ARTIFACTS

Artifacts

- Reverberation Artifact
- Multipath Artifact
- Comet Tail or Ring Down Artifact
- Shadow or Shadowing Artifact
- Enhancement Artifact
- Lateral and Axial Resolution Artifact
- Specular Reflector Artifact
- Refraction or Ghost Image Artifact
- Mirror Image Artifact
- Velocity Error or Range Error Artifact
- Lobe Artifacts
- Slice Thickness Artifact

Artifacts

"6 Assumptions of Imaging Systems"

- *Errors* in imaging occur when these assumptions are not true
  1. **Sound travels in a straight line**
  2. **Sound travels directly to a reflector and back**
  3. **Sound travels in soft tissue at exactly 1540 m/s**
  4. **Reflections arise only from structures positioned in the beam's main axis**
  5. **The imaging plane is very thin**
  6. **The strength of a reflection is related to the characteristics of the tissue creating the reflection**

Artifacts

- Are common and may be the source of misinterpretation or confusion
- Artifacts may appear in some views but may not be present in others
  - True echo anatomy will always be visible
- Try to explain based on physical principles ("applied physics")
- Altering the imaging parameters may be very helpful
- Unfortunately, artifacts are called different names by different authors

Velocity of Sound

Medium	Velocity (m/sec)
"Average" soft tissue	1540
Muscle	1580
Fat	1459
Water	1480
Air	330
Bone	4080

The Dopeler Effect

(dōp'lər ĭ-fĕkt')

1. The tendency of stupid ideas to seem smarter when they come at you rapidly.

2. The tendency of ideas to seem smarter immediately before you say them, and thus branding you an idiot.

Attenuation

POTENTIAL CAUSES

- **Dosing (*high concentration*)**
- **Administration (*infusion rate too fast*)**

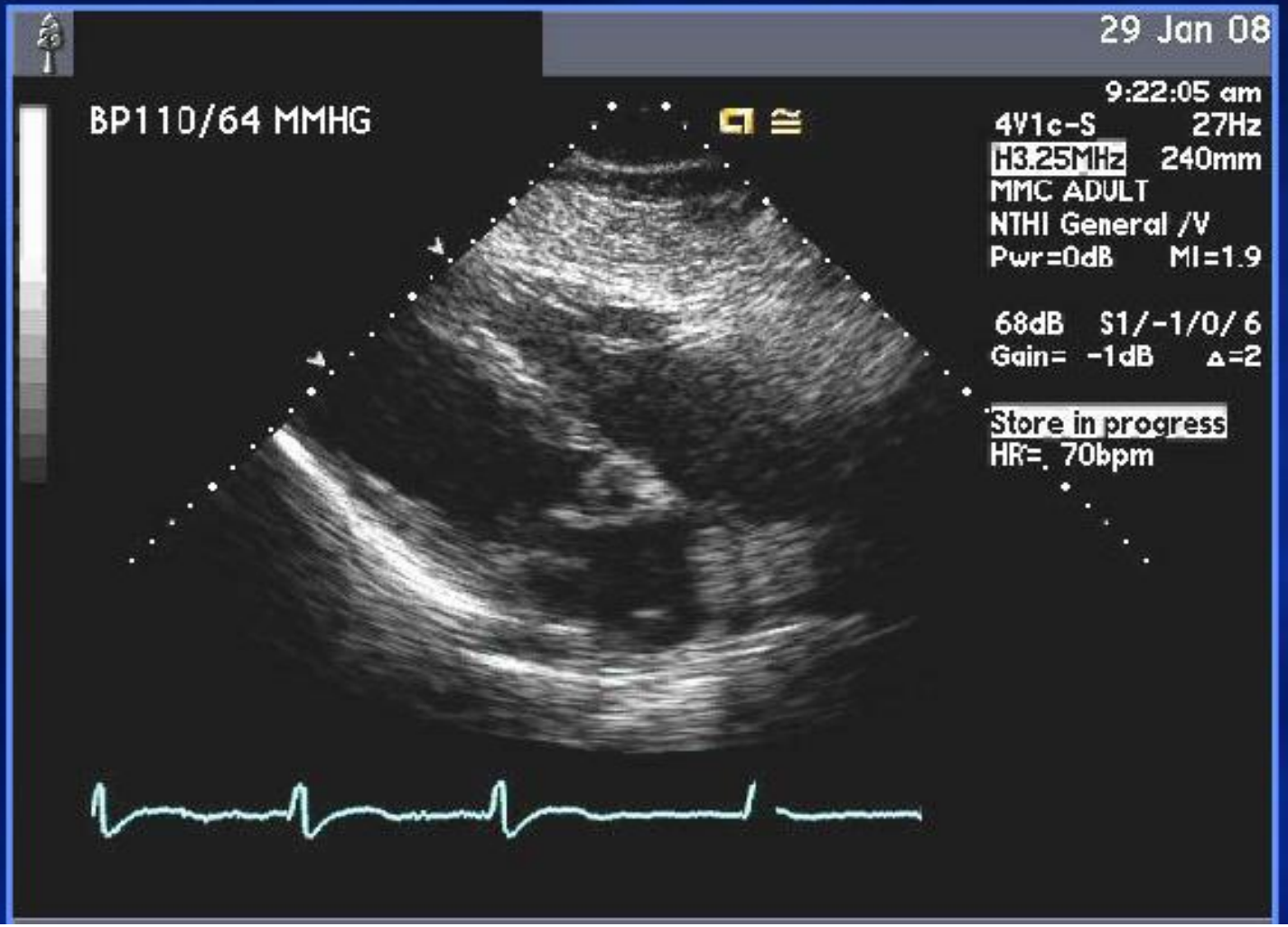
Approximate Attenuation Coefficient Values

Material	*Coefficient (dB/cm MHz)*
Water	0.002
Fat	0.66
Soft tissue (average)	0.9
Muscle (average)	2.0
Air	12.0
Bone	20.0
Lung	40.0

Reverberation Artifact

- Reverberation artifacts appear as multiple, equally spaced echoes caused by the sound wave bouncing between 2 strong reflectors positioned parallel to the ultrasound beam's main axis
- Type of "multipath reflection artifact"

Reverberation Artifact



Reverberation Artifact

- Appears in multiples
- Located parallel to the sound beam
- Resemble the rungs of a ladder

