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A LUNA company

DAS Instrumentation and Data Management for Real Time Geomechanics and Seismology

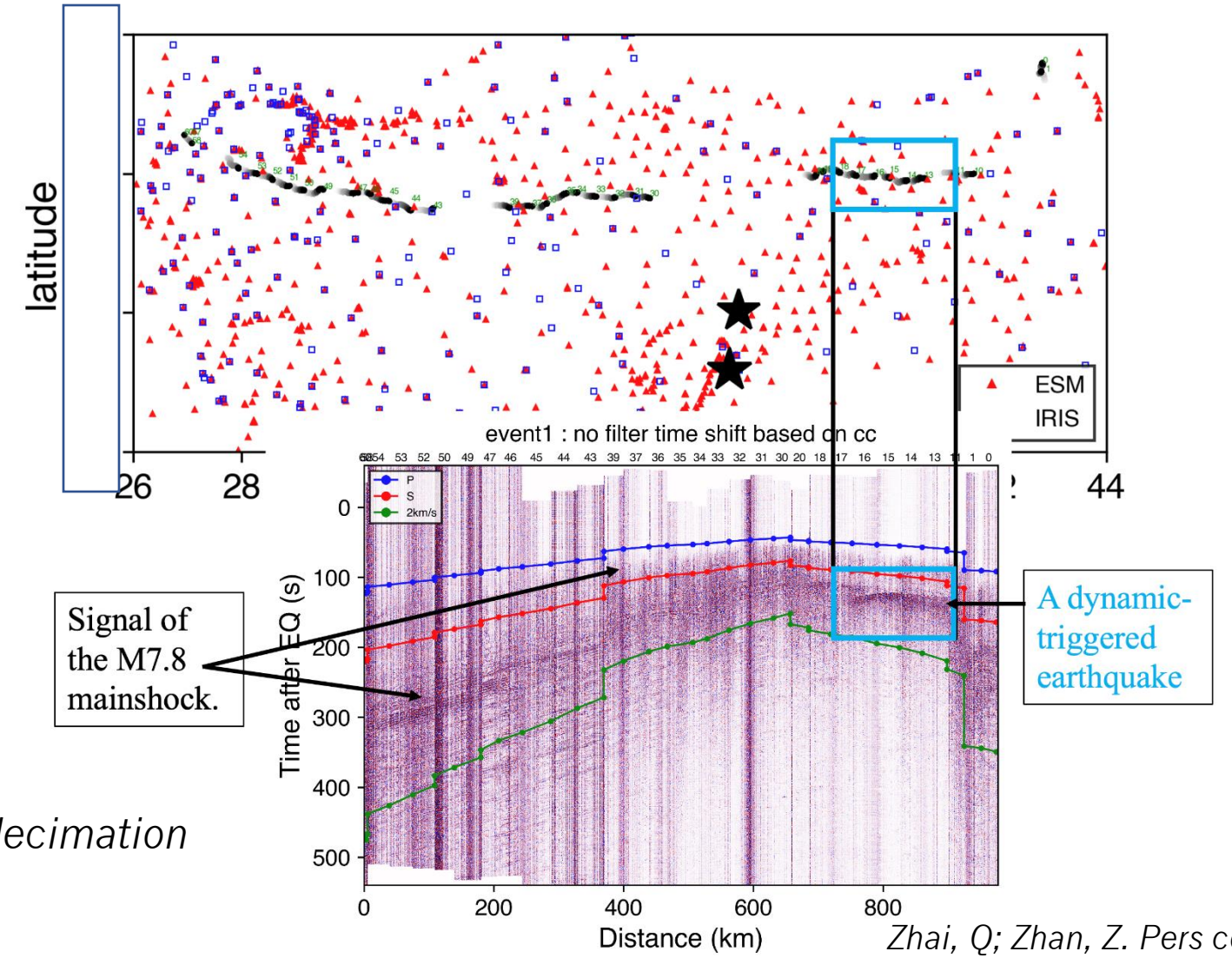
Andres Chavarria, LUNA - OptaSense

Outline

- DAS Sensing 101
- Beyond seismic – Strain sensing and geomechanics
- Tradeoffs of Sensing System
- Earthquake Monitoring / Data Streaming – What can we ship remotely in real time?

Why do Surveillance with DAS?

