The next generation in drillstring imaging

Roman Shor

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NSERC CRSNG
UNIVERSITY OF CALGARY
FACULTY OF SCIENCE
Department of Geoscience

What is drillstring imaging?

Source: bridgat.com

Source: everypart.com

Source: newoilrigs.com

Source: mudpumps.org

Source: eaglefordshale.com

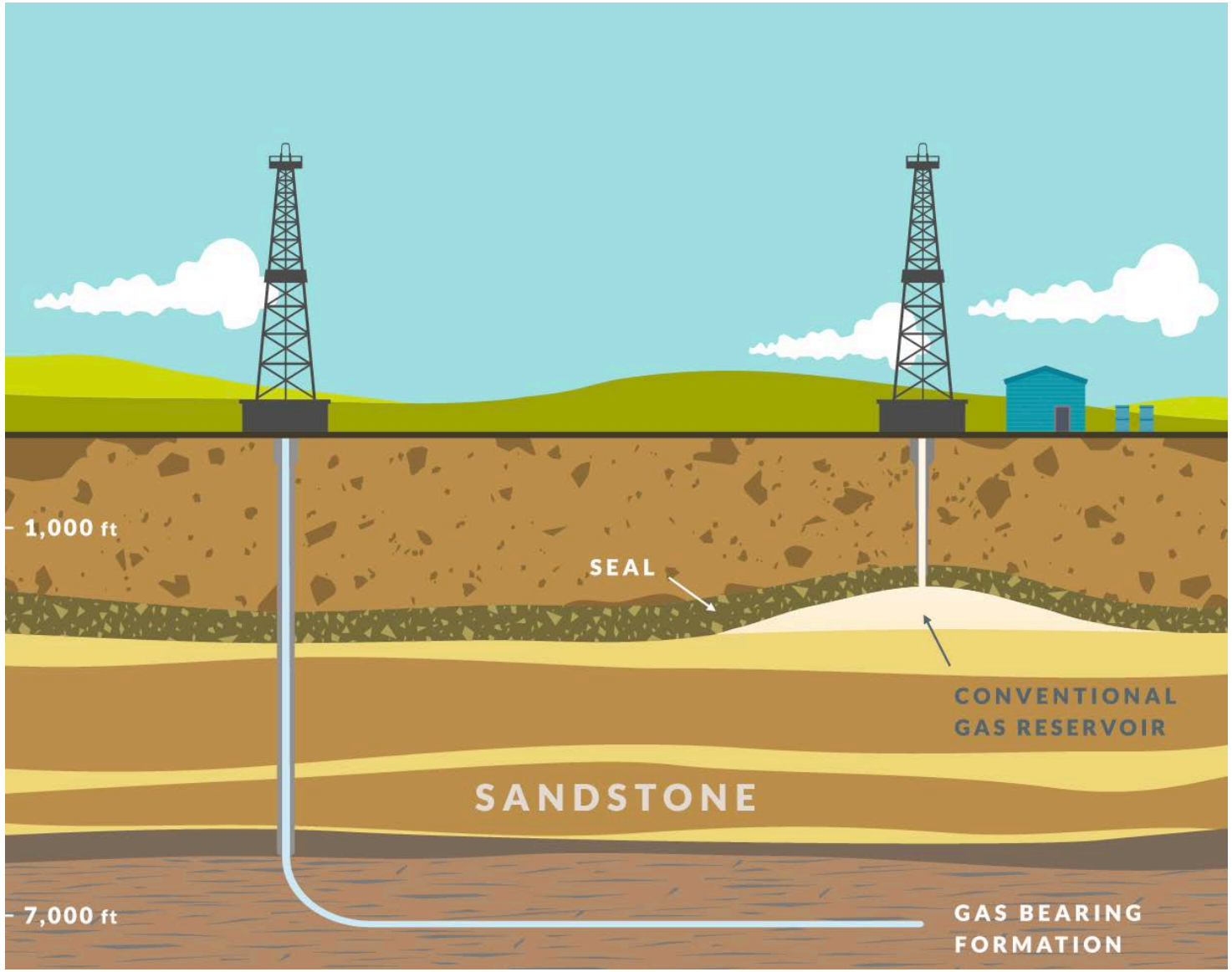
Modified from reelwell

What is drillstring imaging?

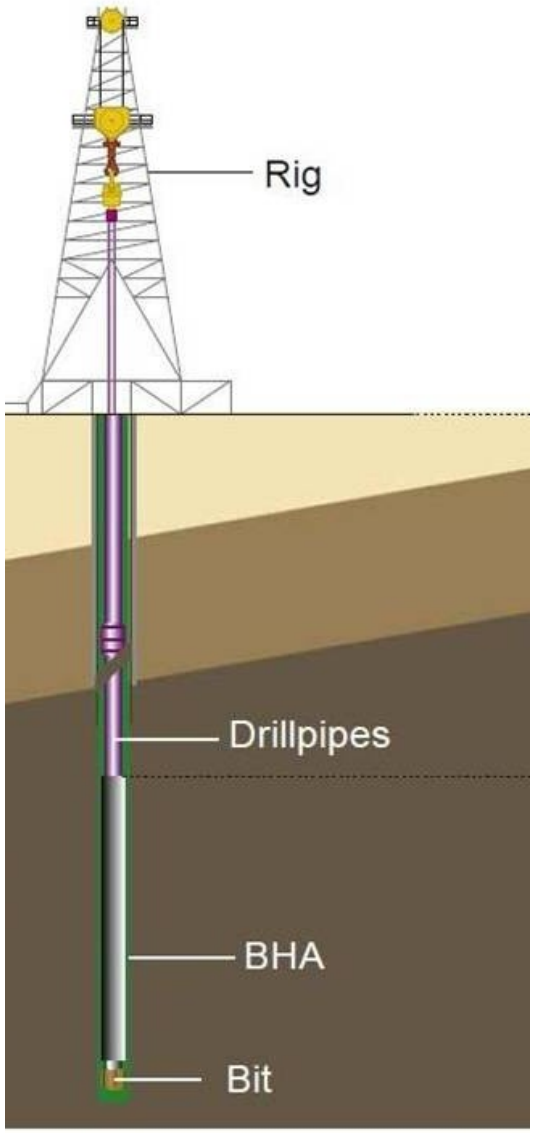
Idea #1 – Can formation type be detected based on the drillstring harmonics?

Idea #2 – Can the borehole quality (cuttings transport, tortuosity, friction points, etc) be imaged?

