Medical Diagnostic Ultrasound

Blood velocity measurements (Doppler Systems)

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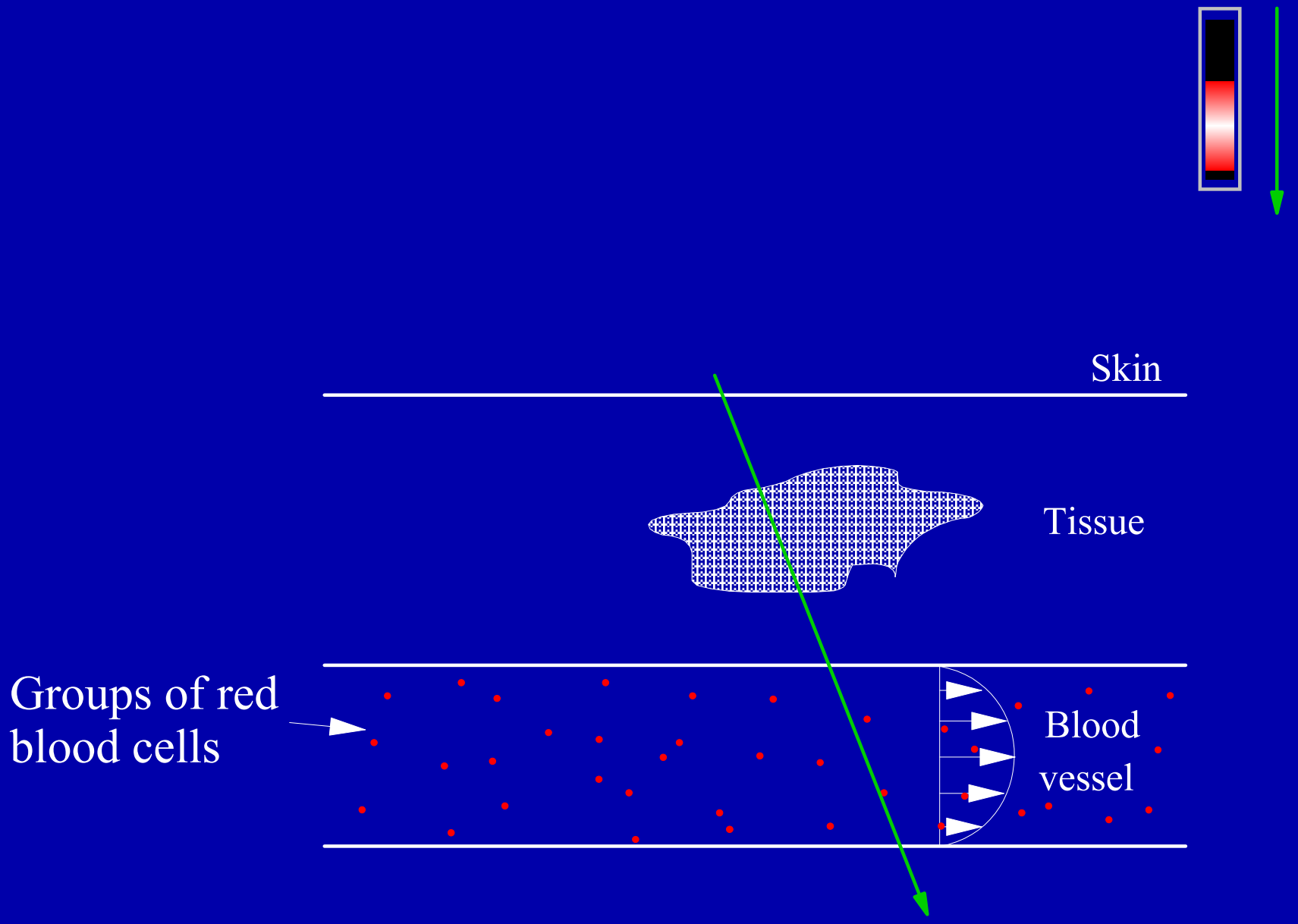
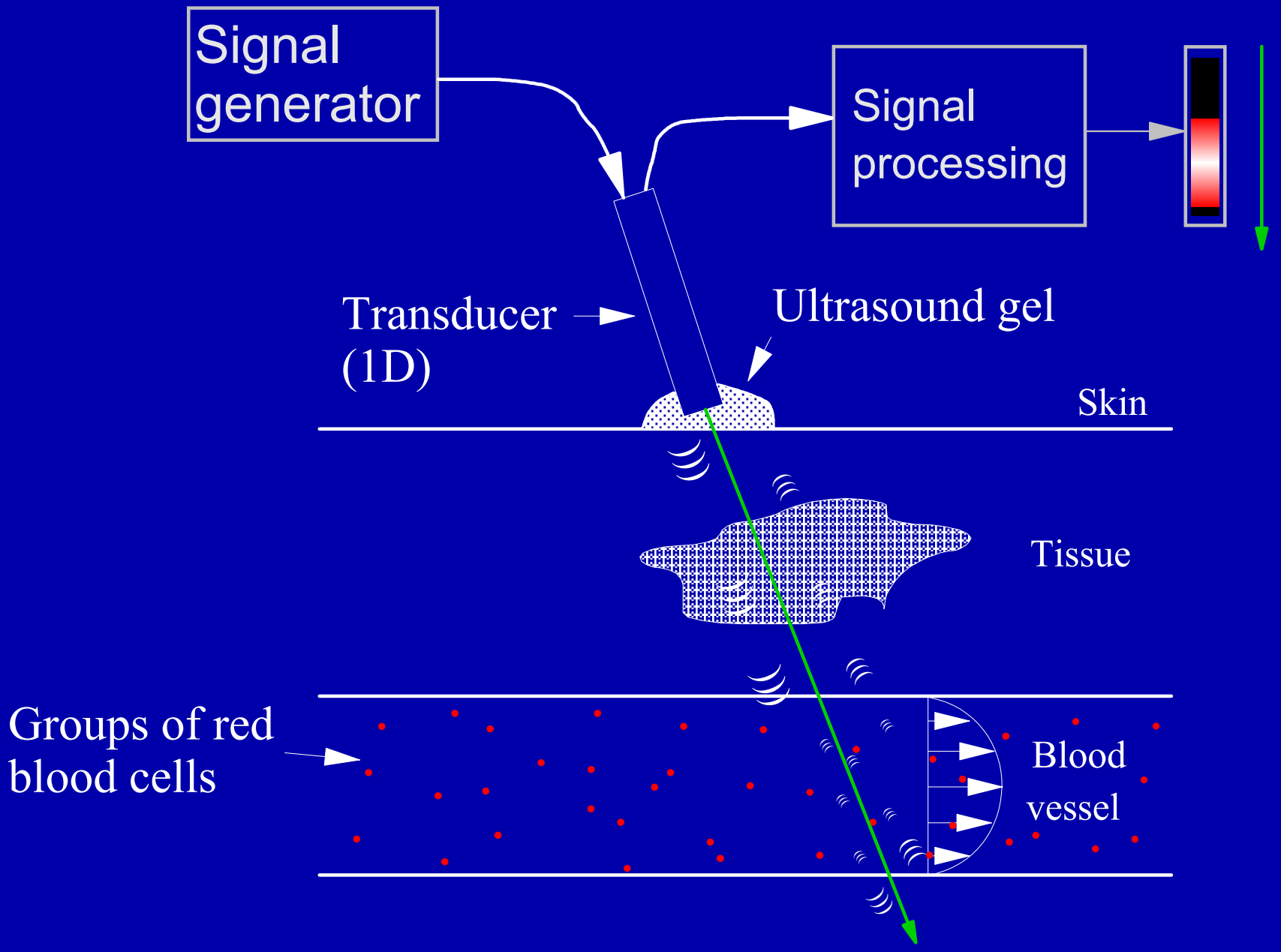
The basic measurement situation