Taking Advantage of Available Fiber Optic Infrastructure

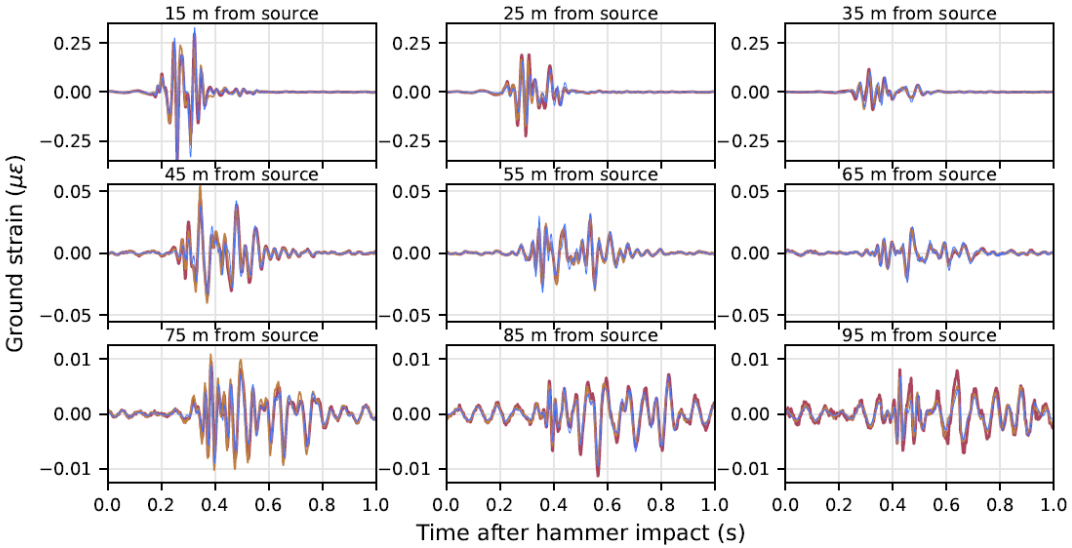


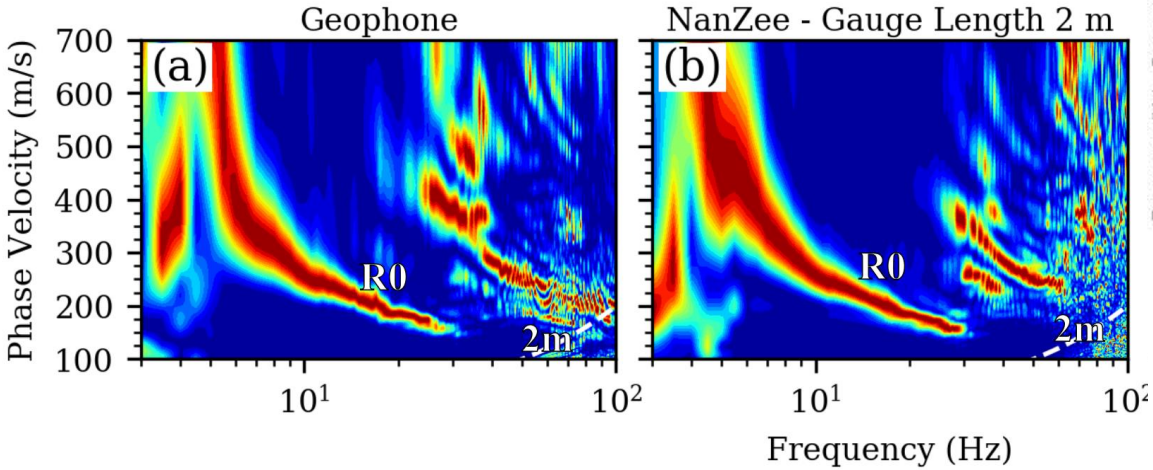
Longest DAS array
19Tb per Day after decimation