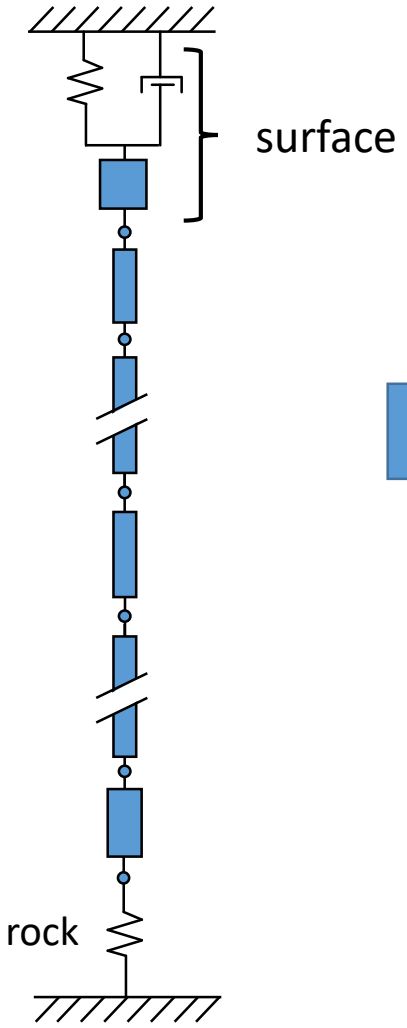
Idea #3 – Seismic-while-drilling

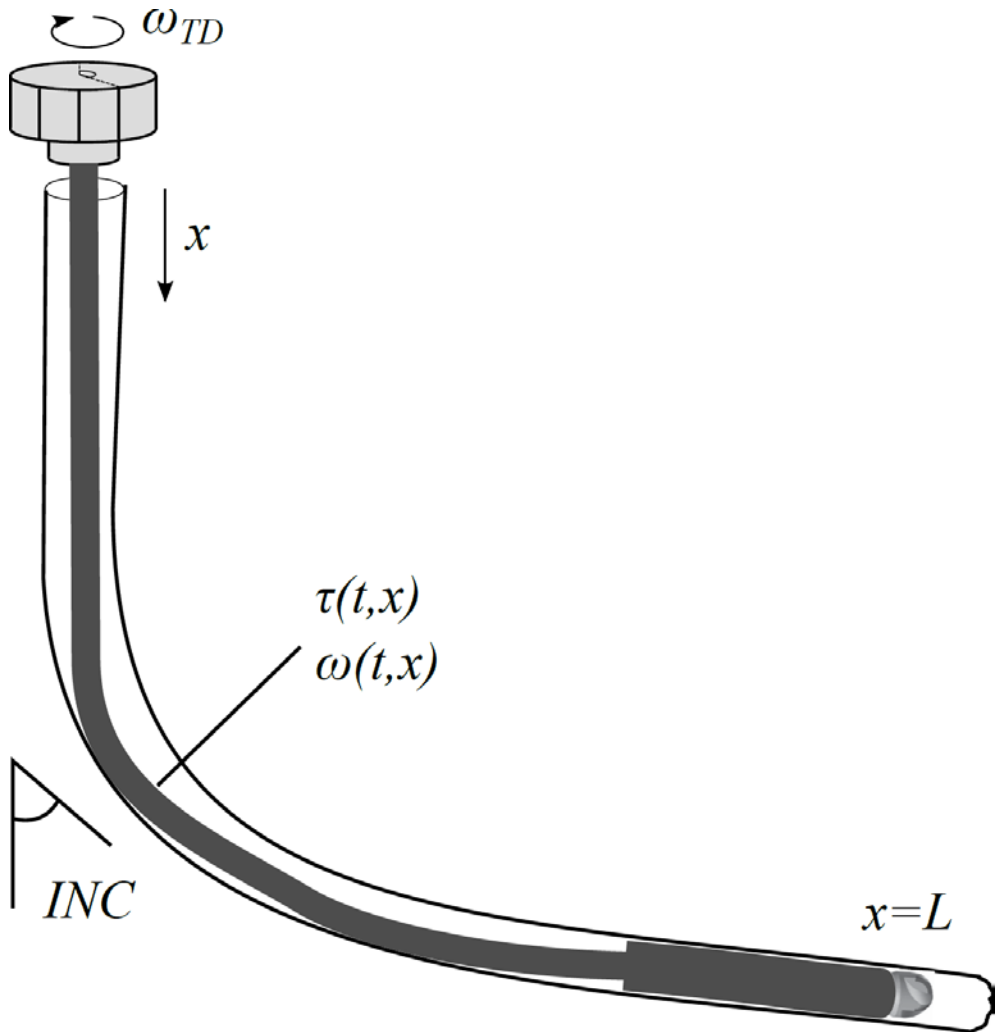


Generalized Drillstring Model

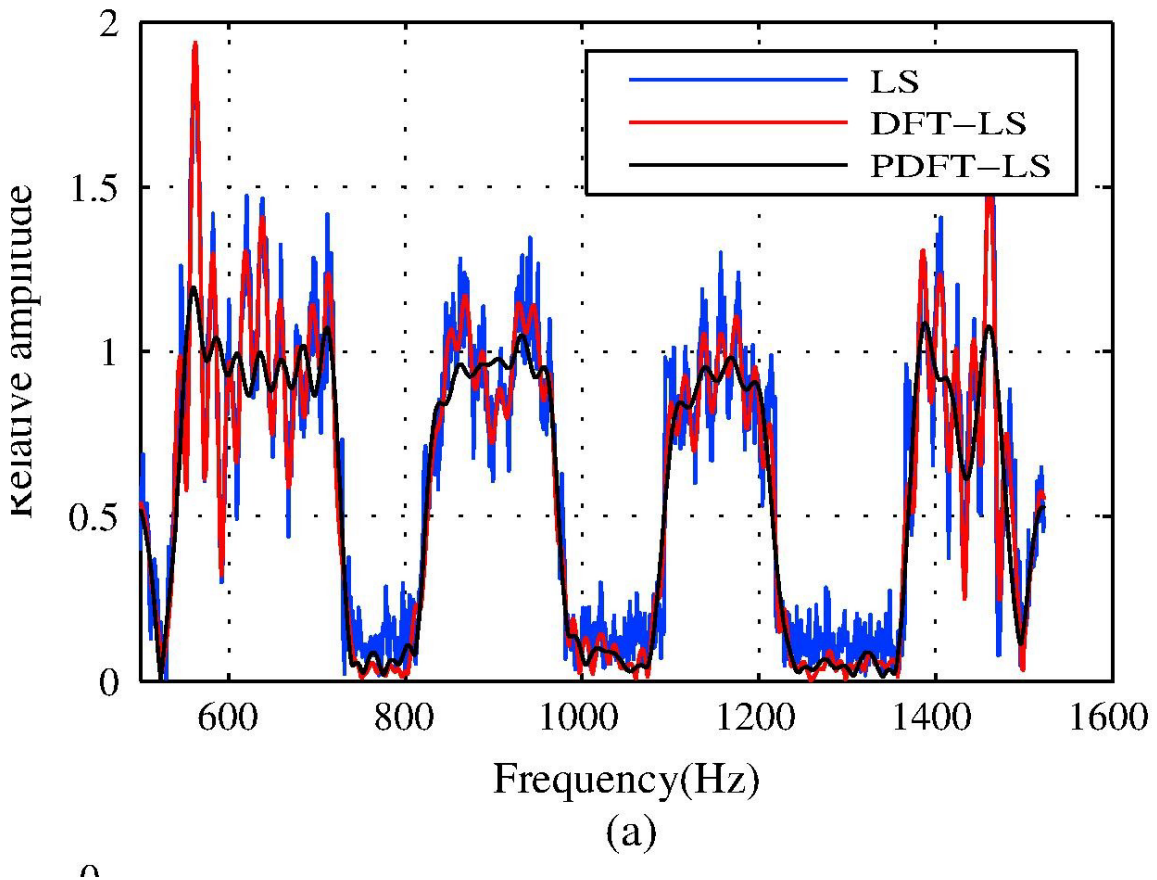


Source: Univ of Aberdeen





Drillstring as a waveguide



