

# Numerical Modeling of Ultrasonic Data for Elastography

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## 1. Introduction

Elastography: definition

Ultrasonic signals analysis

Block-diagram of the elastography method

## 2. Transducer Simulation

## 3. Simulation of Ultrasonic Data

## 4. Deformation Modeling

## 5. Conclusion

# 1.1 Elastography: Definition

- *Elastography* is a non-invasive imaging technique for measurement and visualization of the mechanical properties of biological tissues

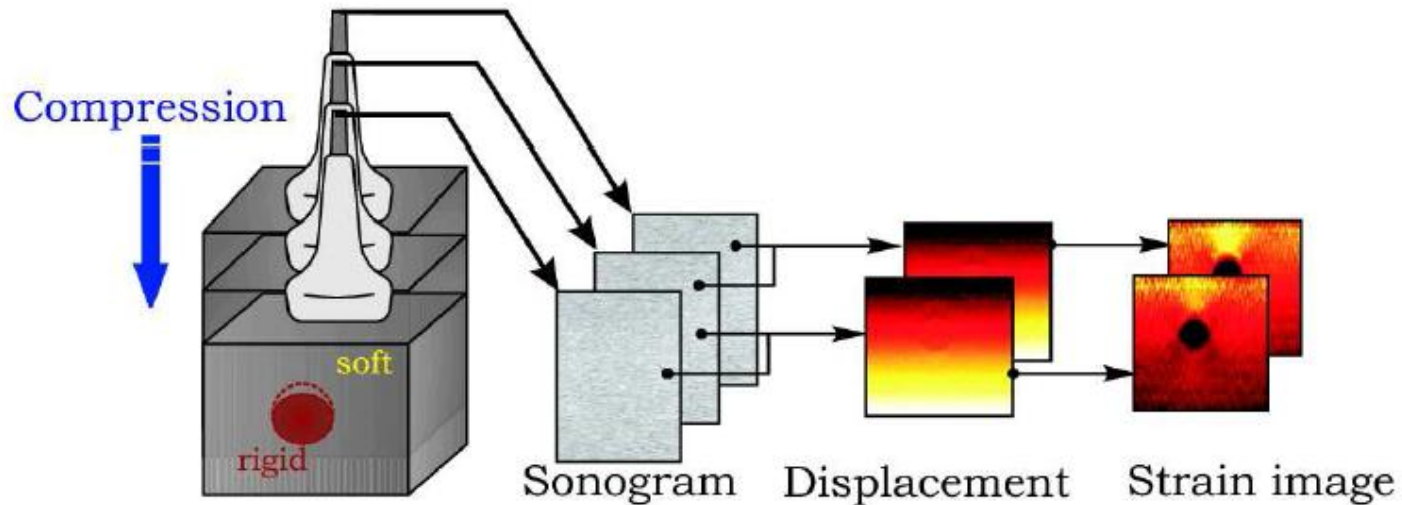


Fig. 1. Stages of producing elastogram

# 1.2 Ultrasonic Signals Analysis

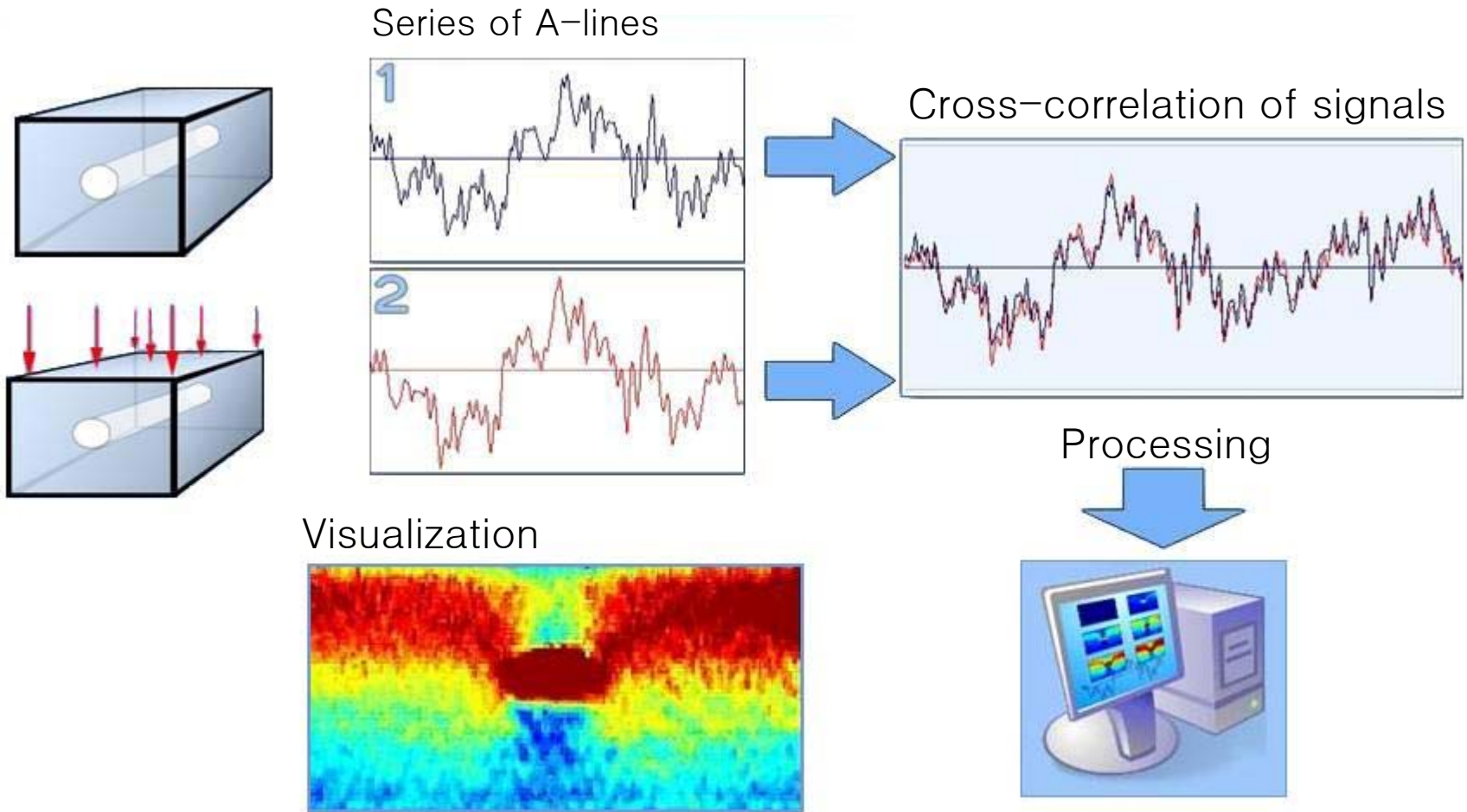
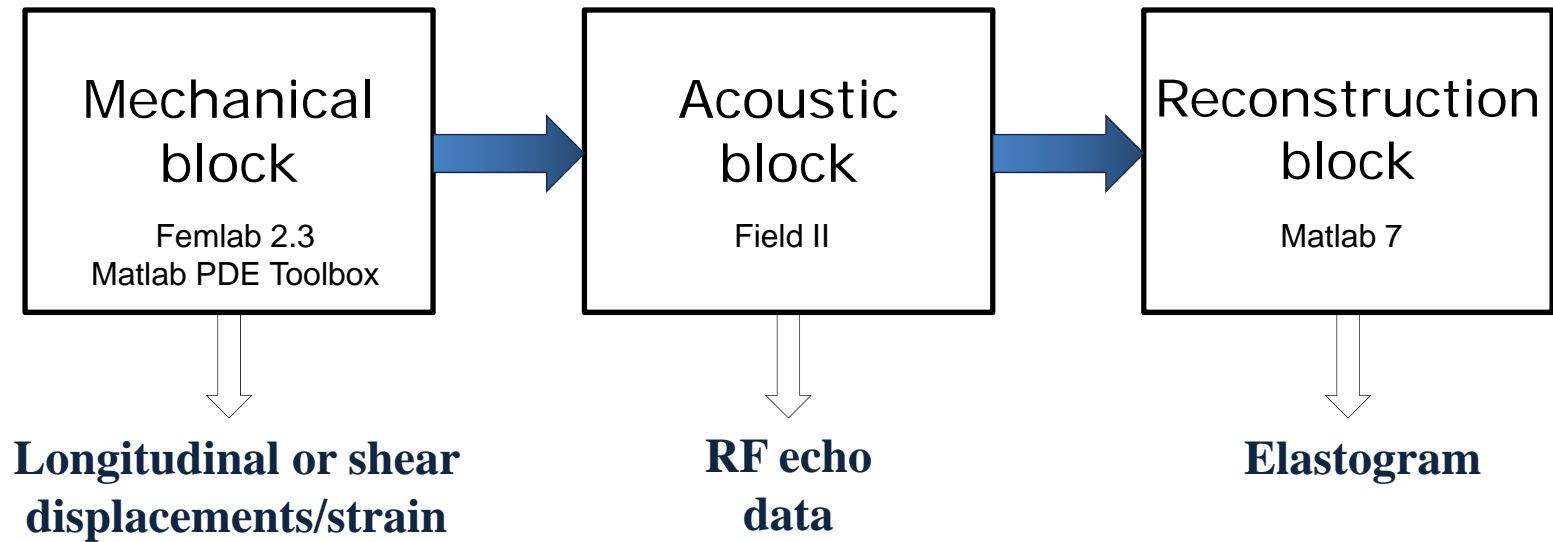


