



Mechanical Damage in Pipelines: Magnetic Flux Leakage Inspection and Neutron Diffraction

(Work in progress)

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Mechanical damage in pipelines

June 10, 1999 - Bellingham, Washington

- 16" diameter gasoline pipeline leaks into a creek
 - ... gasoline ignites, 2km engulfed,
 - ...3 dead
 - ...environmental disaster

August 19, 2000 - Carlsbad, New Mexico

- Natural gas pipeline ruptures near camping area
 - ... 12 campers killed

Prevention???

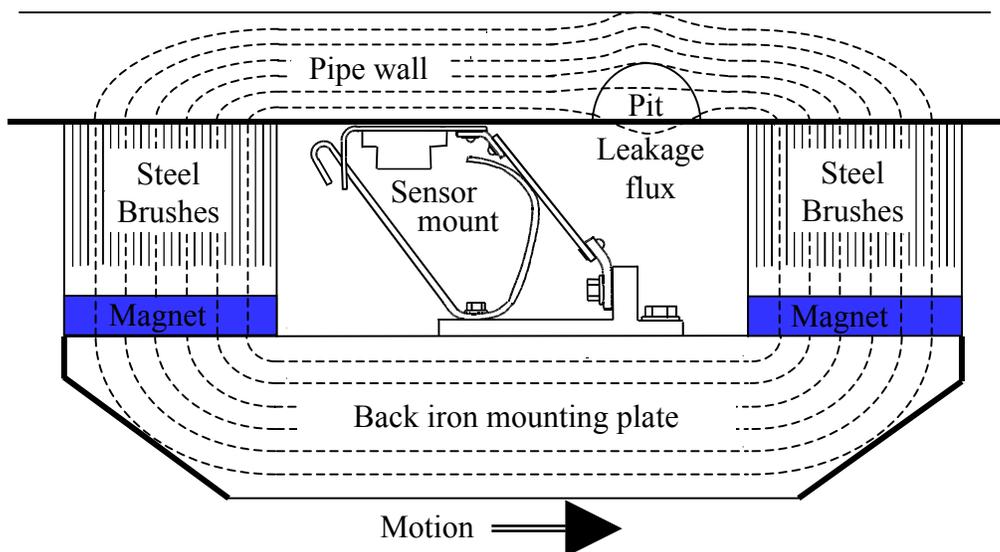
Inspect for this type of damage!



Magnetic Flux Leakage (MFL) Inspection

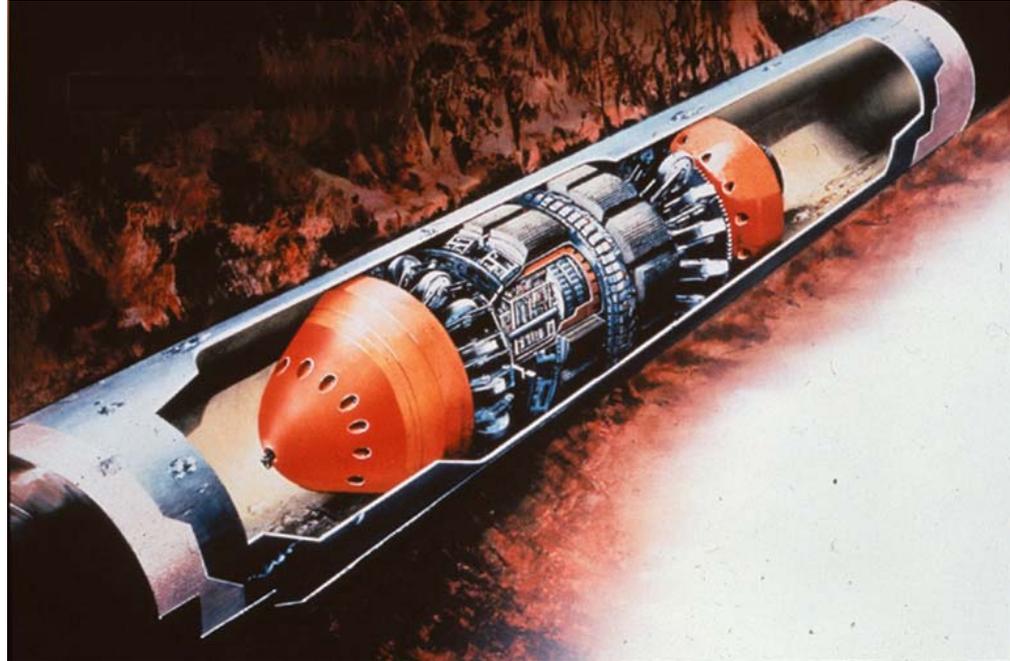
- *MFL the most common and cost-effective in-line inspection technique*
- *Designed for corrosion inspection*

