Universität Hamburg
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Beam waist measurements

MADMAX Summer Collaboration Meeting

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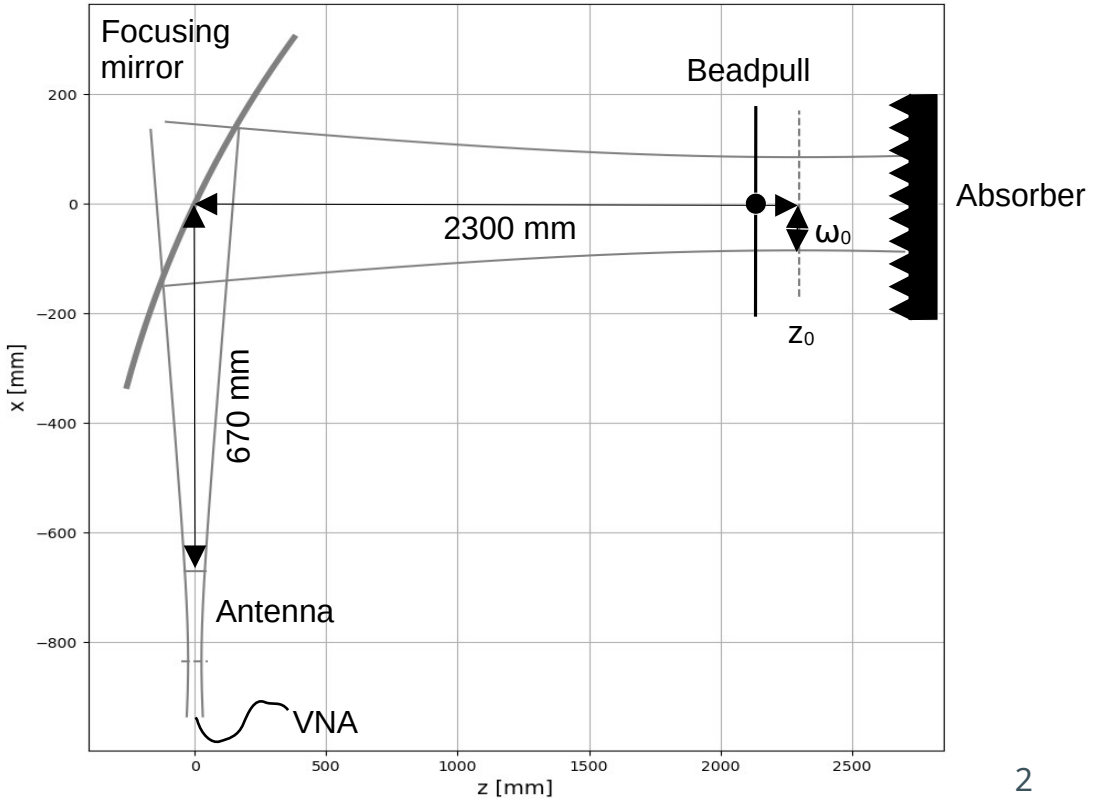
Setup and goal of the measurement

- Measure the beam waist ω_0 and the beam waist position z_0
- Mirror should be placed at z_0 to reflect the light back with the same beam shape and size



Beadpull measurements

- Dimension of the measurement:

	start	stop	stepsize
x	-150 mm	150 mm	10 mm
y	0 mm	0 mm	
z	2230 mm	2380 mm	5 mm

- Z = 2300 mm is the designed mirror position

Measure E(x,y,z)

$$E_{field}(x,y,z) = \sqrt{\Delta\Gamma} \cdot \frac{\sqrt{4 \cdot P_{in}}}{\epsilon_0 \alpha_0 i 2\pi\nu}$$

Known variables:

- Permittivity ϵ_b = 9.2 ± 0.2 A·s·V^{-1}·m^{-1}
- Bead radius r_b = 1.465 ±0.007 mm
- Input power P_{in} = 10 mW (10 dBm)
- Mirror radius r_m = 150 mm
- Polarizability of the bead in the E field:

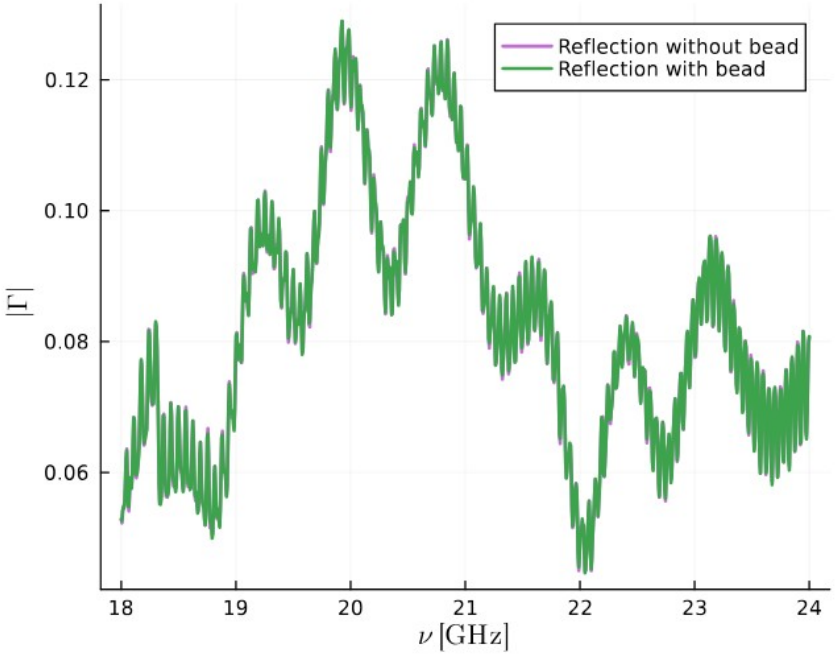
$$\alpha_0 = 4\pi r_b^3 \frac{\epsilon_b - 1}{\epsilon_b + 2}$$

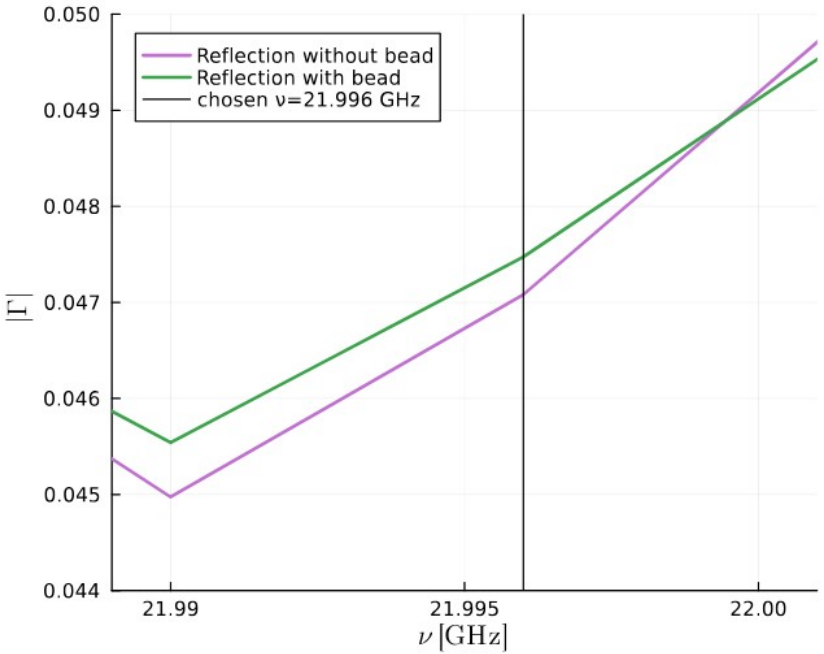
- ν = 18 GHz to 24 GHz in 0.006 GHz steps

Measurement variables:

- Γ_b (reflectivity with bead)
- Γ_0 (reflectivity without the bead)
- $\Delta\Gamma = \Gamma_B - \Gamma_0$