At low frequencies the drillstring acts as a waveguide with low damping

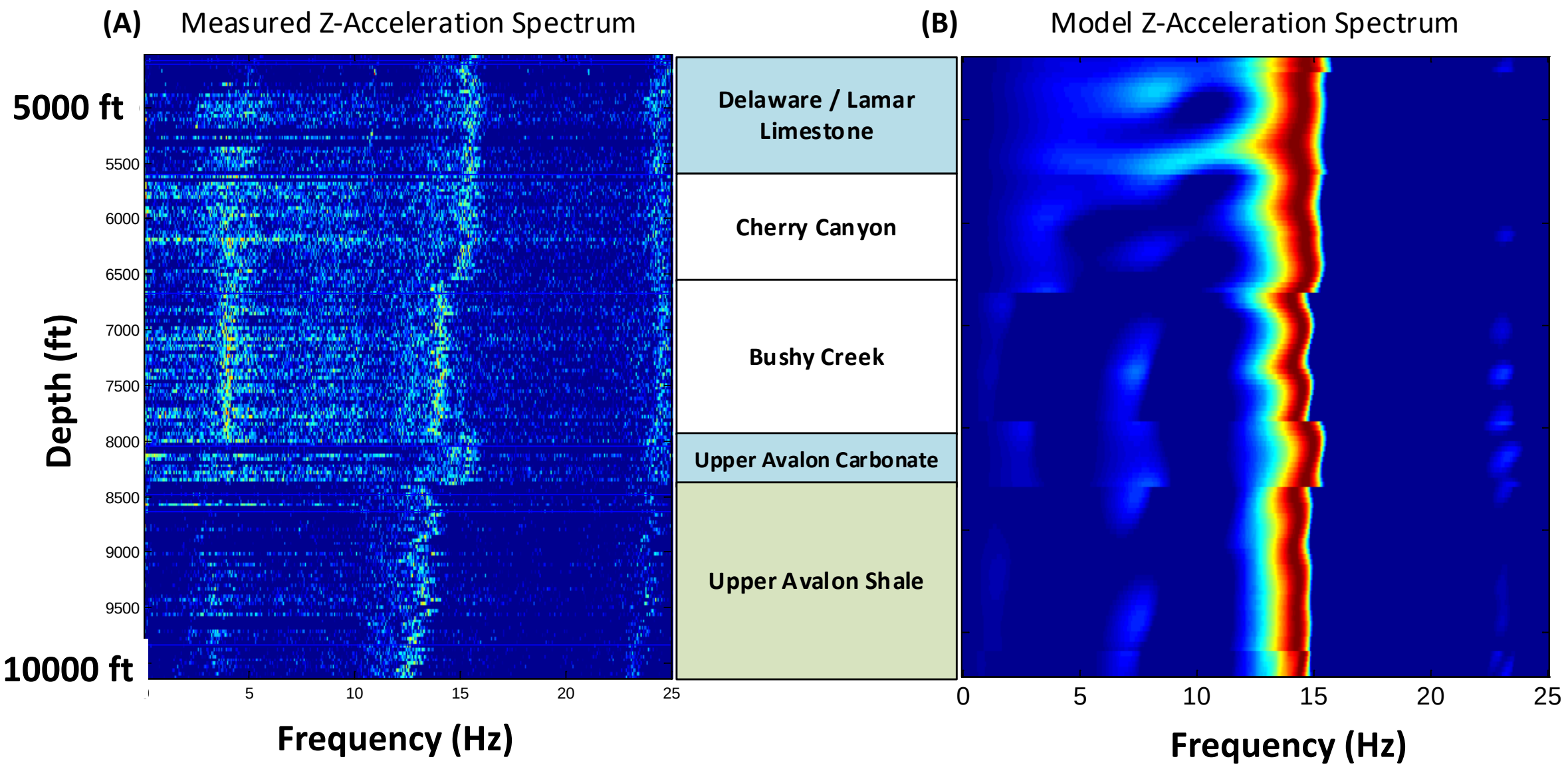
At higher frequencies, the presence of tool joints leads to passbands and deadbands

Used for acoustic telemetry systems (which promise kbps bandwidth and 1-3 second latency)

