SLAC-PUB-2593
CALT 68-792
August 1980
(T/E)

MEASUREMENT OF INCLUSIVE η PRODUCTION IN e^+e^- INTERACTIONS NEAR CHARM THRESHOLD*

F. C. Porter
(Representing the Crystal Ball Collaboration)[1]
Stanford Linear Accelerator Center
Stanford University, Stanford, California 94305
and
California Institute of Technology
Pasadena, California 91125

ABSTRACT

We have measured the inclusive cross section for η production in e^+e^- interactions near charm threshold using the Crystal Ball detector at SPEAR. By comparing the inclusive η production above and below charm threshold we obtain the limits: $R(e^+e^- \to F\bar{F}X)\,BR(F \to \eta x) < 0.3$ (90% C.L., $E_{c.m.} < 4.5$ GeV); $BR(D \to \eta x) < 0.13$ (90% C.L., averaged over charged and neutral D components of the ψ'').

INTRODUCTION

It is expected that the charmed-strange F-meson has a significant branching fraction to η's.[2] As early as 1977, the DASP collaboration found a strong threshold in inclusive η production in e^+e^- interactions at $E_{c.m.} \sim 4.4$ GeV, which they interpreted as evidence for production of the F meson.[3,4] In this paper, we present a higher statistics measurement of inclusive η production as a function of $E_{c.m.}$ at similar energies using the Crystal Ball detector at SPEAR. No evidence for strong thresholds in η production is found.

METHOD

The Crystal Ball detector has been described elsewhere,[5] so only a summary of the relevant parameters is presented here. This detector consists primarily of a segmented array of NaI(Tℓ) crystals for high-resolution ($\sigma_E/E \sim 2.6\%/[E(\mathrm{GeV})]^{1/4}$) measurement of electromagnetic showers. The solid angle coverage is 94% of 4π steradians with the main array, which is extended to 98% of 4π with crystals in the end-cap regions. The angular resolution for photons is $1-2^{\circ}$, depending on energy. In addition, there are spark and proportional chambers for charged particle detection and tracking (no magnetic field).

Table I summarizes the data used in the present inclusive measurement. The data for $E_{c.m.} = 3.878$ to 4.500 GeV are divided into bins in $E_{c.m.}$ as motivated by the structure in R (Fig. 1). The hadron selection efficiency is estimated at $(93 \pm 5)\%$.

The number of η's at each energy was extracted by performing fits to the $m_{\gamma\gamma}$ mass plots for the $\eta \to \gamma\gamma$ decay. To be included in the mass plots, photons had to satisfy the following conditions:

* Supported in part by the Department of Energy, contracts DE-AC03-76SF00515 and DE-AC03-79ER0068, and by a Chaim Weizmann Fellowship.

(Invited talk presented at the XXth International Conference on High Energy Physics, Madison, Wisconsin, July 17-23, 1980.)

Table I

Data Sample for Inclusive η Measurement

$E_{c.m.}$ GeV	$\int Ldt$ nb^{-1}
Fixed Points	
J/ψ (3.095) [a]	110
3.670	500
ψ' (3.684) [a]	290
ψ" (3.77)	1700
4.028	840
5.2	6700
Scan Data	
3.878-4.004	370
4.005-4.082	850
4.083-4.142	1700
4.143-4.225	2100
4.226-4.300	1100
4.301-4.364	820
4.365-4.500	1500

[a]The full data samples at J/ψ, ψ' are considerably larger.

