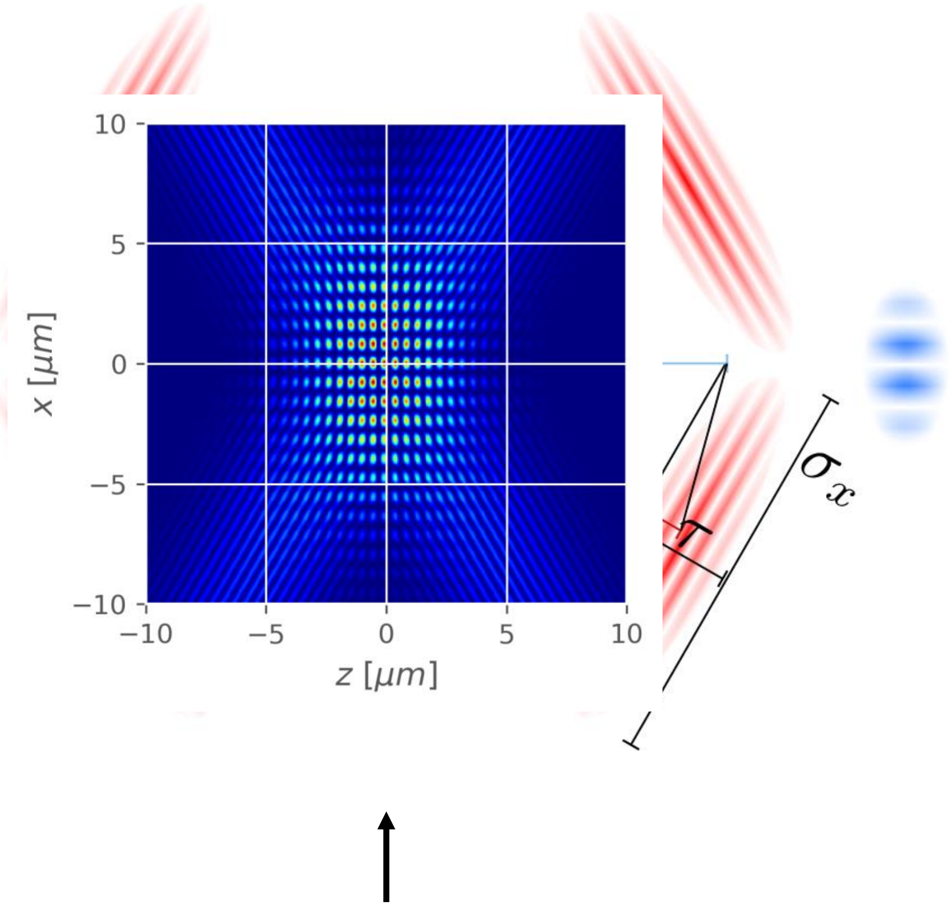
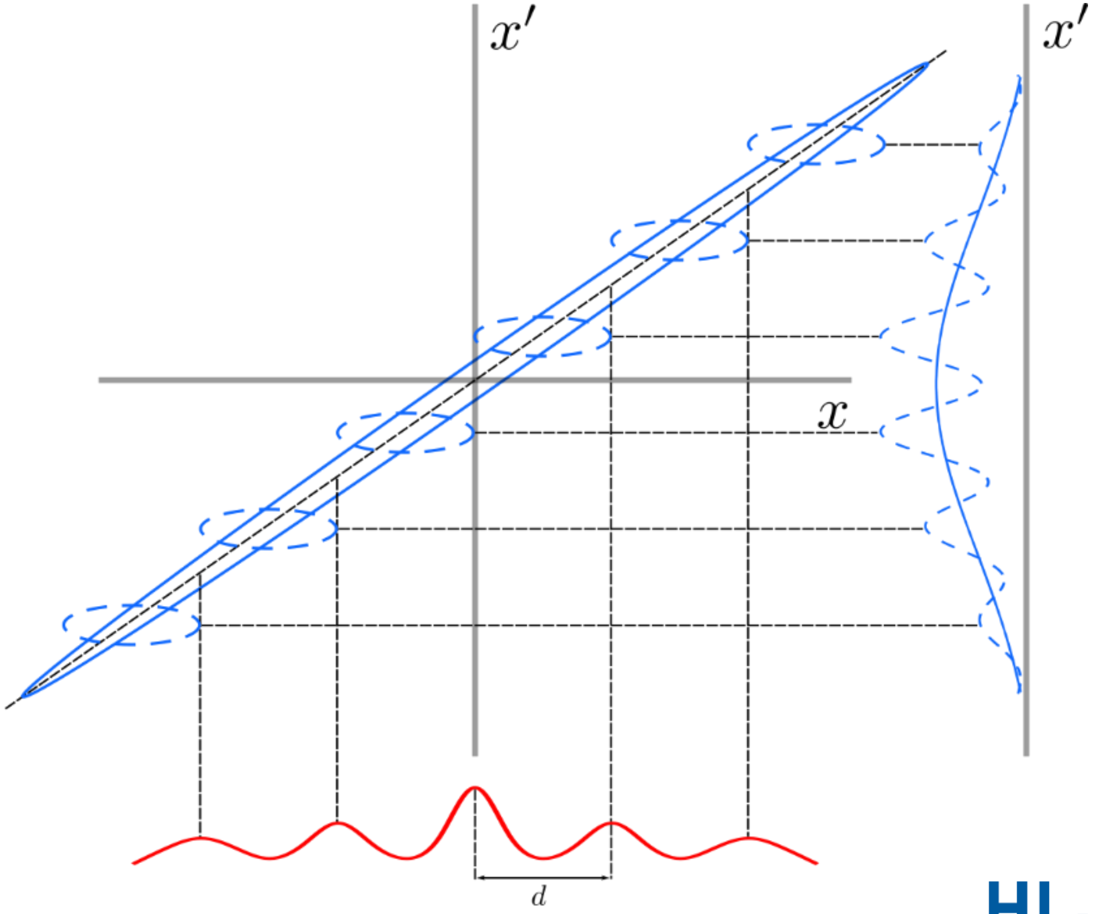
# Characterizing ultra-low emittance electron beams using structured light fields

