Regina BCAL Standalone MC - Sampling Fraction Fluctuations - GlueX-doc-827-v3

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1 Sampling Fraction

I spent a bit more time looking at the sampling fraction of the BCal in my standalone Monte Carlo. Figure 1 shows the photon energy sampling fraction, f_γ, as a function of the photon energy. It is easy to see that it is linear within this energy range.

$$f_\gamma = \frac{E_{SciFi}}{E_\gamma} \tag{1}$$

where E_{SciFi} is the energy deposited in the scintillating fibre core and E_γ is the incident photon energy.

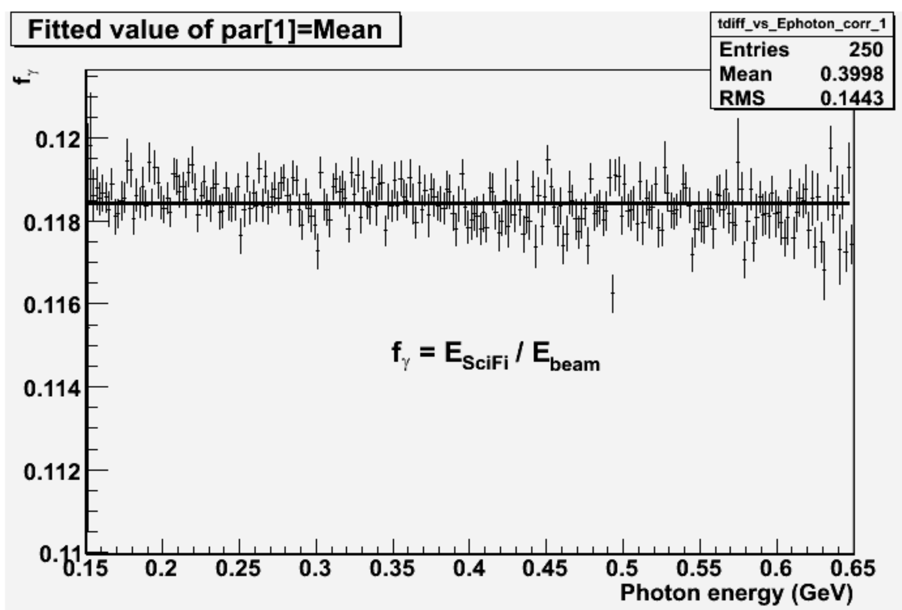

Figure 1: The photon energy sampling fraction plotted as a function of the energy

I think the more relevant quantity is the sampling fraction of the deposited energy,

$$f = \frac{E_{SciFi}}{E_{module}} \tag{2}$$

where E_{module} is the total energy deposited in the module. The sampling fraction is then a result only of the internal geometry of the module and not the size of the module overall which affects the amount of energy lost to leakage out the sides and back. This is the number that should be used a parameter for the full HDGeant simulation. Figure 3 shows the deposited energy sampling fraction to be $f = 0.1247$.

The energy resolution, seen in Figure 4, has a marginally smaller floor term but is nearly the same and has the expected $1/\sqrt{E}$ dependence.

