PHMSA

Pipeline Safety Research and Development Forum

September 11-12, 2018

Work Group #1, Phase II

Improving Assessment Methods for Dents and Cracks

ILI Technology Capabilities and Opportunities for Mechanical Damage Characterization

James Simek

T.D. Williamson, Inc

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Improve ILI Quantification of Denting with Metal Loss

- US Regulations

- Subpart O – Gas Transmission Pipeline IM 192.933 Immediate Conditions:
  - a dent with any indication of metal loss, cracking, or a stress riser

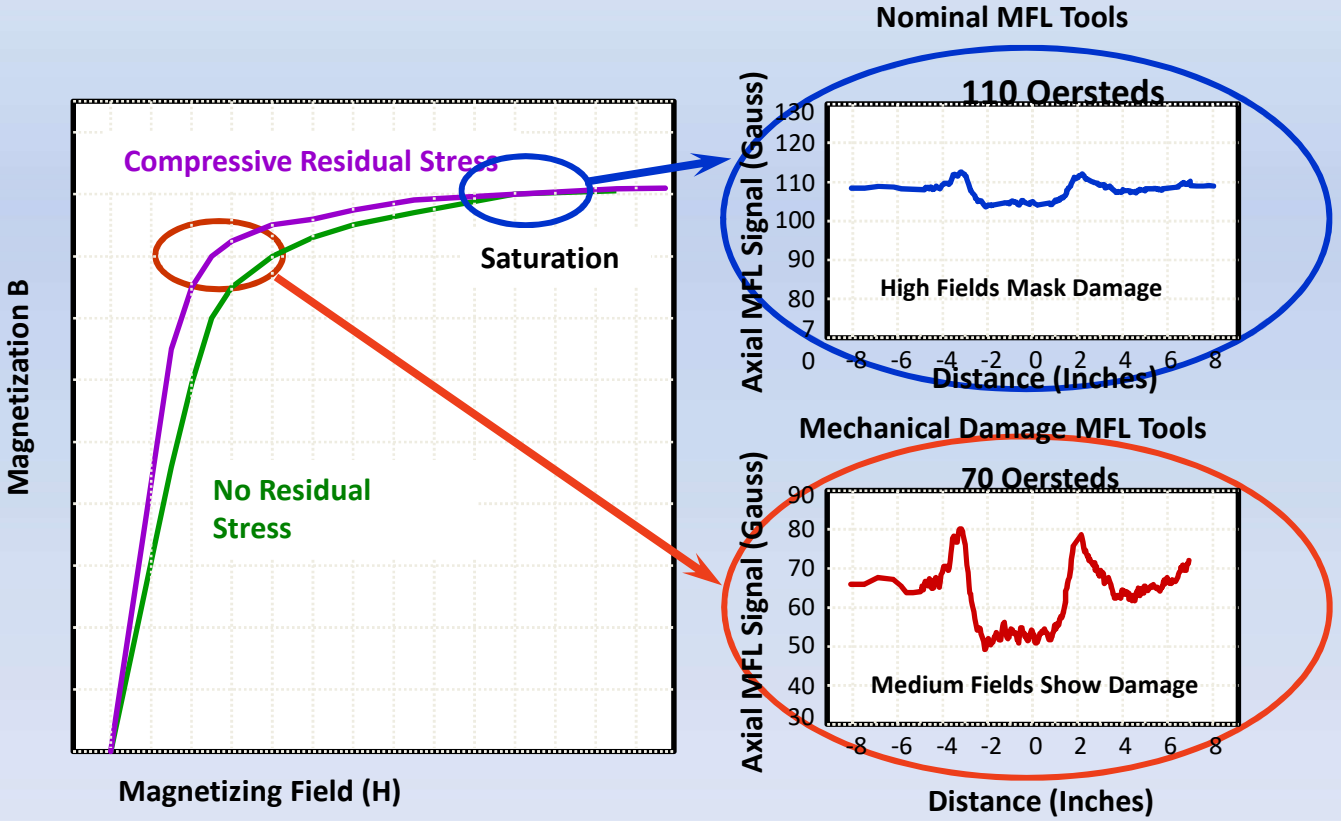
- For liquid pipelines in 49 CFR 195.452(H)(4)(i) immediate repair conditions (C) dents on the top of the pipeline (…)
  - with any indicated metal loss

- ASME B31.8 Standard
  - A dent which contains a stress concentrator such as a scratch, gouge, groove, or arc burn shall be removed by cutting out the damaged portion of the pipe as a cylinder
  - All dents that affect the curvature of the pipe at the longitudinal weld or any circumferential weld shall be removed

Prior work

Low Field Magnetic Flux Leakage

Fundamental concept developed in the 1990s in response to incidents in Edison NJ and Bellingham WA



