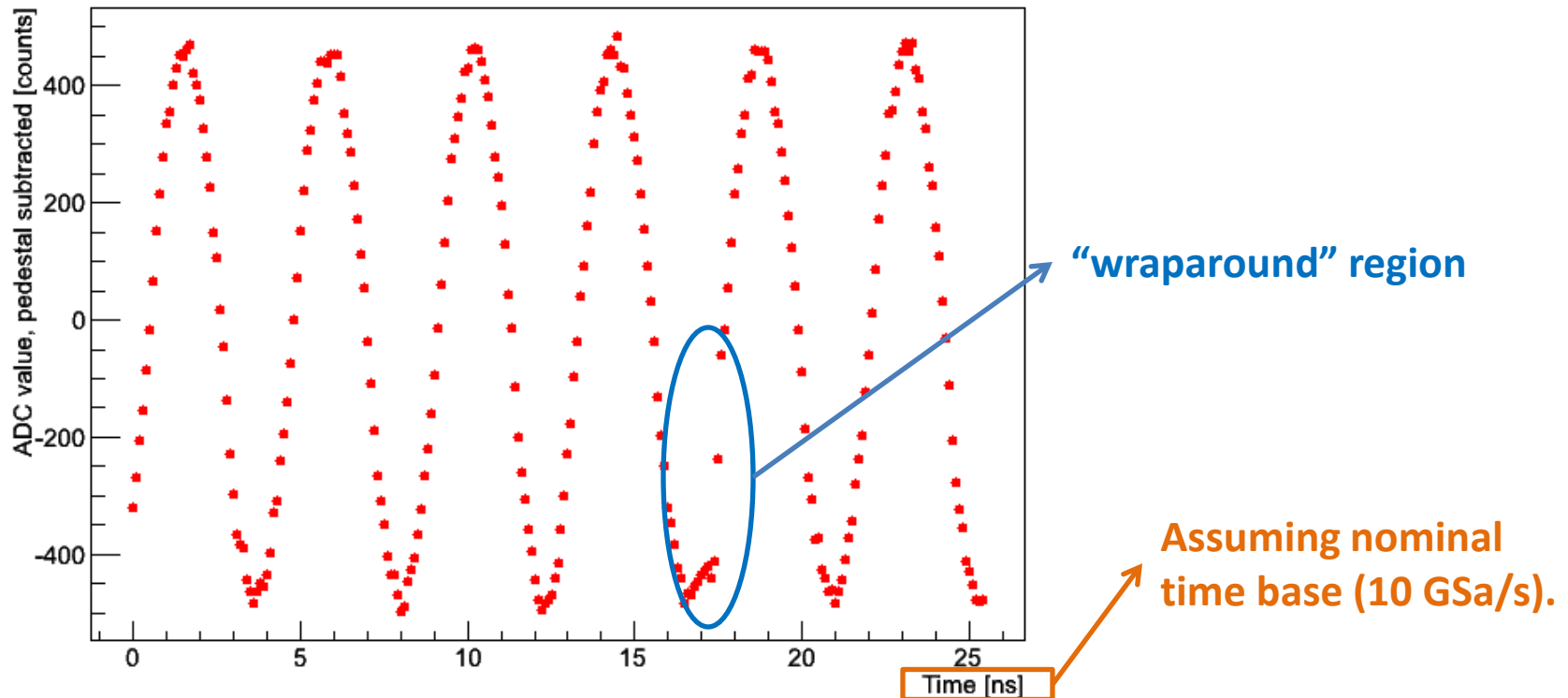# PSEC4 Timing Analysis

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Data Sample

- Data sent by Eric on September 29, 4 files:
  - All at ~10 GSa/s
  - CH3: 240 MHz sine wave input, 2000x2 events
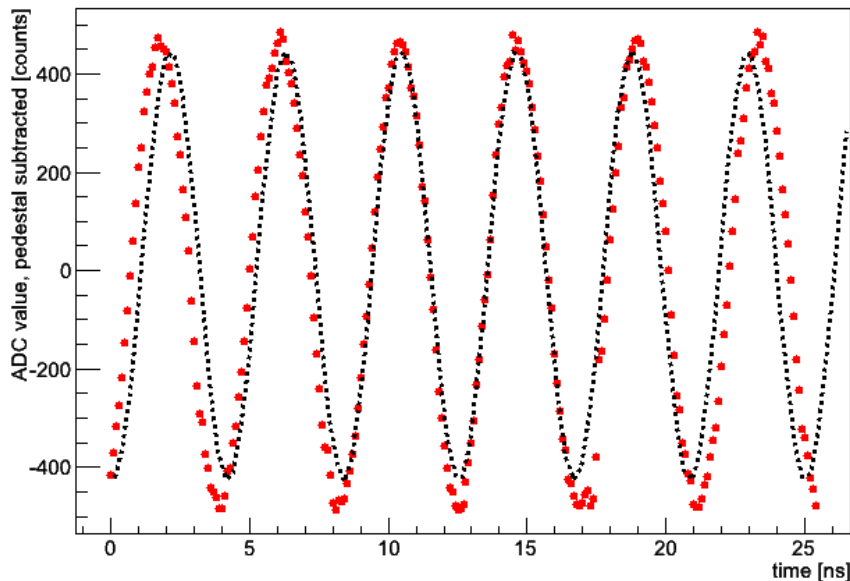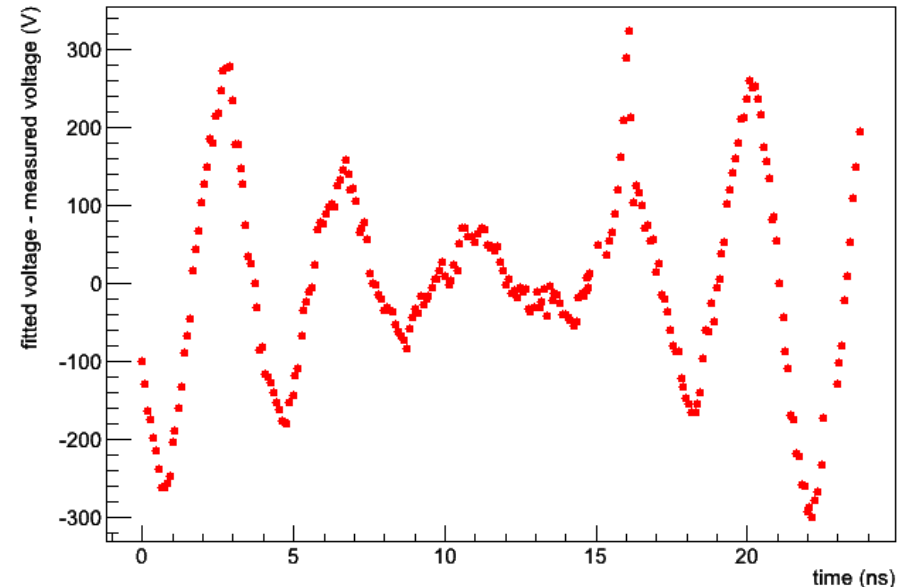 - CH4: 240 MHz sine wave input, 2000x2 events

