



# Emittance Reduction - Status

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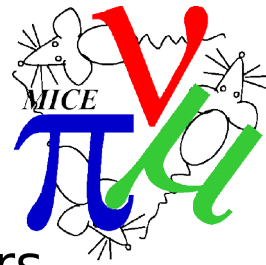
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# Overview



- New analysis using MAUS 2.7.0
  - Only considering cooling channel tag 2016/04 1.2
  - Run 8681:- beamline tag “3-140+M3-Test2”
  - Run 8699:- beamline tag “6-140+M3-Test2”
  - Run 8685:- beamline tag “10-140+M3-Test3”
- Cuts
  - PID cut
- Internal Tracker validation
  - Hall probes vs MAUS
  - Space points vs tracks
  - Kalman P-Value
- Global validation
  - Extrapolated tracks and residuals
  - Misses and downstream efficiency
- Updated amplitude plot

# Biases and Uncertainties

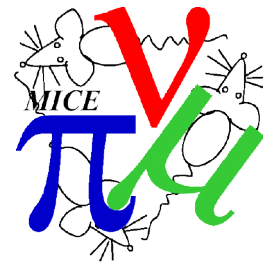


- Seek to measure emittance change across the absorbers
- What are the biases and uncertainties?
- Bias on the measured  $x/p_x/y/p_y$  phase space and transmission
  - Intrinsic detector resolution (scattering and spatial resolution)
  - Detector efficiency
  - Magnetic field in reconstruction region
- Bias on the model of the channel
  - (Magnet) alignment
  - Absorber material
  - (Other) material budget

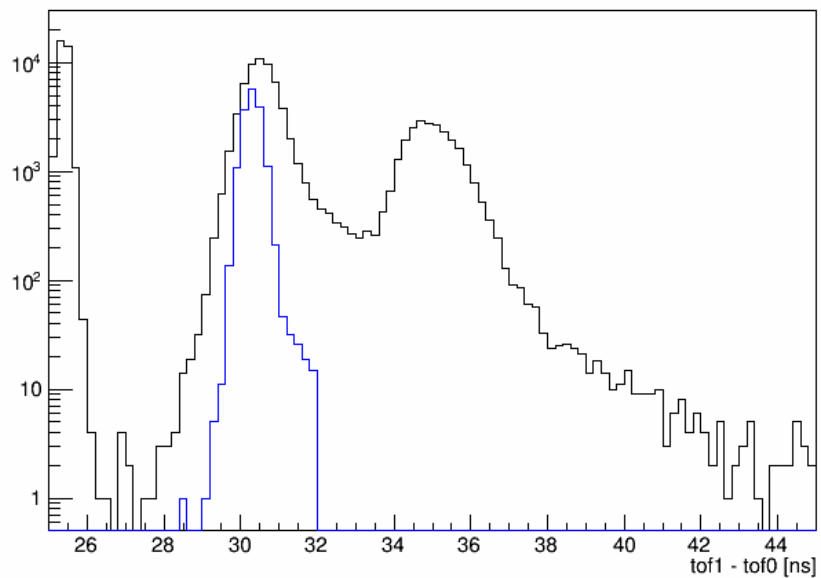
# Cuts



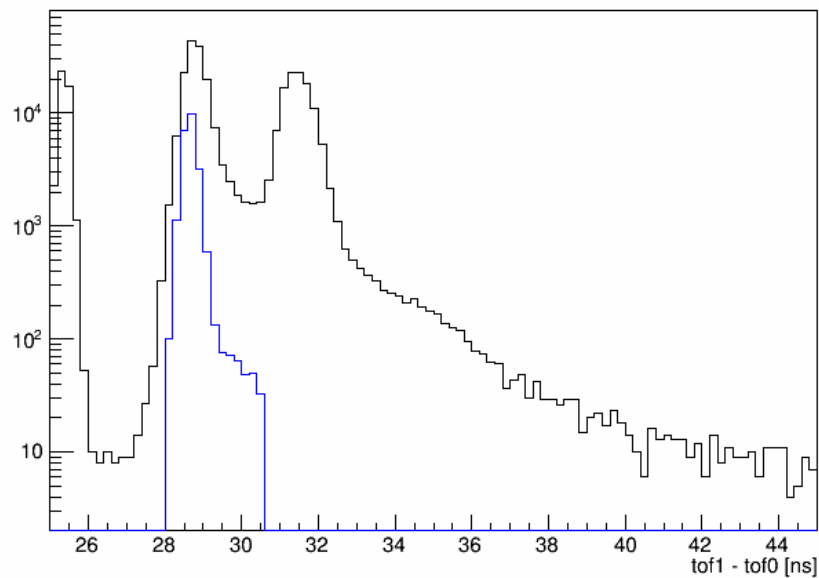
- Following cuts are enabled:
  - Exactly one track in TKU
  - Exactly one space point in TOF0
  - Exactly one space point in TOF1
  - TKU p-value > 0.02
  - tof01 > 28 ns
  - tof01 < 32 ns for run 8681 and 8699
  - tof01 < 30.5 ns for run 8685
  - Require  $\text{abs}(\text{tof01}(\text{measured}) - \text{tof01}(\text{extrapolated})) < 5 \text{ ns}$
  - Require  $135 < p(\text{tku}) < 145 \text{ MeV}/c$