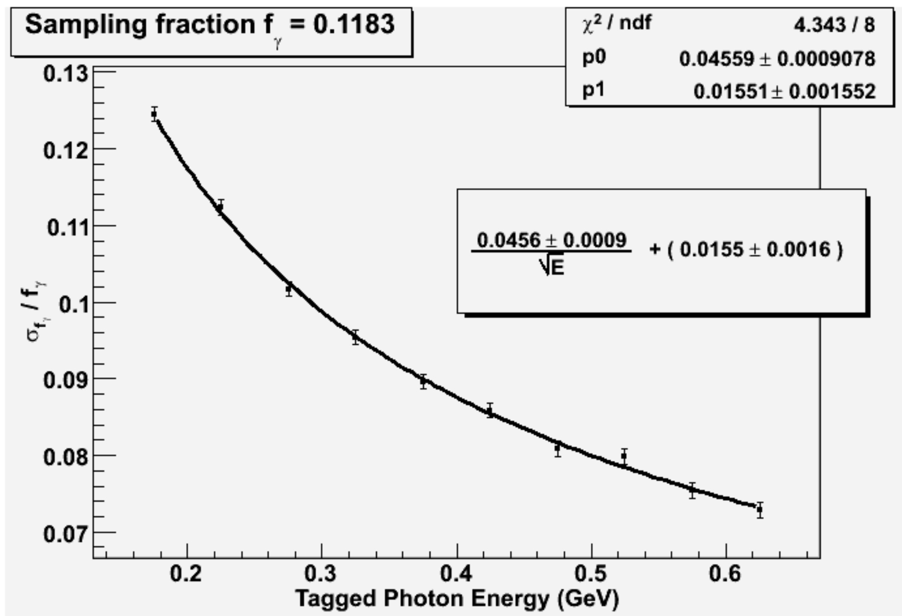

Figure 2: The photon energy sampling fraction resolution.

2 Sampling fraction at low energies

There has been some concern how the the BCal behaves at low energies, specifically near the threshold energies for the GlueX experiment between 20 to 40 MeV. Simulations using the the Regina Standalone Monte Carlo were completed with an incident photon energy ranging over 10 to 50 MeV and the incident photon angle theta varying from 20 to 90 degrees. 90 degrees is perpendicular to the module. The energy and theta distributions are flat. A circular beam spot size of 5mm is used so as not to be sensitive to fibre placement within the module. This has small effect (a few percent) at the low energies on the sampling fraction. Figures 5 through 9 are using the whole theta distribution of 20 through 90 degrees. The effect of theta will be shown after.

Figures 5 and 6 are fit using a Gaussian distribution which fits reasonably well but not perfectly as seen in Figure 7. A Poisson distribution fits much better for these energies near 10 MeV. However, at 50 MeV the distribution becomes Gaussian.

3 Sampling fraction fluctuations over a broader range of energies

We were interested in looking at the sampling fraction and its fluctuations over a broader range of energies. A reduction in the mean of the sampling fraction at lower energie, less than 50 MeV, has been seen and at higher energies it appeared to be flat. Using the Regina Standalone Monte Carlo (ReSAM) 500,000 events were run with a flat photon energy distribution from 10 MeV up to 1 GeV all incident perpendicular to the module.

Looking at the χ^2/ndf in Figure 12 one can see that fitting σ_f/f linearly is a better fit. The two terms are most likely linked and are a result of the internal construction of the module. Fibre spacings would have a large effect on the sampling fraction. One can also see that the *photon energy* sampling fraction, f_γ, decreases as the photon energy increases. This is most likely due to the increase in shower losses outside the module at these higher energies. A plot of the *deposited energy* sampling fraction, f, shows this is the case as it remains flat at the higher energies and can be seen in Figure 13.

