

Three Dimensional Ultrasound Imaging

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Acquisition

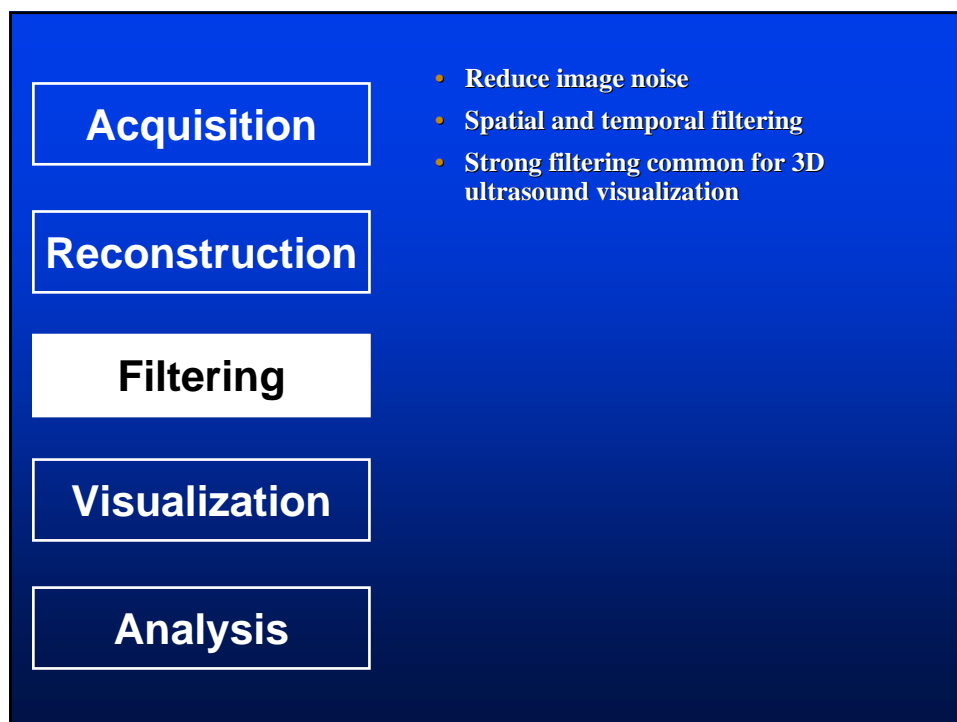
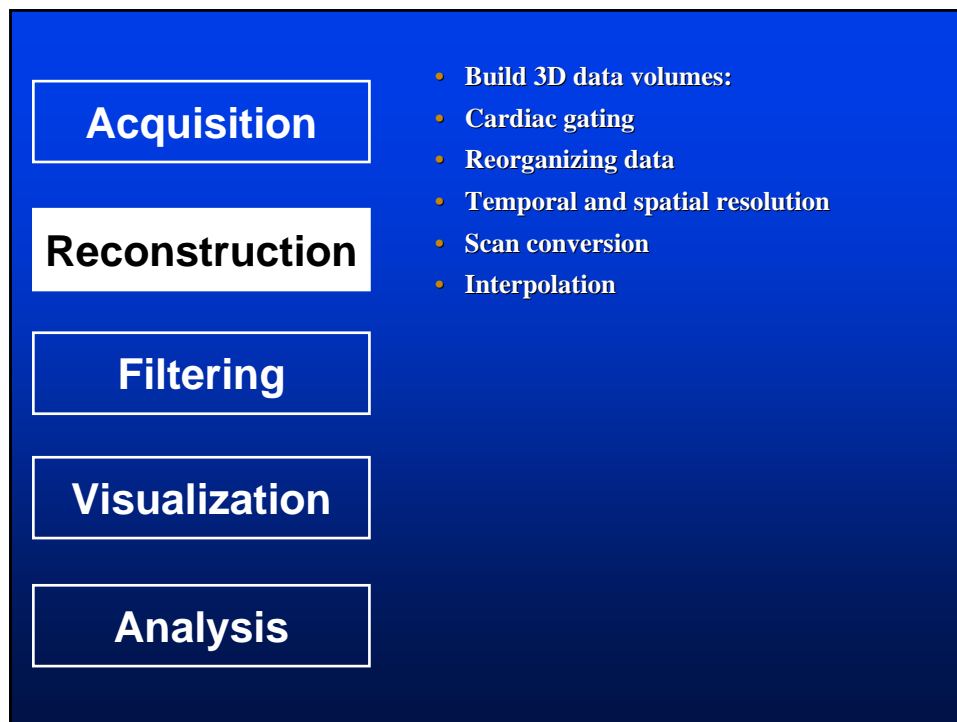
Reconstruction

