

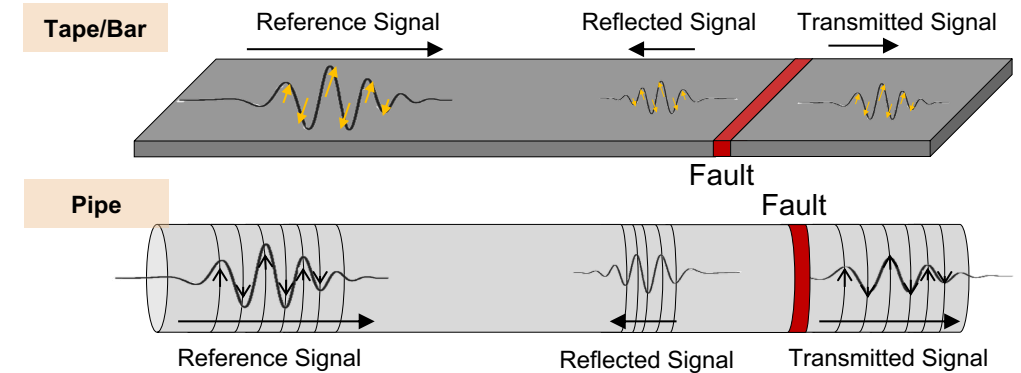
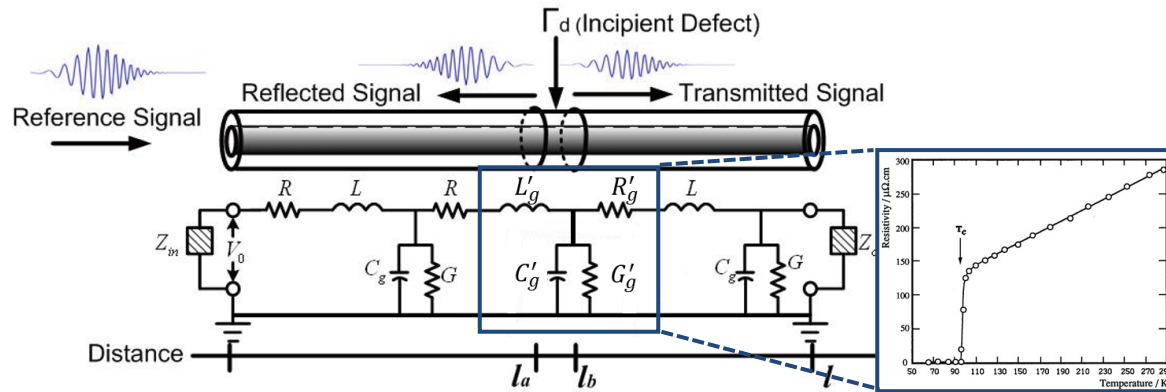
MDP Diagnostics Update (M3)

Time-Frequency Domain Reflectometry for Quench Detection

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*Presentation to US MDP General Meeting
Oct 27, 2021*

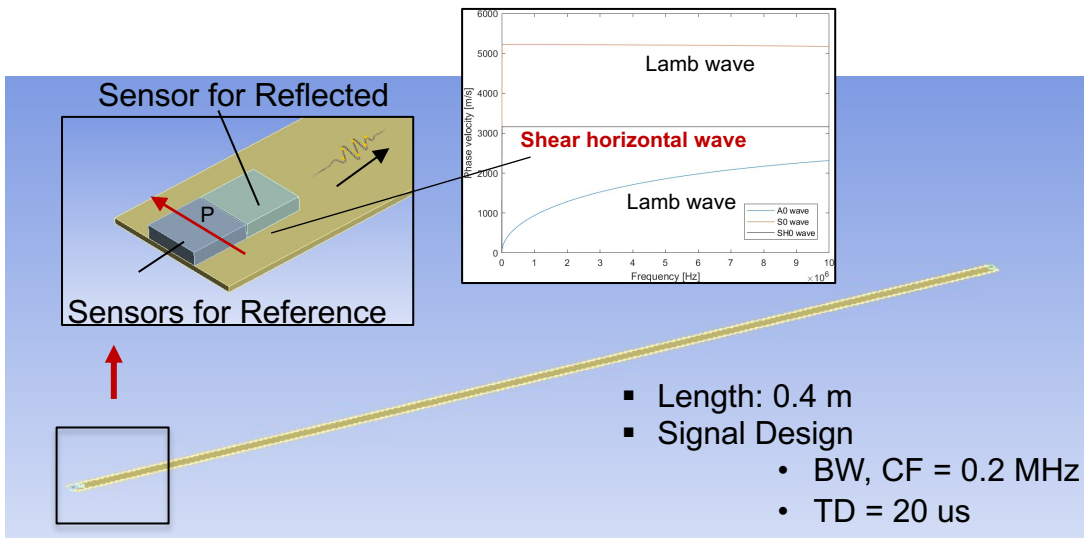
Applicability of reflectometry to magnets



