THE UNIVERSITY of TENNESSEE
HEALTH SCIENCE CENTER

Applied Principles of Ultrasound Physics

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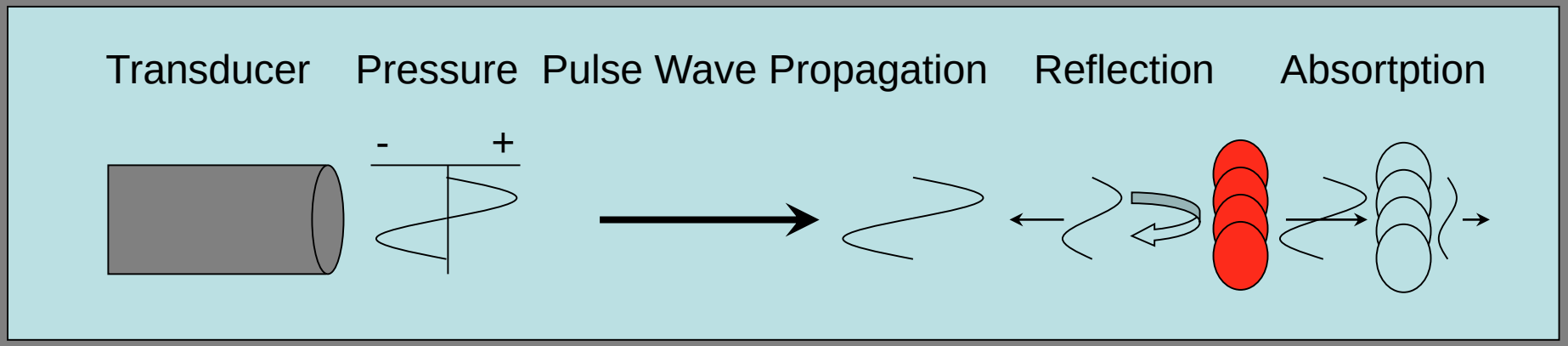
Alexandrov AV. Neurovascular Ultrasound Examination. Wiley: 2013.

Ultrasound Propagation thru Tissues



The reflected wave (echo) carries information about tissues where it originated.

Seven Acoustic Variables describing sound waves

Period	Time that it takes a wave to vibrate in a single cycle (single pulse duration), or the time from the start of a cycle to the start of the next cycle (pulse repetition period); measured in microseconds for medical diagnostic ultrasound.
Frequency	The number of cycles that occur in one second; measured in Hertz (1 cycle / 1 second = 1 Hertz); range kHz (therapeutic) and MHz (therapeutic and diagnostic ultrasound).
Amplitude	The difference between the maximum positive or negative values over un-disturbed value for pressure (measured in Pascals), density (measured in g/cm^3), or particle motion or distance (measured in mm or cm).
Power	The rate of energy transfer, i.e. rate at which work is performed; measured in Watts; range under 700 mW for diagnostic ultrasound.
Intensity	The concentration of energy in the sound beam, i.e. power distribution in the area the beam is applied to; measured in W/cm^2.
Wavelength	The spatial length of a single complete pulse cycle; inversely related to frequency; measured in mm or cm.
Propagation speed	The distance that ultrasound travels in one second; measured as in m/s; average speed of ultrasound in sift tissues is 1540 m/s or "a mile a second".

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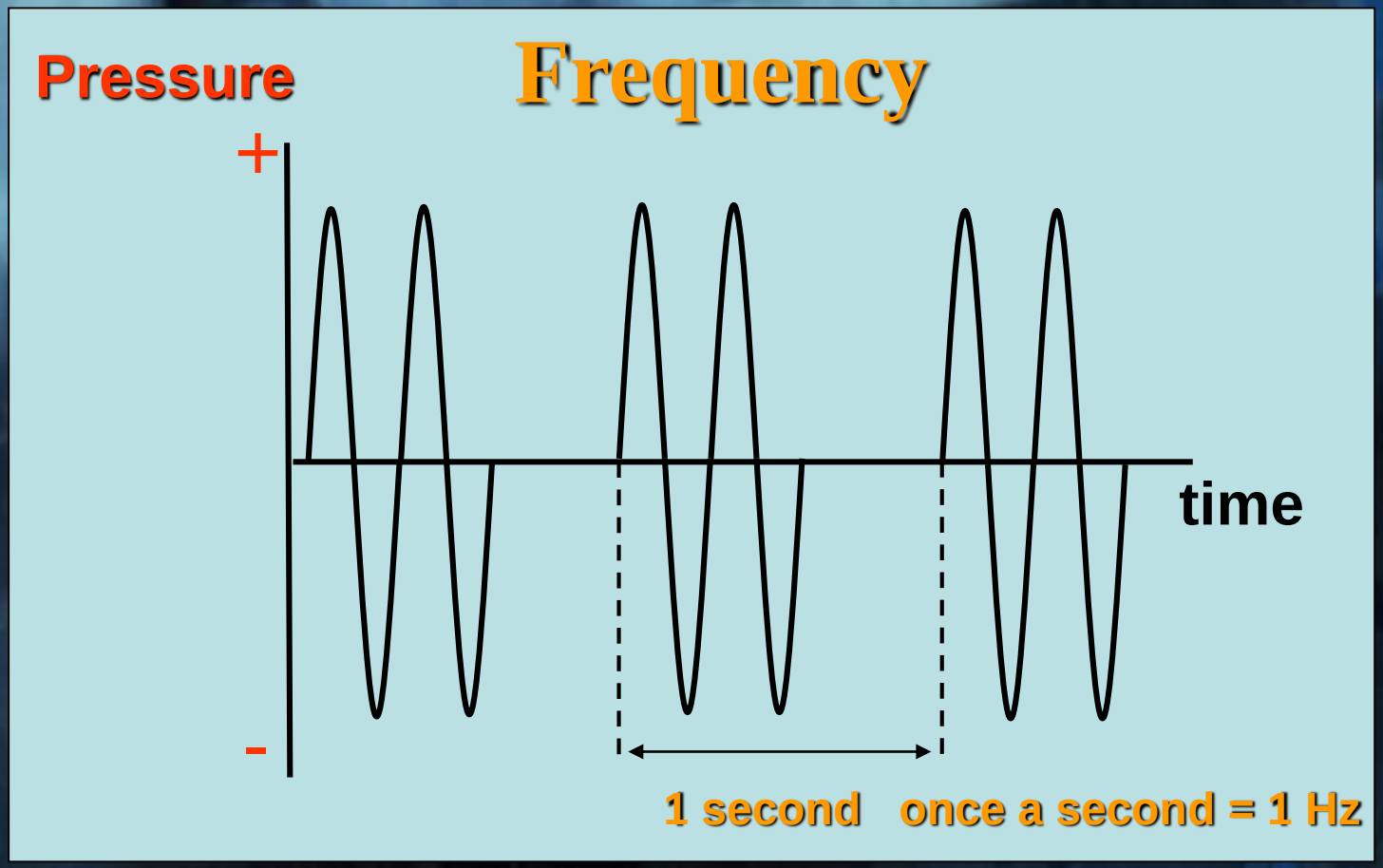

Diagnostic Ultrasound range 1 MHz – 12 MHz
(Intravascular ultrasound >20 MHz)

thousand times a second = 1 kHz

million times a second = 1 MHz

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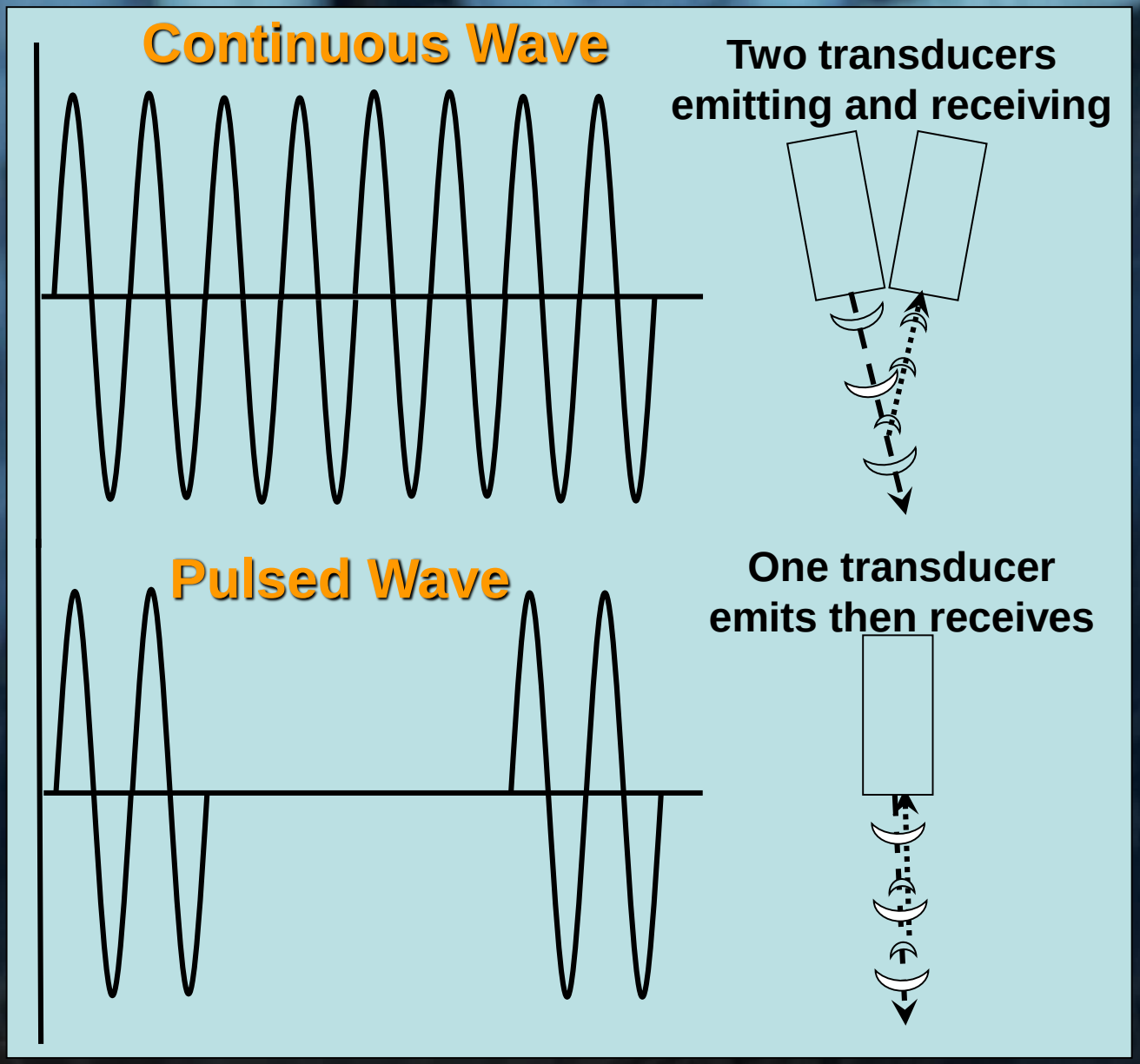

