

# A new NDT tool for pavement evaluation: Step-Frequency GPR

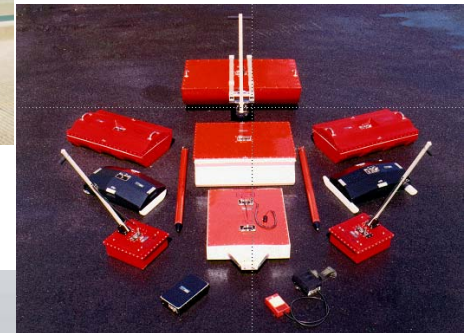
H. Thomas Yu  
Office of Asset Management,  
Pavement, and Construction  
Federal Highway Administration



# Ground Penetrating Radar



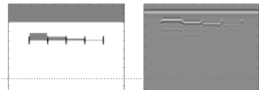
- RS AB Subecho 1200\*
- RS AB Subecho 900\*
- RS AB Subecho 150\*



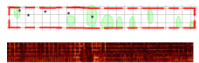
- GSSI 4105
  - 2.2 GHz
- GSSI
  - 900 MHz
- GSSI 5106
  - 200 MHz



## HERMES I/II



GPR Modeling



Signal Processing  
Pattern Recognition

Field/Laboratory  
Bridge Deck Evaluation

Pavement Evaluation



# The APE



U.S. Department of Transportation  
Federal Highway Administration

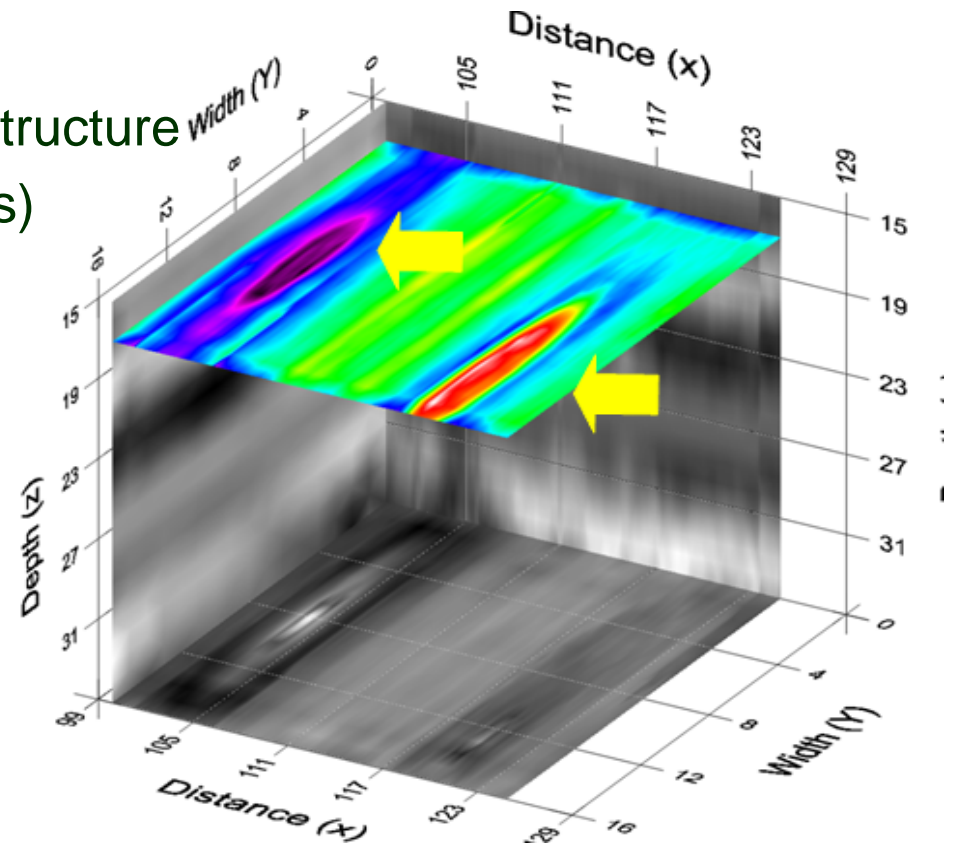
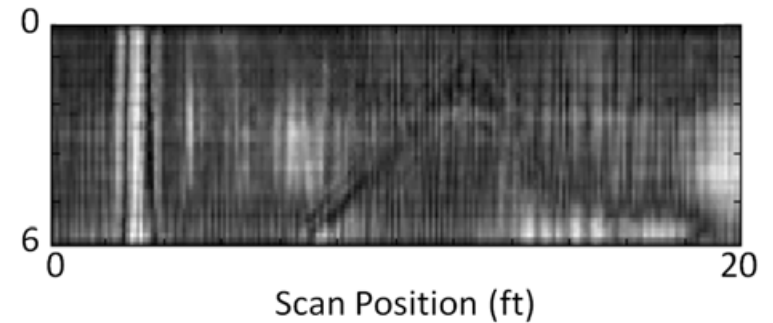
# SF-GPR

## ■ Advantages

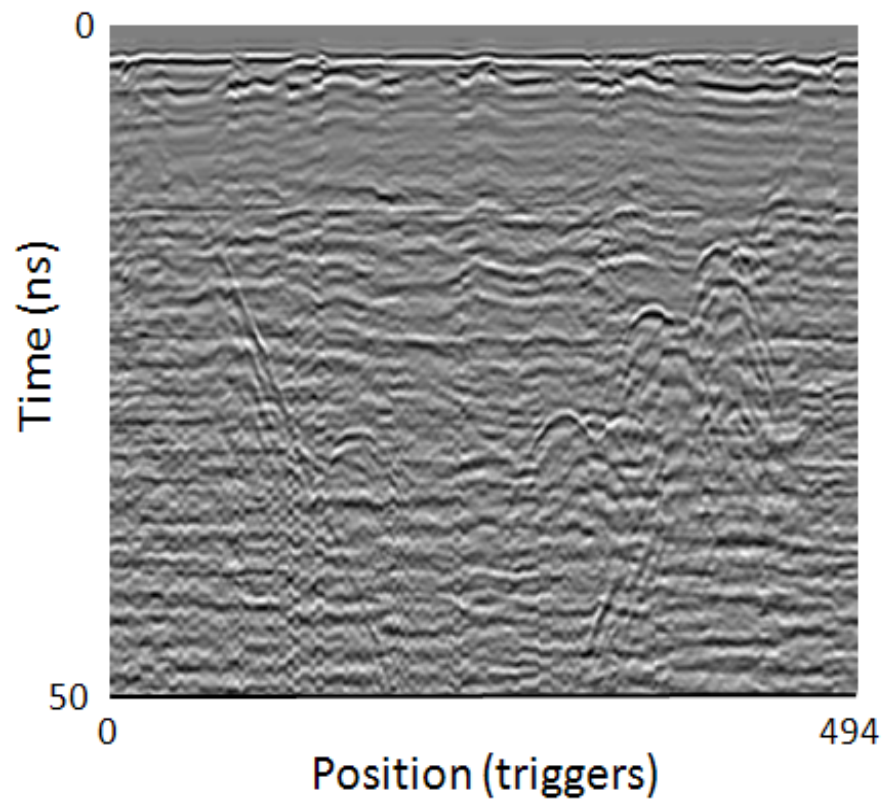
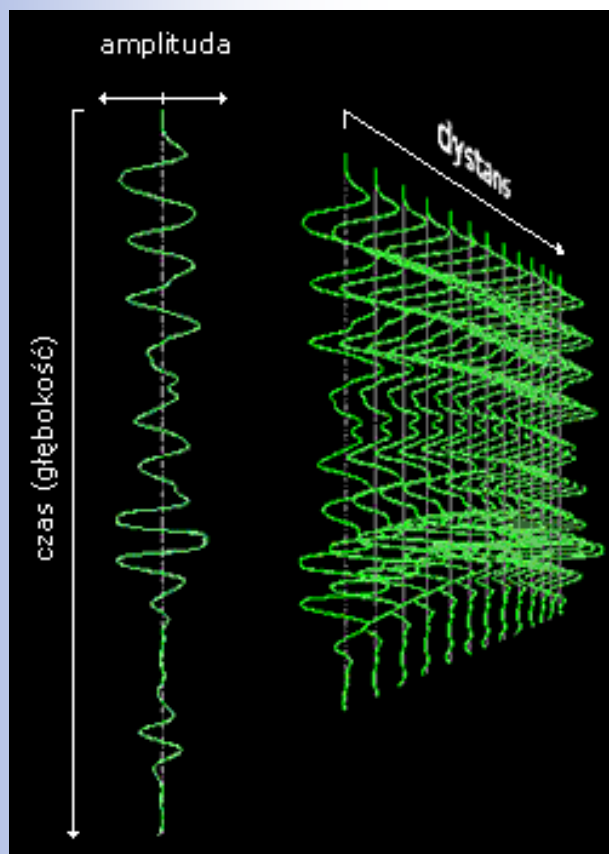
- Wide detection range (0 to 20+ ft)
- Full coverage of a lane in 2 passes
- Continuous calibration
- Insensitive to external interference

## ■ Potential Applications

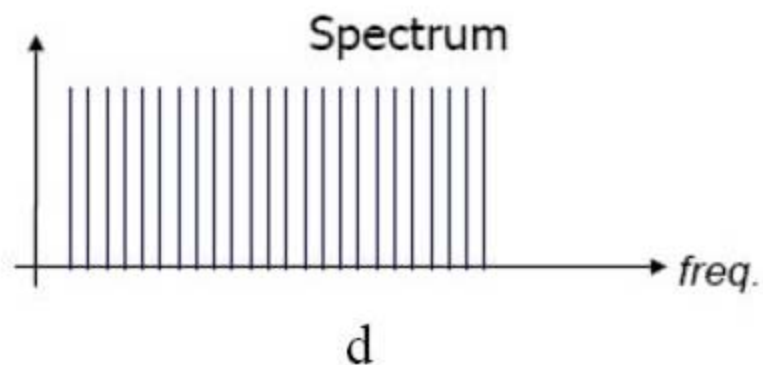
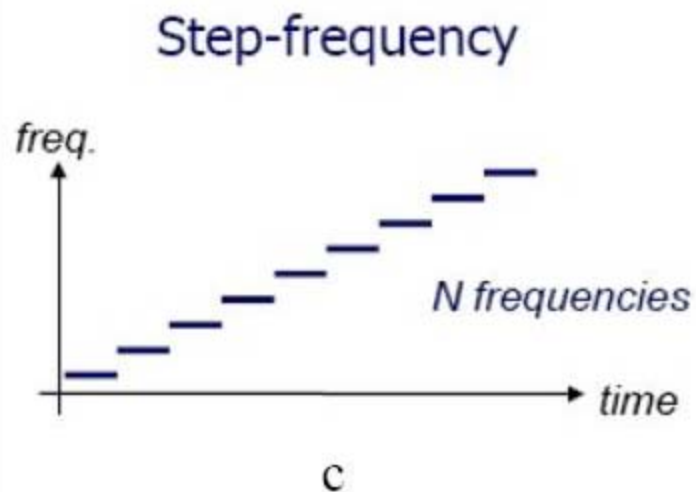
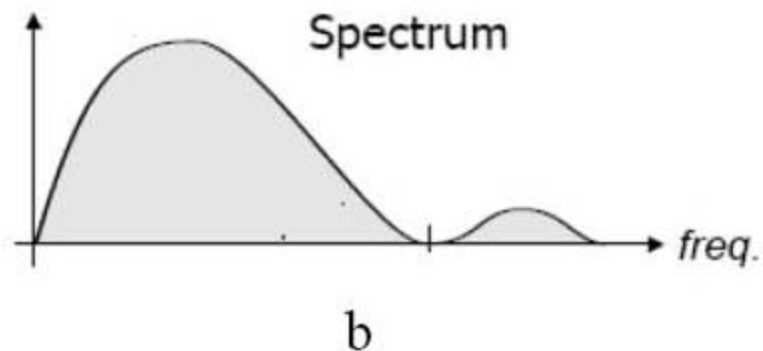
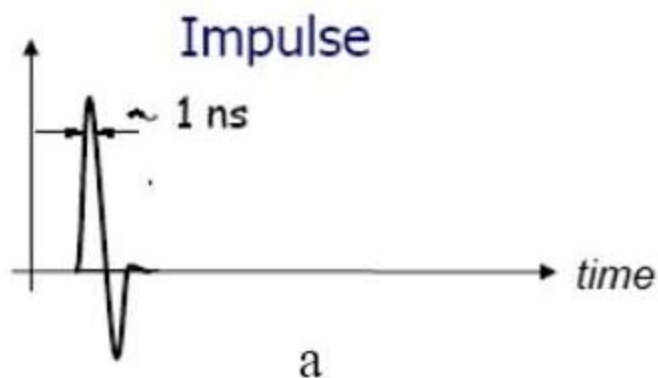
- Pavement layer thickness and structure
- Feature detection (voids, objects)
- Material property variations
  - HMA density variations
  - In consistencies in PCC mix
  - Material degradation
- Moisture detection
- Cover depth detection



