Argon Scintillation Time Components From Preliminary uBooNE PMT Data

Zander Moss – MIT

July 29, 2015

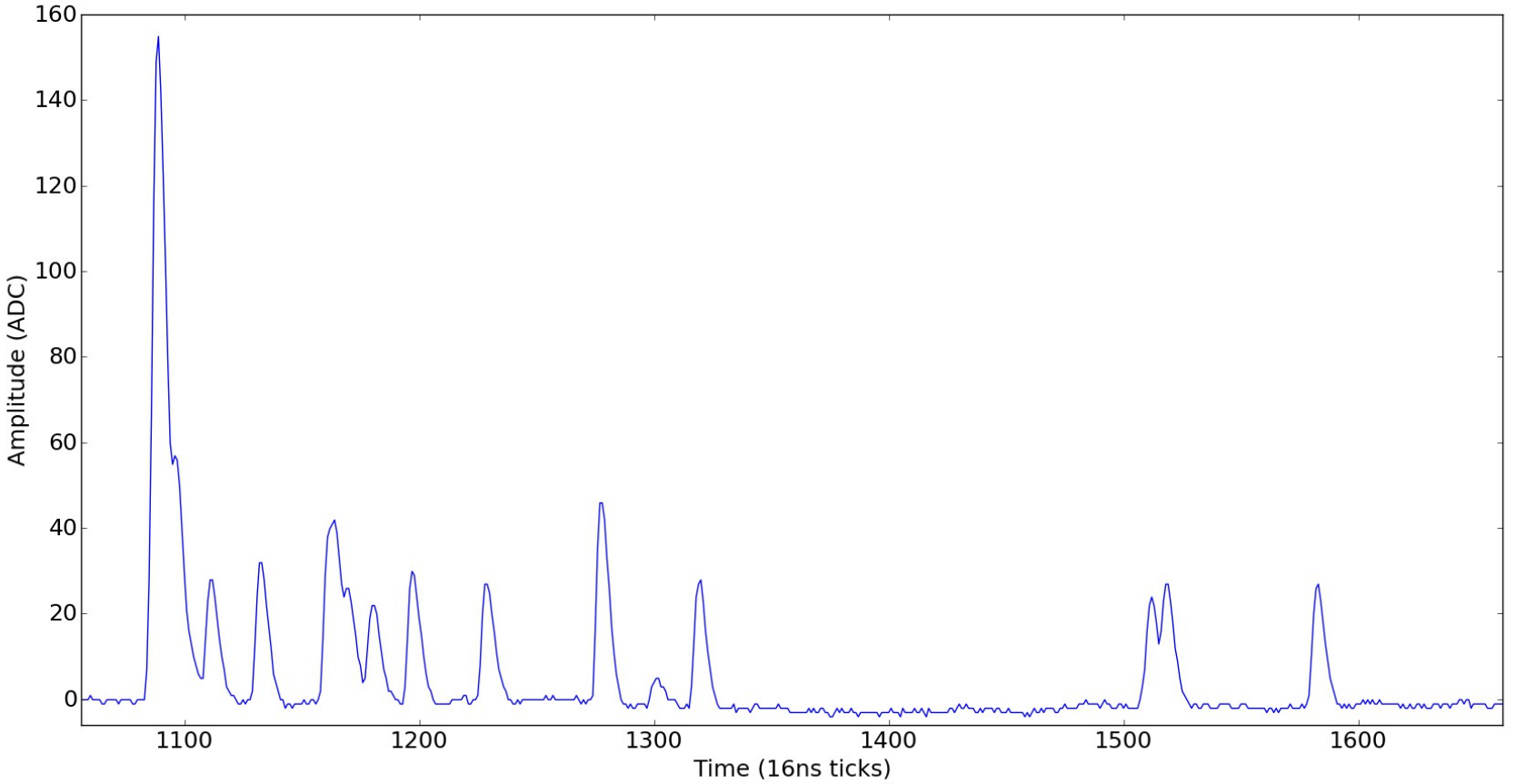
Summer Projects

- Anode-coupled Readout (arXiv:1507.01997, submitted to JINST).
- PMT Commissioning (Taritree and Jarrett will speak at length about this tomorrow)..
- Time component study: new! (last week)

