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PROPOSAL

A 10^4 CHARM DECAY STUDY WITH EMULSIONS COUPLED TO A MAGNETIC SPECTROMETER AND A HIGH RESOLUTION VERTEX DETECTOR

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ABSTRACT:

An experiment is proposed to study charm decays with a 10^4 decay statistics. The experiment is of a hybrid type, using a magnetic spectrometer (Ω'), a high resolution multivertex detector (CCD telescope), and nuclear emulsions.

The main aims of the experiment are:
1. to study charm decays (D, Λ_c, F) with high statistics;
2. to study the production mechanisms by 350 GeV/c π^- and by 70 to 200 GeV γ's;
3. to study the capability of the CCD telescope device as a stand alone high energy multivertex detector.

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Introduction

A study of charmed particles requires to collect a very high statistics sample to give an answer to many questions (branching ratios, rare decays, production mechanisms etc).

This fact requires mainly a selective trigger to enrich the sample over the background without biasing too much the statistics, and a good vertex detector.

Up to now many possibilities for high resolution vertex detectors have been proposed. The oldest and more precise of these methods is based on nuclear emulsions. This method gives an unsurpassed resolution of a few microns and is not so time consuming if a good localization of the interactions into the emulsions is provided (as proved by WA58, WA71, WA75, E531). If moreover an external multivertex identification could be possible, a good enrichment of the sample of the decays over the background can be obtained with a correspondent shortening of the scanning time.

Obviously a multivertex identification done with an electronic device allows, in principle, to study directly the decays.

Several electronic multivertex detectors for studying short lived decays have been proposed. They are based on microstrip detectors, silicon slices as live targets, optical fibers coupled with CCD's etc. A method based on CCD detectors as particles detectors has been developed by us and it is described in ref. 1.

Each of these methods promises a precision and two tracks resolution of the order of 10 μm.

In any case many problems have to be preliminary solved before a reliable use of these devices in a very high statistics experiment. The most important of all these problems is to ascertain what is the true spatial resolution. In fact the impact parameter for charm decays is, in the mean, of the order of 100 μm, very close to the claimed resolution. Moreover it has to be pointed out that, in a purely electronic experiment which might resolve the decay vertices, there does not exist the certitude that the tracks associated to each vertex do really belong to that one. This fact increases the combinatorial background over which the true physical signal can be observed.

To try to give an answer to these problems and to check the real possibilities of the electronic multivertex detectors we propose a charm decay study based on nuclear emulsions coupled with a CCD telescope.

The experiment can give good physical results based on about 10^4 charm decays. The multivertex capability of the CCD telescope is used to obtain a very good localization of the interactions inside the emulsion and to enrich the sample with charm decays.

We think that this is a necessary and preliminary step before the use of this type of detectors in fixed target physics as well as in colliding beam physics as stand alone detectors.

Physical aims

During the last few years some of the most important features of open charm particles have been determined using different experimental techniques. The life-times of the charged and neutral D mesons have been measured together with their branching ratios for several decay channels.

Mark III (2) measured the D branching ratios given that thousands of D particles are produced in $e^{+} e^{-}$ collisions; it was thus possible to reveal even rare decay channels.

On the contrary the life-time of the charmed baryons and of other charmed particles containing the s quark ($F^{\pm}$, A^{+}, T°) are still uncertain. The number of collected events and the ambiguity in recognizing the charmed particle are such that a big experimental effort is still necessary in order to give an answer to the problem of determining the intrinsic properties of these charmed particles. To achieve this goal it becomes necessary to use visual techniques as nuclear emulsions or bubble chambers or equivalent electronic devices. In order to collect a sufficient number of events for each type of particle a suitable choice of the incident beam is also necessary. The charged and neutral D meson have been produced in many experiments by collisions of leptons (ν and μ), of photons and of hadrons (π , p). But few examples of the F meson have been detected in an unequivocal way; for instance the last data on the 360 GeV/c π^- p interactions published by the LEBC-EHS collaboration (3) do not show any unambiguous signal of F in a total of 185 charm decays.

The F production seems on the contrary more abundant in photoproduction and leptoproductions (4).

It seems therefore profitable to collect a high statistics by γ - nucleus interactions in order to separate a significant sample of particles with charm and strangeness and to determine their life-time.

Concerning the cross section and the production mechanism of charmed particles in the different reactions induced by different beams, the data are still very uncertain or completely defective (5,6,7,).

The techniques to be used to get information about cross sections and production mechanism are of different kinds:

a) beam dump experiments, where the leptons from semi-leptonic decays of charmed particles are identified ; in order to compute the cross sections it is necessary to know with high accuracy the semileptonic branching-ratios of the different charmed particles and to formulate a hypothesis on the production mechanism.

b) experiments showing a peak in the mass spectrum of peculiar combinations of final state particles; if the branching ratio of the charmed particles in that exclusive channel is known, then it is possible to go back to the total number of produced charmed particles of that type. The combinatorial background is almost always considerable because of the high multiplicity of the final state at high energy, and so the computation of the acceptance of the apparatus and the influence of the trigger used make such determination uncertain.

c) experiments where the charmed particles are directly "seen" (nuclear emulsions, bubble chambers); in this case the problem arises mainly from the poor statistics.

The results obtained so far with these different methods are considerably uncertain because of the poor knowledge of some branching ratios that, being anyhow of the order of one percent, leads to large correction factors.

Moreover it is not clear how to compare the results in order to obtain the significant data due to the fact that the experiments are done on different targets and with different beams. A method that can eliminate some difficulties and give useful information about the properties of the charmed particles produced from different reactions is to use different beams on the same active target with the same experimental apparatus for the detection.

The comparison between data taken under the same acceptance conditions can be better than the comparison between data taken under different conditions. The ratio between the cross sections is at least achievable more directly and many corrections cancel out.

For these reasons we intend to study charmed particles by an experiment using different incident beams, the same target and the same detecting apparatus. The use of nuclear emulsions together with a telescope of CCD's for the detection of the interactions vertices will allow us to collect events of production of charmed particles pairs both in photoproduction and in hadroproduction (beams of π or K, p, $\bar{p}$) with a negligible background. The collection of some thousands of events with charm will allow the study of the correlations between the produced particles, and this will in turn allow to discriminate between the different production models.

Experimental technique

A γ tagged beam with momentum between 70 and 200 GeV/c and a 350 GeV/c π^- beam hit a nuclear emulsion target.

The beams have both a cross section of about 2 cm^2 and the emulsion stacks are moved to cover all the surface of the stack when the foreseen dose is locally reached.

Immediately after the emulsion target there is a telescope of detectors with high spatial resolution*. This
(*Fig. 1)

telescope will allow the reconstruction of vertices with an accuracy of about 10 μm in the perpendicular directions to the beam and of about 100 μm in the longitudinal direction (see Appendix 1).

The emulsion stacks and the telescope are inside a magnetic spectrometer which will give an accurate reconstruction of the kinematics of the interaction and of the decay. Finally a suitable trigger will allow an enrichment of the sample of the detected events with decay candidates.

The focal points of the experiments are then:

1) The emulsions and the high resolution telescope.
2) The spectrometer, the particle identification and the trigger.

In particular we propose to use the upgraded Ω' spectrometer(8). The Ω' system provides in fact enough spatial resolution and good momentum measurements. The RICH (9) detector and the large area calorimeter (10) can give good enough particle identification to obtain a complete kinematical reconstruction of the events. The foreseen set-up is shown in Fig. 2.

