Beam Deflection in PANDA-Dipole Magnet

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Dimensions of the HESR beam-line in the PANDA region were defined in April 2013 by Raimund Tölle:

There are 3 dipole magnets which form a chicane (a figure of the set-up is shown on the following page). The deflection angles of these dipoles are

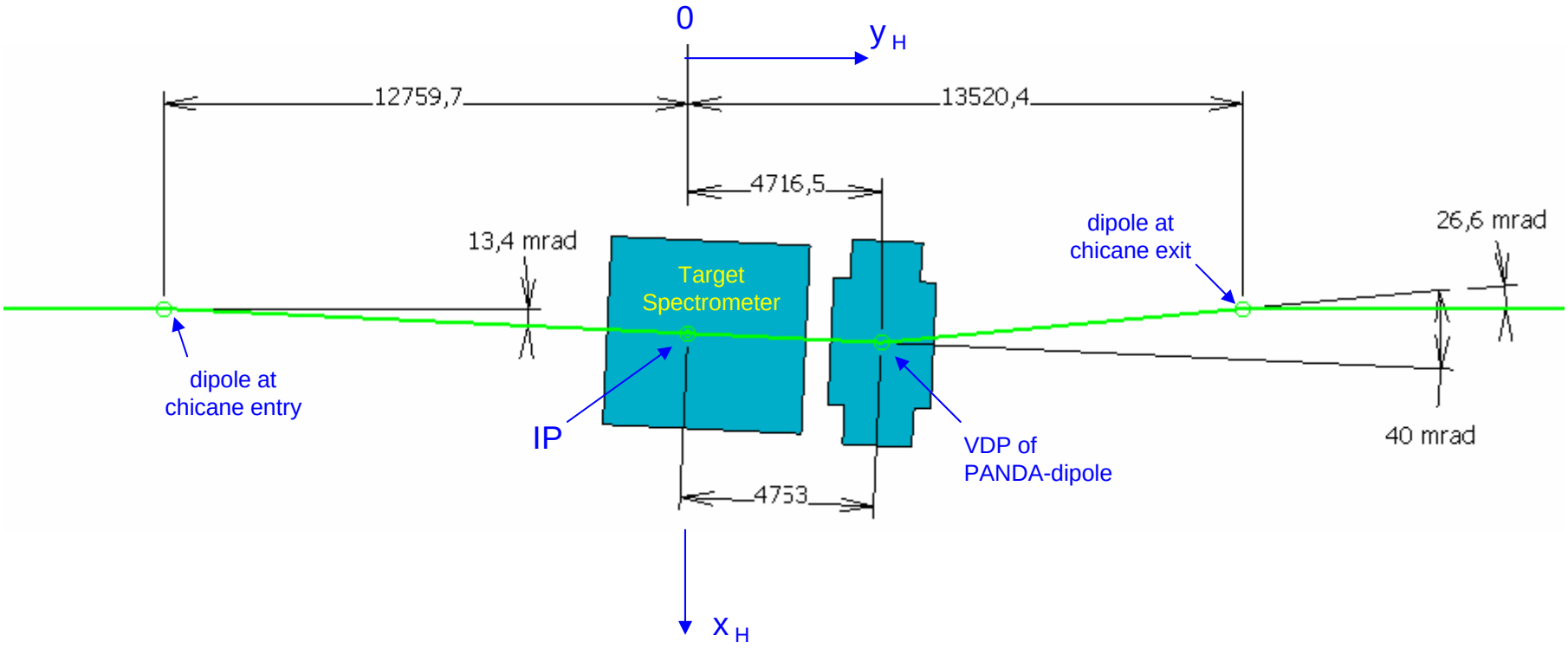
- -13.4 mrad (at chicane entry)
- +40.0 mrad (big PANDA dipole)
- -26.6 mrad (at chicane exit)

Extrapolating the straight beam line at the entry of a dipole and the straight beam line at the exit an intersection point (virtual deflection point, abbreviated VDP) can be found. The nominal positions of these points for the 3 dipoles (in meters of the HESR-coordinate system, where y_H is not the vertical direction but the south-to-north direction), are:

- x_H = 46.2940, y_H = -12.7597 (chicane entry)
- x_H = 46.5282, y_H = 4.7165 (big PANDA dipole)
- x_H = 46.2940, y_H = 13.5204 (chicane exit)

The position of the PANDA-IP (target) is slightly below the x-axis of the HESR, at y_H = -0.0361 m (x_H = 46.4645 m). It follows that the nominal distance between the IP and the VDP of the big dipole is 4.7526 m (= z_{PANDA} = 4.7165 m + 0.0361 m).

