CERN LIBRARIES, GENEVA

CM-P00046654

SPSC 88-30
SPSC/~~M438~~ R75
31.08.1988

Addendum to Memorandum SPSC/P-235

from: R. Stock (NA35 spokesman)
re. NA35 Upgrade

I. Overview

The amendment proposal of experiment NA35, for an anticipated ^{32}S running period in 1990, has left a set of questions unanswered as outlined by the SPSC, chiefly addressing the usefulness of adding the adapted WA44 Streamer Chamber downstream of our main Streamer Chamber and regarding the detailed design and implementation schedule of a large area Ring Imaging Cerenkov Detector (RICH). These proposals extend the original goals of NA35, which dealt exclusively with Oxygen beams, to a similar physics program for the next Sulphur beam period in 1990. They are based on our experience with Oxygen and Sulphur data which are available either as published data or as conference contributions. The following considerations have guided our upgrade proposal:

1. NA 35 provides the only setup with approximate 4π coverage and momentum measurement. For S interactions with heavy targets, we need expansion of our good efficiency acceptance, in order to study:

   Multiplicity distributions;
   Rapidity distributions and multiparticle correlations in y;
   p_T spectra in a wide acceptance (as fct. of y);
   Net charge and proton y-distributions and spectra;
   $2\pi^-$-correlations in a wide acceptance, particularly at $4 < y < 5$;
   Neutral strange particle yield and spectra.

   Above and beyond these goals we will attempt hadron identification by means of ionization measurement in the relativistic rise, and by a RICH-Cerenkov detector.

2. Our principal goal is to search for signals indicative of Quark Gluon Plasma formation. We expect to reach the highest energy density and the largest interaction volume in S + Ag, S + Au collisions, which cannot be studied satisfactorily (because of their high multiplicity) unless a second, downstream tracking detector is added.

3. It is unlikely that QM formation occurs in the average central collision. We need an additional detector for off-line selection of subsamples, according to properties that can be evaluated at high speed (i.e. straight tracks in the downstream chamber) and can serve to distinguish average from candidate events.

4. We need to increase our data analysis rate by about an order of magnitude for reasonable statistics in p_T spectra, correlation analysis, fluctuation analysis etc.

In detail the following considerations have lead to our amendment proposal.

A. Results obtained thus far

The NA35 Streamer Chamber of 2 x 1.2 x 0.7 m^3 inside a 1.5 T magnetic field was meant to determine charged particle multiplicity distributions in as close to 4π coverage as we could get, to measure positive and negative particle spectra, to study the correlation between negative particles, with negatives being considered as π^- in the absence of further means of particle identification, and to determine K_0^s, Λ and $\bar{\Lambda}$ yields and spectra. Furthermore, the set of electromagnetic and hadronic calorimeters, inherited from experiment NA24, and augmented by addition of a new calorimeter for the forwarded angle domain $0.3° < \theta < 2.5°$, allowed for a determination of the electromagnetic/hadronic shower energy in the domain of pseudorapidity $2.4 < \eta < 6$, and of the E_T distributions in the interval $2.4 < \eta < 3.8$. Our present status with respect to these goals is as follows:

1. Multiplicity distribution

First results on the dependence of ^{16}O + Pb, 200 GeV/nucl. multiplicities on the forward energy flow (into $y > 5.5$) were presented in ref. [1]. A detailed study of multiplicity distributions in inelastic ^{16}O interactions at 60 and 200 GeV/nucl., with targets ranging from A = 20 to 197 was then presented in ref. [2]. It turned out that significant acceptance losses, due to excessive spatial track density, did not occur in proton and ^{16}O collisions with any target and neither in $^{32}S + {}^{32}S$ reactions at 200 GeV/A (publication in progress). However, the reactions of ^{32}S at 200 GeV/A with heavy targets Ag and Au, present unsurmountable track density problems at $y > 3.5$ already at the level of track counting. Thus we fall short of 4π event characterization here.

2. Particle spectra

From Streamer Chamber track measurements, carried out initially at the CERN ERASME and Heidelberg PEPR facilities and, since 1987, at fully digital operator supervised work stations at Frankfurt and München, we have obtained [3] rapidity distributions and p_T spectra for proton and ^{16}O beams on ^{197}Au targets. The high quality acceptance domain was $0.5 < y < 4.0$. Likewise, we have analyzed 300 central collision events $^{32}S + {}^{32}S$ at 200 GeV/A (publication in progress), in $0.5 < y < 3.5$. In the former reactions the acceptance covers the essential phase space as y_{CM} is found to be between 2 and 2.5; in the latter reaction it is sufficient to cover the backward half of phase space, $y \lesssim 3$, due to the reflection symmetry about $y_{CM} = 3$.

