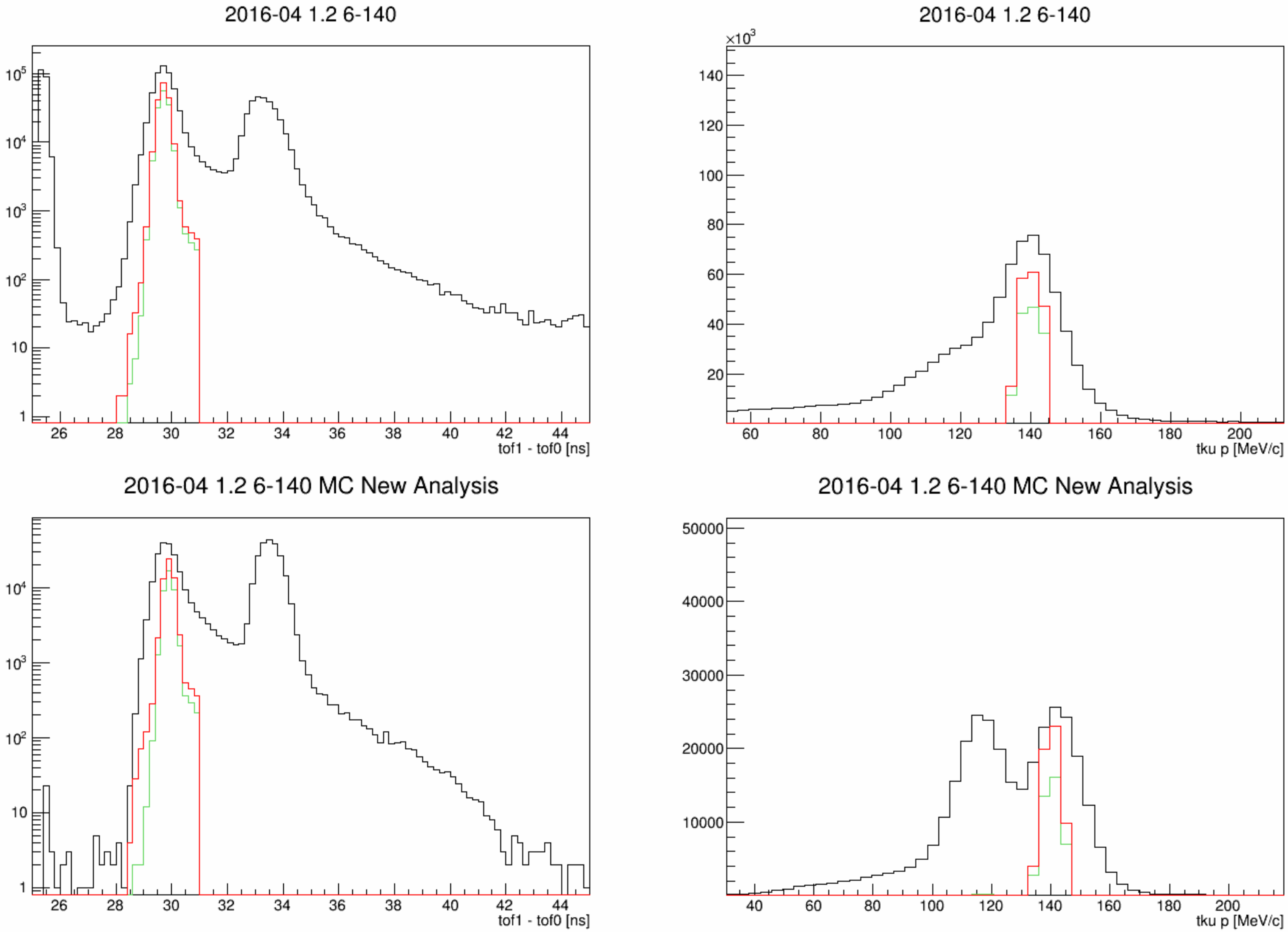