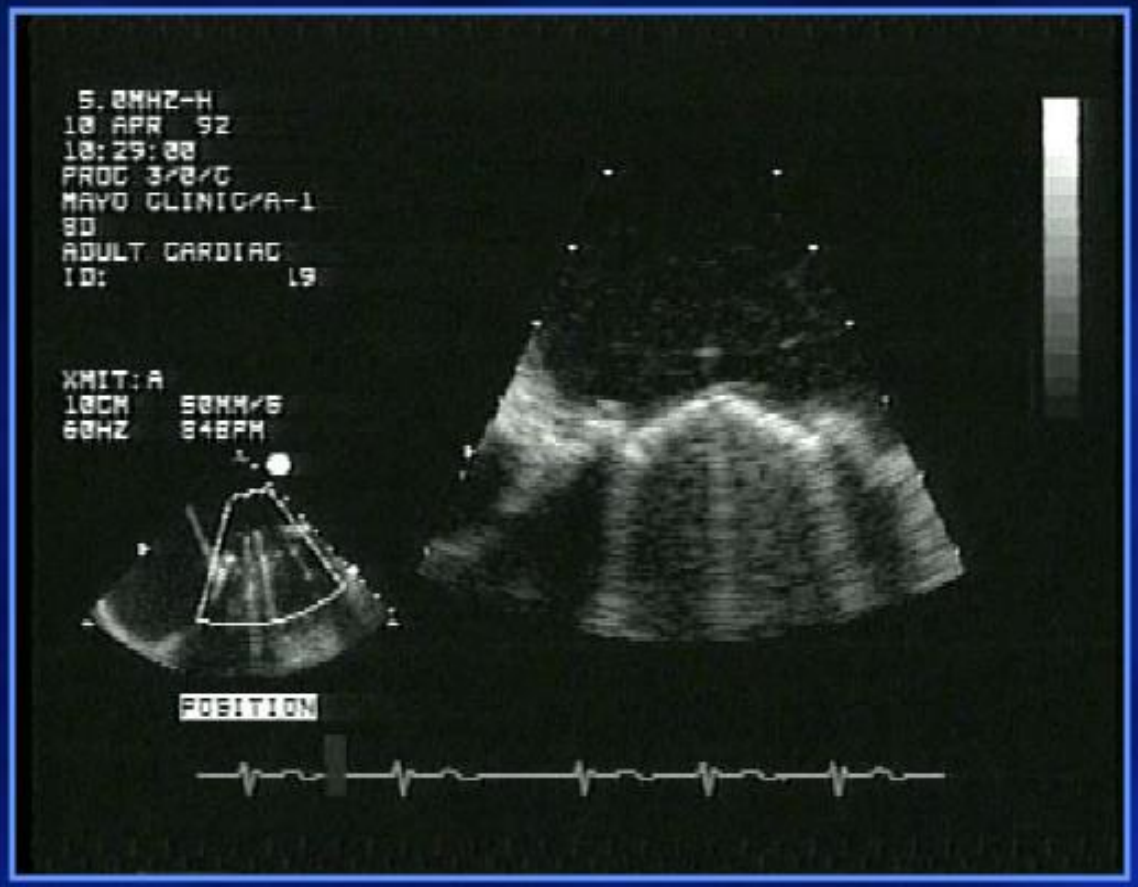
Reverberation Artifact

Slight angulation change: artifact resolved

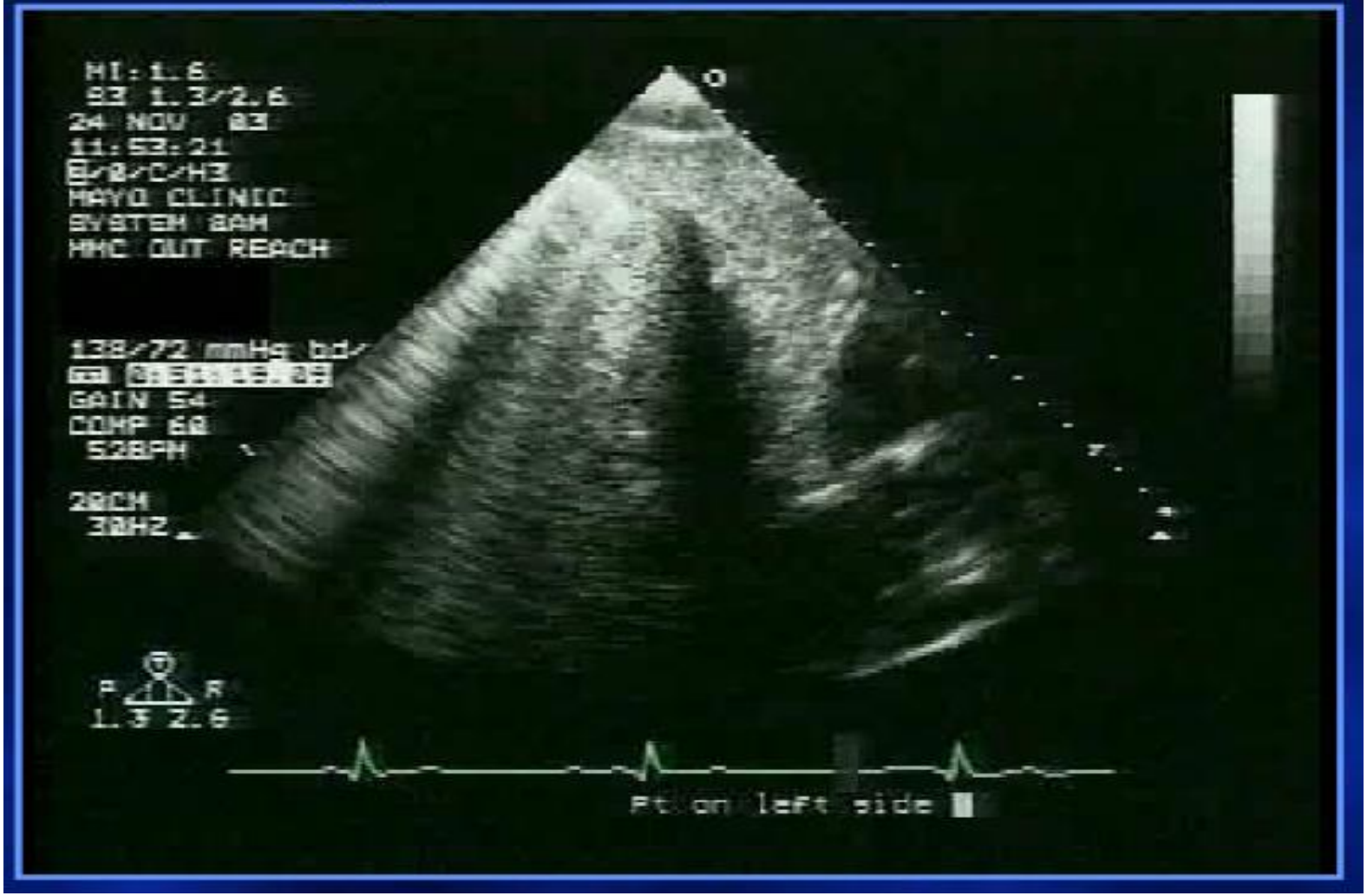
Comet Tail Artifact

- Type of reverberation artifact
  - But no spaces between reverberation echoes
  - Closely spaced reverberations merge
- Also known as “ring down artifact”
- Appears as a single hyperechoic line
- Located parallel to the sound beam’s main axis

Comet Tail Artifact



Ring Down Artifact



Shadow Artifact "Shadowing"

- Hypoechoic or anechoic region extending downward from a structure causing strong attenuation
- Prevents the display of true anatomic structures
- Not related to the speed of sound in a medium

Shadowing:

the reduction in the strength of returning echoes caused by intervening structures of high attenuation