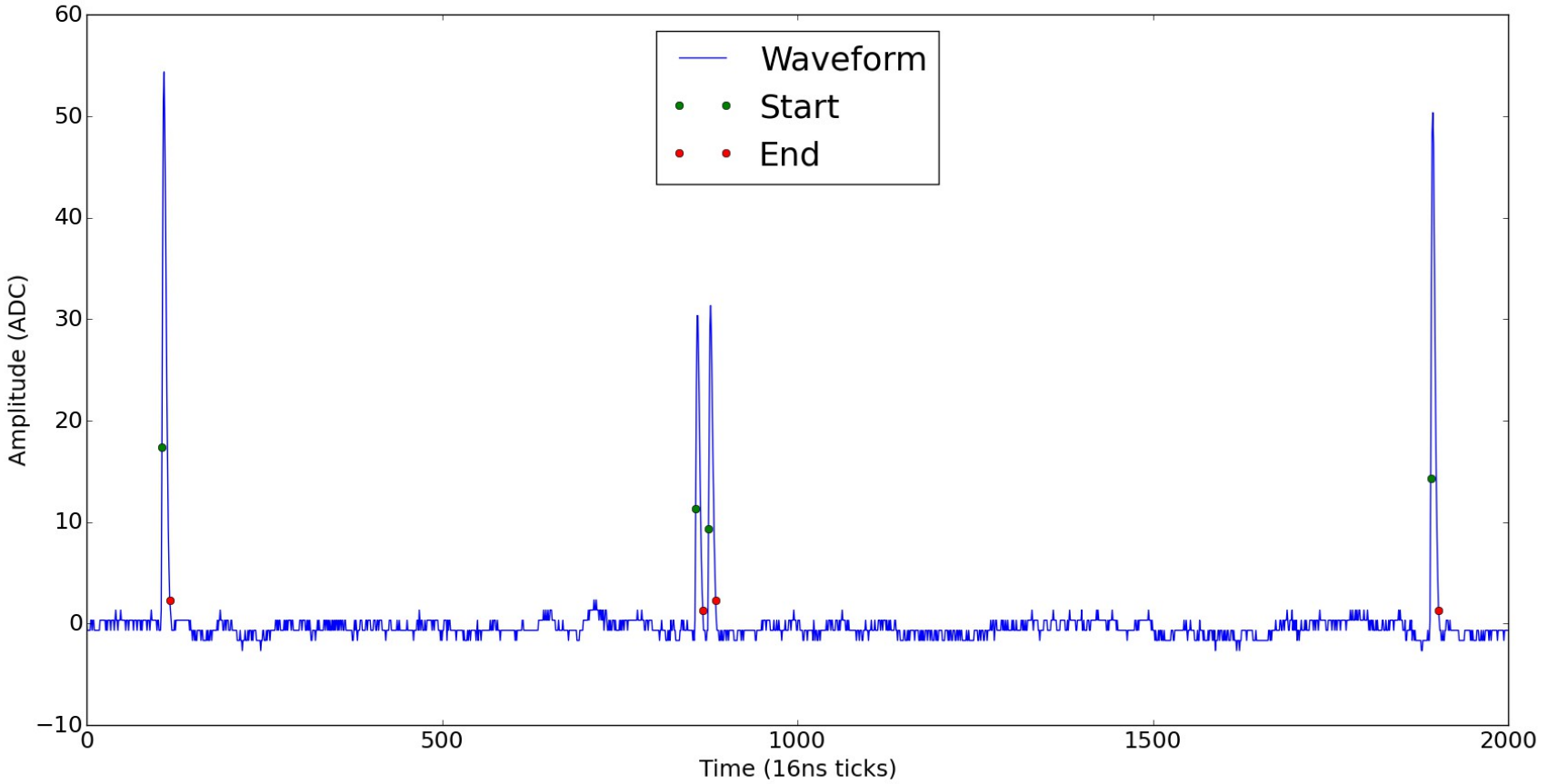
Time Components

- Argon dimers have two low energy states: a singlet and a triplet.
- The two have very different lifetimes (6 ns and 1500 ns, respectively).
- They are produced in different ratios depending on the exciting particle.
- We can produce a timing distribution using cosmic data from an unbiased readout.

