The 2D-ACAR spectrometer at MLL Hall 2

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Abstract

Angular Correlation of Annihilation Radiation (ACAR) is a well established technique for the investigation of the electric structure. A 2D-ACAR spectrometer has been set up in the experimental hall 2 of the MLL. In this article the principle of 2D-ACAR measurements and the experimental setup are presented.

2D-ACAR PRINCIPLE

In an ACAR experiments the deviation from the anti-parallel propagation directions of the two electron positron annihilation quanta is measured. This way, using spatially resolved detectors, two dimensional projections of the electron-positron momentum density can be measured, which can be used to reconstruct the three dimensional electron momentum density of the sample.

EXPERIMENTAL SETUP

The 2D-ACAR spectrometer consists of two main components, the source-sample chamber including the sample environment, and the detector assembly consisting of two Anger-type γ-cameras [1], which were obtained from the positron group of Bristol university. A total view of the spectrometer is given in figure 1 and a detailed view of

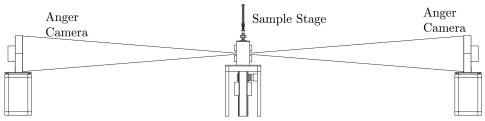

Figure 1: Side view of the 2D-ACAR spectrometer. Baseline 16.5 m

the source-sample chamber is presented in figure 2. The positrons are emitted from a ^{22}Na source deposited on a Ta reflector inside a standard source capsule. A Ta backening is used to increase the emission of positrons. The position of the source capsule and the sample are symmetric with respect to the pole pieces of the electromagnet. A source and sample distance of 20 mm was chosen, as this value turned out to be optimal with regard to the background produced by the source itself and the positron transport from the source to the sample.

To produce the guiding field two custom build soft-iron pole pieces are used. The layout of the pole pieces was developed using the FEM physics simulation toolkit COMSOL. The two Anger cameras are positioned symmetrically at a distance of 8.25 m to the source-sample chamber. As the typical angular correlation lies in the order of milliradians, a long baseline is needed to resolve such small angles. The cameras consist of a large 44 cm diameter NaI:Tl scintillation crystal with a thickness of 10.5 mm coupled to 61 photomultiplier tubes. The angle between the two annihilation quanta is then calculated from the impact positions on the detectors.

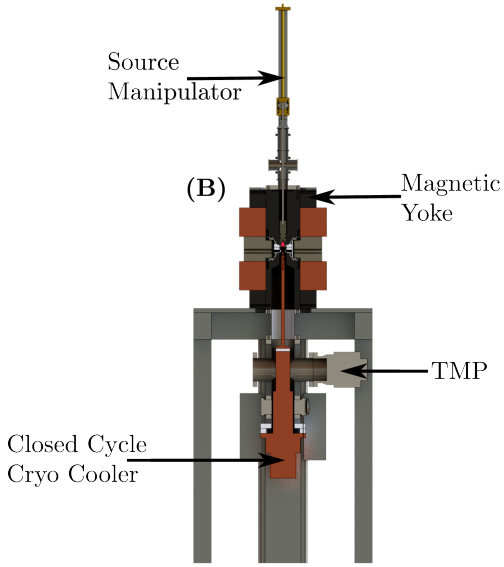

Figure 2: Cut through the source-sample chamber.

RECENT EXPERIMENTS

Since the spectrometer went into operation several studies of the electronic structure have been conducted. A 2D-ACAR measurement of delocalised positronium in α-Quarz together with a detailed description of the setup and its performance can be found in [2]. 2D-ACAR measurements on the electronic structure of chromium [3] and copper [4] revealed interesting physics in both systems (for details refer to the cited articles).

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