IMPLEMENTATION OF QUALITY CONTROL PROTOCOL IN DIGITAL BREAST TOMOSYNTHESIS (DBT)

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PURPOSE:

The aim of this work is the implementation of a quality control protocol in DBT with the aid of different phantoms and the comparison of the results obtained on two mammography systems

MATERIALS AND METHODS:

We analyzed several aspects of DBT: X-ray output, image detector, image quality and dosimetry.

Equipments:

Two Hologic Selenia Dimension

- ASST Nord Milano
- Fondazione IRCCS Ca'Granda Ospedale Maggiore Policlinico

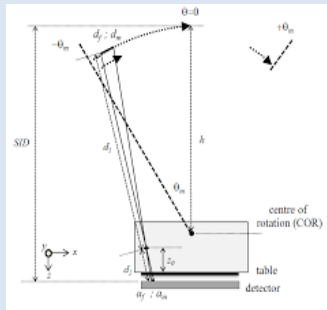## Phantoms:

Home made phantom, CDMAM, Agatha Phantom

Image Type:

Reconstructed

| BTO | ImageJ ($\geq$ vers.1.49) |
| CT | Viewer Dicom |

SC gview (H) / Gexpand (H)

Projection

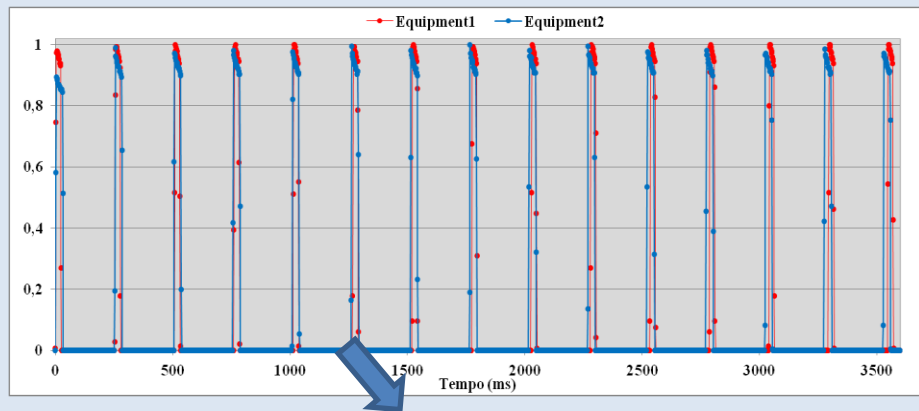SC gview (H) / gexpand (H)

Image type used in this work: SC

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Focal Spot Motion:

$$d_m = 2h\theta_m \frac{t_{proj}}{t_{scan}}$$

Multimeter measurements
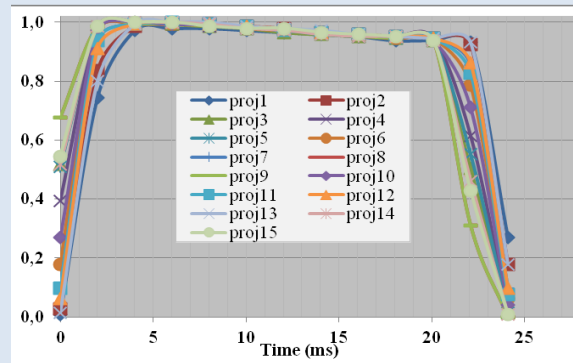
1. T_{scan}:

2. T_{proj}:
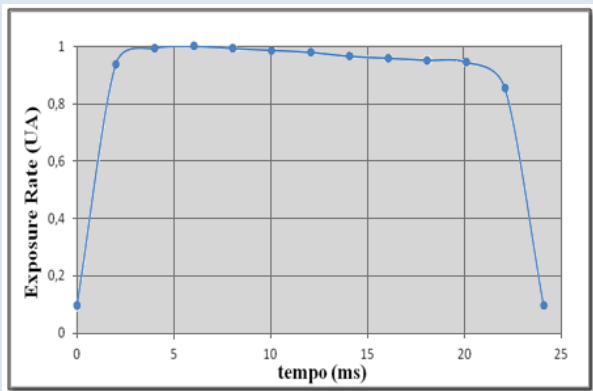
T_{proj} calculated as FWHM
Equipment #2: first projection same T_{proj}
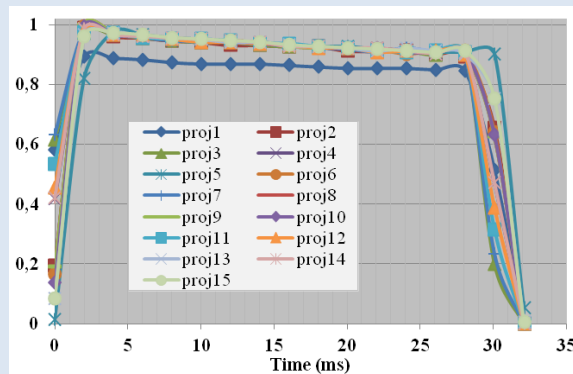but lower dose (- 5%)

Exposure distribution per projection image:

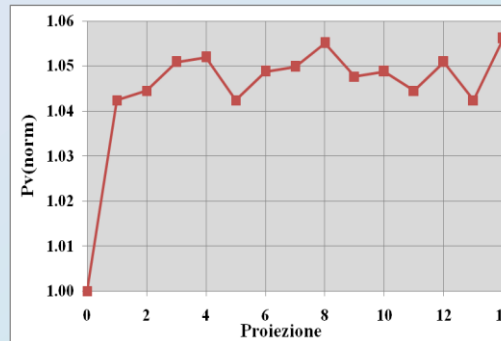### Multimeter measurements

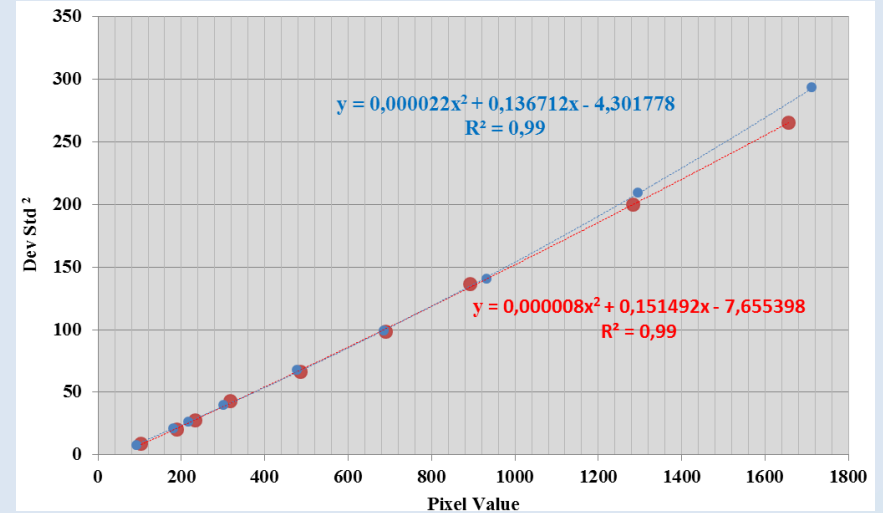### Overlapping of the peaks

Equipment #1

Equipment #2

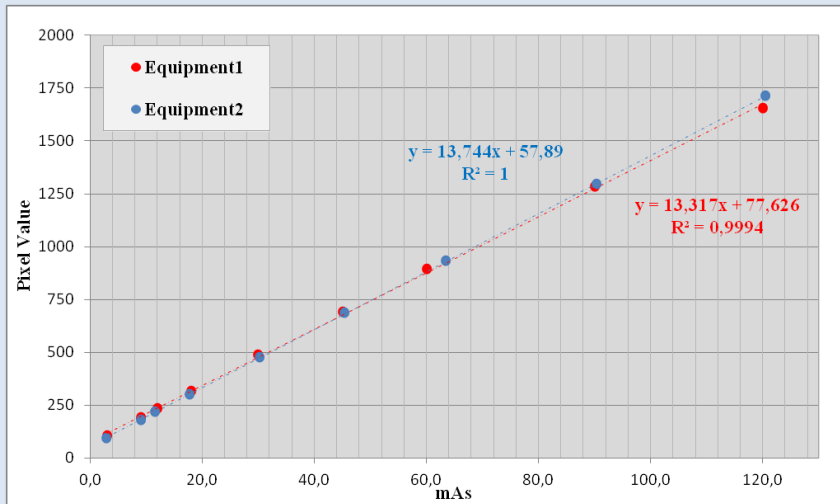### Projection image

Ghost effect →
Pixel Value not
to be used

Image detector response:

$y = 13{,}744x + 57{,}89$
$R^2 = 1$

$y = 13{,}317x + 77{,}626$
$R^2 = 0{,}9994$

$y = 0{,}000022x^2 + 0{,}136712x - 4{,}301778$
$R^2 = 0{,}99$

$y = 0{,}000008x^2 + 0{,}151492x - 7{,}655398$
$R^2 = 0{,}99$

The detector response functions are quite similar

SDNR:

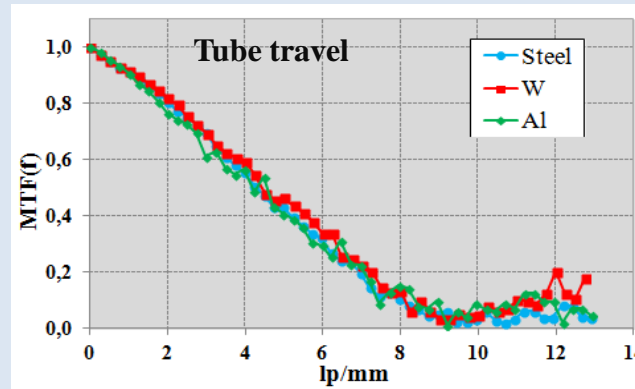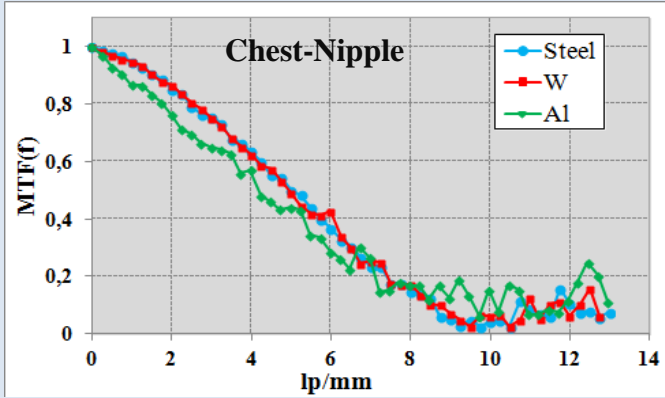**Equipment #2 seems to be slightly better optimized in terms of SDNR.**
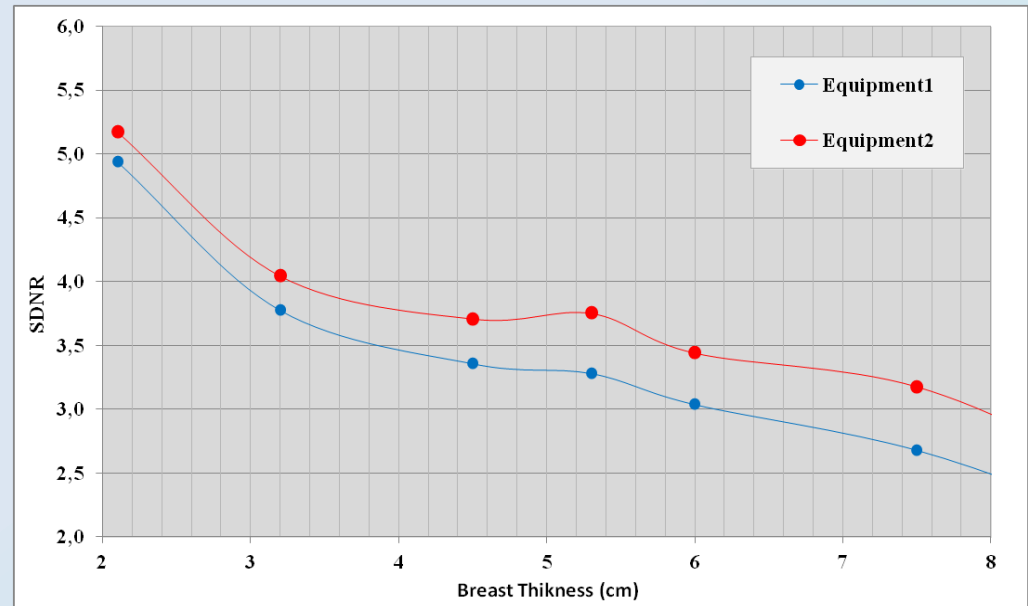
MTF in x-y plane:

Comparison of three different edges

