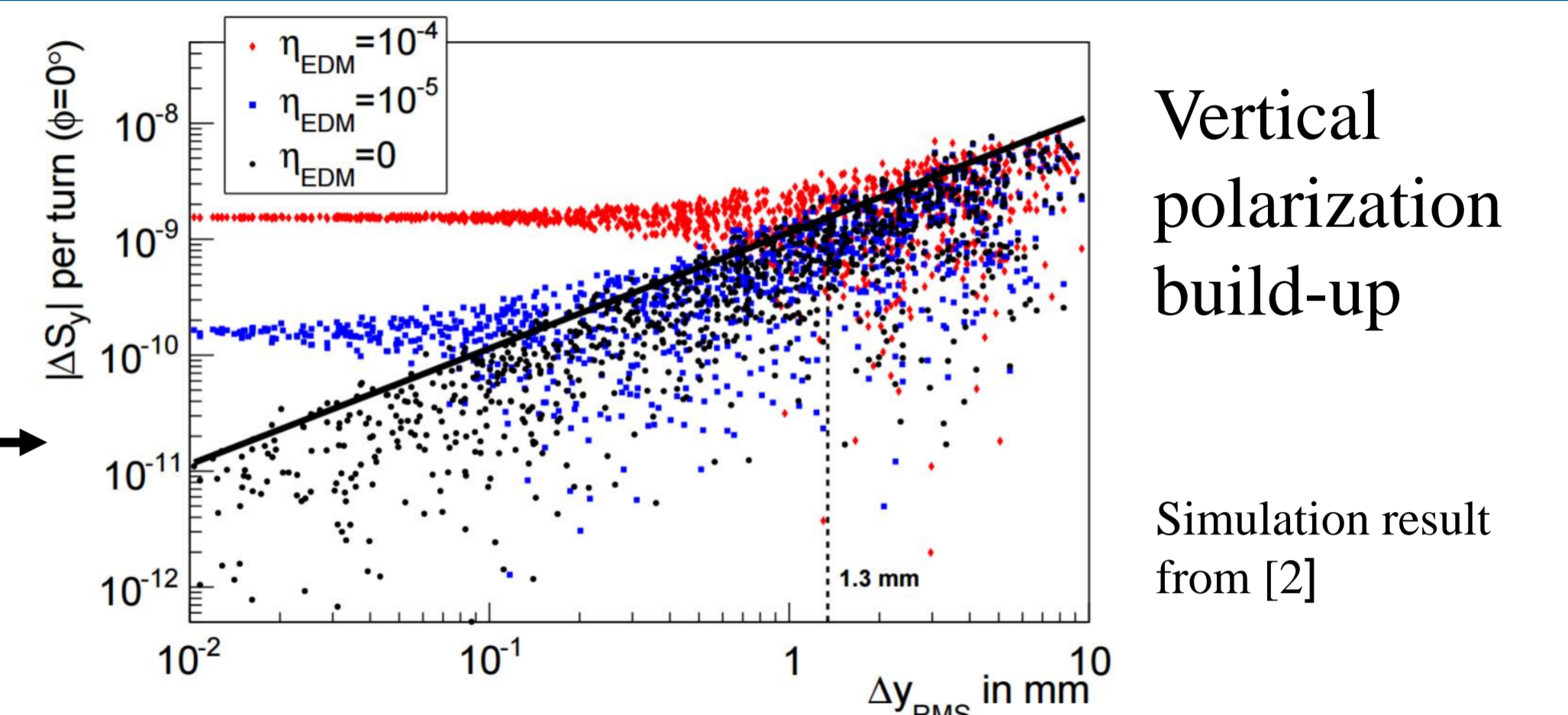


# ANALYSIS OF CLOSED ORBIT DEVIATIONS FOR A FIRST DIRECT DEUTERON ELECTRIC DIPOLE MOMENT MEASUREMENT AT THE COOLER SYNCHROTRON COSY

