Cone type Phased Array Design for High Speed Hollow Axle Inspection

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Abstract

To increase inspection speed and inspection reliability the use of phased array system is a superior solution. Especially for shaft inspection phased array setups are commonly used. For hollow axle inspection typically a number conventional probes rotating through the axles drilling are applied, without demounting the axes and without dismantling the wheels and the brake discs.

A new approach using a cone type array operated in immersion technique will allows to increase inspection speed and reduce the mechanical effort of the inspection system by rotating the sound field for the circumferential scan electronically. Only a linear movement of the probe is necessary to move the phased array cone forward and backwards inside the drilling. By applying additional focal laws the beam can be inclined exactly and be focused in the plane vertical to the specimen axis to concentrate the sound in the zones close to the external surface of the railway axle.

The cone type phased array probe has been optimized to detect transversal flaws in and close to the outer surface of the hollow axle, whose surface lies in the radial-radial plane.

The prototype probe system and its performance will be presented.

Sicherheit in Technik und Chemie

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CONE TYPE PHASED ARRAY DESIGN FOR HIGH SPEED HOLLOW AXLE INSPECTION

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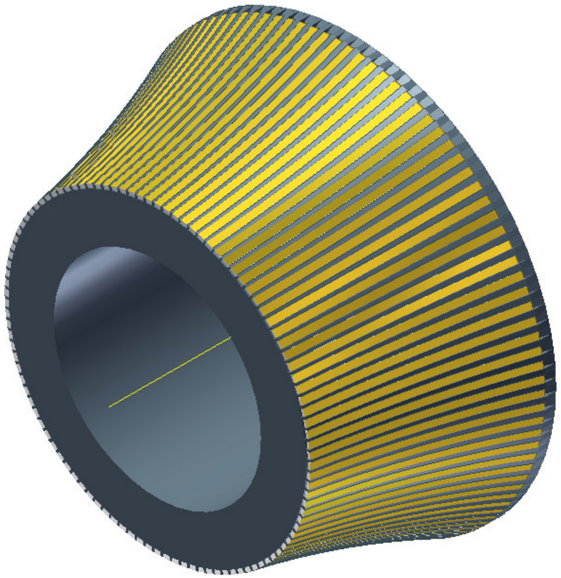
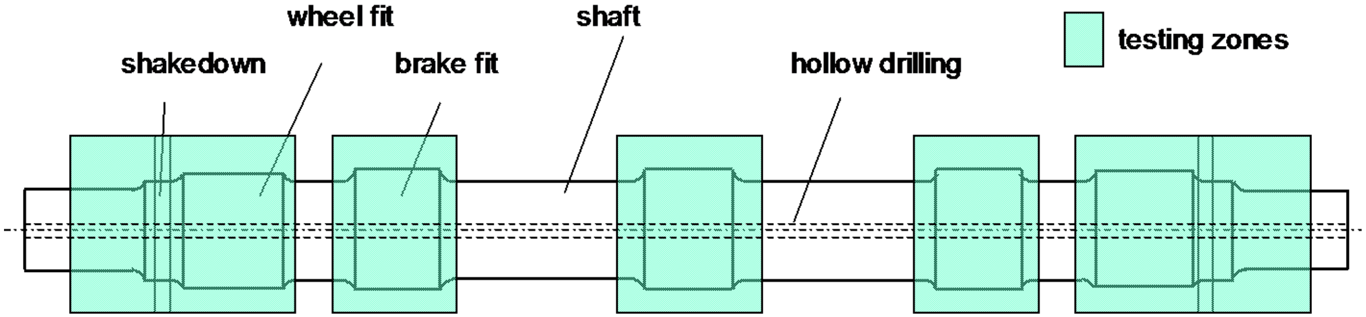
CONTENT

- Task
- Principle of the scanning technique
- Prior developments
- New array design
- Conclusion



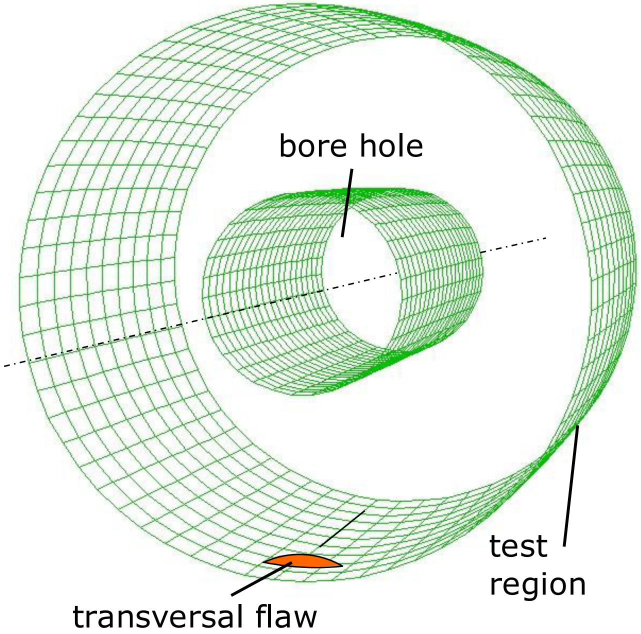
New Array Design for Electronic Rotation Scanning