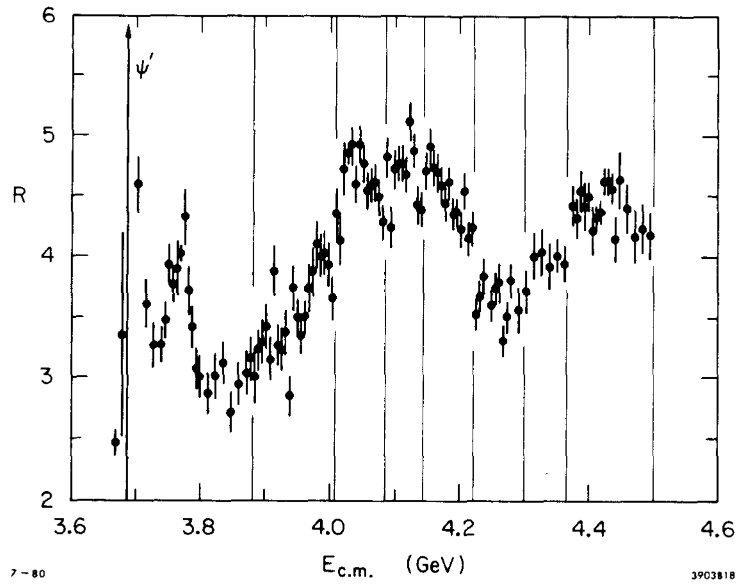

Fig. 1. Crystal Ball measurement of R (1979 data), showing the center-of-mass binning used for the inclusive η analysis (light vertical lines). [Contributions from the τ are excluded, but no radiative corrections have been made. The errors are statistical only.][6]

i) $|\cos\theta_{\gamma\cdot beam}| < 0.85$; ii) $\cos\theta_{\gamma t} < 0.9$, where $\theta_{\gamma t}$ is the opening angle between the γ and any other track in the event; iii)$E_{\gamma} > 30$ MeV (irrevelant for $m_{\gamma\gamma}$ in the η region, but can affect π^0 subtraction). Optionally, the elimination of γ's which form a π^0 with another γ ("π^0 subtraction"), and/or the elimination of γ's which do not exhibit a reasonable lateral shower distribution ("pattern cut") has been used. For example, Fig. 2(a-m) shows the $m_{\gamma\gamma}$ mass distributions after application of the above cuts, including π^0 subtraction but not the pattern cut.

A fit is performed to each $m_{\gamma\gamma}$ distribution assuming a Gaussian shape for the η peak, the width ($\sigma \sim 4\%$) corresponding to our resolution. Various checks have been made to estimate the sensitivity of the number of η's found to the width and mean of the peak and the shape of the background assumed in the fits. The background form used in the fits shown in Fig. 2(a-m) is a quadratic times $m_{\gamma\gamma}^{-2.7}$.

RESULTS

Figure 3 shows f_{η}, the number of η's per hadronic event, as a function of the center-of-mass energy. The error bars do not include the estimated uncertainty in absolute normalization ($\sim 25\%$). It should be noted that an η signal is observed everywhere, including at the off-resonance point below charm threshold (3.67 GeV).

