



SSAB

On-line grain size gauge for the hot strip mill based on laser ultrasonics

Mikael Malmström¹, Anton Jansson¹,
Bevis Hutchinson¹, Peter Lundin¹,
Lars Gillgren², Linda Bäcke², Hans Sollander,
Matthias Bärwald³, Frenk Van den Berg⁴

¹ Swerim AB, Stockholm, Sweden.

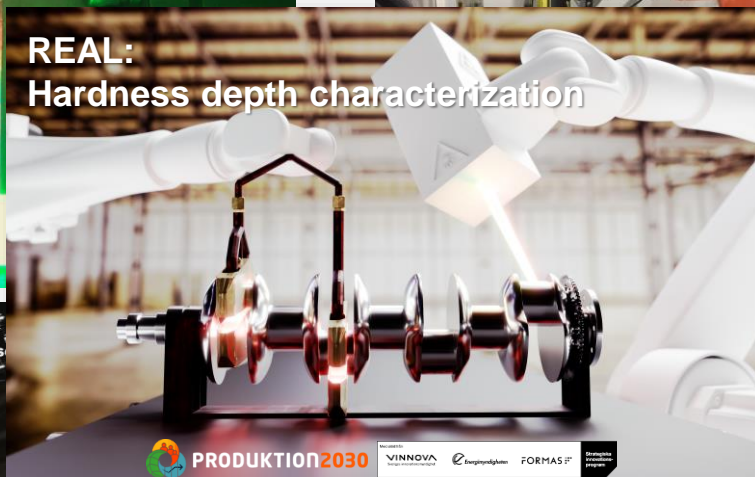
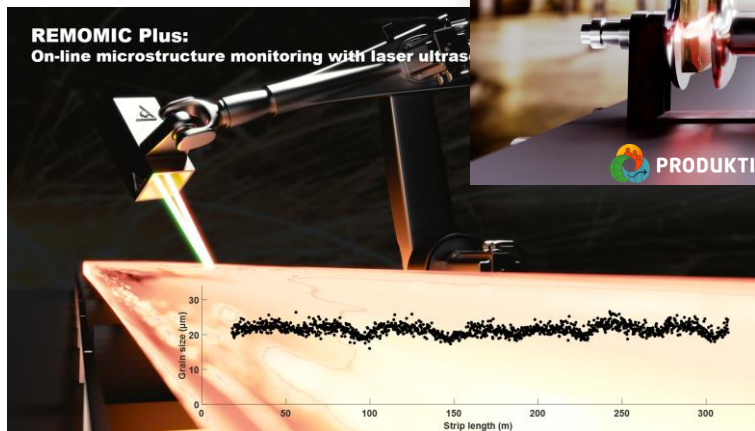
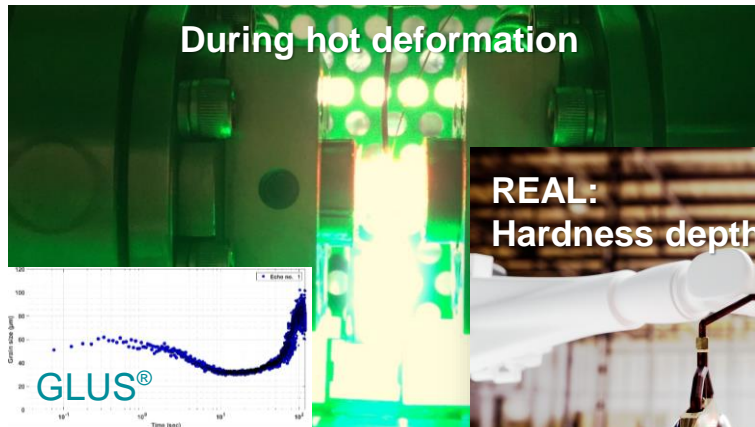
² SSAB EMEA AB, Borlänge, Sweden,

³ EMG Automation Wenden, Germany

⁴ Tata Steel, Velsen Noord, The Netherlands.

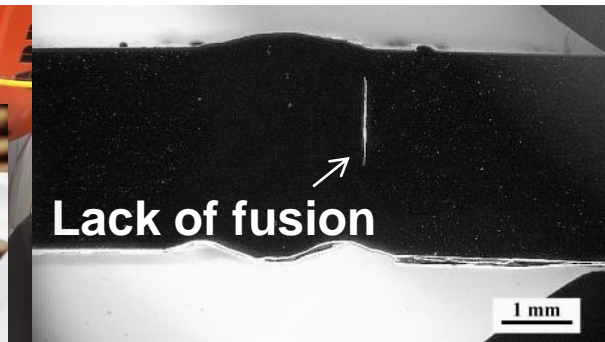


Microstructure characterization

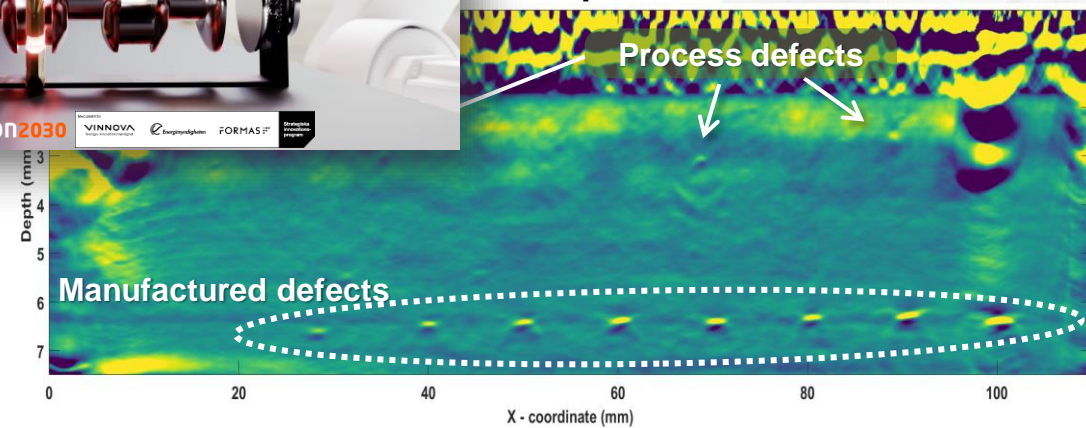


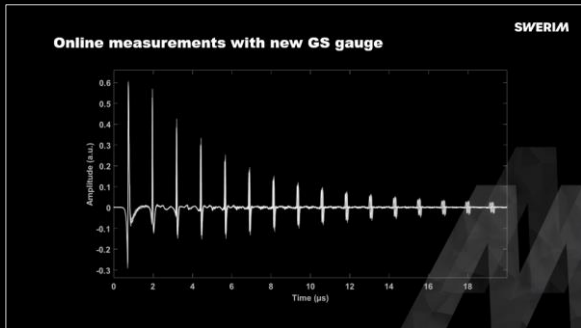
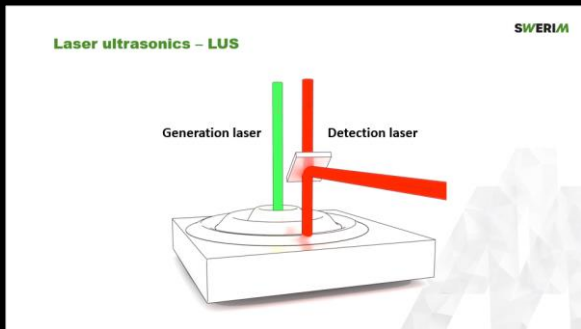
Defect detection

