Precursor Experiment
- Status of Preparation -

September 1, 2016 | Andreas Lehrach

RWTH Aachen University & Forschungszentrum Jülich

on behalf of the JEDI collaboration

(Jülich Electric Dipole Moment Investigations)

Outline

Introduction

Methods

Developments

Beam and Spin Simulation

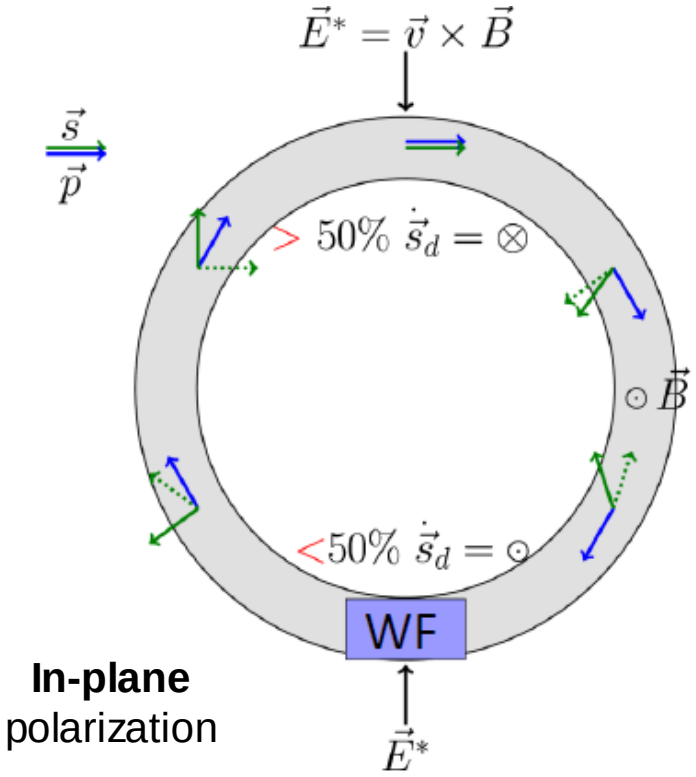
RF Wien Filter

Conclusion

Resonance Method in Magnetic Rings

RF *ExB* dipole in "Wien filter" mode
→ Avoids coherent betatron oscillations

$\boldsymbol{E^* = 0 \Rightarrow E_R = -\beta \times B_y}$ „Magic RF Wien Filter" no Lorentz force
→ **Indirect** EDM effect



In-plane polarization

- Modulation of horizontal spin precession in the RF Wien filter
- EDM's interaction with the motional electric field in the rest of the ring

→ continuous buildup of vertical polarization in a horizontally polarized beam.

