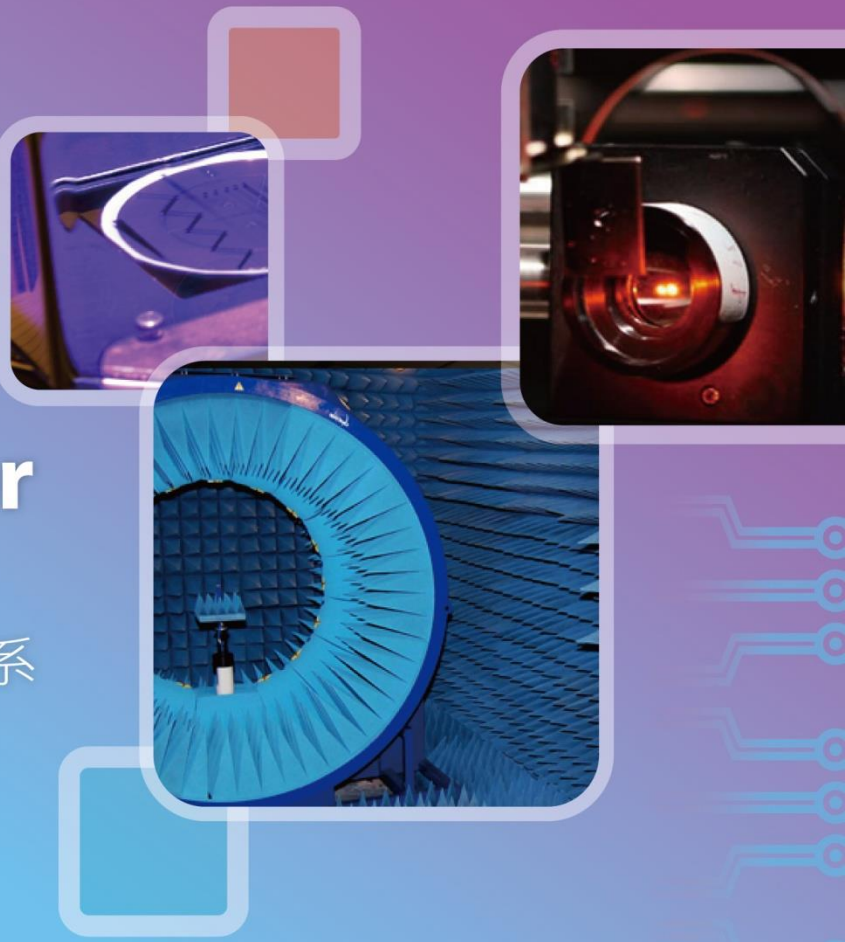
THE HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY

