FUJIFILM

Value from Innovation

The Making Of A Good Digital Radiographic Image

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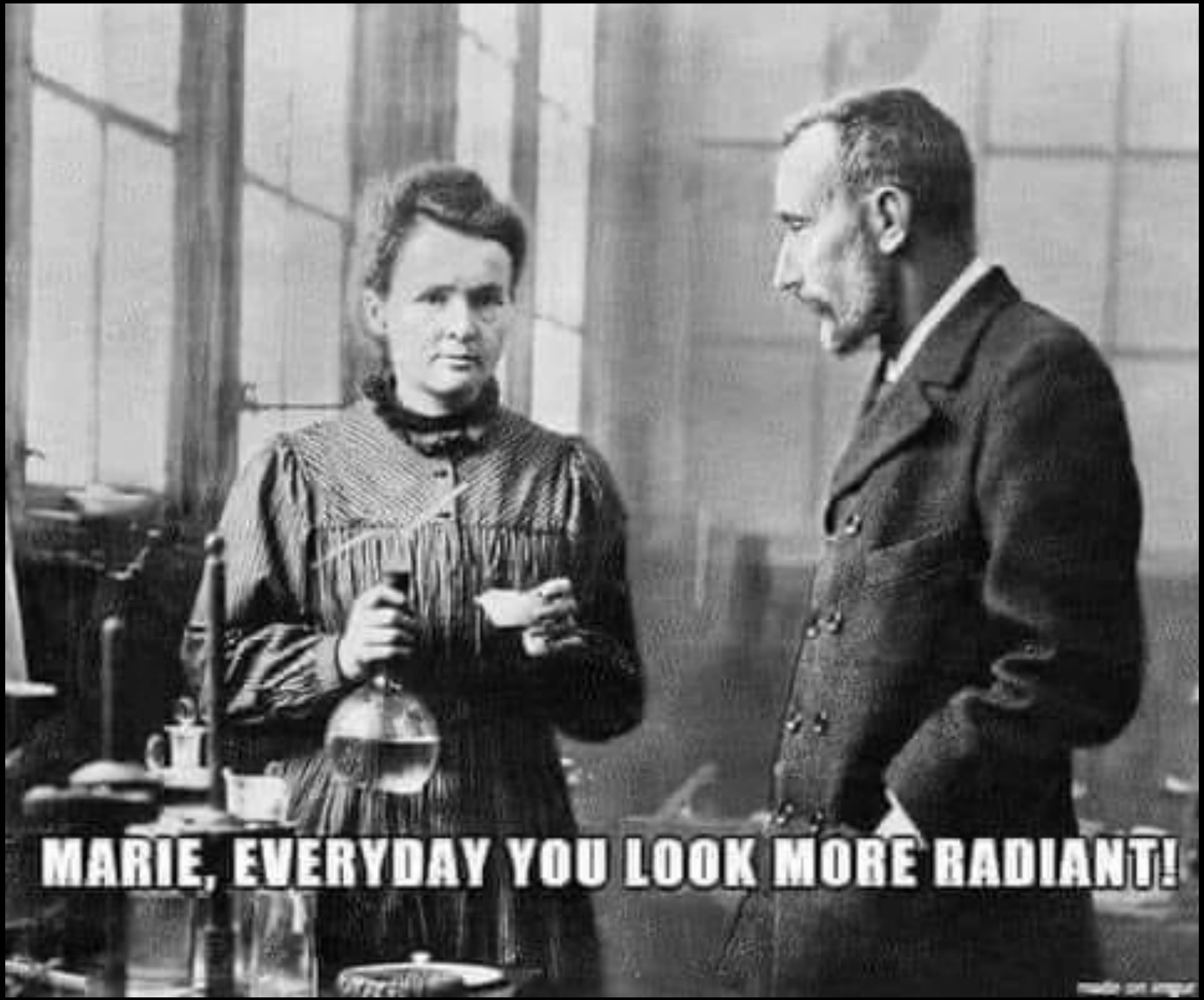
IN THE BEGINNING…



Overview

WHY IS THIS IMPORTANT?
- DIGITAL IS MAGIC
- TRAINING REQUIREMENTS
- BASIC RT PRINCIPLES
- TECHNICAL INFORMATION
- SCATTER RADIATION IS NOT YOUR FRIEND
- IMPORTANCE OF KV, MA, TIME, DISTANCE, AND SCREENS
- PV? SNR? CNR? PLATEAU?
- WHAT ARE THE CHARACTERISTICS OF A GOOD IMAGE?
- SUMMARY
- QUESTIONS

DIGITAL IS MAGIC!

Filters/Algorithms are all you need!

I can dial in the image and it will be good enough…

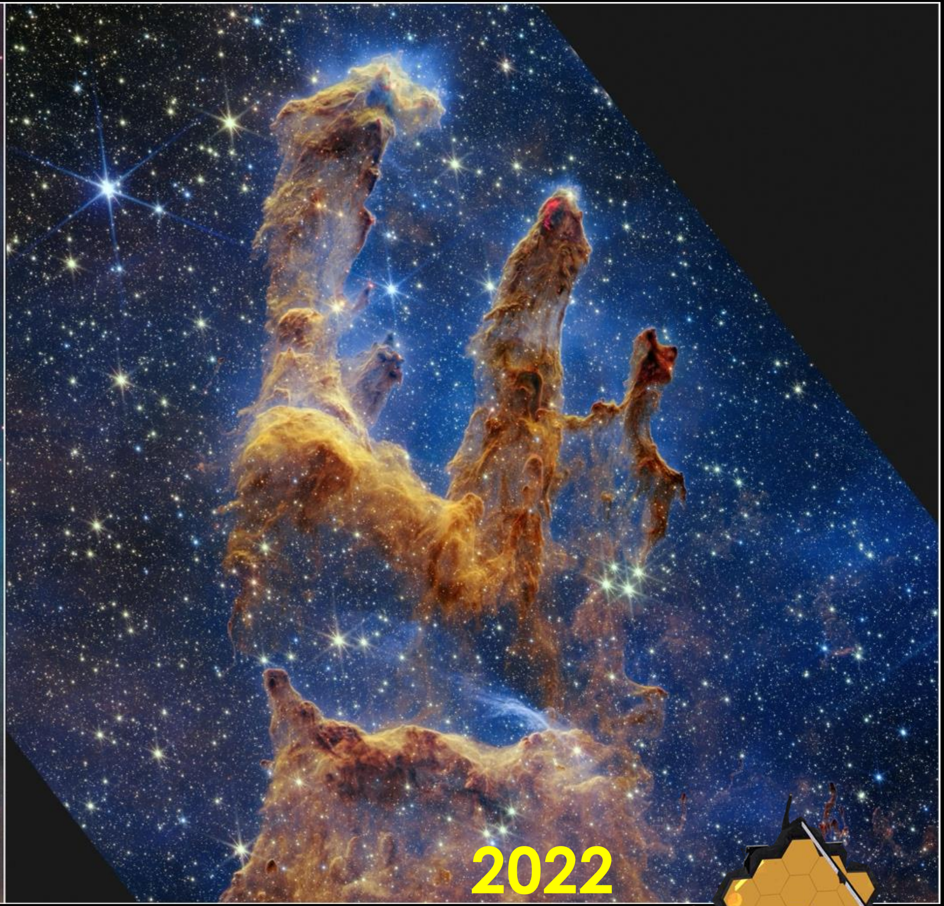
The raw image is unimportant, the processed image is all that matters!

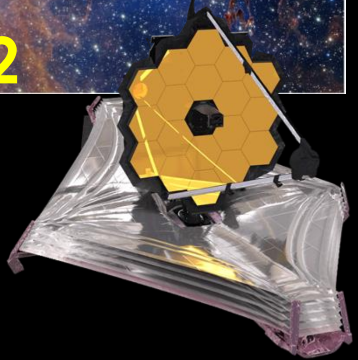
As long as I can see the "T" hole…

SNR/SRB? What's that?

KV and MA don't really matter with Digital Radiography

PILLARS OF CREATION





Photos courtesy of Wikipedia and NASA

SNT-TC-1A 2020

Table 6.3.1.A Recommended Initial Training and Experience Hours					
Method	NDT Level	Technique	Training Hours	Min Experience Hours in Method or Technique	Total Hours in NDT
Radiographic Testing	I	Radiographic (Film)	40	210	400
	II		40	630	1200
	I	Computed Radiography	40	210	400
	II		40	630	1200
	I	Computed Tomography	40	210	400
	II		40	630	1200
	I	Digital Radiography (DDA)	40	210	400
	II		40	630	1200

7.0 If an individual is currently certified in a Radiographic Testing (Film) Technique and a full course was used to meet the initial qualifications in that technique, the minimum additional hours to qualify in another technique at the same level should be 24 hours (of which at least 16 hours should be equipment familiarization).

If an individual is currently certified in a technique, the minimum experience to qualify for another technique at the same level may be reduced by up to 50 percent, as defined in the employer's written practice.

NAS410 REV. 5

Formal Training hours			
Method	Level 1	Level 2 with previous Level 1 certification	Level 2 without previous Level 1 certification
RT Film or Non-Film	40	40	80
RT Film & Non-Film	60	60	120
Additional formal training hours for currently certified personnel to certify in Film & Non-Film			
Current Level 1	Current Level 2	Current Level 1 to Level 2 Film & Non-Film	
20	40	80	

Level 3: Current Level 3 Radiography Personnel need an additional 40 hours of training to transition to Film or Non-Film.

