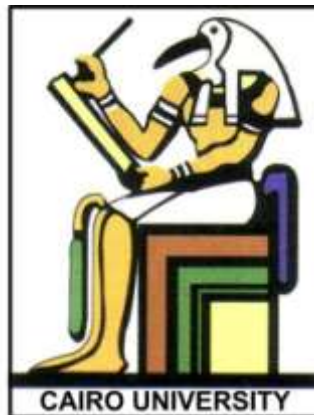
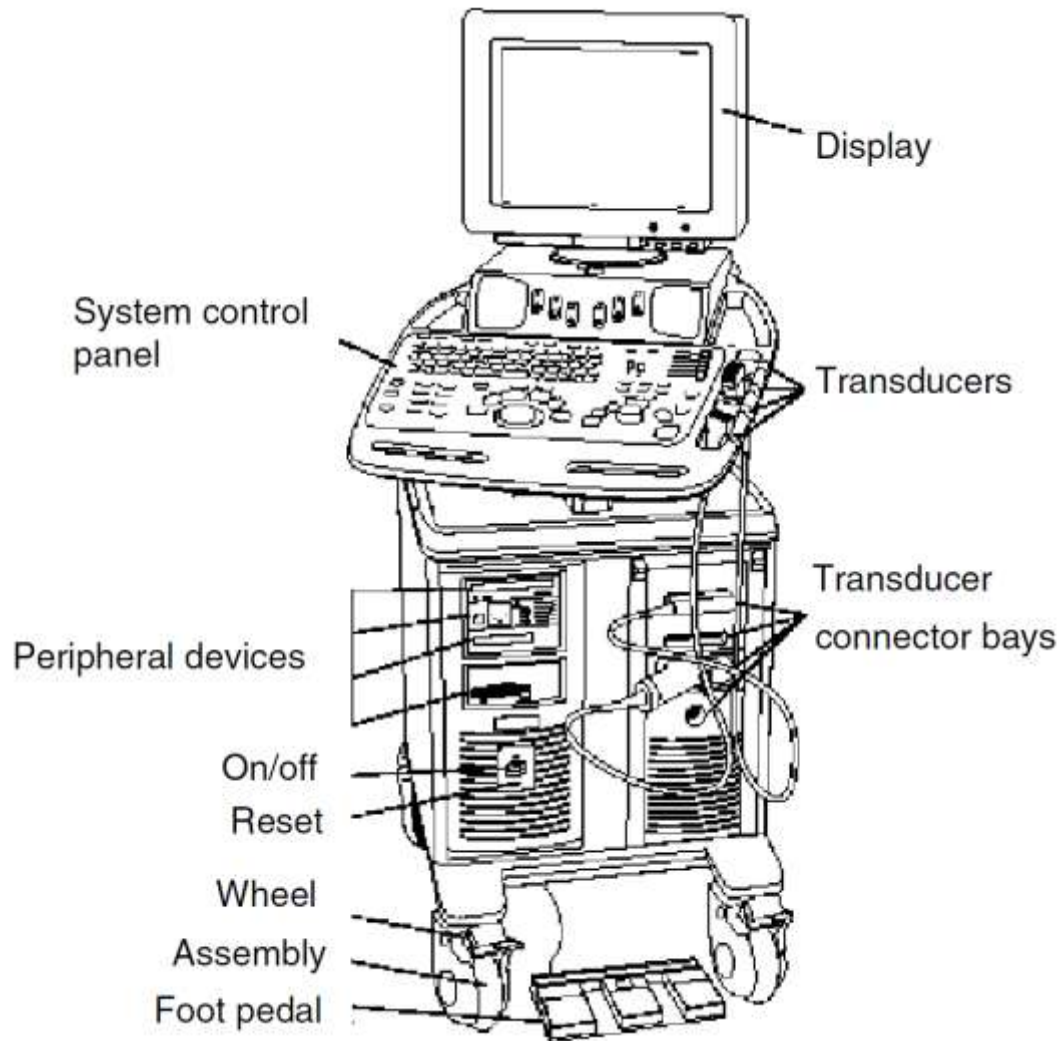


# Ultrasound Bioinstrumentation

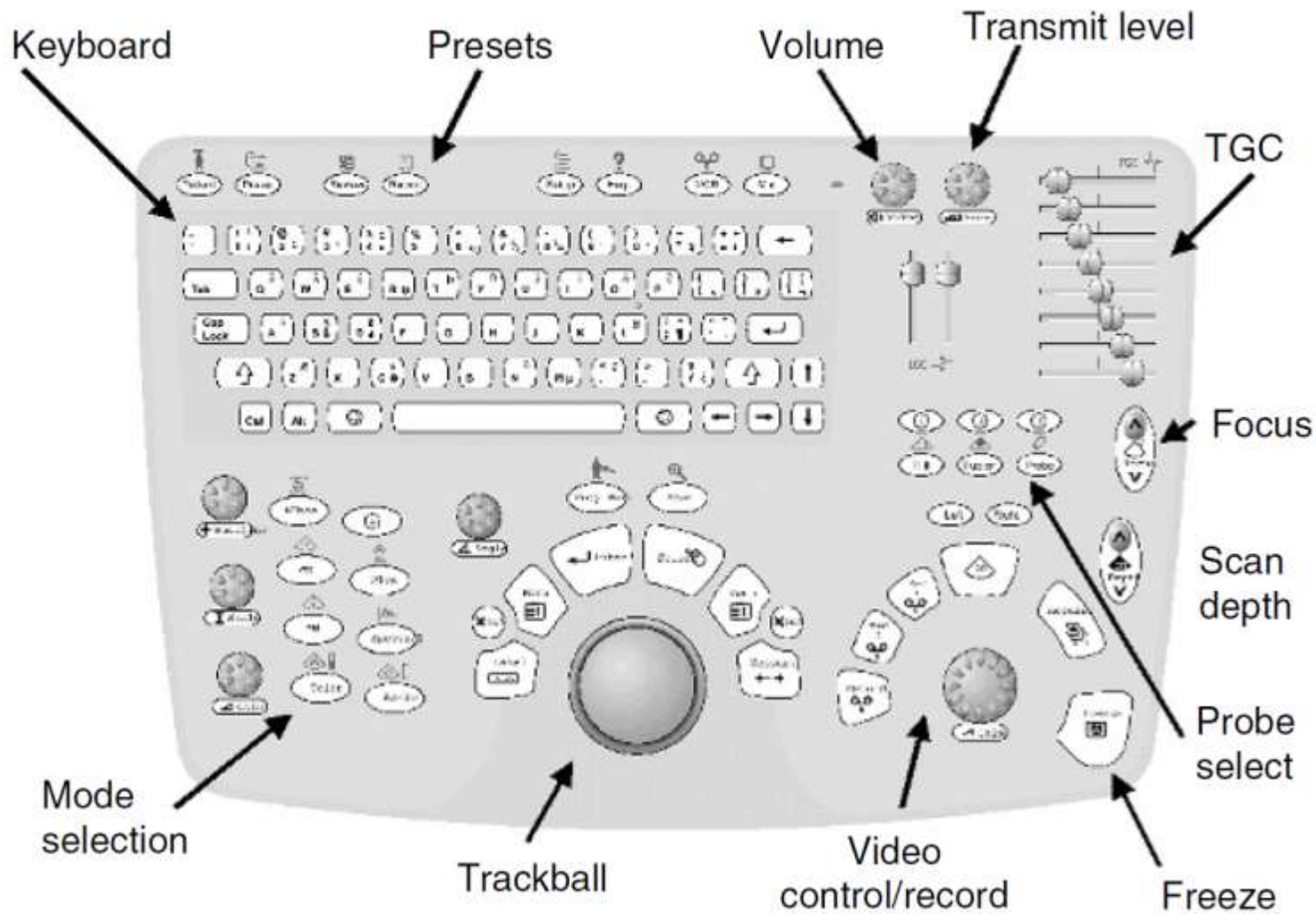
## Topic 5: Lectures 9 Ultrasound System Design