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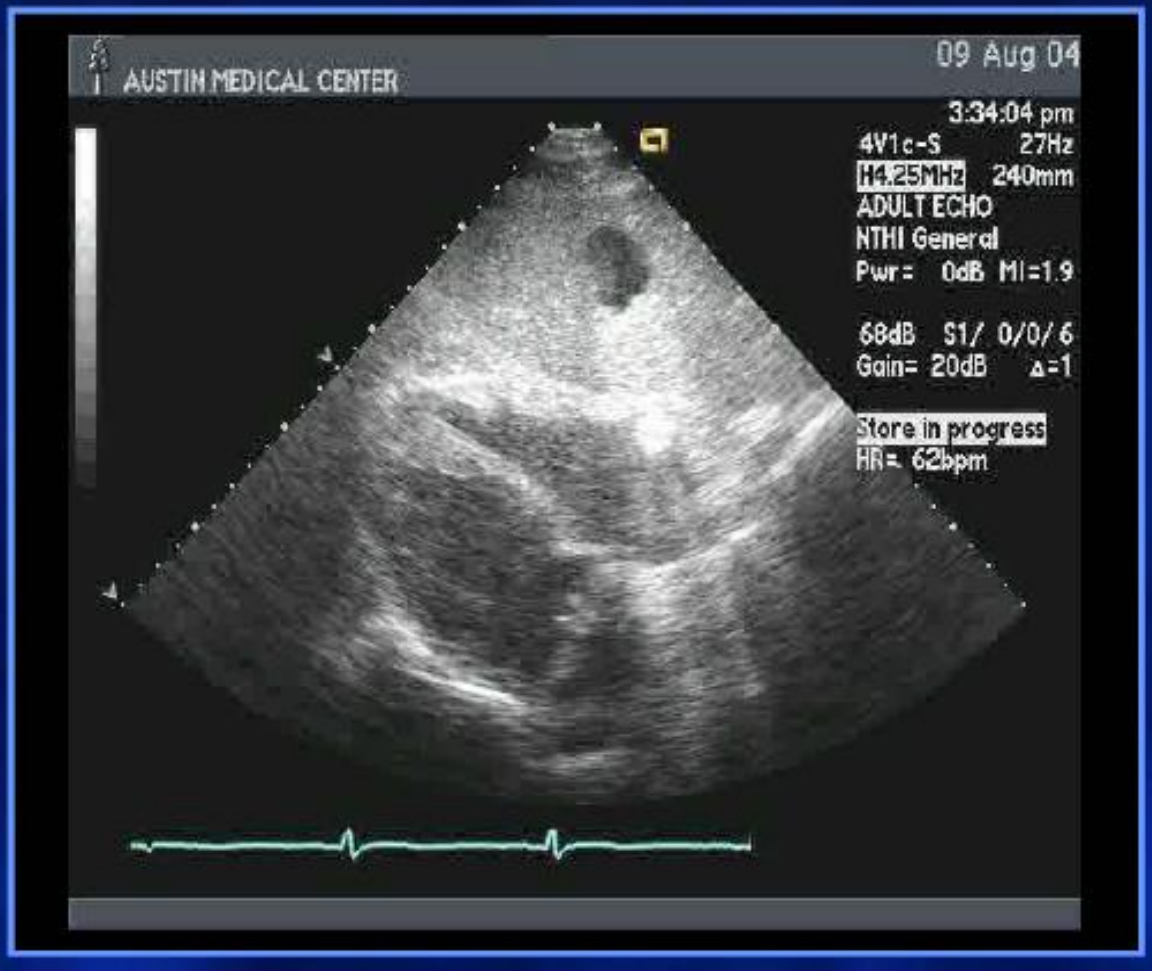
Enhancement Artifact

- Hyperechoic region located beneath tissues with abnormally low attenuation
- Result of too little attenuation
- Opposite of shadowing

Image downloaded from Emergencyultrasoundteaching.com

Shadowing and Enhancement



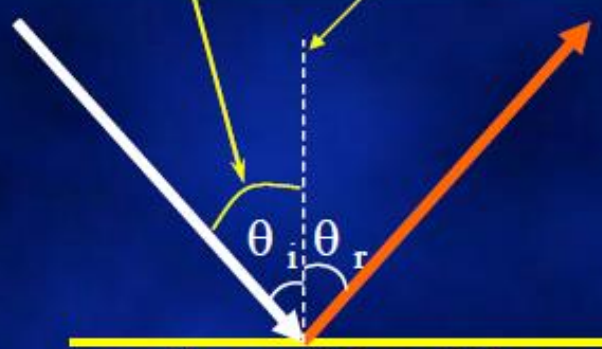
Edge Shadow Artifact

- Hypoechoic region extending along the edge of a curved reflector
- The sound beam refracts at the edge of a curved reflector
- The beam simultaneously diverges, resulting in a drop in intensity

Reflection

- Sound wave strikes specular interface
- Sound wave rebounds off interface

Note that the angle of incidence (θ_i) is the beam direction compared to the line we drew for normal incidence



Normal incidence = 90° relative to interface

BUT NOTE:
$\theta_i = 0°$

Angle of incidence = angle of reflection

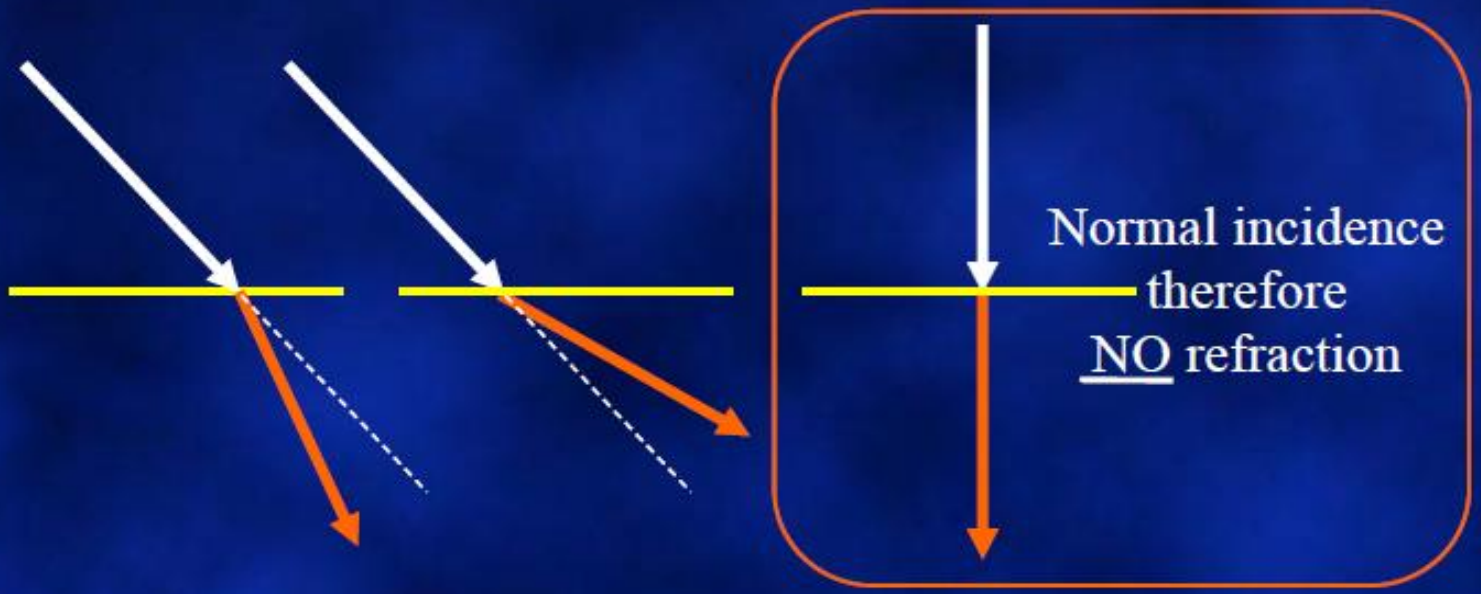
Angle of incidence = angle of reflection

