Conclusion: Raystation fallback planning is an advanced feature that allows switching patient plans between alternative treatment machines and techniques. This could be useful to reduce impact of machine downtime on patient treatments. However, this process could introduce potential risks as distinct TPS and beam deliveries are involved. The results presented here show that a difference between calculated HT and mimicked RS fallback plans match the measured differences found throughout the end-to-end tests. Results based on a 5%/5mm tolerance show that we can expect at most 0.3% agreement from the difference between original and fallback plans displayed by the RS TPS. Further work will involve the study of clinical plans on various tumors sites.

EP-1585
PRIMO software as a tool for Monte Carlo treatment quality control in IMRT: a preliminary study
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Purpose or Objective: Monte Carlo (MC) approach is considered the gold standard method to perform absorbed dose calculations in external radiotherapy[1], because it provides the most detailed and complete description of radiation fields and particle transport in tissues. Several codes are available and recently a new MC Penelope based code and graphic platform named PRIMO was developed [2]. PRIMO has a user-friendly approach, a suitable and competitive characteristic for clinical activity. Nevertheless, advanced features such as IMRT are not introduced yet. This work is a preliminary study for the PRIMO software as a tool for MC based quality control of IMRT treatment.

Material and Methods: The simulated beam parameters of a Varian CLINAC 2300 were adjusted based on measurements in a water tank for 6 MeV energy and 10x10 cm² field. The water tank was divided in 81x81x155 voxels with dimensions of 2x2x2 mm³. The Gamma Function (GF) was used for agreement assessment and a phase-space was obtained above the MLC. A solid water phantom with a PTW OCTAVIUS® 729 2D ionization chamber array inserted was imaged by a CT scan and used in PRIMO. A dynamic IMRT plan was calculated by the Eclipse™ TPS and irradiated. The LINAC Dynalog files were analysed and the dynamic delivery was divided into series of static fields in PRIMO. MATLAB was used to analyse the PRIMO output and to create images of dose distributions at specific locations. The simulated dose at the ion chamber matrix position in the phantom was compared with the matrix measurement using the 2D GF through the PTW Verisoft program.

Results: The best agreement for the beam parameters of the LINAC numerical model was obtained with initial electron energy of 5.9±0.2 MeV and beam divergence of 1.5°. The gamma function analysis (2%, 2mm) showed that 97% of the points was lower than 1, confirming the good agreement with the experimental data. For the IMRT plan, the measured and simulated dose distributions at the ion chamber matrix (fig 1A-B) show good agreement, as the gamma points lower than 1 were 96% (fig 1C).

EP-1586
Characterization of a new EPID-based system for in vivo dosimetry in VMAT treatments
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Purpose or Objective: The aim of this paper is to evaluate the EPID detector sensitivity and specificity for in vivo dosimetry of VMAT treatments to identify dosimetric and geometric errors and anatomical variations.

Material and Methods: Measurements were performed by using TrueBeam STx accelerator equipped with EPID aS1000 (Varian, Palo Alto, CA) and PerFracion (PF) software (Sun Nuclear Corporation, Melbourne, FL). PF is a commercial EPID-based dosimetry software, which allows performing transit dosimetry, to provide an independent daily verification of the treatment. Performance of the EPID detector and of the PF software on anthropomorphic phantom was studied, simulating 17 perturbations of the reference VMAT plan. Systematic variations in dose values (1%-5% output variation), shifts (2,5-11 mm in anterior direction), anatomical variations (adding bolus over phantom), and MLC positioning (locked leaf position for different arc extensions) were applied. The difference in local and global gamma pass rate (%GP) between the no-error and error-simulated measurements with 1%/1mm, 2%/2mm and 3%/3mm tolerances was calculated. The clinical impact of these errors was also analyzed through the calculation of the difference between the reference DVH and the perturbed DVH (%DE). We defined as clinically meaningful a variation higher than 3% between calculated and perturbated doses. A value of %GP equal to 95% and 90% and %DE equal to 3% were used as thresholds to calculate sensitivity and specificity.

Results: Repeatability and reproducibility of no-error measurements were excellent with %GP=100% for all gamma
methods. 1%/1mm and local normalization is able to detect all type of errors (1%/1mm with global normalization is not able to detect the systematic shift of 2.5 mm), but it could overestimate some errors that have not clinical impact. In the table, we reported the results of sensitivity and specificity of PF to detect clinically relevant errors.

<table>
<thead>
<tr>
<th>%GP&gt;95%</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>γ-local</td>
<td>0.3</td>
<td>0.7</td>
</tr>
<tr>
<td>γ-global</td>
<td>0.4</td>
<td>0.7</td>
</tr>
<tr>
<td>γ-local</td>
<td>0.5</td>
<td>0.6</td>
</tr>
<tr>
<td>γ-global</td>
<td>0.5</td>
<td>0.6</td>
</tr>
<tr>
<td>γ-local</td>
<td>1.0</td>
<td>0.2</td>
</tr>
<tr>
<td>γ-global</td>
<td>0.9</td>
<td>0.3</td>
</tr>
<tr>
<td>γ-local</td>
<td>0.1</td>
<td>1.0</td>
</tr>
<tr>
<td>γ-global</td>
<td>0.1</td>
<td>1.0</td>
</tr>
<tr>
<td>γ-local</td>
<td>0.3</td>
<td>0.9</td>
</tr>
<tr>
<td>γ-global</td>
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</tr>
<tr>
<td>γ-local</td>
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<td>0.5</td>
</tr>
<tr>
<td>γ-global</td>
<td>0.7</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Conclusion: EPID device and PF software can be confidently used in clinical routine to detect dosimetric, geometrical and anatomical discrepancies. The possibility of this in vivo evaluation and the potentiality of this new system have a very positive impact on improving daily patient QA.