Fig. 2. Algorithm of strain estimation from RF signals

## 1.3 Block Diagram of the Elastography Method



1. Introduction

## 2. **Transducer Simulation**

Modeling of linear array

Optimization of parameters

Comparison with experiment

3. Simulation of Ultrasonic Data

4. Deformation Modeling

5. Conclusion

# 2.1 Modeling of Linear Array

The screenshot displays the 'linear\_array\_GUI' software interface. The window title is 'linear\_array\_GUI' and the menu bar includes 'RUS/ENG', 'Exit GUI', 'About FIELD II GUI', 'File', 'Edit', 'View', 'Insert', 'Tools', 'Desktop', 'Window', and 'Help'. The main title is 'Linear array'.

**Language:** Russian (selected), English

**Transducer parameters:**

- Number of elements: 32
- Elevation focus (mm): 0
- Width: 0.4
- Kerf: 0.02
- Height: 5
- Focal point (mm): 0 0 60
- Number subdivisions(x): 1
- Number subdivisions(y): 10

**Element manipulation:**

- Transmit steering angle: 0
- Receive steering angle: 0
- Transmit apodization: Box
- Receive apodization: Box
- Dynamic focusing: Yes
- Expanding aperture: Yes

**Measurement points:**

- Number of points(x): 75
- Number of points(z): 45
- Start point(x) [mm]: -10
- End point(x) [mm]: 10
- Start point(z) [mm]: 5
- End point(z) [mm]: 100

**General settings:**

- Sampling frequency (MHz): 100
- Sound speed (m/s): 1540
- Excitation pulse: sin
- Number of cycles: 1.5
- Center frequency (MHz): 2.5
- Fractional bandwidth (%): 60

**Calculate:** Plot (selected)

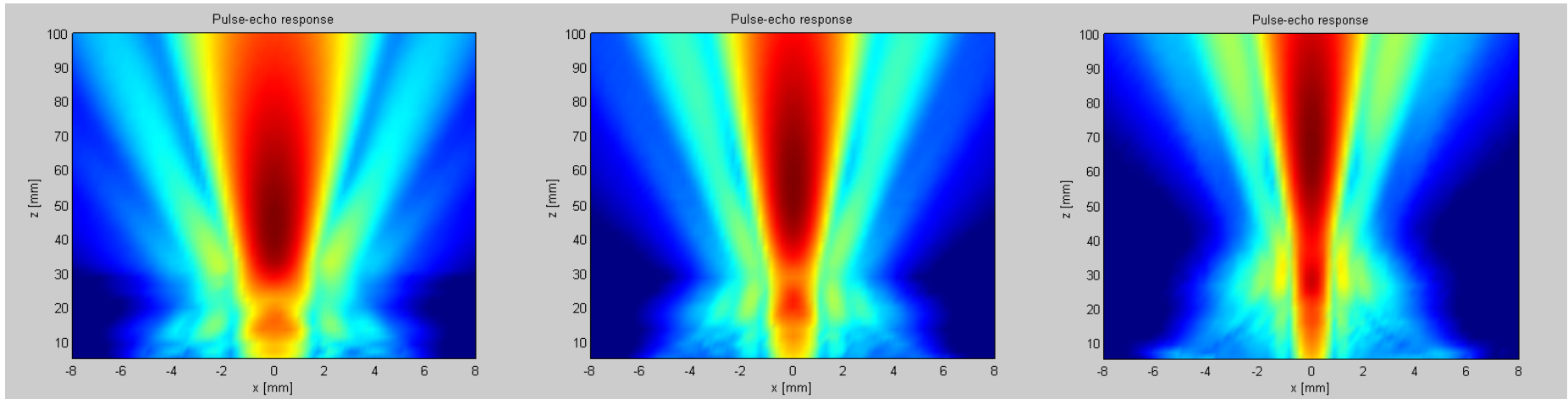
- Impulse response
- Excitation pulse
- Apodization
- Transmit pressure field
- Receive sensitivity
- Pulse-echo response

