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GLAST Tracker Converter Study

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Abstract
The basic ideas behind changing the distribution of the converter mass in the GLAST tracker (TKR) are shown. Simulations of the tracking performance of one selected layout (EL) are shown in comparison with the AO layout.

I. Photon Conversion Probability vs. Converter Mass

The number of photons converted in the tracker is a unique function of the total mass, conveniently expressed in radiation length (RL). This can be evaluated analytically (spread sheet) by taking into account the attenuation of the beam in the upper layers of the tracker, and normalizing it to the AO numbers which are the results of MC simulations. Figure 1 shows the effective area for the AO tracker footprint as a function of the mass. Due to the change in silicon detector size, this number has to be reduced by 6%.

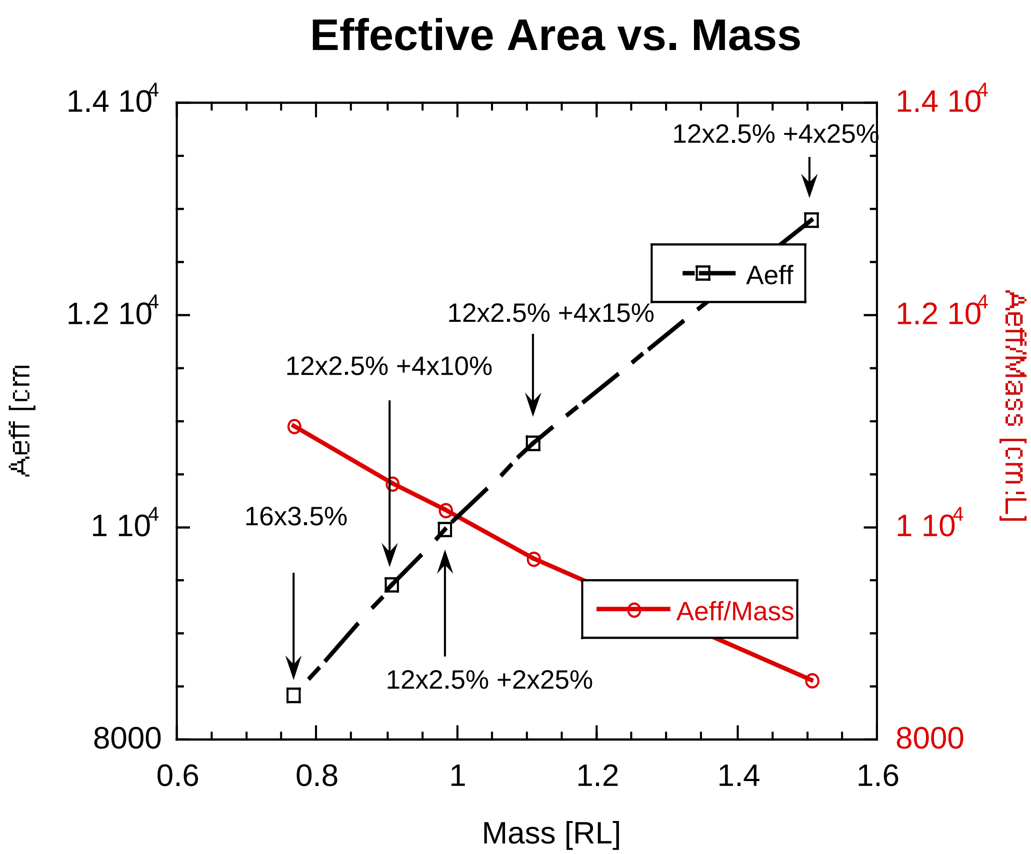

Figure 1 Effective Area A_{eff} in cm^2 vs. tracker mass in radiation length RL. AO footprint. Also shown is the ratio A_{eff}/Mass in cm^2/RL (spread sheet results)

Assuming we want to design for an effective area of 10,000cm^2, we need a total mass of 1.06RL.

II. Layouts with different Converter Distributions

We will assume in the following that we will keep the 18 x-y layer structure of the AO design: as we all know, more is better, but more expensive in power and cost. Again this is done with the analytical method.

