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The e^+e^- and $\pi^+\pi^-$ pair peak positions in the relative momentum components spectra

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Abstract

One of the main problem in the metastable $\pi^+\pi^-$ bound states observation in the DIRAC Experiment is the separation of π^+ and π^- pairs produced in Be target and pairs, produced by breakdown metastable atoms in Pt foil. Therefore we used a horizontal magnetic field to separate these $\pi^+\pi^-$ pairs. In this field the Q_y component of the relative momentum is significant larger for $\pi^+\pi^-$ pairs produced in Be target, as long as $\pi^+\pi^-$ pairs produced in the Pt foil have smaller Q_y. The present paper evaluate these Q_y values based on e^+ and e^- pairs produced in the Be target and e^+ and e^- pairs produced in the Pt foil. The particle pairs produced in the Be target have a mean value $Q_y \approx 12.7$ MeV/c and the pairs produced in the Pt foil have a mean value $Q_y \approx 2.3$MeV/c.

1. Introduction

The $\pi^+\pi^-$ (or e^+e^-) relative momentum components Q_x and especially Q_y, can provide useful information about the $\pi^+\pi^-$ metastable states (excited, long-lived atom). After production in the Be target some metastable atoms will decay and some others will break-up (see lower part of **Fig. 1**) in the Pt foil, producing n_A^{Pt} atomic pairs, the searched atomic pairs.

The horizontal magnetic field, which separates on Q_y the $\pi^+\pi^-$ pairs originating in Be target, is not zero in the Pt foil position. Therefore, the Q_y values of the particle pairs, produced in the Pt foil, have non-zero values. We used the Fujio Takeutchi's propoal to investigate the e^+e^- pairs, produced in Be and respective Pt foil, to evaluate the Q_y relative momentum component of the searched $\pi^+\pi^-$ particle pairs.

The main signal we are looking for is $\pi^+\pi^-$ metastable states by measuring the π^+ and π^- pairs produced by breakdown metastable states in the Pt foil. They have lower Q_y values. This paper shows the presence of a Q_y = 2.3 MeV/c peak and the parameters of this peak were calculated using e^+e^- pairs.

The analysis of the Q_y distribution of the e^+e^- pairs shows a large Q_y=0 MeV/c peak (see **Fig. 2**). It is mainly due to e^+e^- pair production by photons interaction with materials after magnet. In the same time, the Q_y=12.7 MeV/c peak (see **Fig. 2**) is due to the e^+e^- pair production before magnet.

In the $\pi^+\pi^-$ pairs analysis, the Q_y=12.7 MeV/c $\pi^+\pi^-$ pairs produced in Be target as atomic, Coulomb, non-Coulomb or accidental pairs (see **Fig. 1**) can produce a large background which can interfere with the signal of 2.3 MeV/c, produced by pairs from long-lived, metastable states, which break-up in Pt foil.

The influence of the possible source of background was investigated and contributions of the 0 MeV/c and 12.7 MeV/c peaks to the 2.3 MeV/c peak were evaluated.

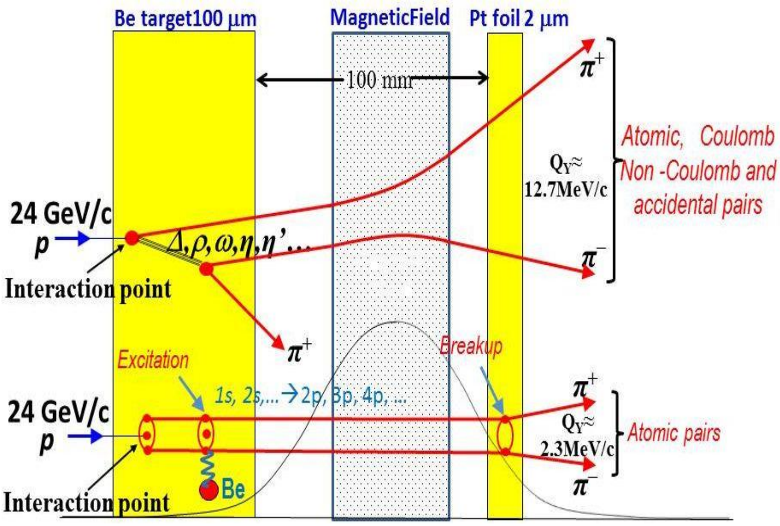

Figure 1. Production and observation of long-lived $A_{2\pi}$ atoms with break-up Pt foil