Emulsions and high resolution telescope

Two types of emulsion targets are foreseen:

The first one is done with emulsions exposed perpendicularly to the beam for a total thickness of 1.5 cm. This exposure allows a density of about 3000/mm^2 crossing particles (π^- or collimated electrons pairs).

The second one has the emulsion parallel to the beam and cut in strips of 1.5 cm. This type of exposure is more suitable for an accurate measurement of short lived particles but support a track density of 2000 tracks/mm^2.

In any case the first cm is used as fiducial volume, in order to have at least .5 cm for observing the decays. Each target will have a cross section of 2 cm^2 and hence a volume of 3 cm^3.

We plan to collect an equal number of decays on each type of target, half of them photoproduced, the other half hadroproduced. The CCD telescope is described in ref. 1, together with advantages and disadvantages of this type of device. The main difference is now that the read-out works at 10MHz (6.7 MHz in ref. 1) and a factor 1.5 can be gained in the exposure time for γ rays.

Appendix 1 describes the results on the vertex reconstruction capability of a 7 plane telescope for simulated decays.

The main parameters of the telescope and the results of the simulation are here summarized:
7 planes of 4 CCD arrays for a total area of 4 cm^2 each plane; distance between the planes 1 cm; maximum number of points per plane 1600/(40 ms),(400 for each array), corresponding to a maximum rate of 4×10^4 crossing points per second; vertex localization (taking into account the multiple scattering in emulsion and inside the telescope planes) $\pm$ 10 μm on the plane perpendicular to the beam and $\pm$ 100 μm on the beam direction; vertex resolution 50 μm and 500 μm respectively.

The spectrometer, the particle identification and the trigger

As we have said we foresee to use the Ω' spectrometer together with the RICH counter and the electromagnetic calorimeter.

Appendix 2 describes the details of the assumptions, simulations and calculations performed to obtain the main parameters of the experiments as yield, run time, event selection, scanning time etc.

Here we try to summarize the main points.

1) The only on-line foreseen trigger is a multiplicity trigger (obtained from Ω'), 10 for pions, 8 for γ's.

2) The maximum rate of pions impinging on the emulsion target depends on the maximum number of on-line triggers the data acquisition system of Ω' is able to handle.

3) The maximum rate of γ's impinging on the emulsion target depends on the maximum number of crossing tracks ($e^+ e^-$ pairs from converted γ's) on the telescope planes.

4) Only for the pions an off-line event selection of at least one charged K is applied.

5) For both pions and γ's a multivertex reconstruction is required.

6) With this event selection we obtain for both pions and γ's about 3 fully observed charmed pairs over

100 canditates.

7) For the scanning time evaluation, emulsions exposed to 300 GeV/c protons have been used. These emulsions were fully scanned many years ago and the interaction locations were hence known. We have given to our scanners the interaction coordinates and asked them to find and follow the interaction tracks. The mean time resulting from a sample of about 1000 interactions was about 20 minutes/interaction.

Table A summarizes the main parameters of the experiment for the production of 10^4 observed charmed decays (5.10^3 from π^- and 5.10^3 from γ's)

TABLE A

	Tot numb.	Rate	run time (d)	litres emulsion	on-line triggers	candidates	scanning time (h)
π	1.5×10^8	6.5×10^3/s	2.5	1	2.0×10^6	8.4×10^4	2.8×10^4
γ	2.7×10^{10}	1.2×10^5/s	21	75	7.5×10^5	8.8×10^4	2.9×10^4

Final comments

1) All the data presented have been calculated with a maximum track density of 2×10^3 π/mm^2 for π's, and with the track density we have used in WA58 for γ's, i.e. the density that can be supported by an horizontal plate. An increase of 50% in both cases can be applied for one half of the emulsion vertically exposed. The total yield will be in this case of about 1.2×10^4 charmed decays.

2) The total scanning time is expected to be 5.7×10^4 hours. The collaboration would benefit of the work of a minimum of 25 scanners (8 in Italy, 12 in USSR and 5 in Spain). Hence the scanning can be accomplished in 2.3×10^3 hours i.e. in about 2 years, solar time.

   For the γ's half of the statistics (K selection applied) could be scanned in the first two months.

3) The increased read-out frequency has not been taken into account in the calculations. This gives an improvement of a factor 1.5 in the γ data collection (the maximum number of γ's is limited by the maximum number of tracks/s crossing the telescope).

   This improvement can be used either to increase by this factor the number of decays collected, or to reduce by an equal factor the run time.

4) It is difficult to estimate the expected number of F and Λc we can hope to collect, given the quasi total uncertainty of the data. For the photoproduction,

starting from the WA58 (still unpublished data), we can think to collect about 700 Λ_c (15%) and 150 F (3%).

For the hadroproduction, from the LEBC-EHS data (3) about 650 Λ_c (13%) can be expected. No reliable prevision can be made for the F production. In fact, although the F signal has been observed (NA11) no cross section has been published.

Work Organization

The Italian part of the collaboration will have in charge the construction of the CCD telescope and its management.

The Russian part will have in charge the full supply of the emulsions and their partial management.

The Spanish part will probably have in charge the management of Ω' system (for the part not supported by CERN) before and during the run.

The whole collaboration will contribute to the software development, to the scanning of the emulsion and to the data analysis.

For the Italian part 8 scanners will be full time engaged in this experiment.

For the Russian part at least 12 scanners will work.

For the Spanish part 5 scanners will work.

In the total at least 25 scanners will be full time engaged.

The collaboration expects from CERN:

- the availability and the partial technical collaboration for the management of the Ω' system;
- the availability of the CERN emulsion processing facilities (see Appendix 3)

APPENDIX 1

Event simulation

The background events were generated with the vertex put at random inside the target ($1.5x2x1\ cm^3$). The number of charged particles of the interactions is variable and reproduces the multiplicity distribution experimentally seen. Every event is generated with a number of π° half that of the charged particles. The outgoing π° are then let decay into 2 γ's. The γ's conversion probability in the emulsion is calculated together with the coordinates of the vertex of the pair. The background events, which give in their turn a secondary interaction, are generated as the previous ones, letting one of the outgoing particles interact at random inside the distance between the vertex and the end of the target. The secondary event is generated with an average charged multiplicity $N^{ch}_{sec} = 5$ and the coordinates of the secondary vertex are calculated. The events which charmed particle production are generated according to a model of the type $(1-|X|)^3\ e^{-1.1\ p_T^2}$ (11). For what is concerning vertex coordinates, charged multiplicity and number of π°, the procedure is the same as that adopted for the background events. The two particles generated as charmed are let to decay with an average multiplicity n= 3 and a lifetime $\tau = 5\ 10^{-13}$ s. If the decay occurs inside the emulsion the coordinates of the decay vertex are calculated.

The events with $C\bar{C}$ production which have all the possible decays outside the emulsion are less than 1%.

Simulation of the background due to the beam tracks and to events out of time

One thousand tracks, being parallel and crossing the whole emulsion with constant spatial distribution, are taken into account. Between them about two tracks get into 70 μs (resolving time of the apparatus) with respect to the event under study, about 30 events out of time are generated in addition. In other words there are no events produced inside 70 μs from the production of the event under study.

Simulation of the track trajectories inside the telescope

For each one of the charged tracks of the generated events the multiple and single wide angle scattering inside the emulsion and telescope planes, as well as the Ω' magnetic field of 18 KGauss are taken into account. The direction of the track when it leaves the target is sued to determine the crossing points of its trajectory with each of the 7 planes, each consisting of 4 photodiode arrays. The coordinates are in units of diodes. The same procedure is adopted for the beam tracks and background events. The procedure of reading the information relative to the single planes letting it run in alternatively opposite directions is used. In this way, a trajectory which is not inside the reading time of one row of cells (70 μs) will appear as a broken line.

