Part 1: Gunshot Detection (energy + CUSUM, per-event chunk extraction)
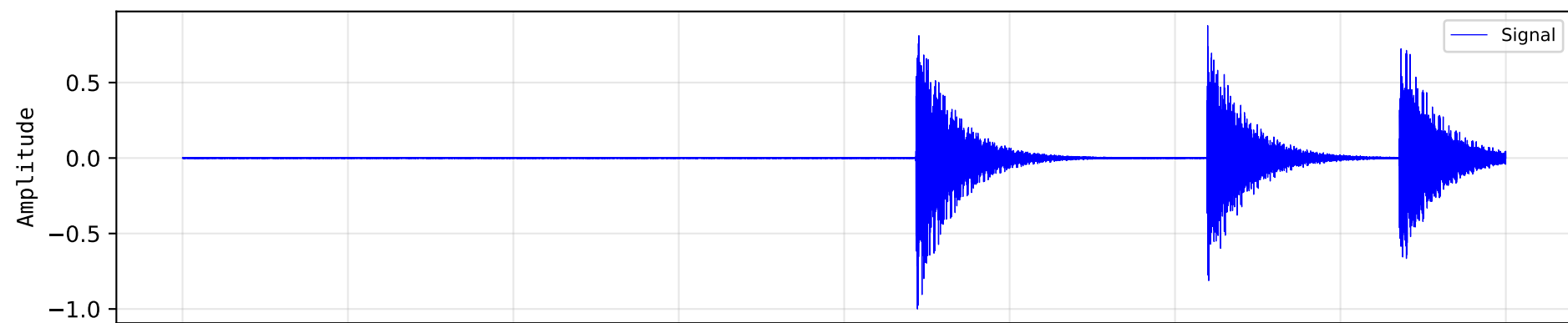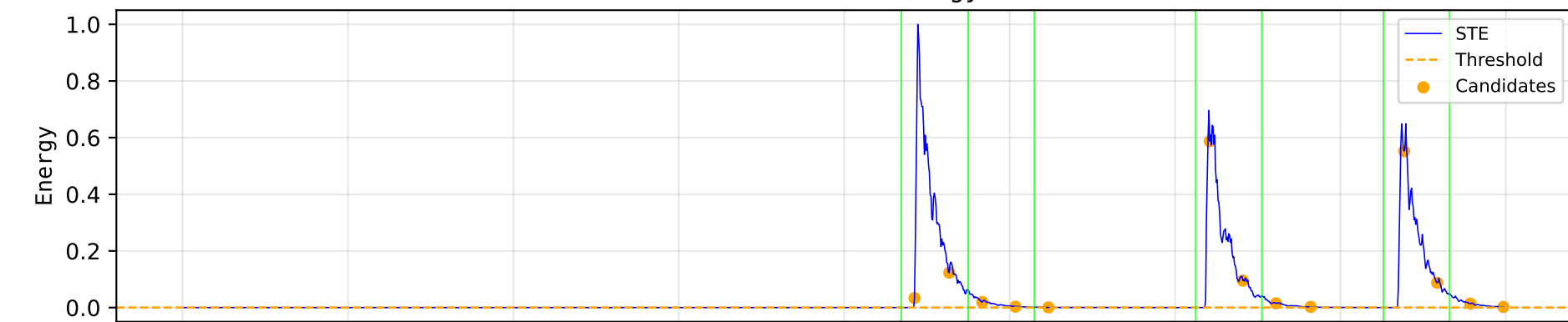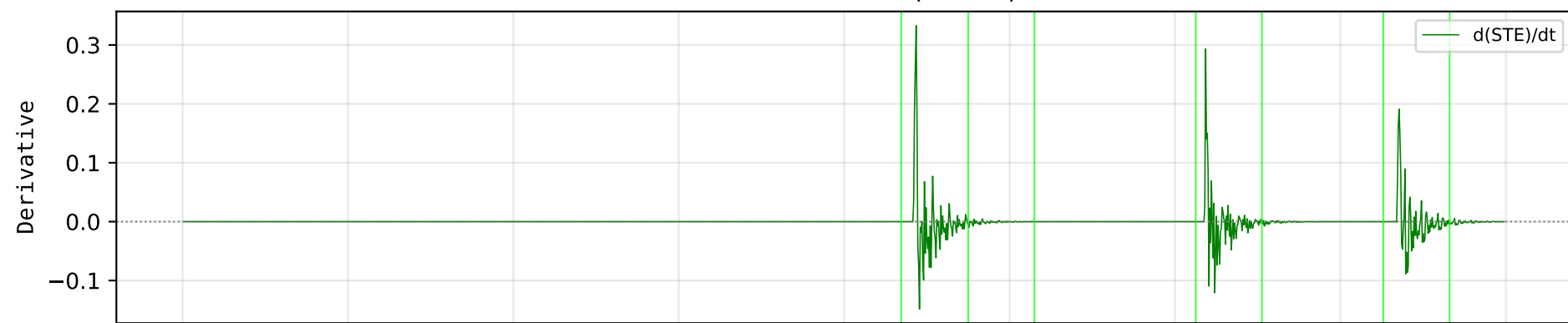
Channel 1 - Waveform

Short-Time Energy

STE Derivative (onset)

