SLAC – PUB – 4466
November 1987
T/E

Indications for the decays $D_s^{\pm} \rightarrow \eta\ \pi^{\pm}$ and $D_s^{\pm} \rightarrow \eta'\ \pi^{\pm}$*

G. WORMSER[a]

Stanford Linear Accelerator Center
Stanford University, Stanford, California 94305

representing

The MarkII Collaboration

ABSTRACT

A search for $D_s^{\pm}$ decays into $\eta\ \pi^{\pm}$ and $\eta'\ \pi^{\pm}$ has been performed by the MarkII collaboration at the PEP e^+e^- storage ring. η particles are reconstructed by their $\gamma\gamma$ decay mode. The η fragmentation has been measured and found to be in good agreement with the Lund model prediction. η' production has been measured for the first time in e^+e^- high energy annihilation. Good indications are found for both decay modes $D_s^{\pm} \rightarrow \eta\ \pi^{\pm}$ and $D_s^{\pm} \rightarrow \eta'\ \pi^{\pm}$.

Presented at the International Symposium on Production
and Decay of Heavy Flavors,
Stanford, California, September 1-5, 1987

---

* This work was supported in part by the Department of Energy, contracts DE-AC03-76SF00515 (SLAC), DE-AC03-76SF00098 (LBL), and DE-AC02-76ER03064(Harvard).

a On leave of absence from the Laboratoire de l'Accélérateur Linéaire,91405 Orsay, France

This paper presents a measurement of inclusive η and η' production in e^+e^- annihilation using the 208 pb^{-1} data sample collected with the MarkII detector at PEP. We also present evidence for exclusive decays of the $D_s^{\pm}$ involving η and η' .

01 THE INCLUSIVE η PRODUCTION

The MarkII detector is described in detail elsewhere[1] . Since the η particles are reconstructed via their $\gamma\gamma$ decay mode, the liquid argon electromagnetic calorimeter is of primary importance for this analysis. Its energy resolution has been measured to be $14\% /\sqrt{E}$ and its angular resolution is 8 mrad.

Hadronic events were selected by requiring a minimum number of 5 charged tracks with a minimum total energy of 7 GeV . The event is divided into 2 hemispheres about the sphericity axis. Events with at least 2 neutral tracks in the same hemisphere were considered, where a neutral track is defined as a energy cluster of at least 200 MeV in the Barrel Liquid Argon Calorimeter.

To reduce the combinatorial background generated by photons coming from π^0 decays, all photons having an invariant mass between 50 MeV and 200 MeV with any other photon were rejected.

The resulting $\gamma\gamma$ invariant mass distribution is shown in Fig.1a and Fig.1b, for z>.2 and z>.3 respectively, where z is the energy of the $\gamma\gamma$ pair divided by the beam energy. The η signal is very clear in the high z region in which we will search for η coming from $D_s^{\pm}$ decays . The fragmentation function is plotted on Fig.2 . The total systematic error is estimated to be 20 %, dominated by the uncertainty in the width of the η signal. The agreement with the LUND prediction as represented by the solid curve is good. The η multiplicity per event

has been estimated using minimal cuts in order to be sensitive to the largest part of the η cross section. 1167 ± 212 η were obtained, in a kinematic region sensitive to roughly 75% of the total cross section. This leads to $N_\eta = 0.68 \pm 0.17 \pm 0.14$ in good agreement with the JADE[2] and HRS[3] measurements of 0.64 ± 0.15 and 0.58 ± 0.10 respectively, and the LUND prediction of 0.70 .

