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Title: PowerPoint: Automated Ultrasound Data Acquisition and Analysis

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Automated Ultrasound Data Acquisition and Analysis

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Outline

- Background and Motivation
- Handyscope HS5 and Setup
- Waveform Generation
- Data Acquisition
- Data Analysis
- Results
- Applications

Background and Motivation

- Ultrasound characterization
  - fast and noninvasive
- Waveform generators and oscilloscopes are large and heavy
  - lack mobility required for portable use in field experiments
- Different scenarios require different waveforms and parameters
  - flexible software with greater user control

Background and Motivation

- Real-time data analysis
  - Saves time from manual data processing
  - Enables real-time monitoring and response
- Dynamic Systems
  - Quickly evolve over time
  - Can be studied using continuous fast ultrasound measurements

Handyscope HS5 and Setup

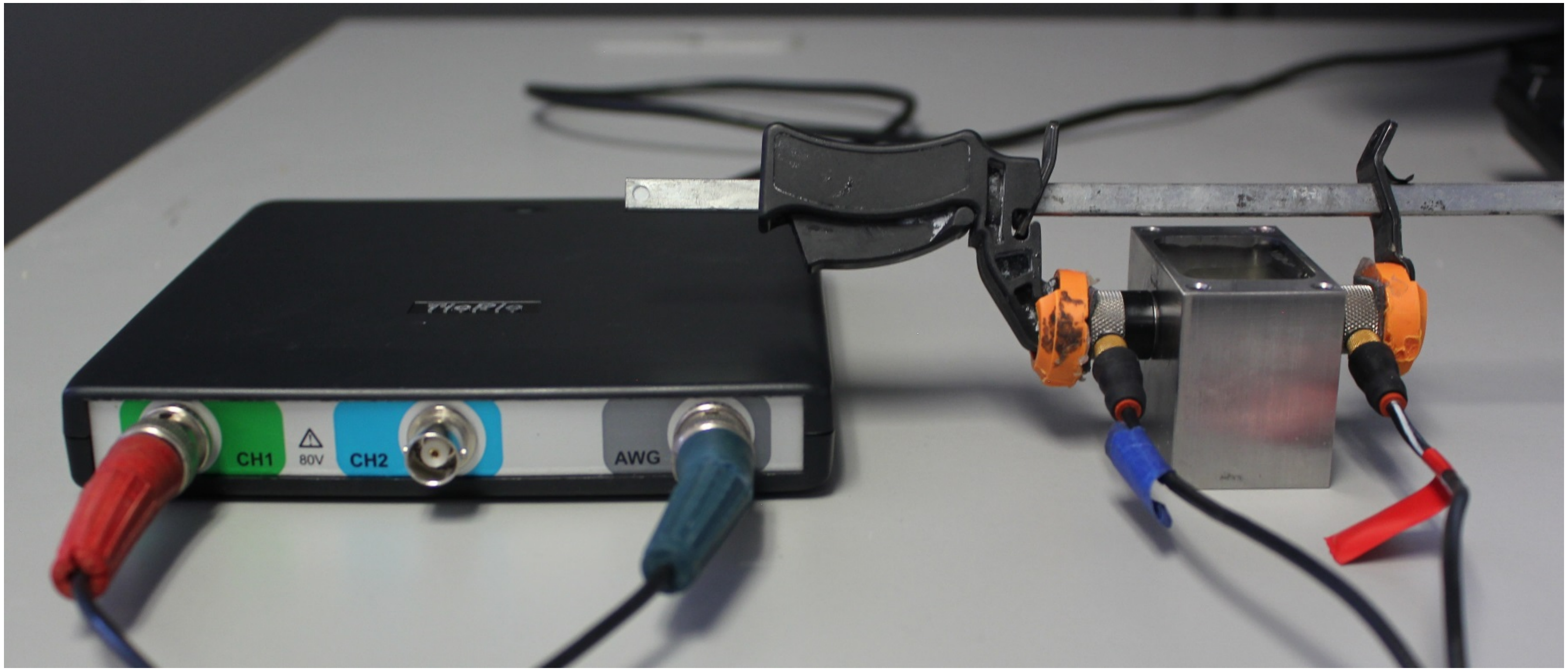


Figure 1: Blue tagged wire leads from AWG to transducer. Red tagged wire leads from receiver to Ch1.

