Hit Error Determination Using Data, MC Hit Time Smearing to Match Data in ArgoNeuT

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Hit Error Determination

Motivation

- Hit Errors are important when we want to quantify a track (as a good or bad track) and eventually quantify a vertex
- Hit Errors as saved in the ‘recob::Hit()’ are small (0.3 tick induction, .15 tick in collection) (shown on slide 5)
- One can use the Data to determine the Hit Errors in the detector

Data Driven Hit Error Determination

- We can calculate the difference in the peak time of three consecutive hits in a track as;

$$D = (t_n + t_{n+2})/2 - t_{n+1}$$

Where t_n is the peak time of hit 'n'

- The difference D would peak at '0' and its RMS relates to the hit error as follows

$$D_{rms} = \mathrm{sqrt}(3/2)*\mathrm{hit\_error}$$

or $$D_{rms} = \mathrm{sqrt}(3/2)*\sigma_t$$

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Data Driven Hit Error Determination

- Generated 100 events – single muon
- Momentum: 10GeV
- Position: (25, 0, 20) cm
- Direction: 0 degree in XZ plane,
  -3.3 degree in YZ plane
- At least 1 cluster is reconstructed in each view per event
- Take first 100 hits in the longest cluster in each view

Reconstruction Chain
LArSoft Frozen Release: S2012.05.09

- physics.producers.caldata: @local::argoneut_calwire
- physics.producers.ffthit: @local::argoneut_hitfinder
- physics.producers.dbcluster: @local::argoneut_dbcluster
- physics.producers.hough: @local::argoneut_houghlinefinder
- physics.producers.linemerger: @local::argoneut_linemerger
- physics.producers.vertex2d: @local::argoneut_vertex2d
- physics.producers.spacepts: @local::argoneut_spacepts
- physics.producers.track3d: @local::argoneut_kalman
- physics.producers.matchtracks: @local::argoneut_matchtracks
- physics.producers.vertex3d: @local::argoneut_vertex3d

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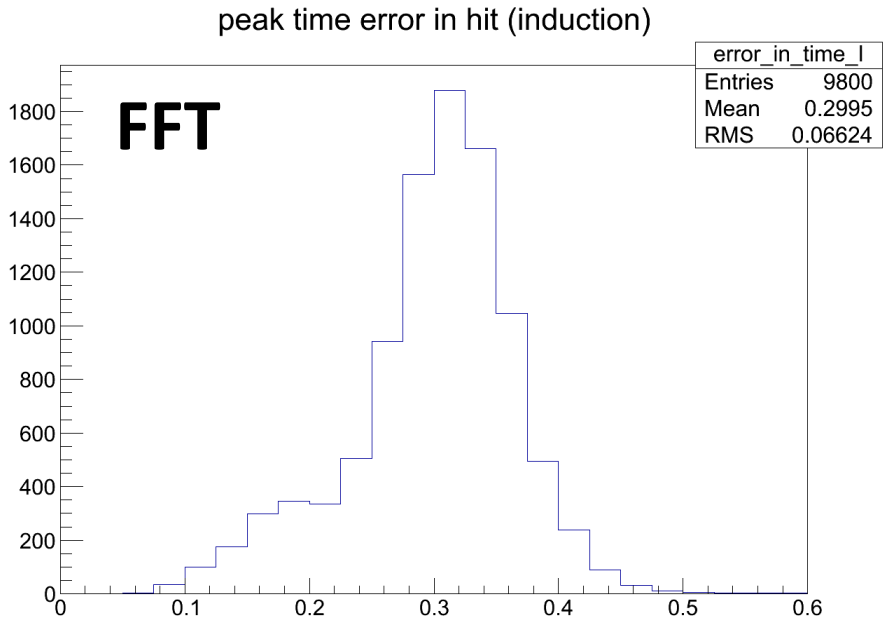
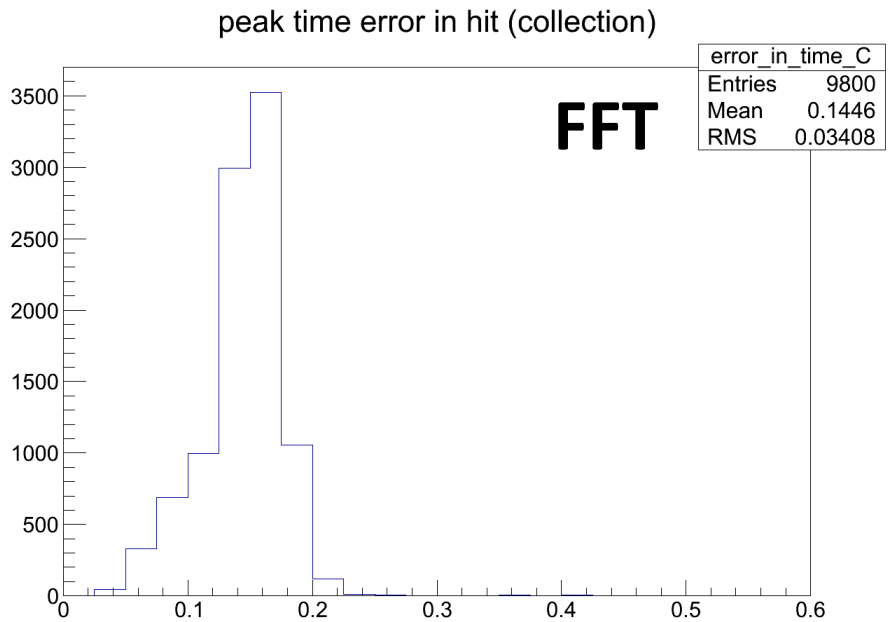
Hit Errors from recob::Hit()