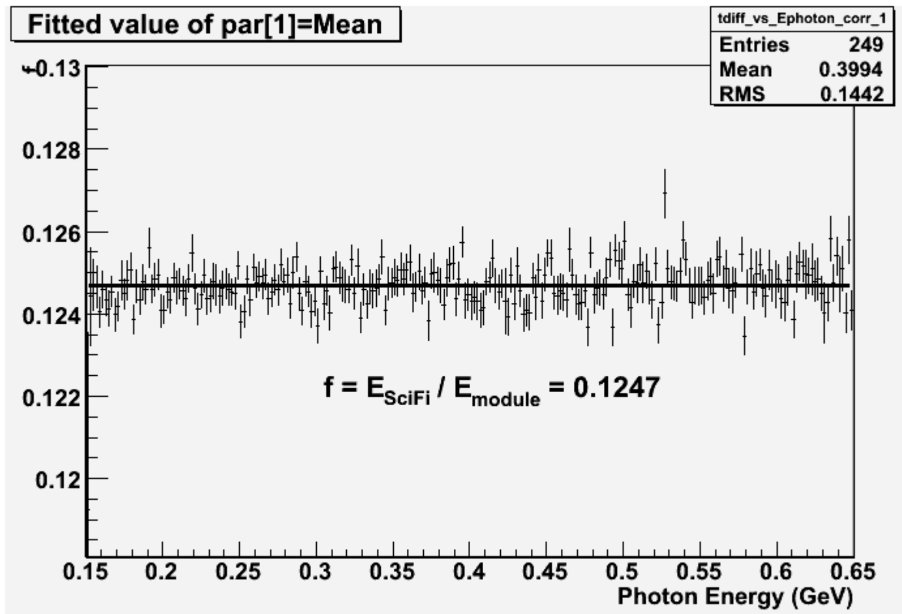

Figure 3: The deposited energy sampling fraction, f, as a function of incident photon energy.

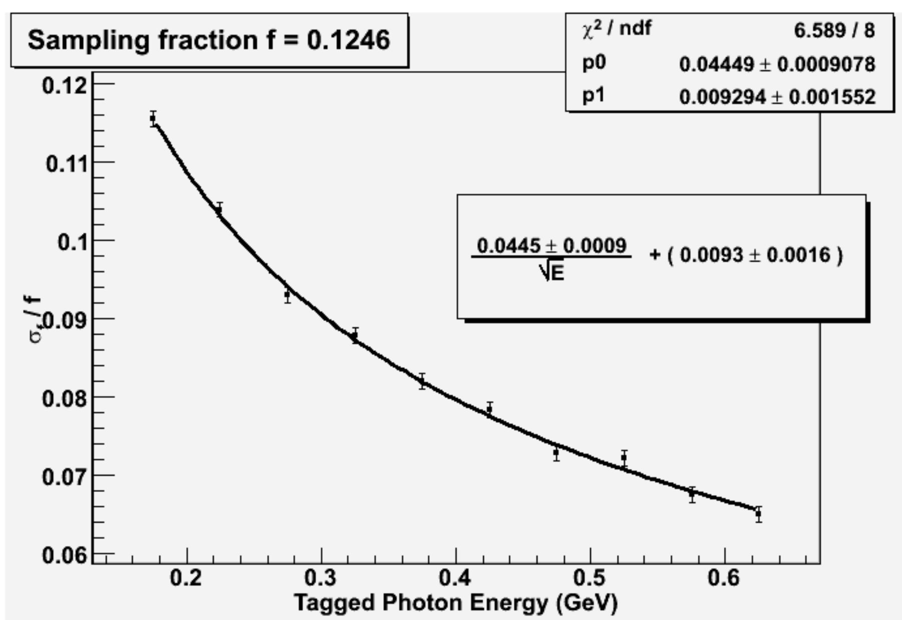

Figure 4: The deposited energy sampling fraction resolution.

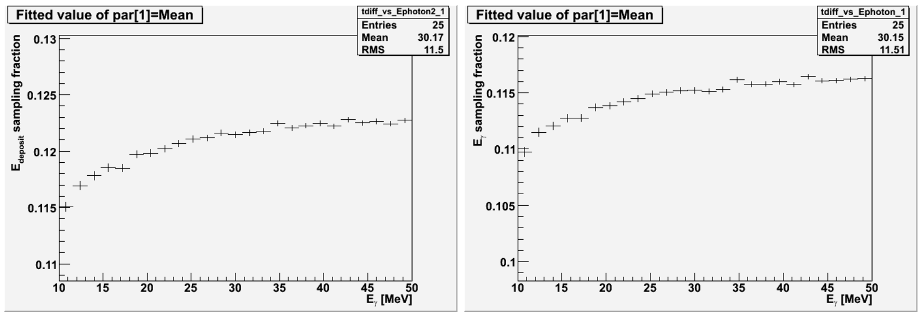

Figure 5: The Monte Carlo sampling fraction, f, of a BCal module at low energies for over the whole theta distribution. Deposited energy sampling fraction is the left panel, Photon energy sampling fraction is the right panel.

