

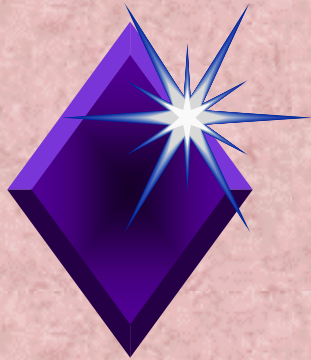
# **Quality Control for Stereotactic Breast Biopsy**



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

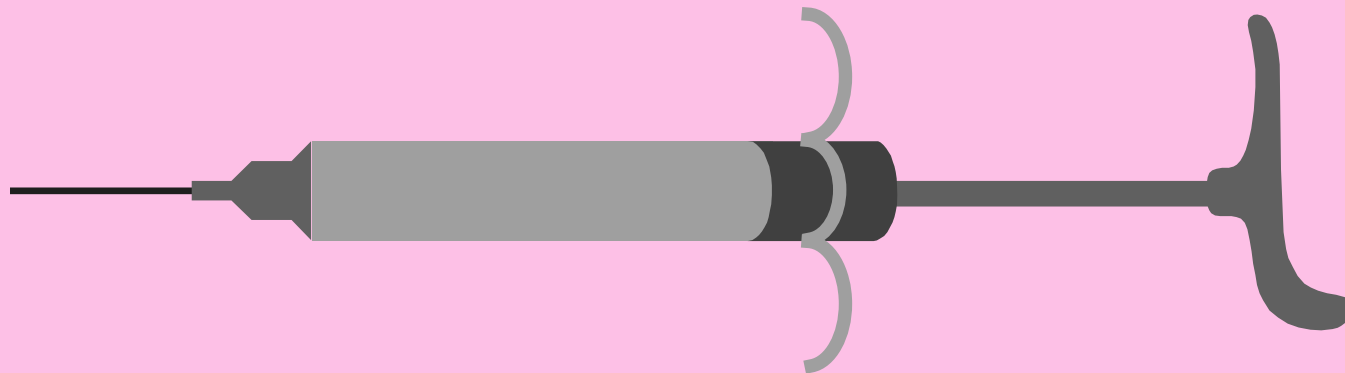
**Upstate Medical Physics, Inc.**

**716-924-0350**

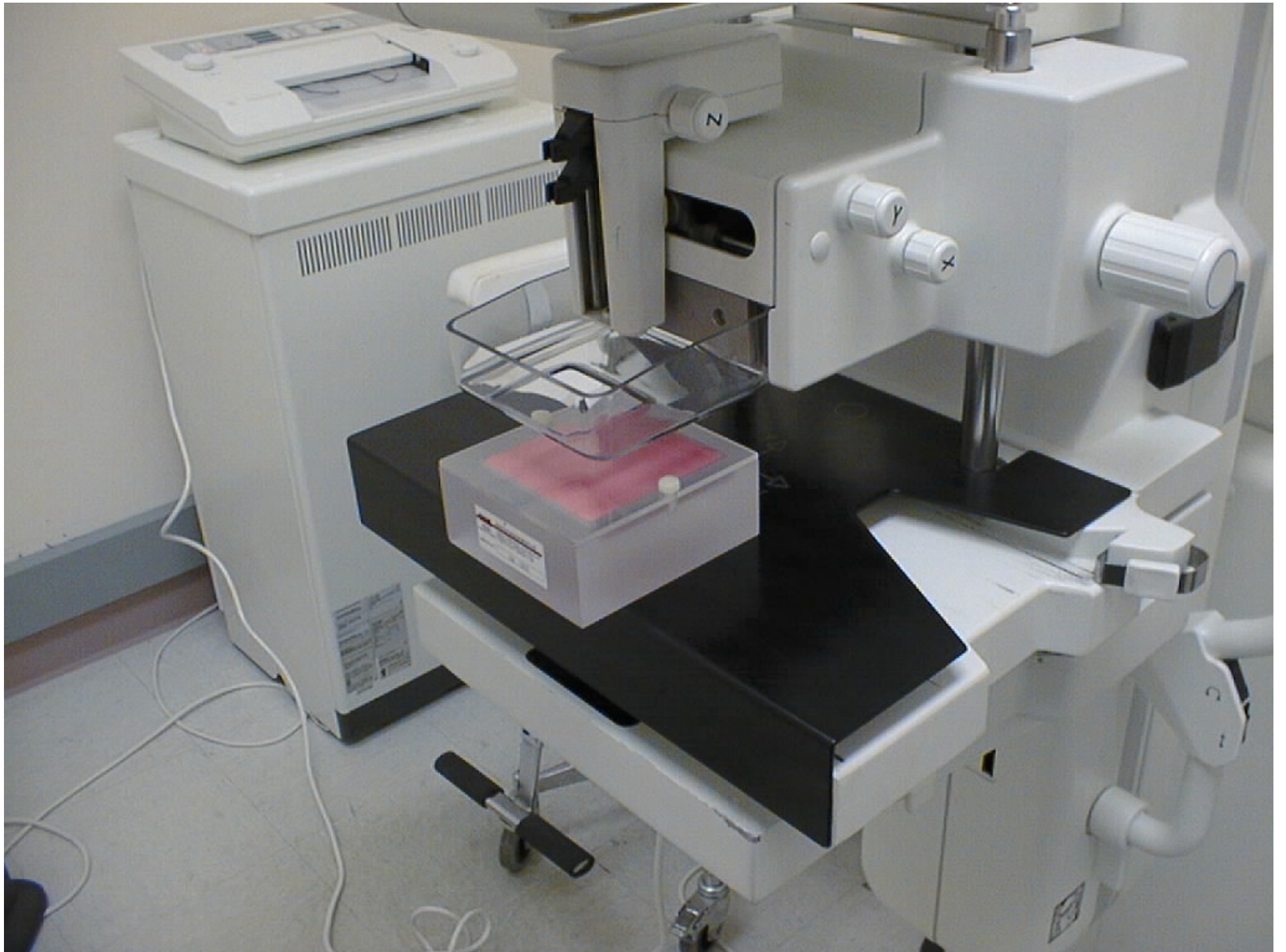


# Methods of Imaging Guided Breast Biopsy

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



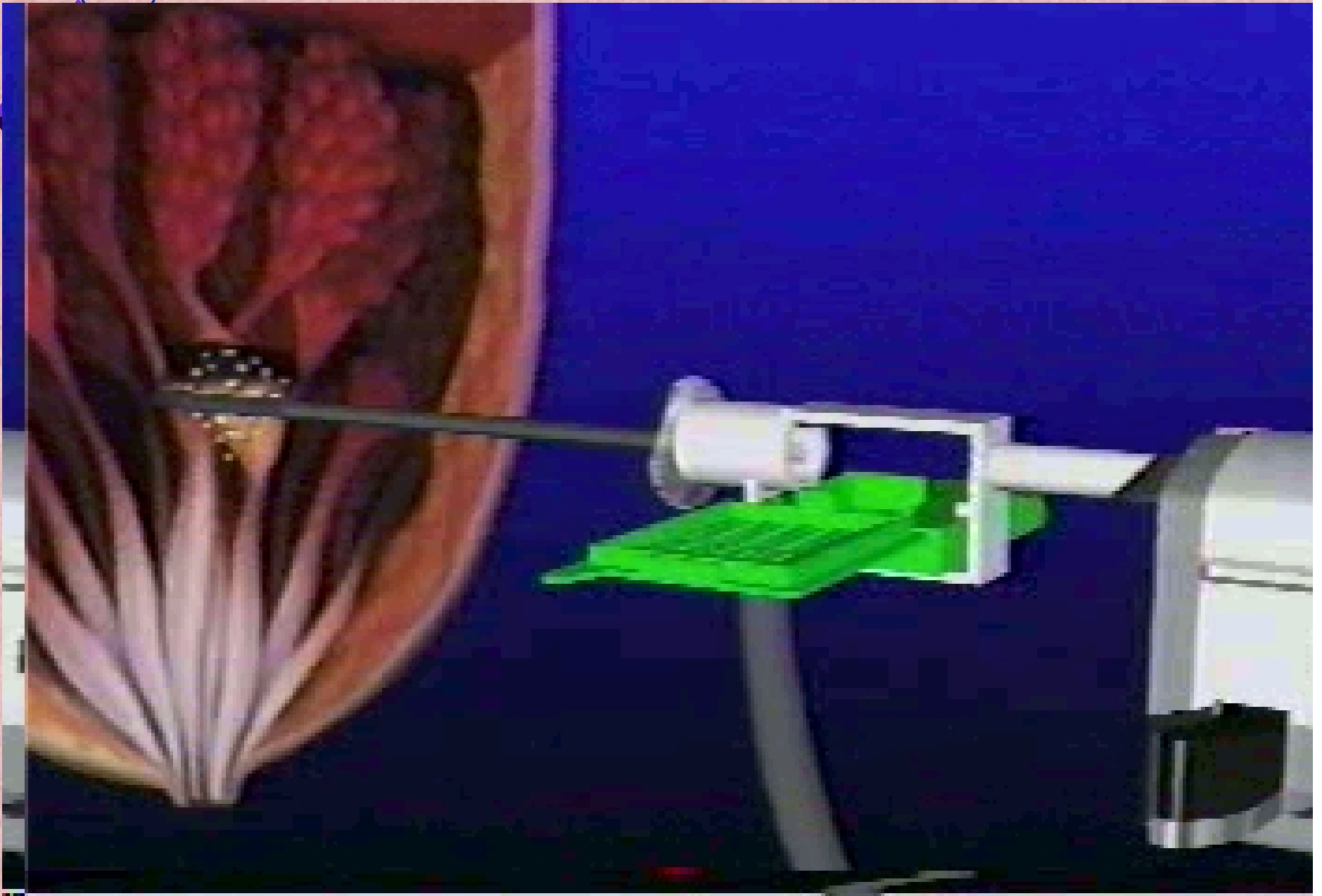








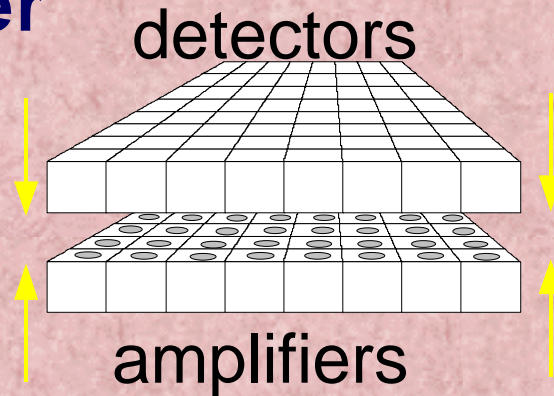
# Core Biopsy



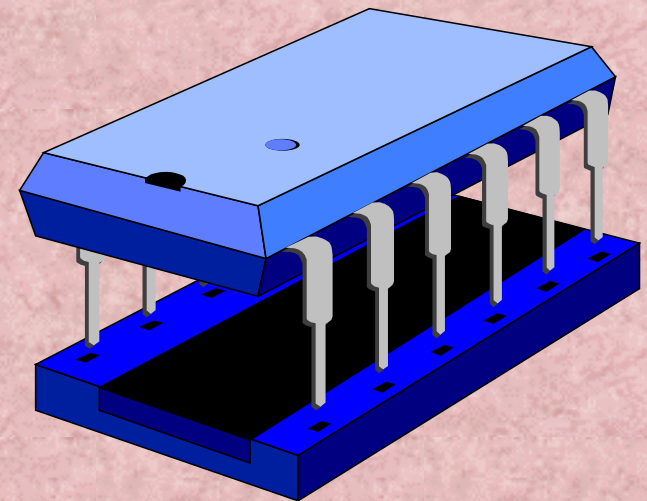
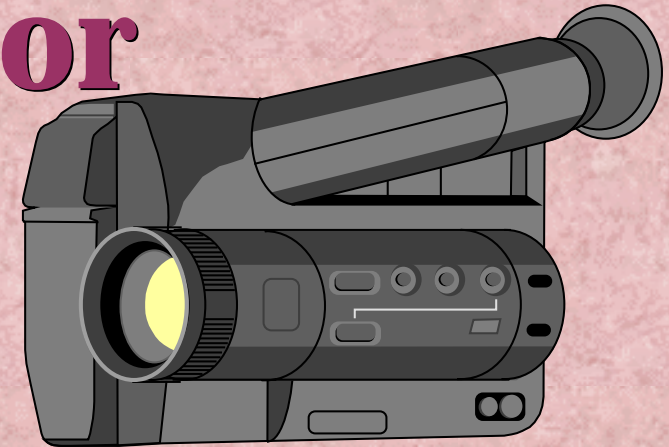


