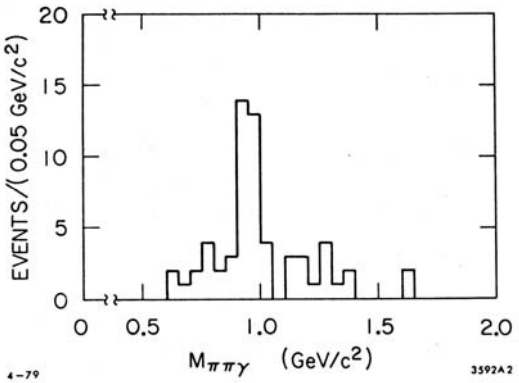

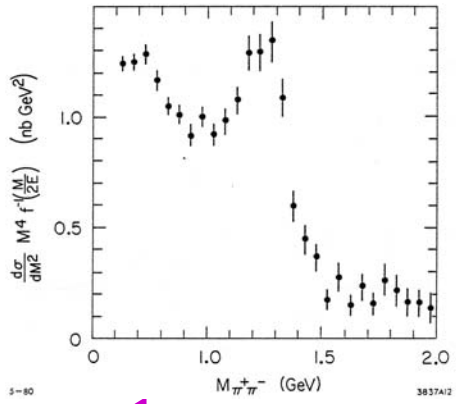

First evidence of two-photon production of C+ resonances at SPEAR with detector Mark-2

Valery Telnov

Budker INP and Novosibirsk St. Univ.

PHOTON 2015, June 16, 2015

Contents

- My visit to SLAC in Oct.1, 1978 – Jan. 20, 1979
- Status of two-photon studies at this time
- Observation of two photon production of η′ and measurement of its $\Gamma_{\gamma\gamma}$
- Observation of two photon production of $f_2(1270)$
- Conclusion

My visit to SLAC

In Oct. 1978 –Jan.1979 I visited SLAC for 3.5 month in the framework of USSR-USA agreement in the field of fundamental research.

It was the first visit of research scientists from out institute to USA for scientific work. I knew a lot about SLAC (Ψ,τ) but did not know in which group I will work and had no idea what I will do there.

Already on the place it became clear that I will work in B. Richter (1976 Noble prize winner) group. In 1978 this group just started new series of experiment at SPEAR with a new detector Mark-2.

After one week I suggested to search for two-photon processes, namely $\gamma\gamma\to\eta'\to\rho\gamma\to\pi^+\pi^-\gamma$ (I new this subject because we prepared in Novosibirsk the experiment MD-1 for studying of two photon interactions). Richter had supported my suggestion with words “many discussion about two-photon physics but there are no results”

Status of two-photon studies in 1978

Existing two-photon results:

In 1970, VEPP-2, Novosibirsk the process e+e-→e+e-e+e- was observed.

In 1972-74, Adone, Frascati, measured e+e-→e+e-e+e- and ee→eeμ+μ-

In 1978 at DORIS (Bonanza) put upper limit $\Gamma_{\gamma\gamma}(\eta') < 11.5$ keV.

In the Bonanza experiment detection of both scattered electrons was required (which considerably reduced the detection efficiency).

It was general believe that for studying two-photon physics it is necessary to detect scattered electrons in order to suppress e+e- annihilation processes. At that time in Novosibirsk we also constructed the detector MD-1 with the scattered electron tagging system (experiments had started in 1980).

At SLAC I decided to study two-photon processes without detection of scattered electrons using their characteristic features:

1) small total transverse momentum
2) total energy << $2E_0$

Detector Mark 2

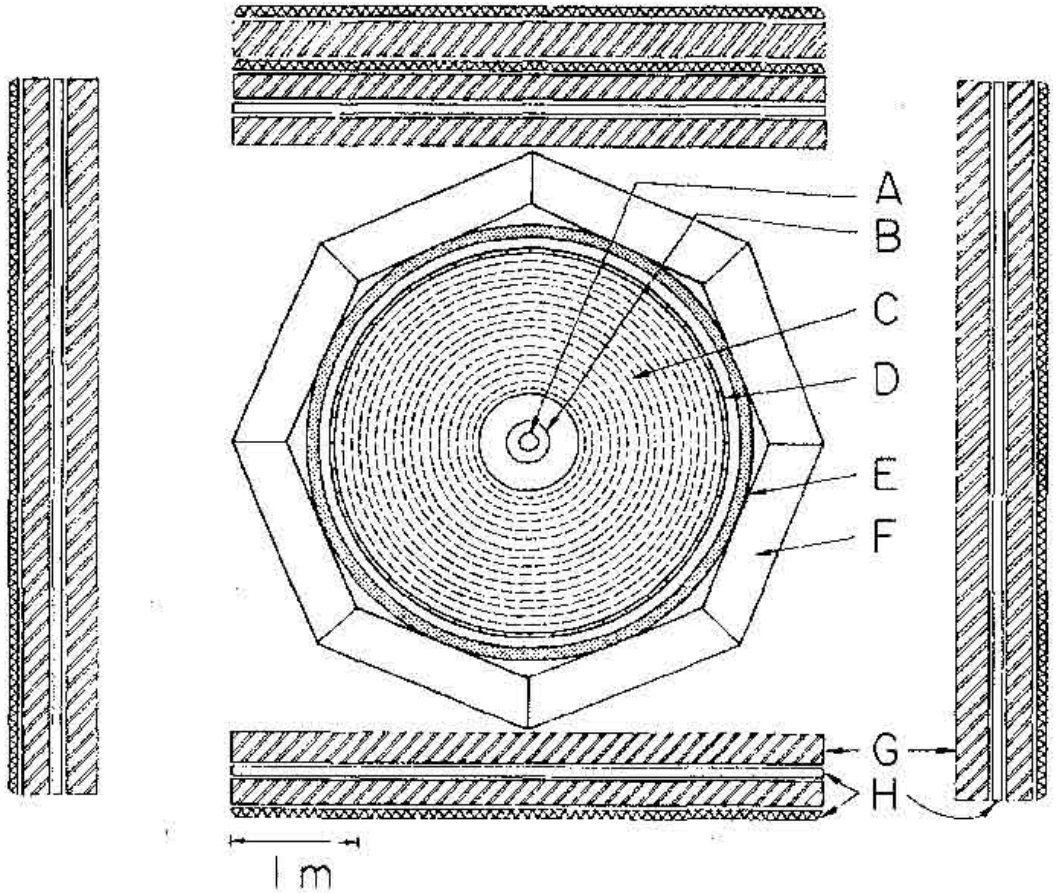

FIG. 1. Schematic view of the Mark II detector: (*A*) vacuum chamber, (*B*) pipe counter, (*C*) drift chamber, (*D*) time-of-flight counters, (*E*) solenoid coil, (*F*) liquid-argon shower counters, (*G*) iron absorber, (*H*) muon proportional tubes.