→ **net effect due to EDM**

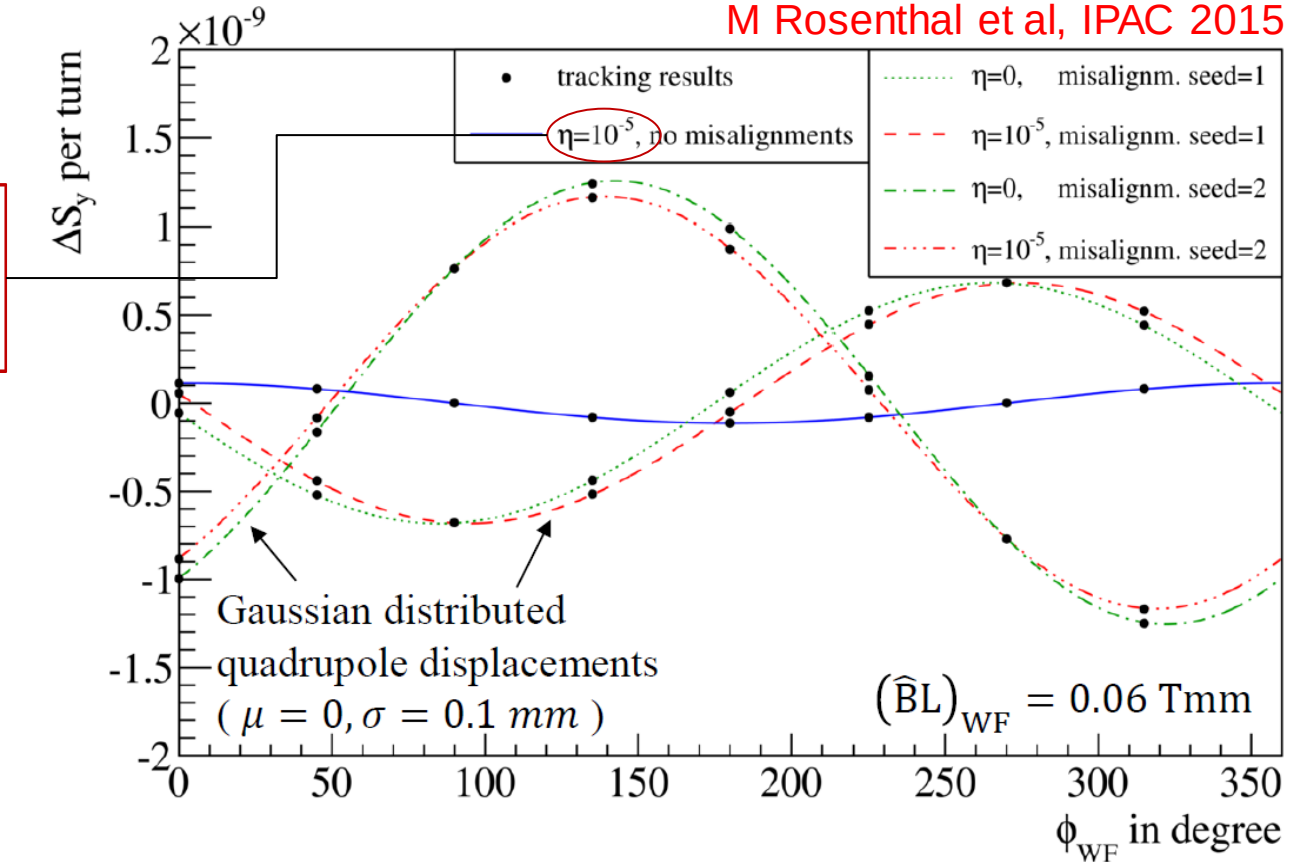
→ Investigation of sensitivity and systematic limitations

Concept for first measurements

Simulations with COSY-INF. and RF Wien filter (E_x, B_y) in EDM buildup mode.

M Rosenthal et al, IPAC 2015

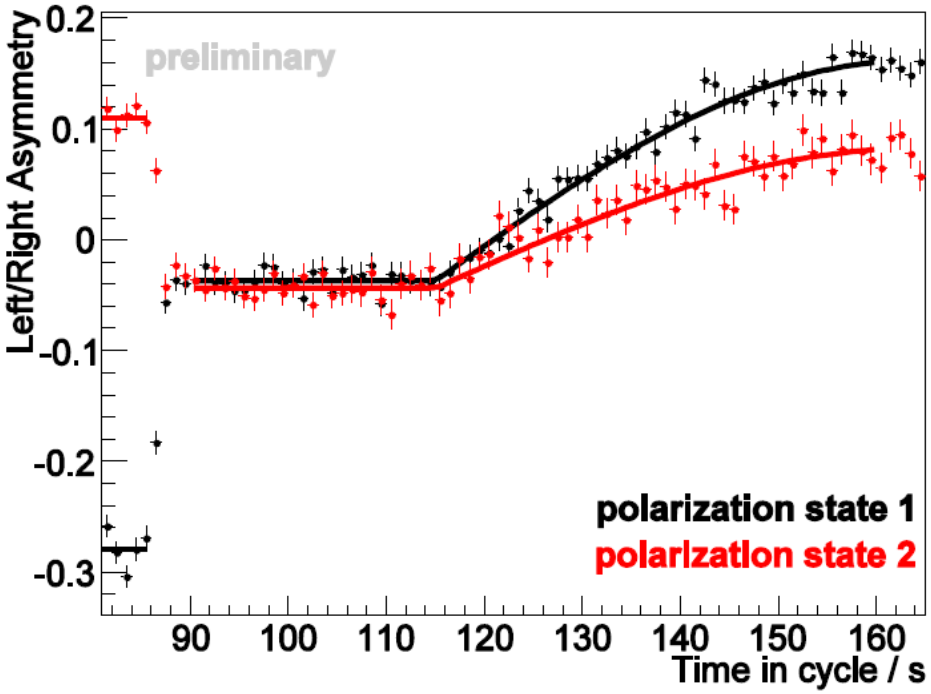
$$\vec{d} = \frac{\eta q \hbar}{2mc}\vec{S}$$
$$d = 5 \cdot 10^{-20} \text{ e cm}$$

