

PHYSICS OF ULTRASOUND

Emergency Ultrasound Course

Justin Bowra

Ultrasound

Rapid

Non-invasive

Painless

Look inside the patient

But it needs fluid!









Theoretical Stuff

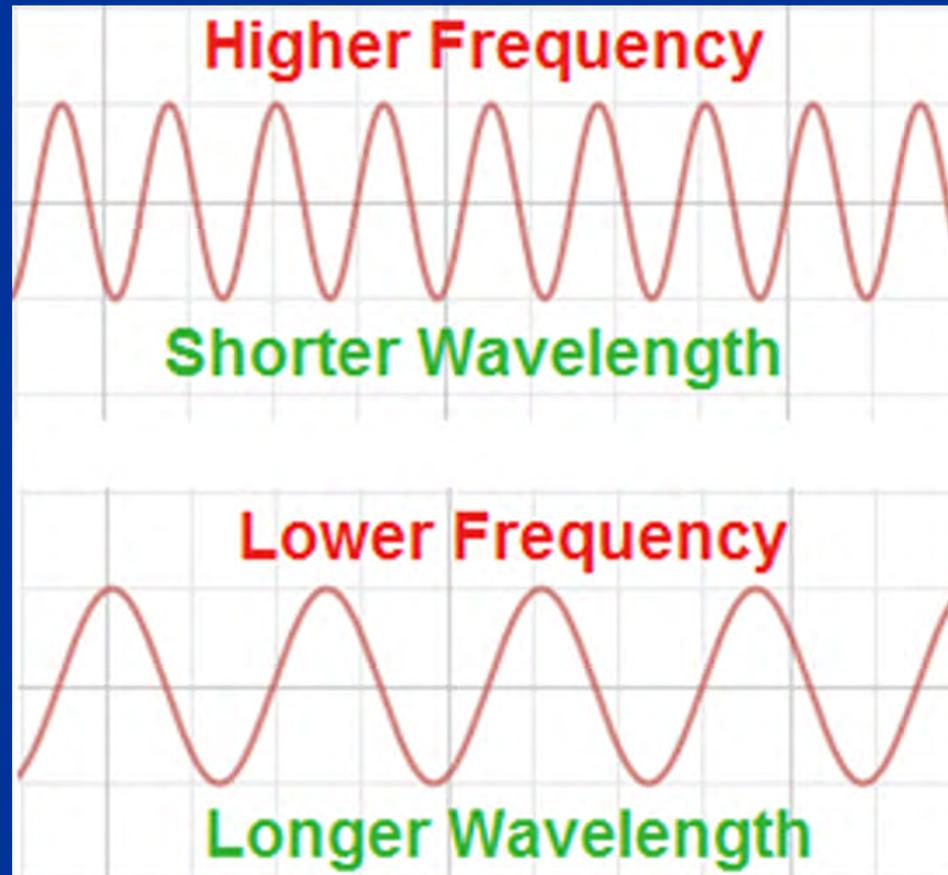
FREQUENCY

No of wavelengths per second

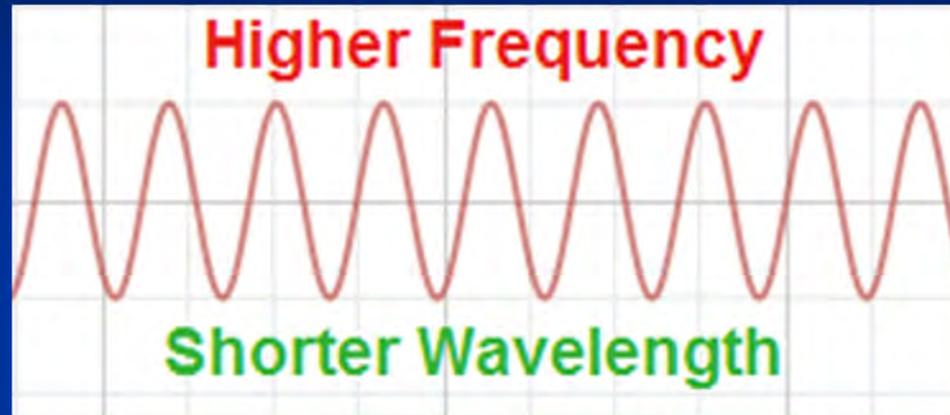
1 cycle = 1 hertz (Hz)

Diagnostic US is 1-20MHz

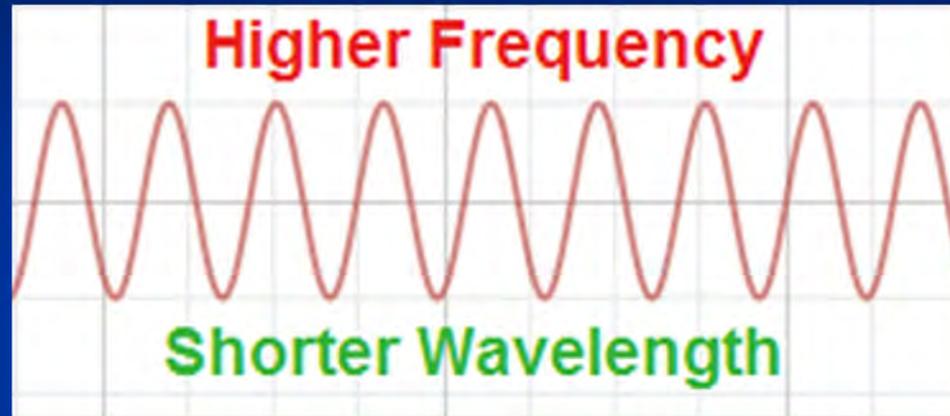
As frequency increases...
Wavelength decreases



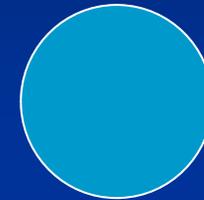
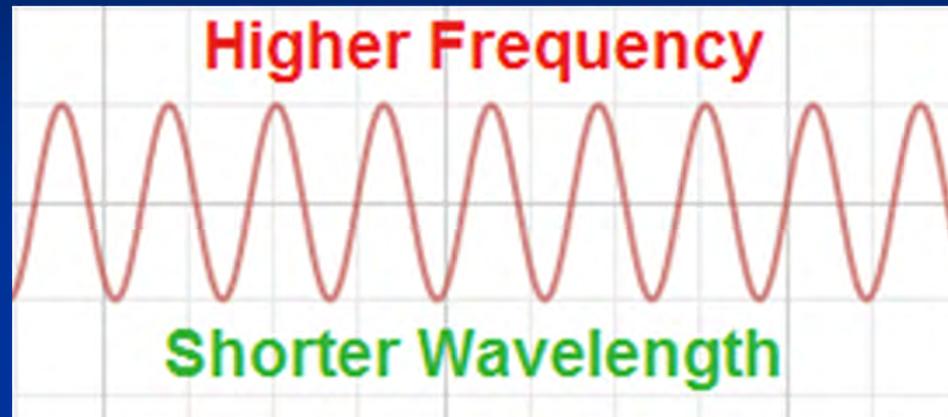
High frequency waves (eg 10 MHz)



High frequency waves (eg 10 MHz)



High frequency waves (eg 10 MHz)

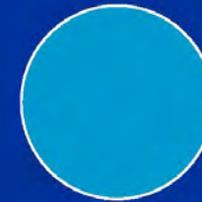
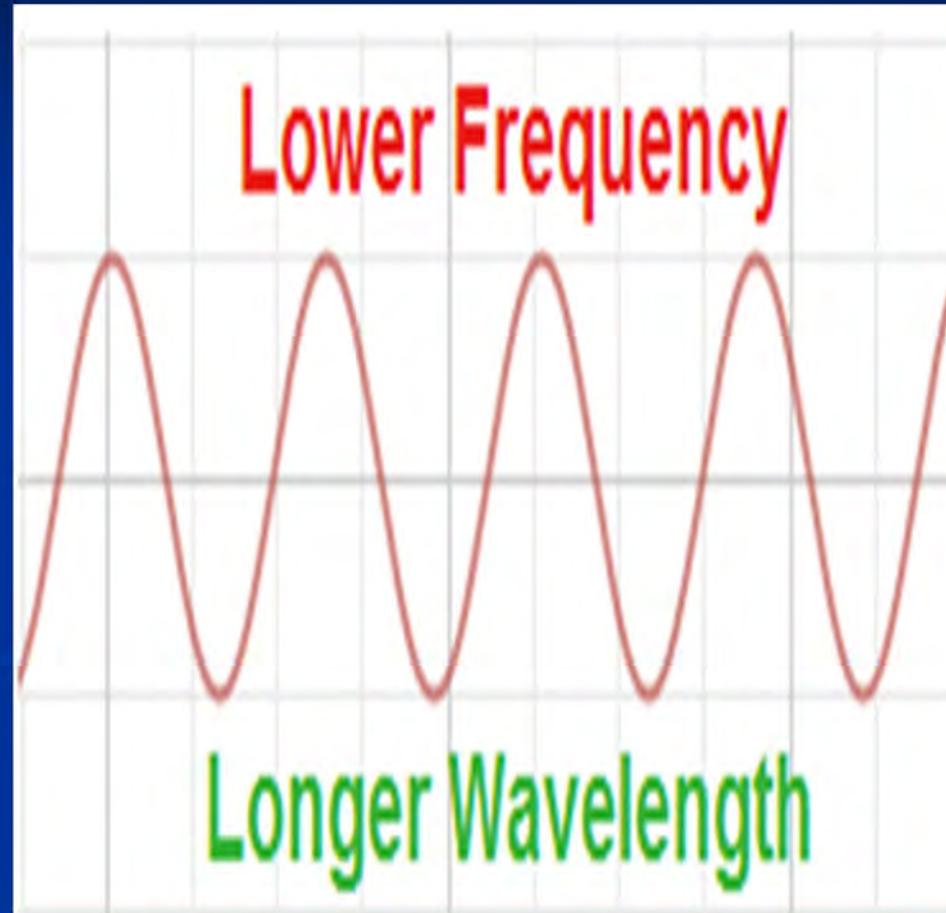


Better resolution

Less penetration

Skinny people, vascular access, kids...

Low frequency waves (eg 3 MHz)



Low frequency waves (eg 3 MHz)

Better penetration

But less resolution!

Fat people / greater depth

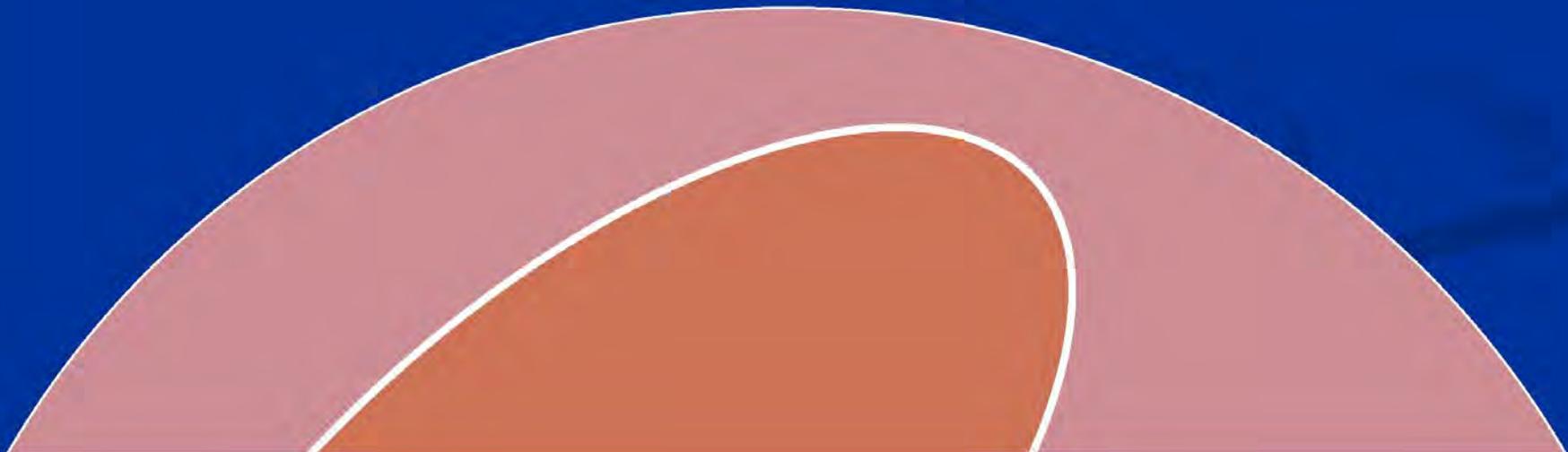
How does it work?

Piezoelectric effect

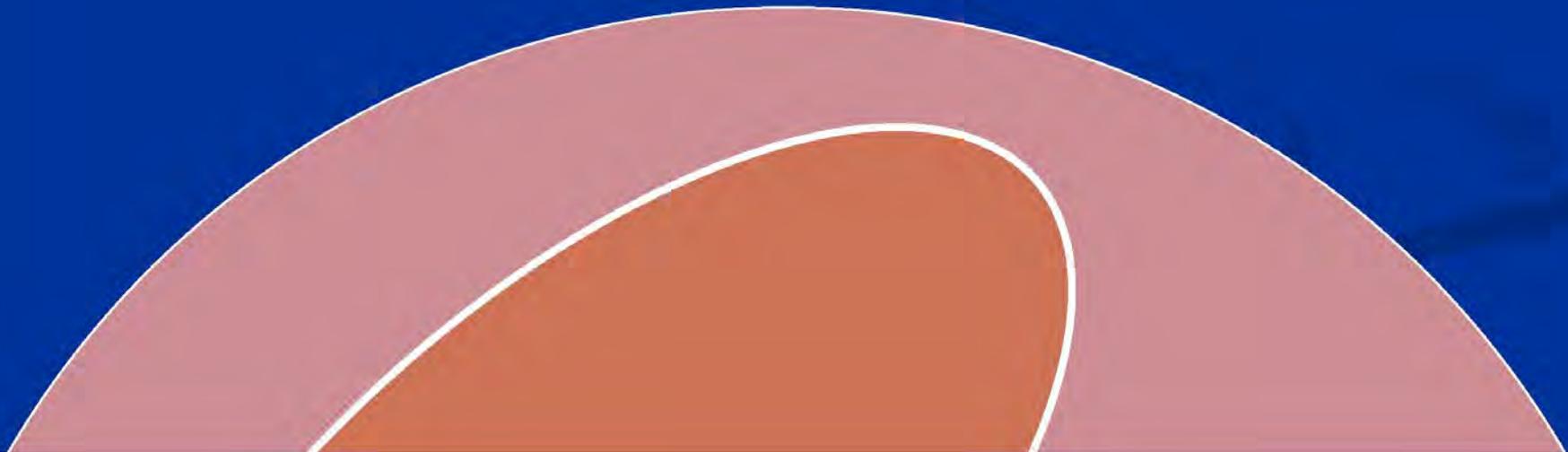
Electricity ↔ sound waves

1. Electrons hit the Piezoelectric crystal
2. Transducer (Probe) transmits sound wave
3. Patient reflects sound wave
4. Wave hits the piezoelectric crystal
5. Electrons travel to processor
6. Image is formed!

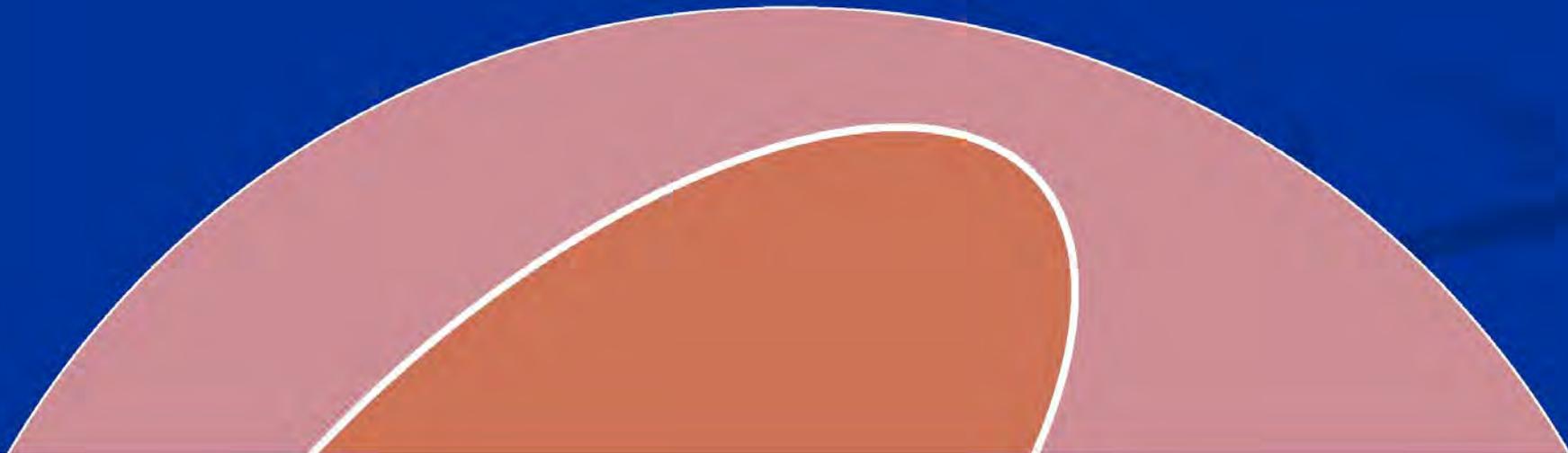
Piezoelectric crystal

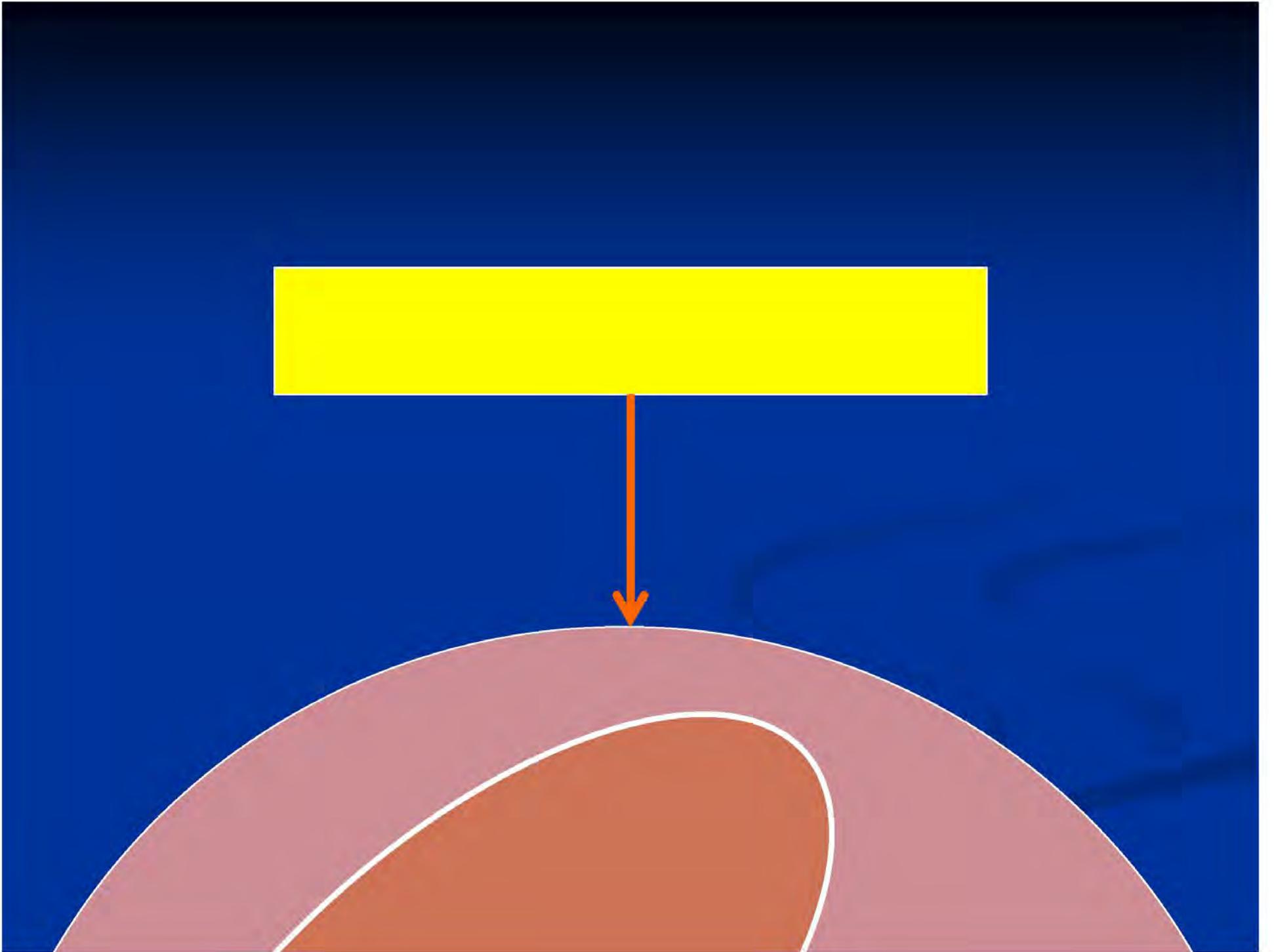


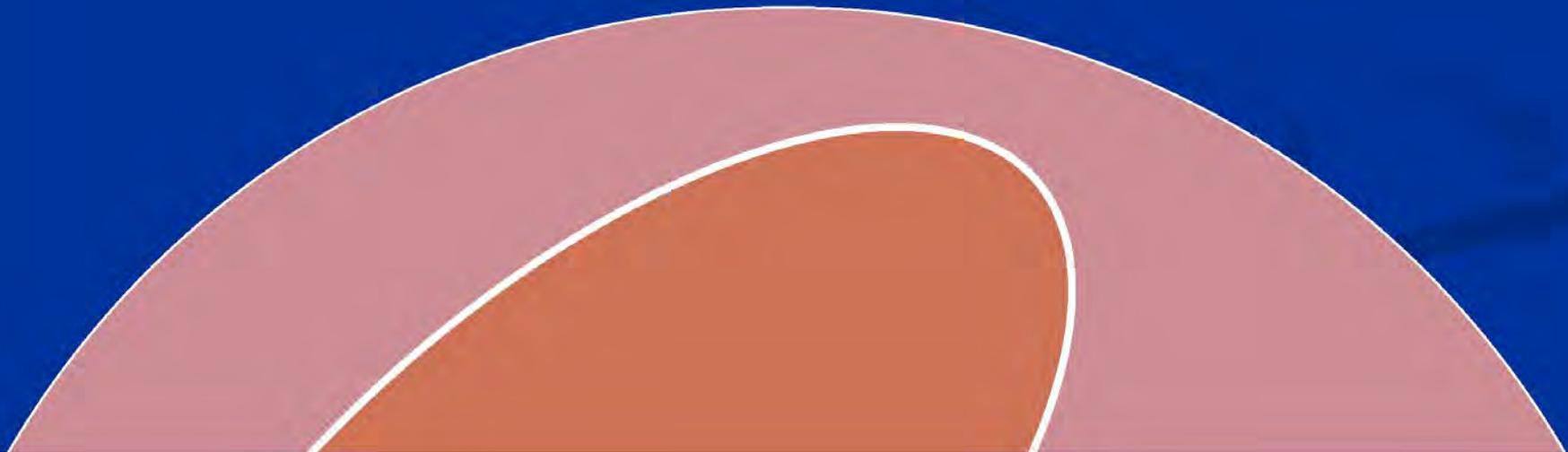
+ -
- +

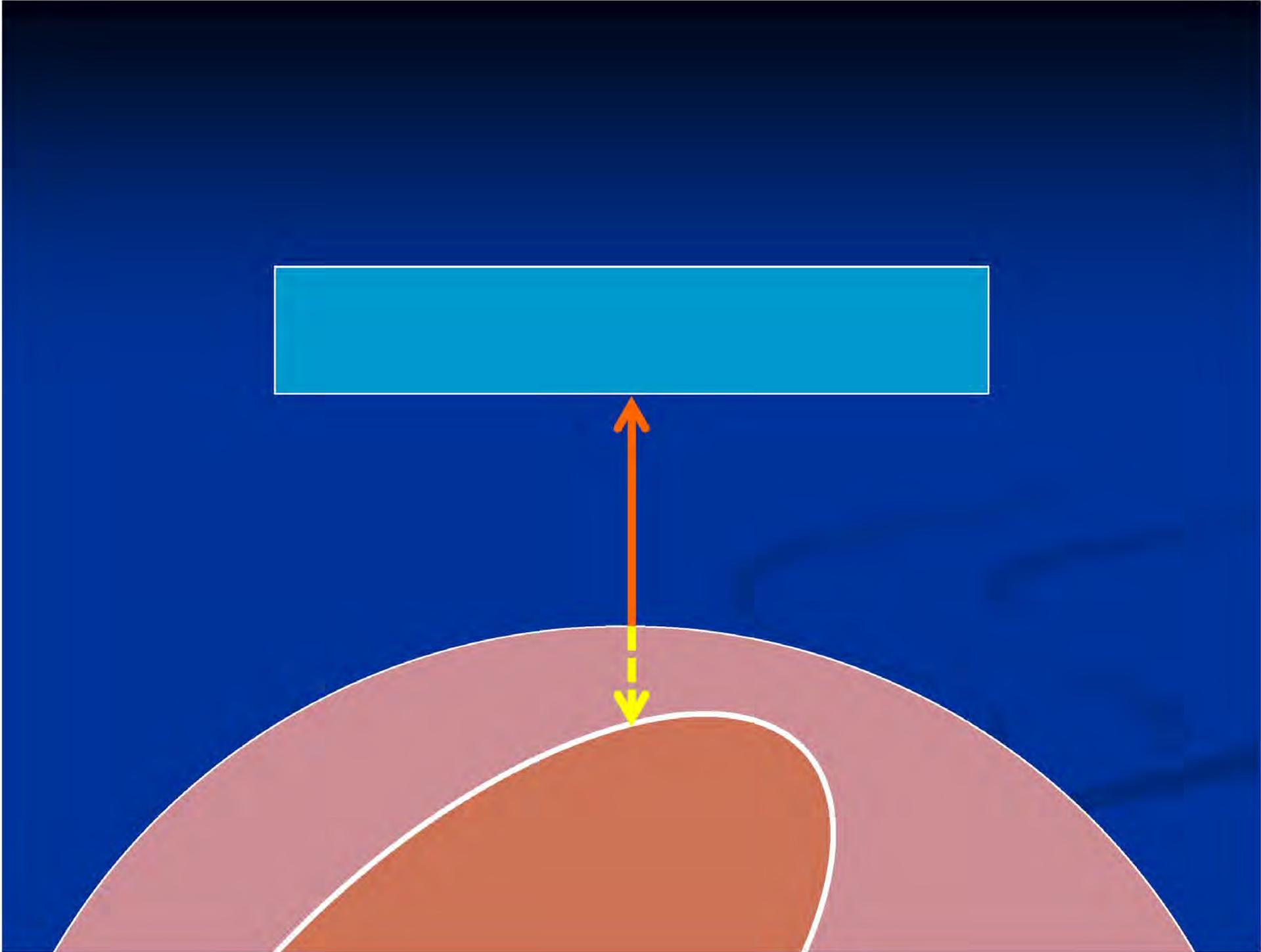


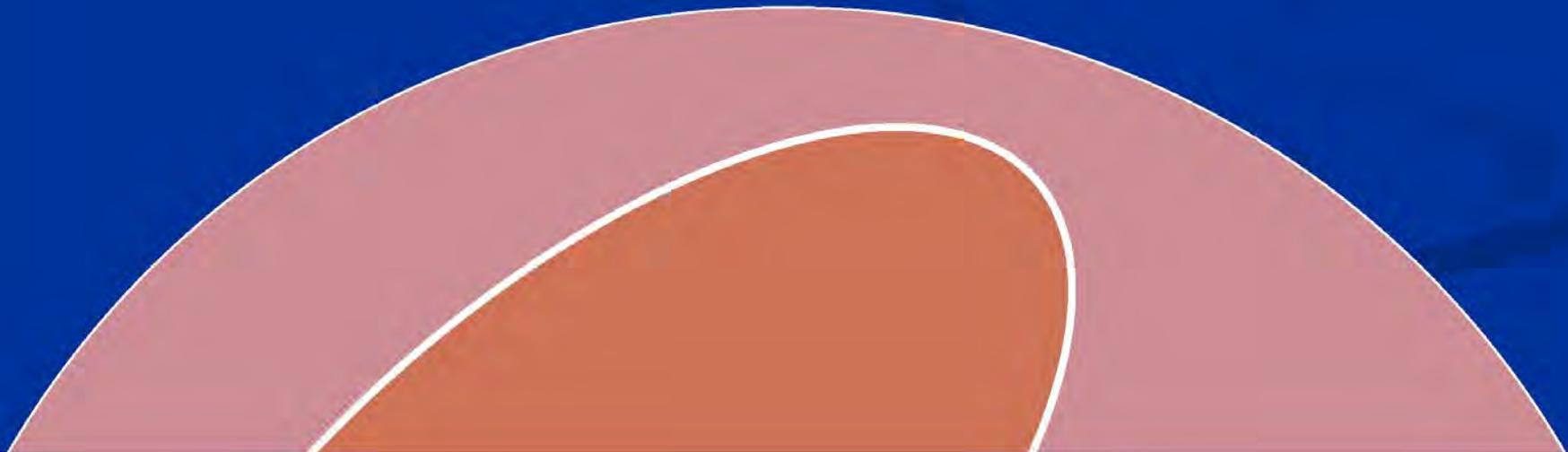
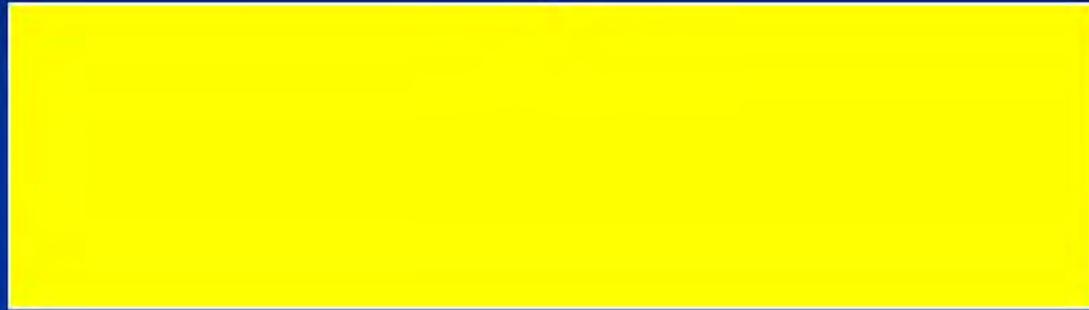
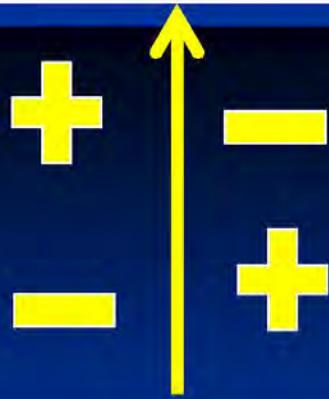
+ -
- +