Cosmic Superposition



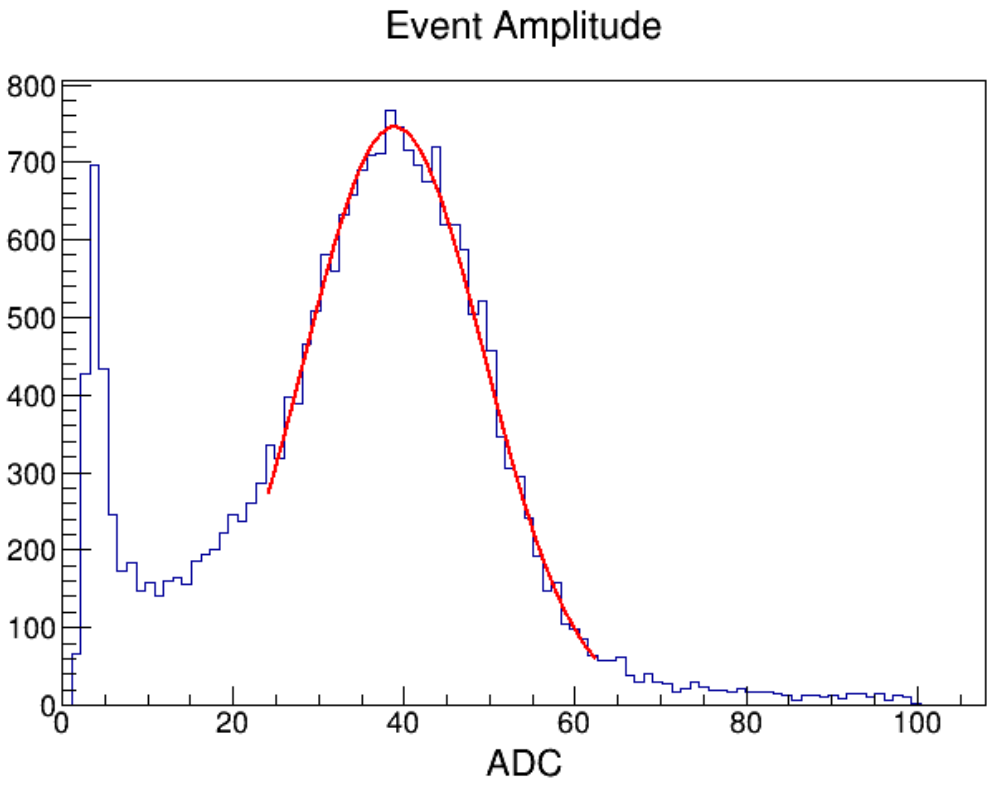
Waveform Processing

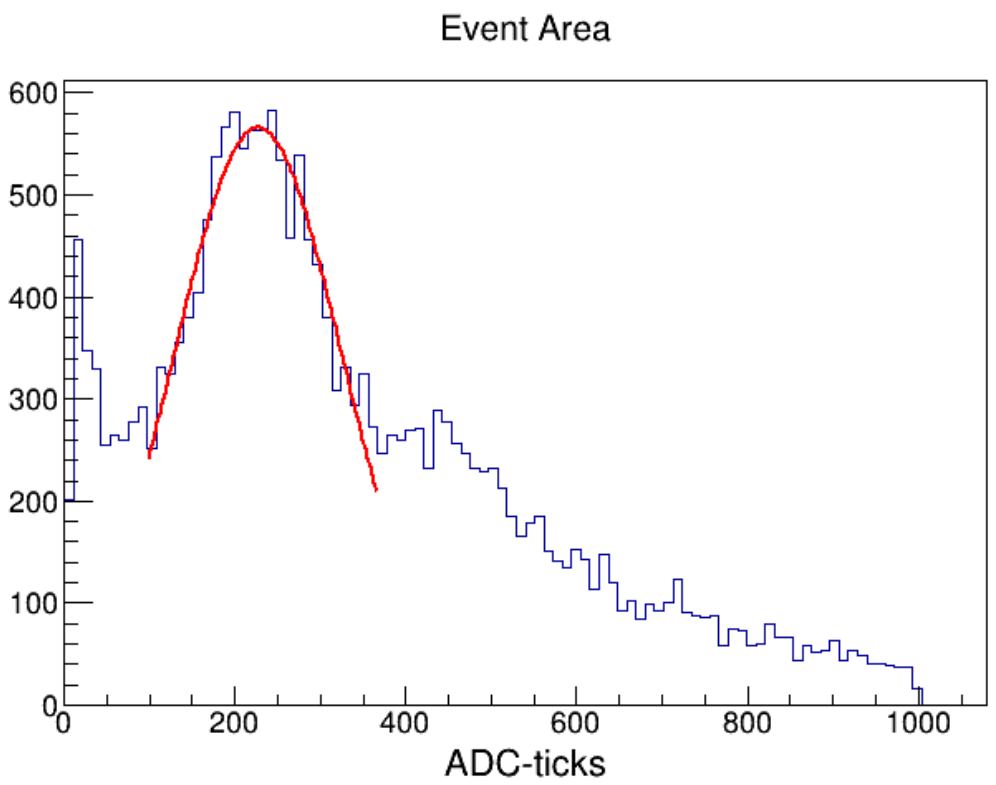


Single Photoelectron (SPE) Kernel Deconvolution

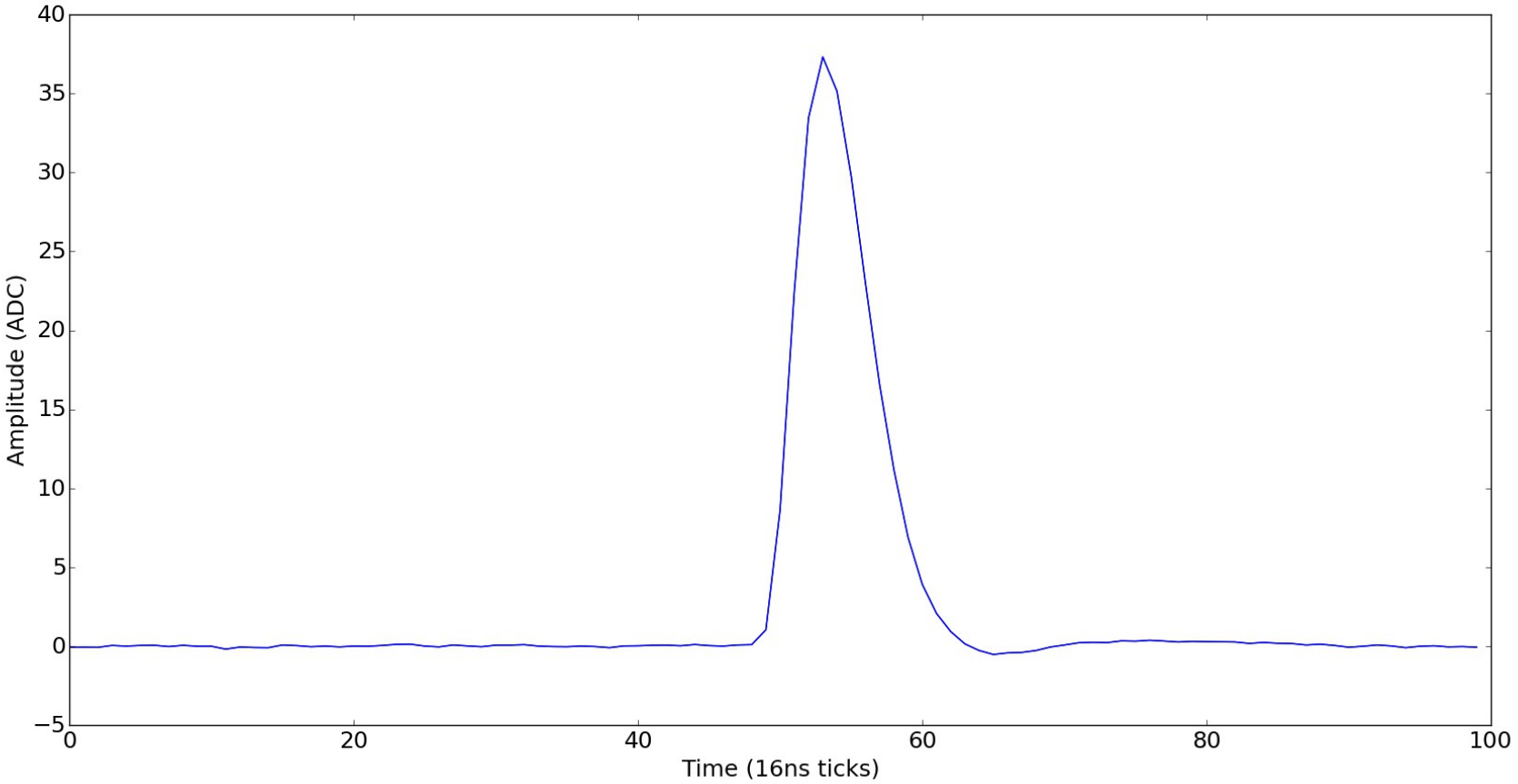
- SPE shape will smear out our distribution!
- We must deconvolve.
- We used simple SPE gaussian fits to determine +/- 1 sigma regions in which to search for SPE pulses.