Waveform Generation

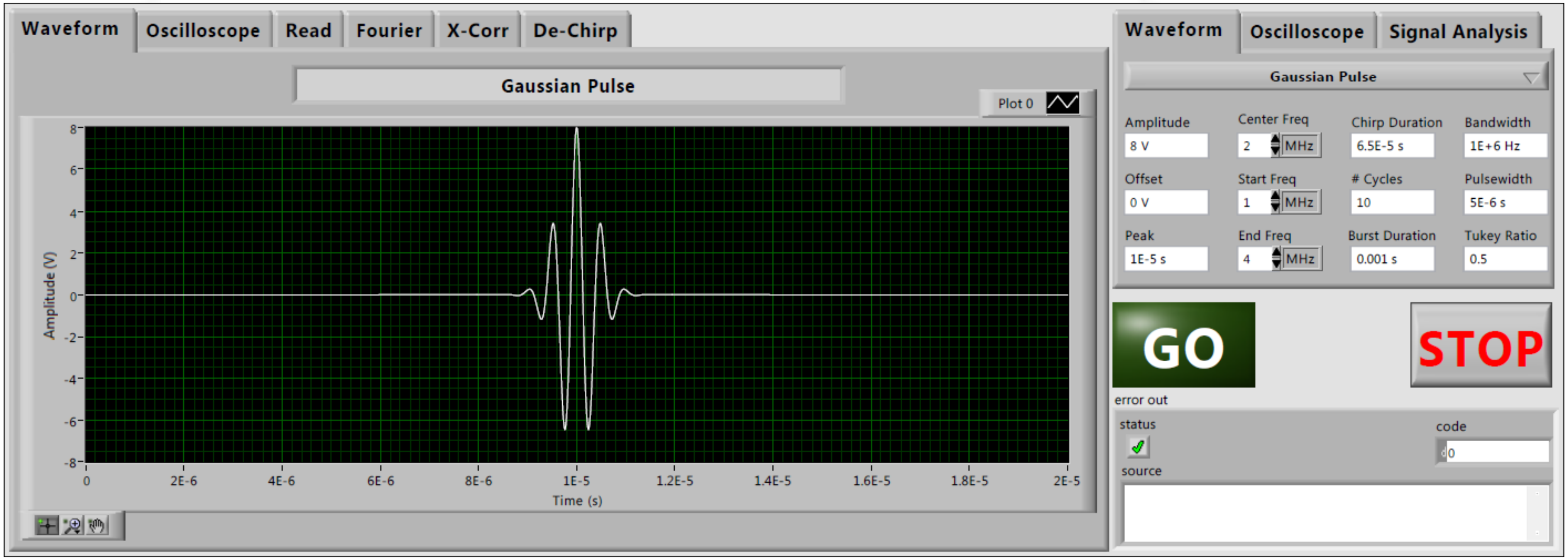


Figure 2: A Gaussian Pulse is one of the common waveforms used to characterize media

Waveform Generation

- Arbitrary Waveform
  - any user defined shape
  - limited only by physical constraints
- New waveforms are easily added if needed