Refraction

- Determined by the media
- Requires oblique incidence
- Requires difference in the velocity of sound in the media

Refraction

- Sound wave strikes interface
- Sound wave bends and continues



Refraction

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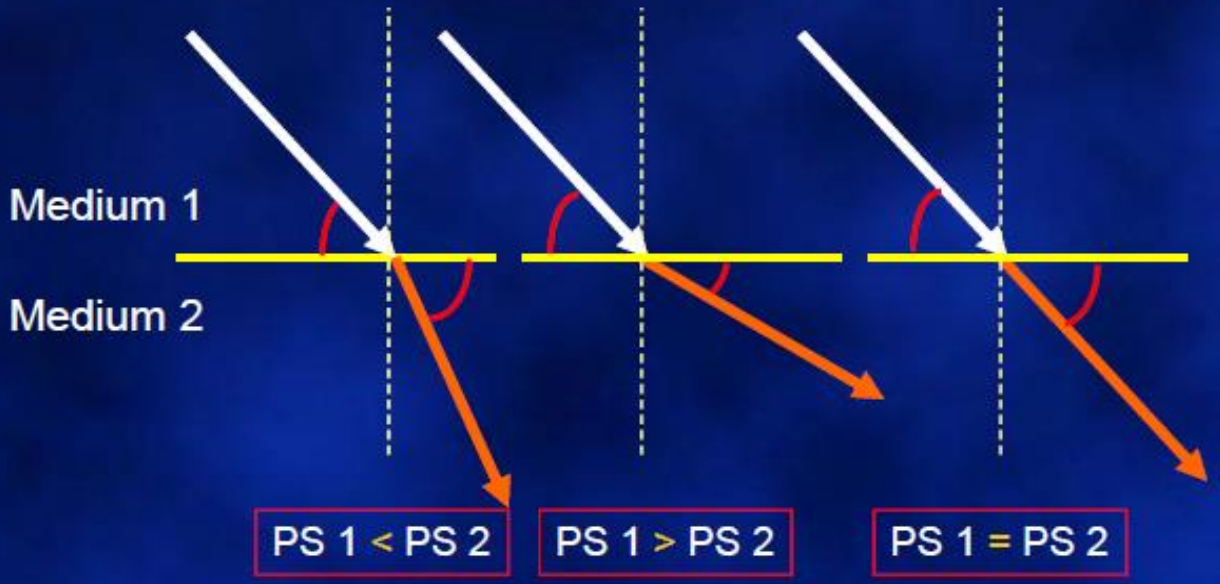

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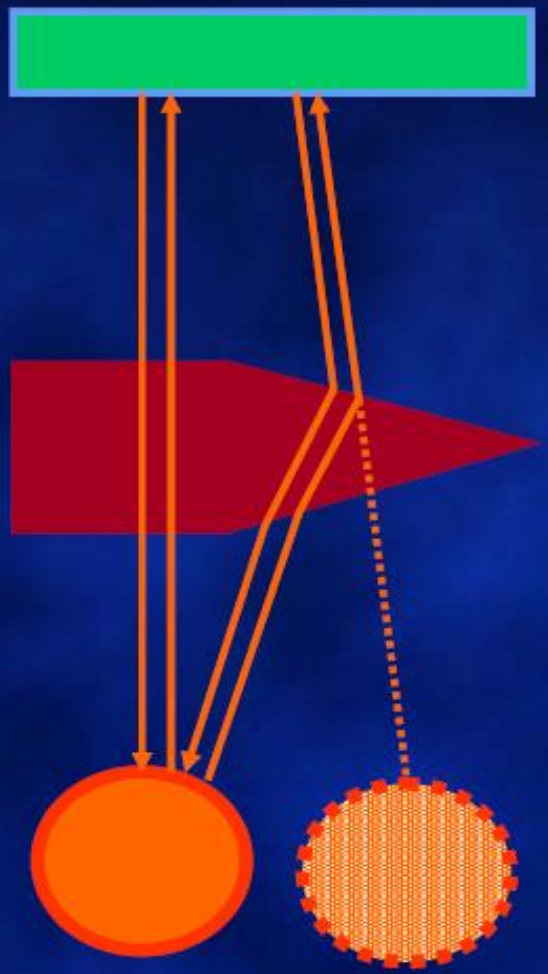
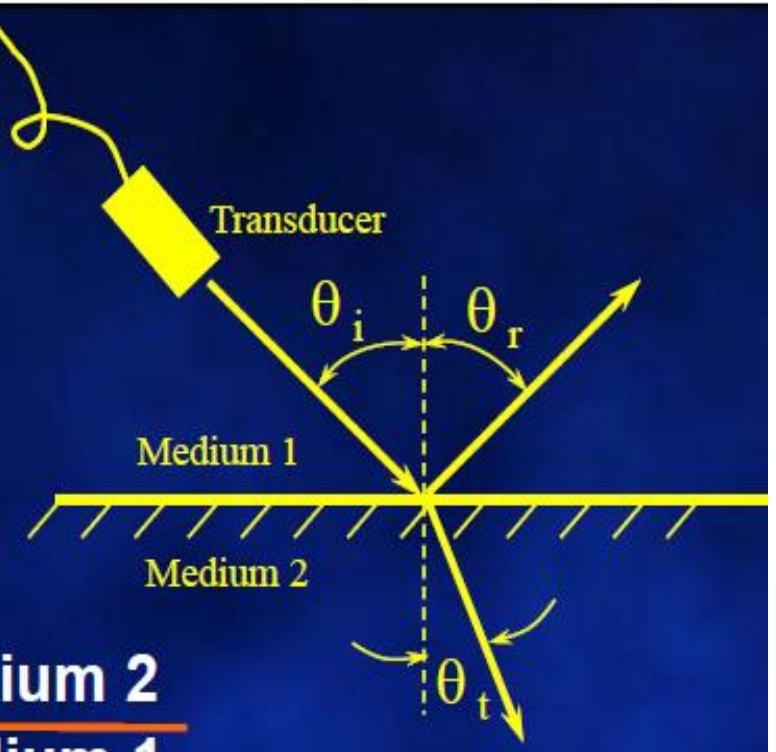
PS = propagation speed