The MFL technique





MFL Inspection Tools





MFL and stress

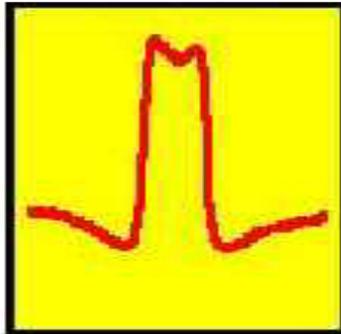
MFL also
stress
sensitive



Potential for
detecting
mechanical damage

MFL signals

Metal loss defect



- large signals
- well understood

Dent



- small signals
- not understood

Gouge



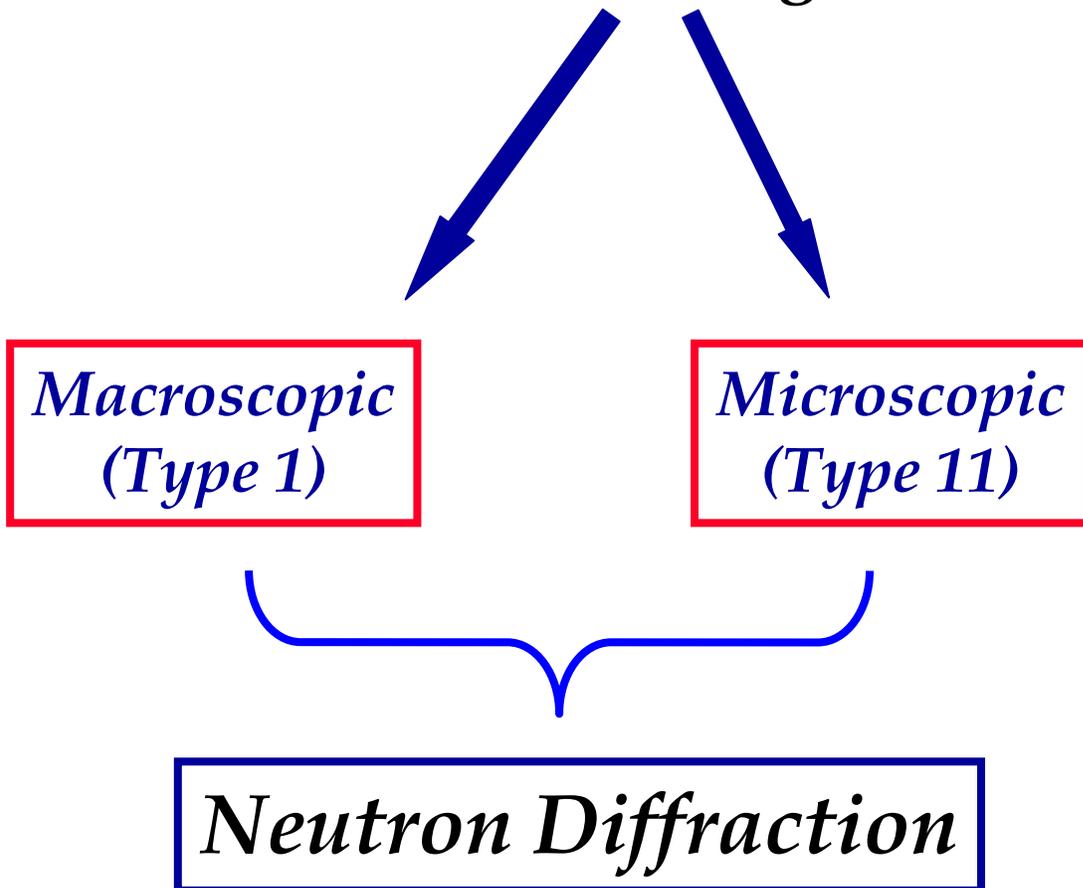
first need to
know *residual stress* patterns