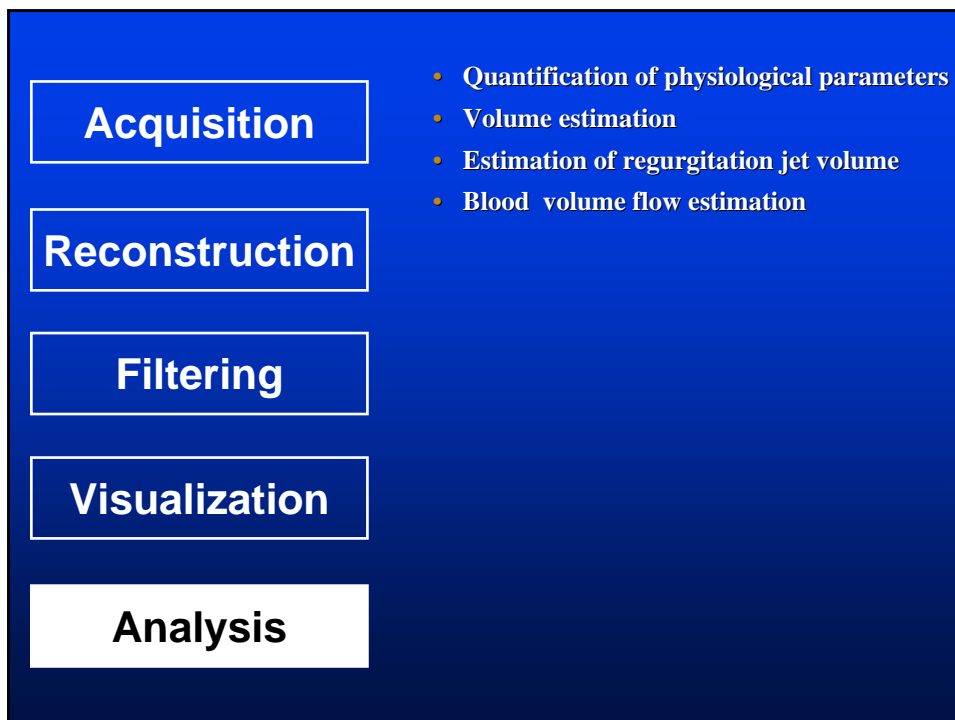
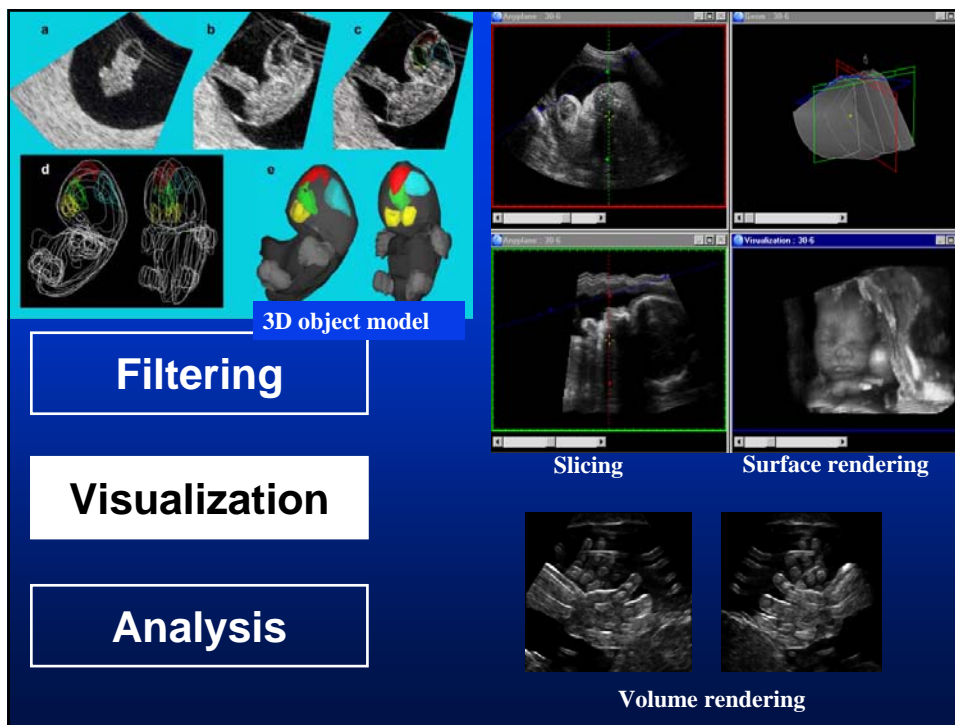
Filtering

Visualization

Analysis

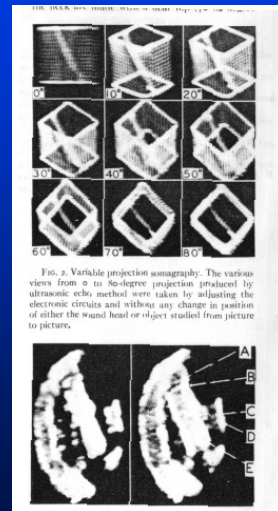
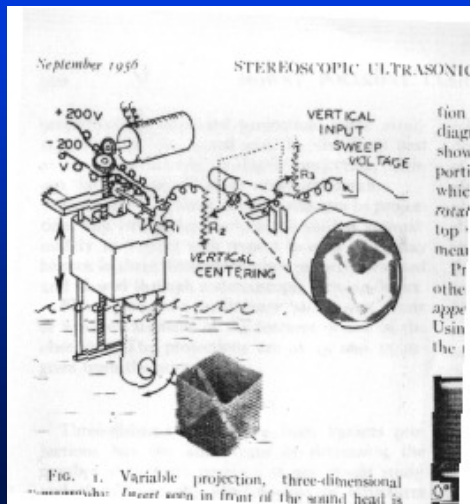
- Collecting ultrasound data
 - Motor devices (paper B, C, E)
 - Position locator systems (paper F)
 - 2D-arrays
- Important factors
 - Accuracy
 - Calibration
 - Temporal and spatial resolution
 - Cardiac gating



