

N.V. Ruiter, T. Hopp, M. Zapf, W.Y. Tan, L. Berger, A. Menshikov, D. Tcherniakhovski, H. Bouquet, B. Osswald, T. Piller, S. Smale, E.A. Kurt, B. Leyrer, P. Schöck, M. Balzer, R. Leys, I. Peric, H. Gemmeke
Karlsruhe Institute of Technology, Karlsruhe, Germany

System description

- Semi-ellipsoidal 3D aperture, diameter 26 cm, height 16 cm
- Approx. spherical waves at 2.5 MHz center frequency and bandwidth 1.5 MHz (-6 dB)
- Virtual transducer positions: rotational and translational movements of sensor system (aperture positions)
- 2041 individual transducers: operated as emitters (628) and receivers (1413)
- Transducer opening angle: 38.2° (standard deviation $\pm 1.5^\circ$) at -6 dB
- Transducer Array Systems (TAS): 4 emitters and 9 receivers including pre-amplifier and control electronics
- Data acquisition system:
 - FPGA based, stores up to 80 GByte (42 million A-scans)
 - 480 parallel channels (12 Bit at 20 MHz)
 - Data acquisition at one aperture position in approx. ten seconds

KIT data

Specifications

- Sampling rate: 20 MHz at data acquisition, bandpass undersampling to 6.6 MHz for storage, 10 MHz after preprocessing
- Emitted pulse: frequency coded chirp with center frequency 2.5 MHz, bandwidth 1.67 MHz and duration 25.6 μ s
- Empty measurement of aperture filled with water is provided for each data set
- Metadata, e.g. temperature trend during data acquisition, transducer coordinates at recorded aperture positions, individual channel gain, etc.

Gelatin phantom:

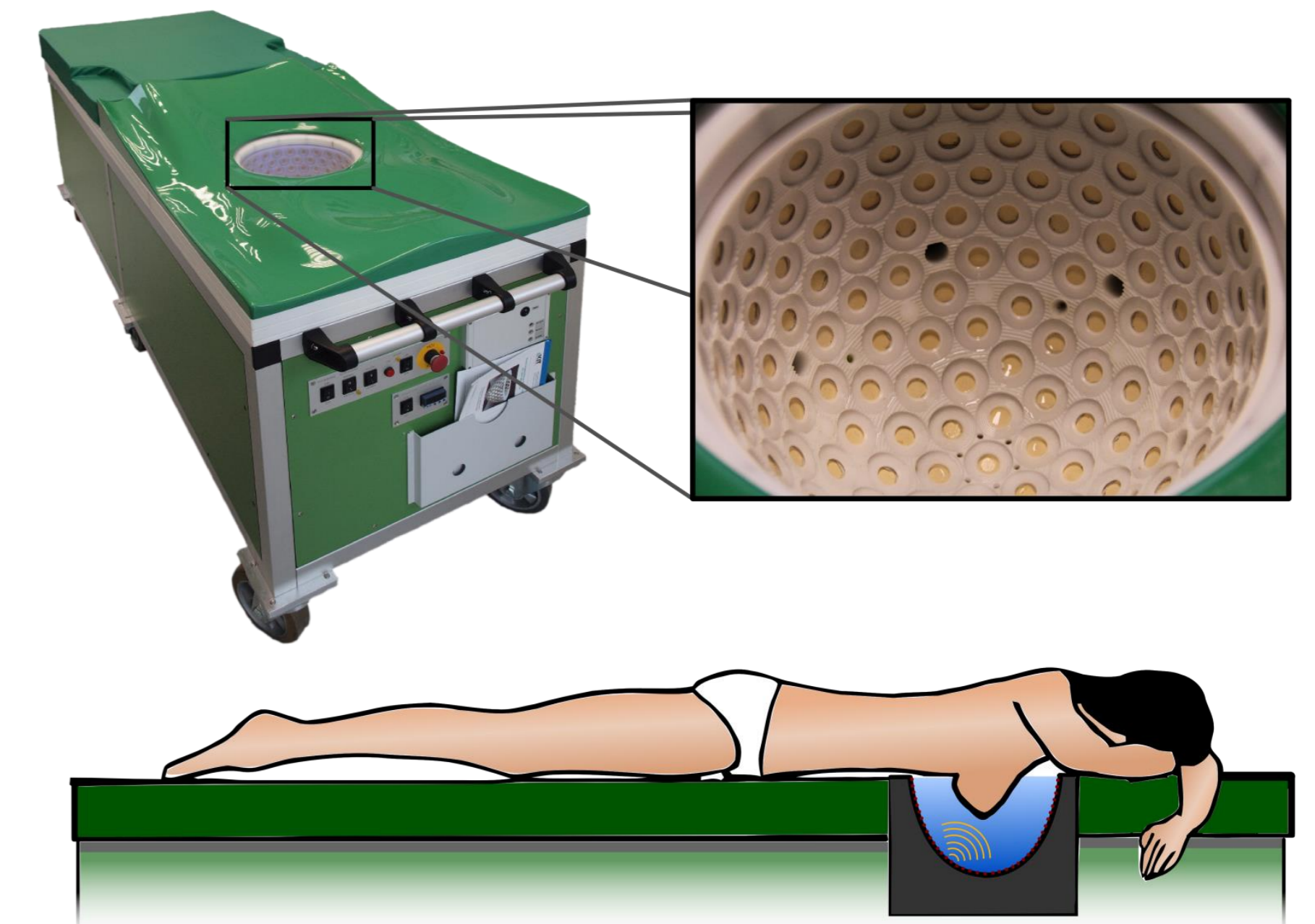
- Gelatin in conical plastic cup with water filled inclusions
- Diameter ~ 7 cm (bottom) and ~ 10 cm (top), height ~ 10 cm
- Speed of sound of gelatin ~ 1515 m/s
- Inclusions: during gelatin curing drinking straws with diameter 5 mm were embedded, straws were removed and inclusions were filled with water
- Amount of data: 10 aperture positions x 157x4 emissions x 157x9 receivers