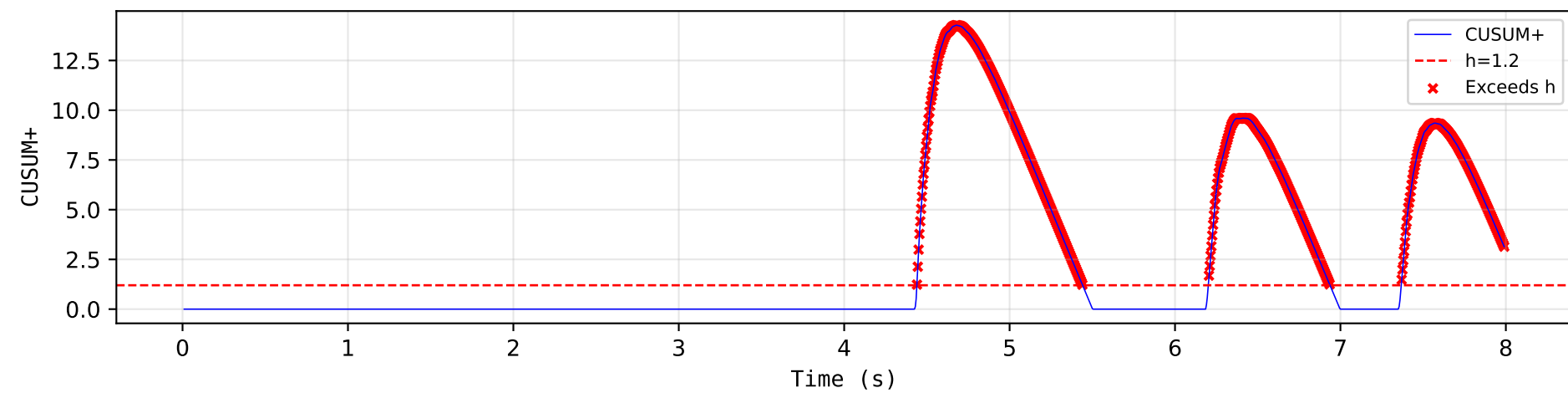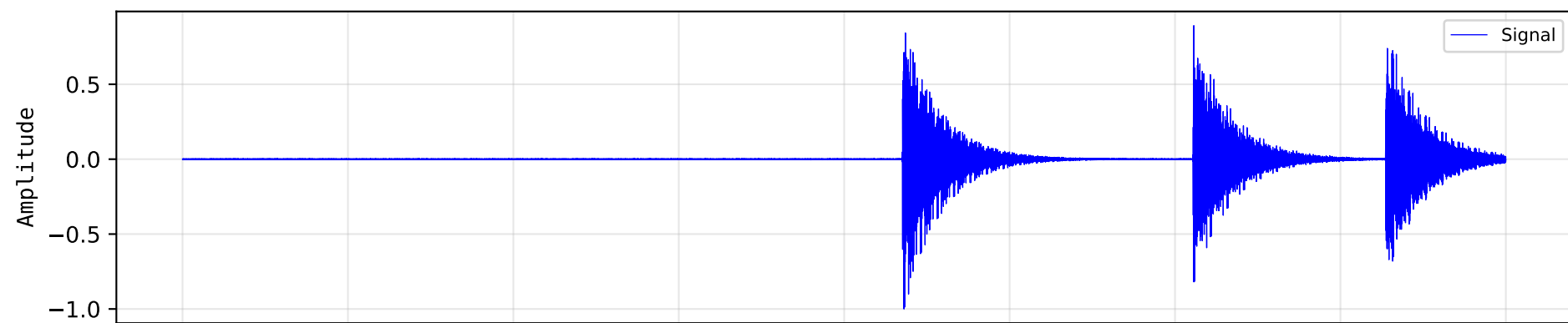**CUSUM Curve**

