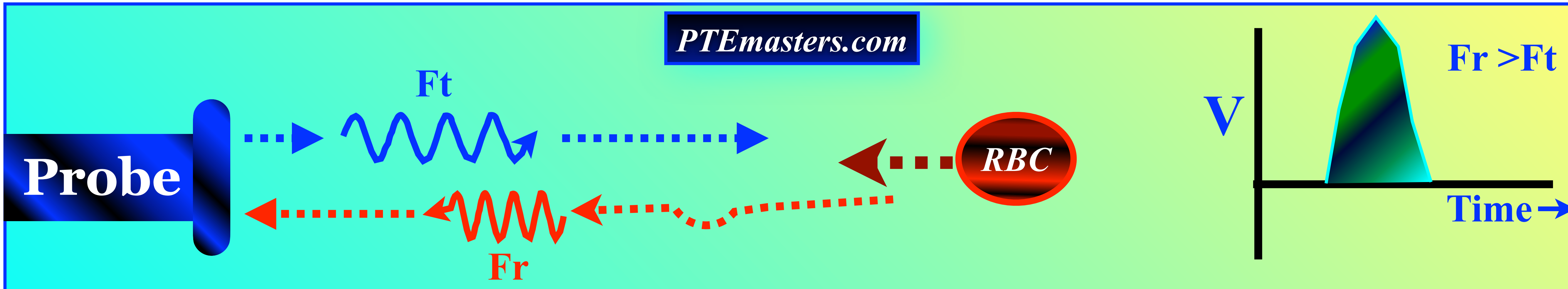
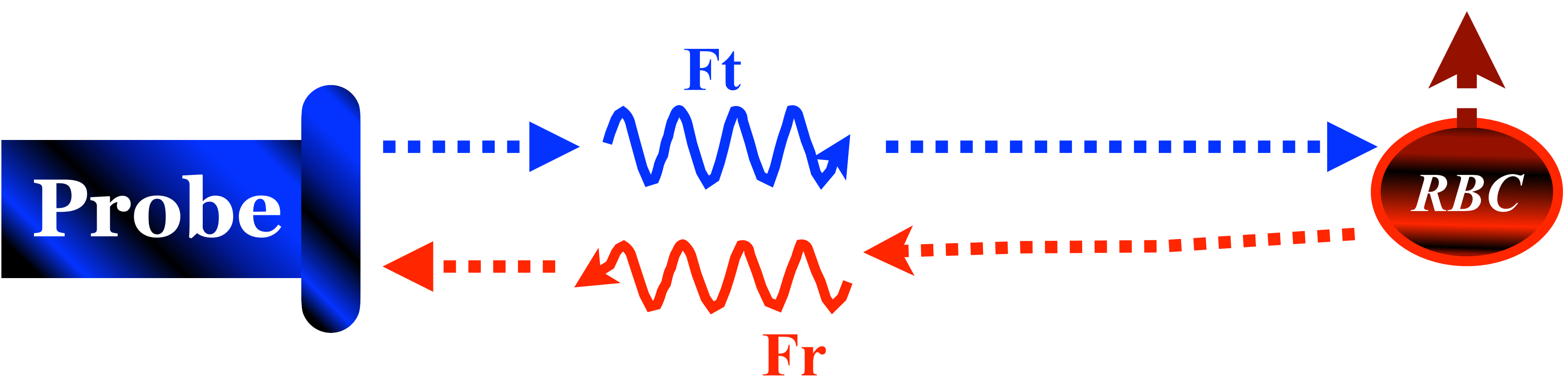
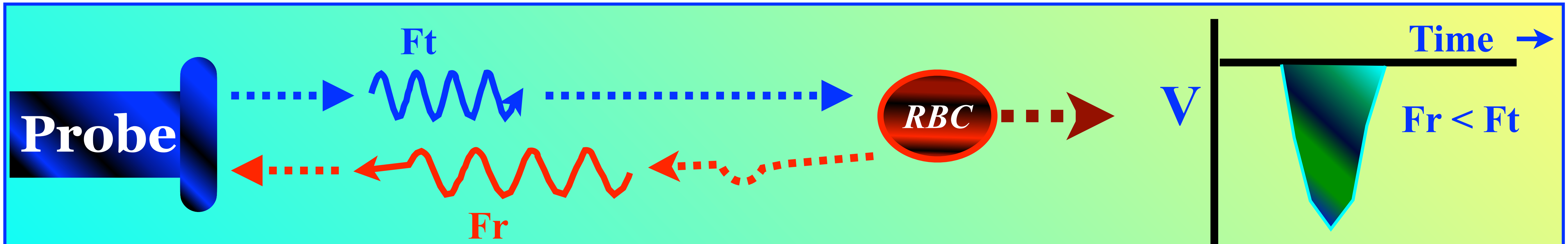