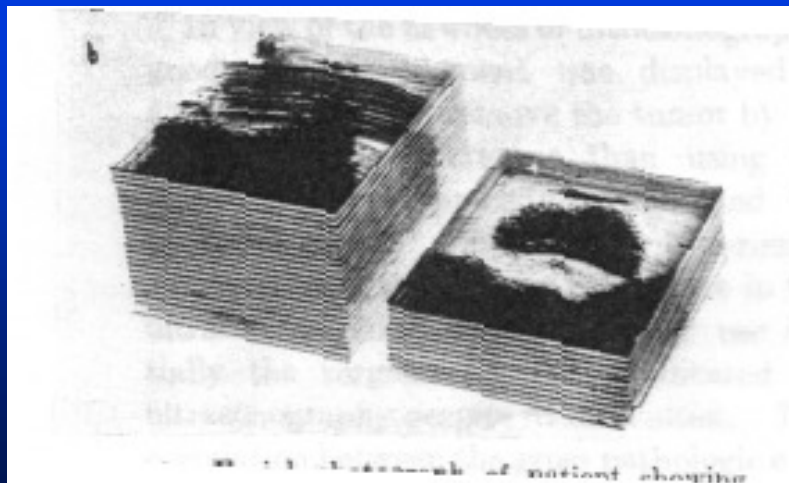


D. H. Howry et al, 1956

J Appl Physiol, vol 9, 1956

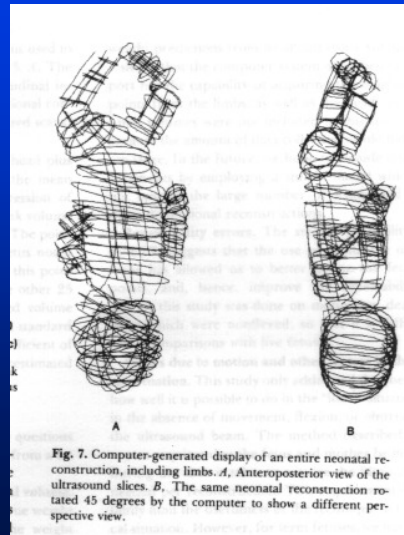


G. Baum et al, 1961



J. F. Brinkley et al, 1982

AM J Obstet Gynecol, vol 144, 1982



J. Roelandt et al, 1994

Thoraxcentre Journal, vol 6, 1994

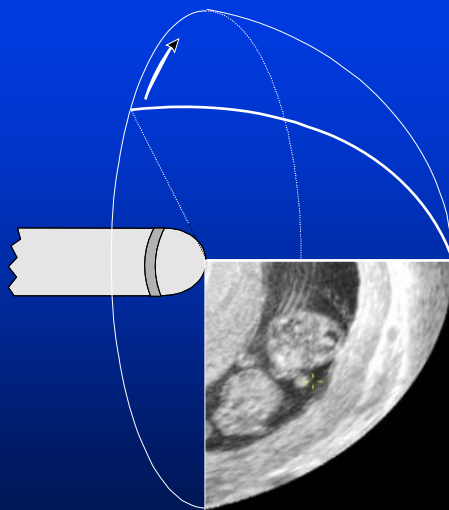


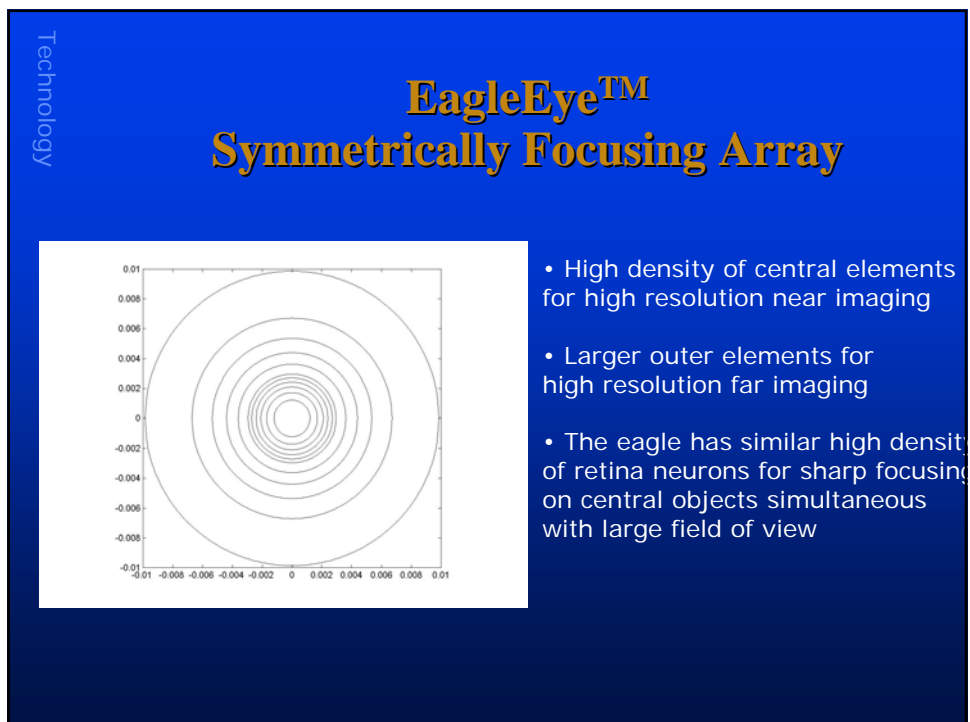
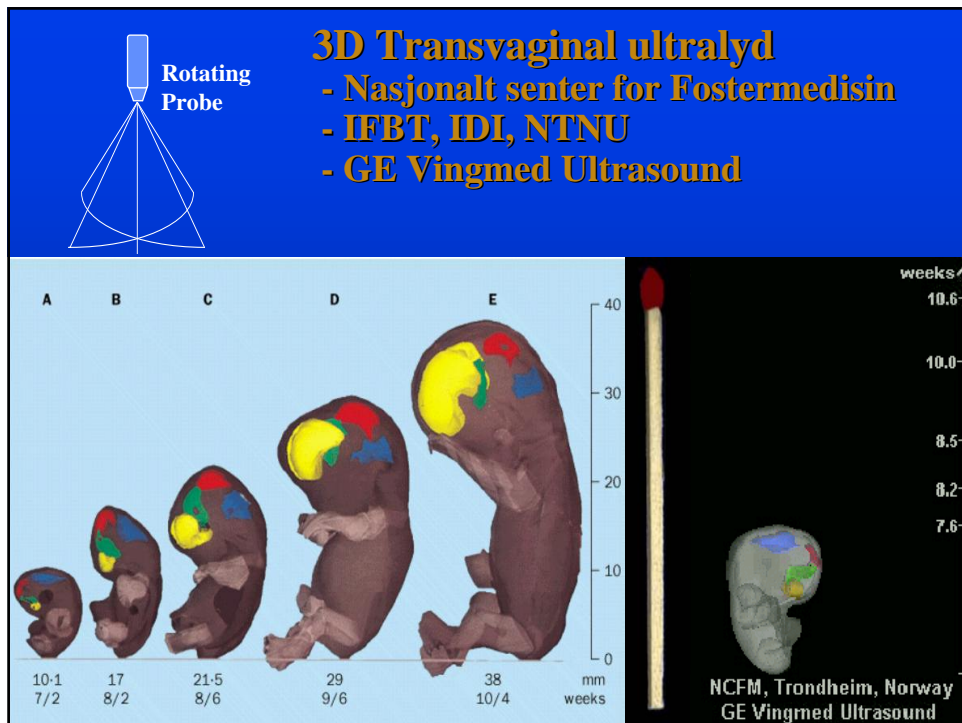