Channel 2 - Waveform
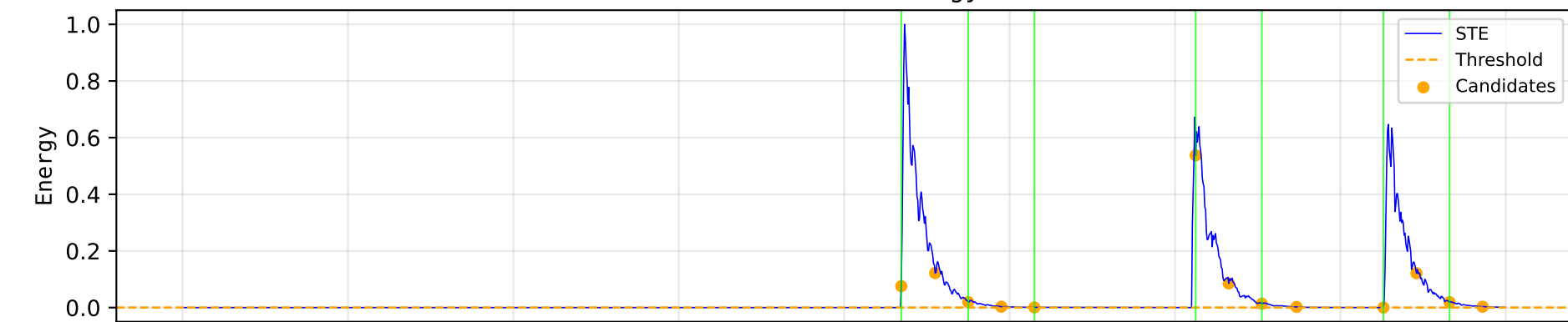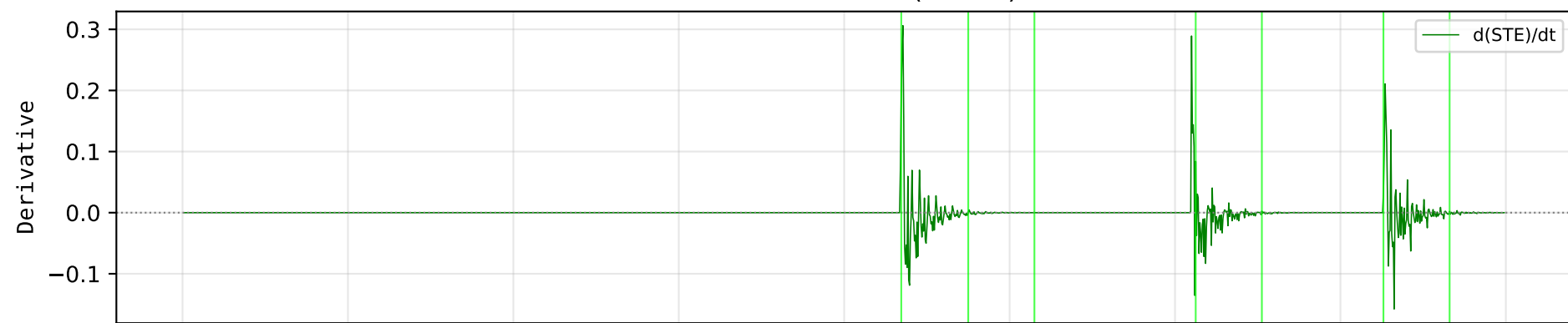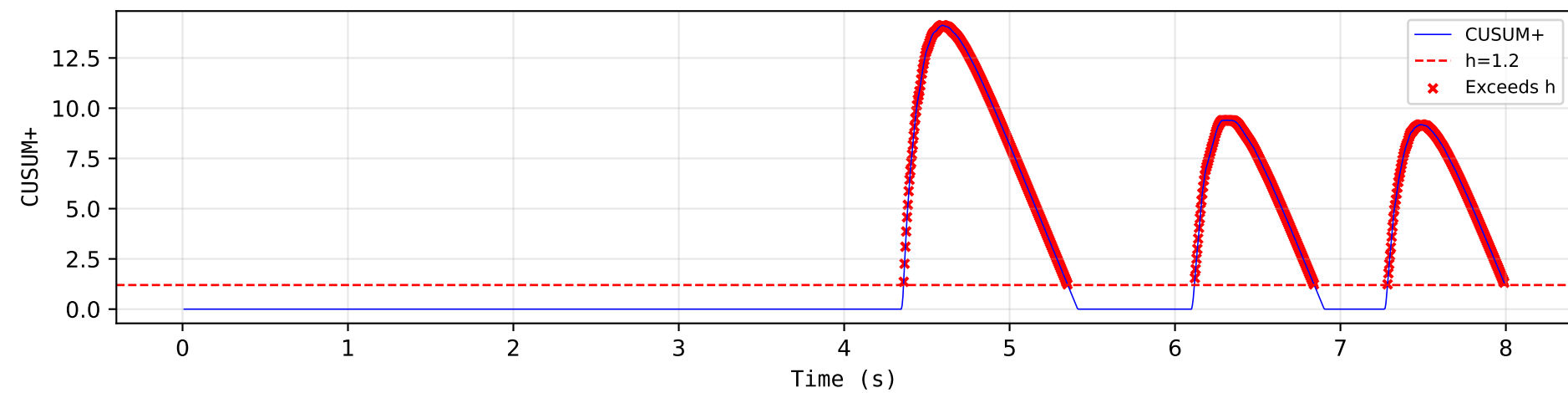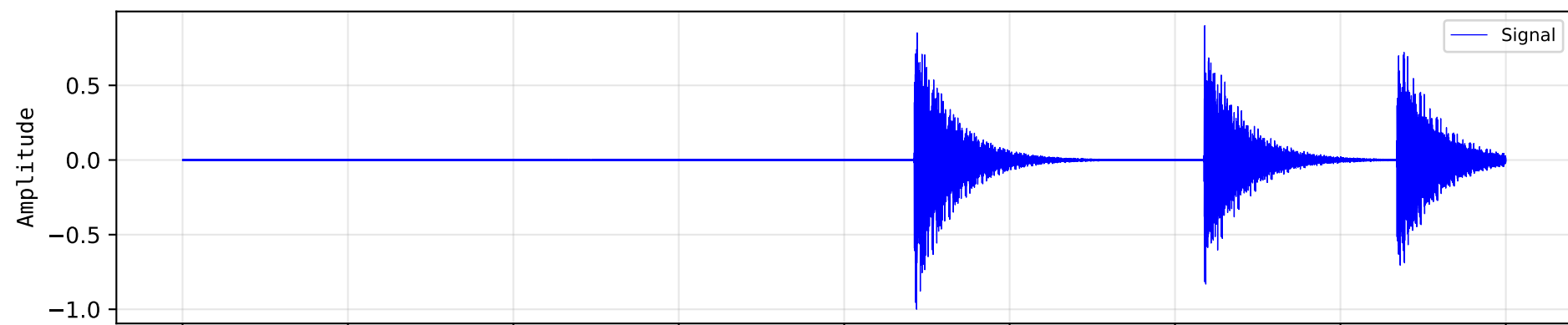
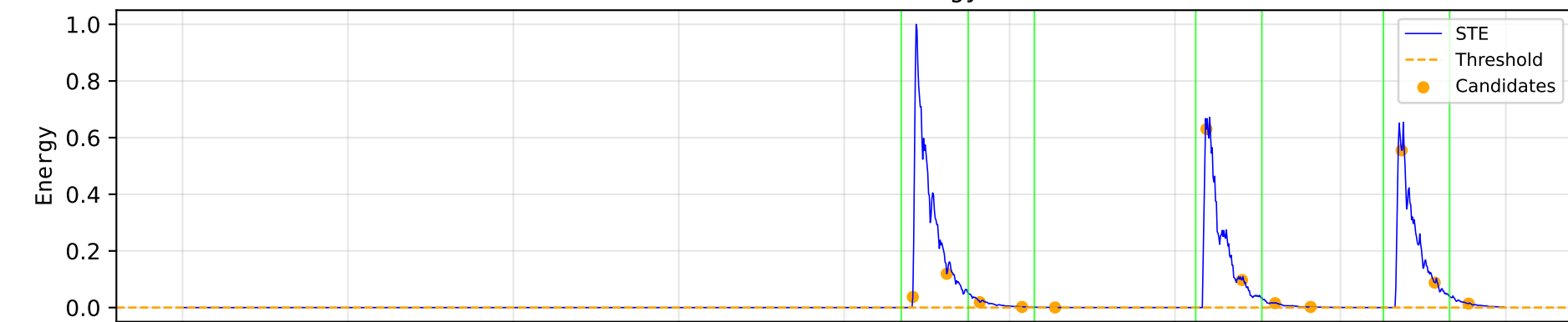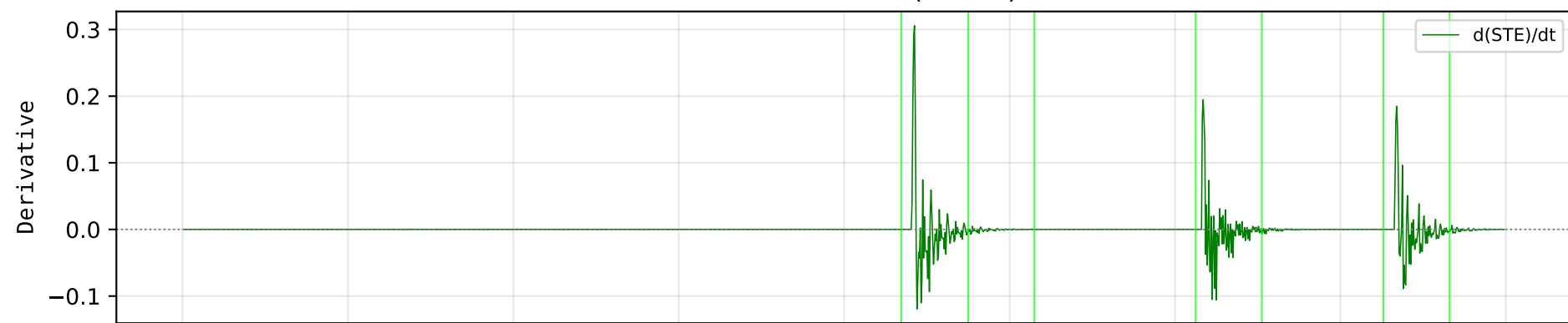Short-Time Energy

