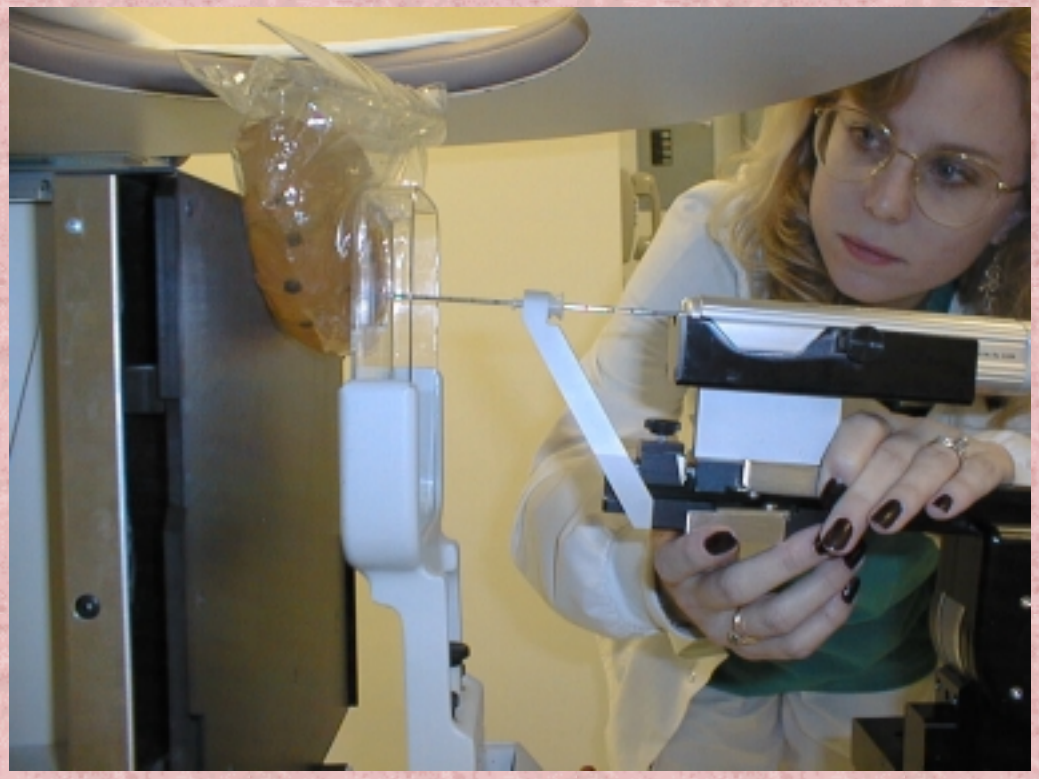
Quality Control for Stereotactic Breast Biopsy



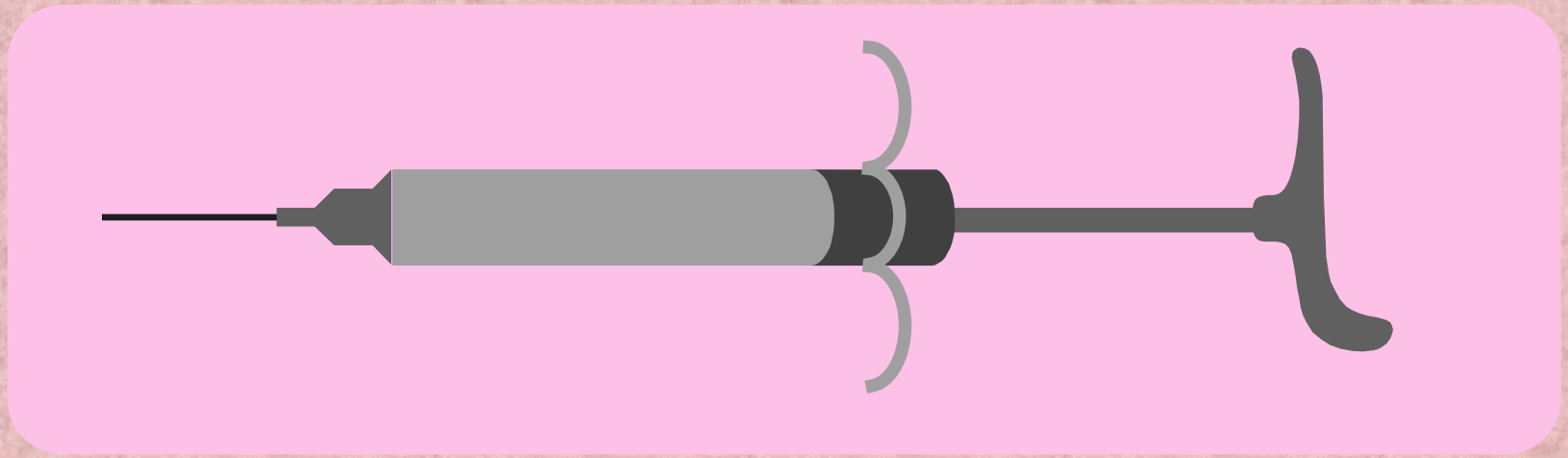
Robert J. Pizzutiello, Jr., F.A.C.M.P.

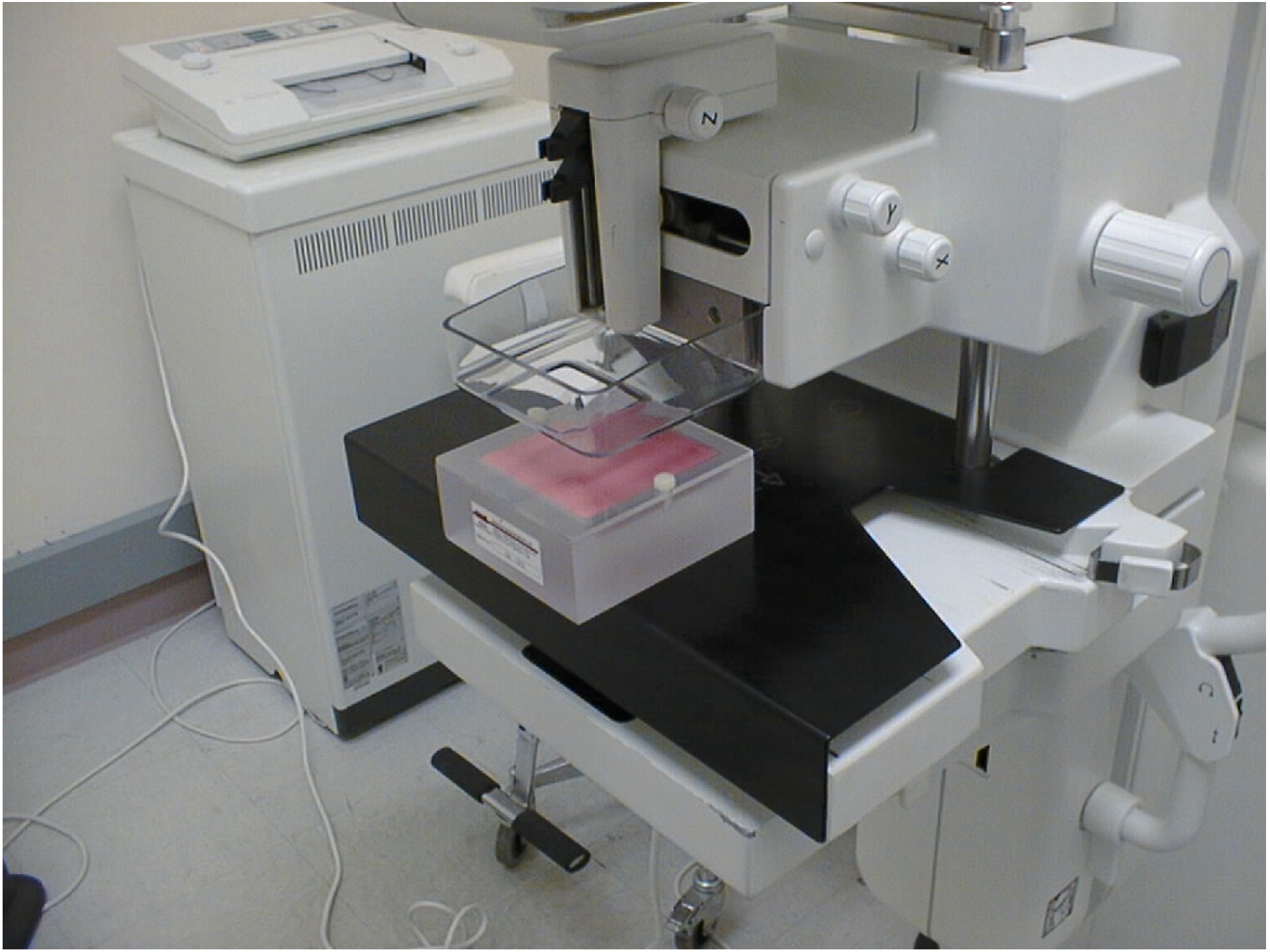
Upstate Medical Physics, Inc.

716-924-0350

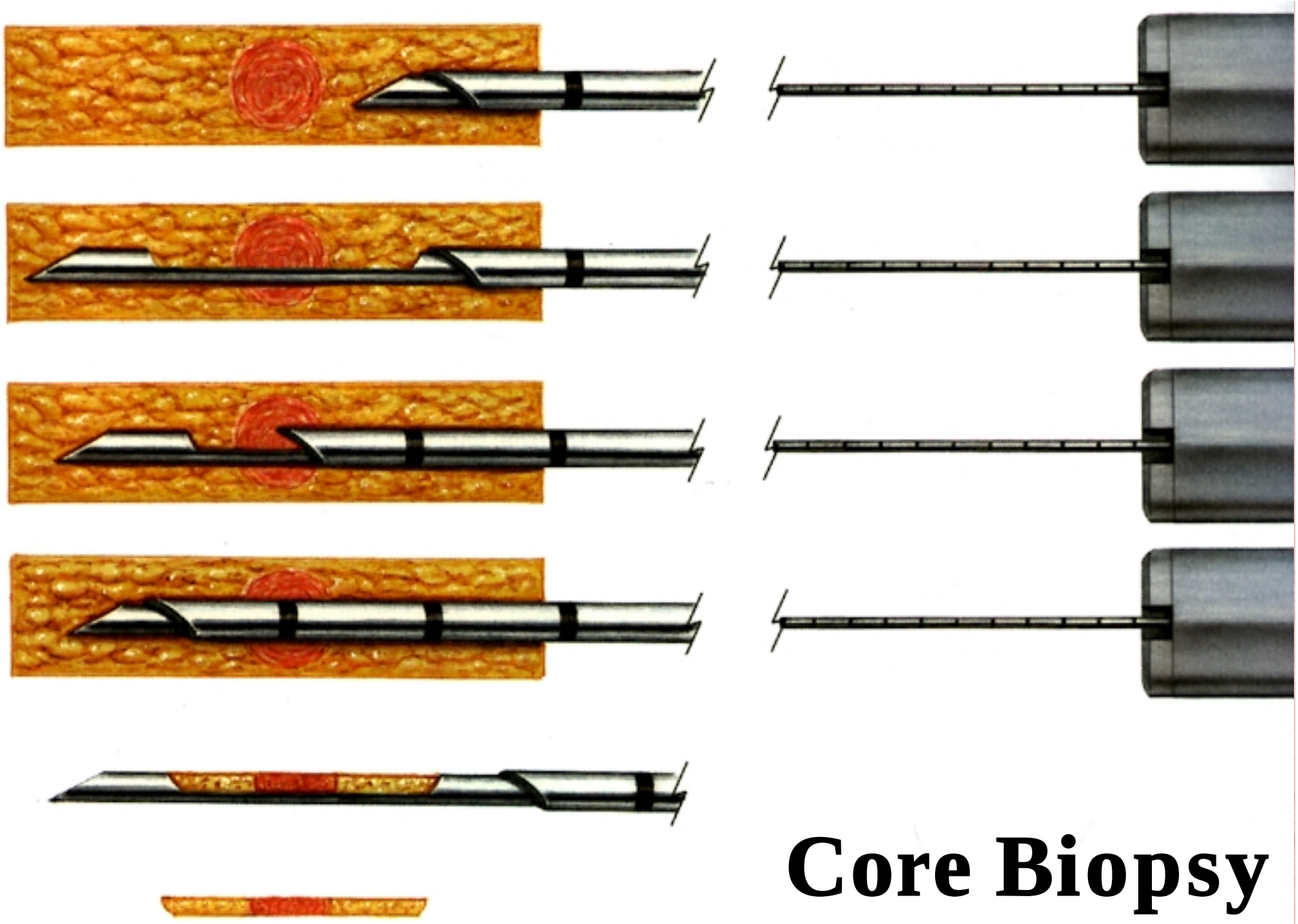
Methods of Imaging Guided Breast Biopsy

- Ultrasound guided, hand-held needle
- Stereotactically guided core biopsy
  - Not visible on ultrasound