Transvaginal 3D probe

- Specially designed 3D probe
- 7.5 MHz annular array transducer
- Raw digital ultrasound data
- No externally moving parts
- Tilted scanning angle



Tilted scanning angle





OwlVision™ 3D visualization software

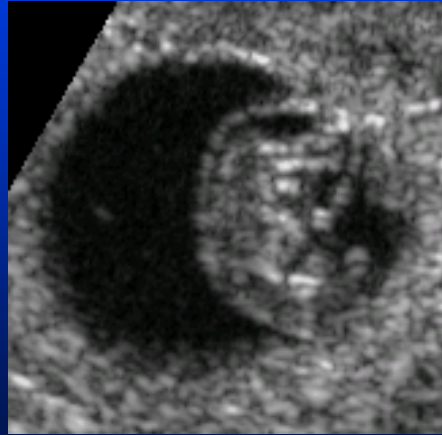


Stage 16 Human Embryo

1 mm

© 2001 Bradley Smith

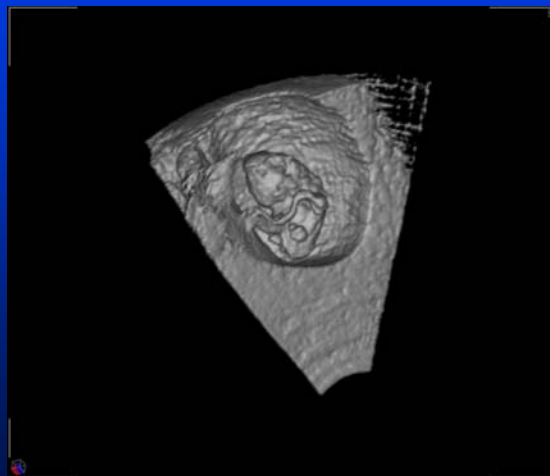
**Crown-rump length 7.5 mm
6 weeks 6 days**