**A. Seidel** [1,2], J. Osterhoff [3] and M. Zepf [1,2]

[1] Institut für Optik und Quantenelektronik, Friedrich-Schiller-Universität Jena
[2] Helmholtz-Institut Jena
[3] Deutsches Elektron-Synchrotron DESY

# Schematic measurement setup

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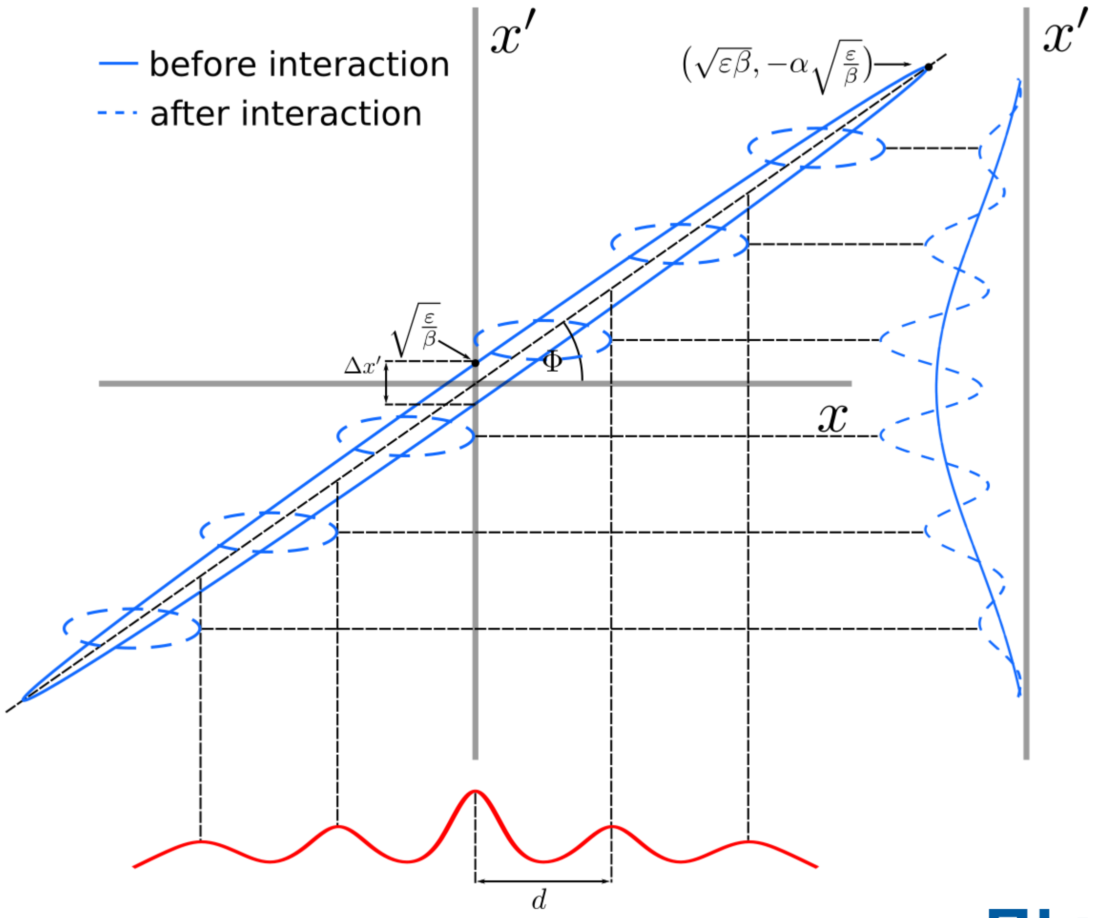
# Method theory