in welds



in AM parts





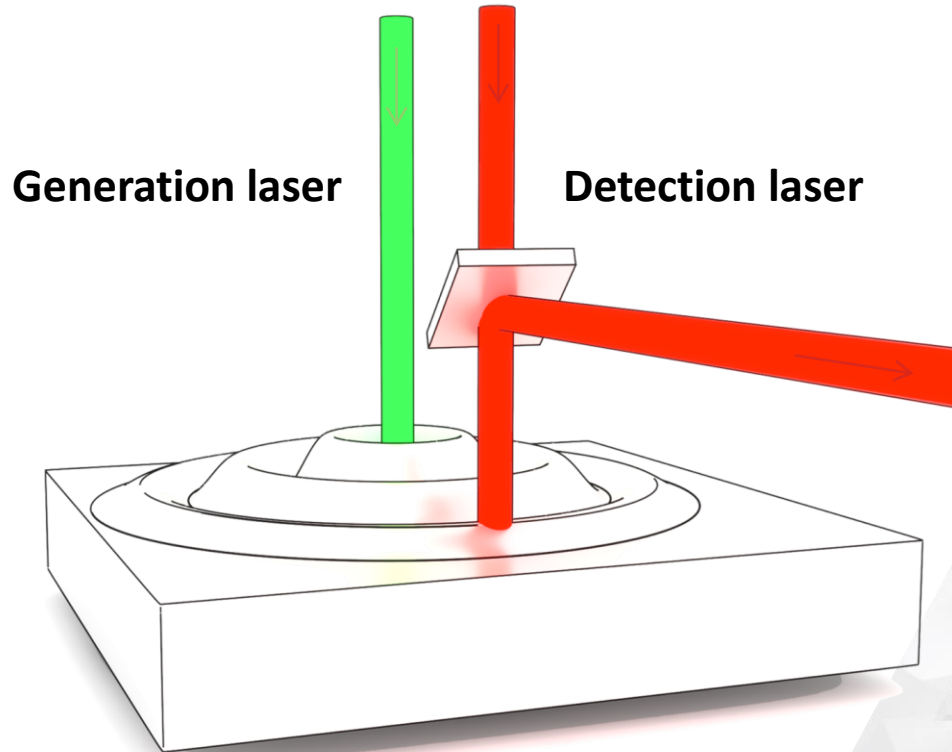
Summary

Process & control

Data handling for manufacturing practices

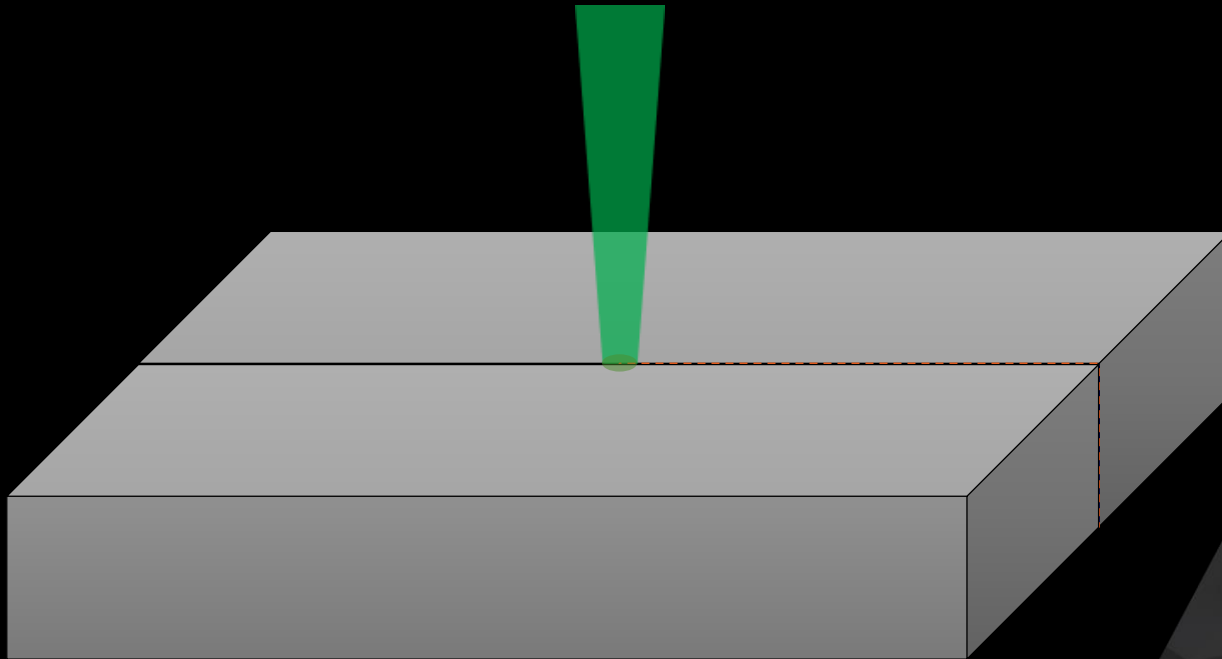
High speed Adaptive Non-Safe Sensor (HANS-S)