[Fr >Ft] $\therefore$ $\Delta F = (Fr - Ft)$ = Positive (above baseline)



[Fr =Ft] $\therefore$ $\Delta F = (Fr - Ft)$ = Zero (no flow detected)



[Fr <Ft] $\therefore$ $\Delta F = (Fr - Ft)$ = Negative (below baseline)

Flash Card: Doppler Equation

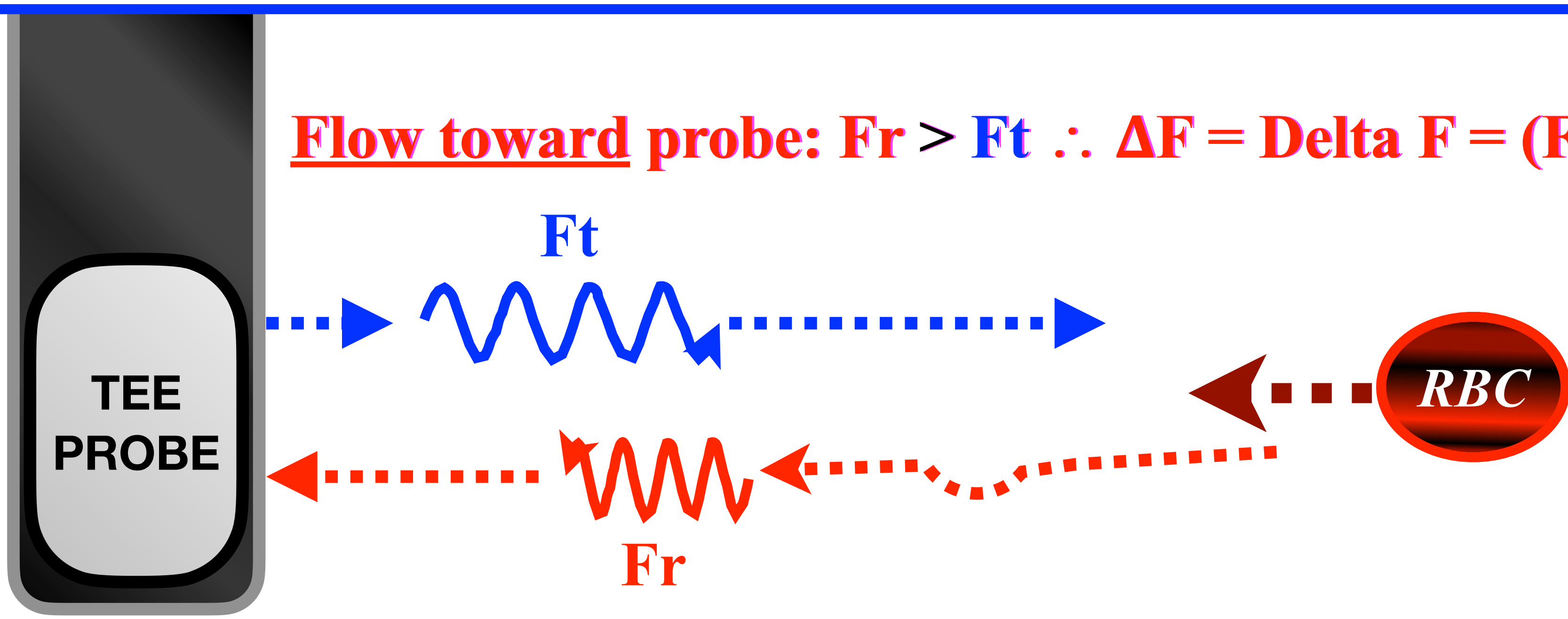
$$\Delta F = V \cos \theta \, 2 Ft / C$$

There is a two in this equation because there are two Doppler shifts.

ΔF = Delta F = (Fr – Ft)
V = velocity of blood flow, This is what we are solving for!
θ = Theta =angle between the US beam and blood flow.
C = 1.54 mm/microsecond = 1540 m/s (speed of sound in soft tissue) (memorize this)

Fr = freq received
Ft = freq transmitted

Flow toward probe: Fr > Ft ∴ ΔF = Delta F = (Fr – Ft) = Positive (above baseline)



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Rewatch the Doppler lectures!

