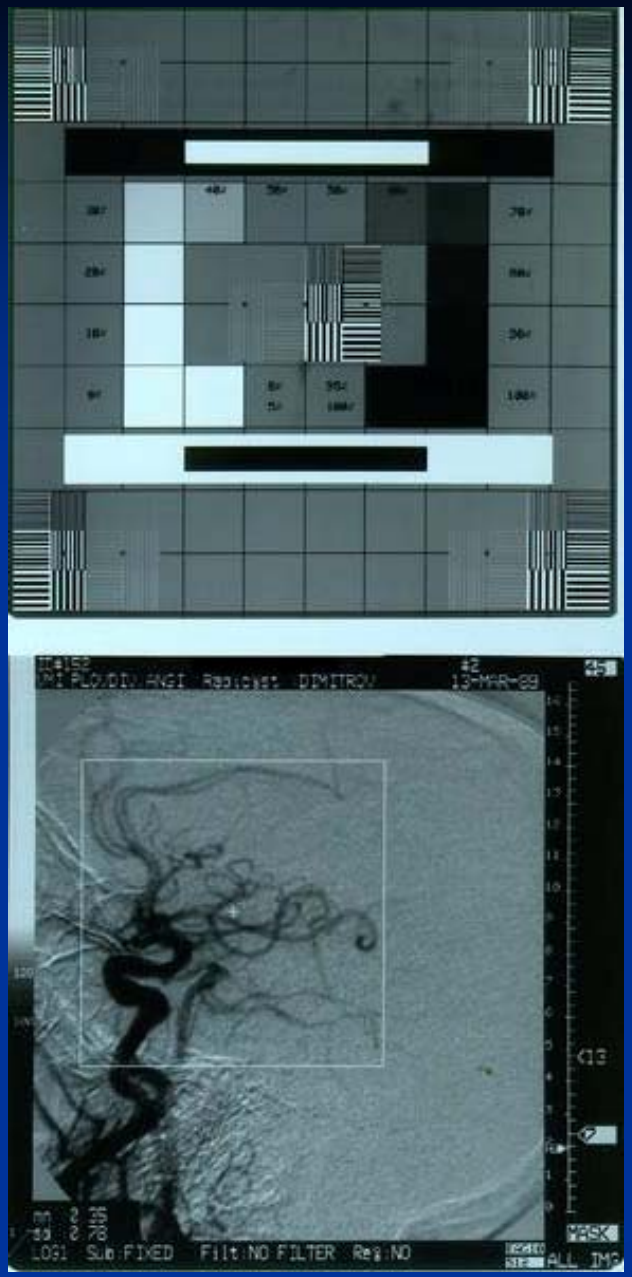

IMAGE QUALITY ASSESSMENT IN X-RAY FLUOROSCOPIC SYSTEMS - PRACTICAL QC

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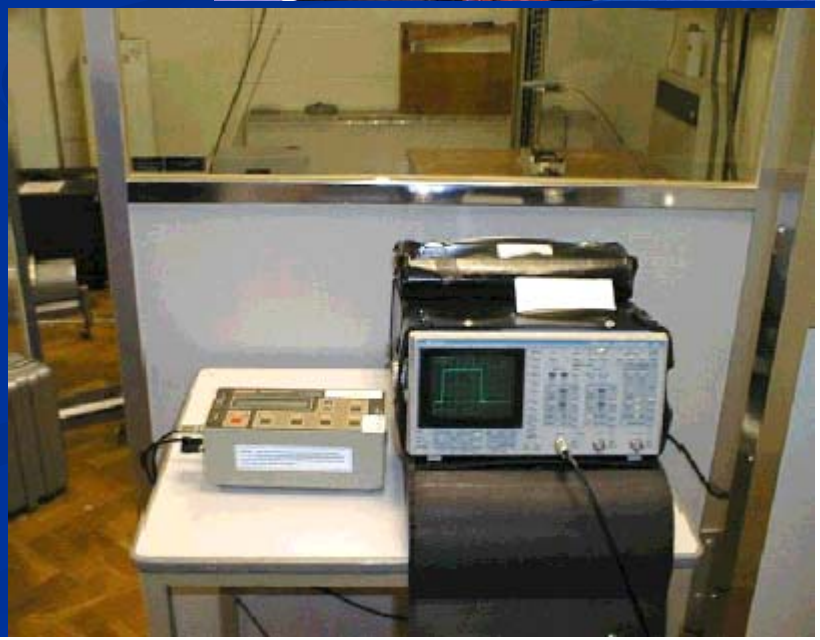
Main steps for a QC survey in Diagnostic Radiology

- General X-ray tube & generator assessment
- Image quality assessment
- Specific parameters assessment
- Quality Control protocols



Fluoroscopy delivers very high patient dose.
This can be illustrated with an example:

The electrical energy imparted to the anode during an exposure is

$$A = C_1 . U_a . I_a . T$$

The X-ray tube anode efficiency is

$$E = C_2 . Z. U_a$$

From the two equations follows that the energy produced in a single exposure will be

$$X = C . A . E = C . Z . (U_a)^2 . I_a . T = (C. Z) . kV^2 . mAs$$

Radiography of the lumbar spine (with parameters 80 kV, 30 mAs):

$$X = k. 80.80.30 = k. 192,000$$

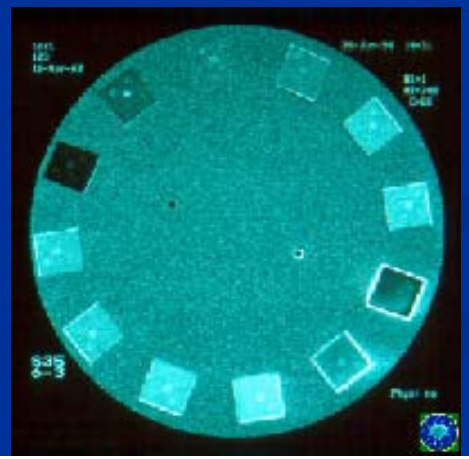
Fluoroscopy - 3 minutes Barium meal (with parameters 80 kV, 1mA)

$$X = k. 80.80.1.3.60 = k. 1,152,000$$

In this example fluoroscopy delivers approx. 6 times more X-ray energy (dose)

QC equipment for Fluoroscopy

- Dosimeter - dose rate - (flat ion. chamber)
- Image quality test objects (at least for contrast scale, limiting spatial resolution, II field size and contrast delectability)
- Attenuators (at least 1mm Cu)
- Special test objects for Fluoroscopy
- (Oscilloscope)



Automatic Brightness Control (ABC/ABS)

- Check fluoroscopy timer-guard (2 min.)
- Measure the maximum dose delivered
- Measure Image Intens. entrance dose with standard beam attenuation (1mm Cu) for all II field sizes (inter-equip. comparison)

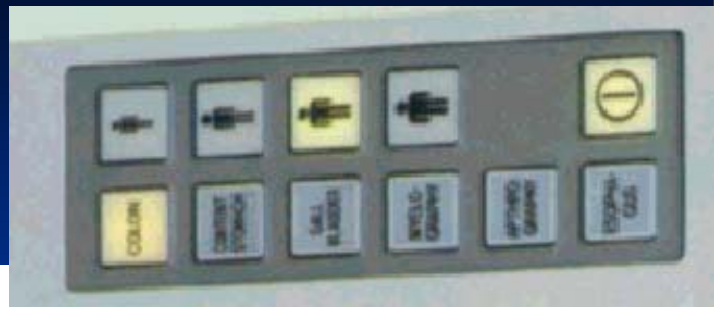
II field size cm	Read kV	Read mA	Dose rate (1mm Cu)	
			(mR/min)	(mGy/s)
30	75	0.9	10.9	0.0016
23	75	2.4	24.8	0.0036
17	75	4.2	40.2	0.0058

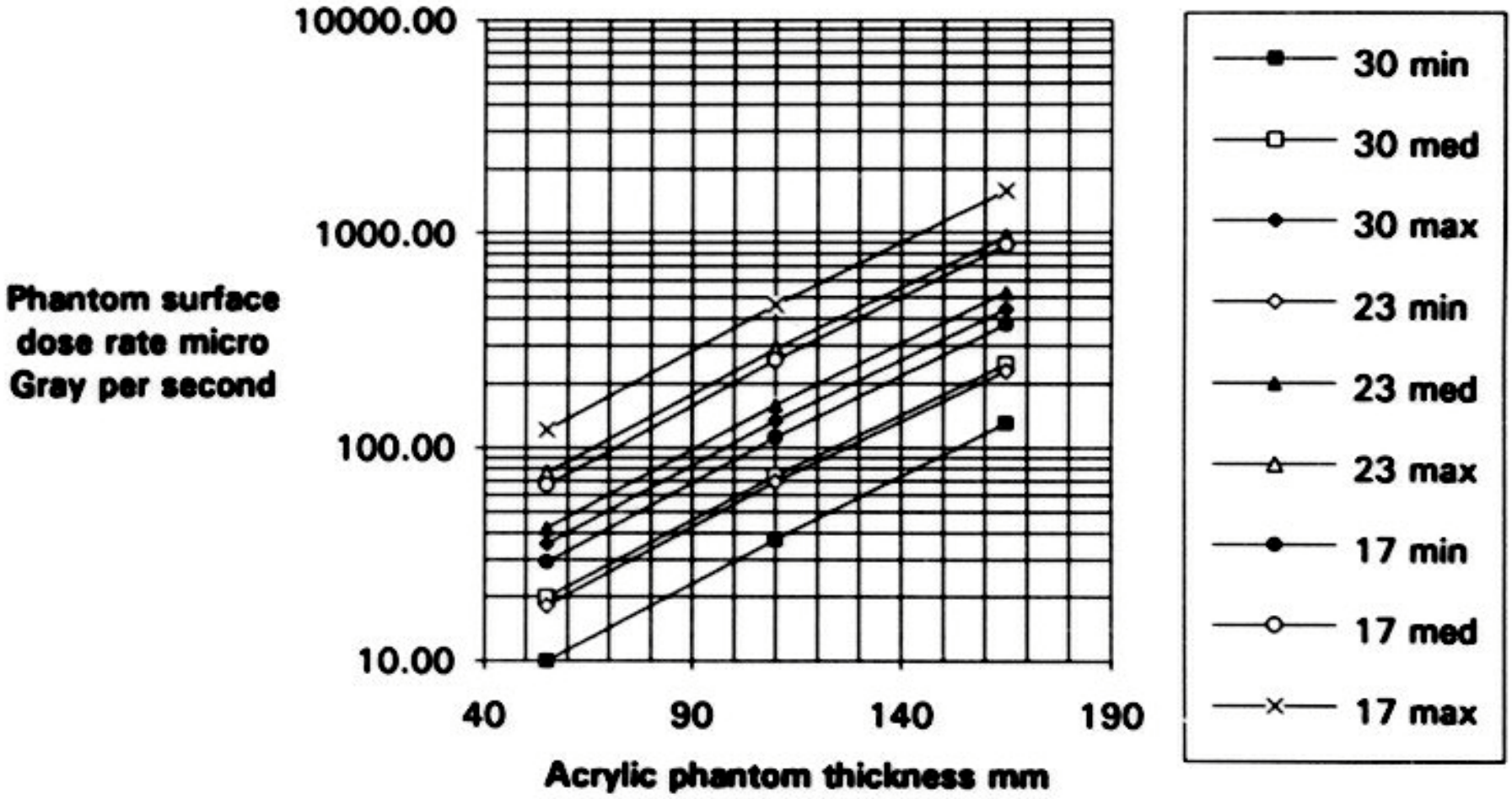
ABC - skin entrance dose

- Test all II field sizes (cm) and dose settings (patient thick.) with various attenuation (perspex ~ 50-200mm)
- Maximal patient skin entrance dose should not exceed 100 mGy/min
- II entrance dose measured together with the skin entrance dose (separately from 1mm Cu)