TASK



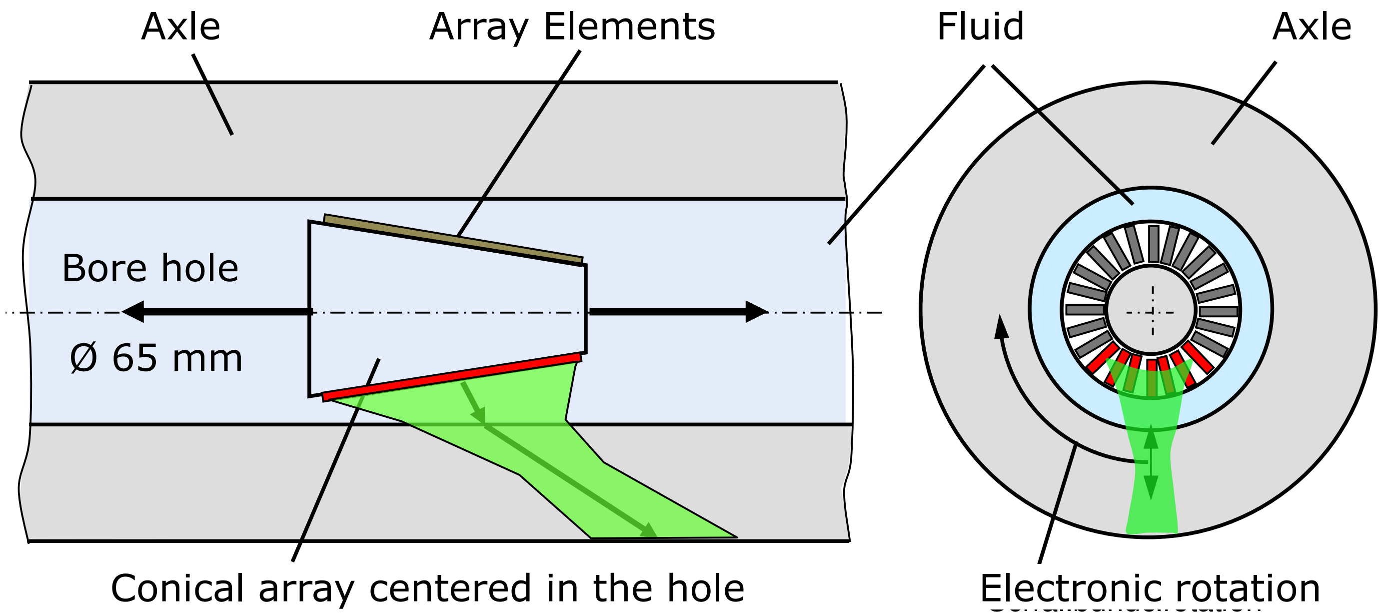
Rail axle with longitudinal bore hole and test zones

TASK



Orientation of transversal flaw in the radial – radial plane

PRINCIPLE OF THE SCANNING TECHNIQUE



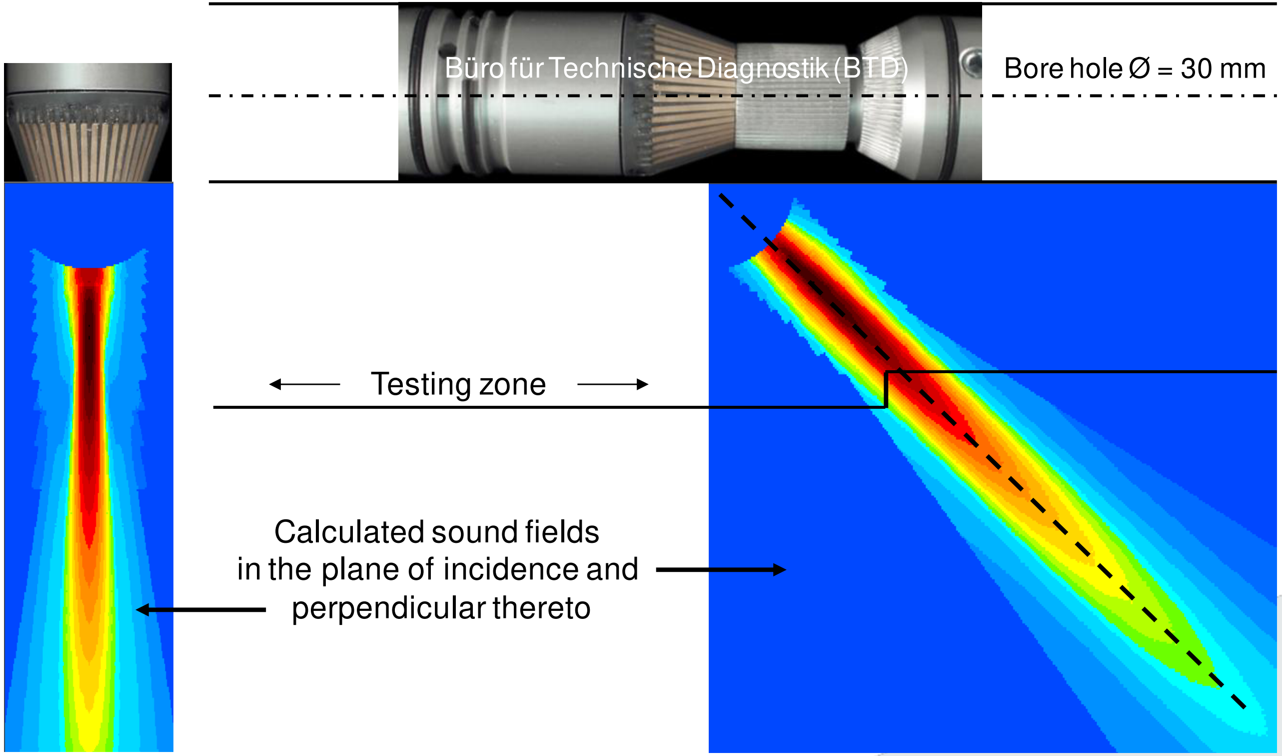
Sketch of the cone shaped phased array for electronic rotation scan