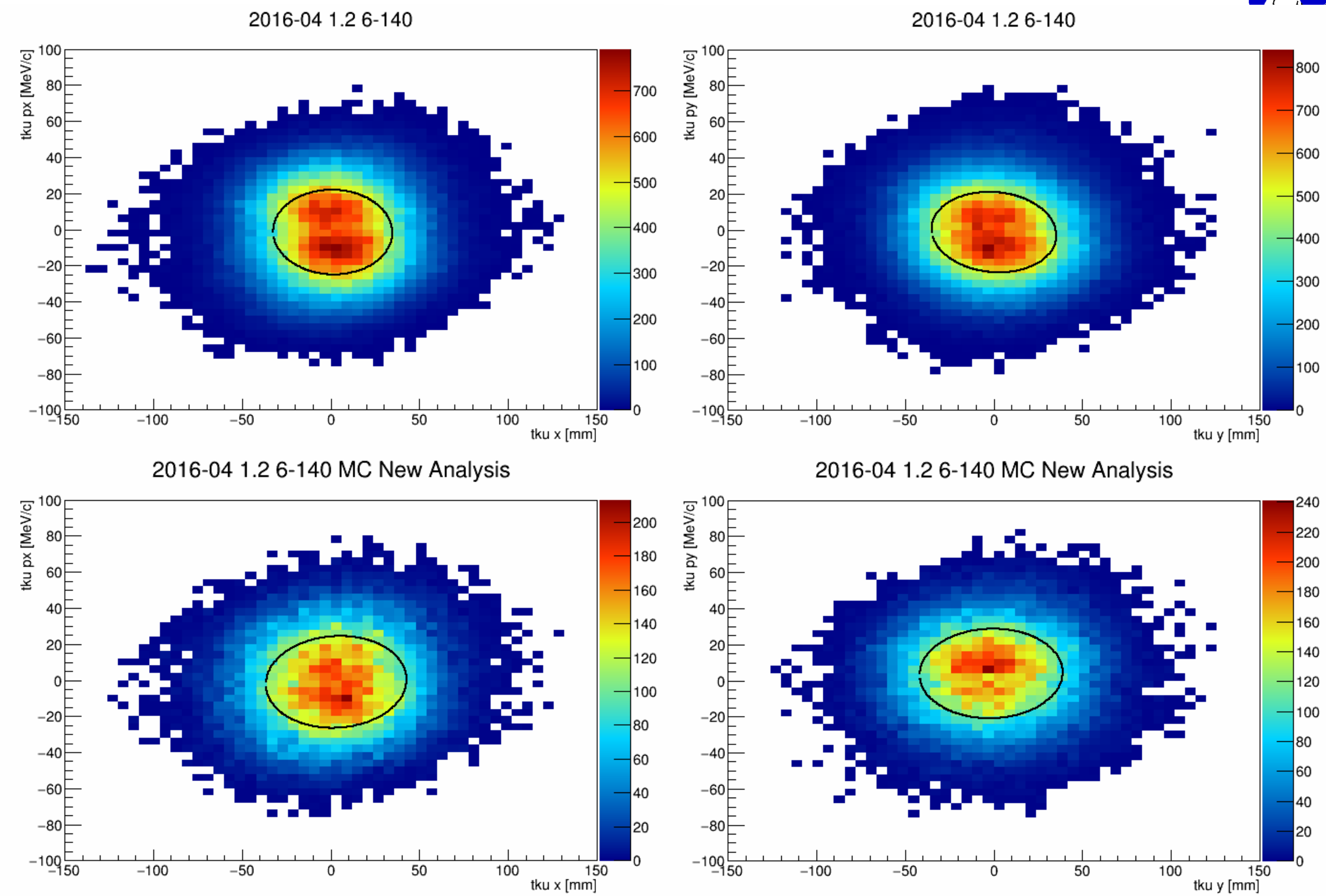
Plans