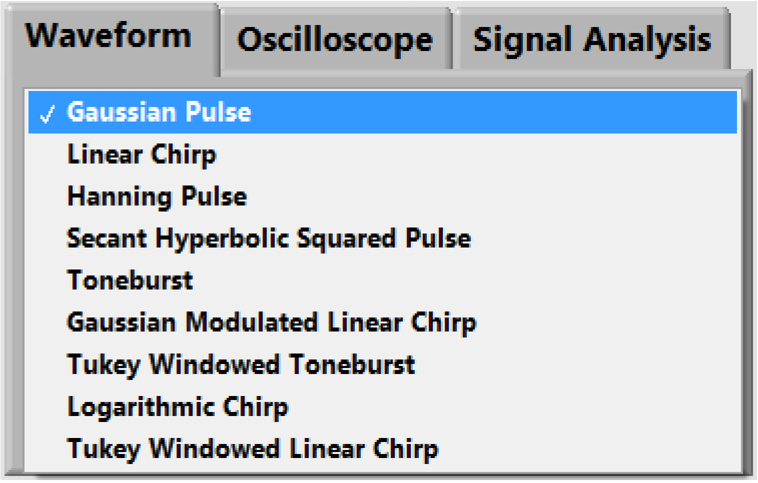


Figure 3: Currently, we have implemented 9 waveforms.

Data Acquisition

- User controls sampling frequency and sample size
- Averaging to reduce random noise
- Data saved in a binary format
  - Memory efficient
- Saving speed (for shown setup):
  - No averaging: 0.447 ms/file
  - 10 wvfms: 3.71 ms/file
  - 100 wvfms: 37.6 ms/file.

Data Acquisition

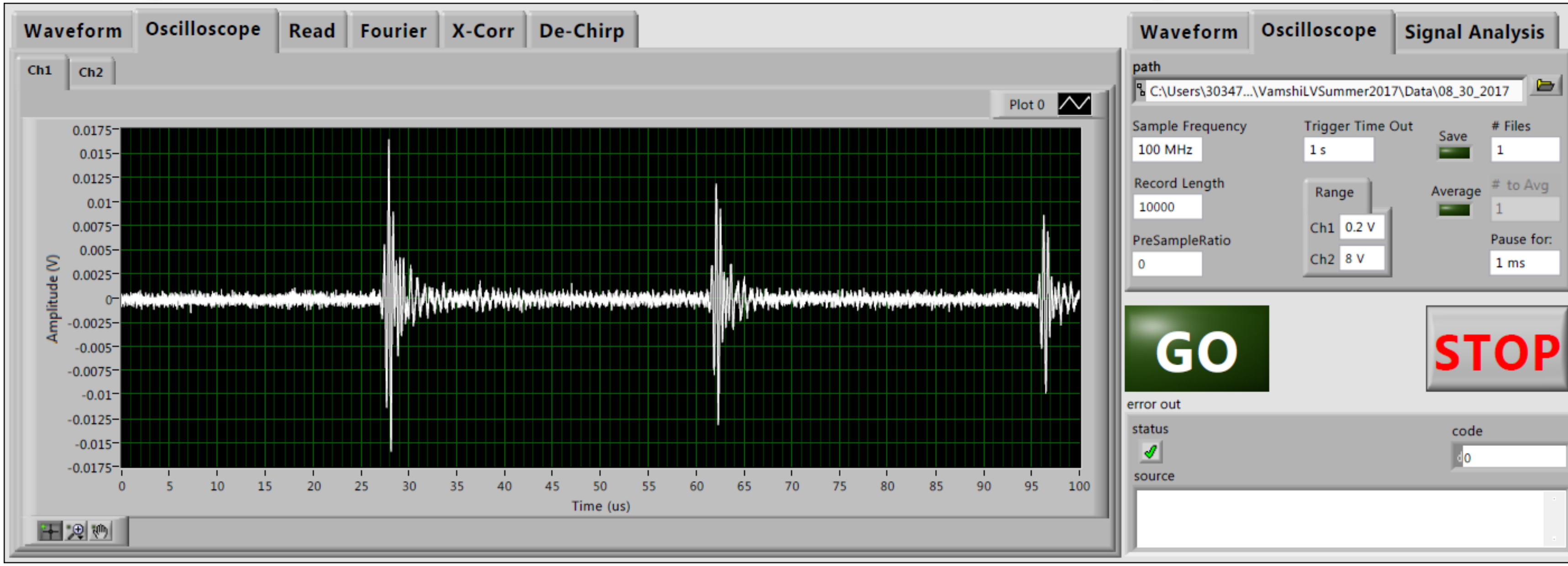


Figure 4: An oscilloscope Channel 1 measurement sampled at 100 MHz for 100 s shows the initial arrival followed by two reflections.