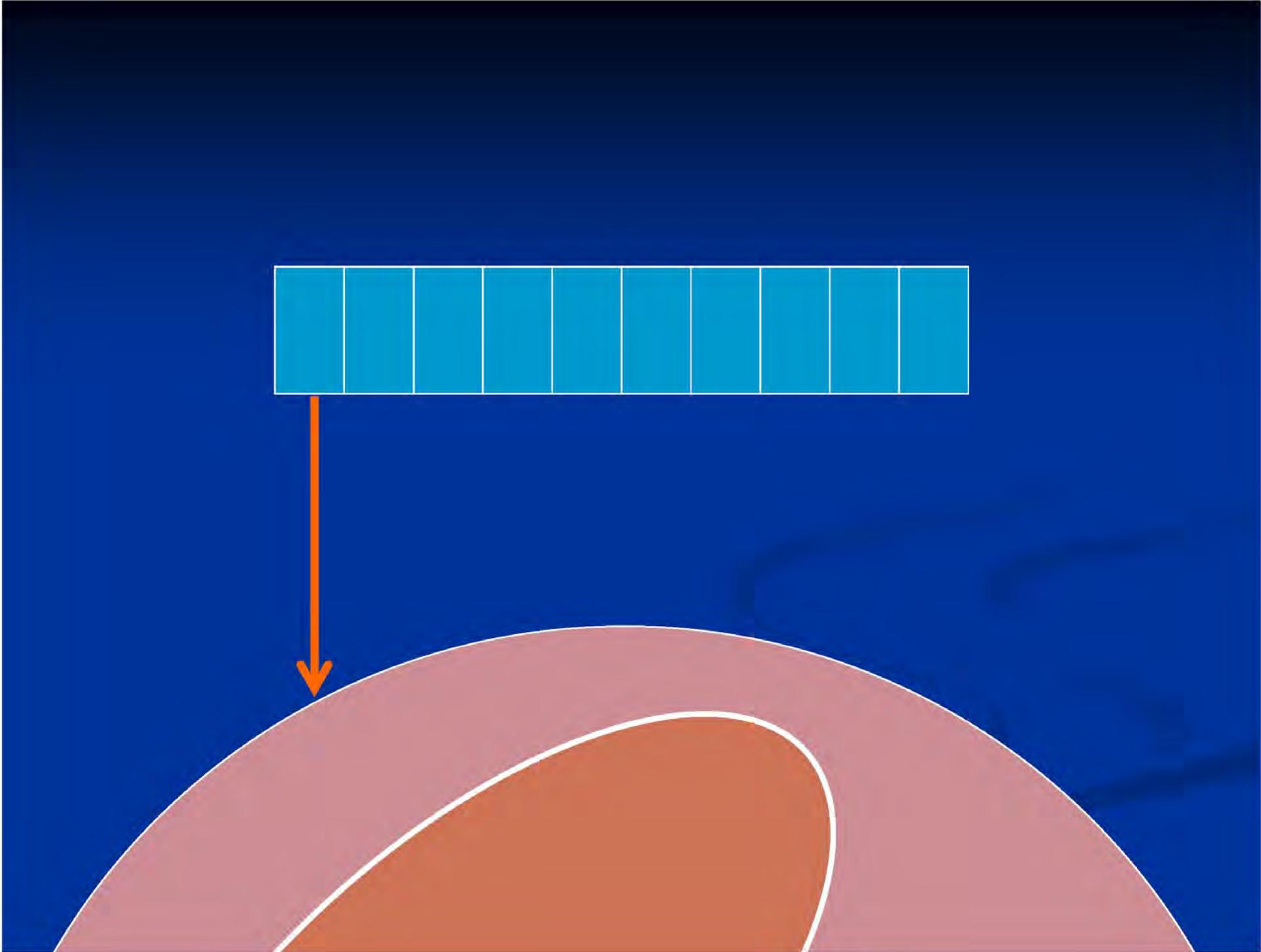


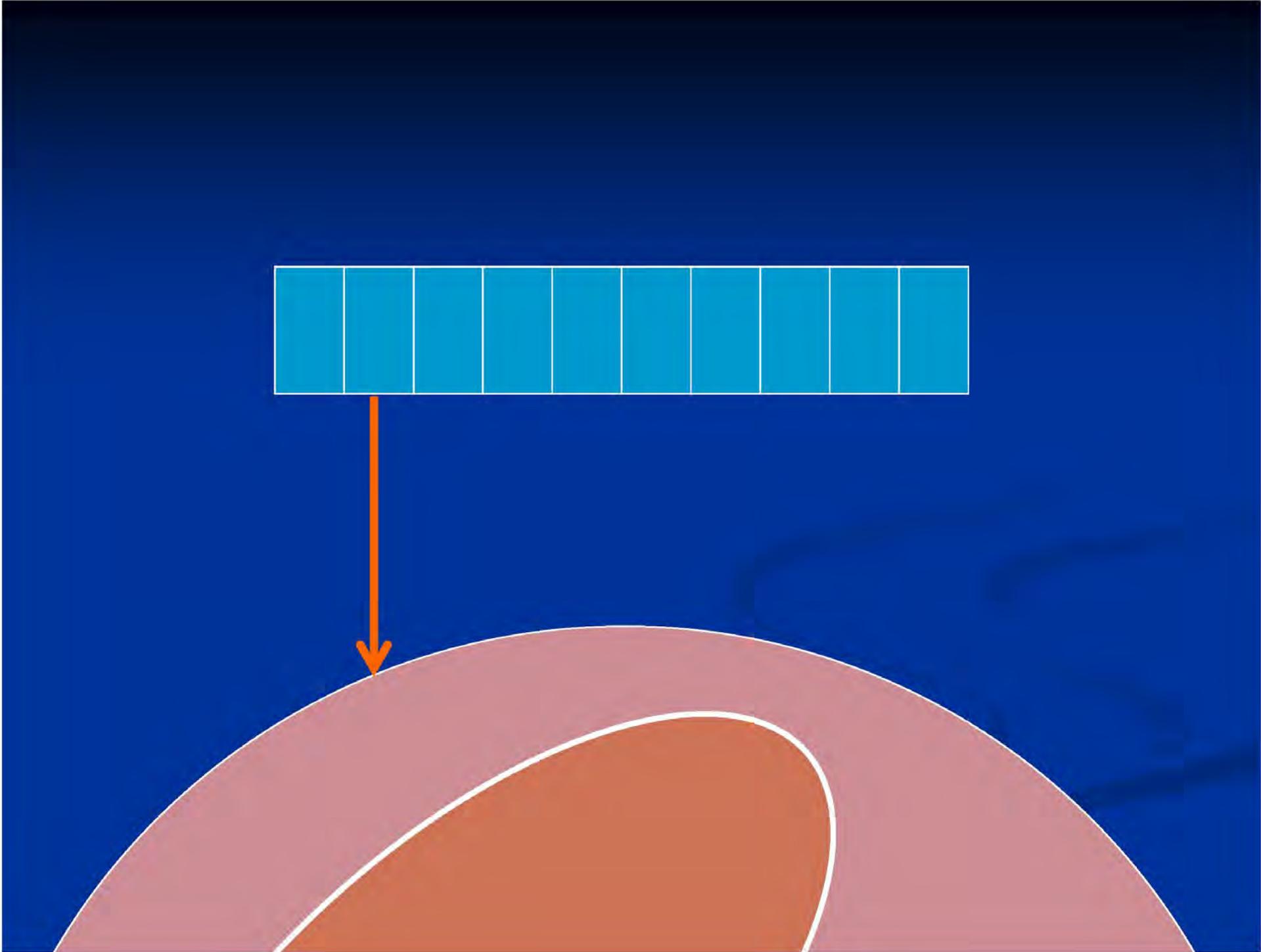


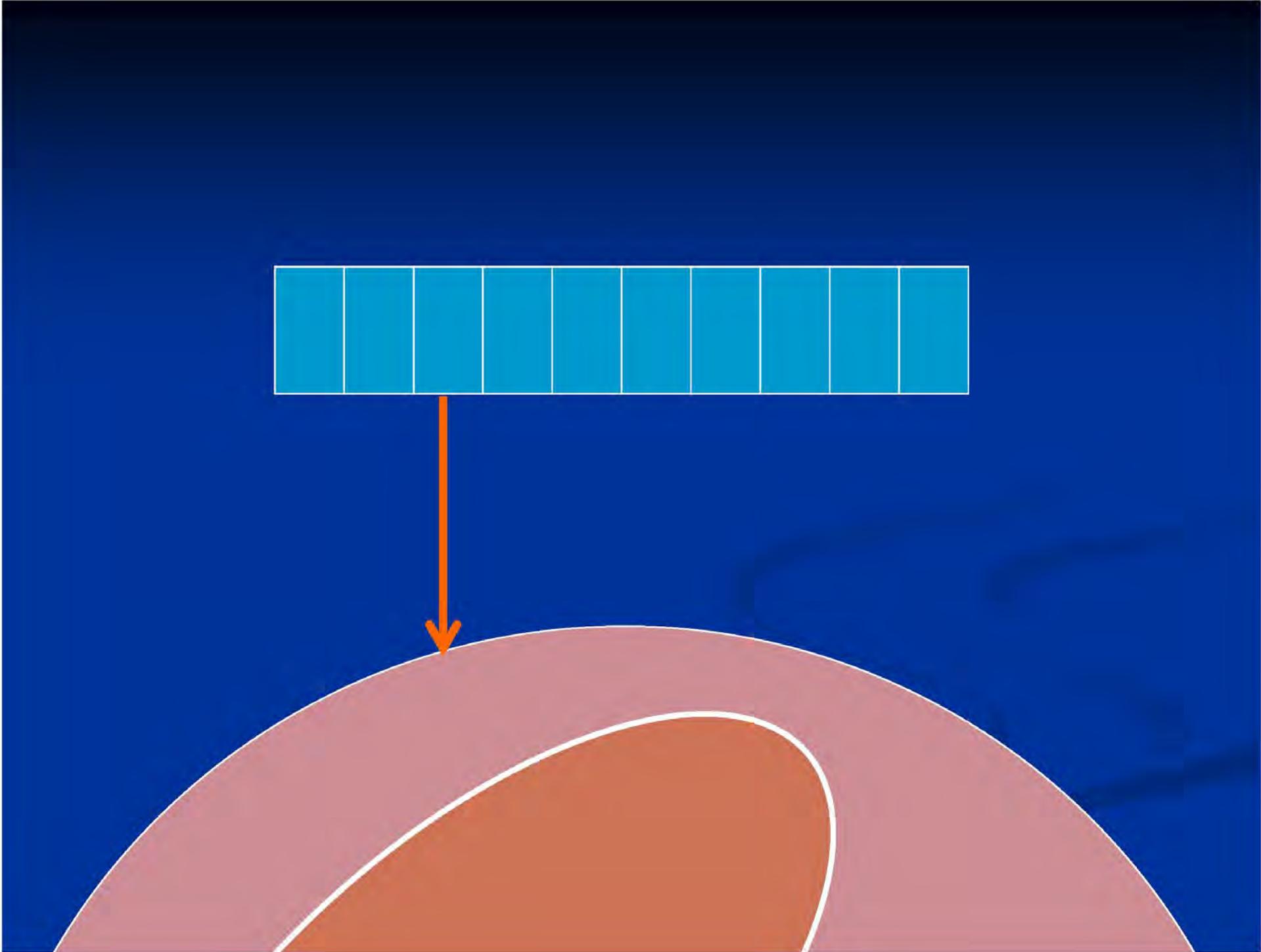


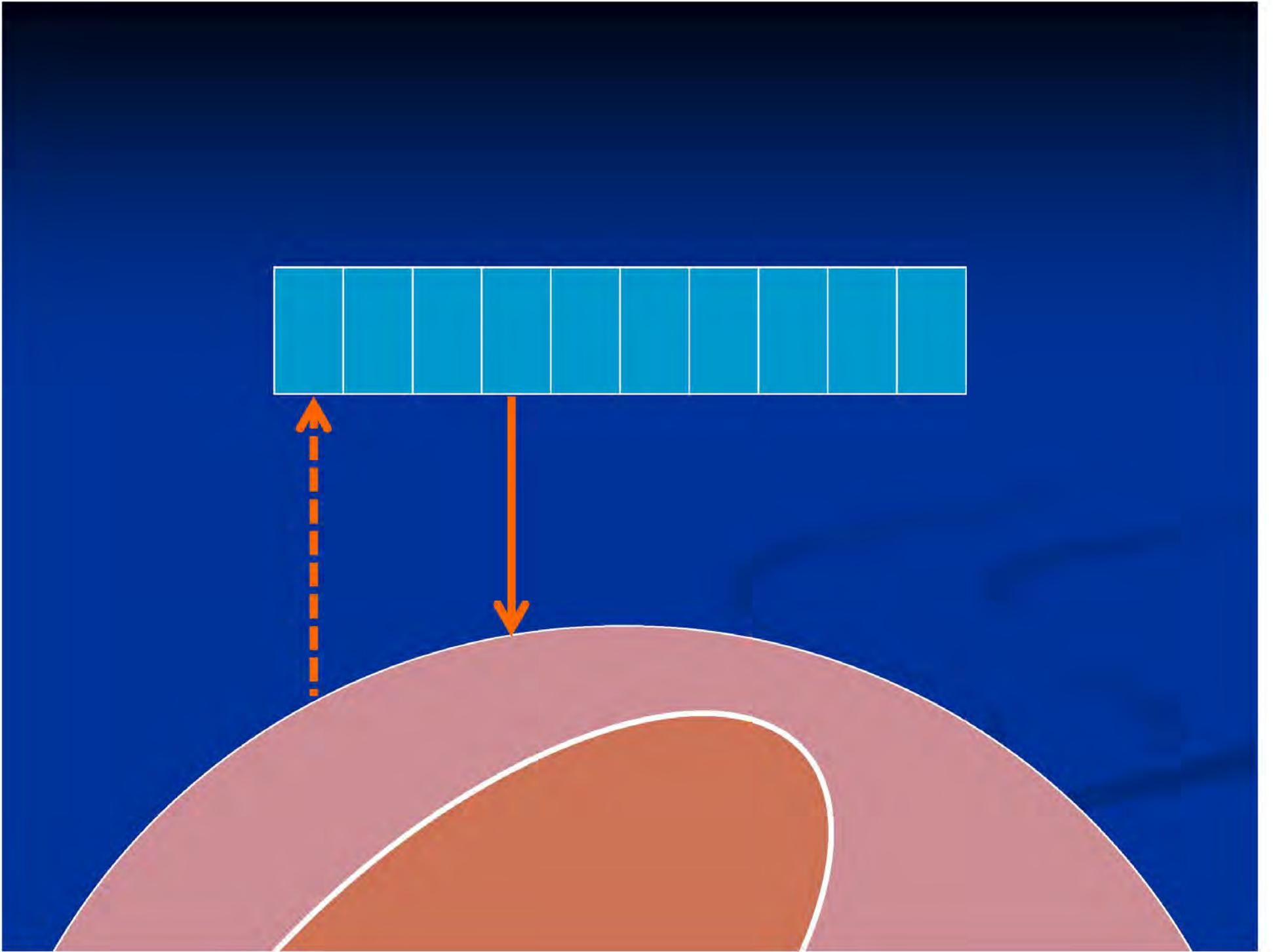


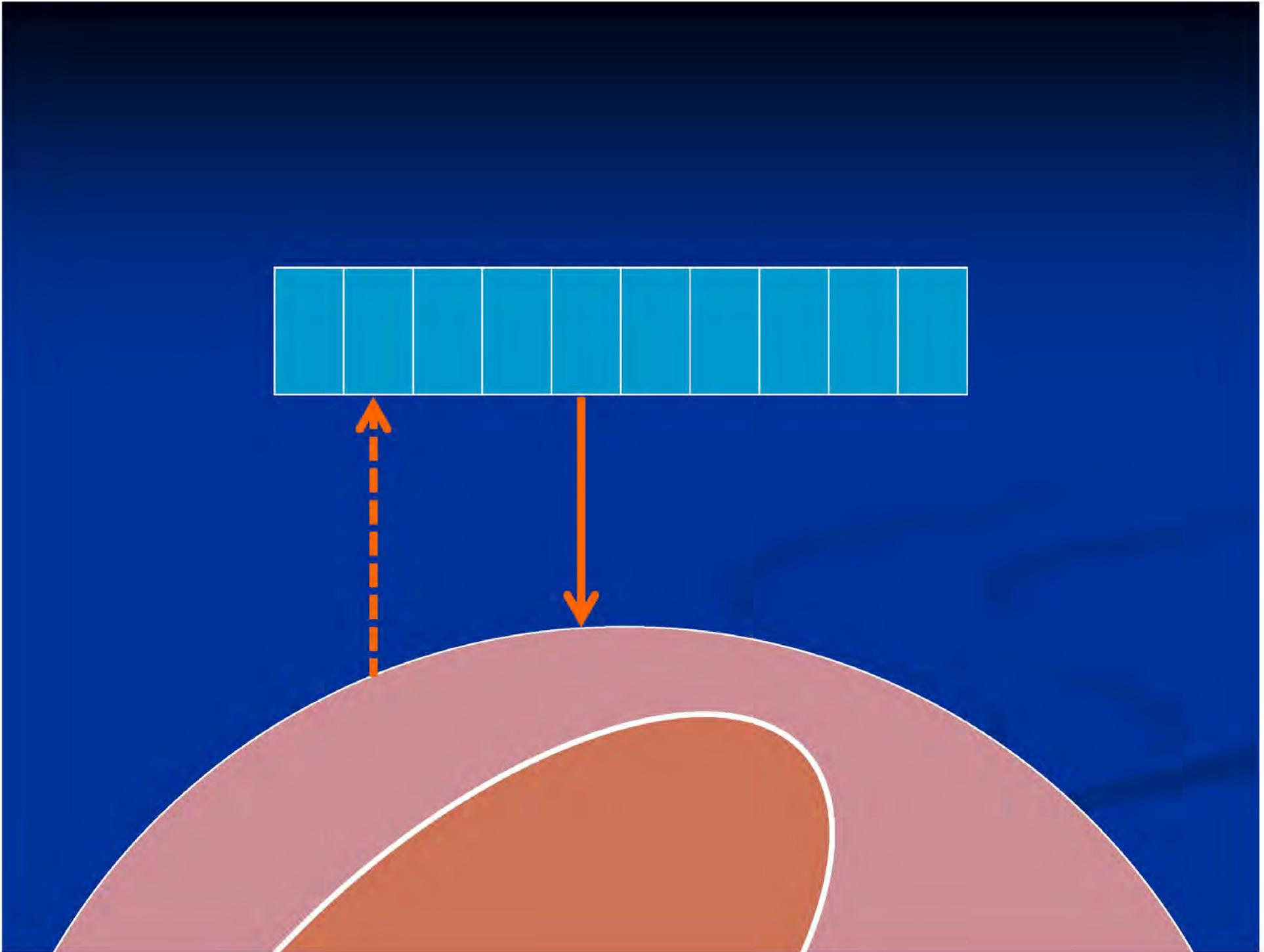


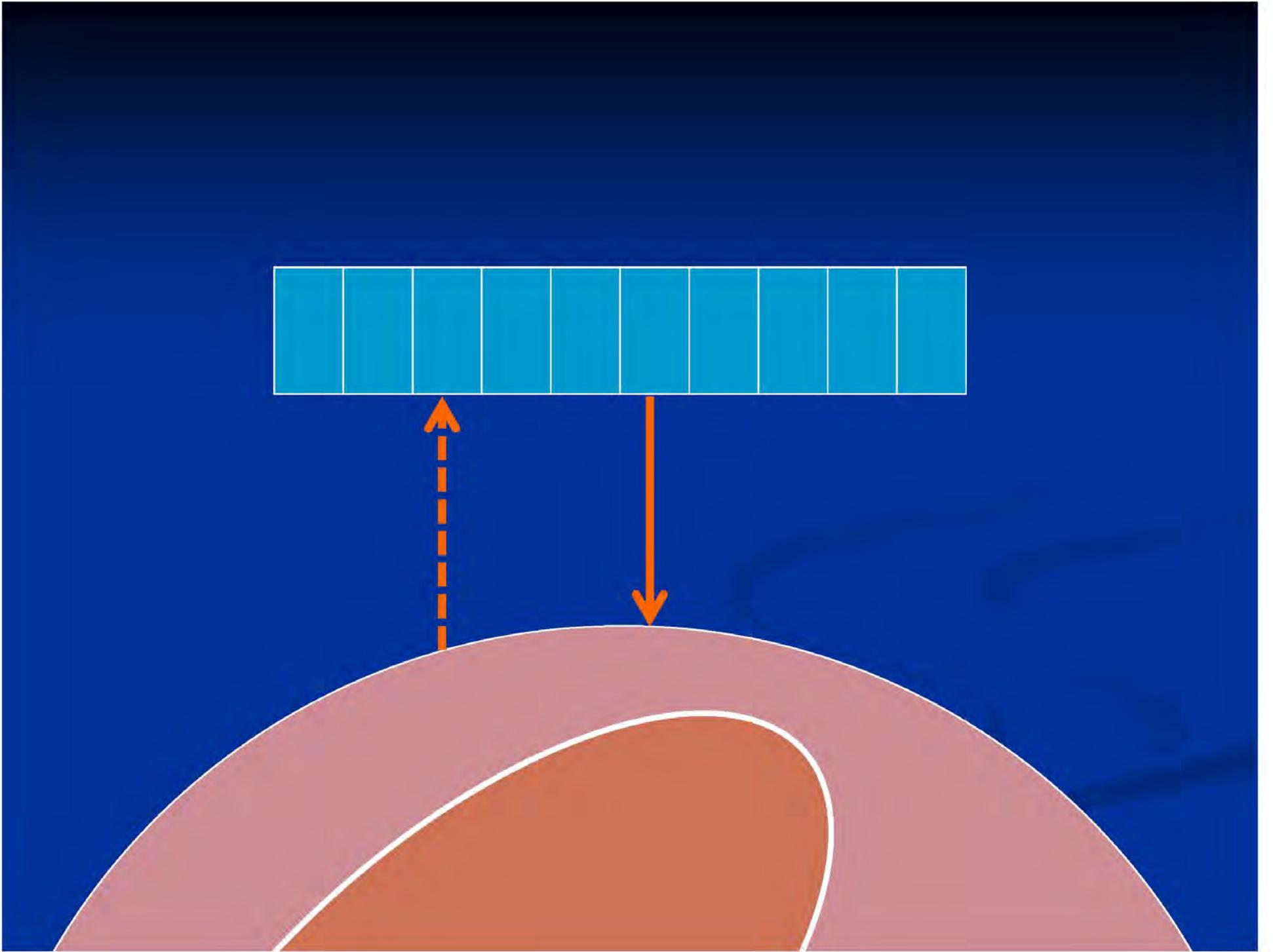


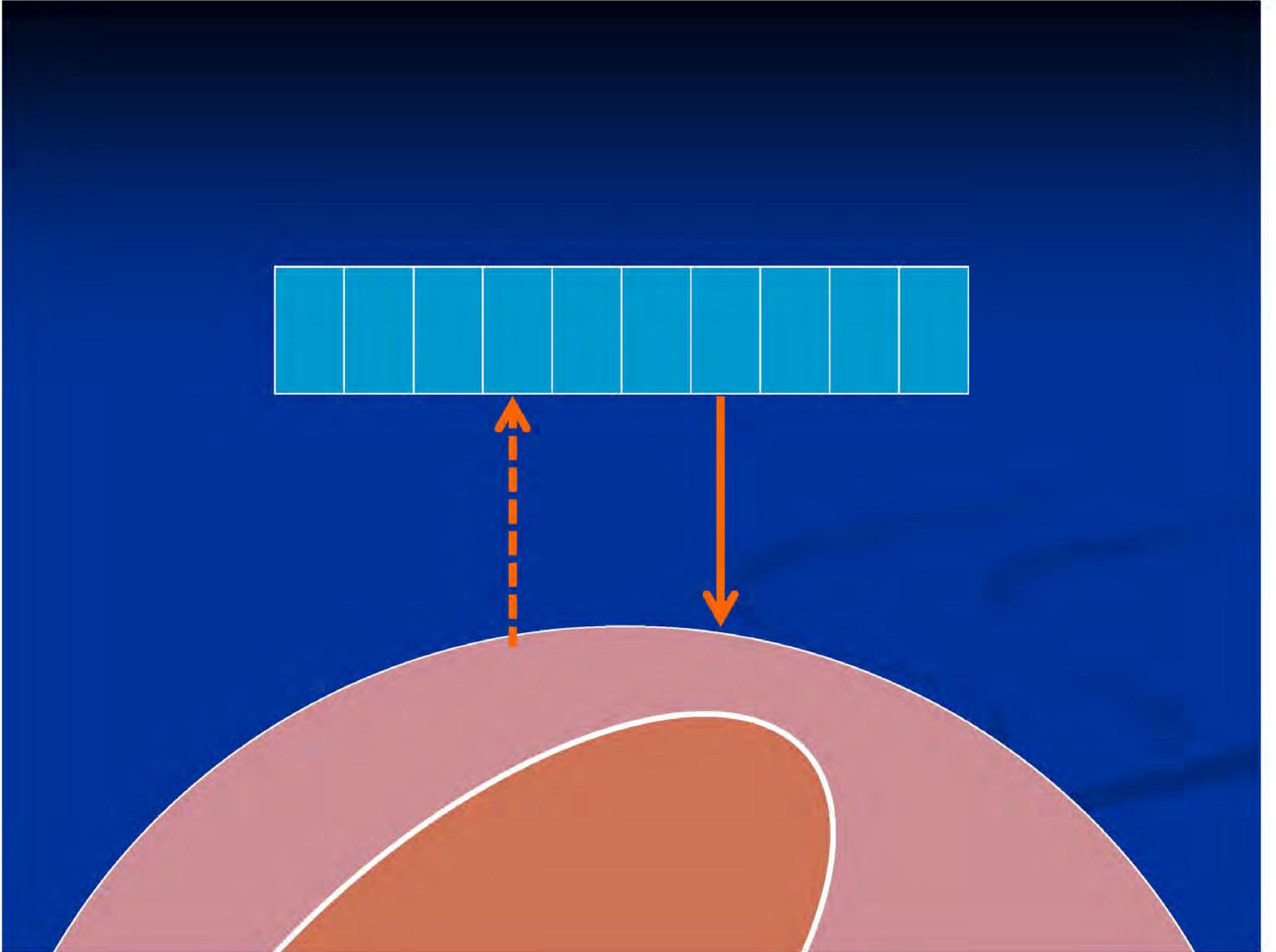


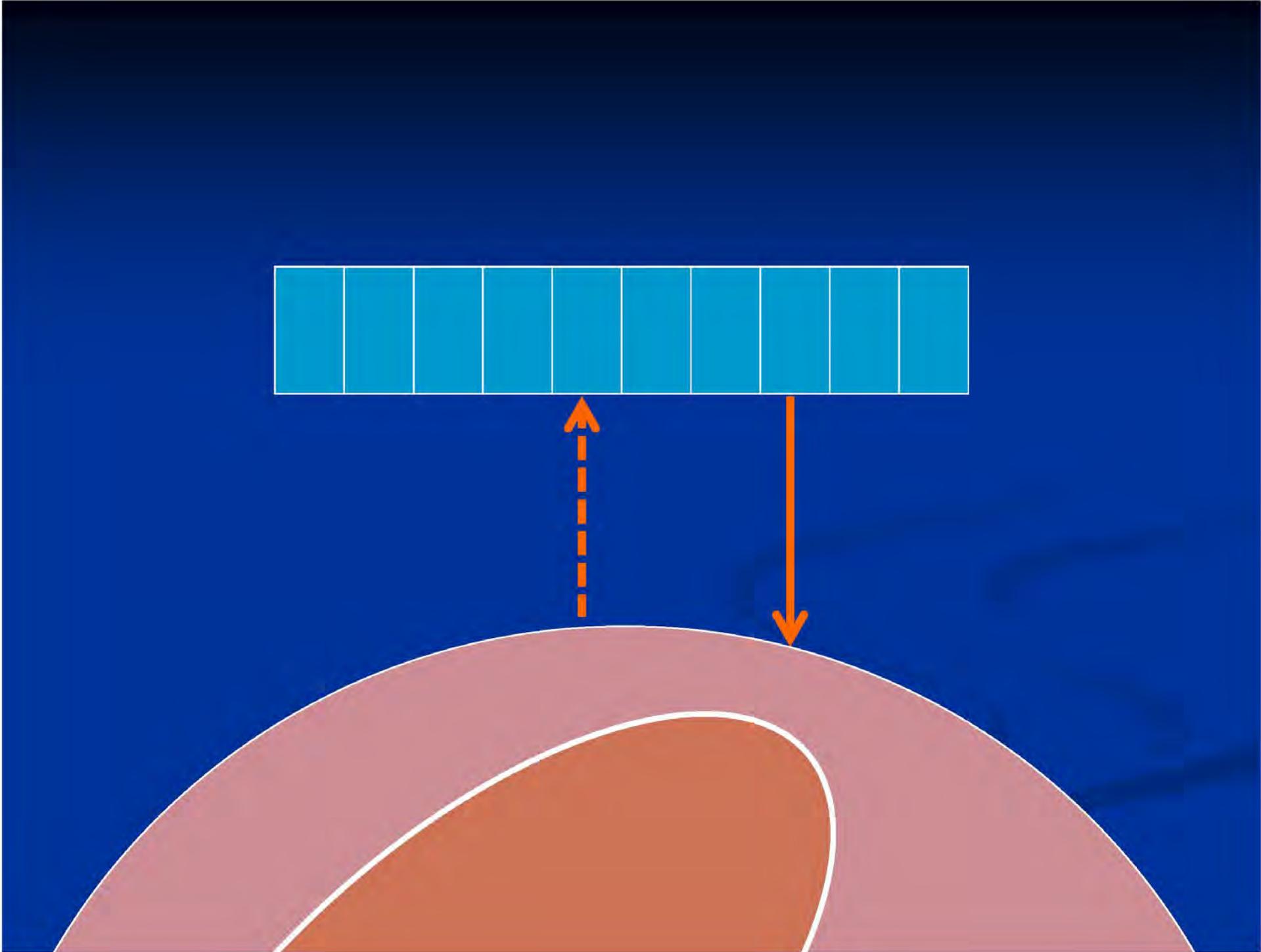


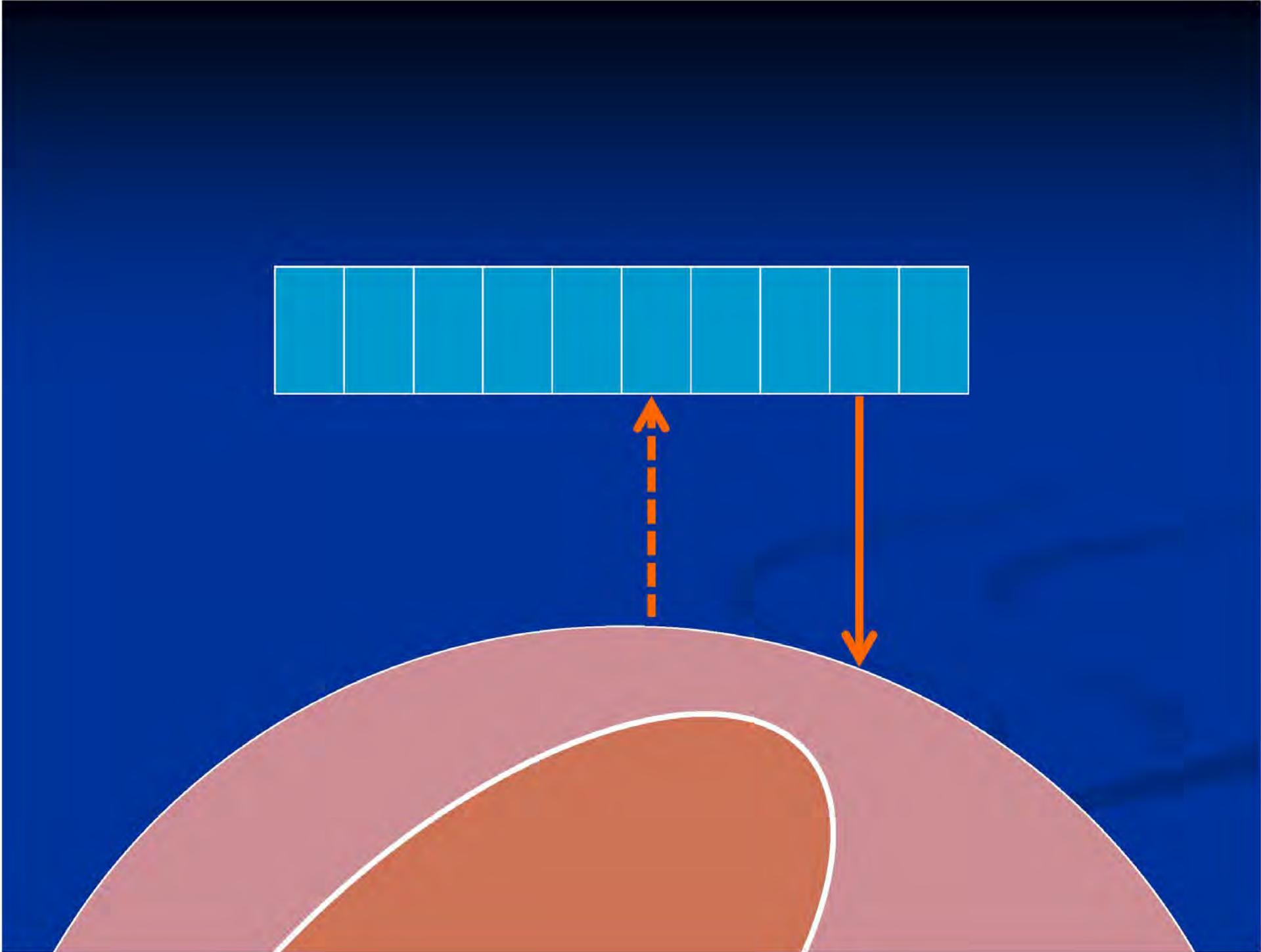


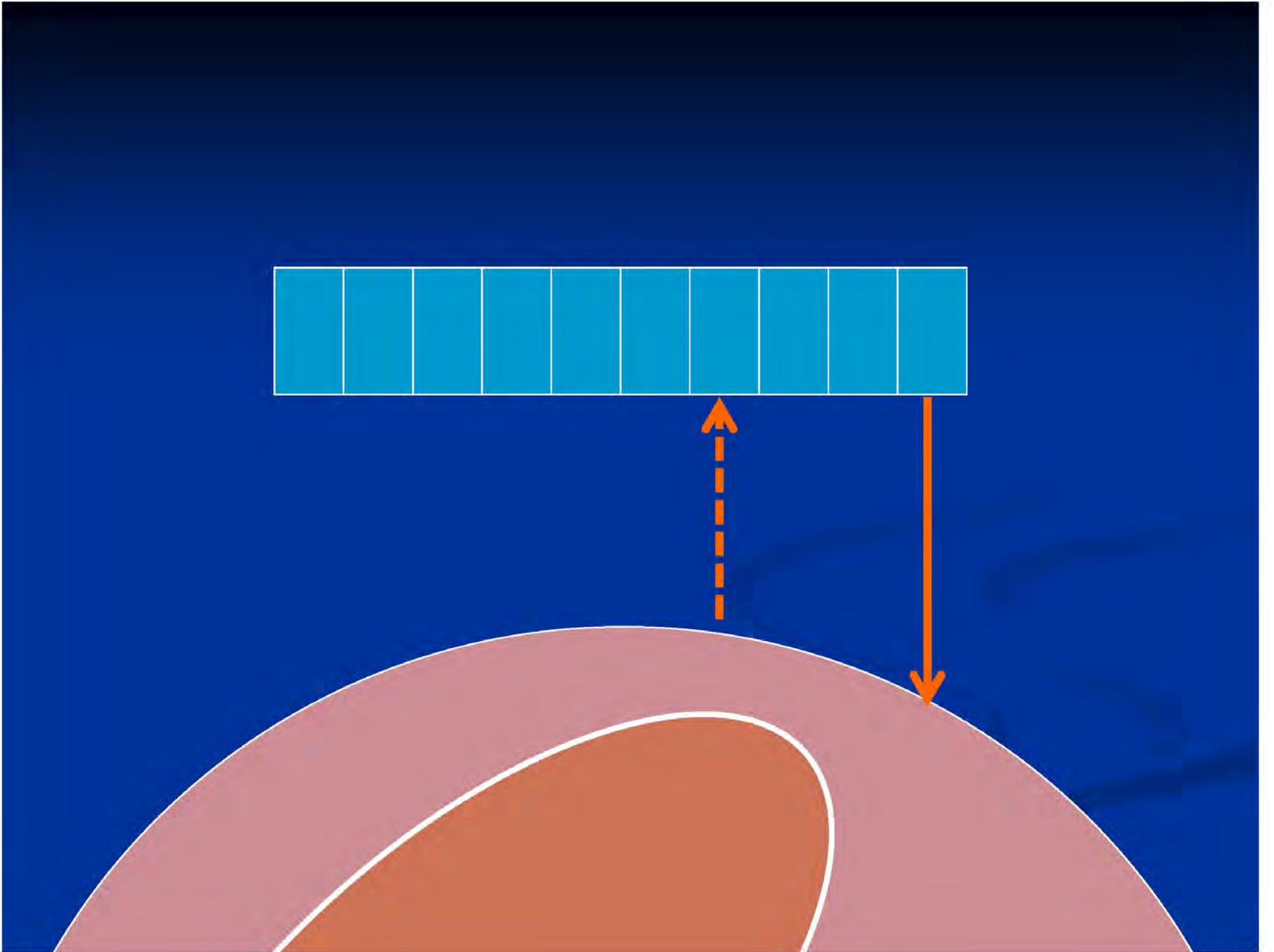