- Refactor analysis routines to deal with more data (30 hours) – Done!
- Tidy up uncertainty analysis (40 hours)
  - Second pass on the general approach
    - Done!
  - Field magnitude in tracker region
  - Effect of uncertainty in tracker alignment to field – In progress
- Improved PID cut (6 hours) – In progress
- Analysis of apertures (40 hours) – In progress
- Event selection to get a matched beam (40 hours)
- Improved amplitude calculation - beam ellipse calculation separate to amplitude calculation (10 hours)
- MC Uncertainties (geometry/densities, fields) (40 hours)
- Also:
  - Replaced p-value cut with chi2/dof cut
  - New MC from Dimitrije & Durga with improved diffuser model

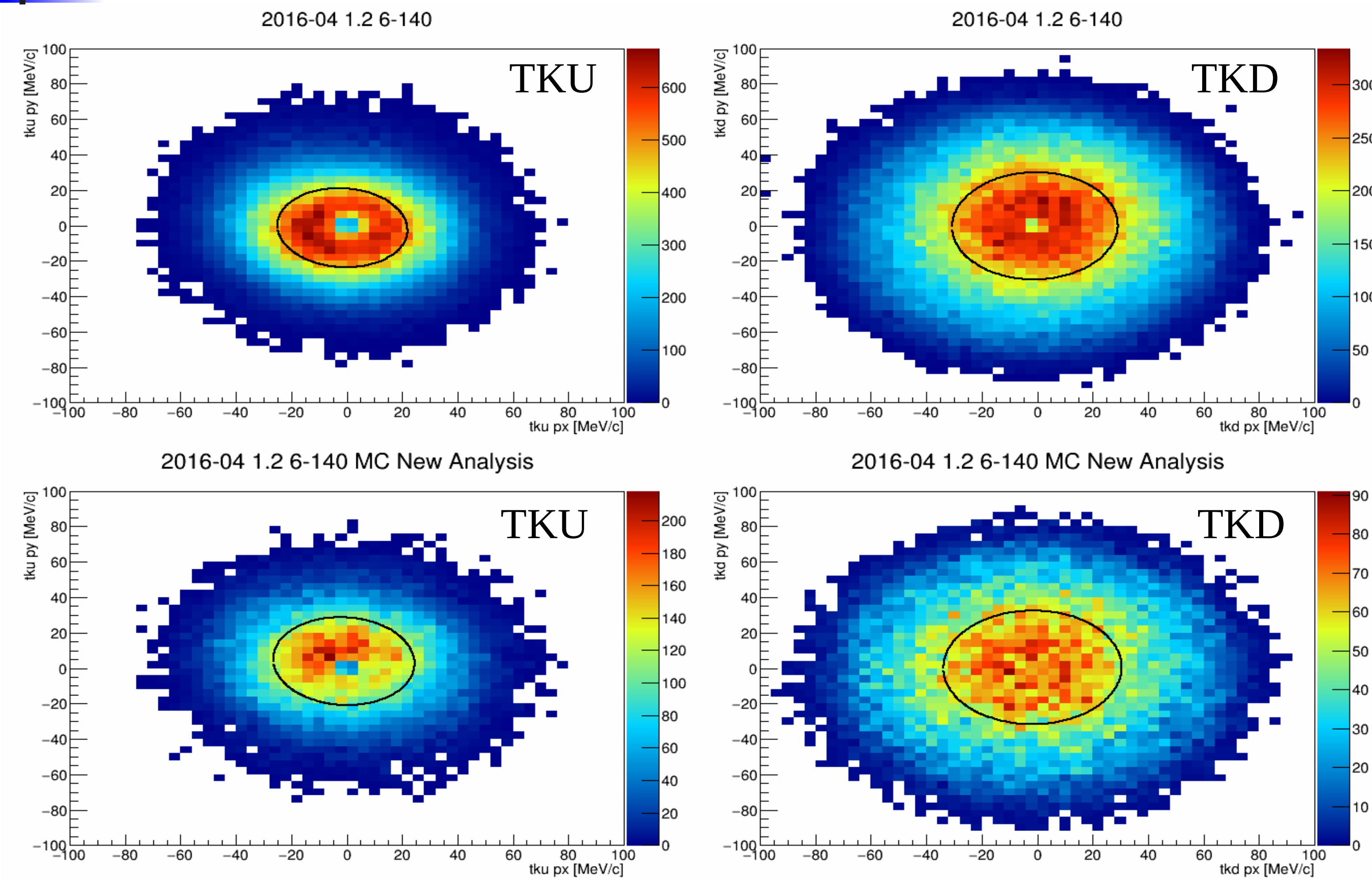
New MC (emittance = 6 mm)



New MC (emittance = 6 mm)



New MC (emittance = 6 mm)