SPE Kernel Deconvolution





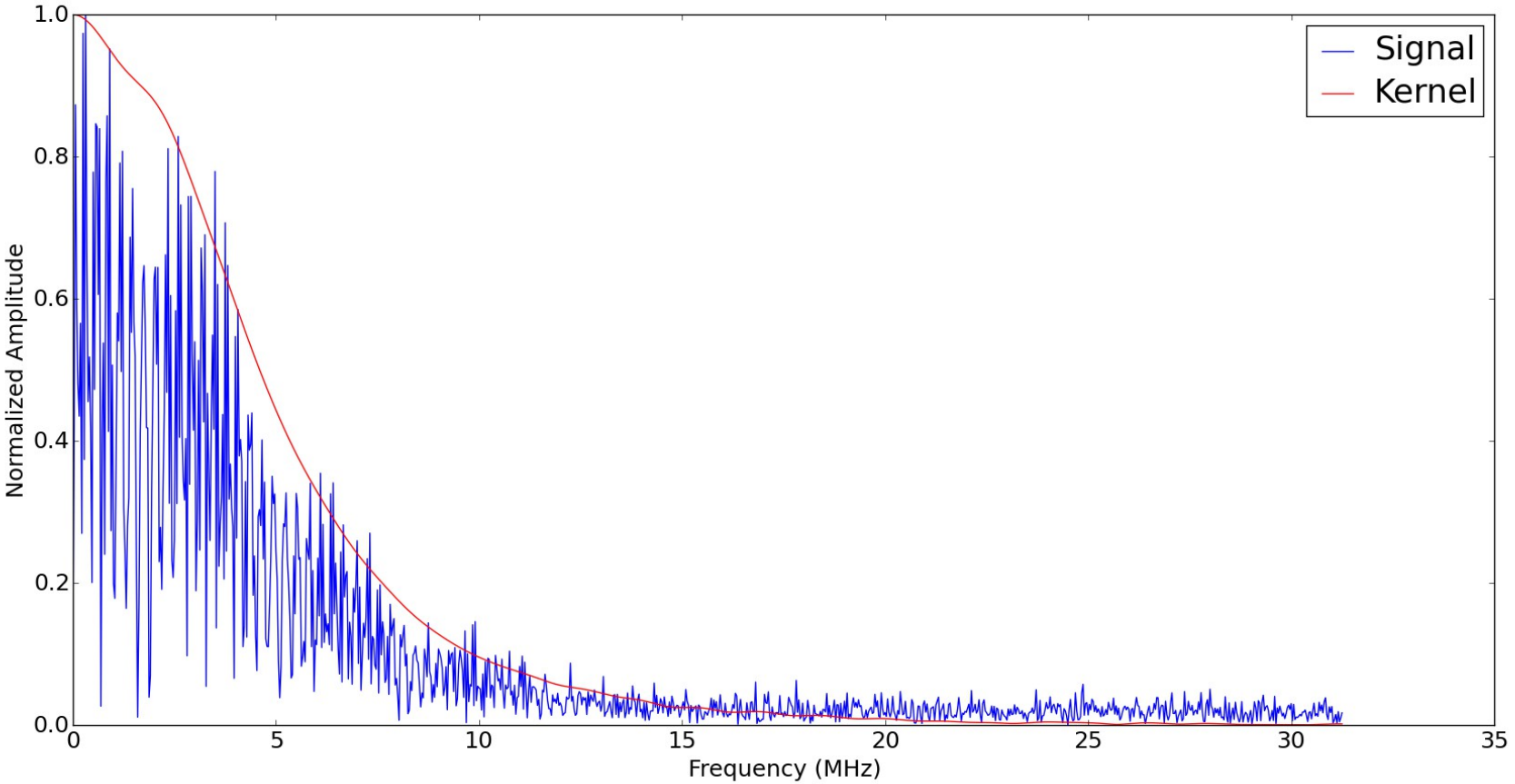
Averaged SPE Pulses



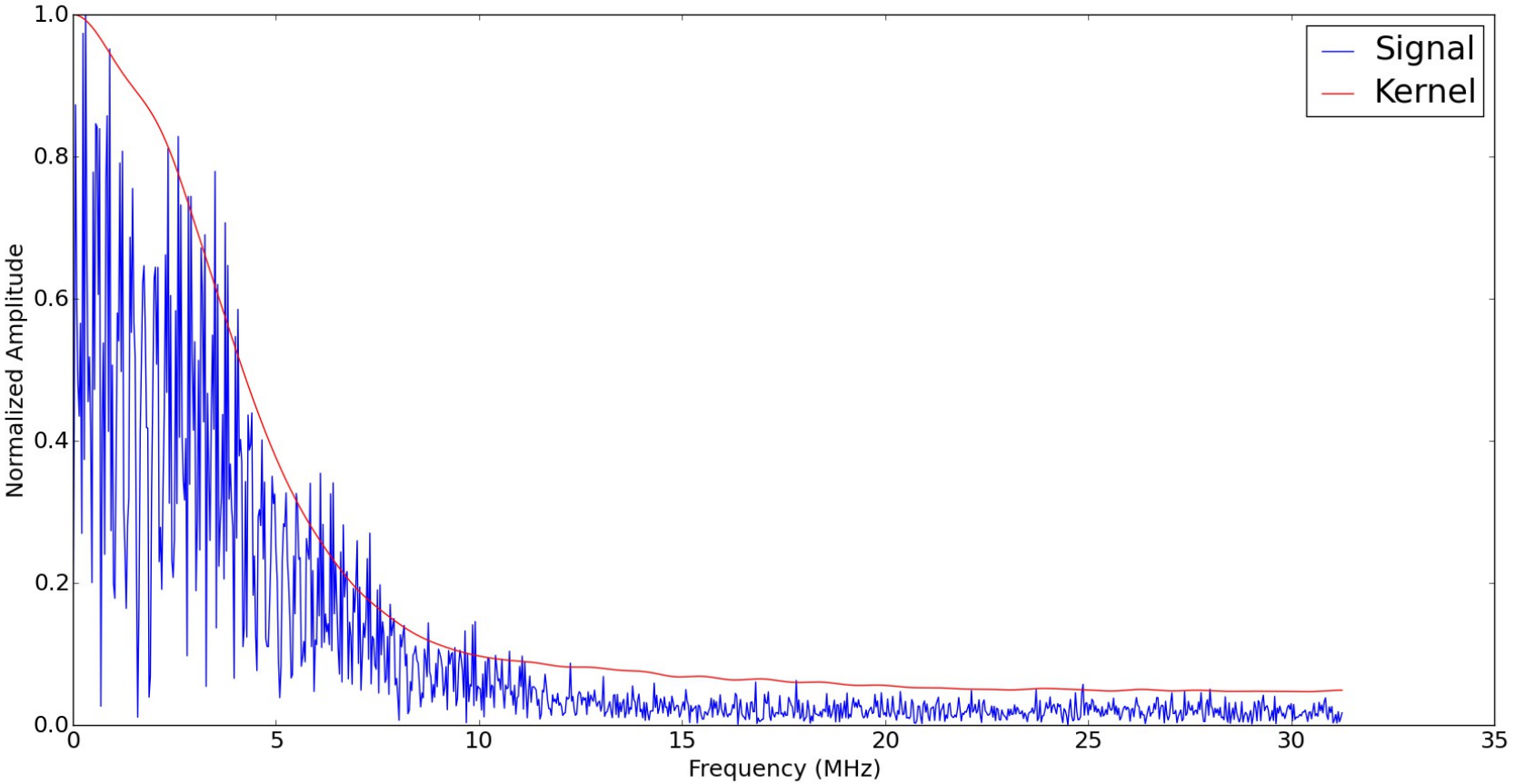
Deconvolution

- Use simple Fourier division
- Stabilize the deconvolution by padding the kernel spectrum.
- Attempted Wiener deconvolution, but it performed poorly.

