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SDC
SOLENOIDAL DETECTOR NOTES

ELECTROMAGNETIC RESOLUTION AS A FUNCTION OF LEAD AND SCINTILLATOR THICKNESS

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As a continuation of the work that Tom Kirk presented in his note "Shower Counter Resolution Scaling" (SDC-91-00108), I have used EGS4 to evaluate the stochastic resolution term as a function of scintillator and lead thickness. Approximately 130 electrons of 20 GeV energy were simulated in each case. The geometry consisted of lead plates alternating with scintillator layers; there was no coil or any other material. The stochastic resolution term ($\sigma_E/E \times \sqrt{20} \times 100\%$) and the fraction of energy that is deposited in the scintillator are listed in table 1 and illustrated in figures 1–3. Note that the resolution does not appear to scale as the square root of the lead thickness for a given scintillator thickness.

In the approximation that the observed light is proportional to the energy deposited in the scintillator, the sampling fraction can be used to predict the number of photo-electrons per GeV. The configuration used in the ANL/WSTC cast lead test module—5 mm lead with 2.5 mm RH4 scintillator—has a sampling fraction $s = 0.047$ and an observed light yield of 123 p.e./GeV, implying that $N_{pe}/\text{GeV} = 2600 \cdot s$. Although this device has a different optical system and a different scintillator than that proposed for SDC, I have blindly used these values to extrapolate to other configurations (fig. 4). (SDC will use extended green pmt's to increase the light yield, but with SCSN-81 scintillator, which is less bright than RH4). The contribution of photostatistics to to the resolutions of the configurations listed in table 1 are summarized in table 2. The figures can be used to interpolate to other cases. For example, 2 mm lead with 2.5 mm scintillator is estimated to have a stochastic resolution of $10.4 \pm 0.5\%/\sqrt{E}$ ($8.5 \pm 0.5\%$ from shower statistics, and 6.0% from photostatistics).

Table 1. Electromagnetic stochastic resolution term from shower statistics and sampling fraction as a function of lead and scintillator thickness. Error in the sampling fraction is < 0.0005.

	Scintillator Thickness (mm)			
Lead Thickness (mm)	2	4	6	8
2	8.7 ± 0.5	7.9 ± 0.5	6.3 ± 0.4	
	0.092	0.160	0.216	
4	13.6 ± 0.8	12.8 ± 0.8	11.1 ± 0.7	
	0.048	0.086	0.120	
6	19.0 ± 1.2	16.4 ± 1.0	13.9 ± 0.9	13.6 ± 0.9
	0.033	0.060	0.083	0.105

Table 2. Number of photo-electrons per GeV, contribution of photo-statistics to the stochastic term, and overall stochastic term as a function of lead and scintillator thickness. The error on the stochastic term is the statistical error on the shower contribution only.

	Scintillator Thickness (mm)			
Lead Thickness (mm)	2	4	6	8
2	239	416	562	
	6.5	4.9	4.2	
	10.9 ± 0.5	9.3 ± 0.5	7.6 ± 0.4	
4	125	224	312	
	8.9	6.7	5.7	
	16.3 ± 0.8	14.4 ± 0.8	12.5 ± 0.7	
6	85	155	216	274
	10.8	8.0	6.8	6.0
	21.9 ± 1.2	18.2 ± 1.0	15.5 ± 0.9	14.9 ± 0.9

FIGURE CAPTIONS

1) Contribution of shower statistics to the stochastic resolution term as a function of scintillator thickness, for various lead thicknesses.

2) Contribution of shower statistics to the stochastic resolution term as a function of lead thickness, for various scintillator thicknesses.

3) Fraction of total electron energy that is deposited in the scintillator as a function of scintillator thickness. The corresponding values for the number of photo-electrons per incident GeV are based on values from the ANL/WSTC cast lead EM module and on the assumption that light output is proportional to deposited energy.

4) Contribution of photo-statistics to the stochastic resolution term as a function of scintillator thickness, for various lead thicknesses.