Field size	Read kV	Read mA	Phantom	I.I. entrance dose		Phantom surf' dose	
cm			thick' mm	(mR/min)	(mGy/s)	(mR/min)	(mGy/min)
30	75	0.3	55	29.9	0.004	264	2.27
	75	1.4	110	43.3	0.006	1010	8.69
	75	5.6	165	68.5	0.010	3880	33.37

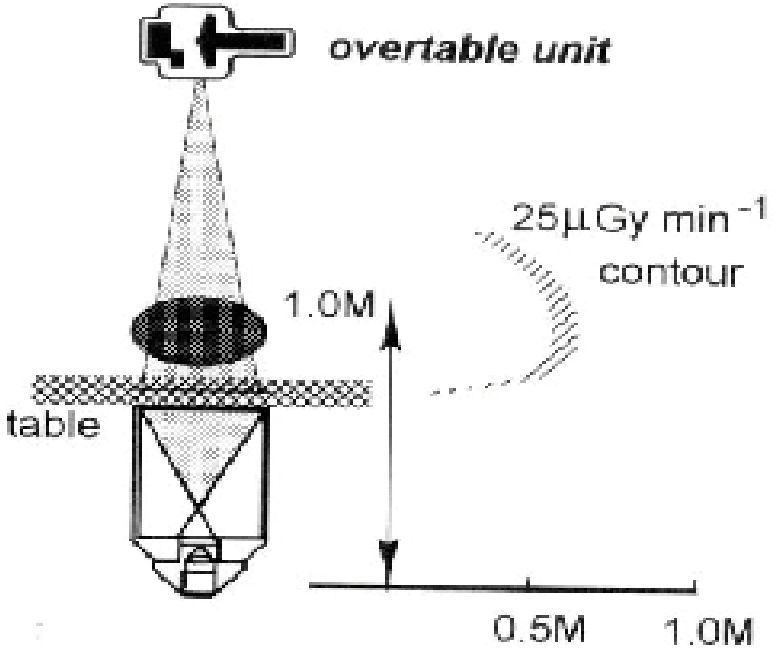
Typical phantom surface (patient entrance) doses - **µGy/sec** during fluoroscopy with ABC





Scatter radiation in fluoroscopy

when the II is above the patient table the scatter radiation to staff is lower



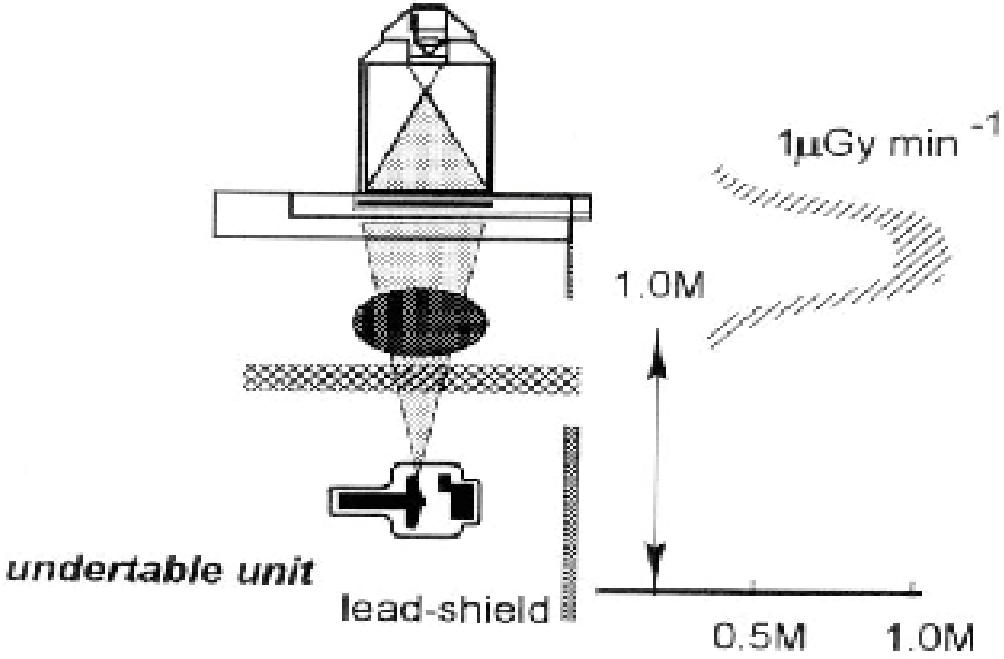
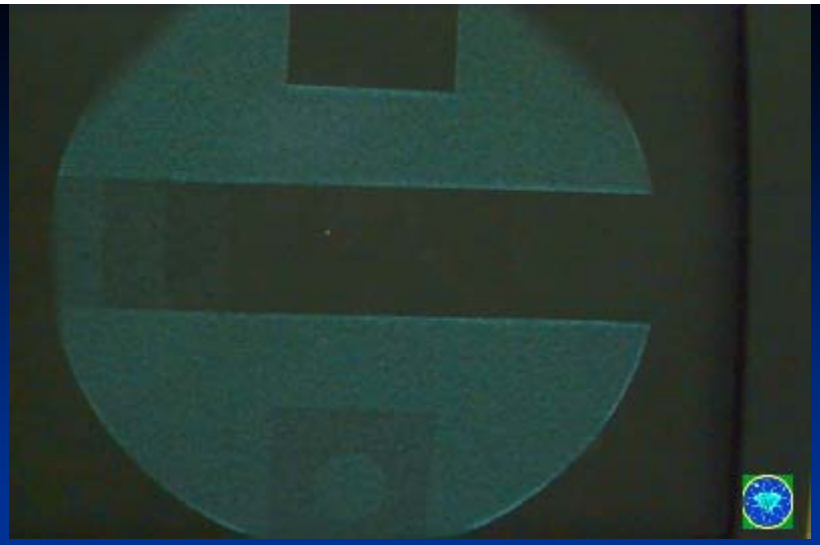
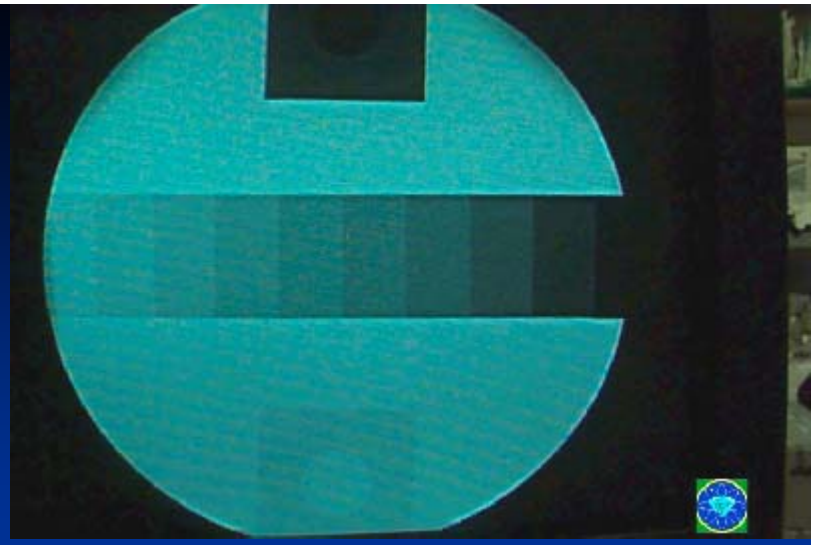


Image quality assessment

- Contrast scale
- Image uniformity and distortion
- Spatial (high contrast) resolution
- Noise (and Video signal)
- Contrast (low contrast) resolution
- Overall Image Quality (Contrast/Detail Diagr.)
- IQ dependence of "window" and matrix
- IQ dependence of reconstruction/frame rate
- IQ dependence of image processing (F,Sub)
- Artefacts



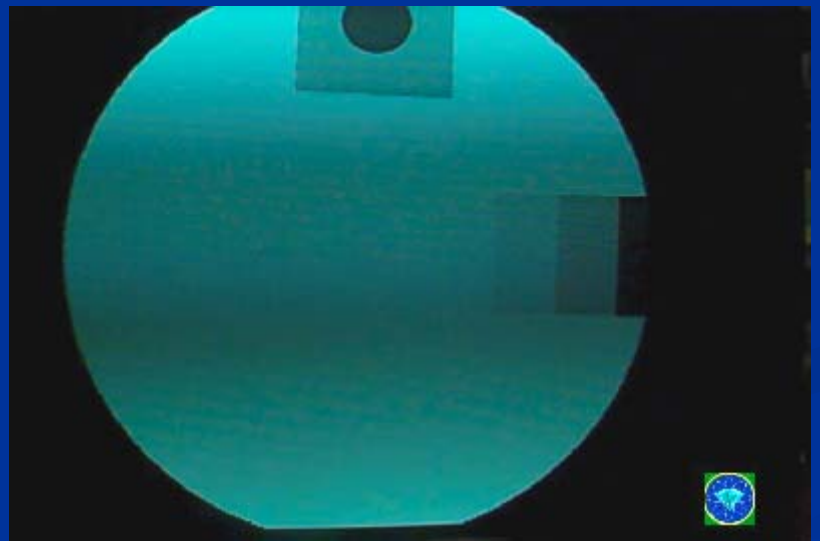
60 kV



70 kV

II contrast with different kV (constant mA)

