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A straw tube detector for the $\overline{\text{P}}$ANDA experiment

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Summary. — The $\overline{\text{P}}$ANDA experiment will be built at the FAIR facility in Darmstadt (Germany) to perform accurate tests of the strong interaction through $\overline{p}p$ and $\overline{p}A$ annihilations. This paper will address the design issue of the Straw Tube Tracker (STT), one of the two options proposed for the $\overline{\text{P}}$ANDA Central Tracker.

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1. – Introduction

$\overline{\text{P}}$ANDA [1] is one of the major experiments that will be installed at the FAIR facility in the site of the GSI laboratory (Darmstadt, Germany). The fixed-target detector will be designed to achieve results with an unprecedented precision, in order to allow significant progresses in the understanding of the strong interaction and hadron structure.

2. – The Straw Tube Tracker (STT)

The Straw Tube Tracker (STT) is one of the two options proposed as Central Tracker for the $\overline{\text{P}}$ANDA detector. It is sensitive to the passage of charged particles and used to determine their position, momentum and energy loss with high resolution.

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The tracker will consist of planar closed-packed, self-supporting double layers of straw tubes arranged in a hexagonal layout, that has to fill up a cylindrical volume with an inner and outer diameter of 15 cm and 41.8 cm, respectively, and a length of 150 cm. The proposed layout will have 4636 straw tubes, arranged in double layers parallel to the detector axis and double layers skewed by $\pm 2.89°$ with respect to the axial straws.

A detailed description of the planned tracker can be found in [2].

3. – Prototype tests

In order to study the mechanical properties and assembly techniques of the hexagonal straw layers stack, more than 2000 straw tubes have been assembled in a first (incomplete) full-scale prototype, at the Jülich Research Center (IKP–FZJ, Germany).

In addition, to develop calibration techniques for the $\overline{\text{P}}$ANDA STT, to understand signal formation, to optimise the matching of the straws with the electronics and to investigate the potentiality of the tracker in particle identification based on energy loss measurements, experimental tests have been performed with setups similar to the $\overline{\text{P}}$ANDA STT.

A small one, consisting of 128 $\overline{\text{P}}$ANDA-like straws arranged in 4 double layers, has been operated to investigate energy loss resolution by means of monoenergetic proton beams extracted from the COSY syncrotron of the IKP-FZJ. From the data analysis with the truncated mean procedure, an energy resolution ranging from 7% to $\sim 9\%$ for protons at $0.64\,\text{GeV}/c$ and $2.85\,\text{GeV}/c$, respectively, has been obtained.

Further experimental tests have been performed with the COSY-STT, the Straw Tube Tracker of the COSY-TOF experiment, consisting of 2704 $\overline{\text{P}}$ANDA-like straw tubes.

A dedicated autocalibration procedure to obtain the isochrone radius - drift time information, easily adaptable for the $\overline{\text{P}}$ANDA STT, has been implemented and tested with the available experimental data. In addition, the single tube resolution has been estimated to be $\sim 140\,\mu\text{m}$. This result can be extrapolated to the $\overline{\text{P}}$ANDA-STT, where the tubes will be operated at a higher pressure (2 bar) and a better resolution is expected.

4. – Simulations

In preparation for the $\overline{\text{P}}$ANDA experiment, large-scale Monte Carlo simulations are ongoing to determine the optimal detector design that allow to reach the best performances in terms of geometrical acceptance, momentum resolution and tracking efficiency.

First of all, the physical processes that govern the functioning of a straw tube, from the electron drift, to the charge multiplication and collection, to the signal formation have been implemented in PandaROOT, the $\overline{\text{P}}$ANDA computing framework.

The tracker performances as a function of different geometric parameters have been investigated by using single-track events at different momentum values and by studying benchmark channels covering relevant topics for the $\overline{\text{P}}$ANDA physics program [2, 3].

The simulation results, as well as the experimental tests, show that the proposed detector setup can fulfil the physics case and the performances are close to the design goal, thus demonstrating that a Straw Tube Tracker is feasible for $\overline{\text{P}}$ANDA.

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