Observation of two photon production of η'

For selection of the process $\gamma\gamma \to \pi^+\pi^-\gamma$ the following cuts were used:

topology: 2 opposite charge tracks from the vertex region, one photon

pions: both TOF, LA or μ-det were used to reject leptons

photon: measured in the LA barrel calorimeter

against e+e→hadrons:

$P_\perp(\pi\pi\gamma) < 250$ MeV

$\Delta\Phi_{\pi\pi\text{-}\gamma} < 20°$

against rad.degraded Bhabha's

$p_\pi < 1$ GeV, $m_{\pi\pi} < 1$ GeV

against 2 prong two photon events (ee, μμ, ππ) with a fake γ

$P_\perp(\pi\pi) > 50$ MeV

$\Delta\Phi\pi\pi > 3°$

As result the number of events decreased by a factor of 1000 (compared to 2 prongs,±)

Results on η'

(First results on η' was obtained at the end of November 1978, after my departure on Jan. 20, 1979 this work was finished by Peter Jenni)

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DATE: 15 February 1979

TO : Mark II Physicists

FROM : V. I. Telnov, P. Jenni

SUBJECT: Observation of η' Production from Two Photon Interaction

In this short note we show the first results from our search for hadronic states produced by two photon interaction. We have observed evidence for η' production. This is, to our knowledge, the first observation of a narrow resonance produced by the two photon process (there are indeed only a very few candidate events for hadron production in $\gamma\gamma$ interactions published). The interest of this measurement is (in addition to the fact of its observation alone) a first determination of $\Gamma_{\gamma\gamma}$ of the η', which gives, together with the known BR(η' → $\gamma\gamma$), the unknown lifetime of the η'. Furthermore, conclusions are possible on the quark charges in the frame work of SU(3) + color under some assumptions.

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PHYSICAL REVIEW
LETTERS

VOLUME 43 | 13 AUGUST 1979 | NUMBER 7

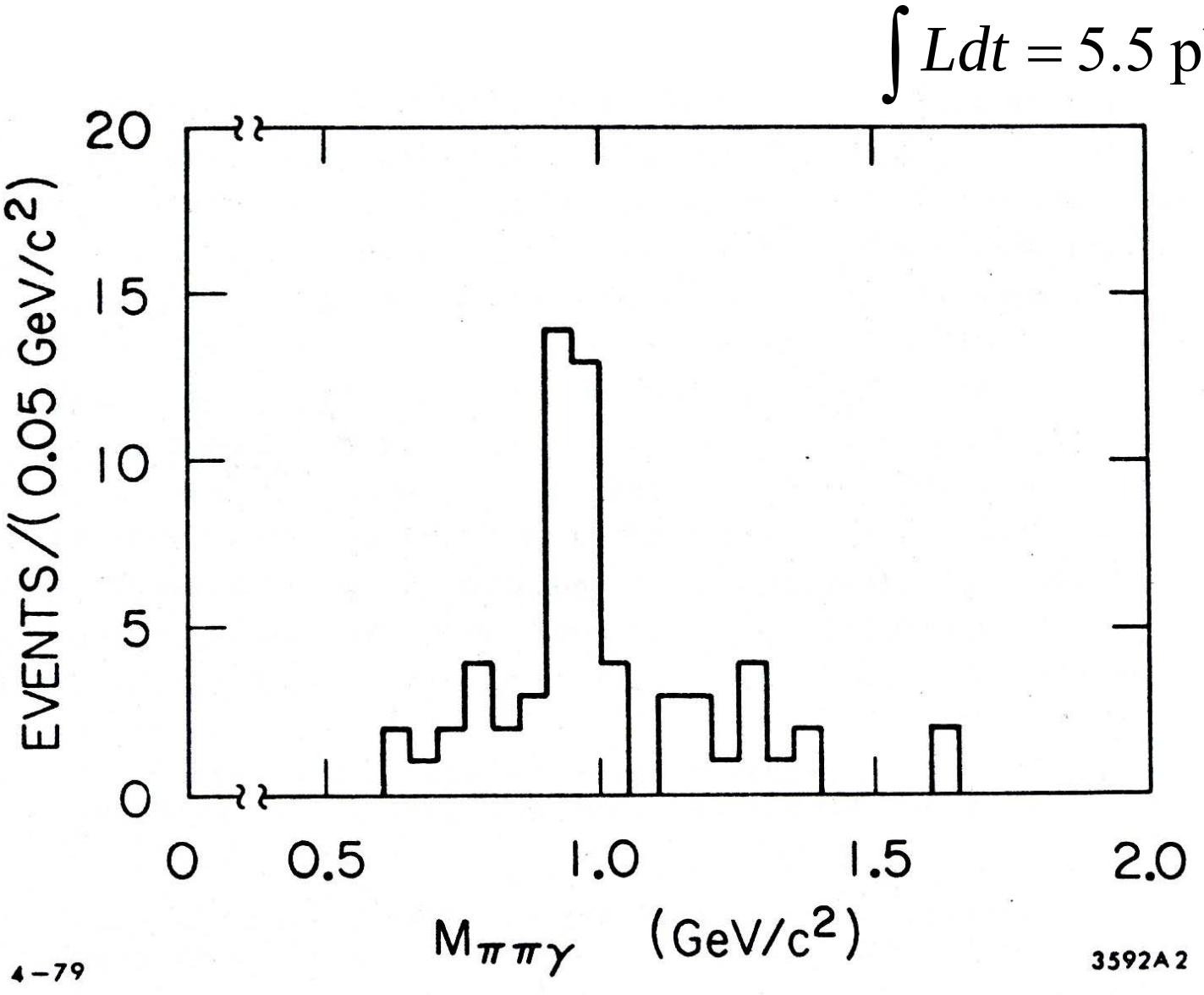
Measurement of the Radiative Width of the η' in Two-Photon Interaction at SPEAR

