Infrasonic Evolution

MTV Workshop, 2020

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Milton Garces
University of Hawaii

Year 1: Introduction and Motivation

TA3.1.Y1. Infrasound

- Address diversity of emplacement conditions and delivery systems for low, high, and nuclear explosives.
- Apply new blast pulse scaling and parametrization developed during CVT to airborne and near-surface stationary, subsonic, supersonic, and hypersonic explosive sources.

Students on Infrasound Thrust (see Falcon 9 study in their poster)

- Kei Takasawa
- Jonathan Tobin

Lab Collaborations

- LLNL: Keehoon Kim, Jessie Gaylord and Steven Magana-Zook.
- SNL: Daniel Bowman. Airborne platforms.
- NNSS: Cleat Zeiler. LANL: Jim Smith. Source physics and processes.
- INL: David Chichester. Pursue new signatures and methods.

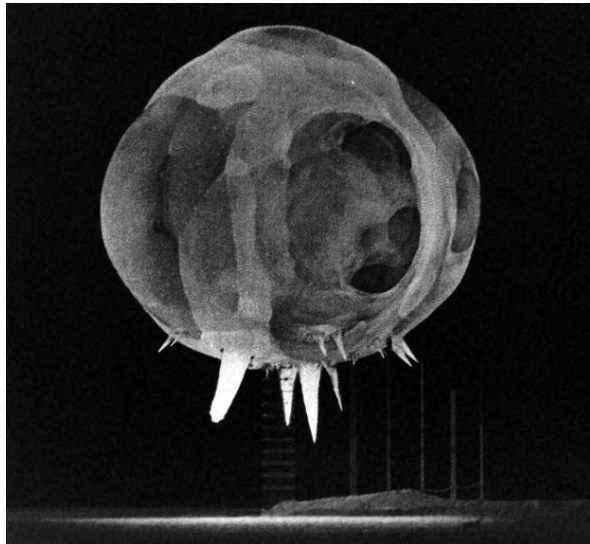National Nuclear Security Administration
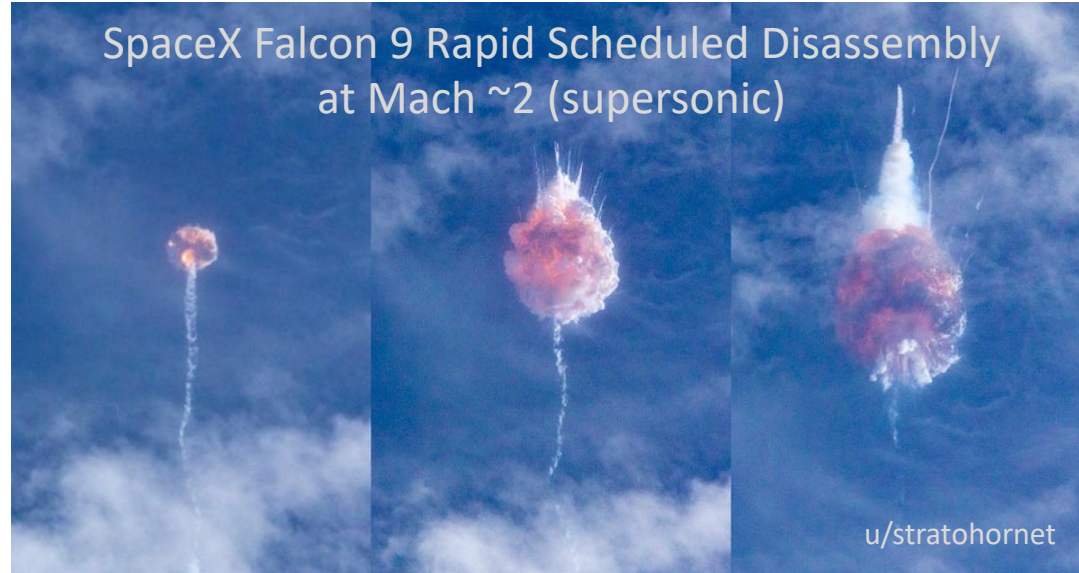
Blasts: from kilotons to tons

Modernize geophysical sensing systems and methods that can be deployed globally to effectively monitor explosive events and fuel cycle activity.
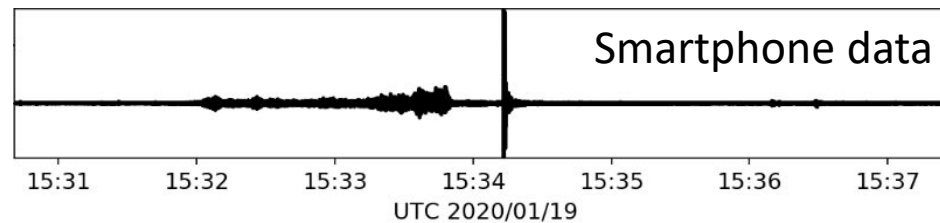

