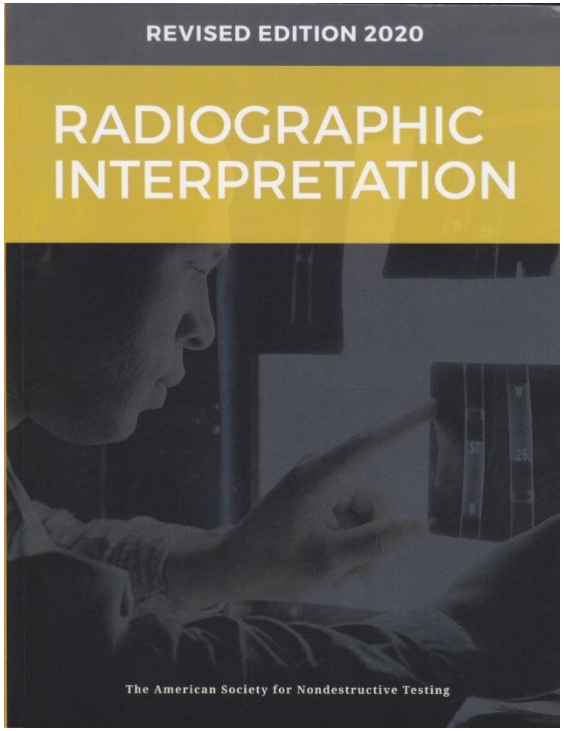
“Uso de diferentes fuentes de radiación y sus implicaciones al aplicarlas en radiografía digital (CR y DR ventajas y desventajas)”

Gabriel Cortés

TOPICS



General

- Digital Radiography Techniques and Technologies
- Difference between CR & DR.

Technical

- Sources (X-Ray, Gamma)
- Image Capture (Film, CR, DR)
- Radiographic Geometry
- Scatter…
- Signal to Noise Ratio
- Contras to Noise Ratio

Applications

- Sensitivity of Iridium and Selenium for DDA and CR systems.
- Sensitivity of Xray source with DDA and CR systems
- Sensitivity of Pulse Xray with DDA and CR systems.
- Direct Comparison between Xray and Pulse Xray.

Digital Radiography Techniques and Technologies

Most common;

Computed Radiography (CR)

Digital Detector Array Radiography

- ASNT uses (DR) for digital detector array radiography
- ASTM uses (DDA) for digital detector array radiography

Computed Tomography (CT)

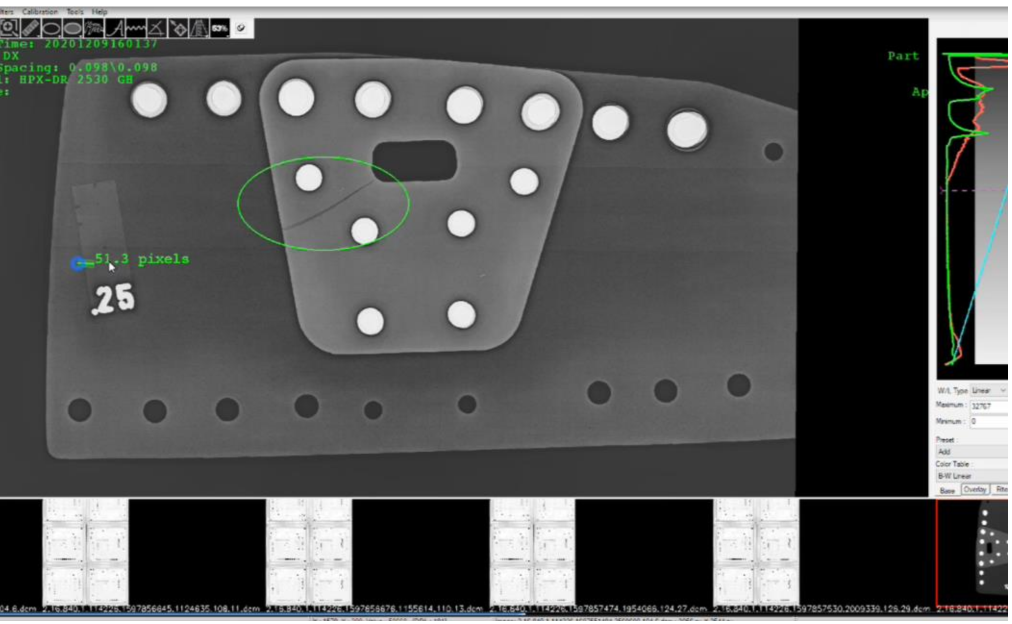
Linear Detector Array Radiography (LDA)

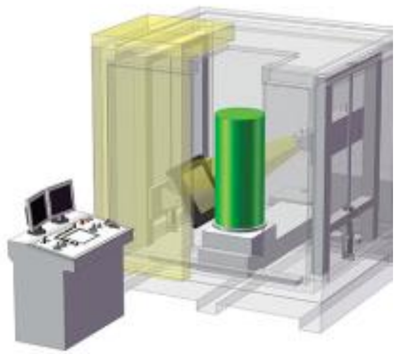
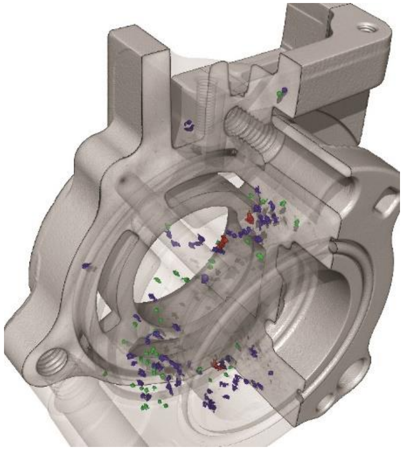
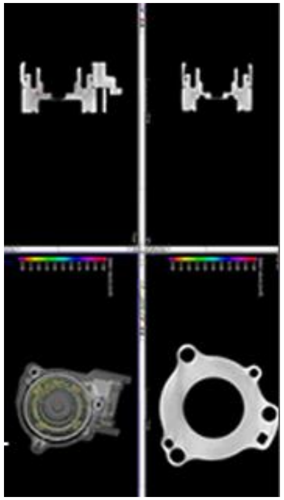
Radioscopy

