The Basic Principles of Ophthalmic Ultrasound Devices

ORBIS International

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Basics of Ultrasonography

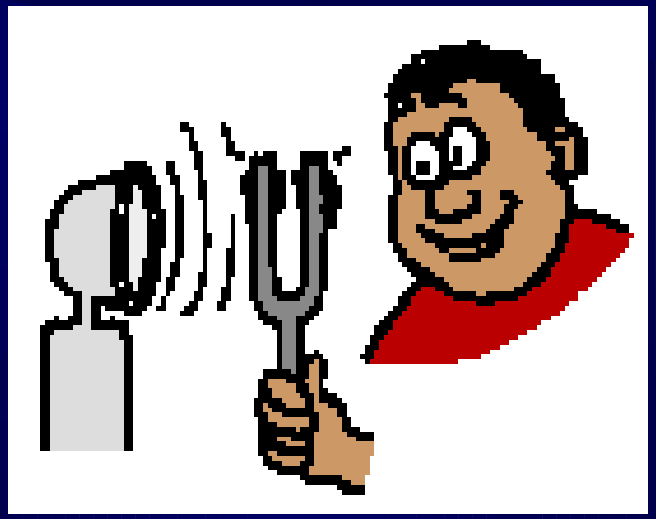
Ultrasound Waves are acoustic waves that have frequencies greater than **20 KHz**.

The audible range to humans is 60 Hz to 20 KHz.

Basics of Ultrasonography

Sound Waves

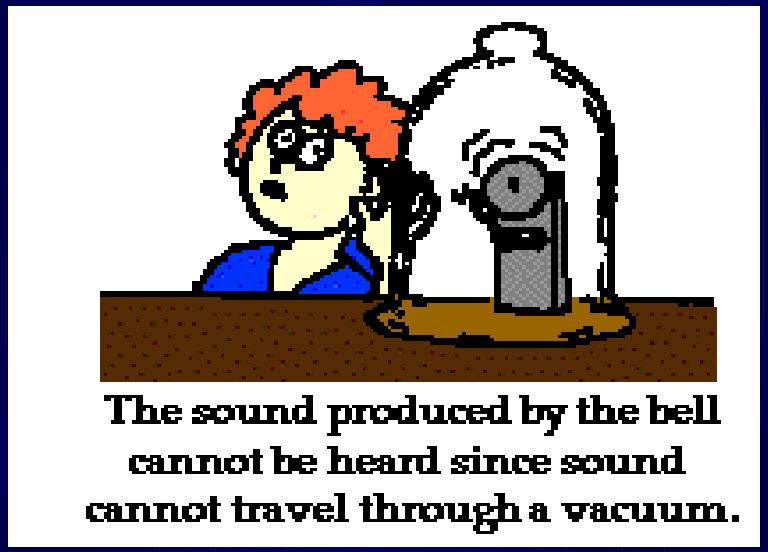
Sound is a **mechanical wave** (pressure wave) which is created by a **vibrating object**.



Basics of Ultrasonography

Sound Waves

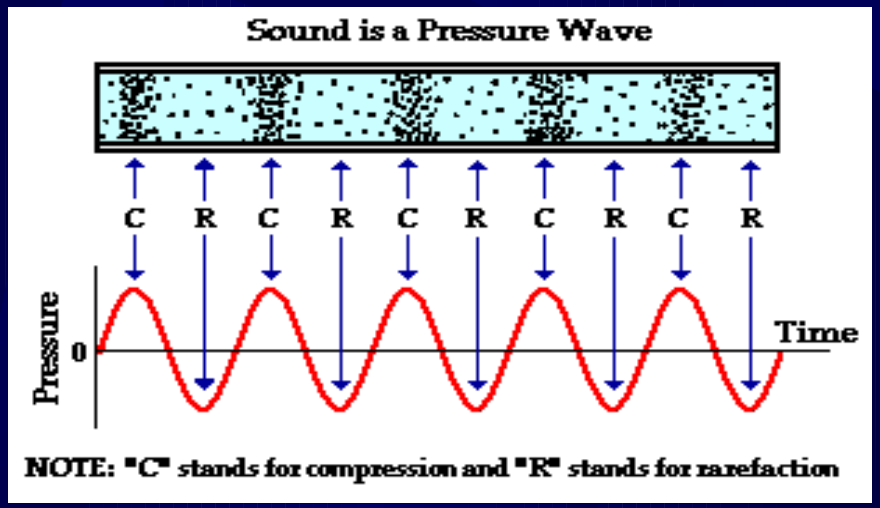
- The energy of vibration is transported through the **media** (for example: air, water, human tissue…).



Basics of Ultrasonography

Sound Waves

- Sound is propagated as a **longitudinal wave**.
- **Longitudinal wave** consists of alternating compressions and rarefactions of molecules as the wave passes through a medium.



Basics of Ultrasonography

Sound Waves

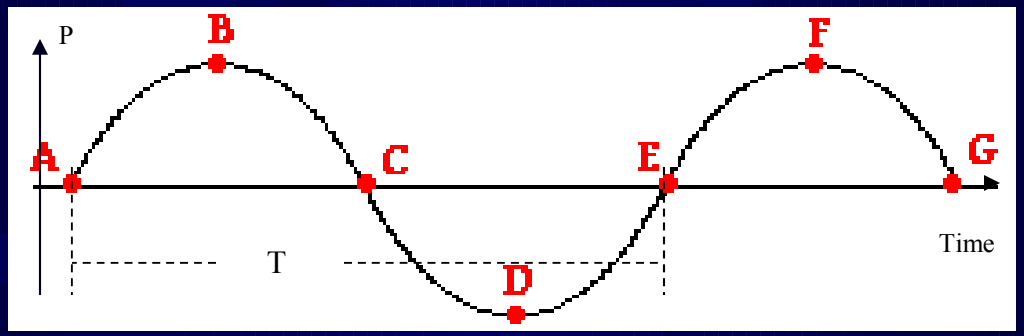
The sound wave is characterized by:

velocity (m/s): the speed of propagation of the wave.

frequency (Hz): number of complete cycles per unit of time.

wavelength (m): the distance traveled by one cycle.

Velocity = Wavelength x Frequency



Basics of Ultrasonography

Sound Waves

Velocity: the speed of sound propagation

Material	Velocity (m/s)
Air	330
Water	1480
Blood	1500
Aqueous and vitreous	1532
Soft tissue	1540
Clear lens	1640
Bone	3500

Density of Material Increasing

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Reflection of Sound Wave

Reflected sound waves are produced by **acoustic interfaces** that have different **acoustic impedances**.

Acoustic Interface:

Acoustic Impedance of a Medium:

is created at the junction of two media (for example: air and rock, soft-tissue and bone…).

is a measure of the efficiency with which sound propagates in the material.

Acoustic Impedance = Sound Velocity x Medium Density

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Acoustic Impedance for Different Materials

Material	Acoustic Impedance (10^6 Rayls)
Air	0.0004
Fat	1.38
Water	1.48
Liver	1.65
Muscle	1.70
Bone	7.80

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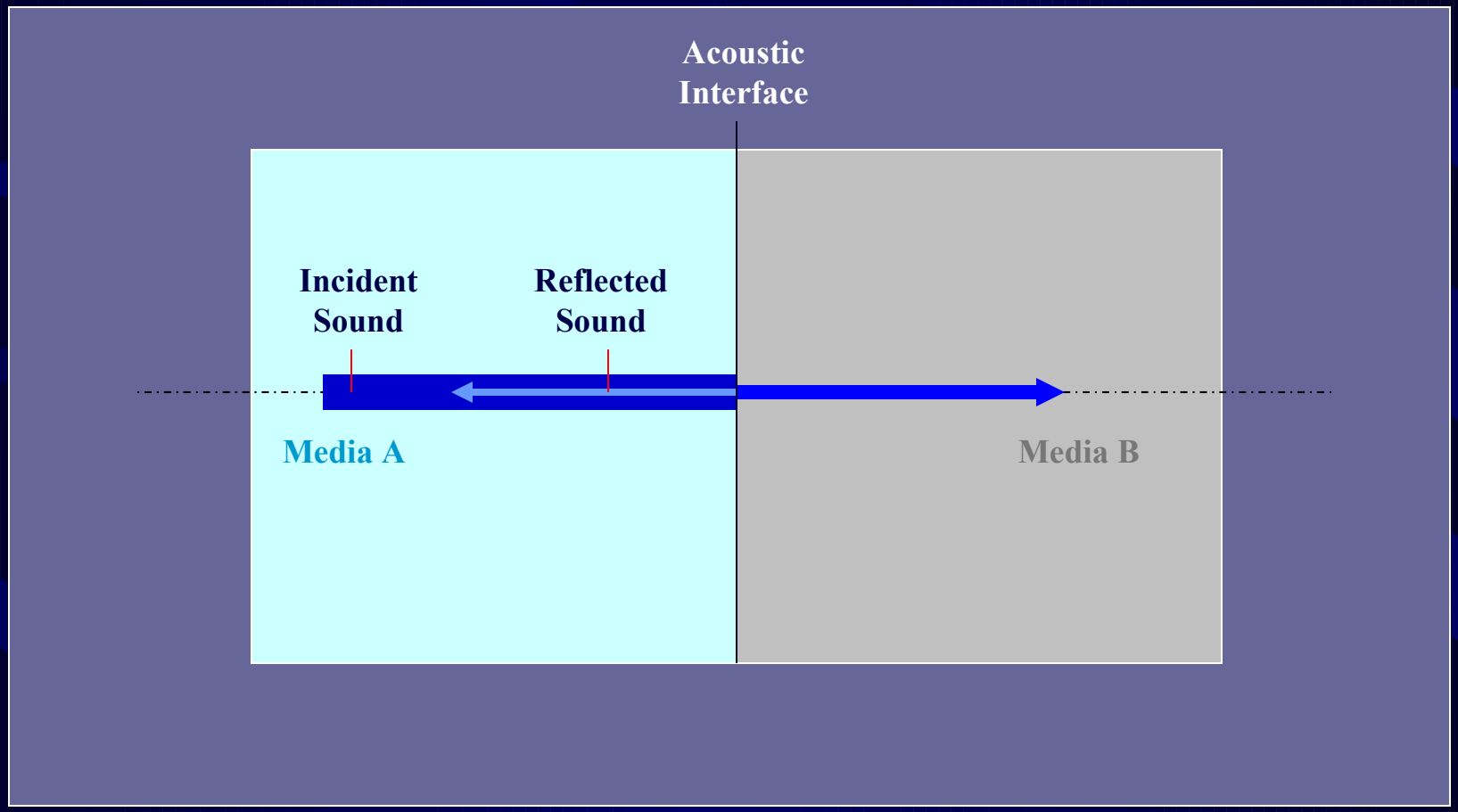
Propagation of Sound Wave at a Perpendicular Surface