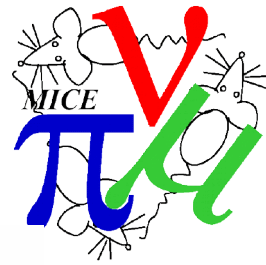
2016-04 1.2 3-140+M3-Test2



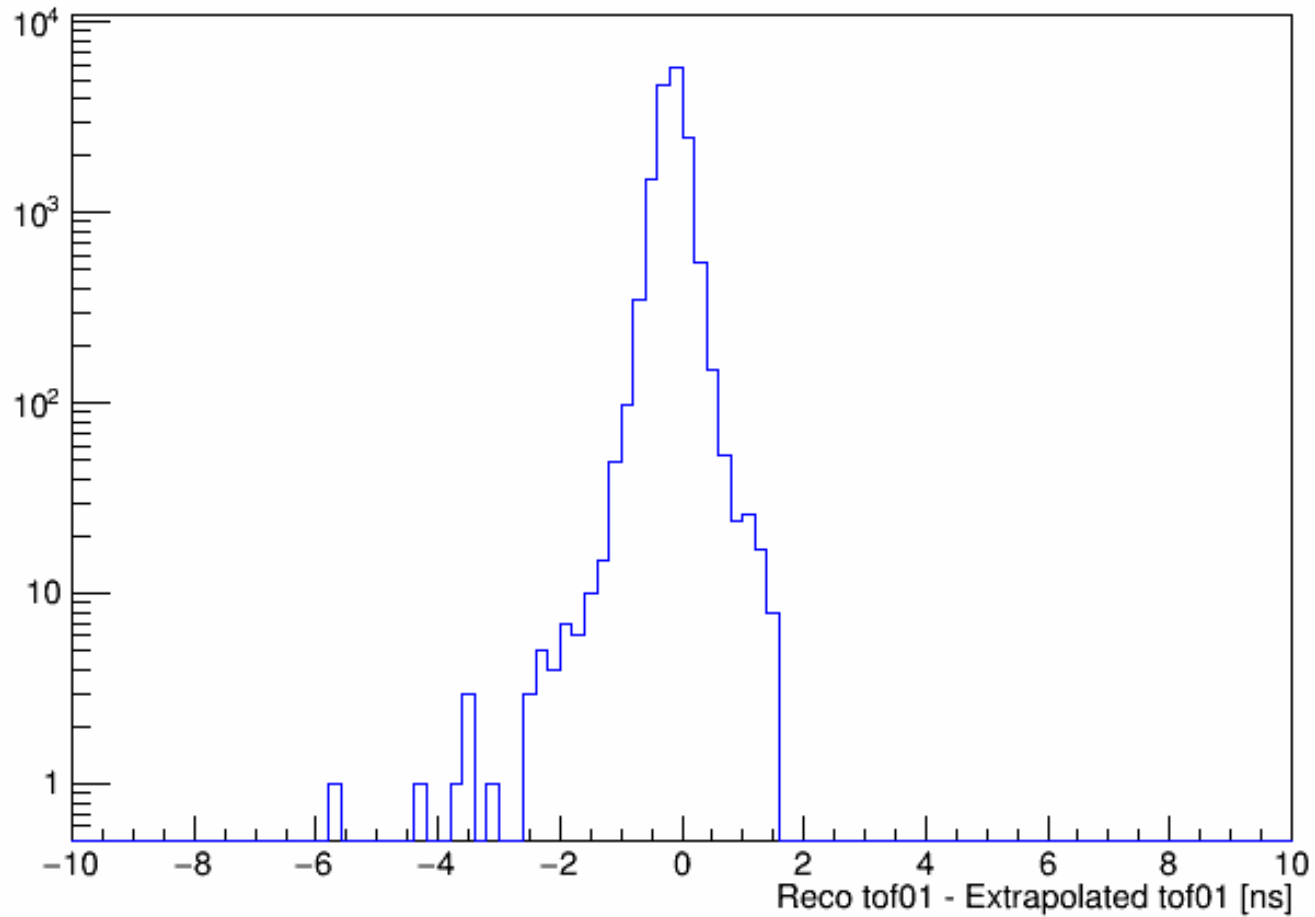
2016-04 1.2 10-140+M3-Test3



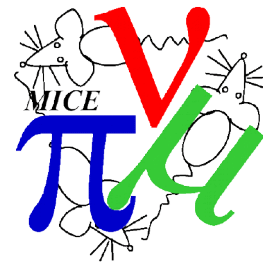
# Delta TOF01



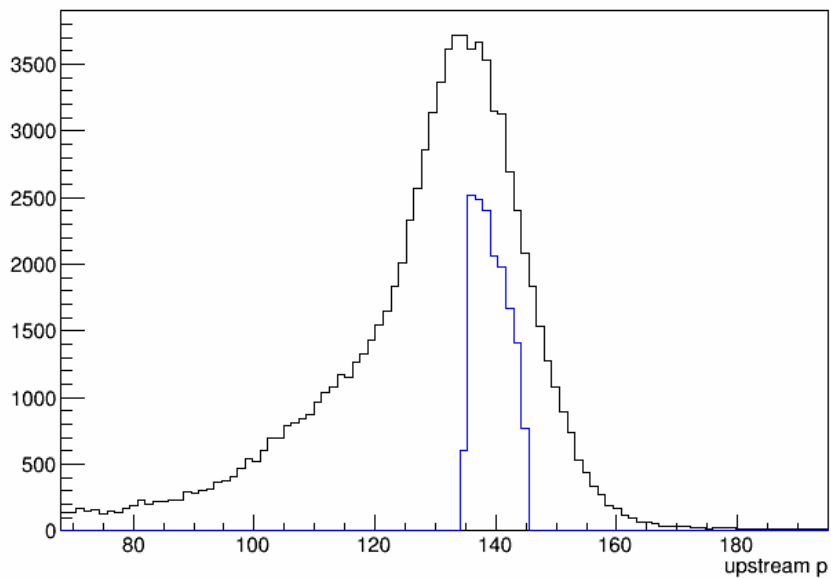
2016-04 1.2 3-140+M3-Test2



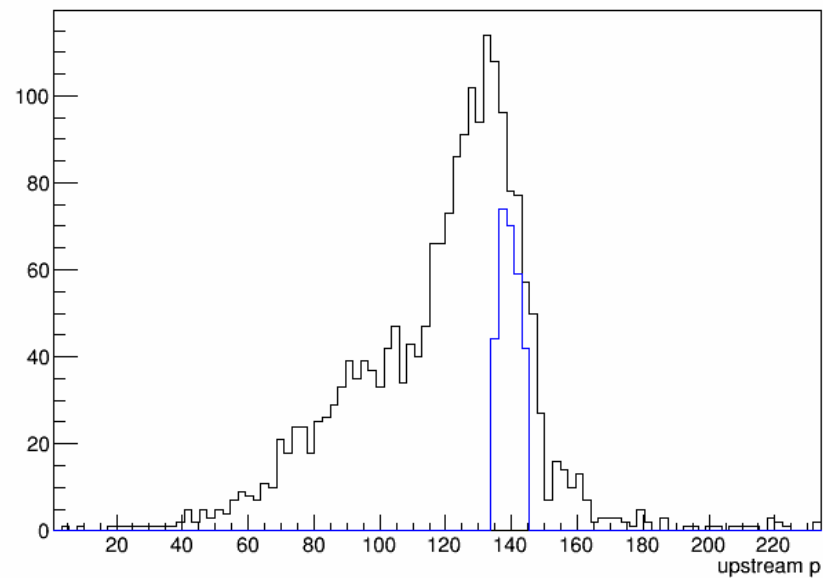
# Upstream p



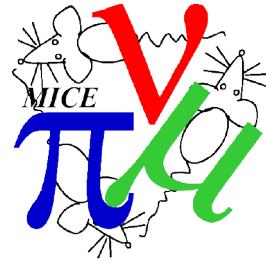
2016-04 1.2 3-140+M3-Test2



2016-04 1.2 10-140+M3-Test3



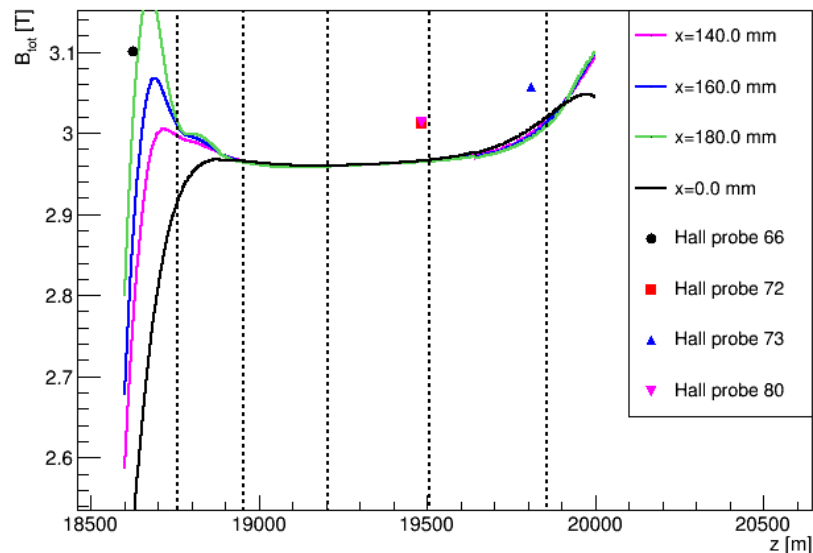
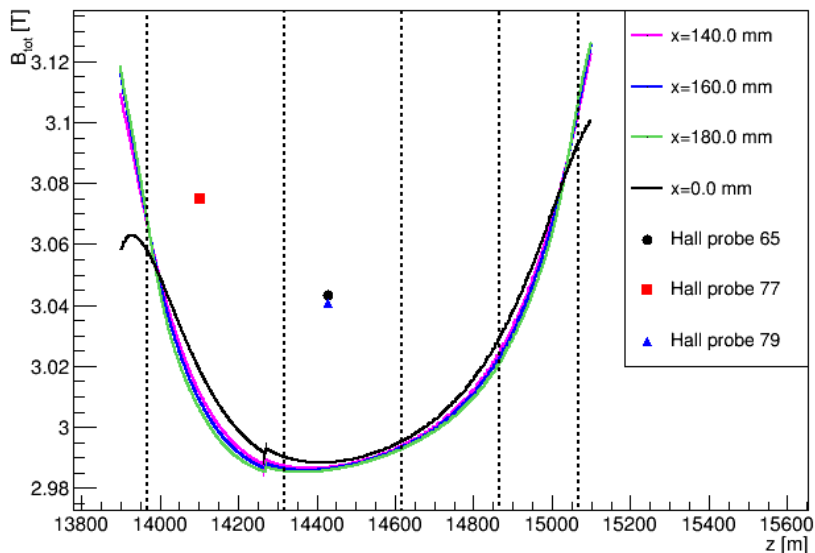
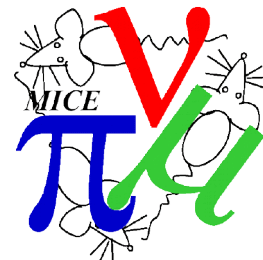
# “Internal” Tracker Validation



- Validate tracker by checking that the internals are self-consistent
  - Field measured in hall probes is consistent with reconstruction
  - Fitted tracks are consistent with measured space points
  - Fitted tracks are not pulled too much (P-value)