Chest-Nipple (Steel, W, Al)

Tube travel (Steel, W, Al)

Var % (W/Steel) < 5%
Var%(W/Al) < 20 %

	Chest-Nipple	Tube travel
h 0 mm		(Equipment1, Equipment2)
h 40 mm		
h 70 mm		
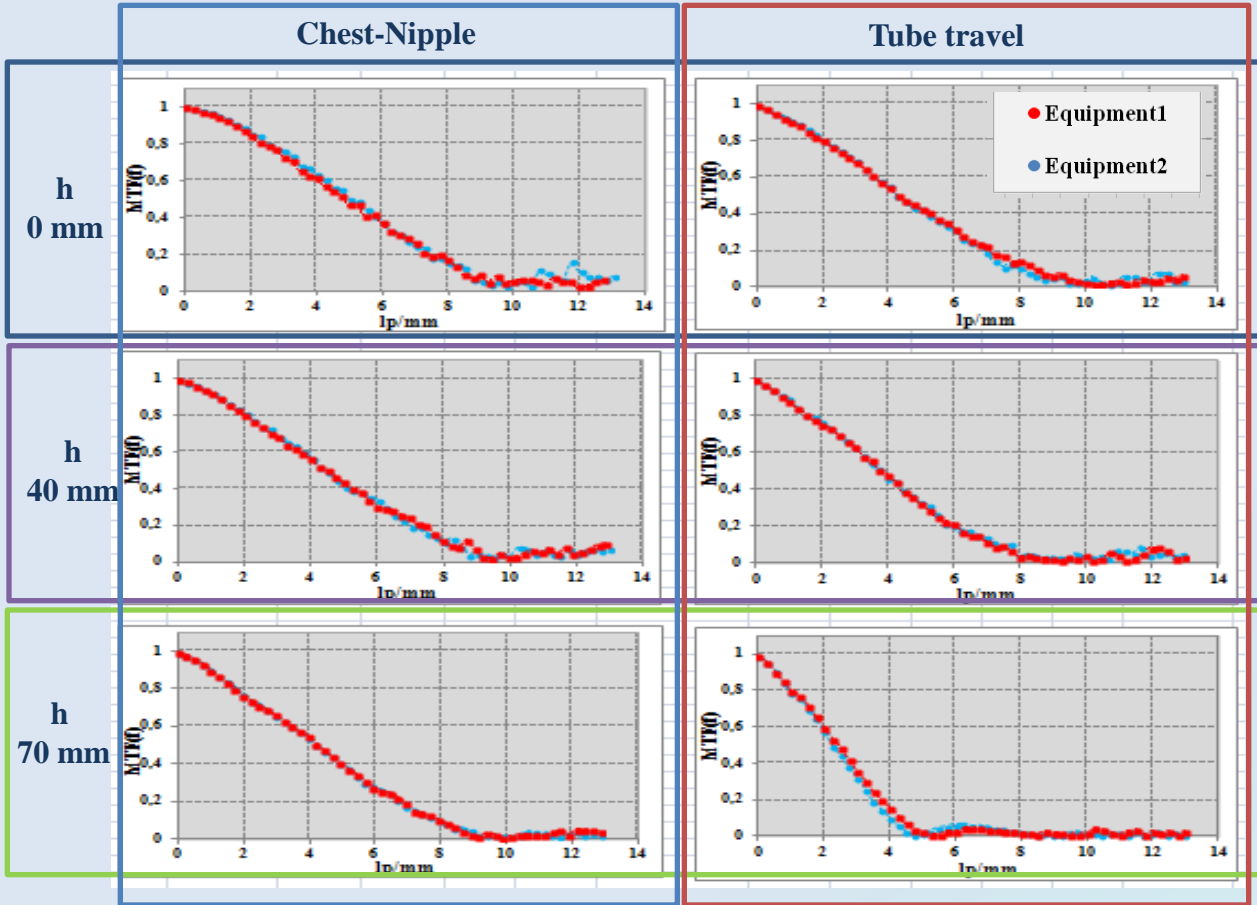
MTF for the two equipments are quiet similar