Tumbler Snapper
(LLNL YouTube Channel)

High Explosive NE Proxies at NNSS

SpaceX Falcon 9 Rapid Scheduled Disassembly at Mach ~2 (supersonic)

u/stratohornet

Supersonic Propellant Blast Proxy

Smartphone data

15:31   15:32   15:33   15:34   15:35   15:36   15:37
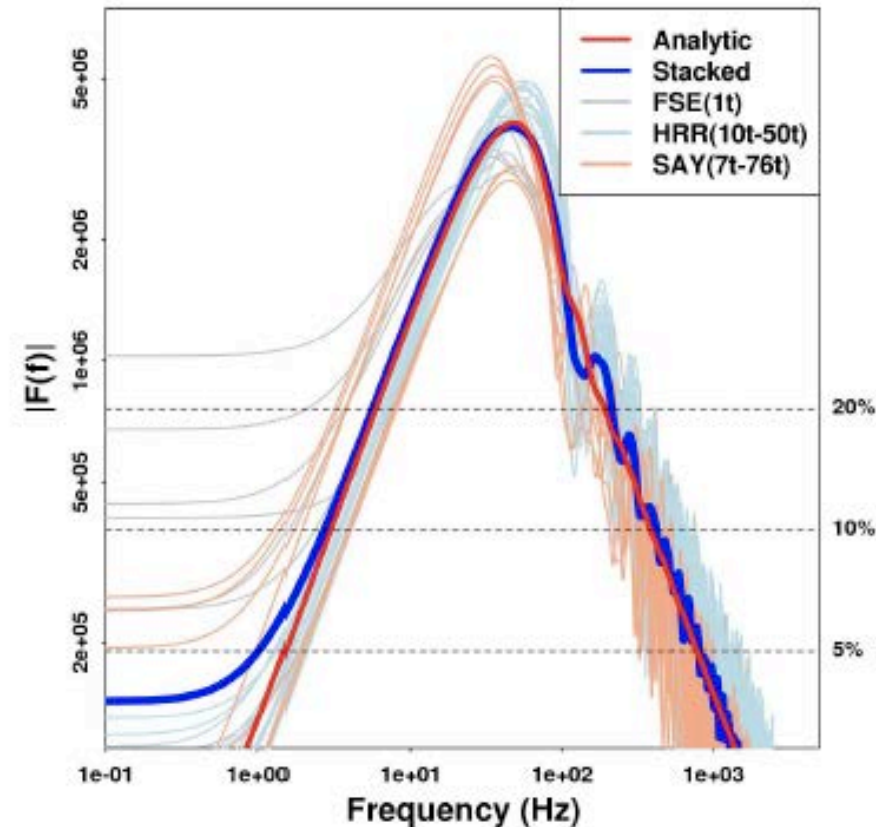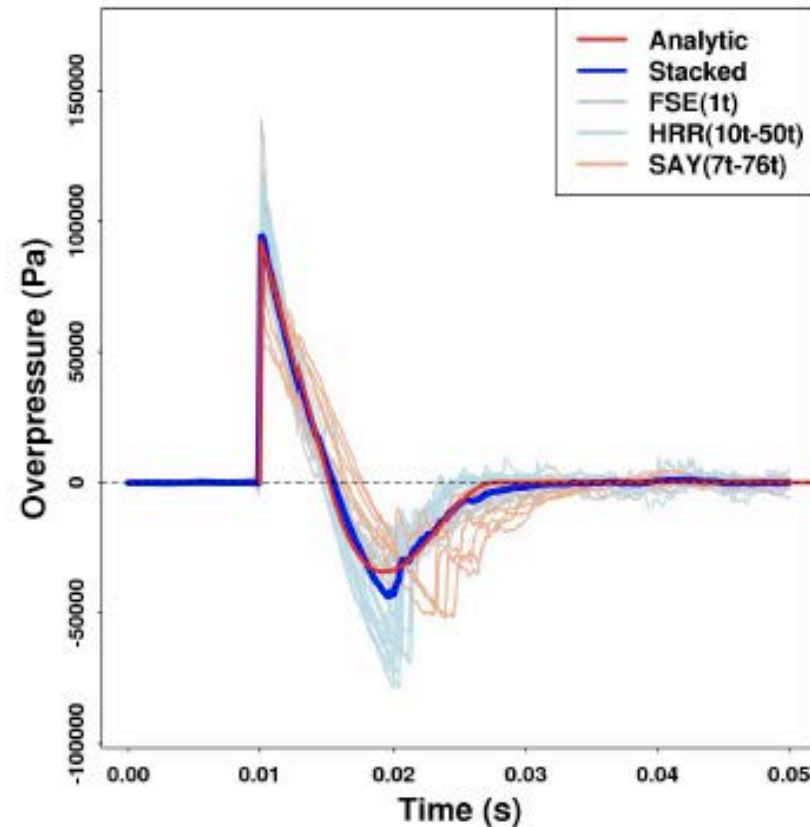UTC 2020/01/19

http://redvox.io/@/a3a8

Launch and photo by D. Bowman.