- Hit Errors as returned by the SigmaPeakTime() method



Induction Hit Error = 0.2995 tick



Collection Hit Error = 0.1446 tick

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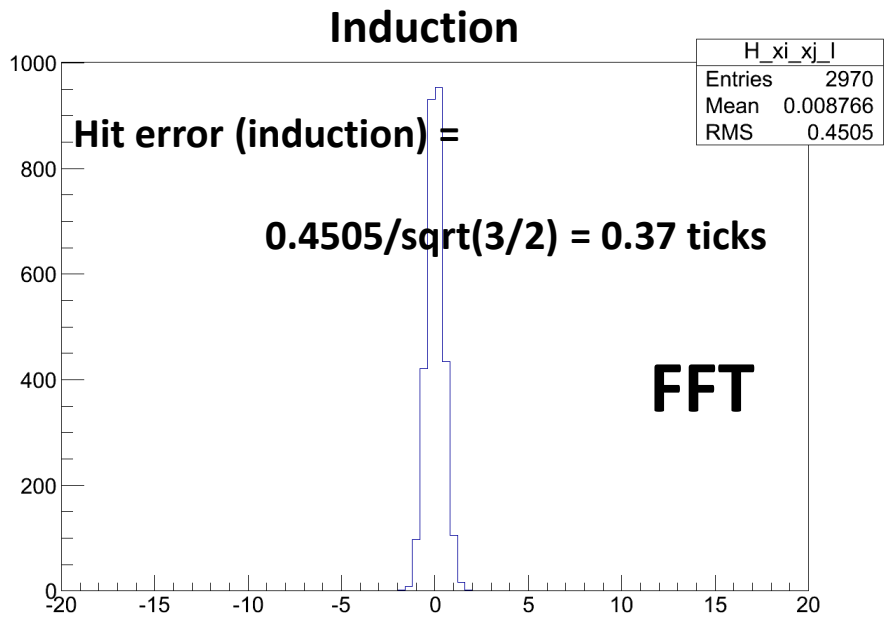
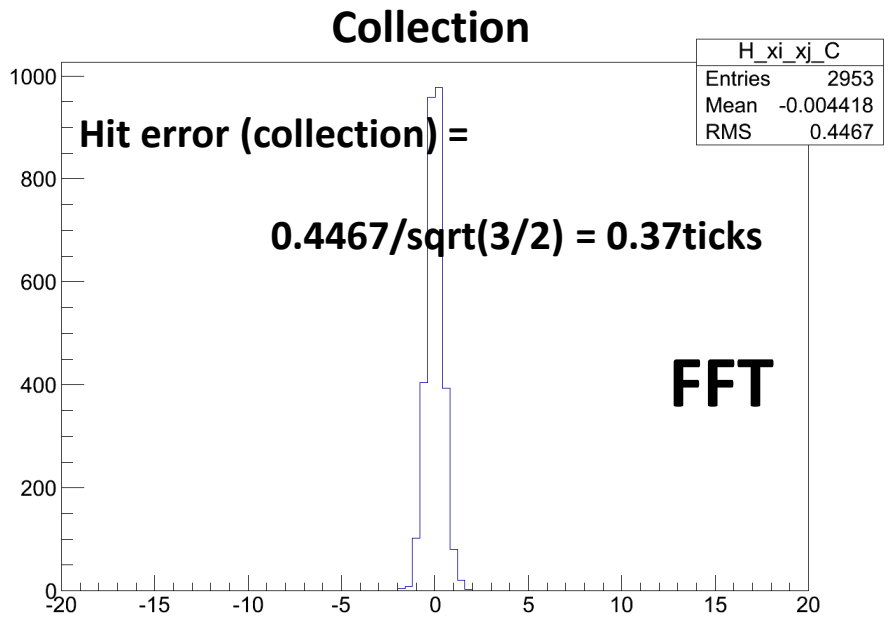
Hit Errors Determination using MC

