# 1 Shape Optimization of a Photo Gun

## 1.1 Geometry

- latest geometry in Figure 1

- corresponding electric field for $p = 3$, $n_{\mathrm{sub}} = 16$, $V_{\mathrm{el}} = -300$ kV and $V_{\mathrm{ar}} = 1$ kV

- (patches 32 . . . 35 are not entirely correct, missing the correct high voltage adapter)
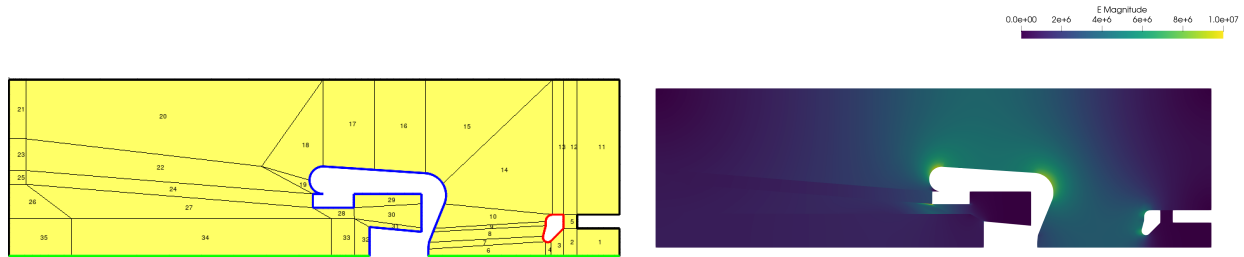


Figure 1: Initial geometry and magnitude of electric field.

## 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 cm$^3$)

- corresponding electric field for $p = 3$, $n_{\mathrm{sub}} = 16$, $V_{\mathrm{el}} = -300$ kV and $V_{\mathrm{ar}} = 1$ kV

- **magnitude of E-field remains large in patch 14** (also around anode ring)

- **results**:

|  | $(V_{\mathrm{el}} - 625)/\mathrm{cm}^3$ | $\max(\|\mathbf{E}\|_2)/\frac{\mathrm{MV}}{\mathrm{m}}$ |
|---|---|---|
| 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]
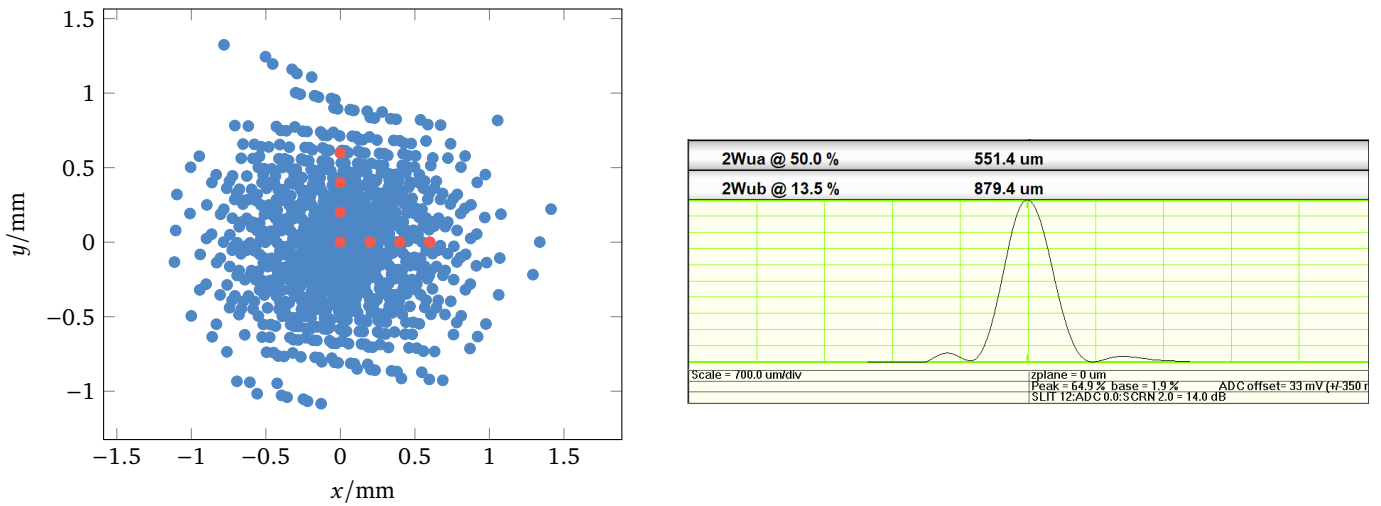