<u>Example event:</u>

"wraparound" region

Assuming nominal time base (10 GSa/s).

Raw Data, Fitted to Sine Wave

- Fit to a waveform with a sine wave:
  - Fixed: input frequency
  - Floated: DC offset, amplitude, phase
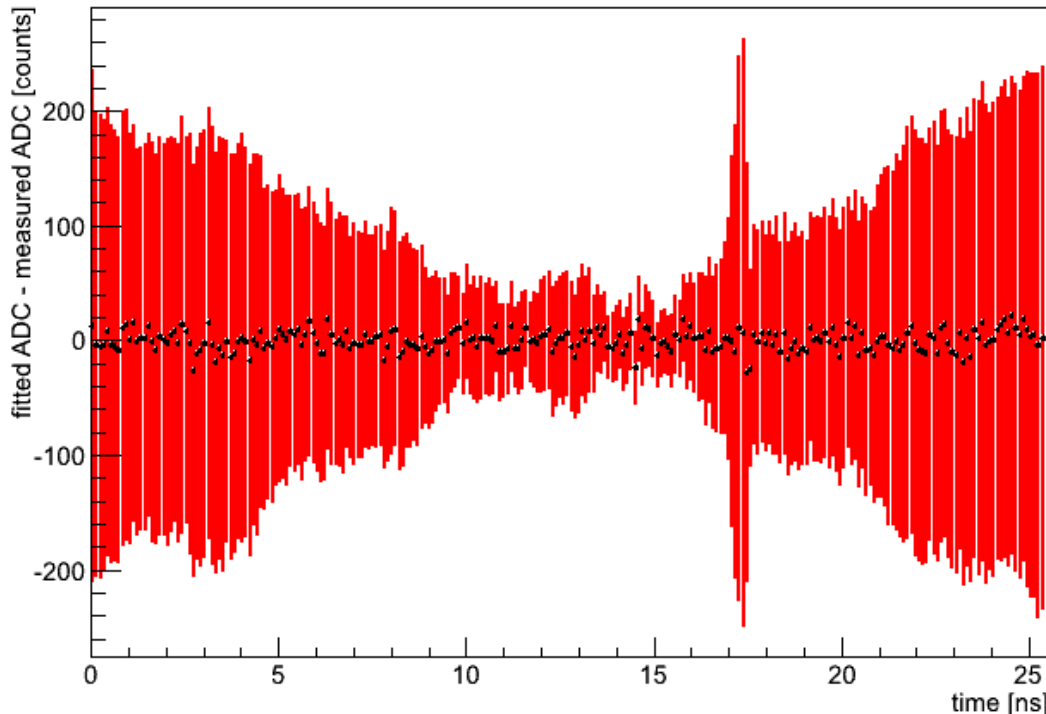
Example fit result:

