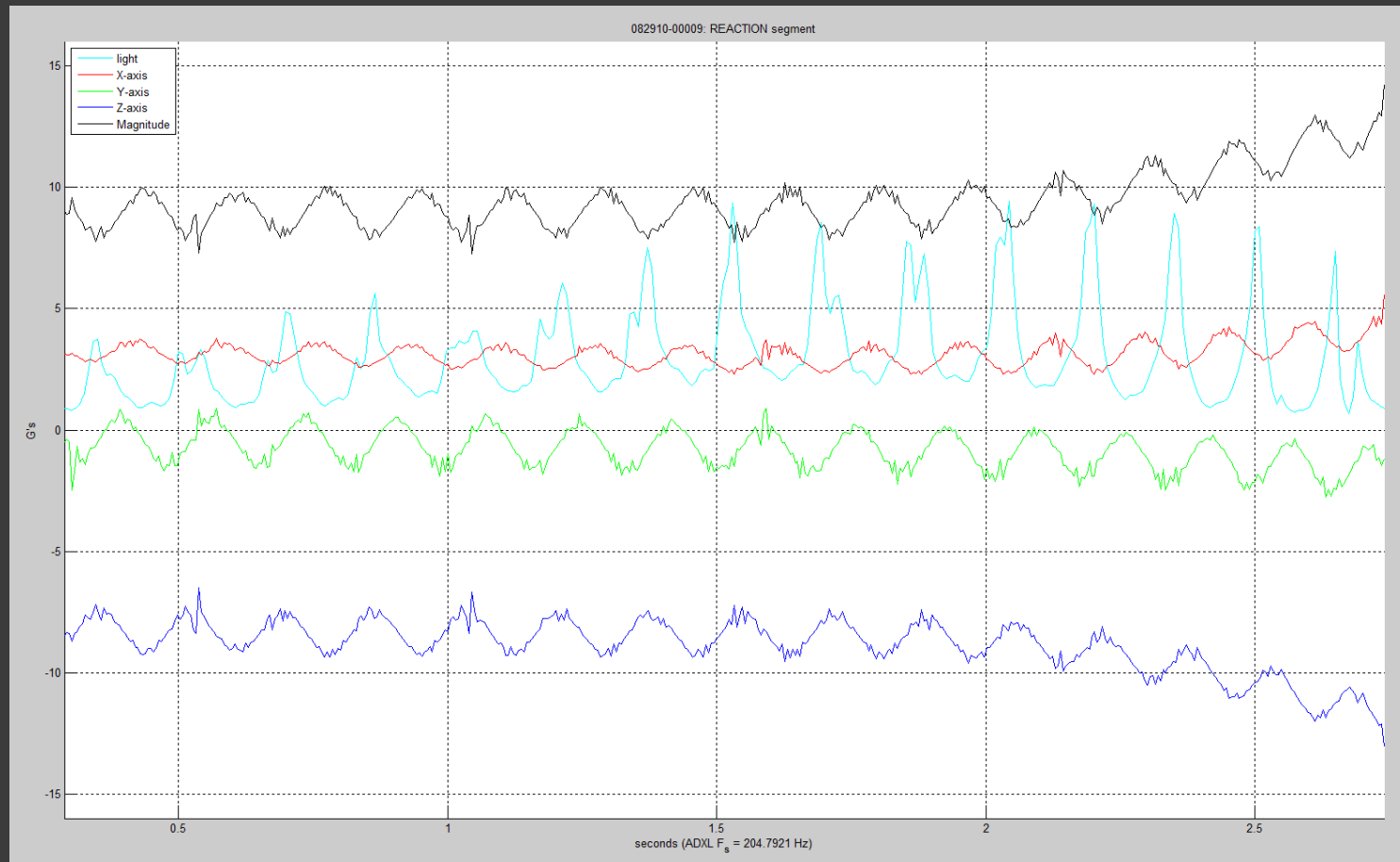


WAVEFORM ANALYSIS

REACTION SEGMENT

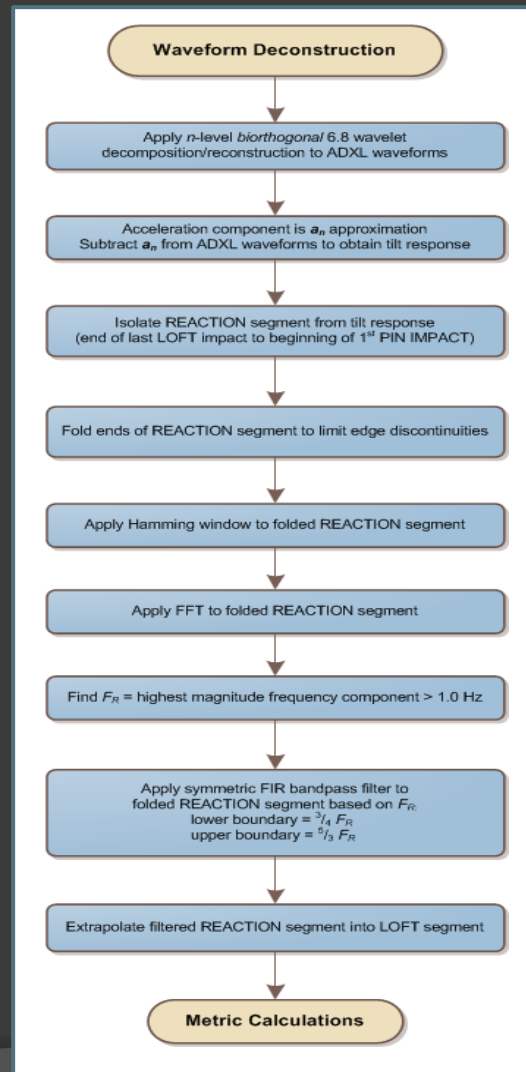


REACTION SEGMENT

- Comprised of three distinct components:
 - ❖ Centripetal acceleration: Generated by centripetal force due to ball's rapid rotation
 - ❖ Sinusoidal tilt response: *SenseModule* rotating through gravitational field
 - ❖ High frequency noise: Irregularities in contact surfaces between ball and lane, *SenseModule* vibration in finger hole, and digital noise infiltrating ADXL345
- Must isolate centripetal acceleration from tilt-response, while filtering out noise
- Wavelets are perfect for this