Prior work

Implemented in the 2000s by

- Tuboscope with PRCI funding
- Rosen with DOT/PRCI funding
- TD Williamson

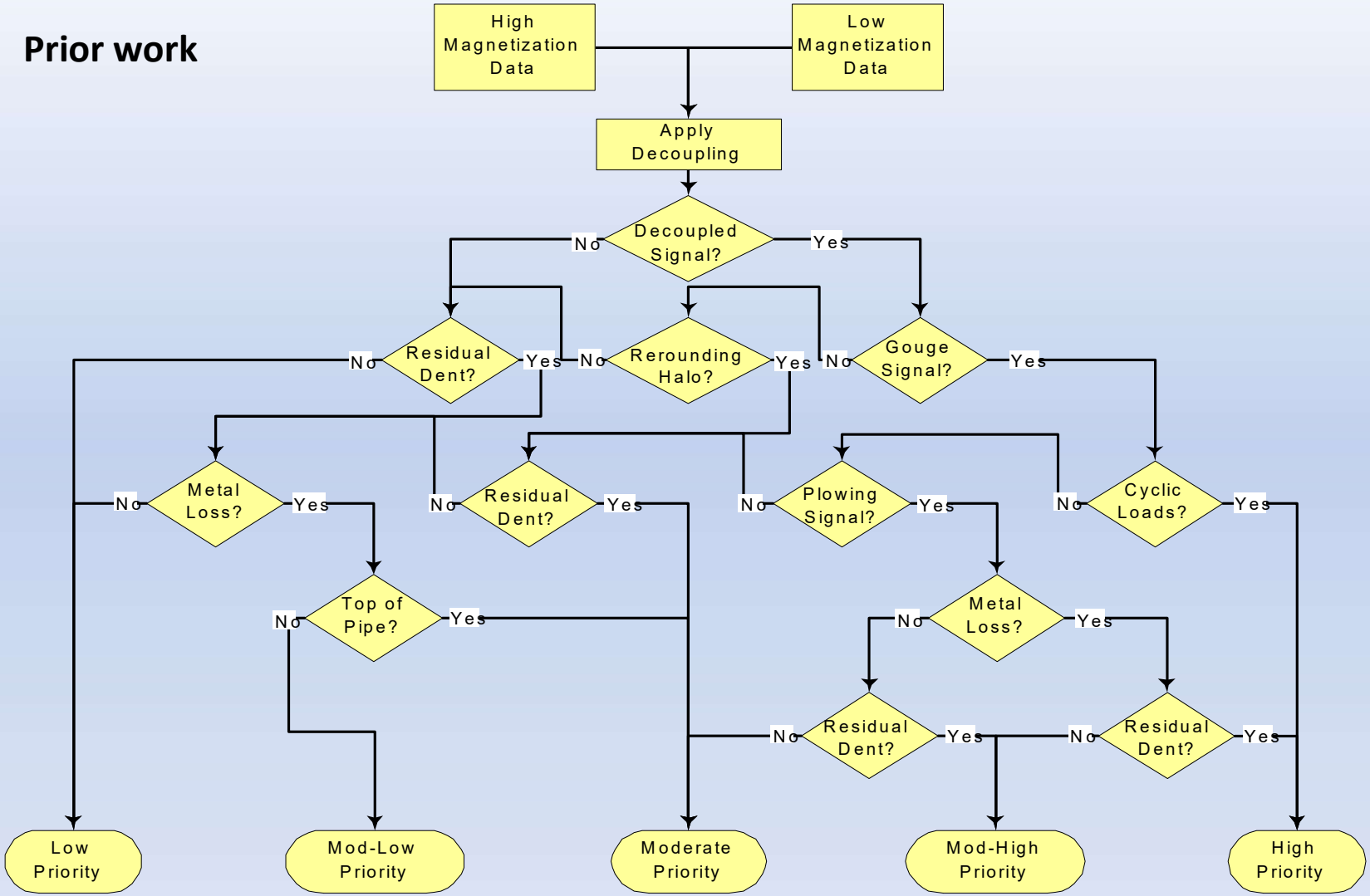
Parallel PRCI work to define severity

- started in 2005 and is still an ongoing project
- additional samples being created

A Mechanical damage prioritization model was implemented

The complexity of the assessment algorithm and the lack of an adequate failure model has limited the use of this approach

Prior work



Simplified prioritization model developed for PRCI. For entire model see PRCI L52084.

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Improve ILI Quantification of Denting with Metal Loss

•Using the prior work for low field MFL and adding additional ILI data sets, a project(1) developed methodology and algorithms to improve characterization of complex features. Two challenges for in-line inspection (ILI) integrity assessment of metal loss defects involve interacting defects:

- Denting and metal loss: Corrosion metal loss in a dent is usually not very severe, whereas metal loss caused by gouging can be severe

- Corrosion on the seam: Modern ILI tools need to differentiate between crack-like selective seam weld corrosion (SSWC) from conventional corrosion that just happens to encounter a low frequency ERW seam

(1)Supported by US DOT PHMSA contract DTPH56-13-T-000009
"Improve and Develop ILI Tools to Locate, Size, and Quantify Complex/Interacting Metal Loss Features" and co-funders.

Gouge vs Corrosion Classifier

- Mechanical damage classifier algorithm development to conservatively classify mechanical damage
- Discriminate dents with corrosion from dents with gouges
- Train a model to recognize feature types based upon ILI signal attributes
  - MFL to LFM/ SMFL amplitude ratios
  - Number of metal loss signatures
  - Estimated metal loss depth
  - Location of metal loss signatures
    - Apex
    - Shoulder
    - Both
- Dismiss many corrosion anomalies in dents as not severe
- Some corrosion is incorrectly classified to ensure conservatism

Gouge vs Corrosion Classifier Performance

	Called Corrosion	Called Gouge	Called None
Is Corrosion	18	6	0
Is Gouge	1	48	1
Is None	2	8	4

Table 2. Classifier confusion matrix.

	Precision	Recall	Samples
Corrosion	0.86	0.75	24
Gouge	0.77	0.96	50
None	0.80	0.29	14
average / total	0.80	0.80	88

Table 3. Classifier performance summary.

