Guided Wave Testing for Inspection of Unpiggable Pipelines

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Industry Needs

- Methods of examination of unpiggable lines and areas which are hard to access,
- Techniques which have a demonstrated and predictable level of test coverage,
- Techniques which are sensitive to defects of types and sizes of relevance to operators,
- Demonstrated performance for defect detection and freedom from false calls.
- Ease of operation by appropriately qualified personnel

Guided waves offer:-

- Reduction in the costs of gaining access to the pipes for inspection,
- Avoidance of removal and reinstatement of insulation or coatings,
- The ability to inspect inaccessible areas, such as at clamps and cased or buried pipes,
- The whole pipe wall is tested, thereby achieving a 100% examination,
- Cost - effective screening of pipes to optimise follow up activity.

FBS Collaboration with Pi/TWI (7 years)

- Frequency Tuning
- Focusing Theory

- Teletest
- Axisymmetric Inspection

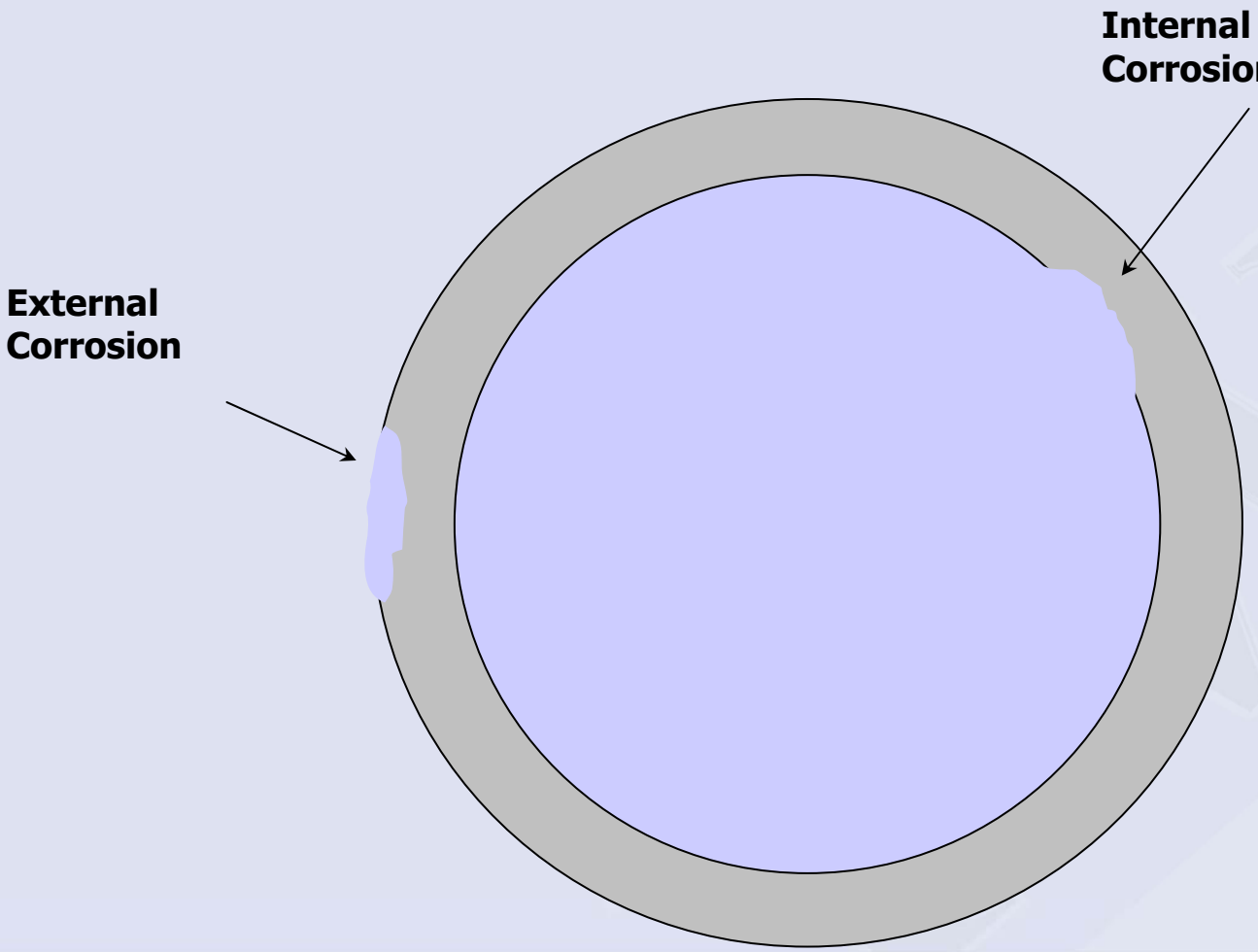
On going collaborative activities:

- Focusing in and around elbows
- Improved circumferential sizing and location
- Enhanced performance in coated pipes
- FBS is an authorized sales rep for Teletest Focus

Project Objectives

- To further develop and to validate guided wave inspection techniques for detection of internal and external defects in unpiggable pipelines.
- Specifically:-
  - Production of field validated procedures,
  - Inclusion of enhanced procedures for detection and evaluation of defects,
  - Assessment of coated and buried pipelines,
  - Validation data to demonstrate performance,
  - Guidance for industrial application of techniques.

The method is sensitive to the defect area which interacts with the advancing wave



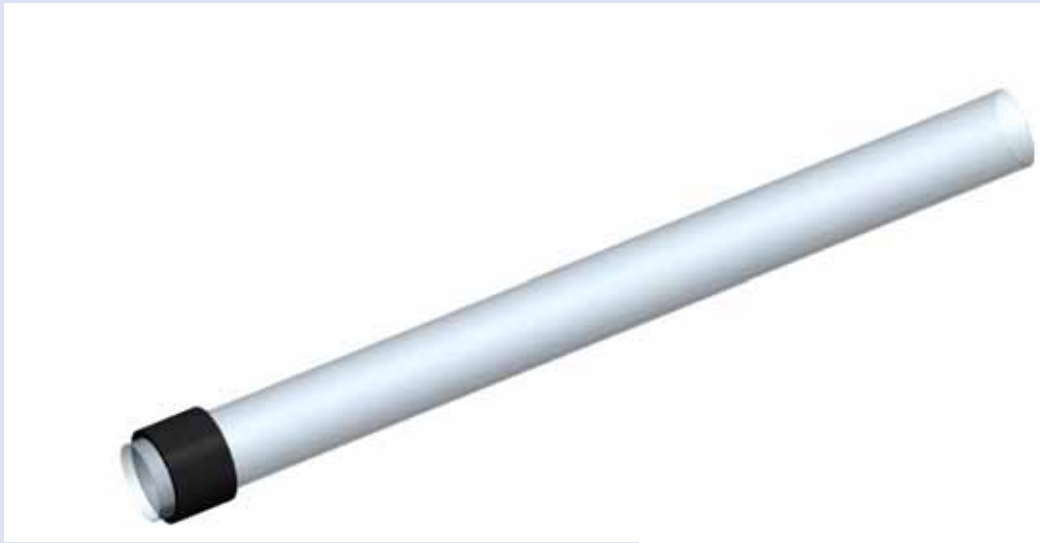
Findings from TWI/FBS/NGA Study

- Use of 2 wave modes (L & T) increases probability of detection (PoD) by “Redundancy and Diversity”. (Use of two independent tests each with a PoD of 80% gives a combined PoD of 98.4%),
- Each mode has a different sensitivity to particular types of defects,
- Mode conversions from a defect can be a combination of longitudinal and torsional modes despite only one mode being transmitted,

