



Near Field – Far Field DAS Diagnostics for Unconventional Reservoir Monitoring

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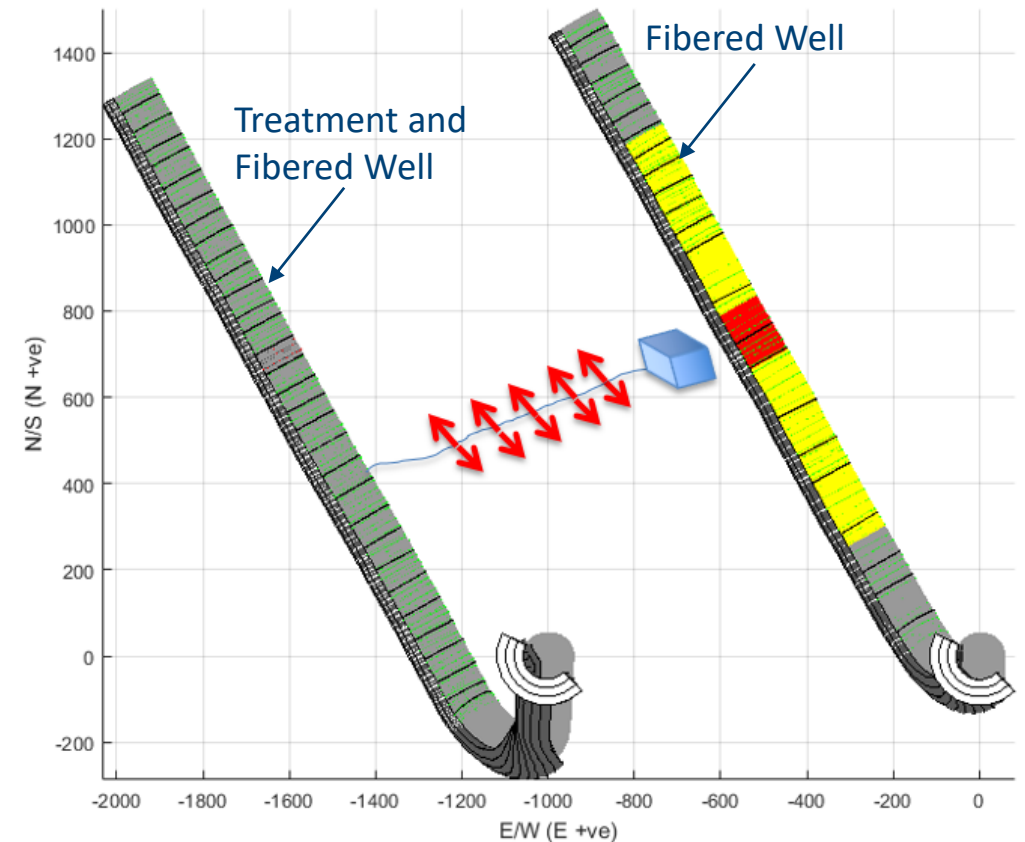
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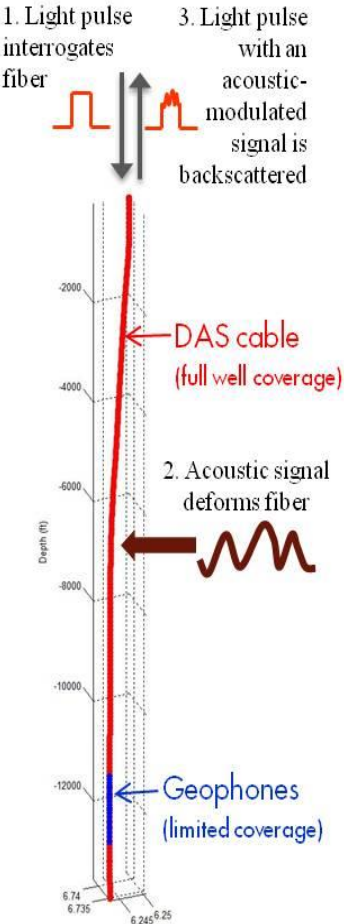
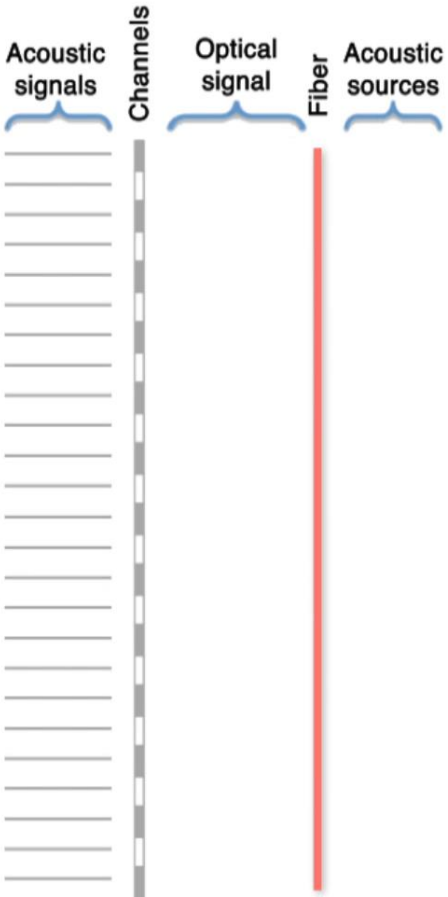
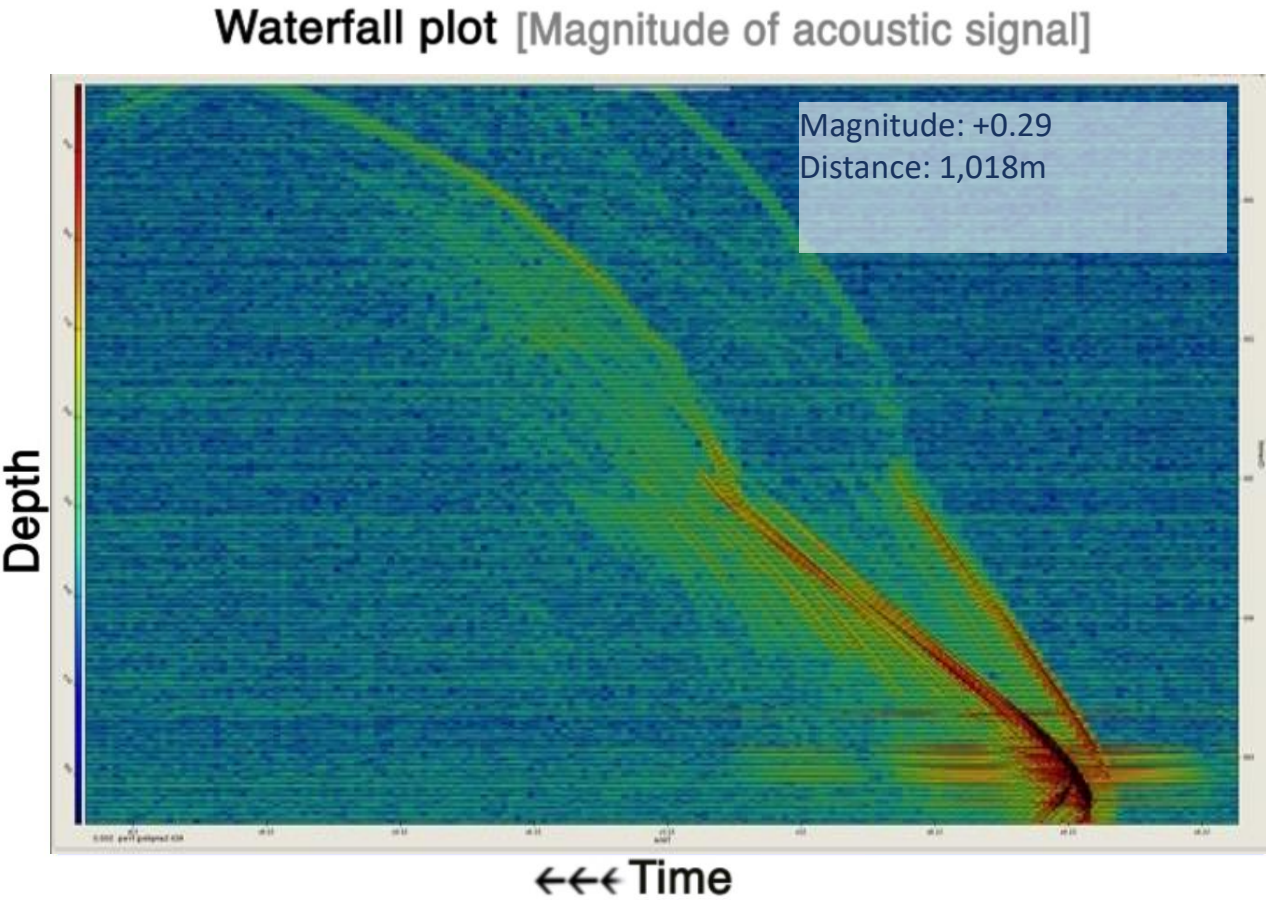
Near Field and Far Field Measurements from Multiple FO wells