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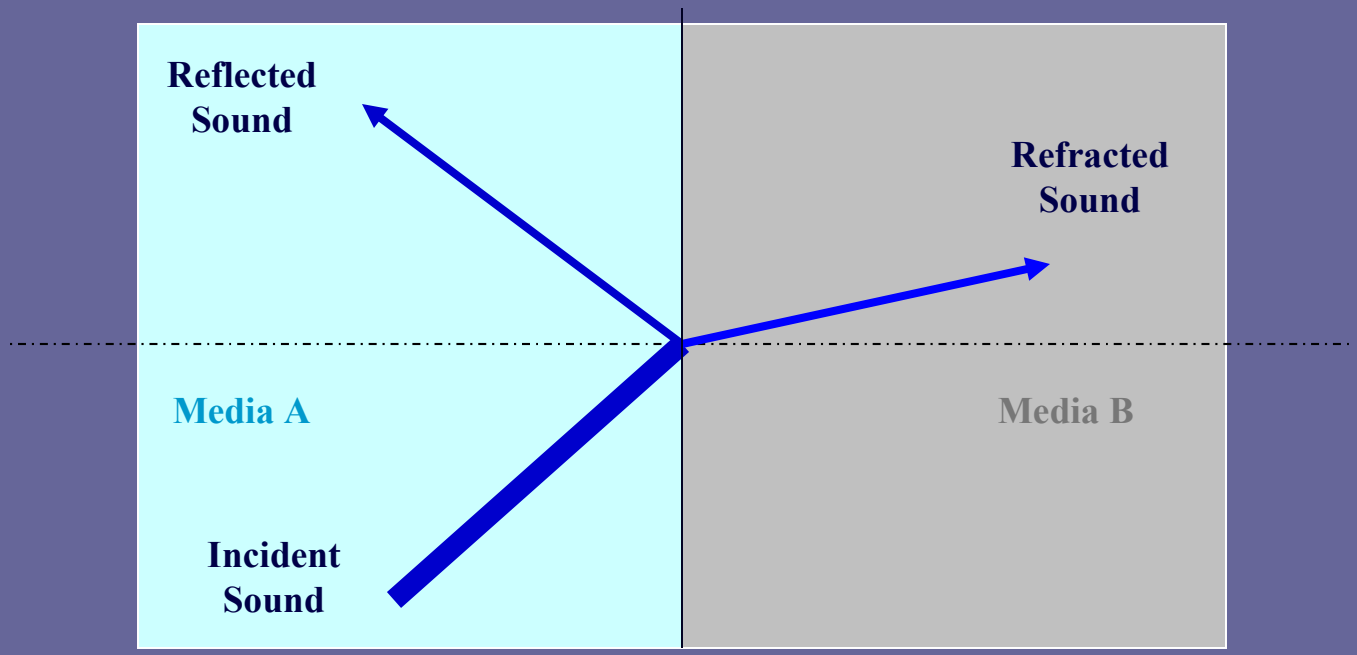
Propagation of Sound Wave at a Non-perpendicular Surface



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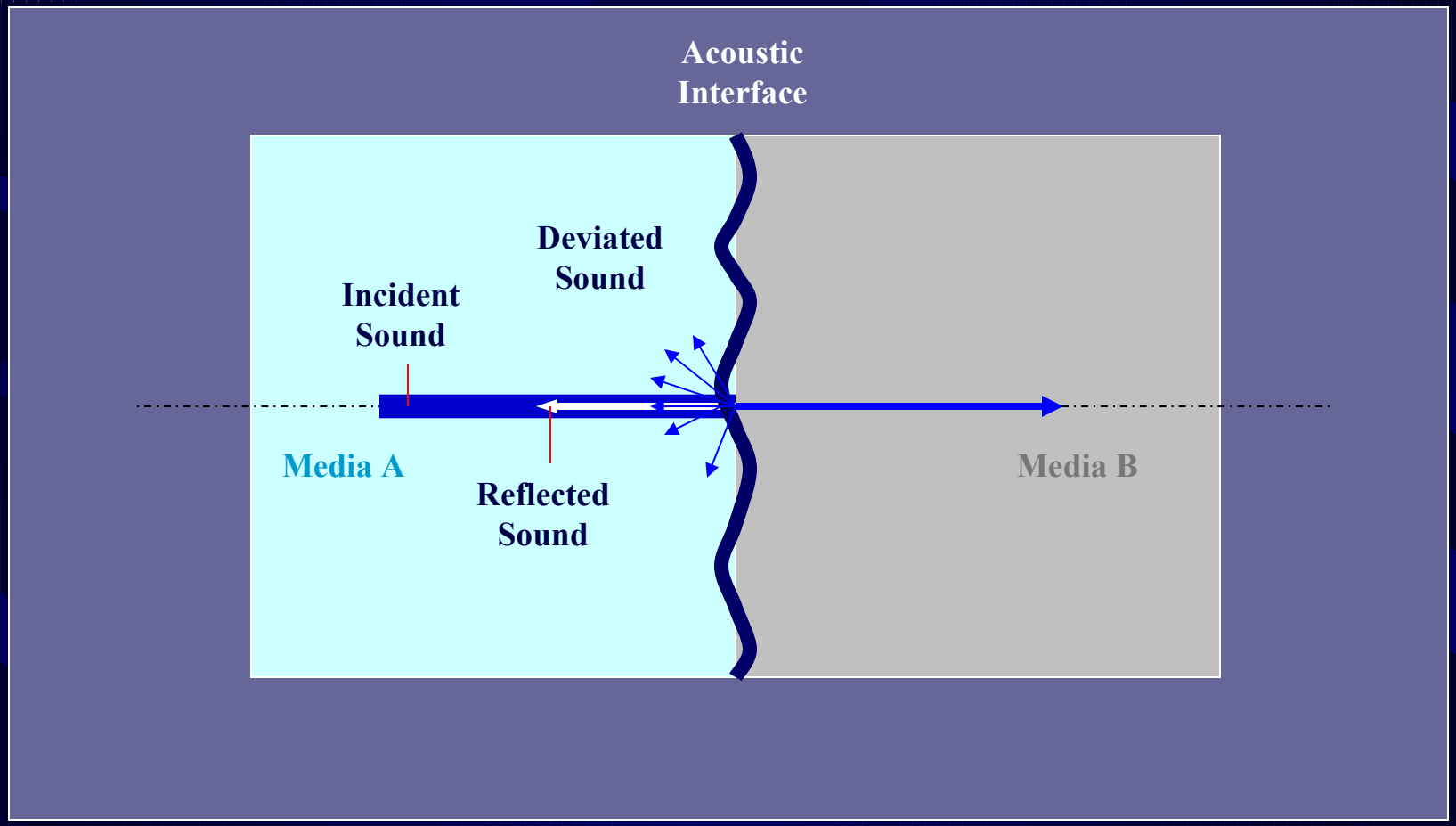
Propagation of Sound Wave at a Irregular Surface



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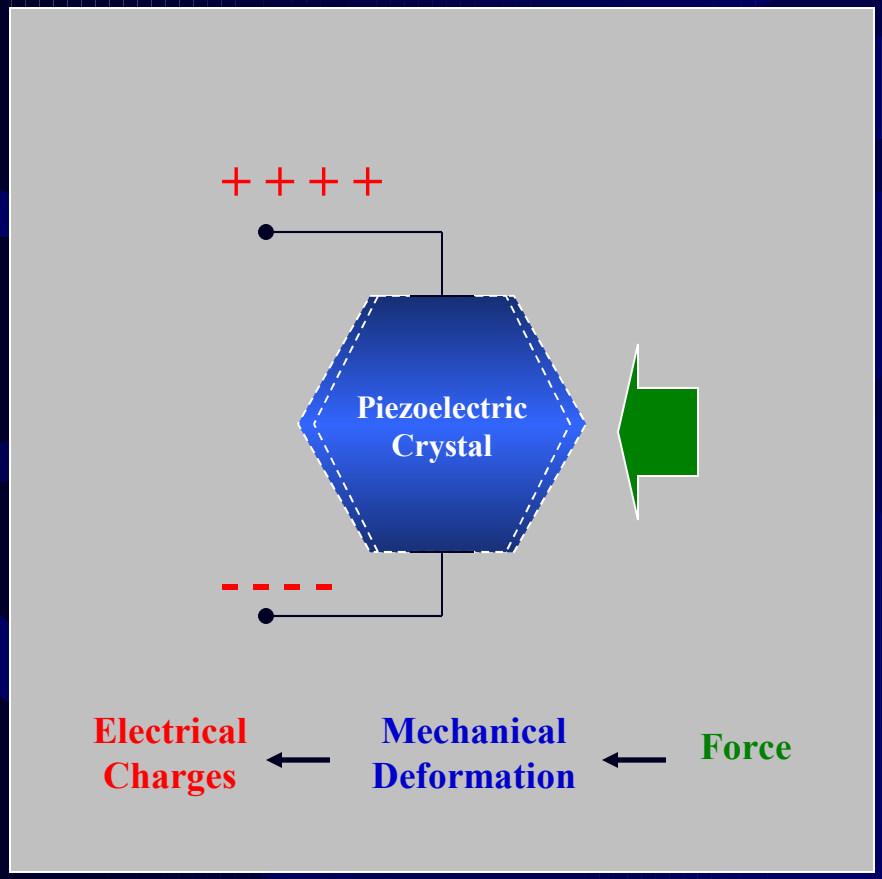
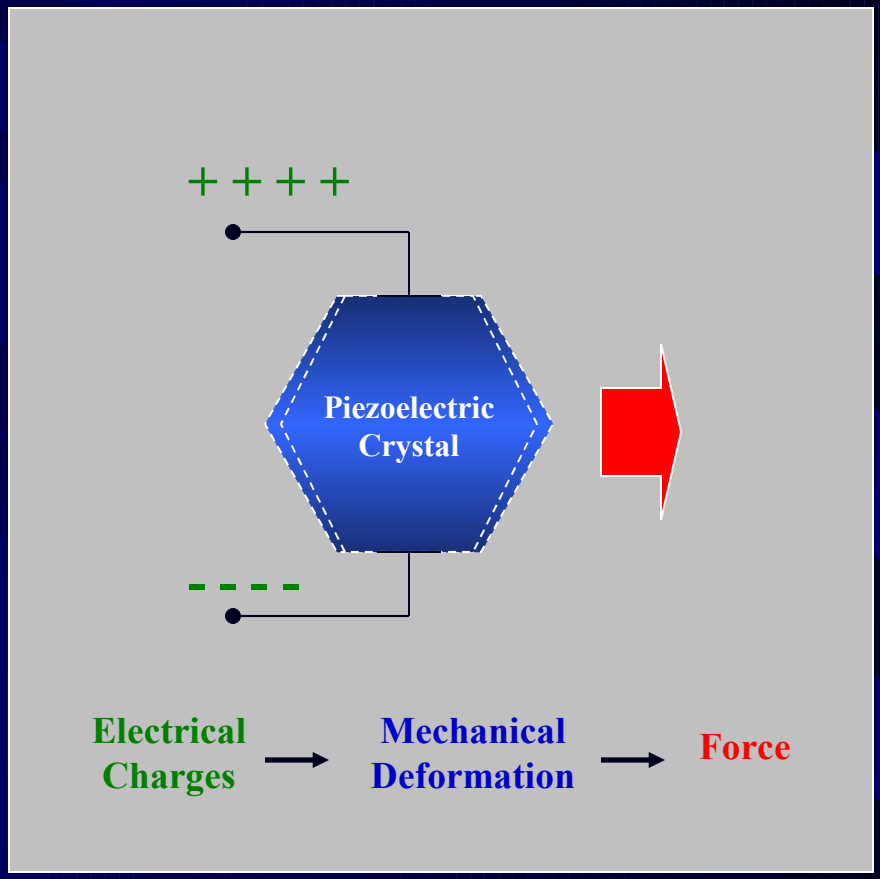
Piezoelectric Effects

