Momentum Resolution of the E877 Spectrometer

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1 Introduction

The finite momentum resolution of our spectrometer smears out the peak in the two-particle correlation function. Understanding the momentum resolution is necessary to understand this distortion of the correlation function. In my previous note on the momentum resolution (/usr/people/e877/pub/notes/mom-resol.ps on skipper) I showed how the resolution can be estimated analytically. I also provided a simple Monte Carlo routine which can be used to smear out momenta of particles in a simulation. Both methods gave results which agreed with the GEANT simulation. In this note I would like to compare the predictions from the previous note to the experimental data. I will first use the experimental mass peak widths to verify the predictions of the analytic formula. Then I will attempt to reproduce the width of the Λ peak using the Monte Carlo routine.

2 Mass resolution

Since the mass is being calculated from momentum and TOF according to

$$m^2 = p^2 \left[\left(\frac{\mathrm{TOF}}{L} \right)^2 - 1 \right] , \tag{1}$$

the momentum and the TOF resolutions determine the widths of peaks in the mass-squared spectrum. Parametrizing the momentum resolution as was done in the thesis of Shigaki

$$\left(\frac{\Delta p}{p} \right)^2 = (c_1 p)^2 + \left(\frac{c_2}{\beta} \right)^2 , \tag{2}$$

we get the following expression for the mass resolution:

$$[\Delta(m^2)]^2 = 4{c_1}^2 m^4 p^2 + 4{c_2}^2 m^4 \left(1 + \frac{m^2}{p^2}\right) + 4{c_3}^2 p^2 (p^2 + m^2) \ . \tag{3}$$

Here $c_3 = \Delta\mathrm{TOF}/L$ describes the TOF resolution. Please note that the corresponding formula in Shigaki's thesis contains a misprint which propagated to several theses in our collaboration.

Now, in my previous note I gave the following expression for the momentum resolution:

$$\left(\frac{\Delta p}{p}\right)^2 = \frac{V^d_{1,1}}{p^2} = \frac{4.06 \cdot 10^{-4} {\Delta x_{DC2}}^2 + 8.84 \cdot 10^{-5} {\Delta x_{DC3}}^2}{(BL)^2} p^2 + \frac{2.07 \cdot 10^{-3}({MS_1}^2 + {MS_3}^2) + 6.20 \cdot 10^{-3} {MS_2}^2}{(BL)^2 \beta^2} \tag{4}$$

where the detectors resolutions are in cm and BL in Tm. Comparing this to (2) we get

$$c_1 = \frac{\sqrt{4.06 \cdot 10^{-4} {\Delta x_{DC2}}^2 + 8.84 \cdot 10^{-5} {\Delta x_{DC3}}^2}}{BL} \tag{5}$$

$$c_2 = \frac{\sqrt{2.07 \cdot 10^{-3}({MS_1}^2 + {MS_3}^2) + 6.20 \cdot 10^{-3} {MS_2}^2}}{BL} \tag{6}$$

Thus the c_1 and c_2 constants describe the detector resolution and the multiple scattering, respectively. Using the Δx and MS values from my old note, I obtain the following c_1 and c_2:

	c_1 ((GeV/c)$^{-1}$)	c_2
1993	0.0030	0.028
1994	0.0024	0.022
1995	0.0024	0.023

Using Eq.(3) with c_1=0.0024 c/GeV and c_2=0.022, and assuming $c_3 = 0.002$, corresponding to the TOF resolution of 82 ps, I can now calculate the width of the mass-squared peaks as a function of momentum for different particle species. The result (solid line) is compared in Fig. 1 to the experimental 1994 data, kindly made available by Yi Dai. The agreement is satisfactory.

