

Gunshot recordings from a criminal incident: Who shot first?

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Outline

- Introduction
 - Audio forensic analysis
 - Gunshot acoustics
 - Forensic acoustical interpretation
- Example 1: who shot first?
- Example 2: who shot first?
- Conclusion

Introduction

- Audio Forensics is the field of forensic science relating to the acquisition, analysis, and evaluation of sound recordings that may ultimately be presented in court or some official venue.
- Primary forensic concerns:
 - i. authenticity*
 - ii. enhancement*
 - iii. interpretation and documentation*

Gunshot Acoustics

- Confined combustion of gunpowder propels the bullet out of the gun barrel.
- The explosive gases expand rapidly behind the bullet causing the *muzzle blast*.
- The muzzle blast can exceed 150dB in the vicinity of the firearm.
- The muzzle blast is directional.

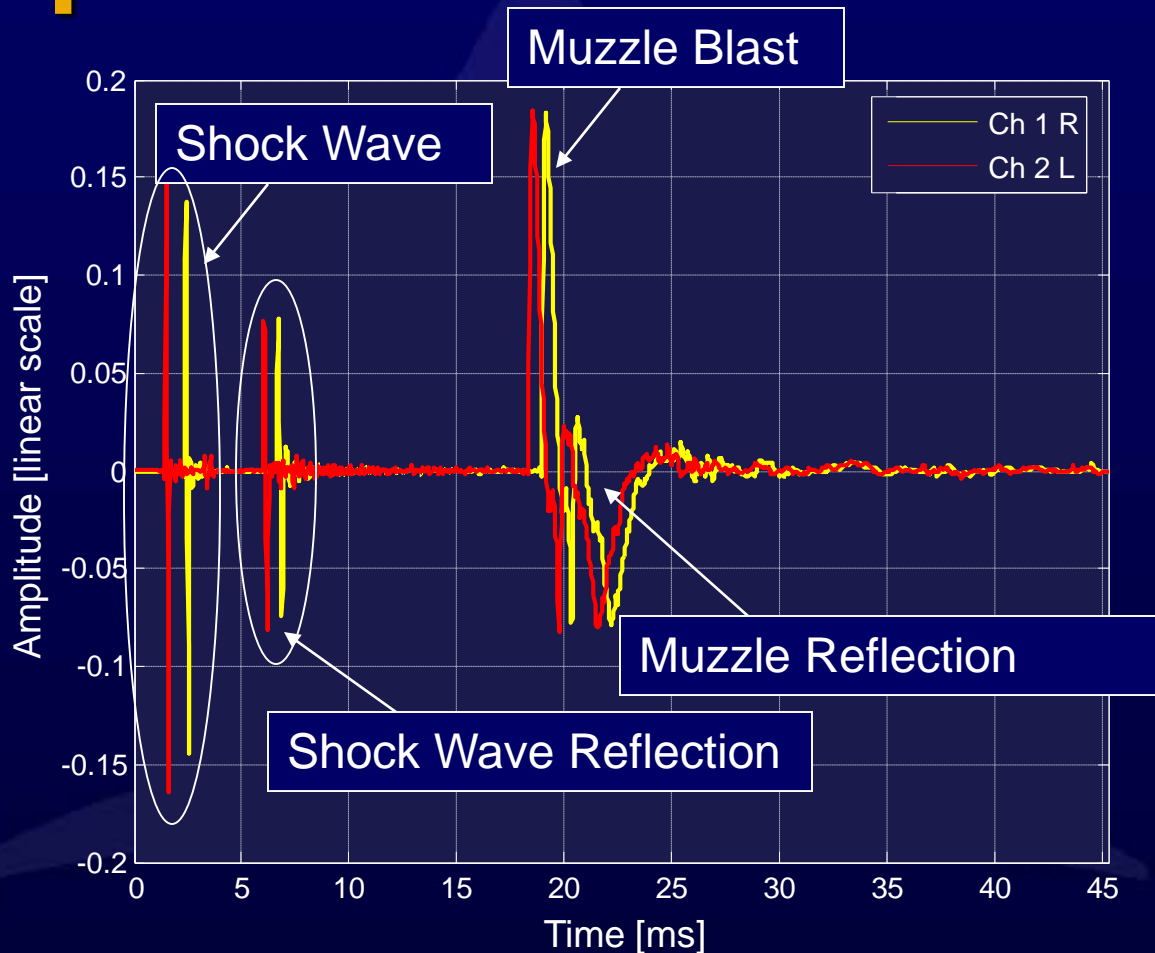
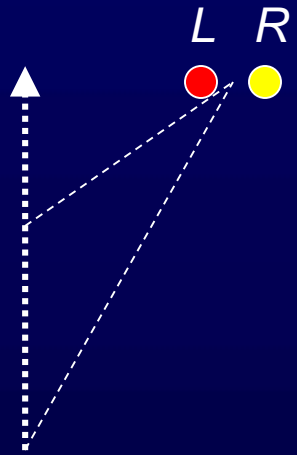
Gunshot Acoustic Evidence Near the Shooter