- Detection technique based on the reflection of waves at the discontinuity
 - Electrical signal: Apply reference signal to two voltage lines with insulation
 - Acoustic signal: Apply reference signal in the wave guide
- **How do we apply reflectometry to the magnet?**
 1. Additional wires with conductors
 2. Magnet mandrel (pipe)
 3. Conductor (tape/bar)
- Quench detection and localization
 - Crack, thermal load, thermal expansion ...

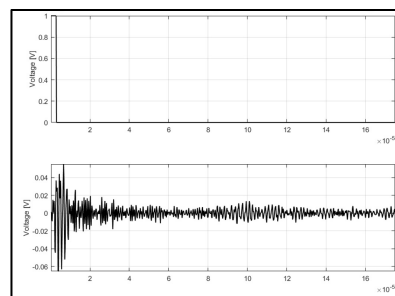
AlIId-M3	Development and test of a linear quench localization sensor on a Bi-2212 subscale and/or ReBCO CCT series
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Guided wave propagation in REBCO tape (ANSYS)

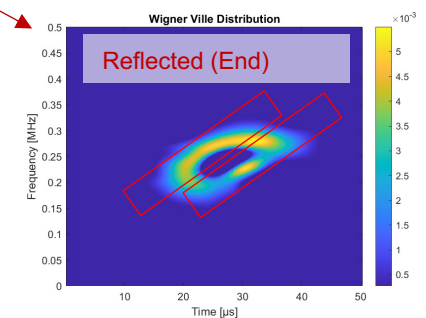
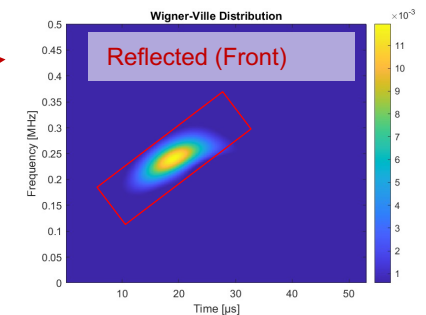
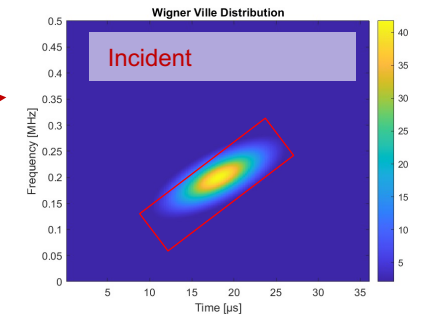
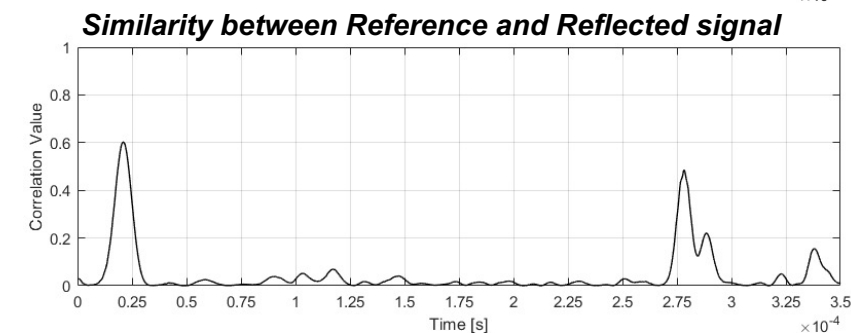
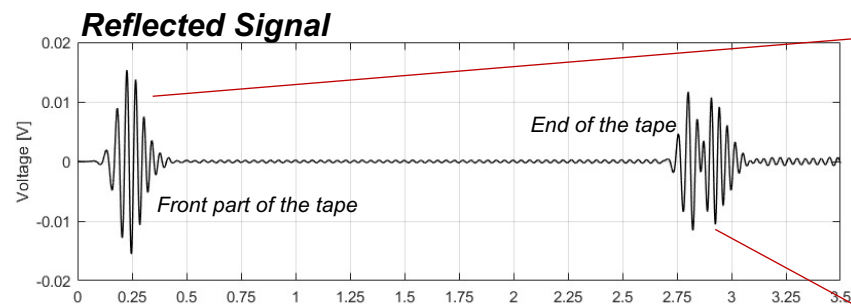
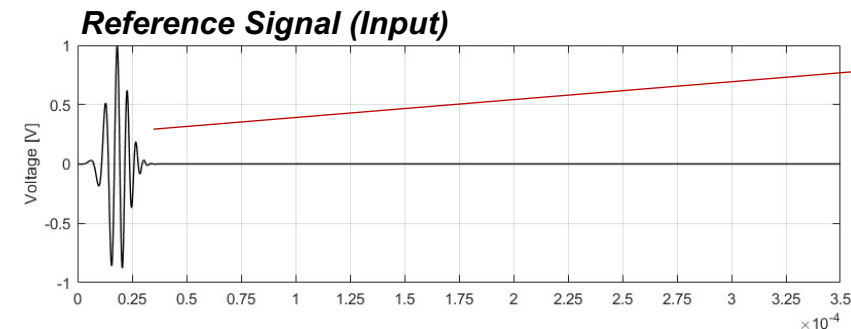


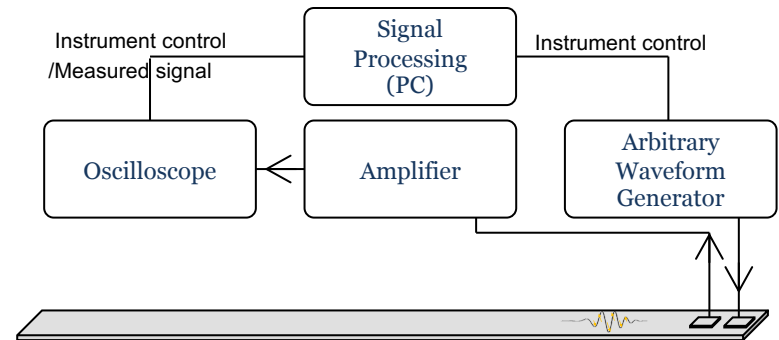
■ Ansys simulation of REBCO Tape

- SH (Shear-Horizontal) mode
- The chirp signal is easy for localization. (compared to step and sinusoidal)
 - Time-frequency domain reflectometry (TFDR)