- Optical cable is installed outside casing of one or more wells (Fibered Well).
- During treatment, one or more fractures extend toward the neighboring well
- Pressure in the fracture changes the stresses on the rock face when the fracture opens
- The stress causes strain (deformation) of the rock, which is coupled to the fiber via the cement.



Bringing It All Together – The DAS Waterfall

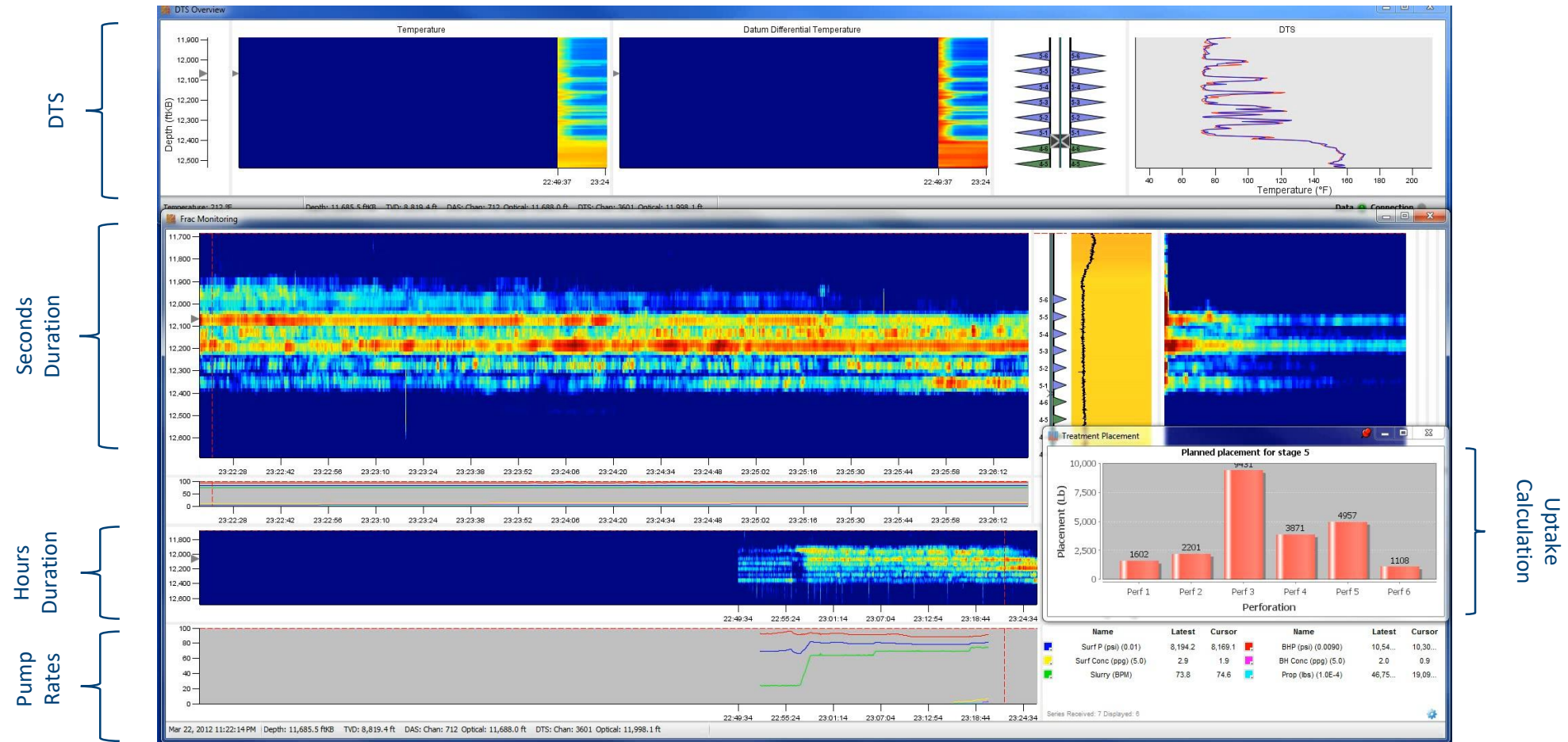
How DAS Data Is Converted Into Waterfall Visualizations