- Mechanical Action
- Muzzle Blast
- Supersonic Projectile (shock wave)
- Surface Vibration
- Reflections

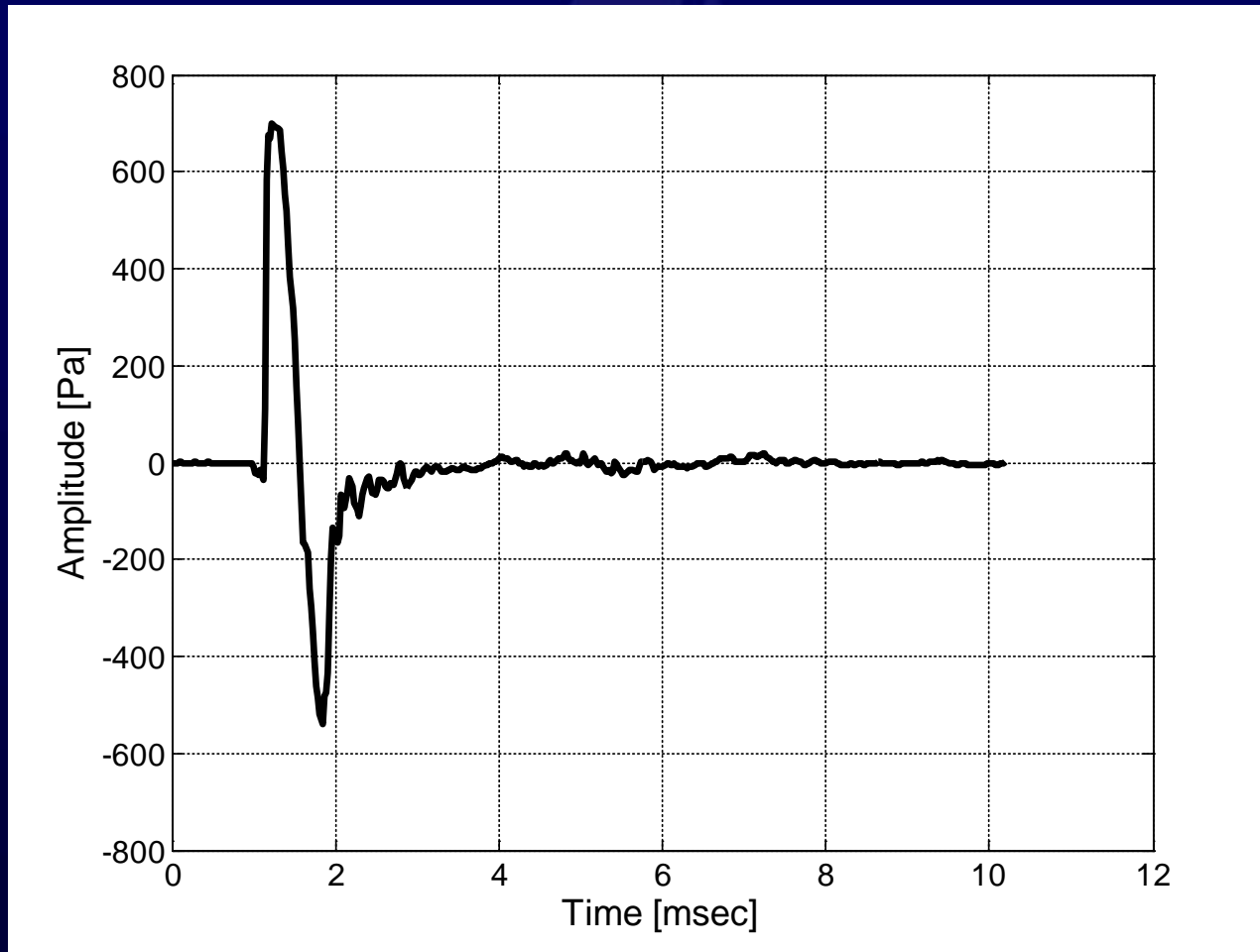
Note:

Limitations of microphone and audio recording chain (e.g., codecs)

