



Performance Testing Of Medical Ultrasound Equipment

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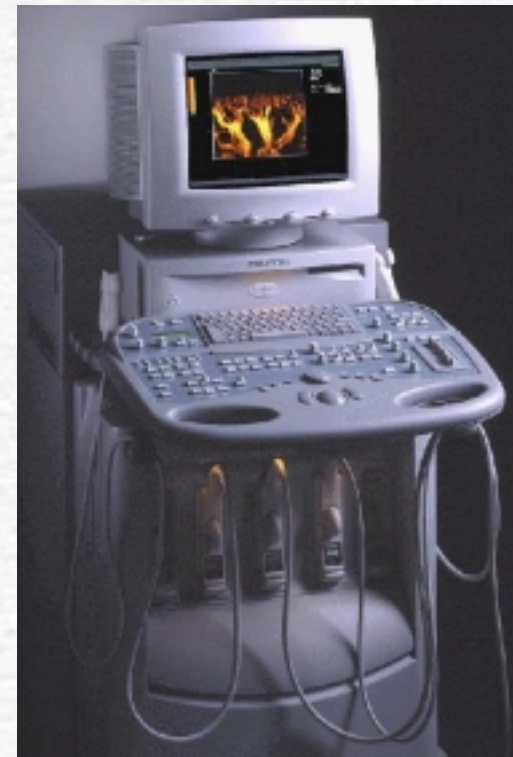
Depts. of Medical Physics, Radiology,
and Human Oncology

University of Wisconsin, Madison, WI

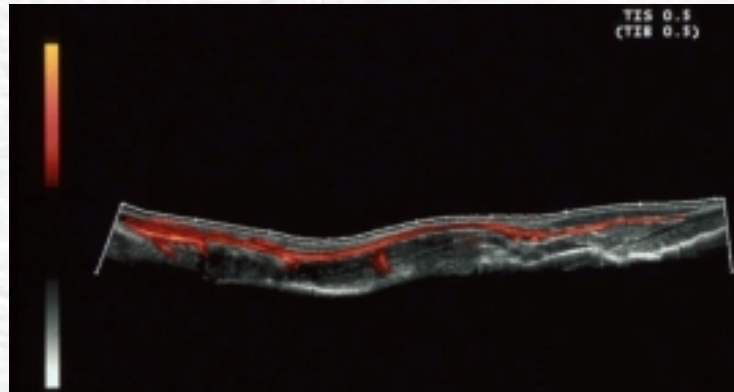


Should we do routine performance testing in ultrasound?

- Some say "It is not beneficial."
- Others believe there is not sufficient manpower, especially in physics and bme.
- Phantoms are perceived to be expensive and inadequate.



Routine performance testing ...



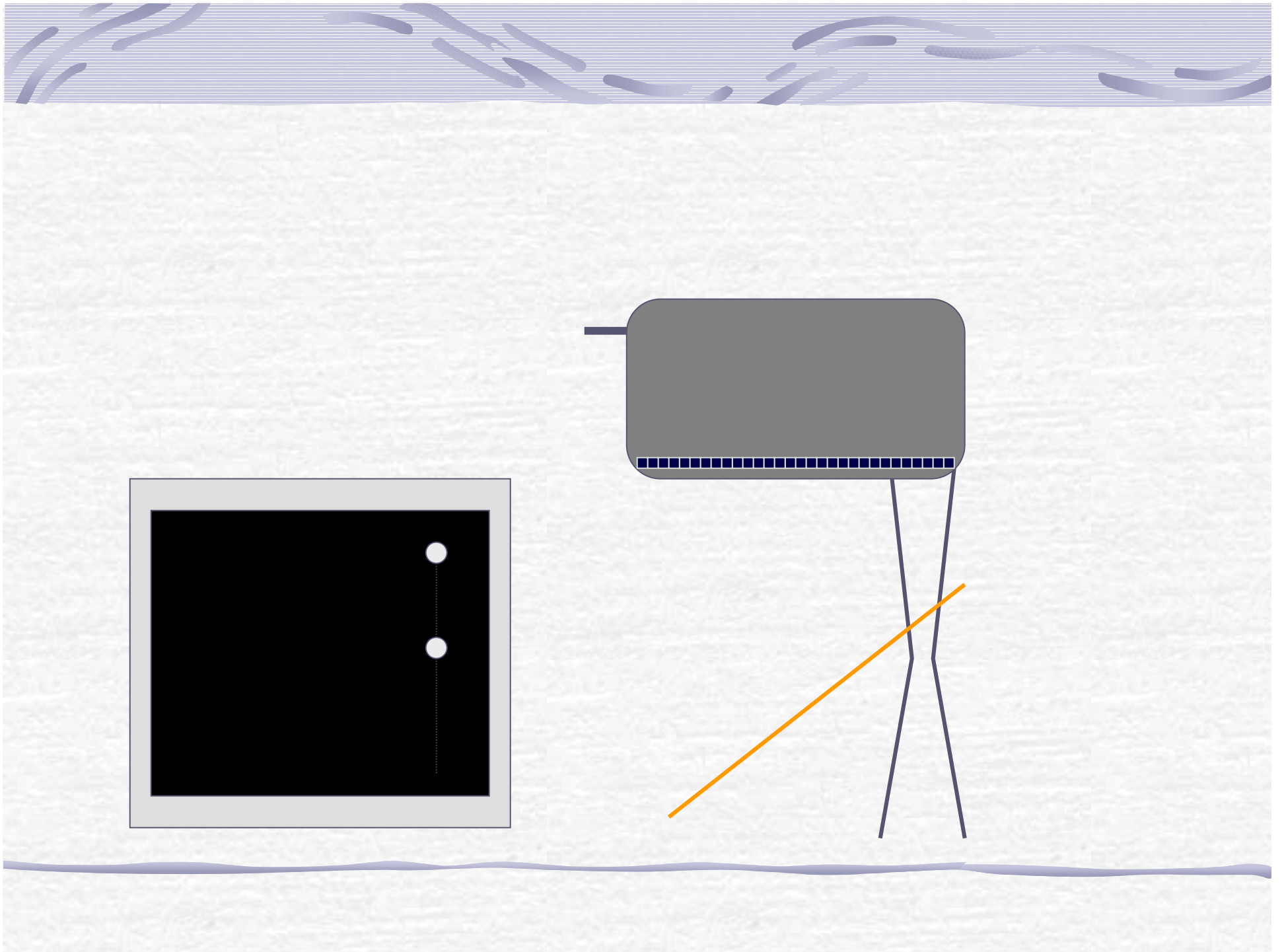
- No established performance standards.
 - Geometry, no problem; image quality is!
- Lack of correlation between performance parameters and clinical performance.
- Imaging is simple; specifying performance is complex.

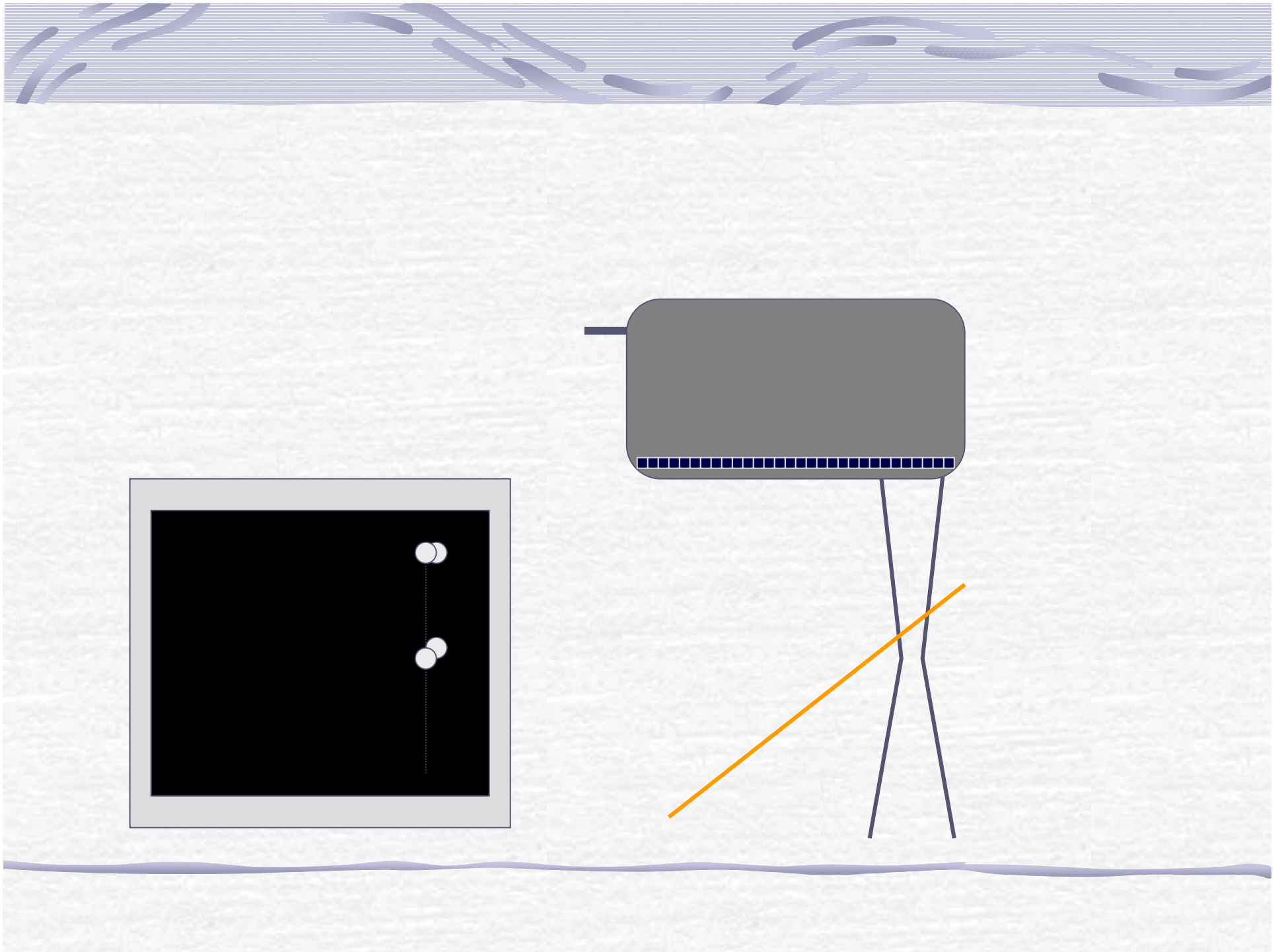
Contents

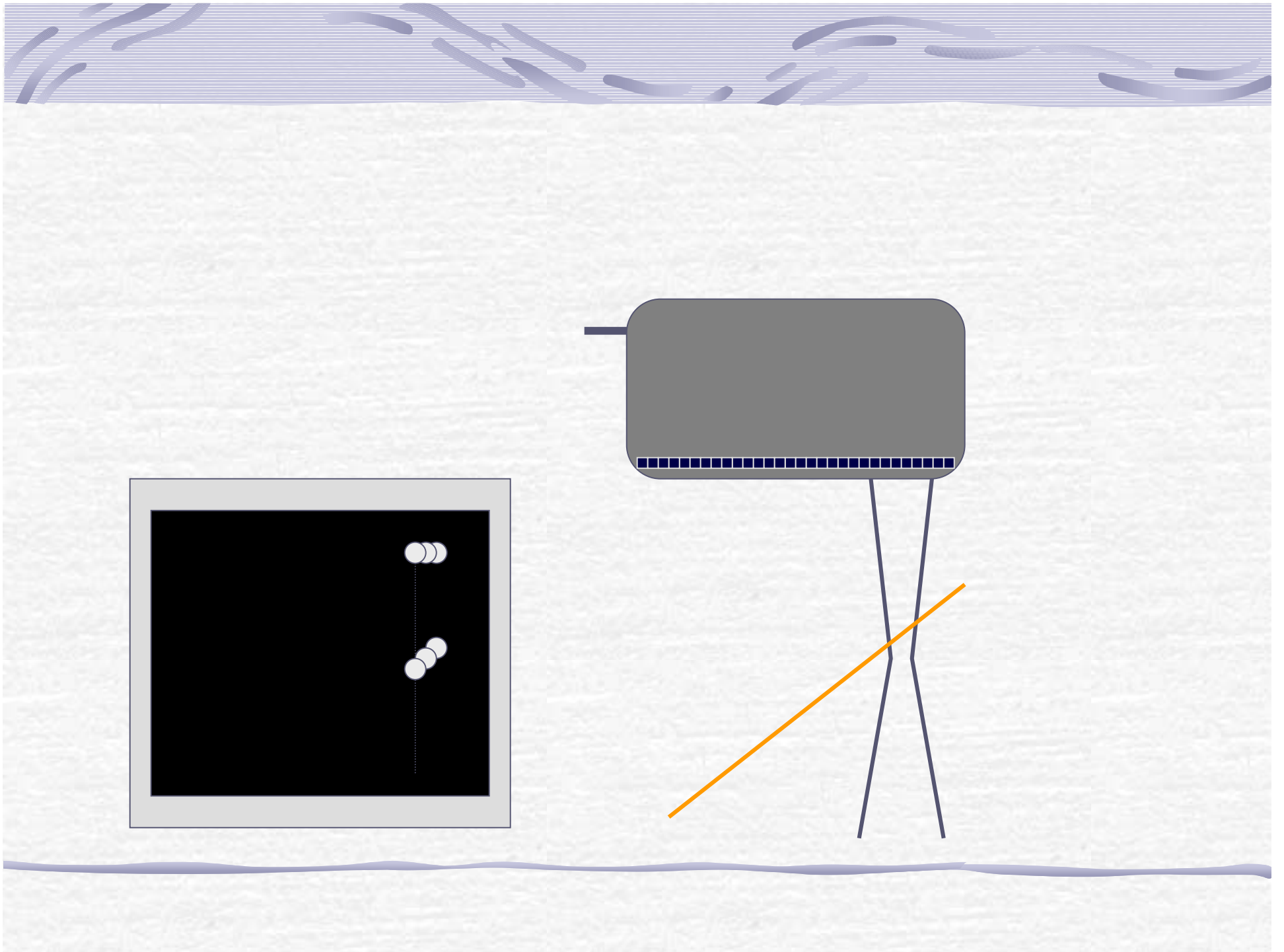
- ☛ Review characteristics of equipment
- ☛ Discuss factors related to physicists measurements of imaging performance
- ☛ Recommend basic QA
- ☛ Discuss role of medical physicists

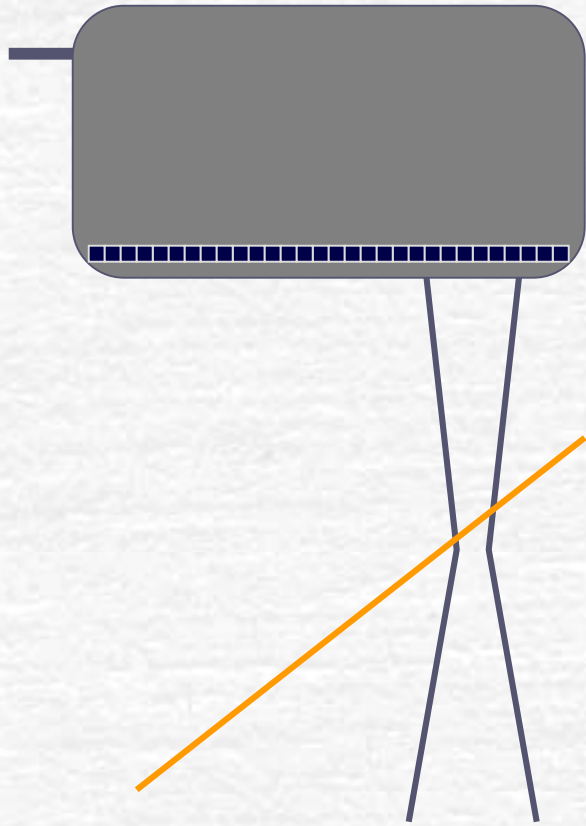
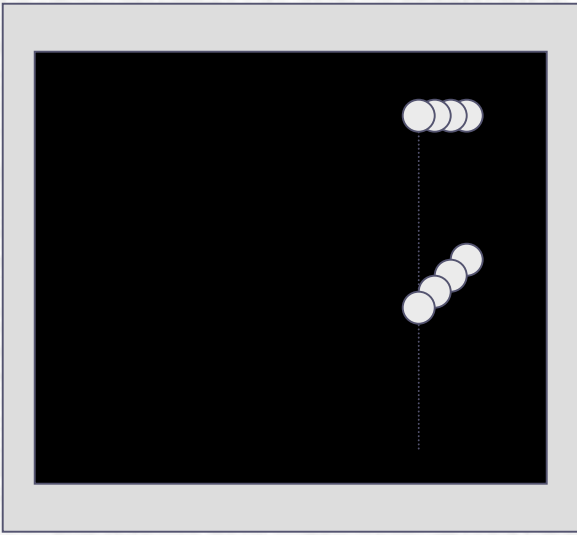
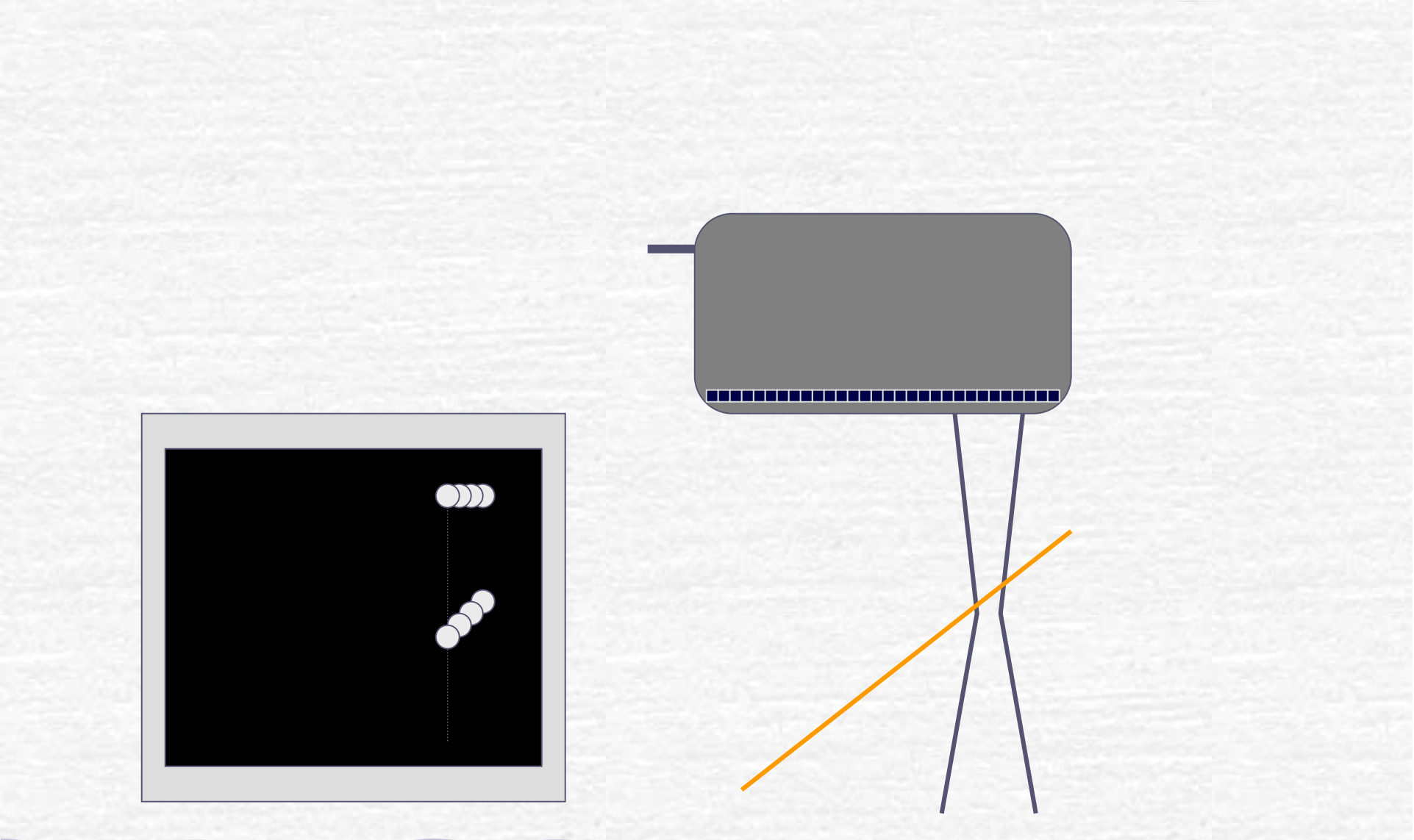
A-MODE AND B-MODE

