# A Comparison between the Las Vegas and the PTW EPID QC PHANTOM® for portal imaging quality assurance

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**Abstract**

Electronic portal imaging device (EPID) is widely used for patient position verification. The regular quality assurance (QA) of EPID image quality is necessary to ensure treatment efficacy. The purpose of the study was to compare the Las Vegas phantom and PTW EPID QA PHANTOM® in an amorphous silicon EPID image quality investigation. The Elekta iViewGT system was investigated with the PTW EPID QA PHANTOM® and compared with the Las Vegas phantom. We exposed both phantoms by for x-low (6 MV x-ray) and x-high (10 MV X-ray), at dose rate of 200 and 400 MU/min (the normal dose rate which used in routine) and the monitor units from 1, 2, 4, 6, 8, 10, 50 and 100. The results showed that the Las Vegas phantom could be shown only the number of holes that could be seen. The visible holes in raw and column in the Las Vegas image determines the contrast and resolution of EPID. For x-low beams showed more holes than x-high. More MU used, more holes could be seen. The dose rate of the x-low and x-high do not affected the number of holes. For the PTW EPID QC PHANTOM® showed the mean values of signal-to-noise-ratio and contrast resolutions. X-high showed the higher values of the SNRs than x-low. The 25% MTF high contrast (horizontal) lp/mm for the x-low is in the range of 0.61 - 0.62, xhigh is 0.56 - 0.58 lp/min. The 25% MTF high contrast (vertical) lp/mm for x-high is 0.50 and 0.46 for x-low.

## Introduction

ELEKTA SYNERGY linear accelerator (Elekta Oncology Systems Ltd, Crawley, UK) was installed at Rajavithi Hospital in 2009. An Elekta SYNERGY equipped with the electronic portal imaging device (EPID), which is mounted orthogonally to the treatment head. The EPID is a powerful tool in the reduction of treatment setup errors and the quality assurance and verification of complex treatments. So quality control is required to optimize the operating and to maintain image quality. It is generally accepted that the quality of the image acquired using megavoltage x-ray is poorer than acquired with kilovoltage x-rays. The comparison using the Las Vegas phantom and the PTW EPID QA PHANTOM® for the image qualities were studied. When the linear accelerator acceptance test has been done, the image quality of the EPID was tested using the Las Vegas phantom supplied by Elekta. The numbers of holes were counted. Visualizing holes in the Las Vegas image determines the contrast and resolution of EPID. No analyses of the SNRs or the contrast curves were suggested. The initial images obtained during acceptance test represent the reference data for continuing quality assurance of the EPID. When we started to use the EPID for verifying the treatment's fields at the end of 2010, we started to use the PTW EPID QA PHANTOM® for the image quality verification. It consists of 5 essential tool to measure the geometric accuracy, signal to noise ratio (SNR), dose linearity, the low and the high contrast resolutions and are aligned with divergence to measure the imaging and geometric parameters in horizontal and vertical directions. The pelvis phantom was also used to test for this purpose and kept the results as the references images.

## Materials & Method

The Las Vegas phantom

The phantom was designed with holes of various diameters and depths. (Fig. 1) No data are provided on the holes depths and contrast values for the phantom provided by Elekta with iViewGT system.

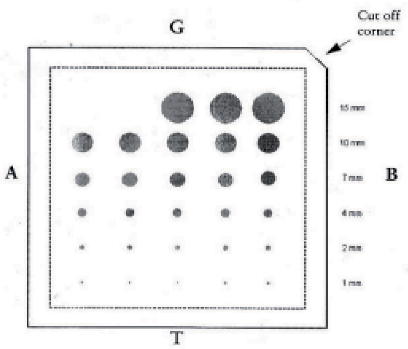


**Figure 1.** Positioning of the Las Vegas phantom

## The PTW EPID QC PHANTOM®

The PTW EPID QC PHANTOM® was developed for checking the constancy of the image quality of EPIDs for high-energy photon radiations in radiation therapy. (Fig.2)

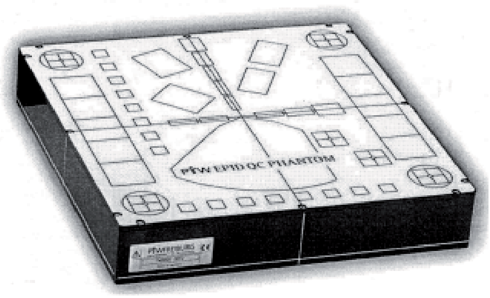


**Figure 2.** The PTW EPID QC phantom

## The pelvis phantom

The pelvis phantom is the product of BrainLAB, ET verification phantom, s/n prototype 3051.