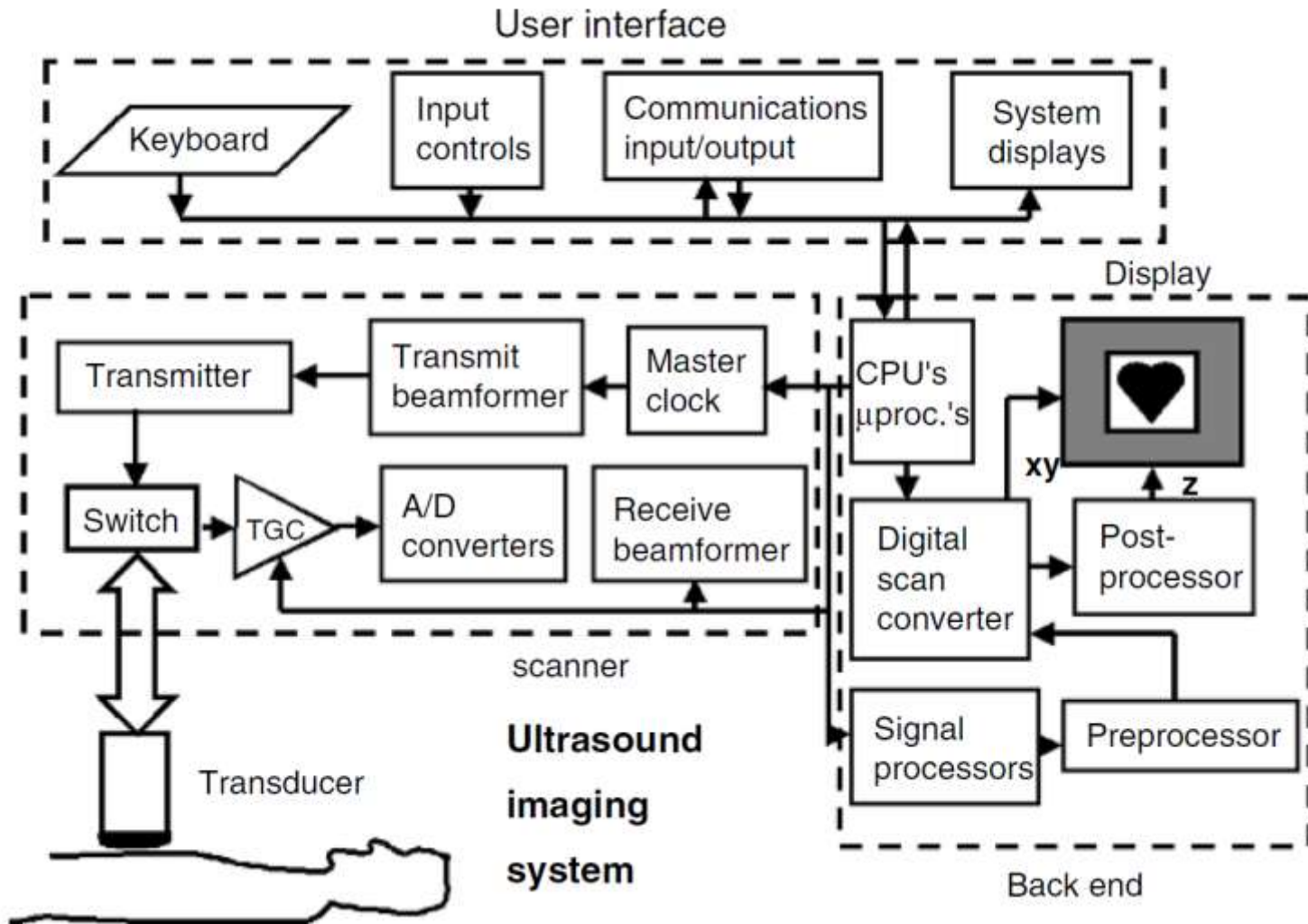
# Ultrasound Imaging System: External Look



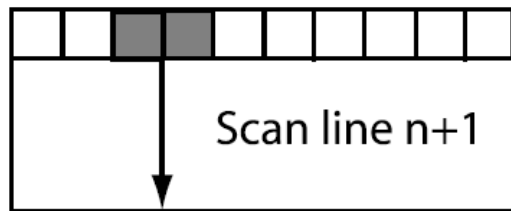
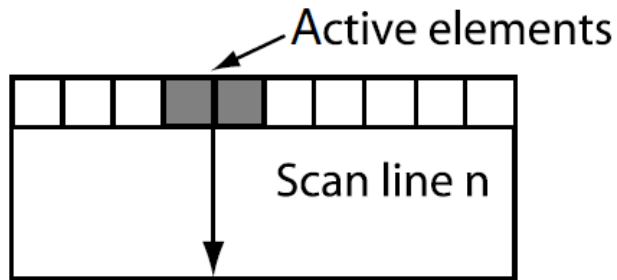
# Keyboard Controls