WAVEFORM ANALYSIS

REACTION SEGMENT DECONSTRUCTION

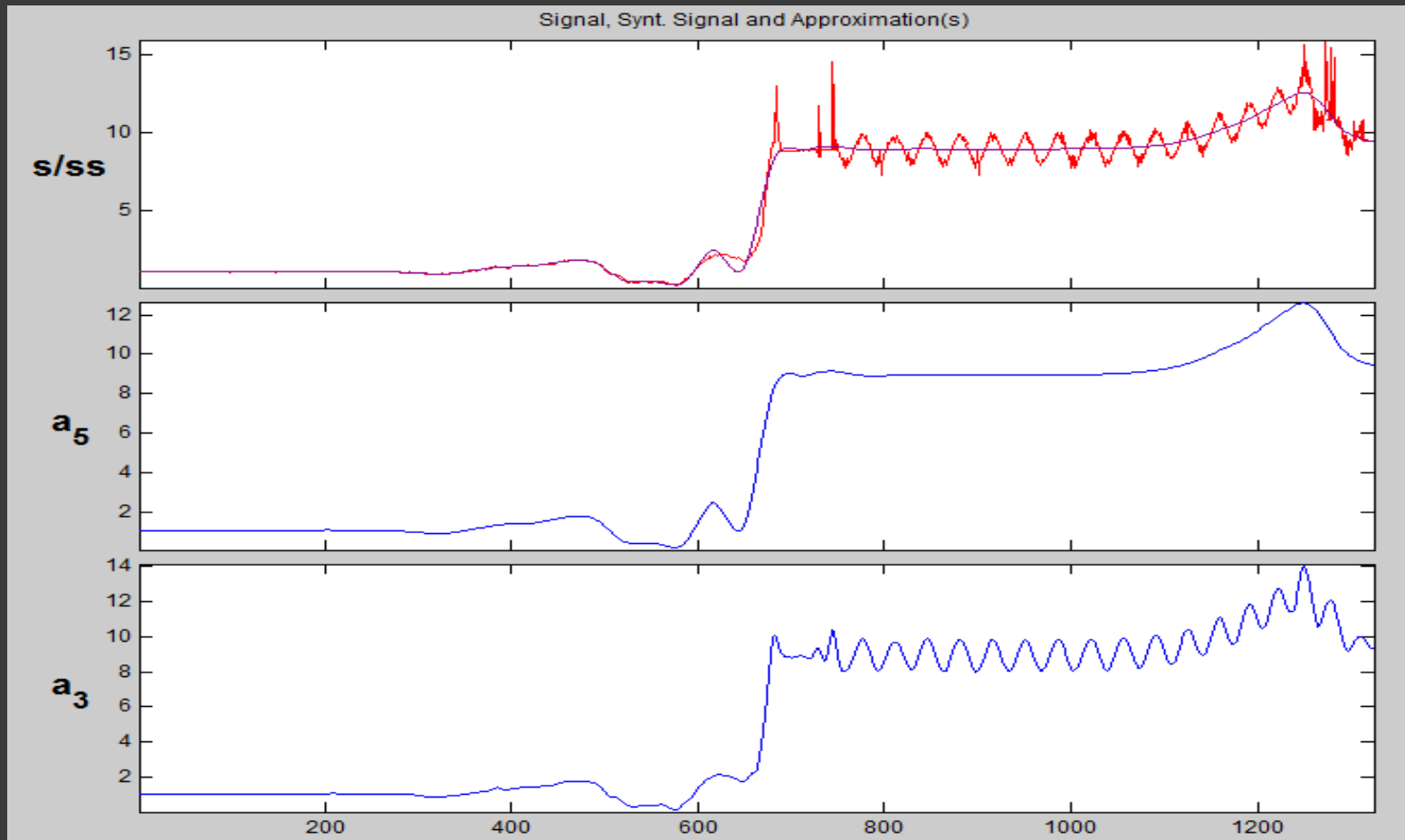


REACTION SEGMENT DECONSTRUCTION

- Results of 3rd and 5th-level *biorthogonal* 6.8 wavelet decomposition and reconstruction
- 3rd-level approximation (a_3) yields tilt-response superimposed on centripetal acceleration
- 5th-level approximation (a_5) isolates centripetal acceleration
- $a_3 - a_5$ isolates tilt-response from centripetal acceleration