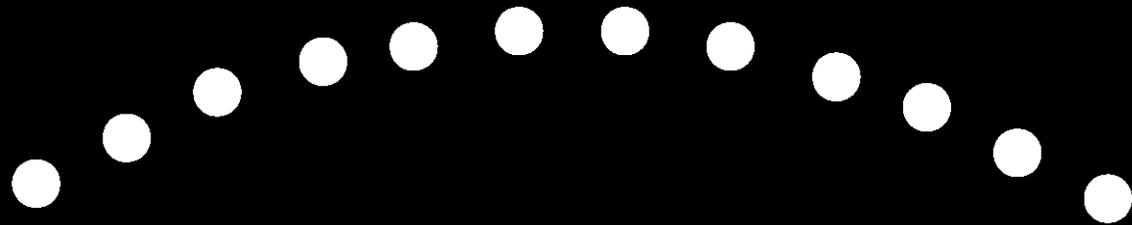


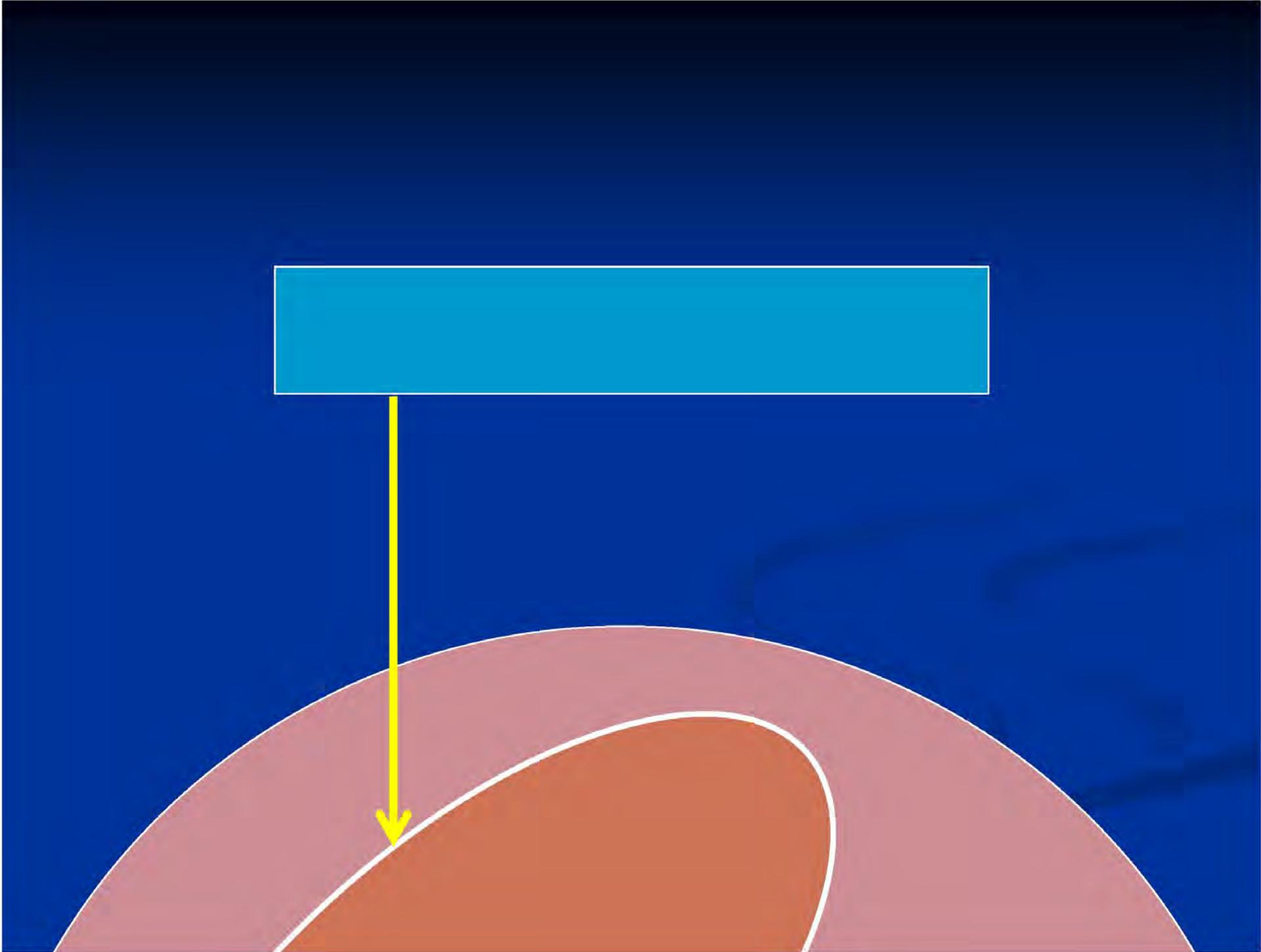


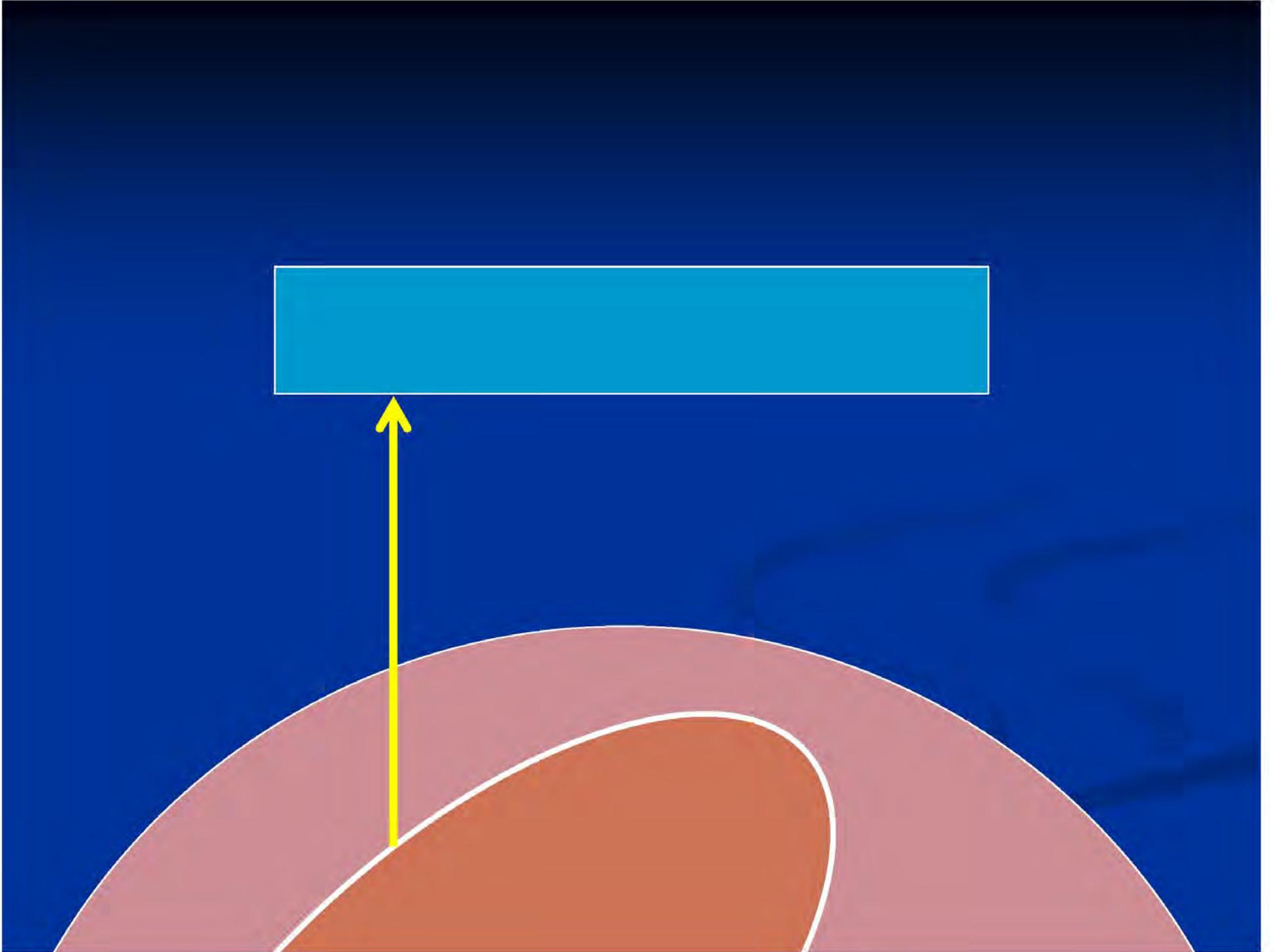


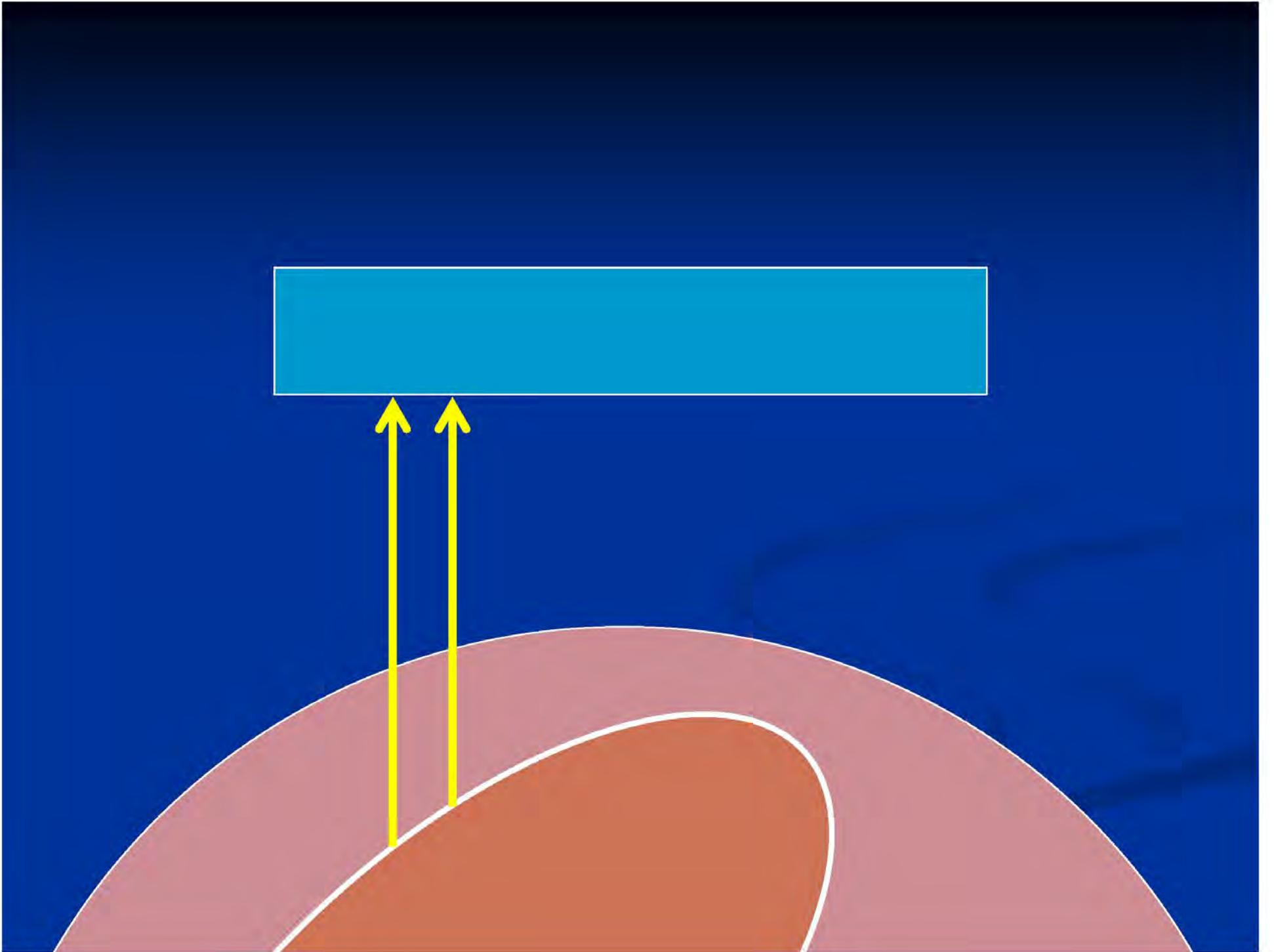


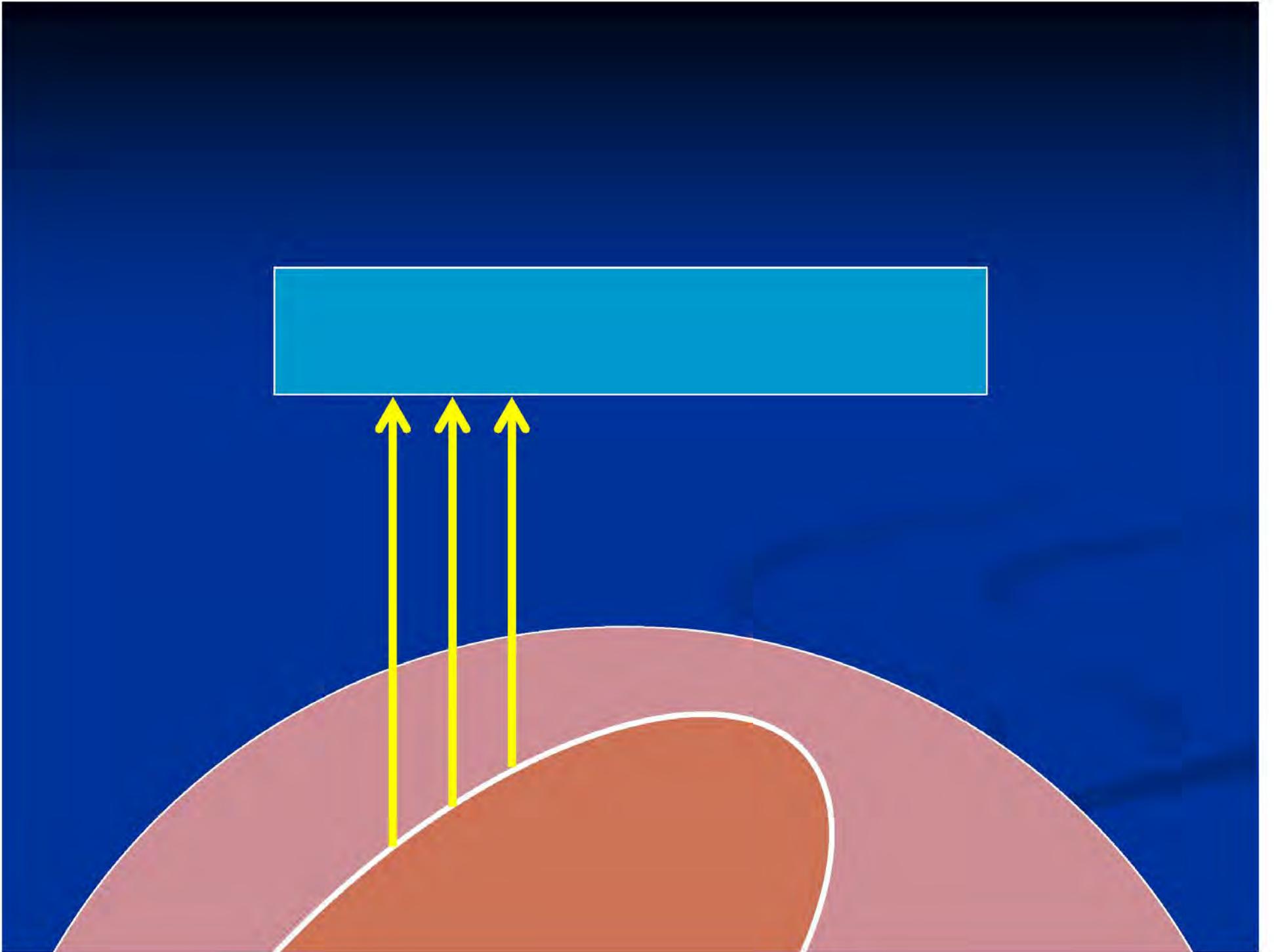


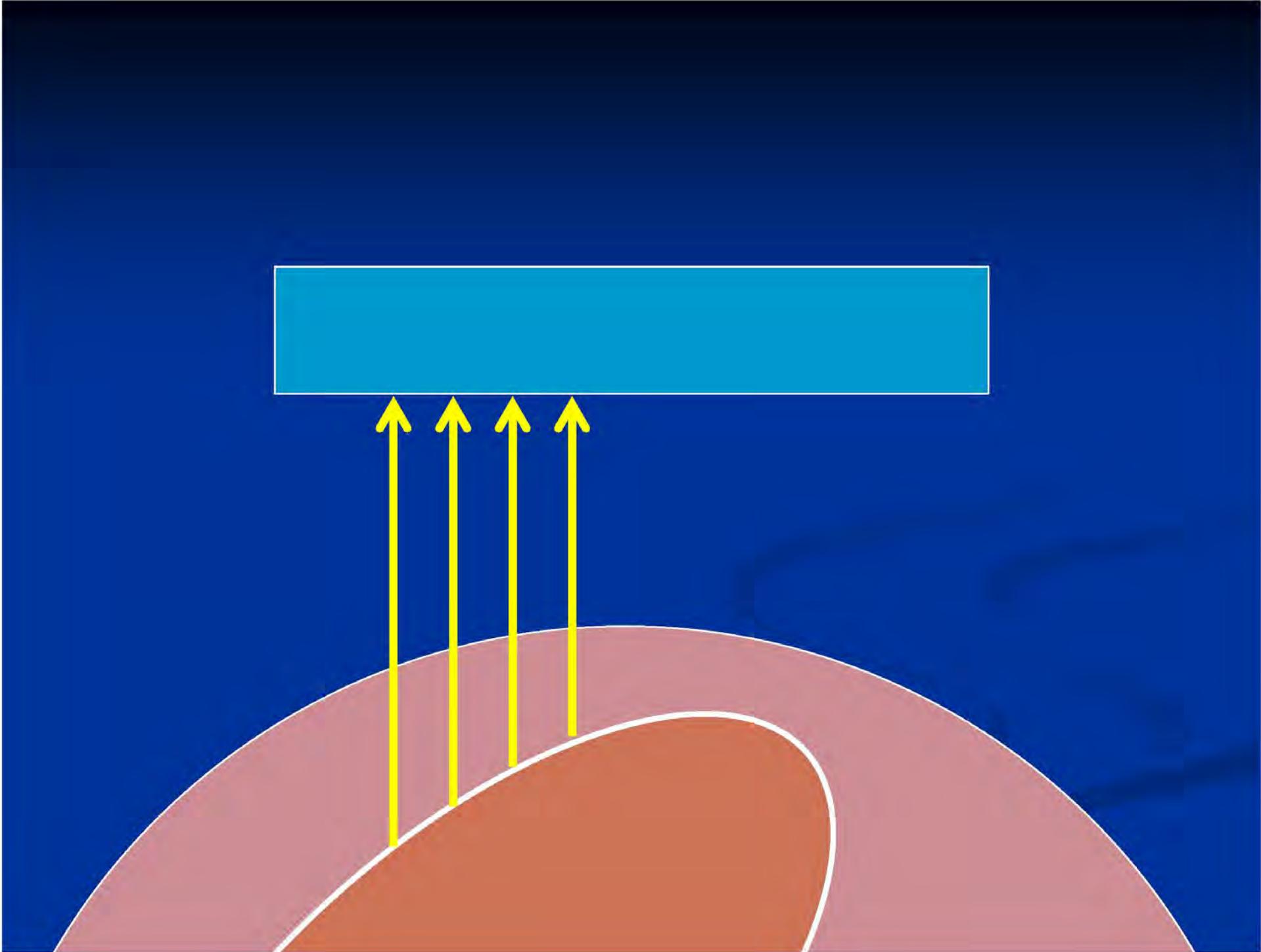


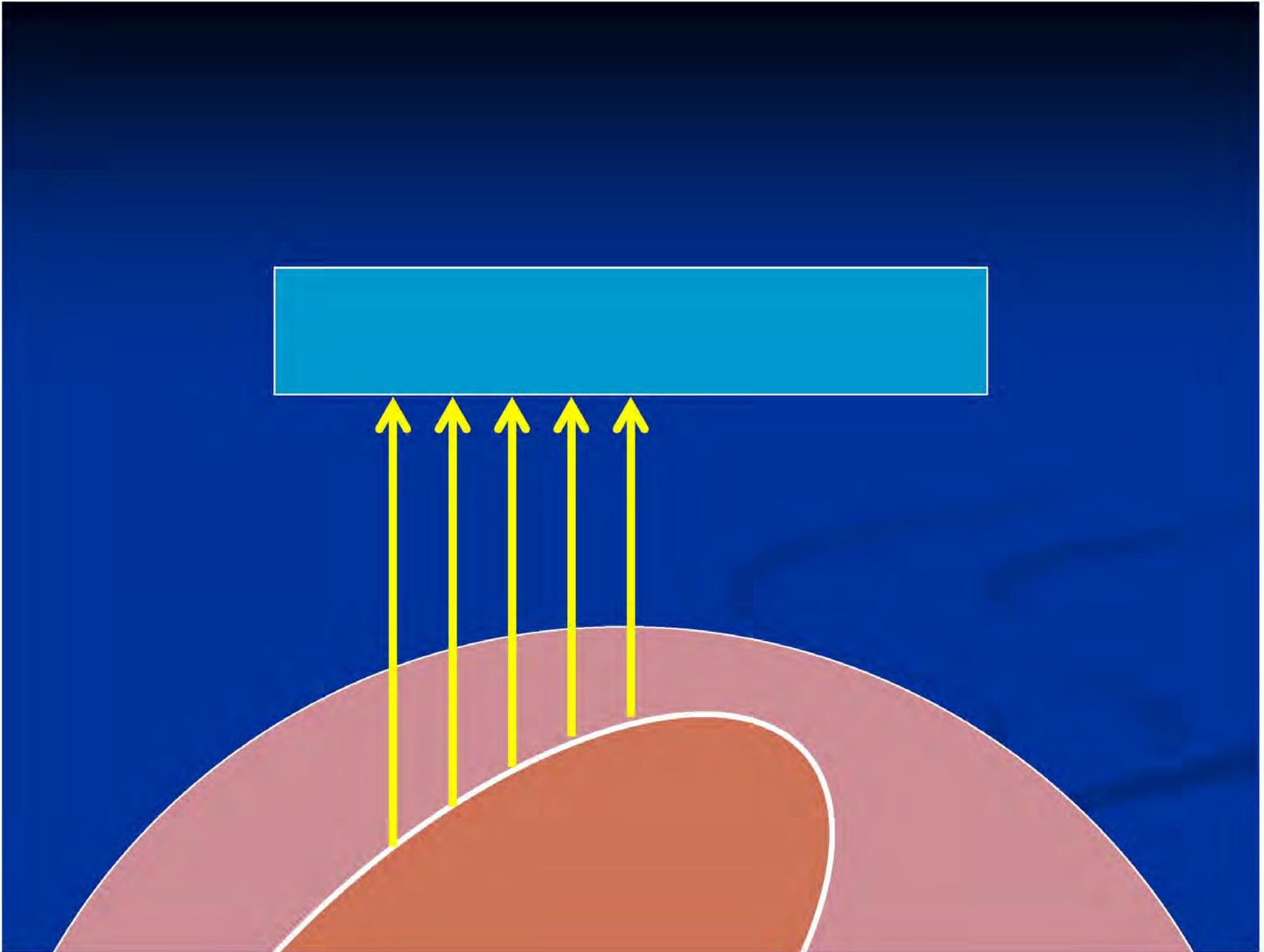


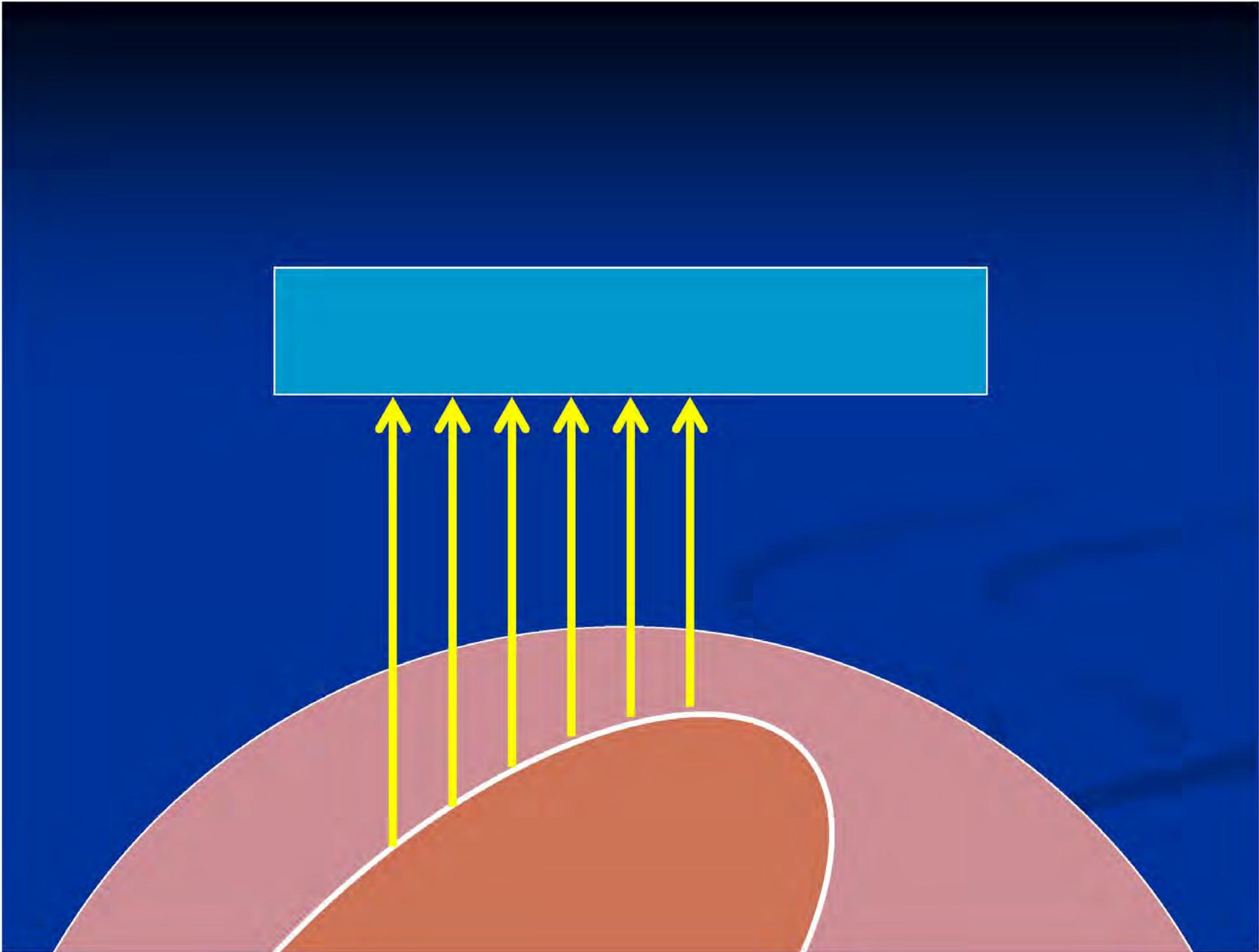


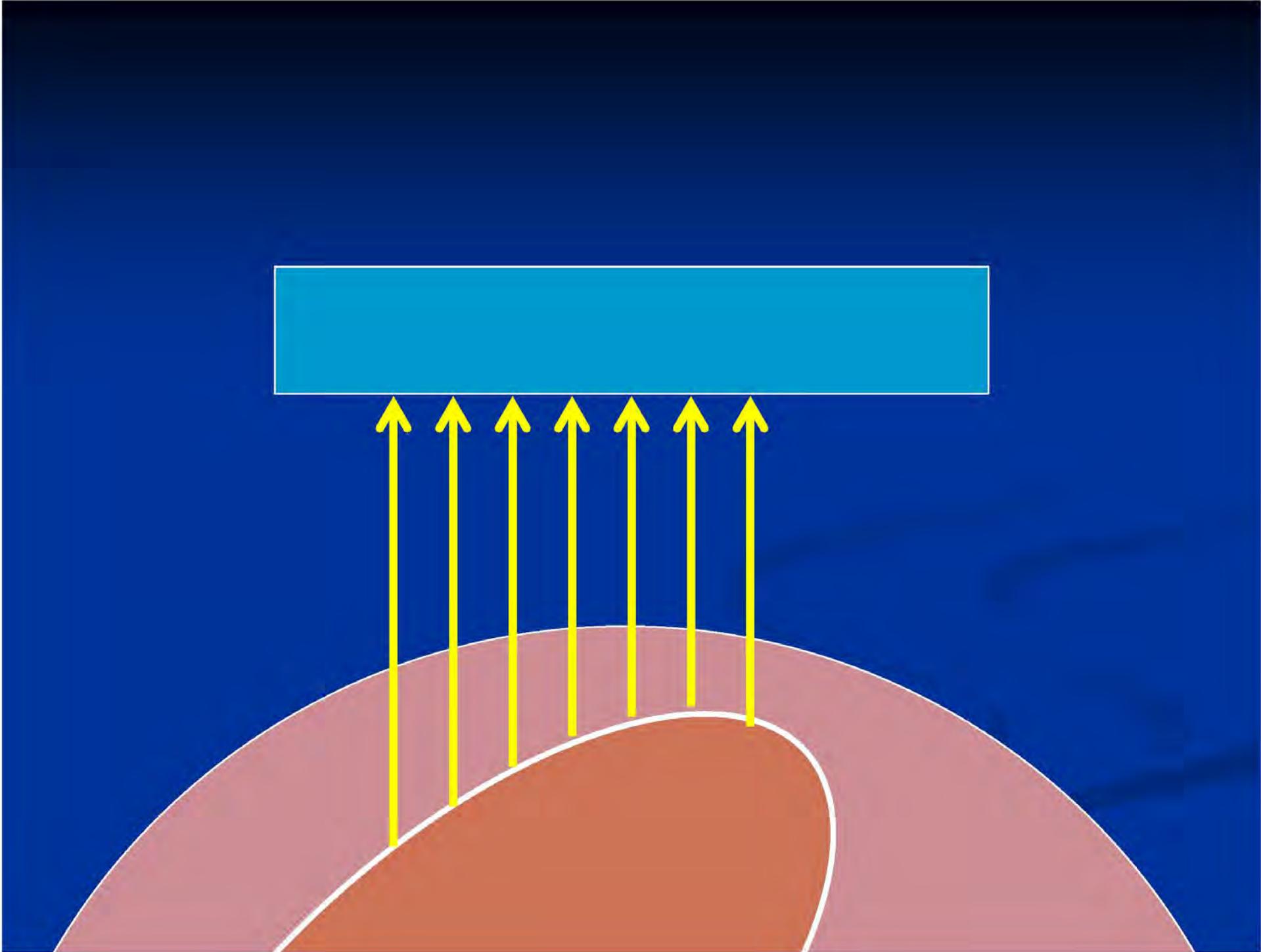


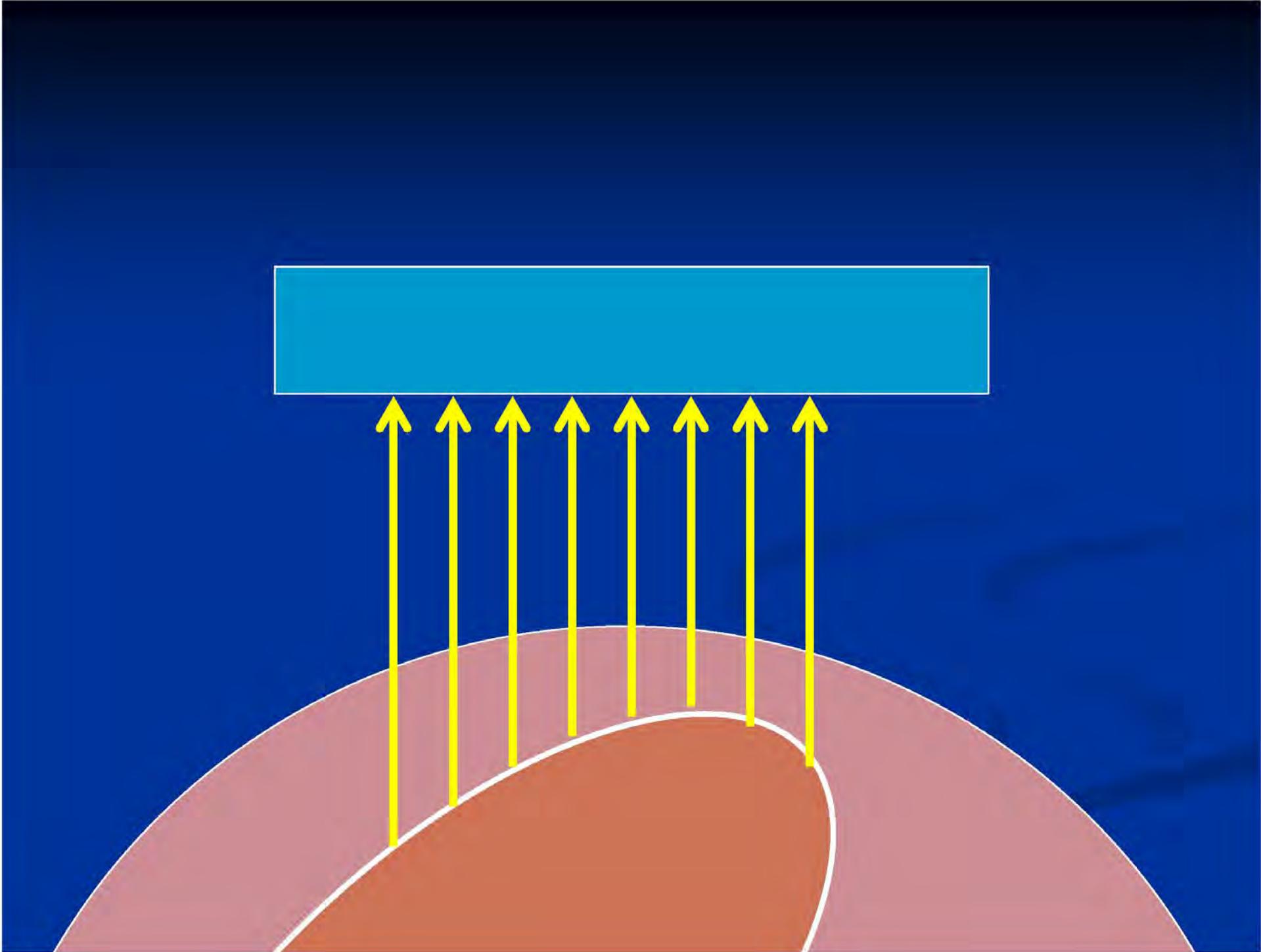