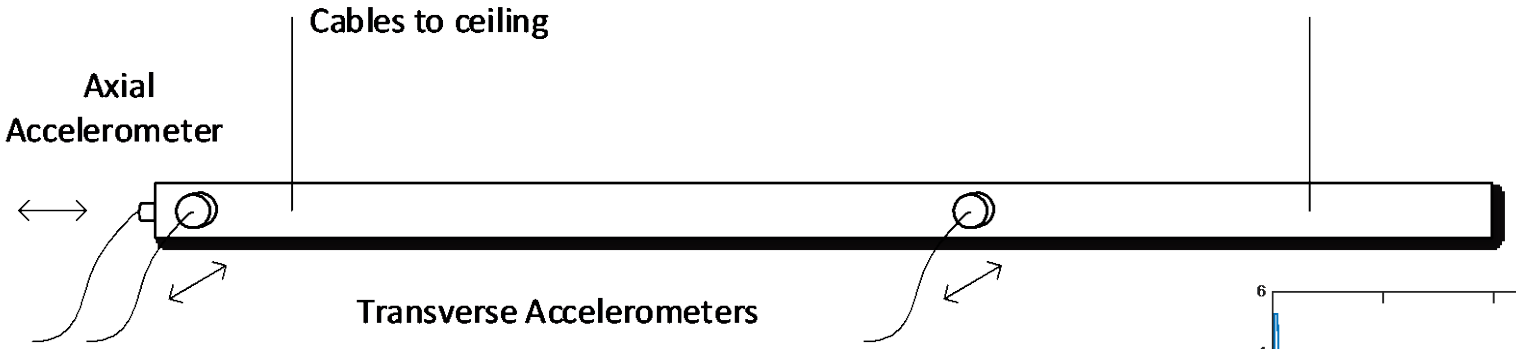
Gives an opportunity to image (or probe) the bit-rock interaction

Dong Ma, Yibing Shi, Wei Zhang, and Guozhen Liu. Design of acoustic transmission along drill strings for logging while drilling data based on adaptive NC-OFDM. AEU - International Journal of Electronics and Communications. Volume 83, 2018, pp 329-338.

