AAPM Meeting
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Art of Imaging:
Diagnostic Ultrasound Image Artifacts

James A. Zagzebski, Ph.D.,
Department of Medical Physics, University of Wisconsin – Madison

Zheng Feng Lu, Ph.D.,
Department of Radiology, University of Chicago

Introduction

- Underlying assumptions when forming B-mode images
- Artifacts for specular reflectors
- Reverberations
- Scatter effects, speckle, speckle reduction
- Mirror image artifacts
- Common artifacts in Doppler
- Refraction
- Attenuation, shadowing, enhancement

For those with “SAMs” audience response clickers,
Trial question:

Illinois is known as the “Land of Lincoln;” Wisconsin is called “________.”

20%	1.	The Beehive State
20%	2.	America’s Dairyland
20%	3.	The Coyote state
20%	4.	The Beaver State
20%	5.	The Lone Star State

10

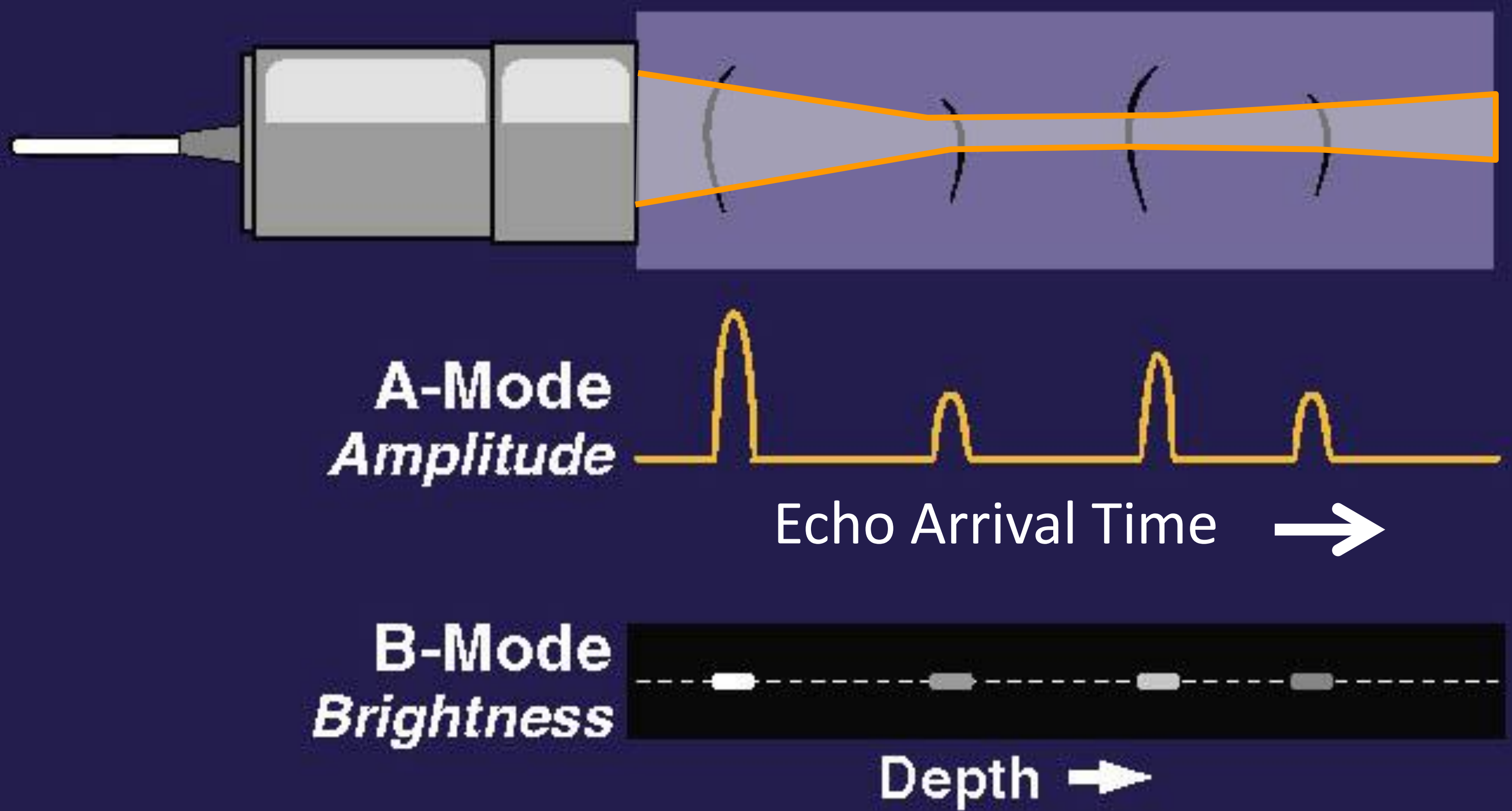
Answer 2 America's Dairyland

(http://en.wikipedia.org/wiki/List_of_U.S._state_nicknames)

1. The Beehive State (Utah)
2. America's Dairyland (Wisconsin)
3. The Coyote state (S. Dakota; officially, Mt Rushmore state)
4. The Beaver State (Oregon)
5. The Lone Star State (Texas)

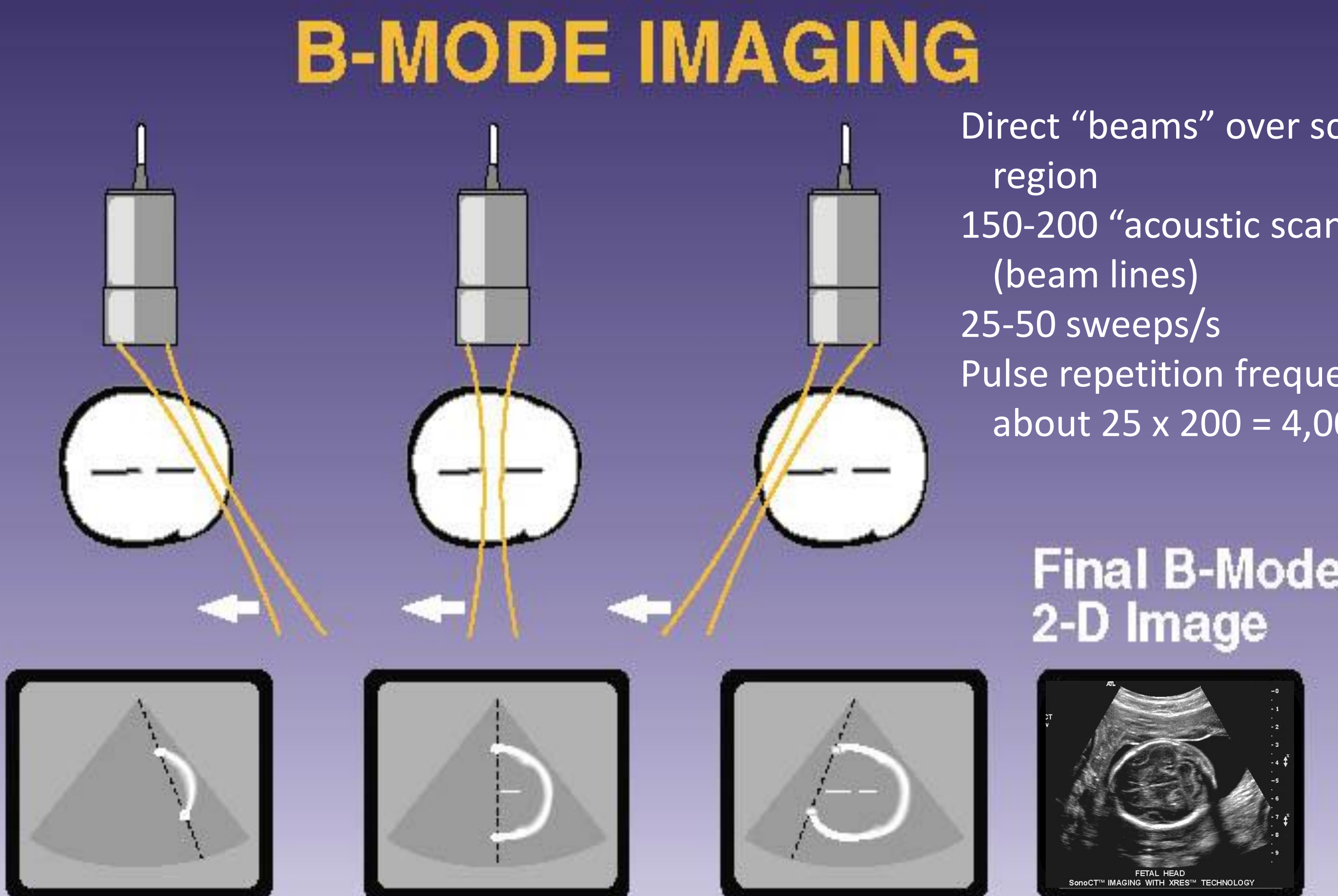
Underlying Assumptions when forming images:

A-MODE AND B-MODE



(Assumes a Sound Speed, usually 1,540 m/s)

Underlying Assumptions when forming images:



- Direct "beams" over scanned region
- 150-200 "acoustic scan lines" (beam lines)
- 25-50 sweeps/s
- Pulse repetition frequency of about 25 x 200 = 4,000 /s

Dots representing echo signals are displayed along a line that represents the ultrasound beam axis. Location along the line depends on echo arrival times.

Underlying Assumptions when forming images:

Dot brightness represents the echo signal amplitude. Try to optimize TGC, etc., so this indicates relative reflectivity.

Which of the following is NOT assumed implicitly during the formation of a conventional ultrasound B-mode image?

20%	1.	echoes originate from along “beam” axes
20%	2.	wave speed is 1540 m/s
20%	3.	brightness indicates reflectivity level
20%	4.	speckle reveals microscopic details of scatterers
20%	5.	TGC corrects for attenuation throughout

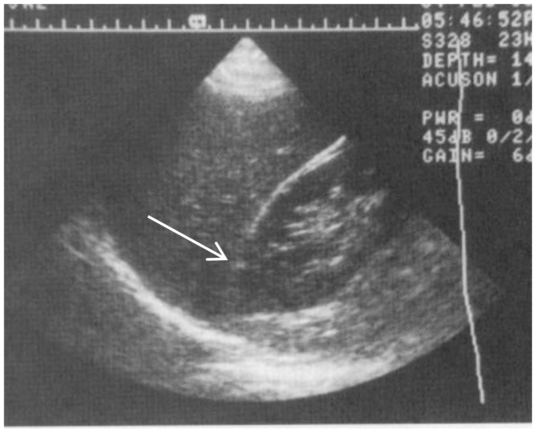
10

Answer 4: "speckle reveals microscopic details of scatterers" is not an assumption.

B-mode Imaging Assumptions

- Pulse-echo transit times can be converted to reflector depth through uniform tissue models.
- Echoes originate (only) from locations along the transmit-receive axes of pulse propagation path.
- First order correction schemes (such as TGC) adequately account for acoustic wave attenuation and absorption.
- Display brightness encodes tissue echogenicity.

JA Zagzebski, *Essentials of Ultrasound Physics*, Mosby, St Louis, 1996. Chapter 7.
F Kremkau, Chapter 6 in *Textbook of Diagnostic Sonography*, SL Hagen Ansert, Elsevier, 2012, Chapter 6.



Echoes from the superior pole of the kidney are weaker (do not appear as bright) than those from the proximal surface because of changes in ____ over the liver-kidney interface.

20%	1.	Beam focusing
20%	2.	frequency
20%	3.	acoustic impedance
20%	4.	depth
20%	5.	incident beam angle

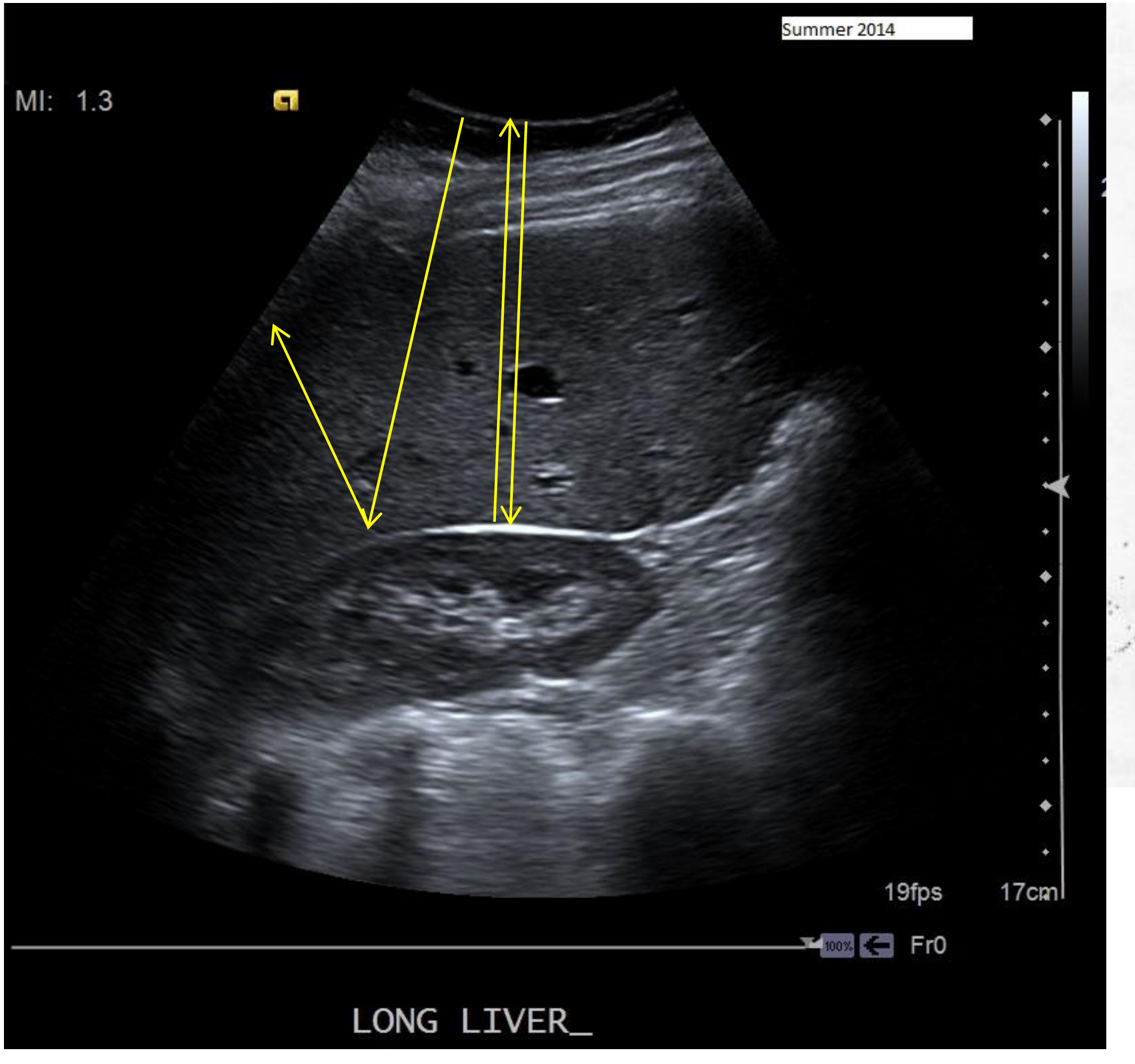
Answer 5: changes in incident beam angle

Specular Reflector: effects on ability to outline an object

Impedance change at liver-to-kidney interface likely is uniform

Beams from a curvilinear array emerge perpendicular to surface of aperture

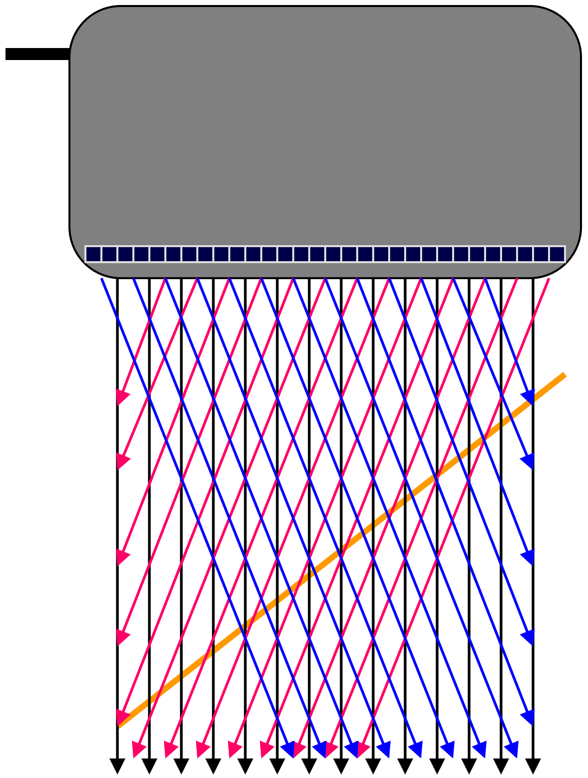
Strong effects of beam angle on detected amplitude, display brightness

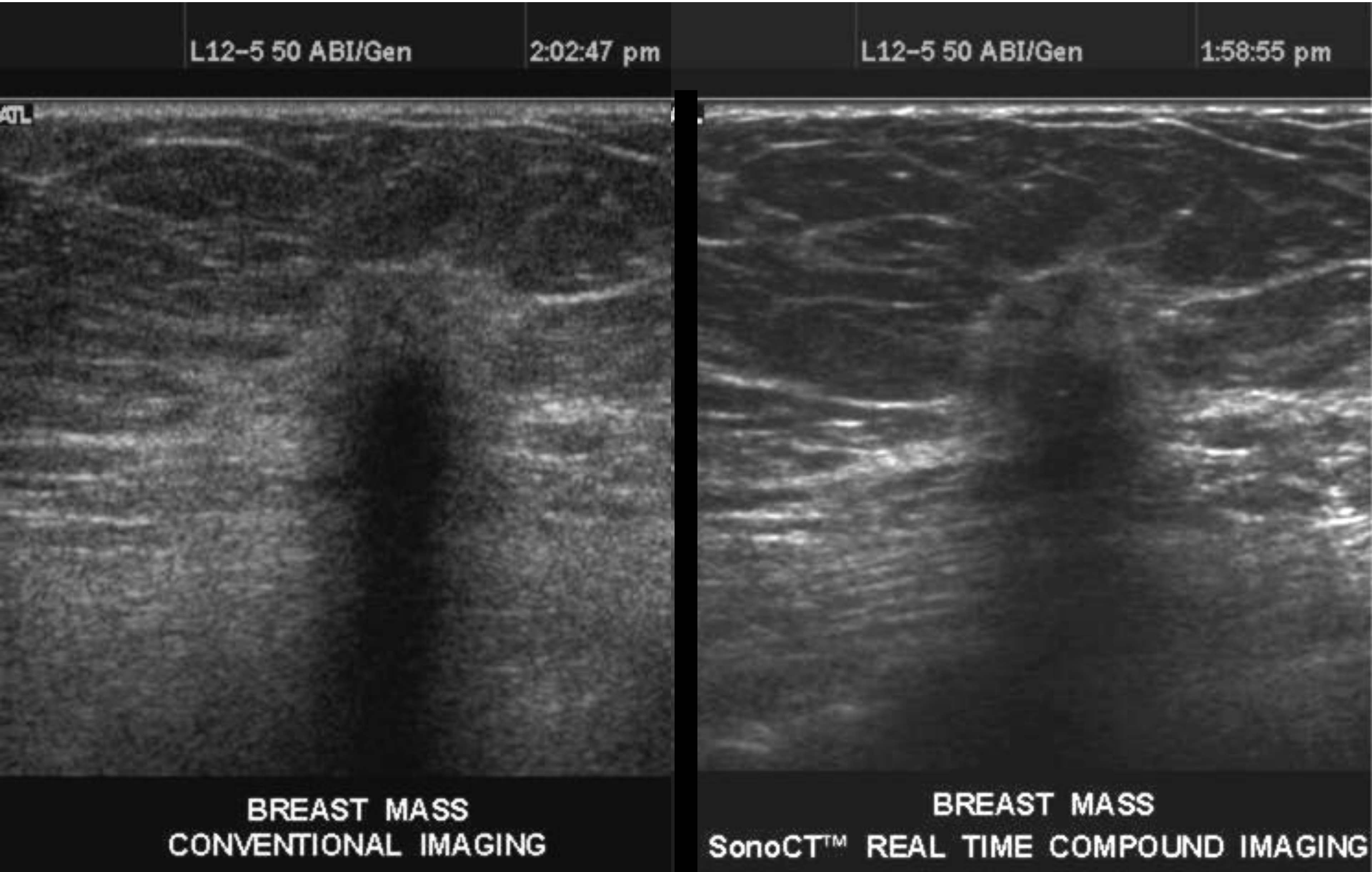


JA Zagzebski, *Essentials of Ultrasound Physics*, Mosby, St Louis, 1996. Chapter 7.

Spatial Compounding

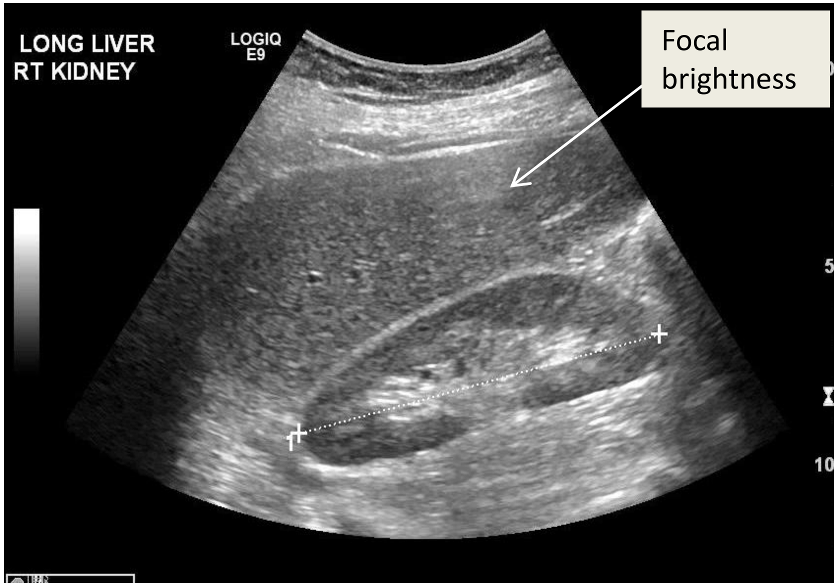
- Uses "beam steering" technology
- Combines scans from different angles
- More completely outlines interfaces that are not perpendicular to primary beam direction
- Smoothes random dots called speckle





Entrekin RR[1], Porter BA, Sillesen HH, Wong AD, Cooperberg PL. " Real-time spatial compound imaging: application to breast, vascular, and musculoskeletal ultrasound." Semin Ultrasound CT MR. 2001 Feb;22(1):50-64

The region of brighter echoes in this longitudunal view of the liver and kidney are most likely due to which of the following?



20%	1.	A focal mass
20%	2.	Higher speed of sound in this region
20%	3.	Side lobe artifacts
20%	4.	Reverberations
20%	5.	Stress from a swollen kidney

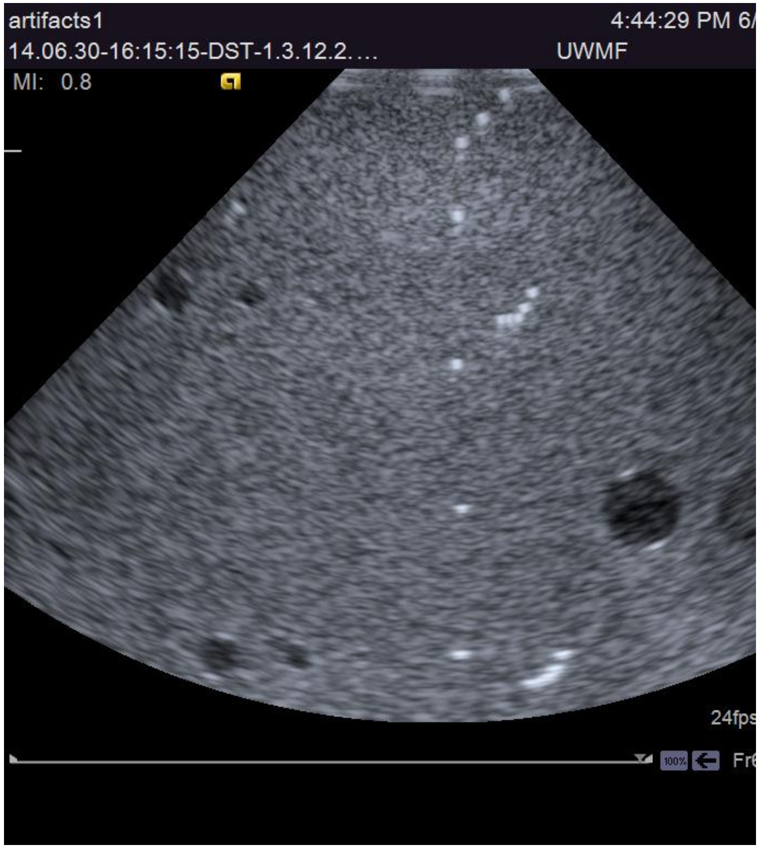
10

Answer 4: Reverberations (likely, the most ubiquitous ultrasound artifact)

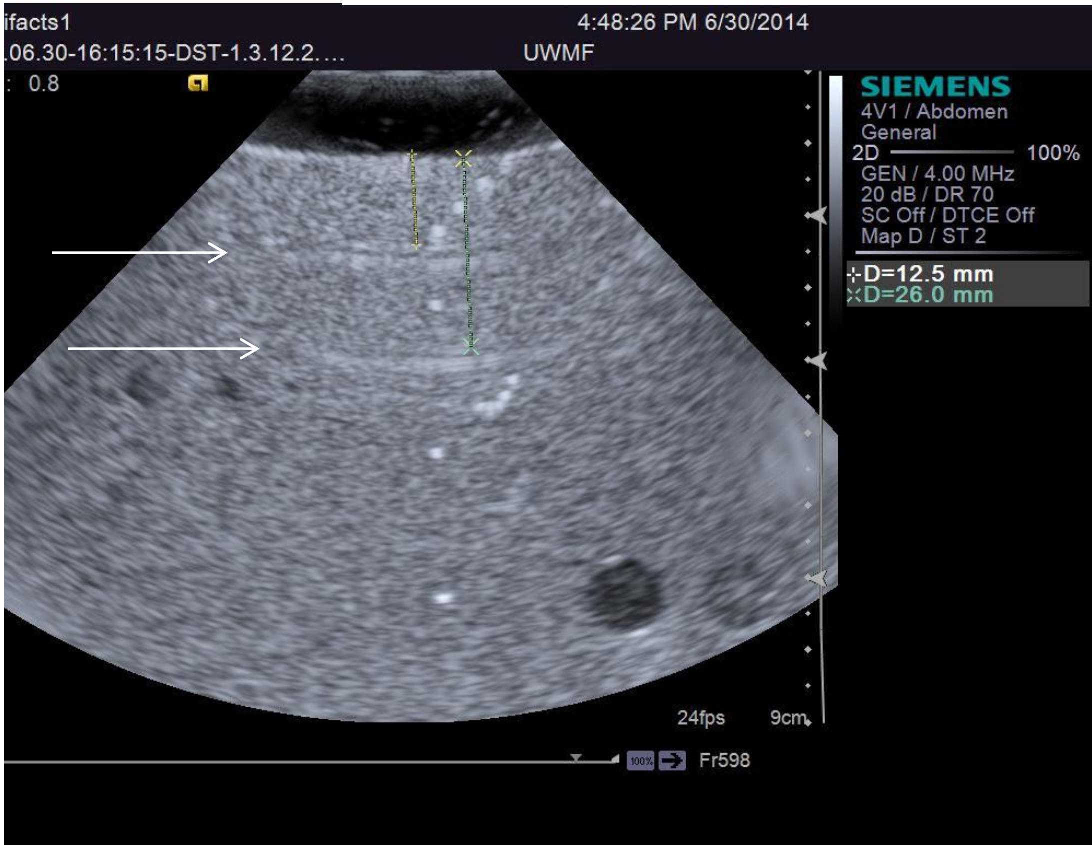
JA Zagzebski, *Essentials of Ultrasound Physics*, Elsevier, 1996.
FW Kremkau, *Sonography Principles and Instruments*,, Elsevier, 2011.

Images of a Gammex 403 Phantom

Transducer in direct contact



12 mm tissue-like layer between the transducer and the phantom

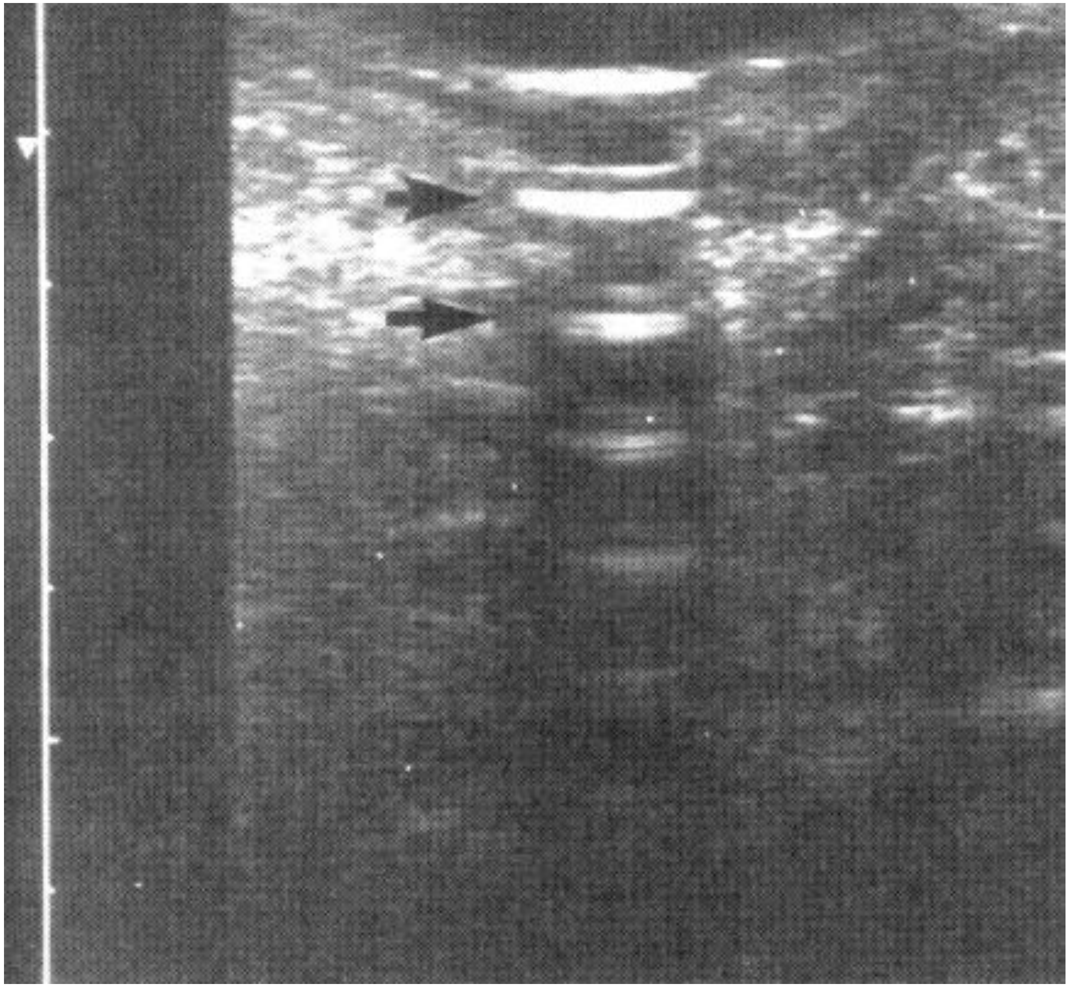


REVERBERATION ARTIFACT

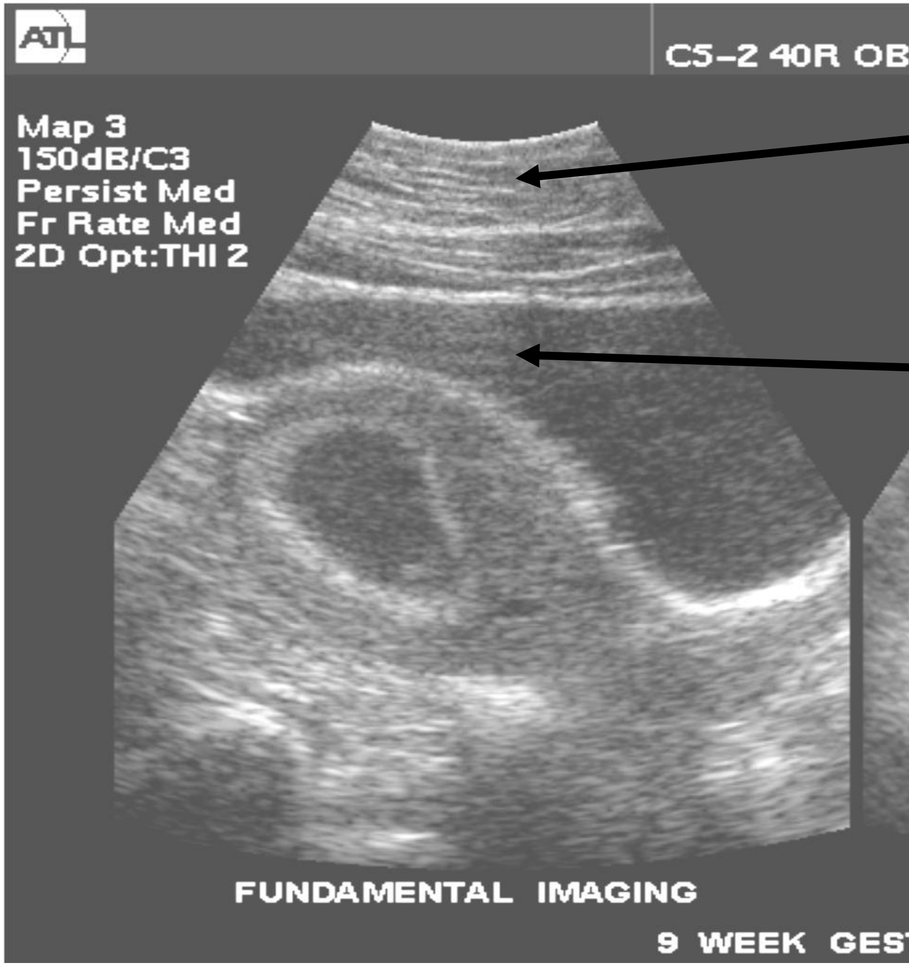
Beam bounces back and forth between transducer and target

Reverberation Artifacts

Air bubble in a water-filled condom.



Reverberations



Reverberations here

Produce “noise” here

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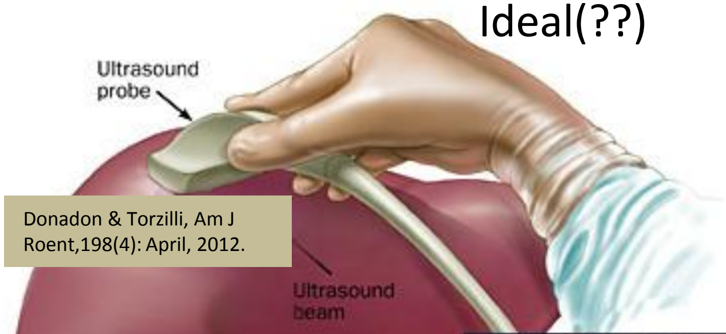
Entrekin RR[1], Porter BA, Sillesen HH, Wong AD, Cooperberg PL. “ Real-time spatial compound imaging: application to breast, vascular, and musculoskeletal ultrasound.” Semin Ultrasound CT MR. 2001 Feb;22(1):50-64

Reverberations

.
Entrekin et al, Semin Ultrasound CT MR. 2001 Feb;22(1):50-64

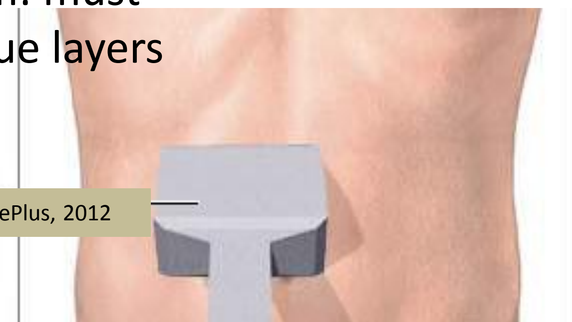
Reverberations

Ideal(??)

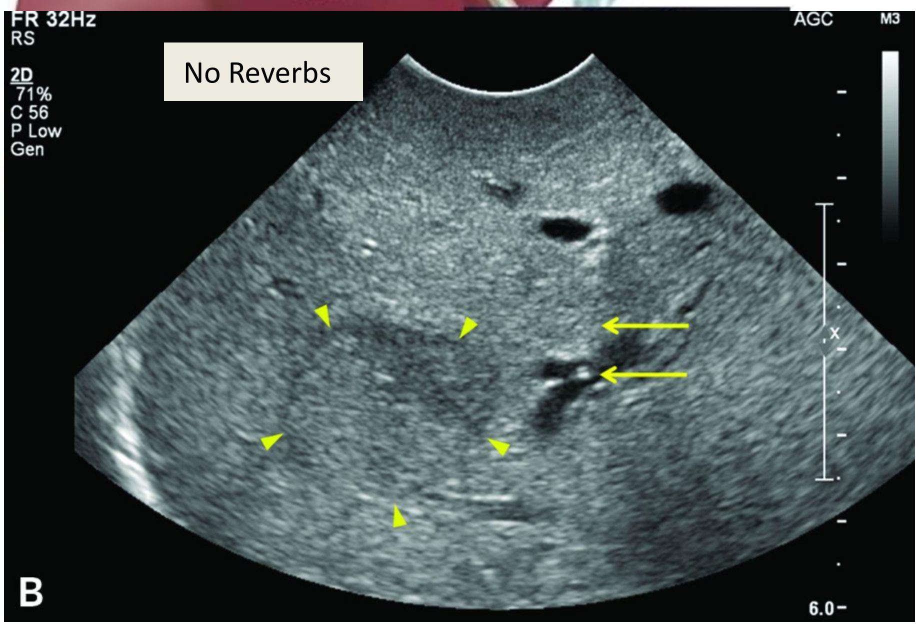


Donadon & Torzilli, Am J Roent,198(4): April, 2012.

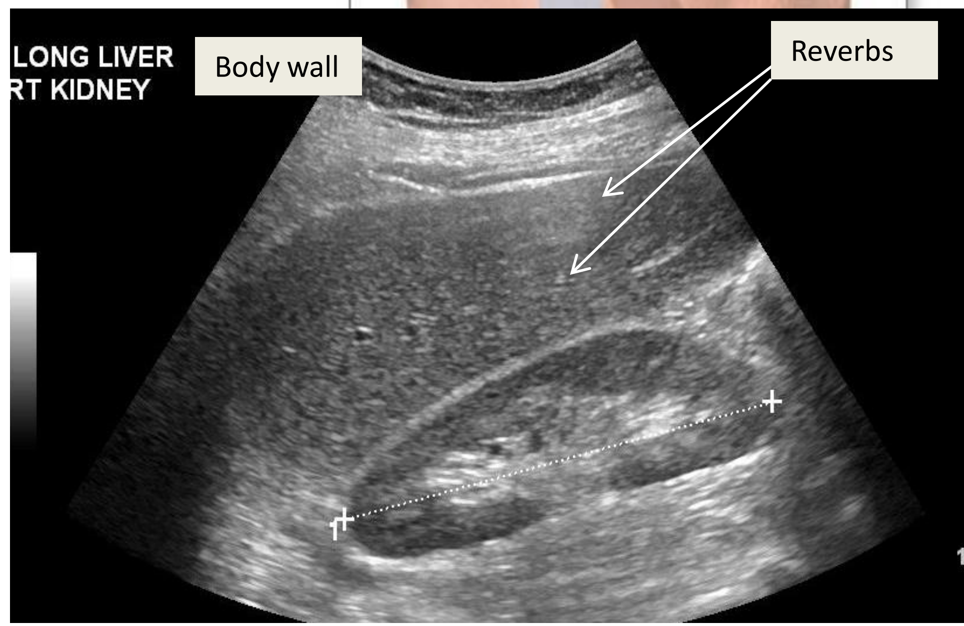
Fundamental problem: must transmit through tissue layers



MedlinePlus, 2012



Park et al, “Introperative Contrast –enhanced sonographic …,” J Ultrasound Med 35(7): 1287-91, 2014.