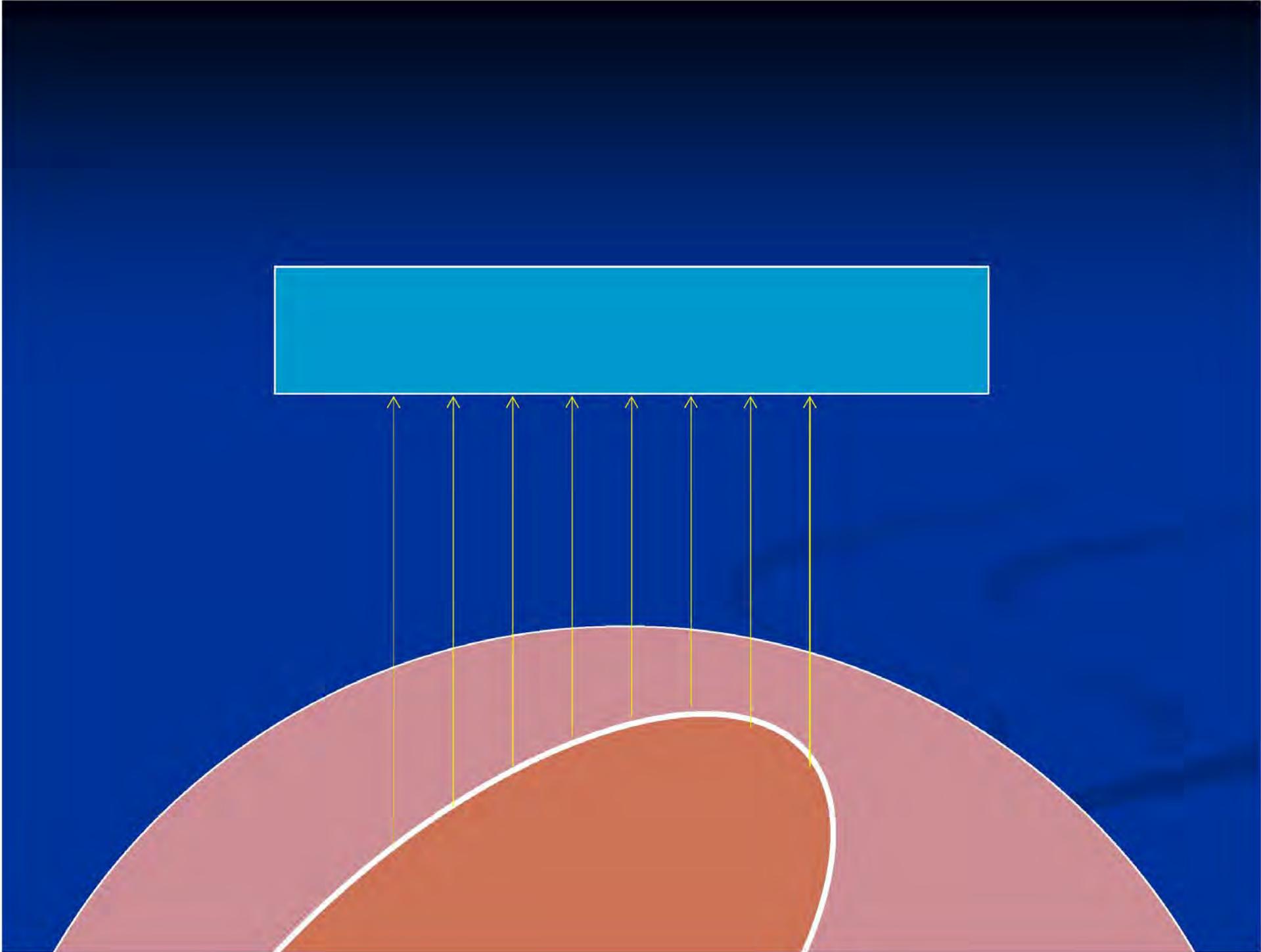


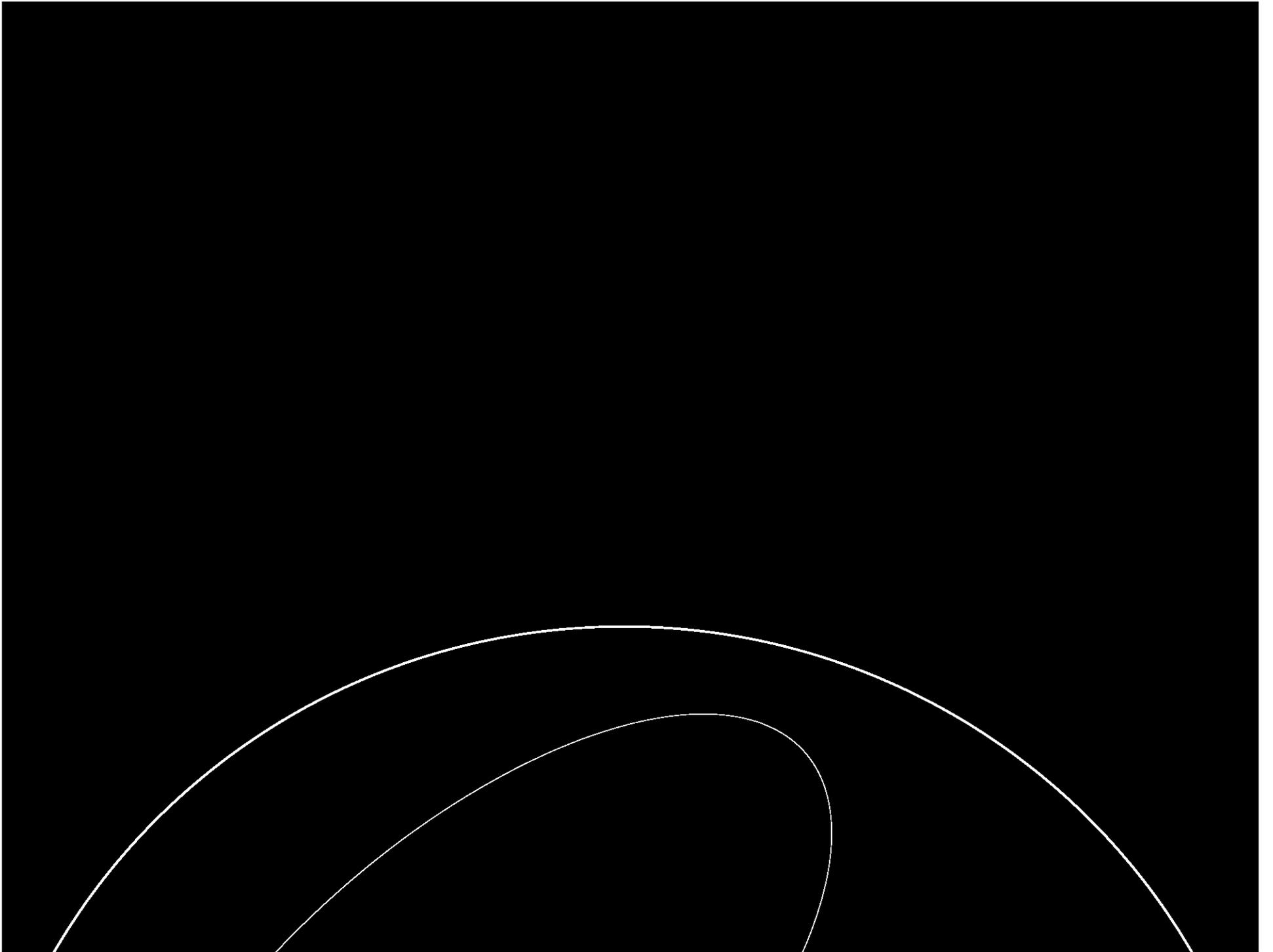


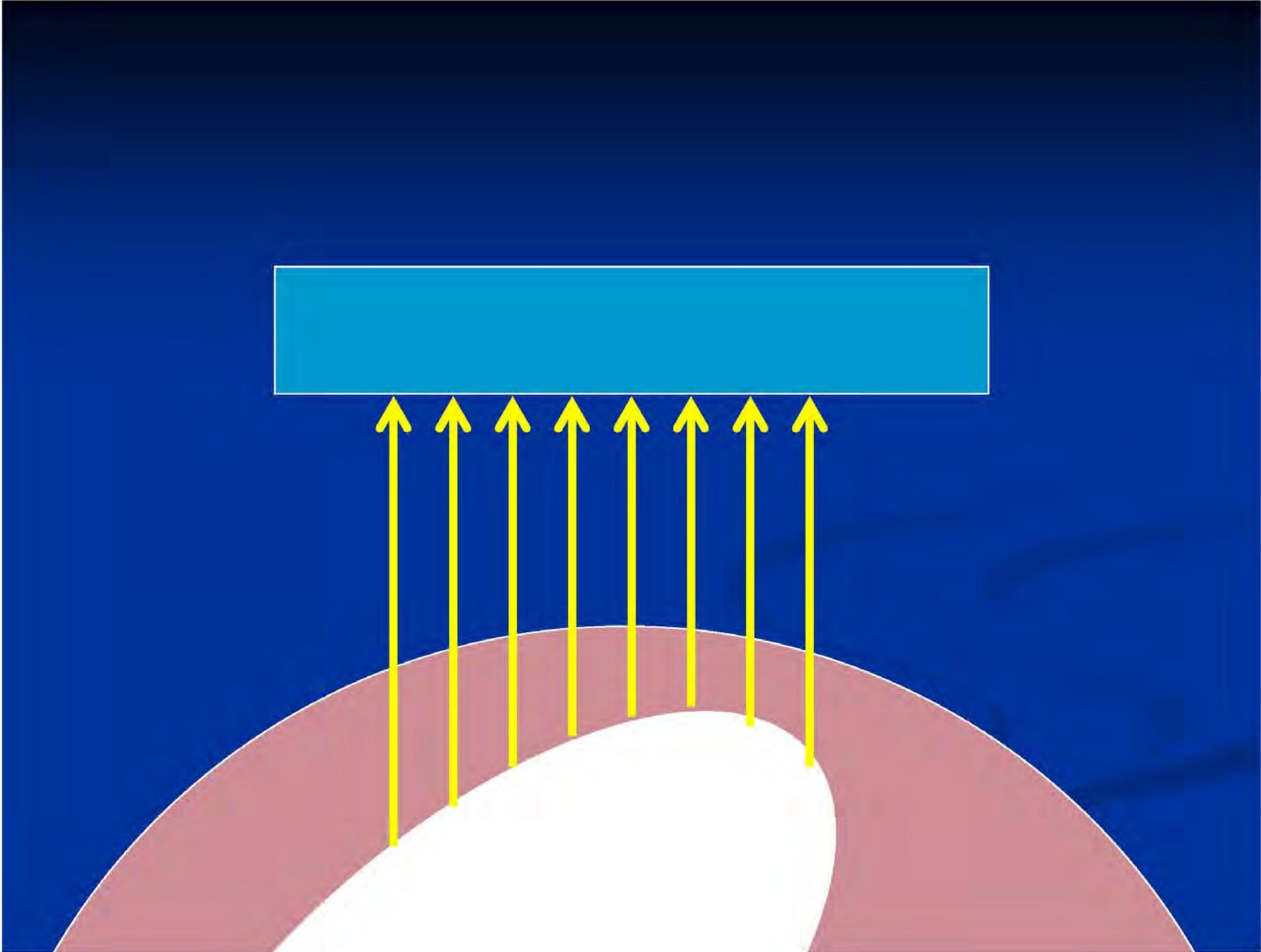
How is the image formed?

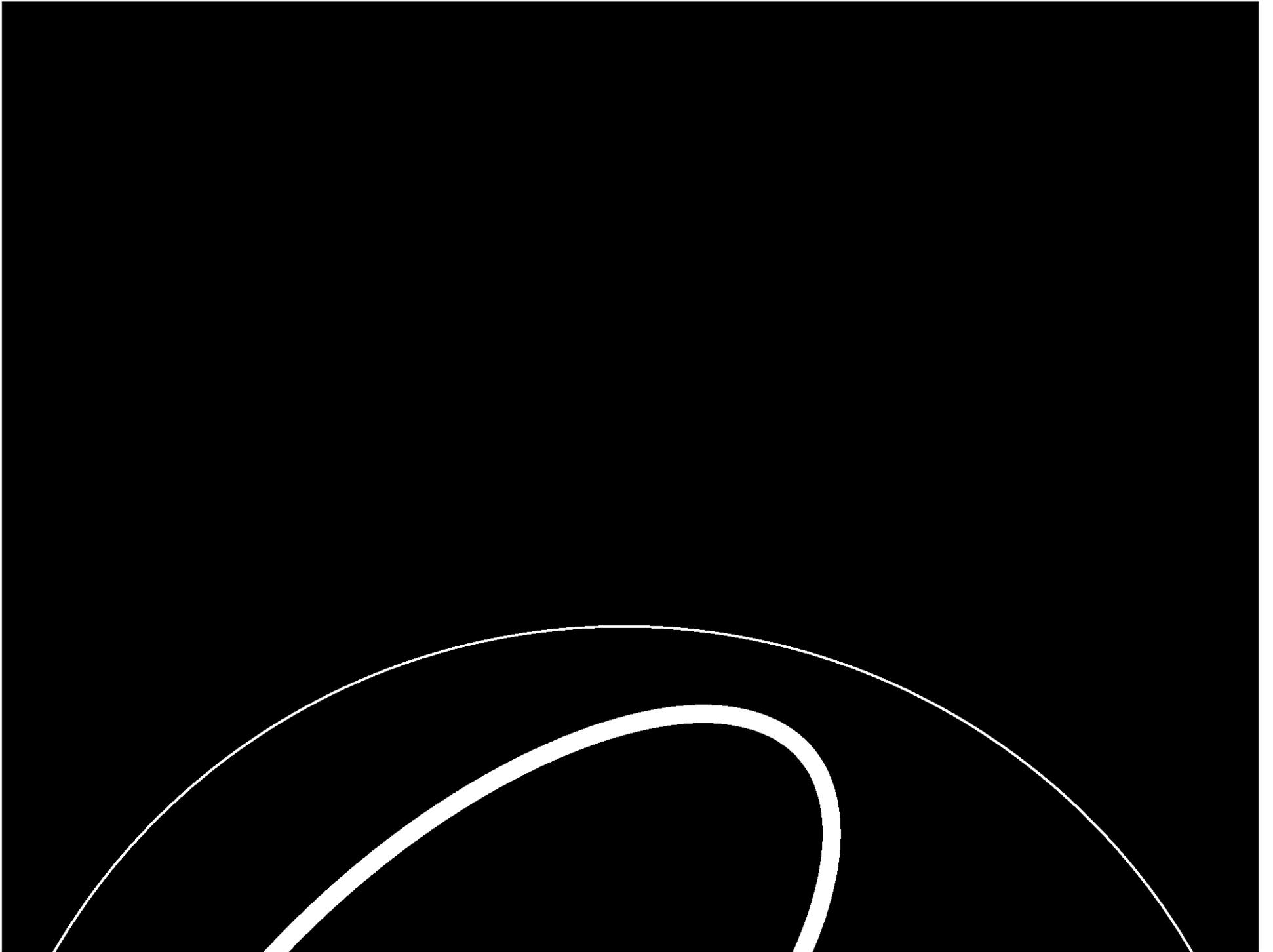
Dots on screen

Brightness proportional to **strength** of returning
echoes









But...

Location of the dots is determined by **travel time, NOT DISTANCE**

More on this later

Interfaces

This is where the action is!

