# 1 Shape Optimization of a Photo Gun

## 1.1 Geometry

- latest geometry in Figure 1
- corresponding electric field for $p = 3$, $n_{\text{sub}} = 16$, $V_{\text{el}} = -300$ kV and $V_{\text{ar}} = 1$ kV
- (patches $32 \dots 35$ are not entirely correct, missing the correct high voltage adapter)

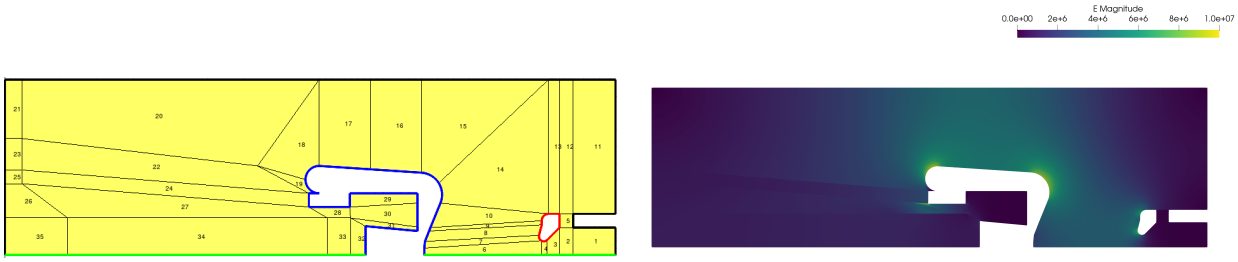


Figure 1: Initial geometry and magnitude of electric field.

## 1.2 Optimization

- optimized geometry in Figure 2
- cost function only takes into account electric field
- only the upper electrode shape is optimized (volume constraint could be kept as before at 625 $\text{cm}^3$)
- corresponding electric field for $p = 3$, $n_{\text{sub}} = 16$, $V_{\text{el}} = -300$ kV and $V_{\text{ar}} = 1$ kV
- magnitude of E-field remains large in patch 14 (also around anode ring)
- results:

| | $(V_{\text{el}} - 625)/\text{cm}^3$ | $\max(\|\mathbf{E}\|_2)/\frac{\text{MV}}{\text{m}}$ |
|---|---|---|
| initial | 2.445 | 9.295 |
| optimized | -12.872 | 8.49 |

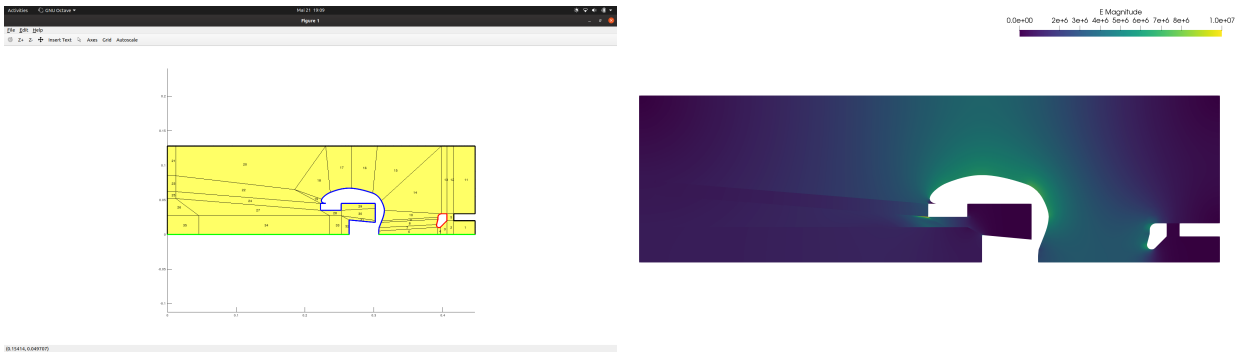


Figure 2: Optimized geometry and electric field.

