Hit Finding

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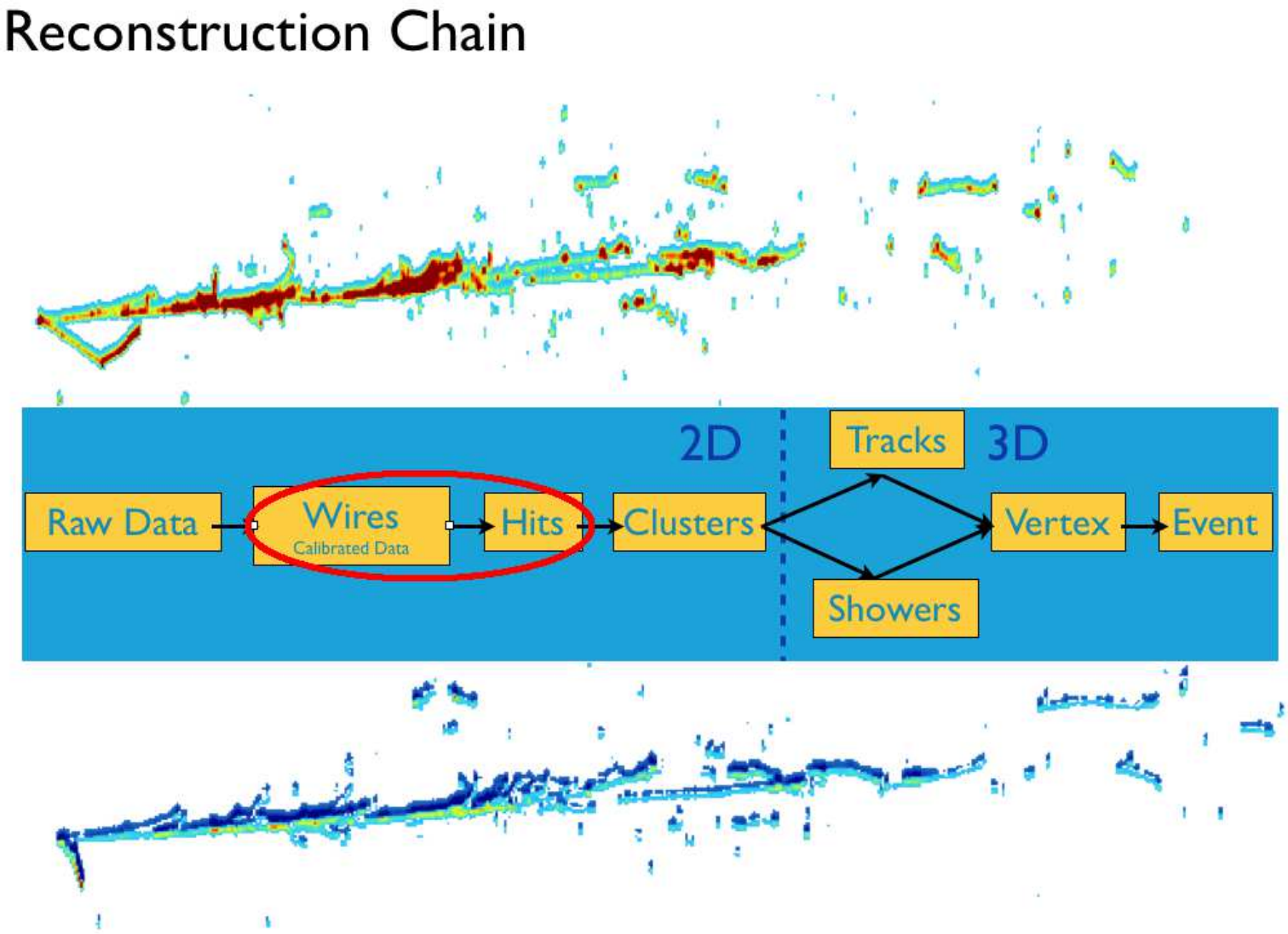
Hit Finding

- Reconstruction and wire deconvolution
- Two-hit separation efficiency
- Hit finding on GENIE ν events
- Summary

Reconstruction Chain



Wire Calibration

- CalWire module reads in raw digit collections from saved events (MC and real)
- Loops over all wires and uncompresses adc counts
  - Too slow and memory inefficient for LBNE large far detectors
- Pedestal from raw digits subtracted from adc vector
- adc vector deconvoluted by FFT
- Unpacked, deconvoluted adc vector is saved to wire collection (art object recob::Wire)

Hit Finding

- FFTHitFinder was standard hit finding module, now deprecated
- GausHitFinder module loads wire collection saved by CalWire module, loops over all wires
- Loops over signal vectors to find up to 3 hit candidates by checking minima and maxima
- Hit candidates are fit to Gaussians with MINUIT via ROOT
- Hits saved to hit collection with start and end times, mean positions, total charge, amplitude, multiplicity
- Hit collection must be disambiguated before being passed to cluster finder
  - APAHitFinder
  - DisambigCheater

Process Time and Memory Efficiency

- 10 kt events take far too long to reconstruct
- recob::Wire takes up too much memory ($>$ 8 GB) for 10 kT
- Avoid saving wire collections by combining wire calibration and hit finding modules
- Do not uncompress zero suppressed digits
- Don't deconvolute in frequency domain