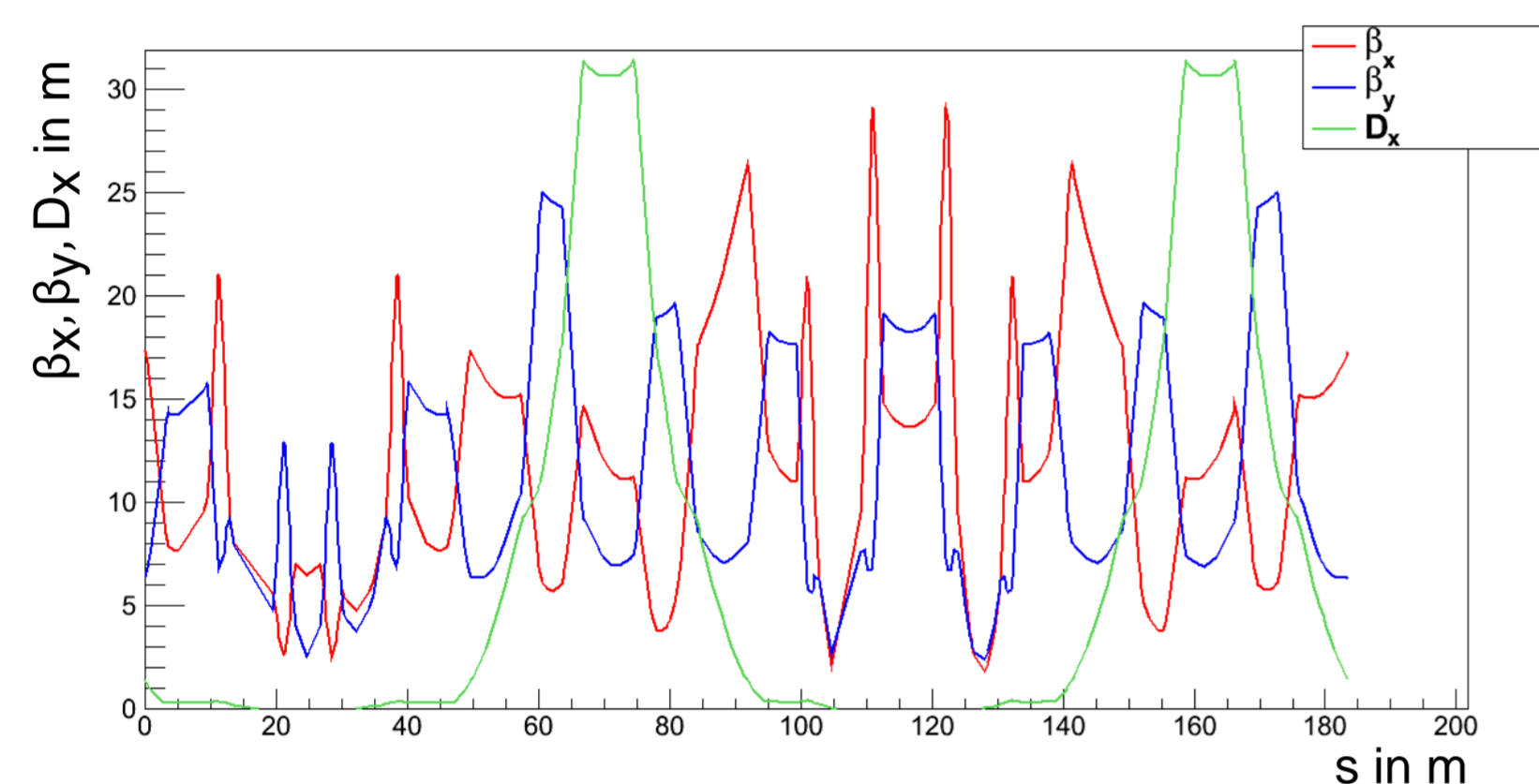
V. Schmidt<sup>1</sup>, A. Lehrach<sup>1,2</sup>, Institut für Kernphysik 4, Forschungszentrum Jülich, 52425 Jülich, Germany,  
<sup>1</sup>also at III. Physikalisches Institut B, RWTH Aachen University <sup>2</sup>and JARA-FAME, 52056 Aachen, Germany