- $\varepsilon = \gamma x^2 + 2\alpha x x' + \beta x'^2$ [1]
- $\Delta x' = 2\sqrt{\frac{\varepsilon}{\beta(z)}}$
- $d > \frac{\Delta x'}{\tan \Phi} \approx 2\sigma_x(0)$




[1] K.Flottmann *et al., Phys. Rev. STAB* ***6*** *(2003)*

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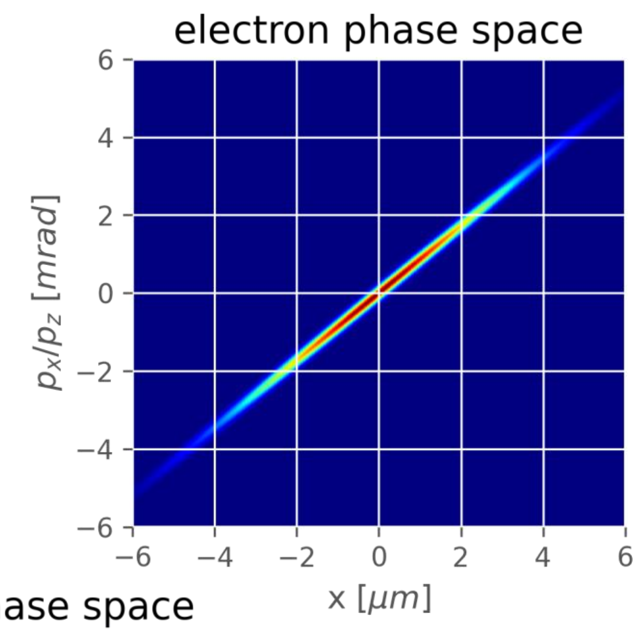
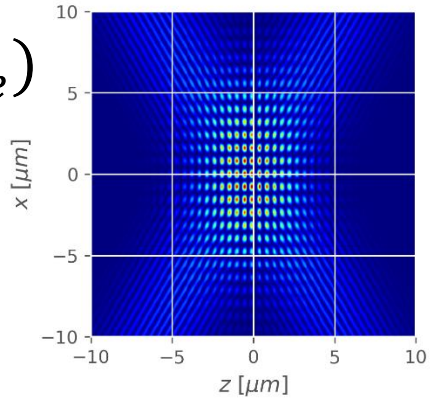
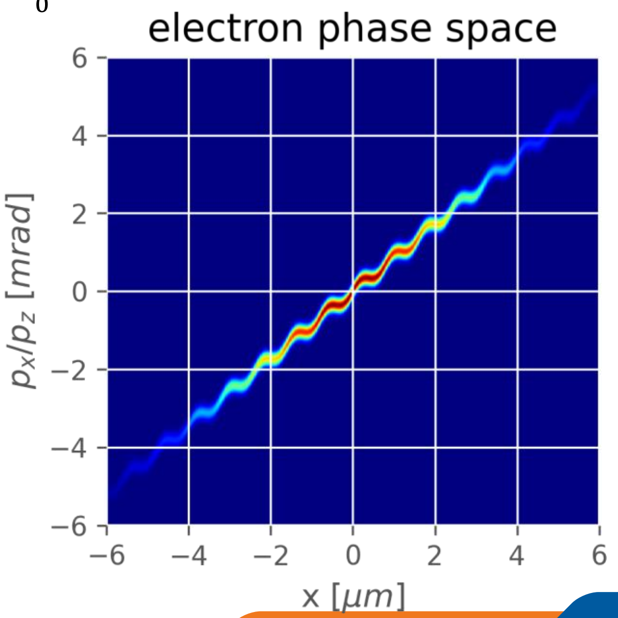
# Analytic Solution