88 dent samples available from a combination of ILI runs and pull tests using manufactured dents

Gouge vs Corrosion Classifier Performance

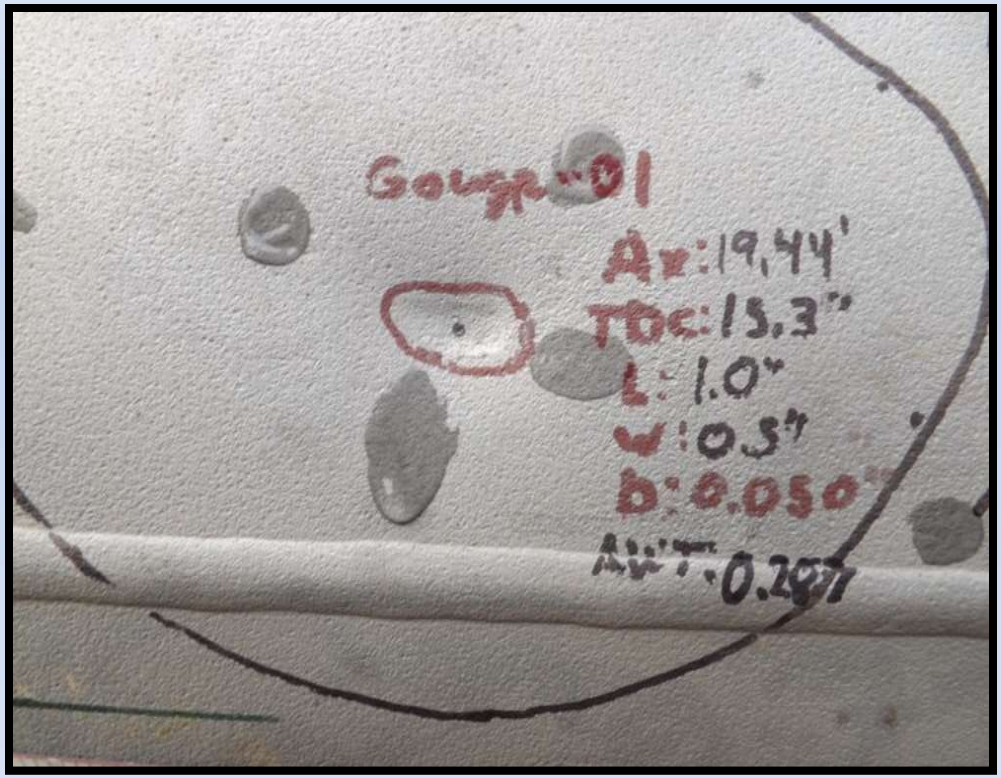
Example

- Detected gouging
- Subjected to internal pressure 100% SMYS
- Repeated 5 times

Gouge vs Corrosion Classifier Performance

Example