The basic measurement situation

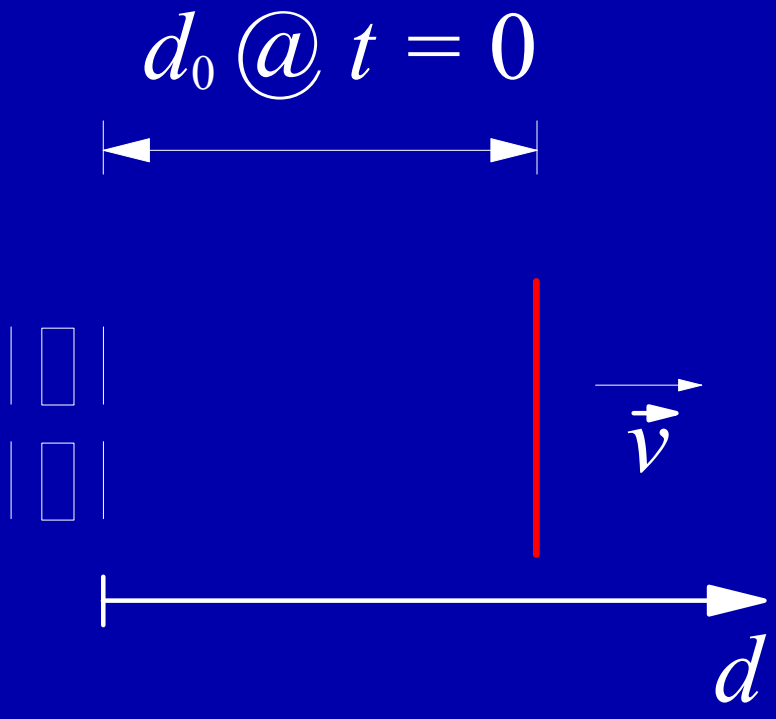


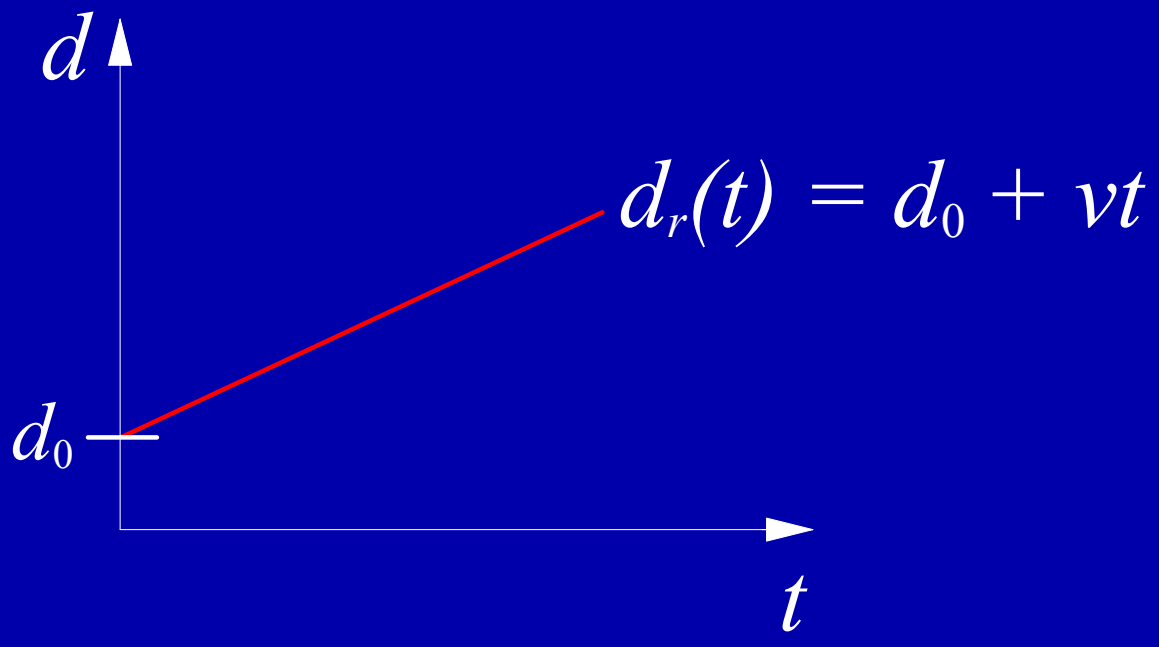
The echo signal from blood

- **Blood consist of:**
  - ►55 % Plasma
  - ►45 % Erythrocytes = red blood cells (Ø = 8.5 µm)
  - ►~1 % Leukocytes = white blood cells (Ø = 7 - 12 µm)
  - ►<0.1 % Platelets (Ø = 2 - 3 µm)

Thus, the red blood cells are responsible for the scattering of ultrasound from blood. The scattering is very weak, and normally, vessel lumens appears black on ultrasound images.

Compression/expansion of emitted signal: The "wide band" Doppler effect

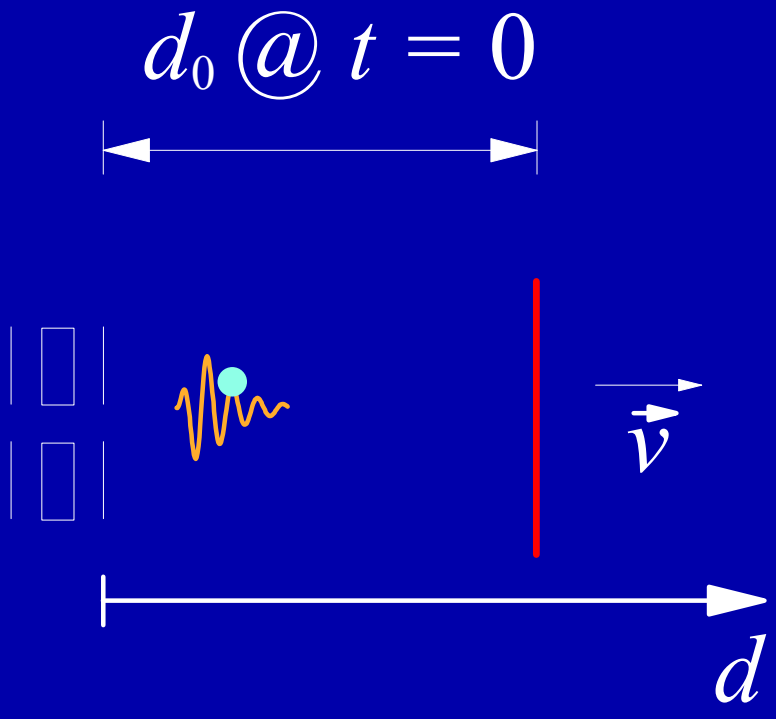


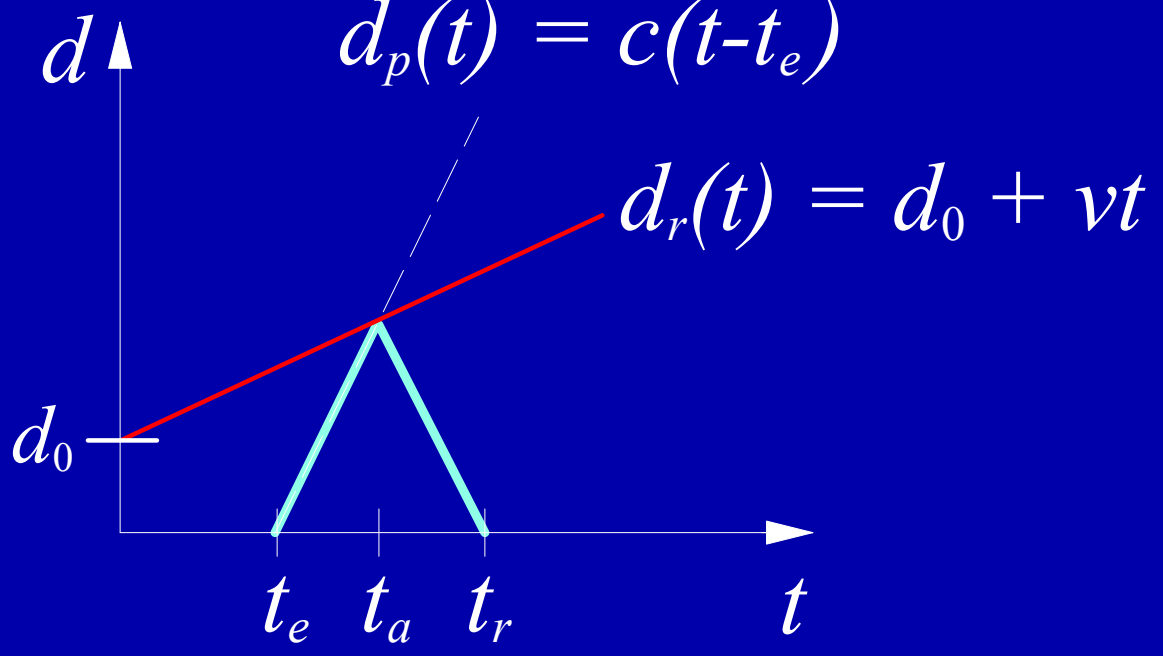


c = speed of sound

(not drawn to scale)