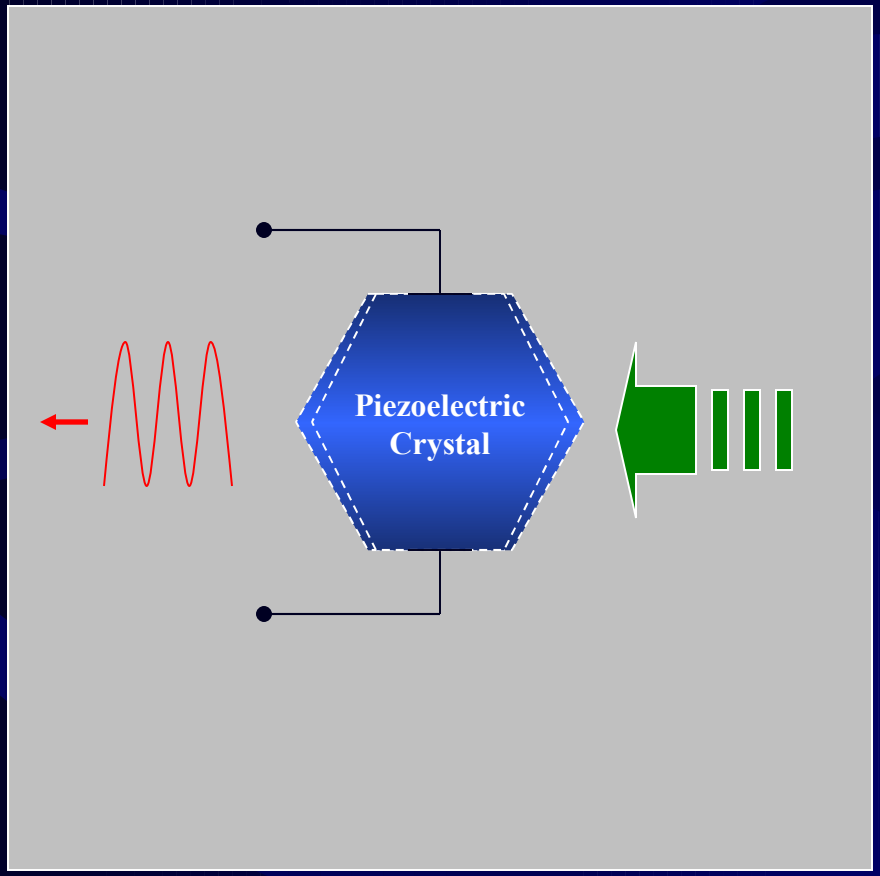


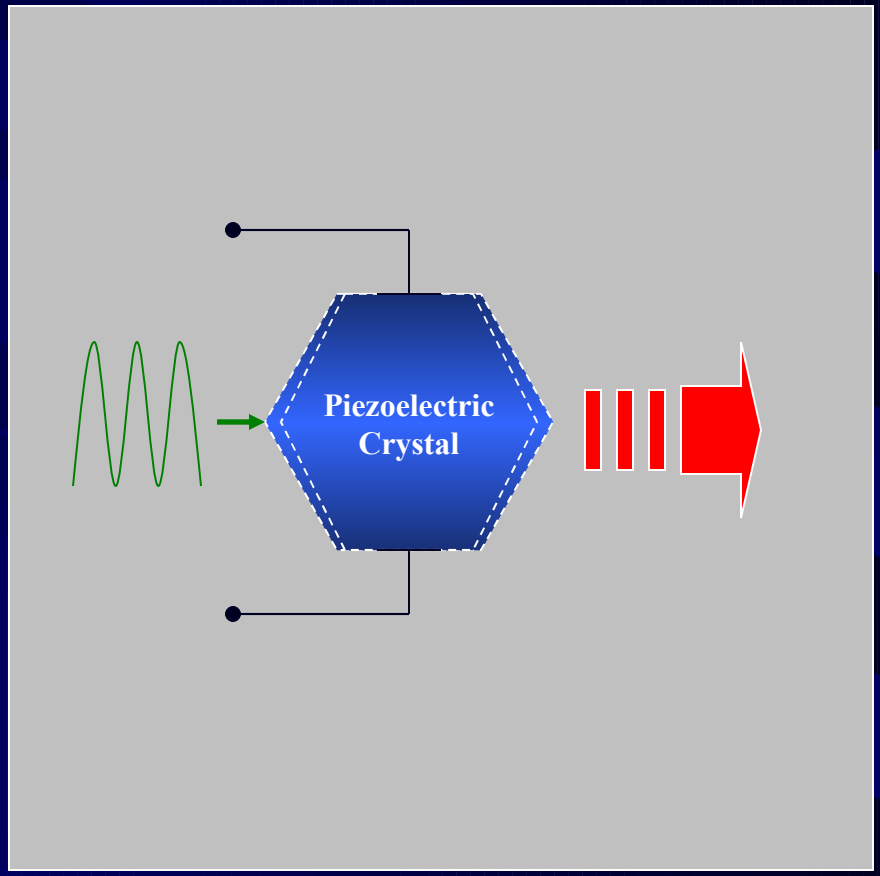


Natural quartz, lead zirconate titanate ….

