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Searching for the Anomalous Internal Pair Creation in ^{8}Be

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In the 1950s, Devons et al. started to carry out experiments in light nuclei that aimed to measure the angular distribution of the relative angle in the emission of the leptons in the Internal Pair Creation (IPC) process. The results were consistent with the Model of Rose published in 1949. In 2016, Krasznahorkay et al. reported the breakthrough of an anomaly in the IPC of ^{8}Be. An unexpected angular correlation distribution in the emission of the pair e^+e^- was found in the isoscalar magnetic dipole transition (18.15 MeV state ($J^\pi = 1^+$, T=0) $\rightarrow$ ground state ($J^\pi = 0^+$, T=0)). According to theoretical calculations performed with the model of Rose, the angular correlation distribution drops quickly with the relative emission angle of the leptons. In contrast, the Hungarian group reported a peak-like behavior at large angles. This result has been interpreted as the signature of the emission of a previously unknown neutral isoscalar particle with a mass of $16.70 \pm 0.35(\text{stat}) \pm 0.5(\text{syst})$ MeV/c^2 and $J^\pi = 1^+$.

The present work reports the development of a dedicated array to study this anomaly at the Laboratori Nazionale di Legnaro (Istituto Nazionale di Fisica Nucleare, Italy). The project aims to measure the angular correlation distribution of the emission of the pair e^+e^- from the transition studied in ^{8}Be at the Atomki Laboratories. The detector unit is a telescope manufactured with the plastic scintillator EJ200. The in-beam commissioning of the setup demonstrated that the array is able to measure the lepton pair in coincidence and reconstruct the energy of the electromagnetic transition in the IPC process. Furthermore, the ΔE layer consists of a system of a double layer of 10 bars designed to detect the incident position of the particles. The IPC of the transition $0^+ \rightarrow 0^+$ in ^{16}O has been studied as a first case. This transition is used as a calibration point of the detectors since the cross-section is orders of magnitude higher than the one in ^{8}Be. During the end of November 2023 and the end of April 2024, the former experiments were carried out at the AN2000 Accelerator. LiF targets from 50-950 μm/cm^2 have been irradiated with a 1.06-1.09 MeV proton beam and a $\sim$500 nA current. The population of the state of interest and the integrity of the target were monitored with a 3×3 in^2 $LaBr_3$ detector. The preliminary results in the study of the isovector and isoscalar magnetic dipole transitions in ^{8}Be are shown.

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