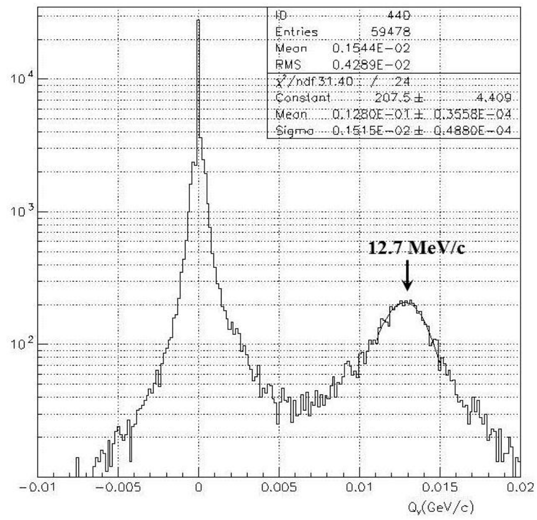

Figure 2. Q_y distribution of e^+e^- pairs

2. The analysis of the experimental data

The evaluation of the existence of the 2.3 MeV/c e^+e^- pairs peak was performed in 4 steps.

a) Check the symmetry in e^+e^- Q_x distribution (see **Fig.3**)

b) Check the asymmetry in e^+e^- Q_y distribution (see **Fig. 4**)

c) The asymmetry analysis by mirroring the Q_y=0 GeV/c peak with respect to Y axis and subsequent subtraction. A Gaussian fit shows a clear 2.3 MeV/c peak position (see **Fig. 5**)

d) Possible tail contribution of the 12.7 MeV/c peak on the 2.3 MeV/c peak background was investigated, (see **Fig. 6**)