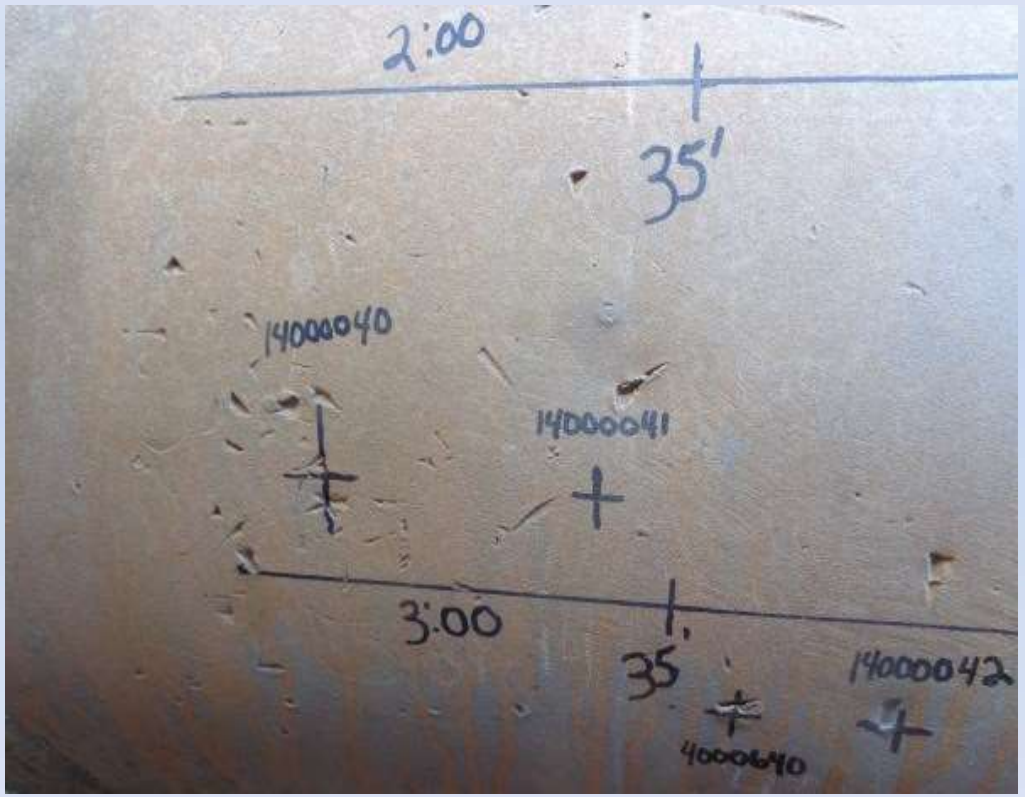
- Detected gouging



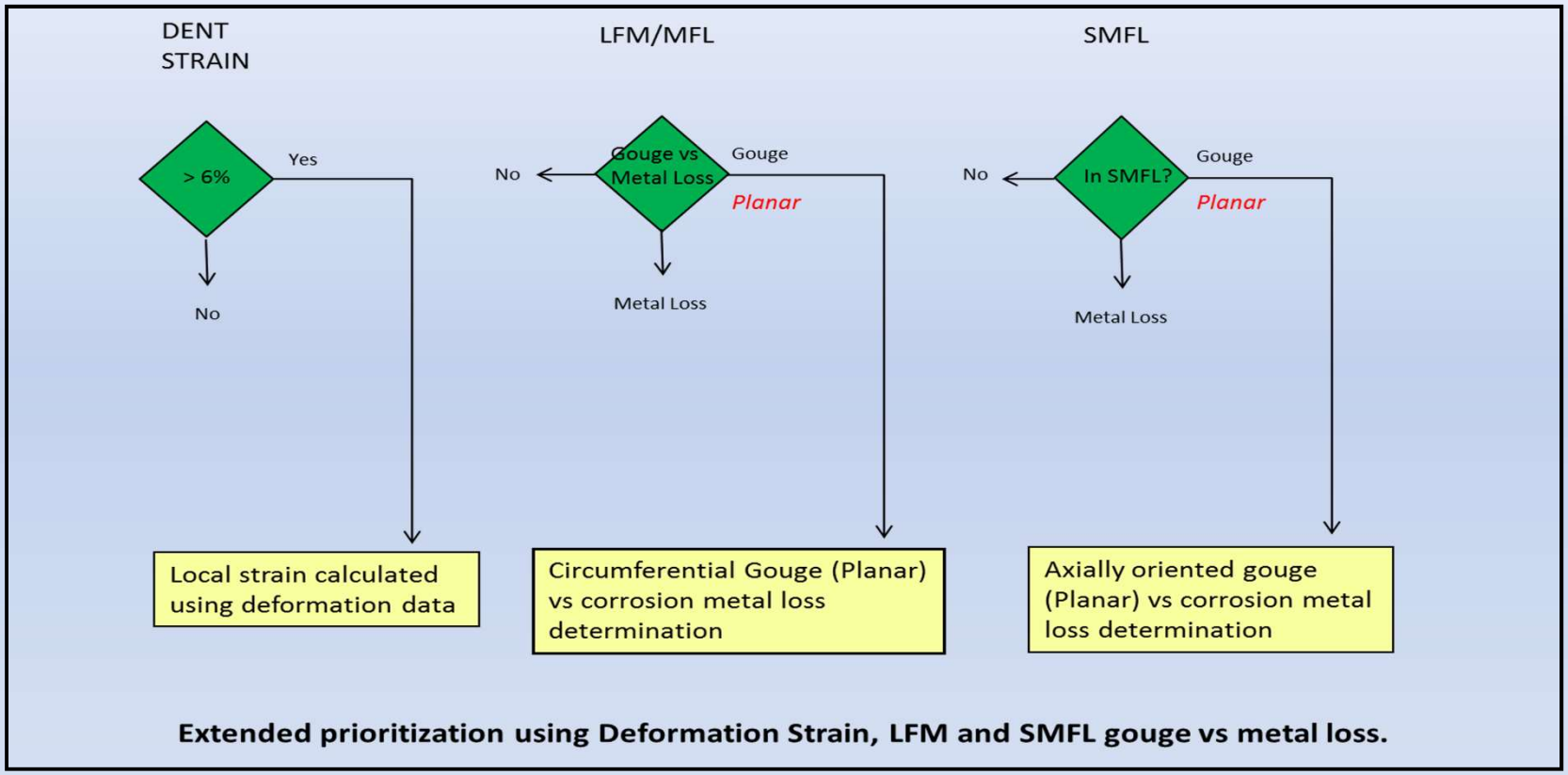
Gouge vs Corrosion Classifier Performance

Example

- Gouging that was called corrosion



Gouge vs Corrosion Classifier Performance



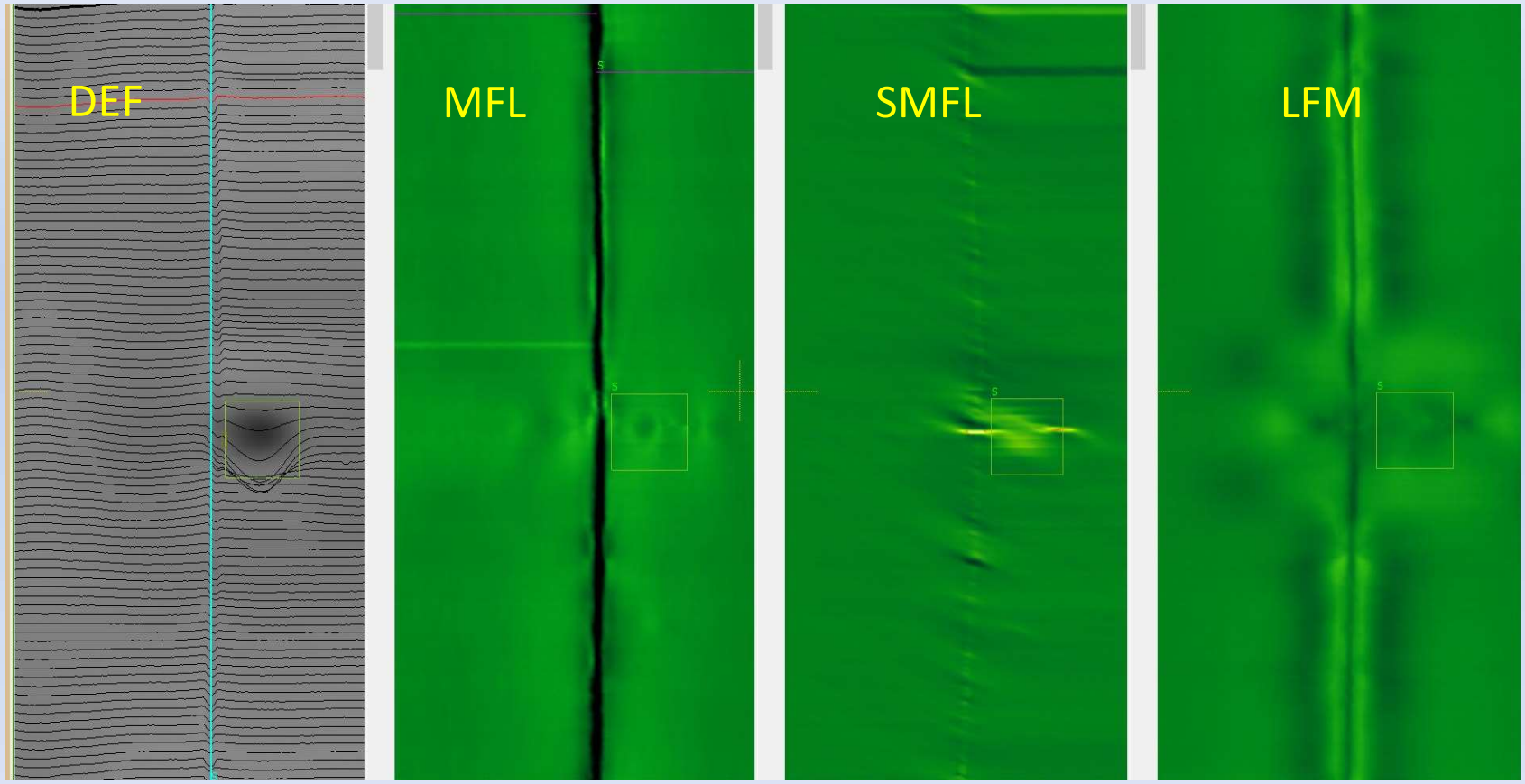
Dent prioritization with Strain and Gouge vs Corrosion discrimination added