Example fit residuals:

Raw Data, Fitted to Sine Wave

- Fit to a waveform with a sine wave:
  - Fixed: input frequency
  - Floated: DC offset, amplitude, phase

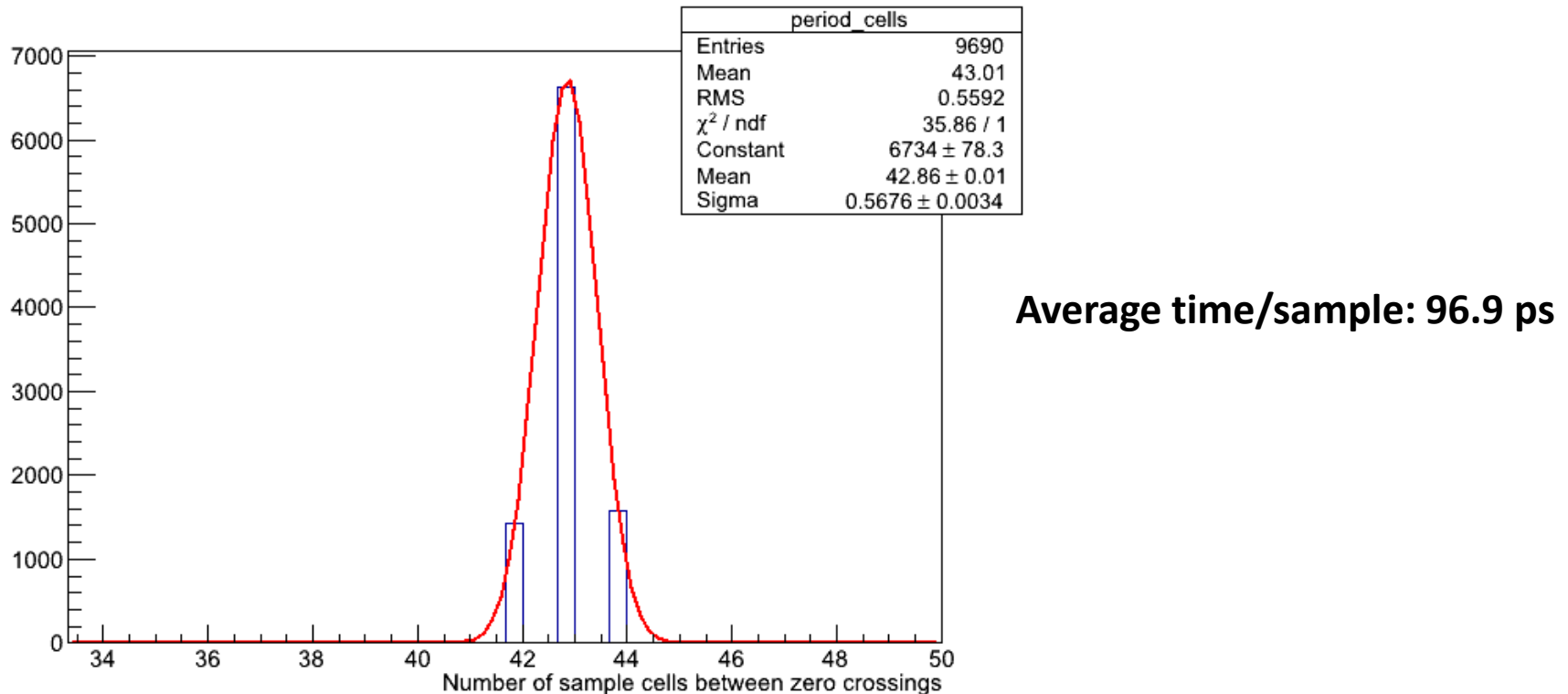**Profile of fit residuals for 2000 events**:

Black points – mean value of residuals over 2000 events

Red bars – RMS of residuals over 2000 events

Two observations:
1. Time base seems to require an overall correction.
2. Residuals near center of window seem better behaved.