Figure 6: The Monte Carlo photon energy sampling fraction, f_γ, of a BCal module at low energies for over the whole theta distribution using a Gaussian fit.

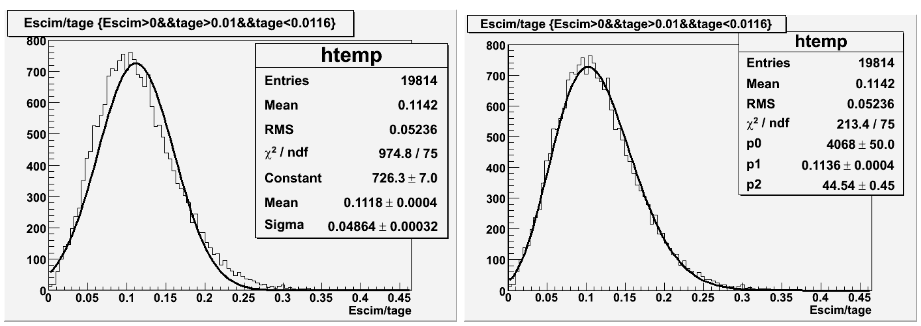

Figure 7: f_γ for 10 to 11.6 MeV (all theta) with a Gaussian fit (left panel) and a Poisson fit (right panel).

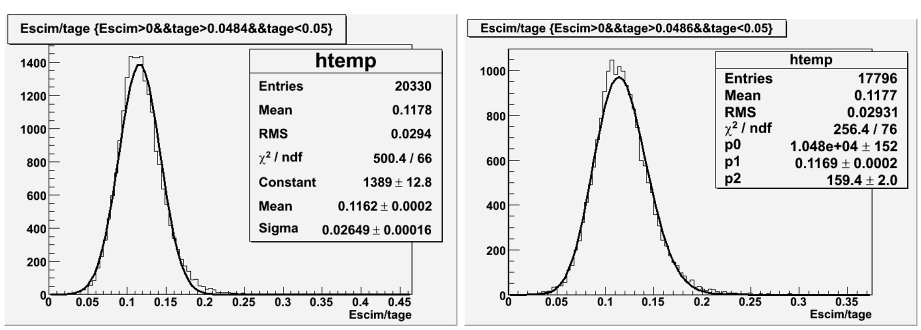

Figure 8: f_γ for 48.6 to 50 MeV (all theta) with a Gaussian fit (left panel) and a Poisson fit (right panel).

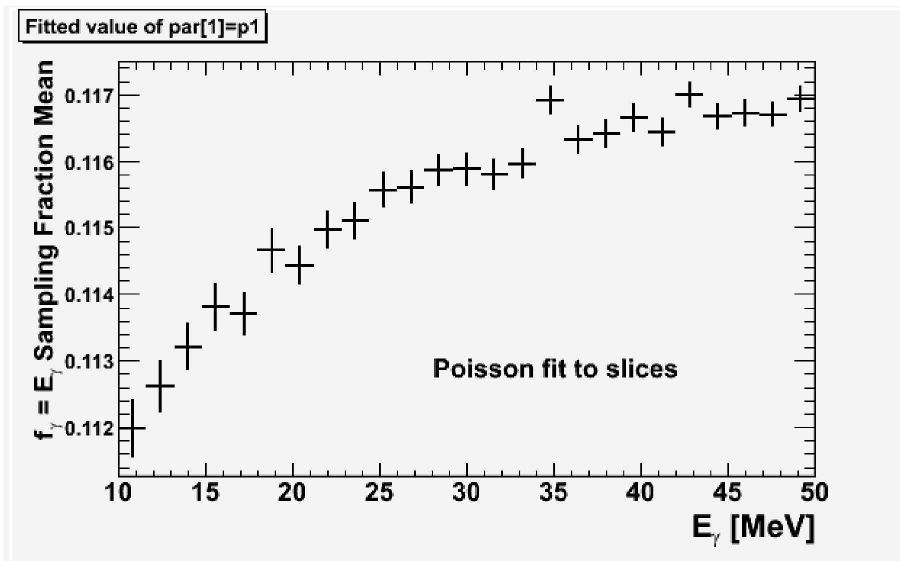

Figure 9: The photon sampling fraction fitting the distributions with a Poisson fit. The points are the means of the Poisson distribution. For Theta = [20,90]