Gouge vs Corrosion Classifier Performance

- A process was developed that conservatively detects gouging in dents
- Conservatism allows corrosion anomalies in dents to be flagged as gouges
- Further development and continued refinement of technique to decrease excess conservatism

Improve ILI Quantification of Denting with Metal Loss

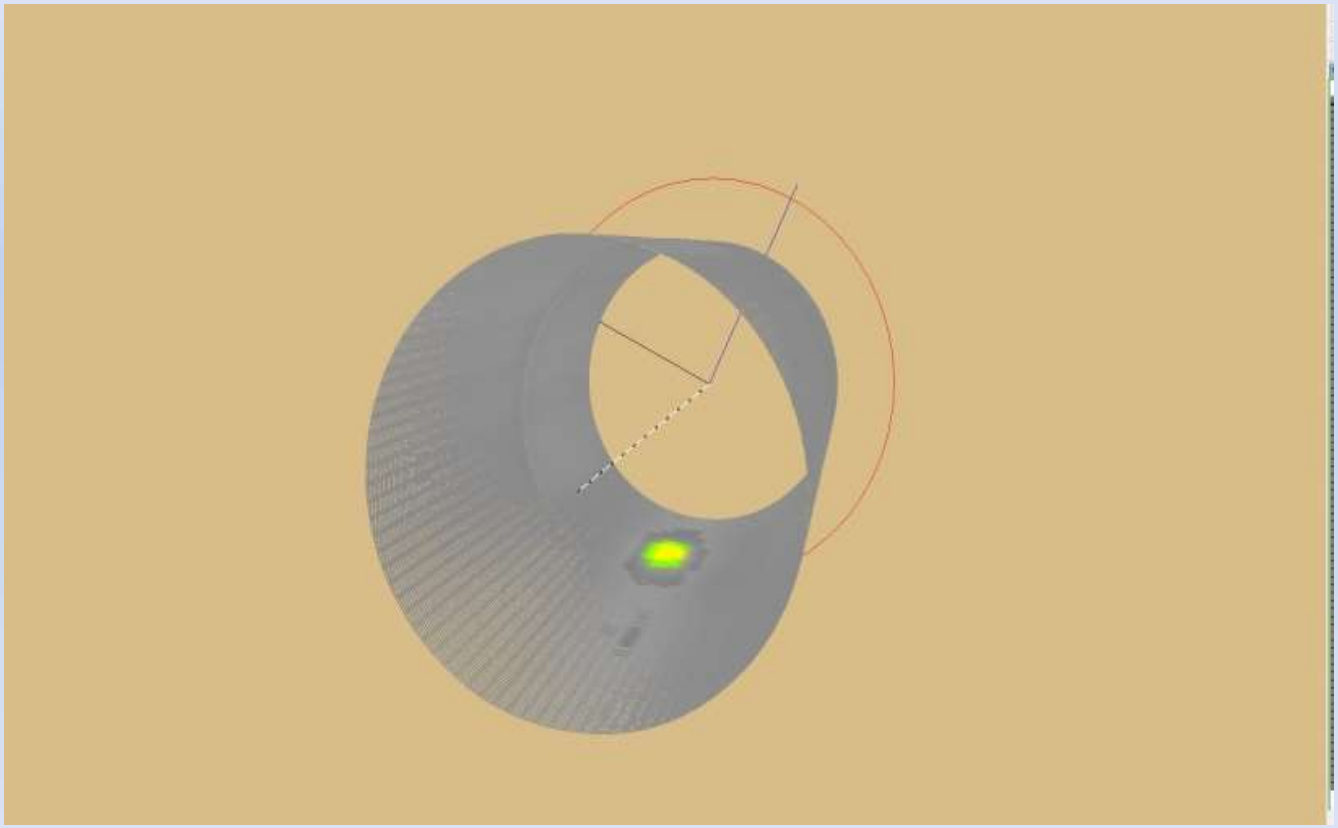
- Example showing deformation coincident with girth weld and axially oriented planar features



