SLAC – PUB – 3683
May 1985
(E)

# THE STATUS OF THE $\varsigma(8.3)$*

Stephen T. Lowe
(Representing the Crystal Ball Collaboration)[1]
Stanford Linear Accelerator Center
Stanford University, Stanford, California 94305

## ABSTRACT

Results are presented from 22.1 $\mathrm{pb}^{-1}$ of $\Upsilon(1S)$ data, taken with the Crystal Ball detector at DORIS. These data were taken to further explore the $\varsigma(8.3)$ signal originally seen in 10.4 $\mathrm{pb}^{-1}$ of $\Upsilon(1S)$ data.[2] No evidence for the $\varsigma$ is observed in this new sample. Data quality checks and possible explanations are discussed.

---

* Work supported by the Department of Energy, contract DE-AC03-76SF00515

Contributed to the XXth Rencontre de Moriond: QCD and Beyond
Les Arcs, Savoie, France, March 10-17, 1985.

During the summer of 1984 the Crystal Ball collaboration presented evidence for a narrow state in the $\Upsilon(1S)$ inclusive photon spectrum which we called the $\varsigma(8.3)$.[2] The branching ratio for the process was found to be

$$BR(\Upsilon \to \gamma\varsigma) \times BR(\varsigma \to \text{Hadrons}) = (0.47 \pm 0.11 \pm 0.26)\%.$$

This signal was substantiated by the observation of a second, less significant signal at the same mass using a statistically independent sample of $\Upsilon(1S)$ low multiplicity decays. Both signals were obtained from a 10.4 $\text{pb}^{-1}$ sample taken in 1983.

More data were clearly needed in order to confirm the existence of the $\varsigma$; thus we took an additional 22.1 $\text{pb}^{-1}$ of $\Upsilon(1S)$ data during the autumn of 1984. The first 8.5 $\text{pb}^{-1}$ of this sample were taken with a malfunctioning tracking chamber ADC. This problem was later partially corrected in offline software. The inclusive photon spectrum for the entire 22.1 $\text{pb}^{-1}$ sample is shown in Figure 1.

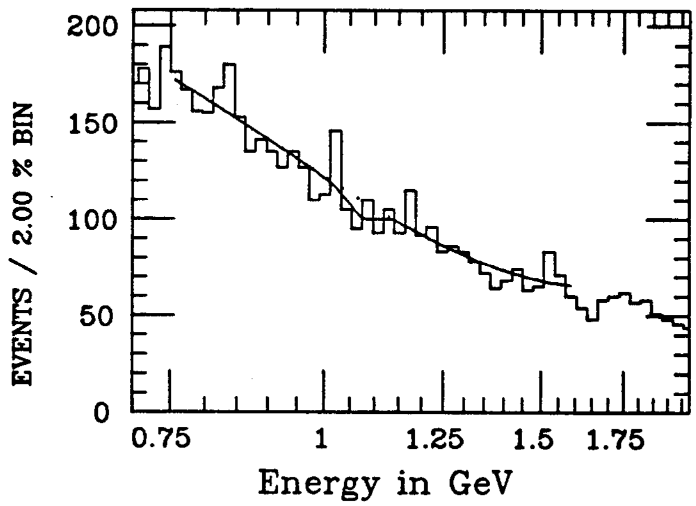

*Fig. 1* The inclusive $\gamma$ spectrum from the 22.1 $\text{pb}^{-1}$ taken in the fall of 1984. The best fit is shown with the mean constrained to ±1.0% of that expected for the $\varsigma$.

Fitting this spectrum we find $-29 \pm 29$ counts at the expected mass of the $\varsigma$. This result and that previously presented disagree to about 4.0 standard deviations. The "low multiplicity" analysis has not yet been completed and will not be presented here.

We have made extensive checks on the data's quality in both the 1983 and 1984 data sets. All $\Upsilon(1S)$ data were divided into 1 $\mathrm{pb}^{-1}$ subsets. Every known "signal" in these data were checked for a consistent mean, amplitude and width over each 1 $\mathrm{pb}^{-1}$ interval. The "signals" involved were the $\pi^0$ and $\eta$ peaks in the 2 photon invariant mass plots, the minimum ionizing peak which is at about 203 MeV in the Crystal Ball and the Bhabha peak. For the $\pi^0$s, one photon was required to have an energy greater than 400 MeV so photons closer to the $\varsigma$ region of about 1070 MeV would be tested. By fitting each of these peaks, we set constraints on any shifts in our energy scale or energy resolution. From the $\pi^0$, $\eta$ and minimum ionizing peaks we found that photon energies in the few hundred MeV range should not have shifted more than ±1.0% from those in the 1983 sample and their width should be within 5.0% of the width seen in 1983. Additionally, Bhabha studies show that photons around 4.6 GeV have a mean within 0.5% and width within 5.0% of that seen in the 1983 data. Photons in the 1 GeV range were studied by fitting 3 photon QED events where one photon was required to be between 500–2000 MeV. No energy shifts were found when fitted and measured energies were compared. These tests indicate that we should have seen the $\varsigma$ with mean within ±1.0% and width within ±5.0% of that seen in the 1983 data.

There is, however, one difference between the 1983 and 1984 data sets; the value of $R_{\mathrm{vis}}$. The average value of $R_{\mathrm{vis}}$ in the 1983 data is 11.1 while the average value in the 1984 data is 12.2. If this shift is real, it implies, together with the 5–6 MeV beam energy resolution at DORIS, a shift in the $e^+e^-$ center-of-mass energy of about ±4 MeV. We also estimate the systematic errors in the measurement of $R_{\mathrm{vis}}$ to imply a ±4 MeV error in the corresponding center-of-mass energy. Thus a conservative estimate for the shift in center-of-mass energies between the 1983 and 1984 data sets is 0–8 MeV.