At each interface:

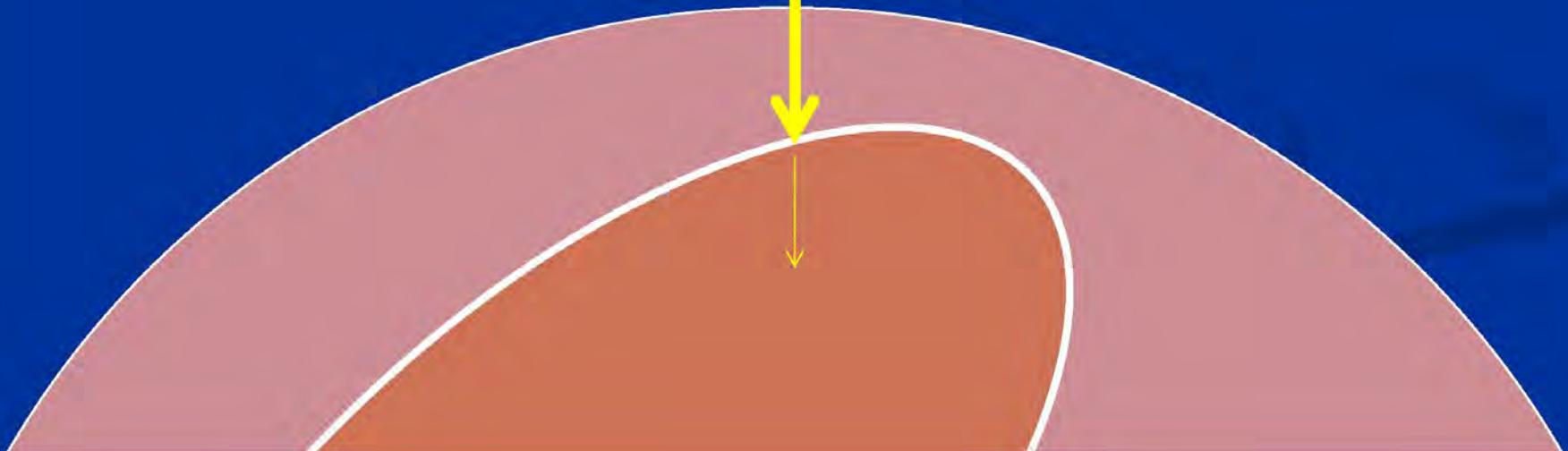
Transmitted

Attenuated

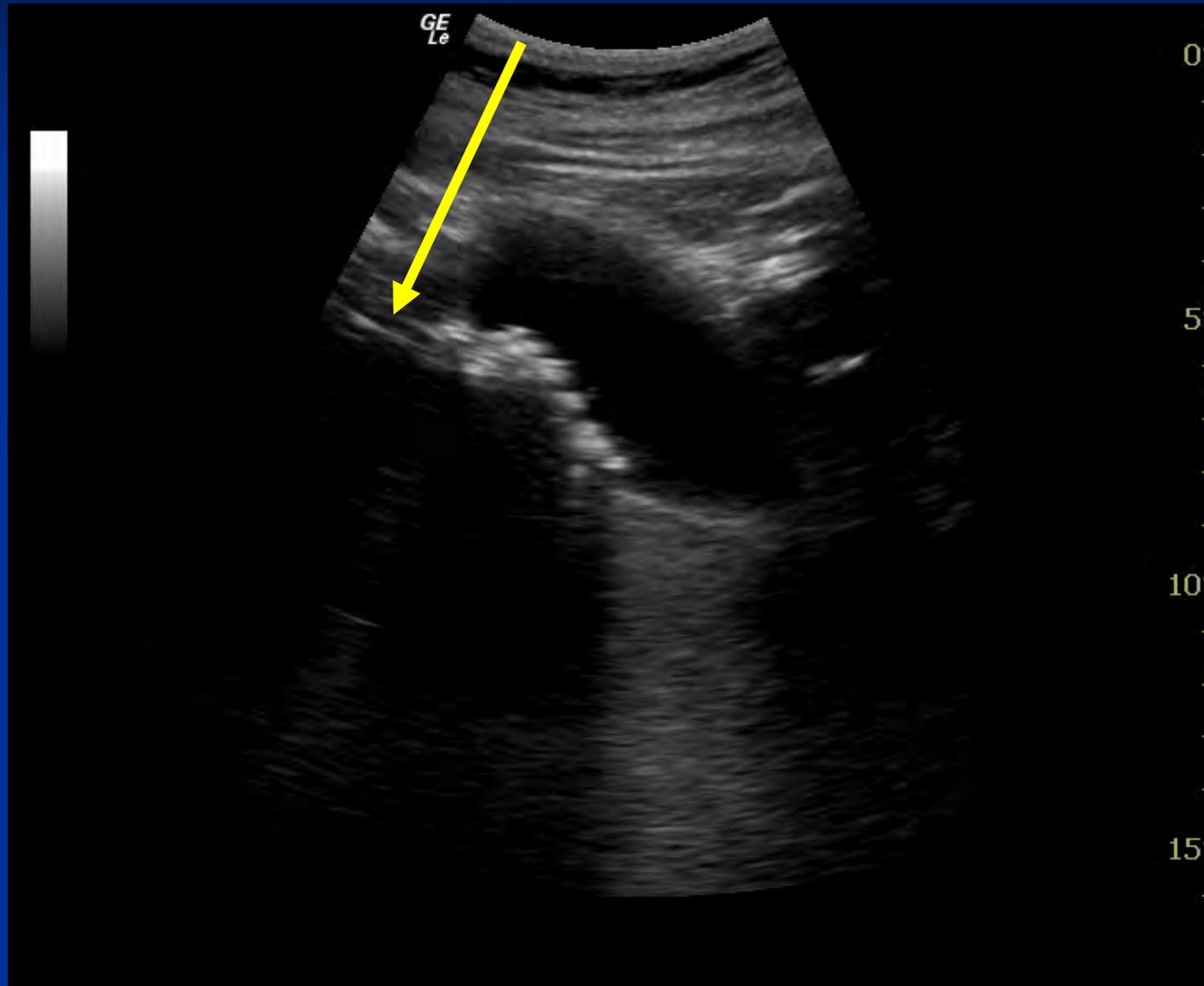
Example

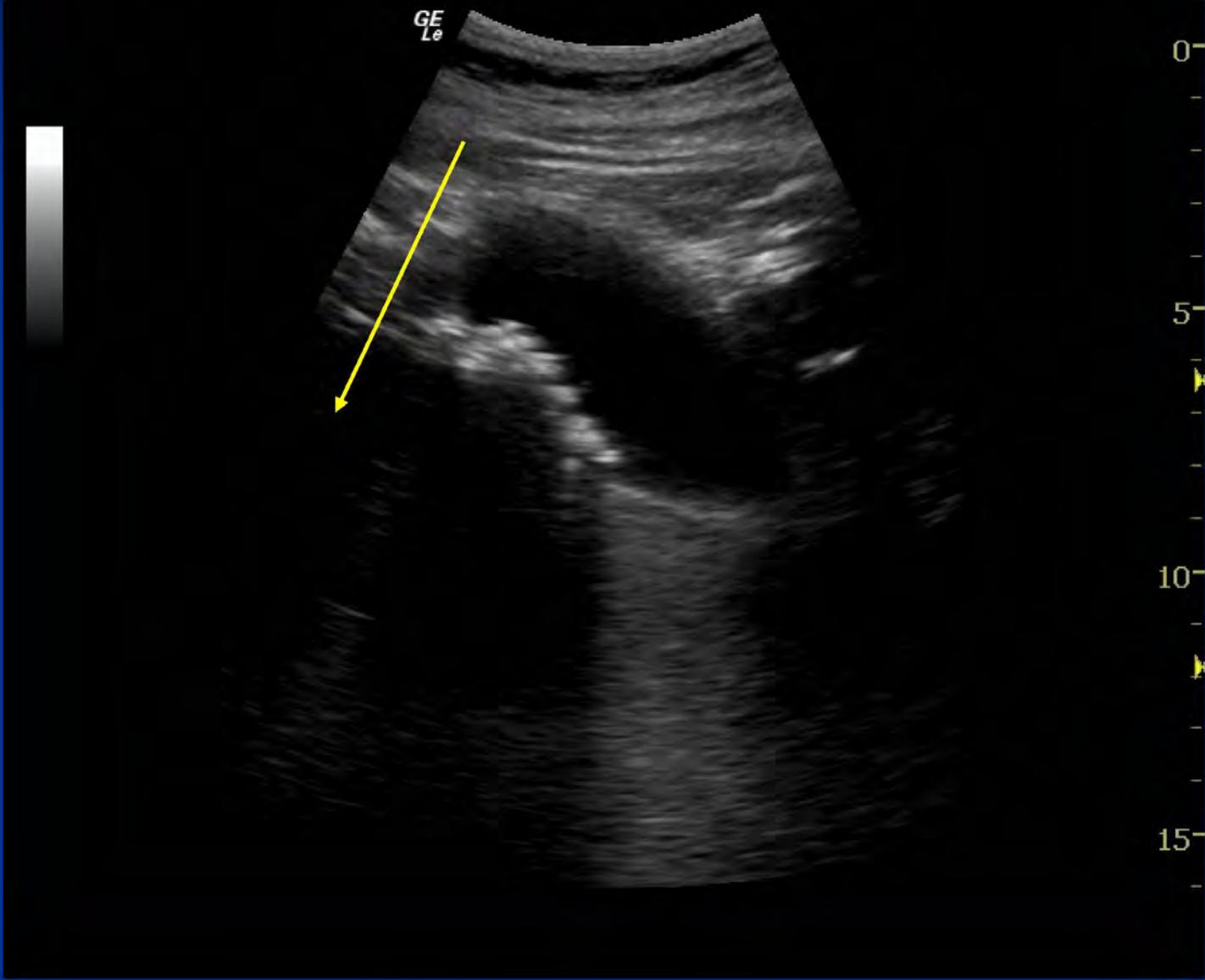


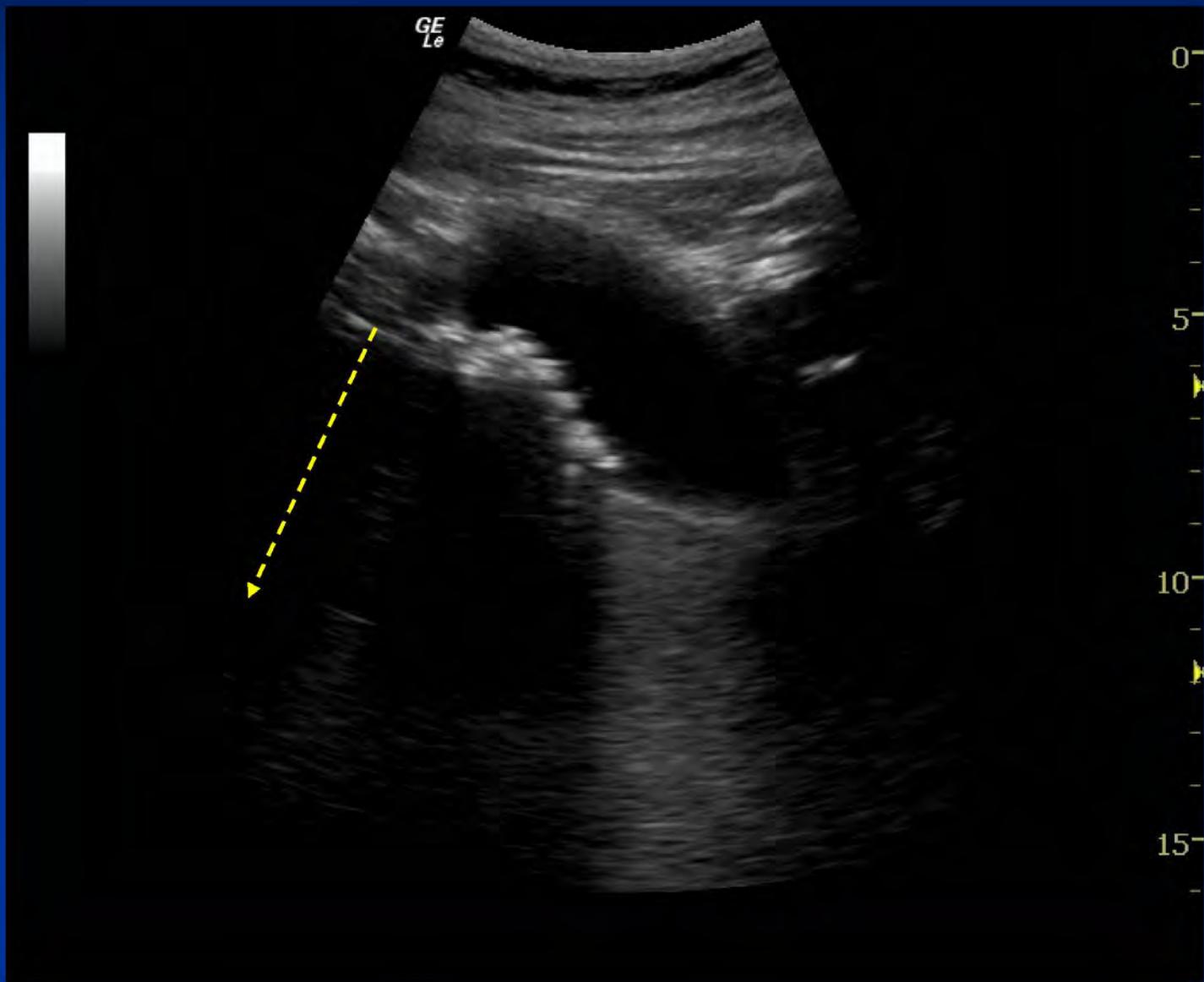
Absorbed



Tissue

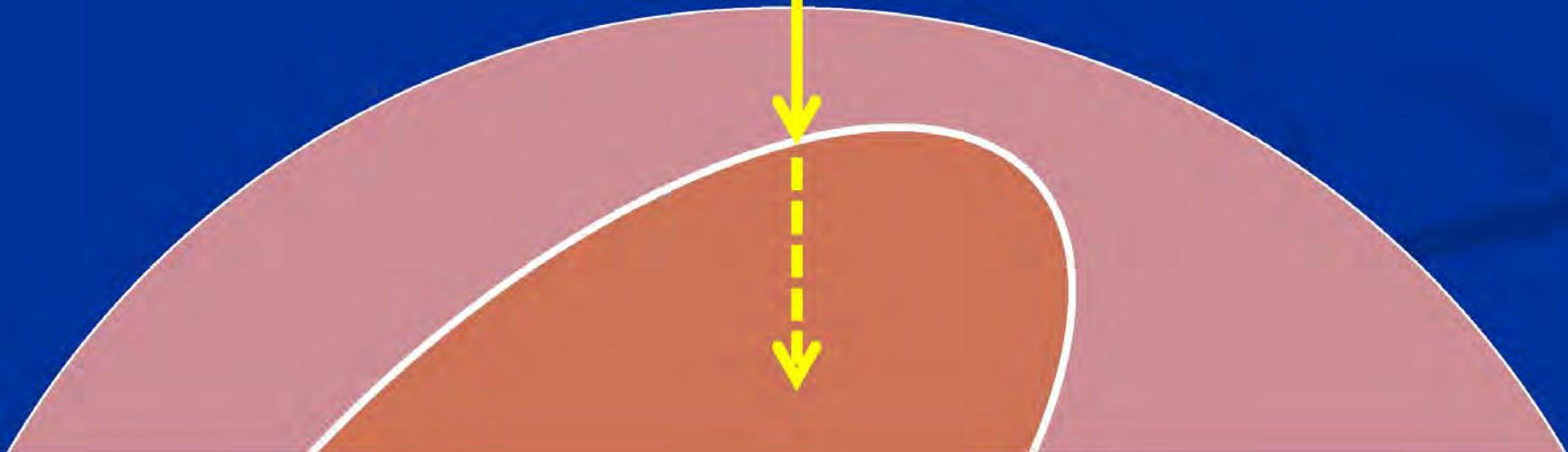




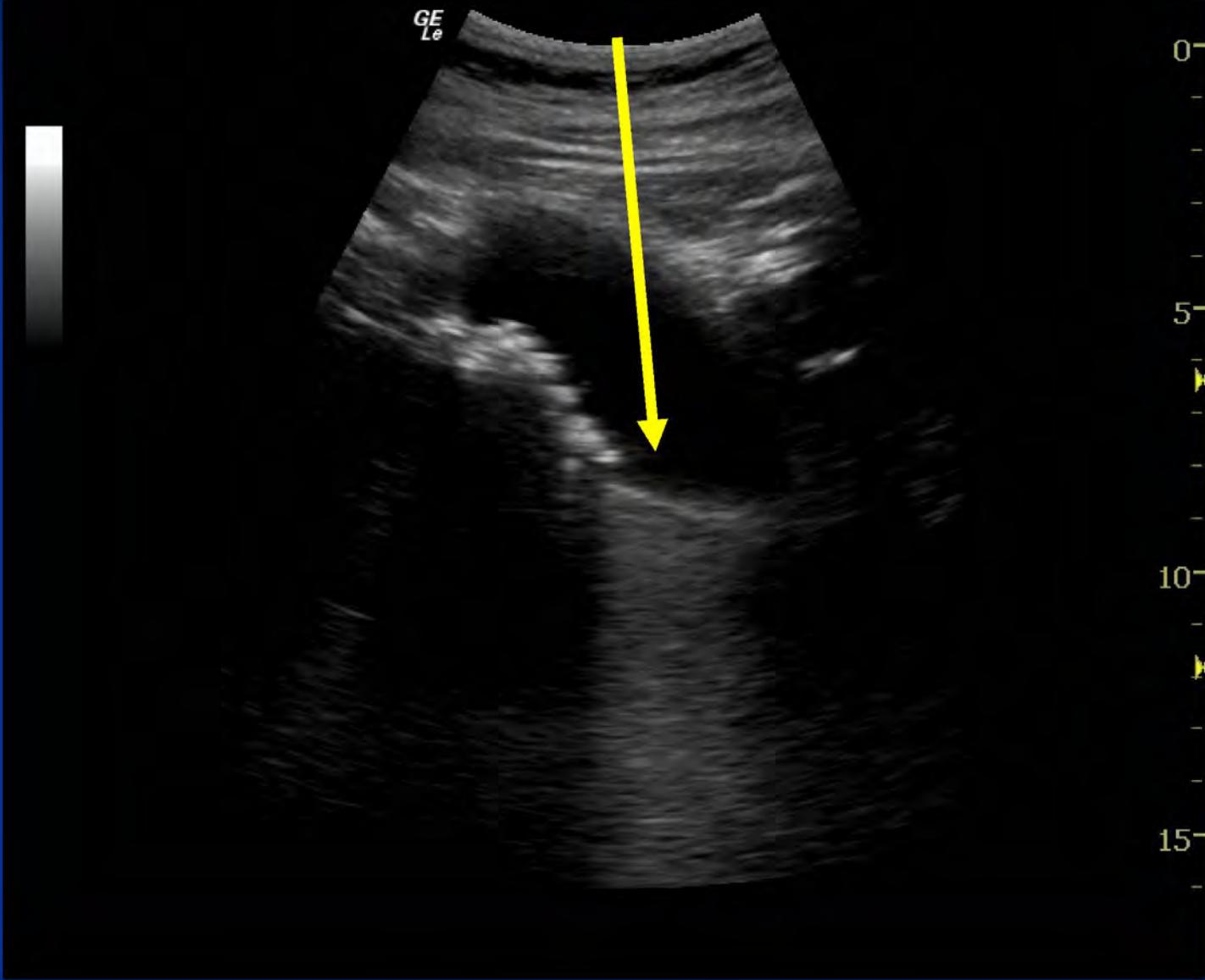




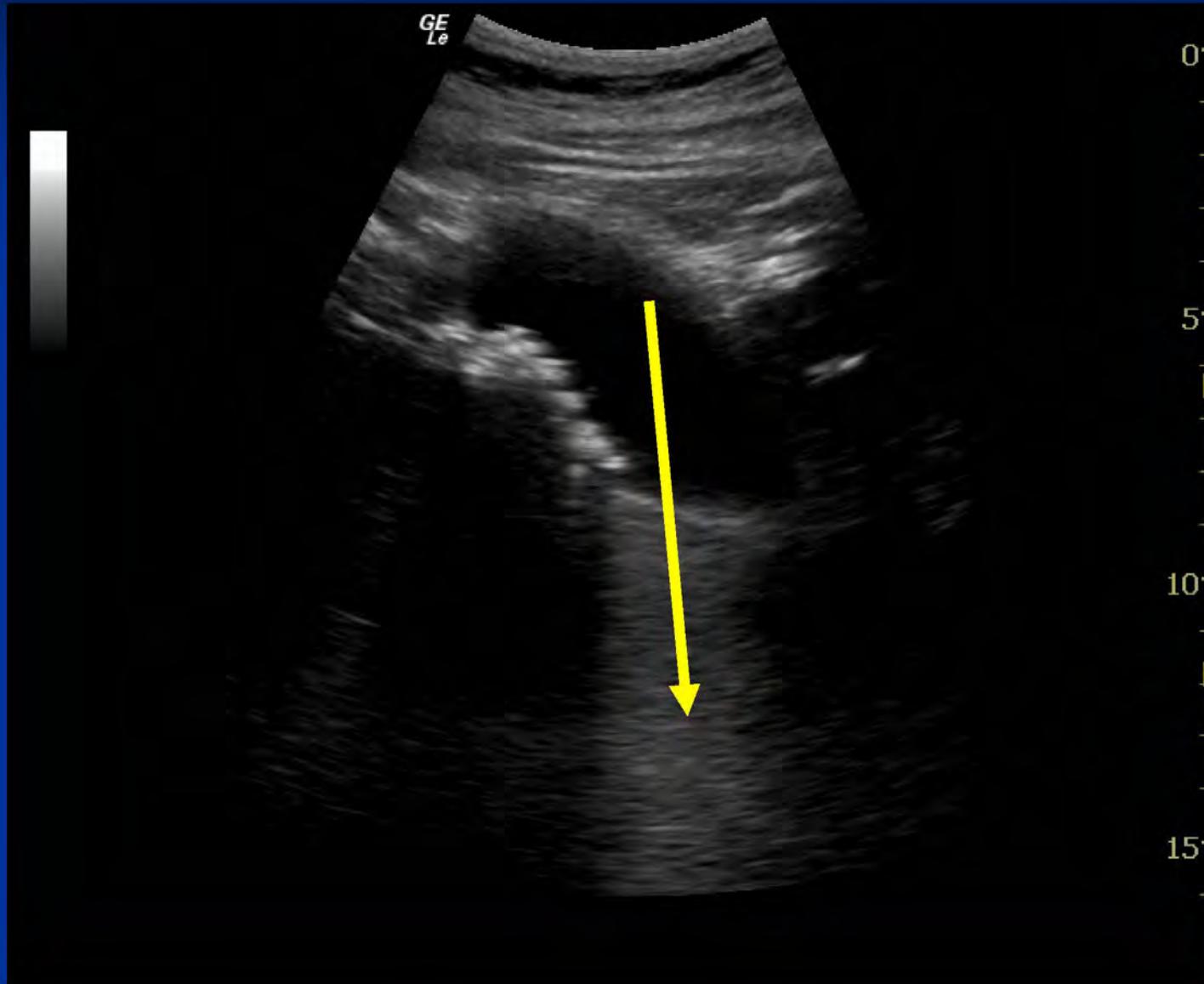
Transmitted



Fluid (GB)



Fluid (GB)



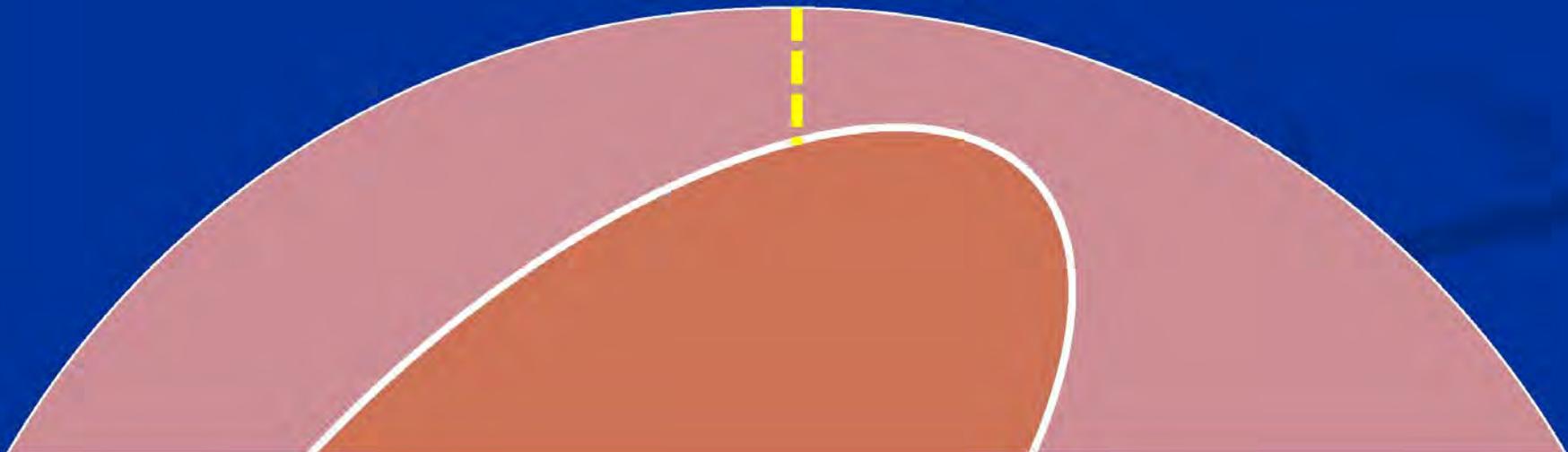
Fluid (GB)



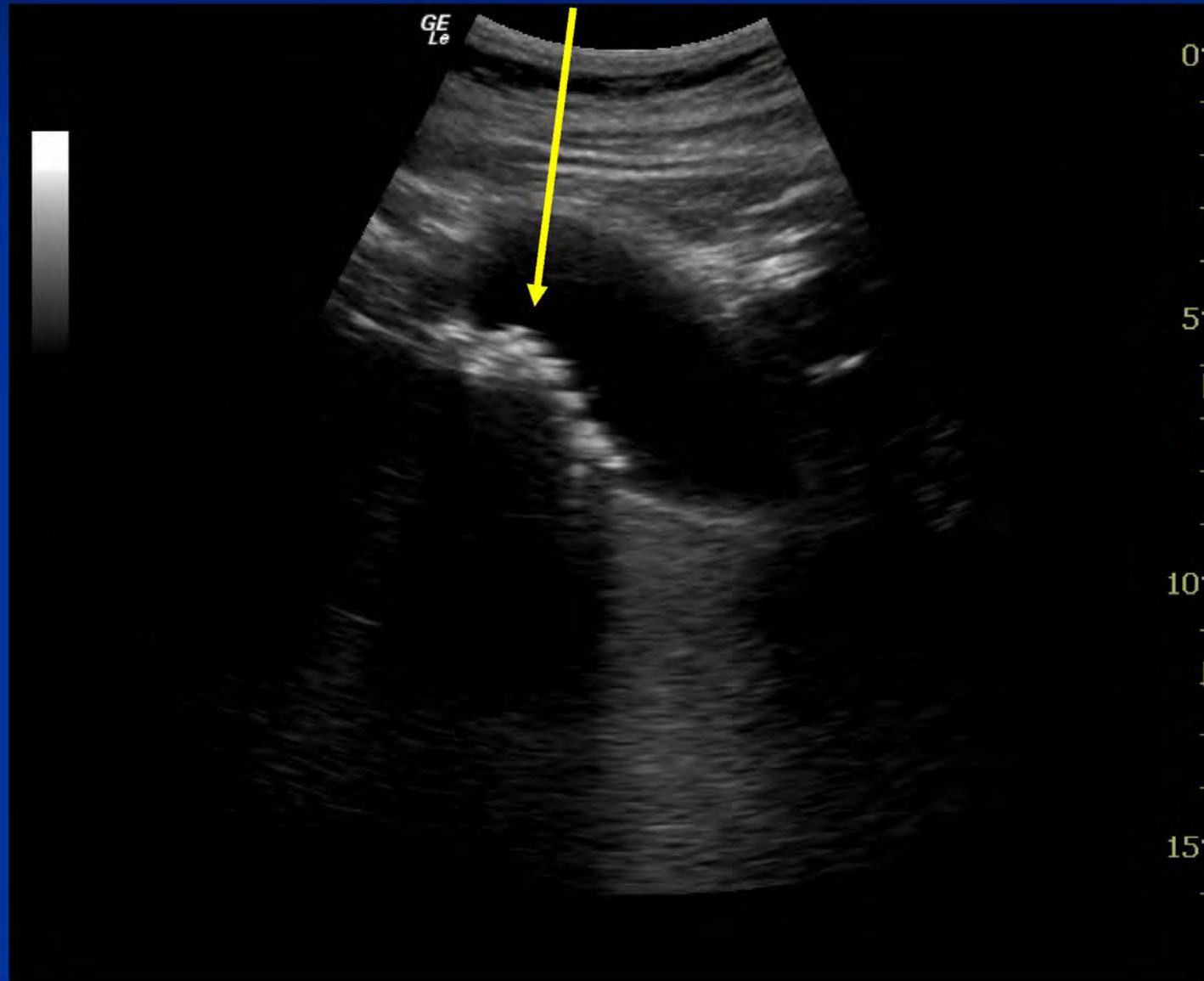
Posterior enhancement

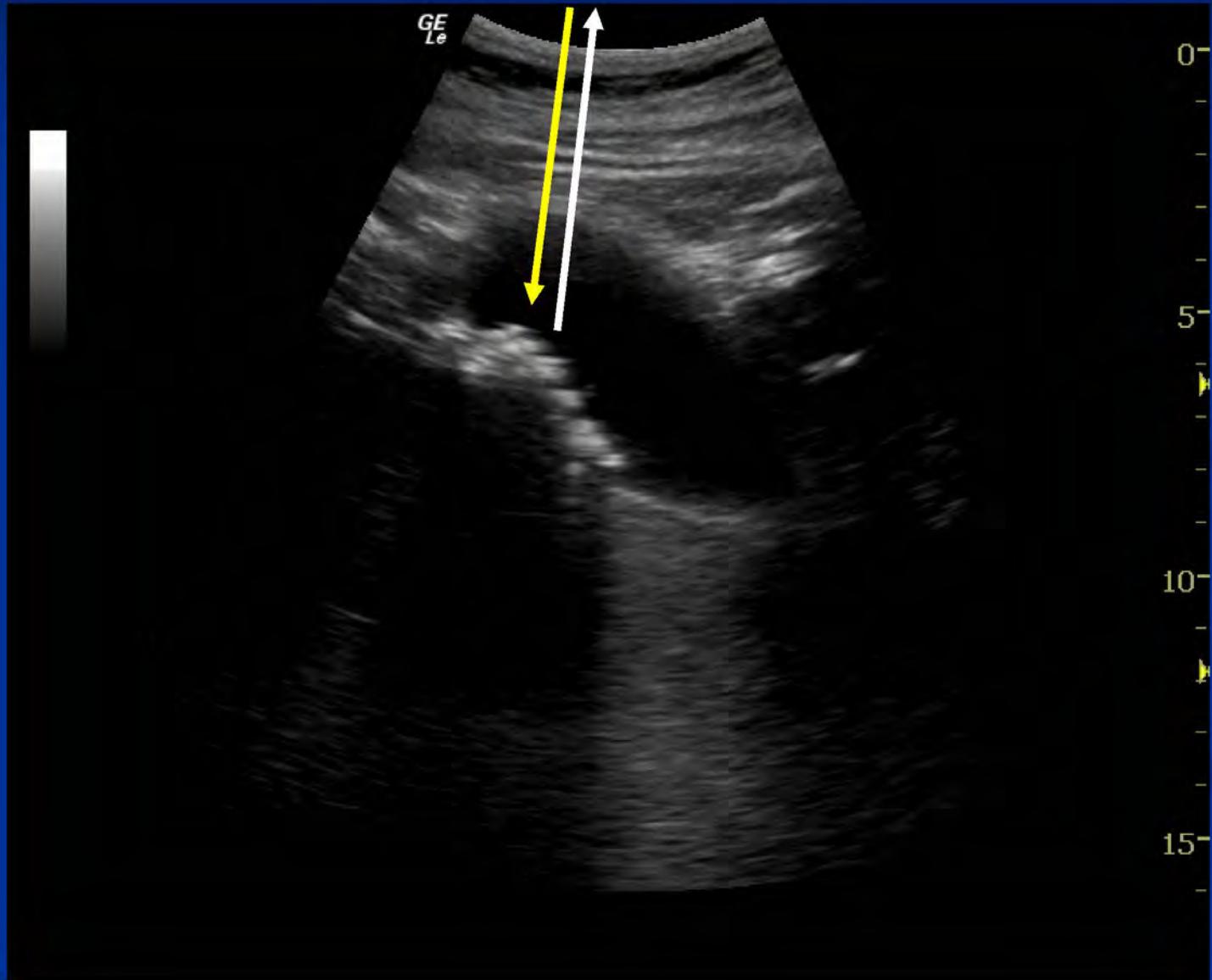


Reflected

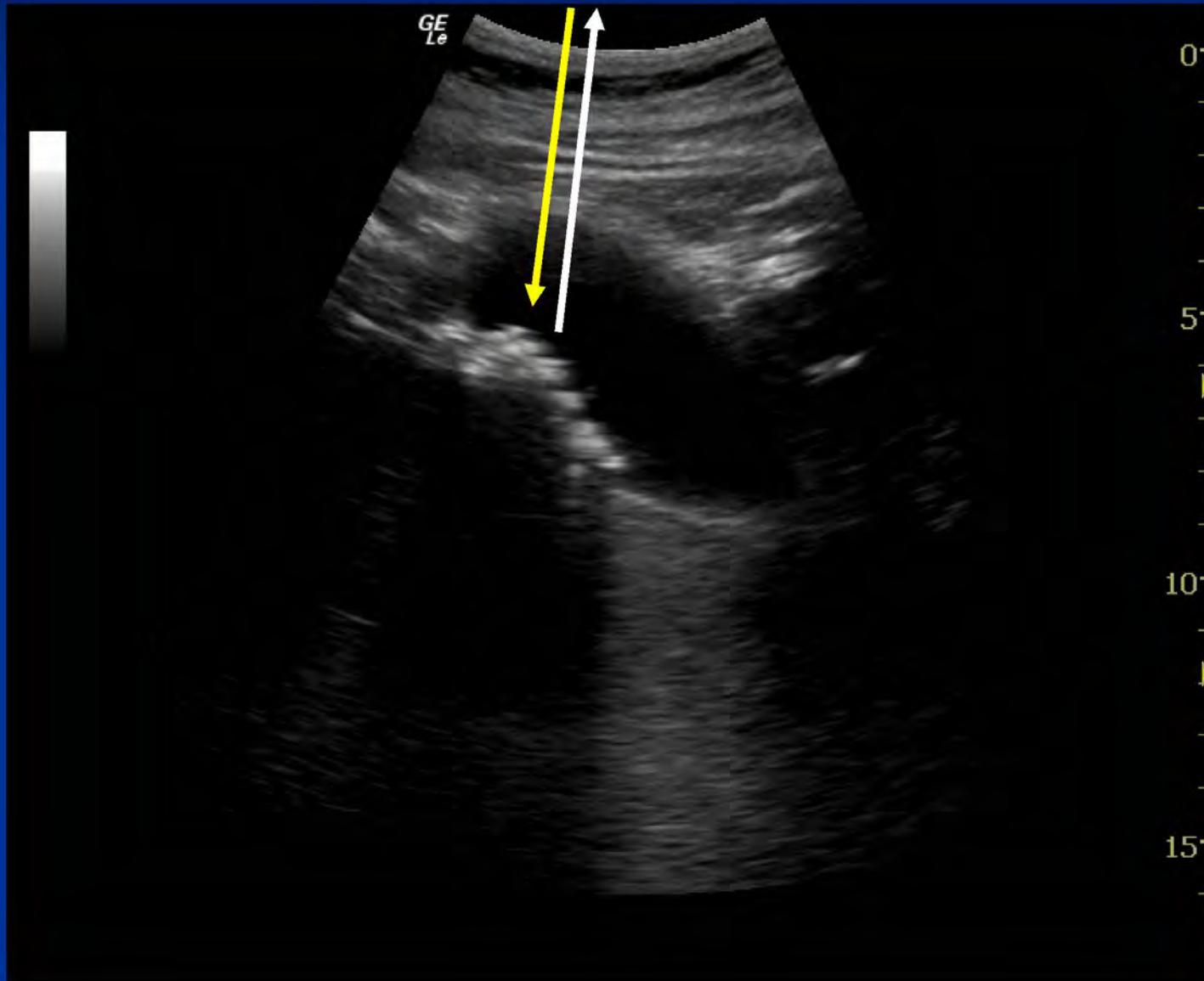


Something very dense (gallstone)