Example Gunshot Recording



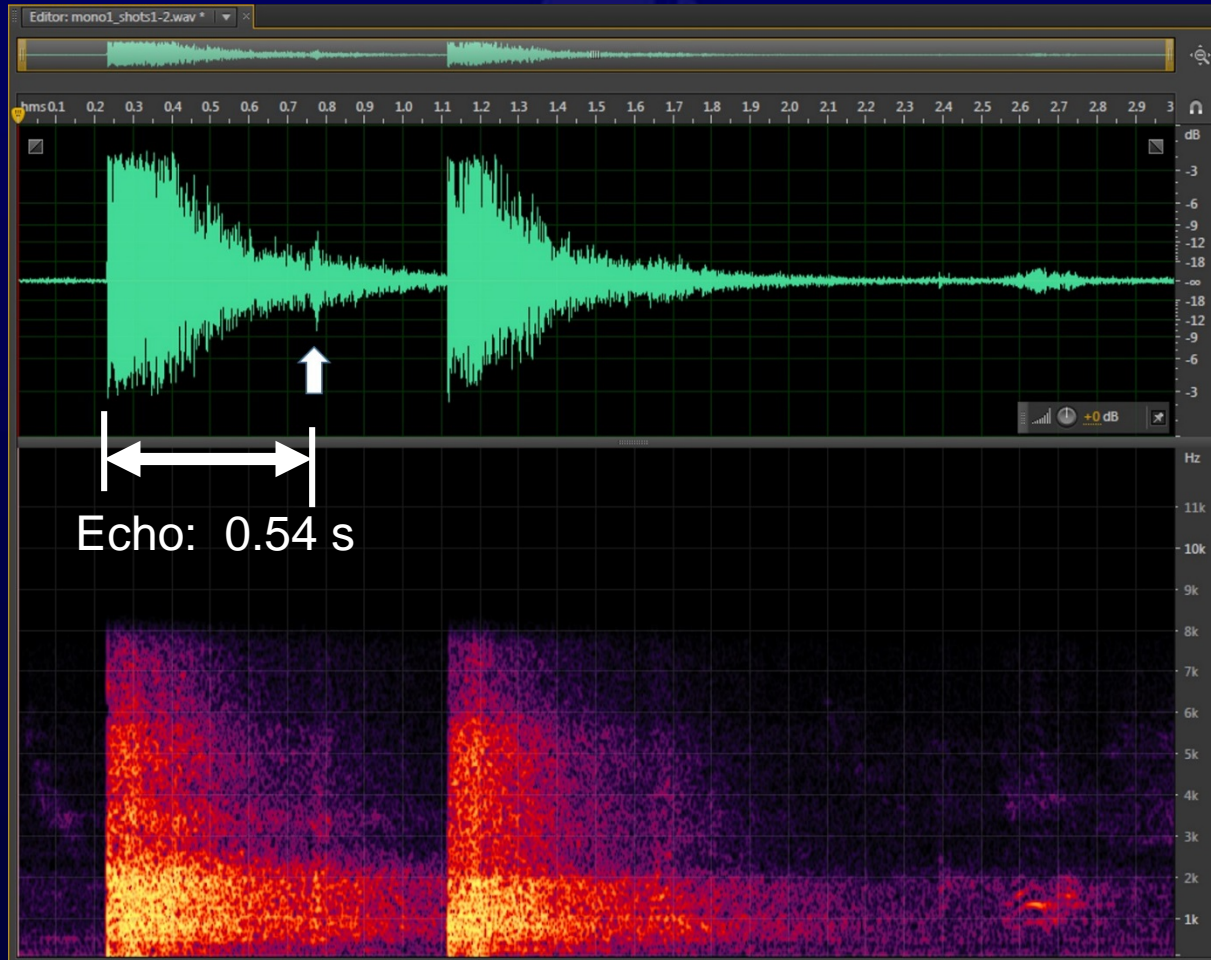
9mm Handgun (anechoic)