OwlVision™ 3D visualization software



**8⁰ weeks
CRL 14.5 mm**



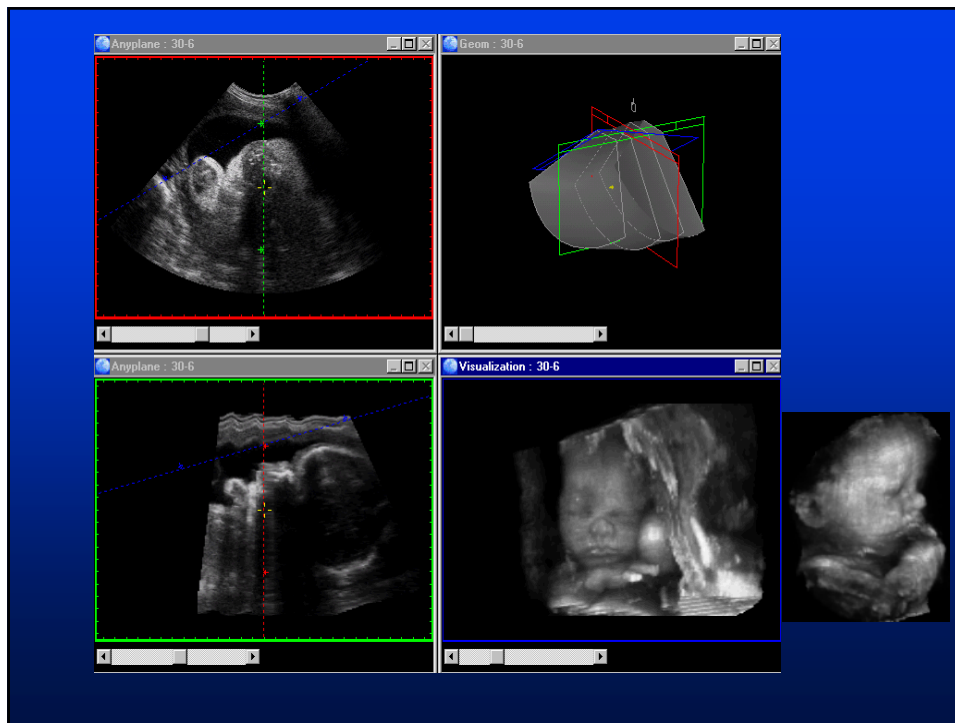
Kretz Ultrasound Curved array tilted by stepper motor



Free-hand probe for 3D

- Magnetic position sensor mounted on probe
- Position data loaded directly into scanner
- Digital ultrasound and position data transferred to external PC for post processing



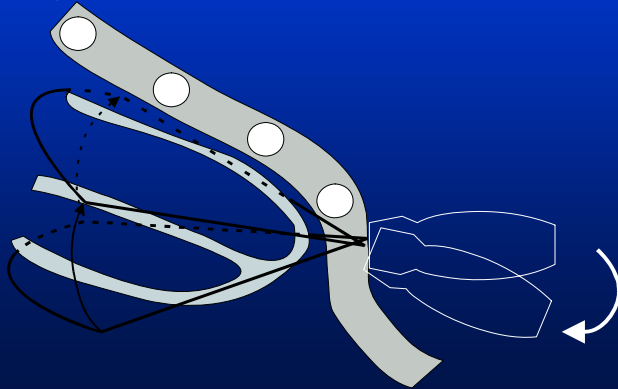


Dynamic 3D data acquisition



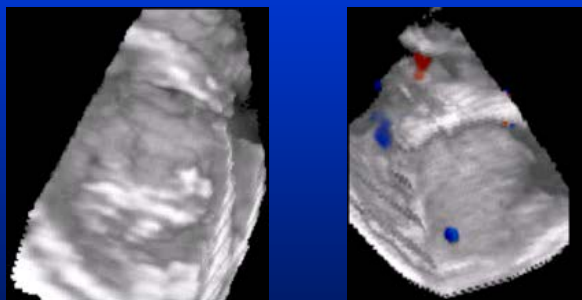
Freehand tilting

- Probe slowly tilted during 10-20 cardiac cycles
- Held end-expiration
- Choosing best acoustic window possible

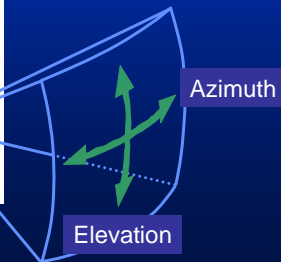
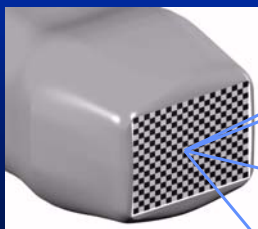
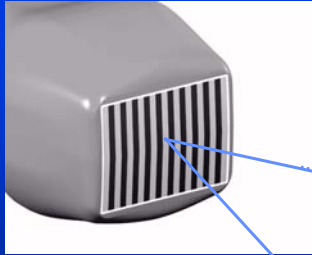


Sevald Berg
NTNU, Norway

Mitral valve surface



2D matrix array – electronic steering of beam



- 32-192 elements in a 1D array
- 32*32 ... 96*96 elements in a 2D array
- 1000 - 10000 elements
- Cable
- Electronics
- Beamformer

The Cardiac 3D Challenge ..