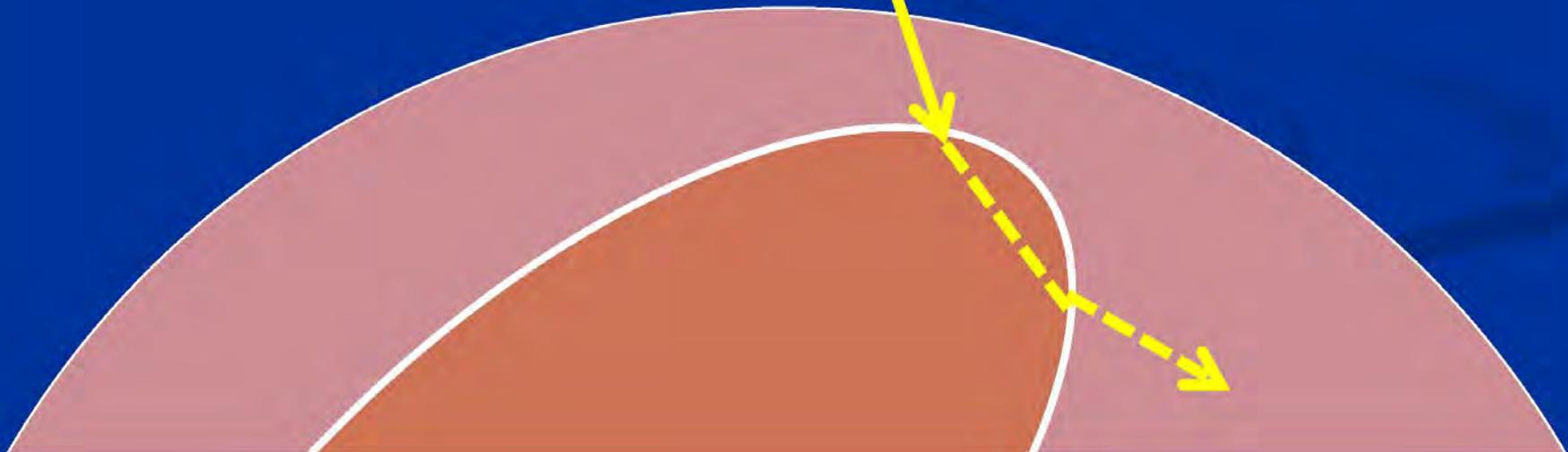
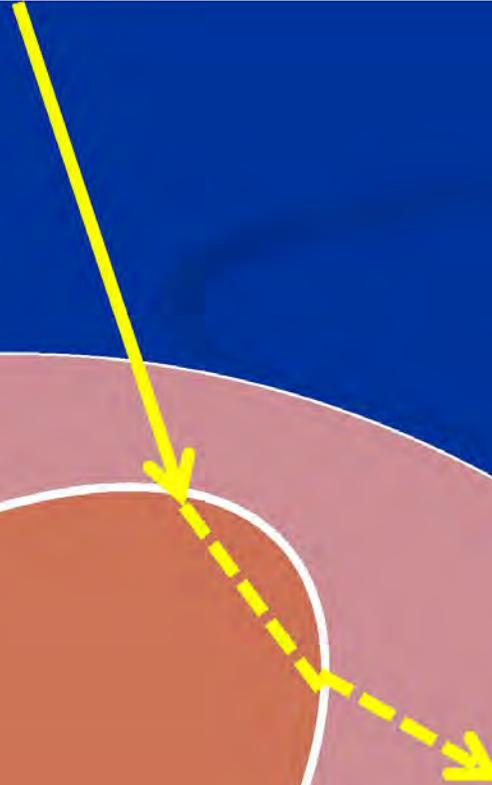




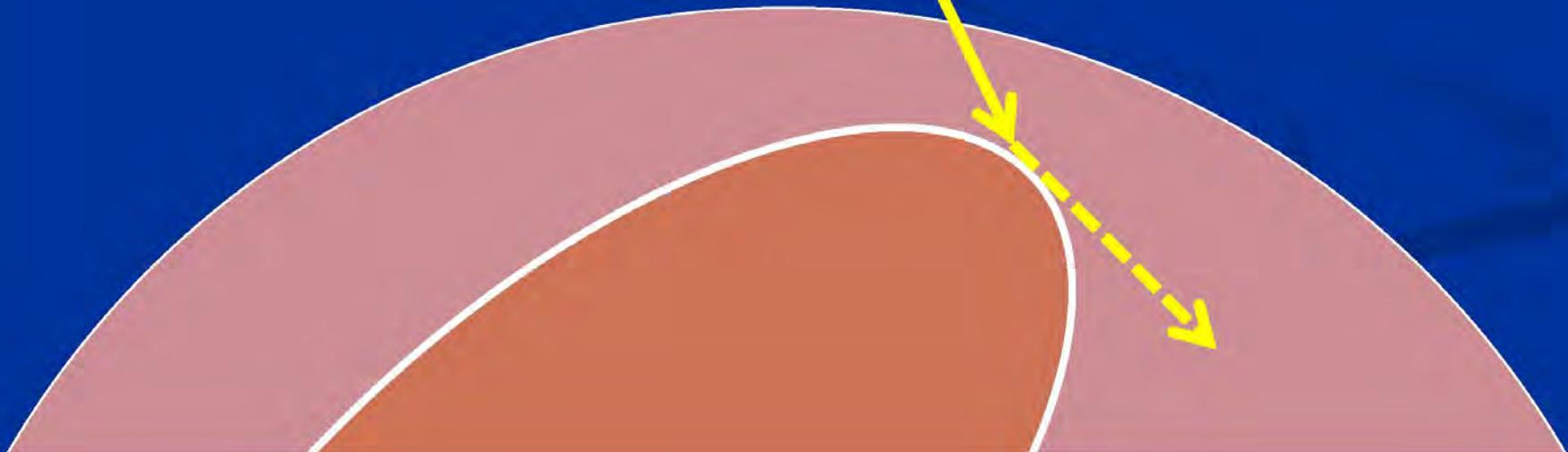
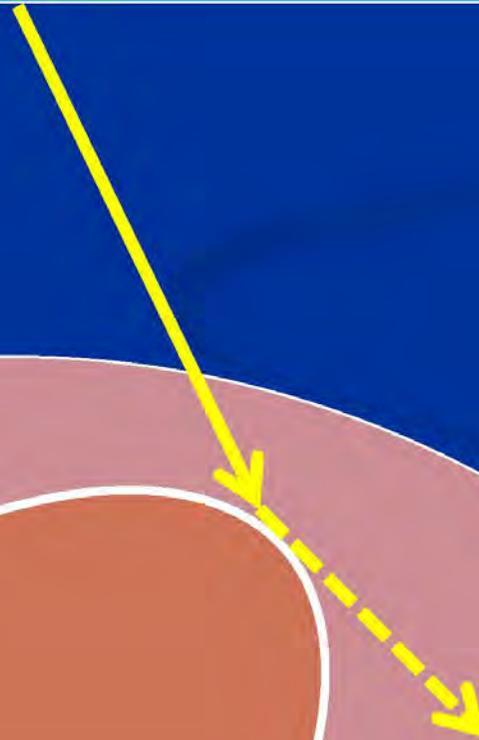
Posterior shadowing



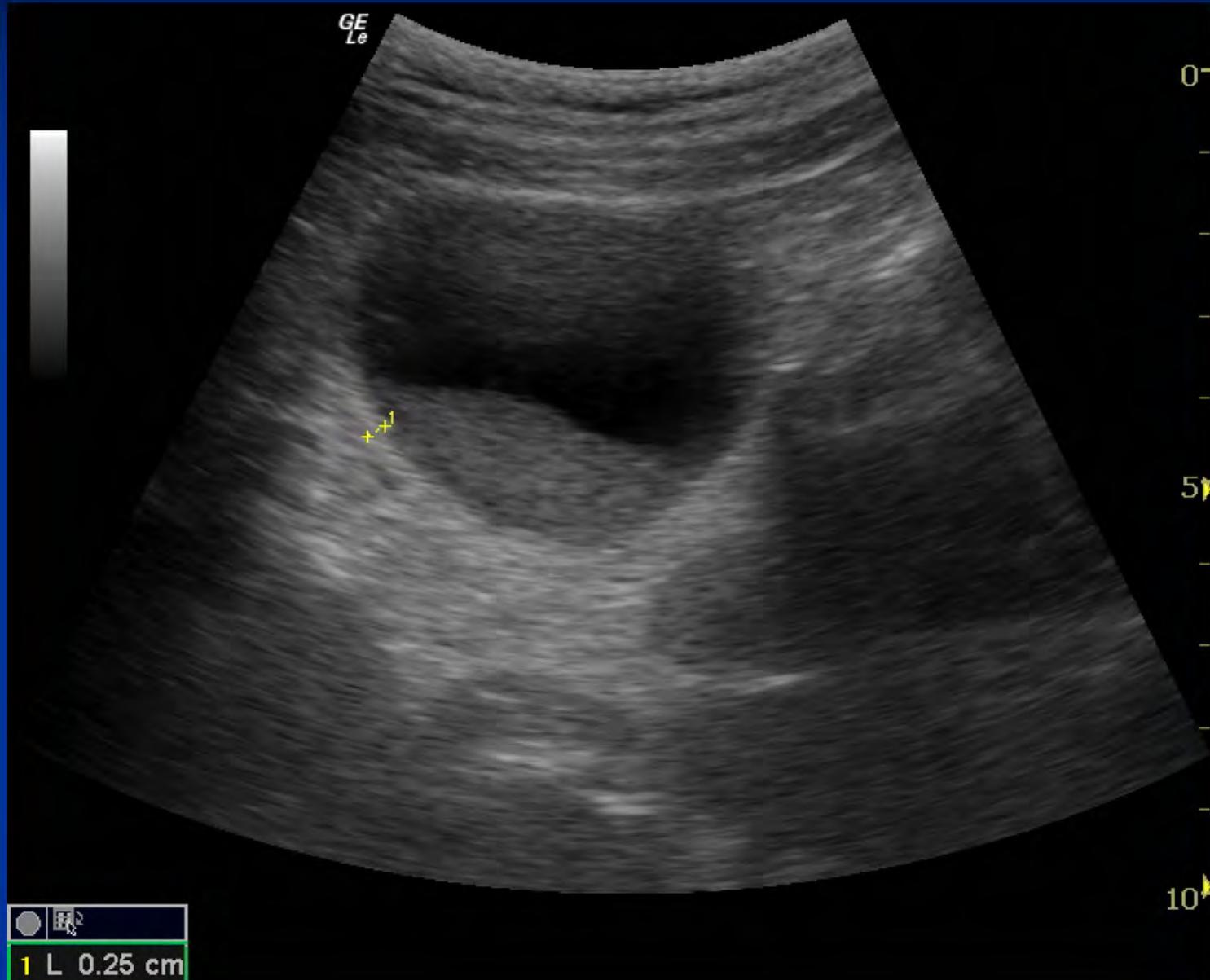
Refracted



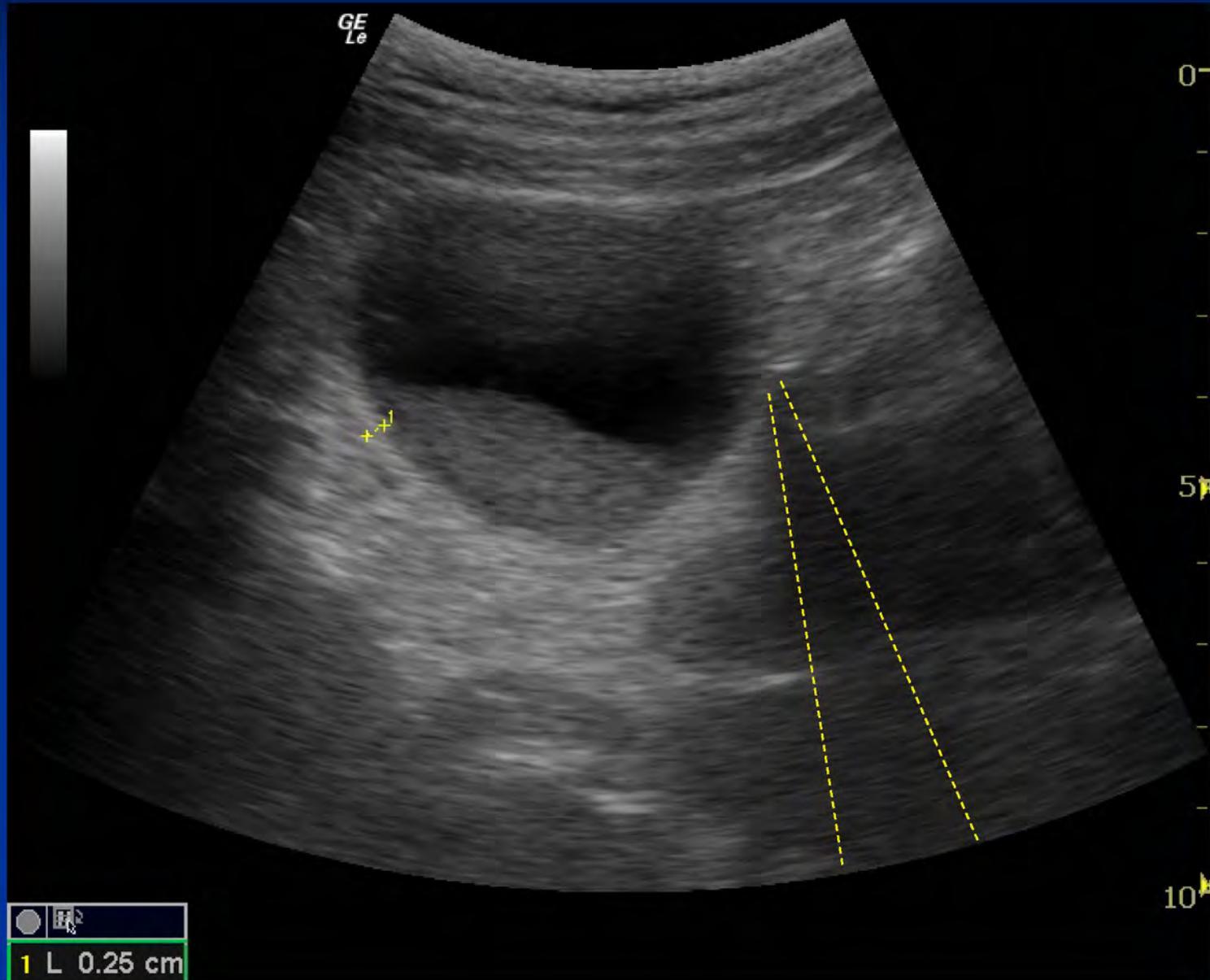
Refracted



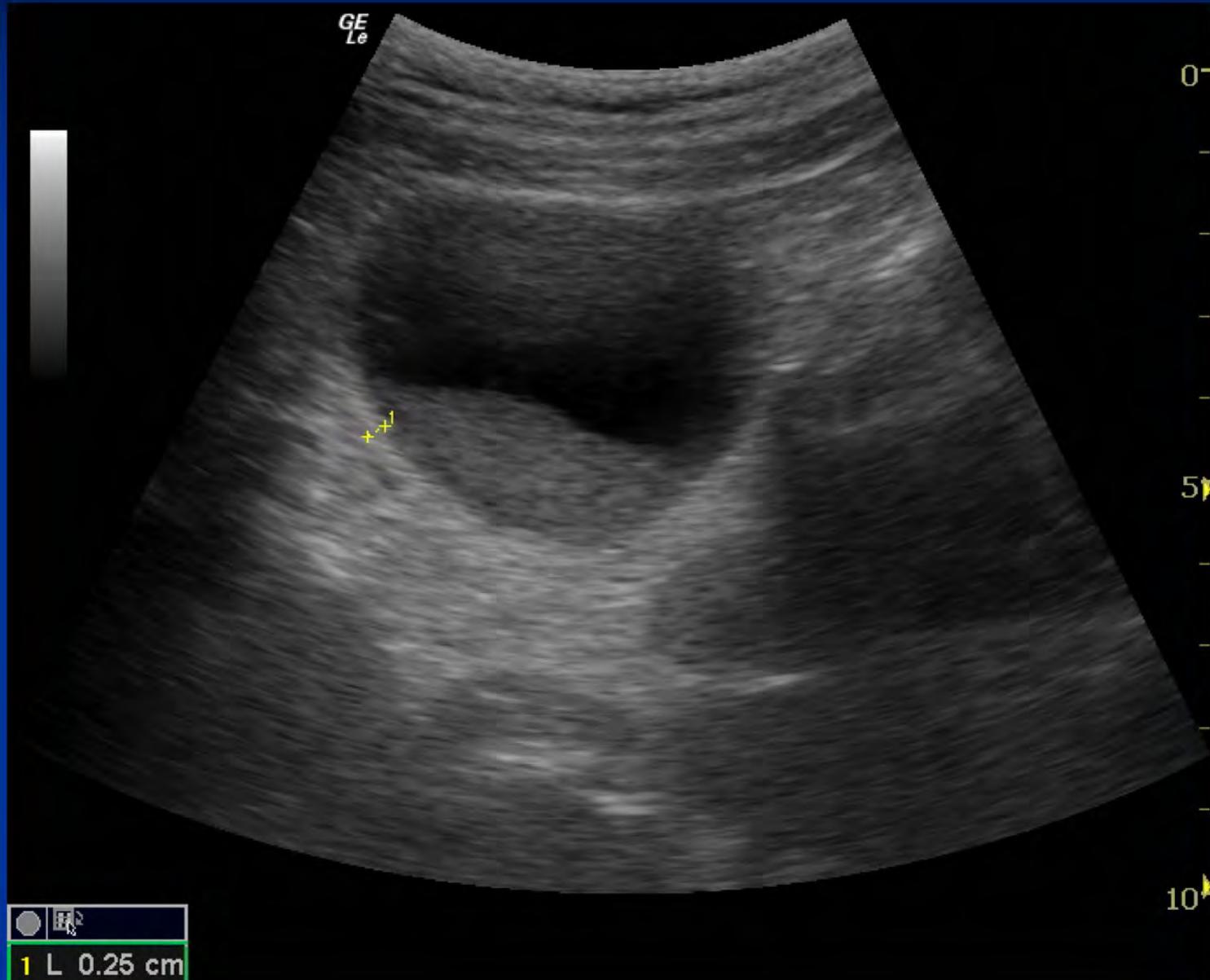
Edge shadowing



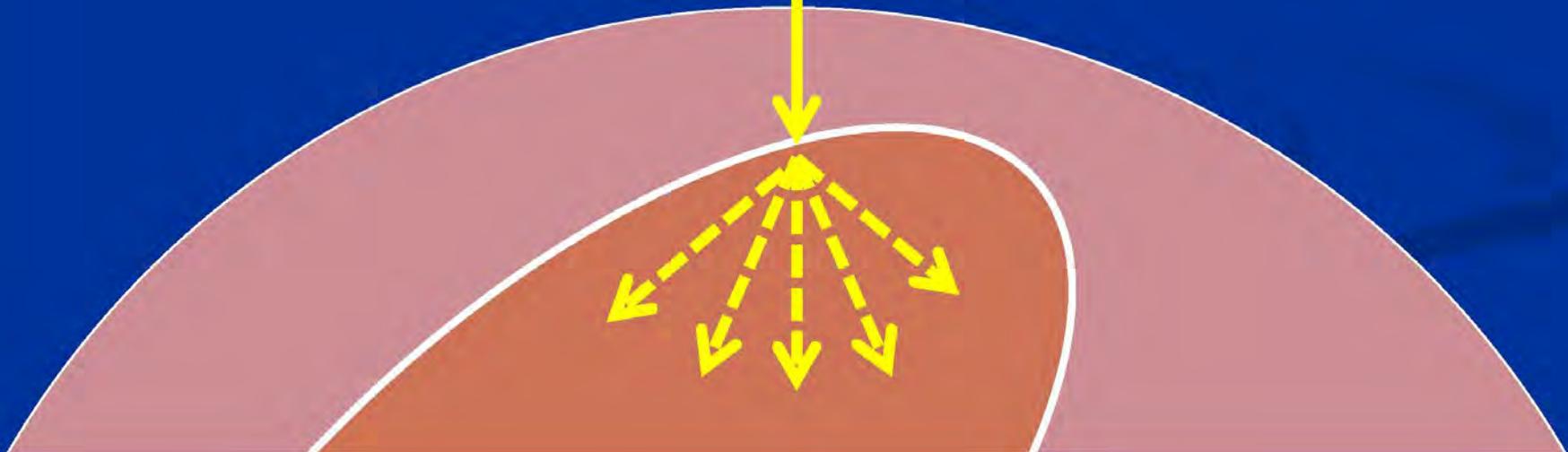
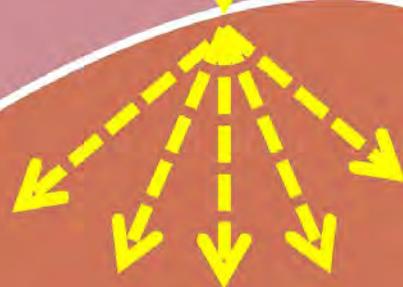
Edge shadowing

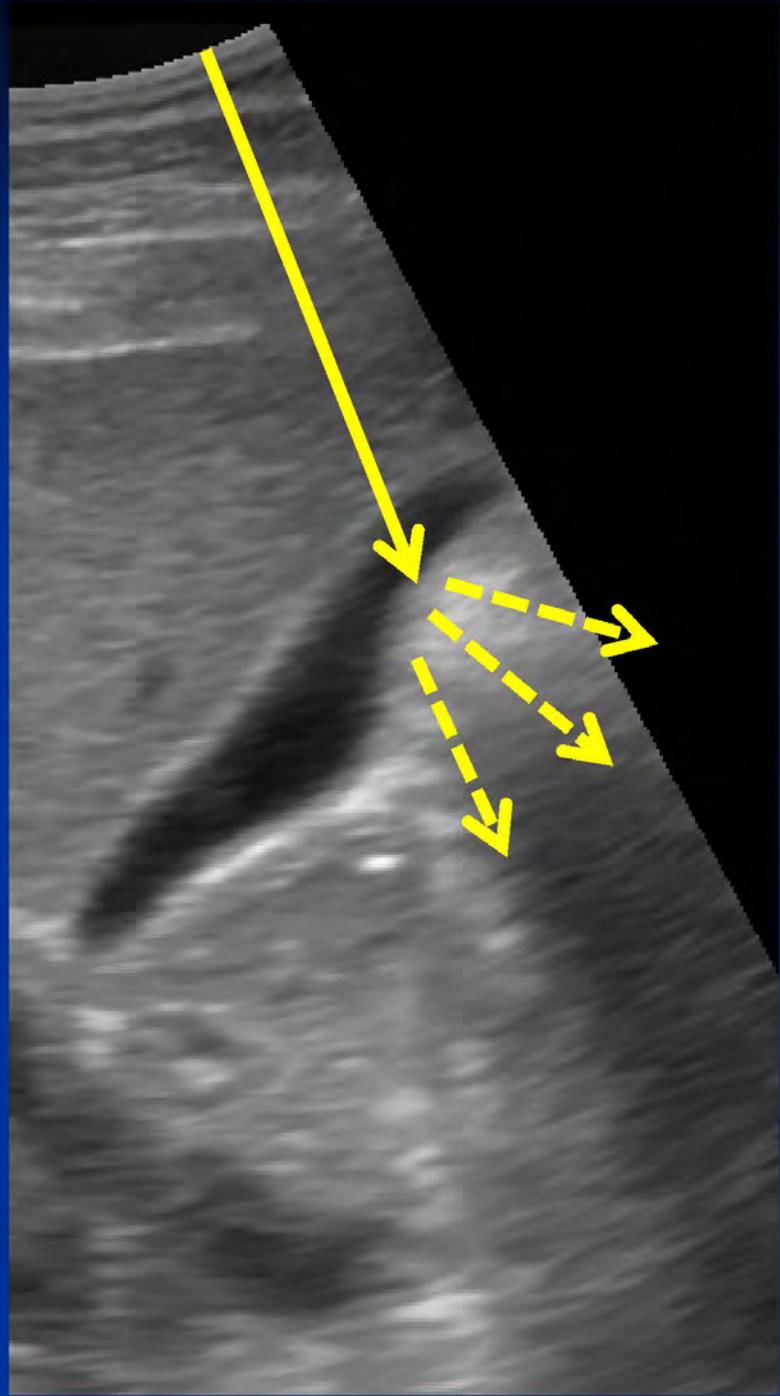
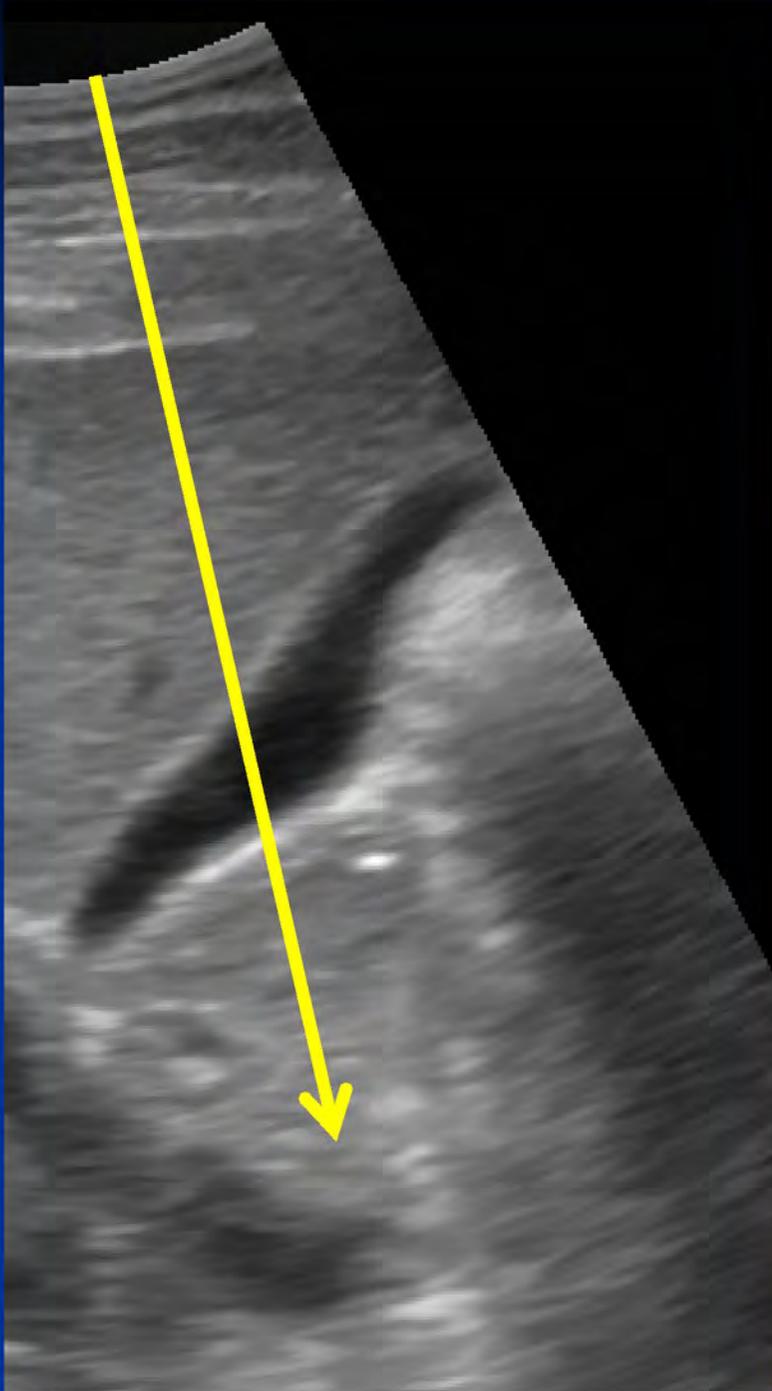