Emerging Collection Platforms

Explosion Source (K. Kim, LLNL).

Canonical Waveform **(Analytic) from Garces (2019)**

- Traditional Mission
- HE Proxy for NE
- Static source and receiver positions
- Transition from CVT to MTV

Kim, K., A. J. Rodgers, M. A. Garces, S. Myers (2019). An Empirical Acoustic Source Model for Chemical Explosions in Air. Amer. Geophys. Union Fall Meeting, SF, CA, 9-13 Dec. Also presented in Jordan ITW (2019)

Stratospheric Blast: Falcon 9 Burn at Mach 2

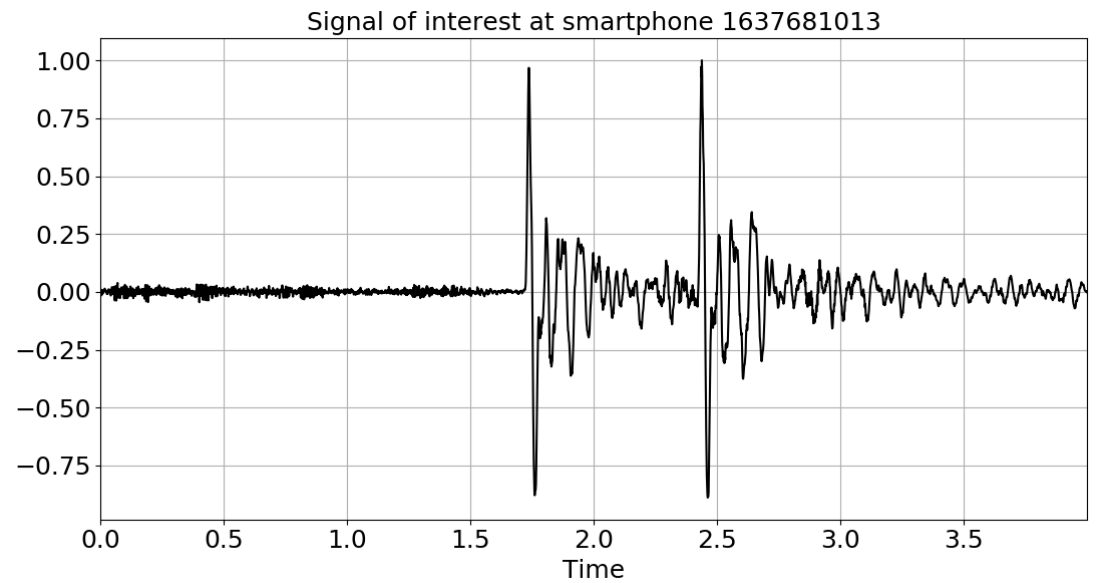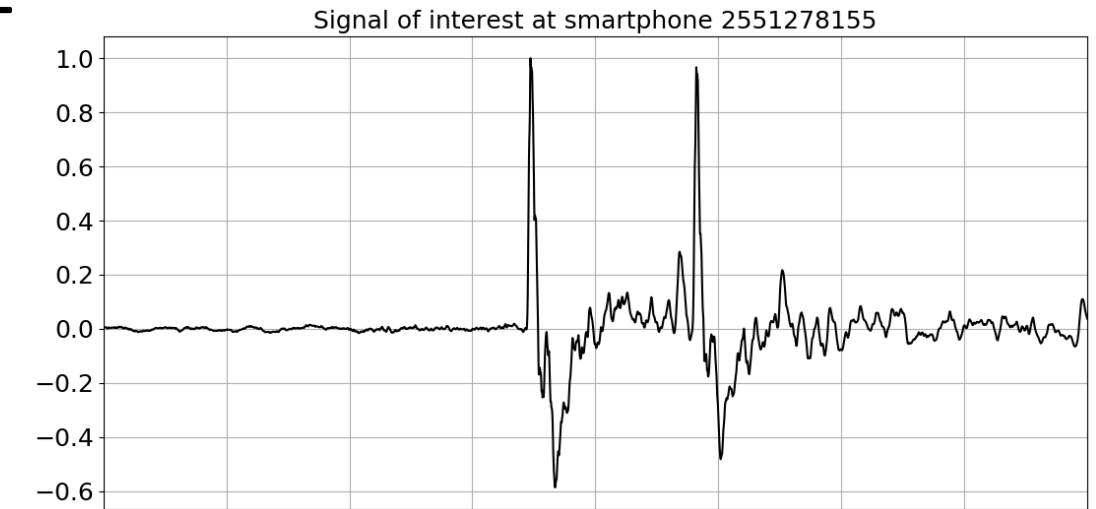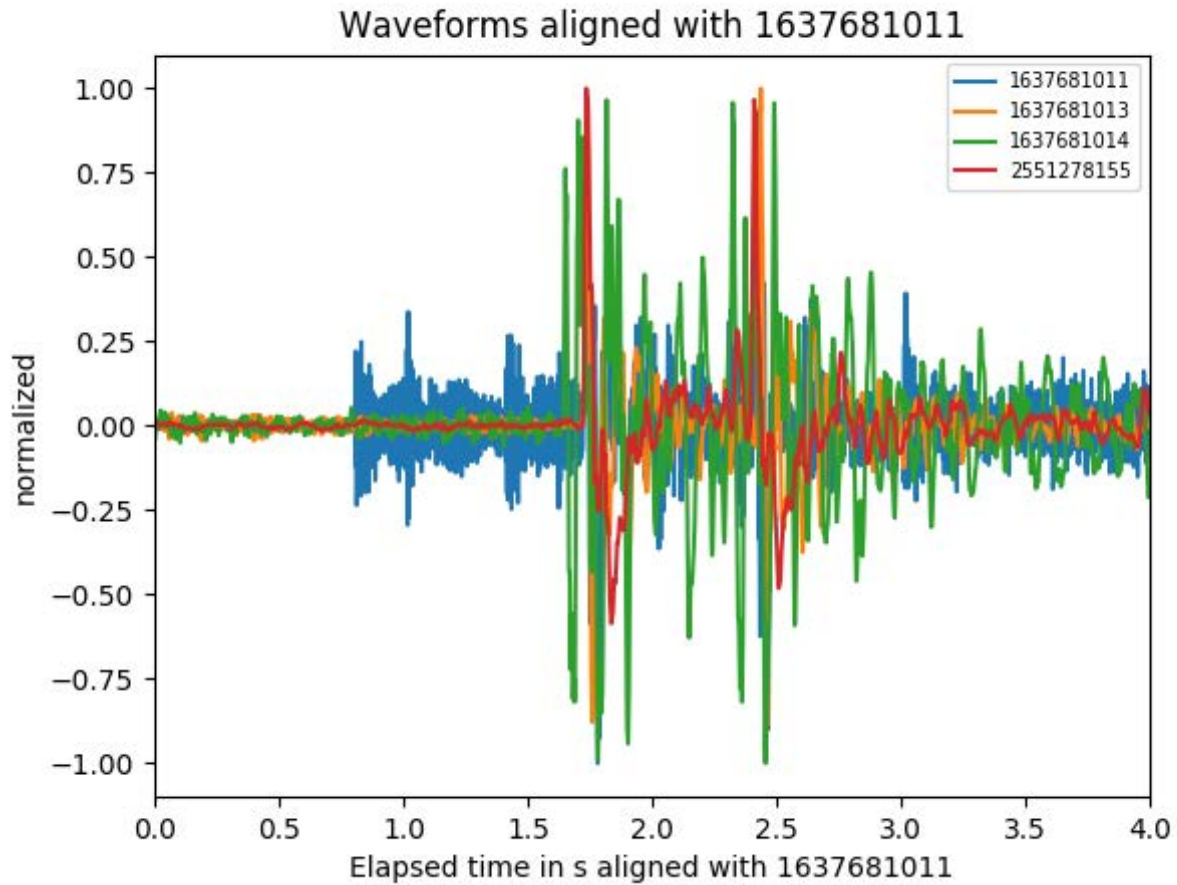Moving Source. Deflagration not the same as a detonation.

Supersonic; shocks expected. Source at ~20 km (stratosphere).