Data Acquisition

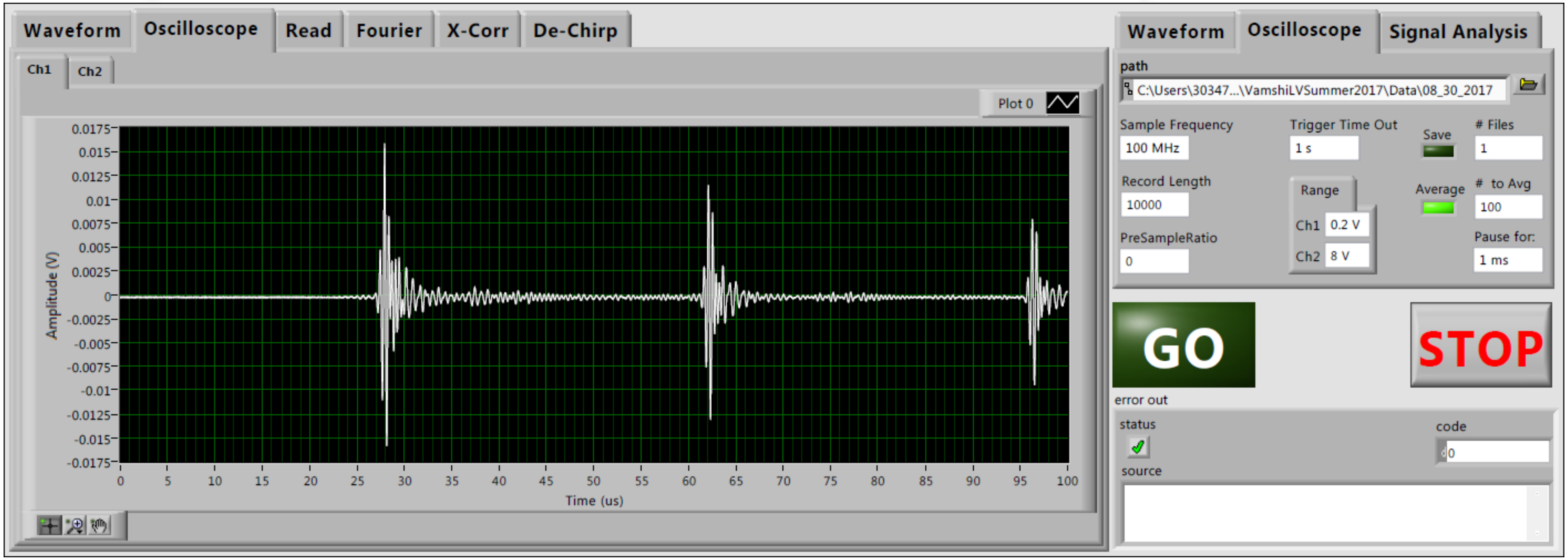


Figure 5: Averaging over 100 waveforms noticeably reduces random noise, producing a clearer signal.