Department of Electronic & Computer Engineering

電 子 及 計 算 機 工 程 學 系



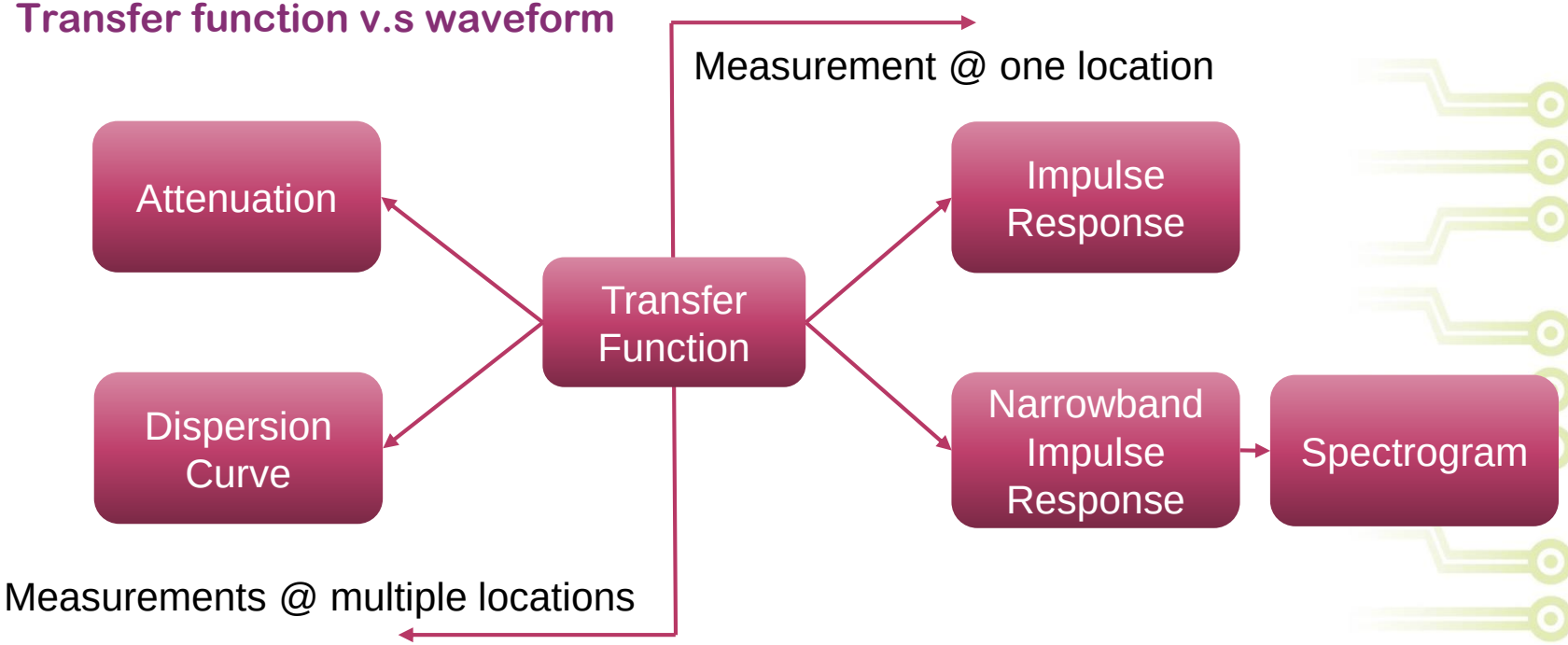
Direct Problem: Wave Propagation in Pipe

21 June 2017

Derek and Liwen
Prof. Murch's group

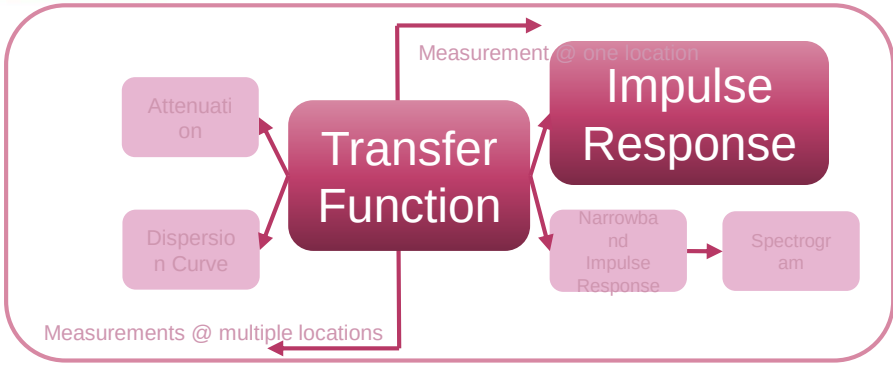
Background

- Models (Analytical, FEM) v.s. Measurement
  - Measurement as ground truth
- VNA v.s. NI
  - Frequency domain v.s. Time domain
  - Transfer function v.s waveform