# The CCD Image Receptor

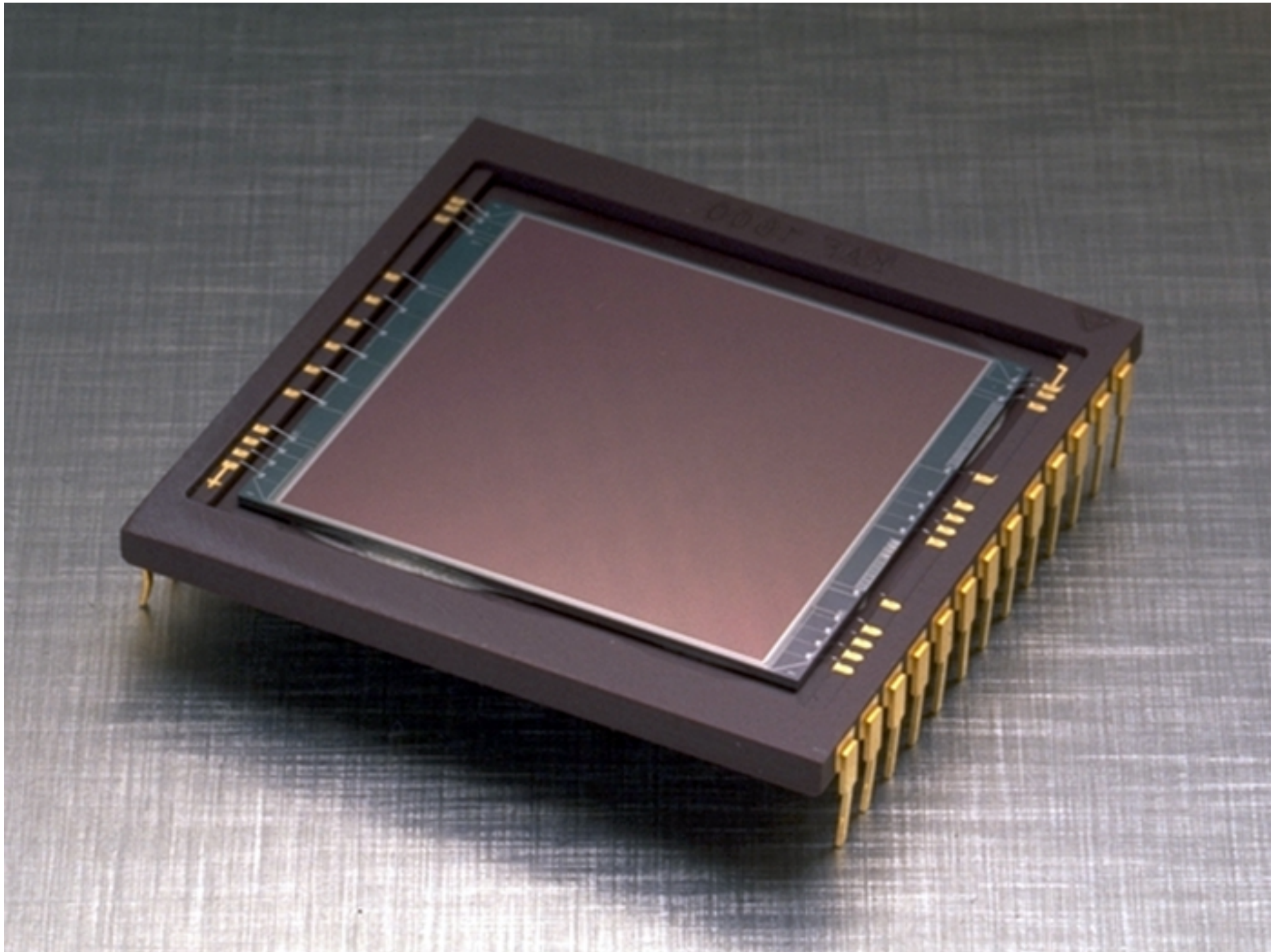
- ◆ Charge-Coupled Device
- ◆ An integrated circuit (chip) silicon wafer



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

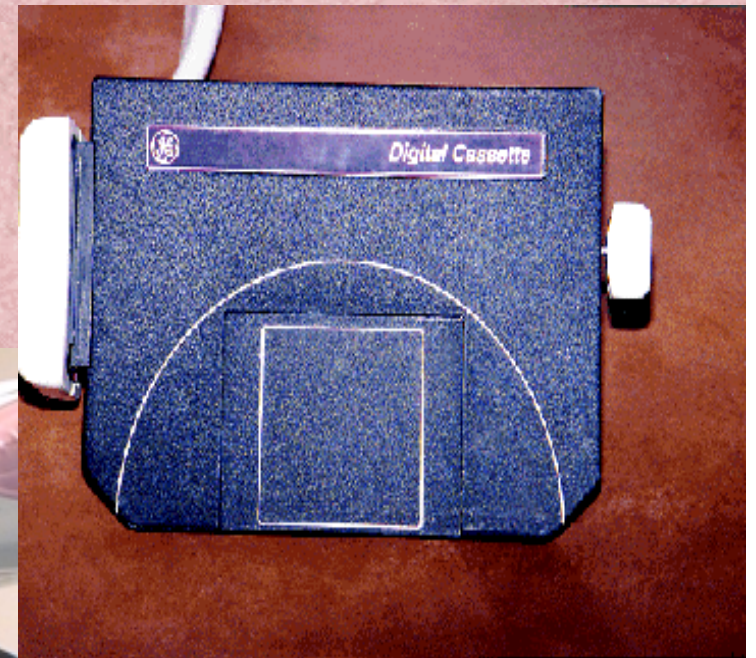
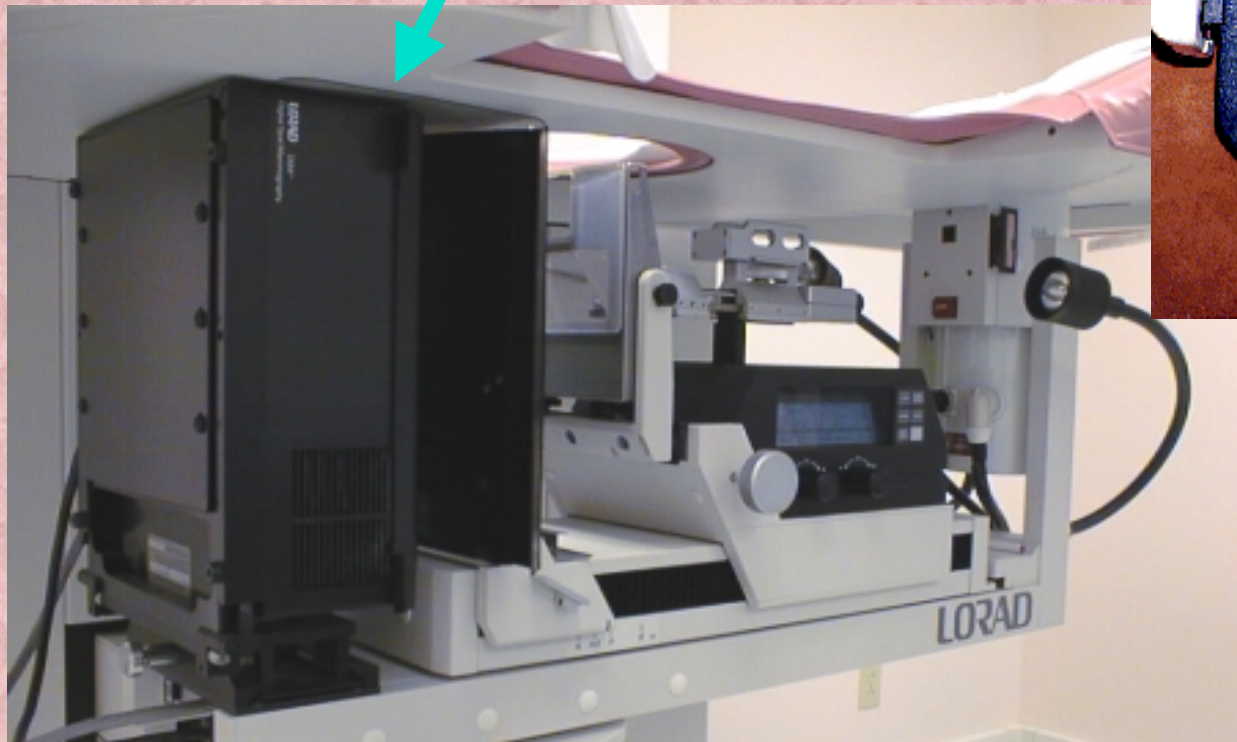






# CCD Image Receptors

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



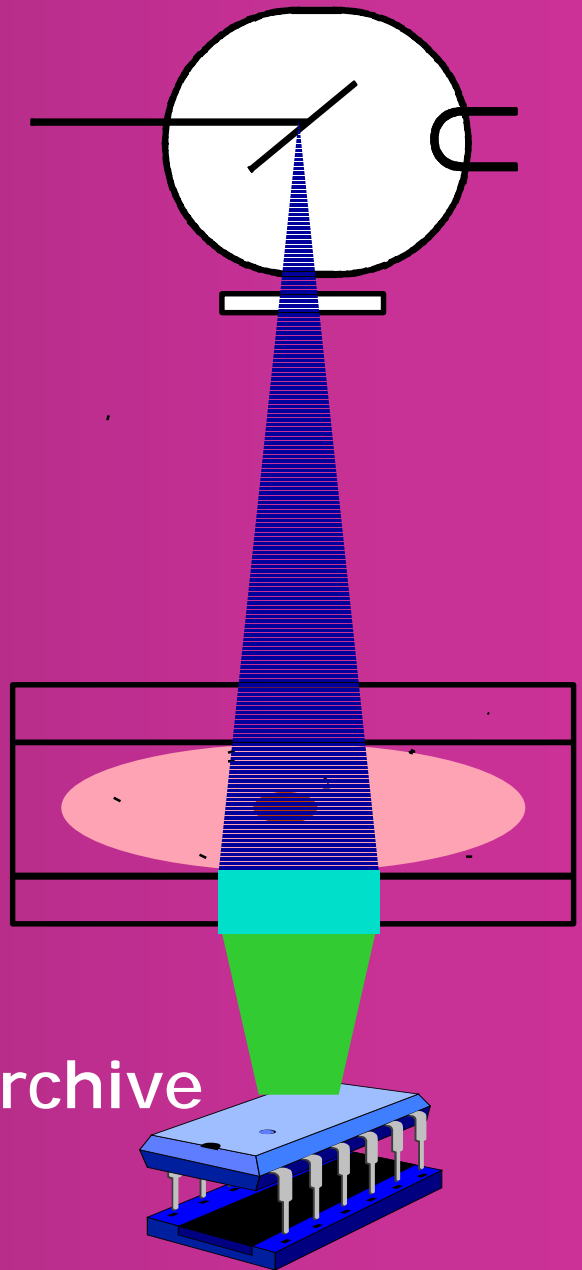
**Conventional x-ray exposure creates an aerial image**