Findings - continued

- Focusing of ultrasound improves signal to noise ratio (reduces false calls) and decreases the defect size limit for detection by a factor of 4,
- Focusing the ultrasound increases the penetrating power (increases the test range) in the presence of coatings

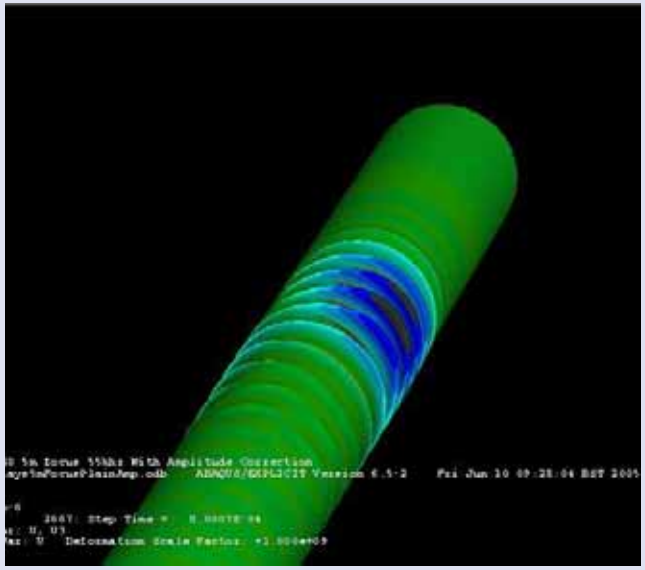
Focusing of ultrasound

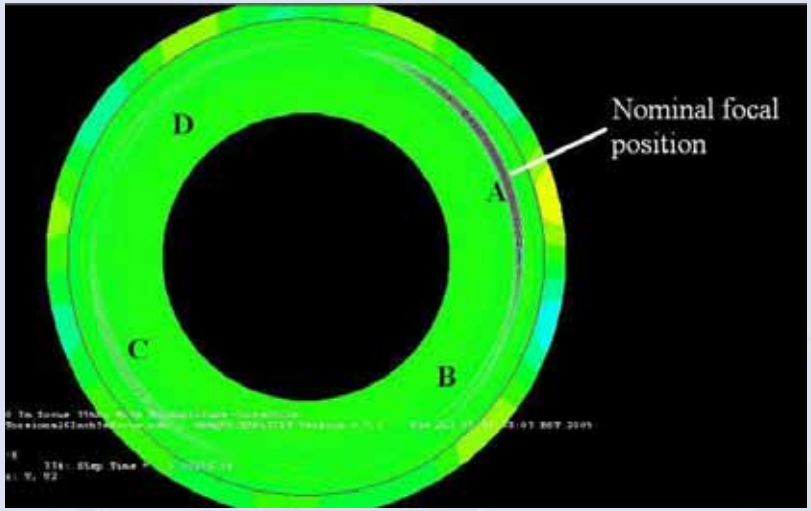


Axi-symmetric test

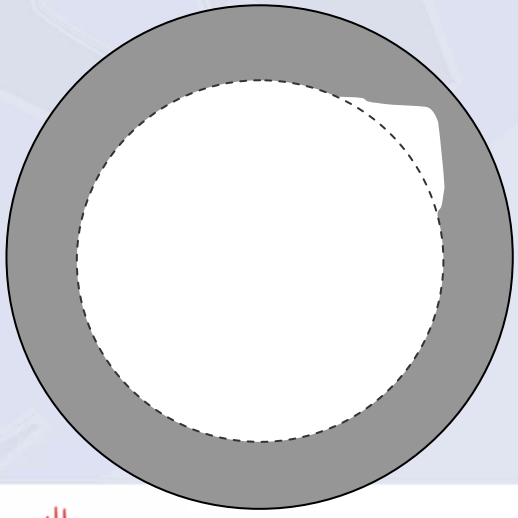
Focused scan

Benefits of focusing

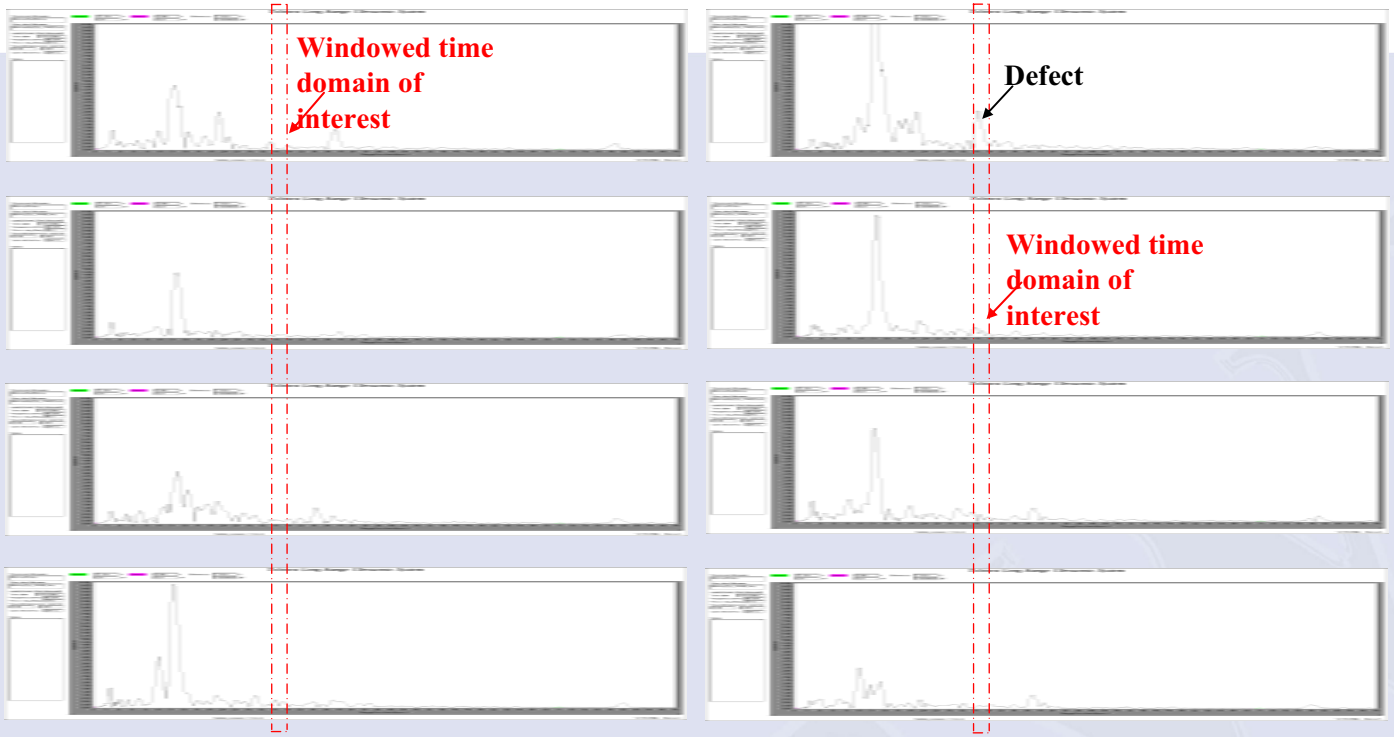




Focusing allows the energy to be concentrated where the defect is, increasing sensitivity and giving position and size information



Increased detection by focusing



The 40 kHz L [m, 2] mode group focused at z= 32.8 ft.