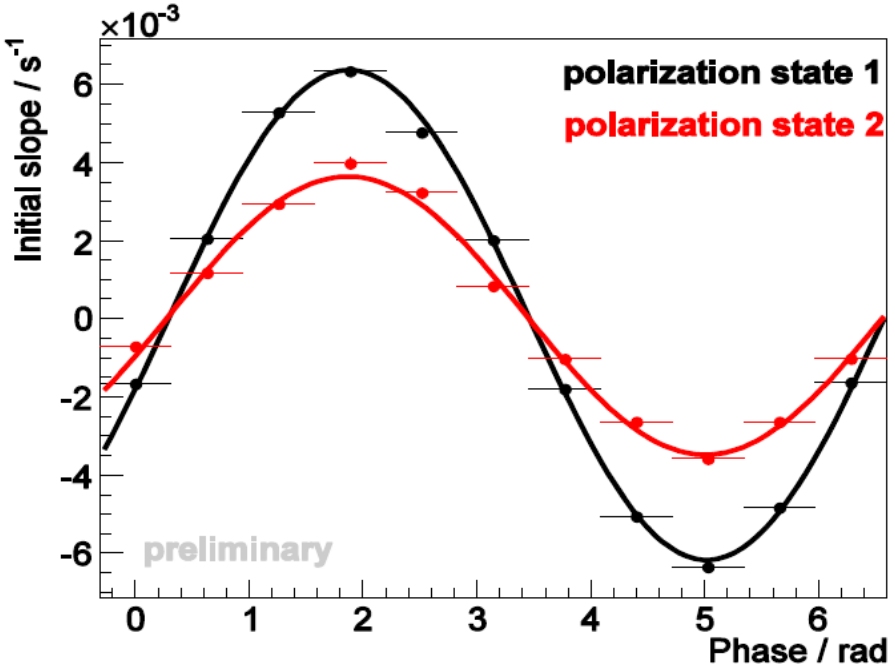


EDM hidden underneath imperfections from magnet misalignments.