**Linear 32-elements array:** A 3D plot showing a green grid representing the array elements in a coordinate system with x [mm] from -5 to 5, y [mm] from -5 to 5, and z [mm] from -2 to 2.

**Relative position of measurement points:** A 3D plot showing a blue vertical rectangular plane representing the measurement points in a coordinate system with x [mm] from -10 to 10, y [mm] from -10 to 10, and z [mm] from 0 to 100.

## 2.2 Optimization of Parameters

Transducer frequency

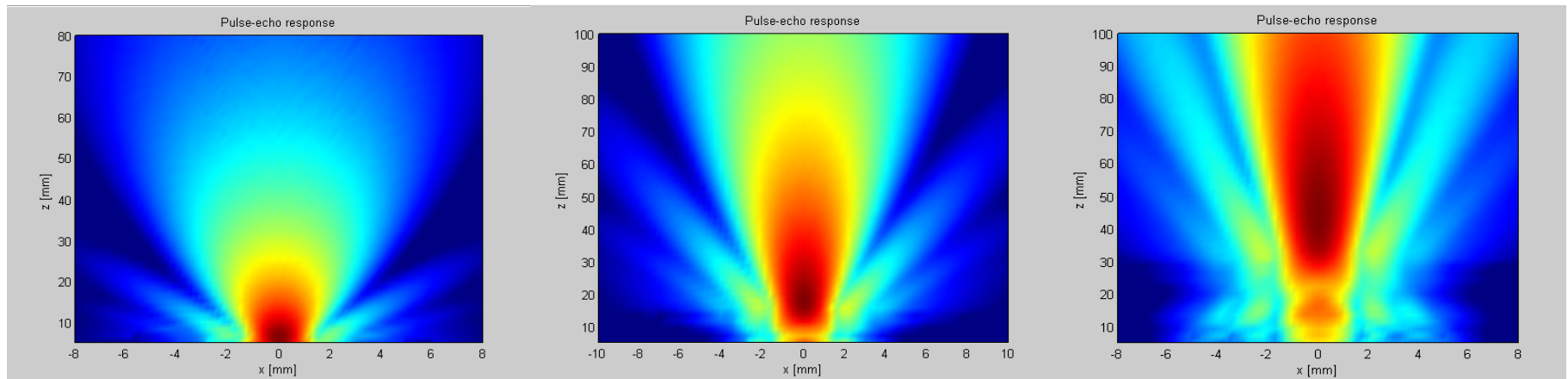


2.5 MHz

3.5 MHz

5 MHz

Aperture size



8 el.

16 el.

32 el.