Event reconstruction

After having generated events and background there are about 1600 coordinates for each plane of photodiode arrays. Firts the incident tracks out of time are removed, analyzing separately the coordinates of the odd and of the even planes and flagging those fitting a trajectory compatible, for its direction, with the beam direction. Each of the tracks reconstructed using only the points of the odd planes is compared with each of the tracks reconstructed using only the points of the even planes. If two of these tracks are coincident inside 1 diode they are accepted as one track in time and the points are kept as tracks points. The remaining points are flagged as points of primary tracks out of time. From all the points not flagged as points of tracks out of time, start the pattern recognition and the fit of the tracks. A track is accepted if it has at least 5 points (i.e. it crosses at least 5 planes). When all the tracks are reconstructed the vertex reconstruction starts and its coordinates with the errors are calculated (Fig. 3).

Results

Table A shows the percentage of reconstructed vertices for different kinds of generated events and for a distance from the emulsion to the telescope of 5 mm. In column 1 between brackets is the percentage of events from which all the decay products have less than 5 points detected by the telescope. To test the capability of the program to work well also in a rather confusing situation 5 more in time events were added. No difference was found in vertices reconstruction.

Figure 4 shows the differences Δx, Δy, Δz between the coordinates of the vertex of the primary event as it was generated and as it was reconstructed.
Fig. 5 shows the same differences for $D\bar{D}$ decays. Fig. 6 shows the generated decay length distribution and the same for the detectable decay vertices.

TABLE A

Type of event	1 reconstructed vertex (%)	2 reconstructed vertices (%)	More than 2 reconstructed vertices (%)
Without secondary interaction	96.	4.0	
With secondary interaction	18.0	77.0	5.0
With $C\overline{C}$ production ($\tau = 5\mathrm{x}10^{-3}$sec)	32.3 (3.0)	62.9	4.3
With $B\overline{B}$ production ($\tau = 2\mathrm{x}10^{-12}$sec)	26.7 (22.6)	24	49.3

APPENDIX 2

A) 350 GeV/c pions in emulsion

Emulsions exposed to 350 GeV/c pions have been scanned. The results obtained are the following:

a) Mean number of minimum ionizing tracks in ± 30° (i.e., which can enter into the CCD telescope and into Ω') 12

b) Events with >10 minimum ionizing tracks (Ns) in ±30° 56%

c) Mean number of ionizing tracks for the events with $Ns > 10$ 16

d) Mean free path in emulsion 62±2cm
(well compatible with $\sigma_{\pi em} = \sigma_{\pi p} \langle A^{2/3} \rangle$

e) Mean free path in emulsion for secondary interactions λ_{sec} 51±6cm

The production cross sections for charged kaons (K^{ch}) in high energy interactions are $^{(12,13)}$.

$\sigma_{\pi p}$ $1K^{ch} = \sigma_{\pi p}/4$
$\sigma_{\pi p}$ $2K^{ch} = \sigma_{\pi p}/10$
$\sigma_{\pi p}$ $3K^{ch} = \sigma_{\pi p}/100$

The charged kaons are recognized as such when their momentum is between 5 and 70 GeV/c. It has also been taken into account that about 1% of the pions in the same momentum interval will be interpreted as kaons.

The momentum distribution of the K's produced in the interactions (Fig.7) has been simulated with a production of the type $e^{-2.2|x|} \cdot e^{-4.5\, p_T^2}$ (Ref.12,13), and 0.24 of the produced K's have a momentum between 5 and 70 GeV/c. The momentum distribution of the pions obtained with a simulation of the type $e^{-3\, p_T^2}$, gives that 0.11 of the pions have the momentum in the same interval.

For the events with multiplicity >10 the events with recognized K^{ch} are the following

a) events without secondary interaction .11

b) events with secondary interaction, background of pions included .17

The momentum distribution of the K's coming from charm decay (Fig. 8) has been simulated with a production of the type $(1-|x|)^3 \times e^{-1.1 p_T^2}$ (11), and it has been obtained that 0.7 of K's have momentum between 5 and 70 GeV/c.

In order to compute the charm pairs percentage detectable, the data of ref.11 have been used for the decay multiplicity.

Requiring that at least one of the two charm decays has at least 2 charged prongs (in order to be able to reconstruct a decay vertex), the 87% of the produced pairs are detectable. The former percentage decreases to 78% for the events with $Ns > 10$.

Assuming (from SLAC data) the following ratios: $\frac{D^{ch} \to K^{ch}}{D^{ch} \to all} = 22\%$ and $\frac{D^\circ \to K^{ch}}{D^\circ \to all} = 44\%$, it has been obtained that 53% of the detectable pairs has $1K^{ch}$ and 11% has $2K^{ch}$. Taking into account the percentage of the K^{ch} having momentum in the $5 \div 70$ GeV/c interval and the background percentages, it comes out that 50% of the events which produce detectable pairs have at least one particle recognizable as kaon. Other useful data for evaluation of the detectable pairs and for the experiment feasibility follow:

a) $\sigma_{\pi p\ tot}=28$mb, $\sigma_{D\bar{D}}=30\mu$b, $\langle A\rangle / \langle A^{eff}\rangle=3.83$ from which it follows that $N_{D\bar{D}}=0.0041\times$ N produced events

b) Maximum number of recordable triggers per second = 100

c) target dimension xyz=$15\times20\times10$ mm^3 with x= beam direction

d) maximum primary track density 2000/mm^2

The maximum total number of pions crossing one target will be $2\times10^5\times2 = 4\times10^5$ for a total path of 6×10^5 cm and about 10^4 interactions will be produced, 6.2×10^3 of which will give a multiplicity trigger. This implies 62 seconds of exposure time, at a rate of 6.5×10^3 π/s. The total number of tracks crossing the telescope will be $7.7\ 10^3$/s, well below the maximum number of 4×10^4/s.

The particles produced in the fiducial volume (1cm) will travel in the mean 1 cm of emulsion and therefore $(16\times1)/50=.32$ of the events will have a secondary interaction. This figure decreases to .28 for the secondary interactions with at least 2 minimum ionizing tracks (i.e. with reconstructable vertex) and to .23 requiring $Ns > 10$.

Table 1 summarizes the events produced by pions in the emulsion.

TABLE 1

Events	Total	in fiducial volume (1cm)	as before $Ns > 10$	as before with $1K^{ch}$	as before with more than 1 vertex reconstructed
without secondary interaction	7200	4800	2700	297	12
with secondary interaction	2800	1870	1534	261	214
with $D\bar{D}$ pairs	41	27	21	10.5	7

Therefore to obtain 5000 reconstructed decays we will need about 360 targets, corresponding to about 1 liter of emulsion. With a 2s burst, a repetition rate of 14 s and a 70% SPS efficiency a 2,5 days run will be needed. The scanning will concern about 8.4×10^4 candidates, corresponding to about 28000 hours.

The finding rate will be 3 charmed pairs per 100 scanned events.

B) (70 - 200 GeV) γ in emulsion

A reasonable estimate of the maximum dose to which the emulsions can be exposed is about $0.5 \times 10^6\ \gamma/\text{cm}^2$. This dose is equivalent to about 1.5×10^5 electron pairs/cm^2.