# Hall Probes vs MAUS

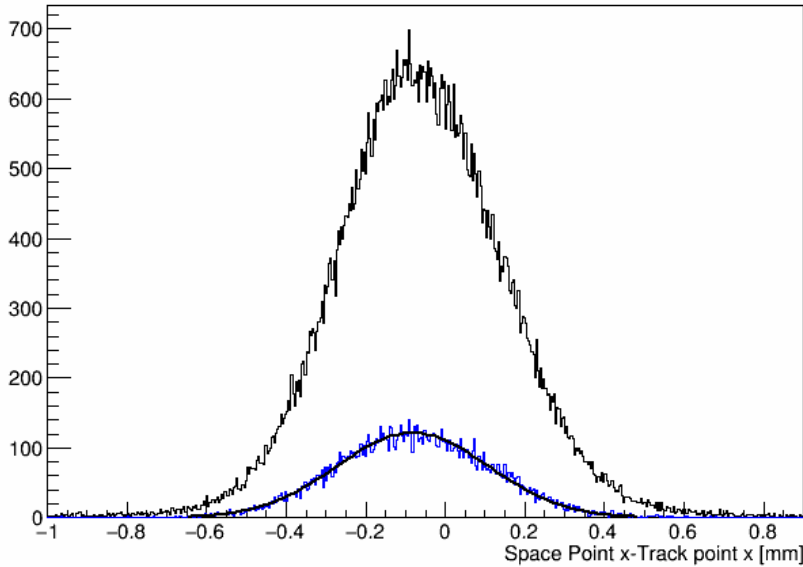


- Hall probes are mounted at  $r \sim 160$  mm
- Approx 2 % discrepancy between MAUS and hall probes
- Nb: trajectory in B-field scales with  $B/p$ 
  - i.e. if we get B-field high by 10 %, it looks exactly like a track with 10 % higher momentum

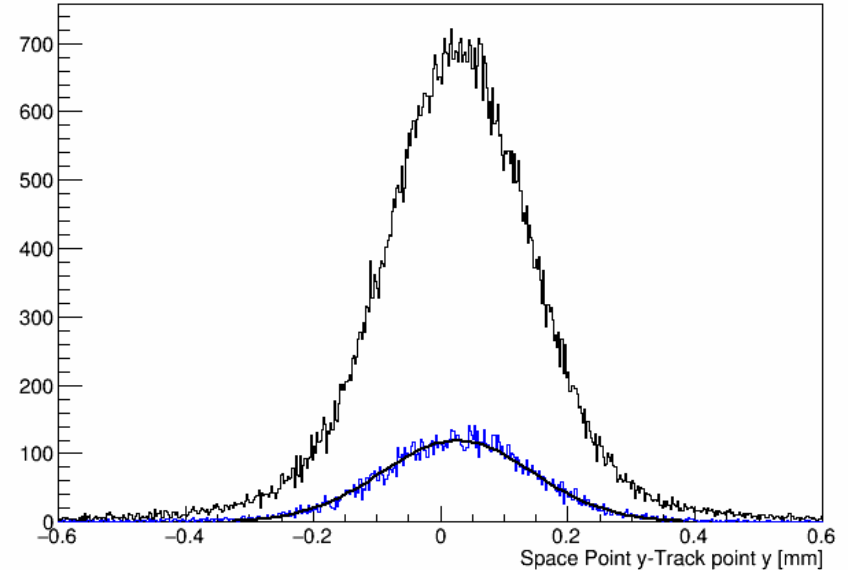
# Space points vs track points (tku)



2016-04 1.2 3-140+M3-Test2 mean -0.0803 sigma 0.1888



2016-04 1.2 3-140+M3-Test2 mean 0.0274 sigma 0.1186

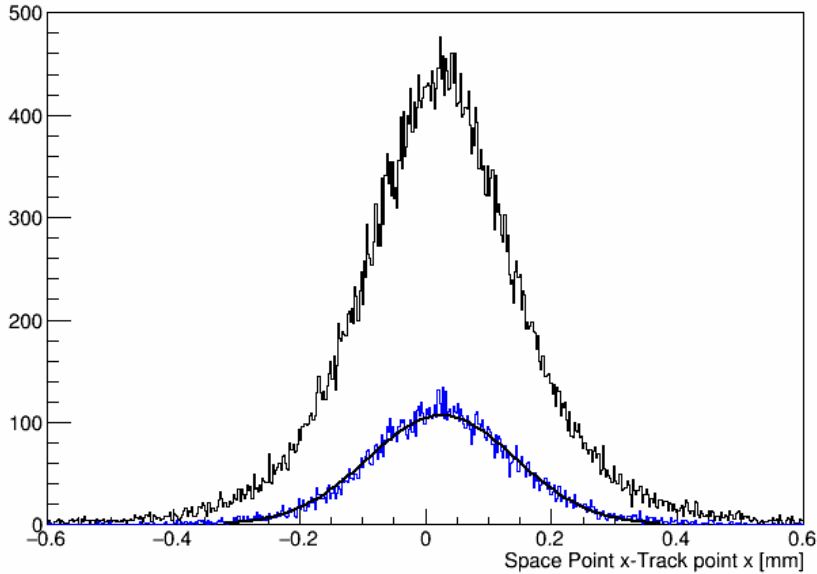


- Track points and space points should be consistent
  - Nb: the track fitting algorithm introduces a correlation here

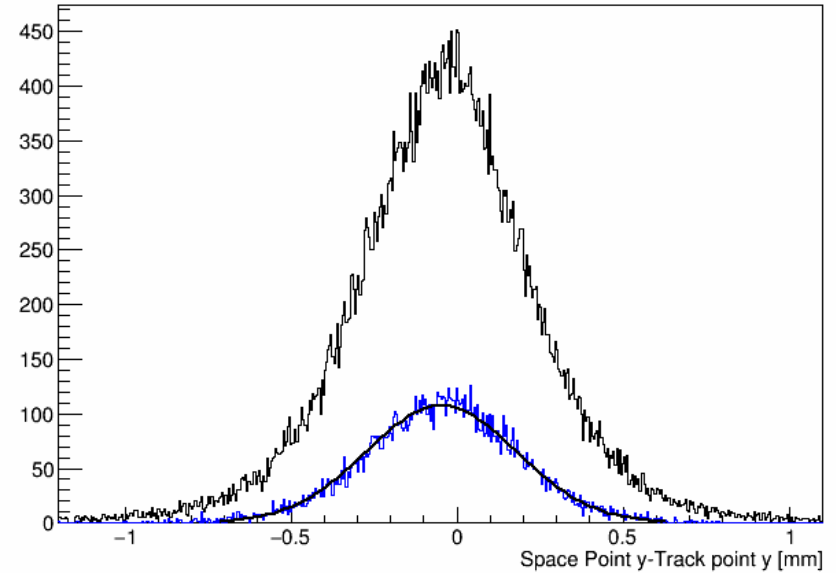
# Space points vs track points (tkd)



2016-04 1.2 3-140+M3-Test2 mean 0.0268 sigma 0.1163



2016-04 1.2 3-140+M3-Test2 mean -0.0453 sigma 0.2252

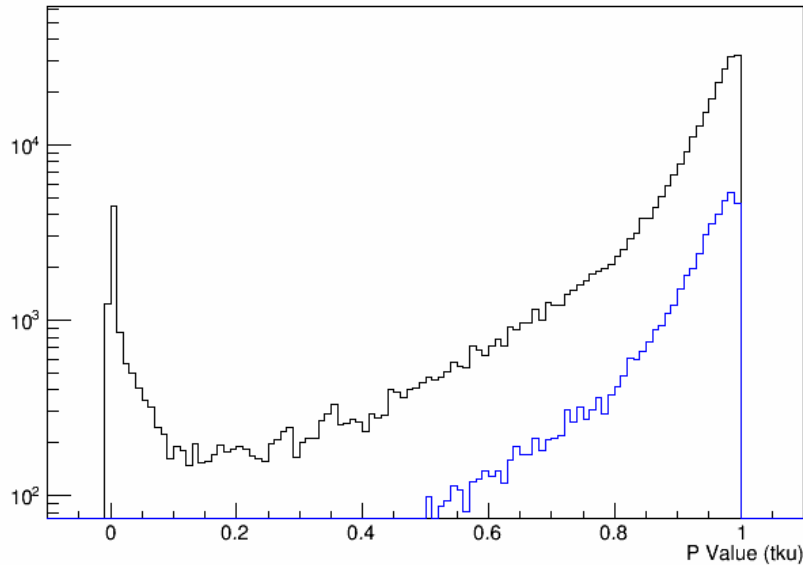


- Track points and space points should be consistent
  - Nb: the track fitting algorithm introduces a correlation here