G. S. Abrams, M. S. Alam, C. A. Blocker, A. M. Boyarski, M. Breidenbach, C. H. Broll,[a]
D. L. Burke, W. C. Carithers, W. Chinowsky, M. W. Coles, S. Cooper, B. Couchman,[b]
W. E. Dieterle, J. B. Dillon, J. Dorenbosch, J. M. Dorfan, M. W. Eaton,
G. J. Feldman, H. G. Fischer,[c] M E. B. Franklin, G. Gidal, G. Goldhaber,
G. Hanson, K. G. Hayes, T. Himel, D. G. Hitlin, R. J. Hollebeek,
W. R. Innes, J. A. Jaros, P. Jenni, A. D. Johnson, J. A. Kadyk,
A. J. Lankford, R. R. Larsen, D. Lüke,[d] V. Lüth, J. F. Martin,[e]
R. E. Millikan, M. E. Nelson, C. Y. Pang, J. F. Patrick,
M. L. Perl, B. Richter, J. J. Russel,[f] D. L. Scharre,
R. H. Schindler, R. F. Schwitters, S. R. Shannon,[b]
J. L. Siegrist, J. Strait, H. Taureg, V. I. Telnov,[g]
M. Tonutti, G. H. Trilling, E. N. Vella, R. A. Vidal,
I. Videau, J. M. Weiss, and H. Zaccone

Stanford Linear Accelerator Center, Stanford University, Stanford, California 94305, and Lawrence Berkeley Laboratory and Department of Physics, University of California, Berkeley, California 94720
(Received 22 May 1979)

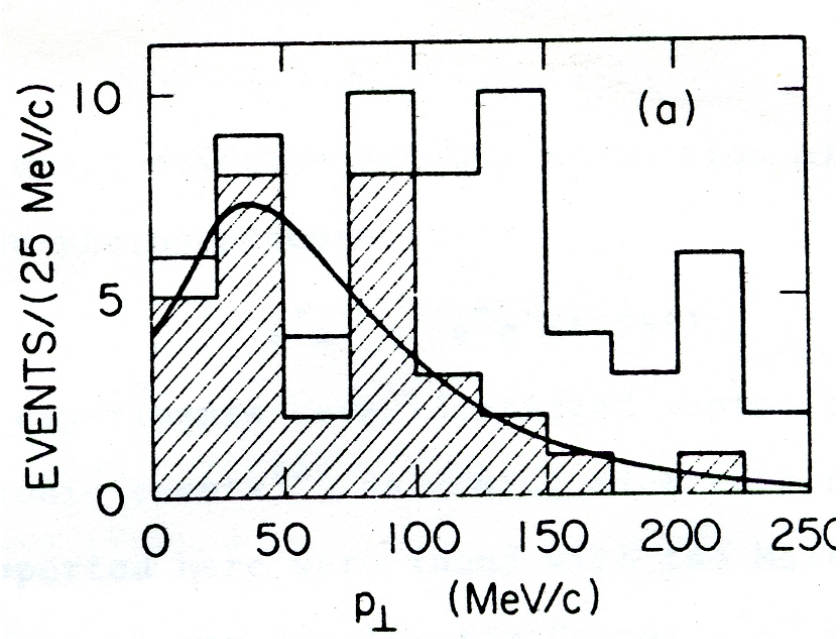
Events of the type $e^+e^- \to e^+e^-\eta'(958)$ have been observed with the Mark II detector at SPEAR by detecting the decay mode $\eta' \to \rho^0\gamma$. From the observed cross section and known branching fractions of the η' is $\Gamma_{\gamma\gamma} = 5.9 \pm 1.6 \pm 1.2$ keV and the total width is $\Gamma = 300 \pm 90 \pm 60$ keV (statistical and systematic errors).

Distribution on invariant mass of $\pi\pi\gamma$ system

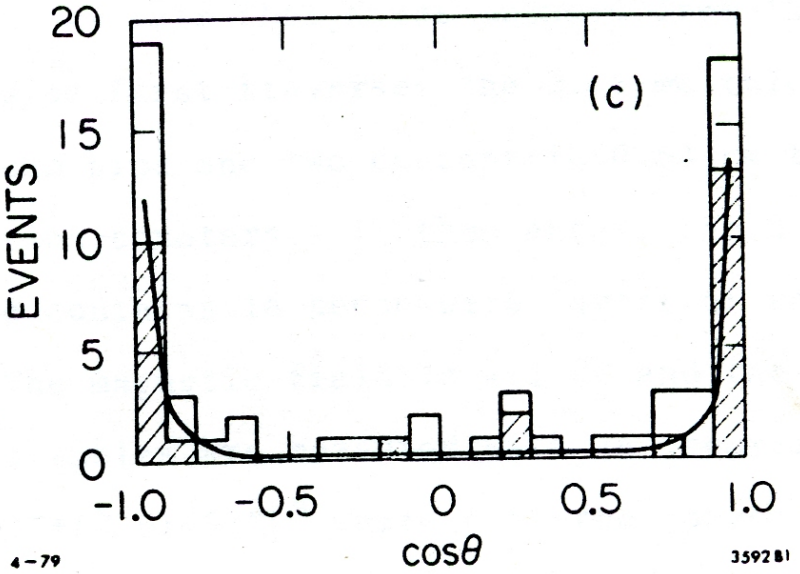


First C+ resonance at e+e- colliders!