In fact we can extrapolate the WA 58 scanning data towards the increased thickness of the emulsion and the increased energy.

This extrapolation gives that about 2000 electron pairs/mm^2 allow an accurate scanning of emulsion, giving rise to about 2000 tracks/mm^2 aligned with the beam, plus something less than 2000 not aligned tracks, these last ones coming mainly from low energy γ's and from γ's converted before the emulsion.

With this number of pairs we obtain easily :

$$N\,\gamma/\text{mm}^2 = N_{\text{pairs}}/(1-e^{-(7/9)\times(1.5/3)}) = 2000/0.32 =$$

$$= 6250\ \gamma/\text{mm}^2$$

With a safety cut of 20%, this is the dose we have before indicated. This dose corresponds to $1.\times10^6$ γ's on the 2 cm^2 target, and hence to about $6.\times10^4$ fully tagged γ's/cm^2 between 70 and 200 GeV. The 1.5×10^5 electron pairs/cm^2 give rise to $3.\times10^5$ tracks/cm^2, 1.7×10^5/cm^2 of which as a maximum enter the CCD telescope, corresponding to 3.4×10^5 tracks entering the telescope from the whole target for a complete dose. This implies ($4.\times10^4$ being the maximum number of tracks per second supported by the telescope) that about 8 s will be the exposure time for each target.

For each second there will be about 1.5×10^4 full tagged γ's on the whole target. This dose/(target x s) implies 1.3×10^5 γ's/s crossing the target, for a total length of crossed emulsion of about 1.9×10^5 cm/s. The data we have used for the evaluation of the detectable pairs of $D\bar{D}$ and for the feasibility of the experiment are the following ones:

a) $\sigma_{\gamma p} = 115\ \mu b$, $\lambda_{\gamma em} = 5700$ cm (for hadronic interactions)

b) $\sigma_{\gamma \to D\bar{D}} = 6\mu b$; $\langle A\rangle / \langle A^{eff}\rangle = 1.52$

c) mean charged multiplicity $\langle N_{ch}\rangle = 10$

d) with a multiplicity cut N_{ch} 8 the $D\bar{D}$ pairs will be 81%, the hadronic interactions 67%.

e) 25% of the events in the fiducial volume will have a secondary interaction, 22% if we ask at least two minimum ionizing tracks and 18% if they have to have a total number of prongs larger than 8.

We first obtain $1.9\times10^5/5700 = 34$ interactions/s. This figure is well below the maximum number of interactions/s that can be handled by the data acquisition system.

Table 2 summarizes the events produced in one target with the above assumptions.

TABLE 2

Events	Total	in fiducial volume	as before Ns > 8	as before with more than 1 vertex reconstructed
without secondary interaction	25	17	11	.4
with secondary interaction	7	5	4	3
with $D\bar{D}$ pairs	.25	.17	.14	.1

Therefore to obtain 5000 reconstructed decays it will be needed 25000 targets, corresponding to 75 litres of emulsion With a ∿ 2s burst, a repetition rate of about 14 and a 70% SPS efficiency, a 21 days run will be needed.

The scanning will concern about 3.5 events/target and therefore 8.8×10^4 events corresponding to about 29000 hours.

The finding rate will be 2.8 charmed pairs per 100 scanned events.

It should be remarked that for γ's no K selection has been used. The reason of this choice is the uncertainty in the RICH functioning with γ beams. If, as it now seems, the K selection can be applied, a reduction of a factor about 4 in the number of the candidates to be observed in the emulsion will be obtained. This reduces the scanning time for the first half of the charm sample to about 8000 hours.

APPENDIX 3

A) Exposure device

As mentioned in Appendix 2, each emulsion target will be exposed for about 30 bursts (for π^-) and for about 4 bursts (for γ's) before it will have reached the exposure dose. This means that the emulsion stack (containing several targets) has to be put in the beam and then moved to be exposed uniformly. This fact implies two separate movements:

1. To place the stack in the beam and to take it out. This will be achieved in a way quite similar to that used in experiment WA58 by means of a gravity operated device. In the final position, the emulsion shuttle will be hydraulically firmly constrained in a reference position .

2. To move the stack by steps in two coordinates, perpendicularly to the beam, will be achieved by hydraulically operated movements and mechanical stops remove-controlled. This operation will ensure a position reproducibility better than .05 mm. This method easily overcomes problems arising from the strong magnetic field because it is not necessary to use ferromagnetic materials.
   This exposure system will be built in Italy.

B) Emulsion Handling

At least 4 main operations will be necessary:

1) Machining of the emulsions to obtain accurately dimensioned stacks.

2) Gridding of the emulsions to create an emulsion reference system.

3) Mounting of the emulsions on glass plates.

4) Processing of the emulsions (development and fixing).

Operations 1) and 2) should be carried out at CERN, and the availability of adequate facilities is requested for these operations.

Operations 3) and 4) will be carried out for half of the emulsions in the USSR and for the other half at CERN. This splitting is desirable in order to reduce as much as possible the time required for processing such a large amount of emulsions.

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FIGURE CAPTIONS

Fig. 1 - CCD telescope beyond the emulsion stack.

Fig. 2 - Layout of the experiment.

Fig. 3 - a) full line: distribution of the generated primary event multiplicity -
dotted line: distribution of the reconstructed primary event multiplicity.
b) same as a) for $D\bar{D}$ decay ($\tau_D = 5\times10^{-13}$ sec)

Fig. 4 - Difference (in microns) between the coordinates of the generated and of the reconstructed vertex.

Fig. 5 - Difference (in microns) between the coordinates of the generated and of the reconstructed vertices of the $D\bar{D}$ pair.

Fig. 6 - Full line: decay length distribution of the generated $D\bar{D}$ decays. Dotted line: decay length distribution of the $D\bar{D}$ decays detectable by means of the CCD telescope.

Fig. 7 - Momentum distribution of the K's from the interactions produced by 350 GeV/c pions.

Fig. 8 - Momentum distribution of the K's from D decays.

