A New Photon Constrained Fitter

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1 Introduction

In the analysis of the LGD data, it has been shown that performing constrained fits on the massive children (π^0's and η's) increases the mass resolution of the parents. Problems have been noted, however, especially in the charge exchange π^0 sample, nemely that the energy and MM^2 distributions do not beave well under the contrained fit. The contrained fitter has traditionally only used the energy resolution of the photons. A new fitter has been developed that also takes into account the position resolution has been developed, and shows great promise.

2 The Old Fitter

The original fitter fit only the energies of the photons. At the time, it was believed that the position resolution was only a small effect and was swamped by the energy resolution. The primary advantge to this sort of fit is speed - you have 2 equations and two unknowns, and you just solve it.

The mass of the parent is given by

$$m^2 = 2E_1'E_2'(1 - \cos\theta), \tag{1}$$

and the quatity to be minimized is

$$\chi^2 = \frac{(E_1' - E_1)^2}{\sigma_{E_1}^2} + \frac{(E_2' - E_2)^2}{\sigma_{E_2}^2}. \tag{2}$$

Here the primed energies refer to the fitted values, and the unprimed energies are the m,easured energies. The χ^2 can be rewritten in terms of only E_1', using (1), as

$$\chi^2 = \frac{(E_1' - E_1)^2}{\sigma_{E_1}^2} + \frac{\left(\frac{m^2}{2E_1'(1-\cos\theta)} - E_2\right)^2}{\sigma_{E_2}^2}. \tag{3}$$

Now the problem is simply minimizing an equation in 1 dimension. This is done by applying Newton's Method to

$$\frac{d\chi^2}{dE_1'} = 0. \tag{4}$$

3 The New Fitter

The new fitter takes into account the fact that the position resolution of the LGD is important. Using the fact that θ is small, and using the identity $2\sin\theta/2 = 1 - \cos\theta$, we can rewrite (1) as

$$m^2 = E_1' E_2' \theta'^2. \tag{5}$$

The new χ^2, taking into account position resolution, is

$$\chi^2 = \frac{(E_1' - E_1)^2}{\sigma_{E_1}^2} + \frac{(E_2' - E_2)^2}{\sigma_{E_2}^2} + \frac{(\theta' - \theta)^2}{\sigma_\theta^2}. \tag{6}$$

Substituting (5) yields

$$\chi^2 = \frac{(E_1' - E_1)^2}{\sigma_{E_1}^2} + \frac{\left(\frac{m^2}{E_1'\theta'^2} - E_2\right)^2}{\sigma_{E_2}^2} + \frac{(\theta' - \theta)^2}{\sigma_\theta^2}. \tag{7}$$

The task now is to minimize (7). This is currently done using *MINUIT*, although a faster method is being worked on. The values for the σ's are

$$\sigma_{E_n} = 0.02E_n + 0.06\sqrt{E_n} \tag{8}$$

and

$$\sigma_\theta = 0.00116, \tag{9}$$

where E is in GeV and θ is in radians. σ_θ is derived from an assumed position resolution of 4.5mm.

4 Results

The most dramatic impact of the new fitter is seen in the charge exchange π^0's. The now common smearing of the MM^2 is gone, as is the mass dependence of the fitted event energy. Similar but less striking results are seen in the charge exchange η's. See the attached plots and their descriptions for details.

5 Conclusions

Allowing the positions of the photons at the face of the glass to vary in the constrained fit greatly increases the quality of the fits. This is important in more complex topologies, such as $f_2 \to \pi^0\pi^0$, where at large $\cos\theta_{GJ}$ the forward going π^0 is very similar to a charge exhange π^0. The old, energy only fitter, should be replaced with the new one.

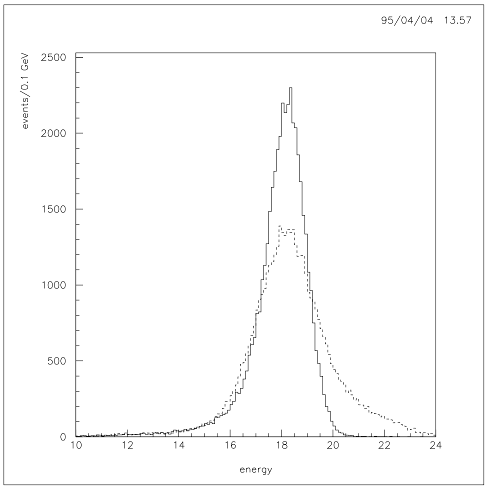

Figure 1. The charge exchange π^0 energy, for the old fitter. The dotted line represents the fitted data and the solid line is the raw, unfitted data.