Reco is MAUS-v2.8.5

MC is MAUS-v2.9.1

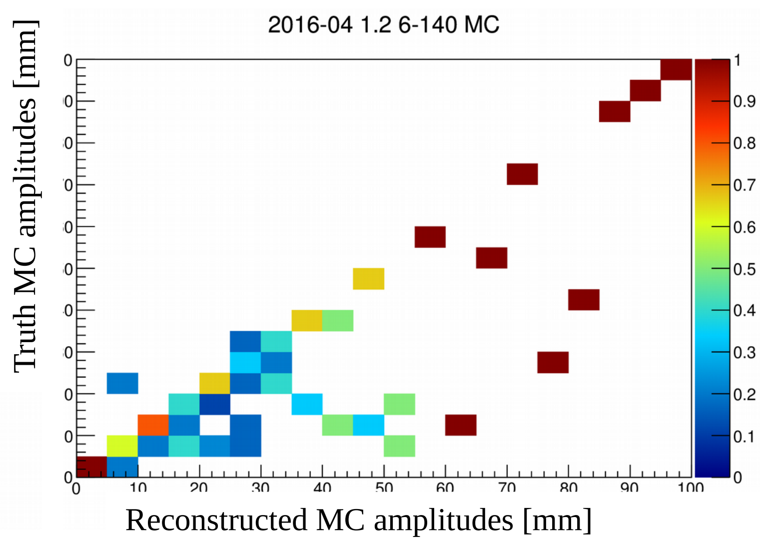
Systematic corrections

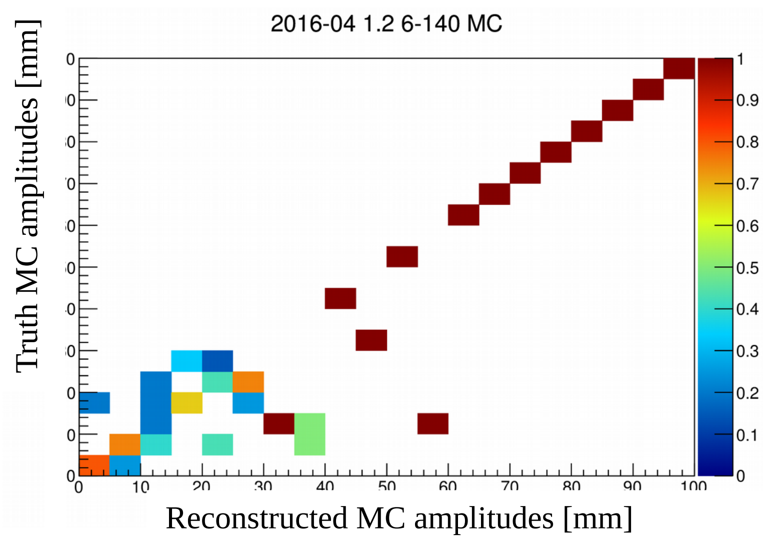
- Uncertainty due to intrinsic tracker resolution
  - Events measured in “this” amplitude bin were really in “that” amplitude bin
  - Can estimate magnitude of the effect → **correction**
- Uncertainty due to inefficiency and purity
  - Reconstruction did not form a track when it should have done
  - An event outside fiducial volume was reconstructed
  - A non-muon was reconstructed
  - Can estimate magnitude of the effect → **correction**
- Uncertainty due to incorrect tracker field
  - MAUS model says “3.01 T” when the field was really “3.03 T” (or whatever)
  - Tracker is not aligned to solenoid correctly
  - Plan to use better MAUS model (i.e. correct indirectly)
  - **Not done yet** (Chris Hunt)

Corrections – detector resolution

- Correction is estimated based on MC
  - Reco sample (r) – reconstructed amplitudes
  - True Reco sample (tr) – MC true amplitudes of all reconstructed events
- Say we have
  - the number of events in reco bin i and MC reco bin j, $\mathbf{n_{ij}}$
  - The number of events in reco bin i A^r_i
  - The number of events in reco bin j A^{tr}_j
- Then
  - $Sum_i(n_{ij}) = A^{tr}_j$
  - $Sum_j(n_{ij}) = A^r_i$
- Estimate the "crossing probability" from bin j to bin i
  - $m_{ij} = P(A^{tr}_j|A^r_i) \sim n_{ij}/A_i^r$
- Use the MC to calculate m_{ij} and apply it to data a
  - $\tilde{A}^{tr}_j \sim Sum_i(m_{ij}\,\tilde{A}^r_i)$

