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 . . . 35 are not correct, missing the correct high voltage adapter)

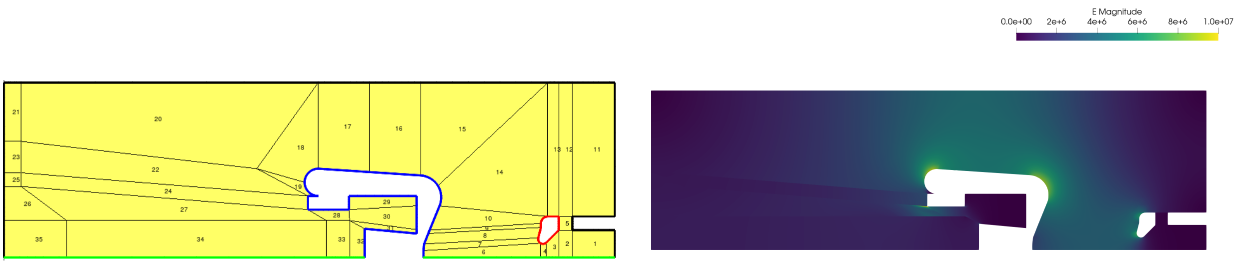

Figure 1: initial geometry and electric field

1.2 Optimization

- optimized geometry in Figure 2
- cost function only takes into account electric field
- only the upper electrode shape is optimized (volume constrained could be kept as before at 625 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**

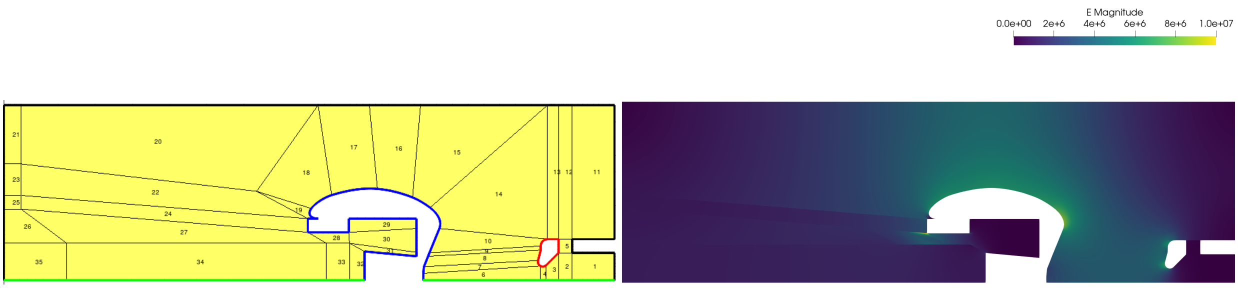

Figure 2: optimized geometry and electric field

1.3 Tracking

- **general settings**: $Q = 100$ fC, temporal bunch length $\tau_b = 30$ ps
- **initial distribution**: Gaussian with $\sigma = 400\ \mu$m, see Figure 3 for comparison with laser measurement (probe particles at 0.5σ, σ, 1.5σ in red)

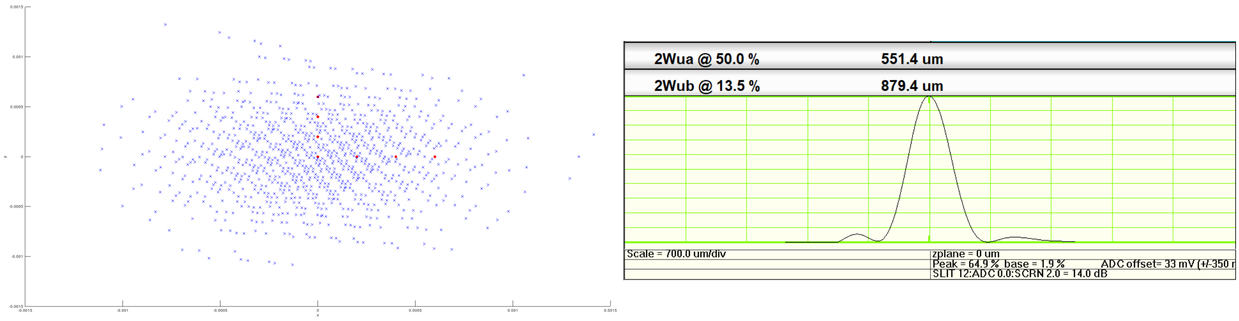

Figure 3: initial distribution (1000 particles) and laser measurement

- **convergence of time integrator**: error of normalized transversal emmitance ϵ is shown in Figure 4 ($H = 2^{-11}$ ns used later on)