Compression/expansion of emitted signal: The "wide band" Doppler effect





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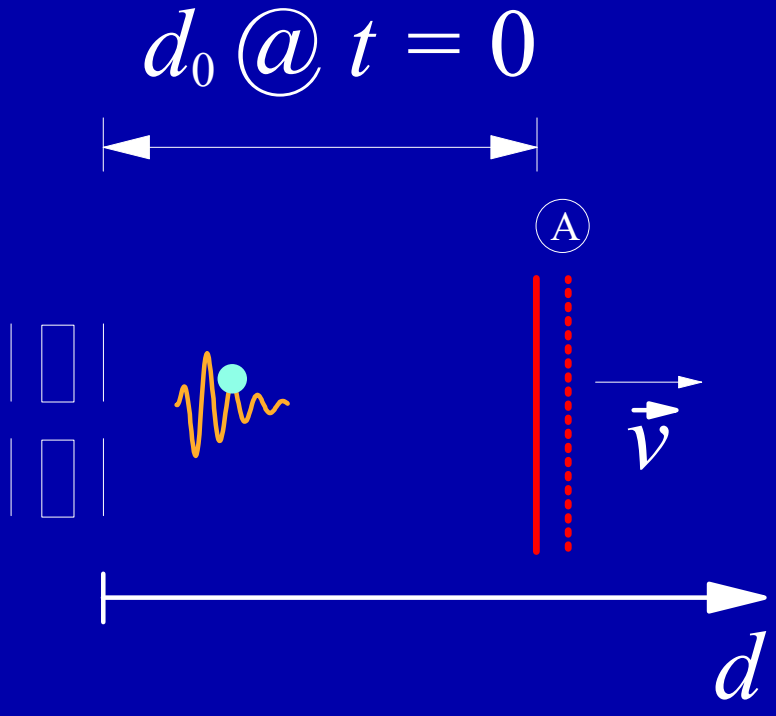
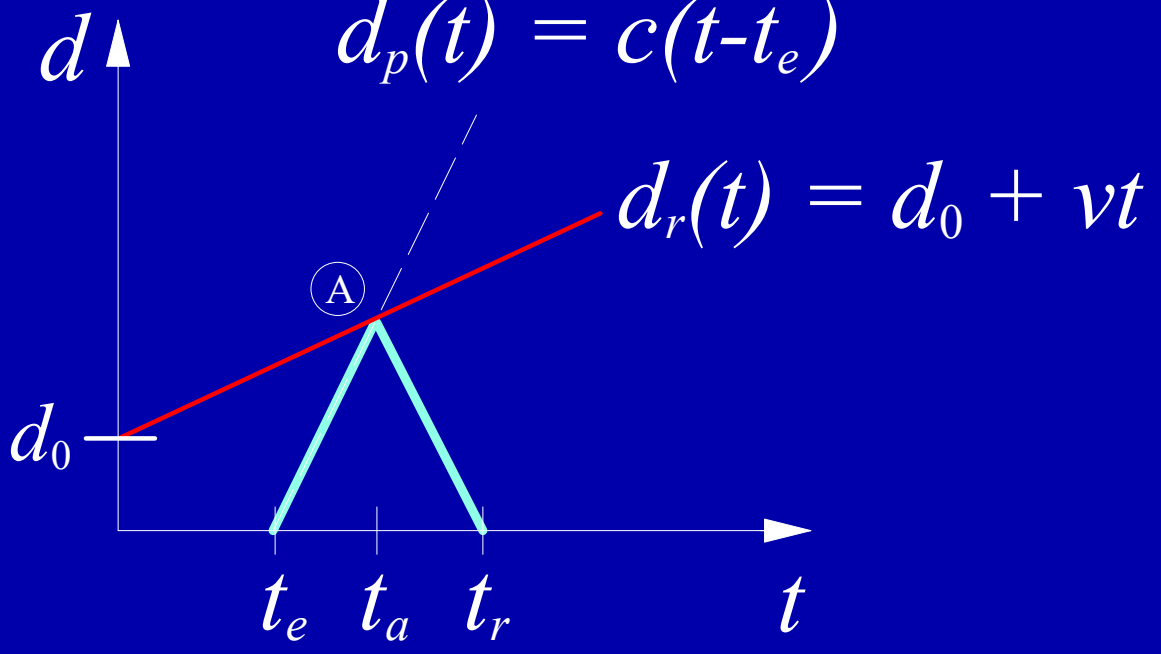
Compression/expansion of emitted signal: The "wide band" Doppler effect





c = speed of sound

(not drawn to scale)

The length of the received signal

Energy emitted at t_e is received at

$$t_r = t_e + 2(t_a - t_e)$$

Now, what is "point of impact" t_a?:

$$d_p(t_a) = d_r(t_a) \Rightarrow t_a = (d_0 + ct_e)/(c-v)$$

so that energy emitted at t is received at

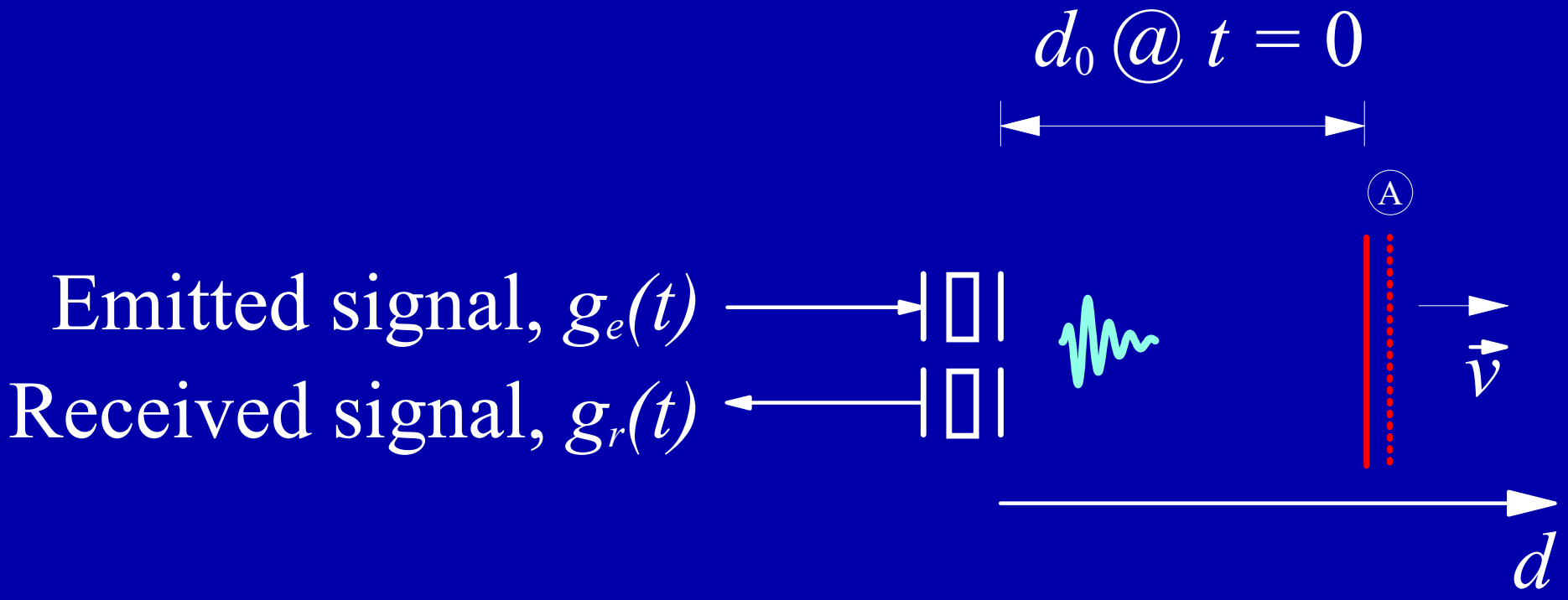
$$t_r(t) = [t + 2d_0/(c+v)] / \beta$$

where $\beta = (c-v)/(c+v)$. Length of the received signal is

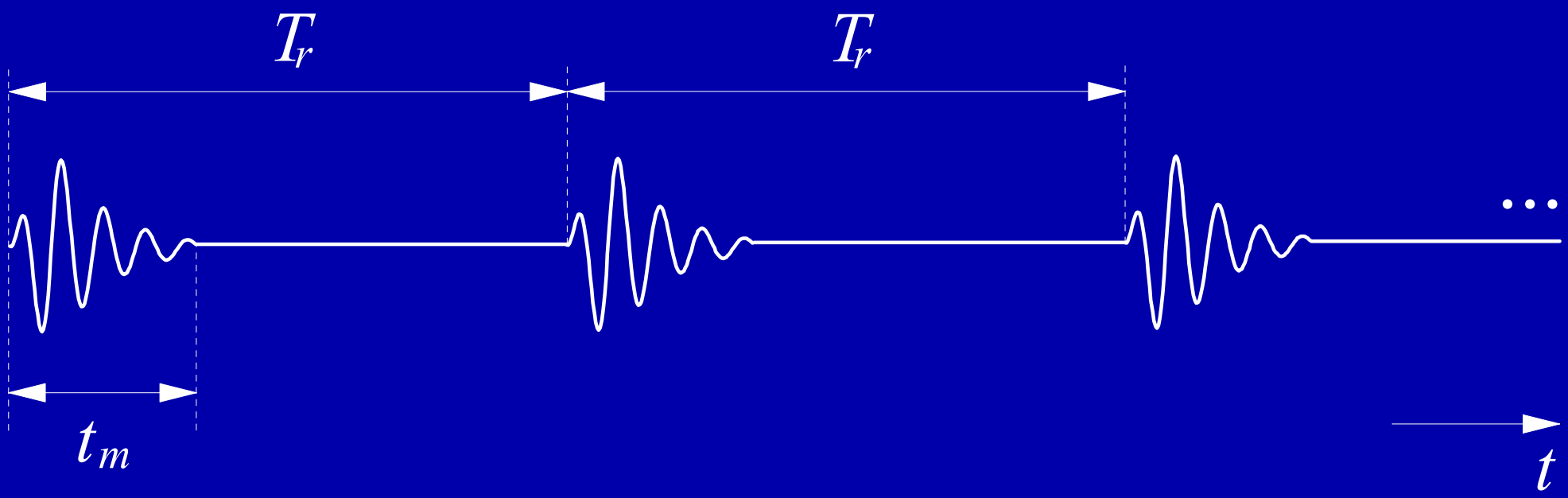
$$t_{m,r} = t_m/\beta$$

when the length of the emitted signal is t_m.

