Research Article

# Commissioning for treatment planning system

## Abstract

**Objective:** A process and system of treatment planning is very important in radiation therapy. The features of the software and the accuracy in the dose calculation and dose distribution will affect to the treatment quality as well as the patient outcome. When a treatment planning system is applied in treatment at the first time, it should be checked and approved all its system information, features, plan assessment tools and dose calculation modules as well. That process is called Commissioning for treatment planning system.

**Materials and methods:** In 2013, Medical and Radiation Oncology department-Cho Ray hospital has utilized Elekta Synergy Platform using XiO vs 4.80 treatment planning system. The commissioning for XiO was performed according to international procedures and protocols which were set up by our Medical Physics. All system information, the features and functions of the software and the beam data were collected as well. To validate and ensure the possibilities in clinical application, some comparisons and assessments between XiO calculations and the actual measurements in water/solid phantom were setup for opened/wedged field size percentage depth doses, beam profiles, algorithms with/without electron density correction, monitor units.

**Results and Conclusions:** The results for percentage depth dose have shown that the maximum accuracy was 0.8% in all treatment depths and less than 1% in the depth of 10cm, with opened-field and wedged-field, respectively. 2.06% of relative dose accuracy in low dose gradients and 0.25mm of spatial accuracy in high dose gradients was estimated. We found the accuracy of 17.55% in nasal cavity and 8.94% in lung case between the algorithms with/without electron density correction. And the maximum accuracy was about 1% in opened-field for monitor unit verification.

**Keywords:** xio, commissioning, treatment planning system, electron density

**Bao Lam, Le Tuan Anh, Dang Van Quy**
James Cancer Hospital and Solove Research Institute, USA

**Correspondence:** Bao Lam, Medical and Radiation Oncology department, Cancer Center, Cho Ray hospital, Vietnam, Email kysulam.ub@gmail.com

**Abbreviations:** TPS, treatment planning system; MPs, medical physicists; CT, computed tomography; LinAc, linear accelerator; PDD, percentage depth dose; OCR, off center ratio; MU, monitor unit; TPR, tissue phantom ratio

## Introduction

A treatment planning system (TPS) is very necessary in radiation process. It can make a simulation, establishment and dose calculation module based on patient's Computed Tomography (CT) and the linear accelerator beam models. To apply in clinical purpose, it should be completely accepted and checked all of features of modules, dose calculations and evaluation tools as well. A process of overall tests ensuring the sufficient package of TPS according to the initial requirements is called Commissioning and Validation.[1] In the end of 2013, Medical and Radiation Oncology department was installed a new radiation system including Elekta Synergy Platform linear accelerator (LinAc), Siemens Emotion Somatom CT Simulator and cms XiO Treatment Planning System (TPS). The Commissioning and Validation process were also built up and implemented by our Medical Physicists (MPs).

## Methods and materials

Some Commissioning forms were designed, collected and checked by at least 2 MPs, consisting of: Commissioning for all information and features; Commissioning for all modules and functions; Commissioning for dosimetry and Measurements, comparisons and evaluations for all algorithms. All measurements were performed with IBA Dosimetry physics tools, such as: Water Blue phantom, RW3 Solid phantom, CC13- FC65G-PPC040 ionization chambers and Omni Pro

Accept version 7.4. Moreover, an Electron Density dataset was also calibrated by using Gammex Tissue Characterization phantom with all CT protocols per each kVp level. To keep our radiation equipments under control, all information of XiO TPS would be completely collected and managed according to our forms (Figure 1).[2]