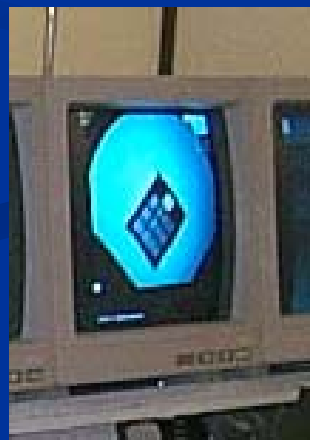
90 kV



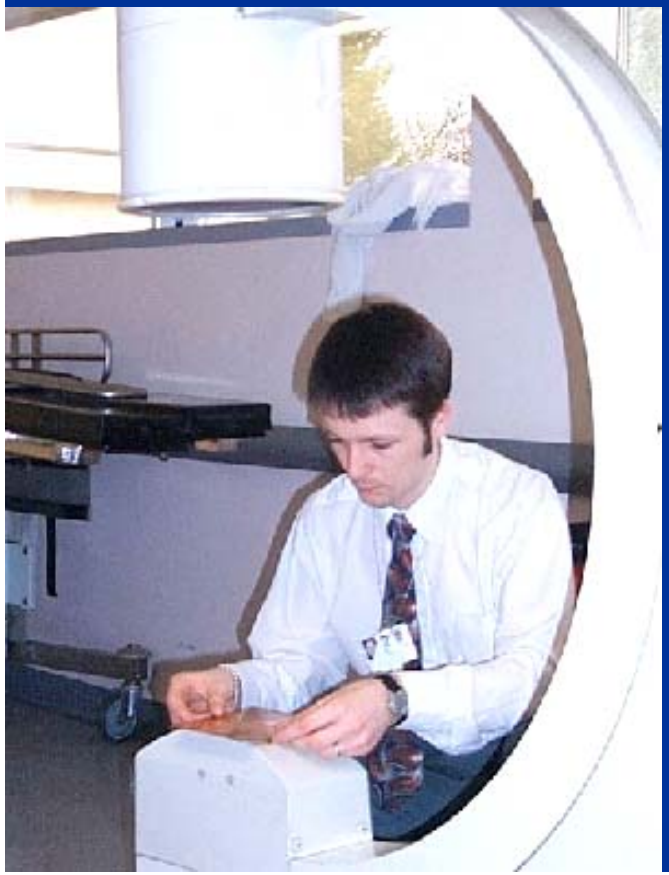
100 kV

Fluoro analogue image quality assessment:

- Subjective assessment (eyes condition)
- Attenuate the X-ray output (1mm Cu)
- Check all II field sizes with all test objects
- Adjust TV monitor (contrast/brightness)
- II visible field size/distortions/homogeneity
- II noise, contrast resolution (contrast/detail)
- II lim.spatial resolution (*no attenuation*)
- (Video signal)



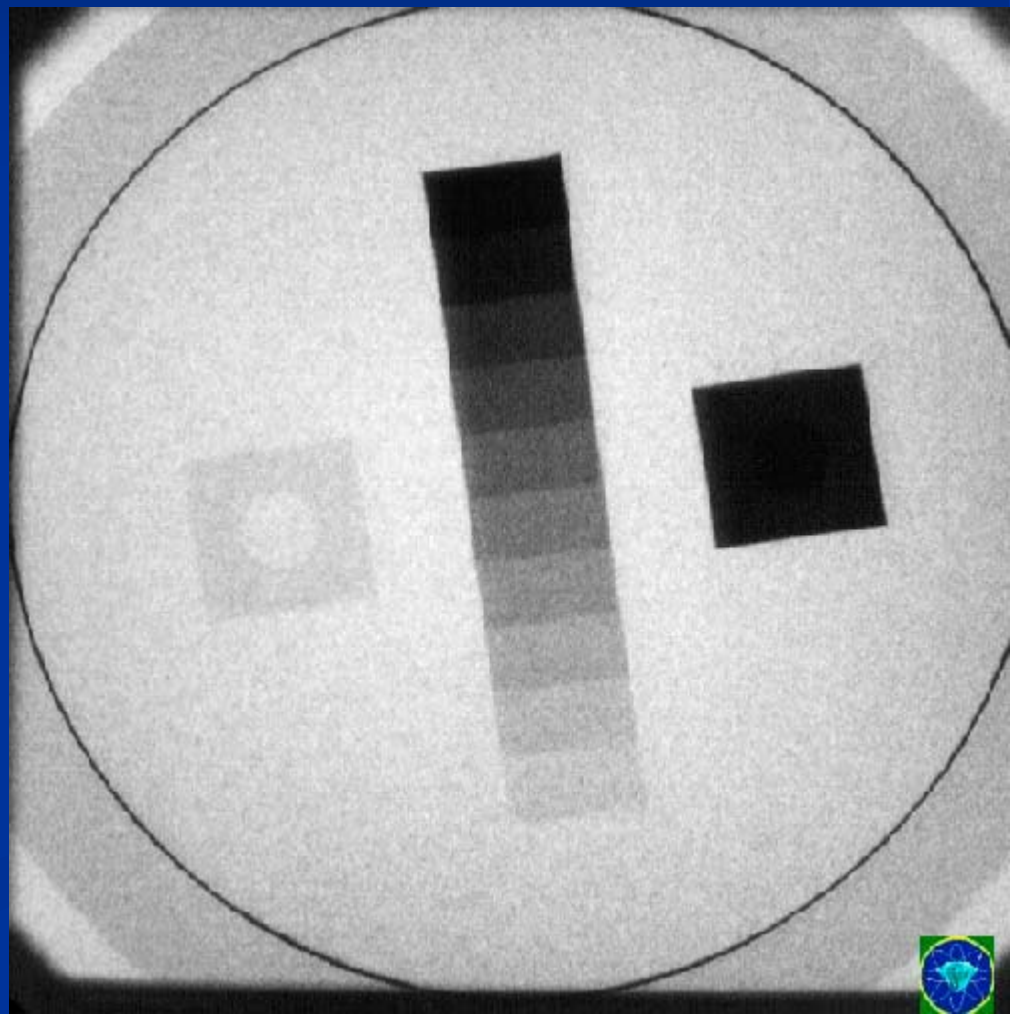
- Attenuating the X-ray tube output with 1mm Cu filter
- Selecting appropriate Test Objects (TO)
- Normally performed by two physicists

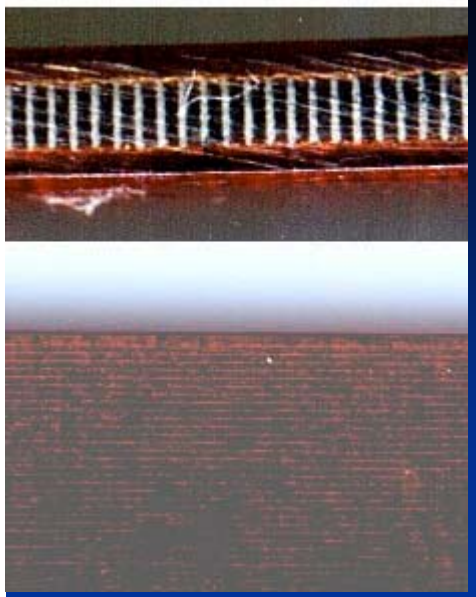


Assessment of Contrast Scale (TV monitor adjustment)

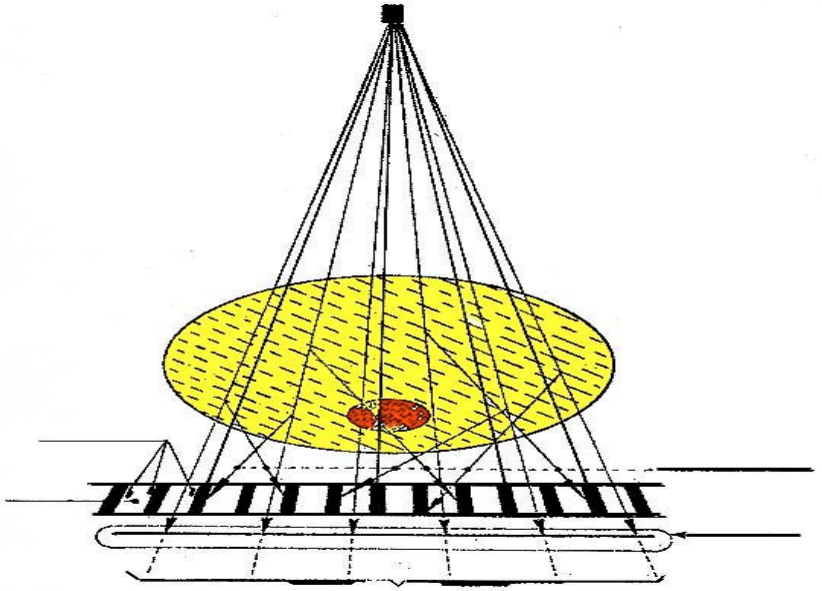
All test objects should be placed at the front of the II

(the presence/absence of the anti-scatter grid must be noted in the QC protocol)