3. Two pion correlation (Hanbury-Brown, Twiss analysis)

We have presented first results on the Bose-Einstein interference of negative particles produced in ^{16}O + Au central collisions at 200 GeV/nucl. [4], and on the event by event study of source shape parameters from single events of high negative multiplicity ($n > 100$) central ^{16}O + Au collisions [5]. Work on π^- correlations in p + Au and S + S collisions at 200 GeV/nucl. is near completion. The useful y acceptance in these reactions is 0.5 to 4, 0.5 to 6 and 0.5 to 3, respectively. No low p_T cutoff occurs which is essential for HBT analysis.

4. Strange particle cross sections and spectra

We have obtained a first set of data on K_o^s, Λ and $\bar{\Lambda}$ production in p and ^{16}O + Au at 60 and 200 GeV/nucl., and in S + S at 200 GeV/nucl. (publication in progress). Our present analysis capacity is about 6000 high multiplicity events per year. At this level, $\bar{\Lambda}$ statistics and Λ, $\bar{\Lambda}$ transverse and longitudinal polarization data will be at a reasonable level by mid-1989. We are also implementing a program for kink and τ-decay ($K^{\pm} \rightarrow$ 3 charged pions) analysis imbedded in the exclusive event measurement of S + S at 200 GeV/A, which will lead to a determination of K^+ and K^- cross sections at the ± 15 % level by mid-1989.

The useful acceptance for V° decays depends on both the reaction type and the particle considered; in ^{16}O + Au central collisions it is $1.3 < y < 2.8$ on the average for K^o, Λ and $\bar{\Lambda}$. However, unlike in charged particle spectra we have a lower p_T cutoff around 0.6 GeV/c. The average overall detection efficiency for Λ particles is about 6% in this y, p_T domain. Similar conditions prevail in S + S at 200 GeV/nucl..

5. Calorimeter data

We have published [1,6] systematic studies of electromagnetic and hadronic E_T spectra and rapidity distributions for p and ^{16}O reactions with targets ranging from Al to Pb. Similar data for ^{32}S-induced reactions are near publication. We consider this part of our proposal to be finished. The set of calorimeters will henceforth (unless new physics ideas come up) only be used for triggering.

6. Limitations of the present setup

The NA35 Vertex chamber works well as a wide acceptance near-4π detector for multiplicity distributions and negative/

positive particle spectra etc. up to multiplicities of about 350. This covers p + Au, ^{16}O + Au and to some extent, ^{32}S + ^{32}S collisions. The dependence of overall efficiency on rapidity for S + S at 200 GeV/nucl. is shown in Fig. 1. It is sufficient for pions but the useful proton acceptance is limited to $y < 2.5$.

These conditions deteriorate in central ^{32}S + heavy target collisions because of excessive track density at $\theta_{lab} \lesssim 8°$ corresponding to pseudorapidity $\eta \gtrsim 2.6$.

Even track counting is heavily biased rendering the determination of charged particle multiplicity impossible. As to the measurement of particle spectra pions (protons) are accessible only up to $y \approx 2.3$ ($y \approx 1.5$). Thus, in S + A collisions proton spectra are measurable only in the spectator rich target rapidity region and pions can only be analyzed below midrapidity. The latter shortcoming precludes a two-pion-correlation analysis in the mid-rapidity region and beyond (see below).

Some of these problems will be reduced by modifications to the Vertex Chamber. The main amendment, to restore the 4π-character of NA35 that we approached successfully in the ^{16}O-data, is to add a downstream Streamer Chamber to cover $\theta_{lab} \lesssim 8°$. Since it will be located outside of the magnetic field, the tracks will be straight which facilitates the picture analysis considerably.

We need to increase the speed of our exclusive full event analysis (presently at the level of about 600 per year) by at least a factor of five to ten in order to get p_T spectra and HBT analysis in subselections of wider data samples, as well as in narrow y, p_T and Q_T windows (HBT).

B. New physics goals

Based on our first results and their discussion we intend to expand certain features of NA35 beyond the initial scope of the proposal.

