Di-proton identification with positive detector of ANKE*

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Processes involving the deuteron, the simplest nucleus, has been studied intensively both experimentally and theoretically. This attracts special interest to processes in which in the final state a diproton (a proton pair with low excitation energy) is produced instead of a deuteron. This quasi-particle will be almost exclusively in the $^1S_0$ state and the reaction kinematics will be similar to processes with the deuteron.

First experiments with diproton detection at ANKE were performed with the forward detector (Fd) [1]. The emerging proton pairs were identified by evaluating the difference $\Delta_{\rm tof}$ between the times of flight measured with the hodoscope and those calculated from the particle momenta, assuming the particles to be protons [2].

The same method can be applied to the pairs recorded in the ANKE Positive detector (Pd). The Pd can identify each of the particles by the TOF between its Start and Stop scintillation counters. Use of $\Delta_{\rm tof}$ is complementary to this possibility. To measure the Start-Stop TOF the two protons must hit different Start and Stop counters, while the $\Delta_{\rm tof}$ criterion can be used as long as the two particles hit different counters in at least one of the counter groups.

To construct an absolute TOF difference one has to know the delays between the counter hits (we assume here that the channel size is known). The delays can be found using events with the particle type tentatively identified by the Start-Stop TOF. Such identification is possible on the basis of spectra of the raw meantimer difference since pion and proton peaks are clearly separated in such spectra built for each Start-Stop counter combination. The delays of every counter can be defined relative to one of them. Then, the delay between the i-th Start and j-th Stop counter is $\Delta_{ij} = \Delta_i^{Sa} - \Delta_j^{So}$, where the latter two delays are defined relative to the selected reference counter, and the total number of parameters is number of Start and Stop counters minus 1. The delays can be found then by minimizing the expression:

$$\chi^2 = \sum_{Sa,So} \frac{\left(T_i - T_j + \Delta_i^{Sa} - \Delta_j^{So} - \tau_{ij}(l,p,m)\right)^2}{\sigma^2},$$

where T_i, T_j are the times measured in i-th Start and j-th Stop counter and $\tau_{ij}(l,p,m)$ is the Start-Stop TOF calculated from the track length between the counters, the reconstructed particle momentum and the particle mass. The sum is constructed over all the Start-Stop counter combinations in the Pd acceptance. Since the χ^2 form is linear over its parameters, the minimization is equivalent to solving a system of linear equations.

In Fig. 1 the TOF difference $\Delta_{\rm tof}$ measured in Pd is compared with the corresponding difference $\Delta\tau(p_1,p_2)$ calculated under assumption of two protons detected. The proton pairs are located on the main diagonal and are clearly distinguishable from the other pairs of particles. The resolution

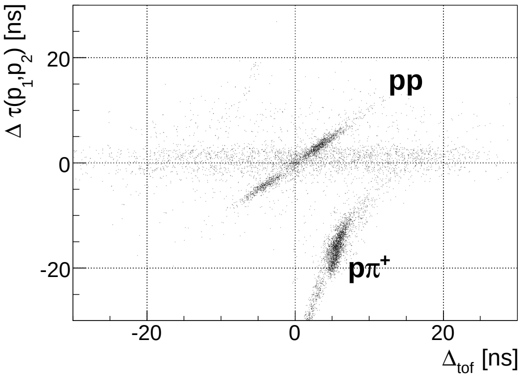

Fig. 1: Measured difference of times of flight of two particles $\Delta_{\rm tof}$ vs. calculated difference $\Delta\tau(p_1,p_2)$

of $\frac{1}{\sqrt{2}}\left(\Delta_{\rm tof} - \Delta\tau(p_1,p_2)\right)$ at 350 MeV proton beam energy is 0.45 ns. The M_X^2 distribution in the process $pp \to \{pp\}_s X$ is shown in Fig. 2 for the events with the diprotons identified by the $\Delta_{\rm tof}$ criterion. One can see two peak, one for single pion production located at $M_X^2 = m_{\pi^0}^2$ and a peak at $M_X^2 = 0$ formed by events from the $pp \to \{pp\}_s\gamma$ process.

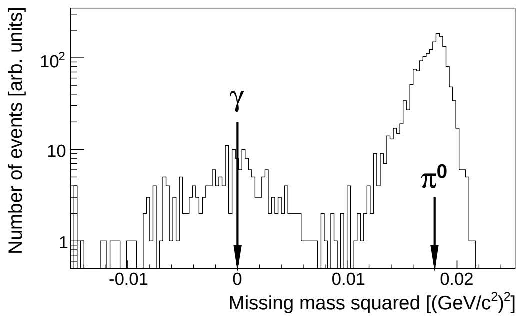

Fig. 2: Missing mass squared distribution in the $pp \to \{pp\}_s X$ process for selected proton pairs.

From such spectra it will be able to obtain the cross section for $pp \to \{pp\}_s X$ reaction over a large angular range.

References:

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