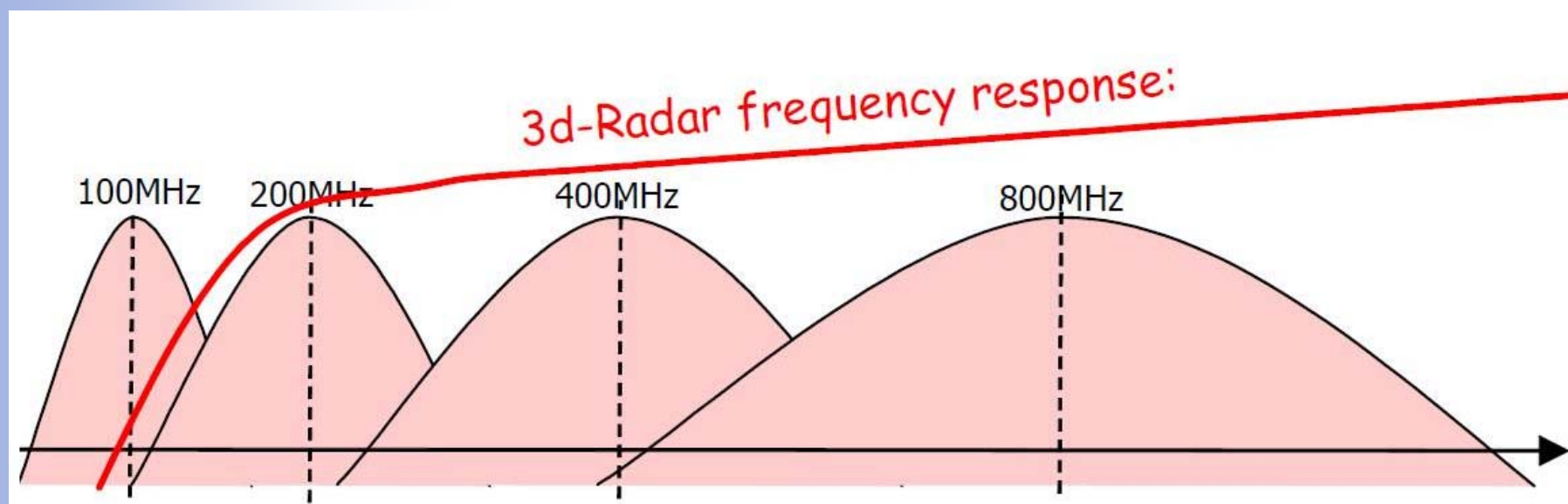
# GPR testing



# Impulse vs. Step-Frequency GPR



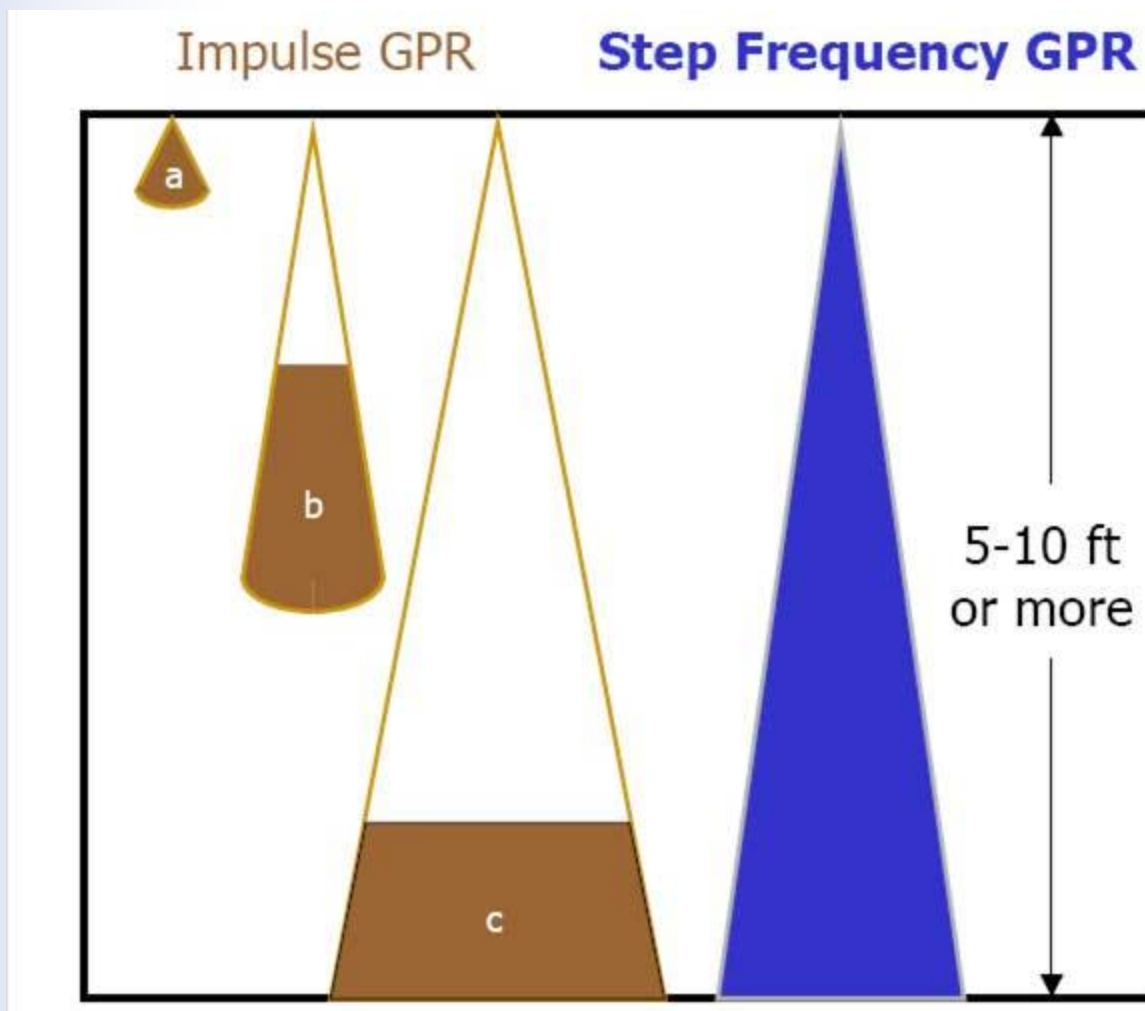
# Impulse vs. Step-Frequency GPR



Impulse radar frequency response

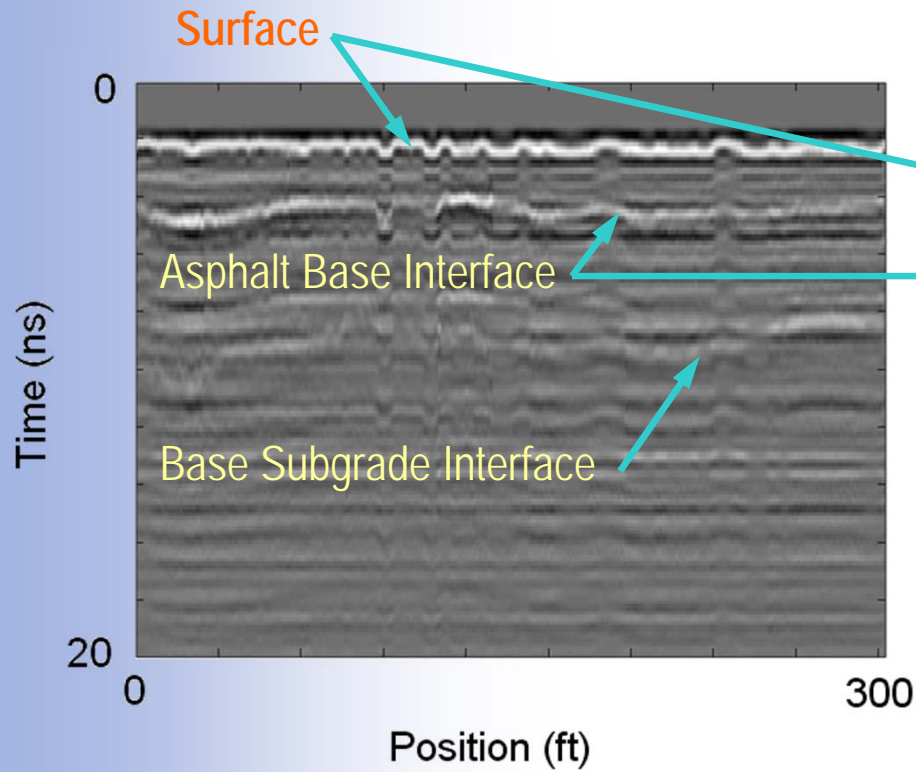


# Impulse vs. Step-Frequency GPR

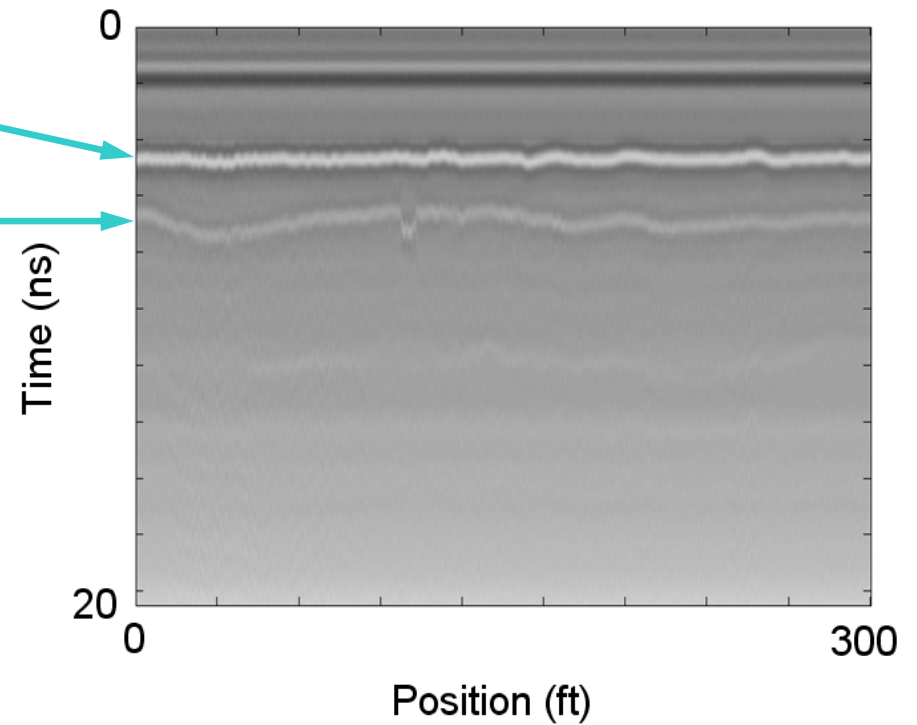




# Comparison of SG-GPR and GSSI results



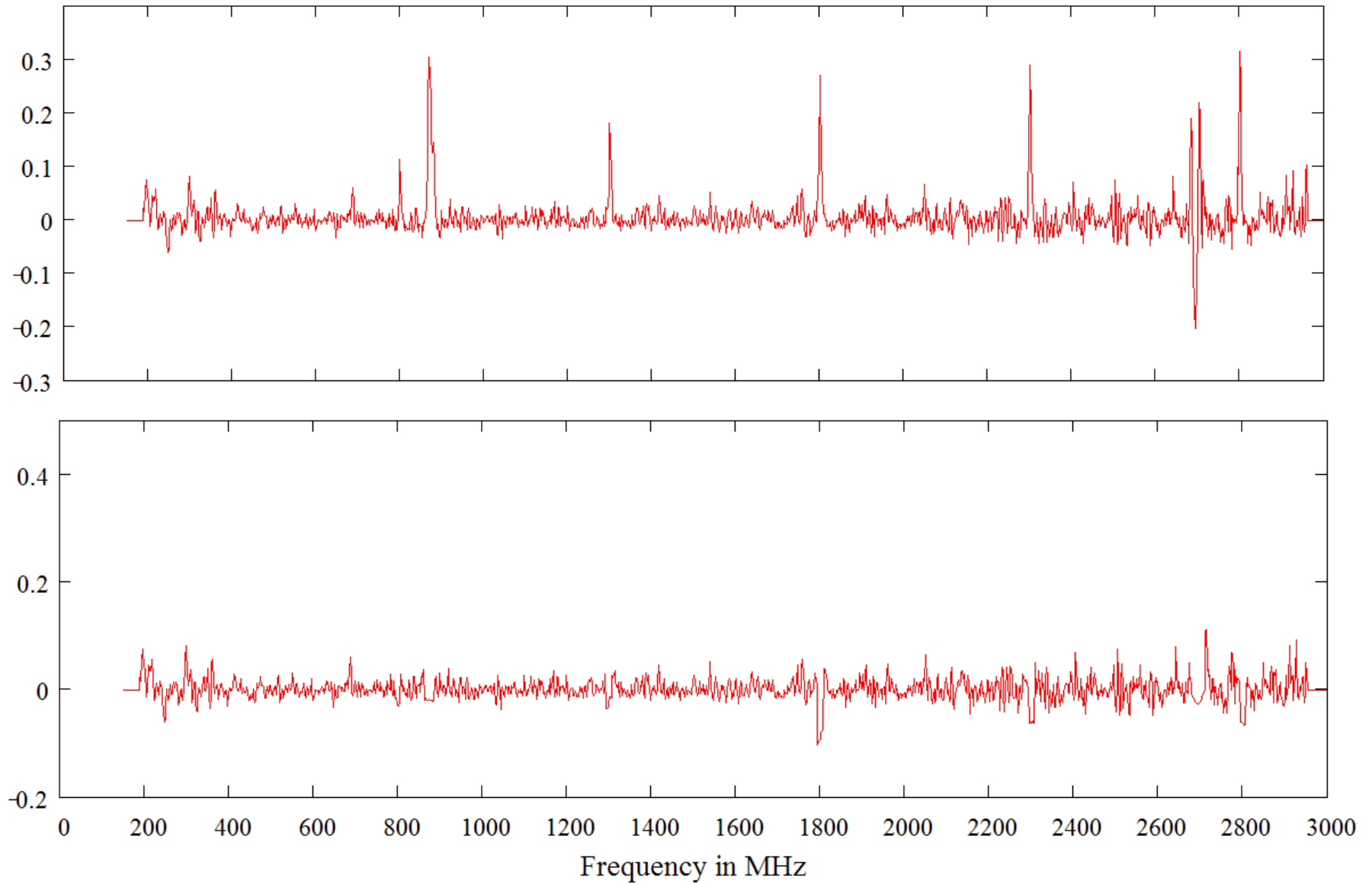
APE System (Single Antenna)