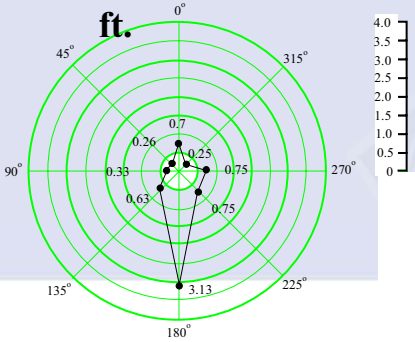
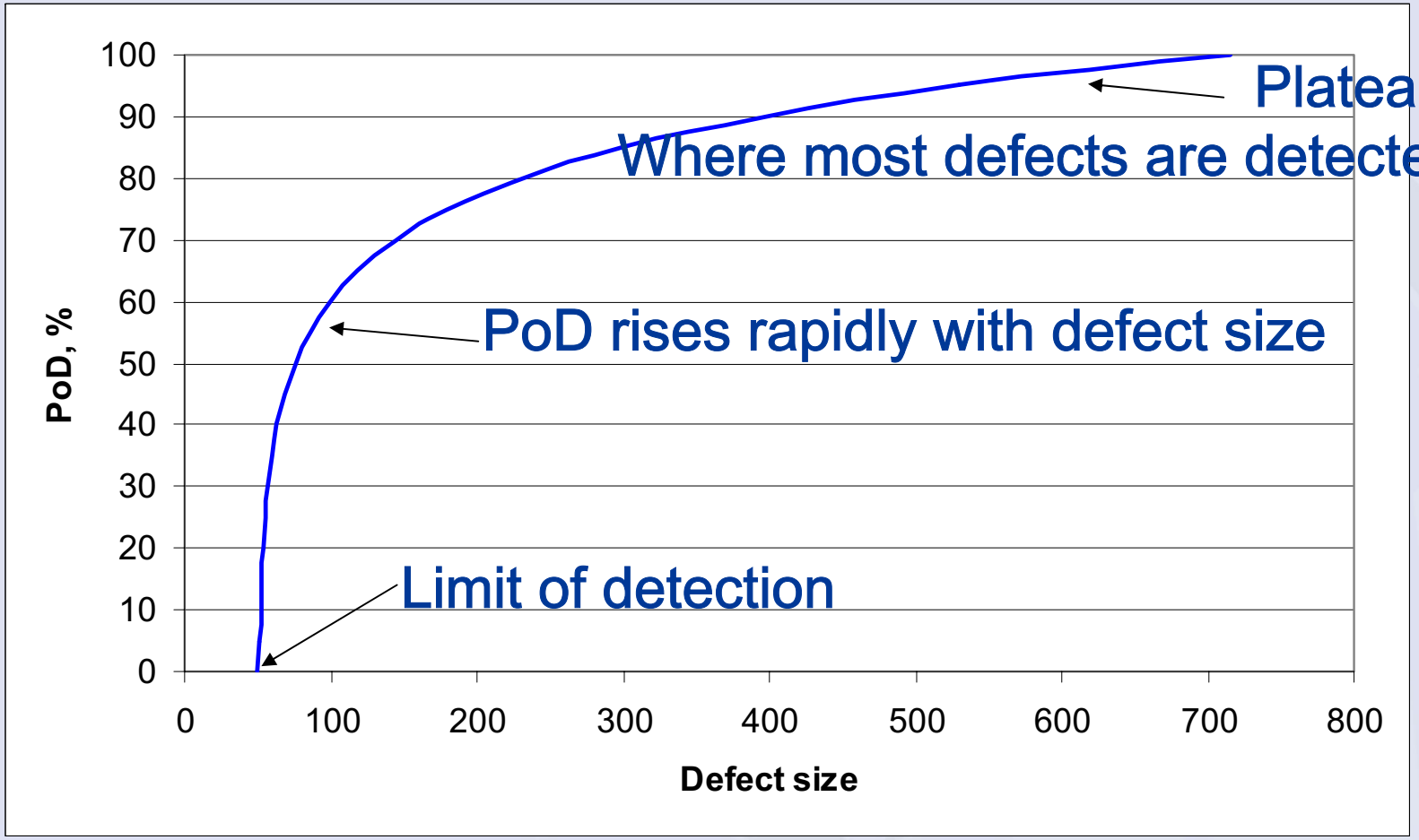


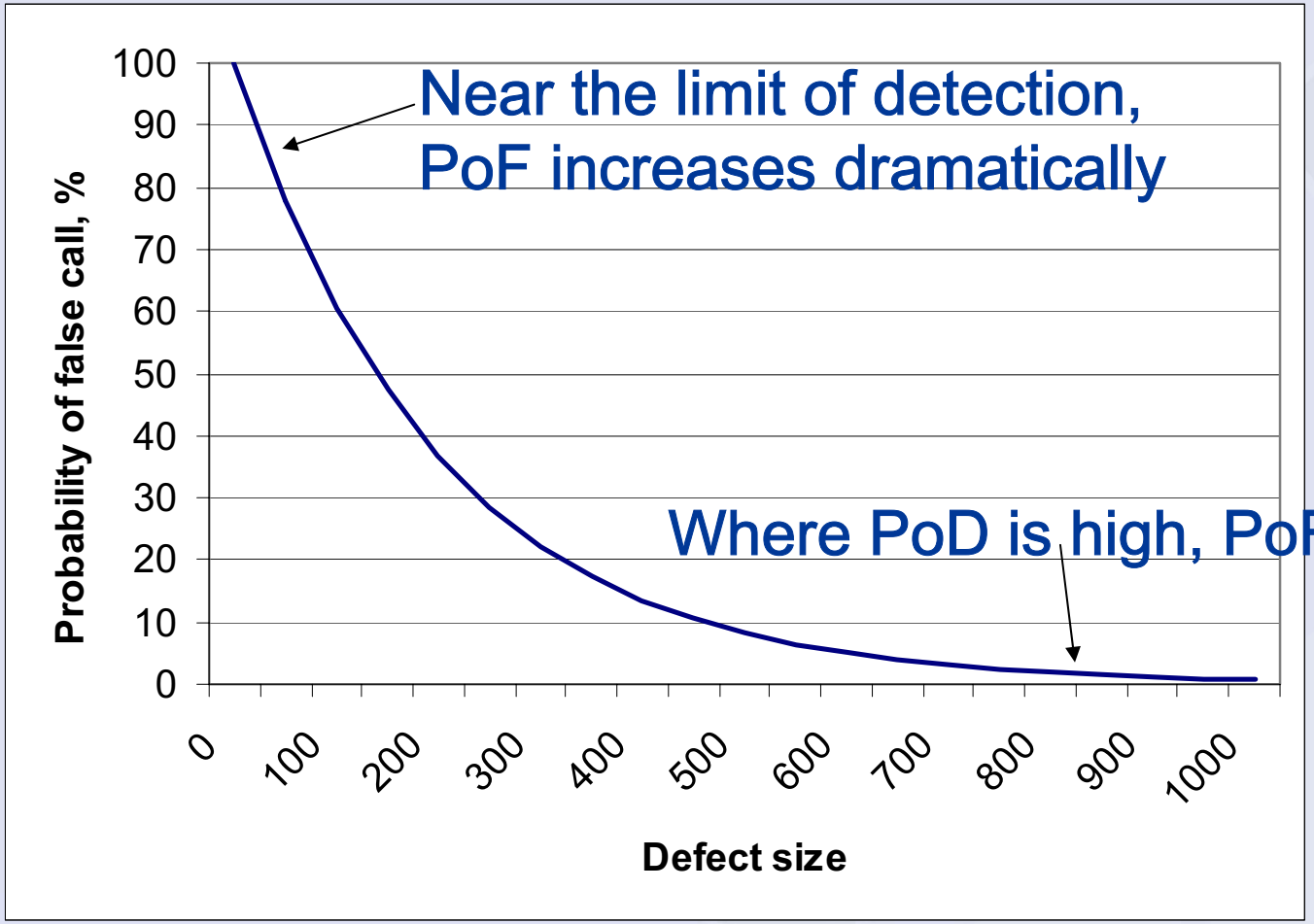
Figure A4-5.