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

**Minify light image to CCD size**

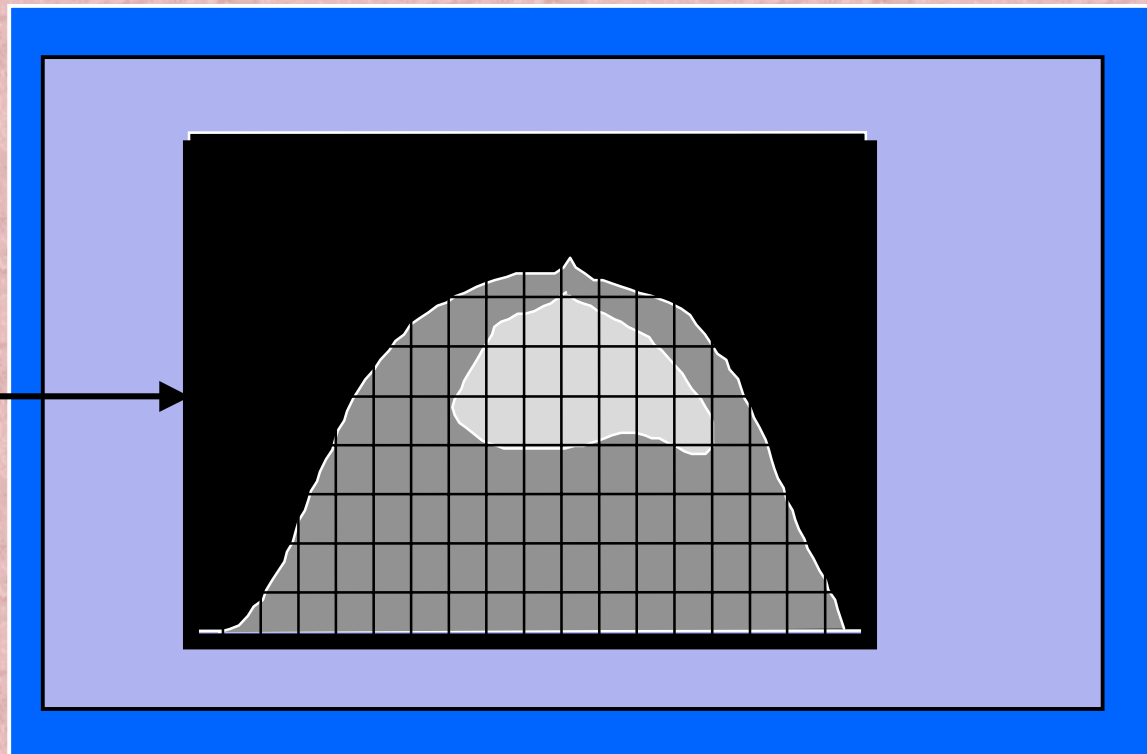
**Readout CCD to computer**

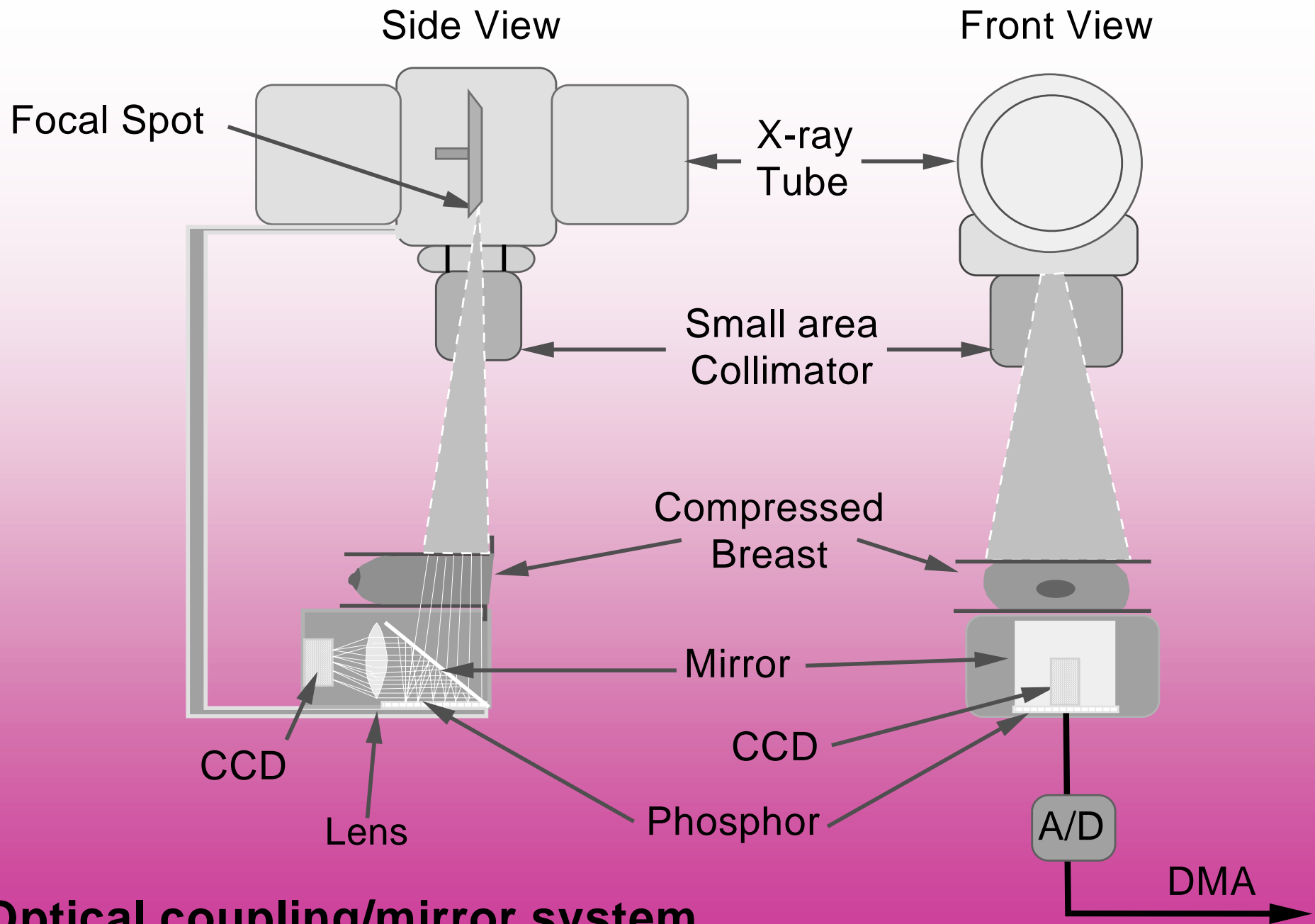
**Display, manipulate, archive digital image**



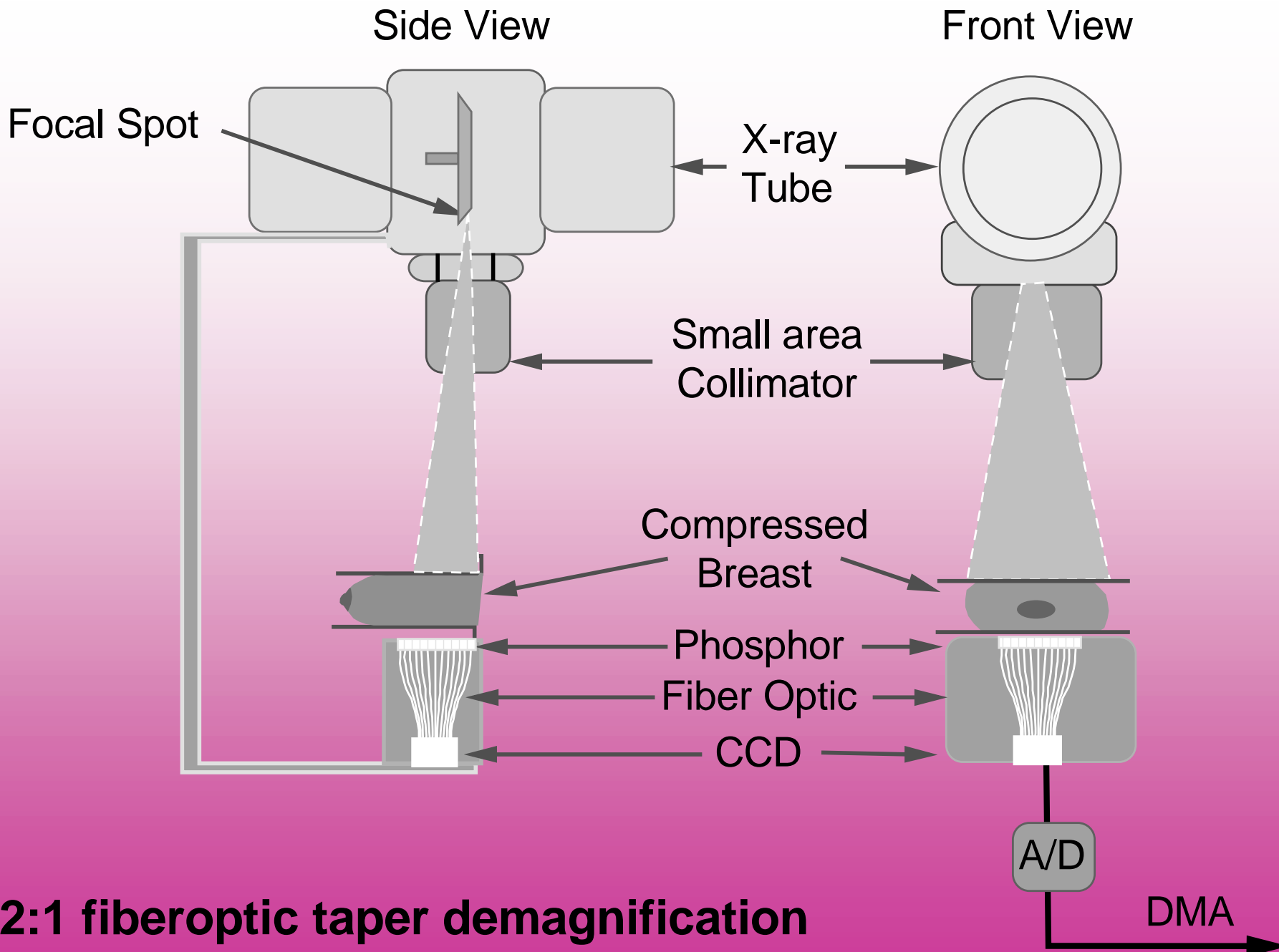


**Light  
sensitive  
region**





**Optical coupling/mirror system**  
**Light reflection from phosphor**

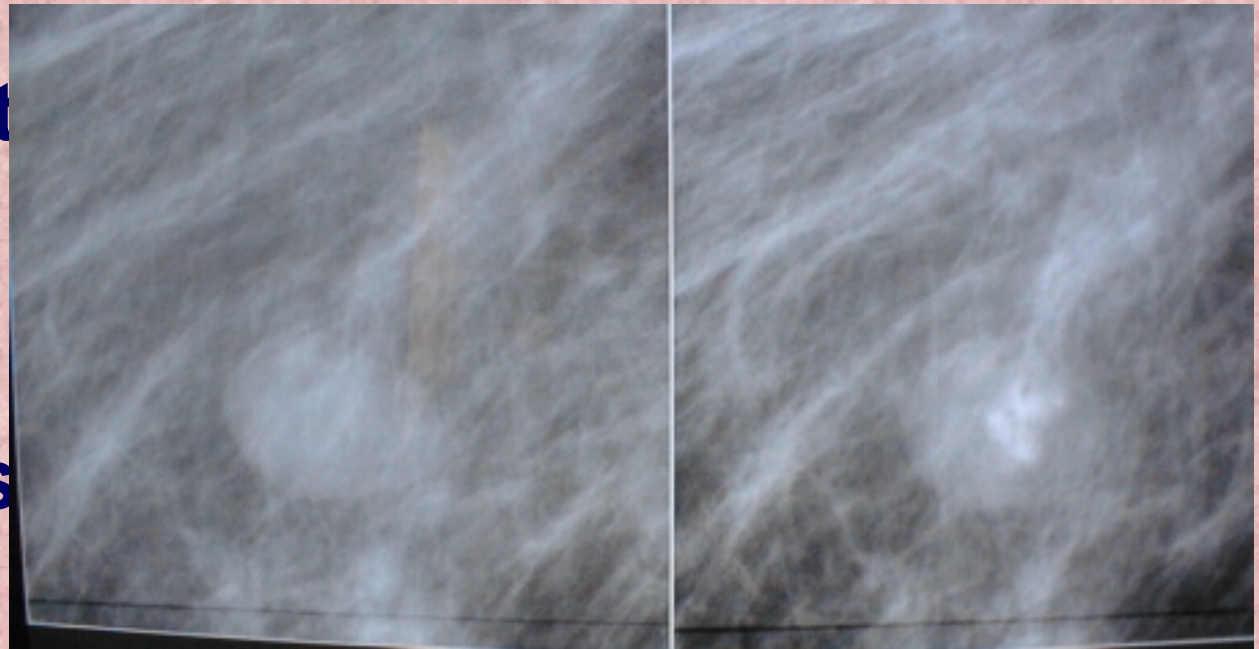


**2:1 fiberoptic taper demagnification**  
**Light transmission through phosphor**



# Digital Image Quality

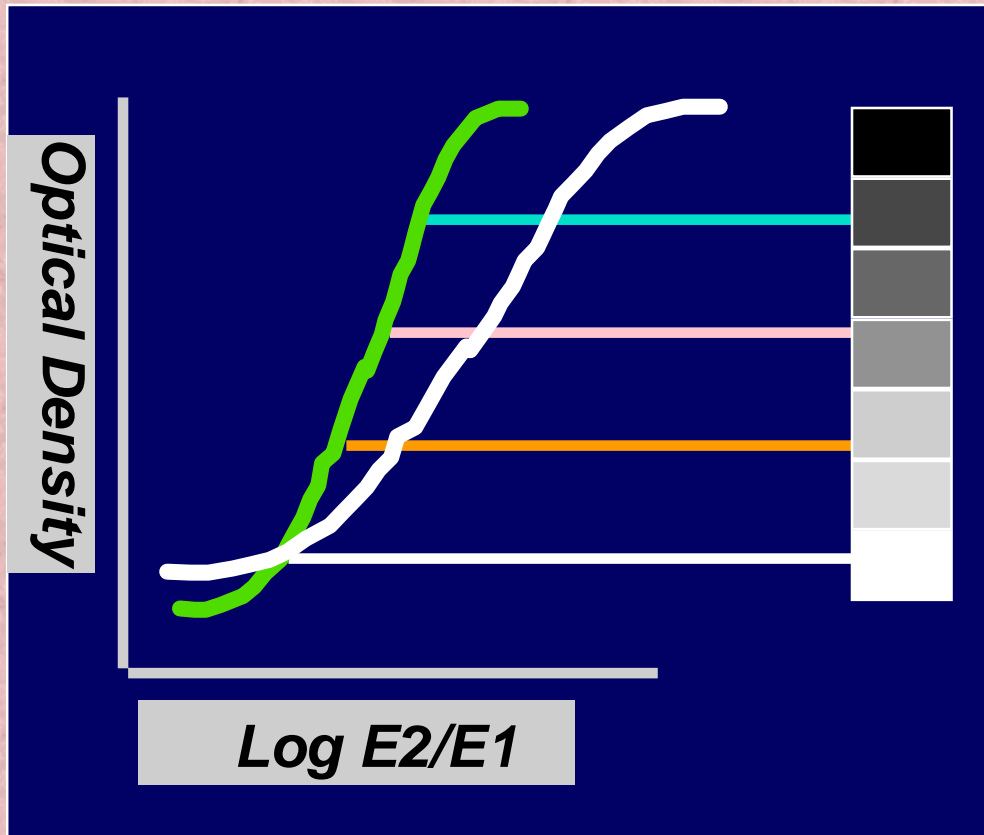
- ◆ Contrast
- ◆ Blur
- ◆ Noise
- ◆ Artifacts
- ◆ Dose