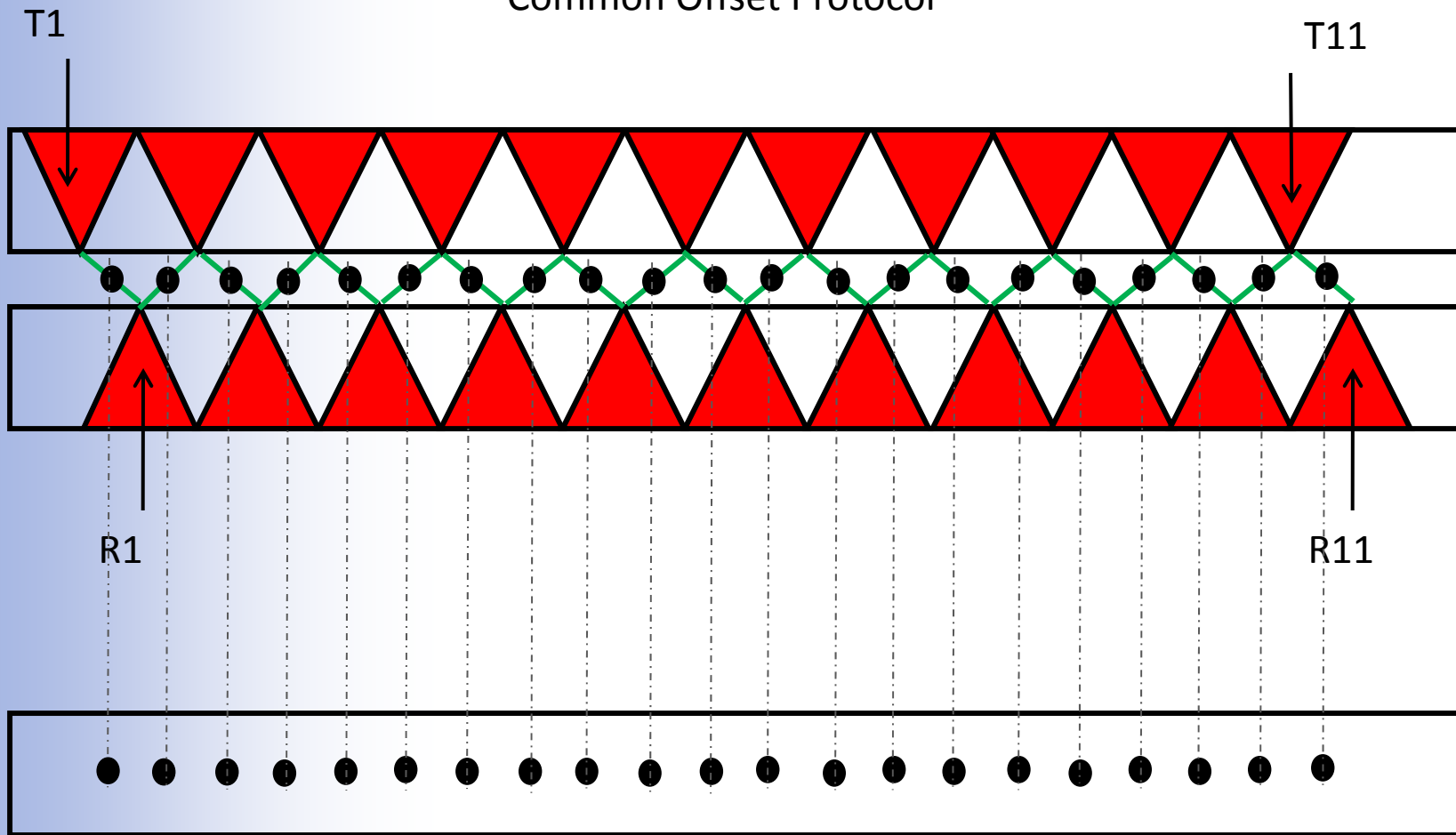
1 GHz GSSI



# External interference



# Common Offset Protocol

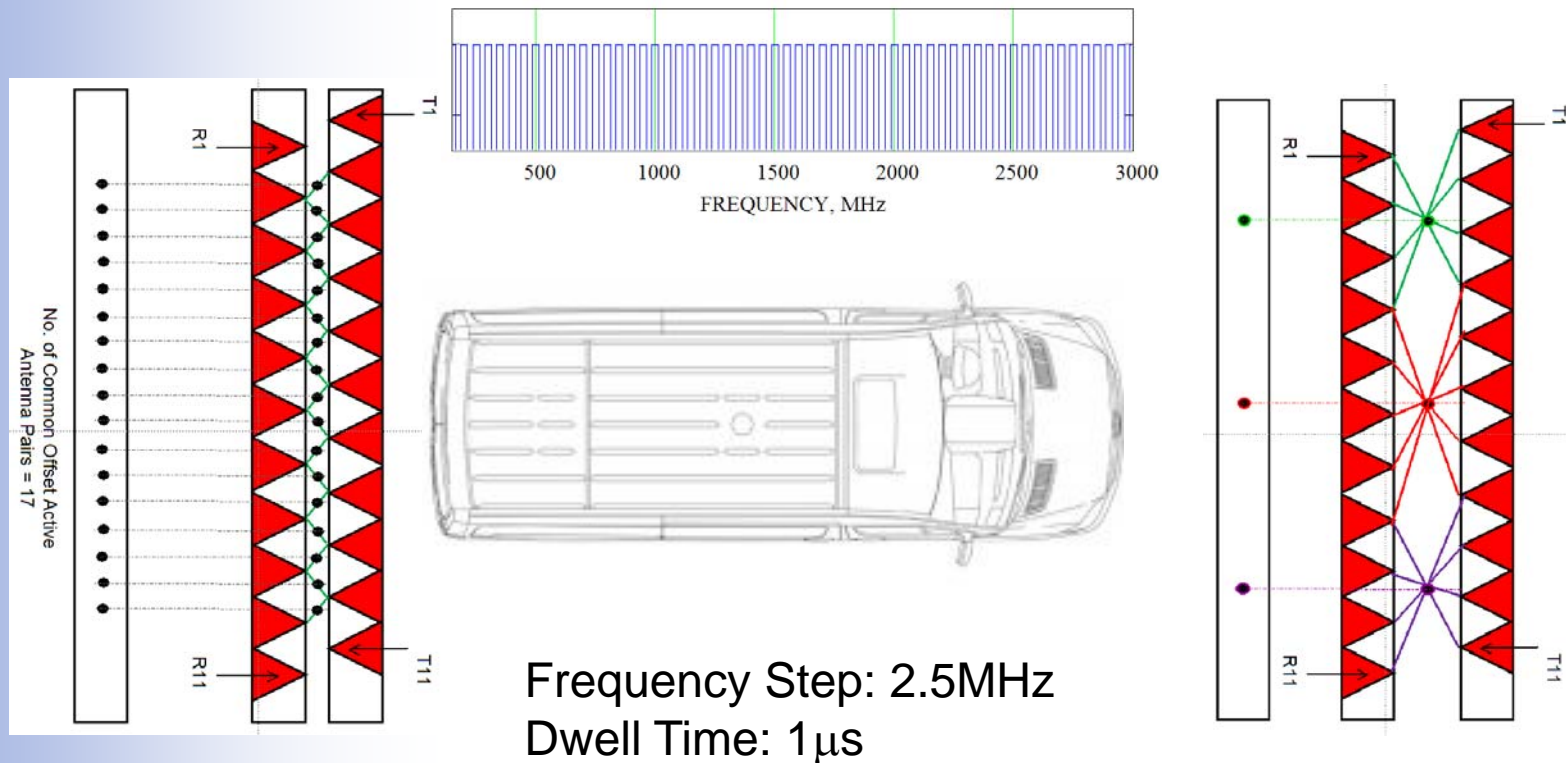


No. of Common Offset Active  
Antenna Pairs = 21

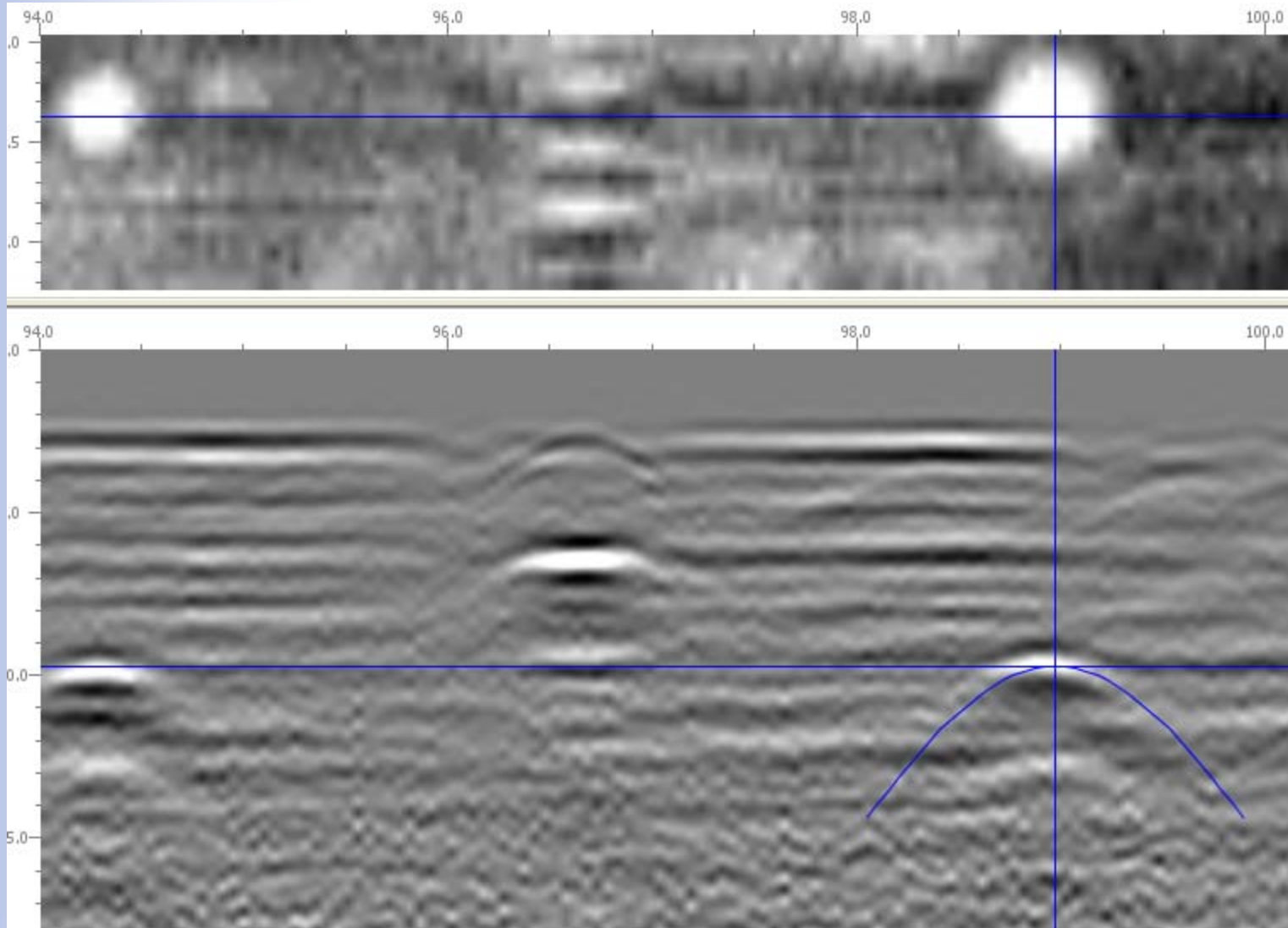


# APE standard testing configuration

Bandwidth: 150 to 3.0 GHz

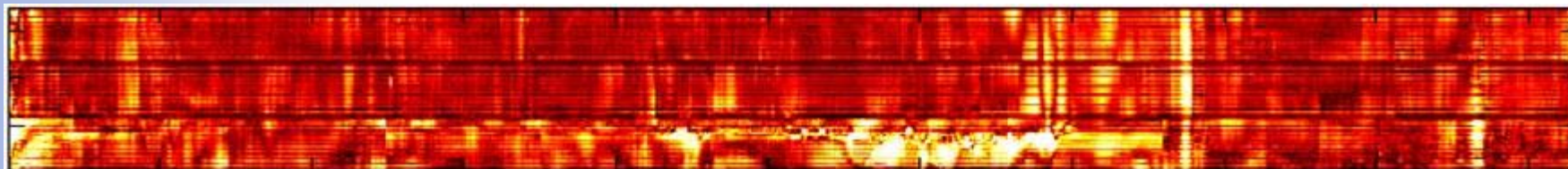