We will also assume that for triggering purposes, we will keep the extra two x-y planes without converters at the bottom of the TKR module. Thus we have to distribute 1.06RL over 16 x-y layers. We assume in the following, that in addition to the converter mass, a mass of 1.3%RL is in the Si detectors, the Kapton, face sheets and hexel core.

The following Converter distributions will be considered:

1) Uniform distribution
   16 layers with (5.3. +1.3)% per layer + 2 empty
2) Diluted AO Layout
   12 layers with (2.5+1.3)% + 4 layers at (13.8+1.3)% + 2 empty
3) Back has ~60% worse resolution
   12 layers with (3.5+1.3)% + 4 layers at (10.8+1.3)% + 2 empty
4) Half of the layers in Front, half in Back,
   8 layers with (3.5+1.3)% +8 layers with (7.2+1.3)% + 2 empty
5) Thin MiniSection in Back
   10 layers with (3.5+1.3)% + 4 layers at (10.8+1.3) %
   + 2layers with (3.5+1.3)% + 2empty.

III. Effective Area Front-Back

The respective front and back effective area are tabulated in table 1 and are compared to the effective area for the descoped AO design in Figure 2. As expected they add up to close to 10,000 cm^2. In Figure 3 we show the gamma conversion probability per layer, which is the relative effective area for each layer. Due to the beam attenuation, it decreases towards the back section. The layouts with heavier back section thus compensate for the attenuated beam with the increase in converter thickness in the back. Note that part of the material in the trays is undesirable because it contributes to the wings in the PSF due to the confusion of the vertex location. Thus one wants to have converter thicknesses quite larger than the 1.3% RL in the trays. This speaks for 3.5% in the front, where we believe that we can reach the SRD requirement for 68% containment angle at low energy. The front section is almost twice as large than the back. One also avoids making the back converters too thick.

We like Layout 5 above, where the Thin MiniSection with Aeff = 630 cm^2 allows conversion close to the calorimeter with very small further absorption. The trigger should be efficient and the energy resolution very good: it is thus optimized for bias free detection of low energy signals and wide band energy spectral investigation of relatively bright sources.

Table 1: Effective Area of different Tracker layouts (spread sheet result)

Layout	Aeff (Front) [cm^2]	Aeff (Back) [cm^2]	Aeff(Total) [cm^2]
Uniform 12x5.3%	9800	0	9800
12*2.5%, 4*13.8%	5230	4660	9890
12*3.5%, 4*10.8%	6320	3570	9890
8*3.5%, 8*7.2%	4520	5450	9970
10+2*3.5%, 4*10.8%	6090 (630 in thin)	3850	9950
12*2.5%, 4*25.8%	5230	6950	12170

The AO alternative to be studied is EL = 12*3.5% + 4*12% radiators. This will be about 1.1R.L.