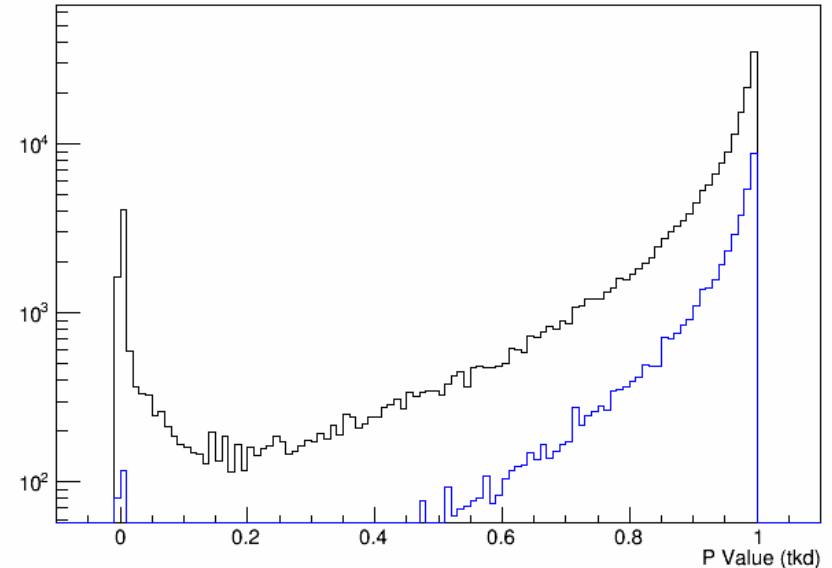
# P-Values



2016-04 1.2 3-140+M3-Test2

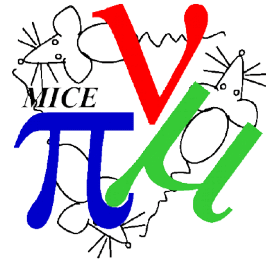


2016-04 1.2 3-140+M3-Test2



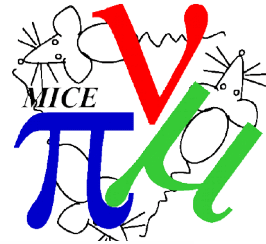
- P-Value reflects the probability that a track is observed
- For an ideal detector, should be uniform between 0 and 1
  - “Ideal” means measurement uncertainty is normally distributed about the true value with a well known RMS

# Global Validation

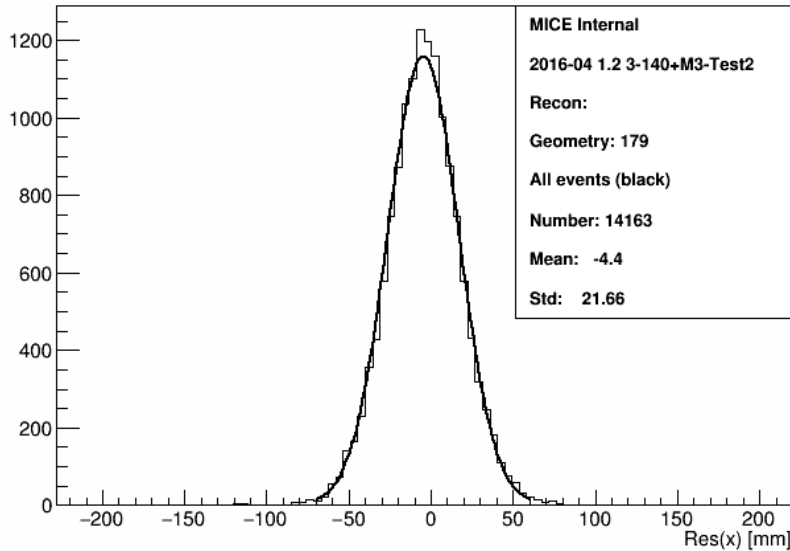


- We can validate measurements by comparing tracks with other detectors
- Take TKU as “reference” position, momentum
- Take TOF1 as “reference” time
- Extrapolate to TOF0, TOF2, TKD
  - Look at the difference between measured and extrapolated track
- For the extrapolation I add an additional cut
  - Extrapolated tracks should not intersect an aperture
  - Incl TKD fiducial volume
  - Downstream hit must be registered in detector to be included in “residuals” plots
    - Already guaranteed in TOF0, TOF1 and TKU by cuts
    - No cuts on downstream detectors

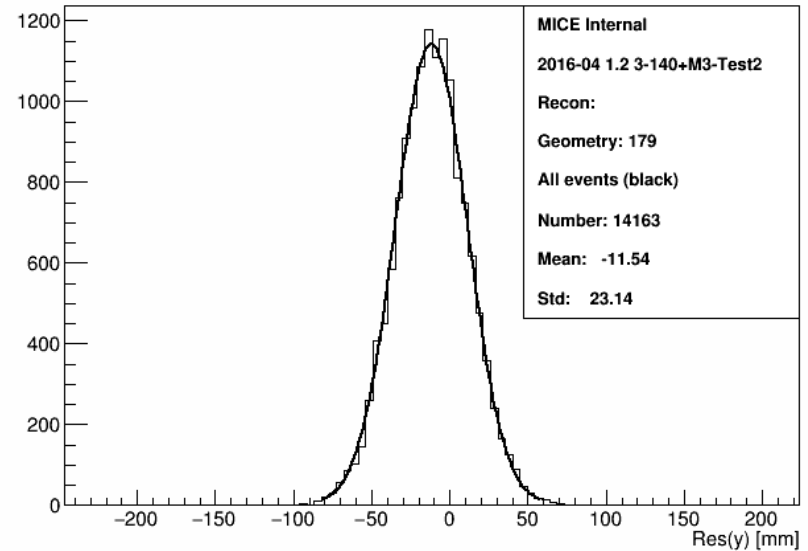
# TKU vs TKD



tkd\_tp: x

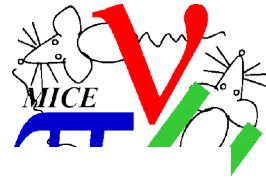


tkd\_tp: y

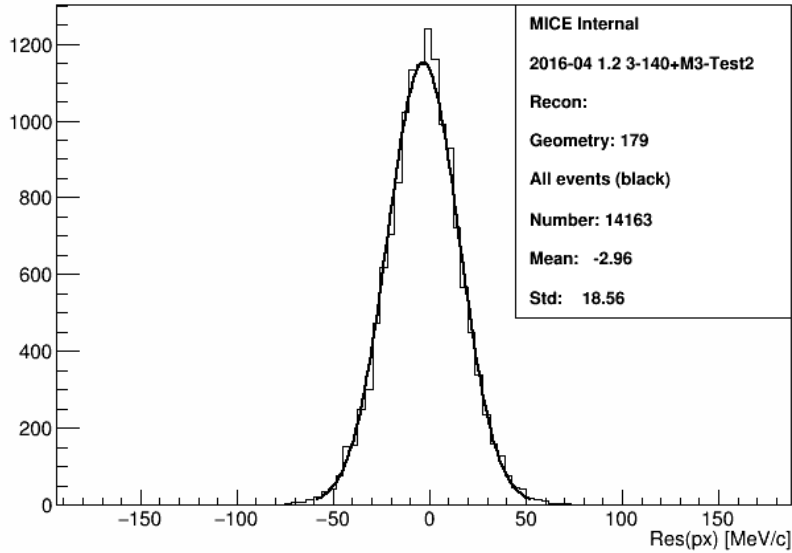


- Extrapolated position
  - Indicative of some misalignment (of magnets presumably)
- Is the distribution width consistent with scattering?
  - “Normalised residuals”