## 1.3 Tracking

- general settings: $Q = 100$ fC
- spatial distribution: Gaussian with $\sigma = 400$ $\mu$m, see Figure 3 for comparison with laser measurement (probe particles at $0.5\sigma$, $\sigma$, $1.5\sigma$ in red)
- temporal distribution: Gaussian with $\sigma = 5$ ps, see Figure 4 for comparison with measurement/model from [1]

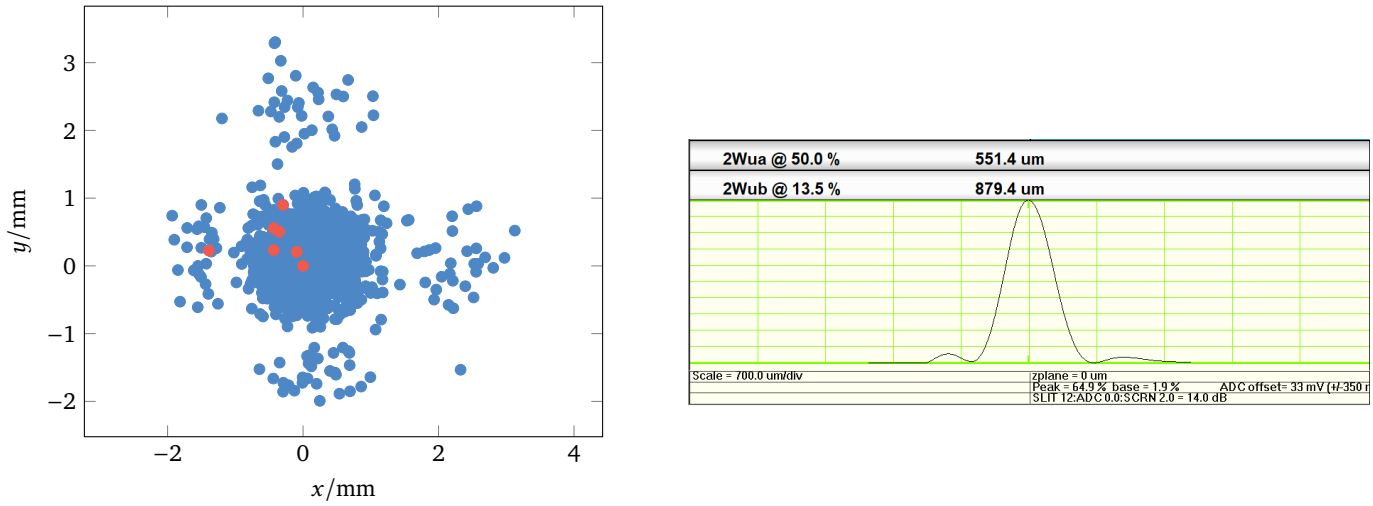


Figure 3: Spatial distribution ($2^{10}$ particles) and laser measurement.