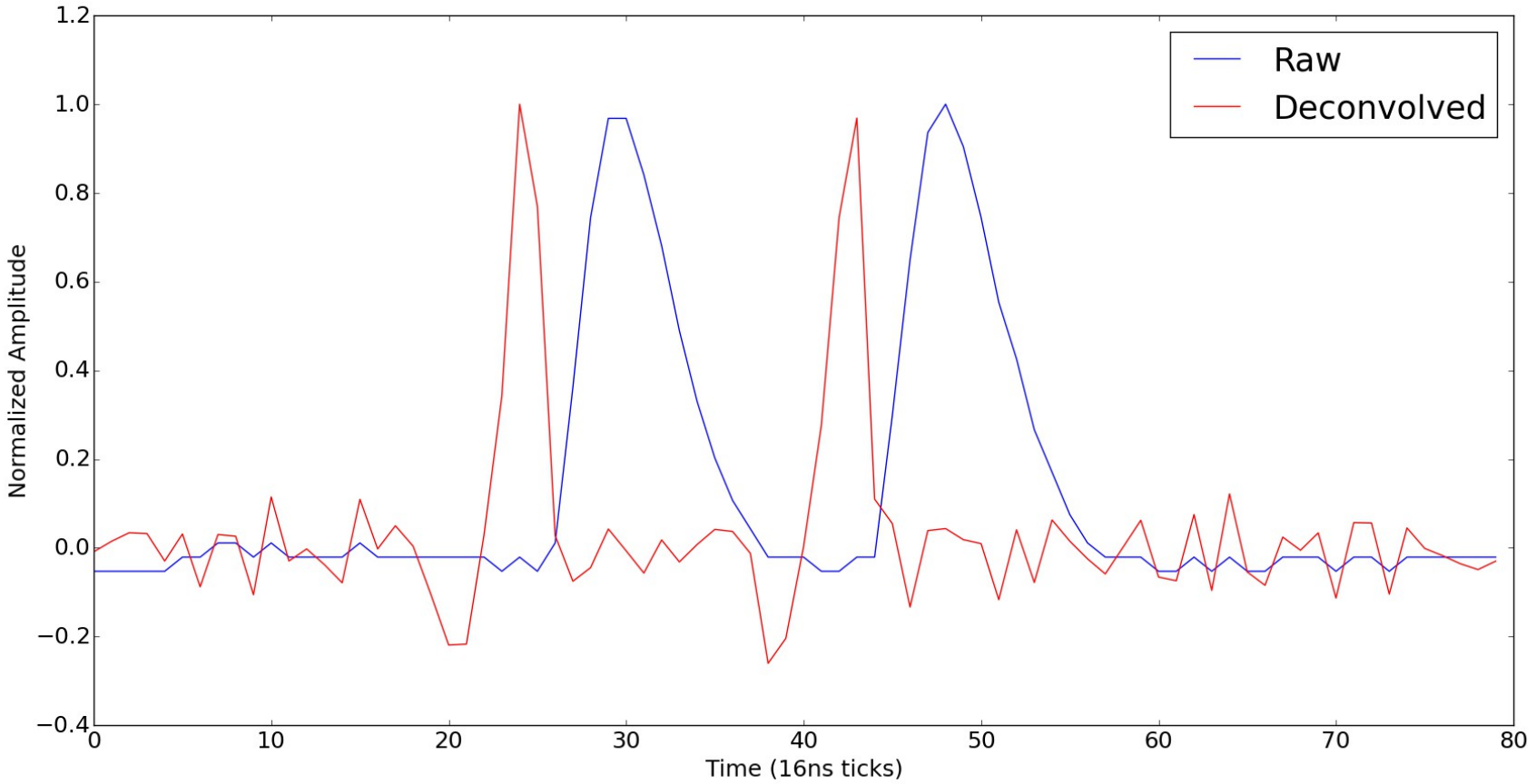
Spectra w/o Padding



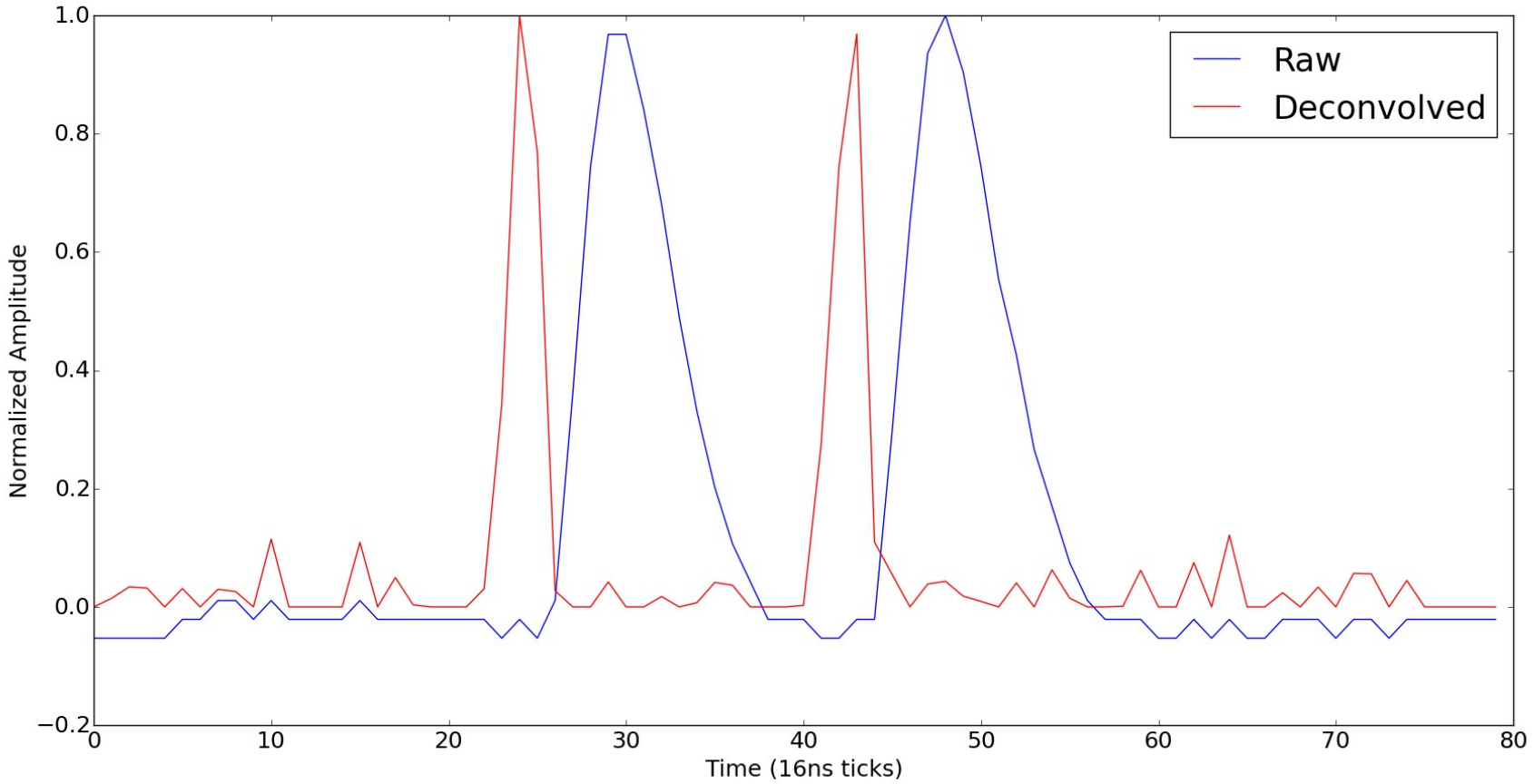
Spectra w/ Padding



Deconvolution: Simple Method



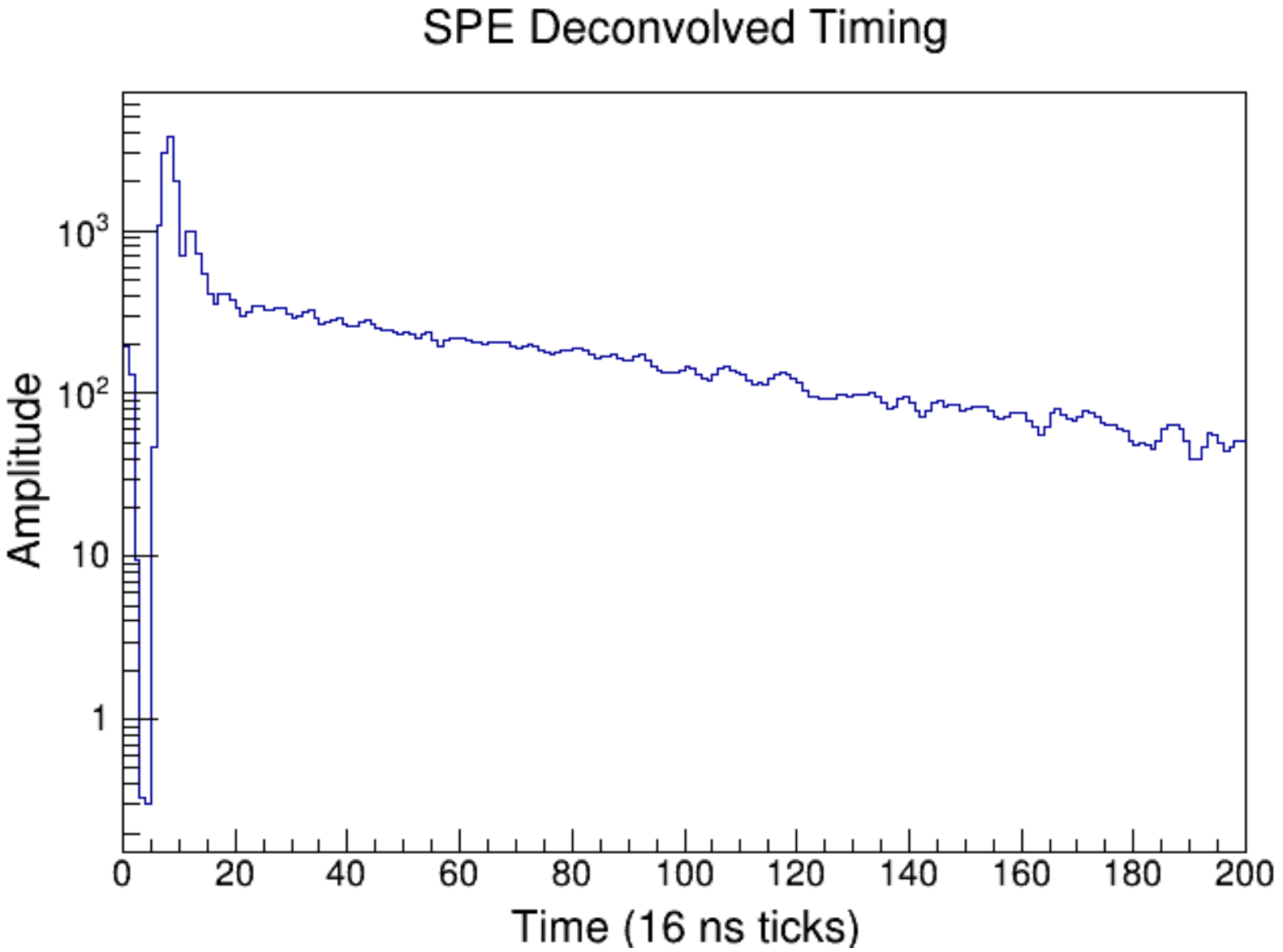
A Kludge


Raw
Deconvolved
Normalized Amplitude
Time (16ns ticks)
1.0
0.8
0.6
0.4
0.2
0.0
−0.2
0
10
20
30
40
50
60
70
80

Cuts and Alignment

