KOPIO TN083

FastMC comparison of standard and E787 photon veto inefficiency

David E. Jaffe, BNL

April 15, 2004

Abstract

I compared the rates of $K_L^0 \to \pi^0\pi^0$, $K_L^0 \to \pi^0\pi^0\pi^0$, $K_L^0 \to \pi^0\pi^+\pi^-$ and $K_L^0 \to e^\pm\pi^\mp\nu\gamma$ backgrounds for the standard KOPIO photon veto inefficiency and a photon veto inefficiency approximating that measured by E787. The $K_L^0 \to \pi^0\pi^0\pi^0$ rate increases by roughly a factor of a hundred and the $K_L^0 \to \pi^0\pi^0$ rate increases by approximately a factor of four.

1 Introduction

The assumptions and methods of this study are described in TN053 [1] for the 100×5 mrad^2 aspect ratio, I merely changed the energy-dependence of the photon veto inefficiency. The standard and approximate E787 photon veto inefficiency is shown in Figure 1. Figure 2 shows the photon veto inefficiency and the ratio of the E787 to the standard photon veto inefficiency as a function of energy.

2 Results

The calculated rates for signal and $K_L^0 \to \pi^0\pi^0$, $K_L^0 \to \pi^0\pi^0\pi^0$, $K_L^0 \to \pi^0\pi^+\pi^-$ and $K_L^0 \to e^\pm\pi^\mp\nu\gamma$ backgrounds are given in Table 1. The $K_L^0 \to \pi^0\pi^0\pi^0$ rates increase by roughly two orders of magnitude. The $K_L^0 \to \pi^0\pi^0$ rates increase by a factor of four to five. The weighted average photon veto inefficiency for the standard and E787 photon veto are given in Tables 2 and 3, respectively. The energy spectra of non-candidate photons for $K_L^0 \to \pi^0\pi^0$ and $K_L^0 \to \pi^0\pi^0\pi^0$ are shown in Figures 3 and 4, respectively, for four of the seven cuts listed in the tables. "Non-candidate photons" are photons that are not included in the candidate π^0. $K_L^0 \to \pi^0\pi^0\pi^0$ events have more photons at lower energy than $K_L^0 \to \pi^0\pi^0$ that are consequently more difficult to veto.

3 Conclusion

KOPIO will be swamped by $K_L^0 \to \pi^0\pi^0\pi^0$ background if the photon veto inefficiency is consistent with the photon veto measurements of E787.

Mode	Standard PV	E787 PV	Cut
kpnn	28.87 ± 0.3748	28.87 ± 0.3748	MZ
kpnn	91.22 ± 0.6632	91.22 ± 0.6632	AK basic
kpnn	60.15 ± 0.5394	60.15 ± 0.5394	AK loose
kpnn	53.63 ± 0.5094	53.63 ± 0.5094	AK lominal
kpnn	36.98 ± 0.4226	36.98 ± 0.4226	AK tight
kpnn	24.34 ± 0.3427	24.34 ± 0.3427	AK tighter
kpnn	21.24 ± 0.3203	21.24 ± 0.3203	AK tightest
kp3	1.001 ± 0.3574	92.55 ± 12.44	MZ
kp3	1.891 ± 0.3867	166.6 ± 14.62	AK basic
kp3	0.8845 ± 0.0669	102.5 ± 9.395	AK loose
kp3	0.8843 ± 0.0669	102.5 ± 9.395	AK lominal
kp3	0.6664 ± 0.0645	71.68 ± 8.386	AK tight
kp3	0.4500 ± 0.0533	49.38 ± 6.063	AK tighter
kp3	0.4031 ± 0.0523	44.16 ± 5.908	AK tightest
kp2	3.715 ± 0.1485	16.19 ± 0.6411	MZ
kp2	110.3 ± 3.379	483.2 ± 19.44	AK basic
kp2	45.24 ± 2.055	199.3 ± 11.21	AK loose
kp2	26.74 ± 0.7125	118.9 ± 1.921	AK lominal
kp2	10.02 ± 0.4826	39.99 ± 1.179	AK tight
kp2	3.176 ± 0.2626	11.83 ± 0.6172	AK tighter
kp2	2.370 ± 0.2388	8.424 ± 0.5097	AK tightest
ke3g	3.536 ± 0.2103	3.974 ± 0.2301	MZ
ke3g	17.34 ± 0.5010	19.63 ± 0.5502	AK basic
ke3g	6.856 ± 0.2972	7.786 ± 0.3271	AK loose
ke3g	6.031 ± 0.2747	6.827 ± 0.3005	AK lominal
ke3g	4.679 ± 0.2398	5.305 ± 0.2628	AK tight
ke3g	3.028 ± 0.1934	3.382 ± 0.2099	AK tighter
ke3g	2.542 ± 0.1757	2.832 ± 0.1906	AK tightest
kcp3	0.6595 ± 0.0866	0.6595 ± 0.0866	MZ
kcp3	15.89 ± 0.4141	15.89 ± 0.4141	AK basic
kcp3	2.233 ± 0.1597	2.233 ± 0.1597	AK loose
kcp3	2.228 ± 0.1596	2.228 ± 0.1596	AK lominal
kcp3	1.437 ± 0.1291	1.437 ± 0.1291	AK tight
kcp3	0.6971 ± 0.0953	0.6971 ± 0.0953	AK tighter
kcp3	0.4408 ± 0.0730	0.4408 ± 0.0730	AK tightest