4

Simple Time Base Calibration

- Count number of sample cells between zero crossings*. Calculate average time/sample.

period_cells	
Entries	9690
Mean	43.01
RMS	0.5592
χ^2 / ndf	35.86 / 1
Constant	6734 ± 78.3
Mean	42.86 ± 0.01
Sigma	0.5676 ± 0.0034

Average time/sample: 96.9 ps

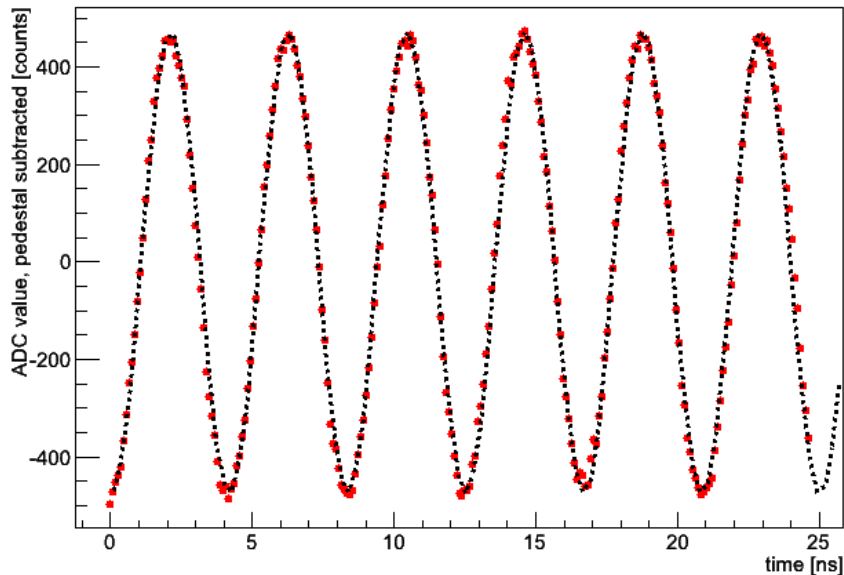Number of sample cells between zero crossings

*Using samples 0-150 to avoid "wraparound" (average time/sample: 96.4 ps if all samples are used).
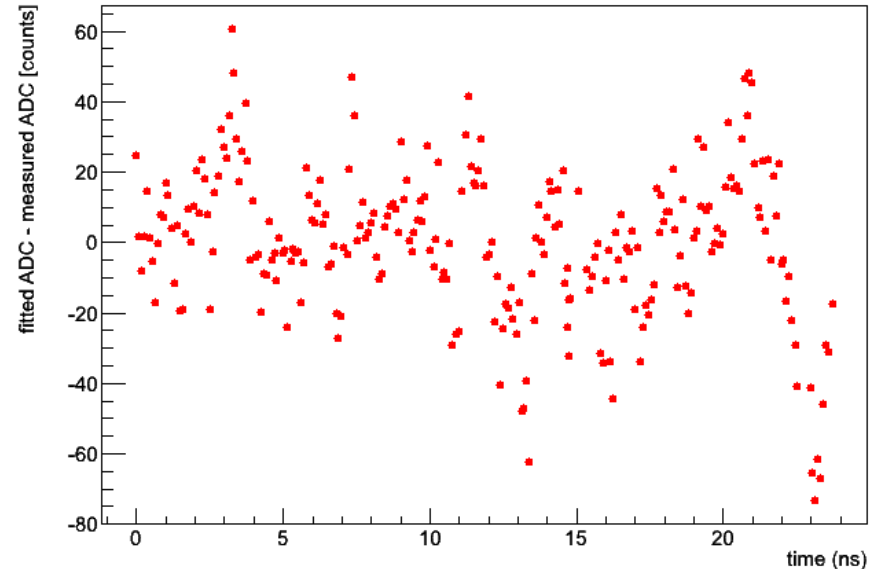
Sine Wave Fits w/ Corrected Time Base