-No depth information
-No imaging possible
-Only flow detection

-Depth discrimination
-Imaging (echo strength)
-Flow detection

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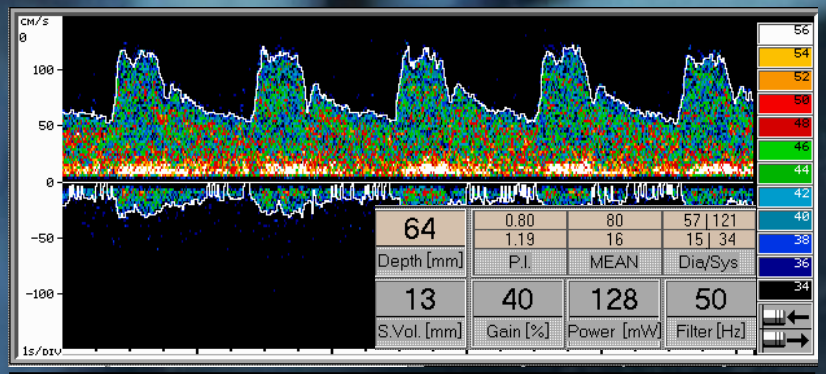
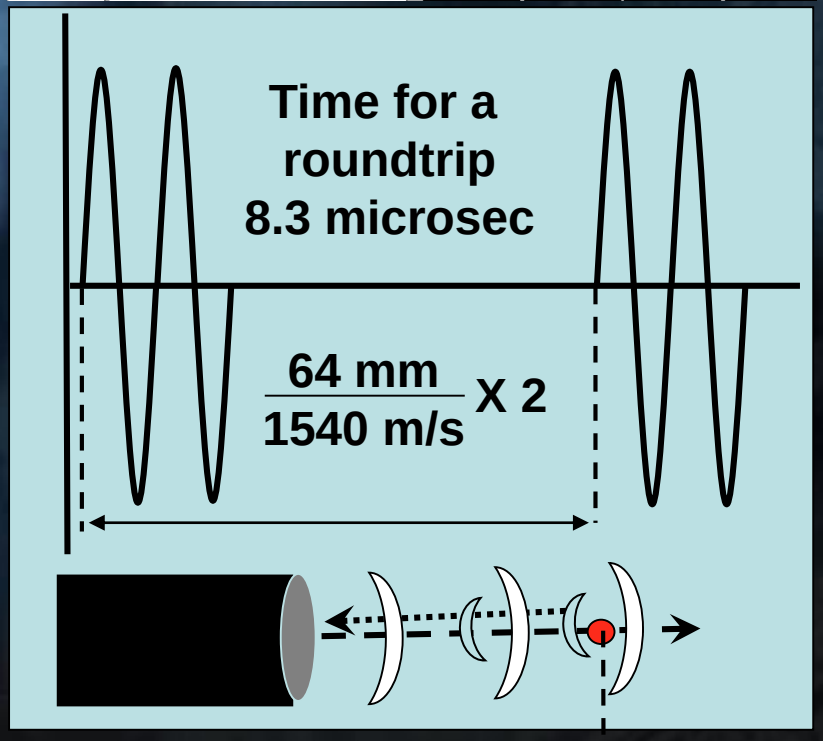
Pulsed Wave Spectral Doppler





Depth is calculated from the average speed of sound in soft tissues:
1540 m/s (a mile a second) and time from firing a pulse to registering returned echos (i.e. round trip time).

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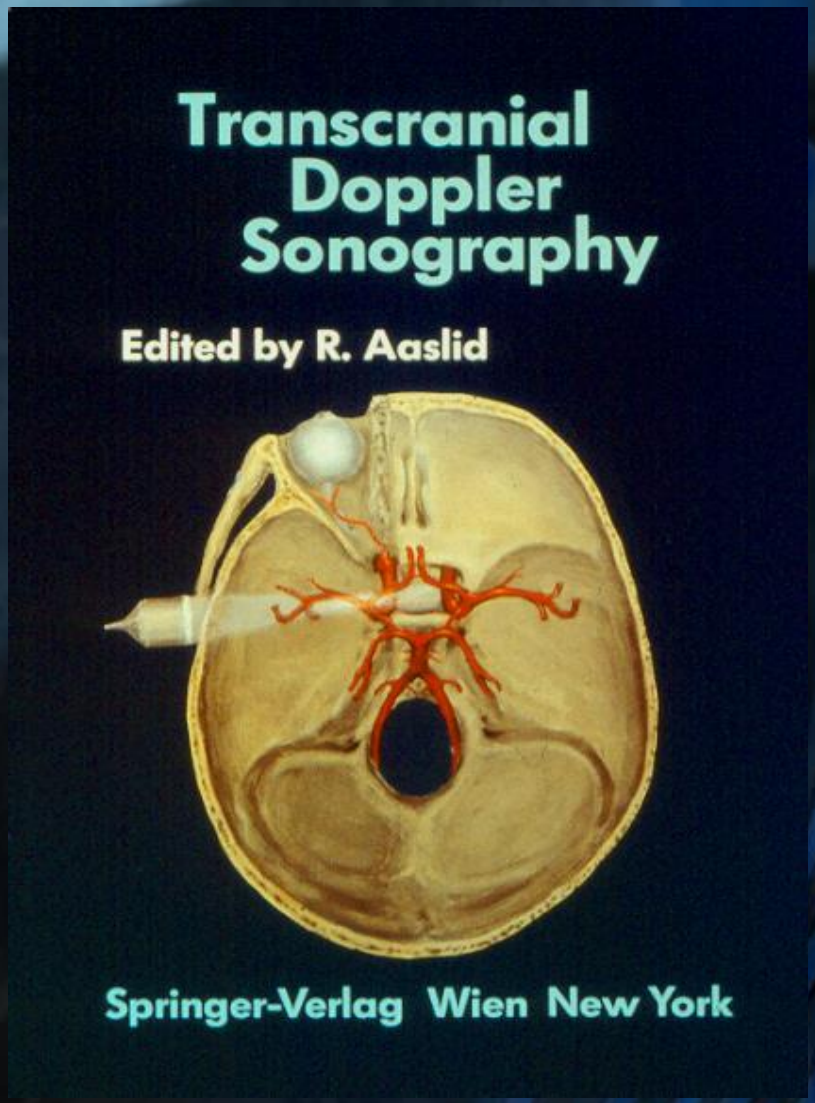
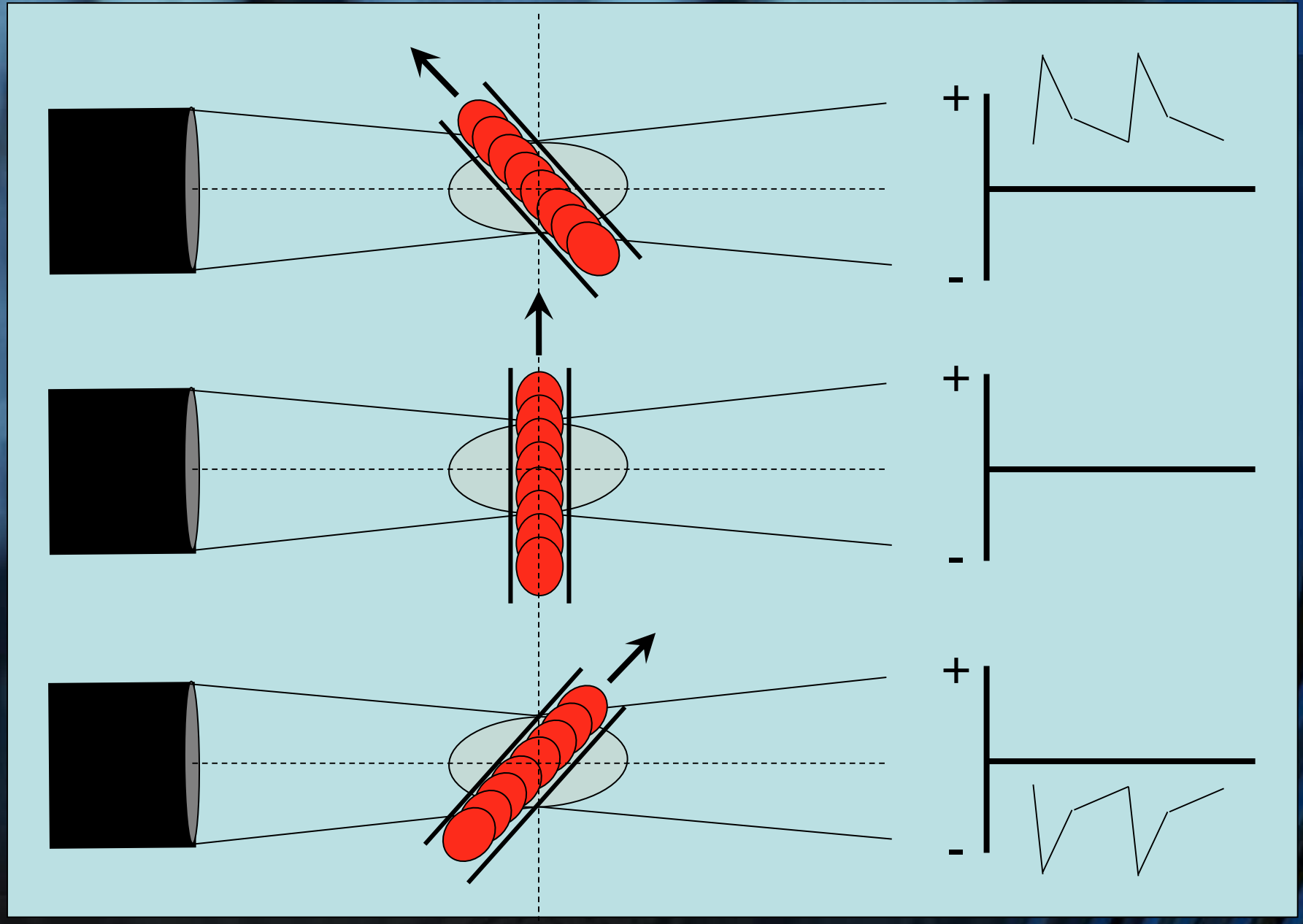
Christian Doppler 1803-1853



1982


GEBURTSHAUS DES PHYSIKERS
CHRISTIAN DOPPLER
ENTDECKERS DES NACH IHM BENANNTEN
ASTROPHYSISCHEN PRINZIPS
GEB·29·NOVEMBER·1803·GEST·17·MÄRZ·1853
Zu seinem hundertsten Geburtsfeste
die Gesellschaft für Salzburger Landeskunde.
NÄGELE & STRUBELL
DIE PARFUMERIE
CHANEL

What is Doppler Shift?



