An estimate of ϕ and ω yields from the 2000 run

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Abstract

The subset of 3 γ events from the full data sample from the LGD is analysed. The dependence of the number of ϕ and ω on the minimum total deposited energy is examined. The number of observed ϕ is larger than expected from the γp -> ϕp cross section. The ratio ω/ϕ is $\approx$ 3 times lower than expected from the cross section and branching ratios. While the mass of the ω is close to its value the ϕ mass is shifted down by $\approx 70 Mev/c^2$, requiring further study of the LGD.

Table 1: ϕ mass, width and yield as a function of minimum deposited energy in the LGD.

$E_{TOT} > [Gev]$	$M_\phi [Gev/c^2]$	$\sigma_\phi [Gev/c^2]$	N_ϕ
3.5	0.931	0.065	555513.0
4.0	0.943	0.065	460076.0
4.5	0.954	0.070	228128.0
5.0	0.967	0.075	87140.4

1 Introduction

The most abundant and well known all-neutral ϕ and ω decays are ϕ -> $\eta\gamma$ (3γ) and ω -> $\pi^0\gamma$ (3γ). They are both 3γ events and they can be used to check the calibration of the Lead Glass Detector (LGD). To examine 3γ events, the invariant mass of every 2γ pair in 3-cluster events is formed. The plot of 2γ invariant mass shows two peaks one high and sharp corresponding to the π^0 and one less pronounced near the η mass. This is used to select desired ϕ or ω events, since π^0 can come from ω decay while η is expected from ϕ decay.

2 ϕ yield

From the 3γ data sample, ϕ events are selected by requiring that there is no π^0 in the event and that η candidates from 2γ pairs are constrained to $\pm 10\%$ of the η mass ($0.5\ GeV/c_2 < M_{2\gamma} < 0.6\ GeV/c^2$). We do not require just the presence of the η because π^0 production is 50 times larger than η. Without cutting on the π^0, the η signal competes with the π^0 combinatoric background. The invariant mass distribution of 3γ is then formed for different minimum total energy in the LGD. These distributions for 4 different energy thresholds are shown in Fig. 1, where one can see how the ϕ peak becomes more prominent when the total energy threshold is increased.

The number of ϕ is found from the fit of these distributions to 3 Gaussians: one corresponding to the residual ω peak, one broad corresponding to the background (BG) and the third one for the ϕ. To keep the number of parameters small, the position of the background Gaussian is set to be equal to the position of the ω peak, while the width of the BG is fixed to the ω width by $\sigma_{BG} = a\sigma_\omega$. In addition, the width of ϕ is kept constant during fitting, $\sigma_\phi = b$. Constants a and b are adjusted until good fits with reasonable looking background is found. Obtained ϕ mass, width and yield for different energy cuts are given in the Table 1.

3 ω yield

The ω sample is selected by requiring that at least one pair of photons have invariant mass within the (0.08, 0.2) GeV window. This corresponds to the case of selecting the π^0 as opposed to rejecting the π^0 for ϕ selection. In the case of ω, no η veto is needed. The π^0 mass is small compared to the ω and in order to form ω, the third photon should have a large separation so that invariant mass formed with one of the remaining photons will often be in the η region. Thus cutting on the η significantly decreases our ω signal.

Invariant mass distributions, obtained with the above criteria, for 4 total energy thresholds are shown in Fig. 2. They are fitted by the sum of two Gaussians, with the one corresponding to the background represented by the dashed line. Similar to the ϕ case, the signal to background ratio is enlarged when the energy threshold in the LGD is increased. The ω mass, width and yield for the corresponding energy cut are given in Table 2. In order to show the influence of π^0 selection on our ω sample, by dotted lines in Fig. 2 are shown invariant mass distributions obtained with a narrower window around the π^0 ($0.1\ GeV/c_2 < M_{2\gamma} < 0.18\ GeV/c^2$). It seems that the signal to background ratio is not affected by narrowing the π^0 window since the reduced events are almost uniformly distributed over the mass range, especially for the higher energy cuts.