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Entrekin et al, Semin Ultrasound CT MR. 2001 Feb;22(1):50-64

Harmonic Imaging

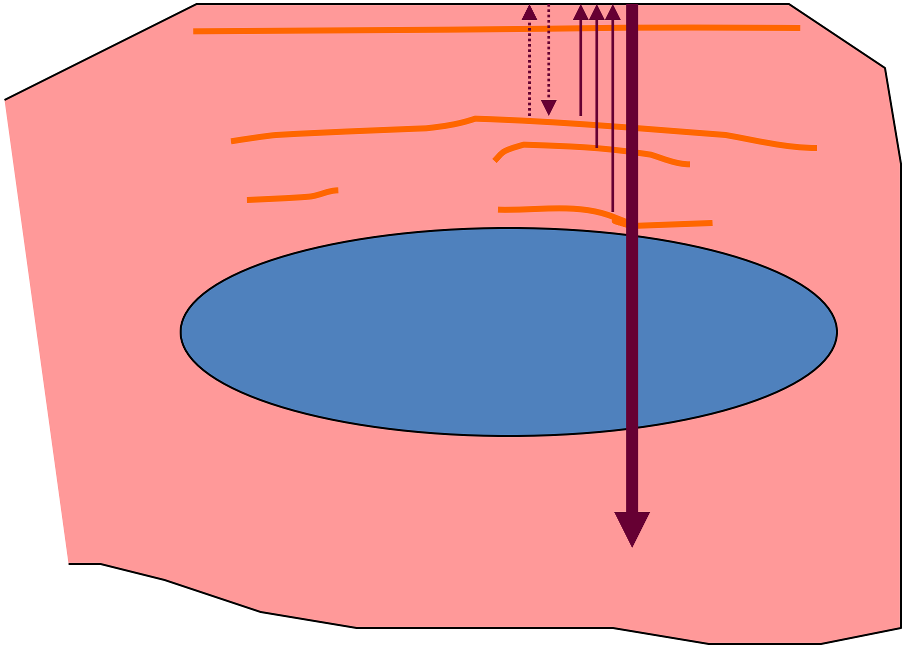
Transmit a low-frequency pulse (2-5 MHz)

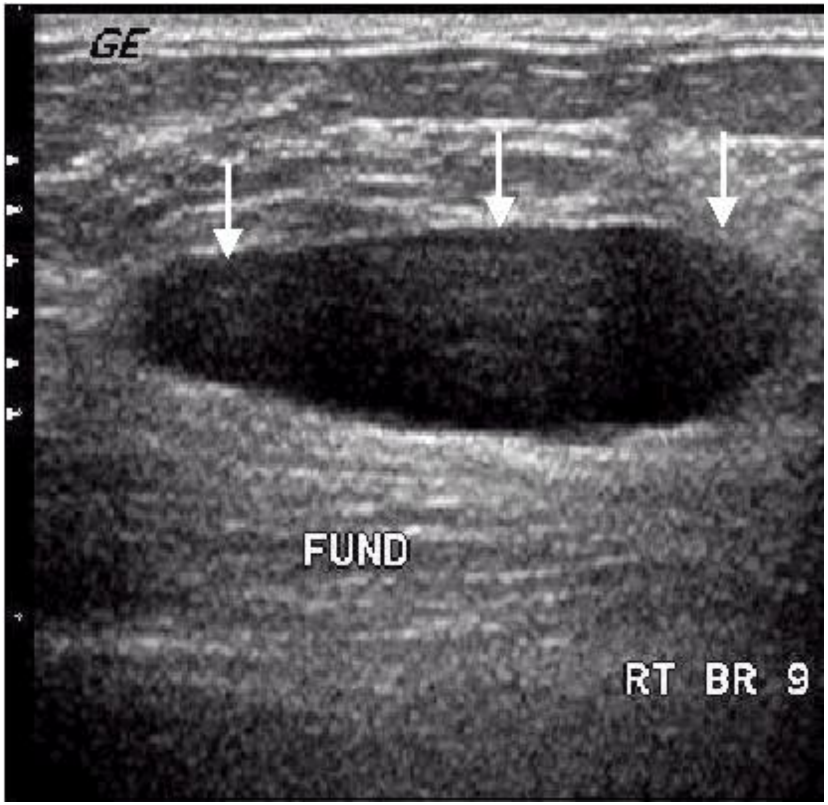
The pulse gradually distorts due to nonlinear propagation

→ second harmonic generation

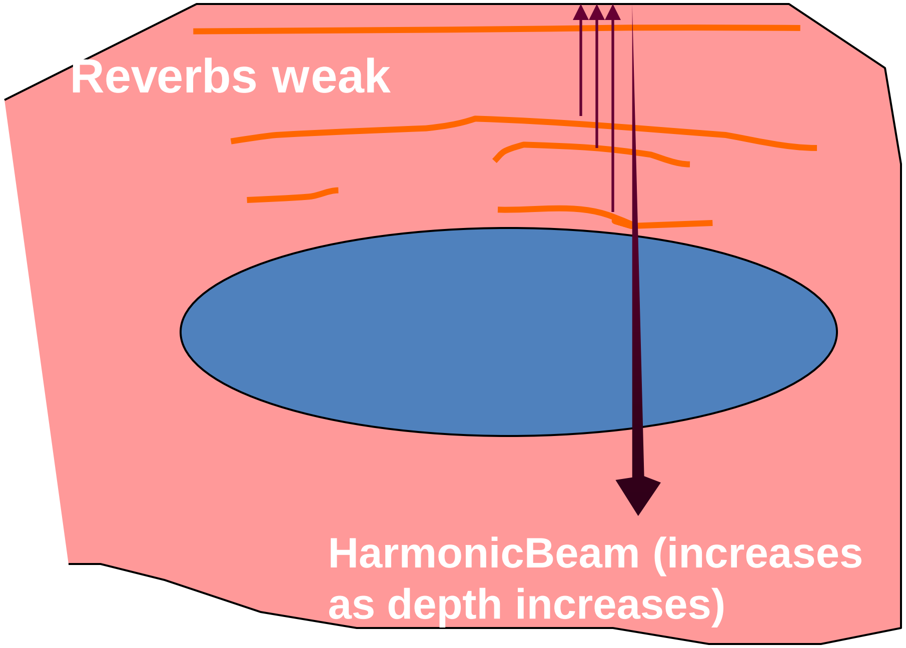
Harmonic field is weaker than fundamental as incident beam propagates through superficial layers

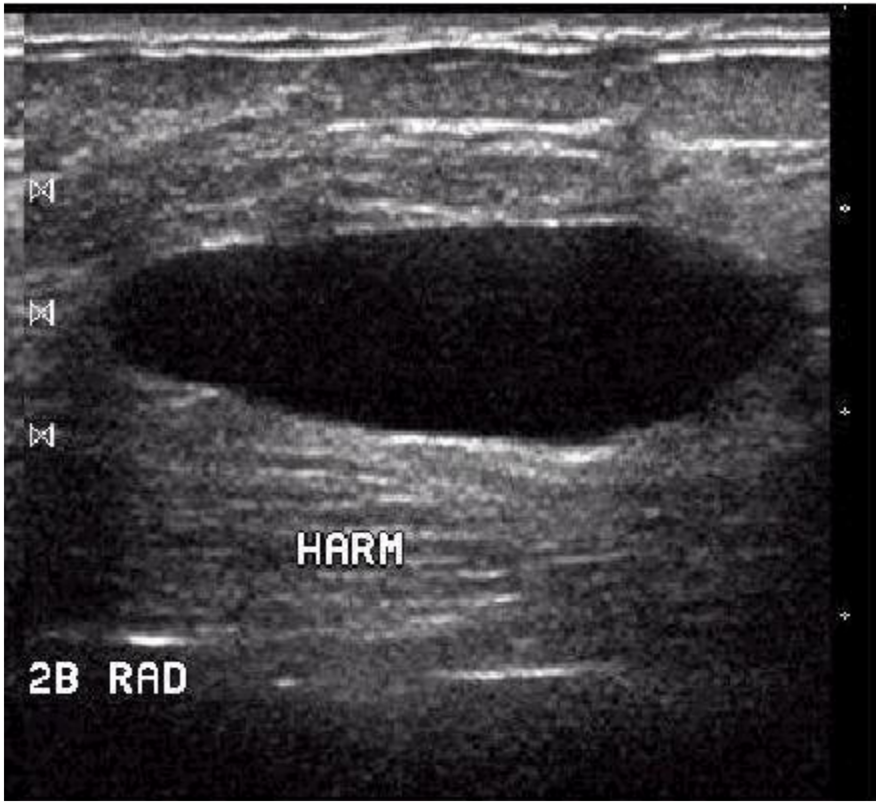
Reverberations





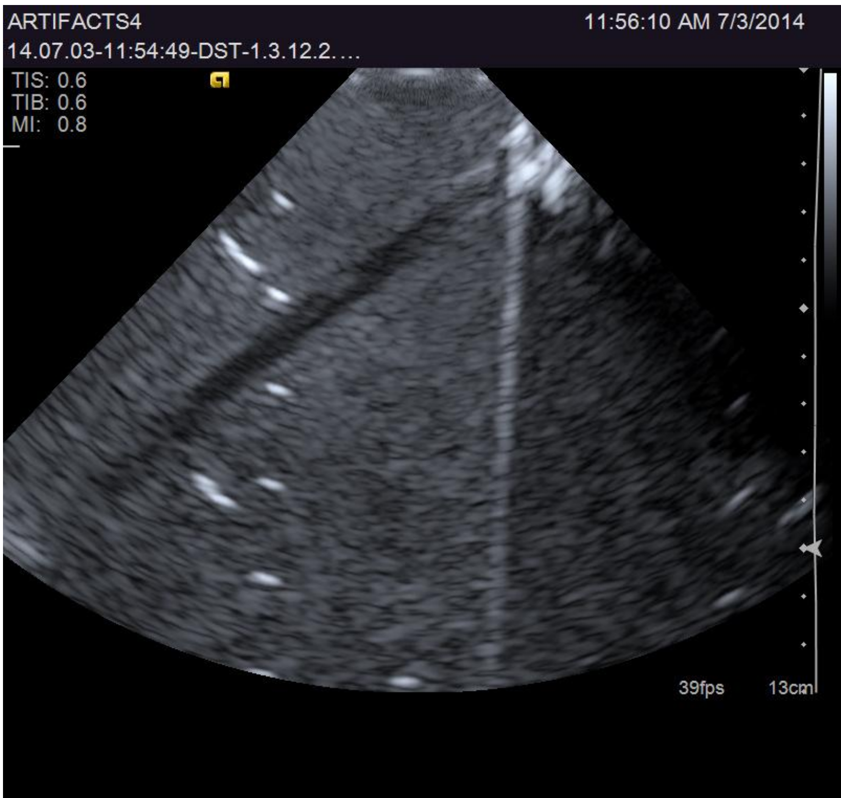
Harmonic Beam



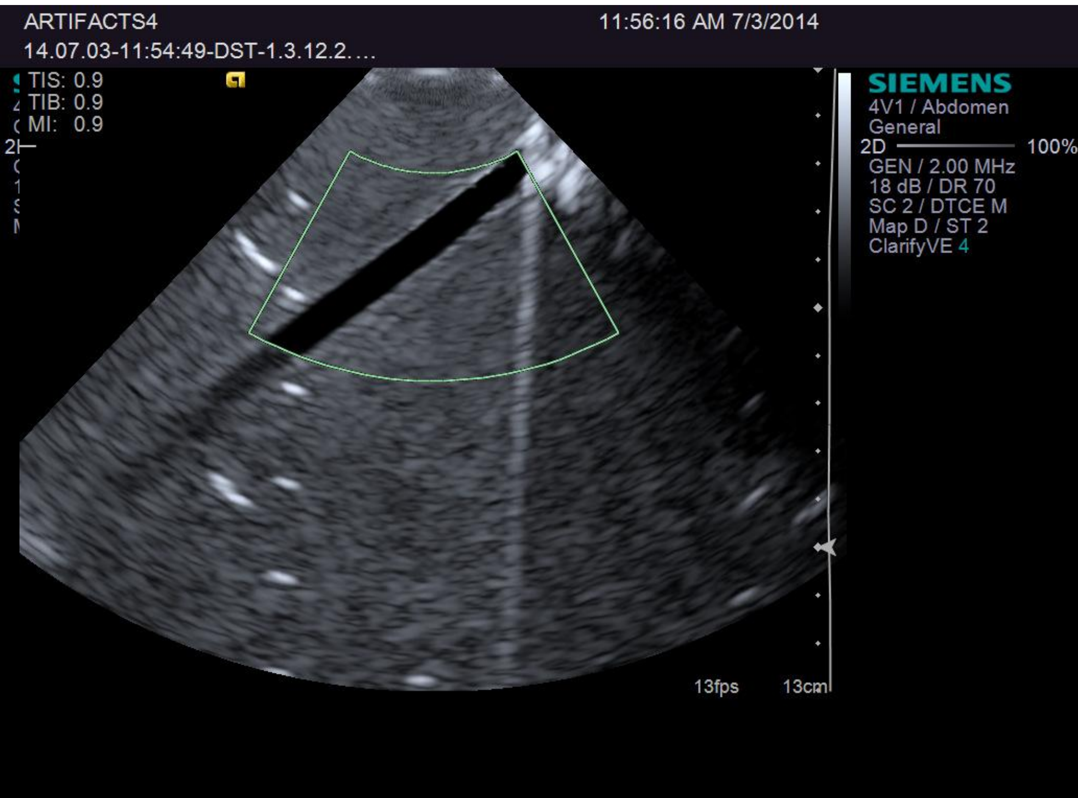


“Clarify” (Siemens Medical Solutions)

Uses power Doppler signals to remove unwanted gray scale echo signals from vessels.

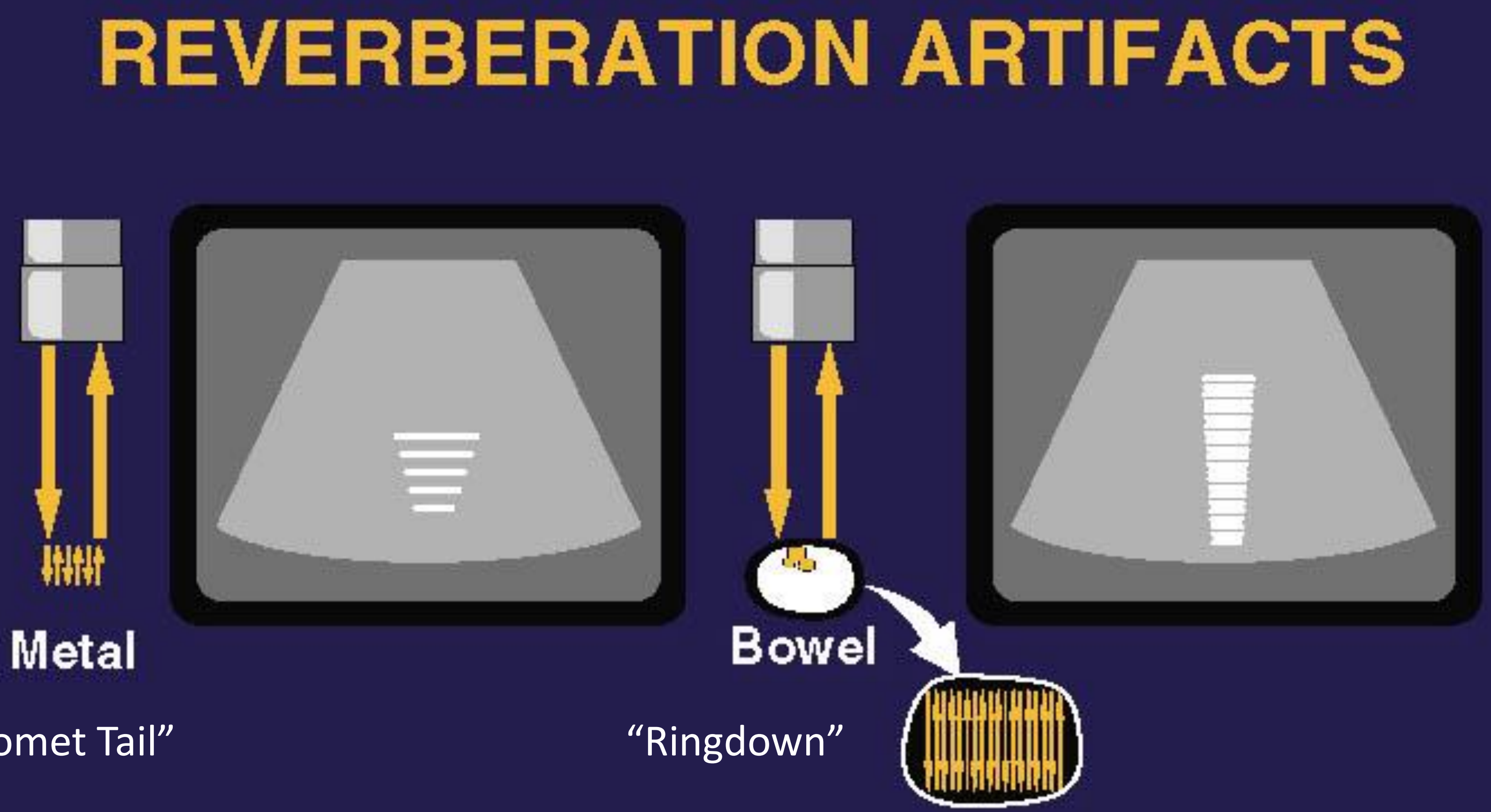


Doppler flow phantom



After applying Clarify

Examples of reverberations occurring within distal objects, not back and forth between transducer and object.

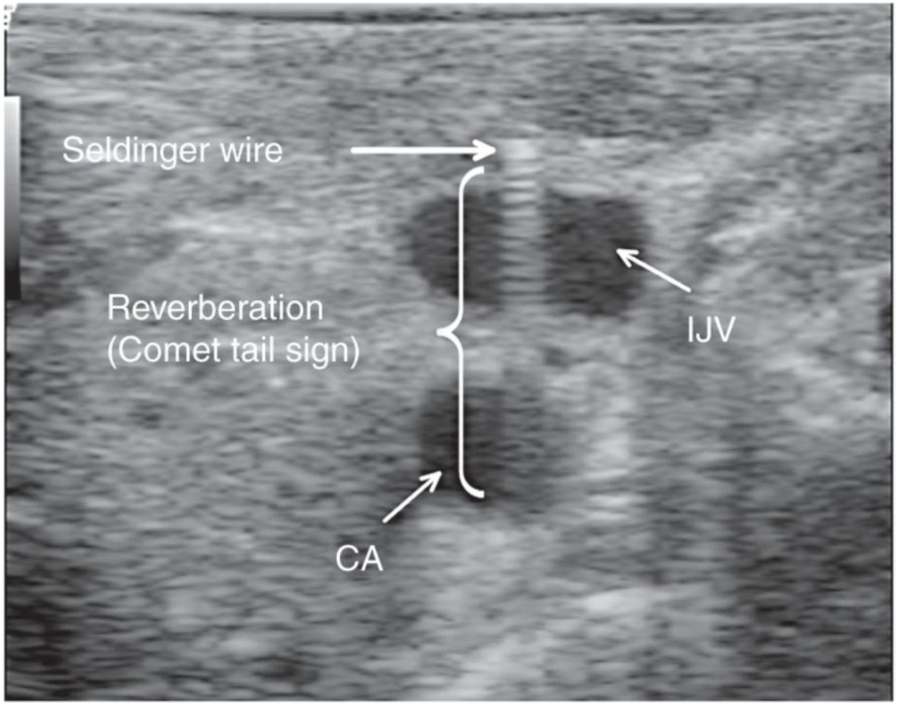


"Comet Tail"

"Ringdown"

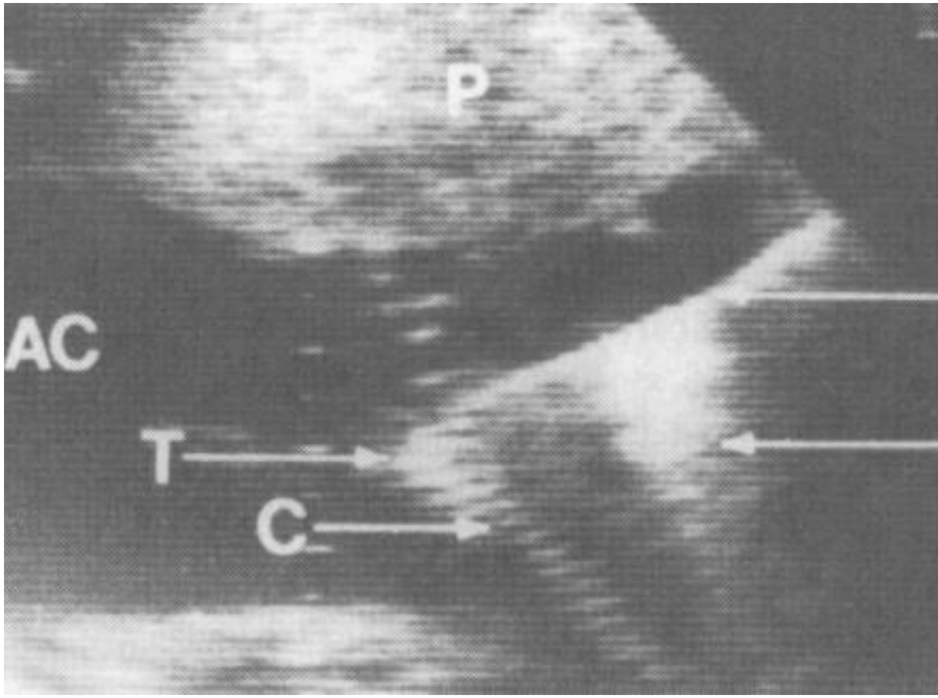
“Comet Tail” Artifacts (a reverberation phenomenon)

Seldinger wire a few millimetres above its entry to the jugular vein.



Reusz G et al. Br. J. Anaesth. 2014;112:794-802

Reverberations within a biopsy needle.



Schwartz DB, Zwiebel WJ, Zagzebski JA, Arbogast AL. ”Use of real-time ultrasound to enhance fetoscopic visualization,” *J Clinical Ultrasound.* **11(3)**: 161-164 (1983).

Ringdown Artifacts

(a reverberation phenomenon)

Water couple a transducer to a phantom; then withdraw the probe from the phantom surface. Effect is as shown on the right.

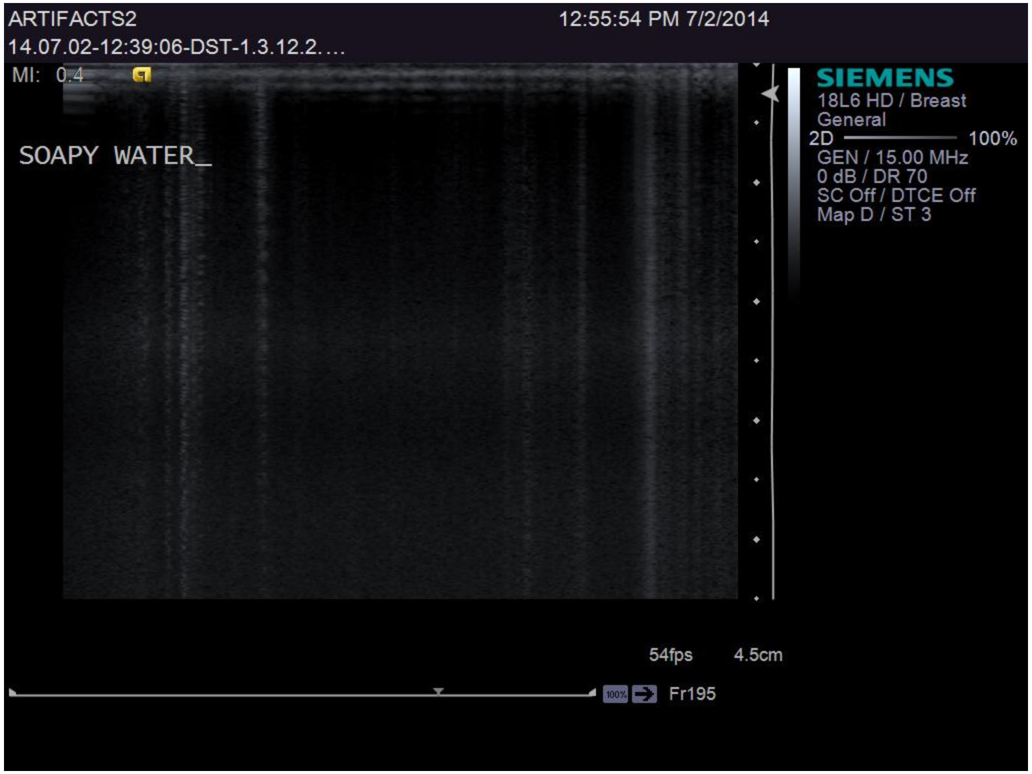
Ringdown Artifacts

(a reverberation phenomenon)

Water couple a transducer to a phantom; then withdraw the probe from the phantom surface. Effect is as shown on the right.

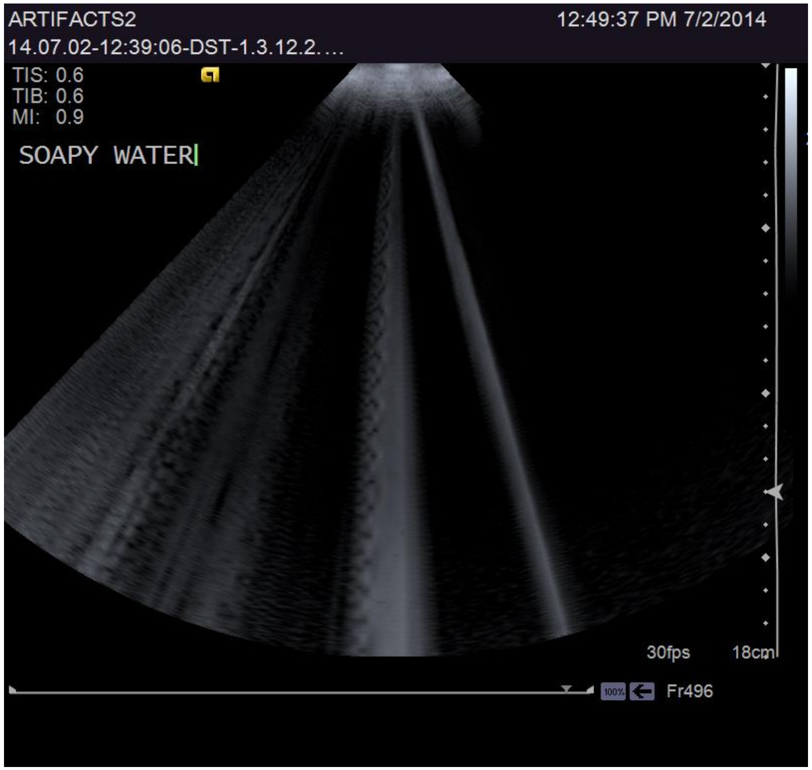
Repeat the experiment after adding detergent to the water. Bubbles result in a "ringing" artifact.

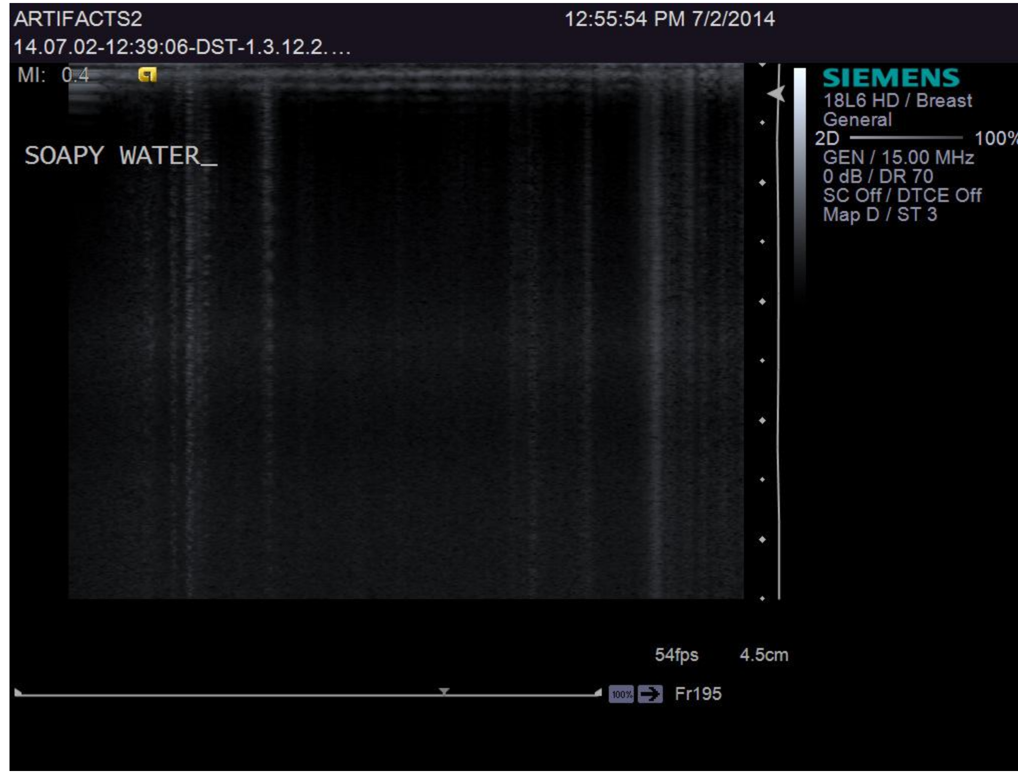
This is the origin of what has come to be known as "ringdown artifacts.



Ringdown Artifacts

(a reverberation phenomenon)

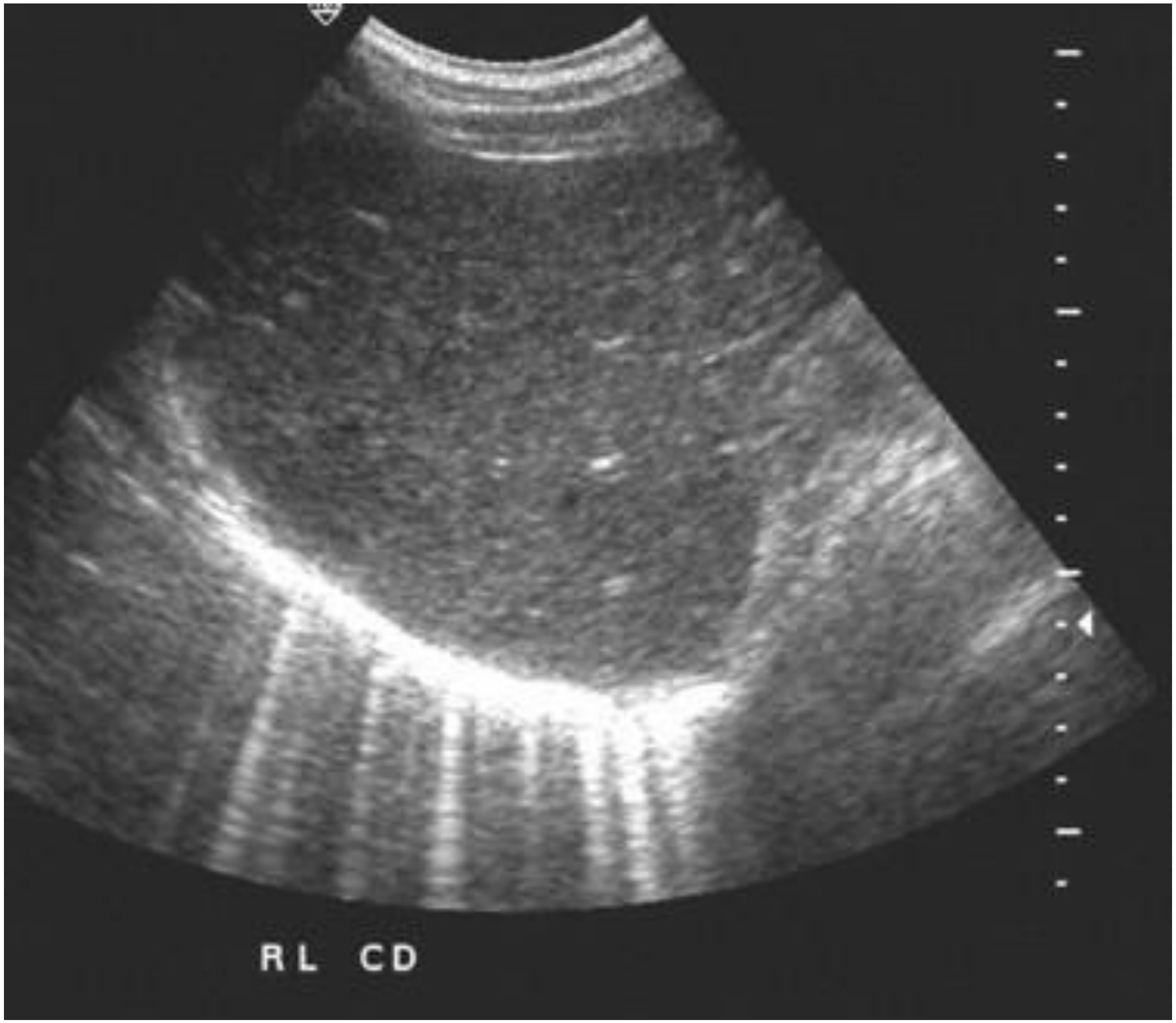




<u>Phased Array</u> (Bubbles result in a "ringing" artifact) **<u>Linear Array</u>**

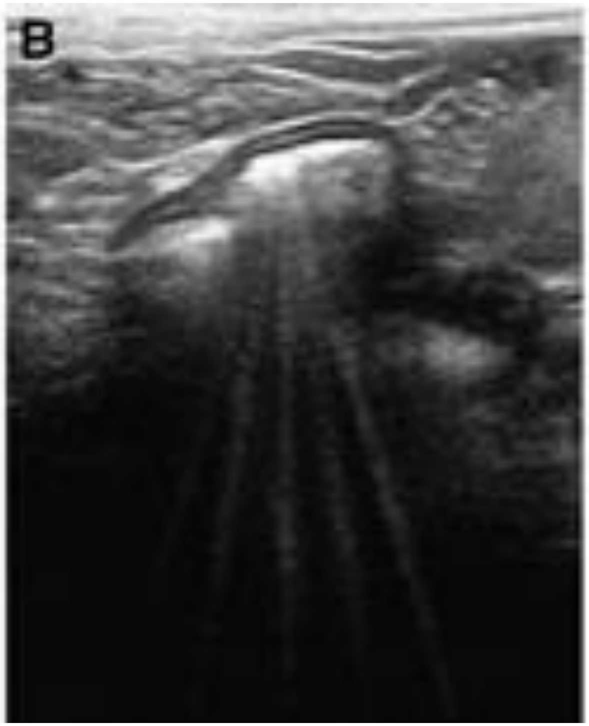
Ringdown Artifacts

(a reverberation phenomenon)



http://www.criticalecho.com/content/tutorial-1-basic-physics-ultrasound-and-doppler-phenomenon

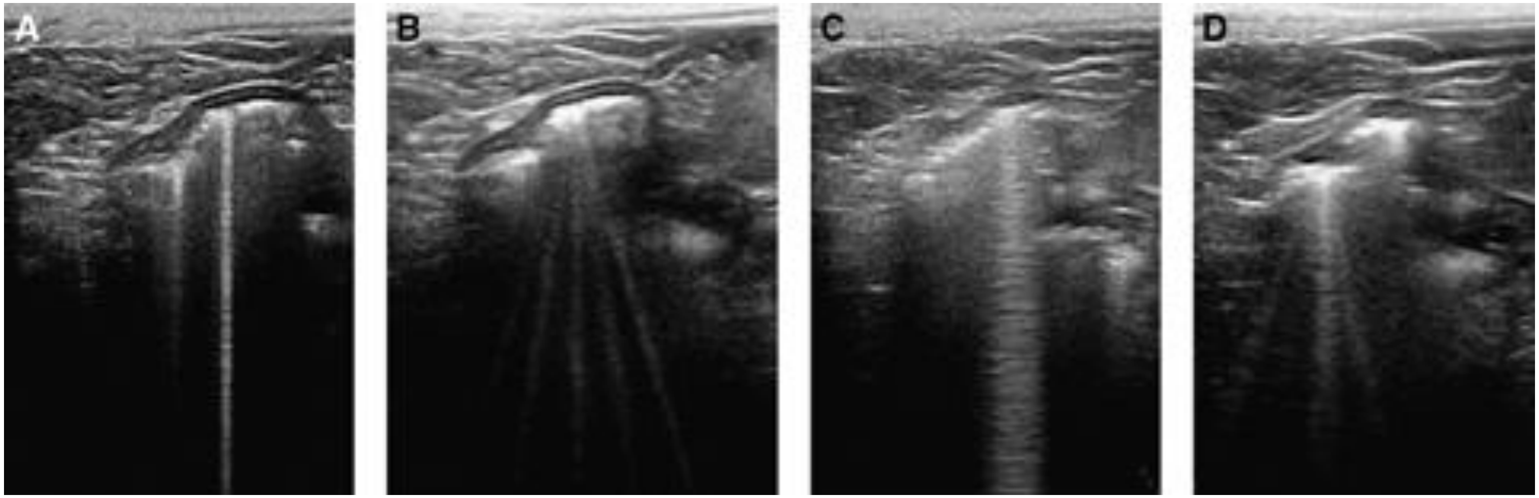
What 2 factors are combined on this B-mode image? (Hint, 1 is an artifact, the other involves acquisition/processing.)