Zhai, Q; Zhan, Z. Pers comm. 2023

Matching of DAS IU and Conventional Sensors

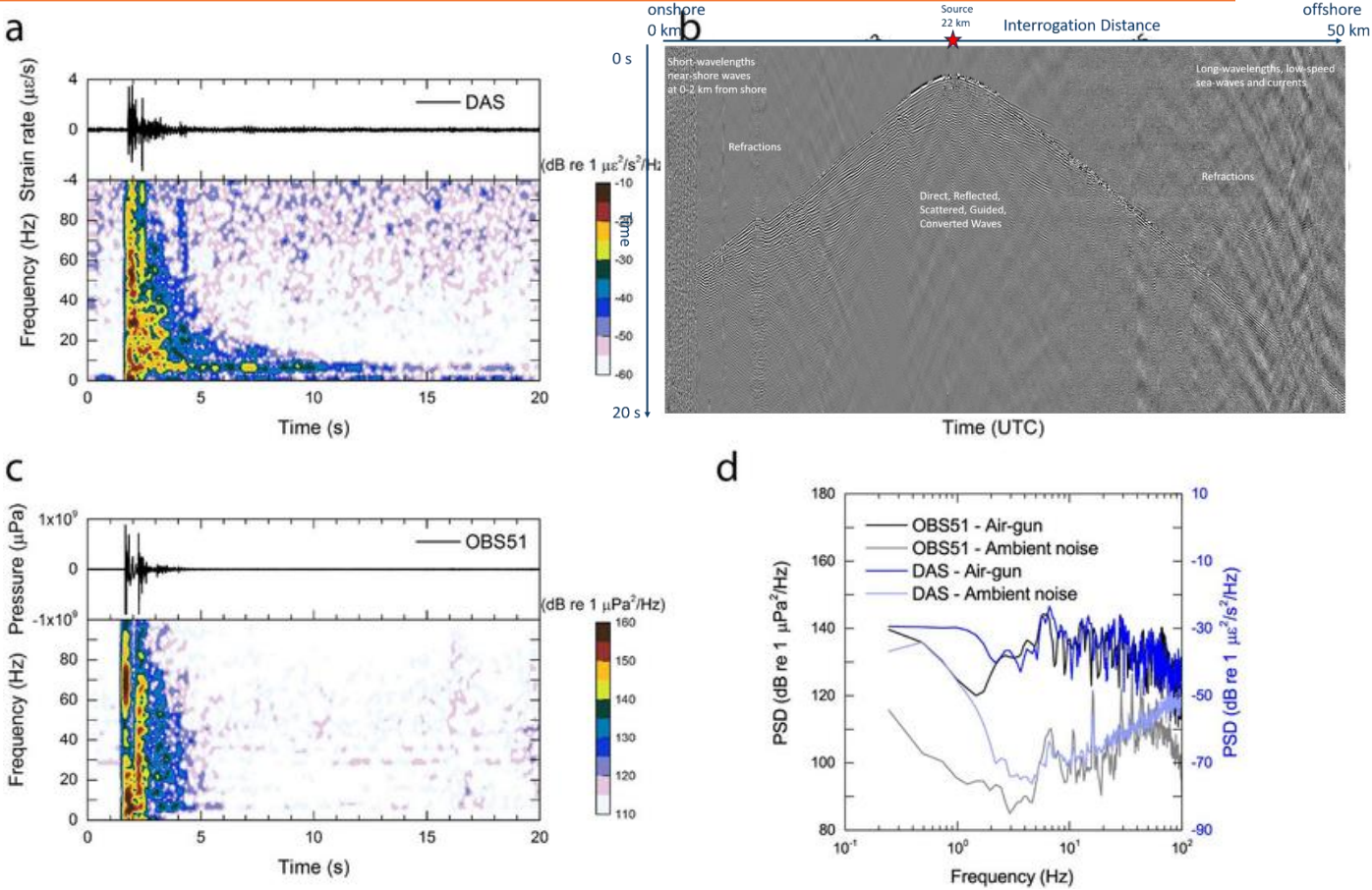
Geophone and DAS





Hubbard et al. 2022. Vantassel et al 2022

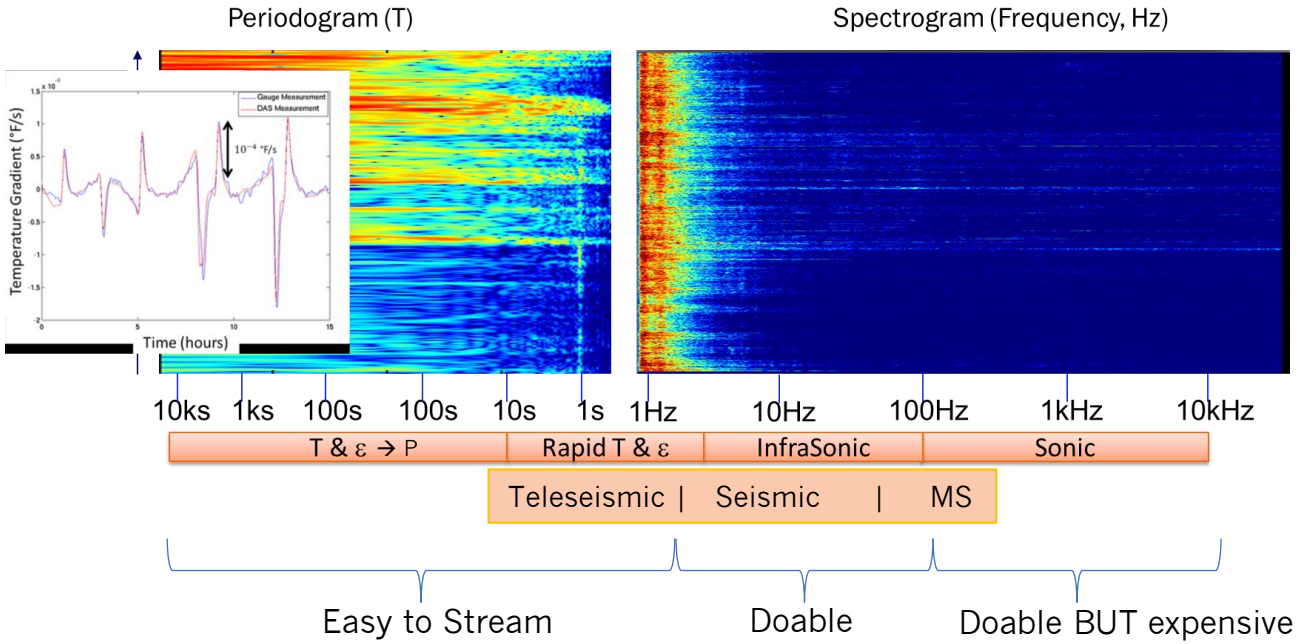
Hydrophone and DAS

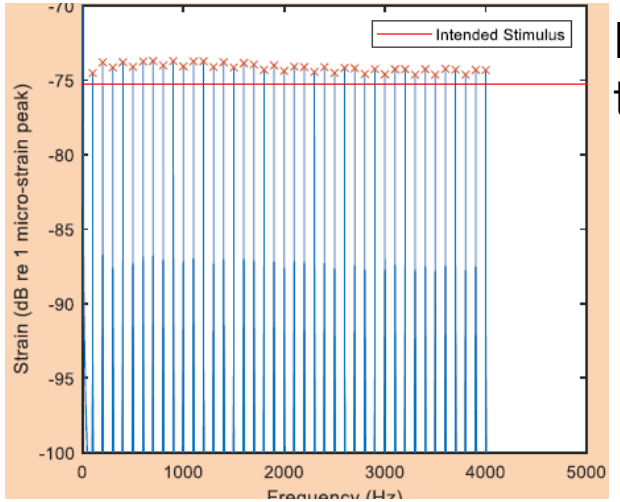


Matsumoto et al.

Geomechanics and DAS → What have we learnt?

Beyond Seismic: What does Rayleigh DAS Sense?