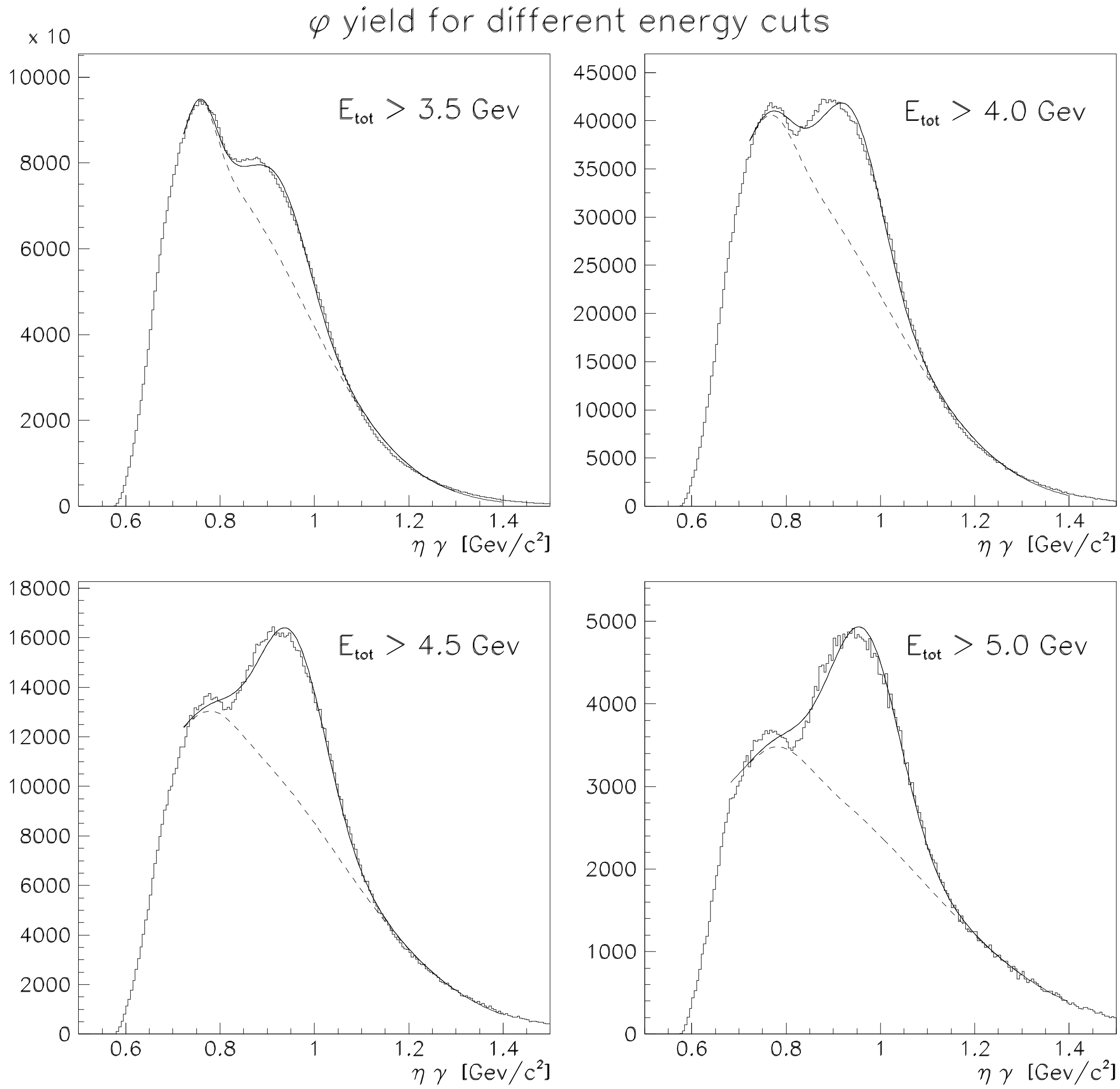

Figure 1: Three Gaussian fit in the limited interval of 3γ invariant mass given by solid line. Dashed line is the sum of background and ω Gaussians.

Table 2: ω mass, width and yield as a function of deposited energy in the LGD.

$E_{TOT} > [Gev]$	$M_{\omega}[Gev/c^2]$	$\sigma_{\omega}[Gev/c^2]$	N_{ω}
3.5	0.791	0.060	$8.98\ 10^6$
4.0	0.798	0.065	$8.30\ 10^6$
4.5	0.805	0.064	$4.83\ 10^6$
5.0	0.819	0.061	$1.95\ 10^6$

4 Discussion

The above results are obtained after hot-block suppression. In order to do that, events with clusters that consist of just one LGD block are eliminated from the sample. Although we can see clear ω and ϕ production there are several problems that have to be resolved. First, the ω mass is close to its right value (782 MeV) for the low energy threshold, but it increases with increasing energy threshold in the LGD. For the last energy cut, it is higher than expected by ≈ 40 MeV. Second, the ϕ mass also increases with energy, but contrary to the ω, the value from the fit is lower than expected (1020 MeV). The difference varies with energy from 90 to 50 Mev. Finally, the ratio of ω/ϕ is less then expected: about 20 times as many ω's as ϕ's, independent of the energy cut. The production cross section is in favour of ω by a factor of ≈ 4. The ratio of branching ratios Br(ω -> $\pi\gamma$)/Br(ϕ -> $\eta\gamma$) is ≈ 6.5 and an additional factor of 2.5 comes from the ratio of π/η decays to 2γ. Putting it all together, we expect $4 * 6.5 * 2.5 \approx 60$ times more ω than ϕ, but we see only 20.

