

FFFFFFFFFFFF	11	5555555555	HH	HH	DDDDDDDDDD	SSSSSSSSSS	9999999999	9999999999
FFFFFFFFFFFF	111	5555555555	HH	HH	DDDDDDDDDD	SSSSSSSSSS	9999999999	9999999999
FF	1111	55	HH	HH	DD	SS	99	99
FF	11	55	HH	HH	DD	SS	99	99
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FF	11	55	HH	HH	DD	SSS	99	99
FF	11	55	HH	HH	DD	SS	99	99
FF	11	55	HH	HH	DD	SS	99	99
FF	1111111111	5555555555	HH	HH	DDDDDDDDDD	SSSSSSSSSS	9999999999	9999999999
FF	1111111111	5555555555	HH	HH	DDDDDDDDDD	SSSSSSSSSS	9999999999	9999999999

Mit herzlichen Grüßen !

H.O. Munk 26/7/82

HH	HH	00000000	5555555555	11	2222222222	8888888888	6666666666
HH	HH	0000000000	5555555555	111	2222222222	8888888888	6666666666
HH	HH	00	55	1111	22	88	66
HH	HH	00	55	11	22	88	66
HH	HH	00	55	11	22	88	66
HHHHHHHHHH	HH	00	5555555555	11	22	8888888888	6666666666
HHHHHHHHHH	HH	00	5555555555	11	22	8888888888	6666666666
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HH	HH	0000000000	5555555555	1111111111	2222222222	8888888888	6666666666
HH	HH	00000000	5555555555	1111111111	2222222222	8888888888	6666666666

HH	HH	00000000	5555555555	11	2222222222	8888888888	6666666666
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HH	HH	00	55	11	22	88	66
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*VERSION 1.3.0 (01 MAY 80) SYSTEM/370 FORTRAN H EXTENDED (ENHANCED) DATE 82.205/15.00.53
 REQUESTED OPTIONS: NODECK, NOLIST, OPT(0)
 OPTIONS IN EFFECT: NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(MAX) AUTODBL(NONE)
 SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF ALC NOANSF TERM IBM FLAG(I)

	C	17/05/82 207140951 MEMBER NAME GSTRUC (HEIMS) FORTRAN	00000000
ISN 0002		SUBROUTINE GSTRUC	00000100
	C----	ROUTINE CALCULATES THE STRUCTURE PARAMETERS N1,N2,N3,N4	00000200
	C----	AUS DEN QUANTENZAHLEN IM COMMON /QUANT/ UND DEN KONSTANTEN	00000300
	C----	IN COMMON /CONST/	00000400
ISN 0003		IMPLICIT REAL*16 (A-H,J-Z)	00000500
ISN 0004		COMMON /CONST/ PI,HQ,C,GAM,BG,SO,FAKMEV,ETA,THETA,EQ,ALFA,AMU,	00000600
		*ALFP,ALFM,XI,EBN,BETA,IPRINT	00000700
ISN 0005		COMMON /QUANT/ N,K,PG,OG,KQ,KAPPA,N1,N2,N3,N4,CS,IK,IPG,IQG,	00000710
		*IKAPPA,EPS,QX,IN,IN1,IN2,IN3,IN4,ICS,IEPS,IQX,IX,IKQ,X,	00000720
		*IK1,IK2,IK3,IK4	00000721
ISN 0006		COMMON /EXCHA/ WGX,AGX,BGX,ALF1,ALF2,ALF3,FN,Q1,Q2,Q3,Q4,	00000730
		*AN1,AN2,AN3,FIG,GKQ,WGK,AN,AQ,KGH,	00000740
		*IQ1,IQ2,IQ3,IQ4	00000750
	C----	COMPUTE FN=F(N)	00001300
ISN 0007	C----	(5-2) F(KQ,K,PG,KAPPA,EPS,LQ) REAL	00001400
		FN=(1.Q0-QG*(2.Q0-K)*(1.Q0-KAPPA))* (AGX*N/(N+2.Q0)+BGX*	00001500
		QSQRT(N(N-2.Q0)))	00001510
	C----	TEST PRINT	00001600
ISN 0008		IF(IPRINT.GE.2) WRITE(6,101) FN	00001700
ISN 0010	101	FORMAT(1X,'FN = ',Q14.5)	00001800
	C----	DETERMINATION OF STRUCTURE PARAMETERS	00001900
	C----	(6-1)	00002000
ISN 0011		W1=WGX*(1.Q0+FN)	00002100
ISN 0012		TEMP=(W1/ALF1)**(1.Q0/3.Q0)	00002200
ISN 0013		IK1=IQINT(TEMP)	00002300
ISN 0014		IN1=IK1-IQ1	00002400
ISN 0015		N1=QFLOAT(IN1)	00002500
	C----		00002600
ISN 0016		W2=W1-QFLOAT(IK1)**3*ALF1	00002700
ISN 0017		TEMP=QSQRT(W2/ALF2)	00002800
ISN 0018		IK2=IQINT(TEMP)	00002900
ISN 0019		IN2=IK2-IQ2	00003000
ISN 0020		N2=QFLOAT(IN2)	00003100
	C----		00003200
ISN 0021		W3=W2-QFLOAT(IK2)**2*ALF2	00003300
ISN 0022		TEMP=W3/ALF3	00003400
ISN 0023		IK3=IQINT(TEMP)	00003500
ISN 0024		IN3=IK3-IQ3	00003600
ISN 0025		N3=QFLOAT(IN3)	00003700
	C----		00003800
ISN 0026		W4=W3-QFLOAT(IK3)*ALF3	00003900
ISN 0027		IF(W4.EQ.0.Q0) GOTO 1	00003910
ISN 0029		IF(W4.GT.1.Q0) GOTO 3	00003920
ISN 0031		REST=QFLOAT(2*IK-1)/QFLOAT(3*IQ4)	00004000
ISN 0032		TEMP=-QLOG(W4)/REST	00004100
ISN 0033		IK4=IQINT(TEMP)	00004200
ISN 0034		GOTO 2	00004210
ISN 0035	1	IK4=IQINT(ALF3*QFLOAT(IK3))	00004220
ISN 0036		GOTO 2	00004230
ISN 0037	3	IK3=IK3-1	00004240
ISN 0038		IN3=IK3-IQ3	00004250
ISN 0039		N3=QFLOAT(IN3)	00004260
ISN 0040		IK4=IK4+IQINT(ALF3*QFLOAT(IK3))	00004270
ISN 0041	2	IN4=IK4-IQ4	00004300

$$e^+e^- \rightarrow \text{HADRONS}$$

RESULTS FROM THE DESY-HEIDELBERG-COLLABORATION

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Heidelberg, Germany

Abstract

Inclusive photon spectra and photon spectra for events with 4 prongs and 1 γ -ray which result from the decay of the (3.1) and (3.7) resonances are presented. The decay (3.7) $\rightarrow$ (3.1) + $\gamma\gamma$ is observed confirming earlier results of the DASP collaboration. In an investigation of 3 γ final states, the decay modes (3.1) $\rightarrow\eta\gamma$ and (3.1) $\rightarrow\eta'\gamma$ are detected. In addition, the data indicate the existence of a new heavy mass particle at 2.75 GeV which decays into two photons. This conclusion is based on an analysis of the 3 γ events from (3.1) decays combining results of the DASP and of the DESY - Heidelberg collaboration.

Paper presented at the 1975 International Symposium on Lepton and Photon Interactions at High Energies, August 21-27, 1975, Stanford University

as well as for the cathode strips. In this way, (ϕ, θ) ambiguities can be removed in multiprong events.

The hodoscopes H and H' are composed of 64 counters in total, each counter covering an azimuthal interval $\Delta\phi = 22.5^\circ$ and a polar angle interval $\theta = 30^\circ$ - 90° or 90° - 150° . A track is identified by a coincidence between corresponding H, H' counters in the internal and external hodoscopes. Different track multiplicities can be selected by the trigger electronics.

A vessel made of epoxy-fibre glass is positioned between the second and the third chamber. It can be filled with mercury. Photons originating from the interaction point see a converter thickness of 2 radiation lengths. The coordinates of the conversion points are measured in the third chamber with accuracies $\Delta\phi \approx \Delta\theta \approx 40$ mrad.

In order to identify electrons and photons and to measure their energies the cylindrical detector is surrounded by an arrangement of NaI (N) and lead glass counter blocks (L). The lead glass blocks on top and bottom have a dimension of $16 \times 18 \times 140$ cm. Phototubes are fixed on both sides of these blocks to compensate light attenuation and to determine the shower position from the time difference. Each of the walls on both sides of the cylindrical detector consists of 12 NaI and 20 lead glass blocks. The NaI counters are used to improve the resolution for photon energies below 500 MeV. All pulse heights are added linearly in order to get a measurement of the energy deposited in the NaI and lead glass blocks. The NaI - lead glass counters cover a solid angle of $\approx 60\%$ of 4π .

Muons are identified by drift chambers (μ) behind a 60 cm thick iron absorber. Cosmic rays can be identified by time of flight measurement between the scintillation counters (C). Close to the beam pipe two scintillation counter hodoscopes (M) of 16 elements each extend the solid angle for charged particles from 86% to 95% of 4π . The scintillation counters (R) veto background triggers from the beam halo.

In the trigger we require several combinations of a certain minimum track multiplicity with a minimum energy deposited in the

NaI - lead glass counters (see table I). The on-line computer, a PDP 9, selects in a fast decision only events that originate from a zone near the interaction point.

Table I

Number of prongs	Minimum Energy recorded
0	1500 MeV
1	900 MeV
2	400 MeV
≥ 3	300 MeV

III. Inclusive photon spectra

In order to obtain the inclusive photon spectra from the decays of the 3.1 GeV and 3.7 GeV resonances, we use only data without the mercury converter. The photon shower has to be inside an octant of the NaI - lead glass walls which is free from charged tracks. At 3.1 GeV (3.7 GeV) out of 53,000 (47,000) hadronic events 25,000 (22,000) had at least one photon fulfilling this criterion.

In Fig. 2 we show the photon energy spectra of both the (3.1)- and (3.7)-decays. They seem to be similar and both can be fitted to the sum of two exponentials with a change in slope at a photon energy of about 600 MeV. At the present state of the evaluation no quantitative conclusion is drawn since no corrections for the acceptance of the apparatus have been applied so far.

A search was made for events with a single photon associated to 4 charged tracks. Out of 22,000 events with photons (3.7 GeV, Fig. 2) 6,700 events had 4 prongs (Fig. 3) and 114 events had 4 prongs and 1 photon (Fig. 4). Most of these events are presumably still due to decays involving π^0 's. We estimate an upper limit ($E_\gamma > 30$ MeV)

$$\frac{\Gamma(3.7) \rightarrow 4 \text{ charged} + 1\gamma}{\Gamma(3.7) \rightarrow \text{all}} < 3\%$$

The branching ratio for transitions involving monoenergetic γ -rays with an energy of ≈ 200 MeV and 4 prongs is $< 1\%$ according to the data of Fig. 4.

IV. $e^+e^- \rightarrow e^+e^- \gamma\gamma$ at 3.7 GeV

We searched for decays (3.7) + $e^+e^- \gamma\gamma$ with an invariant mass of the e^+e^- system of 3.1 GeV. The photon cascade decay shown in Fig. 5a should give rise to such events due to the reaction

$$(3.7) \rightarrow \gamma\gamma + (3.1) \rightarrow e^+e^- \quad (1)$$

Recently, evidence for an intermediate state P_C was found in such an investigation⁴⁾.

In order to select events of type (1) we applied the following scan criteria:

- 1) Two tracks have to be seen in the cylindrical detector and the energy deposited by these tracks in the NaI - lead glass counters has to exceed 800 MeV for each of the tracks. This criterion removes charged hadrons from the sample.
- 2) Two photons are required to convert in the Hg-converter and at least one of the converted photons has to be correlated with energy recorded in the NaI - lead glass counters. Events with energy correlated with neither tracks nor converted photons were removed from the sample.

Using only the measured ϕ and θ angles we calculate the energies of all four outgoing particles imposing energy and momentum conservation. Fig. 5b shows the invariant mass of the e^+e^- system. There is a peak at 3.1 GeV superimposed to background.

The main source of background is the decay

$$(3.7) \rightarrow \pi^0 \pi^0 + (3.1) \rightarrow e^+e^- \quad (2)$$

when only two of the four photons from π^0 decay are detected. If such events are analyzed assuming reaction (1) usually wrong values for the (e^+e^-) -invariant mass are obtained.

The dashed curve in fig. 5b is a Monte Carlo calculation of this background. In order to study the background experimentally we included in the analysis events with at least one additional γ -ray recorded in the NaI - lead glass counters. These events were treated in the same way as our candidate events for reaction (1). In fig. 5c the effective mass of the e^+e^- system of the those events is plotted. A peak is observed at a central value of 3.3 GeV, in agreement with the Monte Carlo calculation.

Comparing the two figures we conclude that the peak at 3.1 GeV in fig. 5b has to be attributed to reaction (1). In the mass interval 3.0 - 3.2 GeV we find 20 events with an estimated background of 5 events. According to the $\gamma\gamma$ opening angle distribution only a small fraction of these events can be due to the decay $(3.7) \rightarrow (3,1) + \eta, \eta \rightarrow 2\gamma$.

We conclude that we observe the same type of events as the ones reported in Ref. 4. Such events can be considered as evidence for the existence of an intermediate state P_C . A preliminary estimate gives a branching ratio of a few percent for the 2γ - cascade. A more detailed evaluation including the energy measurements of the two photons is in progress.

$V. e^+e^- \rightarrow 3\gamma$ at 3.1 GeV and 3.7 GeV

We have searched for 3γ events in the data taken at 3.1 GeV and 3.7 GeV, in order to investigate decays of the type

$$(3.1), (3.7) \rightarrow \gamma + m, \quad m \rightarrow \gamma + \gamma,$$

m being an η, η' , or a new heavy-mass state. These decay modes have to be discriminated against the QED process $e^+e^- \rightarrow 3\gamma$ and against other decays with more than 3 photons in the final state.

From the data recorded with the Hg-converter, we selected 3γ -event candidates requiring (1) three conversion points seen in the cylindrical detector, (2) a recorded energy > 50 MeV behind

each conversion point, (3) no uncorrelated energy seen in the NaI and lead-glass counters, and (4) unique assignment of ϕ , θ coordinates to each conversion point.

All candidates were analyzed assuming that they are 3γ events. The reconstruction was performed using the coordinates of the three conversion points and assuming energy and momentum conservation. The analysis yielded the three photon energies and the coordinate z of the interaction point along the beam axis. Figure 6 shows the z -distribution of the 3γ events as well as of background events (4 photons seen and 1 photon ignored). As a reference, we show in Fig. 6c the vertex distribution of events from the QED process $e^+e^- \rightarrow 2\gamma$. From the comparison of these distributions we conclude that the 3 photon events are contaminated only by a minor background due to multiple photon events. A cut was applied to eliminate events with $|z| > 25$ mm. The correct reconstruction of the events was tested by comparing the calculated photon energies with the measured ones. About 5% of the events were rejected because of inconsistent energies⁵⁾.

A total of 47 events $e^+e^- \rightarrow 3\gamma$ were found. 13 events were recorded at 3.7 GeV (integrated luminosity $\approx 400 \text{ nb}^{-1}$), 34 events at 3.1 GeV ($\approx 240 \text{ nb}^{-1}$) and no event at 3.05 GeV ($\approx 24 \text{ nb}^{-1}$).

Three different invariant masses $m_{\gamma\gamma}$ are obtained for each event. In a fully symmetric Dalitz plot, m_{12}^2 vs. m_{13}^2 , every event gives 6 points. In order to obtain a Dalitz plot with only 1 point per event, we plotted the lowest m^2 vs. the highest m^2 , confining the points to the hatched triangle in Fig. 7. If the 3γ decay proceeds via an intermediate state with mass m , the points should accumulate along the trajectories indicated in Fig. 7. The density of points should be constant along each of the straight lines in the original Dalitz plot m_{12}^2 vs. m_{13}^2 . If the three photons come from the QED process $e^+e^- \rightarrow 3\gamma$, a completely different distribution is expected. Monte Carlo calculations of this process have been performed for $\sqrt{s} = 3.1$ GeV and $\sqrt{s} = 3.7$ GeV⁶⁾. Results are shown in Fig. 8.

The detection efficiency for 3γ events is approximately constant in the whole Dalitz plot except the corner with the highest

values of m_H^2 . Above $m_H^2 = 9 \text{ GeV}^2$ at 3.1 GeV and above $m_H^2 = 13 \text{ GeV}^2$ at 3.7 GeV , the soft photon has an energy below 100 MeV . The efficiency is reduced in this corner.

The Dalitz plot of 3γ events observed at 3.7 GeV is shown in Fig. 9. The distribution is compatible with the Monte Carlo calculation for the QED process. Also, the absolute number of events agrees within a factor of two with the QED prediction. A more accurate comparison is not possible at present, since we have not yet determined the efficiency of the event selection criteria. One event is possibly due to the decay $(3.7) \rightarrow \gamma\eta$.

The Dalitz plot for the 3γ events observed at 3.1 GeV exhibits a more interesting structure. Similar observations have been made by the DASP collaboration.² Figure 10 shows the Dalitz plot of the events observed in both experiments. The bands for the reaction $(3.1) \rightarrow \gamma\eta$ and $(3.1) \rightarrow \gamma\eta'$ are indicated. The widths correspond to estimates of the experimental error. Both in the DASP and in the DESY-Heidelberg experiment, accumulations of events in the η band and at high values of m_H^2 are observed. Some events lie in the η' band. In the following, an analysis of the Dalitz plot, combining the results of both experiments, is presented.

Since at high masses there is a region of possible confusion, we analyze first the part of the Dalitz plot with $m_H^2 < 6.8 \text{ GeV}^2$. There are 12 events within the η band, 3 events within the η' band and 9 events outside these bands. These latter events are probably due to the QED reaction⁷⁾. The population of this part of the Dalitz plot can therefore be explained in terms of $(3.1) \rightarrow \eta\gamma$, $(3.1) \rightarrow \eta'\gamma$ and $e^+e^- \rightarrow 3\gamma$ (QED).

Taking into account that 46% of the η band and 57% of the η' band are below $m_H^2 = 6.8 \text{ GeV}^2$ and correcting for the different branching fractions of $\eta \rightarrow 2\gamma$ and $\eta' \rightarrow 2\gamma$ a ratio

$$\frac{(3.1) \rightarrow \gamma\eta'}{(3.1) \rightarrow \gamma\eta} = 4 \pm 2.5$$

is obtained.

In the further analysis of the events, we consider the m_H^2 distribution for all events within the η band (Fig. 11a) and for the events outside the η band (Fig. 11b). The distribution of the events is approximately flat. Within the η band, most events with $m_H^2 > 6.8 \text{ GeV}^2$ can, therefore, be attributed to the decay $(3.1) \rightarrow \gamma\eta$. The distribution of the events outside the η band has a bump at 7.5 GeV^2 , which is compatible neither with the flat distribution expected for events from the decay $(3.1) \rightarrow \gamma\eta'$ nor with the smoothly rising distribution expected for QED events (Fig. 11c).

The interval $6.8 \text{ GeV}^2 < m_H^2 < 8.2 \text{ GeV}^2$ contains 24 events. 2 ± 1.5 events $(3.1) \rightarrow \eta'\gamma$ are expected, assuming a flat distribution within the η' band. The QED background can be determined without absolute efficiency calculations using either the 3γ events recorded outside the resonance region or the 3γ events recorded at 3.7 GeV , assuming that all of these events are due to QED⁷⁾. Both methods show that the QED process contributes $\lesssim 6$ events to the interval $6.8 \text{ GeV}^2 < m_H^2 < 8.2 \text{ GeV}^2$. There remains an excess of ~ 16 events above the background of 6 to 10 events. The statistical probability for finding 24 events or more, when 10 events are expected, is $\approx 3 \times 10^{-3}$.

It can be seen in Fig. 10 that the excess of events at high values of m_H^2 is uniformly spread in the Dalitz plot along a vertical line near $m_H^2 = 7.5 \text{ GeV}^2$. This suggests the existence of a state X with $m_X = 2.75 \text{ GeV}$. A Monte Carlo calculation for the decay mode,

$$(3.1) \rightarrow \gamma + X \quad X \rightarrow 2\gamma,$$

resulted in a m_H^2 distribution which is compatible with the data (dashed line in Fig. 11b). If the excess of events is attributed to such a state X , we obtain a ratio,

$$\frac{(3.1) \rightarrow \gamma + X}{(3.1) \rightarrow \gamma + \eta} \cdot \frac{\text{Branching ratio } (X \rightarrow 2\gamma)}{\text{Branching ratio } (\eta \rightarrow 2\gamma)} \approx 1$$

Summarizing the above discussion of the DASP and DESY-Heidelberg data, we conclude that at 3.1 GeV the number of observed 3γ events and their distribution in the Dalitz plot cannot fully be explained by the three processes $e^+e^- \rightarrow 3\gamma$ (QED), $(3.1) \rightarrow n\gamma$ and $(3.1) \rightarrow \eta'\gamma$. There remains an excess of 16 events which indicates the existence of a heavy mass state X with $m_X \approx 2.75$ GeV, which is produced by a radiative decay of the (3.1) resonance and which decays into two γ rays.

Note added in proof: The latest evaluation of the DASP Collaboration added three more events to the sample of 3γ -decays. One event is a $(3.1) \rightarrow \gamma n$ decay, one event is a candidate for $(3.1) \rightarrow \gamma X(2750)$; the third event has solutions for $(3.1) \rightarrow \gamma n$ as well as for $(3.1) \rightarrow \gamma X(2750)$.

ISN 0021
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ISN 0040
ISN 0041

W3=W2-QFLOAT(1K2)**2*ALF2
TEMP=W3/ALF3
1K3=IQINT(TEMP)
IN3=1K3-IQ3
N3=QFLOAT(IN3)
C----
W4=W3-QFLOAT(1K3)*ALF3
IF(W4.EQ.0.00) GOTO 1
IF(W4.GT.1.00) GOTO 3
REST=QFLOAT(2*1K-1)/QFLOAT(3*1Q4)
TEMP=-QLOG(W4)/REST
1K4=IQINT(TEMP)
GOTO 2
1 1K4=IQINT(ALF3*QFLOAT(1K3))
GOTO 2
3 1K3=1K3-1
IN3=1K3-IQ3
N3=QFLOAT(IN3)
2 1K4=1K4+IQINT(ALF3*QFLOAT(1K3))
IN4=1K4-IQ4

00002900
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*VERSION 1.3.0 (01 MAY 80) GSTRUC SYSTEM/370 FORTRAN H EXTENDED (ENHANCED) DATE 82.205/15.00.53 PAGE 2
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ISN 0045 200 * W4 REST'/1X,5Q16.8) W1 W2 W3
ISN 0046 100 WRITE(6,100) 1K1,1K2,1K3,1K4,IN1,IN2,IN3,IN4
ISN 0047 100 FORMAT(1X,' 1K1 1K2 1K3 1K4 N1 N2 N3 N4'/1X,8I5)
ISN 0048 RETURN
ISN 0049 END
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STATISTICS SOURCE STATEMENTS = 48, PROGRAM SIZE = 2356, SUBPROGRAM NAME =GSTRUC
STATISTICS NO DIAGNOSTICS GENERATED
***** END OF COMPILATION *****
84K BYTES OF CORE NOT USED

Footnotes and References

- 1) W. Bartel, P. Duinker, P. Steffen (DESY, Hamburg), and J. Heintze, G. Heinzelmann, R.D. Heuer, R. Mundhenke, H. Rieseberg, A. Wagner, A.H. Walenta (Physikal. Institut der Universität Heidelberg, Germany), and B. Schürlein (now at IDAS GmbH, Limburg/Lahn).
- 2) B. Wiik: $e^+e^- \rightarrow \text{Hadrons}$: DORIS results. Paper presented at the 1975 Lepton Photon Symposium, Stanford.
- 3) J. Heintze and A.H. Walenta, Nucl. Instr. and Meth. 111 (1973) 461; A.H. Walenta, IEEC Transactions on Nuclear Science 22 (1975) 251; A.H. Walenta, RHEL/M/H21 (1972) 116
- 4) DASP-collaboration, W. Braunschweig, H.-U. Martyn, H.G. Sander, D. Schmitz, W. Sturm, and W. Wallraff (RWTH Aachen), and K. Berkelman, D. Cords, R. Felst, E. Gadermann, G. Grindhammer, H. Hultschig, P. Joos, W. Koch, U. Kötz, H. Krehbiel, D. Kreinick, J. Ludwig, K.-H. Mess, K.C. Moffeit, A. Petersen, G. Poelz, J. Ringel, K. Sauerberg, P. Schmüser, G. Vogel, B.H. Wiik, and G. Wolf (DESY, Hamburg), and G. Buschhorn, R. Kotthaus, U.E. Kruse, H. Lierl, H. Oberlack, K. Pretzl, and M. Schliwa (MPI für Physik u. Astrophysik, München), and S. Orito, T. Suda, Y. Totsuka, and S. Yamada (University of Tokyo), Phys. Letters 57 B (1975) 407
- 5) The measured photon energies were not used in a constrained fit since it is difficult to account for the energy loss due to the edge effects.
- 6) The Monte Carlo calculations were kindly performed by Dr.P.Bock, Heidelberg. The formulae given by Geshkenbein and Terent'ev, Sov. Journ. Nucl. Phys. 8 (1969) 321 were used.
- 7) The QED background can be determined by measurement of 3γ events outside the resonances. In the combined data of both experiments 2 events with $m_H^2 < 6.8 \text{ GeV}^2$ and 1 event with $6.8 \text{ GeV}^2 \leq m_H^2 < 8.2 \text{ GeV}^2$ were found. The integrated luminosities were $\sim 150 \text{ nb}^{-1}$ outside resonance and $\sim 450 \text{ nb}^{-1}$ at the 3.1 GeV resonance. Consequently, 6 and 3 QED events are expected in the two m_H^2 intervals. Alternatively, the QED background can be determined by assuming that all 3γ events at 3.7 GeV are due to the QED process. Making use of the Monte Carlo calculations for relating the 3.7 GeV and the 3.1 GeV QED events to each other, ~ 5 events are expected in each of the two m_H^2 intervals.

Figure captions

1. Experimental apparatus
2. Inclusive photon spectra at 3.1 GeV and 3.7 GeV
3. Photon spectrum of 4 prong events
4. Photon spectra of events with 4 prongs and 1 γ -ray. The dashed line indicates the resolution at 200 MeV.
5. (a) Photon cascade decay $(3.7) \rightarrow (3.1)$
(b) Invariant mass distribution of e^+e^- pairs ($e^+e^- \rightarrow e^+e^-\gamma\gamma$)
(c) Invariant mass distribution of e^+e^- pairs (background)
6. Distribution of reconstructed interaction points in beam direction.
7. Schematic Dalitz plot for 3γ events.
8. Distribution of QED 3γ events at 3.1 GeV. (Monte Carlo calculation, normalized to 100 events.)
9. Dalitz plot of 3γ events recorded at 3.7 GeV. The numbers indicate the Monte Carlo prediction for the QED process normalized to the number of events observed below 13 GeV^2 .
10. Dalitz plot of 3γ events recorded at 3.1 GeV.
11. Distribution of 3γ events along the m_H^2 -axis in Fig. 8 and Fig. 10.
 - (a) Events within the η band
 - (b) Events outside the η band
 - (c) QED events (Background in D.HD-experiment times 5).

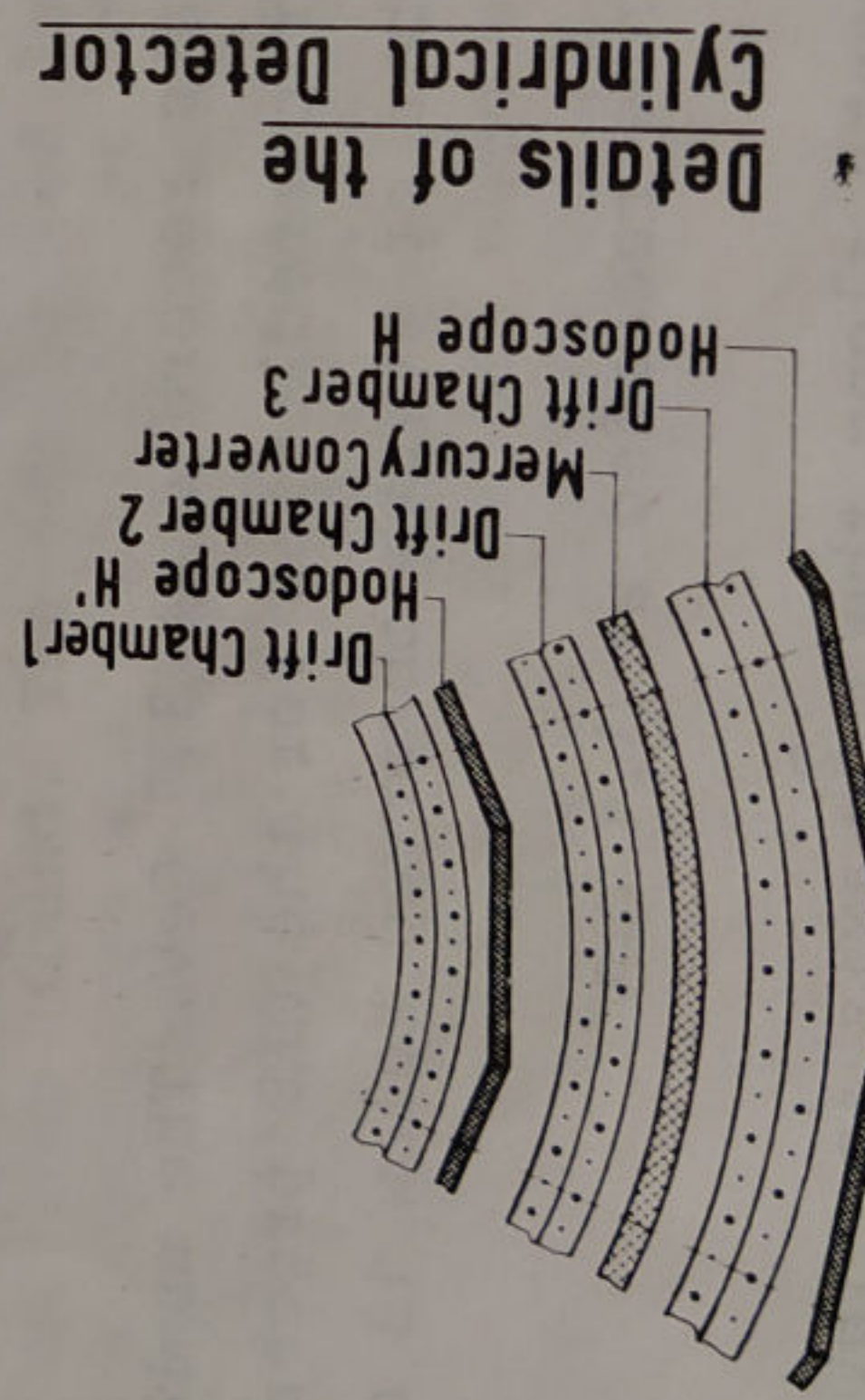
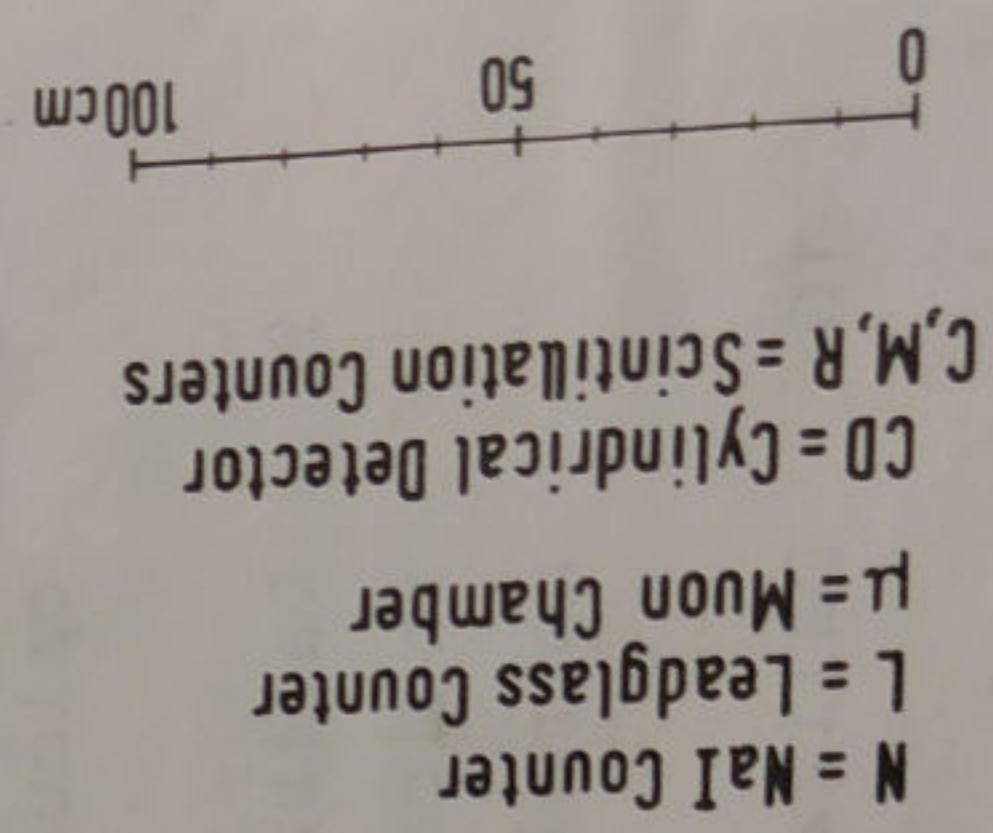
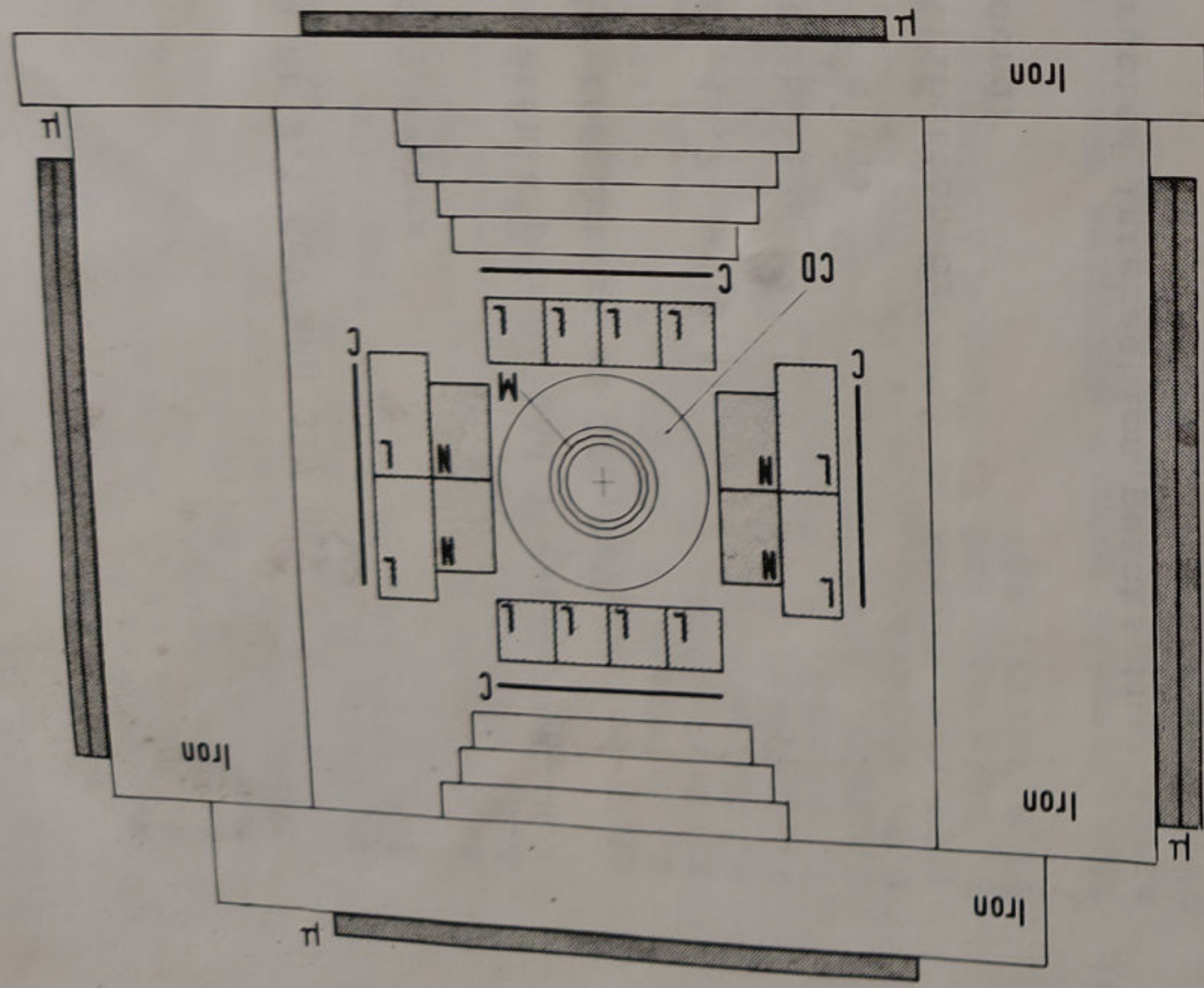
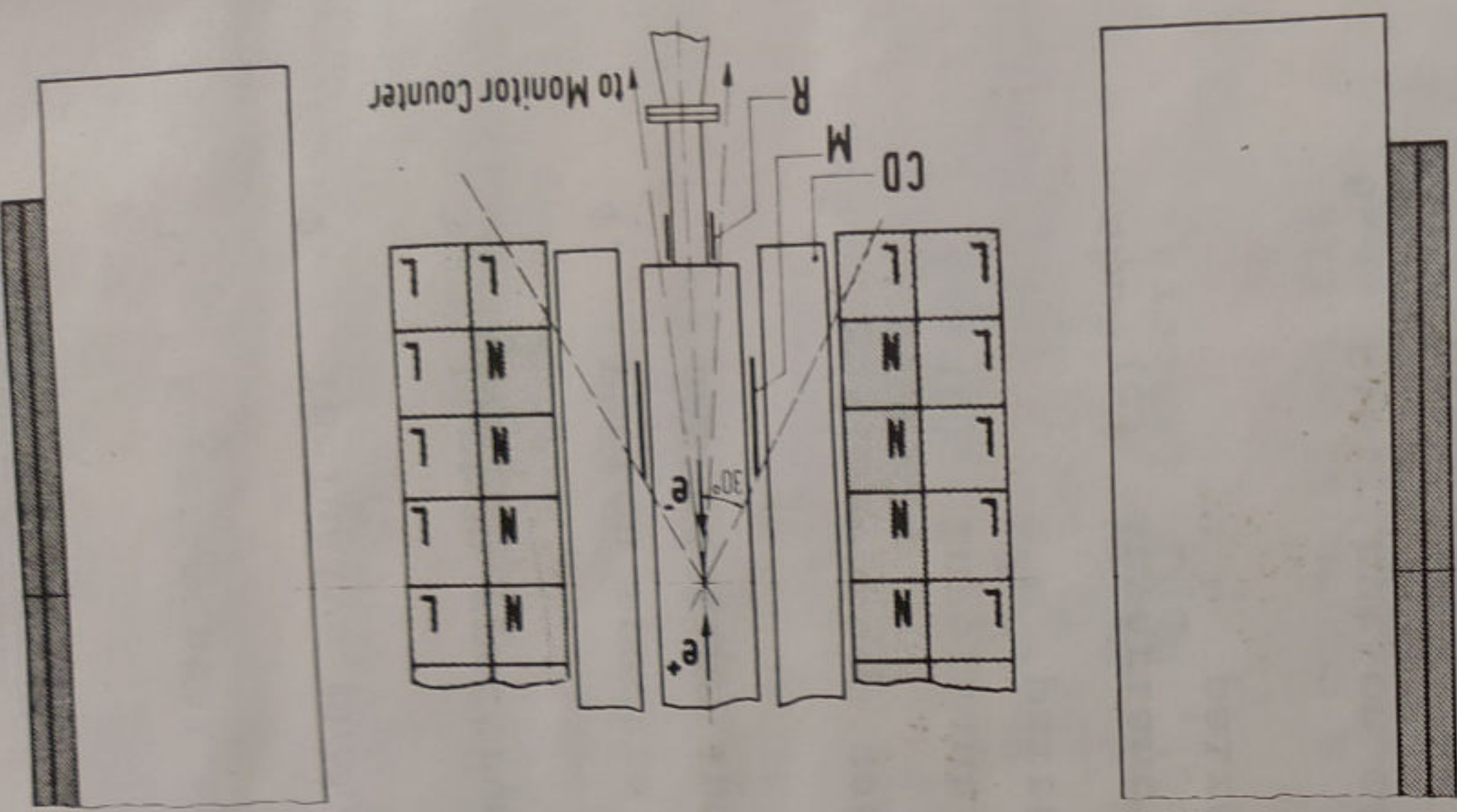
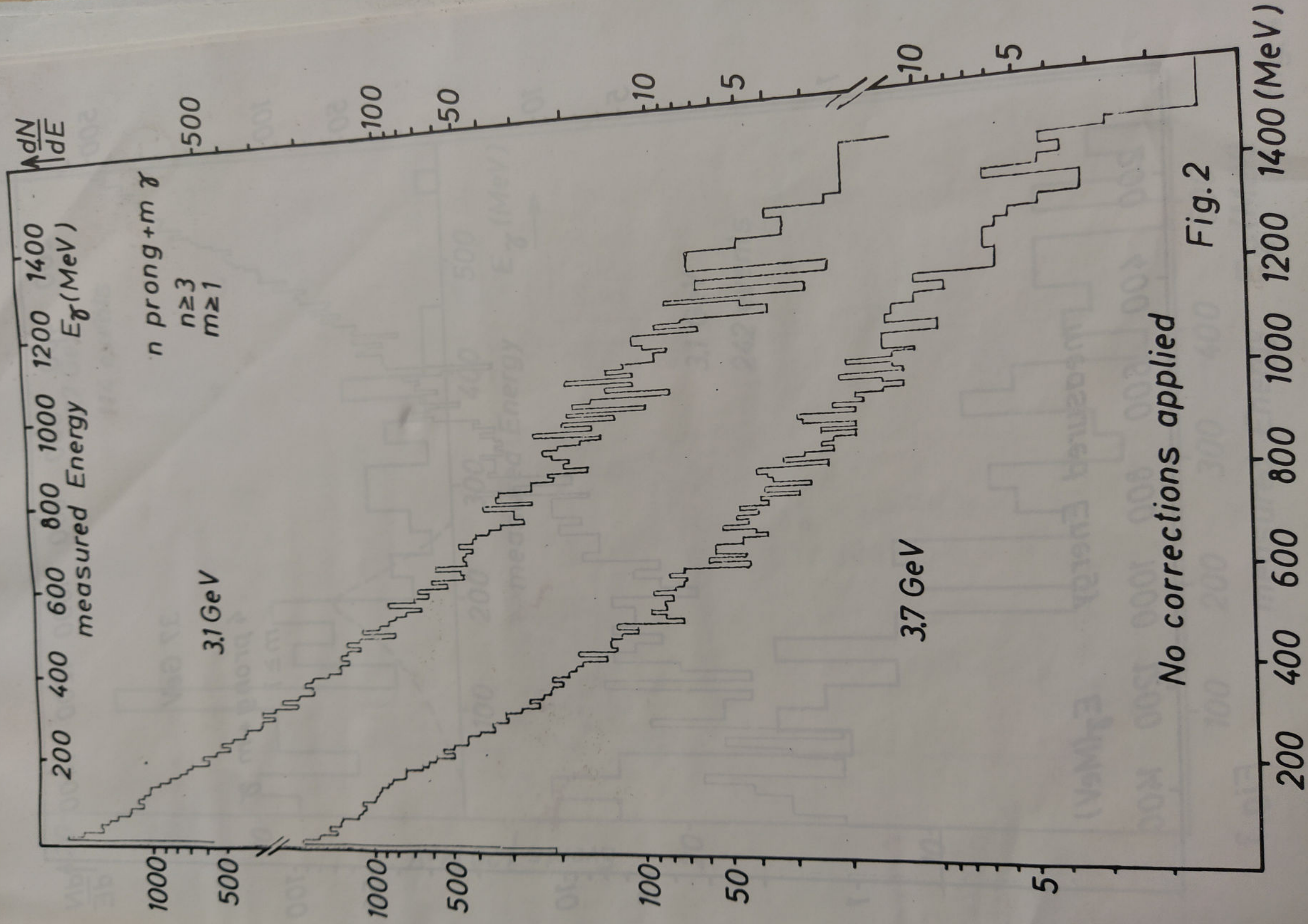


Fig. 1



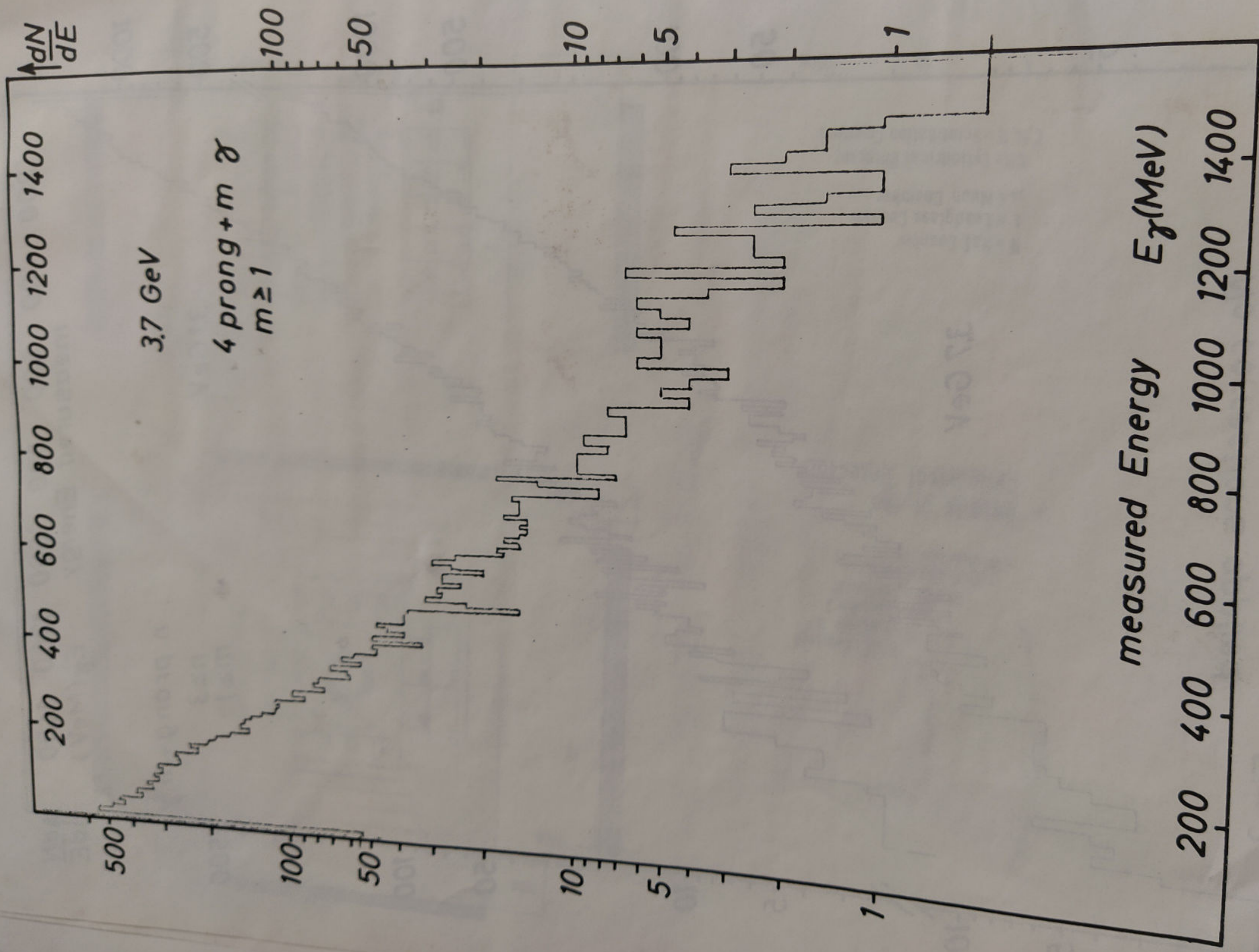
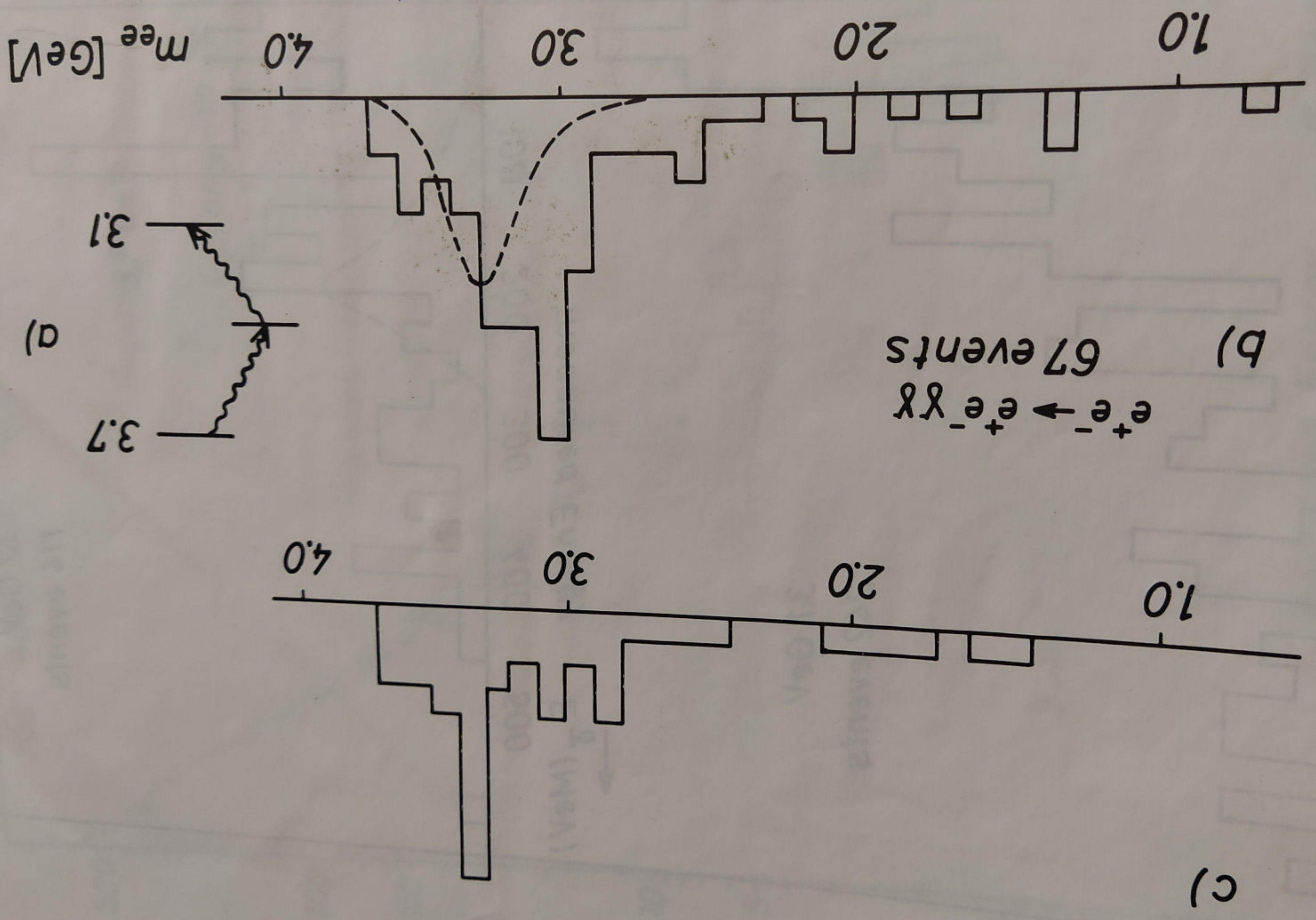
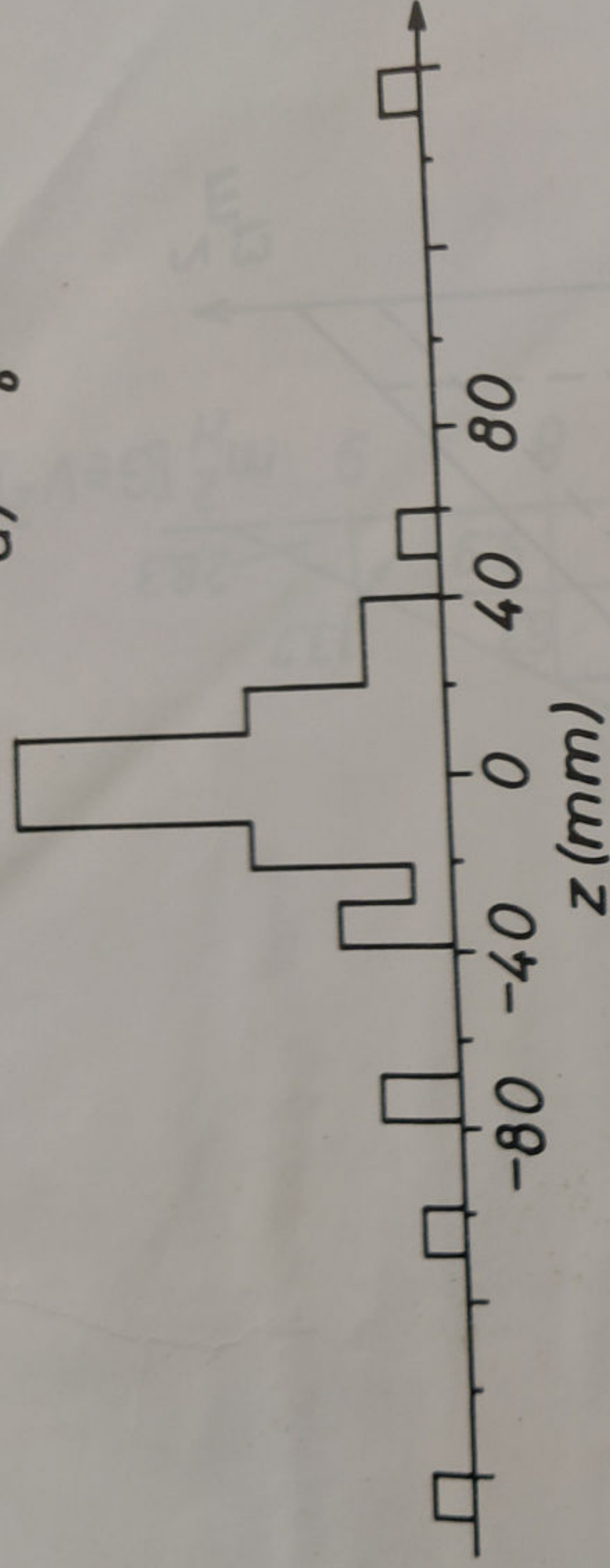