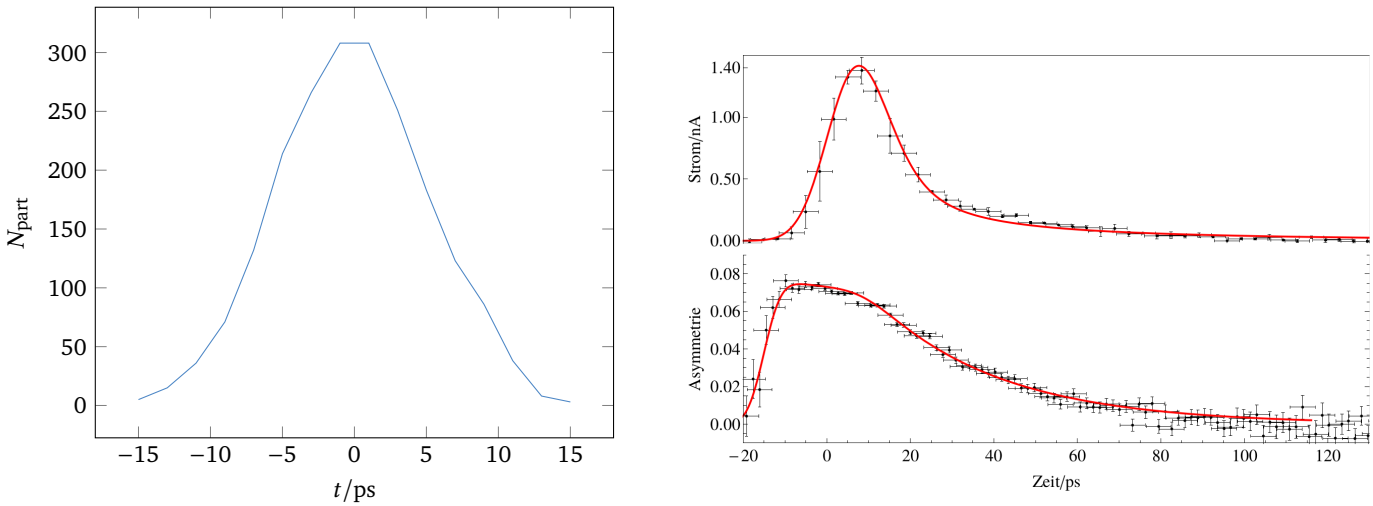


Figure 4: Temporal distribution ($2^{10}$ particles) and measurement/model.

- tracking results: $\epsilon$ and $x_{\text{rms}}$ computed with the determined settings are shown in Figure 5

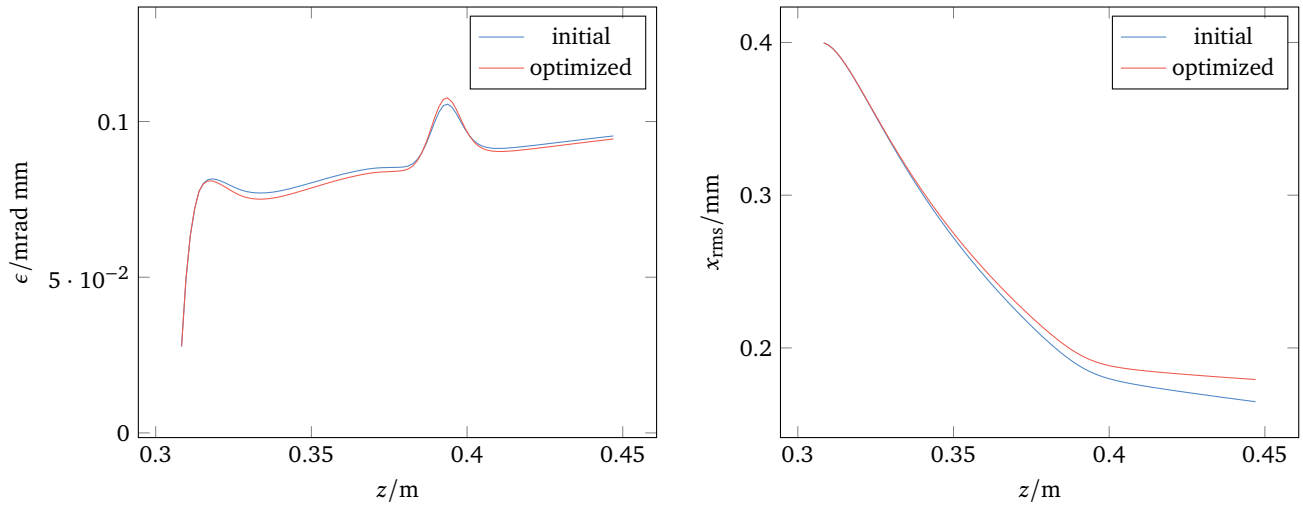


Figure 5: Normalized transverse emmitance and rms beam size.

- remarks: the convergence studies also looked at $x_{rms}$ and the behavior was very similar to that of $\epsilon$
- to minimize the electric field on the entire electrode surface all curves could be taken into account
- this includes the anode ring shape, position and voltage
- also include tracking in optimization via $x_{\mathrm{rms}} \leq 1.5$ mm, also optimize or constrain $\epsilon \leq 1$ mrad mm?

## References

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