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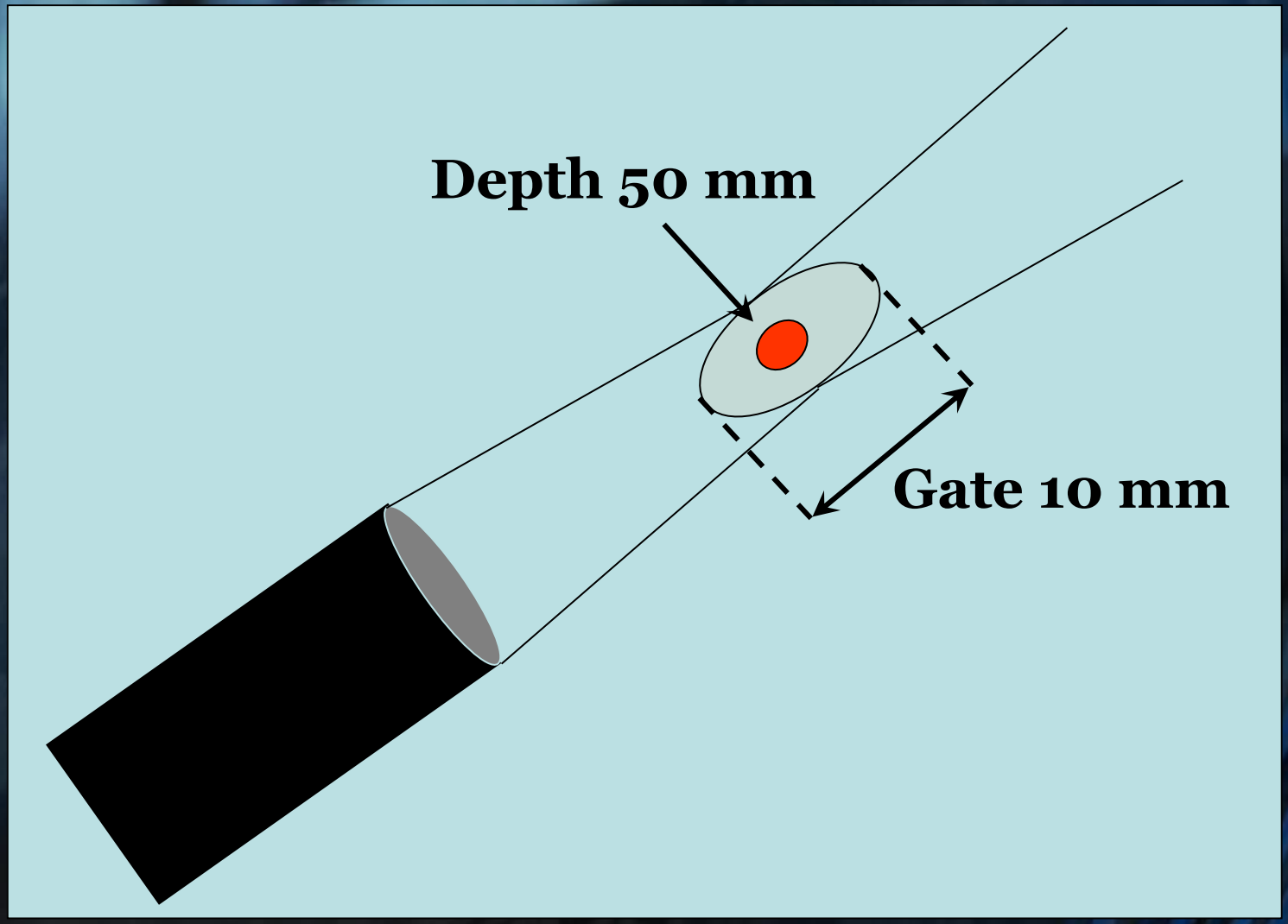
Transcranial Doppler



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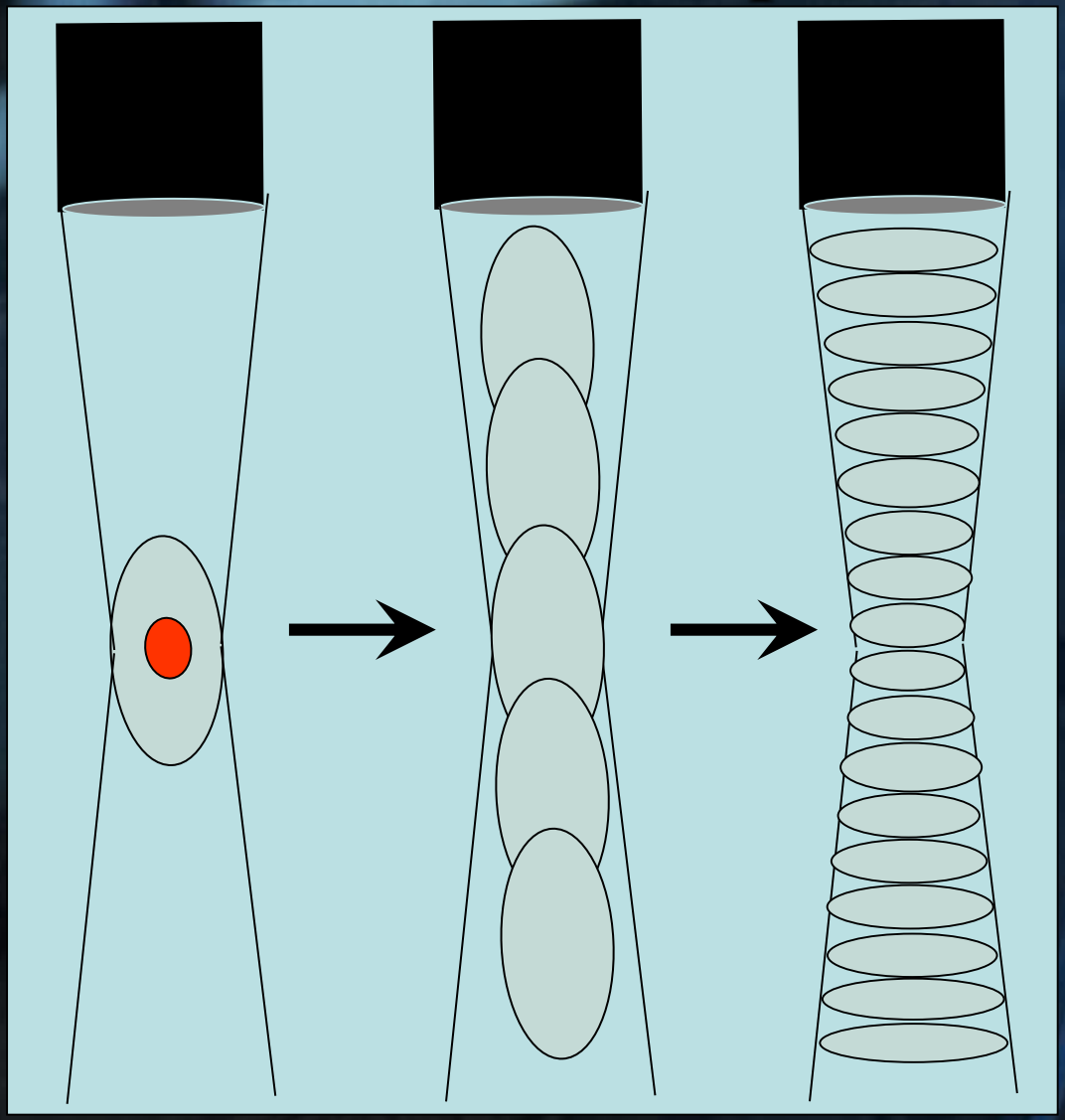
Single Channel Multi-Depth Sampling



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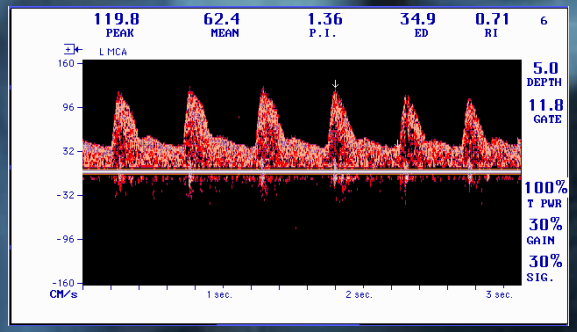
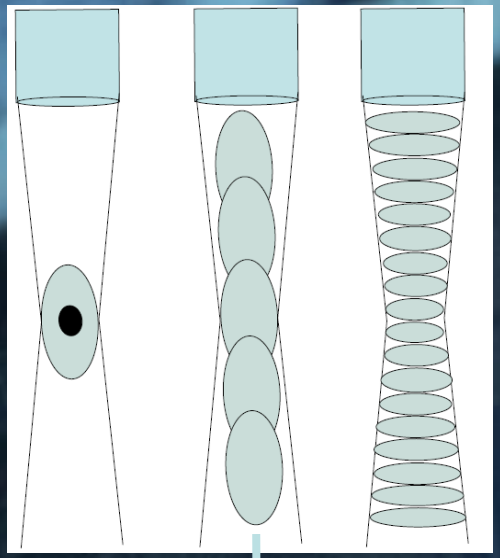
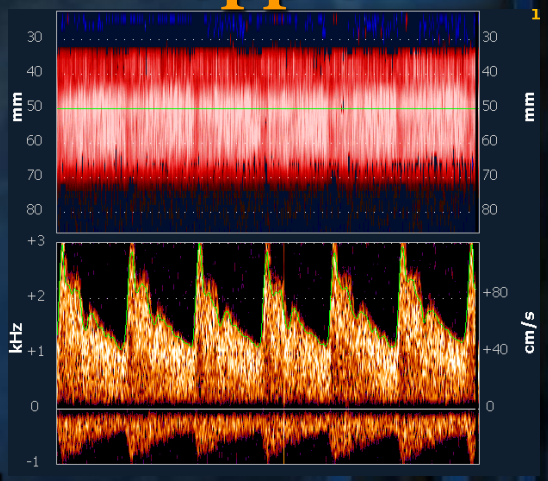
Single gate TCD

