

# 5 MeV Beam Diagnostics at the Mainz Energy-Recovering Superconducting Accelerator MESA

## Abstract

Within the next few years, a new energy-recovering superconducting electron accelerator will be built at the Institute of Nuclear Physics in Mainz. For injection into the main accelerator, an adjustment of the beam parameters is necessary. This requires a high resolution longitudinal beam diagnostic system at the 5 MeV injection arc. The system employs two 90° vertical deflection dipoles to achieve an energy resolution of 240 eV and a phase resolution of 46 μm. As a second challenge, the transverse emittance measurements will take place at full beam current. This demands an extremely heat resistant diagnostic system, realized by a method similar to flying wire.

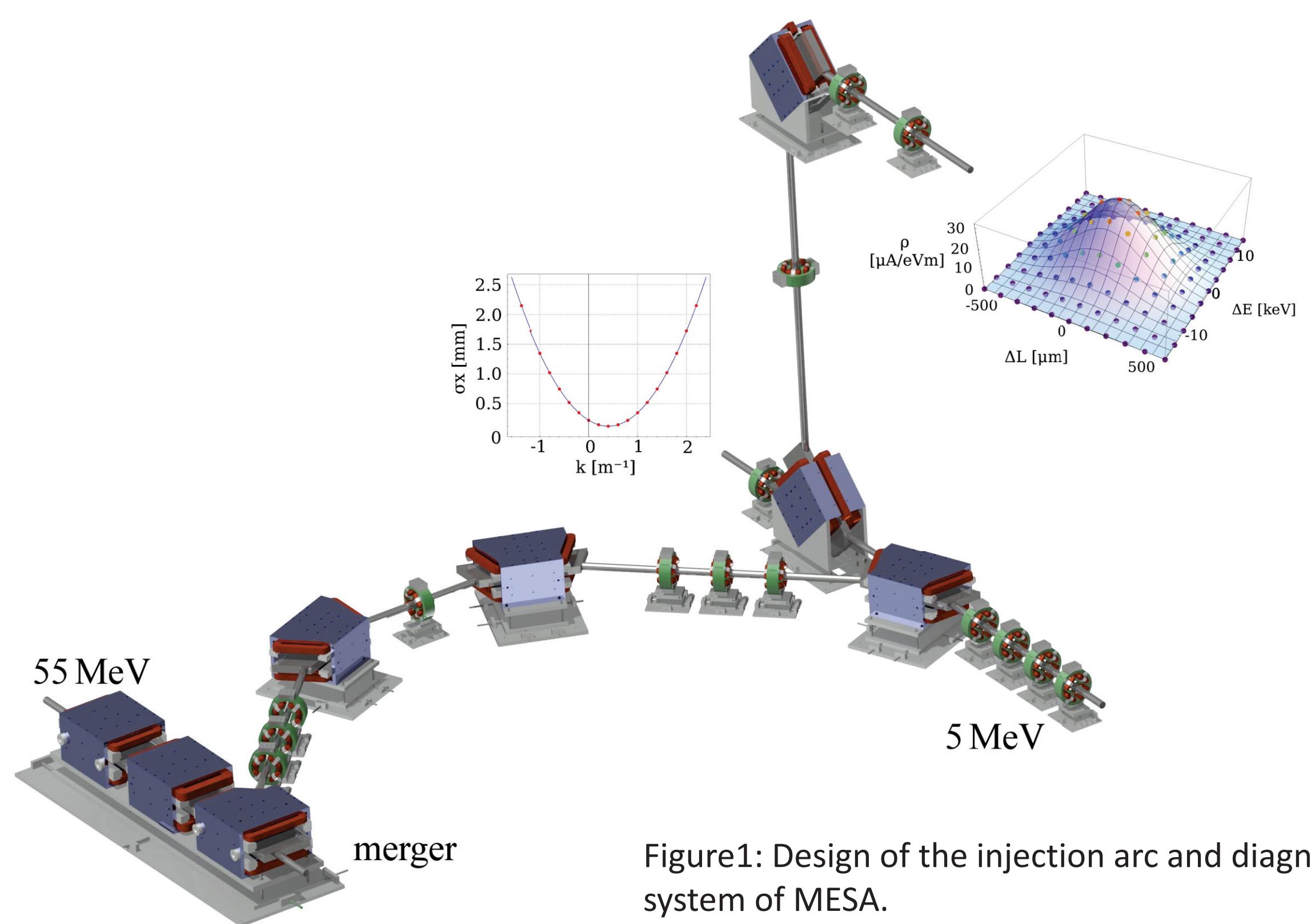


Figure 1: Design of the injection arc and diagnostic system of MESA.