Table 1: The calculated rates and statistical uncertainties for the signal (kpnn), $\mathrm{K_L^0} \to \pi^0\pi^0\pi^0$ (kp3), $\mathrm{K_L^0} \to \pi^0\pi^0$ (kp2), $\mathrm{K_L^0} \to e^{\pm}\pi^{\mp}\nu\gamma$ (ke3g) and $\mathrm{K_L^0} \to \pi^0\pi^+\pi^-$ (kcp3) backgrounds for various sets of cuts for the standard and E787 photon veto inefficiency.

Cut : Mode	kpnn	kp3	kp2	ke3g	kcp3
Zcuts DSV	1.00	0.163E-11	0.290E-07	0.130E-03	0.355E-09
AK basic	1.00	0.951E-12	0.576E-07	0.129E-03	0.371E-09
AK loose	1.00	0.107E-11	0.542E-07	0.128E-03	0.367E-09
AK lominal	1.00	0.107E-11	0.477E-07	0.129E-03	0.367E-09
AK tight	1.00	0.102E-11	0.352E-07	0.130E-03	0.362E-09
AK tighter	1.00	0.970E-12	0.359E-07	0.134E-03	0.384E-09
AK tightest	1.00	0.983E-12	0.330E-07	0.136E-03	0.354E-09

Table 2: Average event weight for the **standard** photon veto ineffiency for each mode and cut.

Cut : Mode	kpnn	kp3	kp2	ke3g	kcp3
Zcuts DSV	1.00	0.158E-09	0.125E-06	0.145E-03	0.355E-09
AK basic	1.00	0.871E-10	0.251E-06	0.145E-03	0.371E-09
AK loose	1.00	0.125E-09	0.234E-06	0.144E-03	0.367E-09
AK lominal	1.00	0.125E-09	0.205E-06	0.144E-03	0.367E-09
AK tight	1.00	0.112E-09	0.139E-06	0.146E-03	0.362E-09
AK tighter	1.00	0.108E-09	0.131E-06	0.149E-03	0.384E-09
AK tightest	1.00	0.110E-09	0.116E-06	0.150E-03	0.354E-09

Table 3: Average event weight for the **E787** photon veto ineffiency for each mode and cut.