Courtesy: M. Rosenthal

Spin-tune Based Feedback System



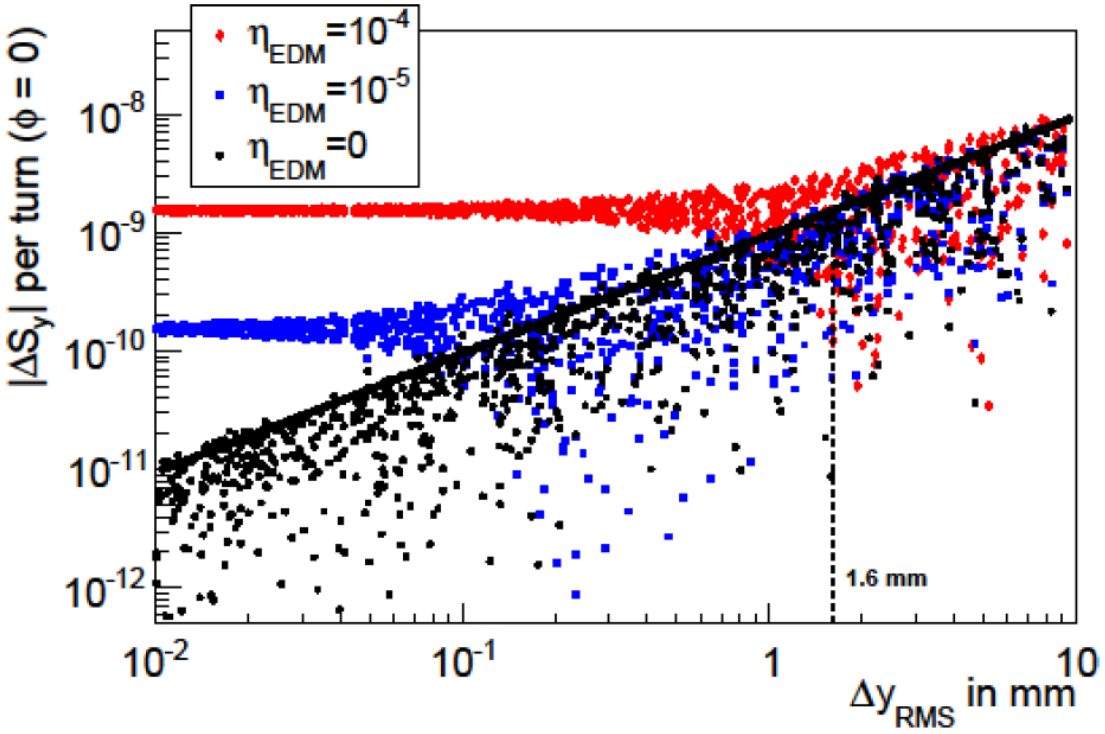


Left/right asymmetry as a measure of the vertical polarization. At t=85 s the spins are rotated into the horizontal plane, at t=115 s the solenoid is turned back on. The absolute values for the build-up for the two states are different as the initial polarization differs.

Initial slope of the polarization build-up as function of the relative phase (online result). The difference in amplitude is due to the different degrees of polarization of the two initial states.