Raw reflection data

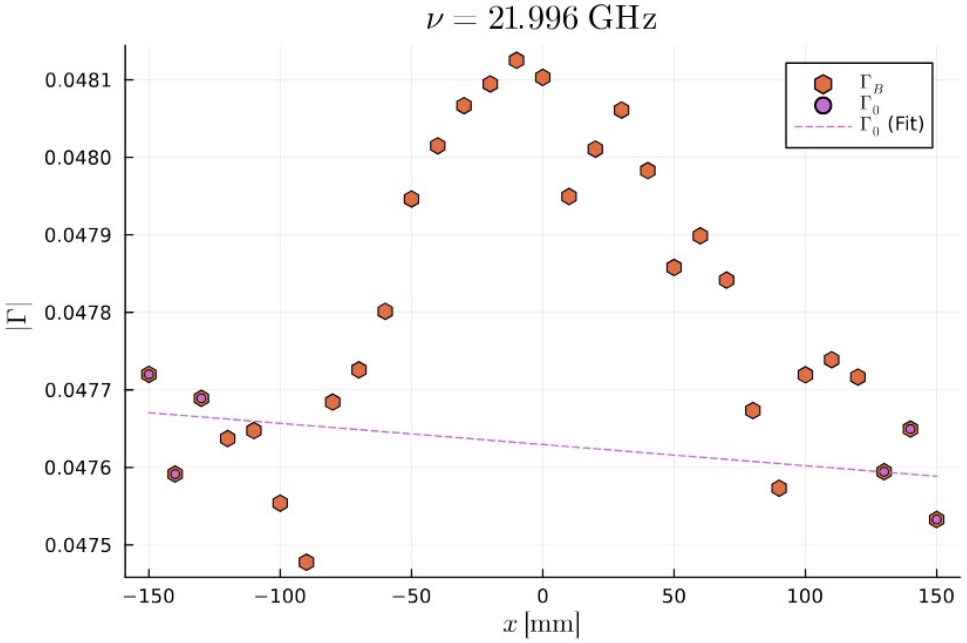




Reflection as $P_{reflected}/P_{in}$ with $P_{in} = 10$ mW

Calculate √(ΔΓ) to measure E(x,y,z)

- Bead outside the beam at ± 125 mm
- Fit Γ_0 for all purple data points
- $\Delta\Gamma = \Gamma_B - \Gamma_0$
- Example at z = 2300 mm and y = 0 mm



Extraction of E field using beadpull

$$E_{field}(x,y,z) = \sqrt{\Delta\Gamma} \cdot \frac{\sqrt{4 \cdot P_{in}}}{\epsilon_0 \alpha_0 i 2\pi\nu}$$

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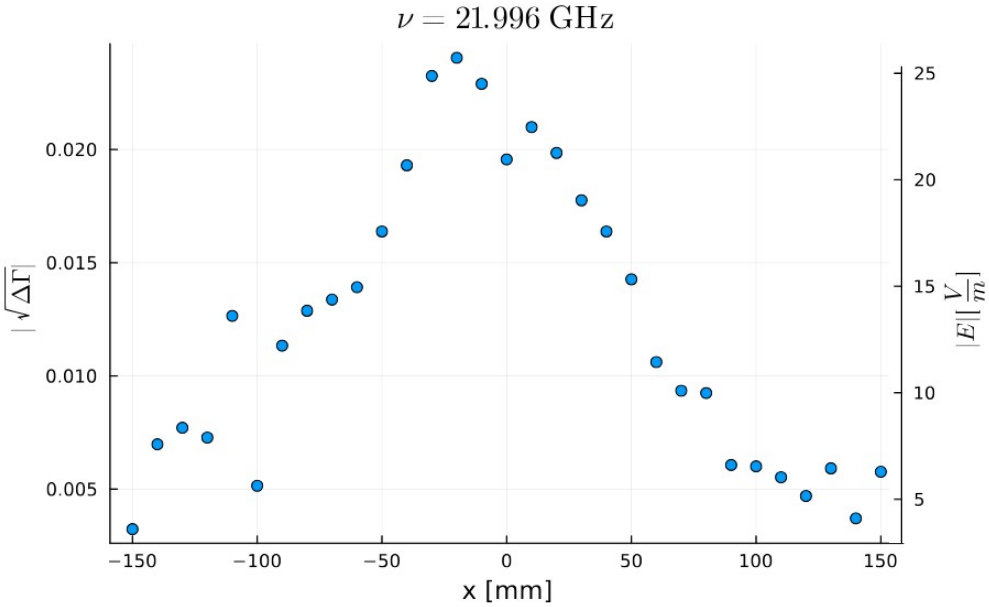
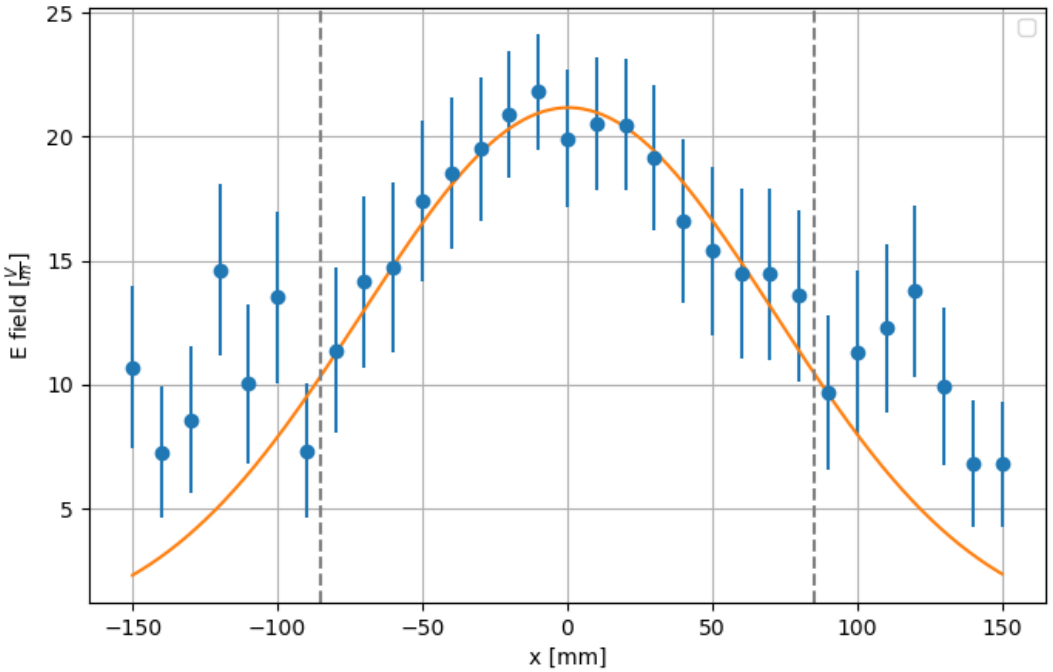


