Doppler in Echocardiography of Valves

Types of Doppler

- Spectral (no image only waveform showing velocity vs. time)
  - Continuous wave
  - Pulsed wave
- Color flow image
  - Produces an image over the 2D but no velocity is shown
  - Also uses pulsed wave to create the image
- Tissue Doppler

- Pulsed Wave Doppler, Continuous wave Doppler and Tissue Doppler are sent to Fast Fourier Transform for conversion of Doppler shift to signals displayed as waveform by the analyzer
- FFT, Fast Fourier Transform analyzer is a common device that performs spectral analysis in ultrasound instruments. In this case, it displays different quadrature Doppler frequencies, or reflector velocities when a sample volume cursor is used (Doppler frequency is proportional to reflector velocity) along time
- Color Flow Doppler is analyzed by Autocorrelator

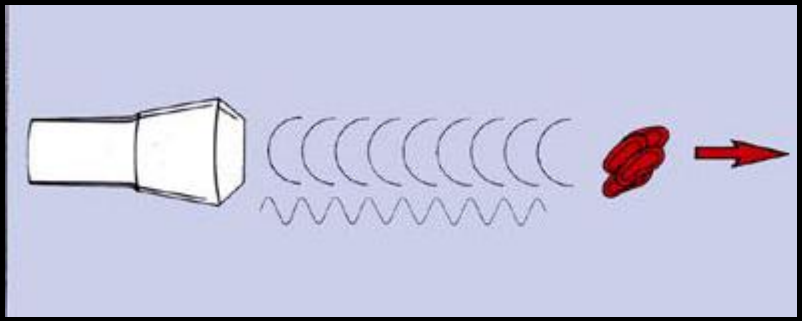
The following information is determined by Doppler

- Direction of flow (+ or – waveform)
- Velocity of flow (y axis)
- Duration of flow (x axis)
- Number of RBCs (brightness of waveform z axis)

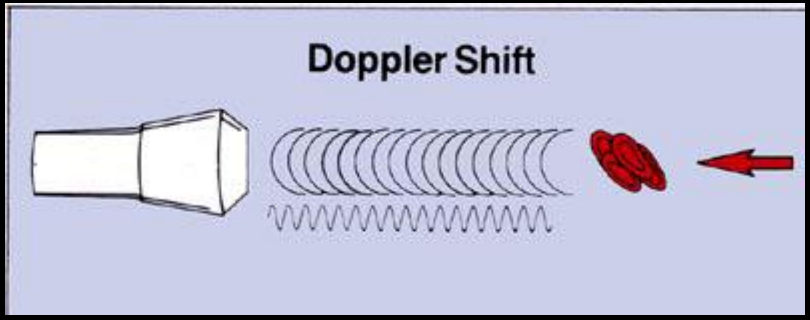
- RBCs and Rayleigh's scattering are the basis for Doppler imaging
- The frequency shift in the echo coming back from the structures dictates the direction of the moving object.
- Cos θ shows the angle dependency, direction of ultrasound beam needs to be parallel to the flow of blood.
- Negative shift shows direction away form the transducer
- Positive shift shows direction towards the transducer
- The shift in KHz is an audible sound that can signify laminar or turbulent flow in the spectral waveform

$$V\ (cm/s) = \frac{C \text{ or } 1540 \times DS\ (kHz)}{2f_o(MHz) \times COS\theta}$$

Negative shift blue in color



Positive shift red in color



Comparing PW and CW

PW	CW
Sampling gate	No sampling gate
Depth specific	No depth specificity
Range specific because of Pulse Duration and SPL	Range ambiguous
Duty factor < 100%	Duty Factor = 100%
Subject to aliasing (speed limitations)	No upper limit for speed
One Crystal for sending and receiving at intervals	Two crystals one sending and one receiving
Deeper maximum focus (full aperture)	Shallower maximum focus (1/2 aperture)
Less bioeffects	More bioeffects