Near Field DAS

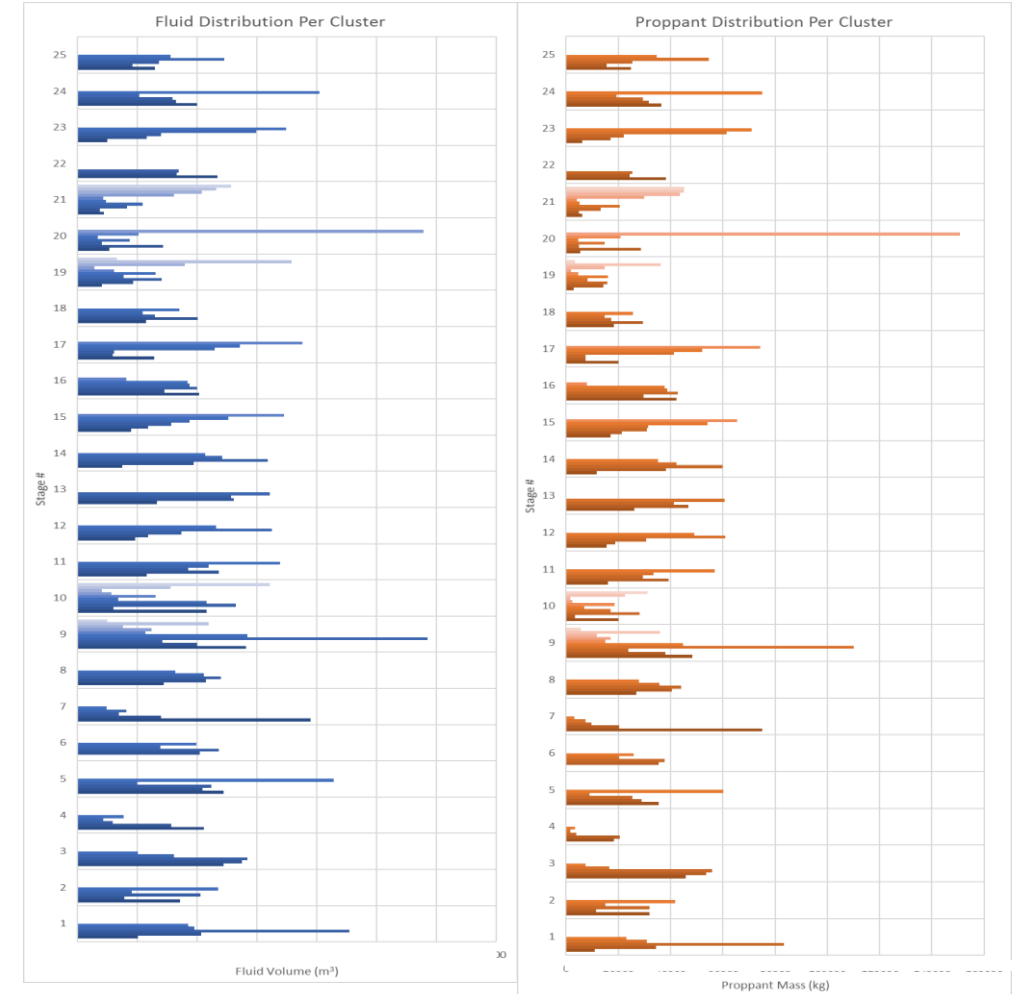
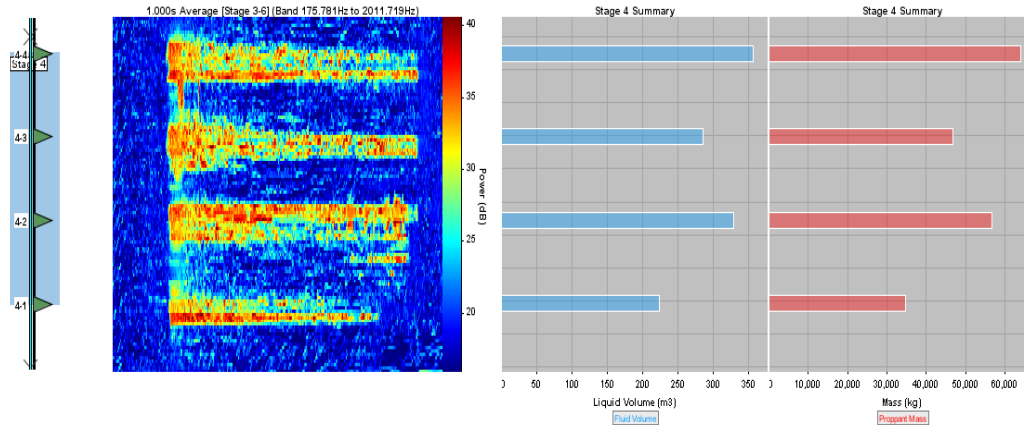
Hydraulic Fracture Profiling (HFP): Real-Time Analysis

Assessing Fluid and Proppant Allocations in Real Time



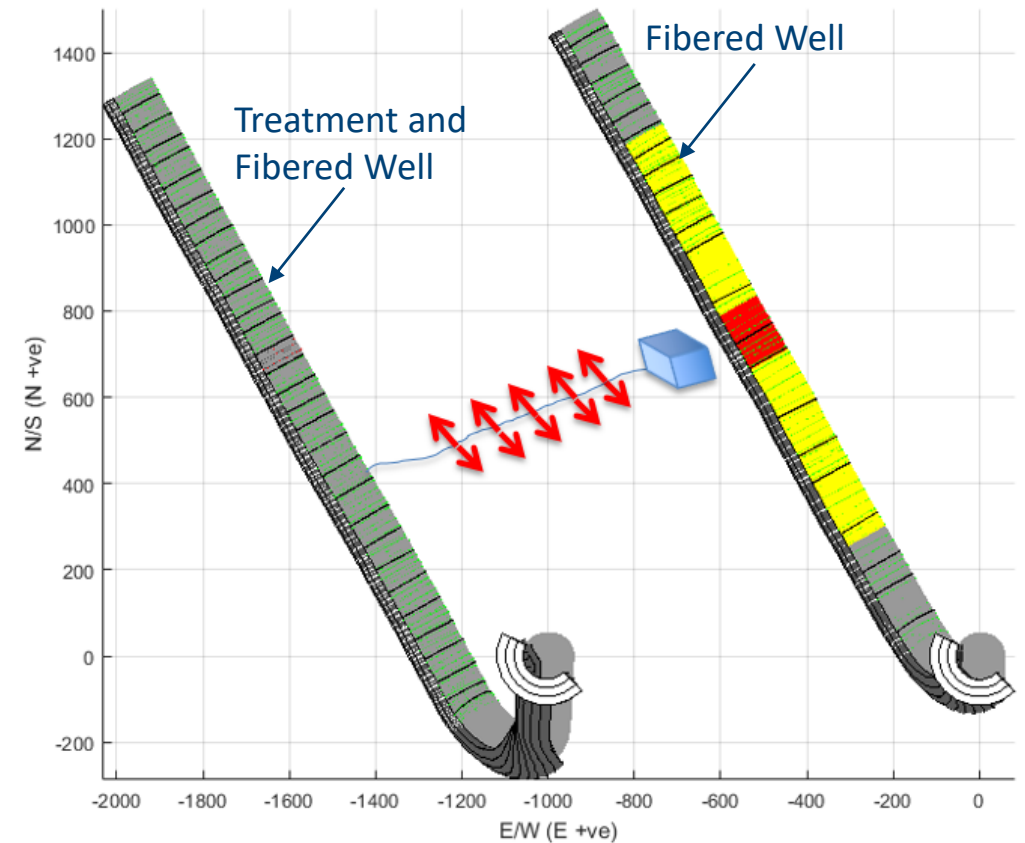
HFP: Hydraulic Fracture Profiling Fluid and Proppant Distribution from DAS