20%	1.	Specular reflection angle effects *and* harmonic imaging
20%	2.	Specular refection angle effects *and* speckle reduction
20%	3.	Ring down *and* Spatial compound imaging
20%	4.	Reverberations *and* harmonic imaging
20%	5.	Shadowing *and* spatial compounding

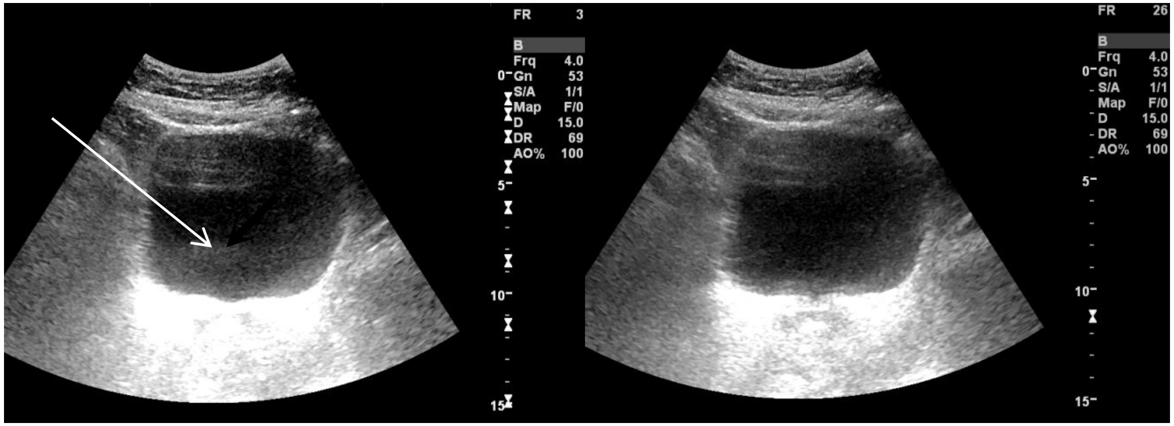
Answer 3: Ringdown artifacts viewed with Spatial compound imaging

Reverberation Artifacts



Ring-down artifacts from the stomach imaged with both conventional (A and C) and spatial compound imaging (B and D)

Veterinary Radiology & Ultrasound Volume 51, Issue 6, pages 621-627, 4 NOV 2010
DOI: 10.1111/j.1740-8261.2010.01724.x
http://onlinelibrary.wiley.com/doi/10.1111/j.1740-8261.2010.01724.x/full#f3



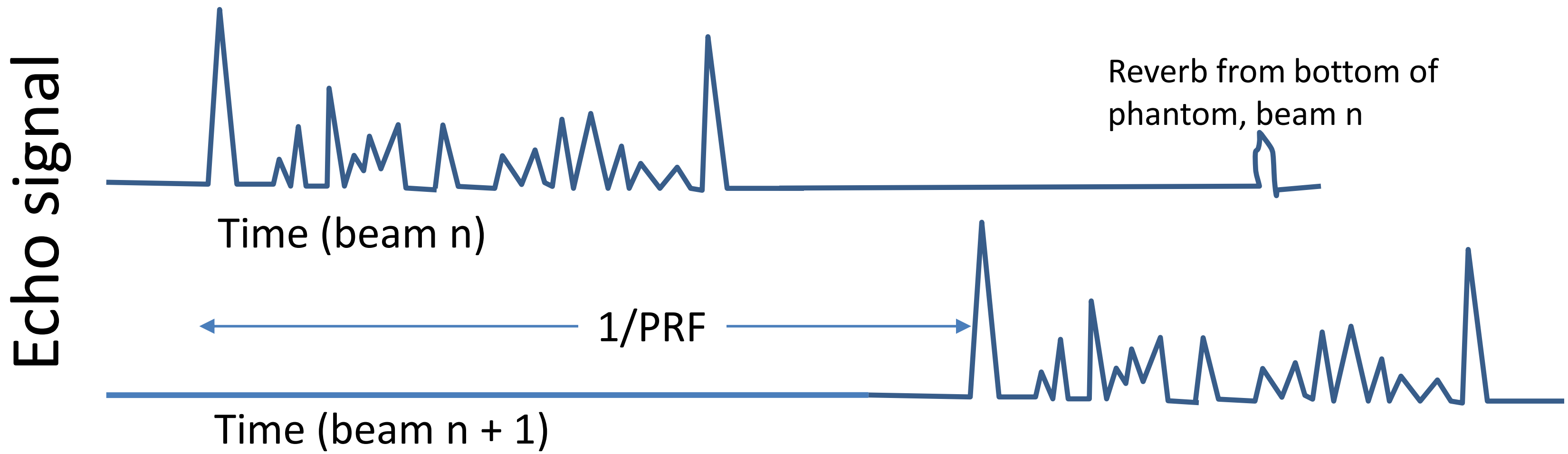
Scan courtesy of Dr. Stephen Thomas, Dept of Radiology, University of Chicago.

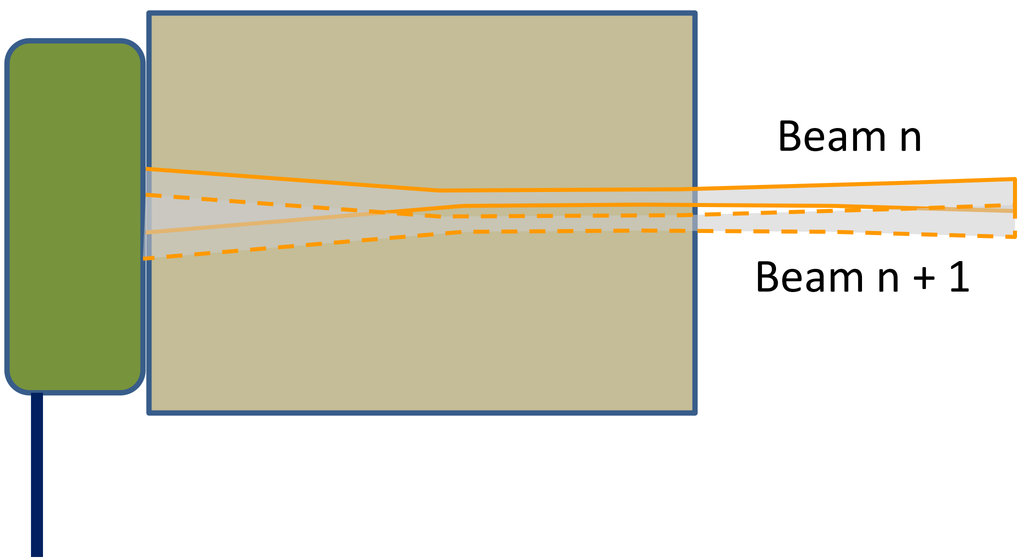
These 2 images of the bladder are identical, except one uses multiple transmit focal zones (left) while the other does not (right). The most likely cause of the echogenic region in the lower half of the bladder on the left is: (Hint, multiple transmit zones often result in an elevated PRF.)

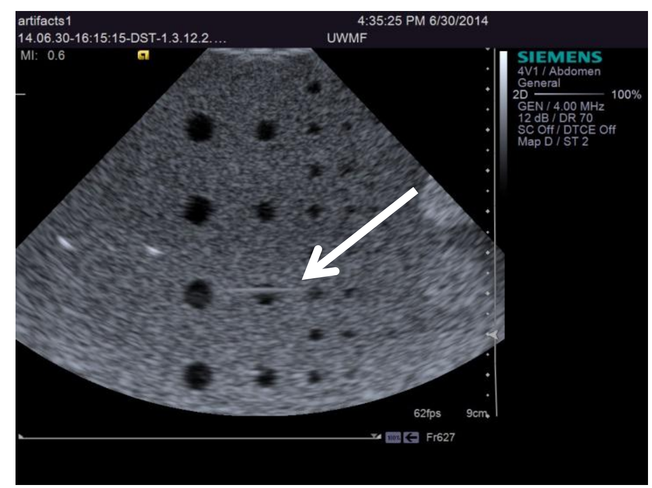
20%	1.	Reverberations
20%	2.	Range ambiguity
20%	3.	Beam width artifacts
20%	4.	Mirror image artifacts
20%	5.	Speed of sound artifacts

Answer 2: Range ambiguity artifact RT O'Brien, JA Zagzebski, FA Delaney, Range ambiguity artifacts, Vet Radiology & Ultrasound 42: 542-545, 2001.

Echo signals, artifacts, acoustic noise from "beam n" arizing beyond the FOV are detected; if PRF is too high, they are picked up after transmitting along beam n + 1.)





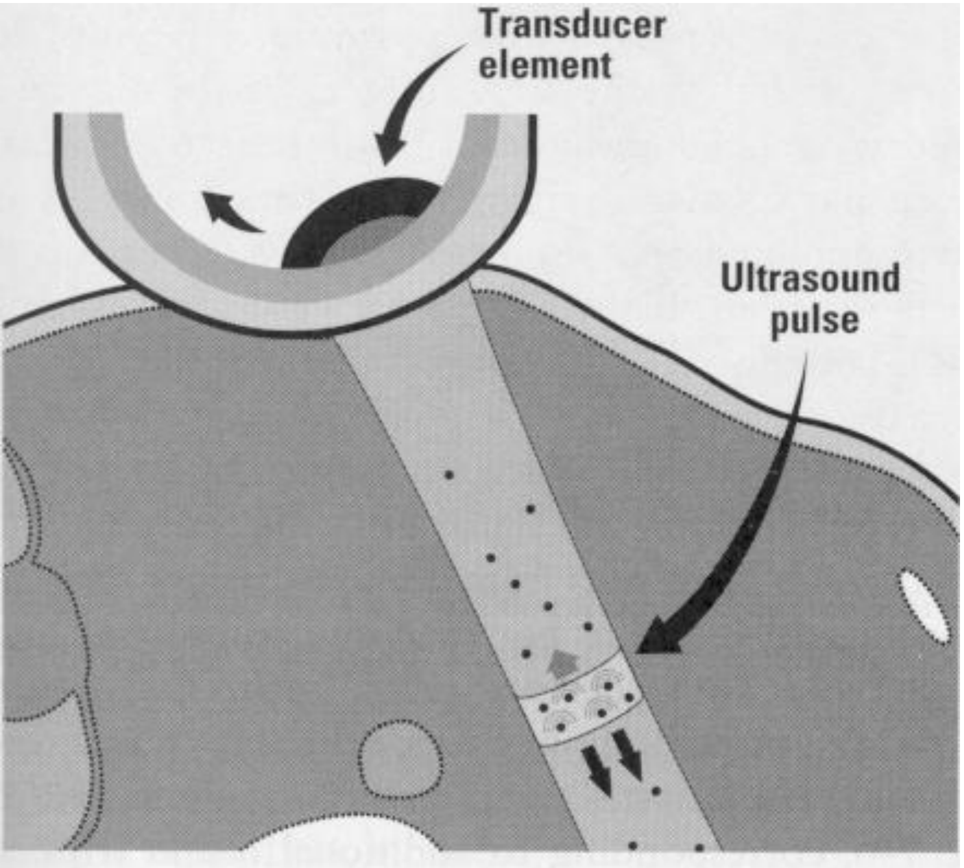


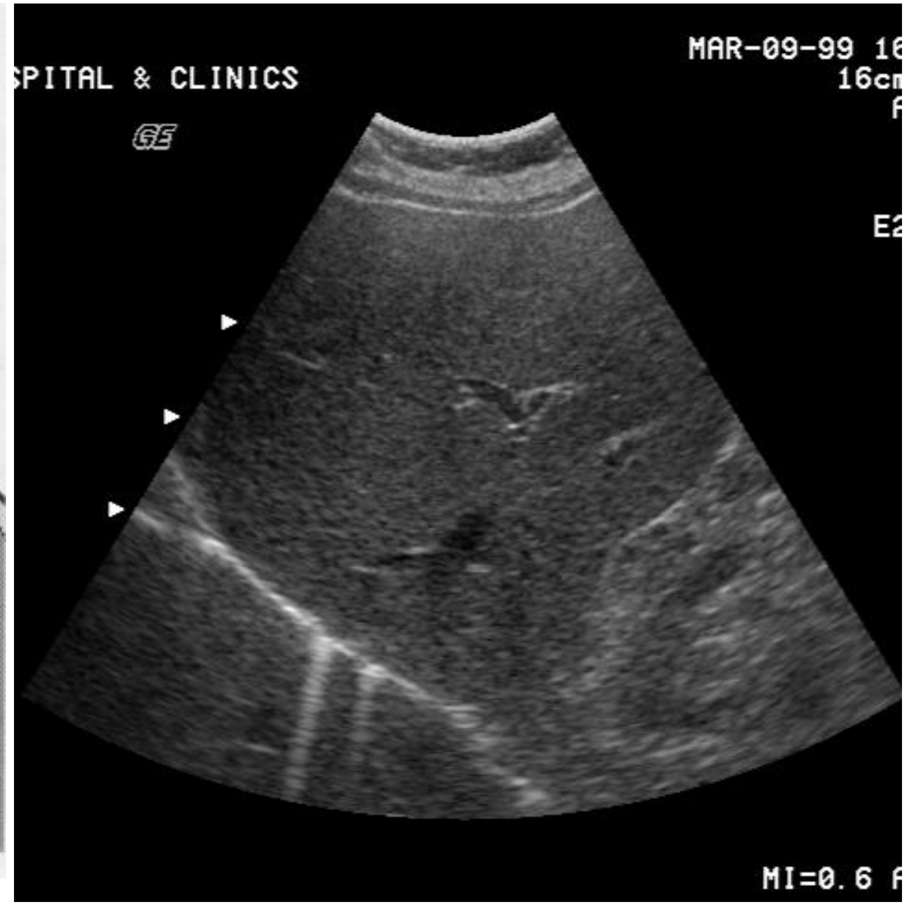
“Specular Reflection” vs Scatter

- Scatter helps visualize normal structures.
- Scatter helps visualize abnormal structures.

Liver Hemangioma visualized because of scatter changes w/normal tissue

Speckle





JA Zagzebski, *Essentials of Ultrasound Physics*, Mosby, St Louis, 1996. Chapter 7.

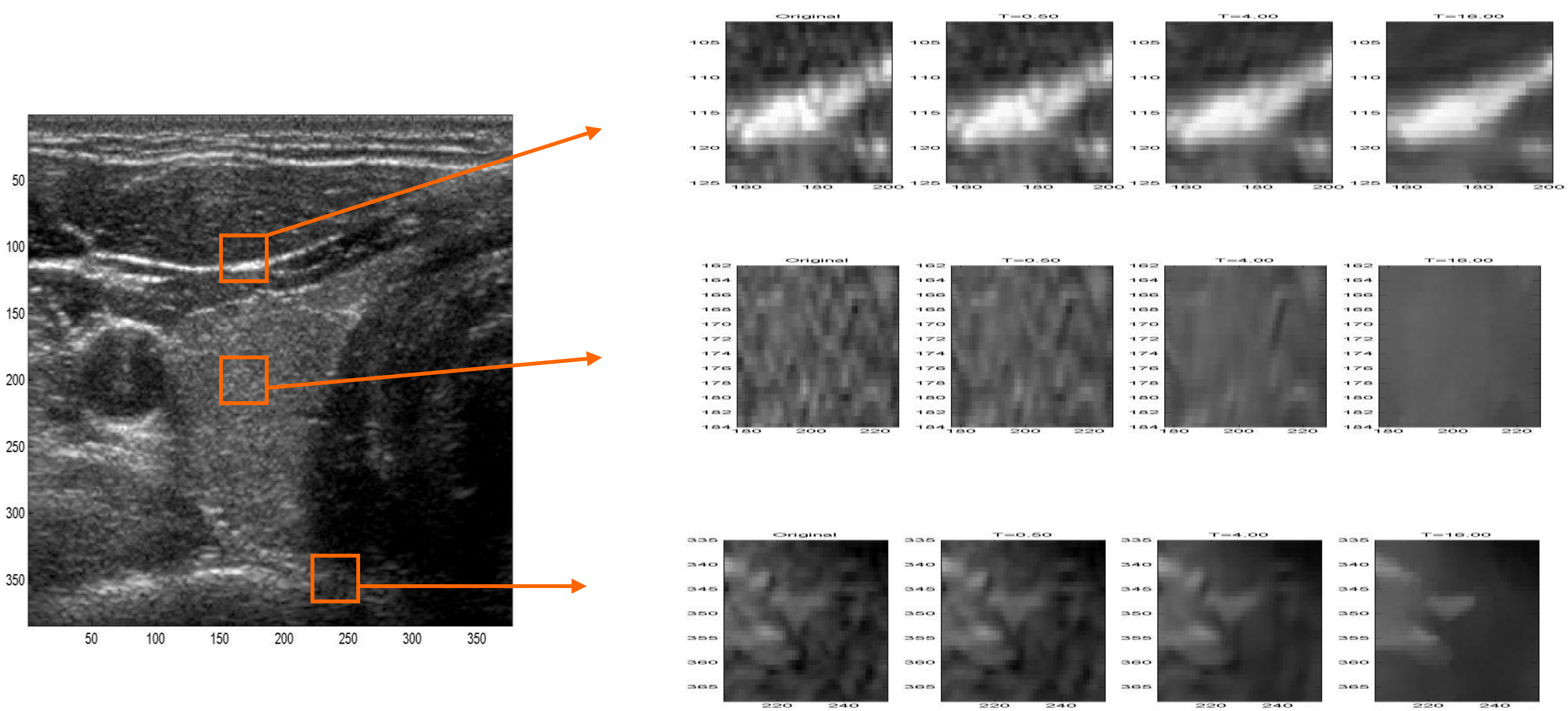
Gray Scale Texture, “Speckle”

- Each dot we see on the image does not represent a single scatterer.
- Each dot is the result of echo signals simultaneously detected from many scatterers insonified by the pulse.
- “Interference” effects help create the dot pattern.
  - Signals from individual scattering entities reinforce, partially cancel, or completely cancel, depending on their relative phases.
- Most consider this a noise phenomenon.
- Spatial compounding combines “views” of the scattering field from different directions; reduces speckle.
- Some manufacturers are taking measures to reduce speckle.

Image of a phantom, showing speckle
(Philips Ultrasound)

Spatially Compound image of a phantom, showing reduced speckle (Philips Ultrasound)

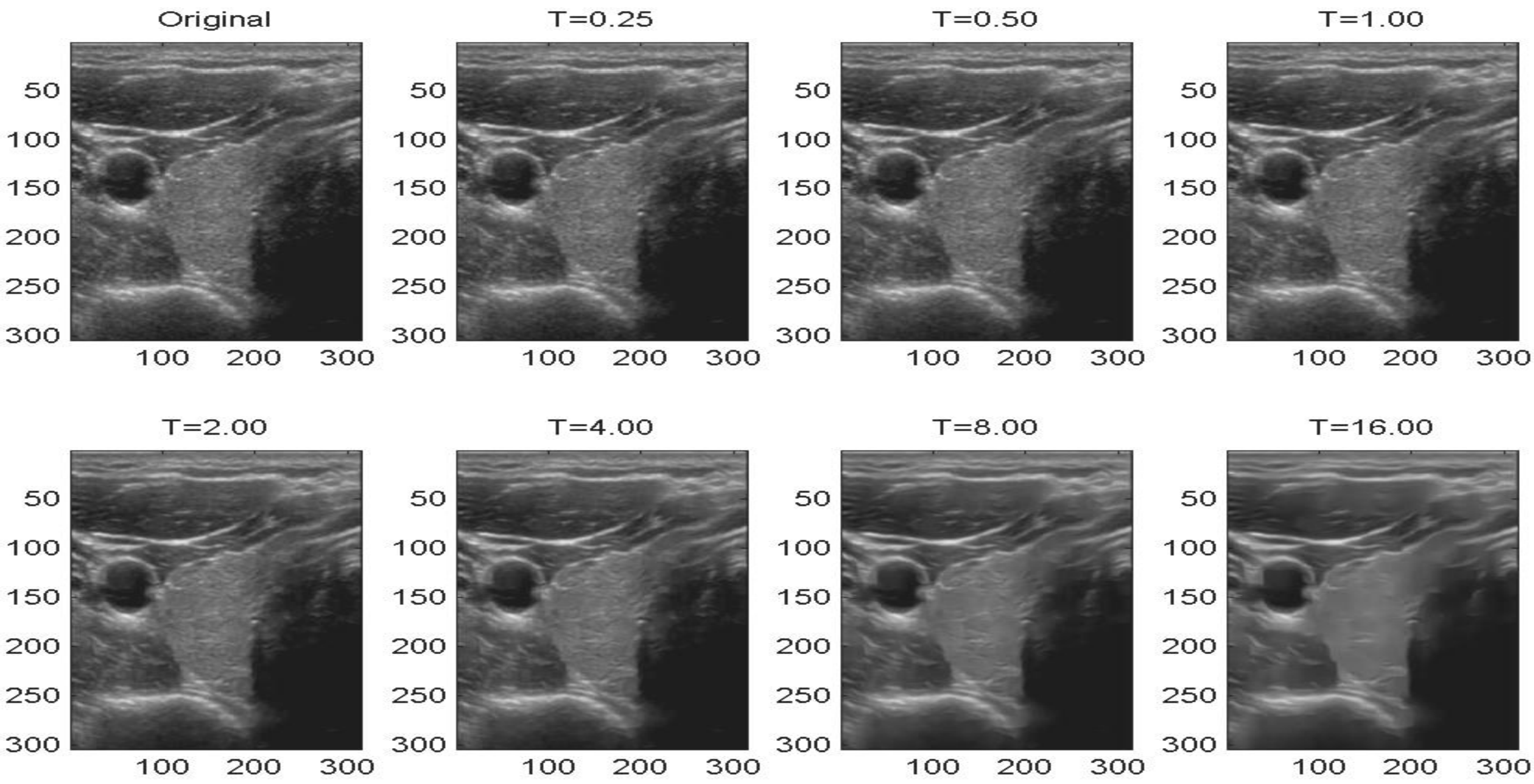
Speckle Reduction Imaging (SRI)
By Coherent Diffusion



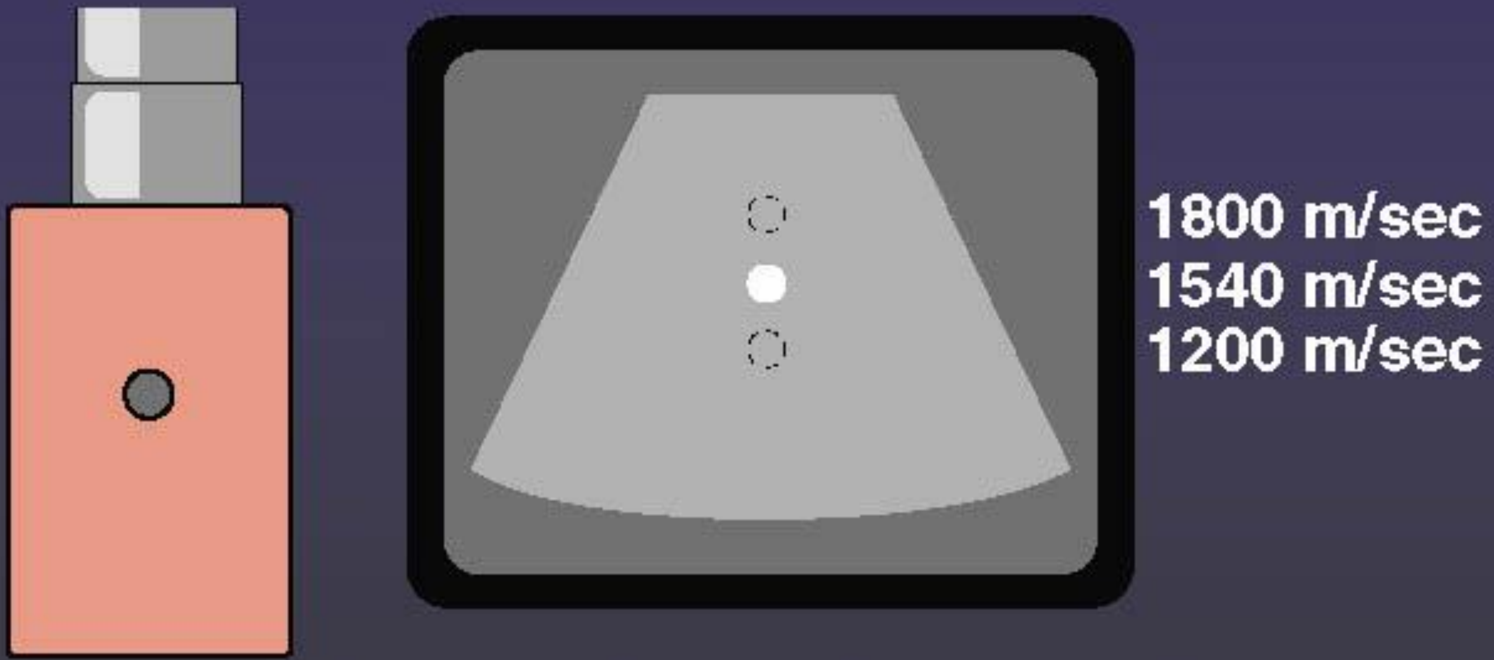
Algorithm Adapts Based on Image Feature; if statistical test results for a pixel region are consistent with the area being "speckle", smoothing is done. If there are specular-type interfaces, the original data are maintained.

(GE Medical)

GE's SRI (Speckle Reduction Imaging)
Different levels of "filtering"

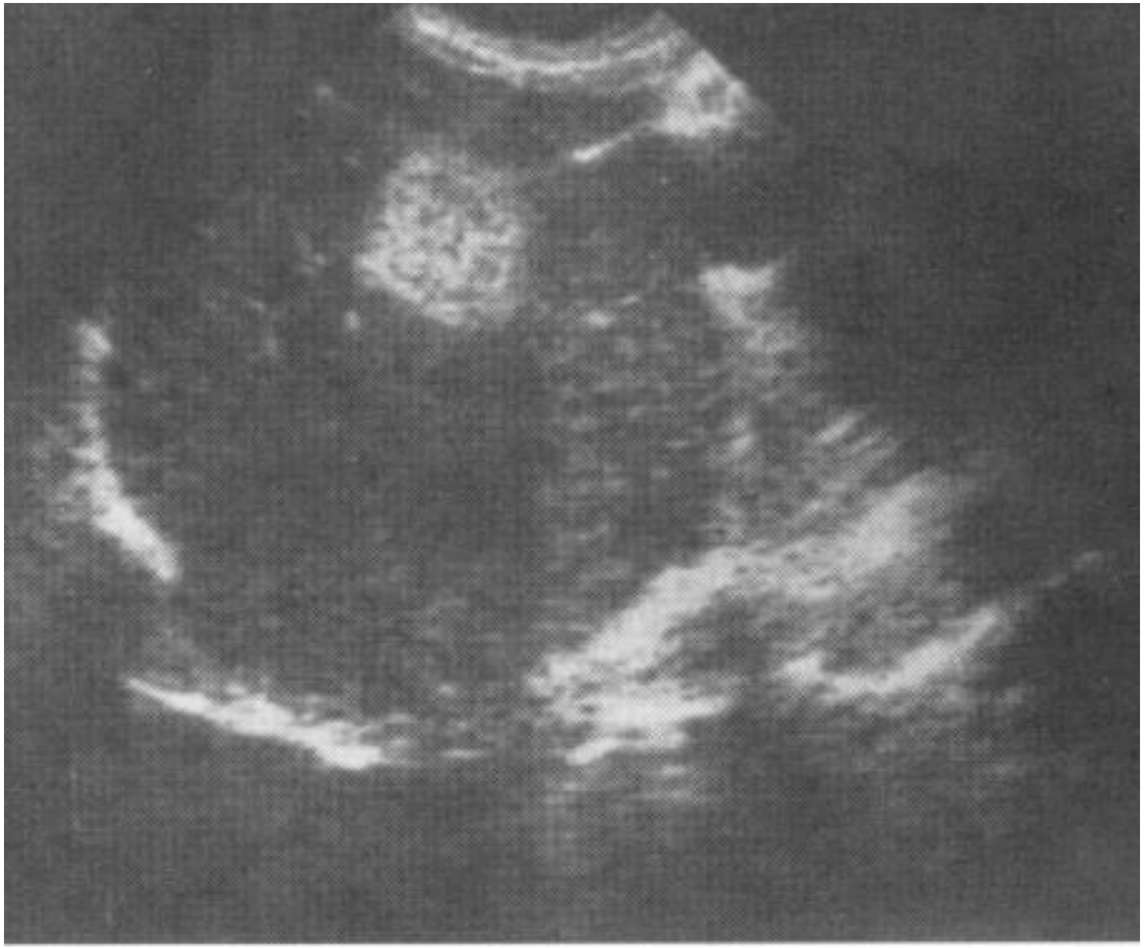


SPEED OF SOUND ARTIFACT



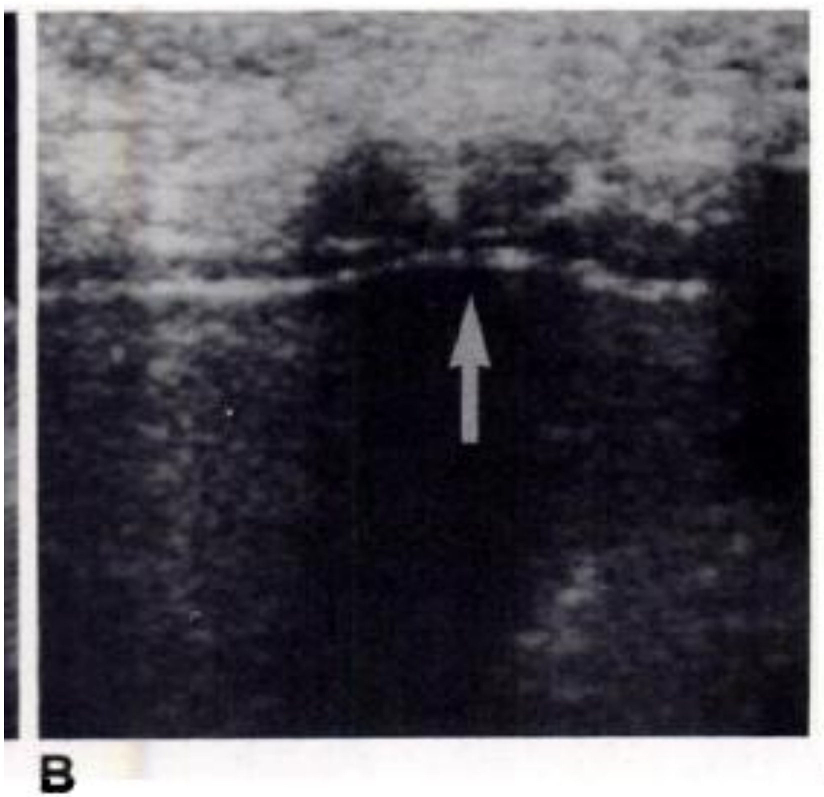
Assumed speed of sound
= 1540 m/sec

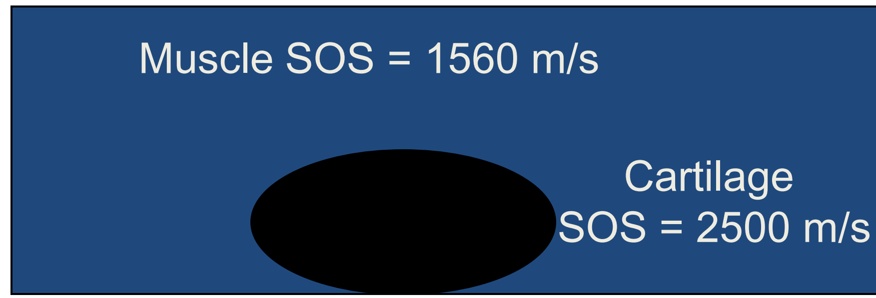
Speed of Sound Artifacts



Kremkau FW, Taylor KJ., “Artifacts in ultrasound imaging,” J Ultrasound Med. 1986 Apr;5(4):227-37.

Speed of Sound Artifacts





The soft tissue-to-lung interface (arrow) should appear straight, but the higher SOS in the cartilage results in the interface appearing curved.

Therapy planning and monitoring

- Superimposed CT and Ultrasound image, after correcting for SOS effects.
- “Density based correction”
- Each pixel along each beam line is shifted according to new SOS estimations based on CT density.

Fontanarosa D, van der Meer S, Bloemen-van Gurp E, “Magnitude of speed of sound aberration corrections for ultrasound image guided radiotherapy for prostate and other anatomical sites.” Med. Phys. 2012; 39 (8): 5286-92.

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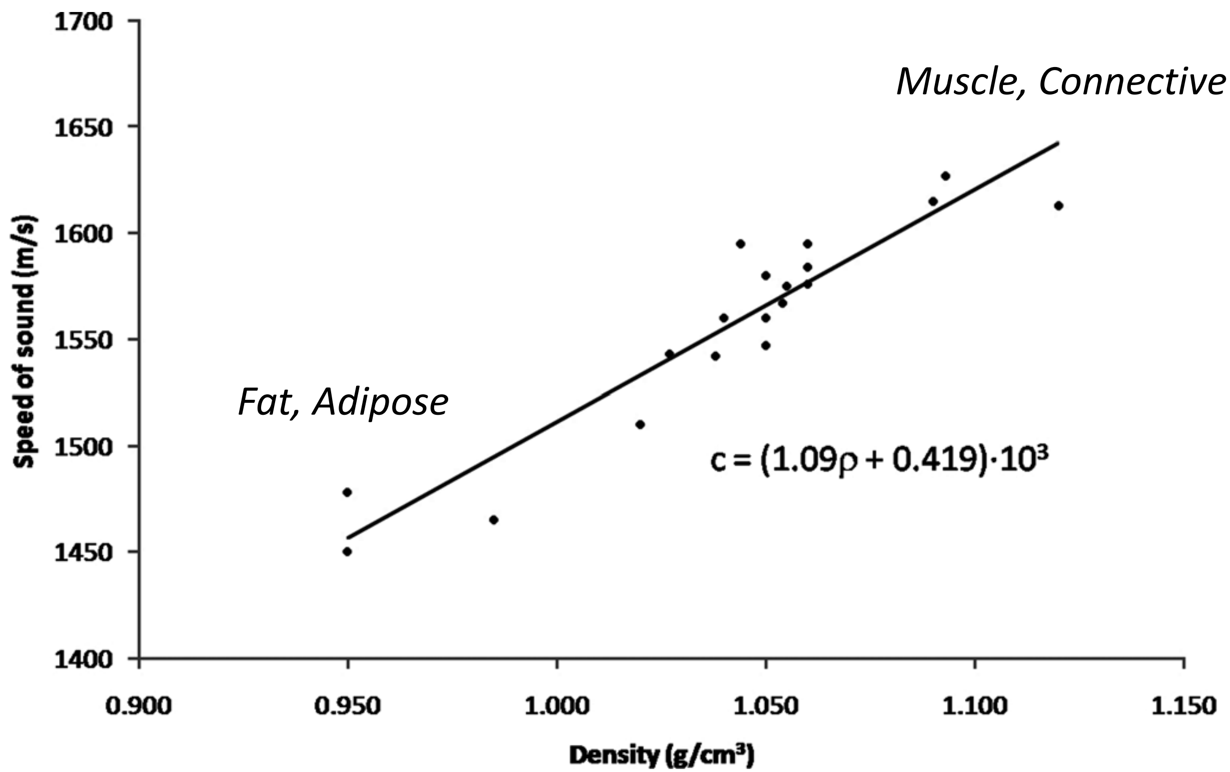
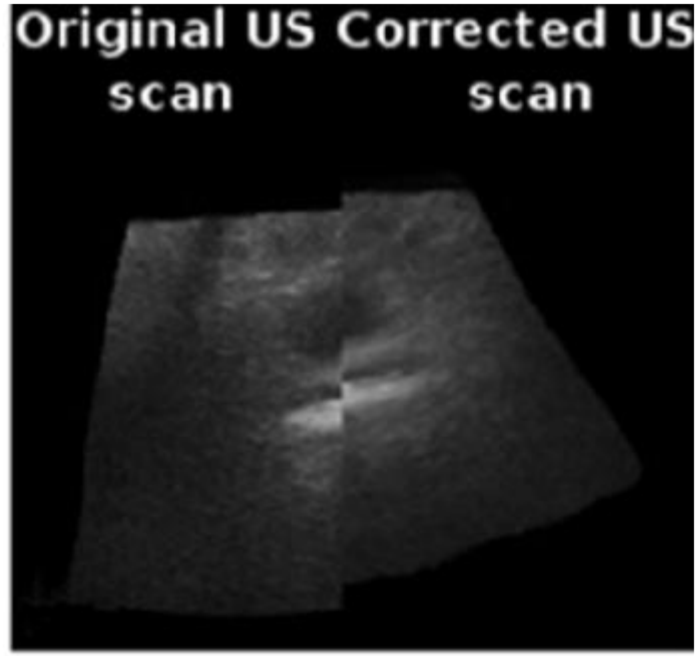


Mast T, "Empirical relationship between acoustic parameters in human soft tissues." Acoustics Research Letters online, 2000; 1:37.

Fontanarosa D, van der Meer S, Bloemen-van Gurp E, "Magnitude of speed of sound aberration corrections for ultrasound image guided radiotherapy for prostate and other anatomical sites." Med. Phys. 2012; 39 (8): 5286-92.

Therapy planning and monitoring

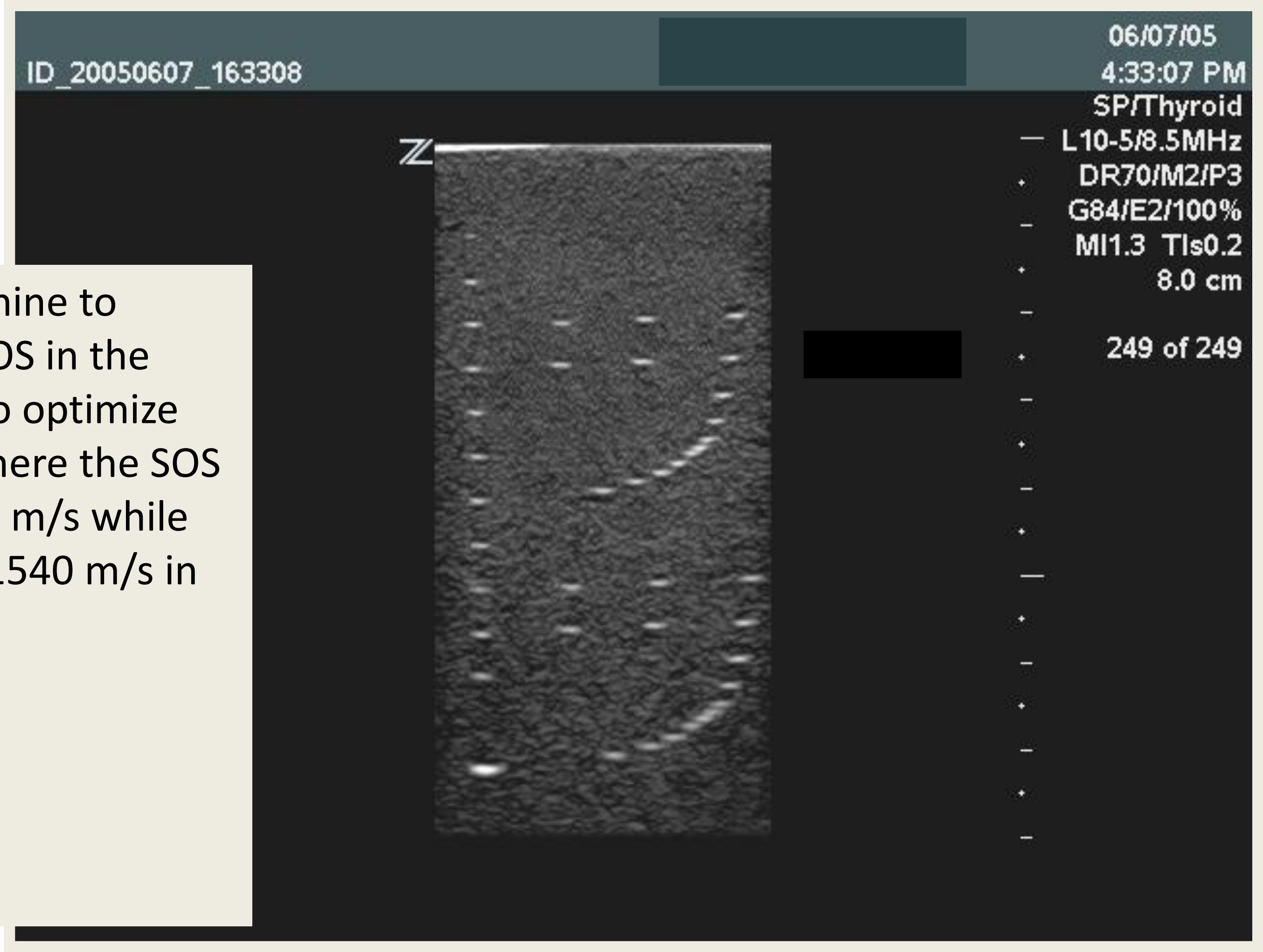
- Typical results for prostate, using the shift of the centroid of the target as a metric:
  - 1p -1.3 mm
  - 2p -3.6 mm
  - 3p -3.1mm
  - 4p -3.3 mm
  - 5p -2.8 mm
  - Average shift, -2.8 mm
- "… a larger apparent depth of the prostate is produced by the SOS aberration, with different magnitudes according to the relative importance of the amount of fat tissue and urine content in the bladder [1520 m/s with respect to muscle tissue [1580 m/s overlying the prostate."