IQWorks

ImageJ

MIQuaELa

MATLAB

Stability of image quality in x-y plane (CDMAM Phantom):

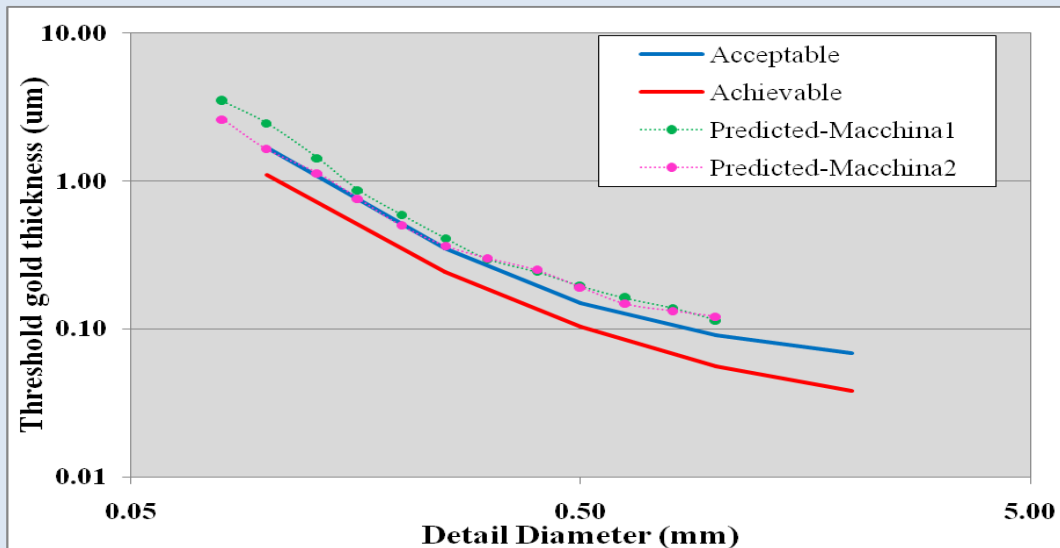**Perceptibility curve versus mAs and kV**
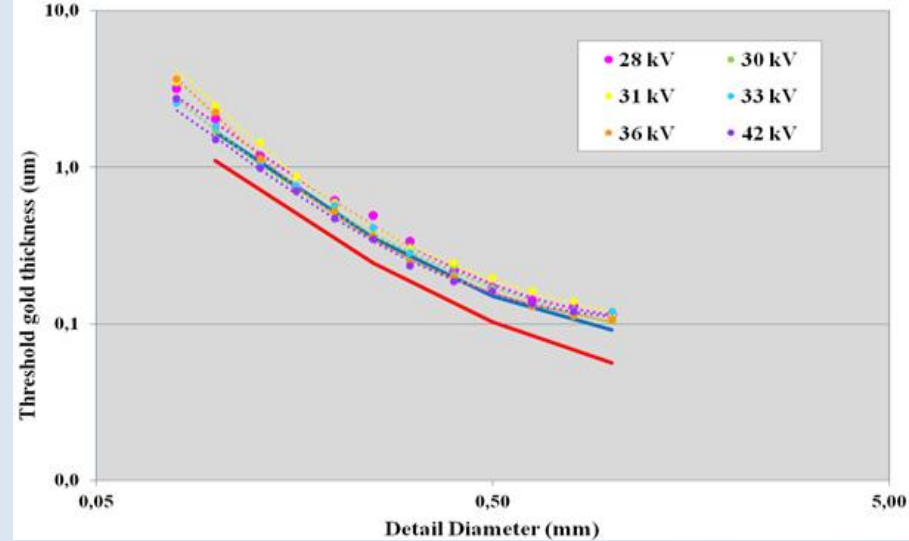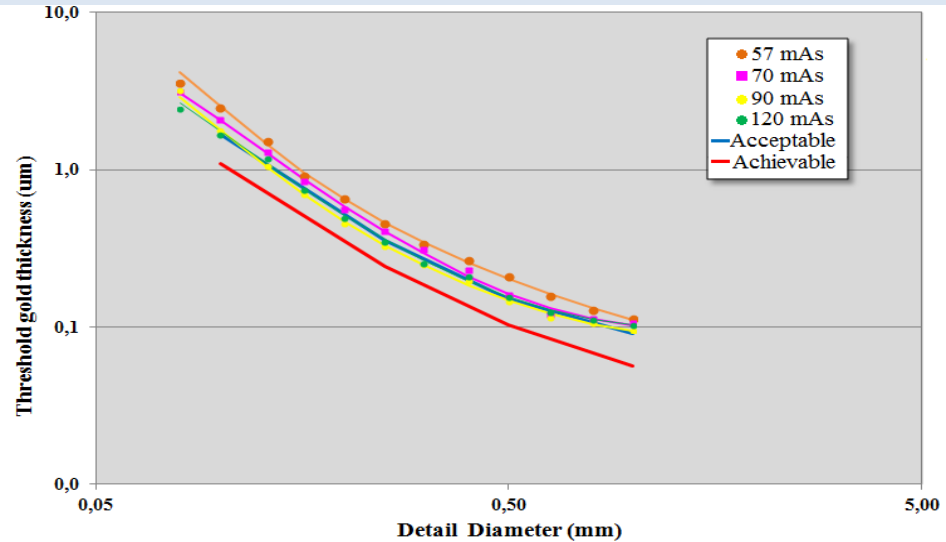
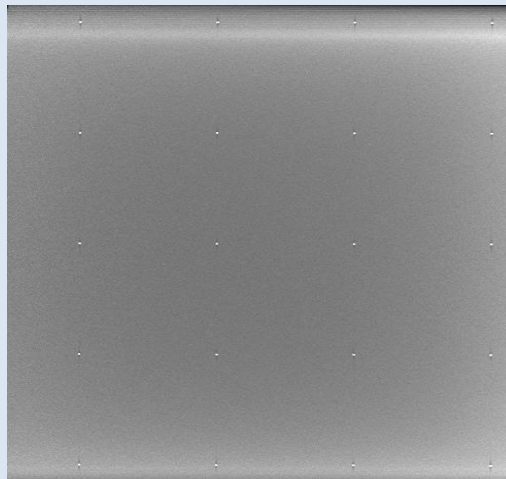**Perceptibility curve between acceptable and achievable can be obtained only with mAs > 90 or kV > 42**

Equipment #2 for detail diameter < 0.5 mm between acceptable and achievable curve
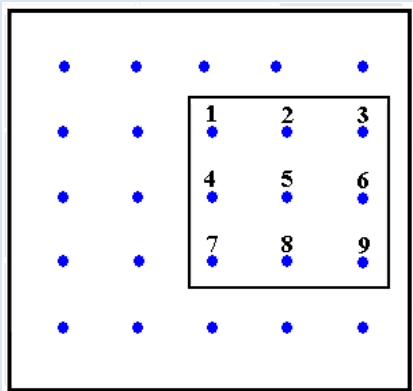
Limits for FFDM

Resolution in x-y plane (home made phantom):