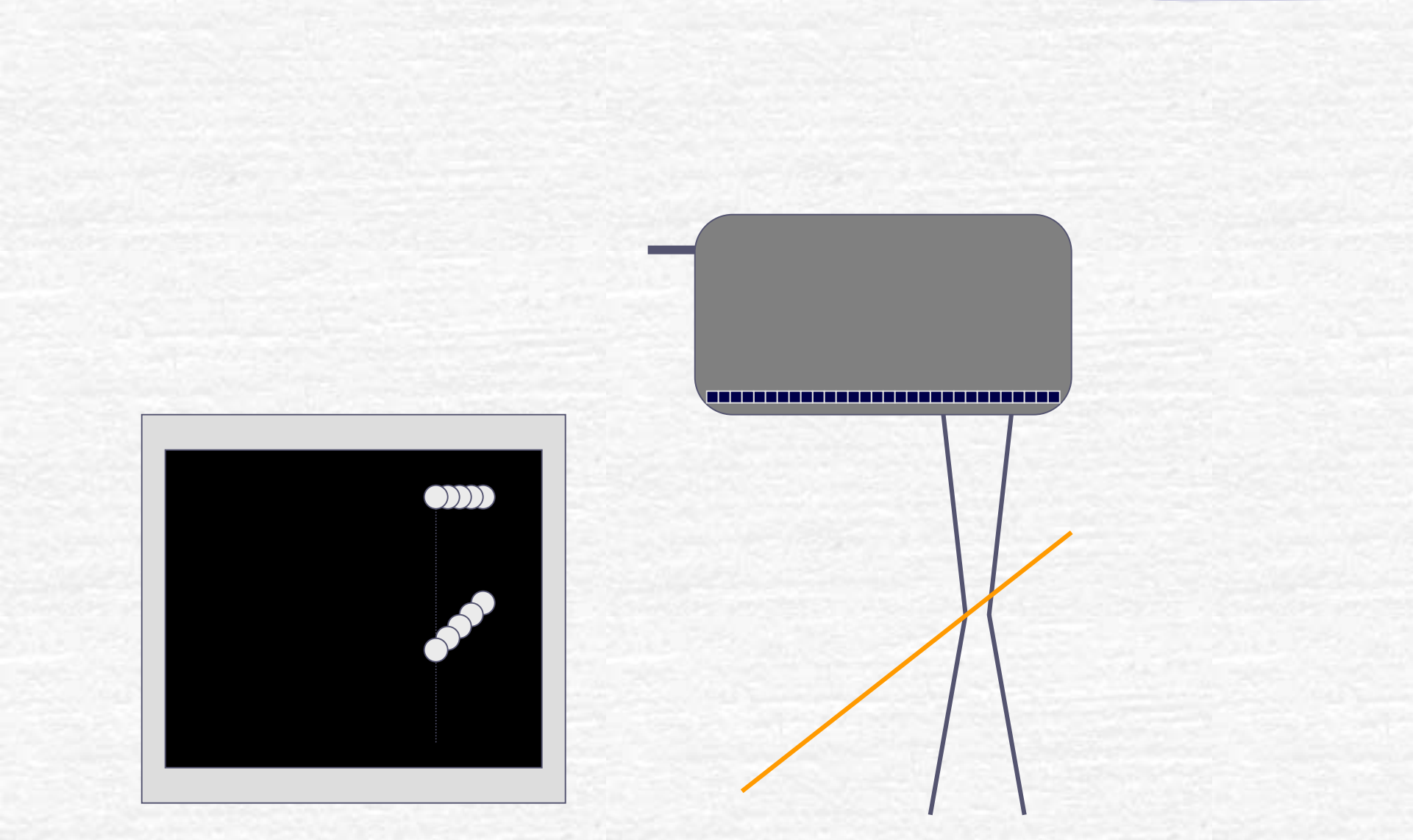


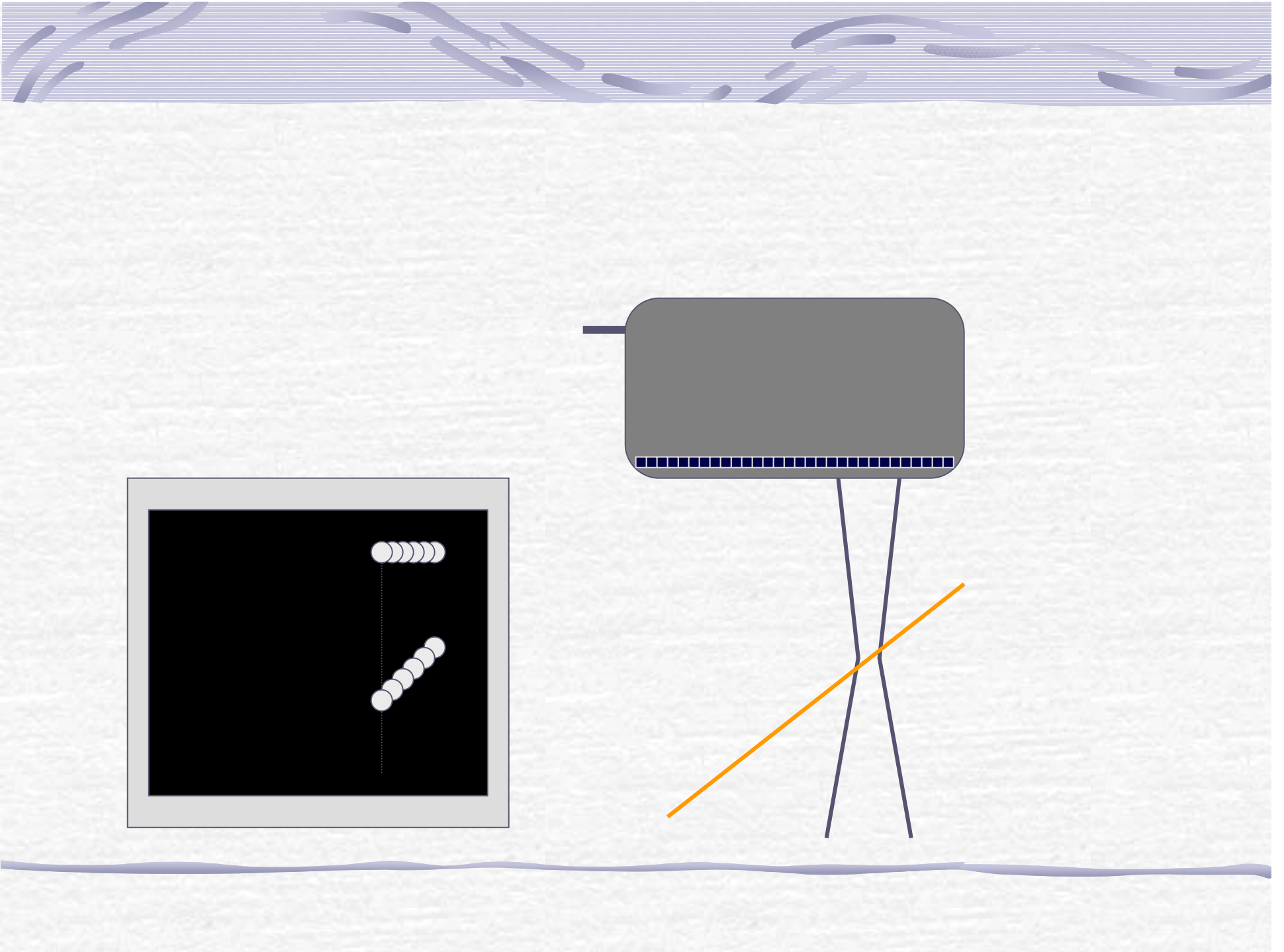


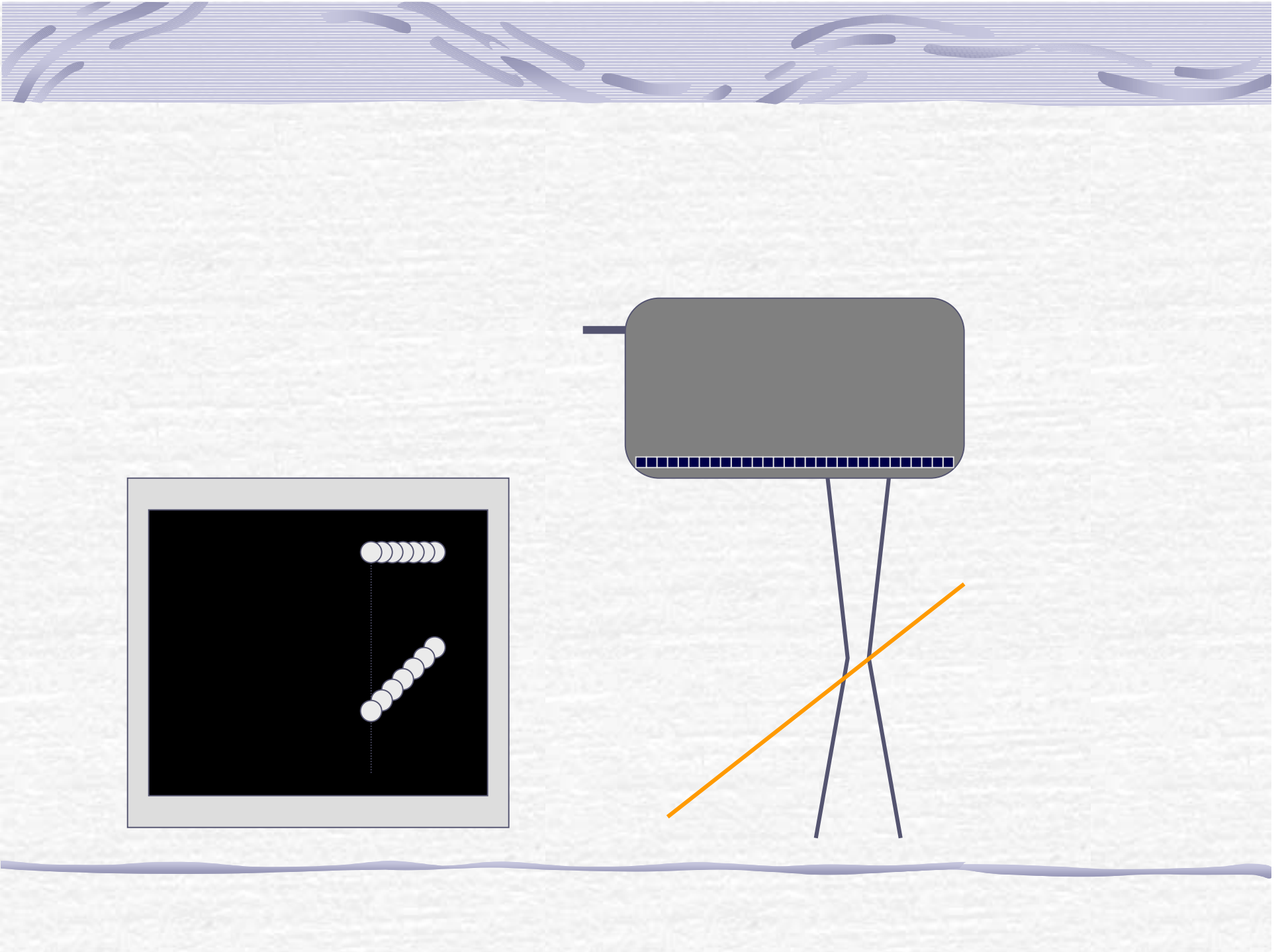


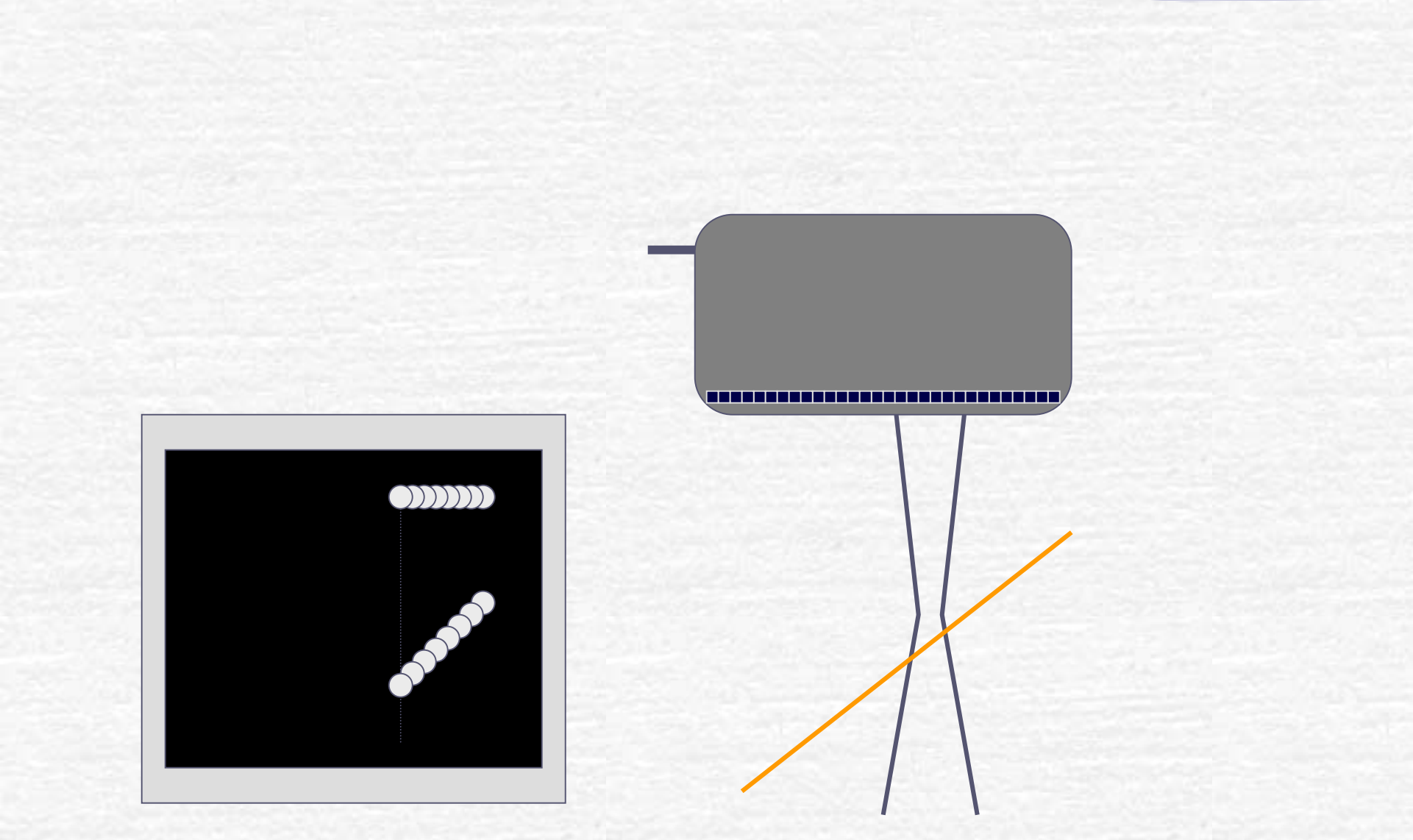


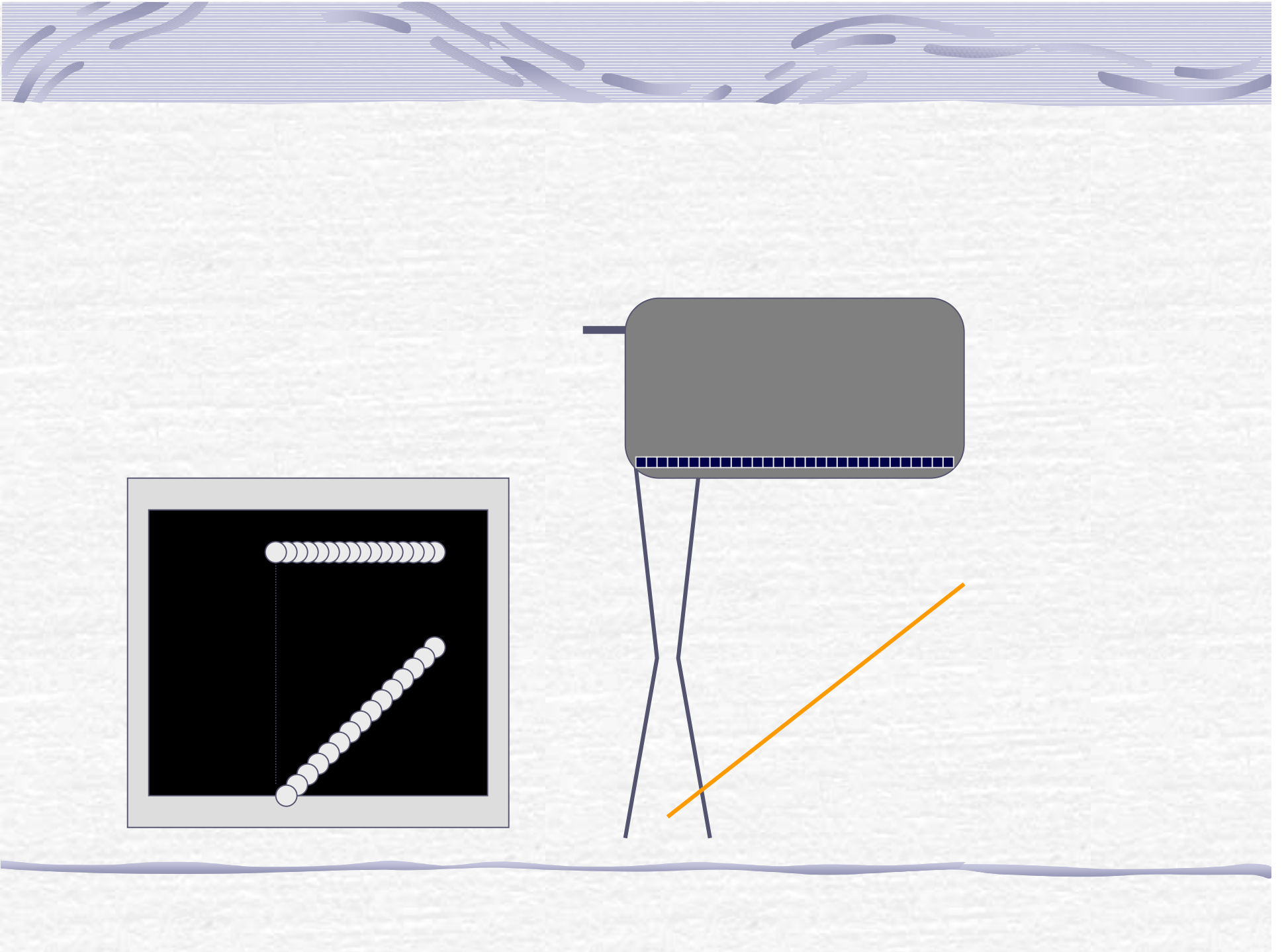




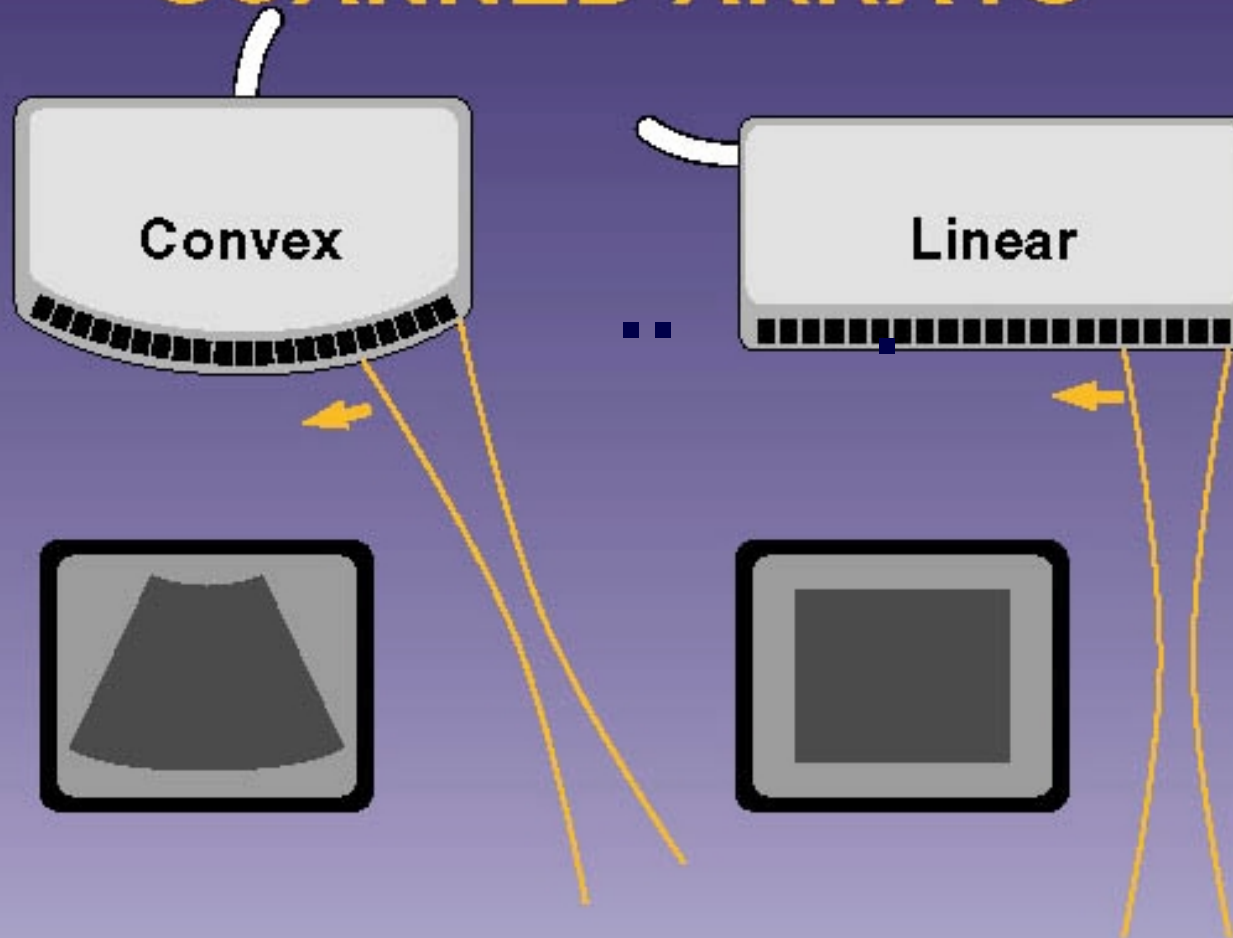




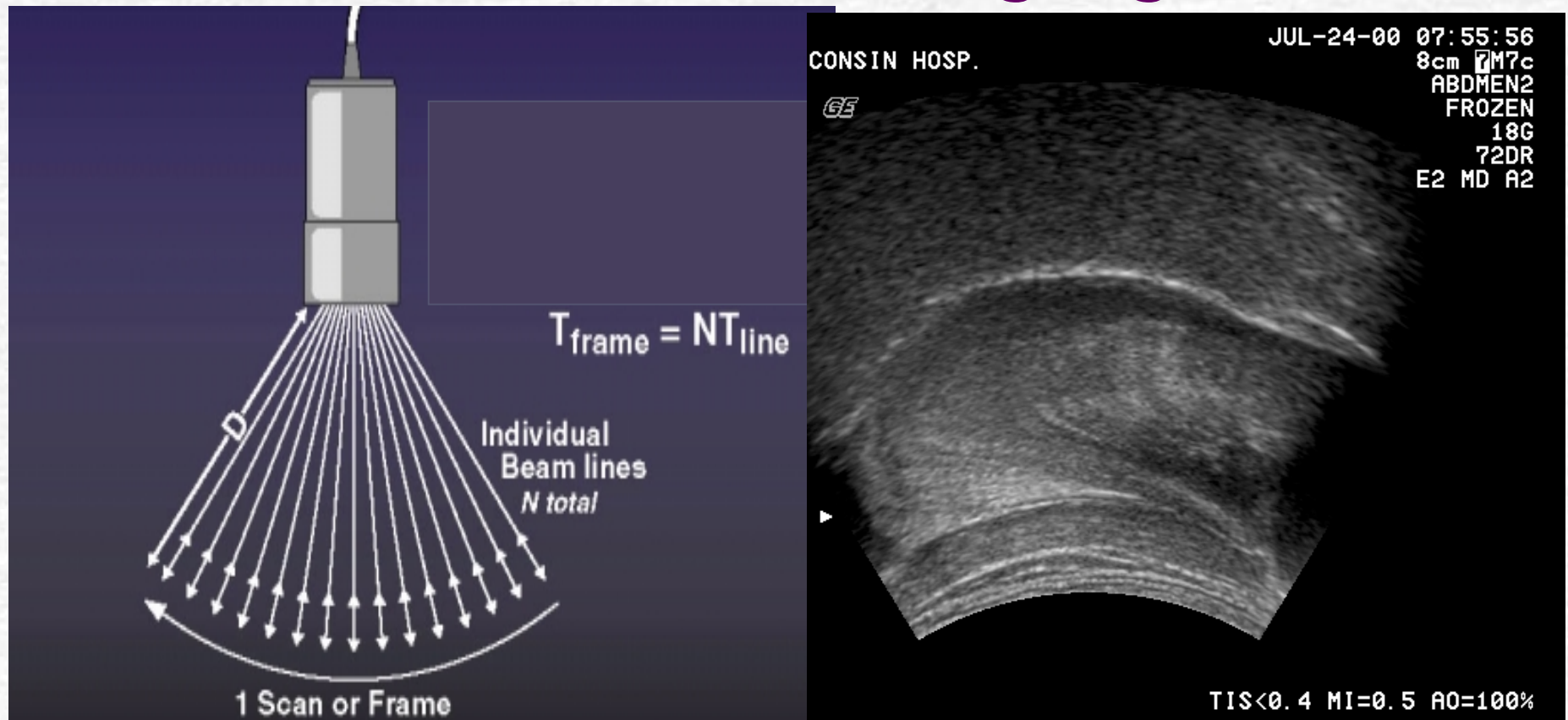