Basics of Ultrasonography

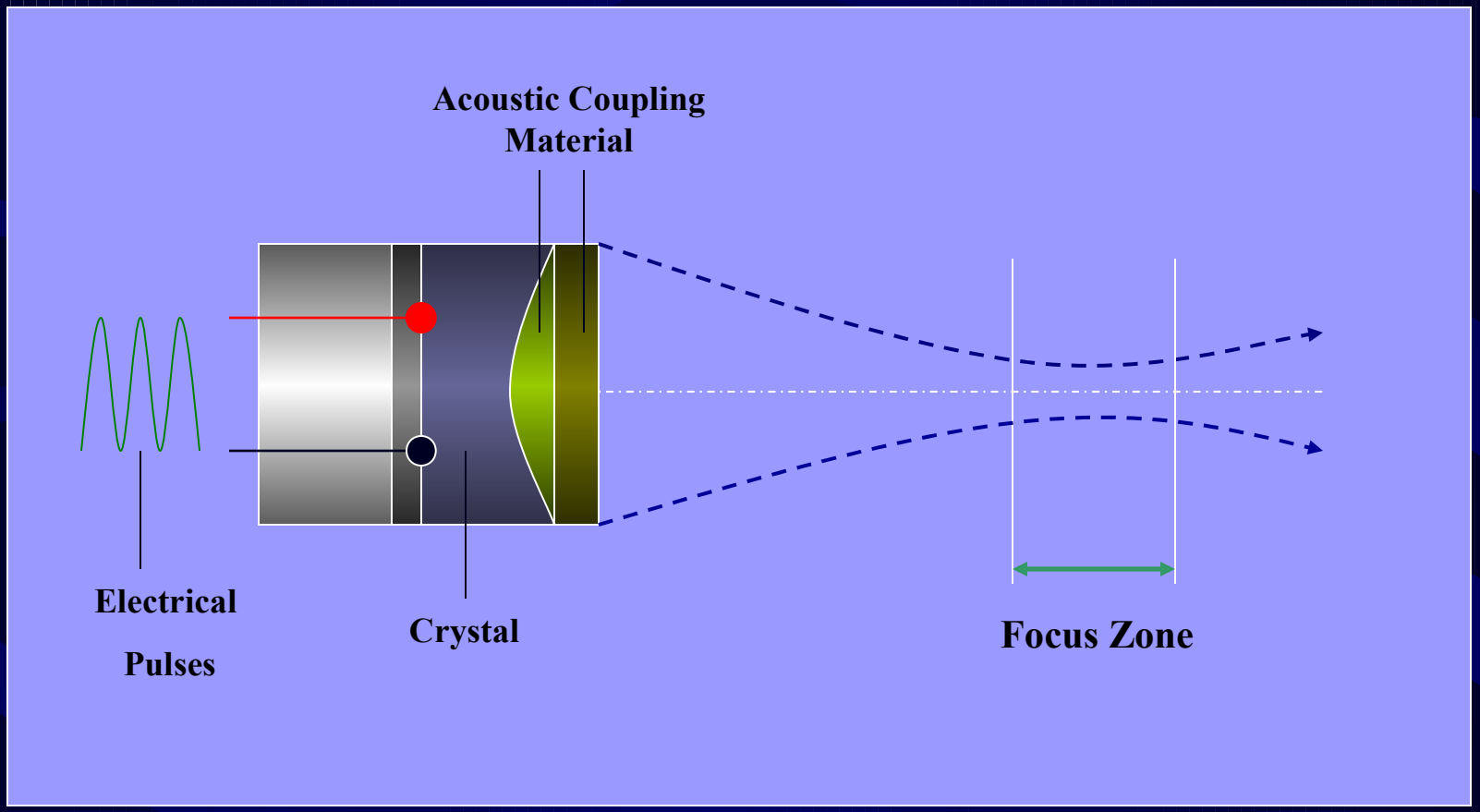
Piezoelectric Effects





Basics of Ultrasonography

Basic Structure of an Ultrasound Transducer



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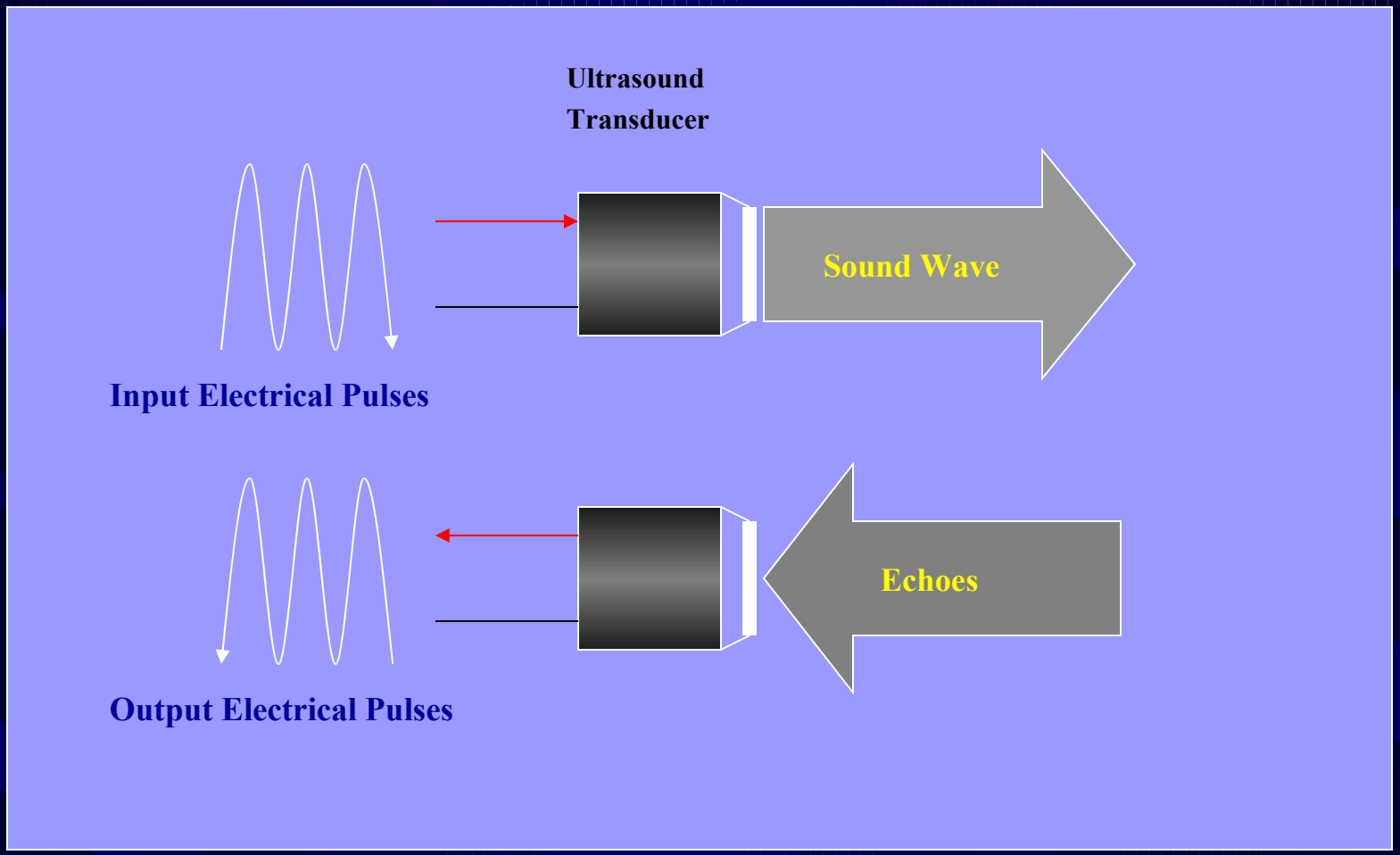

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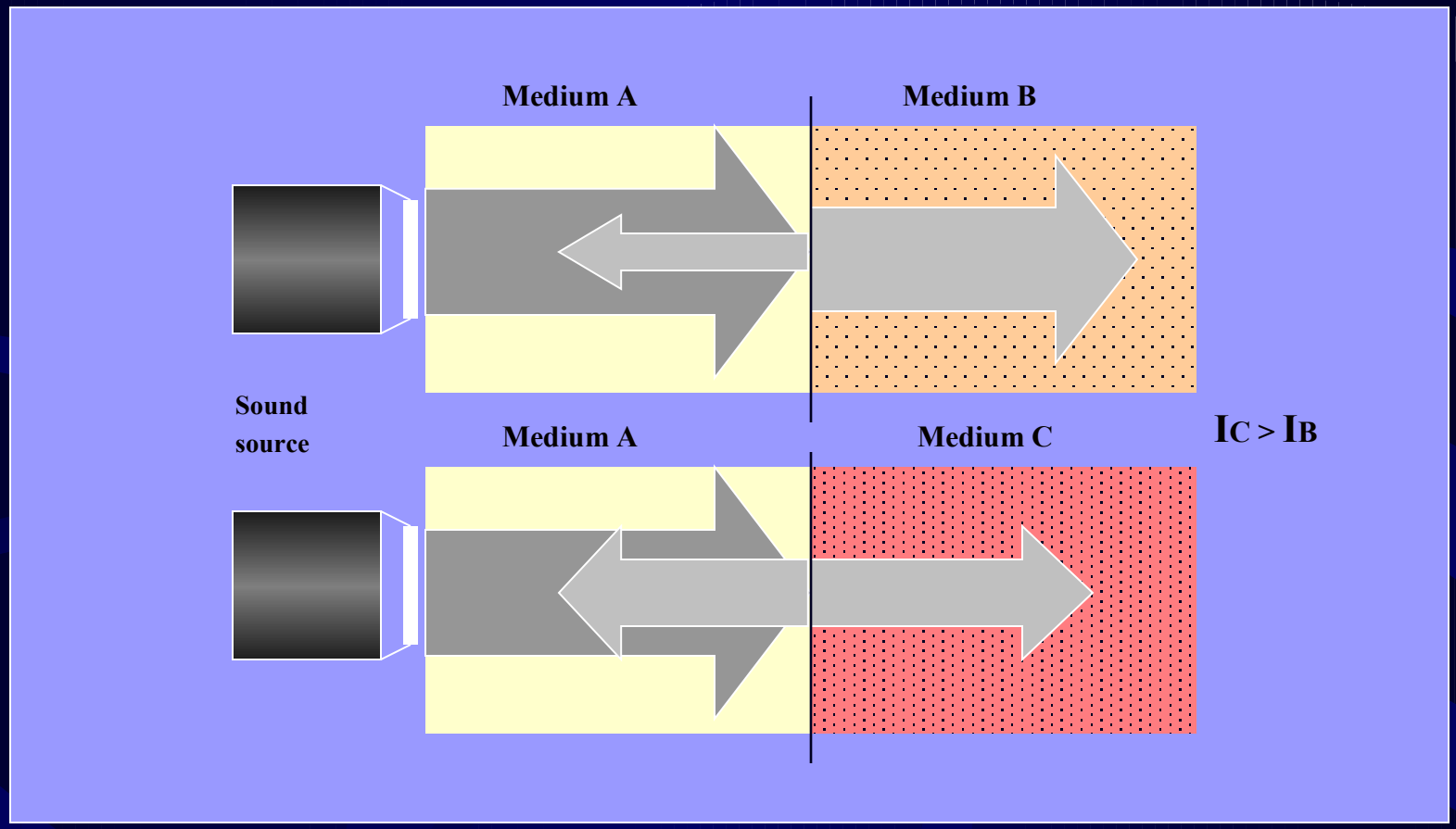


The greater the difference in the acoustic impedance of the two media that produced the interface, the stronger the reflection of the ultrasound wave.

Ophthalmic Ultrasound

Medium A

Medium A

Frequency of Ultrasound ↑ → **Resolution of Ultrasound Imaging** ↑

Frequency of Ultrasound ↑ → **Depth of Penetration** ↓

Frequency of Ultrasound ↓ → **Resolution of Ultrasound Imaging** ↓

Frequency of Ultrasound ↓ → **Depth of Penetration** ↑

Ophthalmic Ultrasound

Ophthalmic ultrasound uses frequencies ranging from 6 to 50 MHz (1MHz=1 million cycles per second)

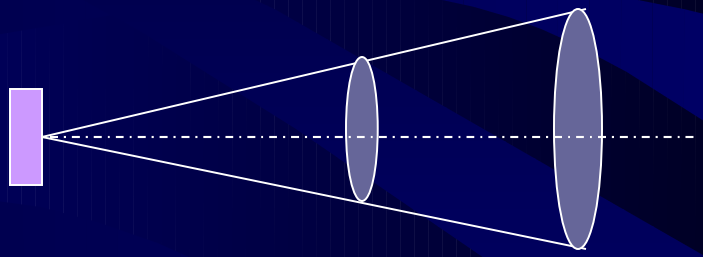
Type of Ultrasound Device	Frequency
A-Scan	6~15 MHz
Ultrasound Biometry	6~15 MHz
B-Scan	8~20 MHz
UBM (Ultrasound Bio-microscopy)	30~50 MHz

Ophthalmic Ultrasound

Absorption and Attenuation of Ultrasound Energy in the Tissues

Causes of Loss Energy:

- **Beamwidth loss ($a = 1/D^2$)**

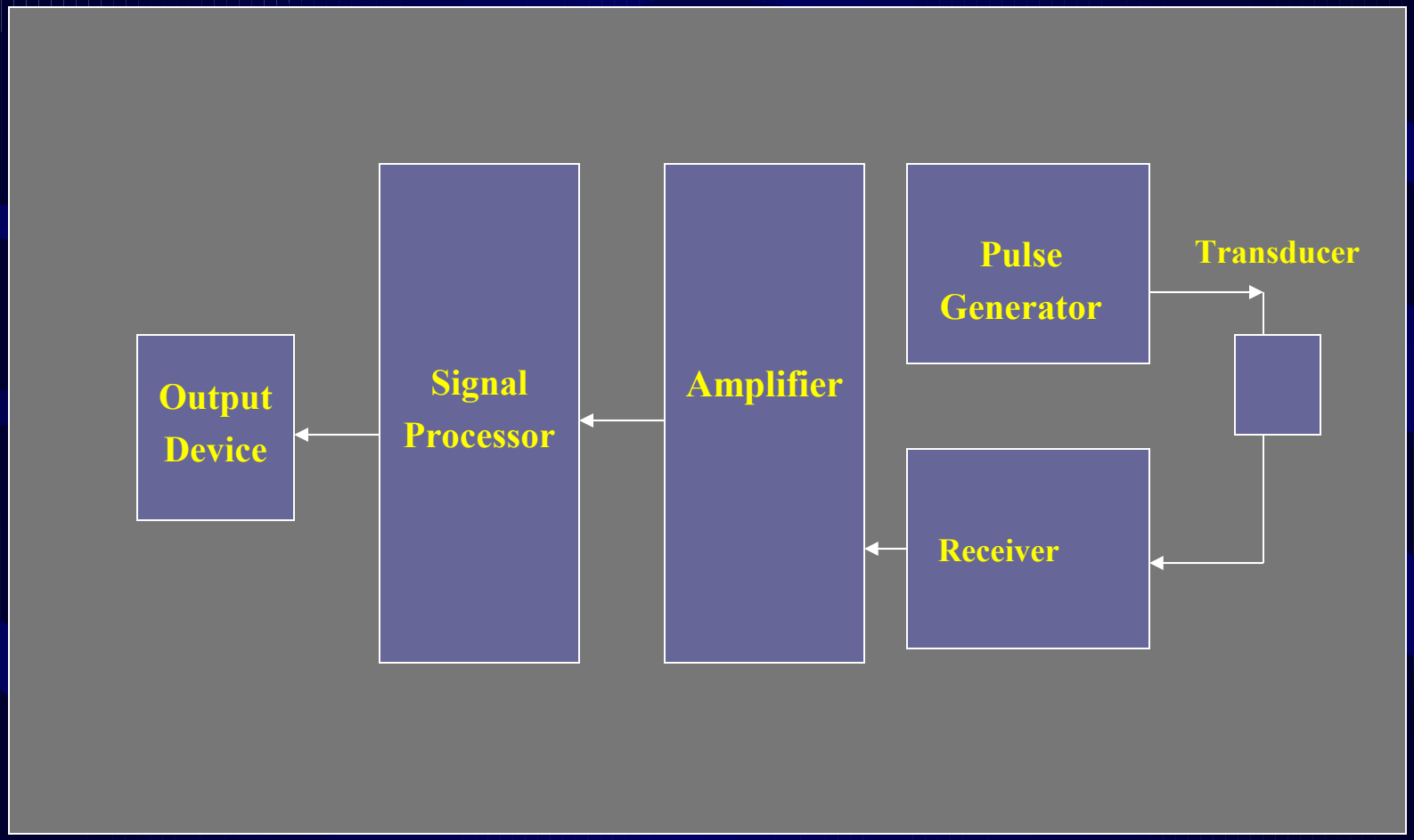


- **Absorption loss (Tissue Acoustic Impedance)**

- **Scattering loss**

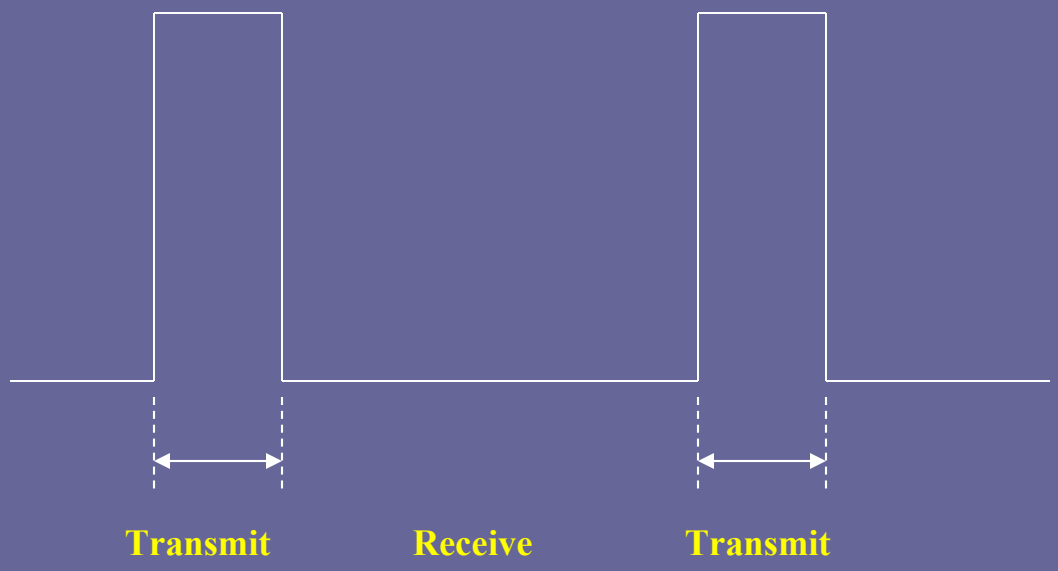
Ophthalmic Ultrasound

Basics of Ultrasound Devices



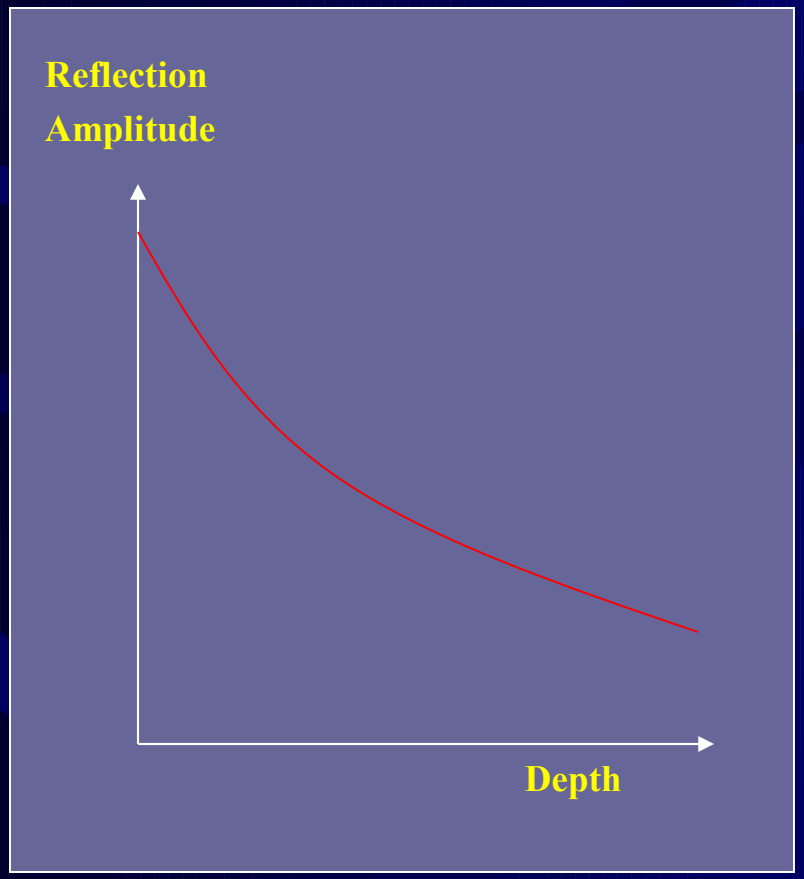
Ophthalmic Ultrasound

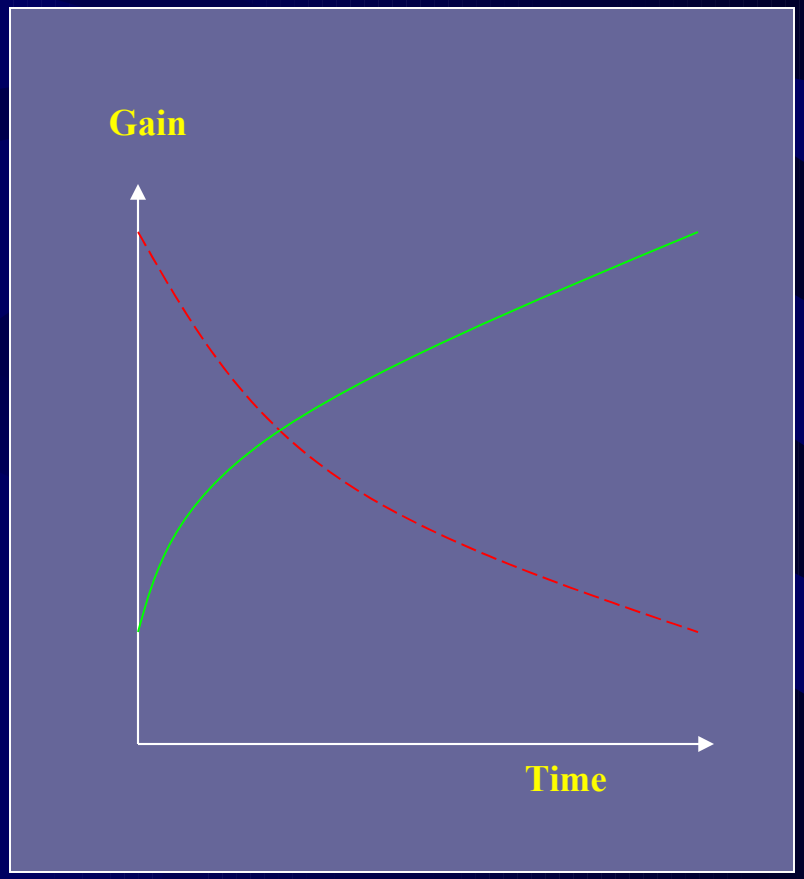
Pulse Ultrasound System



Ophthalmic Ultrasound

Time-Gain Compensation



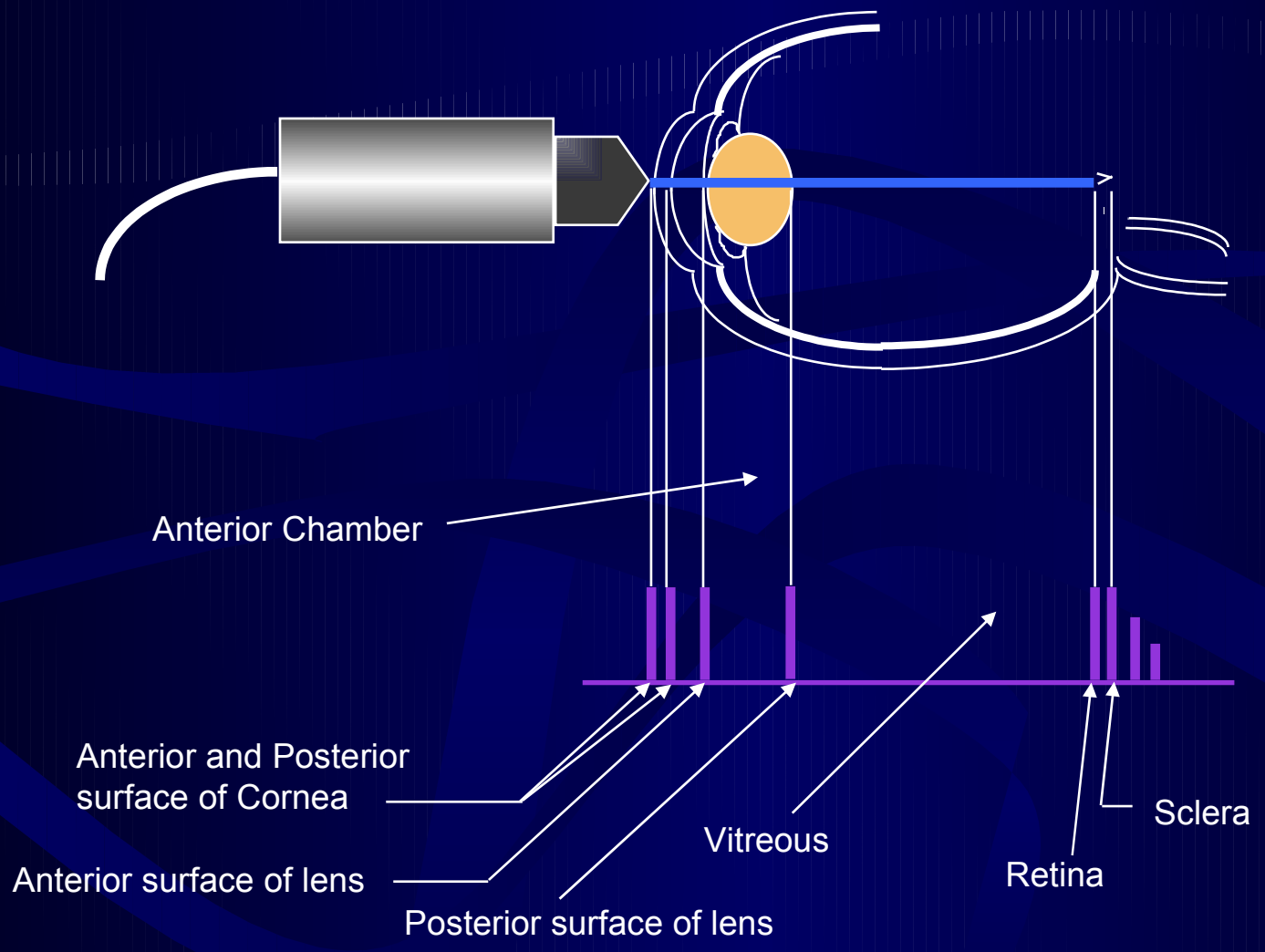


Ophthalmic Ultrasound

Ultrasound Scan Modes

- A scan
- biometry
- B Scan
- UBM

A-SCAN

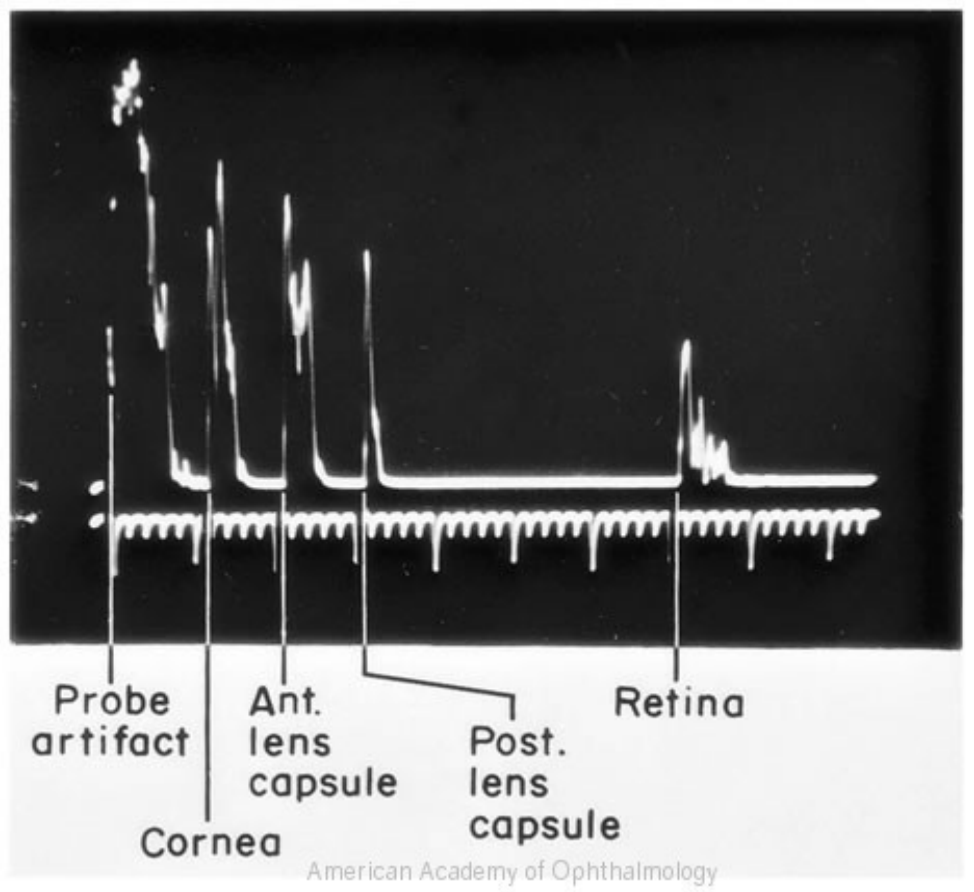

Anterior Chamber
Anterior and Posterior surface of Cornea
Anterior surface of lens
Posterior surface of lens
Vitreous
Retina
Sclera

A-SCAN Biometry

A-Scans are used to measure the axial length of the eye for determining the proper power of the intraocular lens to be implanted. Typical axial length measurements are from 21-26 mm.