Courtesy: V. Hejny

Systematic Limitations for EDM Measurements at COSY



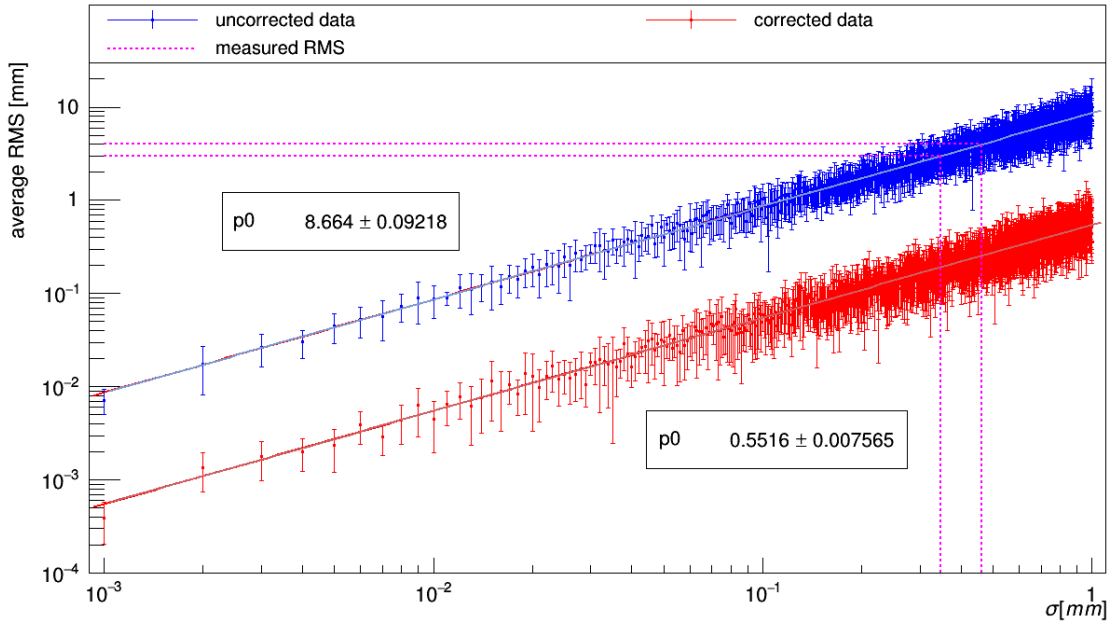
Absolute average change of the vertical spin component ΔS_y per turn for different Δy_{RMS} and an initial Wien filter phase 0°. Utilized Wien filter magnetic field: 10^{-4} mT and corresponding electric field with a length of 0.8 m. Different Δy_{RMS} generated by randomized vertical quadrupole shifts assuming Gaussian distributed misalignment errors. Solid line shows the 90% upper confidence limit for pure misalignments. Dashed line refers to the location for which the false signal by misalignments is equal to an EDM signal corresponding to $\eta_{EDM} = 10^{-4}$.

This value corresponds to an EDM magnitude of $d_d \approx 5 \cdot 10^{-19}\ e$ cm.

Courtesy: M. Rosenthal

Preparation for Improved Closed-Orbit Correction

Horizontal closed-orbit

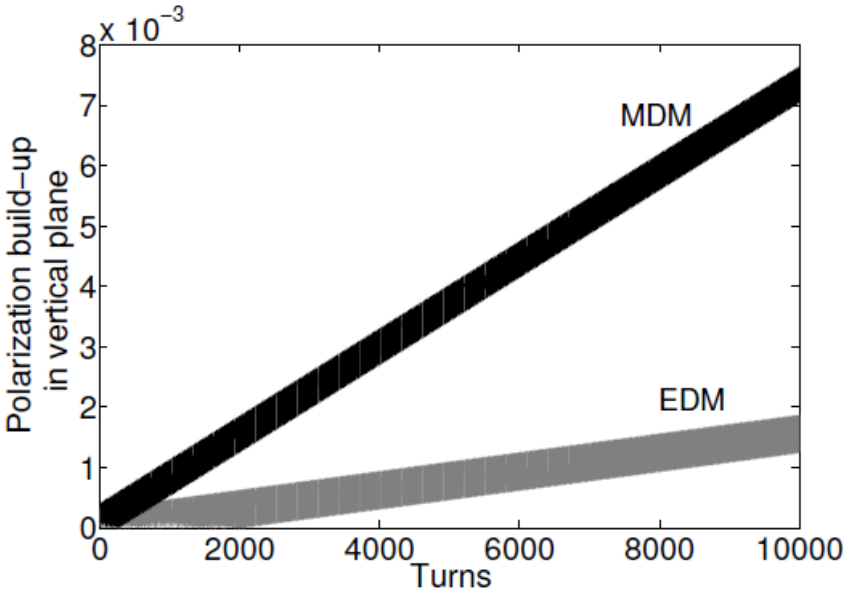


Random positioning and rotation errors of dipoles and quadrupoles Gaussian distributed. For each point 1000 seeds. Dashed line: measured “rms” orbit at COSY. p0: slop of linear fit.