Refraction Artifact

- Ultrasound beam may be bent as it passes through tissues with different sound velocities
- Ultrasound system assumes straight line of flight for all signals
- Violations of assumption produces artifacts
  - Object is placed as if it occurred along intended scan line



Refraction of Sound

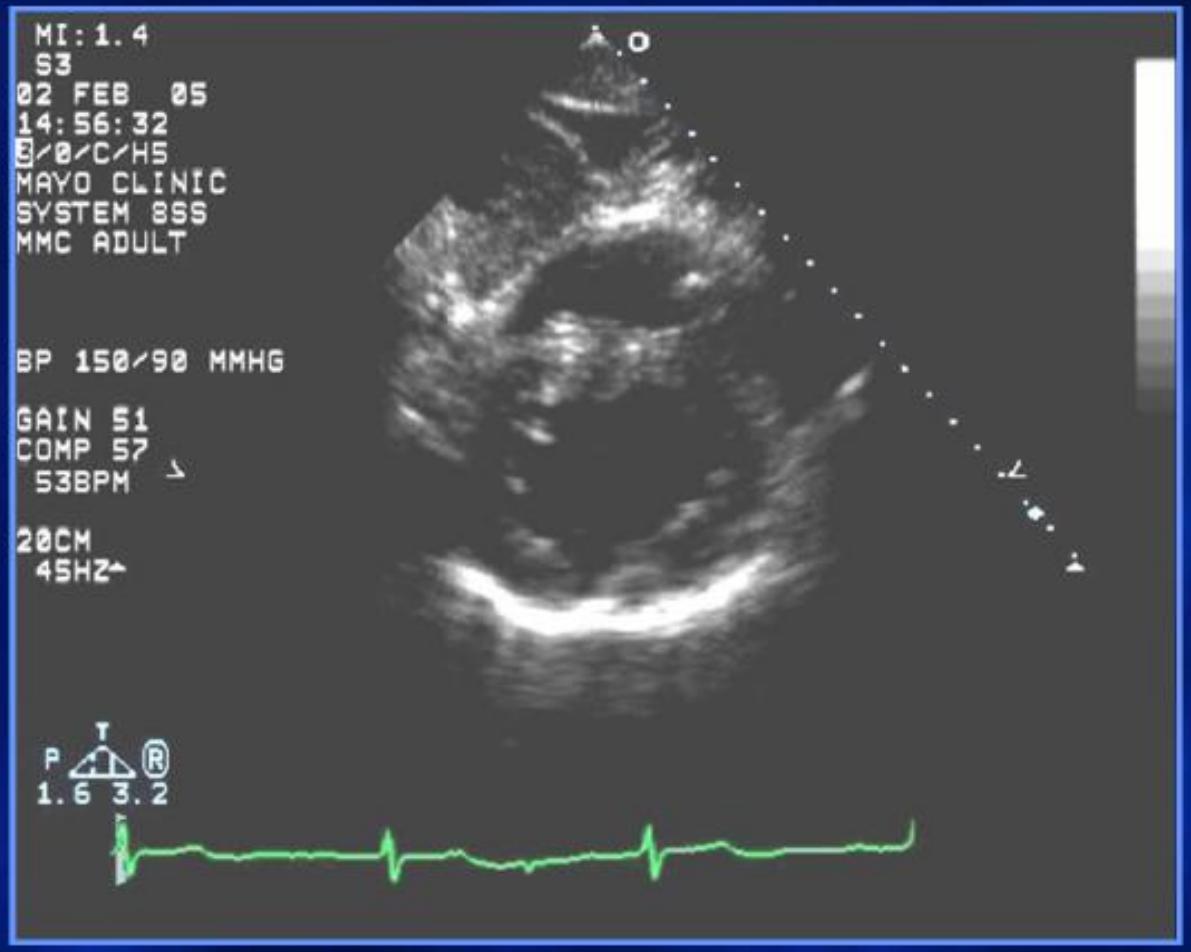


Snell's Law, the law of refraction

$$\frac{\text{sine } \theta_t}{\text{sine } \theta_i} = \frac{\text{Speed Medium 2}}{\text{Speed Medium 1}}$$

- Requires oblique incidence
- Requires differences in propagation speeds

Refraction or Ghost Image Artifact



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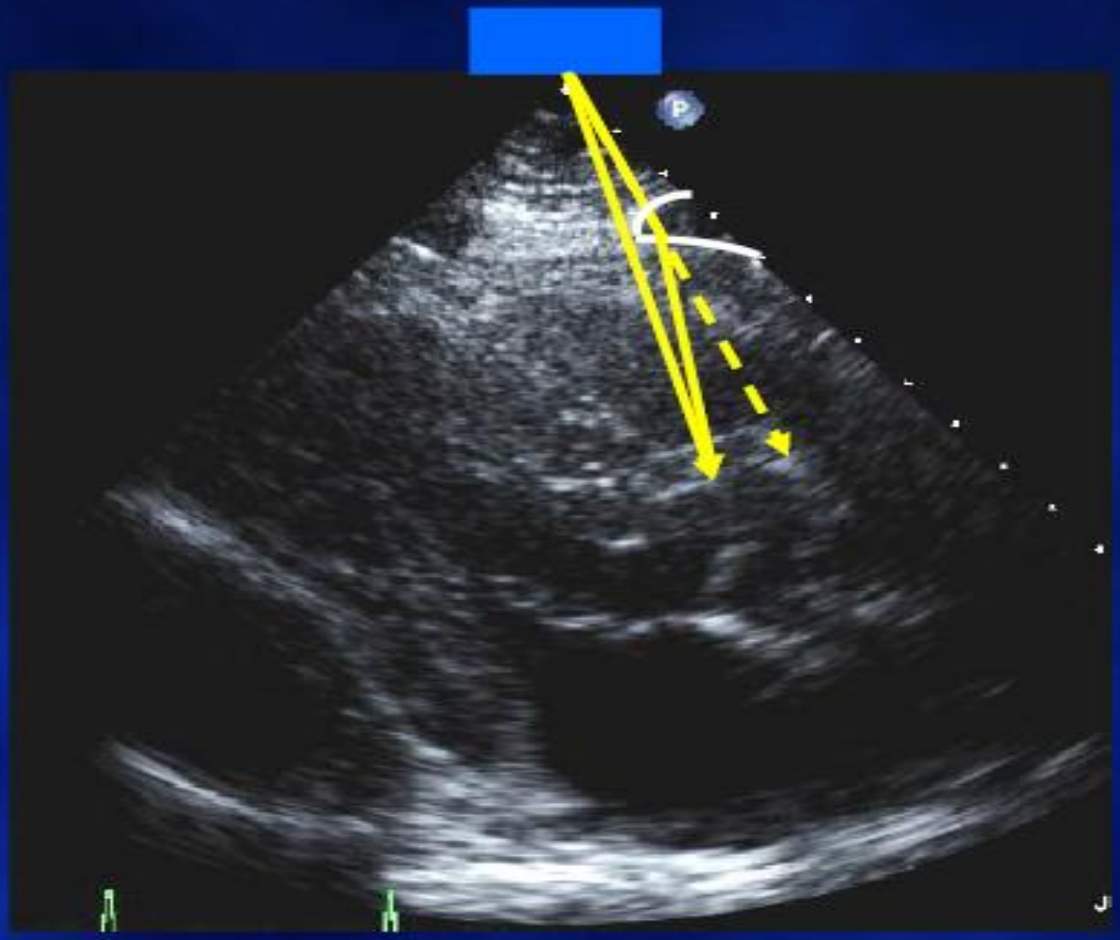
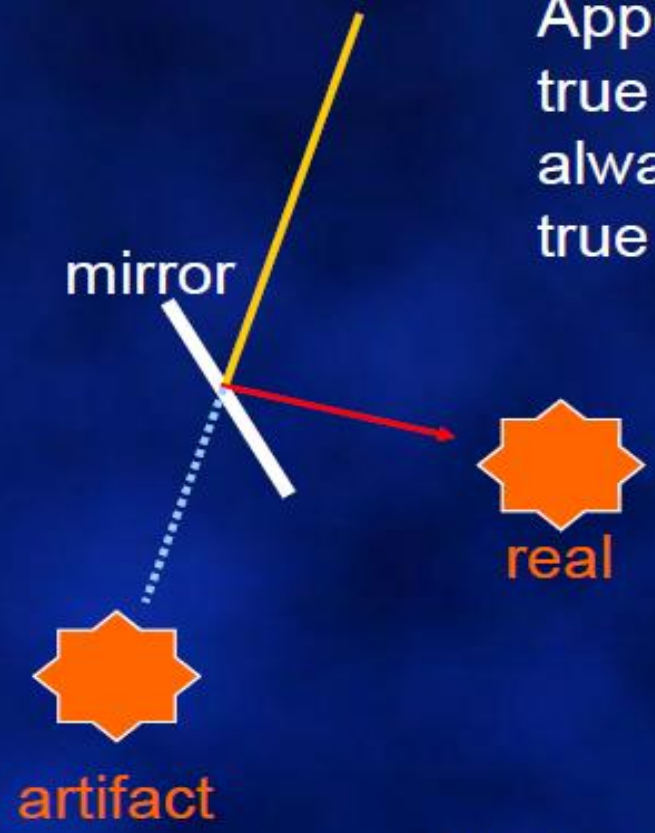
Refraction or Ghost Image Artifact