02 SEARCH FOR $D_s^\pm \rightarrow \eta\ \pi^\pm$

The η candidates are combined with any charged track found in the same hemisphere and compatible with a π according to the Time of Flight system. An η candidate is then defined as follows : a kinematical fit is performed on both photons assuming the angles are perfectly measured. The momentum of each photon is thus rescaled using the nominal η mass as a constraint. Only pairs with unconstrained mass between 450 and 650 MeV and with a χ^2 for the kinematical fit less than 6 are retained. In order to ensure the best possible signal/noise ratio for the η peak, further cuts were applied:

1. Cuts were applied to reject clusters formed by 2 merged γ coming from an energetic π^0 decay. The electromagnetic shower was required to be compatible with the presence of a single photon in the first layer of the liquid argon calorimeter.
2. $\cos\theta^\star$ has to be less than 0.7 , where $\theta^\star$ is the angle between 1 photon and the η line of flight in the η rest frame. The background tends to peak at $\cos\theta^\star = 1$, corresponding to asymmetric photon pairs.
3. The η momentum is required to be over 4.5 GeV (z>.3).

4. One photon has to have a p_t relative to the thrust axis greater than 500 MeV. This cut favors photons from $D_s^{\pm}$ decays compared to the soft photon background.

An excess of events is found in the $D_s^{\pm}$ mass range (Fig.3). The probability that this excess is due to a statistical fluctuation of the background deduced from the observed mass spectrum both in the data and in the MonteCarlo is estimated to be 0.05%. We therefore claim a good indication of the decay $D_s^{\pm} \rightarrow \eta\ \pi^{\pm}$ at a 3 σ level.

A polynomial background and a gaussian of fixed mass and free width were fitted to the data. The fit gave 16 ± 6 $D_s^{\pm}$, with a width of 40 ± 15 MeV consistent with the 50 MeV expectation. This corresponds to a preliminary B.σ of 7 ± 3 pb. This is 3 ± 1.3 times larger than the world averaged B.σ for the $\phi\pi^{\pm}$ mode . Quite interestingly, the MarkIII collaboration has presented evidence[4] for the same decay mode of the $D_s^{\pm}$, with a comparable branching ratio.

03 INCLUSIVE η' PRODUCTION

The η' is searched for in the $\eta\ \pi^+\ \pi^-$ mode. The two pions are required to be in the same hemisphere as the two photons. The η selection is comparable to the one used in the previous section.

A clear η' signal of 45 ± 11 events can be seen on Fig.4. This is the first measurement of η' production in e^+e^- high energy annihilation. The η' fragmentation function is shown on Fig.2 . The number of η' above z=.2 is $N_{\eta'}(z>.2) = 0.09 \pm 0.03 \pm 0.02$, somewhat lower that the Lund number of 0.14 in this z range. Assuming the Lund fragmentation function leads to a number of η' per event of $0.26 \pm 0.09 \pm 0.05$.

04 SEARCH FOR $D_s^{\pm} \rightarrow \eta' \pi^{\pm}$

η' candidates are combined with any charged track above 1 GeV found in the same hemisphere. An η' candidate is considered when the invariant mass of the $\eta \pi^+ \pi^-$ system is between 0.9 and 1 GeV. The η' was then forced onto its mass shell. Furthermore, the η momentum has to be greater than 2.5 GeV.

An excess of events is found in the $D_s^{\pm}$ mass region, indicating the observation of the decay $D_s^{\pm} \rightarrow \eta' \pi^{\pm}$ at a 3 σ level. Preliminary evidence for this branching ratio is that it is at least as large as the $\eta \pi^{\pm}$.

05 CONCLUSION

The η fragmentation function has been measured and found in agreement with previous measurements and with the Lund model. The η' inclusive production has been measured for the first time in high energy annihilation events. Its rate is somewhat lower than predicted by the Lund model. Good indications at a 3 σ level have been found of the decays $D_s^{\pm} \rightarrow \eta \pi^{\pm}$ and $D_s^{\pm} \rightarrow \eta' \pi^{\pm}$. The first decay mode is found to have a branching ratio about 3 times as large as the $D_s^{\pm} \rightarrow \phi\pi^{\pm}$ one, in good agreement with a recent MarkIII result. The $\eta' \pi^{\pm}$ mode is found to be at least as important as the $\eta \pi^{\pm}$ mode .