25 Al bead d=1mm, PMMA thickness 0.5 mm

The two devices have the same performance

x-Profile
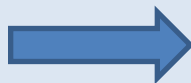
y-Profile
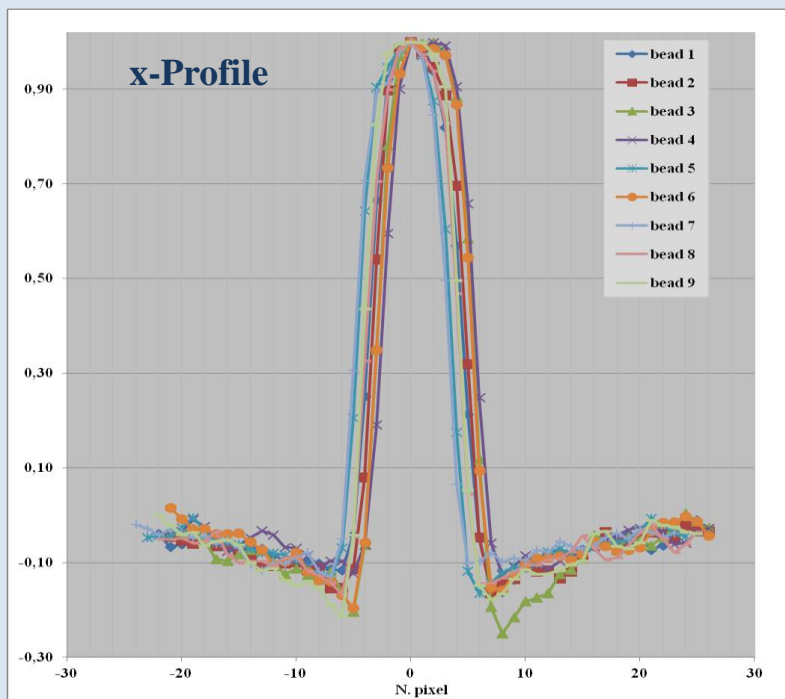
Var < 4 %
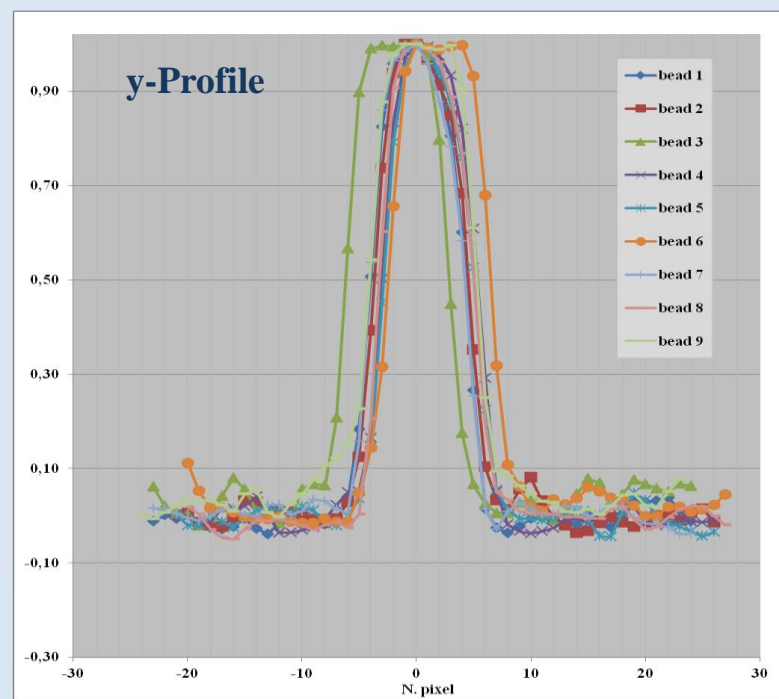
Var < 12 %

Resolution in z plane (home made phantom):

25 Al bead d=1mm
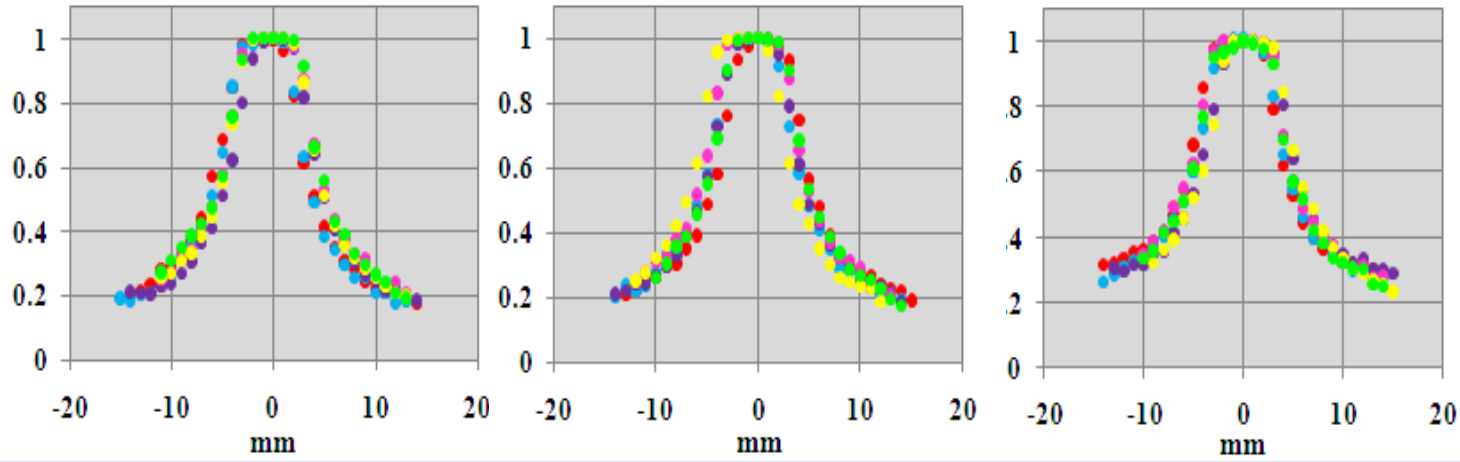
1 4 7
2 5 8 Equipment1
3 6 9
1 4 7
2 5 8 Equipment2
3 6 9

Differences found ≤ 10%

Resolution in x-y and z plane (Agatha phantom):