Fig.3

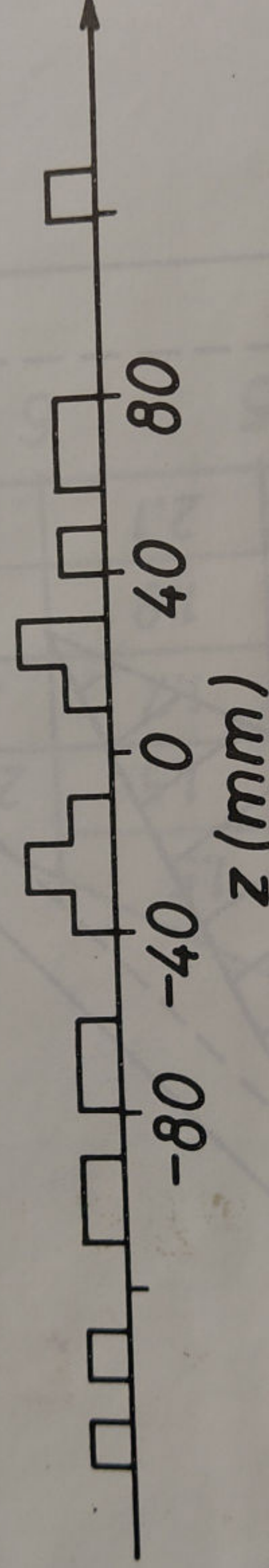
Fig. 5



a) 3γ -events



b) 4γ seen
(1γ ignored)



c) $e^+e^- \rightarrow \gamma\gamma$

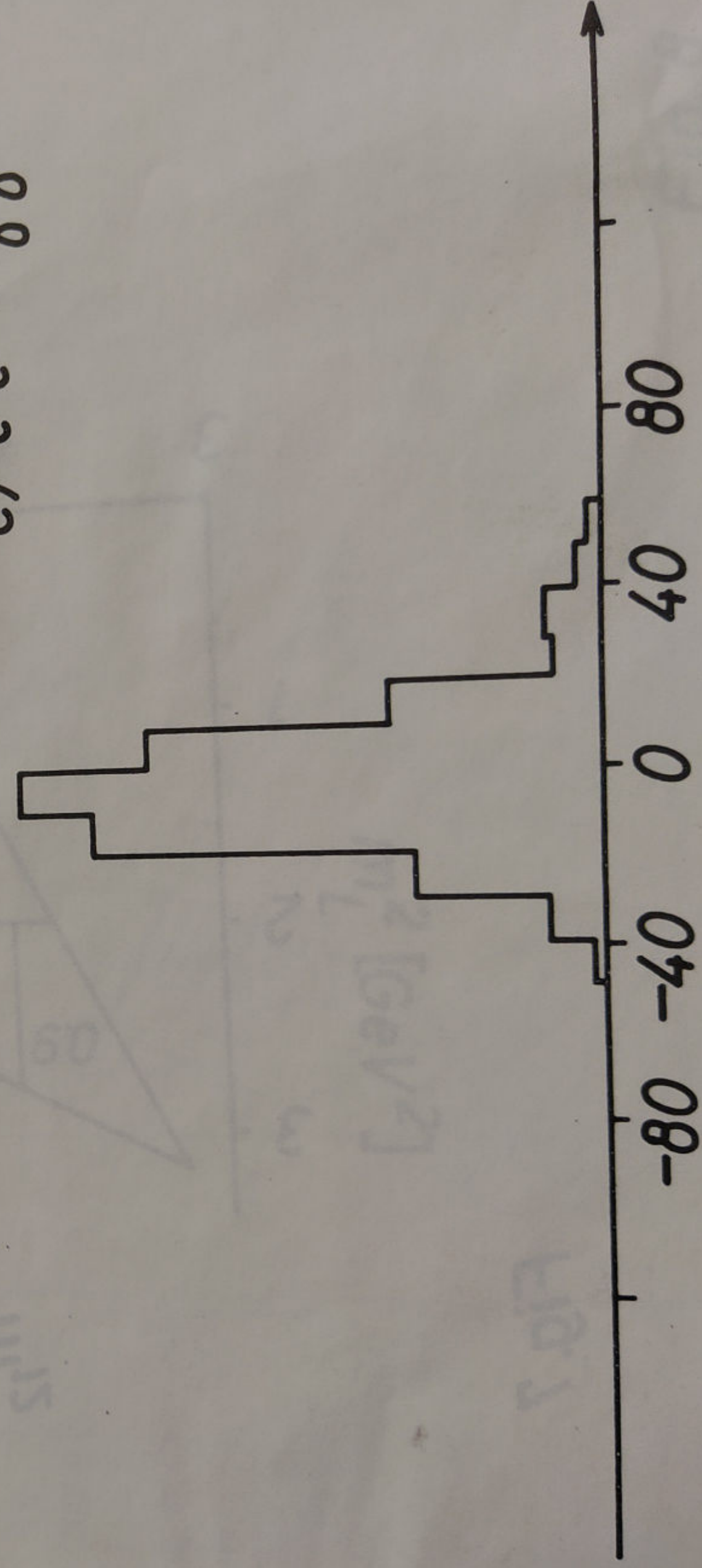


Fig. 6

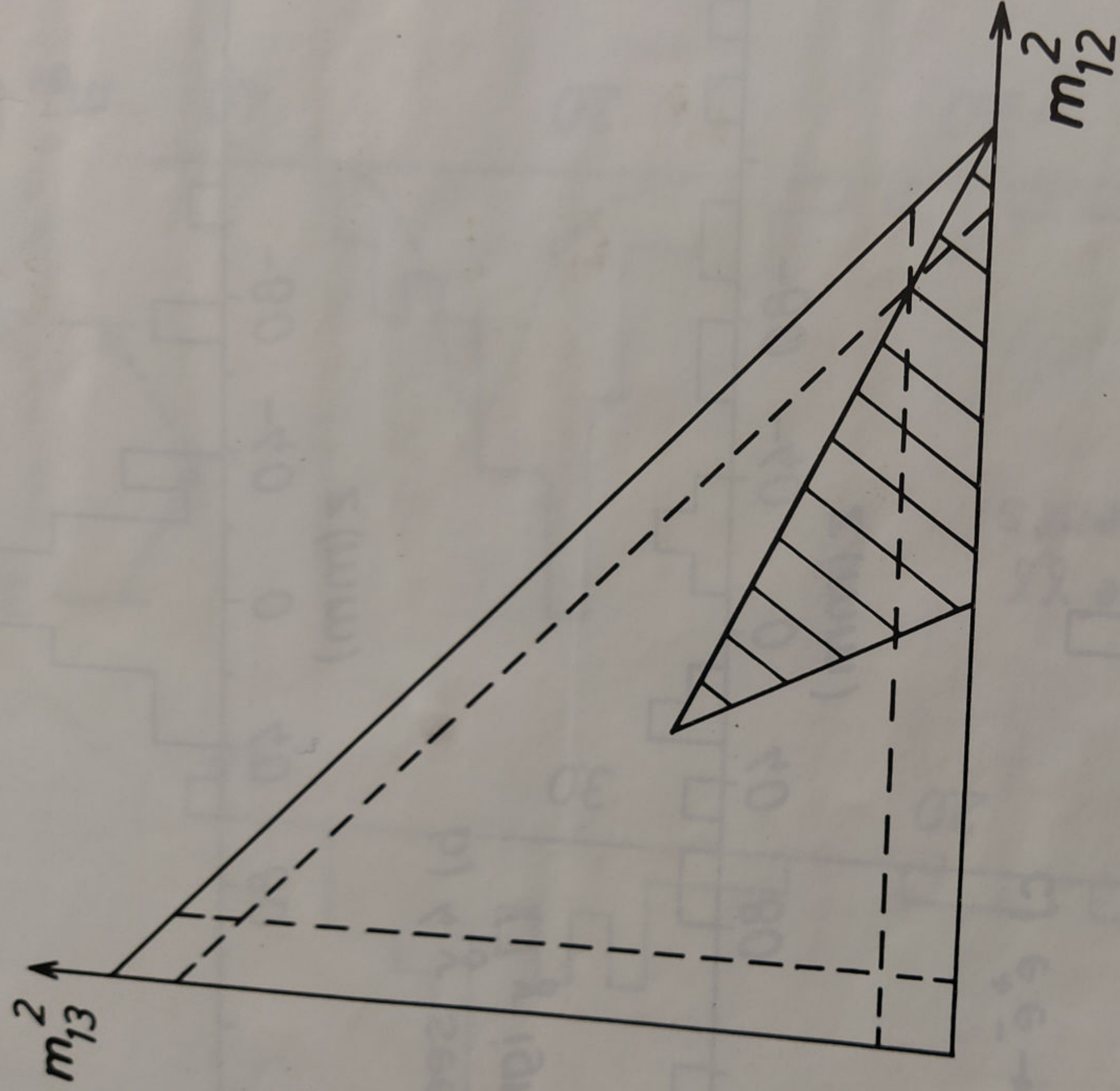


Fig. 7

Fig. 8

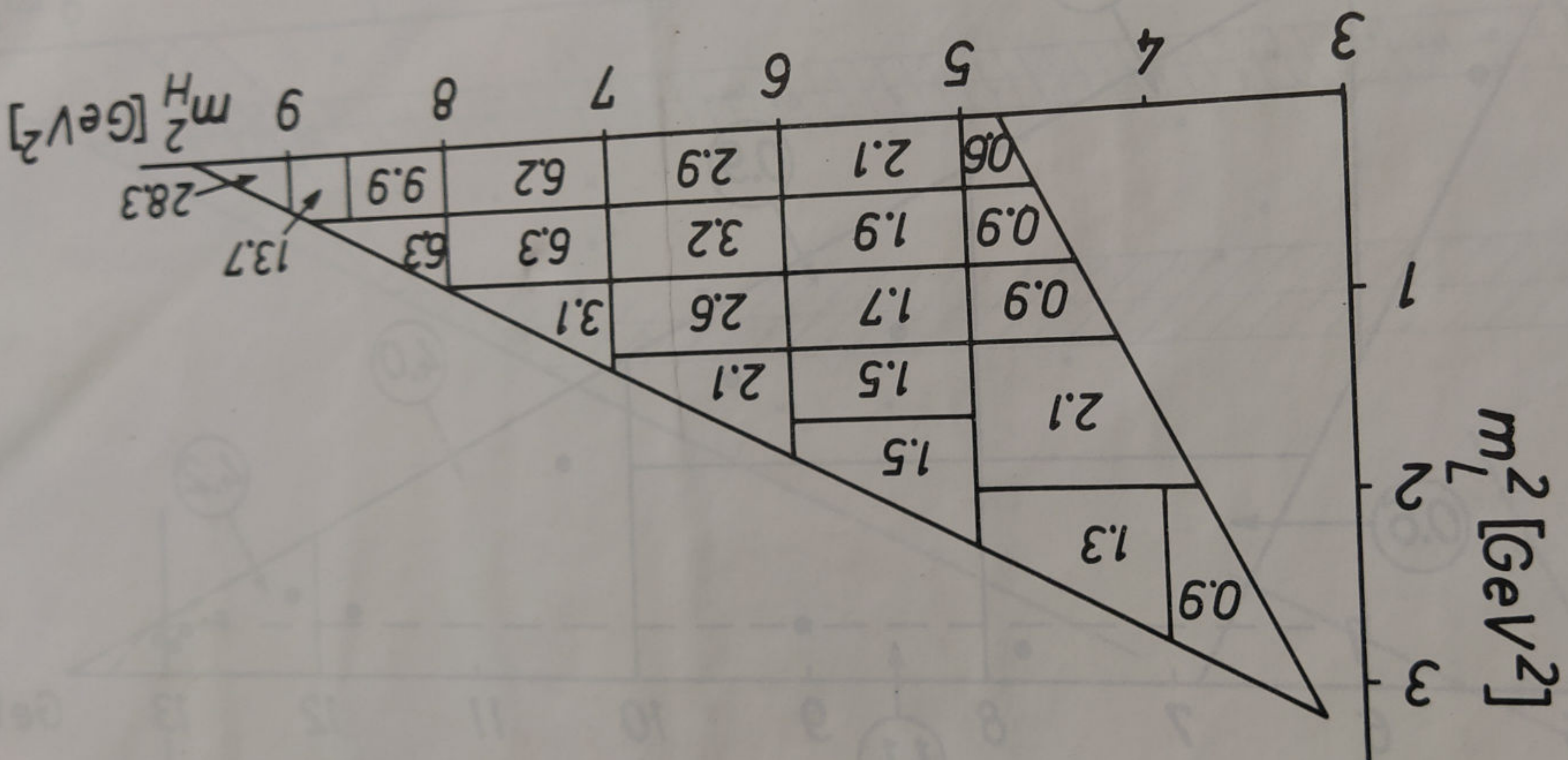
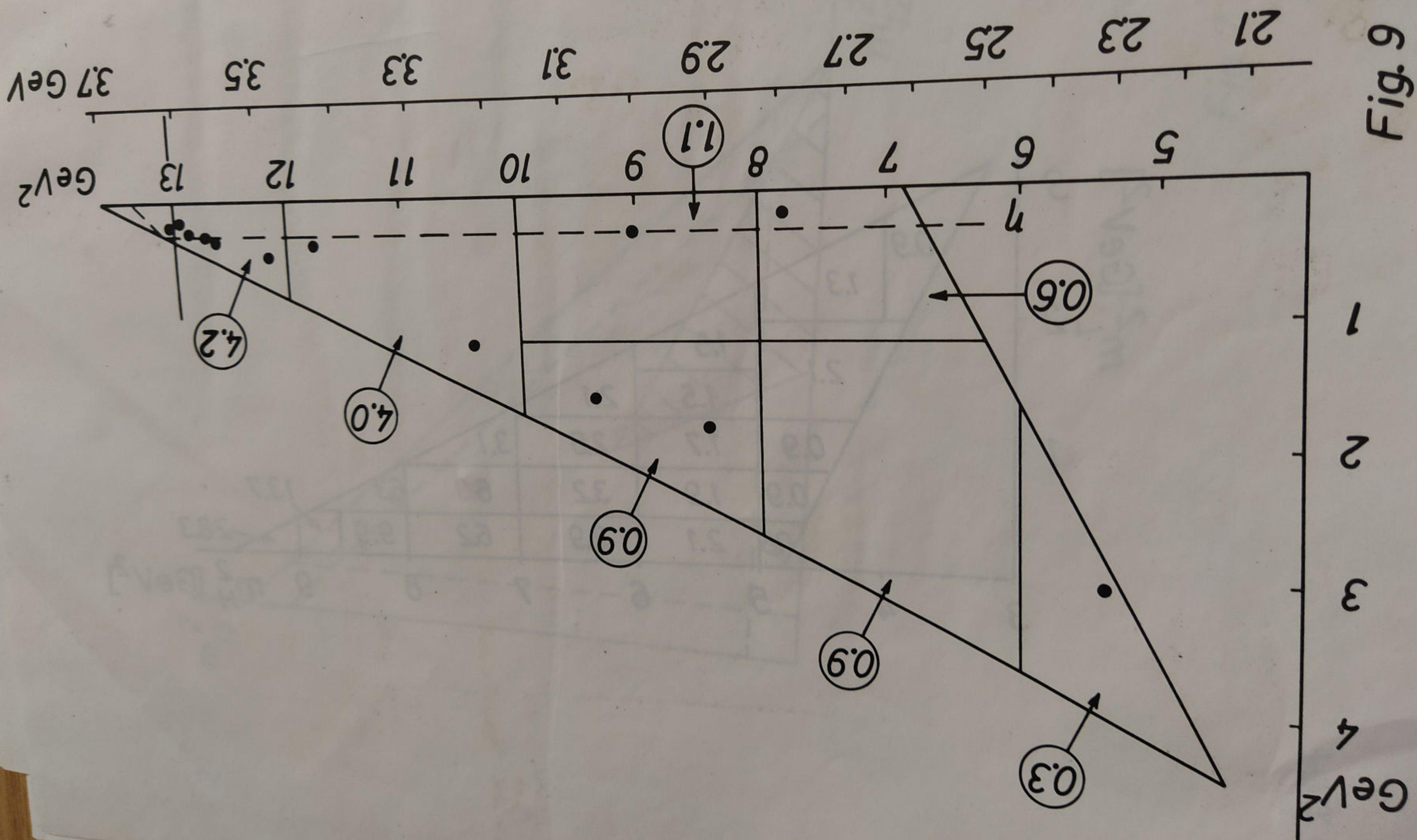


Fig. 9

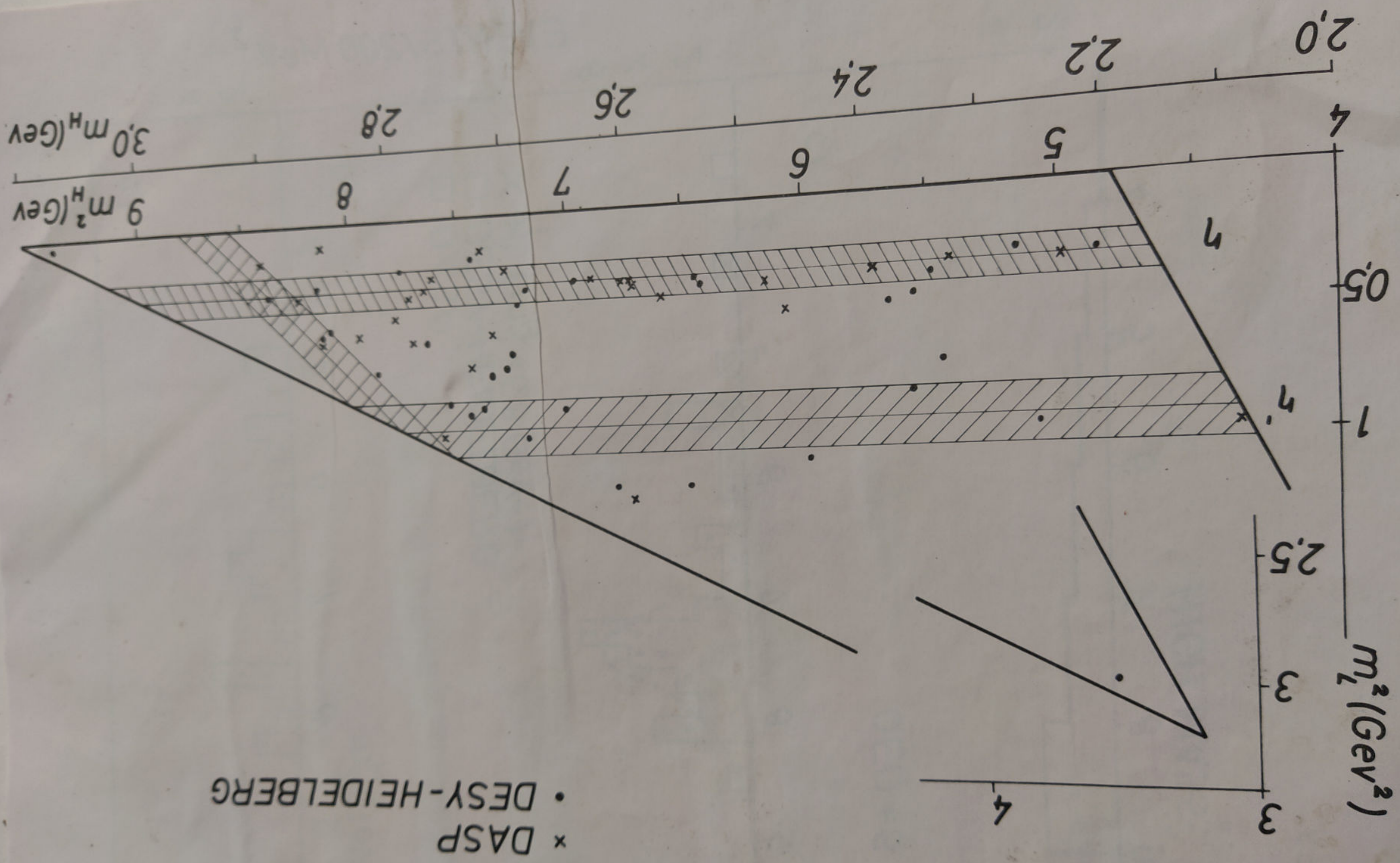


H.O. Munk 26/7/82

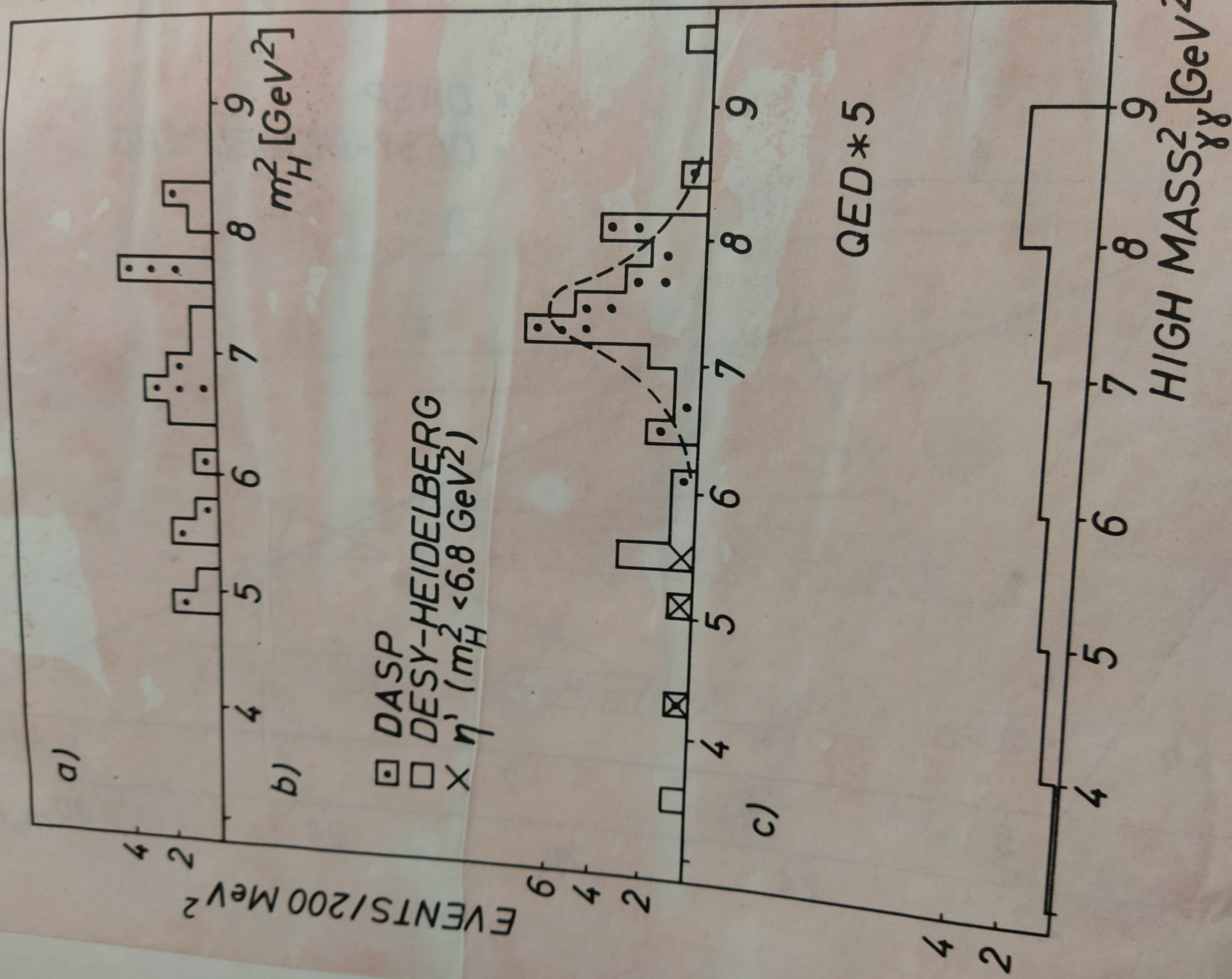
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Fig 10



x DASP
• DESY-HEIDELBERG



Anmerkung zu Seit 4, Zeile 9 bis Zeile 12:

$$w(1) = (1-Q) \left[A_{11} - P(A_{12} + \frac{Q}{\eta_{qk}} A_{13}) - \binom{P}{2} (A_{14} - \frac{Q}{\eta_{qk}} A_{15}) \right] + \mathcal{R} Q \eta_{qk} A_{16}$$

$$\text{und } w(2) = (q-1)A_{21} + (1-P)A_{22} + \binom{P}{2} \left[A_{23} - q \eta_{qk} A_{25}^{(1+A_{24}(1+q_x))^{-1}} \right] + \mathcal{R} (A_{26} + q \eta_{qk}^2 A_{31}) + \binom{Q}{3} \eta_{qk} A_{32} + \binom{P}{3} \left\{ \frac{Q}{3-q} A_{33} (q_x - (-1)^q) + \right.$$

$$\left. + \frac{e(P-Q)\eta^{(q-1)q/4}}{8-A_{66}q(q-1)} \left(1 - \frac{q}{\eta_{qk}} (2-q)A_{34} \right) \frac{1-q_x A_{35}}{\eta_{qk}} - A_{36} \right\}$$

in $\int w_{yx} = [w(1)]^{2-k} + [w(2)]^{k-1}$ können für einzelne Quantenzah-

lensätze bei $k=1$ zu $w(2)=0$ oder bei $k=2$ zu $w(1)=0$ werden, was zu uneigentlichen Termen 0^0 führt, die aber als Strukturpotenzanteile stets den Wert 1 haben müssen. Aus diesem Grunde ist es bei der Programmierung zu empfehlen, $w(1)$ und $w(2)$ durch die numerisch nicht relevanten Summanden $k-1$ und $2-k$ zu ergänzen. Da stets $w(1) \neq -1$ und $w(2) \neq -1$ bleiben, aber nur $k=1$ oder $k=2$ möglich ist, erscheinen in der

Fassung

$$w_{yx}(k) = [k-1+w(1)]^{2-k} + [2-k+w(2)]^{k-1}$$

die uneigentlichen Terme nicht mehr. Für mesonische Strukturen wird $w_{yx}(k=1)=1+w(1)$ und für barionische Strukturen $w_{yx}(k=2)=1+w(2)$ nach dieser Korrektur sofort deutlich.

$N=0$ oder $N \geq 2$ die rechte Seite $W_{yx}(1+f(N))=W_1$ numerisch bestimmen. Nach der Auswahlregel die maximale Kubikzahl K_1' feststellen, deren Produkt mit α_1 noch in W_1 enthalten ist.

Dann $W_1 - \alpha_1 K_1' = W_2' > 0$ einsetzen in $(n_2 + Q_2)' \alpha_2 + (n_3 + Q_3) \alpha_3 + \exp(\frac{1-2k}{3Q_4})(n_4 + Q_4) = W_2$. Jetzt maximale Quadratzahl K_2' derart, daß $\alpha_2 K_2'$ noch in W_2 enthalten ist, also $W_2 - \alpha_2 K_2' = W_3' \geq 0$. Ganz entsprechend in $(n_3 + Q_3) \alpha_3 + \exp(\frac{1-2k}{3Q_4})(n_4 + Q_4) = W_3$ maximale Zahl K_3 im Sinne $W_3 - \alpha_3 K_3 = W_4' \geq 0$ bestimmen. Für W_4 drei Möglichkeiten: (a) $W_4 = 0$, (b) $0 < W_4 \leq 1$, (c) $W_4 > 1$. Allgemeiner Fall (b): $\ln W_4 \leq 0$ und

$K_4((2k-1) - 3Q_4 \ln W_4)$. Im Fall (c) ist $\ln W_4 > 0$ und $K_4 < 0$. Dies ist unmöglich weil stets $n_j + Q_j \geq 0$ bleiben muß. Wegen $n_4 + Q_4 \leq (n_3 + Q_3) \alpha_3$ des Anstiegsprinzips wird dann K_3 um 1 vermindert und $\alpha_3 K_3$ zu $K_4 < 0$ addiert, so daß ein neuer Wert $K_4 > 0$ entsteht. Im Fall (a) hätte $W_4 \rightarrow 0$ die Divergenz $K_4 \rightarrow \infty$ zur Folge doch ist dies wegen $K_4 \leq \alpha_3 K_3$ unmöglich (zumal es divergierende Selbstenergiepotentiale nicht gibt). Aus diesem Grunde wird im Fall (a) der maximale Wert $K_4 = \alpha_3 K_3$ berechnet. Aus den ermittelten K_j folgt $n_j = K_j - Q_j$. Es ist zwar neben $n_j > 0$ auch $n_j < 0$ möglich, doch gilt stets $K_j \geq 0$, also $n_j \geq -Q_j$.

Die so ermittelte Quadrupel n_j wird mit ϕ_{yx} in das Massenspektrum eingesetzt, was numerisch $M_N(yx)$ als Spektralterm des Massenspektrums zu x_{yx} liefert.

Vermerk: Die K_j sind stets ganzzahlig. Im Fall der Bestimmung von K_4 treten jedoch regelmäßig Dezimalstellen auf. Im Fall der Dezimalstellen ,99...99 muss die Identität ,99...99 = 1 verwendet werden. Ist dagegen die Folge der Dezimalstellen von diesem Wert verschieden, dann darf nicht aufgerundet werden. Die Dezimalstellen sind abzuschneiden, weil die K_j die Anzahlen von Strukturentitäten sind.

* was $K_3 > 0$ voraussetzt; denn im Fall $K_3 = 0$ kann diese Dilatation wegen des quadratischen Anstieges von $j=2$ nicht erfolgen, so daß diese Resonanzordnung N für x_{yx} nicht existiert (verbotener Term).

- 7 -

Grenzen der Resonanzspektren:

Allgemeines Bauprinzip der Konfigurationszonen $n_4 + Q_4 \leq (n_3 + Q_3) \alpha_3$,
 $\alpha_3(n_3 + Q_3)(1 + n_3 + Q_3) \leq 2\alpha_2(n_2 + Q_2)^2$, $\alpha_2(n_2 + Q_2)[2(n_2 + Q_2)^2 +$
 $+ 3(n_2 + Q_2) + 1] \leq 6\alpha_1(n_1 + Q_1)^3$. Wird durch den Anstieg N zwischen
zwei Zonen die Gleichheit erreicht, dann $n_j + Q_j \rightarrow 0$ in j ,
während $j-1$ um die Ziffer 1 auf $n_{j-1} + Q_{j-1} + 1$ angehoben
wird. Anregung erfolgt also „von Außen nach Innen“. Stets
 $n_j + Q_j = 0$ ganzzahlig, da Anzahl von Strukturentitäten. Leerraum-
bedingung $n_j = -Q_j$ (n_j)_{max} = $L_j < \infty$ (keine divergierenden Selbst-
energiepotentiale). Intervalle $-Q_j \leq n_j \leq L_j < \infty$ bedingen
 $0 \leq N \leq L < \infty$ der Resonanzordnung. Mit $M_0(x) = M_0$ gilt
 $4\mu\alpha_1 \alpha_1(L_1 + Q_1)^3 = (2(P+1))^{2-k} M_0$ und $G = k+1$ nach dem Bauprinzip
 $\alpha_2(L_2 + Q_2)[2(L_2 + Q_2)^2 + 3(L_2 + Q_2) + 1] = 6\alpha_1(L_1 + Q_1)^3$, $\alpha_3(L_3 + Q_3)(1 +$
 $+ L_3 + Q_3) = 2\alpha_2(L_2 + Q_2)^2$, $L_4 + Q_4 = \alpha_3(L_3 + Q_3)$. Implizit gilt für L
der Resonanzordnungen $\alpha_1(L_1 + Q_1)^3 + \alpha_2(L_2 + Q_2)^2 + \alpha_3(L_3 + Q_3) +$
 $+ \exp(\frac{1-2k}{3Q_4}(L_4 + Q_4)) = W_x(1+f(L))$. Auch bei der Bestimmung von L_j

und L nicht aufrunden, sondern Dezimalstellen abschneiden!
Die aus dem Bauprinzip gewonnenen L_j liefern die absoluten
Maximalmassen $M_{\max}$, aber die aus den L ermittelten Quadru-
peln die realen Grenzterme $M_L < M_{\max}$, die jedoch mit $(M_{\max} - M_L)c^2$
sekundär anregbar sind und dann die $M_{\max}$ erreichen.

NORTHEIM den 25.2.1982

Schillerstraße 2

(Heim)

Verteilt an: Deutsches Elektronen-Synchrotron Hamburg

Eidgenössische technische Hochschule Zürich

Messerschmitt-Bölkow-Blohm GMBH München

Max-Planck-Institut für theoretische Phys. München

Dr. G. Ende, Dr. Kroy, Dipl.-Phys. I.v. Ludwiger

Staatsanwalt G. Seifkow und H. Trosiner.


```

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15:00:40 IAT2000 JOB 1286 F15HDS99 SELECTED AA GRP=MITTEL
//F15HDS99 JOB '10212215,GMAIN',HDSCHULZ,CLASS=K,MSGLEVEL=(0,0), *
// MSGCLASS=T,NOTIFY=F15HDS
1 //F15HDS99 JOB '10212215,GMAIN',HDSCHULZ,CLASS=K,MSGLEVEL=(0,0), *
// MSGCLASS=T,NOTIFY=F15HDS
STMT NO. MESSAGE
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22 IEF686I DDNAME REFERRED TO ON DDNAME KEYWORD IN PRIOR STEP WAS NOT RESOLVED
23 IEF648I INVALID DISP FIELD- PASS SUBSTITUTED
IEF142I F15HDS99 FORT - STEP WAS EXECUTED - COND CODE 0000
IEF373I STEP /FORT / START 82205.1500
IEF374I STEP /FORT / STOP 82205.1501 CPU OMIN 01.70SEC SRB OMIN 00.08SEC VIRT 664K SYS 196K
IEF142I F15HDS99 LKED - STEP WAS EXECUTED - COND CODE 0000
IEF373I STEP /LKED / START 82205.1501
IEF374I STEP /LKED / STOP 82205.1501 CPU OMIN 00.74SEC SRB OMIN 00.22SEC VIRT 304K SYS 172K
IEF142I F15HDS99 GO - STEP WAS EXECUTED - COND CODE 0000
IEF373I STEP /GO / START 82205.1501
IEF374I STEP /GO / STOP 82205.1503 CPU OMIN 47.60SEC SRB OMIN 10.82SEC VIRT 72K SYS 180K
IEF375I JOB /F15HDS99/ START 82205.1500
IEF376I JOB /F15HDS99/ STOP 82205.1503 CPU OMIN 50.04SEC SRB OMIN 11.12SEC

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*VERSION 1.3.0 (01 MAY 80) SYSTEM/370 FORTRAN H EXTENDED (ENHANCED) DATE 82.205/15.00.44 PAGE 1
 REQUESTED OPTIONS: NODECK,NOLIST,OPT(0)
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 SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF ALC NOANSF TERM IBM FLAG(1)

	C	17/03/82 207241459	MEMBER NAME GPROG (HEIMS)	FORTTRAN	00000000
	C----	PROGRAM READS AS INPUT	(BARYON NUMBER +1) = K		00000100
	C----		2 * ISOSPIN = PG		00000200
	C----		2 * SPIN = QG		00000300
	C----		DUBLETT FACTOR = KAPPA		00000400
ISN 0002		IMPLICIT REAL*16 (A-H,J-Z)			00000500
ISN 0003		DIMENSION T1(5),T2(5),T3(5),T4(5)			00000600
ISN 0004		COMMON /CONST/ PI,HQ,C,GAM,RG,S0,FAKMEV,ETA,THETA,EQ,ALFA,AMU,			00000700
		*ALFP,ALFM,XI,EBN,BETA,IPRINT			00000800
ISN 0005		COMMON /QUANT/ N,K,PG,QG,KQ,KAPPA,N1,N2,N3,N4,CS,IK,IPG,IQG,			00000900
		*IKAPPA,EPS,QX,IN,IN1,IN2,IN3,IN4,ICS,IEPS,IQX,IX,IKQ,X,			00001000
		*IK1,IK2,IK3,IK4			00001010
ISN 0006		COMMON /EXCHA/ WGX,AGX,BGX,ALF1,ALF2,ALF3,FN,Q1,Q2,Q3,Q4,			00001020
		*AN1,AN2,AN3,FIG,GKQ,WGXX,AN,AQ,KGH,			00001030
		*IQ1,IQ2,IQ3,IQ4			00001040
	C----	READ IPRINT			00001041
ISN 0007		READ(5,900) TEXT,IPRINT			00001050
ISN 0008	900	FORMAT(A16,I3)			00001060
ISN 0009		WRITE(6,901) TEXT,IPRINT			00001070
ISN 0010	901	FORMAT(1X,A16,I3)			00001080
ISN 0011		CALL GINIT			00001100
ISN 0012		READ(5,400) IJA,IJE			00001110
ISN 0013	400	FORMAT(2I5)			00001120
ISN 0014		DO 4 IJ=IJA,IJE			00001130
ISN 0015		READ(5,100) TEXT,T1,IK,T2,IPG,T3,IQG,T4,IKAPPA			00001200
ISN 0016	100	FORMAT(A16/,3(5A4,I2/),5A4,I2)			00001300
ISN 0017		WRITE(6,200) TEXT,T1,IK,T2,IPG,T3,IQG,T4,IKAPPA			00001400
ISN 0018	200	FORMAT(1X,A16/,4(1X,5A4,I2/))			00001500
ISN 0019		K=QFLOAT(IK)			00001600
ISN 0020		PG=QFLOAT(IPG)			00001700
ISN 0021		QG=QFLOAT(IQG)			00001800
ISN 0022		KAPPA=QFLOAT(IKAPPA)			00001900
	C----	DEFINE PARTICLE -ANTIPARTICLE -> EPS			00002000
ISN 0023		DO 1 IEPSI=1,1			00002100
ISN 0024		IEPS=-(-1)**IEPSI			00002200
ISN 0025		EPS=QFLOAT(IEPS)			00002300
	C----	COMPUTATION OF STRANGENESS			00002400
	C----	(1-3)			00002500
ISN 0026		ITEMP1=IQG*(IKAPPA+IBINOM(IPG,2))			00002600
ISN 0027		IEPSP=IEPS*(-1)**MOD(ITEMP1,2)			00002700
	C----	(1-4)			00002800
ISN 0028		ITEMP2=IQG*(IQG*(IK-1)+IBINOM(IPG,2))			00002900
ISN 0029		IEPSQ=IEPS*(-1)**MOD(ITEMP2,2)			00003000
	C----	(1-1)			00003100
ISN 0030		ICS=2/(IK*(1+IKAPPA))*(IPG*IEPSP+IQG*IEPSQ)*(IK-1+IKAPPA)			00003200
ISN 0031		CS=QFLOAT(ICS)			00003300
	C----	DEFINE ISO MULTIPLETT COMPONENT			00003400
ISN 0032		IXE=IPG+1			00003500
ISN 0033		DO 2 IX=1,IXE			00003600
	C----	(1-5) F(K,PG,QG,KAPPA,EPS) INTEGER			00003700
ISN 0034		X=QFLOAT(IX)			00003800
ISN 0035		IQX=((IPG+2-2*IX)*(1-IKAPPA*IQG*(2-IK))+ICS+IEPS*(IK-1-(1+IKAPPA))			00003900
		**IQG*(2-IX)))/2			00004000
ISN 0036		QX=QFLOAT(IQX)			00004100
	C----	COMPUTE CHARGE KQ			00004200


```

ISN 0037      IKQ=IABS(IQX)
ISN 0038      KQ=QABS(QX)
C----- TEST PRINT
ISN 0039      IF(IPRINT.GE.1) WRITE(6,101) IEPS,IEPSP,IEPSQ,ICS,IKQ,IX,IQX
ISN 0041      101 FORMAT(1X,'=====')
ISN 0042      *===== '/1X,' EPS EPPSP EPSQ CS KQ X QX' /1X,7I5)
ISN 0043      CALL GBASE
ISN 0044      C----- DEFINE EXCITATION LEVEL N
ISN 0045      ILE=5
ISN 0046      INIE=100
ISN 0047      DO 3 INI=1,INIE
ISN 0049      IF(IN.EQ.INIE-1) IN=ILE
ISN 0051      C----- SKIP OVER N = 1, OTHERWISE FN BECOMES IMAGINARY
ISN 0052      C---- HERE THE RESONANCE LIMIT 'ILE' CAN BE COMPUTED
ISN 0053      IF(IN.EQ.1) GOTO 5
ISN 0054      N=QFLOAT(IN)
ISN 0055      103 FORMAT(1X,'-----')
ISN 0056      102 IF(IPRINT.GE.2) WRITE(6,102) IN
ISN 0057      FORMAT(1X,' N = ',I5)
ISN 0058      CALL GSTRUC
ISN 0059      CALL GMASS(AM)
ISN 0060      C----- PRINT OUTPUT
ISN 0061      300 WRITE(6,300) ICS,IKQ,IEPS,IQX,IN,AM
ISN 0062      * /1X,5I5,Q17.8)
ISN 0064      GOTO 3
ISN 0065      C----- COMPUTE THE RESONANCE LIMITS
ISN 0066      5 IF((IQG*(2-IK)*(1-IKAPPA)).EQ.1) GOTO 8
ISN 0067      IL1=IQINT((QFLOAT((2*(IPG+1))*((2-IK)*(IK+1))/(4.Q0*ALF1)*
ISN 0068      *(KGH+FIG))*((1.Q0/3.Q0)-Q1)
ISN 0069      A1=1.5Q0
ISN 0070      A2=0.5Q0
ISN 0071      A3=-3.Q0*ALF1/ALF2*(QFLOAT(IL1+IQ1)**3)
ISN 0072      QA=(3.Q0*A2-A1**2)/9.Q0
ISN 0073      RA=(9.Q0*A1*A2-27.Q0*A3-2.Q0*A1**3)/54.Q0
ISN 0074      DA=QSQRT(QA**3+RA**2)
ISN 0075      SA=(RA+DA)**(1.Q0/3.Q0)
ISN 0076      TA=(RA-DA)**(1.Q0/3.Q0)
ISN 0077      IL2=IQINT(SA+TA-A1/3.Q0-Q2)
ISN 0078      IL3=IQINT(QSQRT(2.Q0*ALF2/ALF3*QFLOAT(IL2+IQ2)**2+0.25Q0)-0.5Q0
ISN 0079      *-Q3)
ISN 0080      IL4=IQINT(ALF3*QFLOAT(IL3+IQ3)-Q4)
ISN 0081      C----- (7-2) DETERMINE MAXIMUM N = ILE
ISN 0082      TEMP1=(ALF1*QFLOAT((IL1+IQ1)**3)+ALF2*QFLOAT((IL2+IQ2)**2)+
ISN 0083      *ALF3*QFLOAT(IL3+IQ3)+QEXP(QFLOAT((1-2*IK)*(IL4+IQ4))/(3.Q0*Q4)))/
ISN 0084      *WGX-1.Q0
ISN 0085      TEMP2=QFLOAT(1-IQG*(2-IK)*(1-IKAPPA))
ISN 0086      DO 6 ILS=1,50000
ISN 0087      ILT=ILS-1
ISN 0088      IF(ILT.EQ.1) GOTO 6
ISN 0089      LT=QFLOAT(ILT)
ISN 0090      FT=TEMP2*(AGX*LT/(LT+2.Q0)+BGX*QSQRT(QFLOAT(ILT*(ILT-2))))
ISN 0091      IF(FT.LE.TEMP1) GOTO 6
ISN 0092      ILE=ILT-1
ISN 0093      GOTO 7
ISN 0094      6 CONTINUE
ISN 0095      C----- PRINT MAXIMUM PARAMETER

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ISN 0076
ISN 0077
ISN 0078
ISN 0079
ISN 0080
ISN 0082
ISN 0083
ISN 0084
ISN 0086
ISN 0087
ISN 0088

```
TEMP1=(ALF1*QFLOAT((IL1+IQ1)**3)+ALF2*QFLOAT((IL2+IQ2)**2)+  
*ALF3*QFLOAT(IL3+IQ3)+QEXP(QFLOAT((1-2*IK)*(IL4+IQ4))/(3*Q0*Q4)))/  
*WGX-1.00  
TEMP2=QFLOAT(1-IQG*(2-IK)*(1-1KAPPA))  
DO 6 ILS=1,50000  
ILT=ILS-1  
IF (ILT.EQ.1) GOTO 6  
LT=QFLOAT(ILT)  
FT=TEMP2*(AGX*LT/(LT+2.Q0)+BGX*QSQRT(QFLOAT(ILT*(ILT-2))))  
IF (FT.LE.TEMP1) GOTO 6  
ILE=ILT-1  
GOTO 7  
6 CONTINUE  
C----- PRINT MAXIMUM PARAMETER
```

00006280
00006290
00006291
00006292
00006294
00006295
00006296
00006298
00006299
00006300
00006301
00006302
00006304
00006305

```
*VERSION 1.3.0 (01 MAY 80) MAIN SYSTEM/370 FORTRAN H EXTENDED (ENHANCED) DATE 82.205/15.00.44 PAGE 3  
ISN 0089 7 WRITE(6,500) ILE,IL1,IL2,IL3,IL4 00006306  
ISN 0090 500 FORMAT(1X,' ILE IL1 IL2 IL3 IL4 /1X,5I5) 00006308  
ISN 0091 IF (IPRINT.GE.2) WRITE(6,600) A1,A2,A3,QA,RA,DA,SA,TA,TEMP1,TEMP2,FT 00006309  
ISN 0093 600 FORMAT(1X,11Q11.3) 00006310  
ISN 0094 3 CONTINUE 00006317  
ISN 0095 GOTO 2 00006318  
C----- NO EXCITATION POSSIBLE 00006327  
ISN 0096 8 WRITE(6,700) 00006337  
ISN 0097 700 FORMAT(1X,'*** NO EXCITATION POSSIBLE ***') 00006347  
ISN 0098 2 CONTINUE 00006400  
ISN 0099 1 CONTINUE 00006500  
ISN 0100 WRITE(6,800) 00006501  
ISN 0101 800 FORMAT(1X,'*****') 00006502  
ISN 0102 4 CONTINUE 00006510  
ISN 0103 STOP 00006600  
ISN 0104 END 00006700  
*OPTIONS IN EFFECT*NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(MAX) AUTODBL(NONE)  
*OPTIONS IN EFFECT*SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF ALC NOANSF TERM IBM FLAG(1)  
*STATISTICS* SOURCE STATEMENTS = 103, PROGRAM SIZE = 5756, SUBPROGRAM NAME = MAIN  
*STATISTICS* NO DIAGNOSTICS GENERATED  
***** END OF COMPILE ***** 68K BYTES OF CORE NOT USED
```