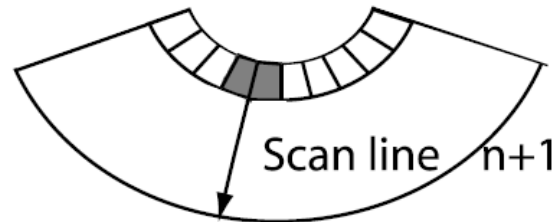
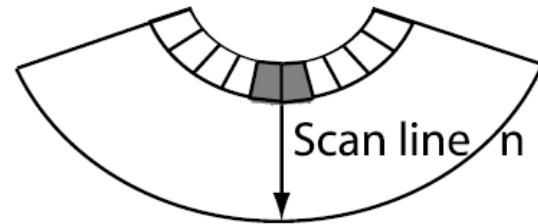
# Block Diagram



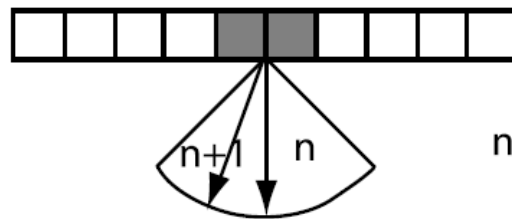
# Image Formats



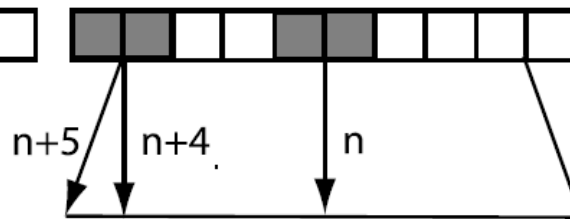
A Linear (translation)



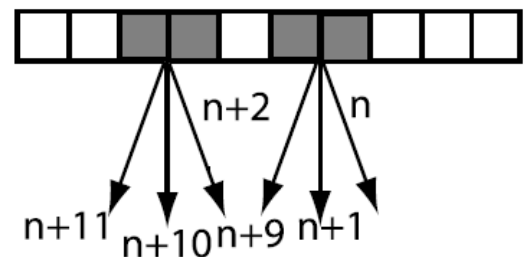
B Convex (translation)



C Sector (rotation)

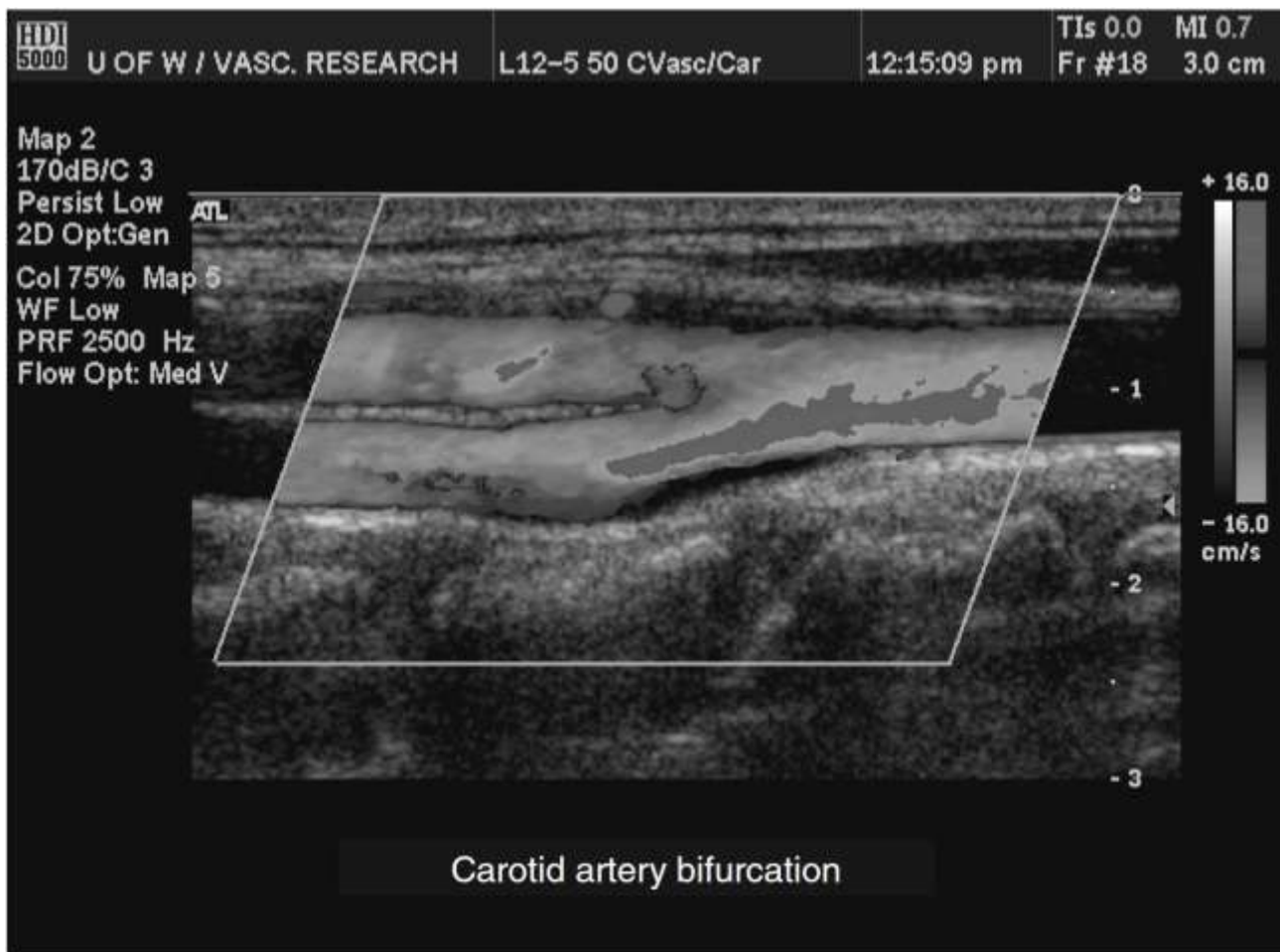


D Trapezoidal (contiguous)



E Compound

# Example Images



# [ Example Images ]



# Major Imaging Categories

- Breast
  - Imaging of female (usually) breasts
- Cardiac
  - Imaging of the heart
- Obstetrics/Gynecologic (OB/GYN)
  - OB: Imaging of fetuses in vivo
  - GYN: Imaging of the female reproductive organs
- Abdominal (Radiology)
  - Imaging of the internal organs of the abdomen
- Pediatrics
  - Imaging of children
- Vascular
  - Imaging of the arteries and veins of the vascular system