WAVEFORM ANALYSIS

REACTION SEGMENT DECONSTRUCTION



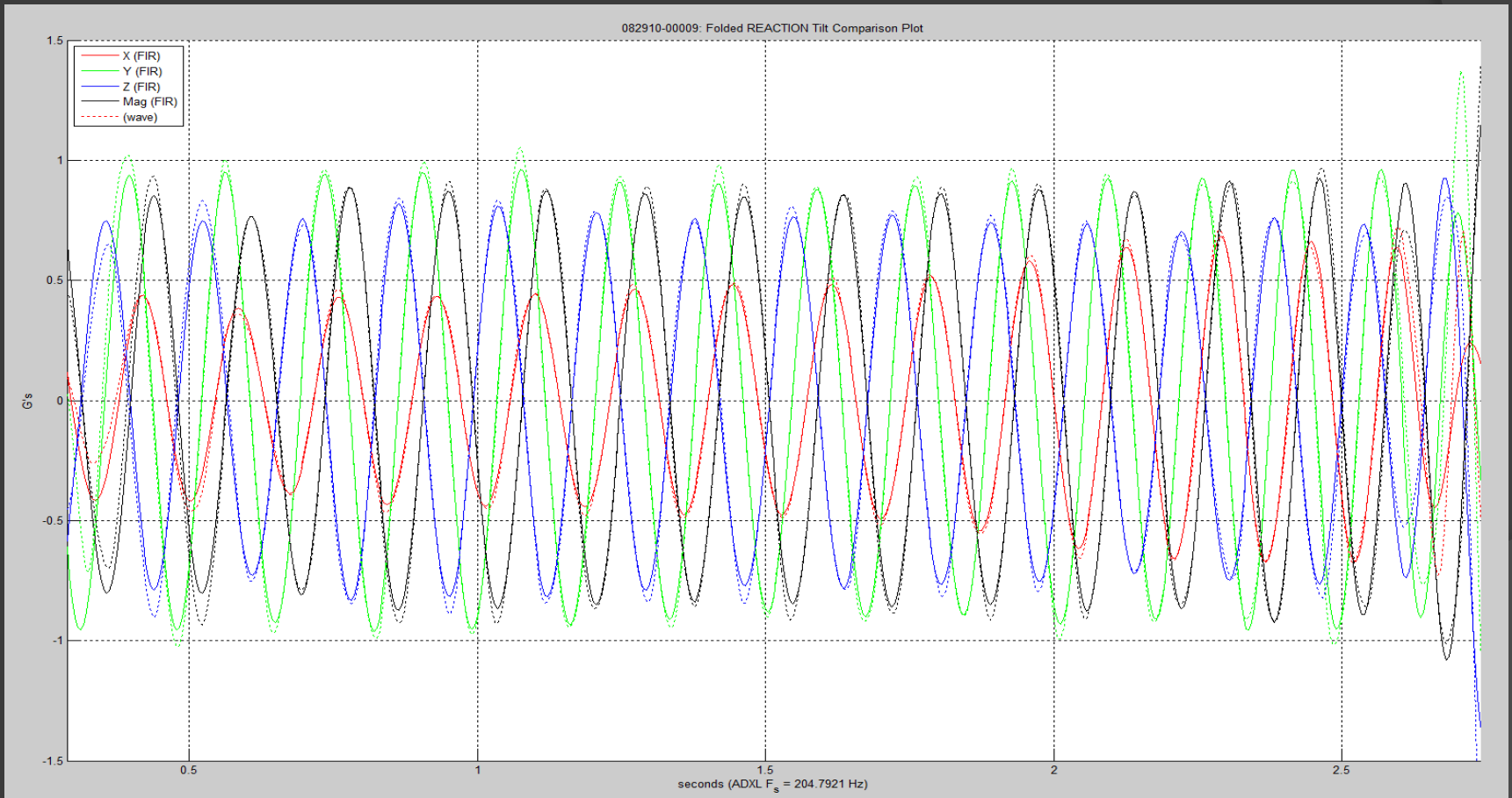
REACTION TILT RESPONSE

- ⦿ Compared filtering performance between FIR and wavelet techniques for tilt response
- ⦿ FIR bandpass filtering uses F_R to establish pass band
 - ❖ Low band = $0.75 * F_R$
 - ❖ High band = $1.67 * F_R$
- ⦿ Better results from FIR filter, with fringes “folded” into loft and pin impact regions before applying Hamming window
- ⦿ Expected, since tilt response is highly sinusoidal
- ⦿ Wavelets used to isolate segments and REACTION segment components (centripetal acceleration, tilt response), while FIR filter used to remove noise from tilt-response
- ⦿ FIR results used for remainder of analysis for tilt response
- ⦿ Following graph shows differences between FIR results and wavelet results

WAVEFORM ANALYSIS

REACTION TILT RESPONSE

Difference between FIR results and Wavelet results
Wavelet results shown with dotted lines