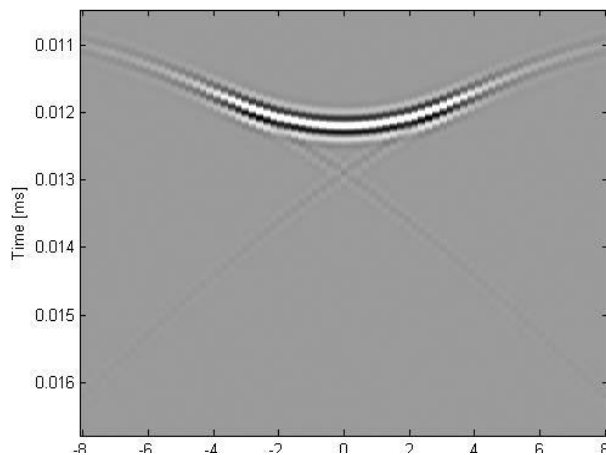
8



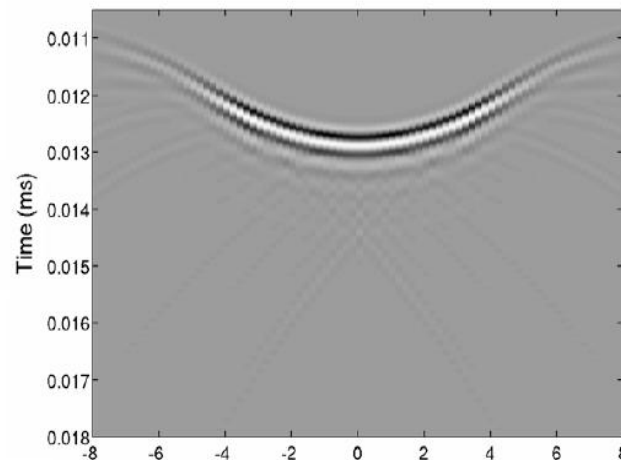
## 2.3 Comparison of Simulated and Experimental Pressure Field

### Simulation

Transmit pressure field at depth =10mm

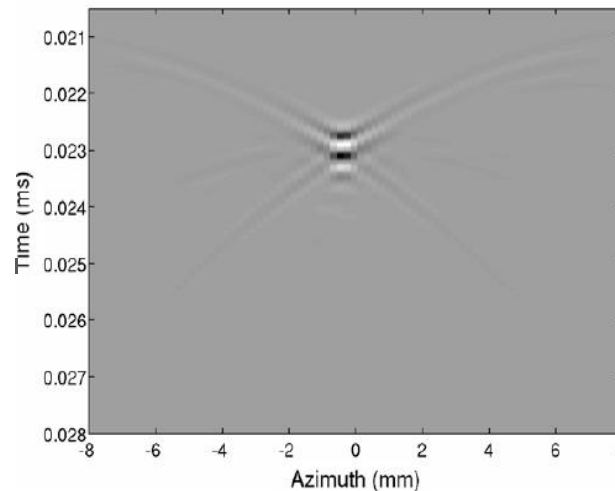
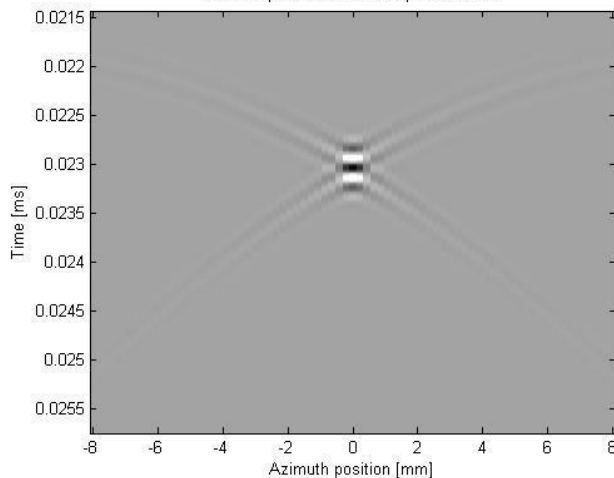


### Experiment \*



Near-field  
(10 mm depth)

Transmit pressure field at depth =30.0mm



Focal plane  
(30 mm depth)