Fontanarosa D, van der Meer S, Bloemen-van Gurp E, "Magnitude of speed of sound aberration corrections for ultrasound image guided radiotherapy for prostate and other anatomical sites." Med. Phys. 2012; 39 (8): 5286-92.

Sound Speed Correction

1.48 mm/μsec ATS Phantom Imaged at 1.54 mm/μsec

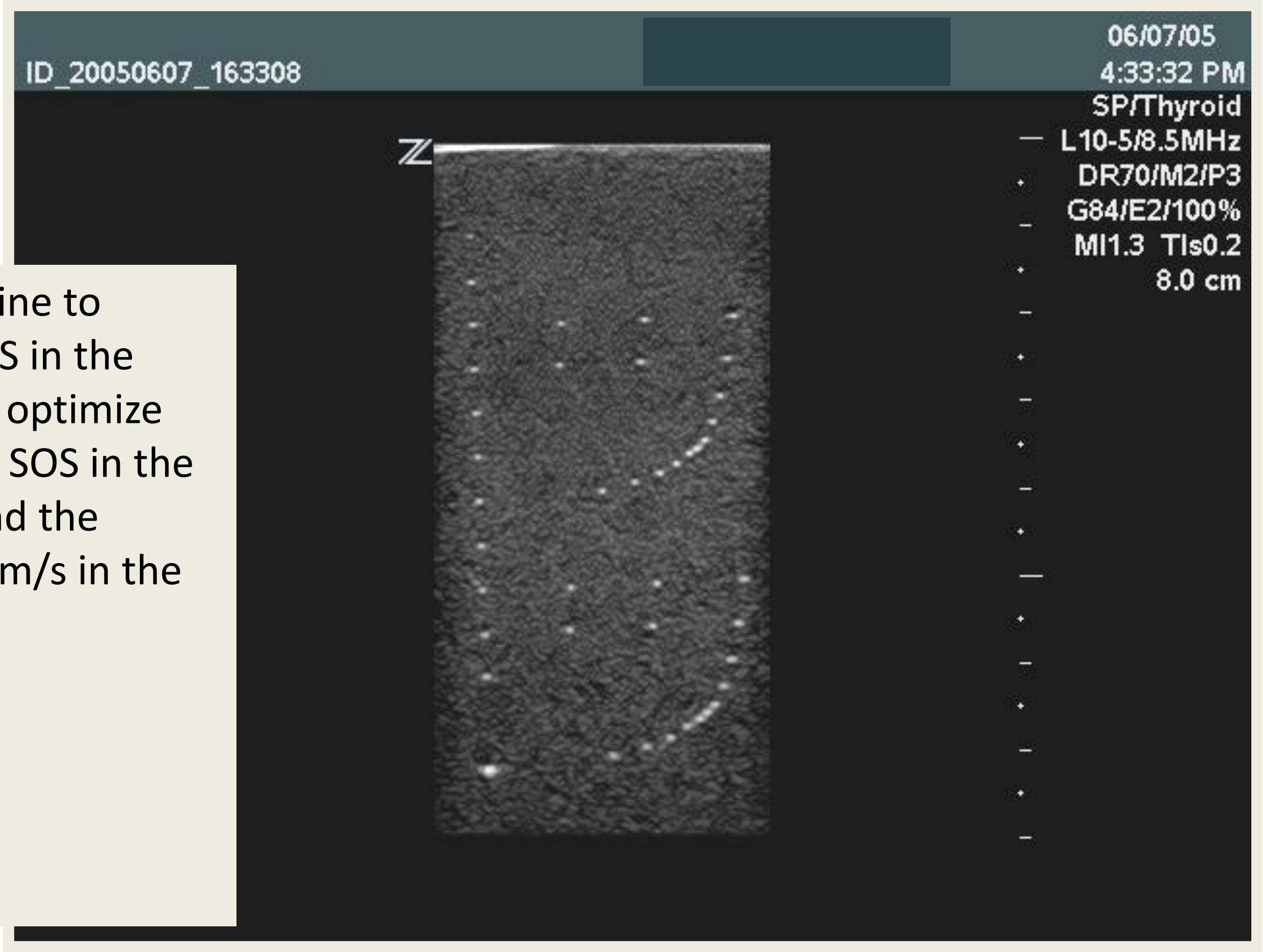


Zonare allows the machine to change the assumed SOS in the beamformer in order to optimize the sharpness. Notive here the SOS in the phantom is 1480 m/s while the machine assumes 1540 m/s in the beamformer.

(Courtesy of Larry Mo, Zonare Corp.)

Sound Speed Correction

1.48 mm/μsec ATS Phantom Imaged at 1.48 mm/μsec



Zonare allows the machine to change the assumed SOS in the beamformer in order to optimize the sharpness. Here the SOS in the phantom is 1480 m/s and the machine assumes 1480 m/s in the beamformer.

Image Rescaled to 1.54 mm/μsec Dimensions

(Courtesy of Larry Mo, Zonare Corp.)

Sound Speed Correction

Average Patient

8.5 MHz Breast Image at 1.54 mm/μsec

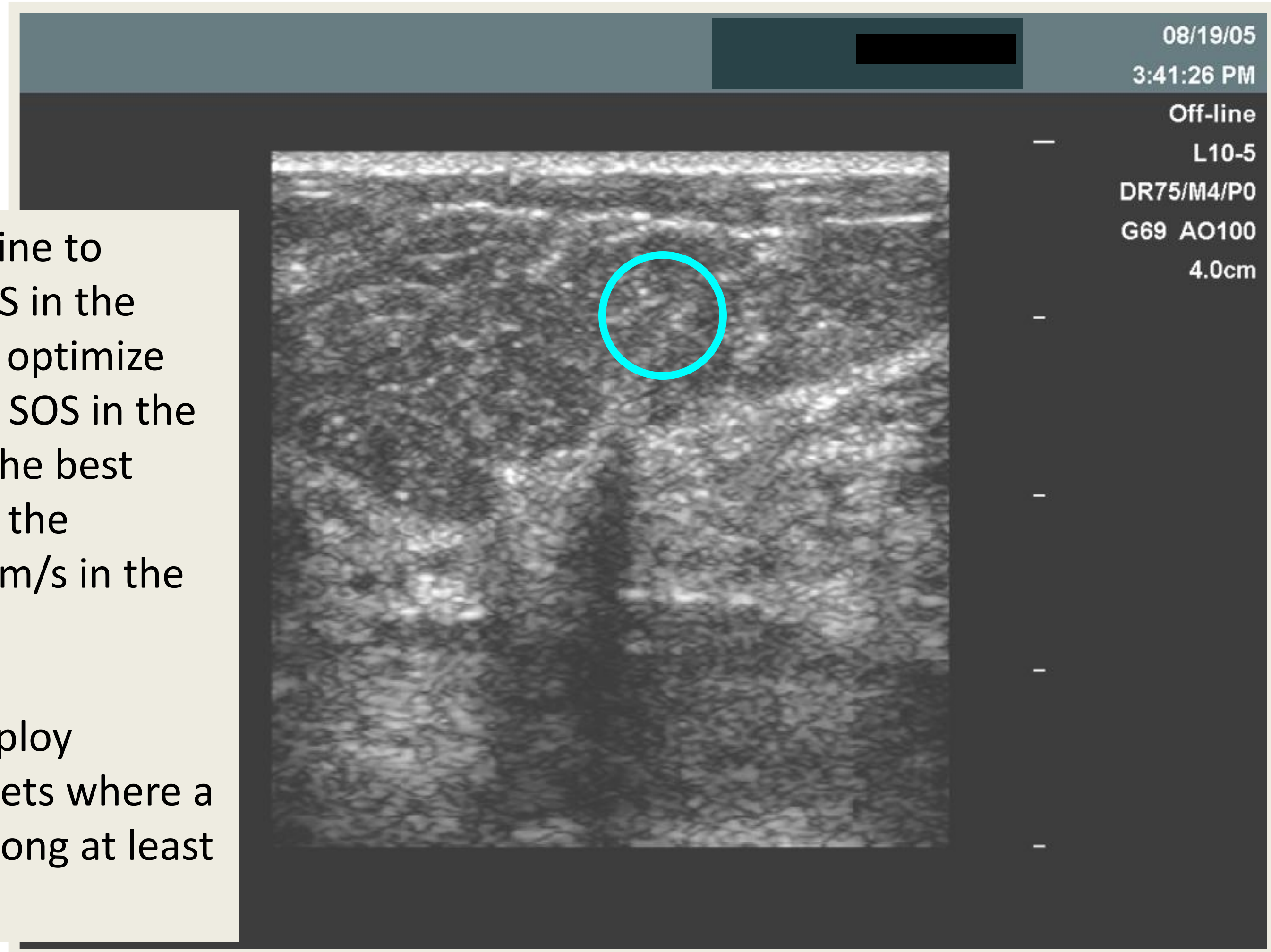
Zonare allows the machine to change the assumed SOS in the beamformer in order to optimize the sharpness. Here the SOS in the tissue is unknown, yet the machine assumes 1540 m/s in the beamformer.

(Courtesy of Larry Mo, Zonare Corp.)

Sound Speed Correction

Average Patient

8.5 MHz Breast Image at 1.44 mm/μsec



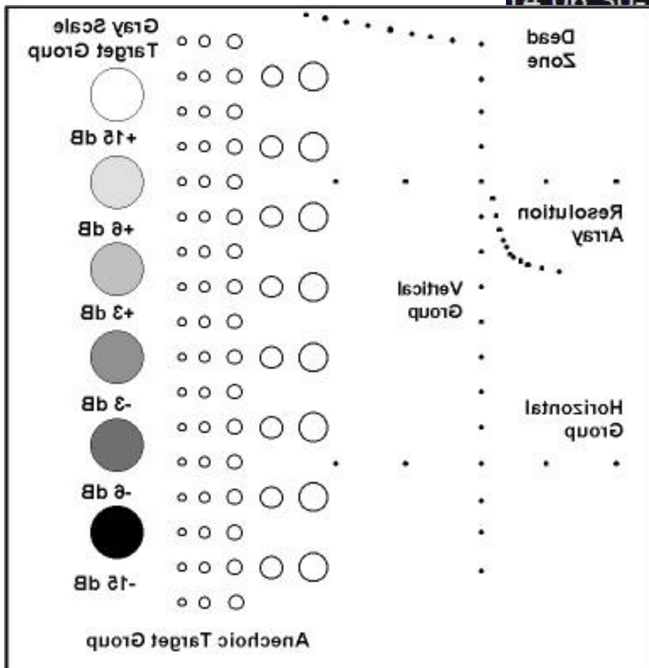
Zonare allows the machine to change the assumed SOS in the beamformer in order to optimize the sharpness. Here the SOS in the tissue is unknown, but the best image is achieved when the machine assumes 1440 m/s in the beamformer.

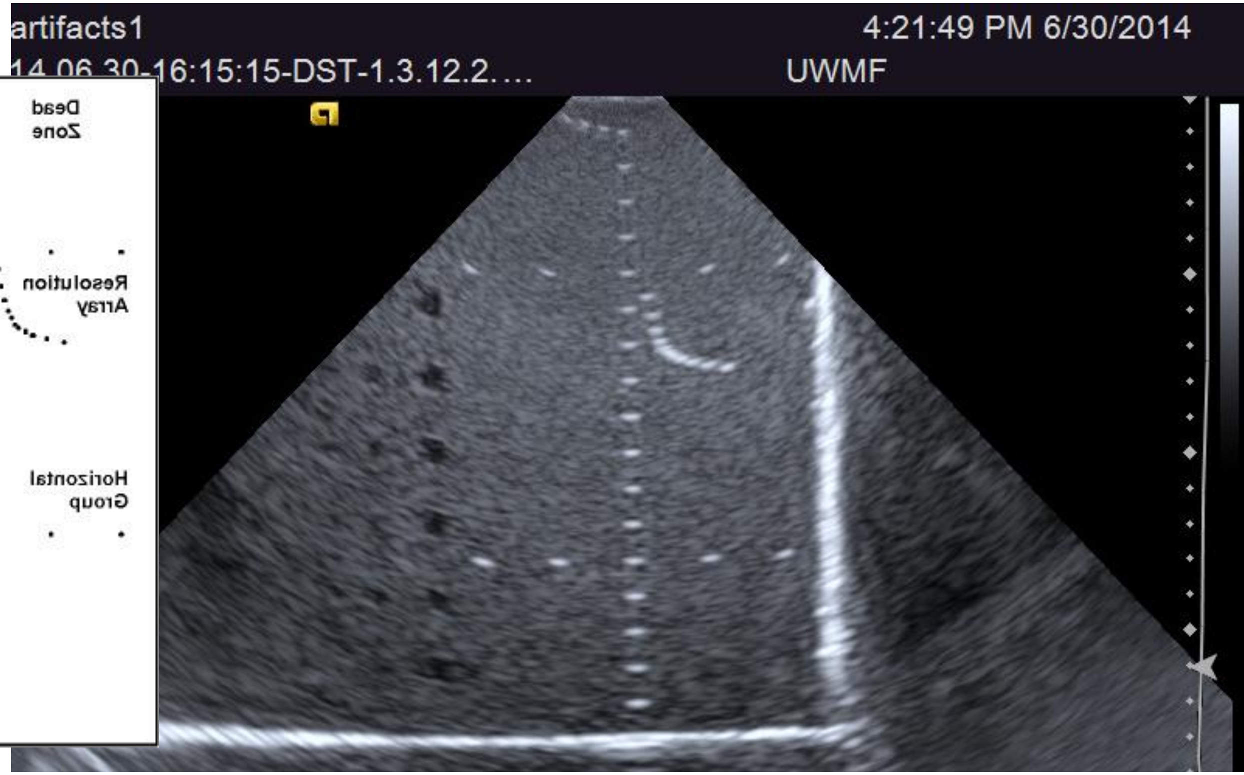
Many scanners now employ application specific presets where a lower SOS is assumed along at least part of the path.

Image Rescaled to 1.54 mm/μsec Dimensions

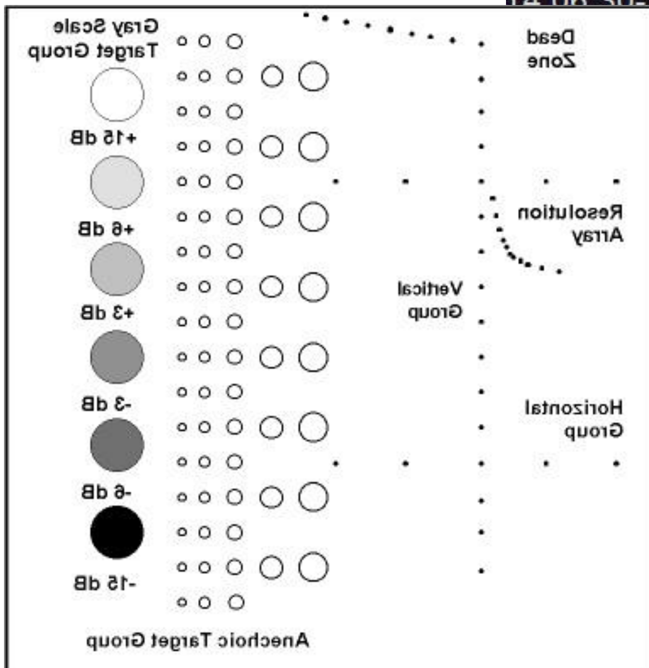
(Courtesy of Larry Mo, Zonare Corp.)

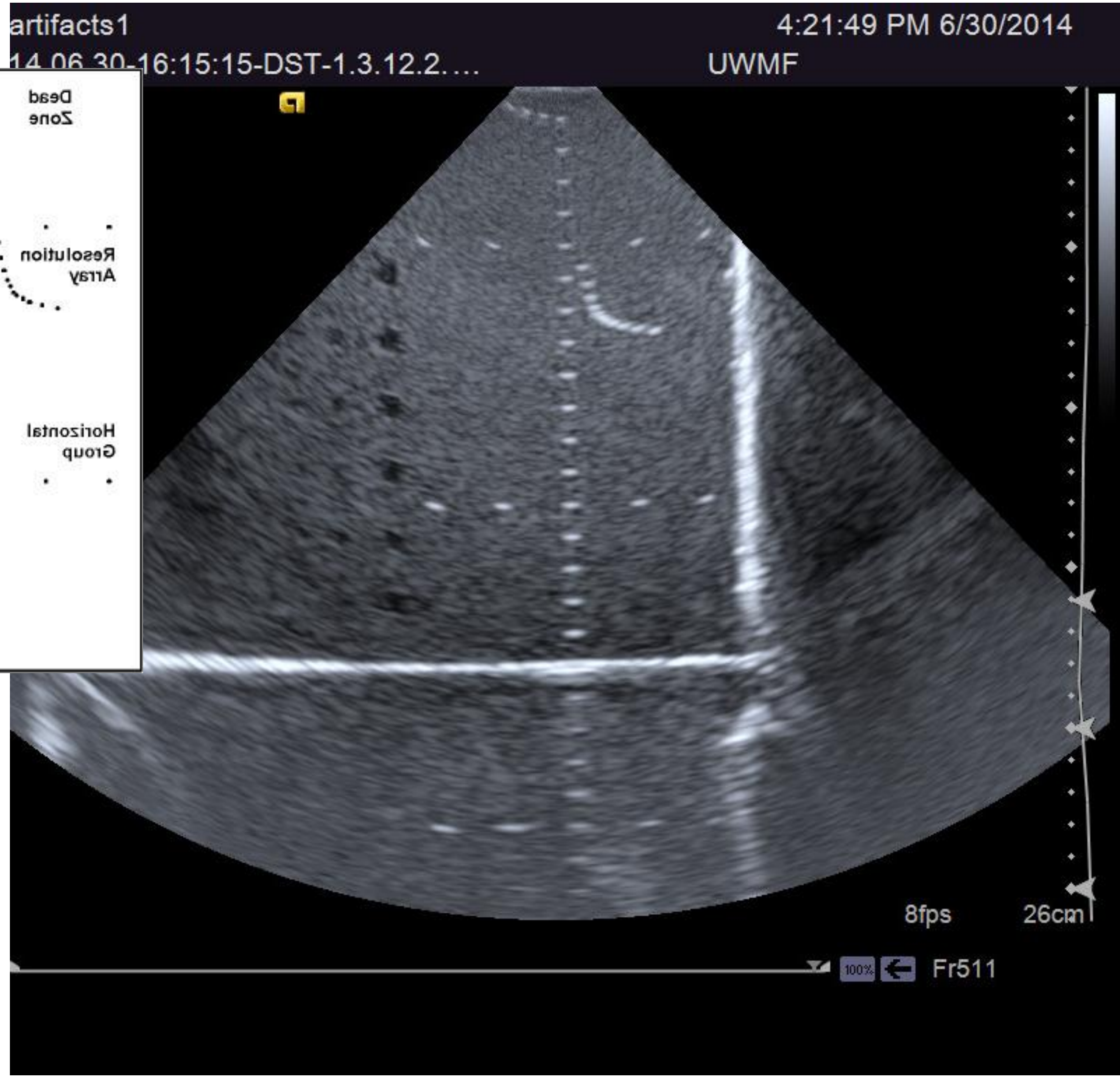
Another artifact: Scan an ATS 539 Phantom



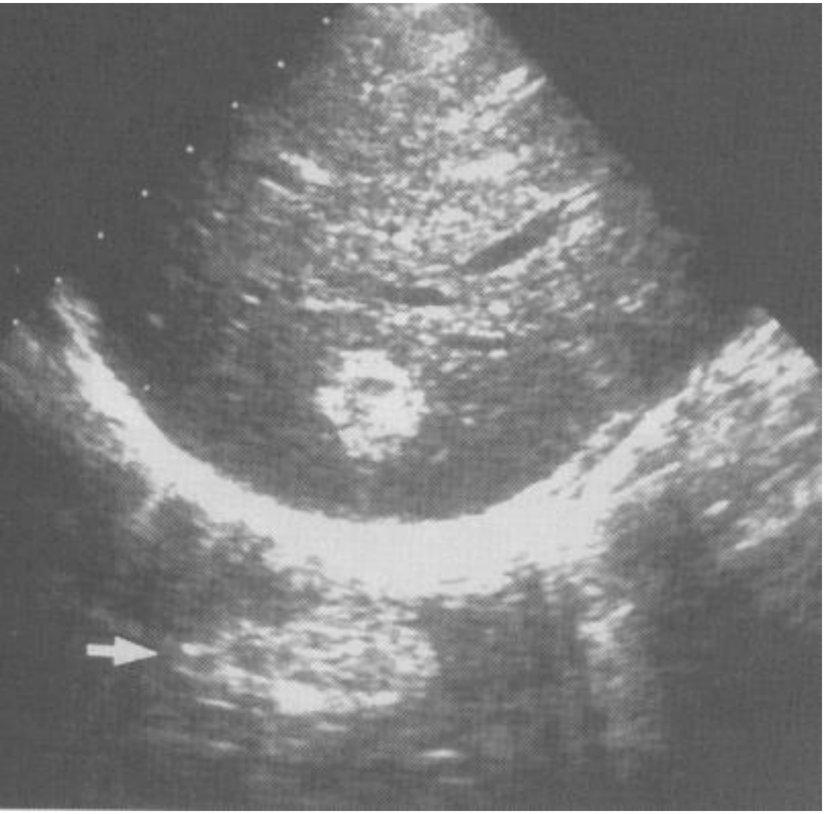


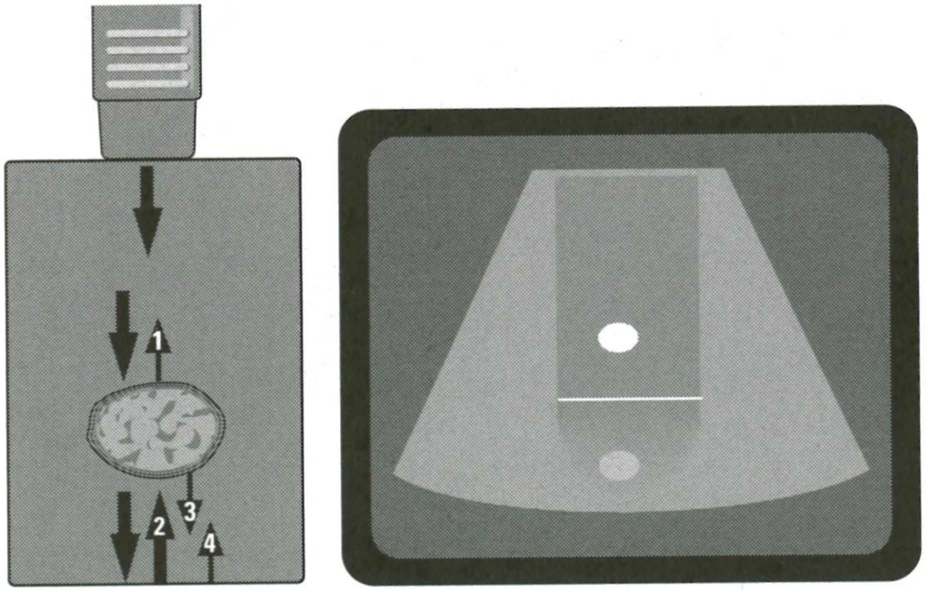
Use a Larger FOV: Mirror Image Artifacts





Mirror Image Artifacts

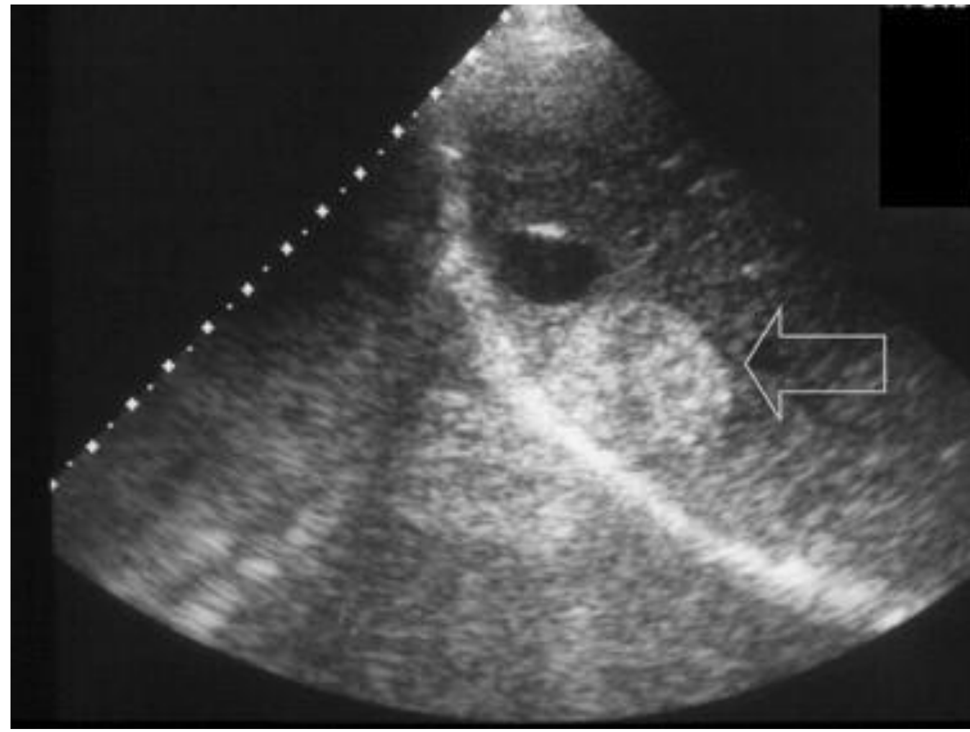




1. Echo from surface of object
2. Echo from strong reflector
3. Echo from object produced by 2
4. 3 reflected by strong reflector

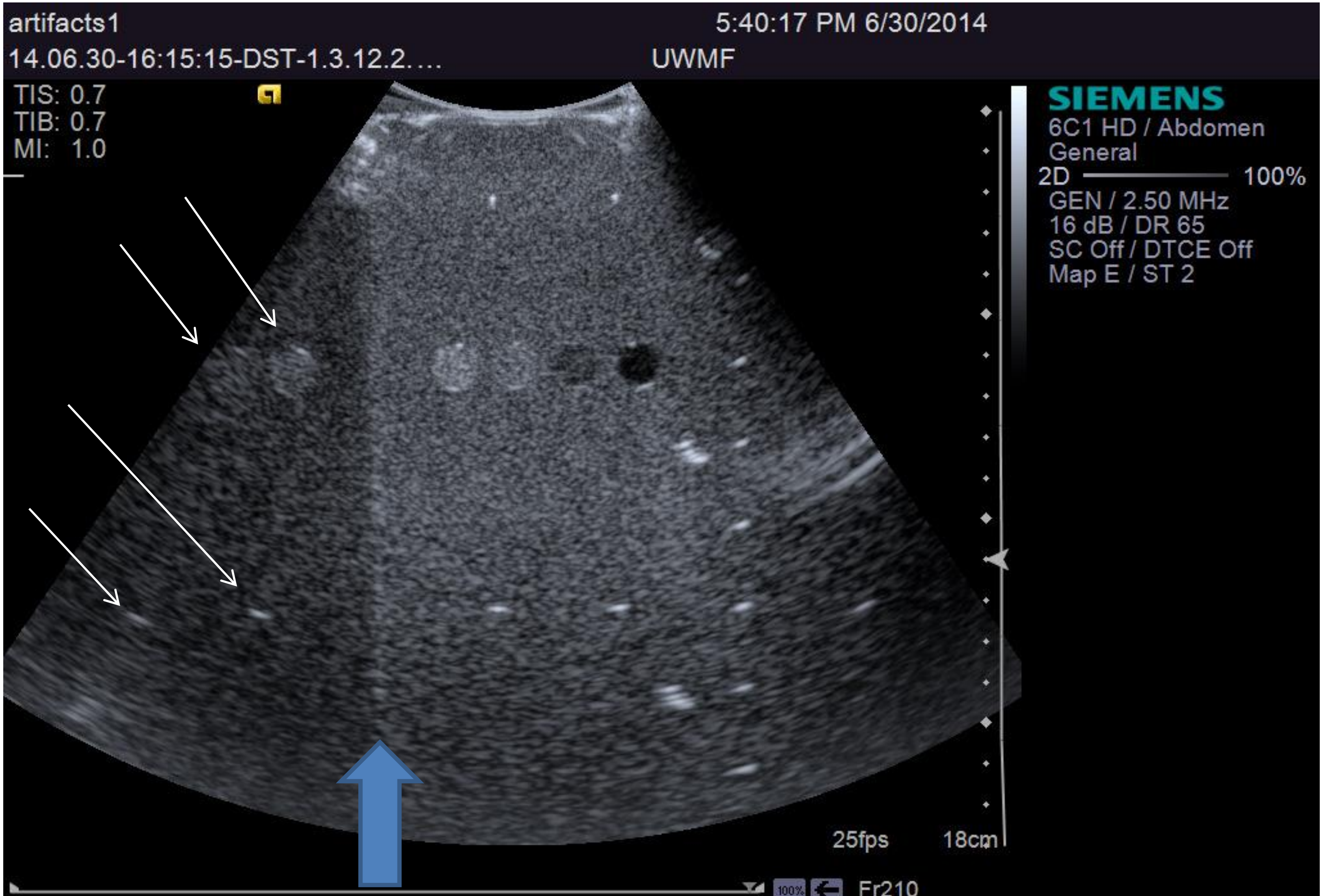
Mirror Image Artifacts

Still, calm Colorado River, canyon, and mirrored canyon.



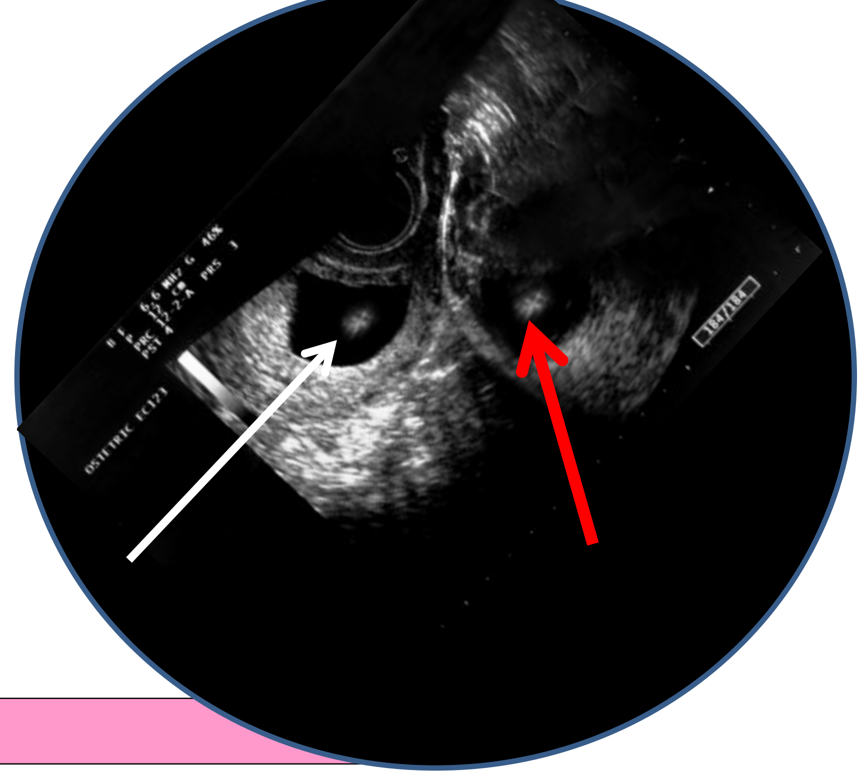
http://www.criticalecho.com/content/tutorial-1-basic-physics-ultrasound-and-doppler-phenomenon

Mirroring can be side-to-side



Side wall of Gammex 403 phantom is the mirror

This B-mode image obtained with a transvaginal transducer, illustrates an early pregnancy (arrow). It also presents an interesting example of what type of artifact? (red arrow)



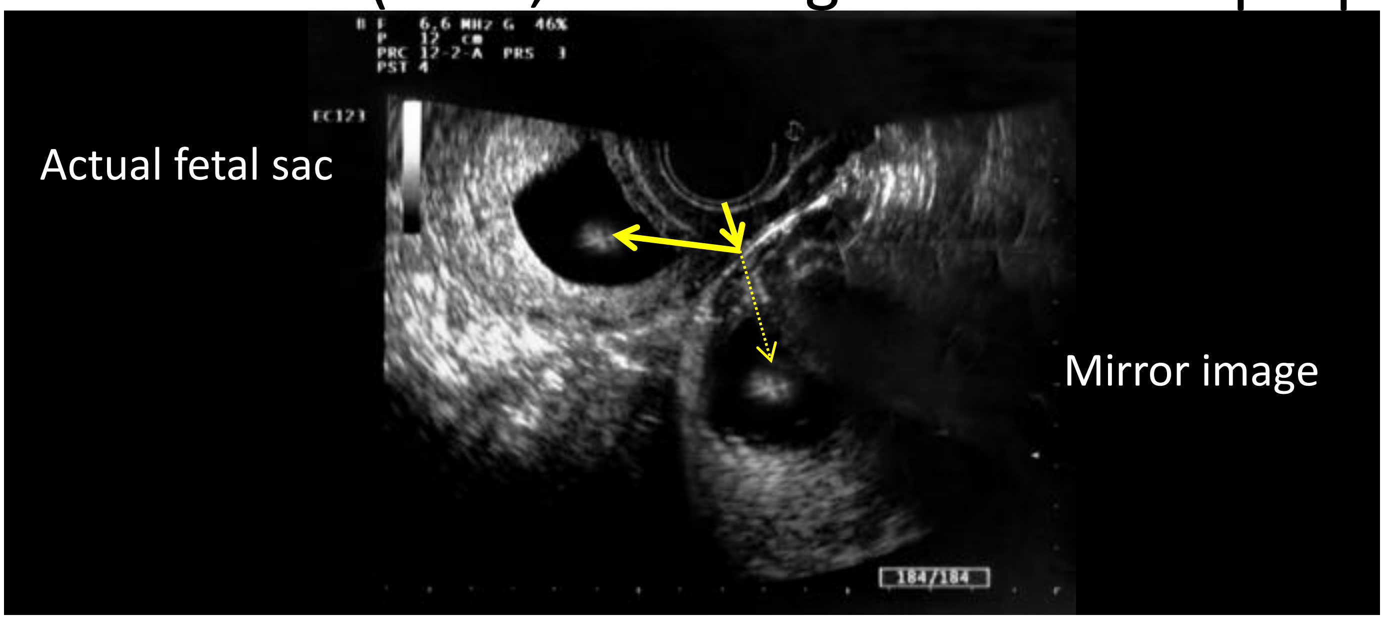
20%	1.	Side lobe
20%	2.	Attenuation
20%	3.	Mirror image
20%	4.	Reverberations
20%	5.	Speed of sound

Answer 3: Mirror image

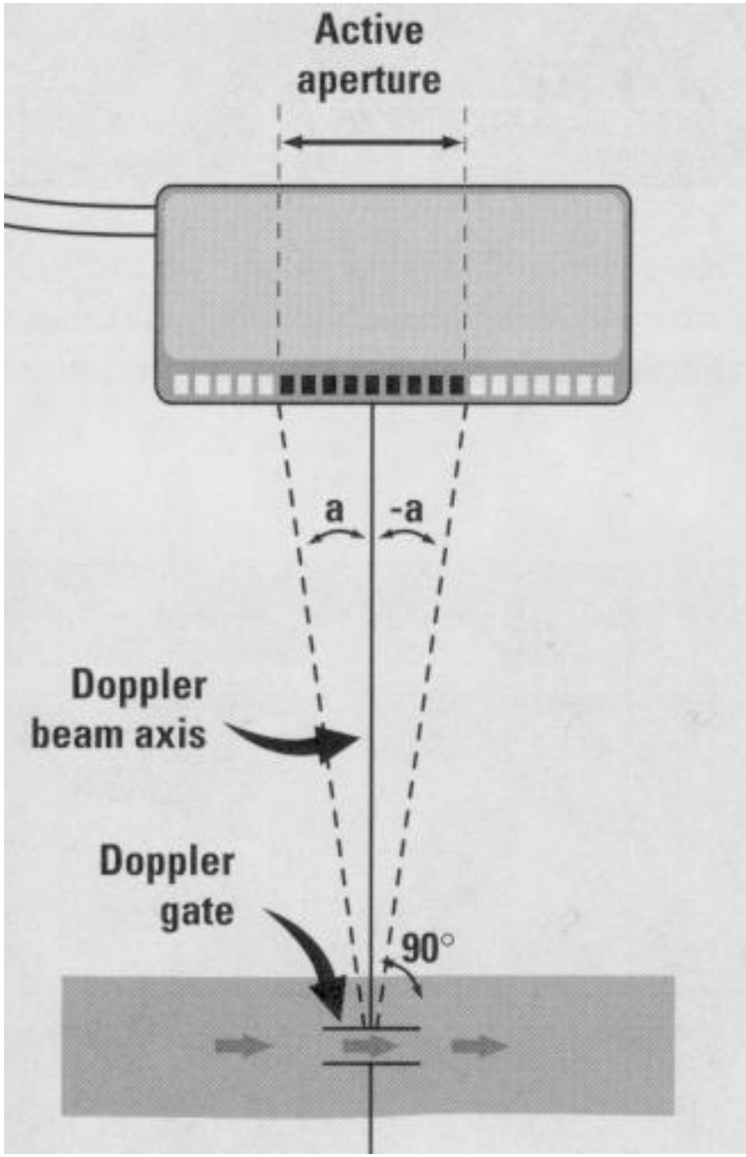
Mirror-Image Artifact of Early Pregnancy on Transvaginal Sonography

JUM November 1, 2012 vol. 31 no. 11 1858-1859

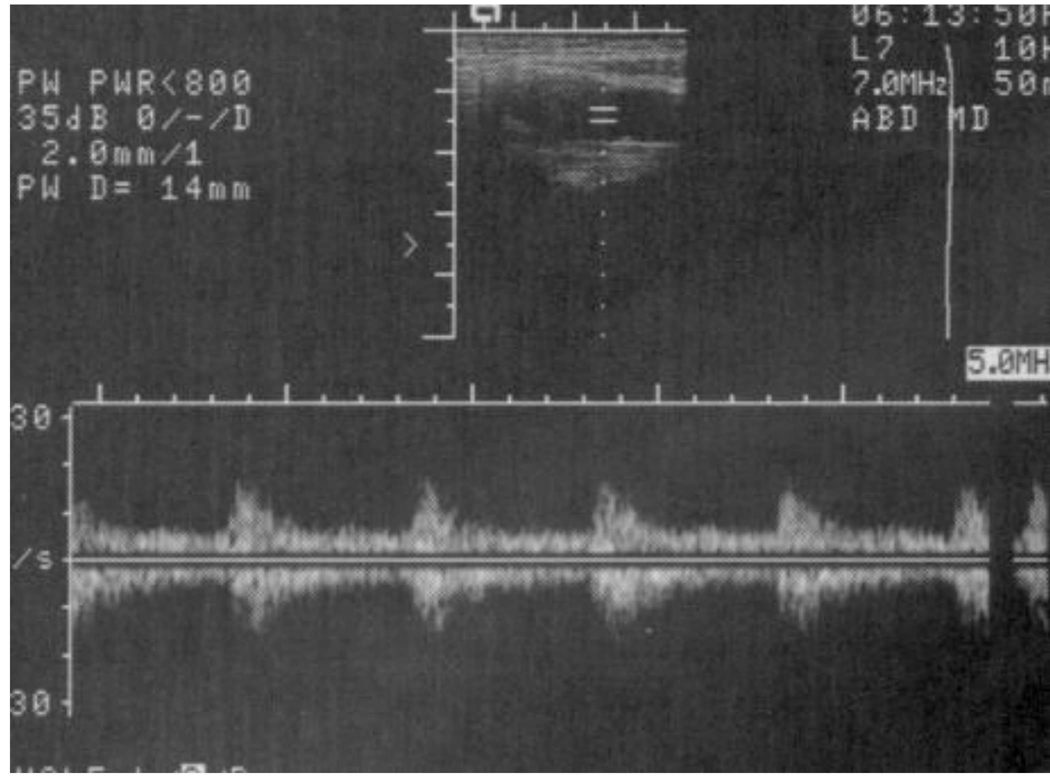
Imaging done with a tightly curved curvilinear transducer (note, this image is oriented properly)



Mirror Image Artifact (Spectral Doppler)



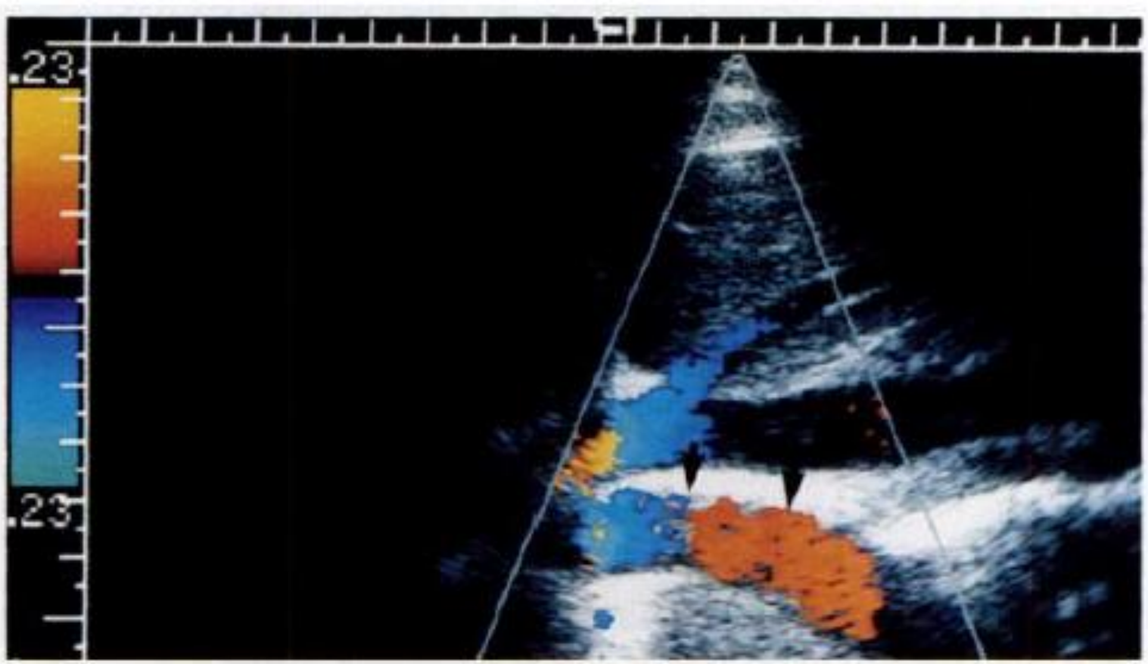
Flow in this carotid artery is right-to-left.
However, it appears bi-directional.