Sample circumferential octant profiles showing a defect at about 180º. [16" coated pipe at Johnson City NY]

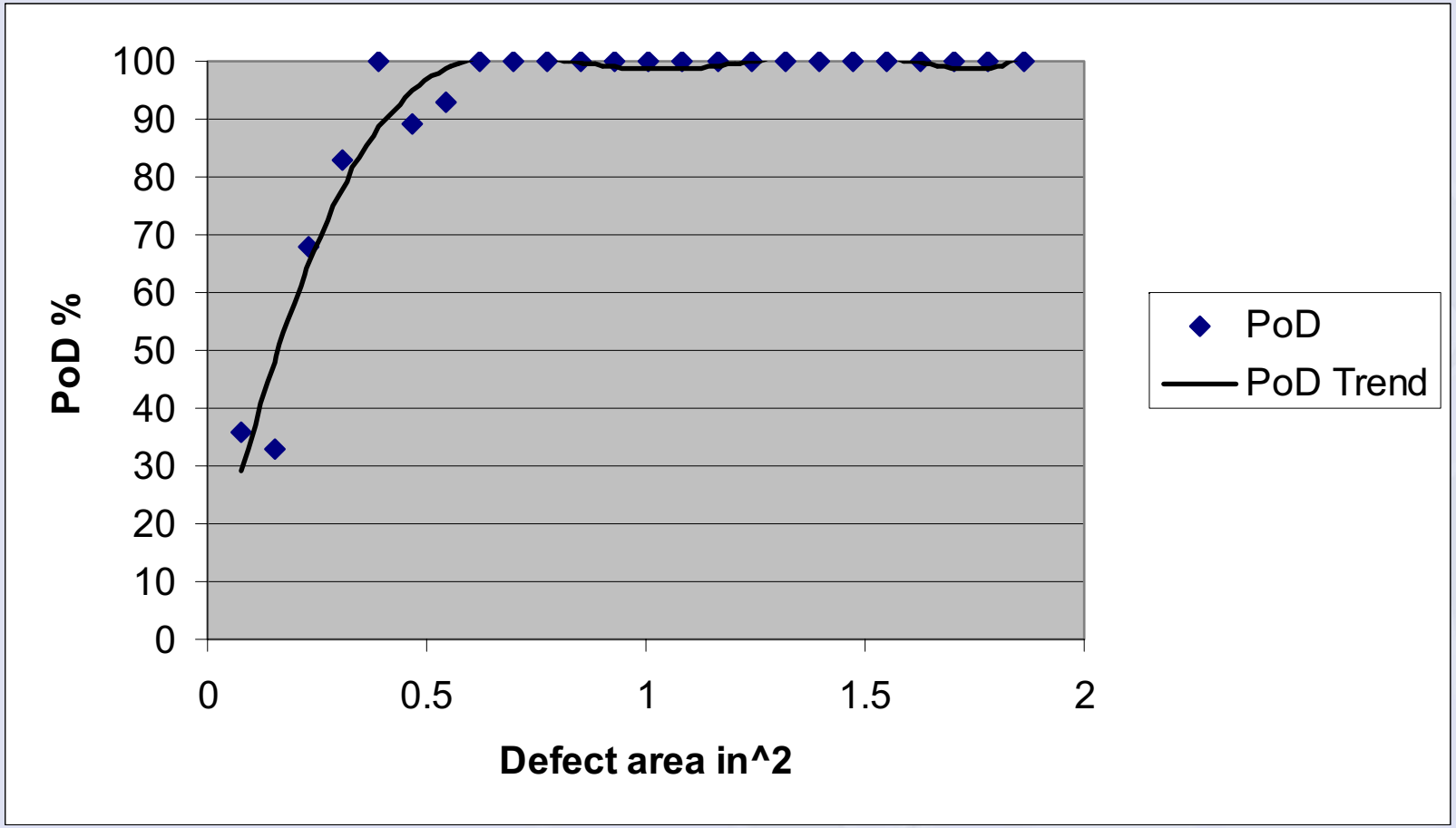
Probability of Detection (PoD) Characteristics



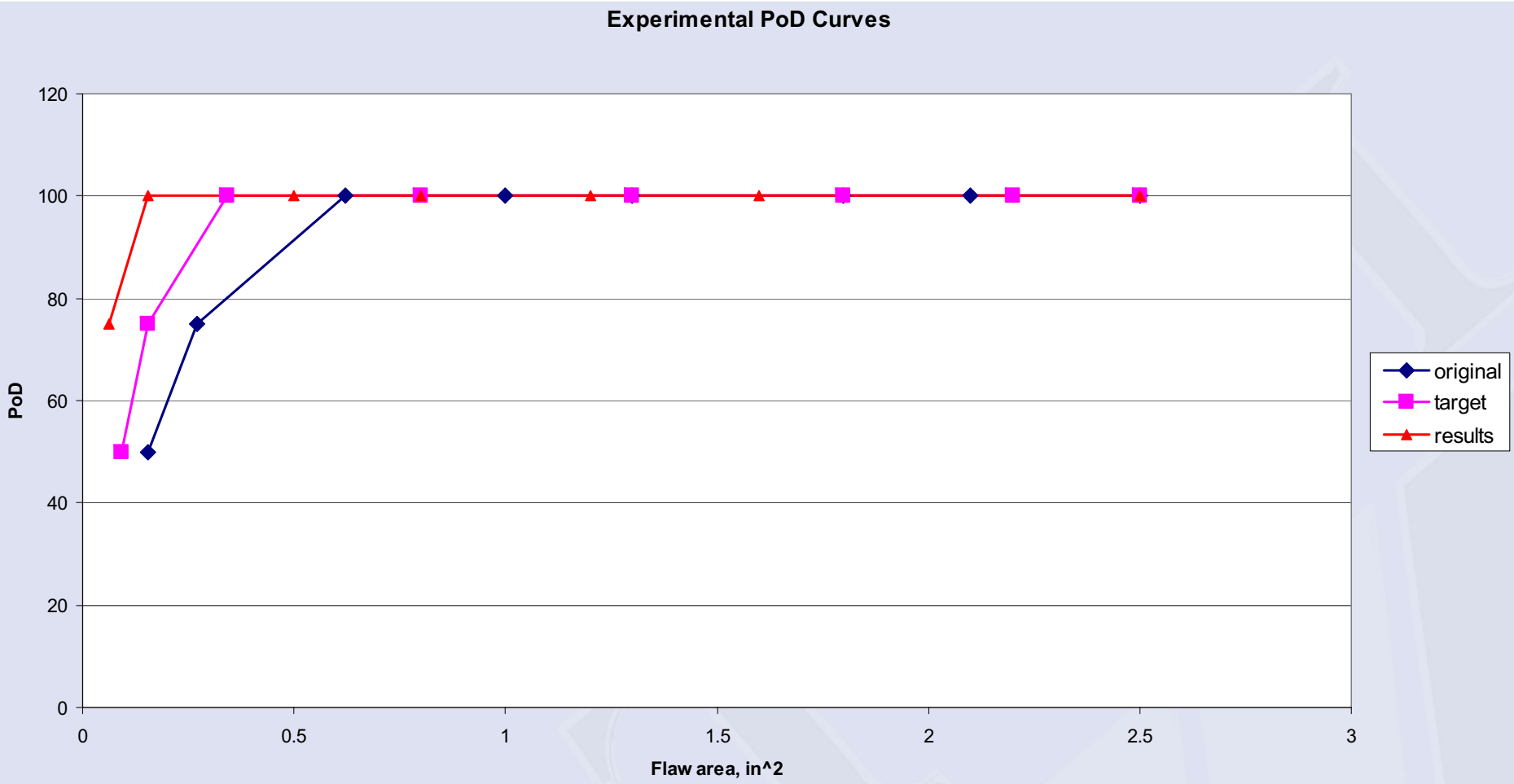
Probability of a false call (PoF)