Scattered radiation
and anti-scatter grid



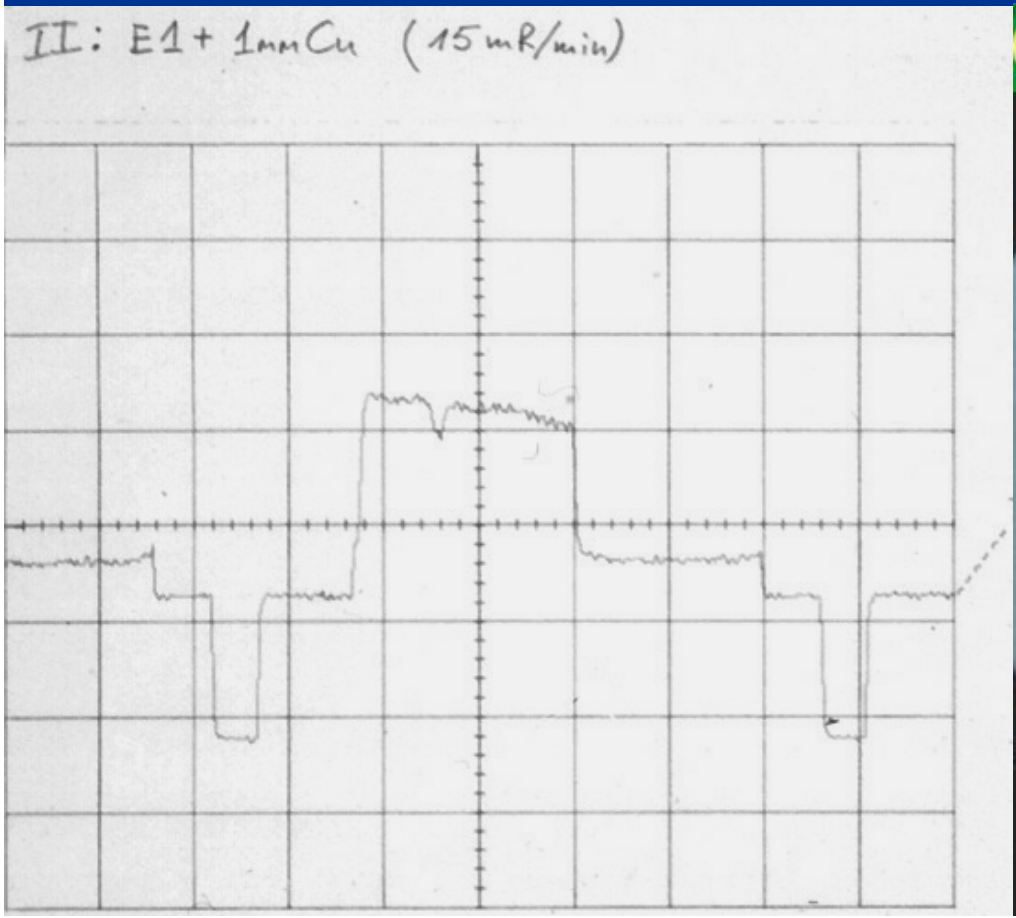
With anti-scatter grid

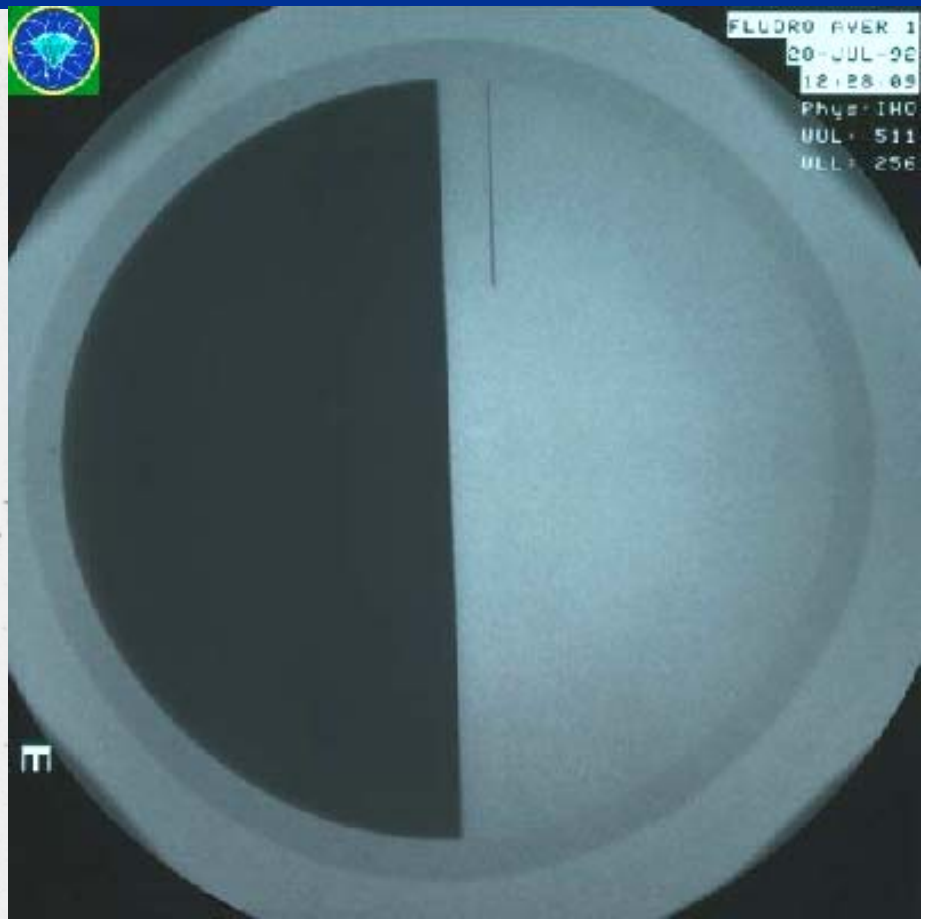
Without anti-scatter grid

Assessment of Sensitivity of the Imaging system (video signal assessment)

- use of a TV line selector is recommended

- do not measure the TV monitor input when assessing digital fluoroscopic systems

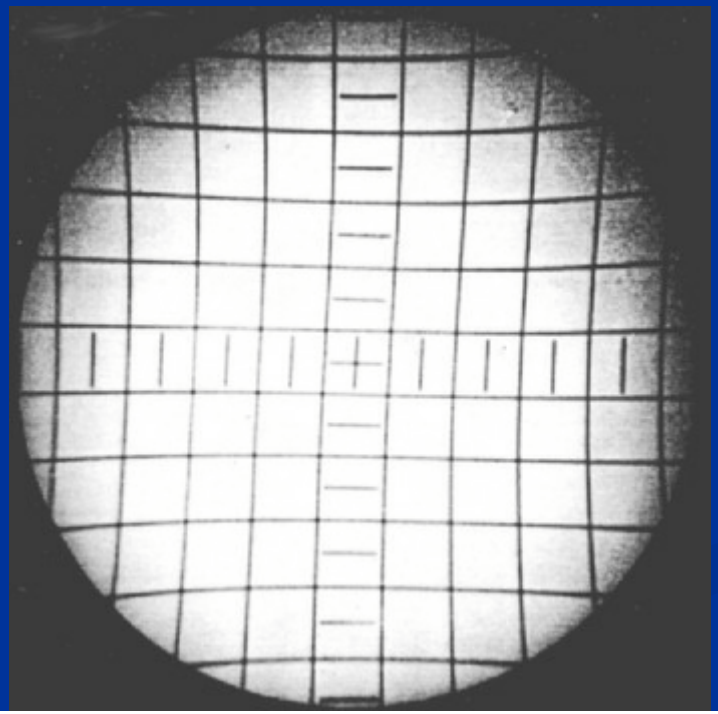


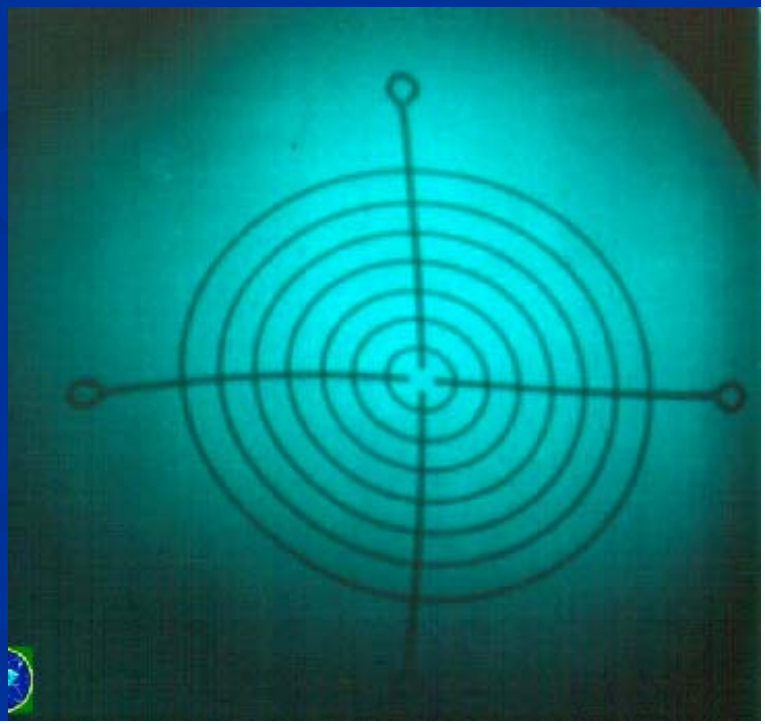


Assessment of Image Geometry and Sizing

- measuring of all II field sizes (horiz. and vert.)

- assessment of image distortion



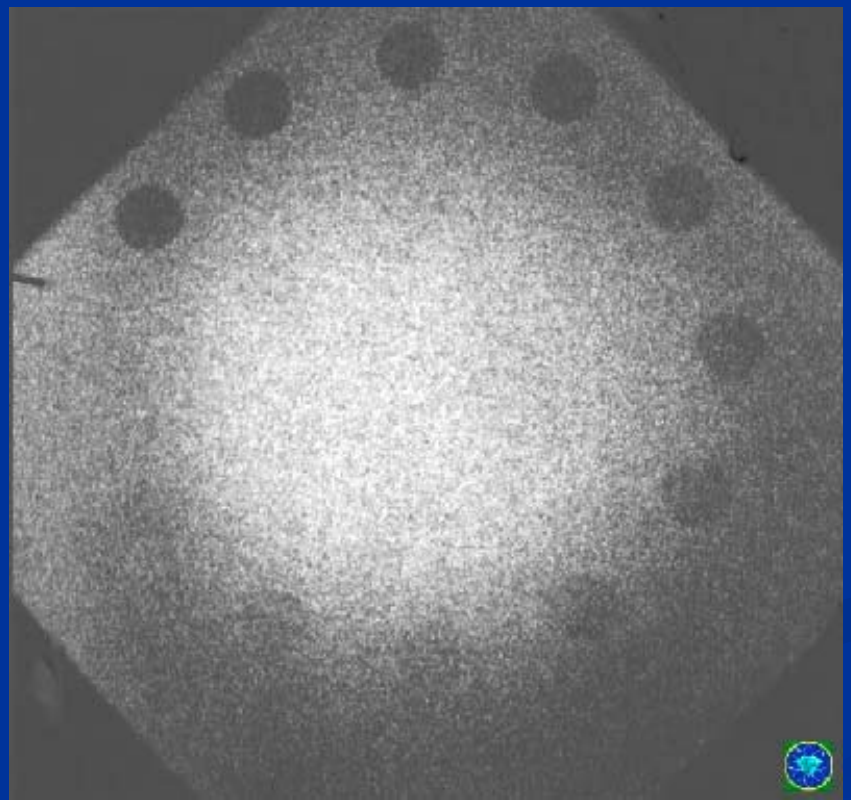


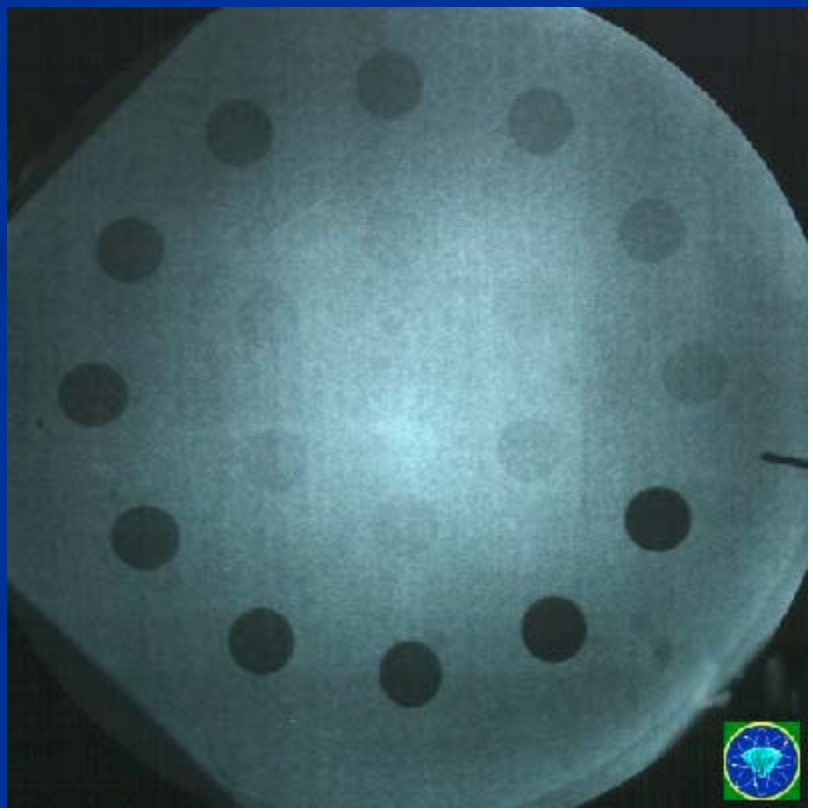
Assessment of Image Noise

- for all II field sizes

- proper adjustment of “Window” (and record of WW, WC !) is essential in digital fluoroscopy

- record the kV/mA displayed for all image quality tests!