This value is needed for design and installation of the curved dipole beam tube.



PANDA-chicane, linear dimensions in millimeters

For a better understandability the angles are shown disproportionately. The actual angles are smaller.

Actual Position of Virtual Deflection Point depends on Dipole Current

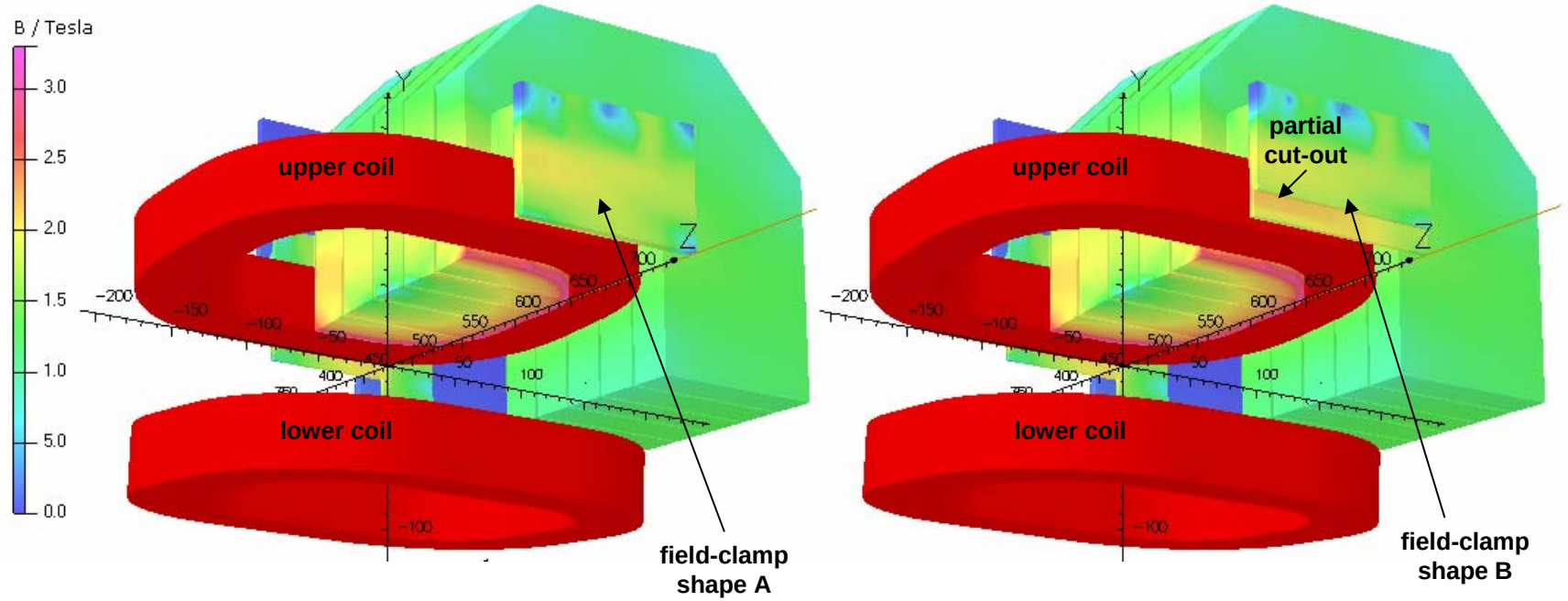
Unfortunately the VDP in the PANDA dipole is not constant. Entry and exit of the dipole are not symmetric.

Due to asymmetric saturation in the iron (mainly in the field clamps) the position of the VDP depends slightly on the dipole current.

The actual position of the VDP has to be found by field measurements.