Girth Weld #1

Improve ILI Quantification of Denting with Metal Loss

- Example showing deformation coincident with girth weld and axially oriented planar features



3D image Girth Weld #1

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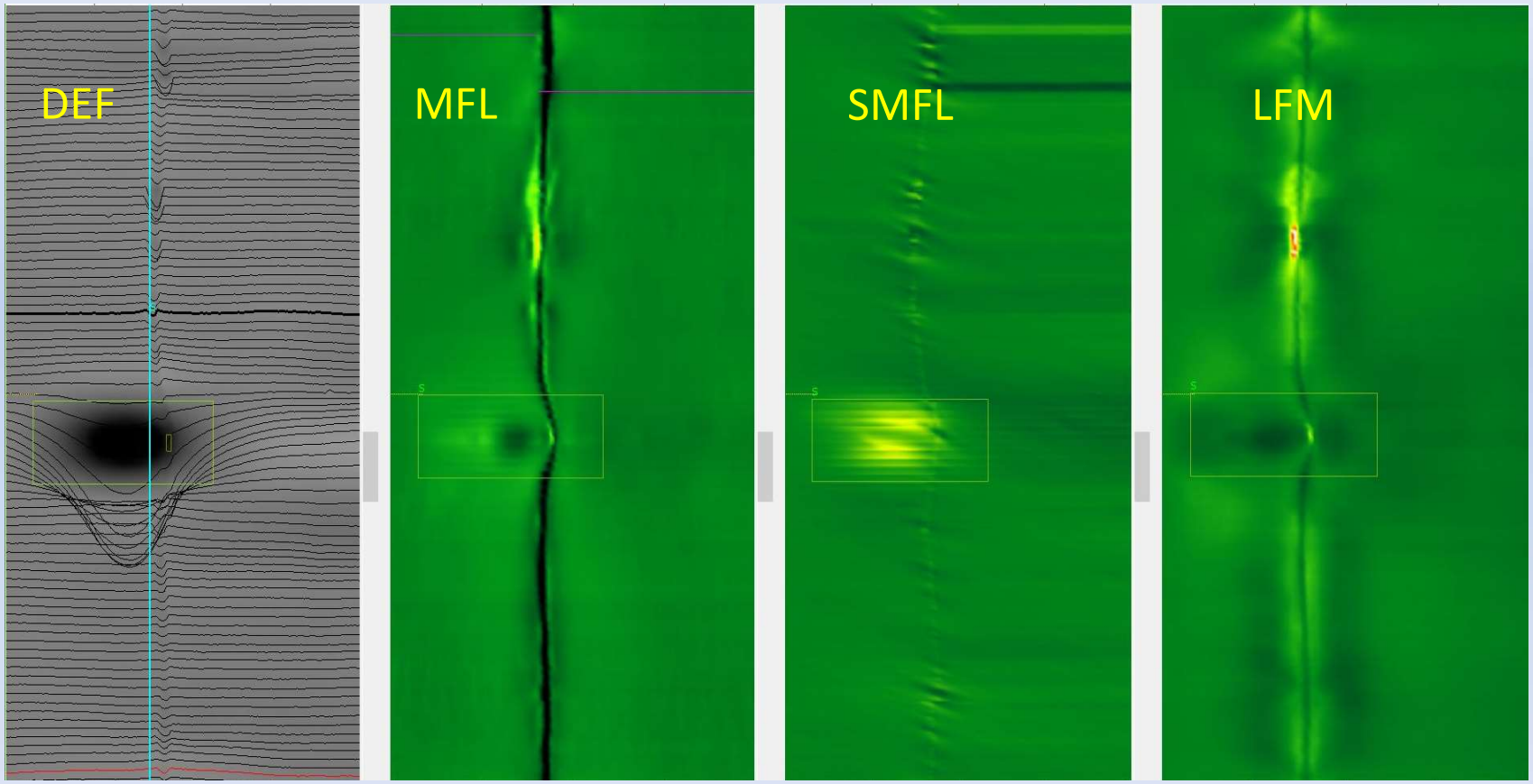
Improve ILI Quantification of Denting with Metal Loss