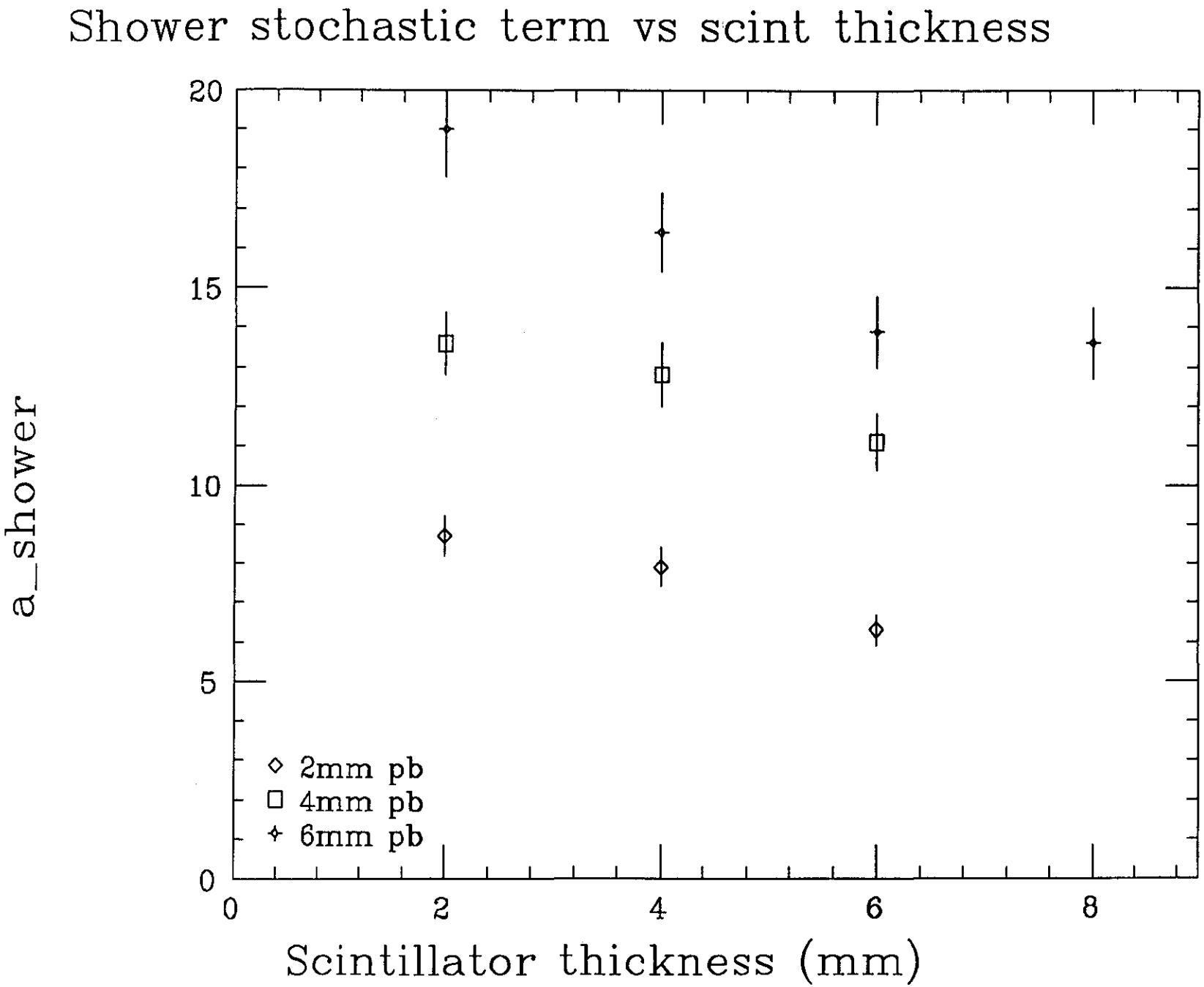
Shower stochastic term vs scint thickness
a_shower
Scintillator thickness (mm)
2mm pb
4mm pb
6mm pb
0
5
10
15
20
0
2
4
6
8