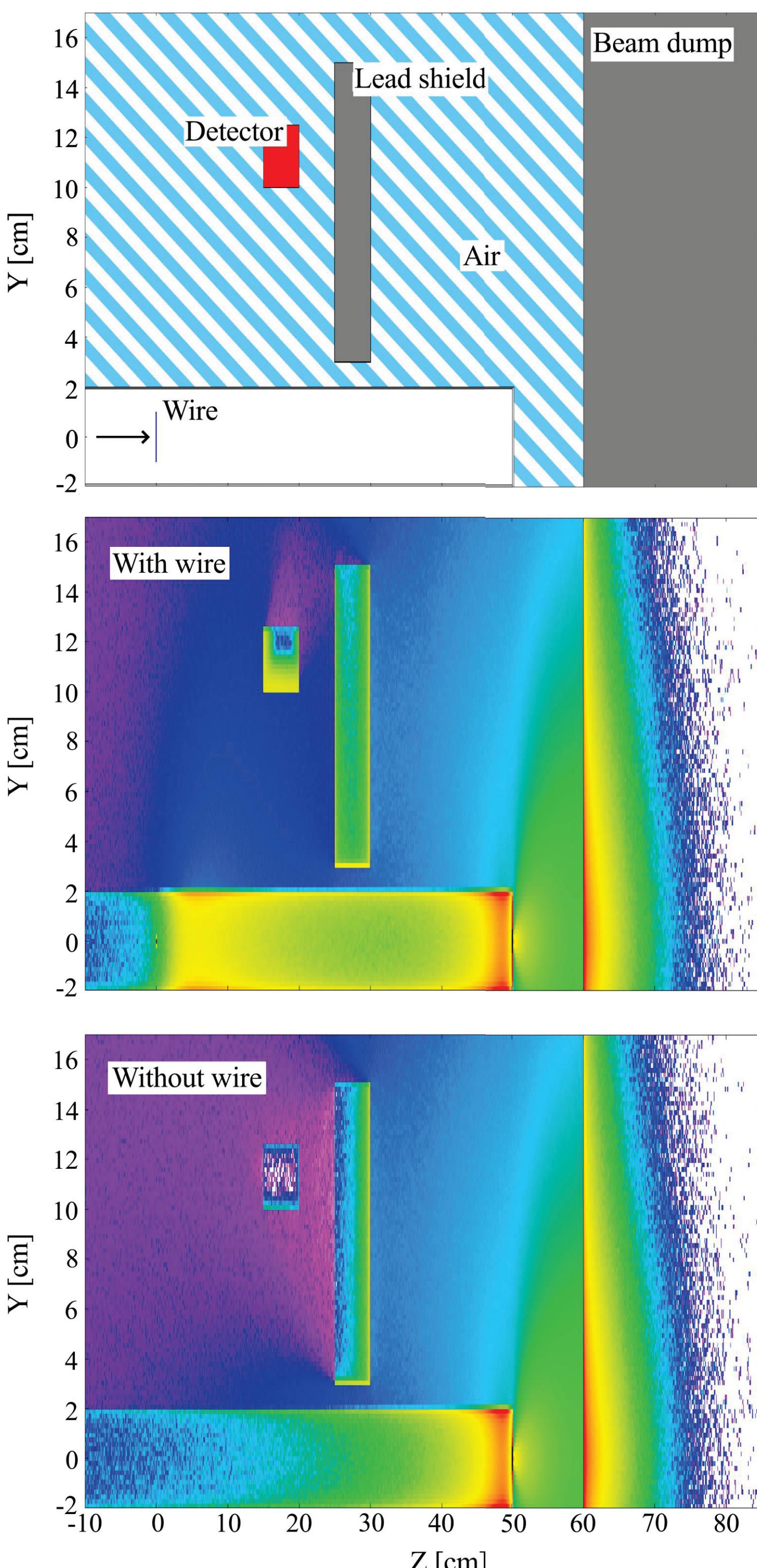


Figure 2: Simulation of detector system with and without diagnostic wire to evaluate the influence of background radiation.