# MIT Scan T2 targets





# Voids under composite pavement



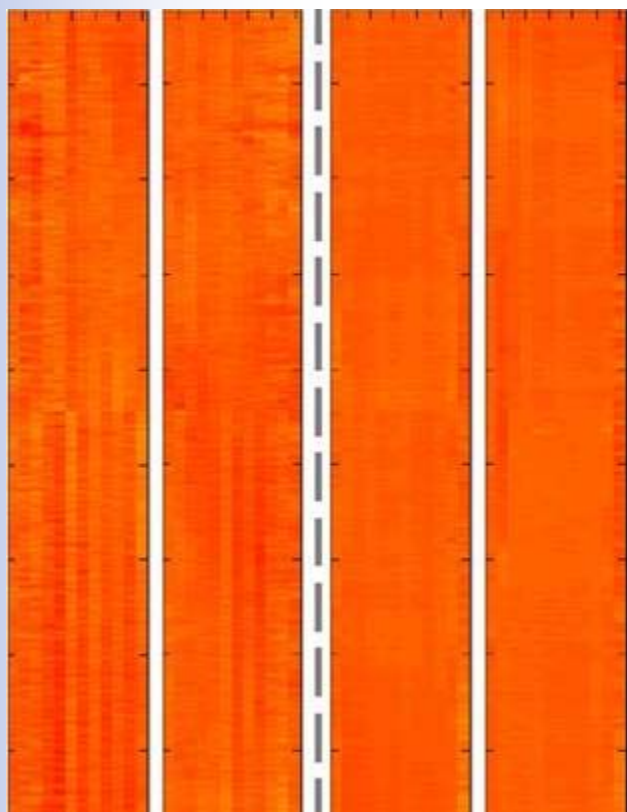
↑  
135+40

↑  
144+00

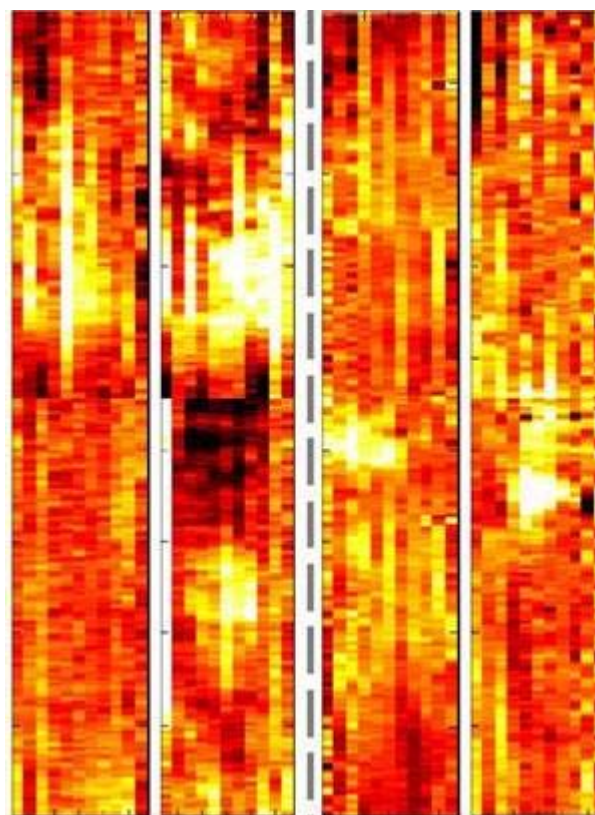




# SF-GPR – scan images



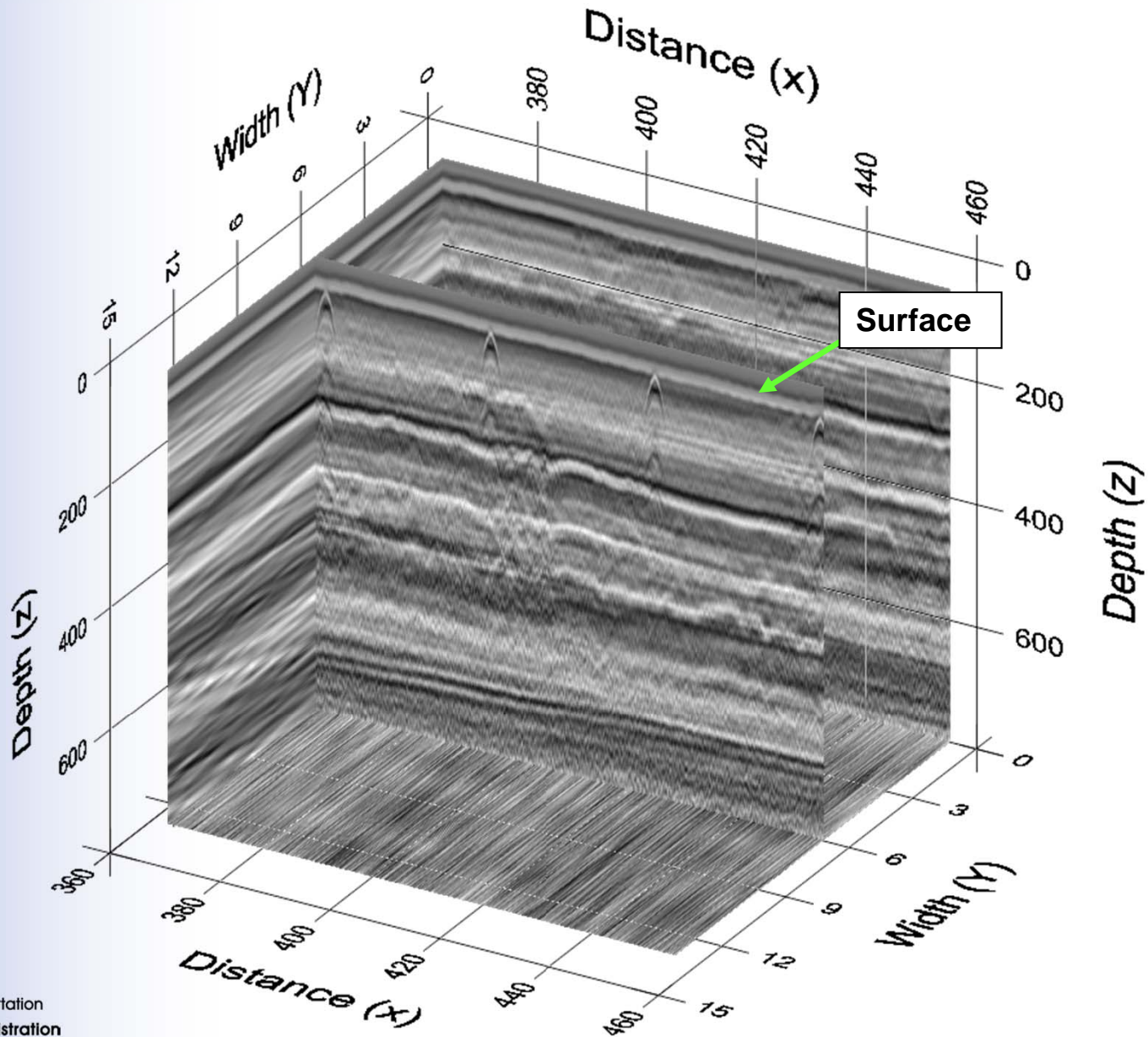
Surface – no distress



Layer interface showing inconsistent condition and presence of water

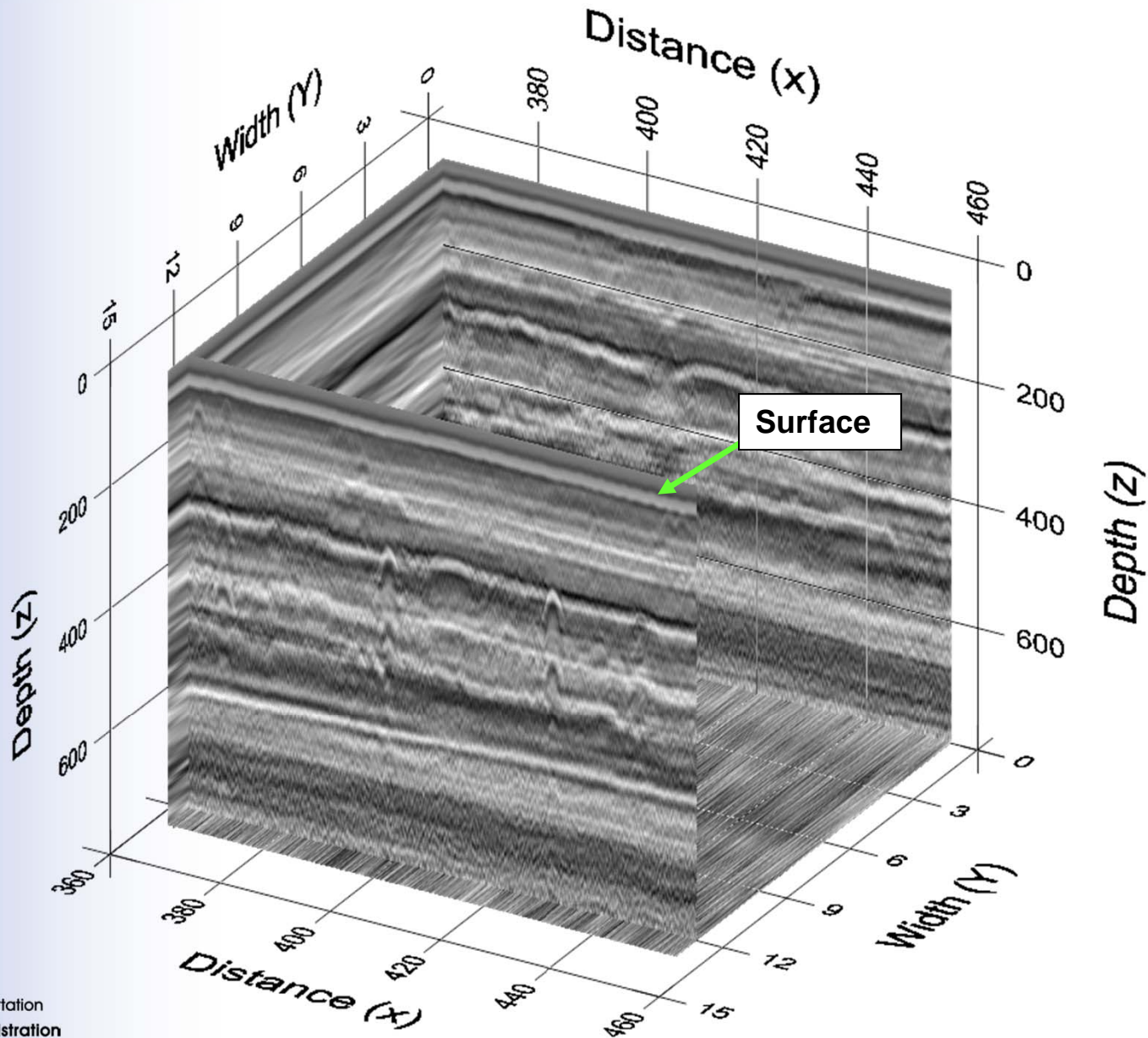