- Using 100 muon tracks (10GeV/c momentum)
- Hits with individual chi2 greater than ~5 sigma are thrown away
- Plotting D, where

$$D = (t_n + t_{n+2})/2 - t_{n+1}$$





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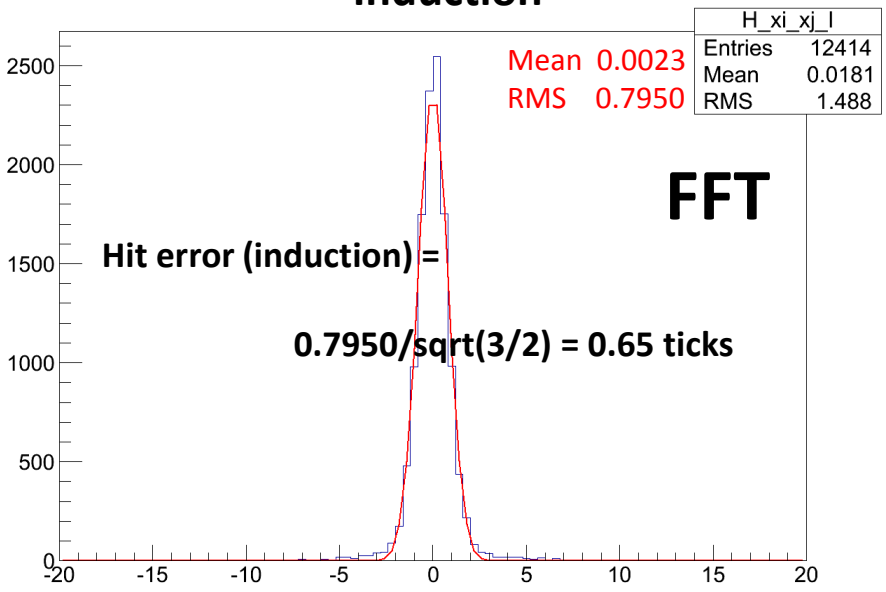
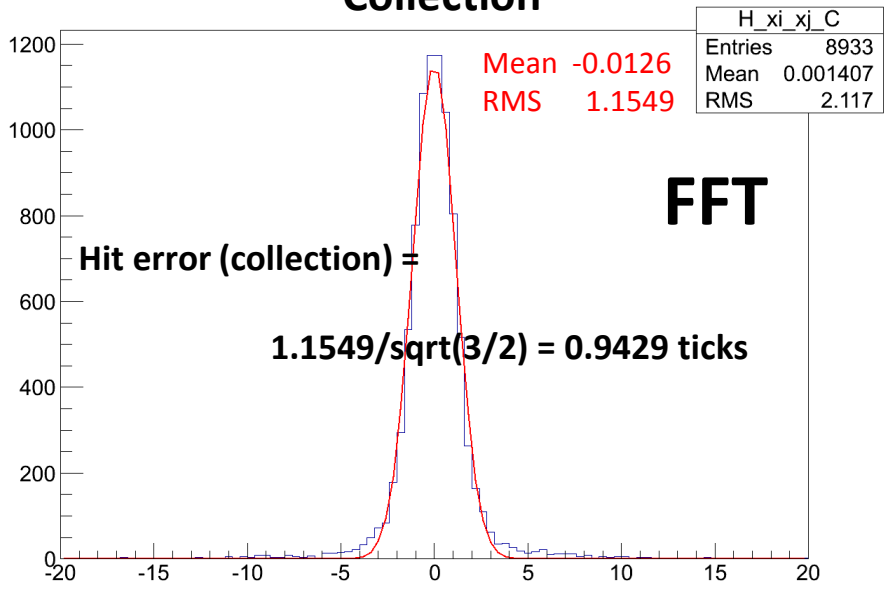
Hit Errors Determination using Data

- Using through going muon events from Ornella: Data Run 621 (Neutrino Mode)
- Hits with individual chi2 greater than ~5 sigma are thrown away
- Plotting D, where
- $D = (t_n + t_{n+2})/2 - t_{n+1}$
- Not considering a set of 3 hits if some of them are before dead wires and some after dead wires in collection plane