*VERSION 1.3.0 (01 MAY 80)

REQUESTED OPTIONS: NODECK, NOLIST, OPT(0)

OPTIONS IN EFFECT:

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PAGE 1

NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(MAX) AUTODBL(NONE)
SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF ALC NOANSF TERM IBM FLAG(1)

ISN 0002

ISN 0003

ISN 0004

ISN 0005

ISN 0006

ISN 0007

ISN 0008

ISN 0009

ISN 0010

ISN 0011

ISN 0012

ISN 0013

ISN 0014

ISN 0015

ISN 0016

ISN 0017

ISN 0018

ISN 0019

ISN 0020

ISN 0021

ISN 0022

ISN 0023

ISN 0024

ISN 0025

```

C 17/03/82 207140922 MEMBER NAME GINIT (HEIMS)
SUBROUTINE GINIT
C----- INITIALISIERT KONSTANTE GROESSEN IM COMMON /CONST/
IMPLICIT REAL*16 (A-H,J-Z)
COMMON /CONST/ PI, HQ, C, GAM, RG, SO, FAKMEV, ETA, THETA, EQ, ALFA, AMU,
*ALFP, ALFM, XI, EBN, BETA, IPRINT
COMMON /PARMAT/ A11, A12, A13, A14, A15, A16, A21, A22, A23, A24, A25, A26,
*A31, A32, A33, A34, A35, A36, A41, A42, A43, A44, A45, A46,
*A51, A52, A53, A54, A55, A56, A61, A62, A63, A64, A65, A66
PI=3.1415926535Q0
EBN=QEXP(1.Q0)
HQ=1.0545887Q-34
C=2.99792458Q8
GAM=6.6732Q-11
RG=376.73037659Q0
SO=1.Q0
FAKMEV=0.05609545Q31
XI=1.61803399Q0
C----- (2B,2-1) # CONST
ETA=PI/(4.Q0+PI**4)**0.25Q0
C----- (2A,2-2) # CONST
THETA=5.Q0*ETA+2.Q0*QSQR(ETA)+1.Q0
C----- (2,2-5) F(CONST)
EQ=3.Q0/(4.Q0*PI**2)*QSQR(2.Q0*THETA*HQ/RG)
C----- (22)
ALFA=1.Q0/137.03602725Q0
C----- (2-6)
BETA=1.Q0/1.00001411Q0
C----- (3-1)
AMU=PI**0.25Q0*(3.Q0*PI*SO*GAM*HQ)**(1.Q0/3.Q0)*QSQR(C*HQ/(3.Q0*
*GAM)/(C*SO))
C----- (3-3) # CONST
TEMP1=1.Q0-2.Q0/3.Q0*XI*ETA**2*(1.Q0-QSQR(ETA))
ALFP=TEMP1/(ETA**2*ETA**2*(1.Q0/3.Q0))-1.Q0
ALFM=TEMP1/(ETA*ETA**2*(1.Q0/3.Q0))-1.Q0
C----- SCHREIBE DIE KONSTANTEN AUS
WRITE(6,100) PI, EBN, HQ, C, GAM, RG, SO, FAKMEV, ETA, THETA, EQ, ALFA, BETA,
*AMU, ALFP, ALFM, XI
100 FORMAT(1X, 'EINGEGEBENE KONSTANTEN: '/1X, '-----' /
*1X, 'PI = ', F12.8 /
*1X, 'BASIS OF NATURAL LOGARITHM: EBN = ', F12.8 /
*1X, 'PLANCK WIRKUNGSQUANTUM/(2*PI): HQ = ', Q14.8, ' (WS*S) ' /
*1X, 'LICHTGESCHWINDIGKEIT : C = ', Q14.8, ' (M/S) ' /
*1X, 'GRAVITATIONSKONSTANTE : GAM = ', Q14.8, ' (M**3*KG**-1*S**-00004000
*2) ' /
*1X, 'WELLENWIDERSTAND DES VAKUUMS: RG = ', F14.8, ' (OHM) ' /
*1X, 'EINHEITSSTRECKE: SO = ', F14.8, ' (M) ' //
*1X, 'ABGELEITETE KONSTANTE: '/1X, '-----' /
*1X, 'UMRECHNUNG KG - MEV: FAKMEV = ', Q14.8, ' (MEV/KG) ' /
*1X, 'ZAHLENFAKTOR: ETA = ', Q14.8 /
*1X, 'ZAHLENFAKTOR: THETA = ', Q14.8 /
*1X, 'ELEMENTARLADUNG: EQ = ', Q14.8, ' (A*S) ' /
*1X, 'FEINSTRUKTURKONSTANTE: ALFA = ', Q14.8 /
*1X, '"STARKE" KONSTANTE: BETA = ', Q14.8 /
*1X, 'MASSENFaktor: AMU = ', Q14.8, ' (KG) ' /

```

00000000
00000100
00000200
00000300
00000400
00000500
00000510
00000520
00000530
00000600
00000700
00000800
00000900
00001000
00001100
00001200
00001300
00001310
00001400
00001500
00001600
00001700
00001800
00001900
00002000
00002100
00002110
00002120
00002200
00002300
00002400
00002500
00002600
00002800
00002900
00003200
00003300
00003400
00003500
00003600
00003700
00003800
00003900
00004000
00004100
00004200
00004300
00004400
00004500
00004600
00004700
00004800
00004900
00004910
00005000

*VERSION 1.3.0 (01 MAY 80)

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```
*IX; *ZAHLENFAKTOR ALPHA PLUS: ALFP =, Q14.8/
*IX; *ZAHLENFAKTOR ALPHA MINUS: ALFM =, Q14.8/
*IX; *ZAHLENFAKTOR: XI =, Q14.8/

C----- (4-8) PARAMETER MATRIX REAL
A11=XI**2*(PI*EBN*XI)**2*(1.Q0-4.Q0*PI*ALFA**2)/(2.Q0*ETA**2)
A12=2.Q0*PI*EBN*XI**2*(THETA/8.Q0-PI*EBN*ETA*ALFA**2/3.Q0)/3.Q0
A13=3.Q0*(4.Q0+ETA*ALFA)*(1.Q0-ETA**2/5.Q0*((1.Q0-QSQRT(ETA))/
*(1.Q0+QSQRT(ETA)))**2)
A14=(1.Q0+3.Q0*ETA/(4.Q0*XI))*(2.Q0*ETA*ALFA-EBN**2*XI*
*((1.Q0-QSQRT(ETA))/(1.Q0+QSQRT(ETA)))**2)/ALFA
A15=EBN**2*(1.Q0-2.Q0*EBN*ALFA**2/ETA)/3.Q0
A16=(PI*EBN)**2*(1.Q0+ALFA/(5.Q0*ETA)*(1.Q0+6.Q0*ALFA/PI))
A21=2.Q0*(EBN*ALFA/(2.Q0*ETA))**2*(1.Q0-ALFA/(2.Q0*XI**2))
A22=XI*(1.Q0-XI*(ALFA*XI/ETA**2)**2)/12.Q0
A23=(ETA**2+6.Q0*XI*ALFA**2)/EBN
A24=2.Q0*XI**2/(3.Q0*ETA)
A25=XI*(PI*EBN)**2*(1.Q0-BETA**2)
A26=2.Q0*(1.Q0-PI/2.Q0*(EBN*XI*ALFA)**2*QSQRT(ETA))/(EBN*XI**2)

C----- (5-1) REAL
A31=(PI*EBN*ALFA)**2*(1.Q0-(PI*EBN)**2*(1.Q0-BETA**2))
A32=XI**2*(1.Q0+(2.Q0*EBN*ALFA/ETA)**2)/6.Q0
A33=(PI*EBN*XI*ALFA)**2*(1.Q0-2.Q0*PI*(EBN*XI)**2*(1.Q0-
*BETA**2))
A34=ETA*QSQRT(2.Q0*PI*ETA)
A35=3.Q0*ALFA/(EBN*XI**2)
A36=1.Q0/(1.Q0-PI*EBN*(XI*EBN)**2*(1.Q0-BETA**2))
A41=(XI*(2.Q0+(XI*ALFA)**2)-2.Q0*BETA)/(2.Q0*BETA-ALFA)
A42=PI*XI**2*ETA*(BETA-3.Q0*ALFA)/2.Q0
A43=XI/2.Q0
A44=2.Q0*(ETA/XI)**2
A45=(3.Q0*BETA-ALFA)/(6.Q0*XI)
A46=PI*EBN/(XI*ETA)-EBN*ETA**2*ALFA/2.Q0
A51=(2.Q0*ALFA+1.Q0)**2
A52=6.Q0*ALFA/ETA**2
A53=(XI/ETA)**3
A54=ALFA*(BETA-ALFA)*QSQRT(3.Q0/2.Q0)
A55=XI**3
A56=(XI/ETA)**4
A61=PI*XI*(2.Q0*BETA-ALFA)/(12.Q0*BETA)
A62=PI**2*(BETA-2.Q0*ALFA)/12.Q0
A63=QSQRT(ETA)/9.Q0
A64=PI/(3.Q0*ETA)
A65=PI/(3.Q0*XI)
A66=XI*ETA
WRITE(6,200) A11,A12,A13,A14,A15,A16,A21,A22,A23,A24,A25,A26,
*A31,A32,A33,A34,A35,A36,A41,A42,A43,A44,A45,A46,
*A51,A52,A53,A54,A55,A56,A61,A62,A63,A64,A65,A66
200 FORMAT(1X,'PARAMETER MATRIX'/(1X,6Q16.8/))
RETURN
END
```

```
*OPTIONS IN EFFECT*NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(MAX) AUTODBL(NONE)
*OPTIONS IN EFFECT*SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF ALC NOANSF TERM IBM FLAG(1)
*STATISTICS* SOURCE STATEMENTS = 64, PROGRAM SIZE = 8300, SUBPROGRAM NAME = GINIT
*STATISTICS* NO DIAGNOSTICS GENERATED
***** END OF COMPILATION *****
```

68K BYTES OF CORE NOT USED

DATE 82.205/15.00.52

*VERSION 1.3.0 (01 MAY 80)

SYSTEM/370 FORTRAN H EXTENDED (ENHANCED)

REQUESTED OPTIONS: NODECK, NOLIST, OPT(0)
 OPTIONS IN EFFECT: NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(MAX) AUTODBL(NONE)
 SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF ALC NOANSF TERM IBM FLAG(I)

```

C 17/03/82 207141003 MEMBER NAME GBASE (HEIMS) FORTRAN
ISN 0002 C----- SUBROUTINE GBASE
ROUTINE COMPUTES NUMBERS FOR THE GROUND LEVEL N=0
ISN 0003 IMPLICIT REAL*16 (A-H, J-Z)
ISN 0004 COMMON /CONST/ PI, HQ, C, GAM, RG, SO, FAKMEV, ETA, THETA, EQ, ALFA, AMU,
*ALFP, ALFM, XI, EBN, BETA, IPRINT
COMMON /QUANT/ N, K, PG, QG, KQ, KAPPA, N1, N2, N3, N4, CS, IK, IPG, IQG,
ISN 0005 *IKAPPA, EPS, QX, IN, IN1, IN2, IN3, IN4, ICS, IEPS, IQX, IX, IKQ, X,
*IK1, IK2, IK3, IK4
COMMON /EXCHA/ WGX, AGX, BGX, ALF1, ALF2, ALF3, FN, Q1, Q2, Q3, Q4,
ISN 0006 *AN1, AN2, AN3, FIG, GKQ, WGXK, AN, AQ, KGH,
*IQ1, IQ2, IQ3, IQ4
COMMON /PARMAT/ A11, A12, A13, A14, A15, A16, A21, A22, A23, A24, A25, A26,
ISN 0007 *A31, A32, A33, A34, A35, A36, A41, A42, A43, A44, A45, A46,
*A51, A52, A53, A54, A55, A56, A61, A62, A63, A64, A65, A66
C----- GROESSEN, DIE ALLEIN VON K ABHAENGEN
ISN 0008 IS=IK**2+1
C----- (3-6) # F(K) INTEGER
ISN 0009 IQ1=3*2** (IS-2)
ISN 0010 Q1=QFLOAT(IQ1)
C----- (3-6) # F(K) INTEGER
ISN 0011 IQ2=2**IS-1
ISN 0012 Q2=QFLOAT(IQ2)
C----- (3-6) # F(K) INTEGER
ISN 0013 IQ3=2**IS+2*(-1)**IK
ISN 0014 Q3=QFLOAT(IQ3)
C----- (3-6) # F(K) INTEGER
ISN 0015 IQ4=2** (IS-1) -1
ISN 0016 Q4=QFLOAT(IQ4)
C----- GROESSEN DIE ZUSAETZLICH NOCH VON DER LADUNGSQUANTENZAH KQ
C----- ABHAENGEN
C----- (3-5) # F(KQ, K) REAL
ISN 0017 ALF1=(1.Q0+QSQRT(ETAQK(KQ, K)))/2.Q0
C----- (3-5) # F(KQ, K) REAL
ISN 0018 AN1=ALF1
C----- (3-5) # F(KQ, K)
ISN 0019 ALF2=1.Q0/ETAQK(KQ, K)
C----- (3-5) # F(KQ, K) REAL
ISN 0020 AN2=2.Q0*ALF2/3.Q0
C----- (3-5) # F(KQ, K) REAL
ISN 0021 ALF3=QEXP(K-1.Q0)/K-KQ*(ALFA/3.Q0*(1.Q0+QSQRT(ETAQK(KQ, K)))*
*(XI/ETAQK(KQ, K)**2)**(2*IK+1)*ETAQK(KQ, K)**3+ETAQK(1.Q0, 1.Q0)/
*(EBN*ETAQK(KQ, K))*(2.Q0*XI*ETAQK(KQ, K))**IK*((1.Q0-
*QSQRT(ETAQK(KQ, K)))/(1.Q0+QSQRT(ETAQK(KQ, K))))**2)
C----- (3-5) # F(KQ, K) REAL
ISN 0022 AN3=2.Q0*ALF3
C----- PRINT INTERMEDIATE RESULTS
ISN 0023 WRITE(6, 300) IS, IQ1, IQ2, IQ3, IQ4
ISN 0024 300 FORMAT(1X, ' IS IQ1 IQ2 IQ3 IQ4'/1X, 5I5)
ISN 0025 IF(IPRINT.GE.2) WRITE(6, 100) ALF1, ALF2, ALF3, AN1, AN2, AN3
ISN 0027 100 FORMAT(1X, ' ALF1 ALF2 ALF3
* AN1 AN2 AN3'/1X, 6Q16.8)
C----- (4-2) REAL
ISN 0028 GKQ=Q1**3*ALF1+Q2**2*ALF2+Q3*ALF3+QEXP((1.Q0-2.Q0*K)/3.Q0)
C----- (4-3) REAL

```


IAT6140 JOB ORIGIN FROM GROUP=ANYLOCAL, DSP=IJP, DEVICE=INTRDR , 000
15:00:39 DAT4402 PRIORITY CHANGED TO 6 ACCORDING TO REQUEST.

15:00:40 IAT2000 JOB 1286 F15HDS99 SELECTED AA GRP=MITTEL
//F15HDS99 JOB '10212215,GMAIN',HDSCHULZ,CLASS=K,MSGLEVEL=(0,0), *

// MSGCLASS=T,NOTIFY=F15HDS

1 //F15HDS99 JOB '10212215,GMAIN',HDSCHULZ,CLASS=K,MSGLEVEL=(0,0), *

// MSGCLASS=T,NOTIFY=F15HDS

STMT NO. MESSAGE

22 IEF686I DDNAME REFERRED TO ON DDNAME KEYWORD IN PRIOR STEP WAS NOT RESOLVED

23 IEF648I INVALID DISP FIELD- PASS SUBSTITUTED

IEF142I F15HDS99 FORT - STEP WAS EXECUTED - COND CODE 0000

IEF373I STEP /FORT / START 82205.1500

IEF374I STEP /FORT / STOP 82205.1501 CPU 0MIN 01.70SEC SRB

0MIN 00.08SEC VIRT 664K SYS 196K

IEF142I F15HDS99 LKED - STEP WAS EXECUTED - COND CODE 0000

IEF373I STEP /LKED / START 82205.1501

IEF374I STEP /LKED / STOP 82205.1501 CPU 0MIN 00.74SEC SRB

0MIN 00.22SEC VIRT 304K SYS 172K

IEF142I F15HDS99 GO - STEP WAS EXECUTED - COND CODE 0000

IEF373I STEP /GO / START 82205.1501

IEF374I STEP /GO / STOP 82205.1503 CPU 0MIN 47.60SEC SRB

0MIN 10.82SEC VIRT 72K SYS 180K

IEF375I JOB /F15HDS99/ START 82205.1500

IEF376I JOB /F15HDS99/ STOP 82205.1503 CPU 0MIN 50.04SEC SRB

0MIN 11.12SEC

ISN 0024
ISN 0025
ISN 0027

100 *
C----- (4-2)
C----- (4-3)

ISN 0028

00004230
00004240
00004341
00004441
00004553

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ISN 0029
ISN 0031
ISN 0032

50 IF (2-1K.NE.0) GOTO 50
GOTO 51
TEMP1 = ((1.Q0-QG)*(A11-PG*(A12+KAPPA*KQ/ETAQK(KQ,K)*A13) -
*QFLOAT (IBINOM (IPG,2)) *(A14-KQ/ETAQK (KQ,K)*A15))
*+KAPPA*QG*ETAQK (KQ,K)*A16)**(2-1K)

ISN 0033
ISN 0034
ISN 0035
ISN 0037
ISN 0038

51 GOTO 54
54 TEMP1=1.Q0
IF (1K-1.NE.0) GOTO 52
GOTO 53
52 TEMP2 = ((KQ-1.Q0)*A21 + (1.Q0-PG)*A22 + QFLOAT (IBINOM (IPG,2)) *(A23-QX*
ETAQK (KQ,K)/(1.Q0+A24(1.Q0+QX))*A25) + KAPPA*(A26+KQ*ETAQK (KQ,K)
***2*A31) + QFLOAT (IBINOM (IPG,3)) *ETAQK (KQ,K)*A32 +
*QFLOAT (IBINOM (IPG,3)) *(KQ**3*A33/(3.Q0-KQ)*(QX-(-1.Q0)**1KQ) +
EBN(PG-QG)*ETA**((KQ-1.Q0)*KQ/4.Q0)/(8.Q0-A66*KQ*(KQ-1.Q0))
((1.Q0-KQ/ETAQK (KQ,K)*(2.Q0-KQ)*A34 (1-1QX)*A35)*
*ETAQK (KQ,K)/ETA**2-A36))** (1K-1)

ISN 0039
ISN 0040
ISN 0041

53 GOTO 55
55 TEMP2=1.Q0
WGXX=TEMP1+TEMP2

ISN 0042

C----- (4-2) REAL

ISN 0043

C----- (4-5) REAL
AN=PG*A42*(1.Q0-KAPPA*A43*(1.Q0+A44*(-ALFA)**(2-1K)*A45** (1K-1))
** (1.Q0-KAPPA*QG*A46*(2.Q0-K))-A51*(K-1.Q0)*(1.Q0-KAPPA))

ISN 0044

C----- (4-6) REAL
AQ=1.Q0-KQ*A52*(1.Q0-2.Q0*KAPPA*A53**1K)*(1.Q0+QX/6.Q0*(3.Q0-QX)
** (K-1.Q0)*(1.Q0-KAPPA))

ISN 0045

C----- (4-4) REAL
AGX=A41/K*(1.Q0+AN*AQ)

ISN 0046

C----- (4-7) REAL
BGX=(A54*A55** (1K-1)*(1.Q0+PG*A56*(1.Q0-KAPPA*A61*A62** (1-1K))*
*(1.Q0+KQ*A63*(1.Q0+KAPPA*A64)))*(1.Q0-1.Q0/K*(A65*(KQ+K-1.Q0))**
*(2.Q0-K)*QFLOAT (IBINOM (IPG,2)) *(1.Q0-QFLOAT (IBINOM (IPG,3))))
*/(K**IPG*(1.Q0+PG+QG+KAPPA*ETA** (2.Q0-KQ)))

ISN 0047

ISN 0049

200 IF (IPRINT.GE.2) WRITE (6,200) GKQ,WGXX,WGX,AN,AQ,AGX,BGX
FORMAT (1X,' GKQ WGXX WGX
* AN AQ AGX BGX',/1X,7Q16

ISN 0050

ISN 0051

*.8)
RETURN
END

*OPTIONS IN EFFECT*NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(MAX) AUTODBL(NONE)
*OPTIONS IN EFFECT*SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF ALC NOANSF TERM IBM FLAG(1)
STATISTICS SOURCE STATEMENTS = 50, PROGRAM SIZE = 6640, SUBPROGRAM NAME = GBASE
STATISTICS NO DIAGNOSTICS GENERATED
***** END OF COMPILATION *****
68K BYTES OF CORE NOT USED

*VERSION 1.3.0 (01 MAY 80)

REQUESTED OPTIONS: NODECK, NOLIST, OPT(0)
 OPTIONS IN EFFECT: NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(MAX) AUTODBL(NONE)
 SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF ALC NOANSF TERM IBM FLAG(I)

SYSTEM/370 FORTRAN H EXTENDED (ENHANCED)

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		C	17/05/82 207140951 MEMBER NAME GSTRUC (HEIMS) FORTRAN	00000000
ISN 0002			SUBROUTINE GSTRUC	00000100
		C----	ROUTINE CALCULATES THE STRUCTURE PARAMETERS N1,N2,N3,N4	00000200
		C----	AUS DEN QUANTENZAHLEN IM COMMON /QUANT/ UND DEN KONSTANTEN	00000300
		C----	IN COMMON /CONST/	00000400
ISN 0003			IMPLICIT REAL*16 (A-H,J-Z)	00000500
ISN 0004			COMMON /CONST/ PI,HQ,C,GAM,RG,SO,FAKMEV,ETA,THETA,EQ,ALFA,AMU,	00000600
			*ALFP,ALFM,XI,EBN,BETA,IPRINT	00000700
ISN 0005			COMMON /QUANT/ N,K,PG,QG,KQ,KAPPA,N1,N2,N3,N4,CS,IK,IPG,IQG,	00000710
			*IKAPPA,EPS,QX,IN,IN1,IN2,IN3,IN4,ICS,IEPS,IQX,IX,IKQ,X,	00000720
			*IK1,IK2,IK3,IK4	00000721
ISN 0006			COMMON /EXCHA/ WGX,AGX,BGX,ALF1,ALF2,ALF3,FN,Q1,Q2,Q3,Q4,	00000730
			*AN1,AN2,AN3,FIG,GKQ,WGXK,AN,AQ,KGH,	00000740
			*IQ1,IQ2,IQ3,IQ4	00000750
		C----	COMPUTE FN=F(N)	00001300
ISN 0007		C----	(5-2) F(KQ,K,PG,KAPPA,EPS,LQ) REAL	00001400
			FN=(1.Q0-QG*(2.Q0-K)*(1.Q0-KAPPA))* (AGX*N/(N+2.Q0)+BGX*	00001500
			QSQRT(N(N-2.Q0)))	00001510
		C----	TEST PRINT	00001600
ISN 0008			IF (IPRINT.GE.2) WRITE(6,101) FN	00001700
ISN 0010	101		FORMAT(1X,'FN = ',Q14.5)	00001800
		C----	DETERMINATION OF STRUCTURE PARAMETERS	00001900
		C----	(6-1)	00002000
ISN 0011			W1=WX*(1.Q0+FN)	00002100
ISN 0012			TEMP=(W1/ALF1)**(1.Q0/3.Q0)	00002200
ISN 0013			IK1=IQINT(TEMP)	00002300
ISN 0014			IN1=IK1-IQ1	00002400
ISN 0015			N1=QFLOAT(IN1)	00002500
		C----		00002600
ISN 0016			W2=W1-QFLOAT(IK1)**3*ALF1	00002700
ISN 0017			TEMP=QSQRT(W2/ALF2)	00002800
ISN 0018			IK2=IQINT(TEMP)	00002900
ISN 0019			IN2=IK2-IQ2	00003000
ISN 0020			N2=QFLOAT(IN2)	00003100
		C----		00003200
ISN 0021			W3=W2-QFLOAT(IK2)**2*ALF2	00003300
ISN 0022			TEMP=W3/ALF3	00003400
ISN 0023			IK3=IQINT(TEMP)	00003500
ISN 0024			IN3=IK3-IQ3	00003600
ISN 0025			N3=QFLOAT(IN3)	00003700
		C----		00003800
ISN 0026			W4=W3-QFLOAT(IK3)*ALF3	00003900
ISN 0027			IF (W4.EQ.0.Q0) GOTO 1	00003910
ISN 0029			IF (W4.GT.1.Q0) GOTO 3	00003920
ISN 0031			REST=QFLOAT(2*IK-1)/QFLOAT(3*IQ4)	00004000
ISN 0032			TEMP=-QLOG(W4)/REST	00004100
ISN 0033			IK4=IQINT(TEMP)	00004200
ISN 0034			GOTO 2	00004210
ISN 0035	1		IK4=IQINT(ALF3*QFLOAT(IK3))	00004220
ISN 0036			GOTO 2	00004230
ISN 0037	3		IK3=IK3-1	00004240
ISN 0038			IN3=IK3-IQ3	00004250
ISN 0039			N3=QFLOAT(IN3)	00004260
ISN 0040			IK4=IK4+IQINT(ALF3*QFLOAT(IK3))	00004270
ISN 0041	2		IN4=IK4-IQ4	00004300

ISN 0024
ISN 0025

ISN 0026
ISN 0027
ISN 0029
ISN 0031
ISN 0032
ISN 0033
ISN 0034
ISN 0035
ISN 0036
ISN 0037
ISN 0038
ISN 0039
ISN 0040
ISN 0041

C-----
N3=QFLOAT(IN3)
W4=W3-QFLOAT(IK3)*ALF3
IF(W4.EQ.0.00) GOTO 1
IF(W4.GT.1.00) GOTO 3
REST=QFLOAT(2*IK-1)/QFLOAT(3*IQ4)
TEMP=-QLOG(W4)/REST
IK4=IQINT(TEMP)
GOTO 2
1 IK4=IQINT(ALF3*QFLOAT(IK3))
GOTO 2
3 IK3=IK3-1
IN3=IK3-IQ3
N3=QFLOAT(IN3)
IK4=IK4+IQINT(ALF3*QFLOAT(IK3))
2 IN4=IK4-IQ4

00003800
00003900
00003910
00003920
00004000
00004100
00004200
00004210
00004220
00004230
00004240
00004250
00004260
00004270
00004300

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PAGE 2

ISN 0042

C-----
N4=QFLOAT(IN4)
TEST AUSDRUCK

ISN 0043
ISN 0045

200 IF(IPRINT.GE.2) WRITE(6,200) W1,W2,W3,W4,REST
FORMAT(1X,' W1 W2 W3 W4 REST')
* W4 REST'/1X,5Q16.8)

ISN 0046
ISN 0047
ISN 0048
ISN 0049

100 WRITE(6,100) IK1,IK2,IK3,IK4,IN1,IN2,IN3,IN4
FORMAT(1X,' IK1 IK2 IK3 IK4 IN1 IN2 IN3 IN4 N4'/1X,8I5)
RETURN
END

00004400
00004500
00004510
00004520
00004530
00004600
00004800
00005000
00005100

*OPTIONS IN EFFECT*NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(MAX) AUTODBL(NONE)
*OPTIONS IN EFFECT*SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF ALC NOANSF TERM IBM FLAG(I)
STATISTICS SOURCE STATEMENTS = 48, PROGRAM SIZE = 2356, SUBPROGRAM NAME =GSTRUC
STATISTICS NO DIAGNOSTICS GENERATED
***** END OF COMPILATION *****

84K BYTES OF CORE NOT USED

*VERSION 1.3.0 (01 MAY 80) SYSTEM/370 FORTRAN H EXTENDED (ENHANCED) DATE 82.205/15.00.53
REQUESTED OPTIONS: NODECK,NOLIST,OPT(0)
OPTIONS IN EFFECT: NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(MAX) AUTODBL(NONE)
SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF ALC NOANSF TERM IBM FLAG(I)

```
ISN 0002      C 18/05/82 207140959 MEMBER NAME GMASS (HEIMS) FORTRAN 00000000
               SUBROUTINE GMASS(AM) 00000100
C----- ROUTINE BERECHNET DIE MASEN UND LEBENSDAUERN DER TEILCHEN 00000200
C----- AUS DEN QUANTENZAHLEN IM COMMON /QUANT/ UND DEN KONSTANTEN 00000300
C----- IM COMMON /CONST/ 00000400
ISN 0003      IMPLICIT REAL*16 (A-H,J-Z) 00000500
ISN 0004      COMMON /CONST/ PI,HQ,C,GAM,RG,SO,FAKMEV,ETA,THETA,EQ,ALFA,AMU, 00000600
               *ALFP,ALFM,XI,EBN,BETA,IPRINT 00000700
ISN 0005      COMMON /QUANT/ N,K,PG,QG,KQ,KAPPA,N1,N2,N3,N4,CS,IK,IPG,IQG, 00000710
               *IKAPPA,EPS,QX,IN,IN1,IN2,IN3,IN4,ICS,IEPS,IQX,IX,IKQ,X, 00000720
               *IK1,IK2,IK3,IK4 00000721
ISN 0006      COMMON /EXCHA/ WGX,AGX,BGX,ALF1,ALF2,ALF3,FN,Q1,Q2,Q3,Q4, 00000730
               *AN1,AN2,AN3,FIG,GKQ,WGKX,AN,AQ,KGH, 00000740
               *IQ1,IQ2,IQ3,IQ4 00000750
ISN 0007      C----- (3-9) # F(K) INTEGER 00001206
               KGH=4.Q0*(ALF1*QFLOAT( (IK1**2*(1+IK1)**2)/4.Q0+ 00001207
               *ALF2*QFLOAT( (IK2*(2*IK2**2+3*IK2+1))/6.Q0+ 00001208
               *ALF3*QFLOAT( (IK3*(IK3+1))/2.Q0+QFLOAT( (IK4) ) ) 00001209
ISN 0008      C----- (3-7) # F(K,KQ,PG,QG,KAPPA) 00001210
               FIG=3.Q0*PG/(PI*QSQR(ETAQK(KQ,K)))*(1.Q0-ALFM/ALFP)*(PG+QG)* 00001211
               *(-1.Q0)**(IPG+IQG)*(1.Q0-ALFA/3.Q0+PI/2.Q0*(K-1.Q0)*3.Q0** 00001212
               *(KQ/2.Q0))*(1.Q0+2.Q0*K*KAPPA/(3.Q0*ETA**2)*XI*(1.Q0+XI**2* 00001213
               *(PG-QG)*(PI**2-KQ)))/(1.Q0+4.Q0*XI/K*QFLOAT( (IBINOM(IPG,2) ) * 00001214
               *(XI/6.Q0)**KQ)*(2.Q0*QSQR(ETAQK(1.Q0,1.Q0)*ETAQK(KQ,K)))+ 00001215
               *KQ*ETA**2*(K-1.Q0))*(1.Q0+(4.Q0*PI*ALFA)/(ETA*QSQR(ETA)))* 00001216
               *(1.Q0+QG*(1.Q0-KAPPA)*(2.Q0-K)*N1/Q1)+4.Q0*(1.Q0-ALFM/ALFP)* 00001217
               *ALFA/XI**2*(PG+QG)+4.Q0*KQ*ALFM/ALFP 00001218
ISN 0009      FIK=(FIG-4.Q0*KQ*ALFM/ALFP)/4.Q0 00001227
ISN 0010      IF(IPRINT.GE.2) WRITE(6,100) IK1,IK2,IK3,IK4,KGH,FIG,FIK 00001237
ISN 0012      100 FORMAT(1X,' IK1 IK2 IK3 IK4 KGH FIG FIK 00001247
               * FIK'/1X,4I5,3Q16.8) 00001257
ISN 0013      C----- (3-9) # F REAL 00001300
ISN 0014      AM=AMU*FAKMEV*ALFP*(KGH+FIG) 00001400
ISN 0015      RETURN 00009600
               END 00009700
```

*OPTIONS IN EFFECT*NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(MAX) AUTODBL(NONE)
*OPTIONS IN EFFECT*SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF ALC NOANSF TERM IBM FLAG(I)
STATISTICS SOURCE STATEMENTS = 14, PROGRAM SIZE = 2998, SUBPROGRAM NAME = GMASS
STATISTICS NO DIAGNOSTICS GENERATED
***** END OF COMPILATION *****
84K BYTES OF CORE NOT USED


```

*VERSION 1.3.0 (01 MAY 80)          SYSTEM/370 FORTRAN H EXTENDED (ENHANCED)    DATE 82.205/15.00.53    PAGE 1
REQUESTED OPTIONS: NODECK,NOLIST,OPT(0)
OPTIONS IN EFFECT: NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(MAX) AUTODBL(NONE)
SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF ALC NOANSF TERM IBM FLAG(I)

ISN 0002      C 28/08/81 109131228 MEMBER NAME ETAQK (HEIMS)      FORTRAN      00000000
              FUNCTION ETAQK(KQ,K)                                00000100
              C----- FORMEL (7A)                                00000200
              IMPLICIT REAL*16 (A-H,J-Z)                          00000210
              PI=3.1415926535Q0                                     00000220
              ETAQK=PI/(KQ**4*(4.Q0+K)+PI**4)**0.25Q0             00000400
              RETURN                                              00000500
              END                                                00000600

*OPTIONS IN EFFECT*NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(MAX) AUTODBL(NONE)
*OPTIONS IN EFFECT*SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF ALC NOANSF TERM IBM FLAG(I)
*STATISTICS*      SOURCE STATEMENTS =      6, PROGRAM SIZE =      532, SUBPROGRAM NAME = ETAQK
*STATISTICS*      NO DIAGNOSTICS GENERATED
***** END OF COMPILATION *****
88K BYTES OF CORE NOT USED

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*VERSION 1.3.0 (01 MAY 80)

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REQUESTED OPTIONS: NODECK,NOLIST,OPT(0)

OPTIONS IN EFFECT: NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(MAX) AUTODBL(NONE)

SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF ALC NOANSF TERM IBM FLAG(I)

ISN 0002	C	27/08/81 109131226	MEMBER NAME	IBINOM	(HEIMS)	FORTTRAN	00000000
			FUNCTION	IBINOM(I,K)			00000100
ISN 0003	C----		COMPUTES	BINOMIAL	COEFFICIENTS		00000200
ISN 0005			IF(I.LT.K)	GOTO 1			00000210
ISN 0006			IBINOM=IFAKUL(I)	/ (IFAKUL(K)*IFAKUL(I-K))			00000300
ISN 0007	1		RETURN				00000400
ISN 0008			IBINOM=0				00000410
ISN 0009			RETURN				00000420
			END				00000500

*OPTIONS IN EFFECT*NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(MAX) AUTODBL(NONE)

*OPTIONS IN EFFECT*SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF ALC NOANSF TERM IBM FLAG(I)

STATISTICS SOURCE STATEMENTS =

8, PROGRAM SIZE =

394, SUBPROGRAM NAME =IBINOM

STATISTICS NO DIAGNOSTICS GENERATED

***** END OF COMPILATION *****

88K BYTES OF CORE NOT USED

STATISTICS NO DIAGNOSTICS THIS STEP

FORTRAN H EXTENDED (ENHANCED)

SOURCE STATEMENTS =	103,	PROGRAM SIZE =	5756,	SUBPROGRAM NAME =	MAIN
SOURCE STATEMENTS =	64,	PROGRAM SIZE =	8300,	SUBPROGRAM NAME =	GINIT
SOURCE STATEMENTS =	50,	PROGRAM SIZE =	6640,	SUBPROGRAM NAME =	GBASE
SOURCE STATEMENTS =	48,	PROGRAM SIZE =	2356,	SUBPROGRAM NAME =	GSTRUC
SOURCE STATEMENTS =	14,	PROGRAM SIZE =	2998,	SUBPROGRAM NAME =	GMASS
SOURCE STATEMENTS =	6,	PROGRAM SIZE =	532,	SUBPROGRAM NAME =	ETAQK
SOURCE STATEMENTS =	8,	PROGRAM SIZE =	394,	SUBPROGRAM NAME =	IBINOM

F64-LEVEL LINKAGE EDITOR OPTIONS SPECIFIED LET,LIST,MAP
 DEFAULT OPTION(S) USED - SIZE=(307200,65536)

MODULE MAP

CONTROL SECTION			ENTRY									
NAME	ORIGIN	LENGTH	NAME	LOCATION	NAME	LOCATION	NAME	LOCATION	NAME	LOCATION	NAME	LOCATION
MAIN	00	167C										
GINIT	1680	206C										
GBASE	36F0	19F0										
GSTRUC	50E0	934										
GMASS	5A18	BB6										
ETAQK	65D0	214										
IBINOM	67E8	18A										
IHOFIXPI*	6978	178	FIXPI#	6978								
IHOFQTEN*	6AF0	110	FQTEN#	6AF0								
IHOFQXPI*	6C00	1A4	FQXPI#	6C00								
IHOFQXPQ*	6DA8	B8C	QEXP	6DA8	IH\$QEXP	6DA8	FQXP2#	6DDE	FQXPQ#	6E12		
			QLOG10	6E3A	IH\$QLOGO	6E3A	QLOG	6E5C	IH\$QLOG	6E5C		
IHOECOMH*	7938	E30	IBCOM#	796C	FDIOCS#	7A28	INTSWTCH	86B0				
FIOAP# *	8768	61C										
IHOCONH2*	8D88	9A5	SEQDASD	915A								
IFAKUL *	9730	E8	QSQRT	9818	IH\$QSQRT	9818						
IHOQSQR*	9818	22C	ADCON#	9A48	FCVAOUTP	9AB4	FCVLOUTP	9ACC	FCVZOUTP	9AE4		
IHOFCVTH*	9A48	CFA	FCVIOU*P	9AFC	FCVEOUTP	9B34	FCVCOU*P	9B34	ADCONI#	A244		
			ADCONO#	A260	INT6SWCH	A741						
IHOEFNTH*	A748	800	ARITH#	A748	ADJSWTCH	ACDC						
IHOEFIOS*	AF48	118C	FIOCS#	AF48	FIOCSBEP	AF4E						
IHOFIOS2*	C0D8	642										
IHOERRM *	C720	624	ERRMON	C720	IHOERRE	C738						
IHOQCONI*	CD48	4										
IHOQCONO*	CD50	4										
IHOQOPT *	CD58	538										
IHOFCONI*	D290	416	FQCONI#	D290								
IHOFCONO*	D6A8	8B8	FQCONO#	D6A8								
IHOETRCH*	DF60	2AE	IHOTRCH	DF60	ERRTRA	DF68						

NAME	ORIGIN	LENGTH
IHOUBTL*	E210	638
IHOFTEN *	E848	220
CONST	EA68	114
QUANT	EB80	128
EXCHA	ECA8	150
PARMAT	EDF8	240

NAME	LOCATION
FTEN#	E848

NAME	LOCATION
------	----------

NAME	LOCATION
------	----------

NAME	LOCATION
------	----------

ENTRY ADDRESS 00

TOTAL LENGTH F038
 *****MAIN DOES NOT EXIST BUT HAS BEEN ADDED TO DATA SET
 AUTHORIZATION CODE IS 0.

IPRINT = 0
EINGEGEBENE KONSTANTEN:

PI = 3.14159265
BASIS OF NATURAL LOGARITHM: EBN = 2.71828183
PLANCK WIRKUNGSQUANTUM/(2*PI): HQ = 0.10545887Q-33 (WS*S)
LICHTGESCHWINDIGKEIT: C = 0.29979246Q+09 (M/S)
GRAVITATIONSKONSTANTE: GAM = 0.66732000Q-10 (M**3*KG**-1*S**-2)
WELLENWIDERSTAND DES VAKUUMS: RG = 376.73037659 (OHM)
EINHEITSSTRECKE: SO = 1.00000000 (M)

ABGELEITETE KONSTANTE:

UMRECHNUNG KG - MEV: FAKMEV = 0.56095450Q+30 (MEV/KG)
ZAHLENFAKTOR: ETA = 0.98998964Q+00
ZAHLENFAKTOR: THETA = 0.79399127Q+01
ELEMENTARLADUNG: EQ = 0.16021775Q-18 (A*S)
FEINSTRUKTURKONSTANTE: ALFA = 0.72973511Q-02
"STARKE" KONSTANTE: BETA = 0.99998589Q+00
MASSENFaktor: AMU = 0.22590219Q-30 (KG)
ZAHLENFAKTOR ALPHA PLUS: ALFP = 0.18322115Q-01
ZAHLENFAKTOR ALPHA MINUS: ALFM = 0.81283449Q-02
ZAHLENFAKTOR: XI = 0.16180340Q+01

PARAMETER MATRIX

0.25483393Q+03	0.14790690Q+02	0.12021658Q+02	0.13793985Q+03	0.24622984Q+01	0.73036070Q+02
0.20045757Q-03	0.13480450Q+00	0.36074128Q+00	0.17630043Q+01	0.33298461Q-02	0.28058241Q+00
0.38754712Q-02	0.43703972Q+00	0.10132166Q-01	0.24690843Q+01	0.30762153Q-02	0.10046837Q+01
0.62043340Q+00	0.39820465Q+01	0.80901699Q+00	0.74871411Q+00	0.30826097Q+00	0.53214928Q+01
0.10294024Q+01	0.44674036Q-01	0.43658717Q+01	0.88720479Q-02	0.42360680Q+01	0.71355583Q+01
0.84410941Q+00	0.81045177Q+00	0.11055358Q+00	0.10577864Q+01	0.64720368Q+00	0.16018369Q+01

--- E ---
BARYON NUMBER + 1 = 1
2 * ISOSPIN PG = 1
2 * SPIN QG = 1
DOUBLETT KAPPA = 0

IS IQ1 IQ2 IQ3 IQ4
2 3 3 2 1

IK1 IK2 IK3 IK4 N1 N2 N3 N4
3 3 2 1 0 0 0 0

CS KQ EPS QX N AM (MEV)
0 0 1 0 0 0.50688314Q+00
*** NO EXCITATION POSSIBLE ***
IS IQ1 IQ2 IQ3 IQ4
2 3 3 2 1

IK1 IK2 IK3 IK4 N1 N2 N3 N4
3 3 2 1 0 0 0 0

CS KQ EPS QX N AM (MEV)
0 1 1 -1 0 0.51100326Q+00
*** NO EXCITATION POSSIBLE ***

--- PI ---
BARYON NUMBER + 1 = 1
2 * ISOSPIN PG = 2
2 * SPIN QG = 0
DOUBLETT KAPPA = 0

IS IQ1 IQ2 IQ3 IQ4
2 3 3 2 1

	C	17/03/82 207241459 MEMBER NAME GPROG (HEIMS) FORTRAN	00000000
	C----	PROGRAM READS AS INPUT (BARYON NUMBER +1) = K	00000100
	C----	2 * ISOSPIN = PG	00000200
	C----	2 * SPIN = QG	00000300
	C----	DUBLETT FACTOR = KAPPA	00000400
ISN 0002		IMPLICIT REAL*16 (A-H, J-Z)	00000500
ISN 0003		DIMENSION T1(5), T2(5), T3(5), T4(5)	00000600
ISN 0004		COMMON /CONST/ PI, HO, C, GAM, RG, SO, FAKMEV, ETA, THETA, EQ, ALFA, AMU,	00000700
		*ALFP, ALFM, XI, EBN, BETA, IPRINT	00000800
ISN 0005		COMMON /QUANT/ N, K, PG, QG, KQ, KAPPA, N1, N2, N3, N4, CS, IK, IPG, IQG,	00000900
		*IKAPPA, EPS, QX, IN, IN1, IN2, IN3, IN4, ICS, IEPS, IQX, IX, IKQ, X,	00001000
		*IK1, IK2, IK3, IK4	00001010
ISN 0006		COMMON /EXCHA/ WGX, AGX, BGX, ALF1, ALF2, ALF3, FN, Q1, Q2, Q3, Q4,	00001020
		*AN1, AN2, AN3, FIG, GKQ, WGXK, AN, AQ, KGH,	00001030
		*IQ1, IQ2, IQ3, IQ4	00001040
	C----	READ IPRINT	00001041
ISN 0007		READ(5, 900) TEXT, IPRINT	00001050
ISN 0008	900	FORMAT(A16, I3)	00001060
ISN 0009		WRITE(6, 901) TEXT, IPRINT	00001070
ISN 0010	901	FORMAT(IX, A16, I3)	00001080
ISN 0011		CALL GINIT	00001100
ISN 0012		READ(5, 400) IJA, IJE	00001110
ISN 0013	400	FORMAT(2I5)	00001120
ISN 0014		DO 4 IJ=1JA, IJE	00001130
ISN 0015		READ(5, 100) TEXT, T1, IK, T2, IPG, T3, IQG, T4, IKAPPA	00001200
ISN 0016	100	FORMAT(A16/, 3(5A4, I2/), 5A4, I2)	00001300
ISN 0017		WRITE(6, 200) TEXT, T1, IK, T2, IPG, T3, IQG, T4, IKAPPA	00001400
ISN 0018	200	FORMAT(IX, A16/, 4(IX, 5A4, I2/))	00001500
ISN 0019		K=QFLOAT(IK)	00001600
ISN 0020		PG=QFLOAT(IPG)	00001700
ISN 0021		QG=QFLOAT(IQG)	00001800
ISN 0022		KAPPA=QFLOAT(IKAPPA)	00001900
	C----	DEFINE PARTICLE -ANTIPARTICLE -> EPS	00002000
ISN 0023		DO 1 IEPSI=1, 1	00002100
ISN 0024		IEPS=-(-1)**IEPSI	00002200
ISN 0025		EPS=QFLOAT(IEPS)	00002300
	C----	COMPUTATION OF STRANGENESS	00002400
	C----	(1-3)	00002500
ISN 0026		ITEMP1=IQG*(IKAPPA+IBINOM(IPG, 2))	00002600
ISN 0027		IEPSP=IEPS*(-1)**MOD(ITEMP1, 2)	00002700
	C----	(1-4)	00002800
ISN 0028		ITEMP2=IQG*(IQG*(IK-1)+IBINOM(IPG, 2))	00002900
ISN 0029		IEPSQ=IEPS*(-1)**MOD(ITEMP2, 2)	00003000
	C----	(1-1)	00003100
ISN 0030		ICS=2/(IK*(1+IKAPPA))*(IPG*IEPSP+IQG*IEPSQ)*(IK-1+IKAPPA)	00003200
ISN 0031		CS=QFLOAT(ICS)	00003300
	C----	DEFINE ISO MULTIPLETT COMPONENT	00003400
ISN 0032		IXE=IPG+1	00003500
ISN 0033		DO 2 IX=1, IXE	00003600
	C----	(1-5) F(K, PG, QG, KAPPA, EPS) INTEGER	00003700
ISN 0034		X=QFLOAT(IX)	00003800
ISN 0035		IQX=((IPG+2-2*IX)*(1-IKAPPA*IQG*(2-IX))+ICS+IEPS*(IK-1-(1+IKAPPA))	00003900
		**IQG*(2-IX))/2	00004000
		QX=QFLOAT(IQX)	00004100
ISN 0036	C----	COMPUTE CHARGE KQ	00004200

BARYON NUMBER + 1 = 1
 2 * ISOSPIN PG = 2
 2 * SPIN QG = 0
 DOUBLETT KAPPA = 0

IS 2	IQ1 3	IQ2 3	IQ3 2	IQ4 1				
IK1 15	IK2 12	IK3 4	IK4 4	N1 12	N2 9	N3 2	N4 3	
CS 0	KQ 1	EPS 1	QX 1	N 0	AM (MEV) 0.13956701Q+03			
ILE 2578	IL1 53	IL2 76	IL3 111	IL4 109				
IK1 23	IK2 27	IK3 33	IK4 7	N1 20	N2 24	N3 31	N4 6	
CS 0	KQ 1	EPS 1	QX 1	N 2	AM (MEV) 0.77559610Q+03			
IK1 24	IK2 33	IK3 0	IK4 8	N1 21	N2 30	N3 -2	N4 7	
CS 0	KQ 1	EPS 1	QX 1	N 3	AM (MEV) 0.95114568Q+03			
IK1 25	IK2 24	IK3 44	IK4 5	N1 22	N2 21	N3 42	N4 4	
CS 0	KQ 1	EPS 1	QX 1	N 4	AM (MEV) 0.10330314Q+04			
IK1 25	IK2 39	IK3 45	IK4 1	N1 22	N2 36	N3 43	N4 0	
CS 0	KQ 1	EPS 1	QX 1	N 5	AM (MEV) 0.11804838Q+04			
IK1 26	IK2 19	IK3 8	IK4 3	N1 23	N2 16	N3 6	N4 2	
CS 0	KQ 1	EPS 1	QX 1	N 6	AM (MEV) 0.11642122Q+04			
IK1 26	IK2 30	IK3 47	IK4 1	N1 23	N2 27	N3 45	N4 0	
CS 0	KQ 1	EPS 1	QX 1	N 7	AM (MEV) 0.12398066Q+04			
IK1 26	IK2 37	IK3 52	IK4 2	N1 23	N2 34	N3 50	N4 1	
CS 0	KQ 1	EPS 1	QX 1	N 8	AM (MEV) 0.13184497Q+04			
IK1 26	IK2 42	IK3 56	IK4 5	N1 23	N2 39	N3 54	N4 4	
CS 0	KQ 1	EPS 1	QX 1	N 9	AM (MEV) 0.13957860Q+04			
IK1 27	IK2 9	IK3 5	IK4 2	N1 24	N2 6	N3 3	N4 1	
CS 0	KQ 1	EPS 1	QX 1	N 10	AM (MEV) 0.13256934Q+04			
IK1 27	IK2 19	IK3 25	IK4 6	N1 24	N2 16	N3 23	N4 5	
CS 0	KQ 1	EPS 1	QX 1	N 11	AM (MEV) 0.13490962Q+04			
IK1	IK2	IK3	IK4	N1	N2	N3	N4	