ELECTRONICALLY SCANNED ARRAYS

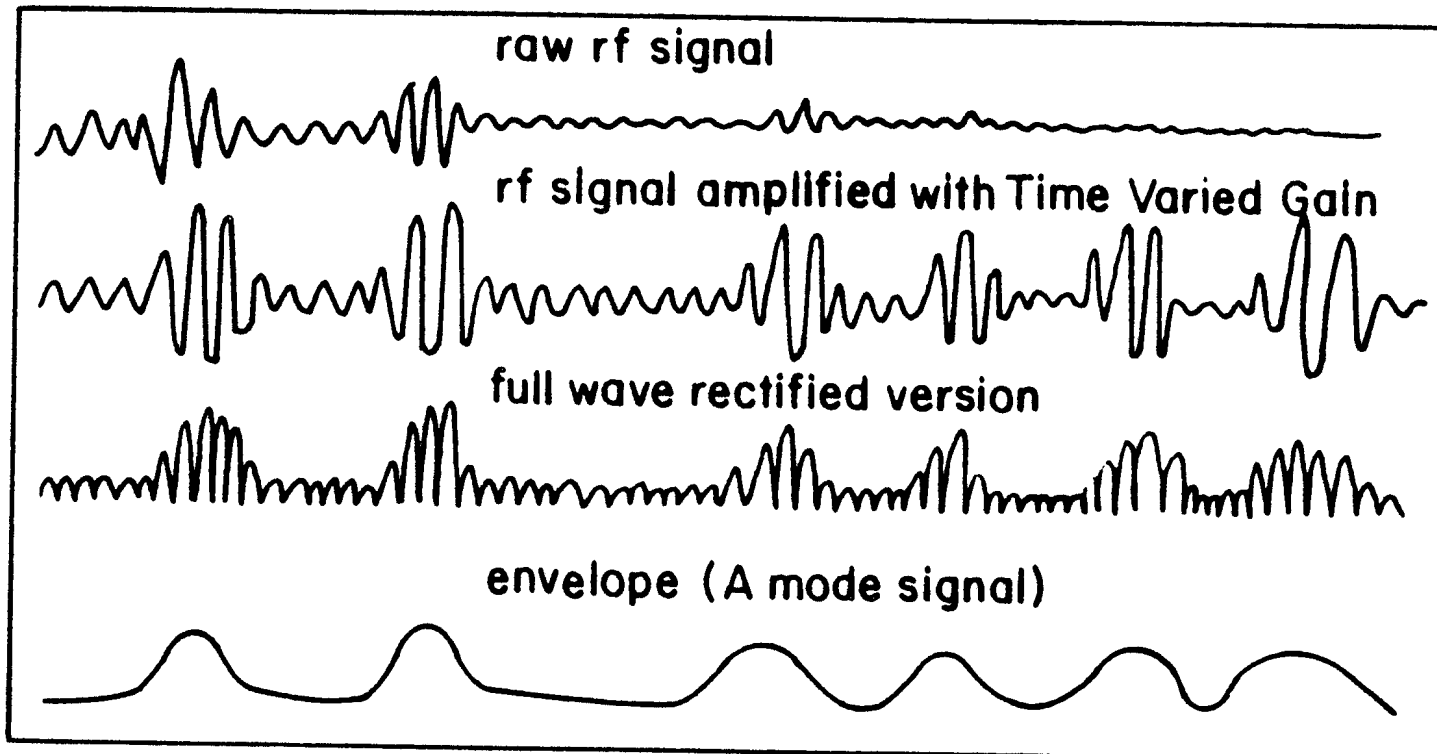


Real-time imaging

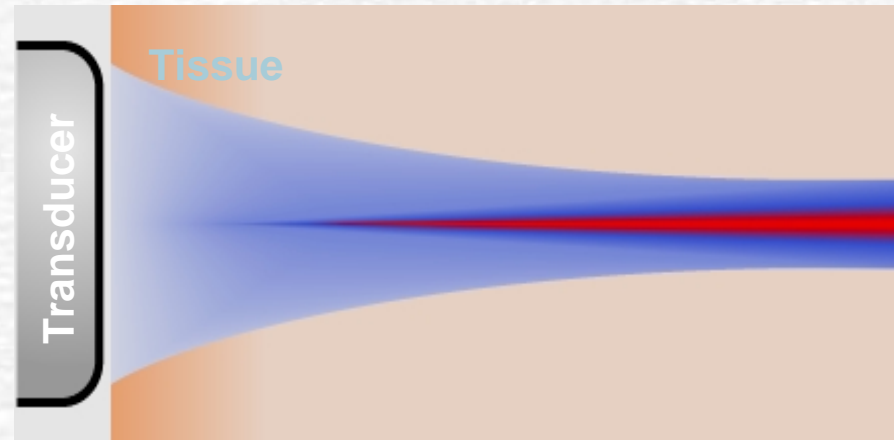
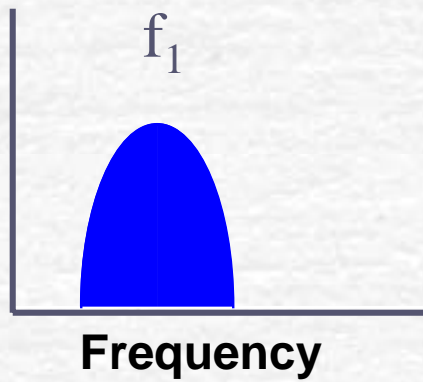


JAZ tongue
30 frames/s

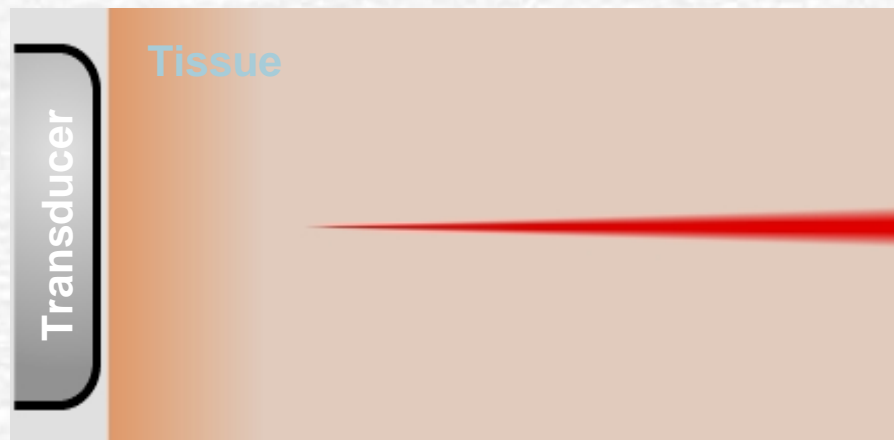
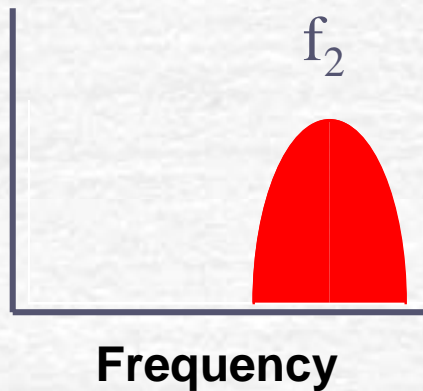
SIGNAL PROCESSING