RESULTS OF PRIOR STUDIES

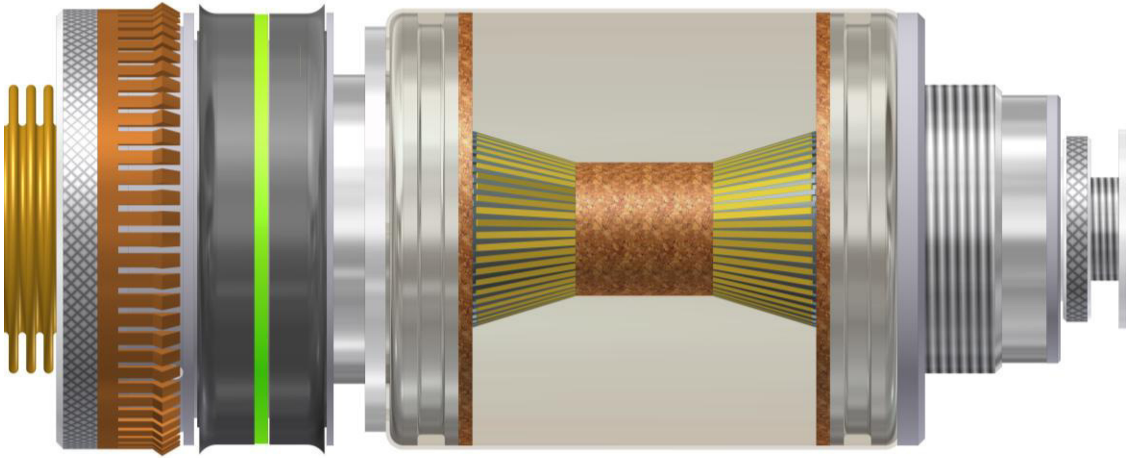
First cone array shown at ECNDT 2006

and

Calculated sound fields

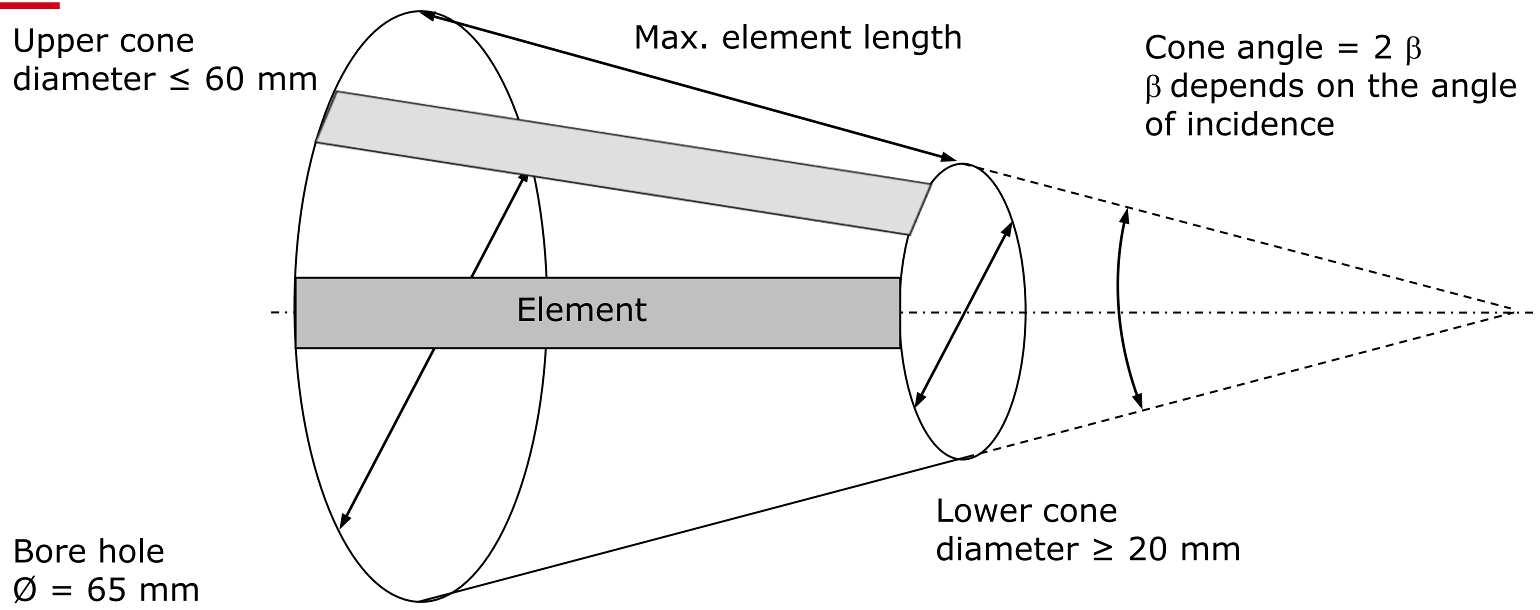


RESULTS OF PRIOR STUDIES



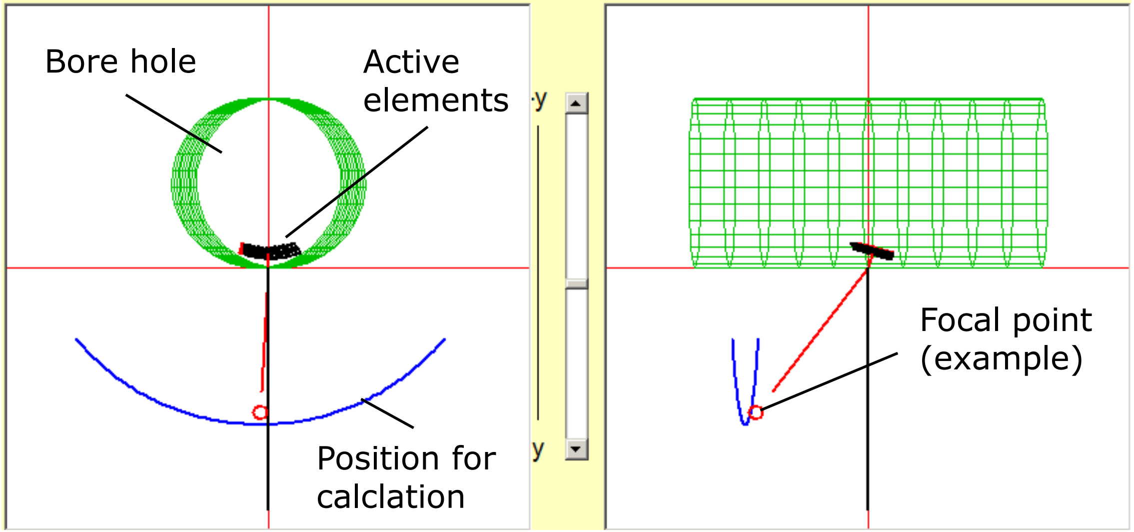
Cone array system encapsulated in an oil cavity for simultanious testing in foreward and backward direction; developed in the project WOLAXIM 2012