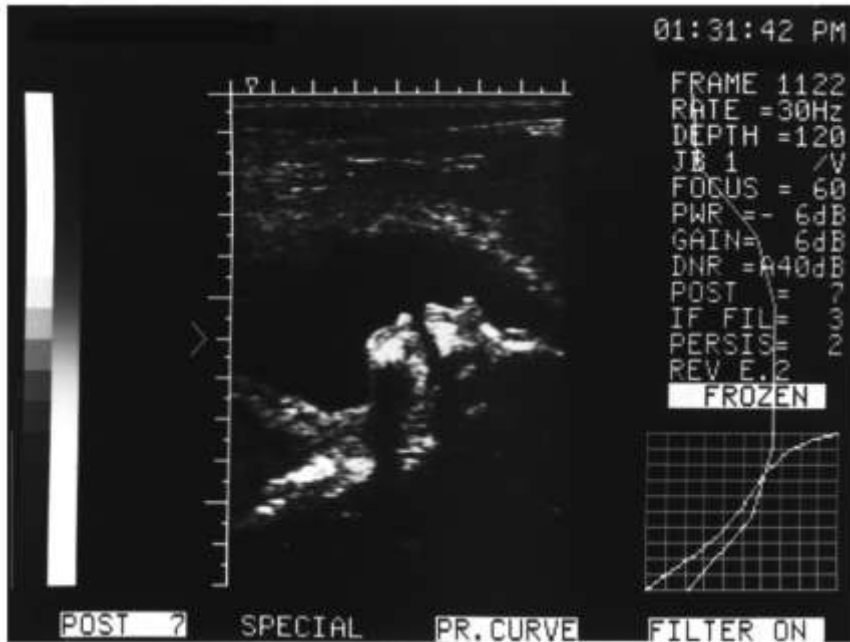
# Ultrasound Applications (1)

- Endovaginal
  - Imaging the female pelvis using the vagina as an acoustic window
- Intracardiac
  - Imaging from within the heart
- Intraoperative
  - Imaging during a surgical procedure
- Intravascular
  - Imaging of the interior of arteries and veins
- Laproscopic
  - Guide and evaluate laparoscopic surgery
- Musculoskeletal
  - Imaging of muscles, tendons, and ligaments

# Ultrasound Applications (2)

- Small parts
  - High-resolution imaging applied to superficial tissues, musculature, and vessels near the skin surface
- Transcranial
  - Imaging through the skull (through temple or eye) of the brain
- Transesophageal
  - Imaging of internal organs (especially the heart) from specially designed probes that go inside the esophagus
- Transorbital
  - Imaging of the eye or through the eye as an acoustic window
- Transrectal
  - Imaging of the pelvis using the rectum as an acoustic window
- Transthoracic
  - External imaging from the surface of the chest

# [ Transmit Focal Zones ]



**Single Zone**

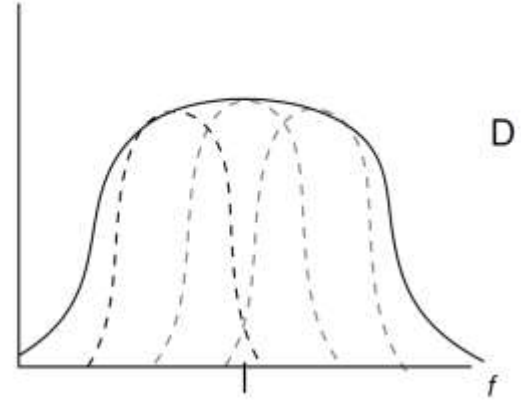
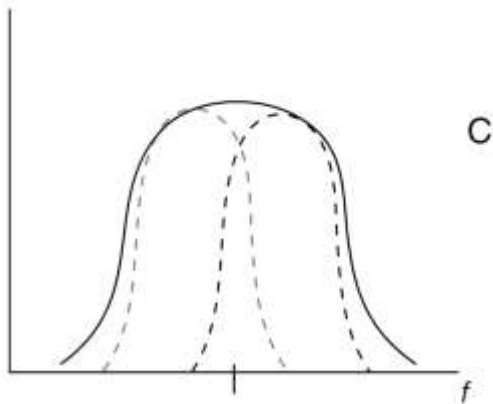
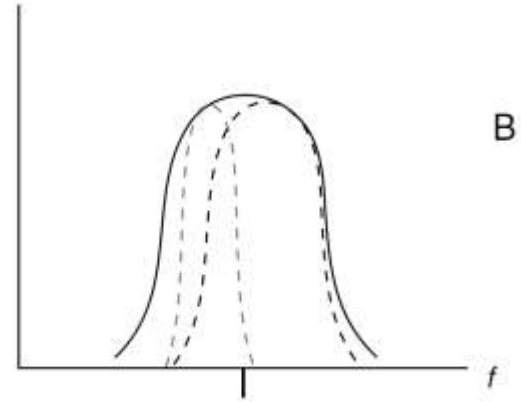
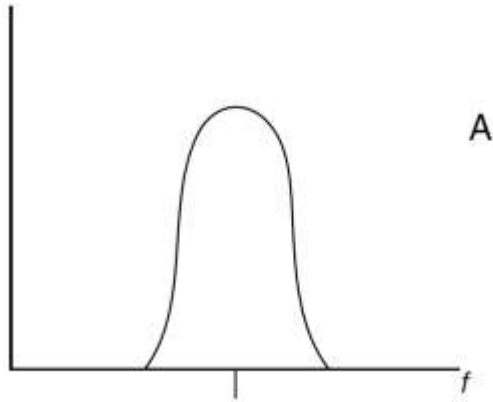