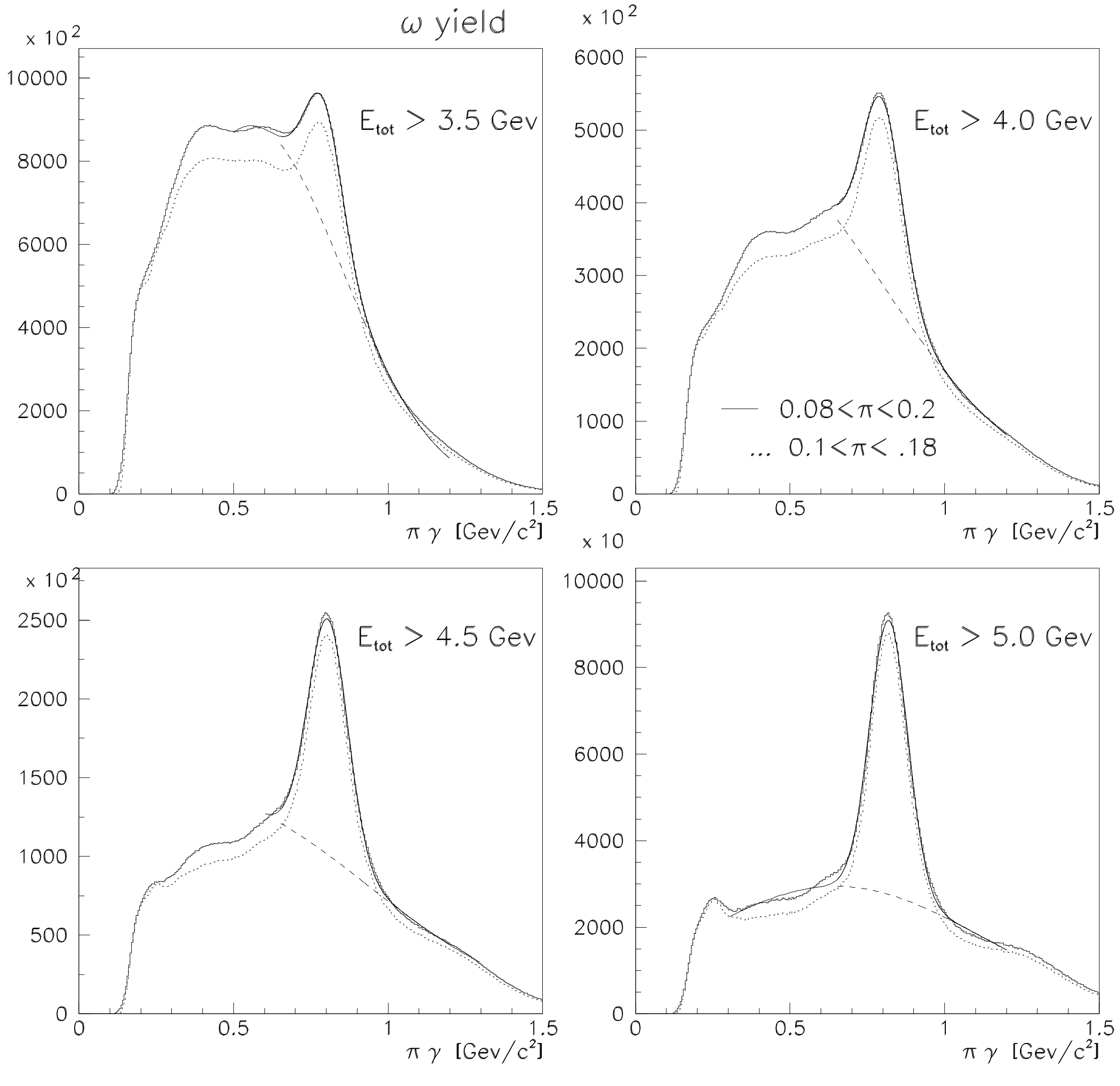

Figure 2: Two Gaussian fit of π γ invariant mass in the range shown by solid line. The background is assumed to be one broad Gaussian (dashed line). The dot lines represent the same distributions for narrower π^0 window.