27	25	26	5	24	22	24	4
CS 0	KQ 1	EPS 1	QX 1	N 12	AM (MEV) 0.13780528Q+04		
IK1 27	IK2 29	IK3 48	IK4 1	N1 24	N2 26	N3 46	N4 0
CS 0	KQ 1	EPS 1	QX 1	N 13	AM (MEV) 0.14140086Q+04		
IK1 27	IK2 33	IK3 15	IK4 4	N1 24	N2 30	N3 13	N4 3
CS 0	KQ 1	EPS 1	QX 1	N 14	AM (MEV) 0.14418105Q+04		
IK1 27	IK2 36	IK3 5	IK4 2	N1 24	N2 33	N3 3	N4 1
CS 0	KQ 1	EPS 1	QX 1	N 15	AM (MEV) 0.14754165Q+04		
IK1 27	IK2 38	IK3 40	IK4 0	N1 24	N2 35	N3 38	N4 -1
CS 0	KQ 1	EPS 1	QX 1	N 16	AM (MEV) 0.15091684Q+04		
IK1 27	IK2 40	IK3 54	IK4 0	N1 24	N2 37	N3 52	N4 -1
CS 0	KQ 1	EPS 1	QX 1	N 17	AM (MEV) 0.15445628Q+04		
IK1 27	IK2 42	IK3 49	IK4 2	N1 24	N2 39	N3 47	N4 1
CS 0	KQ 1	EPS 1	QX 1	N 18	AM (MEV) 0.15746155Q+04		
IK1 27	IK2 44	IK3 26	IK4 9	N1 24	N2 41	N3 24	N4 8
CS 0	KQ 1	EPS 1	QX 1	N 19	AM (MEV) 0.16023314Q+04		
IK1 27	IK2 45	IK3 80	IK4 4	N1 24	N2 42	N3 78	N4 3
CS 0	KQ 1	EPS 1	QX 1	N 20	AM (MEV) 0.16475863Q+04		
IK1 28	IK2 1	IK3 2	IK4 5	N1 25	N2 -2	N3 0	N4 4
CS 0	KQ 1	EPS 1	QX 1	N 21	AM (MEV) 0.15261777Q+04		
IK1 28	IK2 11	IK3 10	IK4 1	N1 25	N2 8	N3 8	N4 0
CS 0	KQ 1	EPS 1	QX 1	N 22	AM (MEV) 0.15313623Q+04		
IK1 28	IK2 15	IK3 30	IK4 4	N1 25	N2 12	N3 28	N4 3
CS 0	KQ 1	EPS 1	QX 1	N 23	AM (MEV) 0.15420193Q+04		
IK1 28	IK2 19	IK3 11	IK4 1	N1 25	N2 16	N3 9	N4 0

0	1	1	1	23	0.15420193Q+04	AM (MEV)	
IK1 28	IK2 19	IK3 11	IK4 1	N1 25	N2 16	N3 9	N4 0
CS 0	KQ 1	EPS 1	QX 1	N 24	0.15499320Q+04		
IK1 28	IK2 22	IK3 2	IK4 4	N1 25	N2 19	N3 0	N4 3
CS 0	KQ 1	EPS 1	QX 1	N 25	0.15618477Q+04		
IK1 28	IK2 24	IK3 20	IK4 0	N1 25	N2 21	N3 18	N4 -1
CS 0	KQ 1	EPS 1	QX 1	N 26	0.15740835Q+04		
IK1 28	IK2 26	IK3 27	IK4 0	N1 25	N2 23	N3 25	N4 -1
CS 0	KQ 1	EPS 1	QX 1	N 27	0.15878452Q+04		
IK1 28	IK2 28	IK3 23	IK4 2	N1 25	N2 25	N3 21	N4 1
CS 0	KQ 1	EPS 1	QX 1	N 28	0.16011652Q+04		
IK1 28	IK2 30	IK3 7	IK4 0	N1 25	N2 27	N3 5	N4 -1
CS 0	KQ 1	EPS 1	QX 1	N 29	0.16152651Q+04		
IK1 28	IK2 31	IK3 46	IK4 1	N1 25	N2 28	N3 44	N4 0
CS 0	KQ 1	EPS 1	QX 1	N 30	0.16338825Q+04		
IK1 28	IK2 33	IK3 13	IK4 1	N1 25	N2 30	N3 11	N4 0
CS 0	KQ 1	EPS 1	QX 1	N 31	0.16447553Q+04		
IK1 28	IK2 34	IK3 41	IK4 1	N1 25	N2 31	N3 39	N4 0
CS 0	KQ 1	EPS 1	QX 1	N 32	0.16626250Q+04		
IK1 28	IK2 35	IK3 65	IK4 1	N1 25	N2 32	N3 63	N4 0
CS 0	KQ 1	EPS 1	QX 1	N 33	0.16858153Q+04		
IK1 28	IK2 37	IK3 10	IK4 3	N1 25	N2 34	N3 8	N4 2
CS 0	KQ 1	EPS 1	QX 1	N 34	0.16918999Q+04		
IK1 28	IK2 38	IK3 24	IK4 1	N1 25	N2 35	N3 22	N4 0
CS 0	KQ 1	EPS 1	QX 1	N 35	0.17076877Q+04		
IK1	IK2	IK3	IK4	N1	N2	N3	N4

28	39	35	2	25	36	33	1
CS 0	KQ 1	EPS 1	QX 1	N 36	AM (MEV) 0.17250000Q+04		
IK1 28	IK2 40	IK3 42	IK4 1	N1 25	N2 37	N3 40	N4 0
CS 0	KQ 1	EPS 1	QX 1	N 37	AM (MEV) 0.17425186Q+04		
IK1 28	IK2 41	IK3 46	IK4 1	N1 25	N2 38	N3 44	N4 0
CS 0	KQ 1	EPS 1	QX 1	N 38	AM (MEV) 0.17599448Q+04		
IK1 28	IK2 42	IK3 47	IK4 3	N1 25	N2 39	N3 45	N4 2
CS 0	KQ 1	EPS 1	QX 1	N 39	AM (MEV) 0.17769794Q+04		
IK1 28	IK2 43	IK3 44	IK4 0	N1 25	N2 40	N3 42	N4 -1
CS 0	KQ 1	EPS 1	QX 1	N 40	AM (MEV) 0.17930855Q+04		
IK1 28	IK2 44	IK3 39	IK4 6	N1 25	N2 41	N3 37	N4 5
CS 0	KQ 1	EPS 1	QX 1	N 41	AM (MEV) 0.18094389Q+04		
IK1 28	IK2 45	IK3 30	IK4 2	N1 25	N2 42	N3 28	N4 1
CS 0	KQ 1	EPS 1	QX 1	N 42	AM (MEV) 0.18255821Q+04		
IK1 28	IK2 46	IK3 18	IK4 0	N1 25	N2 43	N3 16	N4 -1
CS 0	KQ 1	EPS 1	QX 1	N 43	AM (MEV) 0.18427905Q+04		
IK1 28	IK2 47	IK3 4	IK4 3	N1 25	N2 44	N3 2	N4 2
CS 0	KQ 1	EPS 1	QX 1	N 44	AM (MEV) 0.18621287Q+04		
IK1 28	IK2 47	IK3 85	IK4 5	N1 25	N2 44	N3 83	N4 4
CS 0	KQ 1	EPS 1	QX 1	N 45	AM (MEV) 0.18952766Q+04		
IK1 28	IK2 48	IK3 67	IK4 10	N1 25	N2 45	N3 65	N4 9
CS 0	KQ 1	EPS 1	QX 1	N 46	AM (MEV) 0.19044747Q+04		
IK1 29	IK2 6	IK3 10	IK4 0	N1 26	N2 3	N3 8	N4 -1
CS 0	KQ 1	EPS 1	QX 1	N 47	AM (MEV) 0.17532488Q+04		
IK1 29	IK2 11	IK3 1	IK4 1	N1 26	N2 8	N3 -1	N4 0

IK1 29	IK2 6	IK3 10	IK4 0	N1 26	N2 3	N3 -1	N4 -1
CS 0	KQ 1	EPS 1	QX 1	N 47	AM (MEV) 0.17532488Q+04		
IK1 29	IK2 11	IK3 1	IK4 1	N1 26	N2 0	N3 -1	N4 0
CS 0	KQ 1	EPS 1	QX 1	N 48	AM (MEV) 0.17566700Q+04		
IK1 29	IK2 14	IK3 2	IK4 5	N1 26	N2 11	N3 0	N4 4
CS 0	KQ 1	EPS 1	QX 1	N 49	AM (MEV) 0.17615120Q+04		
IK1 29	IK2 16	IK3 17	IK4 1	N1 26	N2 13	N3 15	N4 0
CS 0	KQ 1	EPS 1	QX 1	N 50	AM (MEV) 0.17673616Q+04		
IK1 29	IK2 18	IK3 24	IK4 2	N1 26	N2 15	N3 22	N4 1
CS 0	KQ 1	EPS 1	QX 1	N 51	AM (MEV) 0.17744717Q+04		
IK1 29	IK2 20	IK3 22	IK4 3	N1 26	N2 17	N3 20	N4 2
CS 0	KQ 1	EPS 1	QX 1	N 52	AM (MEV) 0.17812104Q+04		
IK1 29	IK2 22	IK3 11	IK4 2	N1 26	N2 19	N3 9	N4 1
CS 0	KQ 1	EPS 1	QX 1	N 53	AM (MEV) 0.17882003Q+04		
IK1 29	IK2 23	IK3 40	IK4 2	N1 26	N2 20	N3 38	N4 1
CS 0	KQ 1	EPS 1	QX 1	N 54	AM (MEV) 0.18000281Q+04		
IK1 29	IK2 25	IK3 16	IK4 3	N1 26	N2 22	N3 14	N4 2
CS 0	KQ 1	EPS 1	QX 1	N 55	AM (MEV) 0.18051149Q+04		
IK1 29	IK2 26	IK3 38	IK4 3	N1 26	N2 23	N3 36	N4 2
CS 0	KQ 1	EPS 1	QX 1	N 56	AM (MEV) 0.18169709Q+04		
IK1 29	IK2 28	IK3 0	IK4 0	N1 26	N2 25	N3 -2	N4 -1
CS 0	KQ 1	EPS 1	QX 1	N 57	AM (MEV) 0.18244366Q+04		
IK1 29	IK2 29	IK3 15	IK4 0	N1 26	N2 26	N3 13	N4 -1
CS 0	KQ 1	EPS 1	QX 1	N 58	AM (MEV) 0.18334361Q+04		
IK1 29	IK2 30	IK3 28	IK4 2	N1 26	N2 27	N3 26	N4 1
CS 0	KQ 1	EPS 1	QX 1	N 59	AM (MEV) 0.18445179Q+04		
IK1	IK2	IK3	IK4	N1	N2	N3	N4

CS	KQ	EPS	QX	N	AM (MEV)		
0	1	1	-1	94	0.45841040Q+04		
IK1	IK2	IK3	IK4	N1	N2	N3	N4
37	22	28	13	13	-9	-6	-2
0	1	1	-1	95	0.46135972Q+04		
IK1	IK2	IK3	IK4	N1	N2	N3	N4
37	28	29	50	13	-3	-5	35
0	1	1	-1	96	0.46512352Q+04		
IK1	IK2	IK3	IK4	N1	N2	N3	N4
37	33	29	7	13	2	-5	-8
0	1	1	-1	97	0.46962269Q+04		
IK1	IK2	IK3	IK4	N1	N2	N3	N4
37	37	47	3	13	6	13	-12
0	1	1	-1	98	0.47521214Q+04		
IK1	IK2	IK3	IK4	N1	N2	N3	N4
73	104	40	54	49	73	6	39
0	1	1	-1	1227	0.71097817Q+05		

JES3 JOB NO. = 1286

//F15HDS99 JOB '10212215,GMAIN',HDSCHULZ,CLASS=X,MSGLEVEL=(0,0),

*

DATE = 82.205

ELAPSED TIME ON MAIN = AA

= 3.45 MIN., EXECUTION START TIME = 15.00.40

DDNAME =	.	.JESMSG	PRINTED ON PR3	=	3	LINES, COPIES	=	1
DDNAME =	.	.JESJCL	PRINTED ON PR3	=	4	LINES, COPIES	=	1
DDNAME =	.	.SYSMSG	PRINTED ON PR3	=	15	LINES, COPIES	=	1
DDNAME =FORT	.	.SYSPRINT	PRINTED ON PR3	=	522	LINES, COPIES	=	1
DDNAME =FORT	.	.SYSTEM	PRINTED ON PR3	=	8	LINES, COPIES	=	1
DDNAME =LKED	.	.SYSPRINT	PRINTED ON PR3	=	68	LINES, COPIES	=	1
DDNAME =GO	.	.FT06F001	PRINTED ON PR3	=	12612	LINES, COPIES	=	1

FFFFFFFFFFFF	11	5555555555	HH	HH	DDDDDDDDDD	SSSSSSSSSS	00000000	6666666666
FFFFFFFFFFFF	111	5555555555	HH	HH	DDDDDDDDDD	SSSSSSSSSS	00000000	6666666666
FF	1111	55	HH	HH	DD	SS	00	66
FF	11	55	HH	HH	DD	SS	00	66
FF	11	55	HH	HH	DD	SSS	00	66
FFFFFFF	11	5555555555	HHHHHHHHHH	HH	DD	SSSSSSSSSS	00	6666666666
FFFFFFF	11	5555555555	HHHHHHHHHH	HH	DD	SSSSSSSSSS	00	6666666666
FF	11	55	HH	HH	DD	SS	00	66
FF	11	55	HH	HH	DD	SS	00	66
FF	11	55	HH	HH	DD	SS	00	66
FF	1111111111	5555555555	HH	HH	DDDDDDDDDD	SSSSSSSSSS	00000000	6666666666
FF	1111111111	5555555555	HH	HH	DDDDDDDDDD	SSSSSSSSSS	00000000	6666666666

HH	HH	00000000	5555555555	11	7777777777	3333333333
HH	HH	0000000000	5555555555	111	7777777777	3333333333
HH	HH	00	55	1111	77	33
HH	HH	00	55	11	77	33
HH	HH	00	55	11	77	33
HHHHHHHHHH	HH	00	5555555555	11	77	3333
HHHHHHHHHH	HH	00	5555555555	11	77	3333
HH	HH	00	55	11	77	33
HH	HH	00	55	11	77	33
HH	HH	00	55	11	77	33
HH	HH	00	55	11	77	33
HH	HH	0000000000	5555555555	1111111111	77	3333333333
HH	HH	00000000	5555555555	1111111111	77	3333333333

HH	HH	00000000	5555555555	11	7777777777	3333333333
HH	HH	0000000000	5555555555	111	7777777777	3333333333
HH	HH	00	55	1111	77	33
HH	HH	00	55	11	77	33
HH	HH	00	55	11	77	33
HHHHHHHHHH	HH	00	5555555555	11	77	3333
HHHHHHHHHH	HH	00	5555555555	11	77	3333
HH	HH	00	55	11	77	33
HH	HH	00	55	11	77	33
HH	HH	00	55	11	77	33
HH	HH	00	55	11	77	33
HH	HH	0000000000	5555555555	1111111111	77	3333333333
HH	HH	00000000	5555555555	1111111111	77	3333333333

A C H T U N G !

Bei der Erstellung des Programms ist hinsichtlich der sog. Strangness S ein Programmierfehler unterlaufen, der sich jedoch nur bei dem baryonischen Ξ -Doublet bemerkbar macht. Bei richtiger Programmierung ergibt sich für dieses Doublet $S=-2$, was für die elektrischen Ladungsquantenzahlen der Doublettkomponenten $q_1=0$ und $q_2=-1$ bedingt. Im übrigen wäre zu bemerken, daß S nicht unmittelbar hinsichtlich des Massenspektrums relevant ist.

Im Computer-Ausdruck wurde diese Ξ -Doublet mit xi bezeichnet.

[illegible]

```

IAT6140 JOB ORIGIN FROM GROUP=ANYLOCAL, DSP=IJP, DEVICE=INTRDR , 000
09:18:02 DAT4403 PRTY ASSUMED TO 4, SERVICE LIMIT IS REACHED.
09:21:56 IAT2000 JOB 0173 F15HDS06 SELECTED CC GRP=MITTEL
//F15HDS06 JOB '10212215,GMAIN',HDSCHULZ,CLASS=K,MSGLEVEL=(0,0),
// MSGCLASS=T,NOTIFY=F15HDS
1 //F15HDS06 JOB '10212215,GMAIN',HDSCHULZ,CLASS=K,MSGLEVEL=(0,0),
// MSGCLASS=T,NOTIFY=F15HDS
STMT NO. MESSAGE
22 IEF686I DDNAME REFERRED TO ON DDNAME KEYWORD IN PRIOR STEP WAS NOT RESOLVED
23 IEF648I INVALID DISP FIELD- PASS SUBSTITUTED
IEF142I F15HDS06 FORT - STEP WAS EXECUTED - COND CODE 0000
IEF373I STEP /FORT / START 82223.0921
IEF374I STEP /FORT / STOP 82223.0922 CPU OMIN 00.86SEC SRB OMIN 00.04SEC VIET 664K SYS 220K
IEF142I F15HDS06 LKED - STEP WAS EXECUTED - COND CODE 0000
IEF373I STEP /LKED / START 82223.0922
IEF374I STEP /LKED / STOP 82223.0922 CPU OMIN 00.39SEC SRB OMIN 00.12SEC VIET 304K SYS 200K
IEF142I F15HDS06 GO - STEP WAS EXECUTED - COND CODE 0000
IEF373I STEP /GO / START 82223.0922
IEF374I STEP /GO / STOP 82223.0924 CPU OMIN 37.40SEC SRB OMIN 09.08SEC VIHT 72K SYS 204K
IEF375I JOB /F15HDS06/ START 82223.0921
IEF376I JOB /F15HDS06/ STOP 82223.0924 CPU OMIN 38.65SEC SRB OMIN 09.24SEC

```



```

ISN 0037      IKQ=IABS(IQX)
ISN 0038      KQ=QABS(QX)
ISN 0039      C----- TEST PRINT
ISN 0041      101 IF(IPRINT.GE.1) WRITE(6,101) IEPS,IEPSP,IEPSQ,ICS,IKQ,IX,IQX
               *-----'/'X,' EPS EPPS EPSQ CS KQ X QX'/'X,7I5)
ISN 0042      CALL GBASE
ISN 0043      C----- DEFINE EXCITATION LEVEL N
ISN 0044      ILE=5
ISN 0045      INIE=100
ISN 0046      DO 3 INI=1,INIE
ISN 0047      IN=INI-1
               IF(IN.EQ.INIE-1) IN=ILE
C----- SKIP OVER N = 1, OTHERWISE FN BECOMES IMAGINARY
C----- HERE THE RESONANCE LIMIT 'ILE' CAN BE COMPUTED
ISN 0049      IF(IN.EQ.1) GOTO 5
ISN 0051      N=QFLOAT(IN)
ISN 0052      WRITE(6,103)
ISN 0053      103 FORMAT(1X,'-----')
ISN 0054      IF(IPRINT.GE.2) WRITE(6,102) IN
ISN 0056      102 FORMAT(1X,' N = ',I5)
ISN 0057      CALL GSTRUC
ISN 0058      CALL GMASS(AM)
ISN 0059      C----- PRINT OUTPUT
ISN 0060      WRITE(6,300) ICS,IKQ,IEPS,IQX,IN,AM
               300 FORMAT(1H0,' CS KQ EPS QX N AM (MEV) '
               */'X,5I5,Q17.8)
ISN 0061      GOTO 3
ISN 0062      C----- COMPUTE THE RESONANCE LIMITS
ISN 0064      5 IF((IQG*(2-IK)*(1-IKAPPA)).EQ.1) GOTO 8
               IL1=IQINT((QFLOAT((2*(IPG+1))**2*(2-IK)*(IK+1))/(4.Q0*ALF1)*
               *(KQH+FIG))**2*(1.Q0/3.Q0)-Q1)
ISN 0065      A1=1.5Q0
ISN 0066      A2=0.5Q0
ISN 0067      A3=-3.Q0*ALF1/ALF2*(QFLOAT(IL1+IQ1)**3)
ISN 0068      QA=(3.Q0*A2-A1**2)/9.Q0
ISN 0069      RA=(9.Q0*A1*A2-27.Q0*A3-2.Q0*A1**3)/54.Q0
ISN 0070      DA=QSQRT(QA**3+RA**2)
ISN 0071      SA=(RA+DA)**(1.Q0/3.Q0)
ISN 0072      TA=(RA-DA)**(1.Q0/3.Q0)
ISN 0073      IL2=IQINT(SA+TA-A1/3.Q0-Q2)
ISN 0074      IL3=IQINT(QSQRT(2.Q0*ALF2/ALF3*QFLOAT(IL2+IQ2)**2+0.25Q0)-0.5Q0
               *-Q3)
ISN 0075      IL4=IQINT(ALF3*QFLOAT(IL3+IQ3)-Q4)
ISN 0076      C----- (7-2) DETERMINE MAXIMUM N = ILE
               TEMP1=(ALF1*QFLOAT((IL1+IQ1)**3)+ALF2*QFLOAT((IL2+IQ2)**2)+
               *ALF3*QFLOAT(IL3+IQ3)+QEXP(QFLOAT((1-2*IK)*(IL4+IQ4))/(3.Q0*Q4)))/
               *WGX-1.Q0
ISN 0077      TEMP2=QFLOAT(1-IQG*(2-IK)*(1-IKAPPA))
ISN 0078      DO 6 ILS=1,50000
ISN 0079      ILT=ILS-1
ISN 0080      IF(ILT.EQ.1) GOTO 6
ISN 0082      LT=QFLOAT(ILT)
ISN 0083      FT=TEMP2*(AGX*LT/(LT+2.Q0)+BGX*QSQRT(QFLOAT(ILT*(ILT-2))))
ISN 0084      IF(FT.LE.TEMP1) GOTO 6
ISN 0086      ILE=ILT-1
ISN 0087      GOTO 7
ISN 0088      6 CONTINUE
               C----- PRINT MAXIMUM PARAMETER

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00004300
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*VERSION 1.3.0 (01 MAY 80)

SYSTEM/370 FORTRAN H EXTENDED (ENHANCED)

DATE 82.223/09.22.03

PAGE 1

REQUESTED OPTIONS: NODECK, NOLIST, OPT(0)

OPTIONS IN EFFECT: NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(MAX) AUTODBL(NONE)

SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF ALC NOANSF TERM IBM FLAG(I)

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C      17/03/82 208110906 MEMBER NAME GPROG (HEIMS)          FORTRAN          00000000
C----- PROGRAM READS AS INPUT (BARYON NUMBER +1) = K          00000100
C----- 2 * ISOSPIN = PG          00000200
C----- 2 * SPIN = QG          00000300
C----- DUBLETT FACTOR = KAPPA          00000400
ISN 0002      IMPLICIT REAL*16 (A-H,J-Z)          00000500
ISN 0003      DIMENSION T1(5),T2(5),T3(5),T4(5)          00000600
ISN 0004      COMMON /CONST/ PI,HQ,C,GAM,RG,S0,FAKMEV,ETA,THETA,EQ,ALFA,AMU,          00000700
ISN 0005      *ALFP,ALFM,XI,EBN,BETA,IPRINT          00000800
ISN 0006      COMMON /QUANT/ N,K,PG,QG,KQ,KAPPA,N1,N2,N3,N4,CS,IK,IPG,IQG,          00000900
      *IKAPPA,EPS,QX,IN,IN1,IN2,IN3,IN4,ICS,IEPS,IQX,IX,IKQ,X,          00001000
      *IK1,IK2,IK3,IK4          00001010
      COMMON /EXCHA/ WGX,AGX,BGX,ALF1,ALF2,ALF3,FN,Q1,Q2,Q3,Q4,          00001020
      *AN1,AN2,AN3,FIG,GKQ,WGXK,AN,AQ,KGH,          00001030
      *IQ1,IQ2,IQ3,IQ4          00001040
ISN 0007      C----- PRINT TITLE          00001041
ISN 0008      902  FORMAT(1X,'*****')          00001042
      *'/1X,' * MASSENFORMEL DER ELEMENTARTEILCHEN NACH B. HEIM *          00001043
      *'/1X,' * (H. D. SCHULZ, 26/7/82) *          00001044
      *'/1X,' *          00001045
C----- READ IPRINT          00001046
      READ(5,900) TEXT,IPRINT          00001048
ISN 0009      900  FORMAT(A16,I3)          00001050
ISN 0010      WRITE(6,901) TEXT,IPRINT          00001060
ISN 0011      901  FORMAT(1X,A16,I3)          00001070
ISN 0012      CALL GINIT          00001080
ISN 0013      READ(5,400) IJA,IJE          00001100
ISN 0014      400  FORMAT(2I5)          00001110
ISN 0015      DO 4 IJ=IJA,IJE          00001120
ISN 0016      READ(5,100) TEXT,T1,IK,T2,IPG,T3,IQG,T4,IKAPPA          00001130
ISN 0017      100  FORMAT(A16/,3(5A4,I2/),5A4,I2)          00001200
ISN 0018      WRITE(6,200) TEXT,T1,IK,T2,IPG,T3,IQG,T4,IKAPPA          00001300
ISN 0019      200  FORMAT(1X,A16/,4(1X,5A4,I2/))          00001400
ISN 0020      K=QFLOAT(IK)          00001500
ISN 0021      PG=QFLOAT(IPG)          00001600
ISN 0022      QG=QFLOAT(IQG)          00001700
ISN 0023      KAPPA=QFLOAT(IKAPPA)          00001800
ISN 0024      C----- DEFINE PARTICLE -ANTIPARTICLE -> EPS          00001900
      DO 1 IEPSI=1,1          00002000
      IEPS=-(-1)**IEPSI          00002100
      EPS=QFLOAT(IEPSI)          00002200
C----- COMPUTATION OF STRANGENESS          00002300
C----- (1-3)          00002400
      ITEMP1=IQG*(IKAPPA+IBINOM(IPG,2))          00002500
      IEPSI=IEPS*(-1)**MOD(ITEMP1,2)          00002600
ISN 0028      C----- (1-4)          00002700
ISN 0029      ITEMP2=IQG*(IQG*(IK-1)+IBINOM(IPG,2))          00002800
      IEPSQ=IEPS*(-1)**MOD(ITEMP2,2)          00002900
ISN 0030      C----- (1-1)          00003000
ISN 0031      ICS=2/(IK*(1+IKAPPA))*(IPG*IEPSI+IQG*IEPSQ)*(IK-1+IKAPPA)          00003100
ISN 0032      CS=QFLOAT(ICS)          00003200
ISN 0033      C----- DEFINE ISO MULTIPLET COMPONENT          00003300
      IXE=IPG+1          00003400
ISN 0034      DO 2 IX=1,IXE          00003500
ISN 0035

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C----- (1-5) F(K,PG,QG,KAPPA,EPS) INTEGER
ISN 0036      X=QFLOAT(IX)
ISN 0037      IQX=((IPG+2-2*IX)*(1-IKAPPA*IQG*(2-IK))+ICS+IEPS*(IK-1-(1+IKAPPA)
ISN 0038      *IQG*(2-IK)))/2
ISN 0039      QX=QFLOAT(IQX)
ISN 0040      C----- COMPUTE CHARGE KQ
ISN 0041      IKQ=IABS(IQX)
ISN 0042      KQ=QABS(QX)
ISN 0043      C----- TEST PRINT
ISN 0044      IF(IPRINT.GE.1) WRITE(6,101) IEPS,IEPSP,IEPSQ,ICS,IKQ,IX,IQX
ISN 0045      101  FORMAT(1X,'=====')
ISN 0046      *===== '/1X,' EPS EPPSP EPSQ  CS  KQ  X  QX' /1X,715)
ISN 0047      CALL GBASE
ISN 0048      C----- DEFINE EXCITATION LEVEL N
ISN 0049      ILE=5
ISN 0050      INIE=112
ISN 0051      DO 3 INI=1,INIE
ISN 0052      IN=INI-1
ISN 0053      IF(IN.EQ.INIE-1) IN=ILE
ISN 0054      C----- SKIP OVER N = 1, OTHERWISE FN BECOMES IMAGINARY
ISN 0055      C----- HERE THE RESONANCE LIMIT 'ILE' CAN BE COMPUTED
ISN 0056      IF(IN.EQ.1) GOTO 5
ISN 0057      N=QFLOAT(IN)
ISN 0058      WRITE(6,103)
ISN 0059      103  FORMAT(1X,'-----')
ISN 0060      IF(IPRINT.GE.2) WRITE(6,102) IN
ISN 0061      102  FORMAT(1X,' N = ',I5)
ISN 0062      CALL GSTRUC
ISN 0063      CALL GMASS(AM)
ISN 0064      C----- PRINT OUTPUT
ISN 0065      WRITE(6,300) ICS,IKQ,IEPS,IQX,IN,AM
ISN 0066      300  FORMAT(1H0,' CS  KQ  EPS  QX  N  AM (MEV) '
ISN 0067      * /1X,5I5,Q17.8)
ISN 0068      GOTO 3
ISN 0069      C----- COMPUTE THE RESONANCE LIMITS
ISN 0070      5  IF((IQG*(2-IK)*(1-IKAPPA)).EQ.1) GOTO 8
ISN 0071      IL1=IQINT((QFLOAT((2*(IPG+1))*((2-IK)*(IK+1))/(4.Q0*ALF1)*
ISN 0072      *(KQH+FIG))*((1.Q0/3.Q0)-Q1)
ISN 0073      A1=1.5Q0
ISN 0074      A2=0.5Q0
ISN 0075      A3=-3.Q0*ALF1/ALF2*(QFLOAT(IL1+IQ1)**3)
ISN 0076      QA=(3.Q0*A2-A1**2)/9.Q0
ISN 0077      RA=(9.Q0*A1*A2-27.Q0*A3-2.Q0*A1**3)/54.Q0
ISN 0078      DA=QSQRT(QA**3+RA**2)
ISN 0079      SA=(RA+DA)**(1.Q0/3.Q0)
ISN 0080      TA=(RA-DA)**(1.Q0/3.Q0)
ISN 0081      IL2=IQINT(SA+TA-A1/3.Q0-Q2)
ISN 0082      IL3=IQINT(QSQRT(2.Q0*ALF2/ALF3*QFLOAT(IL2+IQ2)**2+0.25Q0)-0.5Q0
ISN 0083      *-Q3)
ISN 0084      IL4=IQINT(ALF3*QFLOAT(IL3+IQ3)-Q4)
ISN 0085      C----- (7-2) DETERMINE MAXIMUM N = ILE
ISN 0086      TEMP1=(ALF1*QFLOAT((IL1+IQ1)**3)+ALF2*QFLOAT((IL2+IQ2)**2)+
ISN 0087      *ALF3*QFLOAT(IL3+IQ3)+QEXP(QFLOAT((1-2*IK)*(IL4+IQ4))/(3.Q0*Q4)))/
ISN 0088      *WGX-1.Q0
ISN 0089      TEMP2=QFLOAT(1-IQG*(2-IK)*(1-IKAPPA))
ISN 0090      DO 6 ILS=1,50000
ISN 0091      ILT=ILS-1
ISN 0092      IF(ILT.EQ.1) GOTO 6
ISN 0093      LT=QFLOAT(ILT)

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ISN 0085 FT=TEMP2*(AGX*LT/(LT+2.Q0)+BGX*QSQR(QFLOAT(ILT*(ILT-2)))) 00006299
ISN 0086 IF (FT.LE.TEMP1) GOTO 6 00006300
ISN 0088 ILE=ILT-1 00006301
ISN 0089 GOTO 7 00006302
ISN 0090 6 CONTINUE 00006304
C----- PRINT MAXIMUM PARAMETER 00006305
ISN 0091 7 WRITE(6,500) ILE,IL1,IL2,IL3,IL4 00006306
ISN 0092 500 FORMAT(1X,' ILE IL1 IL2 IL3 IL4'/1X,5I5) 00006308
ISN 0093 IF (IPRINT.GE.2) WRITE(6,600) A1,A2,A3,QA,RA,DA,SA,TA,TEMP1,TEMP2,FT 00006309
ISN 0095 600 FORMAT(1X,11Q11.3) 00006310
ISN 0096 3 CONTINUE 00006317
ISN 0097 GOTO 2 00006318
C----- NO EXCITATION POSSIBLE 00006327
ISN 0098 8 WRITE(6,700) 00006337
ISN 0099 700 FORMAT(1X,'*** NO EXCITATION POSSIBLE ***') 00006347
ISN 0100 2 CONTINUE 00006400
ISN 0101 1 CONTINUE 00006500
ISN 0102 WRITE(6,800) 00006501
ISN 0103 800 FORMAT(1X,'*****') 00006502
ISN 0104 4 CONTINUE 00006510
ISN 0105 STOP 00006600
ISN 0106 END 00006700
```

*OPTIONS IN EFFECT*NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(MAX) AUTODBL(NONE)

*OPTIONS IN EFFECT*SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF ALC NOANSF TERM IBM FLAG(I)

STATISTICS SOURCE STATEMENTS = 105, PROGRAM SIZE = 6016, SUBPROGRAM NAME = MAIN

STATISTICS NO DIAGNOSTICS GENERATED

***** END OF COMPILATION *****

68K BYTES OF CORE NOT USED

*VERSION 1.3.0 (01 MAY 80)

REQUESTED OPTIONS: NODECK, NOLIST, OPT(0)

OPTIONS IN EFFECT: NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(MAX) AUTODBL(NONE)

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SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF ALC NOANSF TERM IBM FLAG(I)

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C 17/03/82 208091701 MEMBER NAME GINIT (HEIMS) FORTRAN 00000000
ISN 0002 SUBROUTINE GINIT 00000100
C----- INITIALISIERT KONSTANTE GROESSEN IM COMMON /CONST/ 00000200
ISN 0003 IMPLICIT REAL*16 (A-H,J-Z) 00000300
ISN 0004 COMMON /CONST/ PI,HQ,C,GAM,RG,SO,FAKMEV,ETA,THETA,EQ,ALFA,AMU, 00000400
*ALFP,ALFM,XI,EBN,BETA,IPRINT 00000500
ISN 0005 COMMON /PARMAT/ A11,A12,A13,A14,A15,A16,A21,A22,A23,A24,A25,A26, 00000510
*A31,A32,A33,A34,A35,A36,A41,A42,A43,A44,A45,A46, 00000520
*A51,A52,A53,A54,A55,A56,A61,A62,A63,A64,A65,A66 00000530
PI=3.1415926535Q0 00000600
ISN 0006 EBN=QEXP(1.00) 00000700
ISN 0007 HQ=1.0545887Q-34 00000800
ISN 0008 C=2.99792458Q8 00000900
ISN 0009 GAM=6.6732Q-11 00001000
ISN 0010 RG=376.73037659Q0 00001100
ISN 0011 SO=1.00 00001200
ISN 0012 FAKMEV=0.05609545Q31 00001300
ISN 0013 XI=1.61803399Q0 00001310
ISN 0014 C----- (2B,2-1) # CONST REAL 00001400
ETA=PI/(4.Q0+PI**4)**0.25Q0 00001500
ISN 0015 C----- (2A,2-2) # CONST REAL 00001600
THETA=5.Q0*ETA+2.Q0*QSQR(ETA)+1.Q0 00001700
ISN 0016 C----- (2,2-5) F(CONST) 00001800
EQ=3.Q0/(4.Q0*PI**2)*QSQR(2.Q0*THETA*HQ/RG) 00001900
ISN 0017 C----- (22) 00002000
ALFA=1.Q0/137.03602725Q0 00002100
ISN 0018 C----- (2-6) 00002110
BETA=1.Q0/1.00001411Q0 00002120
ISN 0019 C----- (3-1) 00002200
AMU=PI**0.25Q0*(3.Q0*PI*SO*GAM*HQ)**(1.Q0/3.Q0)*QSQR(C*HQ/(3.Q0* 00002300
*GAM))/(C*SO) 00002400
ISN 0021 C----- (3-3) # CONST REAL 00002500
TEMP1=1.Q0-2.Q0/3.Q0*XI*ETA**2*(1.Q0-QSQR(ETA)) 00002600
ISN 0022 ALFP=TEMP1/(ETA**2*ETA**((1.Q0/3.Q0))-1.Q0 00002800
ISN 0023 ALFM=TEMP1/(ETA*ETA**((1.Q0/3.Q0))-1.Q0 00002900
C----- SCHREIBE DIE KONSTANTEN AUS 00003200
ISN 0024 WRITE(6,100) PI,EBN,HQ,C,GAM,RG,SO,FAKMEV,ETA,THETA,EQ,ALFA,BETA, 00003300
*AMU,ALFP,ALFM,XI 00003400
ISN 0025 100 FORMAT(1X,'EINGEGEBENE KONSTANTEN: '/1X,'-----'/' 00003500
*1X,'PI = ',F12.8/ 00003600
*1X,'BASIS OF NATURAL LOGARITHM: EBN = ',F12.8/ 00003700
*1X,'PLANCK WIRKUNGSQUANTUM/(2*PI): HQ = ',Q14.8,' (WS*S) '/' 00003800
*1X,'LICHTGESCHWINDIGKEIT : C = ',Q14.8,' (M/S) '/' 00003900
*1X,'GRAVITATIONSKONSTANTE : GAM = ',Q14.8,' (M**3*KG**-1*S**- 00004000
*2) '/' 00004100
*1X,'WELLENWIDERSTAND DES VAKUUMS: RG = ',F14.8,' (OHM) '/' 00004200
*1X,'EINHEITSSTRECKE: SO = ',F14.8,' (M) '/' 00004300
*1X,'ABGELEITETE KONSTANTE: '/1X,'-----'/' 00004400
*1X,'UMRECHNUNG KG - MEV: FAKMEV = ',Q14.8,' (MEV/KG) '/' 00004500
*1X,'ZAHLENFAKTOR: ETA = ',Q14.8/ 00004600
*1X,'ZAHLENFAKTOR: THETA = ',Q14.8/ 00004700
*1X,'ELEMENTARLADUNG: EQ = ',Q14.8,' (A*S) '/' 00004800
*1X,'FEINSTRUKTURKONSTANTE: ALFA = ',Q14.8/ 00004900
*1X,'STARKE" KONSTANTE: BETA = ',Q14.8/ 00004910
*1X,'MASSENFaktor: AMU = ',Q14.8,' (KG) '/' 00005000

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*1X, ZAHLENFAKTOR ALPHA PLUS: ALFP = ,Q14.8/
*1X, ZAHLENFAKTOR ALPHA MINUS: ALFM = ,Q14.8/
*1X, ZAHLENFAKTOR: XI = ,Q14.8/)
C----- (4-8) PARAMETER MATRIX REAL
A11=XI**2*(PI*EBN*XI)**2*(1.Q0-4.Q0*PI*ALFA**2)/(2.Q0*ETA**2)
A12=2.Q0*PI*EBN*XI**2*(THETA/8.Q0-PI*EBN*ETA*ALFA**2/3.Q0)/3.Q0
A13=3.Q0*(4.Q0+ETA*ALFA)*(1.Q0-ETA**2/5.Q0*((1.Q0-QSQRT(ETA))/
*(1.Q0+QSQRT(ETA)))**2)
A14=(1.Q0+3.Q0*ETA/(4.Q0*XI))*(2.Q0*ETA*ALFA-EBN**2*XI*
*((1.Q0-QSQRT(ETA))/(1.Q0+QSQRT(ETA)))**2)/ALFA
A15=EBN**2*(1.Q0-2.Q0*EBN*ALFA**2/ETA)/3.Q0
A16=(PI*EBN)**2*(1.Q0+ALFA/(5.Q0*ETA))*(1.Q0+6.Q0*ALFA/PI))
A21=2.Q0*(EBN*ALFA/(2.Q0*ETA))**2*(1.Q0-ALFA/(2.Q0*XI**2))
A22=XI*(1.Q0-XI*(ALFA*XI/ETA**2)**2)/12.Q0
A23=(ETA**2+6.Q0*XI*ALFA**2)/EBN
A24=2.Q0*XI**2/(3.Q0*ETA)
A25=XI*(PI*EBN)**2*(1.Q0-BETA**2)
A26=2.Q0*(1.Q0-PI/2.Q0*(EBN*XI*ALFA)**2*QSQRT(ETA))/(EBN*XI**2)
C----- (5-1) REAL
A31=(PI*EBN*ALFA)**2*(1.Q0-(PI*EBN)**2*(1.Q0-BETA**2))
A32=XI**2*(1.Q0+(2.Q0*EBN*ALFA/ETA)**2)/6.Q0
A33=(PI*EBN*XI*ALFA)**2*(1.Q0-2.Q0*PI*(EBN*XI)**2*(1.Q0-
*BETA**2))
A34=ETA*QSQRT(2.Q0*PI*ETA)
A35=3.Q0*ALFA/(EBN*XI**2)
A36=1.Q0/(1.Q0-PI*EBN*(XI*EBN)**2*(1.Q0-BETA**2))
A41=(XI*(2.Q0+(XI*ALFA)**2)-2.Q0*BETA)/(2.Q0*BETA-ALFA)
A42=PI*XI**2*ETA*(BETA-3.Q0*ALFA)/2.Q0
A43=XI/2.Q0
A44=2.Q0*(ETA/XI)**2
A45=(3.Q0*BETA-ALFA)/(6.Q0*XI)
A46=PI*EBN/(XI*ETA)-EBN*ETA**2*ALFA/2.Q0
A51=(2.Q0*ALFA+1.Q0)**2
A52=6.Q0*ALFA/ETA**2
A53=(XI/ETA)**3
A54=ALFA*(BETA-ALFA)*QSQRT(3.Q0/2.Q0)
A55=XI**3
A56=(XI/ETA)**4
A61=PI*XI*(2.Q0*BETA-ALFA)/(12.Q0*BETA)
A62=PI**2*(BETA-2.Q0*ALFA)/12.Q0
A63=QSQRT(ETA)/9.Q0
A64=PI/(3.Q0*ETA)
A65=PI/(3.Q0*XI)
A66=XI*ETA
WRITE(6,200) A11,A12,A13,A14,A15,A16,A21,A22,A23,A24,A25,A26,
*A31,A32,A33,A34,A35,A36,A41,A42,A43,A44,A45,A46,
*A51,A52,A53,A54,A55,A56,A61,A62,A63,A64,A65,A66
200 FORMAT(1X,'PARAMETER MATRIX'/(1X,6Q16.8/))
WRITE(6,300)
300 FORMAT(1X/1X,'=====')
*'/1X, ' BEZEICHNUNGEN: '
*'/1X, ' CS = STRANGENESS QUANTENZAHL '
*'/1X, ' KQ = LADUNGSQUANTENZAHL, ABSOLUTWERT '
*'/1X, ' EPS = /1/-1/ TEILCHEN/ANTITEILCHEN '
*'/1X, ' QX = LADUNGSQUANTENZAHL MIT VORZEICHEN '
*'/1X, ' N = HAUPTQUANTENZAHL (GRUNDZUSTAND N = 0) '
*'/1X, ' AM = MASSE DES TEILCHENS '
*'/1X, ' DIE UEBRIGEN GROESSEN SIND '
*'/1X, ' GANZZAHLIGE STRUKTURKONSTANTE '

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ISN 0063
ISN 0064
ISN 0065

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200 *A51,A52,A53,A54,A55,A56,A61,A62,A63,A64,A65,A66,  
    FORMAT(1X,'PARAMETER MATRIX'/(1X,6Q16.8/))  
    WRITE(6,300)  
300 *A51,A52,A53,A54,A55,A56,A61,A62,A63,A64,A65,A66,  
    FORMAT(1X/1X, '=====')  
    * /1X, 'BEZEICHNUNGEN:'  
    * /1X, 'CS = STRANGENESS QUANTENZAHL'  
    * /1X, 'KQ = LADUNGSQUANTENZAHL, ABSOLUTWERT'  
    * /1X, 'EPS = /1/-1/ TEILCHEN/ANTITEILCHEN'  
    * /1X, 'QX = LADUNGSQUANTENZAHL MIT VORZEICHEN'  
    * /1X, 'N = HAUPTQUANTENZAHL (GRUNDZUSTAND N = 0)'  
    * /1X, 'AM = MASSE DES TEILCHENS'  
    * /1X, 'DIE UEBRIGEN GROESSEN SIND'  
    * /1X, 'GANZZAHLIGE STRUKTURKONSTANTE'
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00005371
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ISN 0066
ISN 0067

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* /1X,  
* )  
RETURN  
END
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*OPTIONS IN EFFECT*NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(MAX) AUTODBL(NONE)  
*OPTIONS IN EFFECT*SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF ALC NOANSF TERM IBM FLAG(I)  
*STATISTICS* SOURCE STATEMENTS = 66, PROGRAM SIZE = 8800, SUBPROGRAM NAME = GINIT  
*STATISTICS* NO DIAGNOSTICS GENERATED  
***** END OF COMPILATION *****
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68K BYTES OF CORE NOT USED


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C 17/03/82 207141003 MEMBER NAME GBASE (HEIMS) FORTRAN 00000000
ISN 0002 SUBROUTINE GBASE 00000100
C---- ROUTINE COMPUTES NUMBERS FOR THE GROUND LEVEL N=0 00000200
ISN 0003 IMPLICIT REAL*16 (A-H, J-Z) 00000300
ISN 0004 COMMON /CONST/ PI, HQ, C, GAM, RG, SO, FAKMEV, ETA, THETA, EQ, ALFA, AMU, 00000400
*ALFP, ALFM, XI, EBN, BETA, IPRINT 00000500
ISN 0005 COMMON /QUANT/ N, K, PG, QG, KQ, KAPPA, N1, N2, N3, N4, CS, IK, IPG, IQG, 00000510
*IKAPPA, EPS, QX, IN, IN1, IN2, IN3, IN4, ICS, IEPS, IQX, IX, IKQ, X, 00000520
*IK1, IK2, IK3, IK4 00000620
ISN 0006 COMMON /EXCHA/ WGX, AGX, BGX, ALF1, ALF2, ALF3, FN, Q1, Q2, Q3, Q4, 00000800
*AN1, AN2, AN3, FIG, GKQ, WGK, AN, AQ, KGH, 00000900
*IQ1, IQ2, IQ3, IQ4 00001000
ISN 0007 COMMON /PARMAT/ A11, A12, A13, A14, A15, A16, A21, A22, A23, A24, A25, A26, 00001010
*A31, A32, A33, A34, A35, A36, A41, A42, A43, A44, A45, A46, 00001020
*A51, A52, A53, A54, A55, A56, A61, A62, A63, A64, A65, A66 00001030
ISN 0008 C---- GROESSEN, DIE ALLEIN VON K ABHAENGEN 00001100
IS=IK**2+1 00001110
ISN 0009 C---- (3-6) # F(K) INTEGER 00001200
ISN 0010 IQ1=3*2** (IS-2) 00001300
Q1=QFLOAT(IQ1) 00001400
C---- (3-6) # F(K) INTEGER 00001500
ISN 0011 IQ2=2**IS-1 00001600
ISN 0012 Q2=QFLOAT(IQ2) 00001700
C---- (3-6) # F(K) INTEGER 00001800
ISN 0013 IQ3=2**IS+2* (-1) **IK 00001900
ISN 0014 Q3=QFLOAT(IQ3) 00002000
C---- (3-6) # F(K) INTEGER 00002100
ISN 0015 IQ4=2** (IS-1) -1 00002200
ISN 0016 Q4=QFLOAT(IQ4) 00002300
C---- GROESSEN DIE ZUSAETZLICH NOCH VON DER LADUNGSQUANTENZAHLE KQ 00002400
C---- ABHAENGEN 00002500
C---- (3-5) # F(KQ, K) REAL 00003310
ISN 0017 ALF1=(1.Q0+QSQRT(ETAQK(KQ, K)))/2.Q0 00003320
C---- (3-5) # F(KQ, K) REAL 00003400
ISN 0018 AN1=ALF1 00003500
C---- (3-5) # F(KQ, K) 00003510
ISN 0019 ALF2=1.Q0/ETAQK(KQ, K) 00003520
C---- (3-5) # F(KQ, K) REAL 00003600
ISN 0020 AN2=2.Q0*ALF2/3.Q0 00003700
C---- (3-5) # F(KQ, K) REAL 00003710
ISN 0021 ALF3=QEXP(K-1.Q0)/K-KQ*(ALFA/3.Q0*(1.Q0+QSQRT(ETAQK(KQ, K)))* 00003711
*(XI/ETAQK(KQ, K)**2)**(2*IK+1)*ETAQK(KQ, K)**3+ETAQK(1.Q0, 1.Q0)/ 00003712
*(EBN*ETAQK(KQ, K))*(2.Q0*X1*ETAQK(KQ, K))**IK*((1.Q0- 00003713
*QSQRT(ETAQK(KQ, K)))/(1.Q0+QSQRT(ETAQK(KQ, K)))*2) 00003714
C---- (3-5) # F(KQ, K) REAL 00004100
ISN 0022 AN3=2.Q0*ALF3 00004200
C---- PRINT INTERMEDIATE RESULTS 00004210
ISN 0023 WRITE(6, 300) IS, IQ1, IQ2, IQ3, IQ4 00004211
ISN 0024 300 FORMAT(1X, ' IS IQ1 IQ2 IQ3 IQ4'/1X, 5I5) 00004212
ISN 0025 IF(IPRINT.GE.2) WRITE(6, 100) ALF1, ALF2, ALF3, AN1, AN2, AN3 00004220
ISN 0027 100 FORMAT(1X, ' ALF1 ALF2 ALF3 00004230
* AN1 AN2 AN3'/1X, 6Q16.8) 00004240
C---- (4-2) REAL 00004341
ISN 0028 GKQ=Q1**3*ALF1+Q2**2*ALF2+Q3*ALF3+QEXP((1.Q0-2.Q0*K)/3.Q0) 00004441
C---- (4-3) REAL 00004553

```