## Motivation

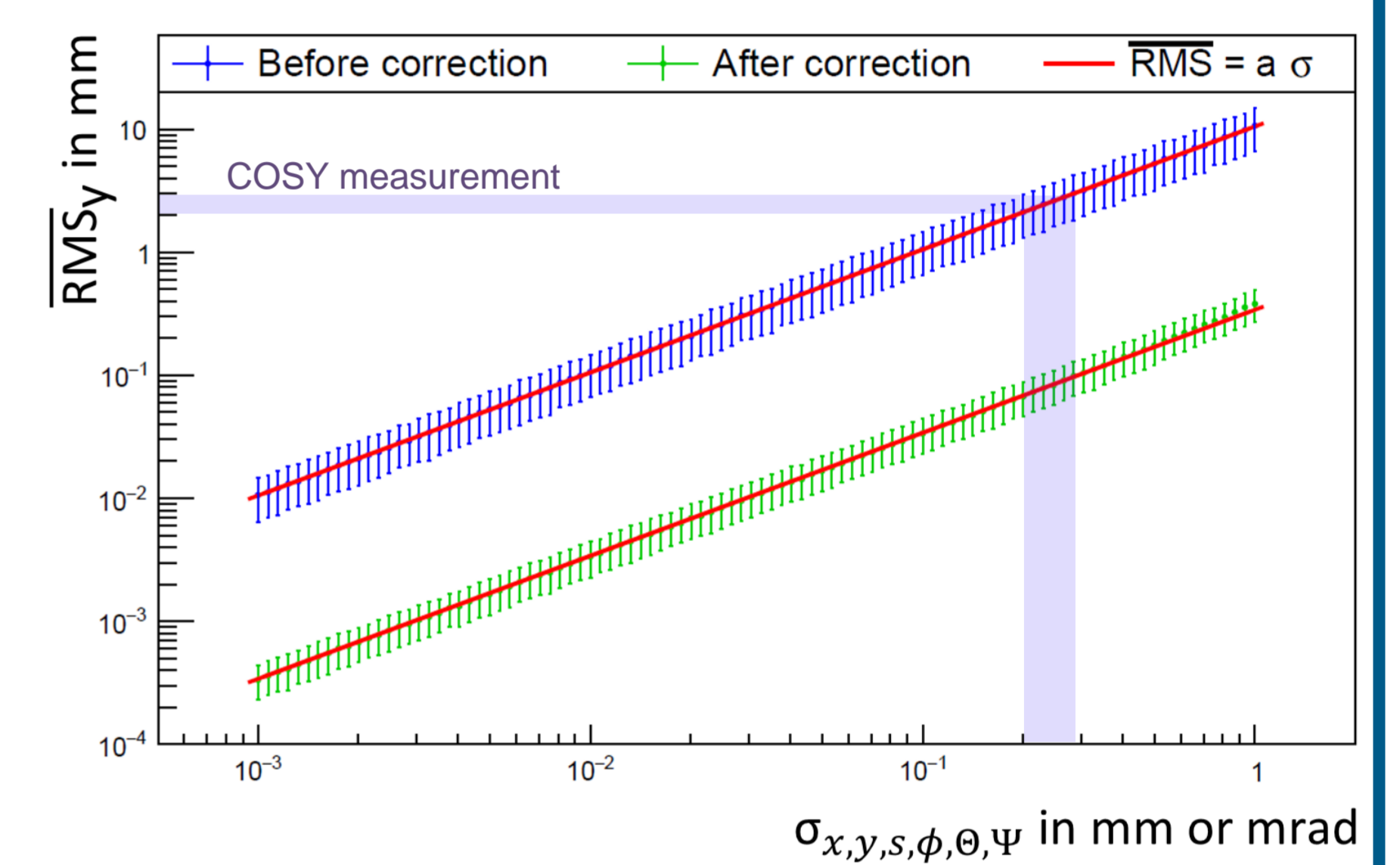
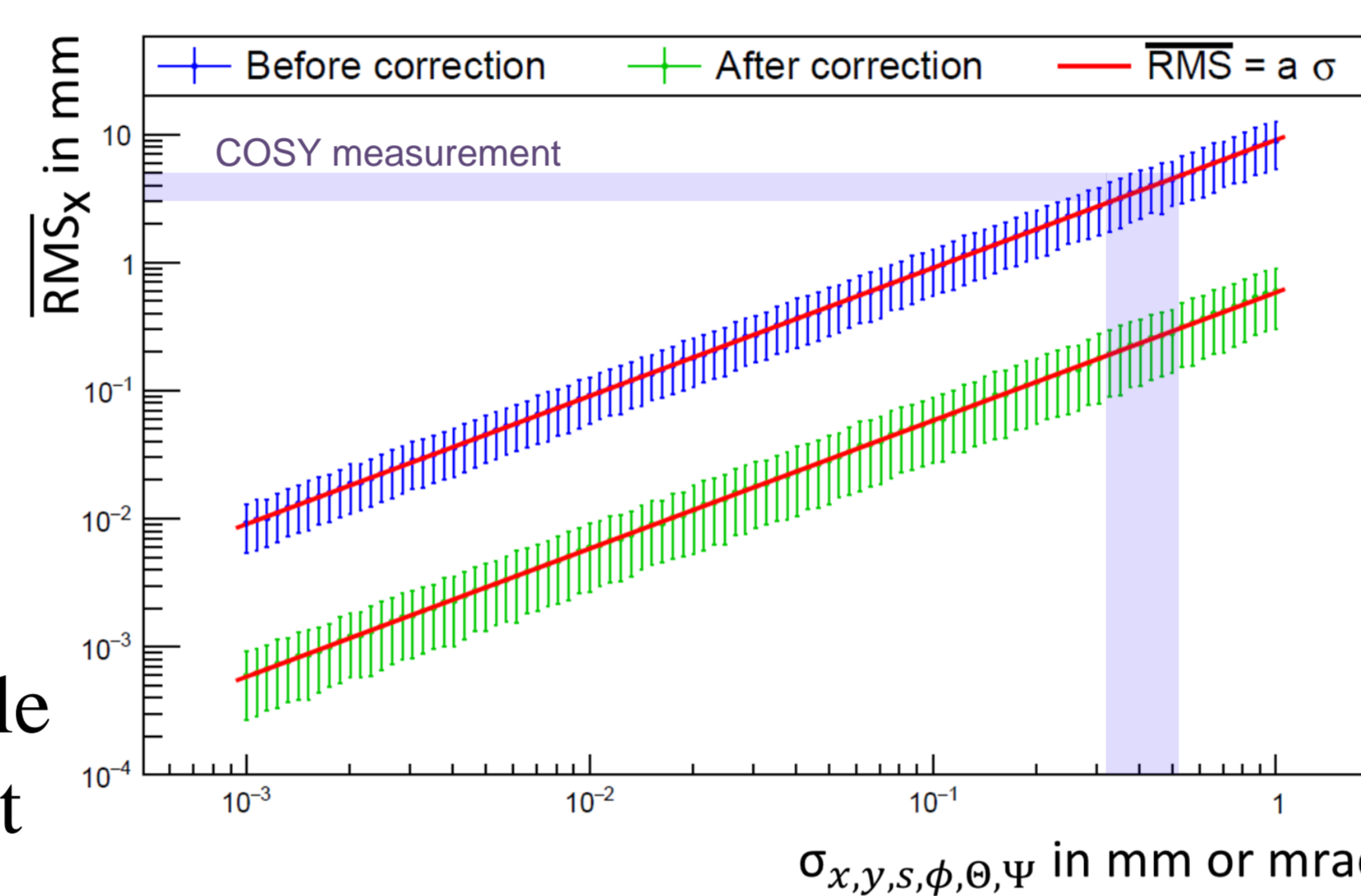
- Measure Electric Dipole Moment (EDM) of charged hadrons at COSY
- Vertical spin build-up as a measure of EDM
- EDM-like signals due to orbit influencing systematic effects
  - Reduction of transverse orbit RMS required
- Study **systematic effects** (misalignments of magnets, power supply oscillations) by simulating the closed orbit