Real time radiography with DDA’s

Digital Radiography Techniques and Technologies

RT – CR – DR : 2D image / no live

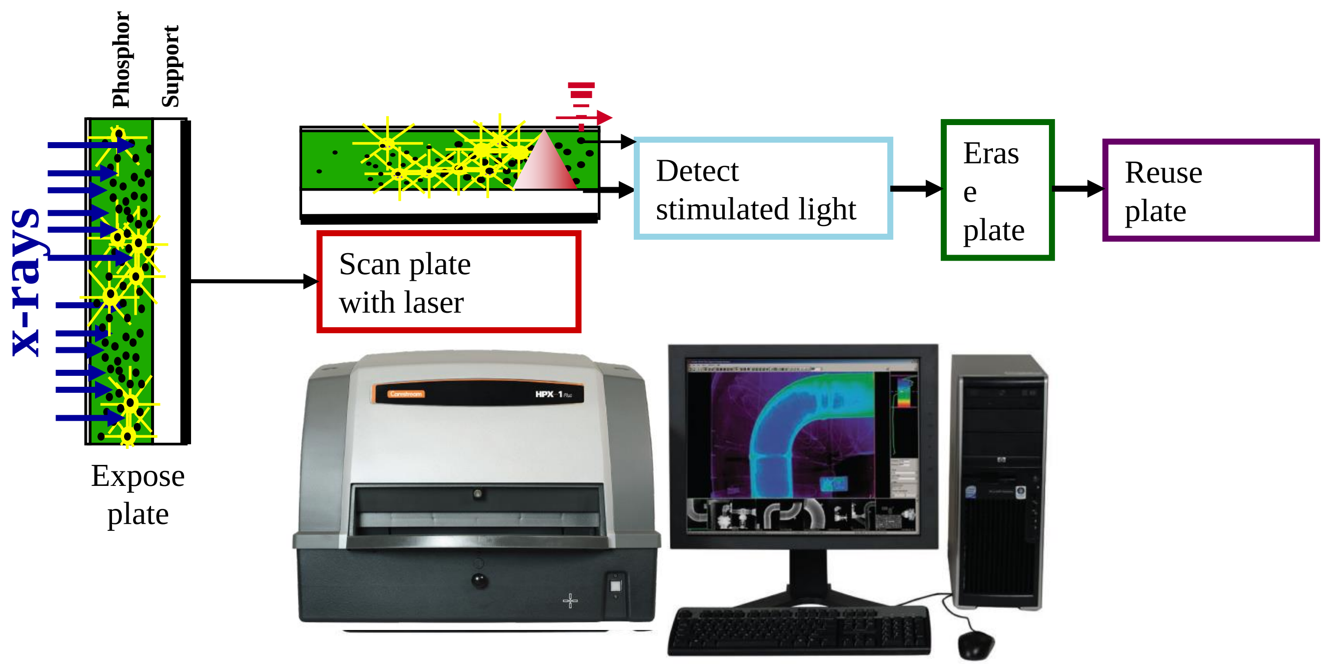


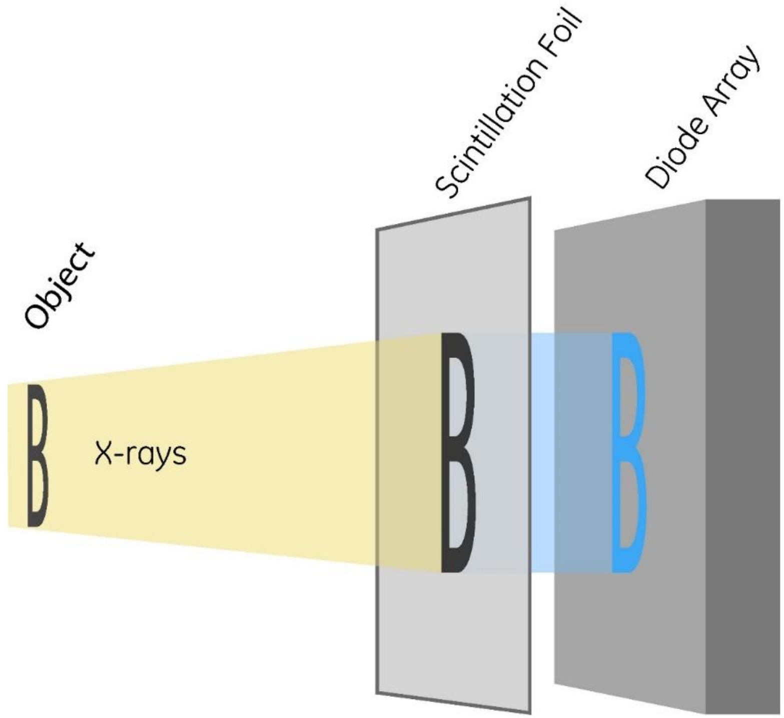

Digital Radiography Techniques and Technologies

CT – LDA – Radioscopy : Live 2D image / Volumetric Inspection

Computed Radiography



Digital Radiography

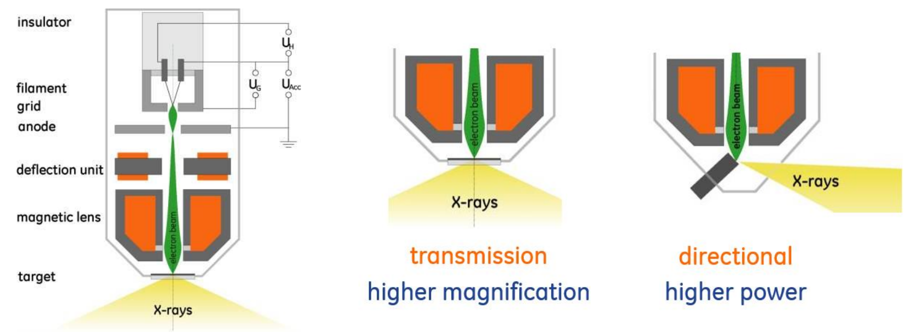


Sources

Gamma (Iridium, Selenium)

X Ray Generator

Pulse X Ray Generator



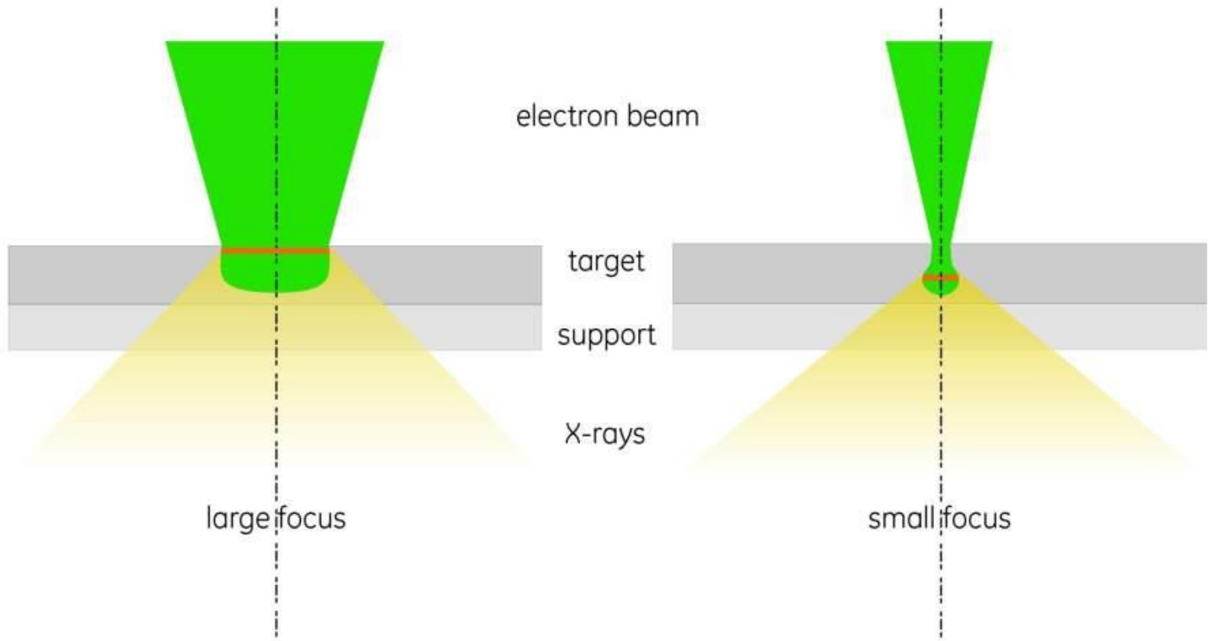
Performance and Packaging: Pulsed technology generates high output voltage using minimal input voltage. The result is extremely small single package generators with significant penetrating capability.
Safety and Simplicity: Minimal side and rear X-ray leakage means the operator safety stand-off distance is 20 feet (6 m) behind the unit. The generators contain no radioactive material. Radiation is only emitted from the generator while it is pulsing. The single package design eliminates the need for connecting cables between tube head, control module, and power supply.

Model	Weight Lbs./Kg	kV	Penetration (steel) in./cm	Dose mR per pulse*	Pulse Width	Pulse rate per sec.	Rear Standoff Distance Ft / m
XR150 20V	6.0 / 2.73	150	0.75 / 1.91	1.8 - 3.0	50 ns	11	10 / 3
XR200 20V	11 / 5.00	150	0.50 / 1.27	2.0 - 3.4	50 ns	10	10 / 3
XRS3 20V	11.80 / 5.40	270	1.00 / 2.54	2.0 - 4.3	25 ns	21	10 / 3
XRS4 20V	18.30 / 8.30	370	1.75 / 4.46	4.0 - 8.5	10 ns	9	20 / 6

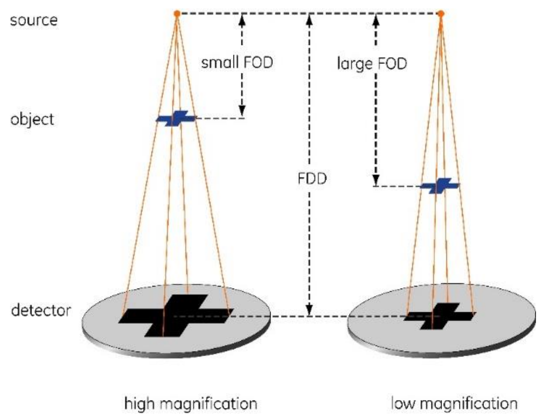
Sources

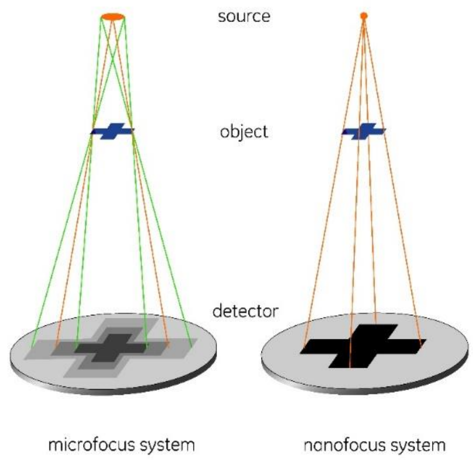
X Ray Generator

Focal Spot directly impact in image resolution.



Geom Mag & Res/Penumbra

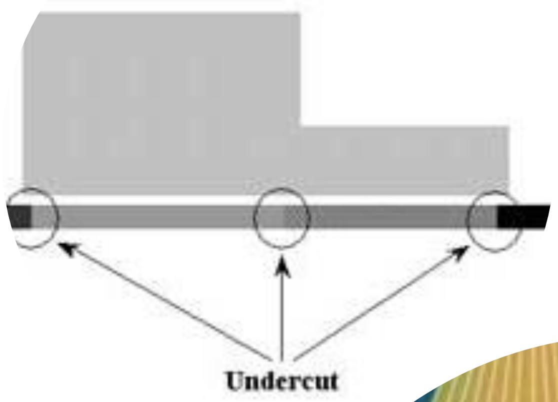




Both have a high impact on image detection.

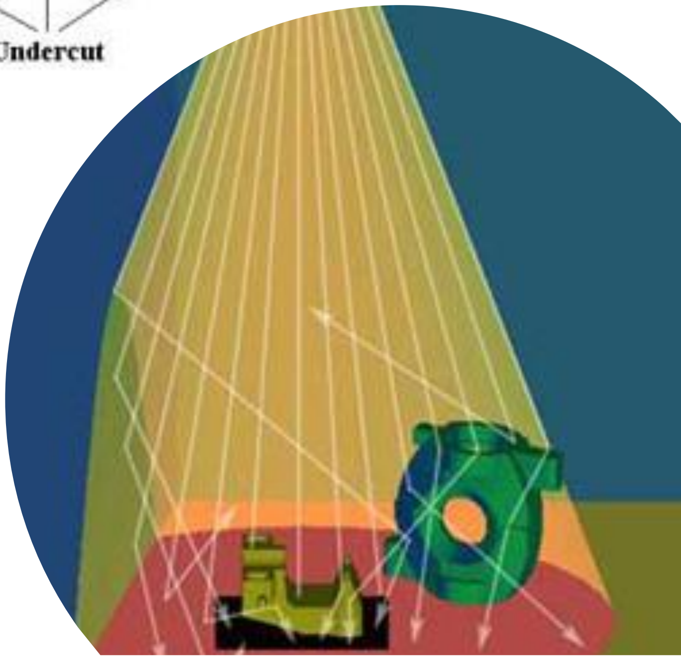
Resolution is always dictated by more than 5 variables.