Fig 1

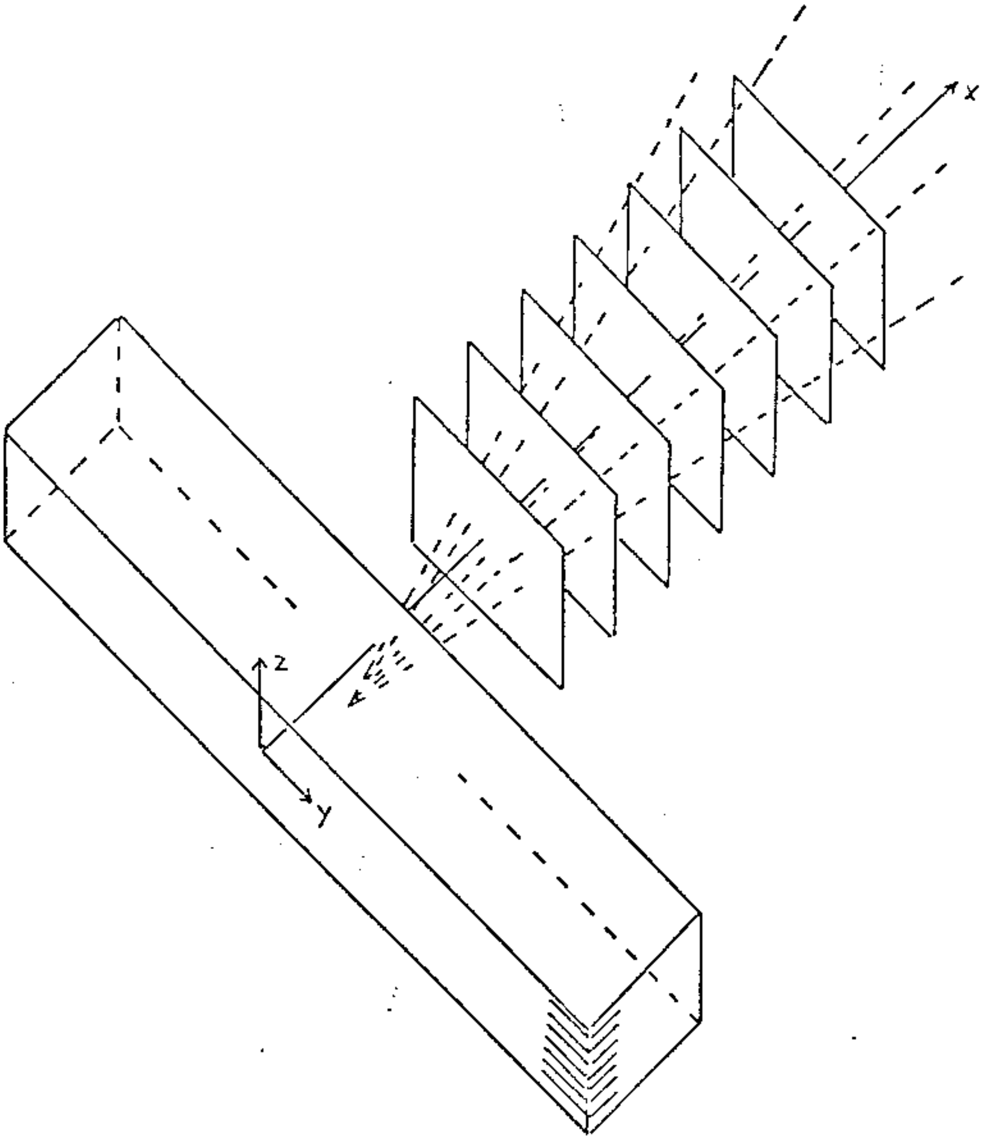


Fig 2

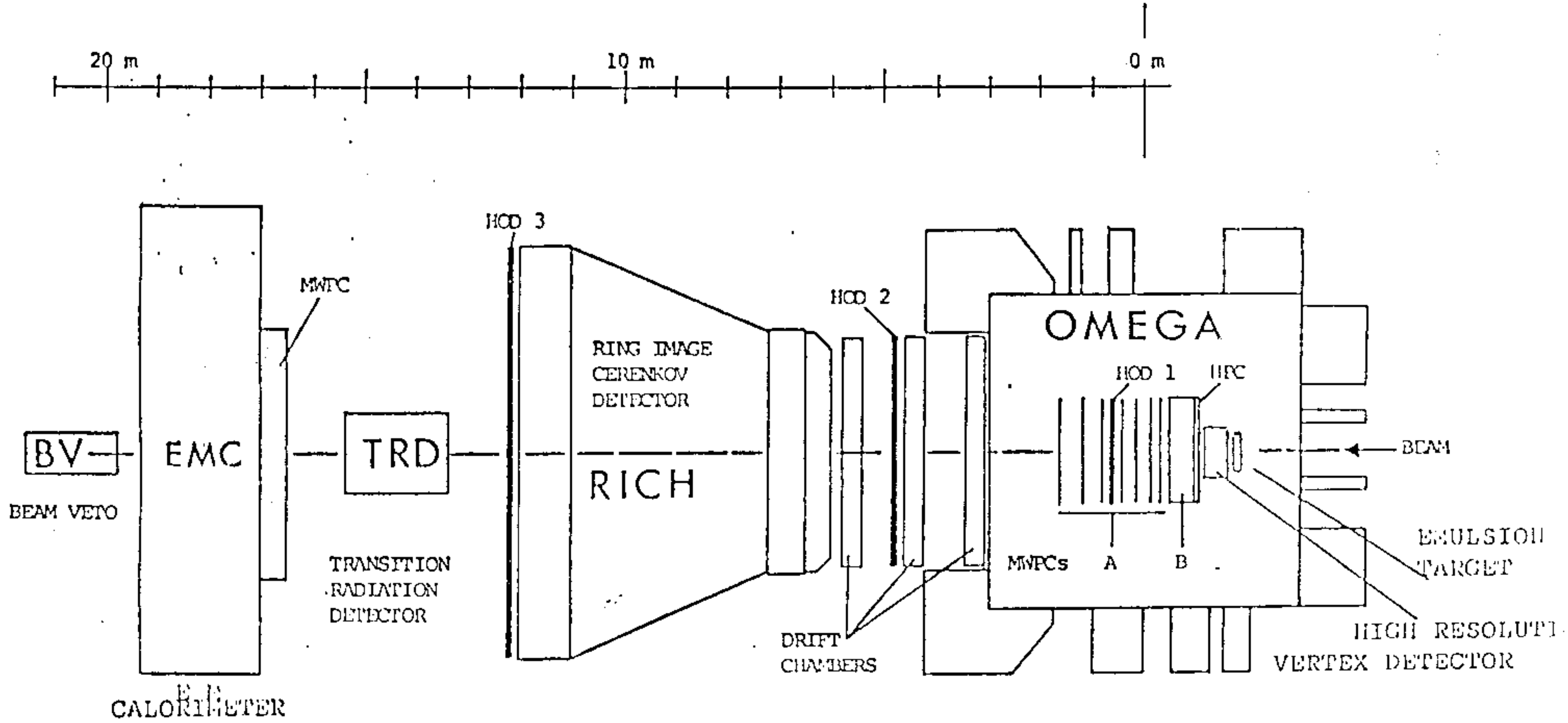

20 m
10 m
0 m
BV
BEAM VETO
EMC
CALORIMETER
MWPC
TRD
TRANSITION
RADIATION
DETECTOR
HOD 3
RING IMAGE
CERENKOV
DETECTOR
RICH
HOD 2
DRIFT
CHAMBERS
OMEGA
HOD 1
HPC
MWPCs
A
B
BEAM
EMULSION
TARGET
HIGH RESOLUTI
VERTEX DETECTOR