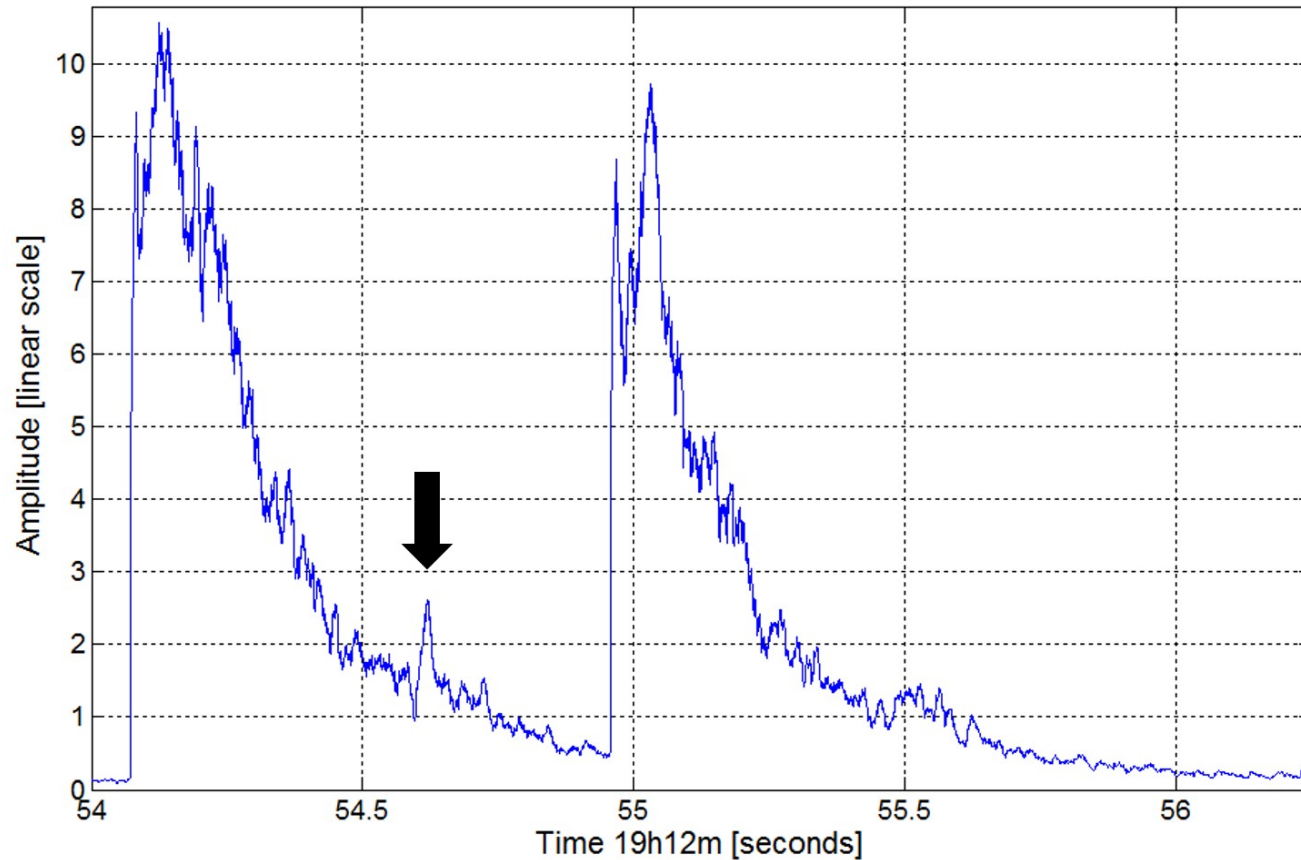
Forensic Example 1

- Two armed perpetrators on a city street
 - Witnesses and evidence that both individuals shot handguns, but not clear who fired first.
 - One of the individuals died due to gunshot wound, the other individual survived and claims self defense.
 - A residential surveillance system recorded the sound of gunfire, but not video of the scene.
 - Who shot first?

First two shots...