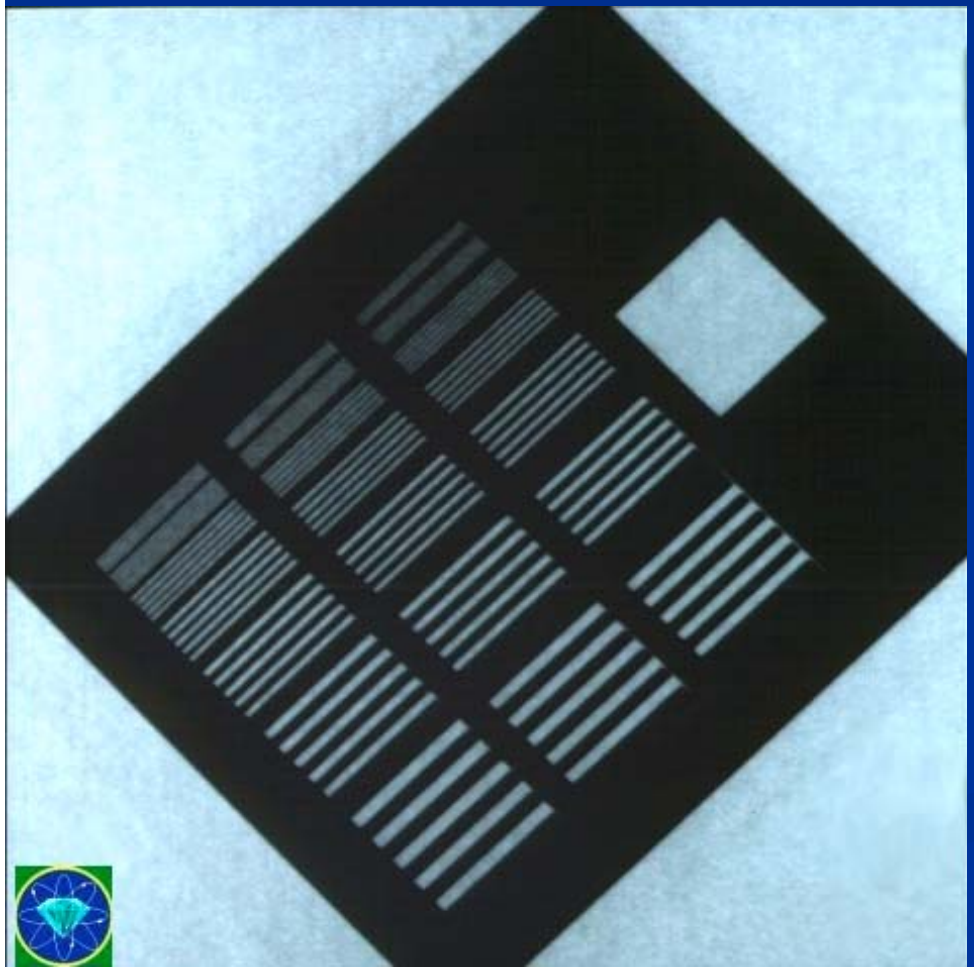


Assessment of Limiting Spatial Resolution (Unsharpness)

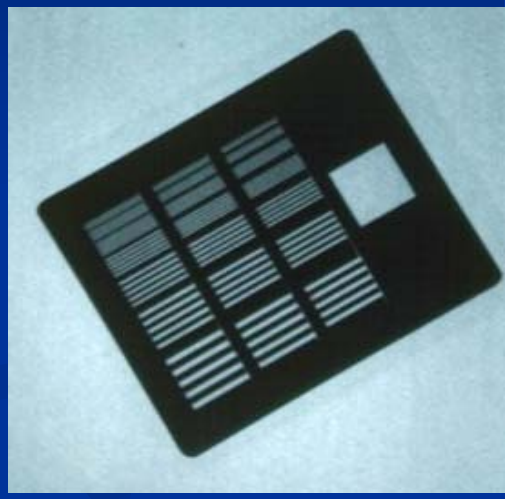
!! REMOVE the 1mm Cu filter !!

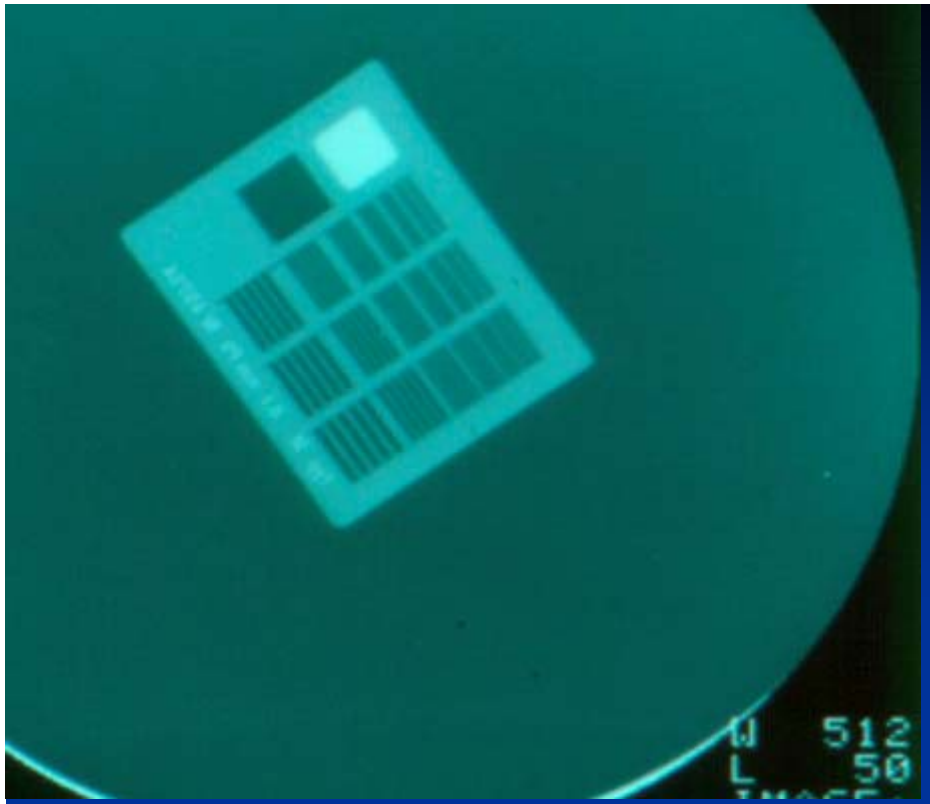
- for all II field sizes

- proper adjustment of “Window” (and record of WW, WC !) is essential in digital fluoroscopy



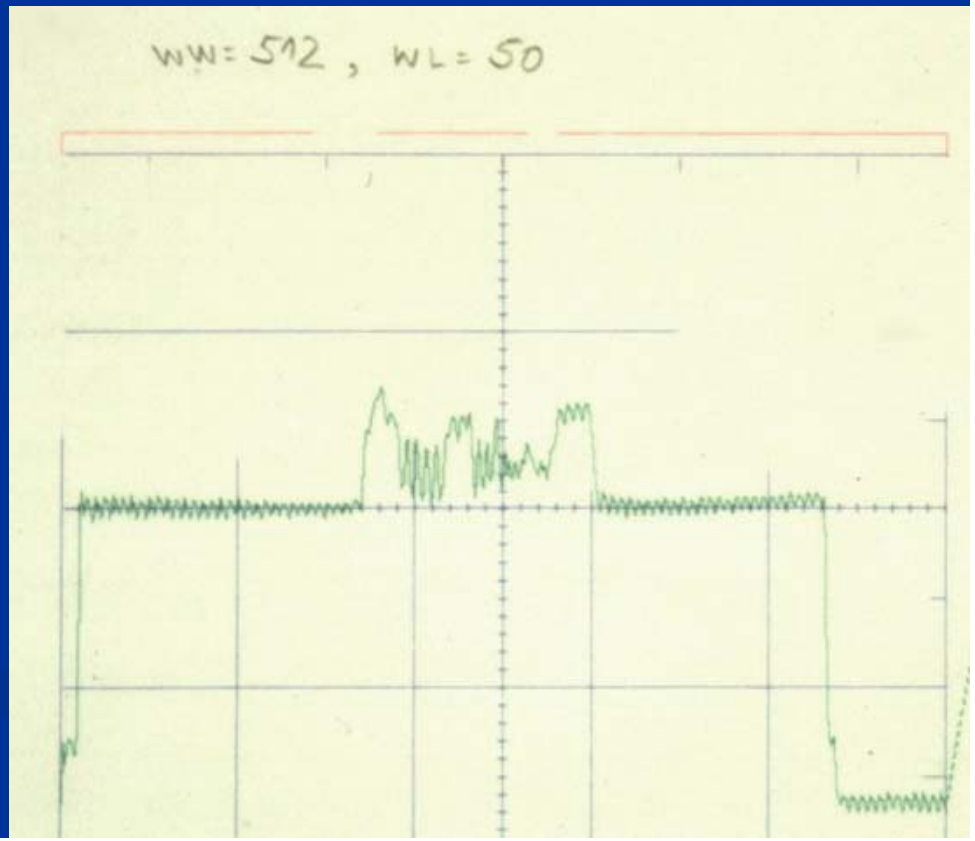
Place the test object at 45^0 to TV raster!