Intrinsic Detector resolution



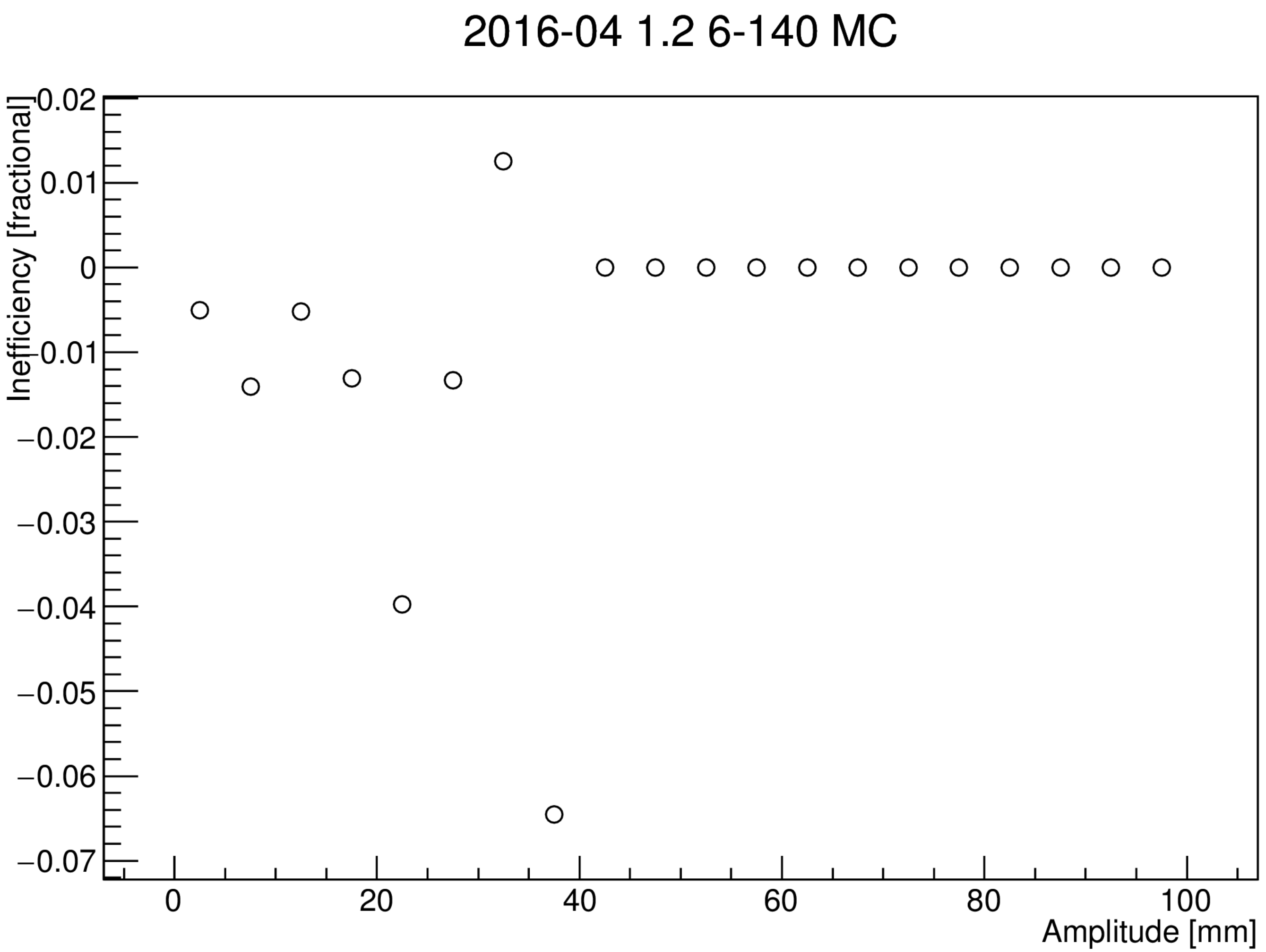


- Nb: 10 % of total MC statistics

Inefficiency and Impurity

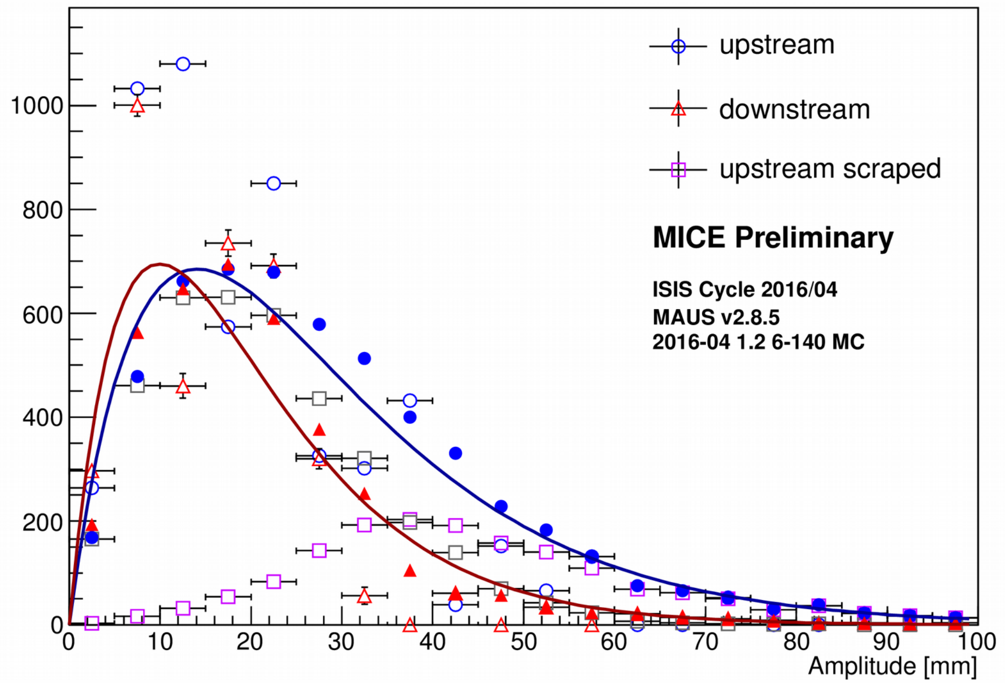
- Correction is estimated based on MC
  - True Reco sample – MC true amplitudes of all reconstructed events
  - True sample – MC true amplitudes of all events
- The correction is given by the ratio of number in each bin