Figure 1

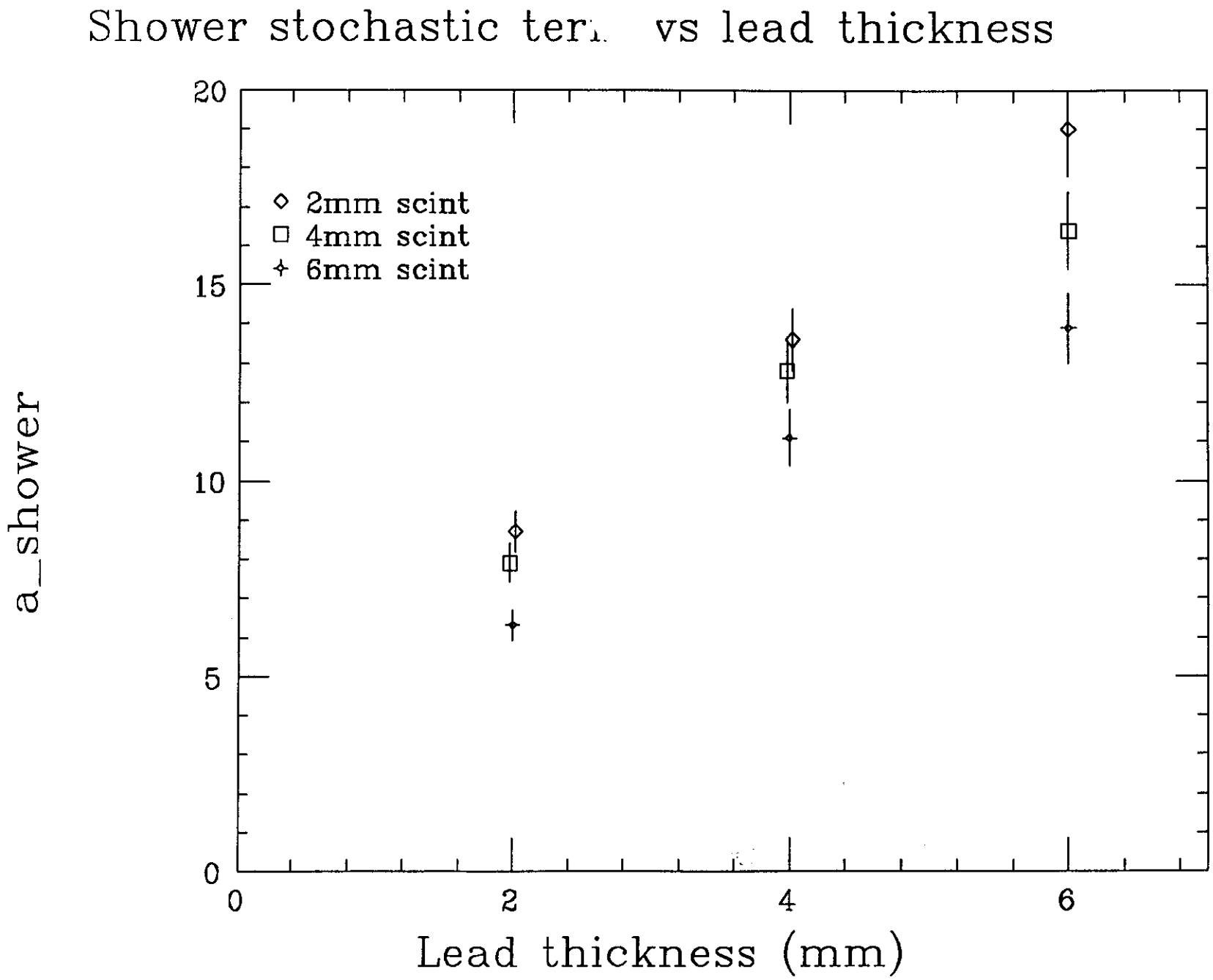
Shower stochastic term vs lead thickness
2mm scint
4mm scint
6mm scint
a_shower
Lead thickness (mm)
0
5
10
15
20
0
2
4
6