- Complete full-well quantitative injection profile

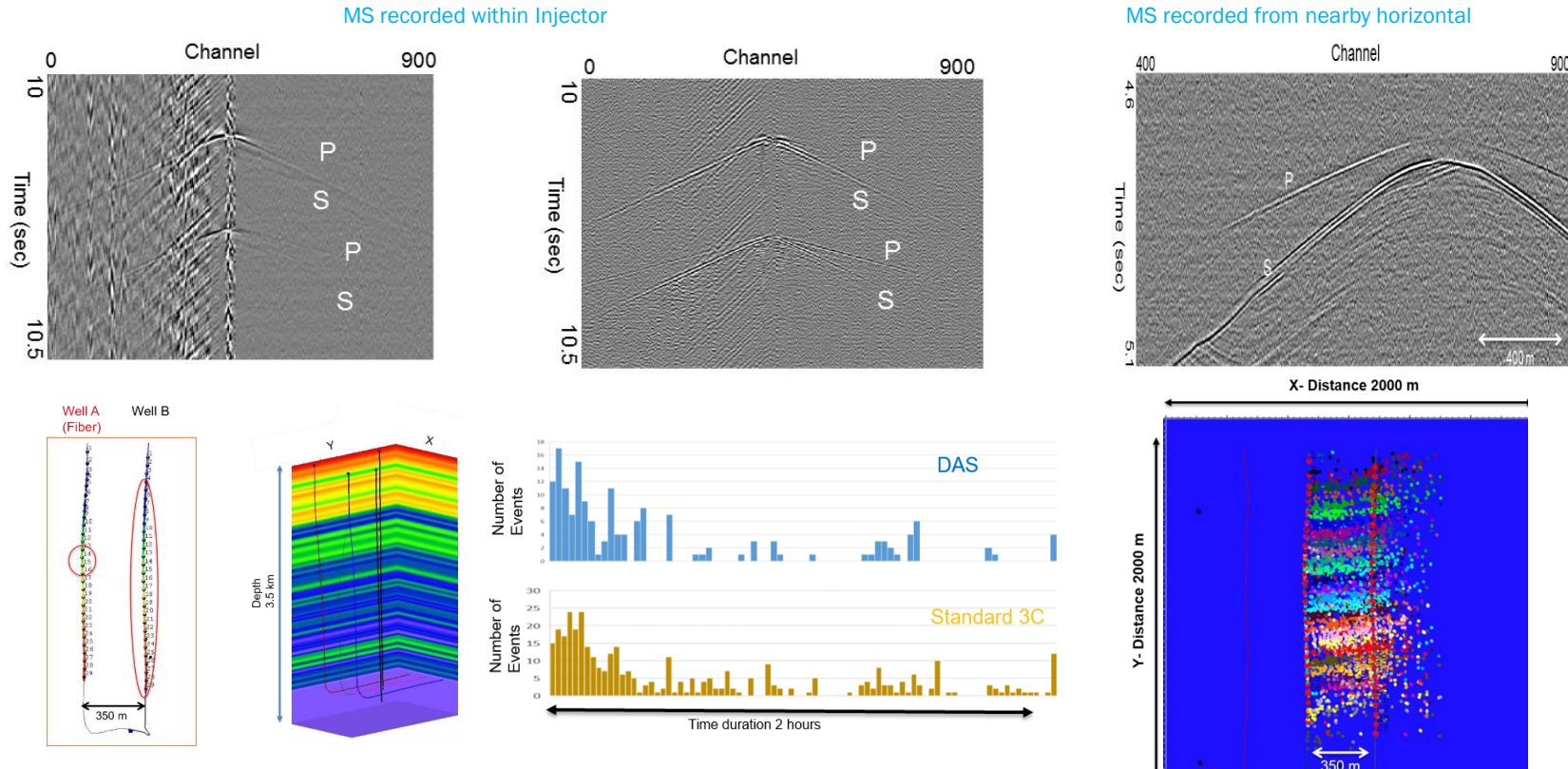


Far Field Measurements from Multiple FO wells

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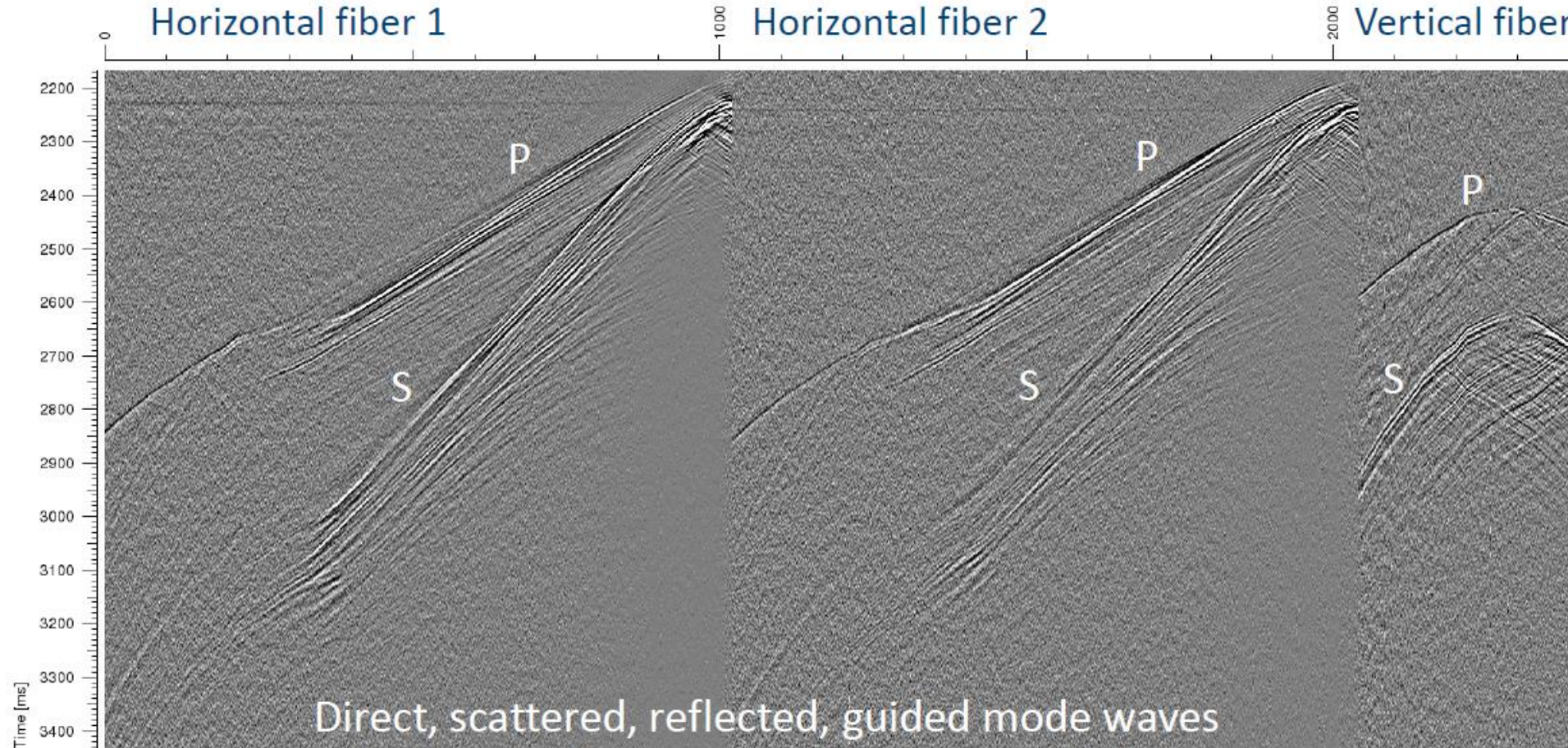
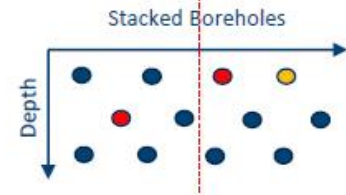