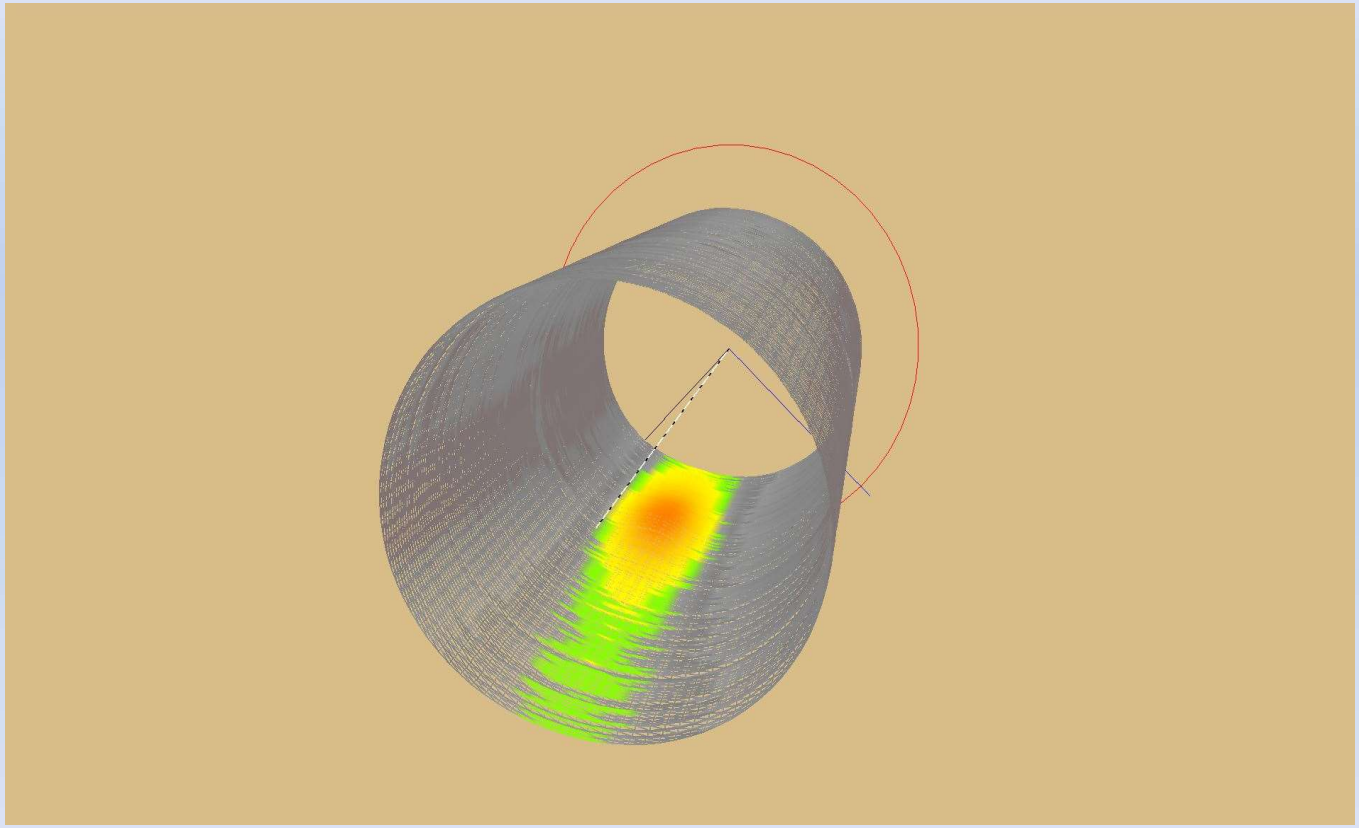
- Example showing deformation coincident with girth weld and circumferentially oriented planar features



Girth Weld #2

Improve ILI Quantification of Denting with Metal Loss

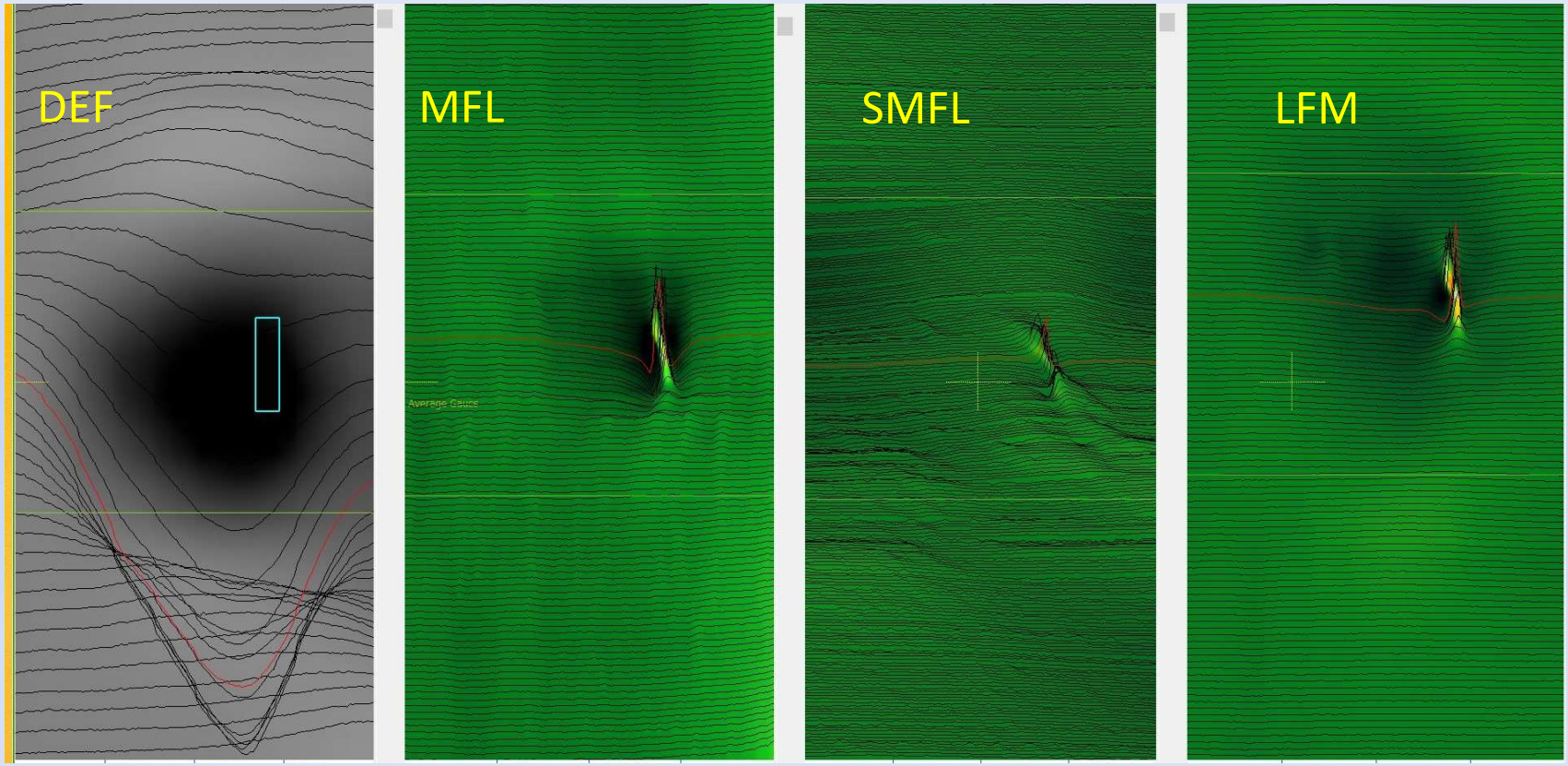
- Example showing deformation coincident with girth weld and circumferentially oriented planar features