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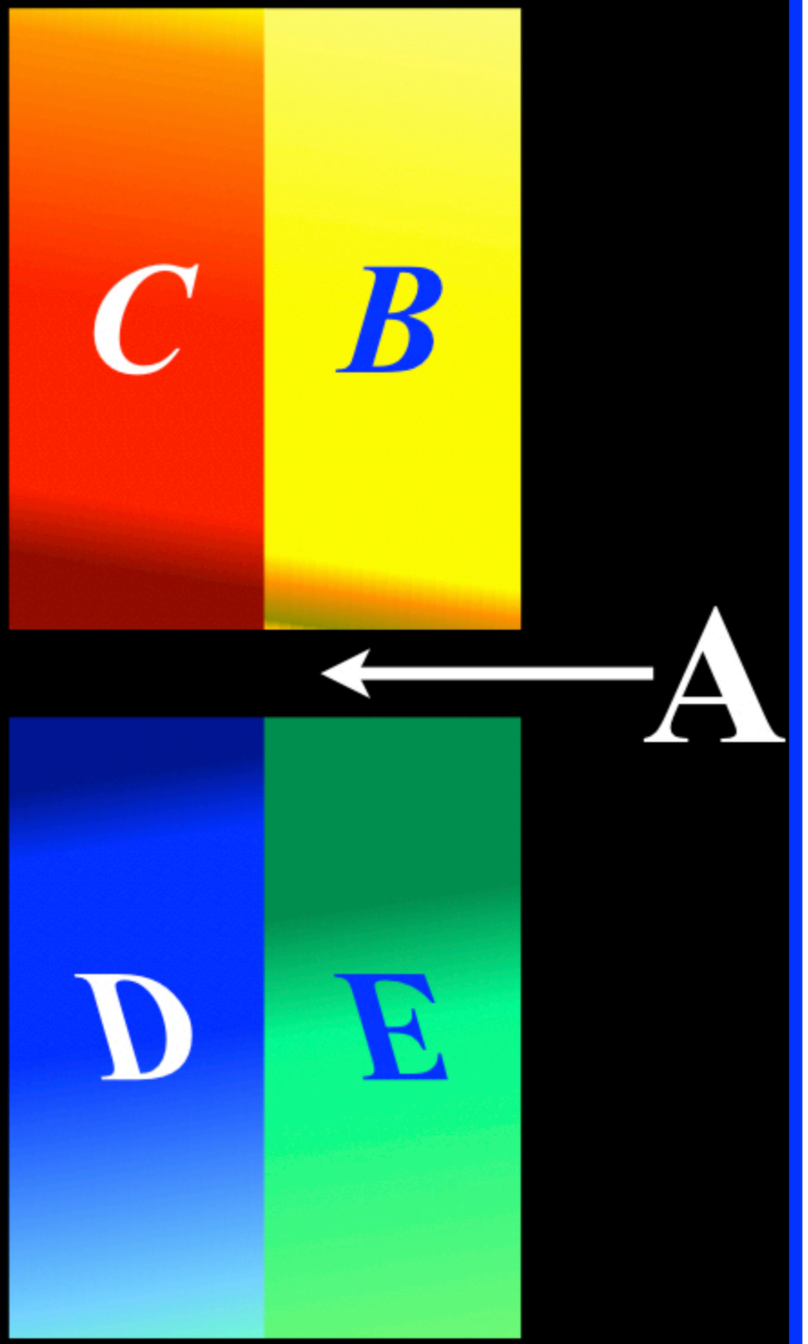

A color MAP = variance map is shown.

The type of flow (velocities) coded for by the color map are as follows:

A = Black = No Doppler shift. No flow detected.

B = Yellow = Turbulent flow toward the probe

C = Red = Laminar flow toward the probe

D = Blue = Laminar away from the probe

E = Green = Turbulent away

References:

1. Understanding Ultrasound Physics by Edelman, SK, 3rd ed. Pages 314

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$\Delta F = V \cos \theta 2Ft / C$

The Nyquist limit is the max Doppler shift (NOT max velocity) that can be measured.

Nyquist limit = ½ x PRF (PRF = pulse repetition frequency)

PRP = pulse repetition period = inverse of PRF, thus Nyquist limit = 2 x PRP.

The Nyquist limit is a delta F = Doppler shift = a Frequency.

The Nyquist limit is also called the Nyquist frequency.