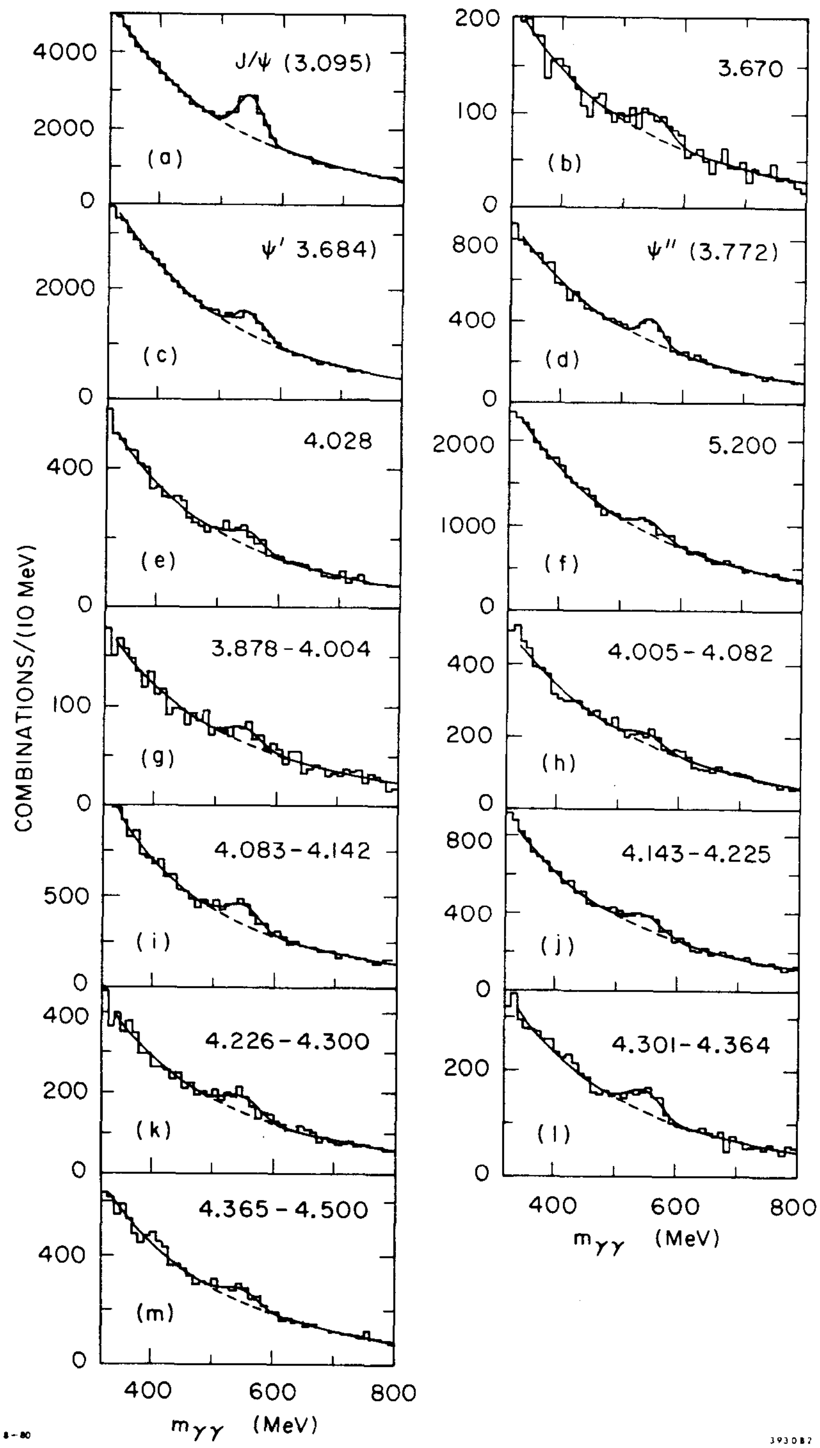

Fig. 2. Examples of the γγ-mass distribution between 320 and 800 MeV for the center-of-mass energies used. The curves are fits to the data (dashed is background, solid is background plus η) as described in the text.

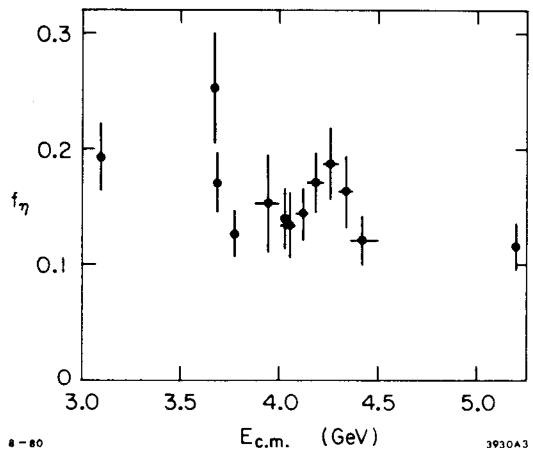

Fig. 3. f_η, the number of η's per hadronic event, versus $E_{c.m.}$ The first four points are (in order) J/ψ, 3.67 GeV, ψ' and ψ''.

In Figure 4(a) we plot the inclusive cross section for η production in the form of $R_\eta = \sigma(e^+e^- \to \eta X)/\sigma(e^+e^- \to \mu^+\mu^-)$. Because R_η at the J/ψ and ψ' resonance is large (off-scale), the contributions from the radiative tails of these resonances to the other points has been subtracted (maximum correction = 0.08, at the ψ'').

Figure 4(a) indicates that the cross section for η production does not vary much in the region above charm threshold from the 3.67 GeV value below threshold. This may be contrasted with Fig. 4(b), in which we have divided the published DASP cross sections[4] by $\sigma(e^+e^- \to \mu^+\mu^-)$ to obtain R_η. The DASP experiment reported η signals only at 4.17, 4.42, and possibly at 4.60 GeV, the 4.42 GeV point implying a strong jump in η production. A number of multiplicity and energy cuts were made in the DASP experiment, but it appears difficult to explain the discrepancy in terms of these cuts, as we have been unable to generate substantial energy-dependence in the 3.9-4.5 GeV region with similar cuts. It should be cautioned, however, that the two detectors are very different, and hence it is impossible to mimic the DASP experiment exactly.