3D image Girth Weld #2

Improve ILI Quantification of Denting with Metal Loss

- Example showing circumferential planar feature coincident with dent peak



Circumferential planar feature detected coincident with dent peak.
LFM exhibits an exaggerated amplitude response relative to MFL

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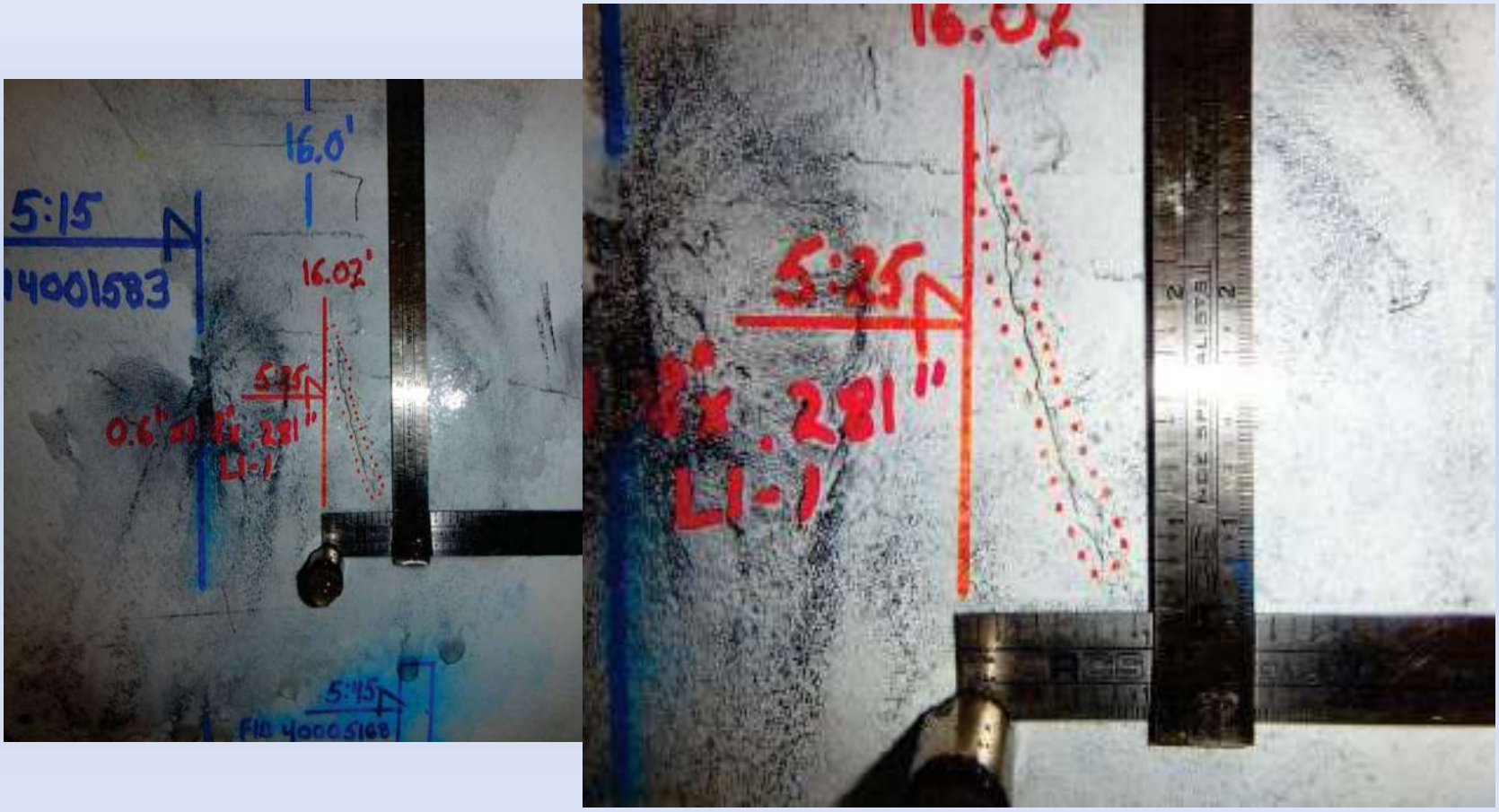
Improve ILI Quantification of Denting with Metal Loss

- Example showing circumferential planar feature coincident with dent peak



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Results of Current work Sponsored by PHMSA/DOT and PRCI

- BMT Fleet Shape Factors
- Determination of restraint parameter for deformation features
- Deformation profiles available for follow on FEA using materials, service history for FFS, ECA processes
- PRCI TDC samples available for testing

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Opportunities for Mechanical Damage Characterization

- Expanding previous magnetic property testing by testing at extended magnetization ranges
- Leverage advances in modeling and samples created as other research to expand first principles of understanding of magnetic response due to cold working, deformation, gouging and cycling
- Develop methods for optimizing MFL based inspection parameters to achieve maximum sensitivity to characterization of mechanical damage effects

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Opportunities for Mechanical Damage Characterization