W-wire (d = 220 µm, θ = 26)
- Equipment1
- Equipment2

Al-bead (d=0.5 mm)
- z_Equipment1
- z_Equipment2
- x_Equipment1
- y_Equipment1
- x_Equipment2
- y_Equipment2
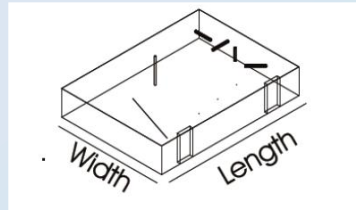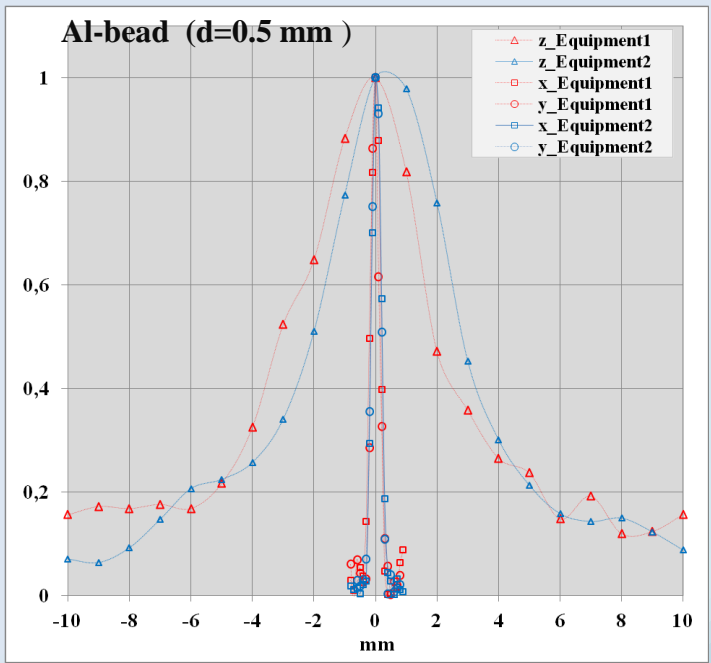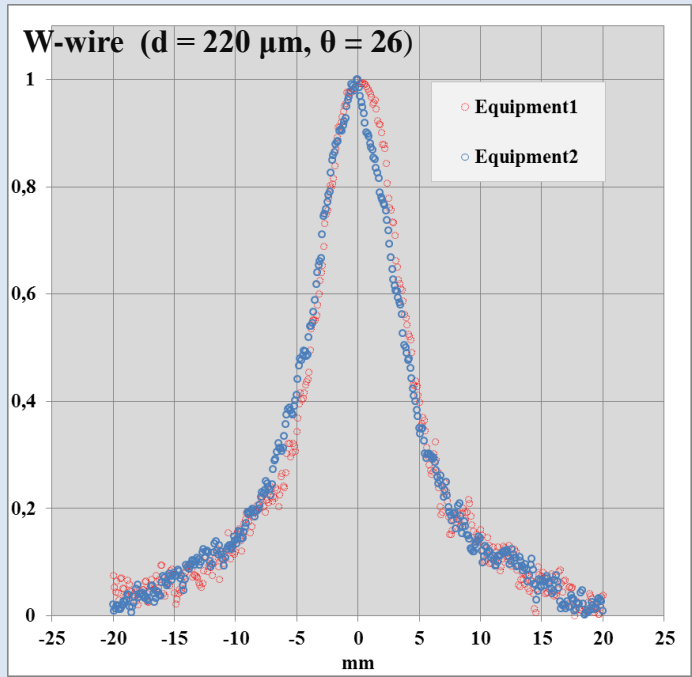
Differences found ≤ 5%

Width   Length

Artefact:

Artefact spread function (Al bead 0.5 – 3 – 5 mm)

