Reliable Metal Loss Grid Data from MFL ILI

Johannes Palmer, Andrey Danilov, Peter Bergmann - Paper 13 (EPRG)

Metal Loss Grid Data

3D metal shape as raster data in a 2D grid

Common practice in ultrasonic techniques

Requirement for MFL in the 2021 Pipeline Operators Forum's standard:

POF 110 Specifications and requirements for UPT data format for in-line inspection of pipelines

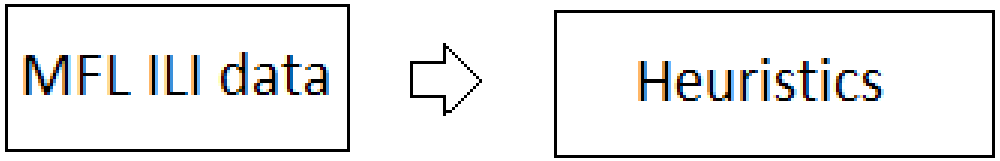
3.3.2.8 MFL Metal Loss

Data field	Description	Dimensions	Factor	Precision/Unit
ML_Depth_Data	Depth of reported metal loss for defined reporting grid	Short [OdoDistance / axial_res, circumf_num]	10	0.1 %t

Table 15: Input Data fields for MFL

Heuristics - “Educated guessing”

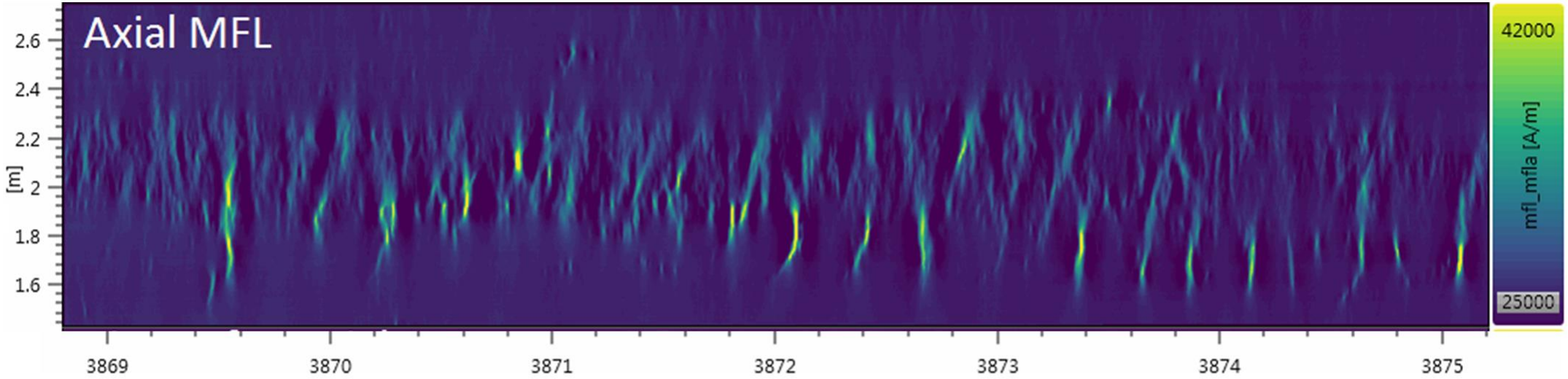
The indirect MFL technology cannot provide grid data directly - it depends on heuristics:



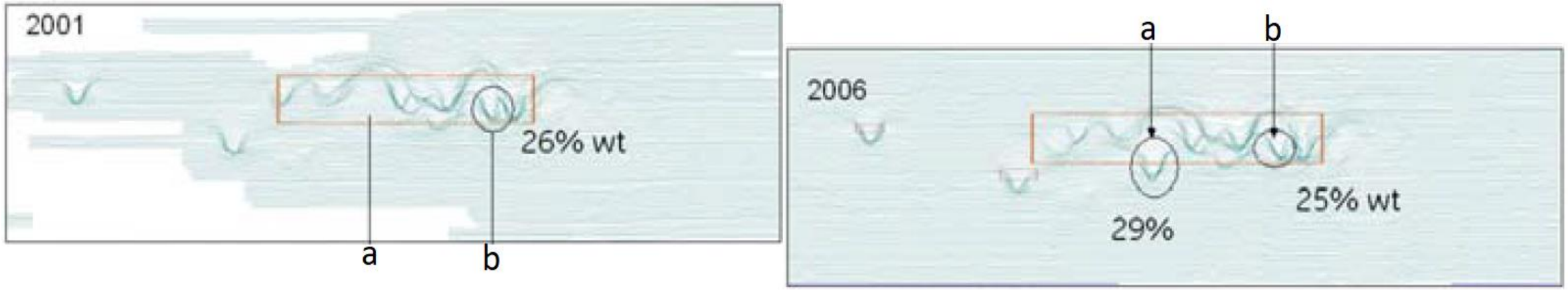
A result based on a certain amount of knowledge, likely to be correct is called an “educated guess” (Collin’s dictionary).

Simplification is another indirect consequence.