Determining residual stress patterns around dents/gouges

- *Very difficult to model residual stresses (many dents even pop out)*
- *residual stress on 2 length scales*

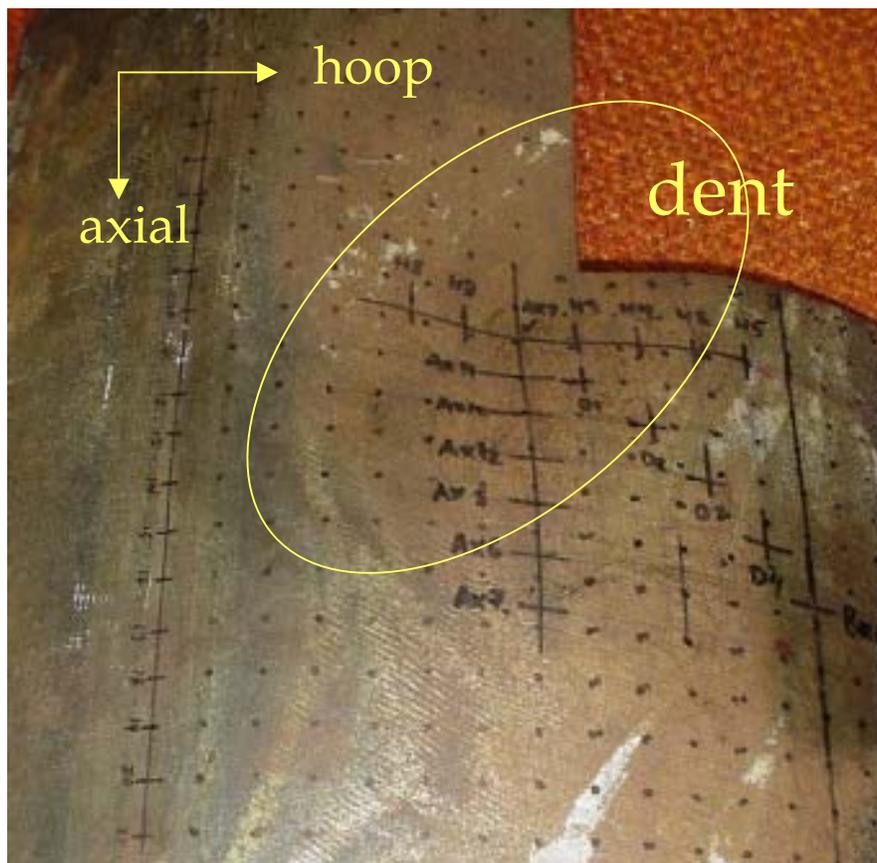




ND of Type 1 residual stresses in dented sample

(with Ron Rogge, R. Sabet, S. White)