Fig 3

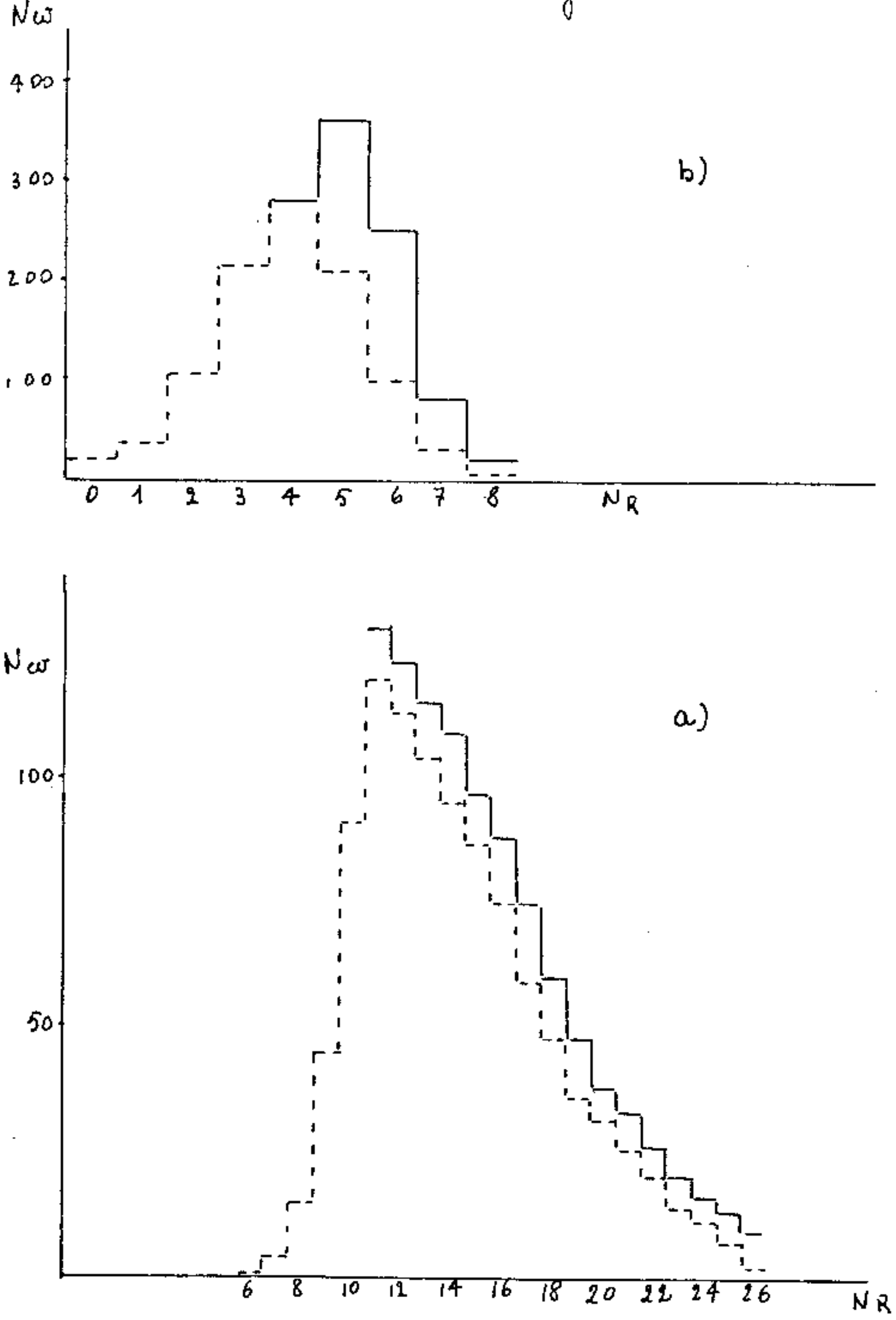

Nω
400
300
200
100
b)
0
1
2
3
4
5
6
7
8
N R
Nω
a)
100
50
6
8
10
12
14
16
18
20
22
24
26
N R

Fig 4

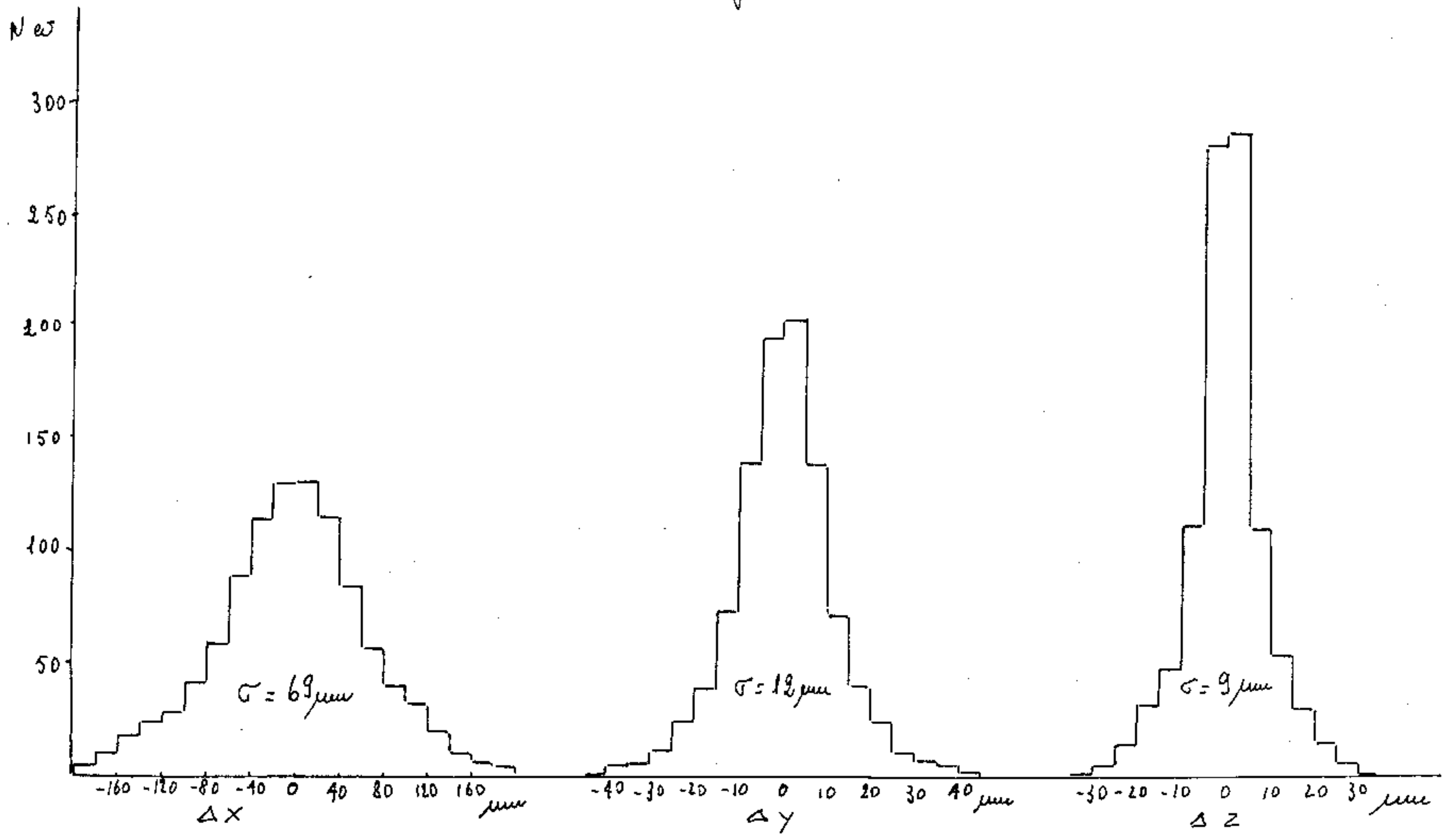

N ev
300
250
200
150
100
50
σ = 69 μm
σ = 12 μm
σ = 9 μm
-160 -120 -80 -40 0 40 80 120 160 μm
ΔX
-40 -30 -20 -10 0 10 20 30 40 μm
ΔY
-30 -20 -10 0 10 20 30 μm
ΔZ

