Estimation of the absolute scale error in the E687 mass measurement

The absolute scale error in the E687 mass measurement was estimated by comparing E687 measurements with '96 PDG values for well defined mass states as listed in Table 1. The *absolute* mass difference, $\Delta M = M_{\mathrm{PDG}} - M_{\mathrm{E687}}$, was calculated for each mass state and the *absolute* error in the mass difference was obtained by combining errors in both the PDG value and E687 value (statistical error only) in quadrature. Figure 1 shows the *absolute* mass difference at each mass state. The absolute mass difference was fit to a straight line using a χ^2 method in which the *absolute* error in the mass difference at each state was included. The χ^2 is defined as:

$$\chi^2 = \sum_i \frac{(f(m_i) - \delta m_i)^2}{\sigma^2_{\delta m_i}},$$

$$f(x) = a + b \cdot x$$

where a and b are free fit parameters, δm_i is the absolute mass difference between the PDG value and E687 value at a given mass state, and $\sigma_{\delta m_i}$ is the error in the absolute mass difference. In the fit, the $f(x)$ was constrained not to be negative. Straight lines in the same plot show fit results: 1) the solid line was obtained by fitting all data points; 2) the dotted one was obtained by excluding the Λ, Ξ^-, and Ω^- states in the fit; 3) the dashed one was obtained by excluding the Λ state which has an exceptionally small error. The extremely small error at the Λ mass state affects the fit results significantly.

The absolute scale errors at the Ξ_c state (2470 MeV/c^2) were found to be about 0.20 MeV/c^2 by fitting all data points; 0.90 MeV/c^2 excluding the Λ state in the fit; 1.57 MeV/c^2 excluding the Λ, Ξ^-, and Ω^- states. The last one is consistent with the old E687 estimation of the absolute scale error, 1.4 MeV/c^2 , at the Ξ_c state, which was quoted as systematic errors in the Ξ_c^+ and Ξ_c^0 mass measurements. Table 2 summaries the absolute scale errors at several interesting mass states obtained in three different methods: numbers in Method 1 were obtained by fitting all data points; Method 2 was obtained excluding the Λ state in the fit; Method 3 was obtained by excluding the Λ, Ξ^-, and Ω^- states. At the bottom line, the returned χ^2 from each fit is given. Including the Λ state in the fit gives an extraordinarily large χ^2 and provides us with an unbelievable result.

References

[1] Part of SSD K^0_S. The error in E687 value is extremely small and taken to be "zero".

[2] All SSD Λ sample.

[3] All *Type*–2 Ξ^-.

Table 1: '96 PDG and E687 mass differences in MeV/c^2 unit.

Mass state	PDG	E687	M(PDG) – M(E687) [10]
K_S^0	497.672±0.031	497.13±0.00 [1]	0.542±0.031
Λ	1115.684±0.006	1115.607±0.002 [2]	0.077±0.006
Ξ^-	1321.32±0.13	1320.90±0.043 [3]	0.42±0.13
Ω^-	1672.45±0.29	1671.26±0.20 [4]	1.19±0.35
D^0	1864.6±0.5	1863.3±0.1 [5]	1.30±0.51
D^+	1869.4±0.4	1867.9±0.1 [6]	1.50±0.41
D_S^+	1868.5±0.7	1967.7±0.6 [7]	0.80±0.92
Λ_c^+	2285.1±0.6	2285.3±0.7 [8]	–0.20±0.92
J/Ψ	3096.88±0.04	3093.0±2.0 [9]	3.88±2.00

Table 2: Absolute scale errors at several interesting mass states in MeV/c^2 unit.

Mass state	Method 1	Method 2	Method 3
D^0/D^+	0.15	0.79	1.25
D_S^+	0.16	0.81	1.30
Λ_c^+	0.18	0.87	1.47
Ξ_c	0.20	0.90	1.57
Ω_c	0.21	0.94	1.68
J/Ψ	0.25	1.02	1.89
χ^2/D.O.F.	42.8	2.00	0.89

[4] All *Type*–2 Ω^-.

[5] $D^0 \to K^-\pi^+$, $K^-\pi^+(D^{*+}$ tag), $K^-\pi^+\pi^+\pi^-$, $K^-\pi^+\pi^+\pi^-(D^{*+}$ tag), and $K_S^0\pi^+\pi^-$ decays.

[6] $D^+ \to K^-\pi^+\pi^+$ decay.

[7] $D_s^+ \to \phi\pi^+$ decay.

[8] $\Lambda_c^+ \to pK^-\pi^+$, pK_S^0, $pK_S^0\pi^+\pi^-$, $\Lambda\pi^+\pi^+\pi^-$, and $\Lambda\pi^+$ decays.

[9] $J/\Psi \to \mu^+\mu^-$ decay.

[10] The error is obtained by combining the errors in the PDG value and E687 value in quadrature.

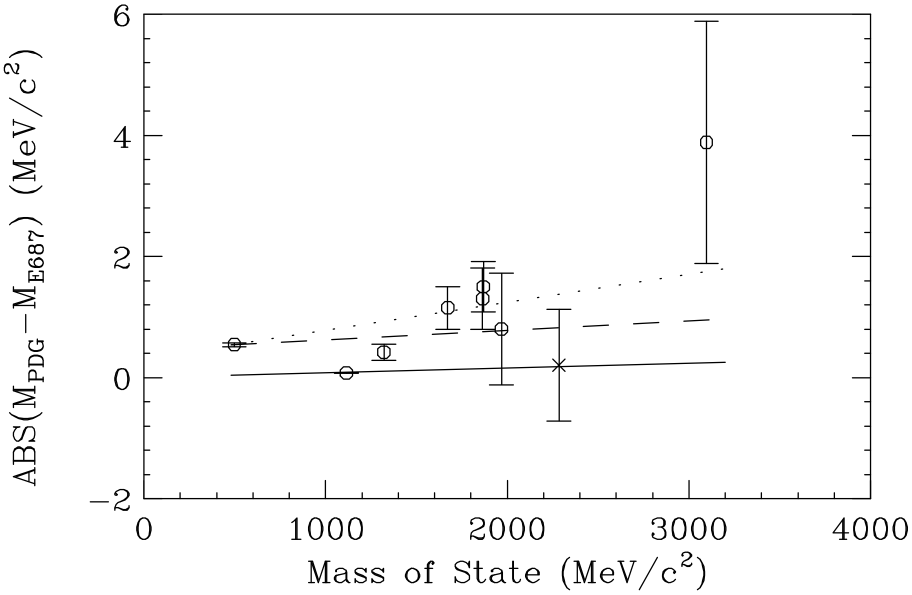

Figure 1: Comparison of the E687 mean mass of several states with Particle Data Group values. The difference between the '96 PDG values and E687 values is plotted as a function of the PDG mass of the state. Straight lines are fits to the mass difference; 1) the solid line was obtained using all data points; 2) the dashed one was obtained by excluding the Λ state in the fit; 3) the dotted one was obtained by excluding the Λ, Ξ^-, and Ω^- states.