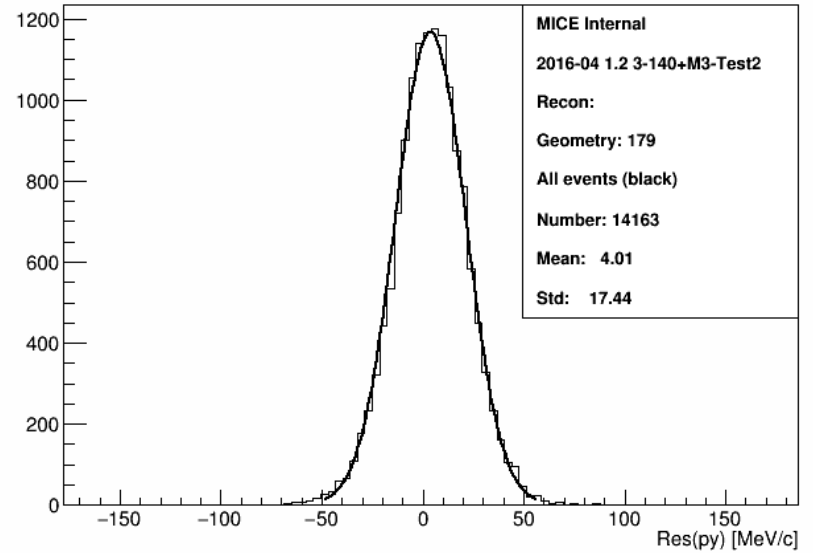
# TKU vs TKD



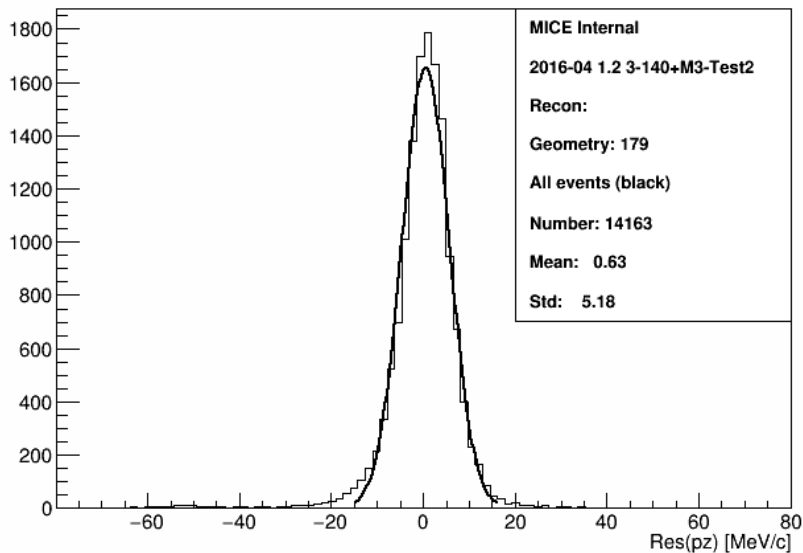
tkd\_tp: px



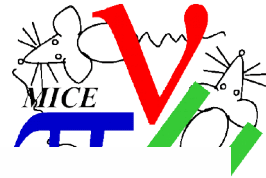
tkd\_tp: py



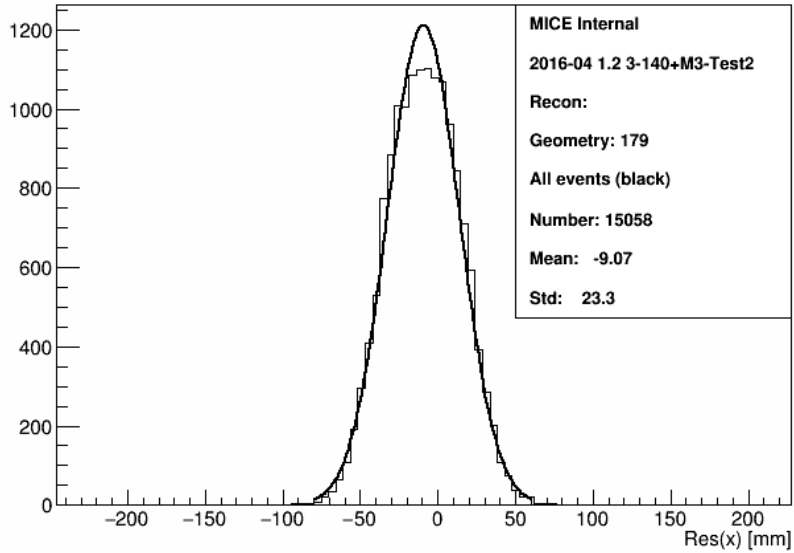
tkd\_tp: pz



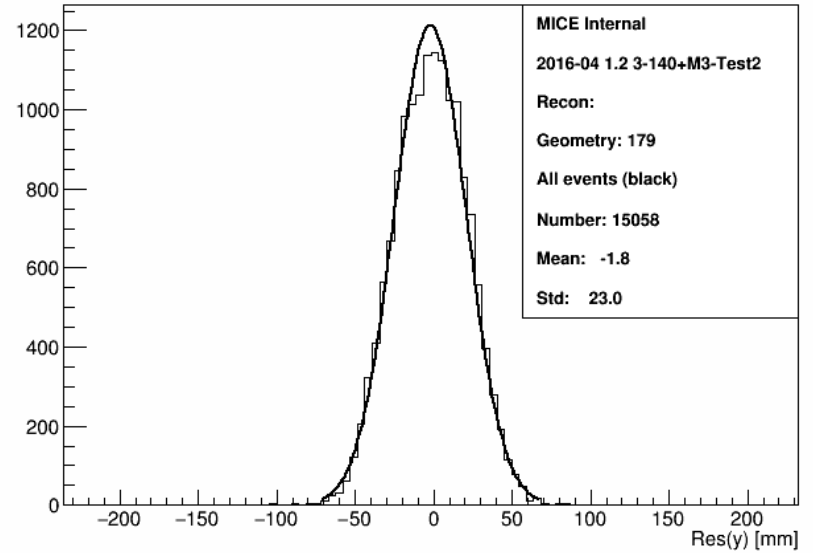
# TKU vs TOF01



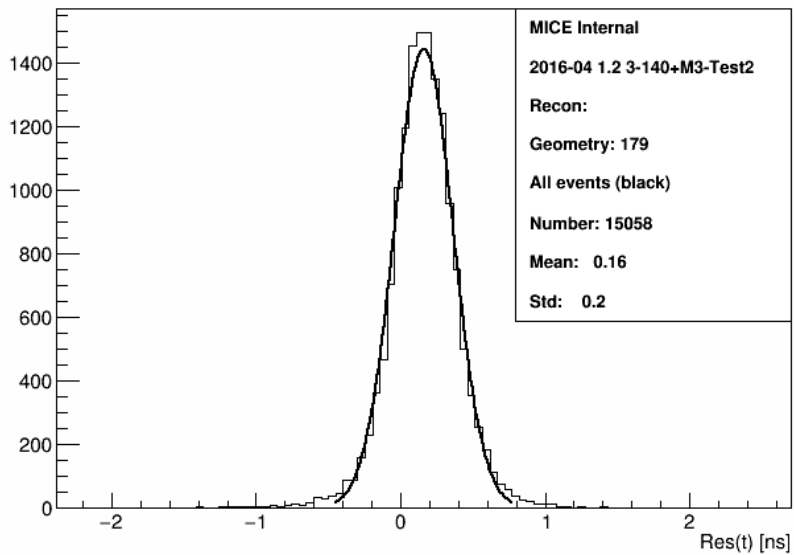
tof1: x



tof1: y



tof0: t

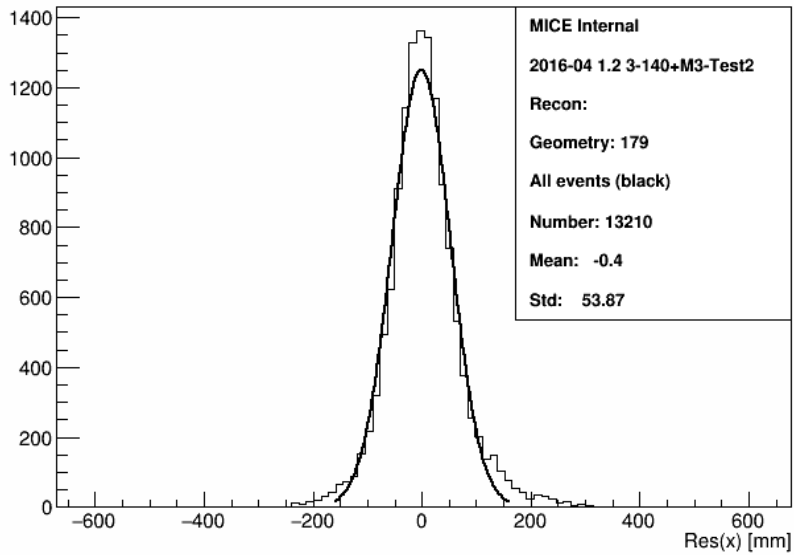




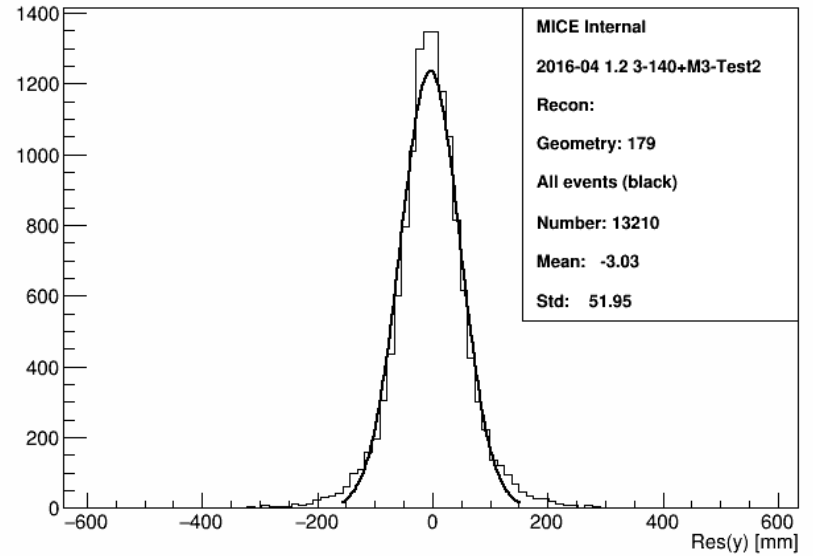
# TKU vs TOF2



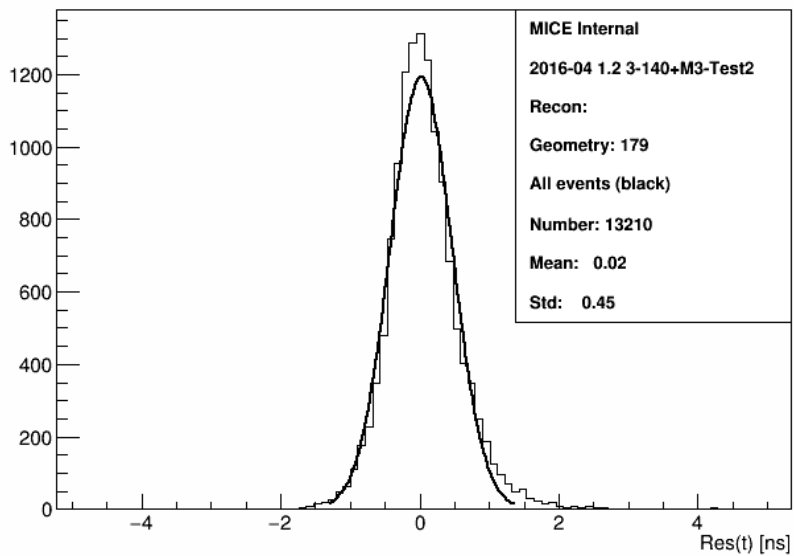
