Document Title **D1 Sensitivity as a Function of Zenith Angle**

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Contents

References

1] “COMPTEL Response Representation for Compound Instrument,” COM-TN-MPE-K70-053, A.W. Strong, W. Hermsen & R. Diehl, 11 November 1986.

2] “Exposure Arrays for DRI dataset,” SKY-AL-002-01, 19 September 1986.

1 Introduction

The spatial response representation used in standard COMPTEL imaging analysis requires knowledge of the D1 detector sensitivity as a function of source zenith angle θ, independent of the rest of the telescope. This information is used by the COMPASS task SKYDRI to compute the exposure function (i.e., DRX dataset). Presently, SKYDRI uses the simple analytic expression

$$S_{\mathrm{D1}}(\theta) \propto 1 - e^{(-0.2 \sec \theta)} \quad (1)$$

for the zenith angle dependence of D1 sensitive area S_{D1}. The factor of 0.2 in the exponent is the energy-averaged D1 detector thickness in radiation lengths. This simple expression does not account for the particular geometry of the COMPTEL D1 module array, nor the energy or energy threshold dependence of the D1 response. In this report, D1 sensitivity is investigated with Monte Carlo simulations which more accurately account for these effects.

2 Analysis

A simple model of the D1 detector array, consisting solely of the seven cylindrical NE213A scintillator volumes, was used in conjunction with the GEANT3.21 Monte Carlo package to simulate the D1 effective area. As illustrated in Figure 1, incident photons were started above the detector plane in a wide, parallel, beam fully encompassing all the D1 scintillators. Several runs were performed, each with a different source zenith direction. In addition, several different power law energy spectra were used. In all cases, the incident photon energy spectrum extended from 50 keV to 90 MeV.

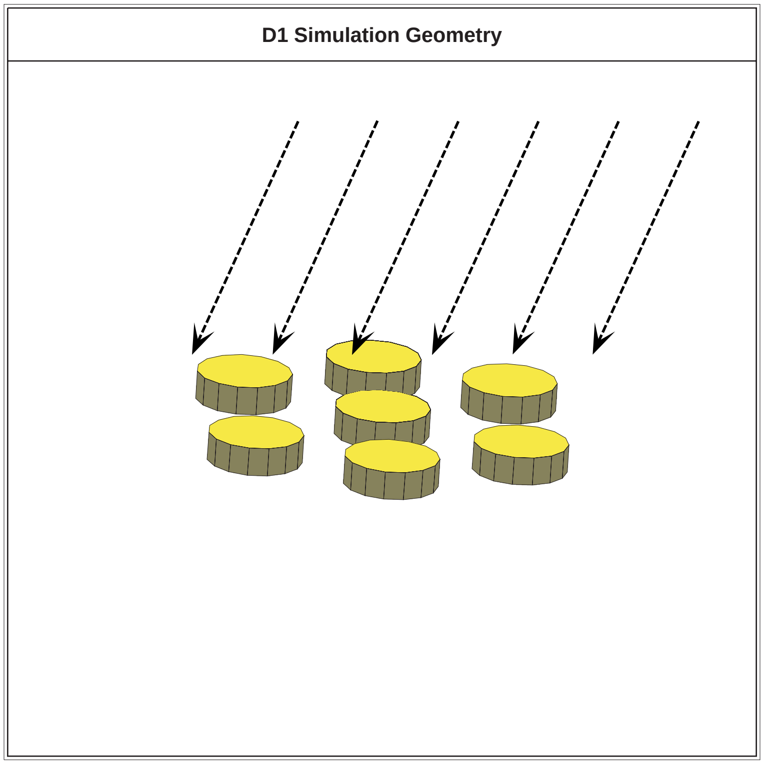

Fig. 1. The simple simulation model and photon beam geometry used in this investigation.

Photons which deposited energy any one of the scintillator volumes were subject to a variable D1 energy deposit threshold. The effective area S_{D1} and its statistical uncertainty were computed with the following expression

$$S_{D1} = A_{beam}\left(\frac{N_{sel}}{N_{inp}}\right) \pm A_{beam}\left(\frac{\sqrt{N_{sel}}}{N_{inp}}\right), \tag{2}$$

where A_{beam} is the incident photon beam area normal to the source direction, N_{sel} is the number of selected events and N_{inp} is the number of incident photons.

3 Results

The following figures and table show the D1 sensitive area as a function of source zenith angle, as determined through Monte Carlo simulations, compared to the analytic approximation of Eq. 1. Note that all results are normalized such that $S_{D1}(\theta=0°) = 1$. Figure 2 illustrates the effect of changing the D1 energy threshold, while Figure 3 shows the effect of changing the incident photon spectrum. The data given in Table 1 is for a D1 energy deposit threshold of 50 keV.