Scatter & Undercut



Secondary or scatter radiation must often be taken into consideration when producing a radiograph

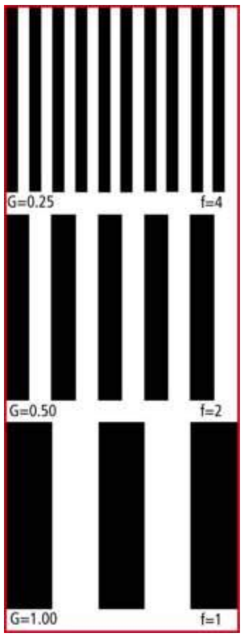
The scattered photons create a loss of contrast and definition

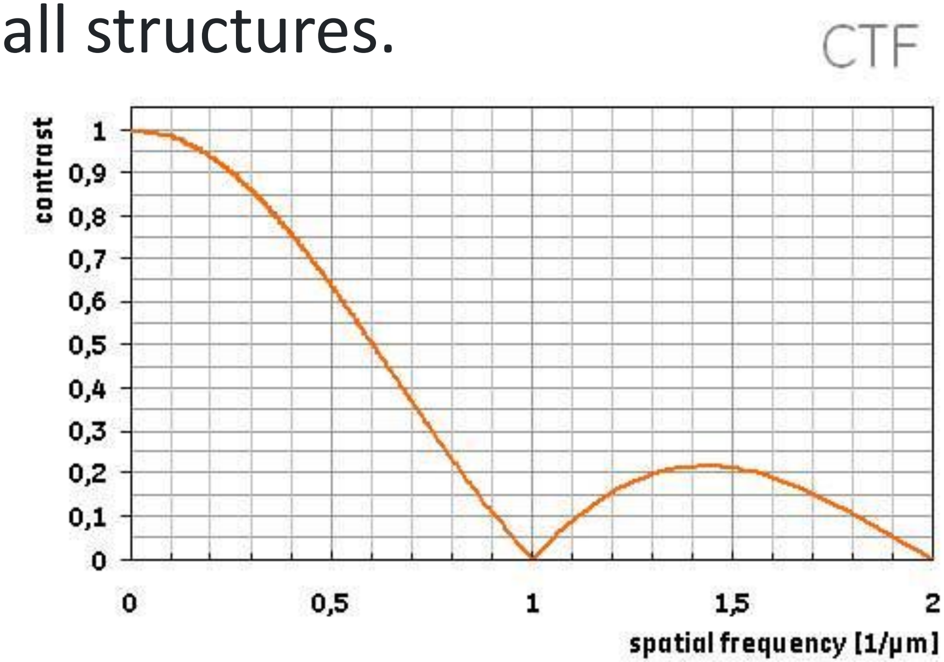


Another condition that must often be controlled when producing a radiograph is called undercut. Parts with holes, hollow areas, or abrupt thickness changes are likely to suffer from undercut if controls are not put in place. Undercut appears as a darkening of the film radiograph in the area of the thickness transition. It appears as a brighter ghosting near the edges in a digital image. This results in a loss of resolution or blurring at the transition area.

Resolution

The spatial resolution of an x-ray system is a measure of how the ability of a system to differentiate small structures.

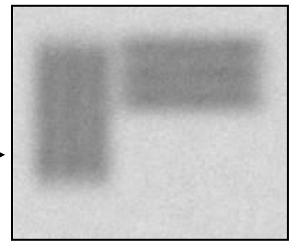


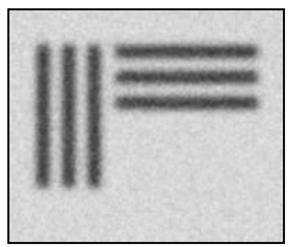


Resolution

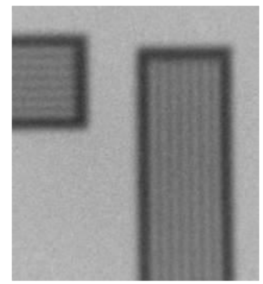
Contrast transfer function / Focal Spot Size

$$CTF = \left| \frac{\sin\left[\pi\, G^{-1}\left(\frac{M-1}{M}\right)\right]}{\left[\pi\, G^{-1}\left(\frac{M-1}{M}\right)\right]} \right| = 0 \rightarrow$$



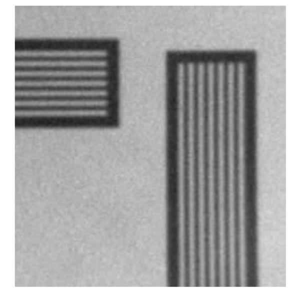


$$for \quad G = F\left(\frac{M-1}{M}\right) \cong F$$



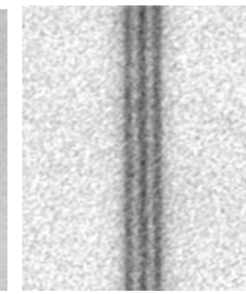
2 µm bars

F < 2.5 µm



2 µm bars

F < 1.5 µm



0.6 µm bars

F < 0.8 µm

Image Quality

Traditional FILM

Densitometry is the quantitative measurement of optical density in light-sensitive materials.

Digital Imaging

Dynamic Range (bit)

Signal to Noise Ratio

Contrast to Noise Ratio

Spatial Resolution

Sensitivity

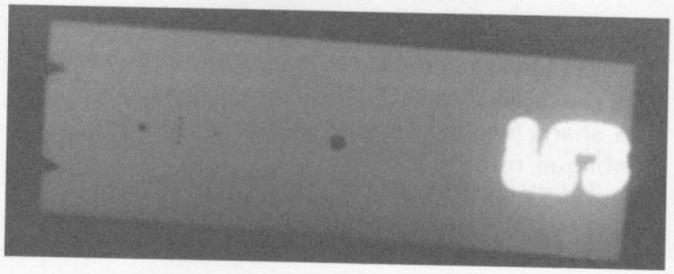
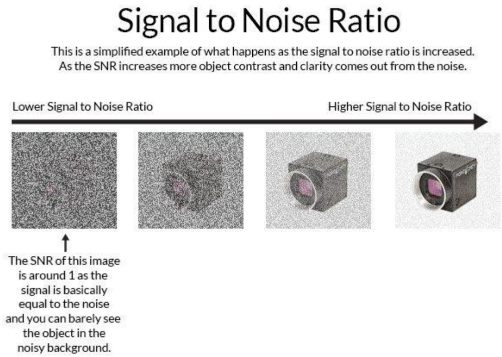


Figure 17. Radiograph of a penetrameter used in radiography.

SnR vs CnR

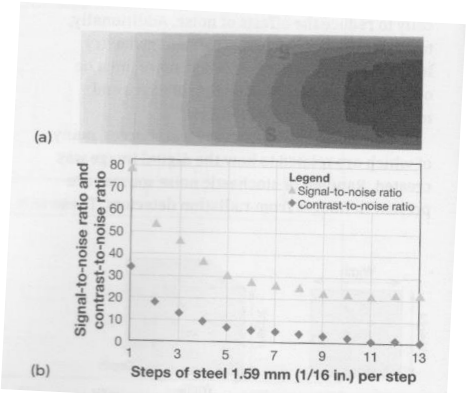
Signal to Noise

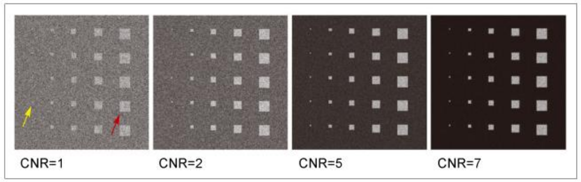
Attempts to quantify a signal or image element value compared to the background noise.



Contras to Noise

Difference in the image element values for adjacent image region. Capacity to differentiate from background.





SnR vs CnR

Signal to Noise

SNR = N/ σN= pixel value; σ= standard deviation

Signal –desirable part of image: increases with dose

Noise –undesirable part of image: influenced by

- –Scatter
- –Statistical noise variation

Guideline is SNR > 100:1

DR can be > 1000:1 with frame averaging

Contras to Noise

Difference between pixel values of adjacent areas inside and outside the hole

Divided by standard deviation of pixel value outside the hole

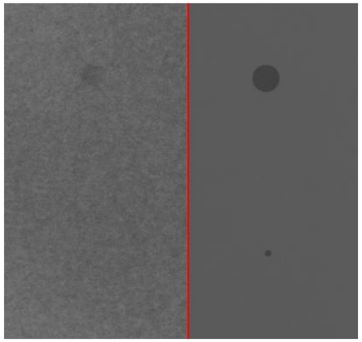
(N2 –N1)/σ

N = pixel value

σ= standard deviation

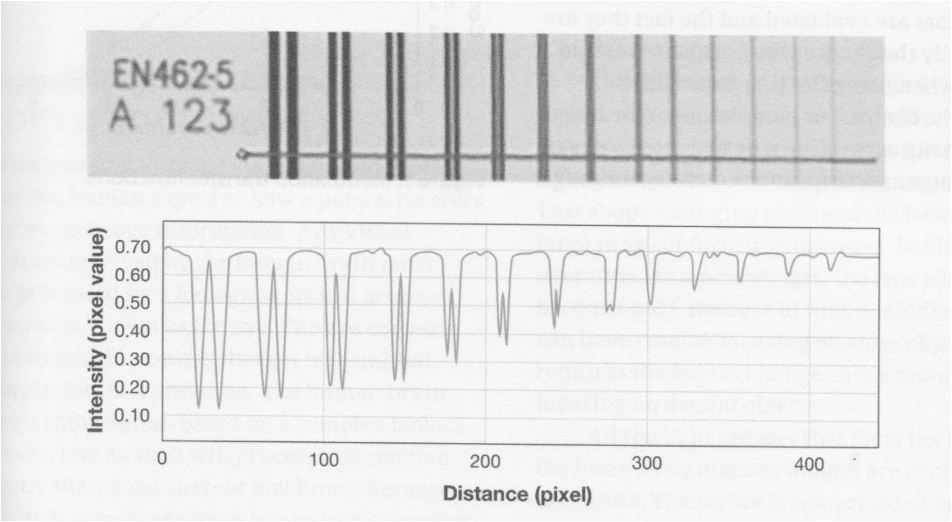
Standards specify this contrast is measured inside the 4T hole, and adjacent to it

