Figure shows the absolute change in the $D_{mean}$ for the anal sphincter (left $y$-axis) and relative change in the $V_{450}$ for the rectal wall (right $y$-axis) expressed as a function of the relative increase in the homogeneity index $HI$ of the dose distribution in the PTV. The mean, the integral, and the coverage doses, as well as the MUs to the OAR and the PTV from DVH- and energy-optimized 2- and 3-beam plans are summarized in the table below. For comparable PTV coverage, the energy optimized plan in the 2-beam case results in lower OAR dose by 6.6%, while the deposited energy to the OAR is lower by 18.5%. Similarly, in the 3-beam scenario the energy optimized plan results in mean and integral dose reduction to the OAR by 9.8% and 26% respectively. The plan MUs in the 2- and 3-beam scenarios differ by less than 2%.

**Materials and Methods**: A DVH-based quadratic objective function is compared to a total energy minimization objective function. A digital phantom-patient. The phantom is built from four 10x10x10 cm$^3$ cubical volumes of interest (VOIs). The central VOI has a density of 1.0 g/cm$^3$ and includes a cylindrical (3 cm in diameter, 3 cm in length) target (PTV). The other three VOIs (on top and two sides of the central cube) an organ at risk (OAR) with three different densities: 0.8 (OAR$_{0.2}$), 0.2 (OAR$_{0.5}$), and 0.5 (OAR$_{0.8}$) g/cm$^3$. Two sets of deliverable plans are generated with DVH and energy-based optimization schemes: a) a 2-beam plan with 2 IMRT segments, and b) a 3-beam plan with 3 IMRT segments. In the 2-beam plan the PTV is irradiated with an AP beam through OAR$_{0.8}$ and an orthogonal beam through OAR$_{0.2}$. In the 3-beam plan an additional orthogonal beam through OAR$_{0.5}$ is added. DVH and energy optimizations were performed for both sets of plans, aiming to deliver a 100 cGy to 95% of the PTV, while minimizing the dose to the OAR as much as possible.

**Results**: The mean, the integral, and the coverage doses, as well as the MUs to the OAR and the PTV from DVH- and energy-optimized 2- and 3-beam plans are summarized in the table below. For comparable PTV coverage, the energy optimized plan in the 2-beam case results in lower OAR dose by 6.6%, while the deposited energy to the OAR is lower by 18.5%. Similarly, in the 3-beam scenario the energy optimized plan results in mean and integral dose reduction to the OAR by 9.8% and 26% respectively. The plan MUs in the 2- and 3-beam scenarios differ by less than 2%.

**Materials and Methods**: A DVH-based quadratic objective function is compared to a total energy minimization objective function. A digital phantom-patient. The phantom is built from four 10x10x10 cm$^3$ cubical volumes of interest (VOIs). The central VOI has a density of 1.0 g/cm$^3$ and includes a cylindrical (3 cm in diameter, 3 cm in length) target (PTV). The other three VOIs (on top and two sides of the central cube) an organ at risk (OAR) with three different densities: 0.8 (OAR$_{0.2}$), 0.2 (OAR$_{0.5}$), and 0.5 (OAR$_{0.8}$) g/cm$^3$. Two sets of deliverable plans are generated with DVH and energy-based optimization schemes: a) a 2-beam plan with 2 IMRT segments, and b) a 3-beam plan with 3 IMRT segments. In the 2-beam plan the PTV is irradiated with an AP beam through OAR$_{0.8}$ and an orthogonal beam through OAR$_{0.2}$. In the 3-beam plan an additional orthogonal beam through OAR$_{0.5}$ is added. DVH and energy optimizations were performed for both sets of plans, aiming to deliver a 100 cGy to 95% of the PTV, while minimizing the dose to the OAR as much as possible.

**Results**: The mean, the integral, and the coverage doses, as well as the MUs to the OAR and the PTV from DVH- and energy-optimized 2- and 3-beam plans are summarized in the table below. For comparable PTV coverage, the energy optimized plan in the 2-beam case results in lower OAR dose by 6.6%, while the deposited energy to the OAR is lower by 18.5%. Similarly, in the 3-beam scenario the energy optimized plan results in mean and integral dose reduction to the OAR by 9.8% and 26% respectively. The plan MUs in the 2- and 3-beam scenarios differ by less than 2%.

**Materials and Methods**: A DVH-based quadratic objective function is compared to a total energy minimization objective function. A digital phantom-patient. The phantom is built from four 10x10x10 cm$^3$ cubical volumes of interest (VOIs). The central VOI has a density of 1.0 g/cm$^3$ and includes a cylindrical (3 cm in diameter, 3 cm in length) target (PTV). The other three VOIs (on top and two sides of the central cube) an organ at risk (OAR) with three different densities: 0.8 (OAR$_{0.2}$), 0.2 (OAR$_{0.5}$), and 0.5 (OAR$_{0.8}$) g/cm$^3$. Two sets of deliverable plans are generated with DVH and energy-based optimization schemes: a) a 2-beam plan with 2 IMRT segments, and b) a 3-beam plan with 3 IMRT segments. In the 2-beam plan the PTV is irradiated with an AP beam through OAR$_{0.8}$ and an orthogonal beam through OAR$_{0.2}$. In the 3-beam plan an additional orthogonal beam through OAR$_{0.5}$ is added. DVH and energy optimizations were performed for both sets of plans, aiming to deliver a 100 cGy to 95% of the PTV, while minimizing the dose to the OAR as much as possible.

**Results**: The mean, the integral, and the coverage doses, as well as the MUs to the OAR and the PTV from DVH- and energy-optimized 2- and 3-beam plans are summarized in the table below. For comparable PTV coverage, the energy optimized plan in the 2-beam case results in lower OAR dose by 6.6%, while the deposited energy to the OAR is lower by 18.5%. Similarly, in the 3-beam scenario the energy optimized plan results in mean and integral dose reduction to the OAR by 9.8% and 26% respectively. The plan MUs in the 2- and 3-beam scenarios differ by less than 2%.