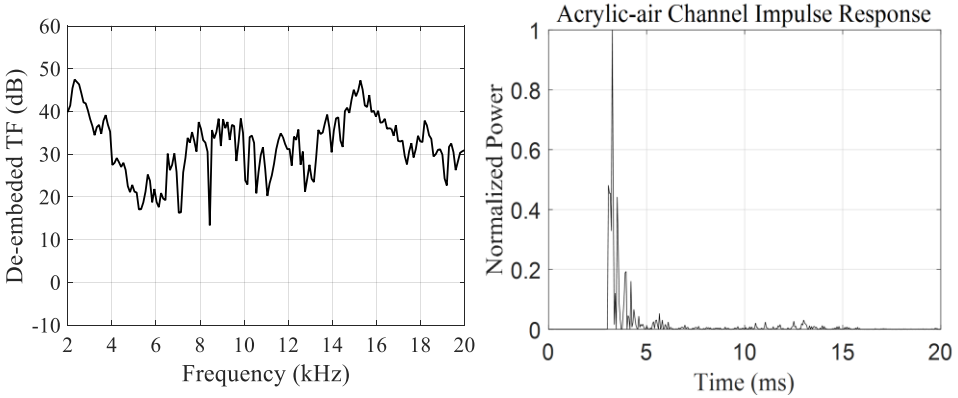


Measurement Result

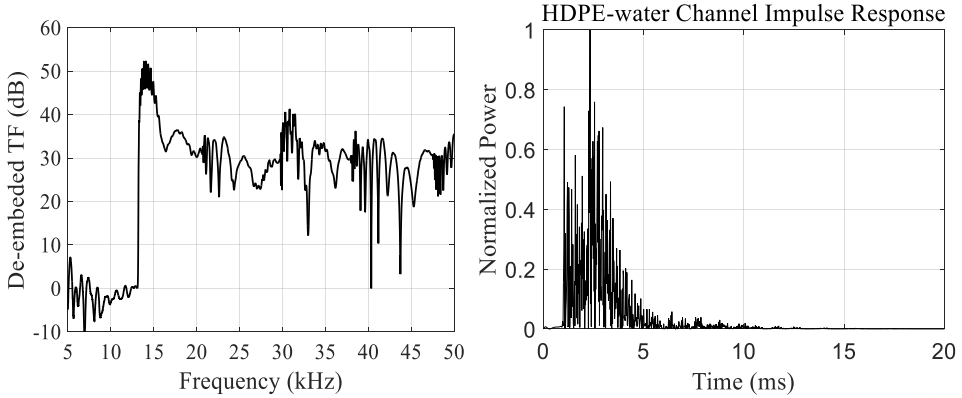
- VNA can measure frequency response at selected frequencies with both amplitude and phase information.
- Calibration channel in air measured in an acoustic chamber, and the calibration channel in water is obtained from BK8104 datasheet.