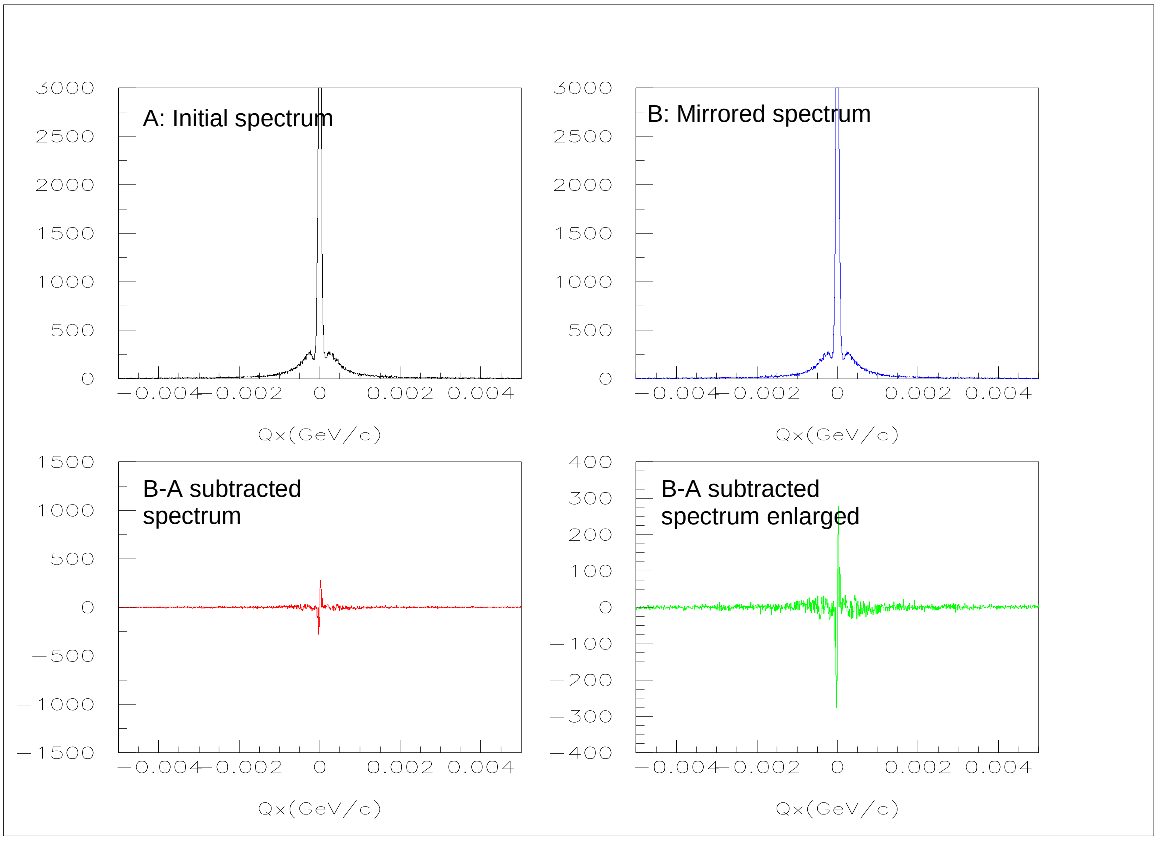

Figure 3. Check for the symmetry of the Q_x e^+e^- distribution (run 2012)