Laser ultrasonics – LUS

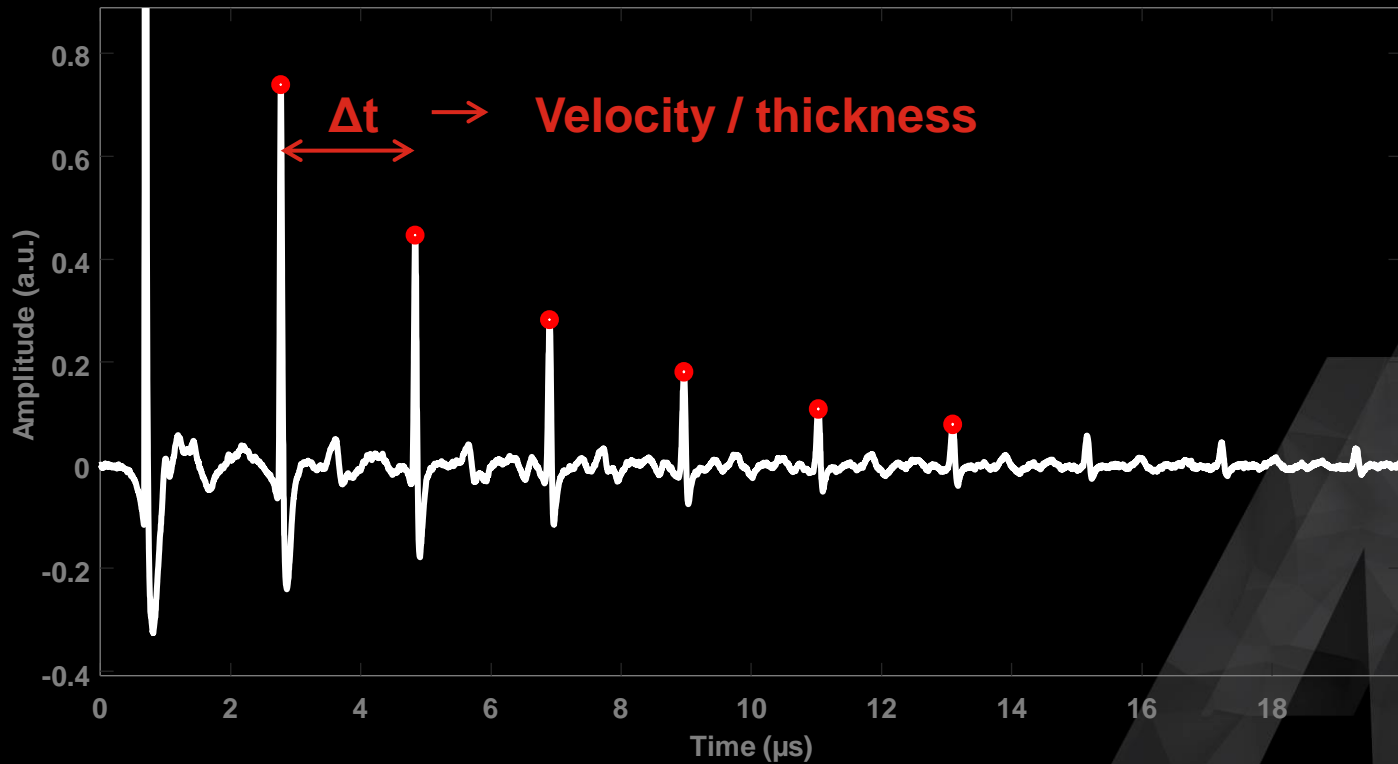


Laser ultrasonics – Grain size calculation

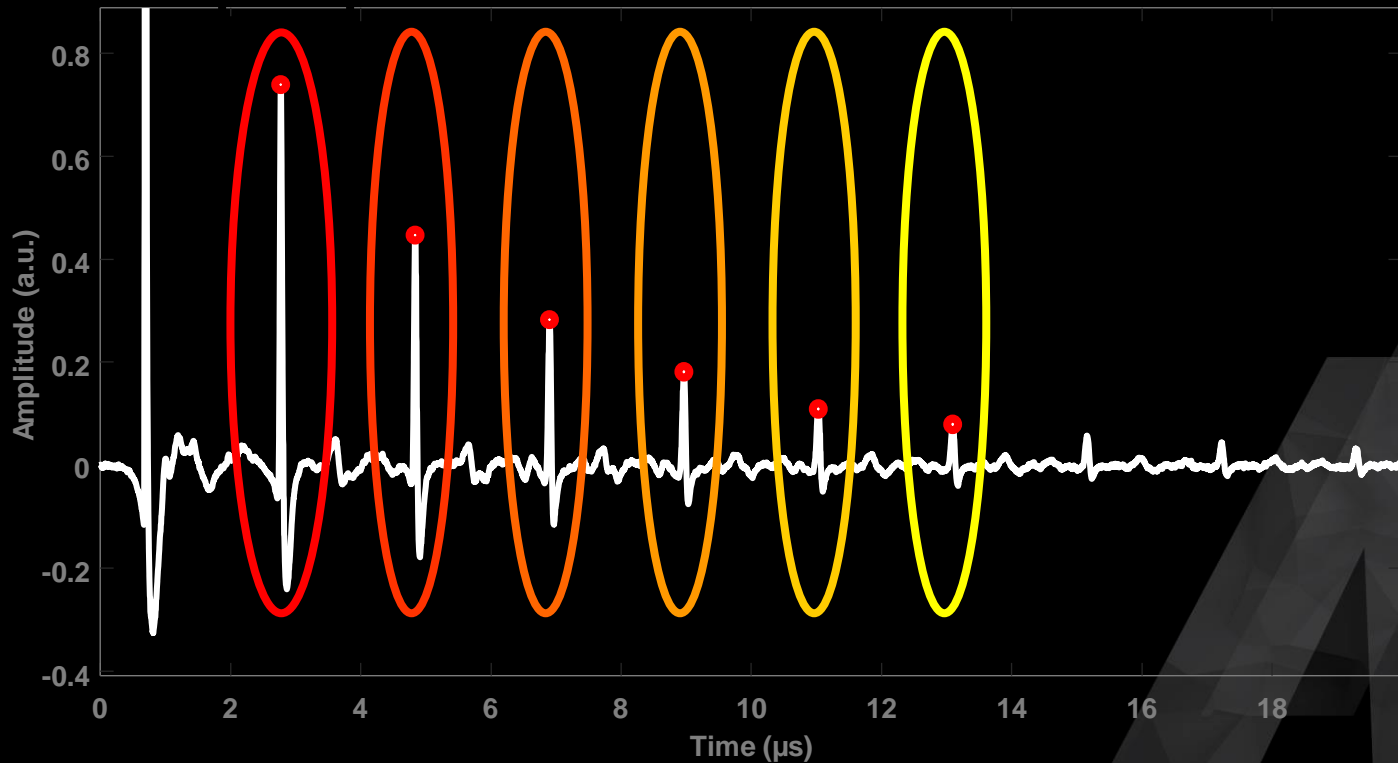
Generation and pulse propagation



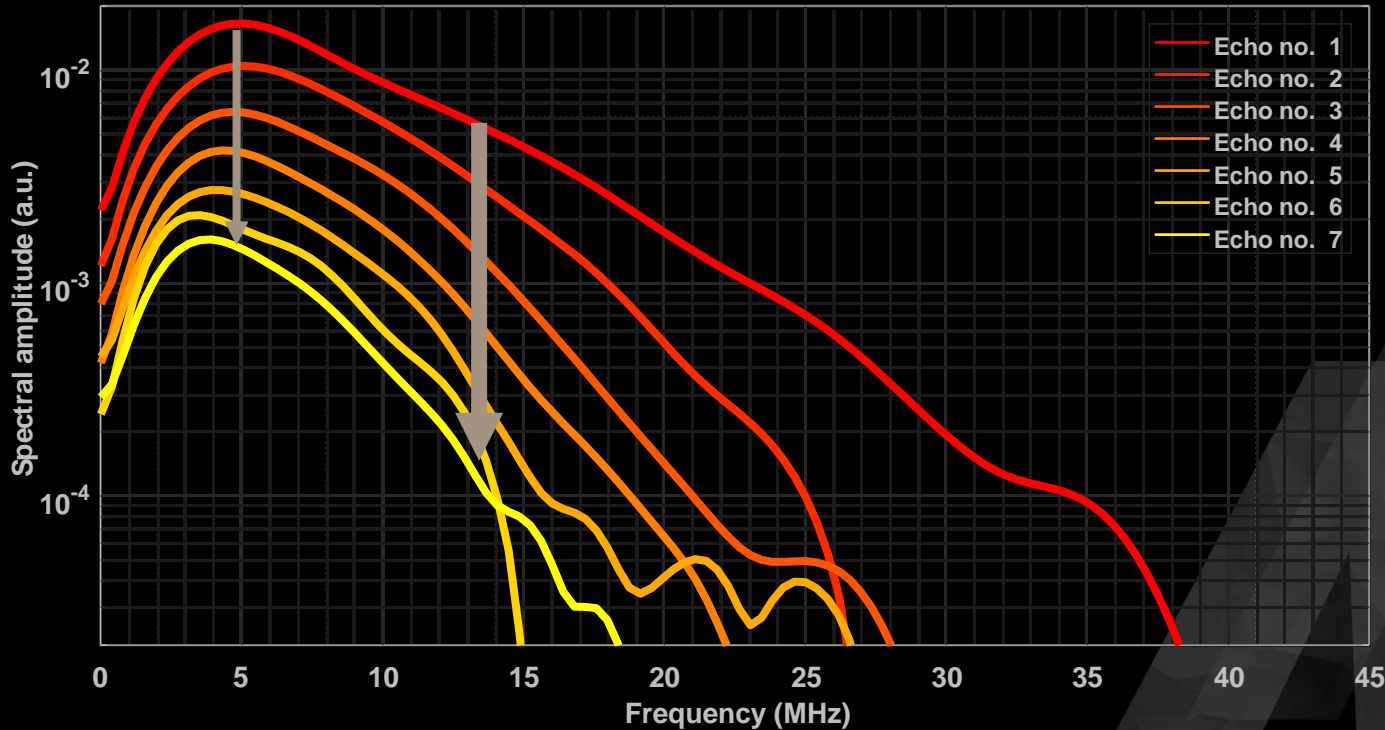
LUS principle A-scan



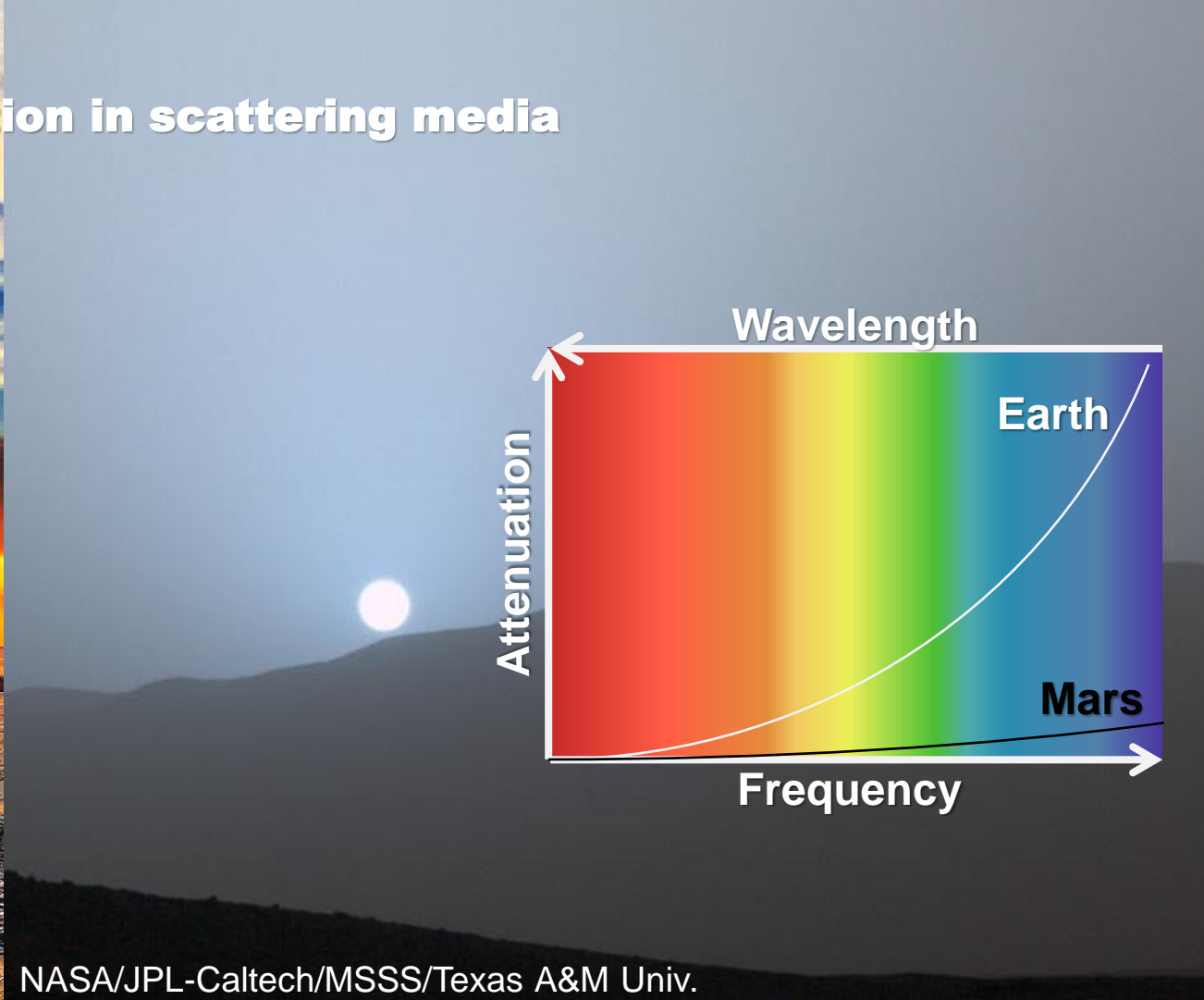
Frequency content of echos



Spectral content

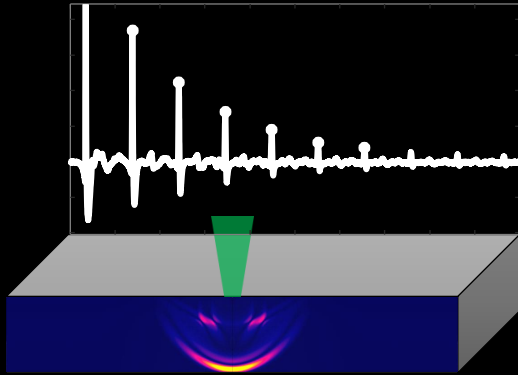


Spectral attenuation in scattering media

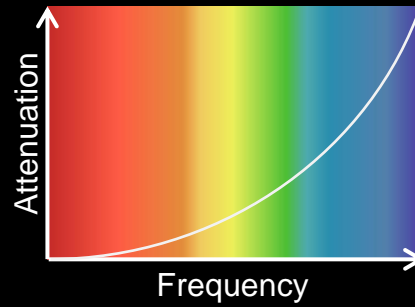


Grain size measurement with LUS

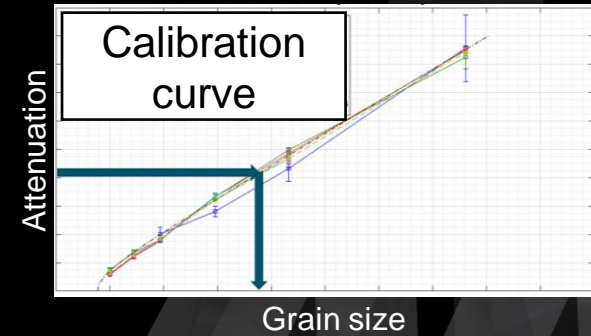