Legend:
- d=0.5 Equipment1
- d=3 Equipment1
- d=5 Equipment1
- d:0.5 Equipment2
- d=3 Equipment2
- d=5 Equipment2
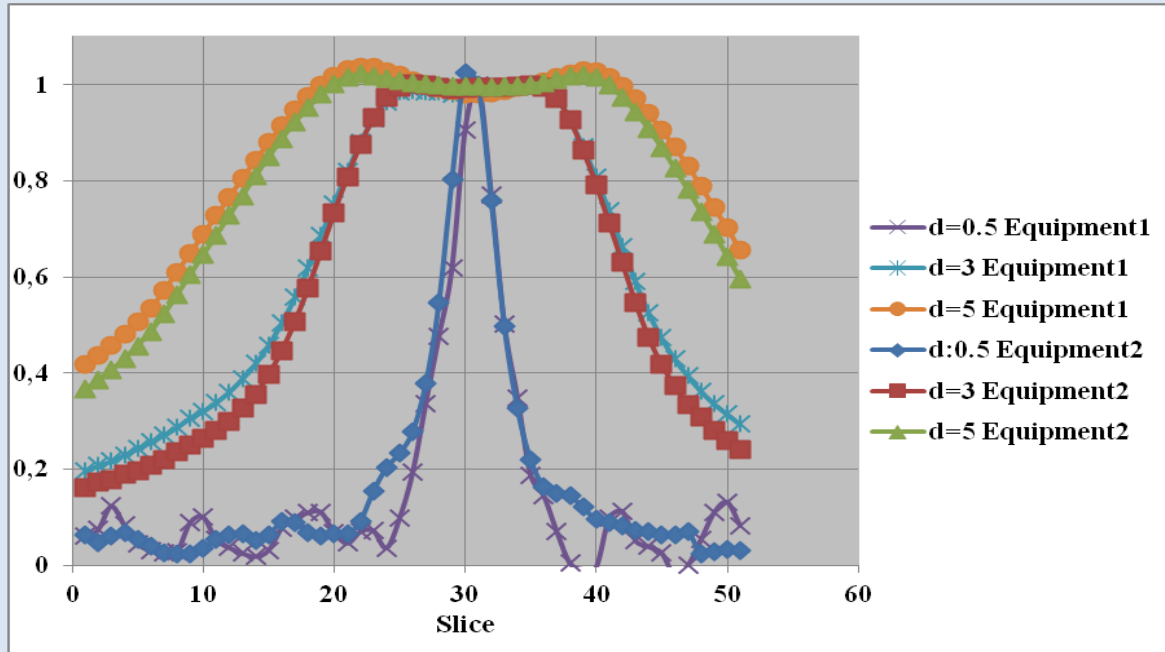
$$ASF(z) = \frac{MPV_{Artifact}(z) - MPV_{BG}(z)}{MPV_{Feature}(z_0) - MPV_{BG}(z_0)}$$

Focus Slice
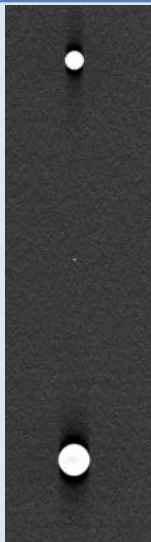
Non-Focus Slice

Artefact example

The two devices have the same performance

Average Glandular Dose:

SEV:

1. **Multimeter 1 (solid state)**
2. **Multimeter 2 (solid state)**
3. **Ionization Chamber**
4. **Header DICOM : campo (0040,0314)**

kV	Mult 1	Mult 2	I.C.	Header Dicom
26	0.52	0.42	0.47	0.43
28	0.58	0.44	0.51	0.47
30	0.62	0.48	0.55	0.51
31	0.64	0.49	0.57	0.52
33	0.68	0.52	0.61	0.56
36	0.73	0.55	0.66	0.61
42	1.12	0.61	0.74	0.69

$$SEV = \frac{X_1 \times \ln\left(\frac{2Y_2}{Y_0}\right) - X_2 \times \ln\left(\frac{2Y_1}{Y_0}\right)}{\ln\left(\frac{Y_2}{Y_1}\right)}$$
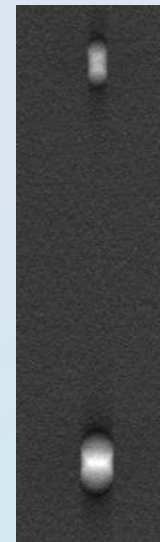
Multimeter #1
resulted not suitable
for this measurements

AGD:

$$D(\theta) = Kgcst(\theta)$$

PMMA (mm)	I.C.	Mult2	Var %
20	**1.1**	1.0	-6.8%
30	**1.3**	1.2	-8.3%
40	**1.8**	1.7	-5.9%
45	**2.5**	2.3	-8.7%
50	**3.0**	2.8	-7.1%
60	**4.5**	4.2	-7.1%
70	**5.7**	5.2	-9.6%

PMMA (mm)	AGD Equipment #1 (mGy)			AGD Equipment #2 (mGy)		
	calc *(mult.2)*	displayed	Var % *(disp.vs. calc)*	calc. *(i.c)*	displayed	Var % *(disp.vs. calc)*
20	**1.0**	0.87	-18.4%	**0.9**	0.94	4.4%
30	**1.2**	1.01	-18.8%	**1.0**	1.03	3.0%
40	**1.7**	1.51	-12.6%	**1.4**	1.44	2.9%
45	**2.3**	2.01	-14.4%	**1.9**	1,91	0.0%
50	**2.8**	2.44	-14.7%	**2.3**	2.3	0.0%
60	**4.2**	3.80	-10.5%	**3.5**	3.63	3.7%
70	**5.2**	5.03	-3.4%	**4.4**	4.85	10.2%

**Multimeter versus ionization chamber
Var % < 10%**

**Calculated AGD versus displayed AGD
Var % < 20%**

CONCLUSIONS:

•The protocol is applicable to both equipments
•The two equipments were comparable for most of the measured parameters
•On both equipments the difference between the measured and displayed dose
is less than 20%
•It's very important to understand the characteristics of the available image
formats to correctly choose images on which to perform the various tests.

Thank you for your attention!!