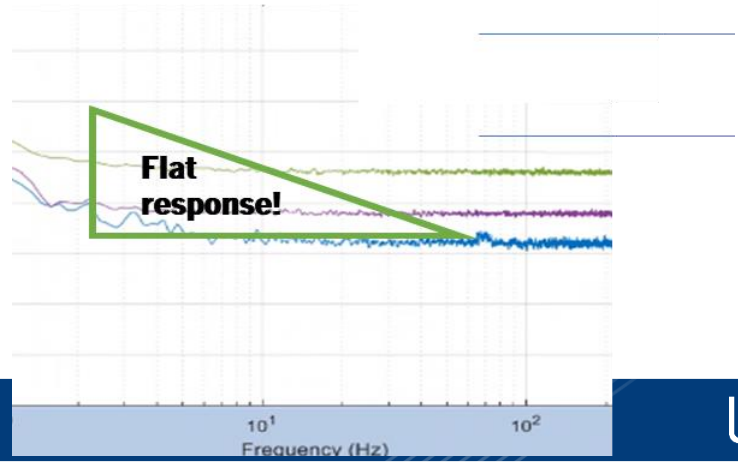




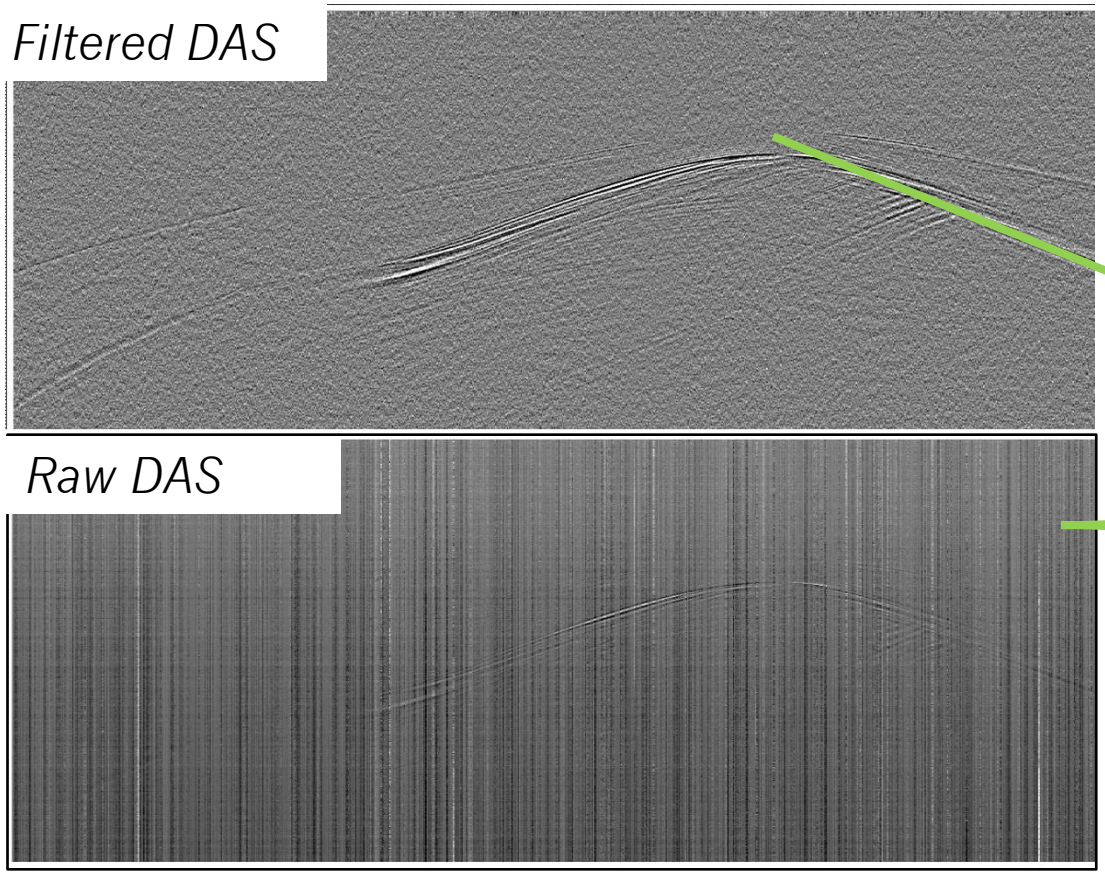
Flat response to DC

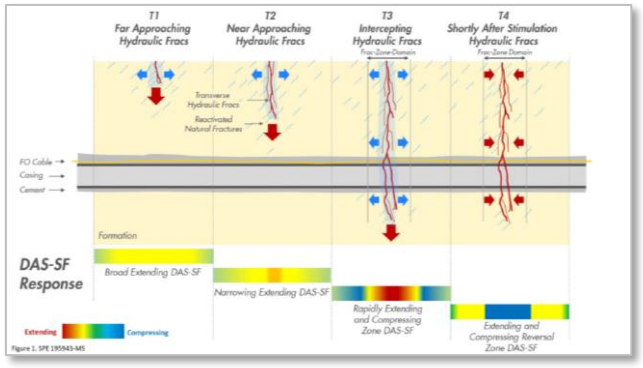
- Low noise floor at low frequencies <<1Hz
- Depending on cable → more strain or temp transduction