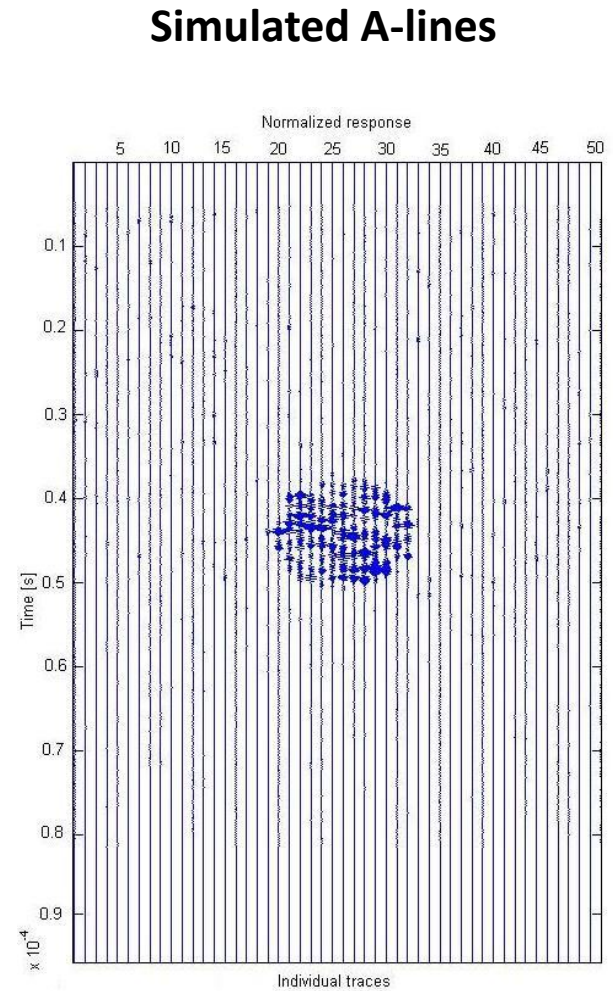
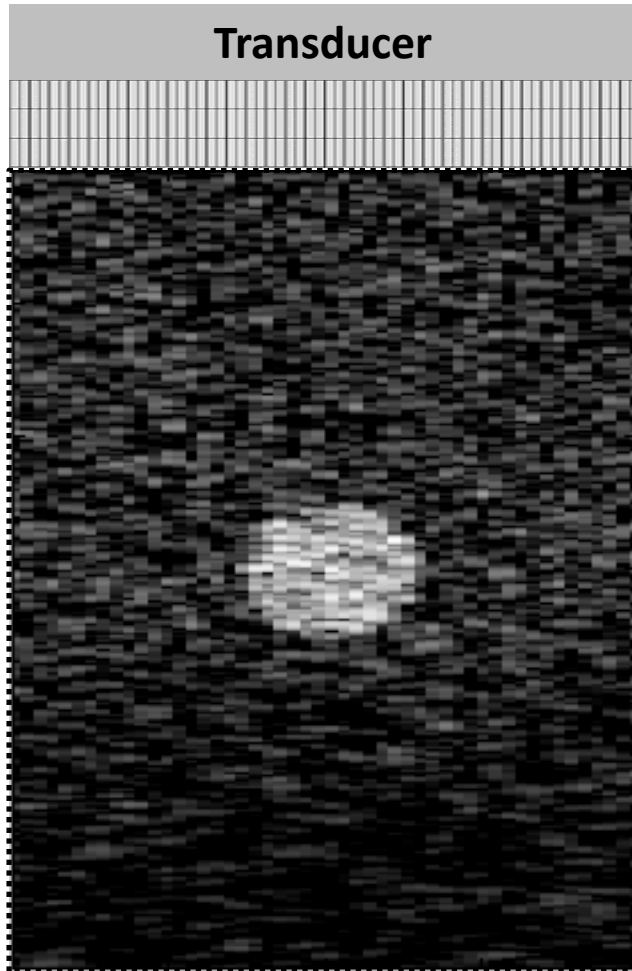
Azimuth position [mm]

Azimuth (mm)