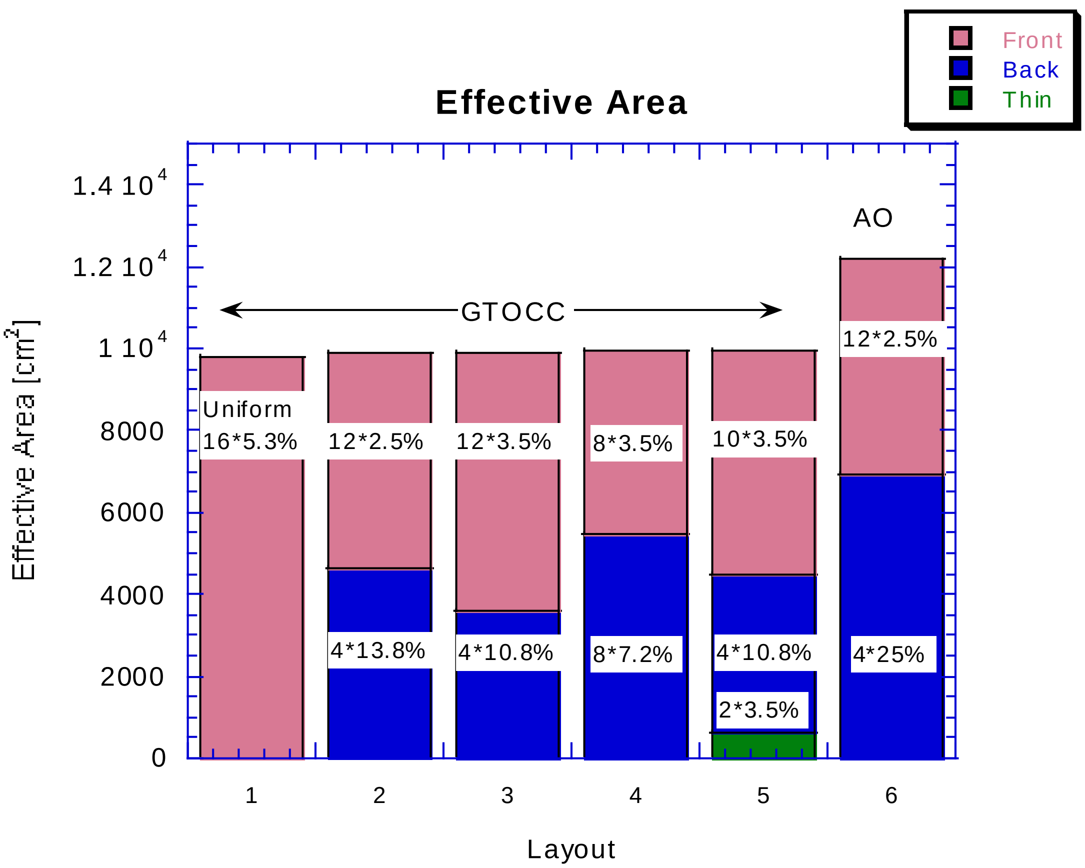

Figure 2: Effective Area for front and back section for different converter distributions (spread sheet result)