Figure 2

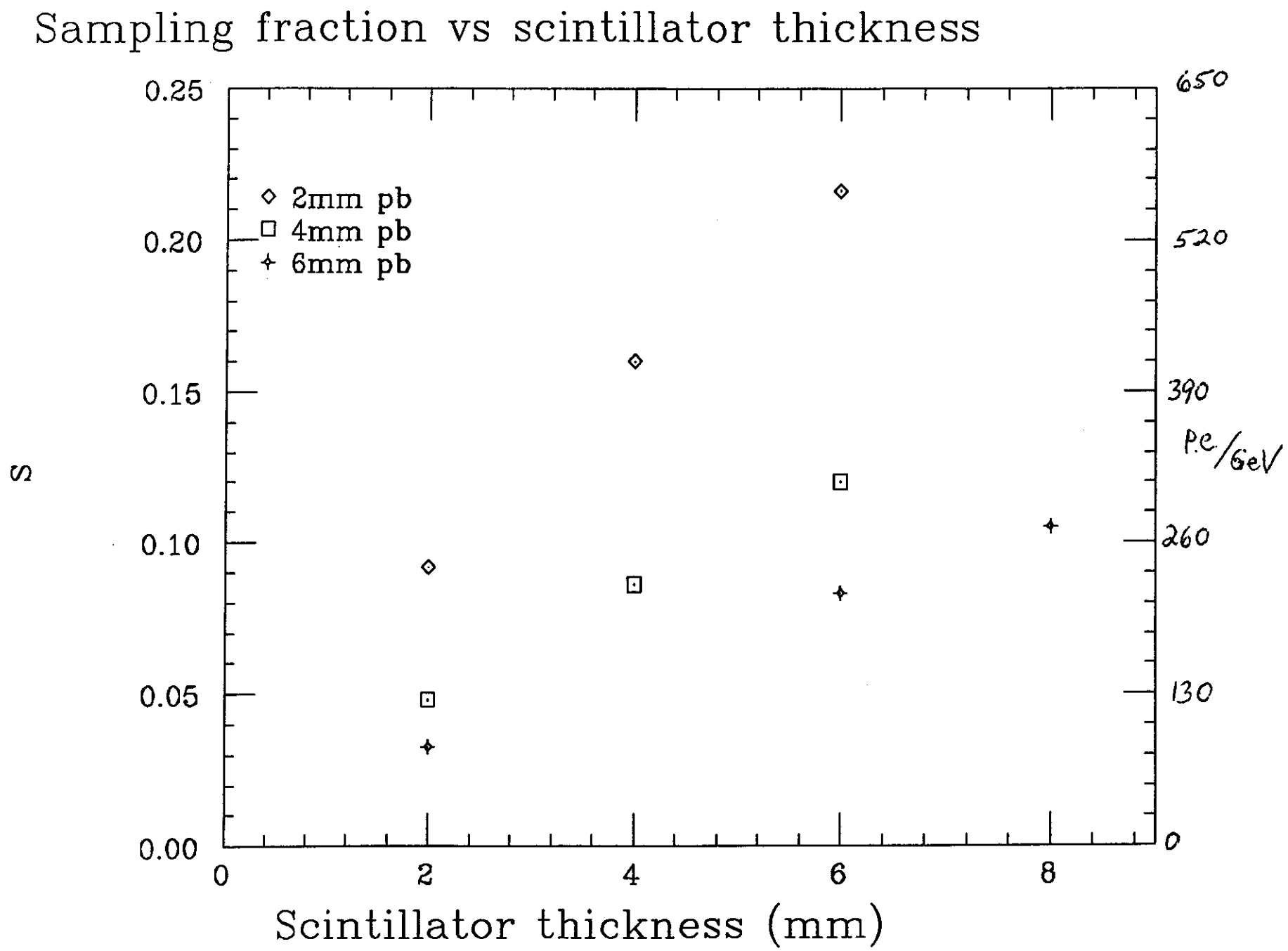
Sampling fraction vs scintillator thickness
0.25
0.20
0.15
0.10
0.05
0.00
S
2mm pb
4mm pb
6mm pb
0
2
4
6
8
Scintillator thickness (mm)
650
520
390
260
130
0
P.e./GeV