Measure



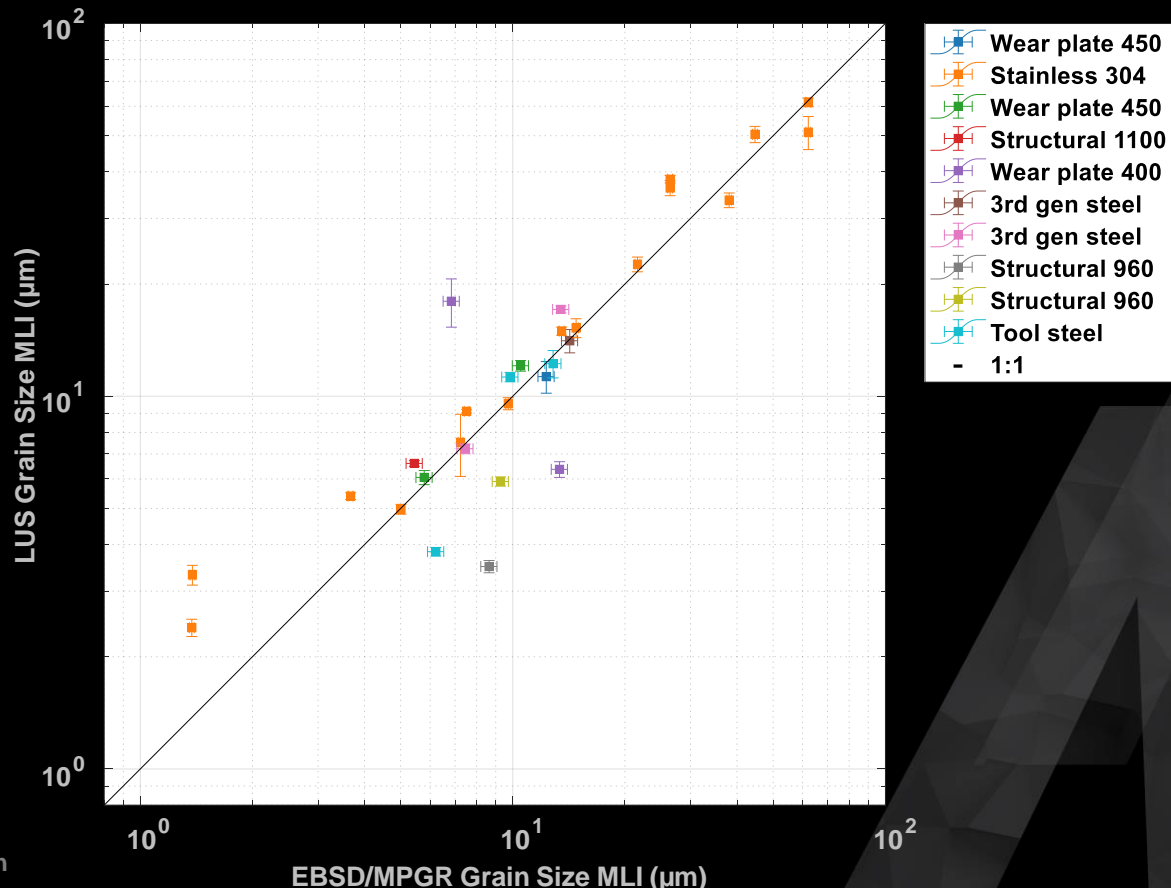
Attenuation



Grain size



LUS grain size vs EBSD/MPGR grain size, from RT to > 1100 °C



EBSD
Electron Back-Scattering Diffraction

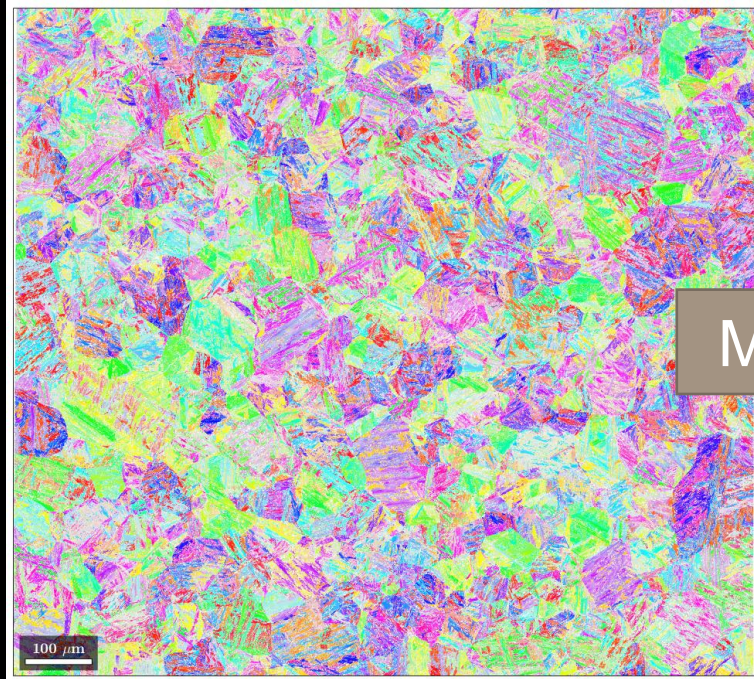
MPGR
Martensite Parent Grain Reconstruction

Reconstruction of PAG orientation map

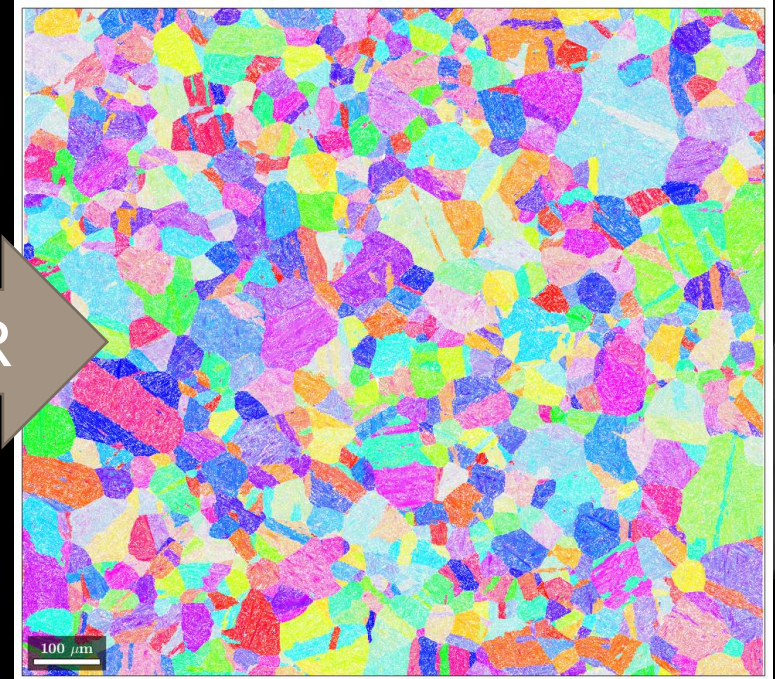
- Algorithm development started in 2015
- Cited in 63 scientific publications

Crystallography, Morphology, and Martensite Transformation of Prior Austenite in Intercritically Annealed High-Aluminum Steel, [Nyvssönen, T., Peura, P., Kuokkala, V.