equally spaced beams with total of 35 segments. Step-and-shoot IMRT with minimum segment area of 5x5 cm and minimum of 10 monitor units per segment was used in each plan. Dvh and Energy plans were normalized such that 95% of the propagated PTV for each phase received the prescription dose. Once prescription was achieved, the doses to OARs, such as spinal cord, heart, esophagus, and healthy lungs were iteratively lowered until standard deviation of the dose across the PTV in each plan became less than 4%. After generating Dvh and Energy plans for each breathing phase, deformable dose accumulation to the reference breathing phase for each optimization scheme was performed. The resulting 4D Dvh and Energy plans were compared on the basis of dose indices (DIs), such as DPTV95% (dose to 95% of the PTV), DCDor1%, Desphagus50%, Dheart33%, Dlungs20%, Dlungs30%, and volume indices (VIs) such as Vlungs2000 cGy, and Vlungs3000 cGy. The differences among the DIs and the Vls were subjected to a two-tailed paired t-test to determine the statistically significant dose differences (p < 0.05). In addition, total deposited energy in the irradiated volume was assessed.

**Results:** The table summarizes statistically significant differences over all quantities. On average the DIs and the Vls from the 4D Energy optimization are lower than the indices obtained with the 4D Dvh optimization. The total energy deposited in the entire irradiated volume outside of the target was lower for all Energy optimized 4D plans with statistically significant difference of 13% as compared to the 4D Dvh plans.

**Conclusion:** In this work time-resolved treatment planning optimization schemes in NSCLC were investigated. The results reveal that 4D Energy based optimization outperforms 4D Dvh based optimization in terms of OAR sparing. For comparable target coverage 4D Energy based plans resulted in statistically significant lower OAR doses ranging from 14% to almost 50%.

### EP-1627

**Knowledge-based IMRT optimization using a model trained with VMAT plans of other setup orientations**

**Purpose or Objective:** Knowledge-based (KB) optimization reduces planning time and quality dependence on humans, yet requires specialty and efforts to develop DVH estimation models. This work applied a model configured with supine VMAT plans to KB optimization (supine & prone) to check the feasibility and dosimetric performance.

**Material and Methods:** Based on Varian RapidPlan, a VMAT model was trained and statistically validated using 81 supine rectal cancer plans of 1 full arc to cover 95% of PGT and PTV with 50.6 and 41.8 Gy respectively in 22 fractions. Without changing any geometric and beam settings (5 fields were almost symmetric but not strictly), the dynamic MLC sequences of 30 clinical IMRT plans (10 supine and 20 prone) were reoptimized using the model. Volume dose of the original plans were recalculated using the same algorithm as KB plans to avoid bias. All plans were normalized to consistent target prescriptions before comparing: 1. homogeneity index of PGT (HI_PGT) and PTV (HI_PTV); 2. conformity index of PGT (CI_PGT) and PTV (CI_PTV); 3. volume% exceeding 107% of PGT prescription (V107%, V54.14Gy); 4. Global maximum dose (Dmax) and PGTV near maximum dose (D2%); 5. mean dose and dose to 50% of the femoral head and urinary bladder (Dmean_FH and Dmean UB; D50%_FH and D50%_UB). To compare normally distributed data, paired T test (original vs. KB re-planning) and independent T-tests (supine vs. prone setups) were performed respectively, otherwise Shapiro-Wilk test and Mann-Whitney U test were performed accordingly.

**Results:** KB IMRT plans of either setups can be optimized successfully by the supine VMAT model. Under comparable target dose coverage, explicitly better dose falloff in CTV and PTV (between V45-90Gy), and much lower dose to the bladder and femoral head were observed in KB group (figure 1: mean DVHs of 30 patients). As shown in table 1, the normal organ sparing of KB was significantly superior than the original plans, however, the HI_PGT, HI_PTV, CI_PTV, and Dmax were underestimated slightly as trade-off (P<0.05). As a possible explanation, hotspots were usually segmented and suppressed specifically during manual optimization, yet was missing by KB process. V107% also appeared in KB group only (1 supine: V107%=0.03%; 5 prone: V107%=0.01, 0.08, 0.10, 1.15 and 1.76% respectively), although the difference of D2% was not significant (P=0.102). Supine VMAT model was not favourable to patients of same setup (P>0.05), however significantly higher D50% and mean dose to femoral head were observed in supine group for both original and KB plans: indicating the difference may be more attributable to setup orientations or field geometry than to KB model.

**Conclusion:** DVH estimation model configured with VMAT plans can be efficiently applied to KB optimization of IMRT plans, including patients of different setup orientations. KB IMRT reduces dose to normal organs, but the concomitant hotspots should be further processed after the automated planning.

### EP-1628

**Single-click automatic radiotherapy treatment planning for breast, prostate and vertebrae**

**Purpose or Objective:** A single-click automatic radiotherapy treatment planning system for breast, prostate, and vertebrae is presented. The system utilizes a deformable DVH estimation model configured with VMAT plans. The system is able to automatically generate IMRT plans for patients with any setup orientation and any kind of target geometry.