Wire Deconvolution

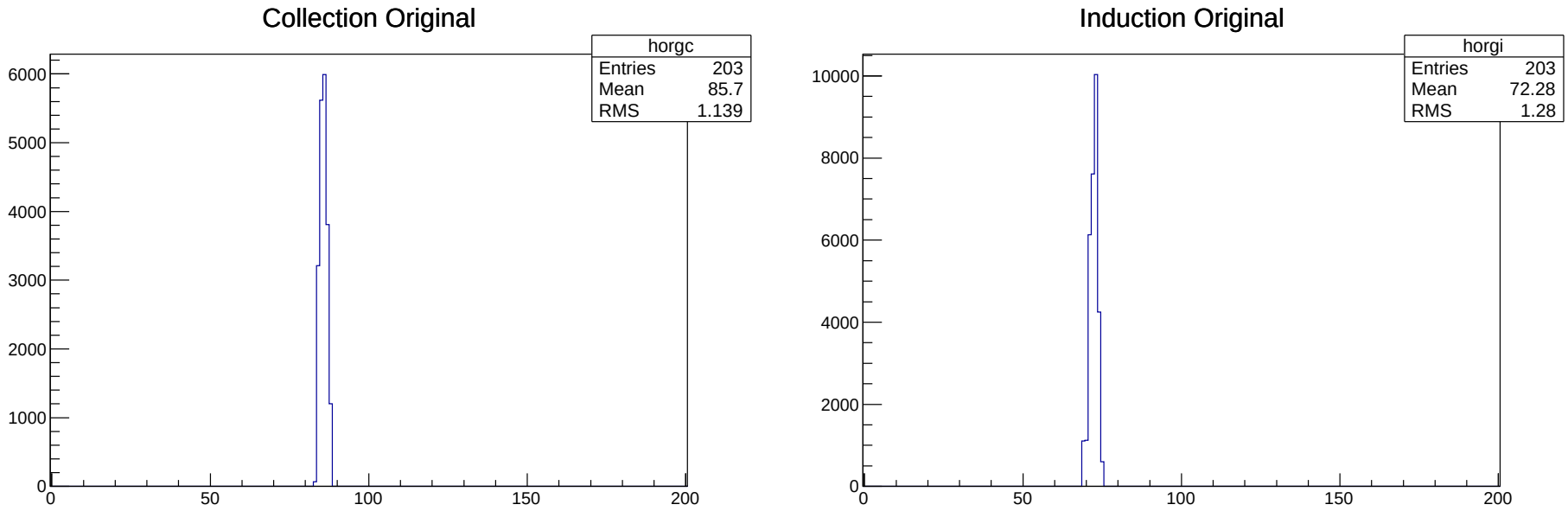


Figure 1: Pre-convoluted signals on collection and induction plane wires

Wire Deconvolution

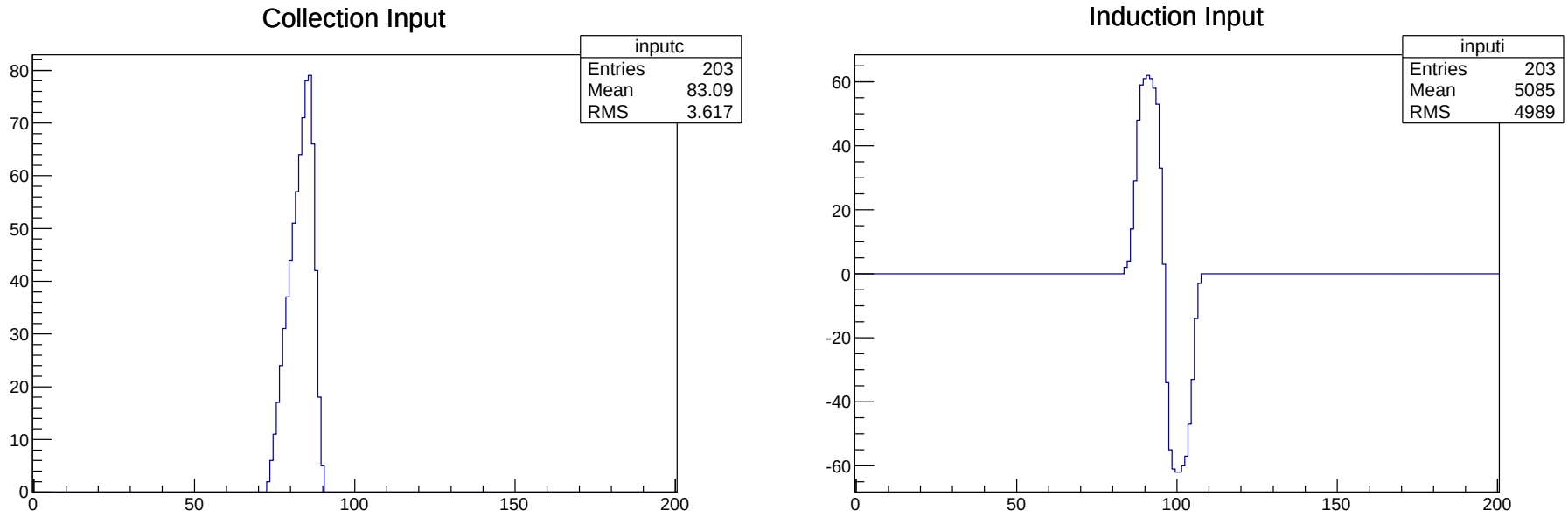


Figure 2: Convoluted signals on collection and induction plane wires

Wire Deconvolution

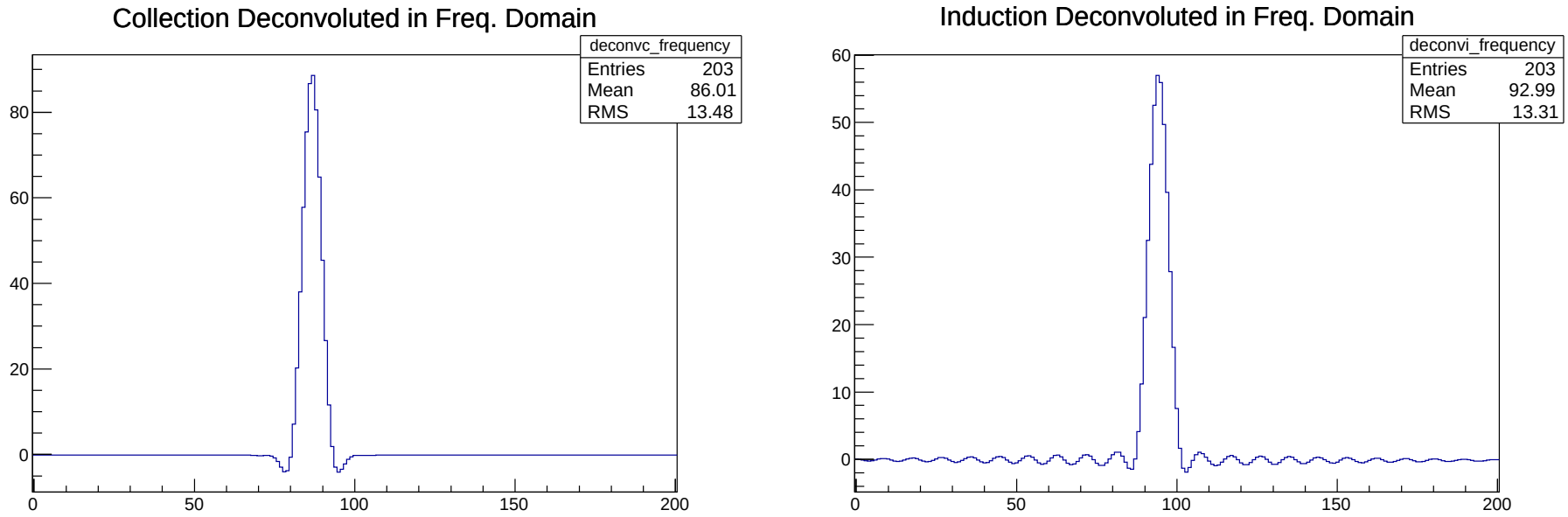


Figure 3: Frequency domain deconvoluted signals on collection and induction plane wires