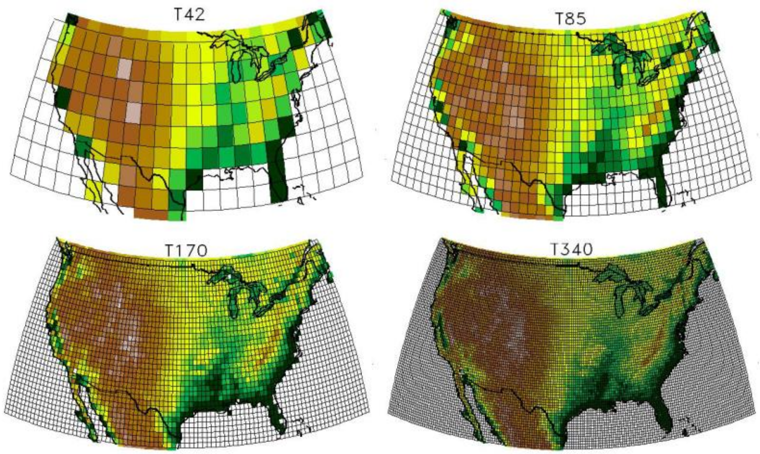
Guideline is CNR > 2.5



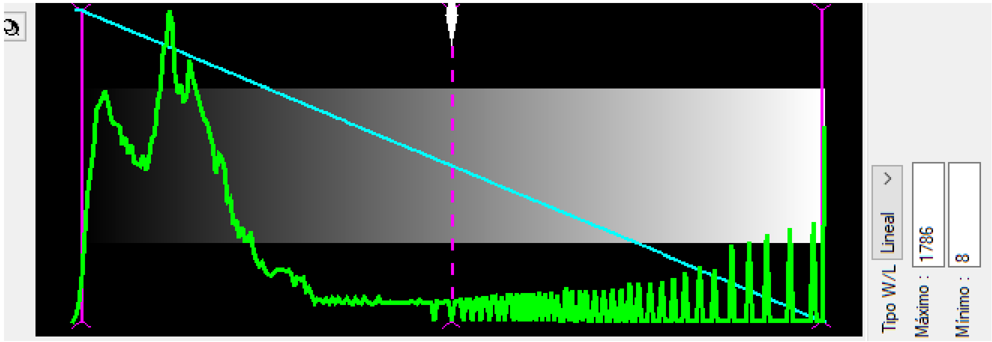
Spatial Resolution

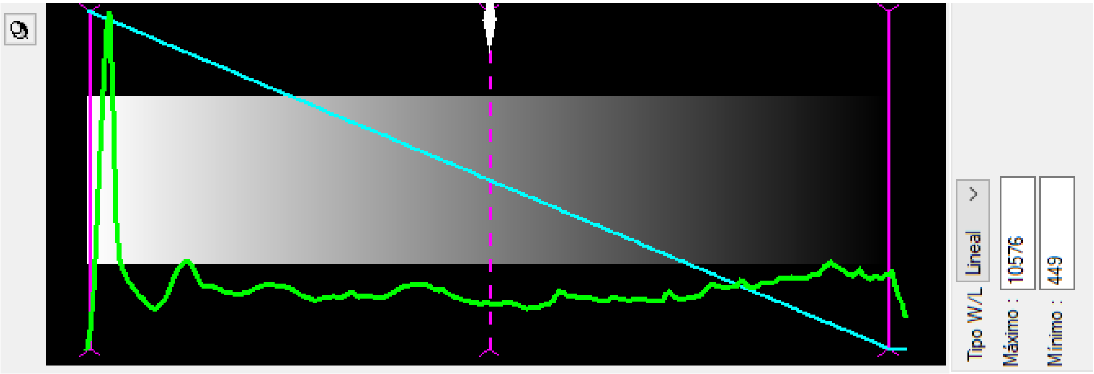
Is the reference to the smallest detectable feature in the image. UnSharpness is the parameter measured.





HISTOGRAM – Key Feature





Main additional - Points to Qualify a System

Scanning Vibration (CR)

Pixel Pitch (DR)

Contrast Sensibility

Digital Shadows

Ghost Image

Dead Pixels (DR)

ATTRIBUTE	CR	DR
Flexible	Yes	No
Reusable Media	1,000 – 5,000	10,000-1,000,000
Capture Speed (vs film)	.20–30 % faster	50-90% faster
Process Speed (vs film)	0.5	0.1
Exp. Latitude	10,000:1	10,000:1
Spatial Resolution	25 – 150 micron	50 – 200 micron
SNR	100 - 250	250 - 2000
ROI	Moderate	High
Environmental Tolerance	Excellent	Moderate / High
Darkroom/Chemicals	No	No
Size Range	2"x2" – 35"x60"	Various sizes
Image Sharing	CD, DVD, E-Mail, Cloud	CD, DVD, E-Mail, Cloud
Accessibility	Immediate	Immediate

Se - 75 vs Ir - 192

Source Type	Gamma Energy	Half-life and Activity Range	Average Emission Energy	Working range with steel	Emissivity rate
Selenium-75	97 to 401 keV	120 days 10 – 120 Ci	~215-230 keV	~0.118 to 1.14 inches ~3 to 29 mm	2.18 R/hr/Ci at 1 foot 5.4 × 10-5 mSv/h/MBq at 1 m
Iridium-192	206 to 612 keV	74 days 10 – 150 Ci	~370-380 keV	~0.47 to 2.48 inches ~12 – 63 mm	5.2 R/hr/Ci at 1 foot 1.3 × 10-4 mSv/h/MBq at 1 m

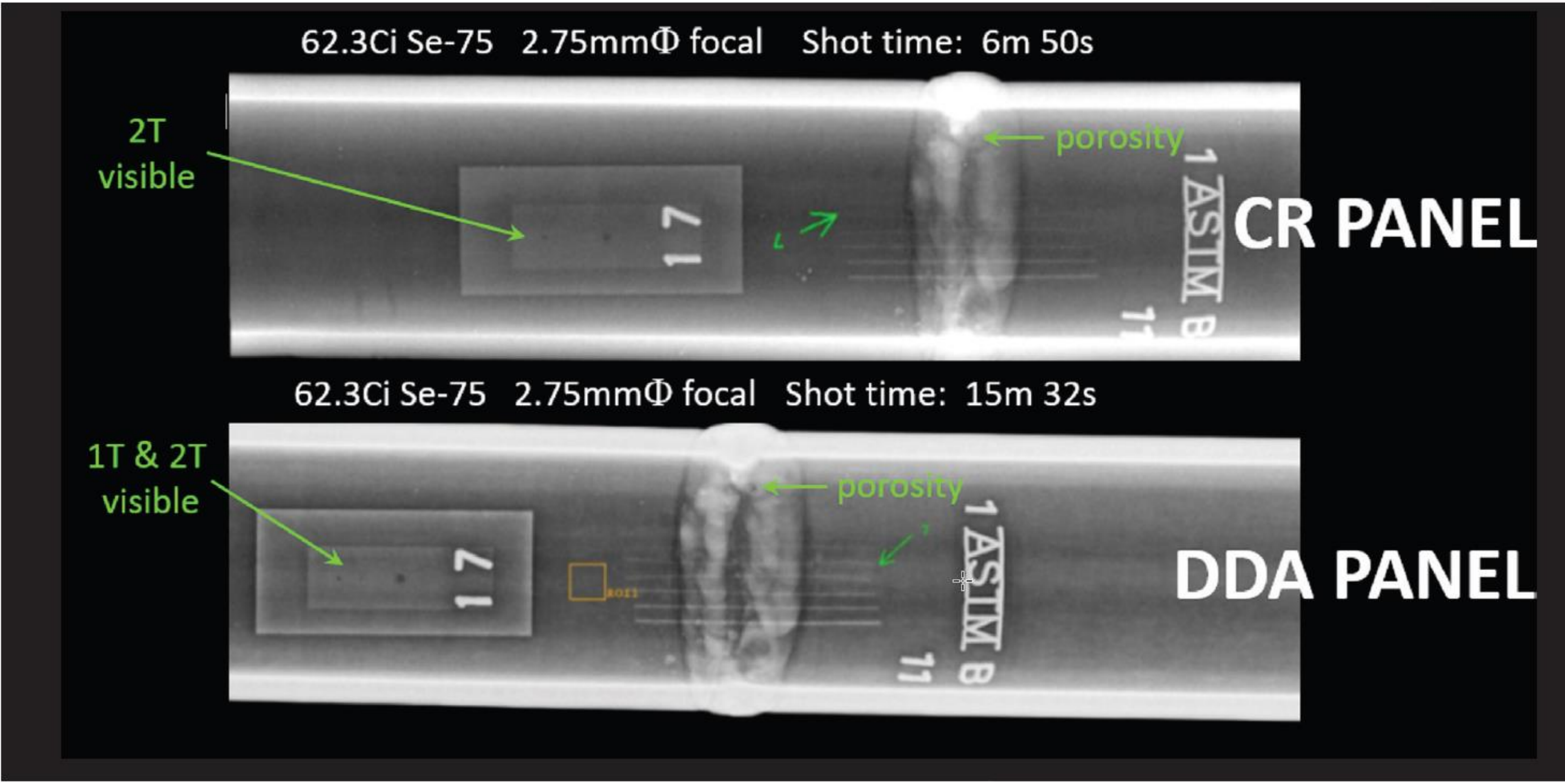
Two sets of experiments with Se-75 and Ir-192 gamma sources were conducted; the first set comprehends obtaining images from a ½-inch stainless steel plate and from a 3/8-inch aluminum plate using both DDAs for DR images and IPs for CR images.

