Conclusion: In-air output ratios were successfully calculated as the ratio of $Kp$ for beams with and without a flattening filter. For FF beams the flattening filter and primary collimator was the largest contributors, while for beams with 2 mm Fe or no filter in the beams line the primary collimator accounts major part of the variation of $Sc$.

EP-1598

Initial validation of a commercial algorithm for volume dose reconstruction with ionization chamber

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Purpose or Objective: We report on our initial experience with the commissioning for fixed-field IMRT of the dose reconstruction algorithm on a phantom with measurements from a helical diode detector array (ArcCheck (AC) from Sun Nuclear (SNC)).

Material and Methods: We designed a set of tests to check on the performance of the dose reconstruction software, 3DVH, which reconstructs the dose inside the AC device from the entrance/exit diode measurements. Dose was measured with and without a small volume ionization chamber (0.125 cc semi-flex by PTW). Dose in the position of the ionization chamber was estimated with the help of 3DVH. TPS calculated dose and reconstructed dose were compared to the ionization chamber dose.

Linearity was assessed by irradiating 10x10 cm2 open fields with different isocenter doses: 0.4, 1, 1.6, 2.2 Gy. The electron density override on the AC was validated with a 2%-2mm gamma analysis on the open fields. Then a set of sliding window gaps (6, 10 and 14 mm) was irradiated with a number of MU matched to obtain 1 and 1.6 Gy at the isocenter plane. The mock cases from TG-119 were transferred to the AC CT for inverse optimization. Finally 16 clinical HN cases were also irradiated. In the mock and HN cases dose was measured in a high dose-low gradient point of the volume.

Results: The dose calculated with 3DVH for the 10x10-cm open fields was lower than the dose measured with the ionization chamber by 1.32% on average. Dose linearity was confirmed and the gamma passing rates were better than 95% for 2%/2mm criteria for all cases which confirmed our electron density override on the AC.

The ratio between the dose delivered with each sweeping gap and a 10x10cm2 field with the same planned dose was calculated. The value of this relationship obtained from the doses reconstructed with 3DVH was 5% larger than expected, while the value calculated with Eclipse TPS and with the ionization chamber were 0.999 and 1.001, respectively.

For the TG-119 cases we obtained that the reconstructed dose is 0.28% higher on average than the measured dose. The biggest discrepancy between reconstructed and measured dose was for the MultiTarget case, with a reconstructed dose 1.42% higher than the ionization chamber measurement. The mock H&N case was the best of them, with an error of 0.29% between reconstructed and measured dose. The average on the reconstructed dose with 3DVH for the 16 clinical patients was 0.78% lower than the camera, being 0.07% the smallest error and 2.91% the largest one.

Conclusion: Reconstructed doses over the AC phantom with 3DVH software are in good agreement with measurements for open fields and also for mock cases and clinical patients. However, differences between calculated and measured doses for simple sweeping gaps are inexplicable large and require further investigation.

EP-1599

How far can we go? Reliability of gamma evaluation in IMRT plans.

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Purpose or Objective: The Intensity-Modulated Radiation Therapy (IMRT) is a widely used treatment for many cancer sites. Independent verification in this kind of treatment is recommended and some countries require it. There are many different ways of pre-treatment verification e.g. point dose measurement, 2D or 3D dose verification and various methods of interpreting the verification result. One of the most popular way is gamma evaluation [Depuydt, 2002]. The aim of this study was to identify the relationship between simulated MLC errors and gamma evaluation result. We compared RT dose for error-induced plans with original plan, both calculated in specified phantom used for verification. Such comparison enabled us to obtain result of gamma analysis influenced only by known MLC error, ceteris paribus.