Fig 5

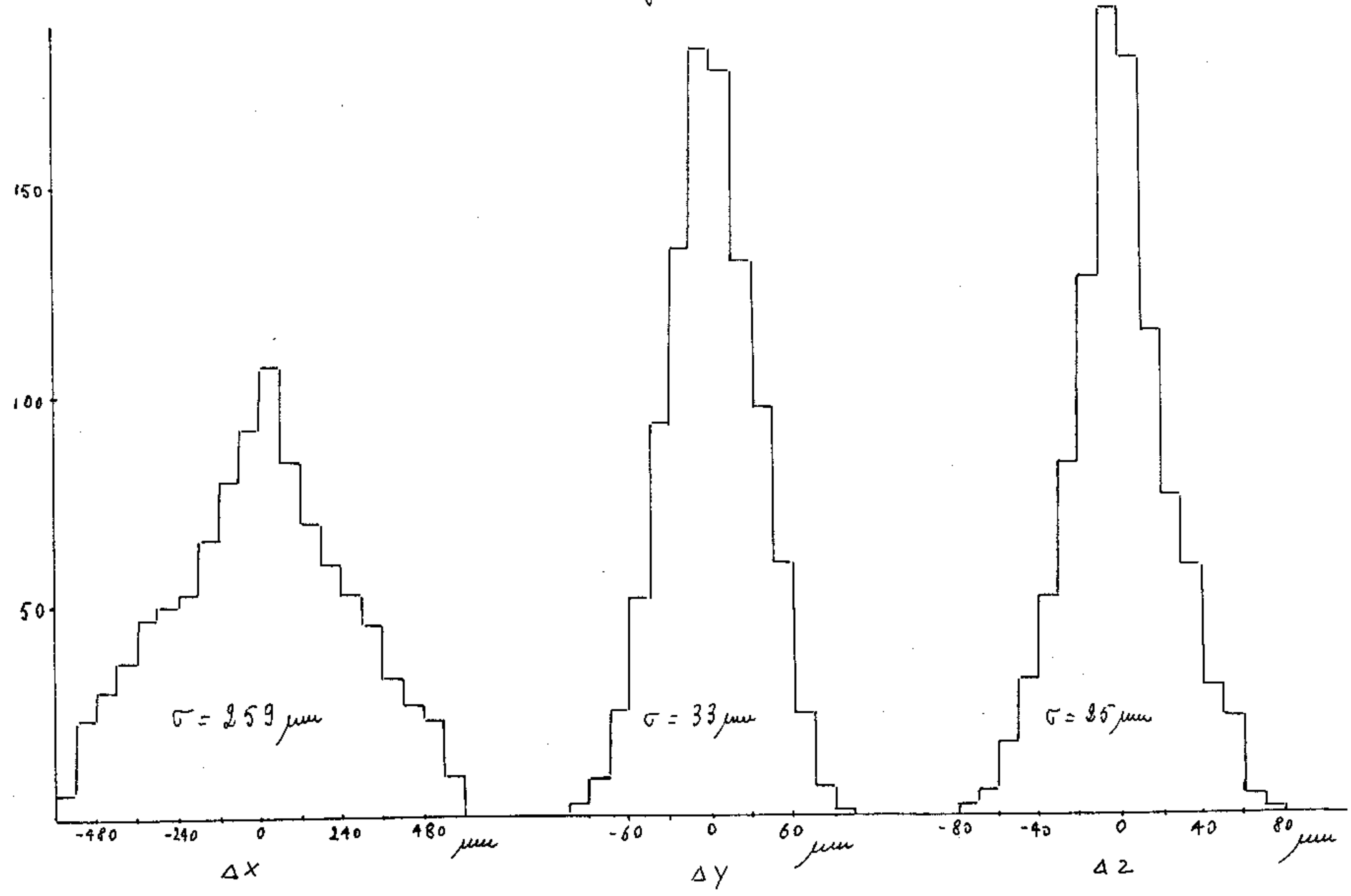
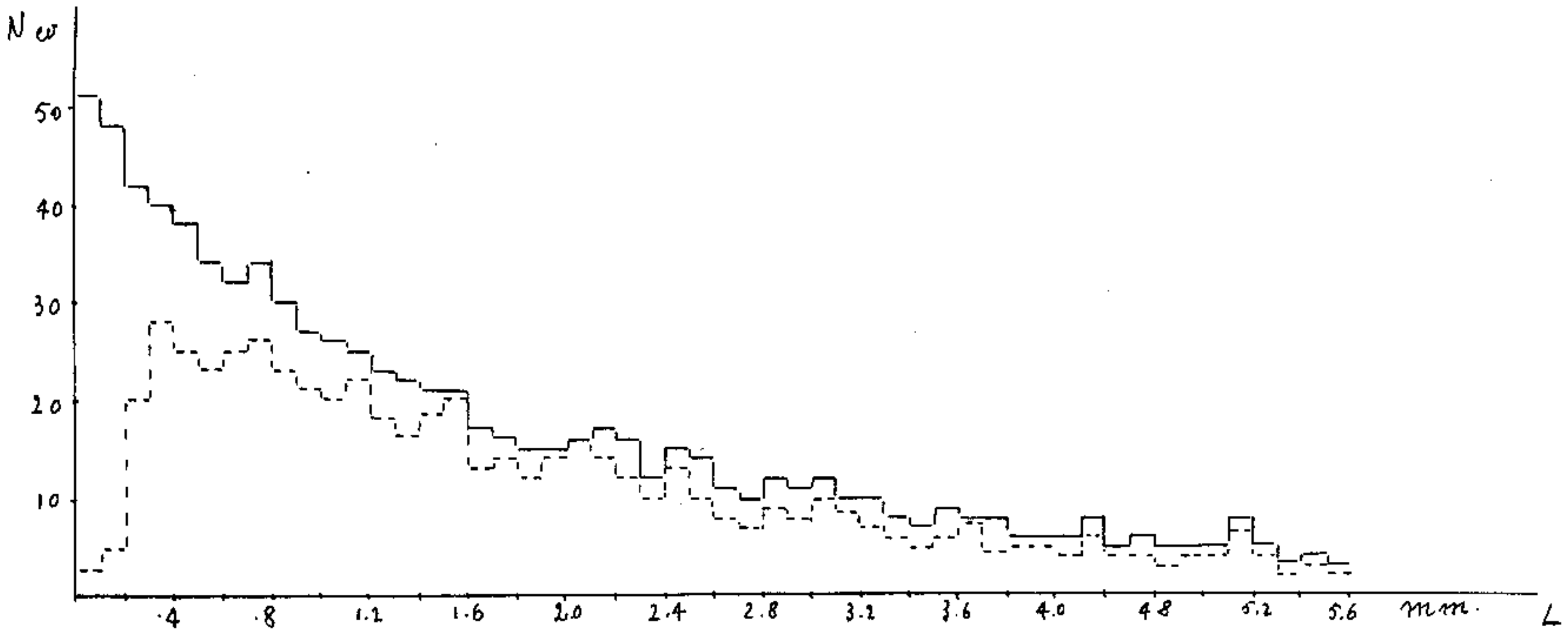

150
100
50
$\sigma = 259\,\mu m$
$\sigma = 33\,\mu m$
$\sigma = 25\,\mu m$
-480
-240
0
240
480
μm
ΔX
-60
0
60
μm
ΔY
-80
-40
0
40
80
μm
ΔZ