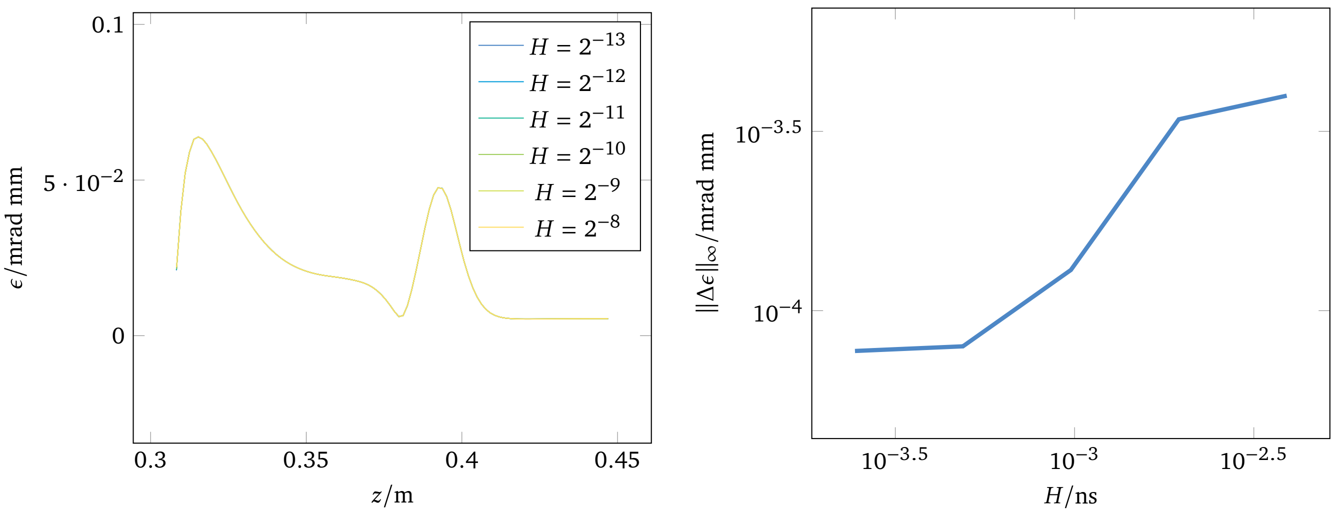

Figure 4: Normalized transversal emmitance and absolute error in l_∞-norm.

- **convergence of field map**: look at convergence in transversal n_x, n_y and longitudinal n_z direction with number of interpolation points given by 2^n
- Figure 5 looks at convergence of n_x, n_y for n_z large and fixed
- Figure 6 looks at convergence of n_z for $n_x = n_y = 4$ fixed
- $n_x = n_y = 4$ and $n_z = 6$ used later on