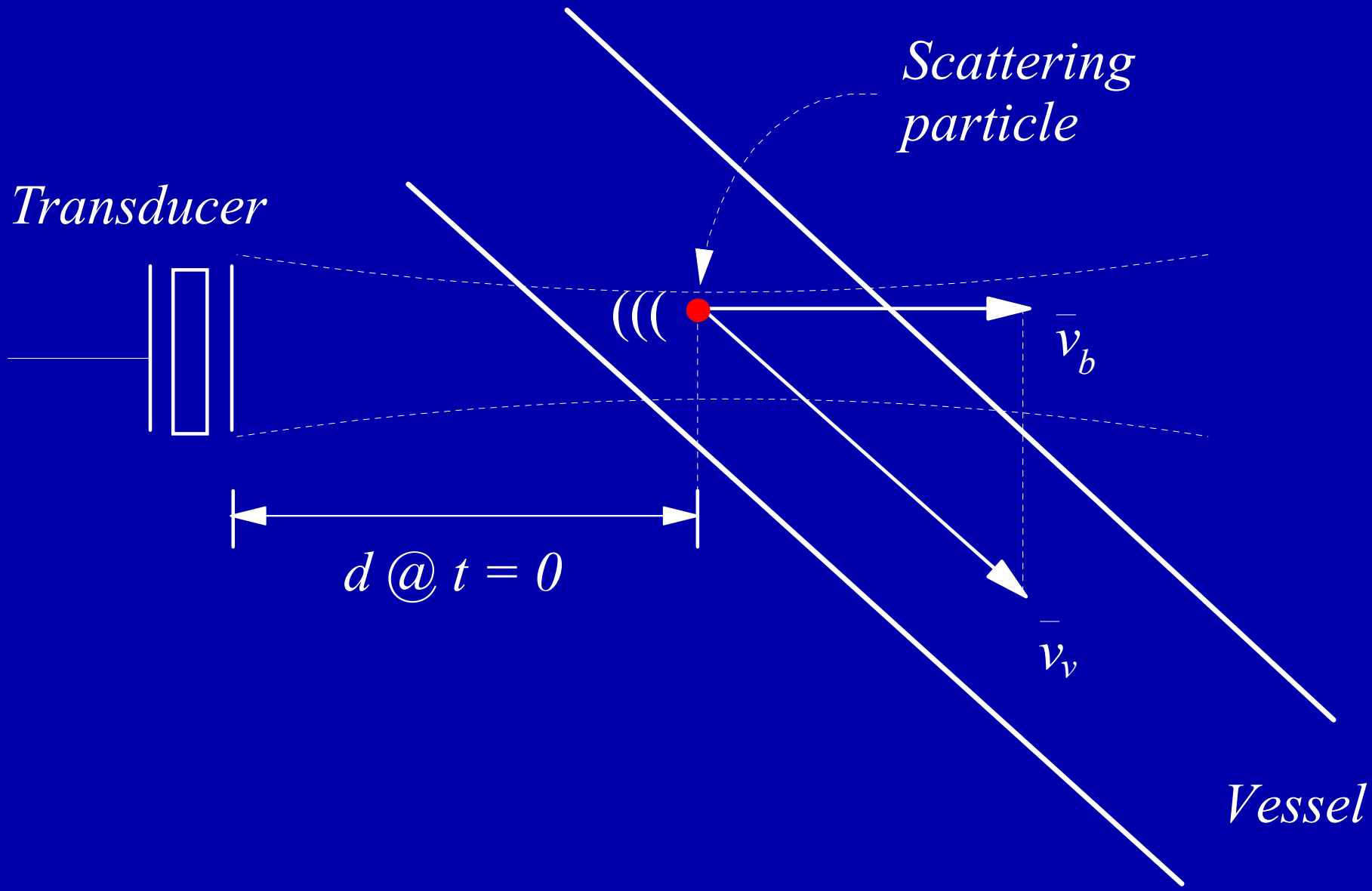
Nomenclature



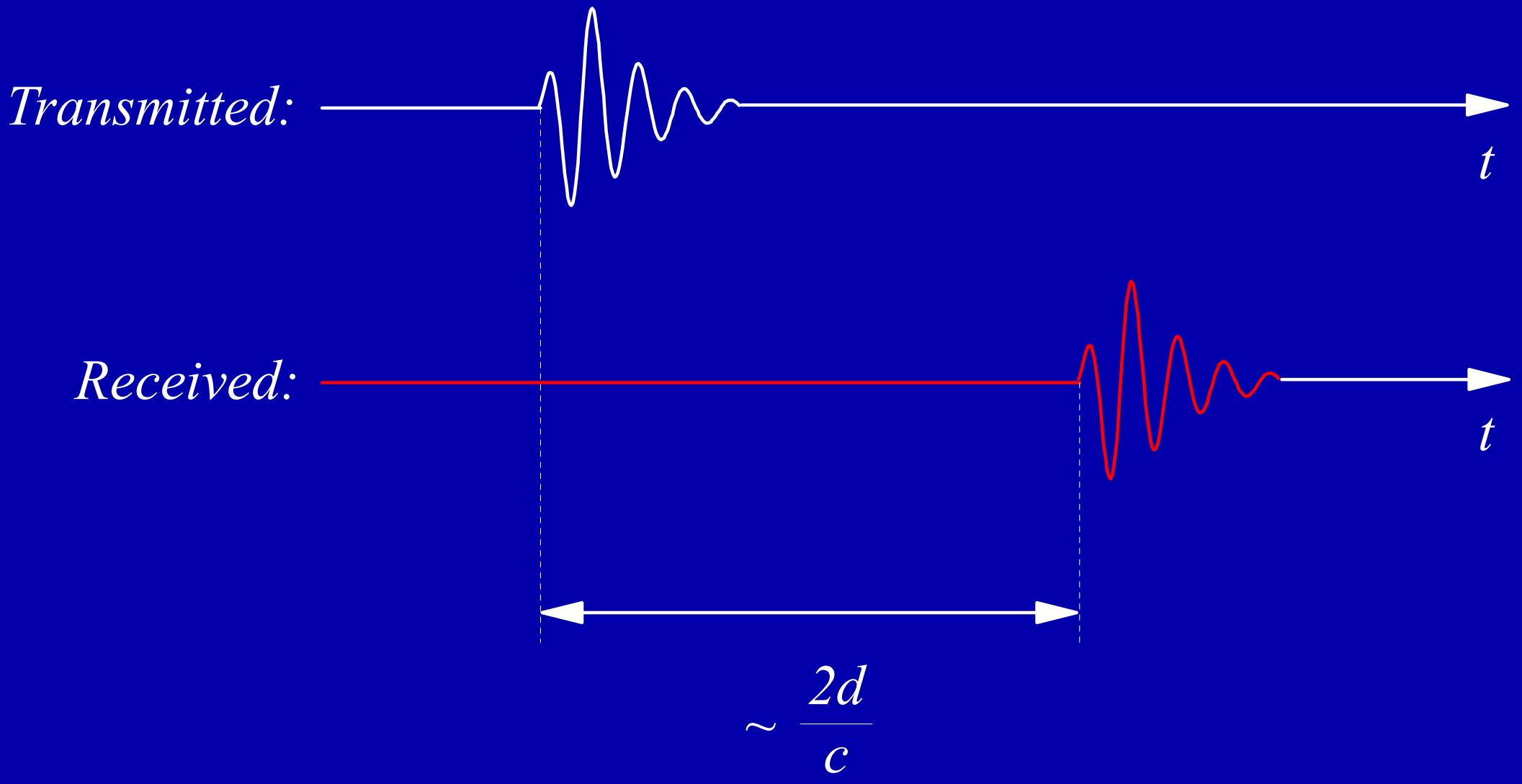
Emission of consecutive pulses



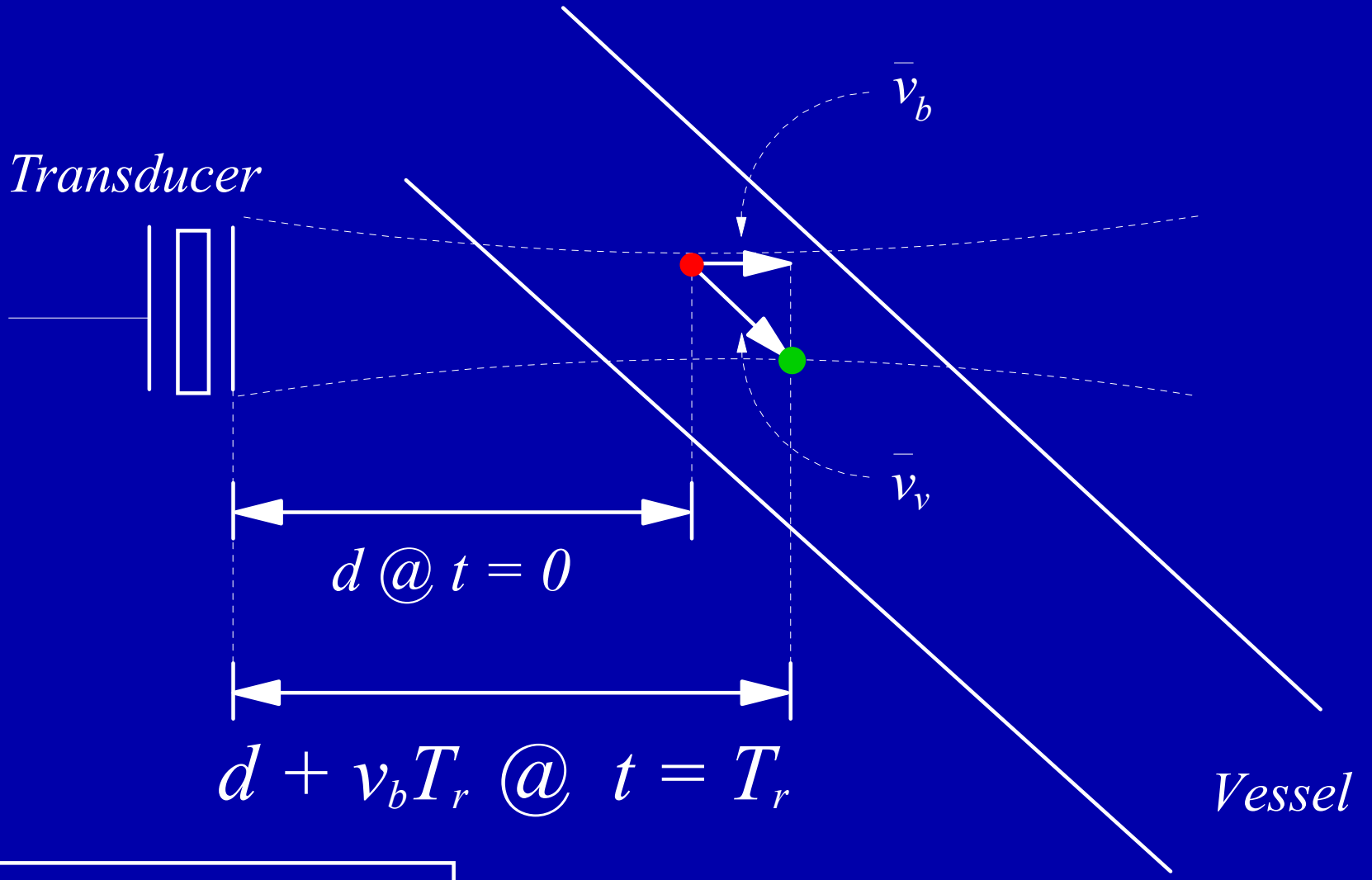
Scattering due to first emitted pulse