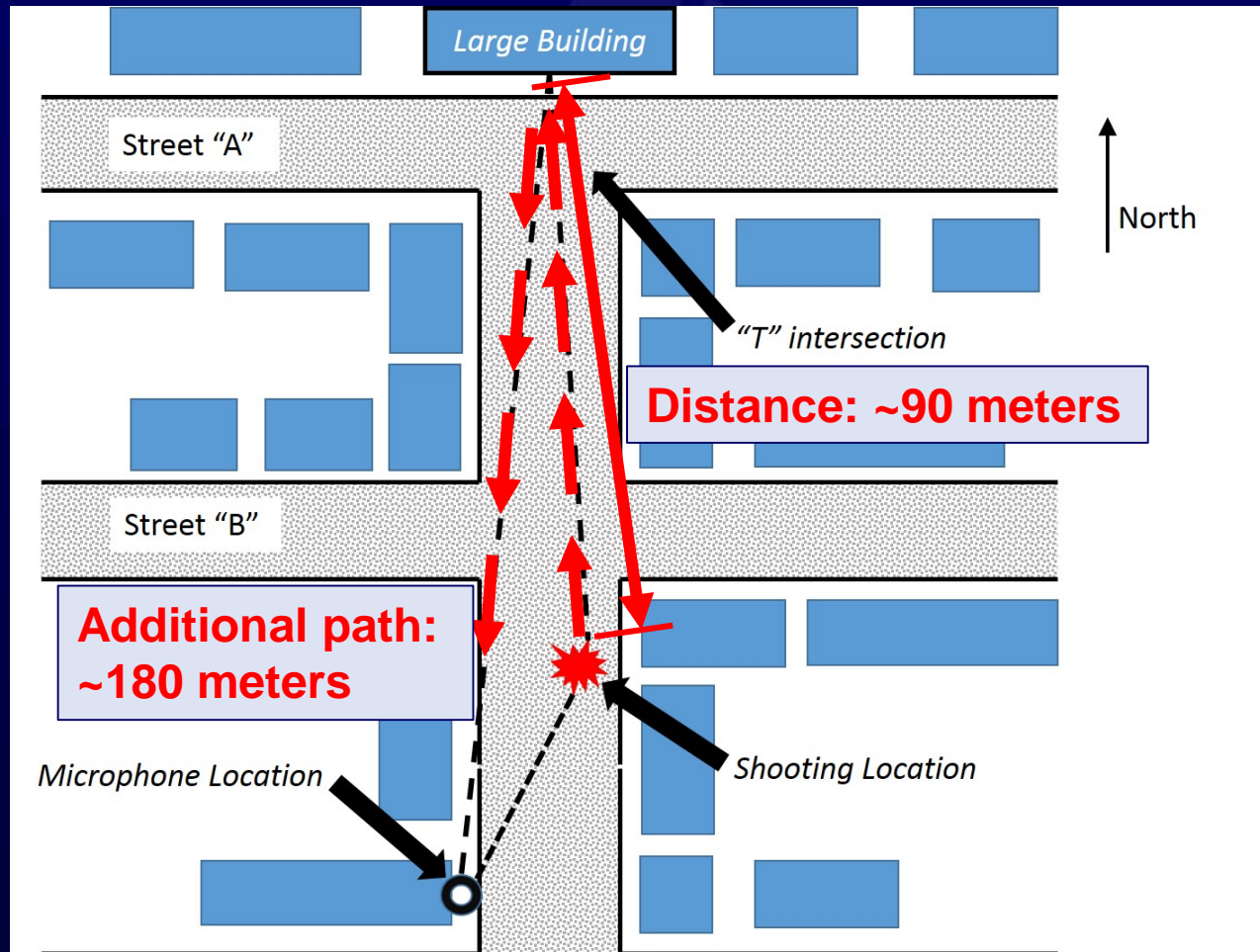
First two shots (cont.)



Echo 0.54 seconds

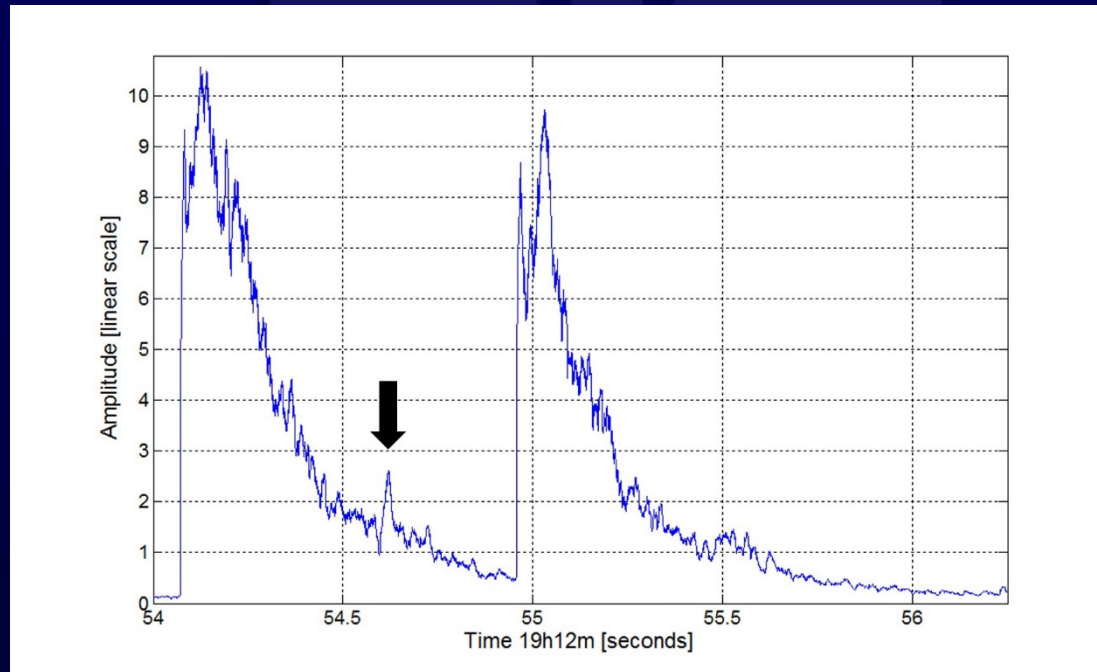
- Air temperature 16 celsius: $c = 341 \text{ m/s}$
- 0.54 seconds == 184 meters