# Contrast

Completely adjustable by the user

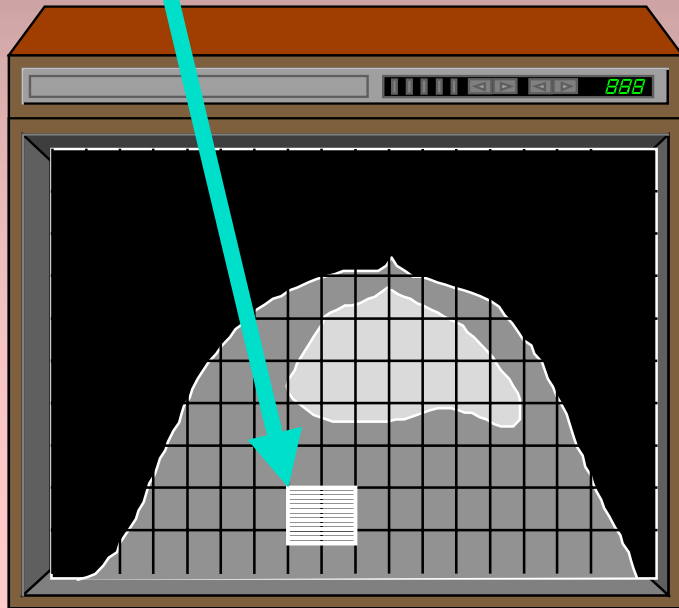




# Image Blur

## Image Matrix

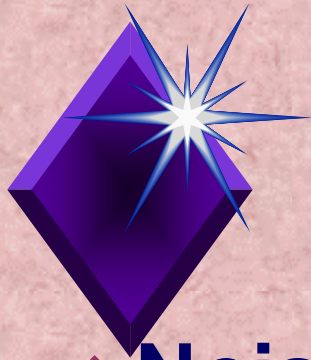
- ◆ 50 mm field of view
- ◆ 1,024 x 1,024 pixels
- ◆ ~0.05 mm per pixel
- ◆ Objects may not be centered on pixel



## 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**

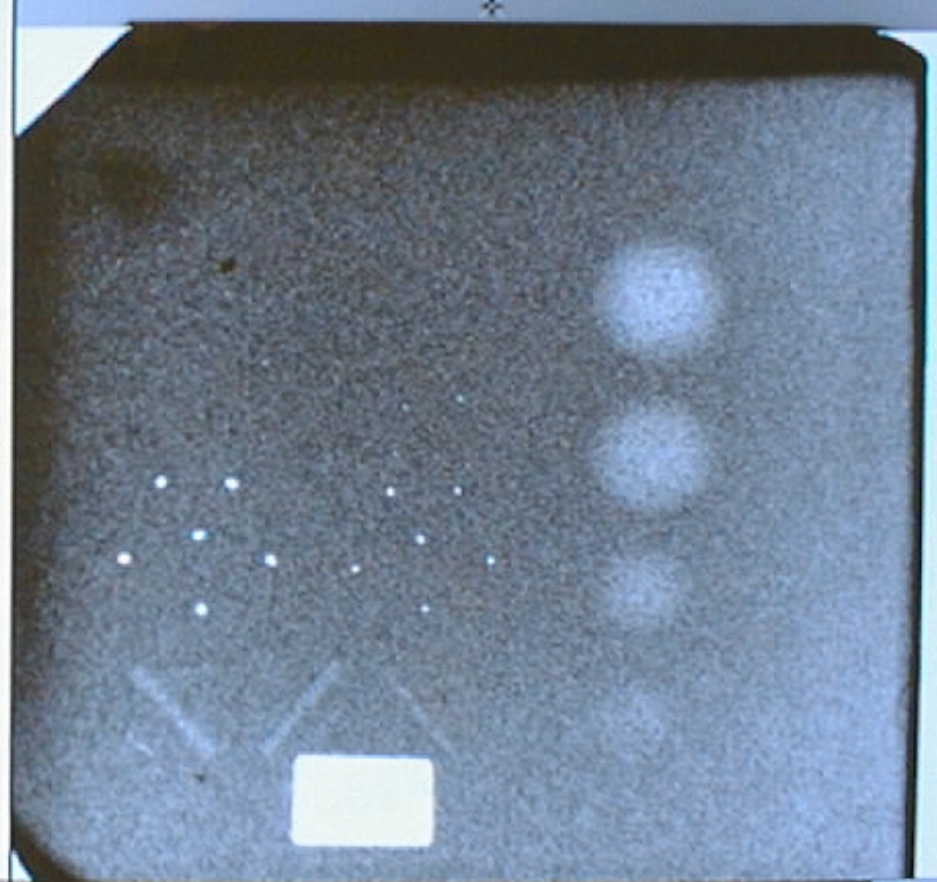
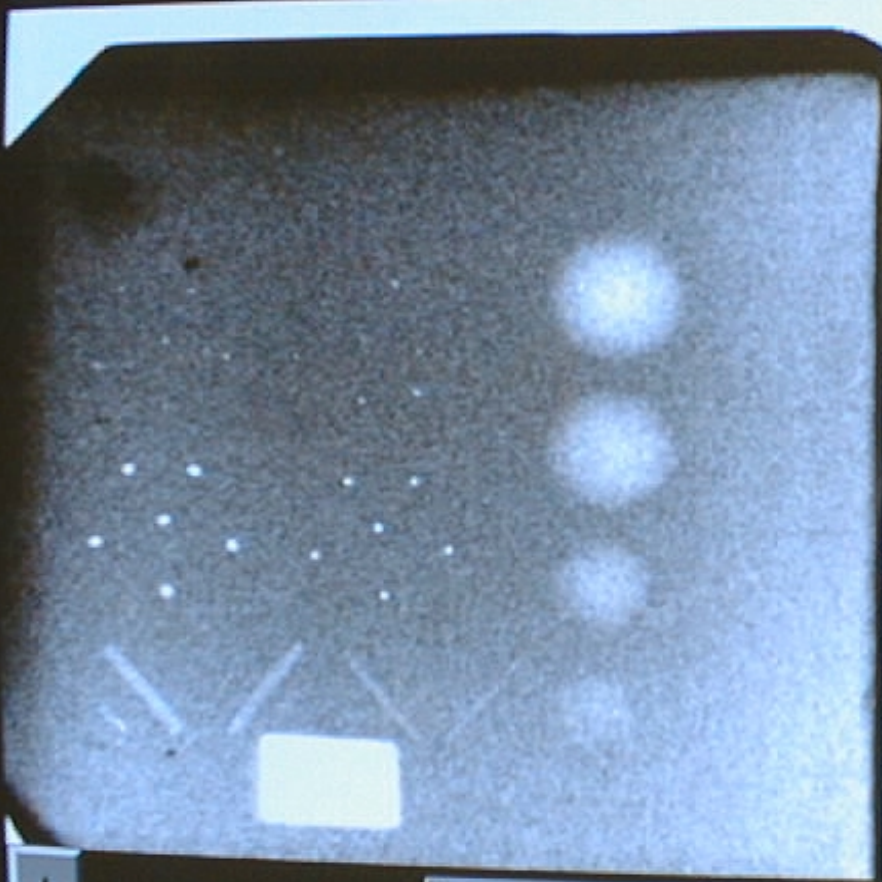
Pt. ID : 99  
Pt. Name: Phantom  
Operator: Inage\_Noise  
Comment :

kUp: 28  
Exp: 2.5  
mAs: 200.0

Date: 09/24/98 Pt. ID : 99  
Time: 09:00:45 Pt. Name: Phantom  
Mode: S12 Operator: Inage\_Noise  
View: ? Comment :

kUp: 28  
Exp: 1.2  
mAs: 96.0

Date: 09/24/98  
Time: 09:00:08  
Mode: S12  
View: ?



Stereo Tools Filter Invert Zoom Bag Window/Level

Pt. ID : 99  
Pt. Name: Phantom  
Operator: Image\_Noise  
Comment :

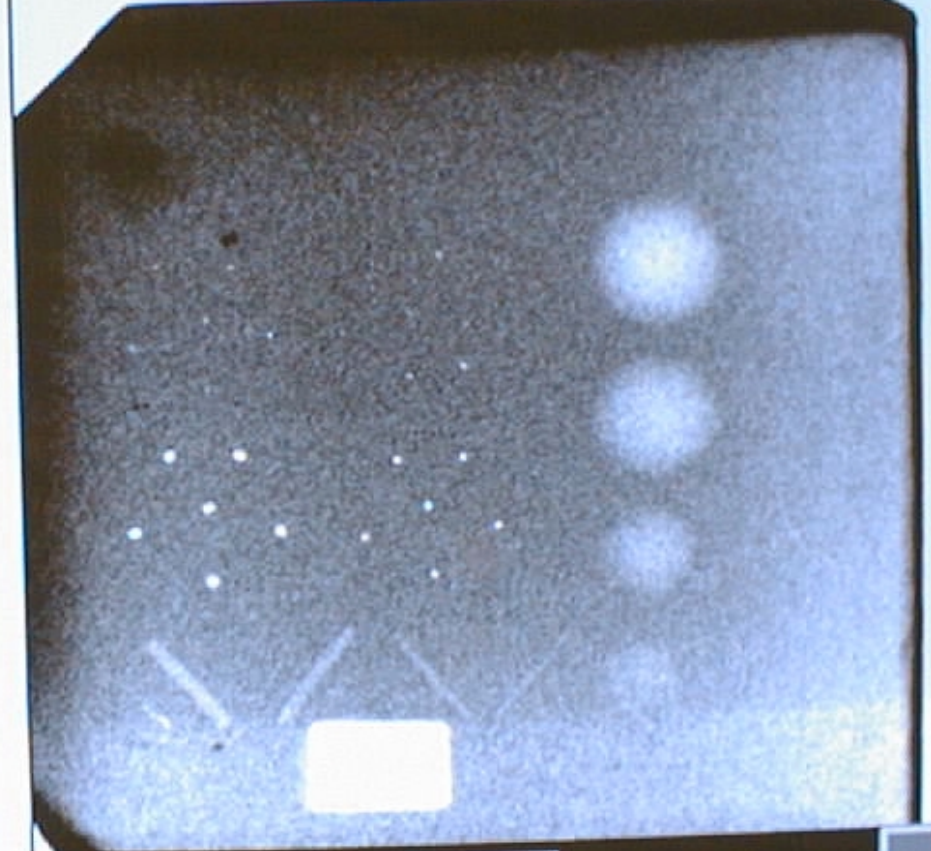
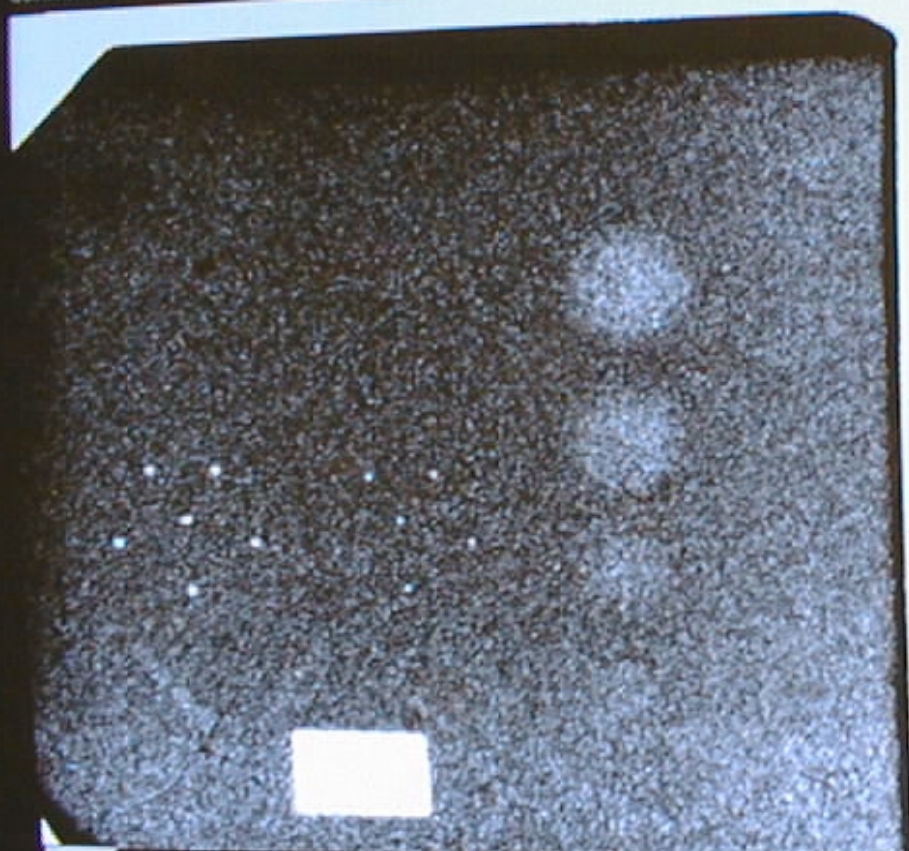
kUp: 28  
Exp: 0.2  
mAs: 16.0

Date: 09/24/98  
Time: 08:59:28  
Mode: S12  
View: ?

