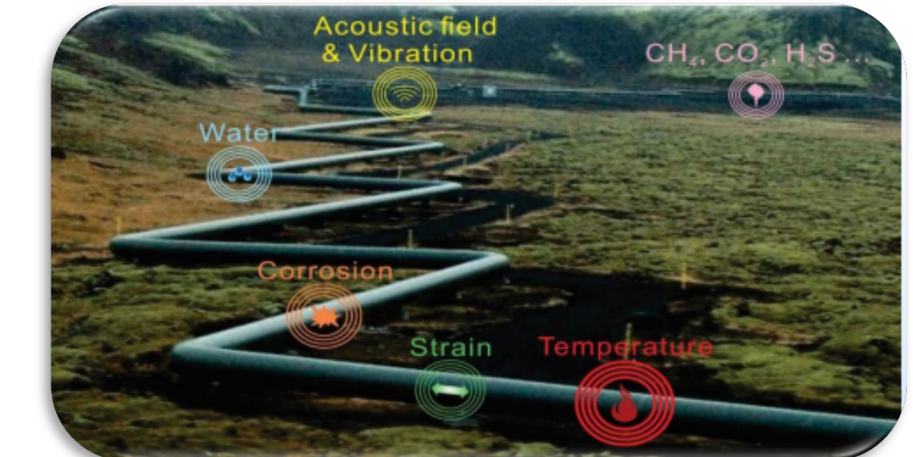


### Pipeline Health Monitoring using Fiber-optic Sensor Technology and Ultrasonic Guidedwave

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#### INTRODUCTION

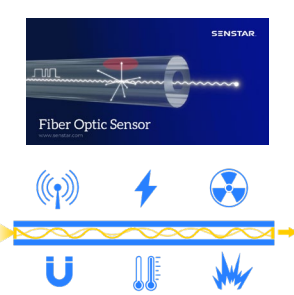
##### Pipelines Infrastructure Monitoring

- Natural Gas, Oil Transport & Storages
- > 300k miles of distribution network
- > 50% built after World war II
- Aging and tend to deteriorate due to corrosion etc.
- Raptures occurs -> Leaks -> Explosion!!