MS Monitoring with FO Instrumented Pads

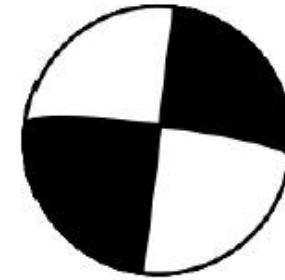
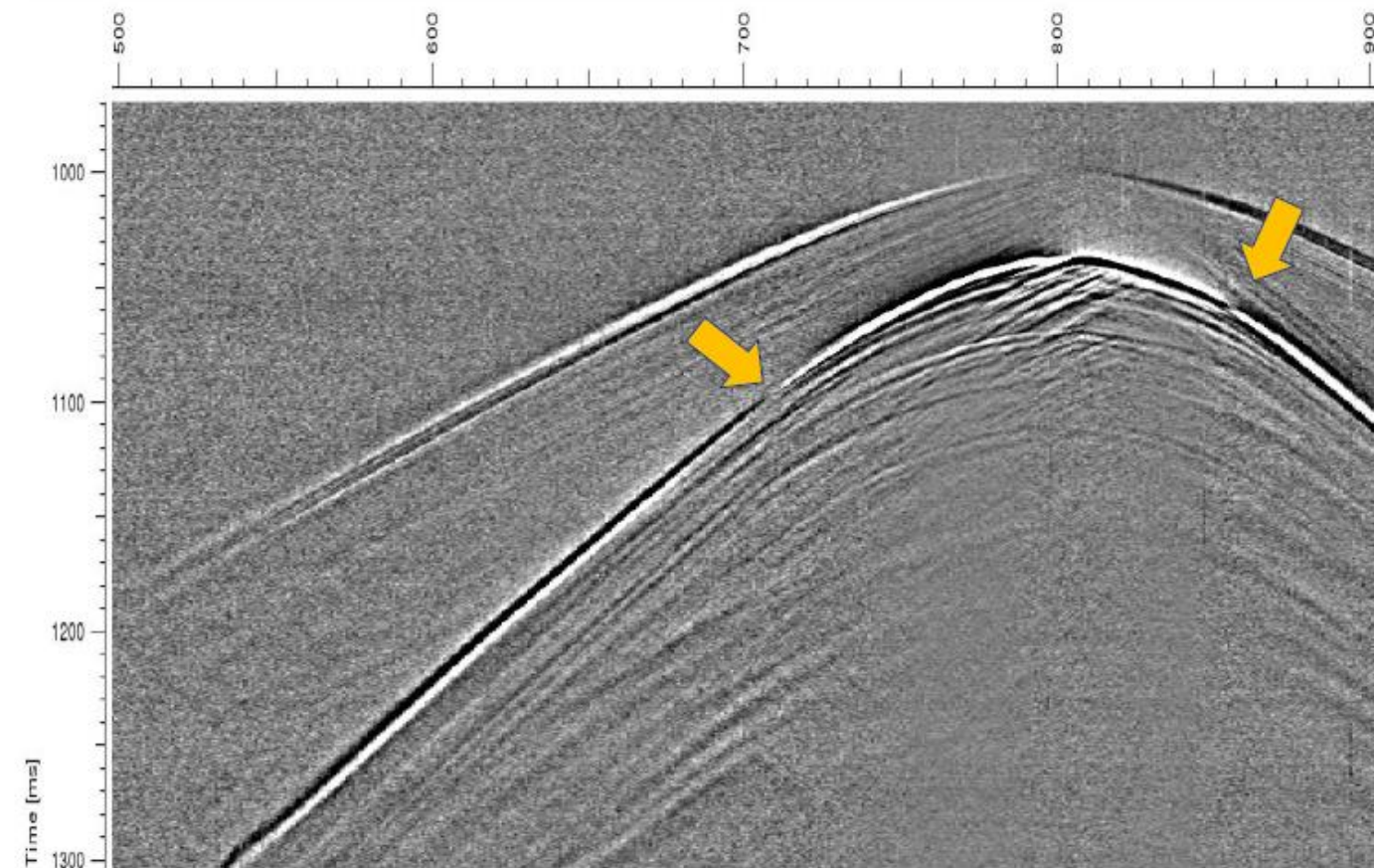


Karrenbach et al., 2017

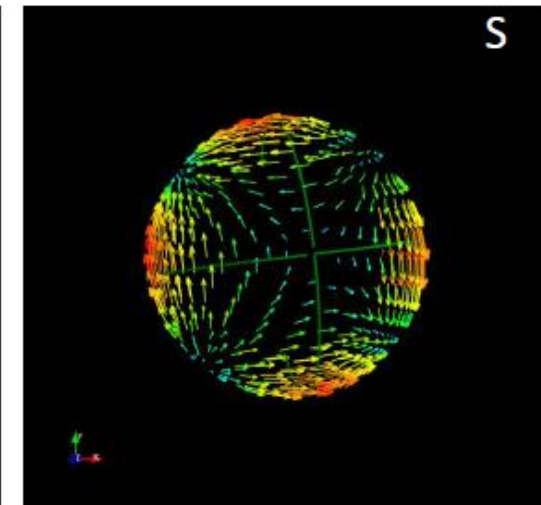
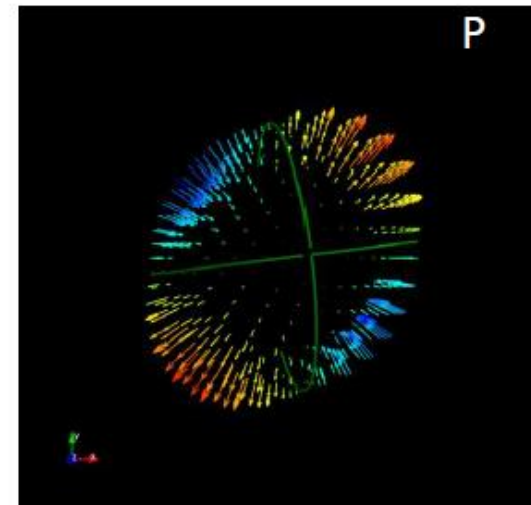
Microseismic event recorded on three fibers