20" dented pipe section: *(the Queen's dent)*

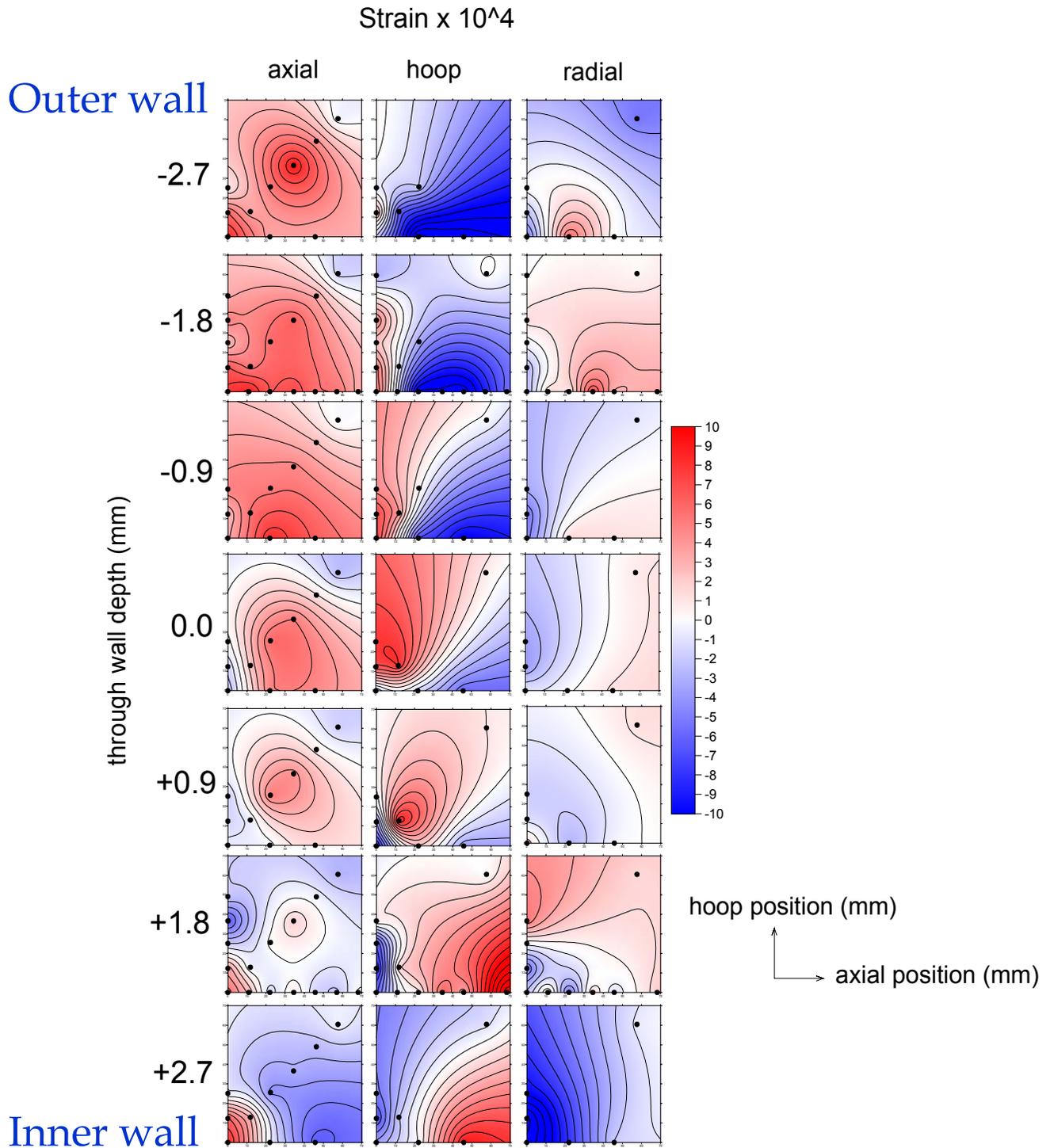


ND strain measurements

- 20 locations around 'quarter-dent'*
 - 5 positions through the thickness*
 - 3 orientations at many locations*
-
-