## Misalignment of Magnets



- Random displacement and rotation of each dipole and quadrupole ⇒ six misalignments per magnet
- Include misalignments into MAD-X model
  - Simulate closed orbit and calculate its RMS
  - 1000 random seeds per standard deviation
  - Calculate average closed orbit RMS

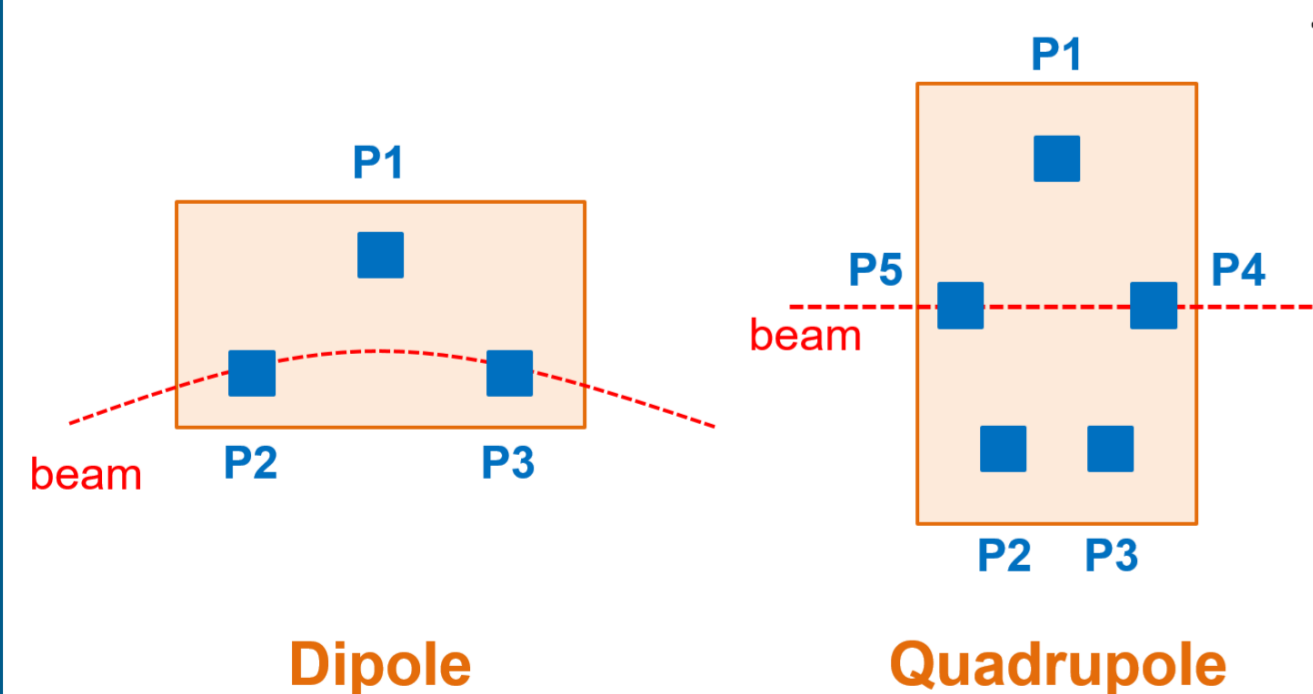
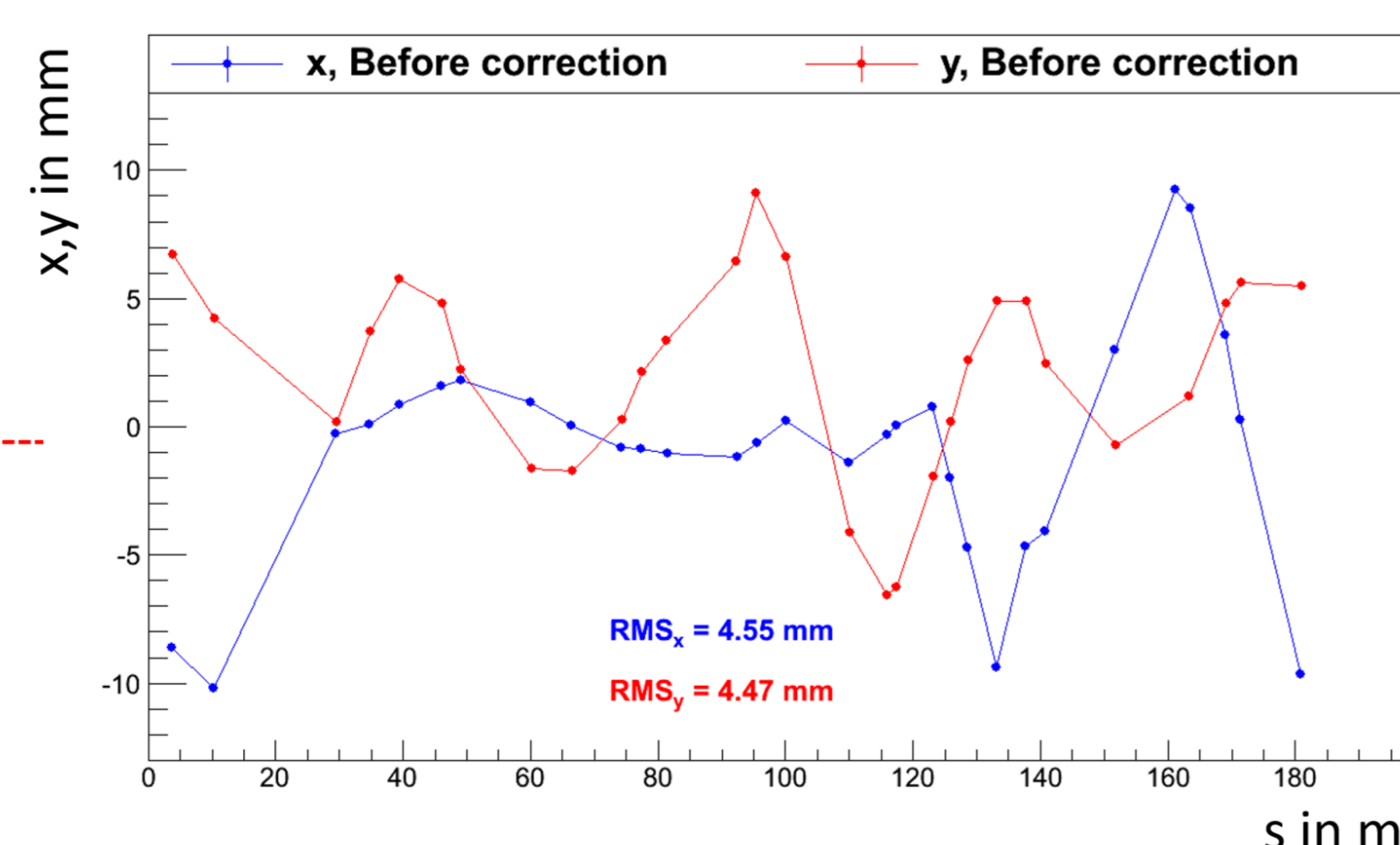
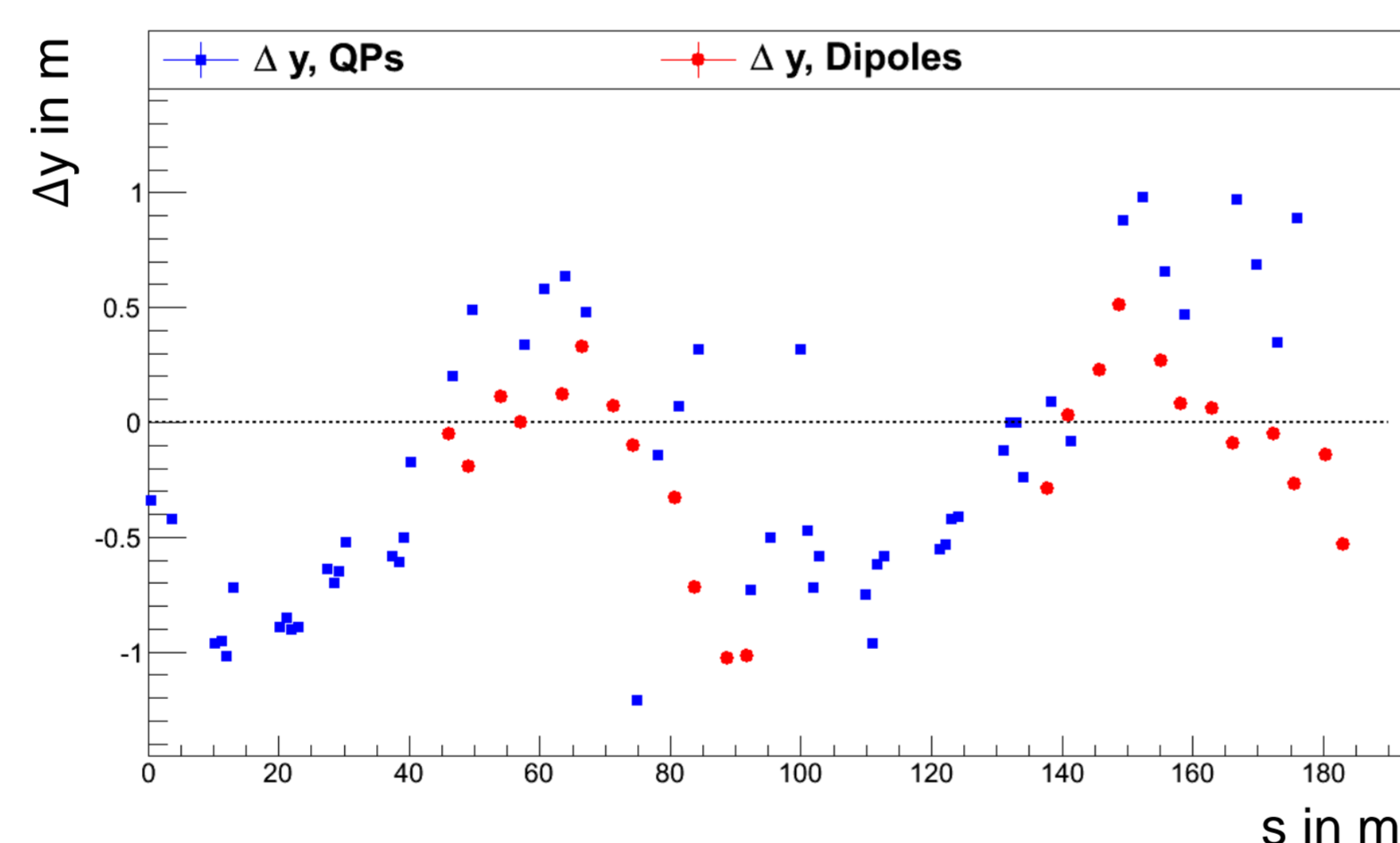