Heuristics - Simplification

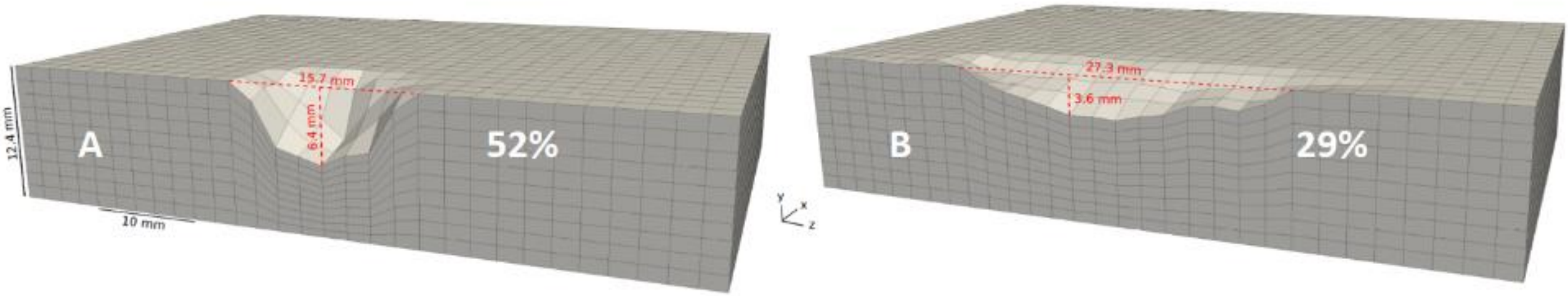


Heuristics - Simplification



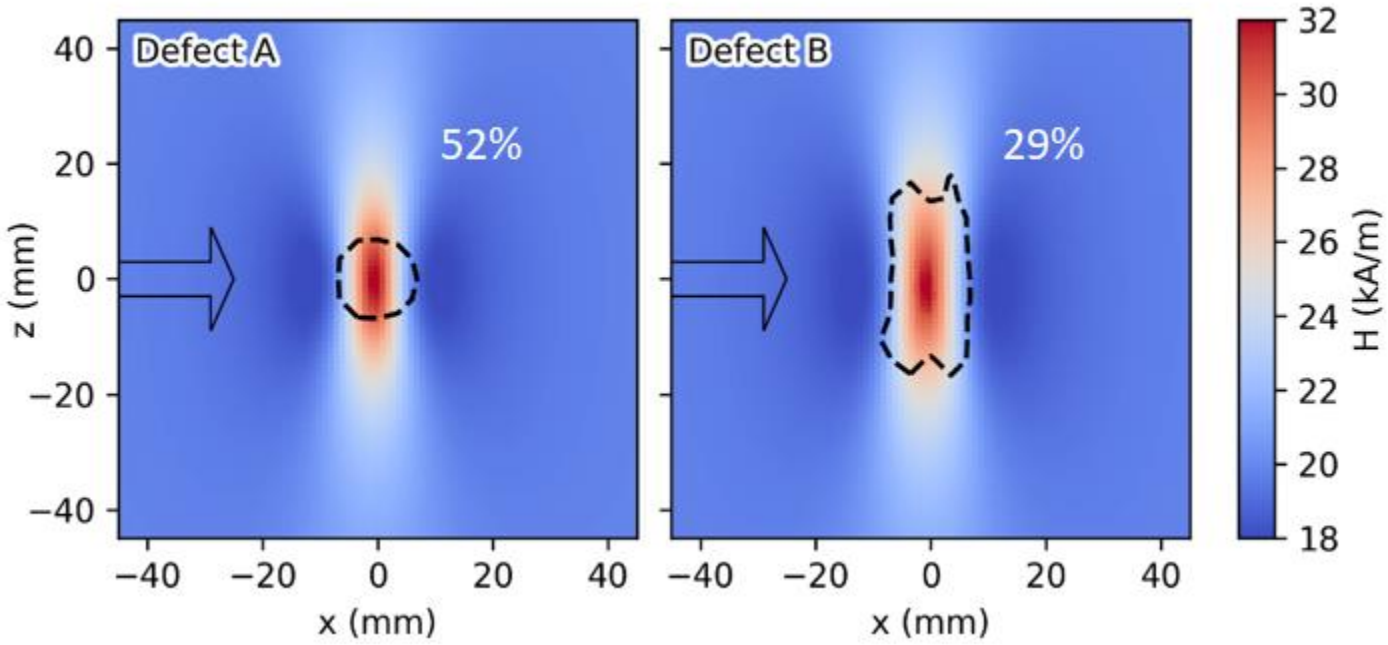
J. Dawson, et al. , 2009, “Understanding and accounting for pipeline corrosion growth rates”, European Pipeline Research Group (EPRG), 17th Joint Technical Meeting, Milano, Italy, 2009

Heuristics – Probability and Ambiguity



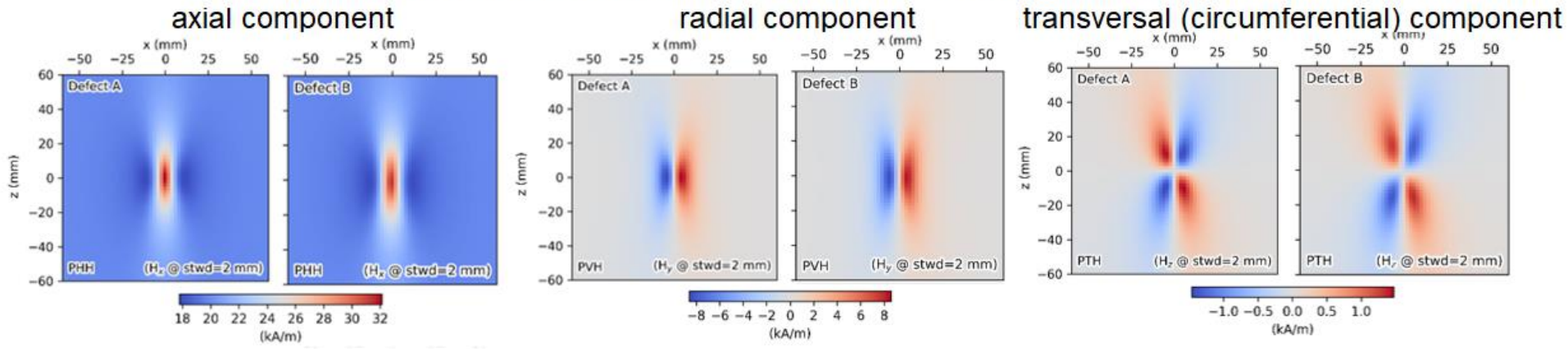
Ambiguity

The MFL-A data are identical.



