Development of new Beam Position Monitors at COSY

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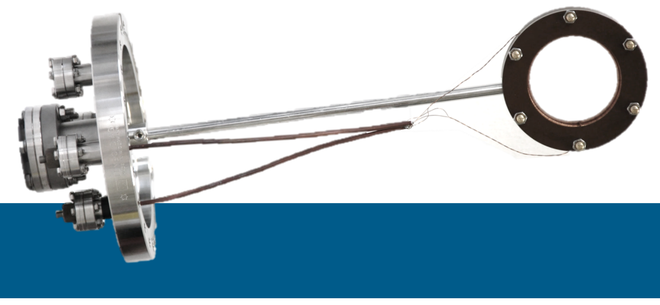
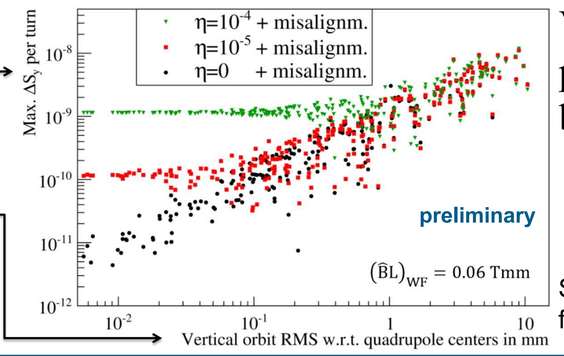
for the JEDI Collaboration



Motivation

- Measure Electric Dipole Moment (EDM) of charged hadrons at COSY
- Use **RF Wien Filter** to rotate polarization
- EDM η **rotates spin** out of horizontal plane $\Rightarrow \frac{\Delta S_y}{\text{turn}}$
- Study **systematic effects**, like misalignments of magnets, by controlling the **orbit** of the beam
  - **Improve** Beam Position Monitor (BPM) system, including new BPMs
    - Magnetostatic pick-ups based on Rogowski coil design

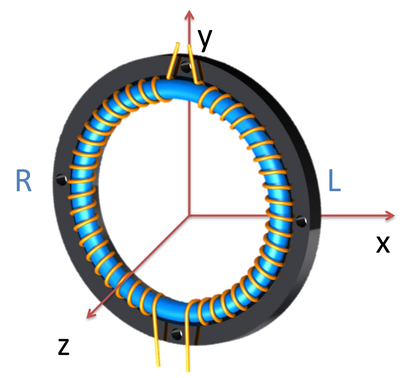


Vertical polarization build-up

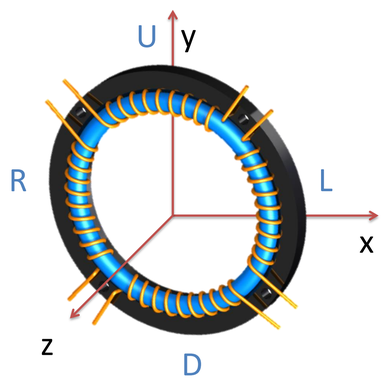
Simulation result from [3]

Design of Rogowski Pick-Up Coils

- Torus with:
  - Major radius $R = 40\ mm$
  - Minor radius $a = 5\ mm$
  - Winding with cooper wire $N = 1400$

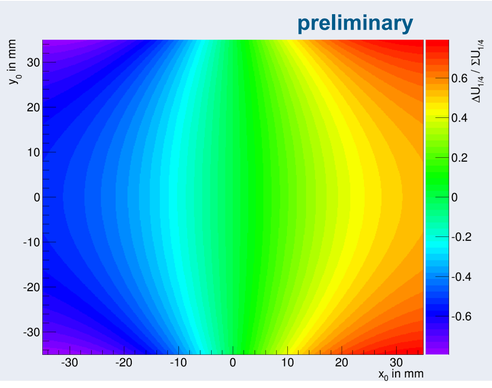


BPM in x-direction (horizontal)



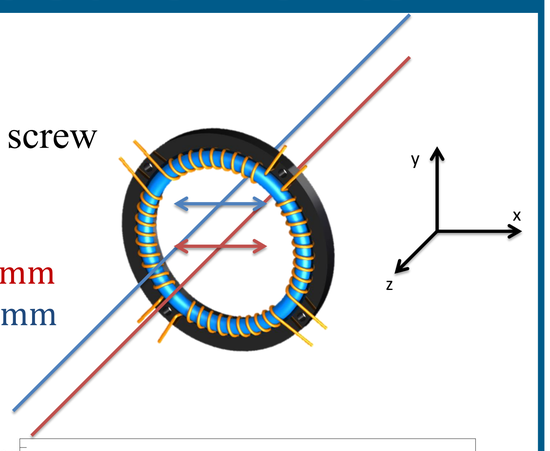
BPM in x- and y-direction (horizontal & vertical)

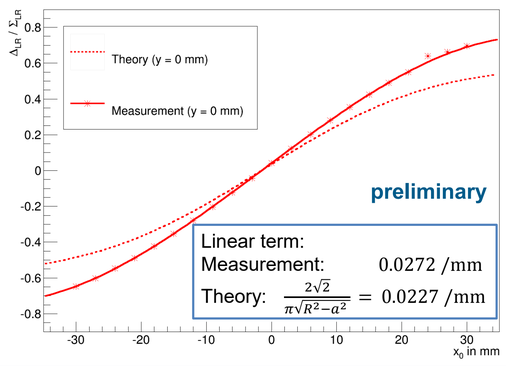
- Voltage induced by magnetic field $\vec{B}$ of particle beam (x_0, y_0) in z-direction:
  - $U_{ind} = -\frac{d}{dt}\int \vec{B}\cdot d\vec{A} = -\frac{d}{dt}\iiint B_\varphi dr dz R d\varphi$