Induction



Collection



- Hit Errors in Data seem higher than in MC
- Next: Will use only high momentum (~10GeV/c) through going muons

Recent Study With MC and Data

For MC:

- Using muons in CCQE Hyperon Events (the track which is matched with MINOS or the longest in the plane)
- Using muons with momentum > 1GeV/c

For DATA:

- Using through going muons as before from Ornella: Data Run 621 (Neutrino Mode)
- Now, using muons with reco momentum > 1GeV/c (by MINOS)

Hit Errors

1. Measured Hit Errors are a combination of error in detection time and diffusion, such that

$$\sigma_t^2 = \sigma_e^2 + k^2T$$

Here,

σ_t^2 = Hit Error (squared)
σ_e^2 = Error in detection time
k^2T = diffusion term

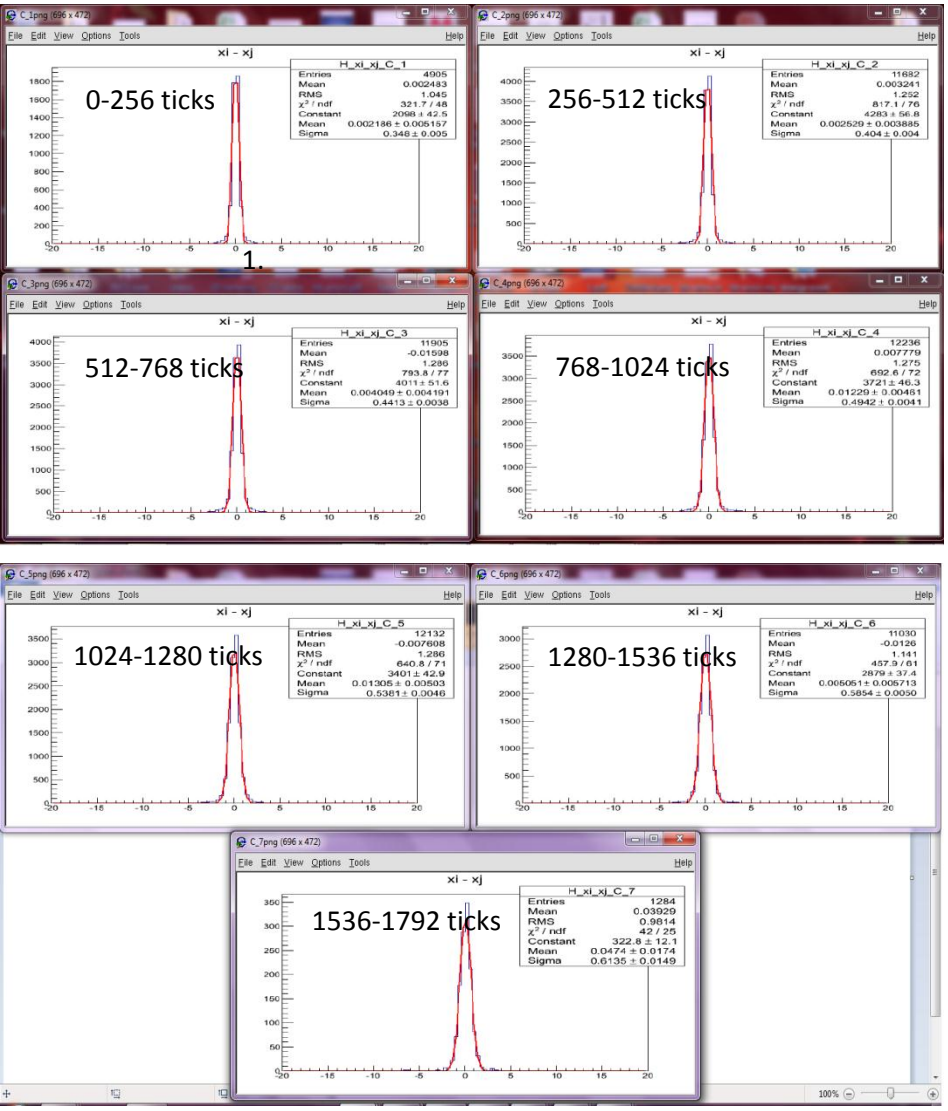
2. Plotting the quantity ‘D’ again but now for different time slices (drift distances) in the detector and determining σ_t^2

3. Using σ_t^2 of different time slices and Mean Times of the slices to determine the Error in detection time and diffusion effects separately

2. Plotting the quantity ‘D’ again but now for different time slices (drift distances) in the detector and determining σ_t^2 (Collection Plane)