Ghost Image Artifact



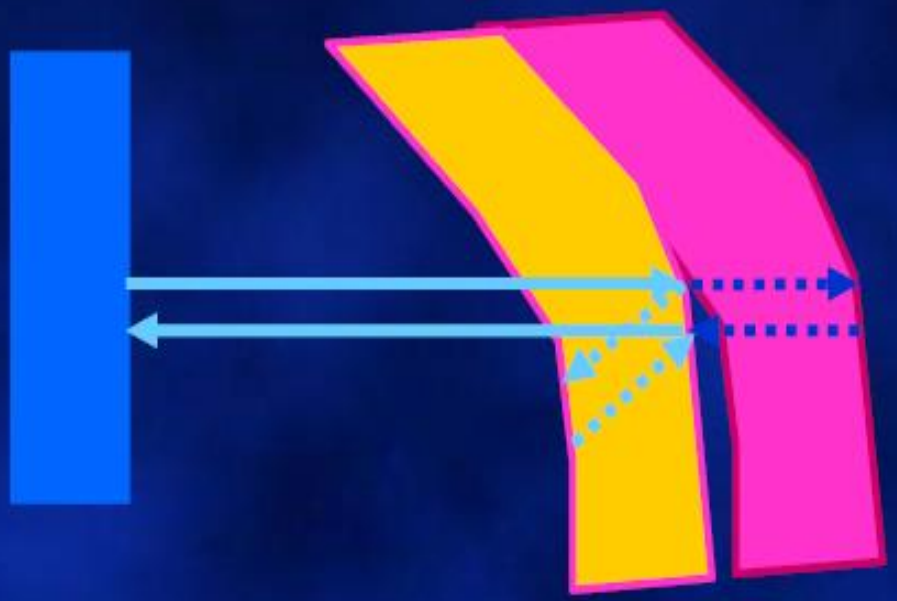
Mirror Image Artifact



Appears as a replica of a true reflector (the artifact is always deeper than the true anatomy)

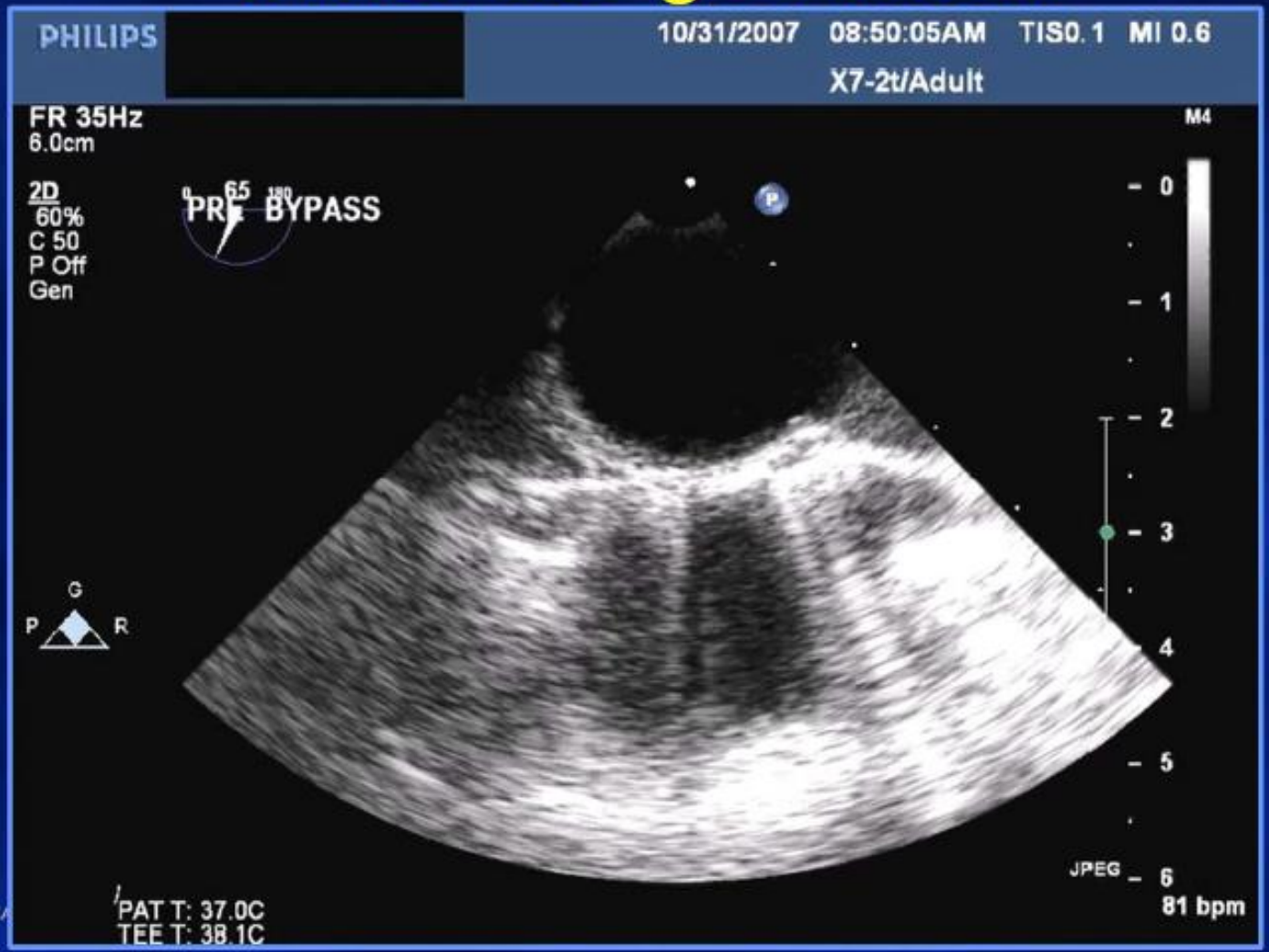
Adapted from Edelman SK Understanding Ultrasound Physics 3rd Edition