TF & IR in Acrylic-air Channel



TF & IR in HDPE-water Channel



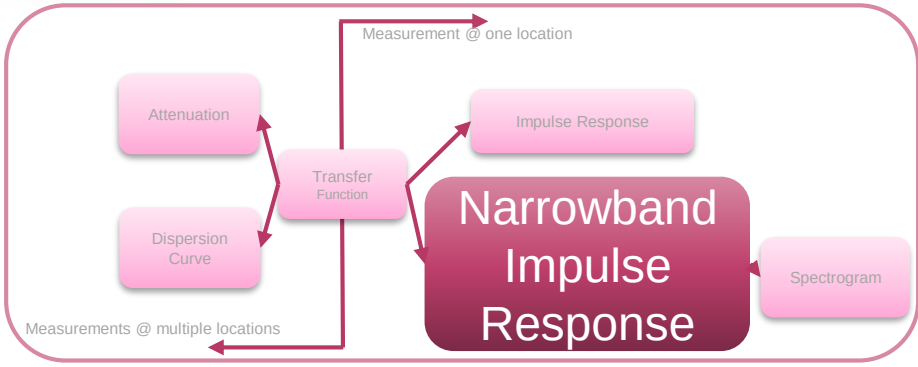
Measurement Result

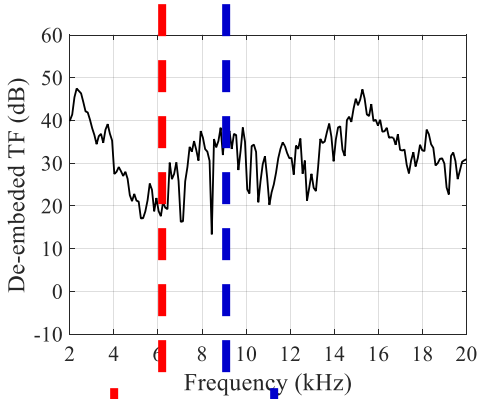
- **Impulse response:**

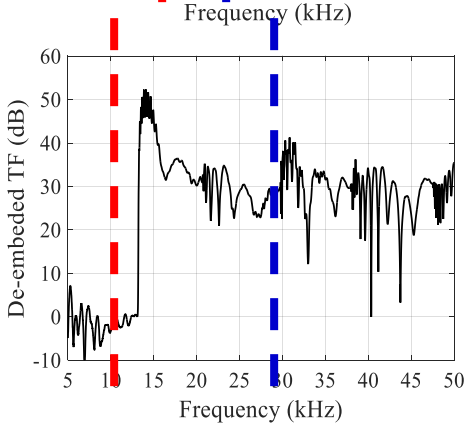
$$h(t) = F^{-1}H(f)$$

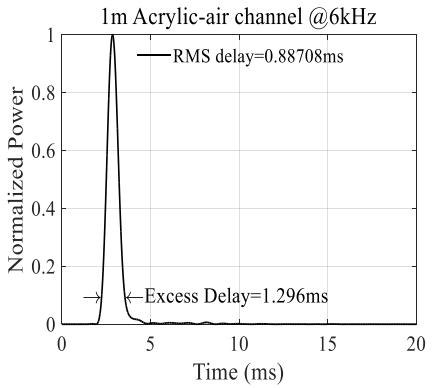
- **Narrowband impulse response:**

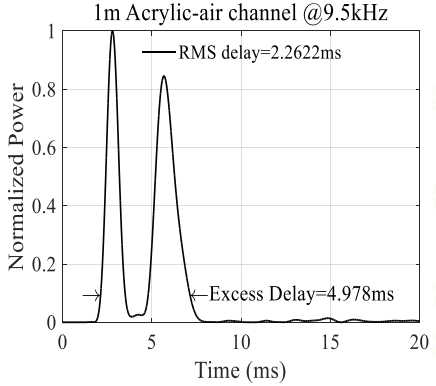
$$h_{\Delta f}(t) = F^{-1}[H(f)\,W(\Delta f)]$$