Transverse momentum

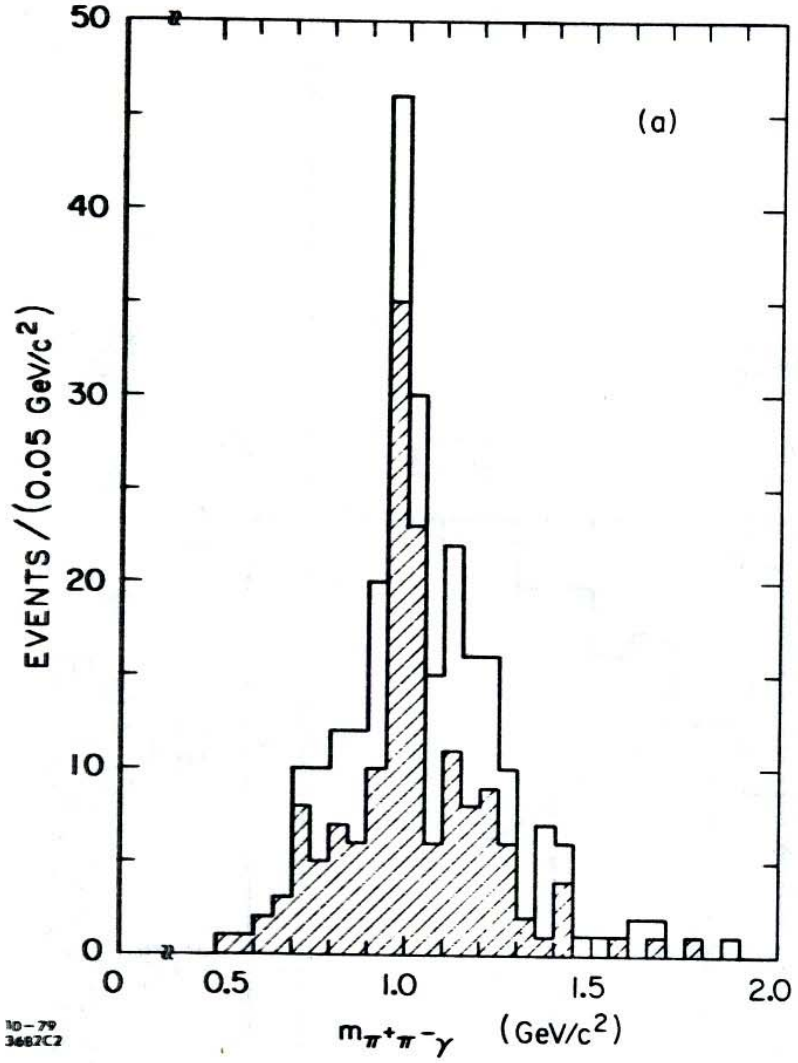


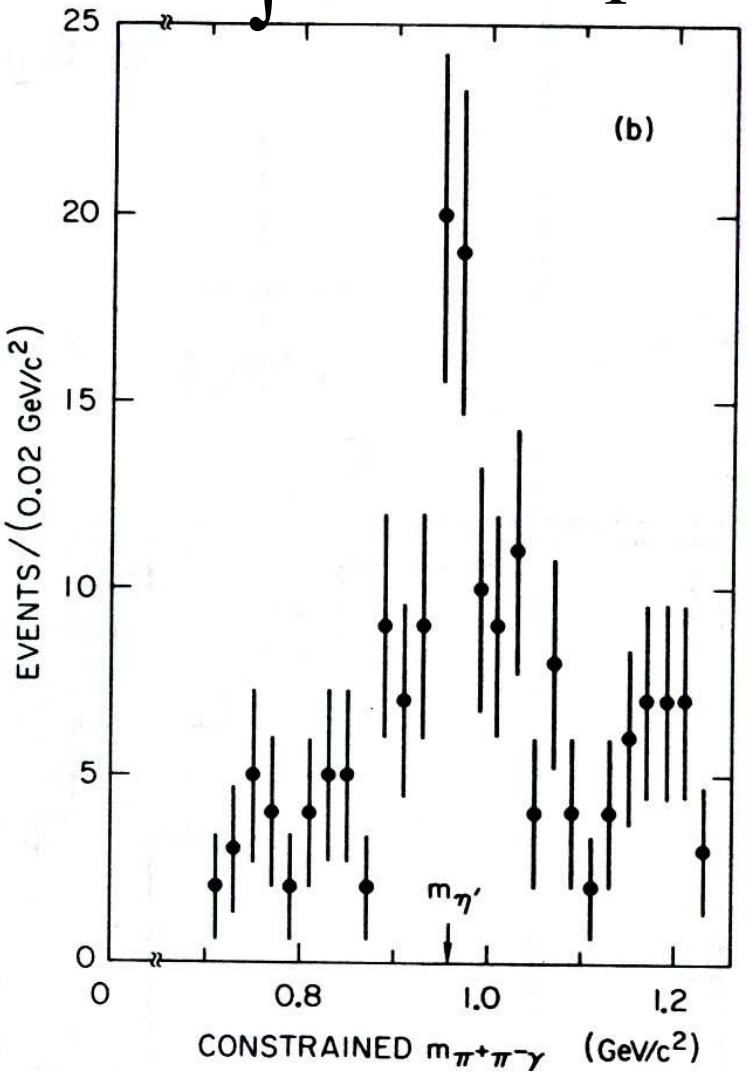
Polar angle



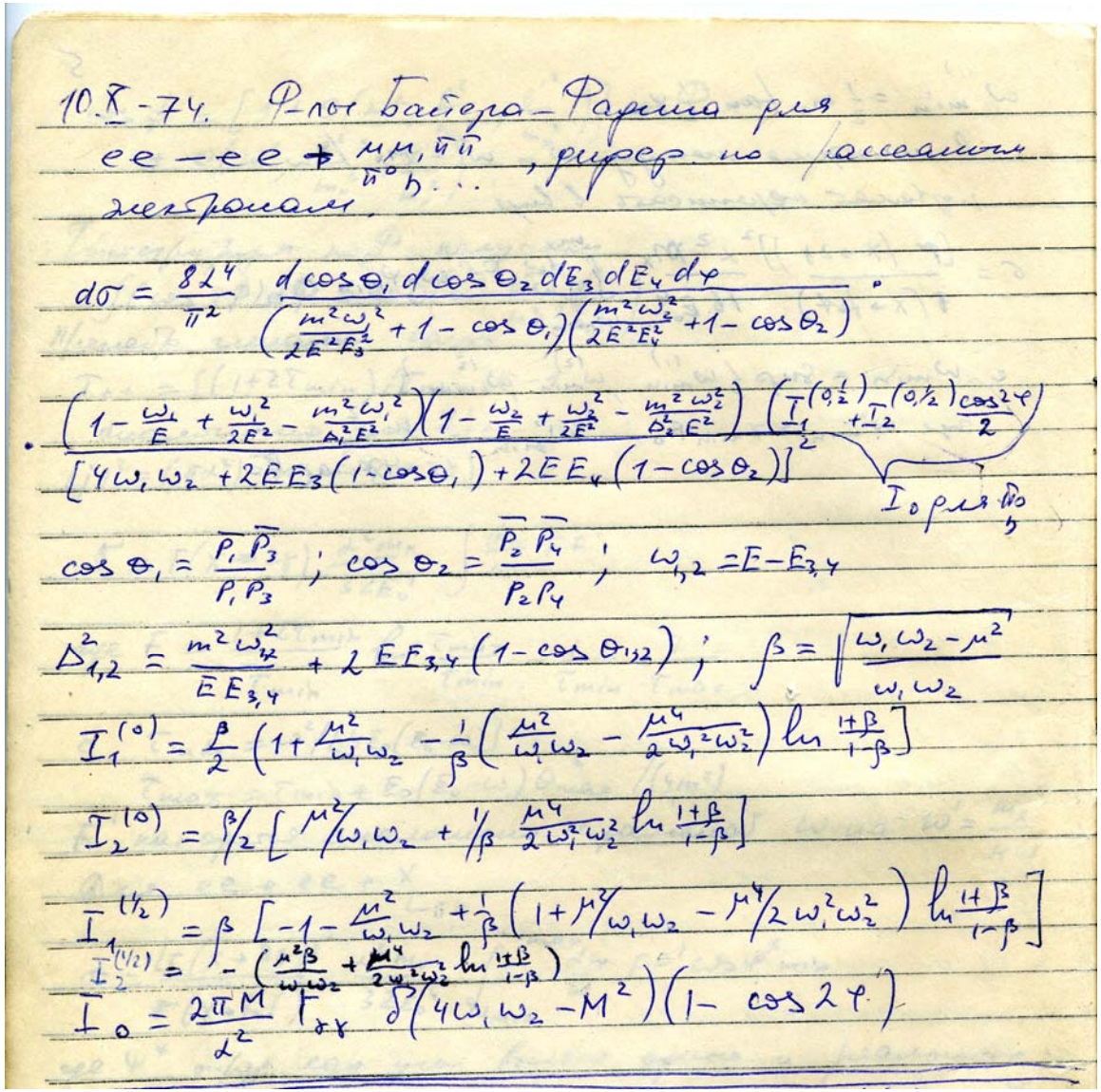
Results for increased luminosity (published somewhat later)