Harmonic Processing

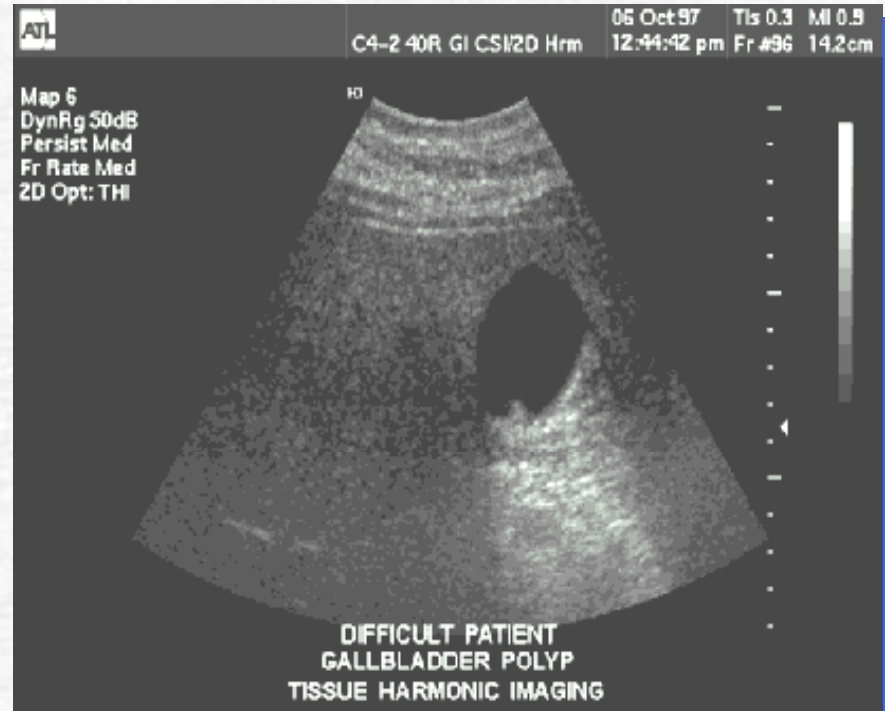


Acoustic field



After processing

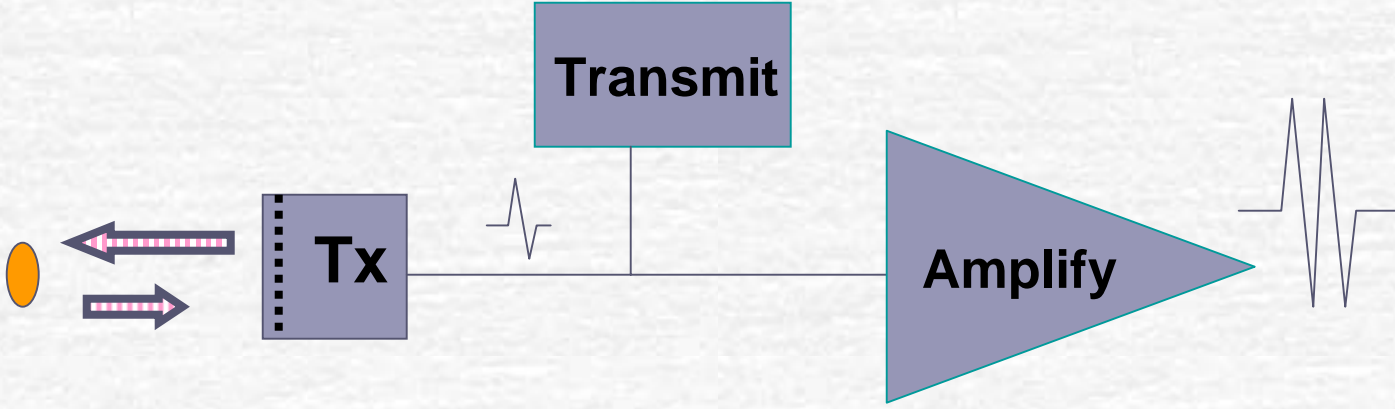
Gallbladder Polyp



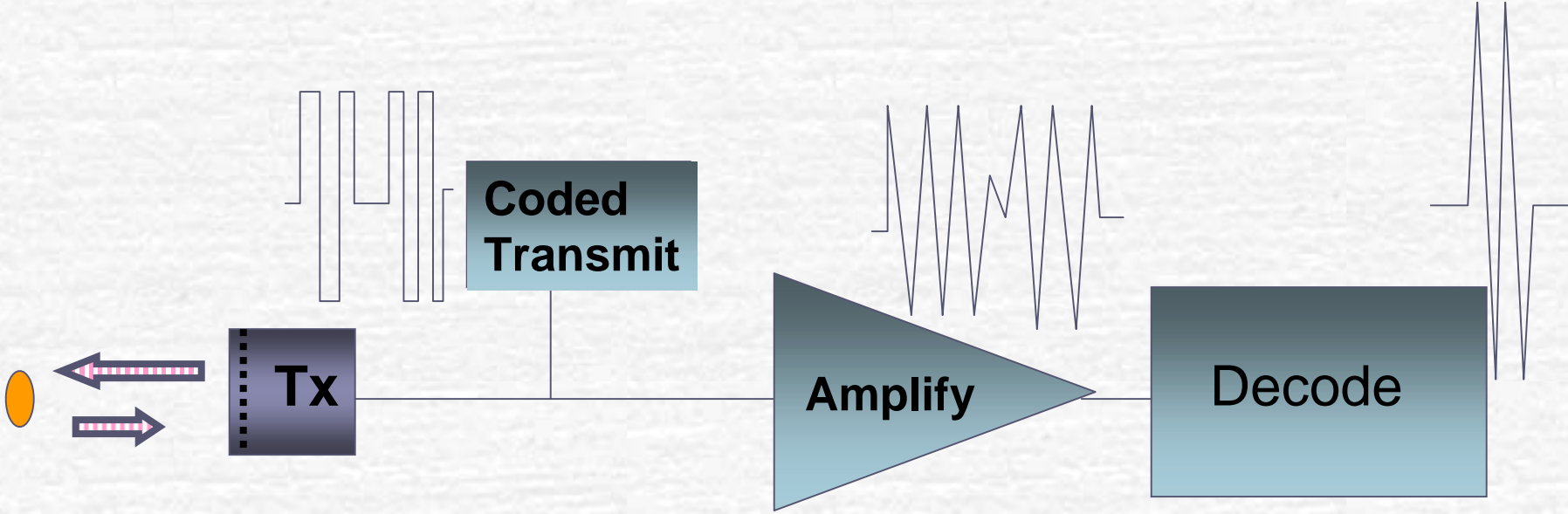
Fundamental



Standard



Coded Excitation



ATS-PHANTOM
UNIV. OF WISCONSIN HOSP.
IM#7 +0:00:00

GE

JUL
UNIV. OF WISCONSIN HOSP.

00

GE

JUL-21-00 17:26:56

18cm 7548c

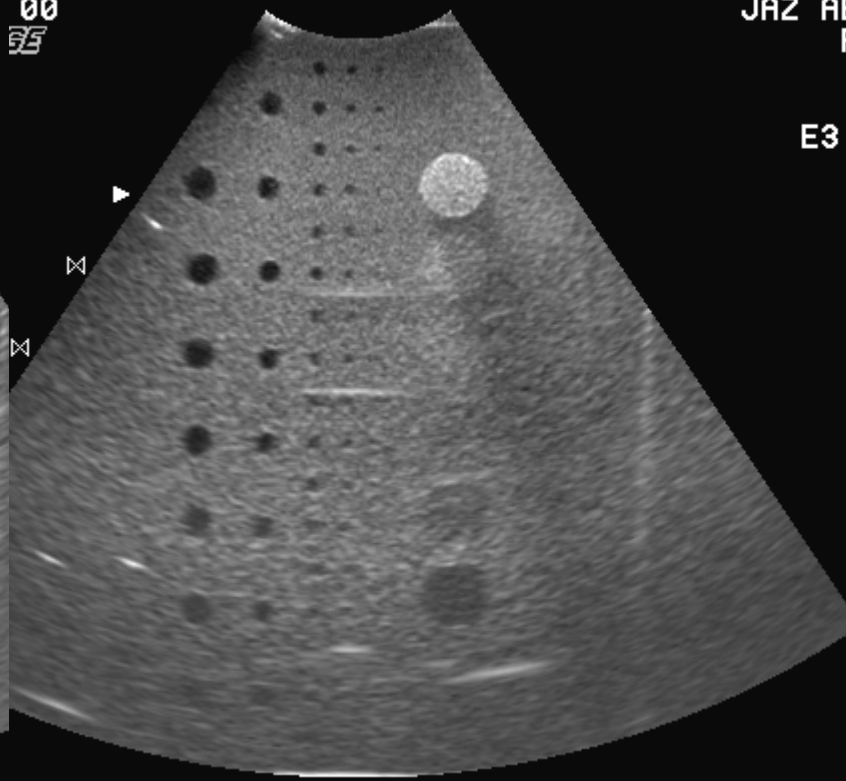
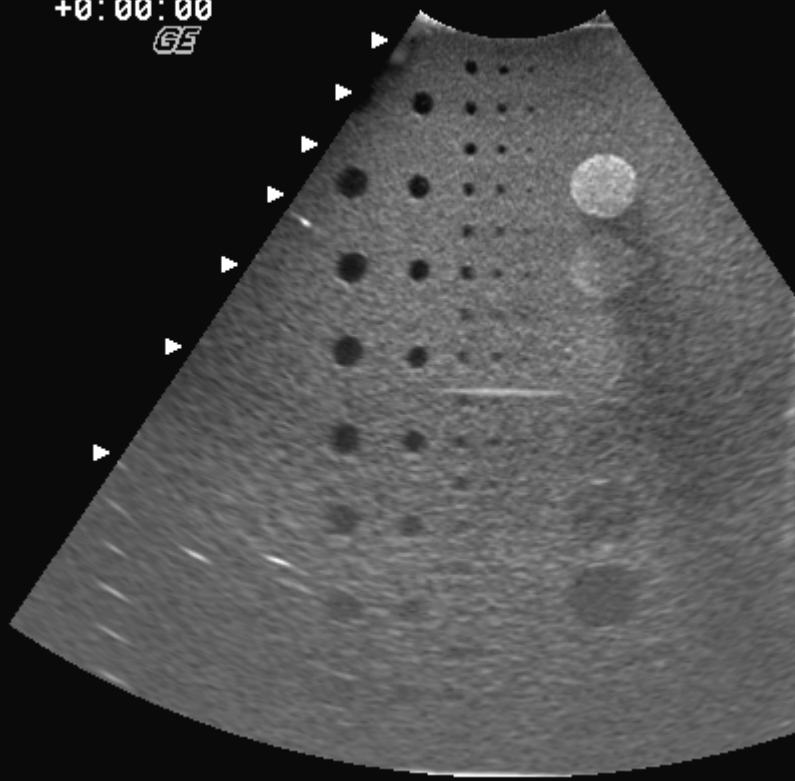
JAZ ABDMEN1

FROZEN

16G

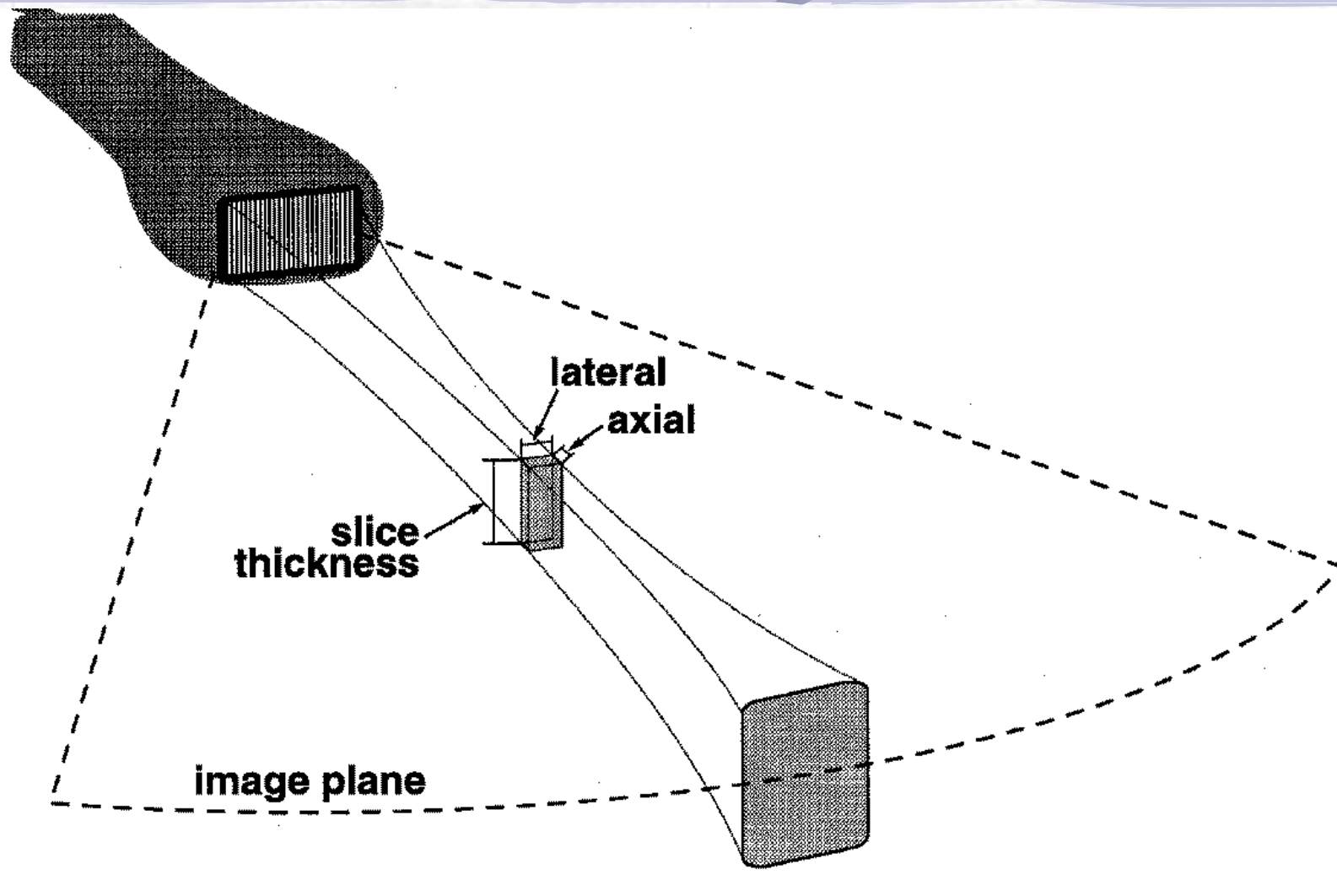
66DR

E3 MB A3



GE 548c
Standard Transmit

GE 548c
Coded Excitation



PULSE DURATION AND FREQUENCY



Low frequency pulse

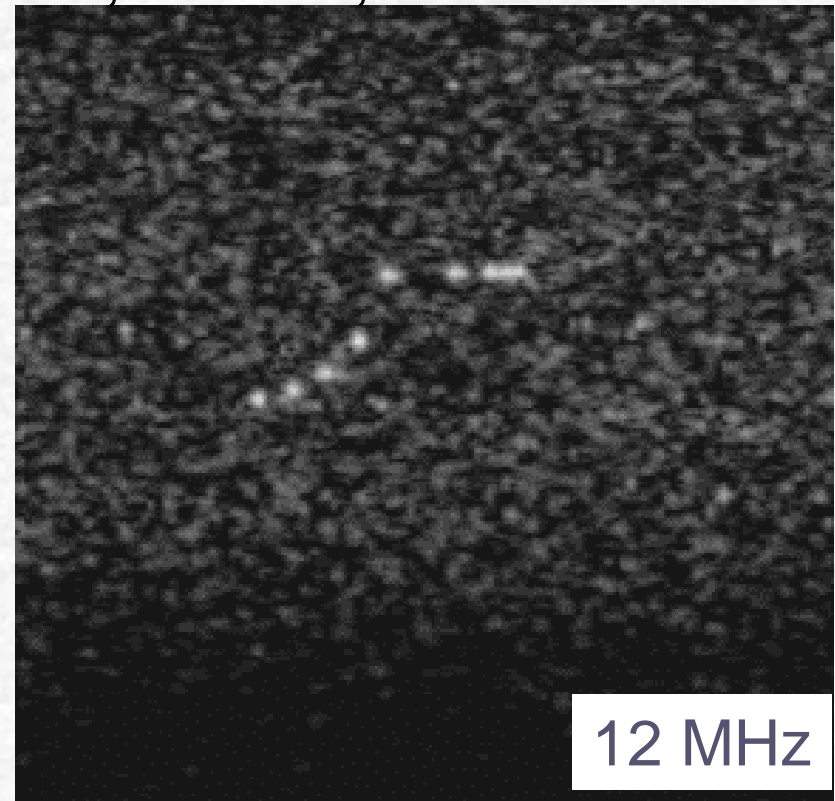
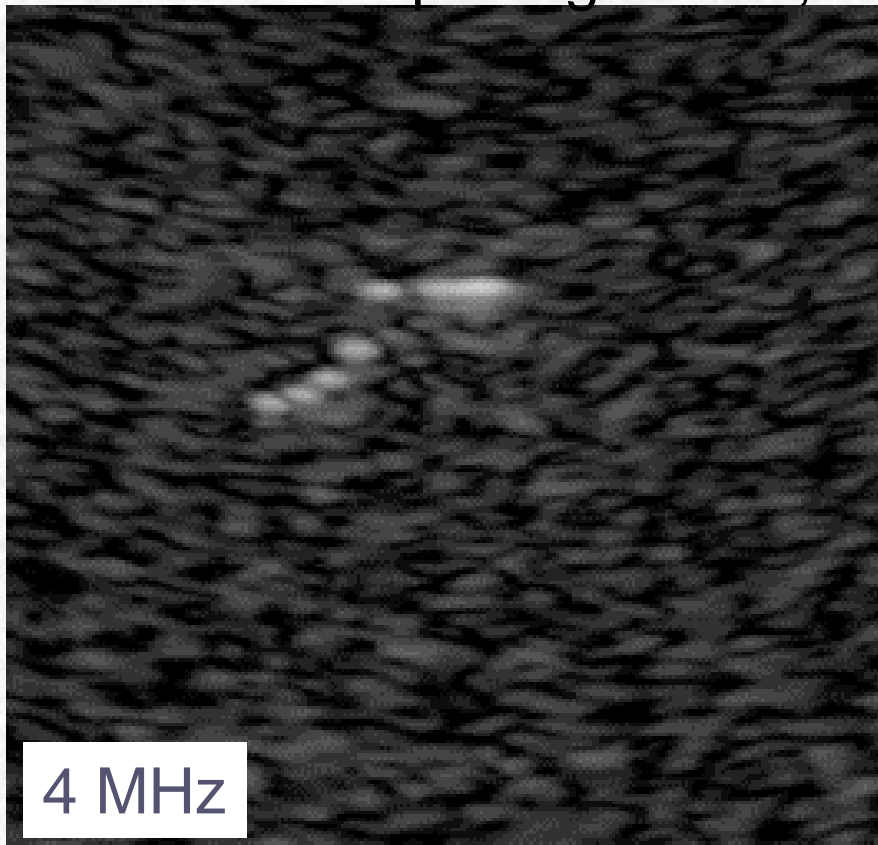
High frequency pulse

- Higher frequencies give shorter duration pulses and better axial resolution

GE Logiq 700

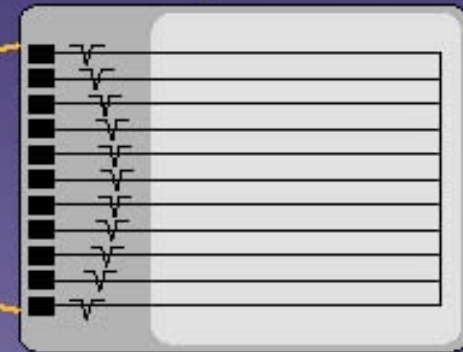
Horizontal spacing: 2 mm, 1 mm, 0.5 mm, 0.25 mm