**Figure 1** XiO TPS information forms.

Like other TPSs, XiO had a lot of interfaces including much different functionality, so we had to checked and confirmed for technical catching, upgrading and exchanging in the near future. We classified into 6 main groups of functionalities: Patient registration and contouring/2D-3D beam simulation/Planning and dose calculation/Plan evaluation/Print-Export and Backup data/Setup of configuration and beam models. To adjust dose calculation in any

tissues with different density, all commercial TPS in general and XiO in particular also used a sample of Electron density dataset, and it was usually installed into XiO at the beginning, but whether it should be suitable or not.[3] XiO based on 2 main algorithms: with/ without correction of Electron density, Convolution or Superposition/ Clarkson, respectively. At Cho Ray hospital, we scanned a density phantom for creating new Electron density dataset and evaluating together with XiO sample dataset at the same time (Figure 2).[4]
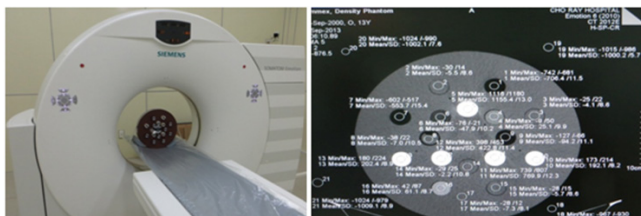


**Figure 2** Scanning of density phantom.

Dosimetry Commissioning was performed on the XiO guideline and focused on beam data collection list. All characteristics of the beam were measured in accordance with a reference of AAPM-TG106.[5] After that, a process of beam modeling would be done and input into XiO. It is very essential that all beam data and beam models should be correct. To do it, some measurements were implemented and compared between XiO calculations and actual measurements at the same setup. Typically, we contoured virtual images which were relative to water by scanning many plates of RW3 phantom on CT scanner (Figure 3). We created some tests of comparison, such as Percentage Depth Dose (PDD), Beam Profiles, Penumbra, Algorithms, Tissue Phantom Ratio (TPR), Off Center Ratio (OCR) and Monitor Unit (MU).
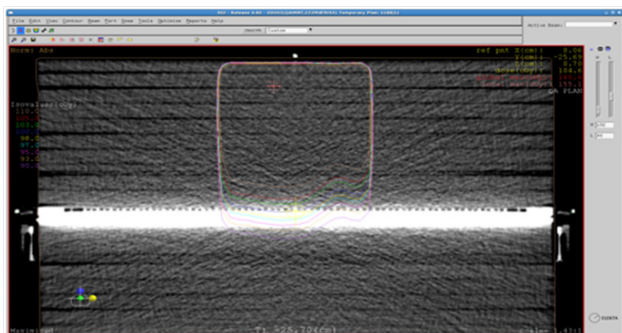


**Figure 3** Dose distribution on RW3.

This measurement showed the accuracy of density be quite different between all CT scan protocols with each kVp; 1-4% accuracy of density with the low Lung material (LN-300) and 0.2-2.5% for high Lung (LN-450). With Adipose, its accuracy was from 2-3%. The others showed a comparison of actual density and the value of XiO reading relative to each material, approximately 1% (Table

1 & Figure 4). On the other hand, the study of Electron density's deviation between actual and XiO sample dataset was evaluated. It showed the accuracy should be 5% for the material's density closed to water (r=1), 1.9% for which density closed to $CaCO_3$ (r=1.3) and 4.2% relative to bone (r=1.7) (Figure 5). It also showed the smaller deviation of density scanning on 130 kVp than 110 kVp. To apply the beam data collection from Commissioning into clinical purpose, we performed a lot of measurements to evaluate the difference between the TPS calculation and actual irradiation. For dose distribution, some opened-fields and standard wedged-field (10x10) were measured at any certain depths (Table 2 and 3).

The results were suitable at all depths for opened-fields and wedged-field at not larger than 20cm depths. Since, the big difference between TPS calculation and measurement in wedged-field was at 20cm depth, 5.71%. An evaluation Beam Profiles, especially for asymmetric field was also considered and both A-B and G-T directions were quite the same. We showed the result of Asymmetric Collimator Profile with 2.5 x 7.5cm at 5cm reference depth (Table 4).[6]
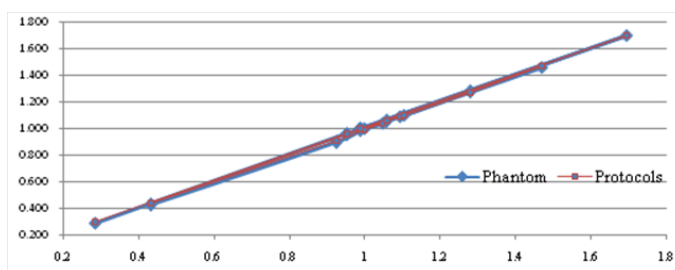