Data Analysis: Frequency

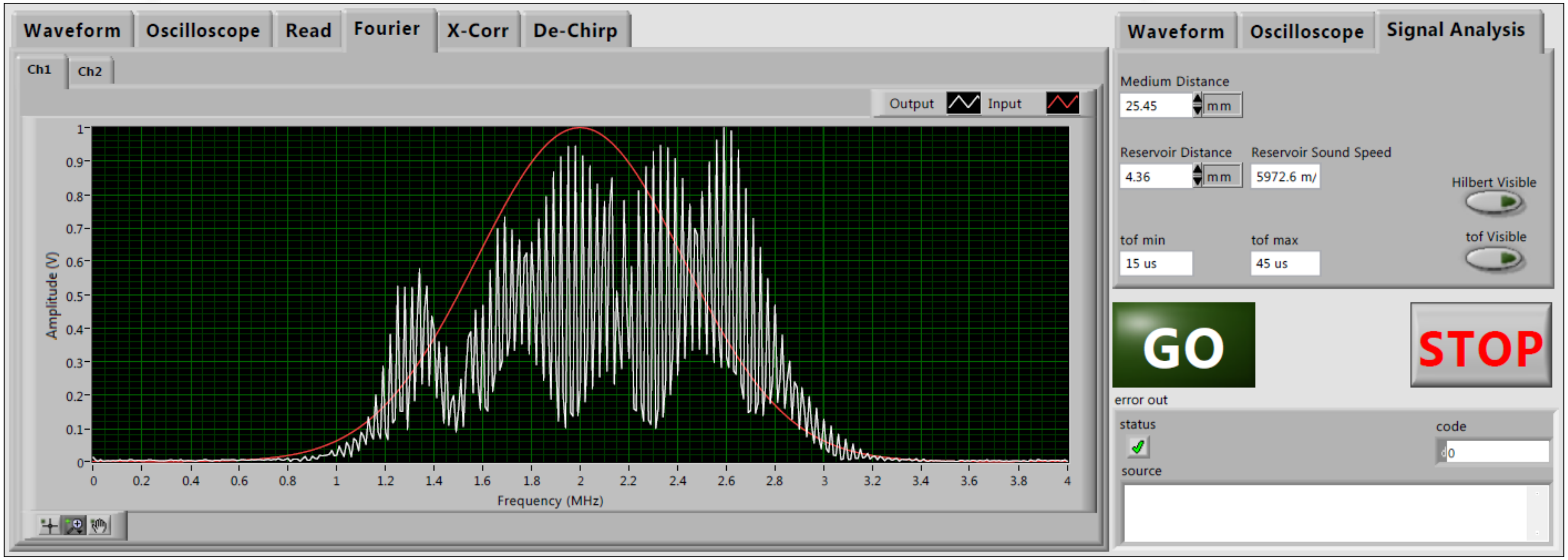


Figure 6: The frequency domain of the input is displayed in red while that of Ch1 is displayed in white.