References

1. R. Schindler et al., *Phys.Rev.* **D21** (1981) 78
2. W. Bartel et al.,Z. Phys. C28 (1985)343
3. S. Abachi et al.,ANL-HEP-PR-87-106
4. I. E. Stockdale,SLAC-PUB 4467 and in the Proceedings of this Symposium

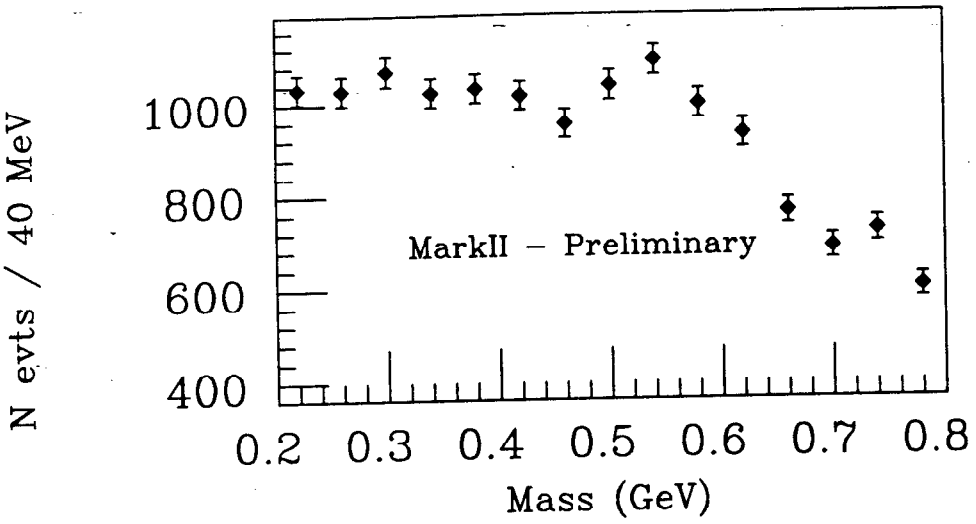

Fig.1a $\gamma\gamma$ Mass spectrum for $z_{\gamma\gamma} > .2$

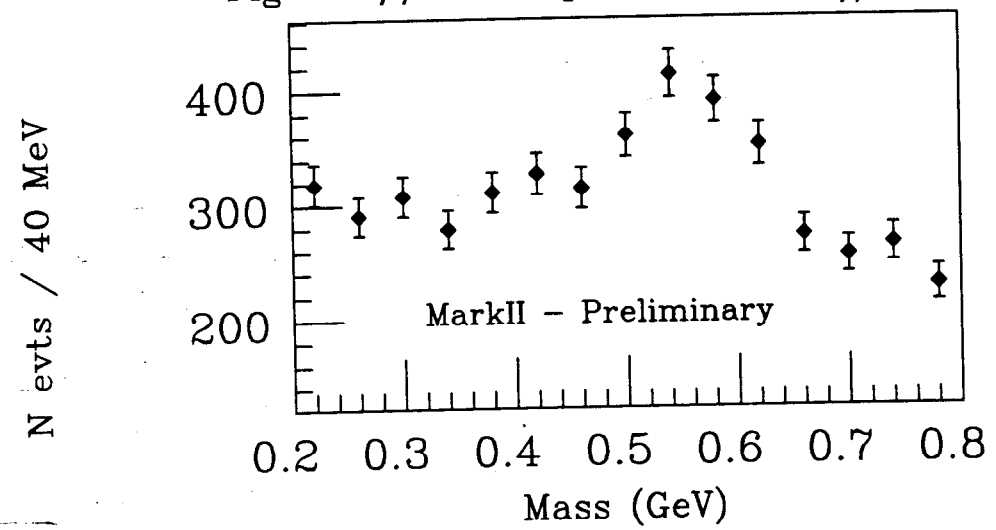