- $n_e(x,p_x) = ne_0 \cdot \exp\left(-\frac{p_x^2}{2\sigma_{px_0}^2} - \frac{x^2}{2\sigma_{x_0}^2}\right)$
- $n_e(x,p_x) = \; ne_0 \cdot \exp\left(-\frac{p_x^2}{2\sigma_{px_0}^2} - \frac{((p_x - \Delta p_x)/(p_z \tan\Phi) - x)^2}{2\sigma_{x_0}^2}\right)$
- $\Delta p_x = \langle F_{pond} \rangle \cdot t_{int}(\gamma_e)$

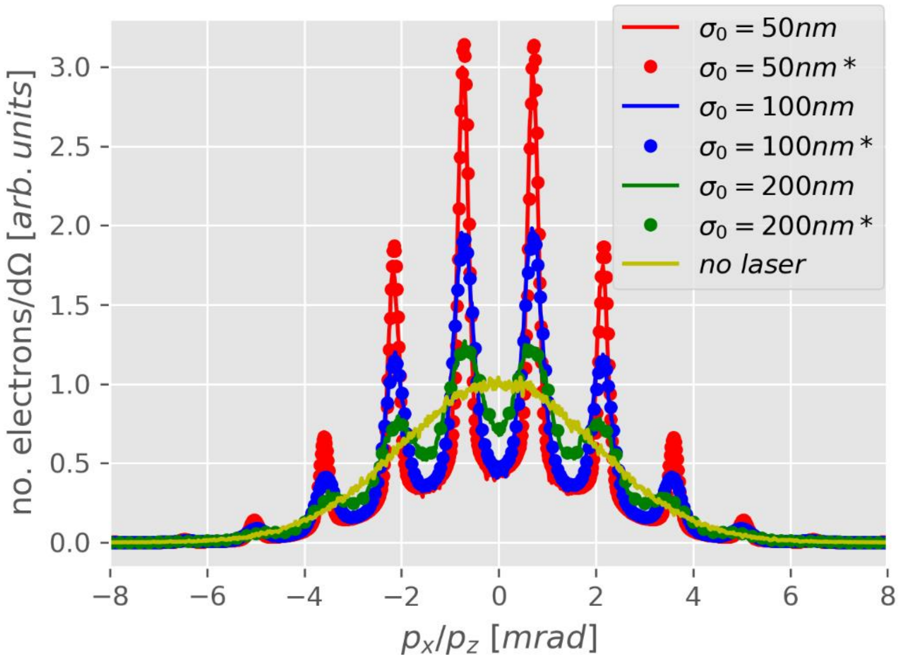


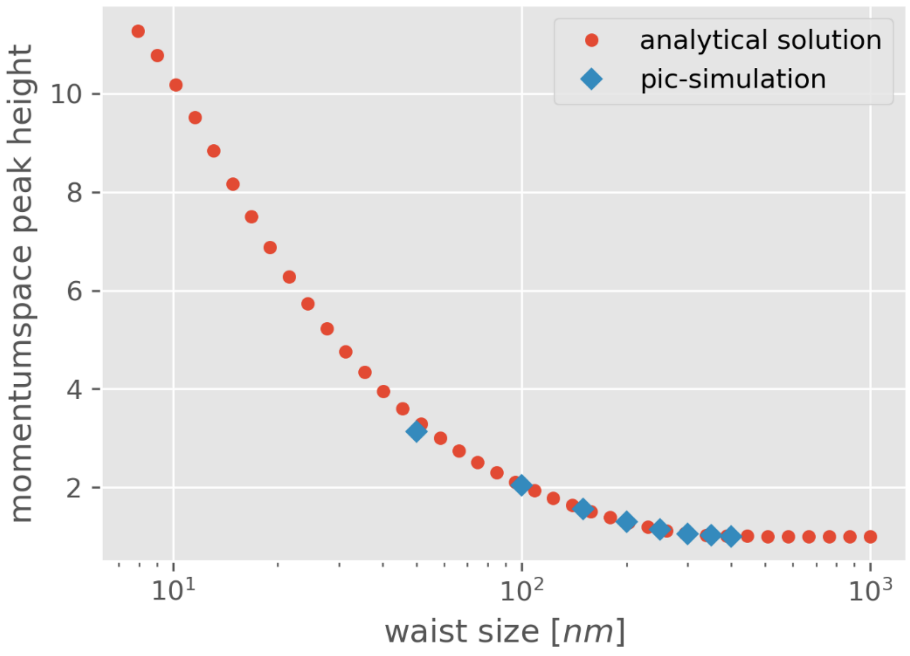



# PIC-Simulation vs Analytical solution

## PIC and Analytical-Solution




## Analytical extrapolation




$$\varepsilon_n = \beta\gamma\sigma_{x0}\sigma_{px0} = 100 \cdot 100nm \cdot 2mrad = 0.020\ mm\ mrad$$

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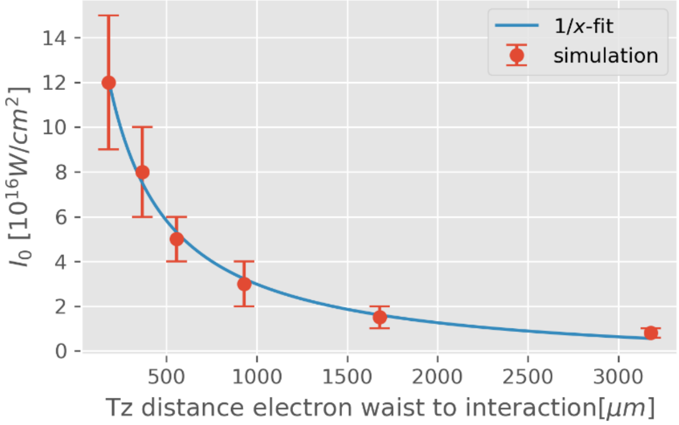
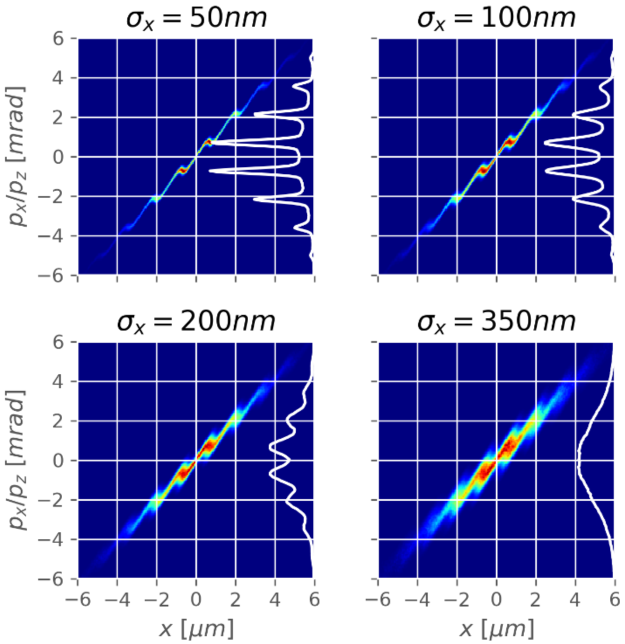
# Measurement Procedure




- Choosing a desired distance between electron beam waist and interaction position with laser intensity accordingly

- From the measured modulation depth in the momentum space source size can be deduced by comparing with pic/analytic solution

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# Summary/Outlook

- ✓ Electron density modulation with moderate laser intensity ($10^{17}$W/cm2) achievable
- ✓ Normalized emittances down to 0.01 mm mrad have been simulated
- ✓ Method is suited for mono energetic beams (from RF linacs) and LWFA beams with broader bandwidth

- Test of the concept in an experiment at JETI 200 in 2021

**Thank you for your attention!**

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