Multipath Duplication: Mirror Image Artifact

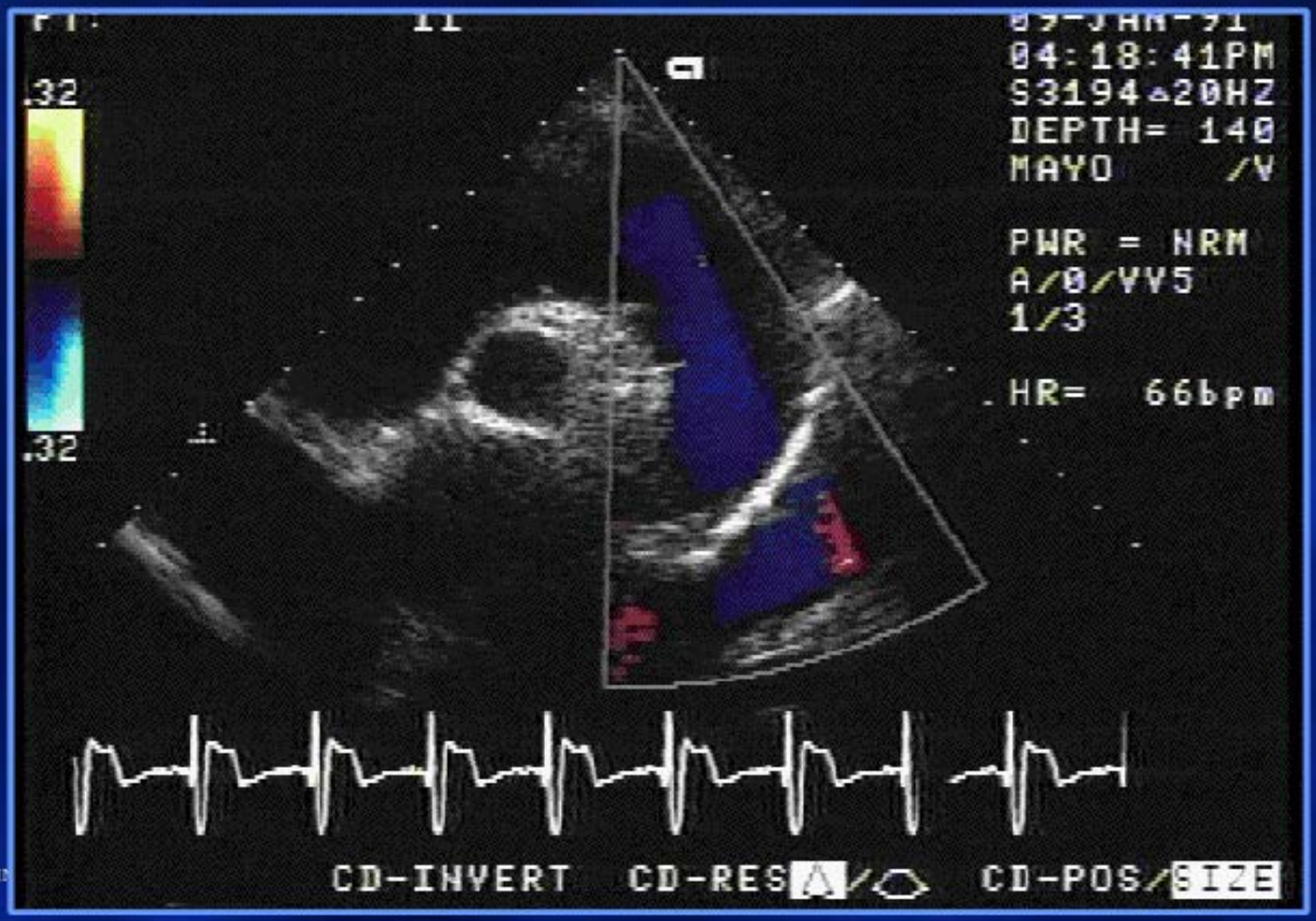


Mirror Image Artifact

Mirror Image Artifact



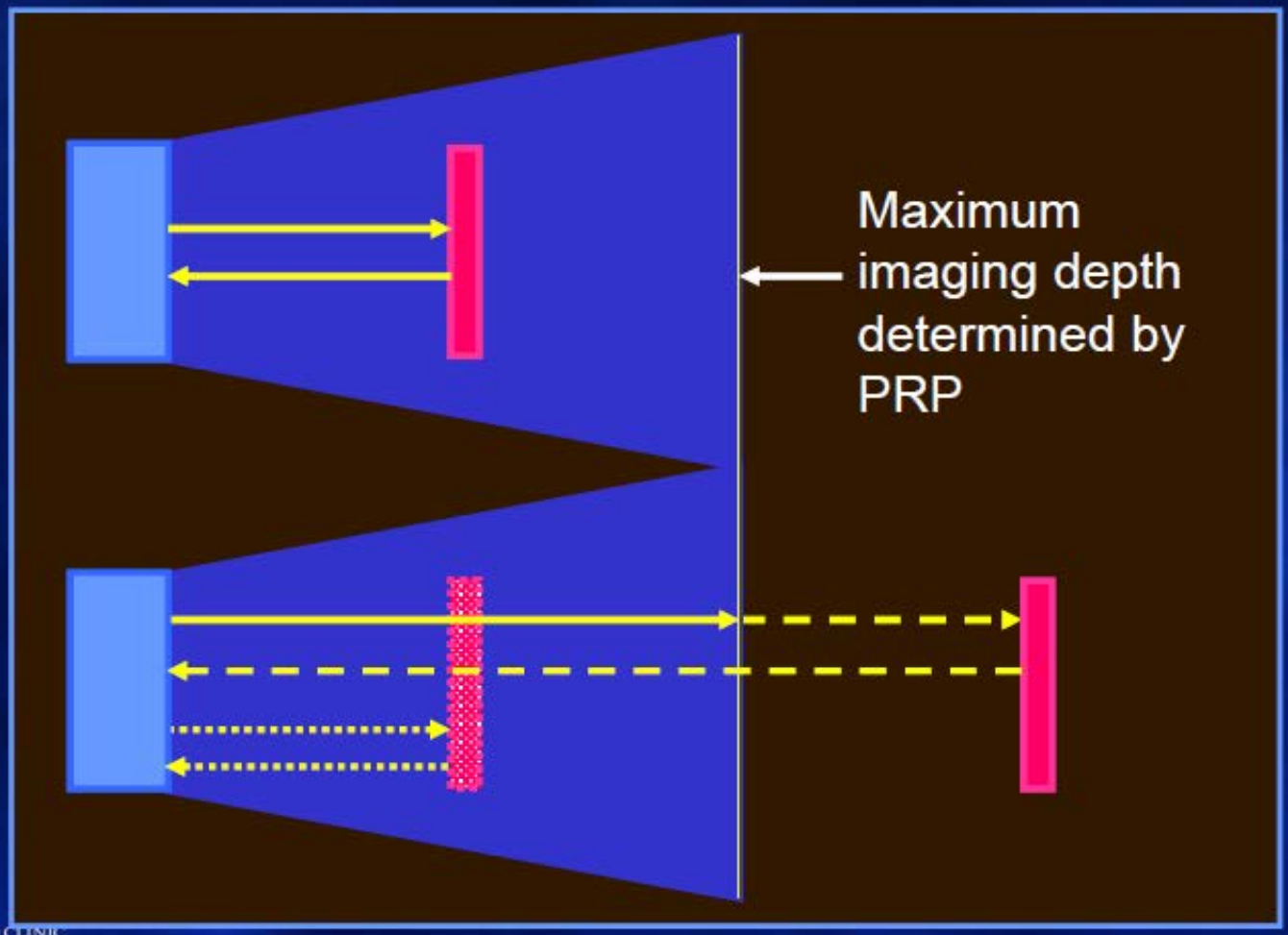
Mirror Image Artifact



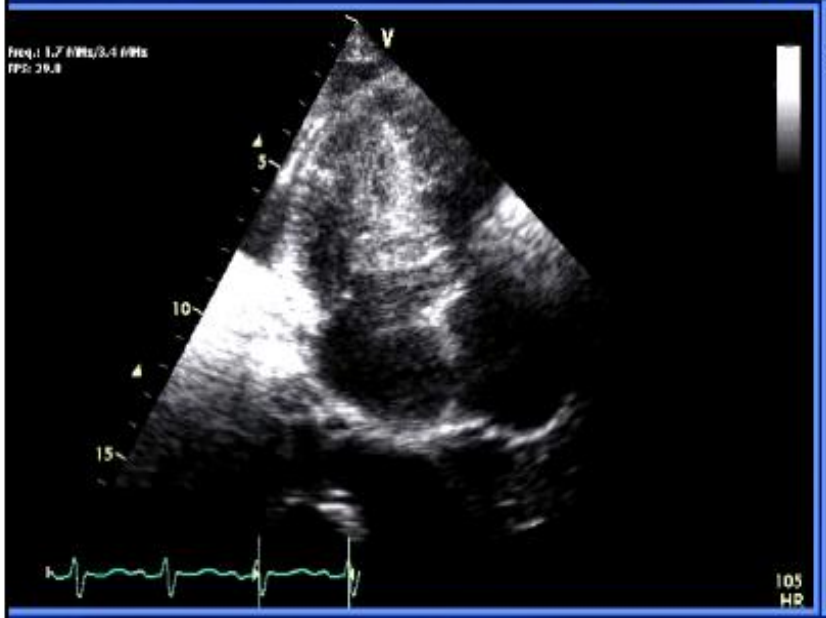
Range Ambiguity Artifact

- Pulse repetition period determines maximum depth imaged
- Machine assumes all returning signals are result of most recent pulse
- Can lead to artifact if this assumption violated
- Caused by a structure distal to the image, so it won't move with cardiac structures
- Often appears to 'float' over the real cardiac structures

Range Ambiguity Artifact



Changing Imaging Depth Resolved the Range Ambiguity Artifact



Scatter

Scatter increases with frequency,

ie. high frequency = increased scatter

- Sound wave strikes small or rough object
- Sound wave scatters off in many directions
- Backscatter → portion that returns to transducer
- Rayleigh scatter (Very small) → sound reflects in all directions