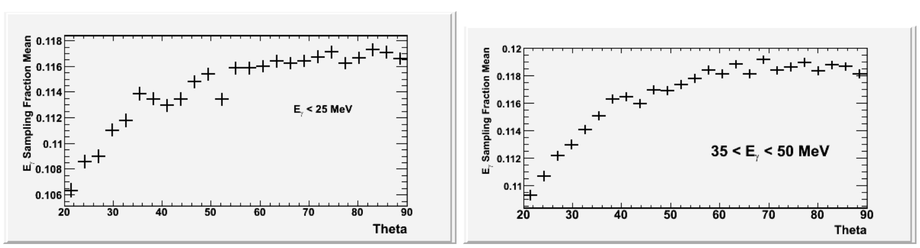

Figure 10: Mean of the Poisson fit versus Theta for photon energy $10 \leq E_\gamma \leq 25MeV$ (left) and $35 \leq E_\gamma \leq 50MeV$ (right)

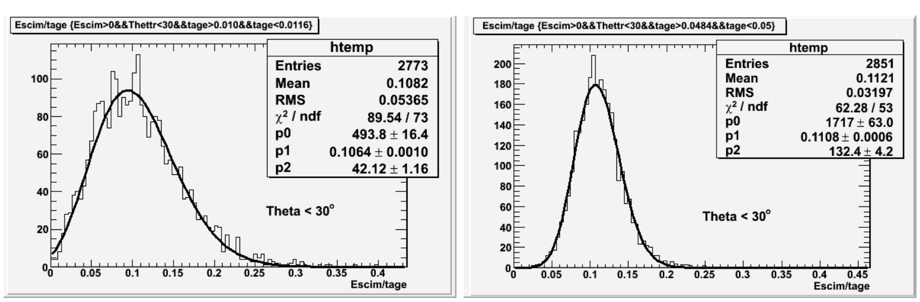

Figure 11: Distributions of the sampling fraction for theta less 30 degrees and $10 \leq E_\gamma \leq 25MeV$ (left) and $35 \leq E_\gamma \leq 50MeV$ (right).