Visualizing Frequency Content vs Depth

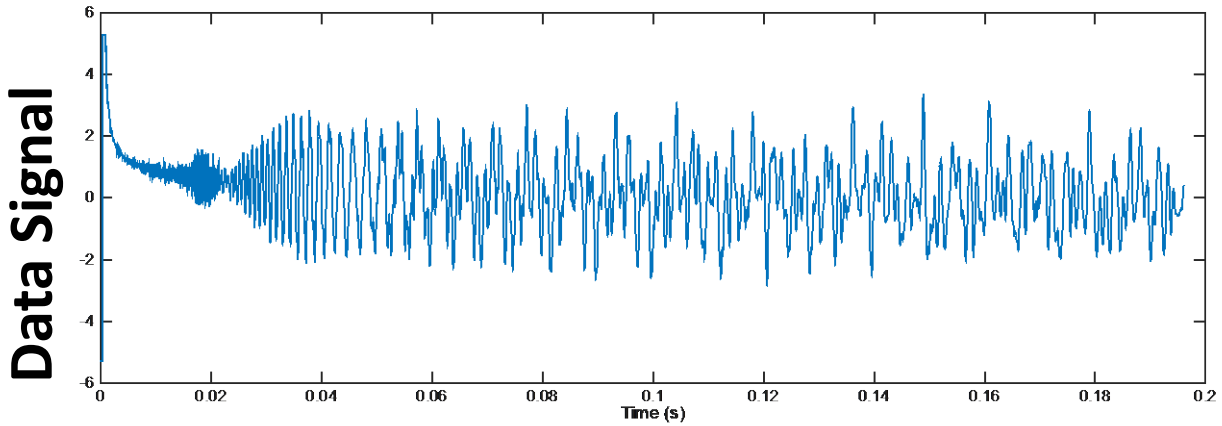


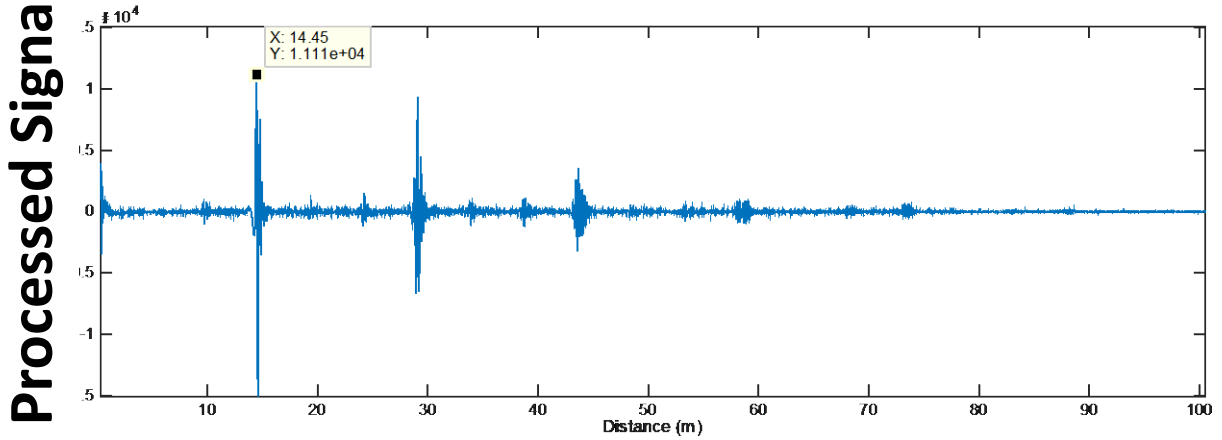
Imaging of a Hanging Beam



- Transverse waves in a steel beam
  - Wave velocity is a function of frequency

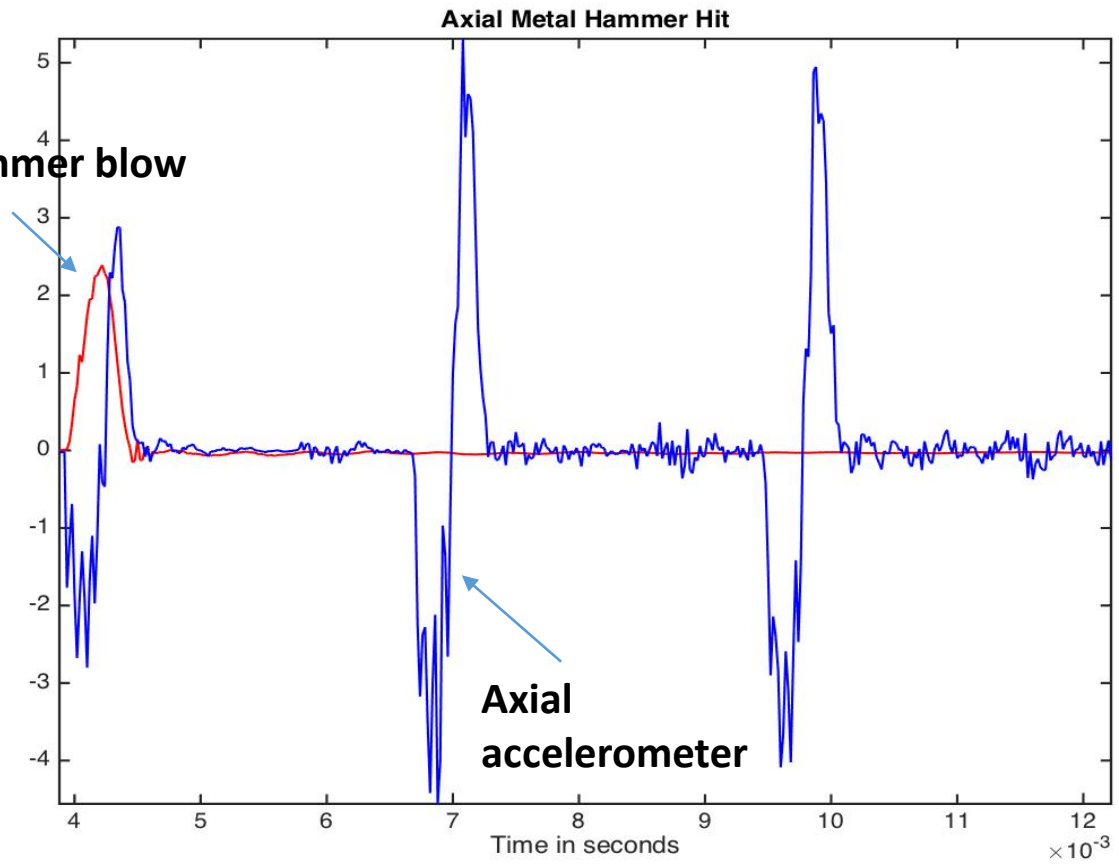
- Question:
  - Can this be adapted to axial or torsional waves?





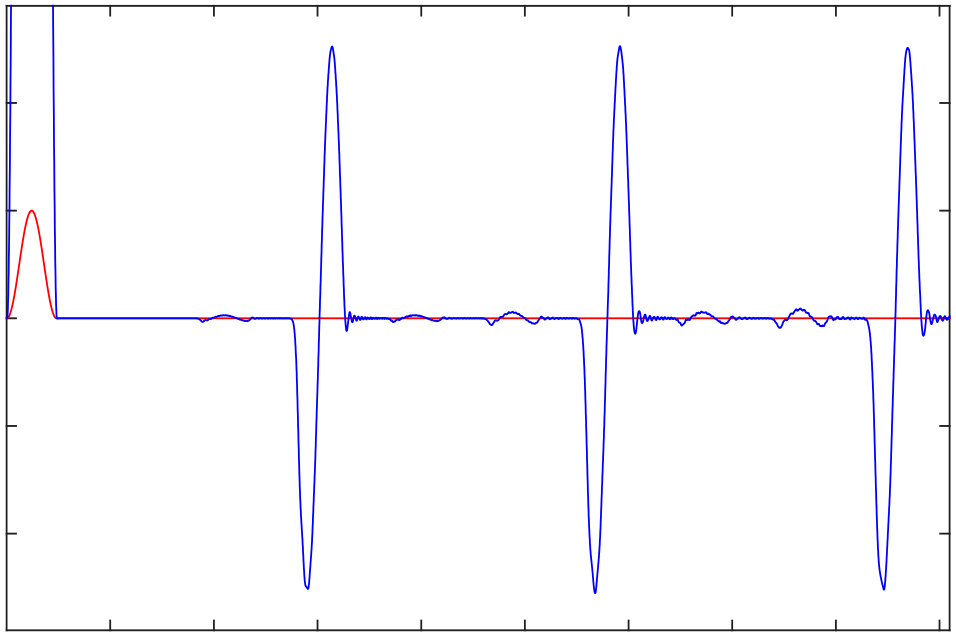
What about axial or torsional waves?