Crowdsourced open data: http://redvox.io/@/f8cf

SpaceX Falcon 9 Rapid Scheduled Disassembly

u/stratohornet
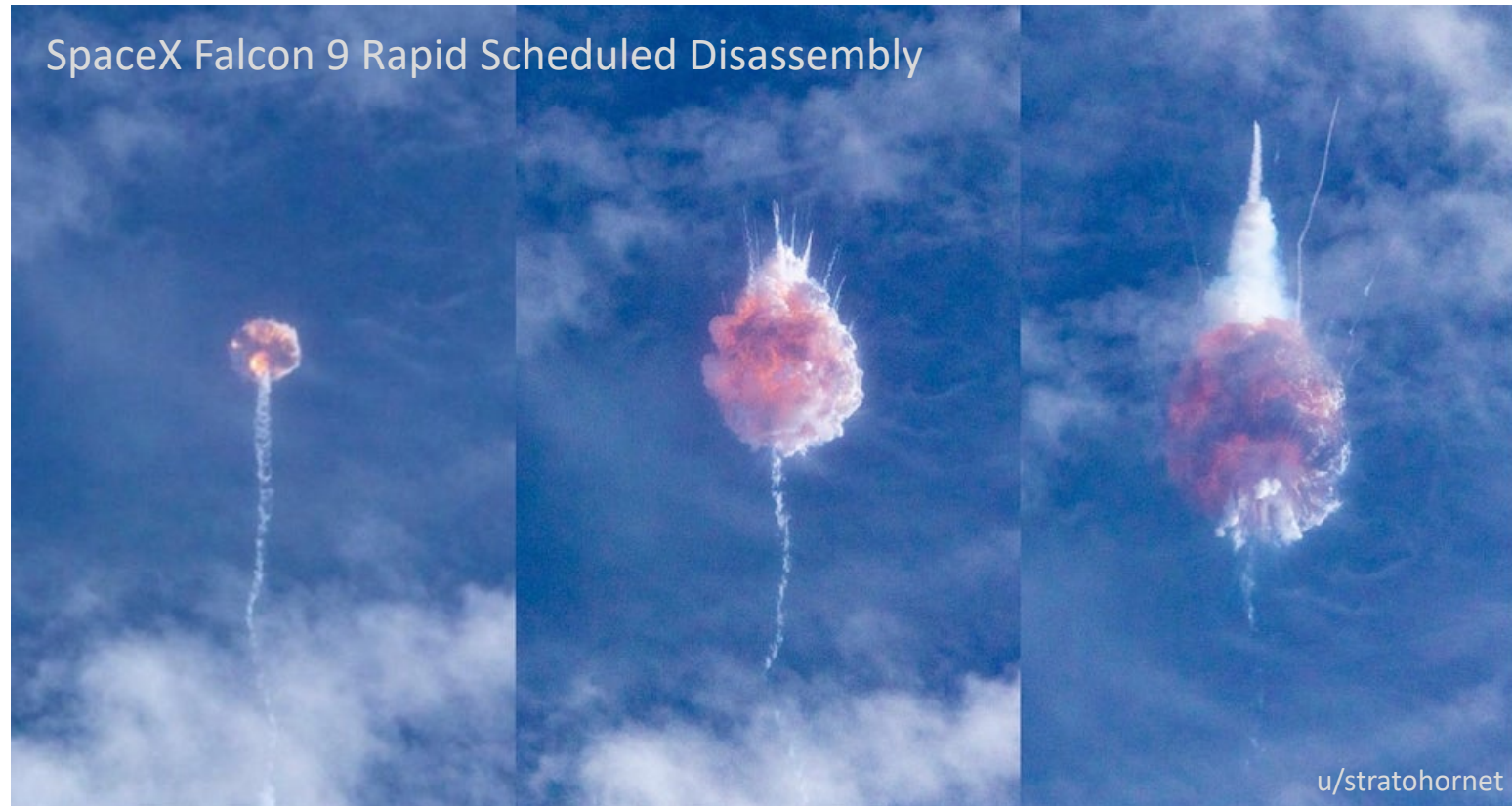
Blasts: Falcon 9 at Mach 2