WAVEFORM ANALYSIS

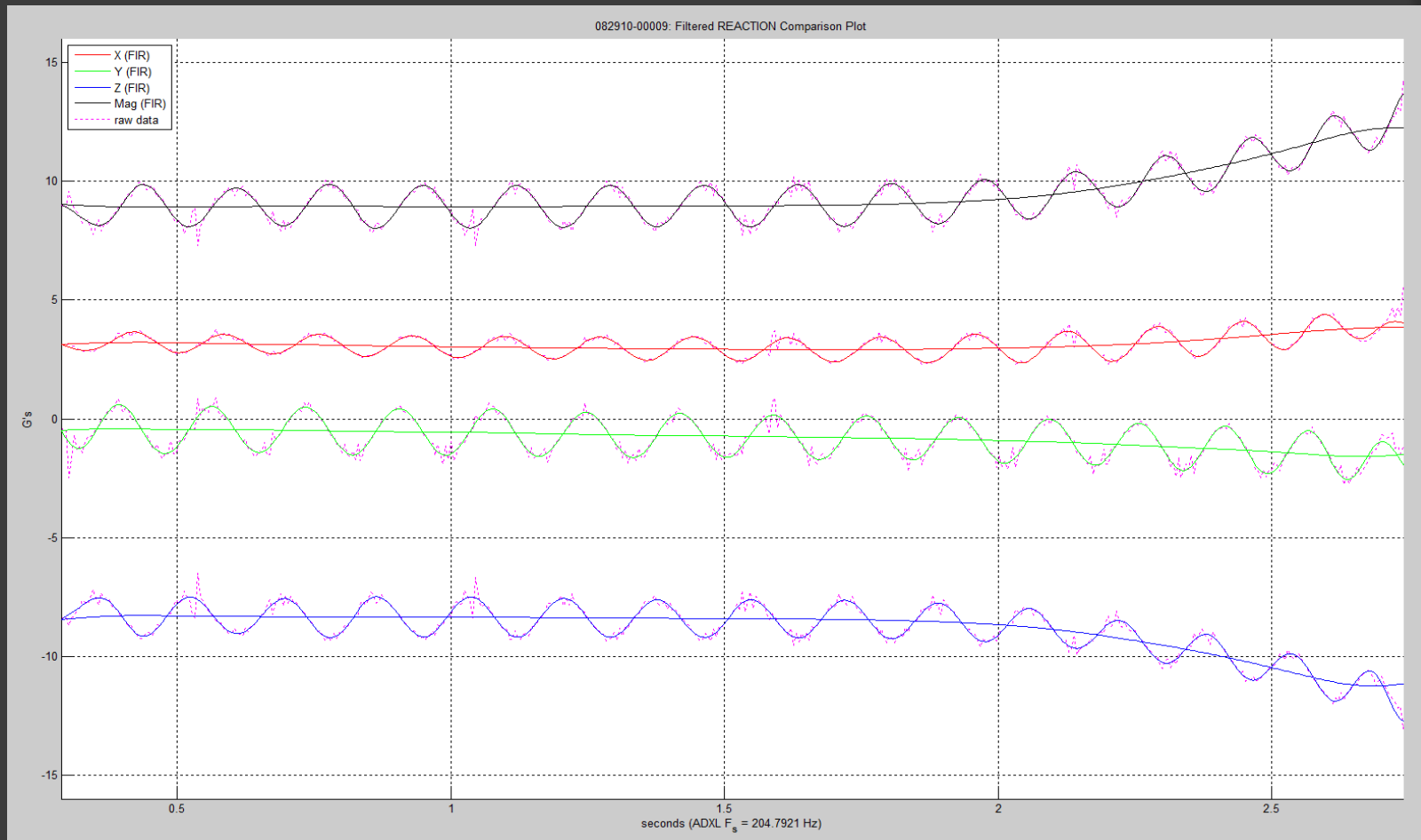
CENTRIPETAL ACCELERATION VS TILT RESPONSE

- ◉ Filtered tilt response closely follows raw data
- ◉ Centripetal acceleration response should closely correspond with peak-to-peak tilt response
- ◉ Can use either/both to find instantaneous angular velocity
- ◉ For tilt response, peak-to-valley, and valley-to-peak times will give discrete angular velocity during each half-revolution
- ◉ Centripetal acceleration curve is continuous, but does not reflect true centripetal acceleration at surface of ball, since *SenseModule* is at bottom of finger hole
- ◉ Need to know depth of *SenseModule* to find angular velocity from centripetal acceleration

WAVEFORM ANALYSIS

CENTRIPETAL ACCELERATION VS TILT RESPONSE

Raw data shown with dotted burgundy lines



WAVEFORM ANALYSIS

REACTION TILT RESPONSE EXTRAPOLATION

Loft region extrapolated from start of Reaction region

