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## 1 Shape Optimization of a Photo Gun

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### 1.1 Current approach with a $C^\infty$ NURBS

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- original geometry and electrode boundary in Figure 1
- inside of the electrode is discretized as well, to compute the volume constraint, see Figure 2

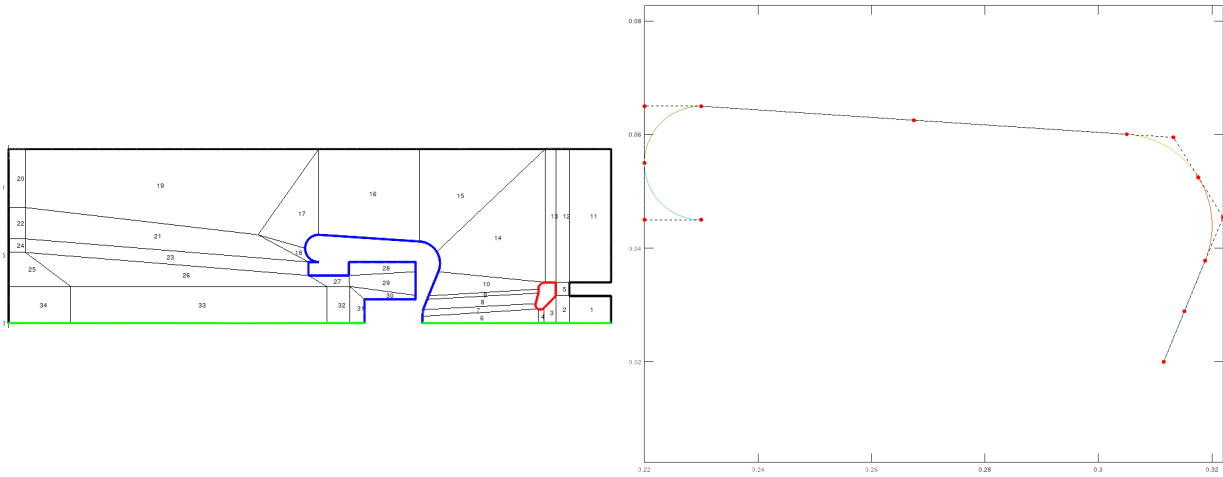


Figure 1: Original geometry and electrode boundary.

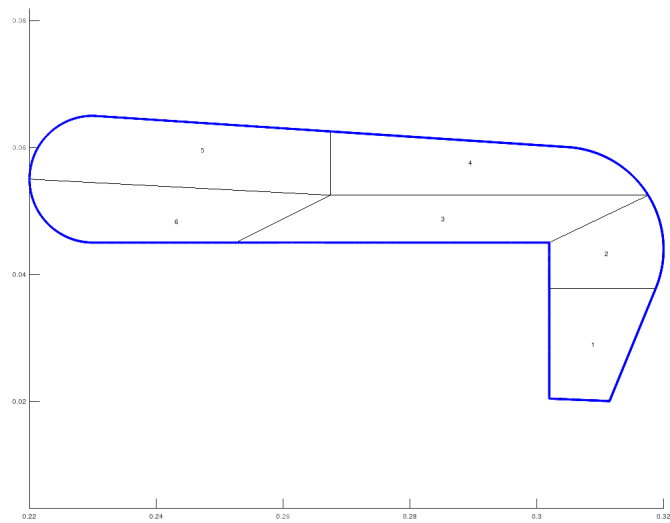


Figure 2: Discretization of the electrode.

- initial NURBS is formed by taking a subset of the control points of the original boundary, see Figure 3
- patch boundaries are chosen by finding the intersections of the original patch boundaries with the deformed NURBS (based on bisection method)
- bounds for the optimization are based on the patch boundaries (seemingly does not affect the results, since no control point is very close to any of the bounds), see Figure 4

