The HADES alignment strategy*

V. Pechenov,[1] *O. Pechenova*[2] *and J. Markert*[2] *for the HADES collaboration*
[1]GSI, Darmstadt, Germany; [2]Goethe Universität, Frankfurt, Germany

To achieve the required momentum resolution of the HADES [1] spectrometer a precise alignment of the detectors is necessary. A set of global alignment parameters of detectors and intrinsic alignment parameters describing detector specific intrinsic geometry are obtained by several procedures:

1) photogrammetric alignment of the MDC [2] plane II with respect to the magnet by means of the Photomodeler software [3]. 2) alignment with reconstructed particle tracks (tracker alignment). Global and intrinsic geometric parameters with respect to the MDC plane II by MillepedeII [4] software. 3) tracker alignment for the RPC, TOF, Shower detectors.

A common problem of tracker alignment algorithms is that the total track χ^2 without constraints is mostly insensitive to so-called "scaling" and "shearing" (fig. 1) of the detectors. To overcome this effect in unconstrained modes [5] we focus on the following prescriptions: (i) take into account the measurements for MDC modules from technical drawings, (ii) define space position for MDC plane II with high accuracy (few hundred micrometers) by photogrammetric alignment, (iii) use MDC plane II as strong constraint, (iv) use simultaneous beam and cosmic tracks.

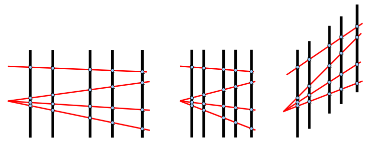

Figure 1: Unconstrained tracker alignment is insensitive to "scaling" and "shearing". Black: detector planes, red lines: reconstructed tracks.

The Photomodeler [3] photogrammetry software provides image-based modeling and accurate measurement to survey objects in 3D. Dedicated markers are positioned on the detector such that they can be resolved with high accuracy in the taken photos for the MDC plane from various views. After processing the space position of the markers including errors are extracted and the planes of the detector frames fitted by a software procedure. Translation and rotation matrices of the MDC module relative to the magnet are obtained and constrain the position of MDC II. These parameters are fixed for the following tracker alignment.

The set of parameters can be classified into alignment and local parameters. Local parameters characterize tracks of charged particles traversing the detector. The main goal of the alignment is to find the optimum values of the alignment parameters. The software package Millepede solves the linear least squares problem by a simultaneous fit of alignment and local track parameters using the last iteration [4] of the track fit only. The alignment procedure adjusts around 500 parameters simultaneously.

The sector to sector alignment is performed using arround 200000 tracks of each cosmic ray and beam data. A straight-line-track model is used for the fit. For the last iteration of the track fit Millepede requieres the partial derivatives provided by the tracking procedures. Due to nonlinearities of the alignment parameters the procedure converges after around 10 iterations to the optimum parameters for translation and rotation of the MDC modules, the orientation of the wires, the layer coordinates and the distance between two layer parts. In simulations the procedure reconstructed an arteficially introduced misalignment by a precision of 25 μm.

The tracker alignment for TOF and RPC detector determines the global alignment and calibration parameters simultaneously using an iterative procedure.

The resulting intrinsic parameters of the tracking detector were found in the range of 100-550 μm for the clearance between two parts of the layer, 0.00-1.03 mrad for the wire orientation in the layer and 50-700 μm for the wire number corresponding to physical center of layer.

A significant improvement has been observed in the track reconstruction compared to an alignment procedure using global parameters for the detectors only. The number of fitted MDC track segments and the number of accepted drift cells per fitted segment were increased at a better value of χ^2/ndf for the fitted segment. As physics observable the peak width of the invariant mass of the direct decays of ω-mesons [7] decreased by a factor of two.

References

[1] G. Agakishiev *et al*. The High-Acceptance Dielectron Spectrometer HADES. Eur. Phys. J. A41 (2009)

[2] C. Müntz *et al*. Nucl. Instr. Meth. A535 (2004) 242.

[3] http://www.photomodeler.com/

[4] V. Blobel. Software alignment for tracking detectors. Nucl. Instr. Meth. A566 (2006) 5-13.

[5] J. Amoraal. Application of vertex and mass constraints in track-based alignment. Nucl. Instr. Meth. A712 (2013) 48-55.

[6] http://seal.web.cern.ch/seal/work-packages/mathlibs/minuit/

[7] G. Agakishiev *et al*. Eur.Phys.J. A48 (2012) 64

* supported by GSI, BMBF (06FY9100I), Helmholtz Alliance EMMI, HIC for FAIR