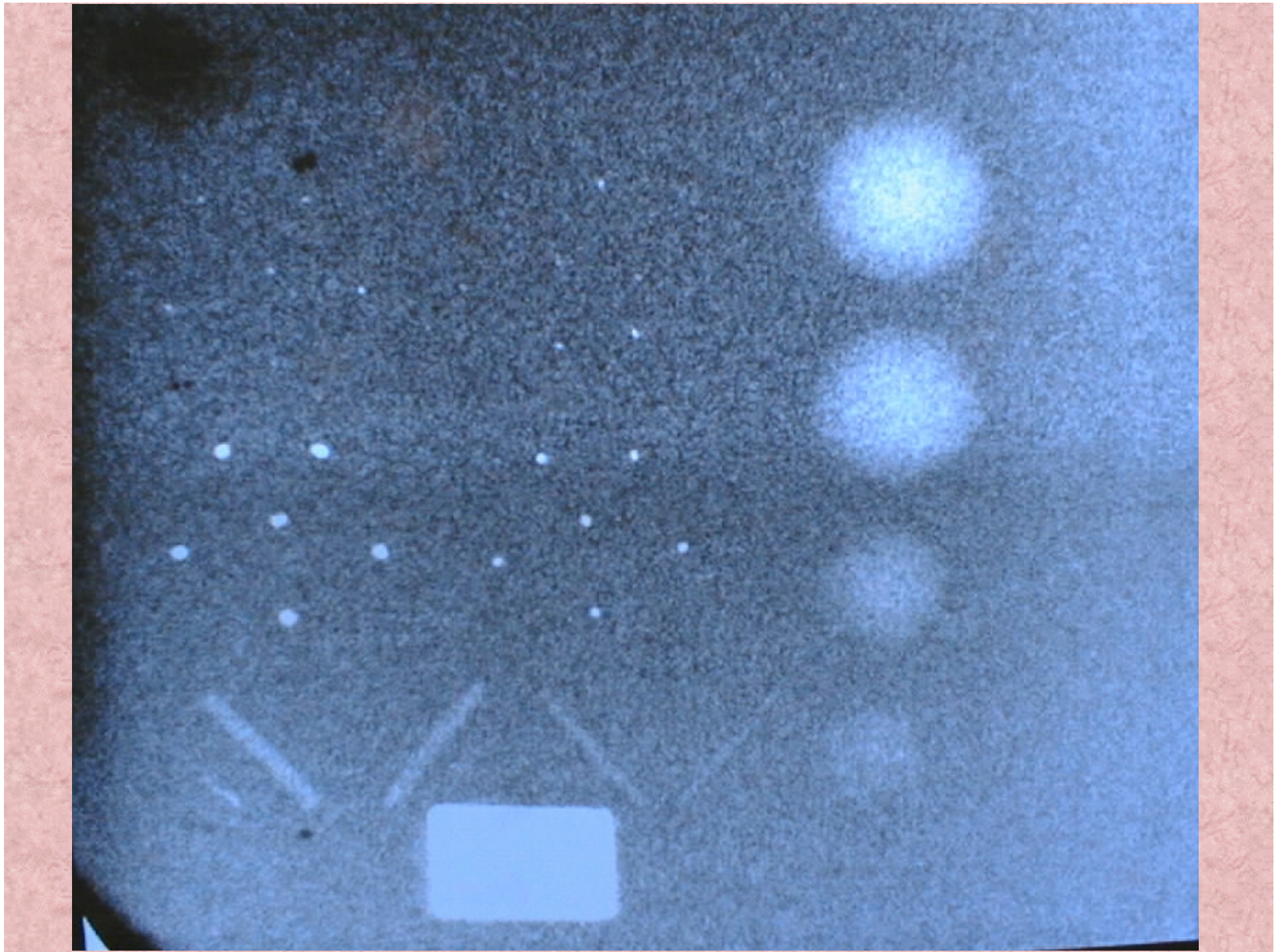
Pt. ID : 99  
Pt. Name: Phantom  
Operator: Image\_Noise  
Comment :

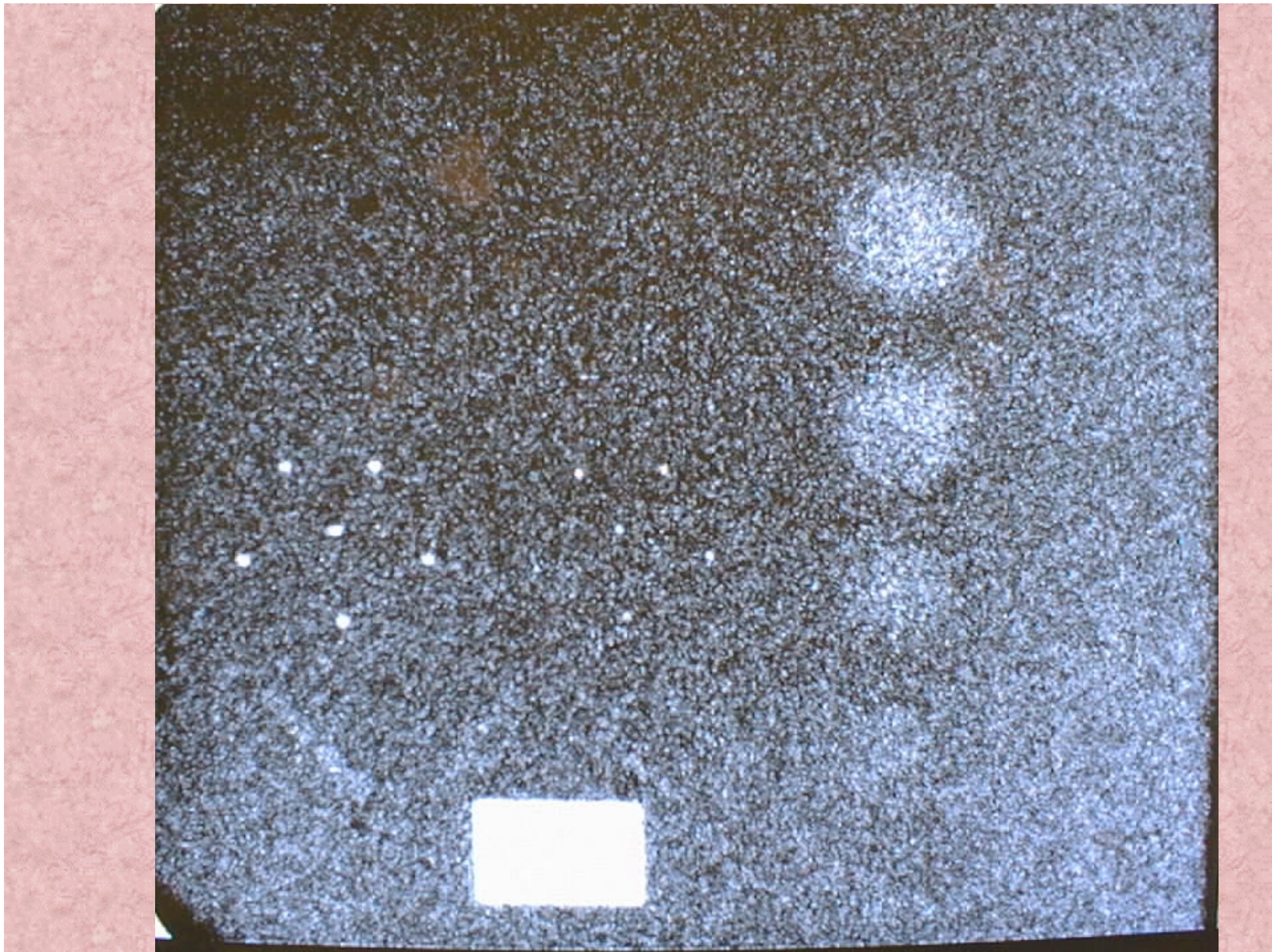
kUp: 28  
Exp: 2.5  
mAs: 200.0

Date: 09/24/98  
Time: 09:00:45  
Mode: S12  
View: ?



▲ Stereo Tools Filter Invert Zoom Bag 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**



~~Revised 500 T~~

Mammography  
Rm. No. \_\_\_\_\_

Phototimer Technique Chart  
Generator 500 T

Switched to Fuji film - <sup>1055</sup> <sub>1055</sub> <sup>1055</sup> <sub>1055</sub>

32

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.

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

Specimens  
22/16  
26/12

Special Techniques

Implant Displaced Views—  
Phototiming same as above chart

Specimens—

Manual Techniques for Implant Views

Breast size	Target	Filter	kVp	mAs
Small <3	moly	moly	26	50
Medium <sup>4+</sup> 5	moly	moly	28	80
Large 7.5	moly	moly	29	100

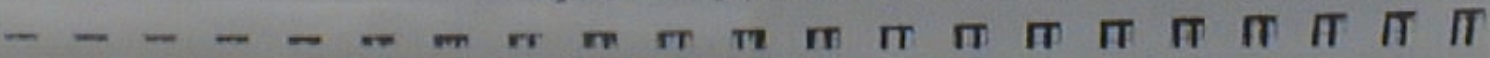
Apply minimal compression—enough to prevent motion.

Manual Technique Only

Breast size	Target	Filter	kVp	mAs
Small	moly	moly	22	16
Medium	moly	moly	23	20
Large	moly	moly	23	25

Specimens must be compressed

Figure 2. Mammography Phototimer Technique Chart



PATIENT ENTRANCE SKIN EXPOSURE FOR: Room 6 Mammo Senographe 500Data 500  
Pt. Thkns SID M.G.Dose Bucky Gap  
22  
0  
12/24  
Specimens

Mammography Quality Control Manual (rev. 04/1)

# **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 1<sup>st</sup> 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

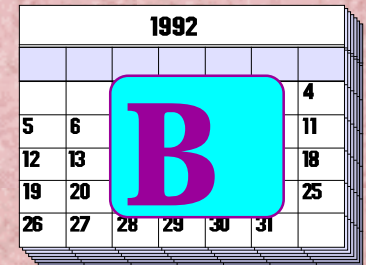


# **QC Tests Unique to SBB**

## **Minimum Testing Frequencies**

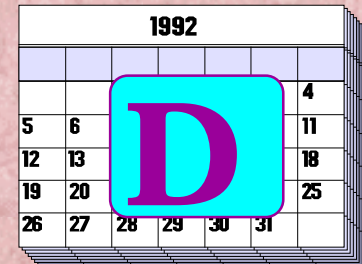
<b>Zero Alignment Test</b> (only on some units)	<b>Before each patient</b>
<b>Localization Accuracy Test (in Air)</b>	<b>Daily</b>
<b>Phantom Image Quality Test</b>	<b>Weekly</b>
<b>Hardcopy Output Quality</b> (if hard copy is produced from digital data)	<b>Monthly</b>
<b>Visual Equipment Check</b>	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

# Zero Alignment Test



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

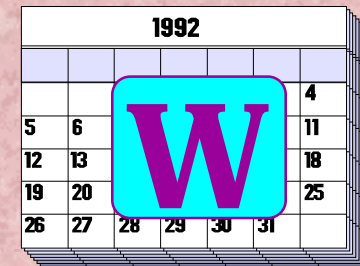
# Localization Accuracy



- ◆ 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
- ◆  $\pm 1.0$  mm sphere

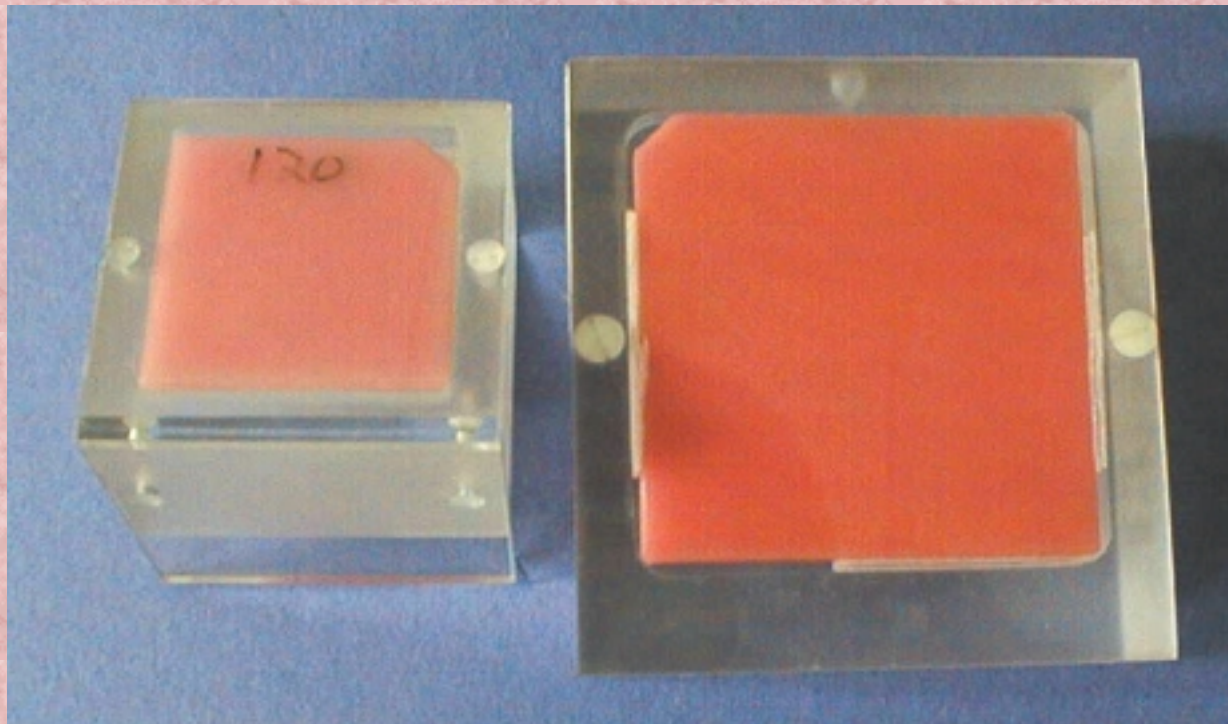
RT

# Phantom Image Quality Evaluation



**Nuclear  
Associates Digital  
Mini Phantom**

**Mammography  
Accreditation  
Phantom**



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

# Minimum Passing Phantom Image Scores

	ACR-MAP	Accreditation Phantom	Mini-Phantom
	Screen/film	Digital	Digital
	Fibers	4.0	5.0
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)