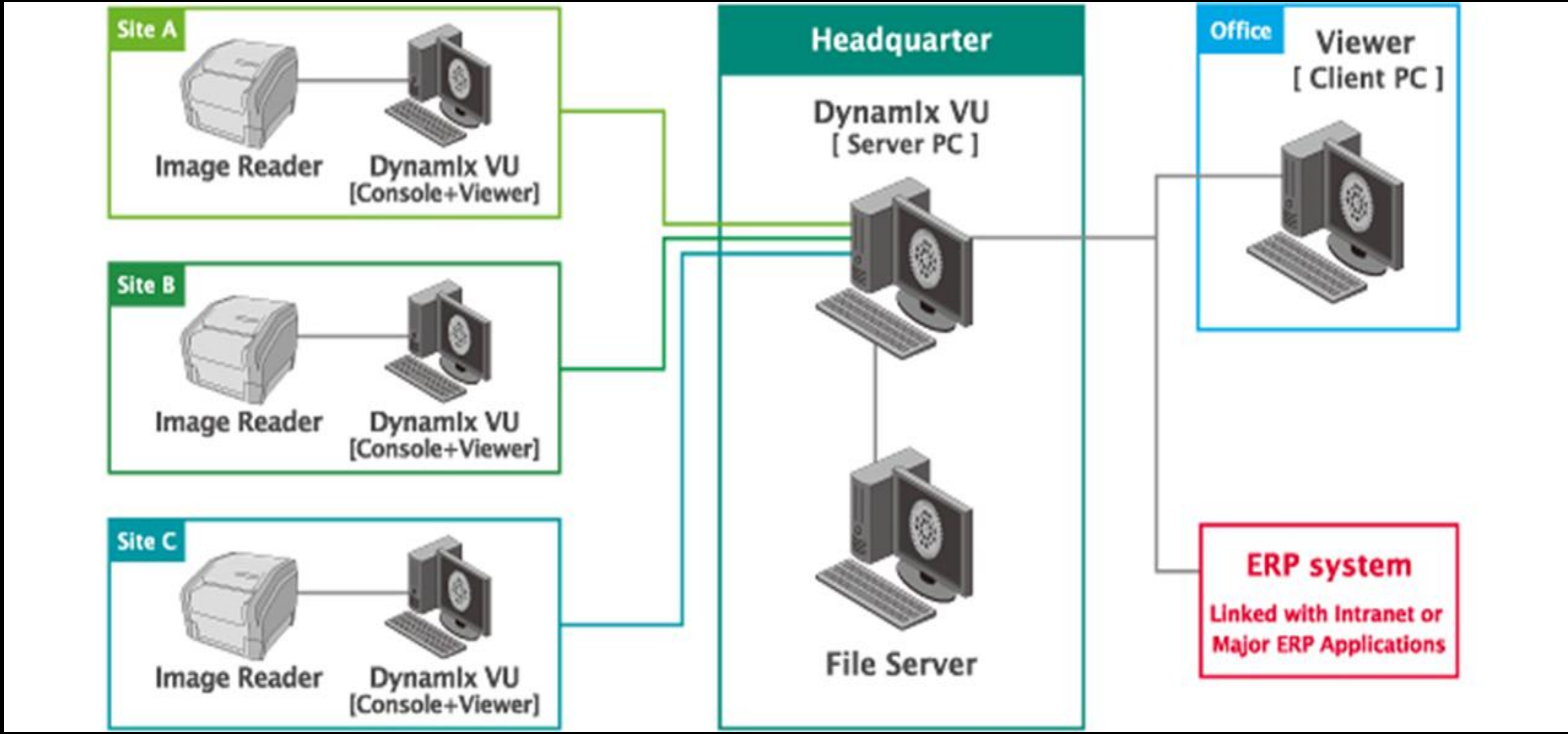
Experience time in hours			
Method	Level 1 (Trainee experience)	Level 2 with previous Level 1 certification	Level 2 without previous Level 1 certification
RT Film or Non-Film	200	600	800
RT Film & Non-Film	220	780	1000
Minimum Experience hours for currently certified personnel to transition to Film & Non-Film			
Current Level 1	Current Level 2	Current Level 1 to Level 2 Film & Non-Film	
20	200	800	

ASME BPVC. SEC V

- **Mandatory Appendix II, Table II-121-1 GENERAL NOTES:**
- **(a) For individuals currently certified in a radiography technique (e.g., film) and a full-course format was used to meet the initial qualifications in that technique, the minimum additional training hours to qualify in another technique at the same level shall be**
- ***(1)* Level I, 24 hrs.**
- ***(2)* Level II, 40 hrs.**

- **(c) For individuals currently certified in a radiography technique (e.g., film) and a full-course format was used to meet the initial qualifications in that technique, the minimum additional experience to qualify in another technique at the same level shall be**
- ***(1)* Level I, 105 hrs.**
- ***(2)* Level II, 320 hrs.**

BASIC CR SYSTEM LAYOUT

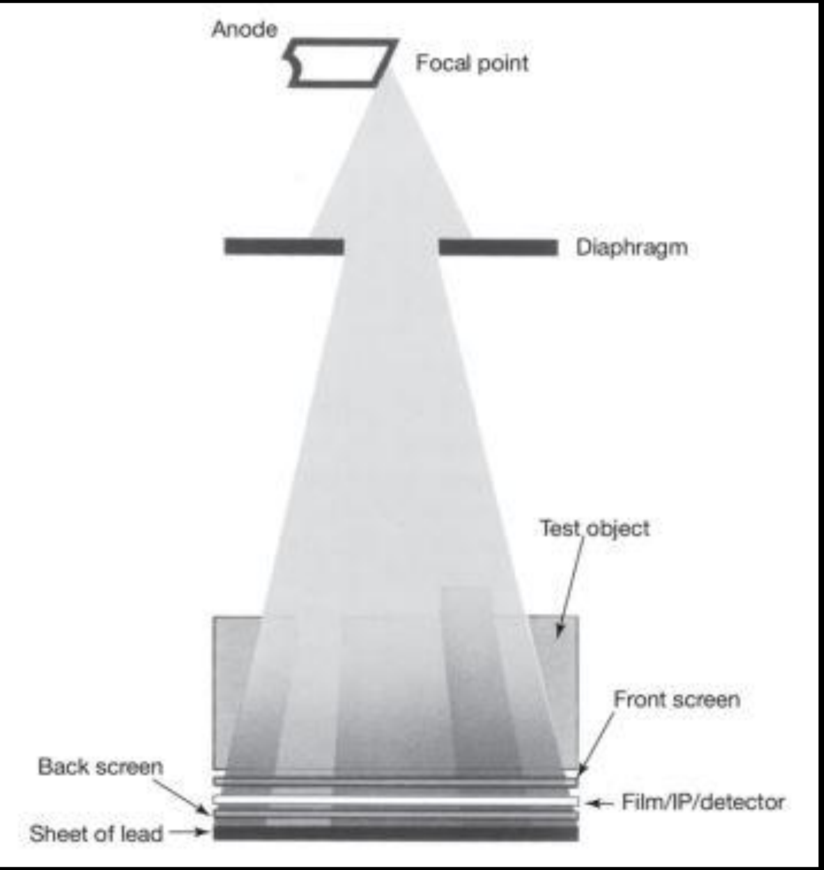


IMAGING PLATES AND CASSETTES

RADIOGRAPHIC TEST SETUP BASICS

1. During a RT exposure, photons (X-rays) travel in straight lines to the test object.
2. Some of the photons will pass through the test object while other photons will be attenuated or absorbed.
3. The amount of photons that are transmitted through the part will be indicated on the film/IP/detector to form a latent image.

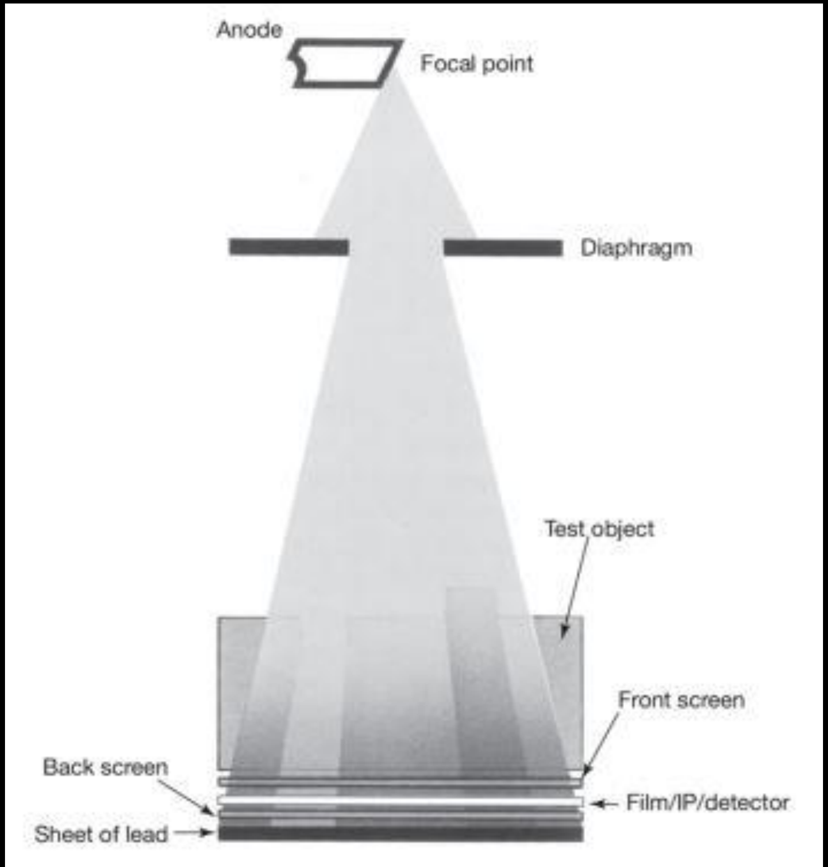
The more photons that reach the film/IP/ detector will result in higher optical density (film) or higher pixel value (CR & DDA).



RADIOGRAPHIC TEST SETUP BASICS

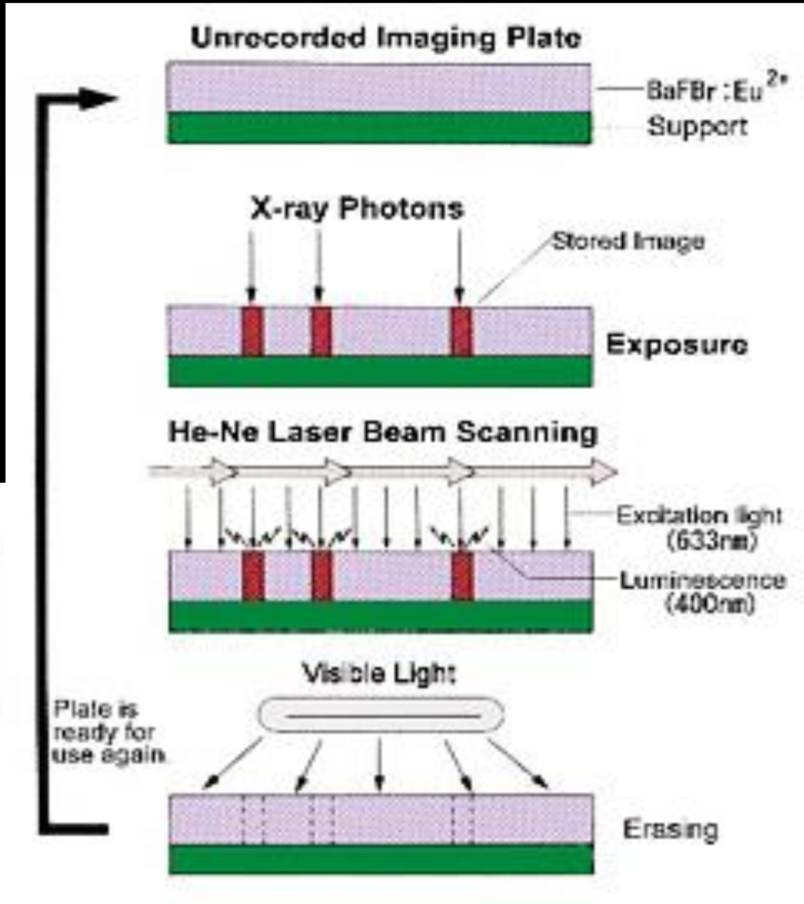
4. Some factors that affect the final radiographic image include the following:

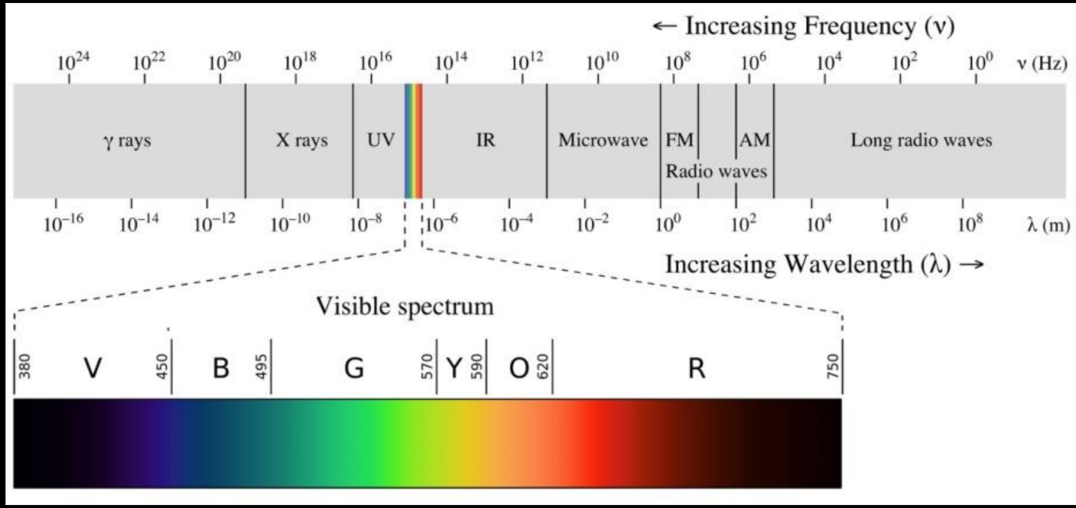
   - The size and strength of the source.
   - Beam quality (Filtration).
   - Source to object distance (SOD).
   - Atomic weight (Density) of the test object.
   - Material type of the test object.
   - Film speed / IP Type / DDA used.
   - Radiographic Technique.



(PSL) PHOTO STIMULATED LUMINESCENCE

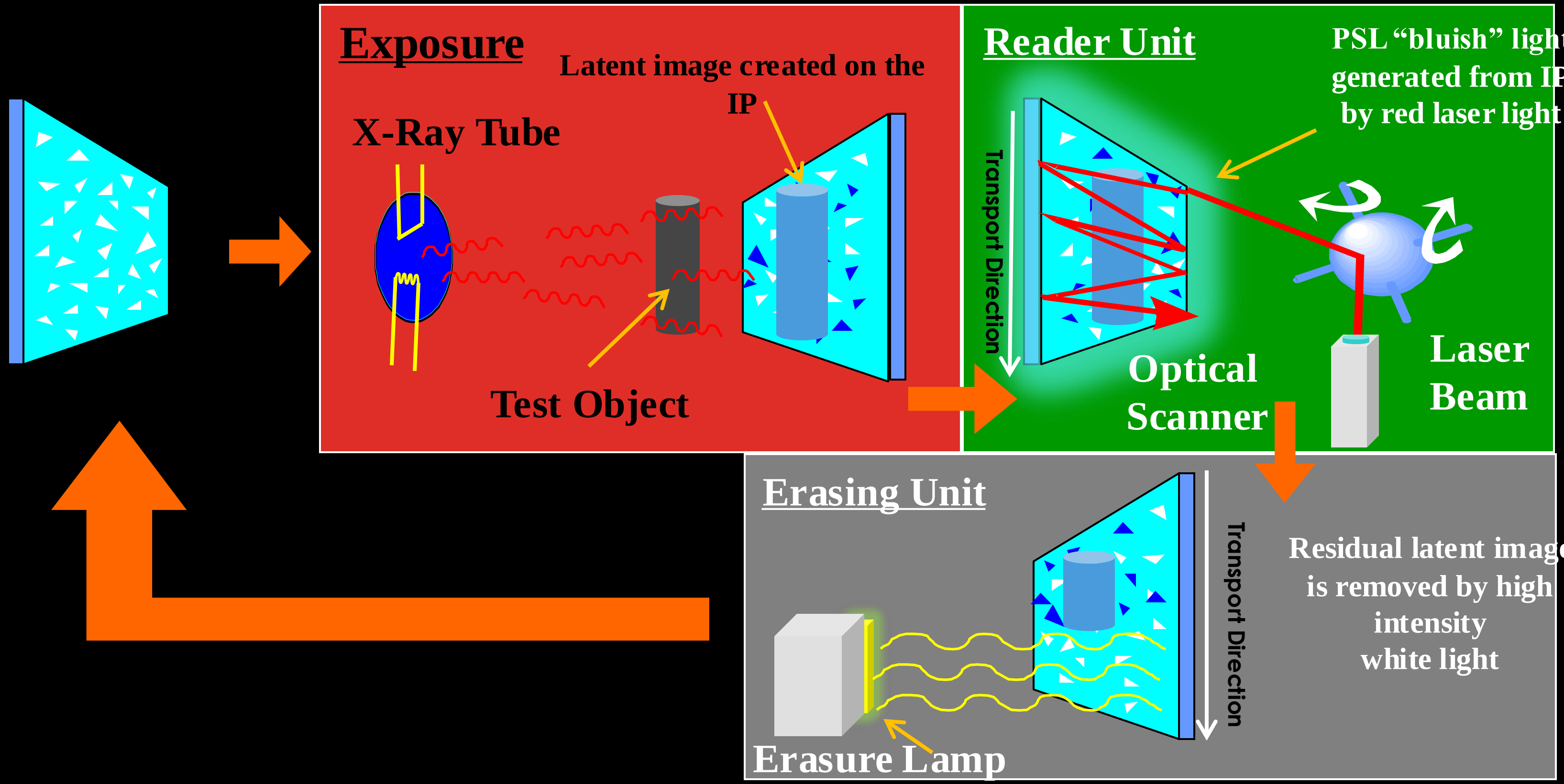
- X-rays create excited electrons in the phosphor material. The free electron enter the conduction band of the crystal and become trapped in the bromine creates a hole trapped in the color centers of the crystal lattice until stimulated by lower wavelength



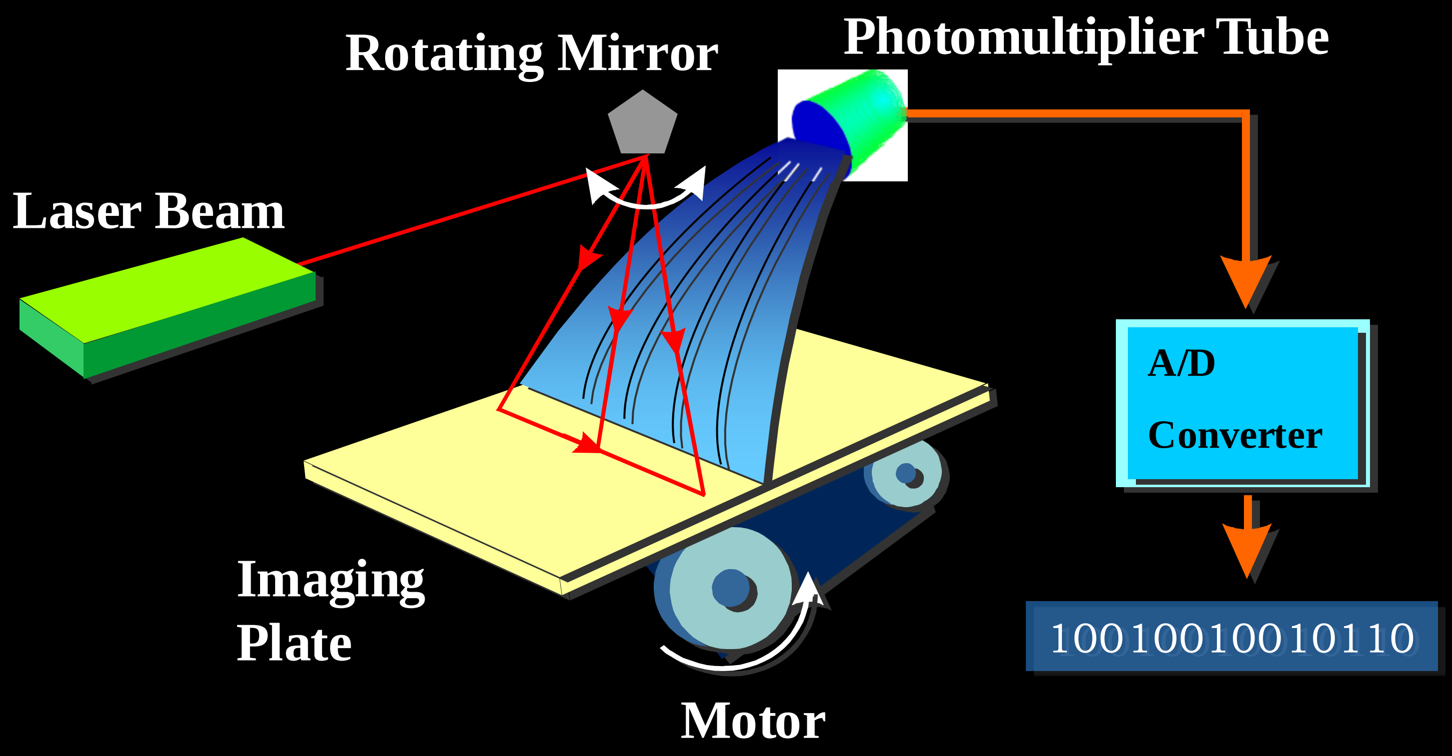


CR BASICS

- STORAGE PHOSPHOR IMAGING PLATE
  - **Photostimulable phosphor plates emit retained X-Ray energy when stimulated by laser beam**