Vertical Spacing: 2 mm, 1 mm, 0.5 mm, 0.25 mm



SELECTABLE TRANSMIT FOCAL DISTANCE

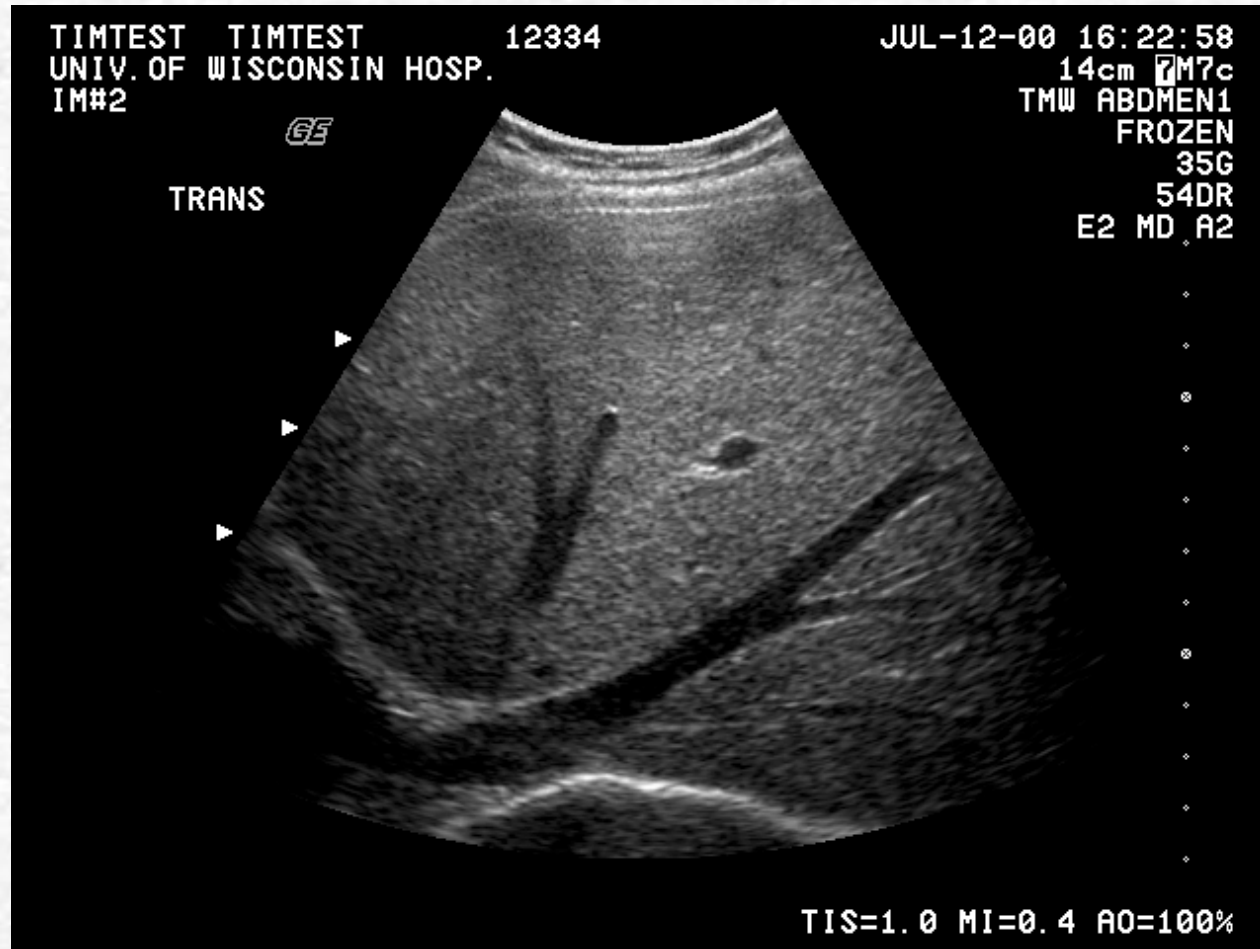
→
delay time



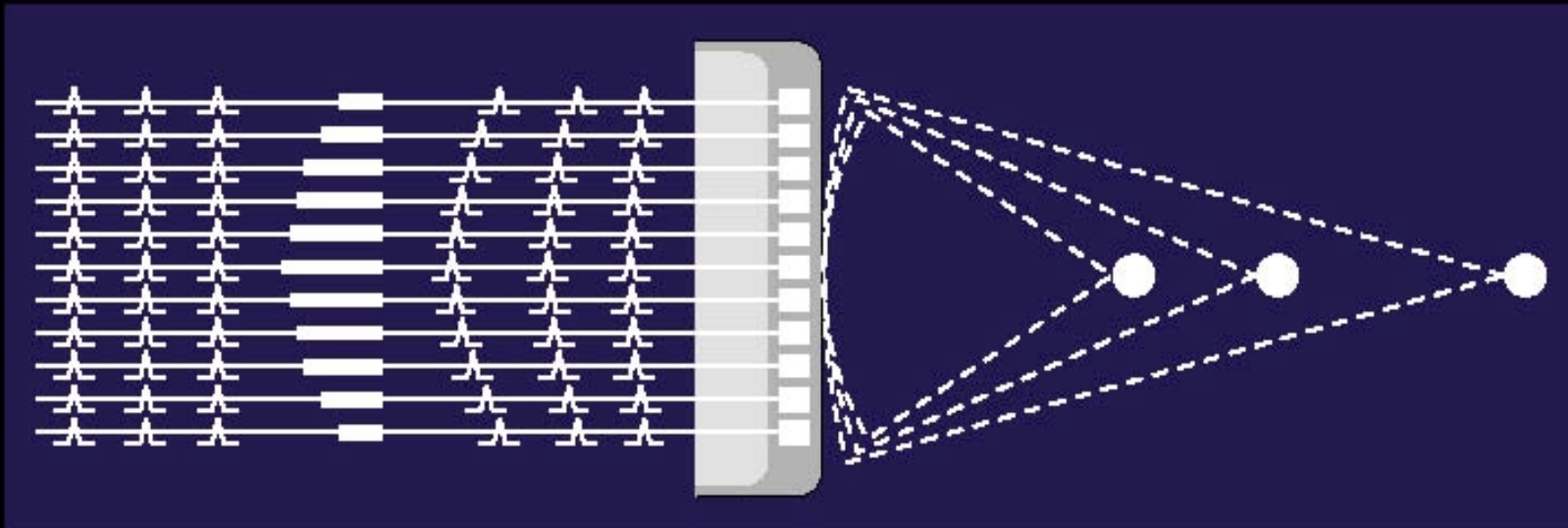
→
delay time



Multiple Transmit Focal Zones

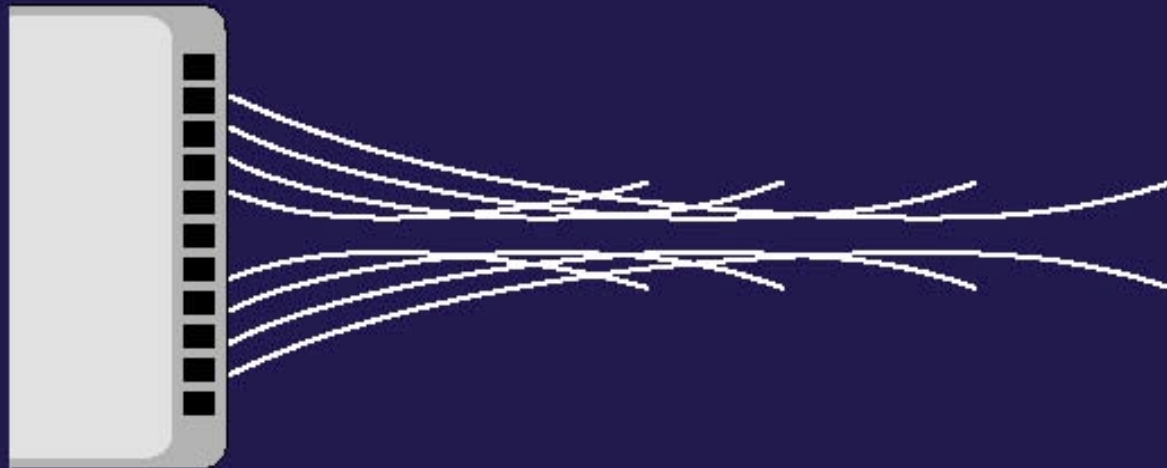


DYNAMIC RECEIVE MODE FOCUSING



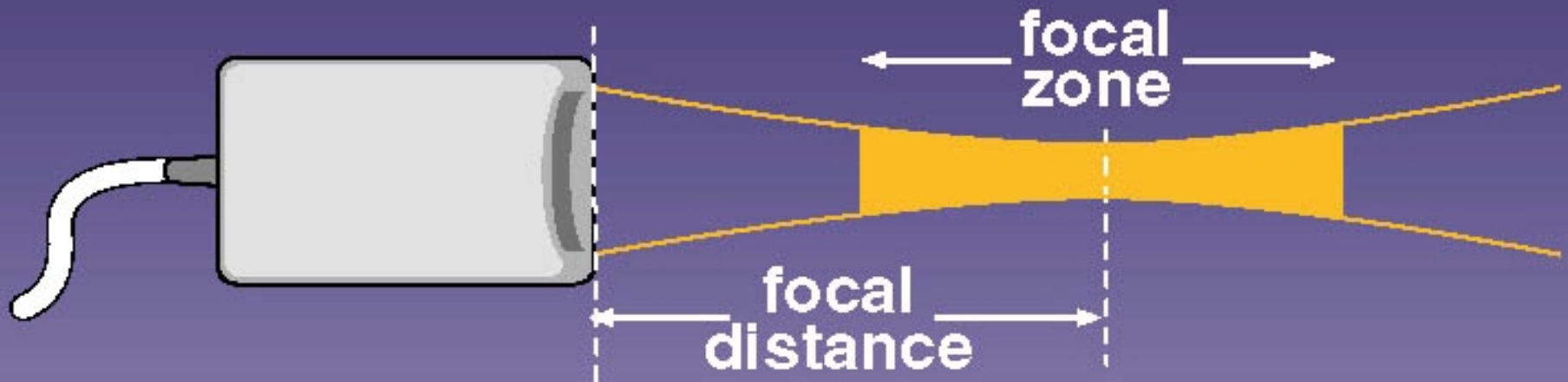
variable
delays

DYNAMIC APERTURE



- Number of elements used increases as echos arrive from progressively deeper structures.

FOCAL ZONE CHARACTERISTICS



$$L \cdot R = \frac{\lambda \cdot F}{D}$$

F = focal distance

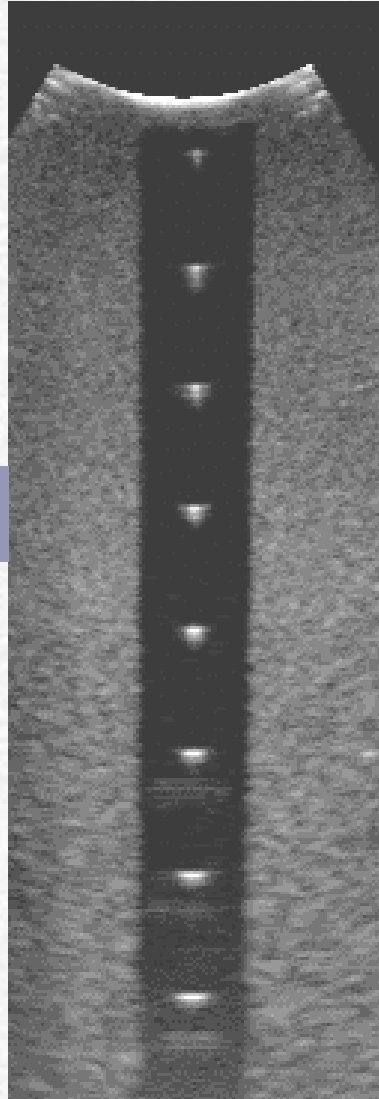
D = aperture (transducer) size

λ = wavelength

(smaller for higher frequencies)

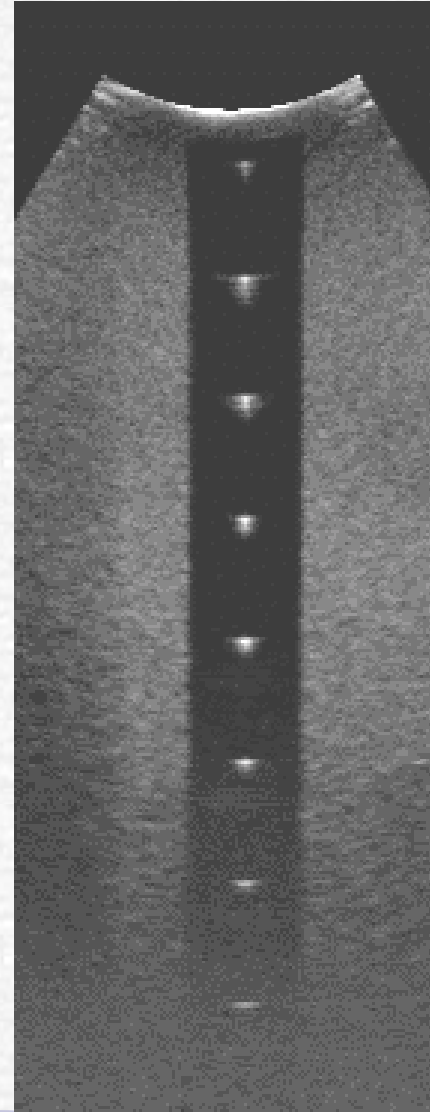
Point targets
in tm material

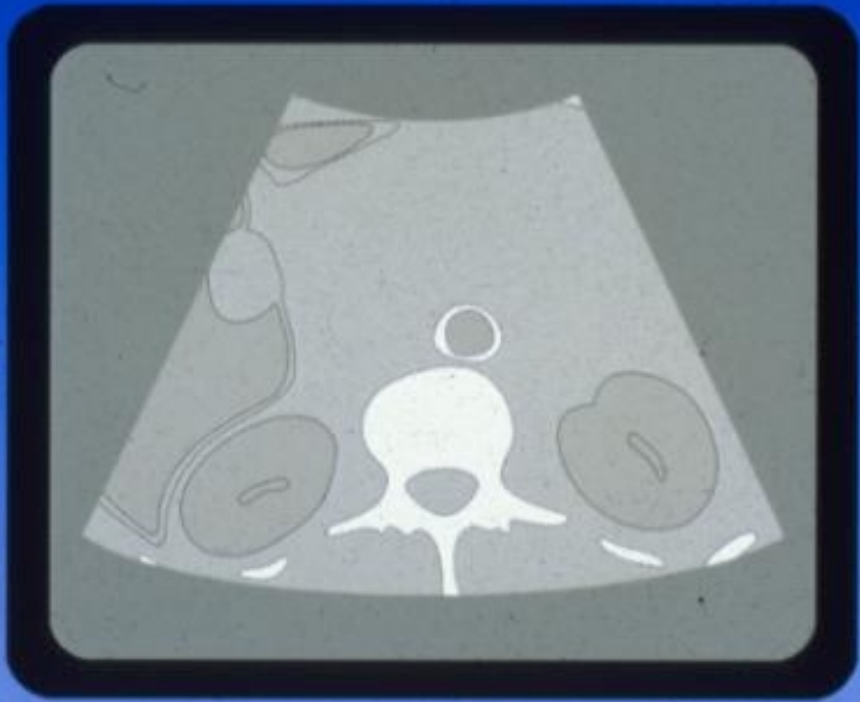
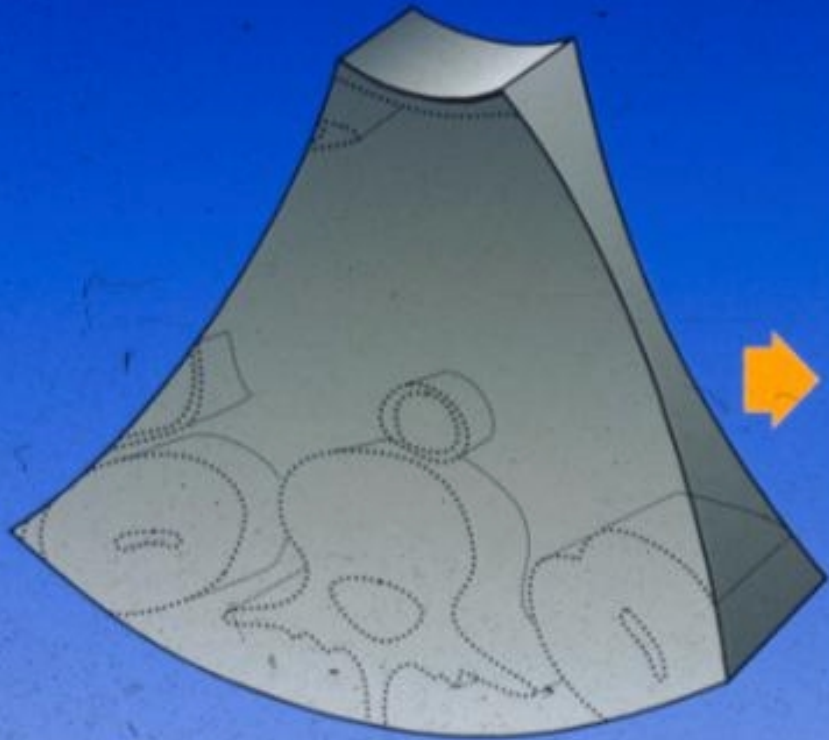
4 MHz



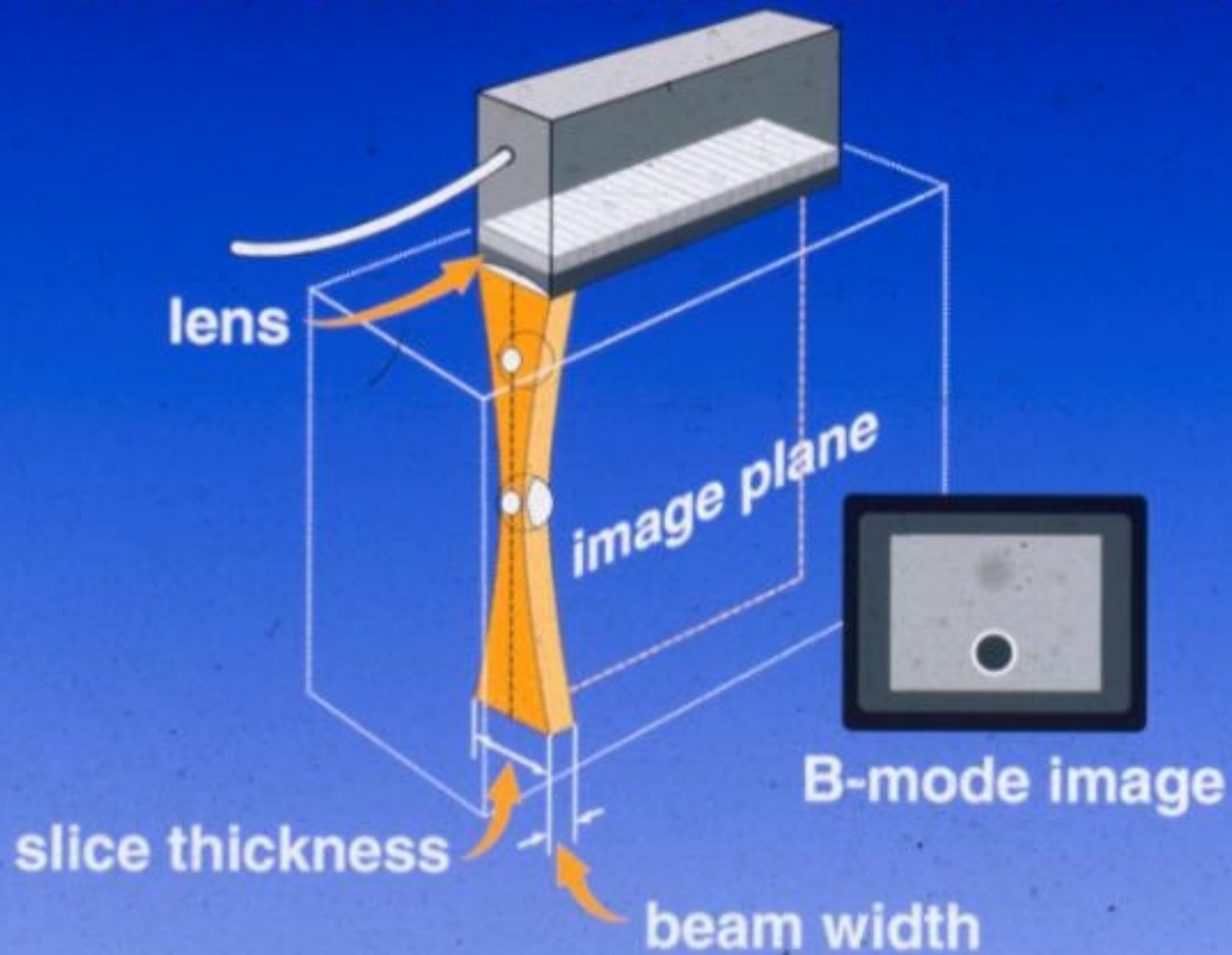
GE C548
transducer

7 MHz





SLICE THICKNESS EFFECTS



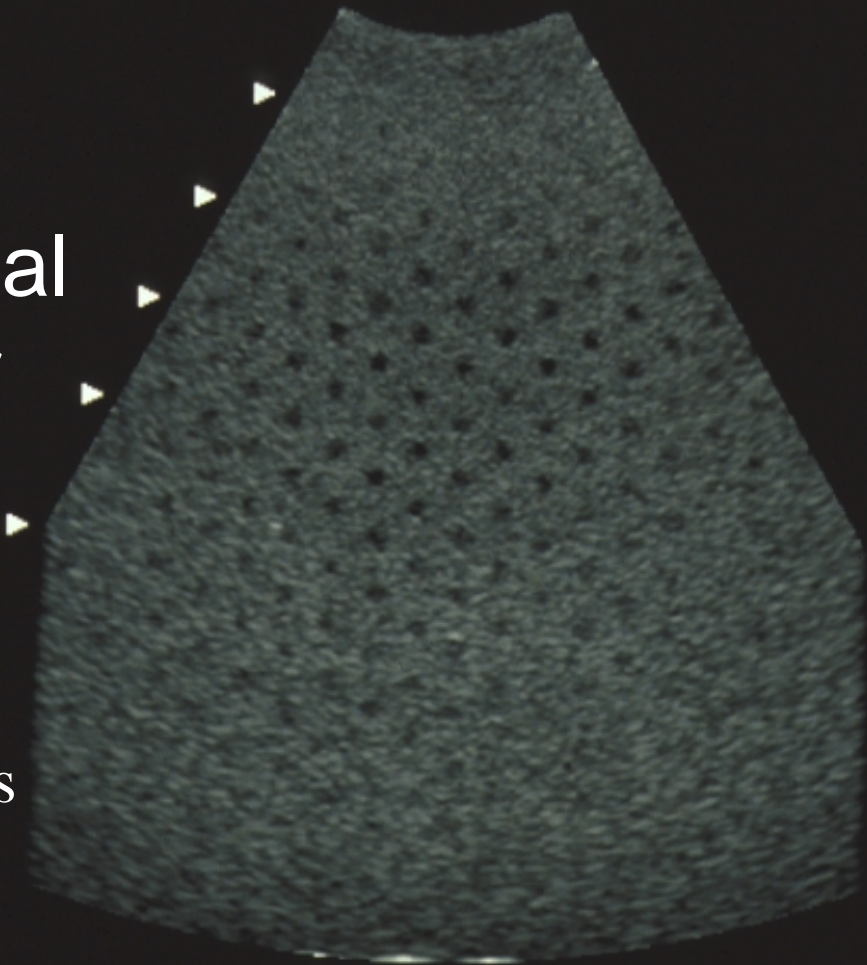
GE MEDICAL SYSTEMS
IM#12



APR-30-97 08:43:19
16cm 348c
ABDMEN1
FROZEN
41G
69DR
E4 ME A2

Conventional
Transducer

4 mm targets



MI=0.4 AO=100%

Important Performance Features

- ✓ Geometric accuracy
 - (Not at levels considered previously when static scanners were used)
- ✓ Resolution
- ✓ Uniformity
- ✓ Penetration and sensitivity
- ✓ Low contrast detection