```

ISN 0002      C 17/05/82 207140951 MEMBER NAME GSTRUC (HEIMS) FORTRAN 00000000
               SUBROUTINE GSTRUC 00000100
C----- ROUTINE CALCULATES THE STRUCTURE PARAMETERS N1,N2,N3,N4 00000200
C----- AUS DEN QUANTENZAHLEN IM COMMON /QUANT/ UND DEN KONSTANTEN 00000300
C----- IM COMMON /CONST/ 00000400
ISN 0003      IMPLICIT REAL*16 (A-H,J-Z) 00000500
ISN 0004      COMMON /CONST/ PI,HQ,C,GAM,RG,S0,FAKMEV,ETA,THETA,EQ,ALFA,AMU, 00000600
               *ALFP,ALFM,XI,EBN,BETA,IPRINT 00000700
ISN 0005      COMMON /QUANT/ N,K,PG,QG,KQ,KAPPA,N1,N2,N3,N4,CS,IK,IPG,IQG, 00000710
               *IKAPPA,EPS,QX,IN,IN1,IN2,IN3,IN4,ICS,IEPS,IQX,IX,IKQ,X, 00000720
               *IK1,IK2,IK3,IK4 00000721
ISN 0006      COMMON /EXCHA/ WGX,AGX,BGX,ALF1,ALF2,ALF3,FN,Q1,Q2,Q3,Q4, 00000730
               *AN1,AN2,AN3,FIG,GKQ,WGXK,AN,AQ,KGH, 00000740
               *IQ1,IQ2,IQ3,IQ4 00000750
C----- COMPUTE FN=F(N) 00001300
C----- (5-2) F(KQ,K,PG,KAPPA,EPS,IQ) REAL 00001400
ISN 0007      FN=(1.Q0-QG*(2.Q0-K)*(1.Q0-KAPPA))* (AGX*N/(N+2.Q0)+BGX* 00001500
               *QSORT(N*(N-2.Q0))) 00001510
C----- TEST PRINT 00001600
ISN 0008      IF (IPRINT.GE.2) WRITE(6,101) FN 00001700
ISN 0010      101 FORMAT(1X,'FN = ',Q14.5) 00001800
C----- DETERMINATION OF STRUCTURE PARAMETERS 00001900
C----- (6-1) 00002000
ISN 0011      W1=WX*(1.Q0+FN) 00002100
ISN 0012      TEMP=(W1/ALF1)**(1.Q0/3.Q0) 00002200
ISN 0013      IK1=IQINT(TEMP) 00002300
ISN 0014      IN1=IK1-IQ1 00002400
ISN 0015      N1=QFLOAT(IN1) 00002500
C----- 00002600
ISN 0016      W2=W1-QFLOAT(IK1)**3*ALF1 00002700
ISN 0017      TEMP=QSORT(W2/ALF2) 00002800
ISN 0018      IK2=IQINT(TEMP) 00002900
ISN 0019      IN2=IK2-IQ2 00003000
ISN 0020      N2=QFLOAT(IN2) 00003100
C----- 00003200
ISN 0021      W3=W2-QFLOAT(IK2)**2*ALF2 00003300
ISN 0022      TEMP=W3/ALF3 00003400
ISN 0023      IK3=IQINT(TEMP) 00003500
ISN 0024      IN3=IK3-IQ3 00003600
ISN 0025      N3=QFLOAT(IN3) 00003700
C----- 00003800
ISN 0026      W4=W3-QFLOAT(IK3)*ALF3 00003900
ISN 0027      IF(W4.EQ.0.Q0) GOTO 1 00003910
ISN 0029      IF(W4.GT.1.Q0) GOTO 3 00003920
ISN 0031      REST=QFLOAT(2*IK-1)/QFLOAT(3*IQ4) 00004000
ISN 0032      TEMP=-QLOG(W4)/REST 00004100
ISN 0033      IK4=IQINT(TEMP) 00004200
ISN 0034      GOTO 2 00004210
ISN 0035      1 IK4=IQINT(ALF3*QFLOAT(IK3)) 00004220
ISN 0036      GOTO 2 00004230
ISN 0037      3 IK3=IK3-1 00004240
ISN 0038      IN3=IK3-IQ3 00004250
ISN 0039      N3=QFLOAT(IN3) 00004260
ISN 0040      IK4=IK4+IQINT(ALF3*QFLOAT(IK3)) 00004270
ISN 0041      2 IN4=IK4-IQ4 00004300

```


ISN 0040
ISN 0041

2

IK1=IK4+IQINT(ALF3*QFLOAT(IK3))
IN4=IK4-IQ4

00004270
00004300

```
*VERSION 1.3.0 (01 MAY 80)  GSTRUC  SYSTEM/370 FORTRAN H EXTENDED (ENHANCED)  DATE 82.223/09.22.05  PAGE  2
ISN 0042      N4=QFLOAT(IN4)
C----- TEST AUSDRUCK
ISN 0043      IF(IPRINT.GE.2) WRITE(6,200) W1,W2,W3,W4,REST
ISN 0045      200  FORMAT(1X,'          W1          W2          W3          W4          REST',/1X,5Q16.8)
ISN 0046      WRITE(6,100) IK1,IK2,IK3,IK4,IN1,IN2,IN3,IN4
ISN 0047      100  FORMAT(1X,' IK1  IK2  IK3  IK4  N1  N2  N3  N4',/1X,8I5)
ISN 0048      RETURN
ISN 0049      END
*OPTIONS IN EFFECT*NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(MAX) AUTODBL(NONE)
*OPTIONS IN EFFECT*SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF ALC NOANSF TERM IBM FLAG(I)
*STATISTICS*  SOURCE STATEMENTS = 48, PROGRAM SIZE = 2356, SUBPROGRAM NAME =GSTRUC
*STATISTICS*  NO DIAGNOSTICS GENERATED
***** END OF COMPILATION *****
```

84K BYTES OF CORE NOT USED

ISN 0083
ISN 0084
ISN 0086
ISN 0087
ISN 0088

FT=TEMP2*(AGX*LT/(LT+2.00)+BGX*QSQR(QFLOAT(ILT*(ILT-2))))
IF (FT.LE.TEMP1) GOTO 6
ILE=ILT-1
GOTO 7
CONTINUE
6----- PRINT MAXIMUM PARAMETER

00006298
00006299
00006300
00006301
00006302
00006304
00006305

*VERSION 1.3.0 (01 MAY 80)

ISN 0089
ISN 0090
ISN 0091
ISN 0093
ISN 0094
ISN 0095

7
500
600
3

MAIN SYSTEM/370 FORTRAN H EXTENDED (ENHANCED)
WRITE(6,500) ILE,IL1,IL2,IL3,IL4
FORMAT(1X,' ILE IL1 IL2 IL3 IL4 '/1X,5I5)
IF (IPRINT.GE.2) WRITE(6,600) A1,A2,A3,QA,RA,DA,SA,TA,TEMP1,TEMP2,FT
FORMAT(1X,11Q11.3)
CONTINUE
GOTO 2

DATE 82.205/15.00.44

PAGE 3

00006306
00006308
00006309
00006310
00006317
00006318
00006327
00006337
00006347
00006400
00006500
00006501
00006502
00006510
00006600
00006700

ISN 0096
ISN 0097
ISN 0098
ISN 0099
ISN 0100
ISN 0101
ISN 0102
ISN 0103
ISN 0104

8
700
2
1
800
4

C----- NO EXCITATION POSSIBLE
WRITE(6,700)
FORMAT(1X,'*** NO EXCITATION POSSIBLE ***')
CONTINUE
CONTINUE
WRITE(6,800)
FORMAT(1X,'*****')
CONTINUE
STOP
END

*OPTIONS IN EFFECT*NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(MAX) AUTODBL(NONE)
*OPTIONS IN EFFECT*SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF ALC NOANSF TERM IBM FLAG(1)
STATISTICS SOURCE STATEMENTS = 103, PROGRAM SIZE = 5756, SUBPROGRAM NAME = MAIN
STATISTICS NO DIAGNOSTICS GENERATED
***** END OF COMPILATION *****

68K BYTES OF CORE NOT USED

*VERSION 1.3.0 (01 MAY 80) SYSTEM/370 FORTRAN H EXTENDED (ENHANCED) DATE 82.223/09.22.06 PAGE 1
 REQUESTED OPTIONS: NODUCK, NOLIST, OPT(0)
 OPTIONS IN EFFECT: NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(MAX) AUTODBL(NONE)
 SOURCE EBCDIC NOLIST NODUCK OBJECT NOMAP NOFORMAT GOSTMT NOXREF ALC NOANSF TERM IBM FLAG(I)