Open data: http://redvox.io/@/f8cf

Twin Blast Signatures: Falcon 9 at Mach 2

Open data: http://redvox.io/@/f8cf
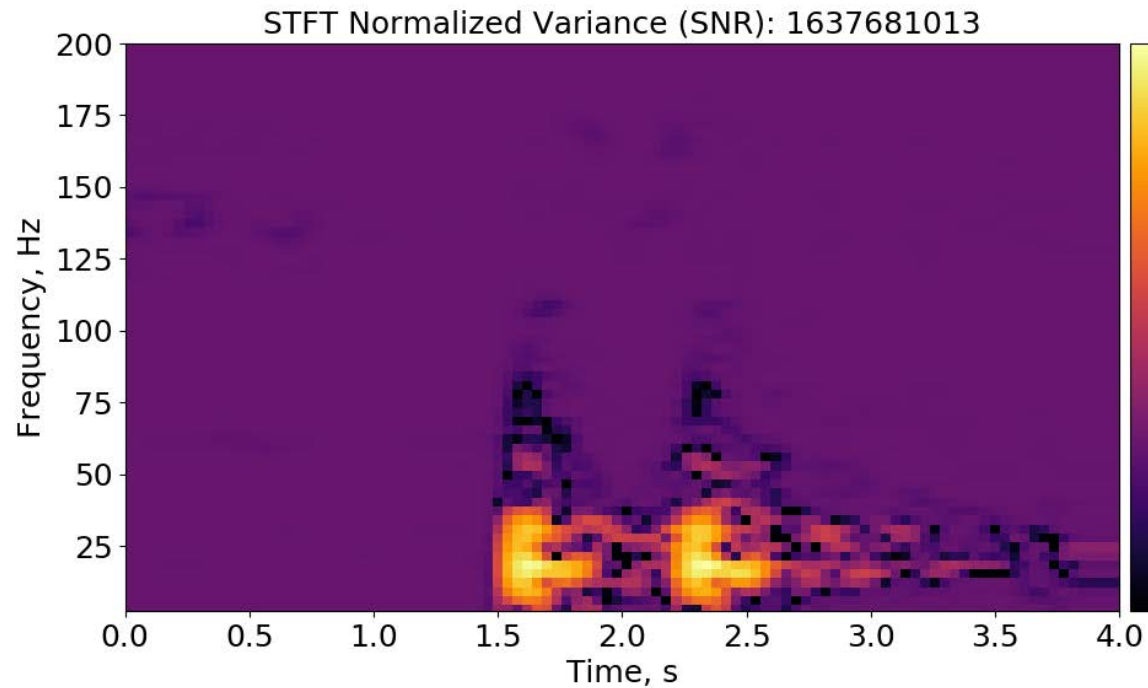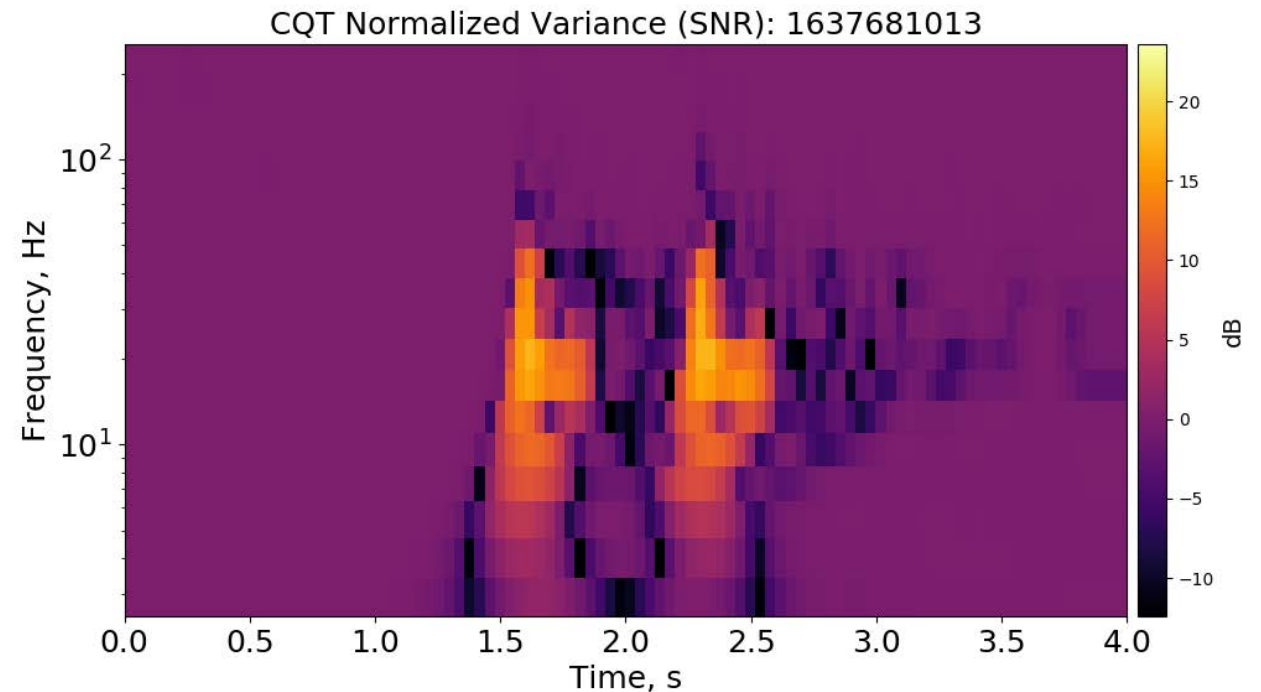