## The Linear accelerator

The Linear accelerator is ELEKTA SYNGERGY which attaches with electronic portal imaging device (EPID) for MV-imaging and XVi (kV imaging system). The MV-imaging is iViewGT system. The distance from the target to the surface of the flat panel is 160 cm.

The Las Vegas phantom was setup on the patient couch of the linear accelerator. The phantom's top surface is at isocenter (100 cm.), with the holes facing down. The phantom was exposed to x-low and x-high beams. By varying the dose rate 200 and 400 MU/min, as well as varied the monitor units (MU) from 1, 2, 4, 6, 8, 10, 50 and 100. The field size was 12 x 12 cm. After exposed the phantom, using the contrast and brightness functions optimized the displayed images.

The PTW EPID QC PHANTOM® should be placed on the patient couch at the place free of absorption with the printed front plate facing the beam. The recessed lines on the side of the phantom should be aligned with room laser. The phantom set to isocenter height 100 cm. (SSD=96.2 cm). The field size is 26 x 26 cm. which cover all test elements of the phantom completely.

The pelvis phantom was exposed to x-low and x-high using double exposure technique. (Table 1) and used SAD technique was 100 cm. The dose rate is 400 MU/min which is normally used in clinical. The pelvis phantom's the mid line depth is 11 cm. The planned field size was 15 x 15 cm. and the open field size was 20 x 20 cm.

**Table 1.** The double exposure techniques to the pelvis phantom.

| Tested | Techniques | Exposure |
|---|---|---|
| 1 | Open field before planned field | 2 MU;2MU |
| 2 | Open field before planned field | 2 MU;1MU |
| 3 | Open field before planned field | 1 MU;2MU |
| 4 | Planned field before open field | 1 MU;2MU |
| 5 | Planned field before open field | 2 MU;2MU |
| 6 | Planned field before open field | 2 MU;1MU |

## Results

The Las Vegas phantom

The images of EPID for x-low beam, the EPID will be able to resolve in the range of 18-26 holes (Fig.3). For x-high, the holes are in the range of 16-25 (Fig.4)