A negative Doppler shift is displayed below the baseline.

A positive Doppler shift is displayed above the baseline

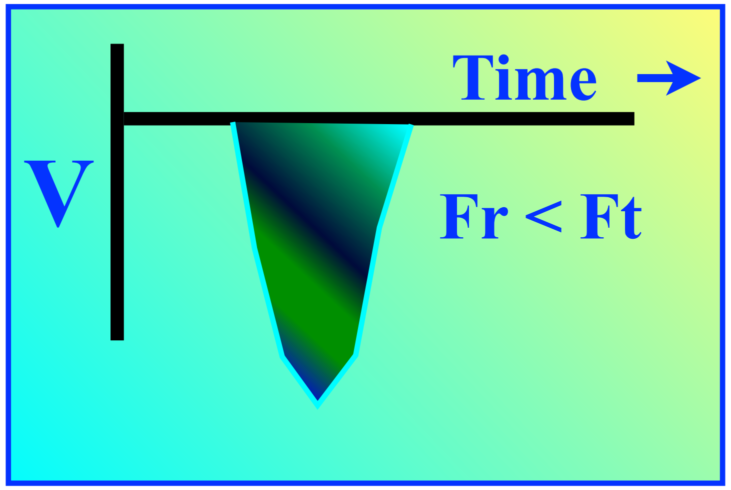
Red cells moving away from the probe cause a NEGATIVE Doppler shift or Delta F.

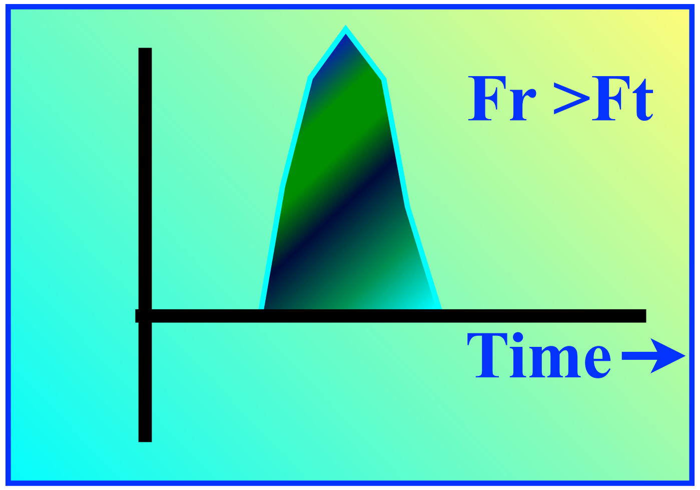
Red cells moving toward the probe will cause a POSITIVE Doppler shift or Delta F = (Received Freq – Transmitted Freq)

ΔF = (Received Freq – Transmitted Freq) = (FR – FT)

A negative Doppler shift occurs when the frequency received is LESS than the frequency transmitted.

A positive Doppler shift occurs when the frequency received is MORE than the frequency transmitted.





References:

1. Understanding Ultrasound Physics by Edelman, SK, 3rd ed. Page 296
2. Mathew, JP et. al. Clinical Manual and Review of TEE, 3rd ed. McGraw-Hill 2019:13-16

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Flash Card Opportunity:

IF Doppler angle is >0, V is underestimated.

Cosine 0 degrees = 1 (estimates actual velocity)

Cosine 20 degrees = 0.94 (6% underestimate of V)

Cosine 30 degrees = 0.87 (13% underestimation of V)

Cosine 50 degrees = 0.64 (36% underestimate of V)

Cosine 60 degrees = 0.50 (50% underestimate of V)

Cosine 90 degrees = 0 (No Doppler shift, No Velocity detected)

Aliasing artifact occurs if the Doppler shift has exceeded ½ PRF.

½ x PRF is known as the Nyquist limit or Nyquist frequency.

If the PRF is increased, it means that ½ x PRF is also increased and if ½ PRF is increased it makes it less likely that the Doppler shift will exceed this "Nyquist limit = Nyquist frequency".

So, if PRF is increased, ½ PRF = Nyquist limit is increased and aliasing is less likely.

½ x PRF = Nyquist limit (Nyquist frequency) = the Doppler shift above which aliasing artifact occurs.

4 Ways to decrease aliasing artifact:

1. **Decrease the depth of the sample volume**
2. **Lower the transmitted frequency**
3. **Adjust (optimize) the baseline to focus on the flow of interest**
4. **Use continuous wave Doppler.**

Decreasing the transmitted frequency (Ft) will **decrease** ***aliasing artifact***.