Turkey phantom:

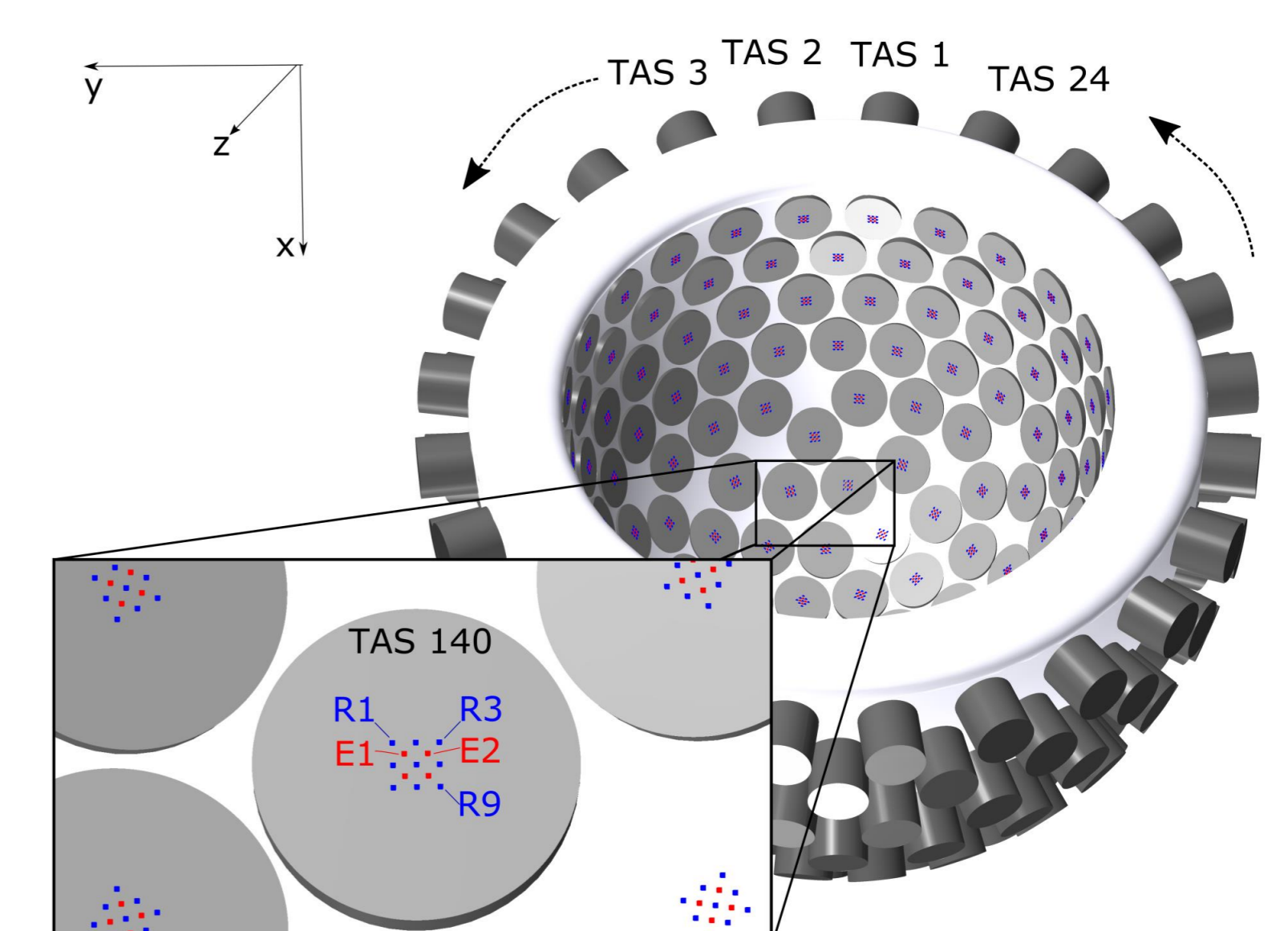
- Two olives without stones wrapped in turkey steak embedded in a gelatin filled condom
- Approx. spherical, diameter ~ 9 cm
- Speed of sound of turkey steak > 1550 m/s, olives ~ 1450 m/s
- Amount of data: 20 aperture positions x 157x4 emissions x 157x9 receivers