MTI and Fault Plane Solution based on P + S amplitude pattern



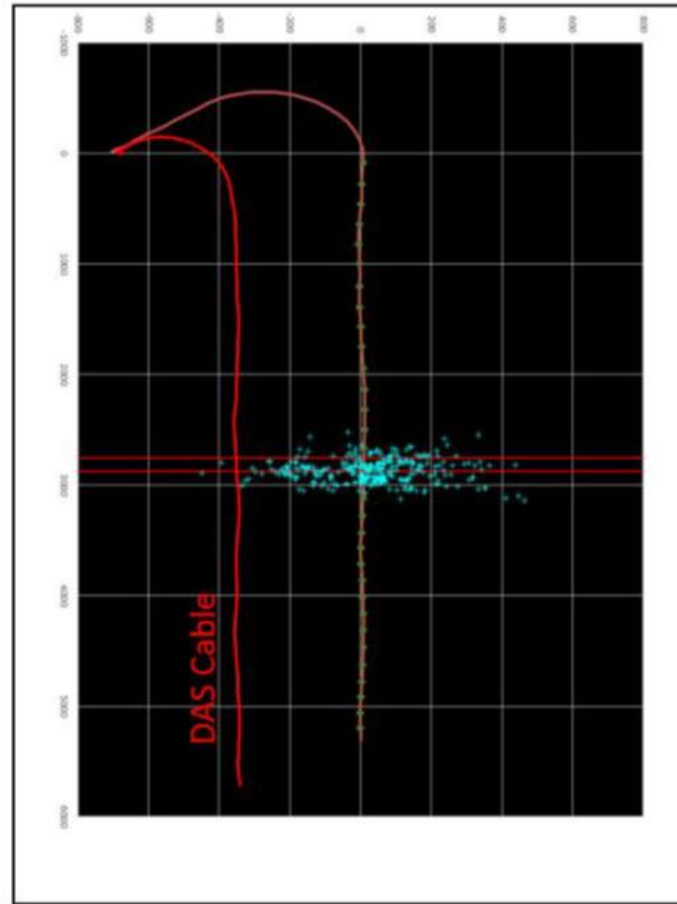
Amplitude Patterns



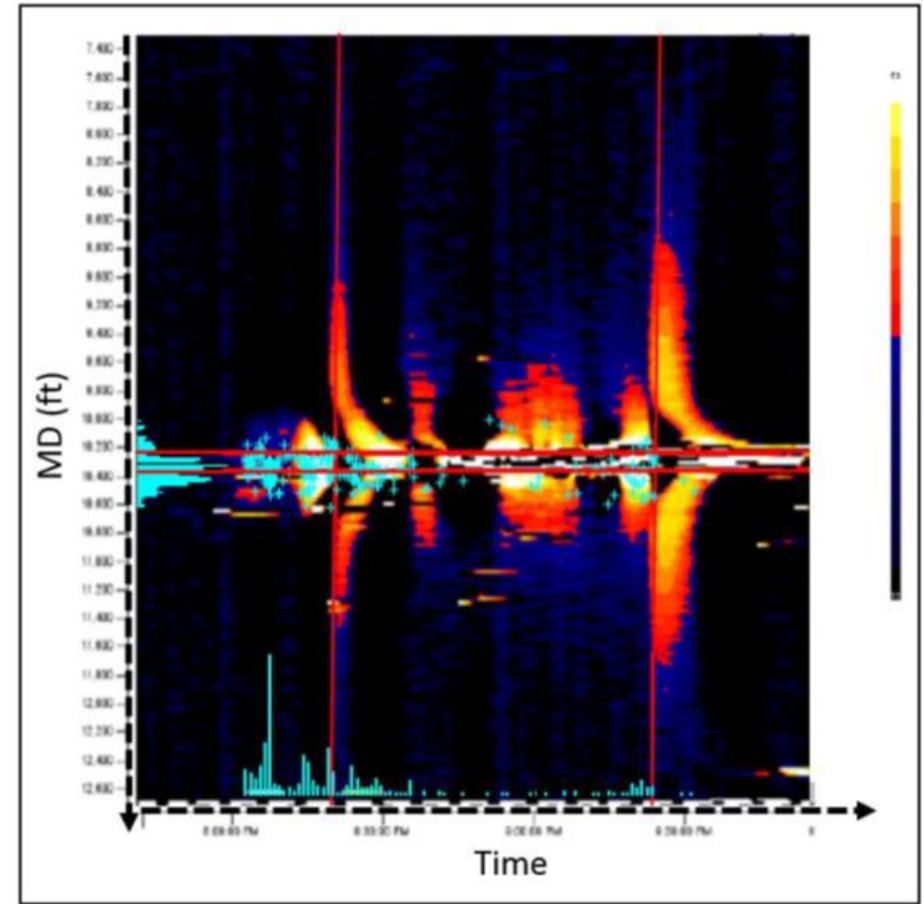
Fracture Dynamics from *Microseismic* and *Strain* Using Horizontal Monitoring Wells