$$\Delta x(y, s, \phi, \theta, \Psi) = \text{Gauss}(0, \sigma_{x(y,s,\phi,\theta,\Psi)})$$

$$\sigma_x = \sigma_y = \sigma_s \text{ and } \sigma_\phi = \sigma_\theta = \sigma_\Psi$$

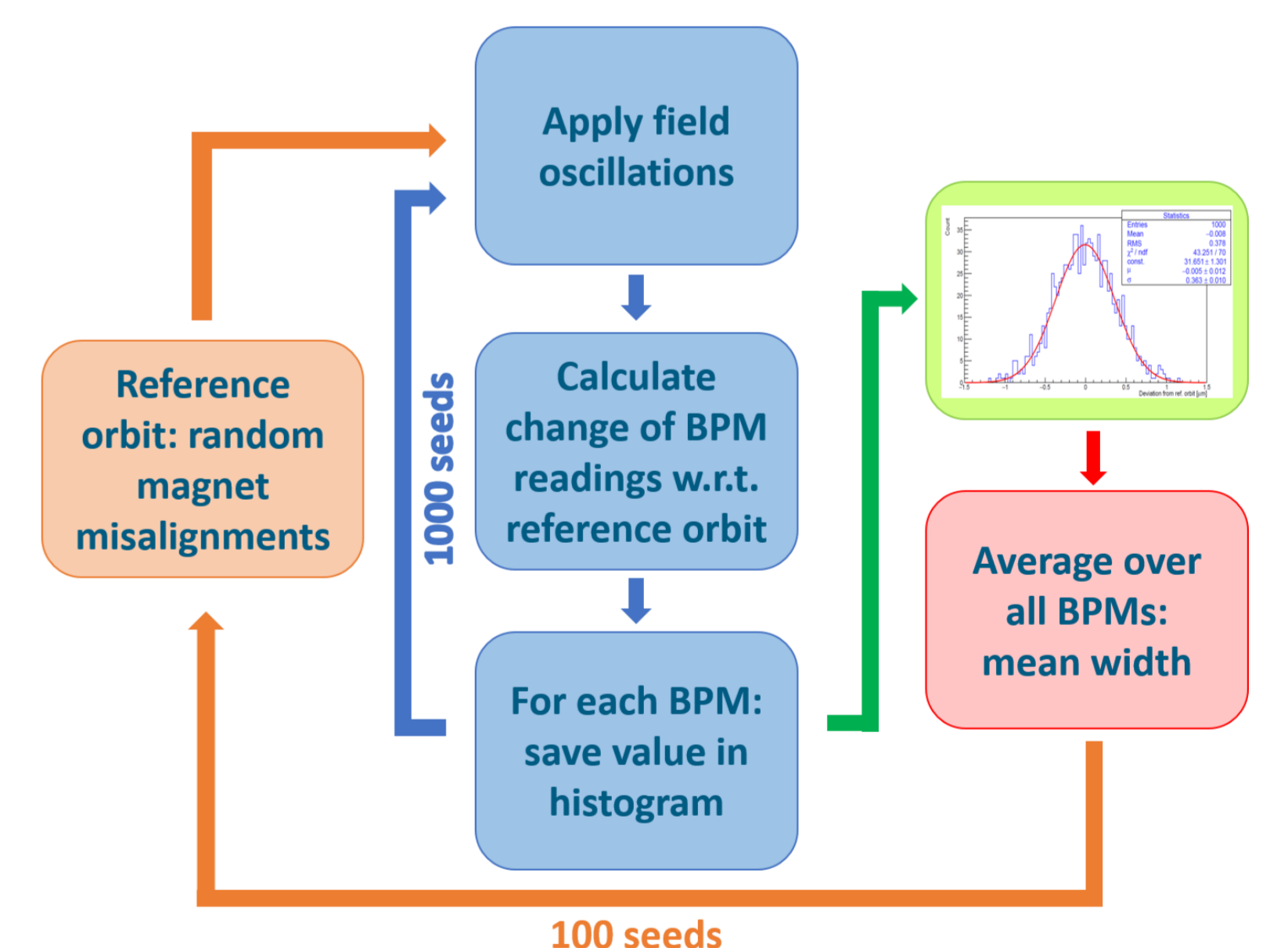
## Survey at COSY

- Laser-based position measurement
- Estimation of best-fit plane
- Calculate deviations of magnets from target plane
- Implement deviations into MAD-X model



## Power Supply Oscillations

- Peak-to-peak value:  $\Delta I_{max}$
- Random current errors:  $\Delta I = \text{Gauss}\left(0, \frac{\Delta I_{max}}{2}\right)$
- For each magnet type: 1000 random seeds



	$\Delta x$	$\Delta y$
Dipole	$(27.69 \pm 0.24) \mu\text{m}$	$(9.00 \pm 0.10) \text{nm}$
Quadrupole	$(1.11 \pm 0.01) \mu\text{m}$	$(0.70 \pm 0.01) \mu\text{m}$
Correctors	$(34.43 \pm 0.30) \mu\text{m}$	$(28.07 \pm 0.22) \mu\text{m}$
Sextupoles	$(48.70 \pm 0.90) \text{nm}$	$(49.90 \pm 0.60) \text{nm}$

## Summary & Outlook

- Magnet misalignments dominate the effect of power supply oscillations
- Simulations of misaligned magnets are in good agreement with survey data
- Magnets at COSY are realigned (2017)
- Future aim: closed orbit RMS of about 100  $\mu\text{m}$
- Commissioning of EDM experimental setup (2017)
- First EDM measurements in 2018

## References

- [1] Methodical Accelerator Design, <http://mad.web.cern.ch/mad/>
- [2] M. Rosenthal, "Experimental Benchmarking of Spin Tracking Algorithms for Electric Dipole Moment Searches at the Cooler Synchrotron COSY", Ph.D. thesis, RWTH Aachen University, 2016.
- [3] Vermessungsbüro Dipl.-Ing. H. J. Stollenwerk, private communication, 50126 Bergheim, Aug. 2016.
- [4] F. Hinder et al, "Beam Position Monitors at COSY", 2015, unpublished.