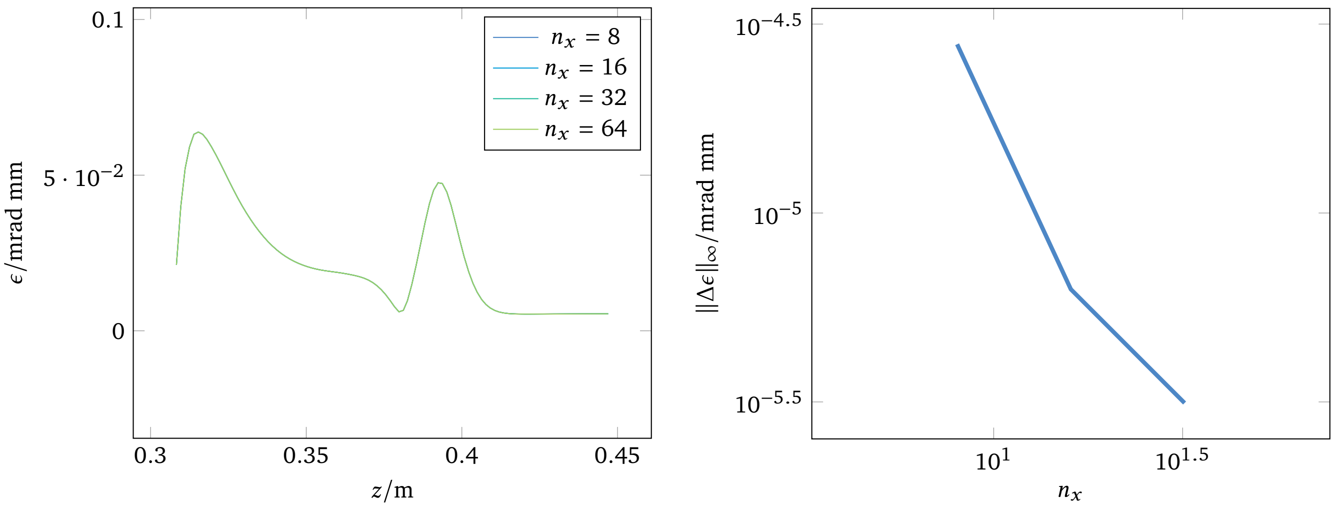

Figure 5: Normalized transversal emmitance and absolute error in l_∞-norm for $n_z = 64$ and $n_x = n_y$ variable.

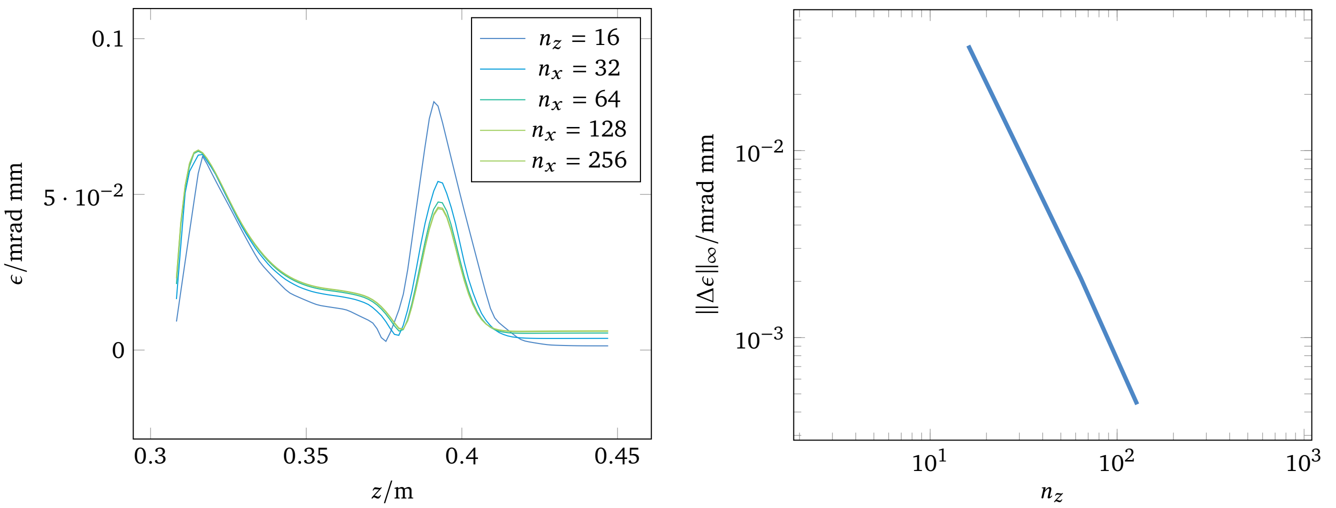

Figure 6: Normalized transversal emmitance and absolute error in l_∞-norm for n_z variable and $n_x = n_y = 16$.

- **convergence of space charge**: look at convergence of grid n_r, n_l and number of particles n_I separately with number of grid cells or particles given by 2^n
- Figure 7 looks at convergence of n_r, n_l for $n_I = 10$ large and fixed
- n_r seems to have a more profound impact, but neither seem to affect the solution too much for $n \geq 8$
- Figure 9 looks at convergence of n_I for $n_r = n_l = 4$
- $n_r = n_l = 4$ and $n_I = 10$ seem sufficient

