| | Effect of magnetic field during | | | | Effect of real-time tumor tracking at | | | |
| | conventional delivery | | MLC tracked delivery | | 0 T | | 1.5 T | |
	Difference	p-value	Difference	p-value	Difference	p-value	Difference	p-value
GTV - $D_{98\%}$ [Gy]	−0.83 ± 0.91	0.03	−0.92 ± 0.76	0.0065	−0.04 ± 1.21	0.92	−0.12 ± 0.60	0.53
Skin - $D_{2\%}$ [Gy]	+1.29 ± 0.52	< 0.0001	+1.38 ± 0.55	< 0.0001	−0.45 ± 0.37	0.0064	−0.36 ± 0.47	0.05
Lungs - D_{mean} [Gy]	−0.09 ± 0.17	0.14	−0.15 ± 0.21	0.06	−0.26 ± 0.29	0.03	−0.32 ± 0.28	0.0083
Integral deposited energy [J]	+0.09 ± 1.17	0.84	−0.01 ± 1.72	0.99	−2.30 ± 2.80	0.07	−2.40 ± 2.61	0.05
Great vessels - $D_{2\%}$ [Gy]	+0.75 ± 1.58	0.19	−0.05 ± 1.73	0.91	−0.20 ± 1.02	0.56	−1.00 ± 0.98	0.02
Oesophagus - $D_{2\%}$ [Gy]	−0.58 ± 1.34	0.23	−1.15 ± 2.15	0.15	+0.52 ± 1.27	0.25	−0.04 ± 1.30	0.93
Proximal airways - $D_{2\%}$ [Gy]	−0.06 ± 0.90	0.83	−0.87 ± 1.85	0.20	+0.58 ± 1.09	0.15	−0.23 ± 0.89	0.46
Ribs - $D_{2\%}$ [Gy]	−0.57 ± 0.87	0.08	−0.63 ± 1.39	0.21	−0.71 ± 0.83	0.03	−0.77 ± 1.52	0.17
Skin - D_{mean} [Gy]	+0.10 ± 0.03	< 0.0001	+0.09 ± 0.03	< 0.0001	−0.05 ± 0.04	0.0054	−0.05 ± 0.04	0.007
Spinal cord - $D_{2\%}$ [Gy]	−0.50 ± 1.84	0.44	−0.11 ± 0.33	0.81	−0.50 ± 0.89	0.13	−0.11 ± 0.53	0.53

Changes with standard deviation in the evaluated dose-volume metrics and integral deposited energy due to either the presence of a 1.5 T magnetic field or real-time MLC tumor tracking, averaged over the entire patient cohort. Statistically significant differences are denoted by red font. The changes of the four primary endpoints are shown at the top of this table and were evaluated at a significance level of p = 0.0125. The differences in the dose-volume metrics investigated in an exploratory analysis are presented in the bottom and were evaluated at p = 0.05.
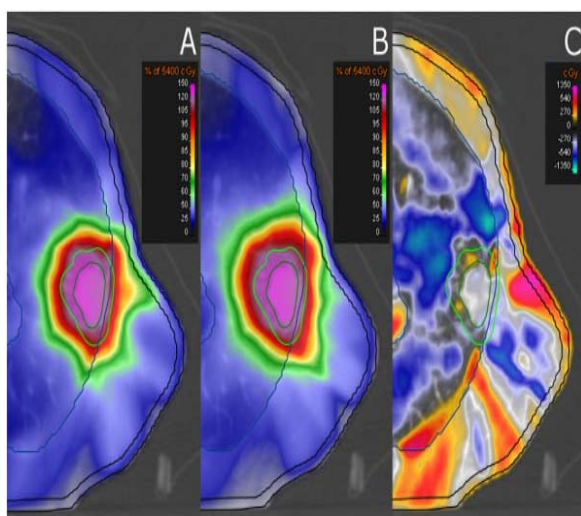
Transversal CT slice of a lung cancer patient. Overlaid are (A) the simulated dose delivered with a 1.5 T magnetic field present, (B) the simulated dose delivered without a magnetic field and (C) the local dose difference. The GTV is contoured in dark green, while the PTV is contoured in light green, the lung in blue and the skin in black.

Conclusion: This study has shown that accounting for the effects of the magnetic field during treatment planning allows for design of clinically acceptable lung SBRT treatments with a MR-linac. Furthermore, it was found that the ability of real-time tumor tracking to decrease dose exposure to healthy tissue was not degraded by a magnetic field.