Experimental Resuls



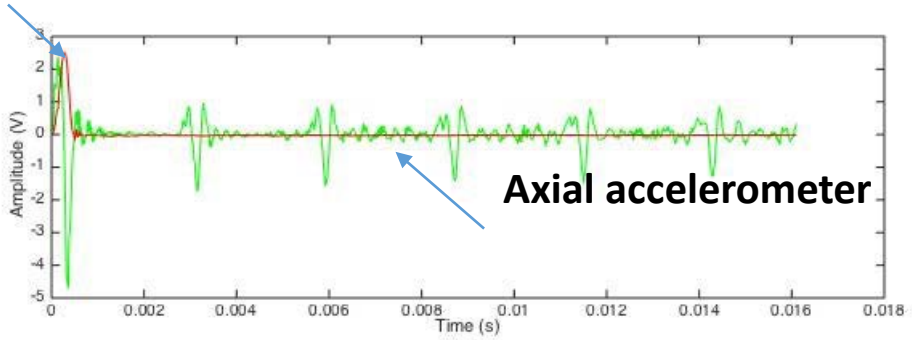
Simulation Results

Mass placed 2/3 of way down

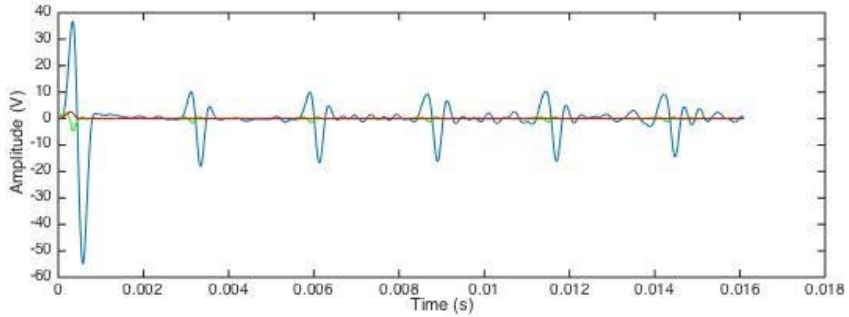


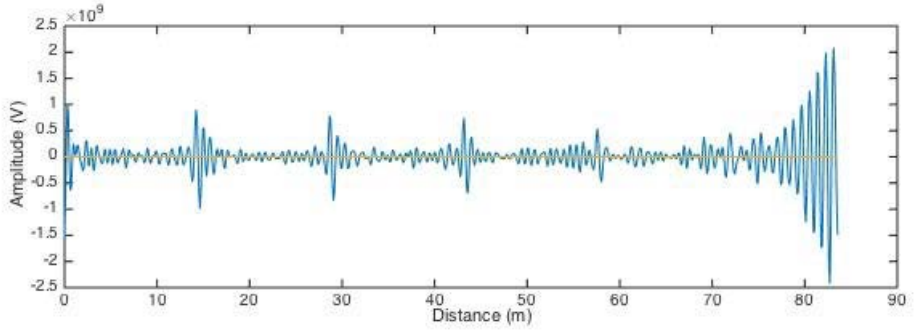
Drillstring Imaging

Hammer blow

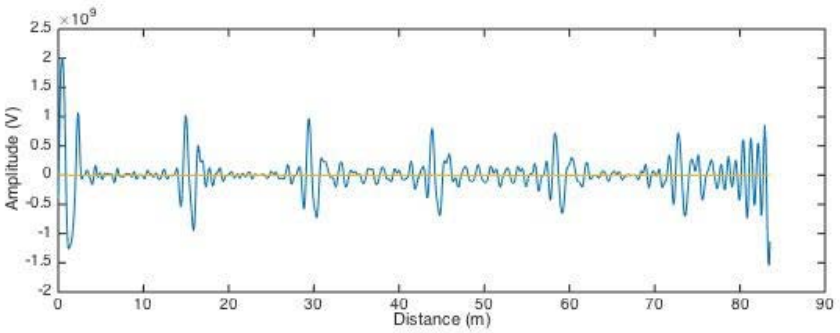


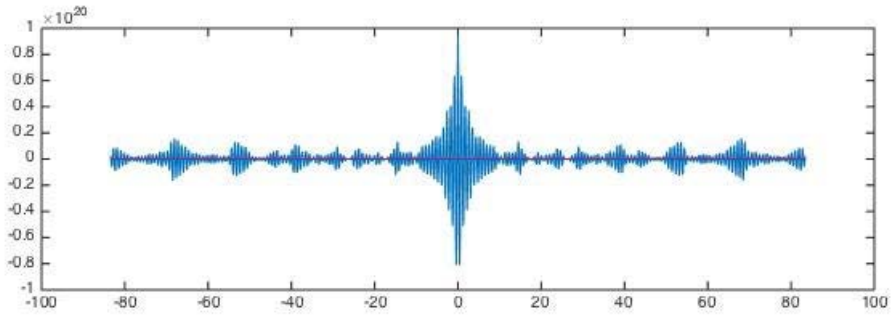
Axial accelerometer



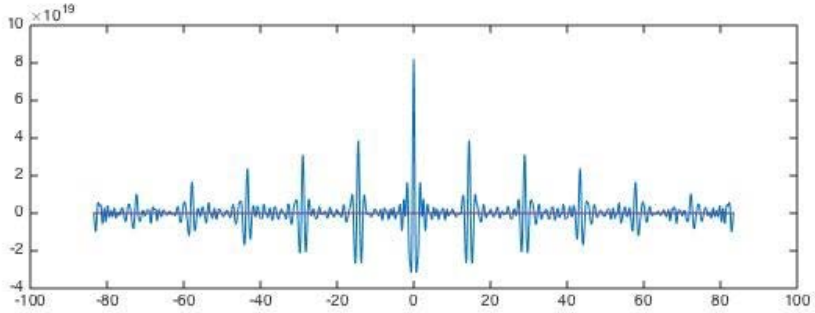


Filtered response