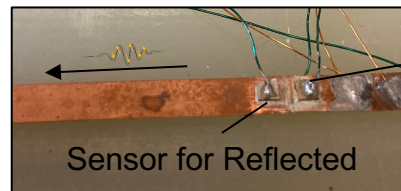


Result of Step pulse

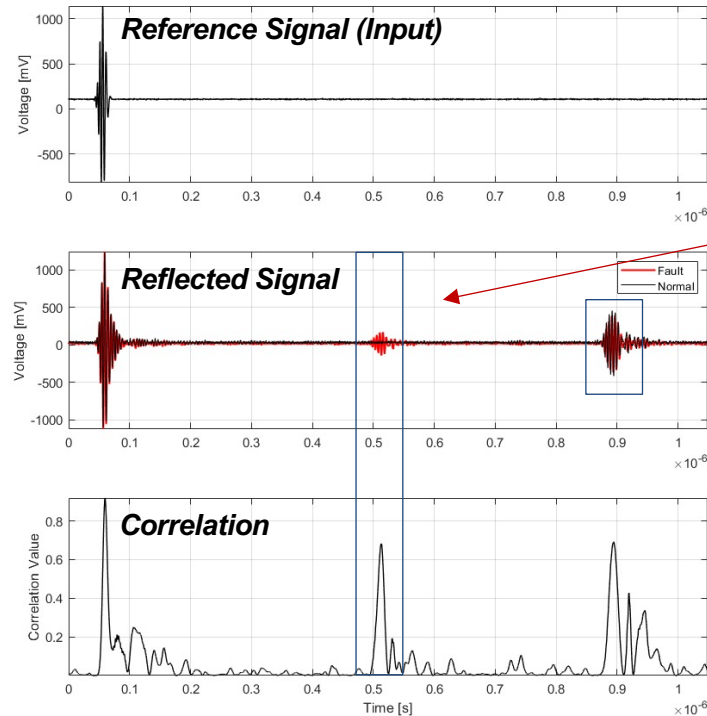




2G HTS REBCO (SuperPower)

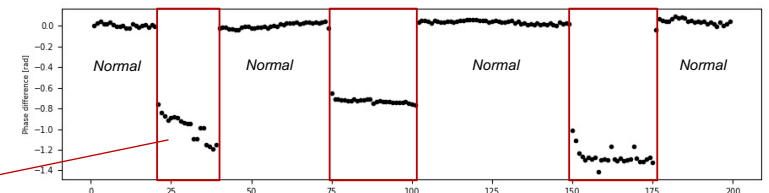


- Length: 1.2 m
- Signal Design
 - BW, CF = 0.2 MHz
 - TD = 20 μ s

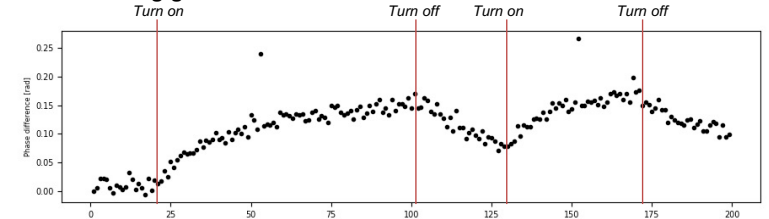


Monitoring the reflected signal of end point

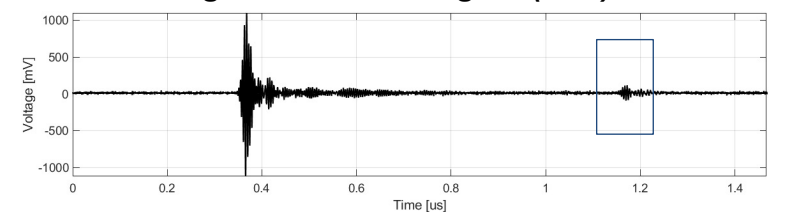
1. Applied mechanical force



2. Heating gun in local area



Measuring the reflected signal (LN2)



- Local change of HTS tape affects the acoustic wave propagation (Quench detection)
- Improvement is required for quench localization (hot spot)
 - Amplifiers, connector, new experimental setups

Present and Future Plans

- Currently, amplifier is used only for measurement signals.
 - Changing the input voltage from 5V to 200V
 - It is expected that the piezo sensor operation will be improved even at cryogenic temperature.
- Low temperature Elasticity of *Dysprosium*
 - Exhibits typical anomalies at specific temperature (87 K)
 - Tried with Foil type, but HTS tape will be covered with epoxy in powder in the next time.
- *TFDR utilizing acoustic sensor can localize the mechanical failures for HTS tapes and cables (pipe), but improvement is still required to localize hot spots (thermal change).*