Wire Deconvolution

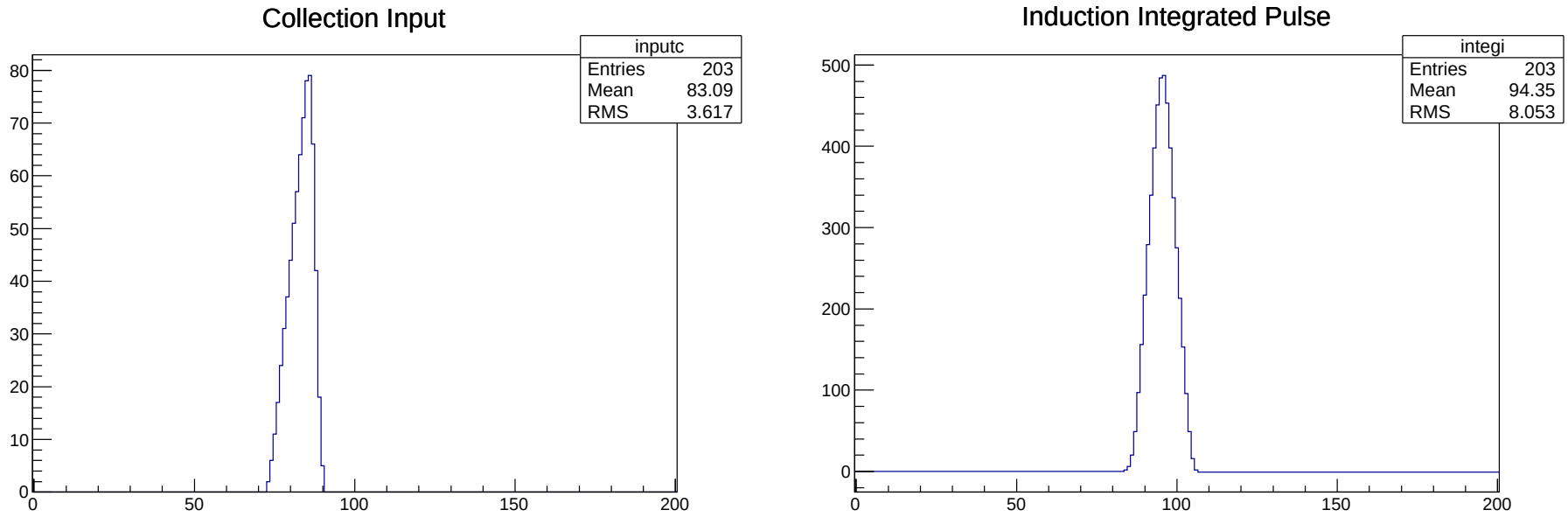


Figure 4: Convoluted collection plane signal and integrated induction plane signal

Fit convoluted collection plane signals and integrated induction plane signals directly

CalGausHitFinder

- Simple combination of CalWire and GausHitFinder which omits recob::Wire to save memory usage
- Raw digits left zero suppressed to avoid creating entire mostly empty detector in memory
- Constant pedestal from raw digits is subtracted
- Nonzero blocks in collection planes are fit directly, nonzero blocks in induction planes are integrated then fit
- LBNE10kt GENIE event with cosmics takes 10 minutes to run
- Not needed for 35 ton events