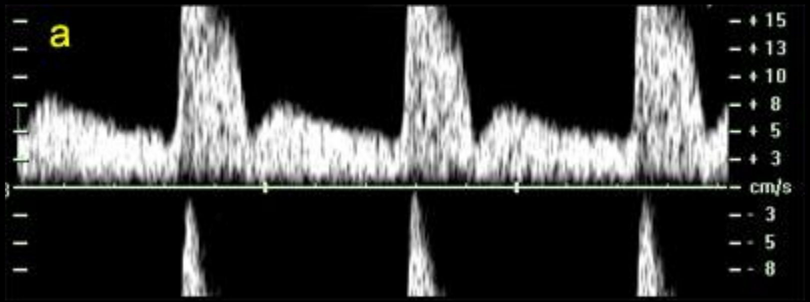
Aliasing

- An artifact of Doppler created when the PRF is less than 2 times the highest frequency of a Doppler signal. (Nyquist limit)
- Aliasing can be eliminated by
  - Moving the baseline
  - Increasing the PRF (scale)
  - Switching to CW
  - Lowering the transducer frequency

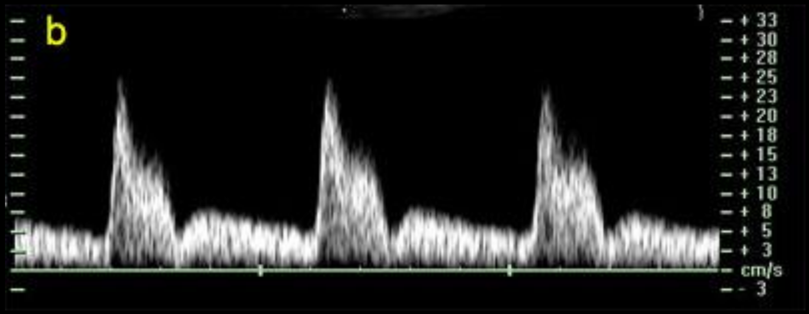
Parameters affecting aliasing

- PRF increase
  - Deeper gate depth
- Doppler shift increase
  - Higher velocity of blood
  - Insonification angle closer to 0° or 180°
  - Higher transmit frequency