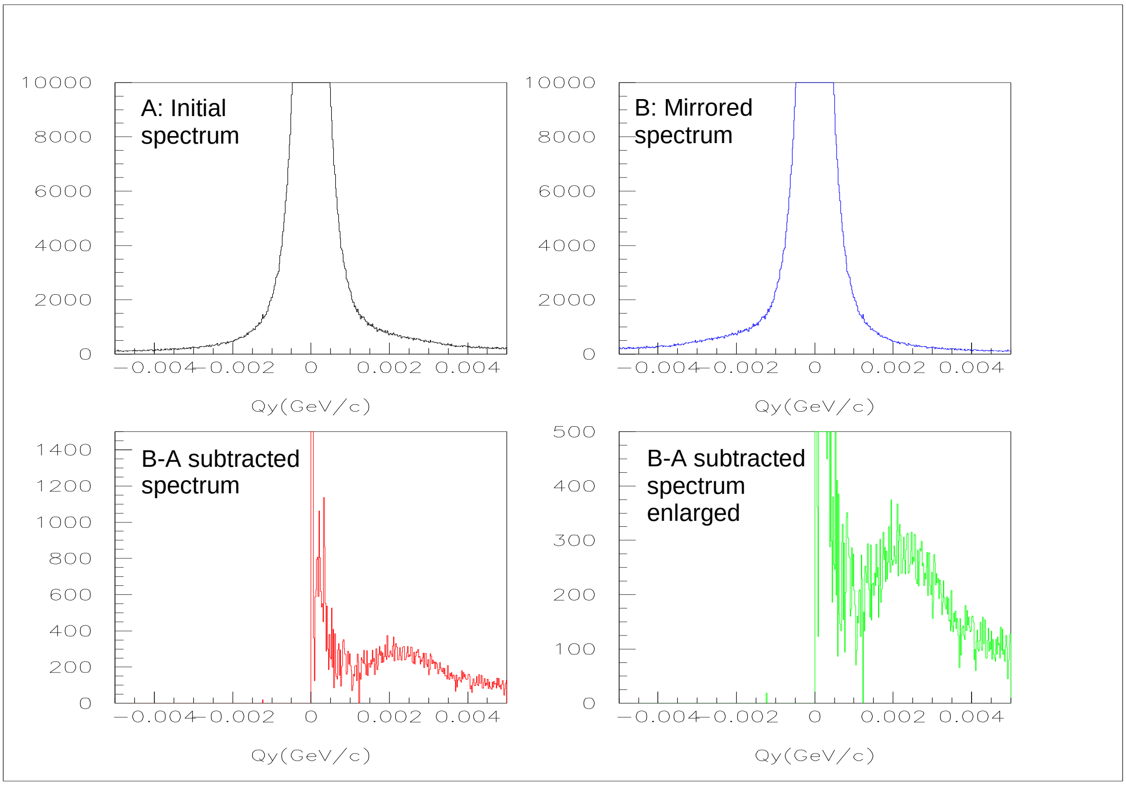

Figure 4. Check for the existence of the 2.3 MeV/c peak as an asymmetry in e^+e^- Q_y distribution

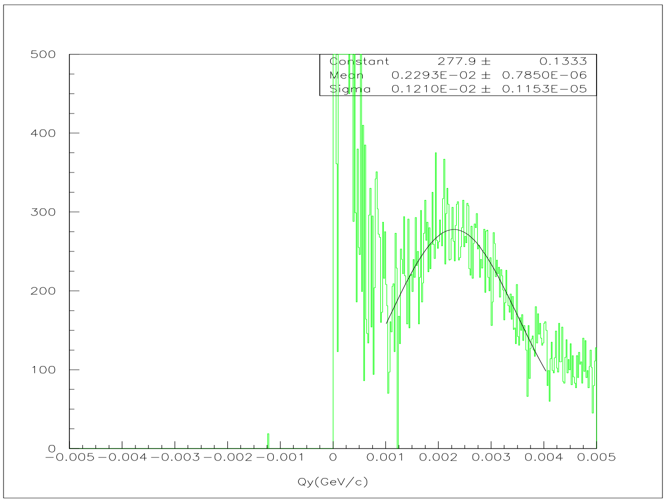

Figure 5. The 2.3 MeV/c peak identification using the mirroring (reversing) of the Q_y peak with respect to Y axis and subtraction; position and FWHM were extracted from Gaussian fit

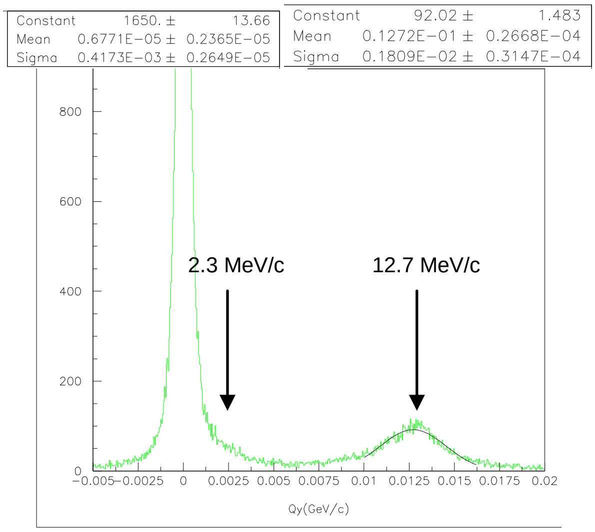

Figure 6 . Q_y e^+e^- peak structure

The Q_y e^+e^- distribution is complex, therefore the possible influence of 12.7 MeV/c peak signals on the background of 2.3 MeV/c peak was analyzed.

The Gaussian fit results (see **Table 1**) show the separation between 12.7 MeV/c peak and 2.3 MeV/c peak μ(12.7) - μ(2.3) = 10.427 MeV/c. This is larger than 3σ(12.7) = 5.43 MeV/c. So, the contribution of 12.7 MeV/c peak tail to the background of 2.3 MeV/c peak is negligible.

The results are presented in Table 1.

TABLE 1.

Peak	μ (MeV/c)	σ (MeV/c)	Relative separation [μ(12.7) - μ(2.3)] > 3σ(12.7)
0 MeV/c	0.007±0.002	0.417±0.003	
2.3 MeV/c	2.293 ±0.001	1.210±0.001	10.427 MeV/c > 5.43 MeV/c
12.7 MeV/c	12.720±0.027	1.809±0.031	