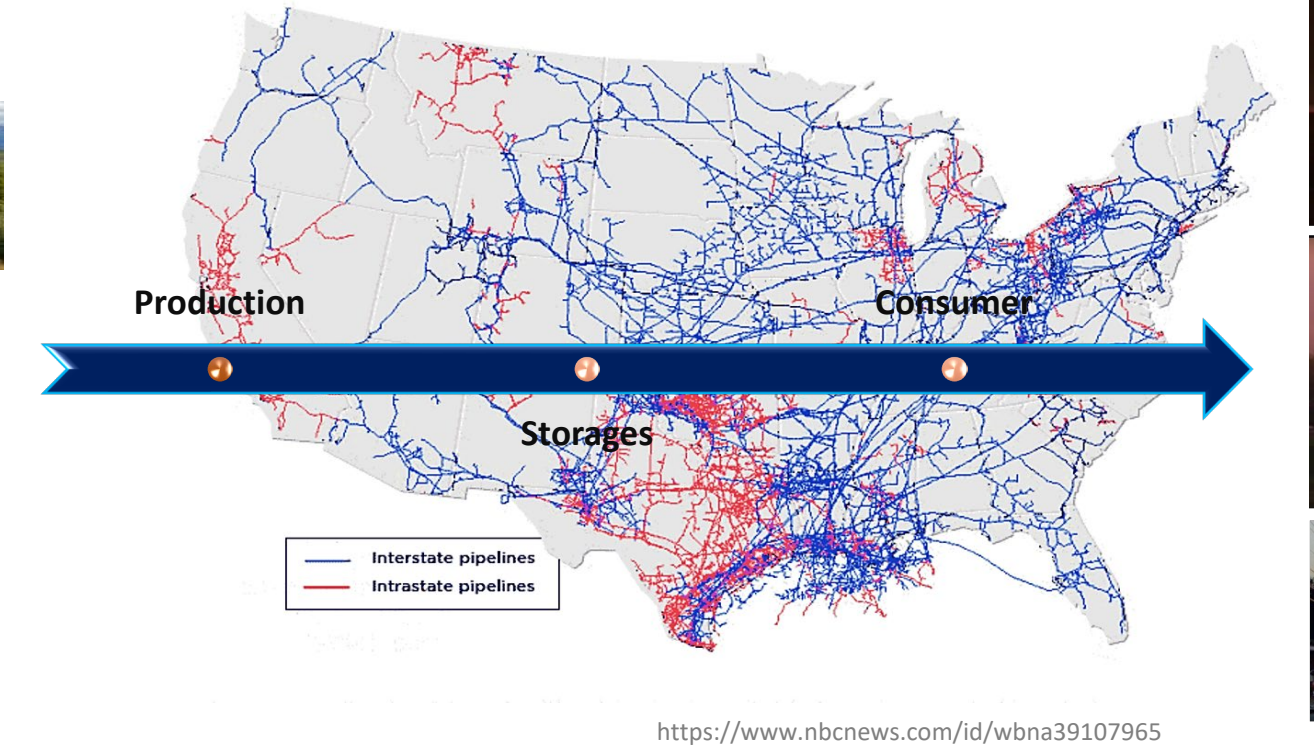


##### Fiber-optic Sensors (FOS) Technology

- Lightweight / embeddable in composite material
- Explosion- and electrical-proof
- Can work upto 1000 °C temperature
- Passive devices
- Point, quasi-distributed and fully-distributed sensing



< Network of major U.S. natural gas pipelines in 2009 >



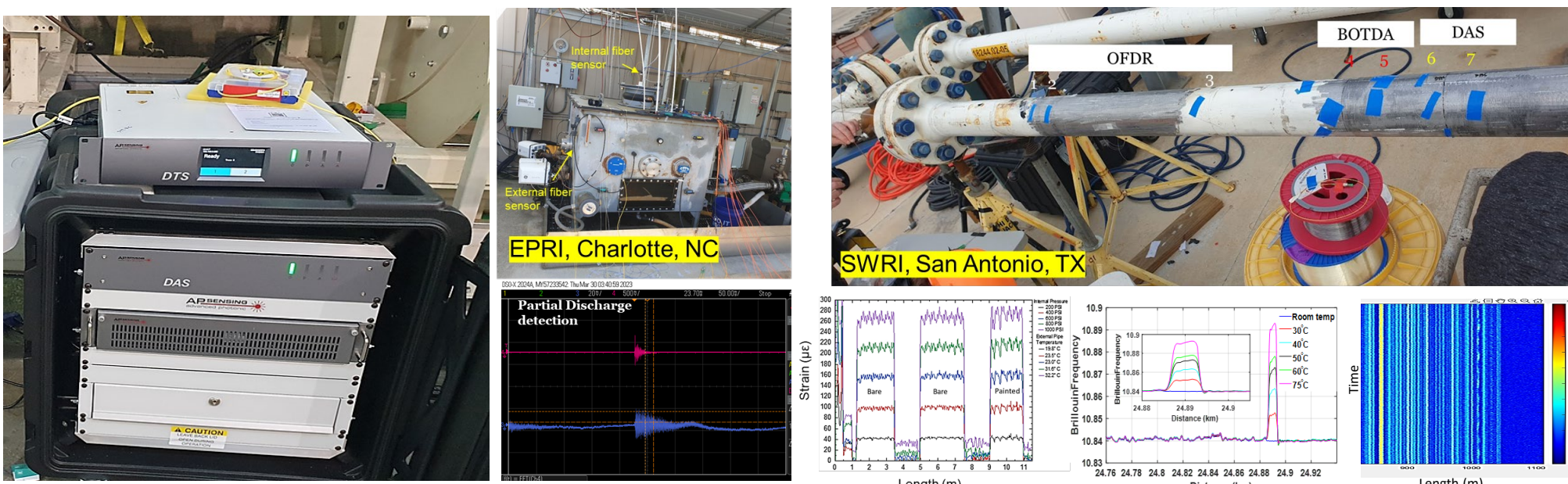
##### Fiber Sensors R&D @ Ohodnicki Lab

###### Custom Benchtop Interrogators

- Acoustics and Vibration -> DAS and Q-DAS
- Strain and Temperature -> OFDR and FBG sensors