I remember this in the following way (might not be perfectly correct but works for me):

IF the transmitted frequency (FT) is decreased, then the calculated Doppler shift (**Δ**F) will be lower. We see this when we look at the Doppler equation:

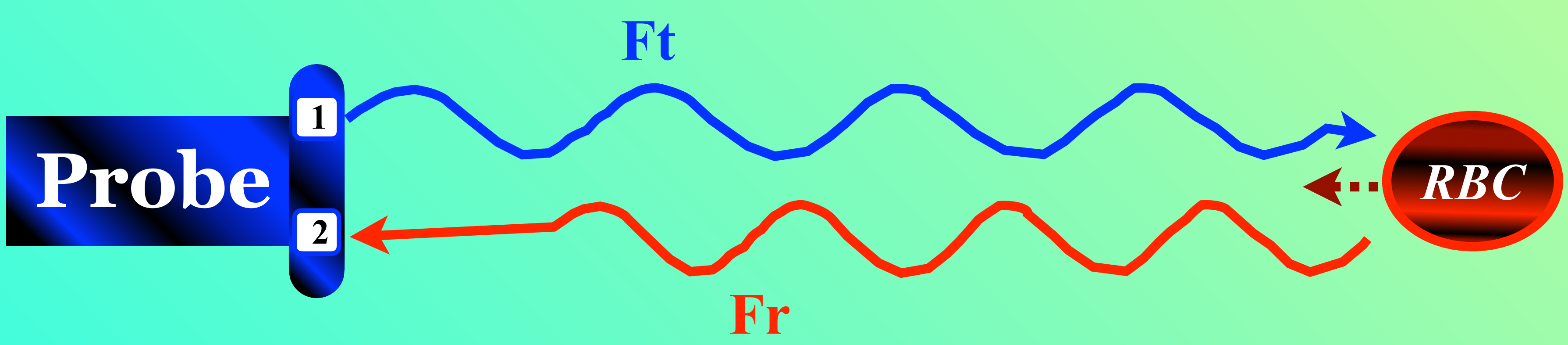
$\Delta F = V \cos\theta \, 2Ft / C$

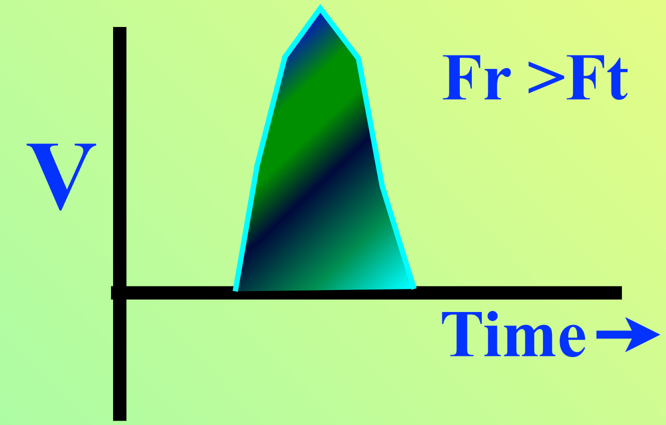
If Ft is lower, then the calculated **Δ** F is lower, and it is less likely to exceed the max **Δ** F or Nyquist frequency = Nyquist limit = ½ x PRF.

References:

1. Understanding Ultrasound Physics by Edelman, SK, 3rd ed. Pages 308-309

CW = Continuous Wave Doppler





[Fr >Ft] $\therefore$ ΔF =(Fr – Ft) = Positive (above baseline)

CW: TWO crystals: 1 & 2
One continuously sending (1)
One continuously receiving (2)

CW Doppler involves NO damping

CW Doppler transducers have a narrow = small bandwidth.

CW Doppler transducers have a high Q factor = Quality factor.

Q factor = Quality factor = Resonant frequency / bandwidth

CW has NO Damping and this gives them a small band width, and increases Q factor.

CW Doppler transducers have two crystals: one continuously sending, one continuously receiving.

CW Doppler can measure high velocities.

CW Doppler lacks the ability to pin point the exact location of velocities

(No range resolution = range ambiguity).

Aliasing does NOT occur with CW Doppler.

References:

1. Understanding Ultrasound Physics by Edelman, SK, 3rd ed. Page 296

2. Mathew, JP et. al. Clinical Manual and Review of TEE, 3rd ed. McGraw-Hill 2019:13-16