Material and Methods: Verification Plans for ten patients for each of three cancer sites (brain, prostate, head and neck) were prepared. For every case original and modified MLC has been used. Two types of MLC errors were tested: open/close error in which both MLC banks moved in opposite direction and shift error with both MLC banks moved in the same direction. Magnitude of these errors were 0.5, 1.0, 2.0, 3.0 mm. The MLC errors were simulated for all control points, on both banks of active MLC leaves only. The dynamic leaf gap and other MLC physical constraints were taken into consideration. For each plan dose distribution was calculated in Eclipse (AAA v. 10.0.28) for phantom geometry and original gantry angles. Afterwards gamma evaluation was performed with the Verisoft software (PTW, v. 6.1). We investigated results for gamma 3mm/3%, 2mm/2%, 1mm/1% for local and maximum dose difference. The suppressed dose value was set to 10% for 3D gamma evaluation.

Results: For head and neck plans MLC open/close errors, equal or larger than 1mm, weren’t detected only for gamma 3mm/3% max dose and passing rate 95%. For brain and prostate plans 2mm open/close errors can be detected with gamma 3mm/3% local and 2mm/2% max dose. For all investigated cancer treatment sites shift errors are hard to detect (1 mm only with passing rate 95% gamma 1mm/1%). For detailed results see Figure. We assume that difference between treatment sites is related to the leaf open/close error (gap width error) as was reported by LoSasso [1998] and plan modulation.

Conclusion: MLC errors may be a reason of unacceptable result of pre-treatment verification. Selection of gamma passing rate and criteria should be preceded with analysis of MLC error which can be detected by used verification method. In the case of Octavius 4D we recommend using 3mm/3% local dose for 3D gamma evaluation in previously mentioned cancer sites. Other cancer sites should be also investigated and tested. Next step should be checking the
influence of dose resolution (re-sampling of the simulated dose distribution to the detector resolution) on gamma result. Clinical relevance of such MLC errors should be also investigated.

**EP-1600**

**VMAT lung SBRT: 3D evaluation in pretreatment patient QA and in vivo dose verification**

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**Purpose or Objective:** SBRT requires patient specific-QA with high spatial resolution, stability and dynamic range. EPID dosimetry has been proved to be efficient to give accurate results for both conventional and special treatments. In this work, a commercial QA software is used for a lung SBRT clinical case to obtain 3D dosimetry from fluences measured by EPID gantry angle-resolved data acquisition. The purpose is obtain information on actual delivered dose to the tumor volume and surrounding critical structures in terms of clinical dosimetric parameters which are meaningful for both physicians and physicists.

**Material and Methods:** VMAT SBRT lung treatment is planned by Varian Eclipse treatment planning system using ACUROS algorithm. Treatment is delivered using a Varian2100CD linear accelerator’s 6 MV x-ray beam. Fluences are acquired on a Varian aSi1000 EPID. Dosimetry Check (Math Resolutions LLC) is a commercial QA software performing 3D treatment plan verification: the necessary measurements for the exit image kernel for SBRT includes EPID images of various field sizes (minimum field size: 1x1 cmxcm). Fluence maps acquired on the EPID during pre-treatment QA and patient treatment are separately applied to the patient’s CT. Agreement between planned and delivered dose distributions for patient-specific SBRT quality assurance is assessed for a lung case utilizing the gamma index method ad dose volume histogram (DVH)-base metrics. The stereotactic approach requires a tight margin: the distance to agreement criterion is set to 1mm. The dose difference is set to 3% if a homogeneous phantom is used and 5% for calculations on a heterogeneous CT set.