NEW DESIGN



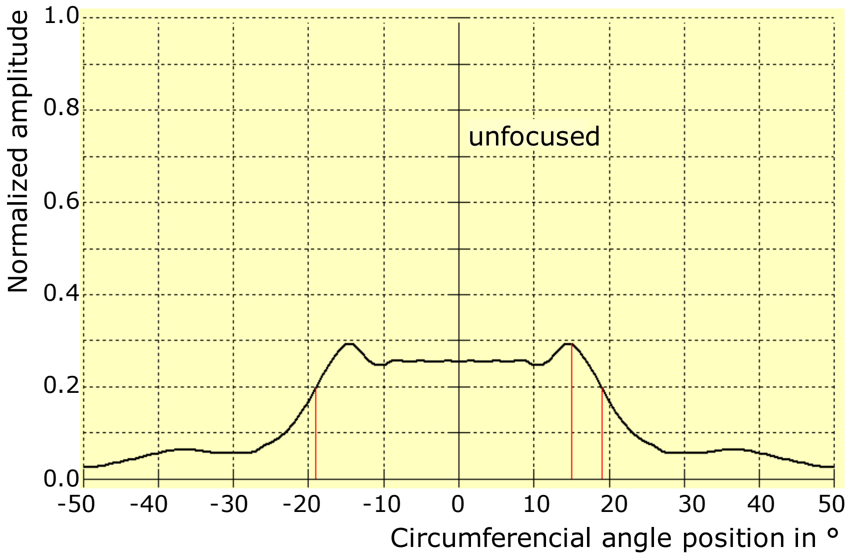
Geometrical boundary conditions for the current task

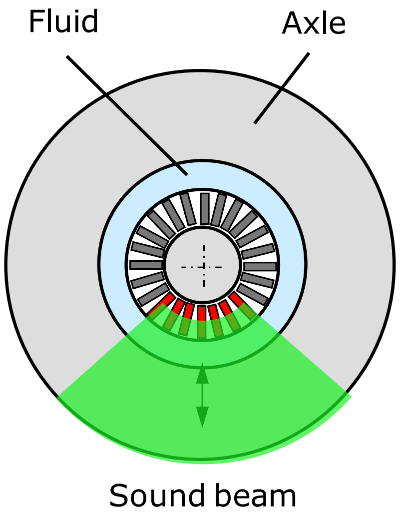
SOUND FIELD SIMULATION



The position of the array in the bore hole and the line of computation points circumferential at the outer surface of the axle with Ø = 175 mm