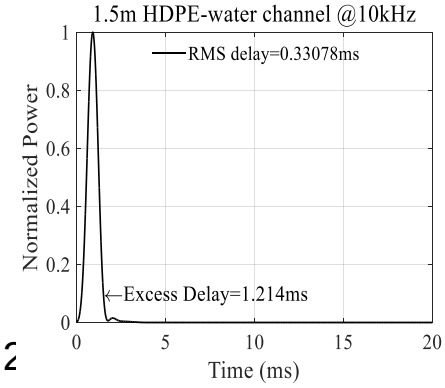


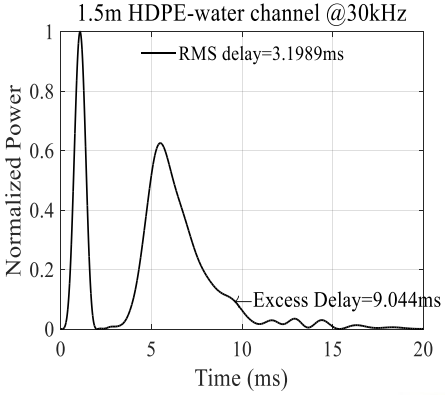






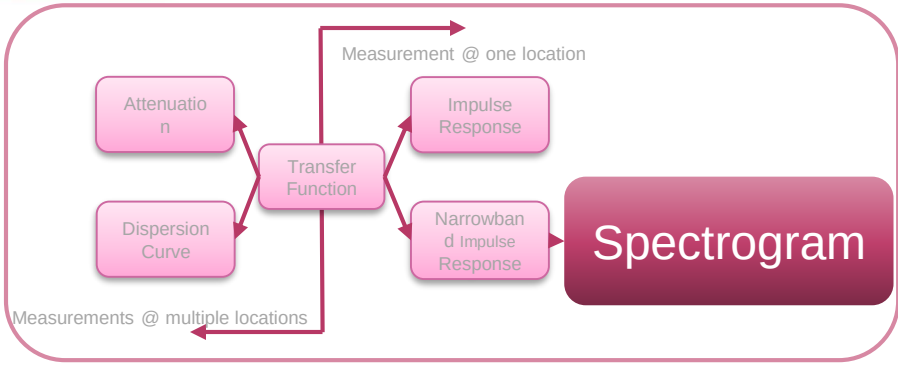




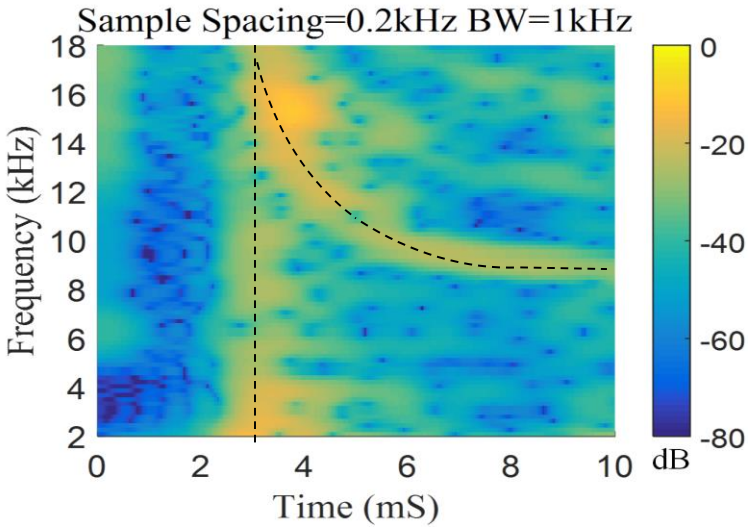


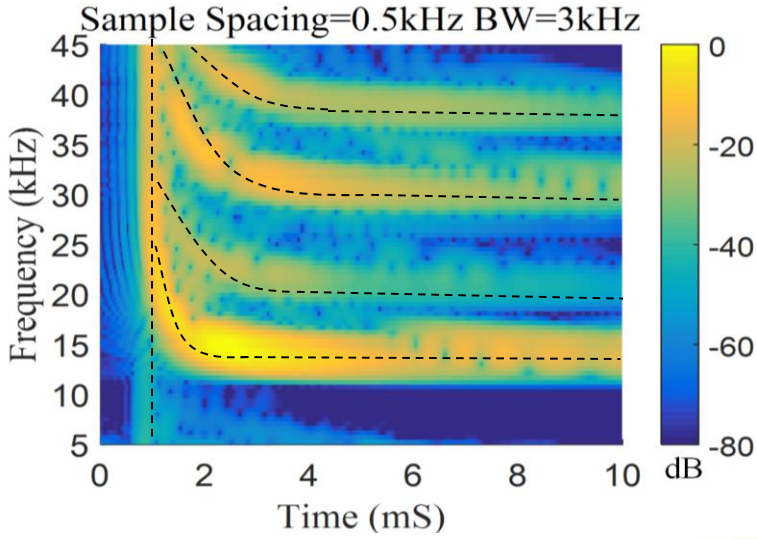
Measurement Result

$$h(t) = \sum_{p=0}^{P-1} h_{\Delta f_p}(t) = \sum_{p=0}^{P-1} H(f)W(\Delta f_p)$$