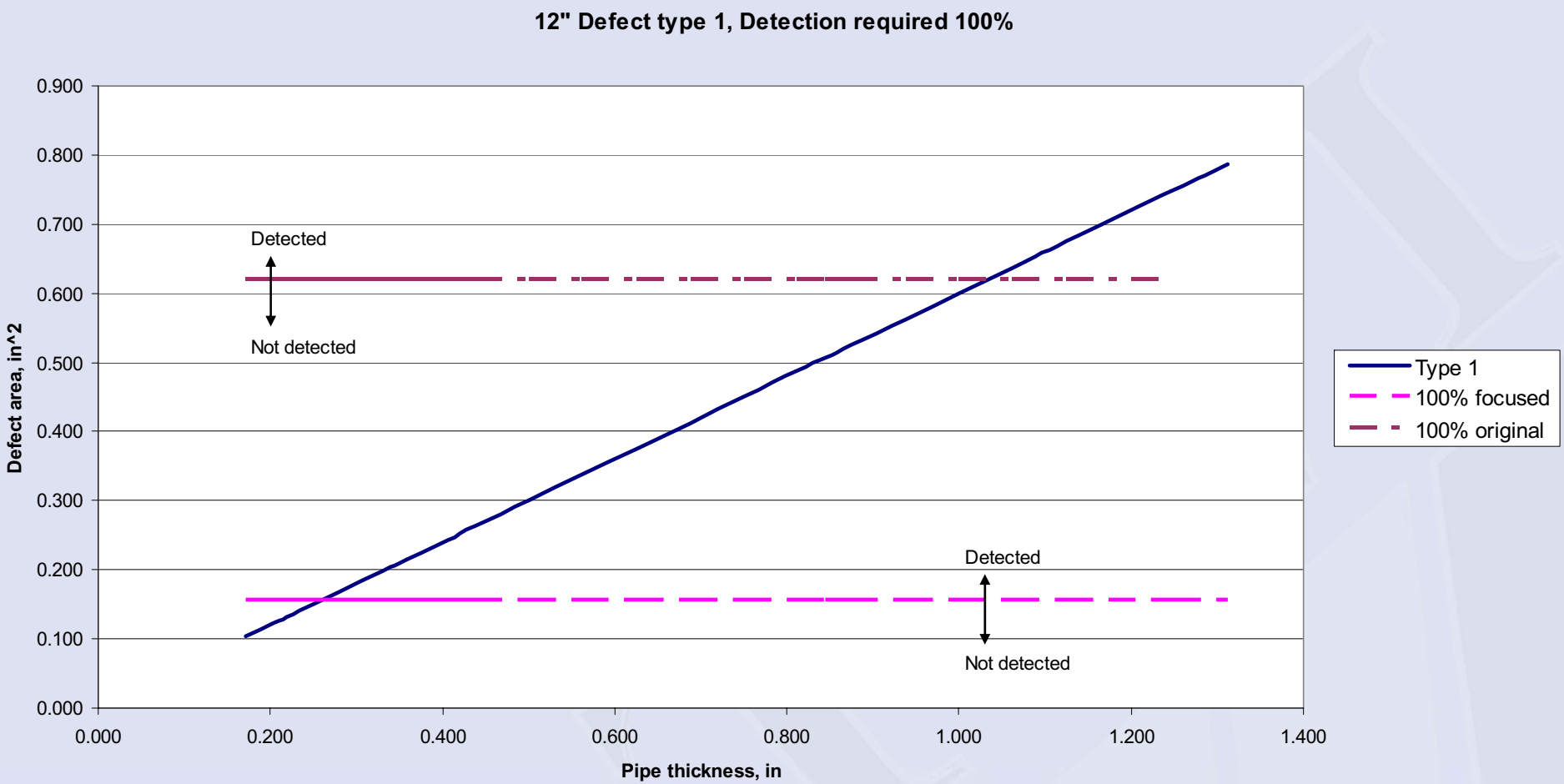
Experimental PoD for Guided Waves



Focused results from lab tests



Effect of focusing, 12” type 1 defect



Cased pipes, NYSEARCH Facility

Detection summary

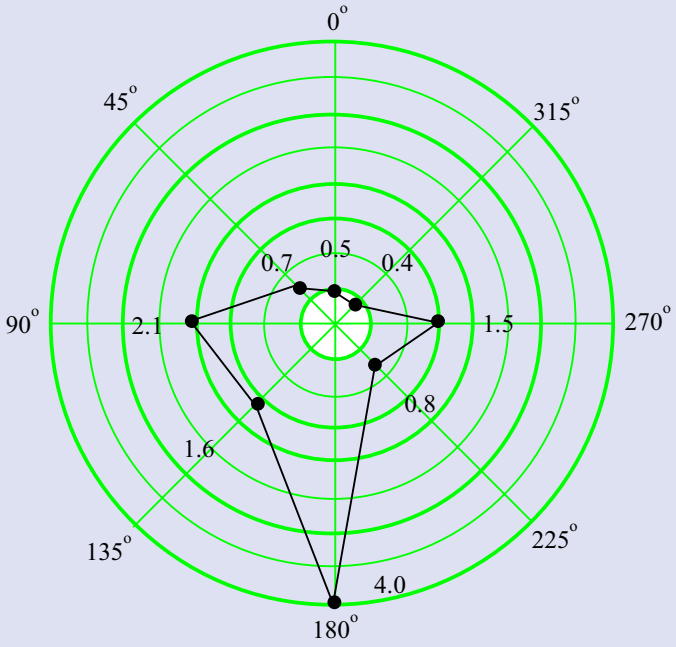
- Demonstrated benefit of “redundancy and diversity” approach,
- Improvements to signal to noise by focusing enhances detection,
- Detection performance in the field appears better than on manufactured specimens,
- Gathering of sufficient data to demonstrate performance is a large task,
- Interpretation of signals is a skilled task,
- Small number of qualified interpreters