Mirror Image Artifacts in Doppler:

- being ~ perpendicular to flow;
- using too high a gain
- dead transducer elements(?)

Mirror Image Artifact (color)



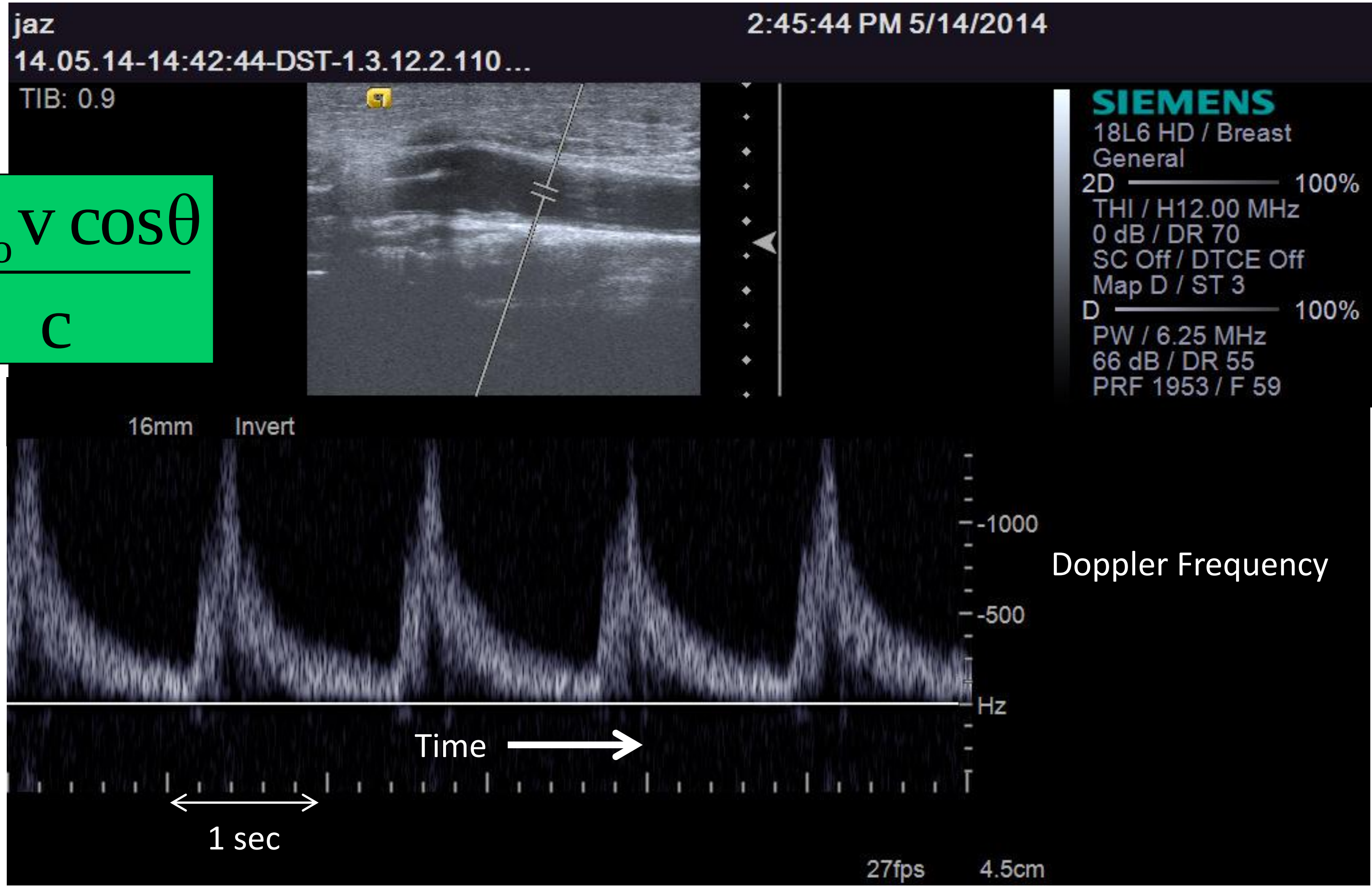
- Inferior vena cava
- “extra” vessel
- Mirror is the diaphragm in this case.

Pozniak, M, Zagzebski, J and Scanlan, K, “Spectral and Color Doppler Artifacts,” Radiographics12, 35-44, 1992.

PW Doppler Processing and Spectral Display

Sensitive to the changing phase of the returning echo signals

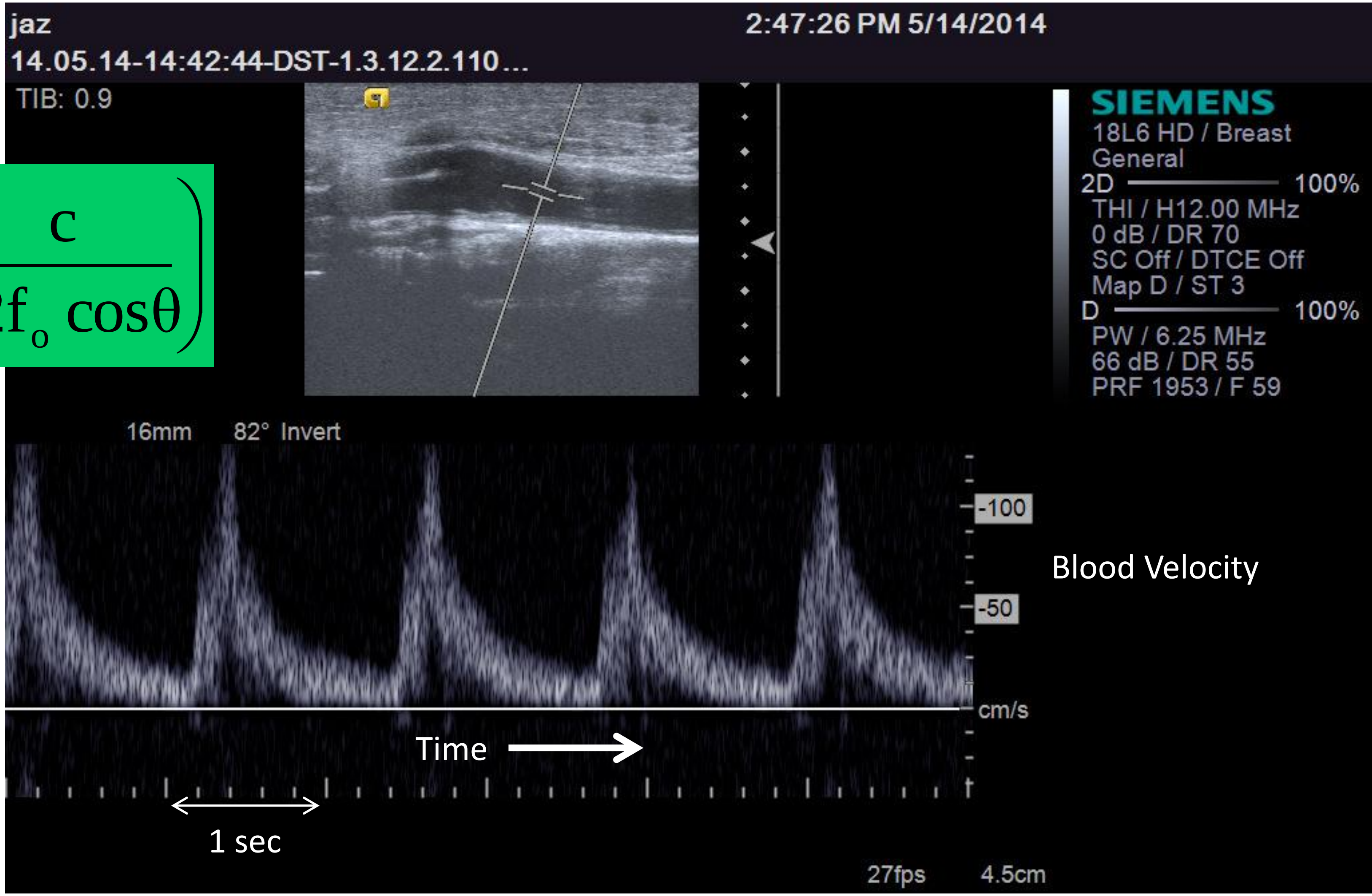
$$F_D = \frac{2 f_o v \cos\theta}{c}$$



PW Doppler Processing and Spectral Display

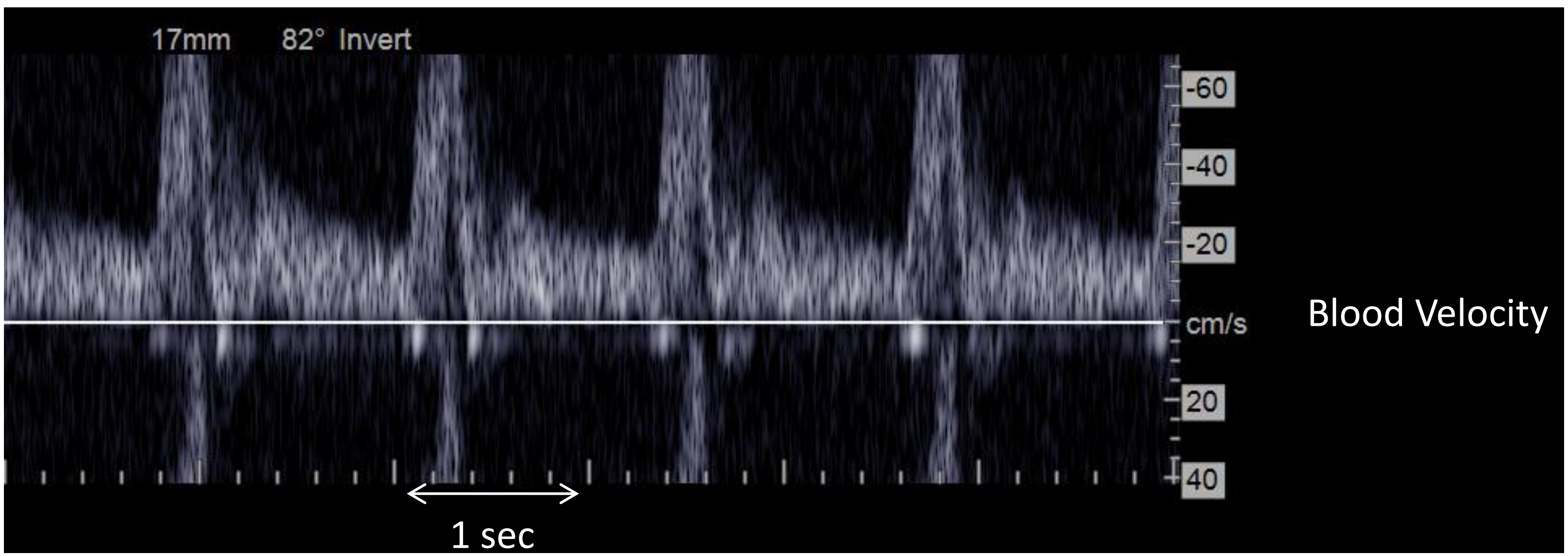
With proper "angle correct", can display as a velocity vs. time

$$v = F_D \left(\frac{c}{2 f_o \cos\theta} \right)$$



This Doppler signal waveform is inadequate, mainly because of which artifact?

20%	1.	Aliasing
20%	2.	Speckle
20%	3.	Ring down
20%	4.	Speed of sound
20%	5.	Spectral mirroring

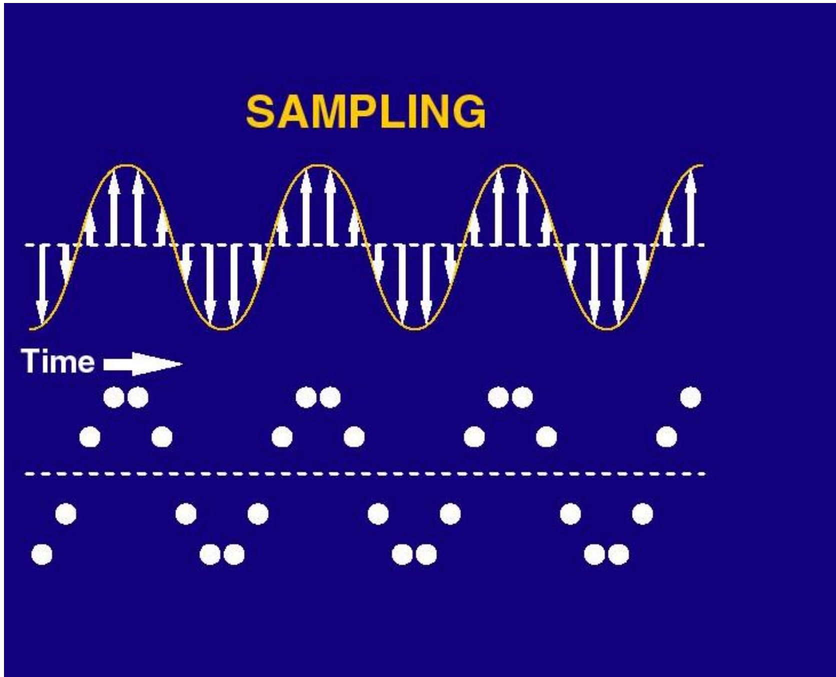


10

Answer 1: Aliasing

Doppler Signal Formation with PW Doppler (Sampling at the PRF)

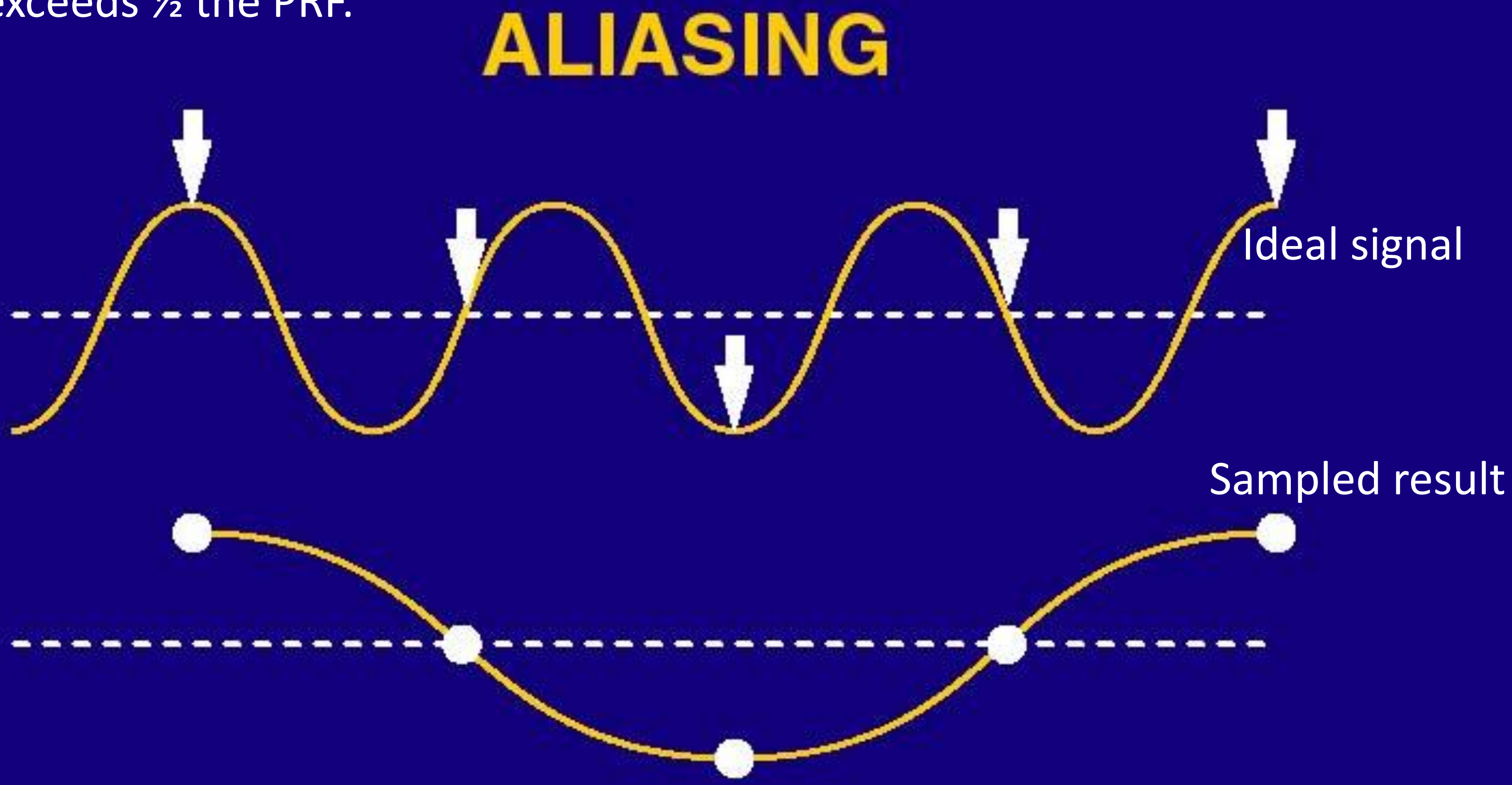
1. Doppler mode pulses transmitted along a “Doppler beam line”
2. Operator selects location, gate size of a “sample volume”
3. Doppler signal (yellow signal curve for example) from this volume is generated through a “sampling” process
   - ie, shown here with the white arrows
4. The sample rate equals the pulse repetition frequency (PRF)!



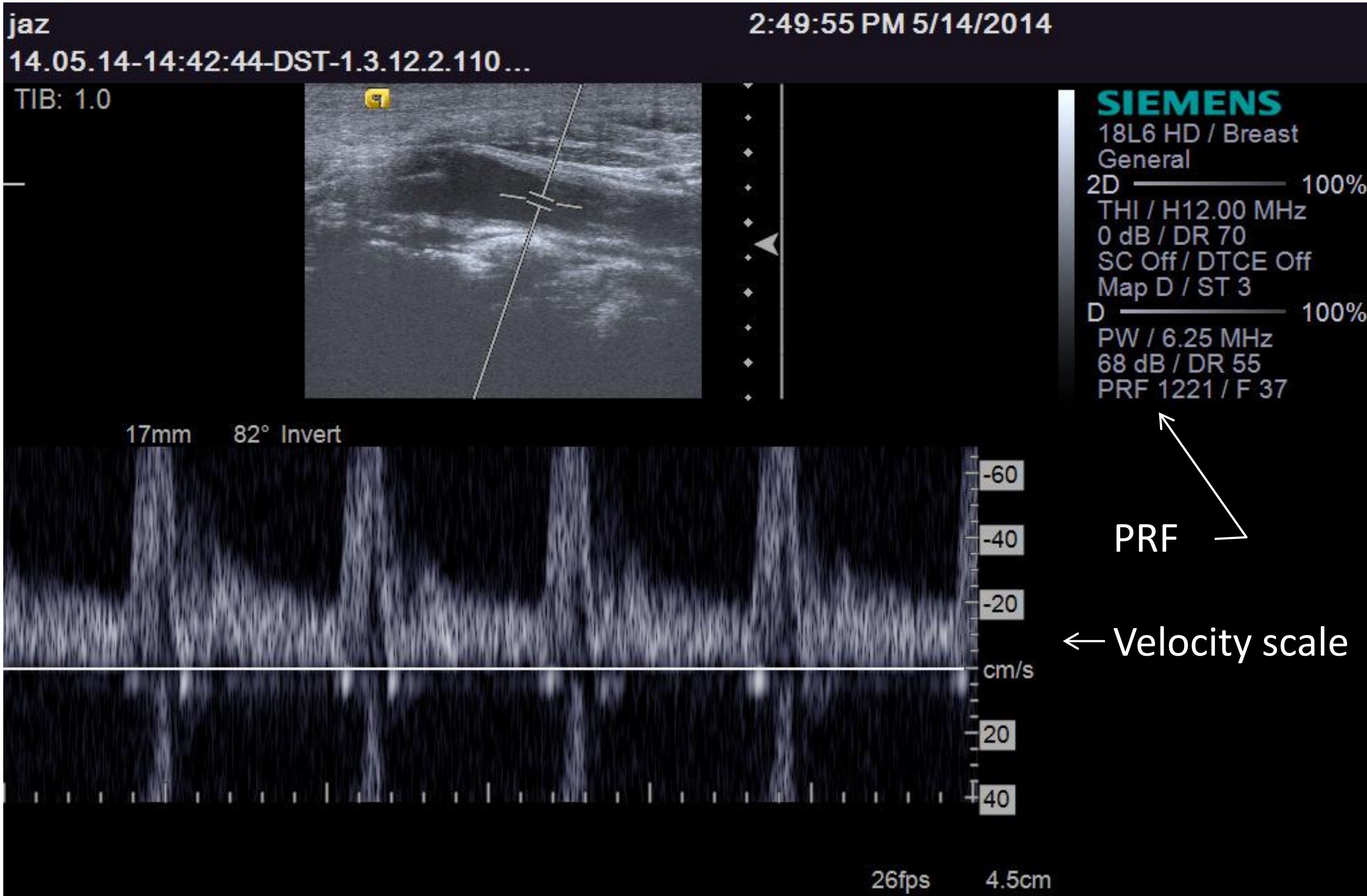
JA Zagzebski, *Essentials of Ultrasound Physics*, Mosby, St Louis, 1996. Chapter 5.

Arrows represent sampling times

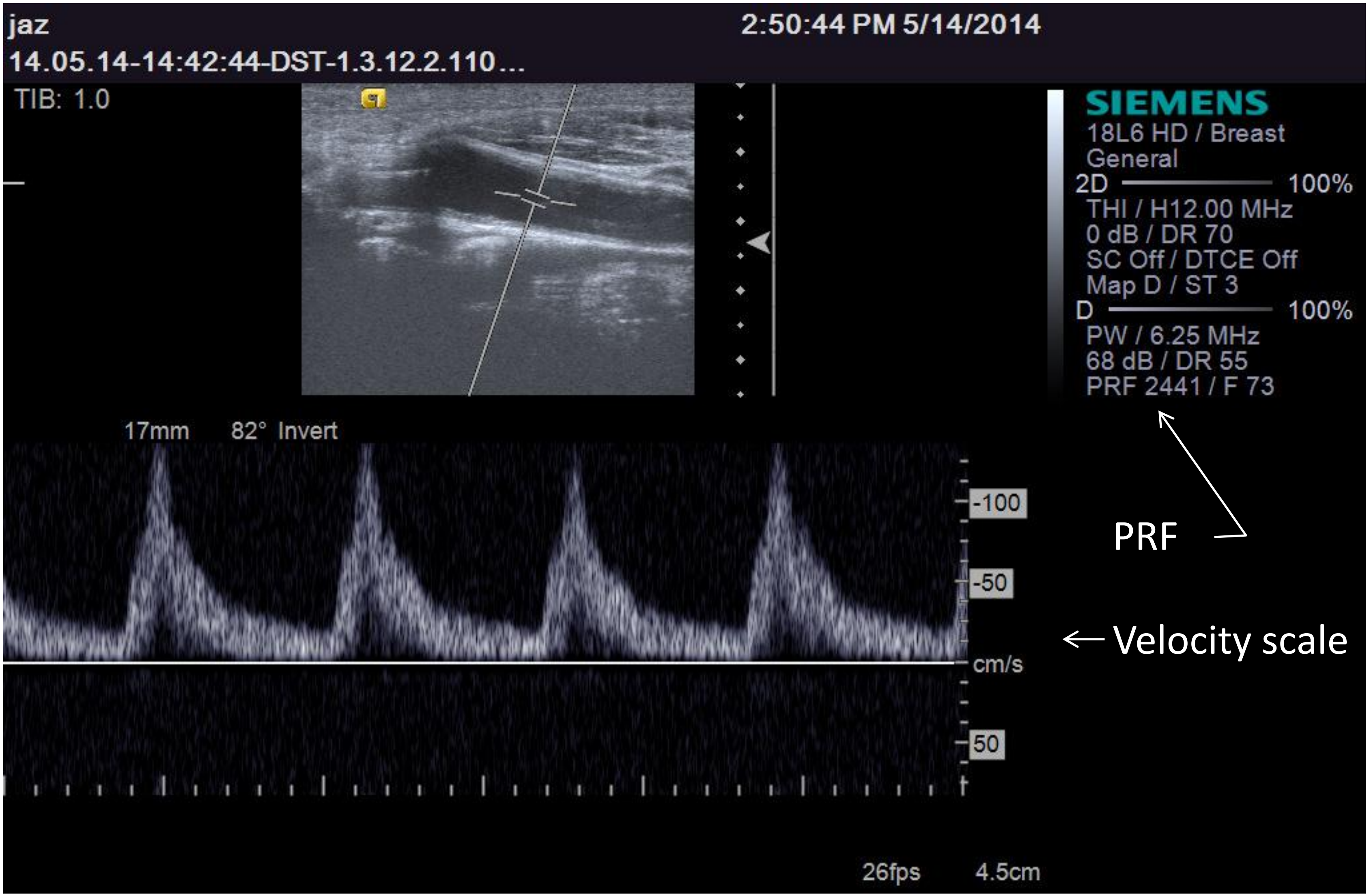
Aliasing occurs if the Doppler frequency exceeds ½ the PRF.



Manifestation of Aliasing

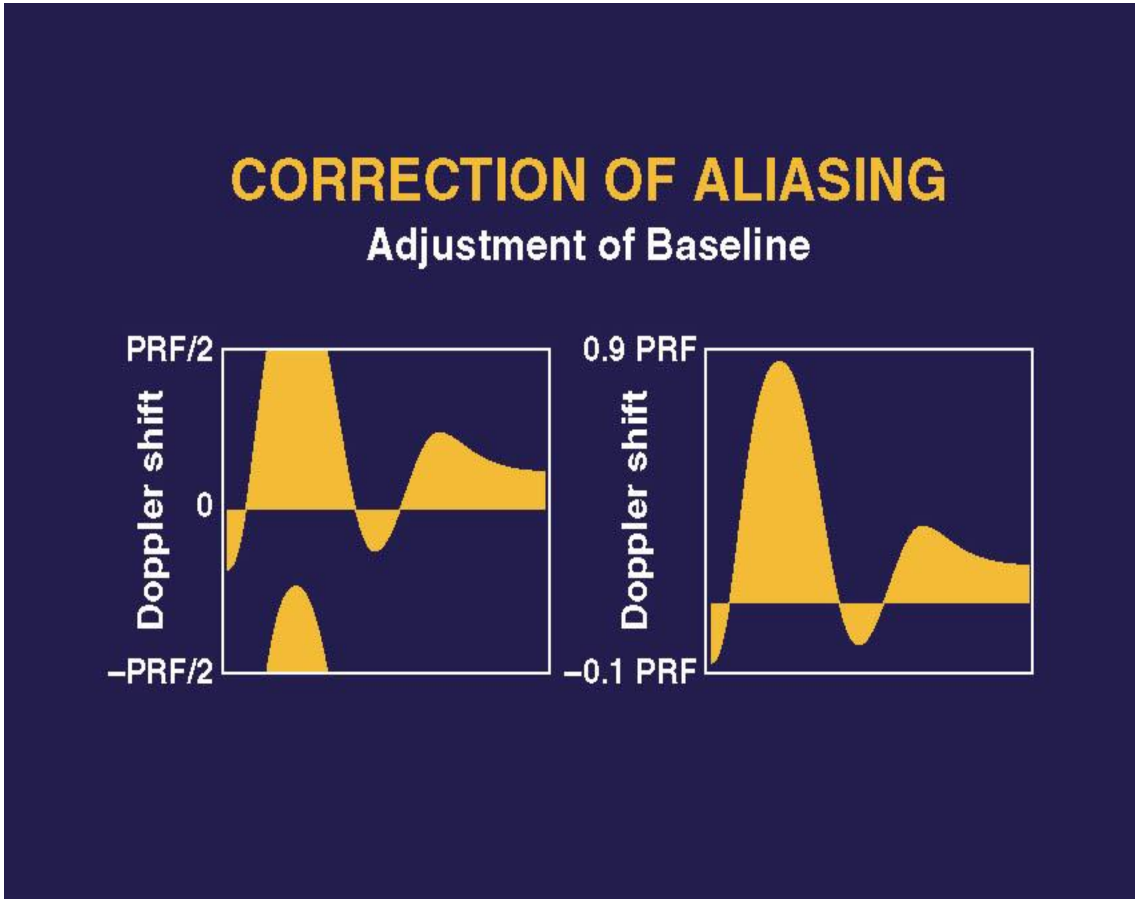


After increasing the Velocity Scale (or the PRF)



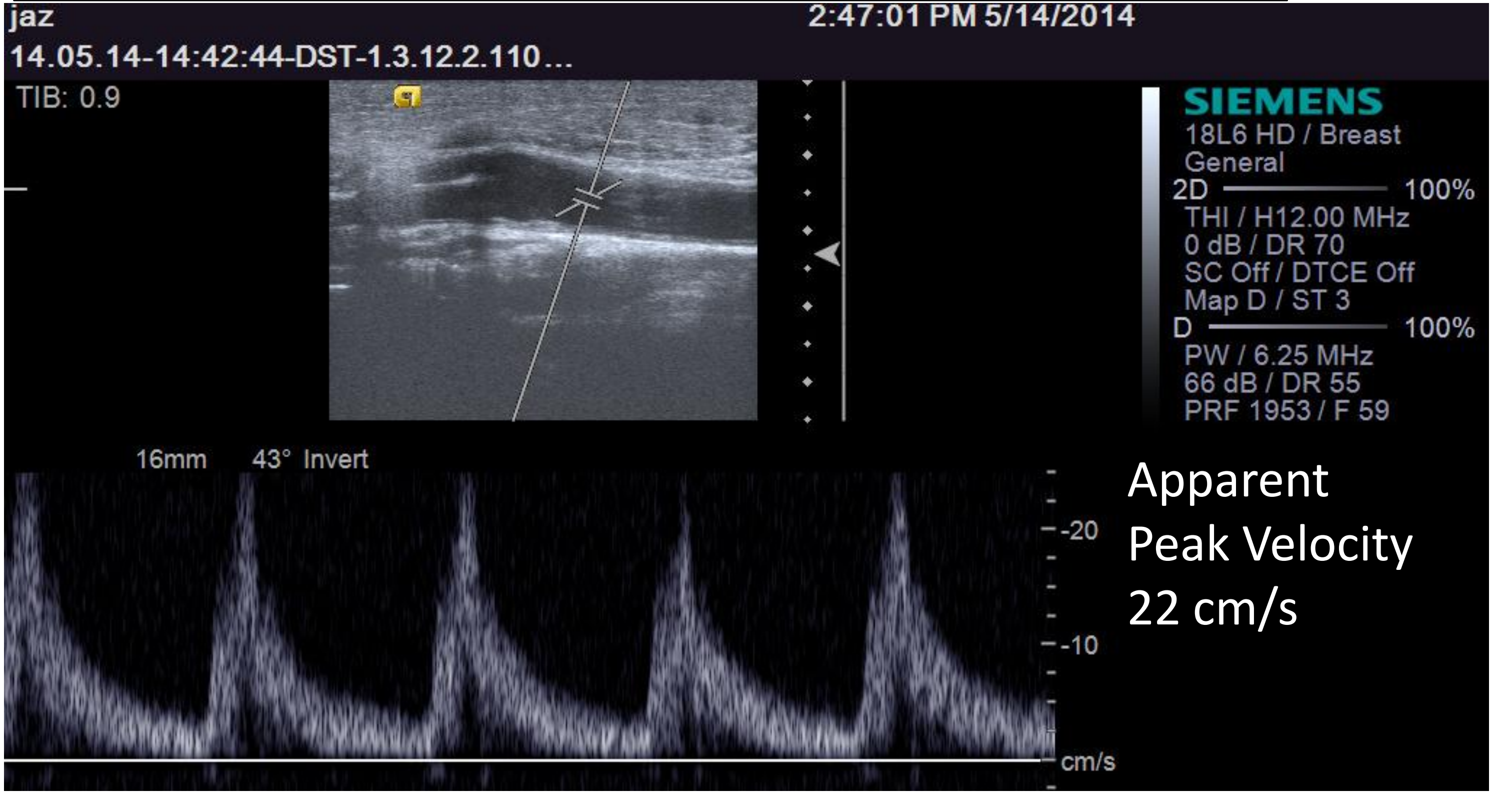
To get rid of aliasing:

- Change the velocity scale
- Change the baseline
- Use a <u>lower</u> ultrasound frequency



This image illustrates an example of:

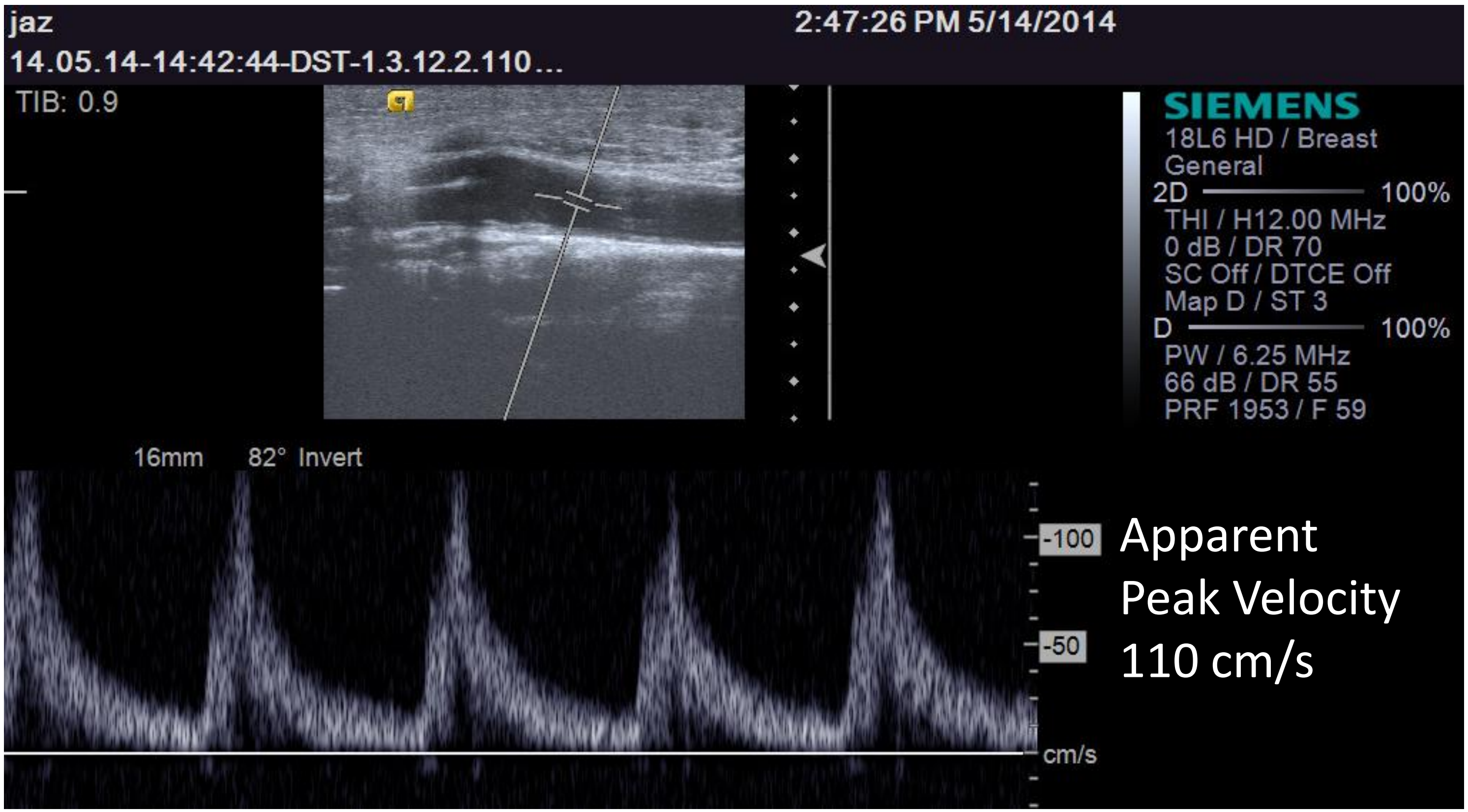
20%	1.	Aliasing
20%	2.	Spectral mirroring
20%	3.	Poor Doppler angle
20%	4.	Erroneous angle correct
20%	5.	Too low a PW ultrasonic frequency



Answer 4: Erroneous angle correct

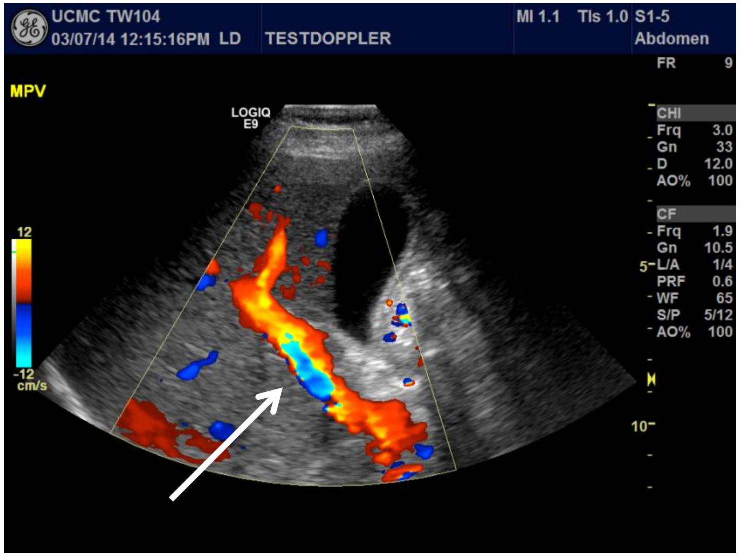
The angle correct is established by the sonographer. The erroneous setting in the previous case resulted in an apparent peak velocity of 22 cm/s.