**Figure 4** Comparison of actual density and XiO reading.

Dose difference between 2 Electron Density correction algorithms in Nasal cavity and Lung case was reported in Table 5. It showed the big deviation between Convolution and Super position algorithm for each case which had significant variation of Electron density. Moreover, the result of TPR, OCR in standard field 10x10 field size were suitable, 0.76% and 0.5% respectively. We also setup the MU calculation at (0,0,10) iso-center and estimated the results of all algorithms for each weighting point (Table 6). For asymmetric field, dose differences were smaller than 2%.[7]
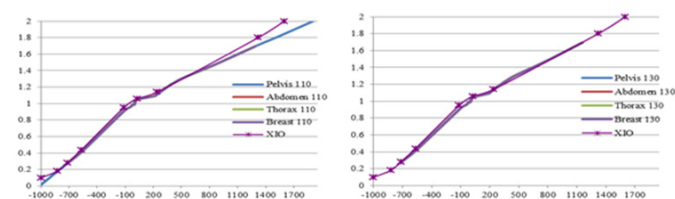


**Figure 5** Comparison between XiO dataset and all CT Protocols in 110 and 130 kVp.

**Table 1** Accuracy of electron density-130 kVp

| Materials | Electron Density | Pelvis (%) | Breast (%) | Thorax (%) | Abdomen (%) |
|---|---|---|---|---|---|
| LN-300 Lung | 0.285 | 3.04 | 1.05 | 2.81 | 4.44 |
| CT Solid Water | 0.988 | 0.71 | 1.21 | 1.45 | 0.98 |
| Cortical Bone | 1.695 | 0.22 | 0.73 | 0.43 | 0.29 |
| CT Solid Water | 0.988 | 0.44 | 1.45 | 0.98 | 0.98 |
| BRN-SR2 Brain | 1.049 | 0.41 | 1.24 | 0.57 | 0.79 |
| Breast | 0.955 | 0.84 | 0.94 | 0.21 | 0.21 |
| LN-450 Lung | 0.432 | 0.23 | 0.46 | 1.39 | 2.55 |

Table continued...

| Materials | Electron Density | Pelvis (%) | Breast (%) | Thorax (%) | Abdomen (%) |
|---|---|---|---|---|---|
| Adipose | 0.926 | 2.74 | 2.09 | 3.06 | 2.05 |
| Water Insert | 1 | 0.23 | 2.17 | 0.23 | 1.17 |
| Inner Bone | 1.093 | 0.76 | 0.73 | 0 | 0 |
| CaCO3-50% | 1.469 | 0.59 | 0.09 | 0.34 | 0.16 |
| CaCO3-30% | 1.28 | 0.89 | 0.63 | 0.1 | 0.47 |
| Bone Mineral | 1.104 | 0.42 | 0.27 | 0.36 | 0.36 |
| CT Solid Water | 0.988 | 1.45 | 1.45 | 1.69 | 1.45 |
| CT Solid Water | 0.988 | 0.44 | 1.21 | 0.03 | 1.72 |
| LV1 Liver | 1.059 | 0.31 | 0.35 | 0.03 | 0.26 |

**Table 2** Dose distribution in opened-field

| Field size (cm²) | Depth (cm) | Dose Accuracy (%) | Spatial Accuracy (mm) |
|---|---|---|---|
| 3x3 | $d_{max}$ | 0 | 0 |
| | d5 | 0 | 0.2 |
| | d10 | 0 | 0.2 |
| | d20 | 0 | 0.1 |
| 7x7 | $d_{max}$ | 0 | 0 |
| | d5 | 0.47 | 0.1 |
| | d10 | 0.46 | 0.1 |
| | d20 | 0.8 | 0.1 |
| 10x10 | $d_{max}$ | 0 | 0 |
| | d5 | 0 | 0 |
| | d10 | 0 | 0 |
| | d20 | 0 | 0 |
| 15x15 | $d_{max}$ | 0 | 0 |
| | d5 | 0.46 | 0.1 |
| | d10 | 0 | 0 |
| | d20 | 0.24 | 0.1 |
| 25x25 | $d_{max}$ | 0 | 0 |
| | d5 | 0.34 | 0.06 |
| | d10 | 0.21 | 0.03 |
| | d20 | 0 | 0.1 |