Common US phantoms



Gel Phantom Material Properties

Property	Value	Degree of Control
Density	10^3 kg/m^3	Good
SOS	1,540 m/s	Very Good
Attenuation	0.5 to 0.7 dB/cm-MHz	Good
Scatter	Liver like	Good
B/A	Water-like	Fair

Water-based Gel Phantoms

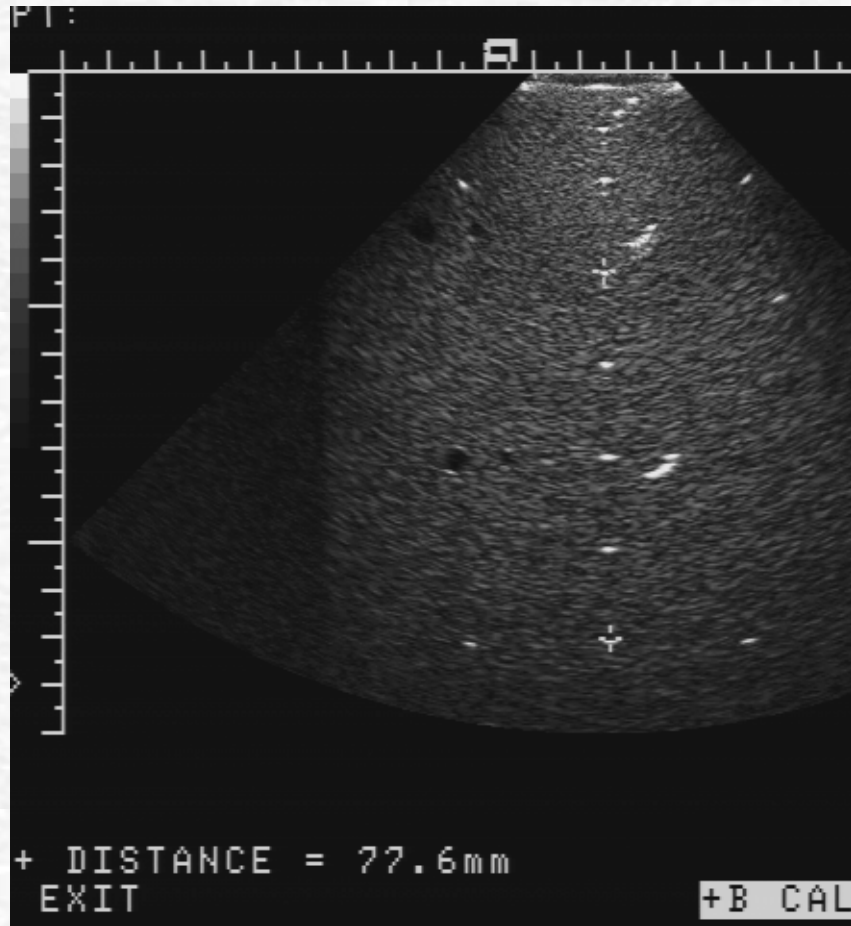
- Gel materials cannot be machined.
- Even **little** bubbles cause **big** problems.
- Care is needed to avoid desiccation.



Alternative Materials

- Polyurethane rubber
 - stable
- SOS = 1455 m/s
 - (Too low)
- Attenuation changes too rapidly with freq.
- QA tests only?
 - (Goodsitt et al, 1998, Med Physics)





Vertical Distance Accuracy

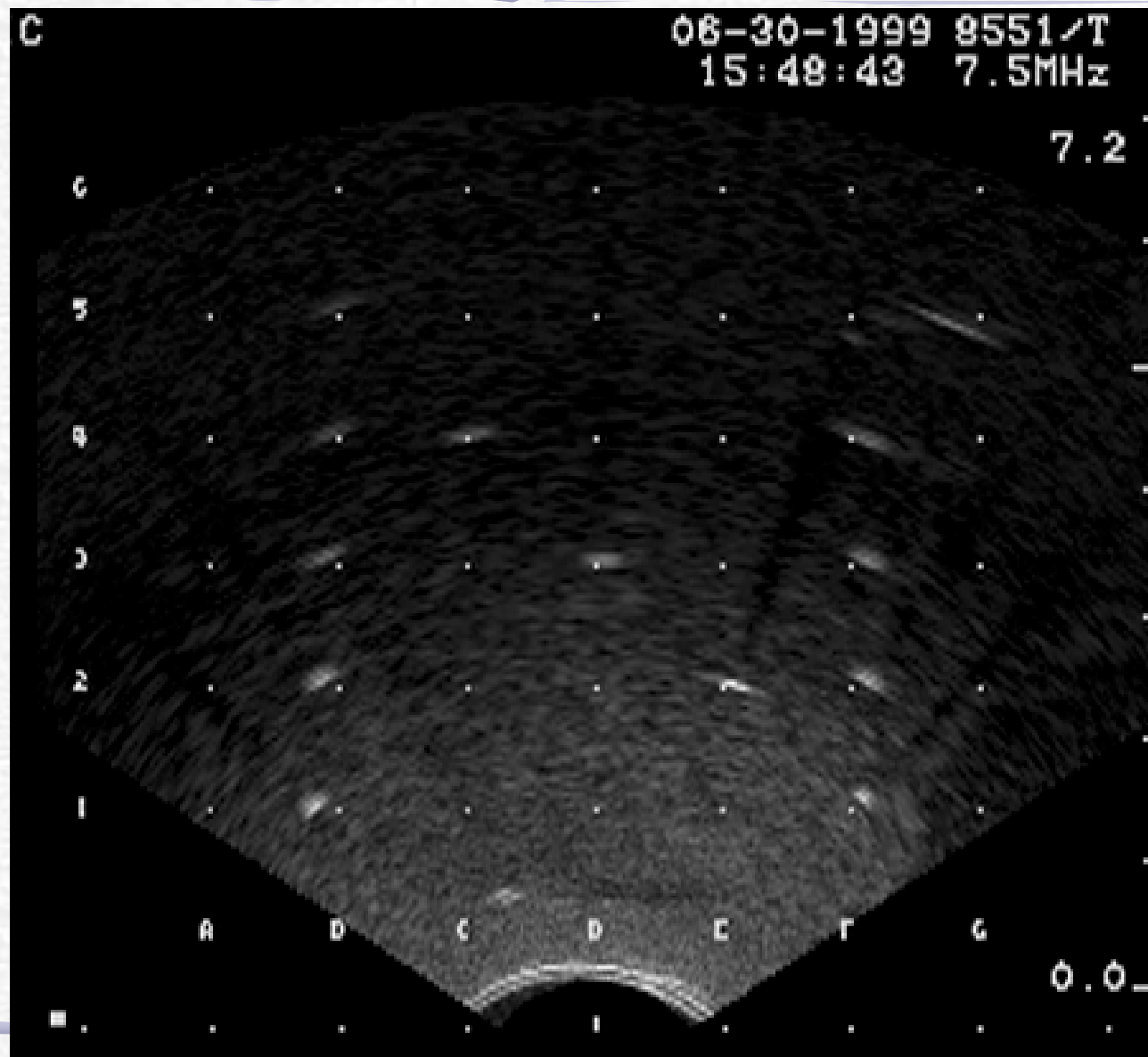


Horizontal Distance Accuracy

Prostate Implant phantom

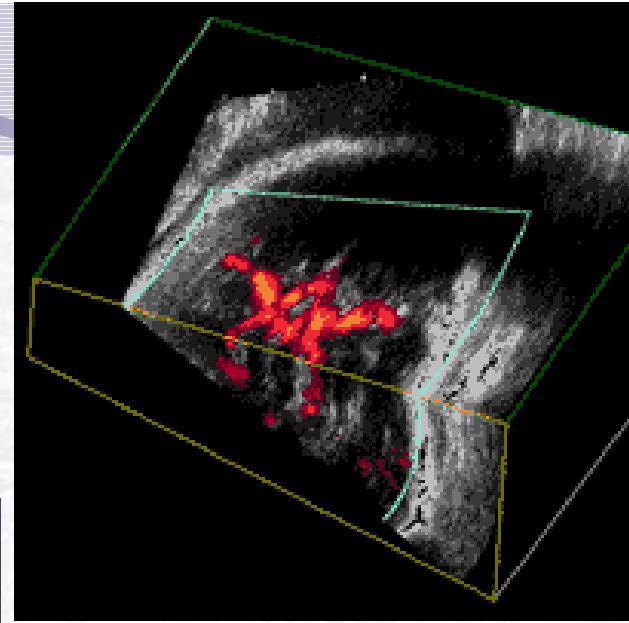
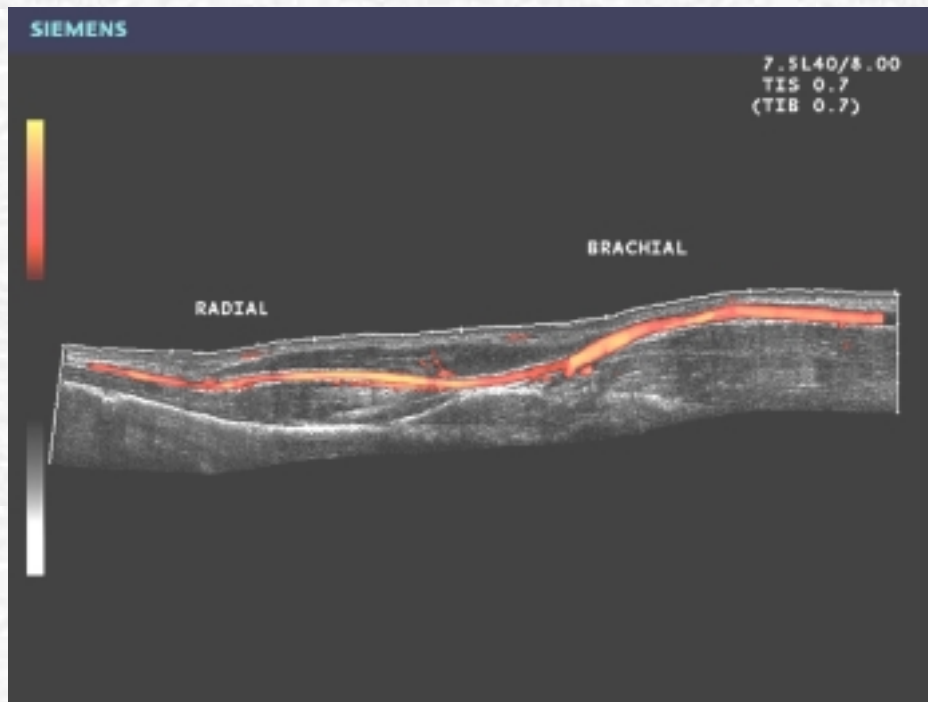
Dots indicate templates for insertion points.

Targets should align with template.



(Courtesy of CIRS)

Extended Fields

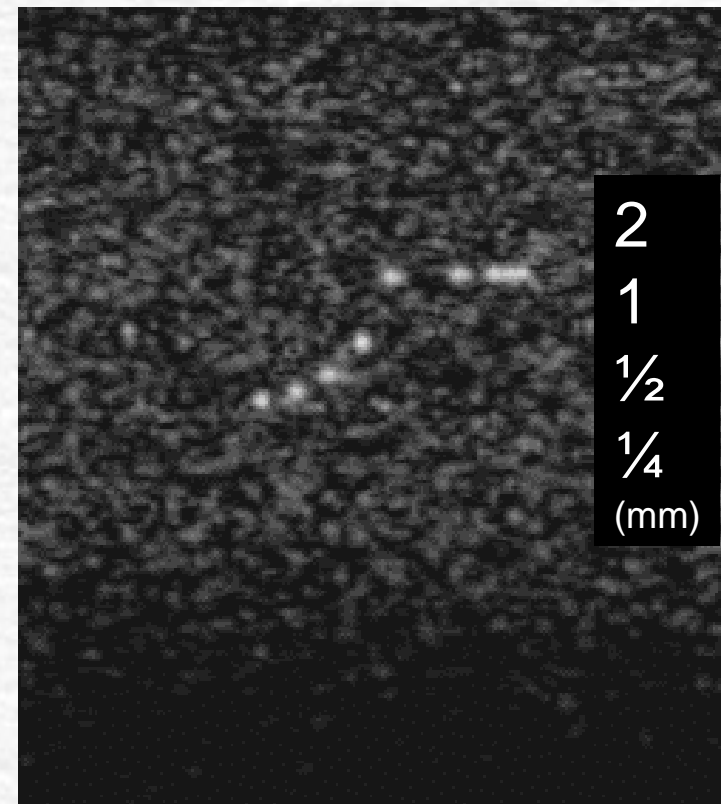
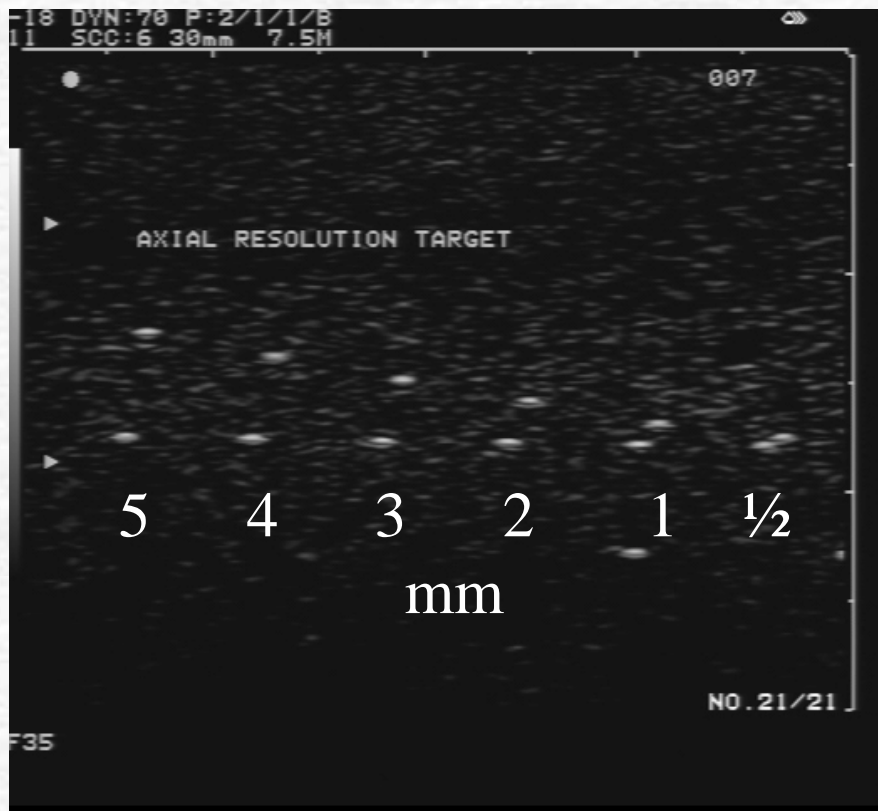


3-D

3-D “Egg-Phantom”