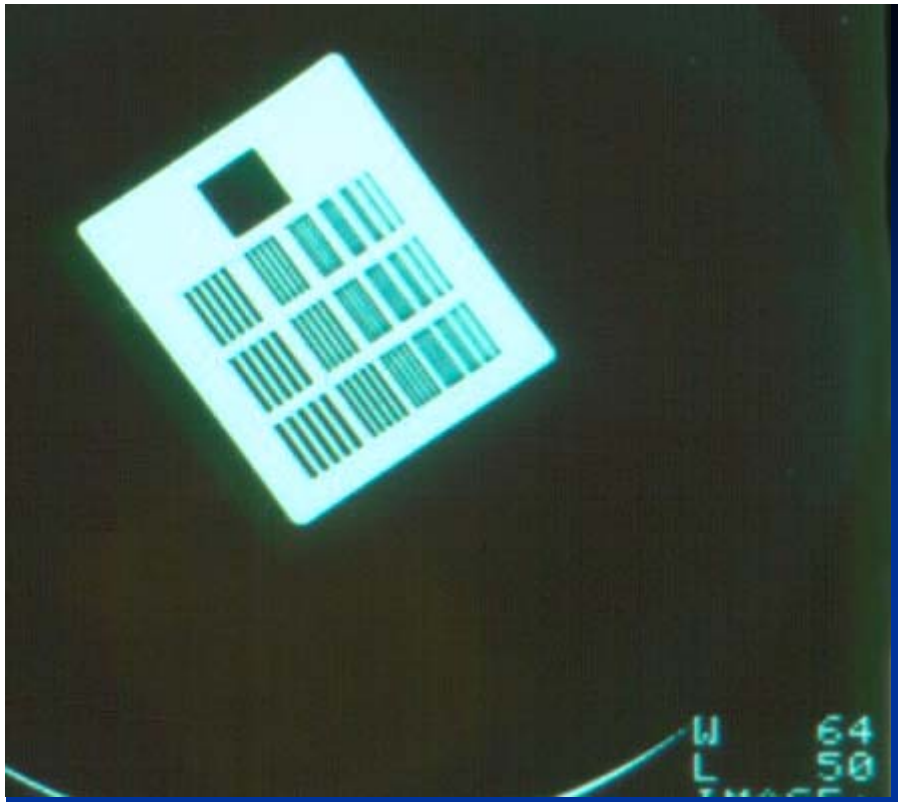




WINDOW PARAMETERS IN DIGITAL FLUOROSCOPY

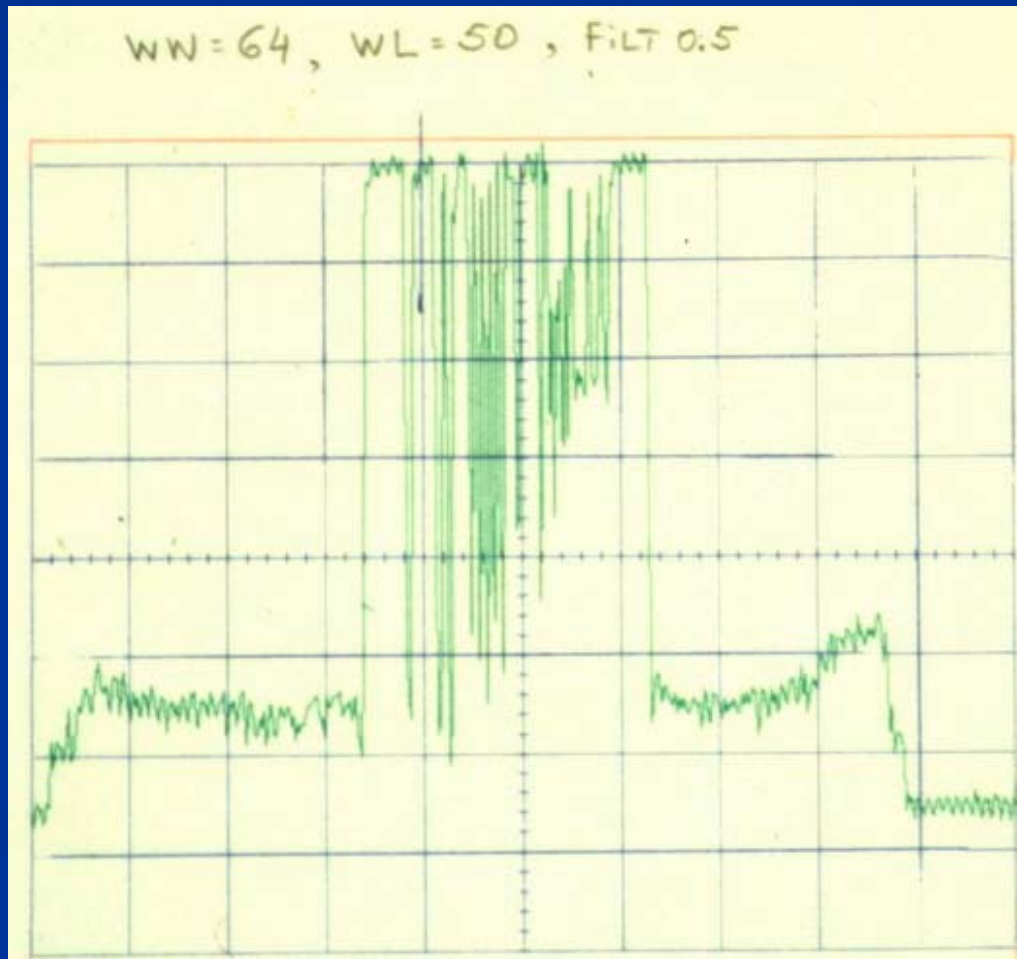
WW changes the image contrast - its amplitude is well seen from the video signal of the displayed image.





Small WW increases the contrast dynamic, what lead to visual increase of the spatial resolution.

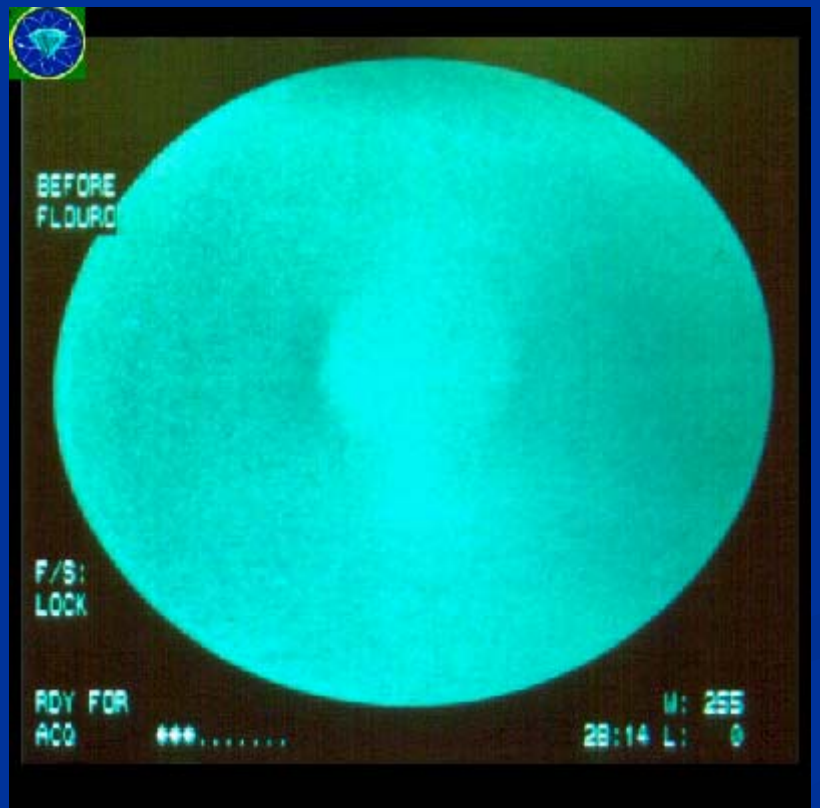
WW and WC change dramatically the digital image quality!

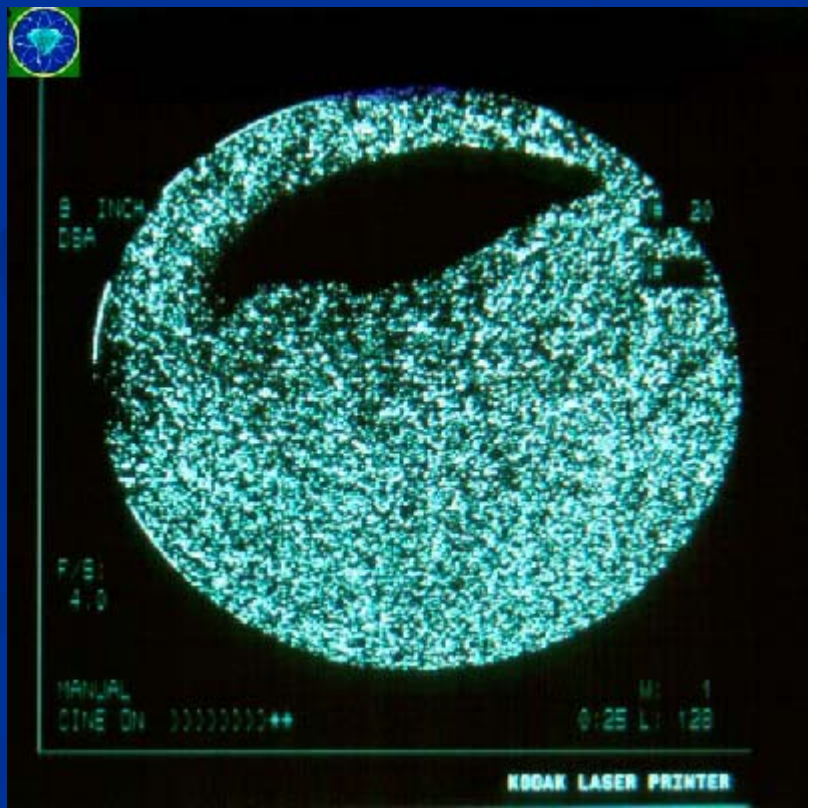


Example of II non-uniformity

Note that using default WW and WC (on the left image) does not visualise the non-uniform region.

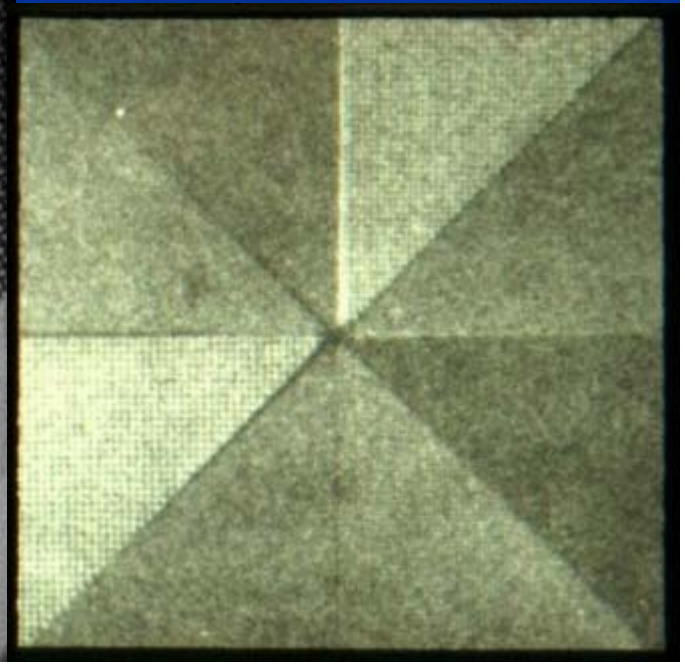
The substantial II defect is seen only with a narrow WW and precise WC (the right image).