Equipment

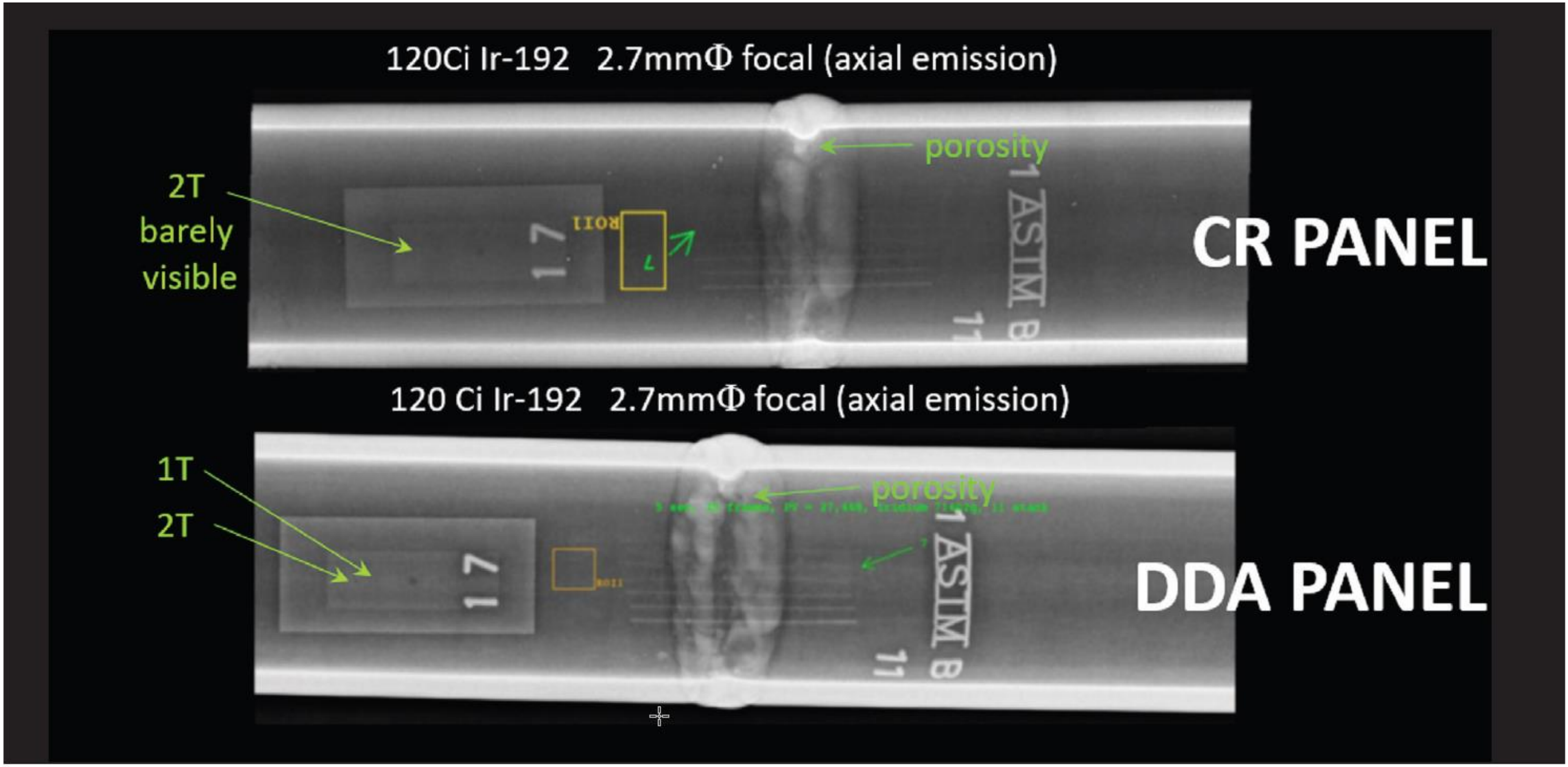
For computed radiography, the source-to-detector distance was 20-inches. **HPX-PRO** radiography system was utilized in conjunction with **INDUSTREX Version 5.1 Software** for image capture. Exposures were done at 7 R with an aim pixel intensity of 6000 through the base metal on a 16 bit linear scale. An HR type imaging plate was used. Images were captured at 50 mm pixel size with a photomultiplier tube setting of 10.

For digital detector array radiography, the source-to-detector distance was 29-inches. A **139 mm pixel pitch HPX-DR 3543 Non Glass** radiography system was utilized in conjunction with **INDUSTREX Version 5.1 Software** for image capture. Exposures were done at 0.08 R for Iridium and 0.04 R for Selenium with an aim pixel intensity of 20,000 through the base metal on a 16 bit linear scale. Integration times were typically 5 seconds for Iridium and 14 seconds for Selenium, with 25 averaged frames.

Se-75


62.3Ci Se-75 2.75mmΦ focal Shot time: 6m 50s
2T visible
porosity
CR PANEL
62.3Ci Se-75 2.75mmΦ focal Shot time: 15m 32s
1T & 2T visible
porosity
DDA PANEL

IR-192


120Ci Ir-192 2.7mmΦ focal (axial emission)
2T
barely
visible
porosity
ROI1
ASTM B
CR PANEL
120 Ci Ir-192 2.7mmΦ focal (axial emission)
1T
2T
porosity
ROI1
ASTM B
DDA PANEL

Conclusions

System	Gamma Source in Use	Observed Hole	Observed Wire
HPX-PRO	Se-75	2T	7
HPX-DR		1T	6
HPX-PRO	Ir-192	4T	7
HPX-DR		1T	7

Radiographic detectability was best for Selenium radioisotopes used in conjunction with digital detector array systems because Selenium produced images with less noise.

Likewise, digital detector array radiography systems produced images with reduced noise, which resulted in higher contrast-to-noise ratios and improved detectability. This can reduce shot time and extends the practical working life of sources.

X-ray vs Pulse Xray

For Xray was used a ECO 200DS Comet tube at 160KV and 5ma in all cases.

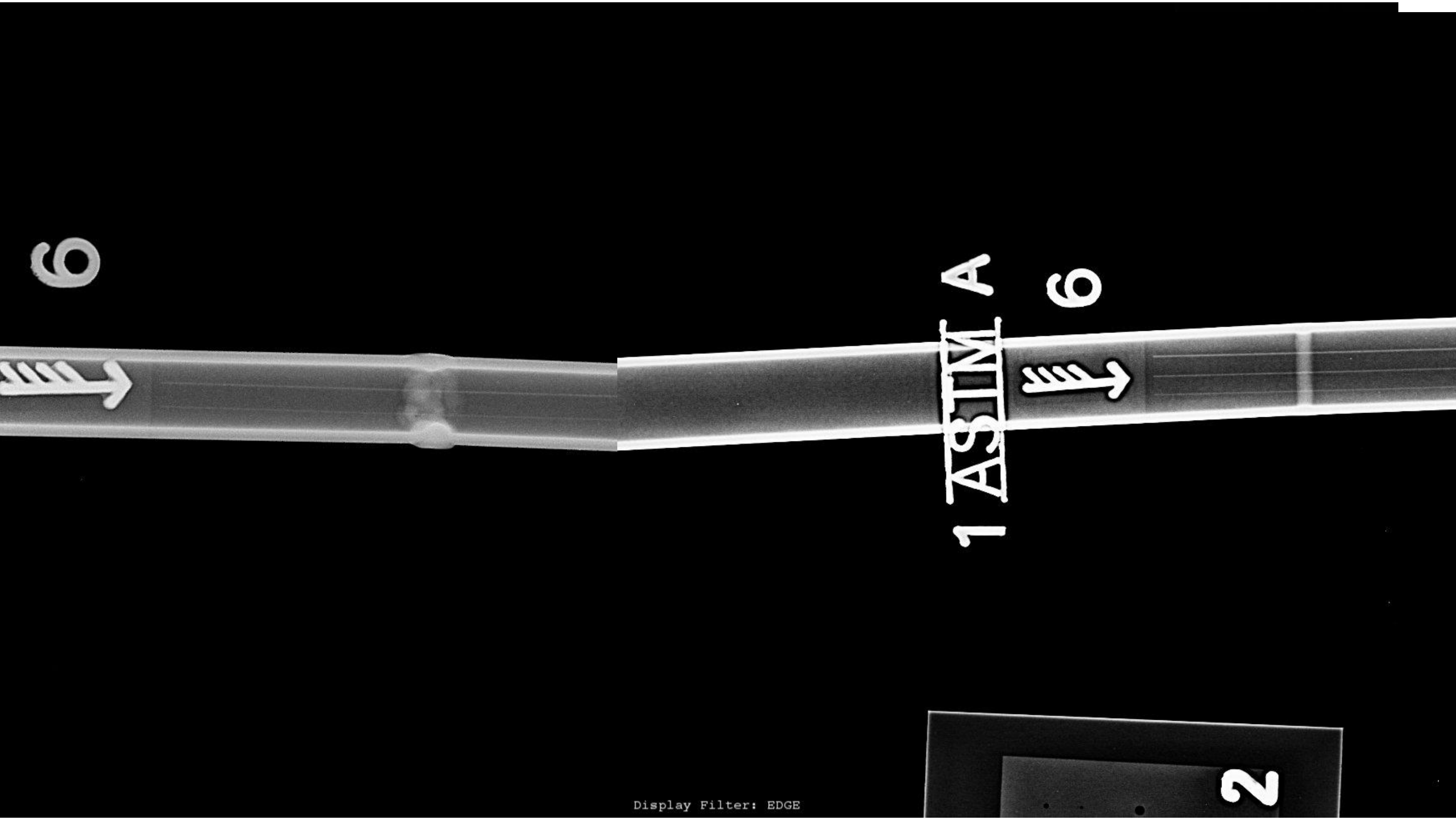
For pulse generator a XRS3 model with 195KV pulse with 15ns. For CR 650 pulses were used. For DR 90 pulses.