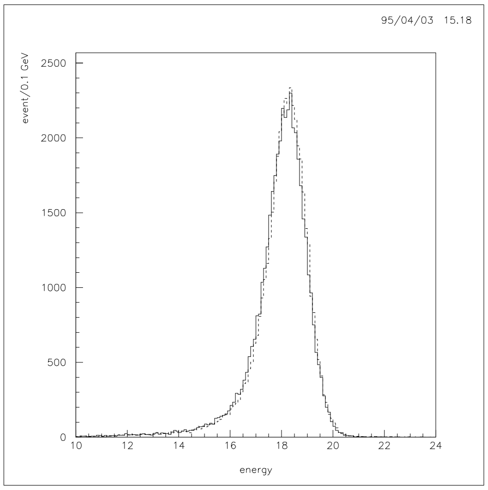

Figure 2. The charge exchange π^0 energy, for the new fitter. The dotted line represents the fitted data and the solid line is the raw, unfitted data.

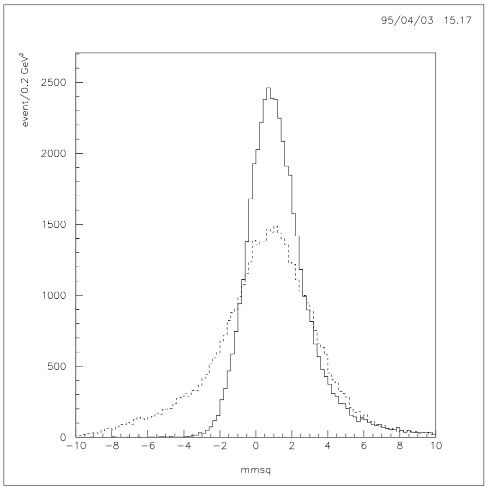

Figure 3. The charge exchange π^0 MM^2, for the old fitter. The dotted line represents the fitted data and the solid line is the raw, unfitted data.

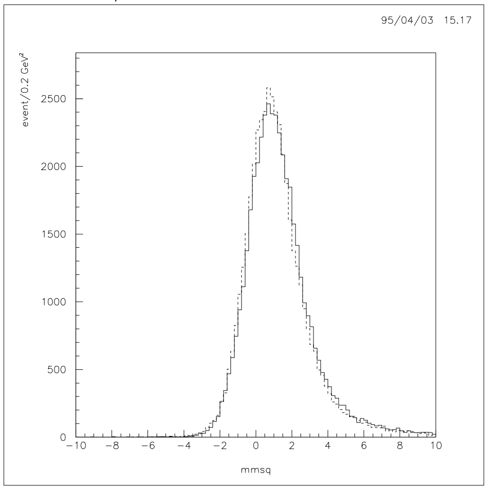

Figure 4. The charge exchange π^0 MM^2, for the new fitter. The dotted line represents the fitted data and the solid line is the raw, unfitted data.

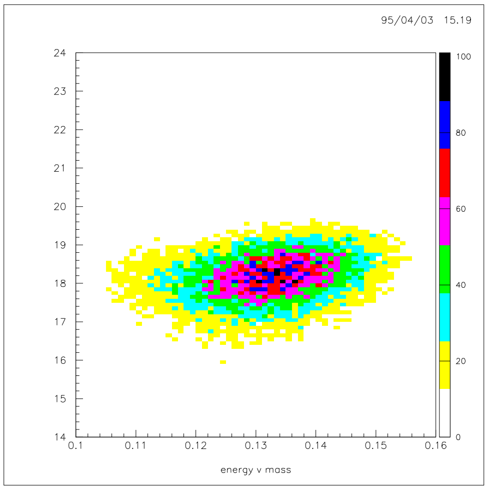

Figure 5. Event energy vs. mass for the charge exchange π^0's, unfitted. The expected behavior, i.e. increasing mass $\rightarrow$ increasing energy, is observed.