```

ISN 0002      C 18/05/82 207140959 MEMBER NAME GMASS (HEIMS) FORTRAN 00000000
               SUBROUTINE GMASS(AM) 00000100
C----- ROUTINE BERECHNET DIE MASEN UND LEBENSDAUERN DER TEILCHEN 00000200
C----- AUS DEN QUANTENZAHLEN IM COMMON /QUANT/ UND DEN KONSTANTEN 00000300
C----- IM COMMON /CONST/ 00000400
ISN 0003      IMPLICIT REAL*16 (A-H, J-Z) 00000500
ISN 0004      COMMON /CONST/ PI, HQ, C, GAM, RG, SO, FAKMEV, ETA, THETA, EQ, ALFA, AMU, 00000600
               *ALFP, ALFM, XI, EBN, BETA, IPRINT 00000700
ISN 0005      COMMON /QUANT/ N, K, PG, QG, KQ, KAPPA, N1, N2, N3, N4, CS, IK, IPG, IQG, 00000710
               *IKAPPA, EPS, QX, IN, IN1, IN2, IN3, IN4, ICS, IEPS, IQX, IX, IKQ, X, 00000720
ISN 0006      *IK1, IK2, IK3, IK4 00000721
               COMMON /EXCHA/ WGX, AGX, BGX, ALF1, ALF2, ALF3, FN, Q1, Q2, Q3, Q4, 00000730
               *AN1, AN2, AN3, FIG, GKQ, WGXK, AN, AQ, KGH, 00000740
               *IQ1, IQ2, IQ3, IQ4 00000750
ISN 0007      C----- (3-9) # F(K) INTEGER 00001206
               KGH=4.00*(ALF1*QFLOAT(IK1**2*(1+IK1)**2)/4.00+ 00001207
               *ALF2*QFLOAT(IK2*(2*IK2**2+3*IK2+1))/6.00+ 00001208
               *ALF3*QFLOAT(IK3*(IK3+1))/2.00+QFLOAT(IK4)) 00001209
ISN 0008      C----- (3-7) # F(K, KQ, PG, QG, KAPPA) 00001210
               FIG=3.00*PG/(PI*QSQRT(ETAQK(KQ, K)))*(1.00-ALFM/ALFP)*(PG+QG)* 00001211
               *(-1.00)**(IPG+IQG)*(1.00-ALFA/3.00+PI/2.00*(K-1.00)*3.00** 00001212
               *KQ/2.00)*(1.00+2.00*K*KAPPA/(3.00*ETA**2)*XI*(1.00+XI**2)* 00001213
               *(PG-QG)*(PI**2-KQ))/(1.00+4.00*XI/K*QFLOAT(1BINOM(IPG, 2)))* 00001214
               *(XI/6.00)**KQ*(2.00*QSQRT(ETAQK(1.00, 1.00)*ETAQK(KQ, K))+ 00001215
               *KQ*ETA**2*(K-1.00))*(1.00+(4.00*PI*ALFA)/(ETA*QSQRT(ETA)))* 00001216
               *(1.00+QG*(1.00-KAPPA)*(2.00-K)*N1/Q1)+4.00*(1.00-ALFM/ALFP)* 00001217
               *ALFA/XI**2*(PG+QG)+4.00*KQ*ALFM/ALFP 00001218
ISN 0009      FIK=(FIG-4.00*KQ*ALFM/ALFP)/4.00 00001227
ISN 0010      IF (IPRINT.GE.2) WRITE(6,100) IK1, IK2, IK3, IK4, KGH, FIG, FIK 00001237
ISN 0012      100 FORMAT(1X, ' IK1 IK2 IK3 IK4 KGH FIG 00001247
               * FIK'/1X, 4I5, 3Q16.8) 00001257
ISN 0013      C----- (3-9) # F REAL 00001300
ISN 0014      AM=AMU*FAKMEV*ALFP*(KGH+FIG) 00001400
ISN 0015      RETURN 00009600
               END 00009700

```

*OPTIONS IN EFFECT*NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(MAX) AUTODBL(NONE)
 *OPTIONS IN EFFECT*SOURCE EBCDIC NOLIST NODUCK OBJECT NOMAP NOFORMAT GOSTMT NOXREF ALC NOANSF TERM IBM FLAG(I)
 STATISTICS SOURCE STATEMENTS = 14, PROGRAM SIZE = 2998, SUBPROGRAM NAME = GMASS
 STATISTICS NO DIAGNOSTICS GENERATED
 ***** END OF COMPILATION *****
 84K BYTES OF CORE NOT USED

*VERSION 1.3.0 (01 MAY 80) SYSTEM/370 FORTRAN H EXTENDED (ENHANCED) DATE 82.223/09.22.06 PAGE 1

REQUESTED OPTIONS: NODECK,NOLIST,OPT(0)

OPTIONS IN EFFECT: NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(MAX) AUTODBL(NONE)
SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF ALC NOANSF TERM IBM FLAG(I)

ISN 0002	C	28/08/81 109131228	MEMBER NAME	ETAQK	(HEIMS)	FORTTRAN	00000000
			FUNCTION	ETAQK(KQ,K)			00000100
	C----		FORMEL	(7A)			00000200
ISN 0003			IMPLICIT	REAL*16	(A-H,J-Z)		00000210
ISN 0004			PI=3.141592653500				00000220
ISN 0005			ETAQK=PI/(KQ**4*(4.Q0+K)+PI**4)**0.25Q0				00000400
ISN 0006			RETURN				00000500
ISN 0007			END				00000600

*OPTIONS IN EFFECT*NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(MAX) AUTODBL(NONE)

*OPTIONS IN EFFECT*SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF ALC NOANSF TERM IBM FLAG(I)

STATISTICS SOURCE STATEMENTS = 6, PROGRAM SIZE = 532, SUBPROGRAM NAME = ETAQK

STATISTICS NO DIAGNOSTICS GENERATED

***** END OF COMPILATION *****

88K BYTES OF CCRE NOT USED

*VERSION 1.3.0 (01 MAY 80)

SYSTEM/370 FORTRAN H EXTENDED (ENHANCED)

DATE 82.223/09.22.06

PAGE 1

REQUESTED OPTIONS: NODECK,NOLIST,OPT(0)

OPTIONS IN EFFECT: NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(MAX) AUTODBL(NONE)
SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF ALC NOANSF TERM IBM FLAG(I)

ISN 0002	C	27/08/81 109131226	MEMBER NAME	IBINOM	(HEIMS)	FORTRAN	00000000
			FUNCTION	IBINOM(I,K)			00000100
	C----		COMPUTES	BINOMIAL	COEFFICIENTS		00000200
ISN 0003			IF(I.LT.K)	GOTO 1			00000210
ISN 0005			IBINOM=	IFAKUL(I)/(IFAKUL(K)*IFAKUL(I-K))			00000300
ISN 0006			RETURN				00000400
ISN 0007	1		IBINOM=	0			00000410
ISN 0008			RETURN				00000420
ISN 0009			END				00000500

*OPTIONS IN EFFECT*NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(MAX) AUTODBL(NONE)

*OPTIONS IN EFFECT*SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF ALC NOANSF TERM IBM FLAG(I)

STATISTICS SOURCE STATEMENTS =

8, PROGRAM SIZE =

394, SUBPROGRAM NAME =IBINOM

STATISTICS NO DIAGNOSTICS GENERATED

88K BYTES OF CORE NOT USED

STATISTICS NO DIAGNOSTICS THIS STEP

FORTRAN H EXTENDED (ENHANCED)

SOURCE STATEMENTS =	105,	PROGRAM SIZE =	6016,	SUBPROGRAM NAME =	MAIN
SOURCE STATEMENTS =	66,	PROGRAM SIZE =	8800,	SUBPROGRAM NAME =	GINIT
SOURCE STATEMENTS =	50,	PROGRAM SIZE =	6640,	SUBPROGRAM NAME =	GBASE
SOURCE STATEMENTS =	48,	PROGRAM SIZE =	2356,	SUBPROGRAM NAME =	GSTRUC
SOURCE STATEMENTS =	14,	PROGRAM SIZE =	2998,	SUBPROGRAM NAME =	GMASS
SOURCE STATEMENTS =	6,	PROGRAM SIZE =	532,	SUBPROGRAM NAME =	ETAQK
SOURCE STATEMENTS =	8,	PROGRAM SIZE =	394,	SUBPROGRAM NAME =	IBINOM

F64-LEVEL LINKAGE EDITOR OPTIONS SPECIFIED LET LIST MAP
 DEFAULT OPTION(S) USED - SIZE=(307200,65536)

MODULE MAP

CONTROL SECTION			ENTRY									
NAME	ORIGIN	LENGTH	NAME	LOCATION	NAME	LOCATION	NAME	LOCATION	NAME	LOCATION	NAME	LOCATION
MAIN	00	1780										
GINIT	1780	2260										
GBASE	39E0	19F0										
GSTRUC	53D0	934										
GMASS	5D08	BB6										
ETAQK	68C0	214										
IBINOM	6AD8	18A										
IHOFIXPI*	6C68	178	FIXPI#	6C68								
IHOQFQTEN*	6DE0	110	FQFQTEN#	6DE0								
IHOQFQXPI*	6EF0	1A4	FQXPI#	6EF0								
IHOQFQXPQ*	7098	B8C	QEXP	7098	IH\$QEXP	7098	FQXP2#	70CE	FQXPQ#	7102		
			QLOG10	712A	IH\$QLOG0	712A	QLOG	714C	IH\$QLOG	714C		
IHOECOMH*	7C28	E30	IBCOM#	7C5C	FDIOCS#	7D18	INTSWTCH	89A0				
FIOAP# *	8A58	61C										
IHOECOMH2*	9078	9A5	SEQDASD	944A								
IFAKUL *	9A20	E8										
IHOQSQRT*	9B08	22C	QSQRT	9B08	IH\$QSQRT	9B08						
IHOFCVTH*	9D38	CFA	ADCON#	9D38	FCVAOUTP	9DA4	FCVLOUTP	9DBC	FCVZOUTP	9DD4		
			FCVLOUTP	9DEC	FCVEOUTP	9E24	FCVCOUTP	9E24	ADCONI#	A534		
			ADCONO#	A550	INT6SWCH	AA31						
IHOEFNTH*	AA38	800	ARITH#	AA38	ADJSWTCH	AFCC						
IHOEFIOS*	B238	118C	FIOCS#	B238	FIOCSBEP	B23E						
IHOEFIOS2*	C3C8	642										
IHOERRM *	CA10	624	ERRMON	CA10	IHOERRE	CA28						
IHOQCONI*	D038	4										
IHOQCONO*	D040	4										
IHOQOPT *	D048	538										
IHOFCONI*	D580	416	FQCONI#	D580								
IHOFCONO*	D998	8B8	FQCONO#	D998								
IHOETRCH*	E250	2AE	IHOTRCH	E250	ERRTRA	E258						

NAME	ORIGIN	LENGTH
IHOUBTL*	E500	638
IHOFTEN *	EB38	220
CONST	ED58	114
QUANT	EE70	128
EXCHA	EF98	150
PARMAT	FOE8	240

NAME	LOCATION
FTEN#	EB38

NAME	LOCATION
------	----------

NAME	LOCATION
------	----------

NAME	LOCATION
------	----------

ENTRY ADDRESS 00

TOTAL LENGTH F328
 ***MAIN DOES NOT EXIST BUT HAS BEEN ADDED TO DATA SET
 AUTHORIZATION CODE IS 0.

 * MASSENFORMEL DER ELEMENTARTEILCHEN NACH B. HEIM *
 * (H. D. SCHULZ, 26/7/82) *

IPRINT = 0
 EINGEGEBENE KONSTANTEN:

PI = 3.14159265
 BASIS OF NATURAL LOGARITHM: EBN = 2.71828183
 PLANCK WIRKUNGSQUANTUM/(2*PI): HQ = 0.10545887Q-33 (WS*S)
 LICHTGESCHWINDIGKEIT: C = 0.29979246Q+09 (M/S)
 GRAVITATIONSKONSTANTE: GAM = 0.66732000Q-10 (M**3*KG**-1*S**-2)
 WELLENWIDERSTAND DES VAKUUMS: RG = 376.73037659 (OHM)
 EINHEITSSTRECKE: SO = 1.00000000 (M)

ABGELEITETE KONSTANTE:

UMRECHNUNG KG - MEV: FAKMEV = 0.56095450Q+30 (MEV/KG)
 ZAHLENFAKTOR: ETA = 0.98998964Q+00
 ZAHLENFAKTOR: THETA = 0.79399127Q+01
 ELEMENTARLADUNG: EQ = 0.16021775Q-18 (A*S)
 FEINSTRUKTURKONSTANTE: ALFA = 0.72973511Q-02
 "STARKE" KONSTANTE: BETA = 0.99998589Q+00
 MASSENFaktor: AMU = 0.22590219Q-30 (KG)
 ZAHLENFAKTOR ALPHA PLUS: ALFP = 0.18322115Q-01
 ZAHLENFAKTOR ALPHA MINUS: ALFM = 0.81283449Q-02
 ZAHLENFAKTOR: XI = 0.16180340Q+01

PARAMETER MATRIX

0.25483393Q+03	0.14790690Q+02	0.12021658Q+02	0.13793985Q+03	0.24622984Q+01	0.73036070Q+02
0.20045757Q-03	0.13480450Q+00	0.36074128Q+00	0.17630043Q+01	0.33298461Q-02	0.28058241Q+00
0.38754712Q-02	0.43703972Q+00	0.10132166Q-01	0.24690843Q+01	0.30762153Q-02	0.10046837Q+01
0.62043340Q+00	0.39820465Q+01	0.80901699Q+00	0.74871411Q+00	0.30826097Q+00	0.53214928Q+01
0.10294024Q+01	0.44674036Q-01	0.43658717Q+01	0.88720479Q-02	0.42360680Q+01	0.71355583Q+01
0.84410941Q+00	0.81045177Q+00	0.11055358Q+00	0.10577864Q+01	0.64720368Q+00	0.16018369Q+01

=====

BEZEICHNUNGEN:

CS = STRANGENESS QUANTENZAHL
 KQ = LADUNGSQUANTENZAHL, ABSOLUTWERT
 EPS = /1/-1/ TEILCHEN/ANTITEILCHEN
 QX = LADUNGSQUANTENZAHL MIT VORZEICHEN
 N = HAUPTQUANTENZAHL (GRUNDZUSTAND N = 0)
 AM = MASSE DES TEILCHENS
 DIE UEBRIGEN GROESSEN SIND
 GANZZAHLIGE STRUKTURKONSTANTE

----- E -----
 BARYON NUMBER + 1 = 1
 2 * ISOSPIN PG = 1
 2 * SPIN QG = 1
 DOUBLETT KAPPA = 0

IS IQ1 IQ2 IQ3 IQ4
 2 3 3 2 1

 IK1 IK2 IK3 IK4 N1 N2 N3 N4

IK1	IK2	IK3	IK4	N1	N2	N3	N4
3	3	2	1	0	0	0	0
CS	KQ	EPS	QX	N	AM (MEV)		
0	0	1	0	0	0.50688314Q+00		
*** NO EXCITATION POSSIBLE ***							
IS	IQ1	IQ2	IQ3	IQ4			
2	3	3	2	1			

IK1	IK2	IK3	IK4	N1	N2	N3	N4
3	3	2	1	0	0	0	0
CS	KQ	EPS	QX	N	AM (MEV)		
0	1	1	-1	0	0.51100326Q+00		
*** NO EXCITATION POSSIBLE ***							

--- MU ---

BARYON NUMBER + 1 = 1

2 * ISOSPIN PG = 1

2 * SPIN QG = 1

DOUBLETT KAPPA = 1

IS	IQ1	IQ2	IQ3	IQ4
2	3	3	2	1

IK1	IK2	IK3	IK4	N1	N2	N3	N4
14	9	13	7	11	6	11	6
CS	KQ	EPS	QX	N	AM (MEV)		
0	1	1	-1	0	0.10565945Q+03		
ILE	IL1	IL2	IL3	IL4			
3252	42	61	89	88			

IK1	IK2	IK3	IK4	N1	N2	N3	N4
29	21	8	3	26	18	6	2
CS	KQ	EPS	QX	N	AM (MEV)		
0	1	1	-1	2	0.17833926Q+04		

IK1	IK2	IK3	IK4	N1	N2	N3	N4
30	47	28	0	27	44	26	-1
CS	KQ	EPS	QX	N	AM (MEV)		
0	1	1	-1	3	0.23414777Q+04		

IK1	IK2	IK3	IK4	N1	N2	N3	N4
31	48	93	8	28	45	91	7
CS	KQ	EPS	QX	N	AM (MEV)		
0	1	1	-1	4	0.26750683Q+04		

IK1	IK2	IK3	IK4	N1	N2	N3	N4
32	39	21	2	29	36	19	1
CS	KQ	EPS	QX	N	AM (MEV)		
0	1	1	-1	5	0.27763355Q+04		

IK1	IK2	IK3	IK4	N1	N2	N3	N4
32	55	82	7	29	52	80	6
CS	KQ	EPS	QX	N	AM (MEV)		
0	1	1	-1	6	0.31478985Q+04		

IK1	IK2	IK3	IK4	N1	N2	N3	N4
33	34	48	1	30	31	46	0
CS	KQ	EPS	QX	N	AM (MEV)		
0	1	1	-1	7	0.30531624Q+04		

IK1	IK2	IK3	IK4	N1	N2	N3	N4
33	46	67	10	30	43	65	9
CS	KQ	EPS	QX	N	AM (MEV)		
0	1	1	-1	8	0.32497082Q+04		

IK1	IK2	IK3	IK4	N1	N2	N3	N4
33	54	69	0	30	51	67	-1

CS	KQ	EPS	QX	N	AM (MEV)
0	1	1	1	9	0.34431185Q+04
IK1	IK2	IK3	IK4	N1	N2 N3 N4
34	16	16	31	15	14 0
CS	KQ	EPS	QX	N	AM (MEV)
0	1	1	1	10	0.32987325Q+04
IK1	IK2	IK3	IK4	N1	N2 N3 N4
34	30	10	31	27	8 0
CS	KQ	EPS	QX	N	AM (MEV)
0	1	1	1	11	0.33670790Q+04
IK1	IK2	IK3	IK4	N1	N2 N3 N4
34	37	33	31	34	31 2
CS	KQ	EPS	QX	N	AM (MEV)
0	1	1	1	12	0.344400581Q+04
IK1	IK2	IK3	IK4	N1	N2 N3 N4
34	42	66	0	39	64 -1
CS	KQ	EPS	QX	N	AM (MEV)
0	1	1	1	13	0.35303541Q+04
IK1	IK2	IK3	IK4	N1	N2 N3 N4
34	46	91	2	43	89 1
CS	KQ	EPS	QX	N	AM (MEV)
0	1	1	1	14	0.36308605Q+04
IK1	IK2	IK3	IK4	N1	N2 N3 N4
34	50	39	8	47	37 7
CS	KQ	EPS	QX	N	AM (MEV)
0	1	1	1	15	0.36884696Q+04
IK1	IK2	IK3	IK4	N1	N2 N3 N4
34	53	27	31	50	25 0
CS	KQ	EPS	QX	N	AM (MEV)
0	1	1	1	16	0.37610759Q+04
IK1	IK2	IK3	IK4	N1	N2 N3 N4
34	55	81	31	52	79 0
CS	KQ	EPS	QX	N	AM (MEV)
0	1	1	1	17	0.38436946Q+04
IK1	IK2	IK3	IK4	N1	N2 N3 N4
34	57	100	31	54	98 -1
CS	KQ	EPS	QX	N	AM (MEV)
0	1	1	1	18	0.39194455Q+04
IK1	IK2	IK3	IK4	N1	N2 N3 N4
35	7	3	5	4	1 4
CS	KQ	EPS	QX	N	AM (MEV)
0	1	1	1	19	0.36760171Q+04
IK1	IK2	IK3	IK4	N1	N2 N3 N4
35	15	30	3	12	28 2
CS	KQ	EPS	QX	N	AM (MEV)
0	1	1	1	20	0.36905150Q+04
IK1	IK2	IK3	IK4	N1	N2 N3 N4
35	20	41	1	17	39 0
CS	KQ	EPS	QX	N	AM (MEV)
0	1	1	1	21	0.37094243Q+04
IK1	IK2	IK3	IK4	N1	N2 N3 N4
35	24	37	3	21	35 2
CS	KQ	EPS	QX	N	AM (MEV)
0	1	1	1	22	0.37270972Q+04
IK1	IK2	IK3	IK4	N1	N2 N3 N4
35	27	43	1	24	41 0
CS	KQ	EPS	QX	N	AM (MEV)
0	1	1	1	23	0.37483777Q+04
IK1	IK2	IK3	IK4	N1	N2 N3 N4
35	30	19	0	27	17 -1
CS	KQ	EPS	QX	N	AM (MEV)
0	1	1	1	24	0.37652425Q+04
IK1	IK2	IK3	IK4	N1	N2 N3 N4
35	32	34	2	29	32 1
CS	KQ	EPS	QX	N	AM (MEV)
0	1	1	1	25	0.37876093Q+04
IK1	IK2	IK3	IK4	N1	N2 N3 N4
35	34	31	0	31	29 -1
CS	KQ	EPS	QX	N	AM (MEV)
0	1	1	1	26	0.38078032Q+04
IK1	IK2	IK3	IK4	N1	N2 N3 N4
35	36	12	1	32	33 0
CS	KQ	EPS	QX	N	AM (MEV)
0	1	1	1	27	0.38277211Q+04
IK1	IK2	IK3	IK4	N1	N2 N3 N4
35	37	55	3	34	53 2
CS	KQ	EPS	QX	N	AM (MEV)
0	1	1	1	28	0.38539020Q+04
IK1	IK2	IK3	IK4	N1	N2 N3 N4
35	39	9	1	32	36 7 0
CS	KQ	EPS	QX	N	AM (MEV)
0	1	1	1	29	0.38681786Q+04
IK1	IK2	IK3	IK4	N1	N2 N3 N4
35	40	33	1	32	37 31 0
CS	KQ	EPS	QX	N	AM (MEV)
0	1	1	1	30	0.38879151Q+04
IK1	IK2	IK3	IK4	N1	N2 N3 N4
35	41	49	0	32	38 47 -1
CS	KQ	EPS	QX	N	AM (MEV)
0	1	1	1	31	0.39097493Q+04
IK1	IK2	IK3	IK4	N1	N2 N3 N4
35	42	59	6	32	39 57 5
CS	KQ	EPS	QX	N	AM (MEV)
0	1	1	1	32	0.39313474Q+04
IK1	IK2	IK3	IK4	N1	N2 N3 N4
35	43	61	0	32	40 33 0

CS	KQ	EPS	QX	N	AM (MEV)
0	1	1	35	0.39497960+04	
IK1	IK2	IK3	IK4	N1	N2
35	44	58	52	87	86
CS	KQ	EPS	QX	N	AM (MEV)
0	1	1	34	0.39664150+04	
IK1	IK2	IK3	IK4	N1	N2
35	45	48	32	42	83
CS	KQ	EPS	QX	N	AM (MEV)
0	1	1	35	0.39005401+04	
IK1	IK2	IK3	IK4	N1	N2
35	46	33	32	43	31
CS	KQ	EPS	QX	N	AM (MEV)
0	1	1	36	0.39948587+04	
IK1	IK2	IK3	IK4	N1	N2
35	47	12	32	44	10
CS	KQ	EPS	QX	N	AM (MEV)
0	1	1	37	0.40112239+04	
IK1	IK2	IK3	IK4	N1	N2
35	48	85	32	44	83
CS	KQ	EPS	QX	N	AM (MEV)
0	1	1	38	0.40437445+04	
IK1	IK2	IK3	IK4	N1	N2
35	49	88	32	45	55
CS	KQ	EPS	QX	N	AM (MEV)
0	1	1	39	0.40472526+04	
IK1	IK2	IK3	IK4	N1	N2
35	50	49	32	46	22
CS	KQ	EPS	QX	N	AM (MEV)
0	1	1	40	0.40575531+04	
IK1	IK2	IK3	IK4	N1	N2
35	51	63	32	46	86
CS	KQ	EPS	QX	N	AM (MEV)
0	1	1	41	0.40903538+04	
IK1	IK2	IK3	IK4	N1	N2
35	52	5	32	47	47
CS	KQ	EPS	QX	N	AM (MEV)
0	1	1	42	0.40894614+04	
IK1	IK2	IK3	IK4	N1	N2
35	53	13	32	48	3
CS	KQ	EPS	QX	N	AM (MEV)
0	1	1	43	0.41029239+04	
IK1	IK2	IK3	IK4	N1	N2
35	54	65	32	48	61
CS	KQ	EPS	QX	N	AM (MEV)
0	1	1	44	0.41210645+04	
IK1	IK2	IK3	IK4	N1	N2
35	55	1	32	49	11
CS	KQ	EPS	QX	N	AM (MEV)
0	1	1	45	0.41289877+04	
IK1	IK2	IK3	IK4	N1	N2
35	56	68	32	49	66
CS	KQ	EPS	QX	N	AM (MEV)
0	1	1	46	0.41494926+04	
IK1	IK2	IK3	IK4	N1	N2
35	57	13	32	50	11
CS	KQ	EPS	QX	N	AM (MEV)
0	1	1	47	0.41554224+04	
IK1	IK2	IK3	IK4	N1	N2
35	58	65	32	50	63
CS	KQ	EPS	QX	N	AM (MEV)
0	1	1	48	0.41741098+04	
IK1	IK2	IK3	IK4	N1	N2
35	59	4	32	51	2
CS	KQ	EPS	QX	N	AM (MEV)
0	1	1	49	0.41820901+04	
IK1	IK2	IK3	IK4	N1	N2
35	60	53	32	51	51
CS	KQ	EPS	QX	N	AM (MEV)
0	1	1	50	0.41950055+04	
IK1	IK2	IK3	IK4	N1	N2
35	61	101	32	51	99
CS	KQ	EPS	QX	N	AM (MEV)
0	1	1	51	0.42288258+04	
IK1	IK2	IK3	IK4	N1	N2
35	62	35	32	52	33
CS	KQ	EPS	QX	N	AM (MEV)
0	1	1	52	0.42161913+04	
IK1	IK2	IK3	IK4	N1	N2
35	63	80	32	52	78
CS	KQ	EPS	QX	N	AM (MEV)
0	1	1	53	0.42398950+04	
IK1	IK2	IK3	IK4	N1	N2
35	64	10	32	53	8
CS	KQ	EPS	QX	N	AM (MEV)
0	1	1	54	0.42404658+04	
IK1	IK2	IK3	IK4	N1	N2
35	65	53	32	53	51
CS	KQ	EPS	QX	N	AM (MEV)
0	1	1	55	0.42529536+04	
IK1	IK2	IK3	IK4	N1	N2
35	66	95	32	53	93
CS	KQ	EPS	QX	N	AM (MEV)
0	1	1	56	0.42813838+04	
IK1	IK2	IK3	IK4	N1	N2
35	67	1	32	54	0

*VERSION 1.3.0 (01 MAY 80)

REQUESTED OPTIONS: NODECK, NOLIST, OPT(0)

OPTIONS IN EFFECT: NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(MAX) AUTODBL(NONE)

SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF ALC NOANSF TERM IBM FLAG(I)

SYSTEM/370 FORTRAN H EXTENDED (ENHANCED)

DATE 82.205/15.00.51

PAGE 1

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C 17/03/82 207140922 MEMBER NAME GINIT (HEIMS) FORTRAN 00000000
ISN 0002 SUBROUTINE GINIT 00000100
C----- INITIALISIERT KONSTANTE GROESSEN IM COMMON /CONST/ 00000200
IMPLICIT REAL*16 (A-H,J-Z) 00000300
COMMON /CONST/ PI,HQ,C,GAM,RG,S0,FAKMEV,ETA,THETA,EQ,ALFA,AMU, 00000400
*ALFP,ALFM,XI,EBN,BETA,IPRINT 00000500
COMMON /PARAMAT/ A11,A12,A13,A14,A15,A16,A21,A22,A23,A24,A25,A26, 00000510
*A31,A32,A33,A34,A35,A36,A41,A42,A43,A44,A45,A46, 00000520
*A51,A52,A53,A54,A55,A56,A61,A62,A63,A64,A65,A66 00000530
PI=3.1415926535Q0 00000600
EBN=QEXP(1.00) 00000700
HQ=1.0545887Q-34 00000800
C=2.99792458Q8 00000900
GAM=6.6732Q-11 00001000
RG=376.73037659Q0 00001100
S0=1.00 00001200
FAKMEV=0.05609545Q31 00001300
XI=1.61803399Q0 00001310
C----- (2B,2-1) # CONST REAL 00001400
ETA=PI/(4.00+PI**4)**0.25Q0 00001500
C----- (2A,2-2) # CONST REAL 00001600
THETA=5.00*ETA+2.00*QSQR(ETA)+1.00 00001700
C----- (2,2-5) F(CONST) 00001800
EQ=3.00/(4.00*PI**2)*QSQR(2.00*THETA*HQ/RG) 00001900
C----- (22) 00002000
ALFA=1.00/137.03602725Q0 00002100
C----- (2-6) 00002110
BETA=1.00/1.00001411Q0 00002120
C----- (3-1) 00002200
AMU=PI**0.25Q0*(3.00*PI*S0*GAM*HQ)**(1.00/3.00)*QSQR(C*HQ/(3.00* 00002300
*GAM))/(C*S0) 00002400
C----- (3-3) # CONST REAL 00002500
TEMP1=1.00-2.00/3.00*XI*ETA**2*(1.00-QSQR(ETA)) 00002600
ALFP=TEMP1/(ETA**2*ETA**((1.00/3.00))-1.00 00002800
ALFM=TEMP1/(ETA*ETA**((1.00/3.00))-1.00 00002900
C----- SCHREIBE DIE KONSTANTEN AUS 00003200
WRITE(6,100) PI,EBN,HQ,C,GAM,RG,S0,FAKMEV,ETA,THETA,EQ,ALFA,BETA, 00003300
*AMU,ALFP,ALFM,XI 00003400
ISN 0025 100 FORMAT(1X,'EINGEGEBENE KONSTANTEN: '/1X,'-----'/' 00003500
*1X,'PI =',F12.8/ 00003600
*1X,'BASIS OF NATURAL LOGARITHM: EBN =',F12.8/ 00003700
*1X,'PLANCK WIRKUNGSQUANTUM/(2*PI): HQ =',Q14.8,' (WS*S) '/' 00003800
*1X,'LICHTGESCHWINDIGKEIT : C =',Q14.8,' (M/S) '/' 00003900
*1X,'GRAVITATIONSKONSTANTE : GAM =',Q14.8,' (M**3*KG**-1*S**- 00004000
*2) '/' 00004100
*1X,'WELLENWIDERSTAND DES VAKUUMS: RG =',F14.8,' (OHM) '/' 00004200
*1X,'EINHEITSSTRECKE: S0 =',F14.8,' (M) '/' 00004300
*1X,'ABGELEITETE KONSTANTE: '/1X,'-----'/' 00004400
*1X,'UMRECHNUNG KG - MEV: FAKMEV =',Q14.8,' (MEV/KG) '/' 00004500
*1X,'ZAHLENFAKTOR: ETA =',Q14.8/ 00004600
*1X,'ZAHLENFAKTOR: THETA =',Q14.8/ 00004700
*1X,'ELEMENTARLADUNG: EQ =',Q14.8,' (A*S) '/' 00004800
*1X,'FEINSTRUKTURKONSTANTE: ALFA =',Q14.8/ 00004900
*1X,'"STARKE" KONSTANTE: BETA =',Q14.8/ 00004910
*1X,'MASSENFaktor: AMU =',Q14.8,' (KG) '/' 00005000

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IK1	IK2	IK3	IK4	N1	N2	N3	N4
44	20	39	26	20	-11	5	11
CS	KQ	EPS	QX	N	0.87676813Q+04	AM (MEV)	
-2	2	1	-2	102			
IK1	IK2	IK3	IK4	N1	N2	N3	N4
44	30	3	33	20	-1	-31	18
CS	KQ	EPS	QX	N	0.88331266Q+04	AM (MEV)	
-2	2	1	-2	103			
IK1	IK2	IK3	IK4	N1	N2	N3	N4
44	37	3	5	20	6	-31	-10
CS	KQ	EPS	QX	N	0.89223842Q+04	AM (MEV)	
-2	2	1	-2	104			
IK1	IK2	IK3	IK4	N1	N2	N3	N4
44	42	91	4	20	11	57	-11
CS	KQ	EPS	QX	N	0.90496452Q+04	AM (MEV)	
-2	2	1	-2	105			
IK1	IK2	IK3	IK4	N1	N2	N3	N4
44	48	8	16	20	17	-26	1
CS	KQ	EPS	QX	N	0.91482030Q+04	AM (MEV)	
-2	2	1	-2	106			
IK1	IK2	IK3	IK4	N1	N2	N3	N4
44	52	90	11	20	21	56	-4
CS	KQ	EPS	QX	N	0.92985084Q+04	AM (MEV)	
-2	2	1	-2	107			
IK1	IK2	IK3	IK4	N1	N2	N3	N4
44	57	1	32	20	26	-33	17
CS	KQ	EPS	QX	N	0.94273934Q+04	AM (MEV)	
-2	2	1	-2	108			
IK1	IK2	IK3	IK4	N1	N2	N3	N4
44	60	141	26	20	29	107	11
CS	KQ	EPS	QX	N	0.96357985Q+04	AM (MEV)	
-2	2	1	-2	109			
IK1	IK2	IK3	IK4	N1	N2	N3	N4
44	64	109	4	20	33	75	-11
CS	KQ	EPS	QX	N	0.97704683Q+04	AM (MEV)	
-2	2	1	-2	110			
IK1	IK2	IK3	IK4	N1	N2	N3	N4
80	105	58	30	56	74	24	15
CS	KQ	EPS	QX	N	0.97819195Q+05	AM (MEV)	
-2	2	1	-2	860			

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//F15HDS06 JOB '10212215,GMAIN',HDSCHULZ,CLASS=K,MSGLEVEL=(0,0), *

DATE = 82.223

ELAPSED TIME ON MAIN = CC

= 2.24 MIN., EXECUTION START TIME = 09.21.56

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DDNAME =	.	.JESJCL	PRINTED ON PR3	=	4	LINEs,	COPIES =	1
DDNAME =	.	.SYSMSG	PRINTED ON PR3	=	15	LINEs,	COPIES =	1
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DEUTSCHES ELEKTRONEN-SYNCHROTRON DESY

DESY 75/34
September 1975

$e^+e^- \rightarrow$ Hadrons:

Results from the DESY-Heidelberg-Collaboration

presented by

J. Heintze,

Physikalisches Institut, Universität Heidelberg

at the 1975 International Symposium

on Lepton and Photon Interactions at

High Energies, August 1975, Stanford University

2 HAMBURG 52 · NOTKESTIEG 1

RECENT RESULTS FROM DORIS

B.H.Wiik

Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany

The experimental program utilizing the e^+e^- colliding ring DORIS got underway in late 1974. Since then data have been taken using three large, rather complementary detectors. In this talk the present status of the accelerator will be described and the data obtained with the double arm spectrometer DASP and the superconducting solenoid PLUTO discussed. The results obtained with the third detector will be shown by Prof. Heintze.

Most of the data have been collected for energies at or adjacent to the masses of the newly found resonances¹⁾ at 3.09 GeV and 3.68 GeV. Here preliminary results on the following topics will be presented:

- 1) Inclusive distributions, particle ratios, and limits on heavy charged mesons from the decays of the J/ψ and ψ' resonances.
- 2) Hadronic two body decays of J/ψ and ψ' .
- 3) The cascade decay: $\psi' \rightarrow (J/\psi) + X$.
- 4) Evidence for narrow states P_c with even charge conjugation and masses between 3.7 GeV and 3.1 GeV.
- 5) Two photon final states.
- 6) Three photon final states and evidence for a new resonance.

The results on the decay of the resonances into lepton pairs²⁾ agree within the errors with the data reported by the SPEAR solenoid group³⁾ and will not be discussed here.

DORIS

The layout of the DESY accelerator complex is shown in Fig. 1. Electrons and positrons from a 400 MeV linear accelerator are injected into the 7.5 GeV synchrotron to be accelerated to the proper energy for transfer to DORIS. DORIS is in the shape of a race track with two nearly independent rings stacked one above the other. The beams cross in the vertical plane in the middle of the two long straight sections.

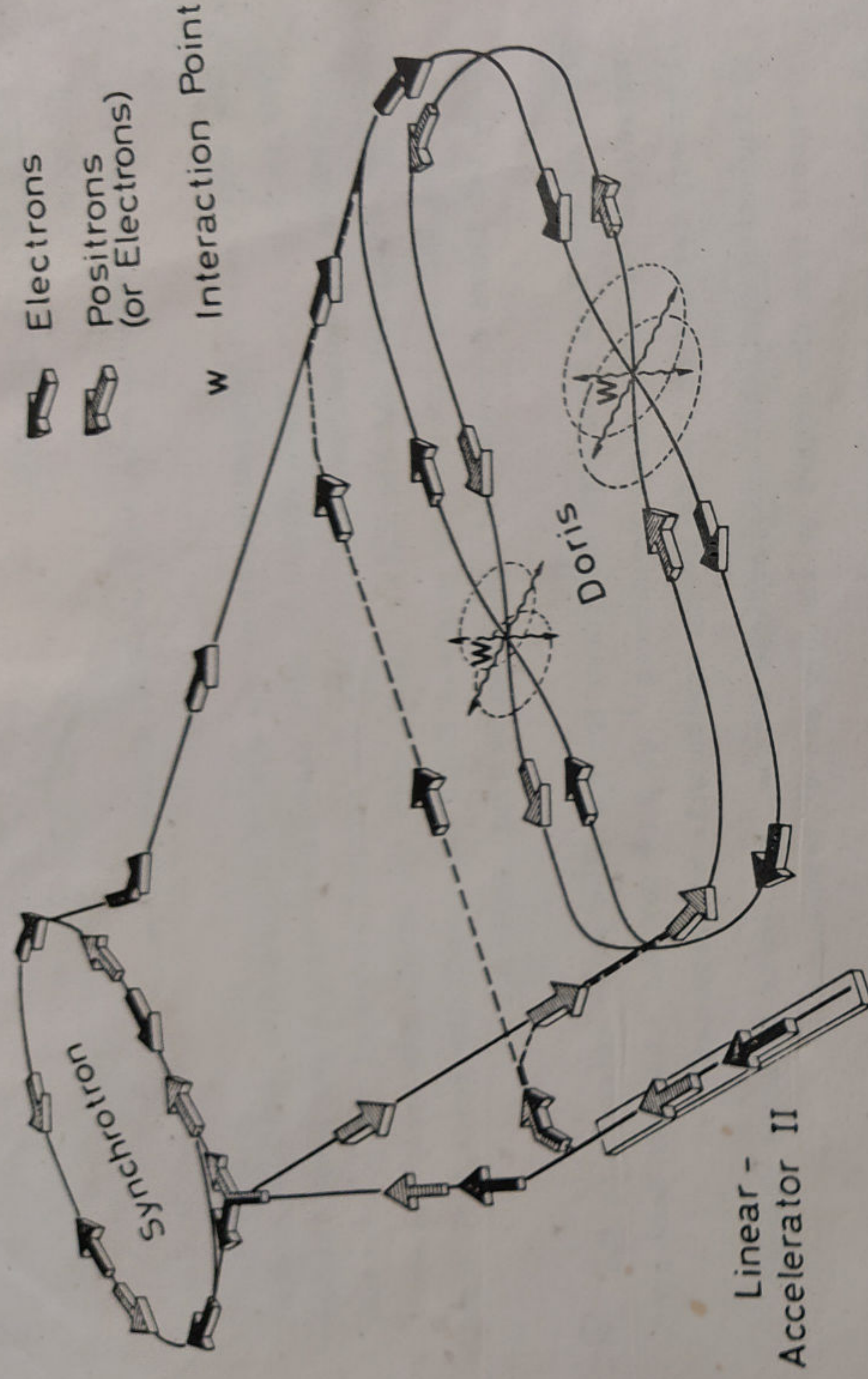


Fig. 1
Layout of the DESY accelerators

Although in principle CMS energies as high as 7 GeV can be reached with the present accelerator, all the data have been collected for energies between 3 GeV and 4.2 GeV. Upgrading the present magnet power supplies and installing all the available r.f. power in one ring will make it possible to reach a CMS energy of 10 GeV.

With the present optics the measured specific luminosity around 4 GeV (CMS) can be written as $10^{31} I^2 \text{ (A}^{-2} \text{ cm}^{-2} \text{ sec}^{-1})$ with the circulating current I measured in Amperes. This is in good agreement with the value of $1.2 I^2 10^{31} \text{ (A}^{-2} \text{ sec}^{-1} \text{ cm}^{-2})$ predicted from the present optics. So far luminosities in excess of $10^{30} \text{ cm}^{-2} \text{ sec}^{-1}$ have been reached with stored currents of 0.3 - 0.4 Ampere in each beam. However, at these high currents, the energy spread in the beam increases due to coherent synchrotron oscillations. These oscillations can be damped for currents less than 0.2 - 0.25 Ampere by a second r.f. transmitter tuned slightly off the resonance frequency. Hence during the data taking at the 3.1 GeV and 3.7 GeV resonances, where a good mass resolution is imperative, the currents were limited to less than 0.25 Ampere. Another important parameter is

the size of the interaction volume. Due to the finite crossing angle and the high r.f. frequency used, the interaction "point" is around 2-3cm long. The transverse dimensions are less than 0.6 mm.

The main parameters of DORIS are summarized in Table I.

TABLE I:

Max. Energy:	7 GeV (9 GeV in the fall of 1975)
Average Circulating current:	0.200 - 0.400 Ampere / Ring
Number of Bunches:	1 - 480
Average Luminosity:	$\sim 3 \times 10^{29} \text{ cm}^2 \text{ sec}^{-1}$
Beam lifetime:	> 6 hrs.
Gas pressure:	$1 - 5 \times 10^{-9} \text{ torr}$ (depending on the current)
Interaction volume: along the beam transverse to the beam	2 - 3 cm < 0.6 mm.

DASP

A schematic drawing of DASP⁴⁾ viewed along the beam direction is shown in Fig. 2

Beam pipe
and

inner detector

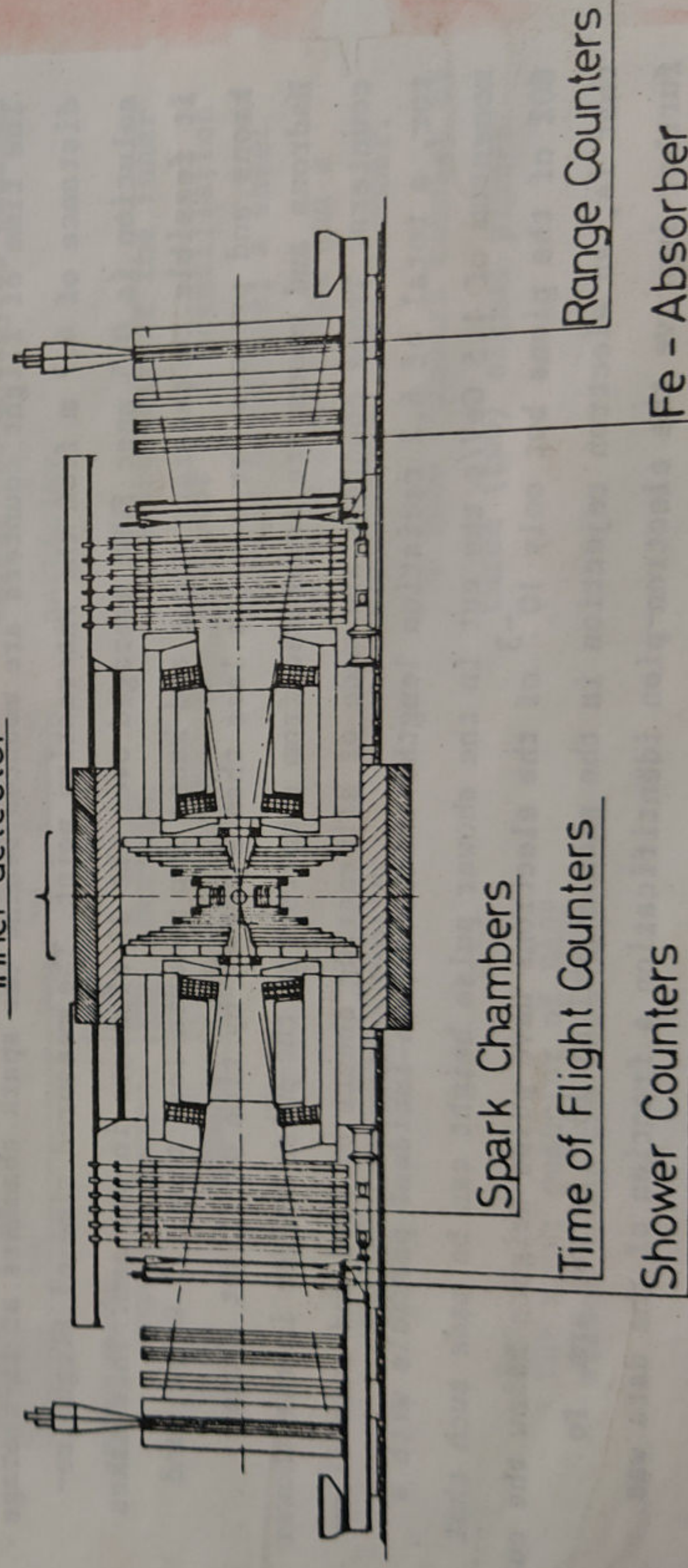


Fig. 2 DASP viewed along the beam direction

Two large H-magnets are positioned symmetric with respect to the interaction point and spaced 2.1 m apart. The geometric acceptance of each magnet is from 48° to 132° in production angle and $\pm 9^\circ$ in azimuth resulting in a solid angle of 2×0.45 sterad for both magnets. The acceptance for a charged particle is smaller than this and depends on the momentum, the field strength and last detector plane required. The maximum field strength is 1.1 Tesla, the integrated field length 1.8 Tm.

A charged particle emerging from the interaction point traverses the following detectors before reaching the magnet gap: a scintillation counter adjacent to the beam pipe, a second scintillation counter which starts the time of flight measurement, two proportional chambers (3 planes in each chamber, 2 mm wire spacing) a third scintillation counter used for triggering and a wire spark chamber with magnetostriuctive readout (2 planes, 1 mm wire spacing).

The momentum of a charged particle is determined from the measurement of one space point on the trajectory in front of the magnet and the knowledge of the trajectory of the particle behind the magnet. The trajectory behind the magnet is measured by 6 wire spark chambers (each has 2 signal planes, 1 mm wire spacing, $5.6 \text{ by } 1.7 \text{ m}^2$ sensitive area). At the present a resolution of $\pm 0.8\%$ is reached for a particle with 1.0 GeV/c momentum.

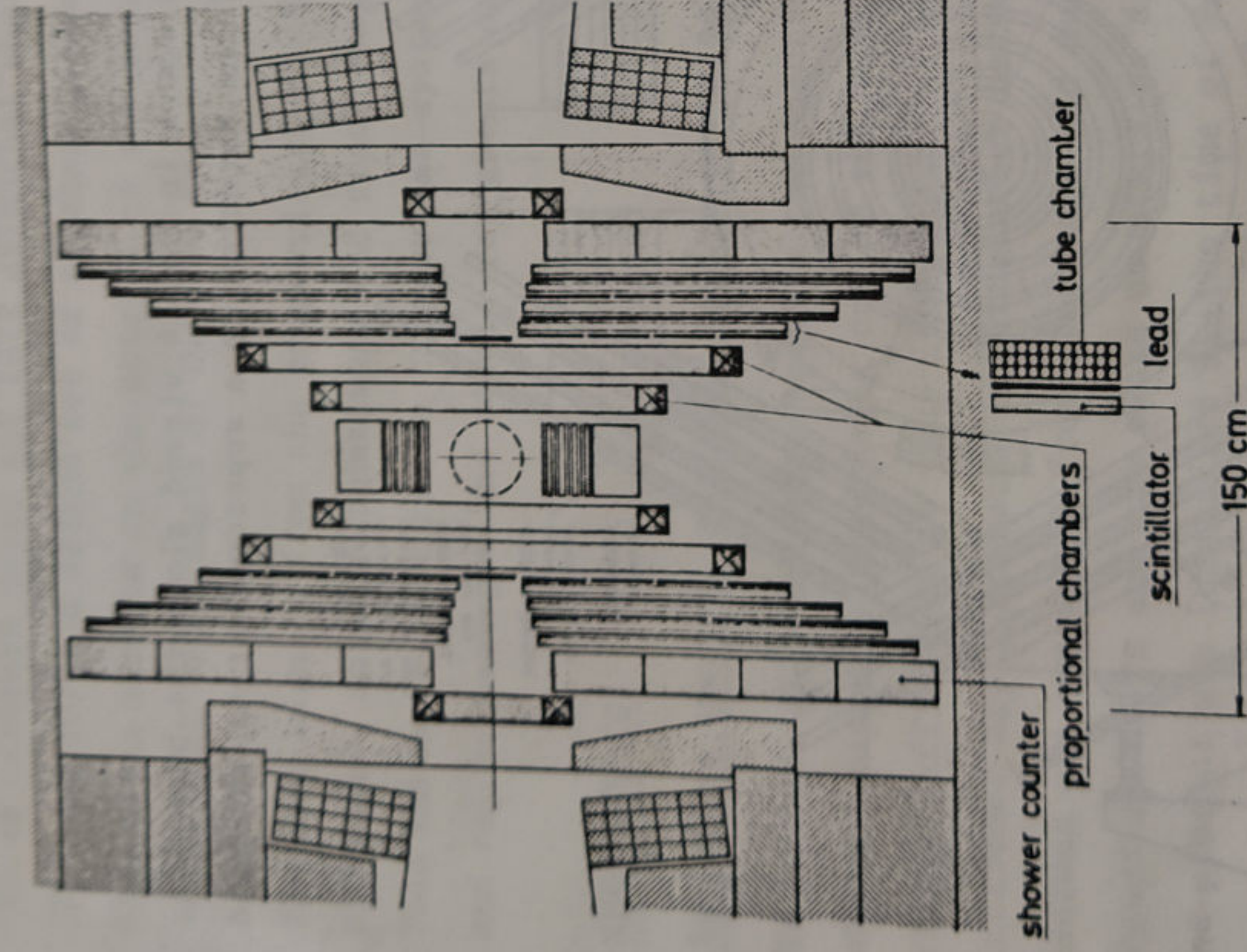
The particles are identified using time of flight, shower and range information:

The time of flight counters are mounted behind the spark chambers at an average distance of 4.7 m from the interaction point. The measured time of flight resolution is 0.5 nsec FWHM averaged over the 31 elements in one arm. This makes it feasible to separate pions and kaons for momenta less than 1.8 GeV/c, and kaons and protons for momenta less than 3 GeV/c, by time of flight alone. Hadrons and muons are separated from electrons by the pulse height in the shower counters. These counters are made of alternating sheets of lead and scintillator, a total of 6.2 radiation lengths thick. For an incident particle with a momentum of 1.5 GeV/c the cut in the shower pulse height can be made such that 80% of the pions but only 10^{-3} of the electrons have pulse heights below the cut, that is, an electron rejection in the pion signal of 10^{-3} in one arm. To further improve the electron-pion identification a fraction of the data was collected with a spark chamber positioned just after the shower counter.

The muons are positively identified by their range. The absorbers in the range telescope are made of iron a total of 90 cm thick, subdivided into plates of different thickness in order to allow for an optimal pion/muon separation at a chosen momentum. After each plate sufficient space for either a scintillation counter hodoscope or a spark chamber is provided. The main portion of the data were taken with one wall of scintillators at depth of 70 cm in the iron. This was later reduced to 60 cm and a spark chamber was installed at a depth of 40 cm in the iron.

The inner detector shown in Fig. 3 is located in the free space between the magnets. It is made out of proportional chambers, scintillation counters, proportional tube chambers, and shower counters. This part of the detector covers more than 70% of 4π and is well suited for a measurement of the direction and energy of photons and also the direction and, in some cases, the energy of charged particles.

The basic unit of the inner detector is a scintillation counter hodoscope, a sheet of lead 5 mm thick and a proportional tube chamber. The tube chambers consist of three (two) signal planes



DASP — Inner Detector

Fig. 3
The inner detector of DASP
viewed along the beam direction

and measure the position to ± 5 mm (± 7.5 mm). A particle emitted in the direction of the inner detector first traverses one of the 22 scintillation counters surrounding the beam pipe, the proportional chambers (in a part of the azimuthal acceptance), then four of the units just described, and finally a lead-scintillator shower counter eight radiation lengths thick. The direction of a shower is determined to about $\pm 2^\circ$, the energy resolution is around 30% for an incident photon of 1 GeV. The detector has a 50% efficiency for detecting a 50 MeV photon.

PLUTO

The DESY 4π detector PLUTO⁵⁾, is shown in Fig. 4 viewed along the beam direction. The main component of the detector is a superconducting solenoid

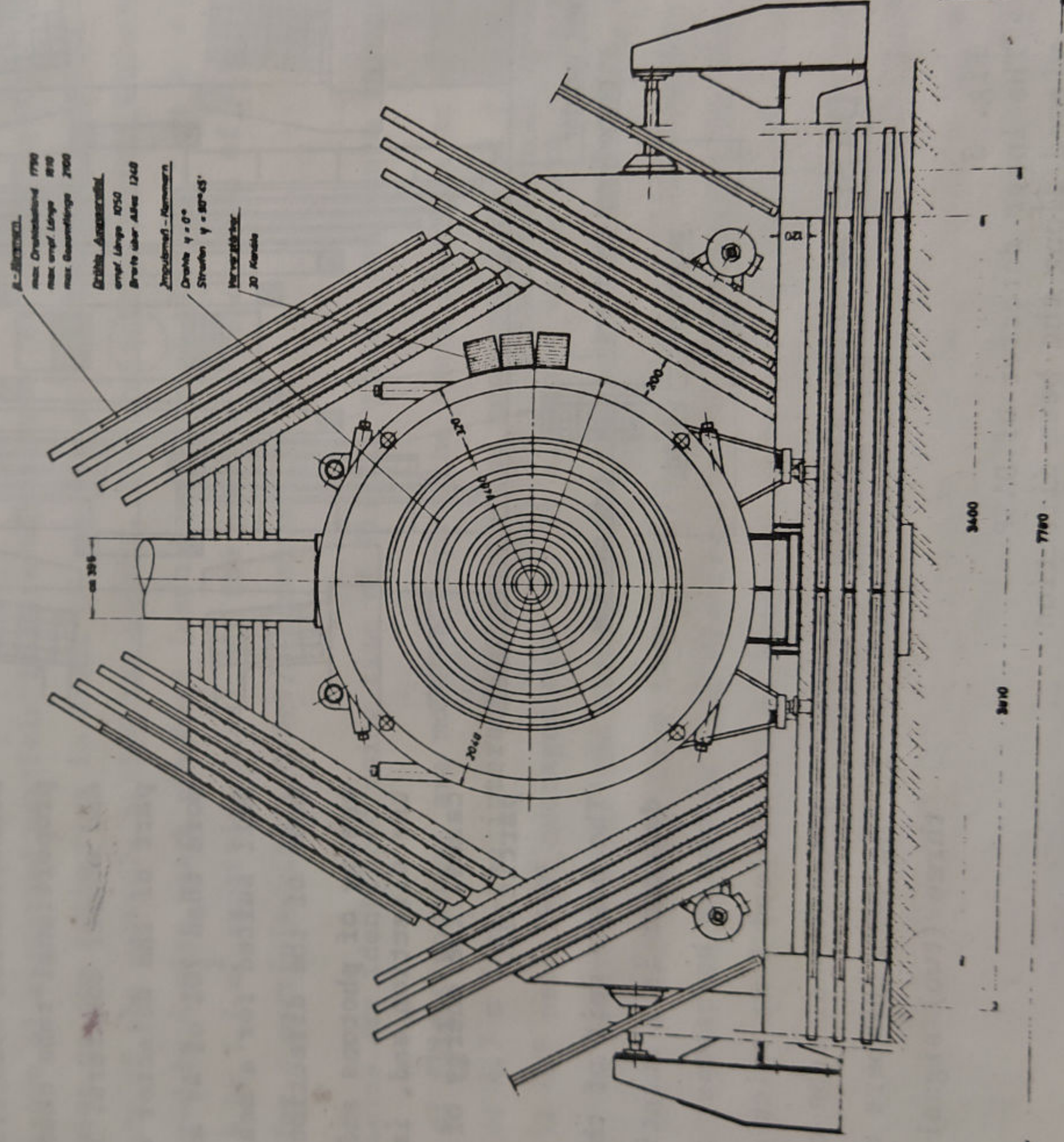


Fig. 4
PLUTO viewed along the beam direction

1.15 m long and 1.4 m in diameter. The magnetic field is parallel to the beam axis; the maximum field strength is 2 Tesla. The solenoid is filled with cylindrical multiwire proportional chambers with wires parallel to the beam axis. The high voltage electrodes are also read out. They are made of strips 16 mm wide, with dip angles of 45° with respect to the signal wires. The chambers cover a solid angle of 85% of 4π . To detect photons a cylindrical lead converter 0.41 of a radiation length thick is inserted at a radius of 39 cm. In the iron return yoke of the solenoid two layers of proportional tube chambers for muon identification are inserted. These chambers cover the full azimuthal angle for production angles between 73° and 107° . A second set of chambers close to the forward and backward directions mounted on the outside of the iron yoke (50 cm thick) covers an additional solid angle of 0.06 of 4π .

The fast signals from the proportional chambers are fed to a hard wired data-processor, which reconstructs the track emerging from the interaction point. This makes it feasible to trigger the system on well defined charged tracks and reject beam-gas and cosmic ray events on line.

THE RESULTS

Inclusive spectra, particle ratios and mass searches

To measure the inclusive spectra the spectrometer was triggered on a single charged particle traversing one of the arms of the spectrometer. The trigger efficiency is thus independent of the final state and does not introduce any systematic uncertainties between pions, kaons and protons. Hadrons are separated from electrons and muons by the information from the shower counters and the range counters as discussed above. Pions, kaons and protons are identified by the time of flight information shown in Fig.5, where $(1/\beta^2 - 1)$ as measured by the time of flight system is plotted versus $1/p^2$ at a CMS energy of 3.1 GeV. Since, $(1/\beta^2 - 1) = M^2/p^2$ particles of mass M will fall along a straight line, the locations predicted for pions, kaons and protons are represented by the solid lines. The measured events cluster along these lines and the plot shows that pions, kaons and protons are well separated at all momenta up to the kinematical boundary.


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*1X, ZAHLENFAKTOR: THETA
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*1X, "STARKE" KONSTANTE: BETA
*1X, MASSENFaktor: AMU

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*VERSION 1.3.0 (01 MAY 80)

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A12=2.Q0*PI*EBN**XI**2*(THETA/8.Q0-PI*EBN*ETA*ALFA**2/3.Q0)/3.Q0
A13=3.Q0*(4.Q0+ETA*ALFA)*(1.Q0-ETA**2/5.Q0*(1.Q0-QSQRT(ETA)))/
*(1.Q0+QSQRT(ETA))**2)
A14=(1.Q0+3.Q0*ETA/(4.Q0*XI)*(2.Q0*ETA*ALFA-EBN**2*XI*
*((1.Q0-QSQRT(ETA))/(1.Q0+QSQRT(ETA))**2))/ALFA
A15=EBN**2*(1.Q0-2.Q0*EBN*ALFA**2/ETA)/3.Q0
A16=(PI*EBN)**2*(1.Q0+ALFA/(5.Q0*ETA)*(1.Q0+6.Q0*ALFA/PI))
A21=2.Q0*(EBN*ALFA/(2.Q0*ETA))**2*(1.Q0-ALFA/(2.Q0*XI**2))
A22=XI*(1.Q0-XI*(ALFA*XI/ETA**2)**2)/12.Q0
A23=(ETA**2+6.Q0*XI*ALFA**2)/EBN
A24=2.Q0*XI**2/(3.Q0*ETA)
A25=XI*(PI*EBN)**2*(1.Q0-BETA**2)
A26=2.Q0*(1.Q0-PI/2.Q0*(EBN*XI*ALFA)**2*QSQRT(ETA))/(EBN*XI**2)
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A31=(PI*EBN*ALFA)**2*(1.Q0-(PI*EBN)**2*(1.Q0-BETA**2))
A32=XI**2*(1.Q0+(2.Q0*EBN*ALFA/ETA)**2)/6.Q0
A33=(PI*EBN*XI*ALFA)**2*(1.Q0-2.Q0*PI*(EBN*XI)**2*(1.Q0-
*BETA**2))
A34=ETA*QSQRT(2.Q0*PI*ETA)
A35=3.Q0*ALFA/(EBN*XI**2)
A36=1.Q0/(1.Q0-PI*EBN*(XI*EBN)**2*(1.Q0-BETA**2))
A41=(XI*(2.Q0+(XI*ALFA)**2)-2.Q0*BETA)/(2.Q0*BETA-ALFA)
A42=PI*XI**2*ETA*(BETA-3.Q0*ALFA)/2.Q0
A43=XI/2.Q0
A44=2.Q0*(ETA/XI)**2
A45=(3.Q0*BETA-ALFA)/(6.Q0*XI)
A46=PI*EBN/(XI*ETA)-EBN*ETA**2*ALFA/2.Q0
A51=(2.Q0*ALFA+1.Q0)**2
A52=6.Q0*ALFA/ETA**2
A53=(XI/ETA)**3
A54=ALFA*(BETA-ALFA)*QSQRT(3.Q0/2.Q0)
A55=XI**3
A56=(XI/ETA)**4
A61=PI*XI*(2.Q0*BETA-ALFA)/(12.Q0*BETA)
A62=PI**2*(BETA-2.Q0*ALFA)/12.Q0
A63=QSQRT(ETA)/9.Q0
A64=PI/(3.Q0*ETA)
A65=PI/(3.Q0*XI)
A66=XI*ETA
WRITE(6,200) A11,A12,A13,A14,A15,A16,A21,A22,A23,A24,A25,A26,
*A31,A32,A33,A34,A35,A36,A41,A42,A43,A44,A45,A46,
*A51,A52,A53,A54,A55,A56,A61,A62,A63,A64,A65,A66
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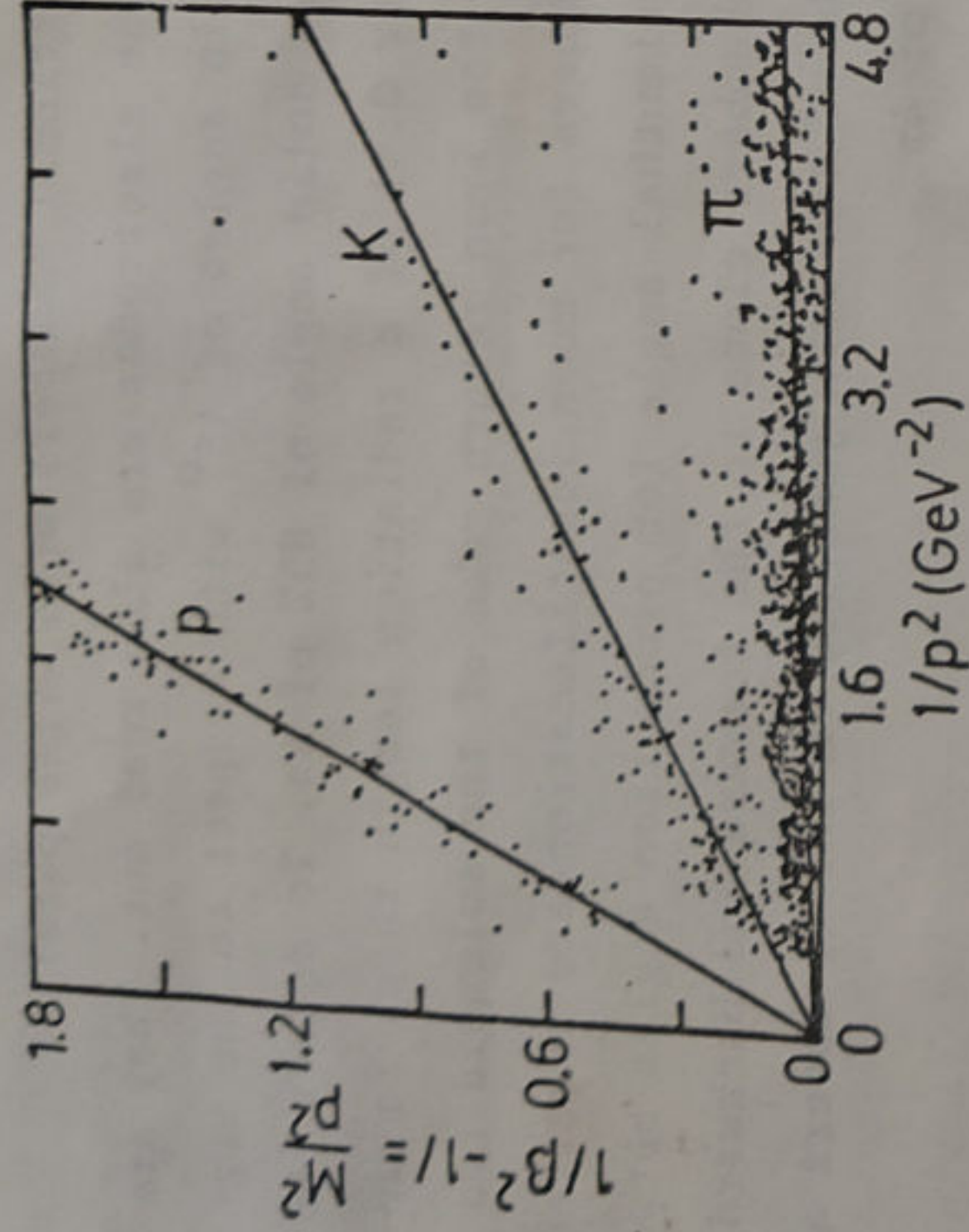
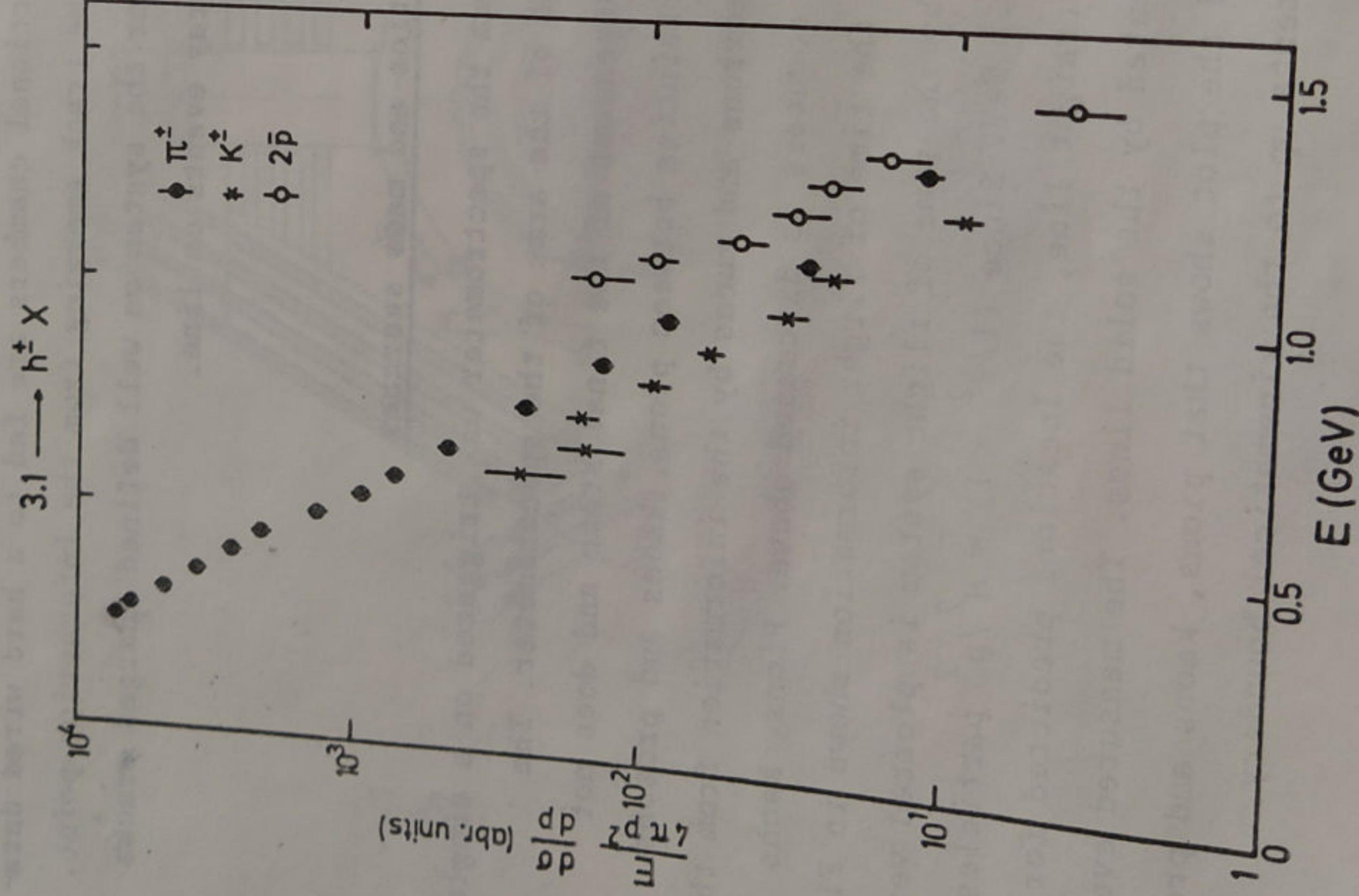



Fig. 5
Time of flight spectrum
measured at
 $2E_{CM} = 3.1 \text{ GeV}$



In Fig. 6 the invariant cross section for the decay $J/\psi \rightarrow h^+ X^-$ is plotted in arbitrary units versus the particle energy for pions, kaons and antiprotons ($\times 2$). The invariant cross section for antiprotons seems to be larger than the cross section for pions and kaons. However, note that the cross sections are roughly all the same within a factor

Fig. 6
The invariant cross section versus the particle energy for the decay $J/\psi \rightarrow h^+ X^-$

of three and tend to approach each other with increasing particle energy. To a good approximation, the invariant cross sections are decreasing exponentially with the particle energy E . For pions the energy dependence is well reproduced by e^{-6E} .

In Fig. 7 the invariant cross section for the decay $\psi' \rightarrow h^+ X^-$ is plotted in arbitrary units versus the particle energy for pions, kaons and anti-protons ($\times 2$). The various cross sections show the same general behaviour as the cross sections measured in the decay of the J/ψ resonance. This similarity might be expected, since the decay

$\psi' \rightarrow J/\psi + X$ accounts⁶⁾ for roughly 60% of all the ψ' decays. The decay mode $\psi' \rightarrow \psi + \pi^+ \pi^-$ is also seen directly as a step in the inclusive pion cross section at low pion energies.

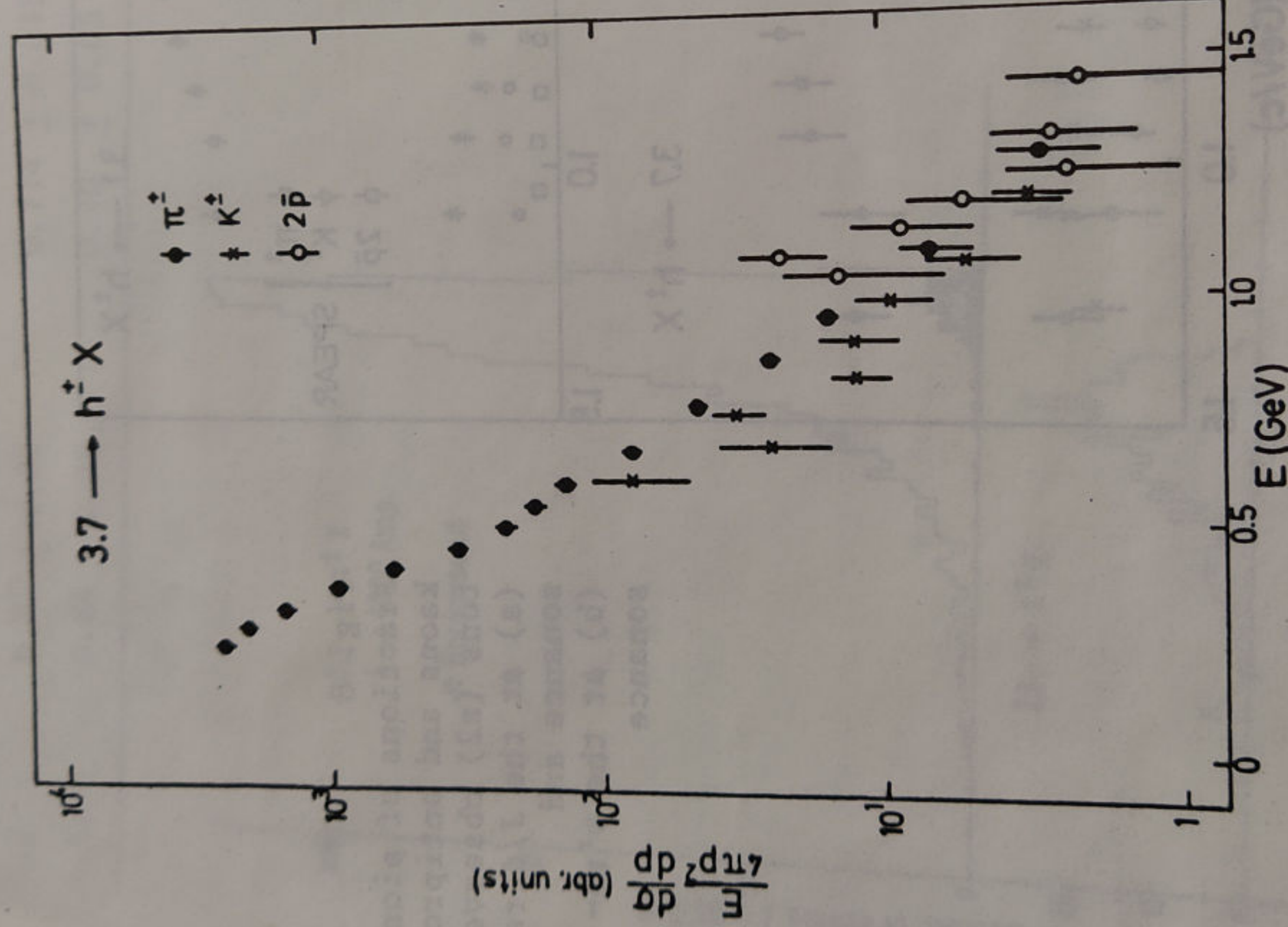


Fig. 7
The invariant cross section versus
the particle energy for the decay
 $\psi' \rightarrow h^+ X^-$

The fraction of pions, kaons and antiprotons observed in the decay of the J/ψ and ψ' resonances is plotted in Fig. 8a, b as a function of momentum. Similar relative particle fractions are found at both resonances; at low momenta mostly pions are produced, but the relative yield of kaons and antiprotons increases with momentum. At a momentum of 1.0 GeV/c the relative fractions are 0.2 for kaons and 0.1 for antiprotons (x2). The data⁷⁾ obtained with the SPEAR solenoid on the particle fractions at the J/ψ resonance are also plotted in Fig. 8 a. The SPEAR results in general give a higher fraction of kaons and antiprotons.

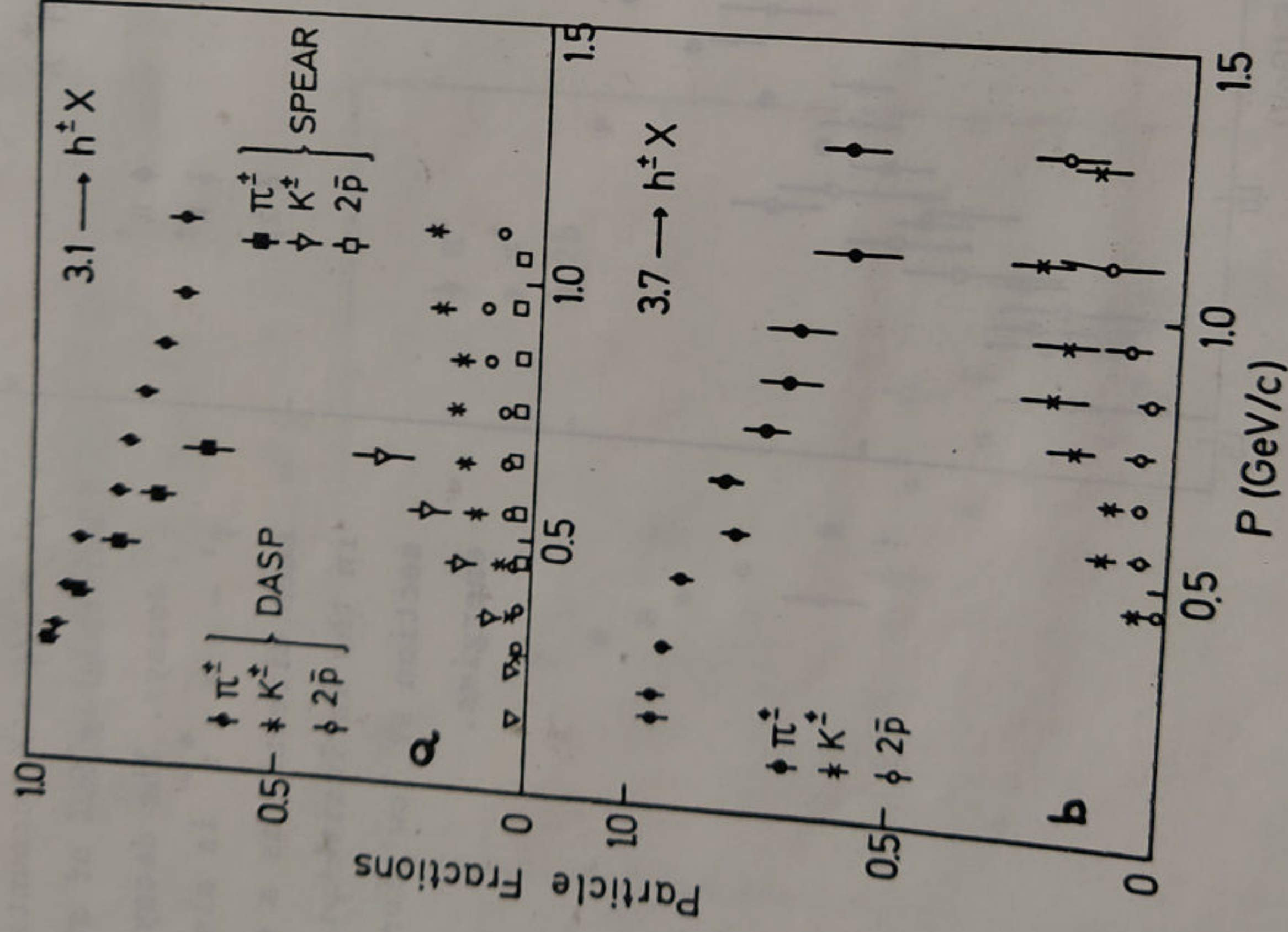
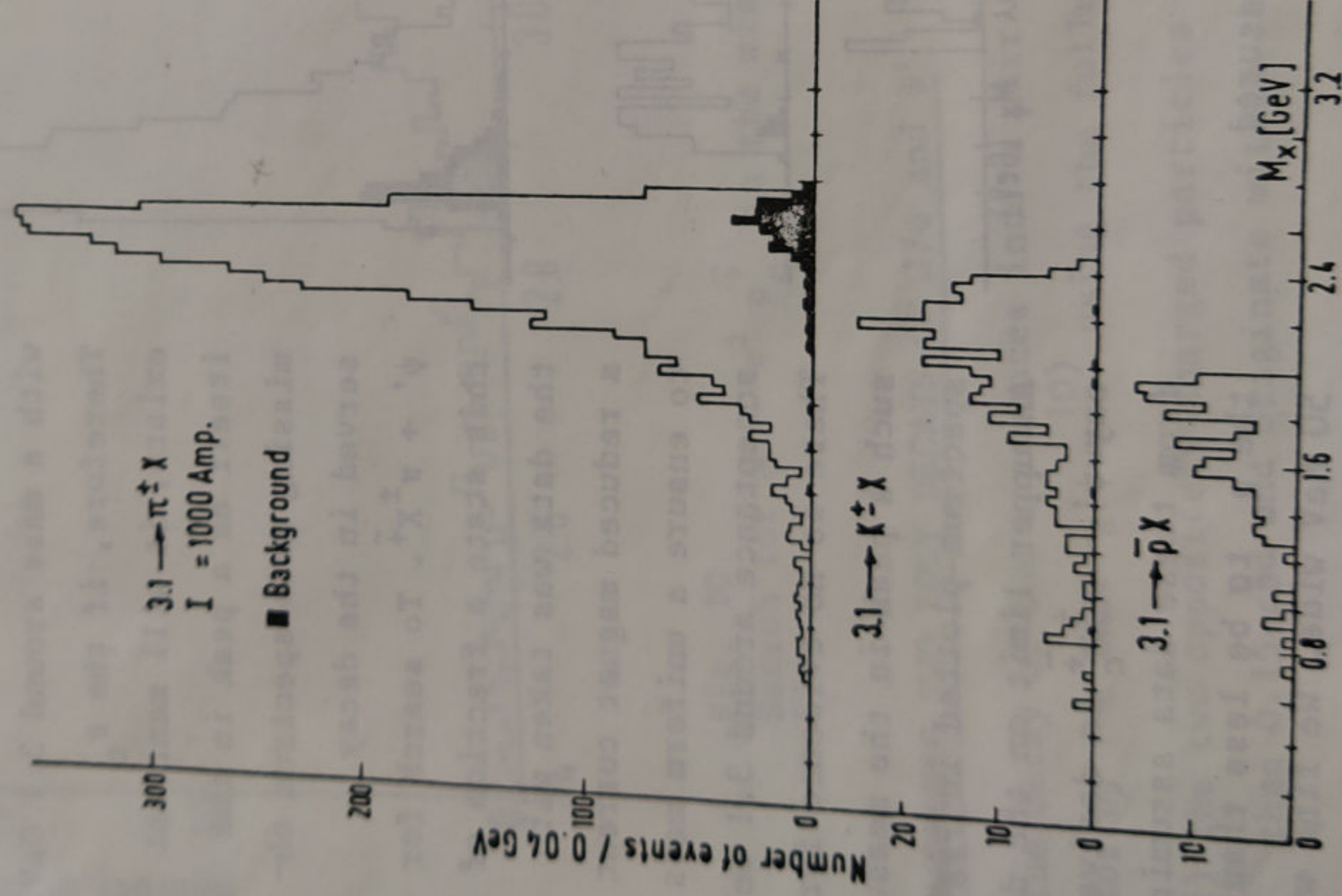


Fig. 8
Fractions of pions,
kaons and antipro-
tons (x2) observed
(a) at the J/ψ re-
sonance and
(b) at the ψ' re-
sonance

It has often been conjectured⁸⁾ that the relative yield of kaons might increase above 4 GeV due to the production and decay of charmed particles. No such increase was observed at a CMS energy of 4.15 GeV. This is seen in Table II where the relative particle fractions observed for momenta between 0.45 GeV/c and 1.3 GeV/c are listed and compared to the results obtained at the resonances.

TABLE II:

$2E_{CM}$	$\pi^\pm/all$	$K^\pm/all$	$2\bar{p}/all$
3.1	0.78 ± 0.008	0.14 ± 0.008	0.062 ± 0.006
3.7	0.82 ± 0.02	0.114 ± 0.013	0.065 ± 0.009
4.15	0.84 ± 0.09	0.10 ± 0.05	-



Any quasi-two body decay of the type $J/\psi(\psi') \rightarrow h + R$ will lead to a peak in the missing mass spectrum of states recoiling against the particle h . The missing mass spectra for the decay channels

$$J/\psi \rightarrow \begin{matrix} \pi^\pm X^\pm \\ K^\pm X^\pm \\ \bar{p} X^\pm \end{matrix}$$

are plotted in Fig. 9. Except for the existence of a possible $KK^*(890)$, no pronounced quasi-two body decays are observed. The background, shown as the black histogram in Fig. 9, was measured simultaneously with the data

Fig. 9
Missing Mass spectrum observed in the decay $J/\psi \rightarrow h^\pm X^\pm$

by selecting events originating outside of the interaction volume. The estimated resolution in missing mass varied between 50 MeV and 10 MeV for missing masses between the mass of the ρ and 2 GeV.

The missing mass spectra for the decay $\psi' \rightarrow h^\pm X^\mp$ are plotted in Fig. 10. No prominent structure with a confidence level of more than 4σ is observed.

According to the color⁹⁾ interpretation of the new resonances, the ψ' is expected to decay with the emission of a single pion into a colored meson ρ_c with a mass around 3.1 GeV.

Therefore, if the ρ_c exists, it will manifest itself as a peak in the missing mass spectrum observed in the decay $\psi' \rightarrow \pi^\pm X^\mp$. To search for this state a fraction of the data was taken with a reduced magnet current to ensure a uniform mass acceptance around 3.1 GeV.

There is no evidence for such a peak in the measured spectrum plotted in Fig. 10. An upper limit on the decay $\psi' \rightarrow \pi^\pm \rho_c^\mp$ is derived from these data assuming the ρ_c to be less than 50 MeV wide. We find with

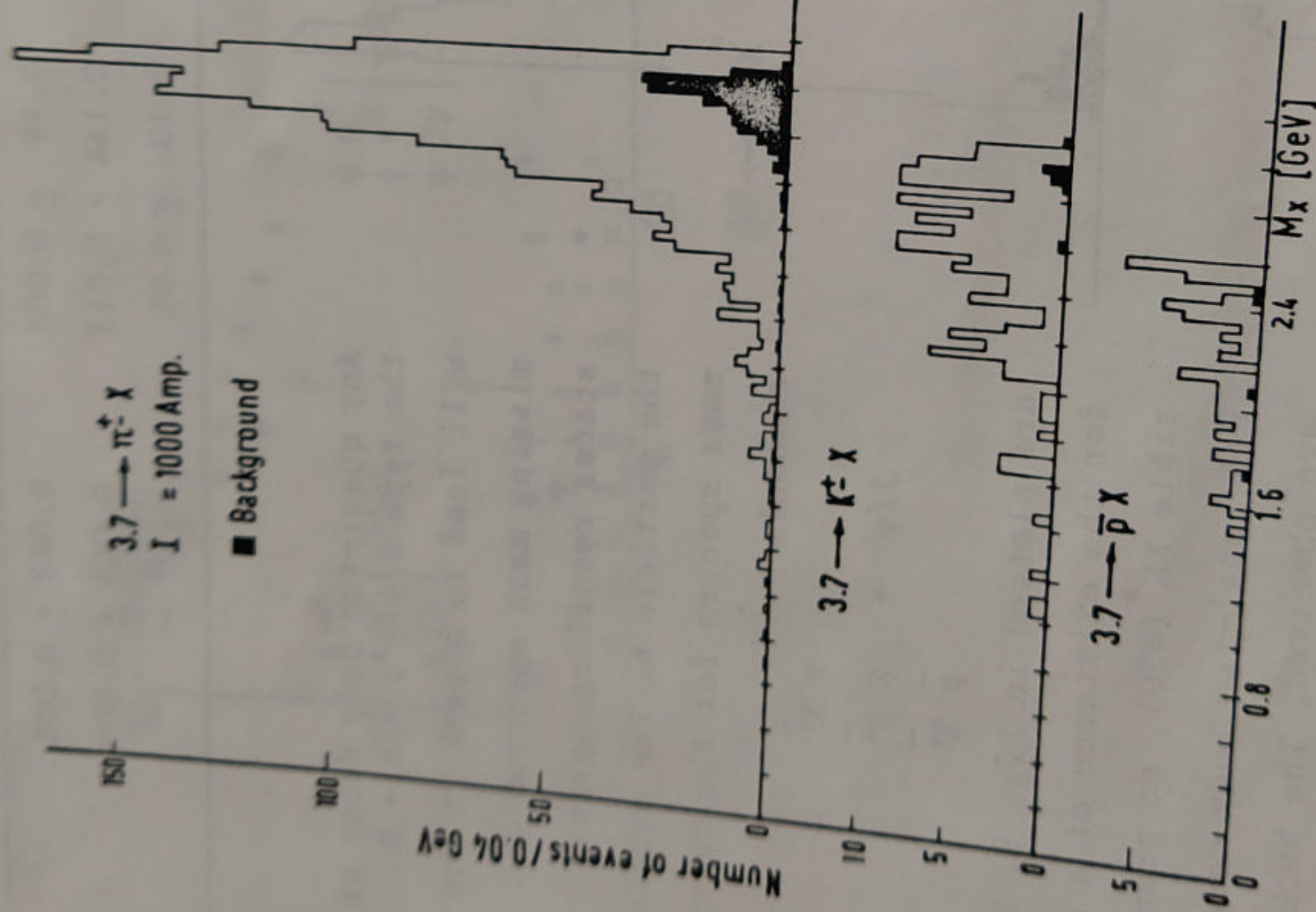


Fig. 10
Missing mass spectra measured
in the decays $\psi' \rightarrow h^\pm X^\mp$

90% confidence that

$$\frac{\Gamma_{\psi' \rightarrow \pi^{\pm} \rho_C^{\mp}}}{\Gamma_{\psi' \rightarrow \text{all}}} < 5 \times 10^{-2}.$$

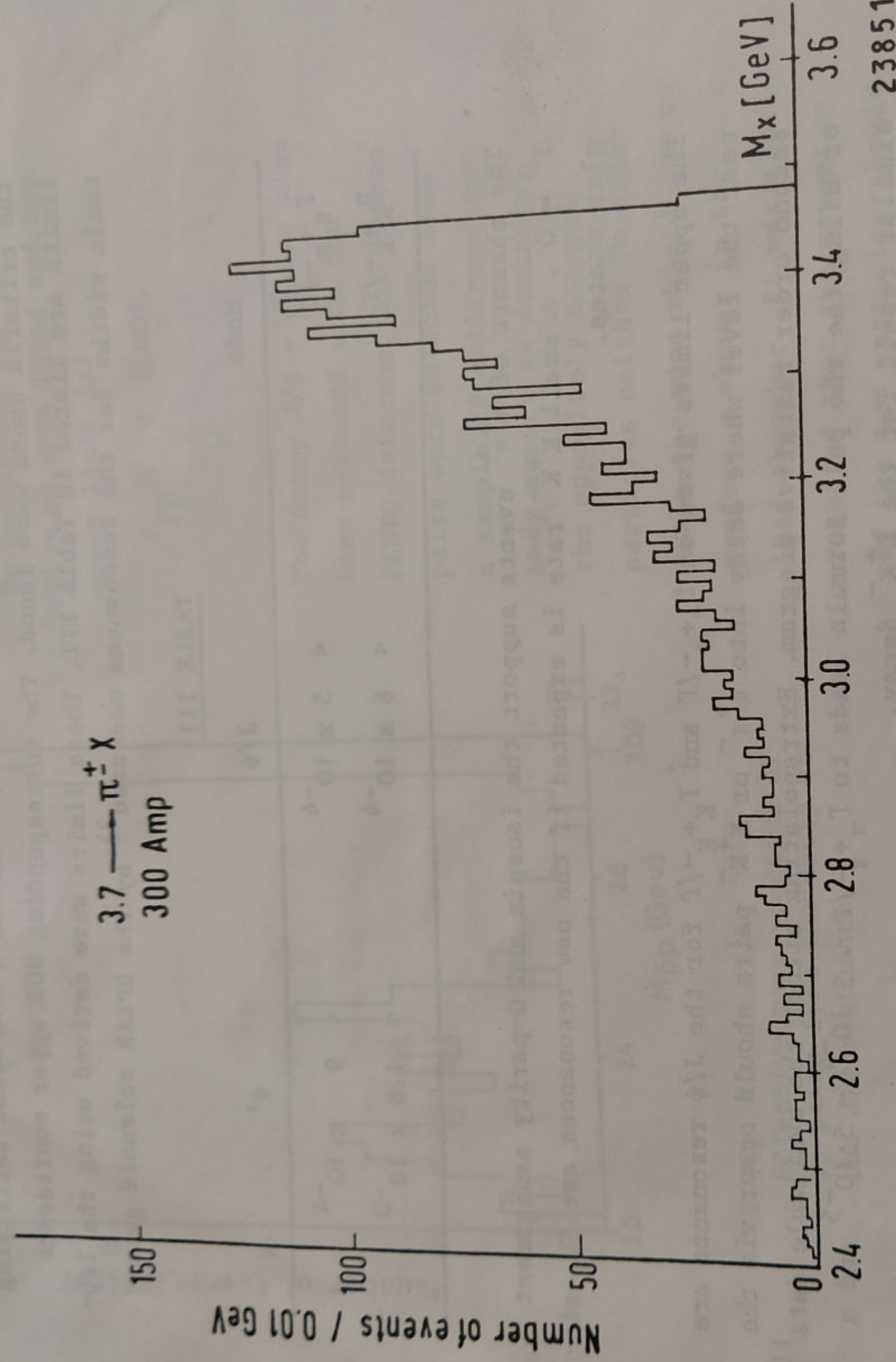


Fig. 10
Search for $\psi' \rightarrow \pi^{\pm} \rho_C^{\mp}$ in the missing mass spectrum

HADRONIC TWO BODY DECAYS OF J/ψ and ψ'

The decay of the resonances into a pair of pions or kaons was searched for by the DASP group¹⁰⁾ using the following criteria:

- 1) The two oppositely charged particles should be collinear to better than 0.15 rad and originate within the interaction volume.
- 2) The pair should have the correct momentum to within ± 50 MeV. The energy loss in the shower counter must be less than four times that

of a minimum ionizing particle and neither particle was permitted to fire the range counters.

At the J/ψ resonance no events, at the ψ' resonance one event satisfying the criteria above were found. The corresponding 90% upper confidence limits are listed in Table III. These limits were derived using the leptonic widths for the resonances measured³⁾ by the SPEAR solenoid group.

TABLE III:

Mode	J/ψ	ψ'
$\Gamma_{\pi^+\pi^-}/\Gamma$	$< 3 \times 10^{-4}$	$< 9 \times 10^{-4}$
$\Gamma_{K^+K^-}/\Gamma$	$< 6 \times 10^{-4}$	$< 1.6 \times 10^{-3}$

The absence of $\pi^+\pi^-$ events support the isospin and G-parity assignment $I^G = 0^-$. A small K^+K^- rate is expected if the new resonances are SU_3 singlet states.

The upper limits given on $\Gamma_{\pi^+\pi^-}/\Gamma$ and $\Gamma_{K^+K^-}/\Gamma$ for the J/ψ resonance are near the level where decay into $\pi^+\pi^-$ or K^+K^- pairs should occur via the second order radiative diagram. Extrapolating either the available data¹¹⁾ or using the rho pole formula leads to $\Gamma_{\pi^+\pi^-}/\Gamma \sim 5 \cdot 10^{-4}$ - $5 \cdot 10^{-5}$ and a similar result for the K^+K^- decay.

The $p\bar{p}$ pairs were selected from the sample of pair events by demanding the correct time of flight. The effective mass spectrum of the $p\bar{p}$ pairs observed in the decay of the J/ψ resonance is plotted in Fig. 12. The elastic peak $J/\psi \rightarrow p\bar{p}$ is clearly seen centered at a mass of 3.09 GeV. To evaluate the branching ratio the angular distribution of the $p\bar{p}$ events must be known.

Assuming the angular distribution to be given by $1 + \cos^2\theta$ we find:

$$\Gamma_{p\bar{p}}^-/\Gamma = (0.0023 \pm 0.0006)$$

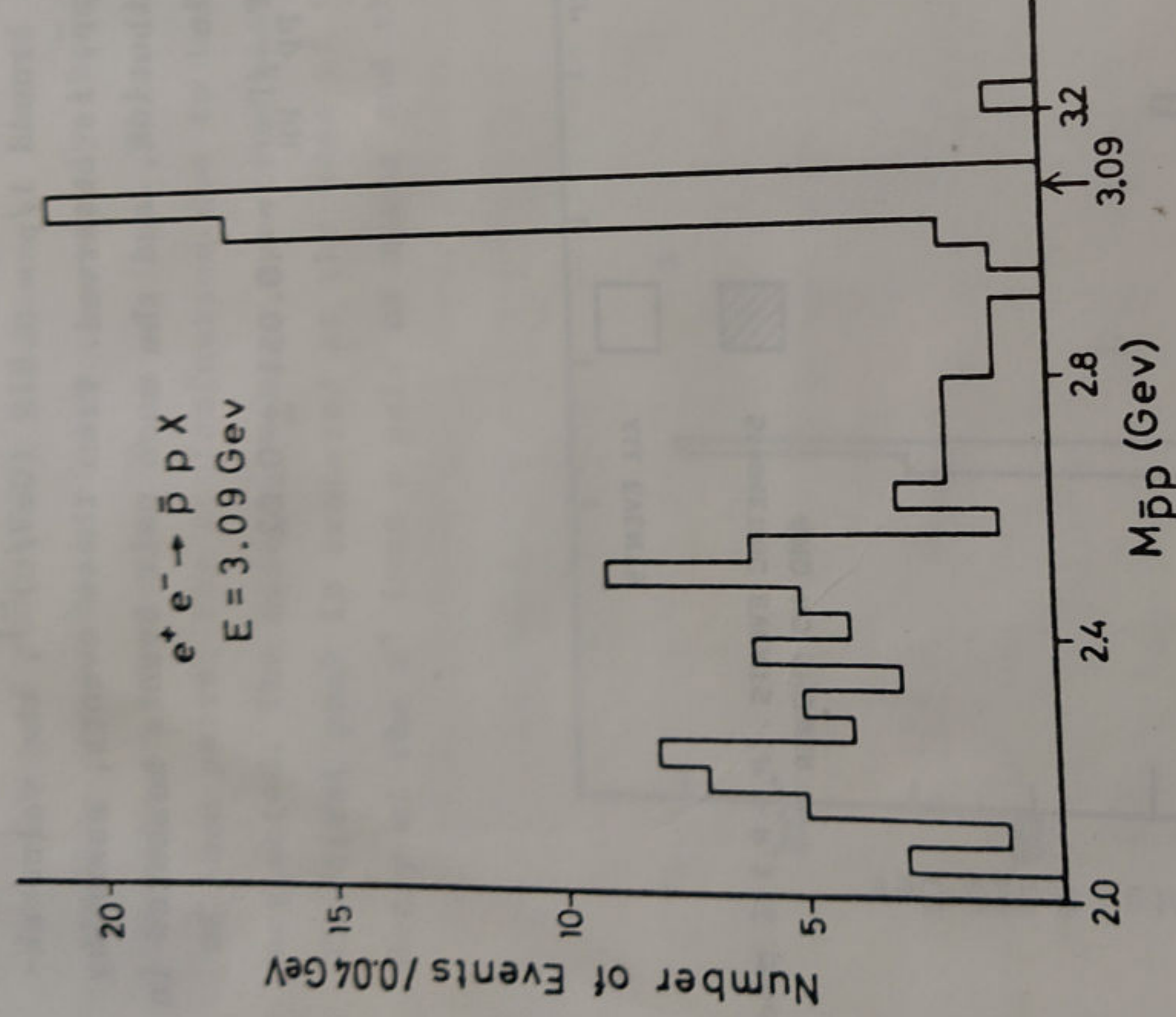


Fig. 12
Effective mass spectrum of
 $\bar{p}p$ pairs from the decay of
the J/ψ resonance

This branching ratio was derived using only a part of the data plotted in

Fig. 12.

No candidates for the decay $\psi' \rightarrow \bar{p}p$ were found and the upper limit is:

$$\Gamma_{\bar{p}p} / \Gamma < 0.001.$$

The decay $J/\psi \rightarrow \bar{p}p$ has also been measured with the PLUTO detector. The hadron pairs were selected from a sample of collinear two body events by demanding the oppositely charged particles neither to penetrate the muon shield nor to produce a shower in the lead absorber. It was further required that the momentum of the two particles should balance to within 150 MeV.

Events satisfying these conditions are plotted in Fig. 13 as a function of l/p . A cluster of events around $l/p = 0.812 \text{ (GeV/c)}^{-1}$, the value expected for the decay $J/\psi \rightarrow p\bar{p}$, is observed. From these events, assuming a $(1 + \cos^2\theta)$ angular distribution, and the muon pair events measured in the same experiment the ratio

$$\Gamma_{p\bar{p}}/\Gamma_{\mu\mu} = 0.051 \pm 0.02$$

is determined directly.

l/p DISTRIBUTION

$E_{\text{BEAM}} \sim 1.545 \text{ GeV}$ $B = 16 \text{ K}\Gamma$

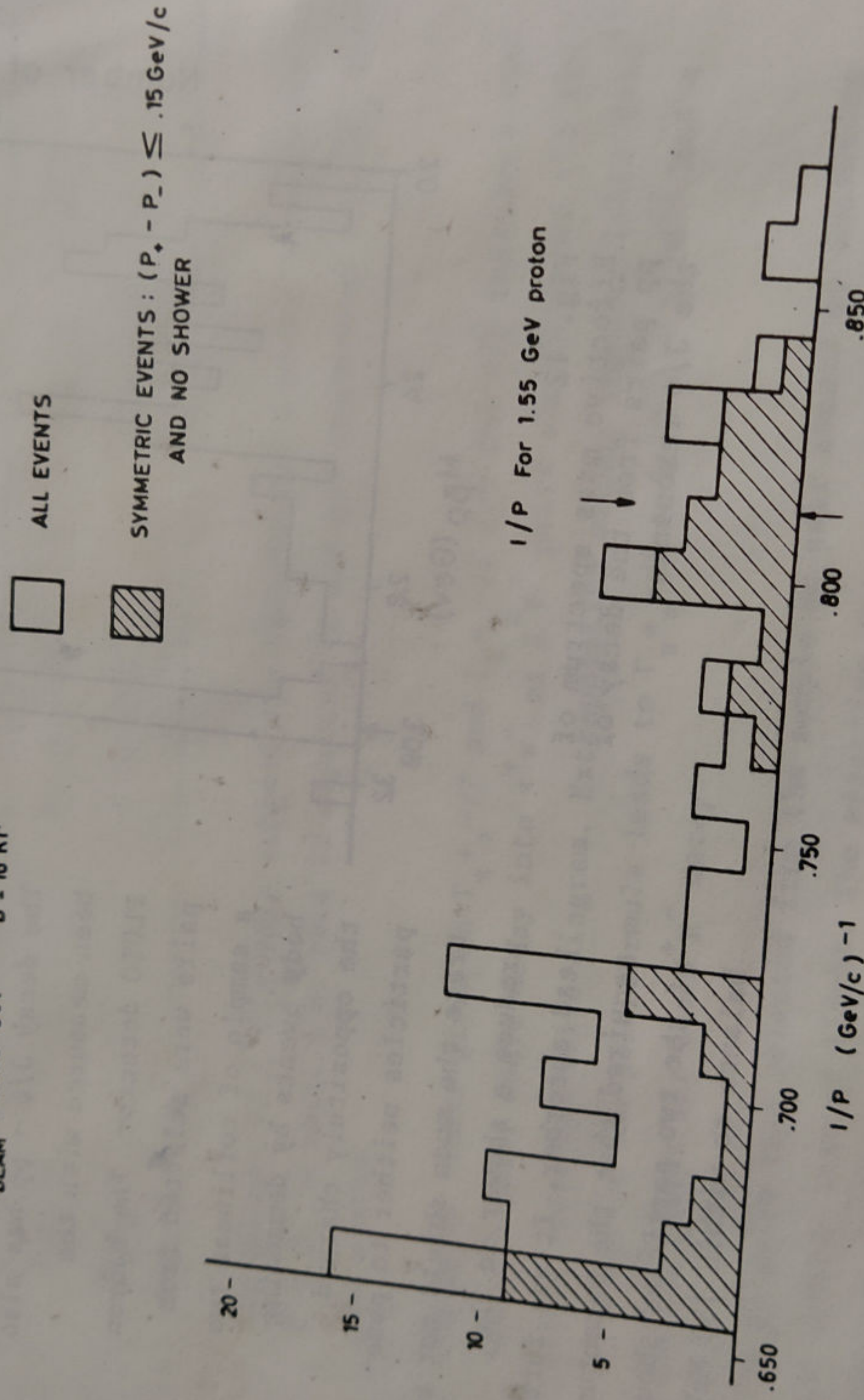


Fig. 13

The l/p distribution for collinear pairs which do not satisfy the criteria for muons or electrons. Events with a large energy loss in one track are excluded in the shaded histogram.

THE CASCADE DECAY: $\psi' \rightarrow J/\psi + X$

The yield of muon pairs produced at the ψ' resonance was measured by demanding one or both of two oppositely charged particles accepted by the magnets to penetrate 70 cm of iron. These criteria provide a clean sample of muon pairs; the contamination due to hadron pairs can be completely neglected. The effective mass spectrum plotted in Fig. 14 shows two peaks. The first peak is centered at the mass of the ψ' and is the sum of the decay of the ψ' into a pair of muons and the muons directly produced by

QED. The second peak at a mass of 3.09 GeV is from the decay of the J/ψ resonance into a pair of muons and is direct evidence⁶⁾ for the decay $\psi' \rightarrow J/\psi + X$. The ψ' decays roughly 60% of the time via this channel.

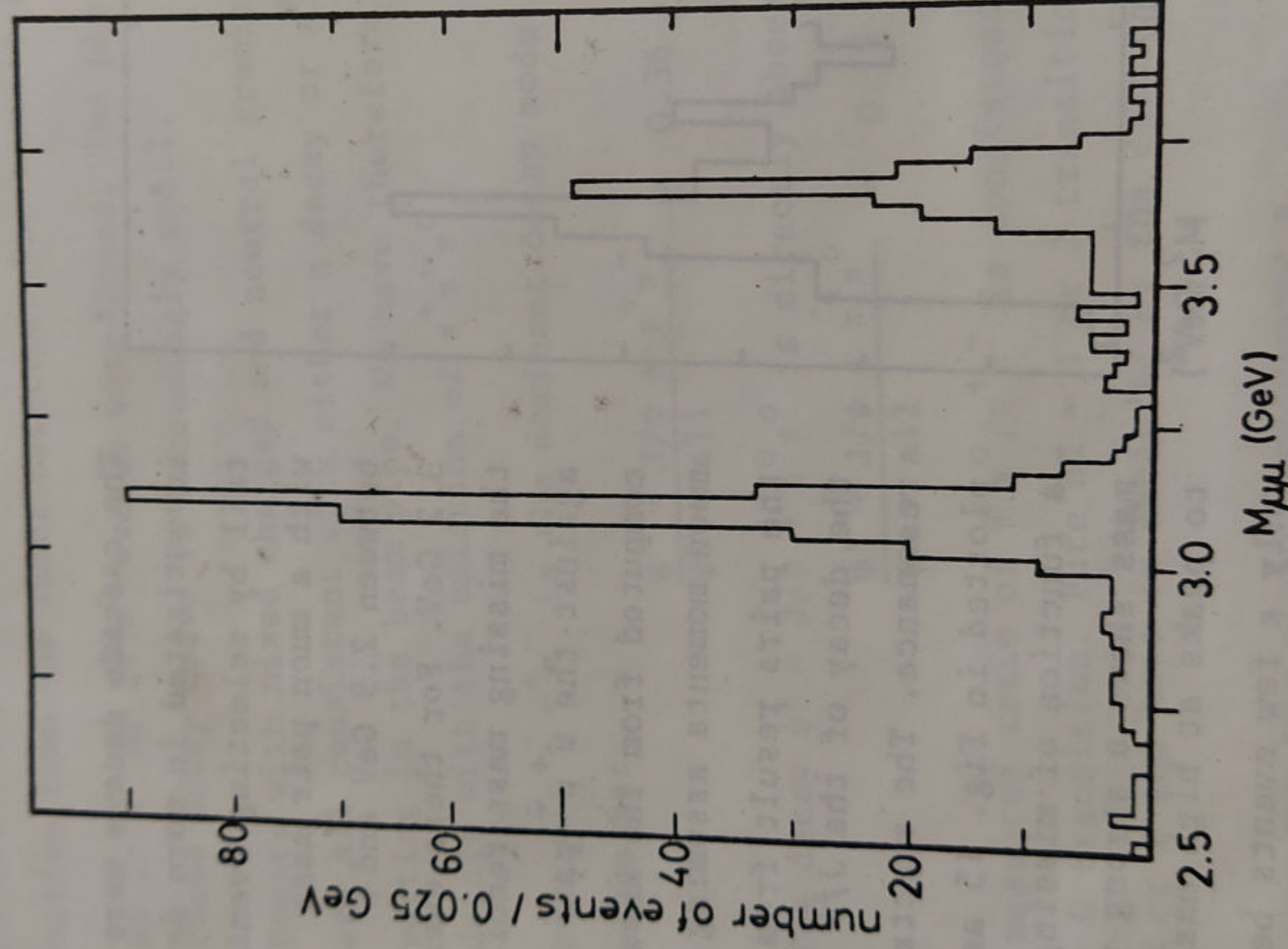


Fig. 14
The yield of muon pairs produced at the ψ' resonance a function of the effective pair mass

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DATE 82.205/15.00.52

PAGE 1

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C----- (3-5) # F(KQ,K) REAL 00003800
ISN 0020 AN2=2.Q0*ALF2/3.Q0 00003900
C----- (3-5) # F(KQ,K) REAL 00004000
ISN 0021 ALF3=QEXP(K-1.Q0)/K-KQ*(ALFA/3.Q0*(1.Q0+QSQRT(ETAQK(KQ,K)))* 00004100
*(XI/ETAQK(KQ,K)**2)**(2*IK+1)*ETAQK(KQ,K)**3+ETAQK(1.Q0,1.Q0)/ 00004200
*(EBN*ETAQK(KQ,K))*(2.Q0*XI*ETAQK(KQ,K))**IK*((1.Q0- 00004300
*QSQRT(ETAQK(KQ,K)))/(1.Q0+QSQRT(ETAQK(KQ,K))))**2) 00004400
C----- (3-5) # F(KQ,K) REAL 00004500
ISN 0022 AN3=2.Q0*ALF3 00004600
C----- PRINT INTERMEDIATE RESULTS 00004700
ISN 0023 WRITE(6,300) IS,IQ1,IQ2,IQ3,IQ4 00004800
ISN 0024 300 FORMAT(1X,' IS IQ1 IQ2 IQ3 IQ4'/1X,5I5) 00004900
ISN 0025 IF(IPRINT.GE.2) WRITE(6,100) ALF1,ALF2,ALF3,AN1,AN2,AN3 00005000
ISN 0027 100 FORMAT(1X,' ALF1 ALF2 ALF3 00005100
* AN1 AN2 AN3'/1X,6Q16.8) 00005200
C----- (4-2) REAL 00005300
ISN 0028 GKQ=Q1**3*ALF1+Q2**2*ALF2+Q3*ALF3+QEXP((1.Q0-2.Q0*K)/3.Q0) 00005400
C----- (4-3) REAL 00005500