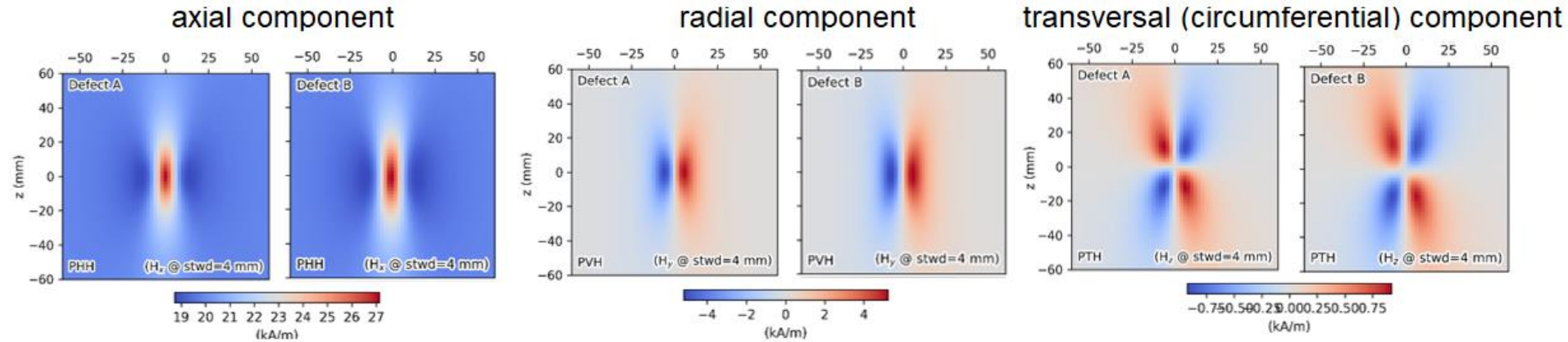
Redundancy of MFL Components

Axial Magnetization (conventional, in pipe direction)



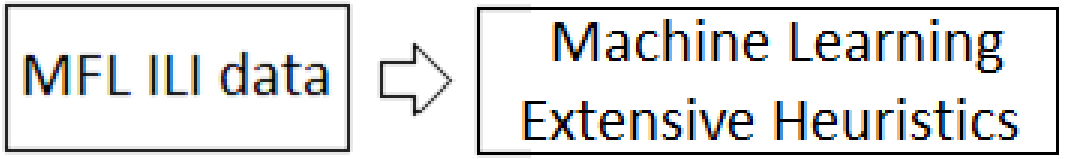
Sensor-to-wall-distance 2 mm

Axial Magnetization (conventional, in pipe direction)



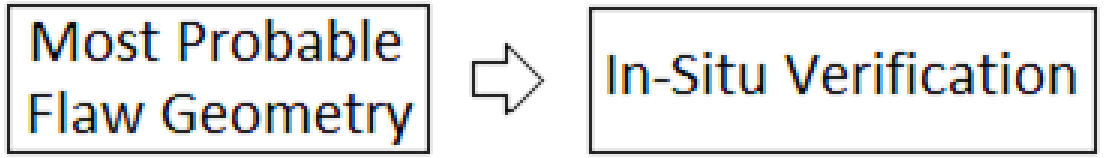
Sensor-to-wall-distance 4 mm

Artificial intelligence versus simplification



Level of detail may increase up to 3D grid level, but character remains “guessing”.

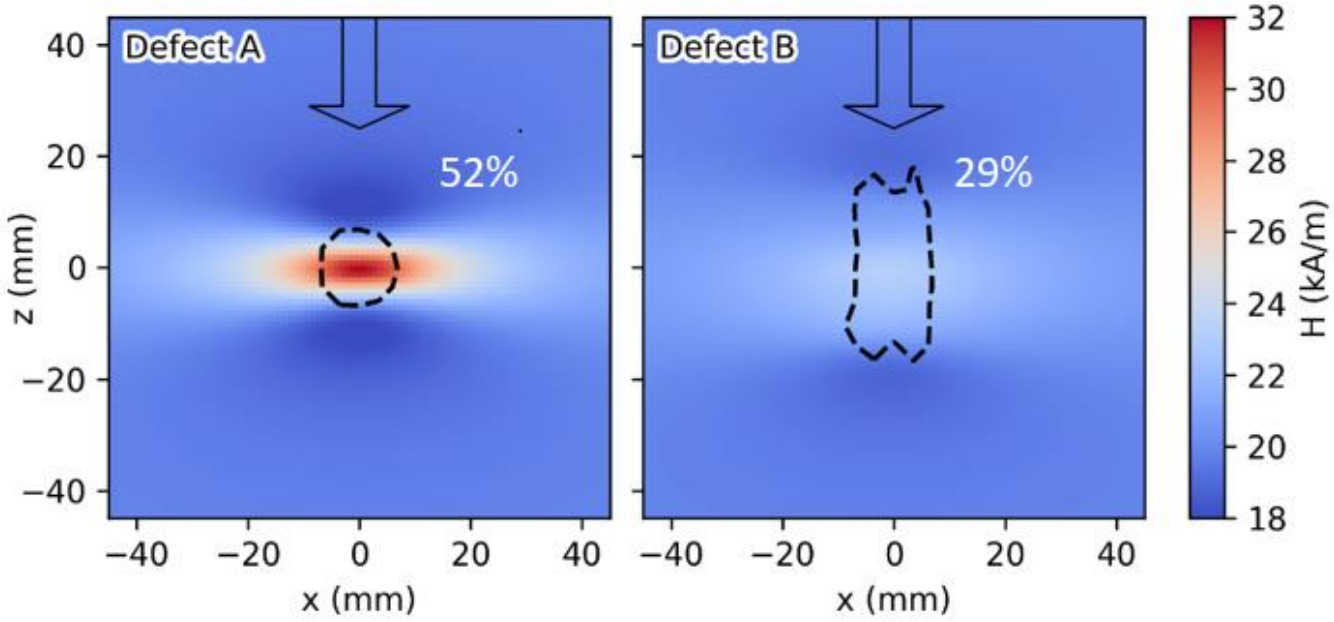
Individual sizing model refinement (e.g. via dig verification)



The probability correctness may increase for certain anomalies, but again the character remains “guessing”.

Reliable Grid Data - Prerequisite

- MFL's weakness is ambiguity and subsequently guessing and simplification
- Finding ***the*** only correct solution is not possible, because there are ***many***
- Calculation of MFL solutions is expansive, therefore requires an unambiguous target!