Dual DAS stream recording allows simultaneous processing of MS and Strain

FO in Horizontal Monitor



a

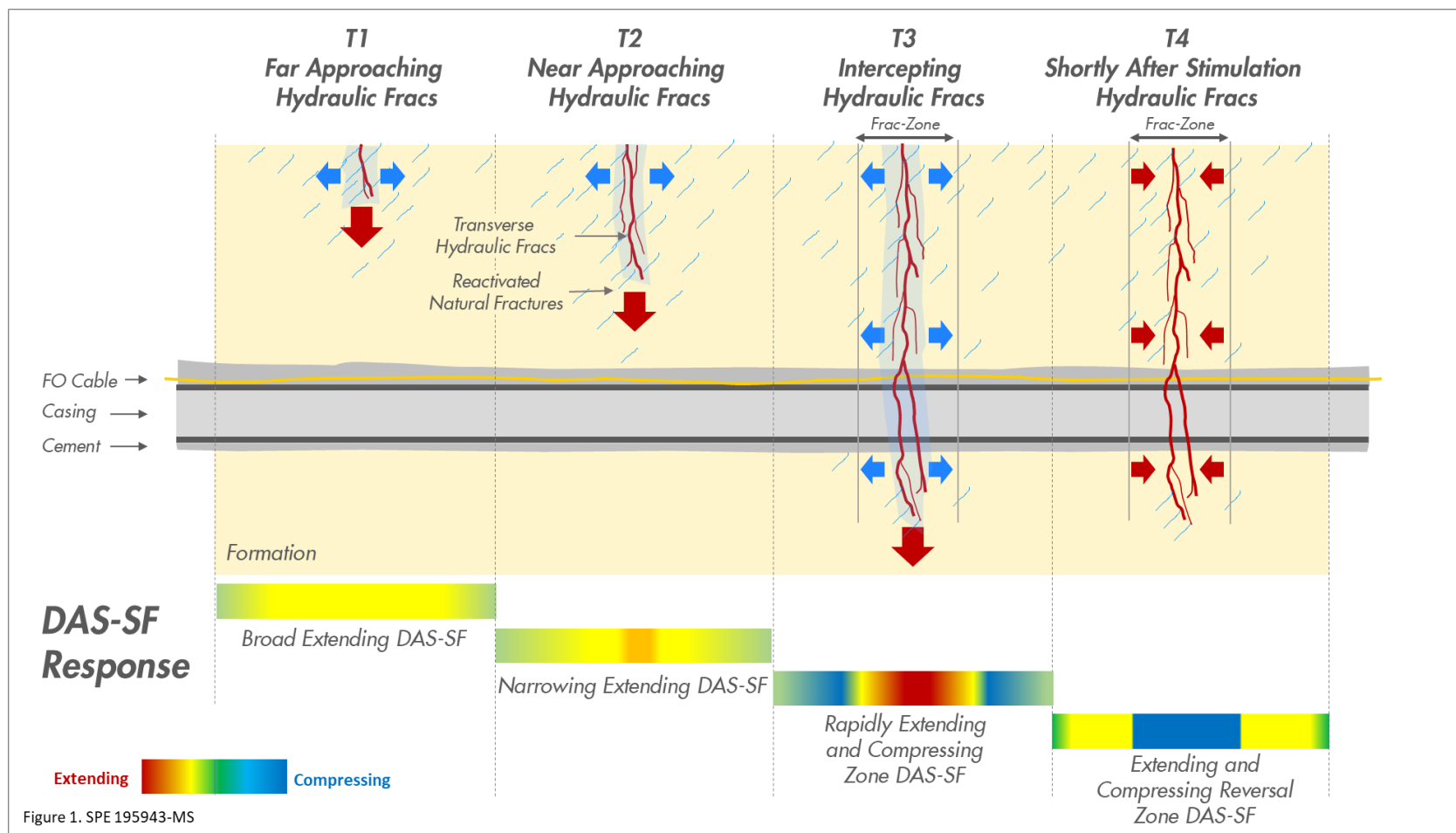


b

Starr et al., 2016

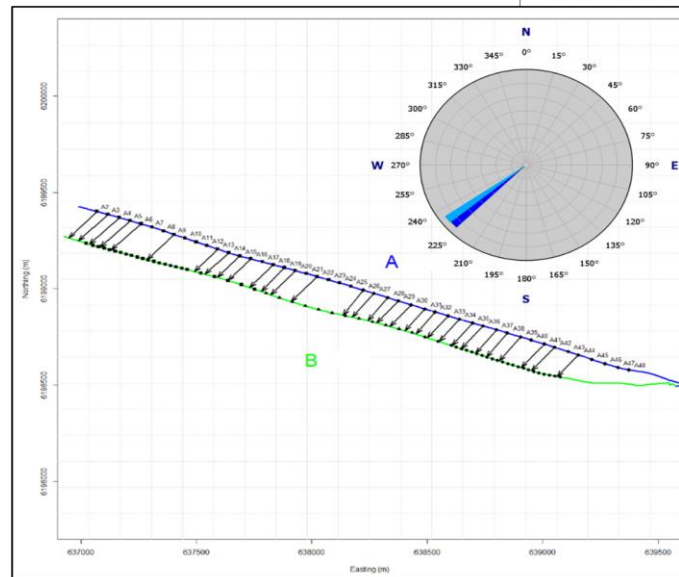
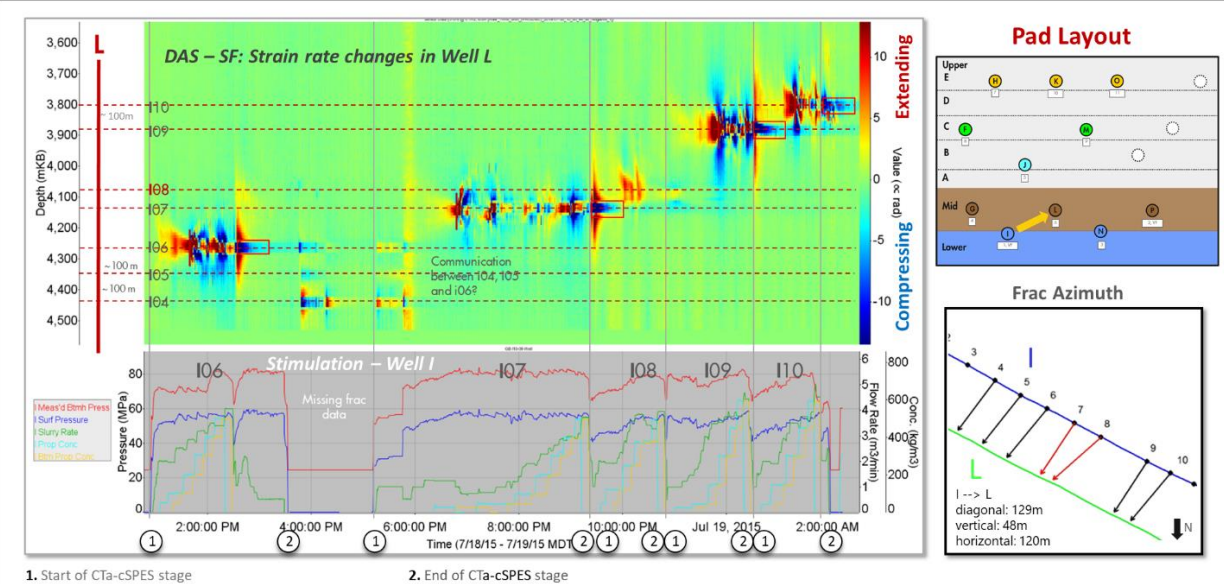
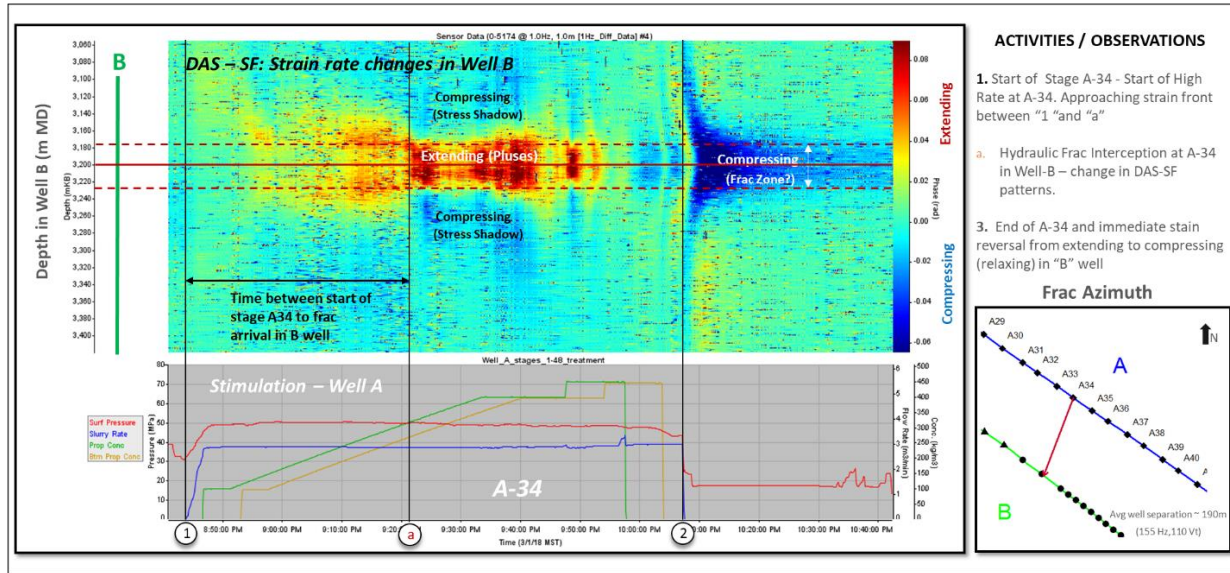
Strain Measurements with DAS