- Refitted with new average Δt, no sample-to-sample corrections.
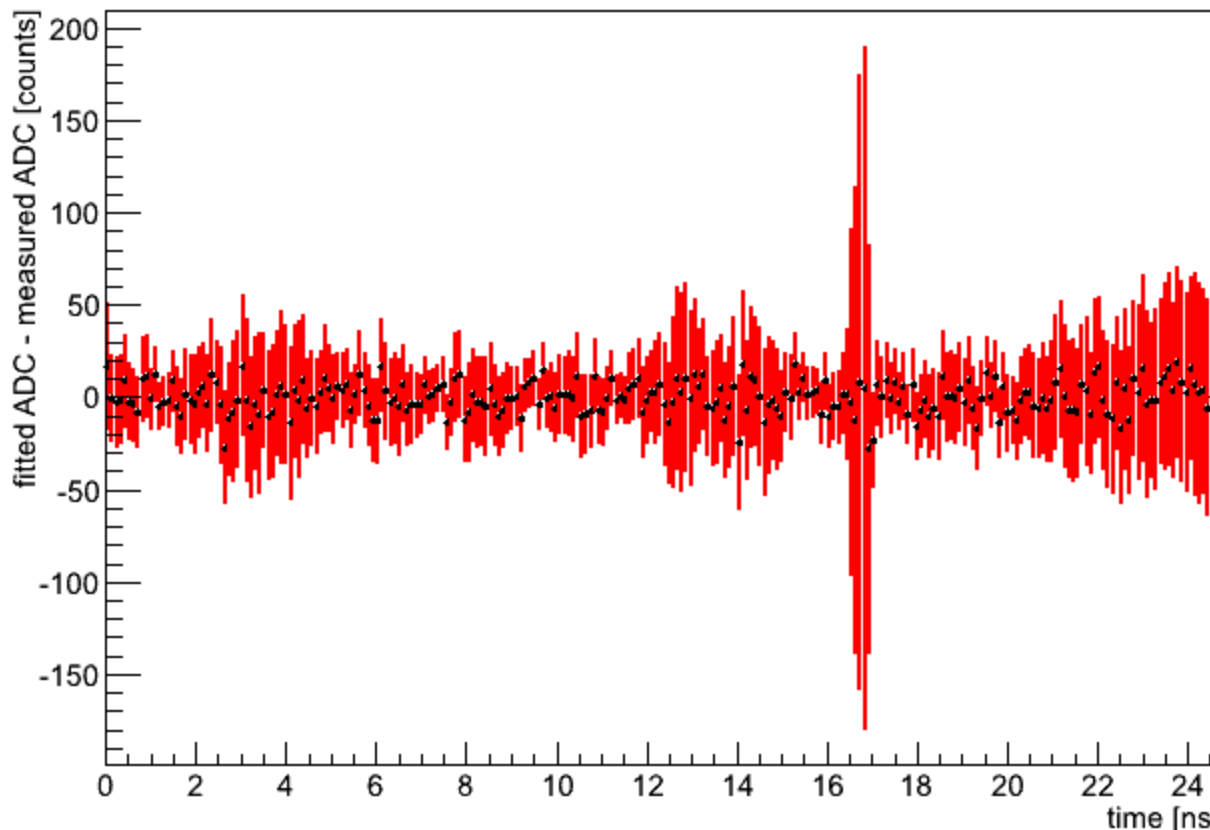
Example fit result:

Example fit residuals:

Sine Wave w/ Corrected Time Base

- Refitted with new average $\triangle t$, no sample-to-sample corrections.

Profile of fit residuals for 2000 events:

Black points – mean value of residuals over 2000 events
Red bars – RMS of residuals over 2000 events

Wraparound still fits poorly, as expected.
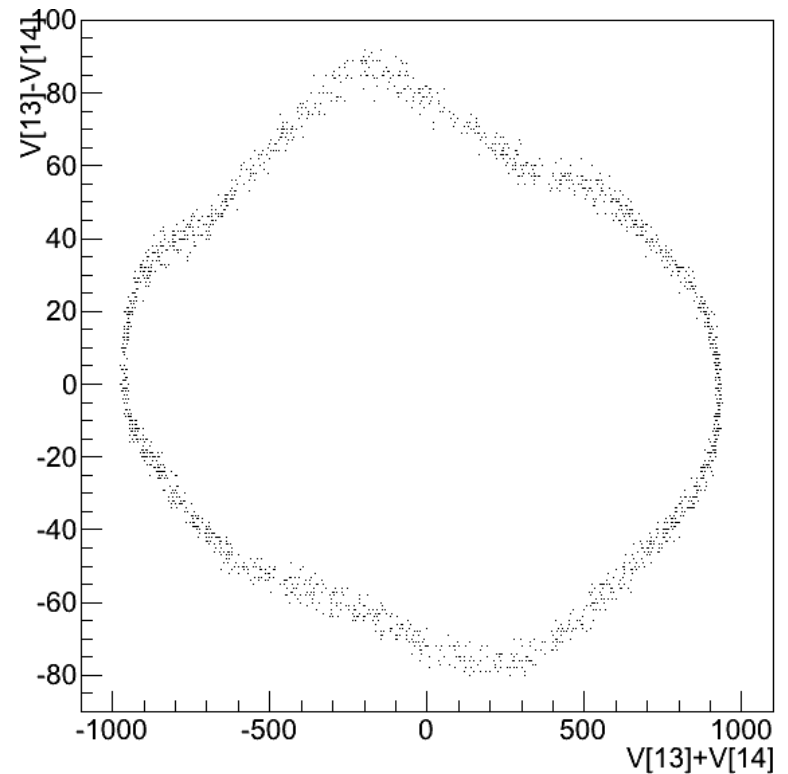Some smaller scale structure persists as well.