Fig.1b $\gamma\gamma$ Mass spectrum for $z_{\gamma\gamma} > .3$

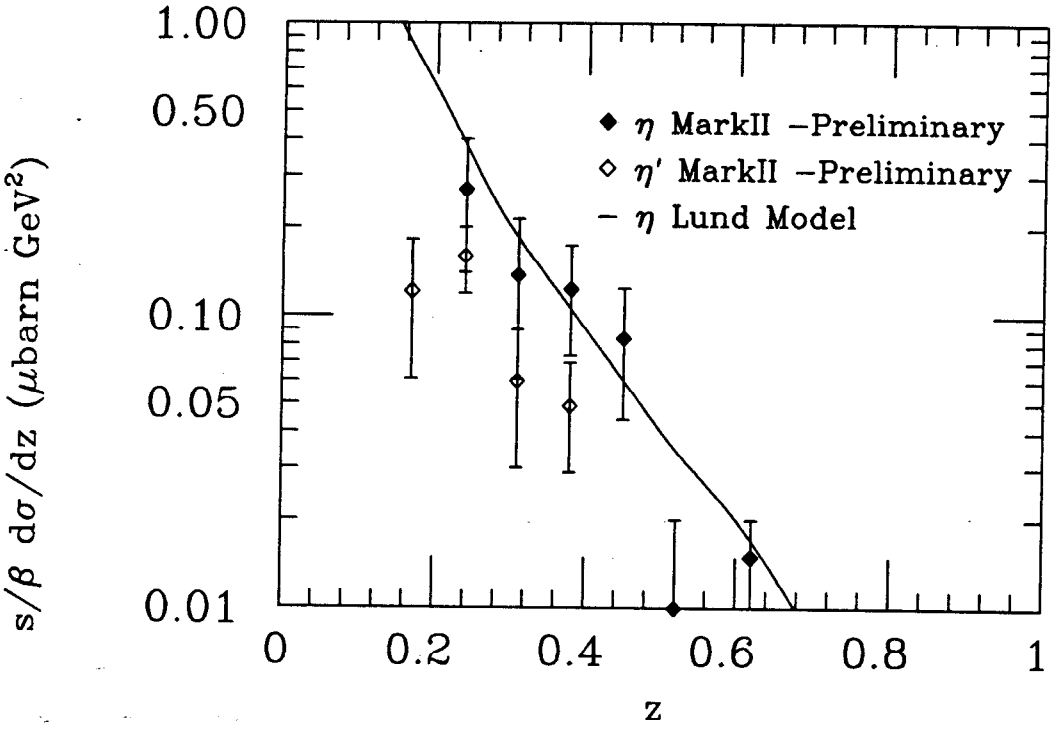

Fig.2 η and η' fragmentation function

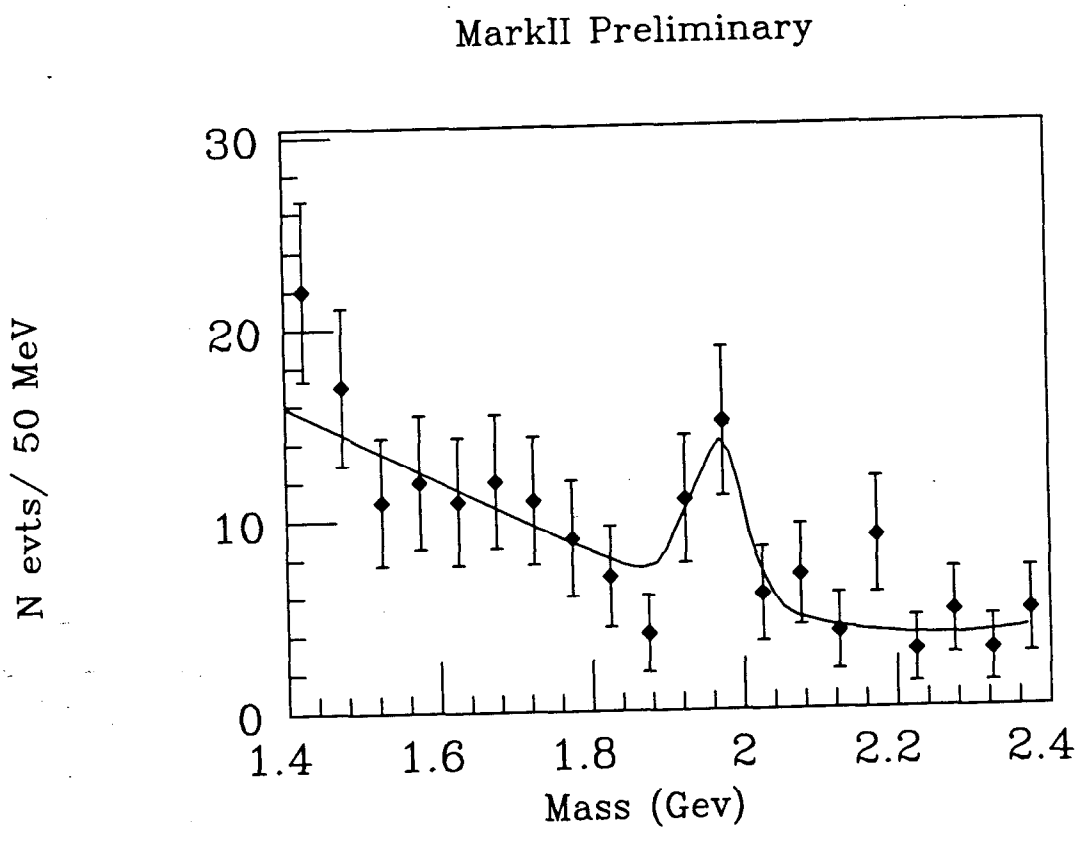