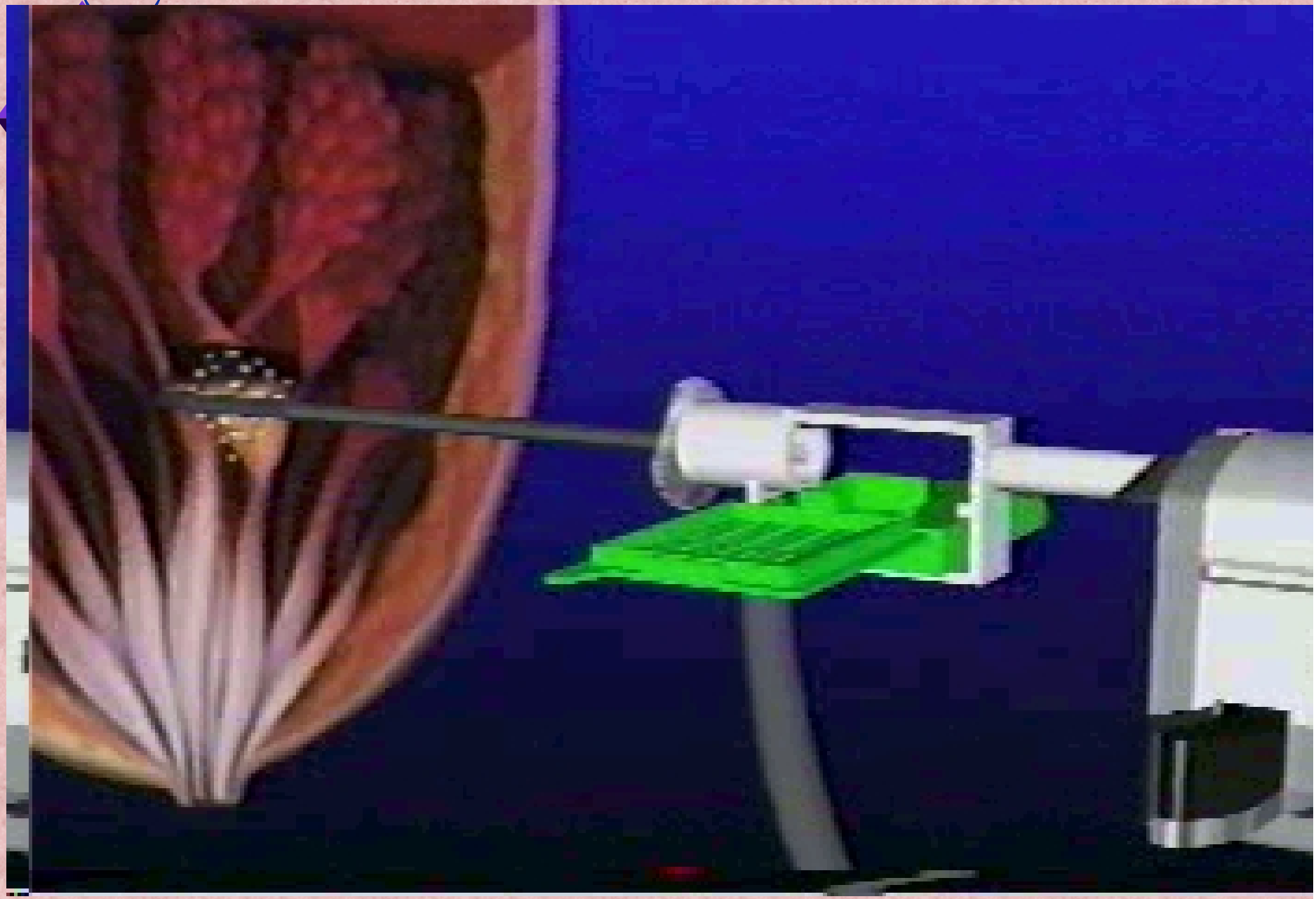



N
Y
X

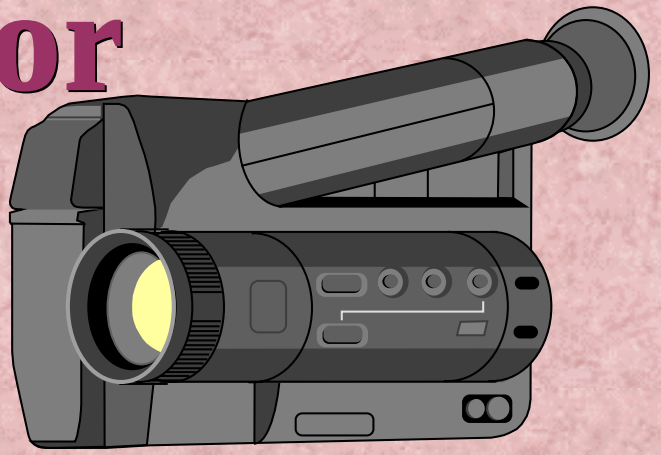

LORAD
Wire Localization
Preset
Compression
51.4mm
Minimum Needle Length 00



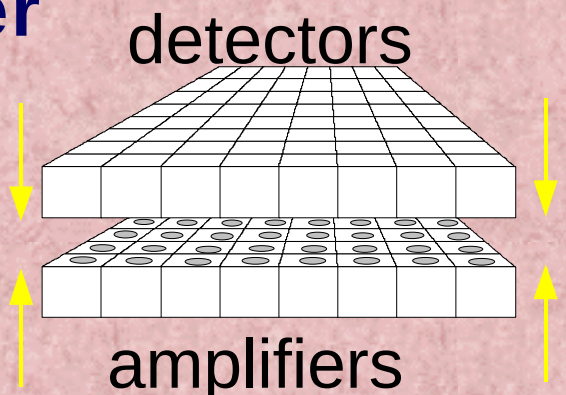
Core Biopsy

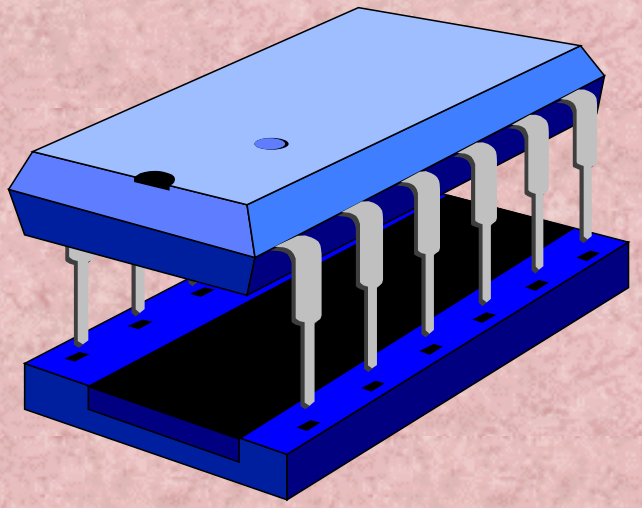


The CCD Image Receptor

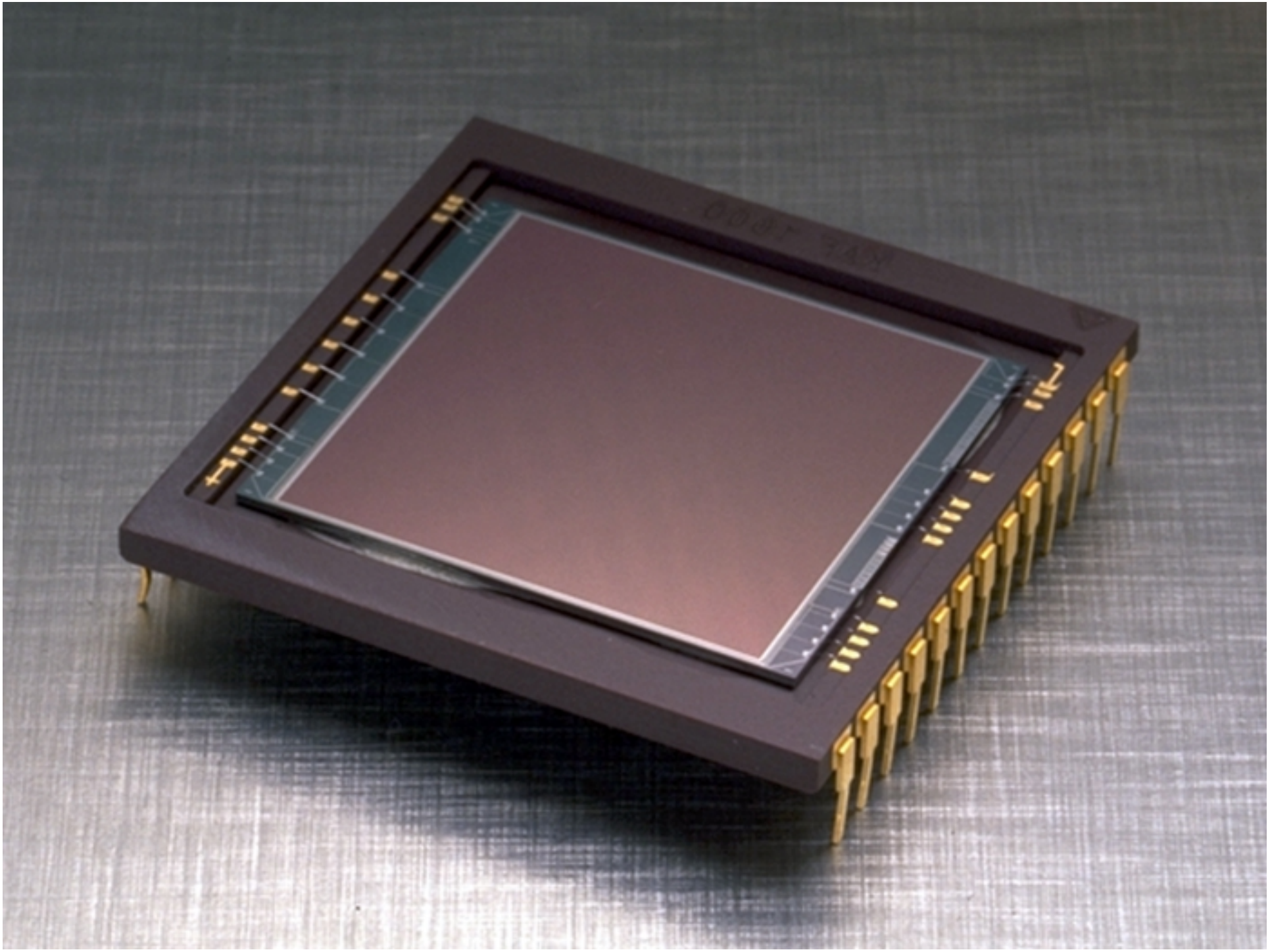


- Charge-Coupled Device
- An integrated circuit (chip) silicon wafer



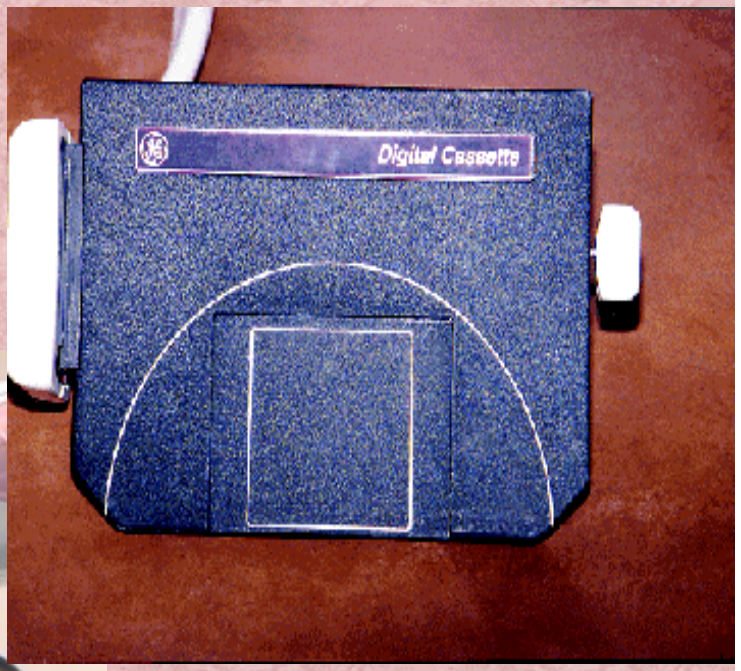


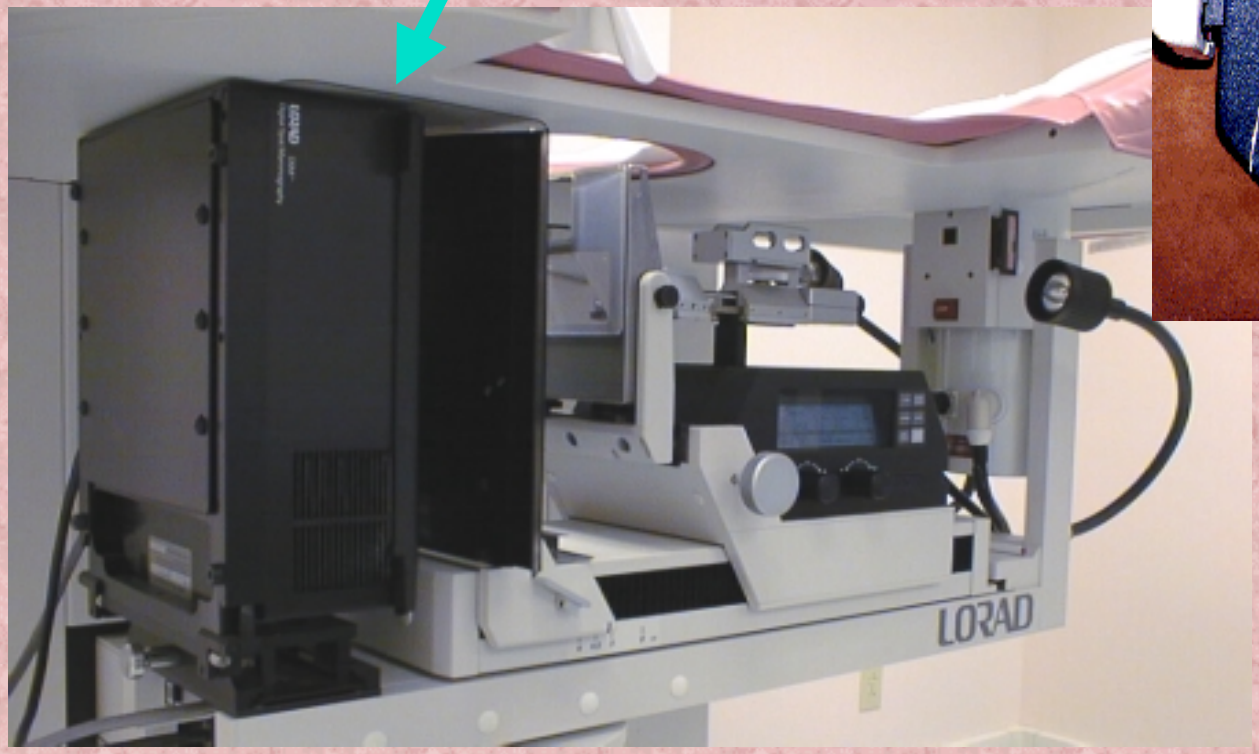
- About the size of a postage stamp
- Converts light into electronic



CCD Image Receptors

- 5cm x 5cm FOV CCD, typical
- LoRad DSM (below) 5 cm x 5 cm
- GE Senovision (right) 8 cm x 8 cm