# 3-D Visualization

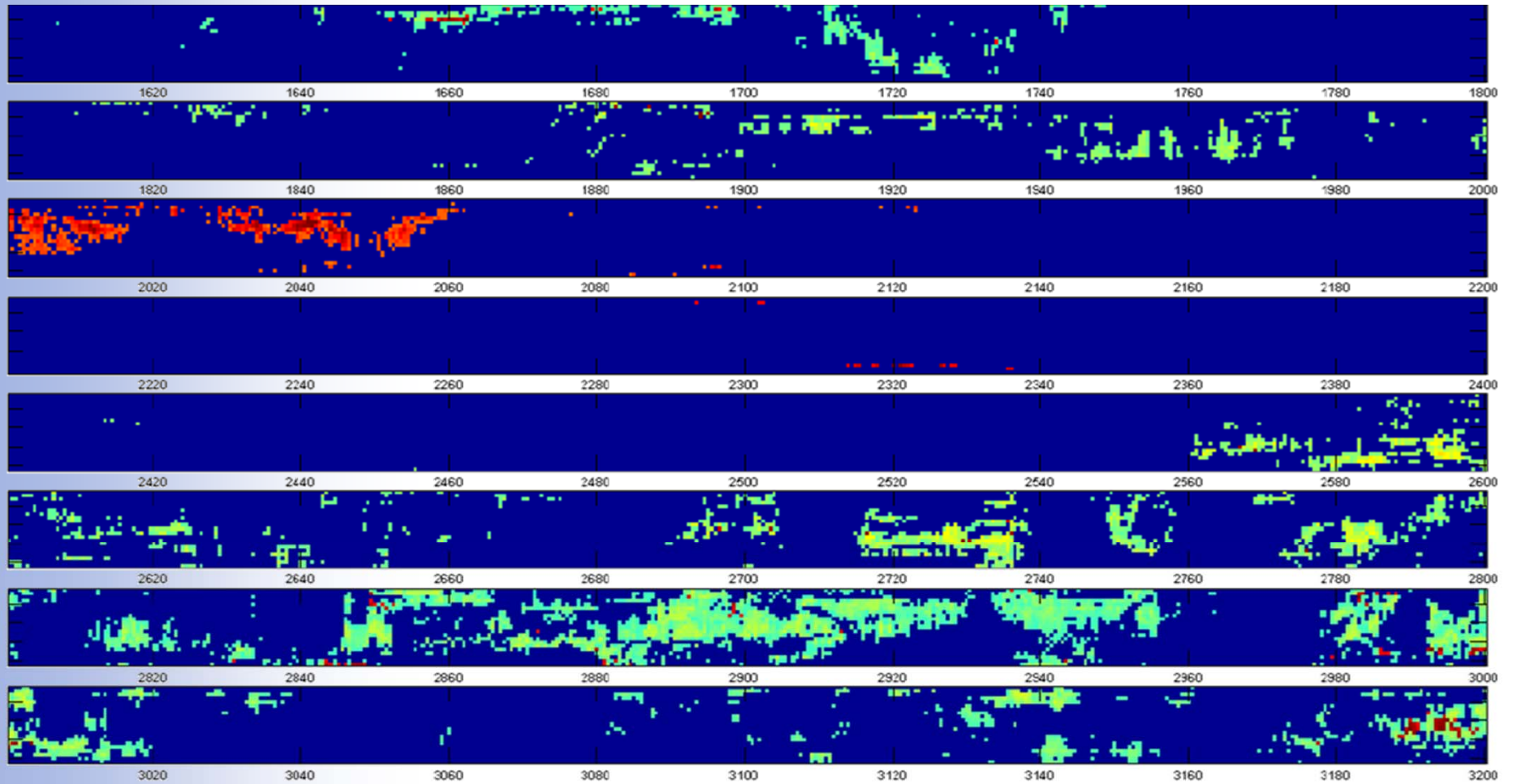




# 3-D Visualization

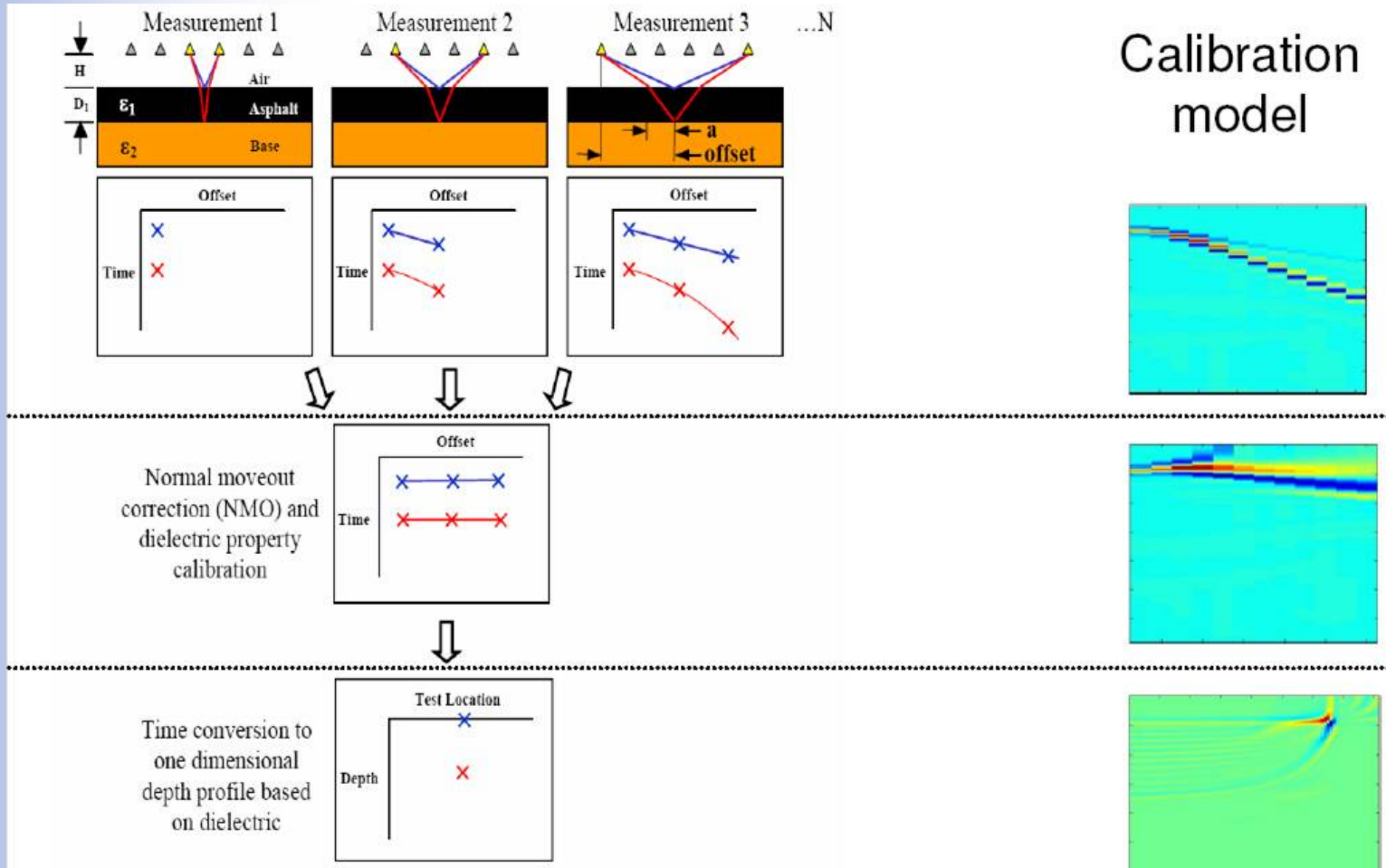


# Feature detection



# Continuous calibration

Continuous calibration by common midpoint (CMP) method without coring

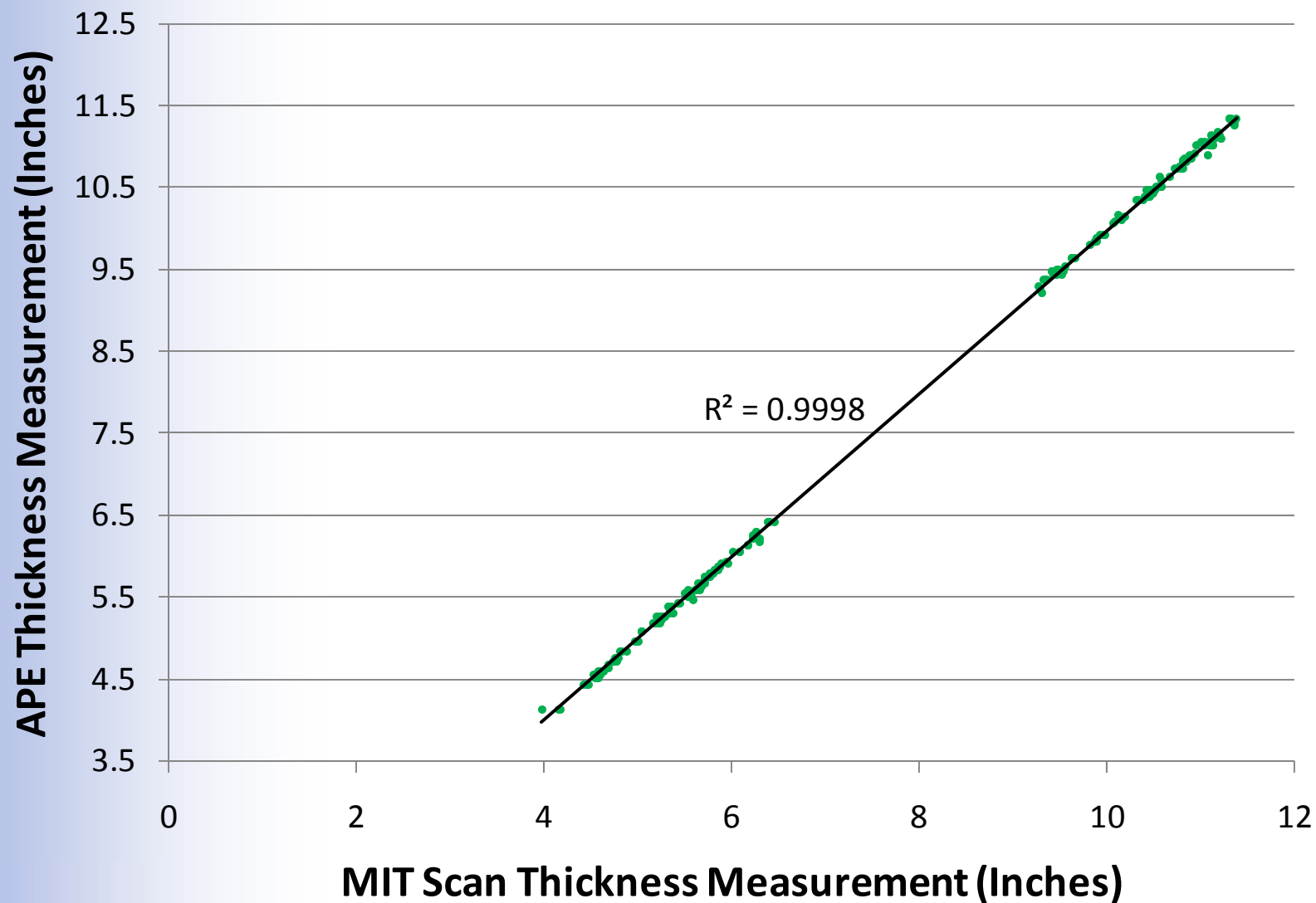




# Validation using MIT Scan-T2



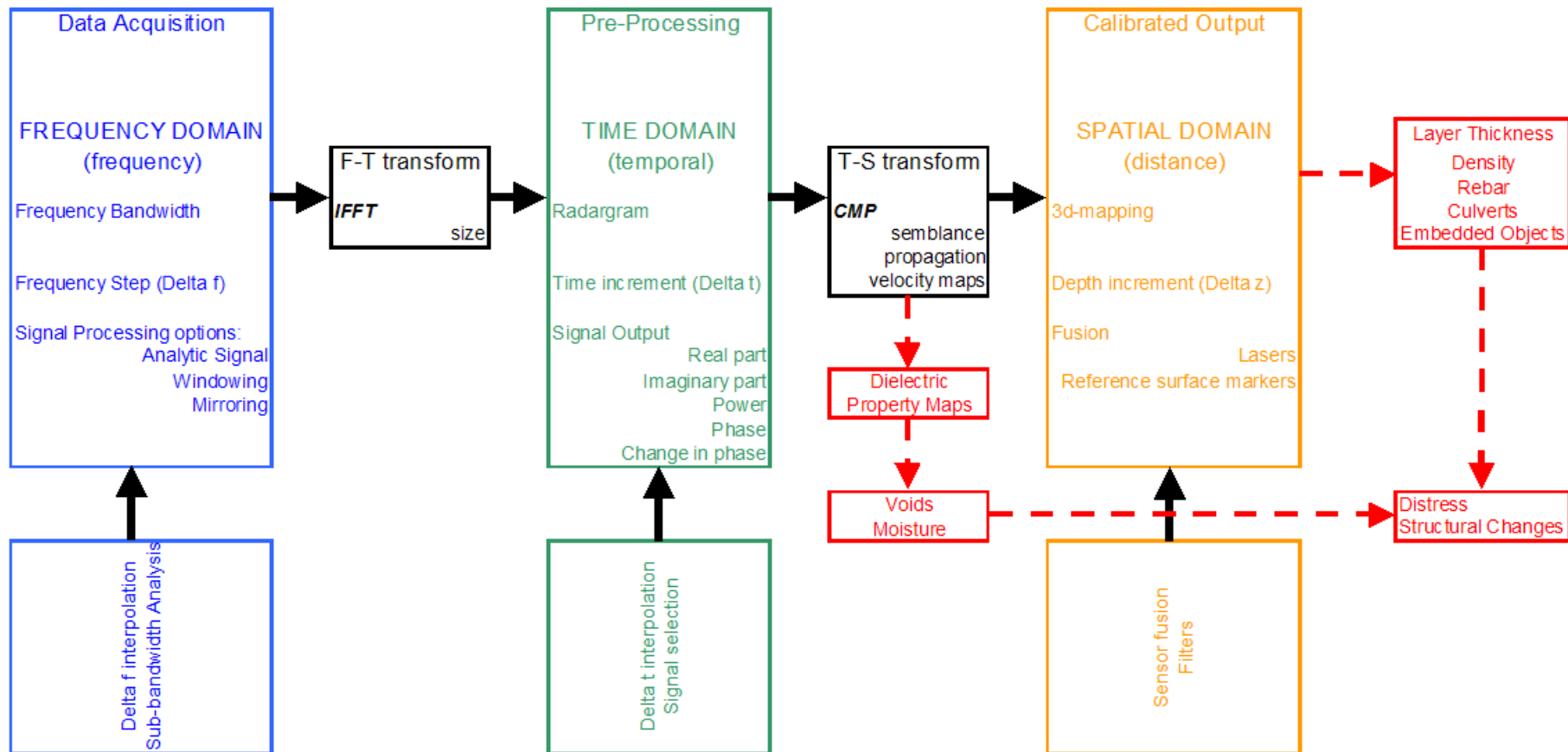