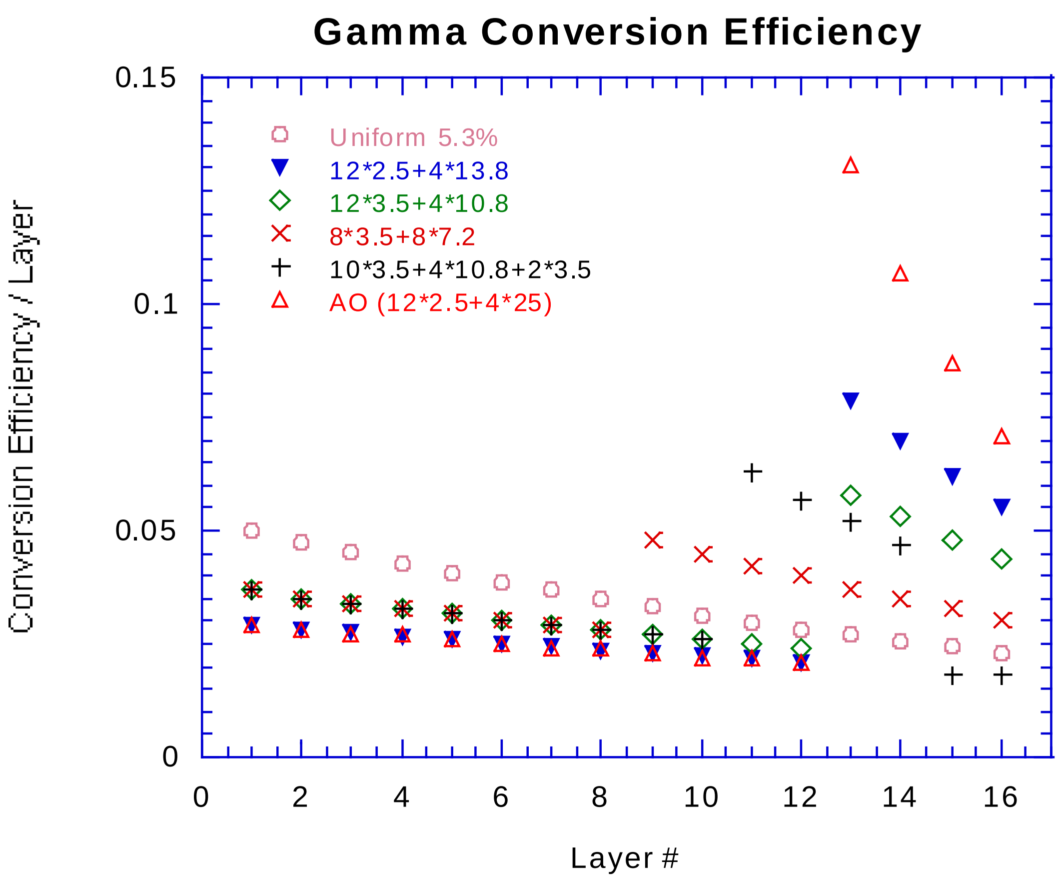

Figure 3 Conversion Efficiency vs. Conversion Plane for several tracker layouts (spread sheet results).

IV. Monte Carlo Simulations of TKR

It was decided to use the GLASTsim and the AO layout. To get the correct effective area's we have to include two factors of 0.94, one of which was applied at the time of the AO, the other a consequence of the recent de-sizing of the SSD. Again, the alternative is EL, which is 3.5% converter in front and 12% converter in the back. In addition, it is believed that 1.3% is contributed by the tray structure. The comparison study was done by Jose Hernando and Brian Baughman.

Figure 4 shows comparison of effective area between AO layout and El layout (both scaled by 0.89). As expected, we get a total effective area of about 10,000cm^2 for EL. The difference to the layout AO is mainly in the back. The front of the EL layout has, as expected, slightly higher effective area than the AO layout.

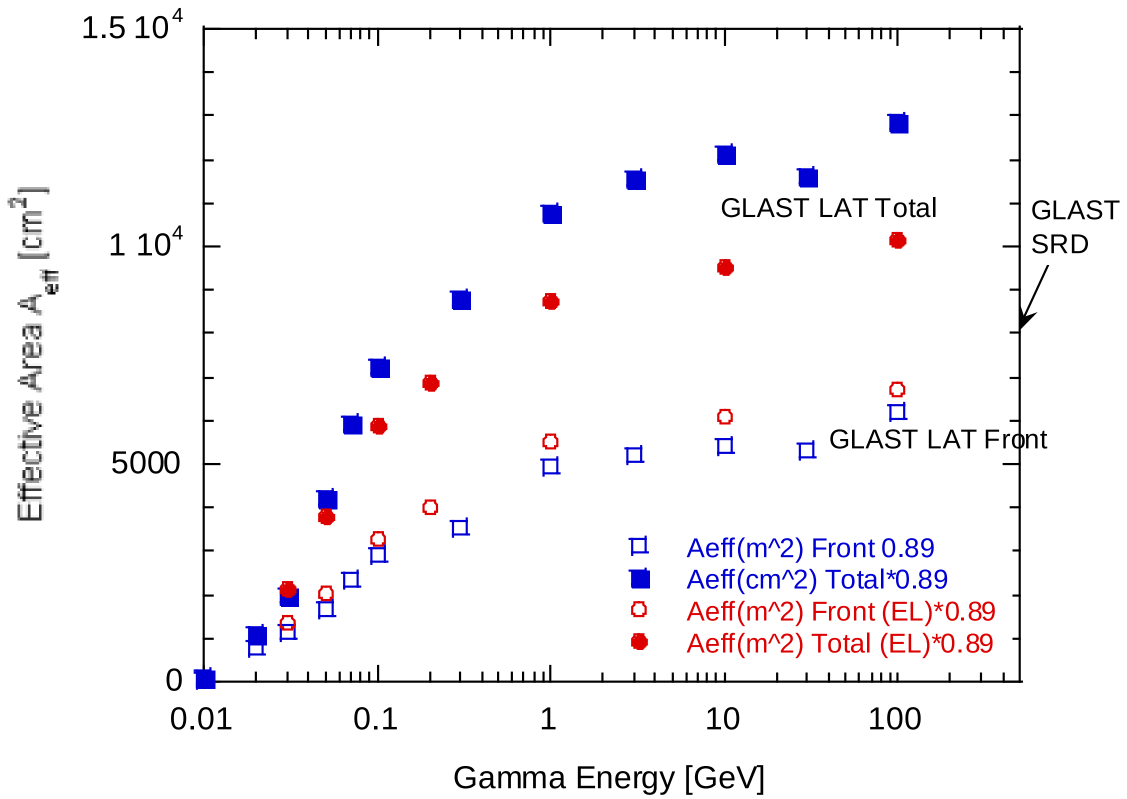

Figure 4 Comparison of Effective Area between AO layout (scaled by 0.89) and El layout (MC simulations courtesy Prof. Jose-Angel Hernando)