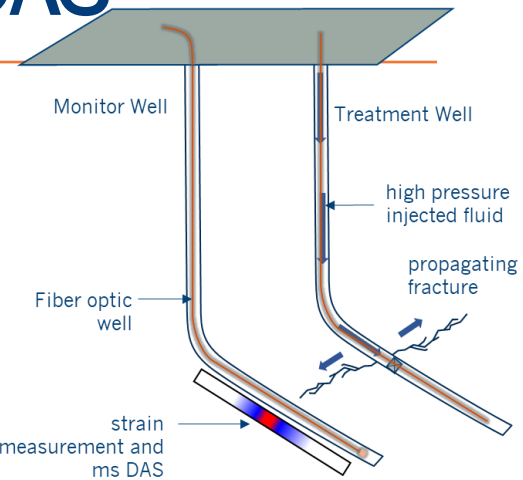
IU Noise Floor
DC Couple DAS

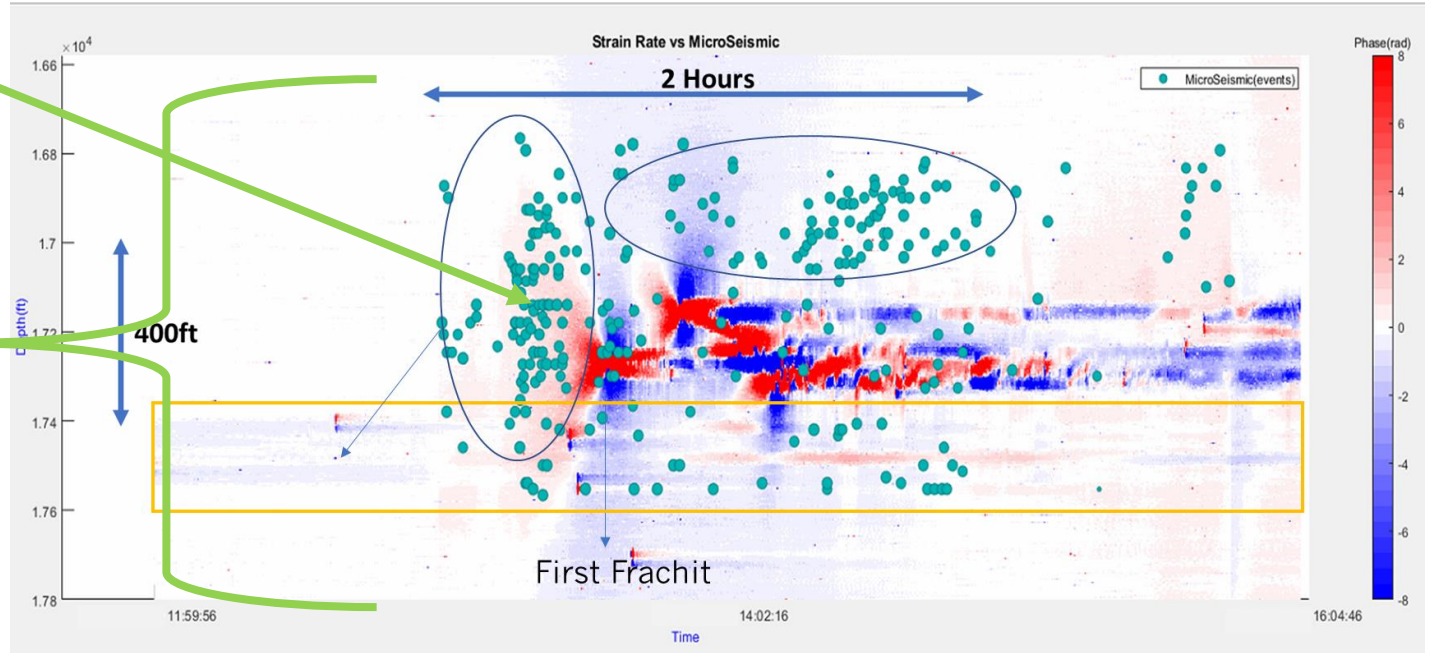


Microseismic and Strain from Broad Bandwidth DAS





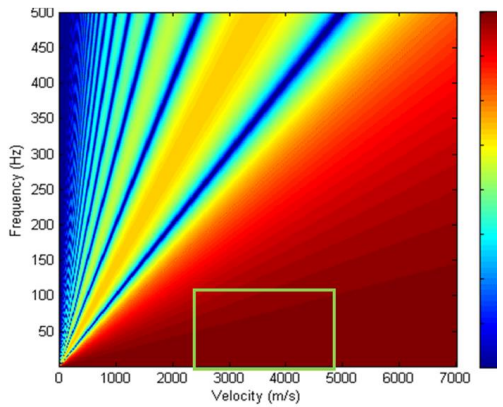




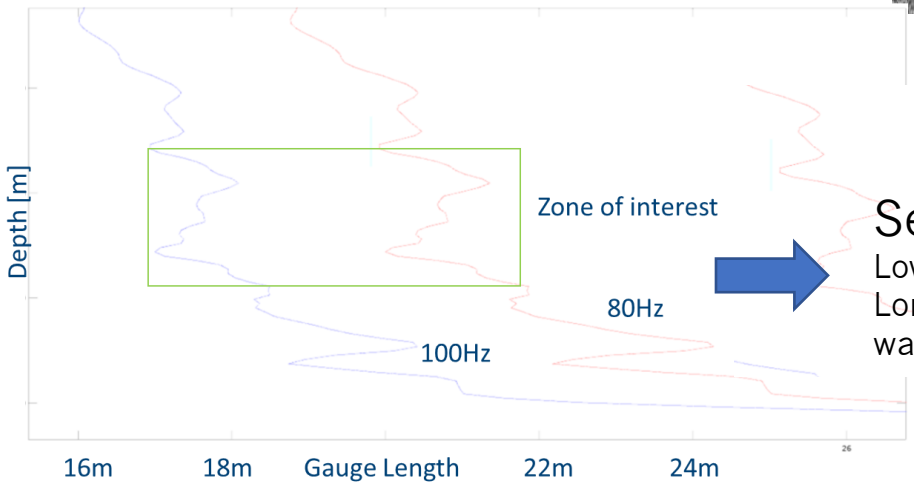
Chavarria et al 2022. ARMA

Optical Settings Matter → Optimized GL for Seismic Waves

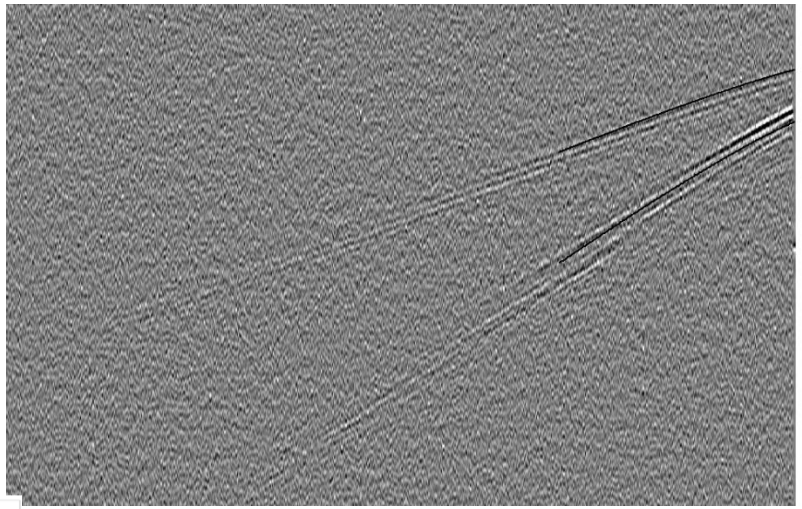
DAS Spectra for a given GL
and velocity model



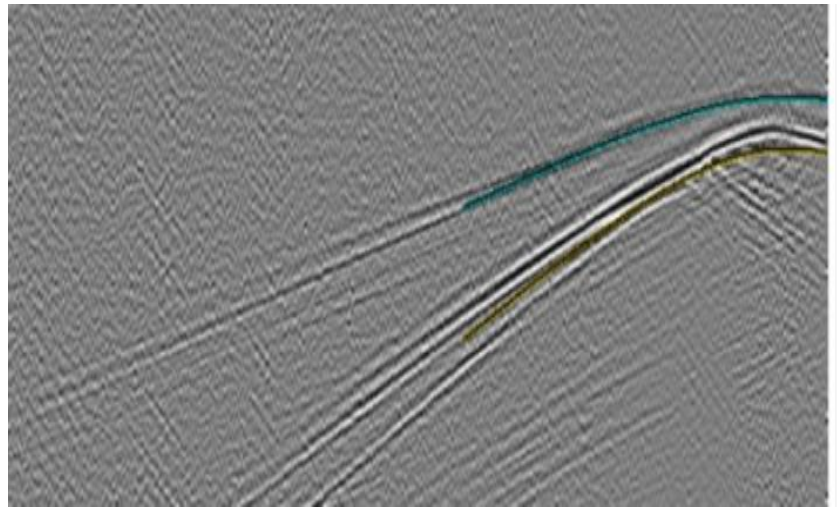
Geologic Model → Seismic Velocities
→ Optical Spatial Resolution (Gauge Length)