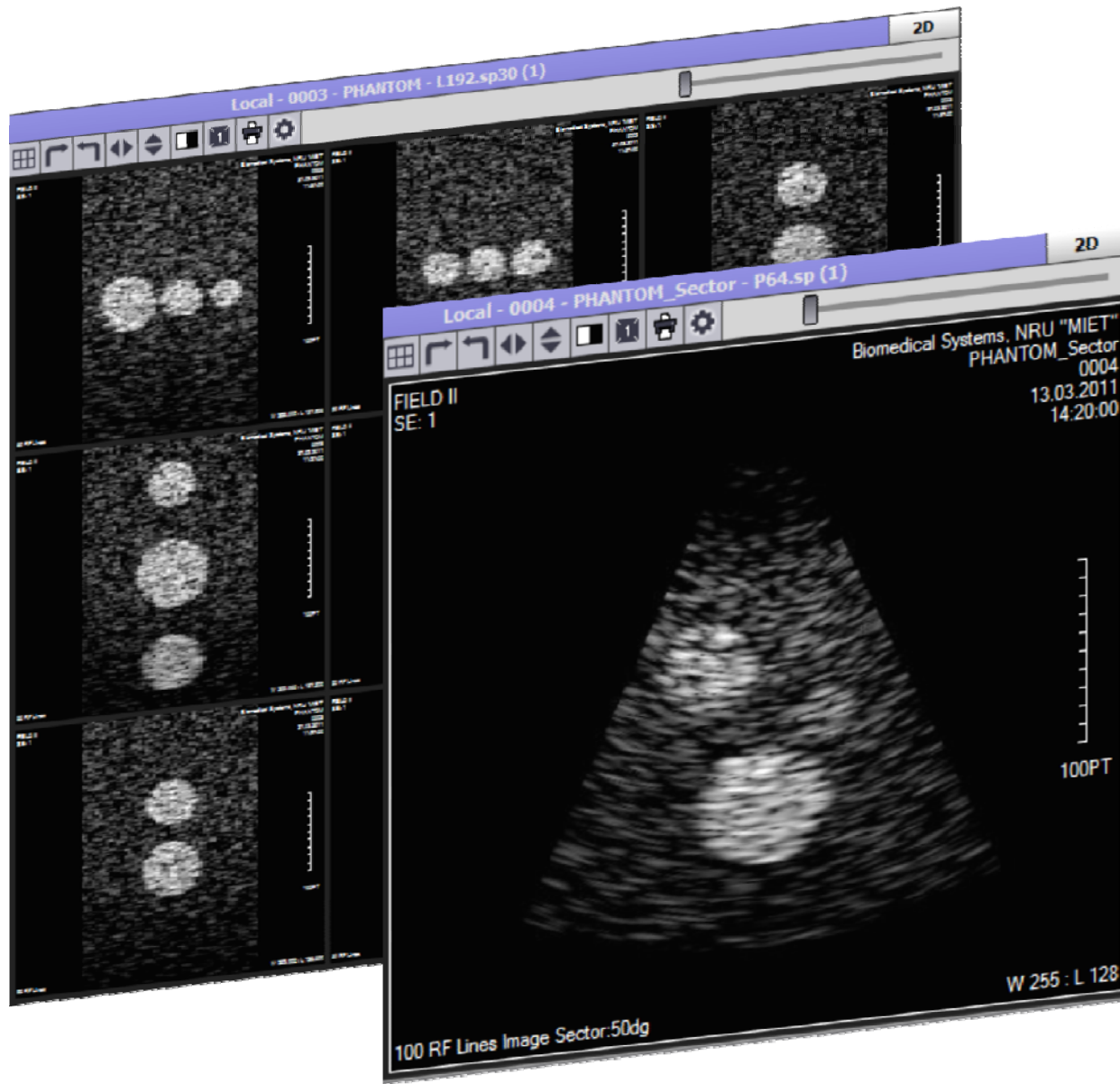
\* Guenther D.A., Walker W.F. A method for accurate *in silico* modeling of ultrasound transducer arrays  
// Ultrasonics. – 2009. – Vol. 49 – P. 404–412

1. Introduction
2. Transducer Simulation
- 3. Simulation of Ultrasonic Data**
  - Algorithm of Image Simulation
  - Data Storage
4. Deformation Modeling
5. Conclusion