Figure 5 shows comparison between AO layout as used in the AO response and El layout of the 68% space containment angle PSF68 both for the front part and the total, where the front and back are combined in quadrature weighted by the respective effective area's. As expected, the front part is slightly worse in the EL layout (for example at 100MeV, the PSF68 is 3.1deg for AO and 3.5deg fro EL. But EL has the best overall PSF68 because of the better behavior of the back. A comparison between the AO program now and the AO figures shows that the simple analysis of the AO and EL used now overestimates the PSF68 by up to 30% at higher energy (>10GeV). This is most likely due to the more sophisticated averaging of contribution from different trays used at AO time. This should be redone here too.

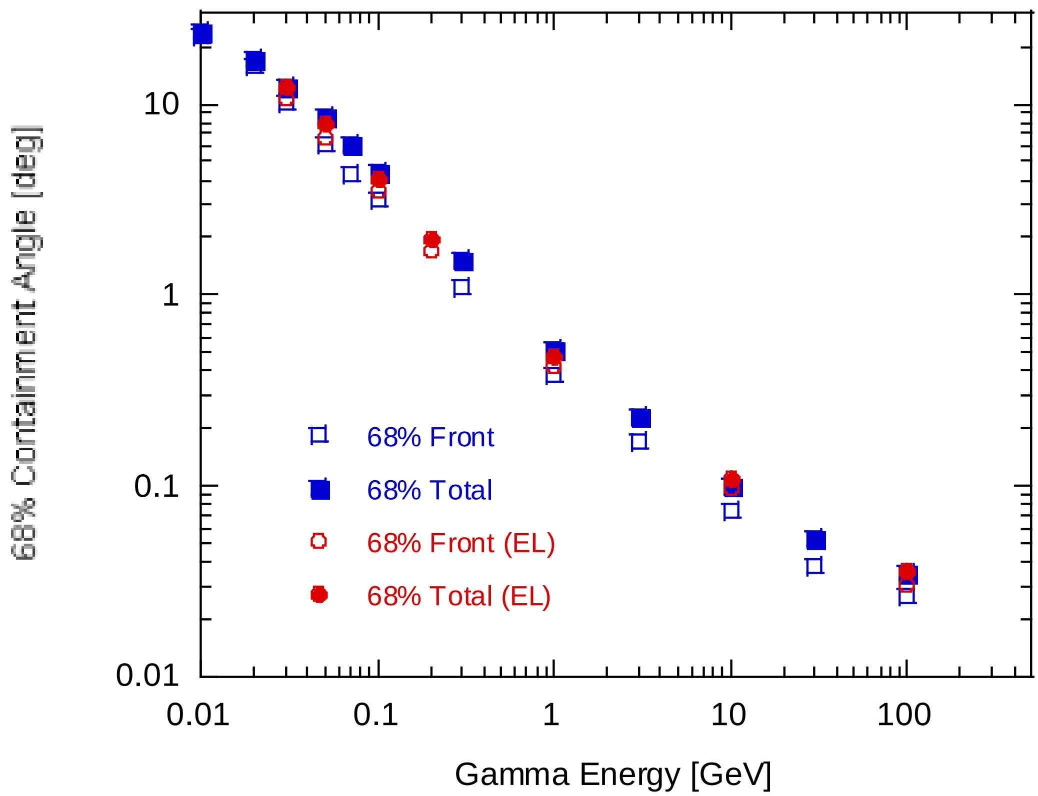

Figure 5 Comparison of the 68 % containment angle between AO and EL layout. The values at 10 and 100GeV are most likely influenced by different methods to combine the data. (MC simulation courtesy Prof. Jose-Angel Hernando)

Figure 6 shows comparison between AO layout as used in the AO response and El layout of the figure of merit FOM for background limited sources. This FOM is given by $A_{eff}^{0.5}$/PSF68. . The FOM for both the AO and the EL layout are very similar, and the deviate only at 10 and 100GeV. This difference will most likely largely disappear once the data are analyzed the same way.