Falcon 9 RP-1 Deflagration at Mach 2
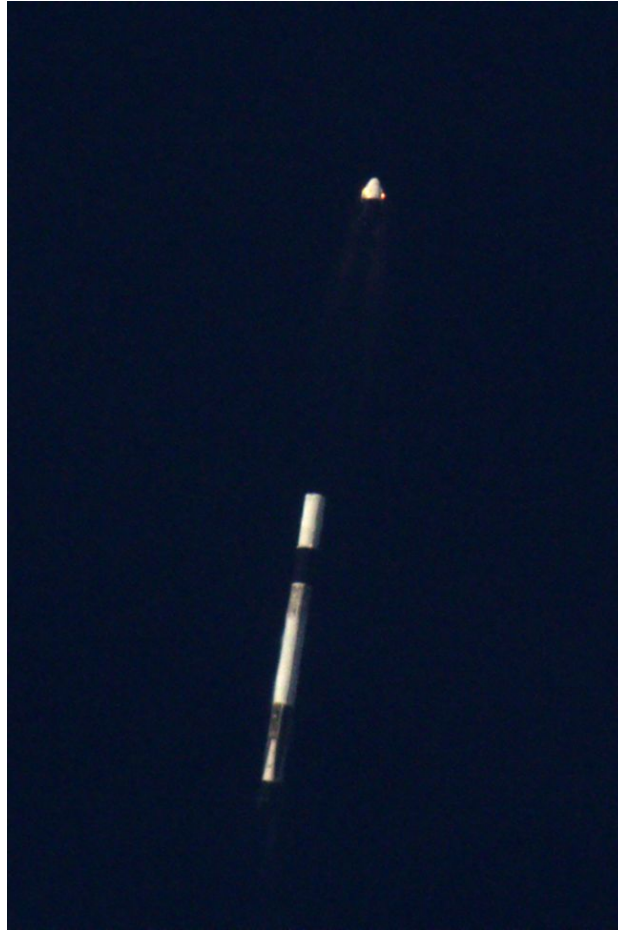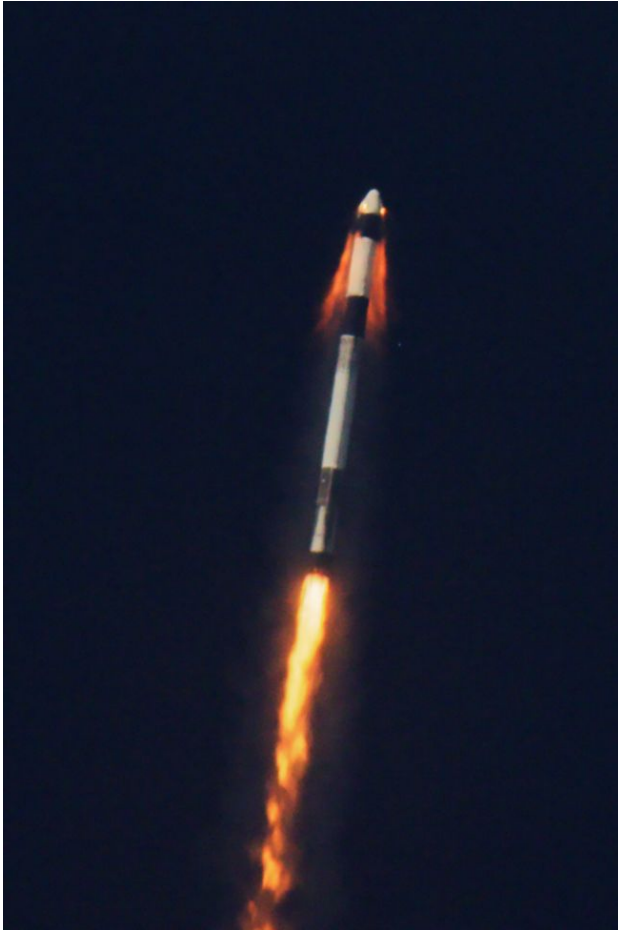
Moving source; NOT a point source.