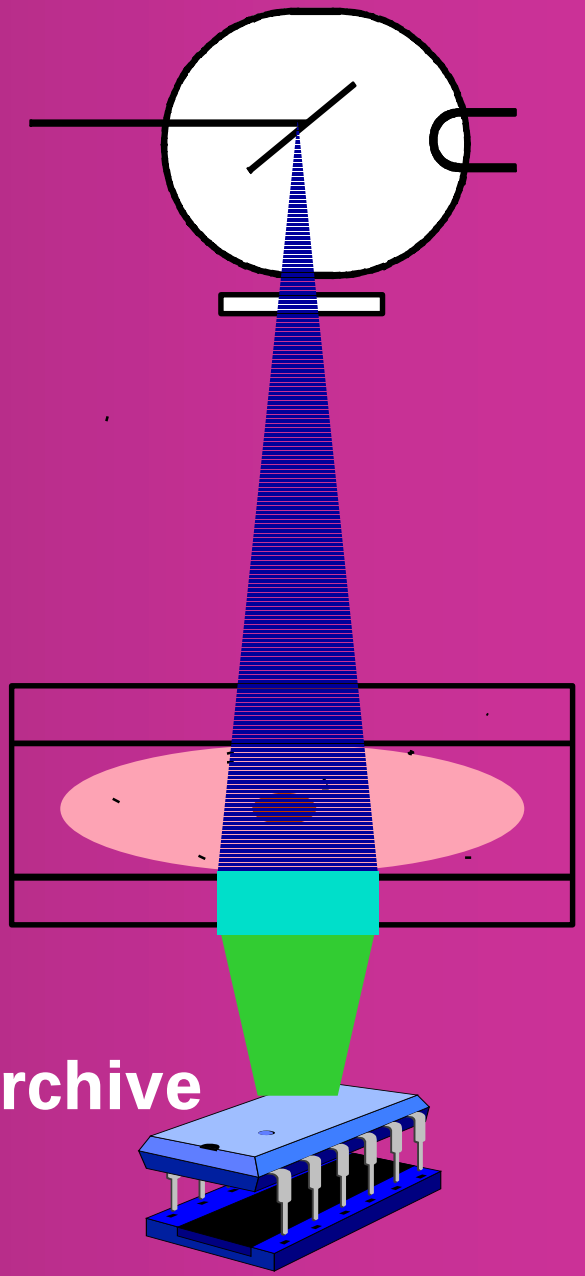
Conventional x-ray exposure creates an aerial image

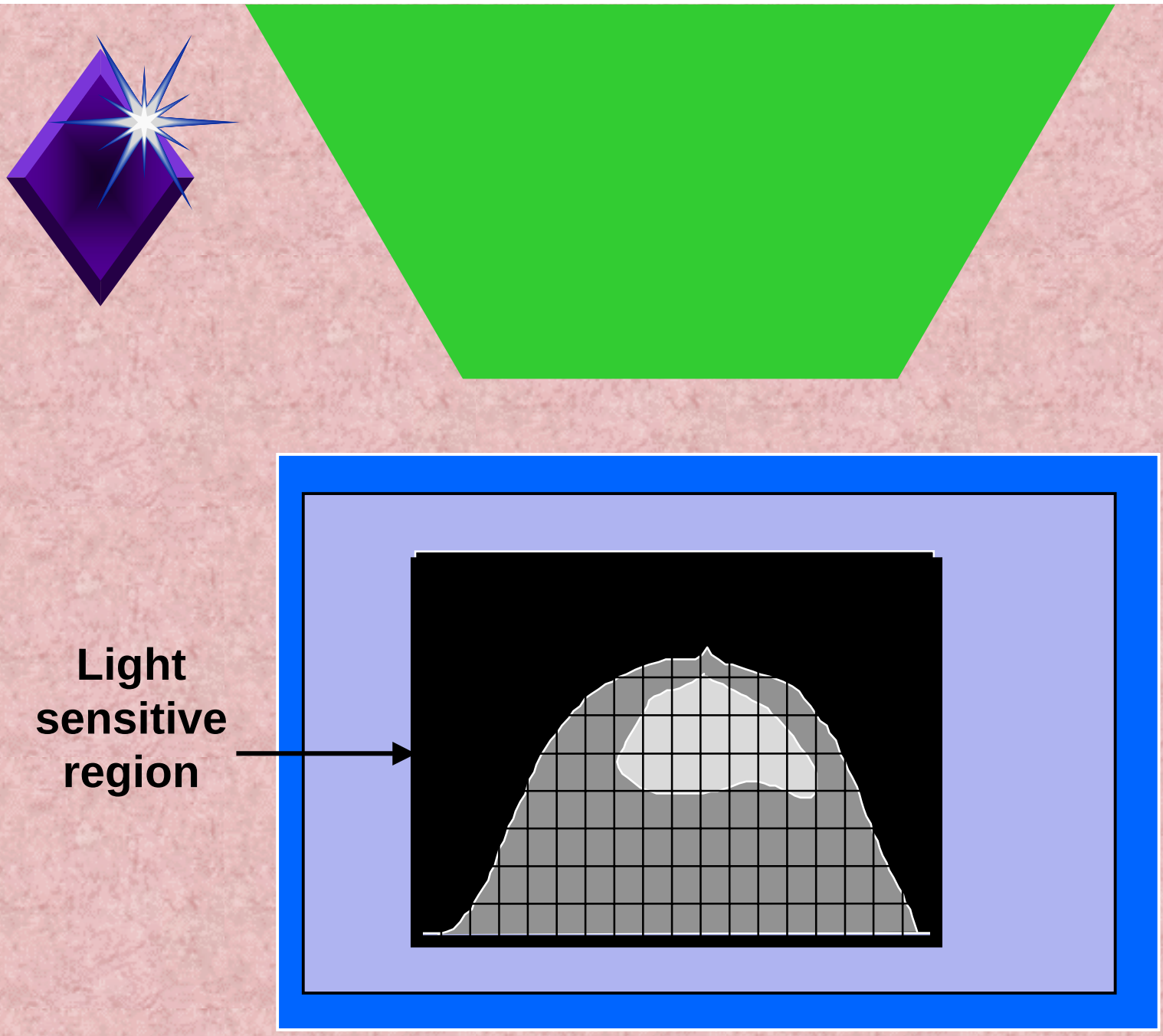
Intensifying screen converts latent x-ray image to visible light image