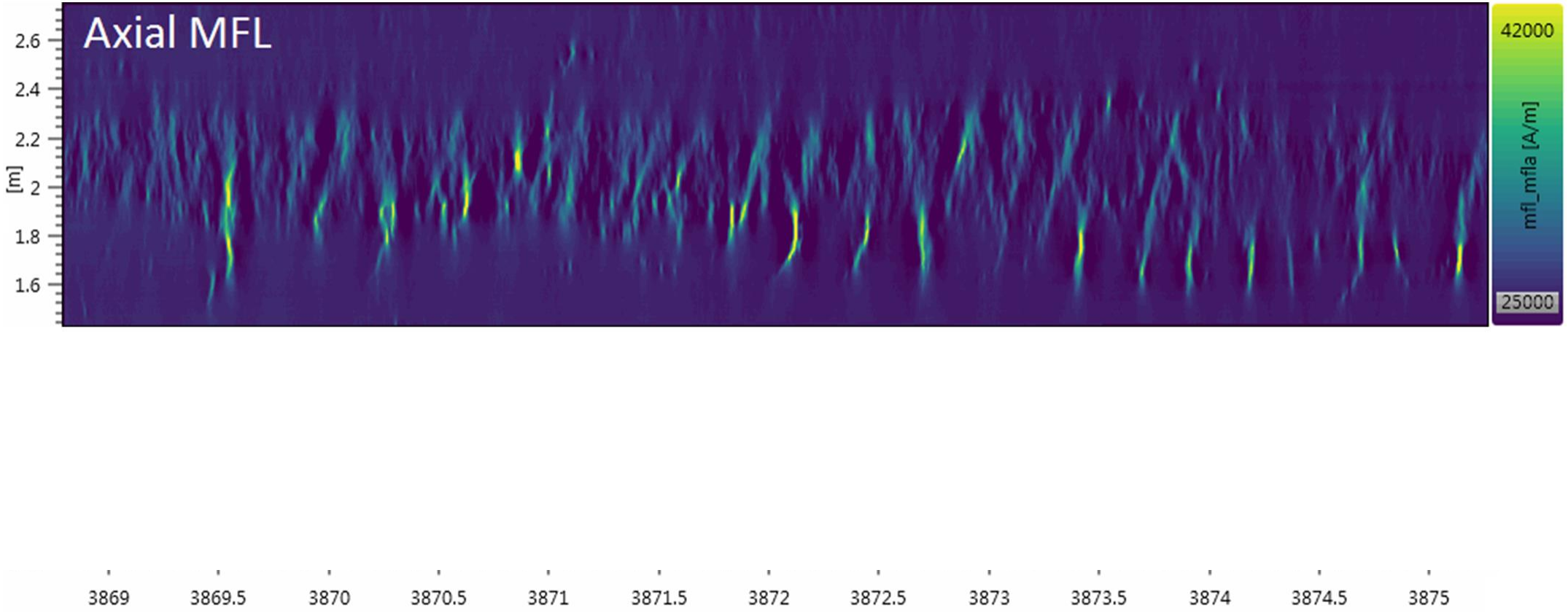


- The integration of the MFL axial and transversal data leaves ***one*** correct solution possible.