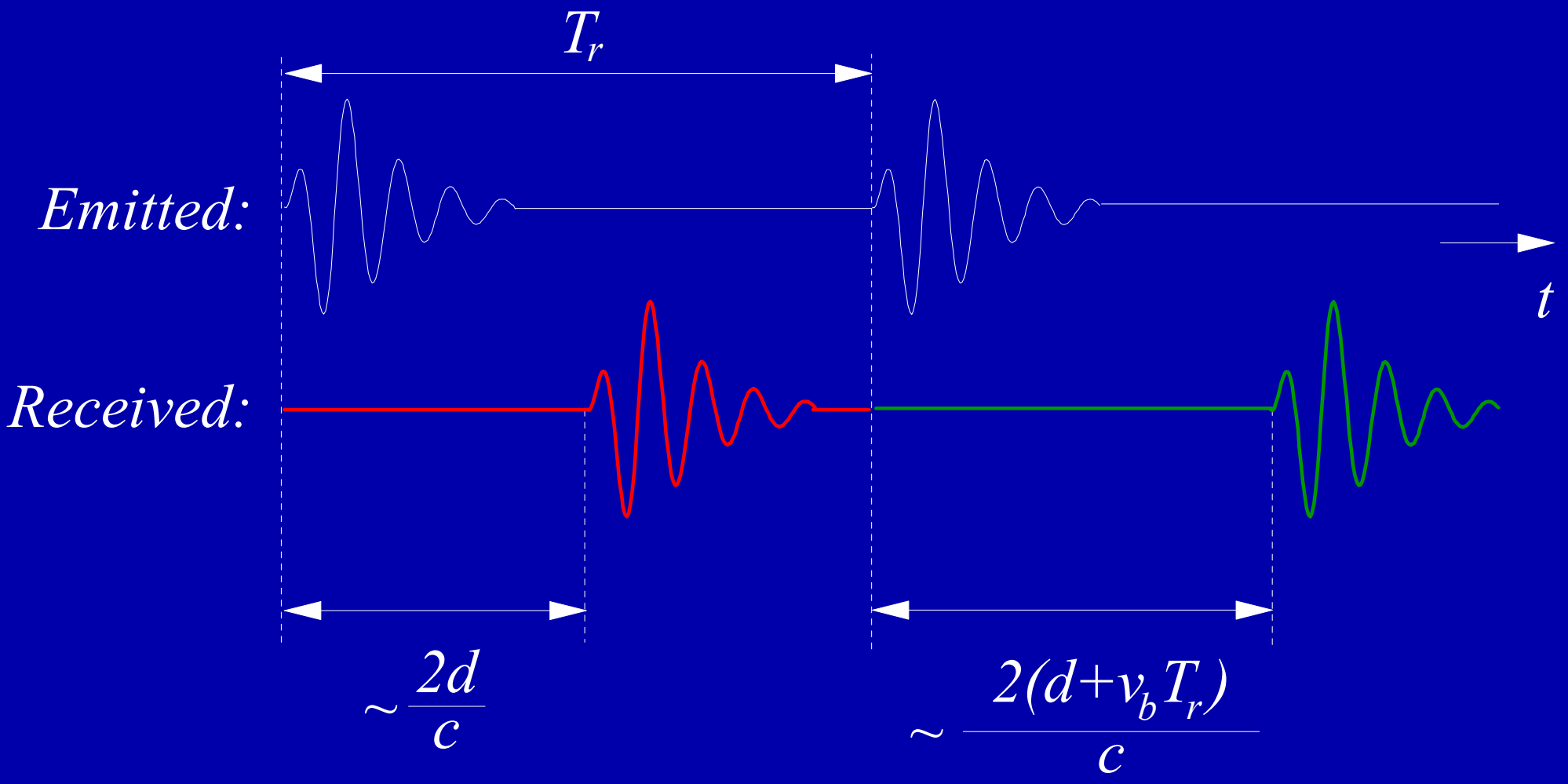
Echo signal due to first emitted pulse



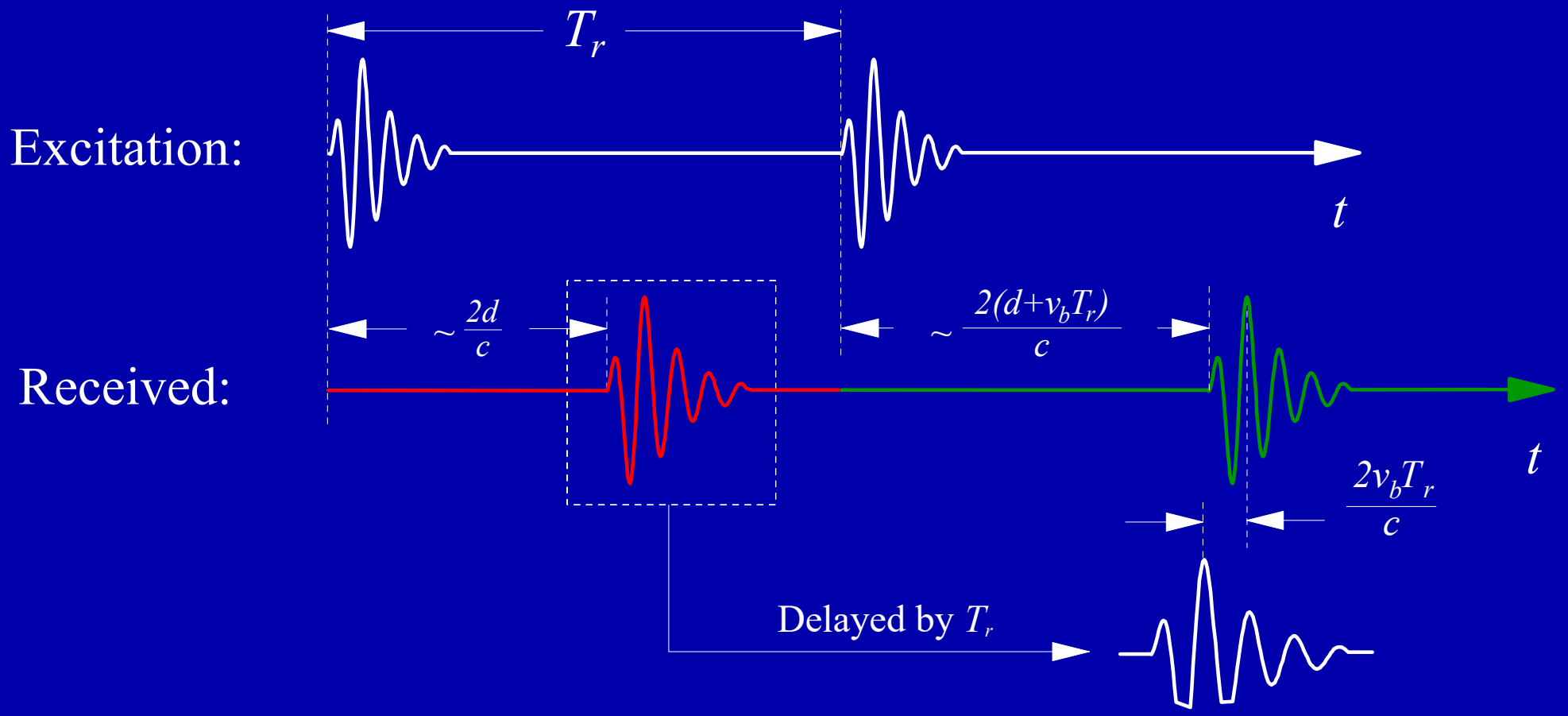
Scattering due to second emitted pulse



Echo signal due to second emitted pulse