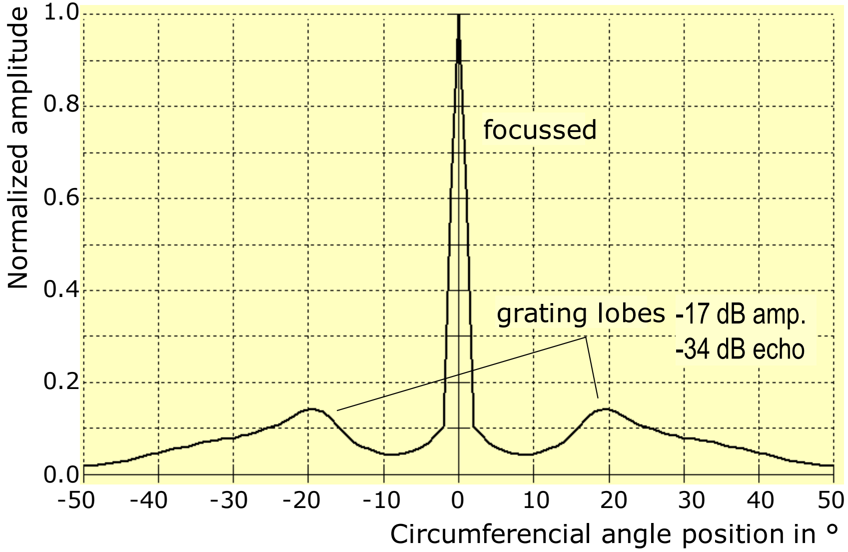
SOUND FIELD SIMULATION, FOCUSING

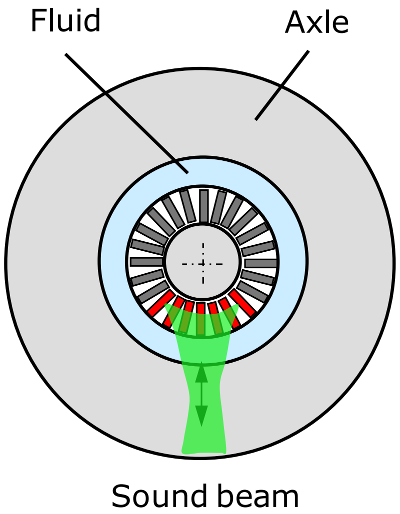




Directivity of the array with 13 active elements from 108 in total

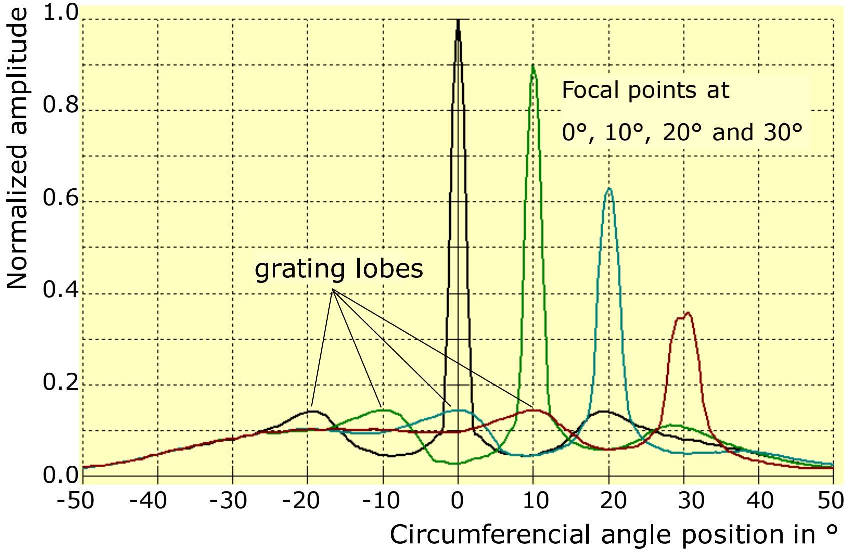
SOUND FIELD SIMULATION, FOCUSING



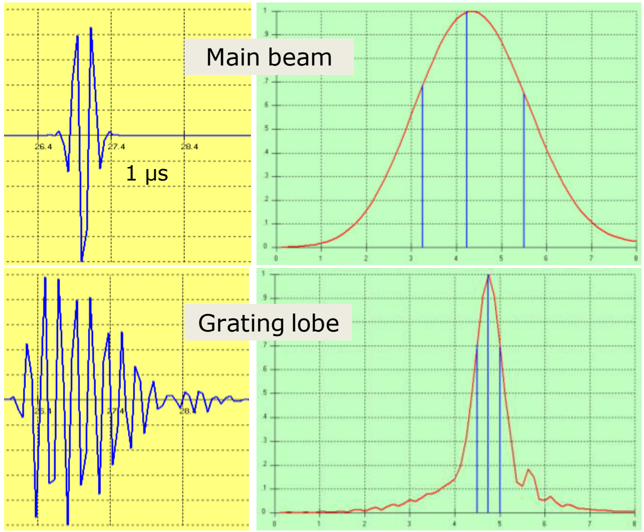


Directivity of the array with 13 active elements from 108 in total, focusing in circumferential direction, focus at the surface of the axle

SOUND FIELD SIMULATION, FOCUSING

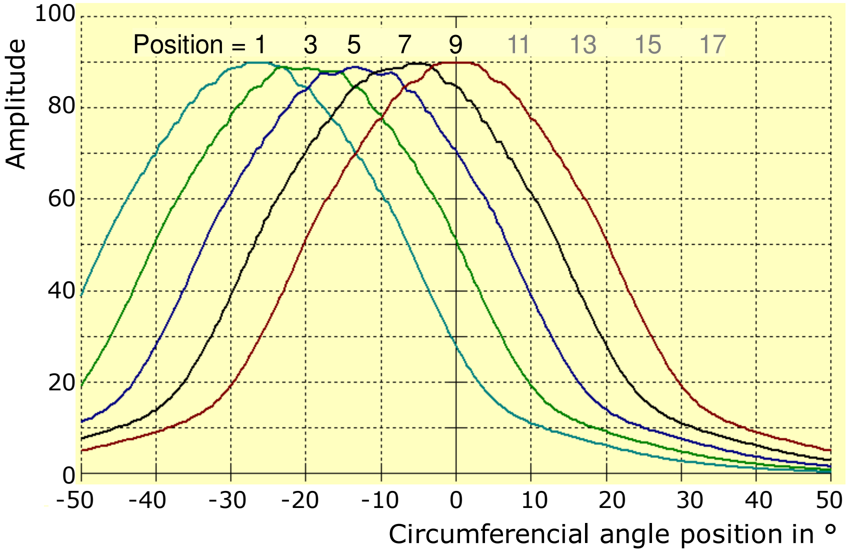


Amplitudes at different swivel angles in relation to the grating lobes

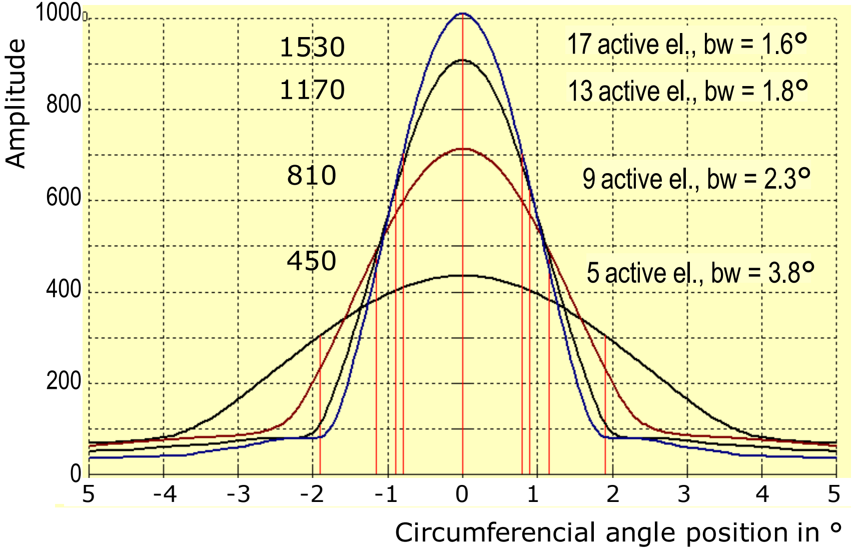


Pulses and spectra at 0° and -20° for the focal point at 0°, normalized amplitudes