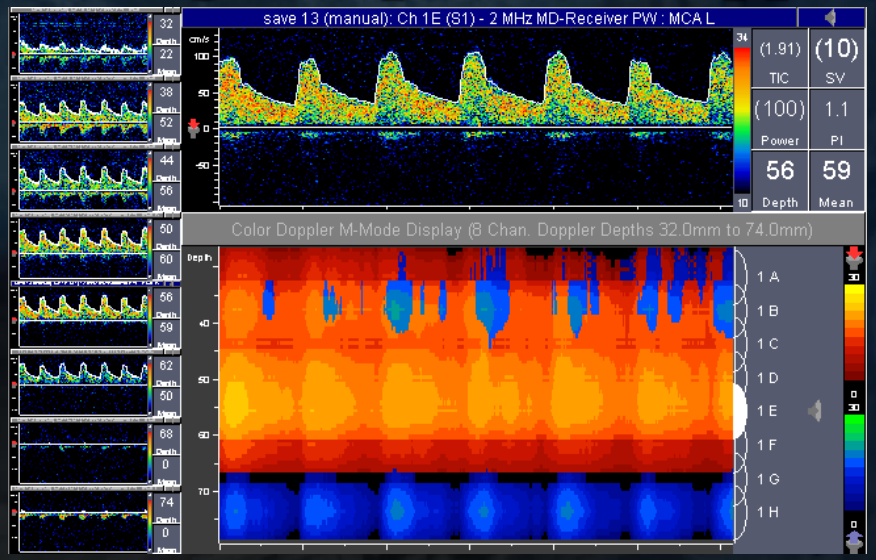




Power Motion Doppler



Multi-gate Spectral Doppler



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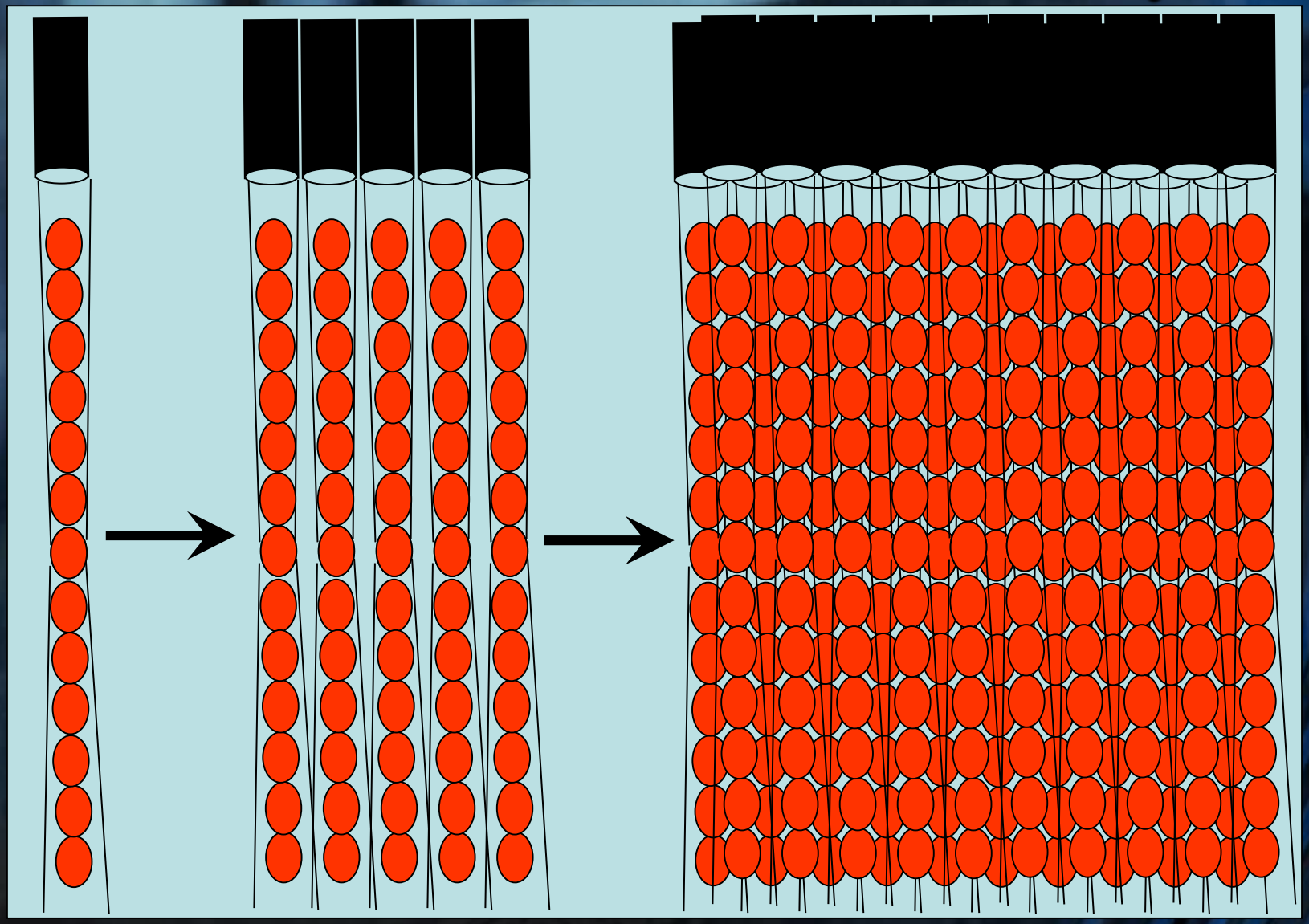
Multi-Transducer Linear Array



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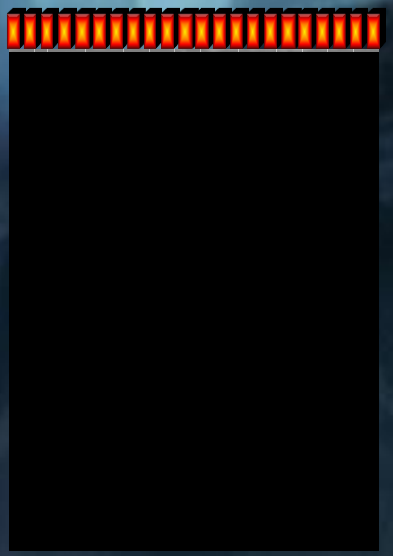
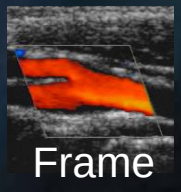
Conventional vs ZS Acquisition

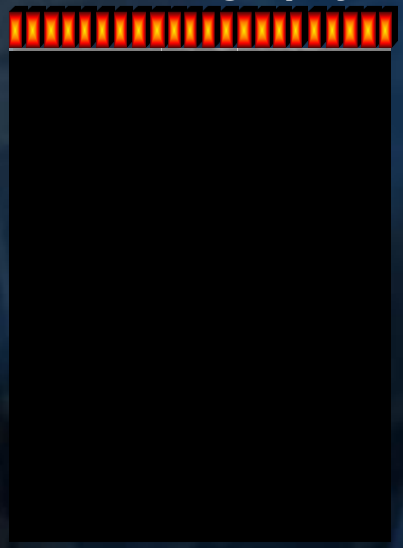
Conventional

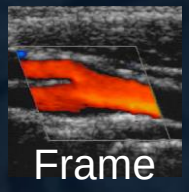




Frame

Zone Sonography™





Frame

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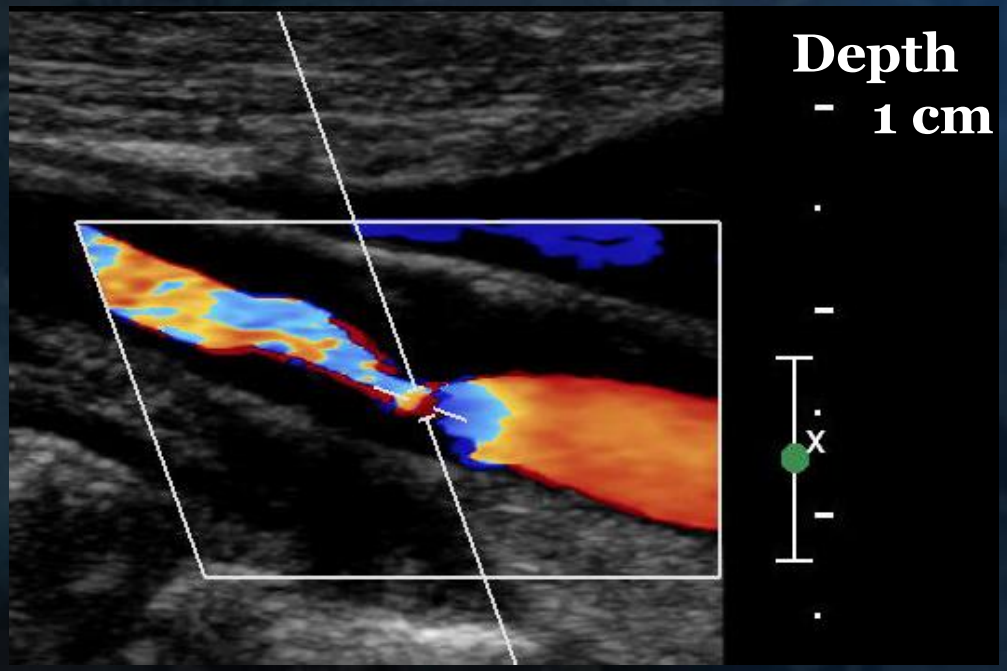
Key Elements of Duplex Imaging

Gray image = B-mode

Color flow = Doppler



B-mode – brightness of returned echoes

Doppler – frequency shift from moving blood

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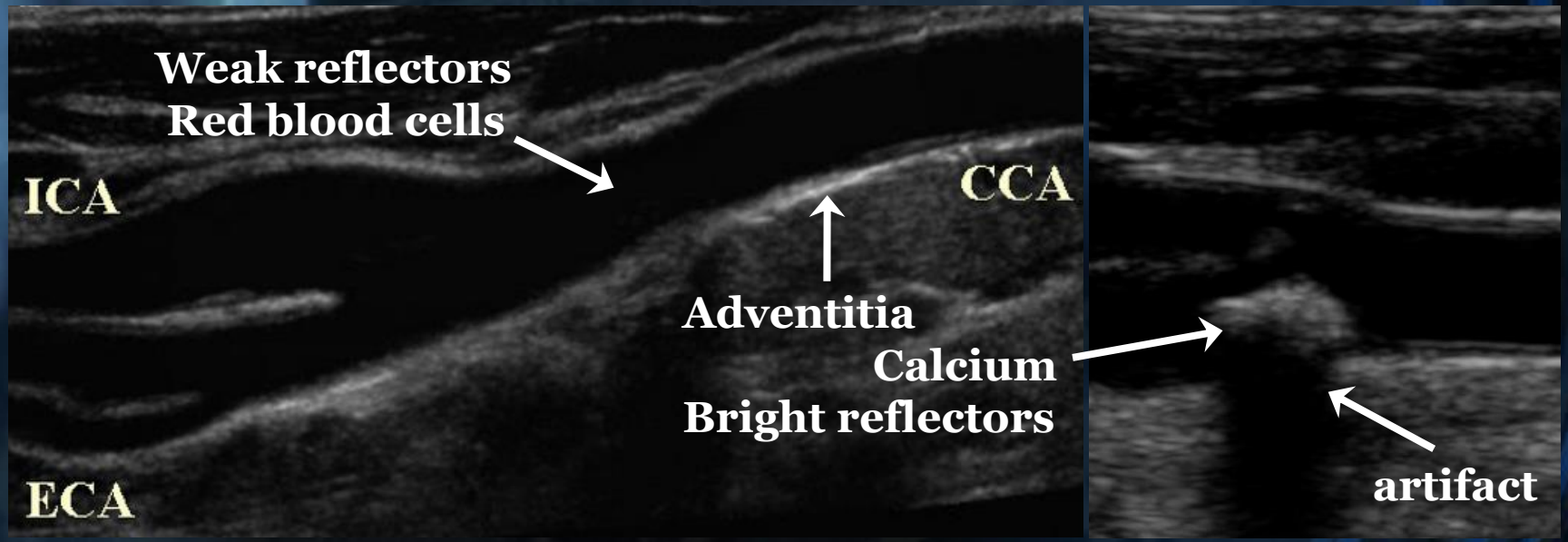
Brightness (B-mode) Ultrasound



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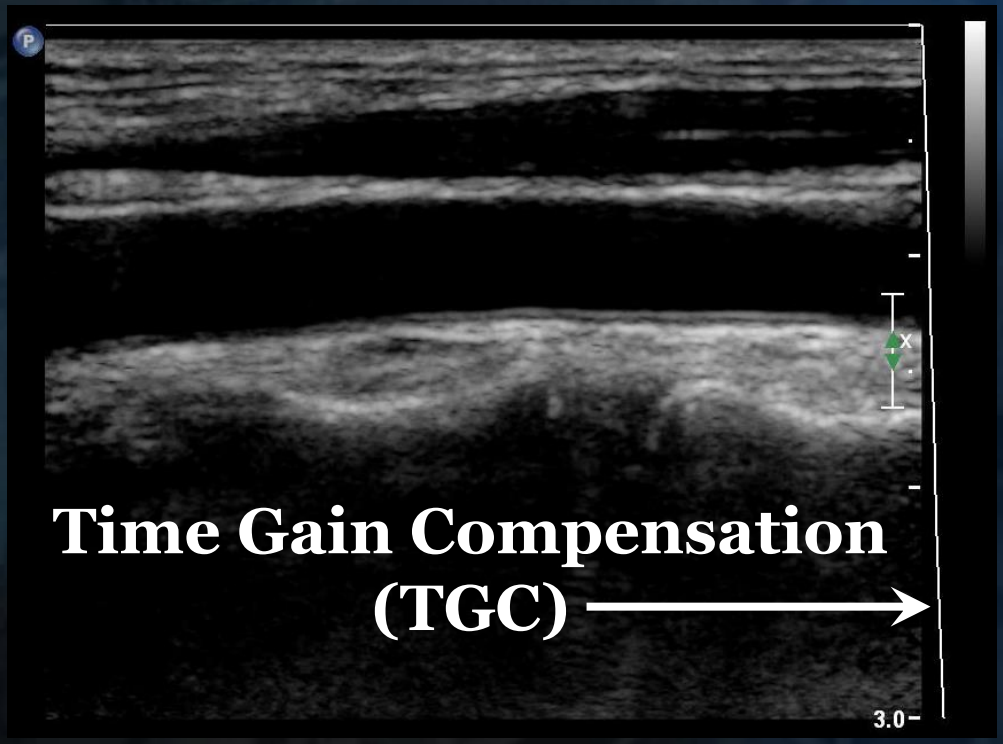
Key Elements of Duplex Imaging