Aliasing

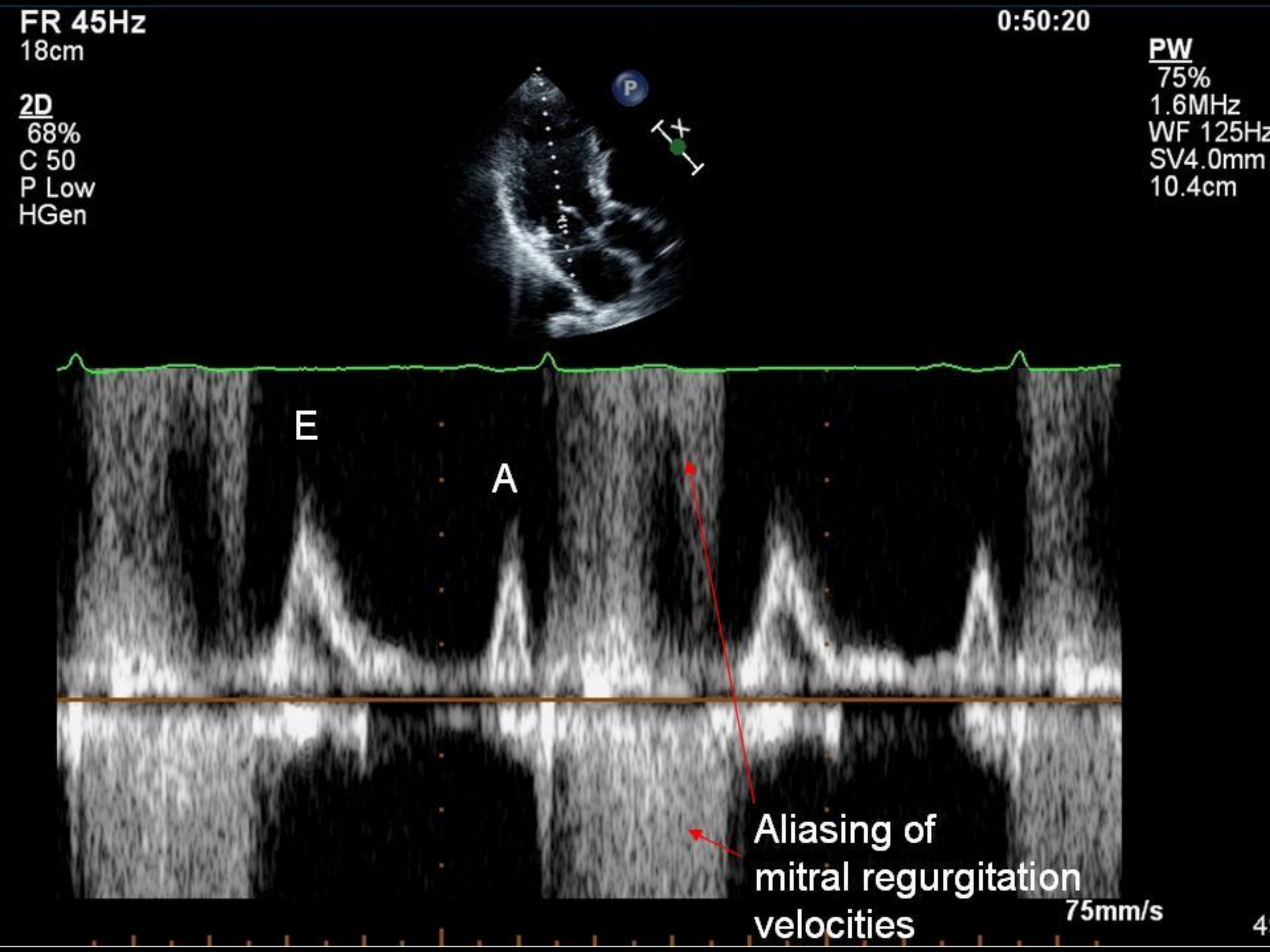


Scale changed to fix aliasing



Mitral Valve Doppler

- Windows are Apical 4, 3 and 2 (sometimes 5)
- Normal spectrum is Diastolic Positive Antegrade flow with upper limit velocity of 1.3 m/s
- In CFD normal flow is RED
- Abnormal flow of Systolic Negative Retrograde flow suggests Mitral Regurgitation
- In CFD MR is mosaic or BLUE