Fig 6



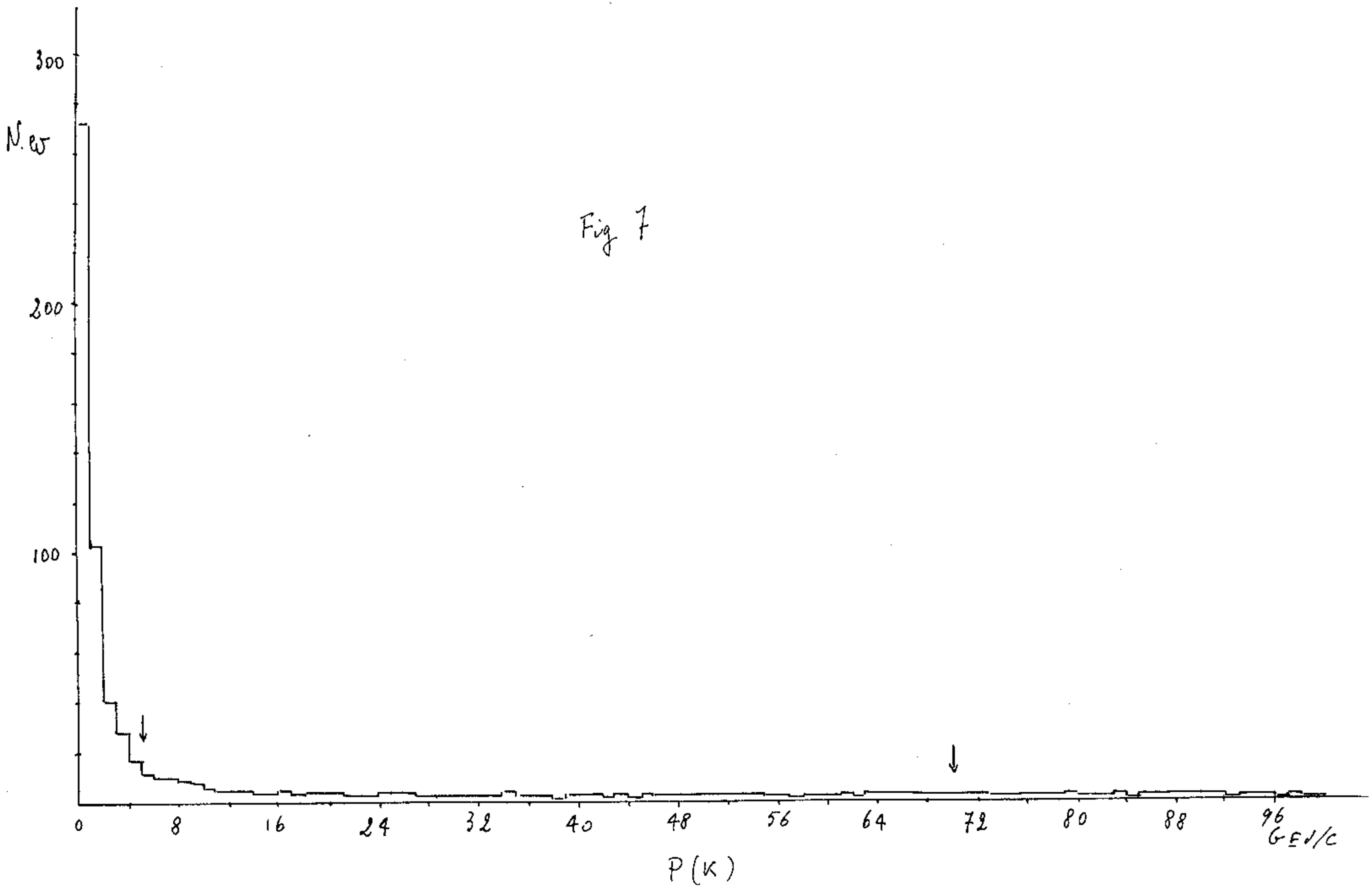
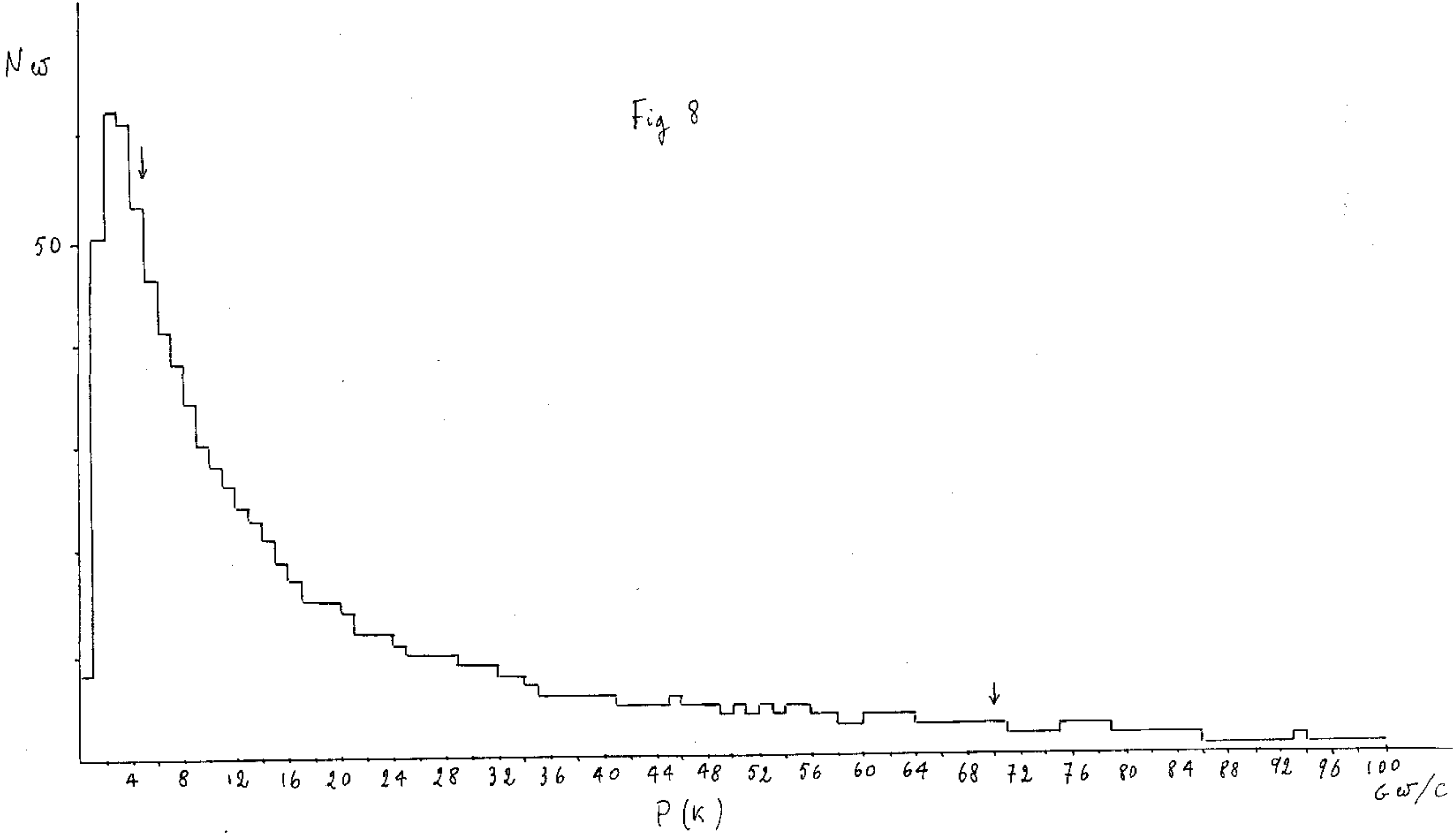


Fig 7

Fig 8


Nω
50
4
8
12
16
20
24
28
32
36
40
44
48
52
56
60
64
68
72
76
80
84
88
92
96
100
Gω/c
P (K)