Equipment

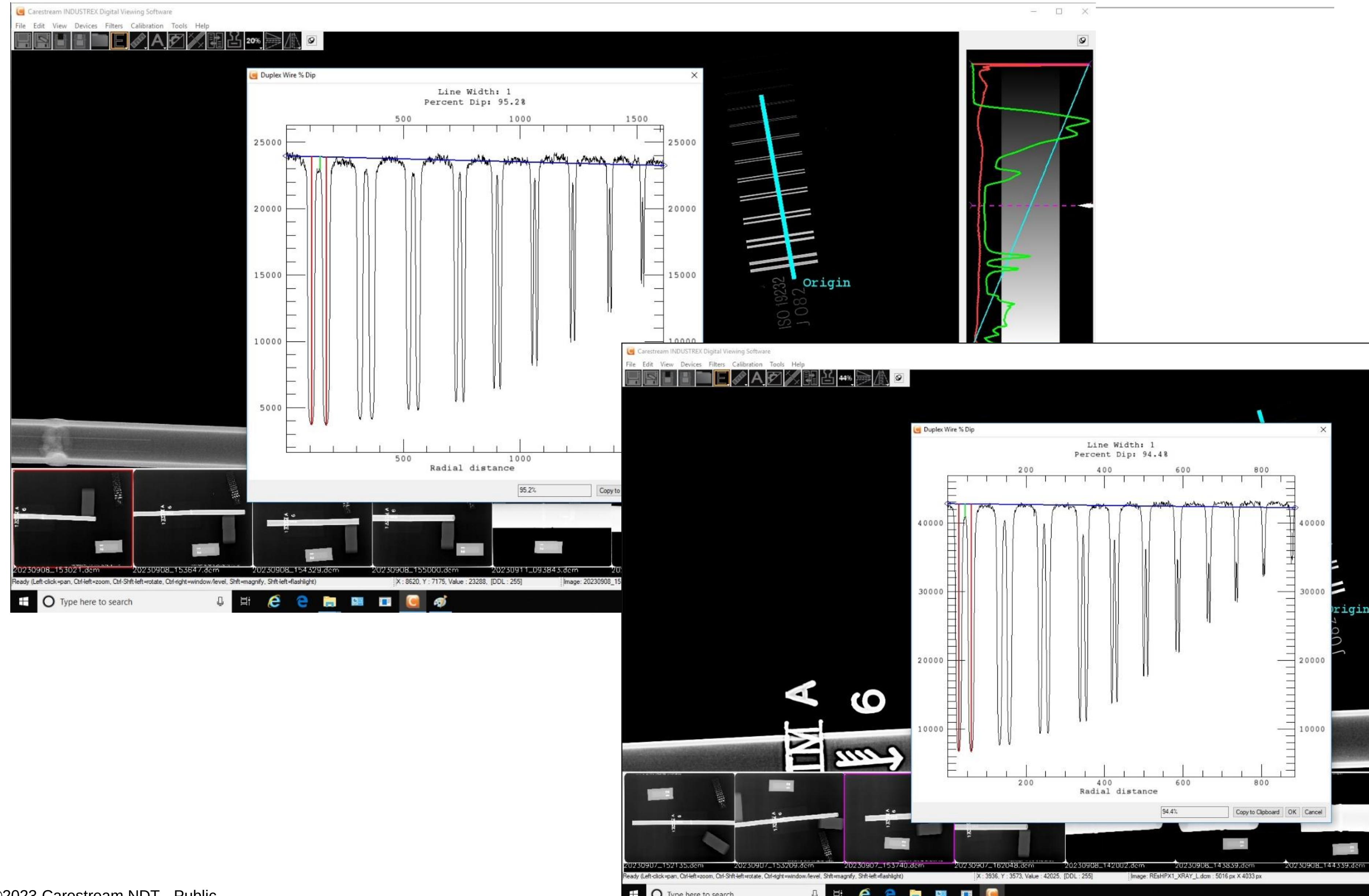
For computed radiography, the source-to-detector distance was 20-inches. **HPX-HPX1plus** radiography system was utilized in conjunction with **INDUSTREX Version 5.4 Software** for image capture. Exposures ……. An HR type imaging plate was used. Images were captured at 50 mm pixel size.

For digital detector array radiography, the source-to-detector distance was 29-inches. A **98 mm pixel pitch HPX-DR 2530 Non Glass** radiography system was utilized in conjunction with **INDUSTREX Version 5.4 Software** **f**or image capture. Exposures were done at ………………. Integration times were typically 1 second for both sources, with 50 averaged frames.