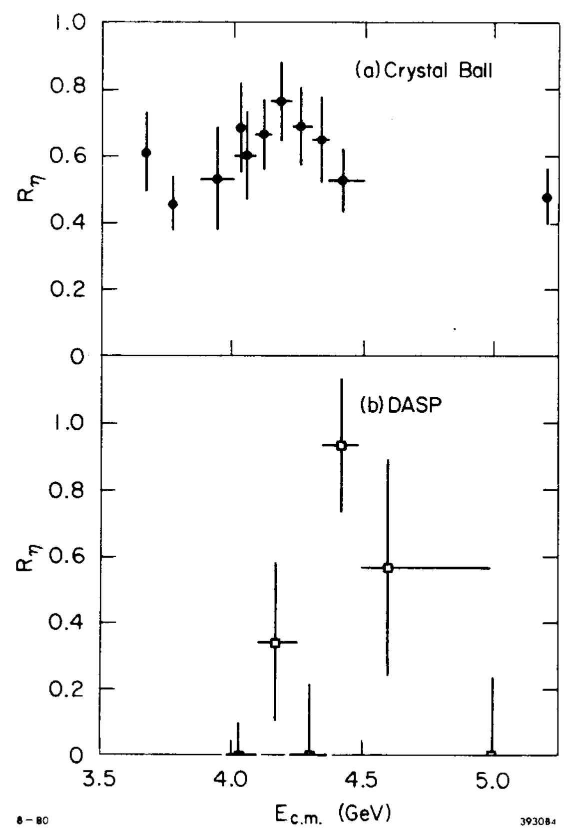

Fig. 4. R_η, the cross section for η production divided by the QED point cross section, versus $E_{c.m.}$: a) Crystal Ball experiment (first two points are 3.67 GeV and ψ''), b) DASP experiment.[4]

Using the highest point, at 4.18 GeV (Fig. 4(a)), we may set an upper limit on the product of the cross section for $F\bar{F}$ production (including excited F's) times the branching ratio for F decay to η: $R(e^+e^- \to F\bar{F}X)\ BR(F \to \eta x) < 0.31$ (90% C.L.).

In this limit, we have corrected for the smaller η-detection efficiency in $F\bar{F}$ events, compared with non-charm events, as indicated by Monte Carlo simulations.

Because we observe no increase in η production at the ψ" resonance, we may also set an upper limit on the inclusive branching ratio for D decay into η's (averaged over the neutral and charged D components of ψ"): $BR(D \to \eta x) < 0.13$ (90% C.L.). The DASP upper limit is 0.02 (unstated C.L.),[4] based on the absence of an η signal at 4.03 GeV. Note, however, that we observe substantially more η's in the 4.03 GeV region than the DASP limit.

CONCLUSIONS

In a measurement of the inclusive cross section for η production as a function of center-of-mass energy with the Crystal Ball, no substantial increase above charm threshold is observed. The implications for the charmed D and F mesons may be summarized in the limits:

$BR(D \to \eta x) < 0.13$ (90% C.L., averaged over neutral and charged D components of ψ")

$R(e^+e^- \to F\bar{F}X)\ BR(F \to \eta x) < 0.3$ (90% C.L., $E_{c.m.} < 4.5$ GeV) .

REFERENCES

1. R. Partridge, C. Peck, F. Porter (Caltech); D. Antreasyan, Y. F. Gu, W. Kollmann, M. L. Richardson, K. Strauch, K. Wacker (Harvard); D. Aschman, T. Burnett, M. Cavalli-Sforza, D. Coyne, M. Joy, H. Sadrozinski (Princeton); R. Hofstadter, R. Horisberger, I. Kirkbride, K. Königsmann, H. Kolanoski, A. Liberman, J. O'Reilly, A. Osterheld, J. Tompkins (Stanford); E. Bloom, F. Bulos, R. Chestnut, J. Gaiser, G. Godfrey, C. Kiesling, W. Lockman, M. Oreglia (SLAC).
2. A. Pais and V. Rittenberg, Phys. Rev. Lett. 34, 707 (1975); G. Altarelli et al., Nucl. Phys. B88, 285 (1975); R. L. Kingsley et al., Phys. Rev. D11, 1919 (1975); Martin B. Einhorn and C. Quigg, Phys. Rev. D12, 2015 (1975); John Ellis et al., Nucl. Phys. B100, 313 (1975).
3. R. Brandelik et al., Phys. Lett. 70B, 132 (1977).
4. R. Brandelik et al., Phys. Lett. 80B, 412 (1979).
5. R. Partridge et al., Phys. Rev. Lett. 44, 712 (1980).
6. D. G. Coyne, Vanderbilt Symposium on High Energy e^+e^- Interactions, Nashville, Tenn., May 1-3, 1980; (also SLAC-PUB-2563).