CalGausHitFinder

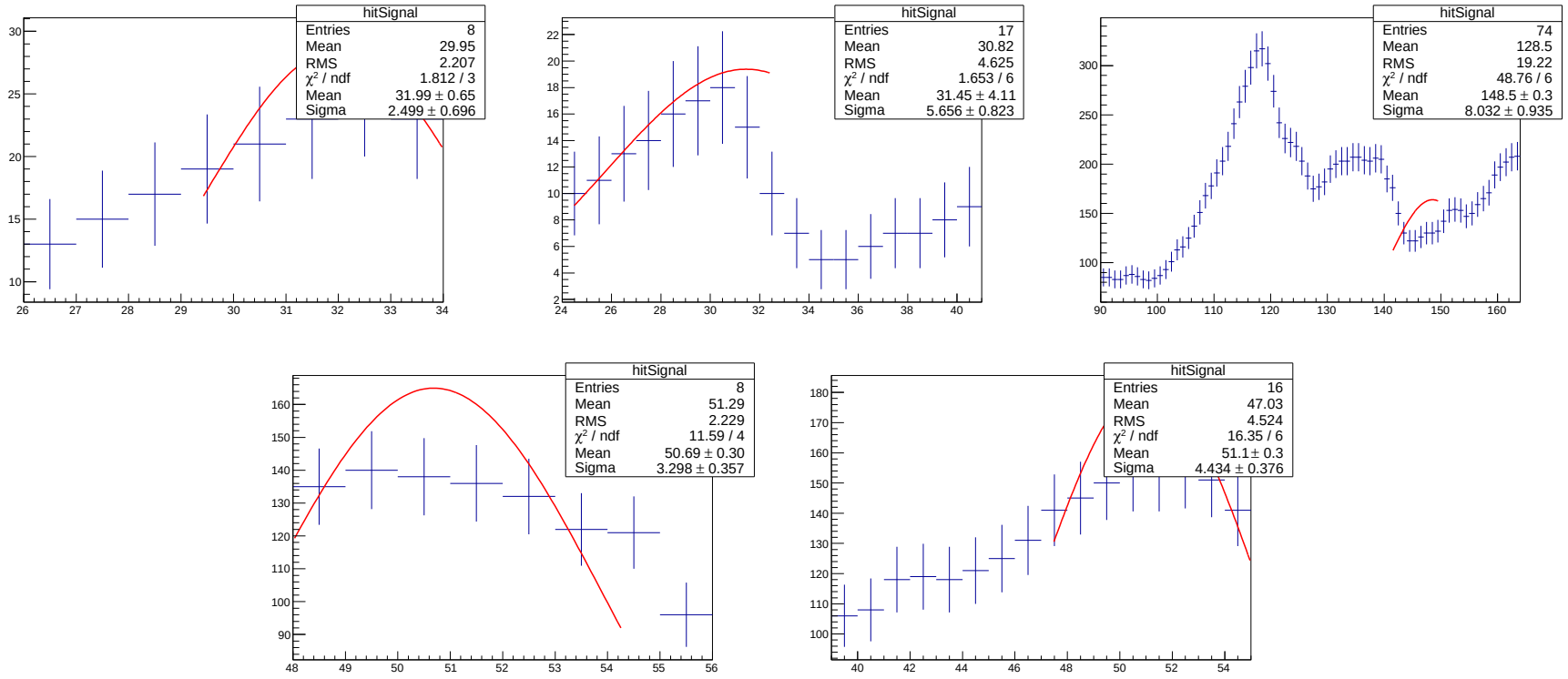


Figure 5: Collection plane signals fit with CalGausHitFinder

CalGausHitFinder

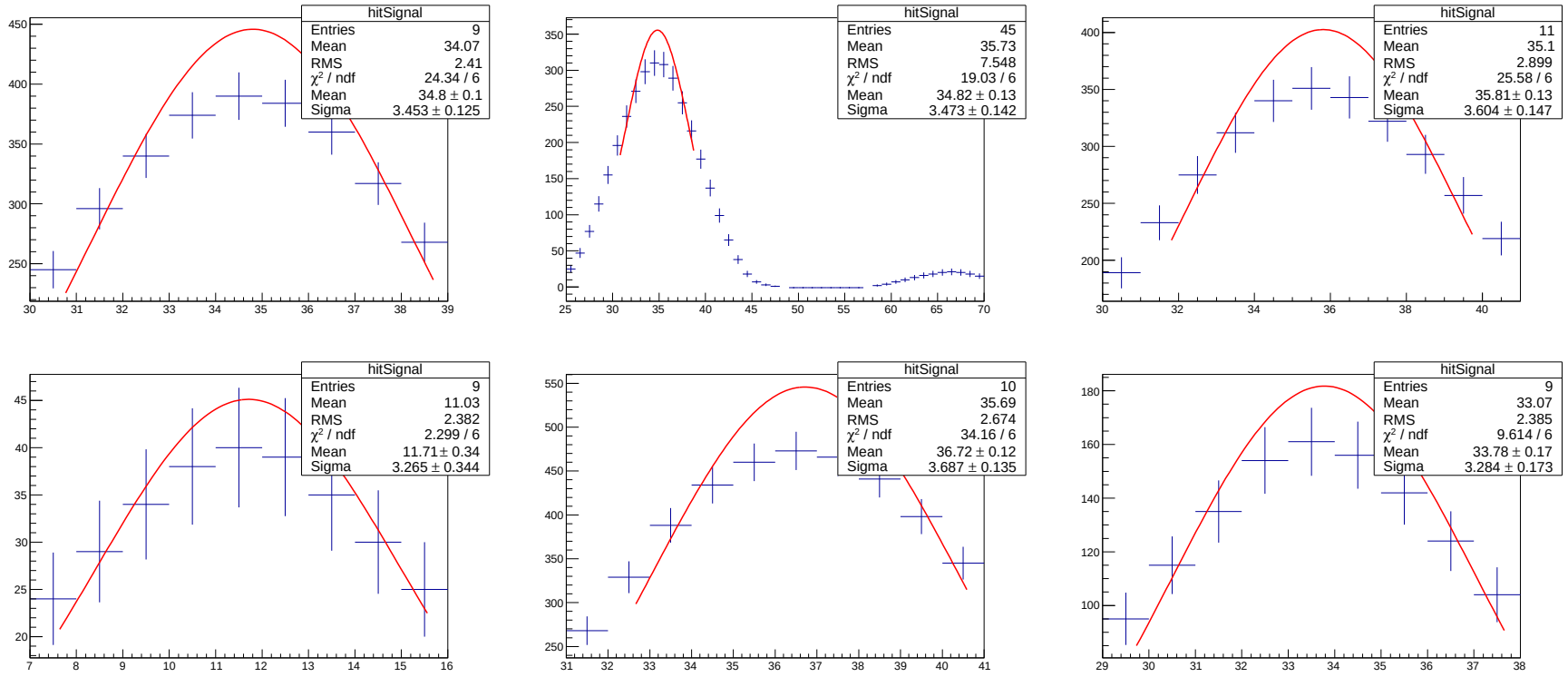


Figure 6: Induction plane signals fit with CalGausHitFinder

Two-hit Separation Efficiency

- Examine ability of hit finder to distinguish hits on same wire separated by short time intervals
- GausHitFinder algorithm applied to unipolar hit shapes
- Signals placed on same wire with variable gap between them
- Also looked at symmetric Gaussian hit shapes