$$\int Ldt = 18\,\mathrm{pb}^{-1}$$





Two-photon production formulas



Formula from my workbook in Novosibirsk, which was sent to me when I decided to work on two photon processes at SLAC

η' two-photon width

$$\Gamma_{\gamma\gamma}(\eta') = 5.9 \pm 1.6 \pm 1.2 \text{ keV}$$ (first publication, 5.5 pb-1)

$$\Gamma_{\gamma\gamma}(\eta') = 5.8 \pm 1.1 \pm 1.2 \text{ keV}$$ (first publication, 18 pb-1)

Theoretical predictions:

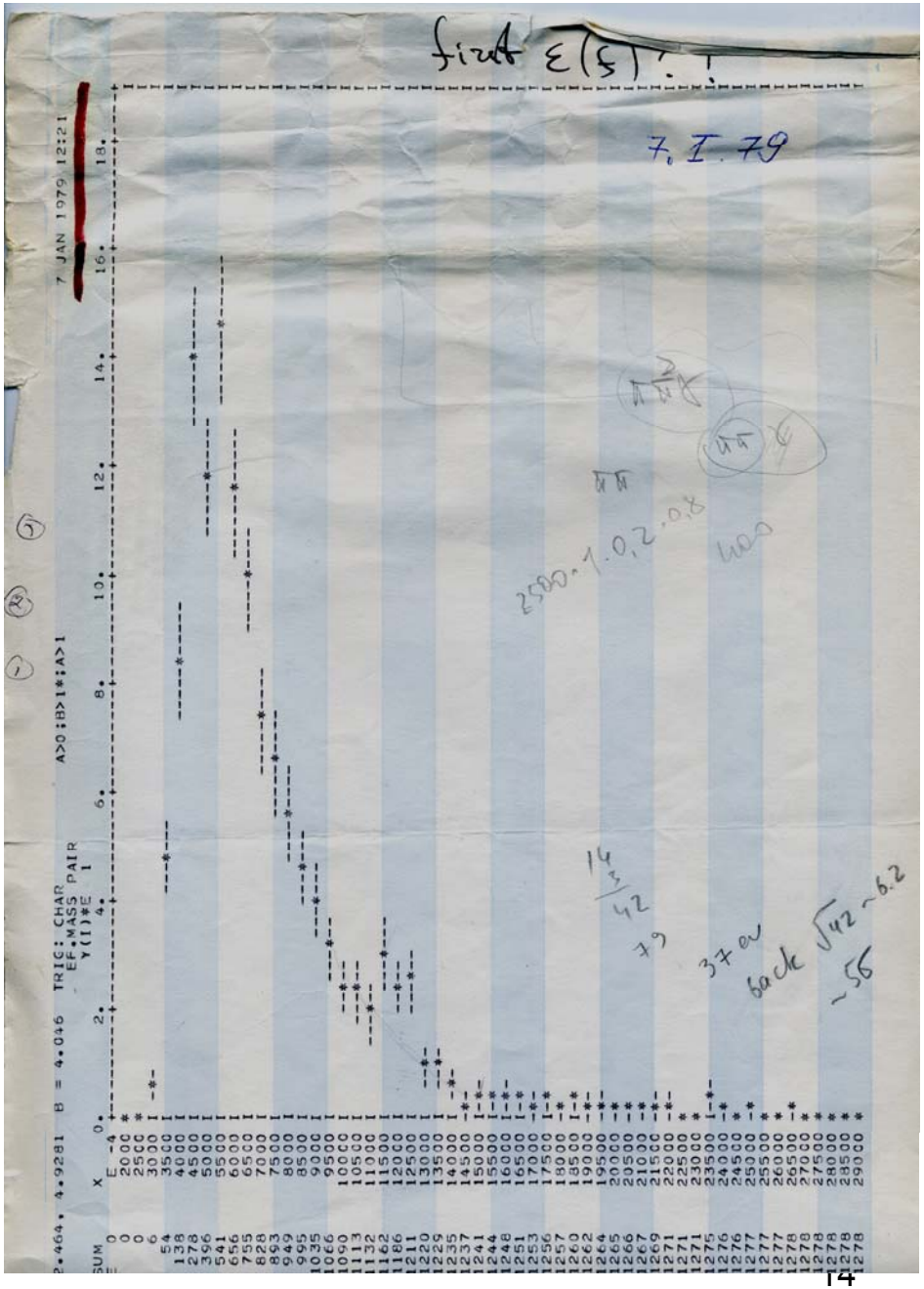
for integer charged quarks (Han-Nambu) - 25 keV