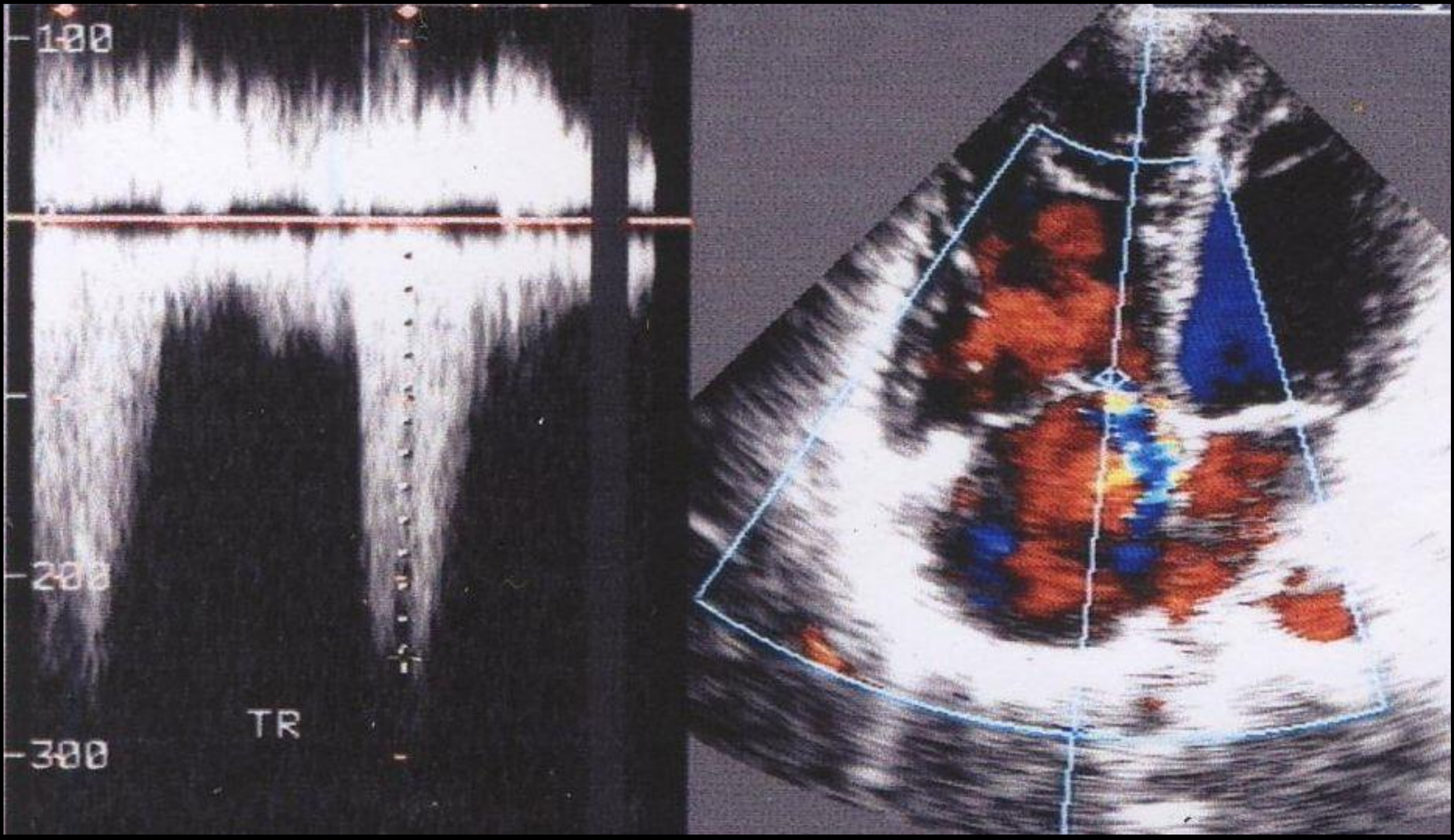
FR 45Hz
18cm
2D
68%
C 50
P Low
HGen
0:50:20
PW
75%
1.6MHz
WF 125Hz
SV4.0mm
10.4cm
E
A
Aliasing of
mitral regurgitation
velocities
75mm/s

- Color flow Doppler of blood flow through MV

Tricuspid Valve Doppler

- Windows are Apical 4 and 5, PSSA Aortic level and sometimes PSLA- RVIF
- Normal spectrum is Diastolic Positive Antegrade flow with upper limit velocity of 0.7 m/s
- In CFD normal flow is RED
- Abnormal flow of Systolic Negative Retrograde flow suggests Tricuspid Regurgitation
- In CFD TR is mosaic or BLUE