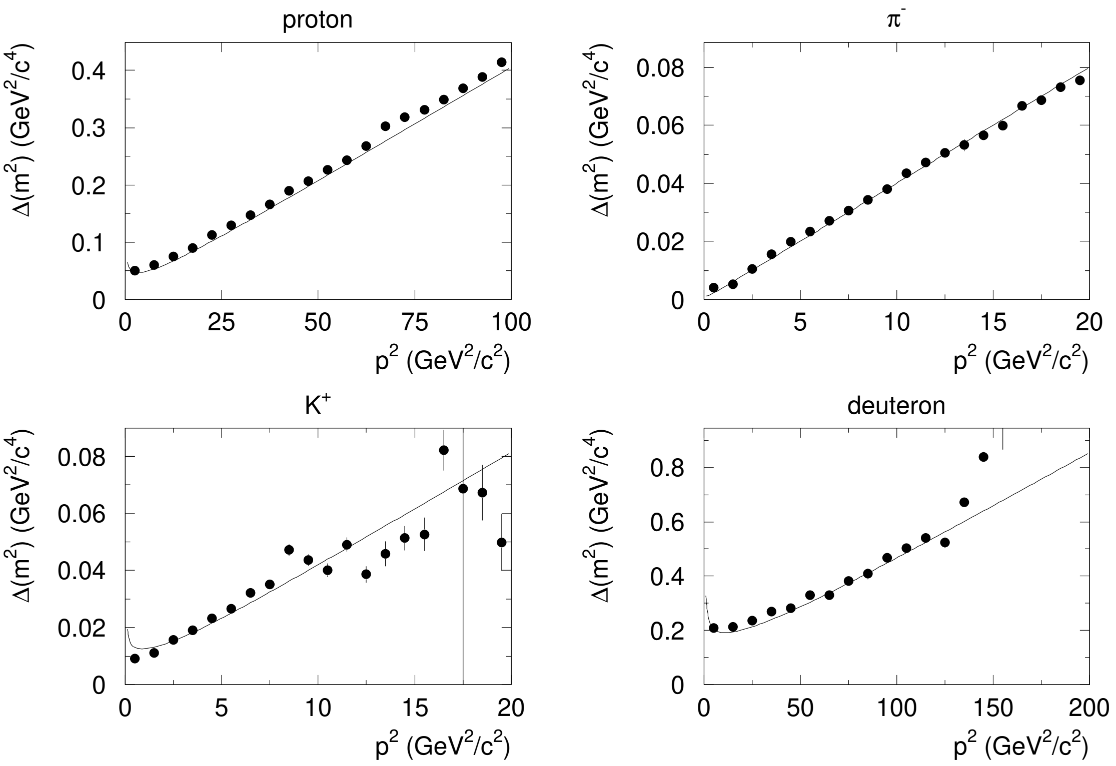

Figure 1: The m^2 resolution (sigma) as a function of the momentum squared, for protons, π^-, K^+ and deutrons. The experimental data (points) are compared to the calculation (line) assuming TOF resolution of 82 ps.

3 Width of the Λ peak

The width of the experimentally observed Λ peak is determined by the momentum resolution. In Fig. 2 the experimental invariant mass distribution is compared to the corresponding distribution obtained from a simulation. The experimental distribution (left hand panel) was obtained by combining negative pions with protons (1994 data). The mixed event background was subtracted. No vertex cut was required. The width (sigma) of the Λ peak is (3.4 ± 0.7) MeV/c. The simulation (right hand panel) was done by generating Λ's with the same momentum distribution as that of protons, and decaying them into a negative pion and a proton. Subsequently, the pion and proton momenta were smeared by the Monte Carlo routine, and the invari-

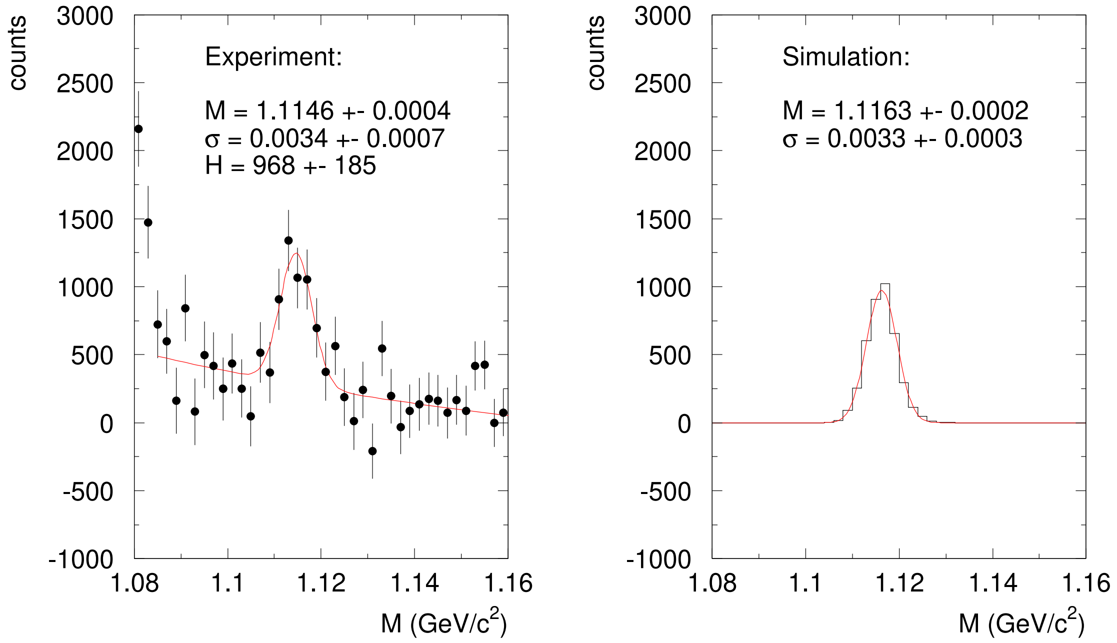

Figure 2: Invariant mass distribution of π^--proton pairs. Left: 1994 data, mixed event background subtracted. Right: simulation using the `propag.f` routine to smear momenta.

ant mass was calculated from the smeared momenta. It appears that this procedure can reproduce quite well the experimental Λ width.

4 Conclusion

Summarizing, we do understand the momentum resolution. The analytic formula, combined with the TOFU resolution of 82 ps, reproduces the experimental mass resolution. The Monte Carlo routine, used to smear the momentum of every simulated track, produces a Λ peak with a realistic width. The routine can be found in `~e877/pub/mom-resol/propag.f`. It is self-explanatory.