  - $E_i = A^{tr}_i / A^t_i$
  - $\tilde{A}^t_i \sim E_i \tilde{A}^{tr}_i$
- So overall correction is
  - $\tilde{A}^t_j \sim E_i \, Sum_i(m_{ij} \tilde{A}^r_i)$

Detector efficiency



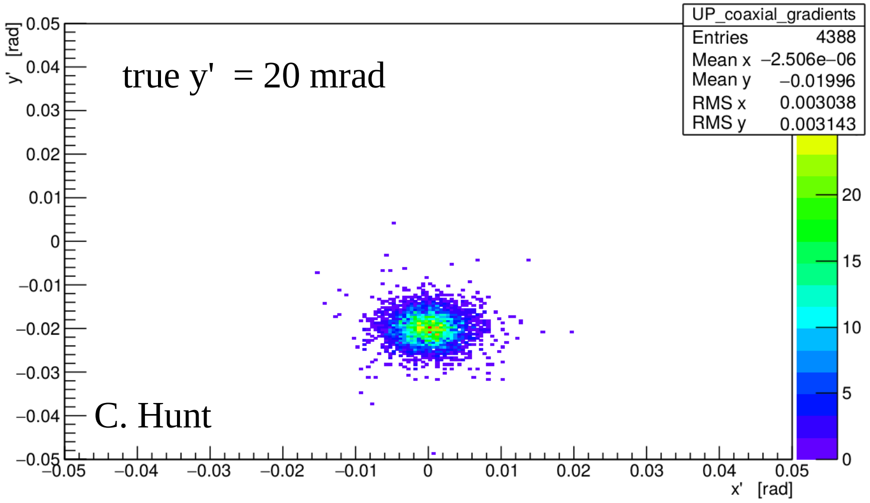
- Nb: 10 % of total MC statistics

Corrected plots



- Nb: 10 % of total MC statistics
- Filled points are “raw” data

Tracker Alignment to field (C. Hunt)