STE Derivative (onset)
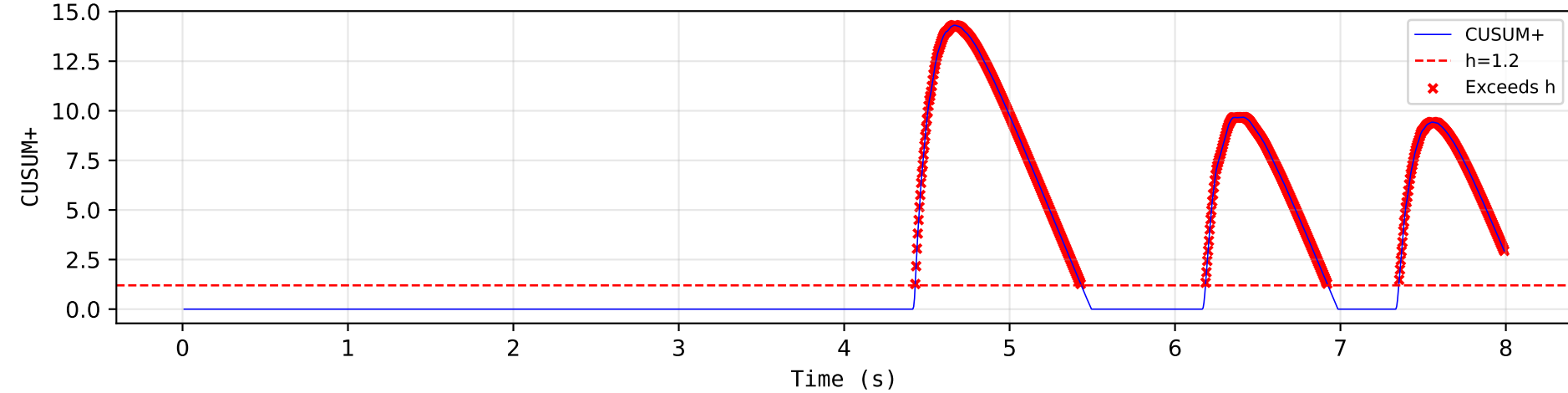
CUSUM Curve

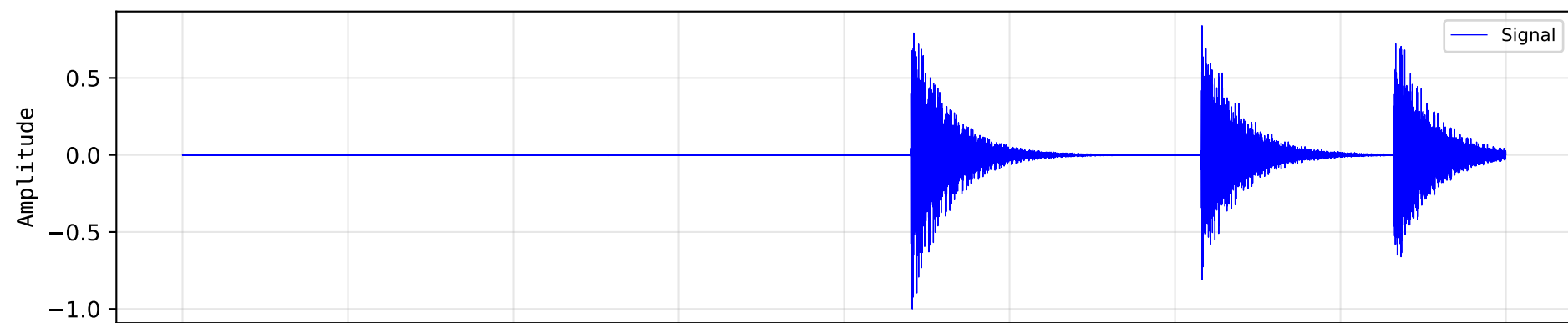Channel 3 - Waveform

Short-Time Energy

STE Derivative (onset)