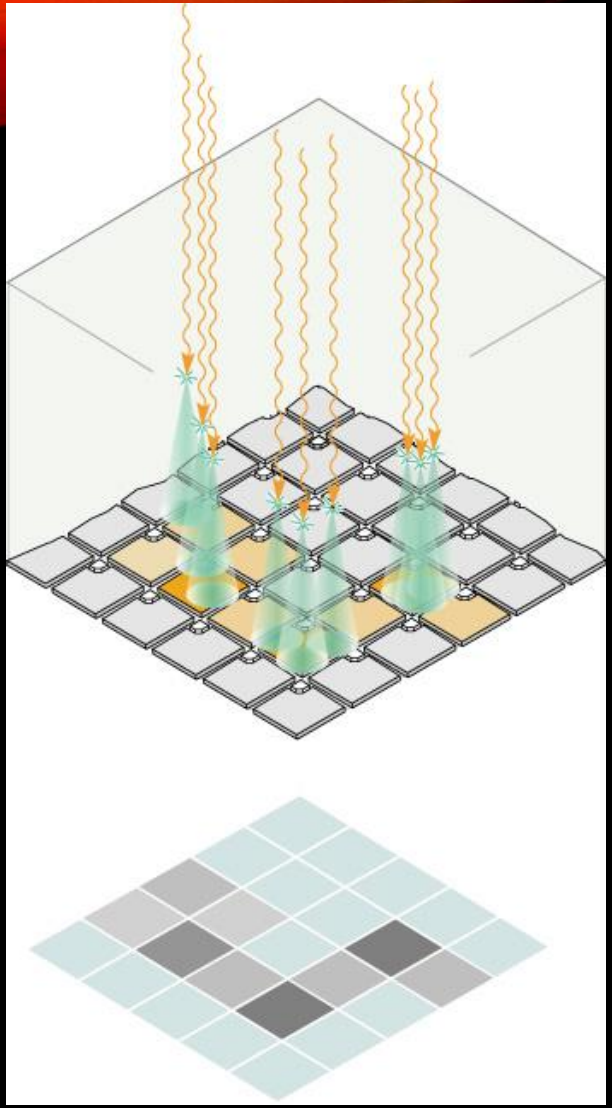


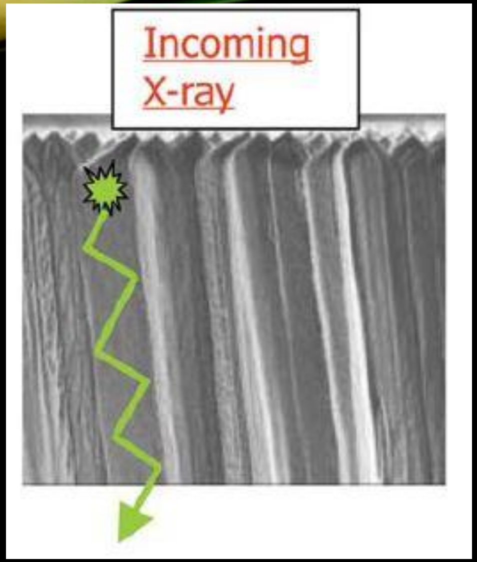
CR BASICS & SCAN RESOLUTION



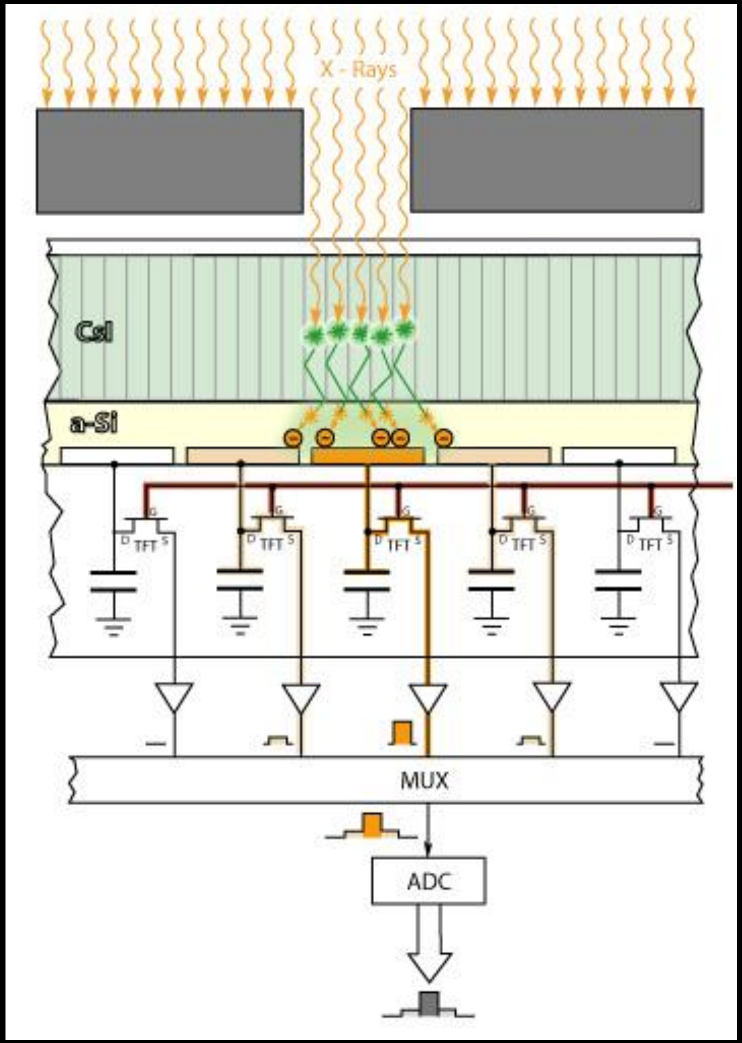
Metric	Imperial
200µm	.0078"
100µm	.0039"
50µm	.0019"
25µm	.0009"

DDA/FPD BASICS



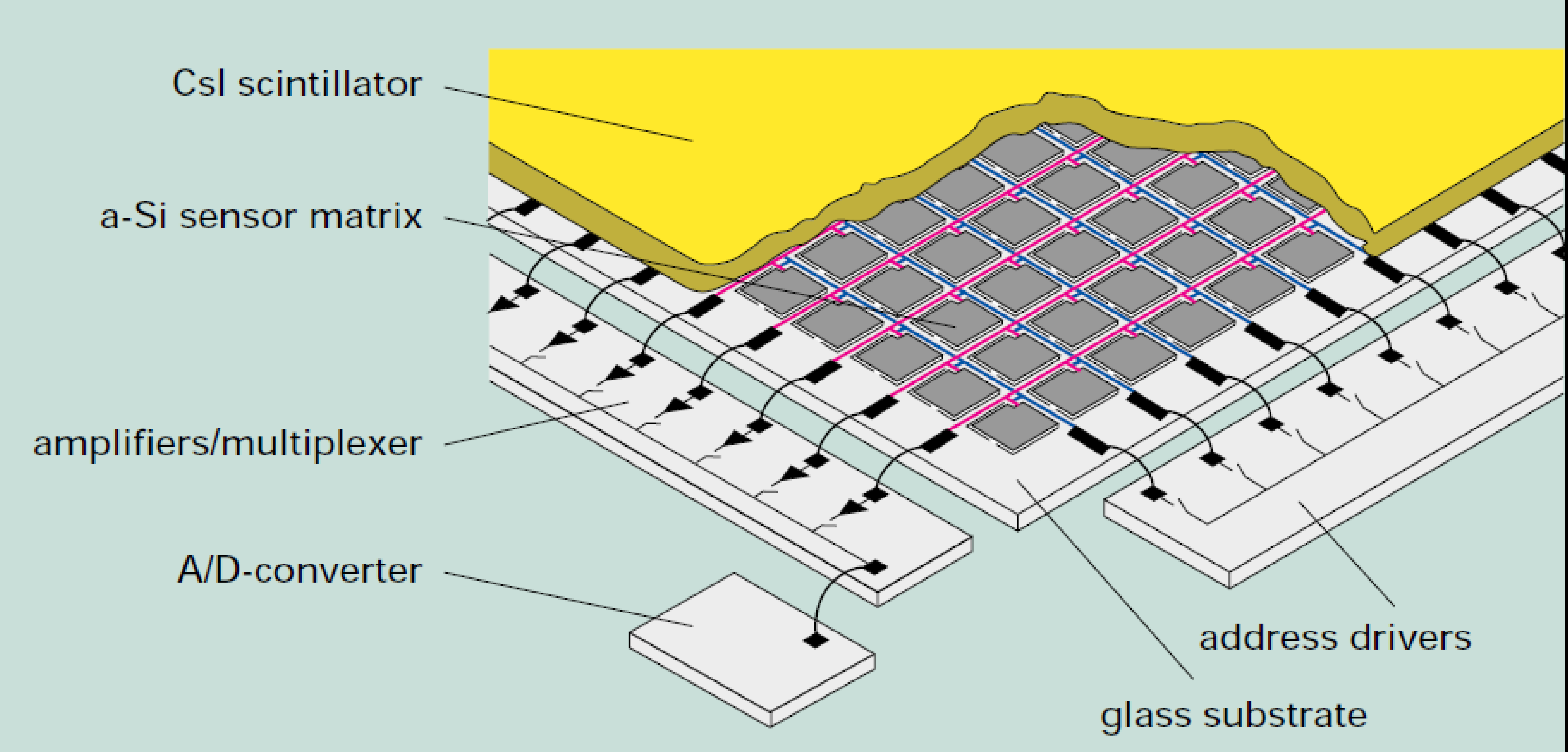


- Cesium Iodide is directly deposited on the Amorphous Silicon (aSi) TFT substrate in a needle structure
- Higher absorption rate than GadOx
- Produces more light than GadOx at the same dose
- Sharper imaging than GadOx
- More prone to ghosting than GadOx
- More expensive than GadOx



Once the charges from the pixel electrodes are read, they multiplexed and sent to the analog to digital converter which creates the image data

DDA/FPD BASICS

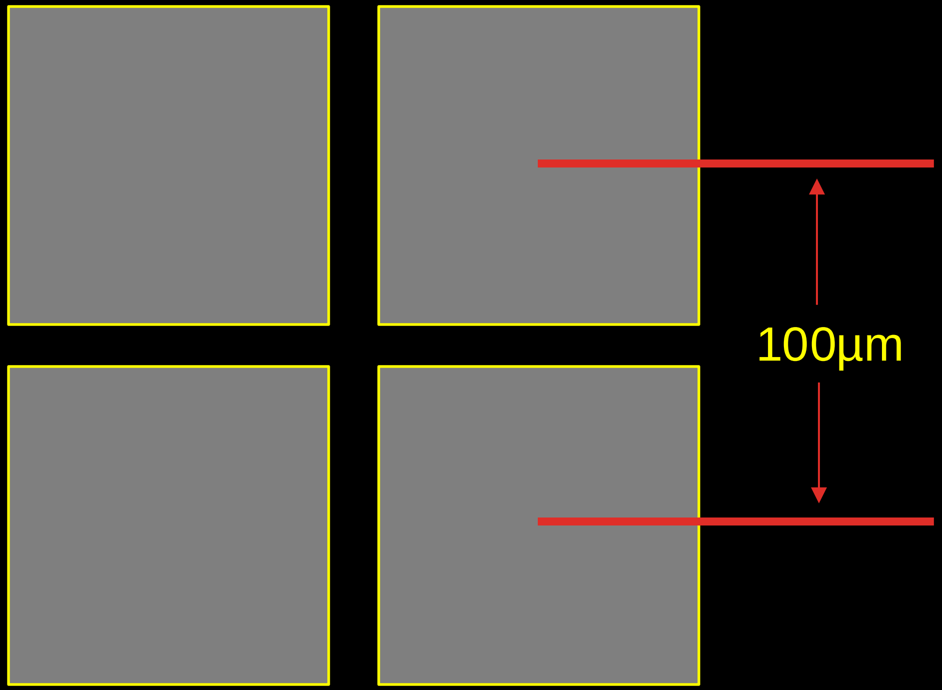


TECHNICAL ITEMS TO CONSIDER

- **DDA Pixel Pitch**
- **CR Scan Resolution**
- **Pixel Coverage**
- **Basic Spatial Resolution**
- **Total Image Unsharpness**
- **Minimum Pixel Values**
- **IQI to AOI Pixel Value correlations**
- **Geometric Magnification**
- **Additional Tools & Gauges**

DDA PIXEL PITCH

- Pixel Pitch is one of the primary considerations when looking to purchase a Digital Detector Array Flat Panel Detector
- What is the smallest size flaws that are required to be detected?



