Title
THE BRANCHING RATIO F (?1 ^ 3*|)/T fy -> n+?""rt|)

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THE BRANCHING RATIO $\Gamma(\eta \to 3\pi^0)/\Gamma(\eta \to \pi^+\pi^-\pi^0)$ *

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In our direct measurement of the branching ratio

$$R \equiv \Gamma(\eta \to 3\pi^0)/\Gamma(\eta \to \pi^+\pi^-\pi^0),$$

the possible eta decay mode $\pi^0\gamma\gamma$ is inseparable from the $3\pi^0$ mode, and was assumed to be absent.[1] Recently Di Cuigno et al. have presented convincing experimental evidence for the existence of the $\pi^0\gamma\gamma$ mode.[2] They find $r \equiv \Gamma(\eta \to \pi^0\gamma\gamma)/\Gamma(\eta \to 3\pi^0)$ $= 1.79 \pm 0.29$. In this paper we assume their result for r, combine it with our calculated detection efficiency for $\eta \to \pi^0\gamma\gamma$, and obtain a corrected value for R. The result is

$$R = 0.38 \pm 0.15. \qquad (1)$$

The same correction applied to the similar direct measurement of R by Foster et al.[3] yields a corrected value $R = 0.41 \pm 0.11$. A second result given by Di Cuigno et al.,[2] $\Gamma(\eta \to 3\pi^0)/\Gamma(\eta \to \text{neutrals}) = 0.209 \pm 0.027$, may be combined with the two known ratios $\Gamma(\eta \to \text{neutrals})/\Gamma(\eta \to \text{charged}) = 2.5 \pm 0.4$ (see Ref. 4) and $\Gamma(\eta \to \text{charged})/\Gamma(\eta \to \pi^+\pi^-\pi^0)$ $= 1.30 \pm 0.06$ (Ref. 5) to give the indirect result $R = 0.68 \pm 0.14$.

These three determinations of R are in reasonable agreement with one another. They are in violent disagreement with the values of R predicted by any of the models that have been fit to the observed spectrum for $\eta \to \pi^+\pi^-\pi^0$.[6]

The remainder of this paper is concerned with our detection efficiency. We detect gamma rays both by their external conversion into electron pairs (or triplets) in the liquid hydrogen, and by their internal conversion into Dalitz electron pairs.

1. External conversion. For our fiducial criteria,[1] we calculate an average probability of 0.0123 per gamma ray for pair production by the four γ's from $\eta \to \pi^0\gamma\gamma \to 4\gamma$. This is practically equal to the conversion probability of 0.0124 per gamma ray that we calculate for the six γ's from $\eta \to 3\pi^0 \to 6\gamma$.

2. Internal (Dalitz) conversion. We demand $m(e^+e^-) < 30$ MeV.[1] For this mass range, we estimate that $\rho_1 \equiv \Gamma(\eta \to \pi^0\, \gamma\, e^+e^-)/\Gamma(\eta \to \pi^0\gamma\gamma)$ is equal to $\rho_2 \equiv \Gamma(\eta \to \gamma\, e^+e^-)/\Gamma(\eta \to \gamma\gamma)$. We also calculate[1] that for $m(e^+e^-) < 30$ we have $\rho_2 = 0.0101$ and $\rho_3 \equiv \Gamma(\pi^0 \to \gamma\, e^+e^-)/\Gamma(\pi^0 \to \gamma\gamma) = 0.0101$. Thus we have $\rho_1 = \rho_2 = \rho_3$. The four gamma rays from the $\pi^0\gamma\gamma$ eta-decay mode therefore have the same average internal-conversion probability per gamma ray as the six from the $3\pi^0$ mode. Combining the results for external and internal conversion we calculate that our overall detection efficiency for $\eta \to \pi^0\gamma\gamma$ is 4/6 of that for $\eta \to 3\pi^0$. To correct our published[1] determination of R, we multiply it by the correction factor $C \equiv [1 + (4/6)r]^{-1} = 0.46$.[7] We thus obtain the result Eq. (1).[8]

FOOTNOTES AND REFERENCES

*Work done under the auspices of the U. S. Atomic Energy Commission.

1. F. S. Crawford, Jr., L. J. Lloyd, and E. C. Fowler, Phys. Rev. Letters 10, 546 (1963).

2. G. Di Guigno, R. Querzoli, G. Troise, F. Vanoli, M. Giorgi, P. Schiavon, and V. Silvestrini, Phys. Rev. Letters (to be published).

3. M. Foster, M. Peters, R. Hartung, R. Matsen, D. Reeder, M. Good, M. Meer, F. Loeffler, and R. McIlwain, Phys. Rev. 138, B652 (1965).

4. An average of the six measurements compiled in A. H. Rosenfeld, A. Barbaro-Galtieri, W. H. Barkas, P. L. Bastien, J. Kirz, and M. Roos, Revs. Mod. Phys. 37, 633 (1965).

5. F. S. Crawford, Jr., and L. R. Price, Phys. Rev. Letters 16, 333 (1966).

6. For example, F. S. Crawford, Jr., R. A. Grossman, L. J. Lloyd, L. R. Price, and E. C. Fowler, Phys. Rev. Letters 11, 564 (1963); 13, 421 (1964) predict R = 1.63±0.03 for the linear-matrix-element (LME) model, and R = 1.28±0.07 for the Brown and Singer (BS) sigma-meson model. Foster et al. (Ref. 3) predict R = 1.63±0.02 for the LME and 1.49±0.07 for the BS model.

7. Our result of 4/6 for the relative detection efficiency for $\eta \to \pi^0\gamma\gamma$ and $\eta \to 3\pi^0$ is insensitive to our estimate that, for $m(e^+e^-) < 30$ MeV, we have $x \equiv (\rho_1/\rho_3) = 1$. For $x \neq 1$, the relative efficiency is $(4/6) + 0.097\,(x - 1)$. Thus if we took $x - 1 = \pm 0.5$, the correction factor C would be 0.46±0.02.

8. Similarly we correct our rate for $3\pi^0$ plus $\pi^0\gamma\gamma$ by multiplying it by $(1 + r)/[1 + (4/6)r] = 1.27$. There is no correction for the $\gamma\gamma$ mode. Our corrected eta-decay ratio for Γ(neutral)/Γ(charged) is 1.83±0.57, in reasonable agreement with the average value 2.5±0.4 from Ref. 4. The same correction factor applied to the results of Foster et al.,[3] gives Γ(neutral)/Γ(charged) = 2.19±0.39.