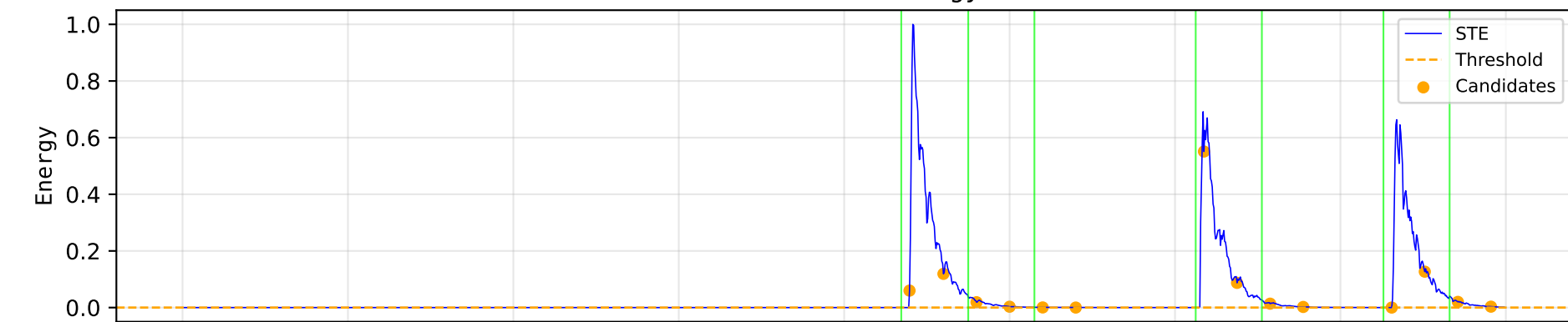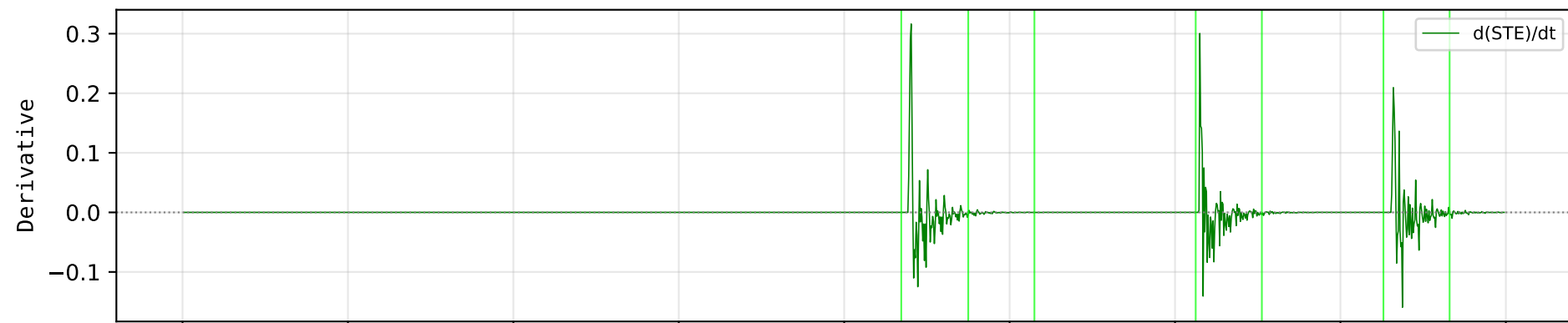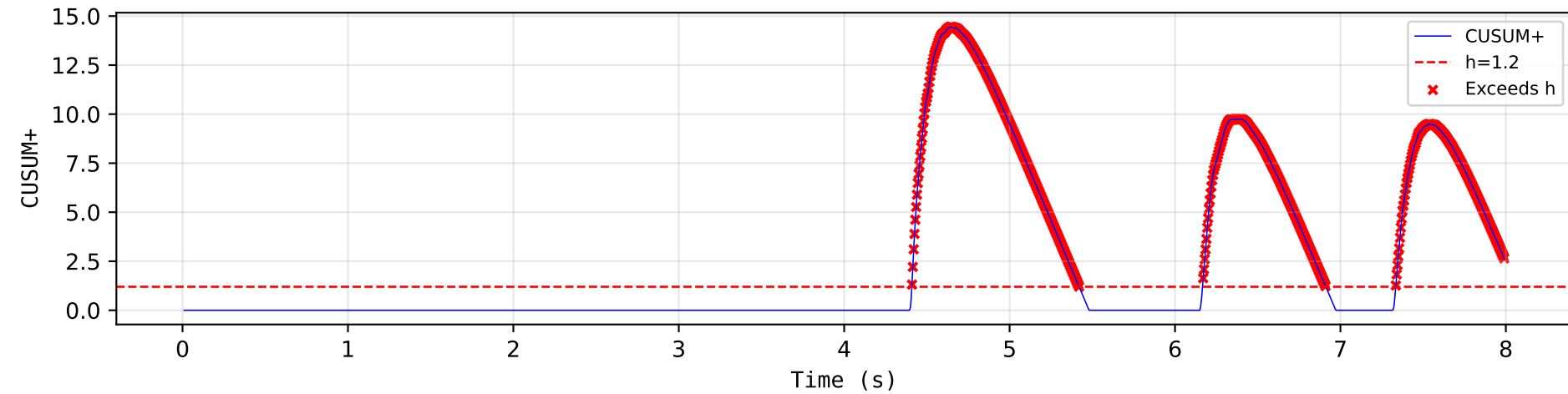CUSUM Curve