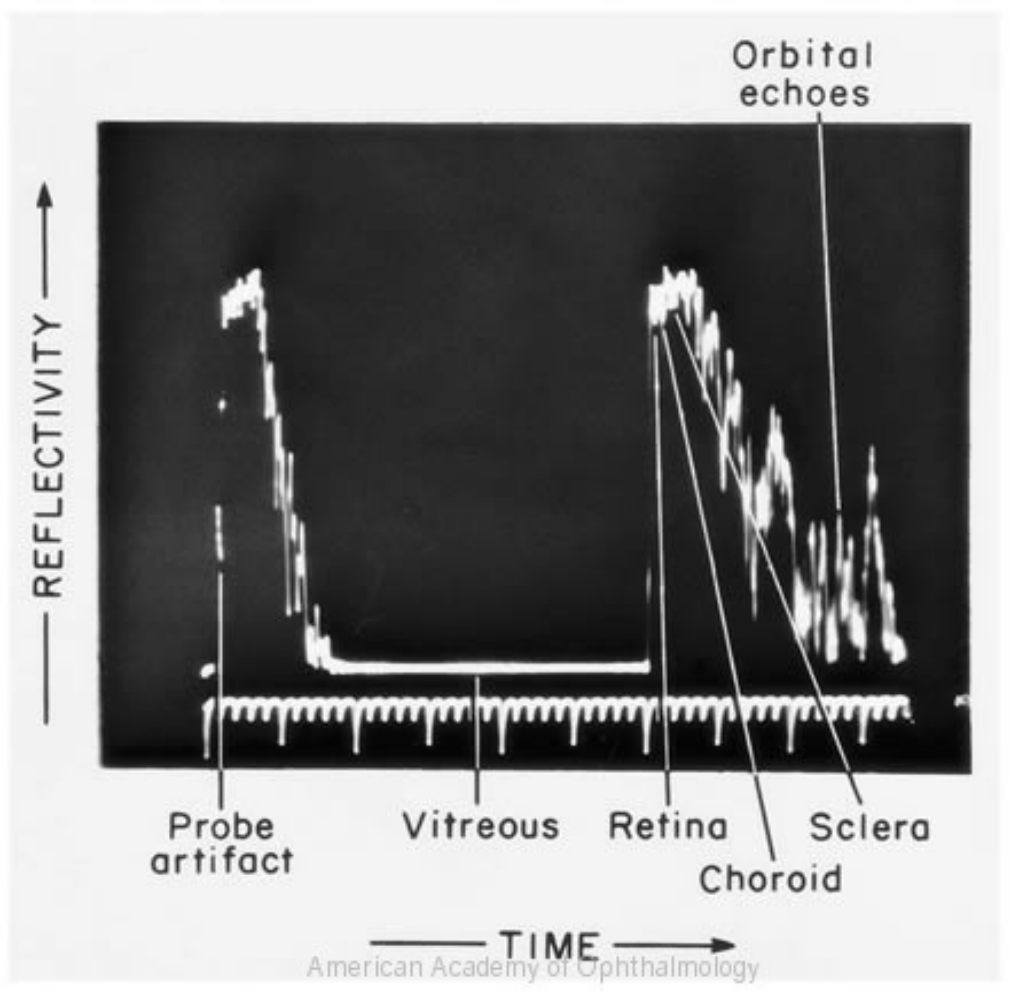
Ophthalmic Ultrasound

A-Scan Example 1

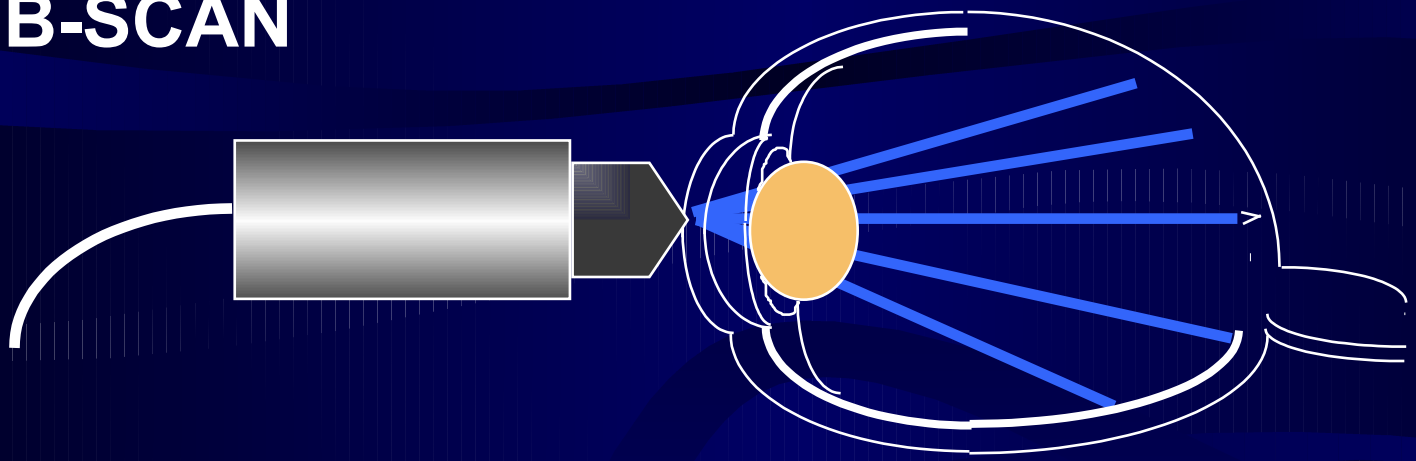


Ophthalmic Ultrasound

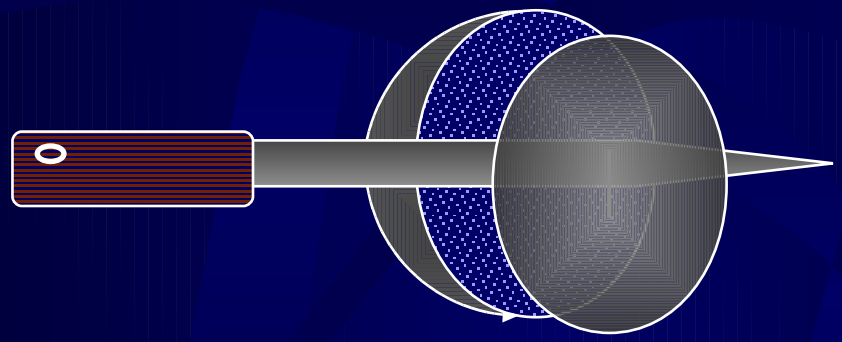
A-Scan Example 2



B-SCAN



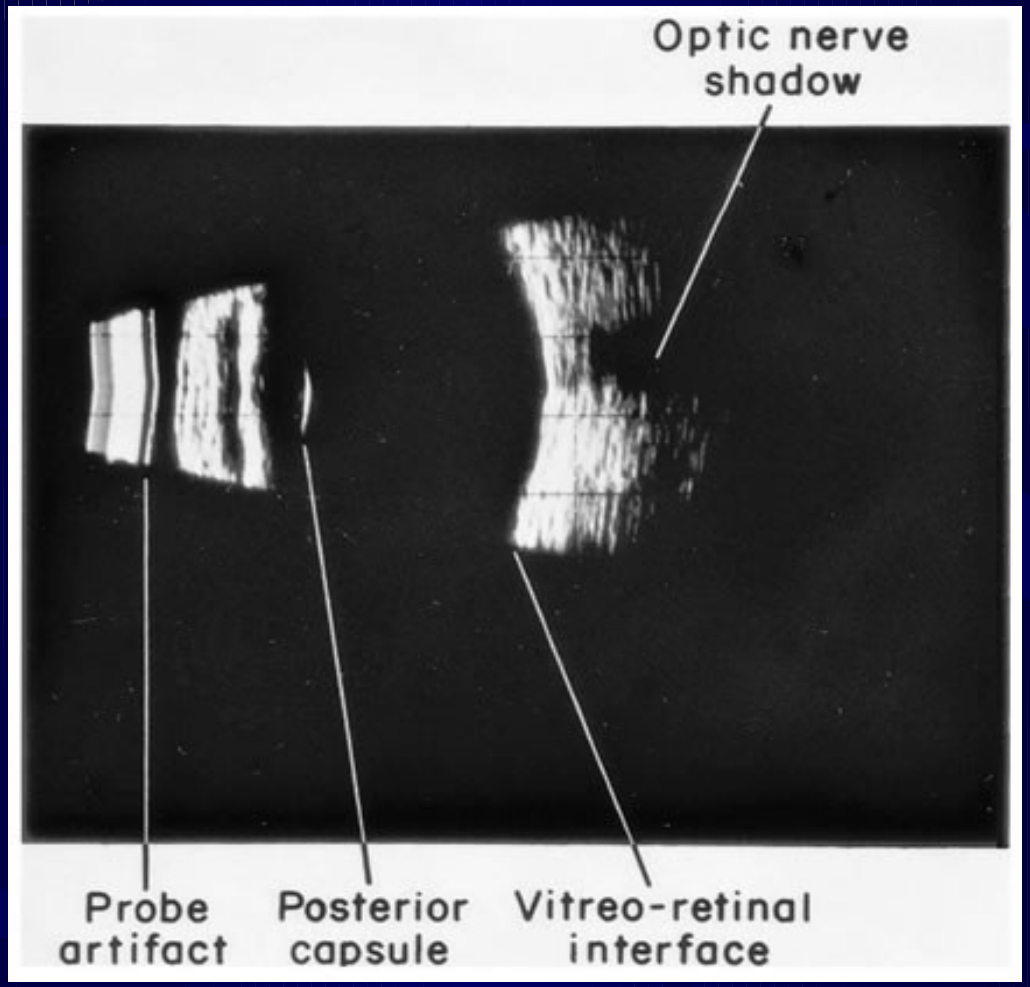
The transducer sweeps back and forth.



The ultrasonic beam is equivalent to a knife blade, exposing a cross section of the cut object.