Pulsed wave - *time shift measurement*



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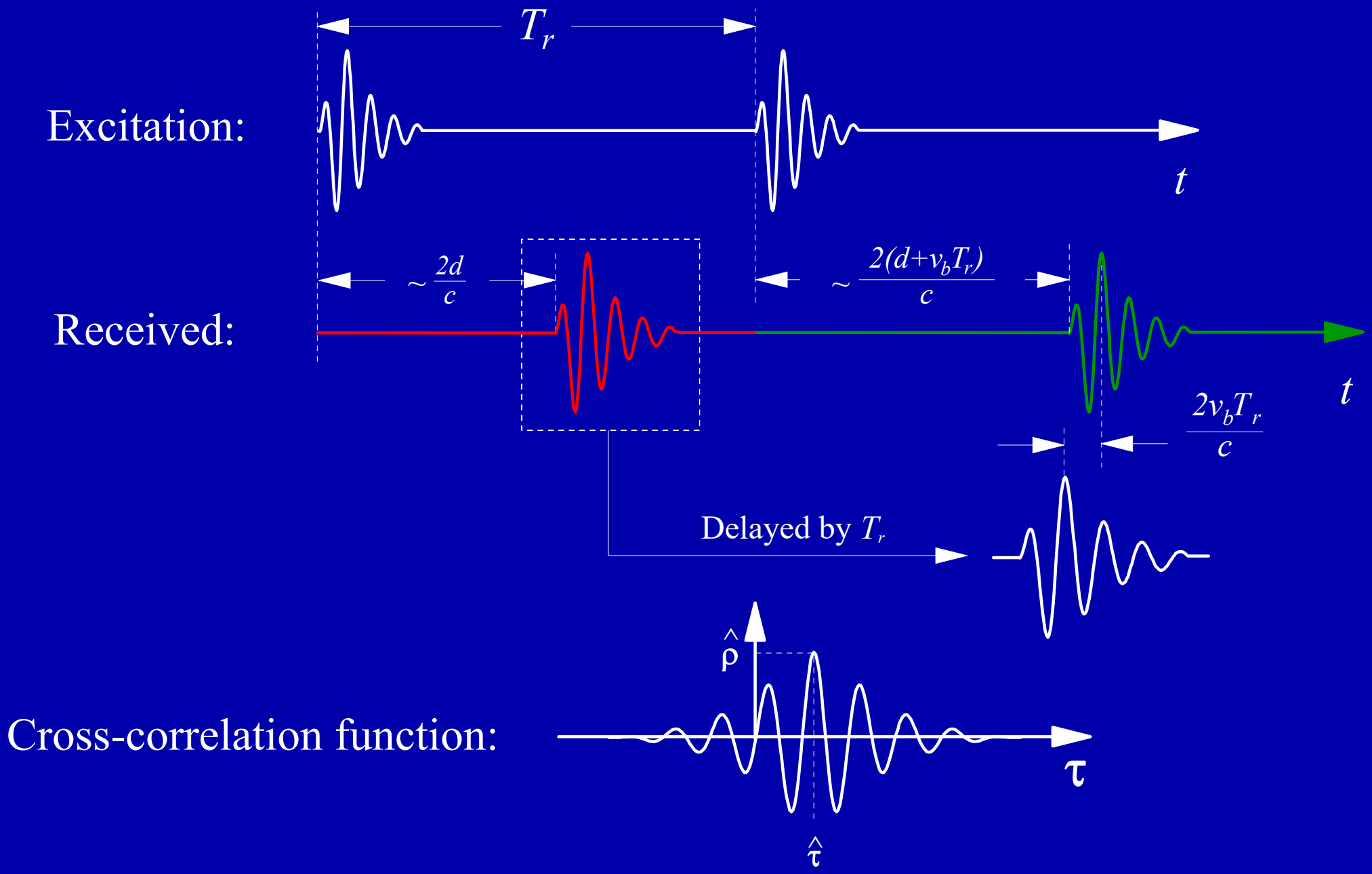
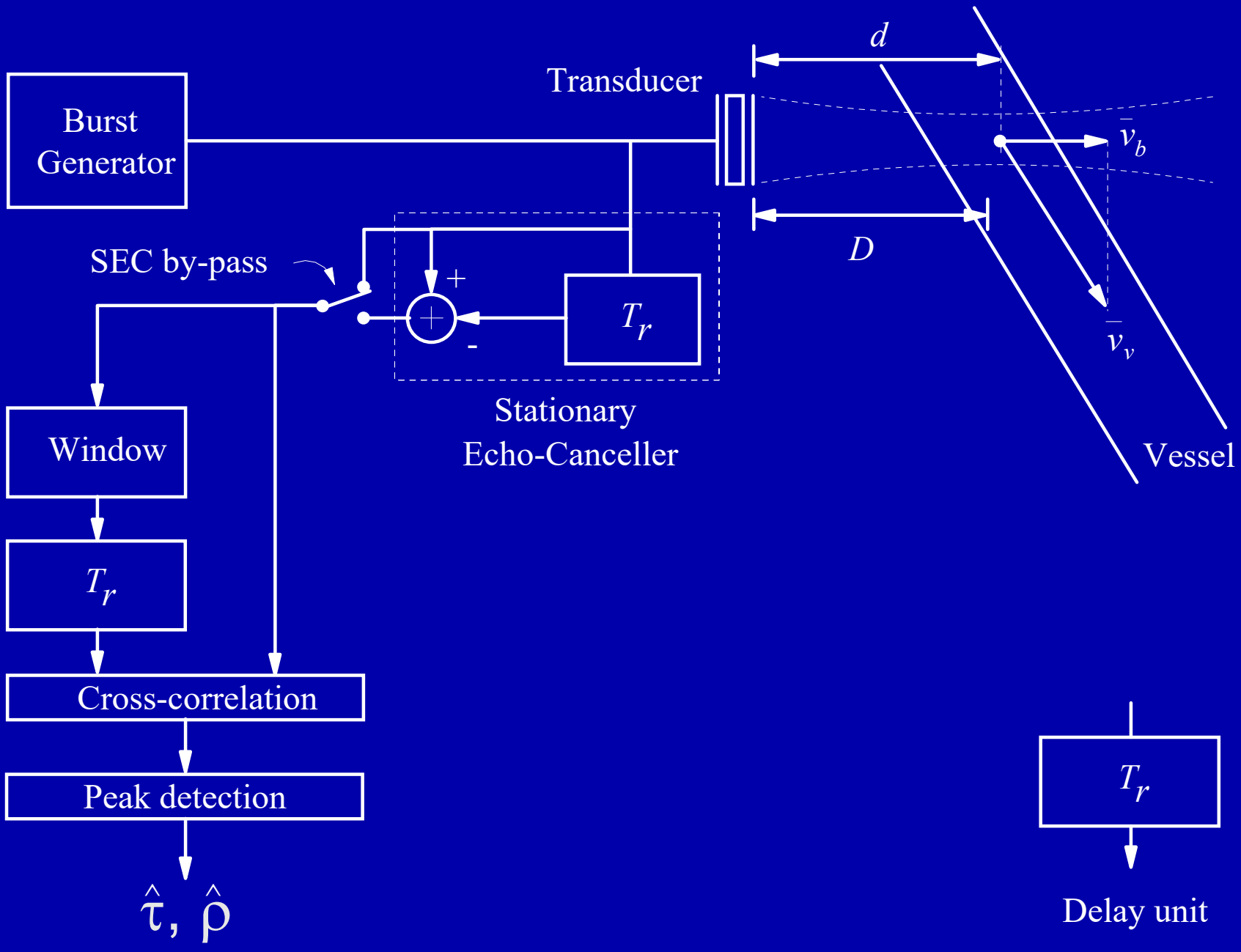
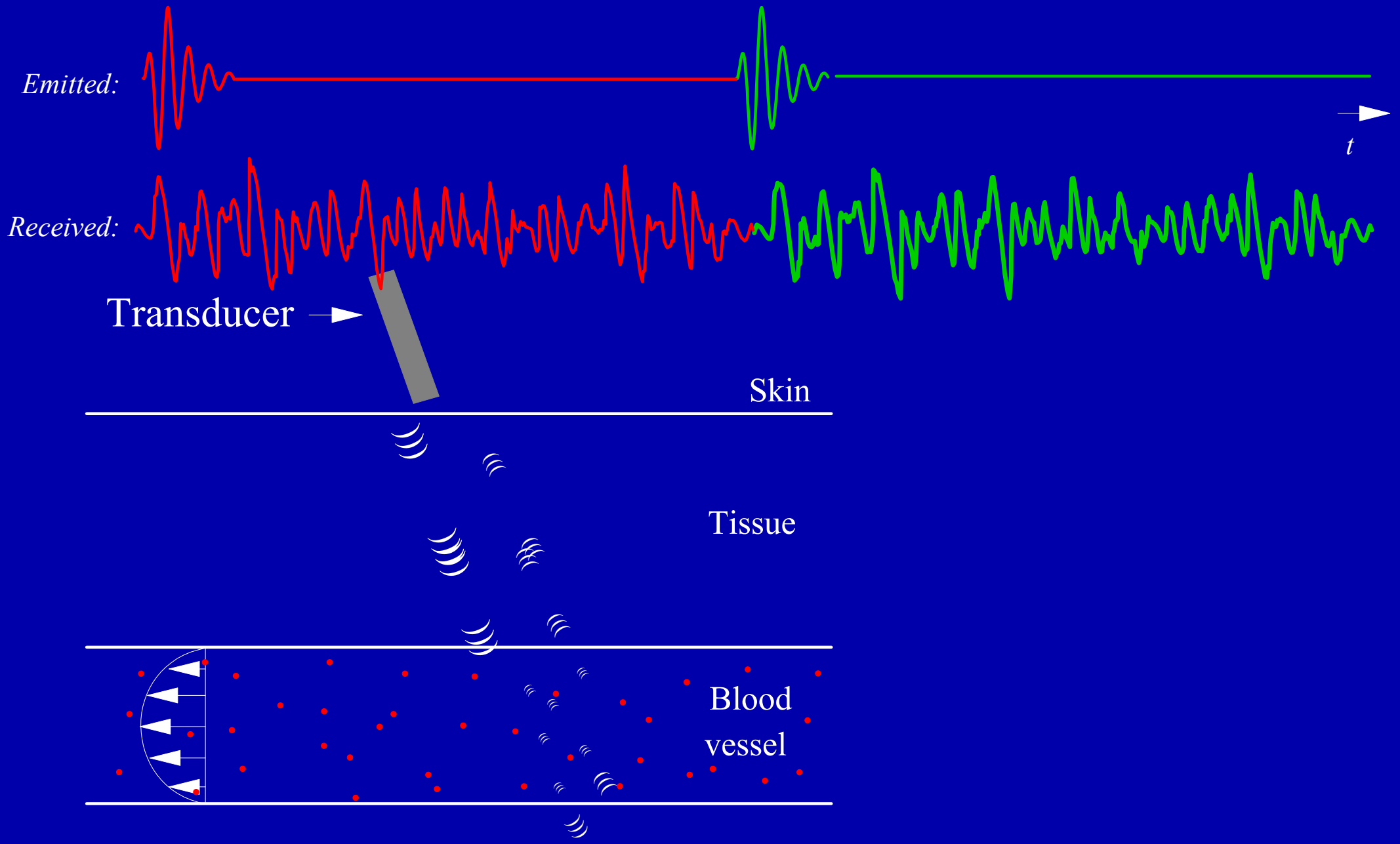