- Measurement of tracker alignment to field
- Make a straight track fit to field-on data
- Reject events that have a poor chi2 (>20/ndf)
- Remaining events are likely to be parallel to field

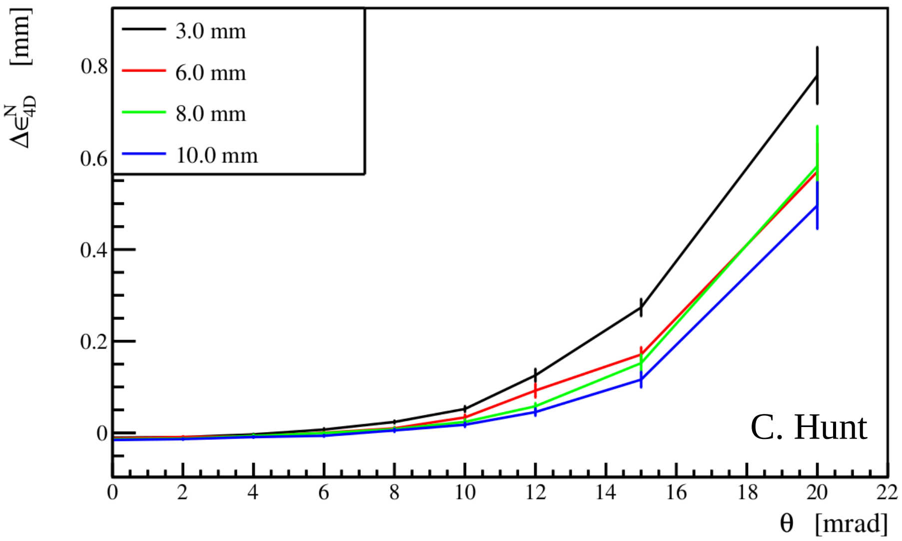
Tracker Alignment to field (C. Hunt)

Upstream Tracker (No. Muons = 3286)
Correction = 0.08 mrad

$\phi_x = 0.13 \text{ mrad} \pm 0.07_{\text{stat}} \pm 0.04_{\text{syst}}$
$\phi_y = -3.31 \text{ mrad} \pm 0.07_{\text{stat}} \pm 0.04_{\text{syst}}$

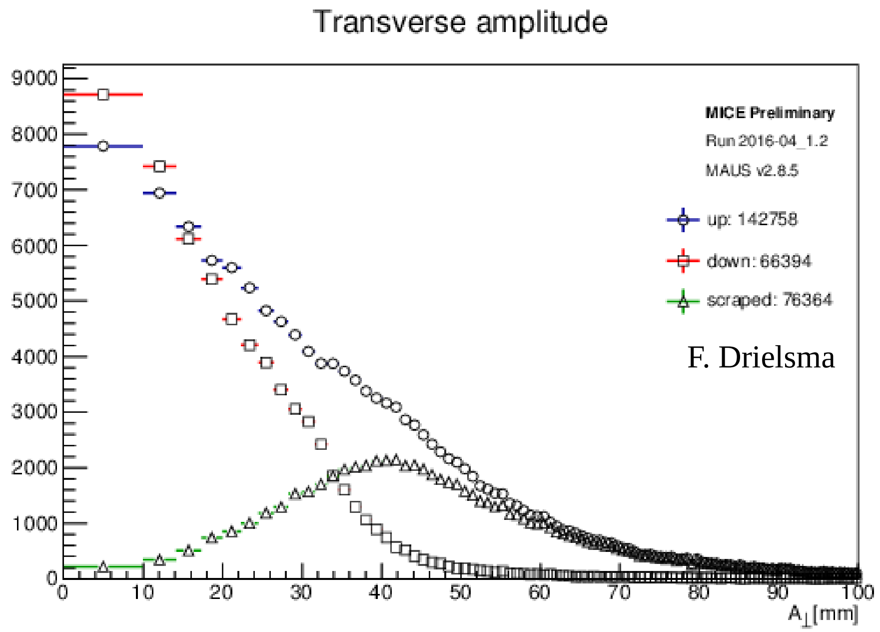
Downstream Tracker (No. Muons = 1980)
Correction = 0.05 mrad