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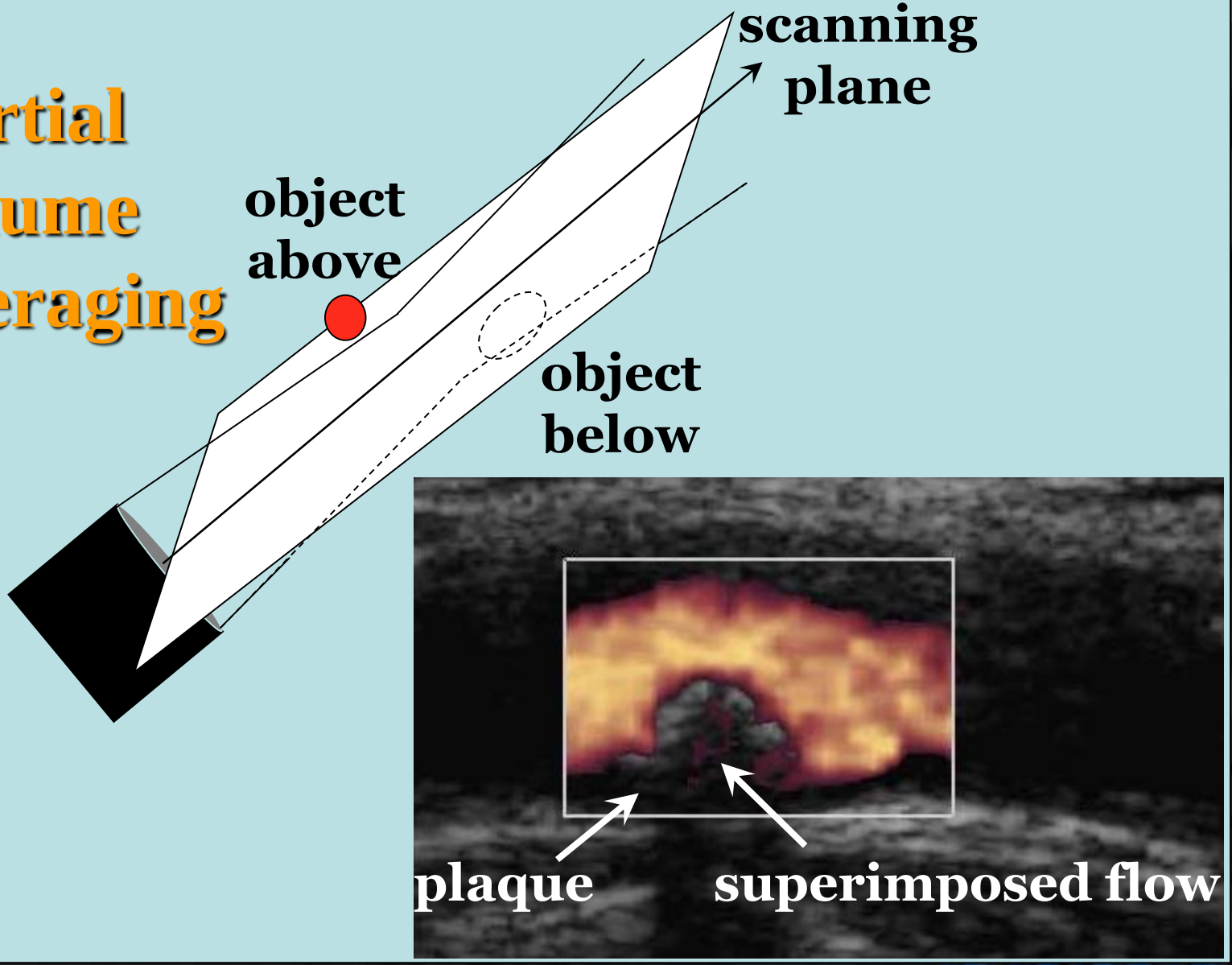
Partial volume averaging



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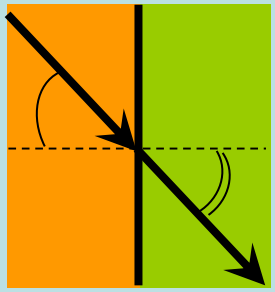
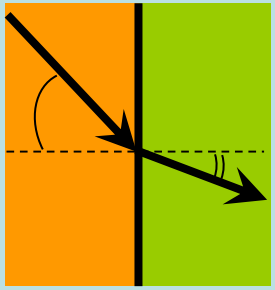
Refraction

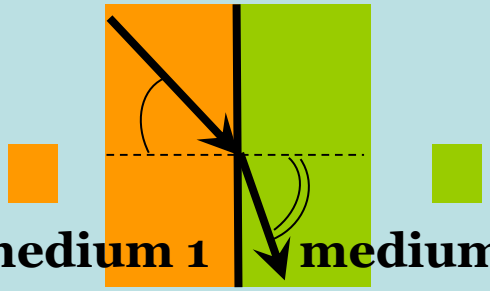
speed 1 = speed 2



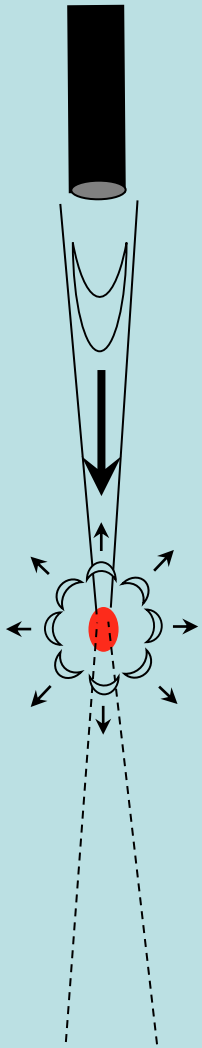
speed 1 > speed 2



speed 1 < speed 2



Rayleigh Scattering



wavelength and emitted pulse amplitude

red blood cell

reflected echo amplitude and direction

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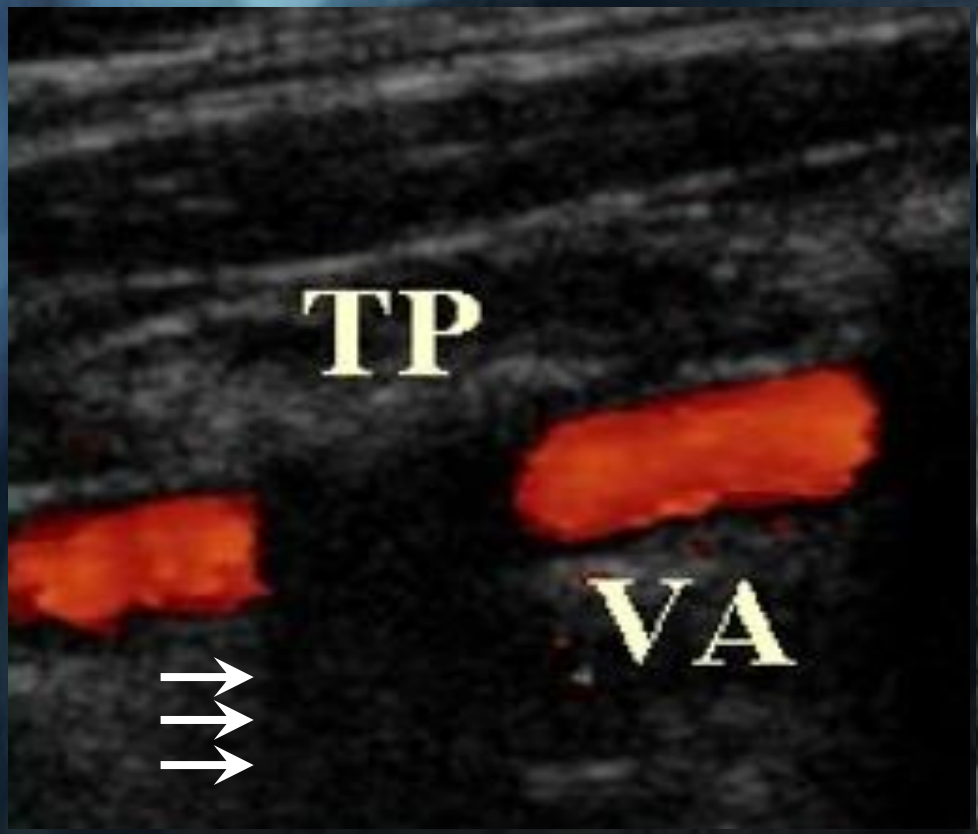
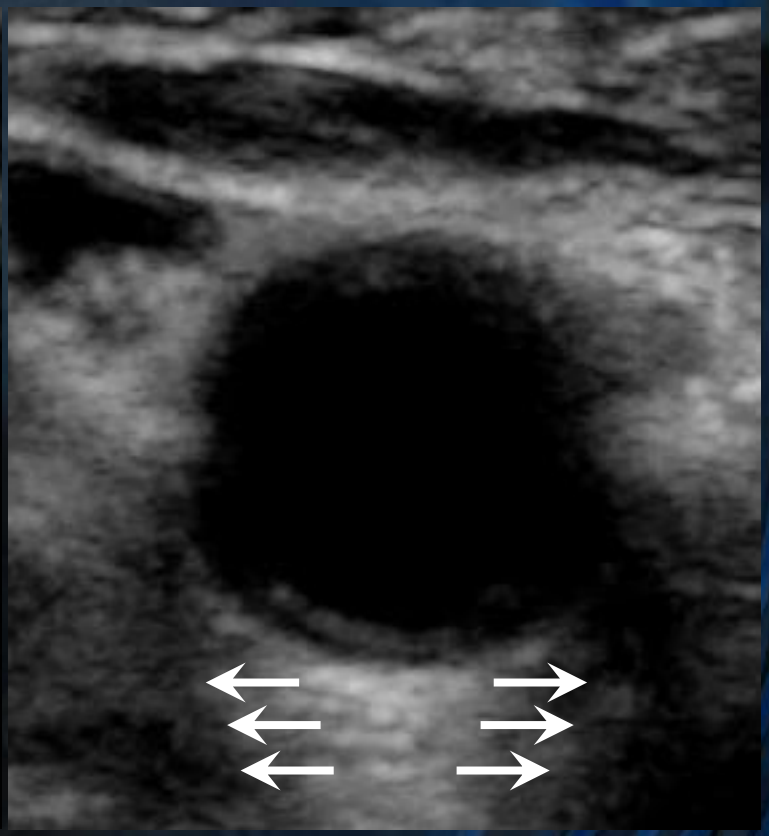
Shadowing Artifact





