ψ' decays to $p\overline{p}$

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ABSTRACT

The BES 1995 and 1996 ψ' datasets have been reexamined for $\psi' \to p\overline{p}$ production. An error in the earlier analysis was uncovered. The progress on fixing the problem is discussed.

1 Previous Work

The analysis of last year was heavily based on a 4-C kinematic fit of $\psi' \to p\overline{p}$. Figure 1 shows the final product of this kinematic fit. However, after examining the pulls of the distributions (not included here for brevity), it was determined that there was a problem with the original analysis.

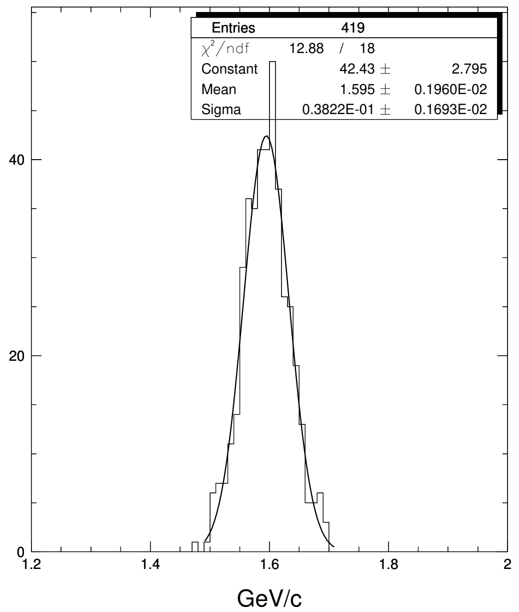

Figure 1: Average momentum ($(p_1 + p_2)/2$) of two prong candidates passing a kinematic fit to $\psi' \to p\overline{p}$. Centroid of gaussian is at the proper momentum bin.

To illustrate this problem, Monte Carlo was generated of "phantom" protons. The actual particles were "protons" (PID=6), generated flat in momentum space from 1.4 GeV/c to 1.8 GeV/c. Figure 2 illustrates the problem.

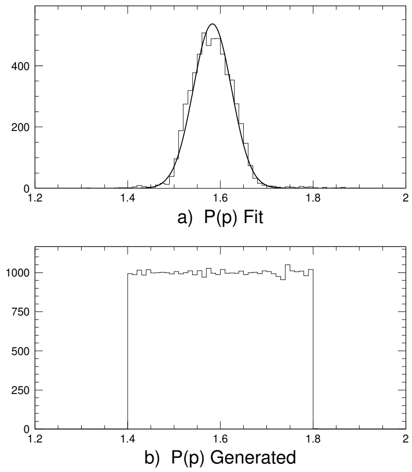

Figure 2: **a:** Averaged momentum from generated "phantom" protons, passed through a kinematic fit to $\psi' \to p\overline{p}$. **b:** Actual generated dataset, effectively pure noise.

2 New Selection Criteria

Some of the selection criteria from the previous analysis were retained. These are, specifically:

- $\min(r_{dca}) < 1.5$ cm
- $\min(z_{dca}) < 15$ cm
- $\mathrm{N_{charge}} = 2$
- Good helix or circle fit
- $|\cos\theta| < 0.80$
- $\sum q = 0$

For the new analysis we provide the following pre-booking cuts:

- NNEU < 2
- $\cos\theta < -.95$ between tracks
- $1.1 < p_{trk} < 2.2$ GeV
- $rxy_1 - rxy_2 < 2$ cm; $z_1 - z_2 < 5$ cm
- $\cos\theta_{mdc} < 0.65$
- $E_{SC}(1,2) \geq 0.0$ GeV

336511 events remain at this point. Further cuts are on vertexing ($rxy_1 - rxy_2 < .2$ cm; $z_1 - z_2 < 3$ cm); TOF difference between tracks ($|\mathrm{TOF}_1 - \mathrm{TOF}_2| < 3$ ns); shower counter rib removal ($|\cos\theta_{SC}| > .1$); muon system coverage ($\cos\theta_{mdc} < 0.6$); muon identification (MUID1, MUID2 $\neq 0$); shower counter energy ($E^{+}_{SC} < 0.7$ GeV); and track colinearity ($\theta_{col} < 2.5°$).

We plot a weighted average momentum:

$$\kappa_{\mathrm{avg}} = \frac{\frac{\kappa_1}{\sigma^2_{\kappa_1}} + \frac{\kappa_2}{\sigma^2_{\kappa_2}}}{\frac{1}{\sigma^2_{\kappa_1}} + \frac{1}{\sigma^2_{\kappa_2}}}; \qquad \tan\lambda_{\mathrm{avg}} = \frac{\frac{\tan\lambda_1}{\sigma^2_{\tan\lambda_1}} + \frac{\tan\lambda_2}{\sigma^2_{\tan\lambda_2}}}{\frac{1}{\sigma^2_{\tan\lambda_1}} + \frac{1}{\sigma^2_{\tan\lambda_2}}}$$

$$p_{\mathrm{avg}} = \frac{\sqrt{1 + (\tan\lambda_{\mathrm{avg}})^2}}{\kappa_{\mathrm{avg}}}; \qquad pz_{\mathrm{avg}} = \frac{\tan\lambda_{\mathrm{avg}}}{\kappa_{\mathrm{avg}}}$$

where κ is the track curvature and $\tan\lambda$ is the tangent of the dip angle. As these are the measured helix parameters, the errors on these quantities are assumed to be gaussian.

The weighted average momentum of the selected two prong candidates is shown in Figure 3. This histogram is fit to a gaussian, plus a quadratic background. From the fit, we get

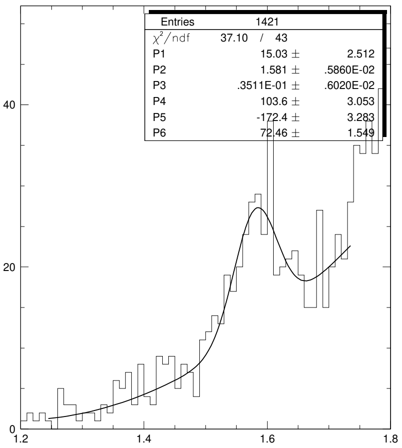

Figure 3: Weighted average momentum of selected two prong candidates, fit to a gaussian plus a quadratic background.

132.2 ± 31.6 protons. Monte Carlo acceptance for all cuts but those from the shower counter is 44%. This gives a product branching ratio of:

$$\mathcal{B}\,(\psi' \to p\overline{p}) \times \epsilon_{SC} = 8.1 \times 10^{-5},$$

where ϵ_{SC} is the efficiency of the shower counter cuts, not well modeled by the Monte Carlo. Expected branching fraction from the 14 percent rule is $\approx 3.1 \times 10^{-4}$.

3 Conclusion

The previous analysis of $\psi' \to p\overline{p}$ which placed a heavy reliance upon a kinematic fit was extremely flawed. The result is not valid in a high background environment, as any noise in the general area is pulled into the fit. The new analysis has no reliance on a kinematic fit and succeeds in drawing a $p\overline{p}$ signal from the noise. Further work is needed on the shower counter efficiencies and systematic errors.