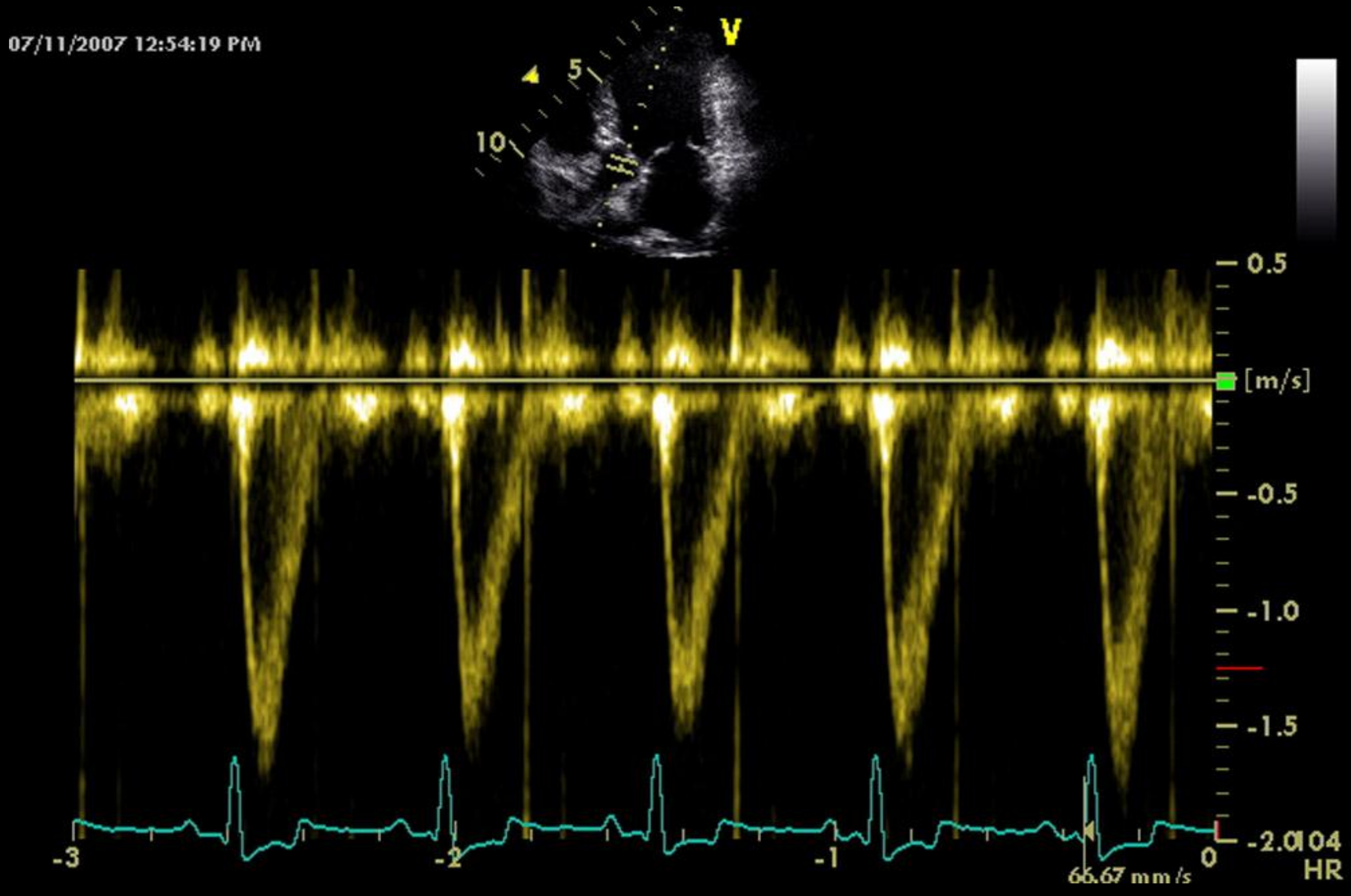
Tricuspid Doppler image and regurgitation with CW