1. Net charge and proton rapidity distribution

It has been speculated that the nuclear stopping power is different for incident quarks and gluons. In central collisions the gluonic energy which is about 0.5 of the total could be stopped at mid-rapidity whereas the valence quarks would only be shifted by an average $\Delta y \approx 1.2$. This is the prediction of the Lund string model which shows two distinct peaks of final state net charge centered at $y = 1.2$ and 4.8, respectively, in the reaction S + S at 200 GeV/A (central collisions) as shown in Fig. 2. Lund/Fritiof shows that the net charge distribution is almost identical to the proton (minus antiproton) distribution. Our first preliminary data, also shown in Fig. 2, deviate from Lund indicating a higher net charge/baryon number density near mid-rapidity, perhaps indicating a higher effective "quark stopping" than forseen in the Lund model. If the stopping suffices already in mass 32 collisions to create a significant baryochemical potential at midrapidity one can perhaps count on complete "quark stopping" in Pb + Pb collisions at 200 GeV/nucl. This is of extreme importance also for the evaluation of collider projects like RHIC or LHC: will the quark stopping power be as high as to exclude the production of "ideal" conditions (zero net baryon number density) at midrapidity in 100 + 100 GeV/nucl. RHIC collisions - contrary to former expectations that this design energy would be safely above what is required?

In order to study this question further additional tracking capabilities are needed in the cone of forward laboratory angles. Those would increase the significance of the S + S data and enable the study of ^{32}S-collisions with heavy nuclei. ^{16}O interactions are not a replacement, because the number of charged baryons produced forward from midrapidity in ^{16}O + A collisions is too small. The Downstream Chamber is well suited to cover the proton rapidity range from 2.4 to 4.4 and will, therefore, provide information about the slowing down of the projectile nucleons when the sulphur nucleons traverse a heavy nucleus. It would be preferrable to use identified protons instead of net charge for such an analysis; therefore we will attempt to separate protons from pions on the basis of an ionization measurement in the relativistic rise region (10 GeV/c < P_{lab} < 30 GeV/c).

2. Two pion correlation at $4 < y < 5$

Bose-Einstein correlations between pions enabled us to determine the "source" size in space-time for ^{16}O + Au central collisions [4,5]. Our finding of a large, thermalized pion source at the rapidity of the effective c.m. frame has attracted a lot of attention. It is equally important to measure the *source size* as far away *from* y_{CM} *as one can get. For* asymmetric projectile/target combinations this can not be done in the spectator region but rather forward from midrapidity. Andersson and Hofmann [7] have suggested that the longitudinal source size R_L measured as a function of rapidity reveals the *mean* coherence length $<\Delta y>$ for BE interference to occur, which should be related to the QCD string tension. It is our intention to follow this idea by extending our pion acceptance in S + Ag, Au collisions up to $y \approx 5$, in order to compare this R_L with similar data from p + Ag, Au (already obtained by us), and from p + p (NA5, NA22). This can only be done in the proposed downstream chamber.

3. Radial flow from pion, kaon, proton p_T spectra

A model of radial, isentropic expansion of the "fireball" has *been formulated by Lee and Heinz [8] suggesting that the* p_T spectra of π, K and p are characteristically different and contain information on the radial expansion mechanisms and on the existence of a "coexistence period" of the quark- and hadronic phases. Fig. 3 shows their prediction along *with* π^0 *data from* WA80 [9], π^--data (negative particles) from NA35, and our preliminary "proton" p_T spectra obtained for S + S from the subtraction method. The pion spectra are convex and the proton spectra concave as the result of ordered radial expansion flow - within the interpretation of this model. In order to conduct a systematic study of these initial observations we intend to develop a RICH detector which, together with the tracking and momentum information provided by the Vertex Streamer Chamber, enables us to identify π^-, K^-, $\bar{p}$ or π^+, K^+, p and obtain p_T spectra in the domain $2 < y < 3$.

This detector type is, at the same time, a prominent candidate for future wide acceptance hadron identification in Pb experiments and, in this view, our development is devoted to a large scale prototype study to be conducted under similar particle density conditions and also involving the entire required analysis chain. We underline, however, that our medium range interest in this detector is motivated primarily by present physics goals connected to ^{32}S runs.

4. Two K^+ HBT analysis

As a limiting possibility of the two major NA35 amendments proposed here (downstream chamber and RICH) we mention the chances to perform a pilot study of two K^+ interferometry. We request, however, not to judge the merits of these amendments in the light of the marginal chance to accomplish this particular goal.