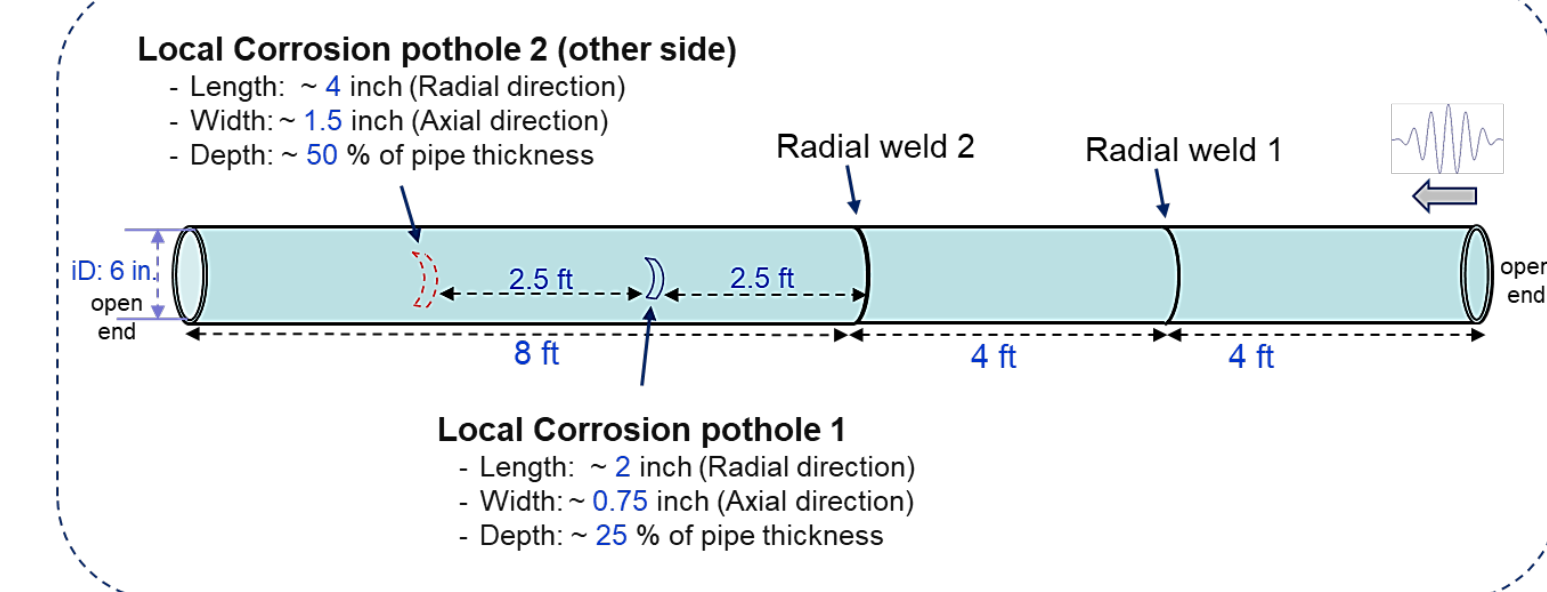
###### Commercial Interrogators

- Distributed Acoustic Sensor (DAS)
- Distributed Temperature sensor (DTS)