# MIT Scan-T2 thickness vs. SF-GPR



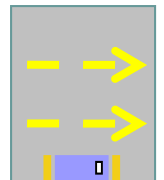
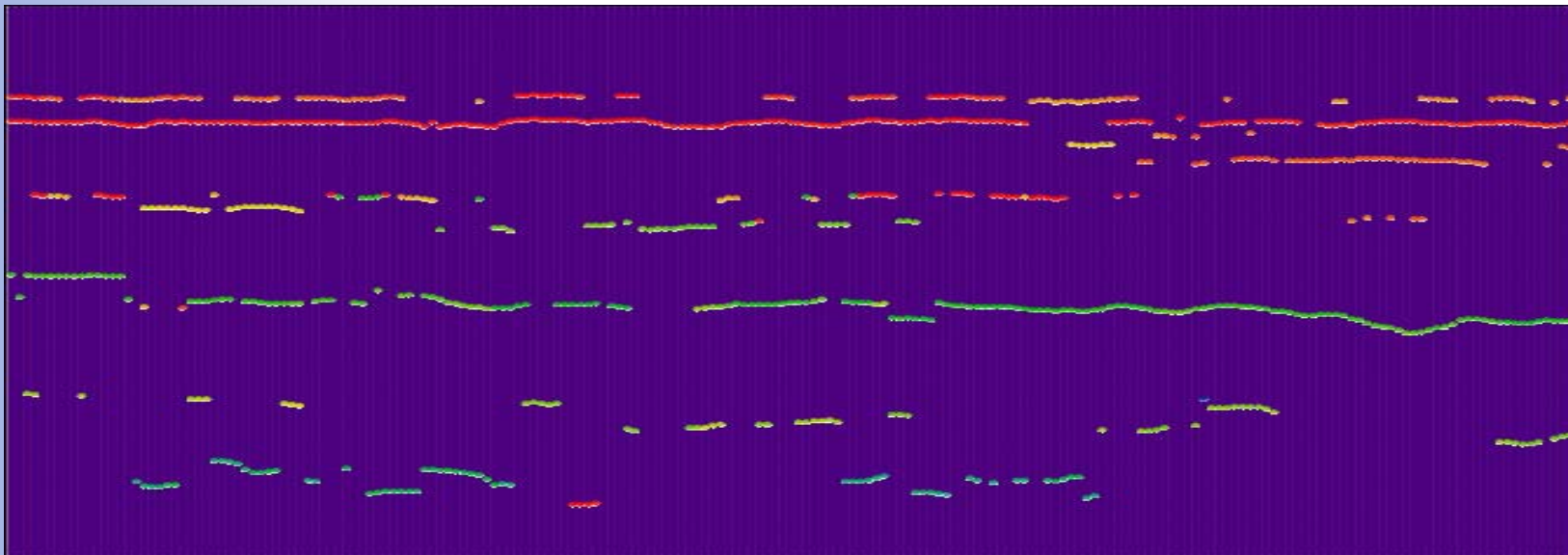
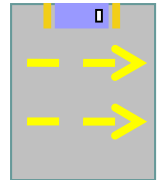
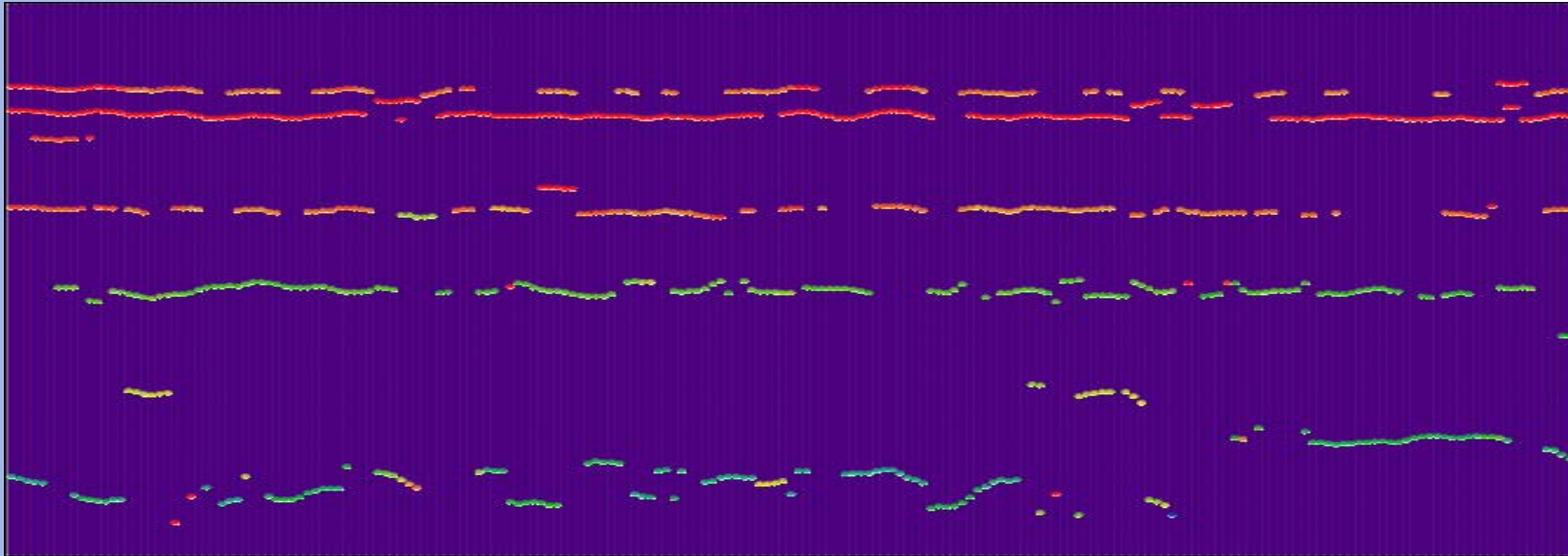


# APE Analysis Domains

**APE System Flow of Computations and Output**



Starting at Segment 2, 200 points (400 feet)