OC-0550
Investigation of magnetic field effects for the treatment planning of lung cancer
O. Schrenk[1,2], C.K. Spindeldreier[1,2], A. Pfaffenberger[1,2]
[1]German Cancer Research Center, Medical Physics in Radiation Oncology, Heidelberg, Germany
[2]Heidelberg Institute for Radiation Oncology HIRO, National Center for Radiation Research in Oncology, Heidelberg, Germany

Purpose or Objective: Combining the capabilities of high resolution soft tissue MR imaging and intensity modulated radiation therapy into a hybrid device has the potential to increase the accuracy of radiotherapy. However, it is known that the magnetic field of the MR manipulates the trajectory of the secondary electrons and leads to a deviation of dose especially at the interfaces between high and low density materials. This study aims to introduce a routine for the evaluation of magnetic field effects to dose delivery and plan optimization using Monte Carlo simulations.

Material and Methods: An EGSnrc Monte Carlo environment, based on the egs++ class library, was developed which can be used for the simulation of IMRT treatment plans in the presence of a magnetic field, based on patient CT data. A routine for the processing of treatment planning parameters

and Monte Carlo simulation data was implemented into the in-house open source treatment planning system matRad. In order to basically validate the implementation, dose distributions at 0 T were compared against collapsed cone calculations by the treatment planning system RayStation. The effect of a magnetic field to the dose distribution was investigated for simulations in a porcine lung phantom. Based on Monte Carlo simulations of patient specific beamlets, plan optimization was performed and analyzed.

Results: Comparison showed that the Monte Carlo simulations of IMRT plans at 0 T are in good agreement with RayStation dose calculations. The effect of a 1.5 T lateral magnetic field on the dose distribution showed distinct alteration in tumor dose. Differences appear to be less when an opposing field technique is used. It could further be proven that the routine is capable of performing plan optimization based on Monte Carlo simulated beamlets in the presence of a magnetic field (see figure 1).
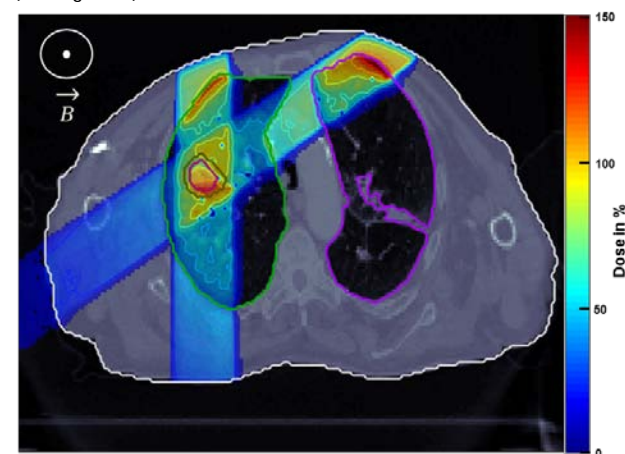

Figure 1: A simplified example of the forward simulation of unmodulated Monte Carlo beamlets in the presence of a lateral 1.5 T magnetic field. Dose hot spots (electron return effect, cf. Raaijkmakers, 2005) are evident at tissue lung interfaces and the tumor boundary.

Conclusion: A routine for dose calculation of IMRT plans with EGSnrc and for plan optimization based on Monte Carlo simulated beamlets using the in-house planning system matRad was developed. This implementation provides the possibility to analyze the effects of a magnetic field during radiotherapy in detail. Additionally it enables the investigation of optimization strategies for an MRI-LINAC system.

OC-0551
Advantage of IMPT over IMRT in treatment of gynaecological cancer with para-aortic nodal involvement
M. Van de Sande[1], C.L. Creutzberg[1], S. Van de Water[2], A.W. Sharfo[2], M.S. Hoogeman[2]
[1]Leiden University Medical Center LUMC, Radiation Oncology, Leiden, The Netherlands
[2]Erasmus MC Cancer Institute, Radiation Oncology, Rotterdam, The Netherlands

Purpose or Objective: High costs and limited capacity in proton therapy requires prioritizing according to expected benefit. The aim of this work is to quantify the clinical advantage of robust intensity-modulated proton therapy (IMPT) in terms of sparing of organs at risk (OARs) for three target volumes in treatment of gynaecological cancers compared with state-of-the-art intensity-modulated photon therapy (IMRT), and to evaluate for which target volume the benefit would justify the use of IMPT.

Material and Methods: Three target volumes were included: pelvic region (primary or postoperative treatment; N=10, 6 with boost dose), pelvic and para-aortic region (N=6, all with