From 1D Array..



64 – 128 array elements

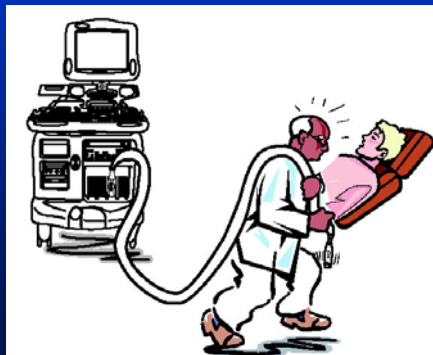
to 2D Array...




2000 – 3000 array elements

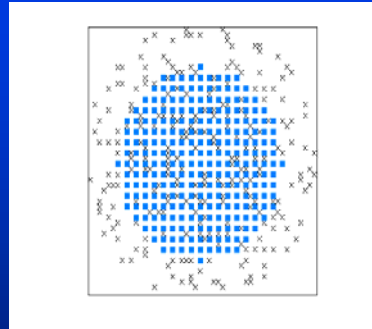
Main Challenges

- Large element count
- Tiny element size.. high electrical impedance

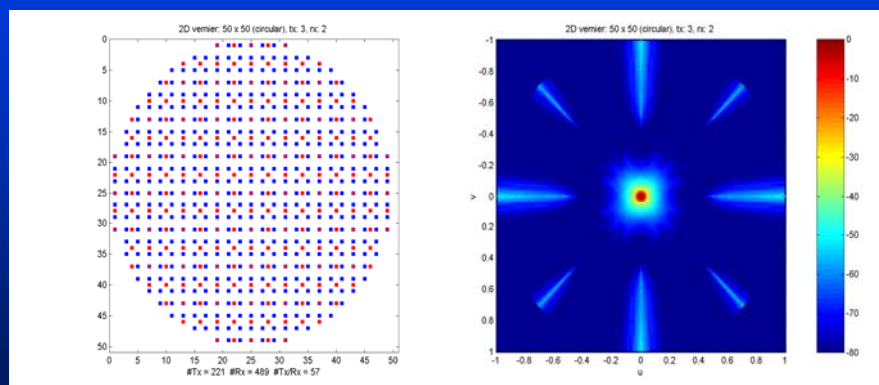


Transducer Thinning

- Sparse 50 x 50 element transducer
- Every second element used for transmitter, totally 253: 
- 256 elements for receiver, x, found by genetic optimization:
 - no overlap with transmitter elements to simplify system electronics
 - optimizes beamwidth and sidelobes of ultrasound beam
 - 10^{358} different layouts to search, (only 10^{80} electrons in the universe!)
- Joint work with IBMT/Fraunhofer Institut

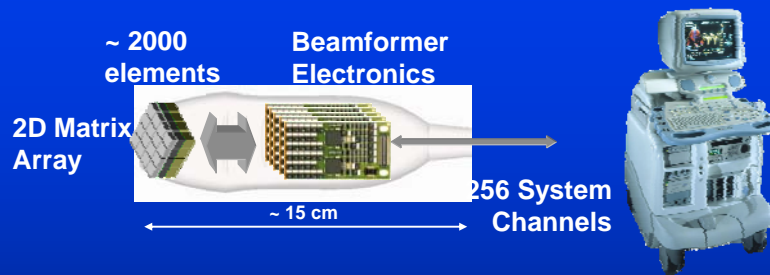


Periodic array (Lockwood et al)
221 Tx, 489 Rx, 57 overlap



Simulations: A. Austeng

The cardiac 3D challenge



Probe Technology Challenges

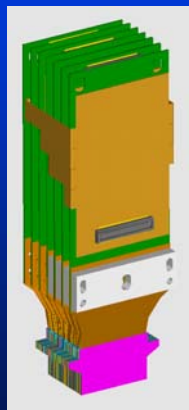
- Matrix Transducer
- Advanced Interconnect
- Low-power Micro Electronics
- Thermal Management
- Probe Assembly Architecture

System Technology Challenges

- 2x Data Acquisition
- 10x Data Processing in Display
- ECG Stitching of Sub-Volumes... for Large-Volume Acquisition
- Application Software

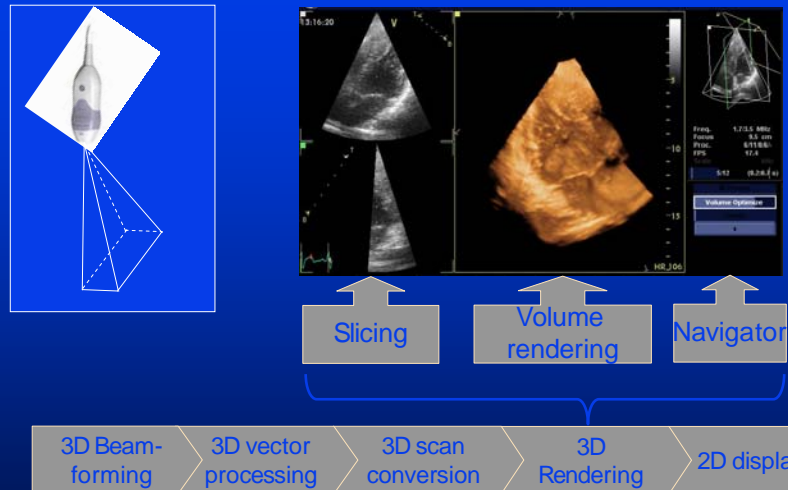
Solved Using Data-reducing Electronics in the Probe Handle