Data Analysis: Cross-Correlation

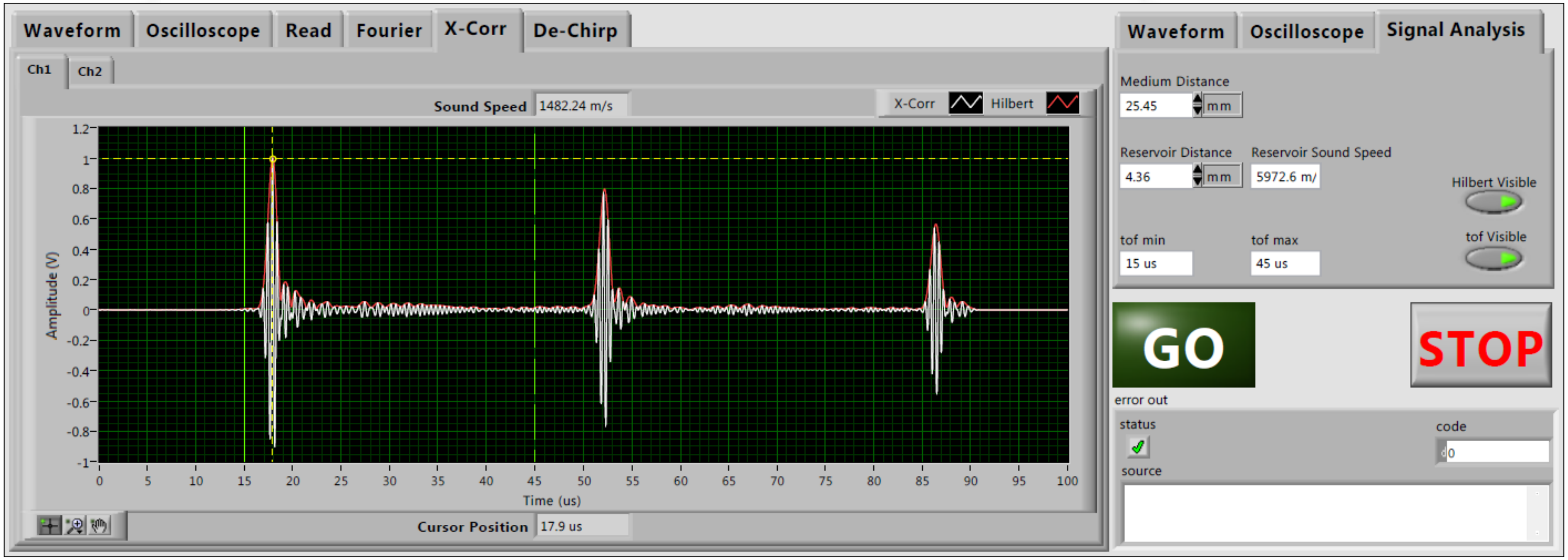


Figure 7: Cross-Correlation graph with time of flight window and Hilbert envelope, displaying the calculated sound speed as 1482.24 m/s. The medium is room-temperature water.

Data Analysis: De-Chirp

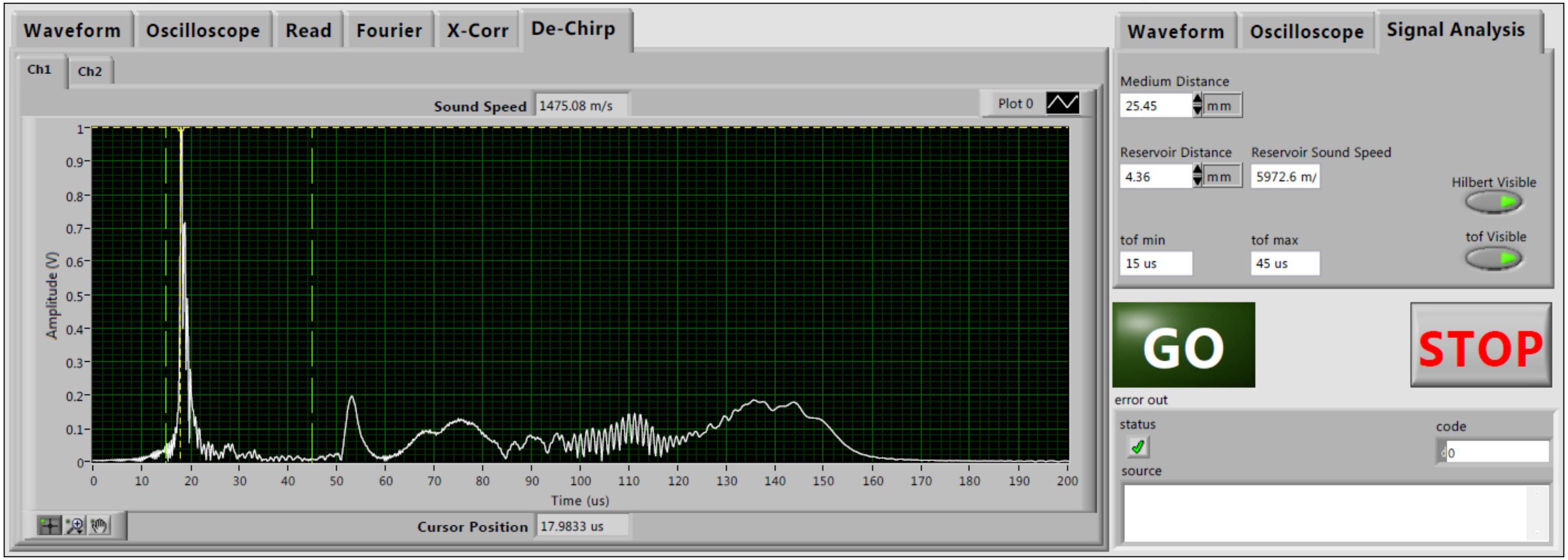


Figure 8: De-Chirp of a Linear Chirp. The Cross-Correlation method (not depicted) finds 1477.93 m/s while the De-Chirp gives 1475.08 m/s, showing the two methods are relatively consistent.