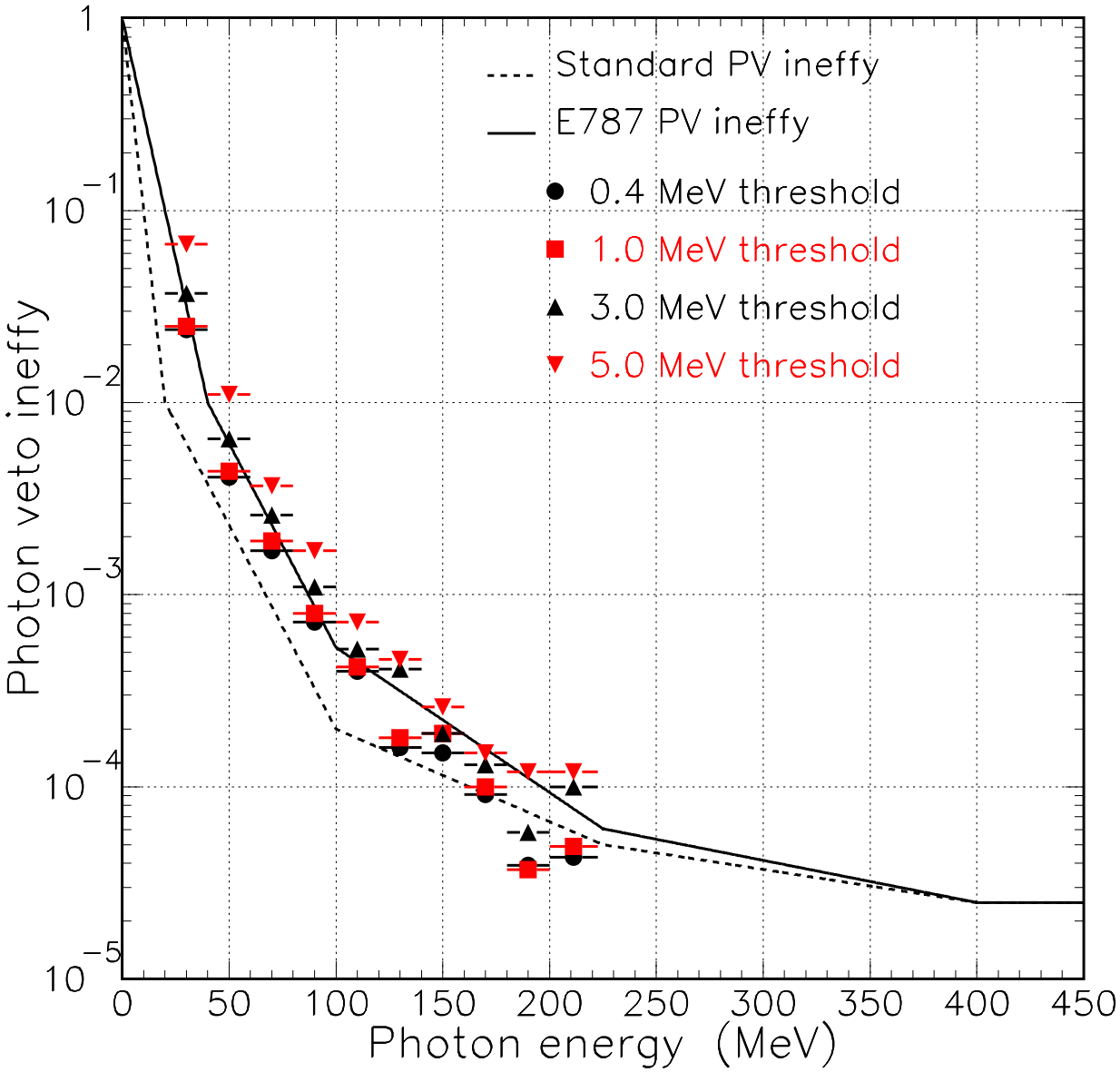

Figure 1: The 'standard' (dashed) and 'E787' (solid) photon veto inefficiency as a function of photon energy. The solid line is a approximation to the points shown. The points are E787 measurements taken from Table 2.1 of TN071 [2]. The uncertainties on the E787 measurements are not shown in the figure. The horizontal error bars represent the bin width of the measurements.

References

[1] D.E. Jaffe, *Beam aspect ratio and FastMC acceptance* KOPIO TN053, 27 Mar 2003.