Metric	Imperial
200µm	.0078”
100µm	.0039”
50µm	.0019”
25µm	.0009”

PIXEL COVERAGE

ASTM E2736 Recommendation

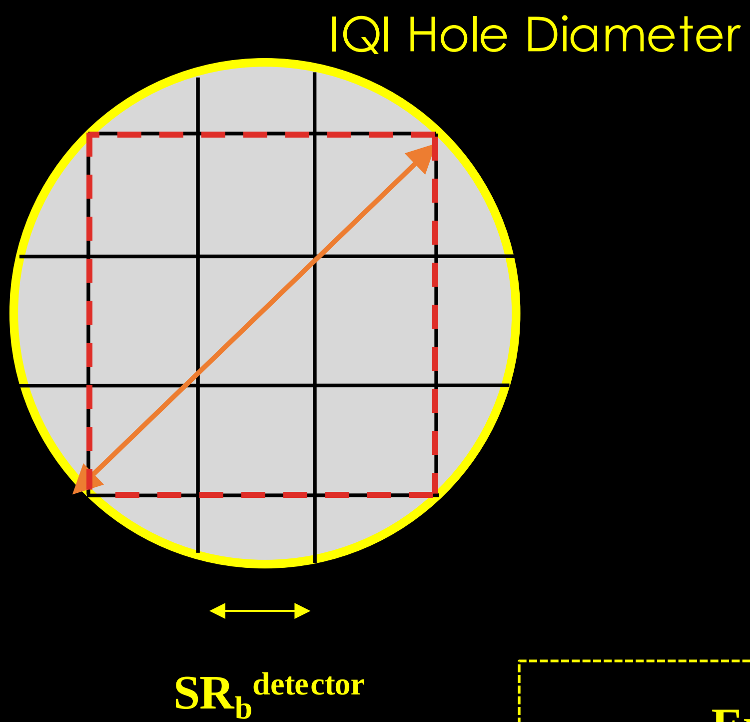
Best number of pixels to cover a defect

Effective # of pixels covering the longest dimension of the defect

1pixel	2-3 pixels	4-6 Pixels	>6 Pixels
High Risk, Not recommended	Moderate Risk	Low Risk	Best Practice, if available

- **Pixel coverage may be obtained by using a smaller pixel pitch or using Geometric Magnification (Note: Geometric Magnification requires a mini or micro focus X-Ray Tube)**
- **If possible, you want a minimum 3 effective pixels covering the longest dimension of a defect from both a detectability and bad pixel management perspective**

PIXEL COVERAGE



Minimum geometric magnification can be determined by the following formula:

$$\upsilon_{min} = \frac{4.25 * (SR_b^{detector})}{d}$$

SRb = of the detector or IP without geometric magnification

***d* = diameter of the essential IQI hole**

Ex. 210µm $SR_b^{detector}$

$$\frac{4.25 \text{ x } .0082''}{.020''} = \upsilon_{min} \ 1.74 \text{ X}$$

1.74 X geo mag is needed

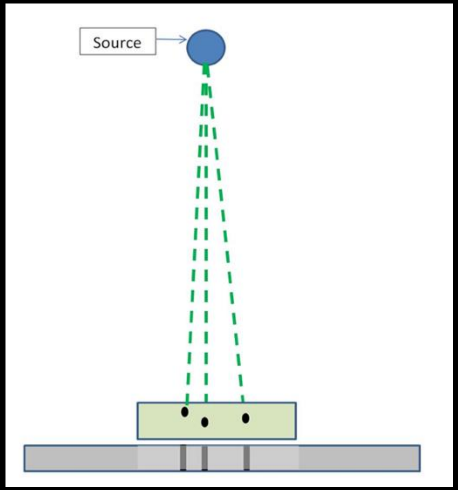
Ex. 110µm $SR_b^{detector}$

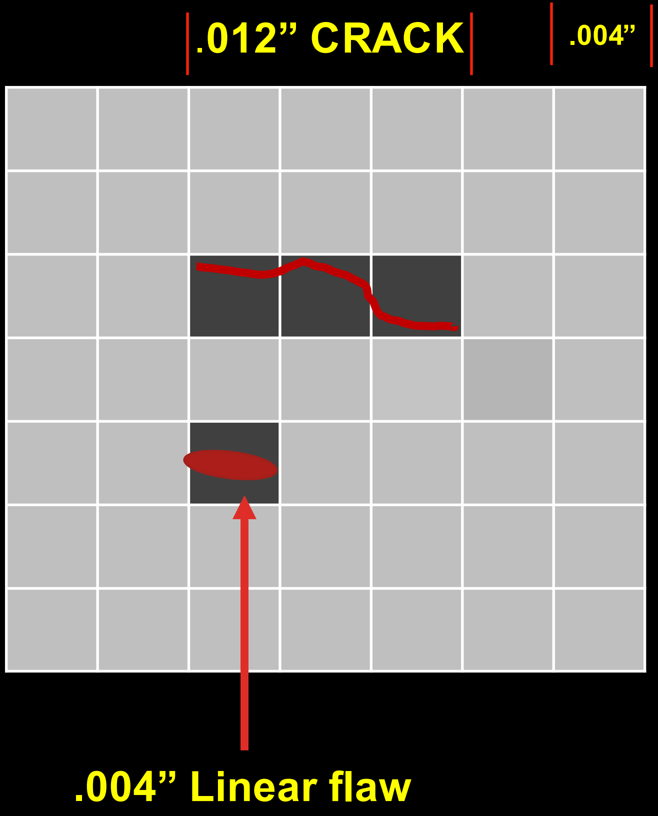
$$\frac{4.25 \text{ x } .0043''}{.020''} = \upsilon_{min} \ 0.91 \text{ X}$$

No geo mag is needed

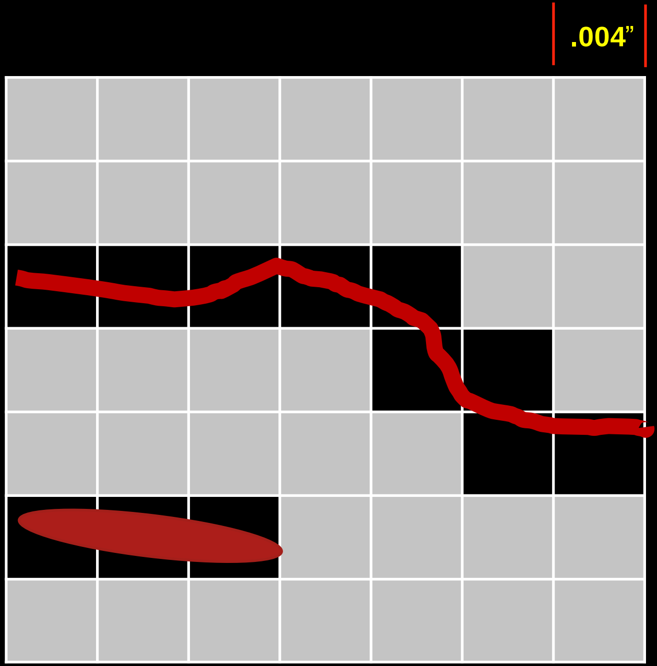
PIXEL COVERAGE

100µm pixel pitch at 1X Geo Mag

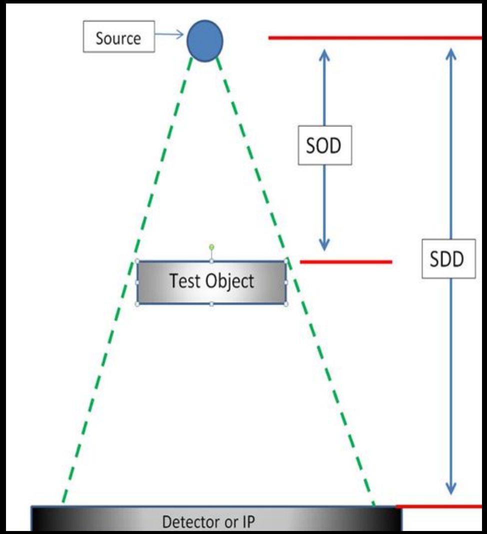




100µm pixel pitch using 2.5X Geo Mag

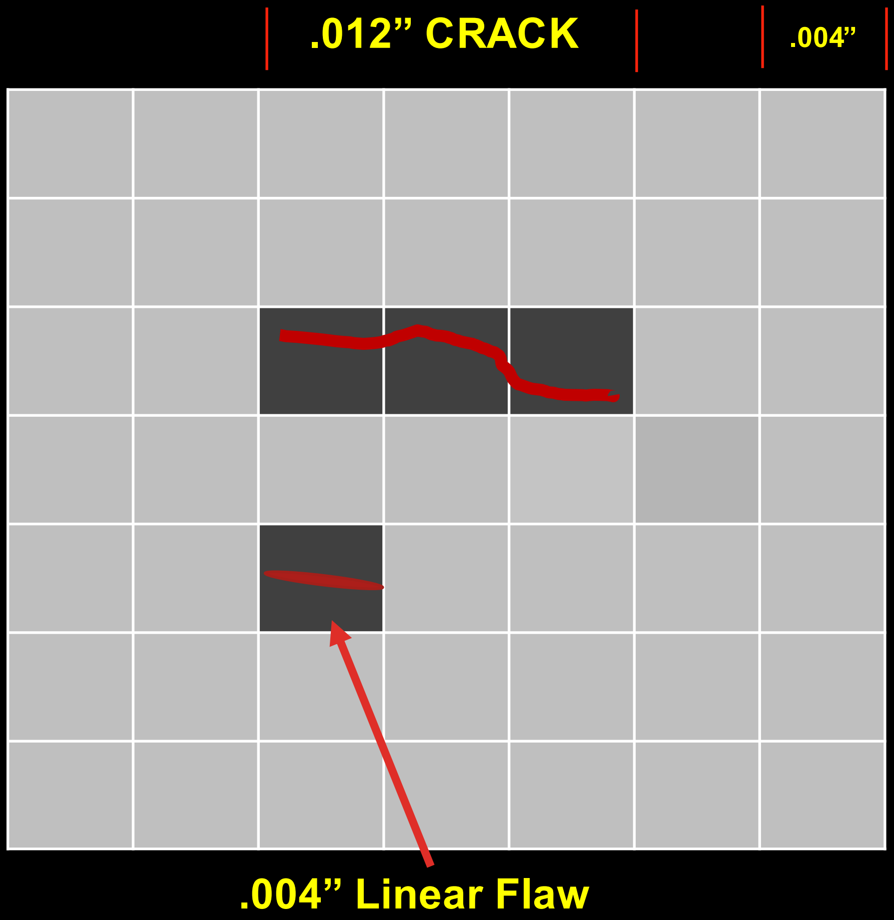


The physical size of the flaws are the same but now appears 2.5 x larger in the image.