**Results:** Results include 3D gamma evaluation and dose volume histogram (DVH). Volumetric, planar, and point dose comparison between measured and computed dose distributions agreed favorably indicating the validity of technique used for VMAT SBRT QA. Gamma pass rate in axial, coronal and sagittal plane through the isocenter is respectively 93.4%, 86.3% and 95.1% for pretreatment QA; 92.8%, 82.6% and 76% for in vivo QA. 3D values are 89.4% and 90%. Significant clinical structure values from DvH are shown in Table 1.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Treatment Planning</th>
<th>Pre-treatment Measurement</th>
<th>In vivo Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTV - D98 (Gy)</td>
<td>52.90</td>
<td>49.50 (-6.4%)</td>
<td>52.25 (-1.2%)</td>
</tr>
<tr>
<td>PTV - D2 (Gy)</td>
<td>56.05</td>
<td>55.95 (-0.2%)</td>
<td>60.65 (+8.2%)</td>
</tr>
<tr>
<td>PTV - D90 (Gy)</td>
<td>54.75</td>
<td>55.85 (+2.0%)</td>
<td>57.25 (+4.6%)</td>
</tr>
<tr>
<td>PTV - Dmean (Gy)</td>
<td>54.64</td>
<td>55.85 (+2.2%)</td>
<td>57.10 (+4.5%)</td>
</tr>
<tr>
<td>Spinal Cord – D2 (Gy)</td>
<td>9.1</td>
<td>9.4 (-2.2%)</td>
<td>10.0 (-17.6%)</td>
</tr>
<tr>
<td>Spinal Cord – D90 (Gy)</td>
<td>9.6</td>
<td>9.7 (-1%)</td>
<td>10.3 (-7.3%)</td>
</tr>
<tr>
<td>Esophagus – V18Gy (Gy)</td>
<td>0.6</td>
<td>0.7 (-1%)</td>
<td>0.6 (-15.9%)</td>
</tr>
<tr>
<td>Omalateral LUNG V20Gy (%)</td>
<td>24.9</td>
<td>25.5 (+2.4%)</td>
<td>28.3 (+13.6%)</td>
</tr>
</tbody>
</table>

**Conclusion:** An efficient procedure of verifying VMAT lung SBRT plans with high accuracy has been obtained. Results from a clinical case are presented in terms of doses to the anatomical structures and in terms of gamma evaluation. Dosimetry Check system employs a pencil beam algorithm in order to calculate dose from fluence measurements taken with the EPID that some dose differences will arise from the pencil beam algorithm used in Dosimetry Check and the more sophisticated algorithms used in TPS. Differences may depend on the level of heterogeneity of the anatomical site. Further research is needed to assess these differences.

**EP-1601**

**Dosimetric consequences of using two common energy matching techniques in Monte Carlo**

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**Purpose or Objective:** The aim of this abstract was to report the observed differences between measured and Monte Carlo (MC) calculated dose distributions when using common incident electron energy matching techniques.

**Material and Methods:** PDDs and profiles on a 6MV Elekta Precise linac were acquired in a PTW MP1 water tank with a semispheric chamber (0.125cm3) at 90cm SSD. A MC model of the linac was created in BEAMnrc. Phase Space files were scored at 90cm from the target at a plane perpendicular to the direction of the beam. The phase space files were used as an input into DOSXYZnrc to calculate dose in a water phantom (60x60x30cm2, 90cm SSD, voxel size=0.3x0.3x0.3cm3). The incident electron beam was set to have a Gaussian distribution with a FWHM in the GT and AB directions of 1.92 and 2.42 mm respectively. The energy spectrum of the incident electron beam had a FWHM of 0.56keV and an energy window of ±0.6MeV. The mean energy of the incident electron beam was determined in two ways:

**Method 1:**

The mean energy of the electron beam was varied until the calculated CAX PDD matched the measured for a 10x10cm2 photon field (between 5-25 cm). 40x40cm2 dose profiles (90cm SSD, 10cm deep) were subsequently calculated and compared to measurement. **Method 2:**

The mean energy of the electron beam was varied until the calculated 40x40cm2 dose profiles matched the measured profiles to within 0.5% (within 80% field width). A 10x10cm2 CAX PDD (90cm SSD) was subsequently calculated and compared to measurement.

**Results:**

**Results 1:**

The agreement between calculated and measured 10x10cm2 CAX PDD was best (between 5-25cm) for an incident electron beam energy of 6.65MeV. The resultant 40x40cm2 profiles at 90cm SSD, 10cm deep, revealed a reduction in the dose horns of 4% in comparison to the measured profile (Figure 1).

**Results 2:**

The agreement between calculated and measured 40x40cm2 profiles at 90cm SSD, 10cm deep was best for an incident electron beam with a mean energy of 6.2MeV. The resultant CAX 10x10cm2 PDD revealed an agreement to within 1% (between 5-25cm) of the measured PDD.

Figure 1. Comparison of profiles for the mean electron energy determined using both methods.