Street Geometry



Echo 0.54 seconds

- Echo explanation fits geometry, but why not a distinct echo for both gunshots?



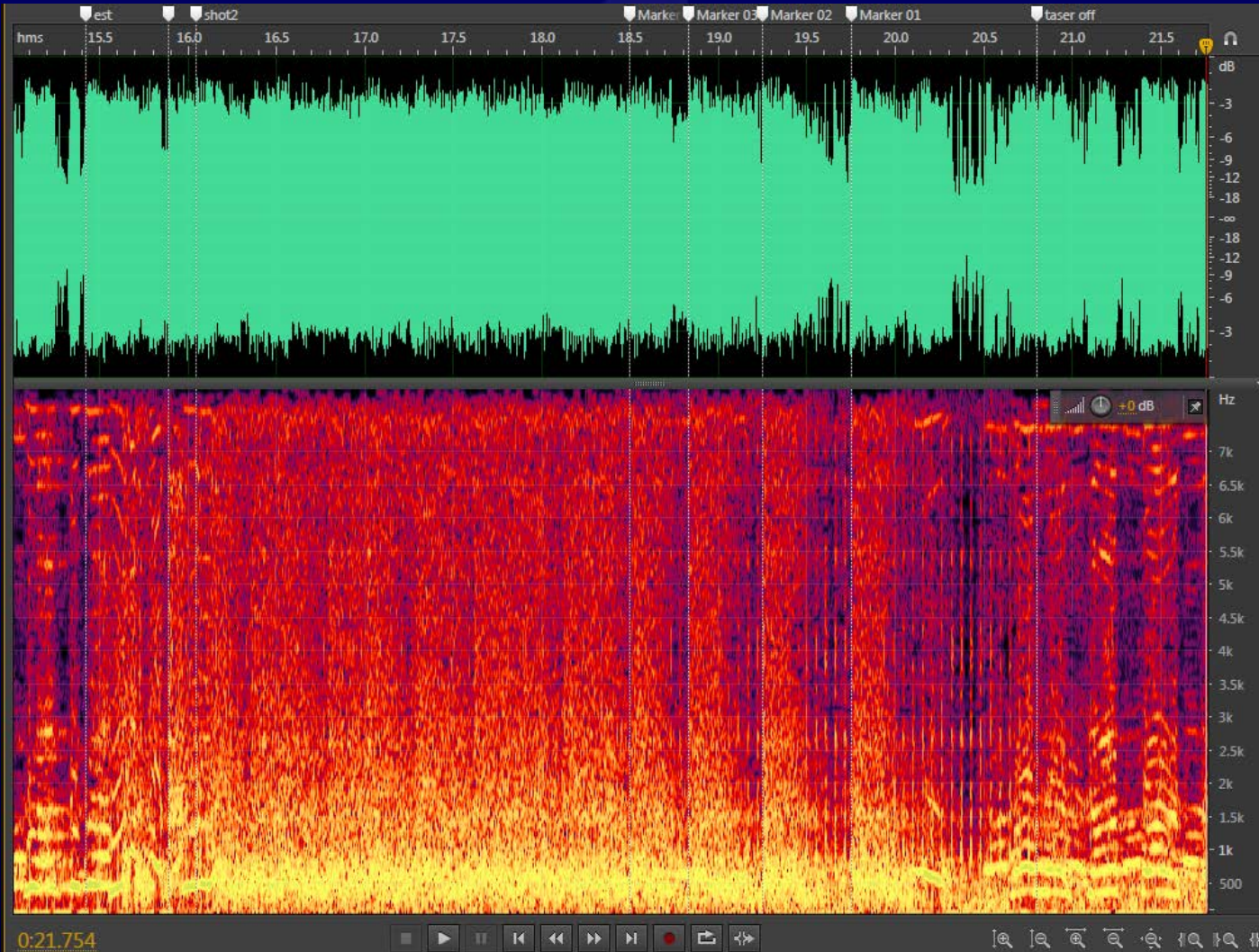
Witnesses agree...