Ophthalmic Ultrasound

B-Scan Example 1

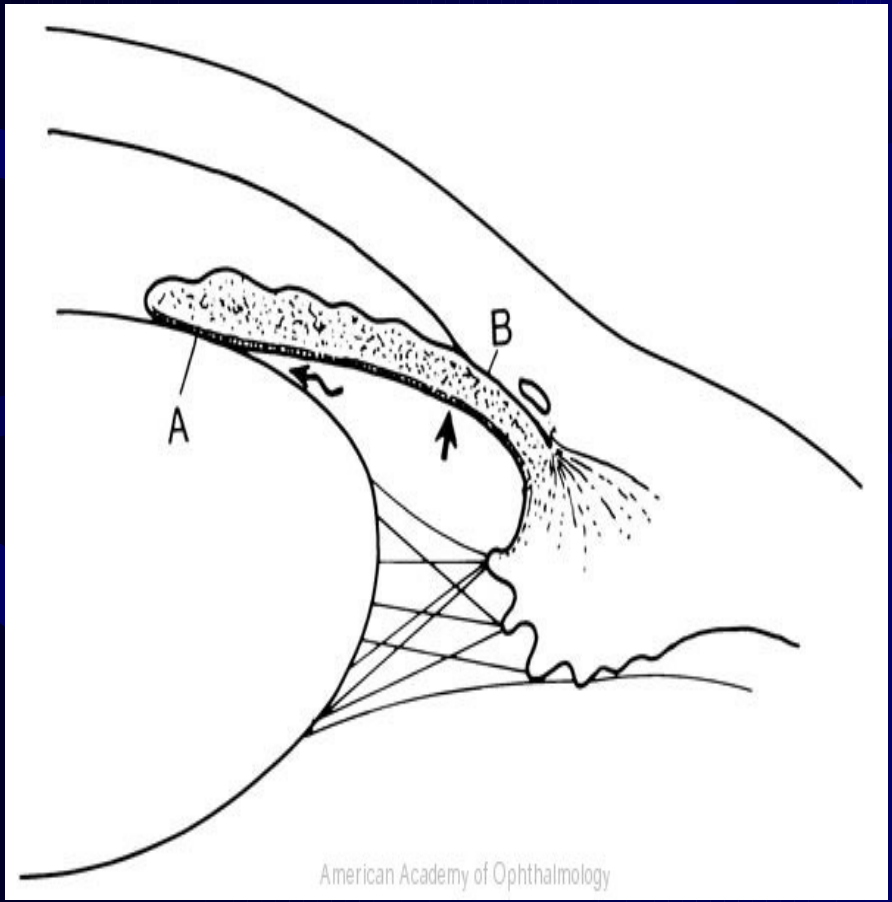


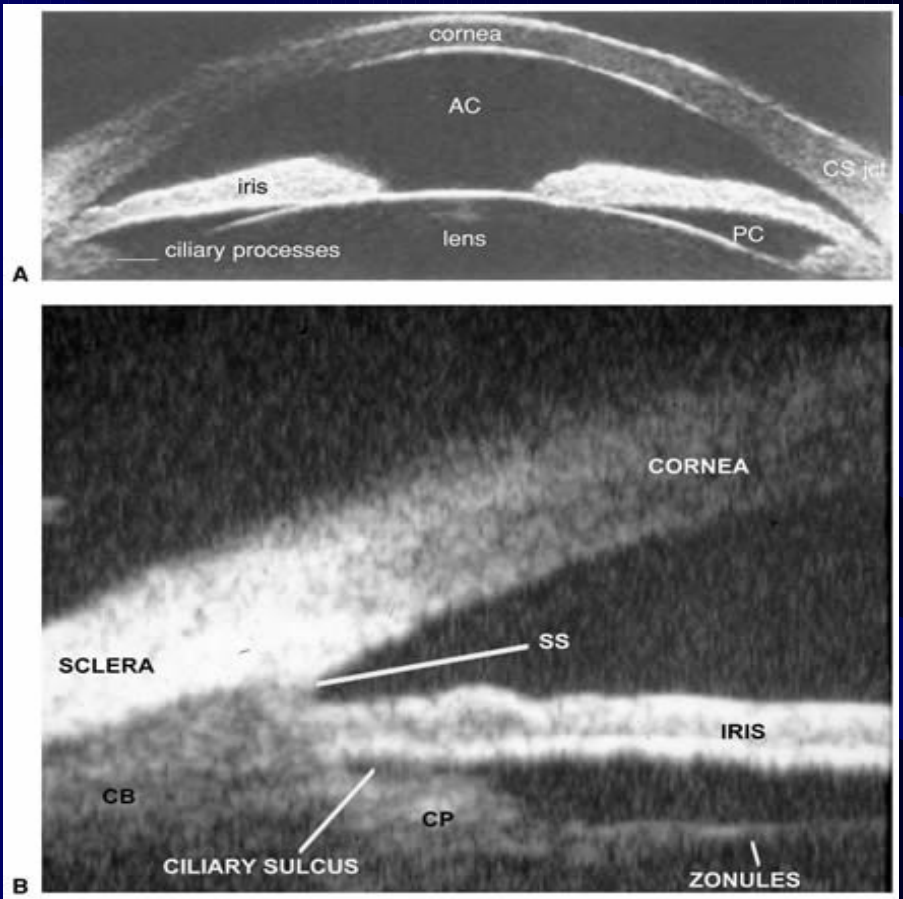
Ophthalmic Ultrasound

B-Scan Example 2

Ophthalmic Ultrasound

UBM Example 1



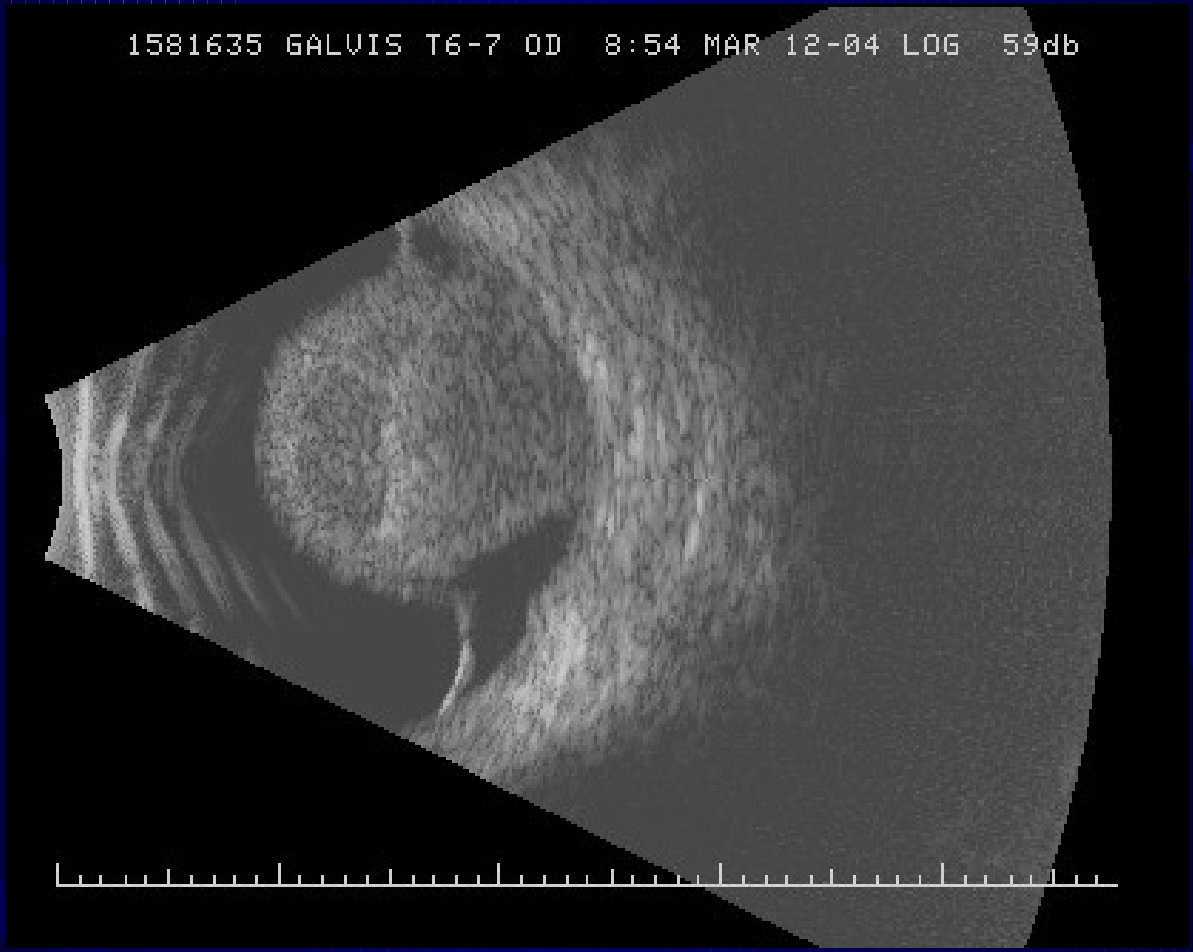


Ophthalmic Ultrasound

More Examples

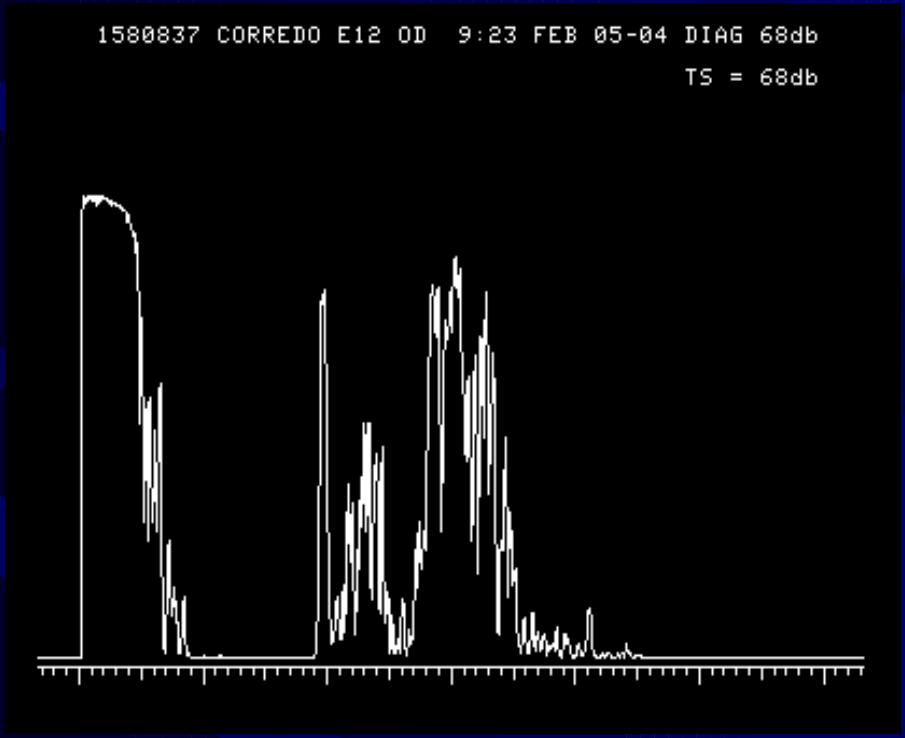