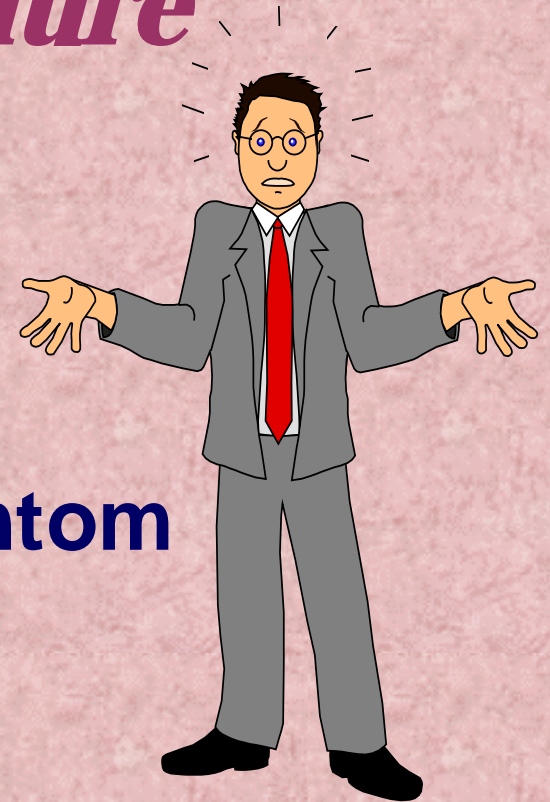
- ◆ **Mammo Accreditation Phantom**

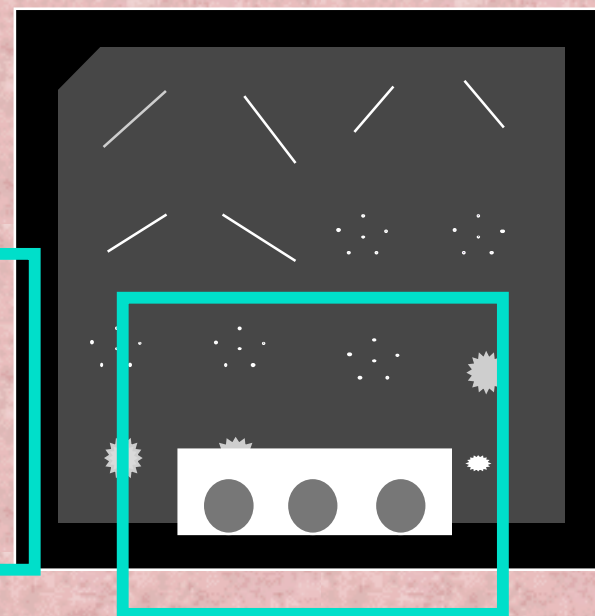
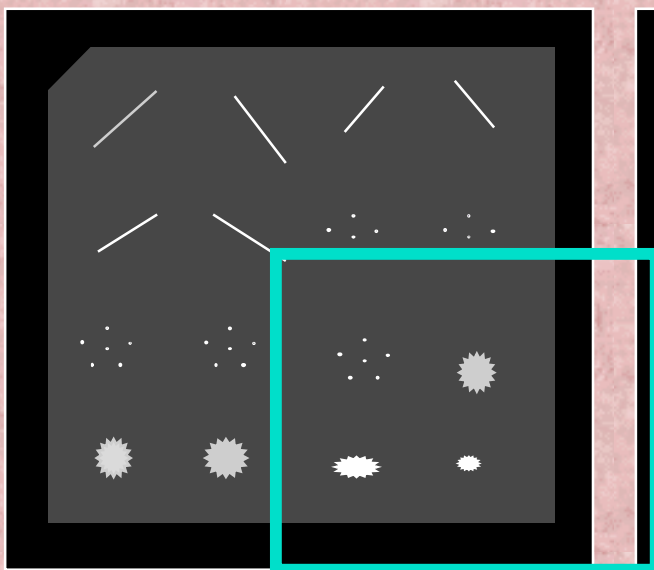
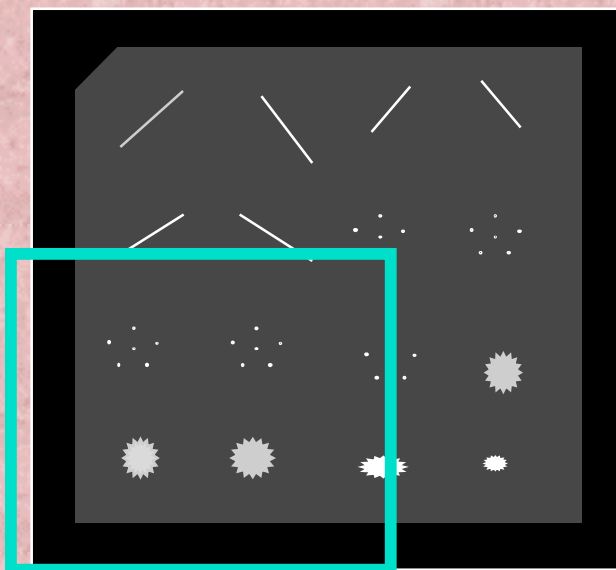
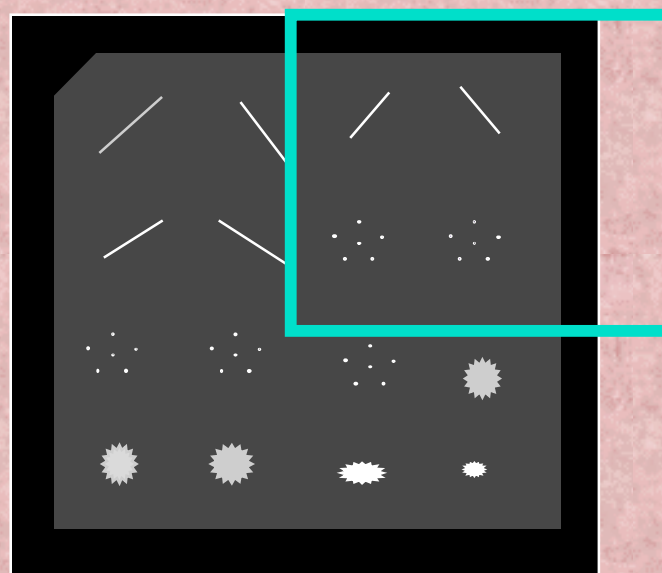
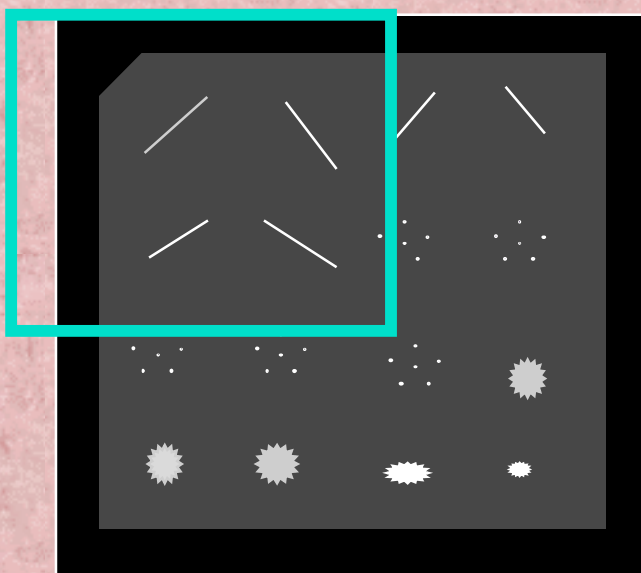
  - 4 images for image quality

  - 5th image for TLD

- ◆ **OK to window/level digital images**

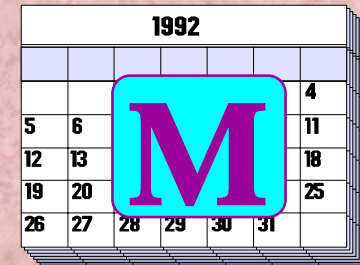
- ◆ **Use grid (or not) per clinical technique**







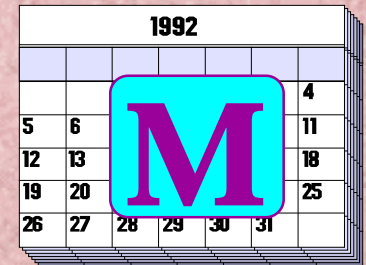
# Hardcopy Output Quality



- ◆ 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

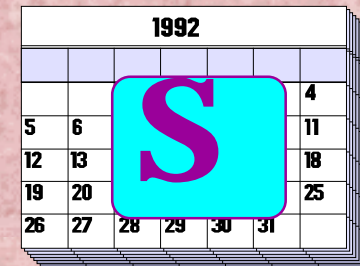


- ◆ Use ACR checklist or equivalent
- ◆ Lights, switches, motion, accessories
- ◆ Customize for your machine/room
- ◆ Documentation (date, initials)



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

**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)**

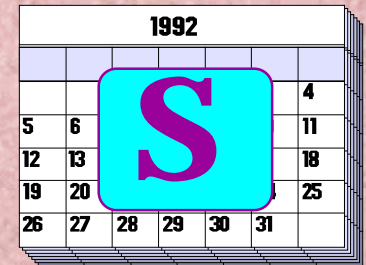
**Six month period**

**From \_\_\_\_\_ to \_\_\_\_\_**

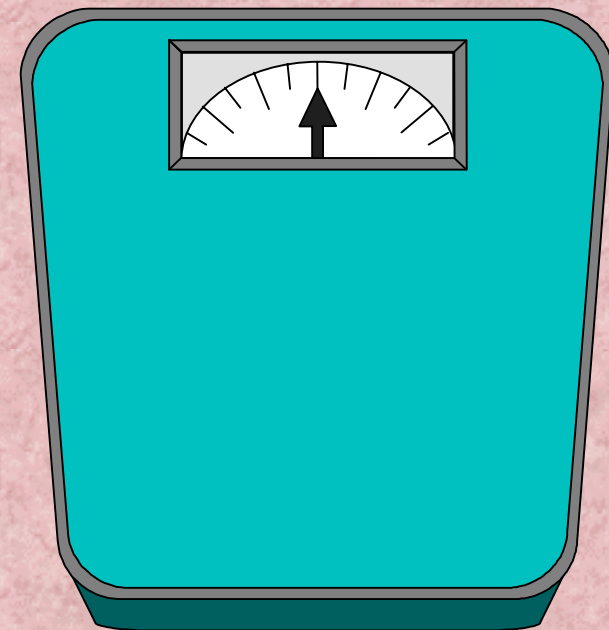
<b>Date</b>	<b>Pt ID</b>	<b>Minimum # Exposures</b>	<b>Actual # exposures</b>	<b># Repeats</b>	<b>RT</b>	<b>MD</b>	<b>Comments</b>

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

# 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



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

## TEST

## FREQUENCY

Darkroom Cleanliness  
processor QC

Daily

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

# Assembly Evaluation

- ◆ Image receptor slides smoothly into holder assembly
- ◆ Compressed breast thickness scale is accurate to  $\pm 0.5$  cm, reproducible to  $\pm 2$  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