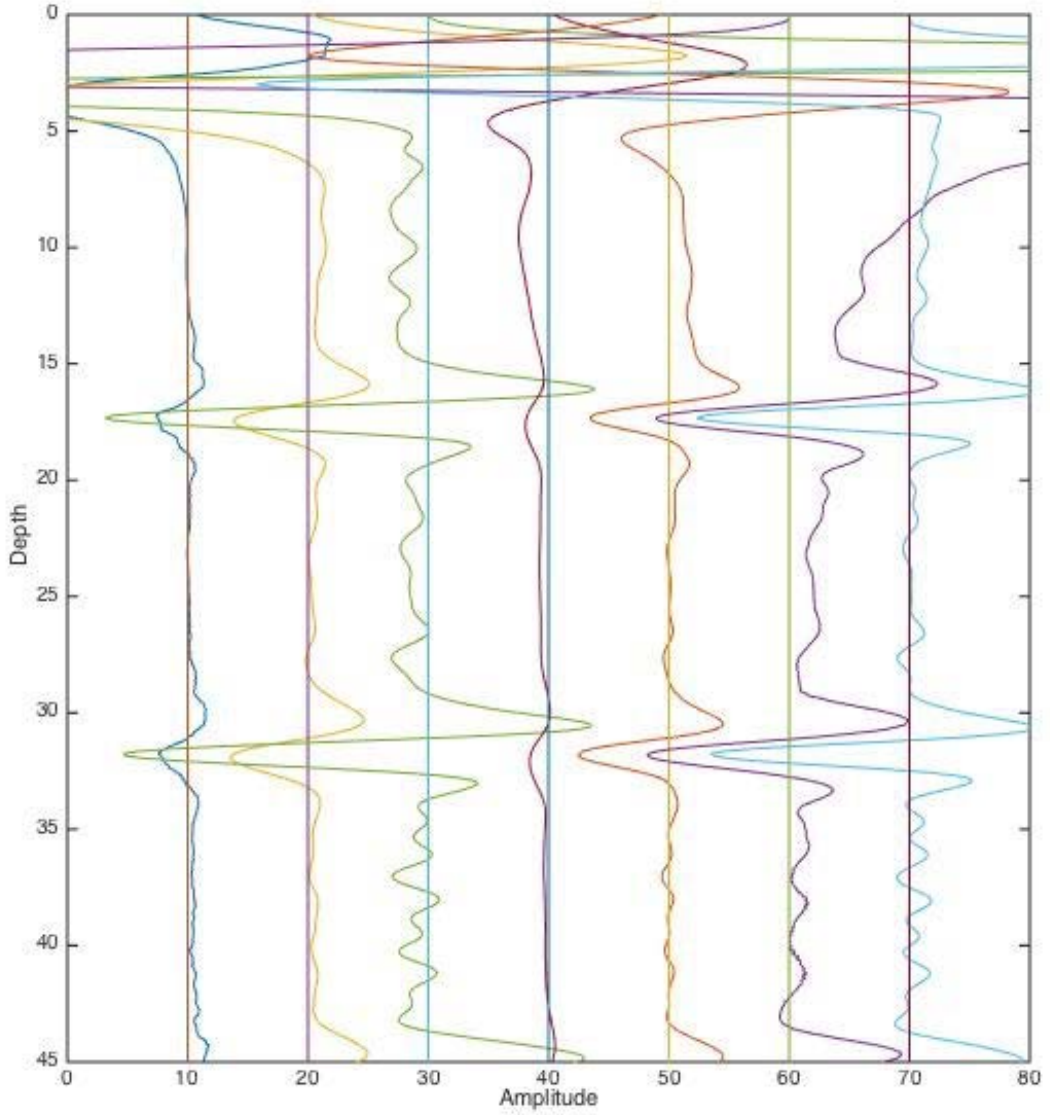


Autocorrelation



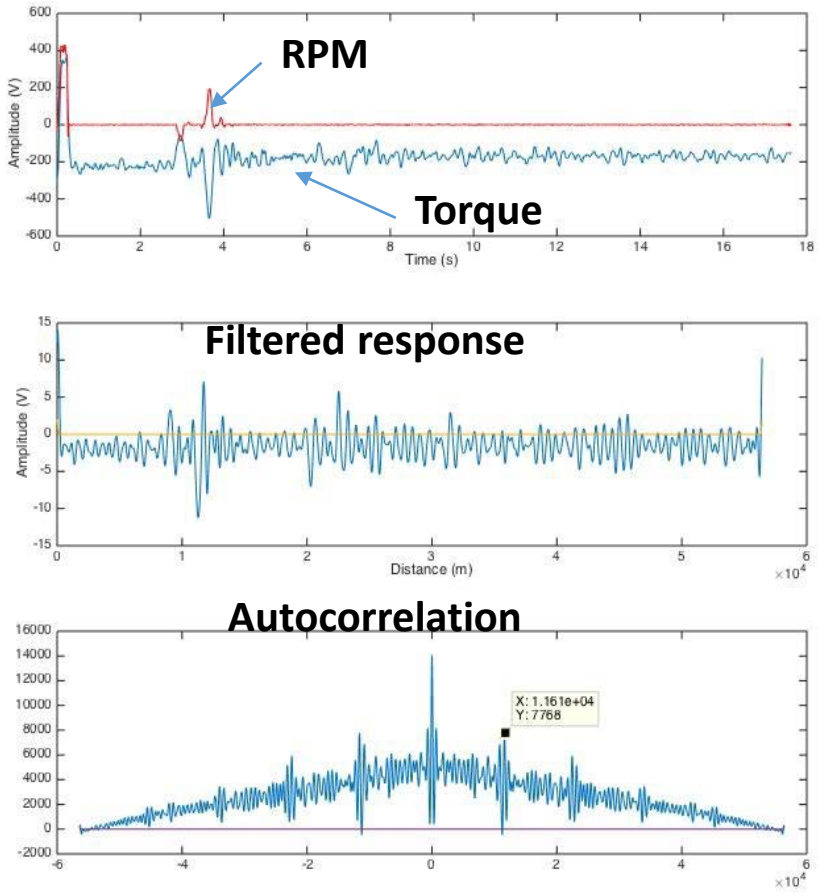
Drillstring Imaging

- Consistent results with the hanging beam
  - End of the beam is easily mapped
  - Small mass less so
    - Why? Pulse width >> mass size
- Limitations
  - Sampling Frequency
    - Gives minimum recordable feature
  - Impulse bandwidth
    - Gives minimum resolvable feature