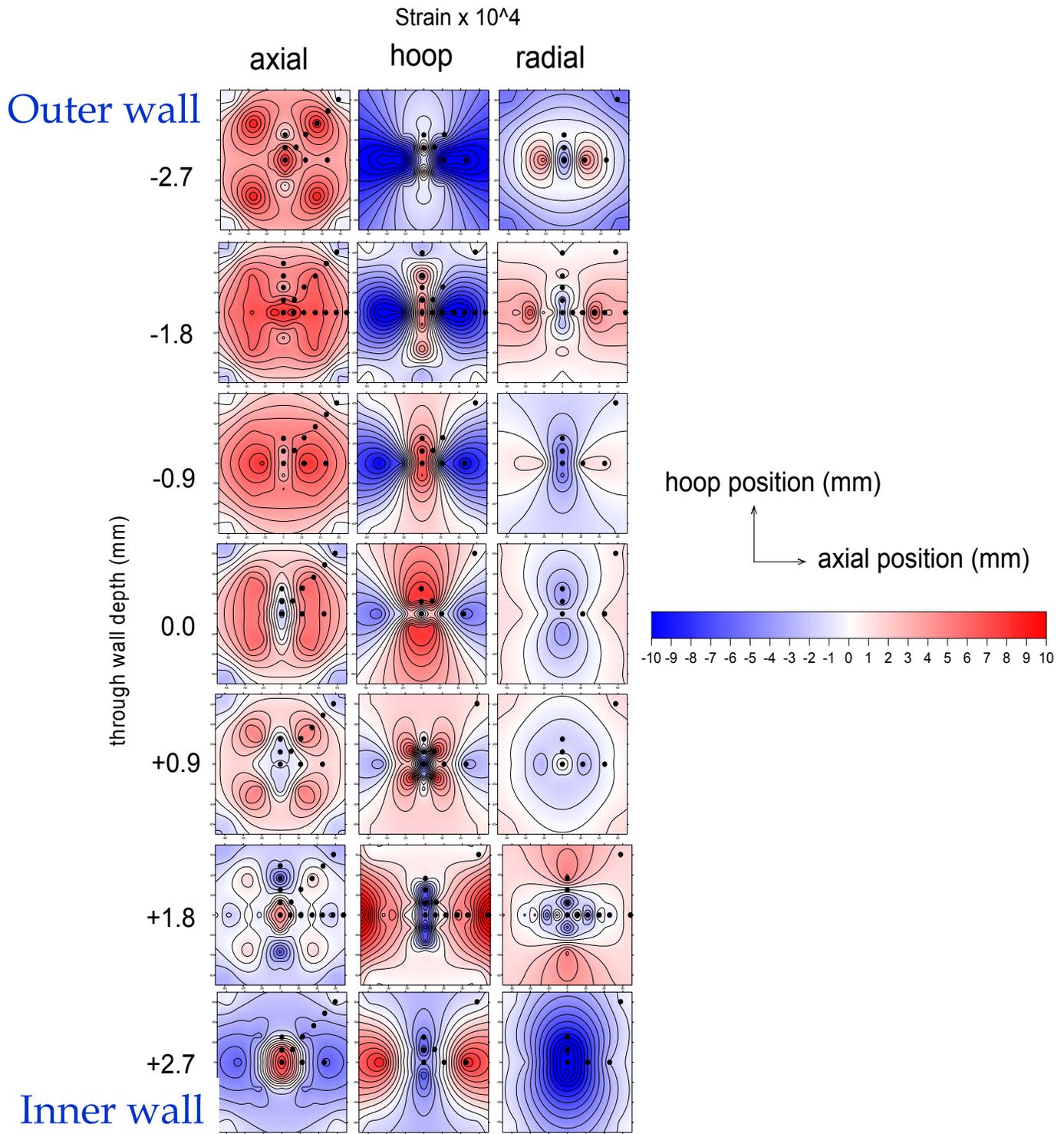


Quarter dent strain plots





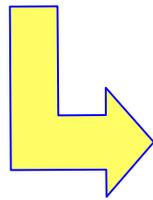
"Complete" dent strain plots



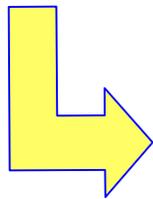


FEA Modeling MFL signals

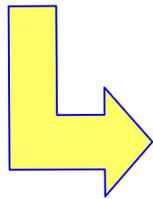
Stress modeled by changing
magnetic permeability μ (tricky)