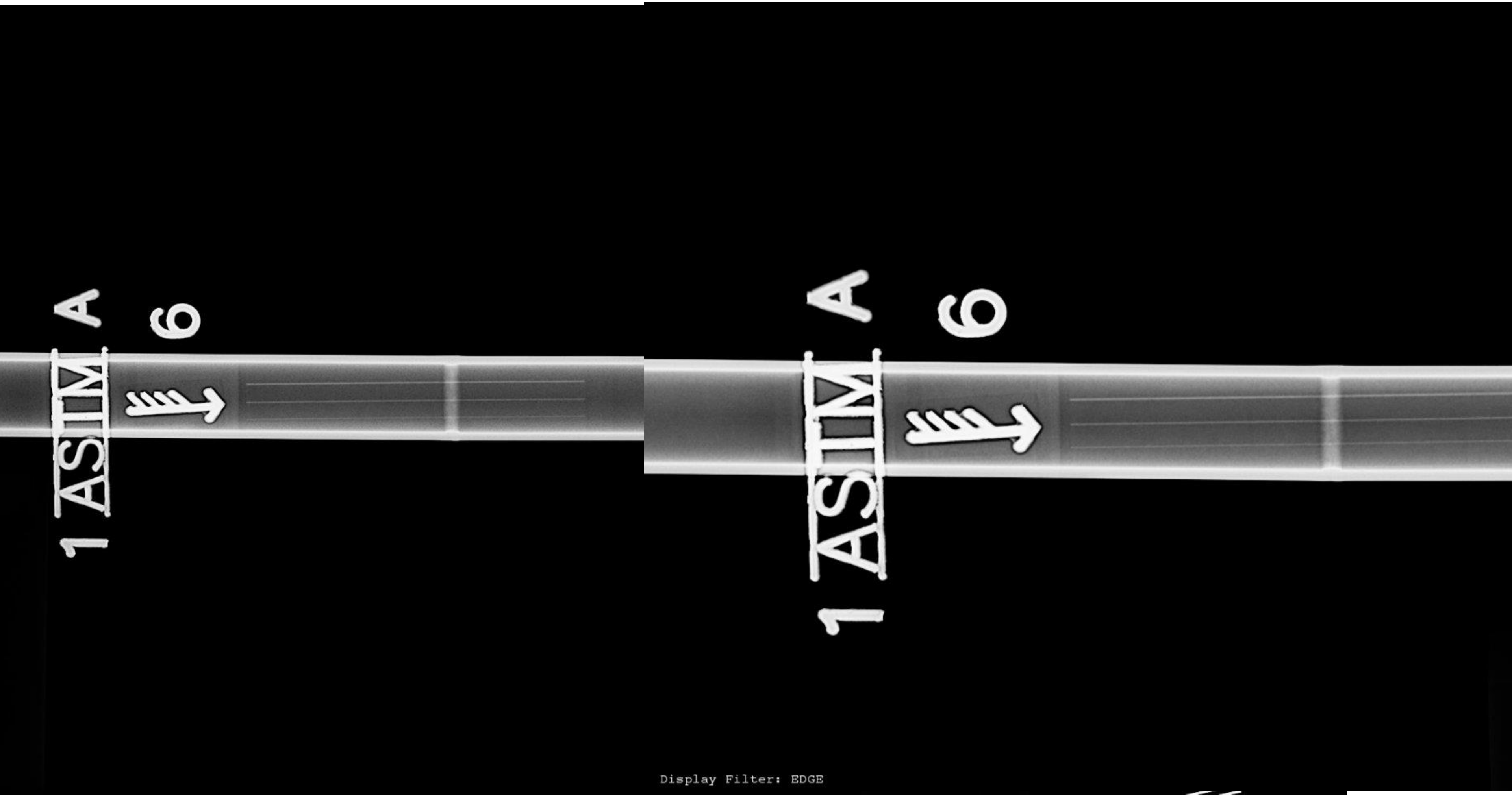
CR Comparison



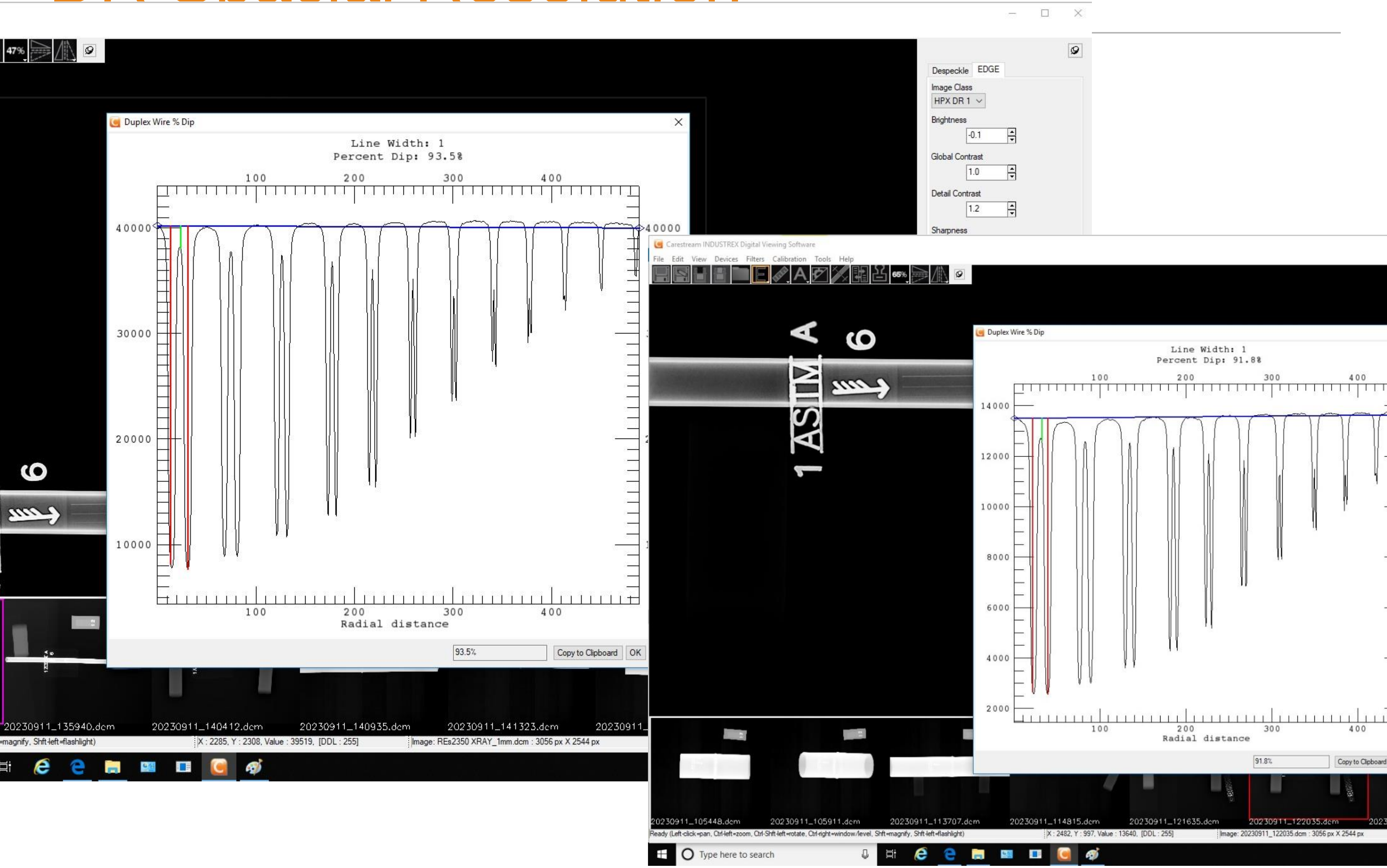
CR Spatial Resolution



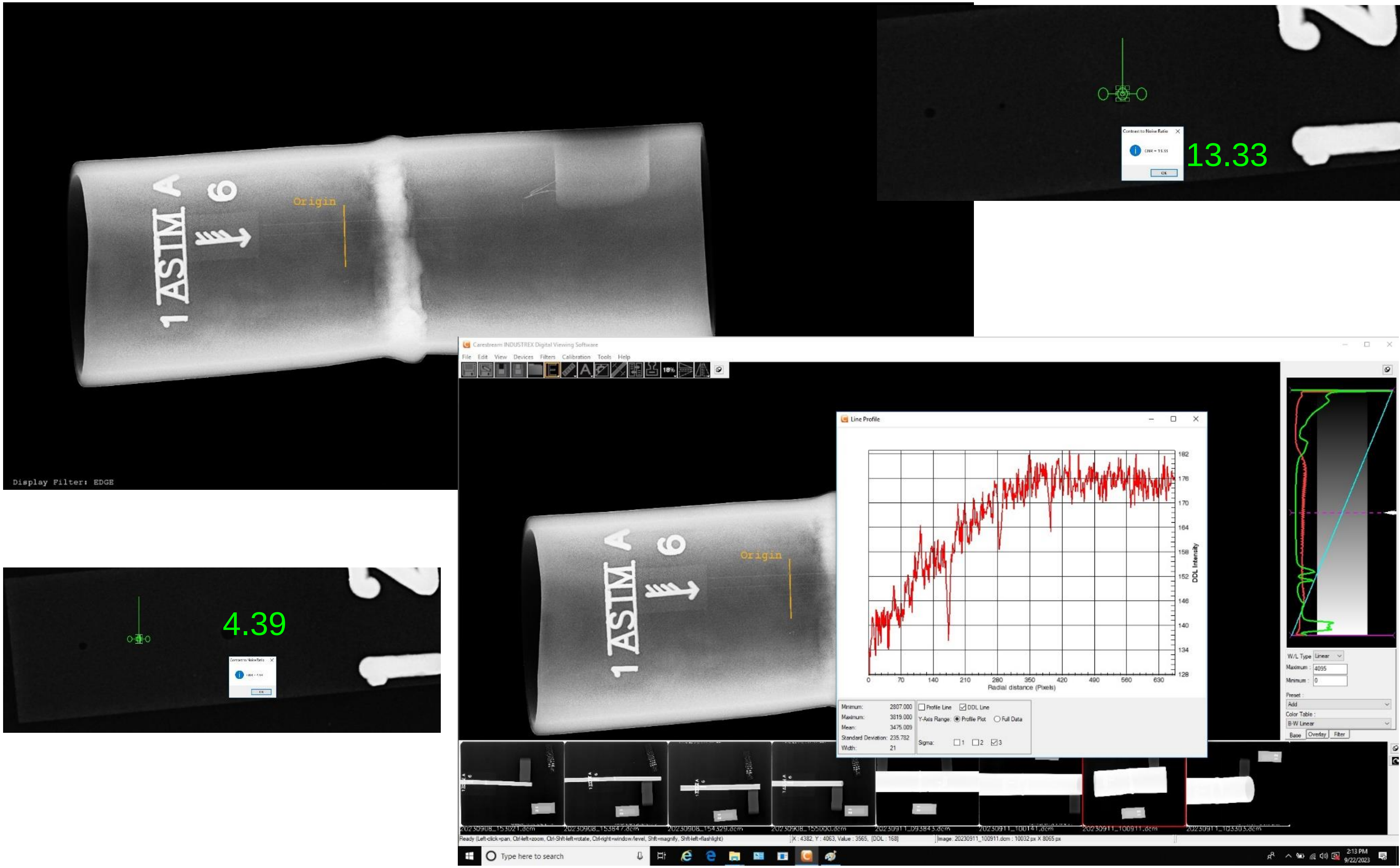
DR Comparison



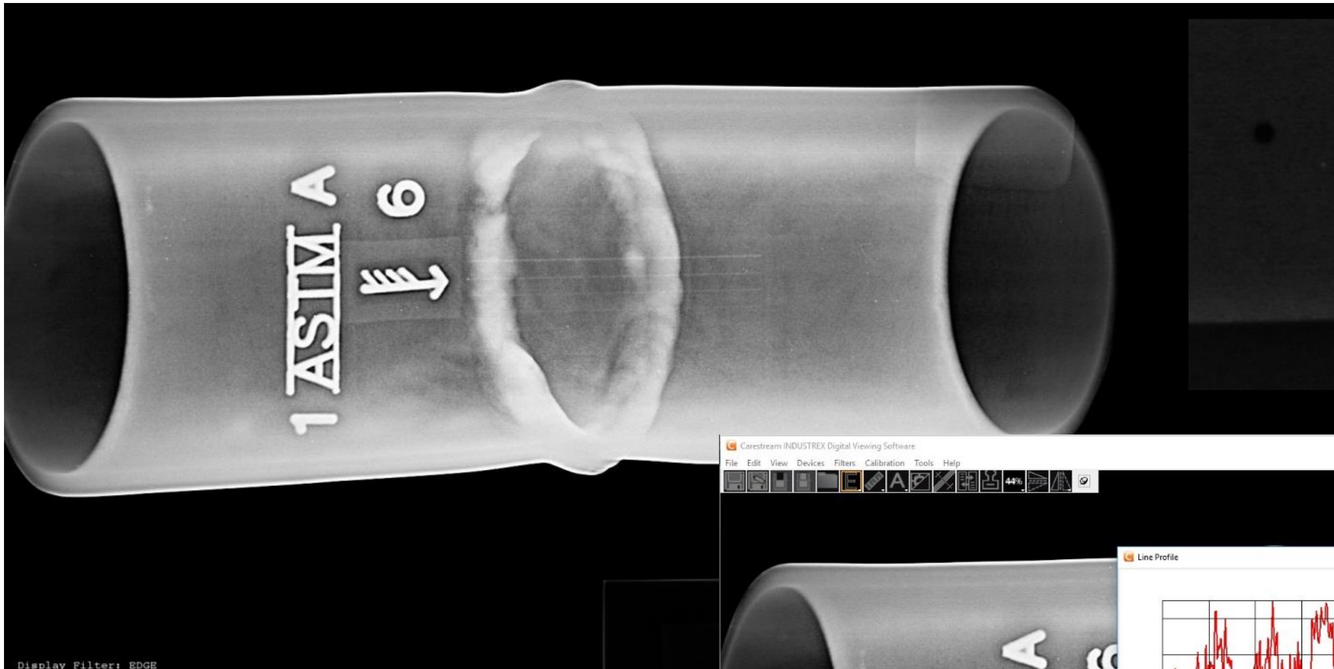
DR Spacial Resolution



CR CNR Pulse


Origin
Display Filter: EDGE
13.33
4.39
Line Profile
Radial distance (Pixels)
DDL Intensity