Interaction of US and tissue

- What the sound wave does depends upon characteristics of what the sound wave hits

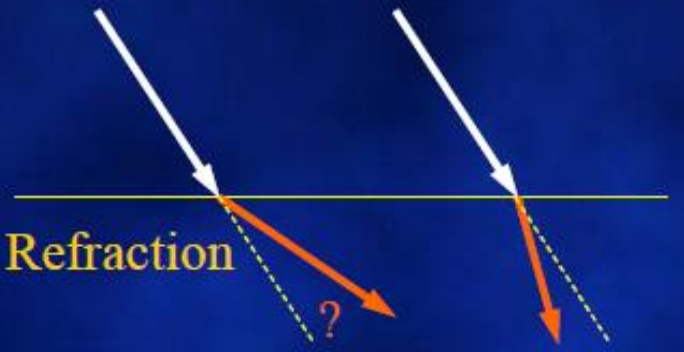
- Boundaries/interfaces/reflectors
  - Specular - LARGE (> λ) and smooth
    - Chamber walls (A mirror is an ideal specular reflector)
    - Diaphragm
    - Vessels
  - Non-specular - small or rough
    - Tissue
    - RBCs

Specular reflectors are stronger reflectors

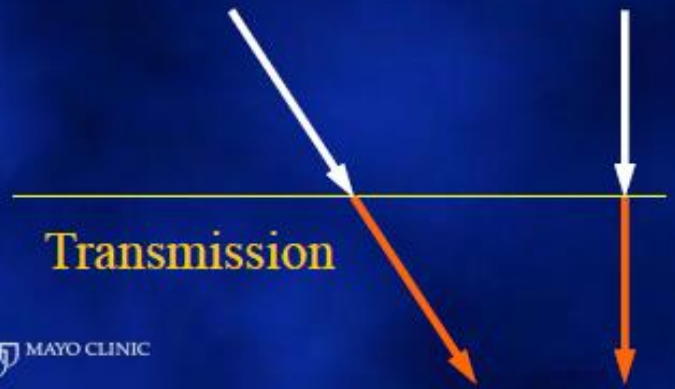
Scatterers are weak reflectors

Sound's options upon encountering an object

Reflection



Refraction



Transmission

Scatter

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Conclusions

- Artifacts are common and may be the source of misinterpretation or confusion
- Artifacts may appear in some views but may not be present in others
  - True echo anatomy will always be visible
- Try to explain based on physical principles ("applied physics")
- Altering the imaging parameters may be very helpful