# 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?

**KODAK MIN-R 2 Cassette**  
with C-1N window  
and KODAK MIN-R screen

Installation Date

Cassette Number

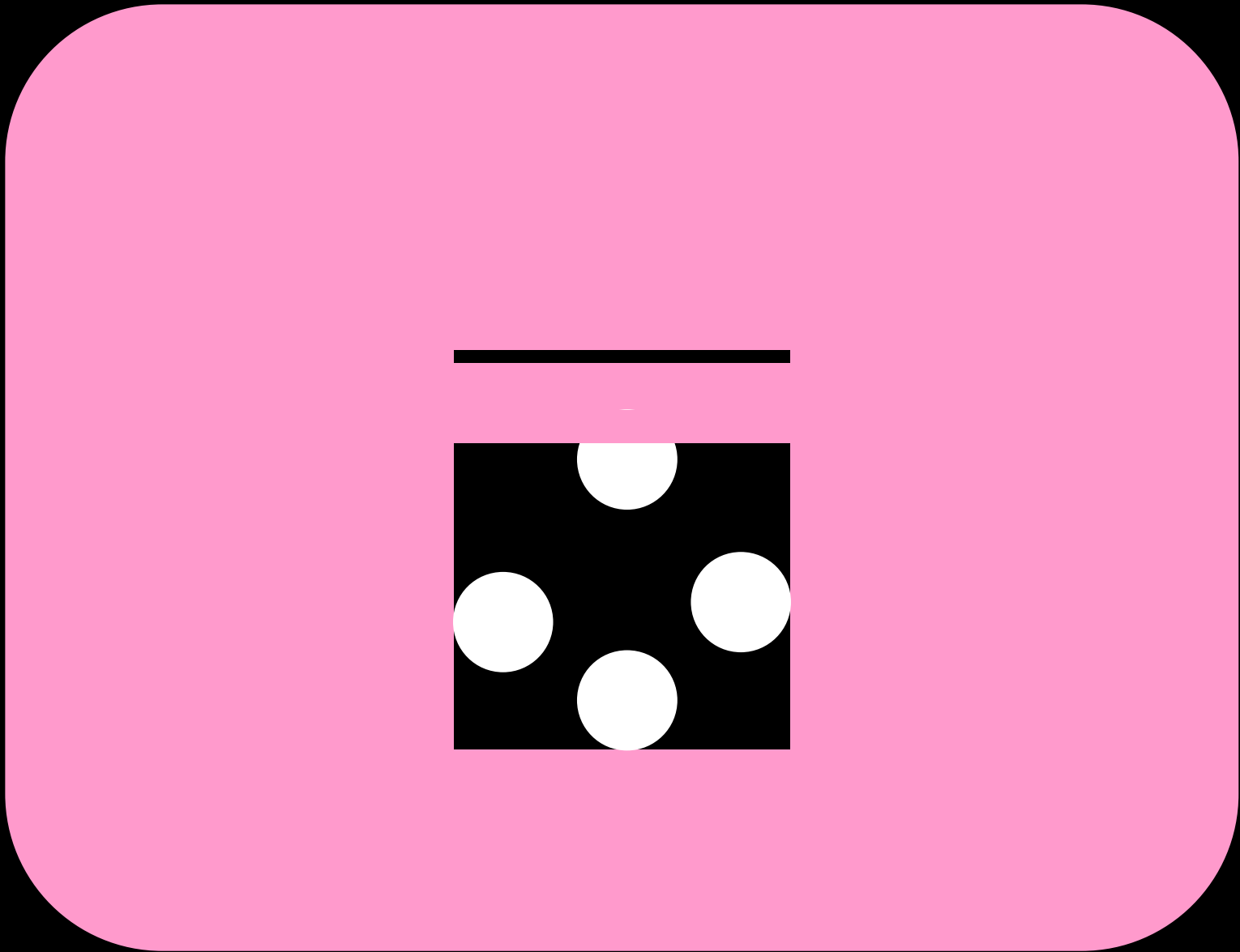
11-3-77 CGH

44

KCP 08531

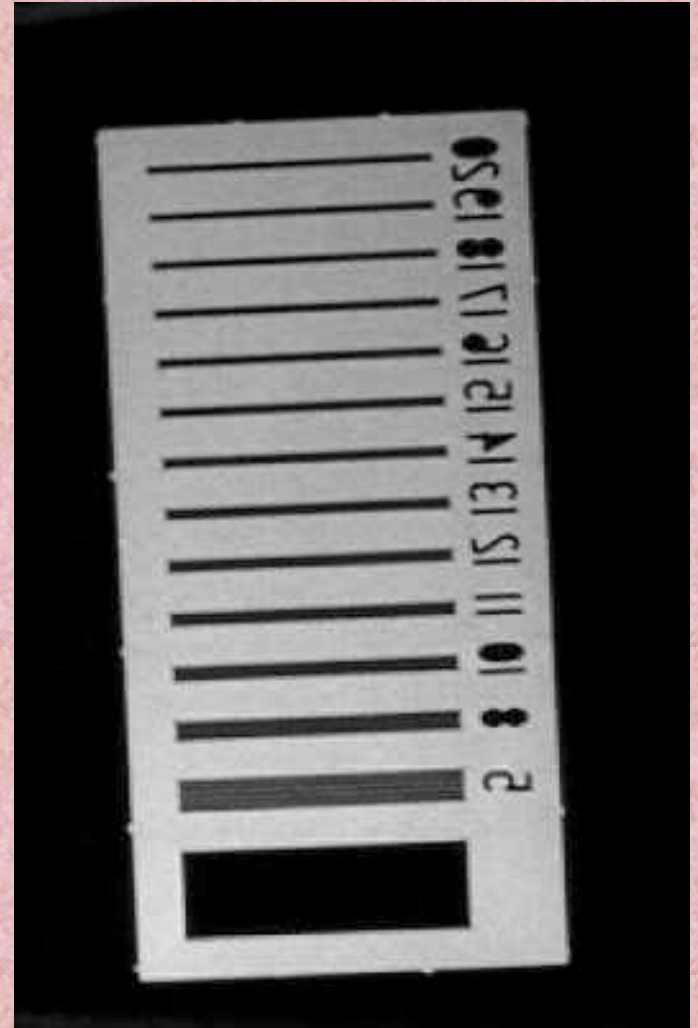
TM KODAK





# 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



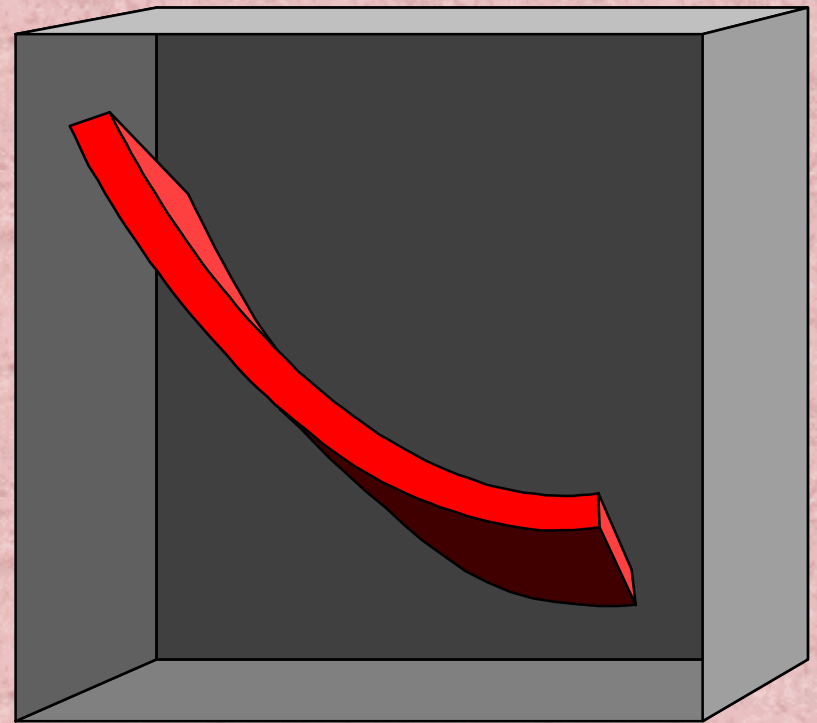
# kVp Accuracy - Reproducibility

- ◆ 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

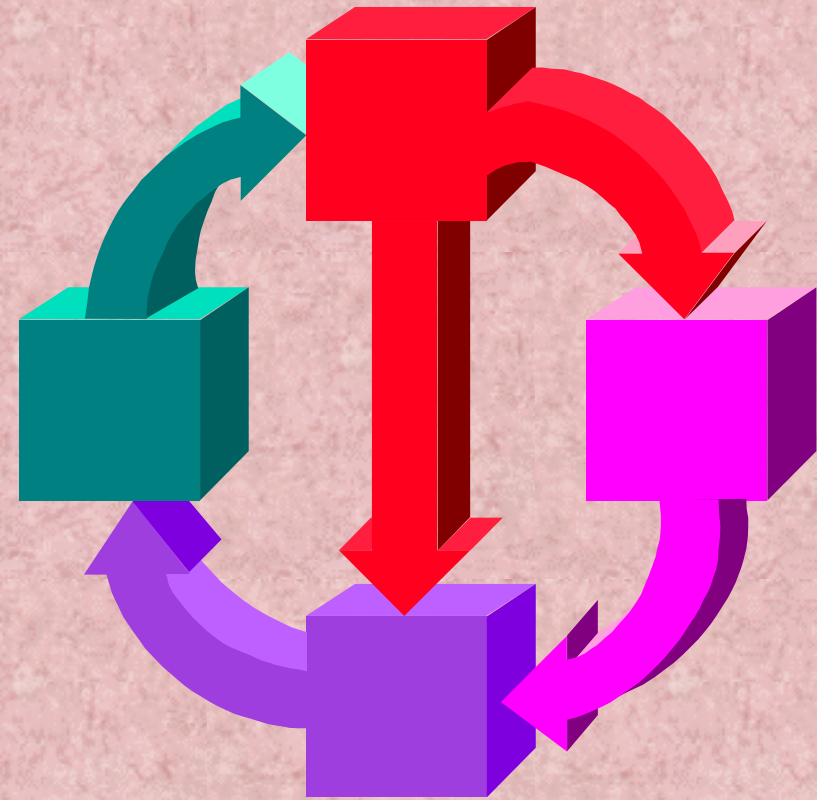


MP

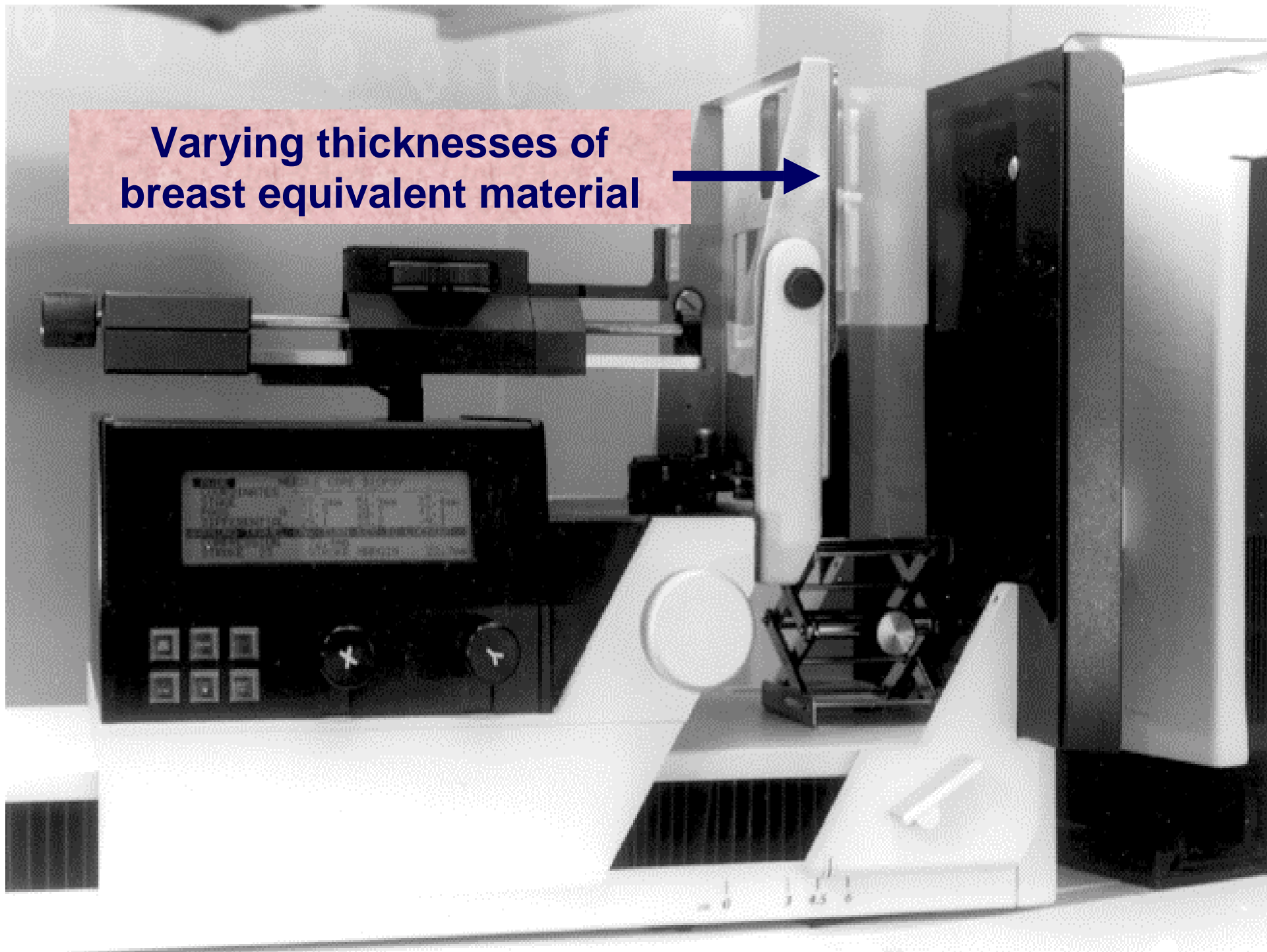


# AEC System Performance

- ◆ 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



**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*

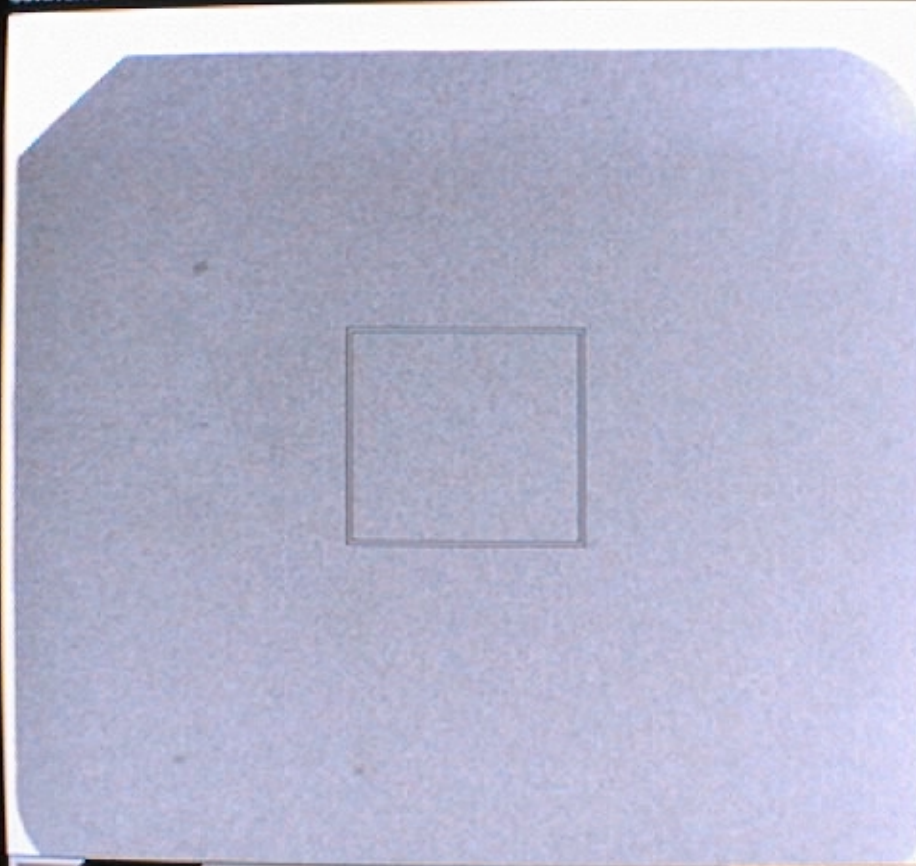
- ◆ Digital Systems

*Digital detector produces uniform signal values across the field of view*

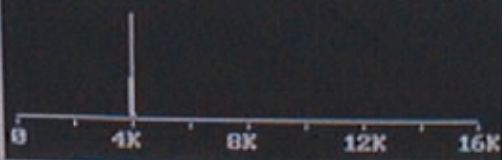
Pt. ID : 123  
Pt. Name: physcis\_survey  
Operator: rjp  
Comment :

kUp: 28  
Exp: 1.0  
mAs: 80.0

Date: 04/13/99  
Time: 11:20:34  
Mode: 512  
View: ?



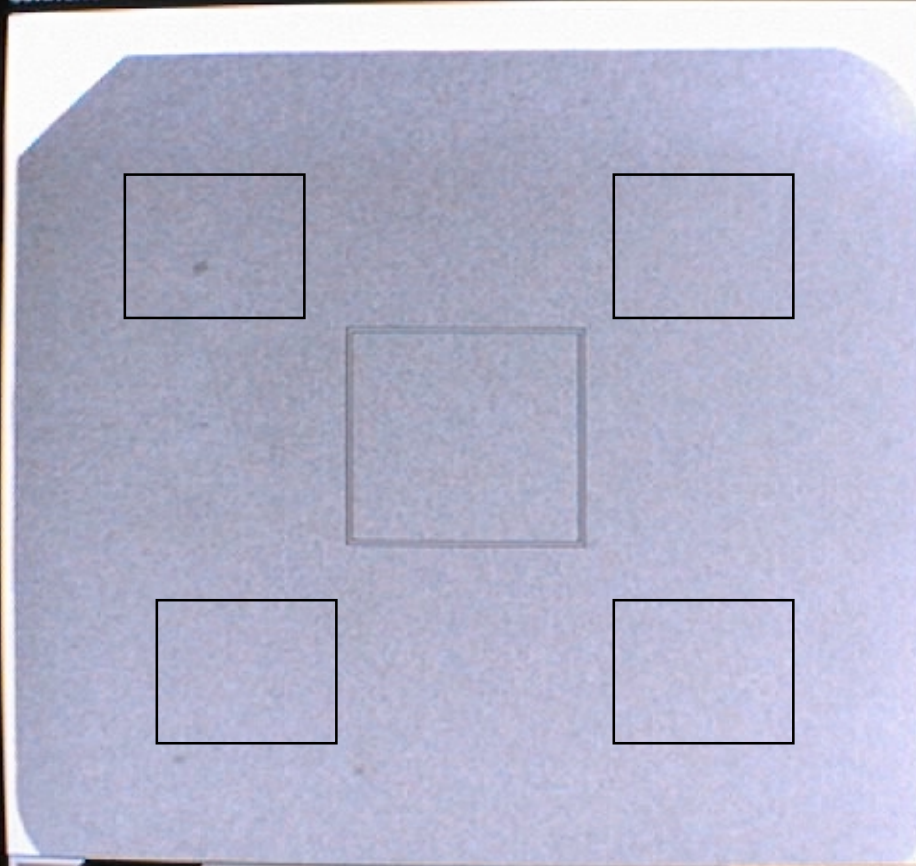