PW-*tsm* Doppler system

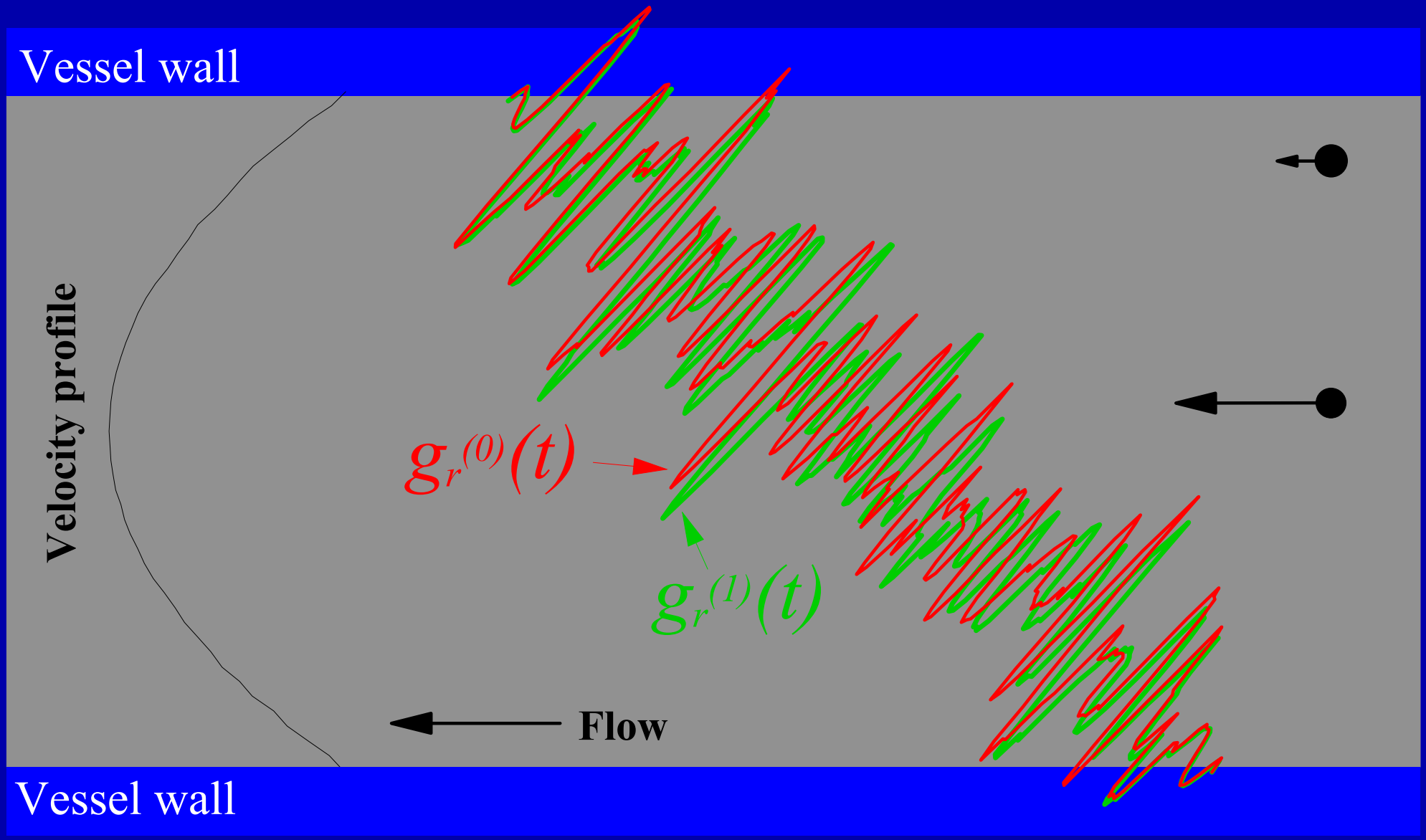


Two consecutive received signals

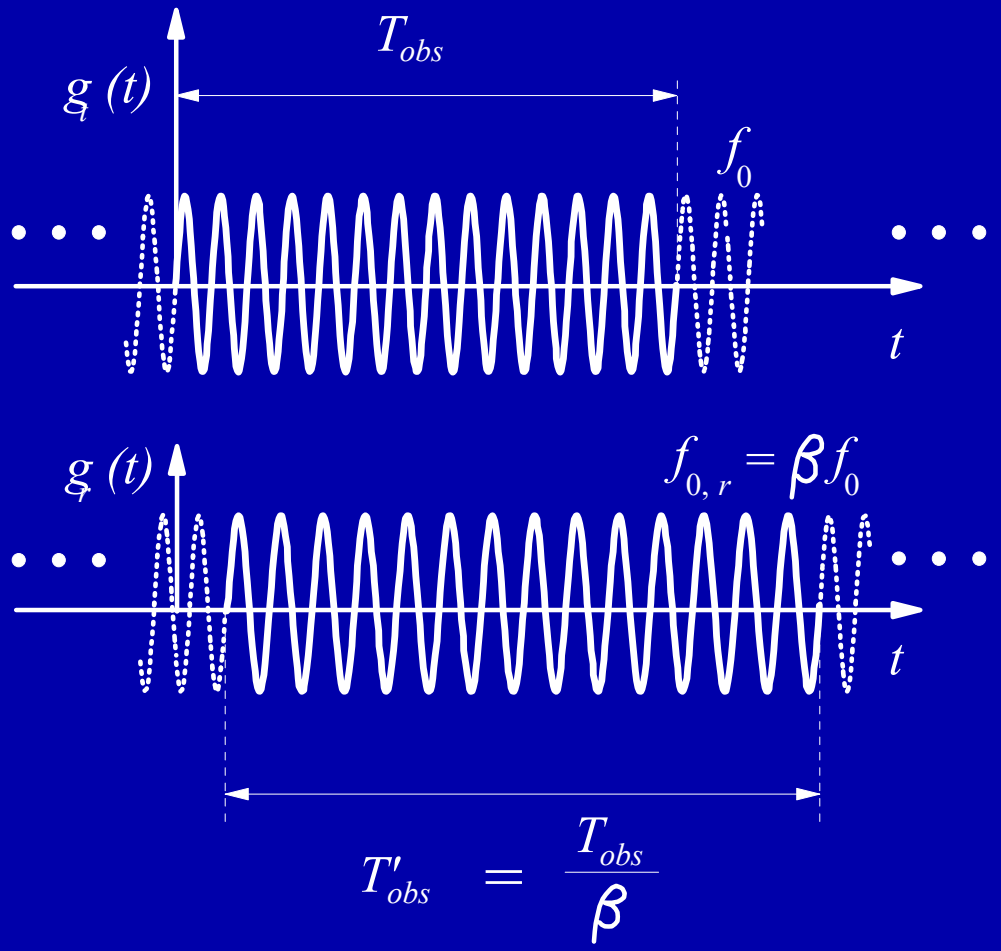


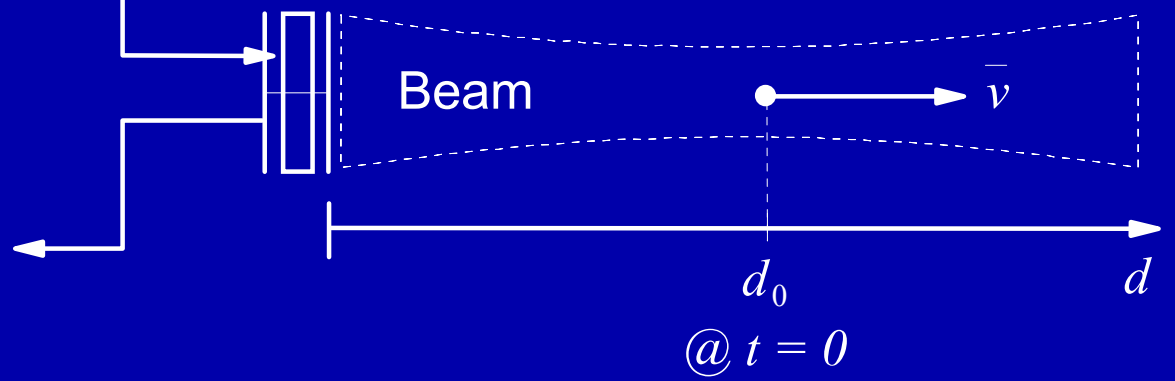
Two consecutive received signals

(superimposed on vessel)



Is it Doppler?





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Is it Doppler?