-T., *Metallurgical and Materials Transactions A*, 2018, 49\(12\), pp. 6426–6441](#)

Iterative Determination of the Orientation Relationship Between Austenite and Martensite from a Large Amount of Grain Pair Misorientations, [Nyvssönen, T., Isakov, M., Peura, P., Kuokkala, V.-T., *Metallurgical and Materials Transactions A*, 2016, 47\(6\), pp. 2587–2590](#)



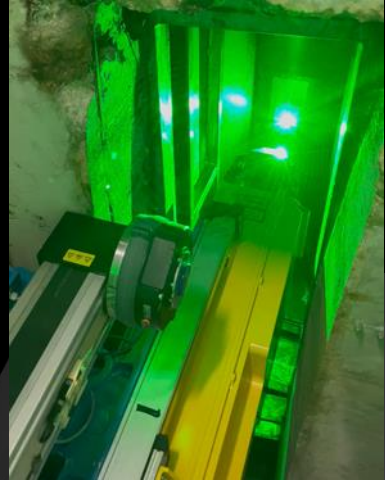
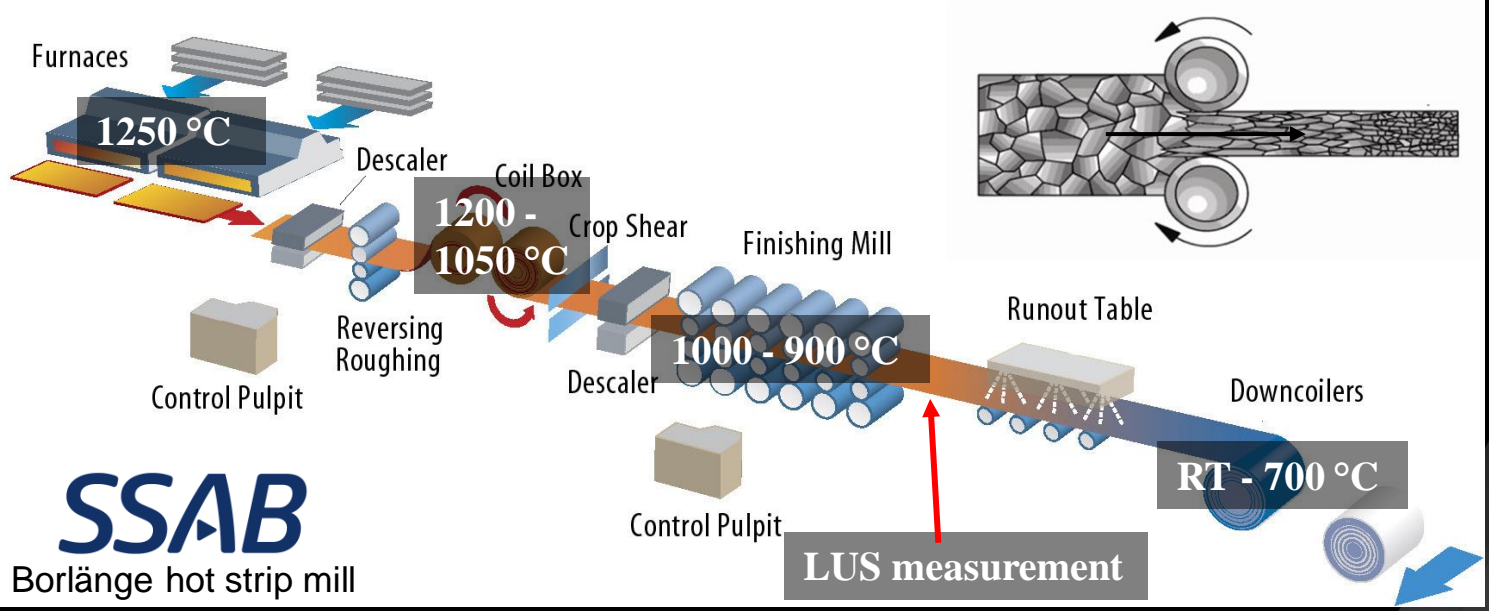
MPGR