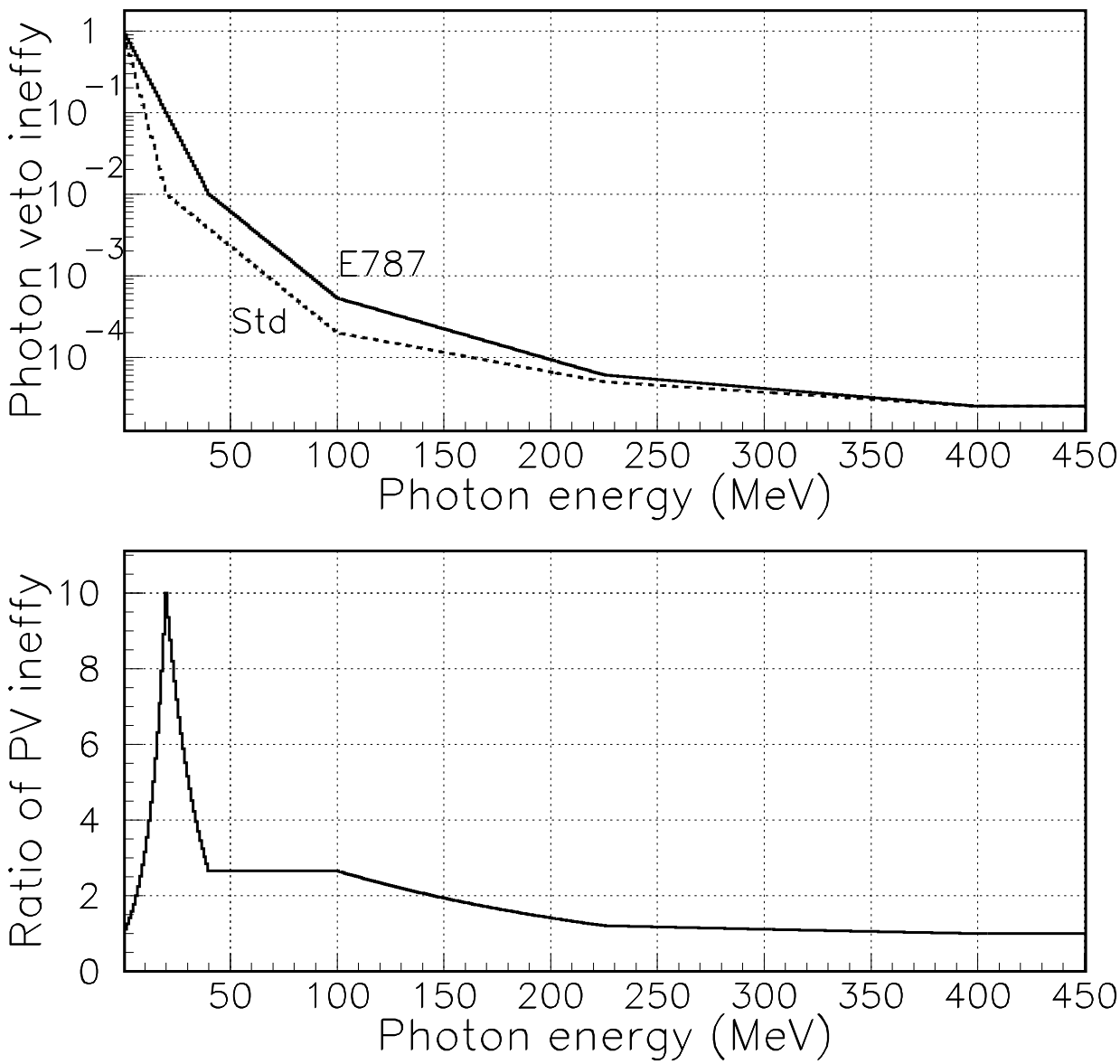

Figure 2: Upper: The 'standard' (dashed) and 'E787' (solid) photon veto inefficiency as a function of photon energy. Lower: The ratio of E787 photon veto inefficiency to standard.

[2] L. Littenberg, *Not quite everything you always wanted to know about photon inefficiency* KOPIO TN071, 28 Nov 2003.

[3] Skim cuts are $0 < E(K) < 1486$ MeV, $0 < Z(K) < 2000$ cm, $0 < E^*(\pi^0) < 240$ MeV, $100 < M([gg]) < 170$ MeV/c^2, $E^*(\pi^0) - |E^*([g]_1) - E^*([g]_2)| > 0$ MeV. All quantities are 'reconstructed' K^0_L or π^0 quantities.