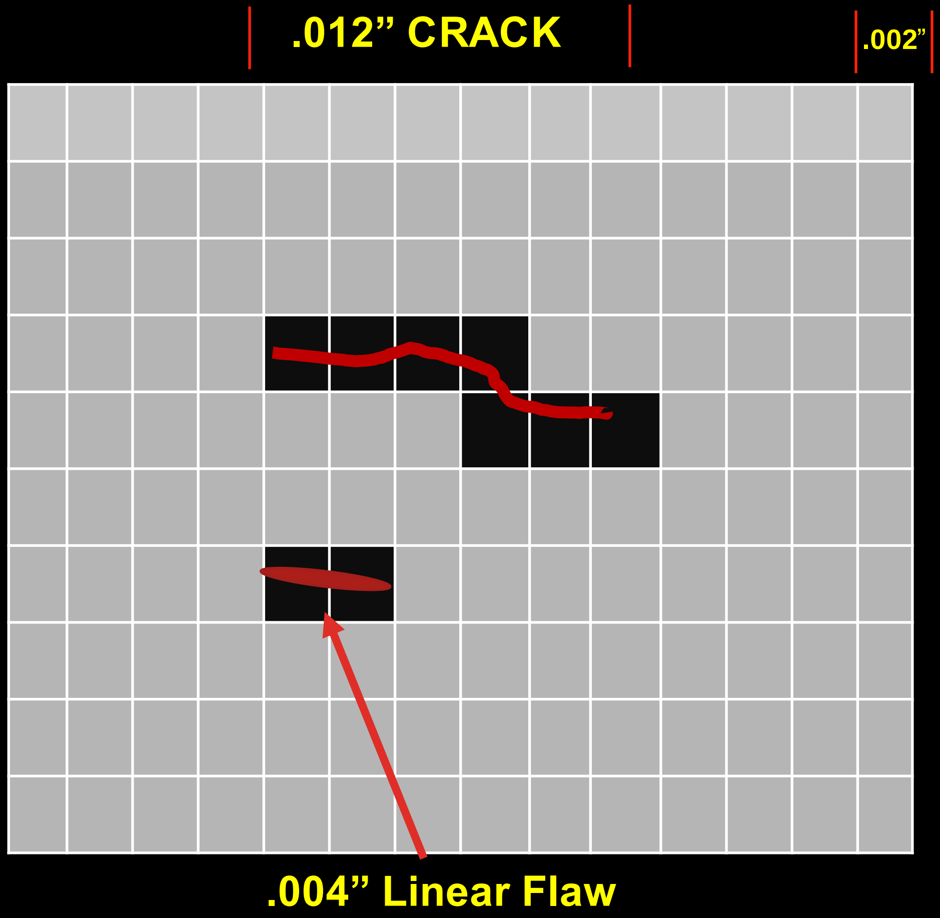


PIXEL COVERAGE

CR IP Scanned at 100µm



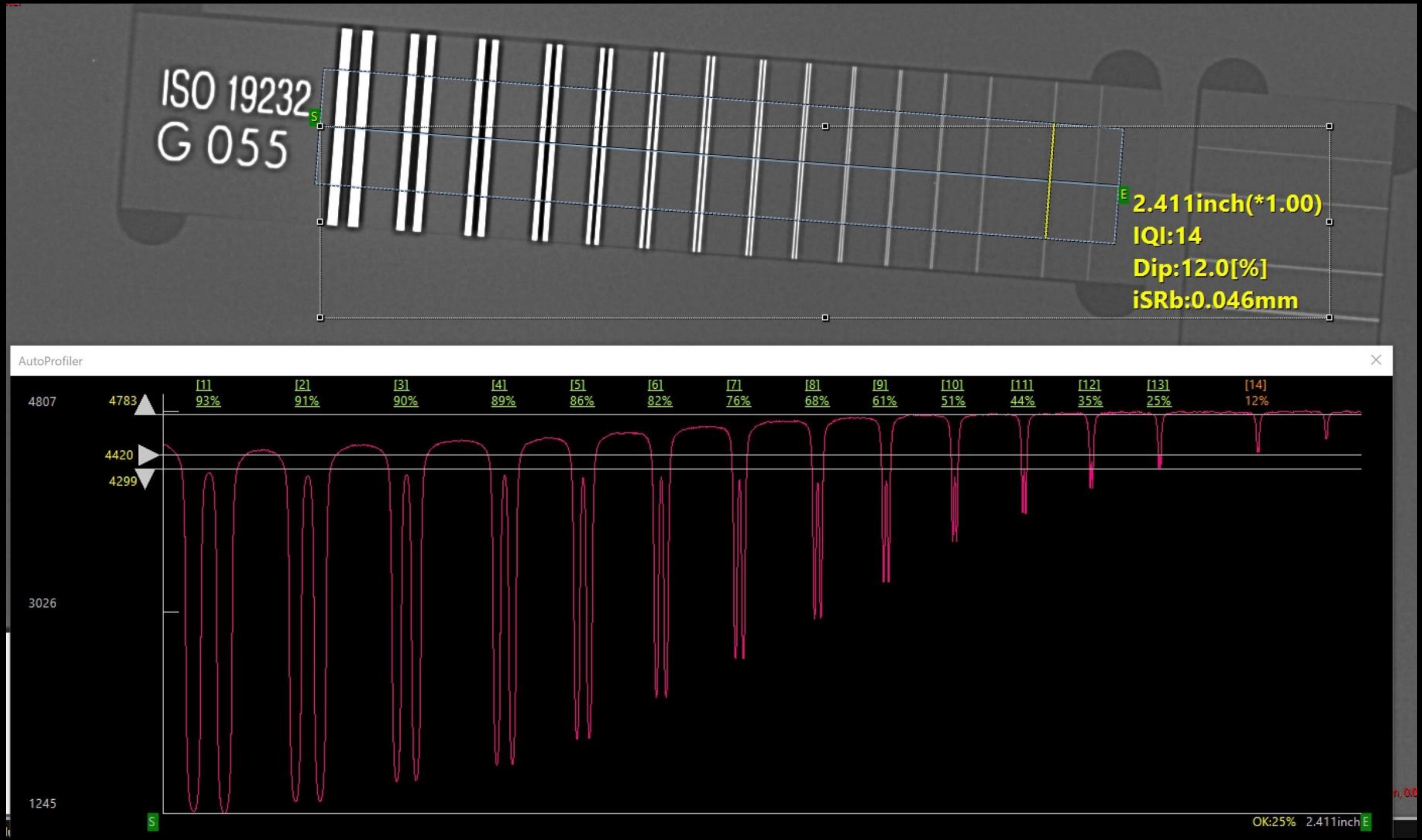
CR IP Scanned at 50µm

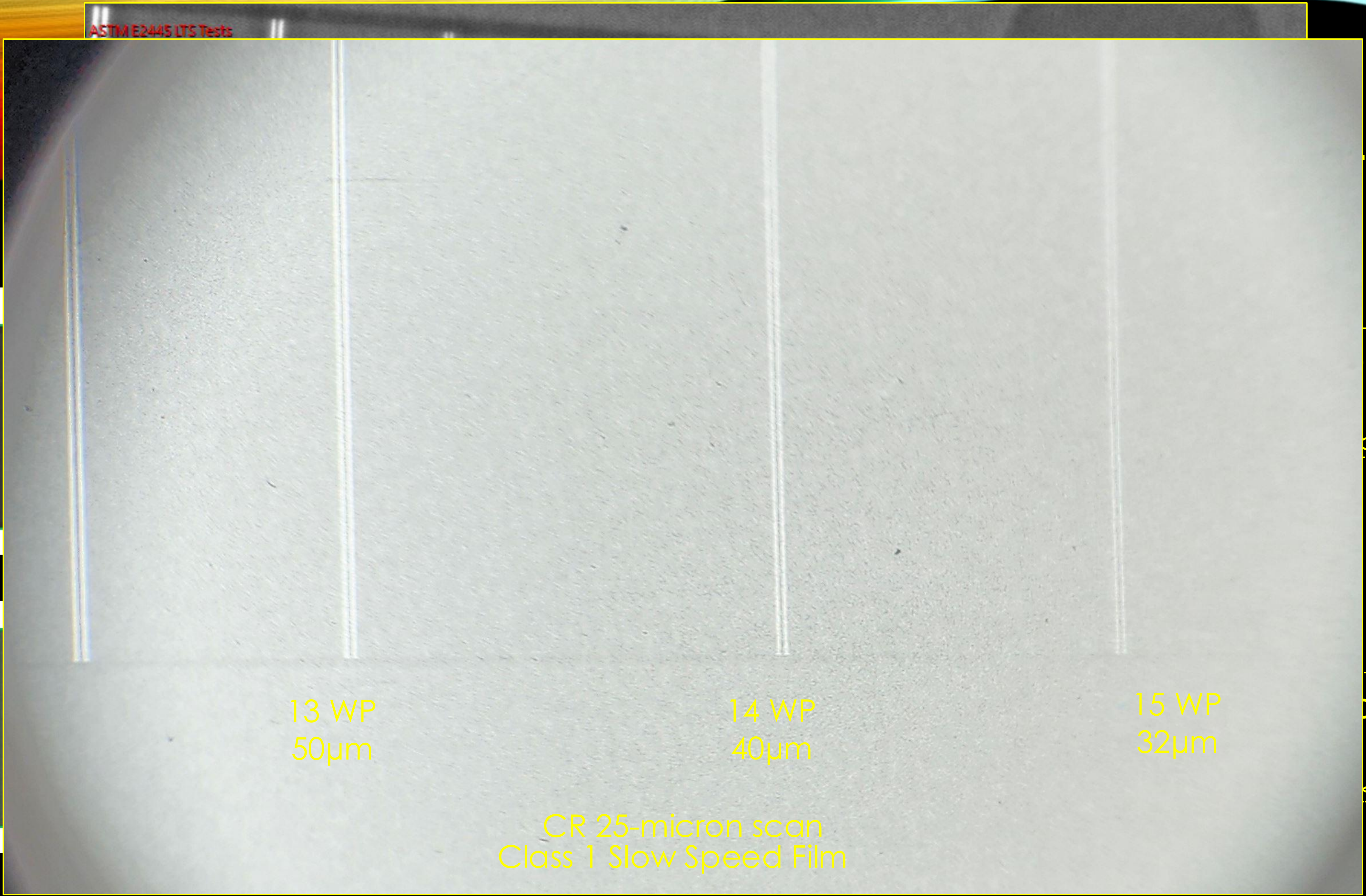


BASIC SPATIAL RESOLUTION

Basic Spatial Resolution (SR_b) is defined as the smallest degree of visible detail within a digital image that is considered the effective pixel size.