Beam waist fit

- Gauss function fit
- Fit the beam size ω, amplitude A and beam position x_0
- Use all data points inside the dashed lines for the fit because outside is a huge fluctuation due to low signal

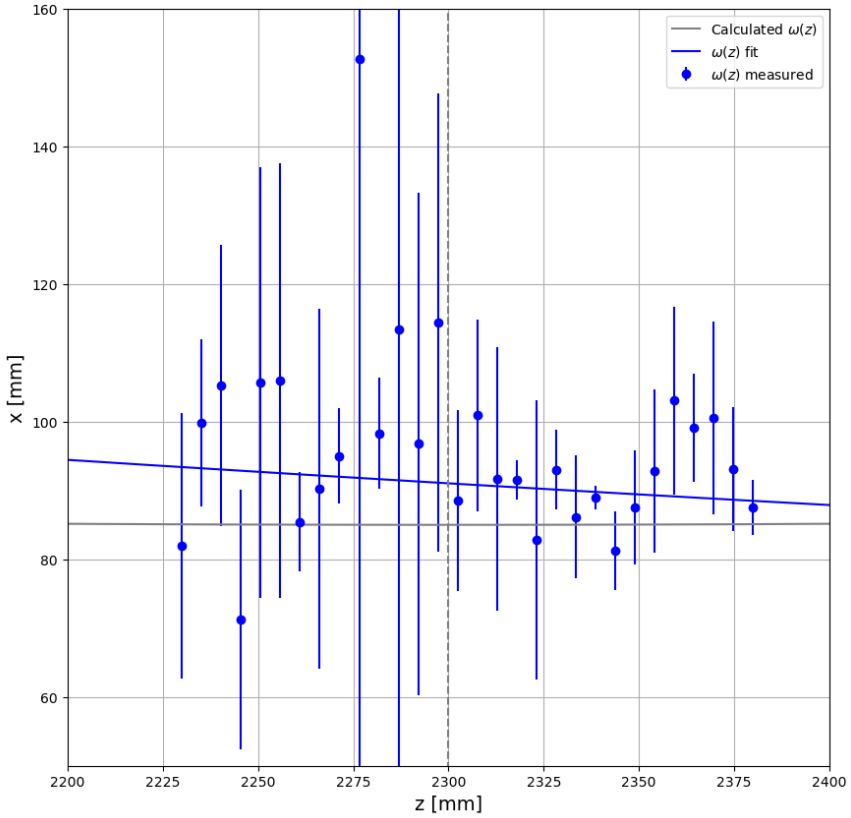


Absorber Measurements

$Z_0 = 3191 \pm 78$ mm, $\omega_0 = 78 \pm 3$ mm

To Do:

- Measure fluctuations dominated by systematic
- Determine systematic errors: hysteresis, reproducibility
- Extend z scan range to see the beam shape
- Improve the stability of the beadpull



Summary & Outlook

- Beam waist position $Z_0 = 3191 \pm 78$ mm, beam waist $\omega_0 = 78 \pm 3$ mm
- Measure the beam waist on a longer distance (1000 mm instead of 150 mm)

Backup

- Errors for each data point from measuring 5 times to left and 5 times to the right

- Line fit a*x+b
- A = -0.018
- B = 0.499