tof2: x



tof2: y



tof2: t



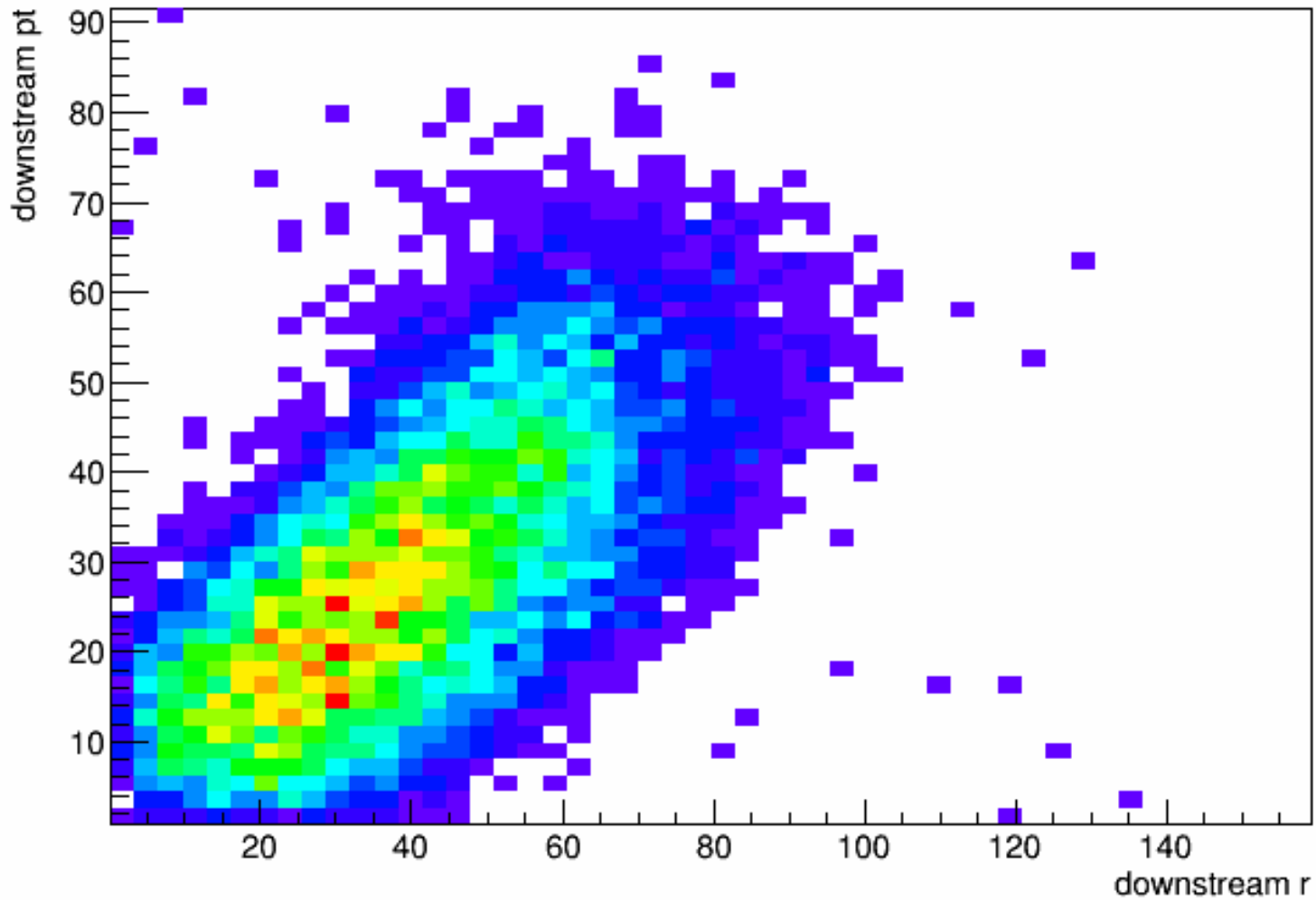


- We can estimate efficiency by looking for missing tracks
  - i.e. take tracks to TKD; if we don't see them, something happened (inefficiency)
  - I only report tracks that have been extrapolated to TOF2
  - Some tracks on the edge may be unluckily scattered off trajectory into an aperture
    - These will be registered as misses
    - Future -> weight/cut events according to how close they go to the edge