SOUND FIELD SIMULATION, NUMBER OF ELEMENTS



Directivity of single elements of an array with 17 active elements



Amplitude and divergence angle bw with different numbers of active elements

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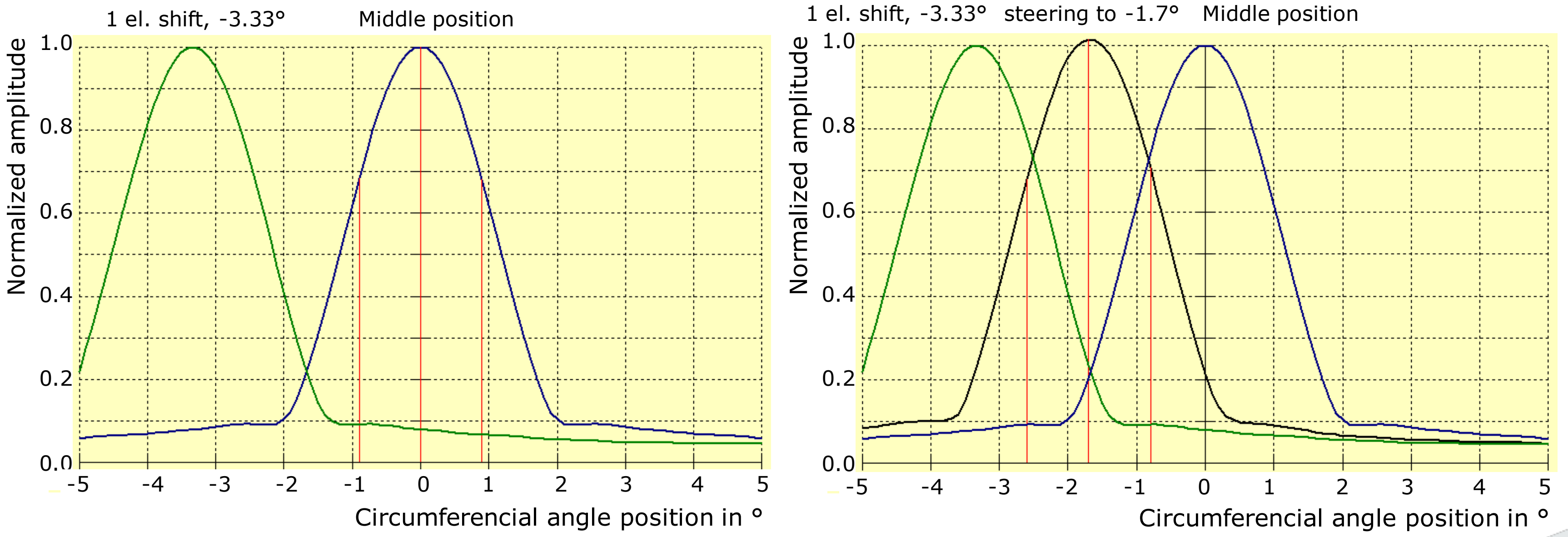
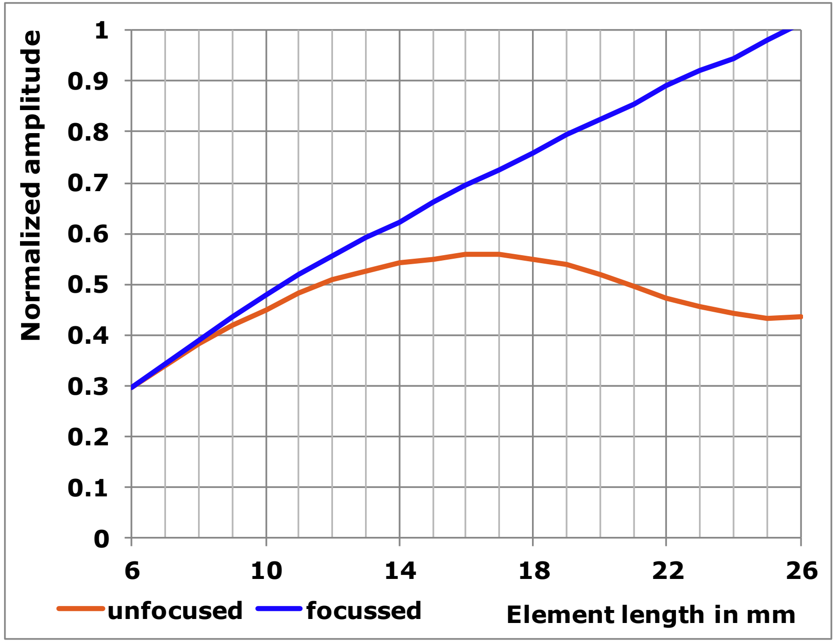
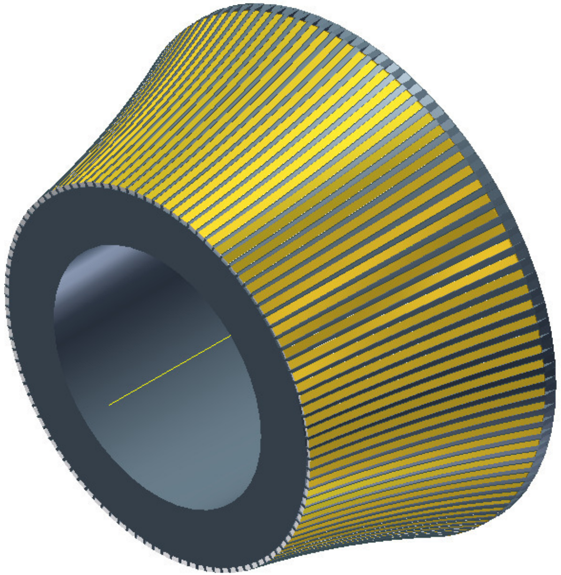
SOUND FIELD SIMULATION, ROTATION SCAN



Rotation of the sound field by shifting the group of active elements and by focal law