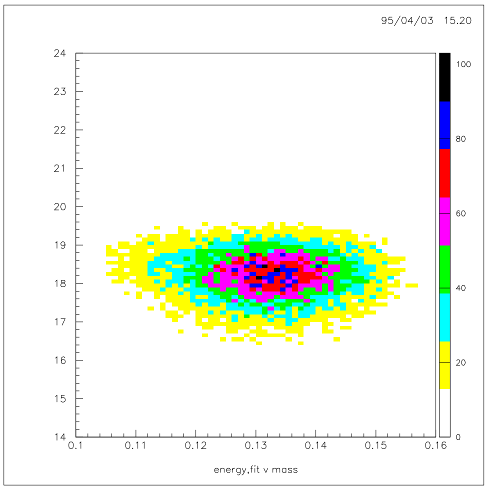

Figure 7. Fitted event energy vs. unfitted mass for the charge exchange π^0's, after applying the new fitter. The energy dependence has been removed.

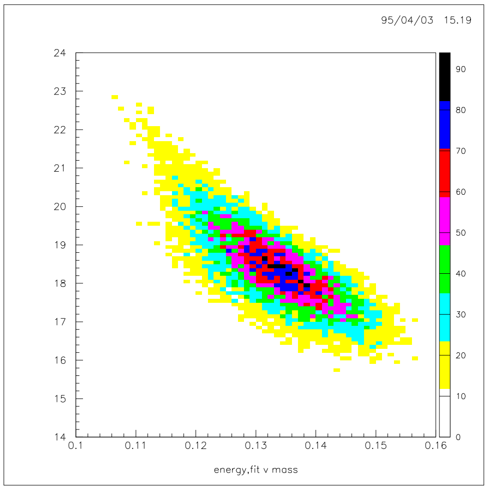

Figure 6. Fitted event energy vs. unfitted mass for the charge exchange π^0's, after applying the old fitter. Note that the enrgies have been overcorrected, and now increasing mass $\rightarrow$ decreasing energy.

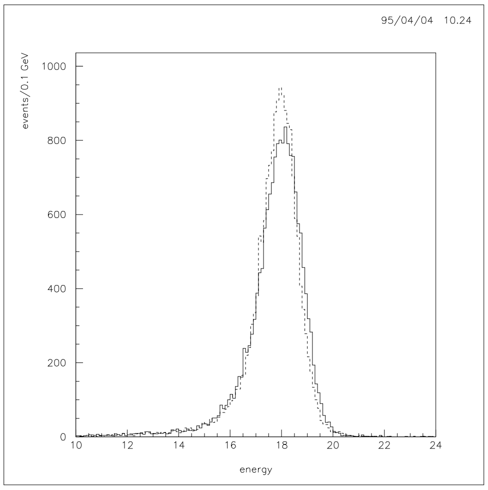

Figure 8. The charge exchange η energy, for the old fitter. The dotted line represents the fitted data and the solid line is the raw, unfitted data.

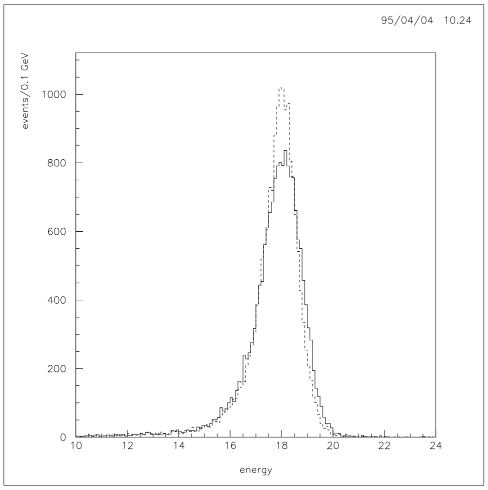

Figure 9. The charge exchange η energy, for the new fitter. The dotted line represents the fitted data and the solid line is the raw, unfitted data.

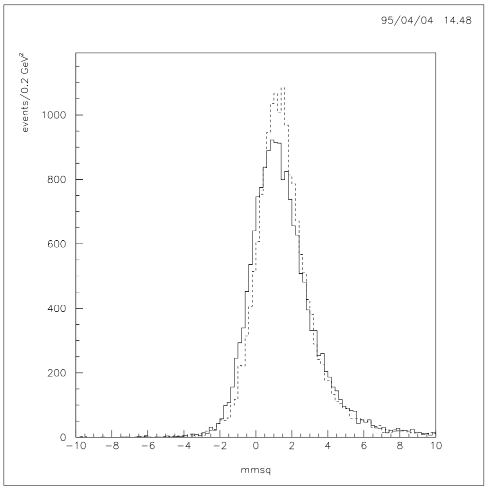

Figure 10. The charge exchange η MM^2, for the old fitter. The dotted line represents the fitted data and the solid line is the raw, unfitted data.