## Longitudinal Beam Diagnostics

- Straight forward scanning of longitudinal phase space
- Step 1: Energy spectrometry with 90° vertically deflecting dipole
- Achromatic set up prevents phase smearing ( $R_{51}=0$ )
- Step 2: Phase spectrometry with dipole cavity
- Increase of cavity kick with adjacent FODO-structure
- Energy resolution: 240 eV
- Phase resolution: 46 μm
- Real time imaging of longitudinal phase space with a repetition rate of 10 Hz

## MESA Injection Arc

- Properties of 5 MeV beam need to be known before superconducting cavity is entered
- Achromatic 180° injection arc allows phase space diagnostics behind first 45° deflection dipole
- To access beam diagnostics set-up, first dipole is switched off
- Expected bunch length: 0.8 mm,
- Expected energy width: 5 keV

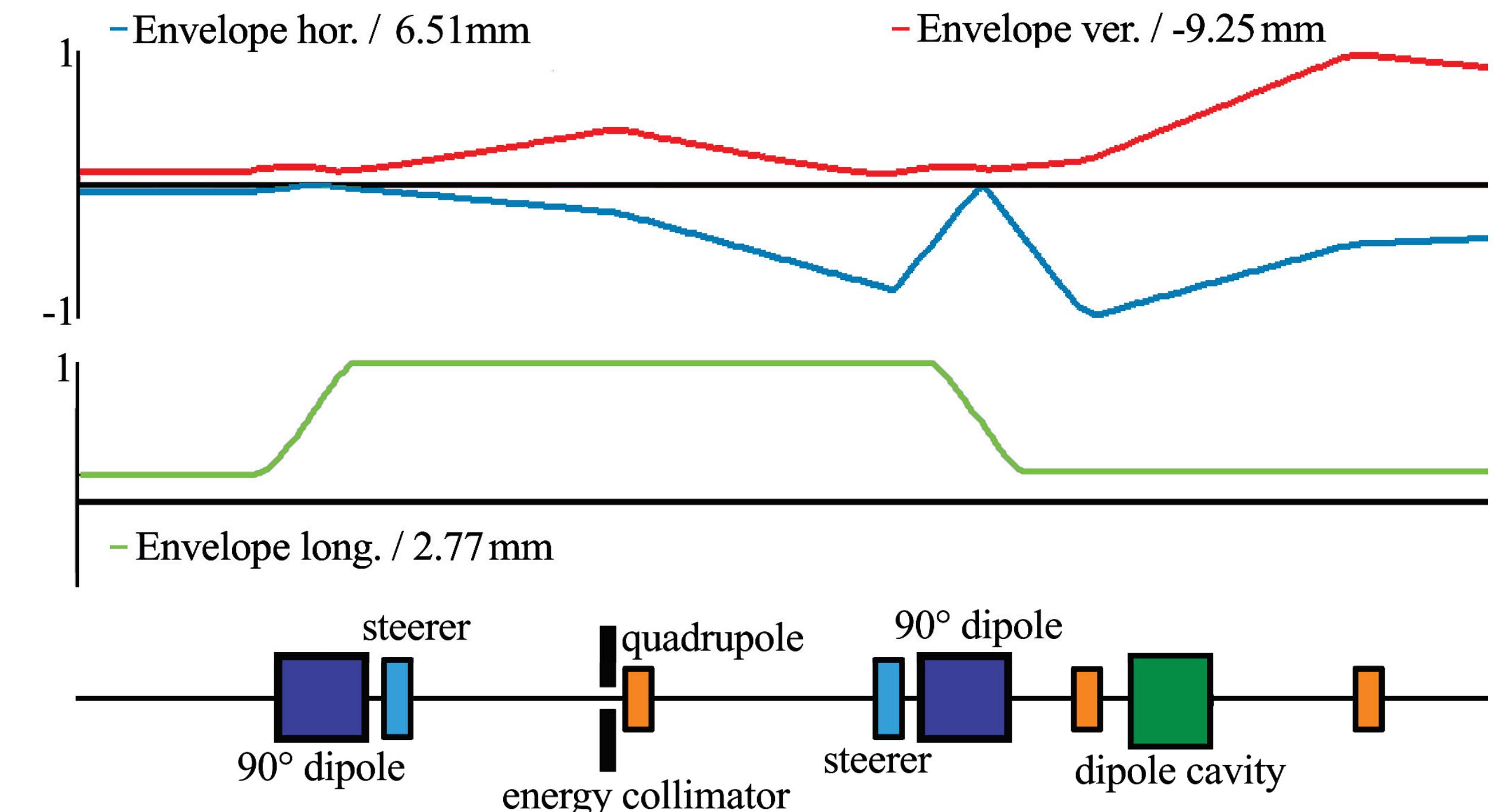


Figure 3: First order transport matrix calculation shows the chromatic correction of the energy spectrometer.