New grain size gauge



New grain size gauge

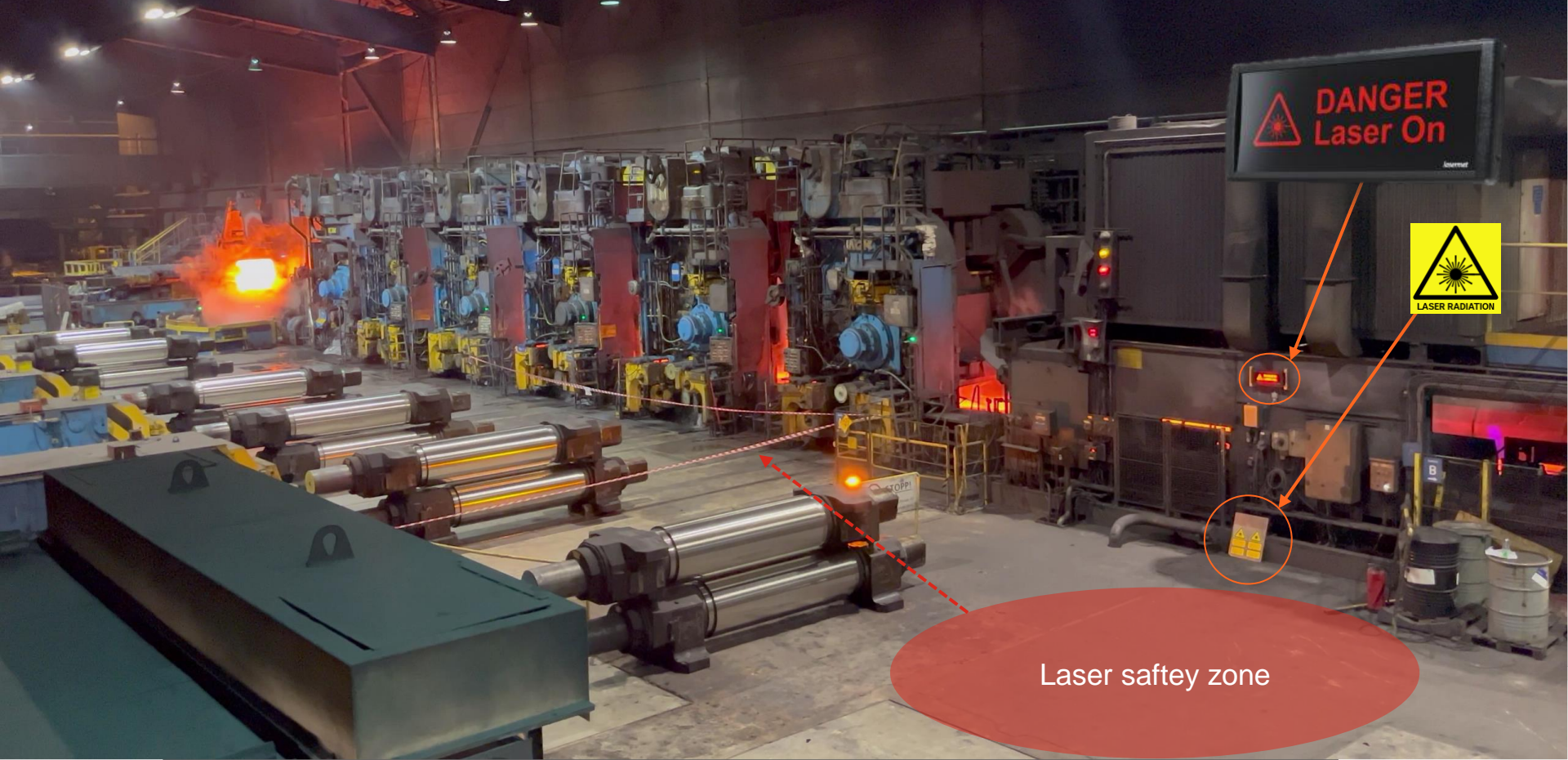


SSAB
Borlänge hot strip mill

Laser ultrasonic grain size measurement in HSM



Laser ultrasonic grain size measurement in HSM

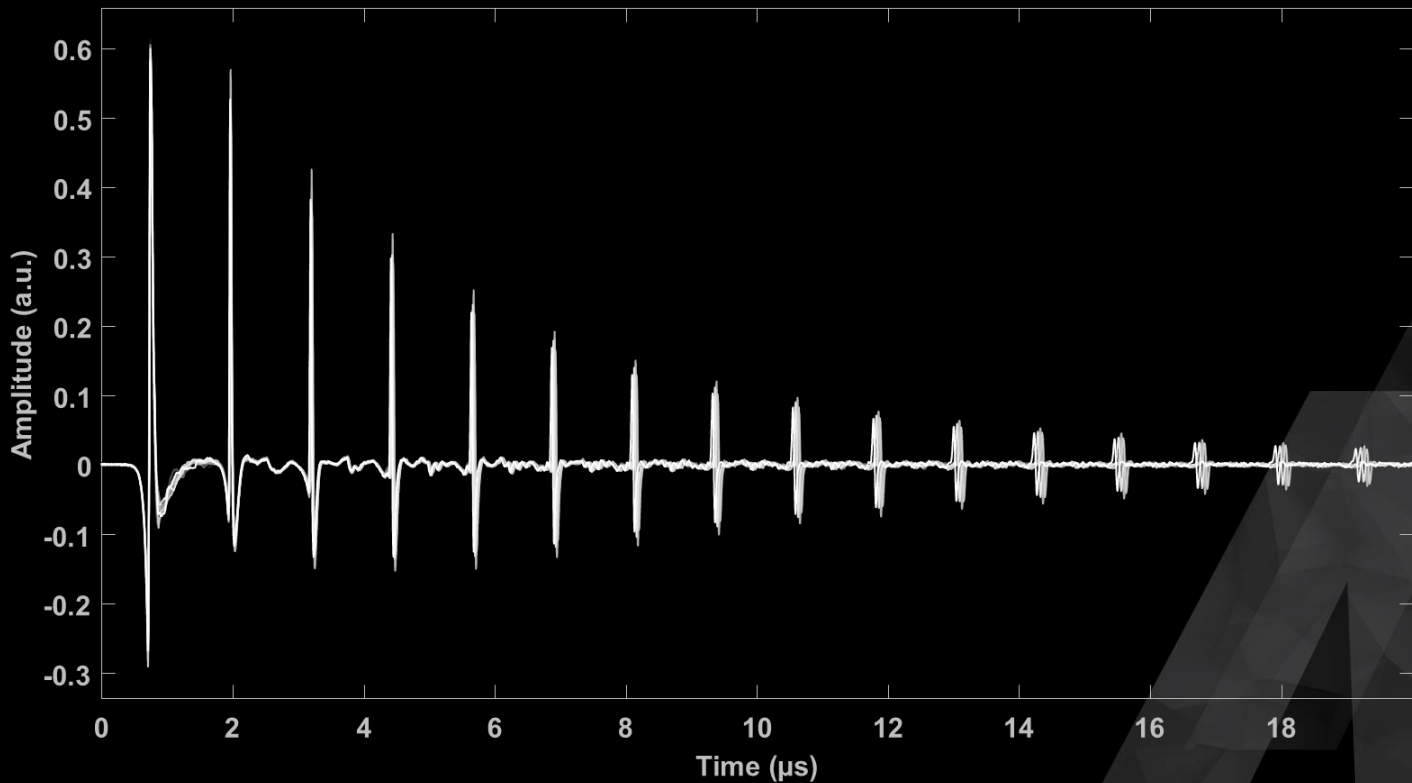


DANGER
Laser On



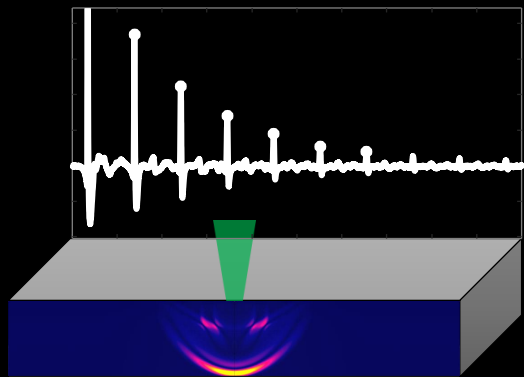
Laser safety zone

Online measurements with new GS gauge

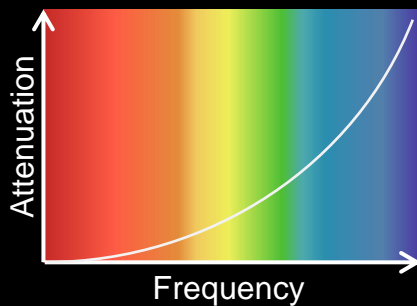


Grain size measurement with LUS