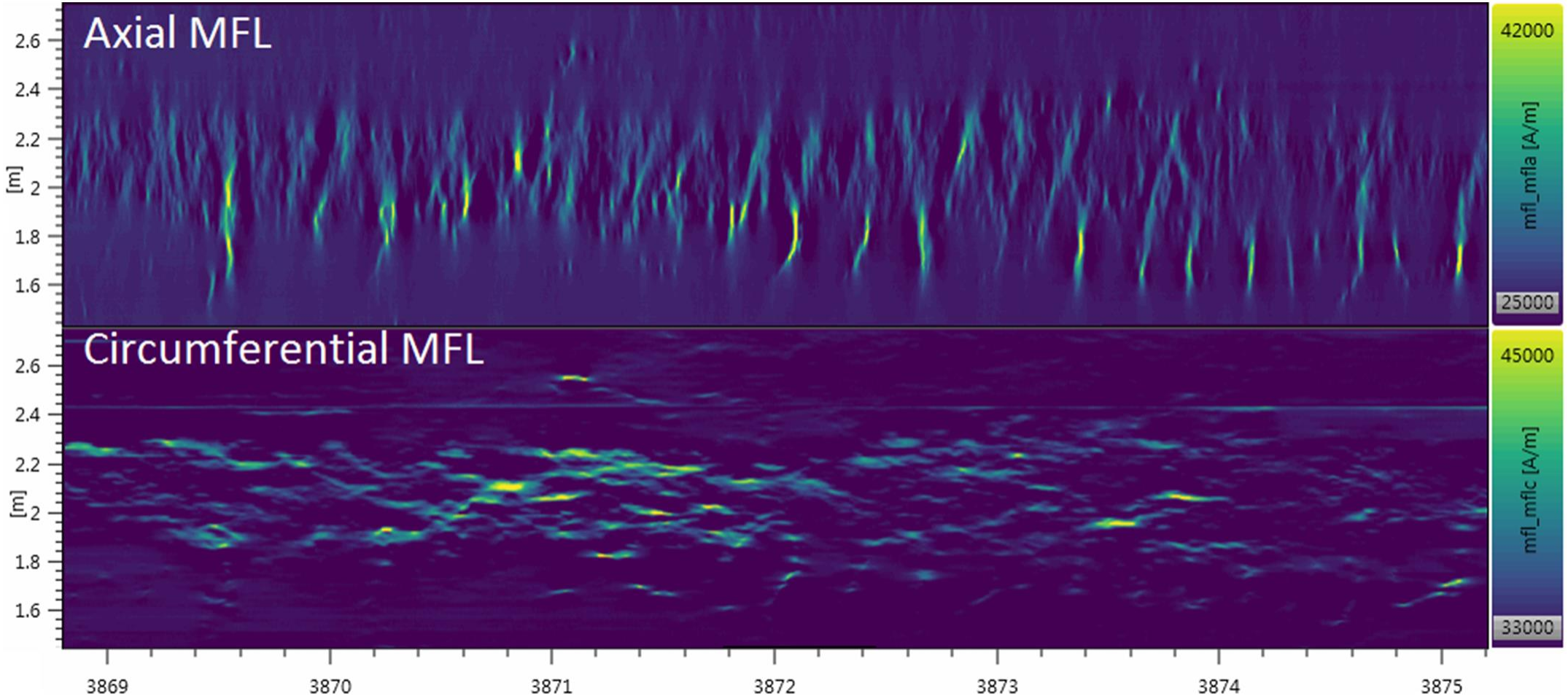
Reliable Grid Data, Process

Virtual Dig Up service,
based on Deep Field Analysis

Reliable Grid Data, Comparison

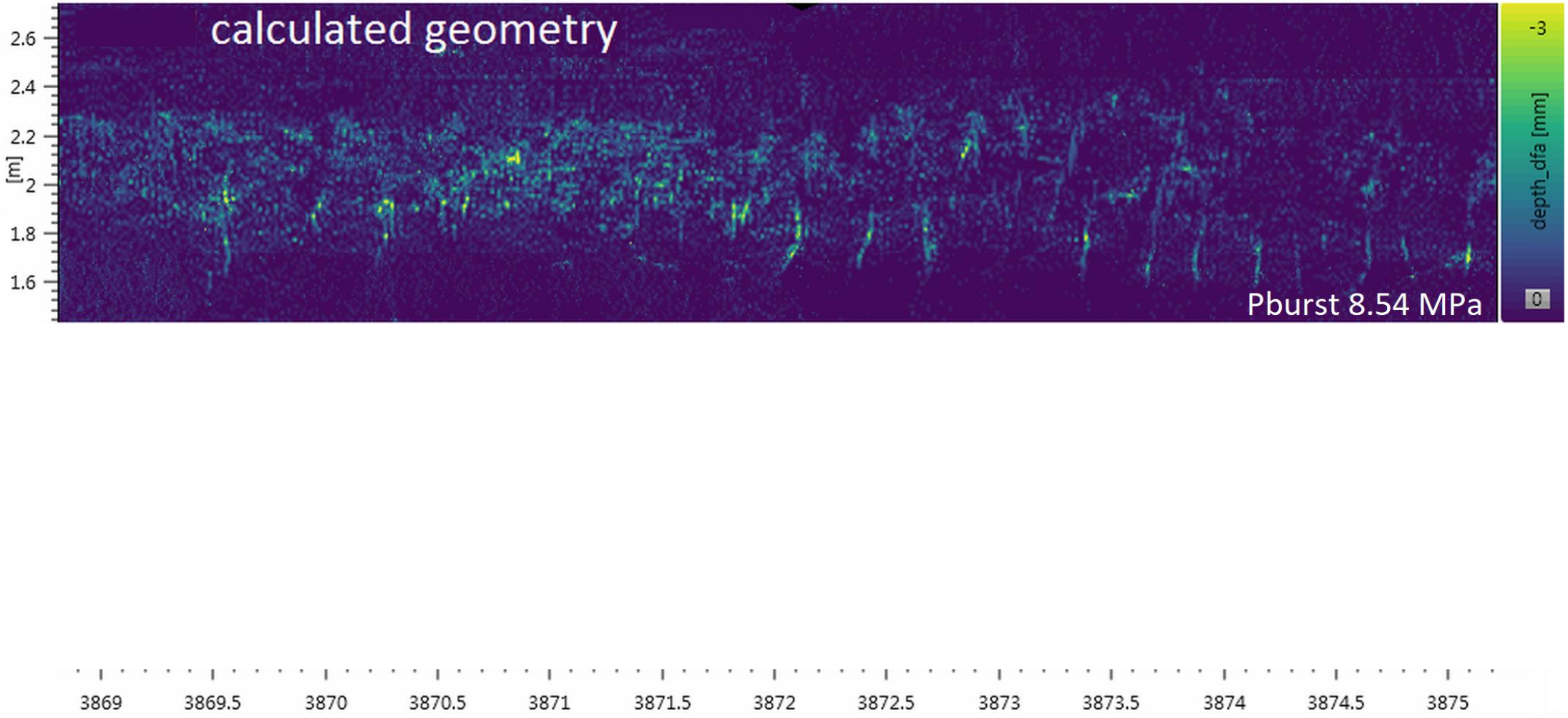


Reliable Grid Data, Input