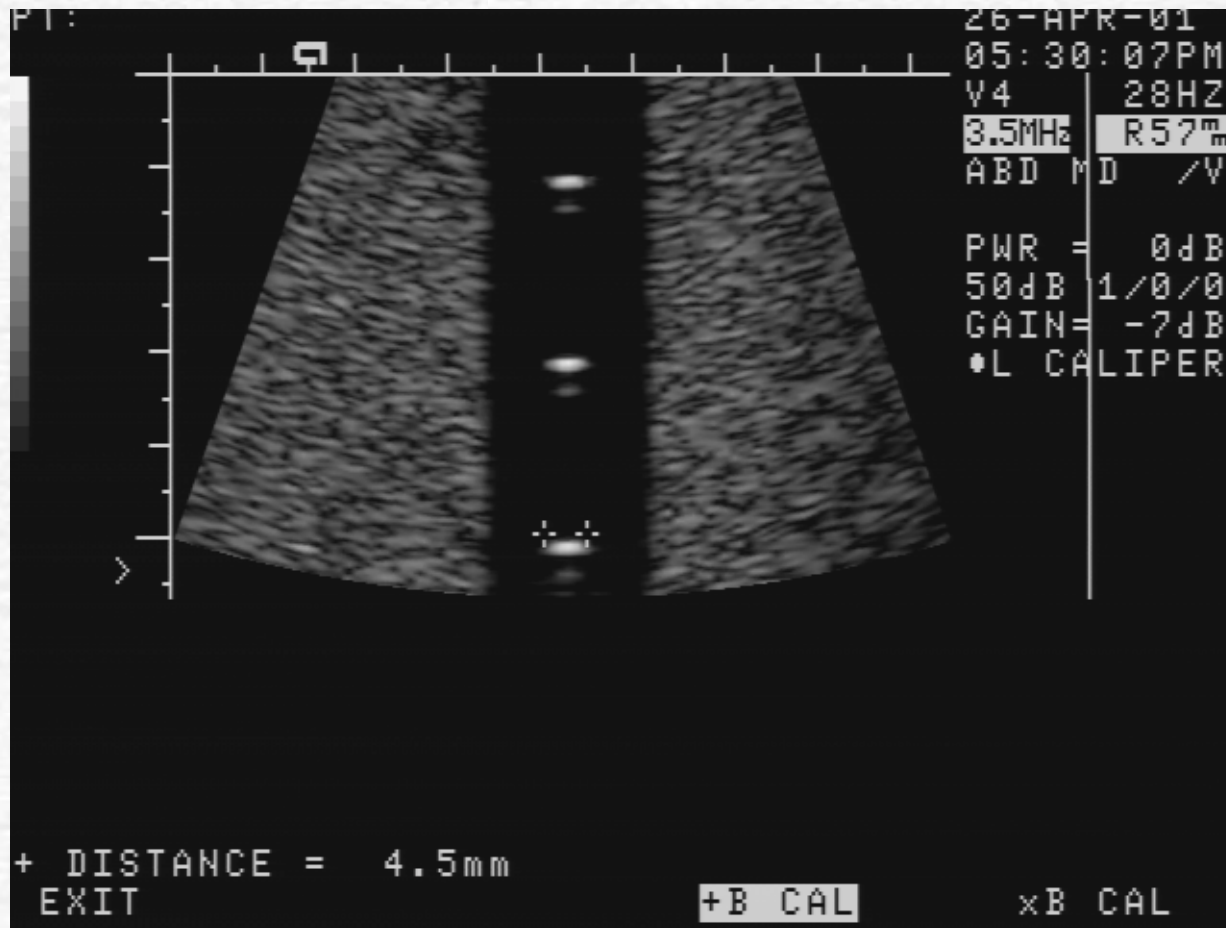
Axial Resolution Targets



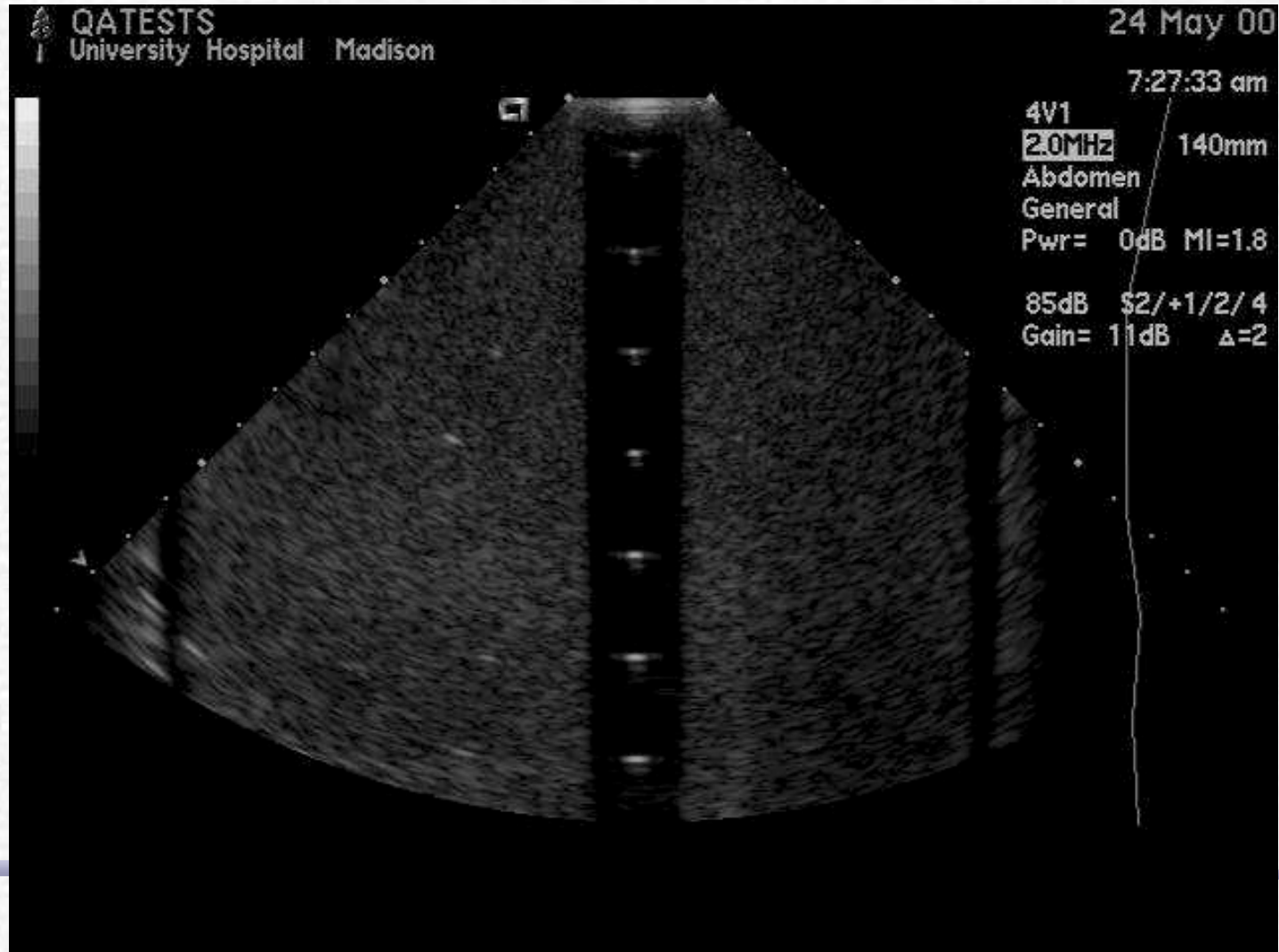
Cautions Regarding Axial Resolution

- ☞ Discrete target separation
 - Scanner performance may fall between target spacing
- ☞ Window material causes reverberations
 - Occasionally see double images of a target
- ☞ Only limited use of quantitation
 - Axial response length (computer or manually)

Reverberations from Scanning Surface



Lateral Resolution



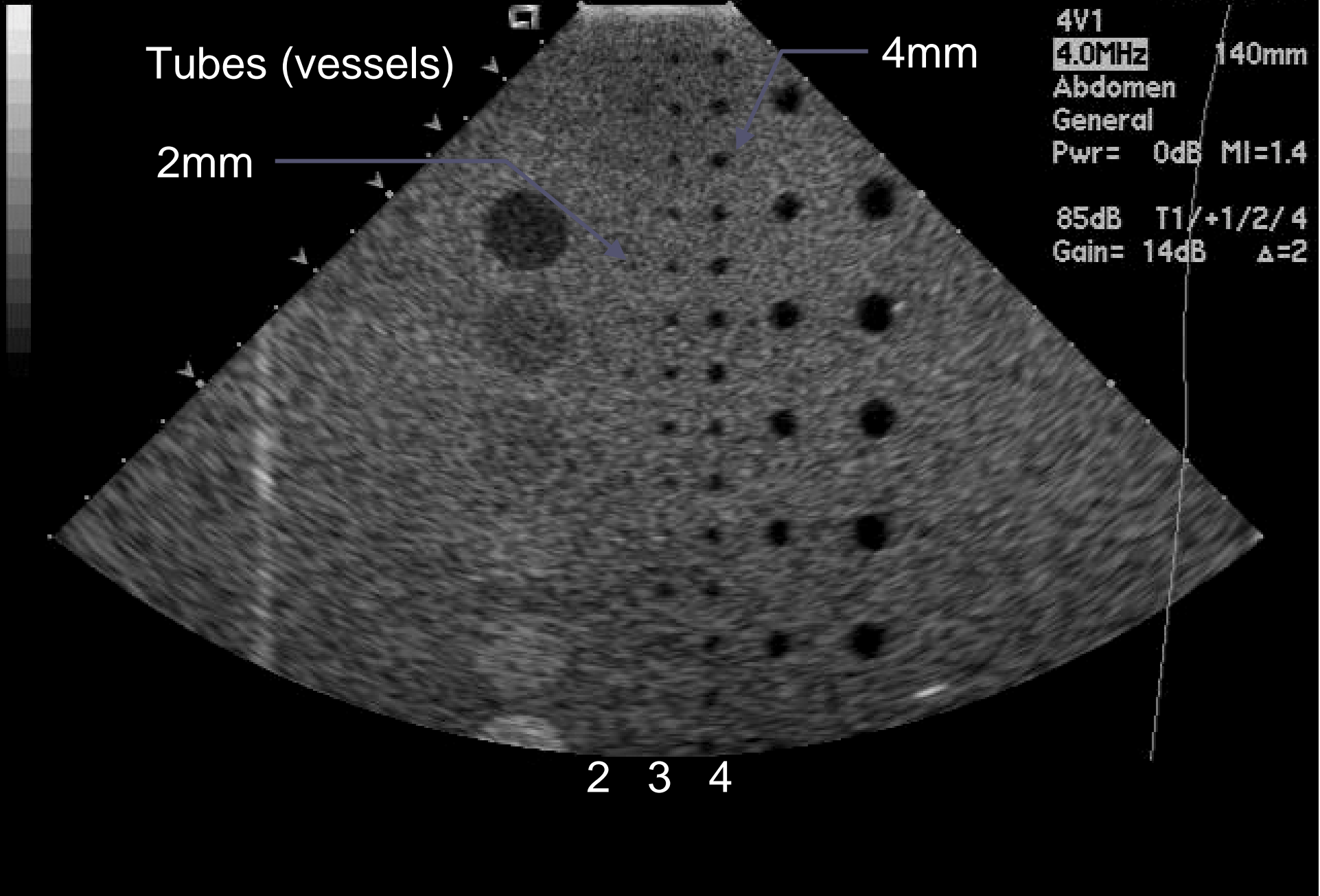
4V1
4.0MHz 140mm
Abdomen
General
Pwr= 0dB MI=1.4
85dB T1/+1/2/4
Gain= 14dB Δ=2

Tubes (vessels)

2mm

4mm

2 3 4



FDI
5000

QA2
U.W. Hospital and Clinic

00/10/18:075554
C5-2 Abd/Gen

18 Oct 00
7:57:51 am

TIs 0.6 MI 1.4
Fr #80 14.7cm

Map 3
150dB/C 3
Persist Med
2D Opt:Res
Fr Rate:High

2mm

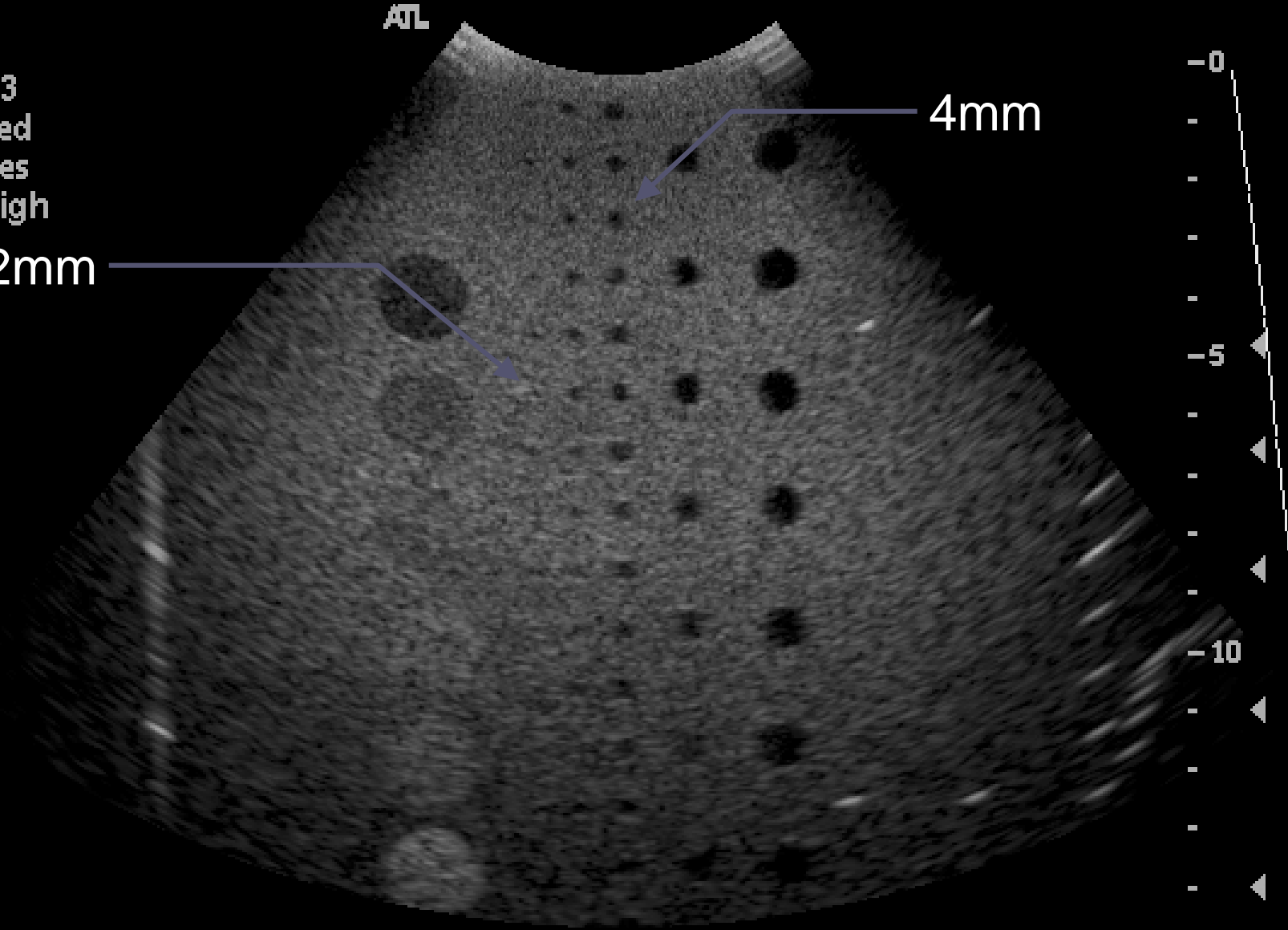
4mm

ATL

-0

-5

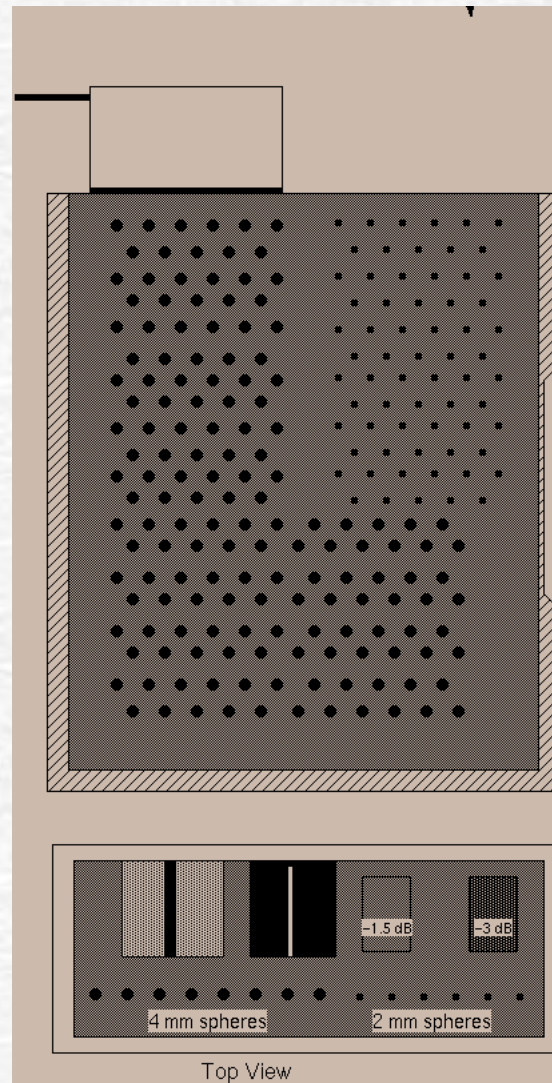
-10



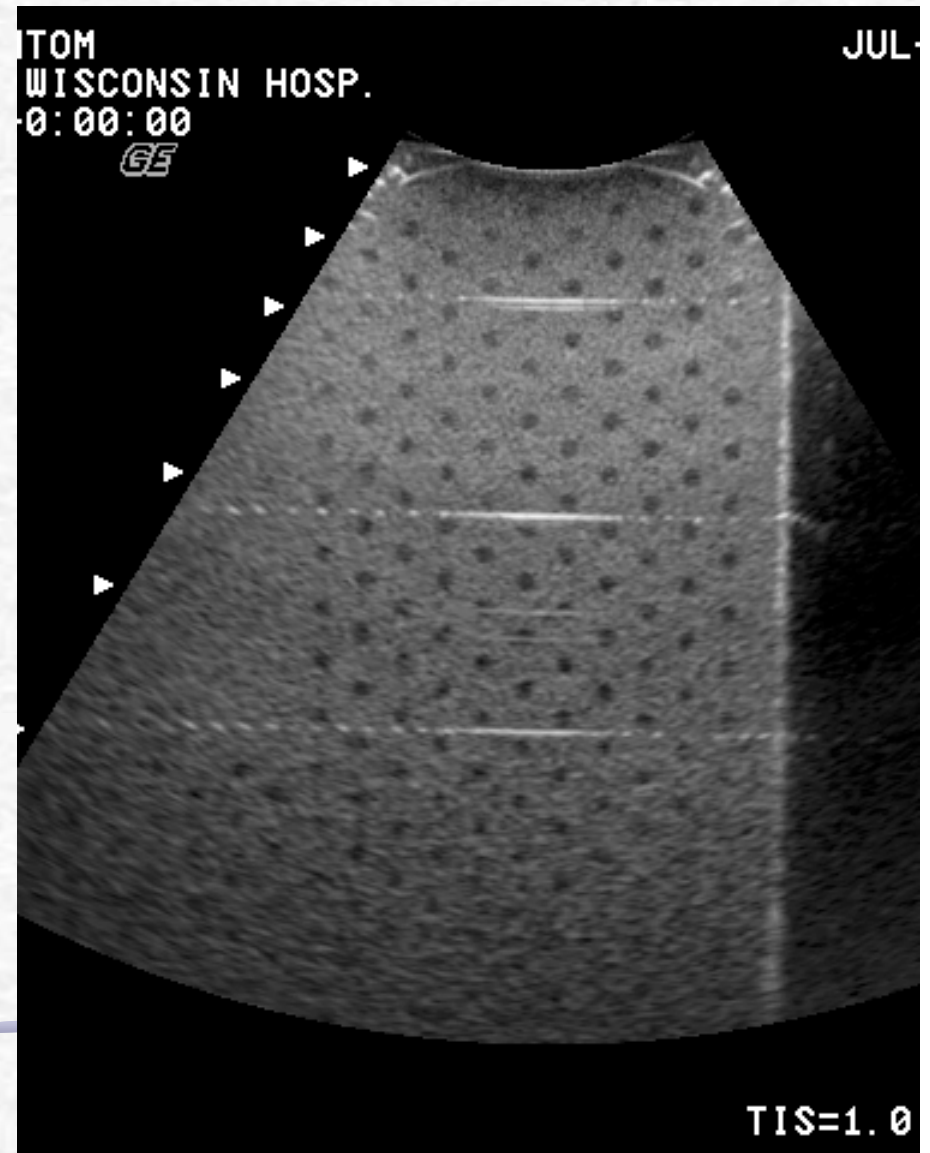
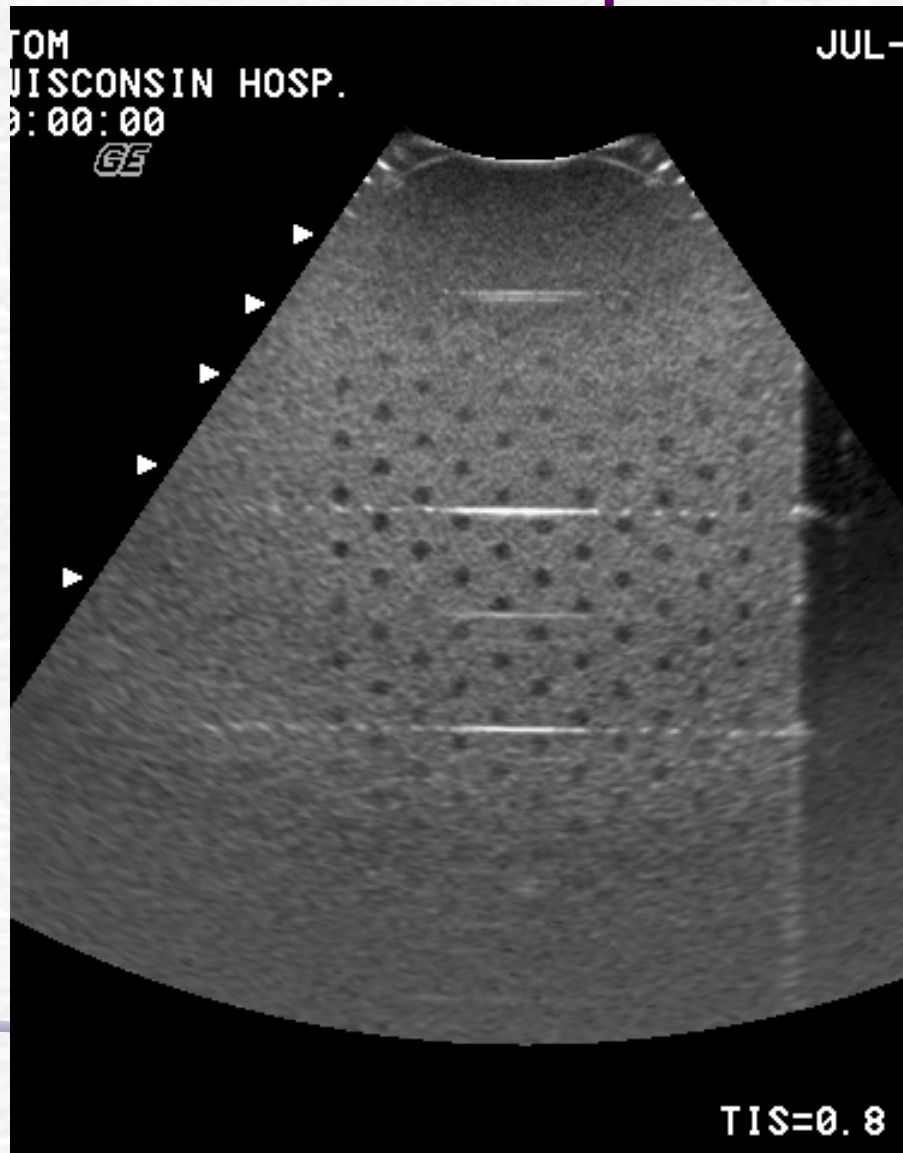
“Standard Phantom” Attempt (ACR)