Drillstring Imaging

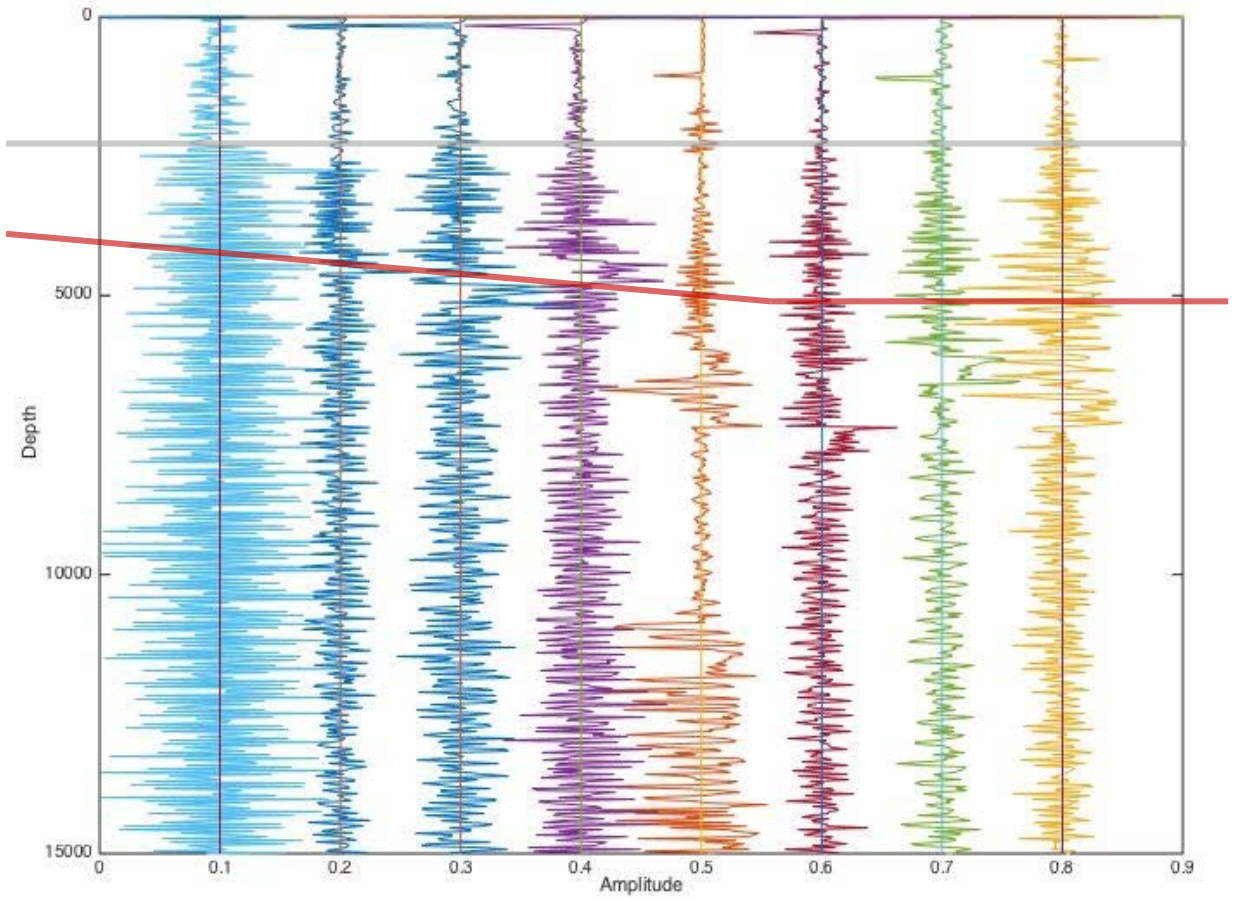
Laboratory Experiments



Field Data

Casing depth

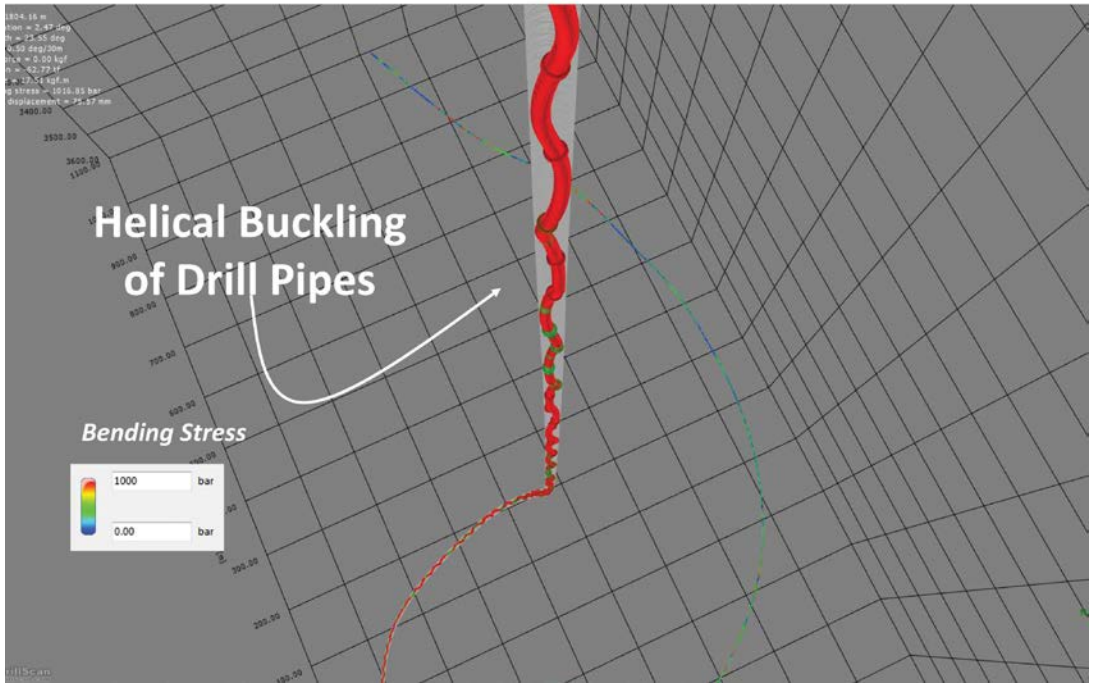
Bit depth



Drillstring Imaging

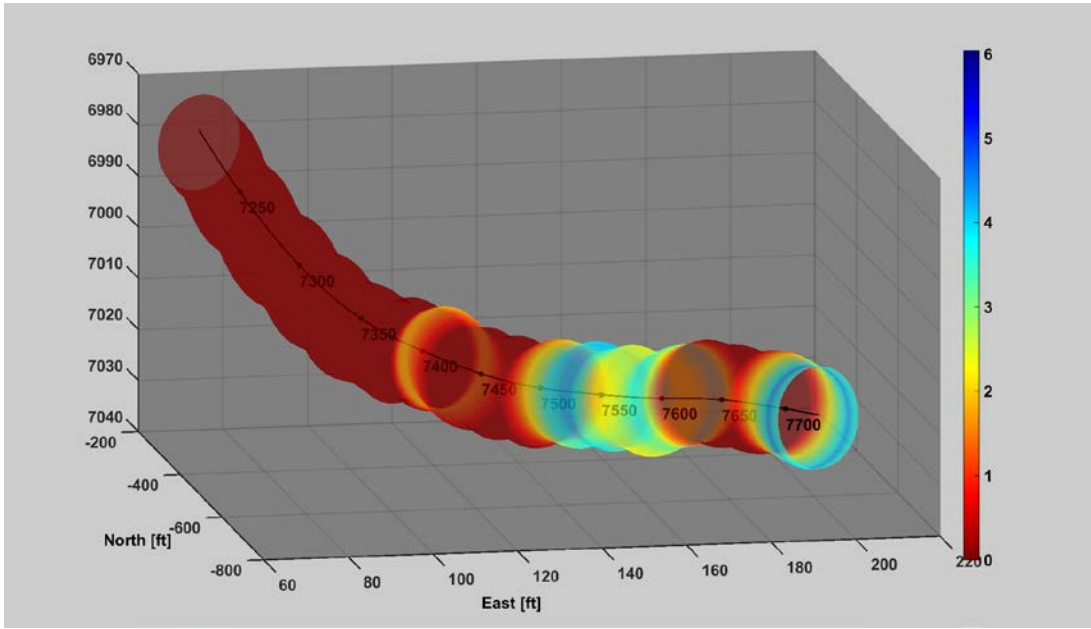
Drillstring buckling & friction points – are these imageable?

3D view of the completion string while running in hole at 5350m – Bending Stress and Helical buckling along the 5 in. drill pipes



SPE/IADC 173141: “Advanced Drilling Engineering Methodology Proves Robust in Preventing Mechanical Lock-up While Deploying Sand-Control Completions Through Complex 3D Drains.”

Wellbore tortuosity and wellbore quality



SPE/IADC 173103: “Wellbore Tortuosity Analyzed by a Novel Method May Help to Improve Drilling, Completion and Production Operations.”

Opportunity

- Borehole quality assessment
- Formation identification
- Cross well seismic
- Fracture diagnostics
- Seismic-while-drilling

Acknowledgements (for background work)

The University of Texas at Austin

- Drilling Rig Automation Group
- RAPID Consortium

The University of Cambridge

- Dynamics and Vibrations Research Group

Shell International E&P

- Drilling Mechanics Technology
- Drilling Optimization & Automation

National Oilwell Varco

Questions?