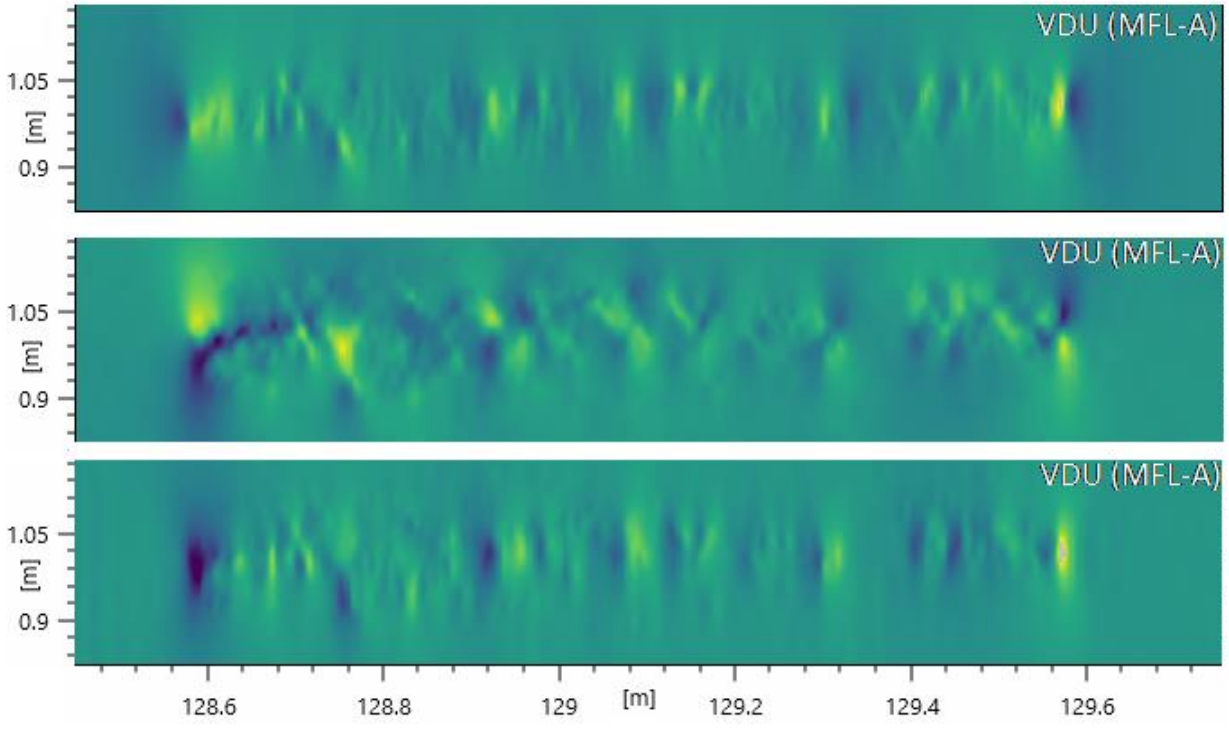


Reliable Grid Data, Process

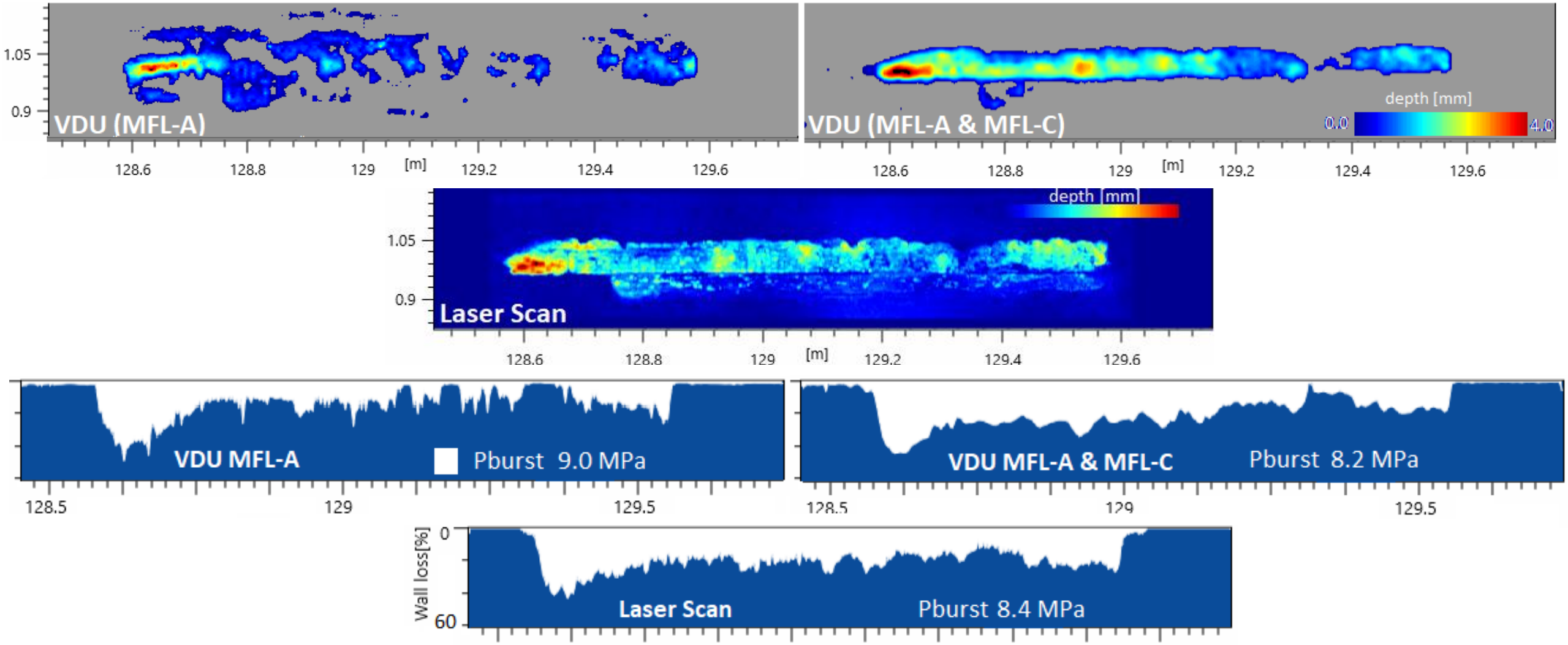
Reliable Grid Data, Output



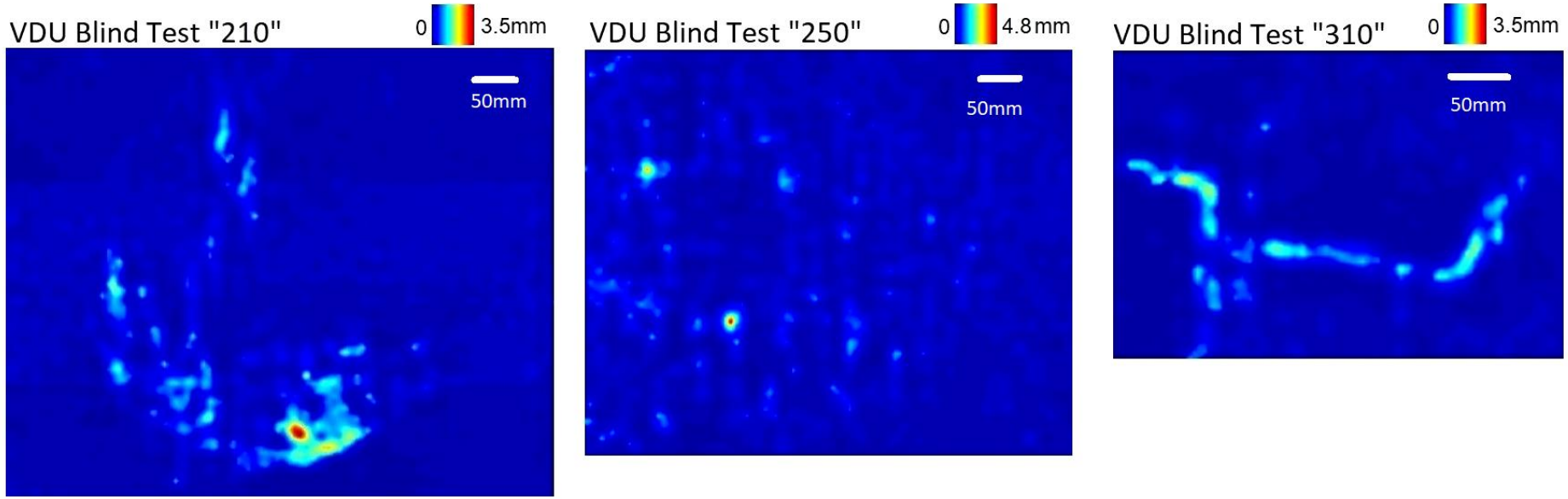
Reliable MFL Grid, Standalone MFL-A?