**Table 3** Dose distribution in 10x10 wedged-field

| Field size (cm²) | Depth (cm) | Relative Dose Accuracy (%) | Spatial Accuracy (mm) |
|---|---|---|---|
| 10 x 10 | $d_{max}$ | 0 | 0 |
| | d5 | 1.03 | 0.2 |
| | d10 | 2.73 | 0.6 |
| | d20 | 5.71 | 1.15 |

**Table 4** Asymmetric collimator profile

| Field size (cm²) | Relative Dose Difference (%) | Spatial Accuracy (mm) |
|---|---|---|
| 2.5x7.5 | 2.06 | 0.25 |

**Table 5** Dose Algorithms verification

| Region | Dose Points Accuracy (%) |
|---|---|
| Nasal cavity | 1.96–17.55 |
| Lung | 8.94 |

**Table 6** Clinical and biochemical variables of individuals with overweight-obesity

| Algorithm | Weighting point | Wedge | Dose Accuracy (%) |
|---|---|---|---|
| Clarkson | (0;0;10) | Open | 0.45 |
| Convolution | (0;0;10) | Open | 0.45 |

| Algorithm | Weighting point | Wedge | Dose Accuracy (%) |
|---|---|---|---|
| Clarkson | (3;0;10) | Open | 0.5 |
| Convolution | (3;0;10) | Open | 1 |
| Clarkson | (3;2.5;5) | Open | 0.6 |
| Convolution | (3;2.5;5) | Open | 0.6 |
| Clarkson | (3;2.5;5) | 300 | 0.2 |
| Convolution | (3;2.5;5) | 300 | 2.35 |
| Convolution | (0;0;10) | 300 | 1.65 |
| Clarkson | (3;2.5;5) | 600 | 0.7 |
| Convolution | (3;2.5;5) | 600 | 4.95 |

## Conclusion

For taking under control and applying into clinical radiotherapy, it is very important that the treatment planning system have to be commissioned and validated by clinical and qualified medical physicists. The overall collection of system information will help us generally assess the situation and directionally expand our TPS, like upgrading or new purchasing. The Electron density measurement showed the different between XiO dataset sample and measurement. Thus, we recommended our planner that the usage of Electron dataset has to be exactly selected, 130kVp was suggested for all protocols due to insignificant accuracy, except for children patient, 110kVp was applied. For selecting the suitable algorithms of dose calculation, we proposed that all cases should plan by algorithm including Electron density correction and Super position was considered as the final algorithm for any special cases, for instance Head and Neck and Thorax regions. The appropriate results smaller than 1% came from dose distribution between TPS calculation and measurement in opened field with 60 wedged-field, a big different closed to 5% for 20cm depth and more. Thus, it is essential that our planner should be careful in planning with any higher depths, especially for wedged-field. It is quite imperative that both calculation and measurement be the same at low dose gradients and enough small at high dose gradients. So, we intend to perform more measurements for checking any points in each profile. The comparison of TPR, OCR and MU value were acceptable.[8] This study is entitled some procedures and forms which were initially implemented in Commissioning and Validation for XiO treatment planning system by our Medical Physics team. Because of insufficient tools, limitations of time and experience, some of measurements are going to be designed and validated, like angle of motorized wedge, MLC effects. In brief, Commissioning is very important and indispensable in radiotherapy. Generally, we recommend all cancer centers and Vietnamese Medical Physicists in particular should focus on its process to finally increase our patients treatment outcome.

## Acknowledgments

## Conflicts of interest

Authors declare there are no conflicts of interest.

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