**Multiple Zones**

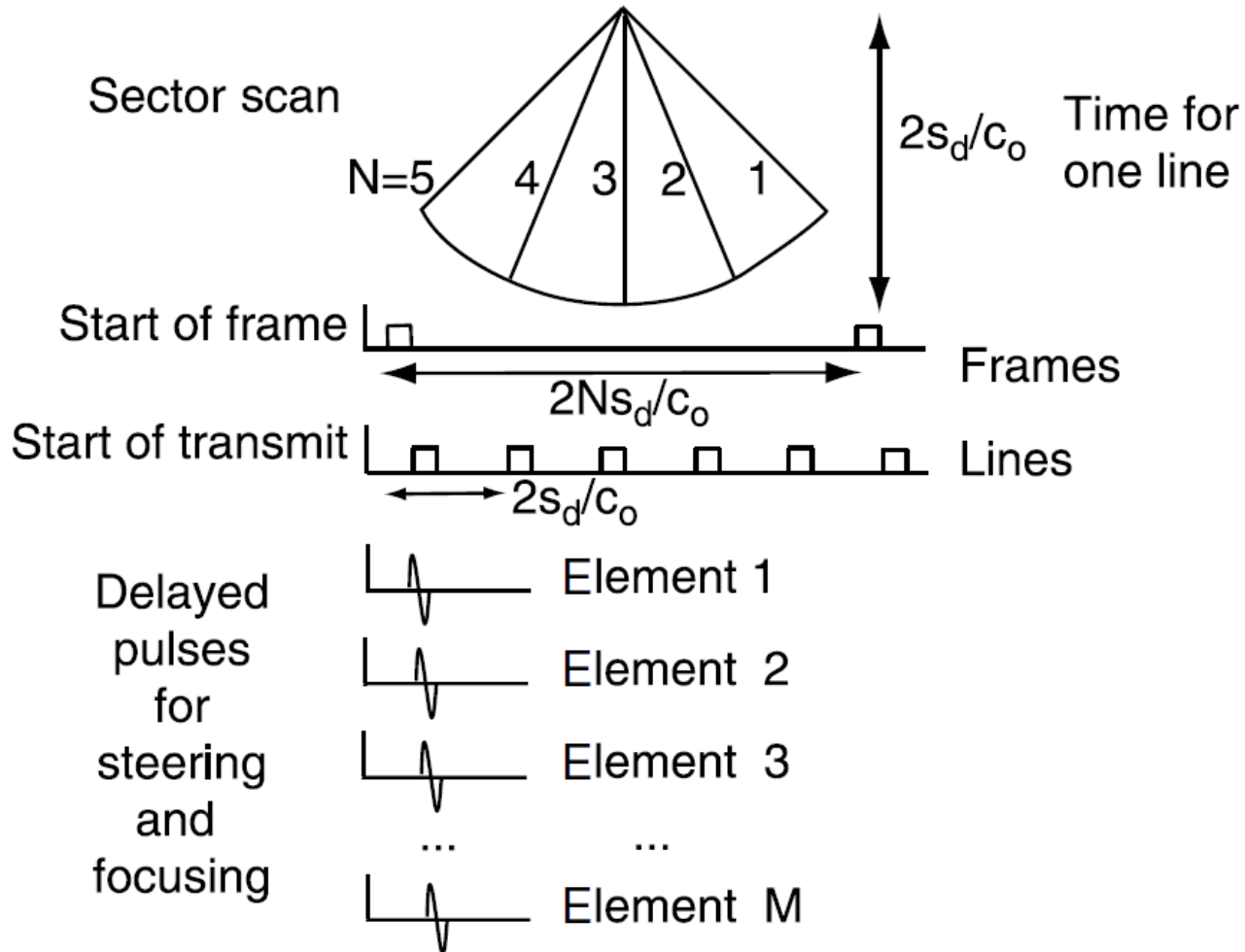
# [ Ultrasound Transducers ]



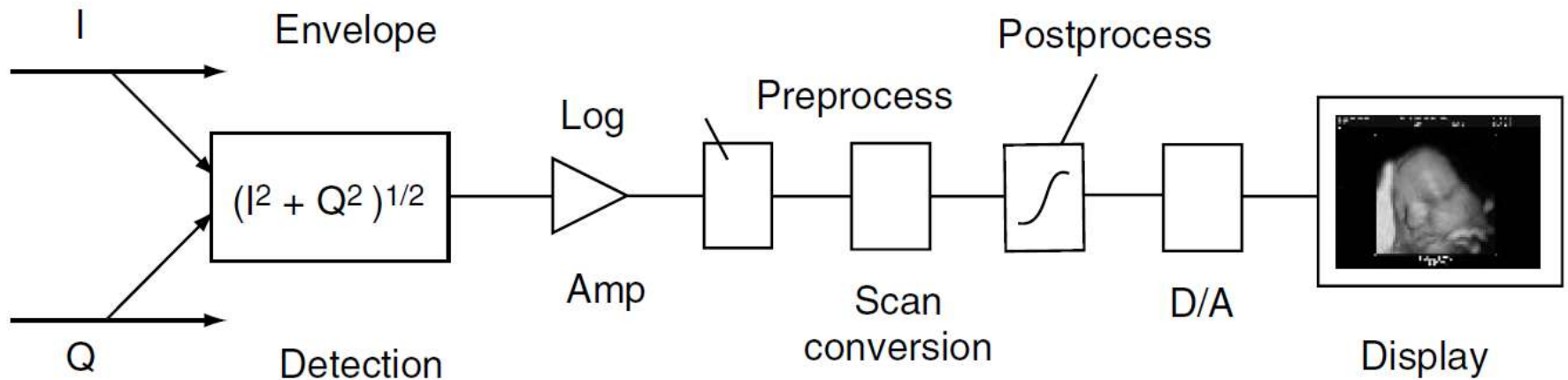
# [ Multi-Frequency Probes ]