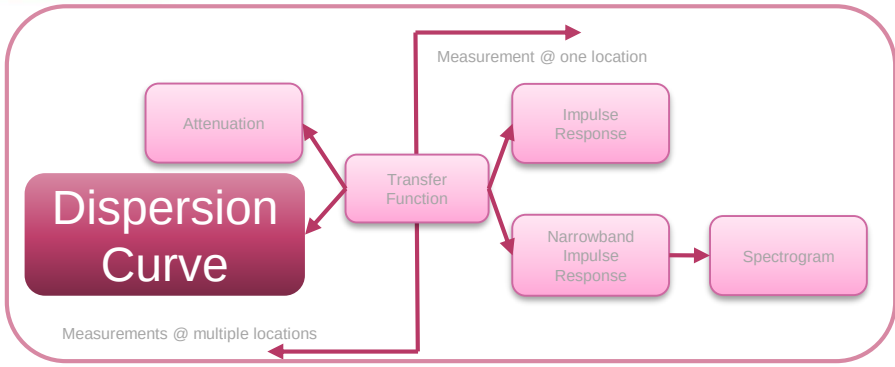
- Spectrogram can be formed by considering the addition of all the narrowband impulse response functions.

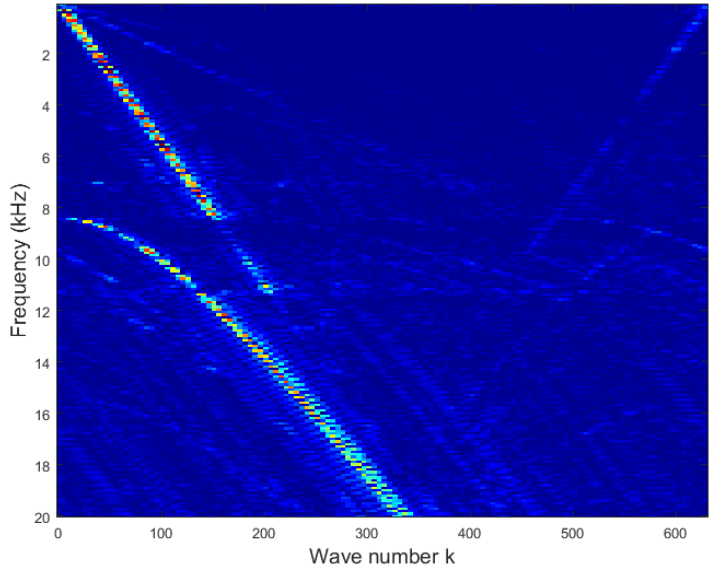


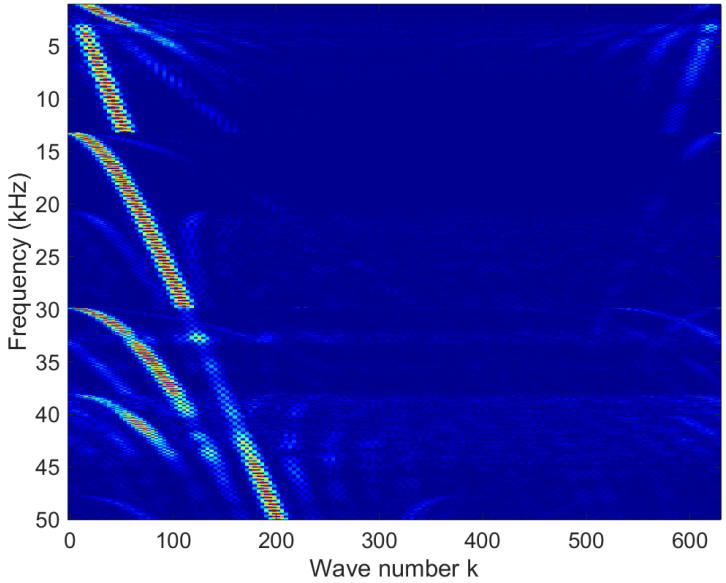


Measurement Result

- The dispersion curve can then be found by applying the spatial domain Fourier transform to transfer functions.
- 2 main modes are found in acrylic-air channel, and 5 main modes are found in HDPE-water channel.