## Transversal Beam Diagnostics

- Beam “flies” over wire instead of wire flying through beam
- Measurement of radiation from wire with scintillation detector
- Signal to noise ratio  $\approx 100$
- Emittance measurement with quadrupole scan
- Resolution  $< 5 \mu\text{m}$

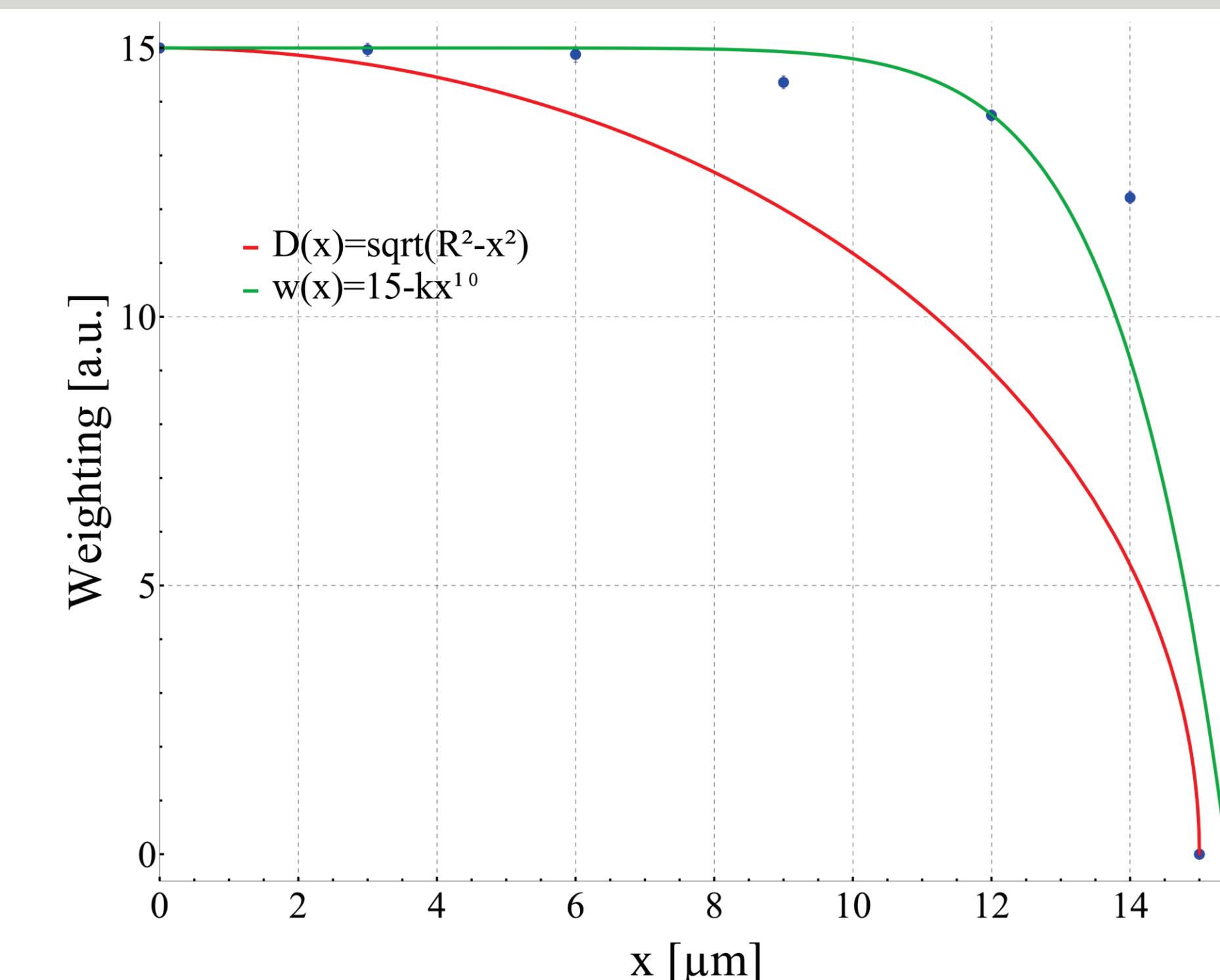


Figure 4: The signal response of the diagnostic wire was simulated for different distances of impacting electrons to the axis of the wire.