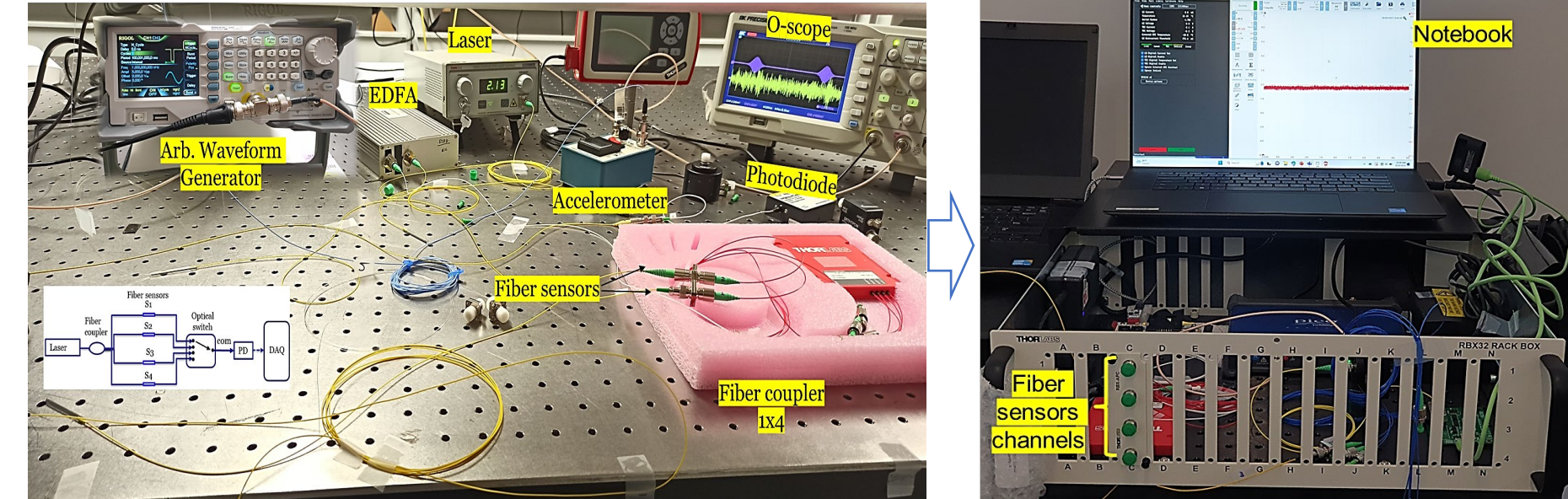


#### DAMAGED DETECTION OF PIPE

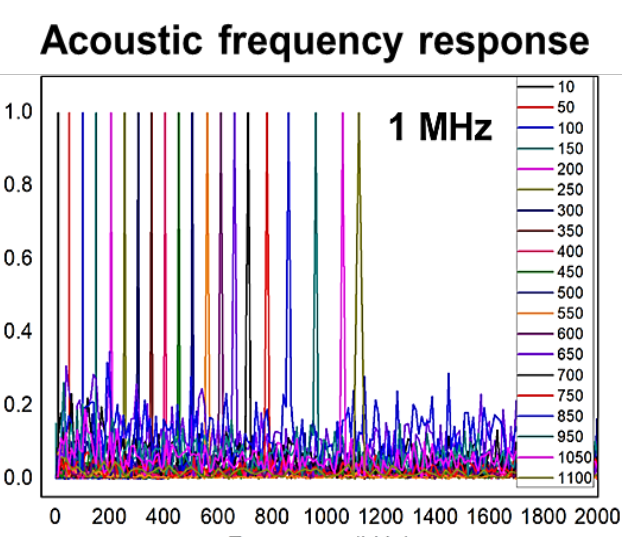
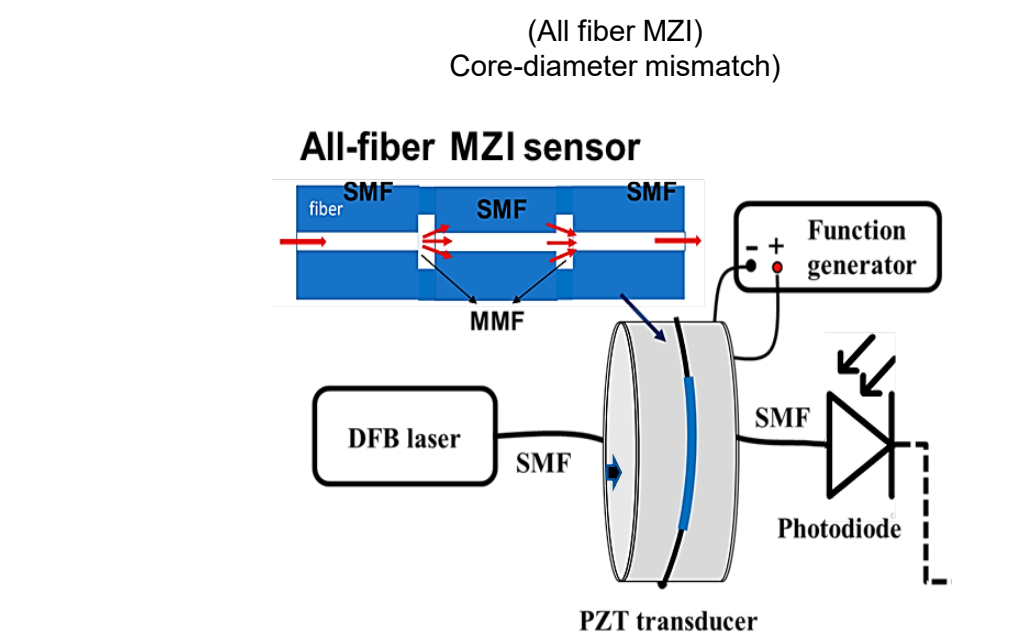
##### Schematics of Damaged Pipeline