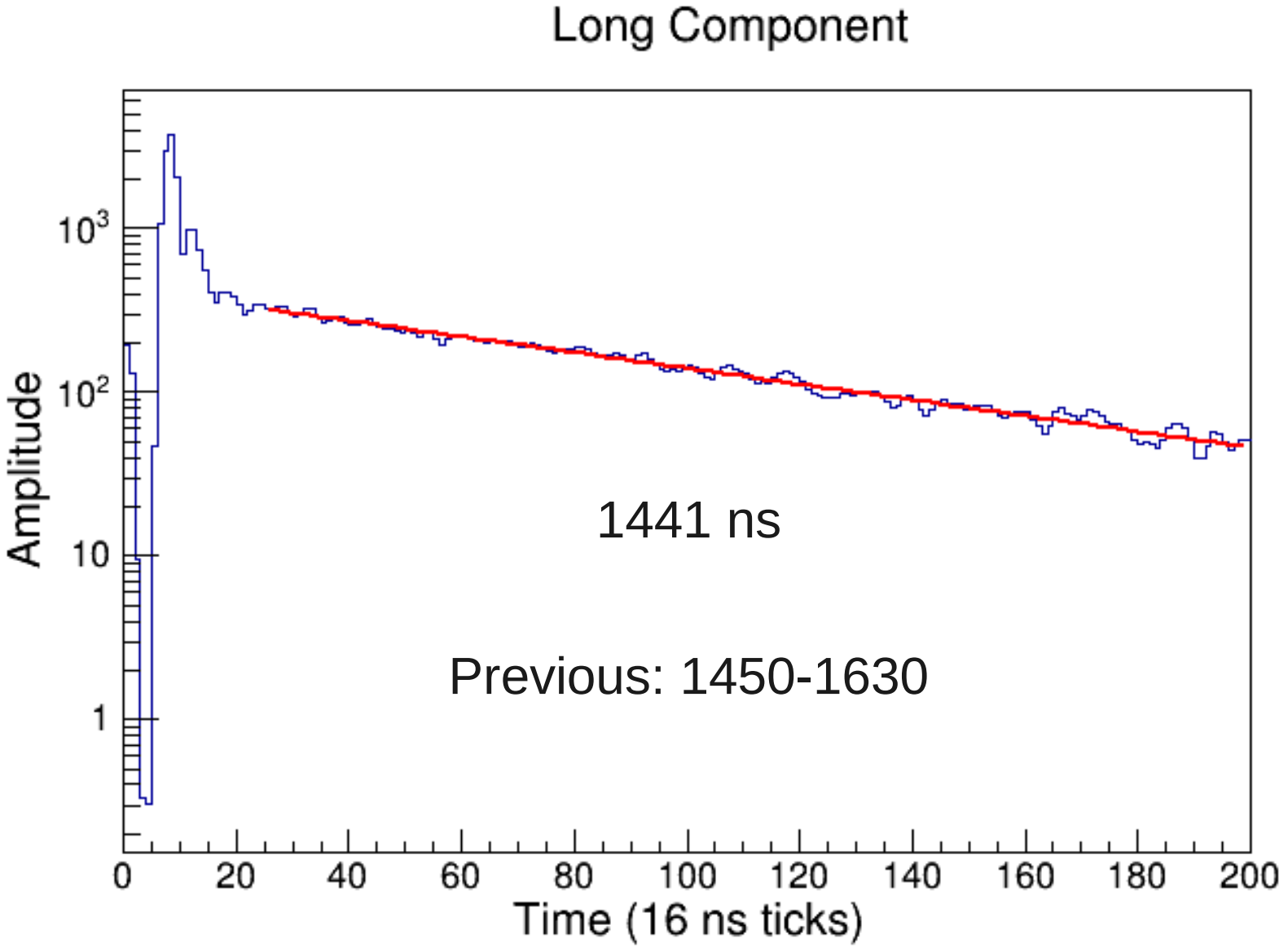
- Waveforms from ch.4 were selected if and only if they had a pulse that overlapped with a pulse from ch.13
- If the largest pulse was not first, the waveform was discarded
- The waveforms were aligned by threshold crossing time of the first pulse.
- Waveforms were then deconvolved and summed.