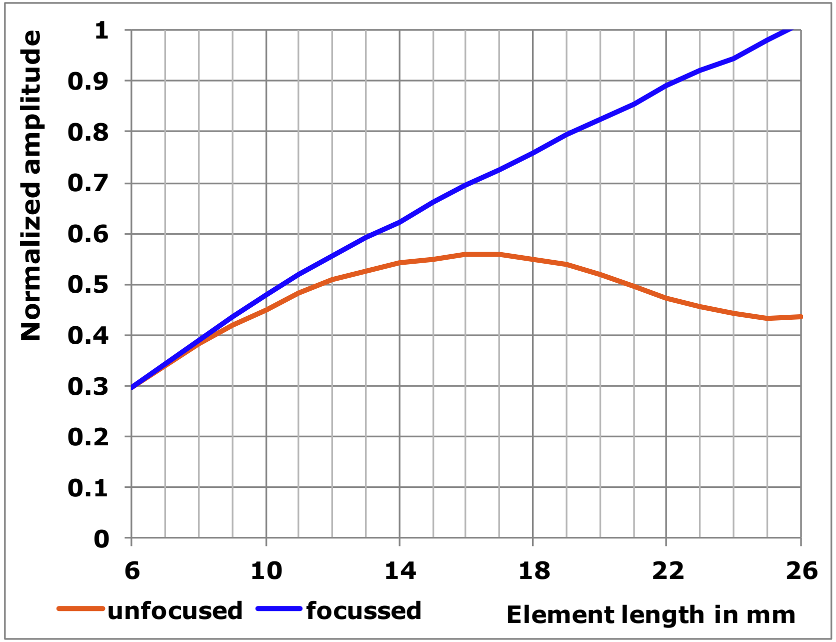
SOUND FIELD SIMULATION, FOCUSING II

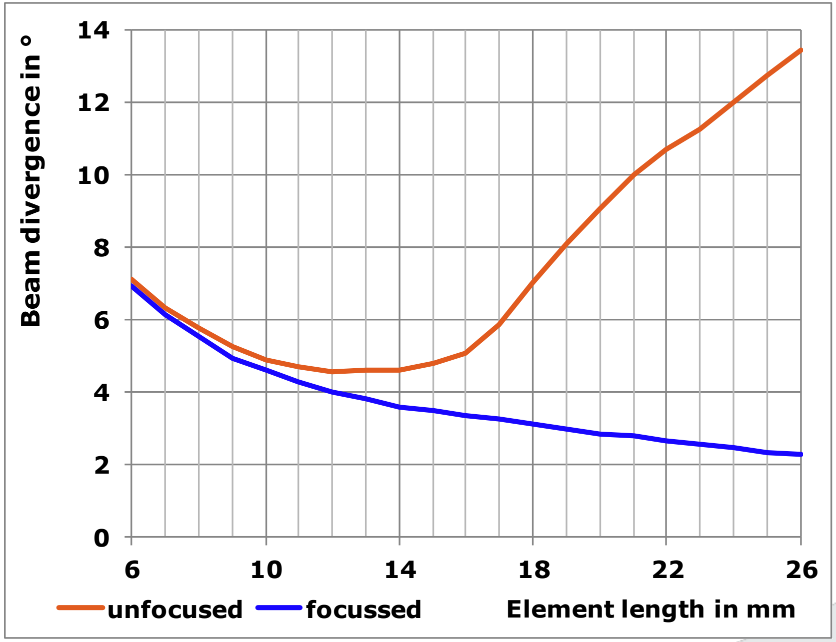




Concave curved elements for focusing in the plane of incidence

SOUND FIELD SIMULATION, FOCUSING II





Concave curved elements for focusing in the plane of incidence

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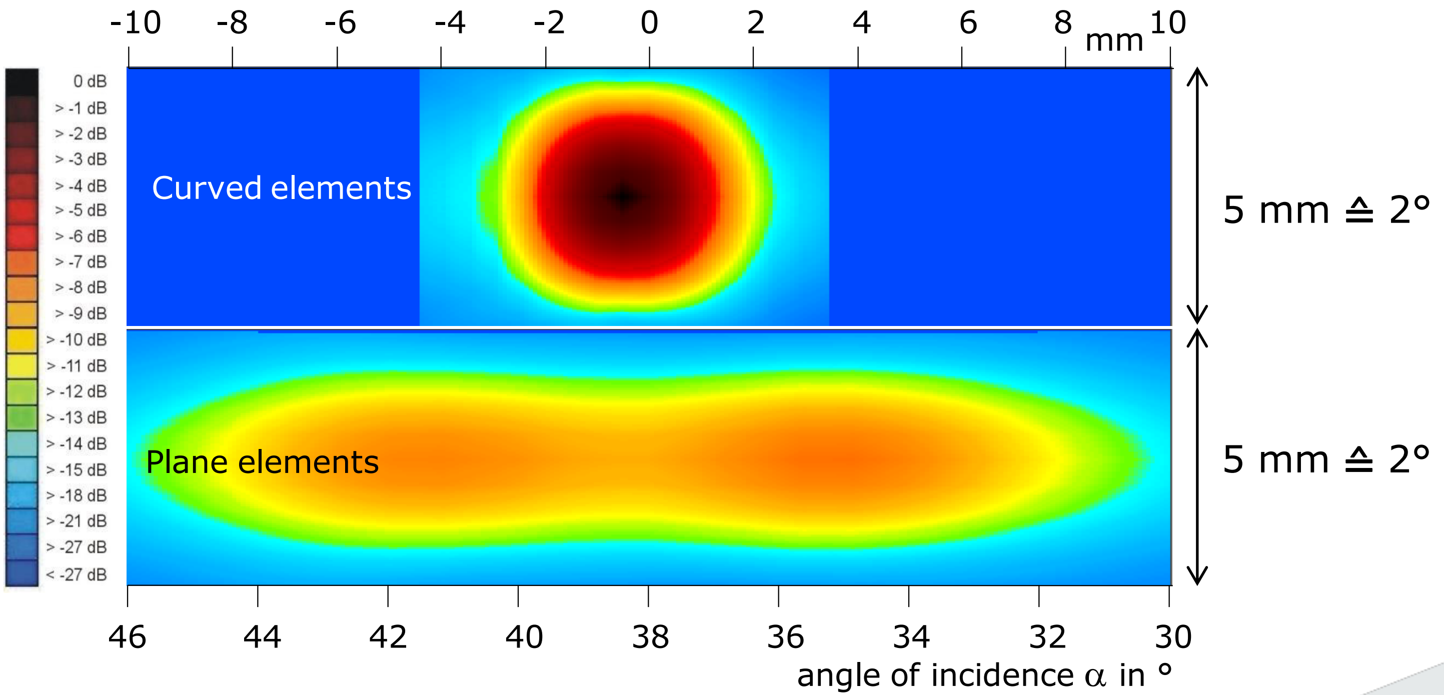
SOUND FIELD SIMULATION, FOCUSING II