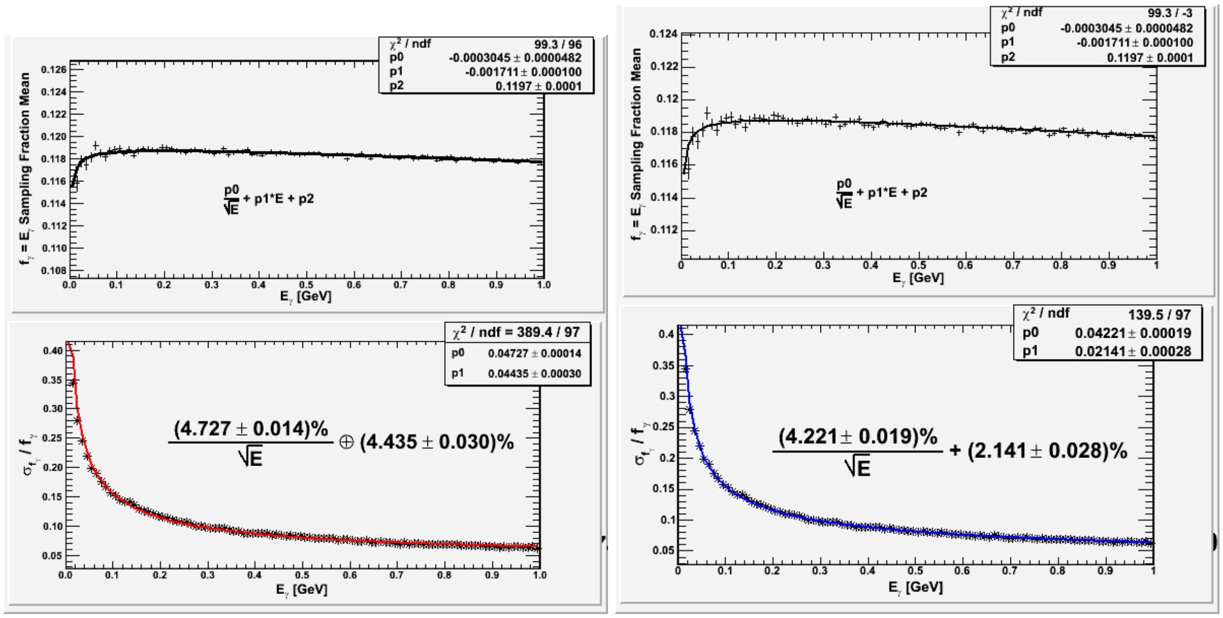

Figure 12: The top panel of the images give a fit to the mean of the *photon energy* sampling fraction. The bottom panels are the resolution of the sampling fraction fitting the distribution with a gaussian. The left image is fit in quadrature and the right is fit linearly.

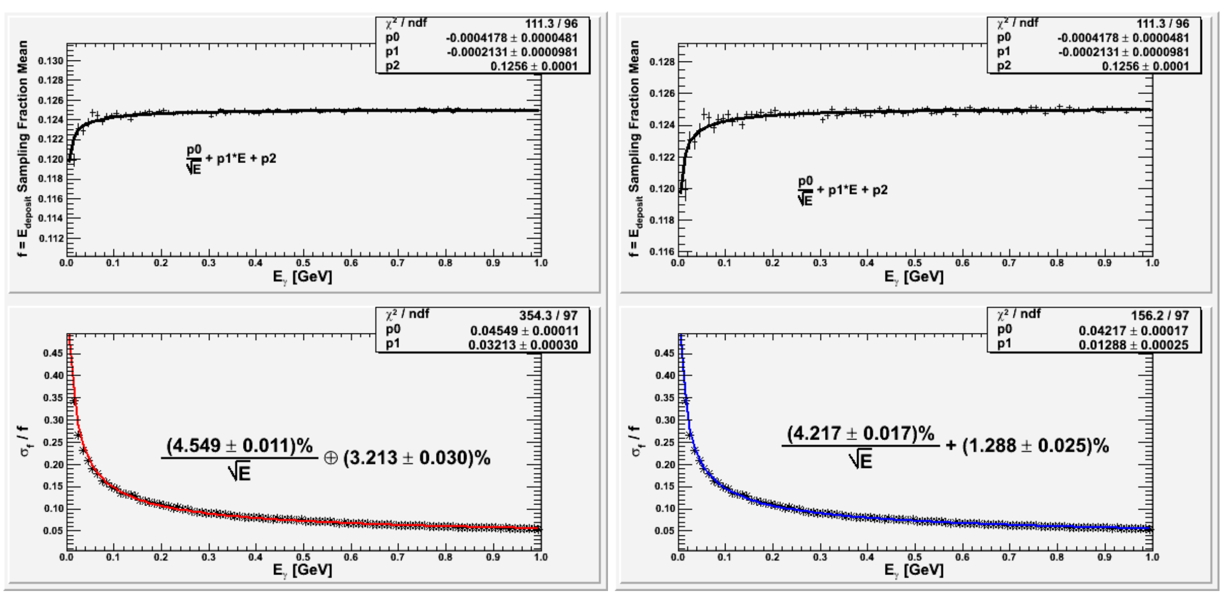

Figure 13: The top panel of the images give a fit to the mean of the *deposited energy* sampling fraction. The bottom panels are the resolution of the sampling fraction fitting the distribution with a gaussian. The left image is fit in quadrature and the right is fit linearly.