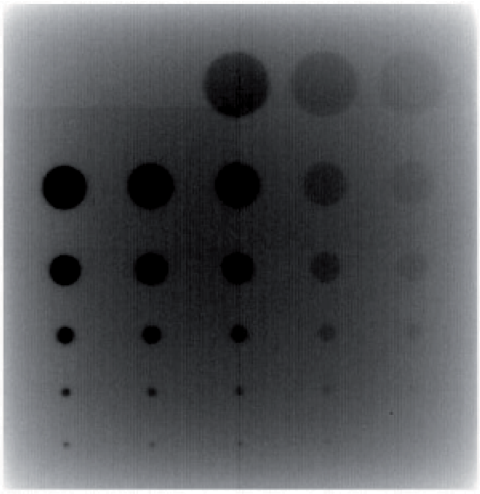

**Figure 3.** The Las Vegas exposed to x-low, dose rate 200 MU/min and 100 monitor unit (MU).

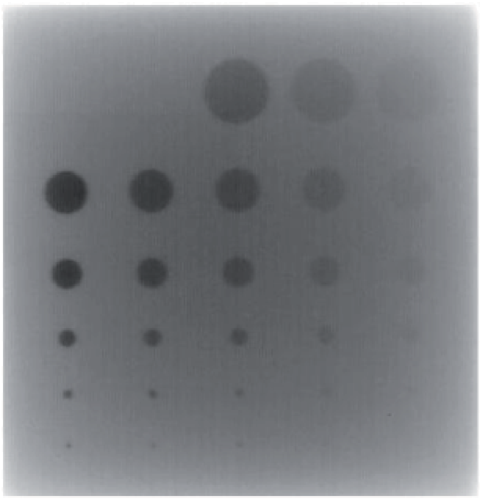

**Figure 4.** The Las Vegas exposed to x-high, dose rate 400 MU/min and 100 monitor unit (MU).

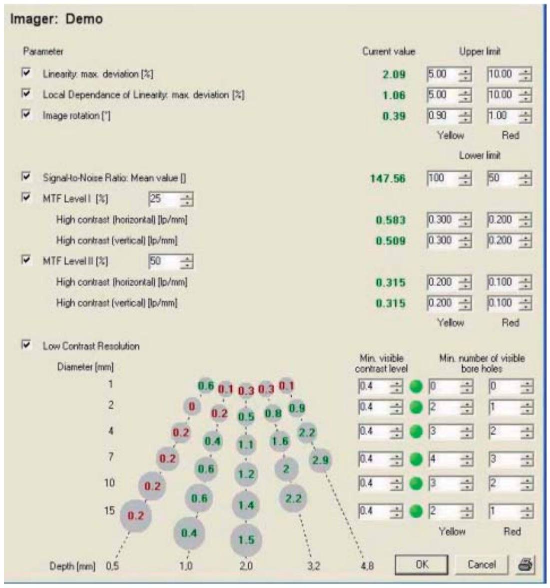


**Figure 5.** The evaluation results.

### The PTW EPID QC PHANTOM®

The image qualities of the PTW EPID QC PHANTOMR were analyzed with epiSoftR 2.1 program (Fig. 5)

When plotting between monitor units (MU) and SNRs at different dose rate (200 and 400 MU/min) of 6 and 10 MV x-ray, the curve showed small SNR at low MU and increasing until about 6 MU the curve became to plateau (Fig.6). For the 25%MTF high contrast (horizontal) lp/mm for the x-low are in the range 0.61 - 0.62, x-high are 0.56 - 0.58 (Fig.7). The 25%MTF high contrast (vertical) lp/mm for the x-low is 0.46, x-high is 0.50 (Fig.8). The 50% MTF high contrast (horizontal & vertical) lp/mm for both x-low and x-high show no difference of the values which are in the range of 0.30-0.31 (Fig.9). For the low contrast of x-low and x-high, the number of holes are 17 -1 9 and 16-19 respectively.