Reliable MFL Grid, Standalone MFL-A?



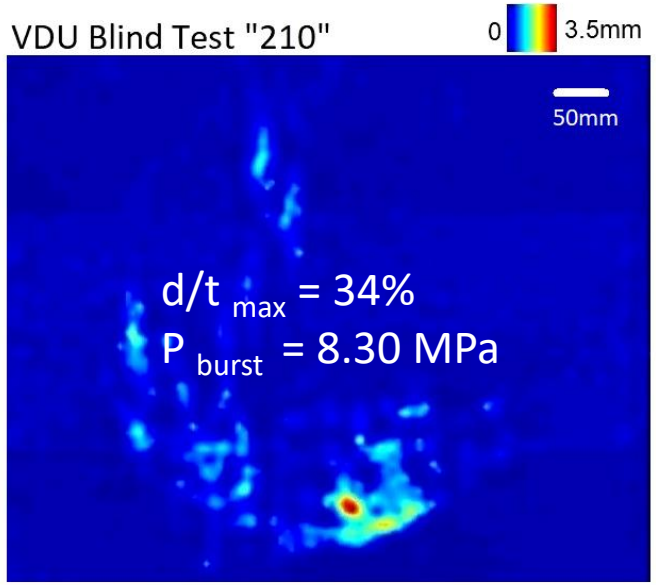
Blind Tests


VDU Blind Test "210"
0
3.5mm
50mm
VDU Blind Test "250"
0
4.8mm
50mm
VDU Blind Test "310"
0
3.5mm
50mm

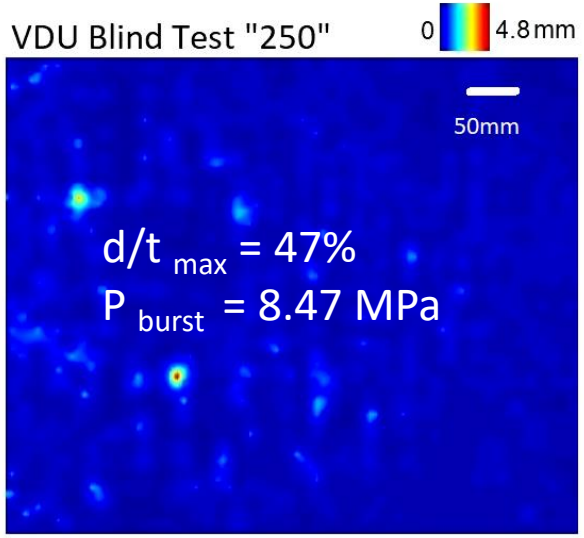
Blind Tests

Results and pinhole smear out appear comparable to UT.

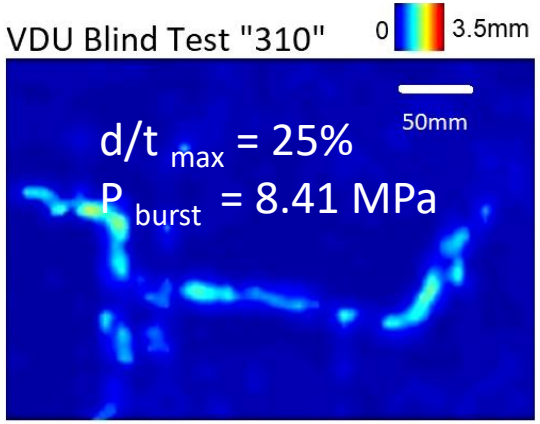
VDU Blind Test "210"

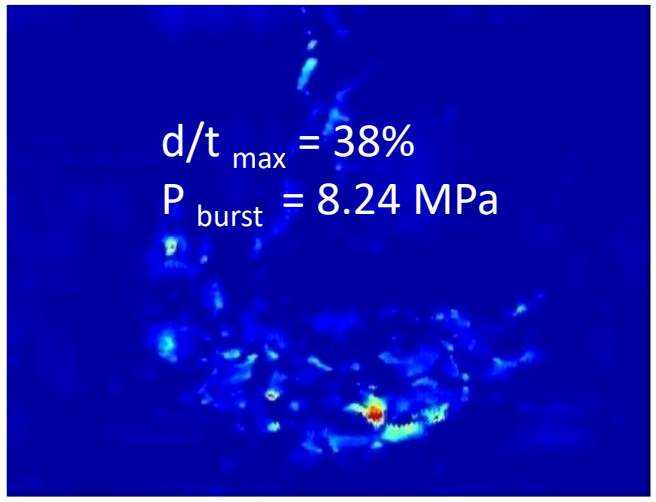


VDU Blind Test "250"

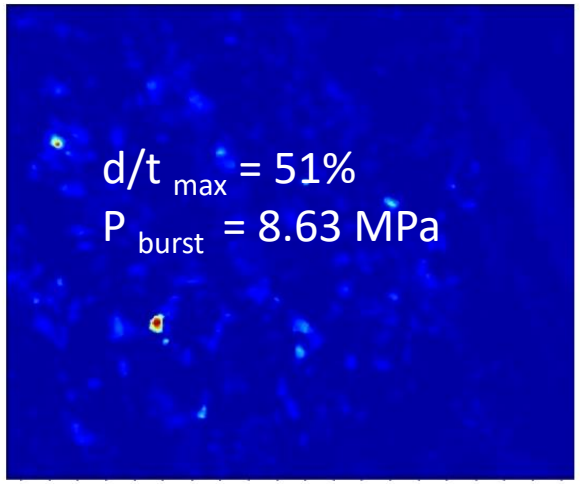


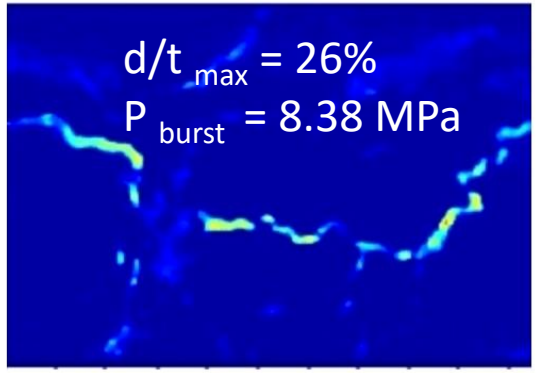
VDU Blind Test "310"