for fractionally charged quarks (Gell-Mann) - 6 keV

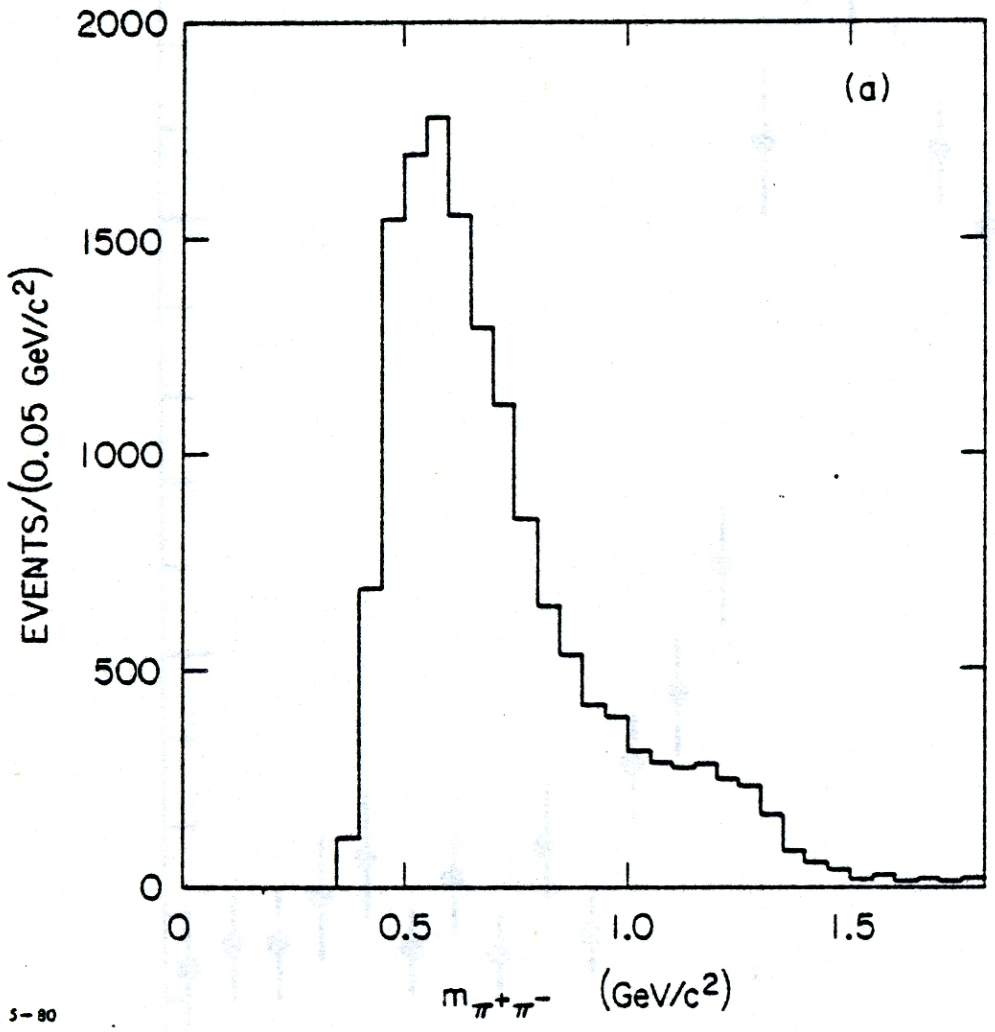
$\gamma\gamma \rightarrow \pi^+\pi^-$

In order to finish η' analysis I asked our INP director to prolong my visit at SLAC by 20 days. Usung extra days I decided to look for π+π- two-photon production.

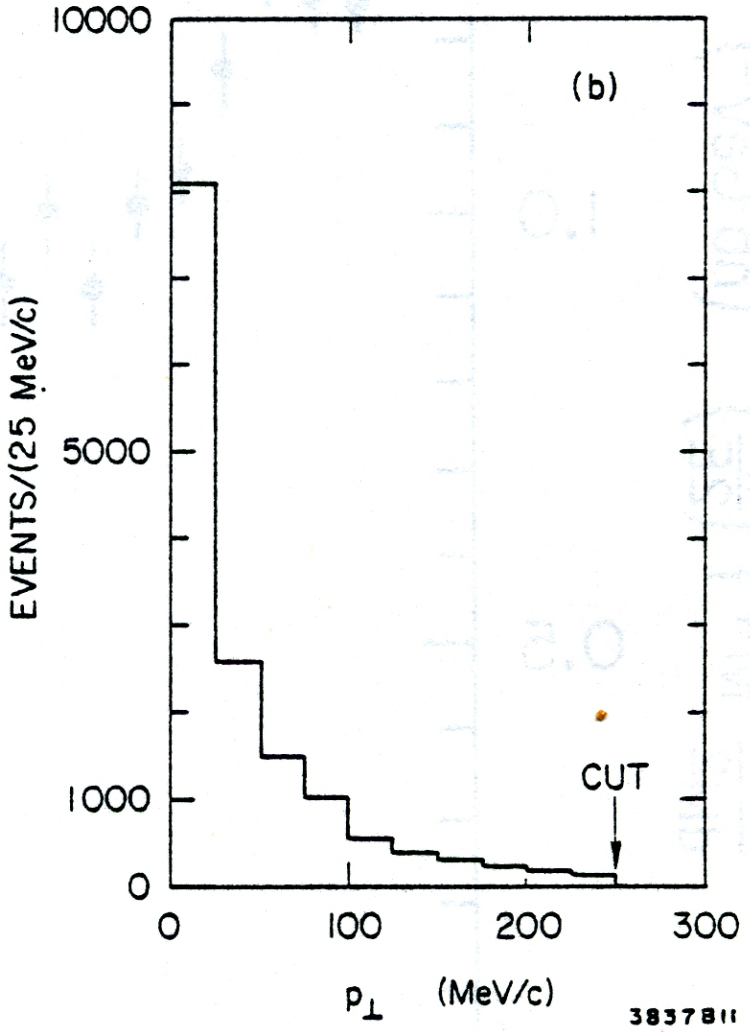
On January 7, 1979 I observed a bump in π+π- invariant mass spectrum in the region around 1240 MeV.