Hypothesis: Shock tube.

Table 2-1: Falcon dimensions and characteristics

| Characteristic	First Stage Core	Second Stage
Structure		
Height	70 m (229 ft) (including both stages, interstage and fairing)	
Diameter	3.66 m (12 ft)	3.66 m (12 ft)
Type	LOX tank – monocoque; Fuel tank – skin and stringer	LOX tank – monocoque Fuel tanks – skin and stringer
Material	Aluminum lithium skin; aluminum domes	
Propulsion		
Engine type	Liquid, gas generator	Liquid, gas generator
Engine designation	Merlin 1D (M1D)	MVac
Engine designer	SpaceX	SpaceX
Engine manufacturer	SpaceX	SpaceX
Number of engines	9	1
Propellant	Liquid oxygen/kerosene (RP-1)	Liquid oxygen/kerosene (RP-1)
Thrust (stage total)	7,686 kN (sea level) (1,710,000 lbf)	981 kN (Vacuum) (220,500 lbf)

https://phys.org/news/2018-09-blast-tube-sandia-simulate-conditions.html

Stratospheric Collection (with D. Bowman, SNL)
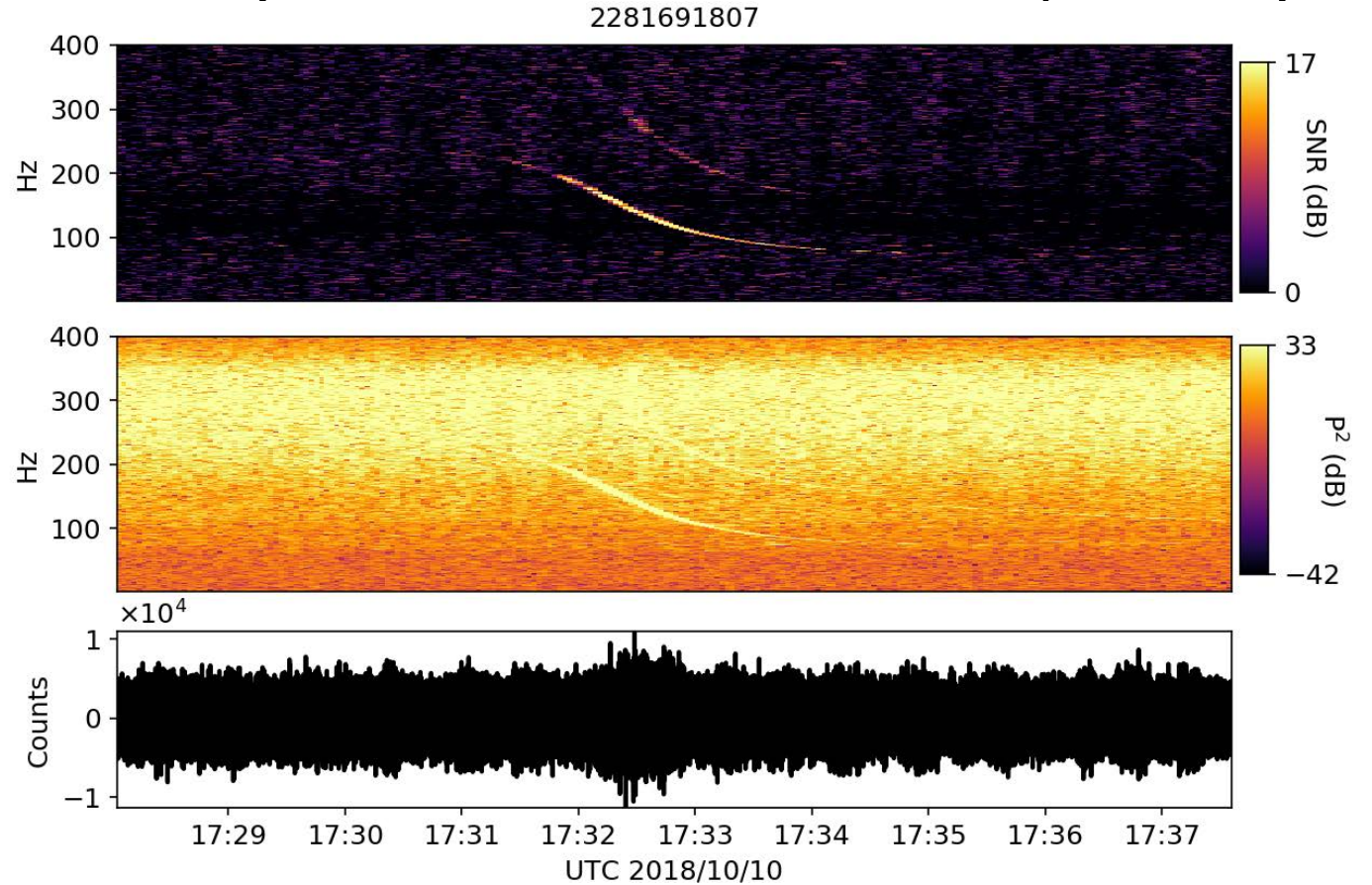
- Light aircraft characterized by Doppler-shifted signatures with fundamental and overtones
- **Moving source, moving receiver**

Trajectory data on 2018/10/10 at 17:28:06 UTC
Lat, Lon, Altitude (m): 34.99350, -104.76358, +19,536 m
Temperature, Pressure: -31.1C, 5965 Pa

Conclusions and Ongoing Work

- Garces (2019) canonical blast pulse validated by LLNL explosion data. Transitioning from CVT to MTV.

- Supersonic blasts: 20200119 SpaceX Dragon case study.

- Theoretical full-wave equations for moving subsonic acoustic sources and receivers with a reflecting boundary rederived, coded, and validated against observations. Collaboration with SNL for collection with airborne platforms.

- Nevada National Security Site (NNSS) blasts scheduled for 2020.

- New deployments in planning stage with INL.