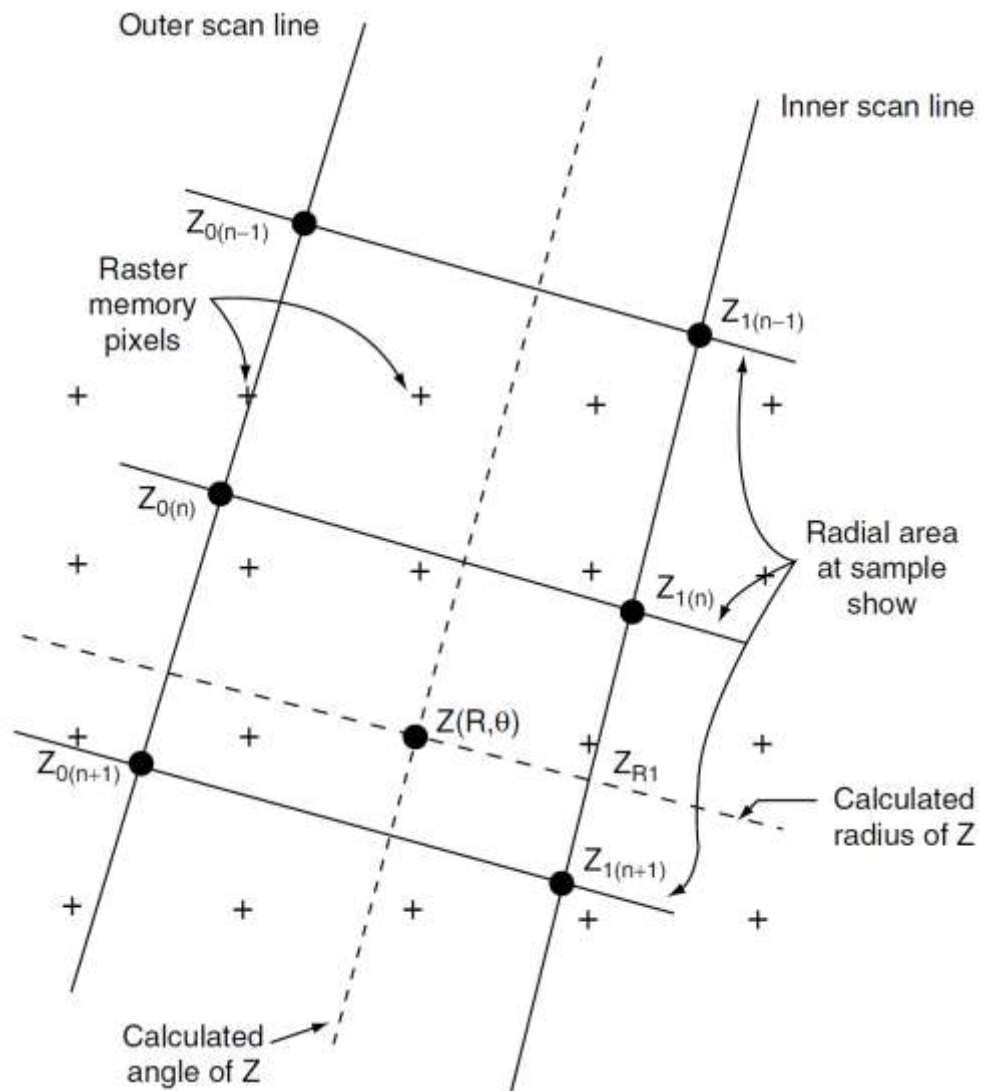
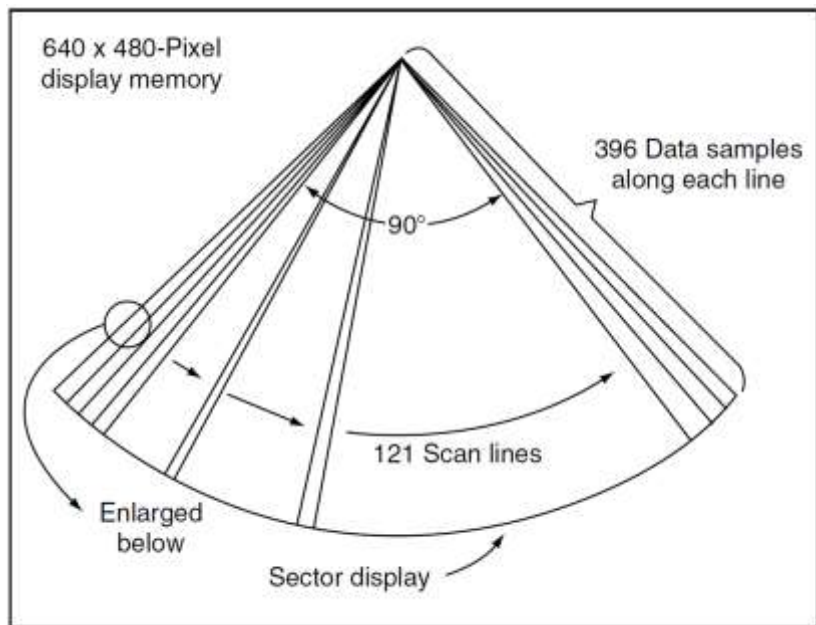
# Ultrasound Pulse Sequencing