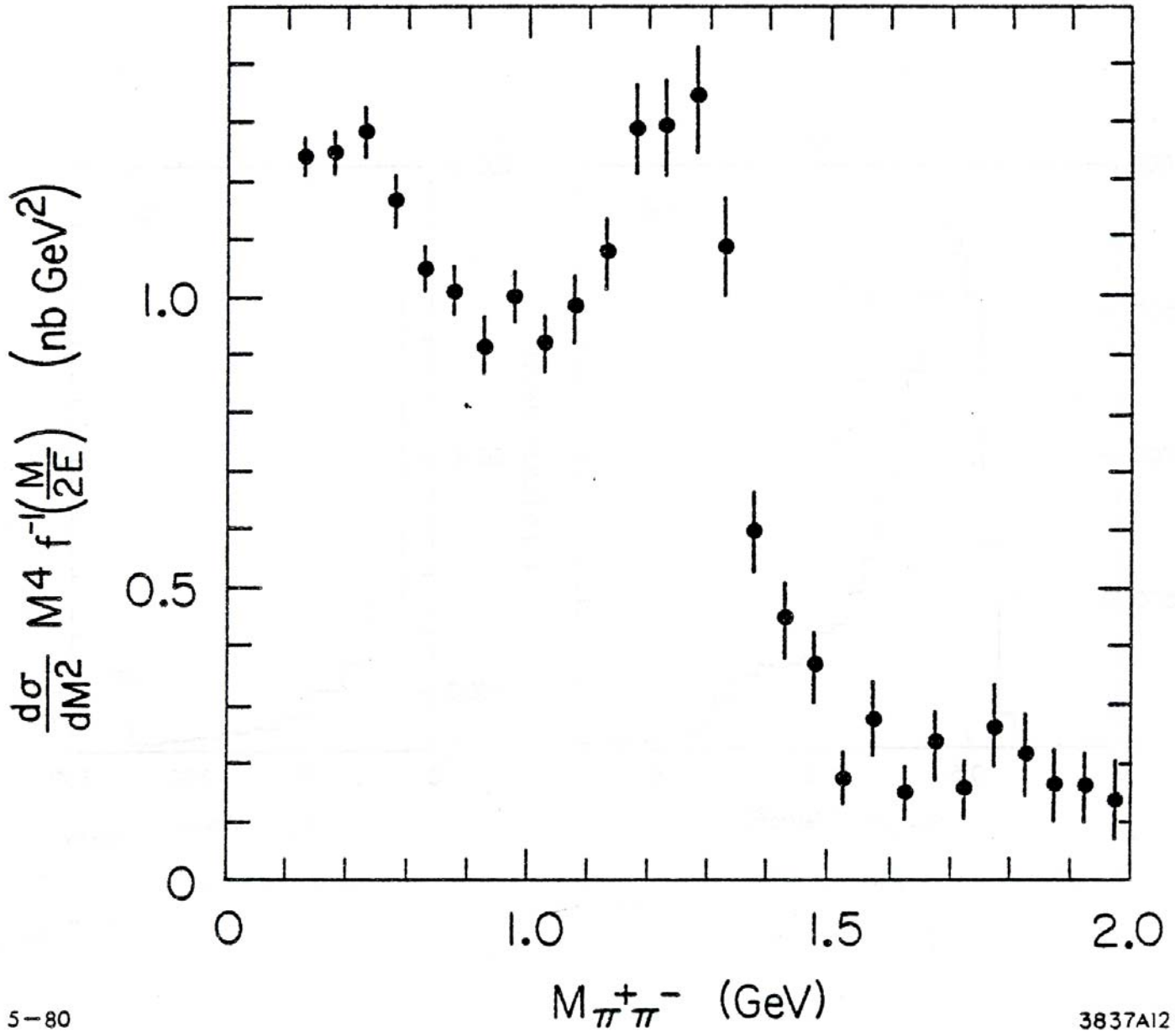
Invariant masses of π+π-system



Distribution on the transverse momentum

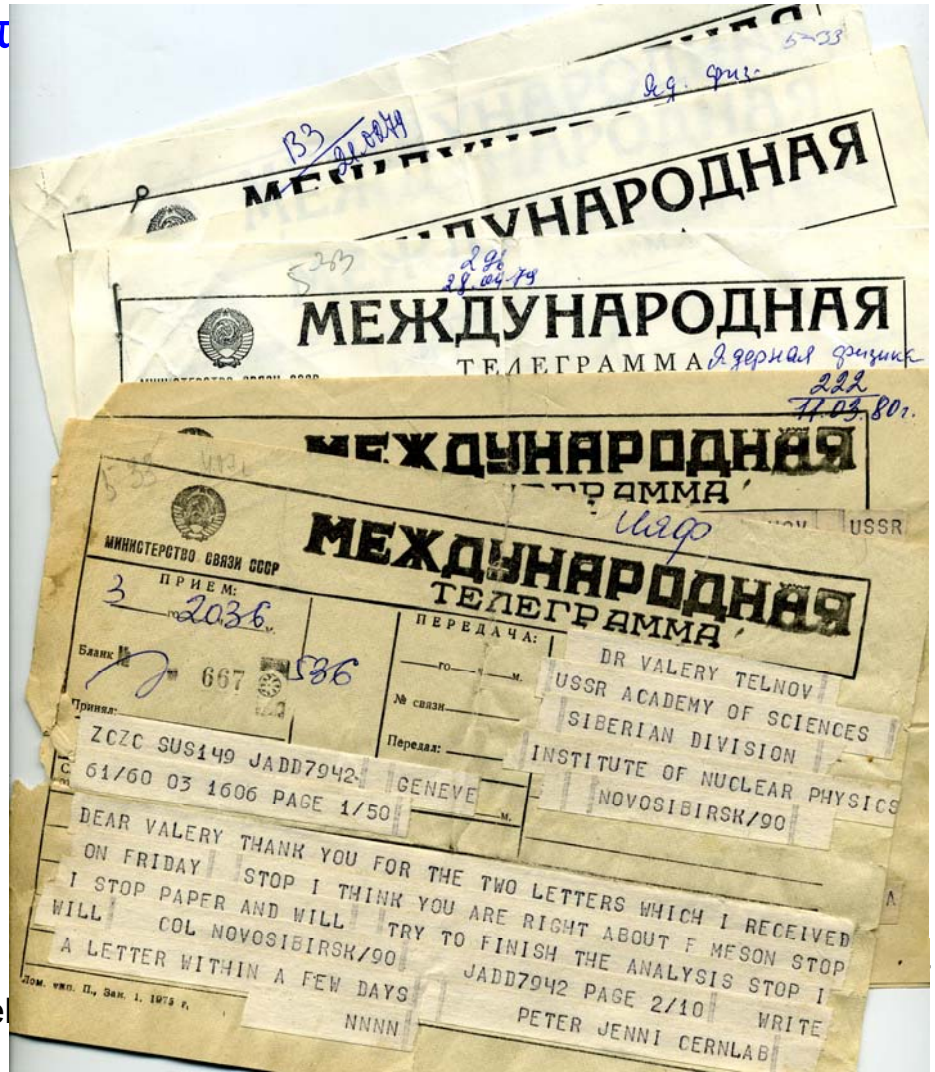


Inv. mass distribution after correction on kinematical factors



This result on γγ→ππ, obtained in the beginning of 1979, was shown by P. Jenni at conferences but was not sent for publication to journals because the mass of this bump was about 1240 MeV, but f_2 meson mass is 1270 MeV, it was not clear how to interpret the result (later it was understood that the mass shift is due to interference between f_2 resonance and non-resonant QED ππ

The second problem (reason): after returning to Novosibirsk the only way to fast communication with P.Jenni were telegrams.



Mark-2 paper on $\gamma\gamma \to f_2$ was published only in 1981 after PLUTO (1980)

Volume 105B, number 4 PHYSICS LETTERS 8 October 1981

PION PAIR PRODUCTION IN PHOTON–PHOTON COLLISIONS AT SPEAR ☆