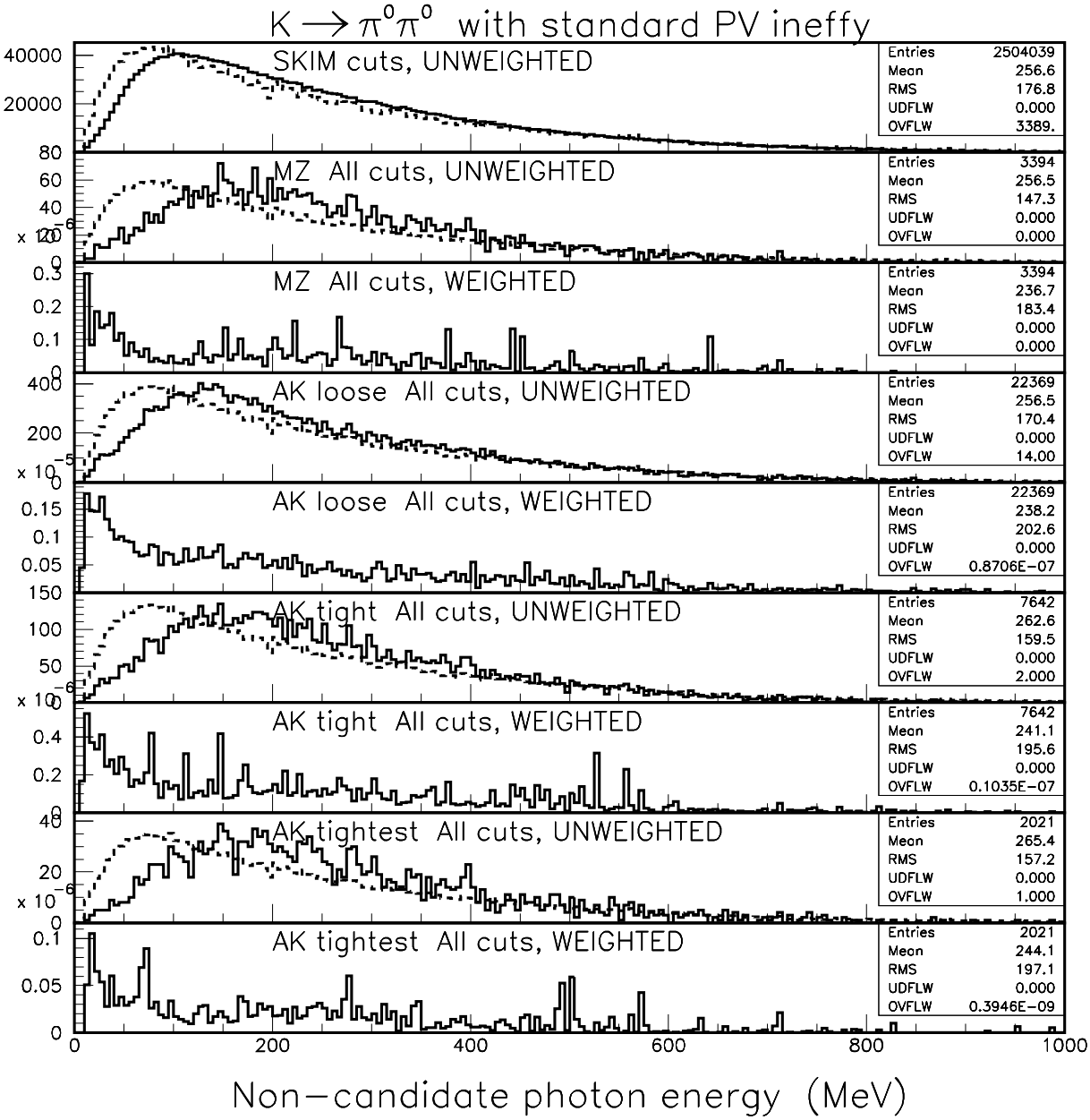

Figure 3: The energy spectrum of photons that are not in the candidate π^0 from $K_L^0 \to \pi^0\pi^0$ decays. From the top: 1) Skim cuts [3], unweighted spectrum. The shape of the **uncut**, unweighted spectrum is shown as the dashed line. 2) After MZ cuts, unweighted. The shape of the **uncut**, unweighted spectrum is shown as the dashed line. 3) After MZ cuts, weighted. The weight is the overall event weight, not just the photon veto inefficiency weight. 4) and 5) For AK loose, 6) and 7) For AK tight, 8) and 9) For AK tightest.