##### Fiber-optic Quasi-Distributed Acoustic Sensor Interrogator

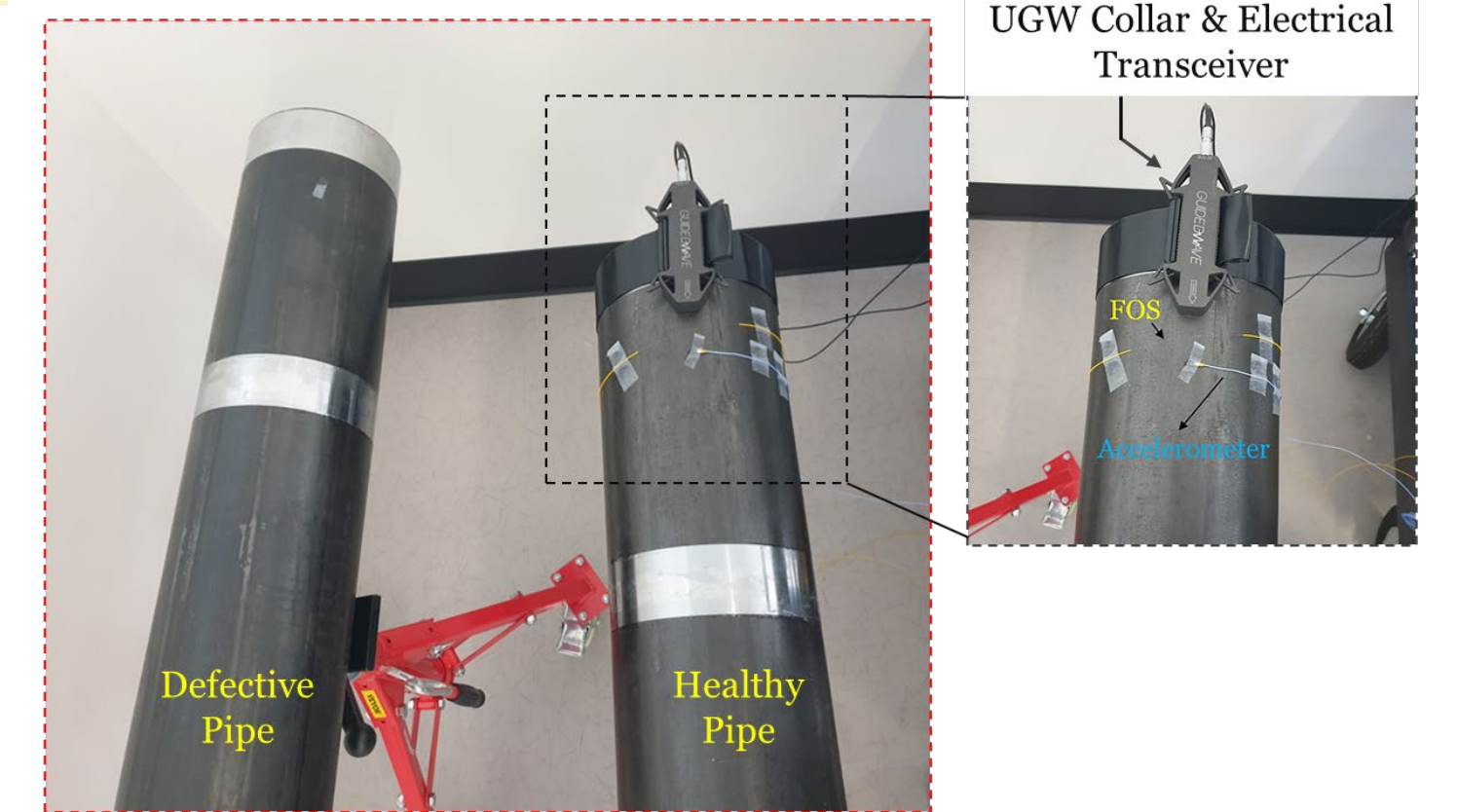


##### Fiber-optic Acoustic Sensor