P Carson
E Boote
T Johnson
A Siebert
J Zagzebski
E Madsen

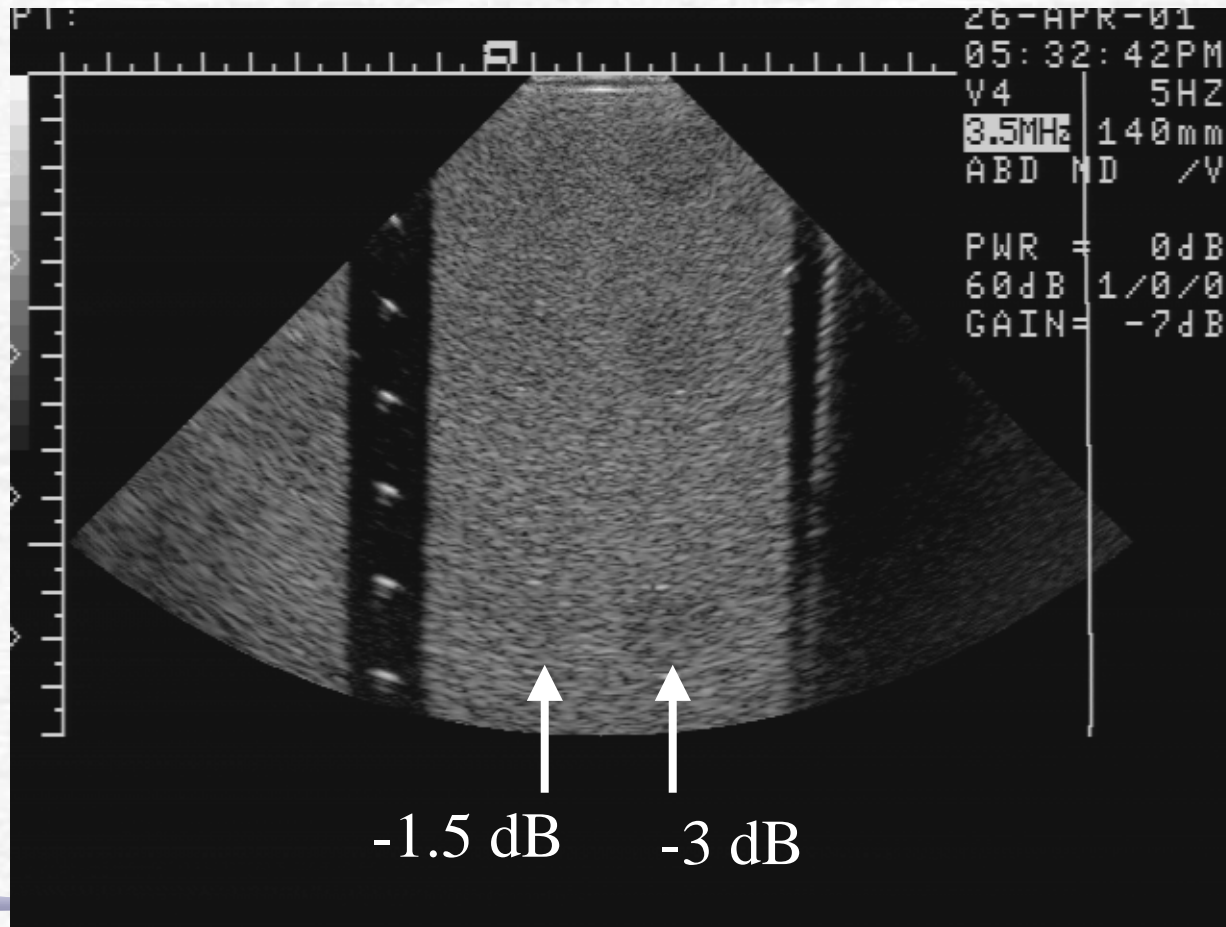
RMI 408A



Spherical Mass



Low Contrast Detection



Routine QA Program

- Equipment inspection
- Penetration into a phantom
- Gray scale photography (workstation monitor)
- Image uniformity
- Distance measurements (where needed)



RMI 403

Inspection

- ☞ Transducers free of cracks, delaminations
- ☞ Cables in good shape
- ☞ Transducers cleaned after each use
- ☞ Viewing monitors clean
- ☞ Air filters
- ☞ Wheels, locks

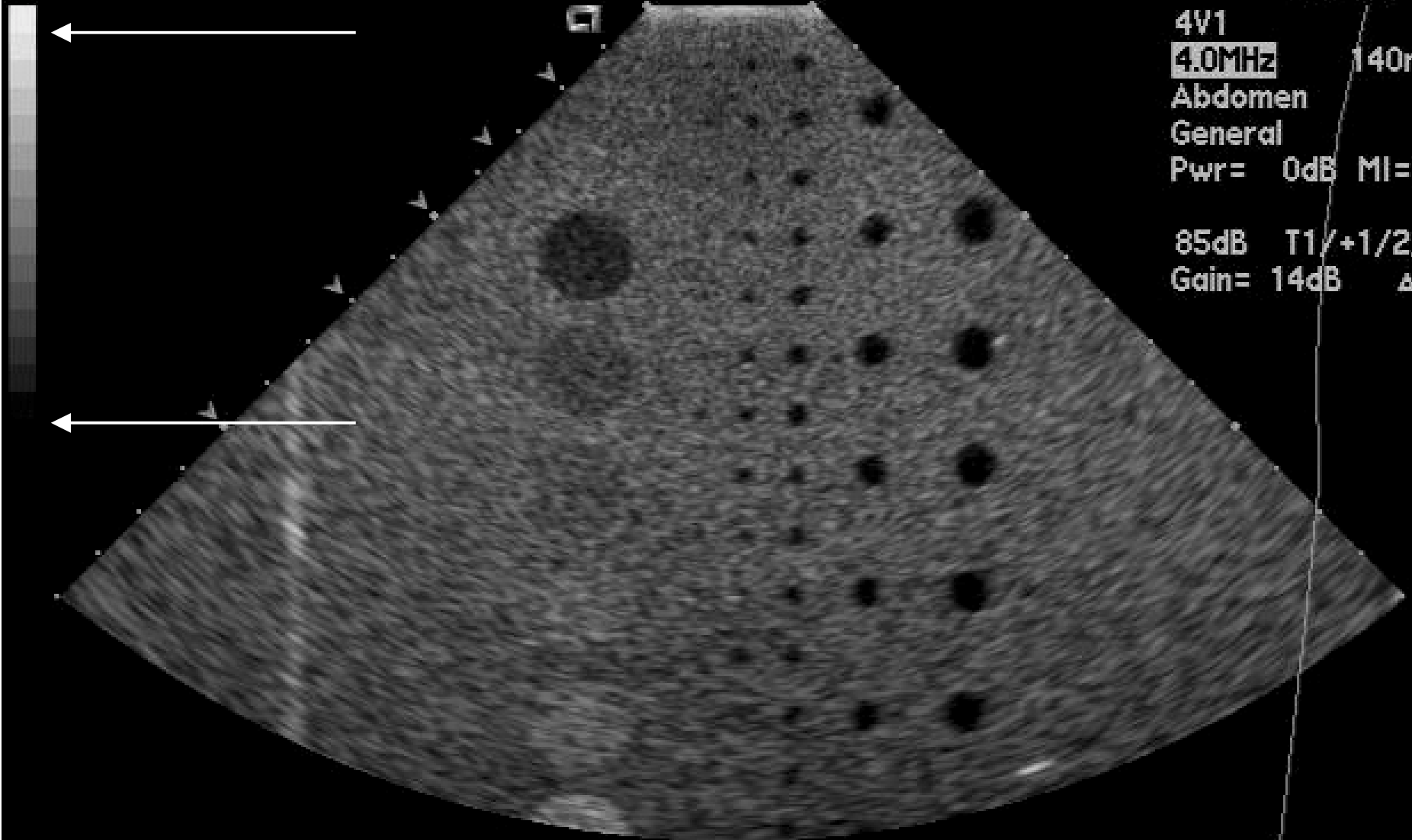
Maximum Depth of Visualization



Photography (gray bar)



4V1
4.0MHz 140mm
Abdomen
General
Pwr= 0dB MI=1.4
85dB T1/+1/2/4
Gain= 14dB Δ=2



2 3 4

Photography (SMPTE)

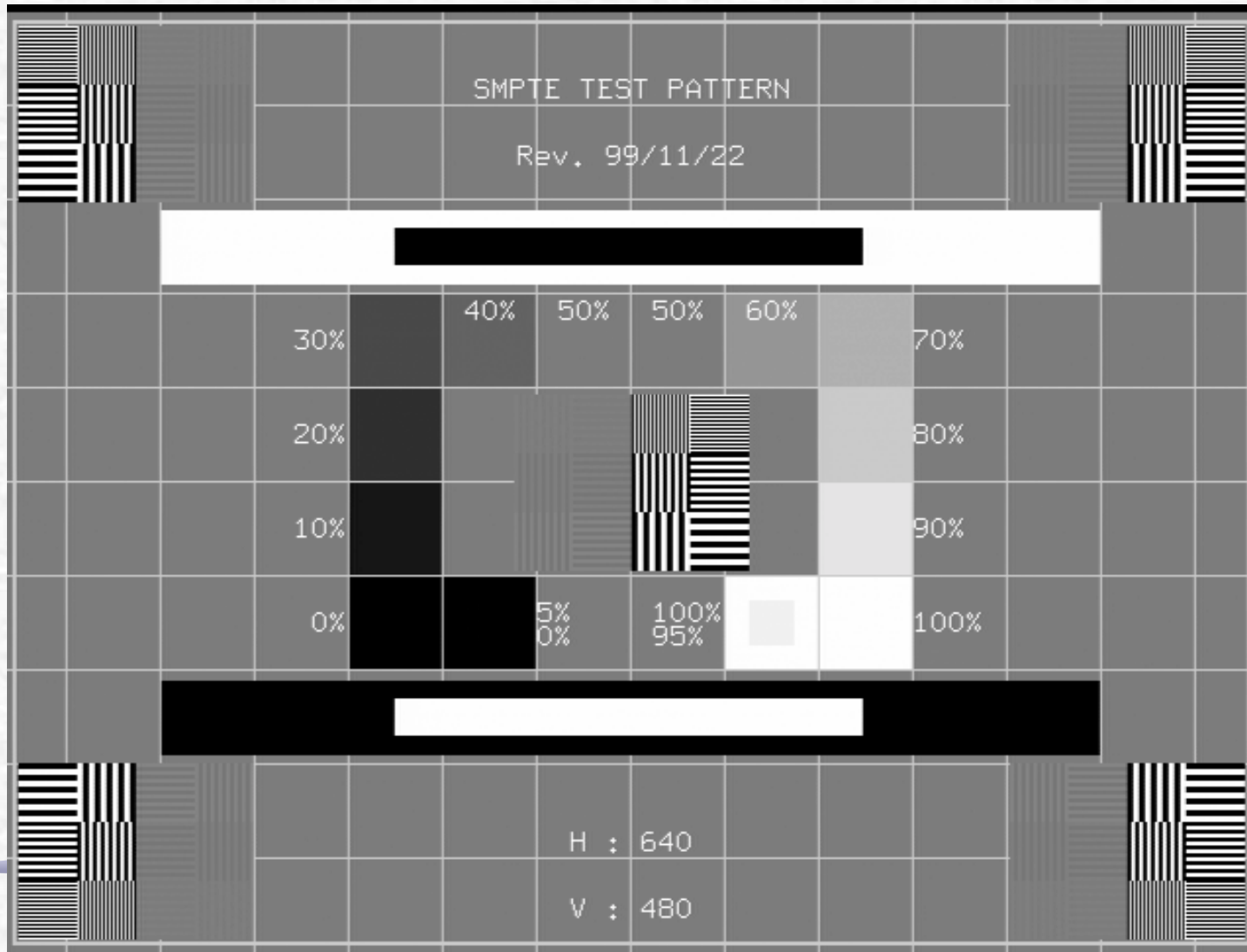
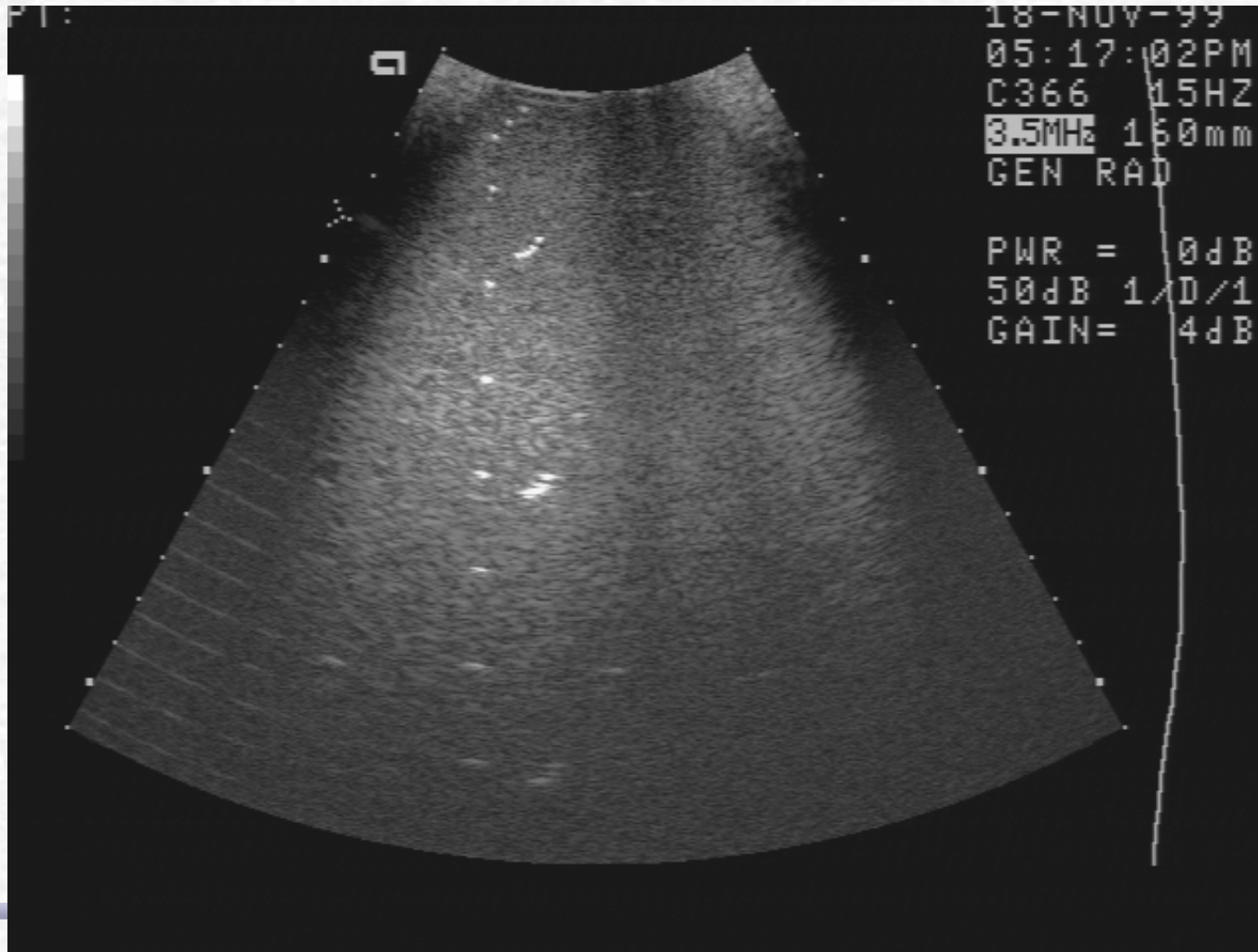


Image Uniformity (dead elements)



Role of The Medical Physicist



Role of The Medical Physicist

- Be knowledgeable in functionality of ultrasound equipment.
- Be aware of issues related to acoustic output levels.
- Help establish QA programs.
- Work beyond routine QA measurements.



Mechanical and Thermal Indices (MI and TI)

- 1992 (US) Acoustic Output Display Std
- Removed application specific intensity limits
- Contrast agents (MI)
- Research mode (NIH)