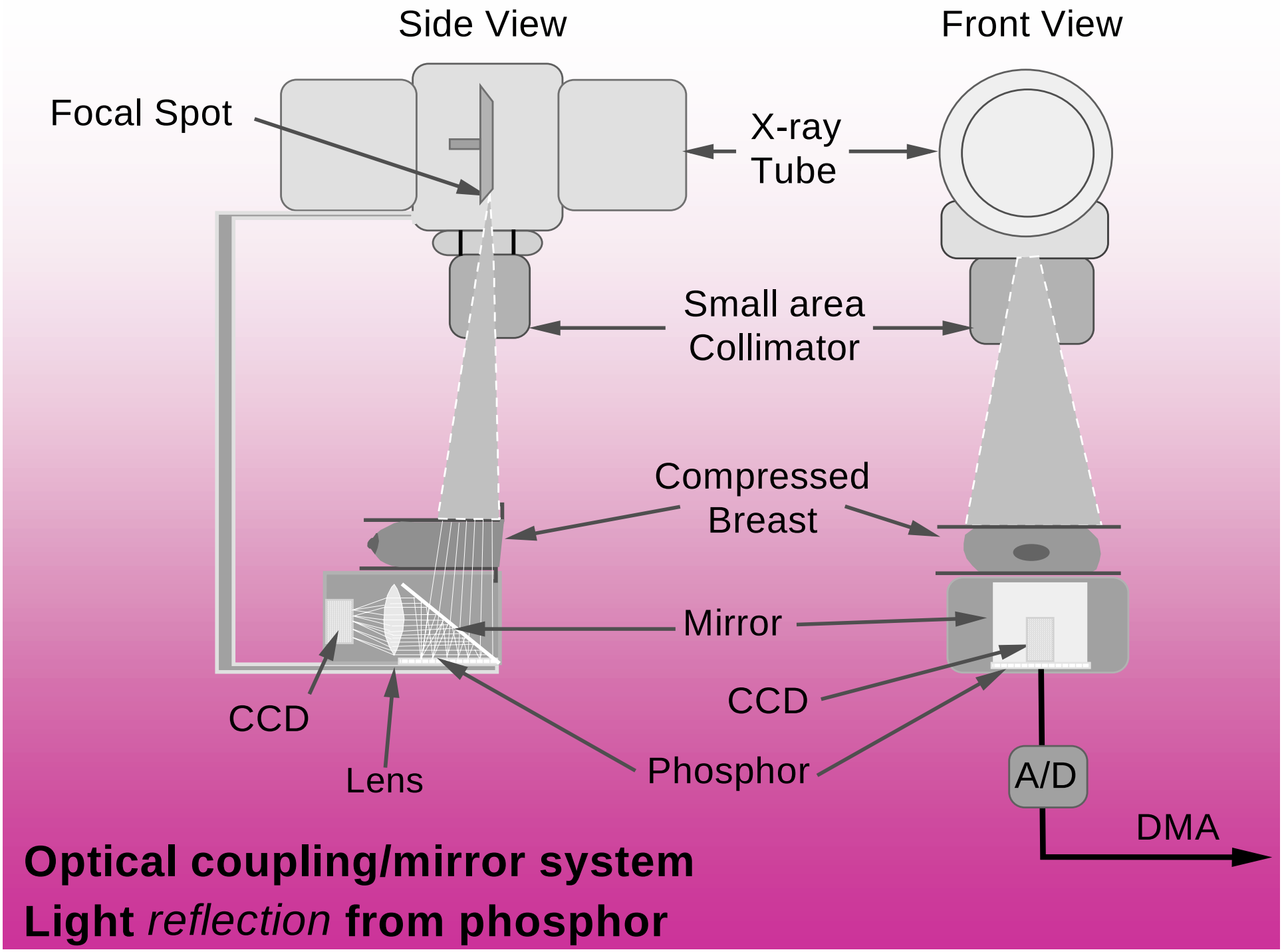
Minify light image to CCD size

Readout CCD to computer

Display, manipulate, archive digital image

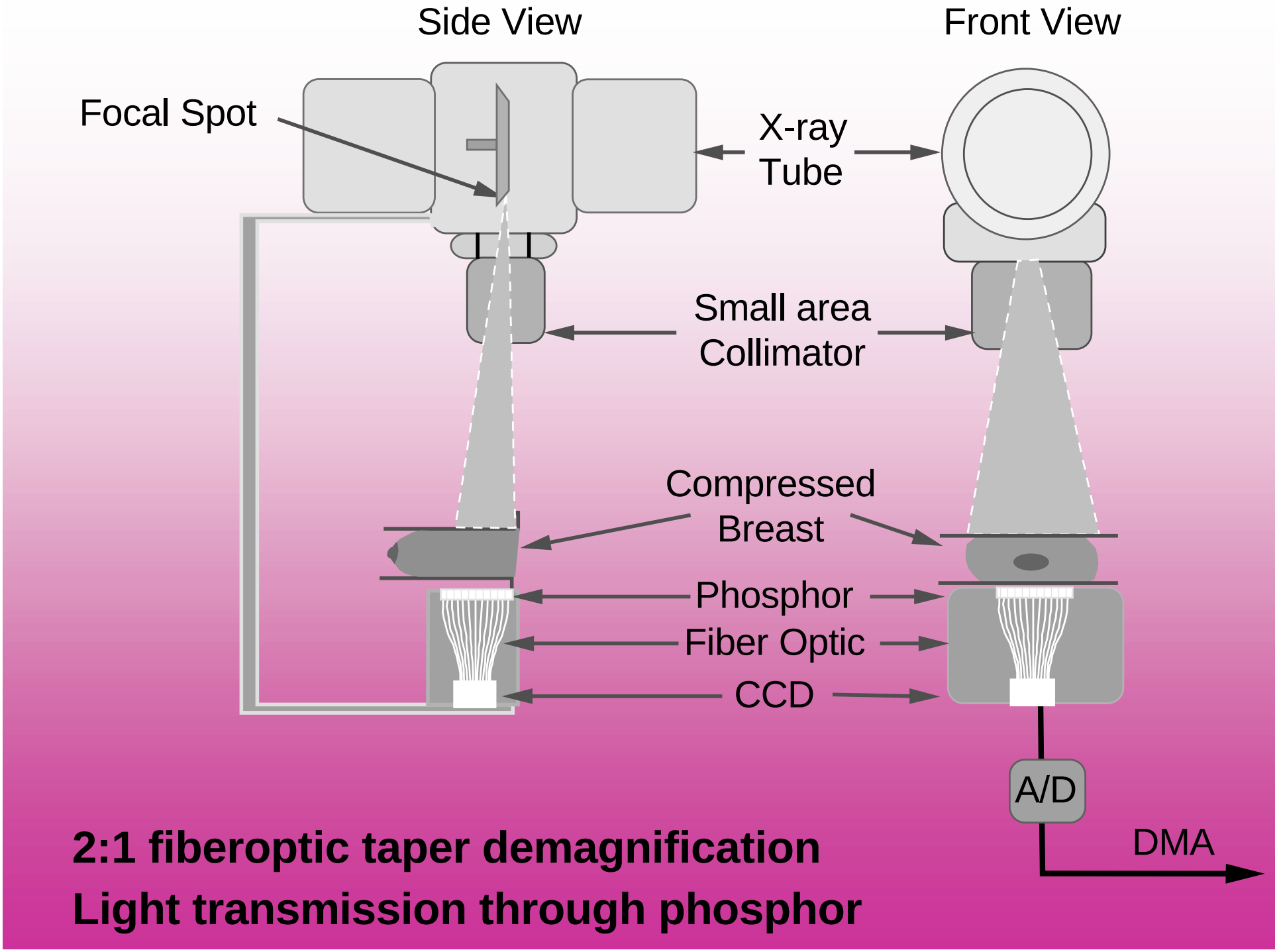



Light
sensitive
region



Optical coupling/mirror system

Light *reflection* from phosphor

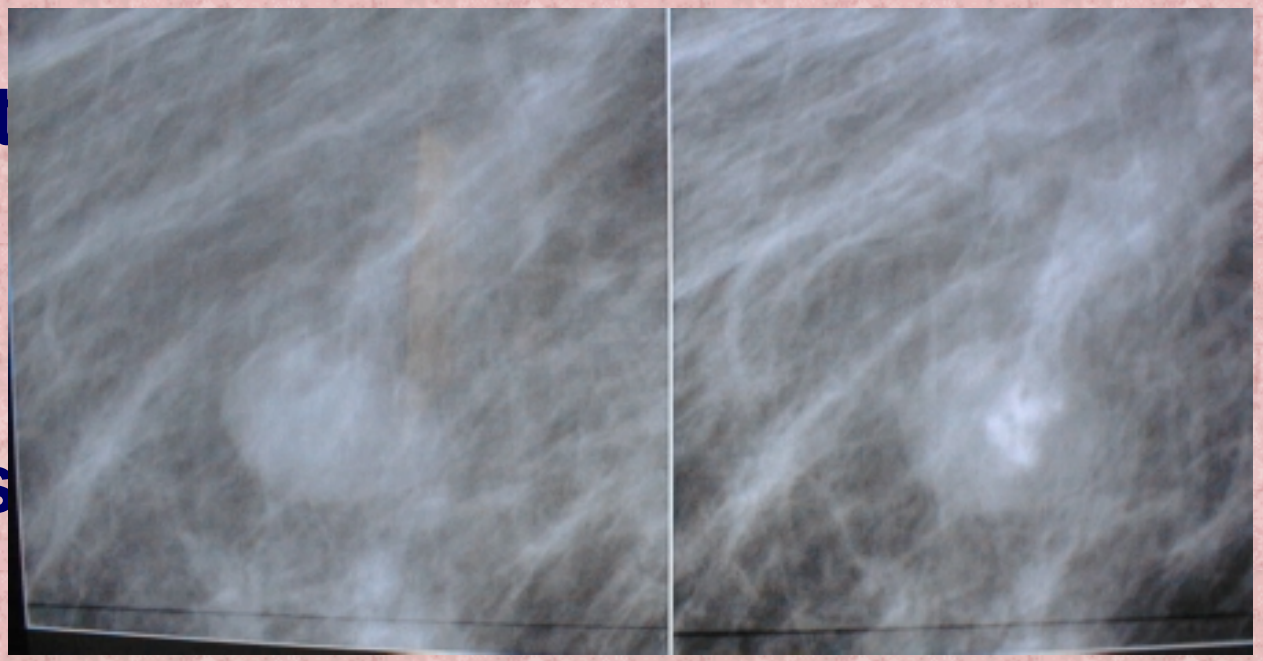


2:1 fiberoptic taper demagnification

Light transmission through phosphor

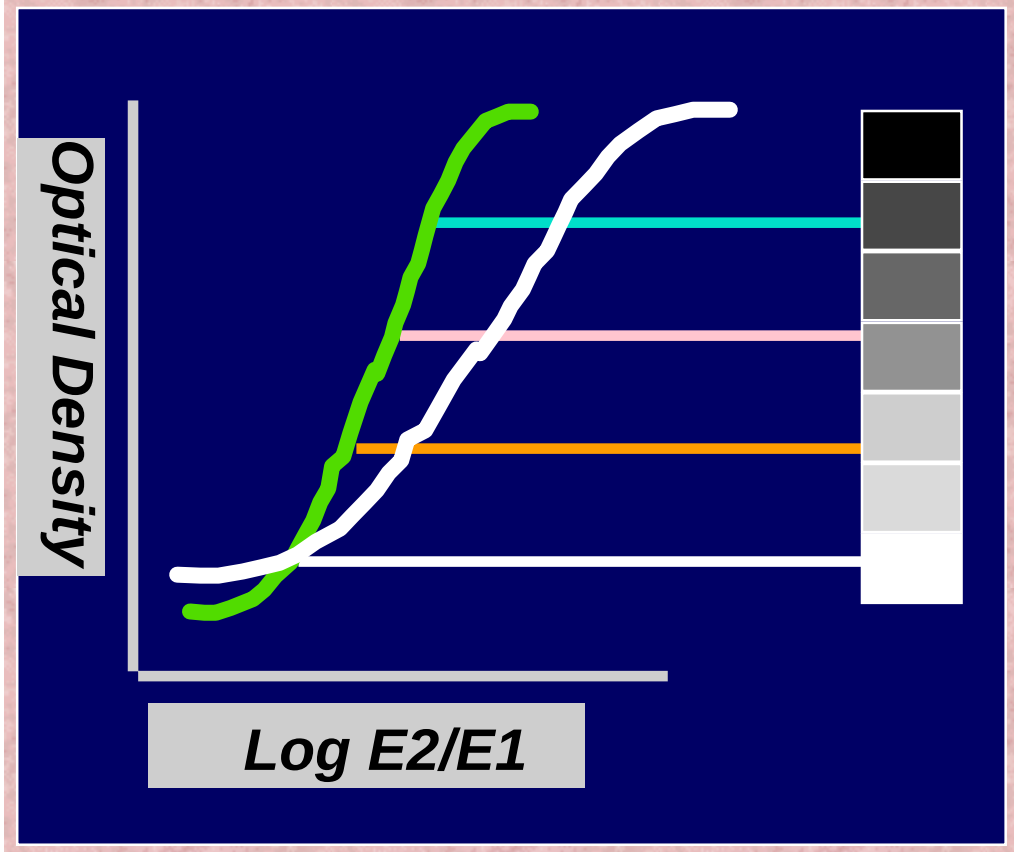
Digital Image Quality

- Contrast
- Blur
- Noise
- Artifacts
- Dose



Contrast

Completely adjustable by the user



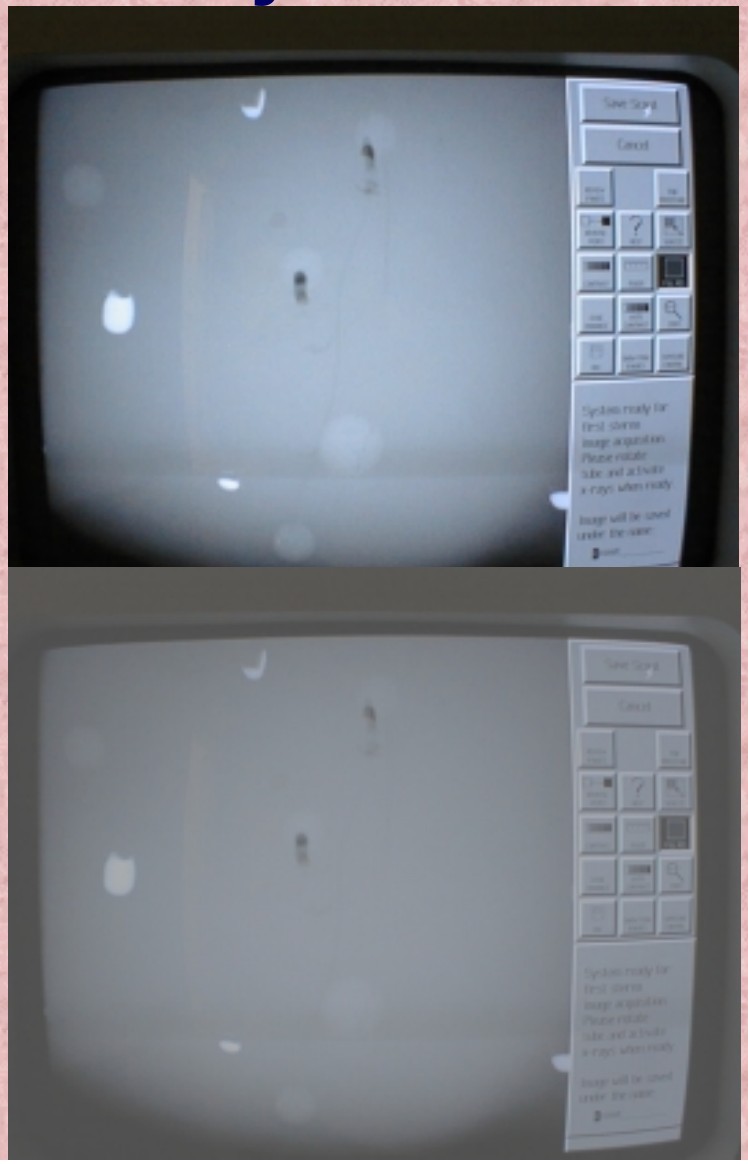
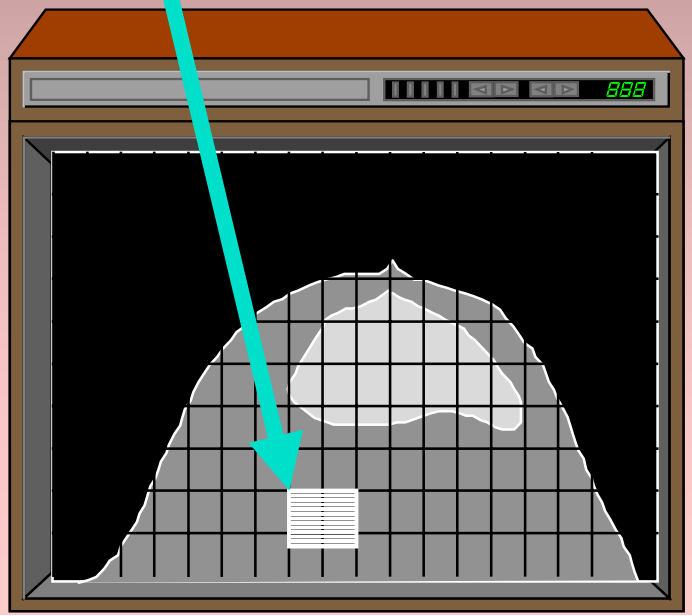


Image Blur

Image Matrix

- 50 mm field of view
- 1,024 x 1,024 pixels
- ~0.05 mm per pixel
- Objects may not be centered on pixel