## Influence of wire diameter

- Thickness of wire and time resolution of detector leads to overestimation of beam size
- For beam size = wire radius: Overestimation about 10%
- Measured beam size results from convolution of transverse current density distribution with temporal and spatial weighting functions
- Resolution could be optimized by applying correction factors

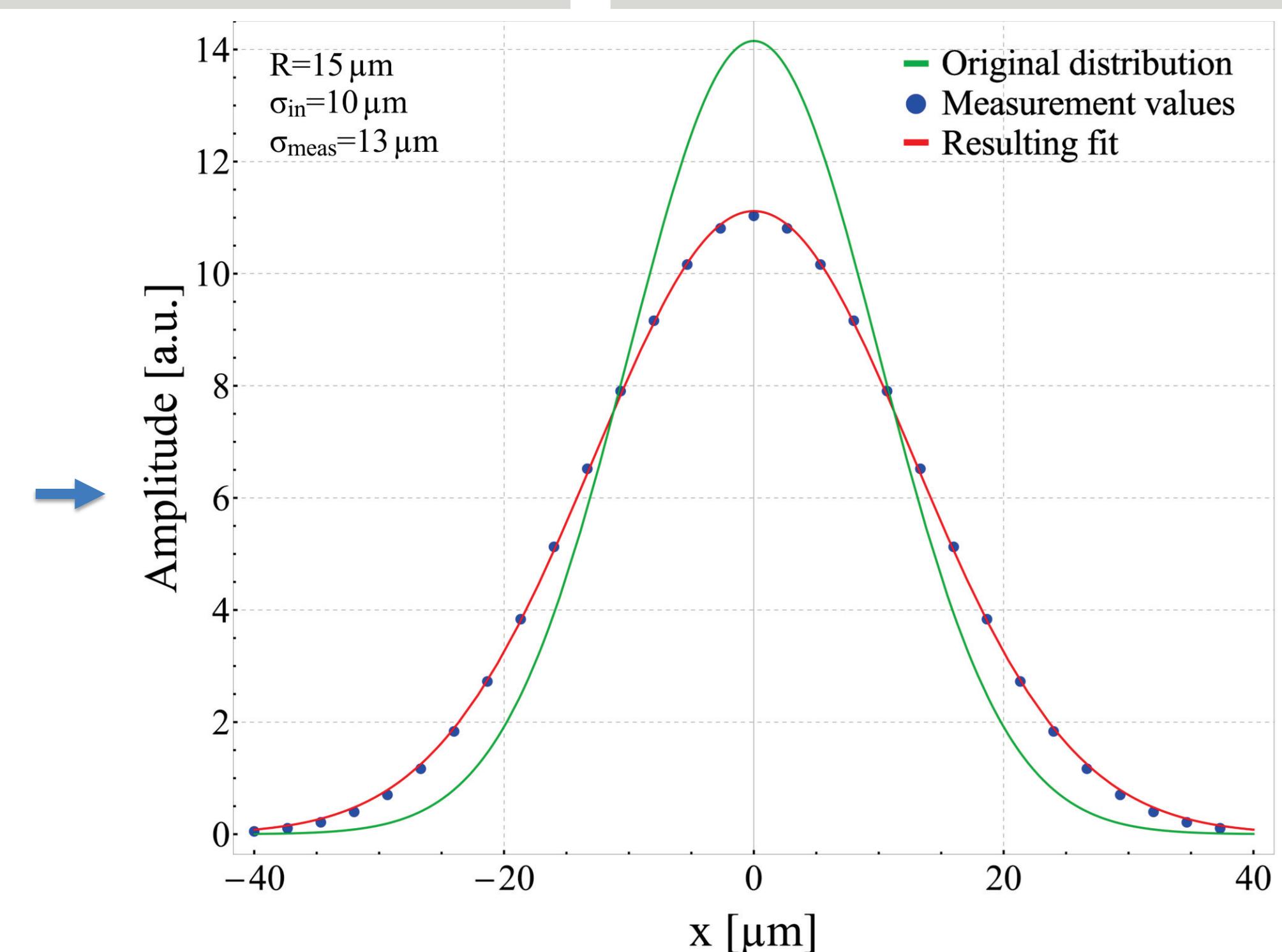


Figure 5: With the resulting weighting function, a beam profile measurement can be simulated. The result shows an overestimation of the beamsize.