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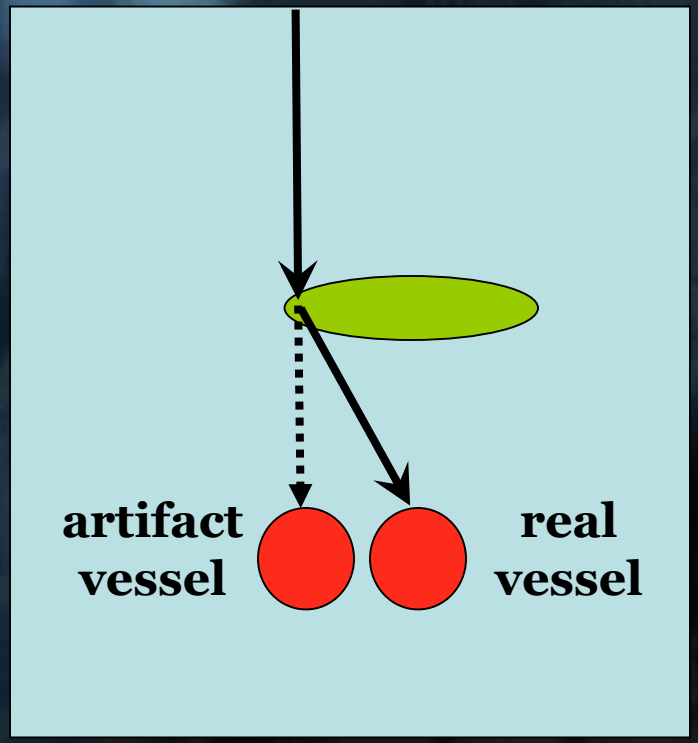
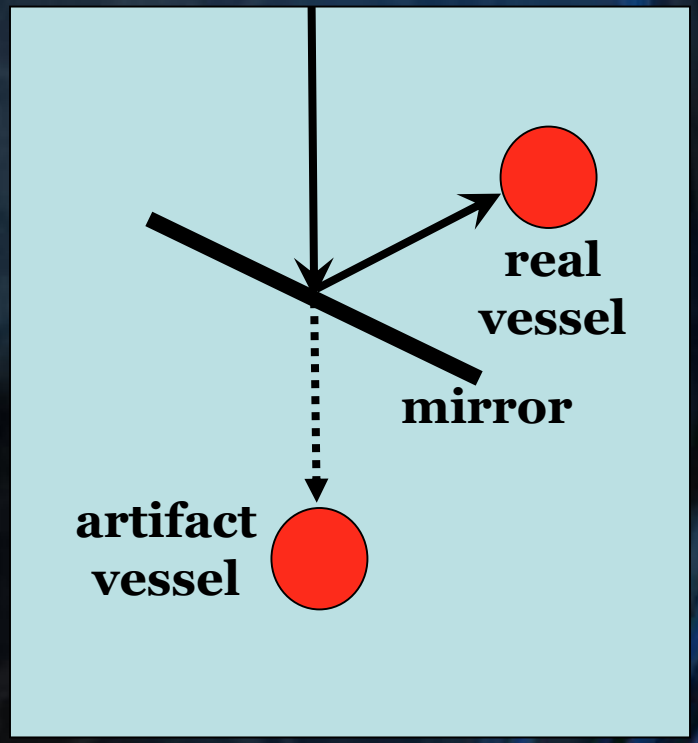
Refraction artifact



Mirror artifact



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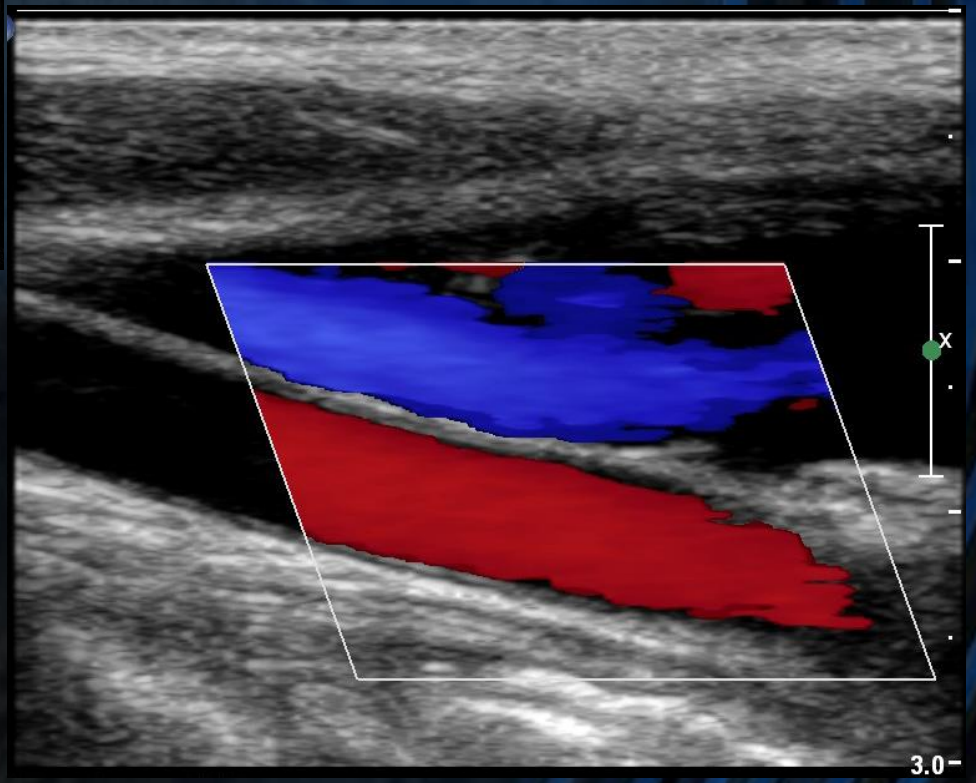

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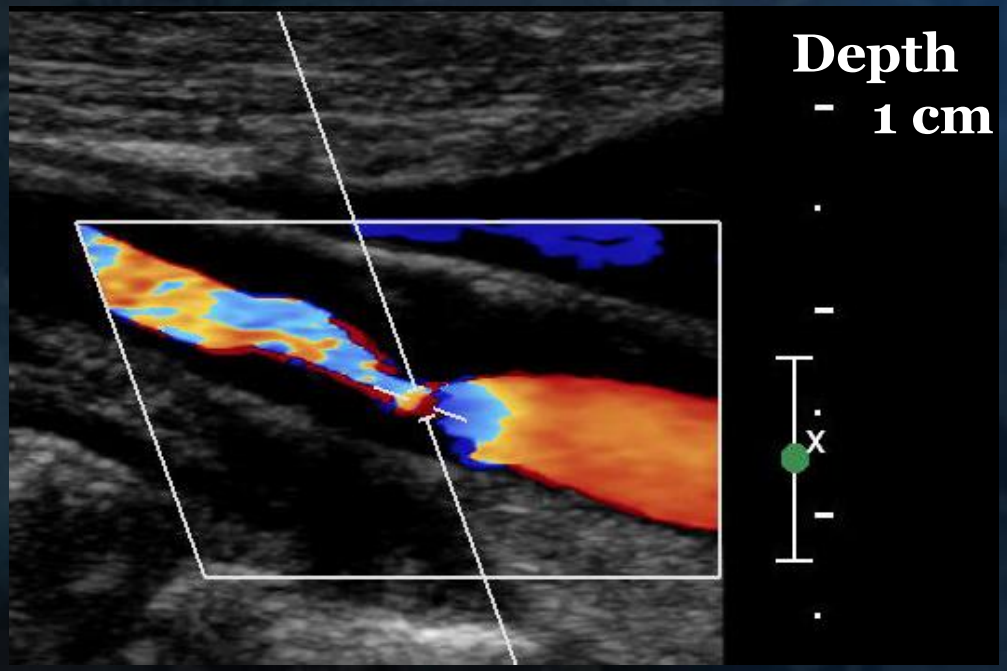
Which Artifact Does this Image Show?



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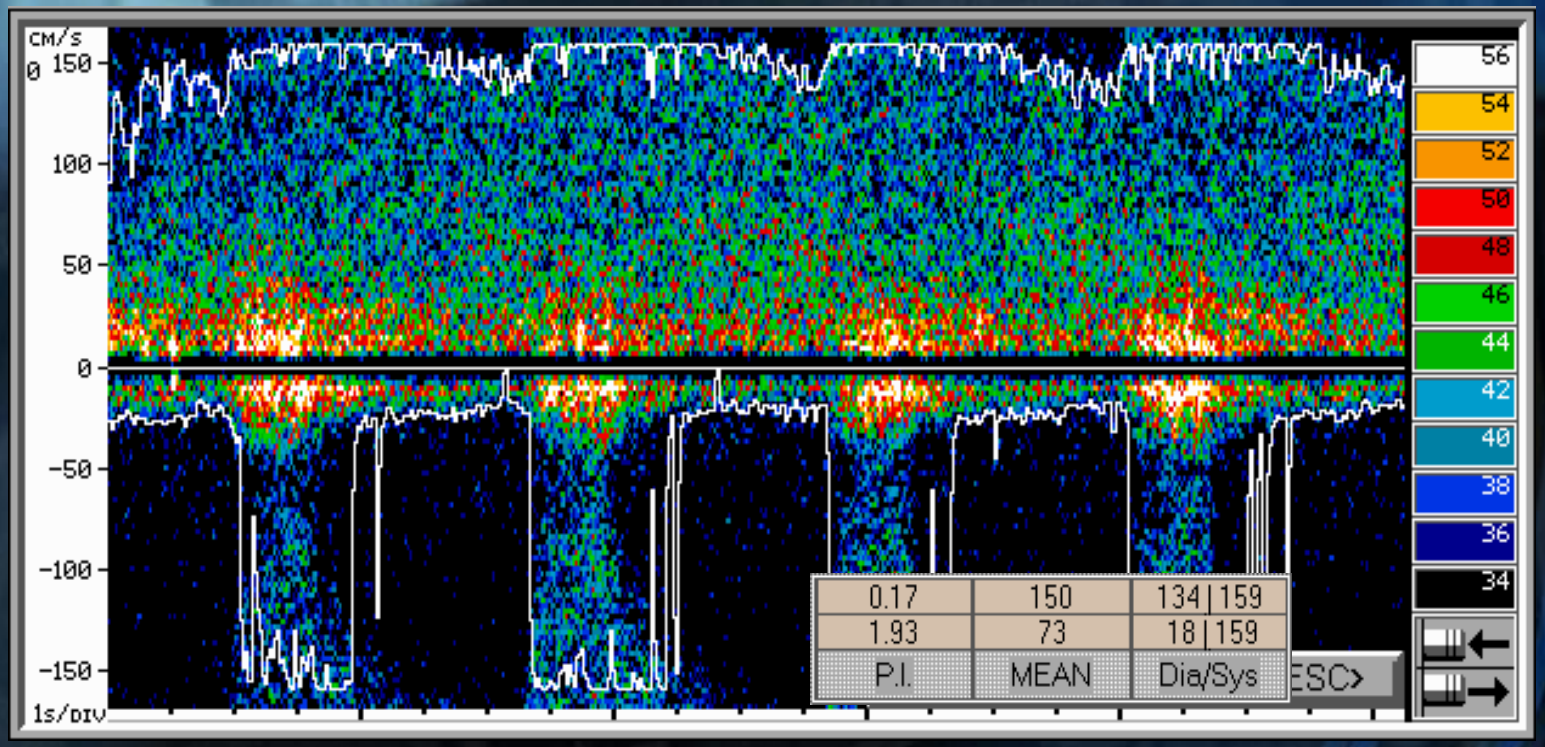
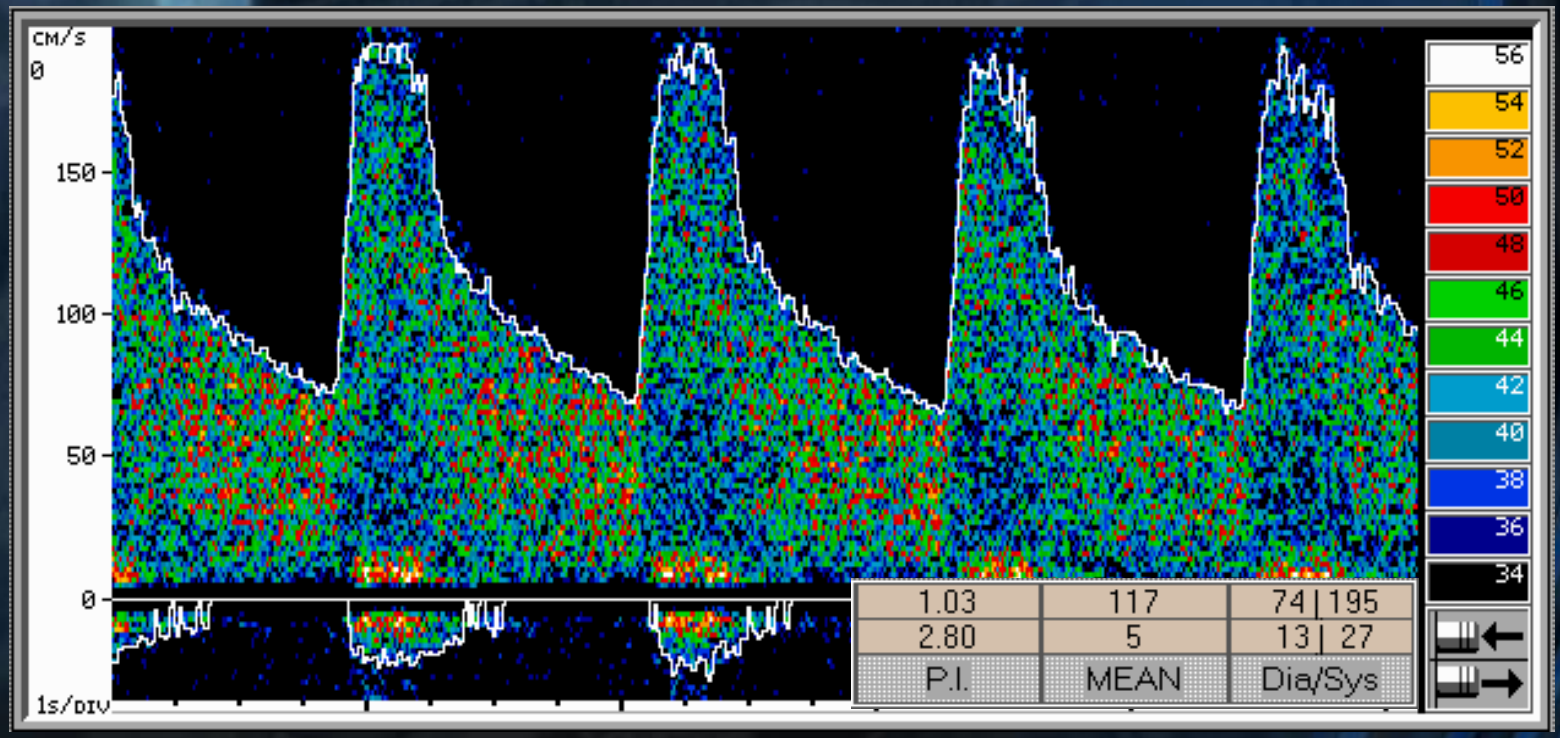