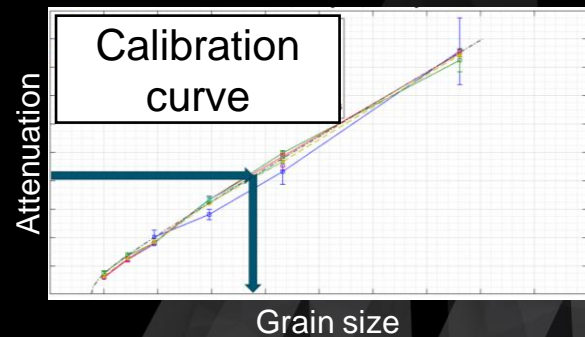
Measure



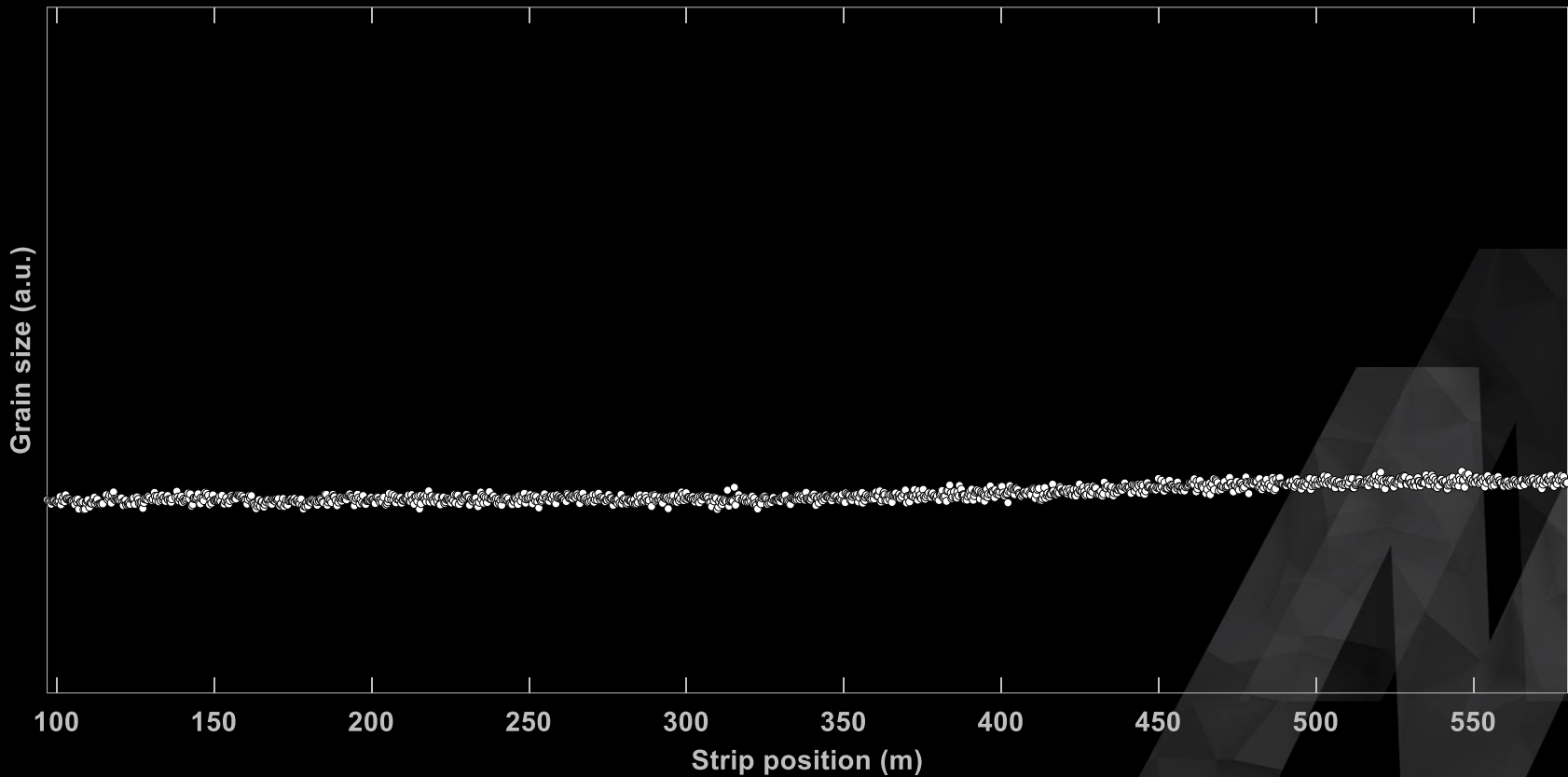
Attenuation



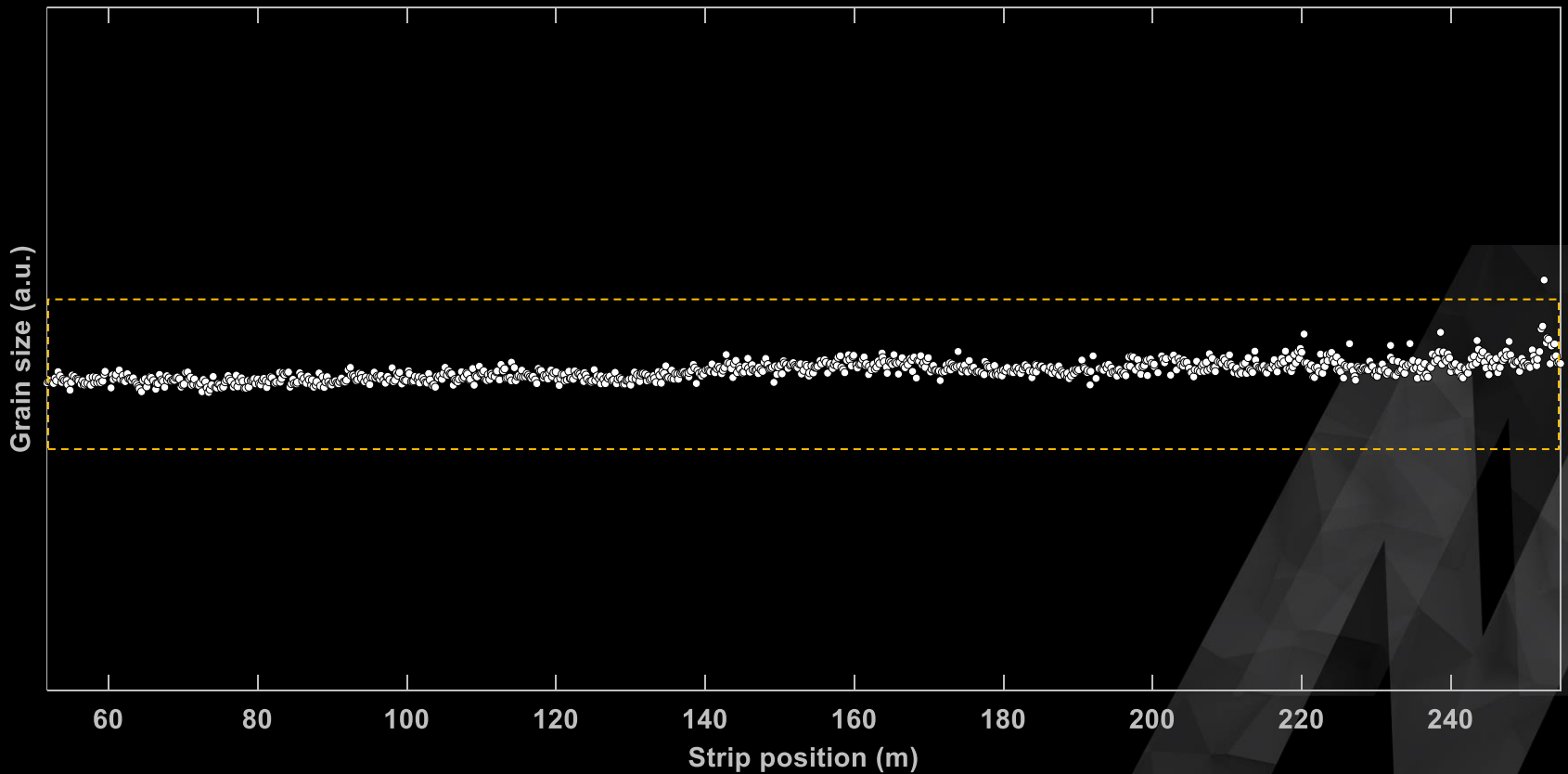
Grain size

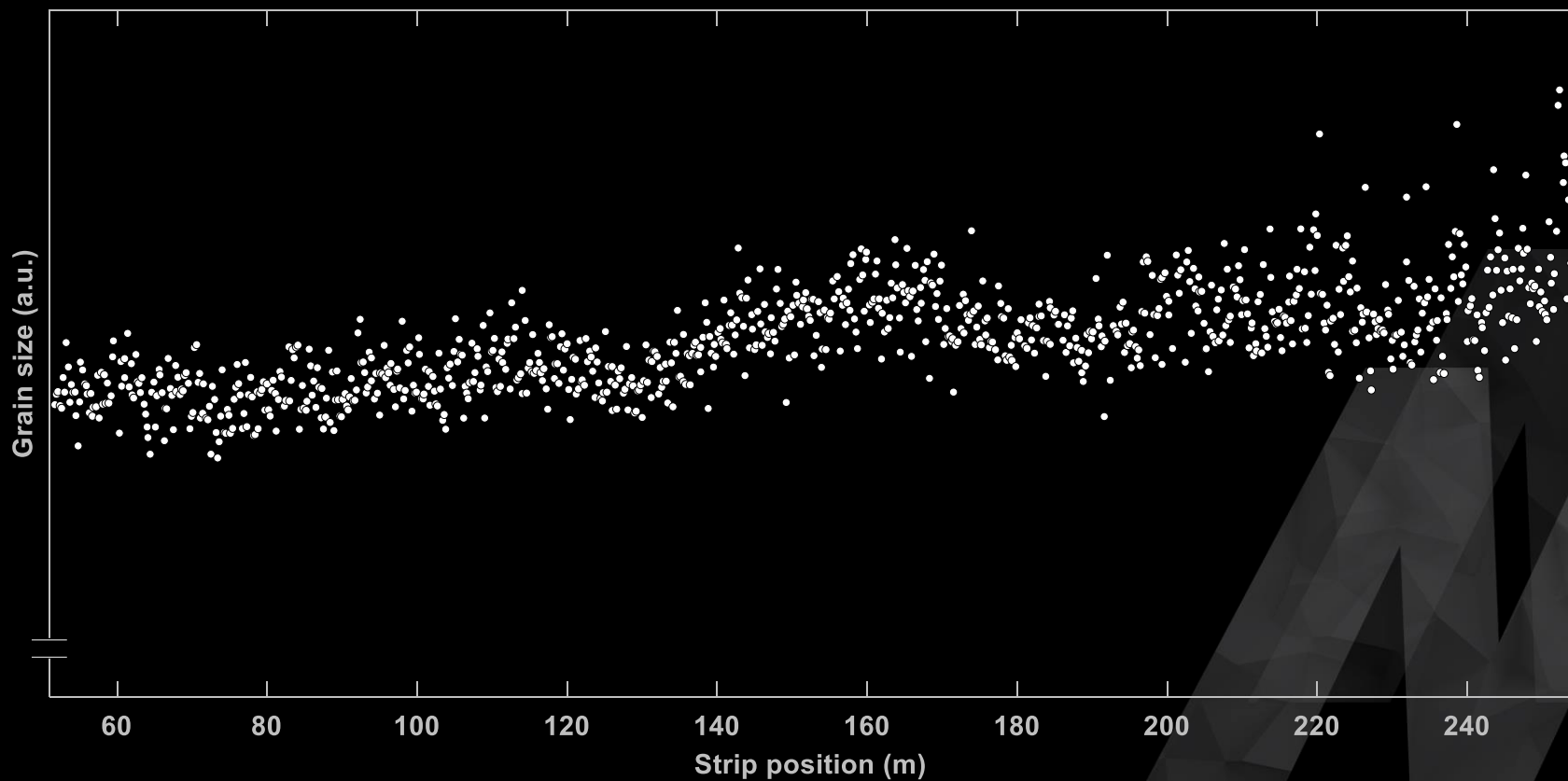


LUS measured grain size of hot strip



LUS measured grain size of hot strip



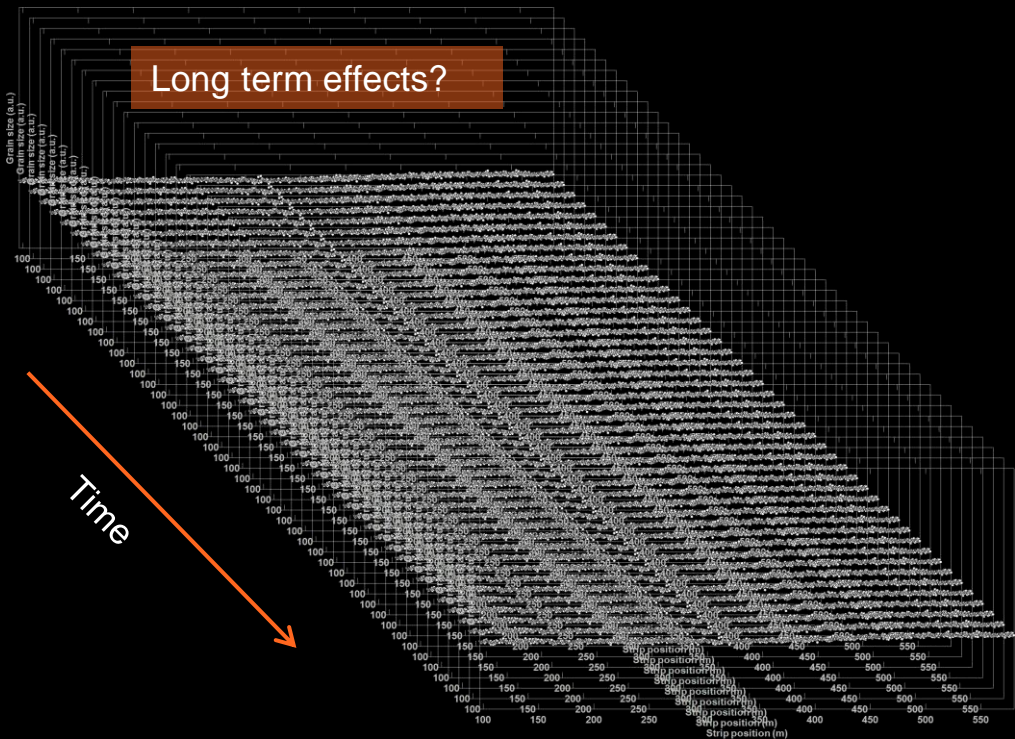
LUS measured grain size of hot strip (zoom)

Reheating furnace

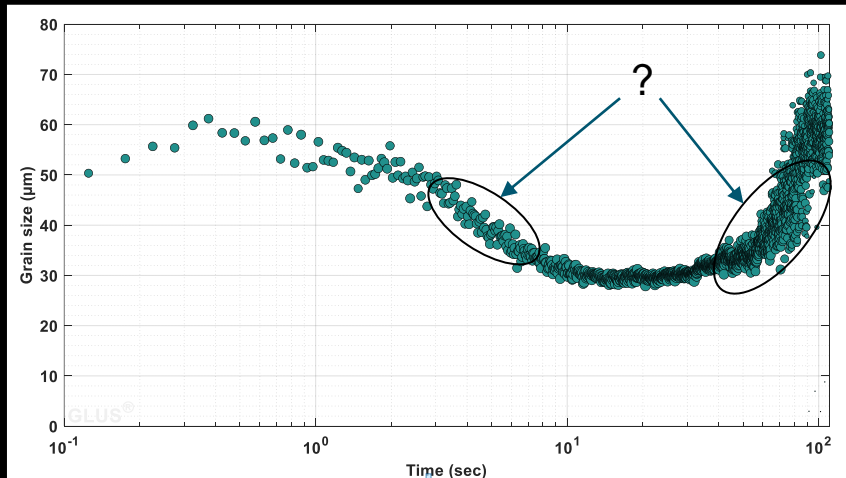
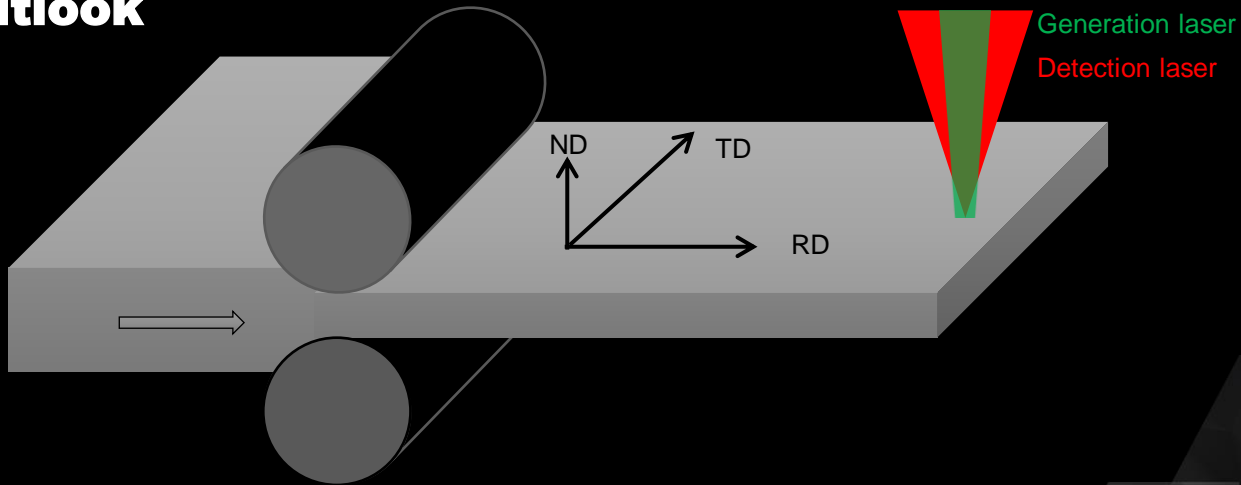