3D Ultralydprobe – high tech



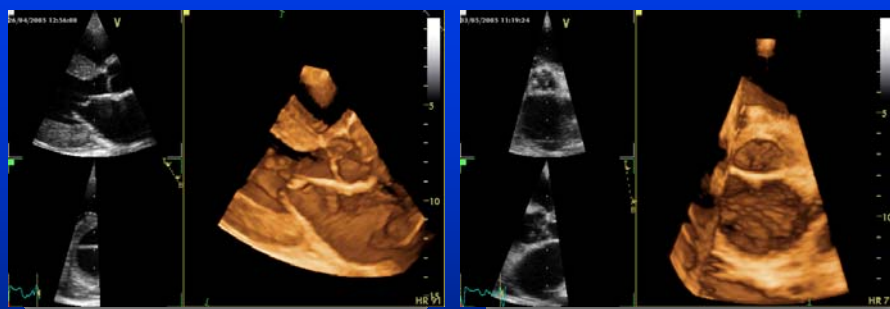
2000 Transducer Elements → 7 Boards, 35 ASICs → 256 System Channels

4D Scanning and Processing



All steps in Real Time

Real time 3D Volume Imaging

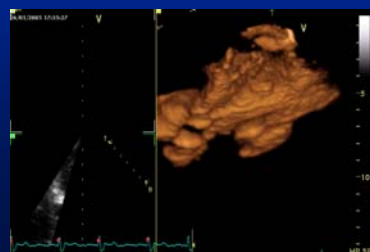
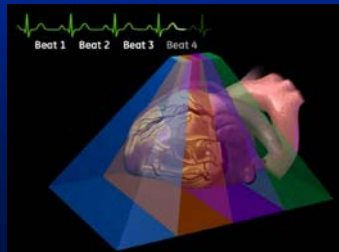
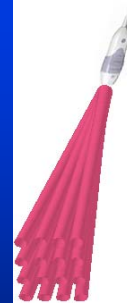
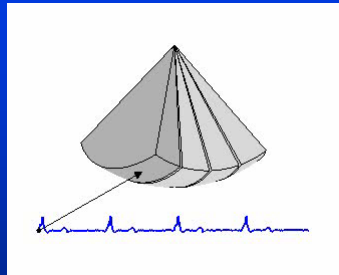


Standard setup

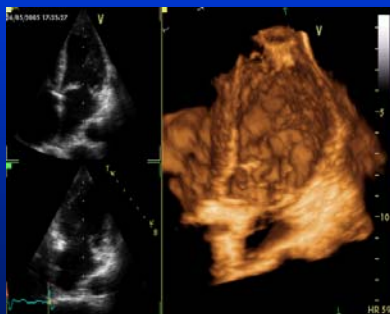
Increased elevation width

- No ECG gating
- Volume rendering / orthogonal slicing
- Volume size: $\sim 20 \times 80^\circ$ / $\sim 35 \times 45^\circ$
- Volume rate: 17-25

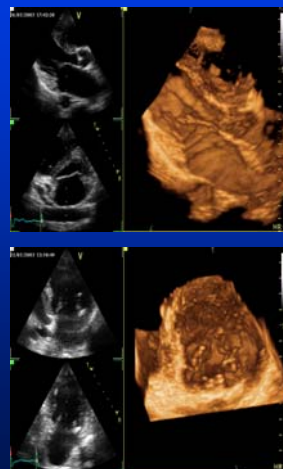
ECG-gated Data Acquisition



Full Volume (ECG gated acquisition)



- Typically acquired in 4 beats

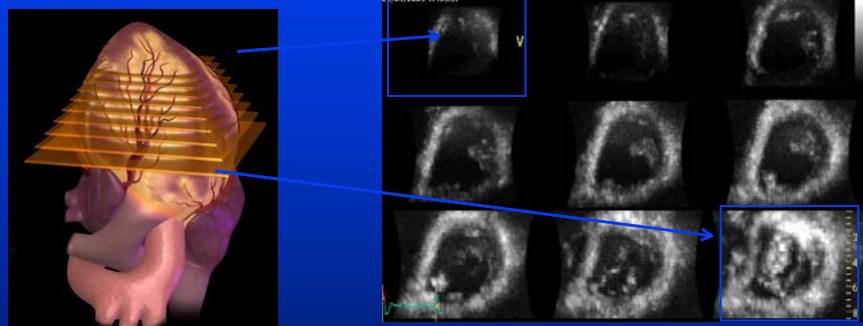


4D LV Volumes

- Chamber quantification based
- on deformable model (TomTec)
 - Ejection Fraction
 - Regional Wall Motion