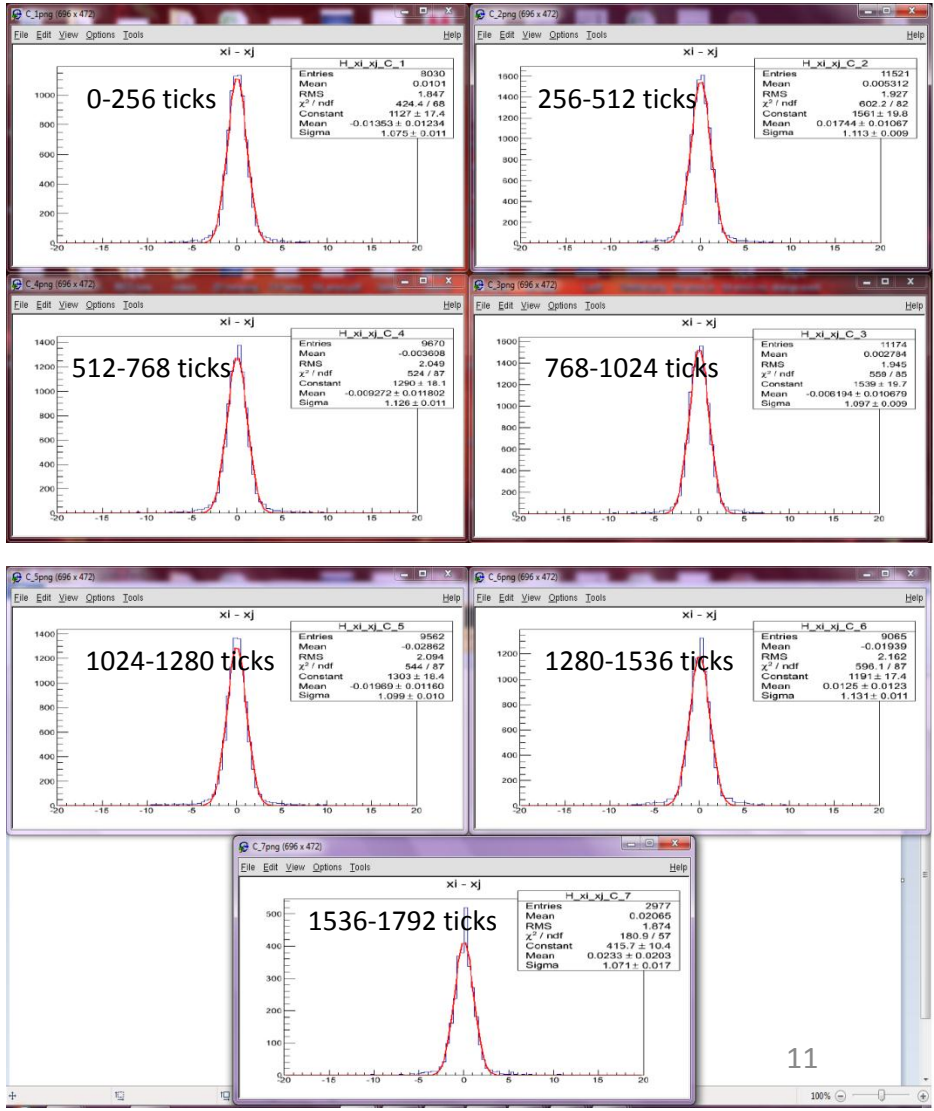
FFT

MC



1.