Figure 3

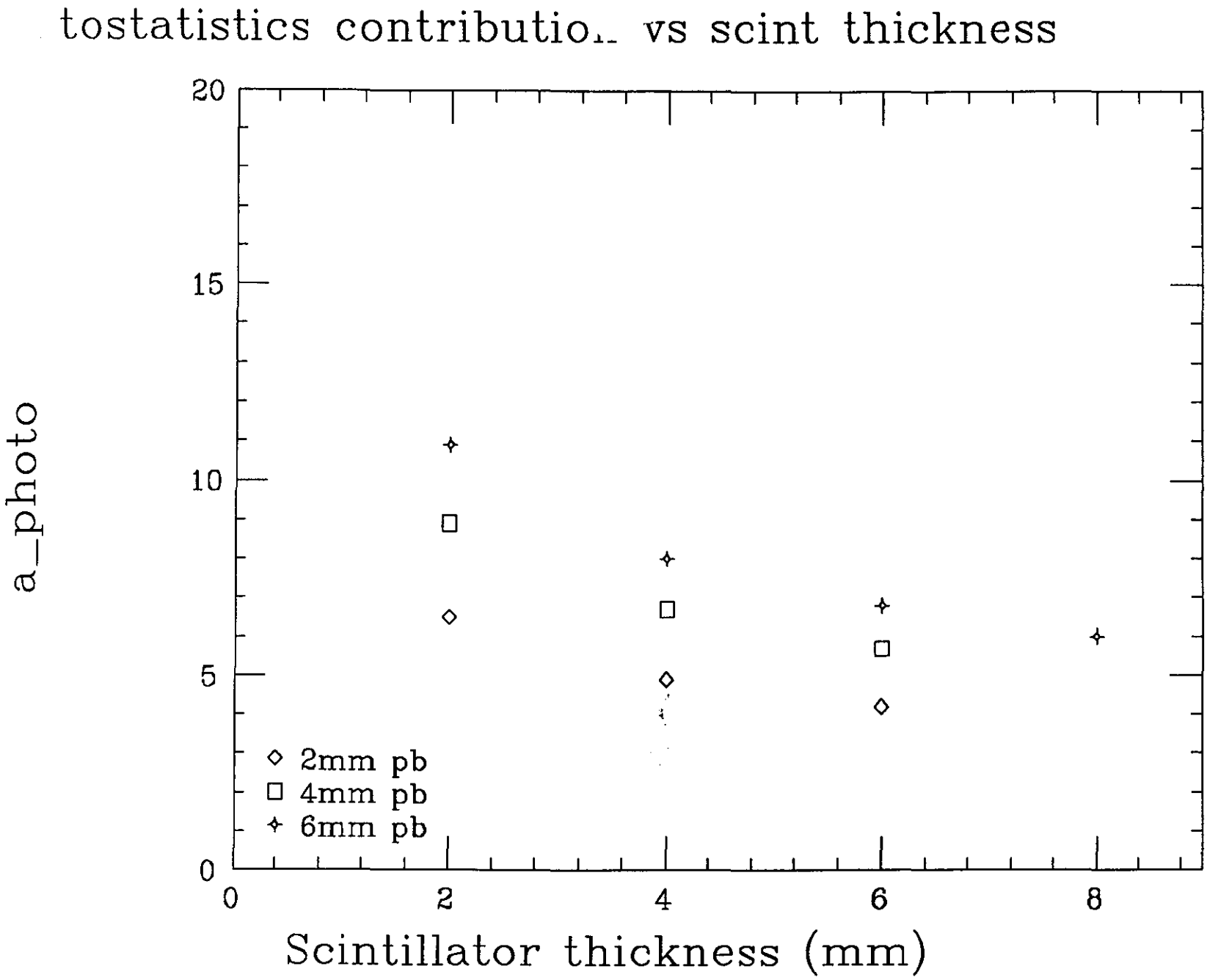
F tostatistics contributio.. vs scint thickness
a_photo
20
15
10
5
0
0
2
4
6
8
Scintillator thickness (mm)
2mm pb
4mm pb
6mm pb

Figure 4