Channel 4 - Waveform

Short-Time Energy

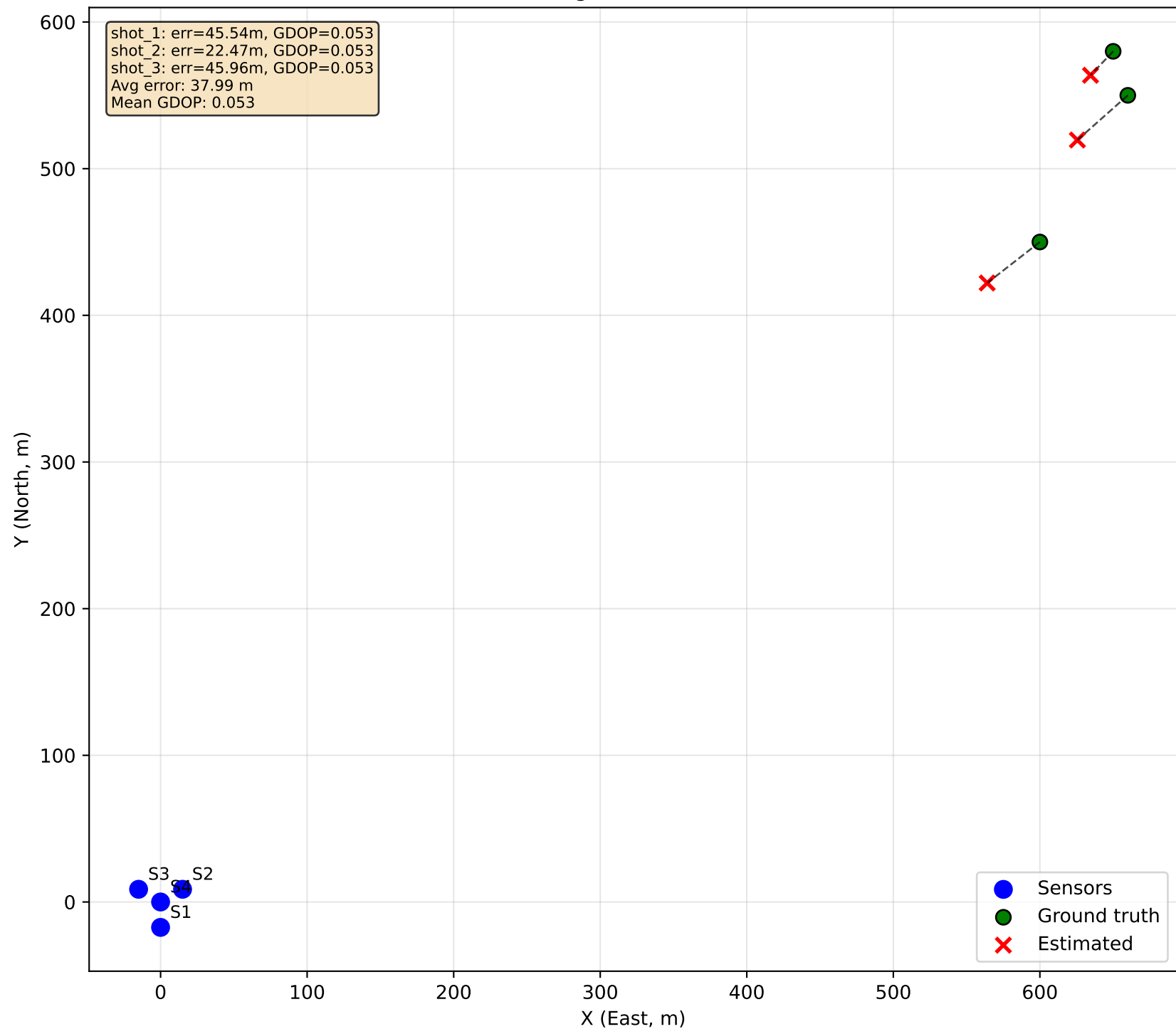STE Derivative (onset)

CUSUM Curve

Part 2: TDOA Localization (GCC-PHAT on per-event chunks, no TOA)

Localization results: error, avg error, GDOP

Position name	Ground truth (x,y,z) m	Estimated (x,y,z) m	Error (m)	GDOP	Uncertainty (m)	Confidence
shot_1	(600.00, 450.00, 2.00)	(564.05, 422.04, 2.00)	45.539	0.053	(2.94,1.53,0.00)	0.950
shot_2	(650.00, 580.00, 2.00)	(634.54, 563.69, 2.00)	22.471	0.053	(3.20,1.67,0.00)	0.950
shot_3	(660.00, 550.00, 2.00)	(625.59, 519.53, 2.00)	45.961	0.053	(3.02,1.58,0.00)	0.950
Summary			Avg error: 37.990 m	Mean GDOP: 0.05		Mean conf: 0.950