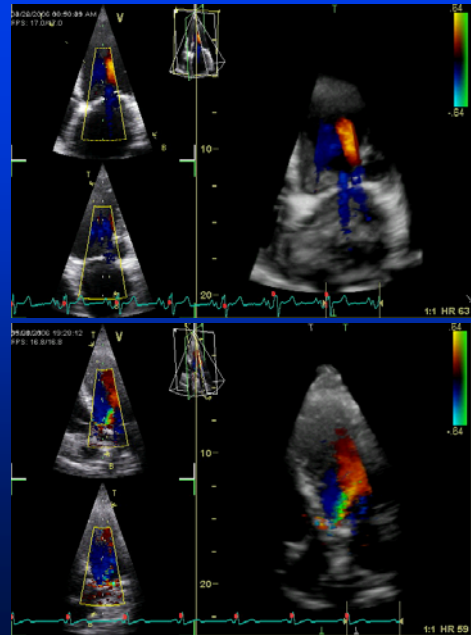
Navigation & Viewing – 9 Slice



Nine equidistant slices
Wall motion assessment

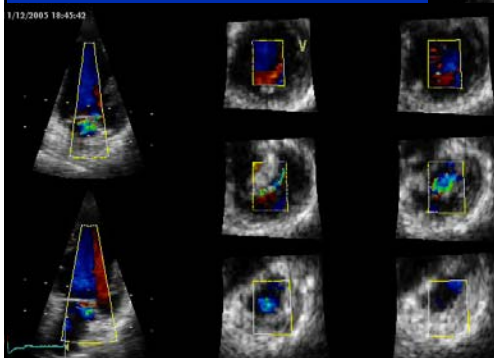
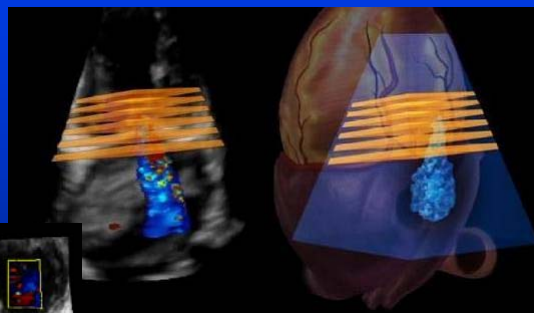
4D Color Imaging (ECG Gated)

- Gated from 7 heart beats
- High frame rates (17-35 frames / second)
- High Color sensitivity
- High Color resolution

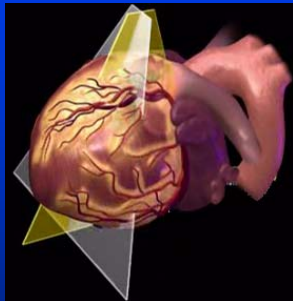


Color 6 Slice View

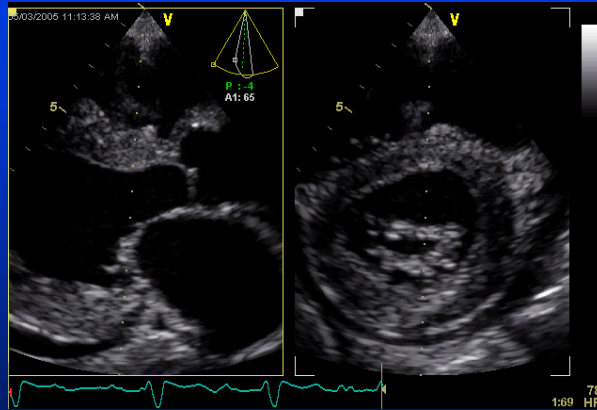
- Parallel slices... easily identify vena contracta
- Planimetry provided



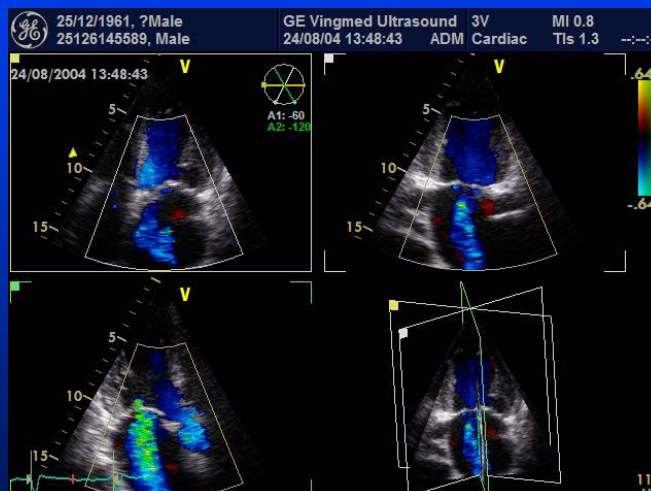
Bi-plane Imaging



Parasternal imaging
Tilt of elevation plane



Tri-plane Imaging



Apical Imaging:
Three
simultaneously
recorded images

All color modes
supported

Sanntid 3D ultralyd - foster