Cross section of the beam at the axle surface focused and unfocused

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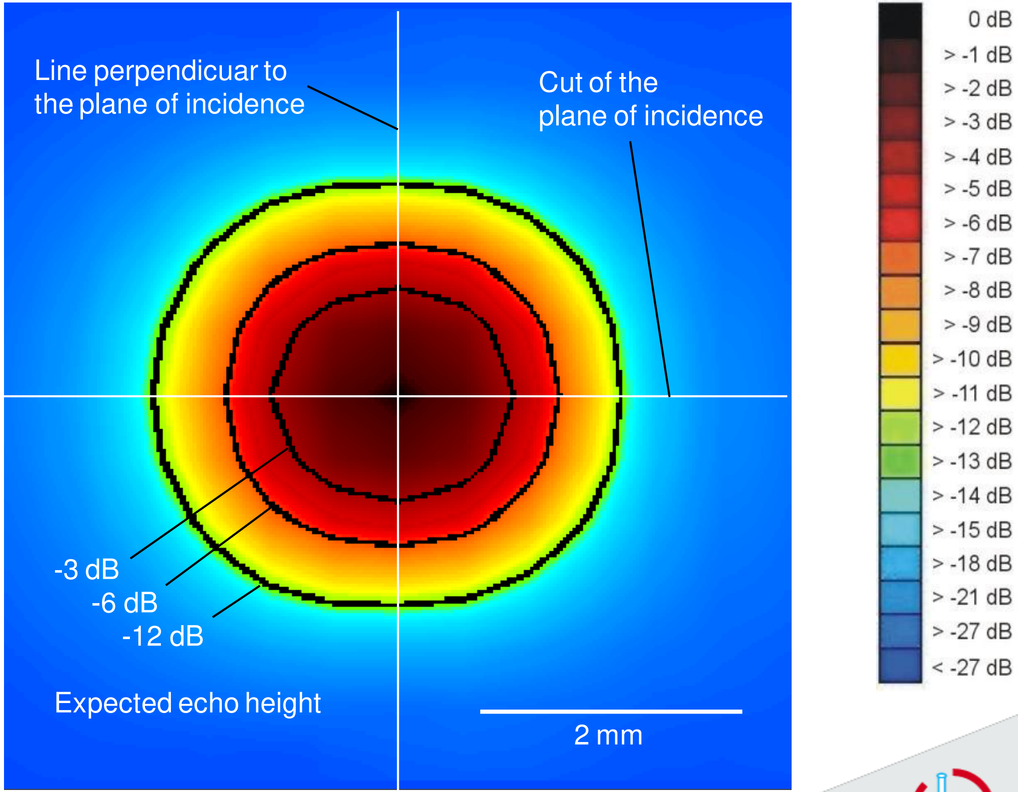
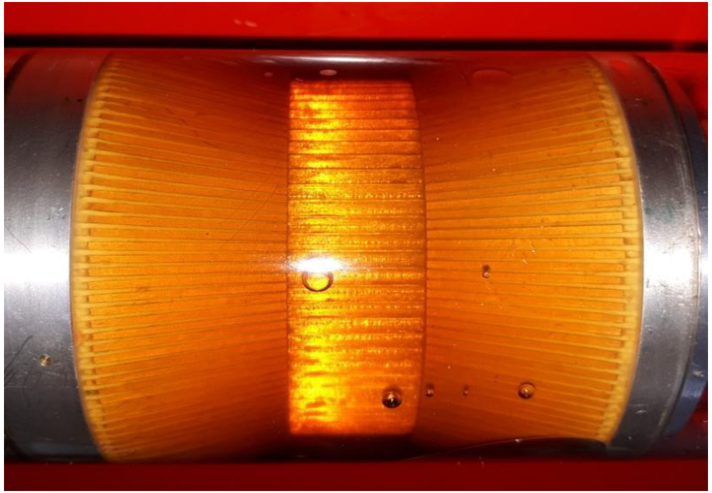
SOUND FIELD SIMULATION, FOCUSING II

Cross section of the focused beam at the axle surface



NEW DESIGNED PHASED ARRAY SYSTEM



CONCLUSION

Properties of the new cone type phased array, (earlyer versions)

- Probe is optimized for a bore hole diameter of 65 mm
- Higher frequency, 4 MHz (2.7 MHz)
- Maximum cone diameter 60 mm (28 mm)
- More elements, 108 (48)
- Narrower elements, 1 mm (1.25 mm)
- Longer elements, 25 mm (12 mm)
- Focussing in the plane of incidence with curved elements
- Nearly cycle shaped beam, or
- adaptable beam divergence in circumferencial direction

All this results in higher resolution and sensitivity

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Bundesanstalt für Materialforschung und -prüfung

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THANK YOU FOR YOUR ATTENTION

QUESTIONS?

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