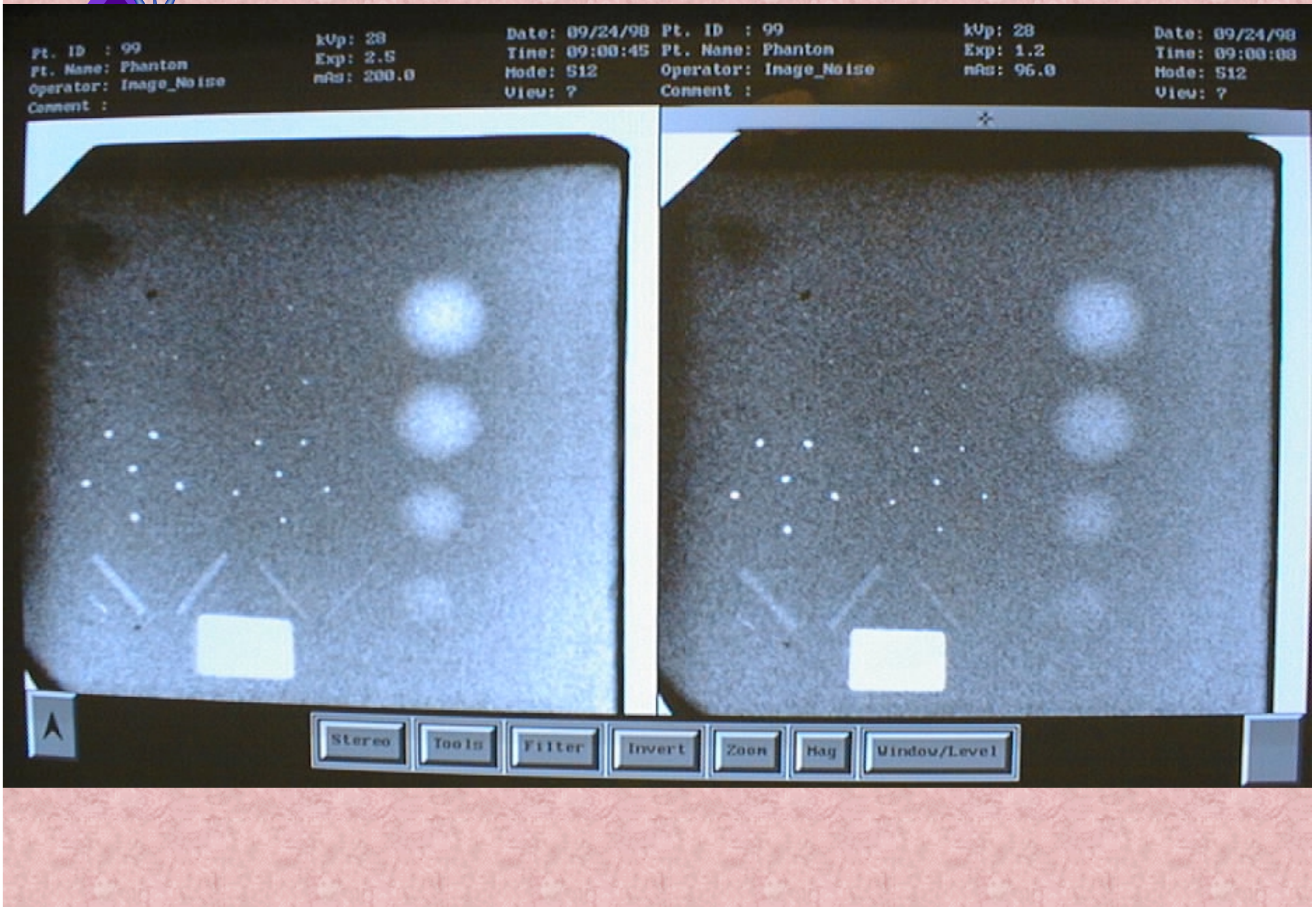


CRT Display

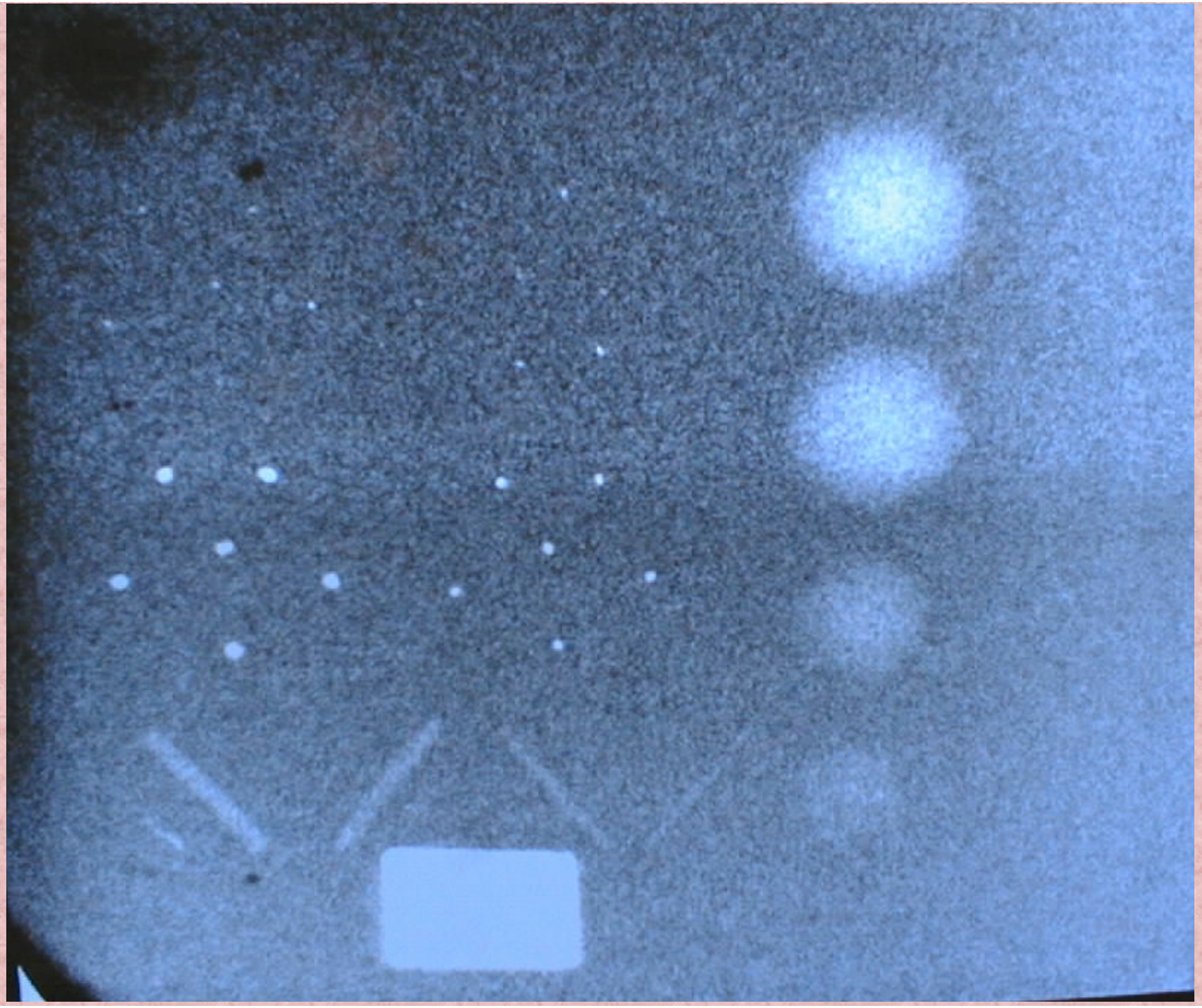
- 20 cm x 30 cm screen
- 480 x 640 pixels (VGA)
- 0.04 cm per pixel
- Mag view

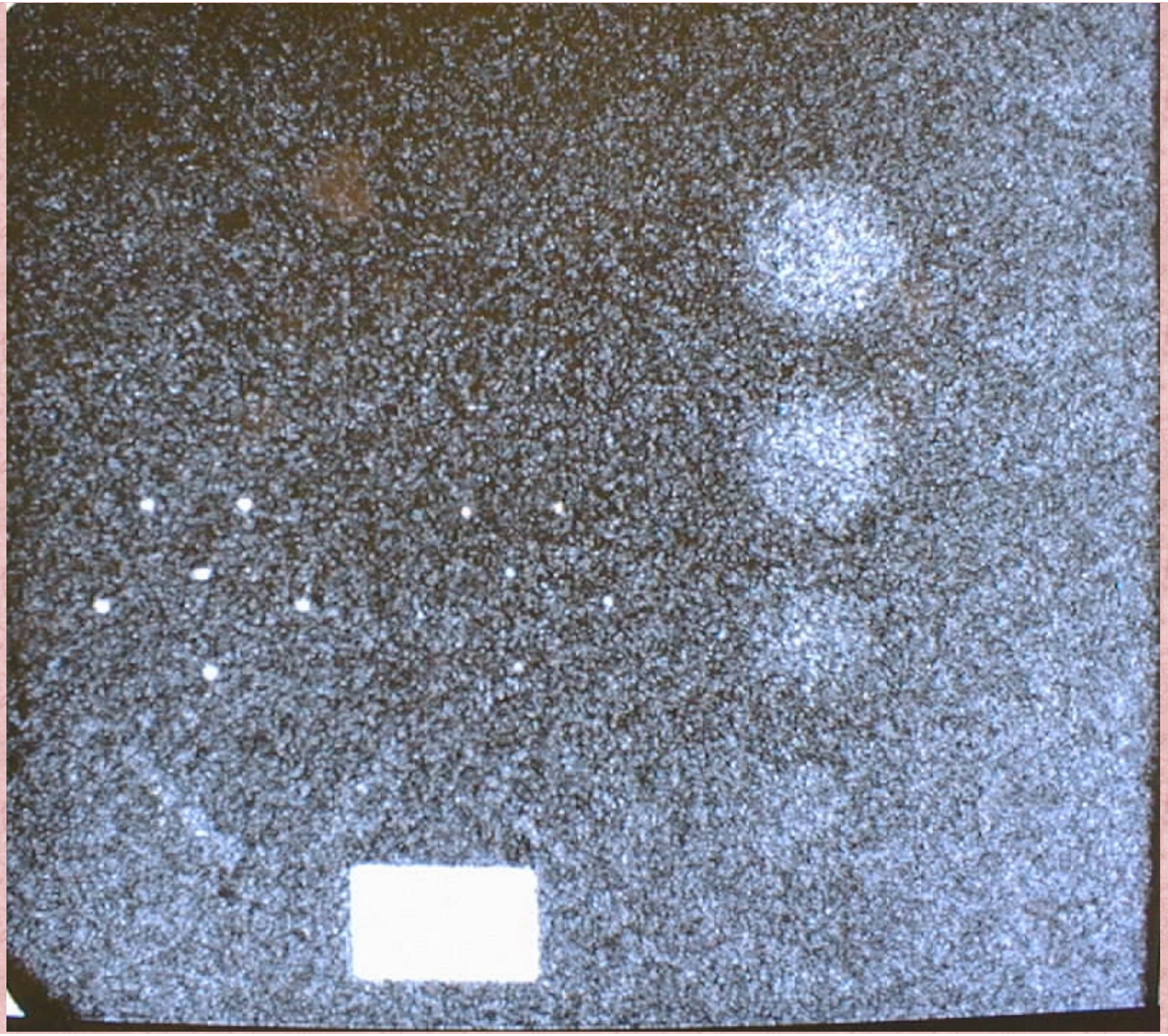
Noise

- Noise decreases (improves) with increasing mAs
- Images may be produced using any mAs technique (from 10 - 500 mAs)
- Window and level controls can be used to make the image “appear” properly exposed
- System noise will change


Pt. ID : 99
Pt. Name: Phantom
Operator: Image_Noise
Comment :
kVp: 28
Exp: 2.5
mAs: 200.0
Date: 09/24/98
Time: 09:00:45
Mode: 512
View: ?
Pt. ID : 99
Pt. Name: Phantom
Operator: Image_Noise
Comment :
kVp: 28
Exp: 1.2
mAs: 96.0
Date: 09/24/98
Time: 09:00:00
Mode: 512
View: ?
Stereo
Tools
Filter
Invert
Zoom
Mag
Window/Level


Pt. ID : 99
Pt. Name: Phanton
Operator: Image_Noise
Comment :
kVp: 28
Exp: 0.2
mAs: 16.0
Date: 09/24/98
Time: 08:59:28
Mode: 512
View: ?
Pt. ID : 99
Pt. Name: Phanton
Operator: Image_Noise
Comment :
kVp: 28
Exp: 2.5
mAs: 200.0
Date: 09/24/98
Time: 09:00:45
Mode: 512
View: ?
Stereo
Tools
Filter
Invert
Zoom
Mag
Window/Level





Factors Affecting Breast Dose

- kVp, mAs
- breast thickness
- breast composition (dense or fatty)
- multiple exposures

- digital image processing does NOT affect dose
- optical density of film (if hardcopy is used) does NOT affect dose

To Minimize Breast Dose

- Develop and maintain a good technique chart
- Obtain manufacturer's suggested techniques
- Evaluate image quality at different mAs values (Technologist and Medical Physicist)
- Moderately higher mAs will reduce image noise, but increase dose
- Insufficient mAs will produce a noisy (grainy) image, but can be made to appear "well exposed" with window/level control
- Excessive mAs images may also appear "OK" with window/level adjustment
- Minimize retakes

Mammography ototimer Technique Chart
Rm. No. _____ Generator 500 T

Switched to Fuji Film - KVP to remain

Compressed Breast Thickness	Fatty Breast				50% Fatty-50% Dense				Dense Breast			
	Target	Filter	kVp	Density	Target	Filter	kVp	Density	Target	Filter	kVp	Density
<3 cm	moly	moly	27	-2	moly	moly	27	-2	moly	moly	27	-1
3 to 5 cm	moly	moly	27	-1	moly	moly	27	-1	moly	moly	27	0
5 to 7 cm	moly	moly	27	0	moly	moly	27	0	moly	moly	27	+2
>7 cm	moly	moly	27	+1	moly	moly	27	+3	moly	moly	27	+4

Techniques based upon proper photocell placement under the most dense portion of breast, screen-film combinations, and processing. Taut compression should be used for all patients except where noted.

Specimens
22 | 16
28 | 12

Focal spot size for:
Nonmagnification Technique: .3 mm
Magnification Technique: .1 mm

Special Techniques

Implant Displaced Views—
Phototiming same as above chart

Manual Techniques for Implant Views

Breast size	Target	Filter	kVp	mAs
Small <3	moly	moly	26	50
Medium 4 to 5	moly	moly	28	80
Large 7 5	moly	moly	29	120

Apply minimal compression—enough to prevent motion.

Specimens-

Manual Technique Only

Breast size	Target	Filter	kVp	mAs
Small	moly	moly	22	16
Medium	moly	moly	22	20
Large	moly	moly	22	25

Specimens must be compressed

Figure 2. Mammography Phototimer Technique Chart

32

Mammography Quality Control Manual (rev. ed.)

PATIENT ENTRANCE SKIN EXPOSURE FOR :Room 6 Manmo Senographe 500Data SOD 22
Pt. Thkns SID M.G.Dose Bucky Gap 0

12/24 Specimens

ACR-SBBAP History

- Committee convened Fall, 1995
  - Develop professional standards
  - Develop SBBAP materials for facilities
- Pilot program 1st quarter, 1996
- Announced at ACR Breast Cancer Meeting (April, 1996)
- Reviewers trained

ACR-SBBAP

- Modeled after ACR-MAP
- 1996 vs. 1987
- Personnel qualifications
- Equipment performance
- QC
- Procedure verification (through clinical image evaluation)
- Image quality (phantom images)
- Dose

Personnel Qualifications Medical Physicist

- **Board Certification or alternate requirements**
- **15 hours CE in Mammo Physics every 3 years**
- **> 6/1/97**

  1 hands-on SBB MP Survey under guidance
- **At least 1 SBB MP Survey per year**
- **3 hrs CE in SBB Physics every 3 years**

Physician Qualifications

Collaborative vs. Independent Practice Model

In a collaborative practice, the patient derives the benefit of consultation and collaboration from the radiologist and surgeon (or other physician) working together.

Where a radiologist or surgeon (or other physician) are practicing independently, the expertise in the diagnosis and management of breast disease of an individual physician may provide the patient with an equivalent benefit

Physician Credentials

- All participating physicians
- Training, Experience
  - Mammography
  - SBB
- Category I SBB courses
- QA
- Radiation Physics Training
- Supervision of RT and MP
- Post biopsy recommendations
- Lesion identification at time of biopsy

Approximate Status May 31, 2001

- 551 facilities applied (active)
- 488 facilities accredited
- 83% accredited on first attempt

- Historically, deficiencies (on 1st attempt)
  - 40% clinical images only
  - 20% phantom images only
  - 10% dose failure

- Nearly 75% passed upon re-submission

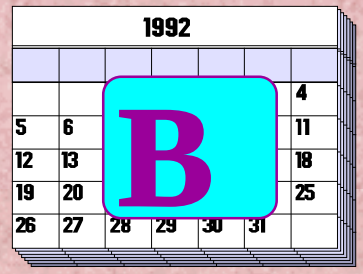
The latest word...

- No longer accepting optical disk or diskette. Hard copy images only.
- FDA will implement regulations mandating accreditation of facilities if they do not comply voluntarily
- Check TLD technique (9% failure rate for dose)
- QC Manual printed and available

QC Tests Unique to SBB
Minimum Testing Frequencies

Zero Alignment Test (only on some units)	Before each patient
Localization Accuracy Test (in Air)	Daily
Phantom Image Quality Test	Weekly
Hardcopy Output Quality (if hard copy is produced from digital data)	Monthly
Visual Equipment Check	Monthly
Repeat Analysis	Semi-annually
Compression Force Test	Semi-annually

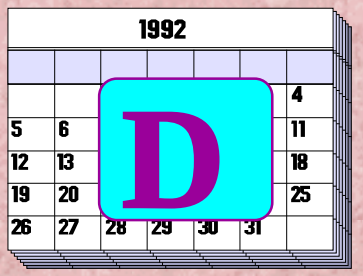
Zero Alignment Test



- Perform before each patient
- Verify that zero coordinate is accurate
- Assures that stereotactic unit is not improperly installed

RT

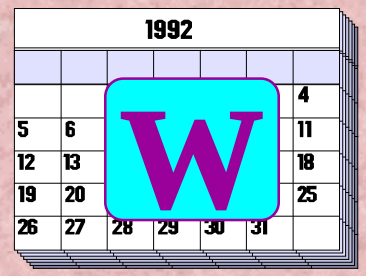
Localization Accuracy



- Closed loop system test
- Position needle to a known coordinate
- Digitize position of needle tip
- Targeting software calculates position of needle tip
- Coordinates should be identical
- ± 1.0 mm sphere

