# Regina BCAL Standalone MC - Sampling Fraction Fluctuations - GlueX-doc-827-v2

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June 11, 2007

## 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, $f_\gamma$, 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 $E_\gamma$ is the incident photon energy.
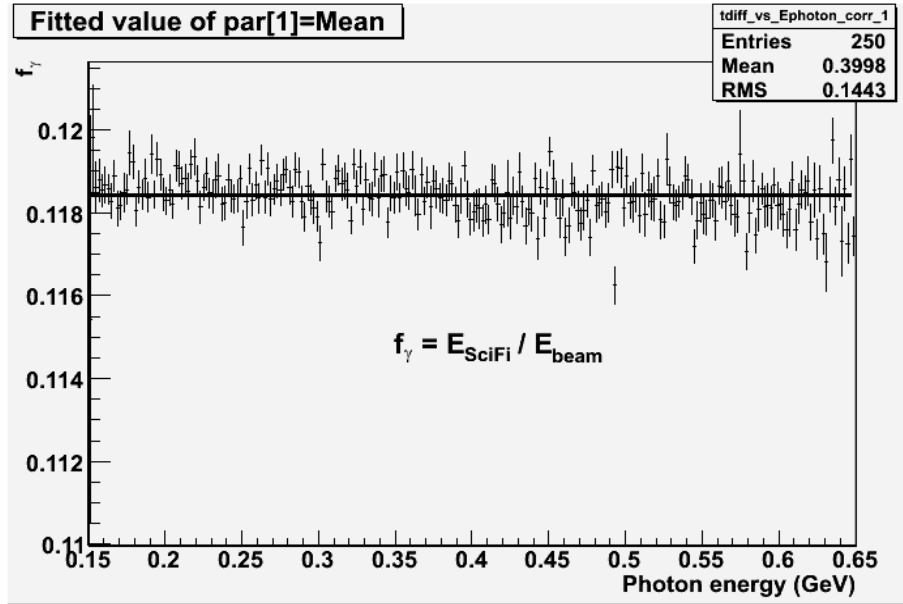


Figure 1: The photon energy sampling fraction plotted as a function of the energy

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.
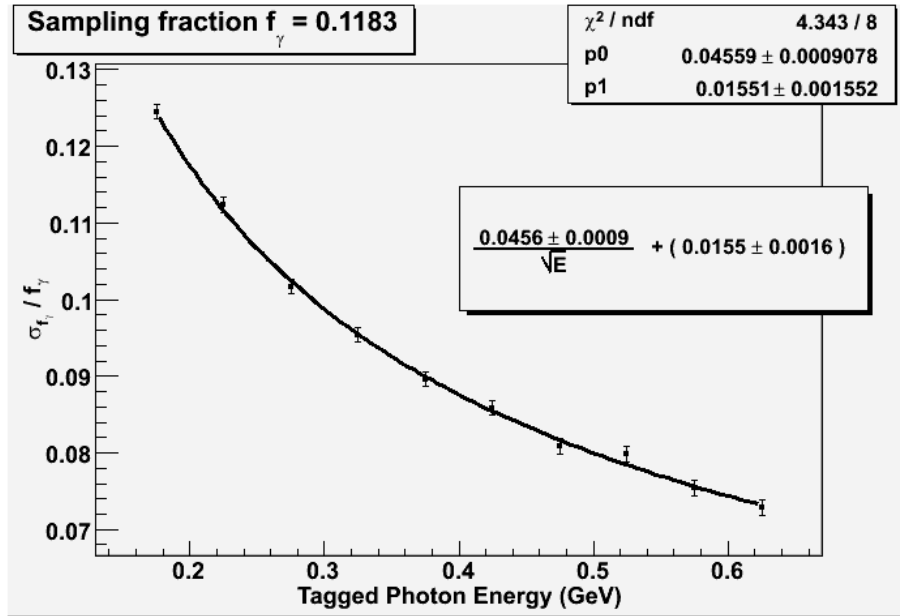
Figure 2: The photon energy sampling fraction resolution.