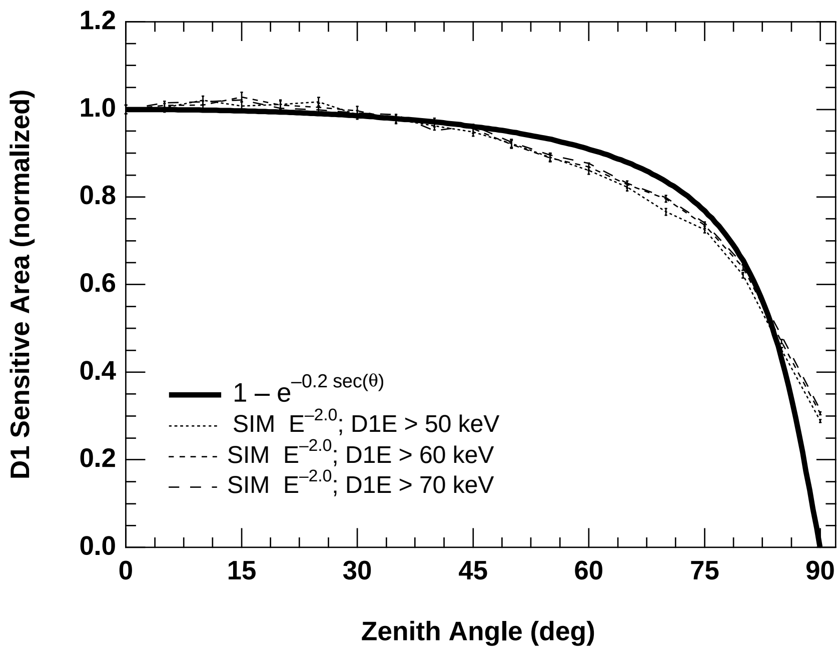

Fig. 2. D1 sensitivity results for different energy deposit thresholds.

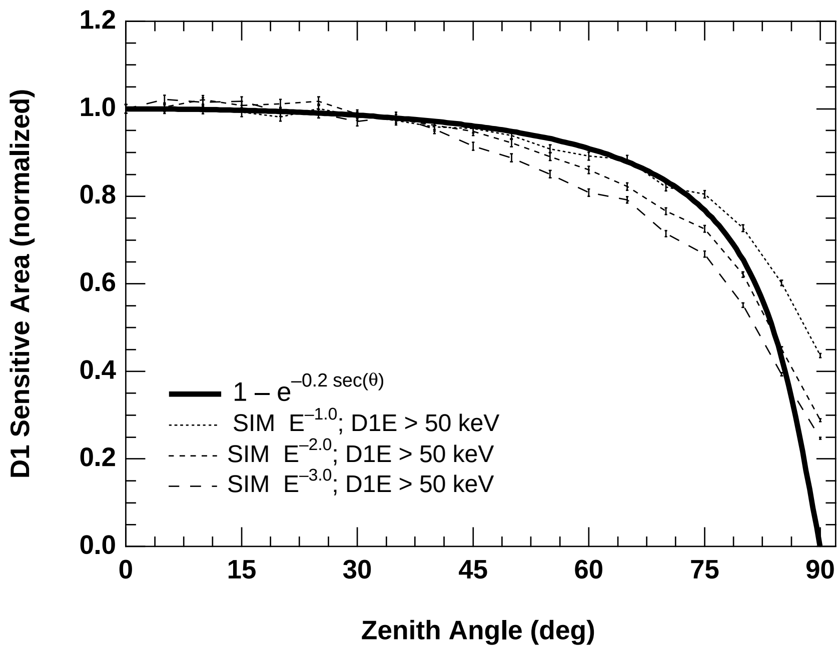

Fig. 3. D1 sensitivity results for different incident photon energy spectra.

Table 1. Monte Carlo D1 Sensitivity vs. Zenith Angle Results.

	E^{-1} Spectrum		E^{-2} Spectrum		E^{-3} Spectrum	
θ (deg)	S_{D1}	±	S_{D1}	±	S_{D1}	±
0.0	1.0000	0.0100	1.0000	0.0100	1.0000	0.0100
5.0	0.9991	0.0100	1.0033	0.0100	1.0213	0.0102
10.0	0.9979	0.0100	1.0207	0.0102	1.0153	0.0102
15.0	0.9925	0.0099	1.0078	0.0101	1.0174	0.0102
20.0	0.9814	0.0098	1.0110	0.0101	0.9929	0.0099
25.0	1.0004	0.0100	1.0174	0.0102	0.9890	0.0099
30.0	0.9828	0.0098	0.9877	0.0099	0.9706	0.0097
35.0	0.9733	0.0097	0.9768	0.0098	0.9822	0.0098
40.0	0.9585	0.0096	0.9628	0.0096	0.9534	0.0095
45.0	0.9546	0.0095	0.9483	0.0095	0.9148	0.0091
50.0	0.9385	0.0094	0.9222	0.0092	0.8880	0.0089
55.0	0.9087	0.0091	0.8911	0.0089	0.8502	0.0085
60.0	0.8919	0.0089	0.8605	0.0086	0.8084	0.0081
65.0	0.8838	0.0088	0.8222	0.0082	0.7917	0.0079
70.0	0.8205	0.0082	0.7657	0.0077	0.7147	0.0071
75.0	0.8048	0.0080	0.7258	0.0073	0.6675	0.0067
80.0	0.7274	0.0073	0.6212	0.0062	0.5508	0.0055
85.0	0.6023	0.0060	0.4511	0.0045	0.3938	0.0039
90.0	0.4360	0.0044	0.2887	0.0029	0.2471	0.0025

4 Conclusions

The Monte Carlo simulation results shown in the previous section indicate that the analytic approximation used by SKYDRI to compute the zenith angle dependence of D1 sensitivity is valid only to $\theta \sim 45°$. For $\theta > 45°$, the D1 sensitive area varies significantly as function of incident spectral hardness. The D1 energy deposit threshold does not significantly affect these results.