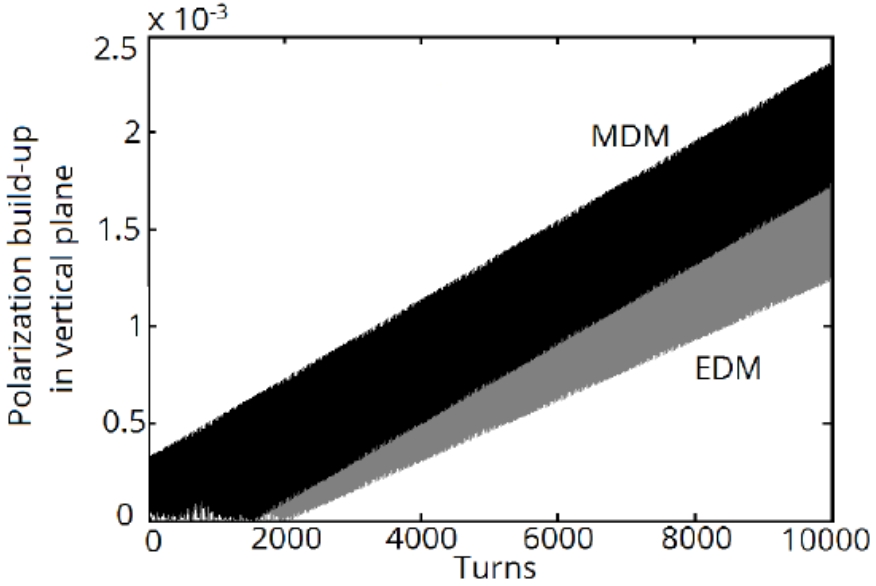
Courtesy: V. Schmidt

New survey of COSY has been provided and discussed.
Alignment procedure will be performed soon.
Upgrade of beam position monitor electronics also in preparation.

Simulation of Resonance Method (Mode)



Black: Misalignments of magnets by 0.1 mm (mrad)
Grey: EDM of $2.6 \cdot 10^{-19}$ e cm



Black: rotation RF Wien filter by of 10^{-4} rad
Grey: EDM of $2.6 \cdot 10^{-19}$ e cm

Error sources:

Magnet misalignments

Wien filter:

- rotation of 10^{-4} rad with respect to invariant spin axis
- relative mismatch between RF Wien filter frequency and the spin resonance frequency of 10^{-5}

→ EDM in the order of $d = 10^{-19}$ e·cm

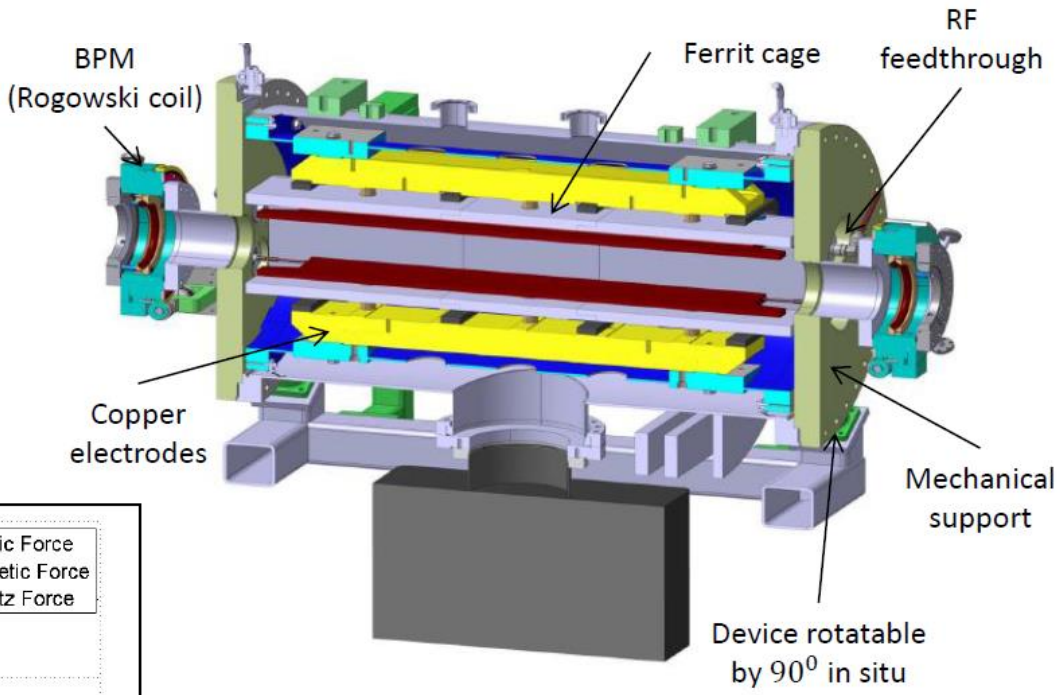
Courtesy: Stas *Chekmenev* (FZJ)