*Varies locally
around the model*



anisotropic



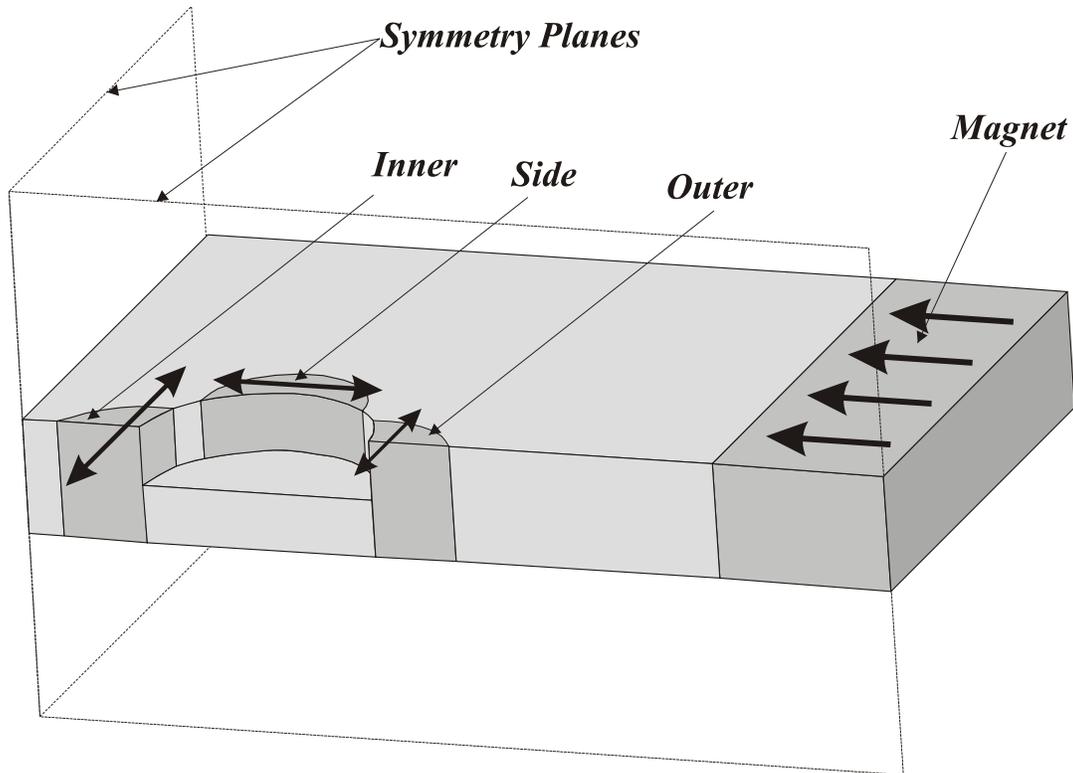
*Non-linear
function of
magnetization*





Earlier work: Magnetic FEA of 2 pits

Modeling local stress effects near pit



Inner/outer/side regions can have...