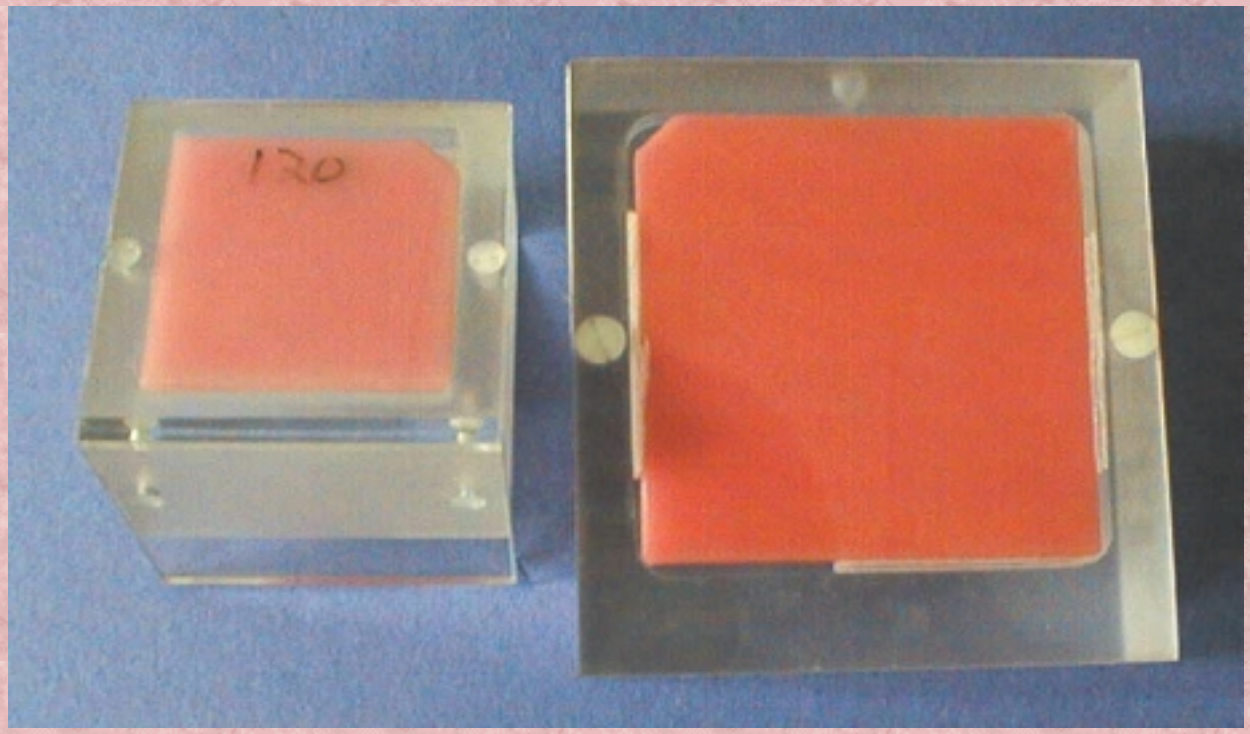
RT

Phantom Image Quality Evaluation



Nuclear Associates Digital Mini Phantom

Mammography Accreditation Phantom



RT

	ACR Accreditation	NA Digital
Fibers	1.56	x
	1.12	x
	0.8	0.93
	0.75	0.74
	0.54	0.54
Specks	0.54	0.54
	0.4	x
	0.32	0.32
	0.24	0.24
	0.16	0.2
Masses	2	x
	1	1
	0.75	0.75
	0.5	0.5
	0.25	0.25

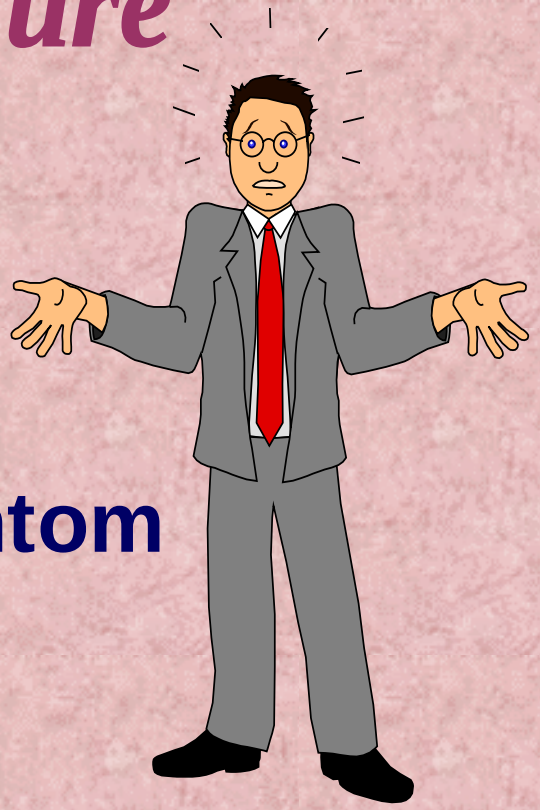
Minimum Passing Phantom Image Scores

	ACR-MAP	Accreditation Phantom	Mini-Phantom
	Screen/film	Digital	Digital
Fibers	4.0	5.0	3.0
Specks	3.0	4.0	3.0
Masses	3.0	3.5	2.5

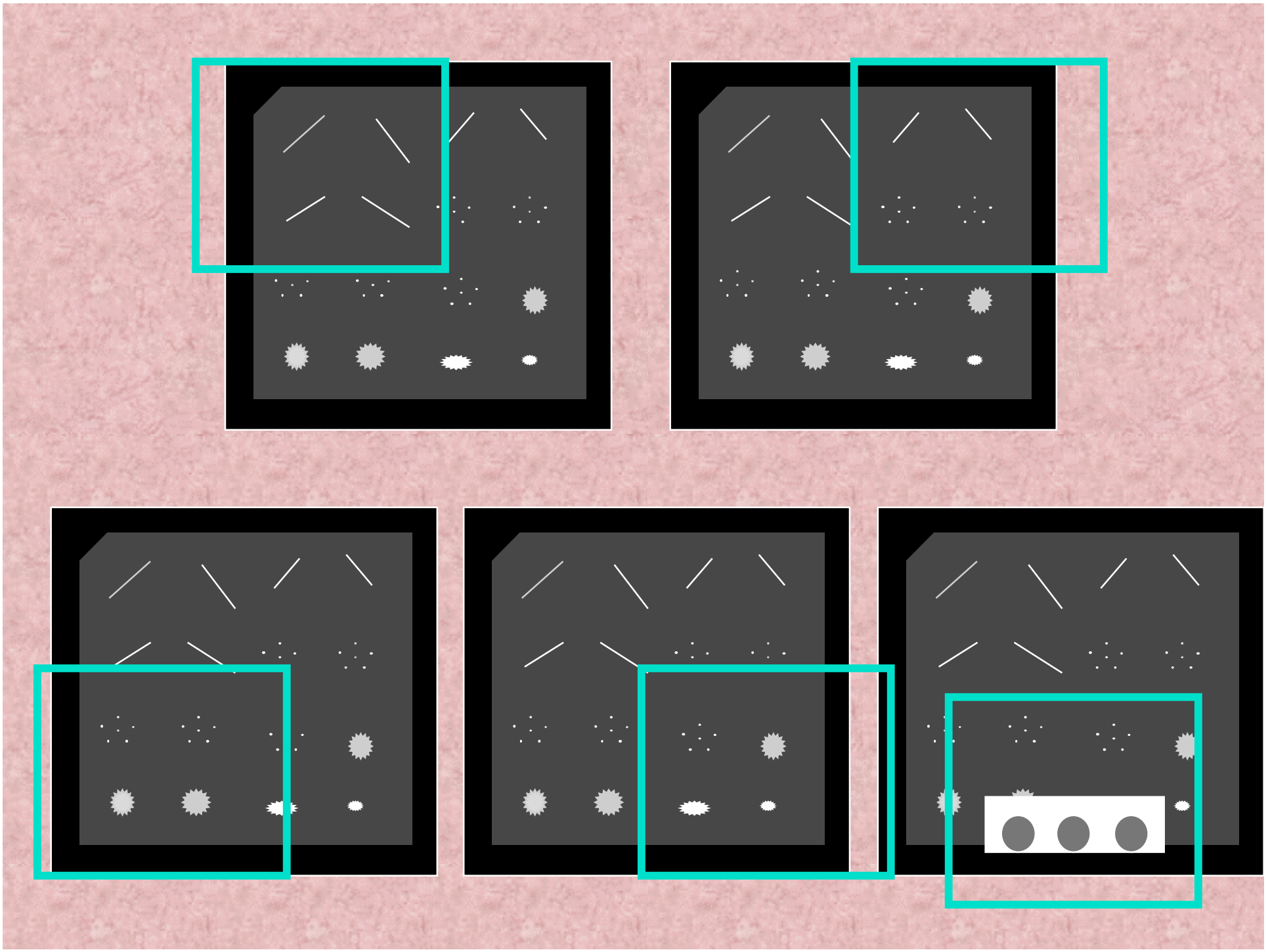
Be sure to use only an approved phantom

Phantom Imaging:

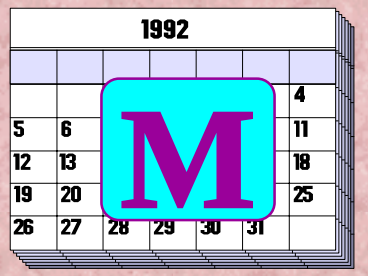
a common avoidable failure



- **NAD Digital Mini Phantom**
  - **1st image (image quality)**
  - **2nd image (TLD)**
- **Mammo Accreditation Phantom**
  - **4 images for image quality**
  - **5th image for TLD**
- **OK to window/level digital images**
- **Use grid (or not) per clinical technique**



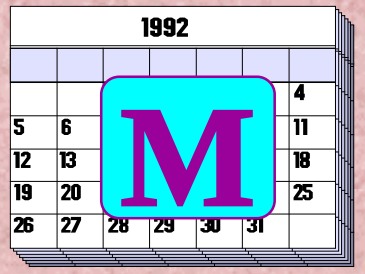
Hardcopy Output Quality



- Laser or multiformat camera
- Evaluate SMPTE Test Pattern, if available
- Record window width, level
- Produce hardcopy
- Measure OD at 4 consistent locations
- Record and monitor for consistency

RT

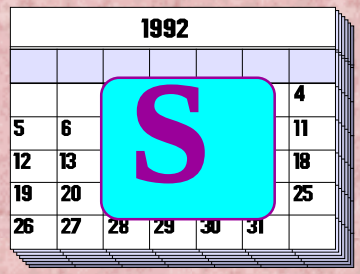
Visual Checklist



- Use ACR checklist or equivalent
- Lights, switches, motion, accessories
- Customize for your machine/room
- Documentation (date, initials)

RT

Repeat Analysis



- Count repeated and rejected film by category and tabulate
- Use a log of images repeated
- Document *analysis* and *corrective action* - even if your repeat rate is low
- Repeat rate probably will not be low

RT

STEREOTATIC BREAST BIOPSY

DIGITAL SBB

REPEAT ANALYSIS WORKSHEET

(For each case performed, document any repeated exposures that required the patient to have additional dose beyond that of a "perfect" exam)

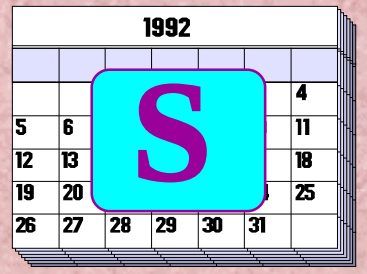
Six month period

From _____ to _____

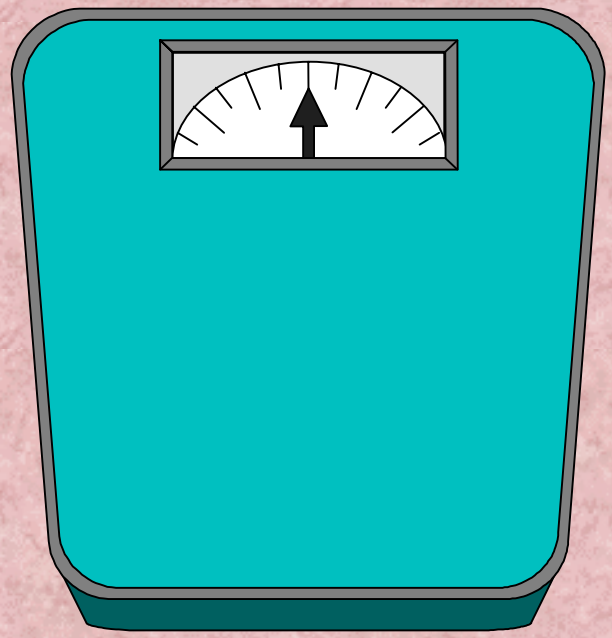
Date	Pt ID	Minimum # Exposures	Actual # exposures	# Repeats	RT	MD	Comments

$$\text{Repeat Rate (\%)} = \frac{100 \times \text{Total \# Repeats}}{\text{Total \# Exposures}}$$

Compression Force



- Bathroom scale or compression gauge
- Measure maximum compression in manual and power modes
- The scale should read 25-40 pounds in automatic mode
- Documentation



RT

Additional Technologist's QC Tests (Screen-Film only)

TEST	FREQUENCY
Darkroom Cleanliness	Daily
processor QC	Daily
Screen Cleanliness	Weekly
Viewboxes & Viewing Conditions	Weekly
Fixer Retention Analysis	Quarterly
Screen-Film Contact	Semi-Annually
Darkroom Fog	Semi-Annually

SBB Annual Medical Physics Survey

- SBB Unit Assembly Evaluation
- Collimation Assessment
- Focal Spot Performance and System Limiting Resolution
- kVp Accuracy and Reproducibility
- Beam Quality Assessment (HVL)
- Automatic Exposure Control System Performance
- Uniformity of Screen Speed or Digital Field
- Breast ESE, AGD, AEC Reproducibility
- Image Quality Evaluation (phantom)
- Artifact Evaluation
- Localization Accuracy

MP

Assembly Evaluation

- Free-standing unit is mechanically stable
- All moving parts move smoothly, without obstructions to motion
- All locks and detents work properly
- Image receptor holder is free from vibrations
- Image receptor is held securely by assembly in any orientation

MP

Assembly Evaluation

- Image receptor slides smoothly into holder assembly
- Compressed breast thickness scale is accurate to ± 0.5 cm, reproducible to ± 2 mm
- Patient or operator is not exposed to sharp or rough edges or other hazards
- Operator technique charts are posted
- Operator protected by adequate radiation shielding

MP

Collimation

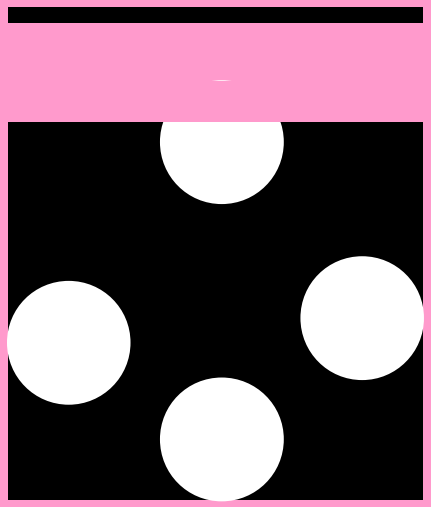
- Does the x-ray beam exceed the image receptor?