**Material and Methods:** The system is based on a deformable DVH estimation model configured with VMAT plans. The model is trained using a large dataset of clinical IMRT plans and is validated using a separate dataset. The system automatically generates IMRT plans for patients with any setup orientation and any kind of target geometry.

**Results:** The system was tested on a large dataset of clinical IMRT plans. The results show that the system is able to automatically generate IMRT plans for patients with any setup orientation and any kind of target geometry. The system is able to automatically generate IMRT plans with similar or better dosimetric quality compared to manual planning.

**Conclusion:** The system is a promising tool for automatic radiotherapy treatment planning for breast, prostate, and vertebrae.
Purpose or Objective: Labour-intensive procedures, such as adaptive radiotherapy and the upcoming new modalities protons and MR linac, result in an increased workload in the treatment planning department. We therefore started the FAST-planning project, a Framework for Automatic Segmentation and Treatment planning. The purpose of this project is to produce single-click automated treatment planning for the majority of tumour sites.

Material and Methods: Easy configuration of treatment protocols was achieved by isolating medical planning protocol relations from software: in-house developed XPP document format (eXtensible Planning Protocol) allows for a complete planning protocol definition in a single document (XML). In FAST planning, the patient ID, dicom identifiers and the selected planning protocol are combined, and an Autoplan document (XML) is composed.

In the framework, each module accepts Autoplan documents and coordinates actions accordingly; e.g. automatic localization of the patient record, import of DICOM objects with delineated target volumes, auto-segmentation of OARs, creation of additional ROIs, creation of advanced beam-setups (VMAT, IMRT), optimization and finally the creation of a report (optionally uploaded to R&E MOSAIQ). The software is written in Python and makes use of Pinnacle3 scripting and transfer protocols DICOM and XML over HTTP. Schemas are used for validation of all XML documents.

Results: The following workflow is automated: after the physician delineated the target, a single mouse-click initiates RT plan generation on our remote treatment planning system Pinnacle3. Subsequently a preview report of the generated plan is send to R&E system MOSAIQ (Fig. 1). The created RT plan is fully optimized and ready for inspection by the dosimetrist. FAST-planning has been implemented into our clinic for Breast, Prostate, and Vertebral metastases. Nine Prostate protocols (VMAT) are in place for a variety of dose-levels (51, 64.6 and 77Gy) and target definitions (boost/no-boost and inclusion of seminal vesicles). For Breast, 8 IMRT plans (variation in beam-setup and OAR definitions (boost/no-boost and inclusion of seminal vesicles)). For vertebral metastases, 2 plans (conformal fields). The automation of these treatment sites has reduced the dosimetrist’s planning time considerably (up to 2 hours per RT plan), while maintaining the same plan quality. The FAST framework is generic and allows for easy RT planning protocol configuration for the EBRT techniques VMAT, IMRT and conformal fields. The workflow automation currently covers approx. 20% of our patient throughput, i.e. 1250 RT planning sessions/year.

Conclusion: We have introduced fully automated RT planning for treatment plans Breast (in 20min), Prostate (in 20min) and palliative Vertebrae (in 7min). The automation of these treatment sites has reduced the dosimetrist’s planning time considerably (up to 2 hours per RT plan), while maintaining the same plan quality. The FAST framework is generic and allows for easy RT planning protocol configuration for the EBRT techniques VMAT, IMRT and conformal fields. The workflow automation currently covers approx. 20% of our patient throughput, i.e. 1250 RT planning sessions/year.

Material and Methods: The treated skin surface could be represented using triangle mesh modeling, the vertices being chosen as points on the treated body contour, and their 3D coordinates obtained from the CT dataset. The optimal beam direction would be parallel to the vector sum of all normal vectors to the defined triangles. For each triangle, the normal vector can be obtained by the cross product of two vectors formed by the triangle vertices. Gantry and couch rotation angles of the electron field could then be derived from the vector sum using simple trigonometric formulation. A computer code based on these formulas was developed. The inputs required are the vertices 3D coordinates, the output being the calculated gantry and couch rotation angles. Ideally, using a larger number of vertices, and consequently a larger number of triangles, increases the similarity between the mesh representation and the real skin surface. For practical reasons, two software versions were generated: one using four vertices selected on the treatment planning system such that they are located on the periphery of the treated skin, and the other using nine points selected on the periphery and evenly distributed within the treated skin. Results were compared for fifteen treatment plans and the root-mean-square deviation being 1.28° for couch rotation angles and 1.9° for gantry angles. When assessed clinically on patients, the derived beam direction appeared fairly normal to the treated skin surface for all cases. A better dose distribution was obtained using the software particularly for cases with large calculated couch rotation angles.

Conclusion: This software tool is an alternative to the historically used method, is more objective and accurate, may provide a better dose distribution, and is reasonably practical using the four vertices based calculation.