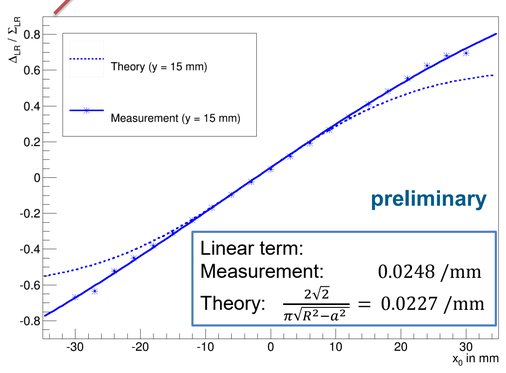
	Two Segments	Four Segments
$\frac{U_L - U_R}{U_L + U_R}$	$\frac{2}{\pi\sqrt{R^2 - a^2}} x_0$	$\frac{2\sqrt{2}}{\pi\sqrt{R^2 - a^2}} x_0 + \mathcal{O}(x_0 y_0, x_0^2, y_0^2)$
Sensitivity	• Complete linear • Independent of beam position in y-direction	

Laboratory Measurements

- Quartered BPM
- Wire representing the particle beam
- Movement of wire with micrometer screw gauge
- Two measurements:
  1. $y_0 = 0\ \text{mm},\ -30\ \text{mm} < x_0 < 30\ \text{mm}$
  2. $y_0 = 15\ \text{mm},\ -30\ \text{mm} < x_0 < 30\ \text{mm}$

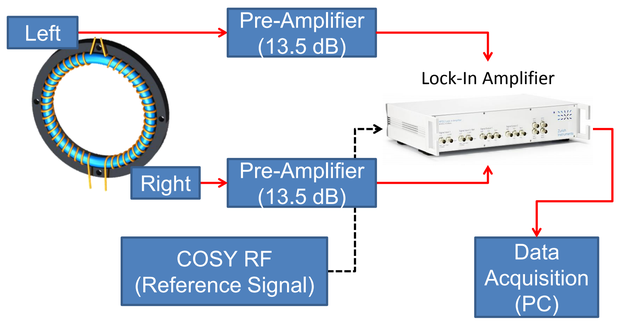




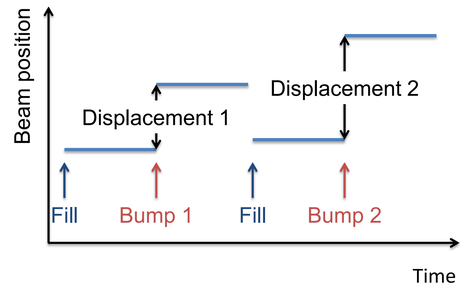


- Linear term 10% higher than expected
- Non-linear corrections smaller
- Investigate these discrepancies with improved new test-bench

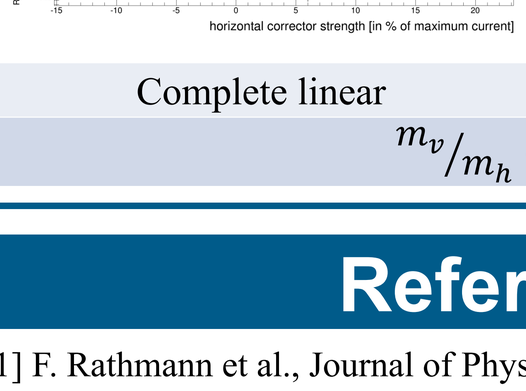
Measurements at COSY



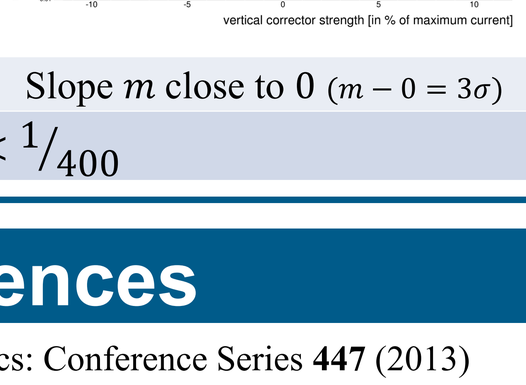
1. Change beam position once per fill
2. Measure displacement



Horizontal Orbit Bump



Vertical Orbit Bump



Complete linear	Slope m close to 0 $(m - 0 = 3\sigma)$
$m_v/m_h < 1/400$	

Summary & Outlook

- The presented magnetostatic pick-up **measures the beam position**
- A halved Rogowski coil shows a **linear sensitivity** over a wide range
  - Negligible sensitivity to perpendicular direction
- **Calibration** of BPMs at new developed test bench ongoing
- Installation of calibrated, quartered Rogowski coils at COSY is planned
  - Improvement of orbit control

References

[1] F. Rathmann et al., Journal of Physics: Conference Series **447** (2013)

[2] W. Morse, Y. Orlov, Y Semertzidis, Phys. Rev. ST Accel. Beams **16** (2013)

[3] M. Rosenthal, A. Lehrach, Conference Proceedings, IPAC15 (2015)

[4] W. Rogowski, W. Steinaus, Archiv für Elektrotechnik **1** (1912)

[5] M. Rezaee et al., Conferecne Proceedings, ICIEA **3** (2008)