- low
- medum
- high

...stresses compared with the background

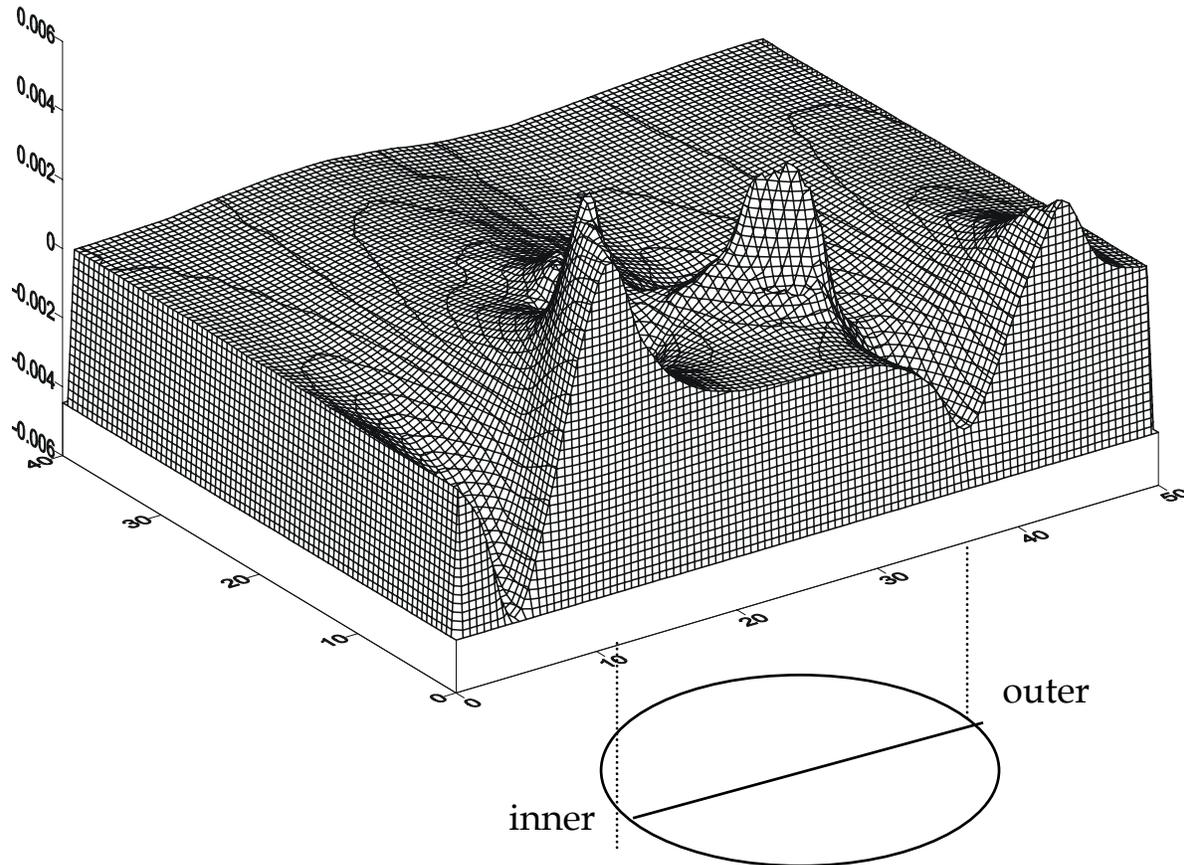




Changes in radial MFL due to 'high' stresses near pit edges

('no-stress' case subtracted from 'stressed')

Radial MFL





At present...

Modeling MFL signals from dents:

ND results

→ *strain levels (3 directions)*

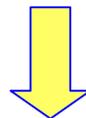
↓ *"translate"*

μ (3 directions)

→ *strain (μ) locations*

Magnetic FEA model

- *dent geometry*
- *meshing*
- μ *assignment*



(with luck)

Prediction of MFL dent signals !!!



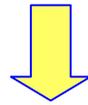
Summary

→ *Mechanical damage in pipelines
can have serious consequences*

yet

we cannot detect it

→ *MFL potentially can be used but
signals need to be better understood*



Magnetic FEA modeling

→ *Neutron diffraction* is playing a
*critical role in determining strain
patterns for input into these models*