ASTM E2002 describes how to use the Duplex Wire Gauge to measure Basic Spatial Resolution.





ION

r 146µm

<20% dip

or 46µm

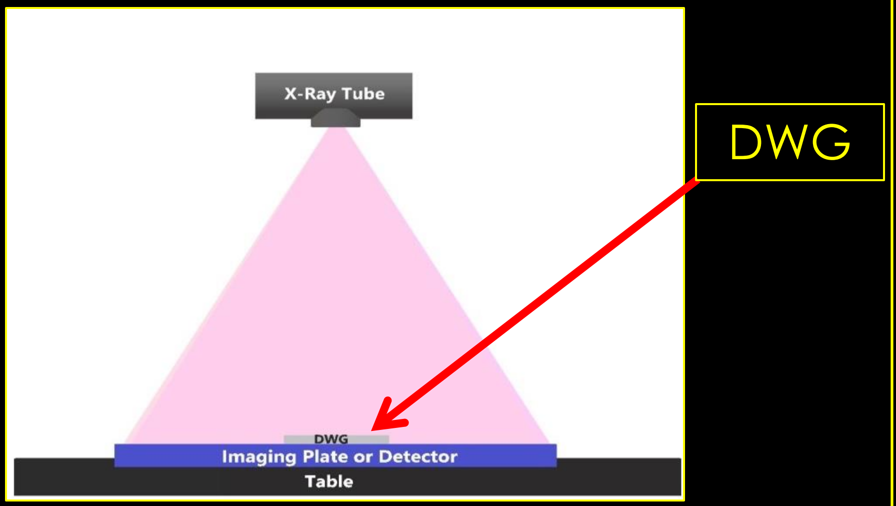
<20% dip


That will be $1200
Your X-RAY showed a broken rib, but we fixed it with Photoshop
boredpanda.com
ifunny.co

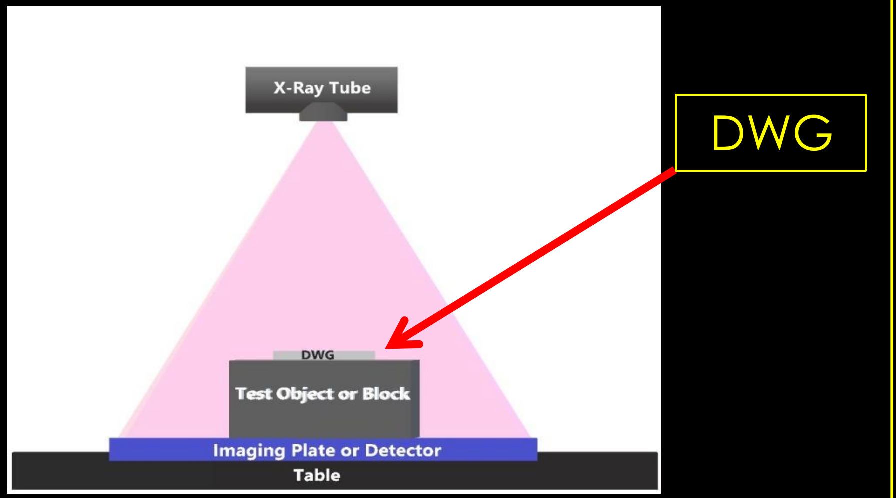
BASIC SPATIAL RESOLUTION

What is the difference between $SR_b^{detector}$ and SR_b^{Image} ?

$SR_b^{detector}$ the basic spatial resolution of a detector, which corresponds to the dimension of the smallest feature that can be resolved at a specified modulation **without geometric magnification**.



SR_b^{image} the basic spatial resolution of a detector, which corresponds to the dimension of the smallest feature that can be resolved at a specified modulation **with geometric magnification**.



GEOMETRIC UNSHARPNESS

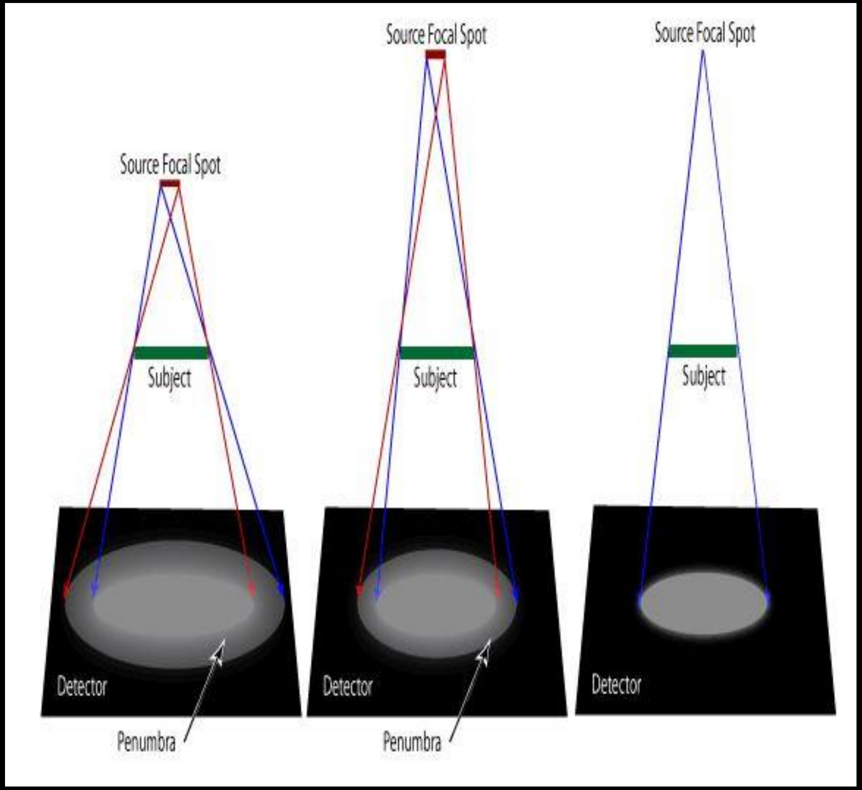
- **Lack of definition in a radiographic image due to Source focal spot size, object to film distance , and the source to object distance**

$$U_g = \frac{Fd}{D}$$

F *= source size(EFSS)*

d *= distance from the source side of the object to the film/IP/detector*

D *= distance from the source of radiation to the test object*



TOTAL IMAGE UNSHARPNESS

- **There are two common methods used to determine Total Image Unsharpness**

1. **Use the Uim formula:**

$$U_{\text{Im}} = \frac{1}{\upsilon} \cdot \sqrt[3]{U_g^3 + (2.0 \cdot SR_b^{\text{detector}})^3}$$

or

2. **Using the duplex wire gauge, measure with the software profile tool to calculate SR_b^{Image} and then multiply the SR_b^{Image} x 2**

$U_{im} = 2 \times SR_b^{Image}$

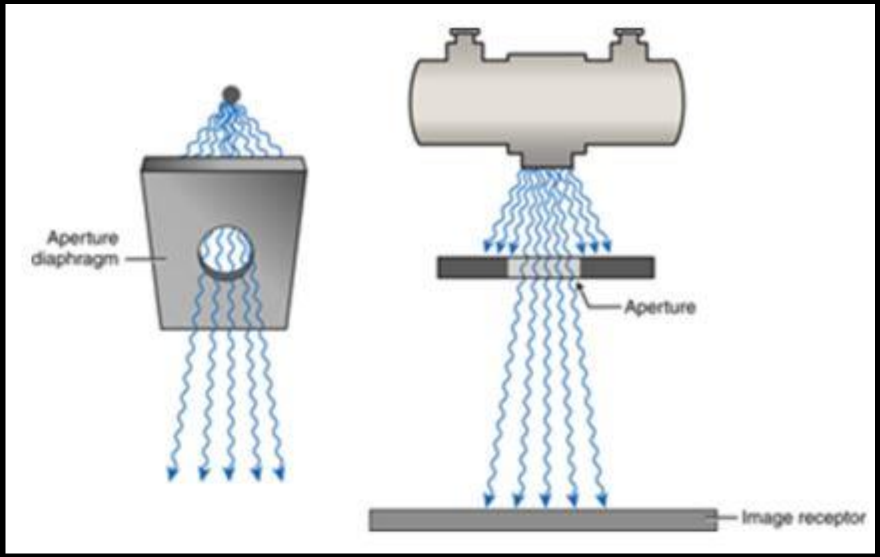
Ex. .046mm SR_b^{image}

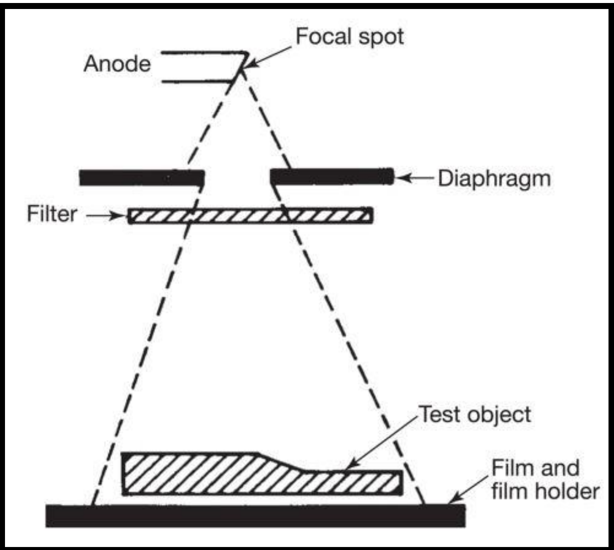
.046mm x 2 = .092mm U_{im}

Material Thickness	Maximum Allowed Image Unsharpness
≤0.5 inch	0.010 inch [0.254mm]
>0.5 through 1 inch	0.015 inch [0.381mm]
>1 through 2 inches	0.020 inch [0.508mm]
>2 through 4 inches	0.030 inch [0.762mm]
>4 inches	0.040 inch [1.016mm]