V. CONCLUSION

The EL layout works quite well, given better overall PSF68 than the AO layout and satisfying the science requirements at low energy with the front and at high energy with the total instrument.

One issue is the relative thickness of the front converter and the tray material. The above AO and EL studies were done with a MC having 1.3%RL in the trays, while the present mechanical designs have about 1.7%RL.

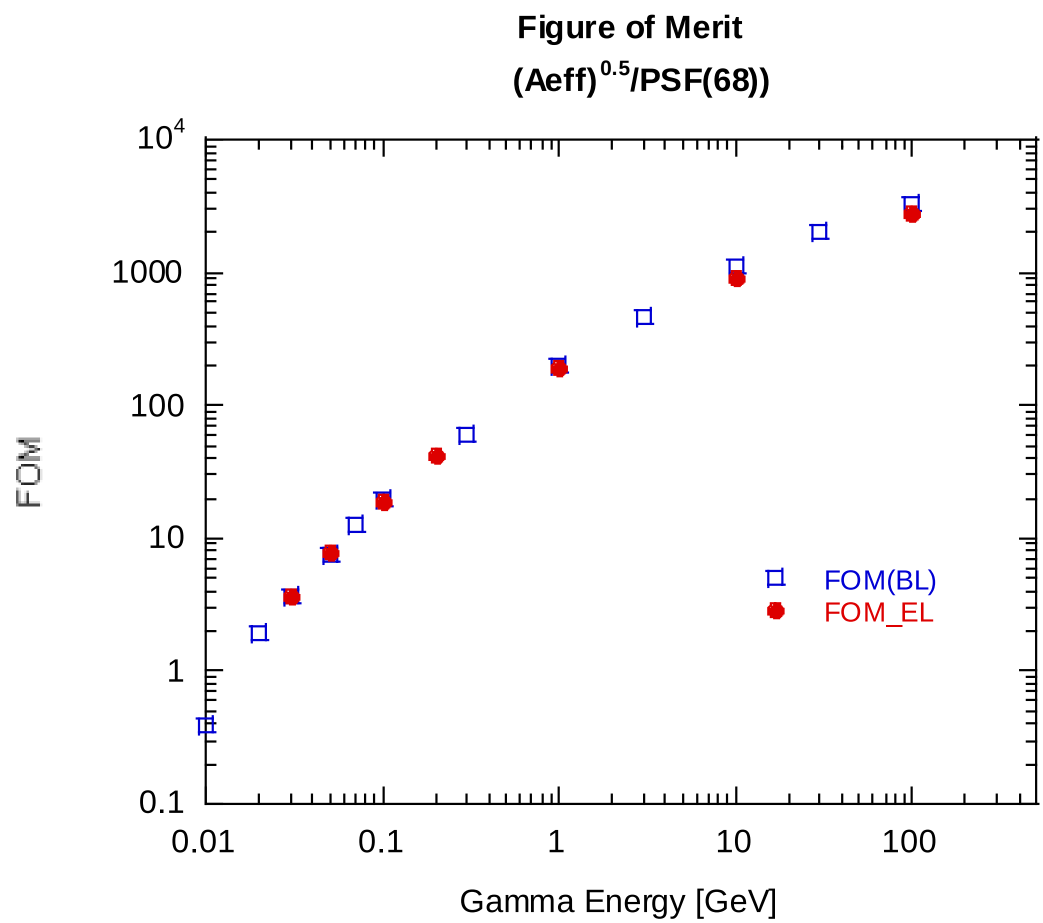

Figure 6 Comparison of the Figure of Merit for detection of background limited source between AO and EL layout. The values at 10 and 100GeV are most likely influenced by different methods to combine the data. (MC simulation courtesy Prof. Jose-Angel Hernando)