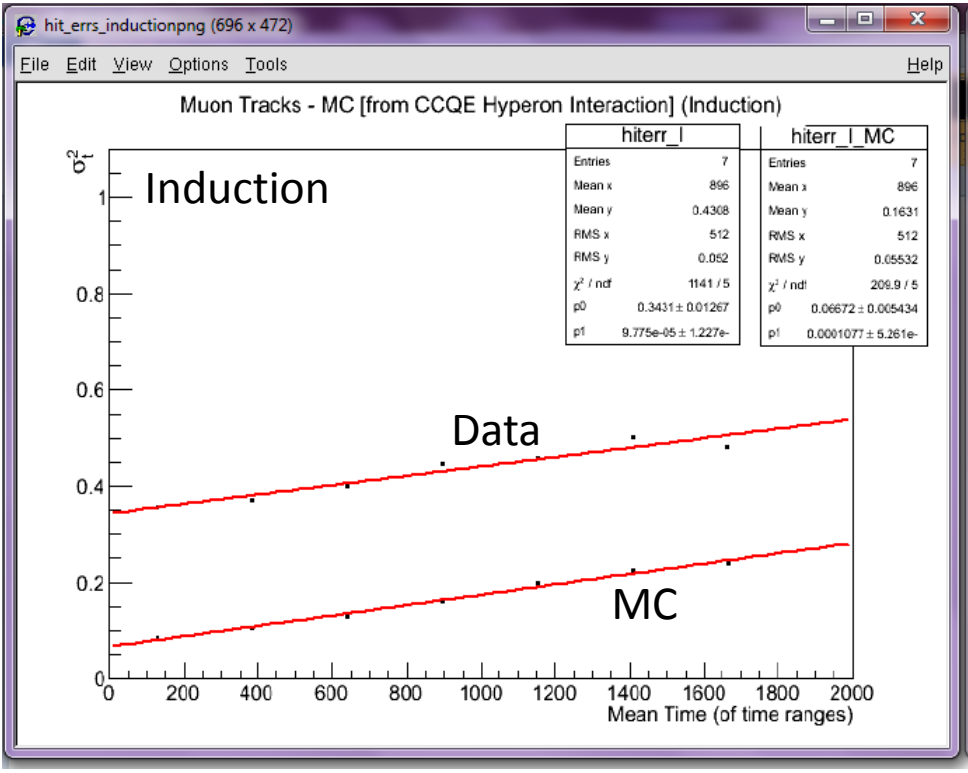
DATA

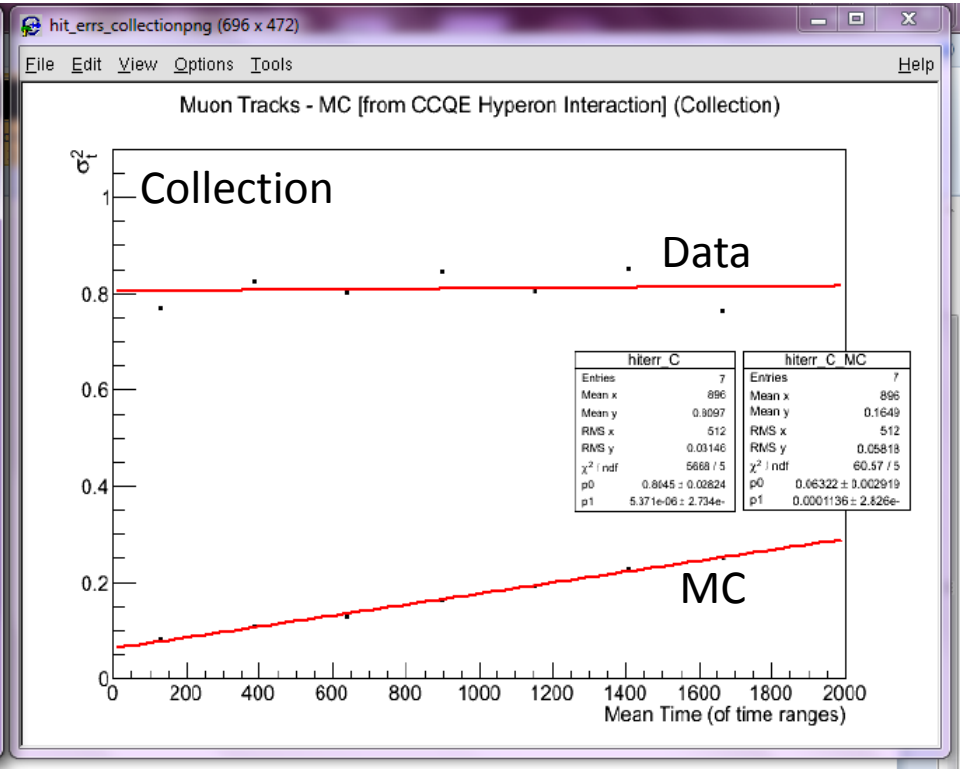


3. Using σ_t^2 of different time slices and Mean Times of the slices to determine the Error in detection time and diffusion effects separately.