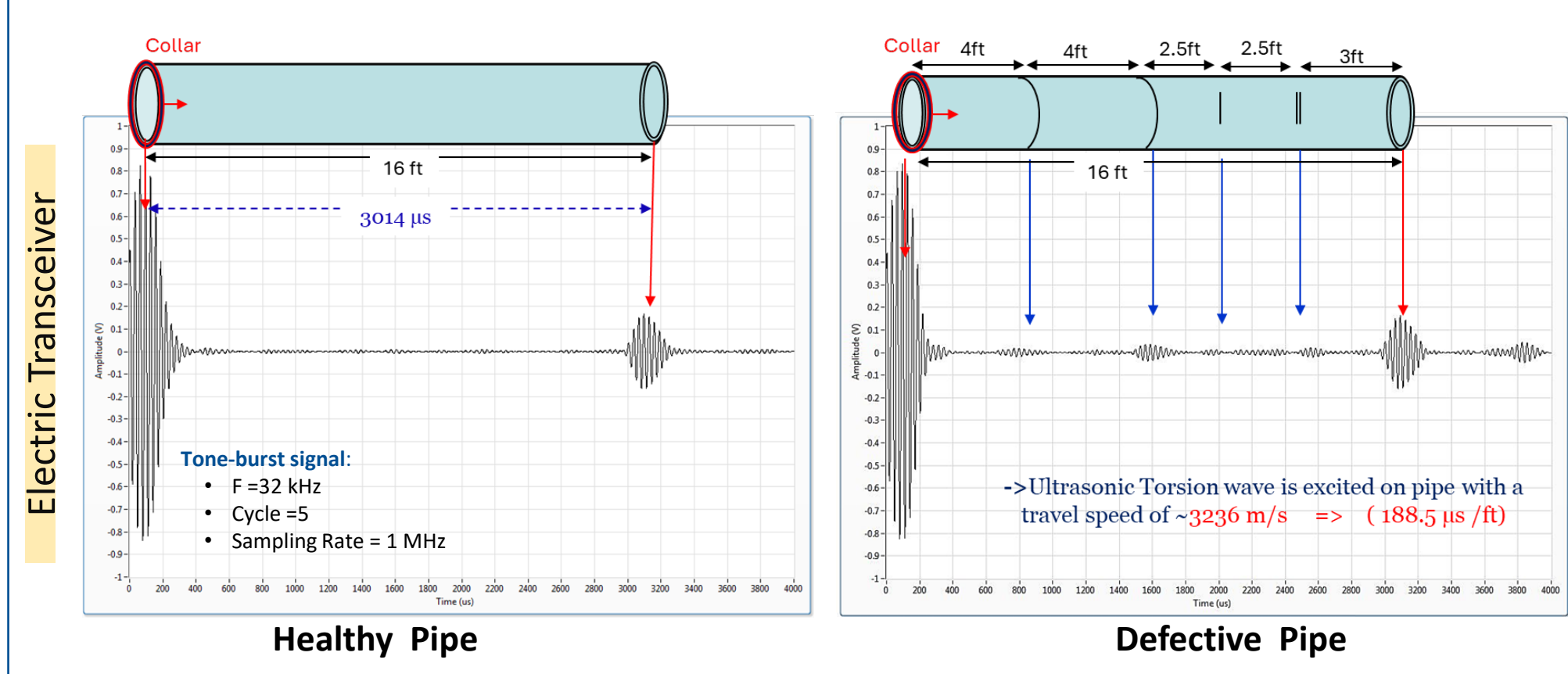
- Remote bonding technique
- Qualitative detection of acoustic event amplitude
- Freq. bandwidth > 1 MHz