With the correct setting, the peak velocity appears to be ~110 cm/s.



JA Zagzebski, *Essentials of Ultrasound Physics*, Mosby, St Louis, 1996. Chapter 5.

This image of a hepatic vein suggests bi-directional flow (arrow) just below the gall bladder. This is a clear manifestation of:



20%	1.	A dissection
20%	2.	The US frequency set too low
20%	3.	A stenosis
20%	4.	Aliasing
20%	5.	The color gain set too high

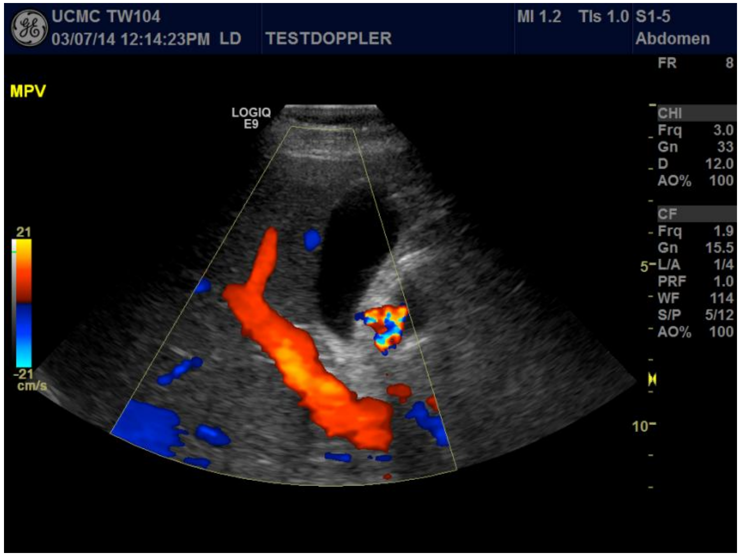
10

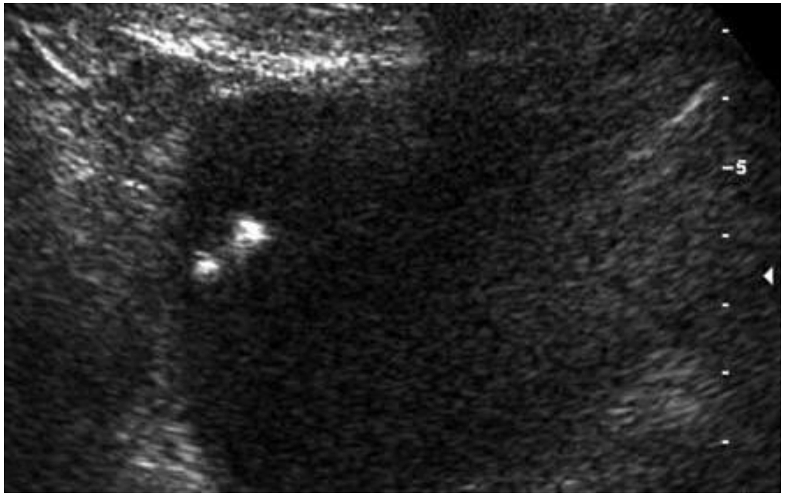
Answer 4, Aliasing

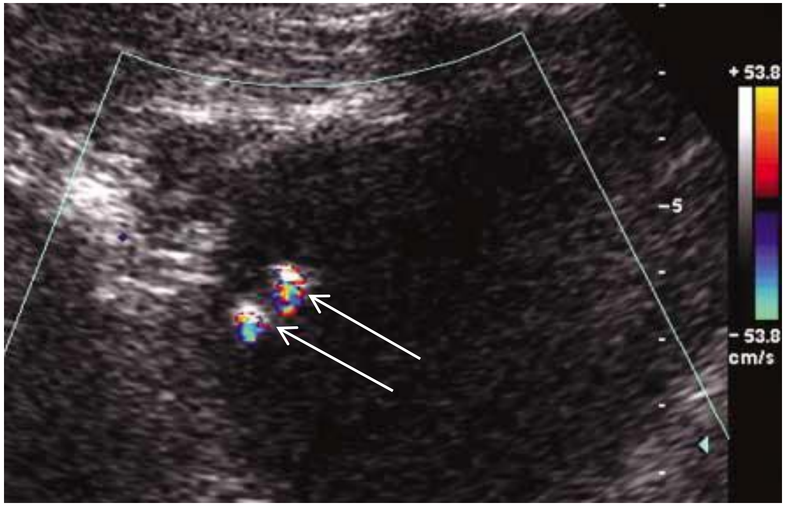
Color flow imaging is based on pulsed Doppler principles. Aliasing occurs if the Doppler frequency exceeds ½ the PRF, and results in a wrapping around on the color scale.

This is an image of the same structure after the velocity scale was increased from ±12 cm/s to ±21 cm/s, and the PRF was increased from 0.6 kHz to 1.0 kHz.

Scan courtesy of Dr. David Paushter, Dept of Radiology, University of Chicago.



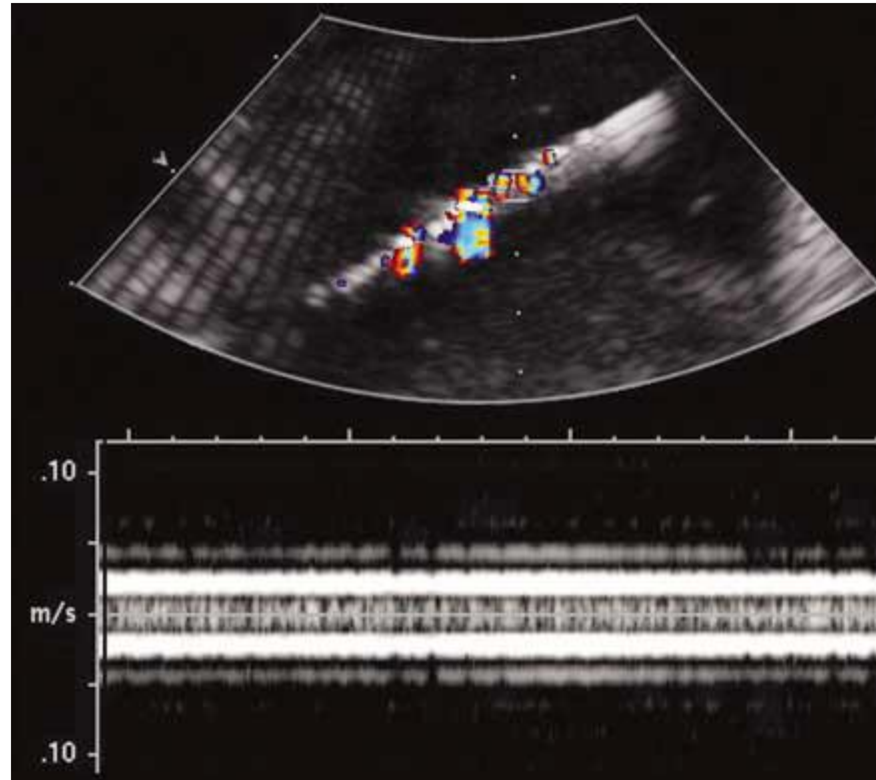




This B-mode image (left) and color flow image (right) shows a urinary bladder. The color image on the right exhibits an artifact (arrows) known as:

20%	1.	twinkling
20%	2.	aliasing
20%	3.	overgaining
20%	4.	enhancement
20%	5.	color bleeding

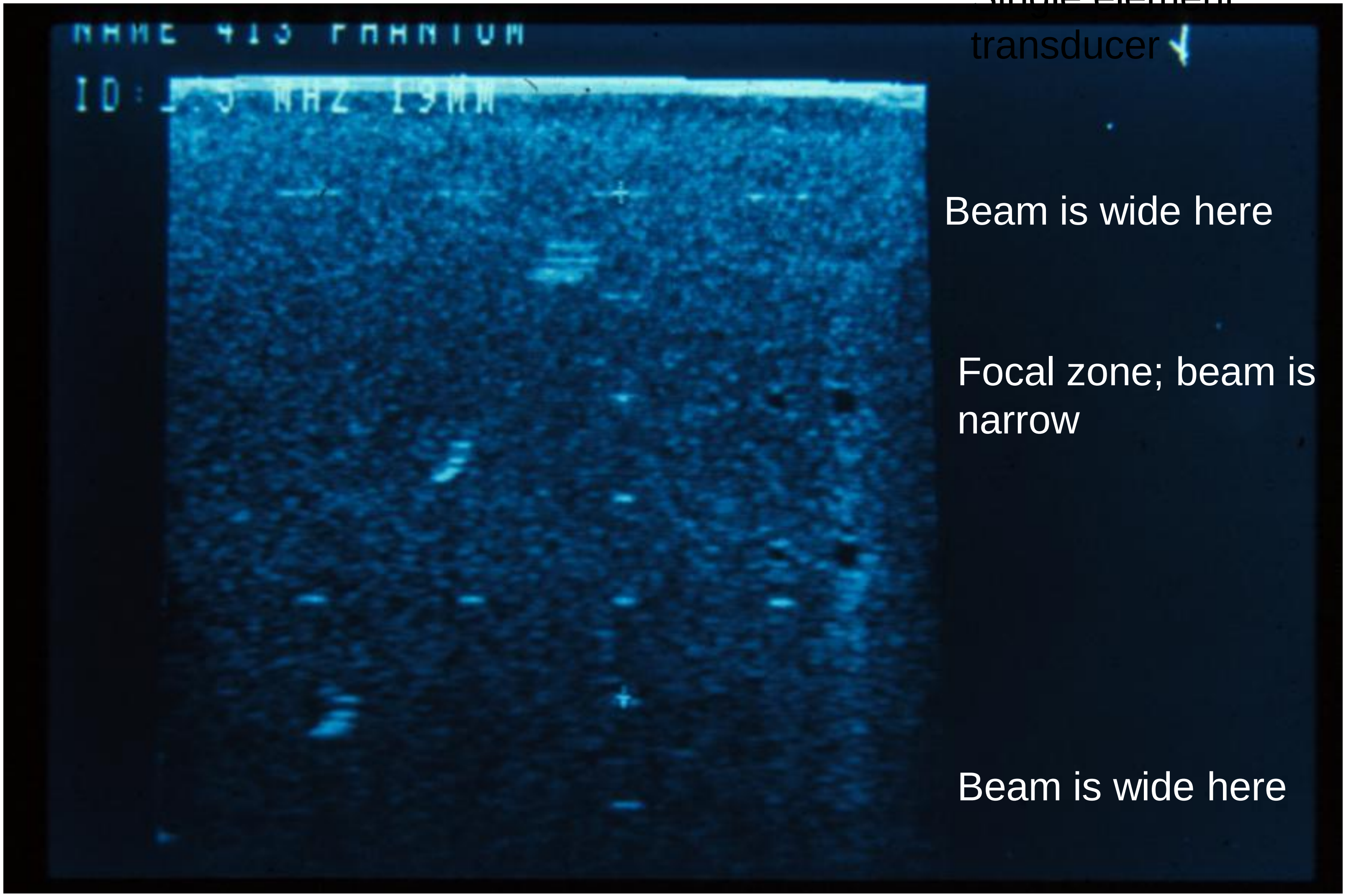
- Answer 1, twinkling
- The twinkle artifact is associated with calcifications, stones, and other rough objects. It has been attributed to system clock jitter, noise, and even bubbles.
- (Mitchell C, Pozniak M, Zagzebski J, Ledwidge M. “Twinkling artifact related to intravascular suture.” J Ultrasound Med 22:1409–1411, 2003.)



BEAM WIDTH ARTIFACT

A point-like reflector will result in a line on the image; the length of the line equals the beam width at the depth of the reflector.

Beam Width Artifacts



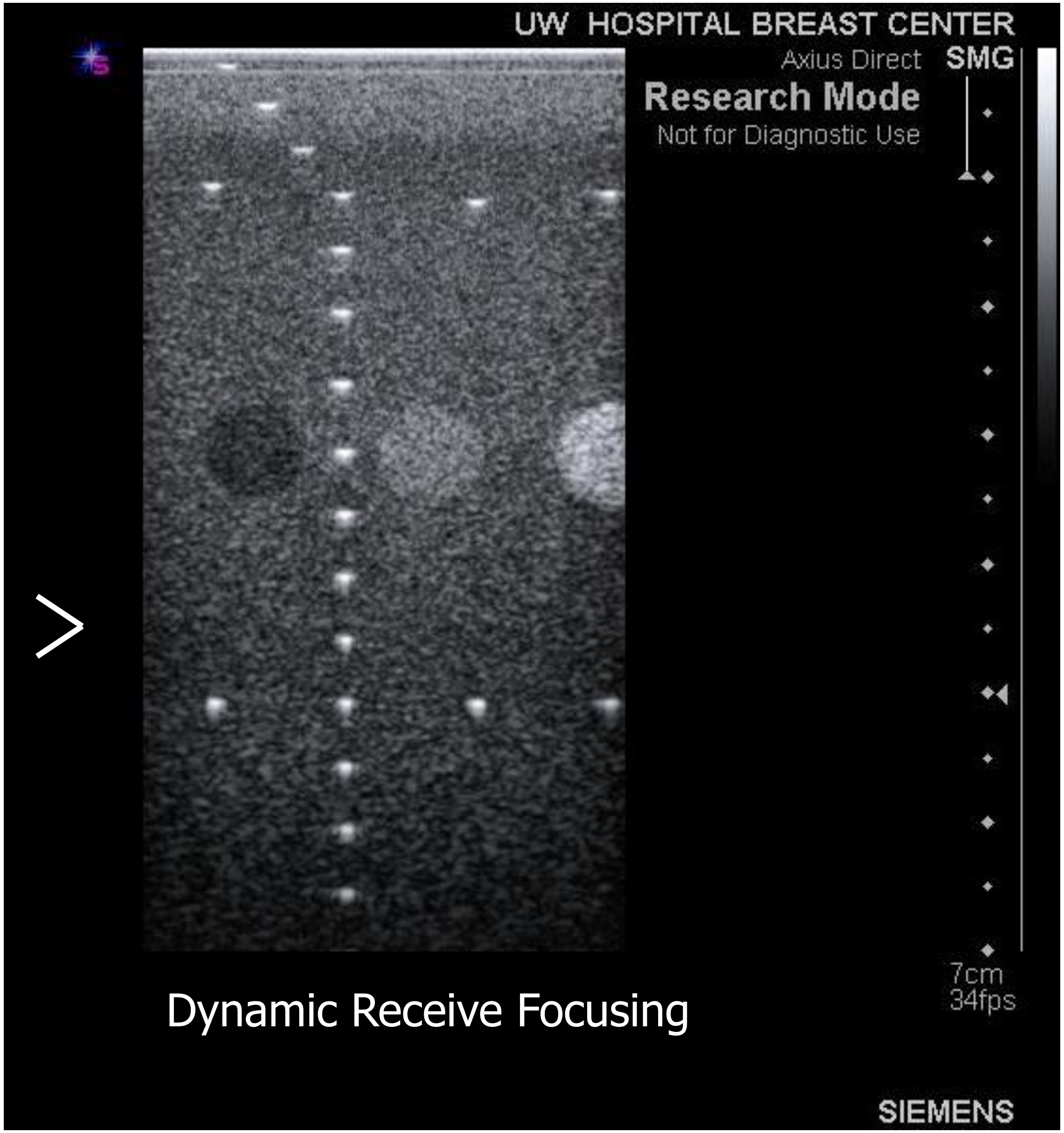
Receive focusing off

Transmit Focusing Only

Transmit focusing applied to a single depth

Receive focusing is disabled

Receive focusing on

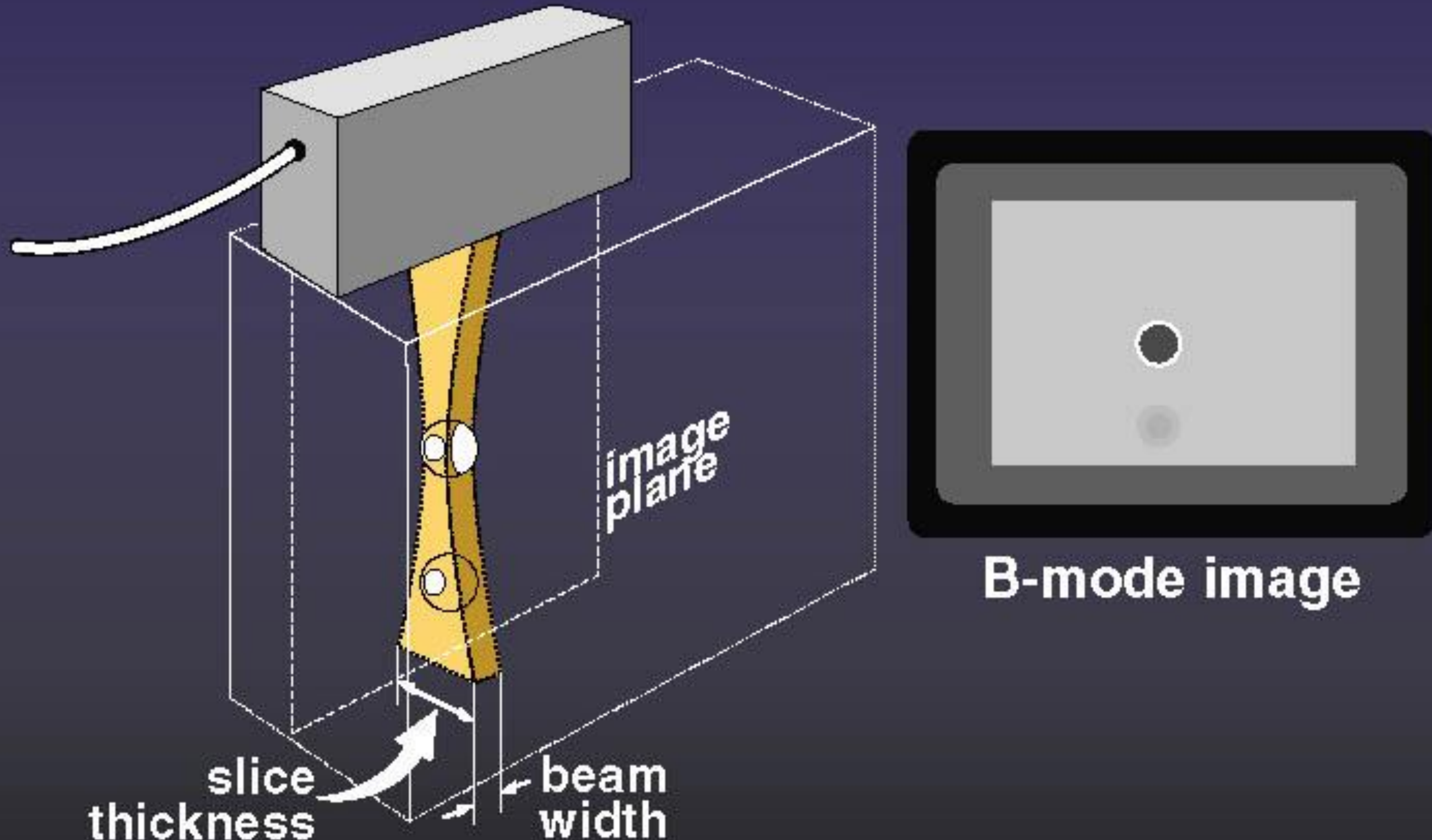


Dynamic Receive Focusing

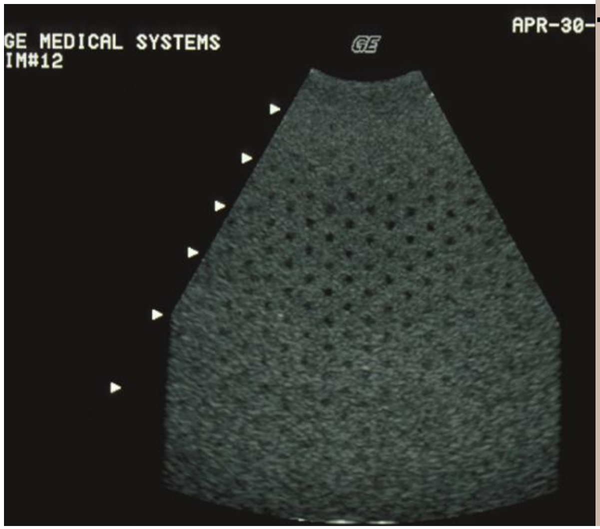
Transmit focusing applied to a single depth

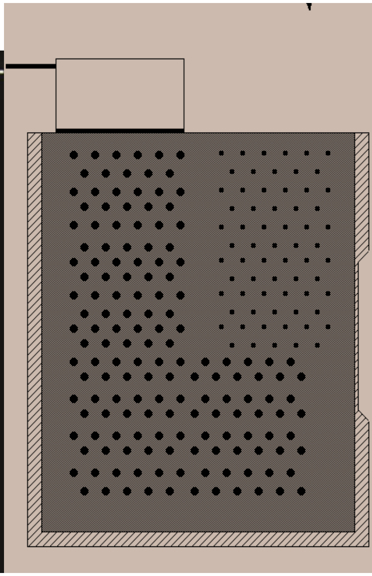
Receive focusing done in the "beam former"
- Uses time delays
- Changes dynamically

SLICE THICKNESS ARTIFACT



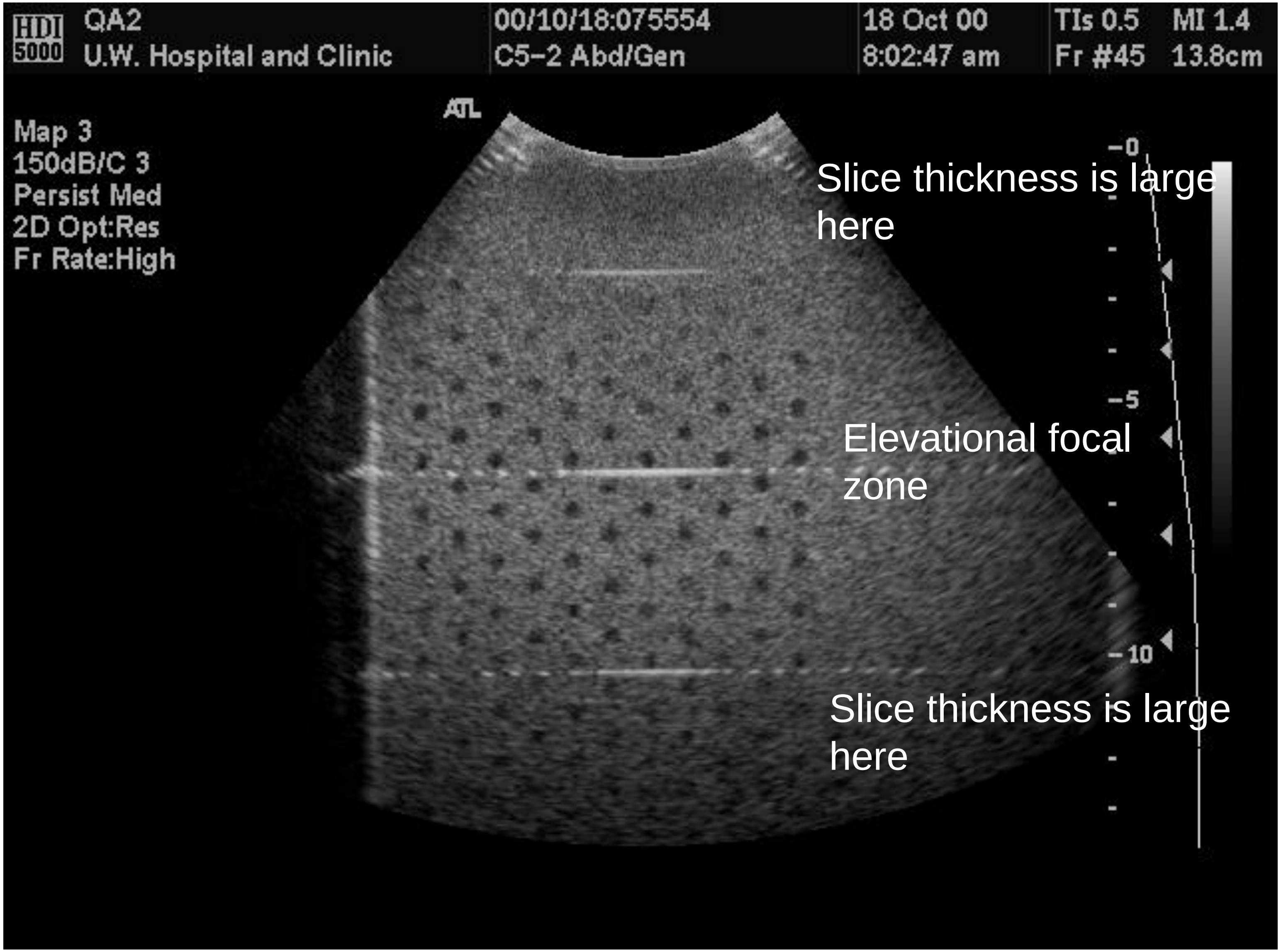
This image is of a phantom that contains 4 mm diameter spherical, low scatter objects. The objects are not visualized over the first 4 .5 cm (see image). This is due to ____________ effects.





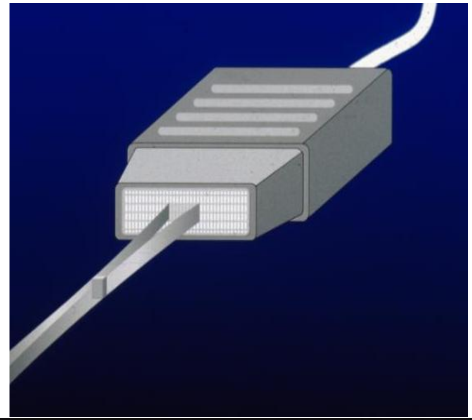
20%	1.	Reverberation
20%	2.	Refraction
20%	3.	Speed of sound
20%	4.	Beam width
20%	5.	Slice thickness

Answer 5, Slice thickness effects.

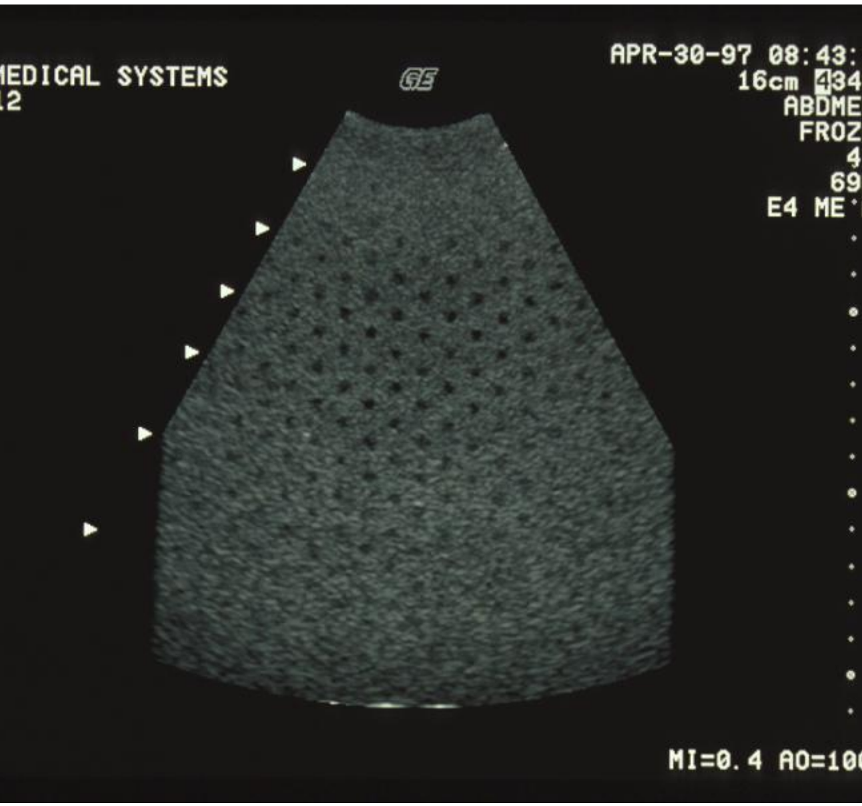


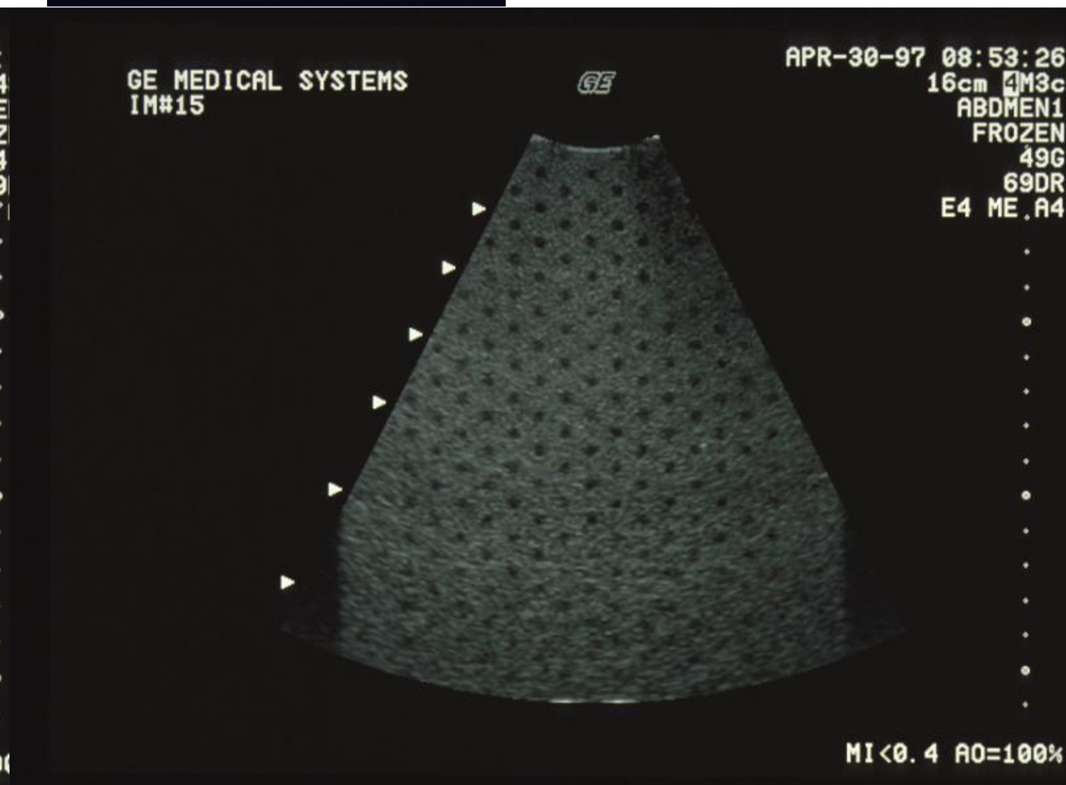
JA Zagzebski, *Essentials of Ultrasound Physics*, Mosby, St Louis, 1996. Chapter 2.