Edge shadowing



Scattered e.g. air







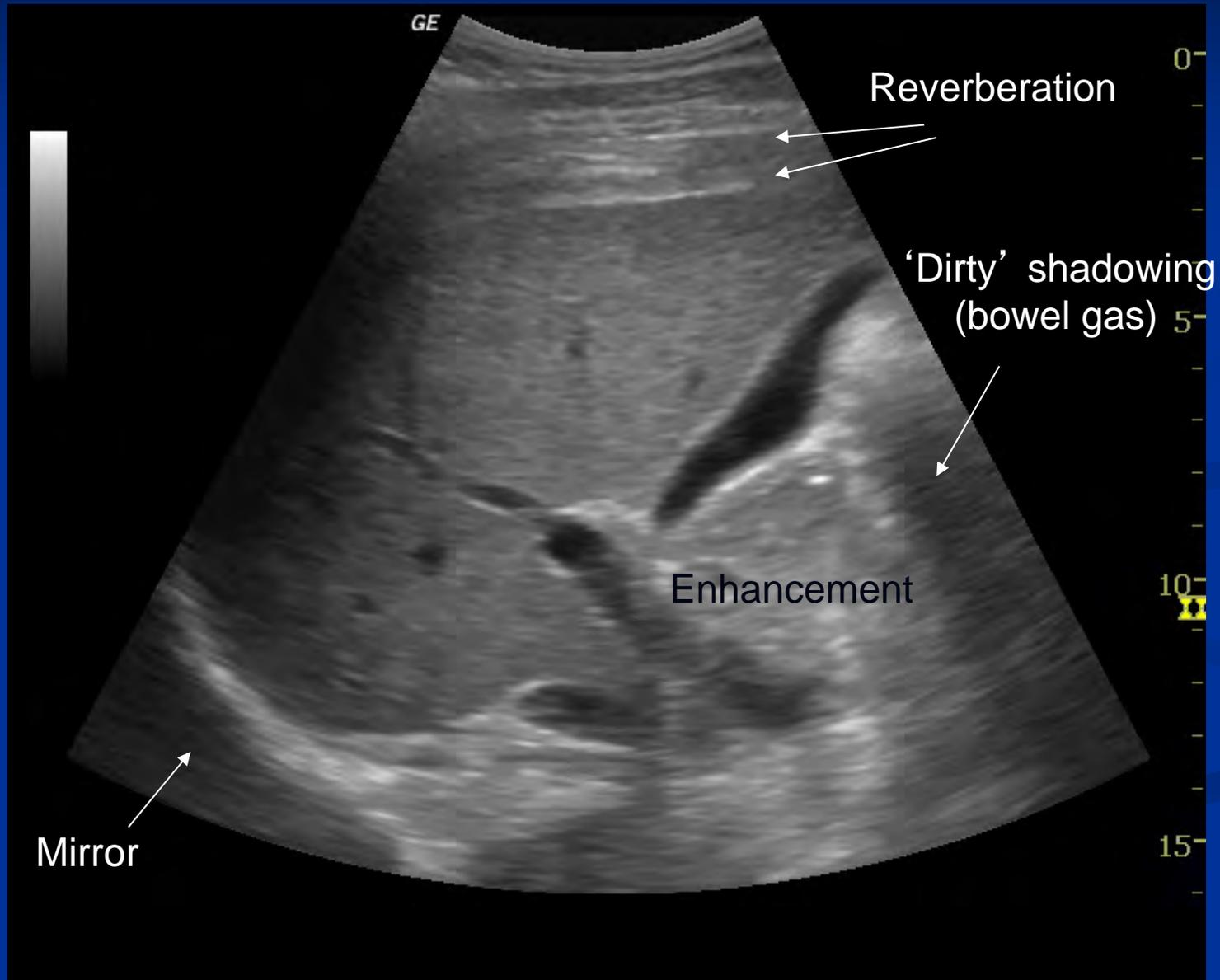
Artefacts

a product of artificial character due to extraneous (as human) agency... caused by manipulation not indicative of actual structural relationships

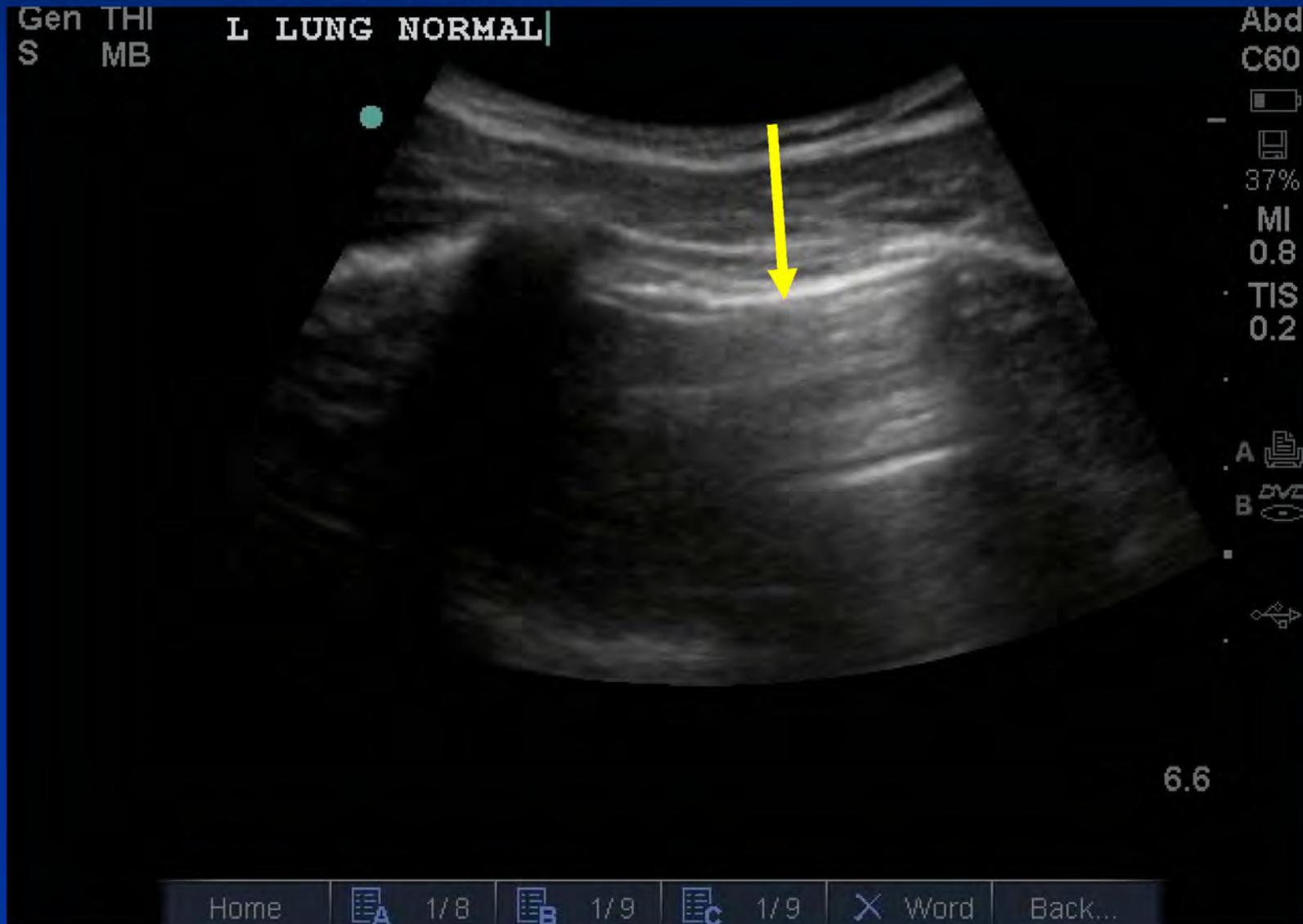
How many artefacts can you see?



Artefacts



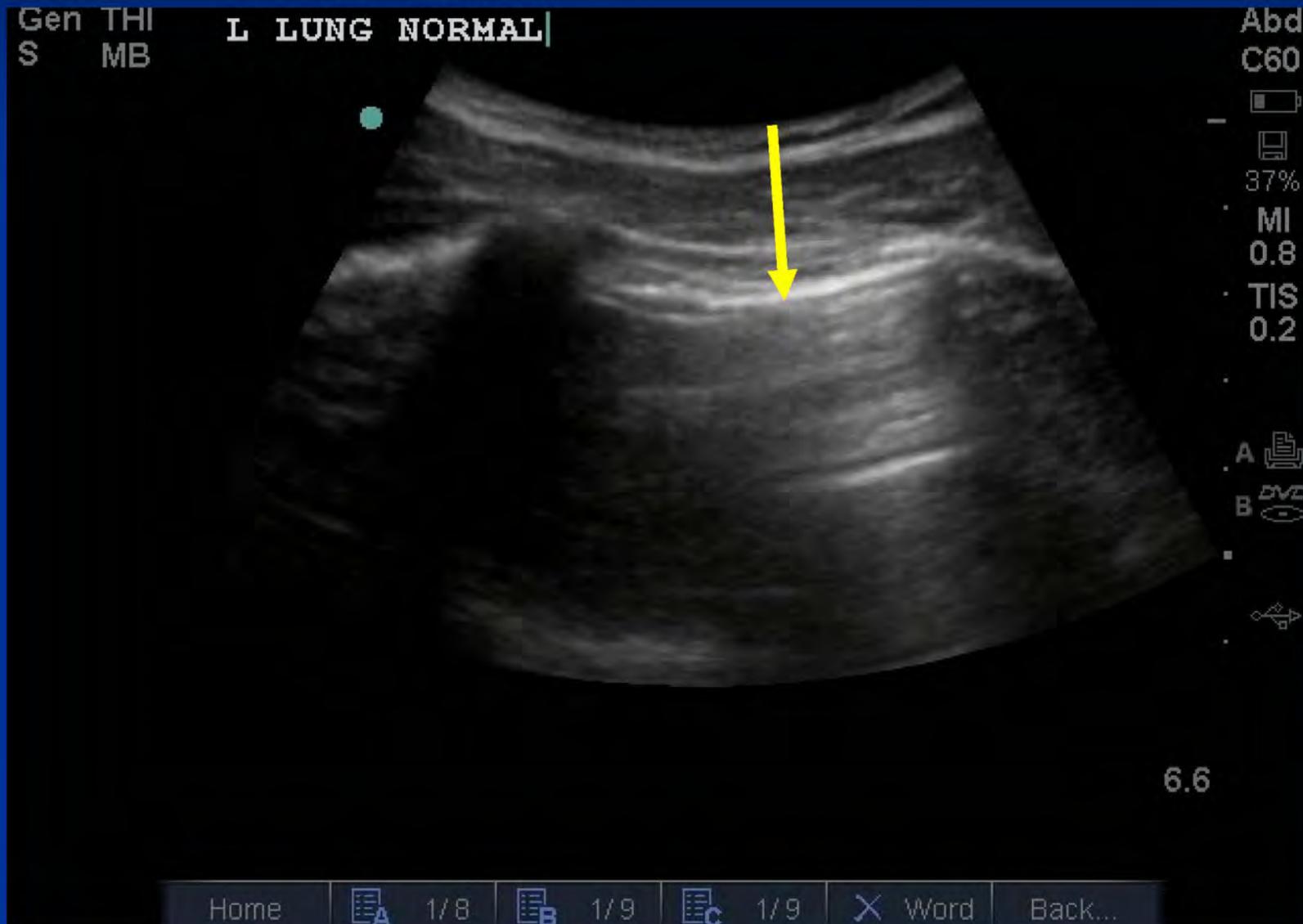
How does reverberation happen?



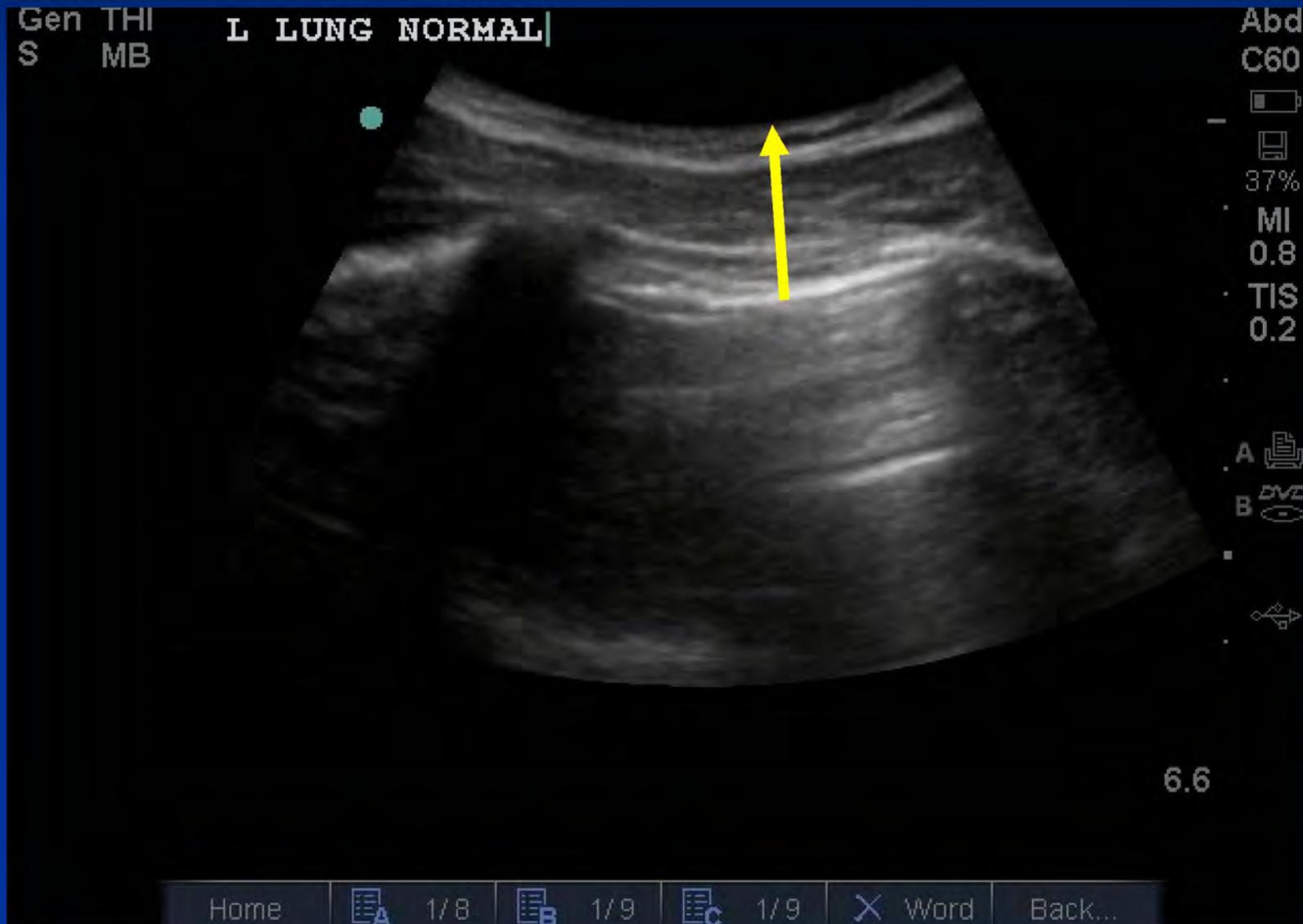
True image of pleural line



But... sound wave bounces off **probe!**



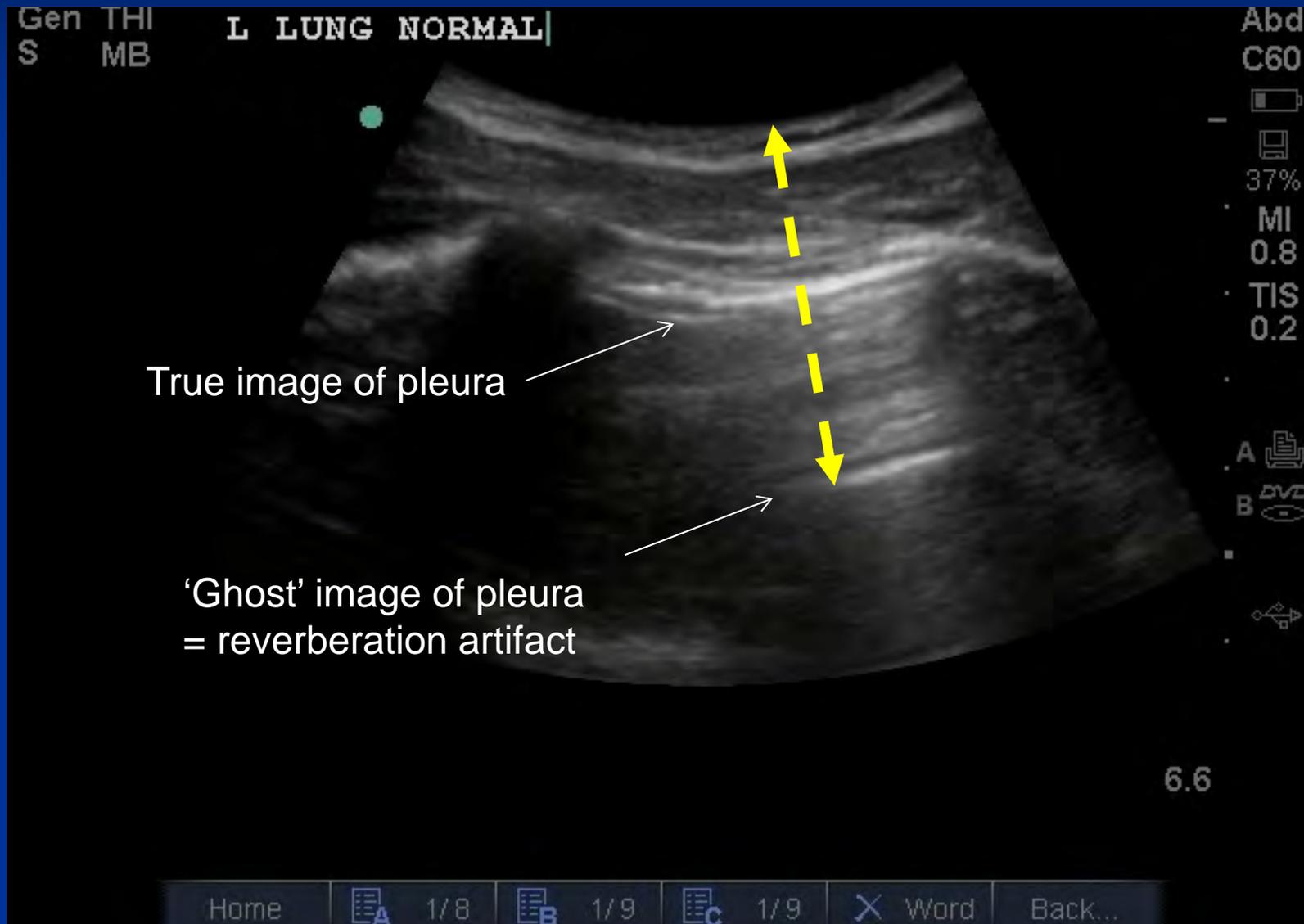
...and off pleura... again



True path



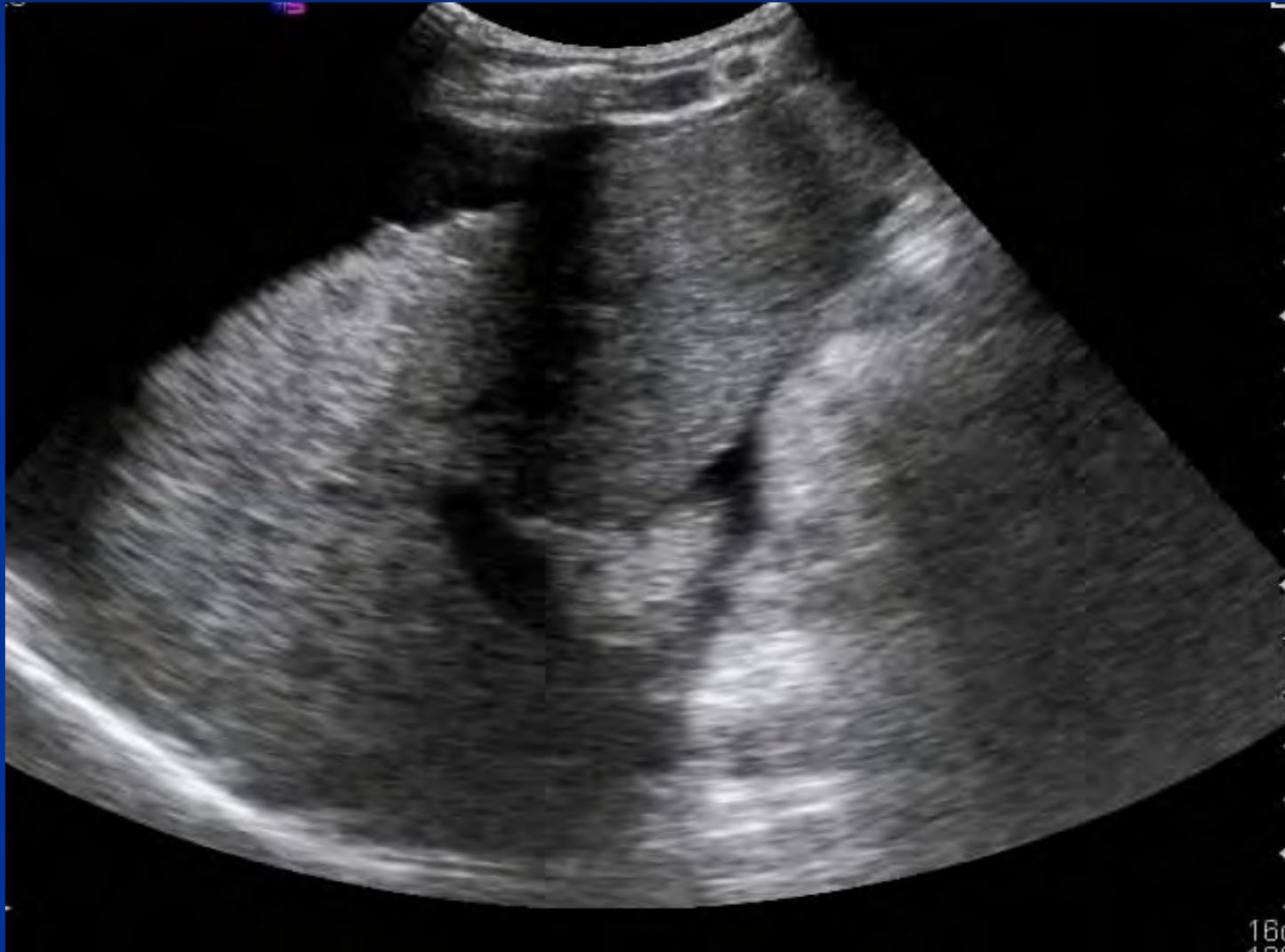
'Ghost image' appears below real image



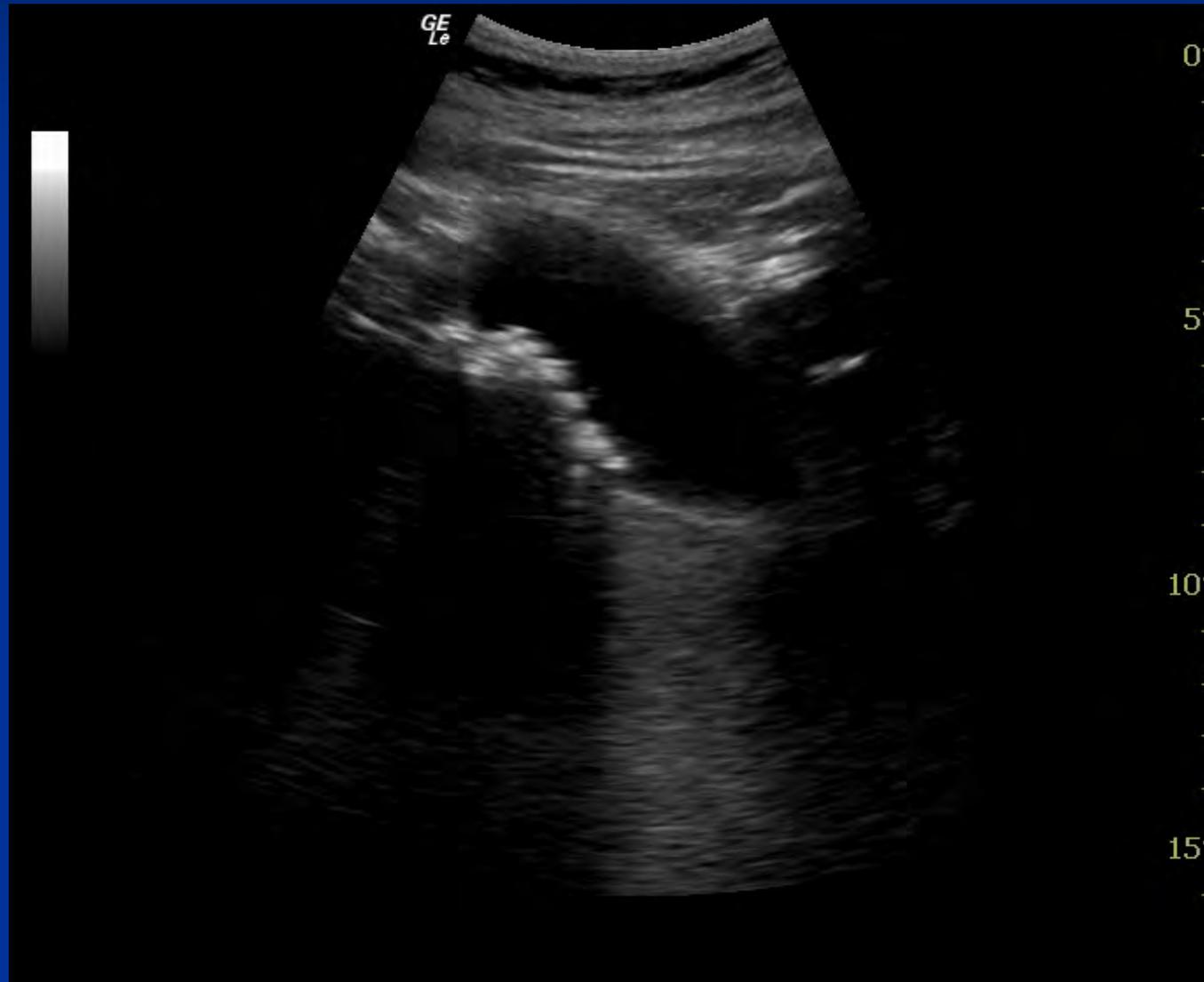
Remember?