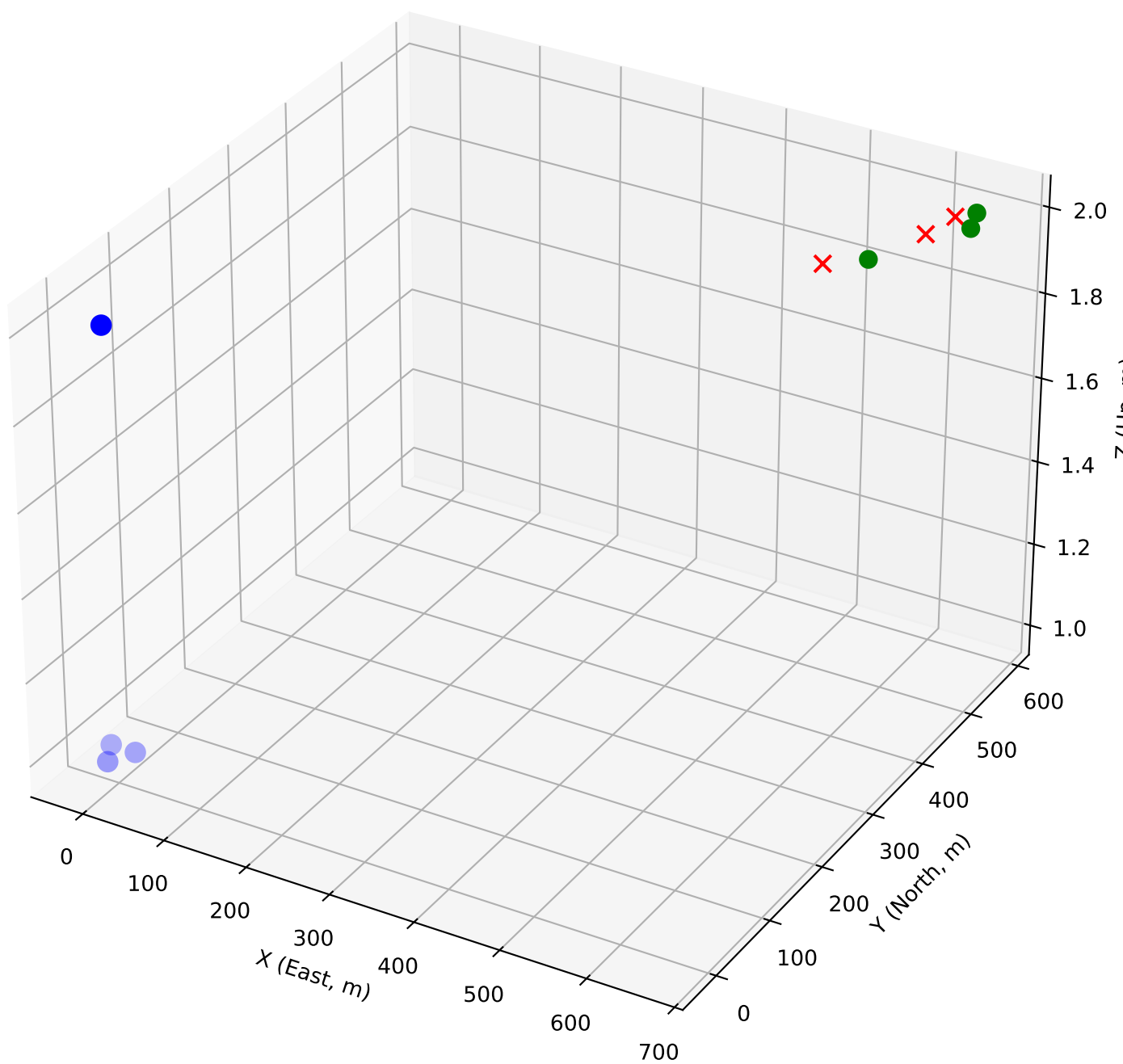2D localization: sensors, ground truth, estimated, error lines

shot_1: err=45.54m, GDOP=0.053
shot_2: err=22.47m, GDOP=0.053
shot_3: err=45.96m, GDOP=0.053
Avg error: 37.99 m
Mean GDOP: 0.053