Conventional Transducer

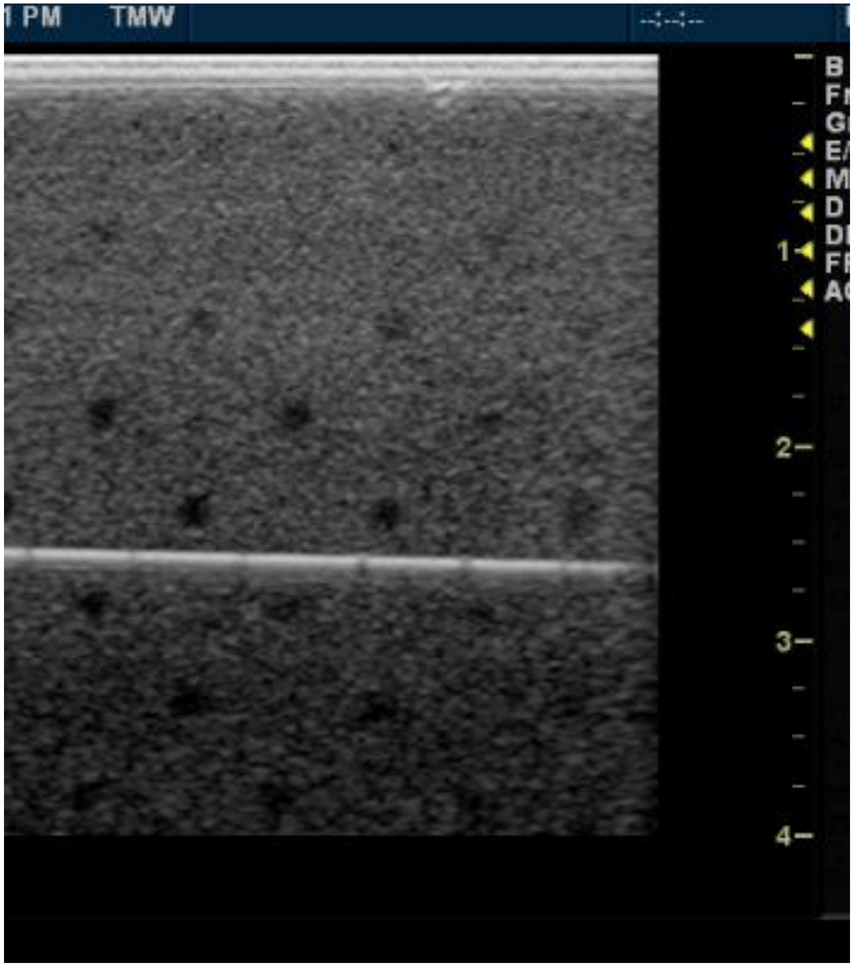


“1 ½ D” Transducer

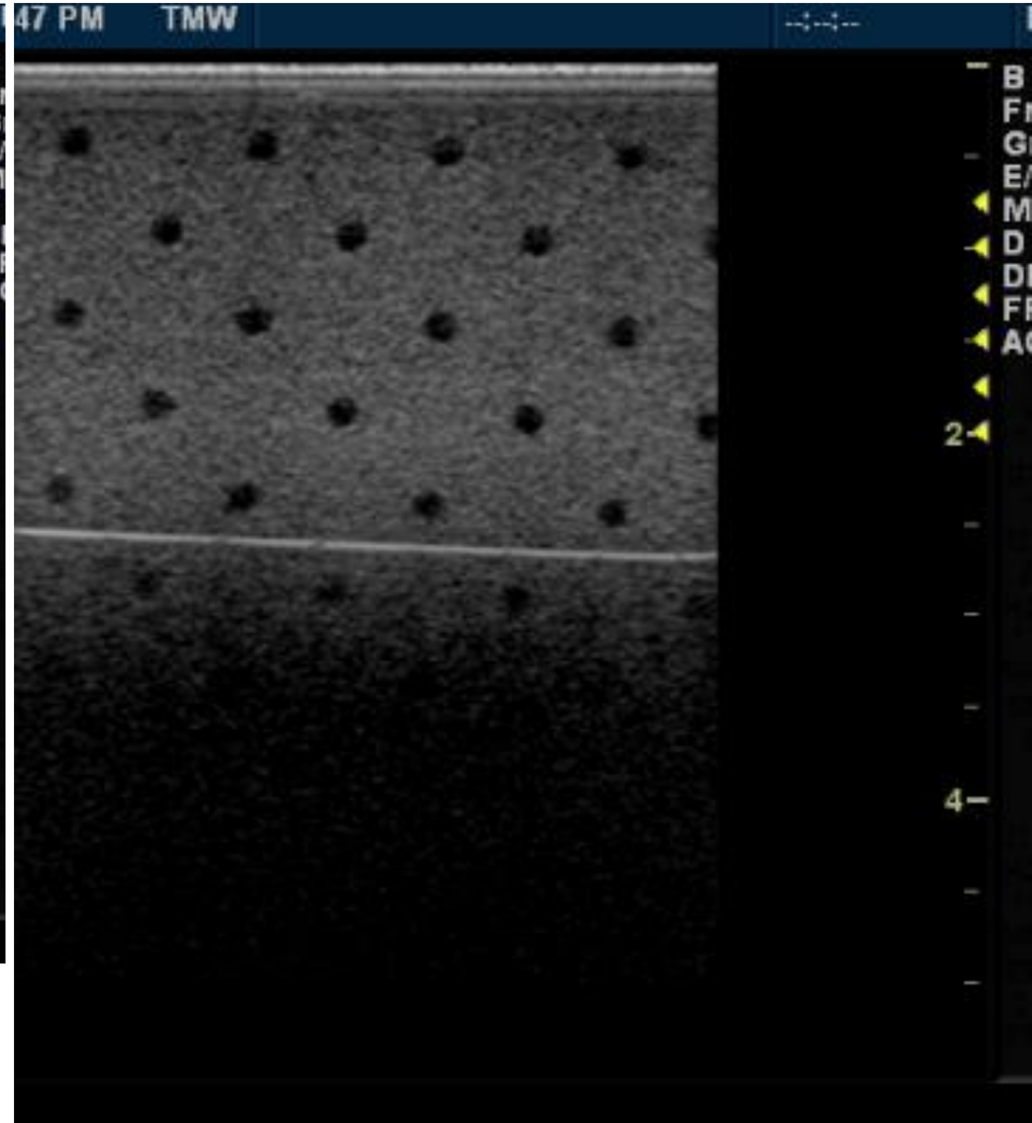




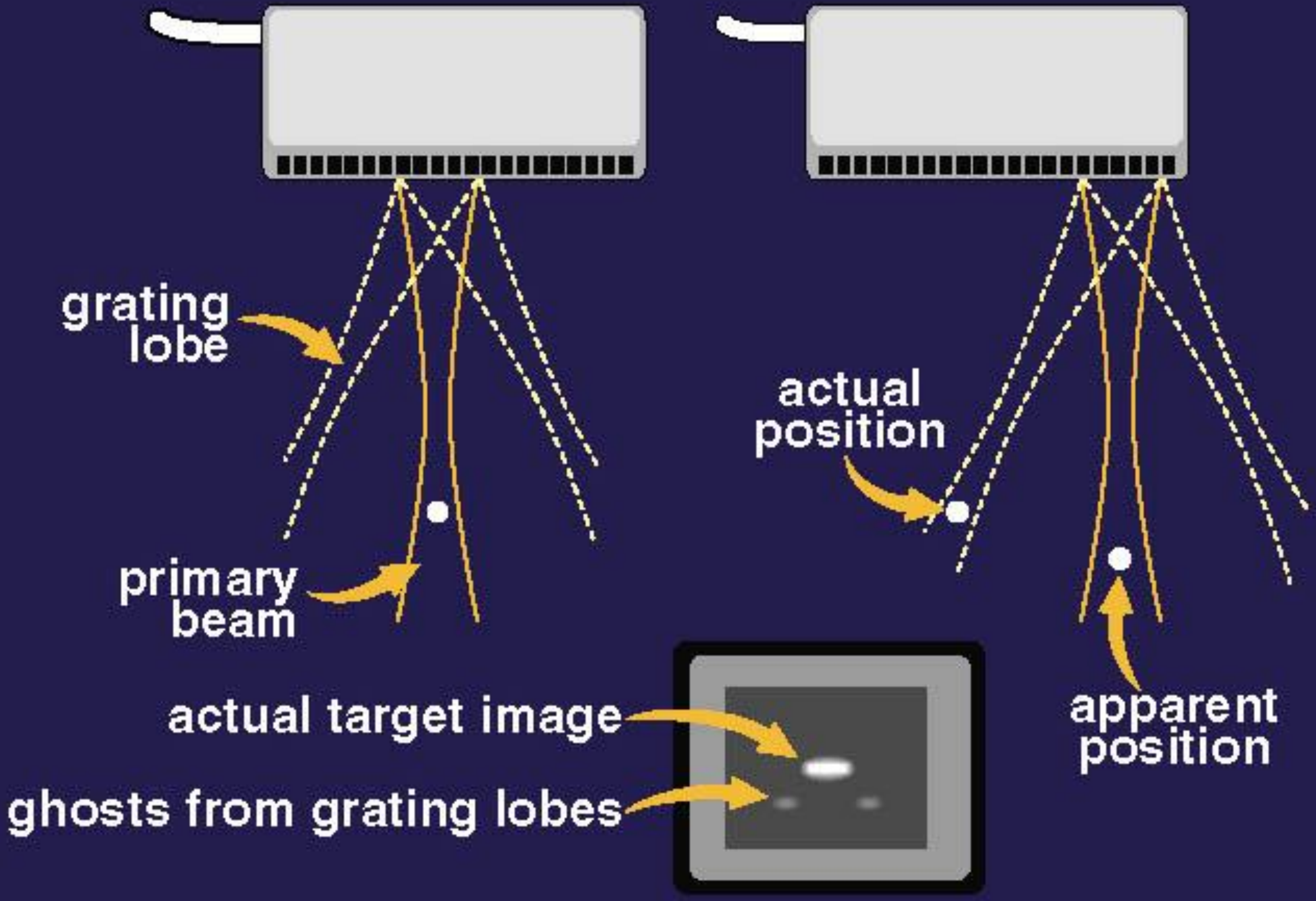
Conventional Transducer

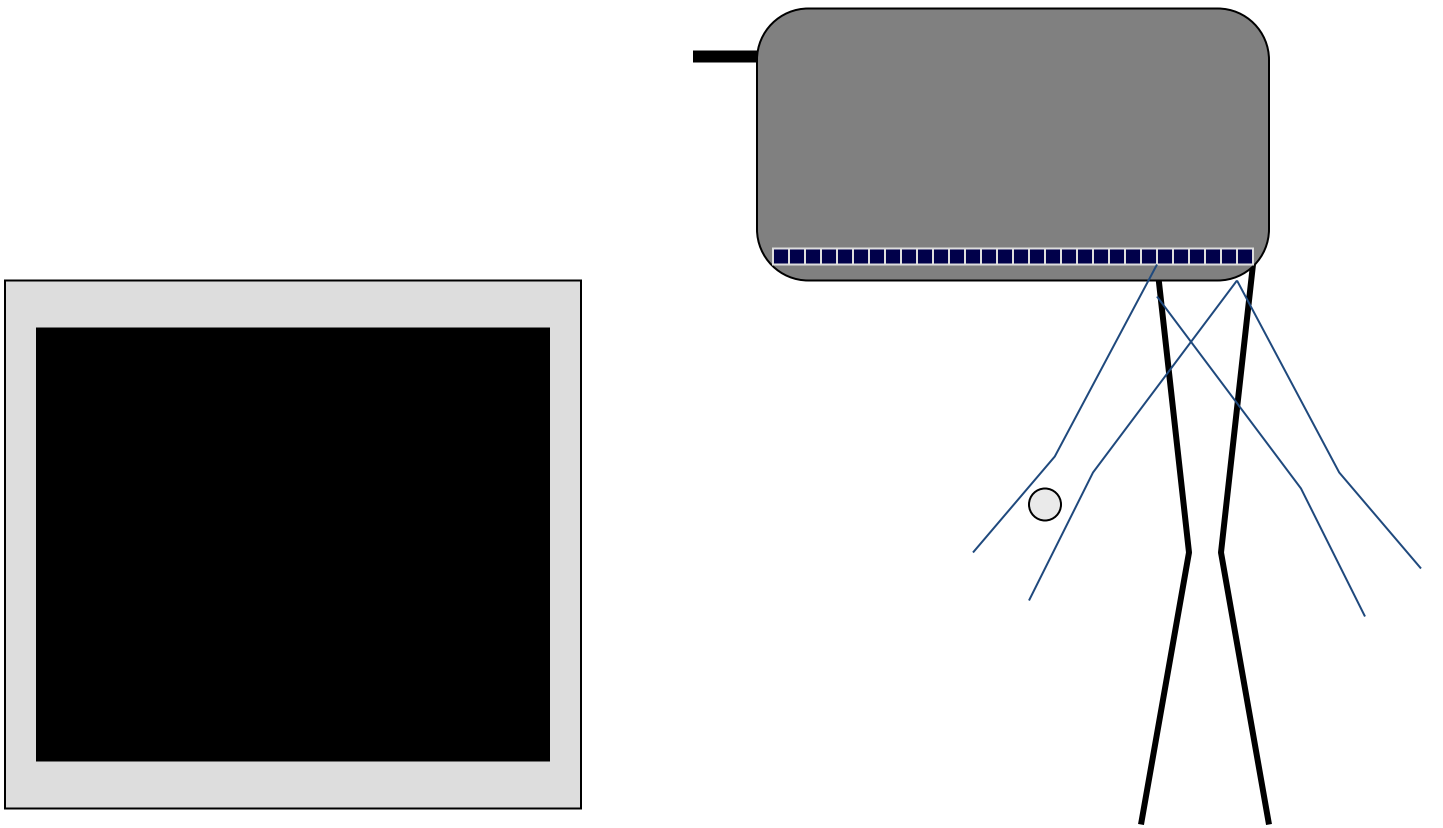


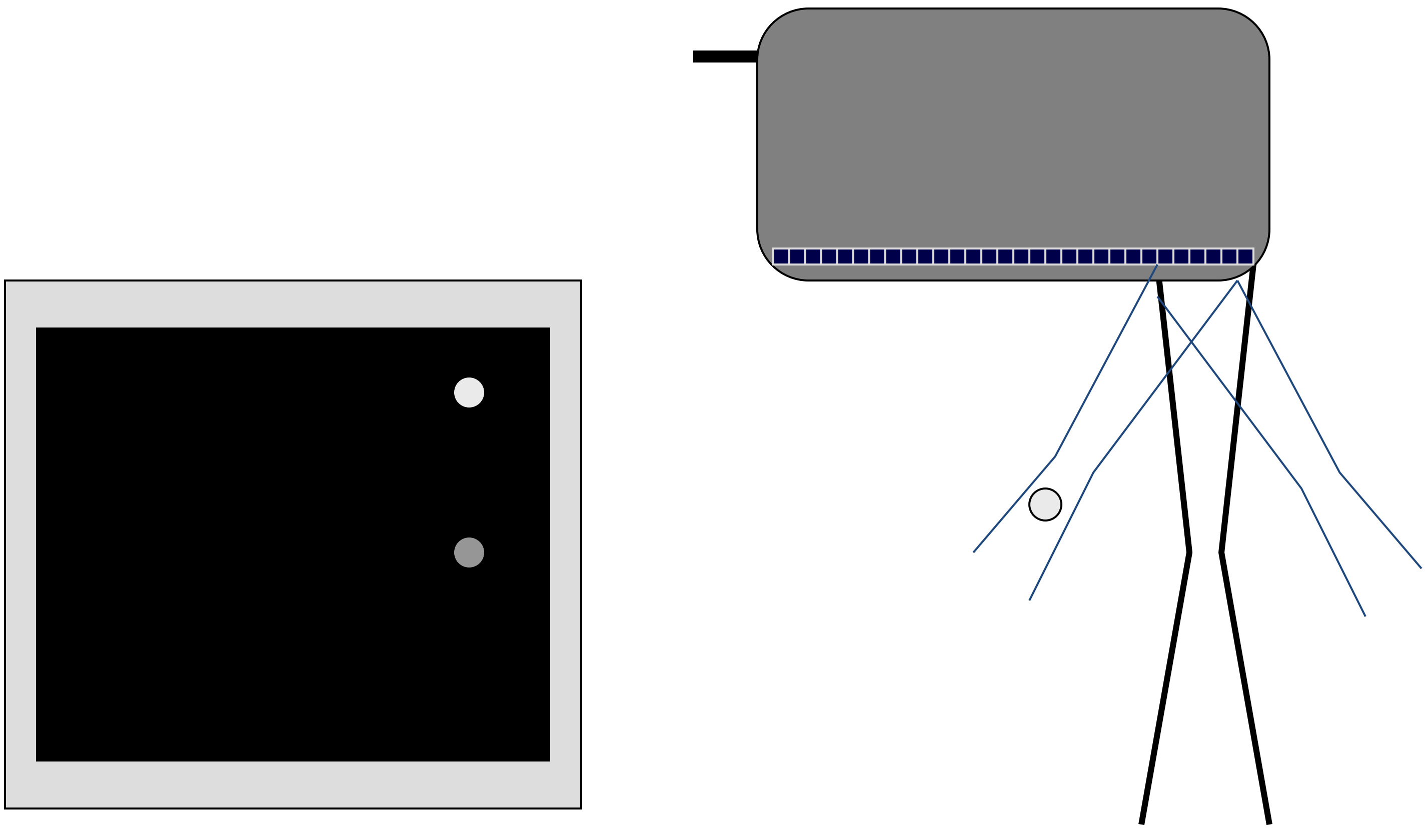
1 ½ D Transducer

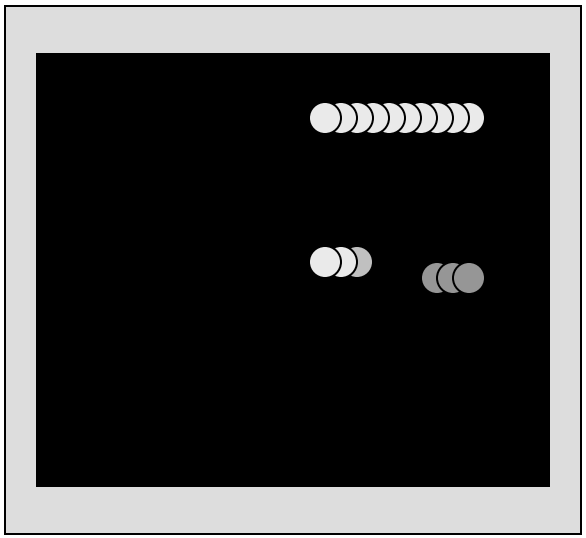


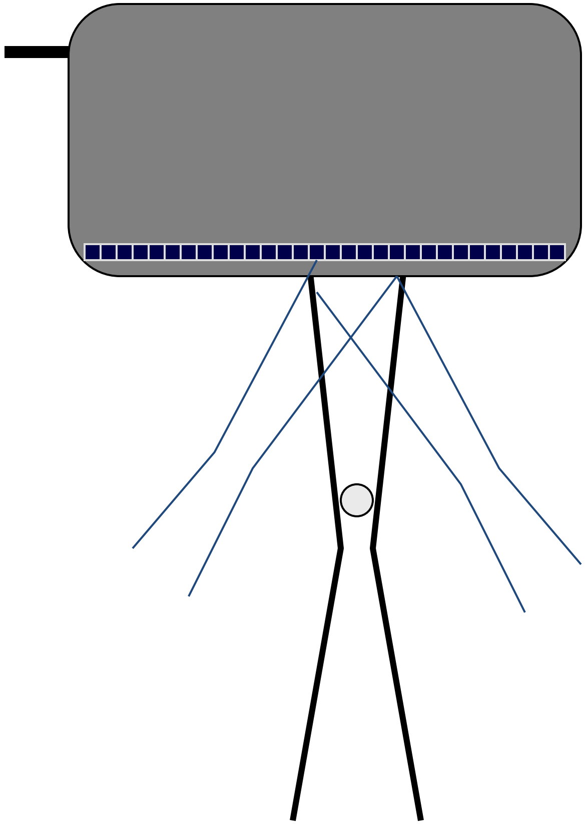
Grating Lobes (array transducers)

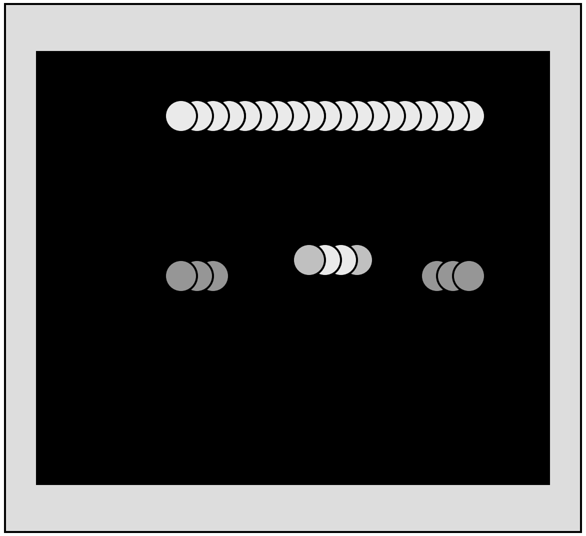


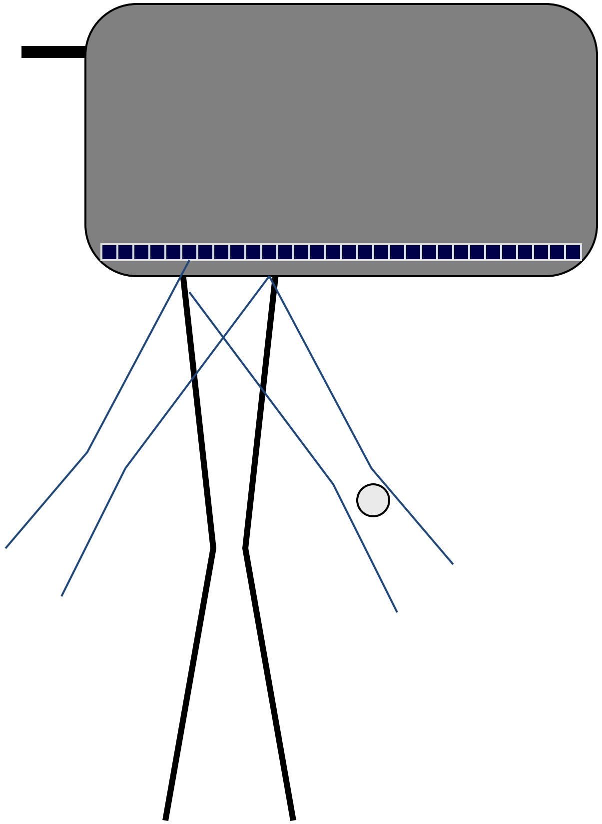




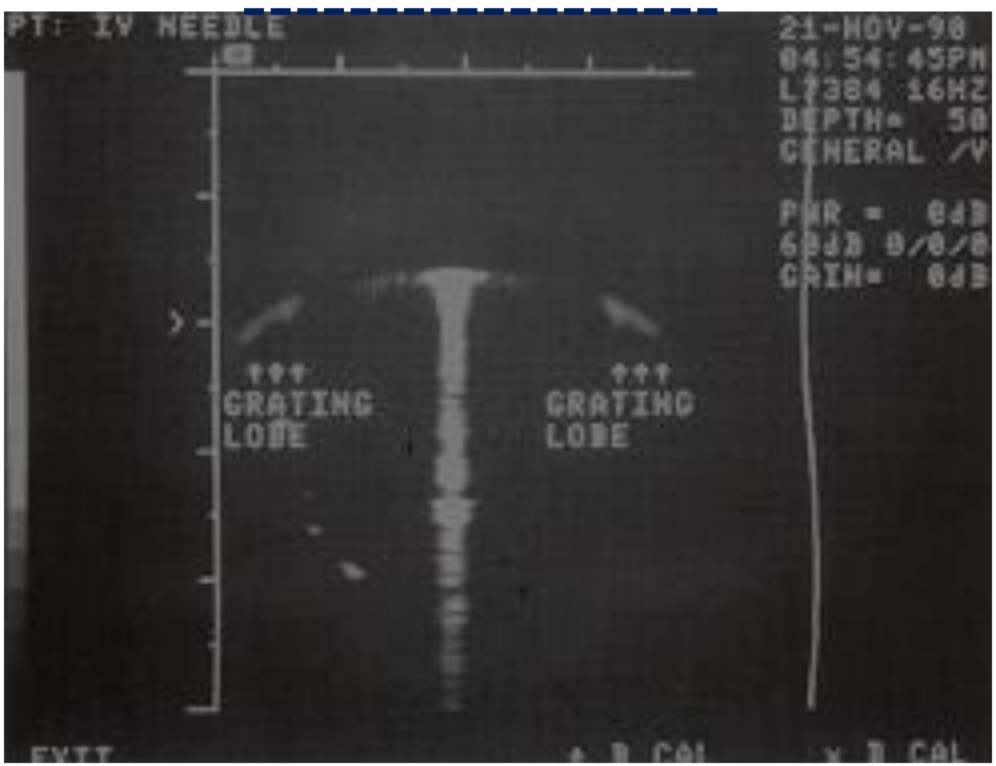


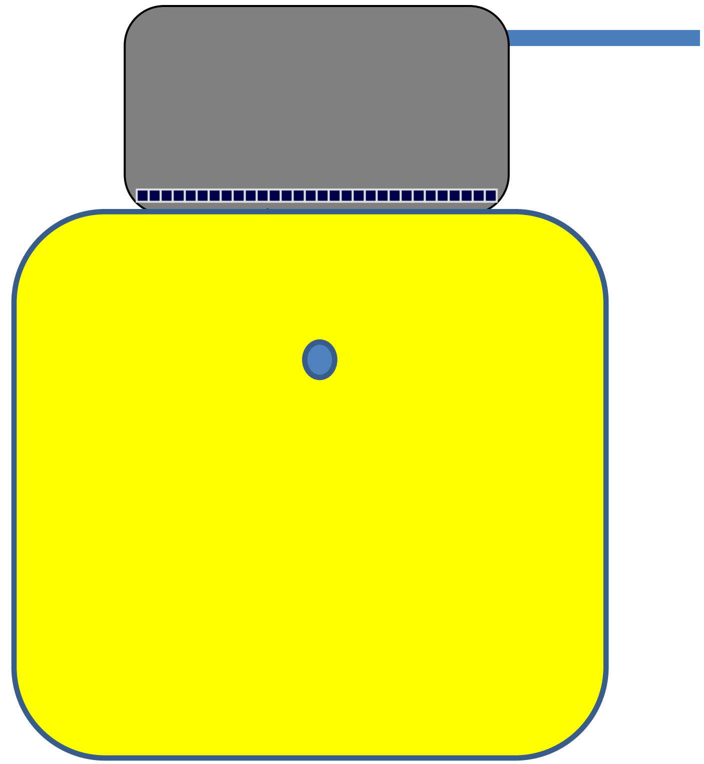




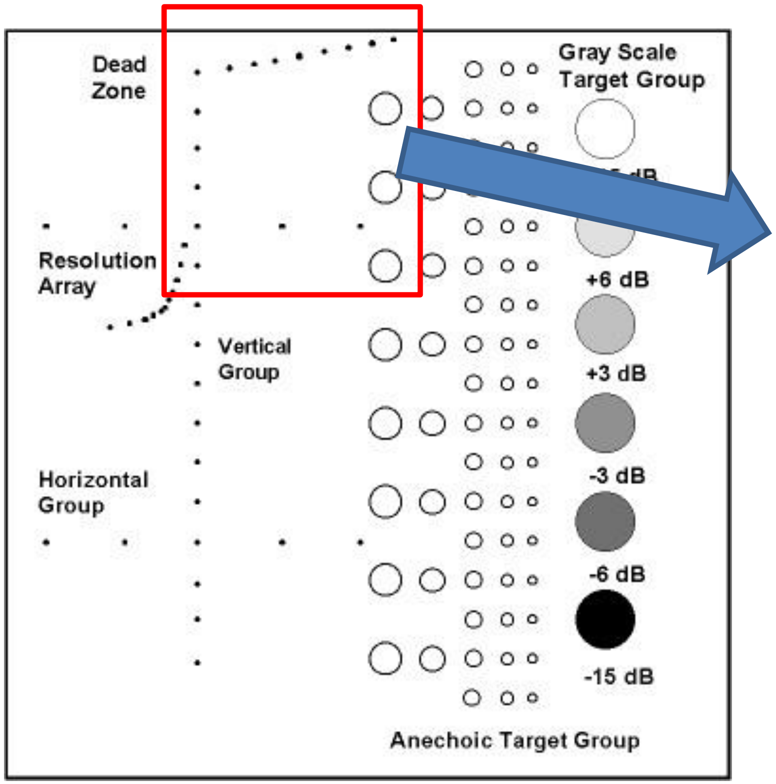


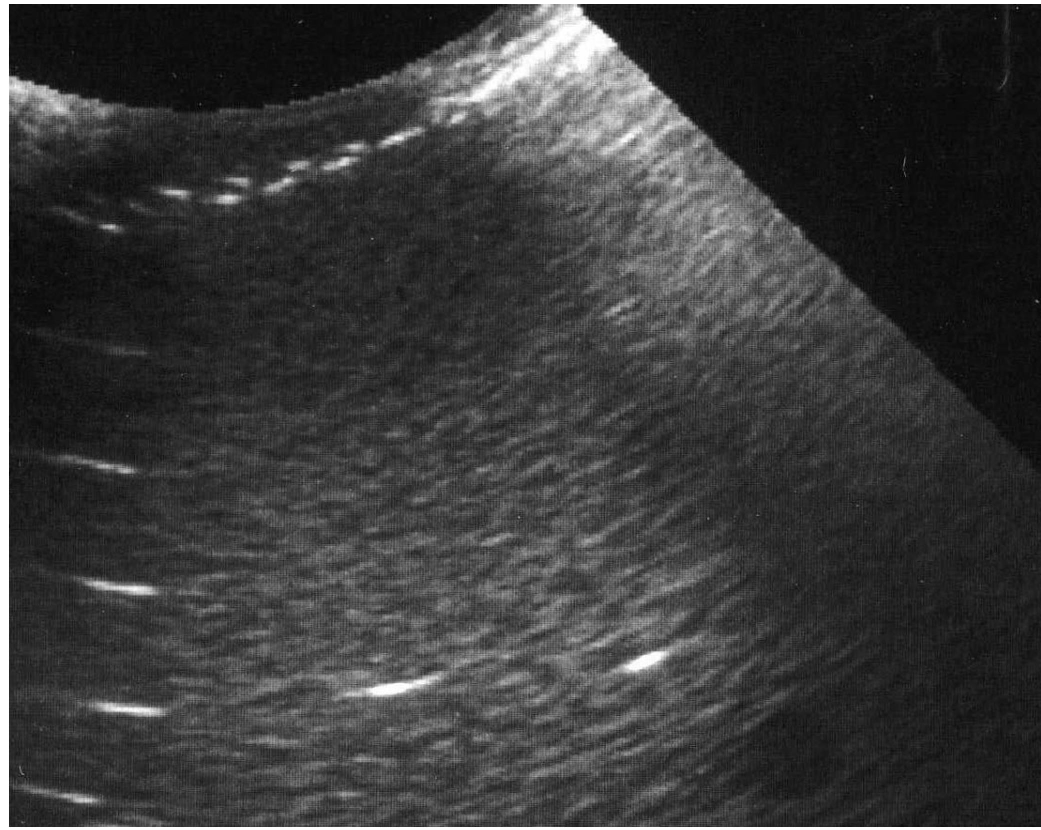
Example of side lobe, grating lobe





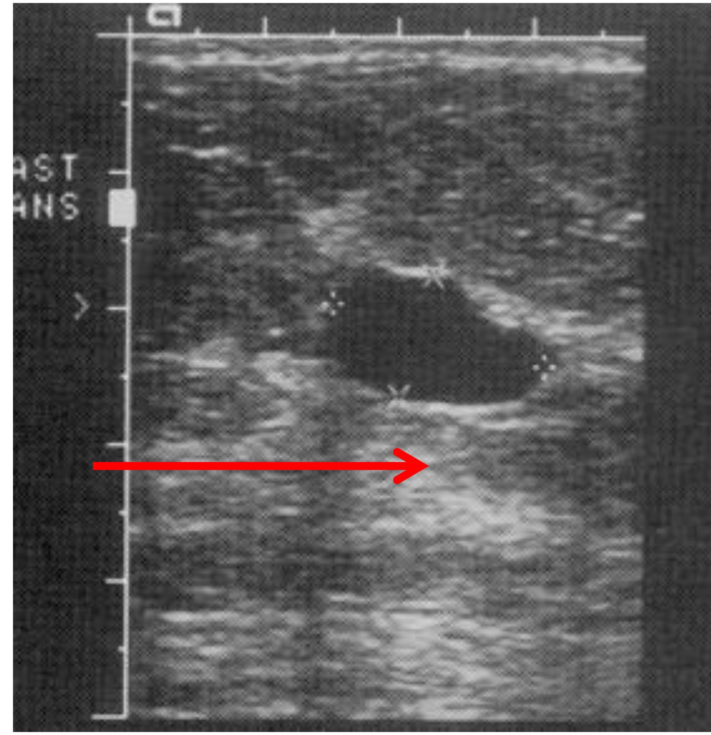
Effects of side/grating lobes from a damaged curvilinear transducer. This image shows a section (red) of an ATS 539 phantom.





Courtesy of Douglas Pfeiffer,
Boulder Community Foothills Hospital

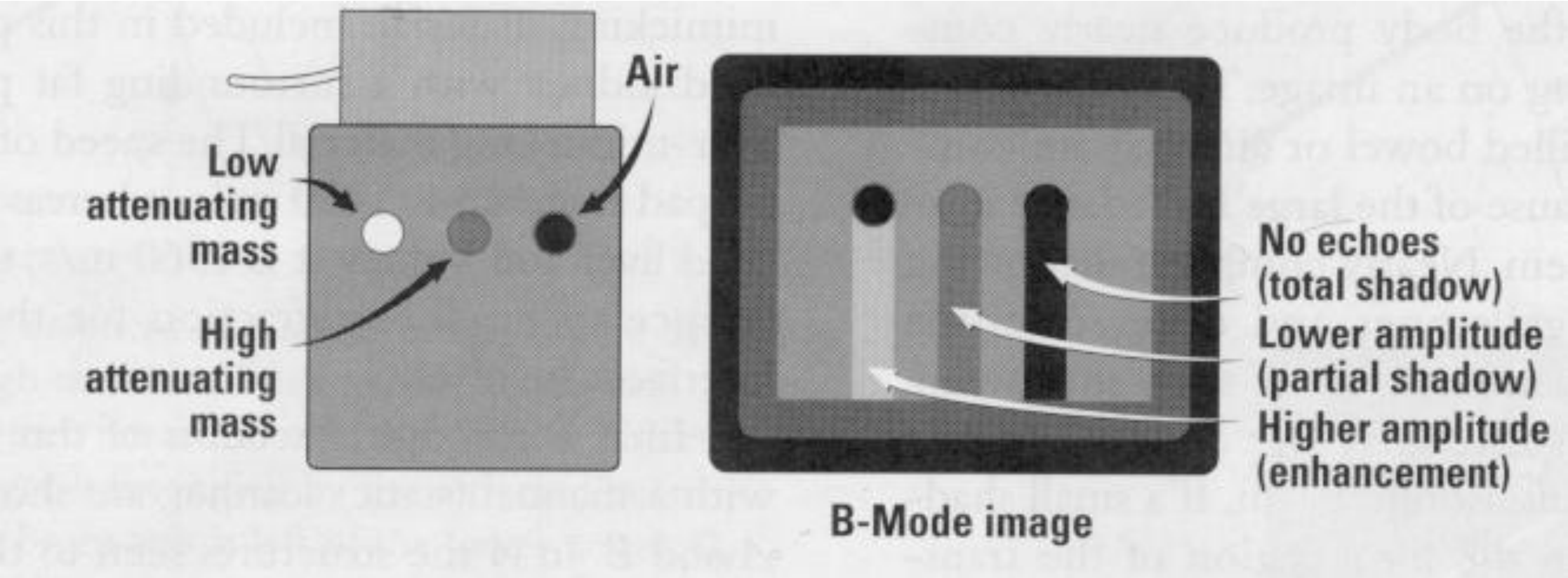
Brighter, or “enhanced” echo signals are seen in this image below the echo free mass. This is a result of:



20%	1.	Improper TGC settings
20%	2.	Lower density in the mass
20%	3.	Lower attenuation in the mass
20%	4.	Higher speed of sound in the mass
20%	5.	Lower acoustic impedance of the mass

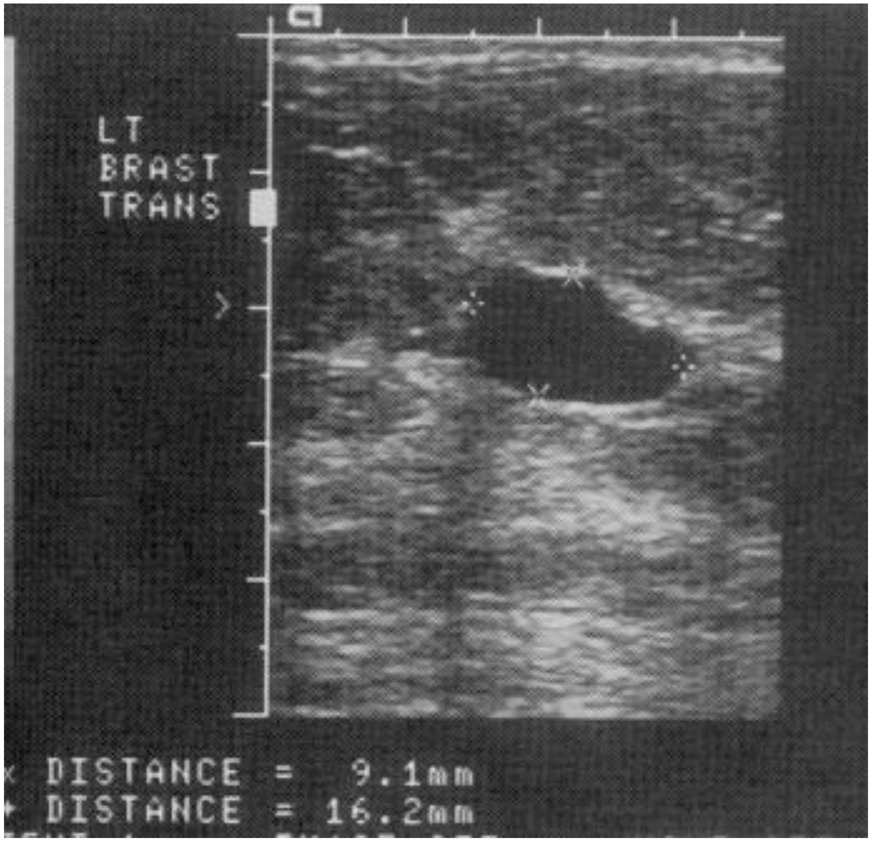
Answer 3: Lower attenuation in the mass introduces "echo enhancement"

Attenuation Artifacts (useful)



JA Zagzebski, *Essentials of Ultrasound Physics*, Mosby, St Louis, 1996. Chapter 7.

Attenuation Artifacts (useful)



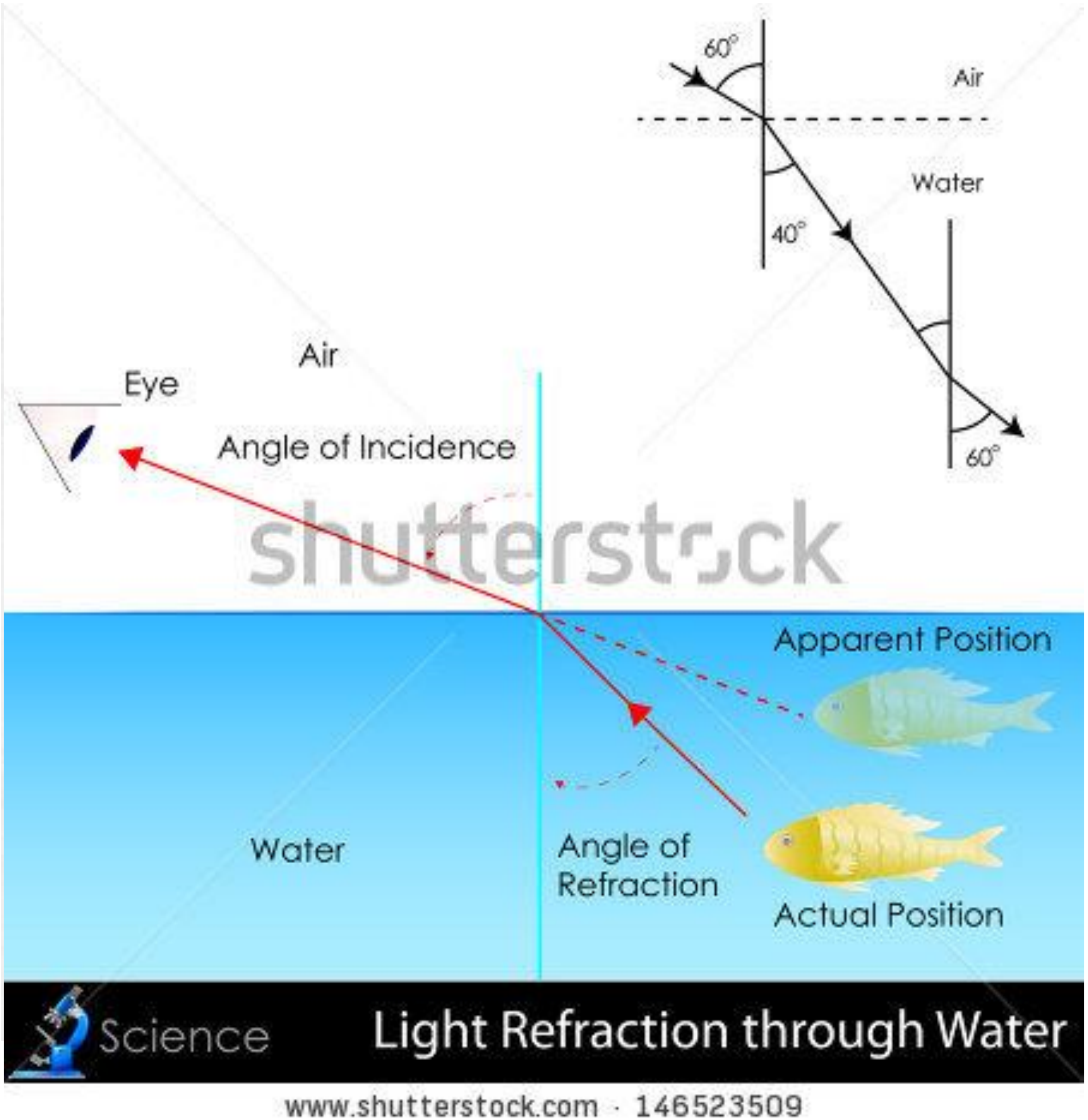
Enhancement

(Attenuation in a cyst is lower than in surrounding tissue)

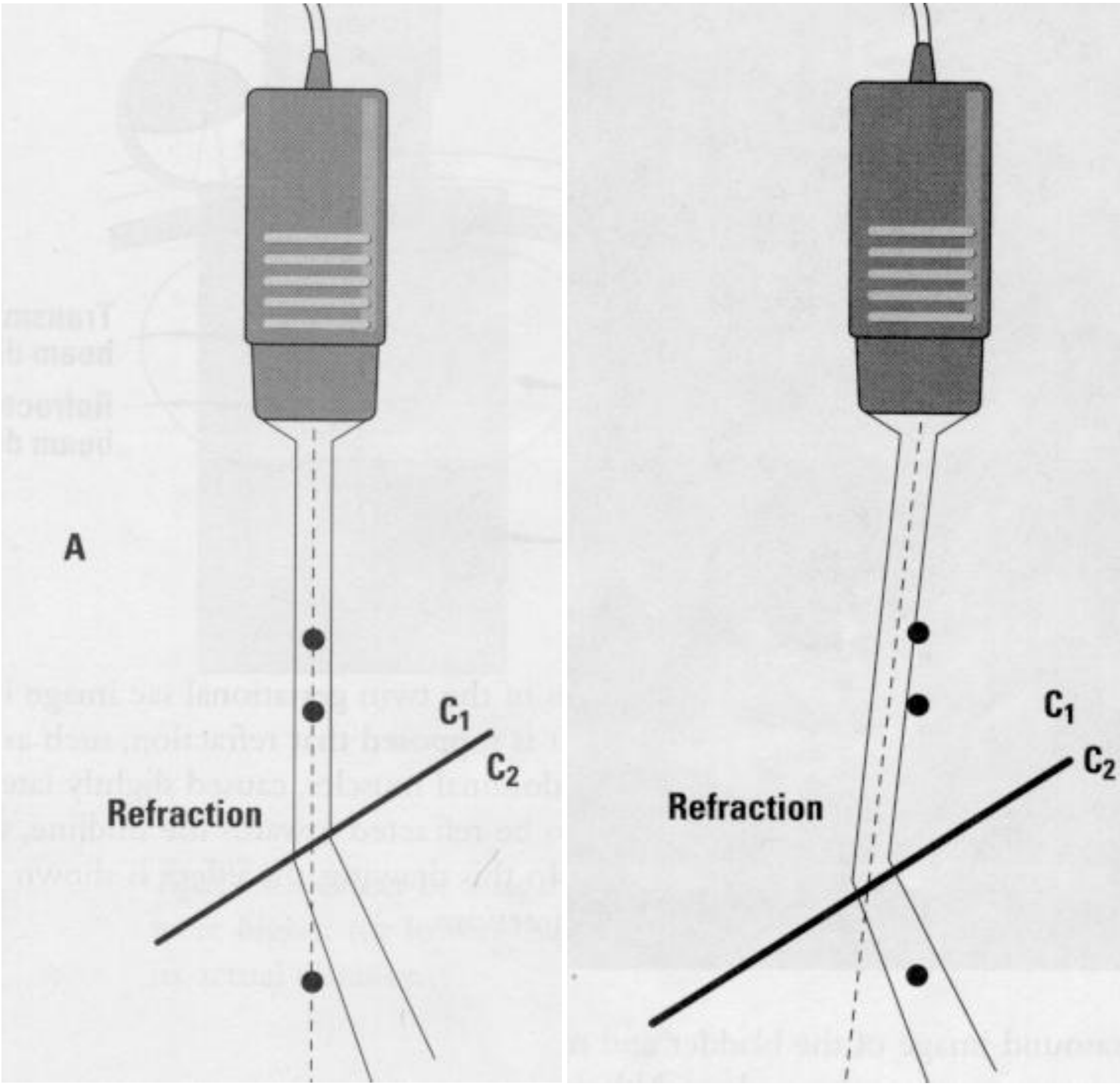
Shadowing

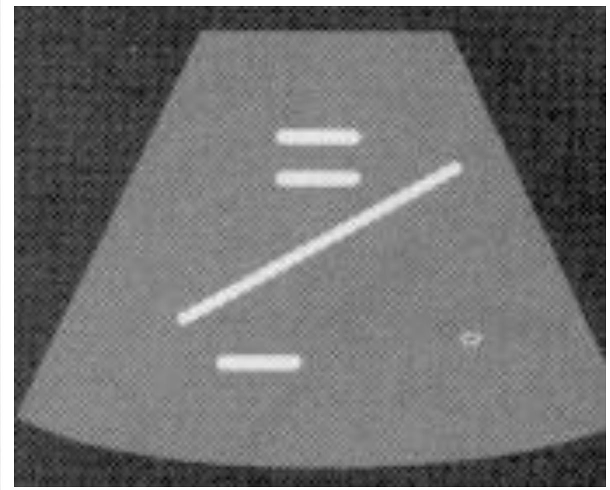
(Attenuation in mass is greater than that in surrounding tissue)