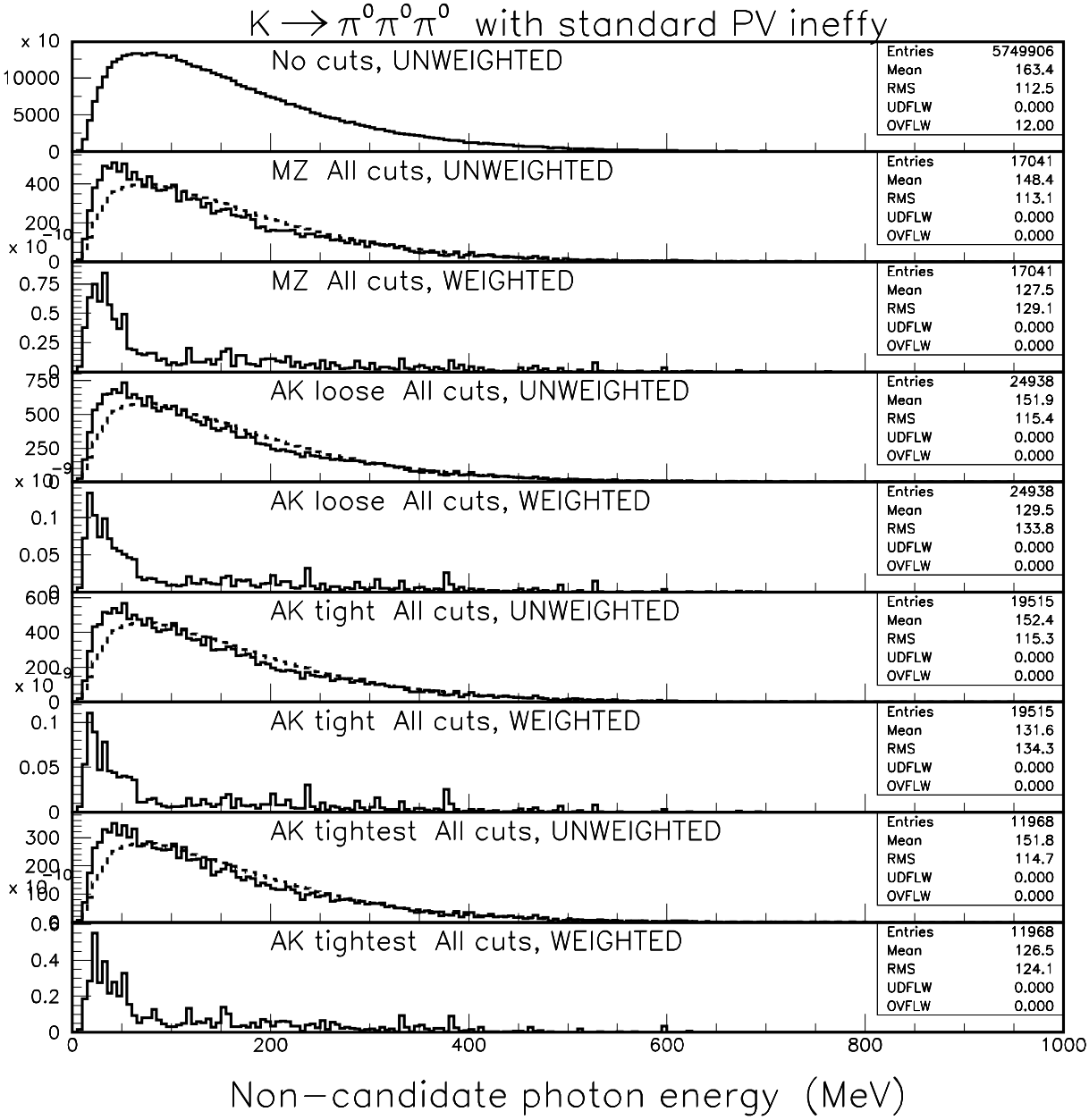

Figure 4: The energy spectrum of photons that are not in the candidate π^0 from $K_L^0 \to \pi^0\pi^0\pi^0$ decays. From the top: 1) Skim cuts [3], unweighted spectrum. 2) After MZ cuts, unweighted. The shape of the **skimmed** unweighted spectrum is shown as the dashed line. 3) After MZ cuts, weighted. The weight is the overall event weight, not just the photon veto inefficiency weight. 4) and 5) For AK loose, 6) and 7) For AK tight, 8) and 9) For AK tightest. **Note that the dashed histogram has a different definition than Figure 3.**