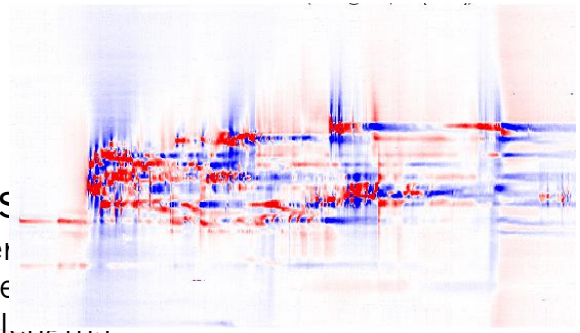
4mGL
Fracture Resolution

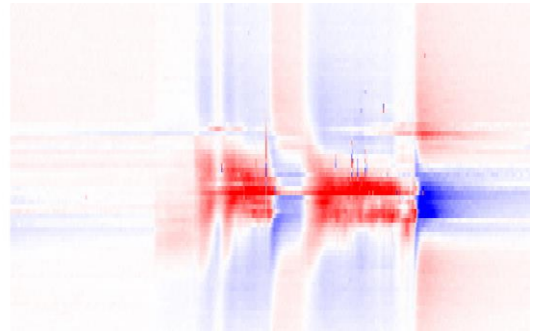


16mGL
Seismic Optimized Style



Seis
Lower
Longe
wavel





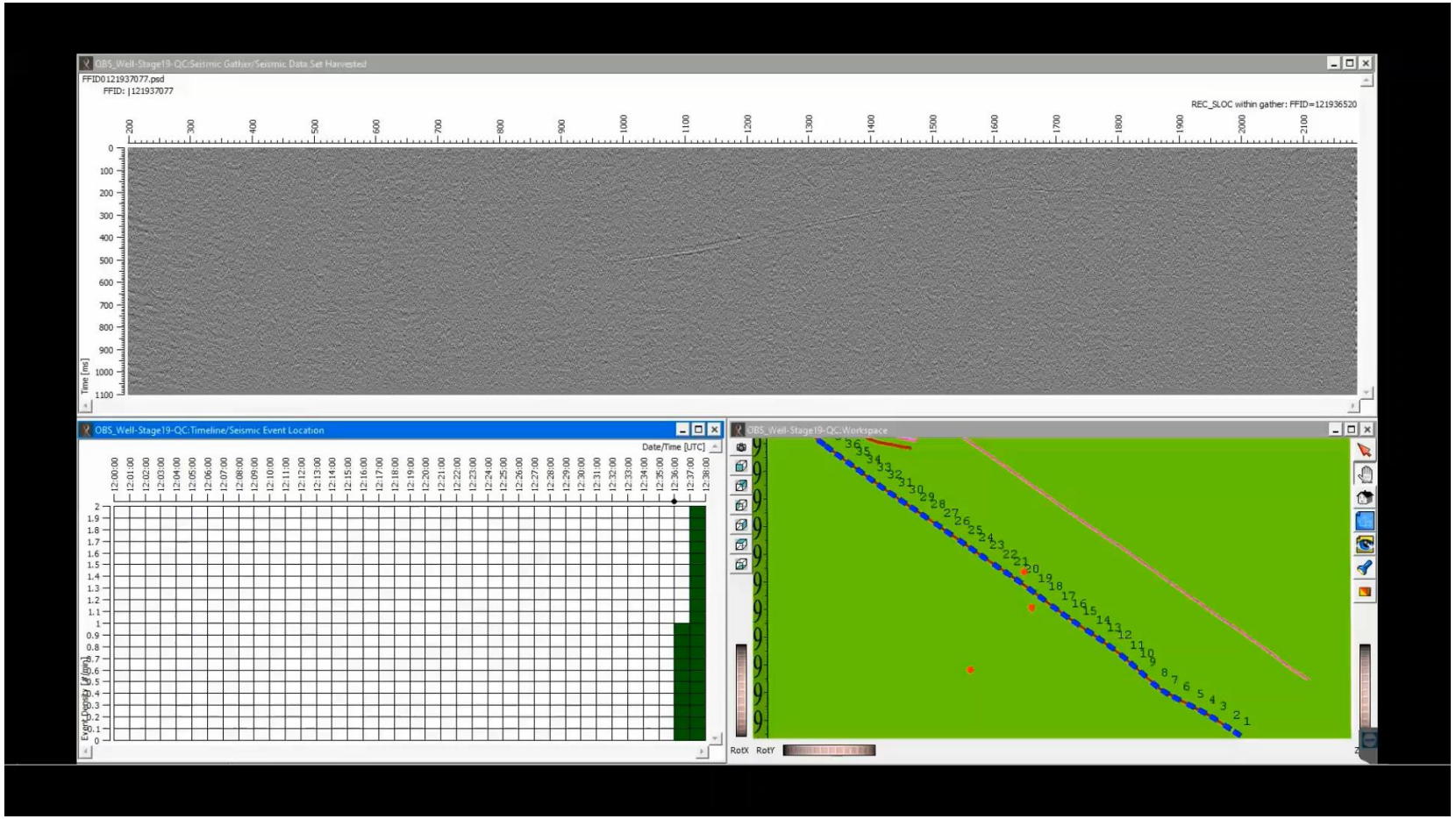
Data Streaming and Event Detectors

- Edge or Remote processing?
- What do we run in the field?
- How much to store?
- How much to stream?
- What to stream?

What do we process and stream in real time?

Over 4G or Satellite

- Seismic Event detection from fibers (hundreds to thousands per day)
- Seismic Event locations (Ascii)
- Display (jpg/zoom)
- Low Frequency Strain (H5) 0.01Hz, 0.1Hz, 1Hz
- Table with strain event picks (Ascii)



Over Dedicated Telecomm

- Triggered DAS (H5 or SEGY) 1000Hz – 2000Hz (M-4.0>)

LIVE Monitoring – Managing Fiber Data Effectively

5000 Channel Array → 5km @ 1m spacing ***OR*** 50km @ 10m spacing

Raw IU Data
~2.1 Tb/day
i.e. 10k ping rate

- *LIVE Monitoring provides a manageable data stream from the IU to remote streaming*
- *Processing done in the field by the IU*

