Precise Transfer Measurement of the Magnetic Axis to outside Monuments

Y. Holler, B. Krause, A. Petrov, J. Prenting, M. Schloesser, Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany

Introduction

The mechanical frame of the new octant of the PETRA III machine is built up of eight repetitive units of four girder each. Each girder carries three magnets as the main components. The accuracy of the quadrupole magnet axis with respect to the beam must be within 100 µm (± 50 µm on average). Therefore a new, precise method for the transfer of the quadrupole magnetic axis to outside survey monuments was developed:

The magnetic axis is determined by the rotating coil method: The coil is shifted until the measured dipole component is minimal. Two optical tooling targets are placed directly onto the coil ends. While the coil rotates slowly the target describes a circle. The center of multiple circles define the rotating axis of the coil in a very precise way. The axis is then transferred to several outside monuments using two laser trackers. This method reduces the errors because the magnetic measurement and the survey alignment is done in one step.

Girder layout: Two short quadrupole magnets (PQK) and a dipole magnet

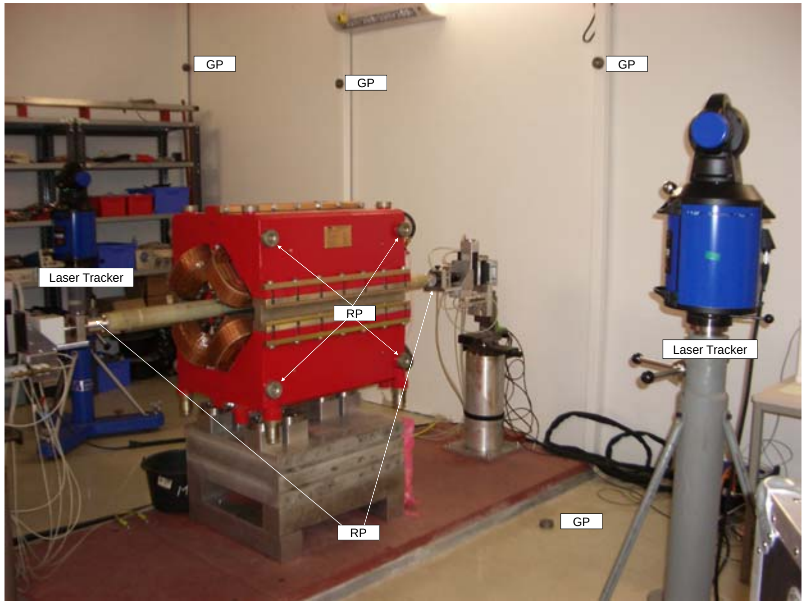
Long quadrupole magnet PQL

Short quadrupole magnet PQK

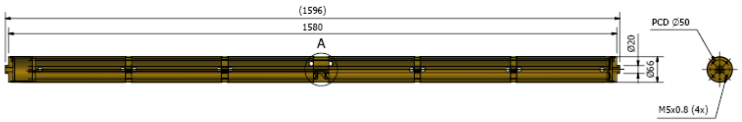
Quadrupole magnets of "eight" type with a length of 0.44 m (78 magnets) and 0.72 m (19 magnets) were built. Their gradient is G=21.5 T/m and their apertures are 2ao=70 mm. The tolerances for the integral field nonlinearity in the good field region (ro < 25 mm) is less than 0.0005.

	Quadrupole PQK	Quadrupole PQL
Field gradient, T/m	21,2	21,2
Length of magnet yoke, m	0,44	0,72
Aperture radius, mm	35	35
Good field region, mm	Ø 50	Ø 50
Field quality, $\Delta B/B_0$	$5 \cdot 10^{-4}$	$5 \cdot 10^{-4}$
Rated current, A	190	190
Voltage drop, V	17	25
Power consumption, kW	3,4	4,5
Conductor dimensions	9x9-Ø5	9x9-Ø5
Magnet weight	990	1560

Main parameter of the quadrupole magnets PQK and PQL

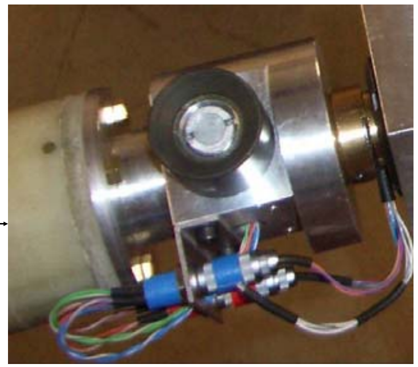


Experimental set-up for the measurement of the magnetic parameters with the rotating coil and simultaneous surveying the magnetic axis to the outside monuments (RP) sitting on the magnet.

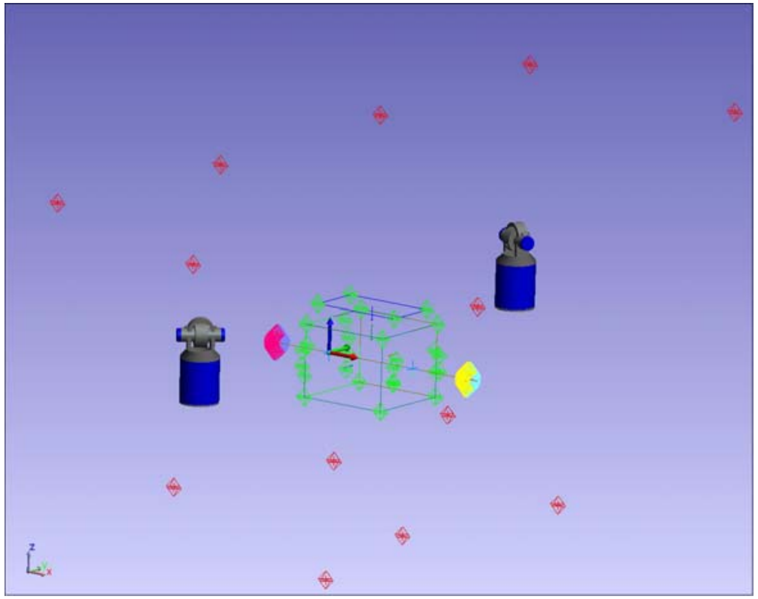


Drawing of the rotating coil made by Danfysik

Rotating coil



Optical tooling holder sitting on the rotating coil support structure



The coil is at both ends supported by remotely controlled cross tables with resolution in horizontal as well as vertical direction of 2.5 µm (Linos Photonics, Germany).

It is driven by a stepping motor (Phyton, Germany) with rotational speed of 1 Hz.

The coil support stand

Target for surveying the geometric axis as a plausibility check

Conclusion:

A new precise method for determine the magnetic axis of a quadrupole magnet was introduced. Plausibility and reproducibility checks have shown that the individual magnetic quadrupole axis could be transferred to the outside survey monuments with an accuracy of σ < 21 µm.

The later magnet alignment on the girder (magnetic axis to magnetic axis) has to be in the range of σ < 50 µm that is achievable with our girder design based on simple and cost-efficient adjustment elements for the magnets.