# Ultrasound Imaging Back-End



# Ultrasound Image Reconstruction





# [ Frequency Compounding ]

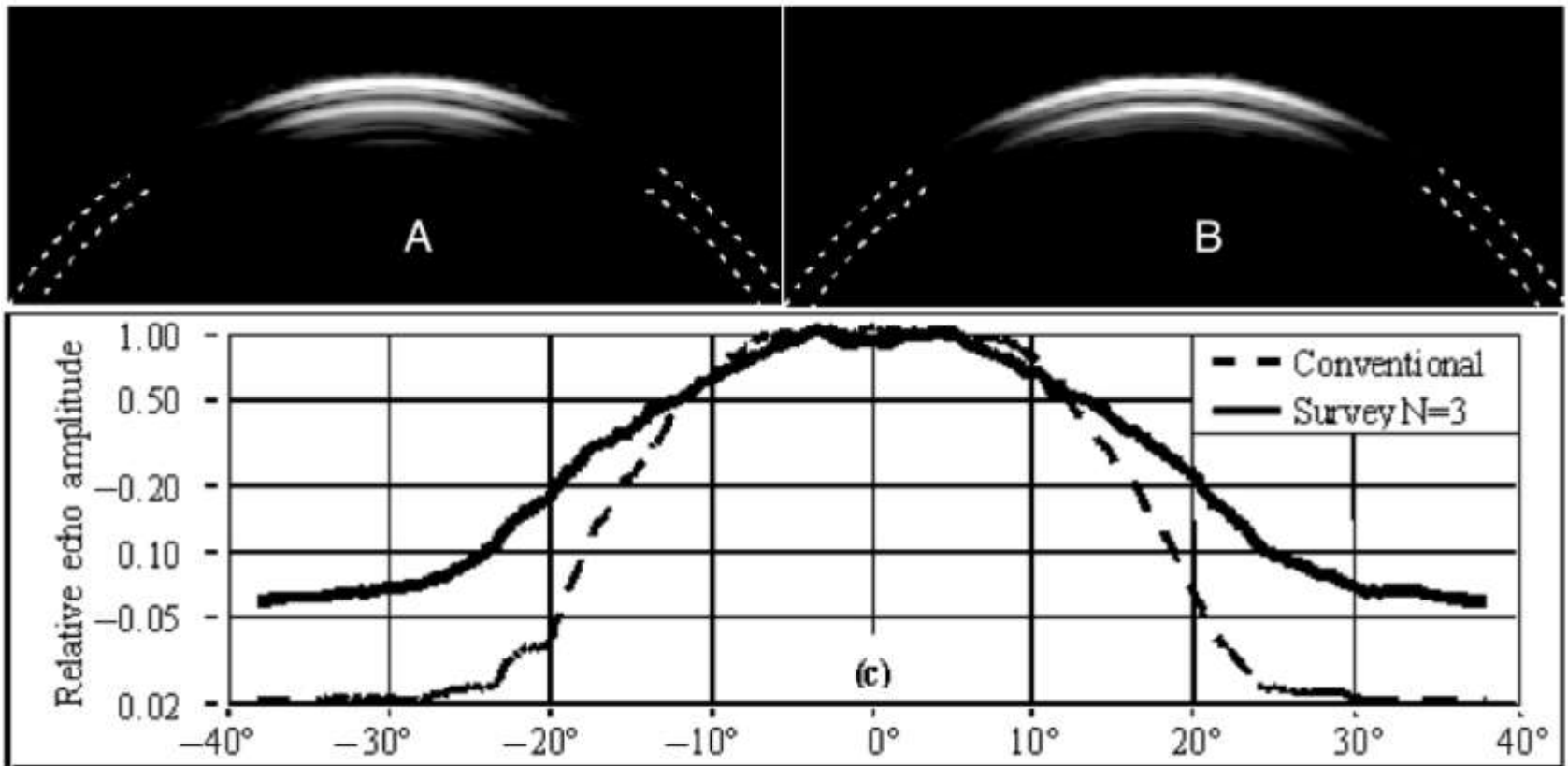


**Conventional Imaging**

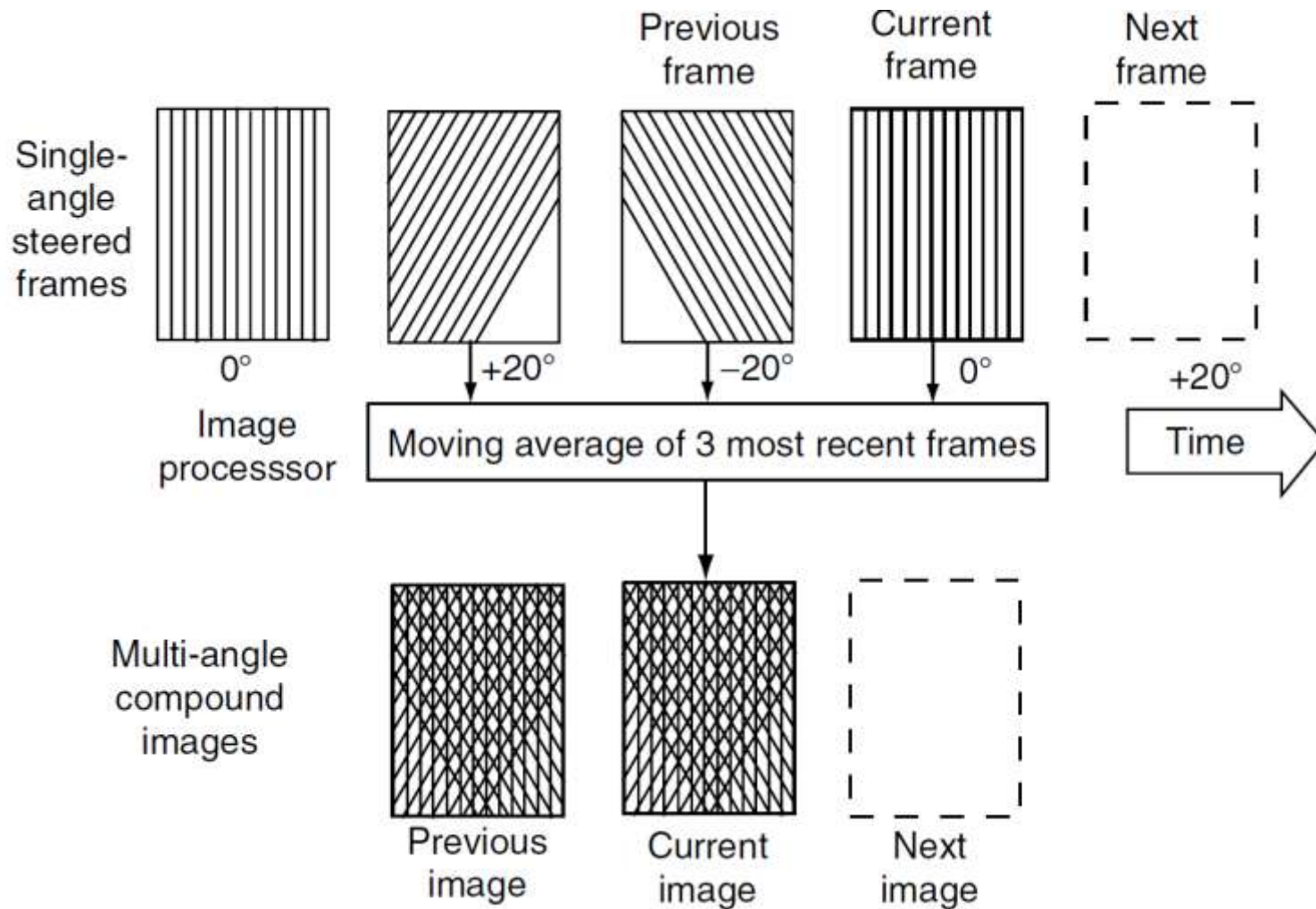


**Frequency Compounding**

# Spatial Compounding



# Spatial Compounding



# Spatial Compounding Example



Conventional Imaging

Spatial Compounding

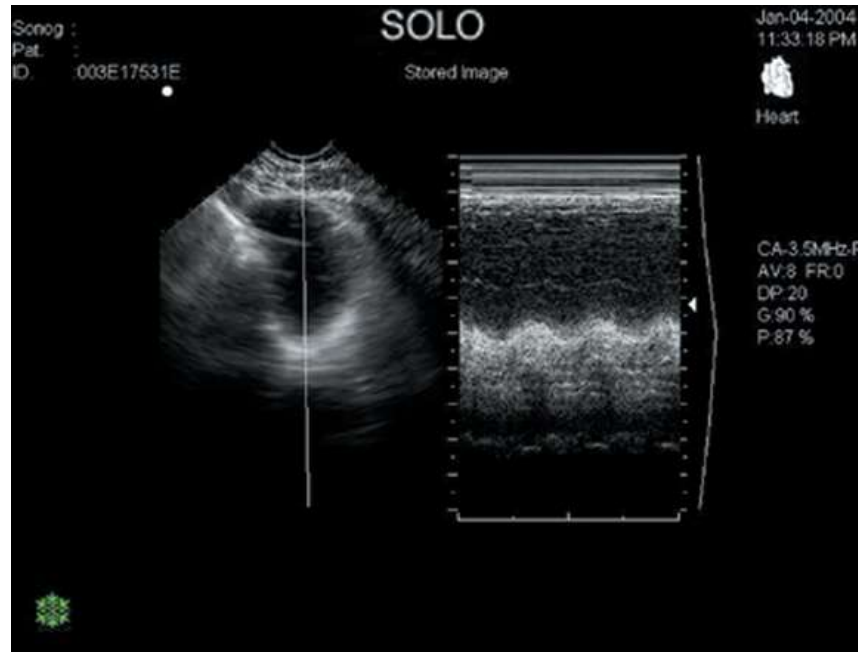
# Major Modes: B-Mode (2D Mode)

- Brightness-modulated image in which depth is along the z axis and azimuth is along the x axis.
  - The position of the echo is determined by its acoustic transit time and beam direction in the plane.



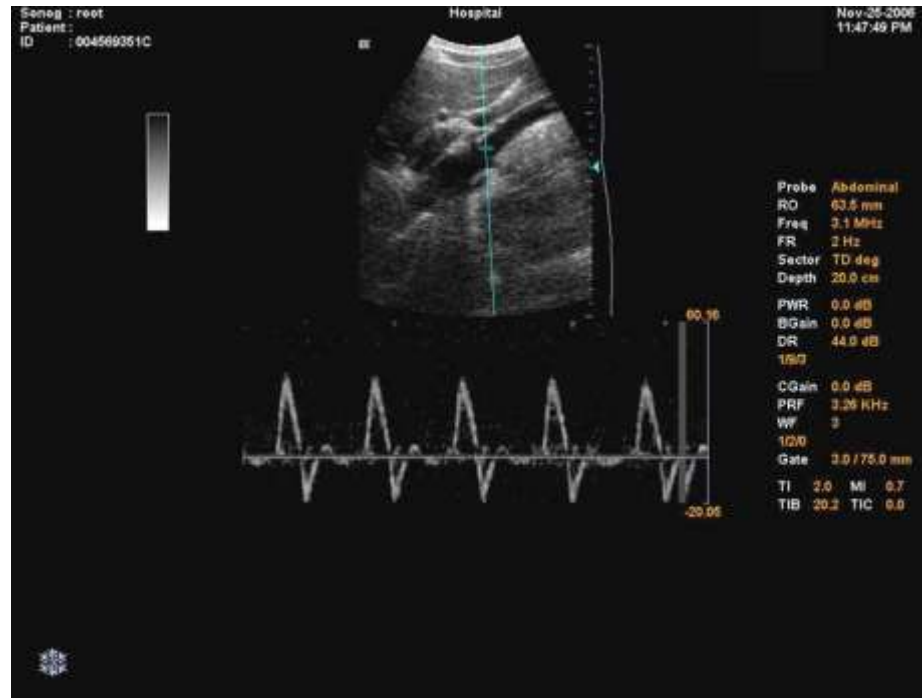
# Major Modes: M-Mode

- Brightness modulated, where depth is the y deflection (fast time), and the x deflection is the same imaging line shown as a function of slow time.
  - Time history of single line at the same position over time



# Major Modes: Doppler-Mode

- This is the presentation of the Doppler spectrum
  - Continuous wave (CW) Doppler