Assessment of II uniformity (non-uniformity)

The Mesh “uniformity” test objects can also be used for assessment of spatial resolution.

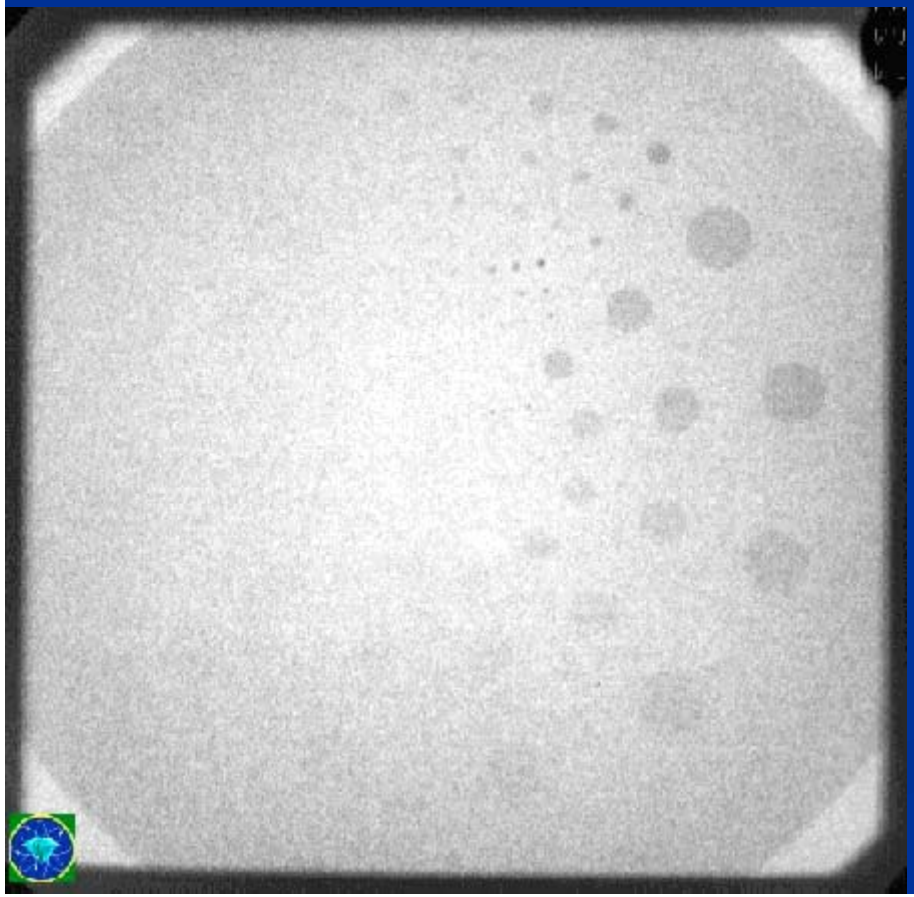


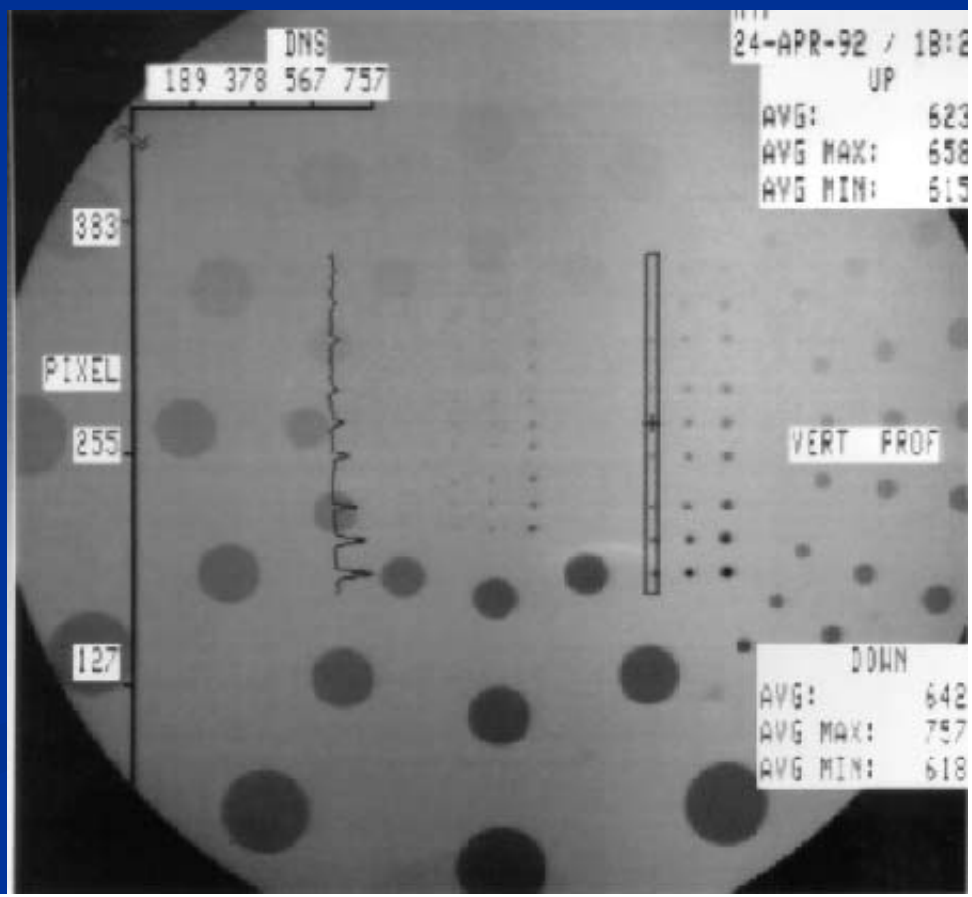
Overall Image Quality Assessment (Contrast Resolution)

!! WITH 1mm Cu filter !!

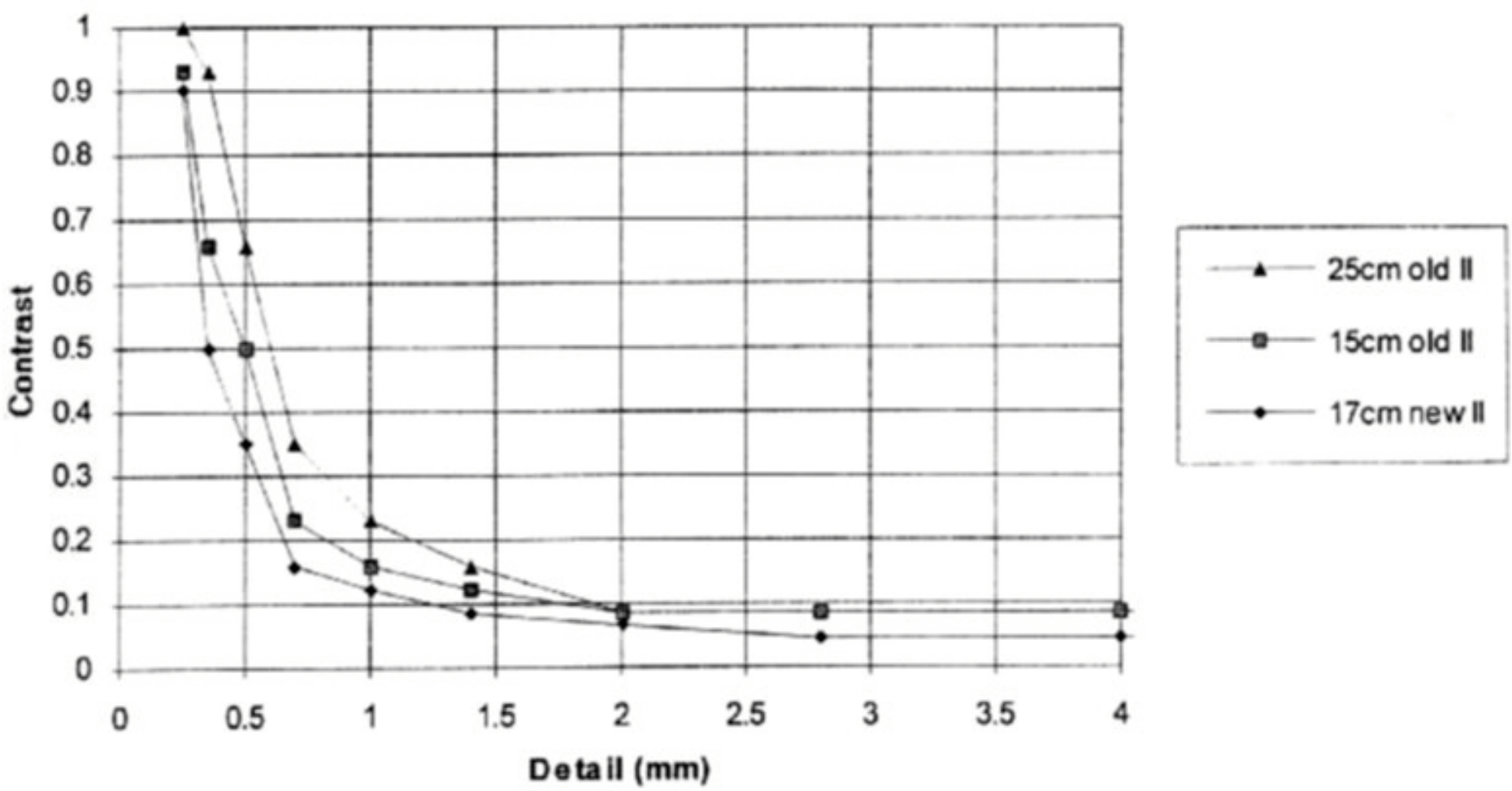
- for all II field sizes

- proper adjustment of “Window” (and record of WW, WC !) is essential in digital fluoroscopy





Typical Contrast/Detail diagram for the *Leeds TO 10* phantom for various II filed sizes (old and new II)



Fluoro digital image quality assessment

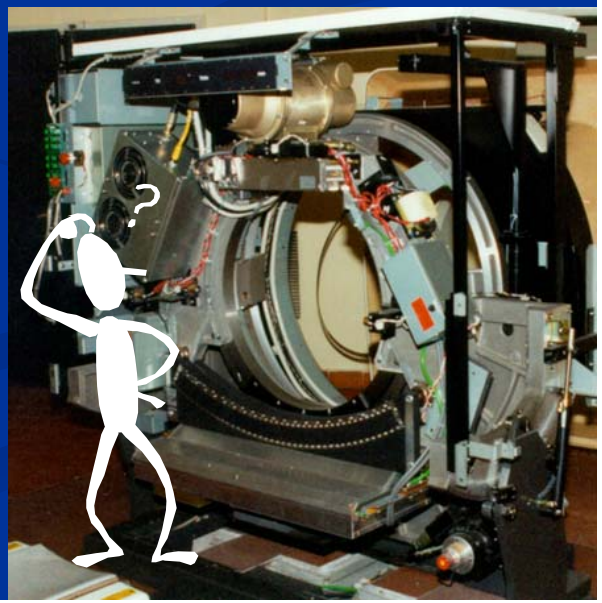
- Objective/subjective assessment
- Perform set-up/calibration of imaging chain
- Record the Window parameters for each measurement (width/centre ; contr/bright)
- Record image processing parameters used (filters, matrix, masks, subtract., frame rate)
- Use the built-in measuring functions and densoprofile
- Special (quantitative) functions
- Other specific parameters (Grey level/Dose, etc)