- Individual #1 (deceased) was pointing firearm southward
- Individual #2 (claiming self defense) was pointing firearm northward
- Conclusion: northward-pointing gun facing reflecting surface caused more distinct echo, so Individual #2 fired first.

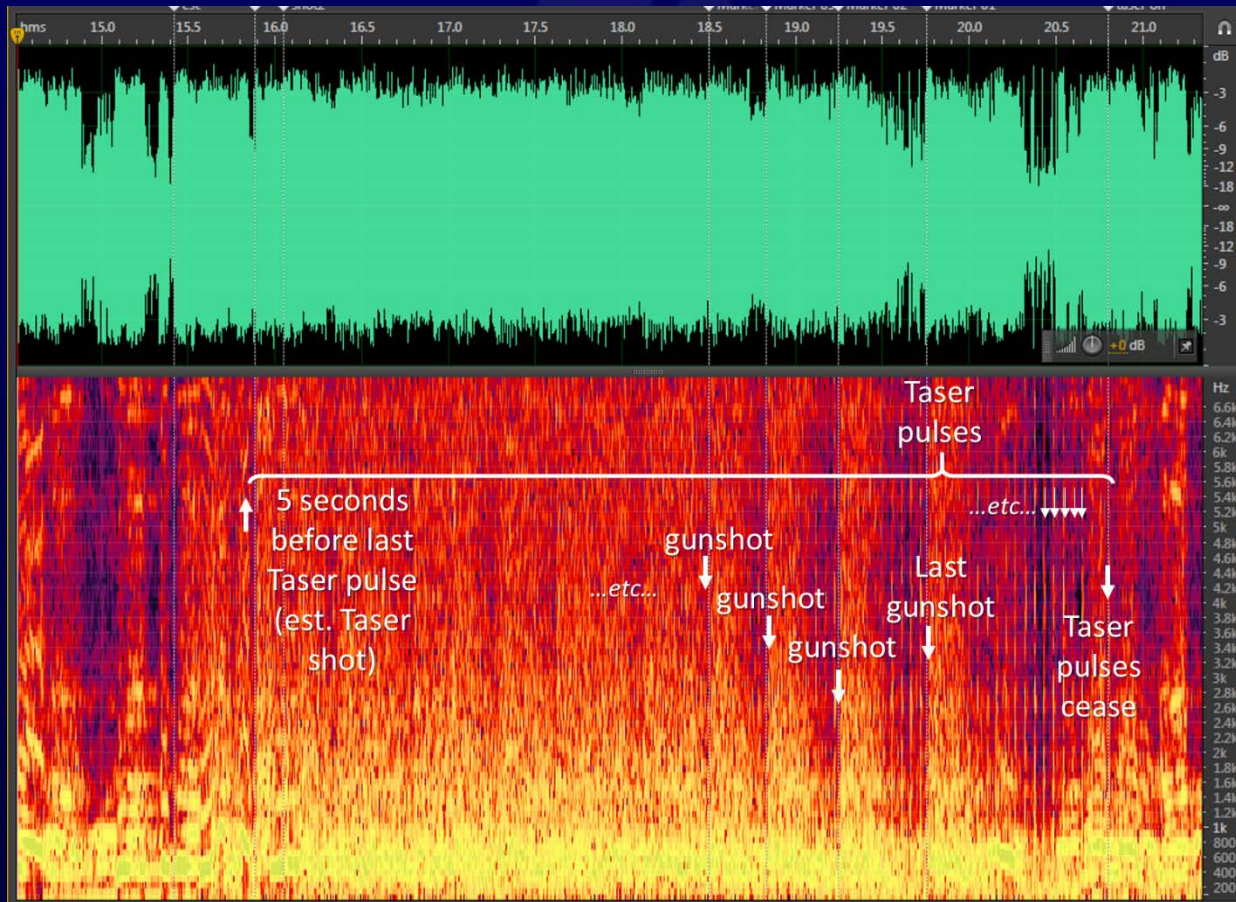
Forensic Example 2

- Law enforcement officers approach a knife-wielding individual.
 - One officer has a Taser, the others have handguns pointed at the suspect.
 - Shots are fired and the Taser is deployed.
 - Audio recordings made by Taser and by nearby dashboard cameras in police cars
 - Which was first, gunshot or Taser?