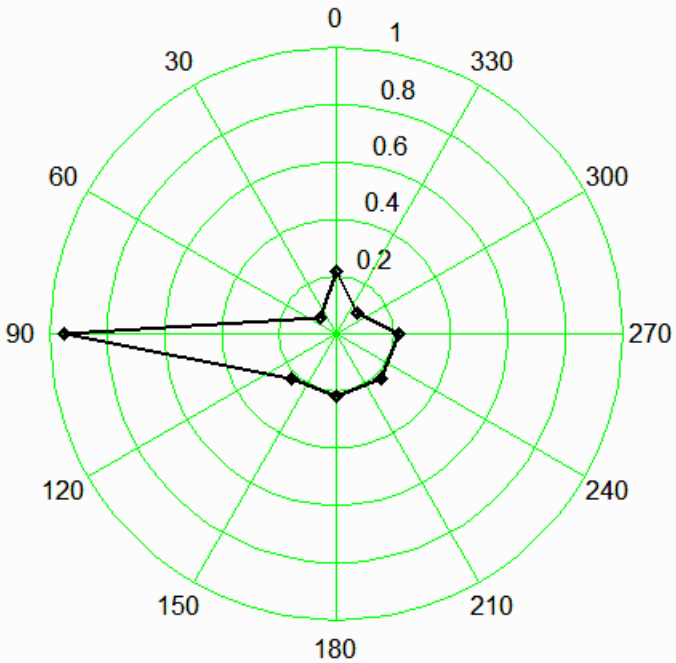
Defect detected in coated and buried line

Location and Sizing

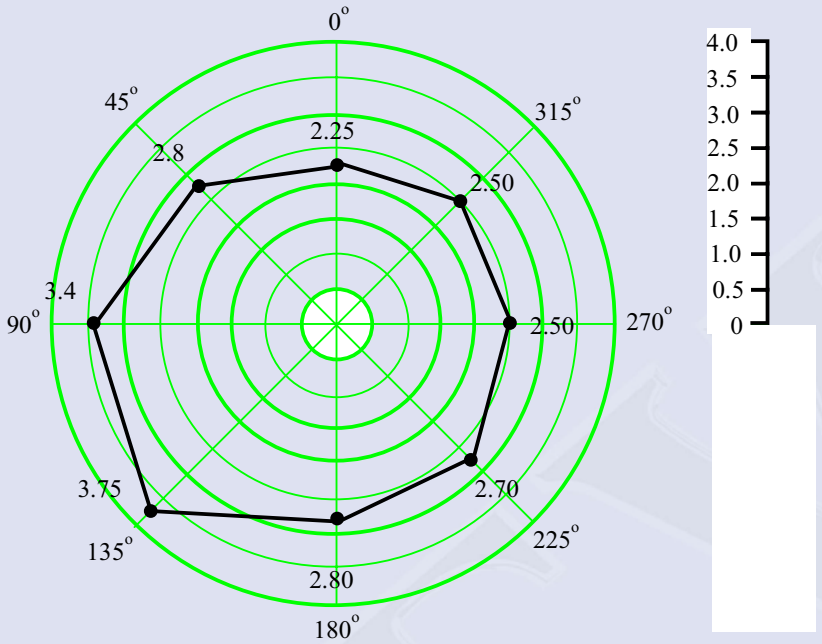
- Amplitude based sizing is unreliable (as for conventional UT),
- Spatial information provided by focusing allows the possibility of quantitative sizing,
- Directionality allows discrimination of defects from welds, spacers etc.

Focused responses – defects at 90 and 180 degrees





Non-directional response from a weld



Focusing summary

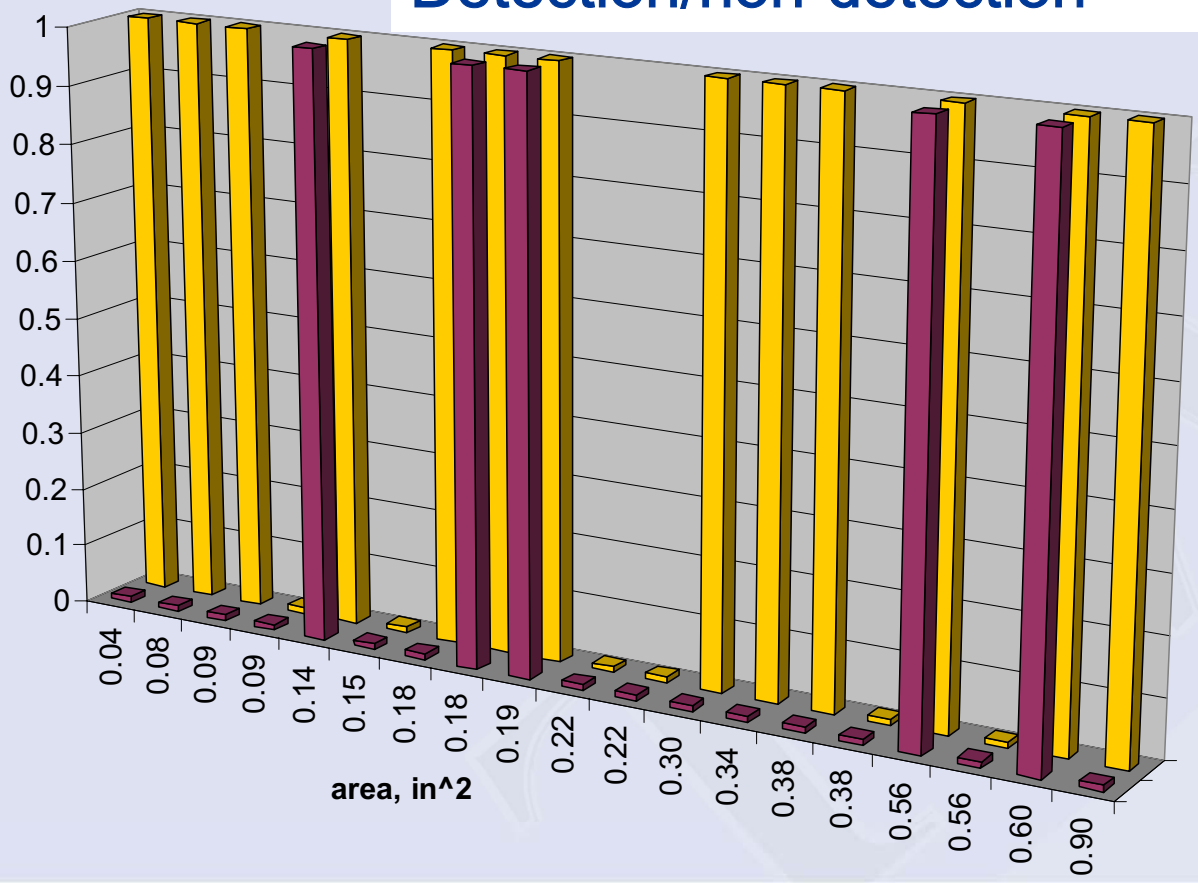
- Focusing allows an improvement in signal to noise ratio, which:
  - Increases the chances of detection, 6dB to infinite signal to noise improvement
  - Lowers the limiting size of defect for detection,
  - Reduces the chances of false calls,
- Focusing provides positional information, which:
  - Assists the operator in interpretation of the type of reflector (defect vs. pipe feature),
  - Allows the circumferential position and extent to be determined,
  - Allows greater certainty in defect depth determination.