# 3.1 Algorithm of Image Simulation



## 3.2 Data Storage



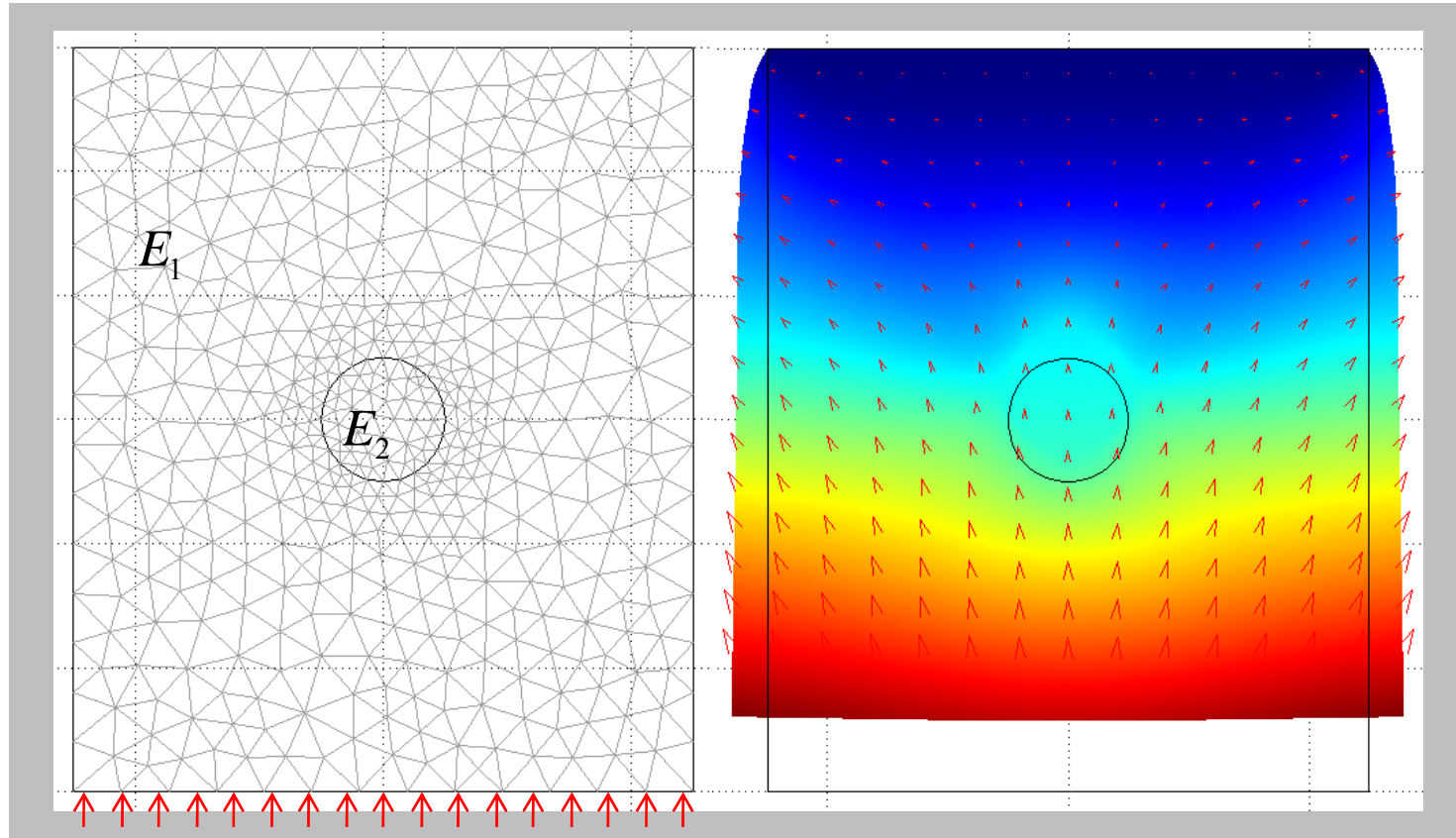
### DICOM format

- + Accurate identification
- + and easy access to large volume of simulated images

# 4. Deformation Modeling

Mesh discretization

Deformed shape



$E_1, E_2$  - The Young's Modulus of regions

$$\frac{E_2}{E_1} = 2 \dots 5$$

## 5. Conclusion

- GUI for linear array modeling allows fine control over the key transducer parameters
- Through effective optimization of simulated transducer a satisfactory agreement with measured acoustic pressure is observed in the focal plane and far-field
- Ultrasound images can be simulated for a variety of phantoms and stored in DICOM data base for later use
- Deformed state of phantom can be modeled using FEM and corresponding RF-signals can then be used for tissue motion analysis



Thank you for your attention!