Nylon thread phantom:

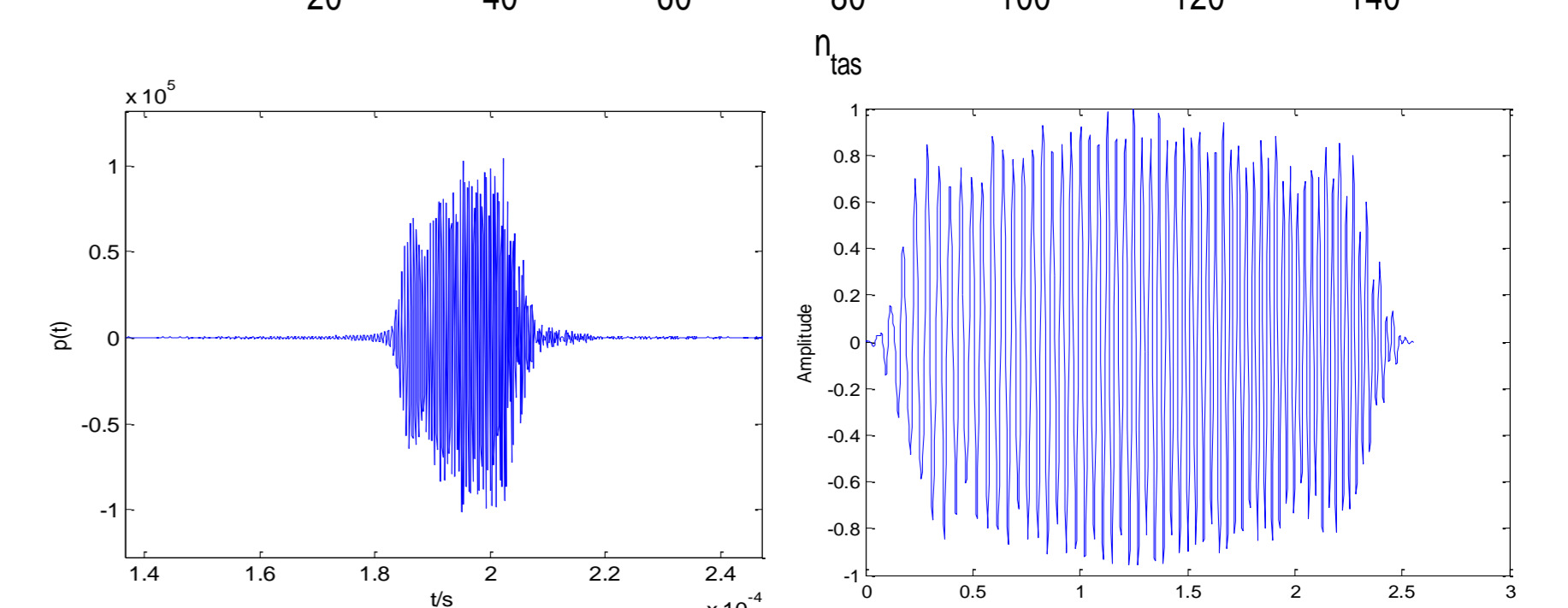
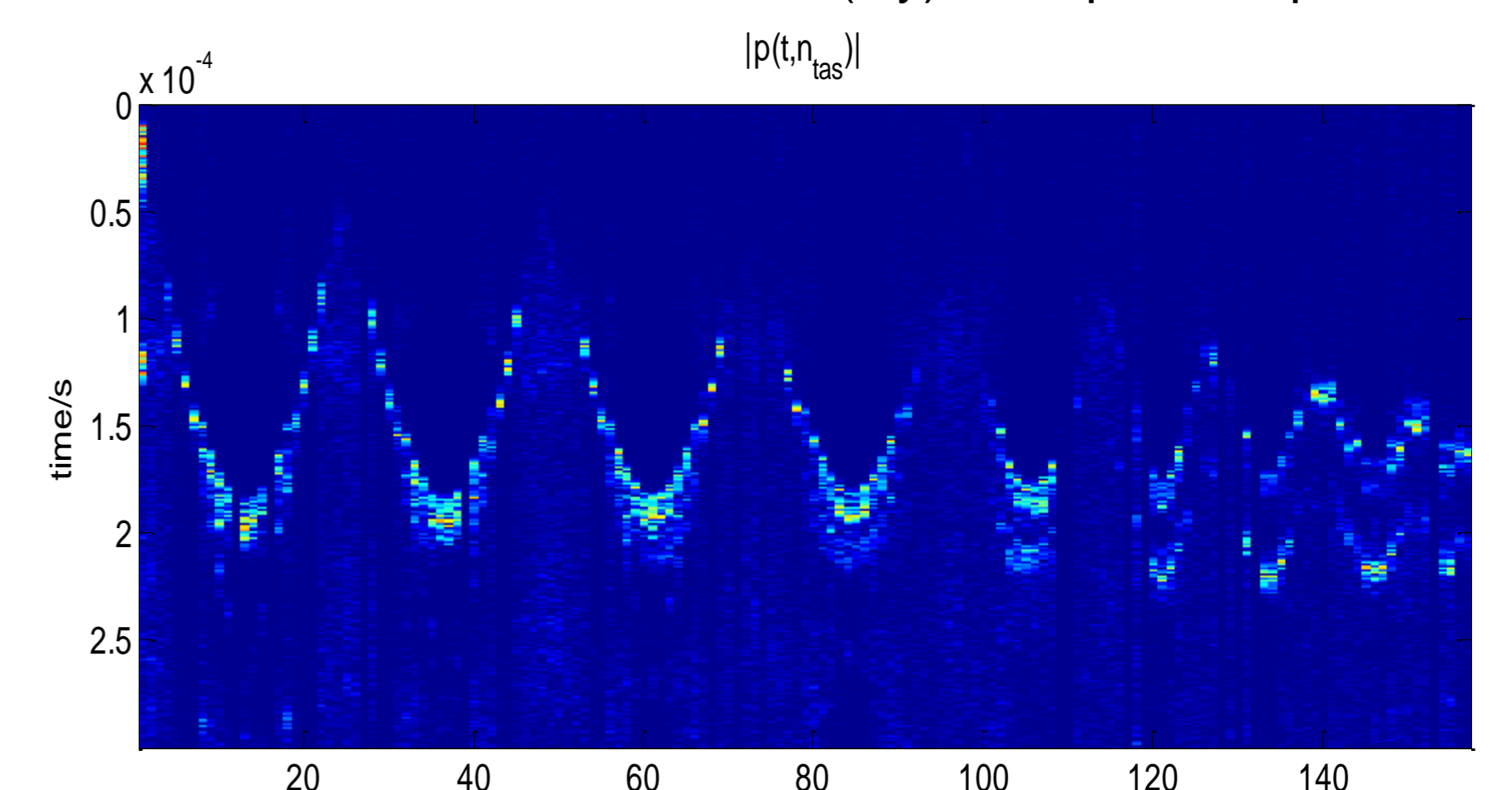
- Gelatin cylinder with embedded twisted nylon thread
- Diameter and height ~ 10 cm, nylon thread diameter 0.2 mm
- Amount of data: 23 aperture positions x 157x4 emissions x 157x9 receivers