## 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.
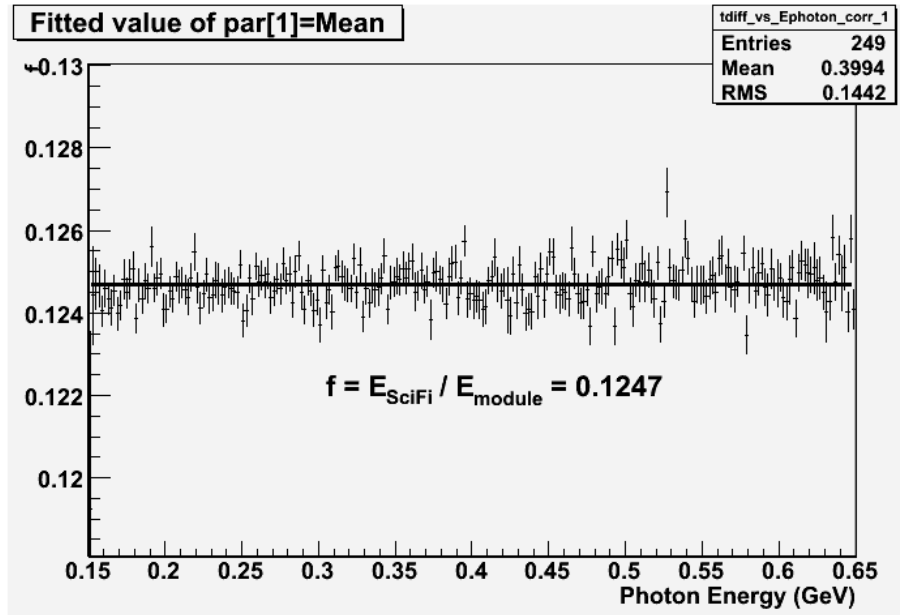
**Fitted value of par[1]=Mean**

| tdiff_vs_Ephoton_corr_1 | |
|---|---|
| Entries | 249 |
| Mean | 0.3994 |
| RMS | 0.1442 |

$f = E_{SciFi} / E_{module} = 0.1247$

Photon Energy (GeV)

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



**Sampling fraction f = 0.1246**

| $\chi^2$ / ndf | 6.589 / 8 |
|---|---|
| p0 | $0.04449 \pm 0.0009078$ |
| p1 | $0.009294 \pm 0.001552$ |