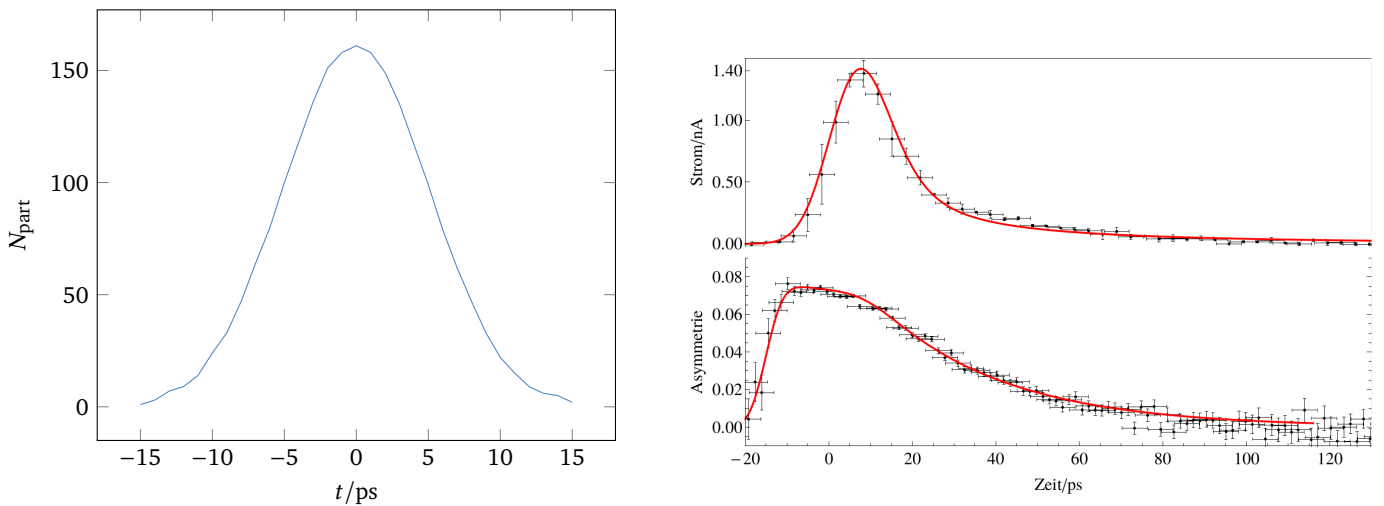Figure 3: Spatial distribution ($2^{10}$ particles) and laser measurement.



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

- **tracking results**: $\epsilon$ and $x_{\mathrm{rms}}$ computed with the determined settings are shown in Figure 10
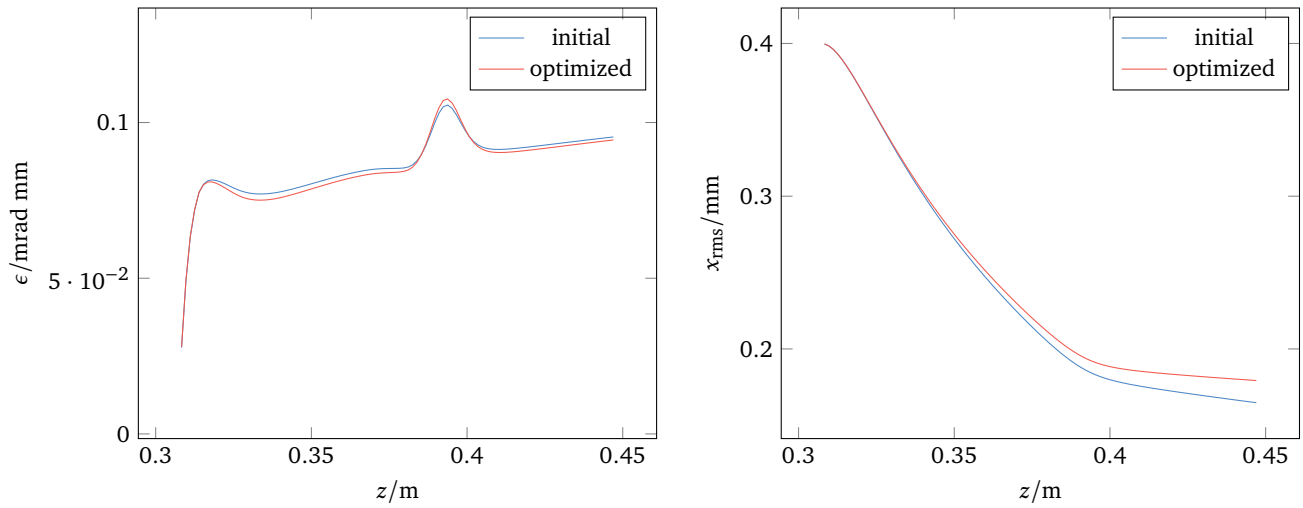
Figure 5: Normalized transverse emmitance and rms beam size.

- **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 $x_{\text{rms}} \leq 1.5$ 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.