Alexandrov AV. Blackwell-Wiley: 2011

Flow Velocity Increase

single most valuable predictor of stenosis severity



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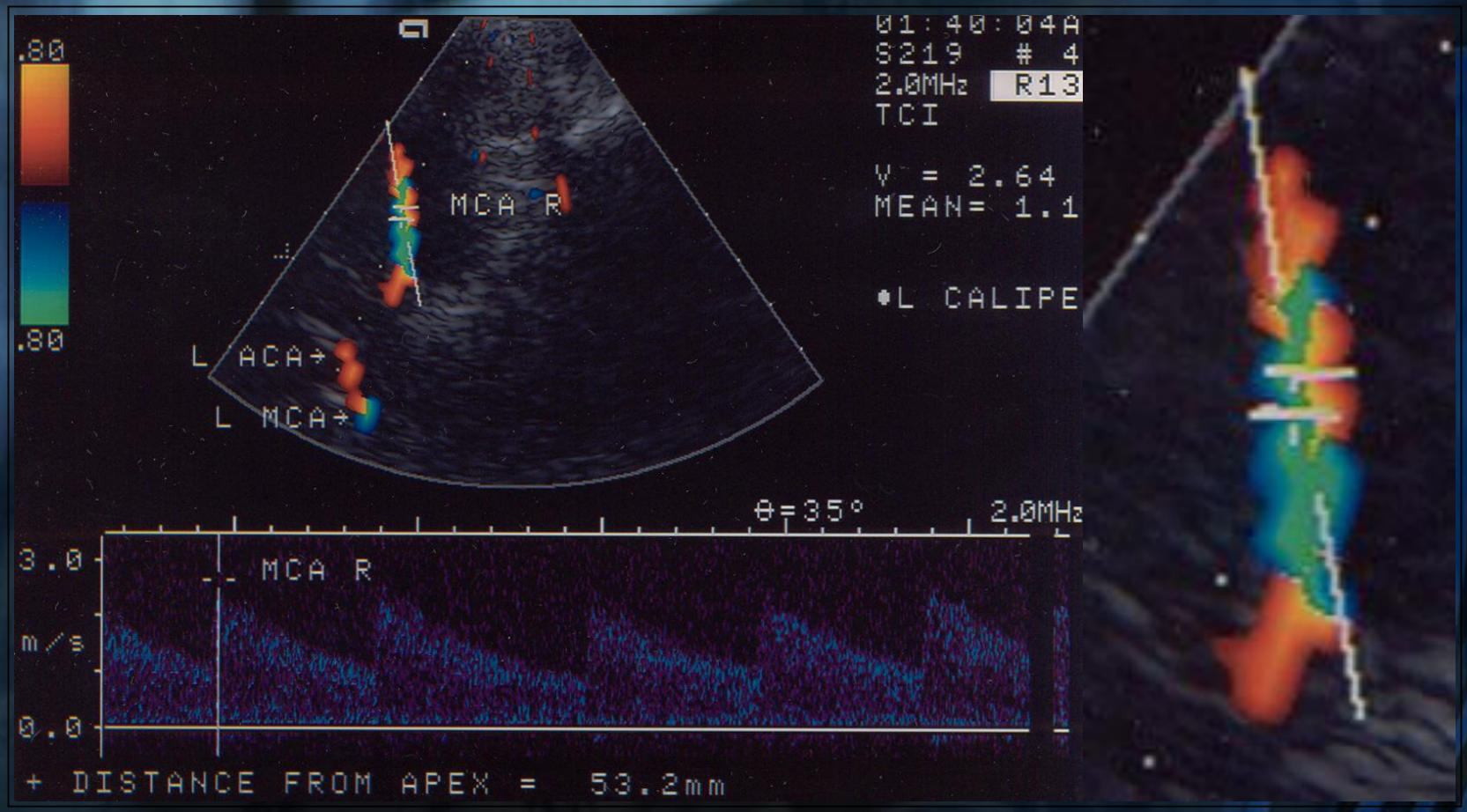

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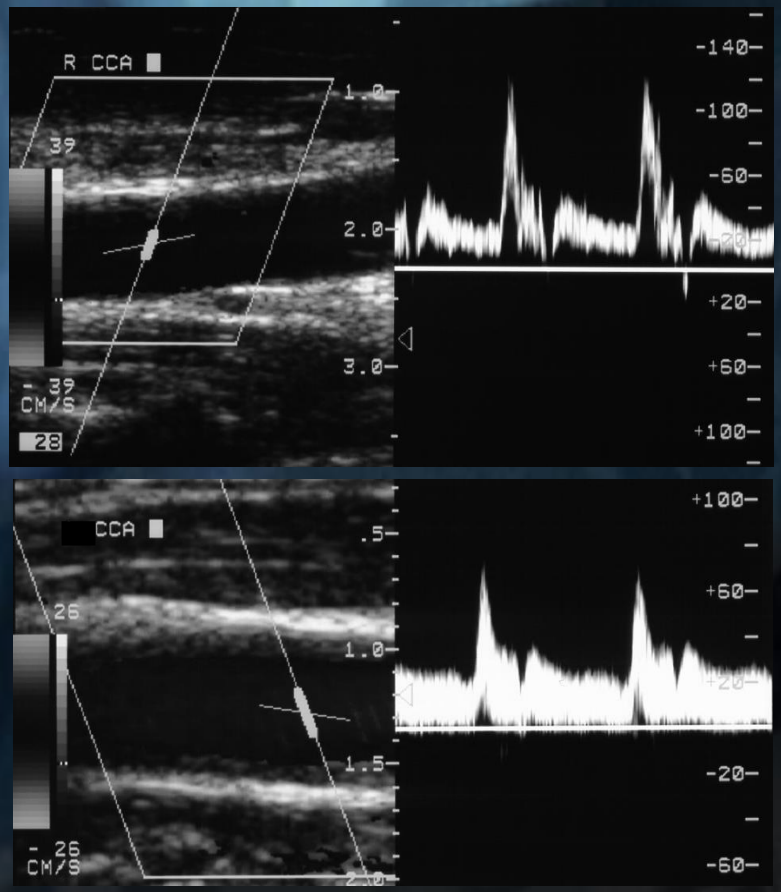
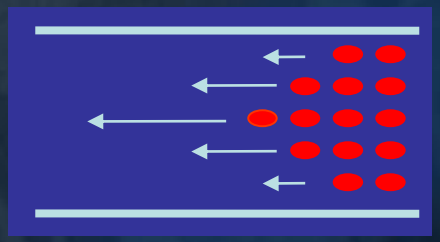
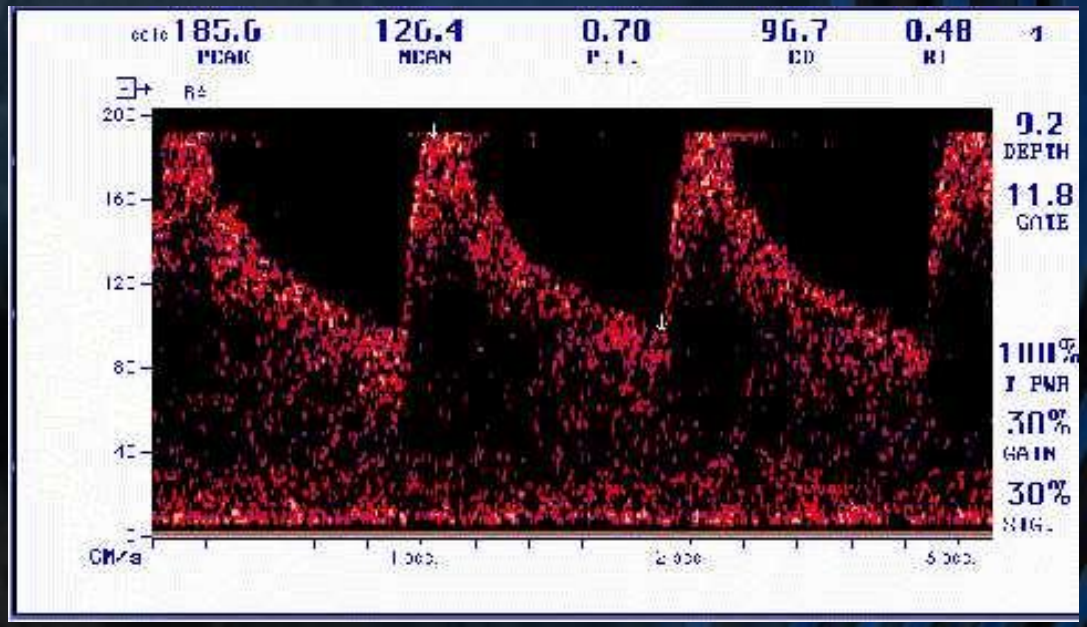
Imaging done by Eva Bartels, MD