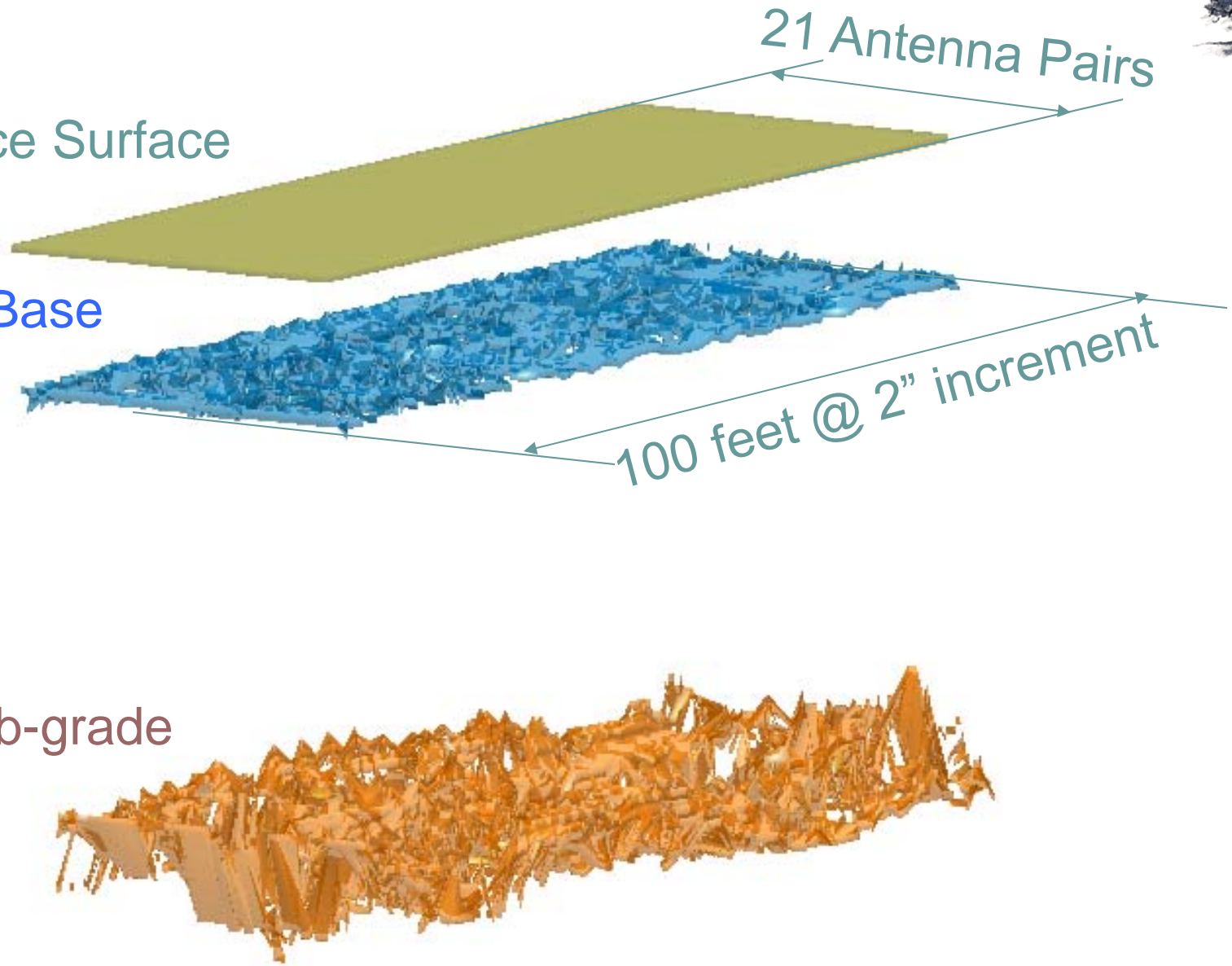




Reference Surface

Asphalt/Base Interface

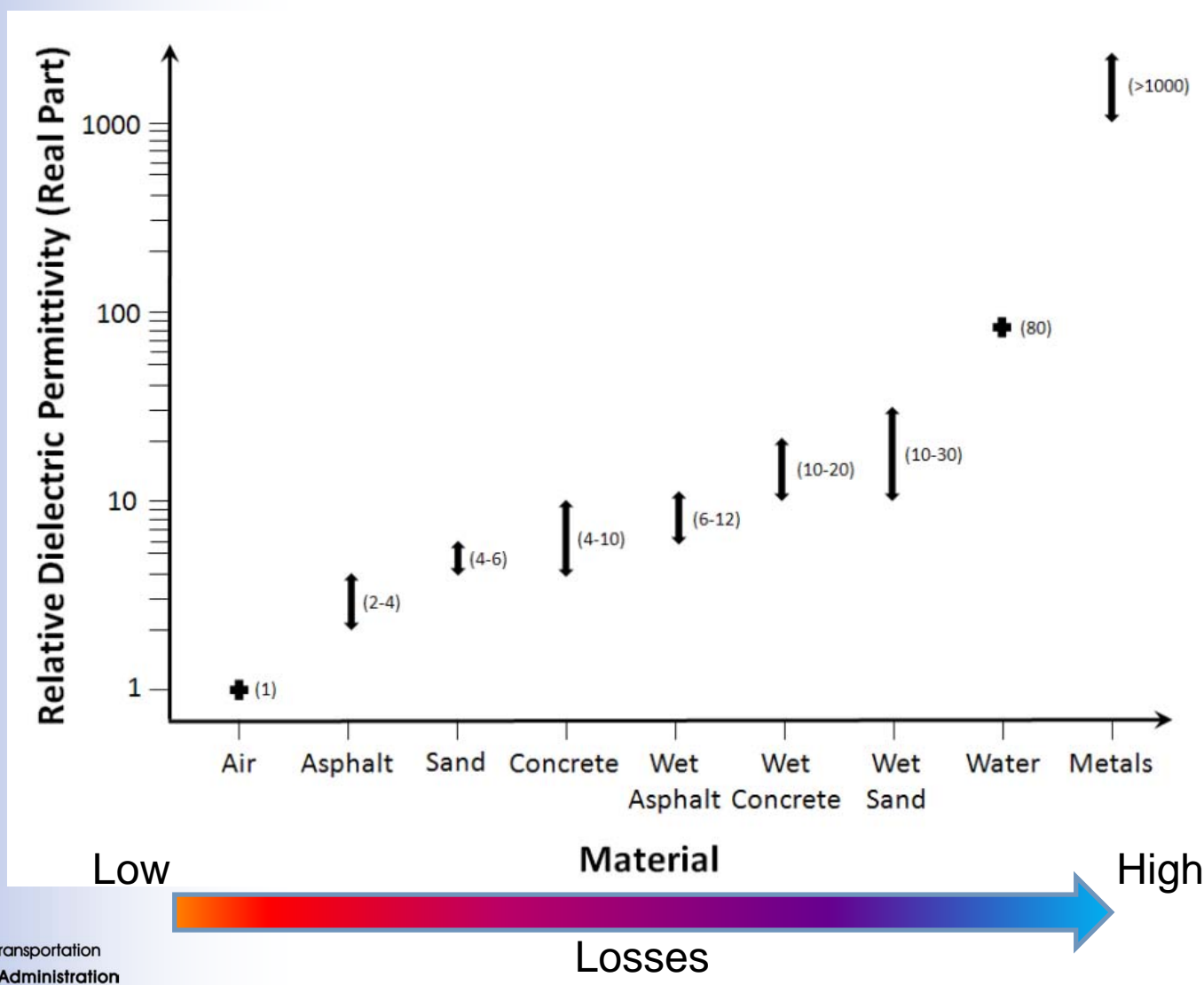
Base/Sub-grade Interface



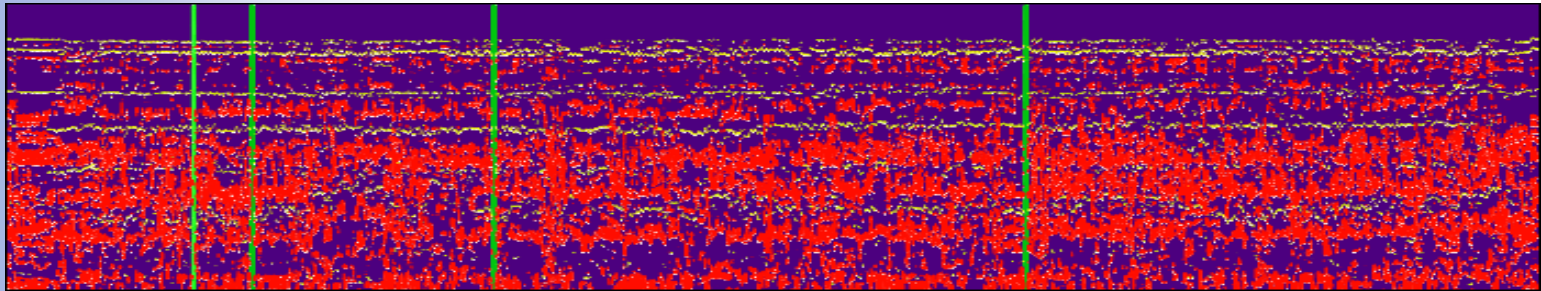
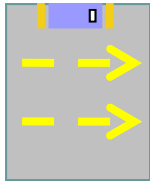




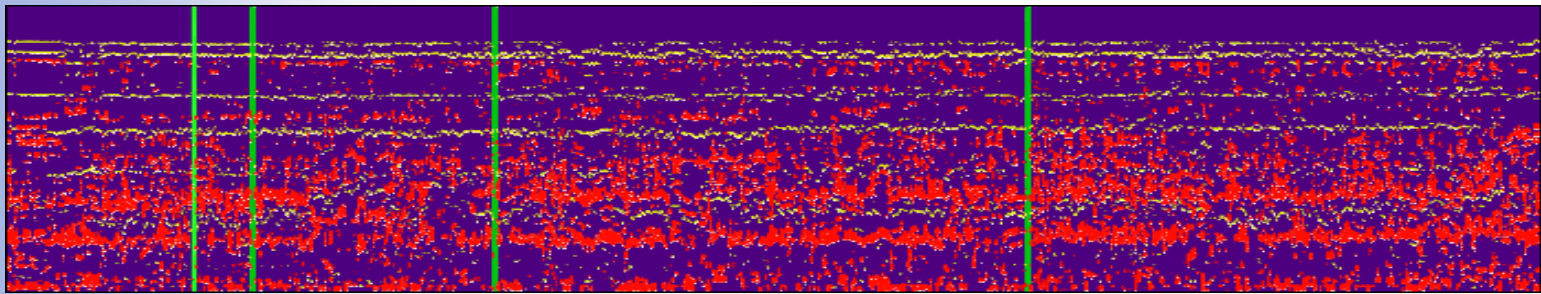
# Relative dielectric permittivity for a selection of materials



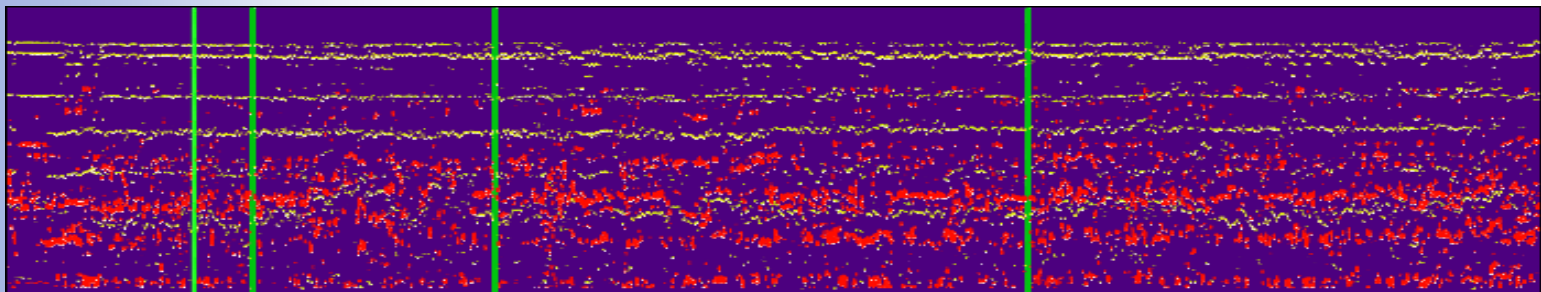
# Relative Dielectric Permittivity Threshold Comparison: Left Lane, Left Position