One model which can explain the $\varsigma$'s disappearance in the 1984 data, that of Tye and Rosenfeld,[3] assumes that the 1983 energy was displaced from the $\Upsilon(1S)$ resonance and the $\varsigma$ peak is the radiative decay of some state near the $\Upsilon(1S)$. The above limit on the shift in center-of-mass energy allows us to put constraints on such a model. Radiative corrections and DORIS's intrinsic energy resolution allows some probability of creating this hypothetical state and seeing its radiative decay and thus a $\varsigma$ signal in the 1984 data. We studied such a possibility and found that even with an

8 MeV shift in the center-of-mass energy, the 1984 result rules out the 1983 result to the 90% confidence level unless some state exists between about 16-26 MeV above the $\Upsilon(1S)$. Thus, this model seems an unlikely possibility for explaining the disagreement between the 1983 and 1984 data sets.

Along with acquiring additional data, we continued looking for problems in the 1983 analysis. One check we performed involved measuring the branching ratio for the process $\Upsilon \to \gamma\varsigma$ as our analysis cuts were applied. This was done by calculating the effective branching ratio after each cut, taken in their nominal order. The branching ratio after all cuts was found to be significantly higher than that obtained after partial cuts, indicating the number of peak events did not behave in the qualitative manner predicted by Monte Carlo calculations. To investigate whether this disagreement could have been a spurious effect (for example, our fitting procedure), we added $\gamma c\bar{c}$ Monte Carlo events to two separate 10 $\text{pb}^{-1}$ subsamples of our 1984 data. While fluctuations in measured branching ratio as a function of cuts were again observed, they were smaller than those found in the 1983 data. While this sort of analysis is not quantitative, it suggests the $\varsigma$ peak is not a true signal.

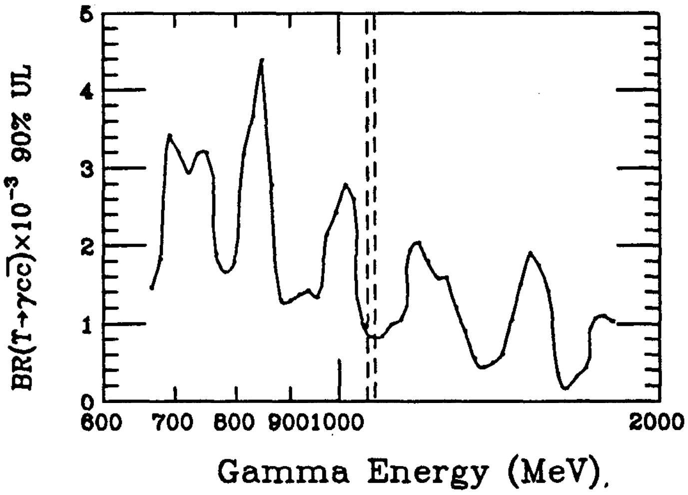

*Fig. 2* The 90% confidence level upper limit from the 1984 data for the process $\Upsilon \to \gamma X$ where $X$ decays hadronically. The hadronic decay is modeled by $c\bar{c}$ jets. The vertical dashed lines show the expected position of the $\varsigma$.

Figure 2 shows the upper limit derived from the 1984 data alone, as shown in Figure 1. From this plot one can read off the following upper limit:

$$BR(\Upsilon \rightarrow \gamma\varsigma) < 0.08\% \text{ (1984 Data : 90\%} C.L. \text{ Upper Limit).}$$

Assuming the 1983 and 1984 data sets can be combined for the study of $\Upsilon$ decay, we find a 1.9 sigma excess at the $\varsigma$ mass leading to the upper limit:

$$BR(\Upsilon \rightarrow \gamma\varsigma) < 0.19\% \text{ (All Data : 90\%} C.L. \text{ Upper Limit).}$$

In summary, the checks performed on the 1983 and 1984 data sets show that both seem to be valid. The absence of the $\varsigma$ in the 1984 high multiplicity analysis, together with our studies of the Tye-Rosenfeld model and our 1983 analysis, indicate the $\varsigma$'s existence is very unlikely.

## REFERENCES

1) The Crystal Ball collaboration: *California Institute of Technology*, Pasadena, USA; *University of Cape Town*, South Africa; *Carnegie-Mellon University*, Pittsburgh, USA; *Cracow Institute of Nuclear Physics*, Cracow, Poland; *Deutsches Elektronen Synchrotron DESY*, Hamburg, Germany; *Universität Erlangen-Nürnberg*, Erlangen, Germany; *INFN and University of Firenze*, Italy; *Universität Hamburg, I. Institut für Experimentalphysik*, Hamburg, Germany; *Harvard University*, Cambridge, USA; *University of Nijmegen and NIKHEF-Nijmegen*, The Netherlands; *Princeton University*, Princeton, USA; *Stanford Linear Accelerator Center*, Stanford University, Stanford, USA; *Stanford University*, Department of Physics and HEPL, Stanford, USA; *Universität Würzburg*, Germany

2) C.W. Peck *et al.*, SLAC-PUB-3380 and DESY-report 84-064 (1984); H. Trost, Contributed paper to the XXII Int. Conf. on High Energy Physics, Leipzig, July 19-25,1984; B. Niczyporuk, SLAC Summer Institute on Particle Physics, July 23-August 3, 1984; D.G. Coyne, Invited talk presented at the Conf. on Physics in Collision IV, University of Santa Cruz, Santa Cruz, California (1984).

3) S.H.H. Tye and C. Rosenfeld, Phys. Rev. Lett. 53 (1984) 2215