Refraction Effects

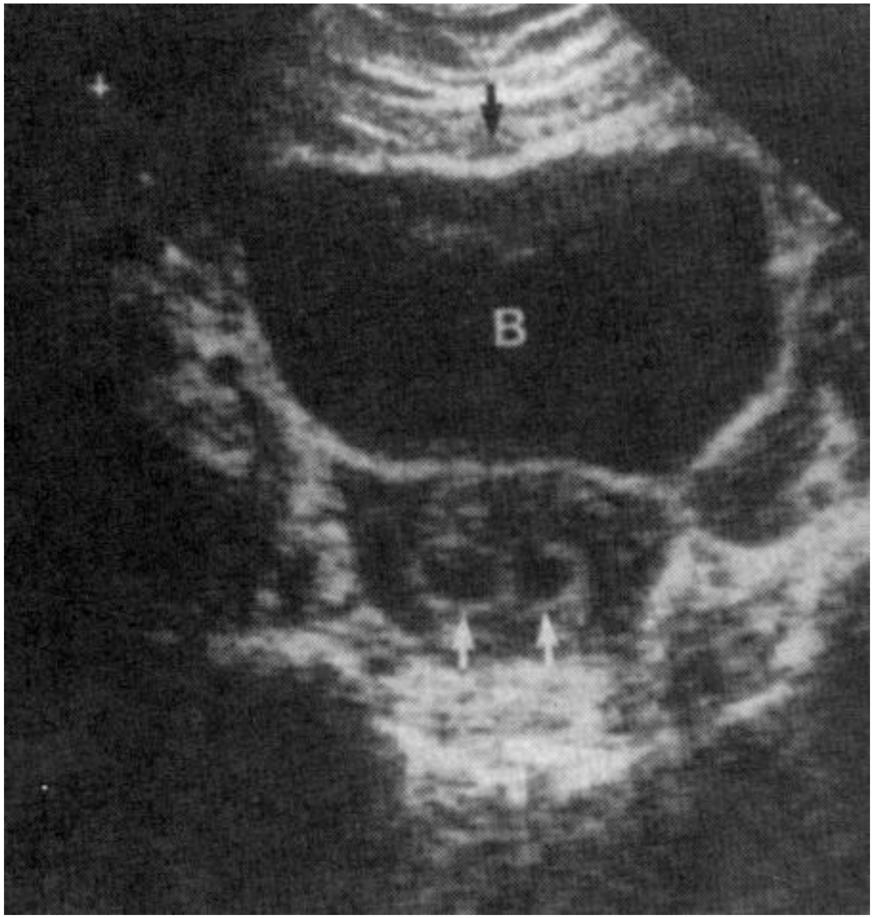


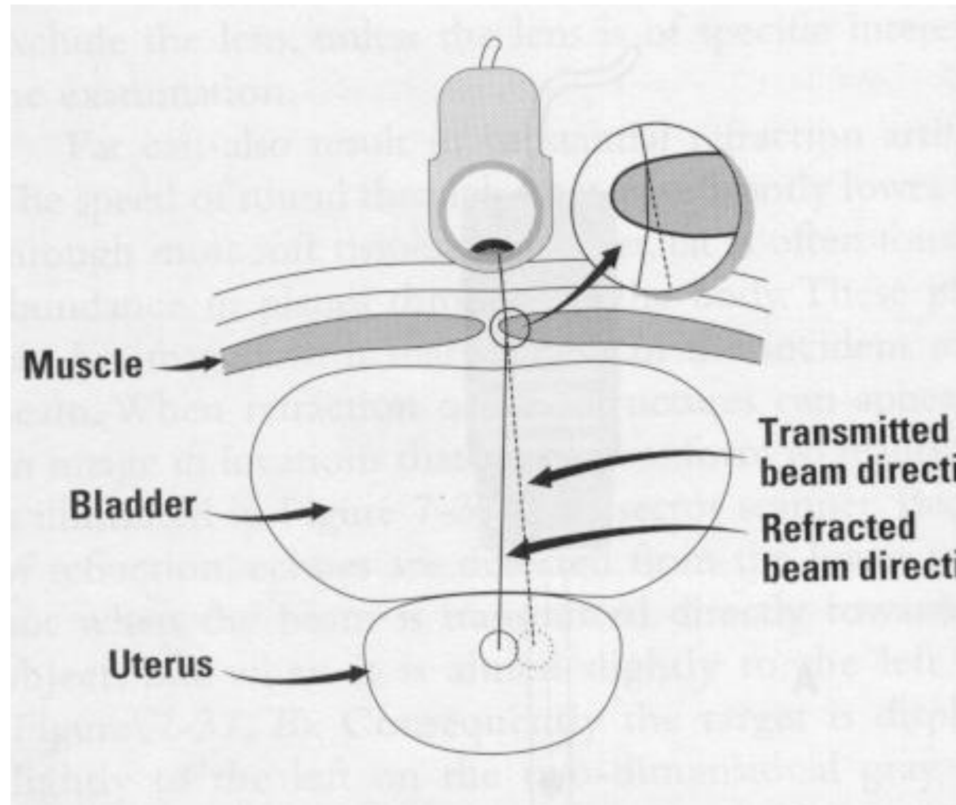
Refraction Effects





Refraction Effects

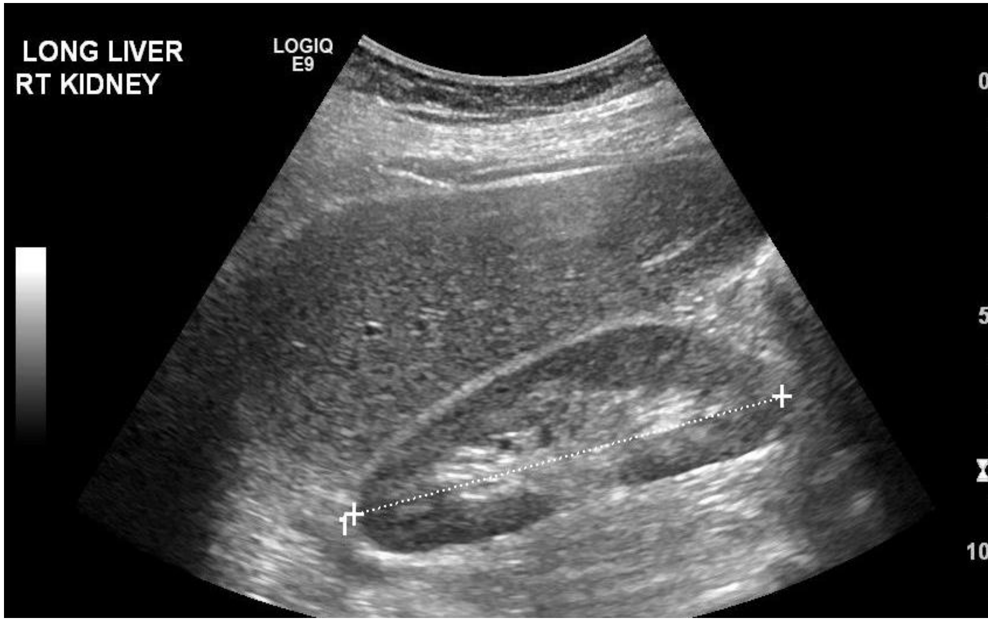




Buttery B, Davison G. **“The ghost artifact,”**
J Ultrasound Med. 1984 Feb;3(2):49-52.

Recap:

Which one of the following will reduce reverberation artifacts



20%	1.	Apply compound imaging
20%	2.	Use coded excitation
20%	3.	Use harmonic imaging
20%	4.	Use a low transmit power
20%	5.	Avoid using curvilinear arrays

10

Answer 3: Harmonic Imaging

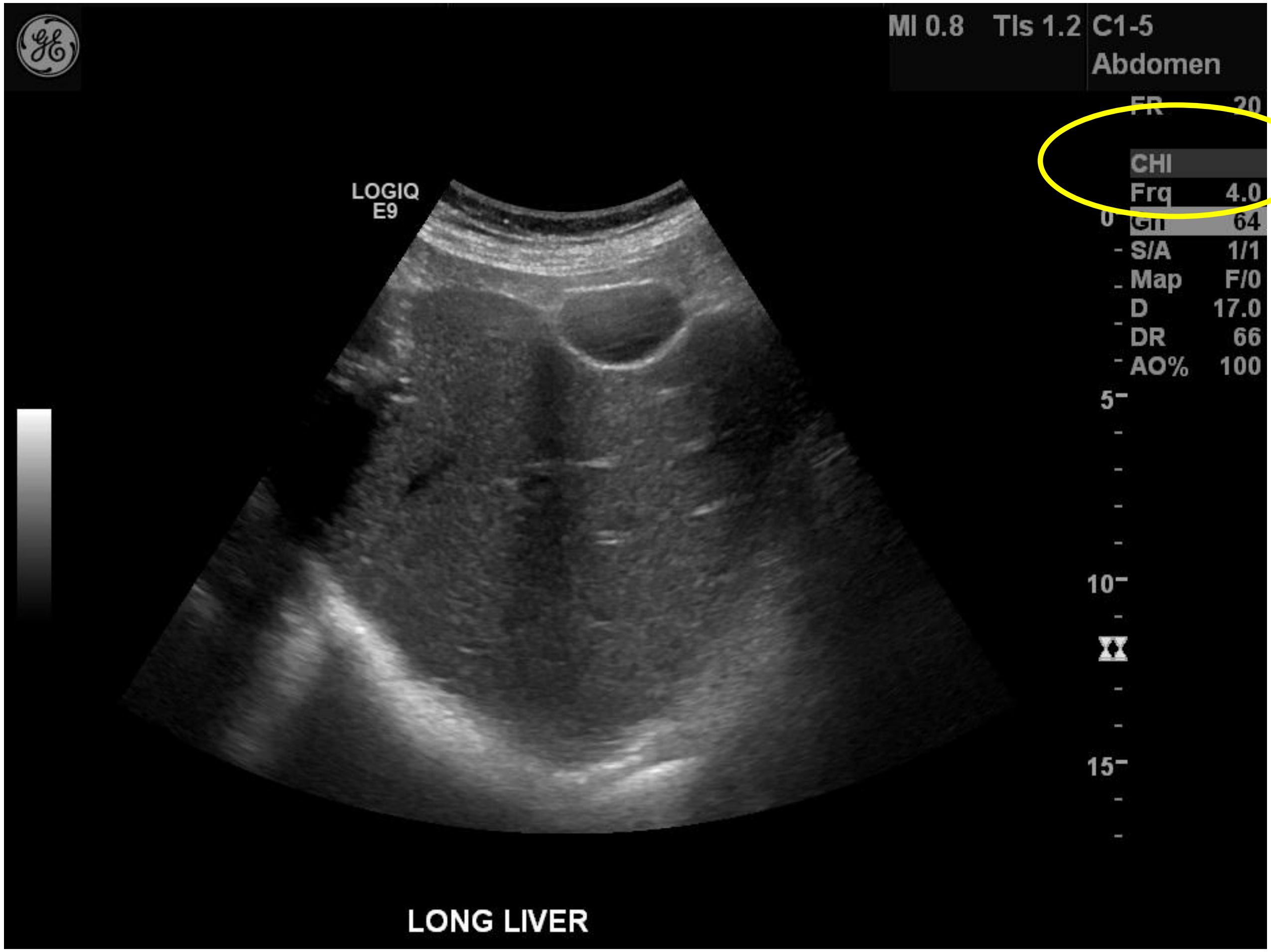
It will at least partially help. Usually do not get the dramatic results as seen in these 2 images.

.

Entrekin RR[1], Porter BA, Sillesen HH, Wong AD, Cooperberg PL. " Real-time spatial compound imaging: application to breast, vascular, and musculoskeletal ultrasound." Semin Ultrasound CT MR. 2001 Feb;22(1):50-64

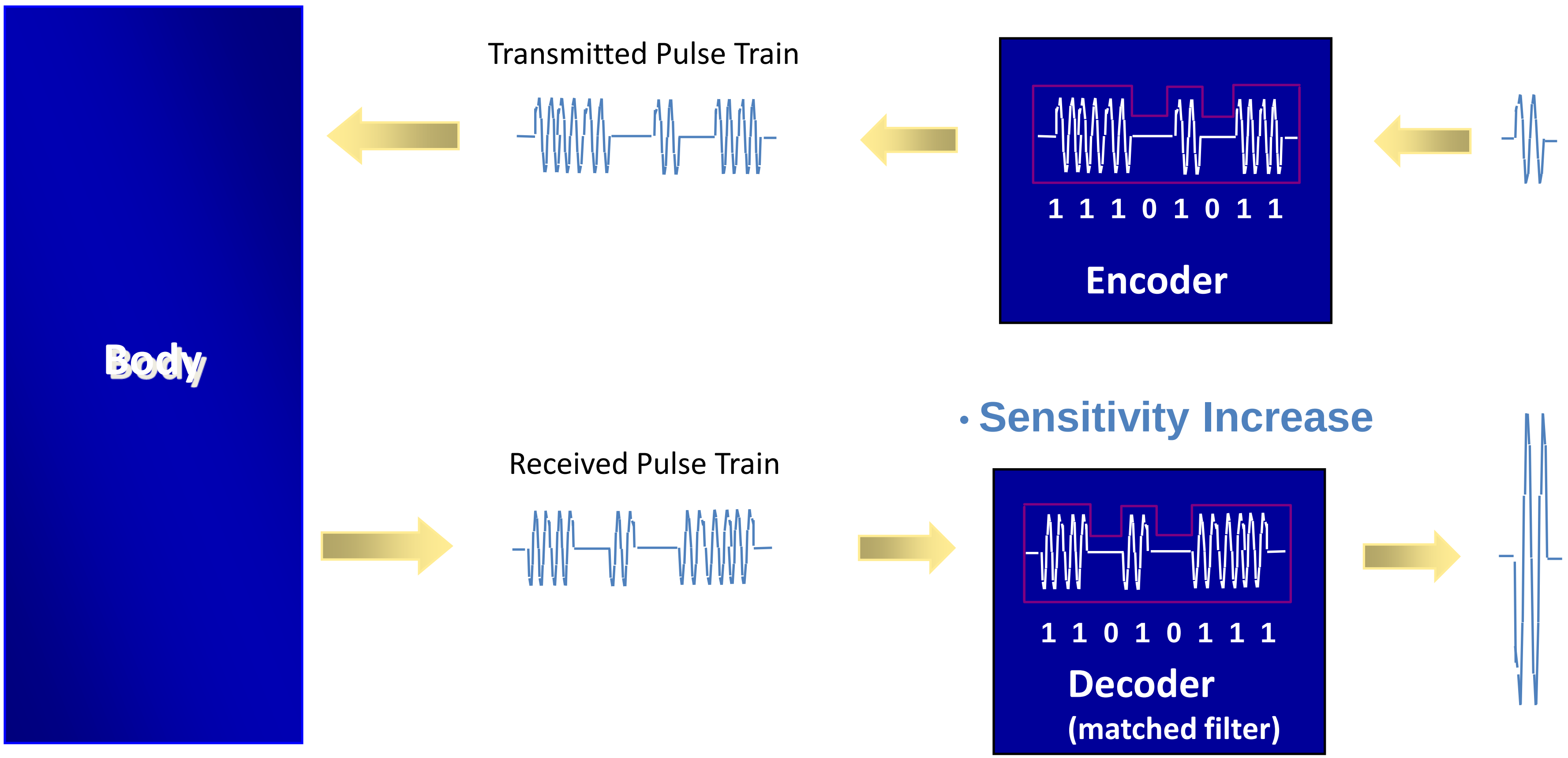
Answer 3: Harmonic Imaging

It will at least partially help. Usually do not get the dramatic results as seen in these 2 images. Typical:



UW Archives

Coded Excitation

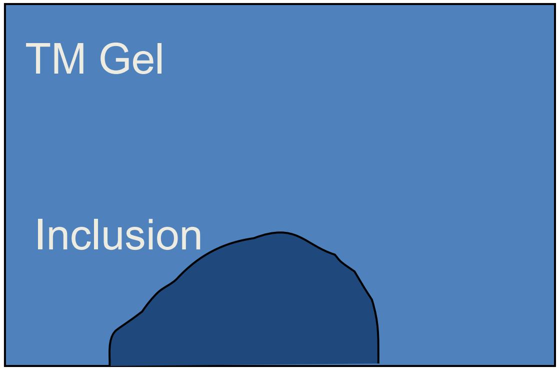


Coded Excitation improves sensitivity without resolution tradeoff

Courtesy of GE Ultrasound

Recap:

This is an image of a tissue-like phantom containing an inclusion. The bottom of the phantom exhibits a discontinuity in the region beneath the inclusion. The inclusion appears to have a _______ than the phantom material.

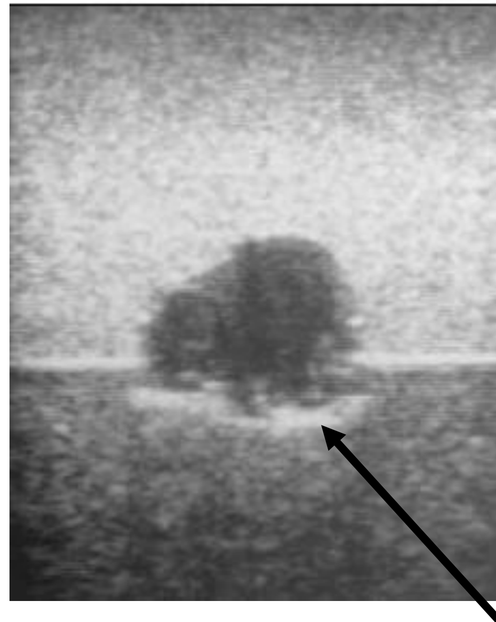


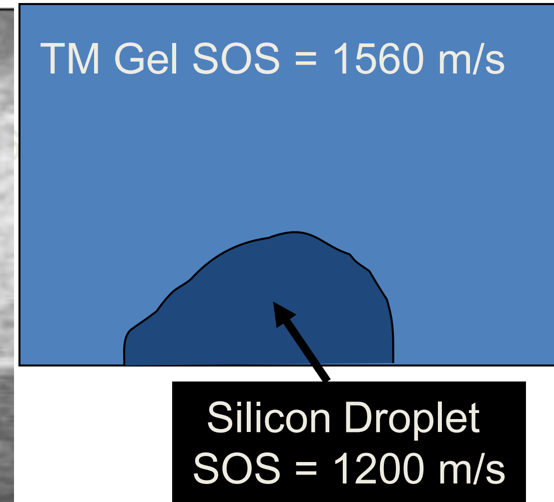
20%	1.	Greater density
20%	2.	Lower attenuation
20%	3.	Higher attenuation
20%	4.	Lower speed of sound
20%	5.	Higher speed of sound

10

Speed of Sound Artifacts

Answer 4, Lower speed of sound, causing the bottom of the phantom to appear displaced downward in the B-mode image.



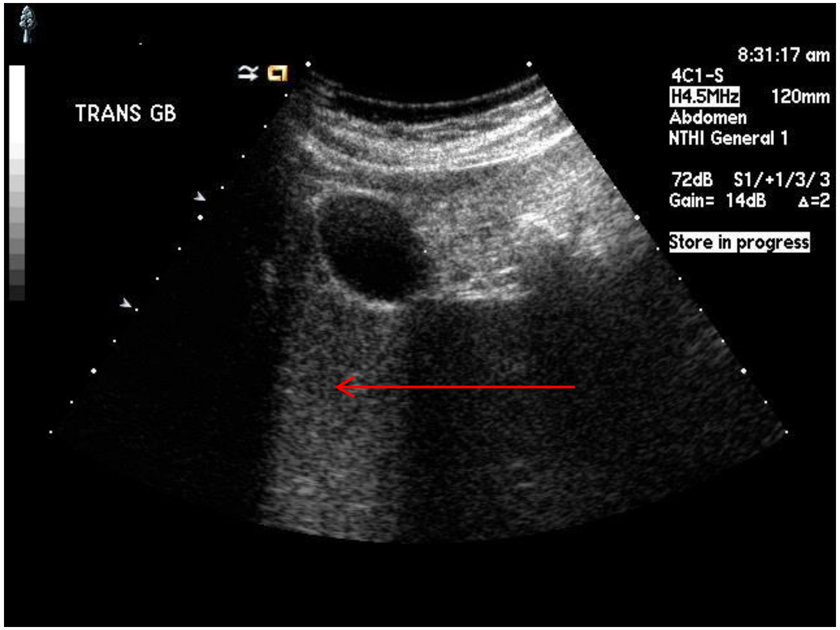


The interface (arrow) should appear straight, but the lower SOS in the silicon results in the interface appearing curved and distorted.

H Lopez, K M Harris "Ultrasound interactions with free silicone in a tissue-mimicking phantom. " J Ultrasound Med 17: 163-170, 1998.

Recap:

Shadowing and enhancement (right) artifacts are most closely related to spatial variations in



20%	1.	Attenuation
20%	2.	Organ shape
20%	3.	Acoustical impedance
20%	4.	Speed of sound
20%	5.	Echogenicity

10

Answer 1

Shadowing and enhancement artifacts are most closely related to spatial variations in attenuation. The gall bladder (GB) is fluid filled, and the attenuation coefficient of bile is lower than that of surrounding tissue. This results in higher amplitude echo signals from distal to the GB.

JA Zagzebski, *Essentials of Ultrasound Physics*, Mosby, St Louis, 1996. Chapter 7.

Recap:

To best visualize shadowing and enhancement features of breast masses, sonographers are advised to avoid use of _________.

20%	1.	Harmonic imaging
20%	2.	Time gain compensation
20%	3.	Speckle reduction
20%	4.	Compound imaging
20%	5.	High ultrasound frequencies

10

Answer: d – compound imaging.

Ref: ACR Breast Ultrasound Accreditation Program Testing Instructions. American College of Radiology, Reston, VA. 12014. Page 2.

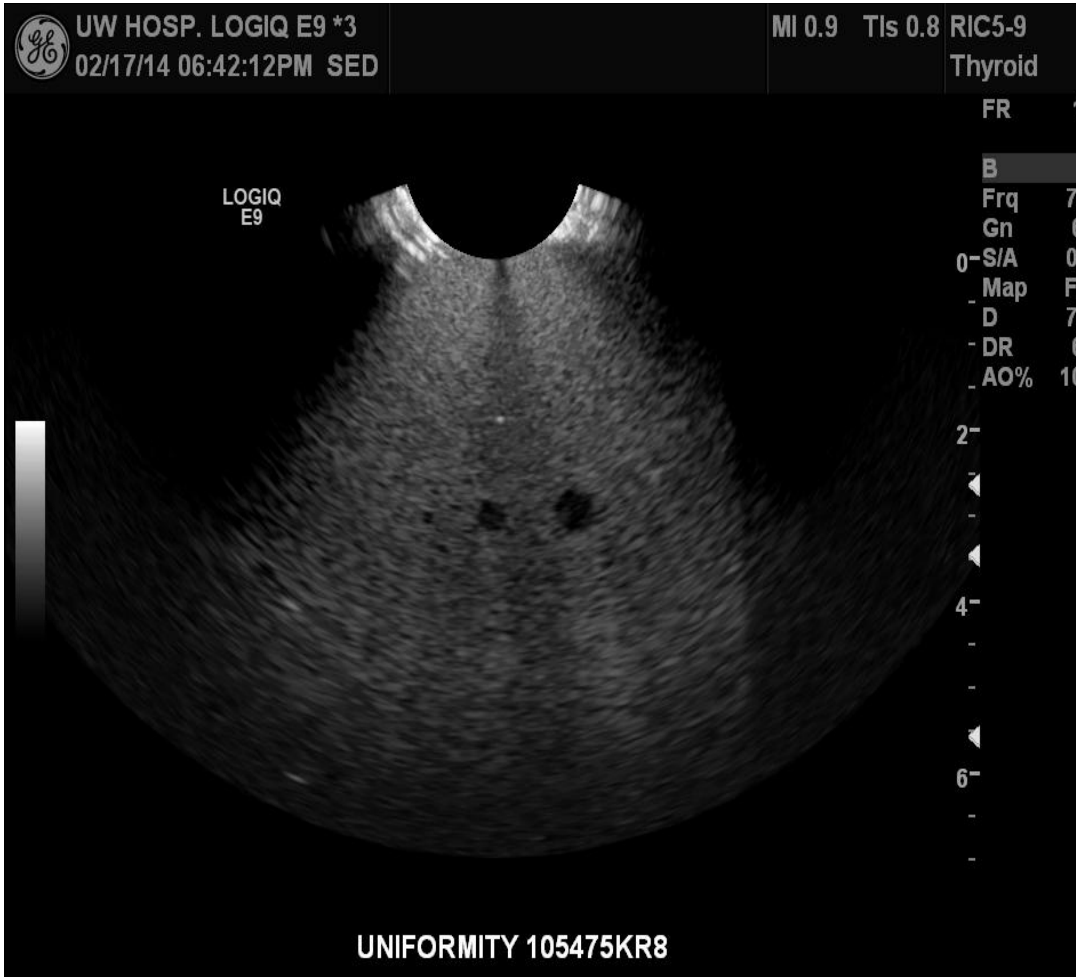
(Supposedly, for small masses that are shallow, it ***might*** hide the shadowing and enhancement artifacts.)

Final Artifact: Difficulties scanning (flat window) phantoms with curvilinear array transducers.

Detecting damaged transducers is the most important QA task.

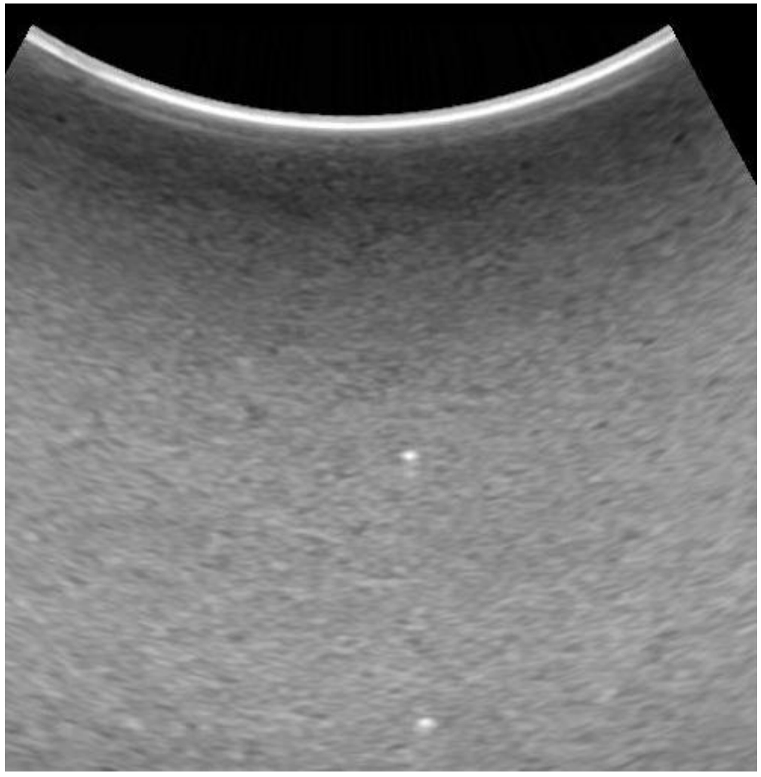
Can only make contact with part of curved probes

Solution 1, with gel coupling, rock transducer



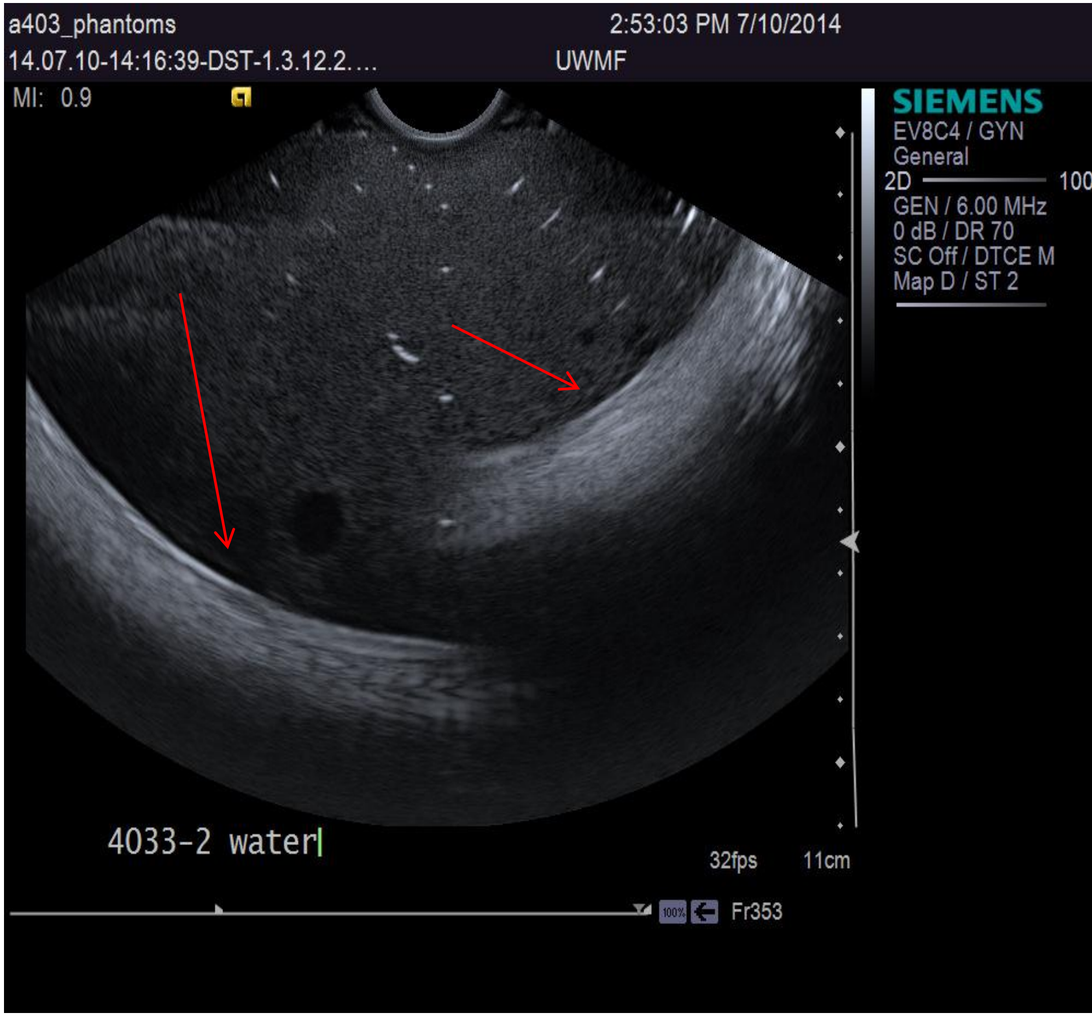
Artifacts when scanning (flat window) phantoms with curvilinear array transducers using water dam.

Solution 2: use a phantom with a curved window



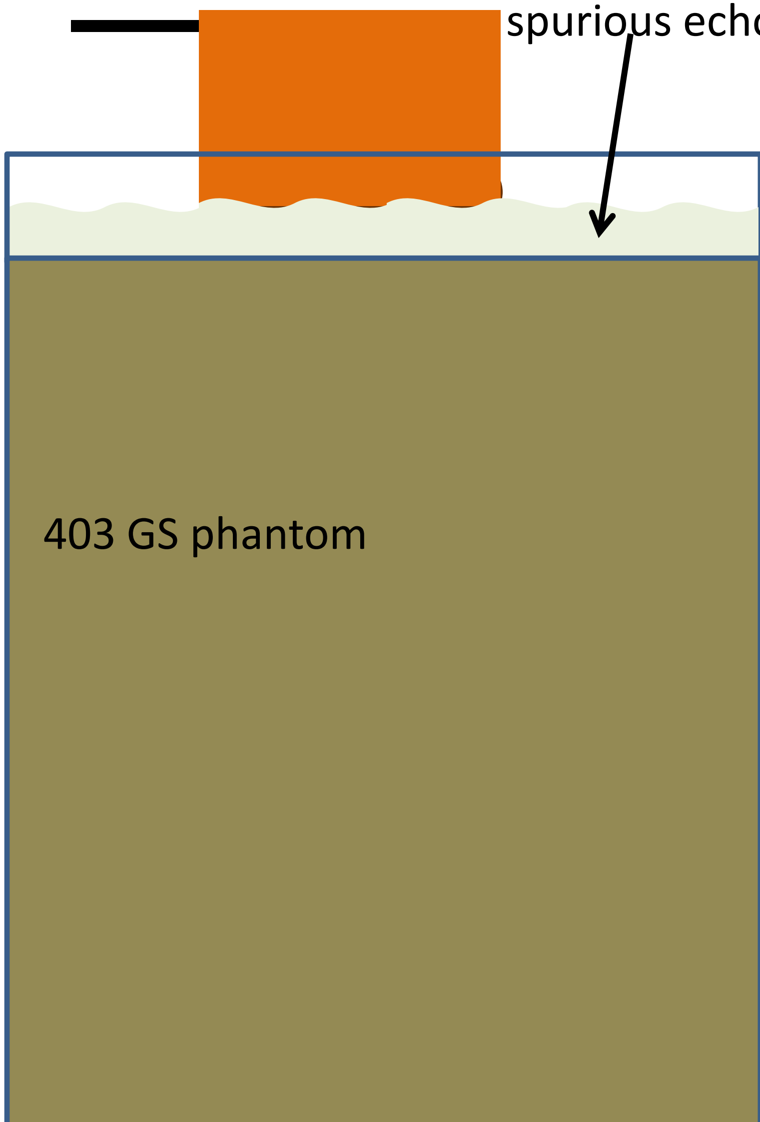
Artifacts when scanning (flat window) phantoms with curvilinear array transducers using water dam.

Solution 2: use a phantom with a curved window
(but most of us have flat window phantoms)
Solution 3: use water in the water dam (bad artifacts!)

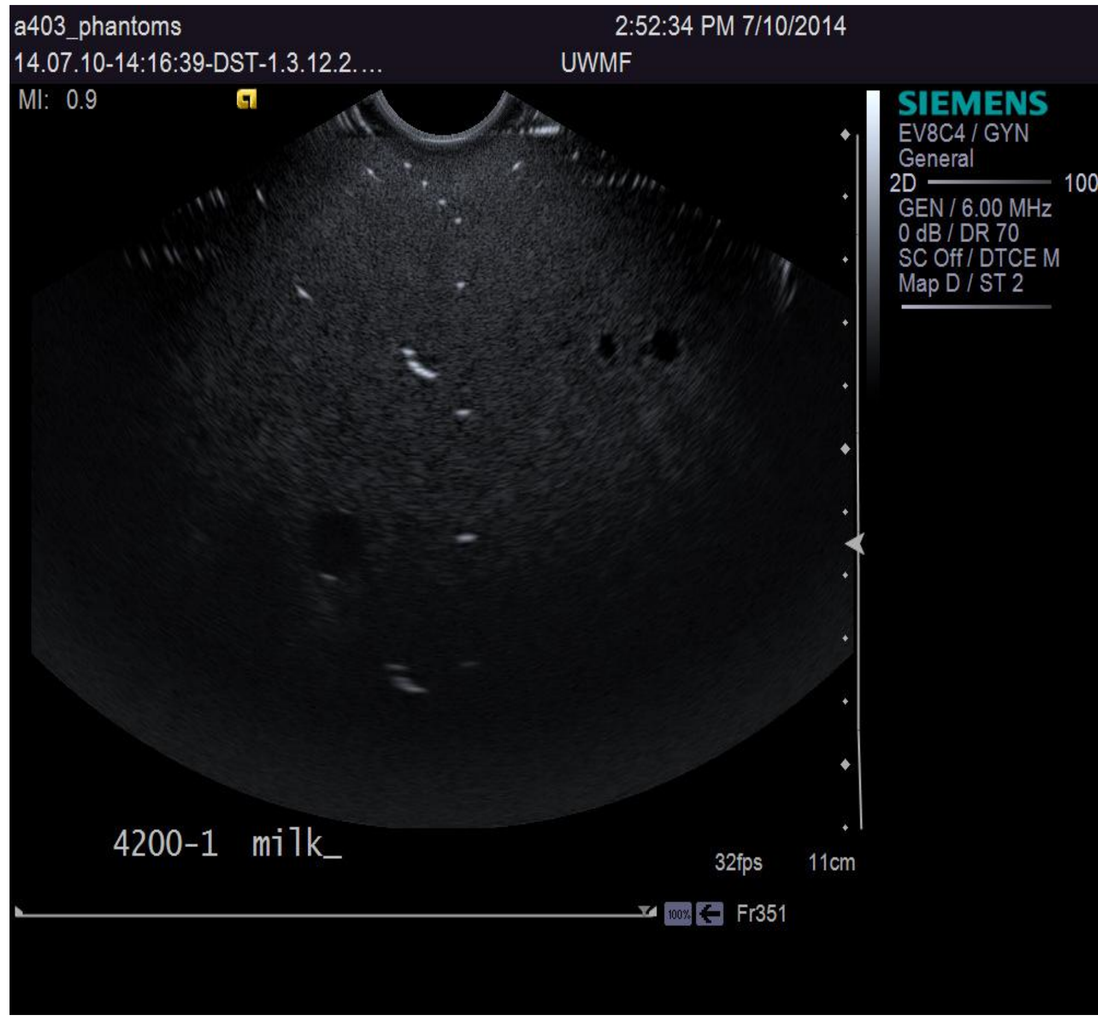


Artifacts are totally removed using whole milk.

Grade A Homogenized milk;
(SOS ~1525-30m/s; sufficient attenuation to cut down spurious echoes)



Solution 4: use milk in the water dam!!!



Thanks, from America's Dairyland, and the Land of Lincoln

Solution 1: rock the transducer
Solution 2: use a phantom with a curved window
Solution 2: use water in the dam (bad artifacts with curved probes
Solution 4: use milk in the water dam