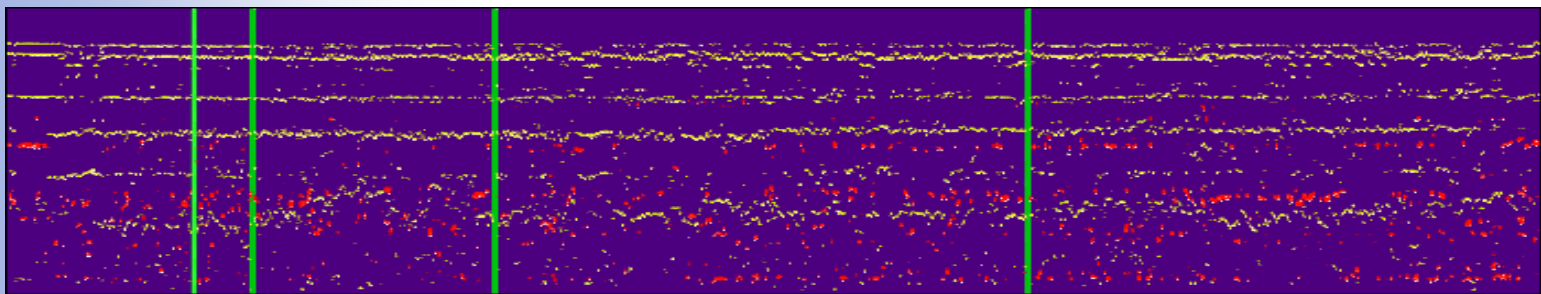
5



10

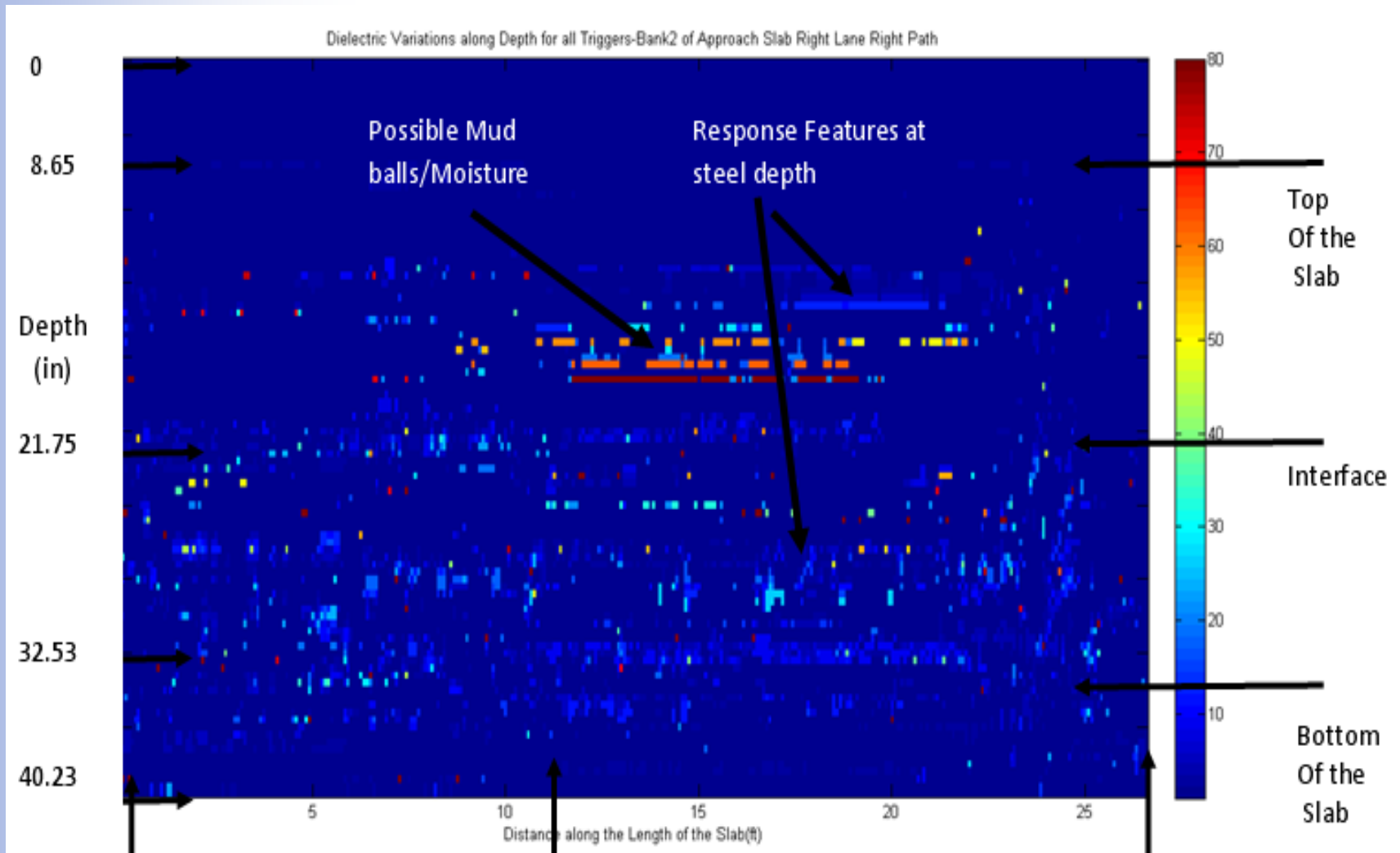


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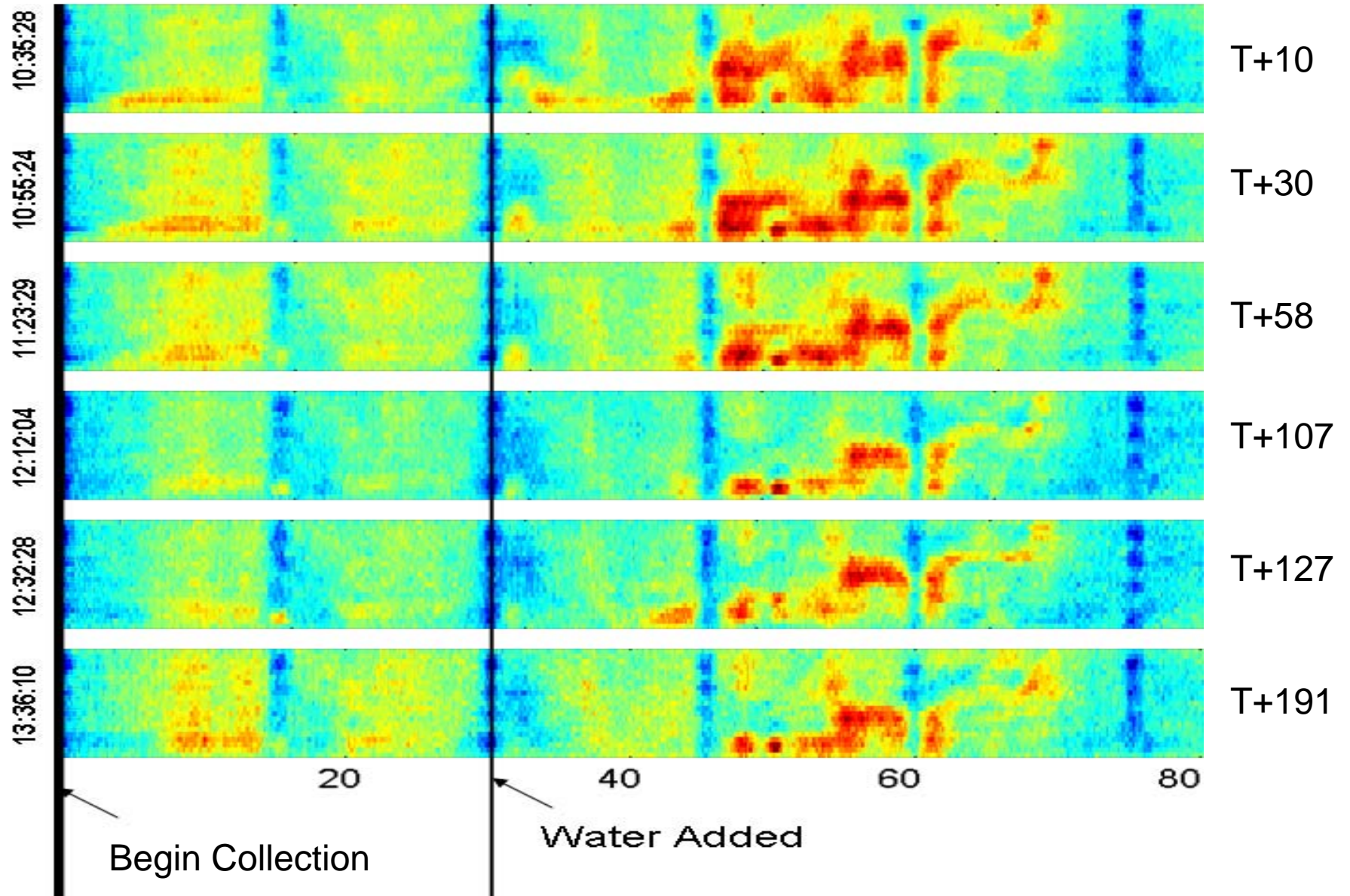


30

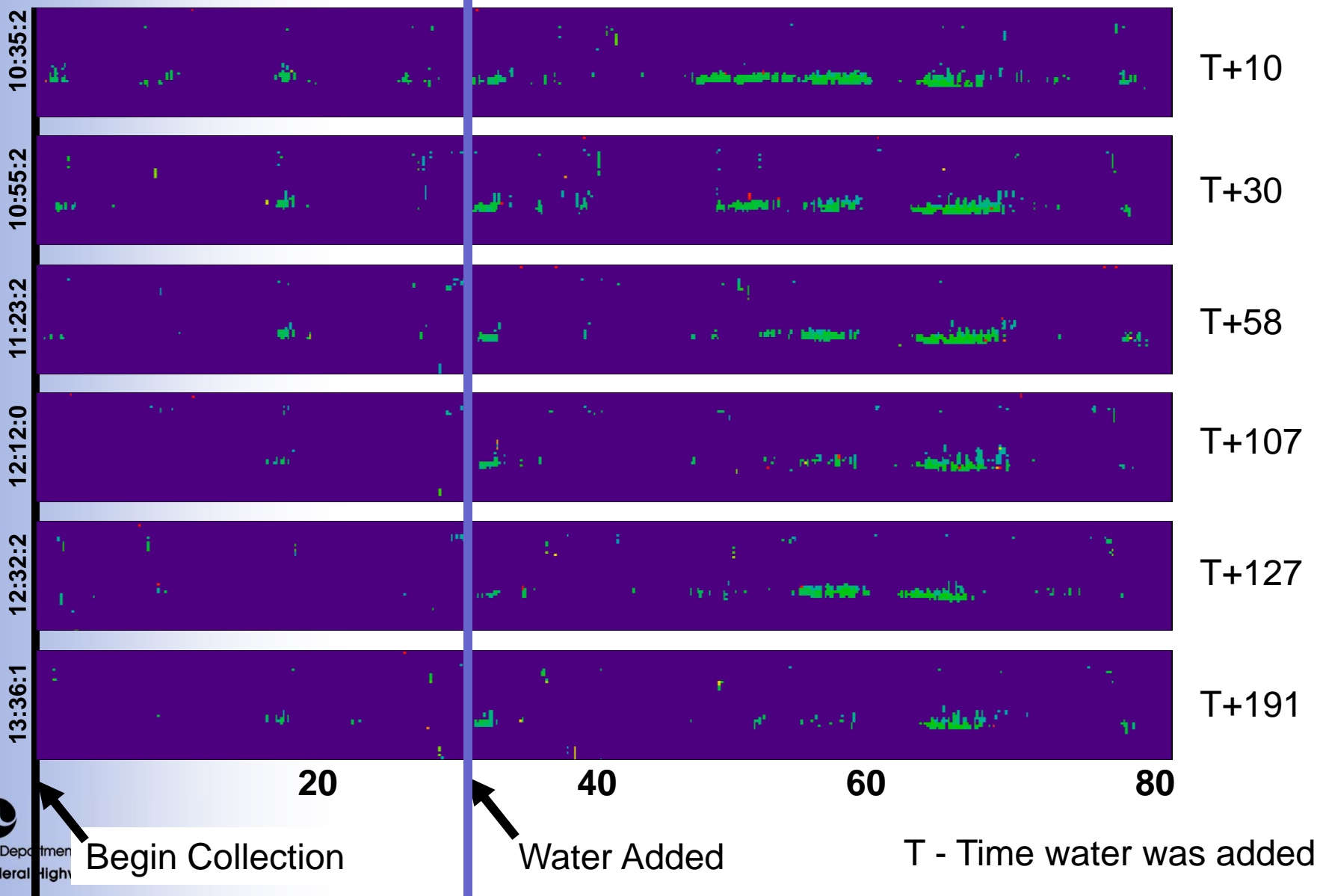
# Mud balls in PCC



# Frequency -196



# D.4.2 Flow of Water, Center



# SF-GPR Status

- Several applications are ready for pilot implementation
  - Surface layer thickness for construction QA
  - Pavement structure survey
  - Feature detection
  - Material property variations
- FHWA plans for FY12
  - Upgrade to GeoScope™ Mark IV
  - Enhance data analysis and visualization tools
  - Conduct demonstrations



# Questions?

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202-366-1198



U.S. Department of Transportation  
Federal Highway Administration