$$\frac{0.0445 \pm 0.0009}{\sqrt{E}} + (\,0.0093 \pm 0.0016\,)$$

$\sigma_z / f$

Tagged Photon Energy (GeV)
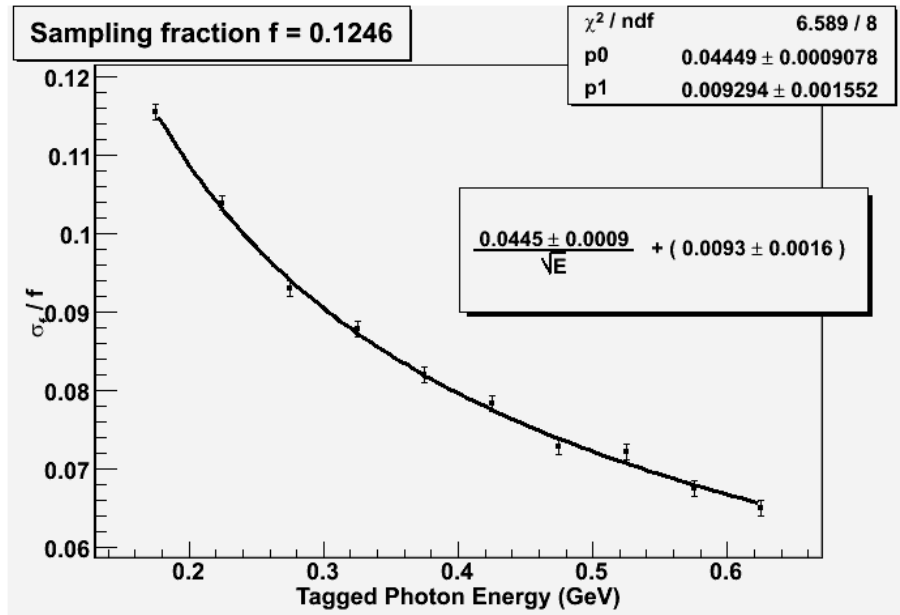
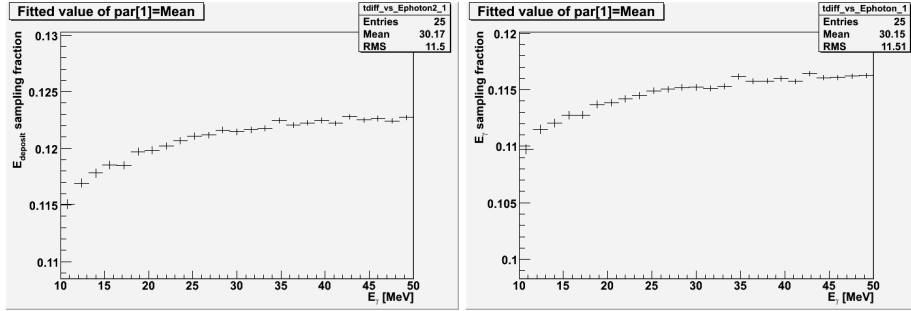Figure 4: The deposited energy sampling fraction resolution.

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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, $f_\gamma$, of a BCal module at low energies for over the whole theta distribution using a Gaussian fit.
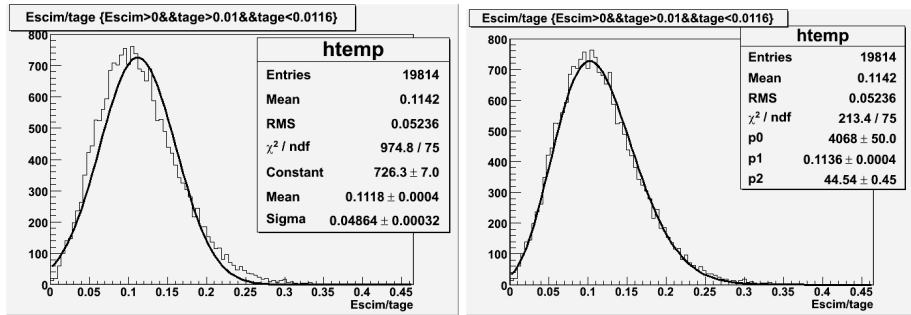


Figure 7: $f_\gamma$ for 10 to 11.6 MeV (all theta) with a Gaussian fit (left panel ) and a Poisson fit (right panel).
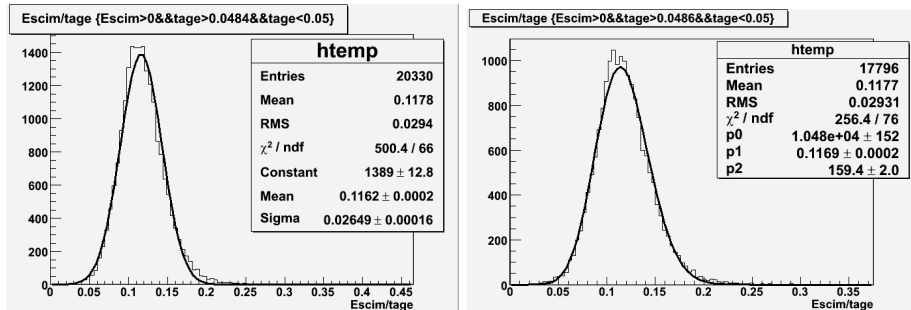