SCATTER RADIATION CONTROL

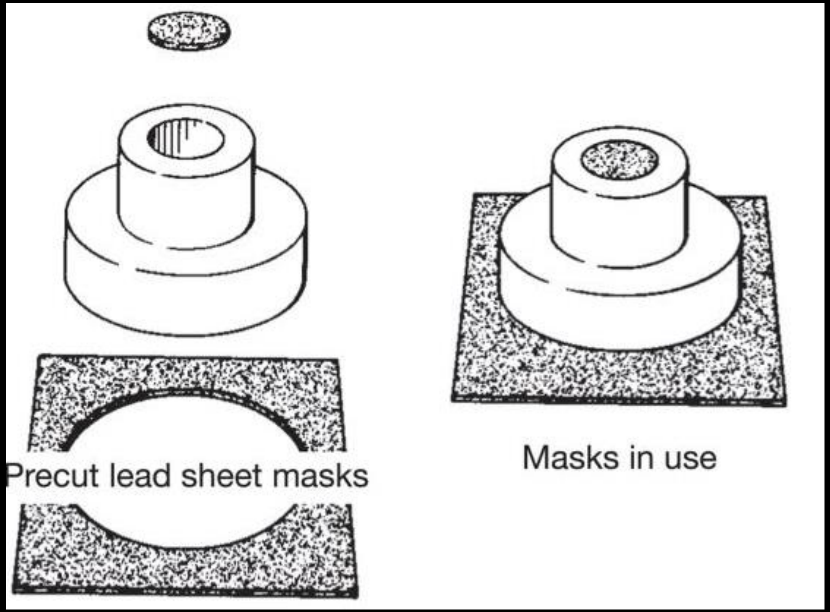
- Collimation
  - Collimators or Diaphrams are made of dense materials, such as lead or tungsten, fitted to the tubehead of X-ray equipment.
  - Limits scatter radiation by limiting the beam to the desired size.
- Filters
  - Filters may vary in size and materials such as copper, lead, steel, or aluminum typically placed at the tube head.
  - Filtration helps to absorb the lower-energy x-ray photons emitted by the tube before they reach the test object.

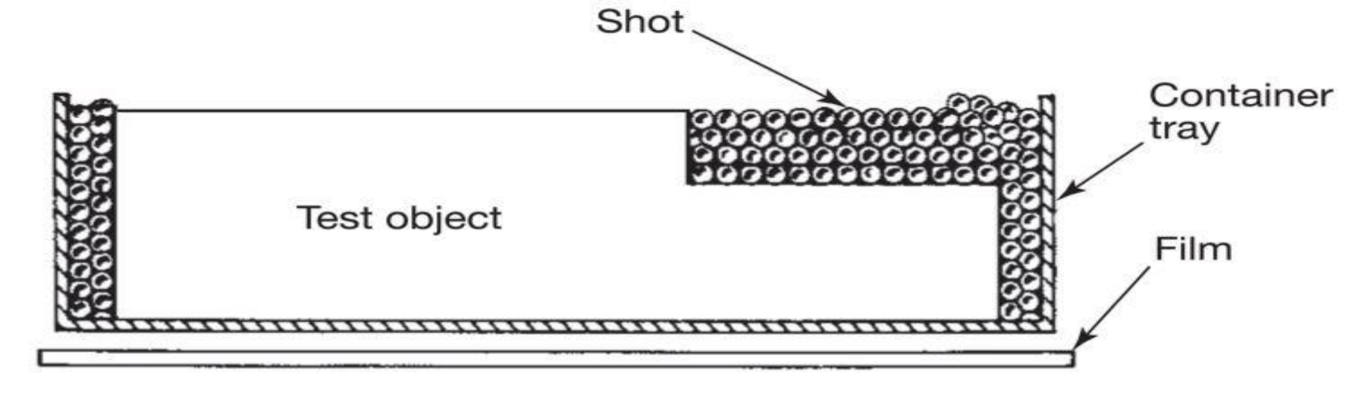




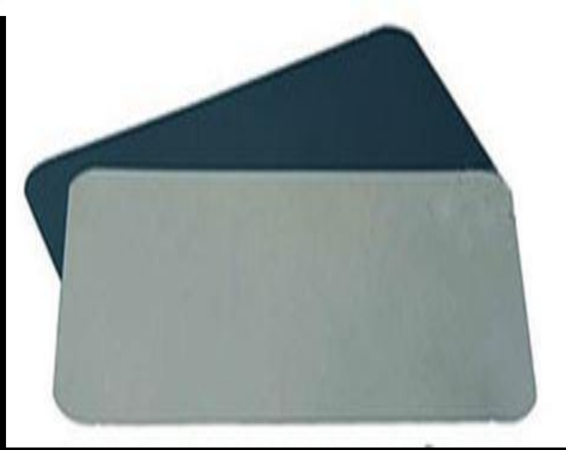
SCATTER RADIATION CONTROL

- Masking
  - Masking is used to cover or surround areas of the test object with highly dense material such as lead during exposure.
  - Highly effective in reducing sidescatter and undercut effects.
  - Masking can also increase DDA panel life by reducing dose.
  - Masking may also reduce ghosting.





SCATTER RADIATION CONTROL

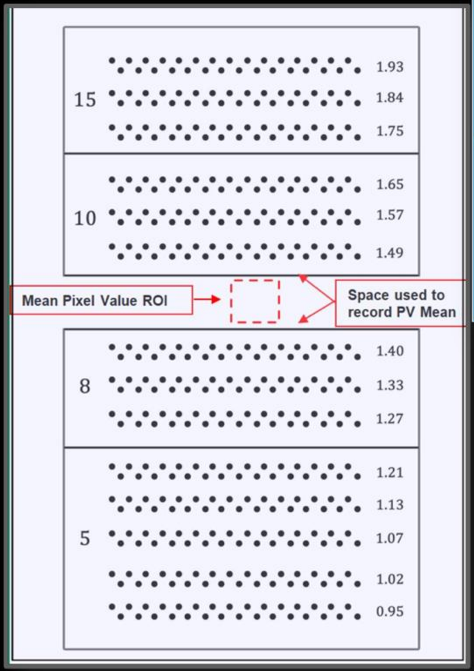


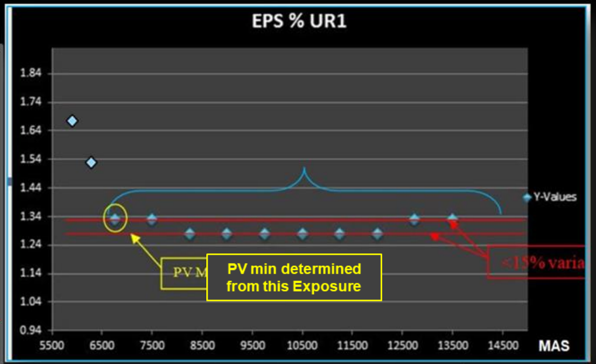
- Screens
  - Lead screens are often used to reduce scatter and improve image quality.
  - Screens do not intensify IPs like they do with film, but they do provide filtering of soft radiation to reduce the effects of scatter.
  - Leaving the protective plastic on the lead screens is recommended, and will help increase the life of the IP.
- Cleanliness
  - Scatter can be created by foreign objects next to the test object during exposure
  - The cabinet, vault, or table should be free of objects that are not needed during exposure. (Ex. Foreign objects, unused fixtures, stepwedges, etc.)

MINIMUM PIXEL VALUE

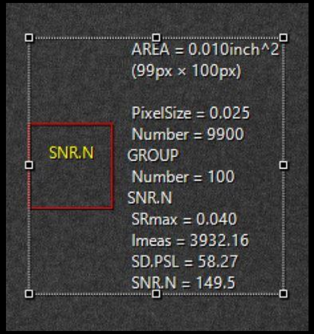
- **If film requires an optical density between 1.5 and 4.0, how does that correlate to PV?**

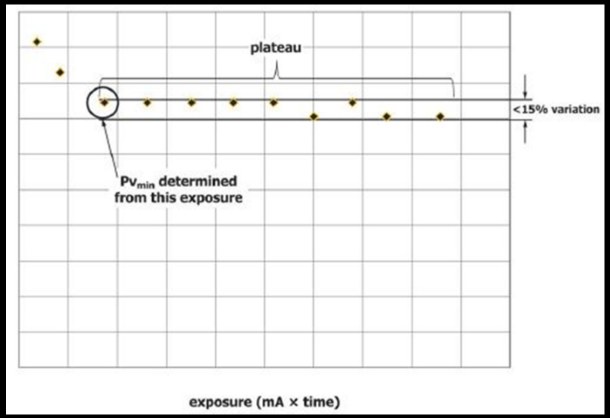
- **On CR systems ASTM E2445 requires you to perform EPS or SNR tests to determine the Minimum Pixel Value.**





Step Thickness	Hole dia.	Plate Thickness	EPS%
0.015	0.028	0.75	1.93
0.015	0.025	0.75	1.84
0.015	0.023	0.75	1.75
0.010	0.031	0.75	1.65
0.010	0.028	0.75	1.57
0.010	0.025	0.75	1.49
0.008	0.028	0.75	1.40
0.008	0.025	0.75	1.33
0.008	0.023	0.75	1.27
0.005	0.032	0.75	1.21
0.005	0.028	0.75	1.13
0.005	0.025	0.75	1.07
0.005	0.023	0.75	1.02
0.005	0.020	0.75	0.95





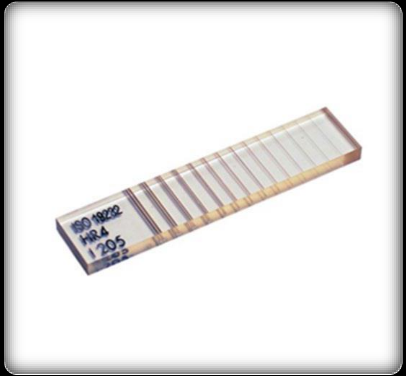
MINIMUM PIXEL VALUE

- **If film requires an optical density between 1.5 and 4.0, how does that correlate to PV?**
- **For DDA ASTM E2698 requires you to achieve a CNR value of 2.5 or greater.**
- **Some standards require an SNR of 130 or greater in the area of interest.**

ADDITIONAL TOOLS & GAUGES

- CR Items
  - Dedicated IPs for Testing
  - Type 1 or 2 Phantom
  - Duplex Wire gauge
  - EPS Plaques and absorber plate
  - Light meter capable of reading cd/m^2
  - X-Ray Tube filters (Cu, Fe, Pb, Br, Sn, etc.)

- DDA Items
  - Duplex Plate Phantom or 5 groove wedge
  - Duplex Wire Gauge
  - Light meter capable of reading cd/m^2
  - X-Ray Tube filters (Cu, AL, Pb, Br, etc.)



WHAT CONSTITUTES A GOOD IMAGE?

GOOD IMAGE?

SUMMARY

- There are additional critical key items that need to be understood in digital radiography when compared to film radiography
- Even a well experienced film radiographer will require additional training to understand the fundamentals of digital radiography
- Additional formal training and experience is essential in digital radiography in order to achieve acceptable POD
- Understanding which digital system will meet your application needs
- Image quality can be measured, and a good image is not necessarily one that just meets the requirement.

QUESTIONS ??