  - Pulsed wave (PW) Doppler



# Major Modes: Color Flow Mapping Mode (CFM)

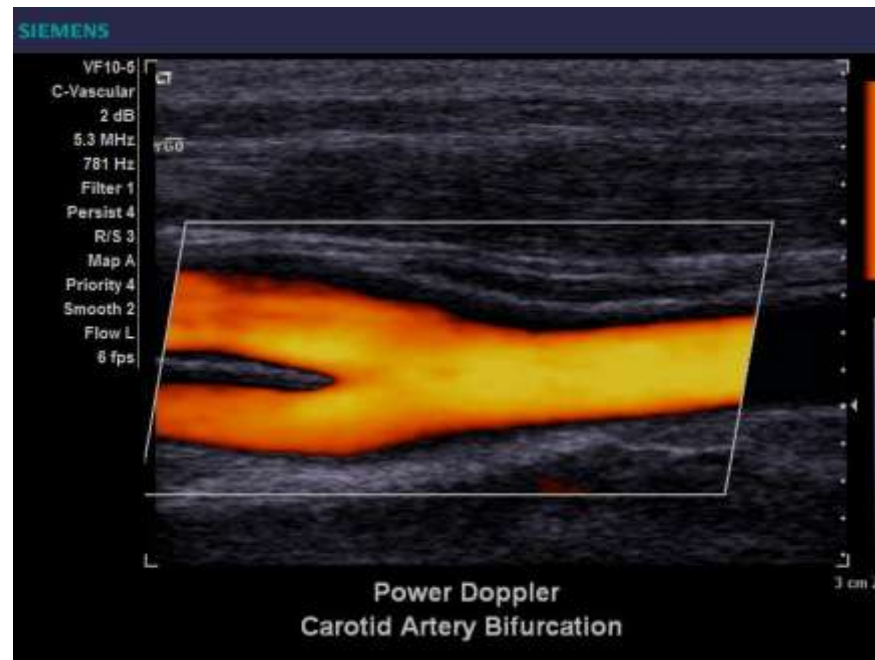
- Spatial map overlaid on a B-mode gray-scale image that depicts an estimate of blood flow mean velocity
  - Direction of flow encoded in colors (blue away from the transducer and red toward it)
  - Amplitude of mean velocity by brightness, and turbulence by a third color (often green).





# Major Modes: Power Doppler Mode

- This color-coded image of blood flow is based on intensity rather than on direction of flow, with a paler color representing higher intensity.
  - It is also known as “angio”



# Secondary Modes

- Duplex
  - Presentation of two modes simultaneously: usually 2D and pulsed (wave) Doppler
- Triplex
  - Presentation of three modes simultaneously: usually 2D, color flow, and pulsed Doppler
- 3D
  - Display or Surface/volume rendering used to visualize volume composed of multiple 2D slices.
- 4D
  - A 3D image moving in time

# [ Next Lecture ]

---

- Unconventional ultrasound applications