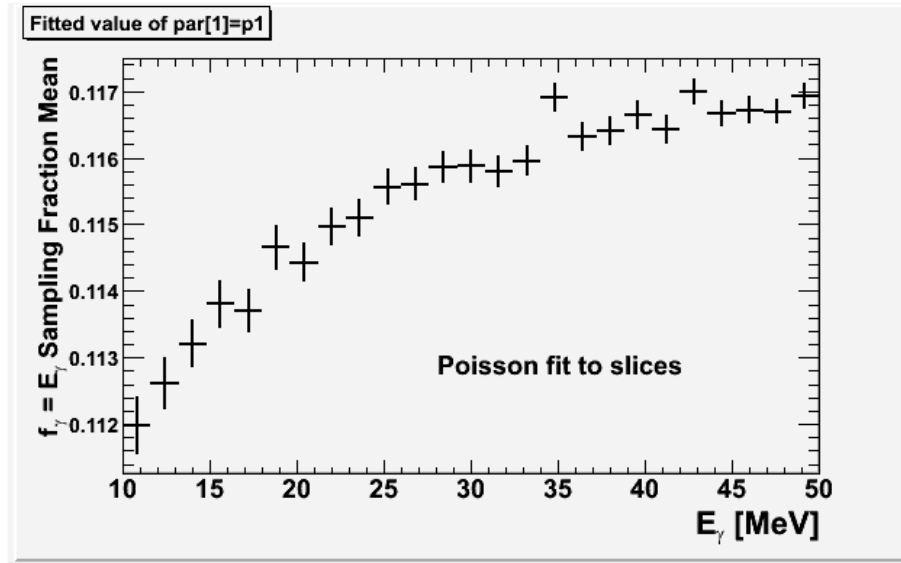Figure 8: $f_\gamma$ for 48.6 to 50 MeV (all theta) with a Gaussian fit (left panel ) and a Poisson fit (right panel).

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]
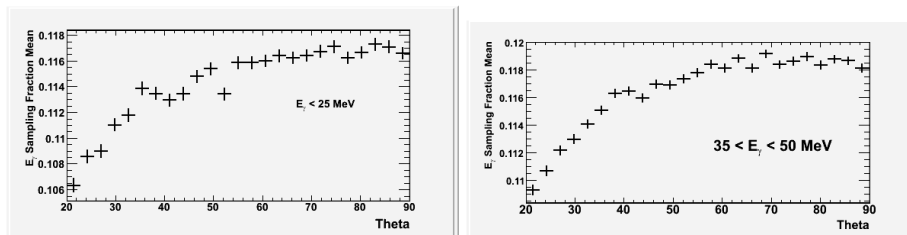


Figure 10: Mean of the Poisson fit versus Theta for photon energy $10 \leq E_\gamma \leq 25 MeV$ (left) and $35 \leq E_\gamma \leq 50 MeV$ (right)
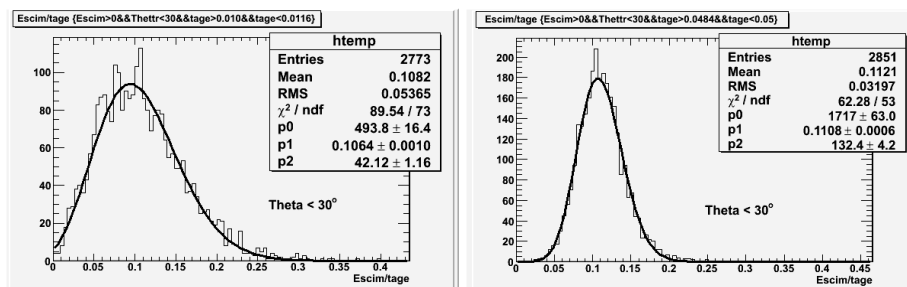


Figure 11: Distributions of the sampling fraction for theta less 30 degrees and $10 \leq E_\gamma \leq 25 MeV$ (left) and $35 \leq E_\gamma \leq 50 MeV$ (right).