Coatings

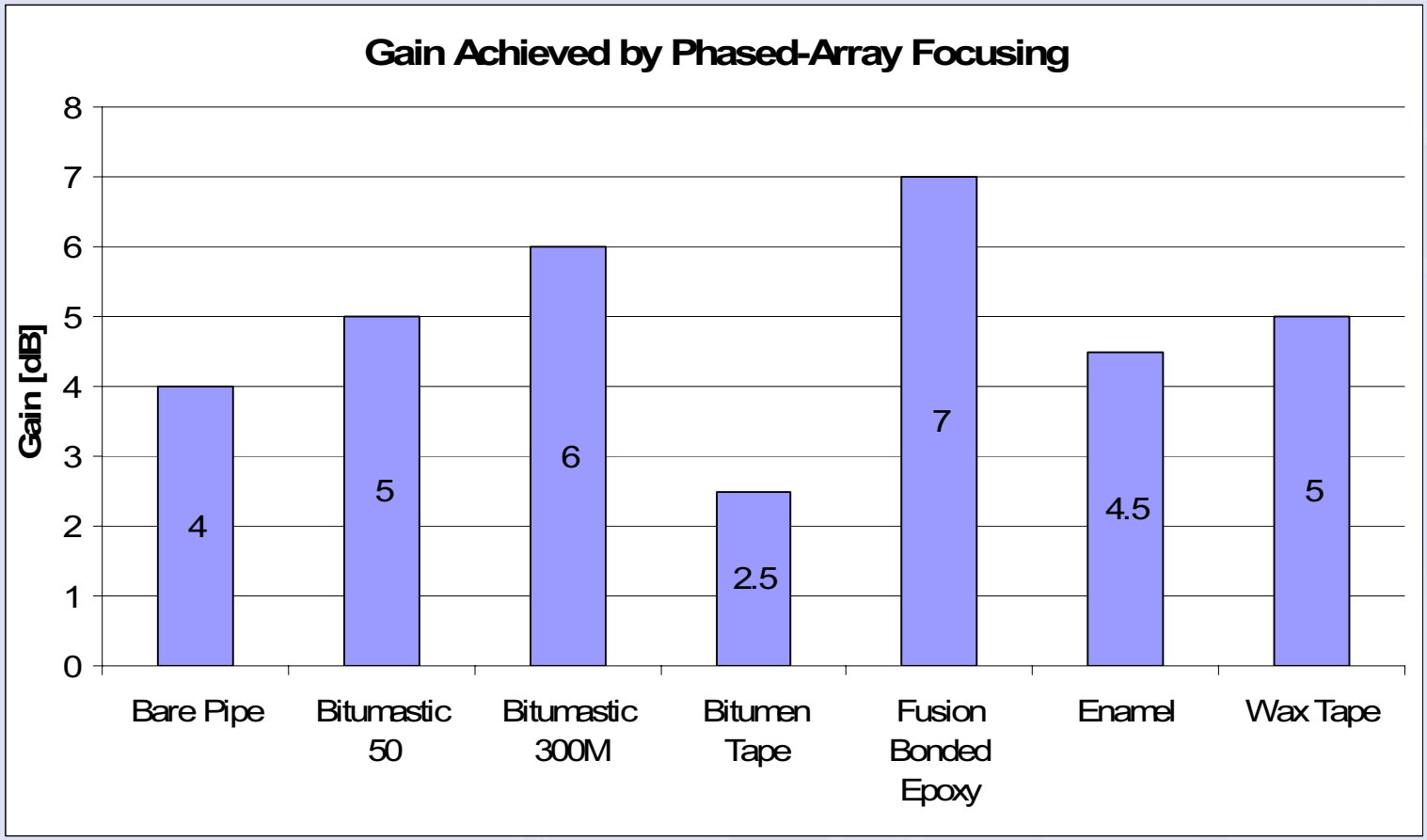
- The effect of coatings is highly variable,
- Materials, thickness, method of application and even temperature affect the attenuation and scattering of ultrasound,
- Coatings can affect the detection performance by reducing the signal to background ratio. Small defects may not be seen and false calls increase,
- Pre-measurement of ultrasonic properties can predict the test range and aid planning of location of excavations etc.