The variance of the position may be estimated by two slightly different FEM-models which are shown on the following page:

Two Slightly Different FEM-Models of the PANDA-Dipole

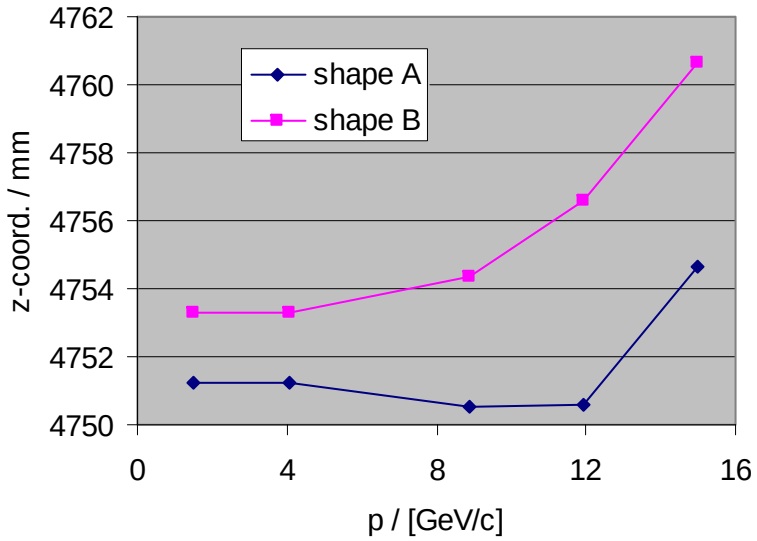


Dipole models, view from the exit side. For symmetry reasons only one quarter of the iron was considered. Where the color is yellow the field in the iron is 2 Tesla.

The only difference between the models is the field clamp on the exit side (s. shape A and shape B). In shape A, the whole field clamp is 8 cm thick. In shape B, the field-clamp is also 8 cm thick but with a partial cut-out at the lower side.

The difference is just an example. Not only the shape but also different material properties (carbon content in steel / iron) can cause asymmetric saturation.

Two Models: Position of Virtual Deflection Point versus Dipole Current



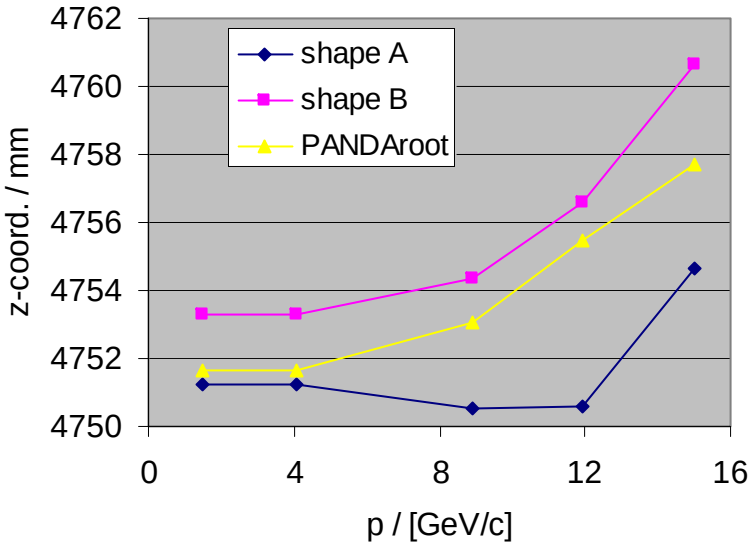
For shape A, the z-position of the VDP changes from 4751 mm @ 4 GeV/c to 4755 mm @ 15 GeV/c.

For shape B, the z-position changes from 4753 mm @ 4 GeV/c to 4761 mm @ 15 GeV/c.

For the latter case, when ramped from 3.7 GeV/c to 15 GeV/c, the parallel displacement of the beam at the exit of the big dipole would be 0.32mm (= 8mm * 40mrad).

Position of Virtual Deflection Point in PANDA field maps

The field maps for the PANDA dipole were cut at z = 660 cm, although the field is not near zero beyond. If assumed that the beam will already be deflected by 40 mrad at the cut the VDP is not so different from the 2 models shown before (s. yellow points in the following diagram).



After the field maps were generated the design of the dipole was slightly modified. In order to further reduce stray fields the field-clamps both at entry and exit were made a little bit thicker. These changes were already taken into account in the 2 FEM-models presented before.

Looking at the diagram above, in respect of the VDP, there seems to be no urgent need to change or add anything in the old dipole field maps.