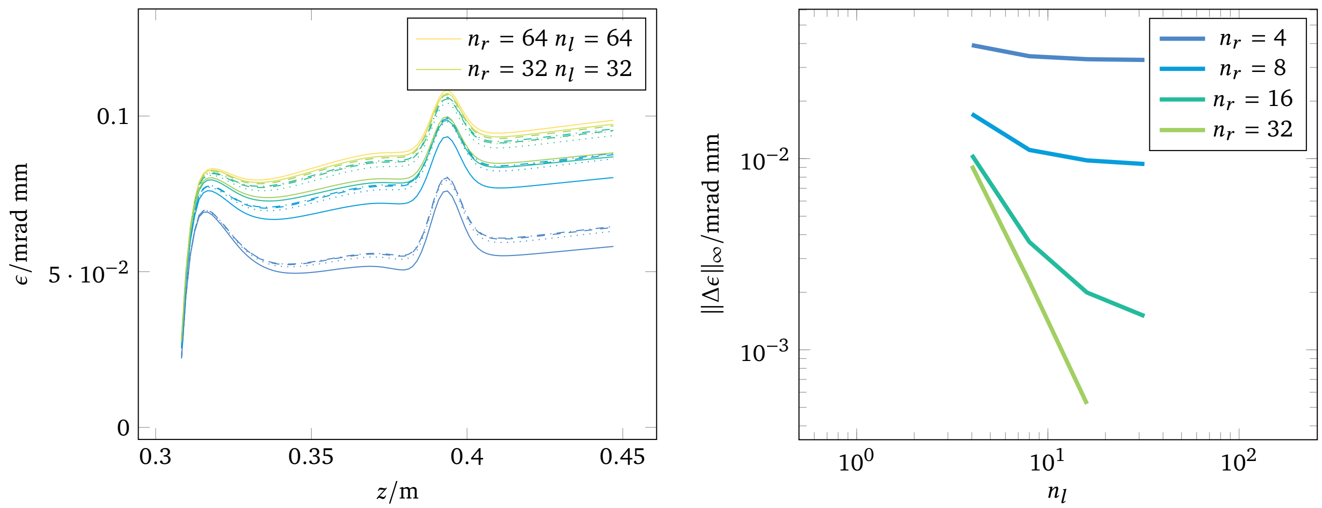

Figure 7: Normalized transversal emmitance and absolute error in l_∞-norm for $n_I = 2^{10}$ and n_l, n_r variable.

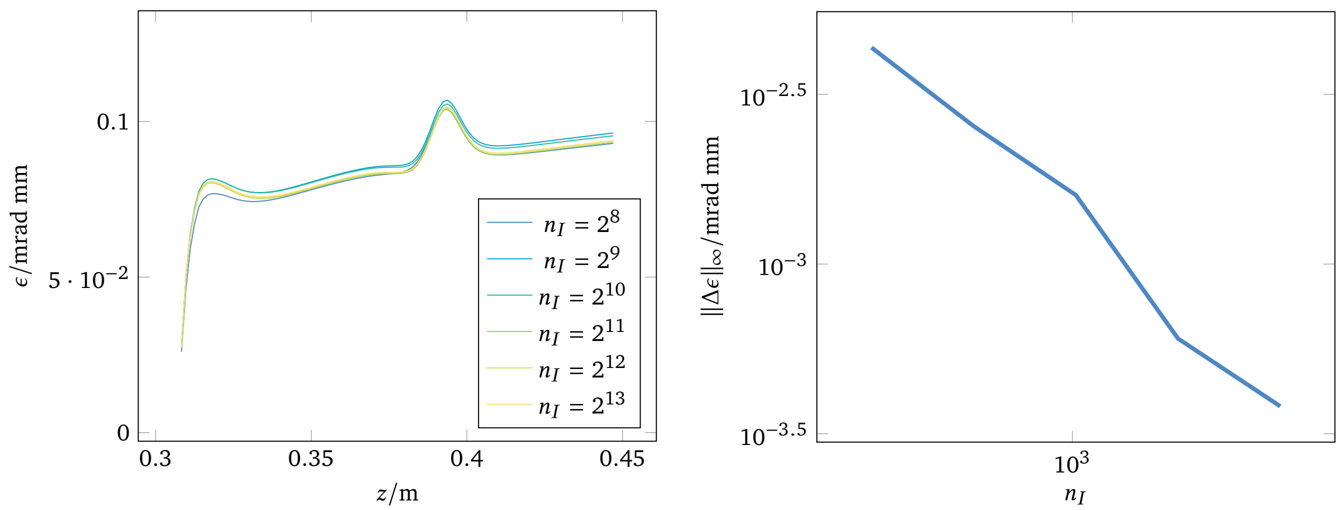

Figure 8: Normalized transversal emmitance and absolute error in l_∞-norm for n_I variable and $n_l = n_r = 16$.

TODO: include plot of initial, optimized tracking and refine plots

- **remarks**: the convergence studies also looked at x_{rms} and the behavior was almost identical to ϵ
- to minimize the electric field on the entire electrode surface all curves could be taken into account
- also anode ring shape, position and voltage
- include tracking to include constraint on $x_{\mathrm{rms}} \leq 1.5$ mm, also optimize or constrain $\epsilon \leq 1$ mrad mm?