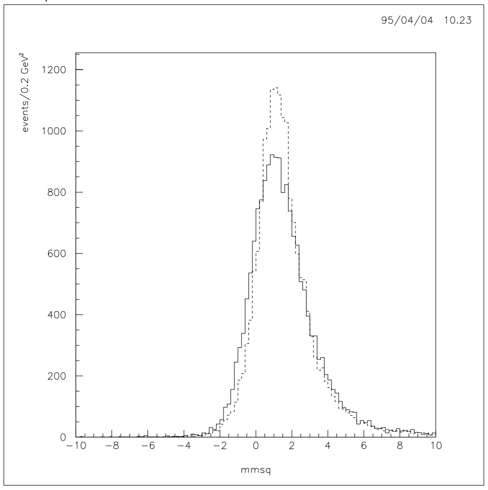

Figure 11. The charge exchange η MM^2, for the new fitter. The dotted line represents the fitted data and the solid line is the raw, unfitted data.

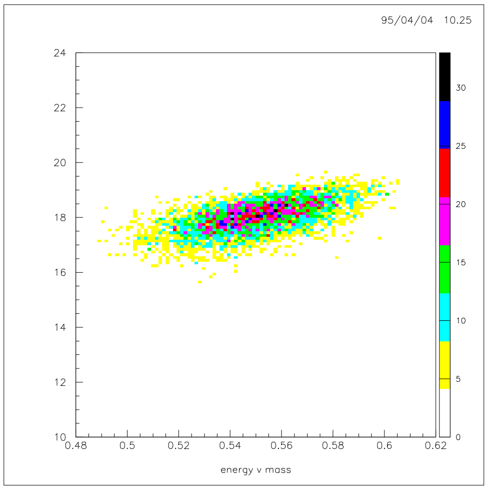

Figure 12. Event energy vs. mass for the charge exchange η's, unfitted. The expected behavior, i.e. increasing mass $\rightarrow$ increasing energy, is observed.

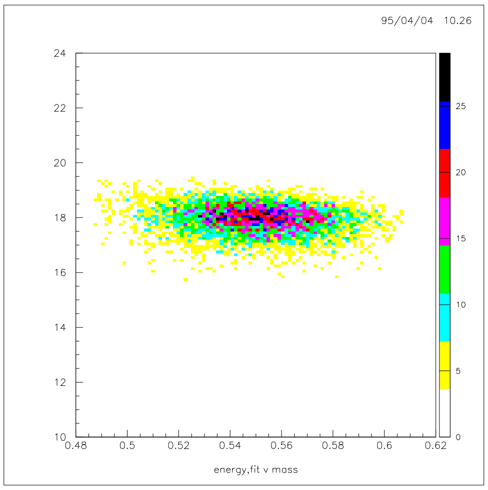

Figure 14. Fitted event energy vs. unfitted mass for the charge exchange η's, after applying the new fitter. The energy dependence has been removed.

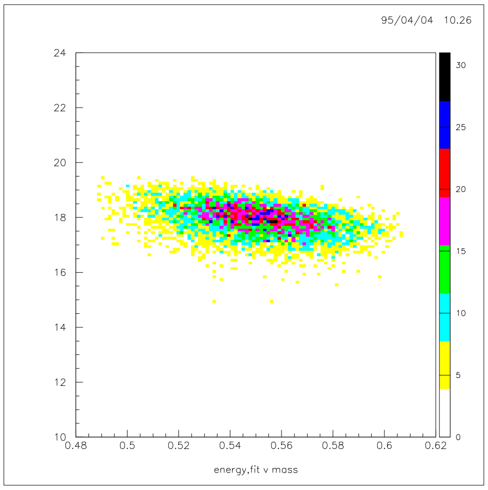

Figure 13. Fitted event energy vs. unfitted mass for the charge exchange η's, after applying the old fitter. Note that the enrgies have been overcorrected, and now increasing mass $\rightarrow$ decreasing energy.