OptaSense's DAS outputs two streams of data: Microseismic and Strain



Ugueto et al 2019

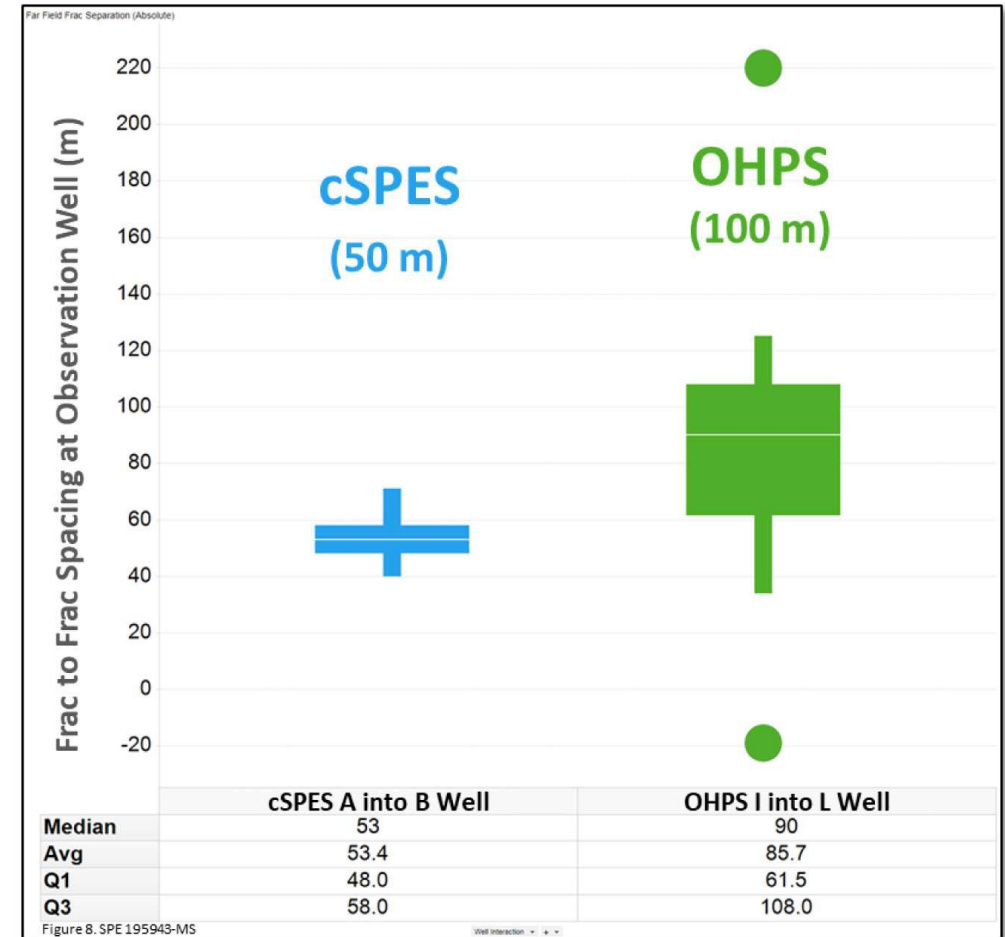
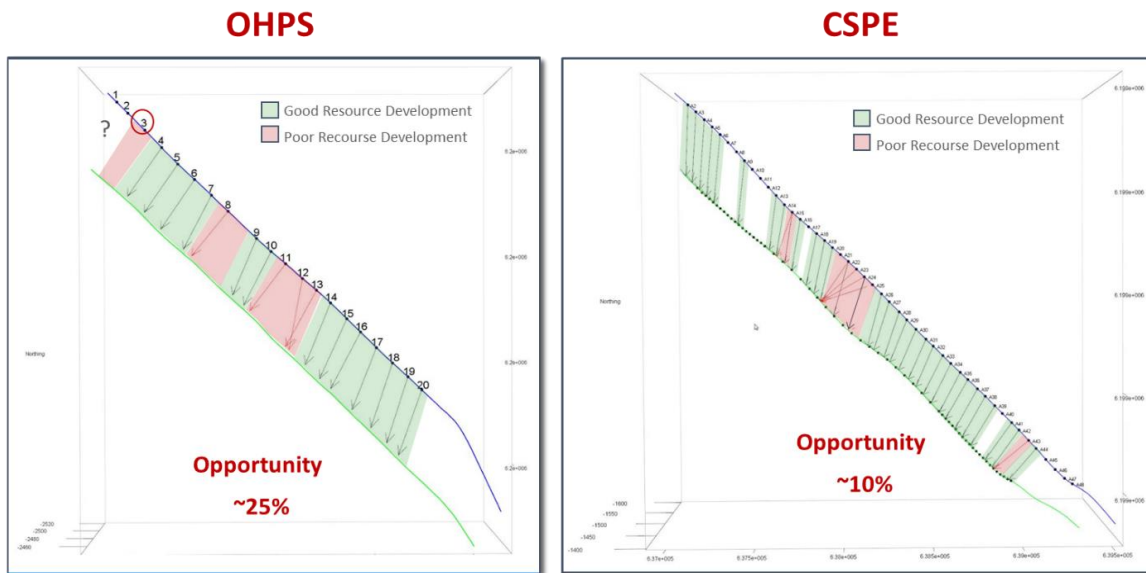
CWC Strain for Completion Design Assessment



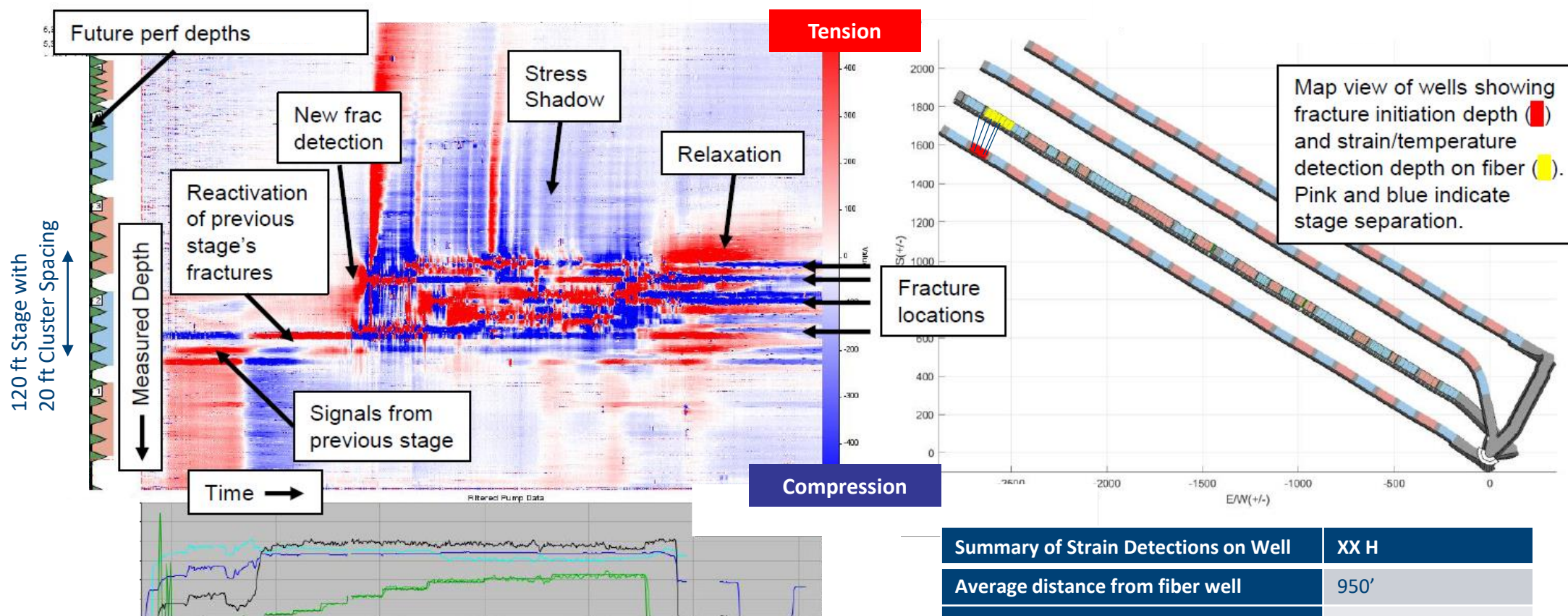
Ugueto et al 2019

Strain Diagnostics – Assessing which completion program is more efficient

Cemented Single Point Entry vs Open Hole Packer Sleeve



Fracture Events from Strain for a Single Stage



Summary of Strain Detections on Well	XX H
Average distance from fiber well	950'
Average # of New Fracs per Stage	5.30
Standard Deviation	2.15
Average Span of Frac Depth Coverage	160.88
Standard Deviation	95.67

Conclusions

- DAS technology monitors the treatment process in real time with both near and far field acoustic data
- Near field acoustics provide direct information on the completion design as well as potential operational issues like stage communication
- Far field DAS measurements include microseismic and strain that are recorded with the broadband fiber optic tools
- Strain measurements can characterize distribution of fracture events as well the orientation
- DAS data can be used to optimize completions and better understand fracture geometry

Questions?

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