Effect of temperature on detection

NYSEARCH 16” coated pipe
Detection/non-detection

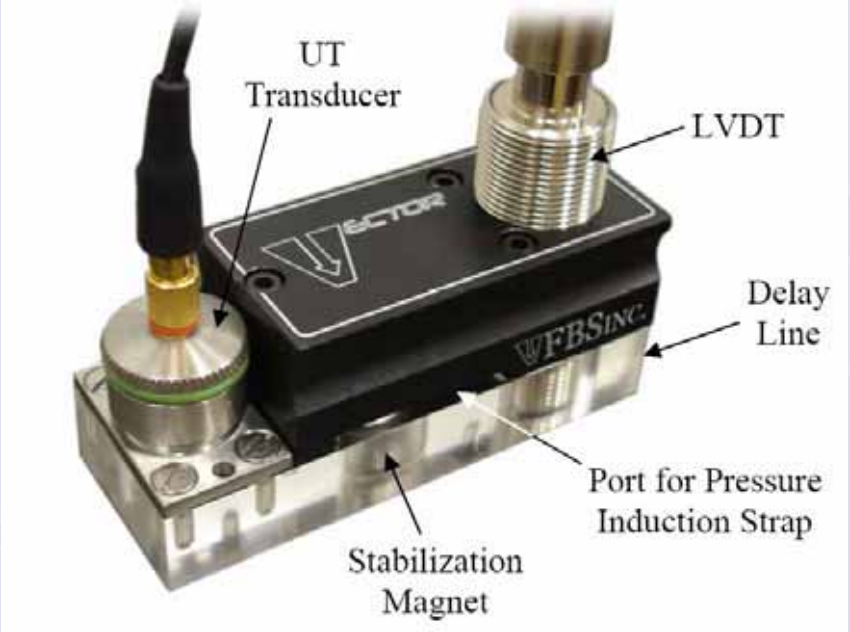


Gain improvements in coated pipe by focusing



Coating characterisation

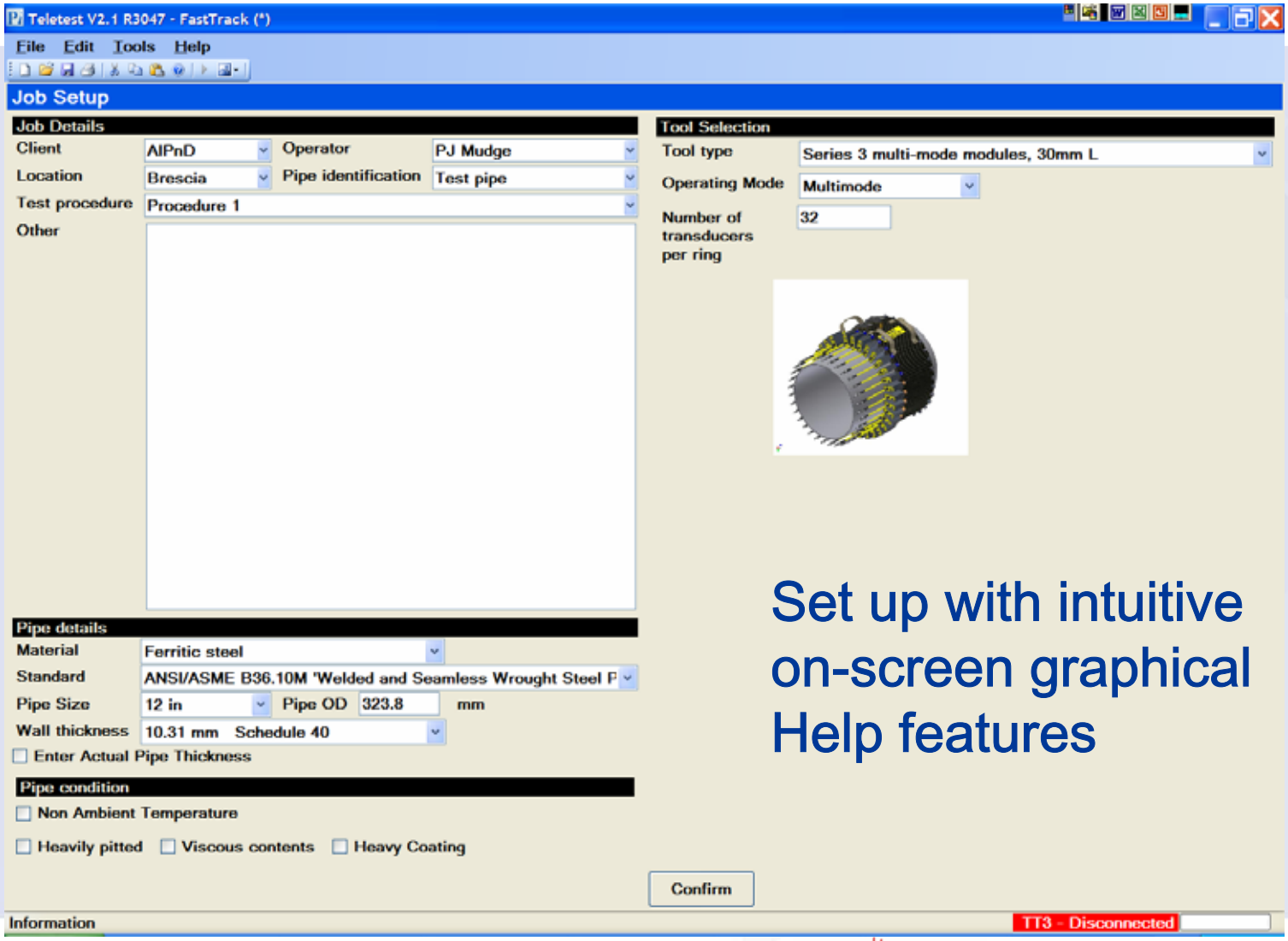
- Measurement of coating properties locally,
- Determination of sound attenuation (and hence test range),
- Determination of dispersion (characteristic) curves for specific tests,
- Prediction of spacing and number of test points (excavations).



Field operations

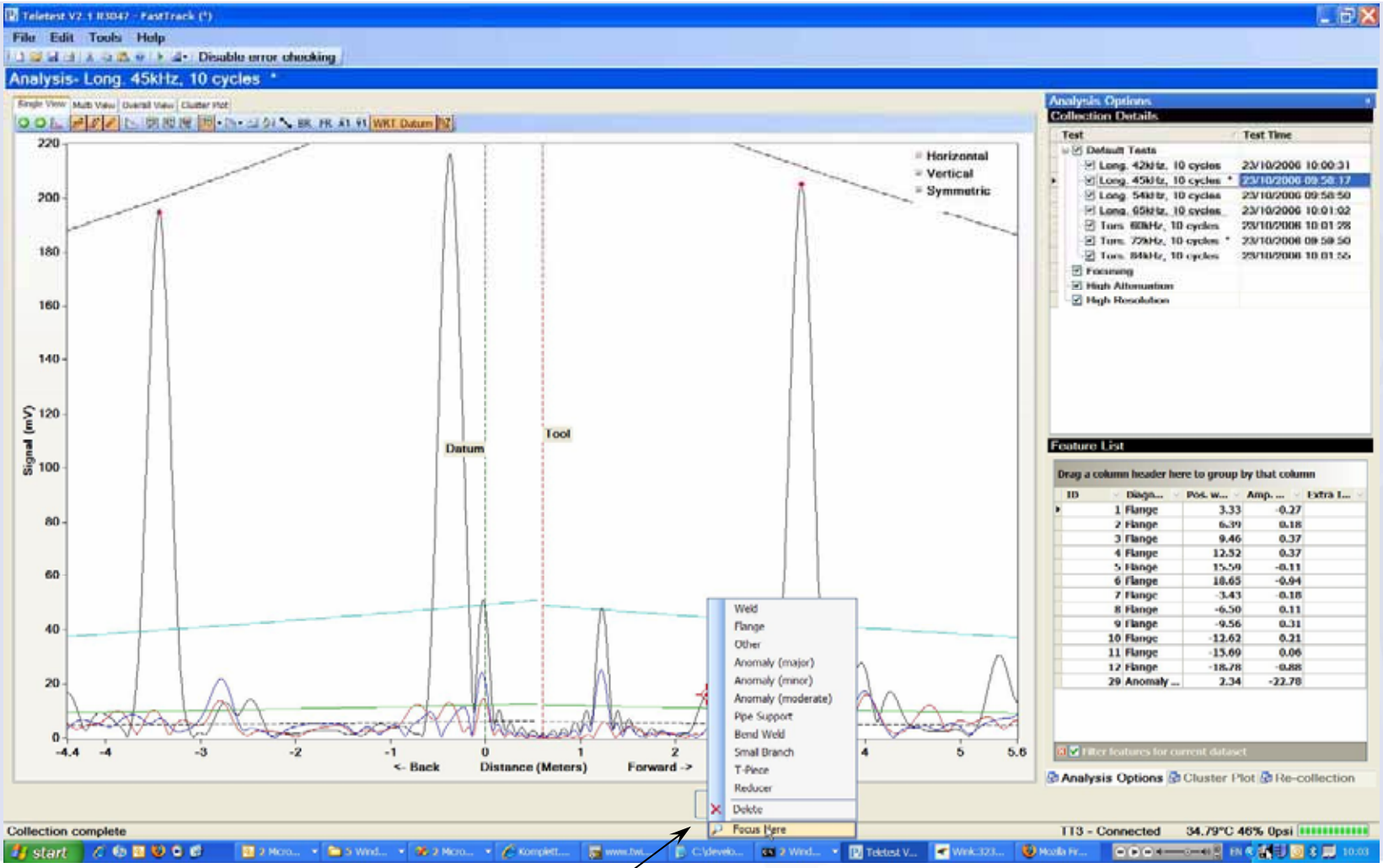
- Needs:
  - Procedures with demonstrable performance expectations
  - Efficient operation by test technicians with industry standard qualifications and experience
  - Rapid turn around of results

Automated test software



Set up with intuitive on-screen graphical Help features

Automated application of focusing



‘Focus here’ option

Recommendations for future directions

- Pipeline operators need to have confidence in test range (e.g. across a cased crossing) and detection performance,
  - Coating characterisation to allow efficient inspections under a variety of field conditions,
  - Quantitative sizing of defects,
  - Enhancements to procedures and equipment to incorporate developments of compensation for coatings and defect sizing,
  - Validation data on structurally significant defects to allow industry acceptance,
  - Better discrimination between pipe features and defects,
  - Extension of capabilities to include geometry effects such as elbows.