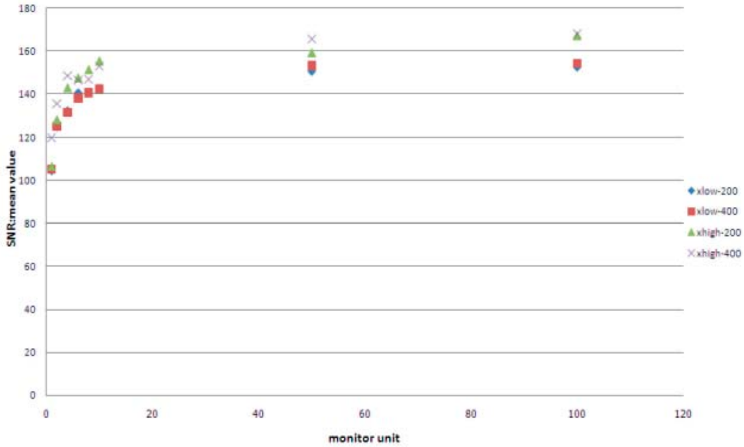


**Figure 6.** The mean values of SNRs by varying energies & dose rate

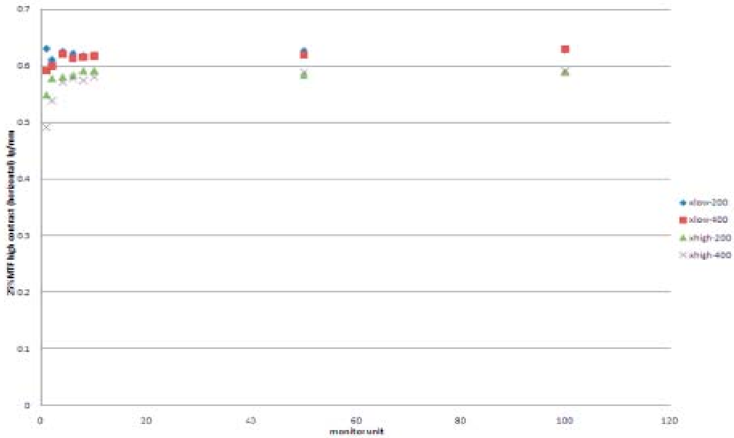


**Figure 7.** 25% MTF high contrast (horizontal) lp/mm

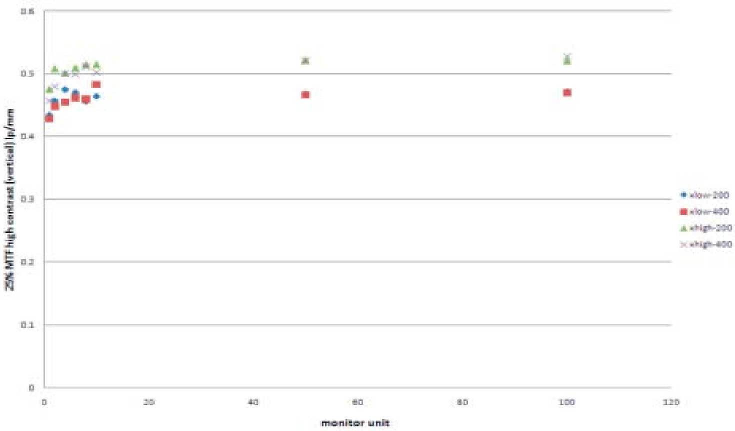


**Figure 8.** 25% MTF high contrast (vertical) lp/mm

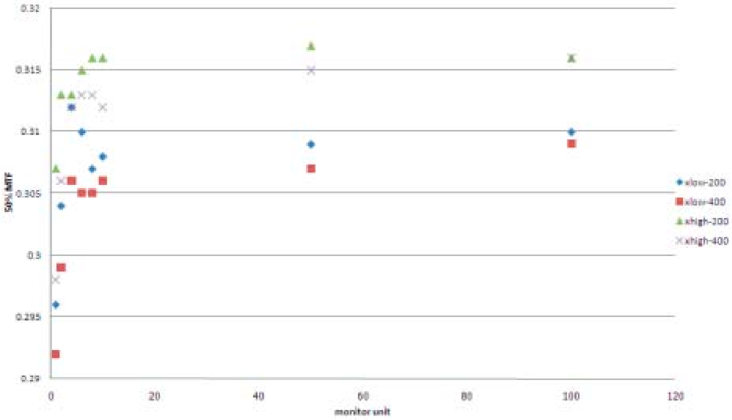


**Figure 9.** 50% MTF high contrast (horizontal & vertical) lp/mm

### The pelvis phantom

Analyzing the images of the pelvis phantom by Elekta iViewGT, the image of the open field exposed before the planned field are better than the images which the planned field exposed first (Fig.10 and Fig.11).

The best result for double exposure technique is 2 MU and 2 MU for the open and planned fields.

### Discussion

The images from the Las Vegas phantom, we can count only the number of visible holes. It gives only visual information. We do not know the contrast of the holes due to the vendor does not provide the data of the depth and contrast for the phantom. The

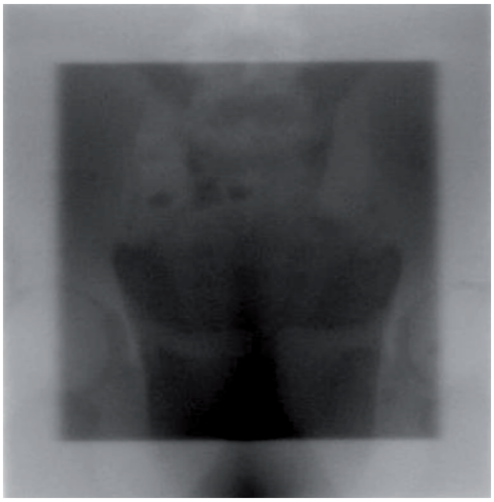

**Figure 10.** The image of pelvis phantom with double exposure, the open field was exposed first, then the planned field by 2 MU & 2 MU and x-low.