  Note: X-rays beyond the digital image receptor will not be seen on the monitor

- Does the biopsy window align with the image field of view?

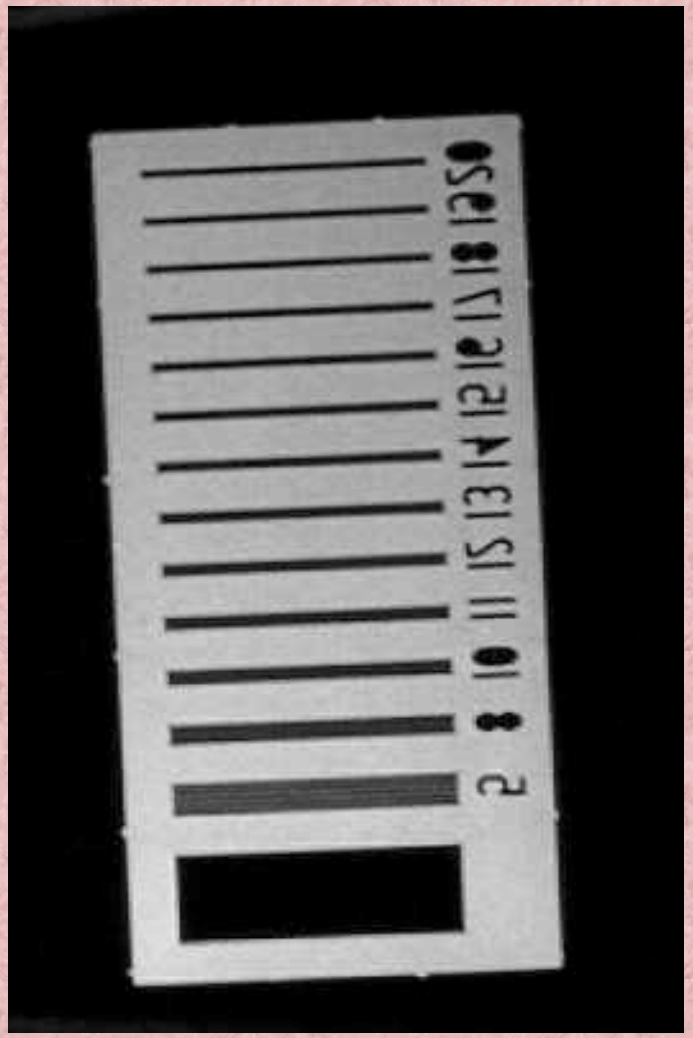
MP


KODAK MIN-R 2 Cassett
with C-1N window
and KODAK MIN-R screen
Installation Date
Cassette Number
44



Focal Spot Size Performance - System Limiting Resolution

- Line Pair Test Pattern
- Use film (x-ray machine)
- Use CRT image (“system”)
- Technique, clinical kVp
- Scoring the image
  - Film - Lines distinct over 1/2 length
  - CRT - Lines distinct, correct # over any part of pattern



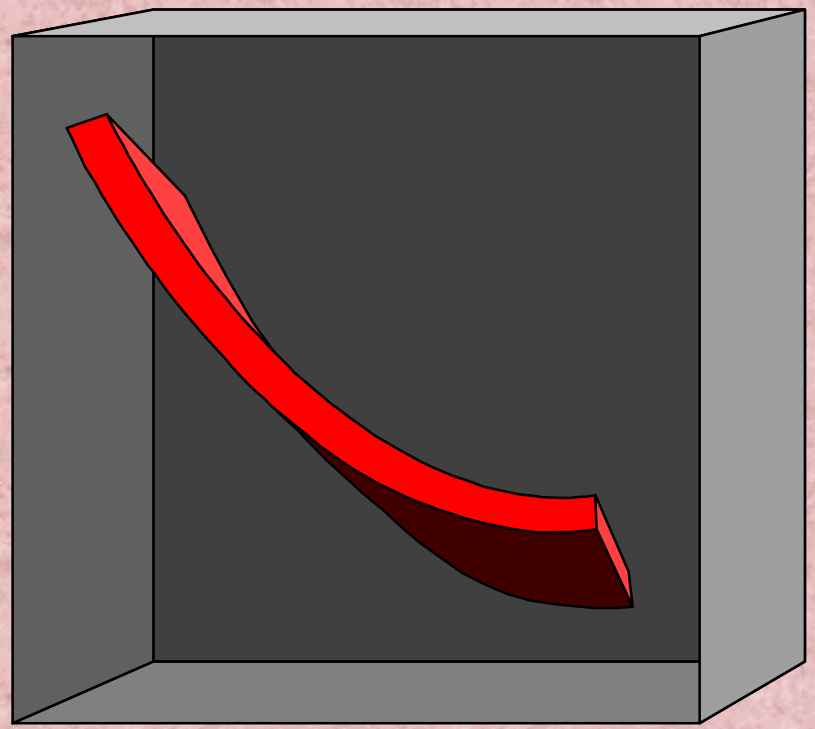
kVp Accuracy - Reproducibility

- Verify that actual kVp's are the same as the indicated kVp's
- Range of clinical kVp values
- Accuracy within 5%
- Reproducible CV < 0.02

MP

Beam Quality (HVL)

- Thickness of aluminum to reduce radiation exposure by one-half
- Affects contrast and dose
- Used in dose calculation
- minimum = kVp/100
- No compression paddle lucite in the beam

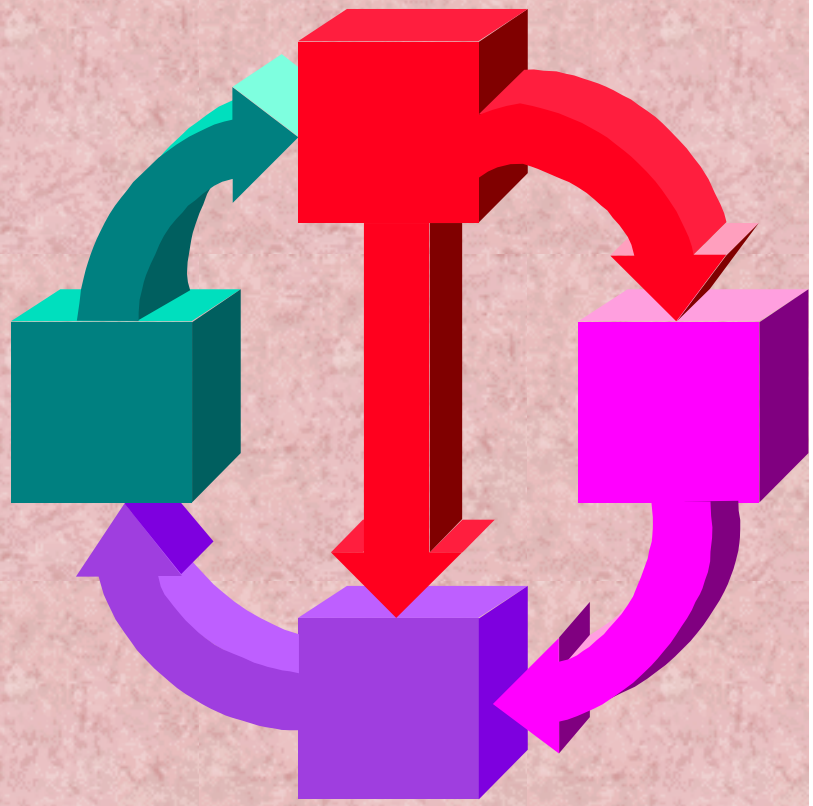


MP

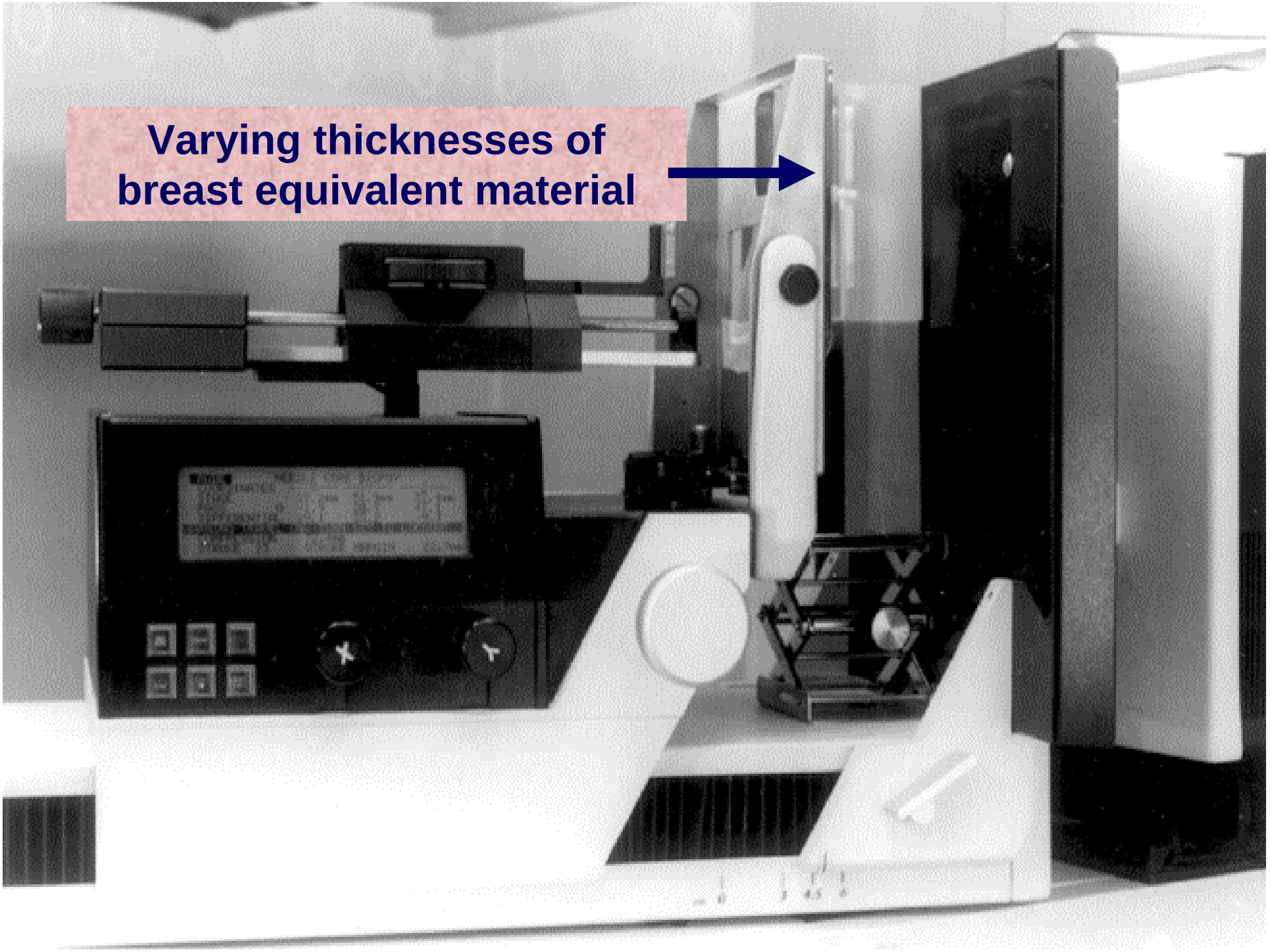
AEC System Performance

- AEC available on some digital SBB units
- Performance Capability

  Record signal level as function of thickness and technique
- Monitor exposure time
- Performance Capability (4,6,8 cm)
- Provide suggested technique chart



MP


Varying thicknesses of
breast equivalent material

Develop a Technique Chart

Thickness	kVp	mAs	Signal Value
< 3 cm	NA	NA	NA
3 - 5 cm			
5 - 7 cm			
> 7 cm			

Uniformity of Screen Speed or Digital Field

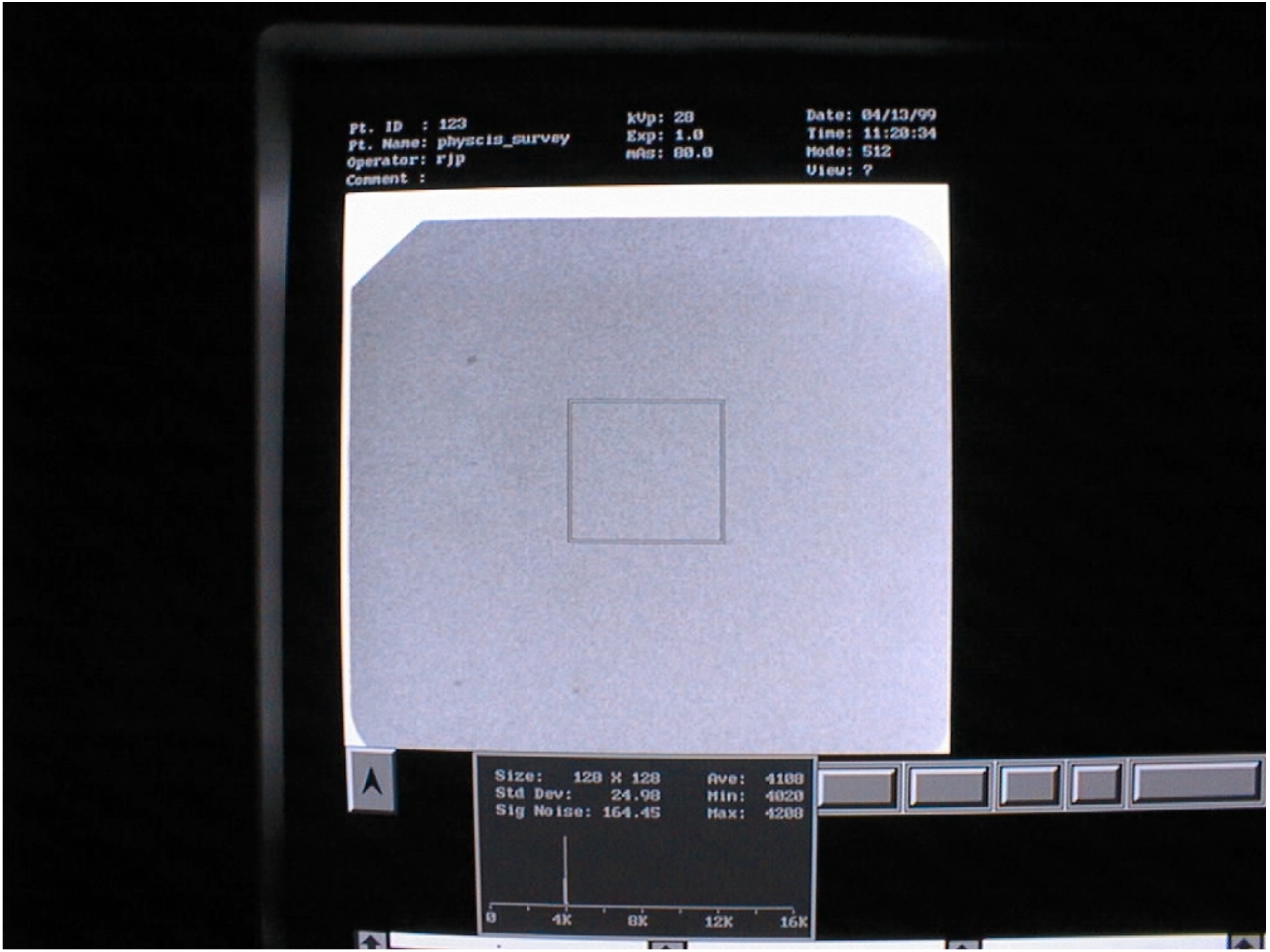
- **Image a uniform phantom**
- **Screen Film systems**