➔ **Overall significant improvement in fit quality!**

What about ellipse method…?

- Ellipse fits w/ cells one-apart are complicated by strange contours:
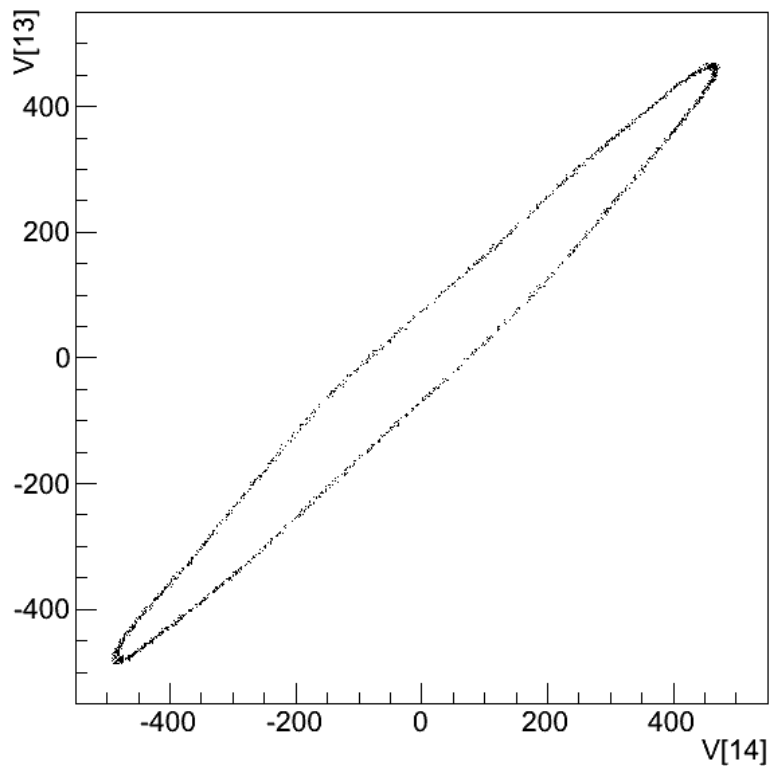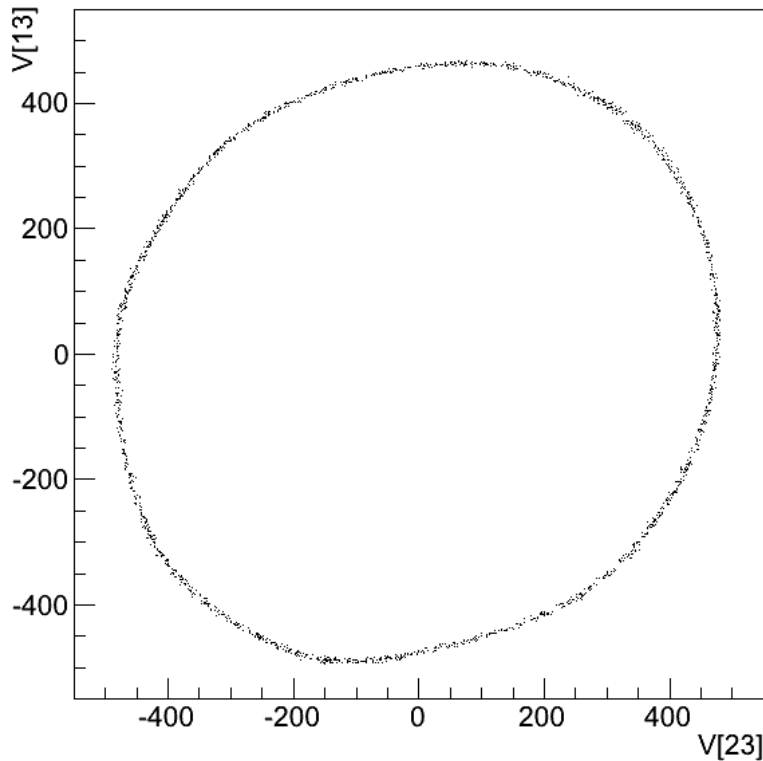