A. ROUSSARIE [1], D.L. BURKE, G.S. ABRAMS, M.S. ALAM [2], C.A. BLOCKER,
A. BLONDEL, A.M. BOYARSKI, M. BREIDENBACH, W.C. CARITHERS, W. CHINOWSKY,

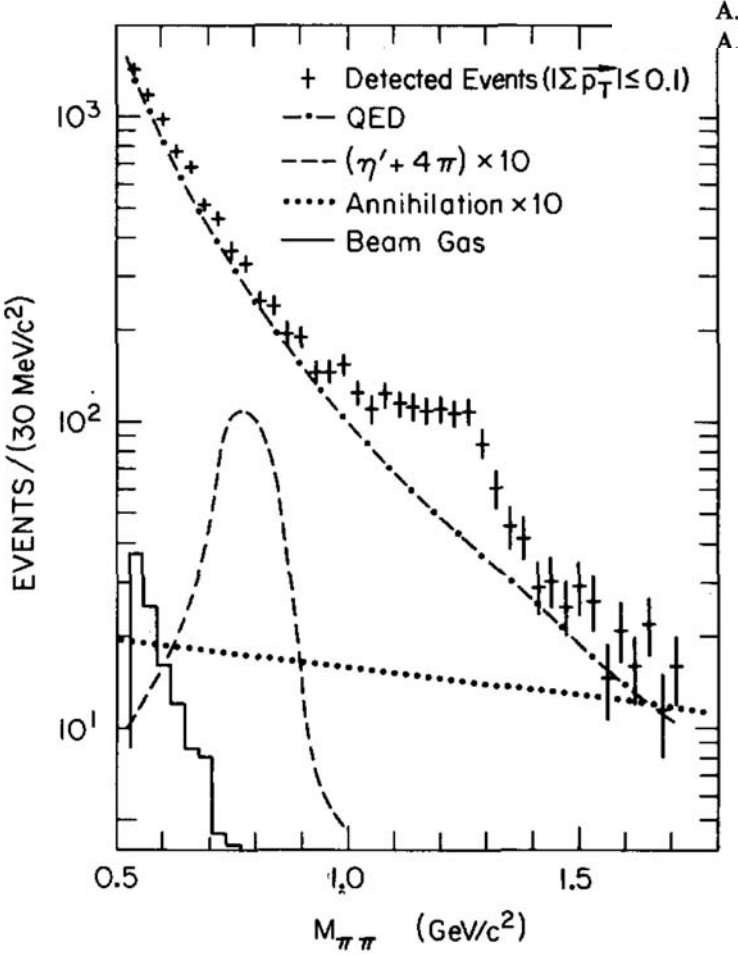


Fig. 1. The observed two-prong mass spectrum. The curves represent various contributions as measured and/or computed.

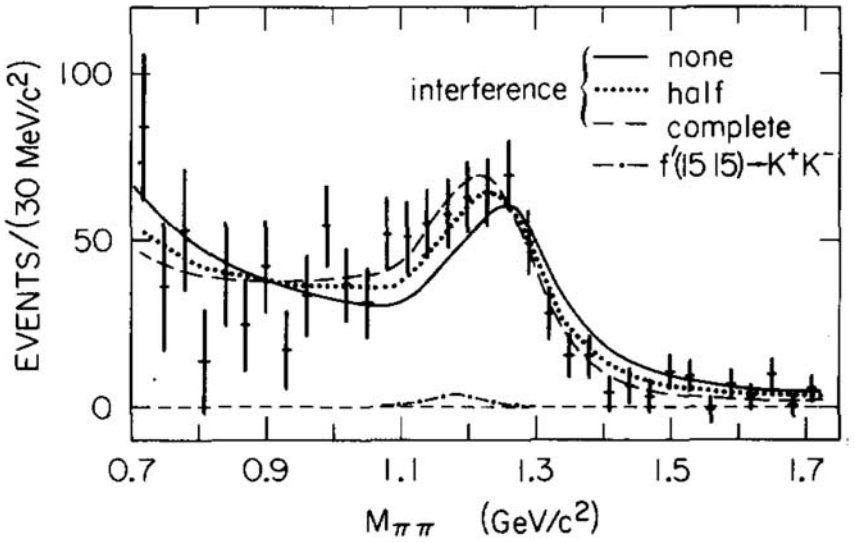


Fig. 4. The non-QED spectrum near the f(1270) mass. The number of misidentified $\gamma\gamma \to f'(1515) \to K^+K^-$ expected from SU(3) is shown for a branching ratio BR($f' \to K^+K^-$) = 50%. The remaining curves are described in the text.

C(*m*). The fits give (for helicity $\lambda = \pm 2$)

$= 3.6 \pm 0.3$ (statistical) ± 0.5 (systematic) keV

PLUTO(PETRA) 2.3±0.5±0.35

Conclusion

The Mark-2 paper on $\Gamma_{\gamma\gamma}(\eta')$ has marked the beginning of systematic studies of two-photon around the world.