**EP-1587**

**Sensitivity and specificity of gamma index method for Tomotherapy plans.**

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**Purpose or Objective:** The aim of this work is to evaluate the perturbed DVHs generated from Tomotherapy dose distributions according to the dose discrepancies detected with pre-treatment measurements. Through perturbed DVHs data, sensitivity and specificity of gamma passing rate (%GP) were calculated to evaluate if Gamma Index (GI) metric correctly differentiates the high dose error plans from low dose error plans. In the literature GI was found to be a poor predictor of dosimetric accuracy with planar and volumetric dosimeters for IMRT and VMAT techniques, we evaluate if this lack of prediction of GI method is valid also for Tomotherapy plans.

**Material and Methods:** 12 patients for prostate cancer (P), and 12 for head and neck (HN) cancer, were enrolled in the study. All the treatments were delivered using the Helical Tomotherapy Hi-ART system (Accuray, Inc., Sunnyvale, CA). Pre-treatment QA measurements were performed by using the diode array ArcCHECKTM and perturbed DVHs were obtained with the 3DVH software (both by Sun Nuclear Corporation, Melbourne, FL). Measured and calculated dose distributions were compared using the global and local GI method with 2%/2 mm, and 3%/3 mm criteria. Low-dose thresholds (TH) of 10% and 30% were applied and analyzed. Percentage dose differences between the dose discrepancies detected with pre-treatment measurements. Through perturbed DVHs data, sensitivity and specificity of gamma passing rate (%GP) were calculated to evaluate if Gamma Index (GI) metric correctly differentiates the high dose error plans from low dose error plans. In the literature GI was found to be a poor predictor of dosimetric accuracy with planar and volumetric dosimeters for IMRT and VMAT techniques, we evaluate if this lack of prediction of GI method is valid also for Tomotherapy plans.

**Results:** We found the higher sensitivity (0.55) for global normalization with 3%/3mm and TH=30% and the higher specificity (0.67) with 3%/3mm for global normalization, both for TH 10% and 30%. Instead we obtained the poorer sensitivity (0) with 2%/2mm, local normalization, and TH=10% because the threshold of 95% is too high for 2%/2mm and local normalization. We observed the poorer specificity (0.39) for 3%/3mm, local normalization, both for TH-10% and 30%. For global normalization, 3%/3mm sensitivity and specificity were always higher than those of 2%/2mm criterion.

**Conclusion:** The low sensitivity and specificity values of GI method, for all the applied criteria, show that the gamma index metric have disputable predictive power for per-patient Tomotherapy QA.

**EP-1588**

**A methodology for deriving clinically indicative gamma index acceptance criteria.**

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**Purpose or Objective:** The gamma index (γ) is a common method for comparing measured and predicted dose distributions. The percentage of points passing with γ<1 (Γ) is the most frequently reported analysis metric. However, the use of Γ has been reported to have weak correlation against clinically relevant metrics and the result also varies depending on the Quality Assurance (QA) system configuration and software used. Other metrics could be extracted from the γ map but have not been rigorously evaluated in the literature to address appropriate acceptance values. This study has developed a methodology to evaluate the suitability of the mean, median, maximum, or near maximum γ metrics (ymean, ymedian, ymax, y1%) and their acceptance criteria.

**Material and Methods:** Investigations were performed using simulated data with deliberate changes created in a virtual phantom test. The changes included: dose deviations of -5% to 5% in 1% steps; and MLC offsets of 1-5mm in 1mm steps. An in-house Matlab-based software was used to perform γ analysis to extract different metrics. The primary PTV mean (PTVmean) and organ at risk maximum (OARmax) dose deviations were extracted from the changed plans. The γ metrics were correlated against PTVmean and OARmax for global γ passing criteria of 3%/2mm (20% threshold relative to a point in high dose low gradient). Acceptance criteria needed to predict a dose deviation >3%, for 3%/2mm, were assessed using Receiver Operator Characteristic (ROC) analysis and assuming 100% sensitivity. The area under the ROC curve (AUC) was assessed for each γ metric to assess statistical reliability. Since the γ calculation can give varying results between different QA systems, the robustness of the proposed methodology was tested by varying γ passing criteria as well calculating in 2D planes and 3D volumes.

**Results:** The ymean, ymedian and y1% metrics had the strongest Pearson correlation coefficient (p) against the PTVmean (p<0.05, p<0.01); (Fig. 1). The Γ had a weaker correlation of p=0.76. These metrics had ROC AUC=0.9 (p=0.01) showing statistically strong accuracy for predicting a PTVmean deviation >3% for 3%/2mm. Optimal acceptance criteria for achieving 100% sensitivity are shown in Table 1. The ymax had the best correlation against OARmax (p<0.8, p<0.01) and the AUC was >0.9 and showed that points with γ>1.1 may be associated with a >3% increase in the OARmax. Correlations between different γ passing criteria were statistically strong at >0.95 (p<0.01) as were correlations between 2D & 3D γ calculations, indicating the robustness of the methodology to the variability in γ calculation that could be caused by QA system configuration and software implementation.