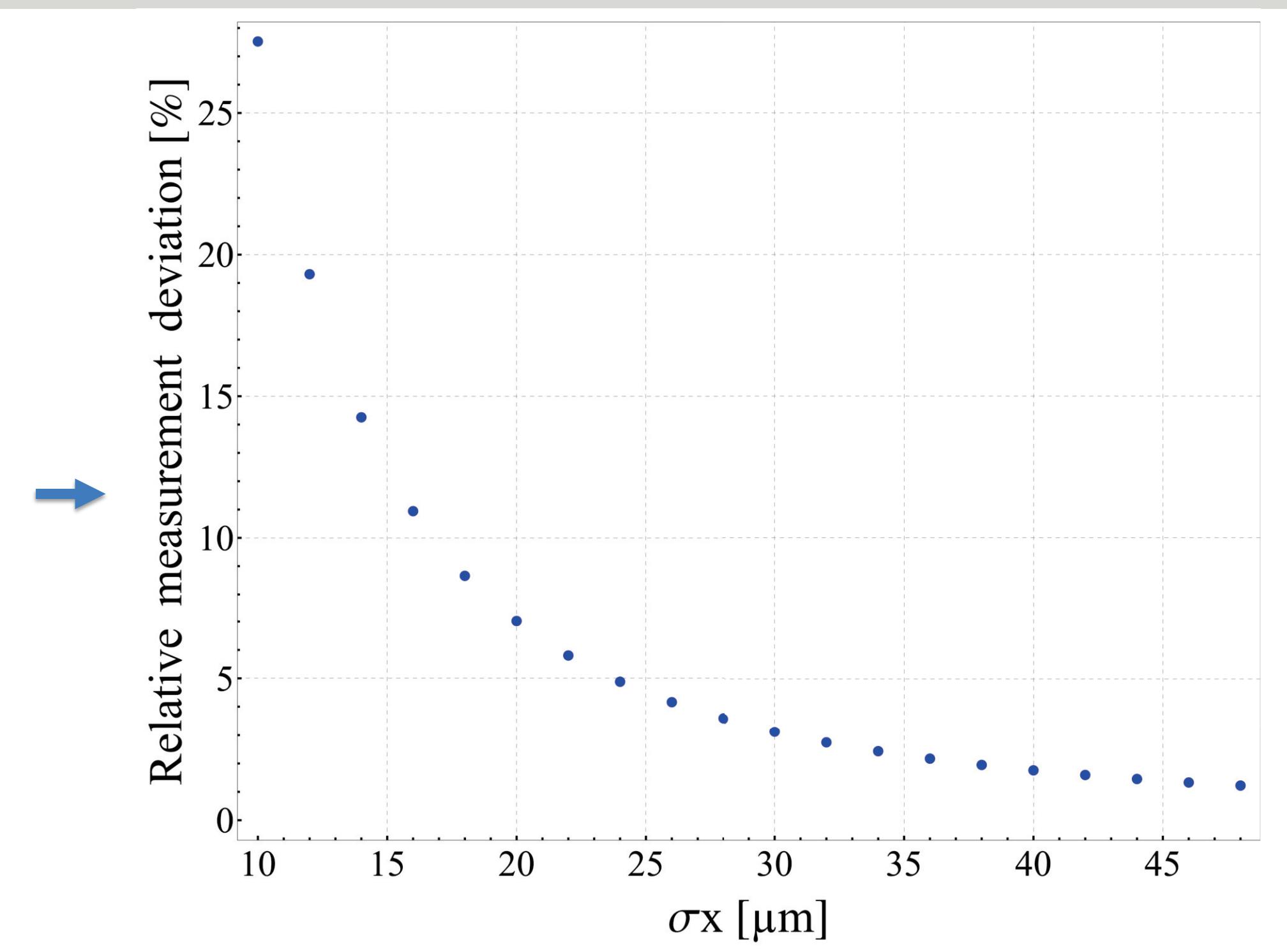


Figure 6: A correction curve is found by repeating the simulations for different beam sizes.