- Sensors
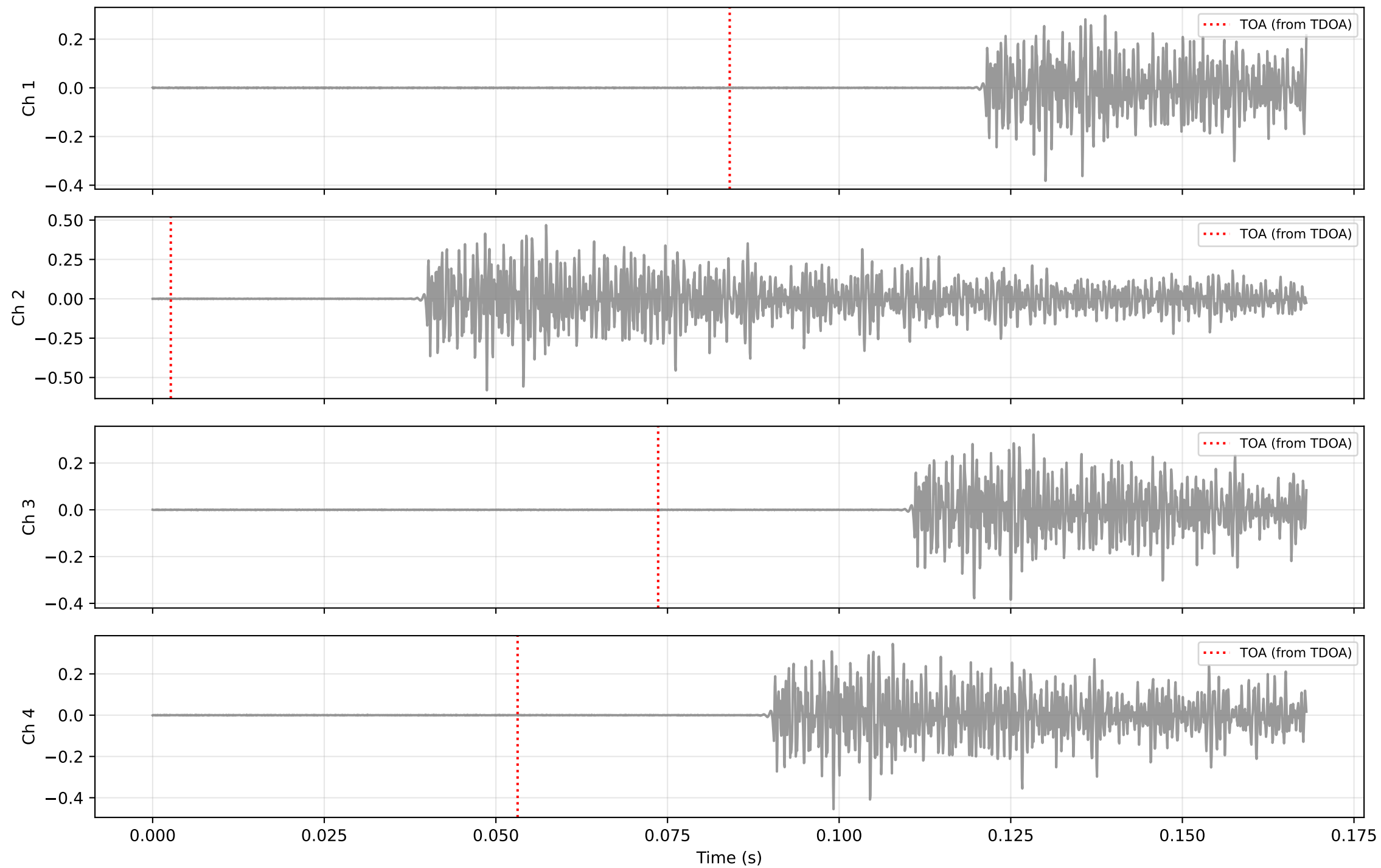- Ground truth
- Estimated

X (East, m)

Y (North, m)

3D localization: sensors, ground truth, estimated
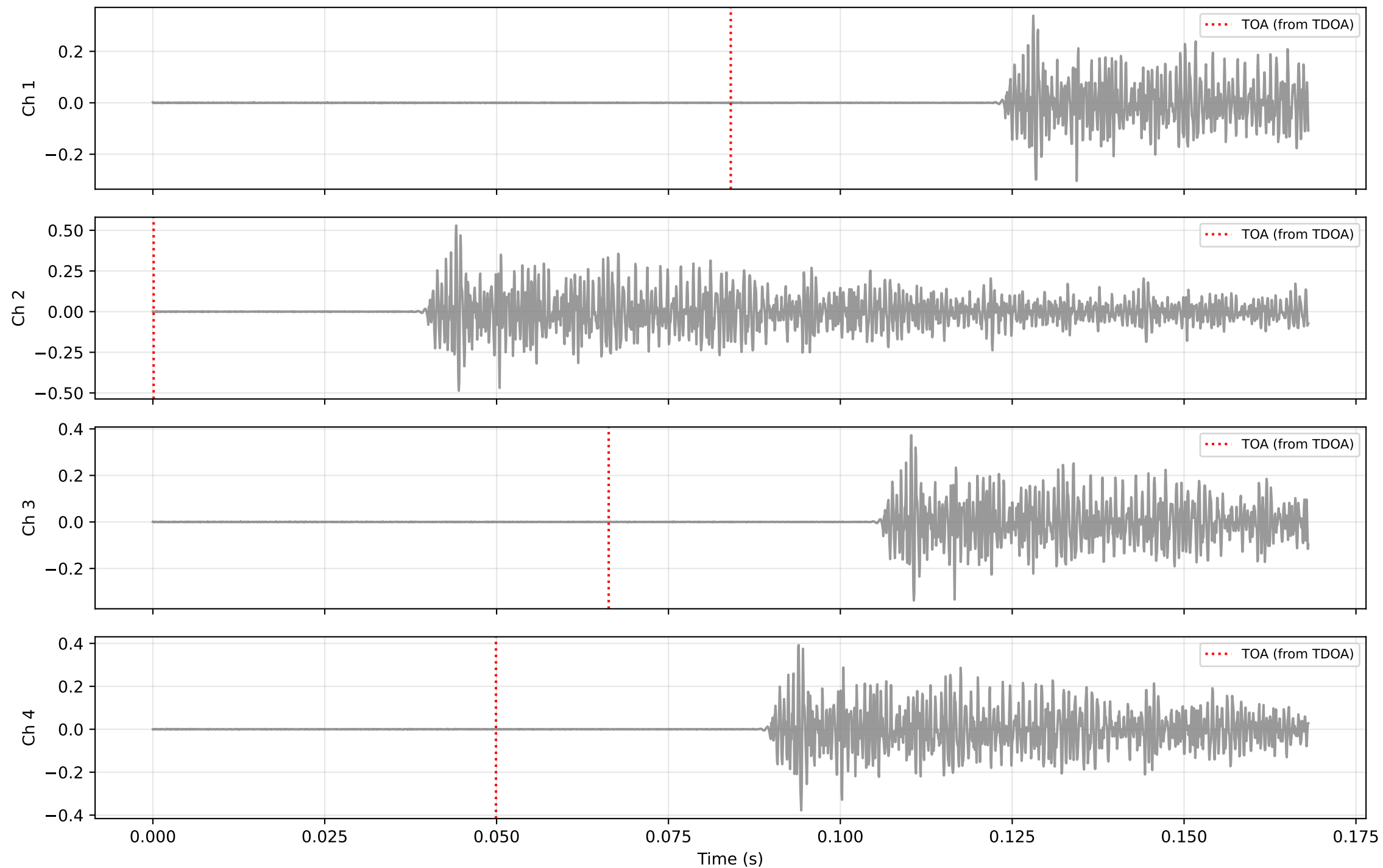
Avg error: 37.99 m
Mean GDOP: 0.053

Sensors

Waveform: shot_1 — TOA marks (visualization only, not used in localization)

Waveform: shot_2 — TOA marks (visualization only, not used in localization)

Waveform: shot_3 — TOA marks (visualization only, not used in localization)