Summation

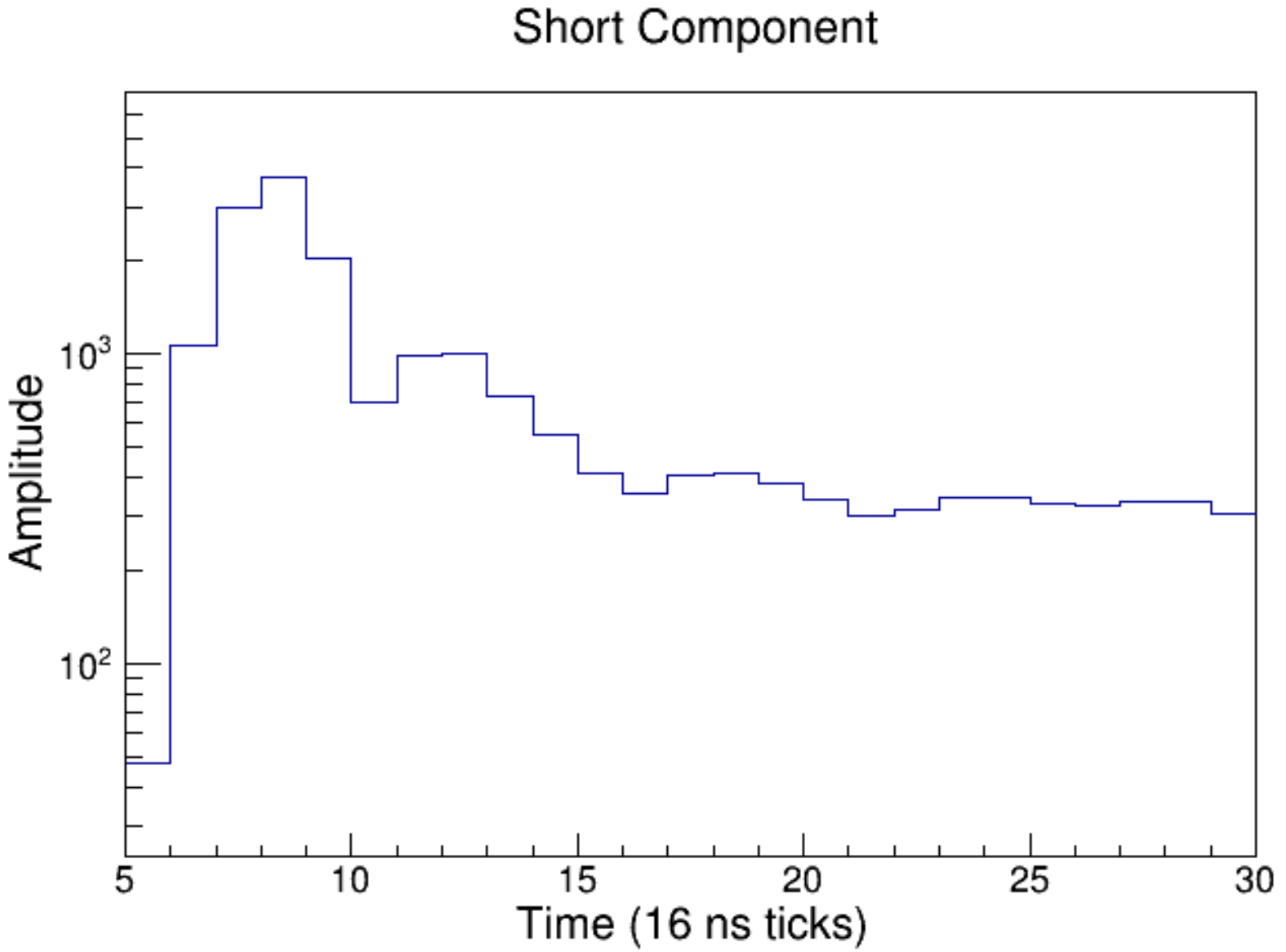


1077 cosmic waveforms

Long Component (Late Light)



Short Component?



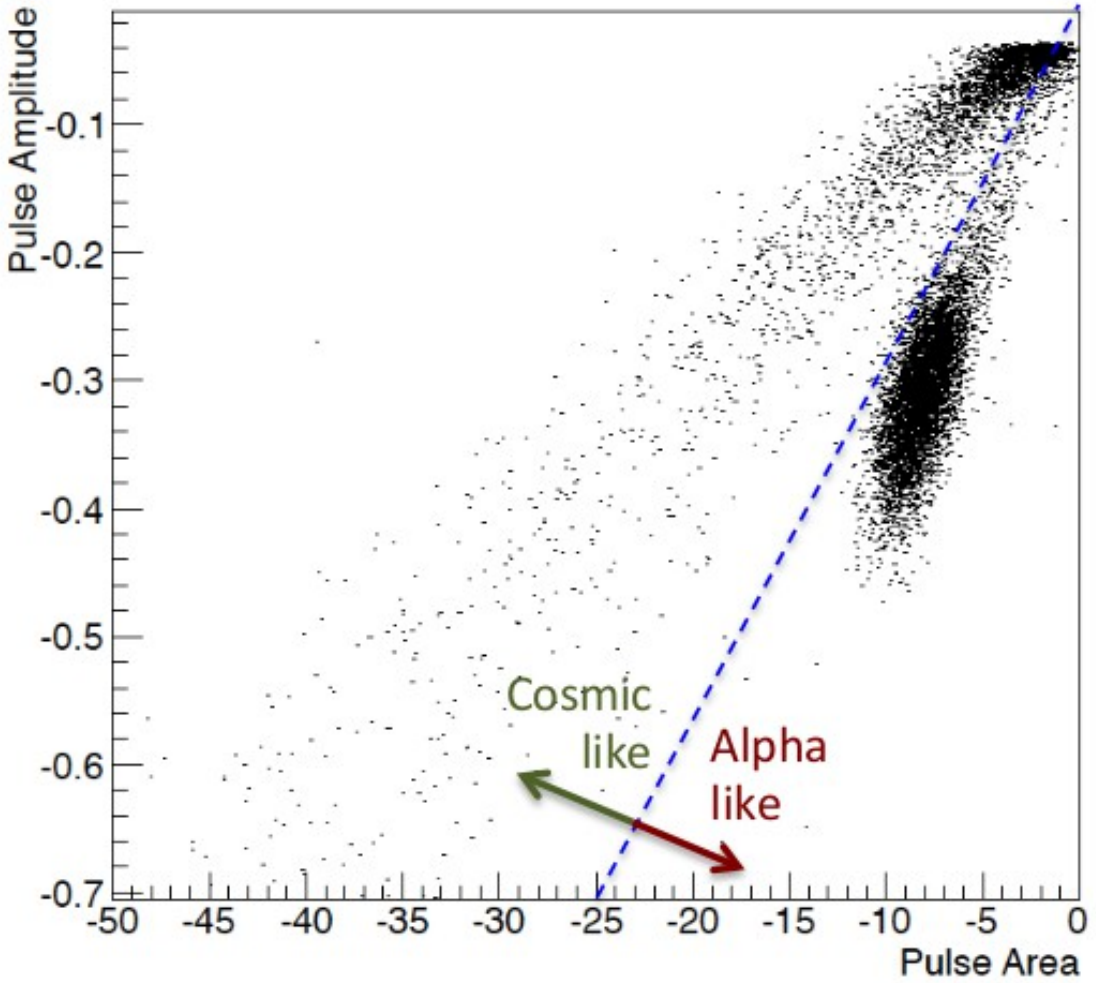
Deconvolution with 2.8 ns gaussian

- We've deconvolved the PMT signals with the SPE kernel, but there is a latent effect from the transit time spread of the PMTs.
- Characterized by a gaussian with 2.8 ns width.
- Attempted interpolation and deconvolution. No difference in late component, small variation in early behavior.