# TKD Hits Distribution



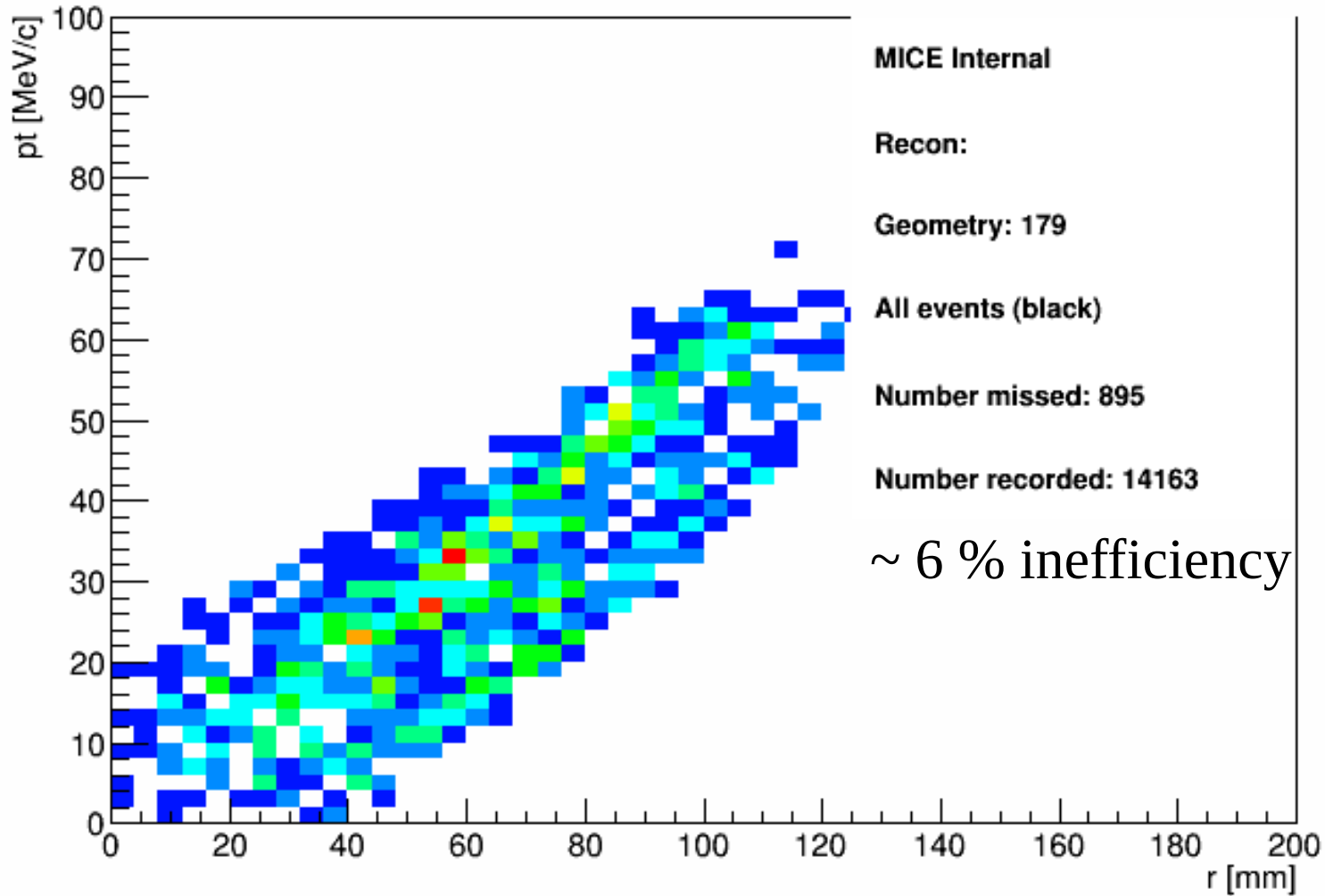
2016-04 1.2 3-140+M3-Test2



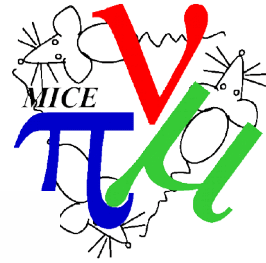
# TKD Misses Distribution



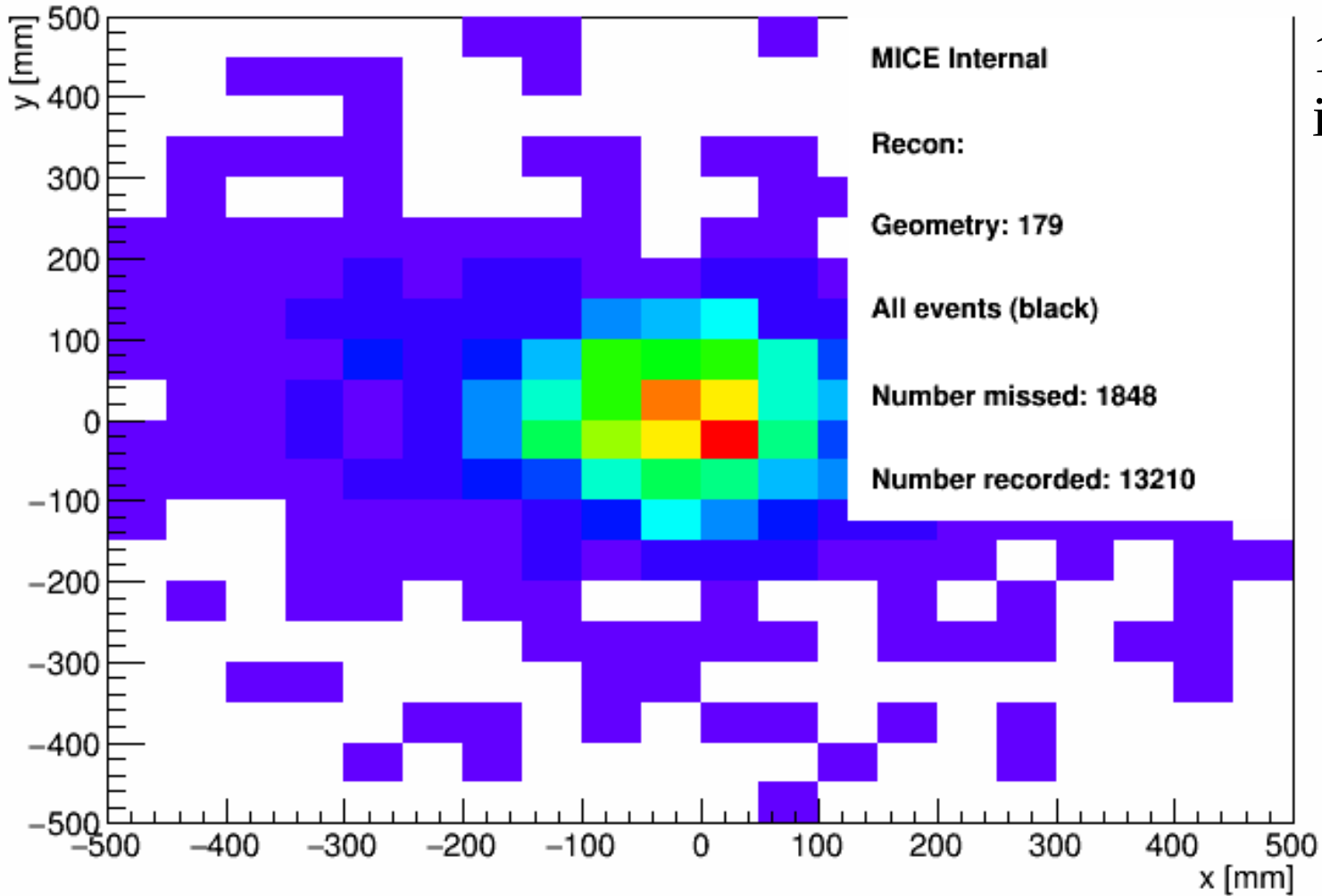
Misses - tkd\_tp



# TOF2 Misses Distribution



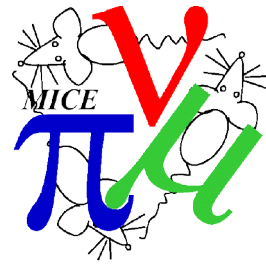
Misses - tof2



14 %  
inefficiency?

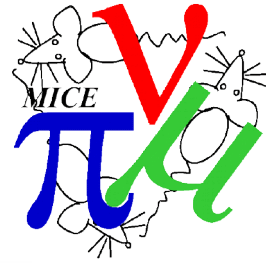
# Performance

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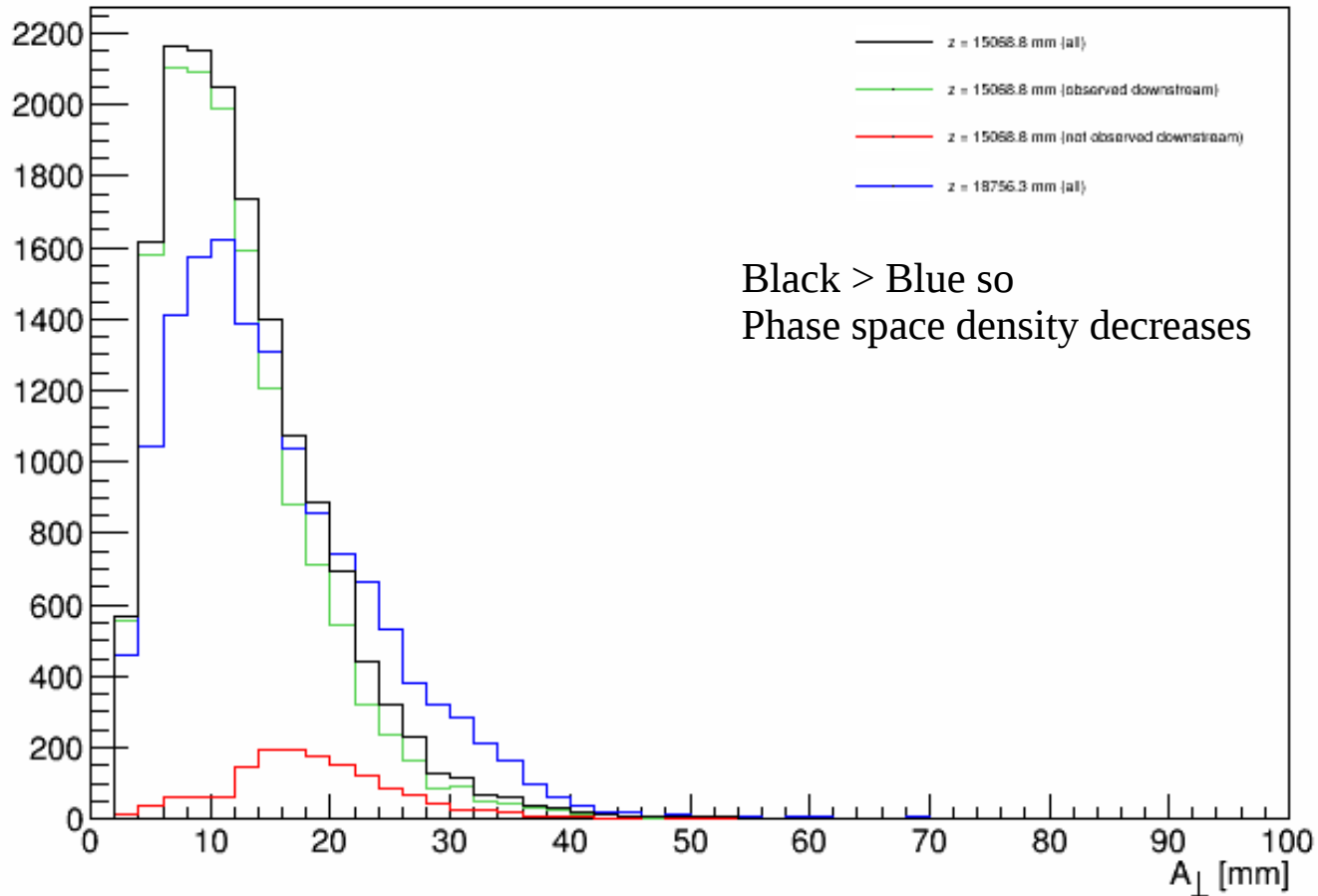


