

BEAM-BASED ALIGNMENT AT COSY Prerequisite for an EDM measurement

July 1, 2019 | <u>Tim Wagner</u>¹, Andrzej Magiera², on behalf of the JEDI Collaboration ¹ IKP-2, Forschungszentrum Jülich, ²Institute of Physics, Jagiellonian University, Kraków







OVERVIEW

- Why is beam-based alignment needed?
- Working principle of beam-based alignment
- Results of the last beam time A15
- Explanation of measurement plan
- Beam time request



WHY IS BEAM-BASED ALIGNMENT NEEDED?

- For an EDM measurement the orbit has to be as good as possible
- Orbit RMS should be lower than 100 μm \rightarrow Orbit Control
- Goal is to go central through all magnets (i.e. quadrupoles)
- Thus BPM to quadrupole offset has to be known
 - \rightarrow Beam-based alignment





- Use beam to optimize the beam position
- Vary quadrupole strength
- Observe orbit change
- Try to minimize the orbit change





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How does the orbit change when varying the quadrupole strength?

$$\Delta x(s) = \frac{\Delta k \cdot x(s_0)I}{B\rho} \cdot \frac{1}{1 - k \frac{I\beta(s_0)}{2B\rho \tan \pi \nu}} \cdot \frac{\sqrt{\beta(s)}\sqrt{\beta(s_0)}}{2\sin \pi \nu} \cos[\phi(s) - \phi(s_0) - \pi \nu]$$

Not possible to calculate x(s₀) due to lack of precise knowledge of all other parameters

$$f = rac{1}{N_{ ext{BPM}}}\sum_{i=1}^{N_{ ext{BPM}}} \left(x_i(+\Delta k) - x_i(-\Delta k)
ight)^2 \propto \left(rac{m{x(s_0)}}{m{s_0}}
ight)^2$$

• By finding the minimum ($f \rightarrow 0$) the optimal beam position can be found



BEAM-BASED ALIGNMENT MEASUREMENT SO FAR

A15 February beam time, 12 quadrupoles

- 4th until 10th February planned
- 6th until 11th February measured due to issues with COSY dipoles
- Measurement for all 12 quadrupoles could be completed





RESULTS

Examples for the fits



RESULTS

Optimal position of the beam within the quadrupoles





RESULTING BPM CALIBRATION

BPM name	Horizontal correction	Vertical correction
BPM02 (s = 10.4 m)	$(1.705\pm0.008)\text{mm}$	$(0.416\pm0.005)\text{mm}$
BPM06 (s = 29.5 m)	(1.371 \pm 0.007) mm	$(3.382\pm0.011)\text{mm}$
BPM18 (s = 100.2 m)	(4.177 \pm 0.007) mm	(1.308 \pm 0.005) mm
BPM19 (s = 110.1 m)	(1.868 \pm 0.005) mm	(3.273 \pm 0.010) mm
BPM20 (s = 123.3 m)	(2.149 \pm 0.007) mm	(0.281 \pm 0.007) mm
BPM21 (s = 133.2 m)	(2.232 \pm 0.008) mm	(1.430 \pm 0.006) mm

Resulting orbit improvement from $RMS_y = 1.21 \text{ mm}$ to 1.01 mm with only 20% of the BPMs calibrated.



MEASUREMENT FOR ALL QUADRUPOLES

- New power supplies bought
- All quadrupoles will be equipped with connectors for the power supplies
- "Plug and play" system can be operated by nearly everyone
- Faster change of quadrupole during the measurement and also possible at any time





BEAM TIME REQUEST

Time requirement

- Measurement of 12 quadrupoles took 1 week
- Extrapolating for 56 quadrupoles would lead to 4.5 weeks
- Faster switching of quadrupoles should make it possible in 3 weeks
- Add one week MD to have a buffer in case something goes wrong like last time



We would like to request **three weeks** of beam time (plus **one week MD**) to perform the beam-based alignment measurement and calibrate all BPMs in COSY.