Two-hit Separation Efficiency

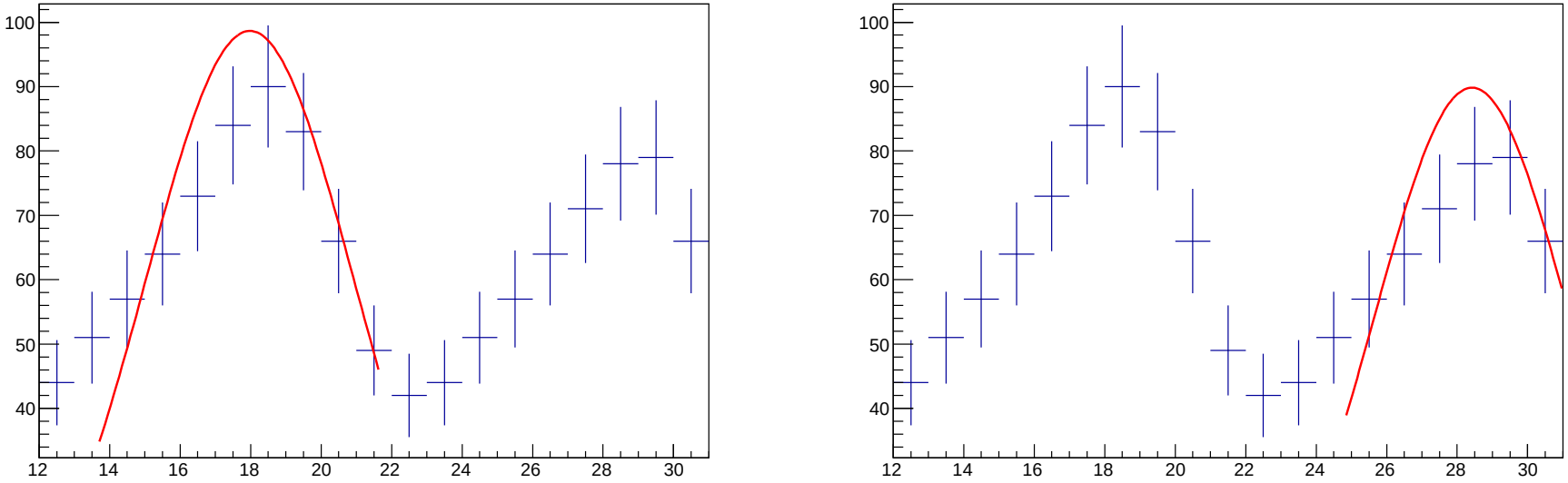


Figure 7: Equal size hits

Successful separation

Two-hit Separation Efficiency

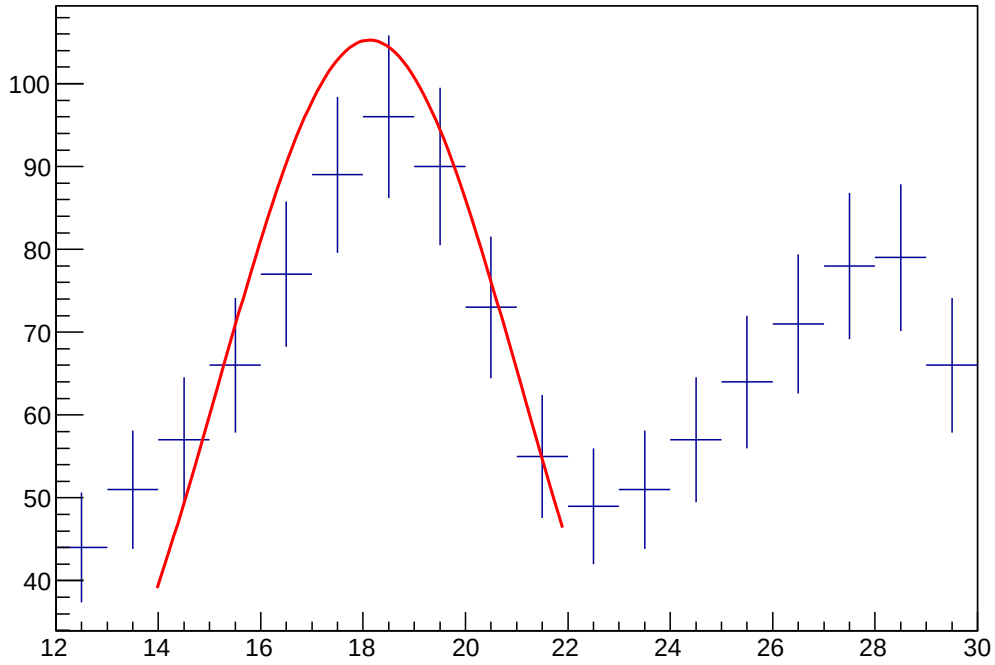


Figure 8: Equal size hits

Failed separation

Two-hit Separation Efficiency

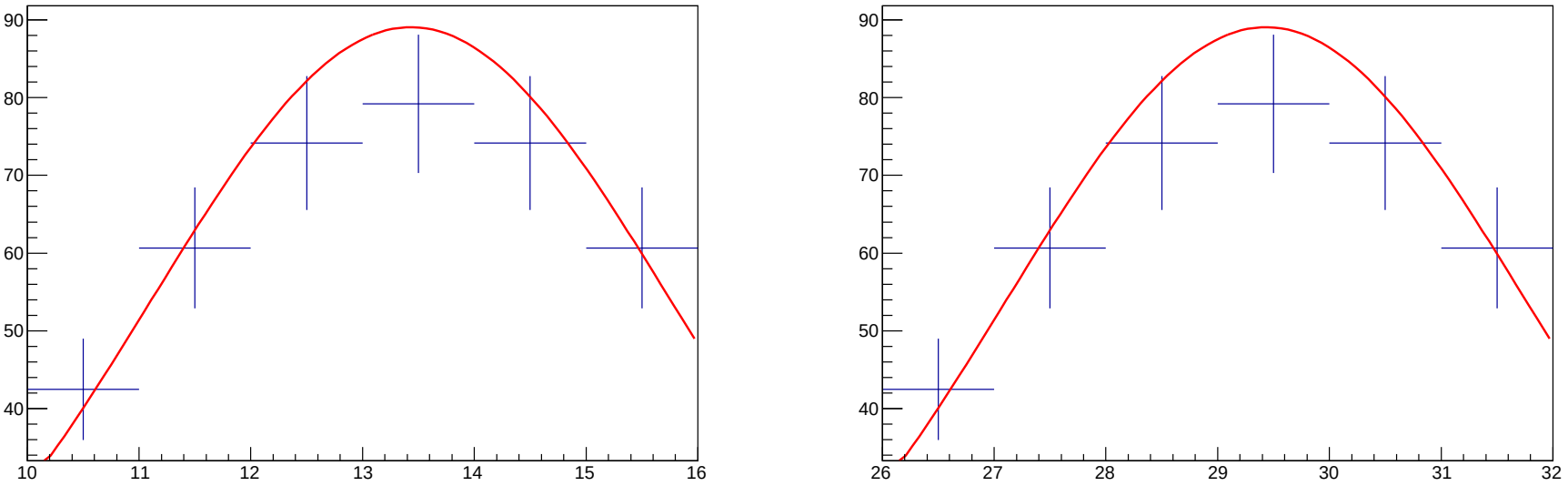


Figure 9: Gaussian equal size hits

Successful separation