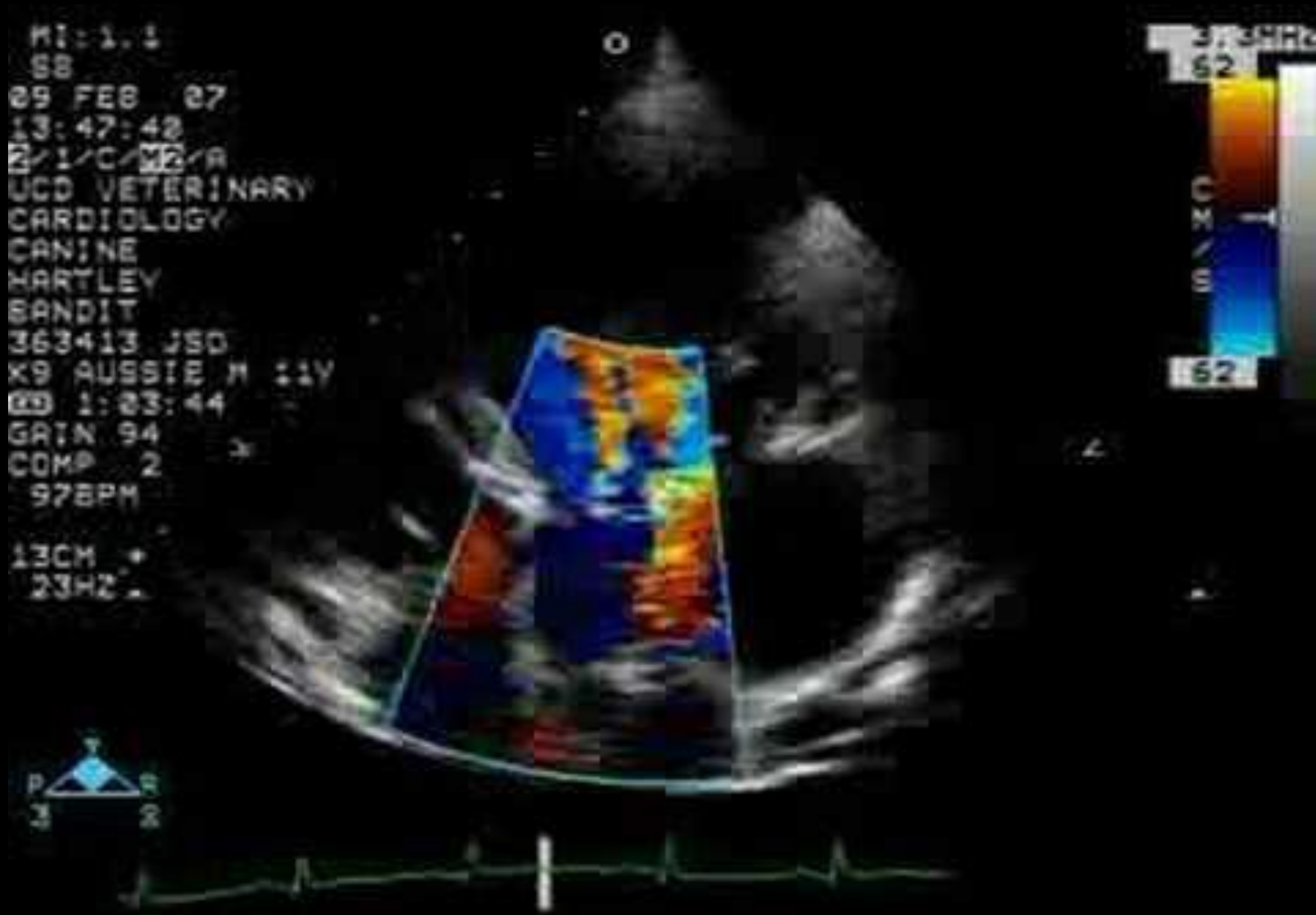
Aortic Valve Doppler

- Windows are Apical 5 and 3
- Normal spectrum is Systolic Negative Retrograde with upper limit velocity of 1.8 m/s
- In CFD normal flow is BLUE
- Abnormal flow of Diastolic Positive Antegrade flow suggests Aortic insufficiency
- In CFC, AI is mosaic or RED