Field Laser Scan



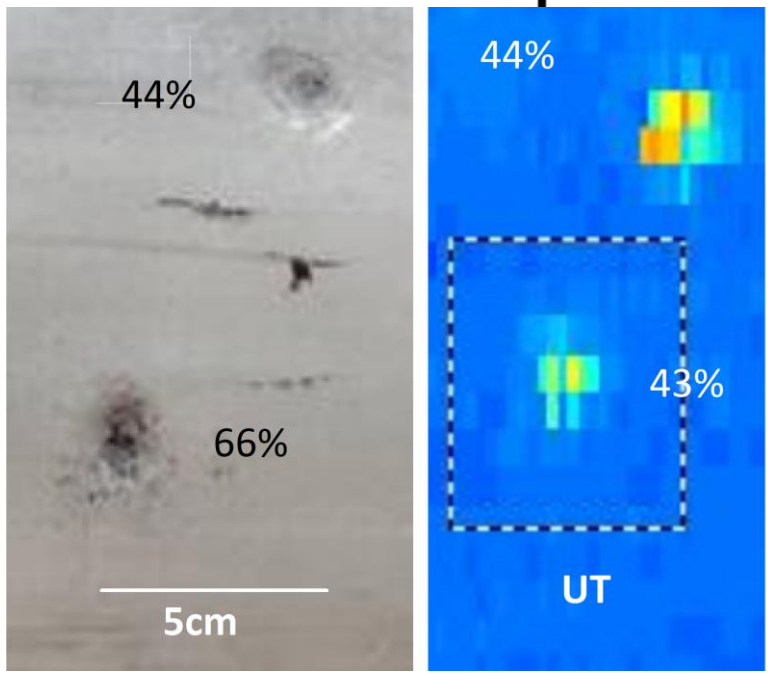


Accuracy Specification

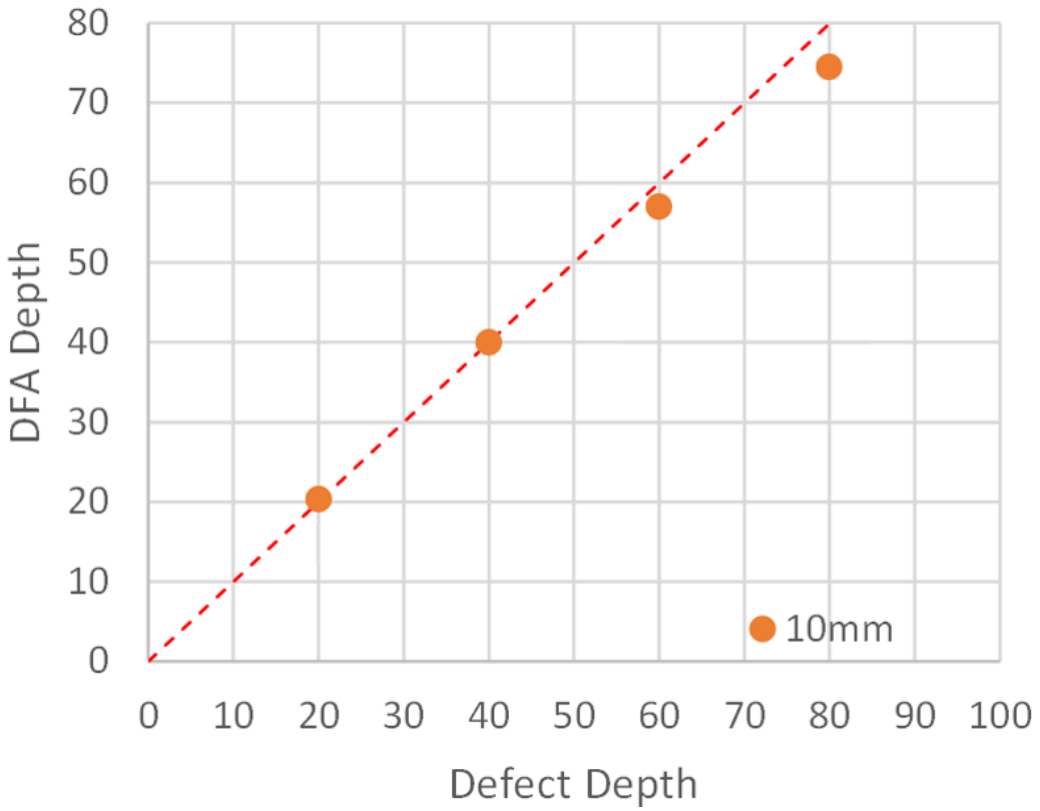
POF 100 Specifications and requirements for in-line inspection of pipelines

Table A4 - 3: Metal loss detection and sizing accuracy for technologies other than MFL.

Detection but no sizing at POD=90%	Minimum diameter	
	Minimum depth	
Detection and sizing at POD=90%	Minimum diameter	
	Minimum depth	
Depth sizing accuracy at 90% certainty		



Accuracy Specification



Draft target options, depending on essential variables set

		A	B
Detection but no sizing at POD = 90%	Minimum diameter	0.8 t	0.5 t
	Minimum depth	15% t	15% t
Detection and sizing at POD = 90%	Minimum diameter	1.5 t	1.0 t
	Minimum depth	12% t	8% t
Depth sizing accuracy at 90% certainty		**±6% t**	**±4% t**

Conclusions

- Ambiguity is a methodical MFL restriction of one magnetization direction.
- Ambiguity prevents unique solutions and leads to probability driven interpretation.
- Data interpretation suggests simplification.
- Artificial intelligence allows to reduce the simplification.
- Even AI does not remove the guessing.
- Two MFL magnetization directions overcome the ambiguity.
- The target of a unique solution makes calculation useful and realistic.
- Calculation allows for 3D metal loss grids.
- 3D grids allow UT like results and specifications with MFL.

Thank you for your attention.