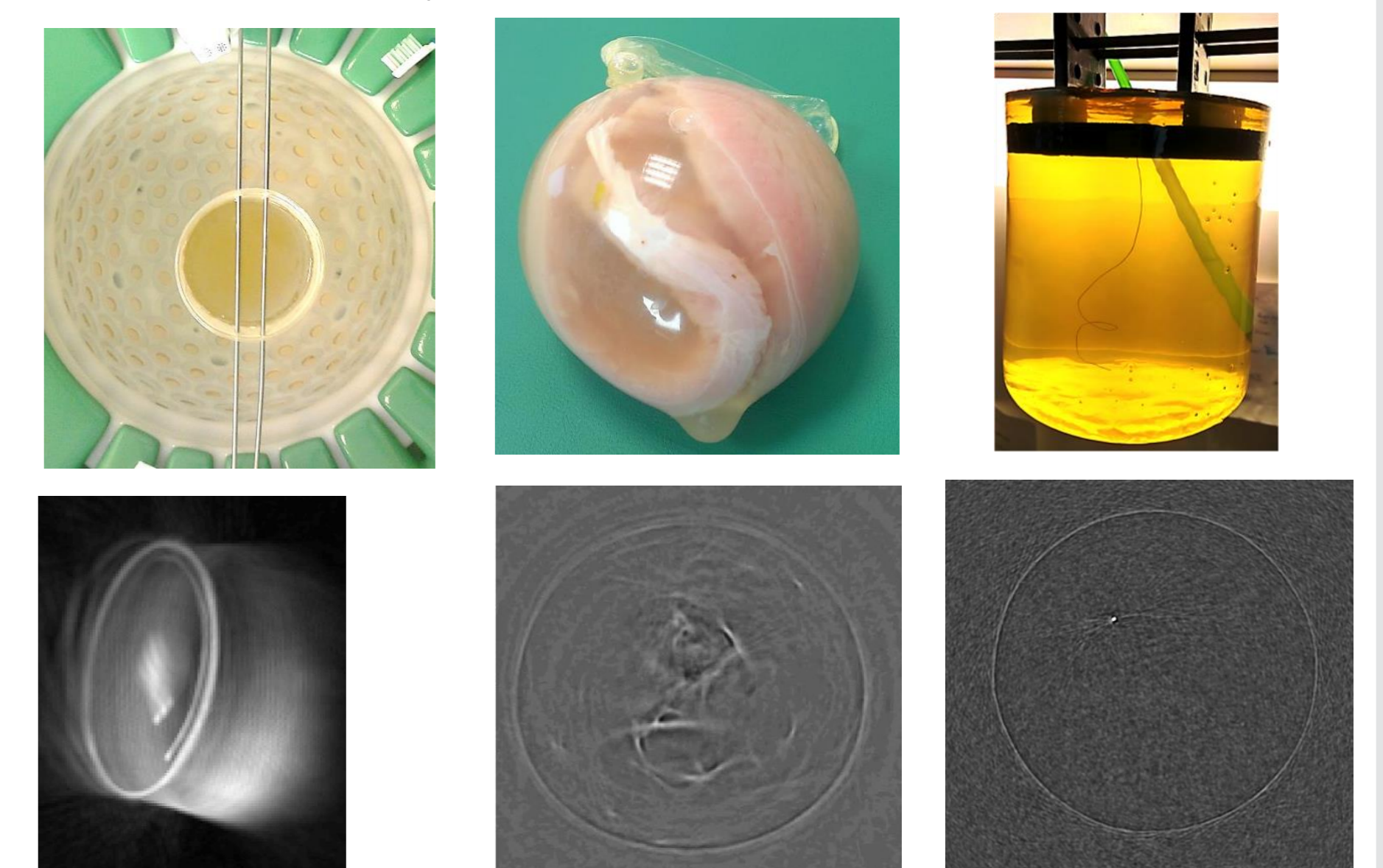
KIT 3D USCT with patient bed (left), transducer aperture (top right) and patient position (bottom right)



Numbering of transducer array systems (TAS) and local numbers of the 4 emitters (E, red) and 9 receivers (R, blue) in each TAS. Origin of right hand coordinate system top (z) and centered (x,y) in respect to aperture.



RF data measured in absence of object; (top) B-scan of top row emitter row; (bottom-left) A-scan and (bottom-right) frequency coded chirp applied for coded excitation.



Photos and reconstructions of scanned phantoms (top left to bottom left): KIT turkey, gelatin and nylon thread phantom.