```


The following decay modes X are allowed by energy, charge and C-parity conservation:

$$\begin{aligned} \psi' &\rightarrow (J/\psi) + \pi^0 \\ &\pi^+ \pi^- \text{ or } \pi^0 \pi^0 \\ &\pi^+ \pi^- \pi^0 \text{ or } \pi^0 \pi^0 \pi^0 \\ &\eta \\ &2\pi^+ \pi^- \text{ or } 2\pi^0 \pi^0 \\ &\gamma \gamma \end{aligned}$$

The $\gamma\gamma$ mode can arise from two successive transitions through a new intermediate state P_c . Evidence for such states has now been obtained¹²⁾ and will be discussed below.

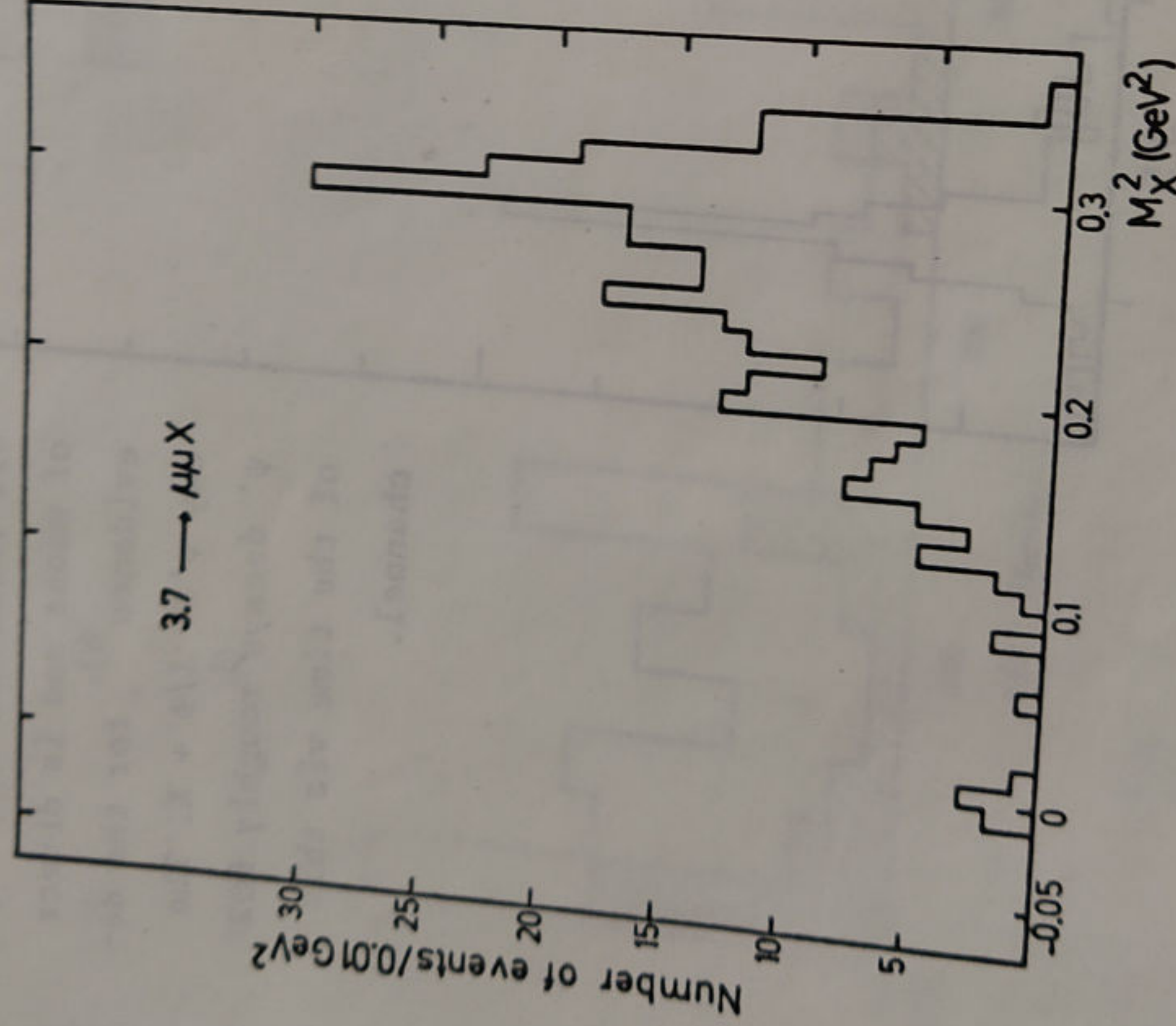


Fig. 15
The spectrum of missing masses in the reaction $e^+e^- \rightarrow \mu^+\mu^- + \text{missing mass}$ produced at the ψ' resonance. The $\mu^+\mu^-$ effective mass is required to be between 2.9 GeV and 3.2 GeV

The cascade decays were investigated in more detail by selecting events with a muon pair mass between 2.9 GeV and 3.2 GeV. For these events, the missing mass recoiling against the $\mu^+\mu^-$ pair was computed from the known muon momenta assuming the pairs result from the decay of the J/ψ resonance. The spectrum, plotted in Fig. 15 as a function of missing mass shows a strong tendency to peaks at high masses, with only a few events below the two pion threshold. In particular there is no evidence for decays with the emission of a single π^0 .

The decay $\psi' \rightarrow J/\psi + \eta$ is observed in the missing mass spectrum as a narrow peak centered around 0.3 GeV^2 . The observed width is consistent with the value expected from the experimental resolution alone. The existence of this decay mode proves that the ψ' and the J/ψ have the same isospin and G-parity.

The measured branching ratio

$$\frac{\psi' \rightarrow J/\psi + \eta}{\psi' \rightarrow \text{all}} = (0.037 \pm 0.015)$$

is surprisingly large considering the small phase space available.

The other decay modes listed above were disentangled using additional information from the inner detector. The results are:

- 1) No $2\pi^+\pi^-$ or $2\pi^0\pi^0$ events were found. The phase space available for these decay modes is exceedingly small.
- 2) Events with mixed charged and neutral tracks were found. These events are all consistent with either η decay or $\pi^0\pi^0$ decays with photons converting in the beam pipe. We have therefore no evidence for direct decays with the emission of $\pi^+\pi^-\pi^0$.

- 3) $\psi' \rightarrow J/\psi + \pi^+\pi^-$ is the dominant decay mode. The measured branching ratio is:

$$\frac{\psi' \rightarrow J/\psi + \pi^+\pi^-}{\psi' \rightarrow \text{all}} = 0.36 \pm 0.06$$

- 4) The decay $\psi' \rightarrow J/\psi + \pi^0\pi^0$ is directly observed with a branching ratio

$$\frac{\psi' \rightarrow J/\psi + \pi^0\pi^0}{\psi \rightarrow \text{all}} = 0.18 \pm 0.06$$

The measured ratio of $\pi^0\pi^0/\pi^+\pi^-$ is consistent with 0.5 as expected for a $\Delta I = 0$ transition. Pure $\Delta I = 1$ or 2 transitions corresponds to a ratio of 0 or 2 and this is excluded by the data.

EVIDENCE FOR NEW NARROW RESONANCES P_C

The decay mode $\psi' \rightarrow J/\psi + \gamma\gamma$ was found in two nearly independent experiments. In the first experiment the $\gamma\gamma$ cascade was identified by measuring the two electrons from the decay of the J/ψ resonance in coincidence with the photons. All four particles were observed in the inner detector

only. In a second experiment, done concurrently with the first, the reaction was identified by observing the decay of the J/ψ into a pair of muons with the magnetic spectrometer and selecting events with just two photons in the inner detector.

Since both experiments give the same absolute rate for the $\gamma\gamma$ transition, but the photon resolution obtained in the first experiment is not sufficient to separate the various transitions, only the second experiment will be discussed here.

The decay $\psi' \rightarrow (J/\psi \rightarrow \mu\mu) + \gamma\gamma$ was measured by first selecting those events which had a pair of muons accepted by the magnets in coincidence with two photons detected in the inner detector.

The muons were measured and identified as discussed above. The effective mass of the muon pair should be between 2.9 GeV and 3.2 GeV.

A photon in the inner detector was defined as follows:

The appropriate beam counters and front counters in the inner detector should not have fired. The photon should convert "in" the detector as evidenced by either a pulse in the shower counter (the energy loss must be greater than 0.3 of that for a minimum ionizing particle) or at least one proportional tube and one scintillation counter fired. The angular resolution for photons is $\pm 2^\circ$ if they convert in front of a proportional tube chamber or $\pm 8^\circ$ in ϕ and $\pm 20^\circ$ in θ if they are detected by the shower counters only.

Altogether 33 events that satisfied these criteria were found. Besides the genuine $\gamma\gamma$ events this sample also contains background events resulting from the decays:

$$\begin{aligned}\psi' &\rightarrow (J/\psi \rightarrow \mu\mu) + \eta \\ &\rightarrow (J/\psi \rightarrow \mu\mu) + \pi^0 \pi^0\end{aligned}$$

where two of the photons produced are detected.

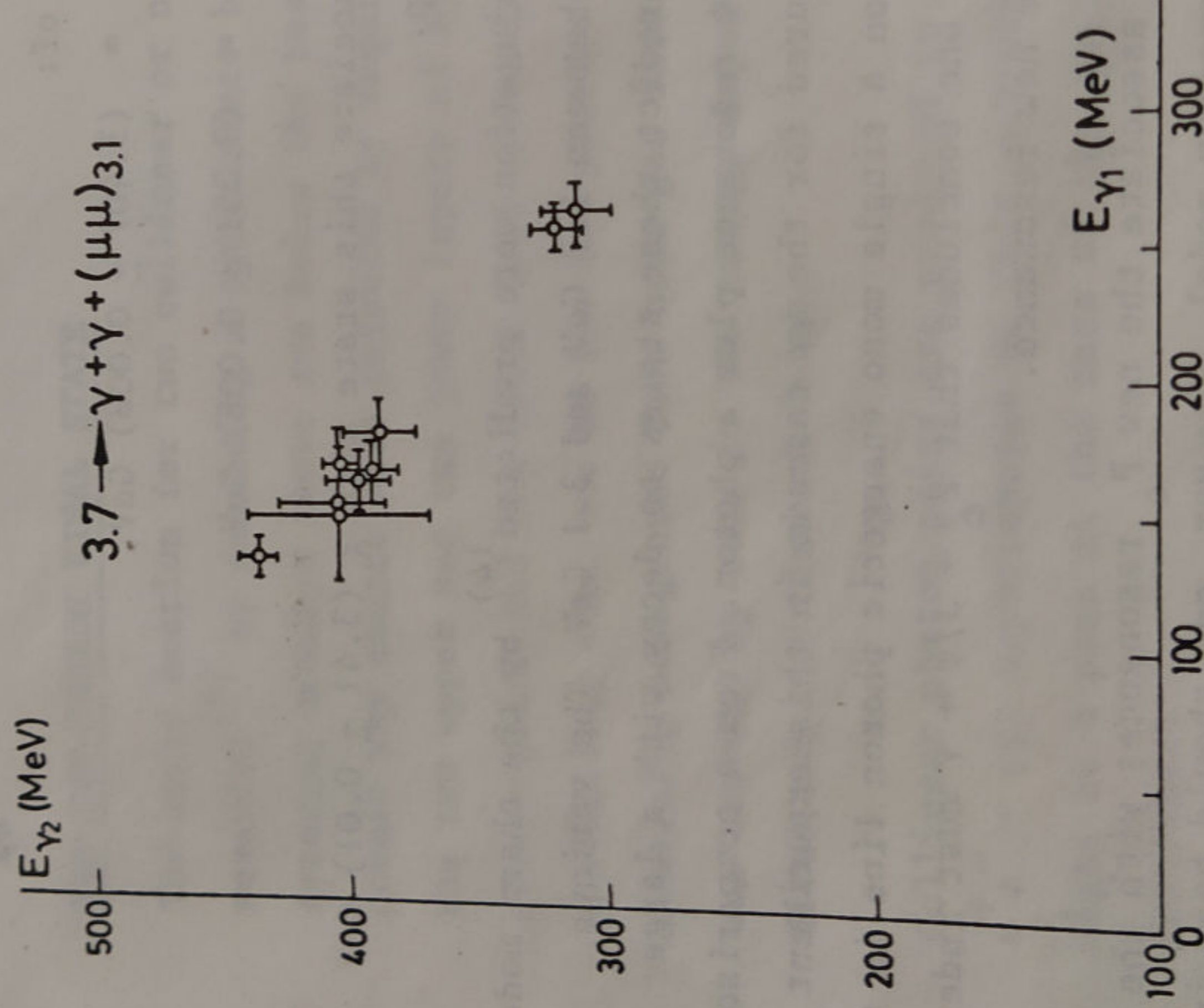
The η background was removed by restricting the missing mass recoiling against the $\mu^+\mu^-$ pair to values less than 520 MeV. To remove the $\pi^0\pi^0$ contribution, a 3C fit to the remaining sample of 29 events was made assuming these events to be genuine $\gamma\gamma$ events. The measured momenta and

angles of the muons and the direction of the photons were used as an input to the computation together with their errors. The events were then plotted as a function of the chi square of the fit. Candidates for genuine $\gamma\gamma$ events were required to have a χ^2 of less than 12. Altogether 9 events satisfied these criteria. The $\pi^0\pi^0$ background remaining in this sample was evaluated by a Monte Carlo calculation, using as input:

1) (The $\pi^0\pi^0$ mass spectrum) = $1/2$ (the $\pi^+\pi^-$ mass spectrum observed in $\psi' \rightarrow J/\psi + \pi^+\pi^-$). This relationship is found experimentally and is predicted for a $\Delta I = 0$ transition.

2) The acceptance of the detector computed from the known geometric acceptance and the measured detection efficiency for a photon.

The Monte Carlo computation predicted that of the remaining 9 events less than 0.8 event results from $\pi^0\pi^0$ decays.



The events are plotted in Fig. 16 as a function of the fitted photon energies. The events cluster in two groups demonstrating the existence of two narrow resonances P_c and P'_c with even charge conjugation.

The first group is centered at:

$$E_{\gamma 1} = (169 \pm 7) \text{ MeV}$$

$$E_{\gamma 2} = (398 \pm 7) \text{ MeV}.$$

It can not yet be decided in which order these photons are emitted and this leads to a twofold ambiguity in the mass of the new particle

Fig. 16
Scatter plot of the two photon energies for candidates for the decay $\psi' \rightarrow (J/\psi \rightarrow \mu^+\mu^-) + \gamma\gamma$

$$M_{P_c} = (3.507 \pm 0.007) \text{ GeV}$$

$$\text{or } M_{P_c} = (3.258 \pm 0.007) \text{ GeV.}$$

It seems, however, natural to associate the P_c resonance with the resonance later observed at $(3.53 \pm 0.02) \text{ GeV}$ by the SPEAR group¹³⁾.

The total branching ratio:

$$\frac{\psi' \rightarrow P_c + \gamma_1}{\psi' \rightarrow \text{all}} \cdot \frac{P_c \rightarrow J/\psi + \gamma_2}{P_c \rightarrow \text{all}} = (0.04 \pm 0.02)$$

A second group, consisting of two events, is centered at:

$$E_1 = (263 \pm 8) \text{ MeV}$$

$$E_2 = (315 \pm 8) \text{ MeV}$$

This corresponds to a mass of:

$$M_{P_c'} = (3.407 \pm 0.008) \text{ GeV}$$

$$M_{P_c'} = (3.351 \pm 0.008) \text{ GeV}$$

It might be tempting to associate this state with χ $(3.41 \pm 0.01) \text{ GeV}$ found¹³⁾ by the SPEAR group.

States with even charge conjugation were predicted¹⁴⁾ by the charm model to exist in the mass range between 3.7 GeV and 3.1 GeV. The various charmonium models further predict these states to decay with a large branching ratio into the J/ψ resonance plus a photon. From a comparison of the branching ratio measured for the $\gamma\gamma$ cascade in this experiment and the limits obtained¹⁵⁾ on a single mono energetic photon line in the decays of the ψ' resonance, one concludes that $P_c \rightarrow J/\psi + \gamma$ must indeed be a major decay mode of the new resonance.

It is therefore tempting to associate the new P_c resonances with the states predicted in the charmonium model. However, one should bear in mind that since these states might also be accommodated in a color model⁹⁾, their mere existence proves neither charm nor color.

If the P_c is a natural spin parity state it can decay into a pair of pseudoscalar mesons. The decay $\psi' \rightarrow (P_c \rightarrow \pi^+ \pi^-, K^+ K^-) + \gamma$ has been searched for by observing pairs of pions (kaons) with the magnetic spectrometers of DASP in coincidence with a photon in the inner detector. Two candidates for this decay are found, one at an invariant pair mass of 3.515 GeV, the other at a mass of 3.439 GeV. Each event represents a branching ratio:

$$\frac{\psi' \rightarrow P_c \cdot \gamma}{\psi' \rightarrow \text{all}} \cdot \frac{P_c \rightarrow \pi^+ \pi^-, K^+ K^-}{P_c \rightarrow \text{all}}$$

of the order of 2×10^{-4} .

The SPEAR solenoid group found¹³⁾ the $\chi(3410)$ to decay into pion plus kaon pairs with a branching ratio, as defined above of $(13 \pm 5) \cdot 10^{-4}$. They found no candidates at the mass of the P_c resonance; their 90% confidence upper limit was 2.7×10^{-4} .

THE TWO PHOTON FINAL STATE

The cross section for two collinear or nearly collinear photons has been measured¹⁶⁾ by demanding a coincidence between the sectors of the inner detector mounted above and below the beam pipe. Bhabha scatters and cosmic ray events were rejected by requiring that no more than two of the two upper and two lower layers of scintillators between the interaction point and the first lead converters be fired. This allows for the possibility that one of the two photons converts in the beam pipe. The remaining background from beam-gas interactions and cosmic ray events was removed by cuts in the energy deposited, number of proportional tubes fired and the time of flight.

Collinear photon pairs are produced in the two photon annihilation

$e^+ e^- \rightarrow \gamma\gamma$. Superimposed on this smoothly decreasing cross section there might be a peak at the mass of the resonances due to any of the following processes:

- 1) Direct decay of the resonances into a pair of collinear photons. This

decay is strictly forbidden for a spin 1 state. It is allowed for all other values of the spin provided C is even or not conserved.

- 2) $e^+e^- \rightarrow \psi/J(\psi') \rightarrow \pi^0 + \gamma$. In this case there will always be two photons non collinear to within an angle of m_π^*/E_π . If the second photon from the π^0 decay is not detected the event will masquerade as a $\gamma\gamma$ event.

- 3) $e^+e^- \rightarrow \psi/J(\psi') \rightarrow (X + \gamma\gamma) + \gamma$

The resonance decays with the emission of a single photon into a heavy particle X which in turn decays into two photons. If the mass of X is close to 3.1 GeV or 3.7 GeV, X will be produced nearly at rest and the two photons from its decay will be nearly collinear.

The measured energy dependence of the $\gamma\gamma$ cross section is plotted in Fig. 17 and Fig. 18 for energies in the vicinity of 3.09 GeV and 3.68 GeV. No re-

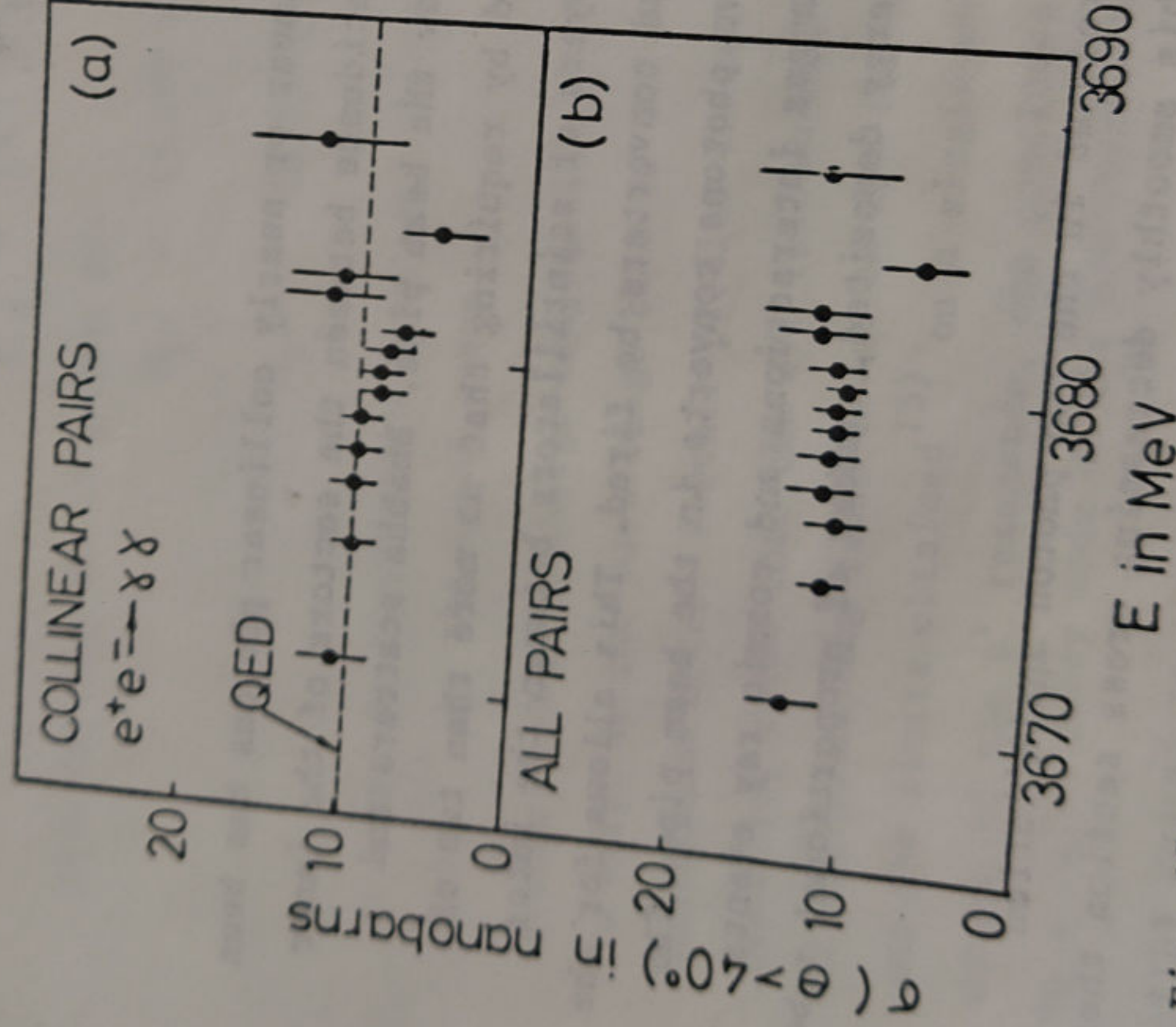


Fig. 17
Cross section for $e^+e^- \rightarrow \gamma\gamma$
as a function of CMS energy
in the vicinity of 3.09 GeV.
The dotted line is the rate
predicted from QED

sonance effect is observed and the absolute value of the cross section is in good agreement with the predicted QED cross section shown as the dotted line.

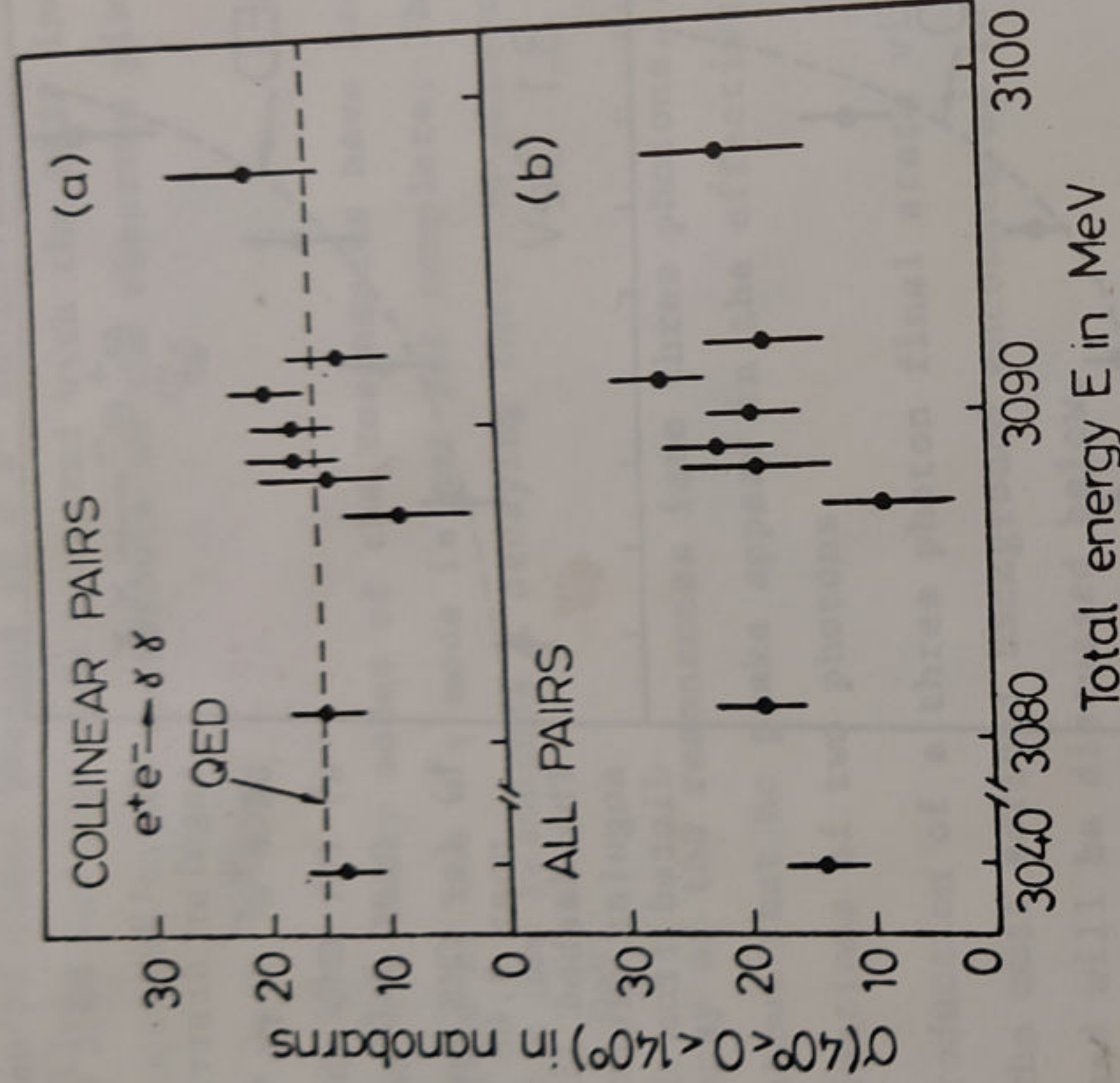


Fig. 18
Cross section for $e^+e^- \rightarrow \gamma\gamma$
as a function of CMS energy
in the vicinity of 3.68 GeV.
The dotted line is the rate
predicted from QED

The angular distributions, plotted in Fig. 19a, b are also consistent with QED predictions, plotted as the dashed line. Upper limits on the various resonance contributions were derived from the observed energy dependence of the cross sections by fitting the data to a nonresonant background plus a Gaussian peak with the mass and the width observed in the total hadron cross section using the same detector. The 90% confidence upper limits are listed in Table IV:

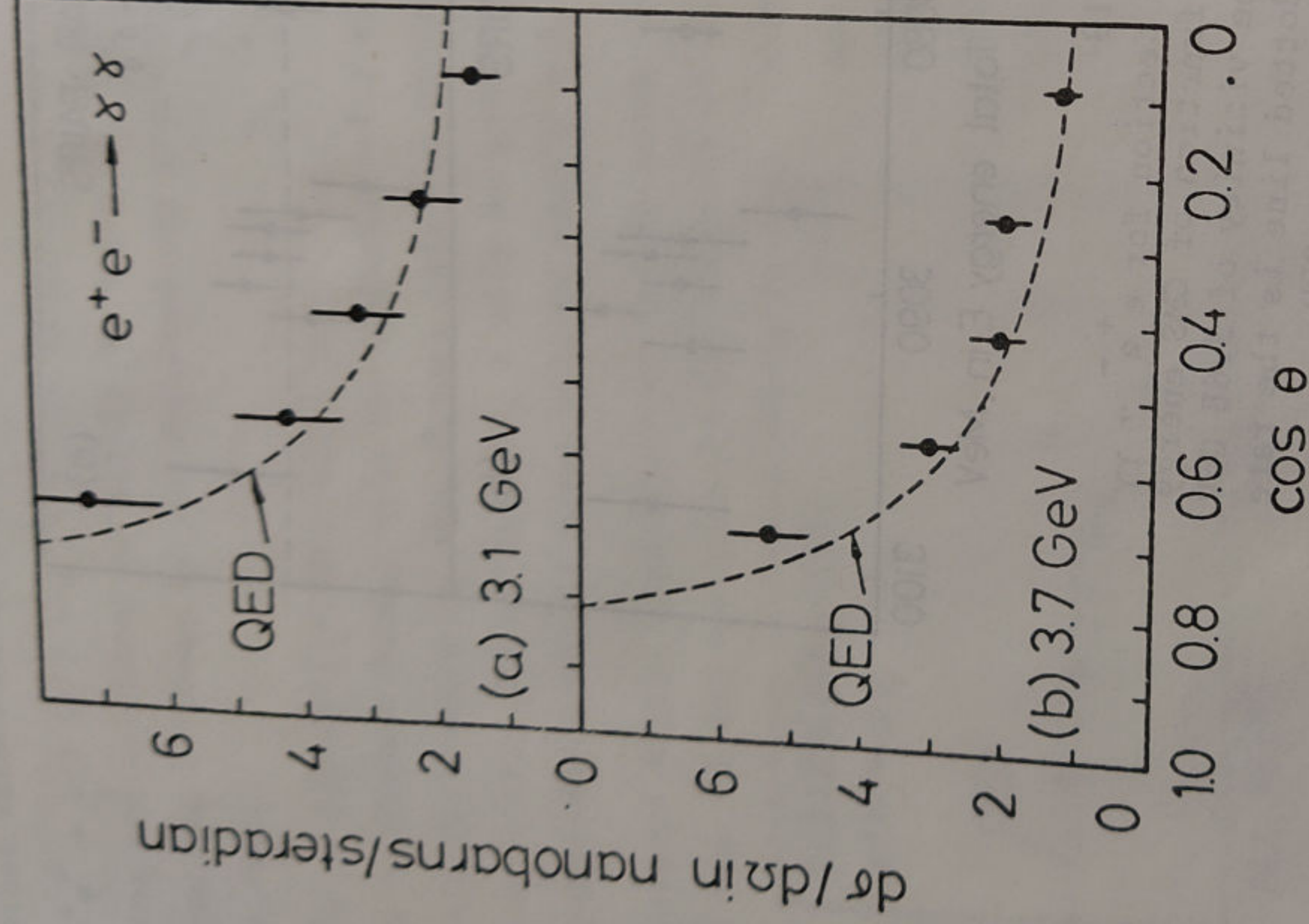


Fig. 19
Angular distributions
of $e^+e^- \rightarrow \gamma\gamma$
a) for CMS energies
near 3.09 GeV
b) for CMS energies
near 3.68 GeV
The dashed lines are the
angular distributions pre-
dicted from QED

TABLE IV:

Mode	J/ψ	ψ'
$\Gamma_{\gamma\gamma}/\Gamma$	0.003	0.008
$\Gamma_{\pi\gamma}/\Gamma$	0.01	0.01
$(\Gamma_{X\gamma}/\Gamma)(\Gamma_{X\rightarrow\gamma\gamma}/\Gamma_{X\rightarrow\text{all}})$	0.003	0.008
	$(2.99\text{GeV} < M_x < 3.09\text{GeV})$	$(3.58\text{GeV} < M_x < 3.68\text{GeV})$

THREE PHOTON FINAL STATE AND EVIDENCE FOR A NEW RESONANCE

The production of three photons in e^+e^- annihilation at CMS energies around 3.09 GeV and 3.68 GeV has been measured with the DASP inner detector. The following processes might contribute to the observed yield:

1) Quasi two body decays:

$$J/\psi (\psi') \rightarrow (X \rightarrow \gamma\gamma) + \gamma$$

The $\eta\gamma$ and $\eta'\gamma$ decay modes of the resonances have been identified, but the analysis of the $\pi^0\gamma$ mode is not yet complete. There is also evidence for a new resonance X decaying into two photons at a mass around

2.75 - 2.8 GeV.

17)

2) Direct decay of the resonances into three photons. An evaluation of this shows that no peaks appear in the effective mass spectrum for any combinations of two photons.

3) Direct production of a three photon final state via the QED diagrams. This is the most serious background encountered in the three photon channel and will be discussed below.