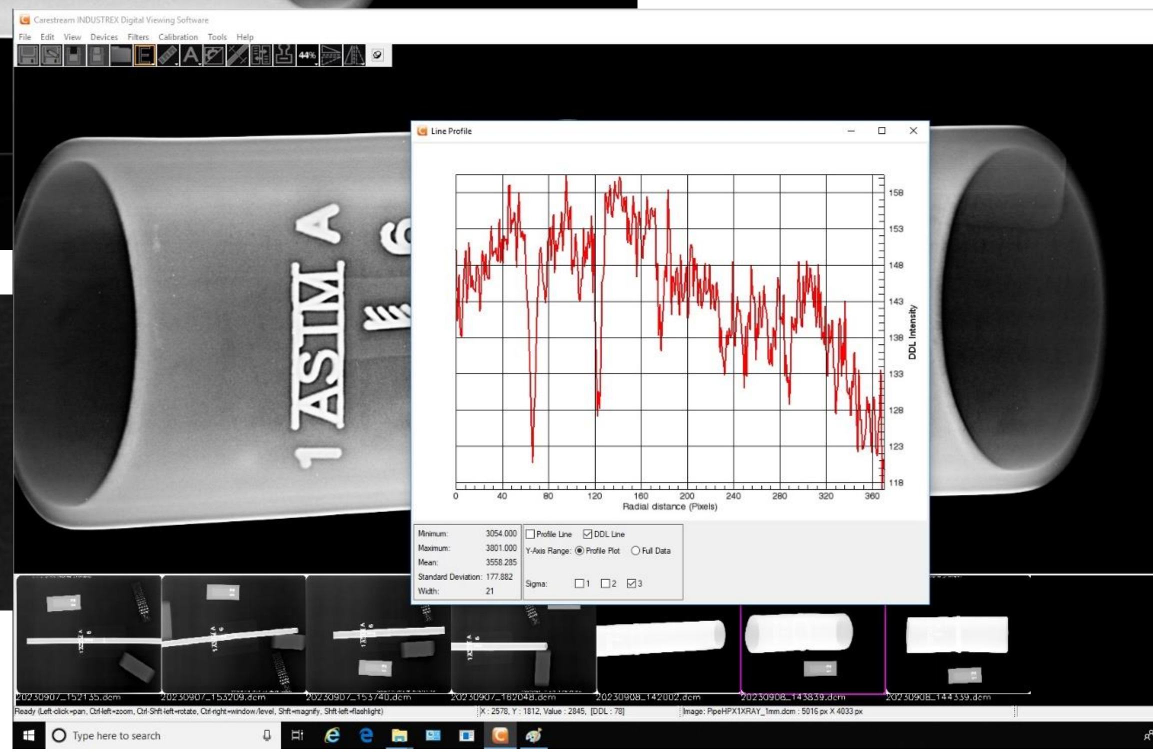
CR CNR Xray



1 ASTM A
6
Display Filter: EDGE

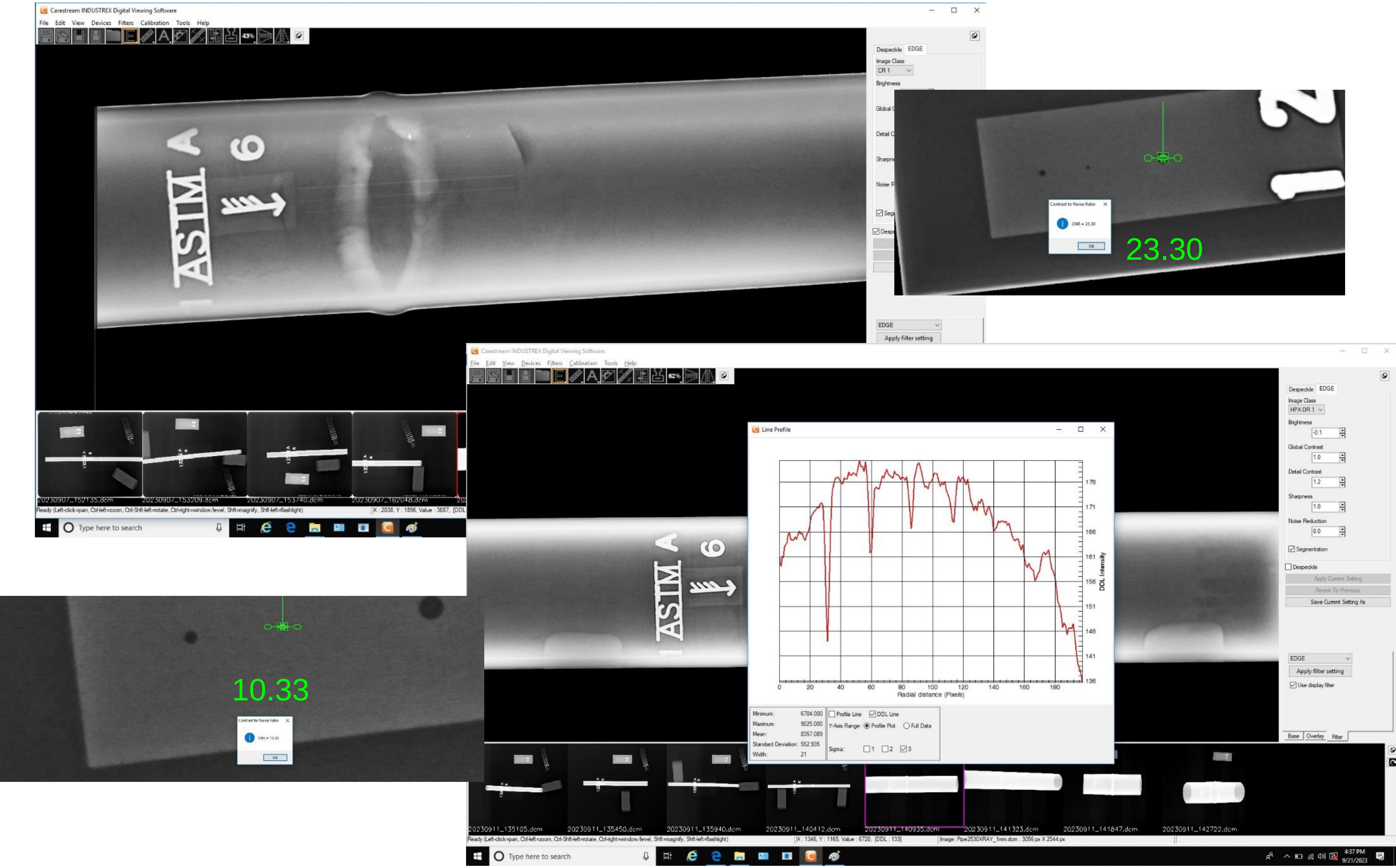
Contrast to Noise Ratio
CNR = 24.61
OK
24.61

8.45
Contrast to Noise Ratio
CNR = 8.45
OK

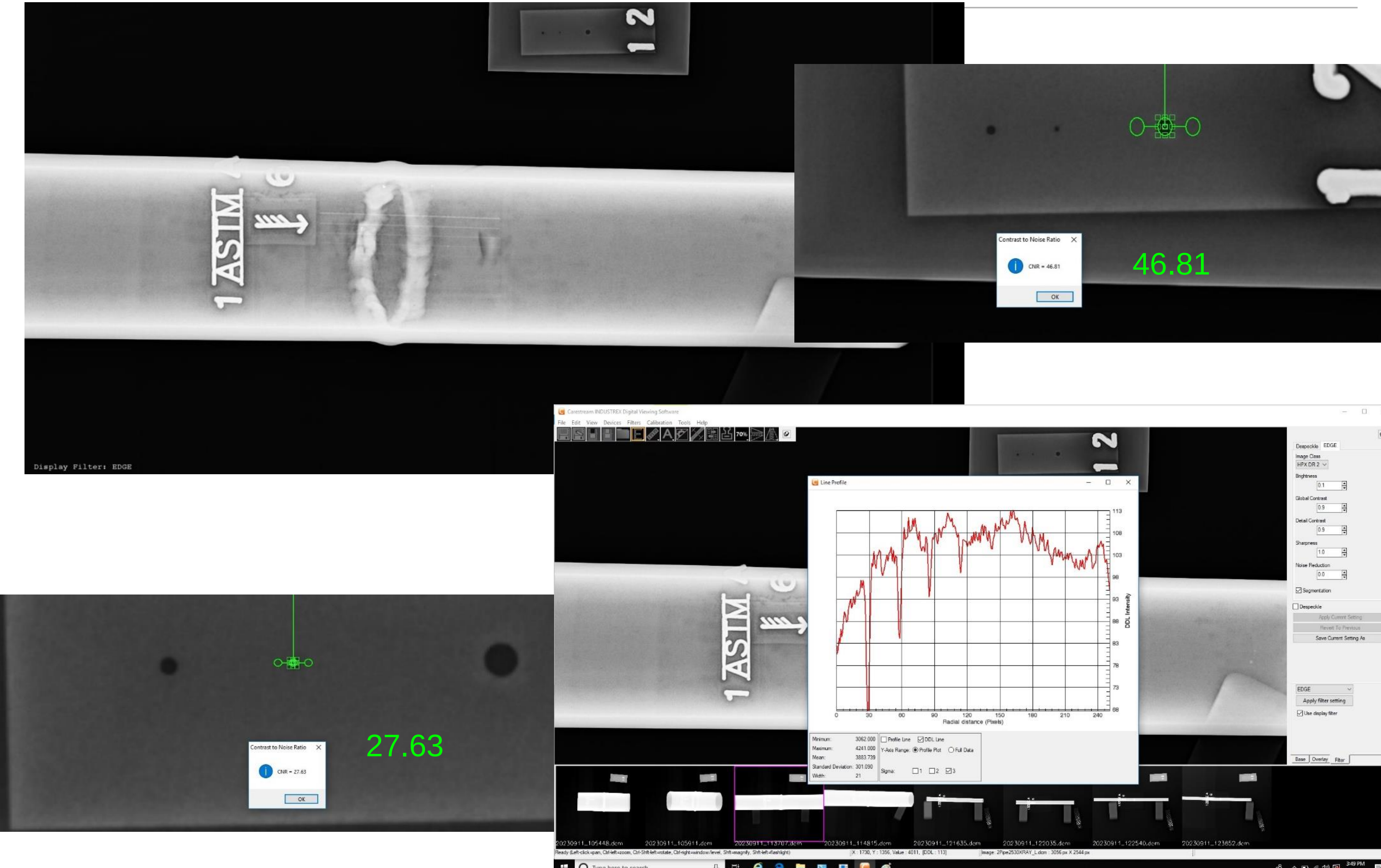


Carestream INDUSTREX Digital Viewing Software
File Edit View Devices Filters Calibration Tools Help
Line Profile
Radial distance (Pixels)
DDL Intensity
Minimum: 3054.000
Maximum: 3801.000
Mean: 3558.285
Standard Deviation: 177.882
Width: 21
Profile Line
DDL Line
Y-Axis Range: Profile Plot
Full Data
Sigma: 1 2 3
Type here to search

DR CNR Pulse


23.30
10.33
Line Profile
Radial distance (Pixels)
DDL Intensity

DR CNR Xray


Display Filter: EDGE
Contrast to Noise Ratio
CNR = 46.81
OK
46.81
Contrast to Noise Ratio
CNR = 27.63
OK
27.63
Line Profile
Radial distance (Pixels)
DDL Intensity

Conclusions

Pulse Xray in CR, represents a high use of the number of pulses and the consequence of rapidly consuming interchangeable tubes. At the same time, quality was downgrade to a limit of not pass CNR standards.

In both cases (Pulse- Xray) digital detector array radiography systems produced images with reduced noise, which resulted in higher contrast-to-noise ratios and improved detectability. This can minimize shot time and extend the practical working life of sources.

CarestreamNDT