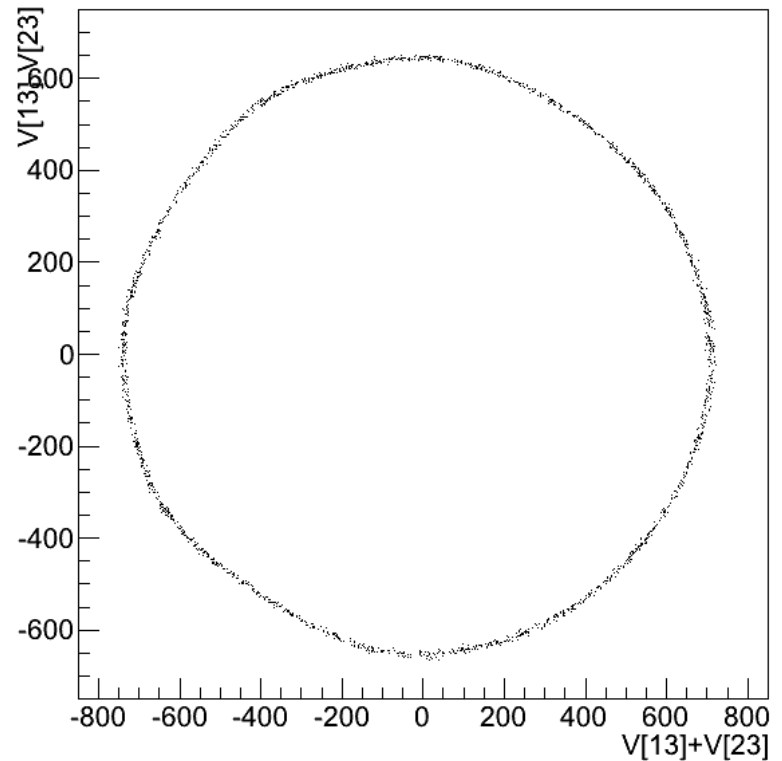Cell 13 vs. Cell 14

Cell 13, 14: difference vs. sum

Is this nonlinearity? Correlated noise? Something else?
Can try applying nonlinearity correction, if available.