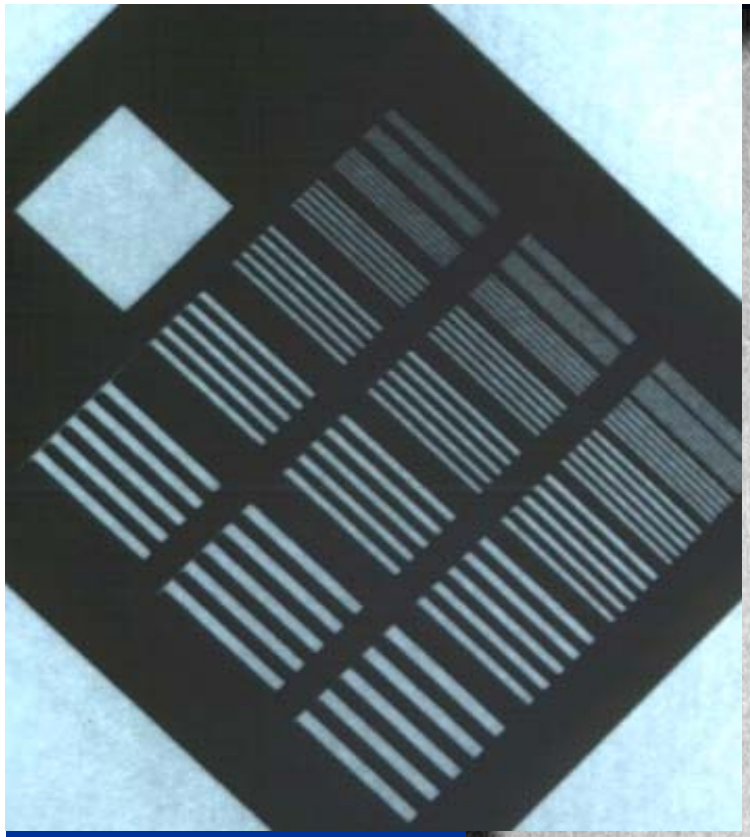
Non-uniform image and loss of contrast most often due to:

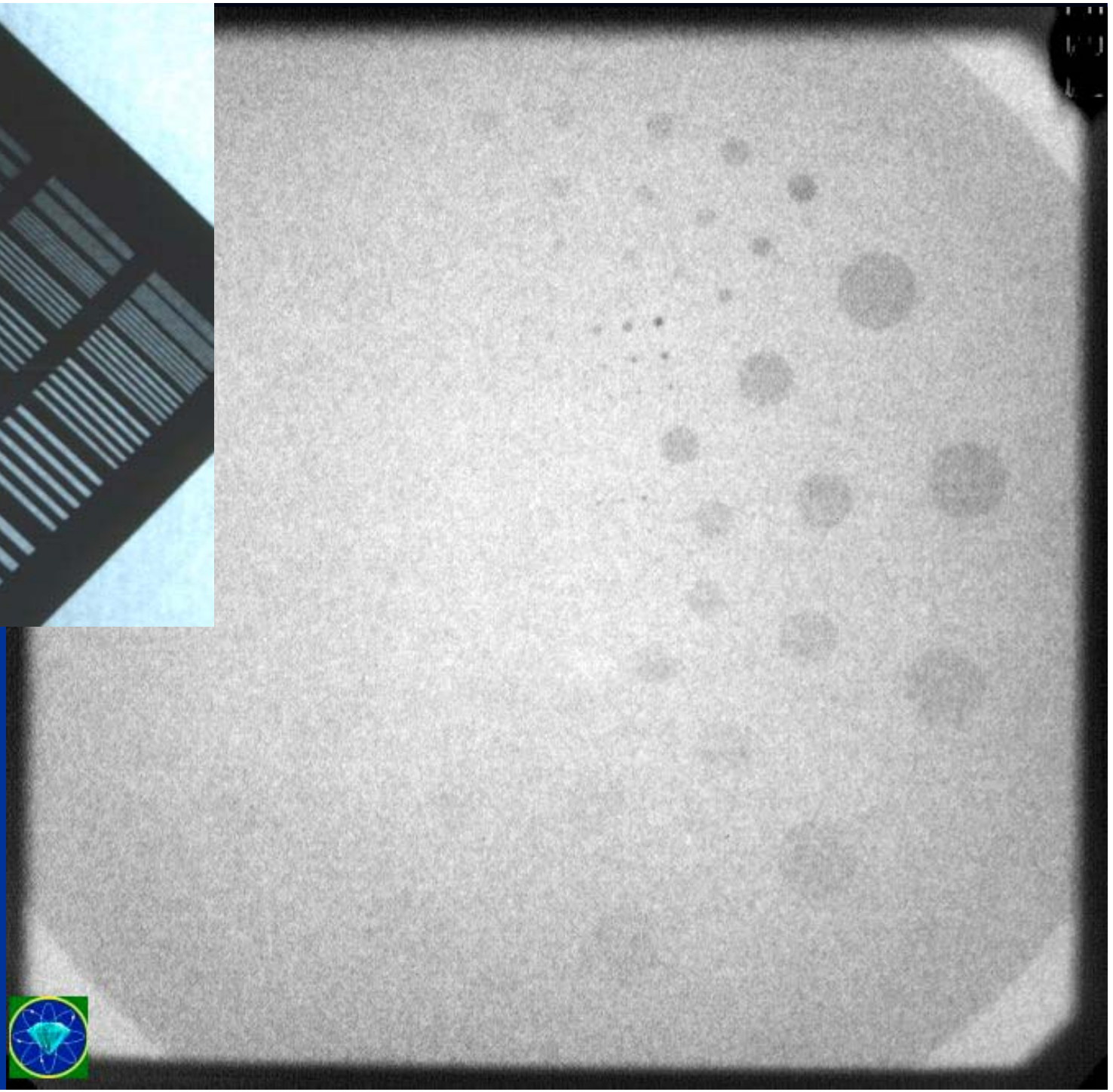
- Non-uniform cassette/film contact
- Poor film developing
- TV contrast/brightness misadjustment
- Non-uniform dose distribution
- Exhausted Image Int.,TV camera, monitor
- Incorrect Window parameters
- Frame speed problem, incorrect filtering

Blurred image & loss of spatial resolution most often due to:

- Exhausted X-ray tube (Broad focus)
- Incorrect bucky/grid centring
- Poor film developing
- Defocused II/TV camera
- Small matrix, incorrect filtering
- Incorrect Window parameters
- Noisy imaging chain





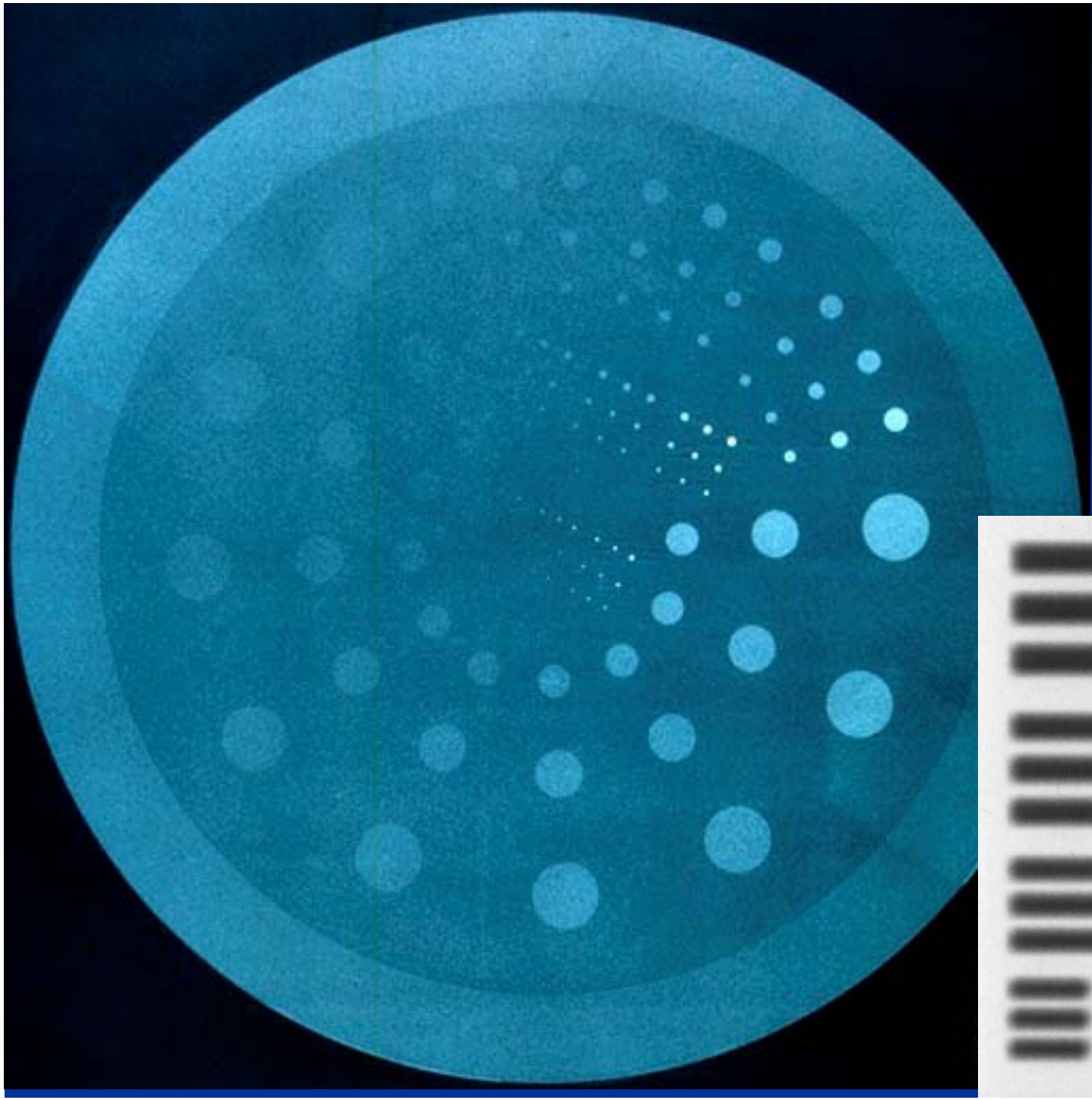


TASK:

*Draw C/D curves for both images (using TO tables);

**Assess sp.res.

***Discuss image quality of both systems



TASK 2:

Where is the limiting sp.res. On the image below