##### Test Setup

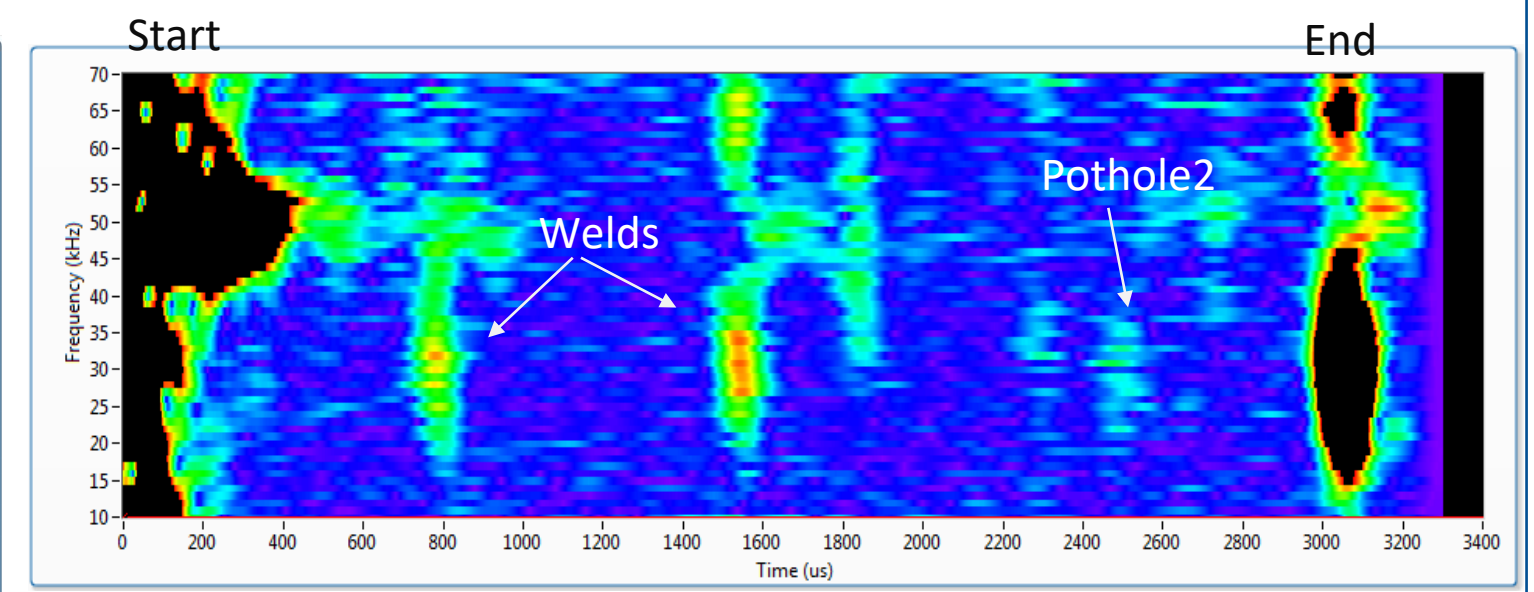


#### RESULTS

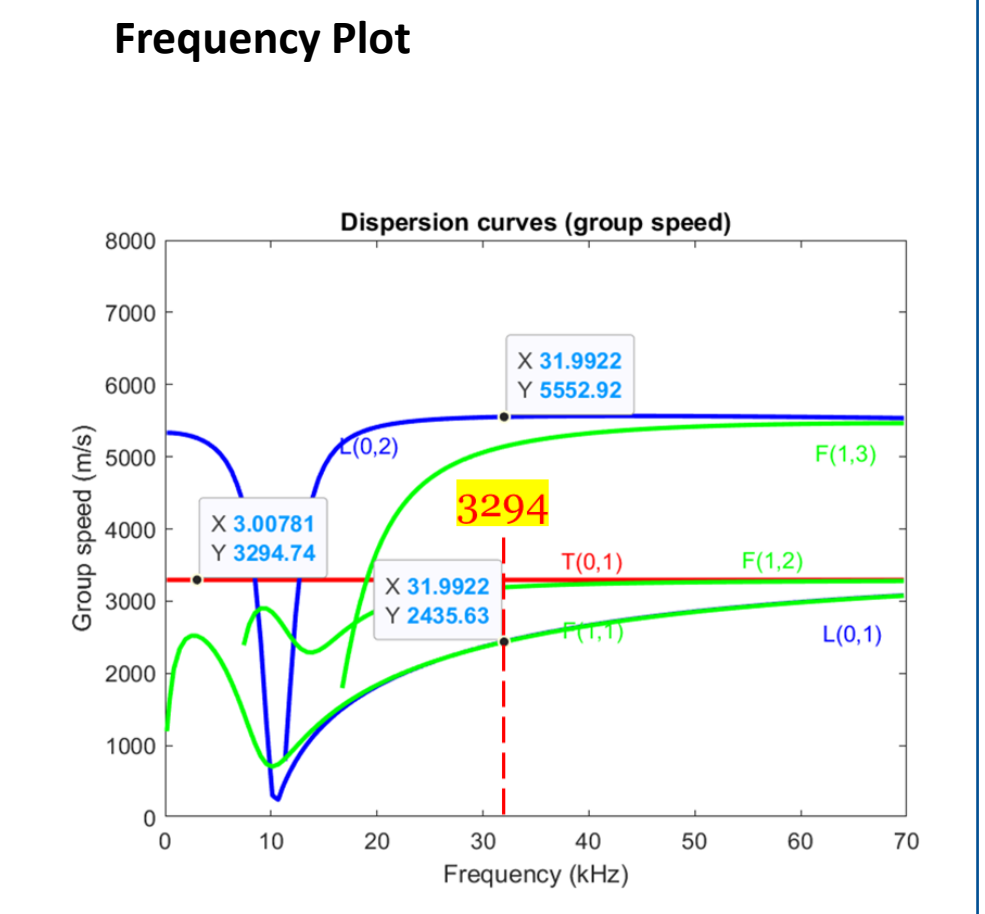
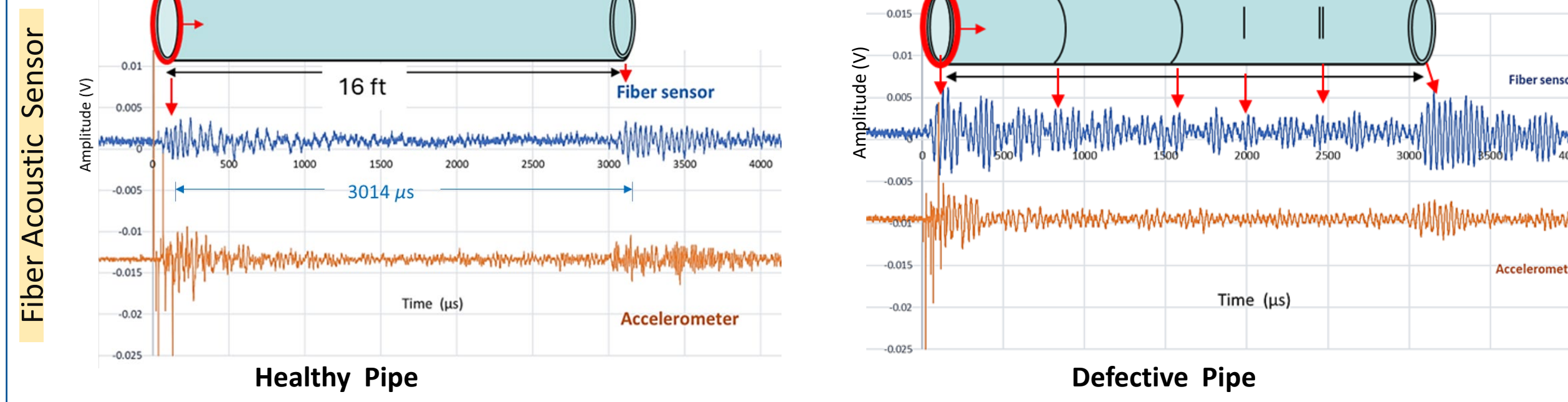
##### 1. Ultrasonic Source: Guided wave collar



-> Torsional mode (symmetric wave) is excited by the UGW collar on the pipe surface.



##### 2. Ultrasonic Source: PZT patch



##### Acknowledgments

We greatly acknowledge the research funding and support from the Nuclear Energy University Program (NEUP) and National Energy Technology Laboratory (NETL).

##### References

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- N. Lalam, P. Westbrook, K. Naeem et al. Pilot-scale testing of natural gas pipeline monitoring based on phase-OTDR and enhanced scatter optical fiber cable. Sci Rep 13, 14037 (2023).
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- P. R. Ohodnicki, E. Sarcinelli, P. Zhang, K. Naeem et al., "Nuclear canister integrity monitoring using quasi-distributed fiber acoustic sensors and physics-based modeling," Proc. SPIE 12532, Optical Waveguide and Laser Sensors II, 125320I (13 June 2023)