Ellipse Plots 9,10 Samples Apart

- Not as obviously misbehaved:
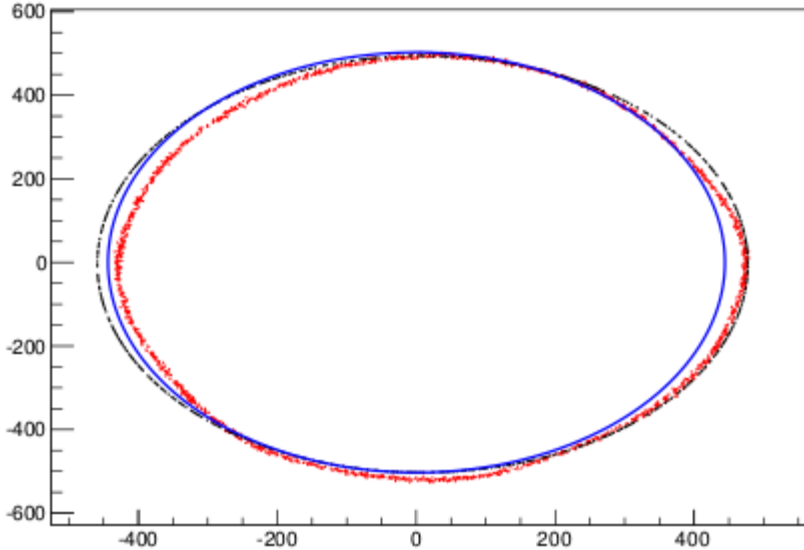

Cell 13 vs. Cell 23
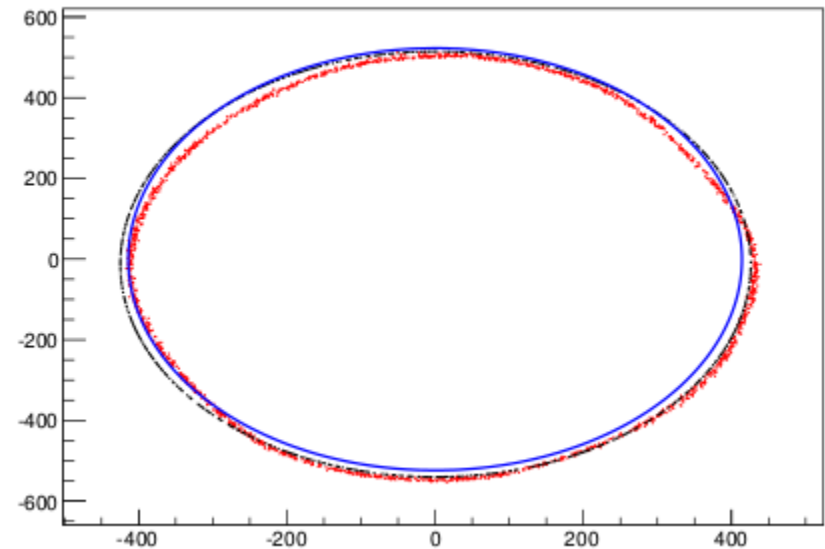

Cell 13, 23: difference vs. sum

Fits to 9,10 Apart Contours

- Fits (assuming gain = 1 for all cells) are fairly well behaved (not too many fit failures), but they clearly miss some features of the data.
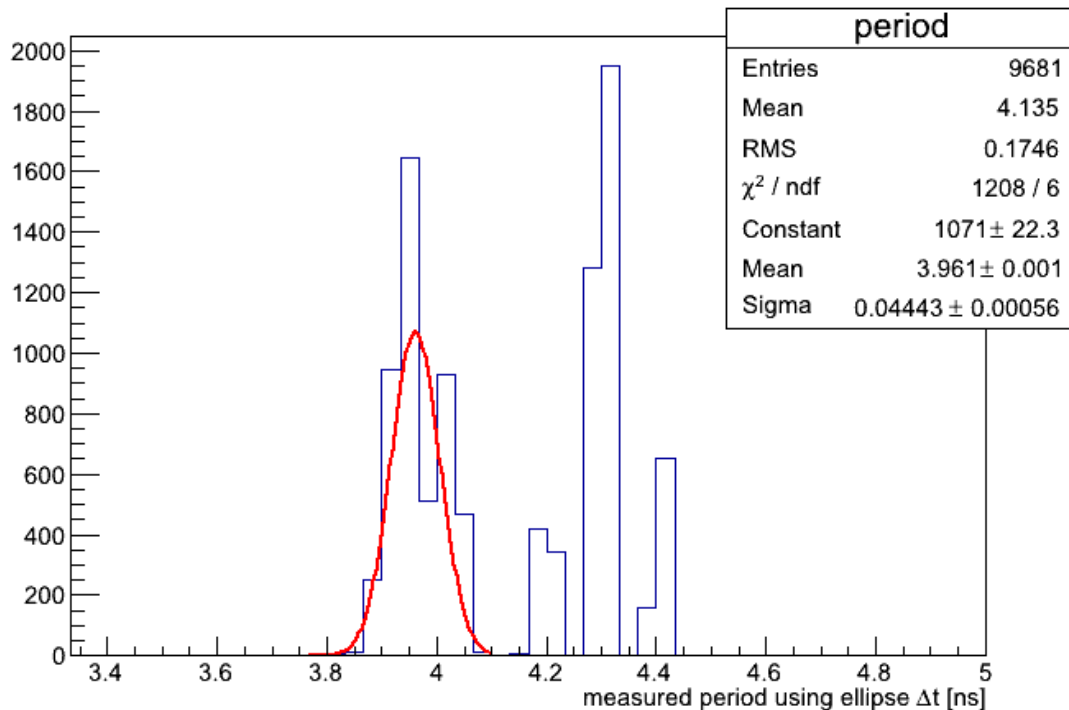

samples 35 and 45

samples 36 and 45

Red – data points, black – nominal 10 GSa/s contour, blue – fitted contour

Cross Check on Ellipse Fits

- Measured period using Δt values from ellipse fits:

True T @ 240 MHz = 4.17 ns

Mean shows something near this value, but only due to some cancellation between different populations.

Summary & Plan

- Sampling rate appears to be slightly faster than 10 GSa/s.

  - Making this correction cleans up data quite a bit.

- For finer corrections, sample-to-sample $\triangle$t:

  - Can perform zero-crossing analysis, but may need more data. (Will try with what I have, first.)

  - Ellipse fitting will require better understanding of "kinks" in plots. As a first pass, I would like to try correcting out nonlinearity.