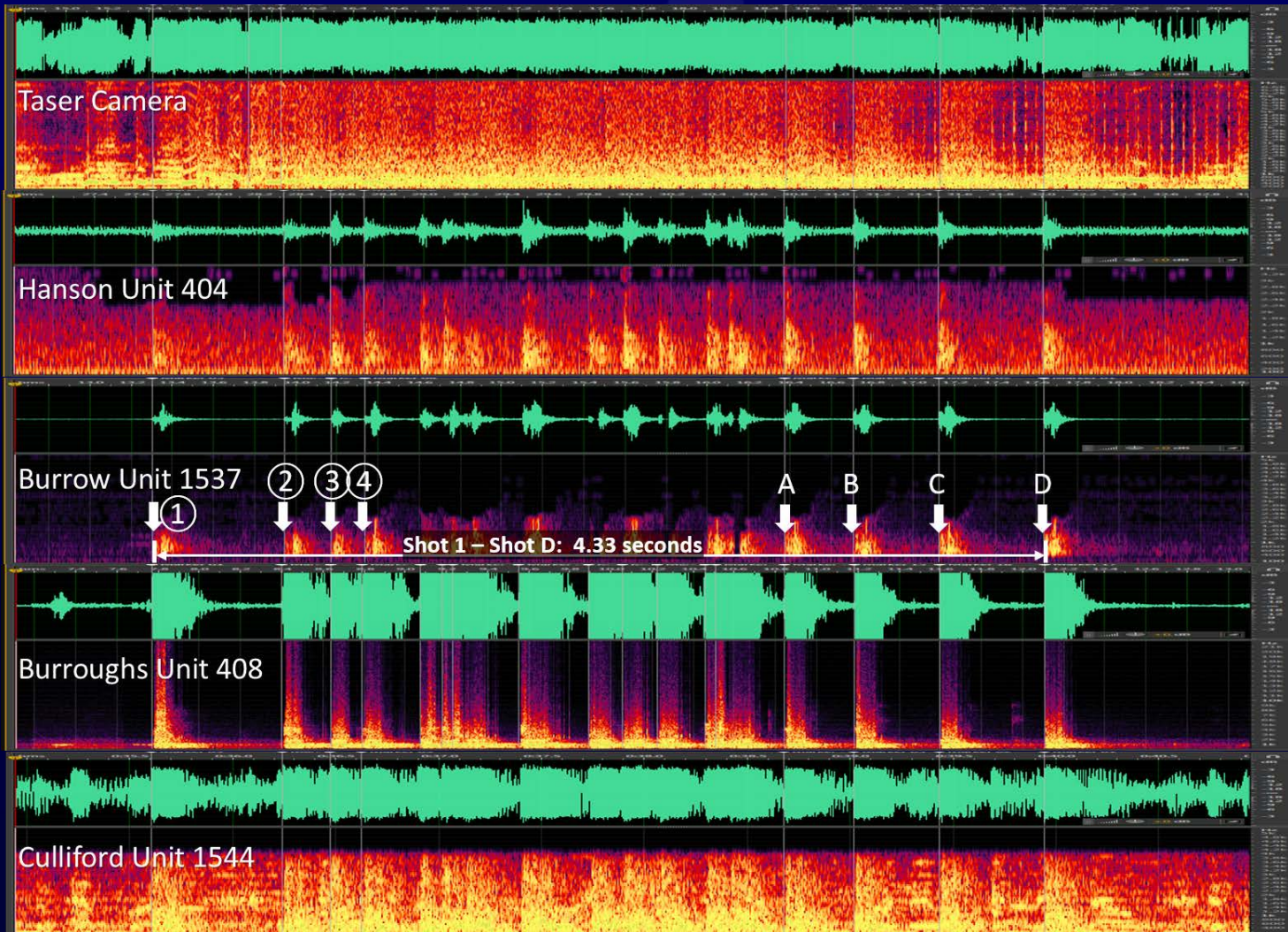
Taser and Shots



Taser Sequence



Dashcam Recordings



Analysis

- Initial sound of Taser is obscured.
 - Dashboard recorders pick up gunshot sounds, but not Taser.
 - Plan: work backward to align timing based on last gunshot.
- Conclusion:
 - First gunshot at 15.4 seconds
 - Taser deployment at 15.8 seconds
 - Gunshot precedes Taser by 0.4 seconds.

Conclusion

- Care is needed to assess the validity of acoustic analysis claims involving gunshot evidence.
- Forensic gunshot recordings generally contain background noise, distortion, clipping, multi-path reflections and reverberation.
- In some cases, timing analysis of the gunshot sounds and acoustic reflections is appropriate.
- Situations involving multiple concurrent recordings of the same event are particularly useful.