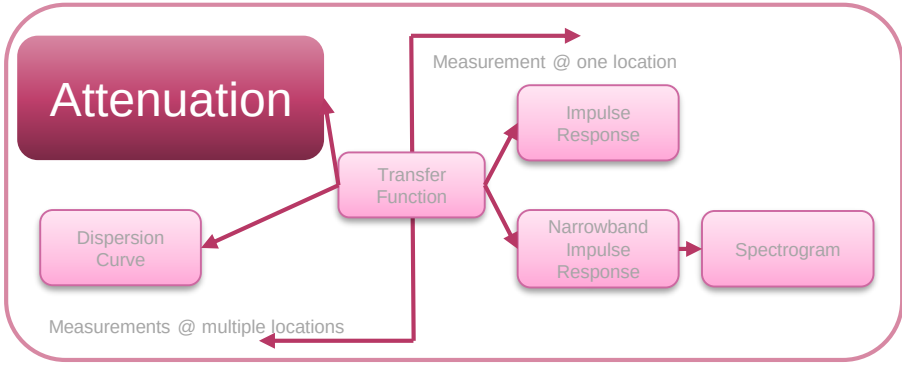


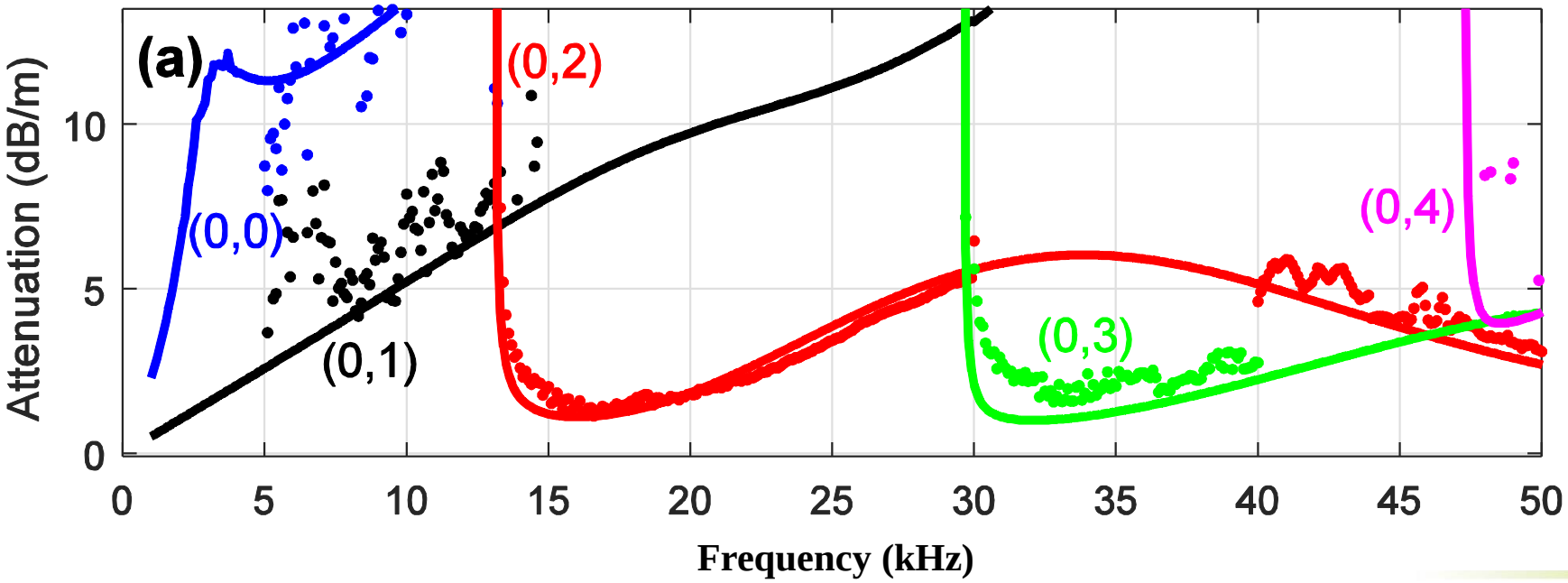




Measurement Result

- Modes are separated in dispersion curves and we can estimate loss in frequency bands when only one mode is dominating.





Conclusion and Future Plans

- We proposed and experimentally validated high frequency wave propagation model for a wide range of pipe materials.
- Good matching is obtained between theory and measurement in terms of dispersion curve, attenuation and etc.
- Systematic procedure for measurement is established.
- Our next step is using HFW for defect detection.