What Next?

- Is the bump from nonlinear PMT response?
- Do we have the requisite resolution to resolve the 6ns component? Can we do it with oscilloscope data?
- Collect a large set of cosmics and look for pulse shape distributions. Can we distinguish protons from muons?

What's Next?

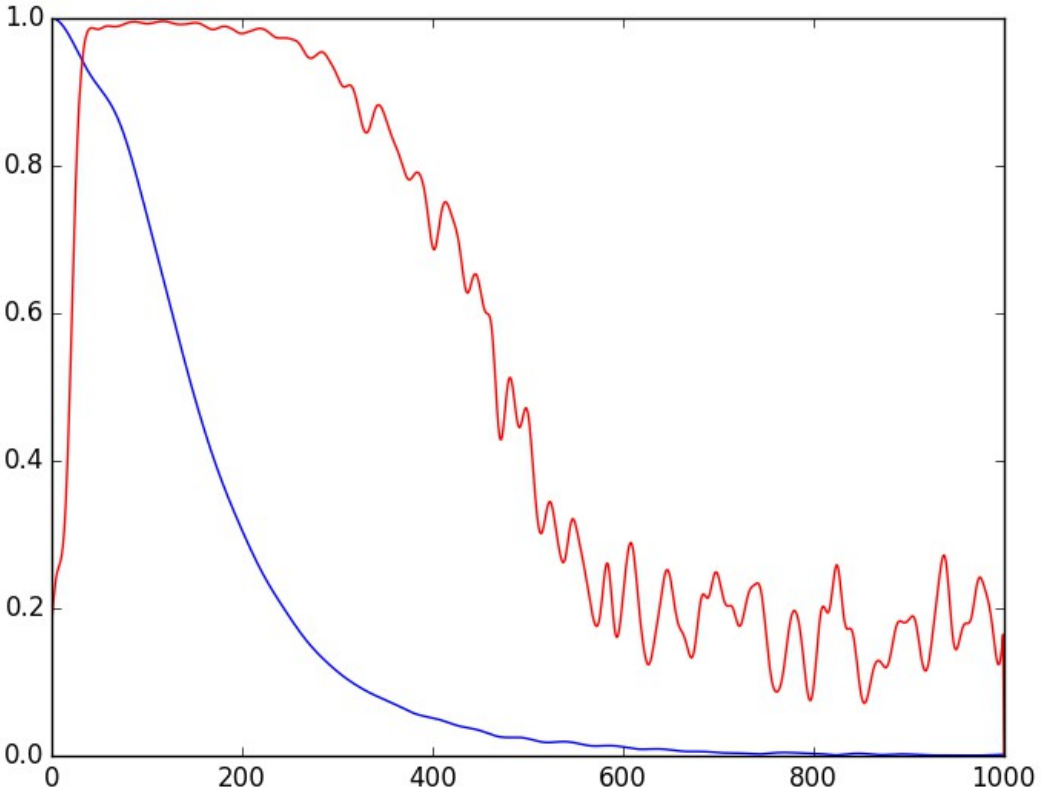


B.J.P. Jones, C.S. Chiu,
et. al. arXiv:1306.4605

Thank you!
Questions?

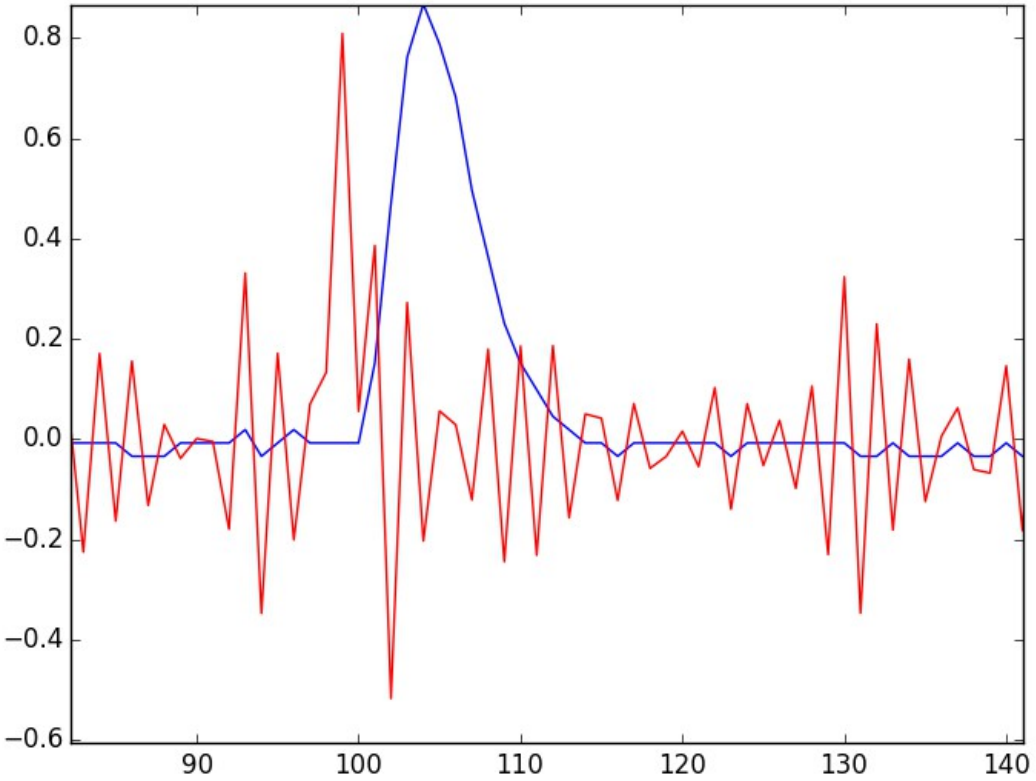
Backup Slides

Wiener Filter



In blue: the amplitude of the kernel FFT. In red: The wiener filter. The filter was so noisy that I had to use a gaussian smoothing algorithm. The brilliance of Wiener is that the filter attenuates the signal in the regions where the kernel is small and causes division errors.

Noisy!



Despite much tinkering, I could never get the wiener deconvolution method to outshine the simple fourier division!

Raw Superposition