Ophthalmic Ultrasound

More Examples



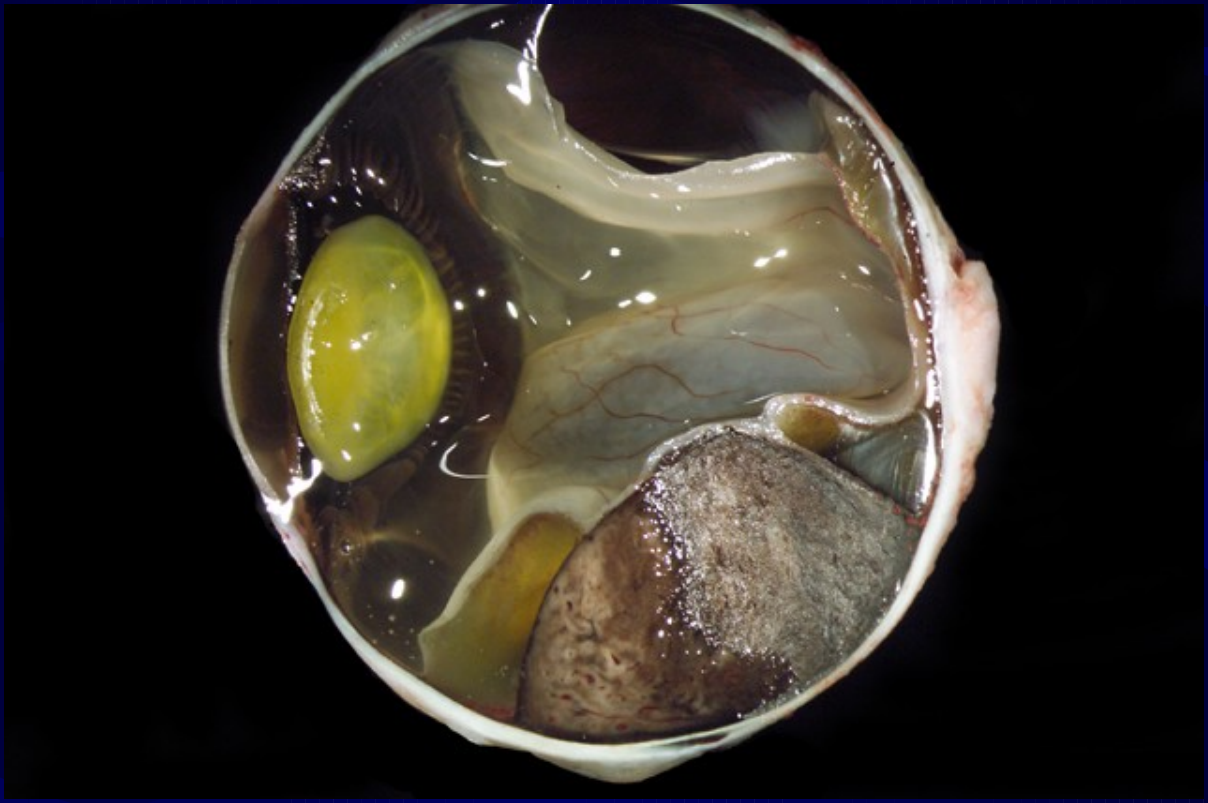
Ophthalmic Ultrasound

More Examples



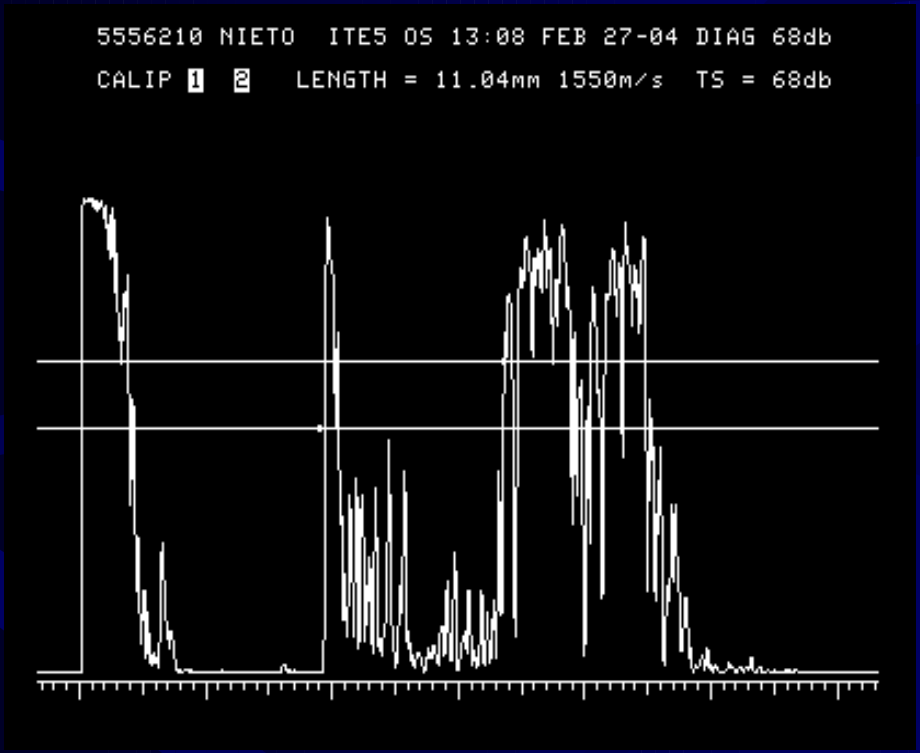
Ophthalmic Ultrasound

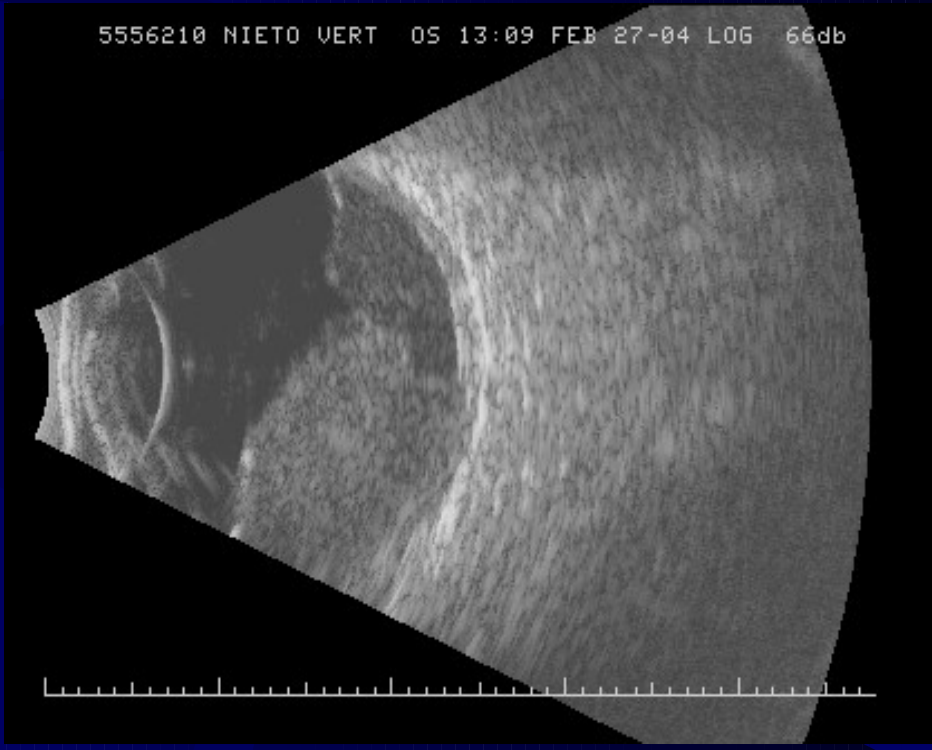
More Examples



Ophthalmic Ultrasound

More Examples





Thank You !