$\phi_x = -2.51 \text{ mrad} \pm 0.1_{\text{stat}} \pm 0.06_{\text{syst}}$
$\phi_y = 0.73 \text{ mrad} \pm 0.1_{\text{stat}} \pm 0.06_{\text{syst}}$



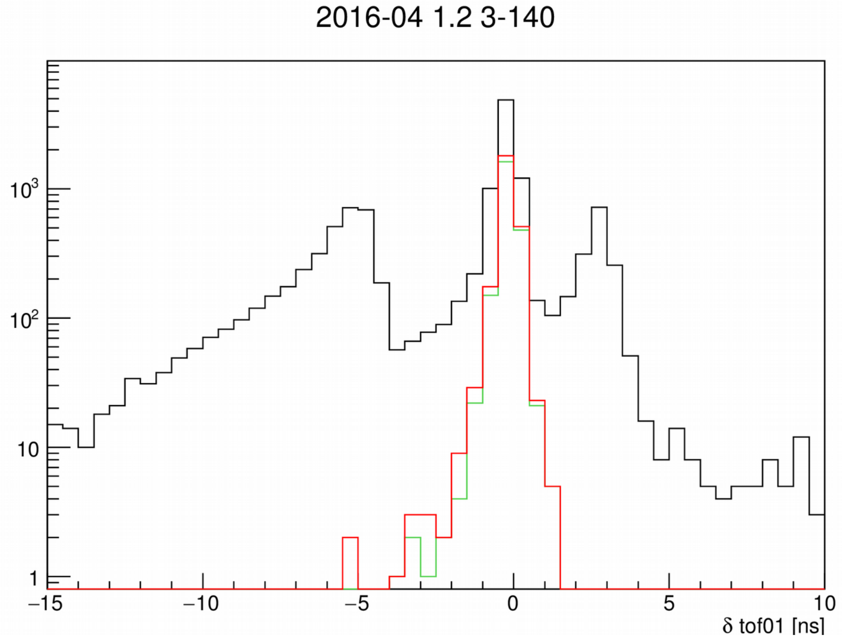
- Further validation of the analysis
  - Better understanding of systematic correction
  - Full MC of measured misalignment
  - Study with bigger data set (and more momenta)
- But not expecting to be a leading cause of uncertainty

Amplitude calculation (F. Drielsma)



- Scott Berg requested an alternate binning
  - Choose bin widths by phase space volume
  - Low amplitude bins have more data
  - Makes it obvious central bins have higher density “by eye”

PID Cut



- Improved PID cut by comparing TOF01 with extrapolated TOF01 from tracker (extrapolate using rk4)
  - I have made various algorithm improvements
  - Tracking is still too slow for analysis level
  - Might be okay to do at batch recon time (Global Recon)
  - Otherwise think again – some transfer matrix method may be appropriate
  - Risk that this could end up relatively complicated
- I need the track extrapolation for aperture studies

Plans

- ~~Refactor analysis routines to deal with more data~~ (30 hours/32 hours)
- Improved PID cut (6 hours/8 hours)
- Analysis of apertures (40 hours)
- Event selection to get a matched beam (40 hours)
- Tidy up uncertainty analysis (40 hours/24 hours)
  - ~~Second pass on the general approach~~
    - But some understanding required
  - Field magnitude in tracker region
  - Effect of uncertainty in tracker alignment to field

Plans

- Improved amplitude calculation - beam ellipse calculation separate to amplitude calculation (10 hours)
- MC Uncertainties (geometry/densities, fields) (40 hours)
- JHC: plot and understand amplitude change wrt phase, etc (6 hours/2 hours)
- JSB: plot/bin by phase space density not amplitude so central bins have higher population (4 hours)

- Seek to be ready by September VC
  - Looks tight
  - Exclude “event selection to get a matched beam” makes it more feasible