- Histograms of particle amplitude follow

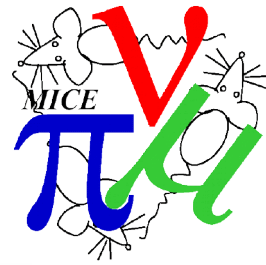
# Measured Amplitude Change



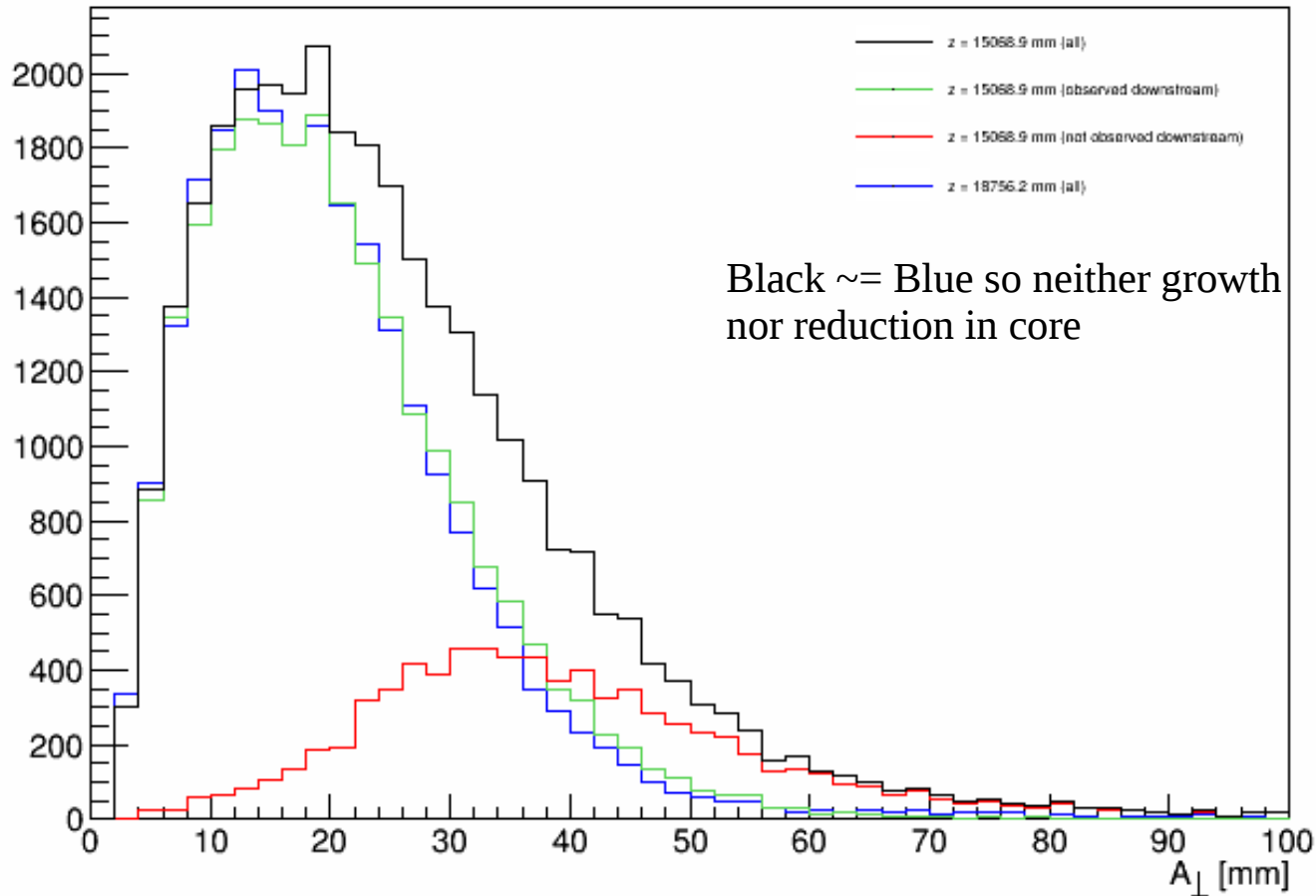
2016-04 1.2 3-140+M3-Test2



# Measured Amplitude Change

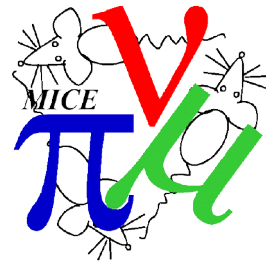


2016-04 1.2 6-140+M3-Test2

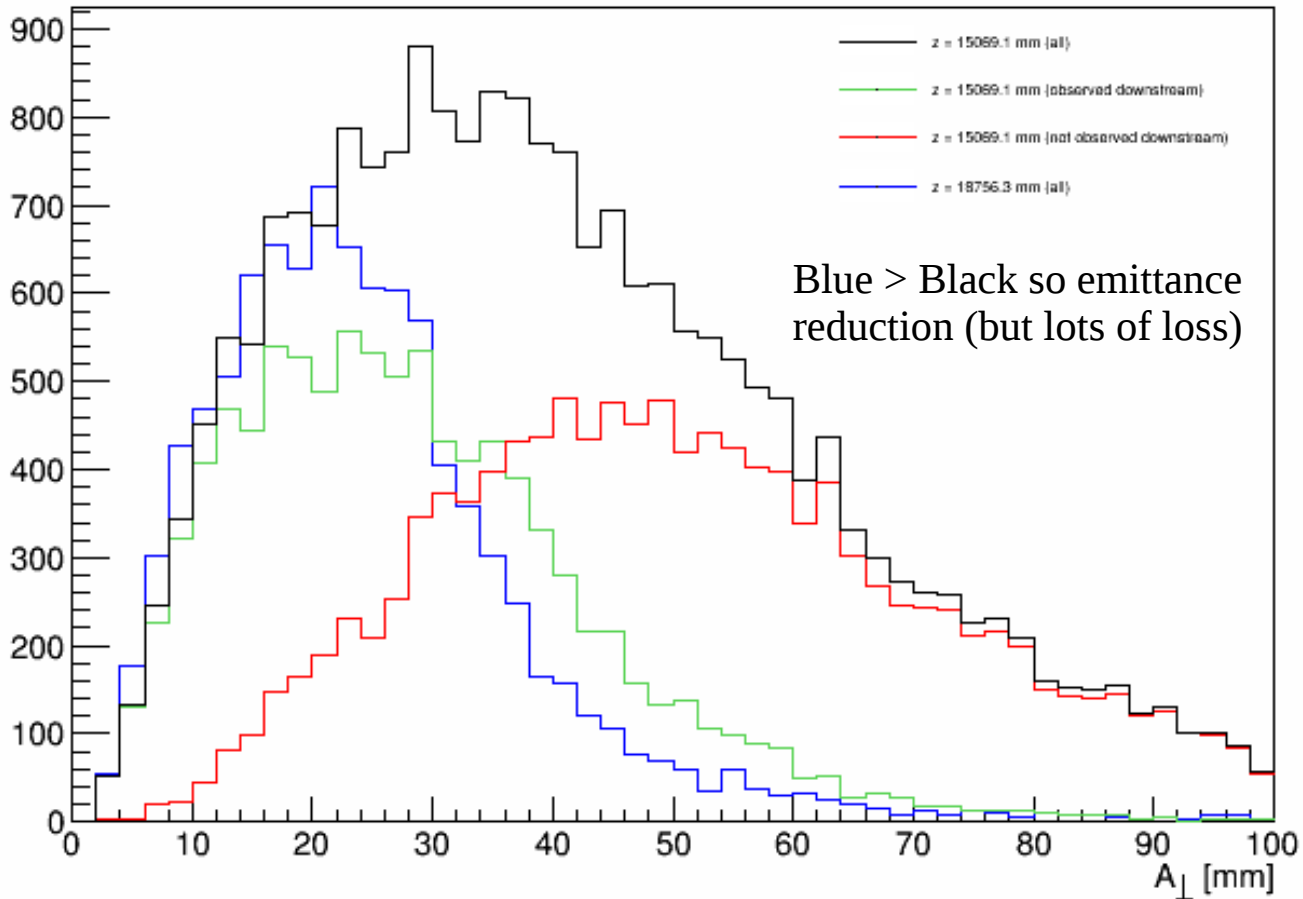




# Measured Amplitude Change



2016-04 1.2 10-140+M3-Test3



# Conclusions



- Detector inefficiency is still the main issue
  - TOF2 and TKD
  - Might give us phase space density increase in 6-140+M3-Test2 settings
- Magnet alignment also needs to be sorted
  - Also resolve  $\sim 2\%$  discrepancy between MAUS and Hall probes
- Detector resolution looks good enough for now
- No beam sampling
  - Is this needed?