Walking beams are the cause of the skid marks

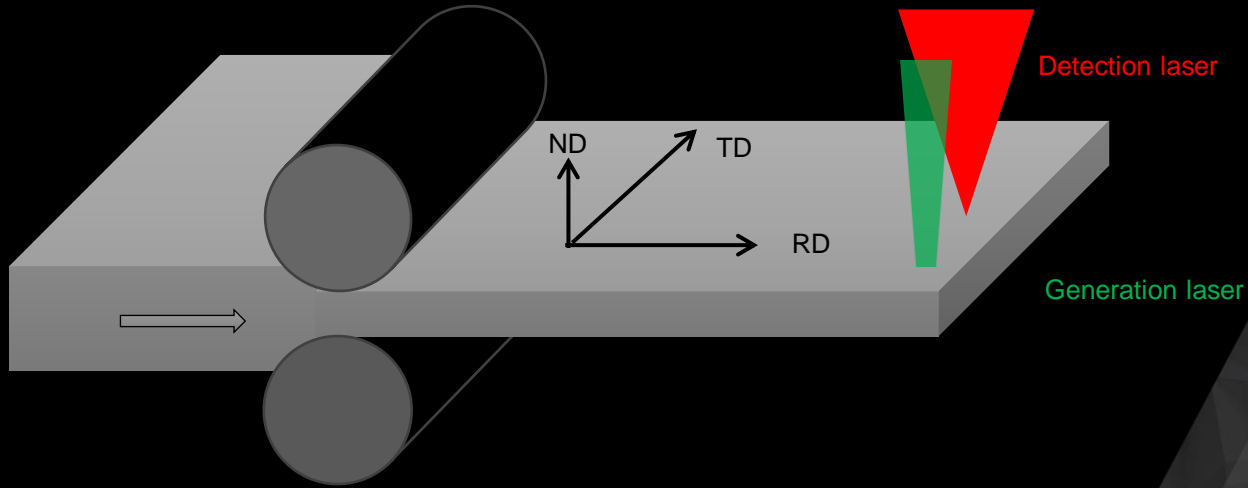
Future & outlook



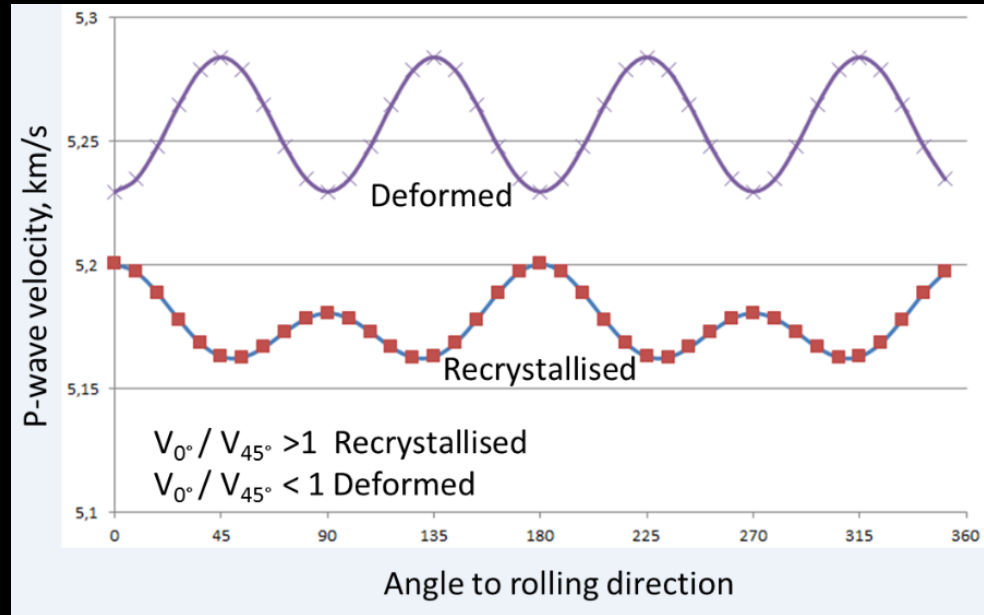
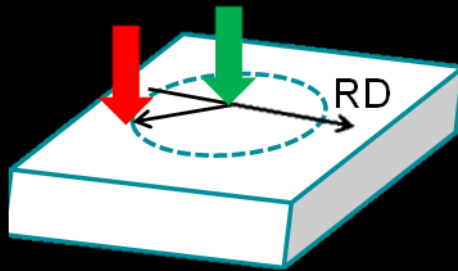
Future & outlook



Use anisotropy for recrystallized fraction estimation



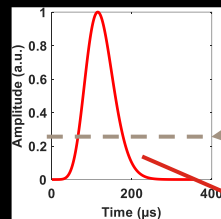
Use anisotropy for recrystallized fraction estimation



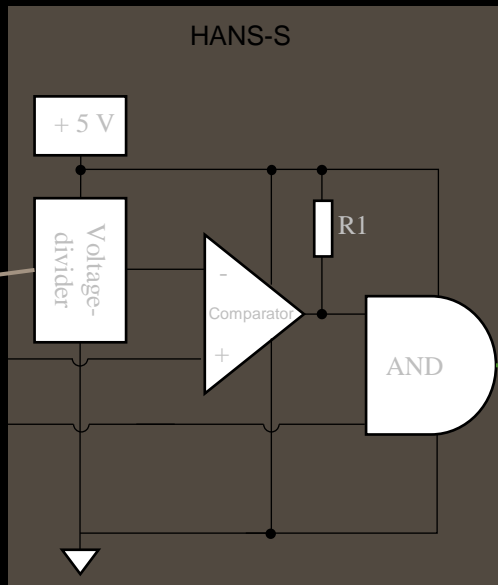
High speed Adverse Non Safe Sensor (HANS-S)



Reference signal



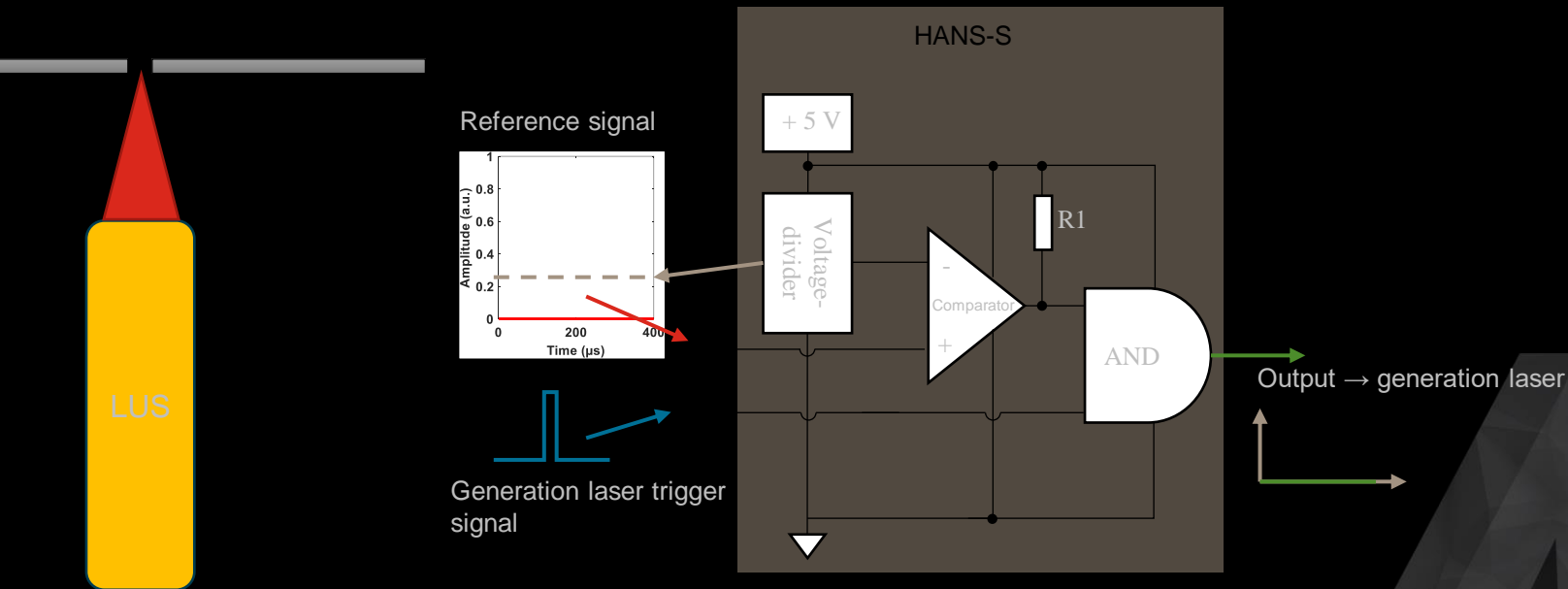
Generation laser trigger signal



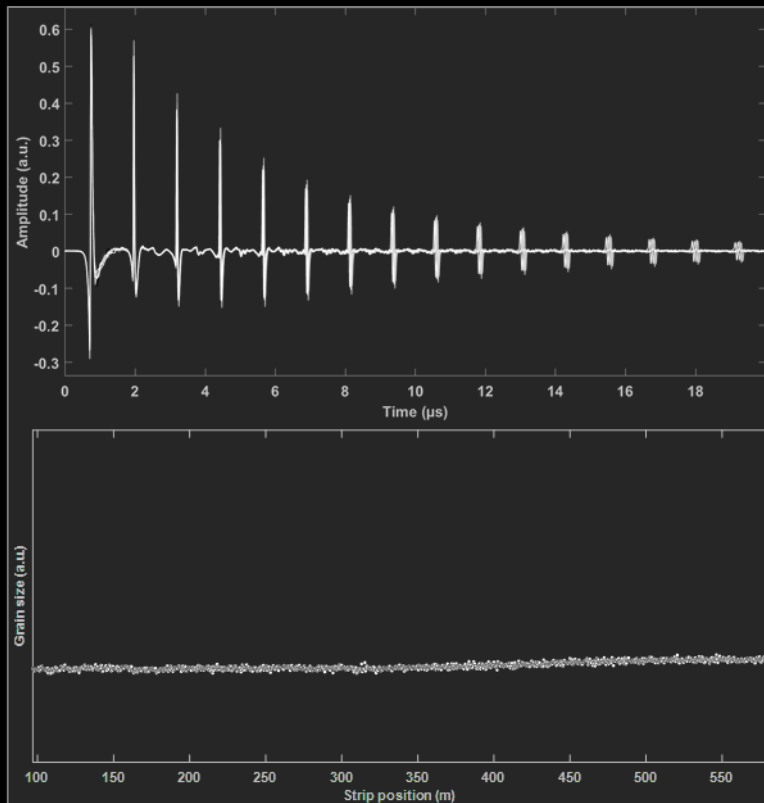
Output → generation laser



High speed Adverse Non Safe Sensor (HANS-S)



Summary



Future & outlook SWERIM

Long term effects?

Use anisotropy for recrystallized fraction SWERIM

Deformed
Recrystallised

$V_{90} / V_{45} > 1$ Recrystallised
 $V_{90} / V_{45} < 1$ Deformed

Angle to rolling direction

Lena Mourizson, Beata Malmström, Prita Båte, Peter Lundin, Mikael Malmström, and Eva Lindh-Jönsson, "Texture Studies Using Laser Ultrasonics (LUS) in Metal Processing", Phasex '20, Communications, 2017. <http://www.phasex.com/wordpress/wp-content/uploads/2017/07/texture-studies-using-laser-ultrasonics-lus.pdf>

High speed Adverse Non Safe Sensor (HANS-S) SWERIM

Reference signal
Generation laser trigger signal
AND
Output → generation laser

Acknowledgement: The authors wish to thank Simon Fitch for the original design of the circuit.



More LUS/GLUS®/LUS-online info:

<https://www.swerim.se/en/services/material-analysis-process-monitoring/laser-ultrasonics-lus/glusr-gleeble-lus>

<https://www.swerim.se/en/services/material-analysis-process-monitoring/laser-ultrasonics-lus>

<http://urn.kb.se/resolve?urn=urn:nbn:se:kth:diva-300906> (Recorded presentation)

<http://urn.kb.se/resolve?urn=urn:nbn:se:kth:diva-259955>