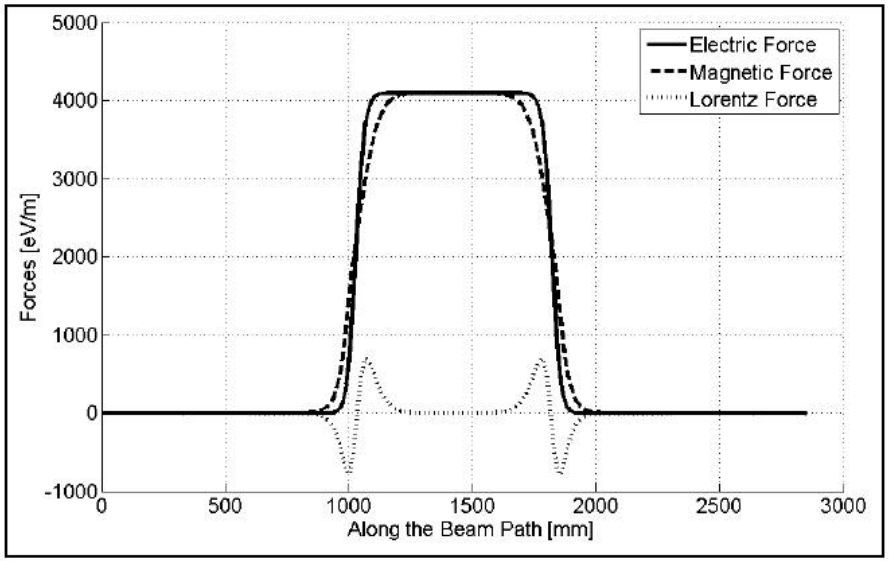
RF $E \times B$ Wien Filter: Strip Line Design

Strip line design provides $\vec{E} \times \vec{B}$

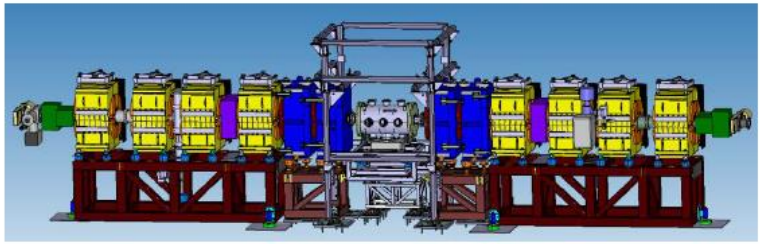
$$\int_{-L}^{L} B_y dz = 0.02371 \text{ Tmm}$$

$$F_L = \frac{1}{2L} \int_{-L}^{L} F_L dz = 1.8 \cdot 10^{-4} \frac{\text{eV}}{\text{m}}$$





Device will be installed in PAX low-β section



In cooperation with RWTH Aachen

Conclusion

RF Wien filter development will be available next year

Required orbit distortion proven by beam and spin tracking

- New survey of COSY has been provided and discussed.
- Alignment procedure will be performed soon.
- Upgrade of beam position monitor electronics also in preparation.


Thank you!