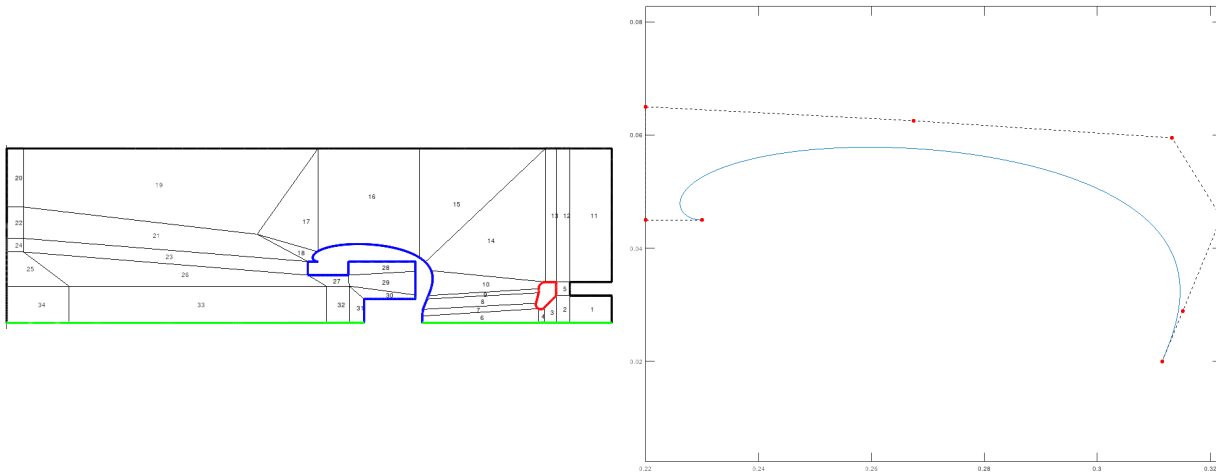


Figure 3: Initial geometry and NURBS.

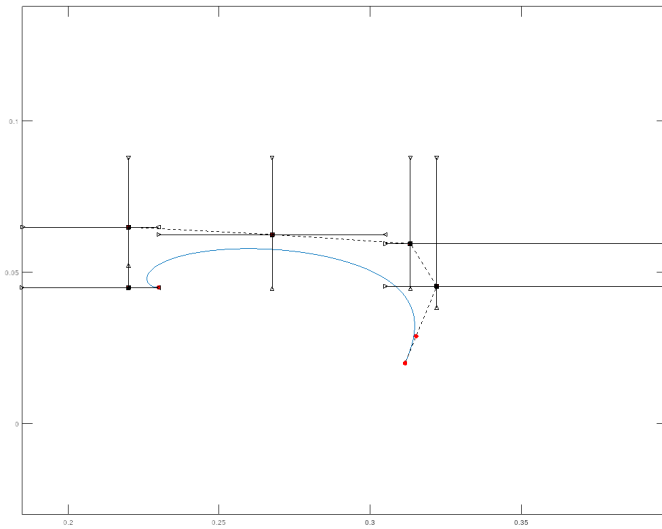


Figure 4: Bounds on the control points during the optimization.

- cost function looks at patches 14, ..., 18
- cost function for the optimization is only based on the absolute maximum, i.e.  $\max_{\mathbf{x} \in \Omega} \|\mathbf{E}(\mathbf{x})\|_2$
- optimized geometry and NURBS in Figure 5

- **results:**

	$(V_{el} - 625)$ in $\text{cm}^3$	$\max_{\mathbf{x} \in \Omega} \ \mathbf{E}(\mathbf{x})\ _2$ in $\frac{\text{MV}}{\text{m}}$ (IGA)	$\max_{\mathbf{x} \in \Omega} \ \mathbf{E}(\mathbf{x})\ _2$ in $\frac{\text{MV}}{\text{m}}$ (CST)
initial	-310.945	9.816	13.056
optimized	-69.551	6.446	9.335
- corresponding electric field (IGA) for  $p = 2$ ,  $n_{\text{sub}} = 128$ ,  $V_{el} = -300$  kV and  $V_{ar} = 1$  kV, see Figure 6
- corresponding electric field (CST) for second order tetrahedral elements, see Figure 7