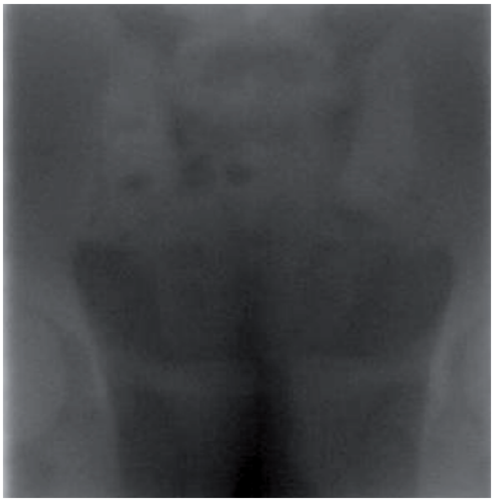

**Figure 11.** The image of pelvis phantom with double exposure, the planned field was exposed first, then the open field by 2 MU & 2 MU and x-low

images of x-low are smoother than x-high. For x-high, the aluminum's lines can be seen on the images since the high energy photon penetrate the Las Vegas phantom. When imaging with low-energy photon beam (6 MV) a properly functioning EPID will be able to resolve the 17 holes.1-2 From the acceptance tests, x-low (6 MV) for 100 MU, dose rate 200 MU/min, the visible holes was 16. X-high (10 MV) for 100 MU, dose rate 200 MU/min, the holes visible was 13 holes. In this test, for x-low, dose rate 200 MU/min, the EPID can be seen 26 holes on 100 MU. For x-high, dose rate 200 MU/min and 100 MU, the holes are 25. So the visible images depend on the observation experience and motivation, room lighting and the doses (MU).

The results of SNRs from the PTW EPID QC PHANTOMR showed that the SNRs increase when the doses (MU) increase and x-high gives higher SNRs than x-low. Since scattered x-rays can reduced the subject contrast and the signal to noise ratio of portal image by generating signals in the image receptor that carry no geometric information about the patient's anatomy but that add noise to the image.2 For EPIDs, the reduction in signal to noise ratio due to x-ray scatter is more important than the reduction in contrast.1 So the testing the PTW EPID QC PHANTOMR, it should be used high dose (above 50 MU) because the SNRs is in the plateau region. For the MTF values or the SNR values are found very few published data. Csilla Pesznyák3 reported the 50% MTF from Elekta iView (which is a camera base, analog signal) were 0.323, 0.324, 0.321, 0.315 and 0.305 for 1, 2, 4, 6 and 8 MU respectively. He did not show which energies were used in his study. In this study, Elekta iViewGT (amorphous silicon, digital signal) the 50% MTF for 6 MV were 0.292, 0.299, 0.306, 0.305 and 0.305 for 1, 2, 4, 6 and 8 MU. For 10 MV, 50% MTF were 0.298, 0.306, 0.312, 0.313 and 0.313.

The Las Vegas phantom gives only visible information, while the PTW EPID QC PHANTOMR gives numeric analysis tool. So the reference values shall be determined during acceptance test of the equipments.

The double exposure of the pelvis phantom for x-low and x-high, the best result of image was irradiation the open field before the planned field. The open field image is used to correct for reproducible treatment field specific characteristics.2 When the planned field was irradiated before the open field, the images looked like double exposure to the planned field, the edge of the field could not see. For verification of patient sets up, the high dose is not necessary to use. 2 MU + 2 MU for double exposure are enough or 2 MU for open field and 1 MU for planned field are enough for a slim patient. Given the high MU, it will be added the doses to the patient.

**Conclusion**

The EPID systems demonstrate the usefulness for verifying patient positioning during IMRT or other conformal radiotherapy techniques. The major difficulty in verification is that megavoltage beam images have inherently poor contrast. The initial images represent baseline data for continuing quality assurance of the EPID. Images of anthropomorphic phantom by EPID should be stored to represent the operation of the image at optimum image quality.2 Quality assurance program is required to optimize the operating parameters and to maintain image quality.2 A monthly recalibration may be necessary depending on the mechanical stability of the EPID. Calibration procedures depend on the type of EPID and vendor recommendations; however in each case it involves exposing the EPID to radiation under specific conditions.1

**References:**

1. Herman MG, Kruse JJ, Hangness CR, Guide to clinical use of electronic portal imaging: J Appl. Clin. Med. Phys. 2000; 1, 38 -57
2. Herman MG, Balter JM, Jaffray DA, et al. Clinical use of electronic portal imaging: Report of AAPM Radiation Therapy Committee Task Group 58: Med. Phys. 2001; 28, 712-736
3. Pesznyák C, Polgár I, Weisz C, et al. Verification of quality parameters for portal images in radiotherapy: Radiol. Oncol. 2011: 45,68-74