Two-hit Separation Efficiency

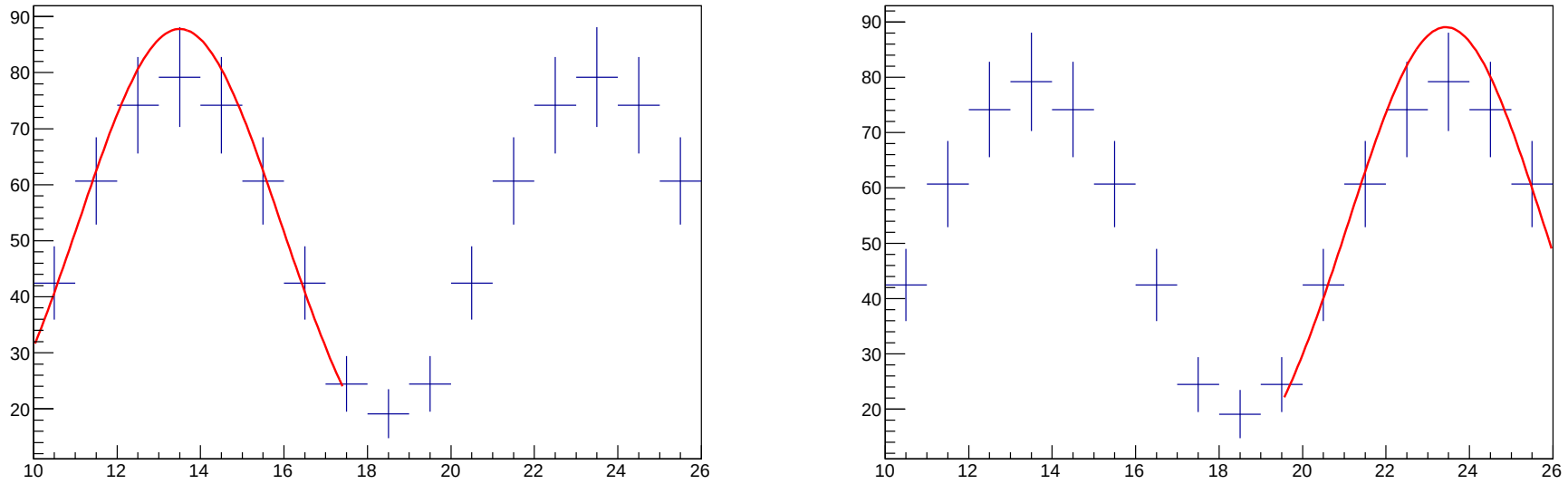


Figure 10: Gaussian equal size hits

Successful separation

Two-hit Separation Efficiency

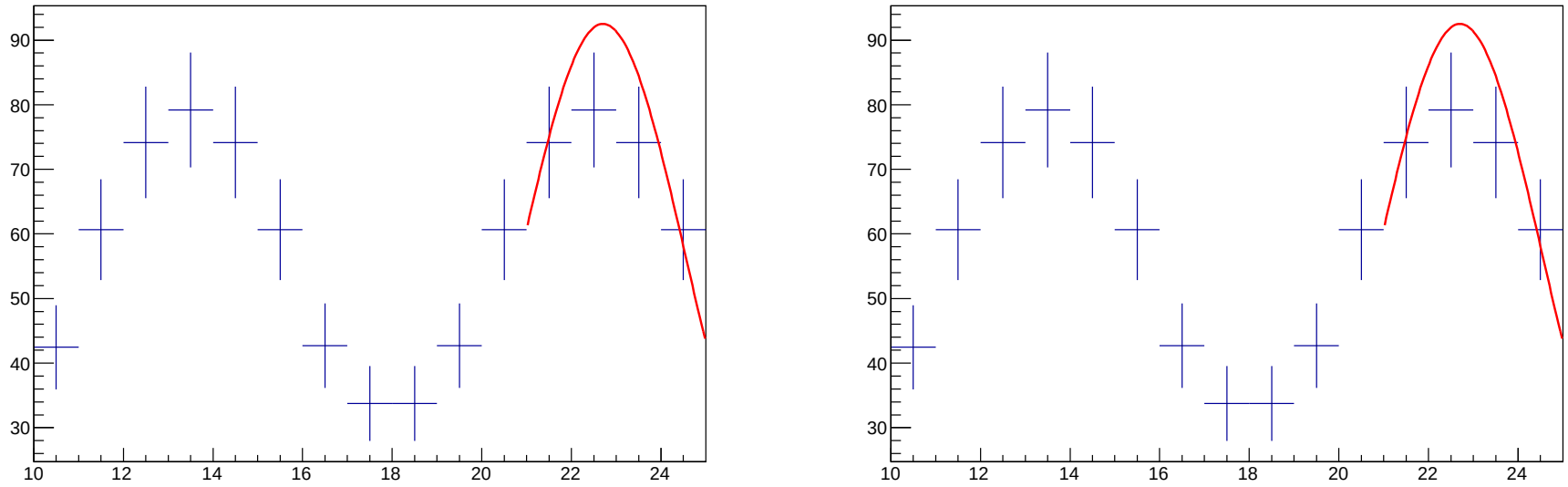


Figure 11: Gaussian equal size hits

Failed separation

Two-hit Separation Efficiency

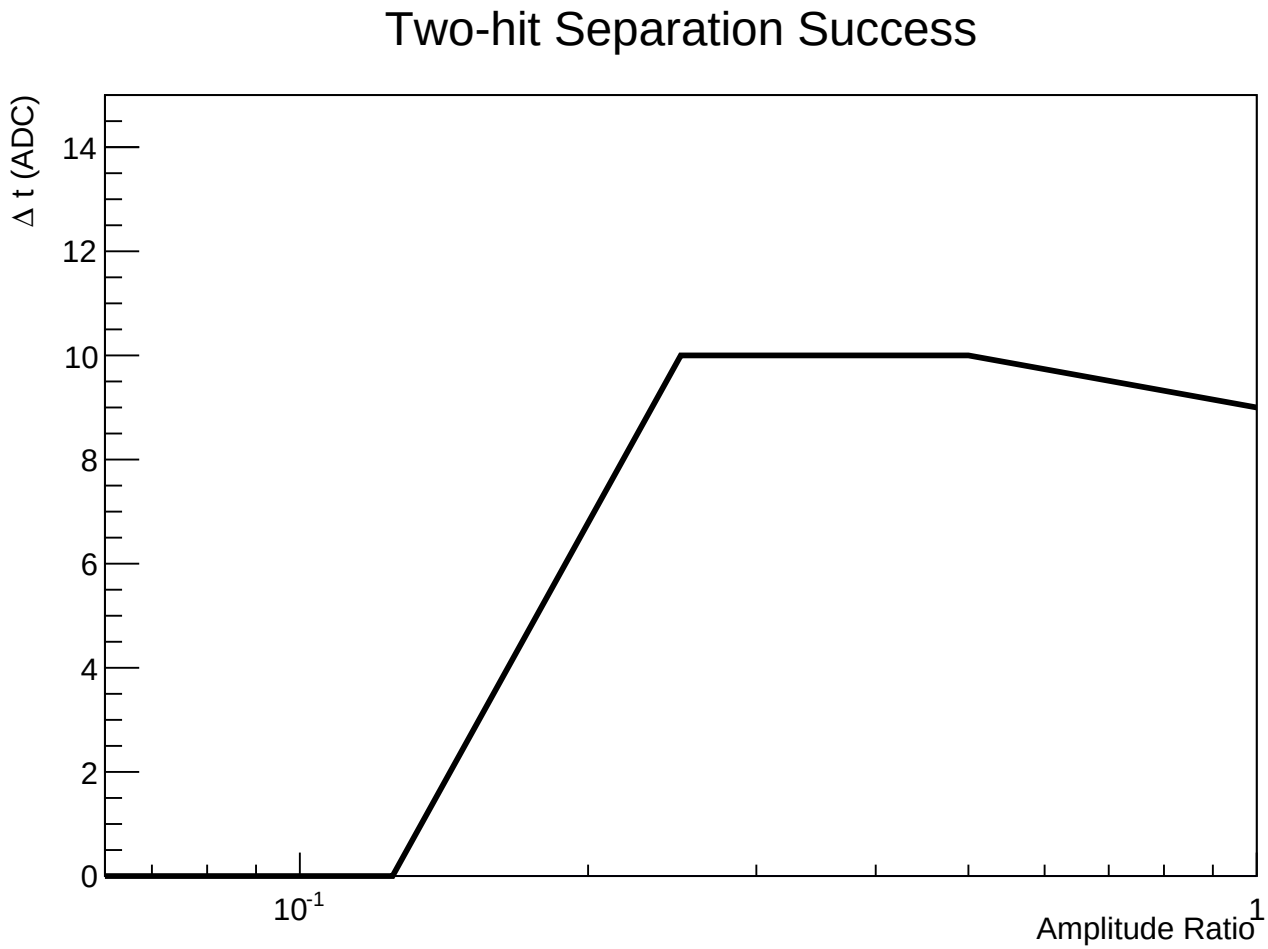
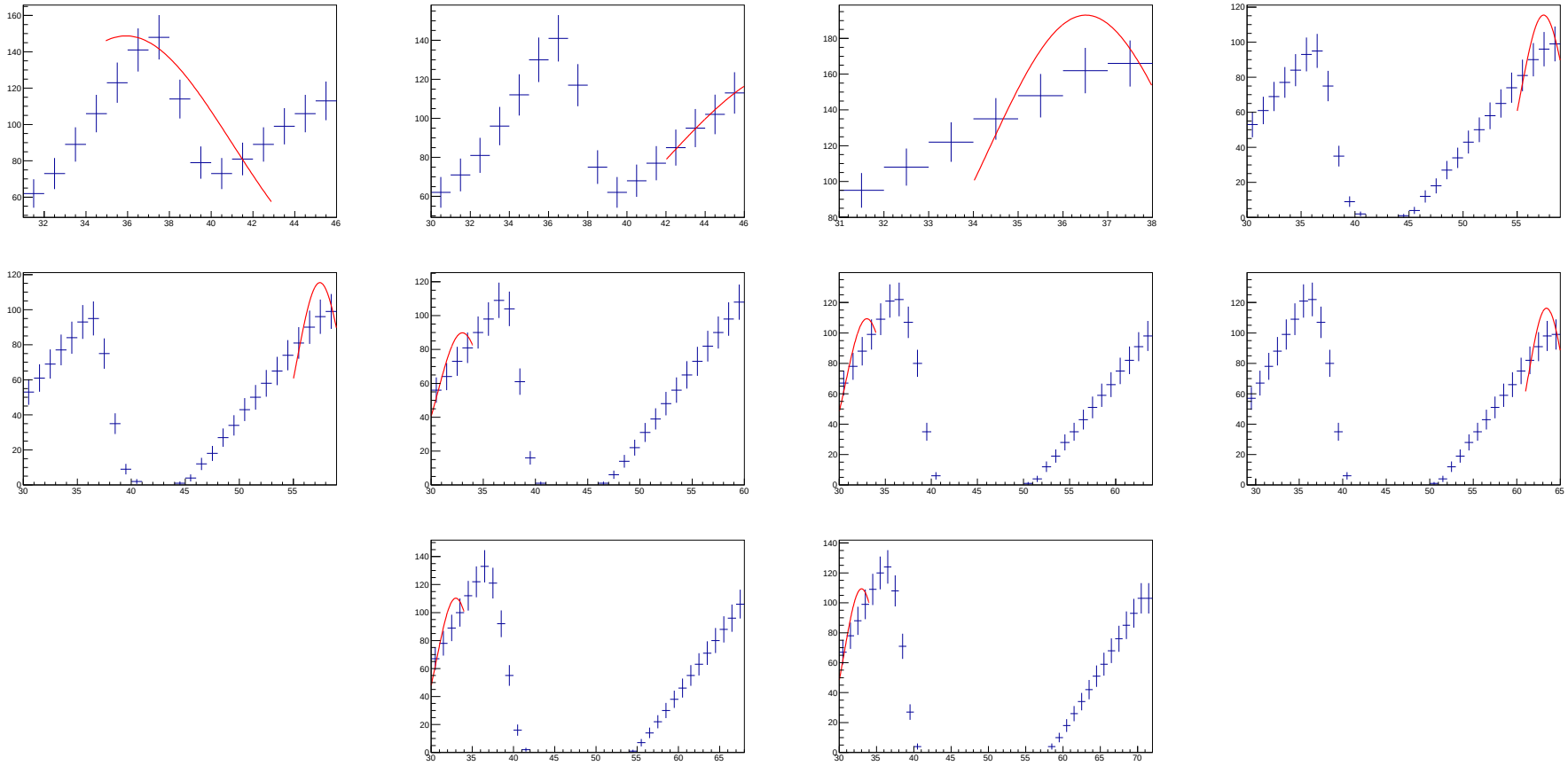