Plotting line: $\sigma_t^2 = \sigma_e^2 + k^2T$

FFT

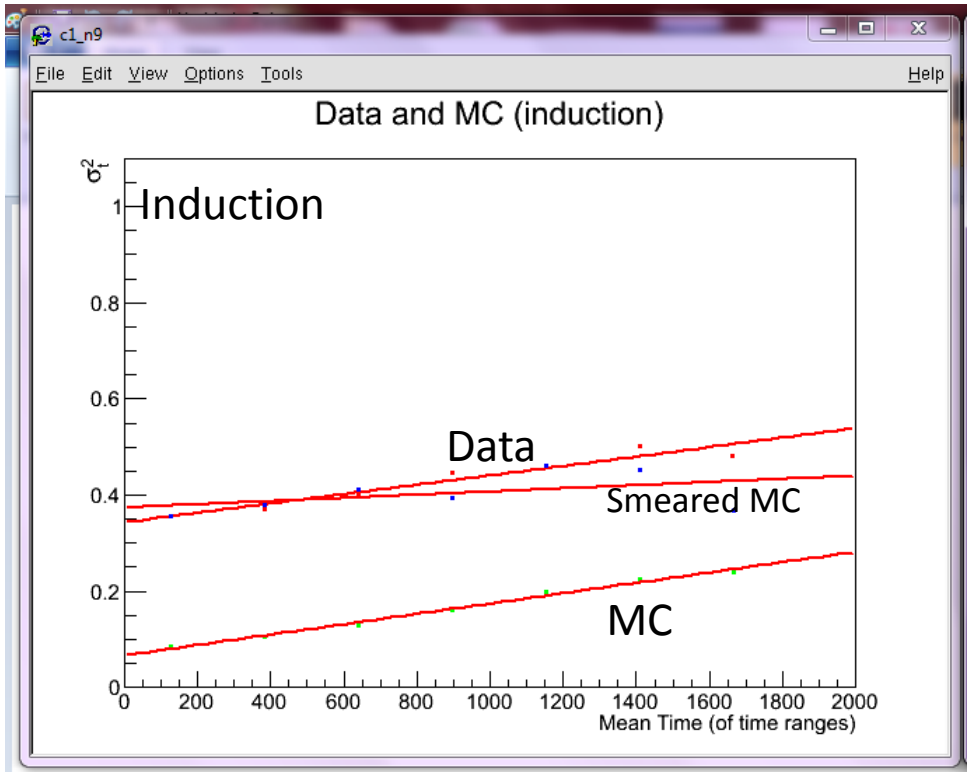


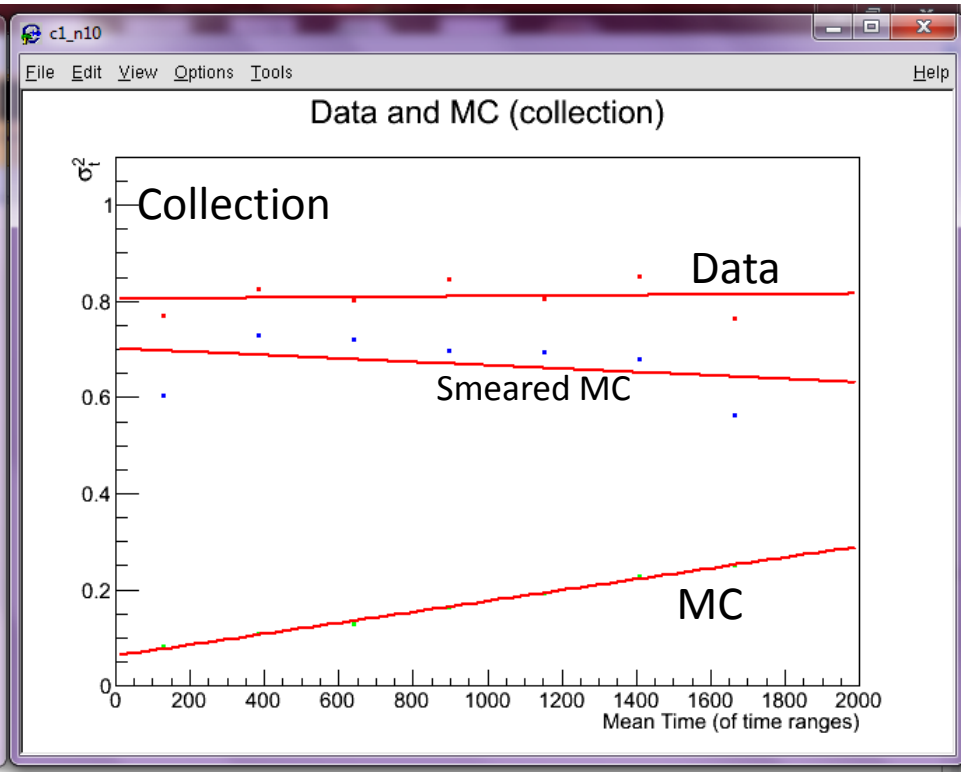


- Hit Errors in Data are bigger than in MC
- Diffusion seems modeled correctly for Induction (as slopes (Data, MC) are same)
- Hit Errors from data in collection are ~2 times bigger than in Induction
- In Collection, Hit Errors in Data are dominated by the timing resolution and do not depend on diffusion
- Next: Attempt to tune the MC to match the Data by smearing the Hit Times