Location of the dots is determined by **travel time, NOT DISTANCE**

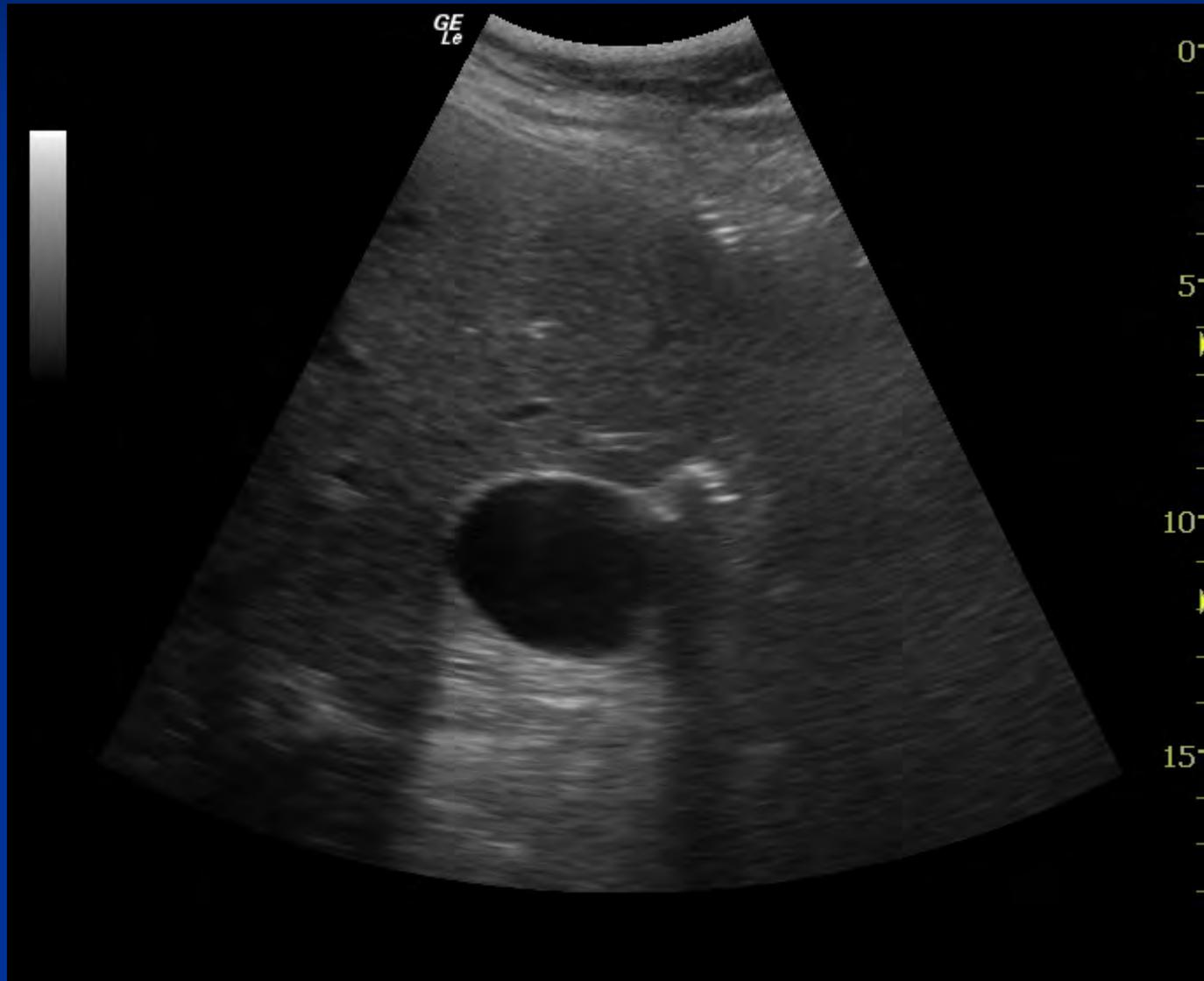
'Bad' acoustic shadowing (rib)



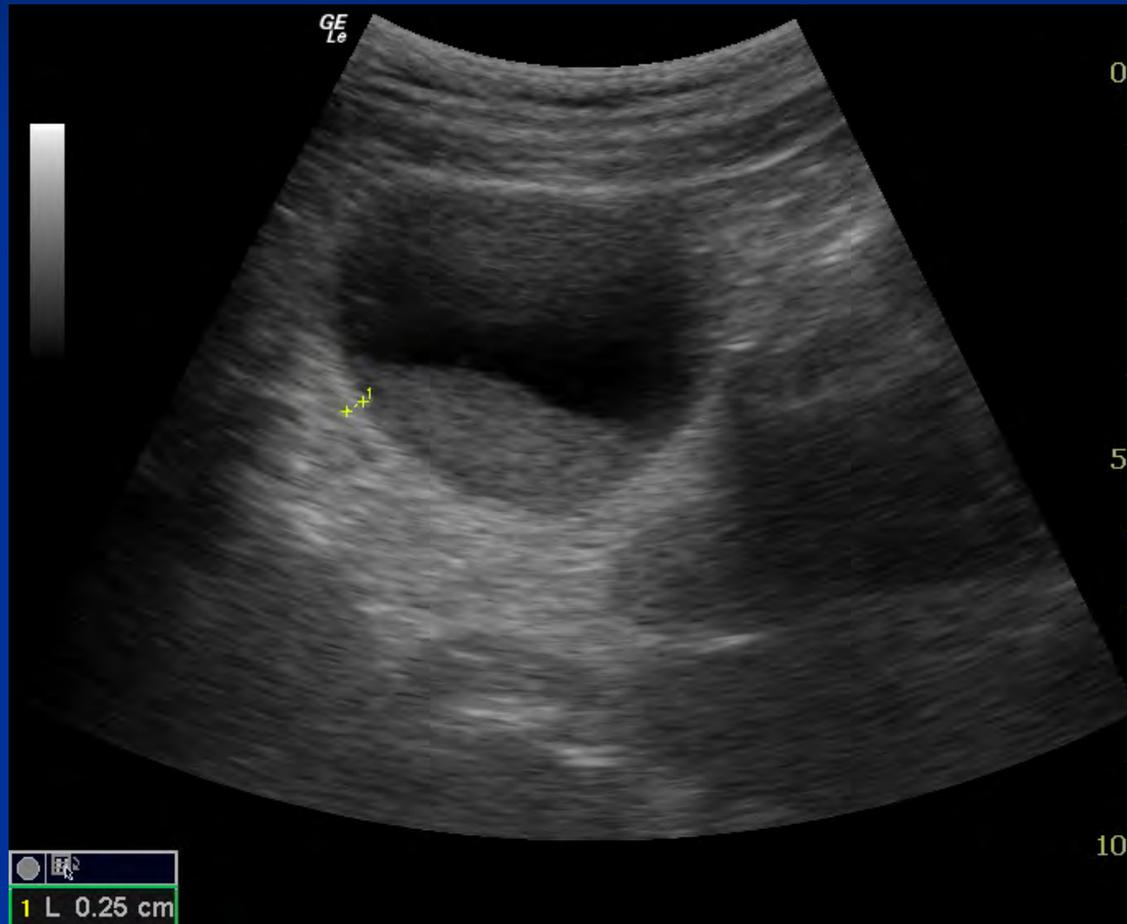
'Good' acoustic shadowing (gallstone)



Acoustic enhancement (GB)



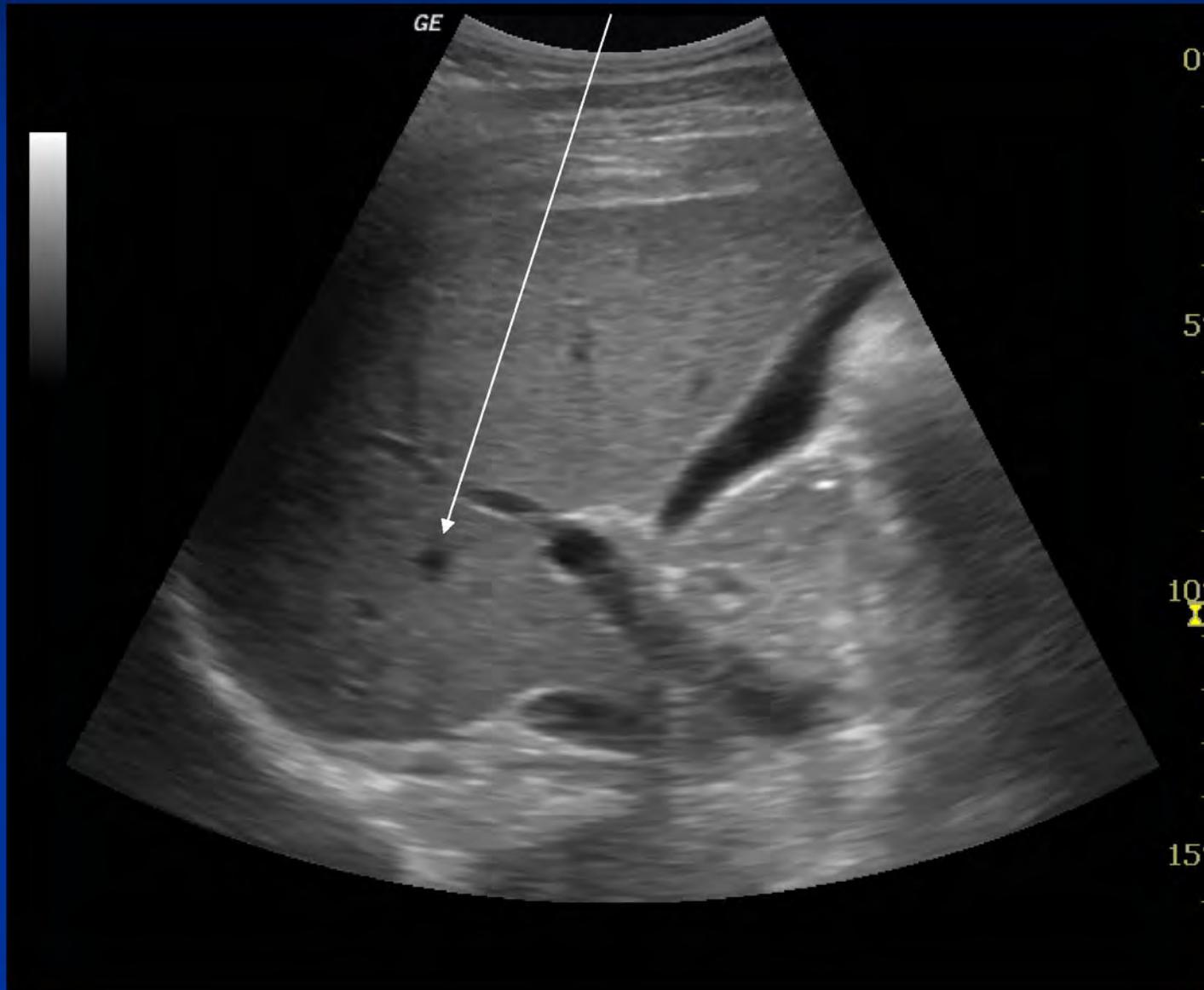
Edge enhancement (GB)



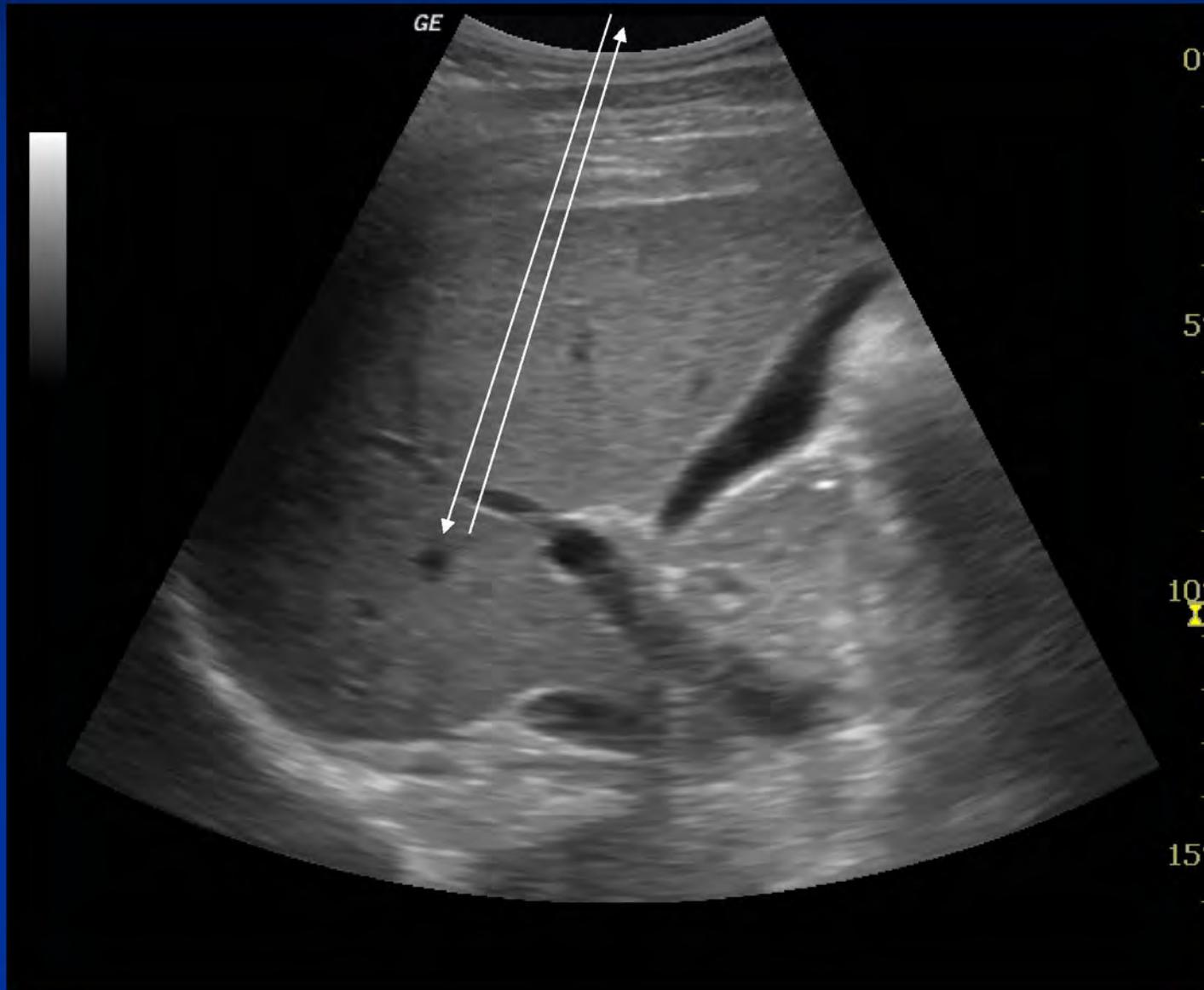
Mirror image



Mirror image 1. (true image)



Mirror image 1. (true image)



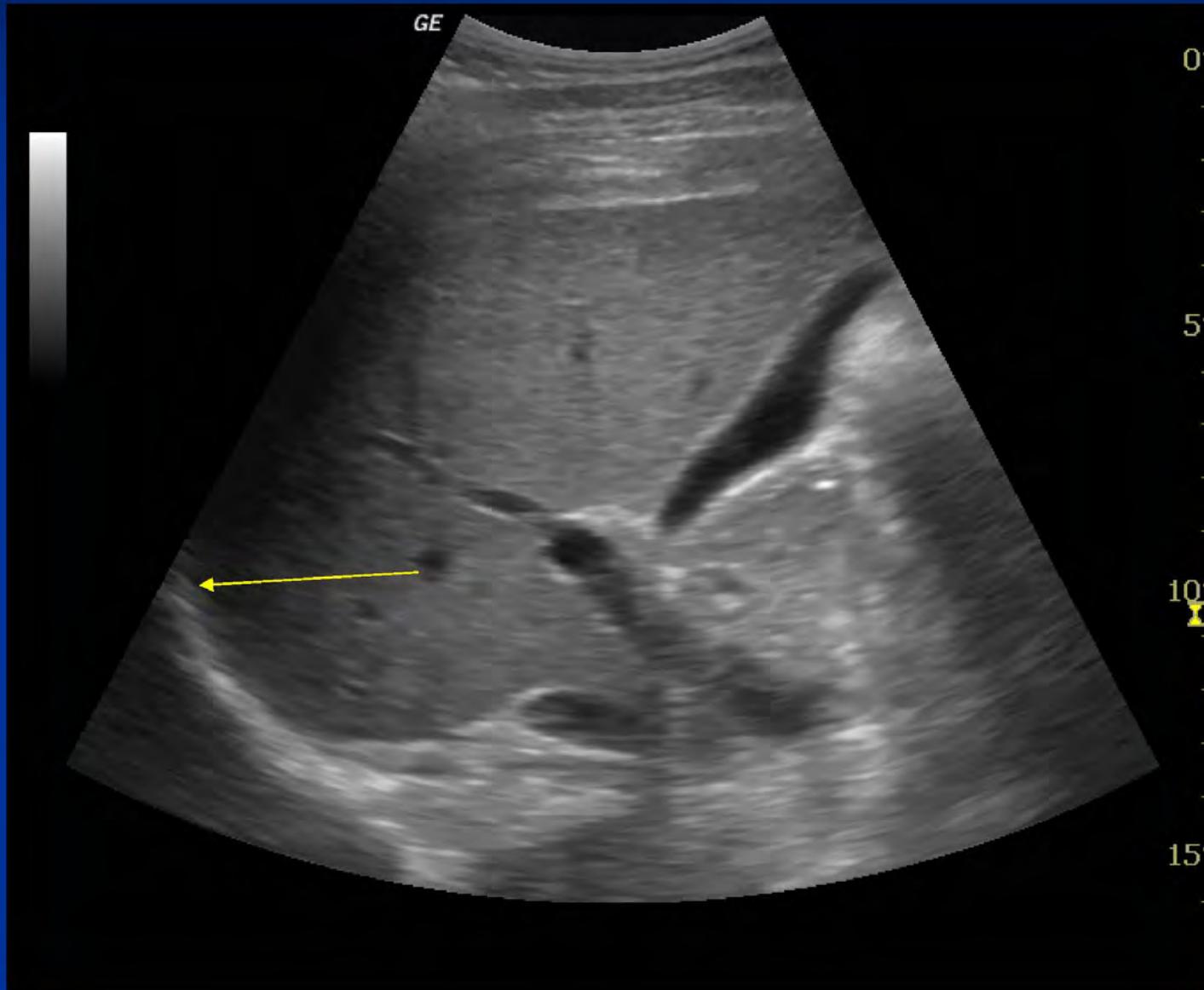
Mirror image 2. (false image)



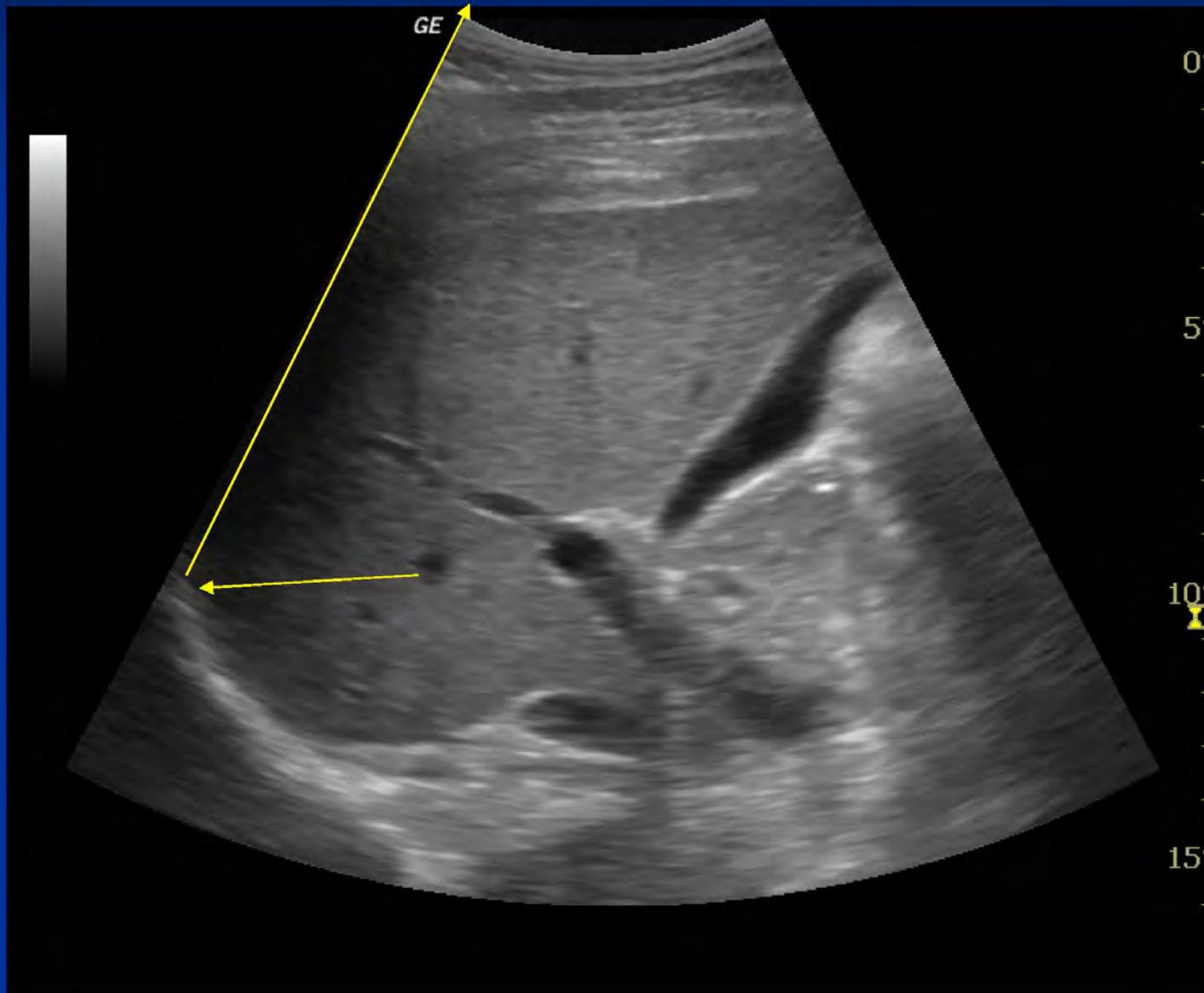
Mirror image 2. (false image)



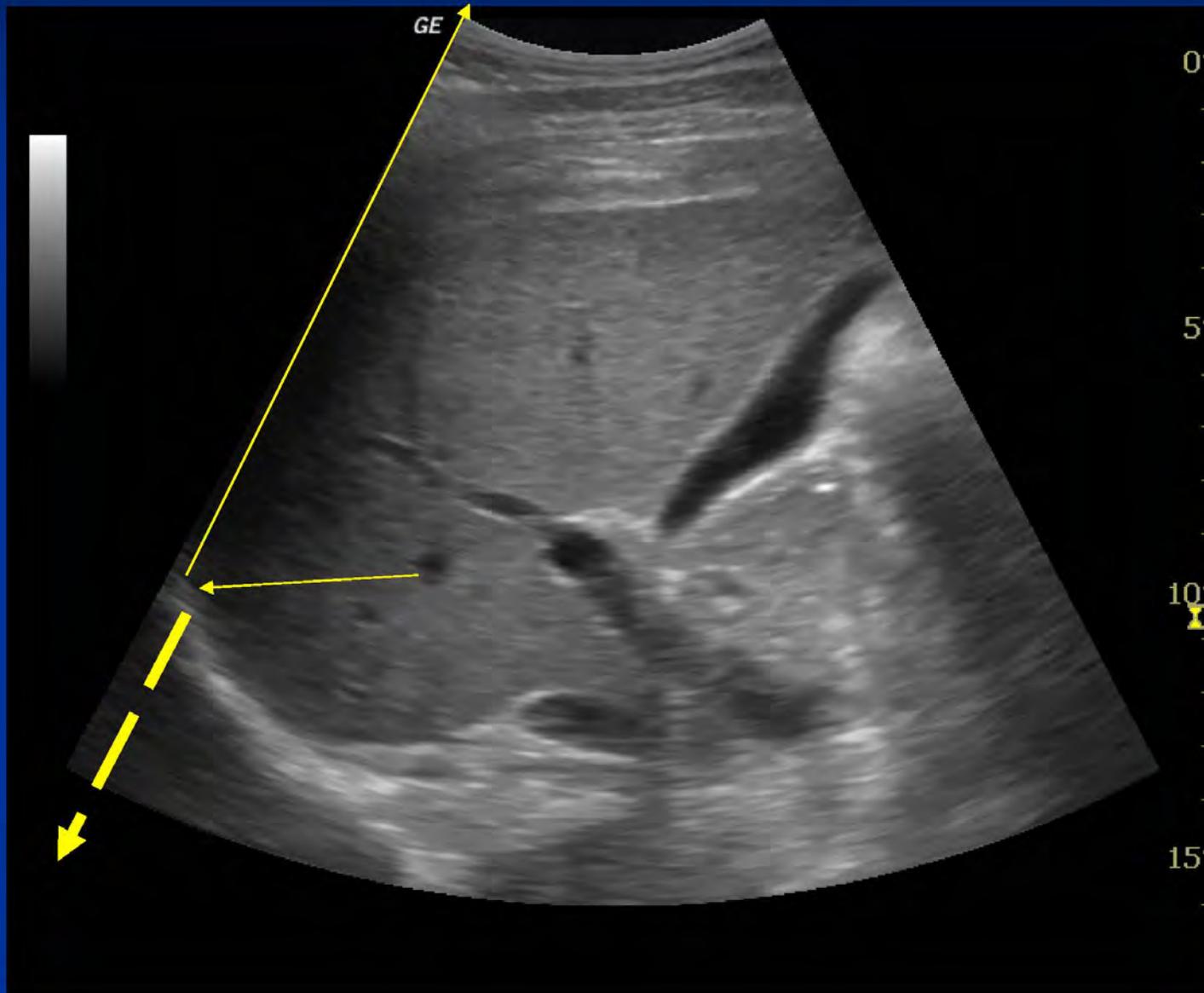
Mirror image 2. (false image)

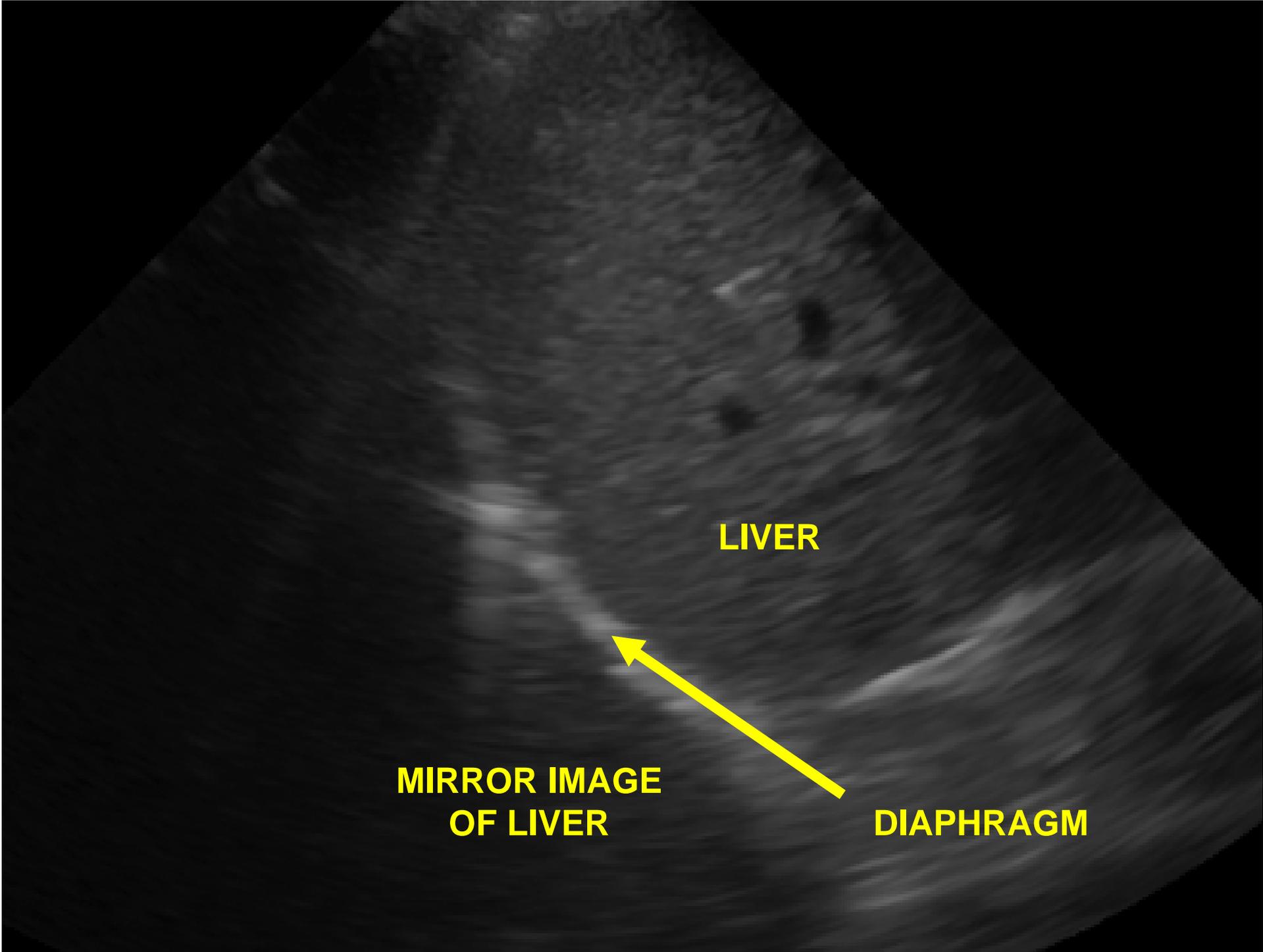


Mirror image 2. (false image)



Mirror image 2. (false image)





LIVER

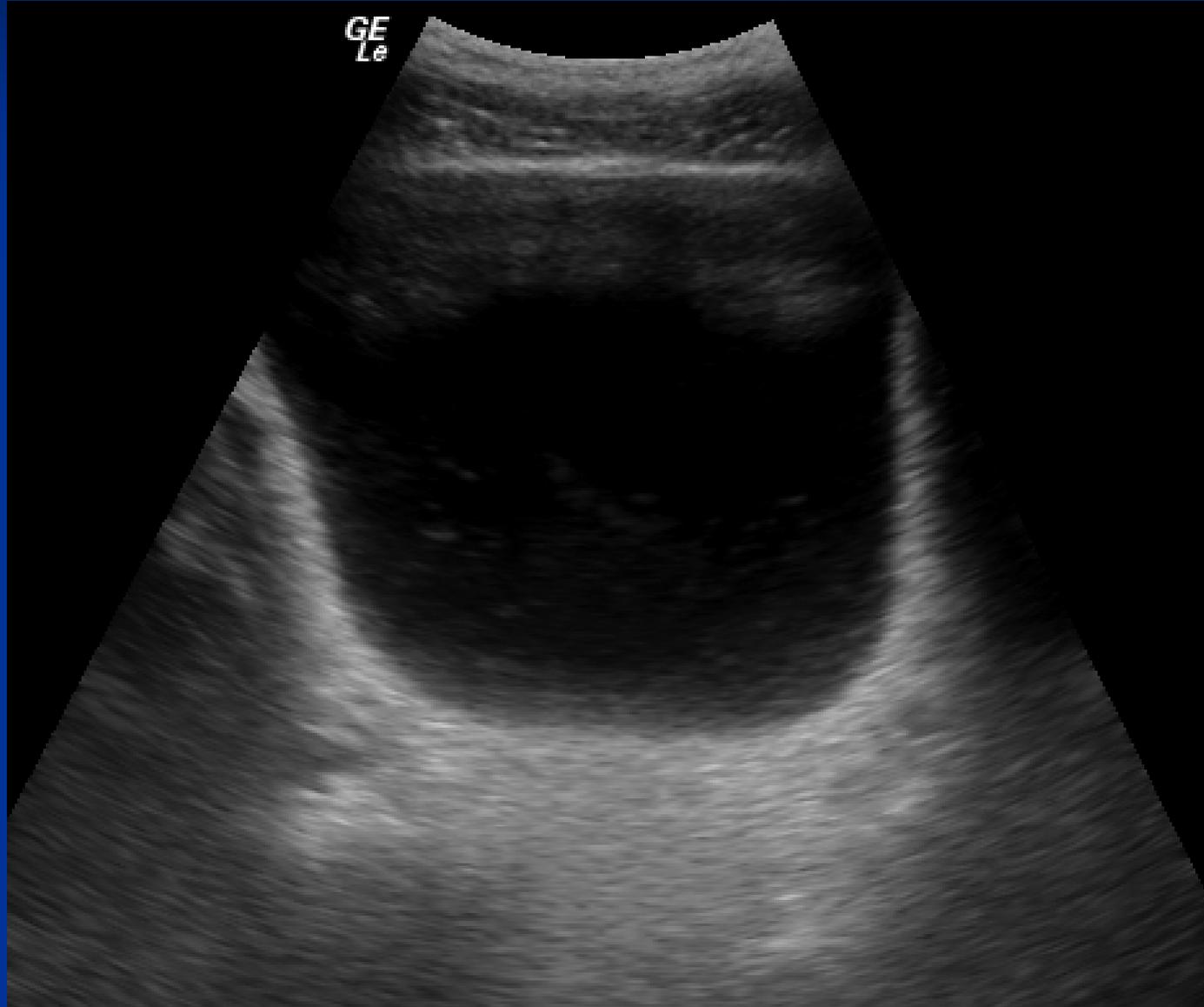
**MIRROR IMAGE
OF LIVER**

DIAPHRAGM

Mirror image



Mirror bladder



Mirror heart



Basic artifacts

- Reverberation
- Posterior shadowing
- Posterior enhancement
- Edge artifact
- Mirror
- B lines (later)



SUMMARY

- Fluid is dark
- Solid organs are grey
- Air and dense things are bright
- Not everything onscreen is actually there!

Thanks

Dr Anjana Amarasekara

<http://images.tutorvista.com/cms/images/83/frequency-wavelength-image1.PNG>