Figure 12: Success of fit for separation of two Gaussian hits on one wire vs. amplitude ratio of two hits

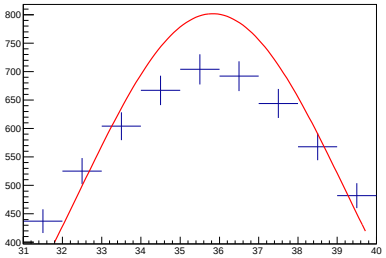
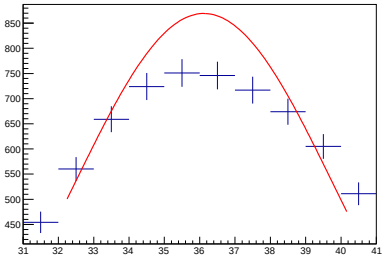
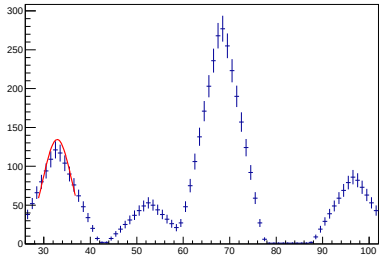
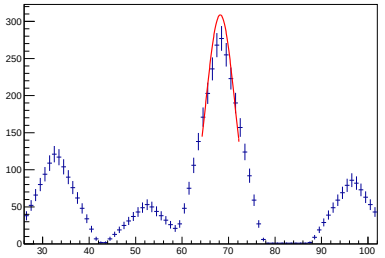
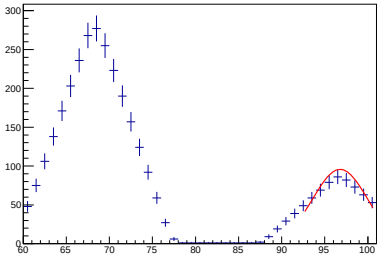
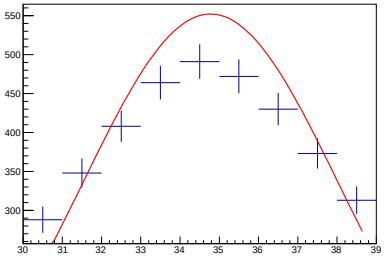
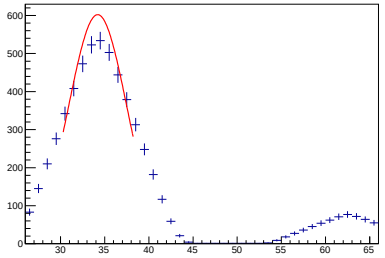
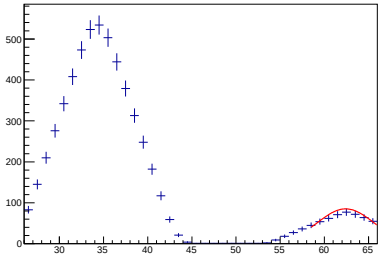
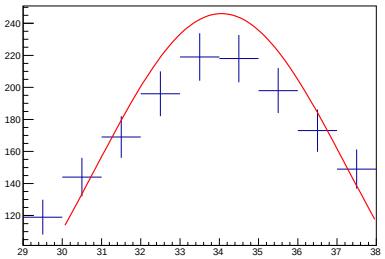
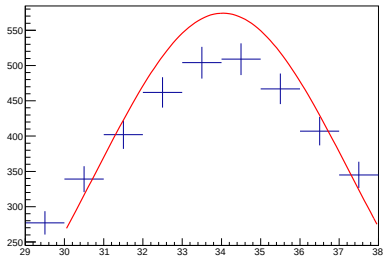
Hit Finding on Neutrino Events

- Reconstructed 100 GENIE events of 4-APA small FD Monte Carlo. $\nu_\mu \rightarrow \nu_e$ flux with 45 deg. wire angle.
- Gaussian hit finder run on 1st event.
- Displaying hits with $\chi^2/\text{NDF} \leq 15$.
- Hits found using method without deconvolution are problematic; hits using old method with deconvolution look excellent. Difference is particularly strong for collection plane hits