Results

- Lubbers and Graff (1998) simplified temperature-dependent water sound-speed equation for temperatures of 15-35 C is:

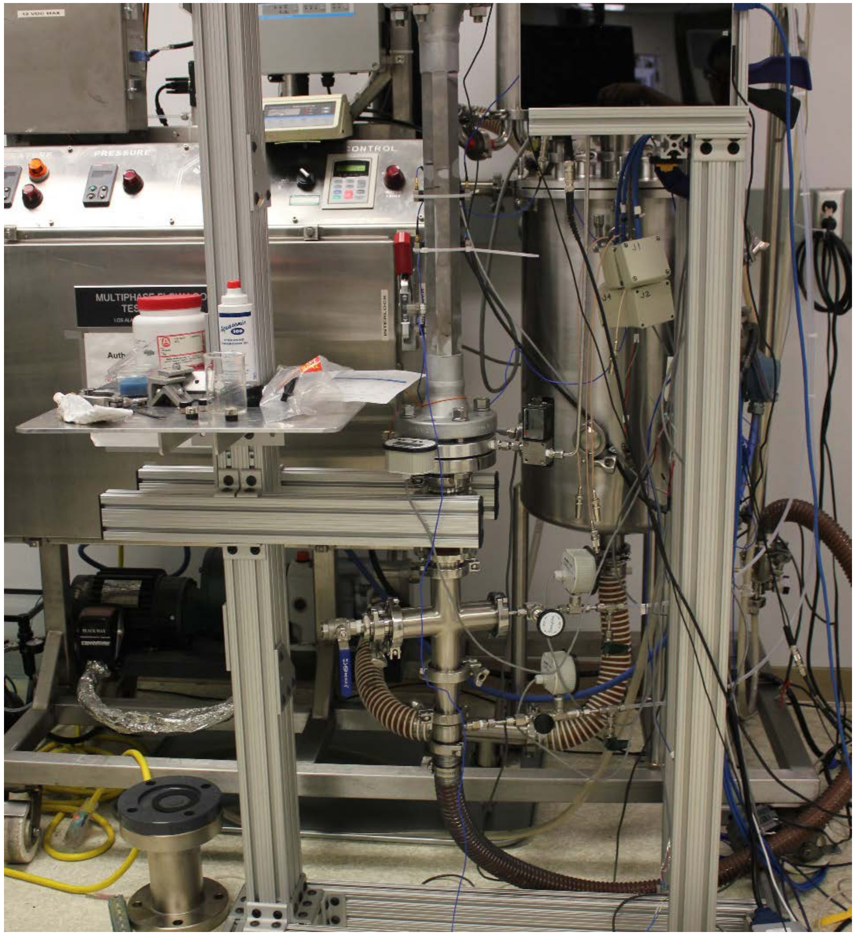
$$c_w = 1404.3 + 4.7T - 0.04T^2$$

- Water measured at 21.3C using a thermocouple. Lubbers and Graff's equation predicts the sound-speed to be about 1486.26 m/s.

Results

- Gaussian Pulse
  - 1482.24 m/s
  - within 0.27% of the predicted value
- Linear Chirp
  - 1477.93 m/s and 1475.08 m/s
  - 0.56% and 0.75% of the predicted value, respectively.
- Measurements are precise and relatively accurate

Applications



- Dynamic System: Flow Loop (left) to study of oil flow with gas bubbles or particles
- Determine deuterium concentration of heavy water using speed of sound measurements

Acknowledgments

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- MPA-11 Acoustics Lab:
  - Dipen Sinha
  - Vamshi Chillara
  - Eric Davis

References

- J. Lubbers & R. Graaff (1998). A simple and accurate formula for the sound velocity in water, Ultrasound Med. Biol. Vol 24, No 7, pp 1065-1068.