In-field processing

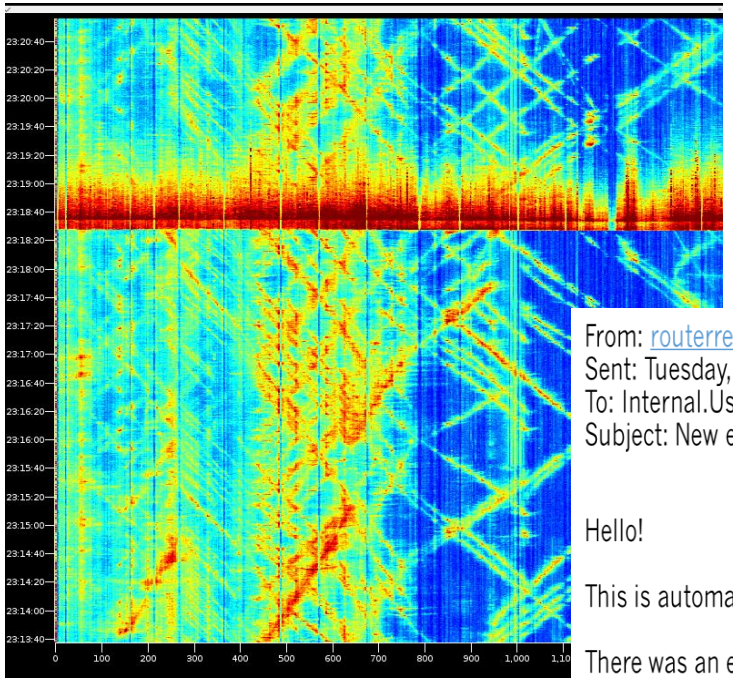
Triggered Events, FBE and LowF DAS
~4.5Gb/day
100Hz/1Hz

In-field processing

Earthquake Diagnostics
~750kb/day
Email/Table/Display

Low Bandwidth Streaming via Portal/SCADA/etc
i.e. 2Mb/s over satellite; 4Mb/s over 4G

Seismicity / Earthquake Real Time Event Detection System



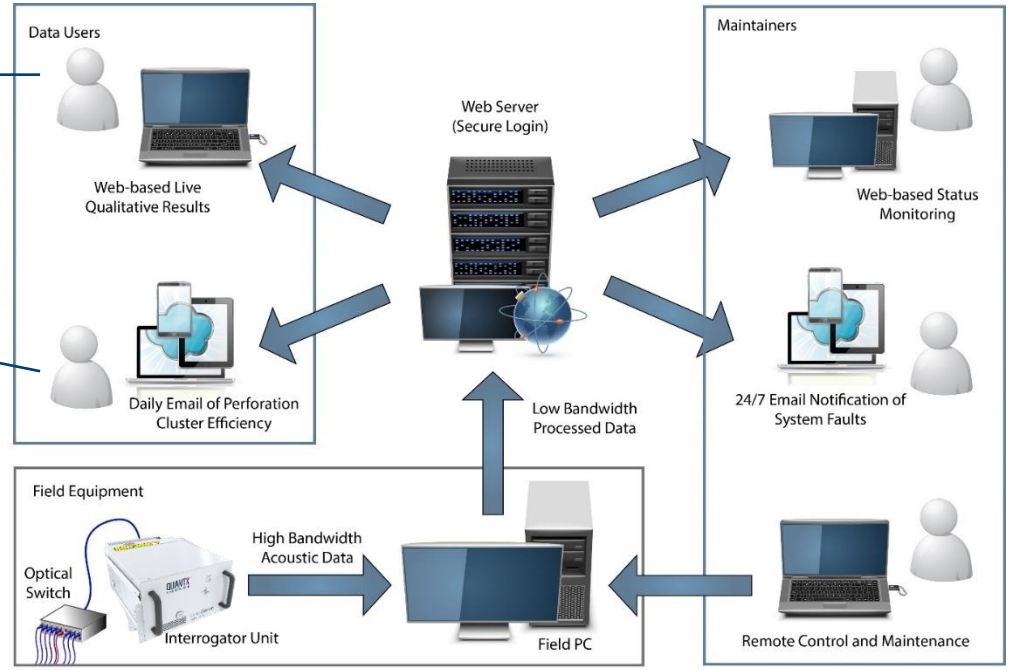
From: routerreport2020@EQxyxyxyxy.com <routerreport2020@EQxyxyxy.com>
Sent: Tuesday, March 21, 2023 4:21 PM
To: Internal.User@optasense.com>; Client1@ClientOrganization.com; Client2... Client3..
Subject: New event detected on 2023-03-21T231928.050000

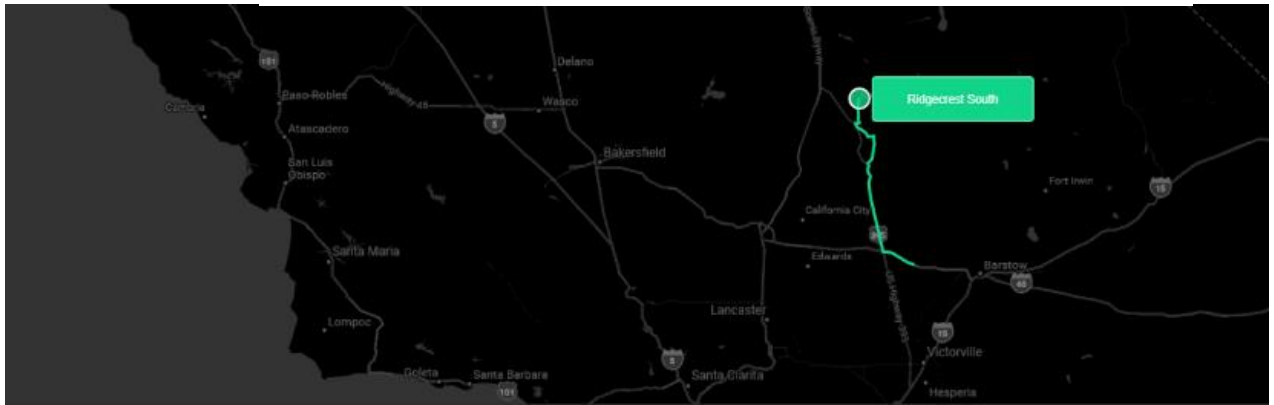
Hello!

This is automatically generated e-mail. Please do not reply.

There was an event detected on 2023-03-21T231928.050000.
Please see attached screenshot for more details.

--OptaSense Team





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Rapid Deployment DAS
Data Products Uploaded to Cloud (AWS)

- Full Edge processing
- Event_SEGY file of given length
  - Sensor_2023-03-21T231928.050000.segy (size depending on spatial and temporal sampling)
  - Options from 1 to 10m spatial channels
  - Options from 0.0005s to seconds time sampling
    - Example 40 second record with 3000 channels with 5m spacing and 100Hz sampling → 290Mb
- Event Screen Display
  - Event_2023-03-21T231928.050000.png (Approximately 1Mb)
- Table with event ID and Time (ascii) (Bytes)

Desired Minimal Bandwidth

- For above example 10 events per day a 20Mbps bandwidth would be sufficient
- 1Gbit/s connection so plenty of room for more

- What about access to continuous data?