The three photon final states were selected using the following criteria:

- 1) Only three photons should be observed in the final state. Events with photons converting in the beam pipe were rejected.
- 2) The opening angle of any pair of photons should be greater than 30° . This removed any $\pi^0\gamma$ events.

Demanding a three photon final state effectively removed the background resulting from beam-gas interactions, cosmic ray events and multihadron events. This is seen in Fig. 20a where the events produced at a CMS energy of 3.09 GeV are plotted versus a coplanarity "angle" $\Delta\theta$. $\Delta\theta$ is defined as the invariant quantity $\arcsin((\vec{n}_1 \times \vec{n}_2) \cdot \vec{n}_3)$ where $\vec{n}_j$ is the unit vector along the direction of the photon j. The distribution peaks at small values of $\Delta\theta$ as expected for genuine three photon events, and the observed width is consistent with the width expected from the experimental resolution. Events with $\Delta\theta > 5^\circ$ were rejected. Of the


```

*VERSION 1.3.0 (01 MAY 80) GBASE SYSTEM/370 FORTRAN H EXTENDED (ENHANCED) DATE 82.205/15.00.52 PAGE 2
  ISN 0029 IF (2-1K.NE.0) GOTO 50
  ISN 0031 GOTO 51
  ISN 0032 50 TEMP1= ((1.00-QG)*(A11-PG*(A12+KAPPA*KQ/ETAQK(KQ,K)*A13)-
    *QFLOAT(IBINOM(IPG,2))*(A14-KQ/ETAQK(KQ,K)*A15))
    *KAPPA*QG*ETAQK(KQ,K)*A16)**(2-1K)
  ISN 0033 GOTO 54
  ISN 0034 51 TEMP1=1.00
  ISN 0035 54 IF (1K-1.NE.0) GOTO 52
  ISN 0037 GOTO 53
  ISN 0038 52 TEMP2= ((KQ-1.00)*A21+(1.00-PG)*A22+QFLOAT(IBINOM(IPG,2))*(A23-QX*
    *ETAQK(KQ,K)/(1.00+A24*(1.00+QX))*A25)+KAPPA*(A26+KQ*ETAQK(KQ,K)
    **2*A31)+QFLOAT(IBINOM(IPG,3))*ETAQK(KQ,K)*A32+
    *QFLOAT(IBINOM(IPG,3))*(KQ**3*A33/(3.00-KQ)*(QX-(-1.00)**1KQ)+
    *EBN*(PG-QG)*ETA**((KQ-1.00)*KQ/4.00)/(8.00-A66*KQ*(KQ-1.00))
    *(1.00-KQ/ETAQK(KQ,K)*(2.00-KQ)*A34**((1-1QX)*A35)*
    *ETAQK(KQ,K)/ETA**2-A36))**((1K-1)
    GOTO 55
  ISN 0039 53 TEMP2=1.00
  ISN 0040 55 WGXX=TEMP1+TEMP2
  ISN 0041 C----- (4-2) REAL
    WGXX=GKQ*WGXX
  ISN 0042 C----- (4-5) REAL
    AN=PG*A42*(1.00-KAPPA*A43*(1.00+A44*(-ALFA)**(2-1K)*A45**((1K-1))
    *(1.00-KAPPA*QG*A46*(2.00-K))-A51*(K-1.00)*(1.00-KAPPA))
  ISN 0043 C----- (4-6) REAL
    AQ=1.00-KQ*A52*(1.00-2.00*KAPPA*A53**1K)*(1.00+QX/6.00*(3.00-QX)
    *(K-1.00)*(1.00-KAPPA))
  ISN 0044 C----- (4-4) REAL
    AGX=A41/K*(1.00+AN*AQ)
  ISN 0045 C----- (4-7) REAL
    BGX=(A54*A55**((1K-1)*(1.00+PG*A56*(1.00-KAPPA*A61*A62**((1-1K))*
    *(1.00+KQ*A63*(1.00+KAPPA*A64)))*((1.00-1.00/K*(A65*(K+K-1.00))**
    *(2.00-K)*QFLOAT(IBINOM(IPG,2))*((1.00-QFLOAT(IBINOM(IPG,3))))
    */(K**IPG*(1.00+PG+QG+KAPPA*ETA**((2.00-KQ))))
  ISN 0047 IF (IPRINT.GE.2) WRITE(6,200) GKQ,WGXX,AN,AQ,AGX,BGX
  ISN 0049 200 FORMAT(1X,' GKQ WGXX AN AQ AGX BGX',/1X,7Q16)
    *      AN AQ AGX BGX
  ISN 0050 *      .8)
  ISN 0051 RETURN
END
TIONS IN EFFECT*NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(MAX) AUTODBL(NONE)
TIONS IN EFFECT*SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF ALC NOANSF TERM IBM FLAG(1)
ATISTICS* SOURCE STATEMENTS = 50, PROGRAM SIZE = 6640, SUBPROGRAM NAME = GBASE
ATISTICS* NO DIAGNOSTICS GENERATED
*** END OF COMPILATION *****
68K BYTES OF CORE NOT USED

```


68 events contained in the plot 52 events survived the cut.

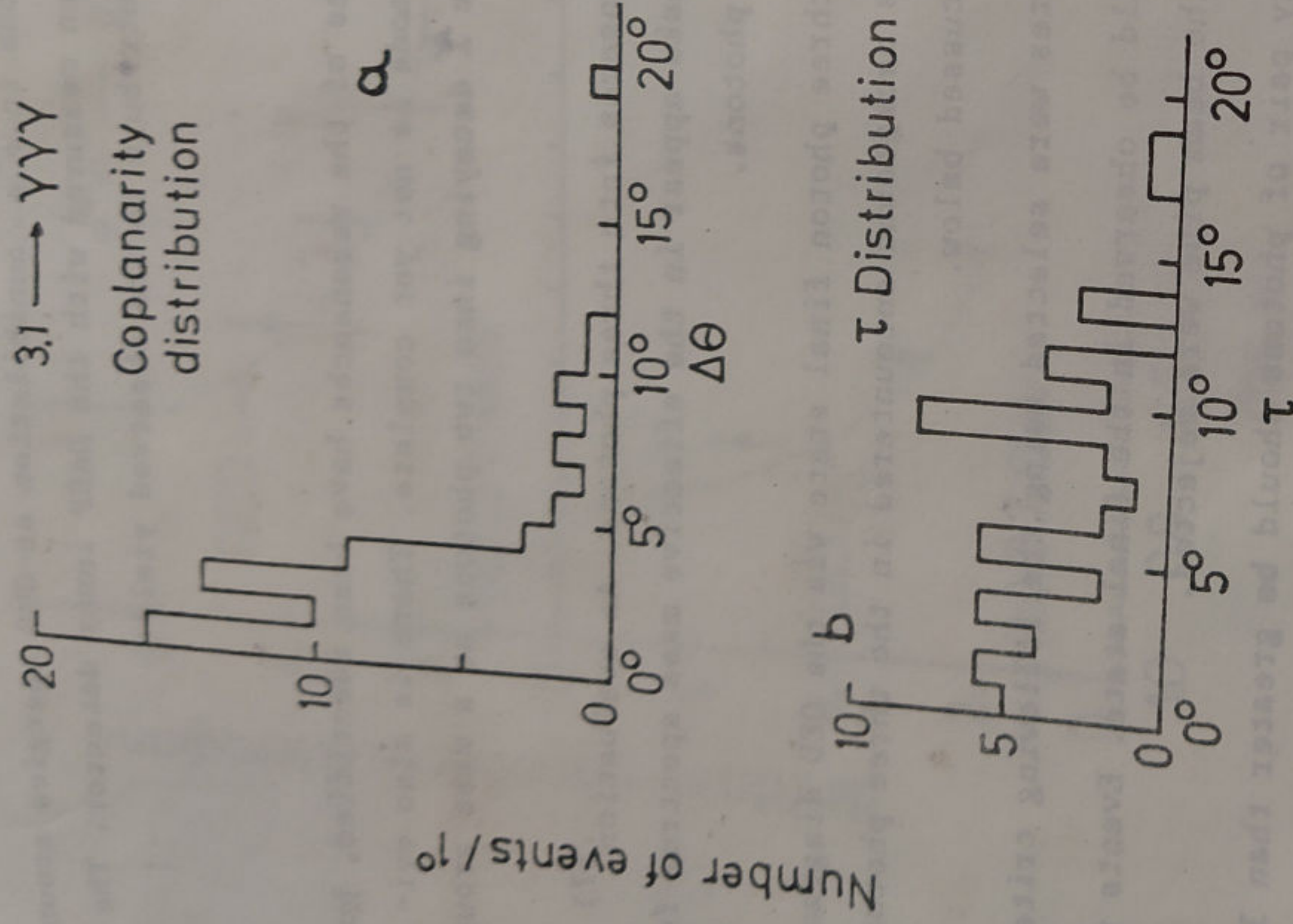


Fig. 20

- a) Number of three photon events versus the coplanarity angle $\Delta\theta$
- b) Number of three photon events with $\Delta\theta < 5^\circ$ versus to the angle τ (defined in the text)

The fraction of QED events in the remaining sample was reduced by excluding events with the beam axis in (or close to) the event plane. This cut was made by projecting the unit vectors $\vec{n}_j$ onto a plane normal to the beam axis and defining the smallest non collinearity angle τ between any of two projected vectors. QED events peak at small values of τ ; the other events do not. Events with $\tau < 5^\circ$ are rejected.

The remaining events and the total integrated luminosity are listed in Table V.

TABLE V:

$2E_{CMS}$	J/ψ	ψ'	Outside the resonances
Number of events	30	15	4
Integrated luminosity	211 nb ⁻¹	367 nb ⁻¹	118 nb ⁻¹

All the events are mapped within the triangle as a function of θ_1 and θ_3 . The smallest opening angle θ_1 varies between 0° and 120° and is constant along lines normal to the hypotenuse of the triangle. The largest opening angle θ_3 varies between 120° and 180° and is constant along the dotted lines. The third opening angle θ_2 varies between 90° and 180° and is the difference between 360° and the sum θ_1 plus θ_3 . It is constant along the point-dotted lines. The errors involved are indicated by the size of the symbol plotted.

Lines of constant effective mass are drawn for the mass of the η , the η' and a hypothetical heavy particle of 2.8 GeV. The distribution of the events along these curves are also indicated. The η and the η' are peaked at small angles, the heavy particles are roughly uniformly distributed along the curve.

The events measured at a CMS energy of 3.68 GeV and 3.09 GeV are plotted in Fig. 22 and Fig. 23 as a function of the opening angles θ_1 and θ_3 . The events observed at the ψ' resonance do not cluster along any particular mass value in contrast to the events measured at the J/ψ resonance. Here a clear clustering of events

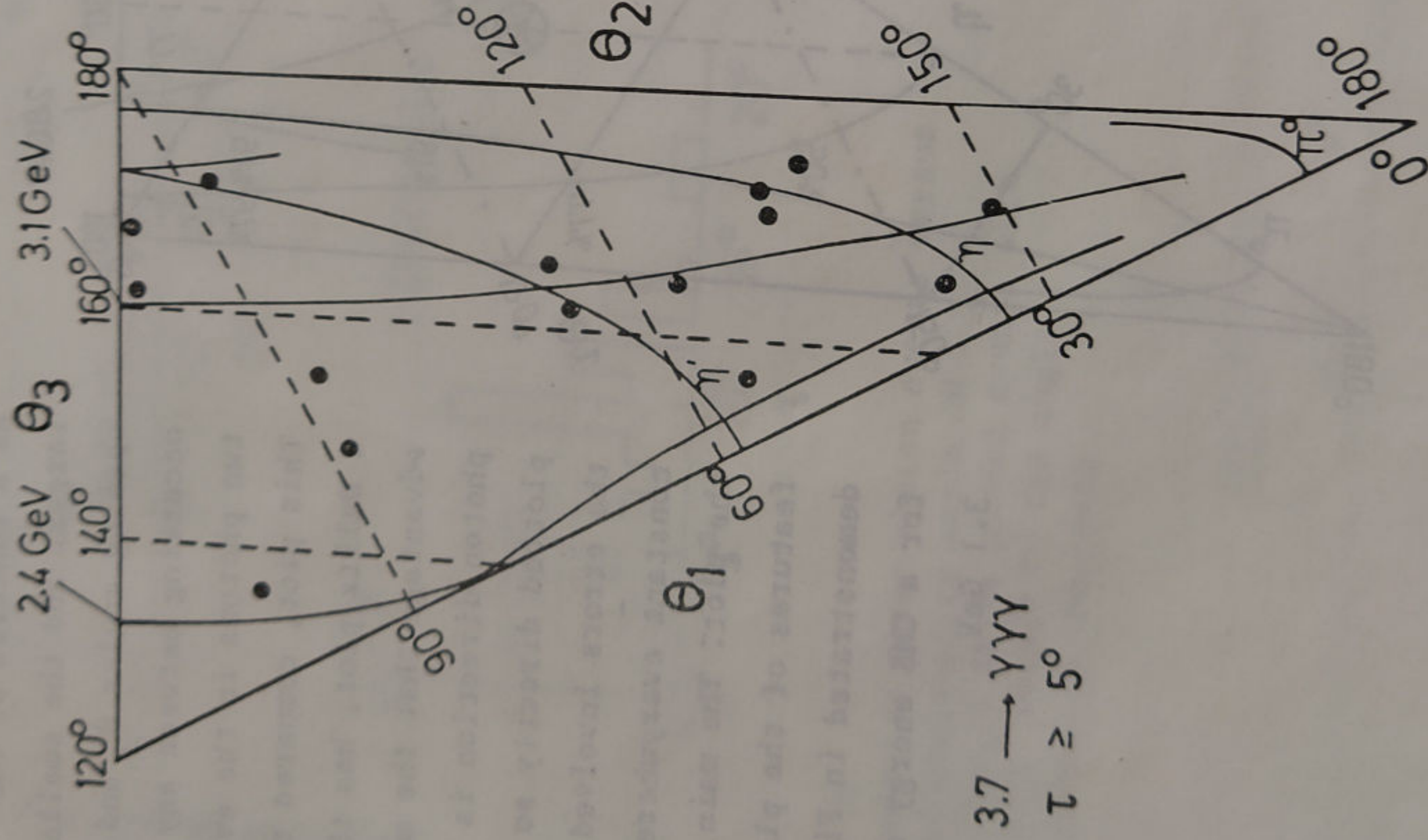


Fig. 22
Plot of the three photon events obtained at the ψ' resonance

is observed along the curves representing the mass of the η and that of a hypothetical heavy particle of mass around 2.8 GeV. The events are plotted as a function of the lowest and the highest effective mass found in each event in Fig. 24 for the ψ' resonance and in Fig. 25 for the J/ψ resonance. In the high mass plot at 3.1 GeV all events which had one of the two remaining effective mass values within $\pm \sigma$ of the mass of an η or an η' are removed from the plot.

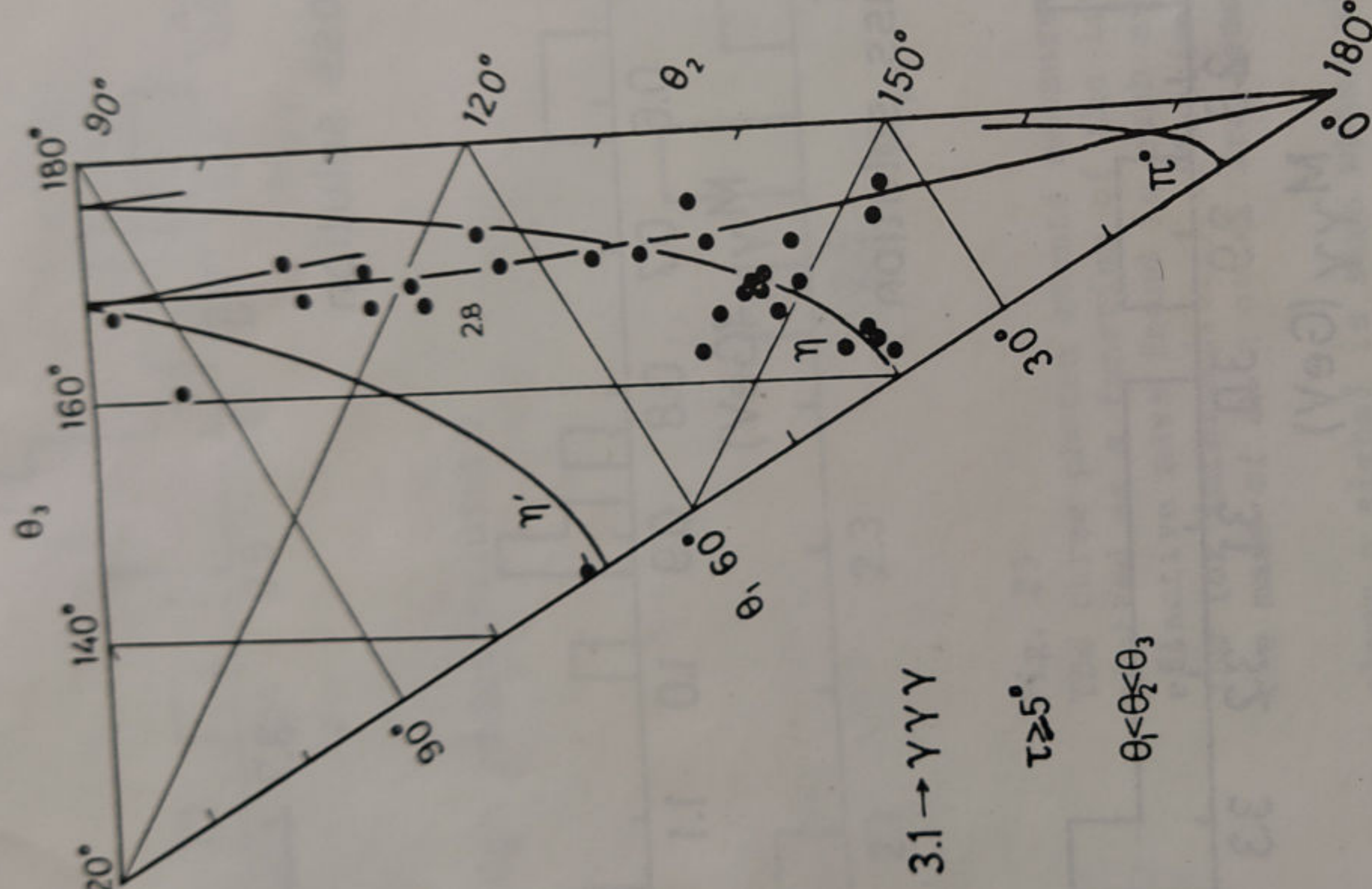


Fig. 23
Plot of the three photon events
obtained at the J/ψ resonance

At the mass of the ψ' the events are essentially uniformly distributed as a function of the low mass solution with neither a clear η nor a η' signal. Also in the high mass solution no significant peaking is observed. The events tend to have

a high effective mass as expected for the QED background.

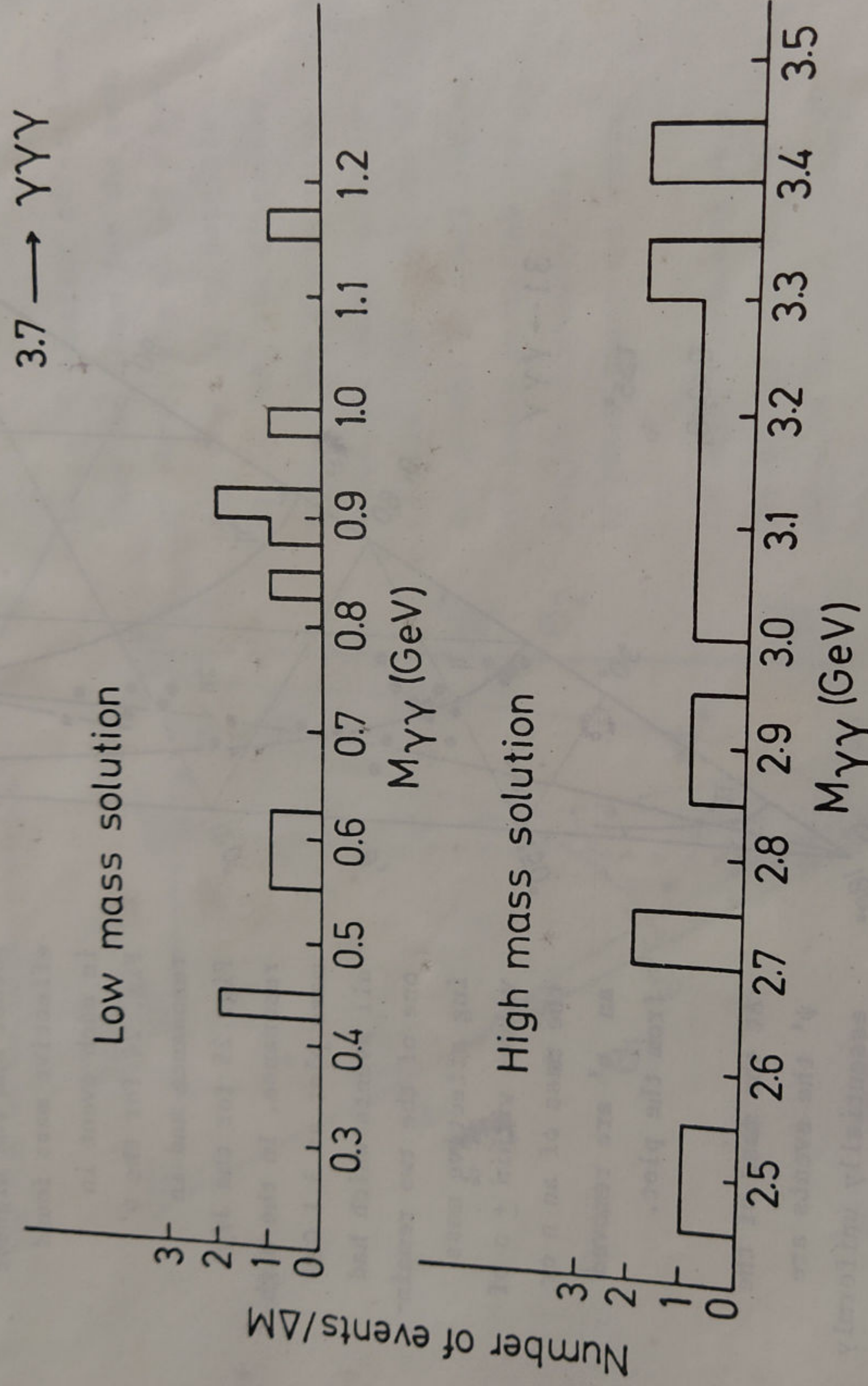


Fig. 24

The three photon events measured at the ψ' resonance plotted as a function of the lowest and the highest effective mass found in each event

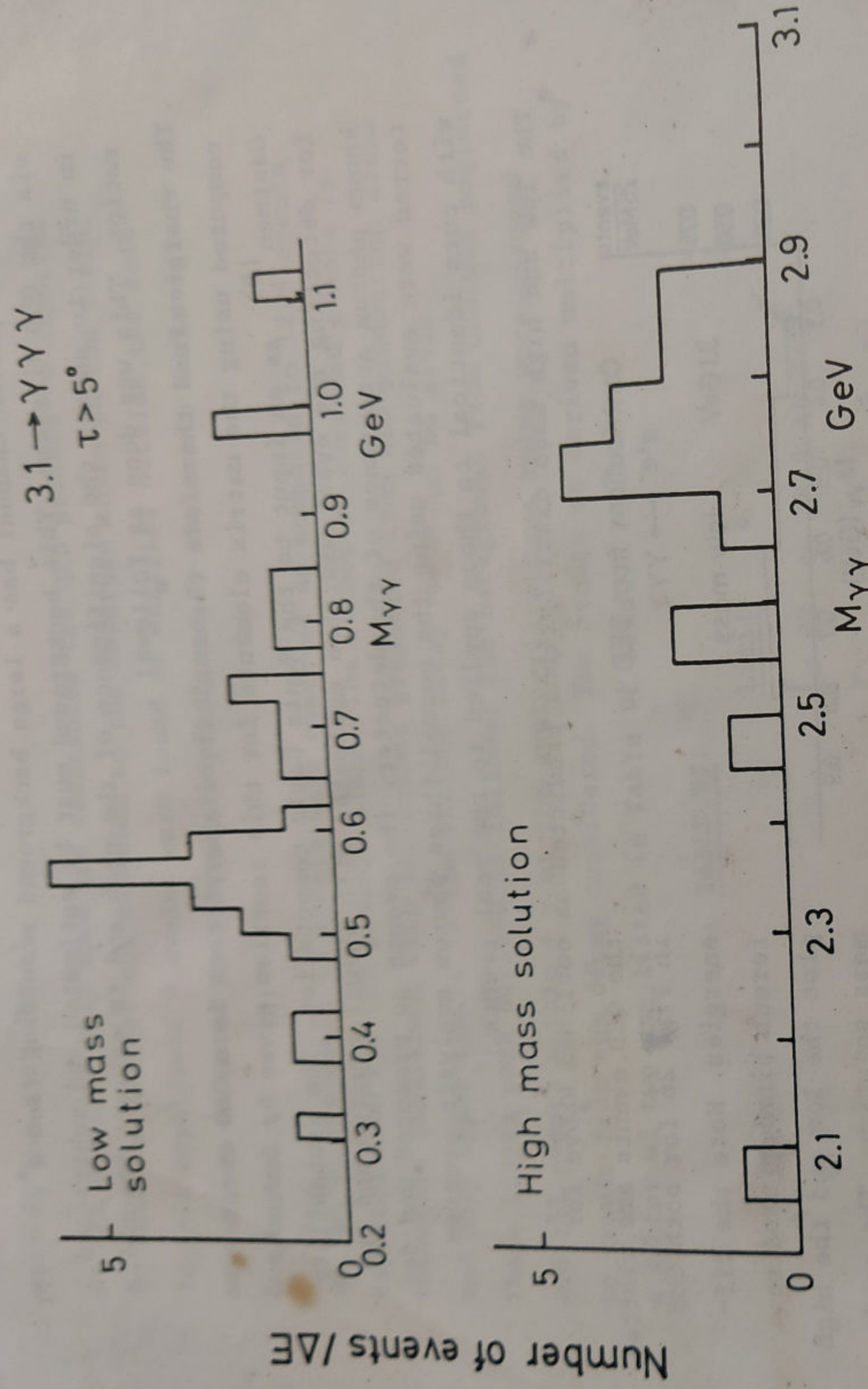


Fig. 25

The three photon events measured at the J/ψ resonance plotted as a function of the lowest and the highest effective mass found in each event. Events within the low (or intermediate) effective mass within $\pm \sigma$ of the mass of an η or η' are removed from the plot.

At the J/ψ mass a clear η signal is seen whose width is consistent with the width expected from the experimental resolution alone. There are two events at the mass of the η' . In the high mass solution there is a clustering of events around a mass of 2.8 GeV. These events might result from the decay of a new resonance X into a pair of photons. Note that a width of ± 50 MeV is expected from the experimental resolution alone for such a resonance. There is a cutoff in effective mass due to the loss of photon detection efficiency at low photon energies. The mass acceptance, however, is uniform up to a mass of 3 GeV, so the observed peak is therefore not caused by the folding of a decreasing mass acceptance with a rapidly increasing QED cross section.

The three photon channel has a large background resulting from $e^+e^- \rightarrow \gamma\gamma\gamma$ via the QED diagrams. This background must be estimated and subtracted in order to assess the significance of the peak and to extract branching ratios. This was done as follows:

The energies (and therefore the angles) of the photons in a QED event were computed using the matrix elements for this reaction given by Berend and Gastman¹⁸⁾ as an input to the Monte Carlo computation. The probability for detecting the event was then evaluated with shower program and the known photon acceptance of the detector. The events so produced and detected were evaluated using the normal three photon analysis program with cuts identical to those applied to the real events.

The low and high mass distributions predicted as outlined above for

the QED events are plotted in Fig. 26 for both CMS energies. Note the different binning used to plot the low and the high mass solution. The cross section for QED production increases with decreasing energy of one of the photons. This is reflected in the peaking of the cross section observed at high effective masses and the low background around the

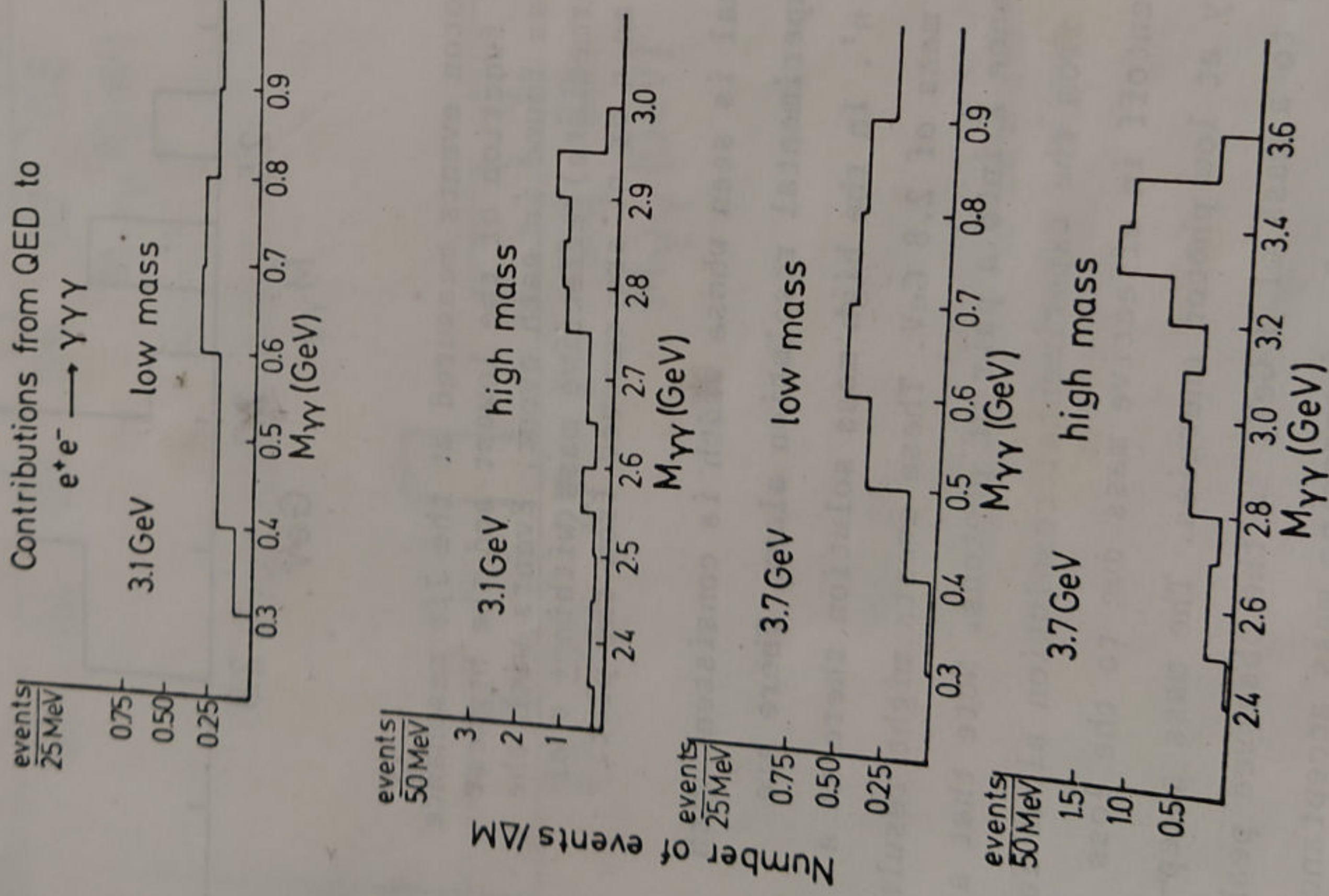


Fig. 26

The rate for $e^+e^- \rightarrow \gamma\gamma\gamma$ predicted from QED alone. Plotted is the low mass and the high mass distribution of the events at the ψ' and the J/ψ resonance properly normalized.

mass of the η or the η' .

At CMS energies away from the resonances the QED process is expected to make the largest contribution to the observed three photon yield. In this experiment 4 events were found at energies outside the resonances, as compared to 4.8 events predicted by the Monto Carlo calculation.

At the ψ' resonance 15 events were observed as compared to 12.9 events expected from the QED process alone. The number of observed events is therefore consistent with the number predicted from QED production alone and only upper limits to the various decay modes can be given. These limits were derived as follows: The background from QED was neglected and all events within $\pm \sigma$ of the appropriate mass value were assumed to result from the decay considered. The limits so derived multiplied by a factor of two are listed in Table VI below.

TABLE VI:

<u>Decay</u>	<u>Limit</u>
$\psi' \rightarrow \eta\gamma$	$\int \sigma dE < 4.9 \text{ nb MeV}$ $\frac{\Gamma_{\eta\gamma}}{\Gamma} < 1.3 \times 10^{-3}$
$\psi' \rightarrow \eta'\gamma$	$\int \sigma dE < 51 \text{ nb MeV}$ $\frac{\Gamma_{\eta'\gamma}}{\Gamma} < 1.4 \times 10^{-2}$
$\psi' \rightarrow X(2.8)\gamma$	$\int \sigma dE < 1.3 \text{ nb MeV}$ $\frac{\Gamma_{X\gamma}}{\Gamma} \cdot \frac{\Gamma_{X \rightarrow \gamma\gamma}}{\Gamma_X} < 3.7 \times 10^{-4}$
$\psi' \rightarrow P_c(3.5)\gamma$	$\int \sigma dE < 0.48 \text{ nb MeV}$ $\frac{\Gamma_{P_c\gamma}}{\Gamma} < \frac{\Gamma_{P_c\gamma}}{\Gamma_{P_c \rightarrow \text{all}}} < 1.3 \times 10^{-5}$

From the measured branching ratio of the decay $\psi' \rightarrow P_c + \gamma \rightarrow J/\psi + \gamma\gamma$ a lower limit $\Gamma_{P_c\gamma}/\Gamma > 4 \times 10^{-2}$ can be derived. This leads to an upper limit on the branching ratio of $P_c \rightarrow \gamma\gamma$: $\Gamma_{P_c \rightarrow \gamma\gamma}/\Gamma_{P_c} < 3.2 \times 10^{-3}$.

Of the 30 events observed at the J/ψ resonance 8.9 events were predicted to be QED events. The following results were obtained:

$J/\psi \rightarrow \eta \gamma$. 14 candidates for this decay were found as compared to 0.9 event predicted from QED. This corresponds to an integrated cross section of (16.6 ± 5.0) nb MeV and a partial width $\Gamma_{\eta\gamma} = (95 \pm 29)$ eV.

For the decay $J/\psi \rightarrow \eta' \gamma$ an upper limit on $\Gamma_{\eta' \gamma}$ is derived. We find $\Gamma_{\eta' \gamma} < 450$ eV. From these values

$$\frac{\Gamma_{J/\psi \rightarrow \eta' \gamma}}{\Gamma_{J/\psi \rightarrow \eta \gamma}} < 5.$$

At a mass between 2.65 GeV and 2.85 GeV 10 events, compared to a predicted QED background of 3.4 events were found. An independent upper limit to background can also be evaluated from the measurements at the ψ' resonance assuming that all these events are from QED. This leads to an expected background of about 3 events in the mass range between 2.65 GeV and 2.85 GeV. Thus both methods of evaluating the QED background indicate an excess of events in this mass region. These events might result from the two photon decay of a new resonance with even charge conjugation and a mass around 2.75 GeV - 2.8 GeV.

The decay $J/\psi \rightarrow \gamma \gamma \gamma$ has also been investigated by the DESY-Heidelberg collaboration¹⁹⁾ using a large non-magnetic detector. Their findings are in good agreement with the results of the DASP group; in particular they also find a clustering of events at masses between 2.65 GeV and 2.85 GeV. The combined data and their statistical significance will be discussed by Prof. Heintze.

ERRATUM

DESY 75/37
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B. H. Wiik: Recent Results from DORIS.

The following footnote was omitted from the title page:
Invited talk at the International Symposium on Lepton and Hadron Interactions,
Stanford University, Stanford, California, August 21-27, 1975.

The data from the DASP-Collaboration presented in this report should be
quoted:

DASP-Collaboration: B. H. Wiik, Invited talk at the International
Symposium on Lepton and Photon Interactions, Stanford University, Stanford,
California, August 21-27, 1975.

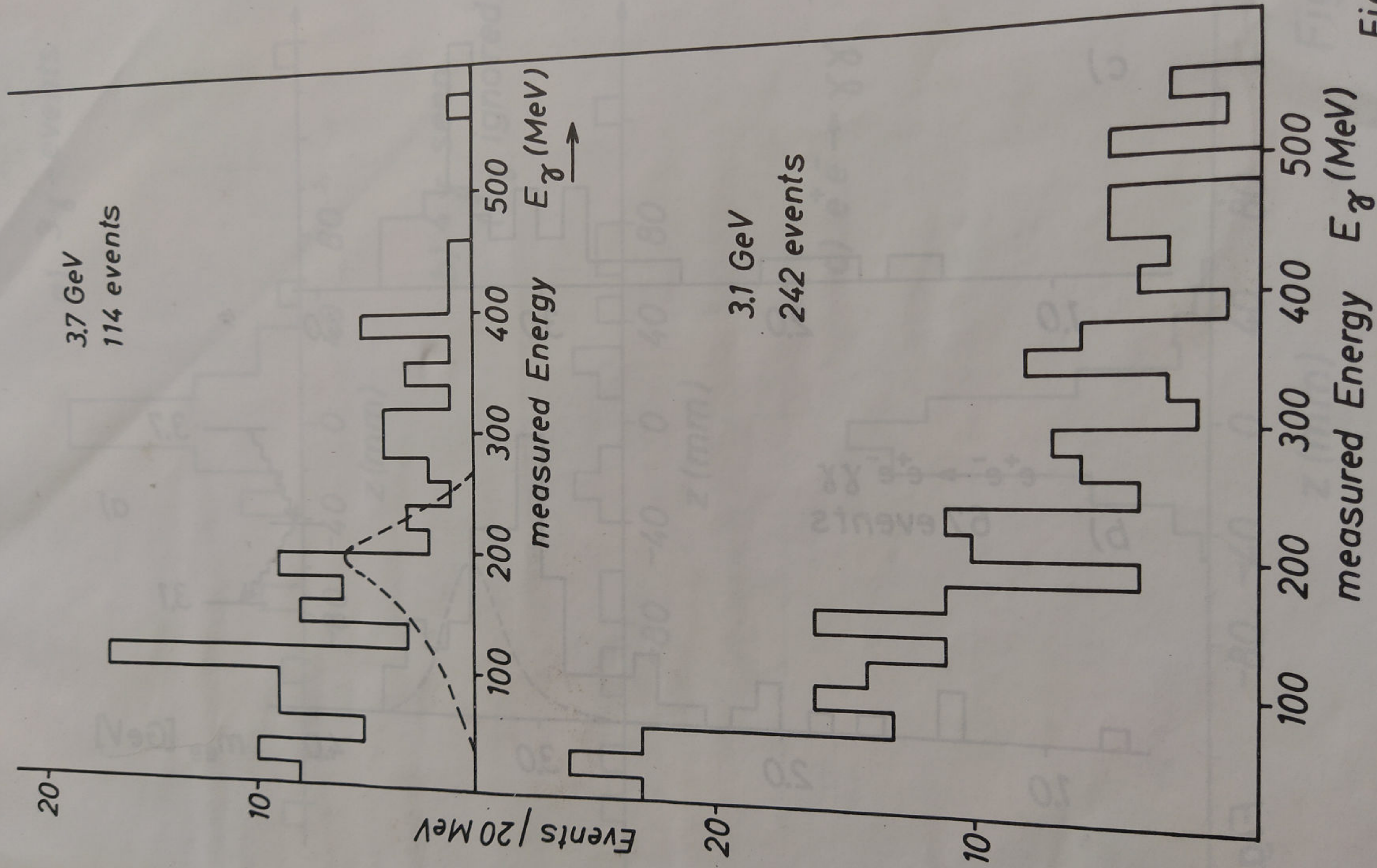


Fig. 4

Anstiegsprinzip der Konfigurationszonen:

$$n_4 + Q_4 = (n_3 + Q_3) \alpha_3 \leq (n_2 + Q_2) \alpha_2 \leq (n_1 + Q_1) \alpha_1$$

Auswahlregel der Konfigurationszonenbesetzungen

$$(n_1 + Q_1) \alpha_1 + (n_2 + Q_2) \alpha_2 + (n_3 + Q_3) \alpha_3 + \exp\left(\frac{1-2k}{3Q_4} (n_4 + Q_4)\right) + iF(\vec{r}) =$$

$$= W_{yx} \left[1 + (1 - Q(2-k))(1 - \mathcal{Q}) \right] \left(a_{yx} \frac{N}{N+2} + b_{yx} \sqrt{N(N-2)} \right)]$$

$$W_{yx} = g(kq) w_{yx}, \text{ Basisanstieg } g(kq) = Q_1^2 \alpha_1 + Q_2^2 \alpha_2 + Q_3^2 \alpha_3 + \exp\left(\frac{1-2k}{3}\right)$$

für $n_j = 0$. Strukturpotenz des diskutierten Zustandes

$x_{\mathcal{A}}(kPQ)_{\epsilon} C(q_x)$ als Komponente x des Multiplikts $\mathcal{A}$ ist:

$$W_{\mathcal{A}} = \left[(1-Q)(A_{11} - P(A_{12} + \frac{Q}{\eta_{qk}} A_{13})) - \left(\frac{P}{2}\right) (A_{14} - \frac{Q}{\eta_{qk}} A_{15}) + \mathcal{Q} Q \eta_{qk} A_{16} \right]^{2-k} +$$

$$+ \left[(q-1)A_{21} + (1-P)A_{22} + \left(\frac{P}{2}\right) (A_{23} - q_x \eta_{qk} (1+A_{24} (1+q_x)))^{-1} A_{25} \right] +$$

$$+ \mathcal{Q} (A_{26} + q \eta_{qk}^2 A_{31}) + \left(\frac{Q}{3}\right) \eta_{qk} A_{32} + \left(\frac{P}{3}\right) \left\{ \frac{q_x A_{33}}{3-q} (q_x - (-1)^q) + \right.$$

$$\left. + \frac{e(P-Q) \eta_{qk} (q-1)^{q/4}}{8 - A_{66} q(q-1)} \left(1 - \frac{Q}{\eta_{qk}} (2-q) A_{34}^{1-q} x A_{35} \right) \frac{\eta_{qk}}{\eta^2} - A_{36} \right\}]^{k-1} \cdot \text{Ferner}$$

gilt als Resonanzbasis $ka_x = A_{41} (1 + a_n a_q)$ mit

$$a_n = P A_{42} [1 - \mathcal{Q} A_{43} (1 + A_{44} (-\alpha)^{2-k} A_{45}^{k-1}) (1 - \mathcal{Q} A_{46} (2-k)) - A_{51} (k-1) (1 - \mathcal{Q})]$$

und $a_q = 1 - q A_{52} (1 - 2 \mathcal{Q} A_{53}^k) (1 + \frac{q_x}{6} (3 - q_x) (k-1) (1 - \mathcal{Q}))$. Resonanz-

raster ist $k^P (1 + P + Q + \mathcal{Q} \eta^{2-q}) b_{yx} = A_{54} A_{55}^{k-1} [1 + P A_{56} (1 - \mathcal{Q} A_{61} A_{62}^{1-k}) (1 +$

$+ q A_{63} (1 + \mathcal{Q} A_{64}))] (1 - k^{-1} (A_{65} (q + k - 1))^{2-k} \left(\frac{P}{2}\right) (1 - \left(\frac{P}{3}\right))$. Die Koeffizienten

A_{rs} können als Elemente der quadratischen Koeffizientenmatrix

$\hat{A} = (A_{rs})_6$ mit $A_{rs} \neq A_{sr}$ und $\text{Im} A_{rs} = 0$ aufgefaßt werden.

Vorschlag zur Bestimmung der Matrixelemente (Reduktion auf π, e und ξ):

$$2\eta^2 A_{11} = \xi^2 (\pi e \xi)^2 (1 - 4\pi \alpha^2), 3A_{12} = 2\pi e \xi^2 \left(\frac{\mathcal{Q}}{8} - \pi \eta \frac{\alpha^2}{3}\right), A_{13} =$$

$$= 3(4 + \eta \alpha) \left(1 - \frac{\eta^2}{5} \left(\frac{1 - \sqrt{\eta}}{1 + \sqrt{\eta}}\right)^2\right), \alpha A_{14} = 1 + \frac{3\eta}{4} \xi (2\eta \alpha - e^2 \xi \left(\frac{1 - \sqrt{\eta}}{1 + \sqrt{\eta}}\right)^2),$$

$$3A_{15} = e^2 (1 - 2e \frac{\alpha^2}{\eta}), A_{16} = (\pi e)^2 \left(1 + \frac{\alpha}{5\eta} (1 + 6 \frac{\alpha}{\pi})\right), A_{21} = 2 \left(\frac{e\alpha}{2\eta}\right)^2 \left(1 - \frac{\alpha}{2}\right),$$

$$12A_{22} = \xi \left(1 - \xi \left(-\frac{\alpha}{\eta^2} \xi\right)^2\right), e A_{23} = \eta^2 + 6 \xi \alpha^2, 3\eta A_{24} = 2 \xi^2,$$

$$A_{25} = \xi (\pi e)^2 (1 - \beta^2), e \xi^2 A_{26} = 2 \left(1 - \frac{\pi}{2} (e \xi \alpha)^2 \sqrt{\eta}\right),$$

* siehe Buchauf

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$$\begin{aligned}
 A_{31} &= (\pi e \alpha)^2 (1 - (\pi e)^2 (1 - \beta^2)), & 6A_{32} &= \xi^2 (1 + (2e\frac{\alpha}{\eta})^2), \\
 A_{33} &= (\pi e \xi \alpha)^2 (1 - 2\pi(e\xi)^2 (1 - \beta^2)), & A_{34} &= \eta \sqrt{2\pi\eta}, & e\xi^2 A_{35} &= 3\alpha, \\
 A_{36} &= (1 - \pi e(\xi e)^2 (1 - \beta^2))^{-1}, & A_{41} &= (2\beta - \alpha) = \xi^2 (2 + (\xi\alpha)^2) - 2\beta \xi / \beta, \\
 2A_{42} &= \pi \xi^2 \eta (\beta - 3\alpha), & 2A_{43} &= \xi, & A_{44} &= 2(\frac{\eta}{\xi})^2, & 6\xi A_{45} &= 3\beta - \alpha, \\
 A_{46} &= \frac{\pi e}{\xi \eta} - e \eta^2 \frac{\alpha}{2}, & A_{51} &= (2\alpha + 1)^2, & \eta^2 A_{52} &= 6\alpha, & A_{53} &= (\frac{\xi}{\eta})^3, \\
 A_{54} &= \alpha(\beta - \alpha) \sqrt{3/2}, & A_{55} &= \xi^2, & A_{56} &= (\frac{\xi}{\eta})^4, & 12\beta A_{61} &= \pi \xi (2\beta - \alpha), \\
 12A_{62} &= \pi^2 (\beta - 2\alpha), & 9A_{63} &= \sqrt{\eta}, & 3\eta A_{64} &= \pi, & 3\xi A_{65} &= \pi, & A_{66} &= \xi \eta.
 \end{aligned}$$

Die Resonanzordnung $N \gg 0$ (positiv ganzzahlig) wählt die zugelassenen Quadrupel n_j mit $1 \leq j \leq 4$. Mit der Kürzung $f(N) = (1 - Q(2-k))(1 - Q)$ $(a_{yx} \frac{N}{N+2} + b_{yx} \sqrt{N(N-2)})$ folgt, daß die unbekannte

Funktion $F(\Gamma) = 0$ für alle $N \neq 1$ bleibt (rechte Seite ist reell).

Im Fall $N=0$ wird $f=0$, so daß $(n_1 + Q_1)^3 \alpha_1 + (n_2 + Q_2)^2 \alpha_2 + (n_3 + Q_3) \alpha_3 + \exp(\frac{1-2k}{3Q_4} (n_4 + Q_4)) = W_{yx}$ die n_j des Zustandes x_{yx} und damit

die Masse $M_0(x)$ der Komponente x des Multipletts x_y beschreibt. Die $N \neq 2$ ordnen x_{yx} ein Spektrum von Besetzungsparemeterquadrupeln und damit nach der Massenformel Resonanzmassen $M_N(x)$ zu. Für jede Komponente x_{yx} also ein Massenspektrum). Im Fall $N=1$ kein Spektralterm. Hier ist nicht $f(N) > 0$, es ist $f(1)$ komplex. Realteil: $(n_1 + Q_1)^3 \alpha_1 + (n_2 + Q_2)^2 \alpha_2 + (n_3 + Q_3) \alpha_3 + \exp(\frac{1-2k}{3Q_4} (n_4 + Q_4)) = W_{yx} (1 + (1 - Q(2-k)(1 - Q)) a_{yx} / 3)$. Imaginärteil $F(\Gamma) = W_{yx} (1 - Q(2-k)(1 - Q)) b_{yx}$. Die n_j und $F(\Gamma)$ stehen mit N in irgendeiner Beziehung zu den vollen Bandbreiten Γ . Auch muß es einen Zusammenhang $Q_N = Q(N)$ zwischen doppelter Spinquantenzahl Q und N geben. Wie könnten diese Zusammenhänge beschaffen sein??

Wird $N=1$ ausgeschlossen, dann $F=0$ und reelle Beziehung $(n_1 + Q_1)^3 \alpha_1 + (n_2 + Q_2)^2 \alpha_2 + (n_3 + Q_3) \alpha_3 + \exp(\frac{1-2k}{3Q_4} (n_4 + Q_4)) = W_{yx} (1 + f)$ diskutieren. Im allgemeinen $f > 0$ für $N \geq 2$ und $f=0$ für $N=0$. Im Fall des Multipletts x_2 jedoch $f=0$ für alle $N \geq 0$, weil hier allein $Q(2-k)(1 - Q) = 1$ ist. Elektronen sind nach diesem Bild nicht anregbar! Bei numerischer Bestimmung von W_{yx}, a_{yx}, b_{yx} und ϕ_{yx} (Quantenzahlenfunktion im Massenspektrum M) nicht $Q_N = Q(N)$ sondern $Q = Q(0)$ des x_y verwenden. Zur Bestimmung der n_j wird das Anstiegsprinzip der Konfigurationszonenbesetzungen berücksichtigt. Zunächst für eine Resonanzordnung