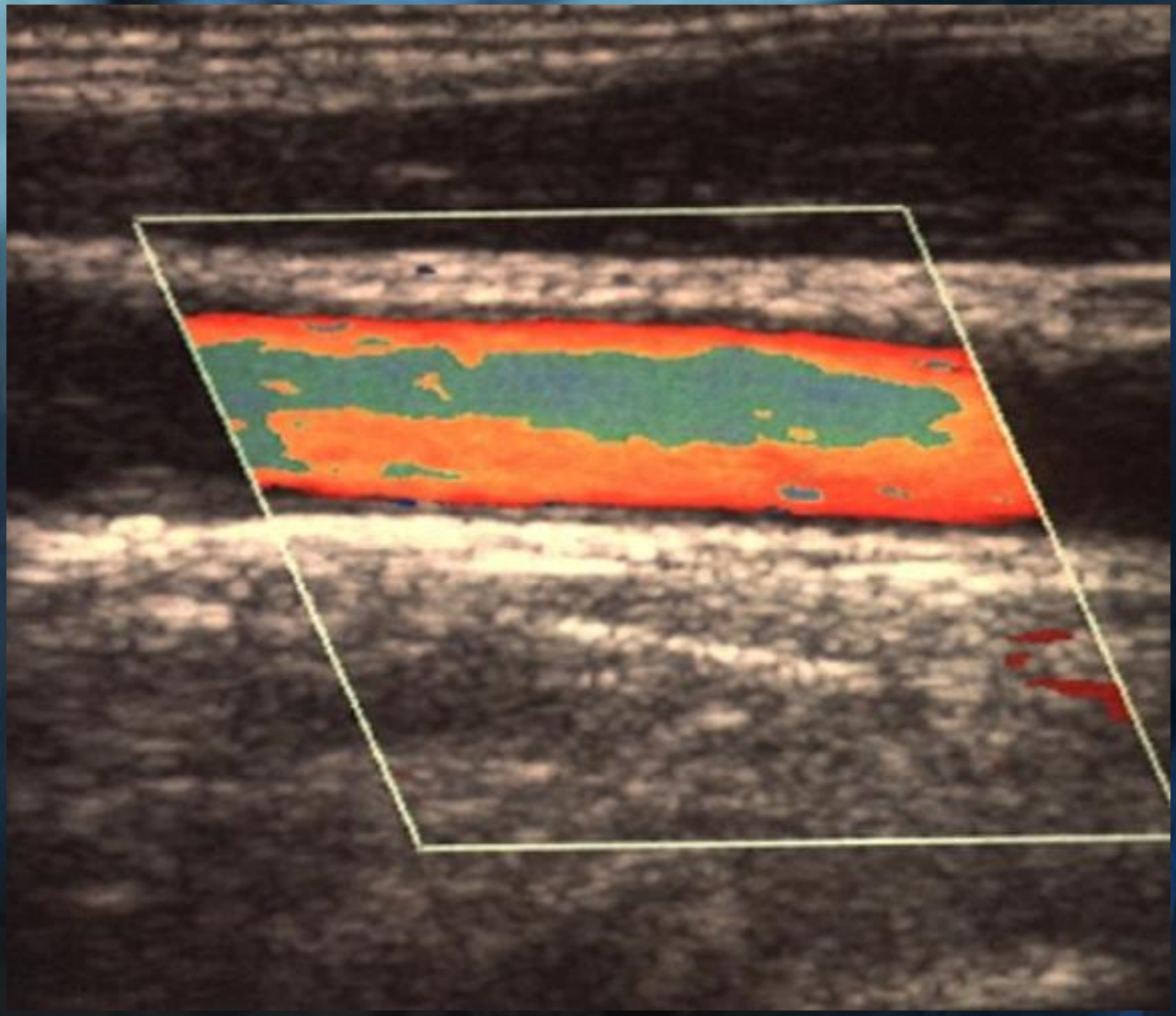
Spectral Broadening vs Narrowing







Alexandrov AV. Cerebrovascular Ultrasound in Stroke Treatment and Prevention. Blackwell: 2004.



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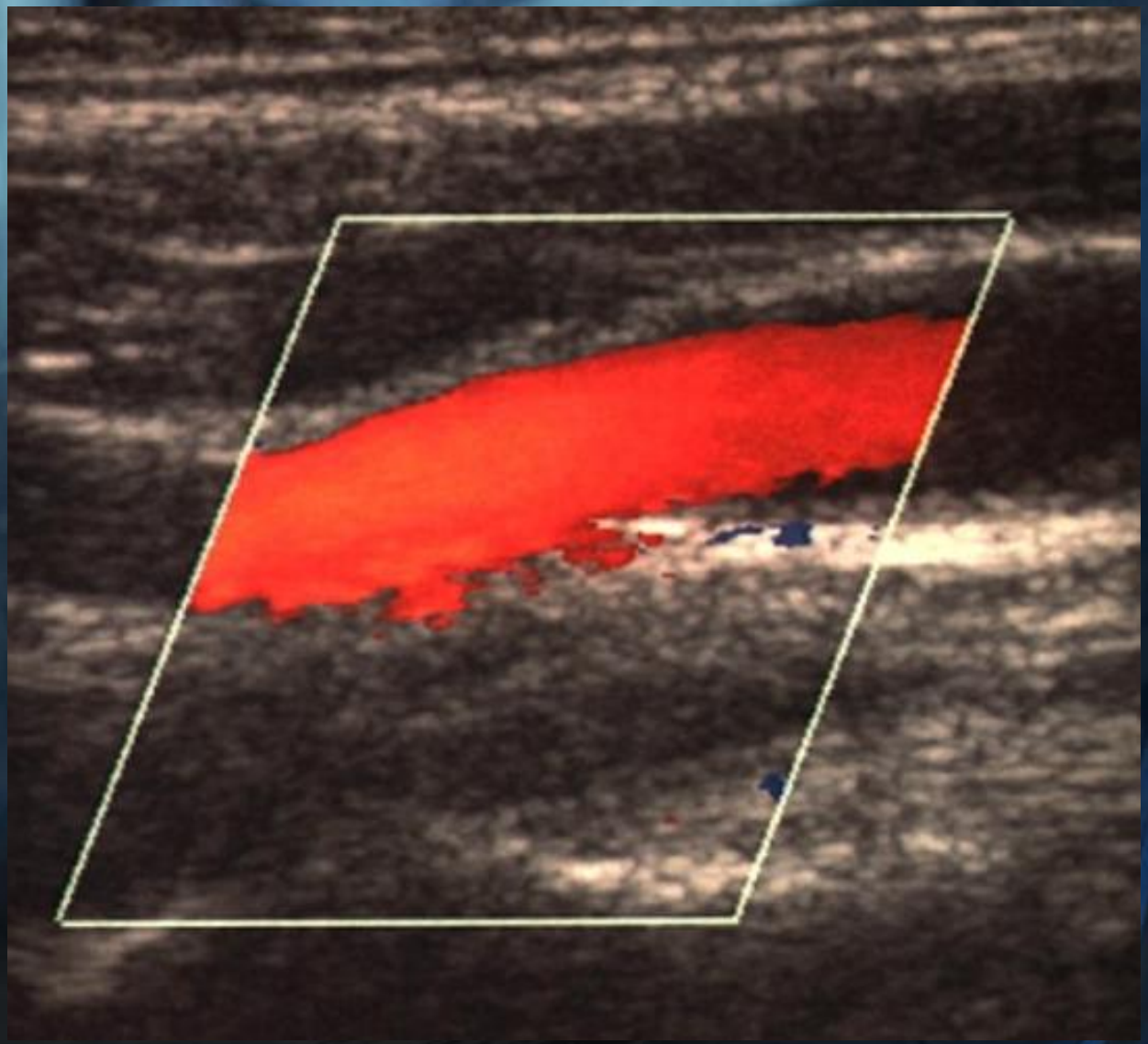

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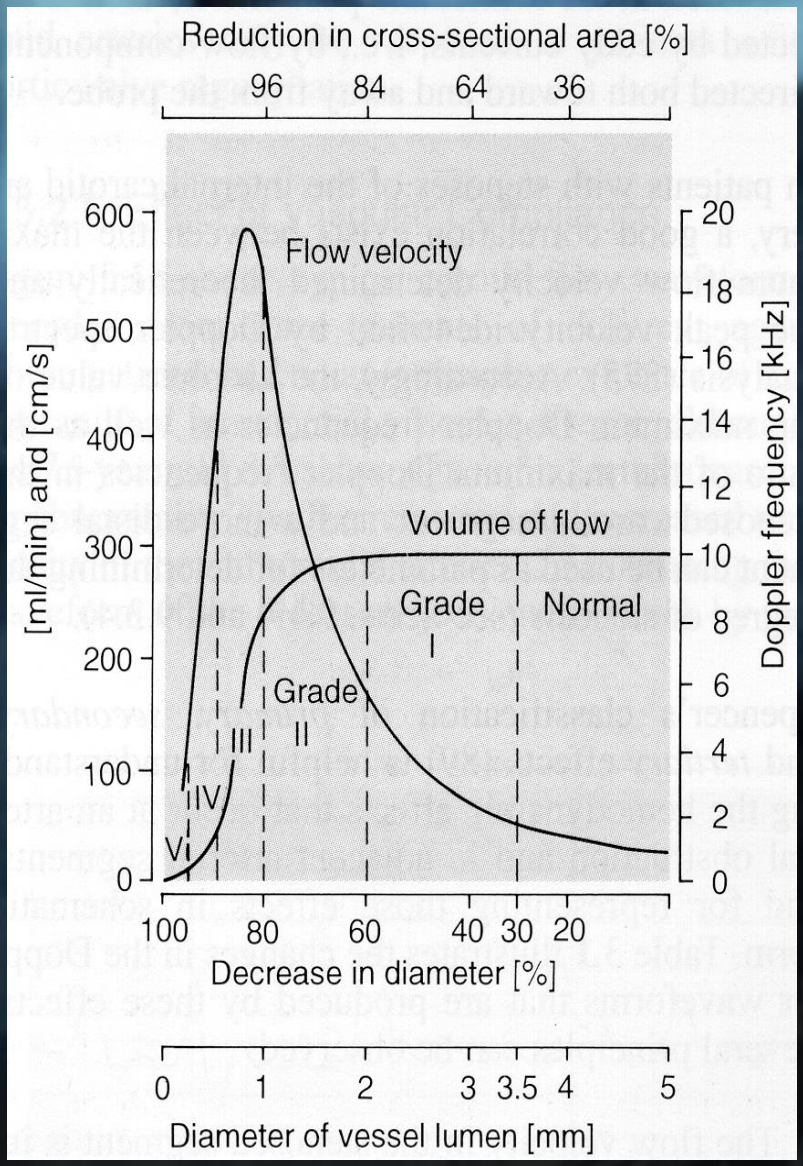

The Spencer's Curve

Spencer&Reid.
Stroke 1978.

Alexandrov AV. The Spencer's curve: clinical implications of a classic hemodynamic model.

J Neuroimaging 2007;17:6-10.