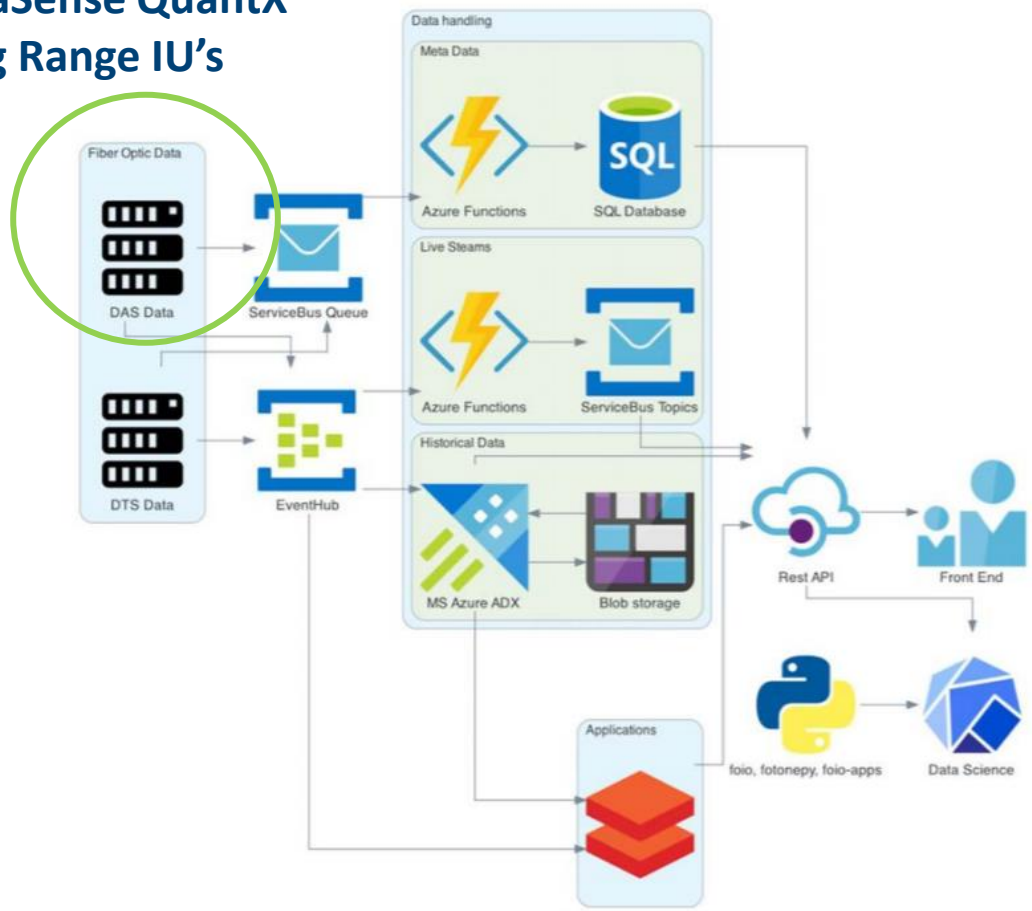
Full Streaming – Up to 10000 Channels – 10kHz

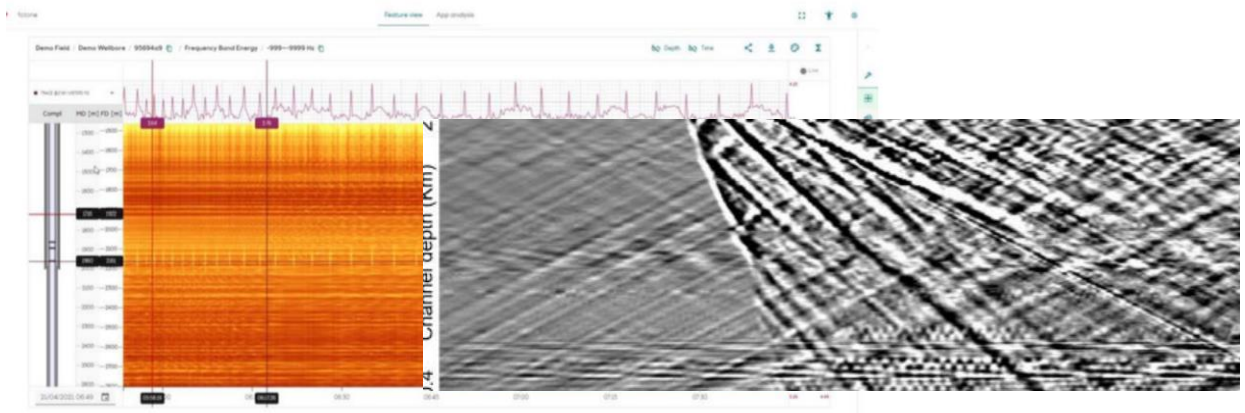
(ie. streaming at ping rate!!!) Do not try at home

Brute force approach → Real time data stream with processing in remote server

OptaSense QuantX
Long Range IU's

Full Streaming





Edge Processing

None → Apache Kafka Streaming

Remote Server

9Tb per Day – 3000 channels

Azure

Pressure/Strain/Seismic/Acoustics

Schuberth et al. 2021; SPE-205405-MS

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Permanent Continuous Data Stream

Current Earthquake Network – 100km - 10000 Channels – 100Hz

- Edge Processing
  - Antialias Filter / Temporal Decimation
  - Spatial Decimation (Due to local Network constraints)
  - Network ~1Gbit/s
- Remote Server
  - 0.3Tb per Day
  - GPU Based
  - Integration to conventional Seismic Network
  - Earthquake Analysis (detection, parameters, etc)
  - Potential latency issues (i.e. less than 1s)

Conclusions

- DAS currently deployed as part of various permanent and rapid deployment networks
- Real time streaming solutions available for DAS data
  - Continuous options for decimated and raw data
  - How much high frequency do we need???
- Edge Processing in Seismology/Geomechanics provides event triggering and parameters; low frequency strain data → Optimal for data sharing
- Event detection can be enhanced by optimizing optical settings

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Questions

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