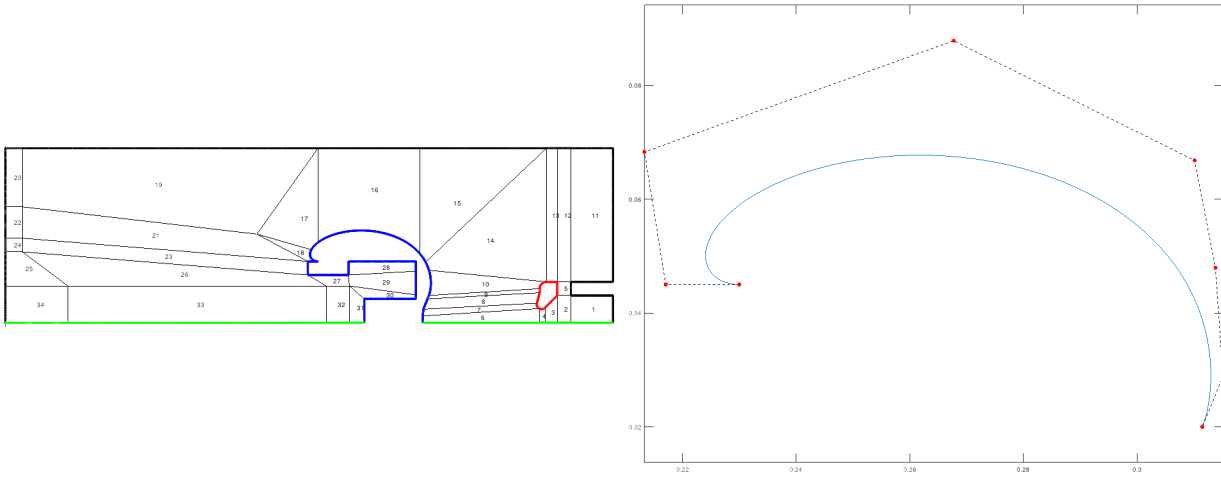


Figure 5: Optimized geometry and NURBS.

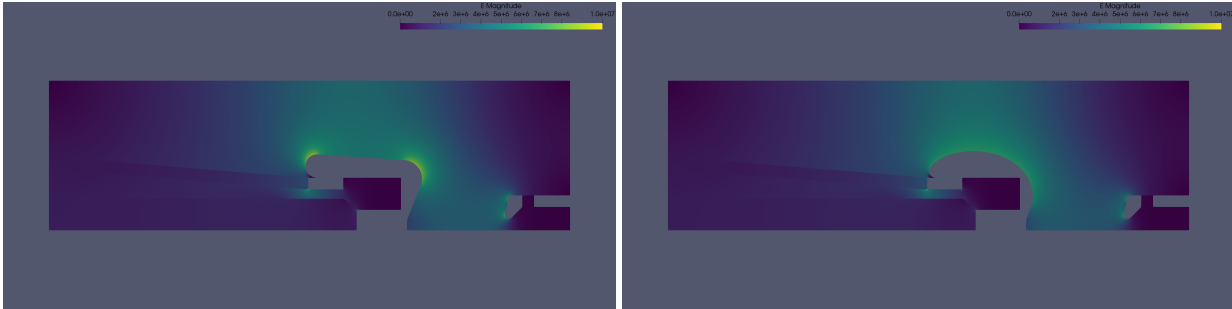


Figure 6: Electric field of original and optimized geometry computed with GeoPDEs.

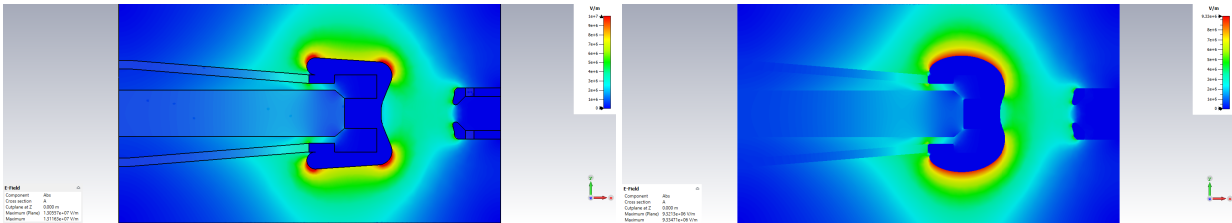


Figure 7: Electric field of original and optimized geometry computed with CST.

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## References

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- [1] Markus Wagner. “Production and investigation of pulsed electron beams at the S-DALINAC”. PhD thesis. Technische Universität Darmstadt, 2013.