  Each cassette produces the same optical density under the same conditions

- **Digital Systems**

  Digital detector produces uniform signal values across the field of view

MP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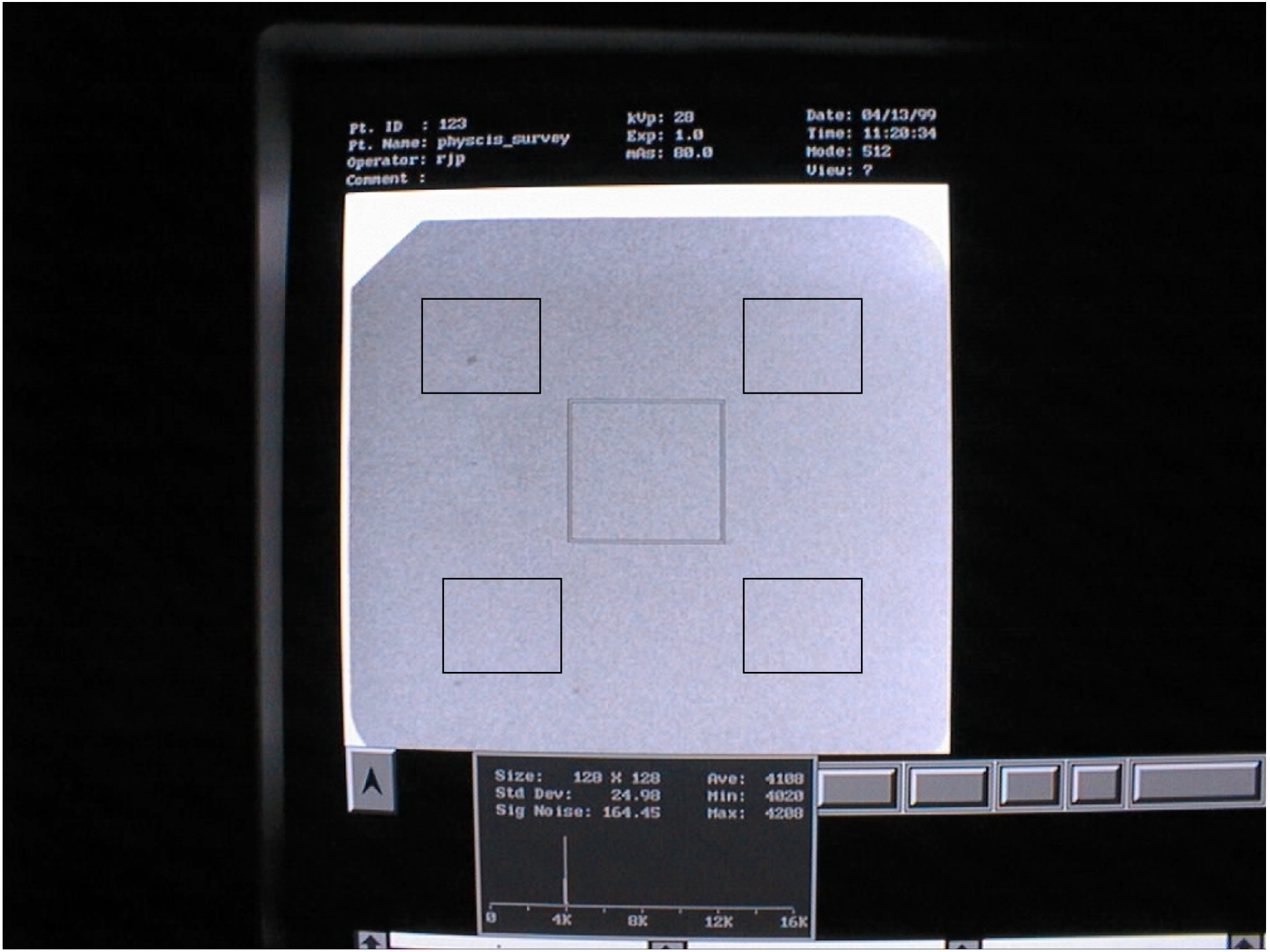
Pt. Name: physcis_survey
Operator: rjp
Comment :
kVp: 28
Exp: 1.0
mAs: 80.0
Date: 04/13/99
Time: 11:28:34
Mode: 512
View: ?
Size: 128 X 128
Std Dev: 24.98
Sig Noise: 164.45
Ave: 4188
Min: 4020
Max: 4288
0
4K
8K
12K
16K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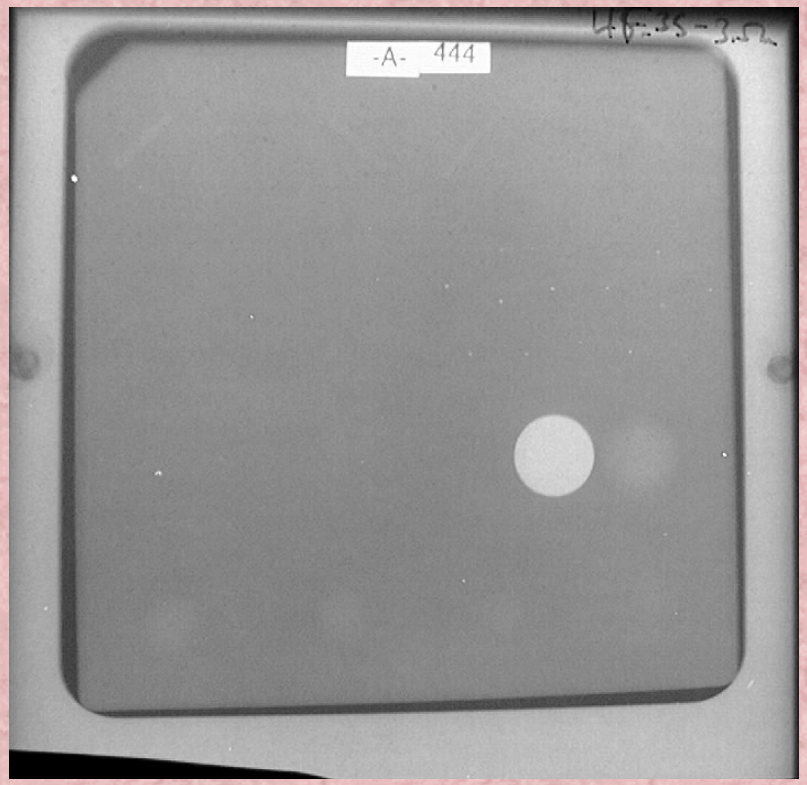
Phantom Image Quality

- Same procedure as for technologists
- Medical Physicist reviews scoring procedure and checks for consistency
- Uses technique factors for dose determination



MP

Breast Entrance Exposure, AGD

- Data per technique chart
- Measure ESE
- HVL determines DgN
- AGD = ESE * DgN
- AGD < 300 mrad
- Dose and Optical Density

MP

Artifact Evaluation

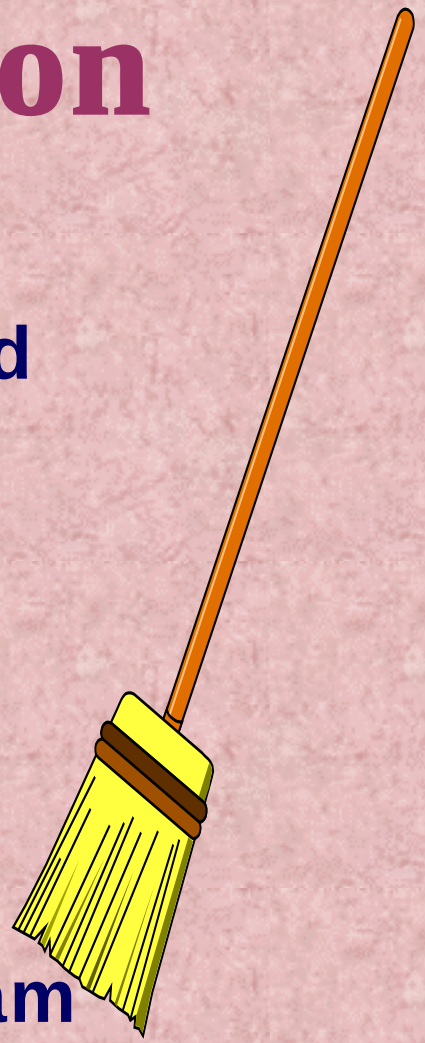
Unwanted irregularity not caused by structures of interest

Causes (Digital)

Digital Image Receptor

Common Causes

Unwanted objects in x-ray beam

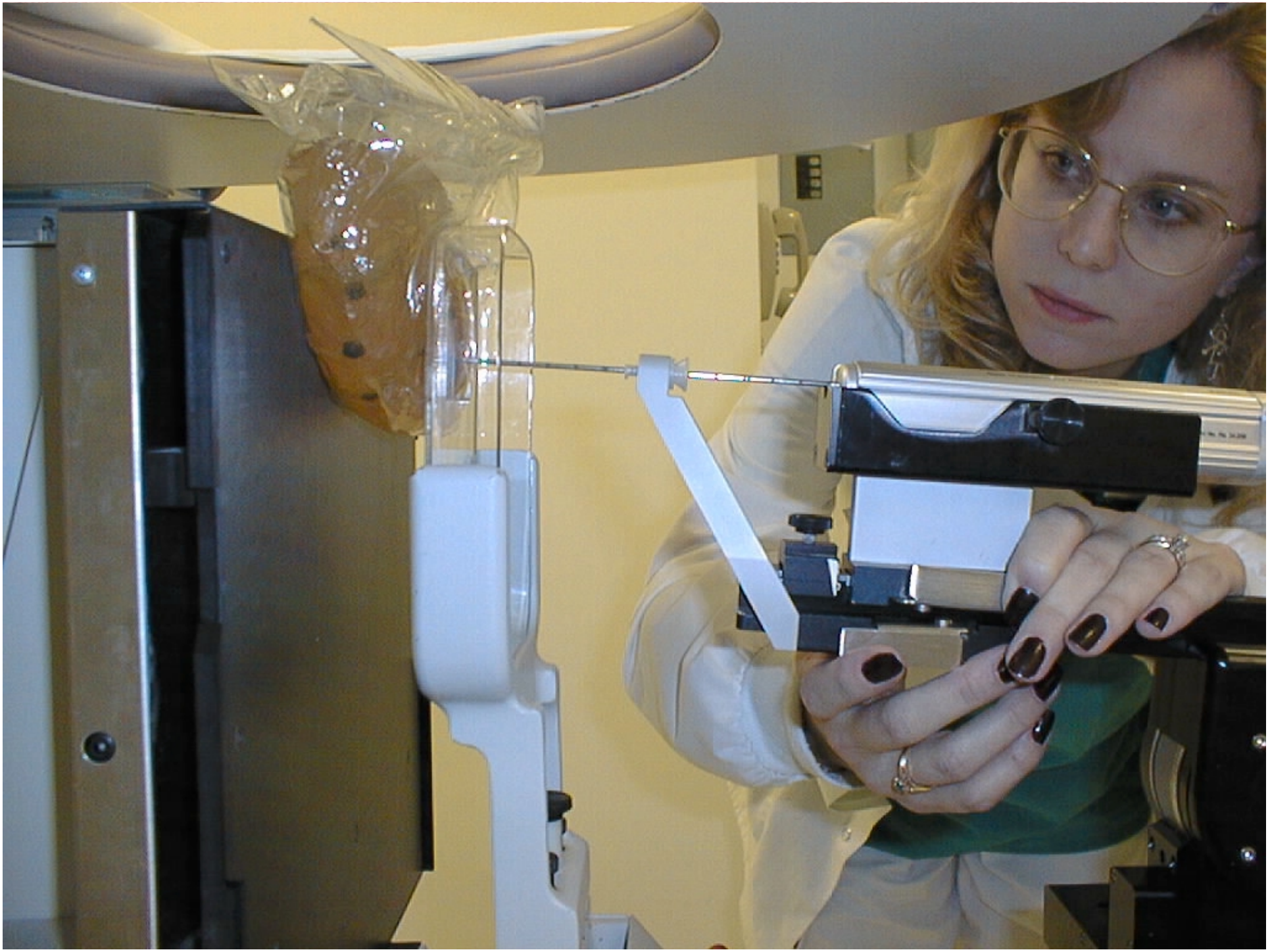


MP

Targeting Accuracy

- Performed annually by technologist under supervision of medical physicist
- Position gel-type phantom
- Image, target and sample
- Result: was the lesion collected?

MP



QC Program Review

For all Technologist QC Tests

- **Review procedures (ACR SBB-QC Manual)**
- **Review documentation**
- **Answer questions**
- **Written recommendations**

MP

Role of the Surgeon in Quality Control

- Understand the importance of QC in SBB
- Assures that personnel remain qualified
- Support QC activities
  - Allow enough time for QC
  - Provide for QC training
  - Periodically check that QC is done as required
- Confer with medical physicist annually
- Assure that follow-up is done if the QC program indicates corrective action is required

Summary

- ACR SBBAP
- Technologist's QC Tests
- Medical Physicists QC Tests