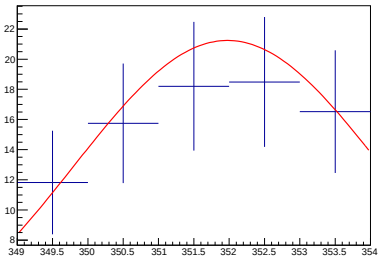
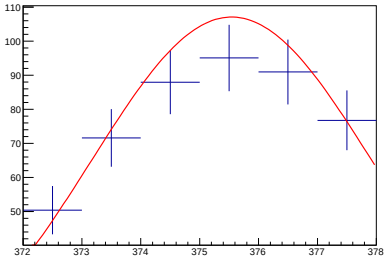
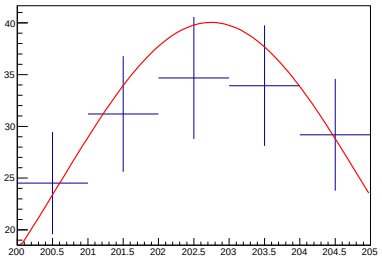
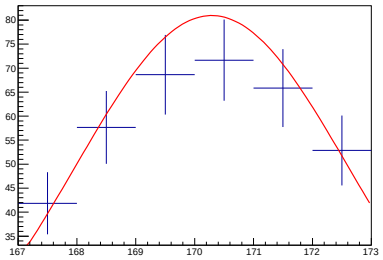
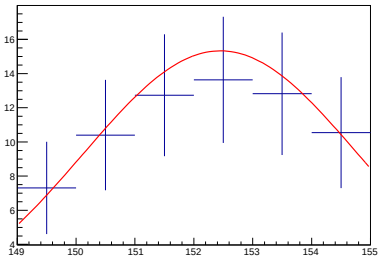
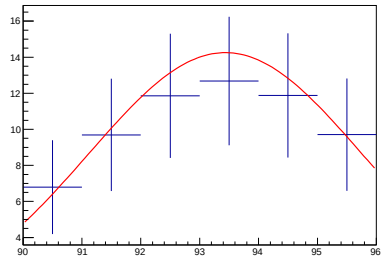
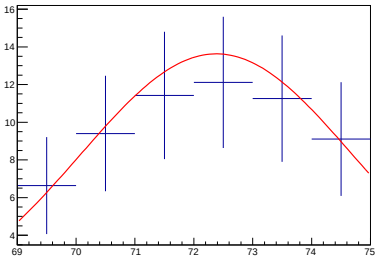
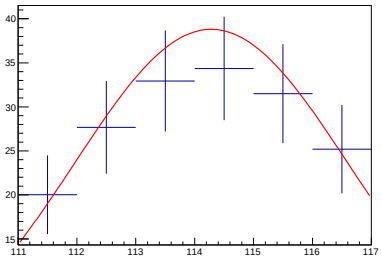
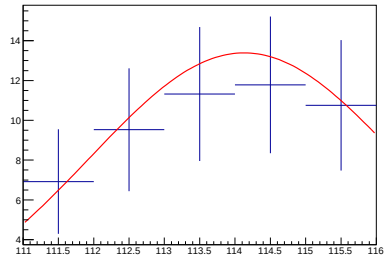
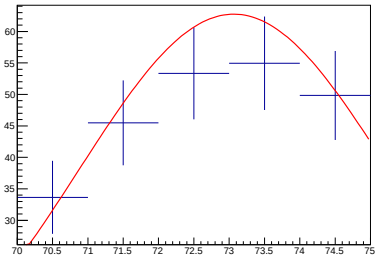
Collection Plane Hits



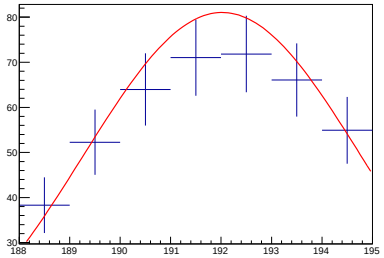
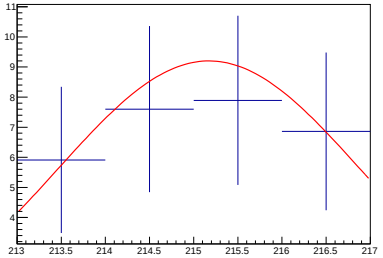
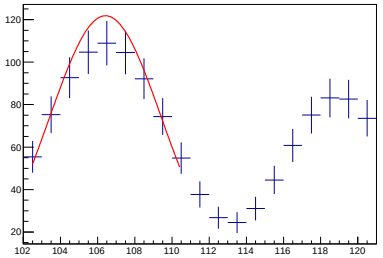
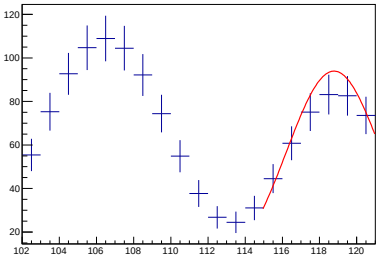
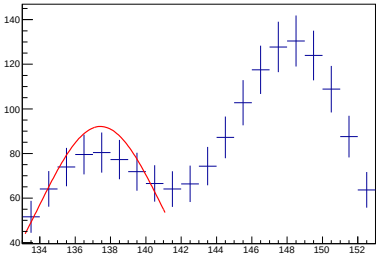
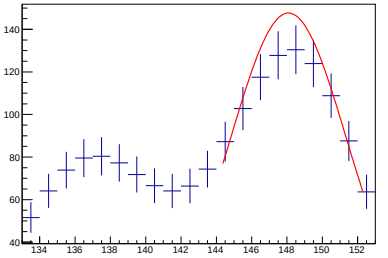
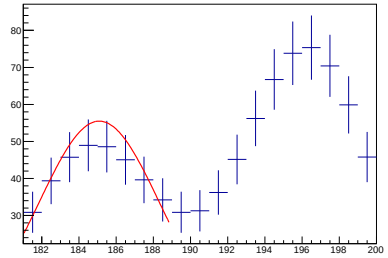
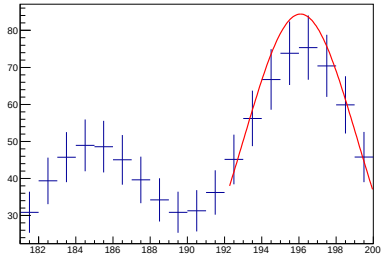
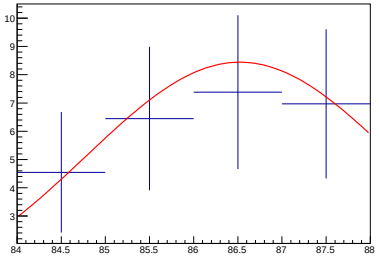
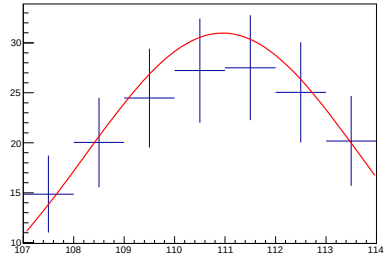
Induction Plane Hits

Collection Plane Hits with Deconvolution

Induction Plane Hits with Deconvolution

Summary

- Deconvolution is prohibitively slow for large (10 kt and above) far detectors
- Hit finding can be performed without proper deconvolution (CalGausHitFinder) to decrease memory and processor requirements
- Two-hit separation efficiency is poor for raw hit shapes, better with Gaussian hit shapes
- Hits from GENIE events found using method without deconvolution are problematic; hits found with deconvolution have much better fits