After few iterations of smearing the MC hit timings to match the Data

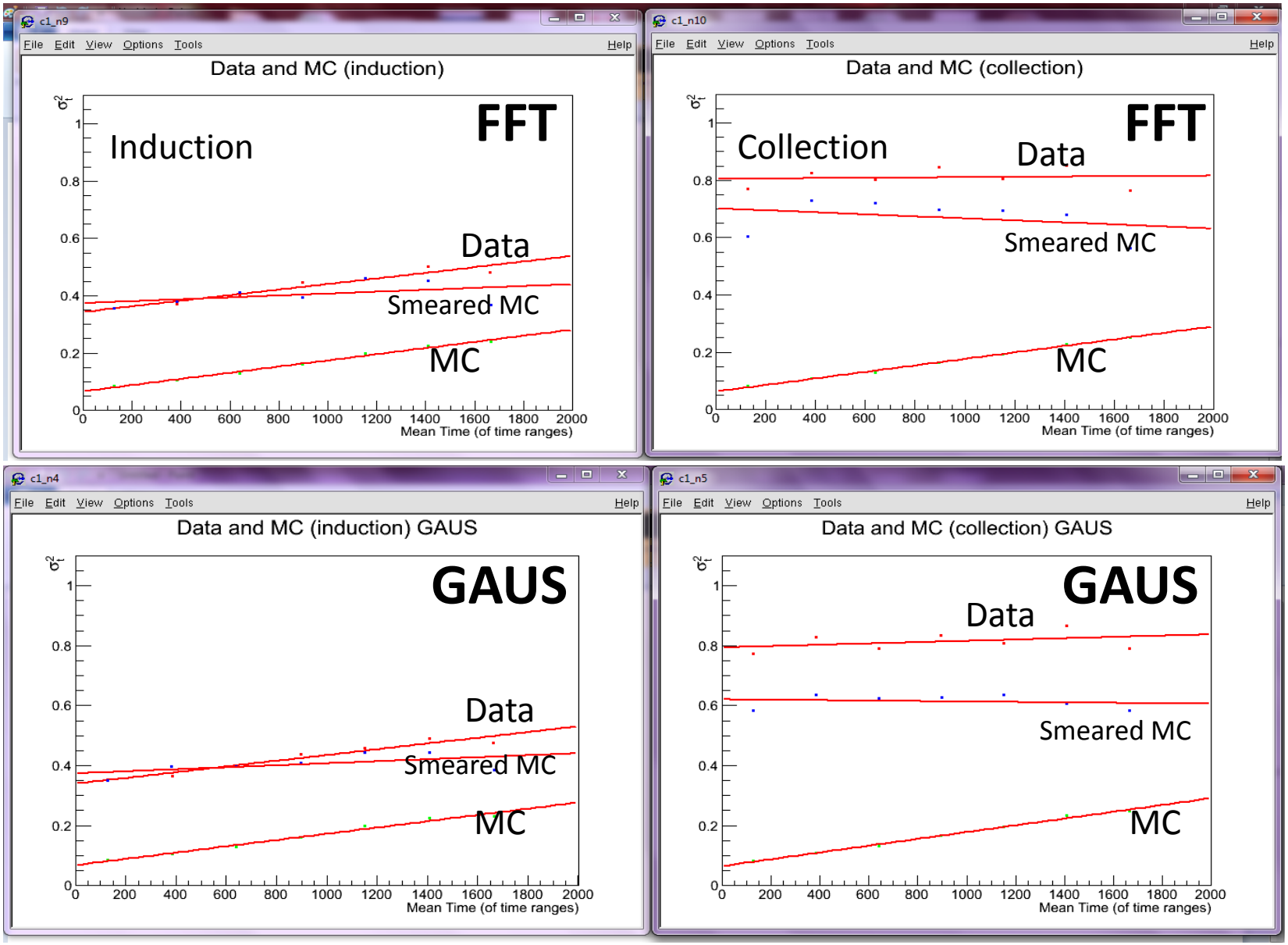
FFT





Working on it, still to make a better match between MC and Data!

Repeating with GausHitFinder



Working on it, still to make a better match between MC and Data!

Summary

- Hit Errors as returned by the SigmaPeakTime() method
- Hit Errors from data in collection are ~2 times bigger than in Induction
- Diffusion seems modeled correctly for Induction Plane
- In Collection, Hit Errors in Data are dominated by the timing resolution and do not depend on diffusion
- Results from GausHitFinder and FFTHitFinder are very similar
- One can tune the MC to match the Data by smearing the Hit Times