Fig. 3 $\eta\ \pi^{\pm}$ Mass spectrum

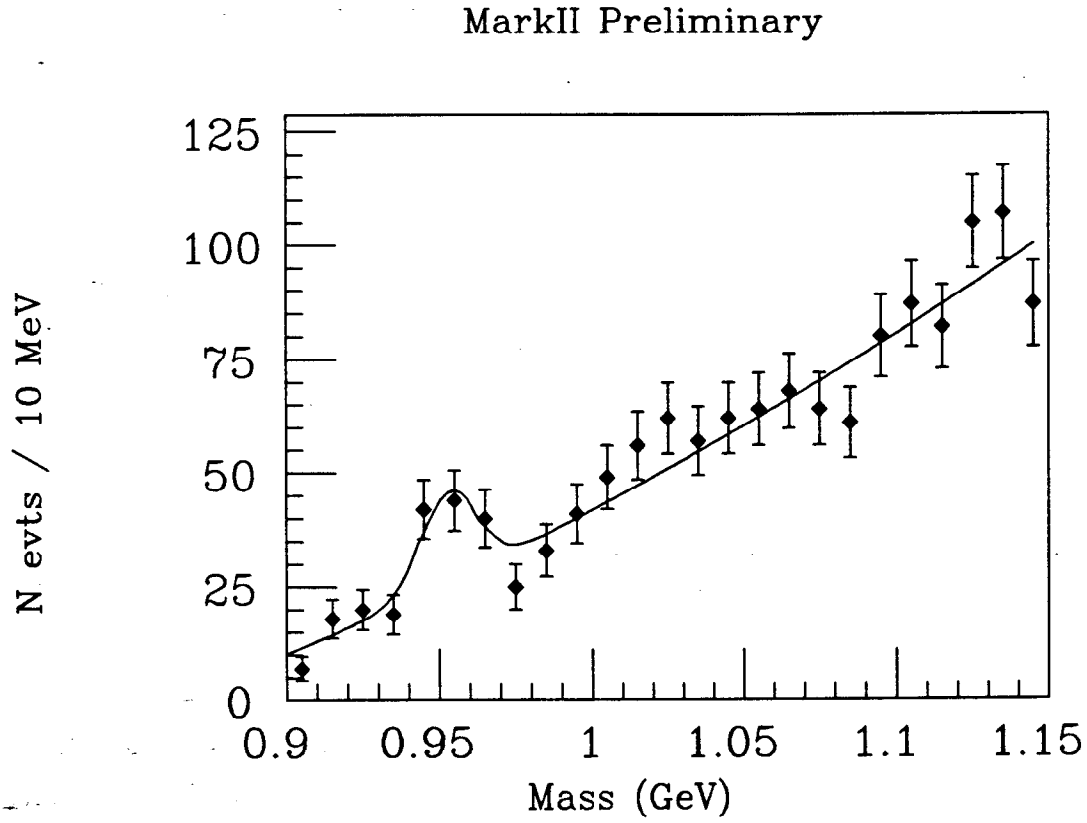

Fig. 4 $\eta\ \pi^+\ \pi^-$ Mass spectrum

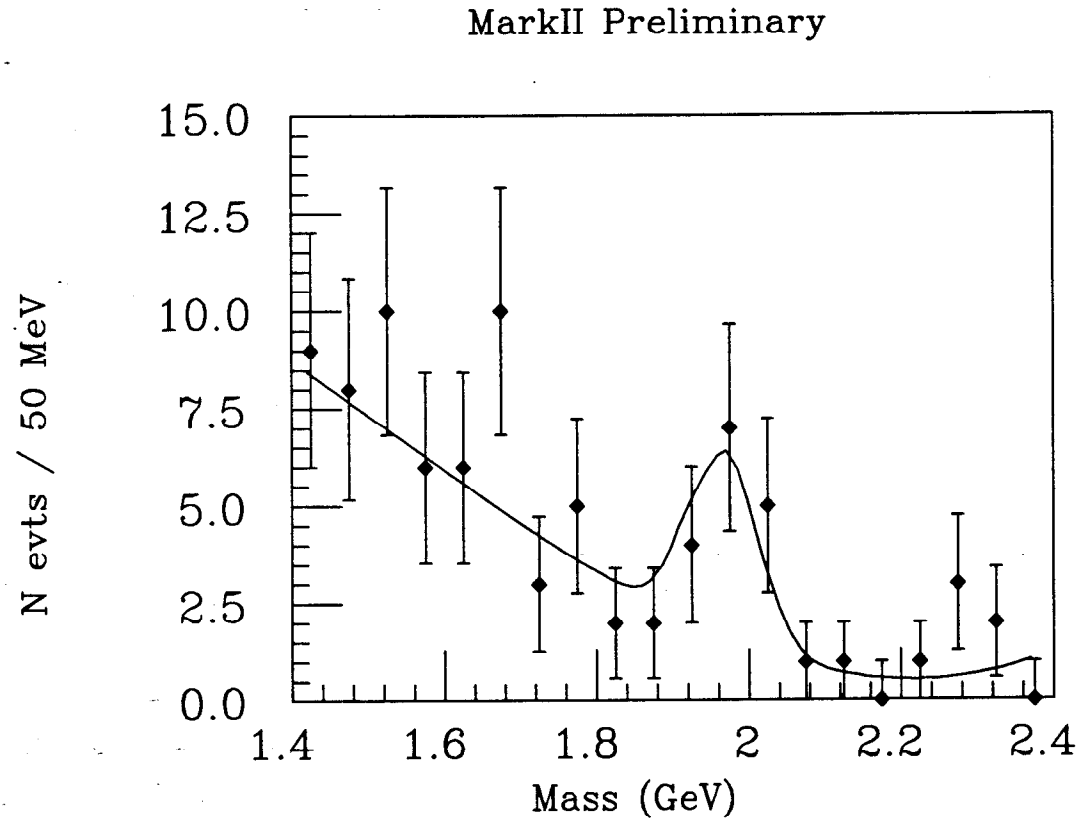

Fig. 5 η' $\pi^{\pm}$ Mass spectrum