Spectral Doppler of Aortic valve in Apical 5



- Color Doppler image of Aortic Valve

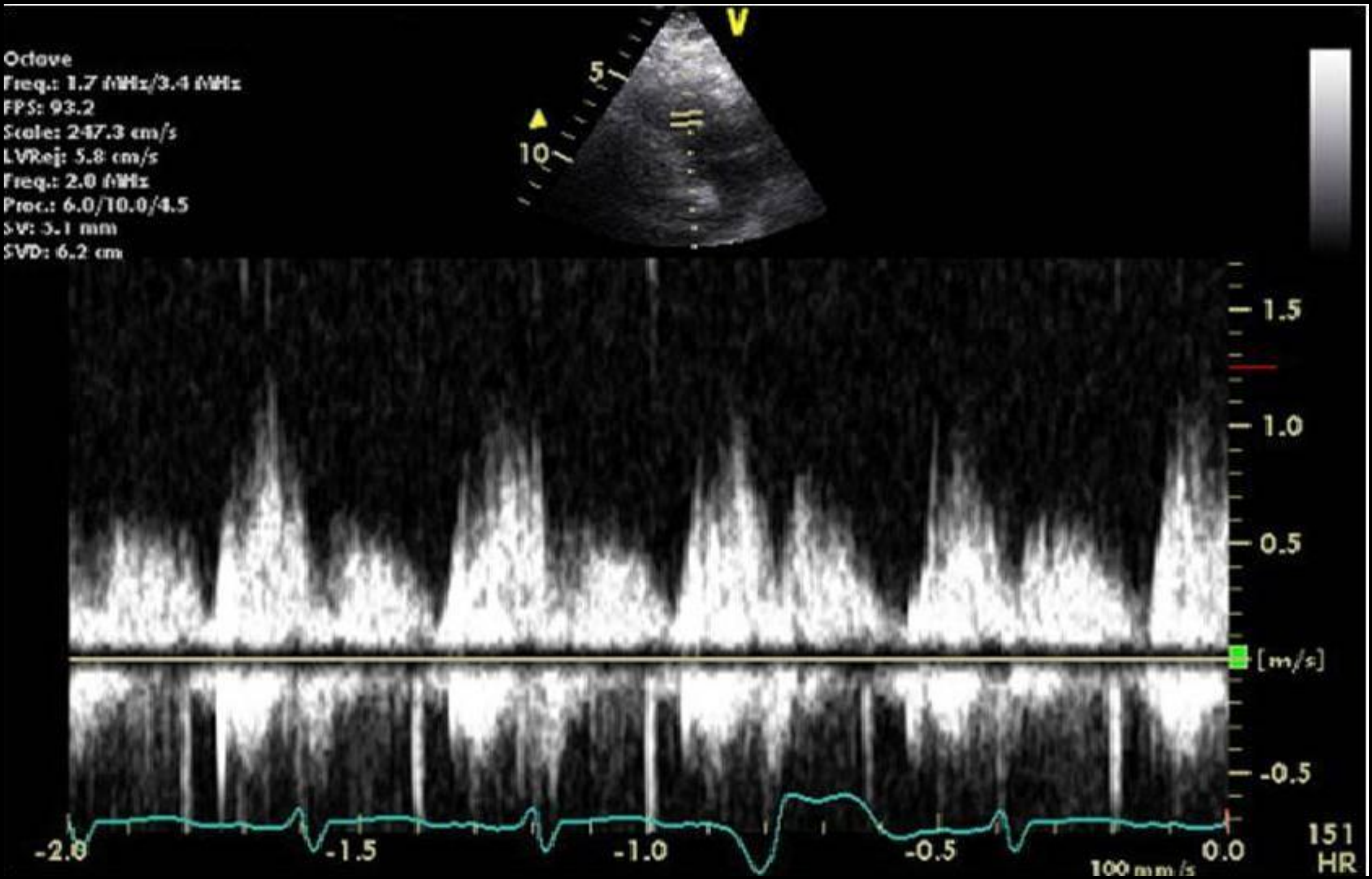


Pulmonic Valve Doppler

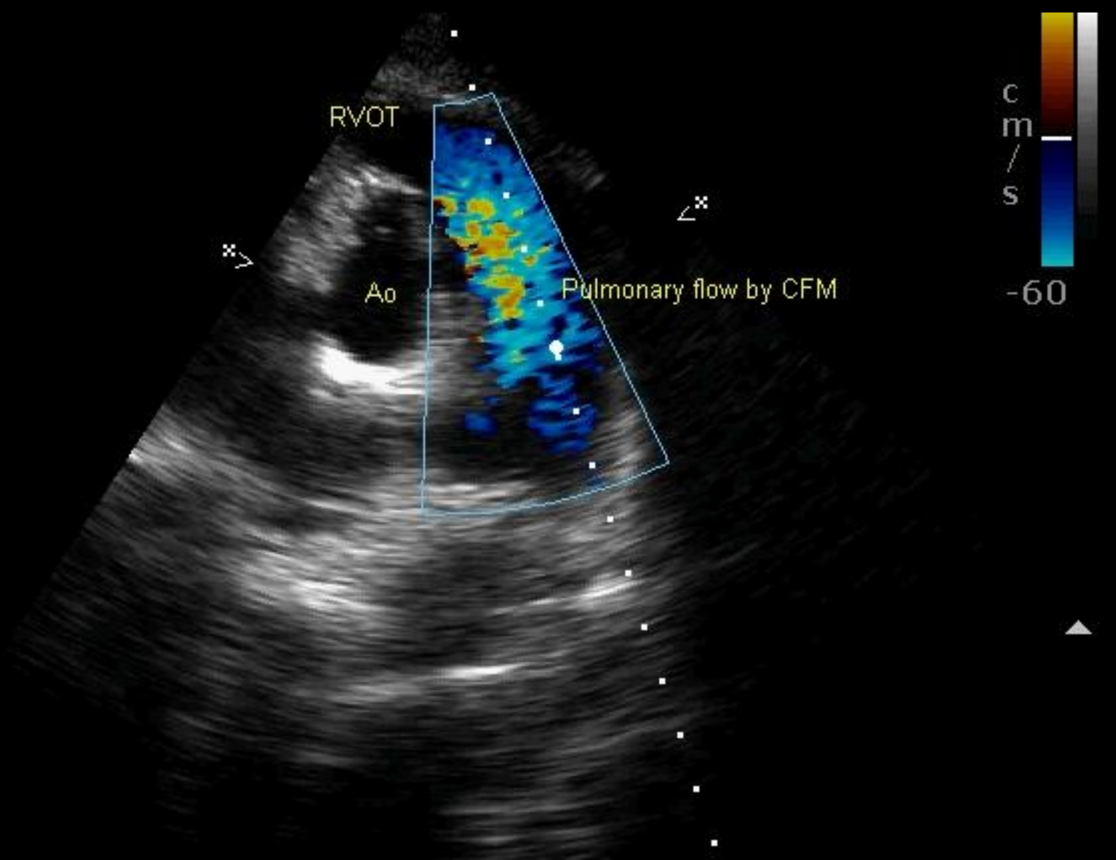
- Windows are PSSA Aortic level, subcostal short axis and sometimes PSLA-RVOF
- Normal spectrum is Systolic Negative Retrograde with upper limit velocity of

  1.0 m/s
- In CFD, normal flow is BLUE
- Abnormal flow of Diastolic Positive Antegrade flow suggests Pulmonic Insufficiency
- In CFD, PI is mosaic or RED

Pulmonic Spectral Doppler



Color Flow image of the Pulmonary valve



Other Doppler Windows

- Subcostal window is best for VSD and ASD and eccentric regurgitations
    - Subcostal window is also best for imaging
        - Trauma to the chest
        - Post cardiac surgery
        - During episodes of Emphysema, Asthma, COPD and Bronchitis
        - Implants or big breasts
        - Pericardial disease
        - IVC assessment or inflow
- PSSA Mitral and Papillary also good windows for VSD

Taken from text written by Narayana Parasad