Size: 128 X 128      Ave: 4188  
Std Dev: 24.98      Min: 4020  
Sig Noise: 164.45    Max: 4288



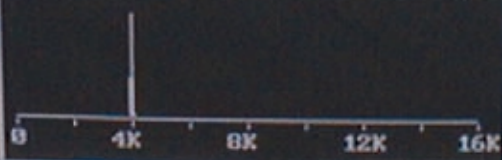
Pt. ID : 123  
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Date: 04/13/99  
Time: 11:20:34  
Mode: 512  
View: ?

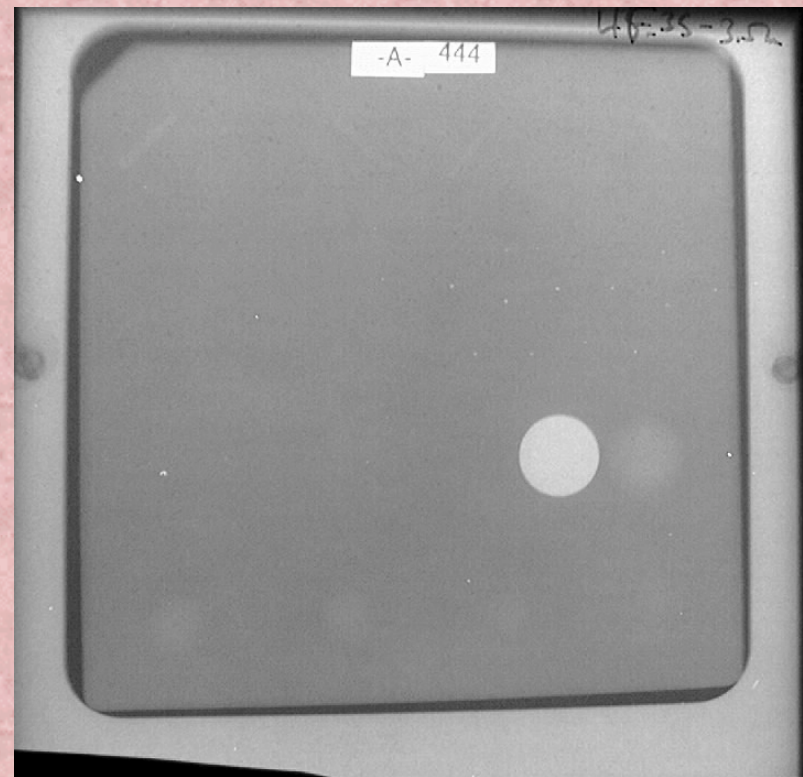


Size: 128 X 128      Ave: 4188  
Std Dev: 24.98      Min: 4020  
Sig Noise: 164.45      Max: 4288



# 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
- ◆  $AGD = ESE * DgN$
- ◆  $AGD < 300 \text{ mrad}$
- ◆ Dose and Optical Density



# Artifact Evaluation

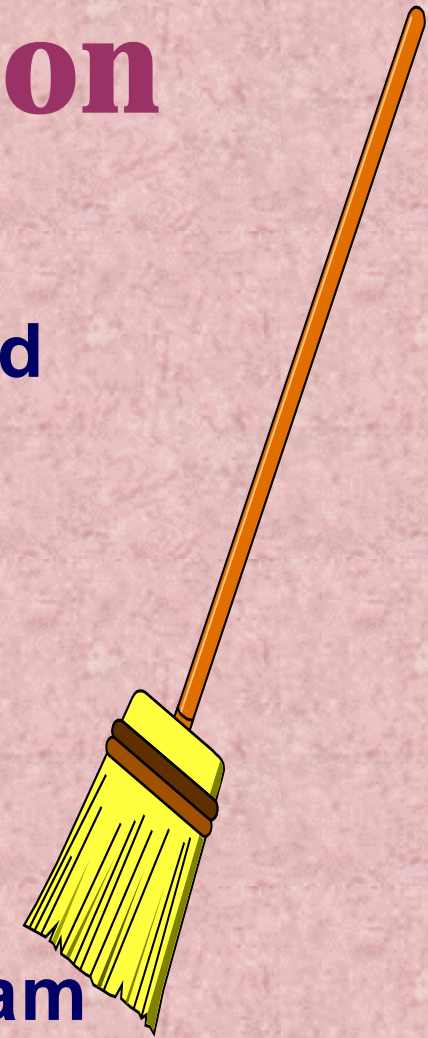
**Unwanted irregularity not caused  
by structures of interest**

**Causes (Digital)**

**Digital Image Receptor**

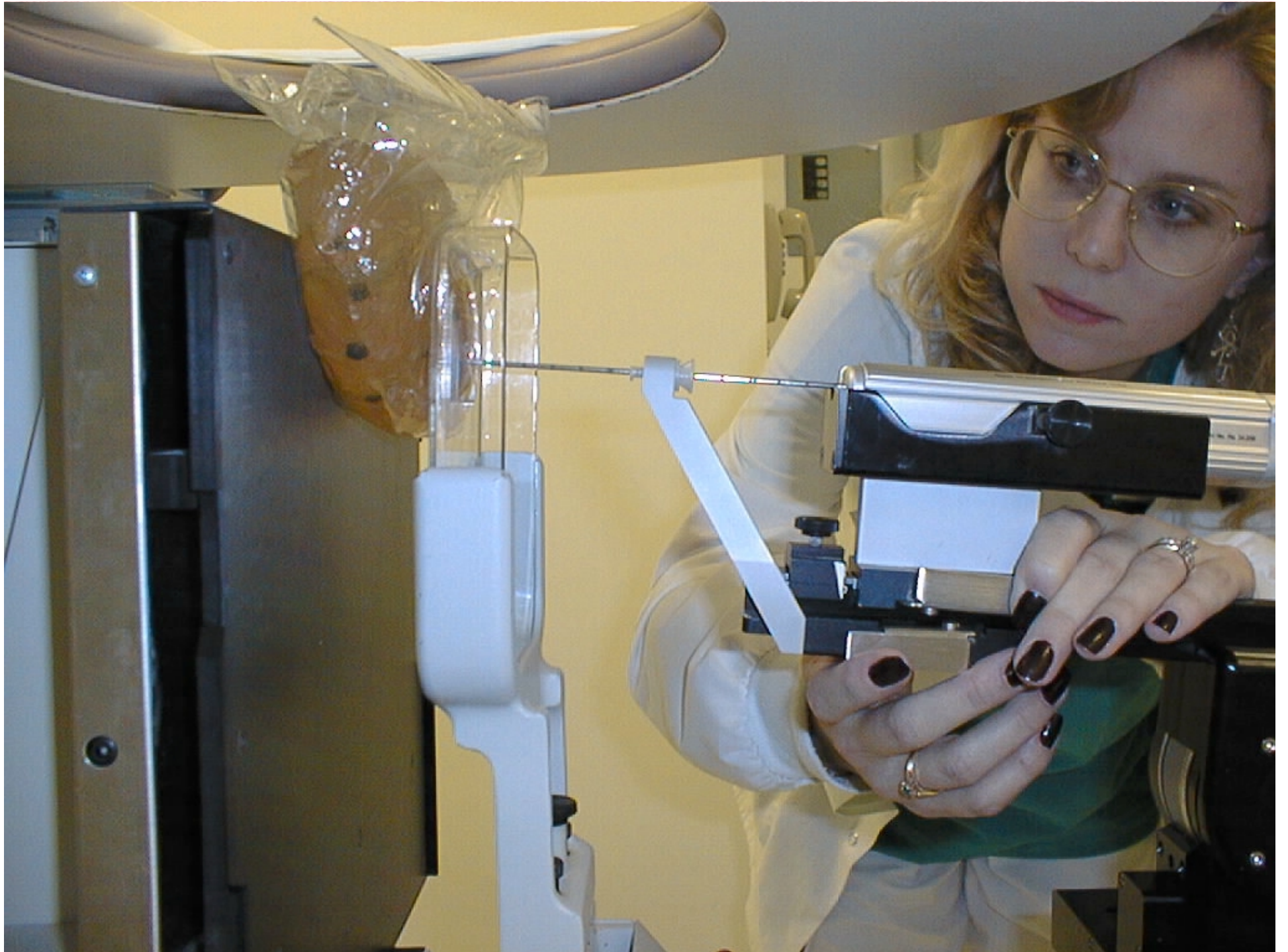
**Common Causes**

**Unwanted objects in x-ray beam**



# Targeting Accuracy

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



# QC Program Review

*For all Technologist QC Tests*

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

# **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**