K^+ Bose Einstein interferometry is supposed to lead to additional, independent information on the space-time expansion of the reaction zone. The K^+ have minimal final state interaction due to their small interaction cross sections. Their interference thus images an earlier expansion stage - they decouple much sooner than the pions.

As will be further outlined in the section concerning the RICH detector, a 1 m^2 sensitive surface placed at a central deflection angle of about 22° outside the Vertex magnet will cover about 40% of the $y = 2.4$ total K^+ yield (from Fritiof simulation of S + Au central collisions at 200 GeV/nucl.). This results in a mean number of 2.2 identified K^+ per event. Note that the K^+ sample in this relatively narrow rapidity/momentum window is implicitely enriched with the relevant close pairs, as compared to a situation with 100% azimuthal coverage.

We expect an average of 2 K^+ pairs per event; thus, 5000 - 10000 analyzed events would lead to reasonable accuracy in both the K^+ p_T spectrum and the K^+ HBT. As the measurement of the corresponding main Streamer Chamber pictures will be required in order to perform the RICH analysis (at least in the partial acceptance of the RICH which is outside the high track density domain in the Vertex Chamber), this proposal also rests on our ability to automatize the picture measurement, advancing to about 5000 analyzed events per year. We expect to reach this level by 1991.

An independent approach will be attempted by relativistic rise ionization measurement in the proposed downstream chamber, in the interval $3.5 < y < 4.5$. The crucial task is to accomplish a sufficient K^+/proton discrimination. Both particle species will be about equally abundant. Separation from the (more abundant) π^+ will be no significant problem as the ionization difference π^+/K^+, p is about twice the p^+/K^+ separation. We consider the chance to accomplish this goal marginal (see the section on the downstream chamber) but will persue it anyhow. It adds no significant extra effort to the automatic digital tracking process as the corresponding algorithms are based on the microscopic track structure, anyhow.

5. Pre-selection of specific event samples

The automatic measurement of the straight tracks in the downstream chamber is state of the art already now. With the corresponding upgrade of our digital work stations we expect to be able to analyze exclusively about 10 times more downstream chamber events per unit time than Vertex Chamber (curved track) events. We will thus be able to pre-select subsamples according to the results of the Downstream Chamber analysis. For example, from positive/negative subtraction we will select for events with extreme "quark stopping" in S + Ag, Au central collisions requiring a low "proton" density at $y > 3$.

6. Consequences

A number of highly interesting physics quantities can not be extracted from the data of the 1987 ^{32}S run and require new detector development:

1. Postive and negative particle multiplicity distributions in near-4π acceptance, as well as the corresponding rapidity distributions and possible short range rapidity correlations [10]. All holistic event properties require the augmentation of our good acceptance by a second tracking device at $y > 3$. This refers to S + Ag, Au collisions.

2. Net charge ("proton") distributions at and beyond mid-rapidity, as well as the analysis of the π^- correlation in the interval $4 < y < 5$ require the upgrade by a downstream chamber.

3. Hadron identification is desirable for the problem of differentiating between net charge and proton rapidity distributions. It will also lead to an analysis of the expansion mechanism as revealed by π, K, p p_T-distribution shapes. We propose to develop a 1 m^2 RICH detector at $y \approx 2 - 2.5$ for this purpose, and to attempt hadron identification by ionization measurement in the downstream chamber. A remote possibility exists for a pilot investigation of K^+ interferometry in either of the two major upgrade devices.

C. Summary of the upgrade

In order to accomplish the initial goals of NA35 in the higher multiplicity situation of S + S, Ag, Au central collisions at 200 GeV/nucl. and, furthermore, for the sake of investigating several new interesting physics observables, we propose an upgrade for the further running period(s) with ^{32}S beam. This will, above all, provide us with a set of comprehensive data, to be analyzed in the period 1990-93 preceeding the possible advent of heavier beams. In part, the developments proposed here (fast processor-intelligence event analysis, RICH) are valuable for the design of Pb experiments. The data expected from an amended NA35 configuration in 1990 will provide a wide body of interesting material for the next years. In particular, we propose the following upgrades:

1. Modifications of the existing Vertex Streamer Chamber: insertion of a (retractable) intransparent separating foil in the mid-plane, thus cutting the sensitive volume (and thus the track density) to half the full azimuth.

2. Addition of the existing WA44 avalanche chamber downstream, at a variable distance from the target in order to cover the high track density domain $\theta_{lab} < 8°$ at larger distance, thus extending our acceptance to $y < 5$. The main justification of this chamber is in the observables resulting from track measurement. We will also attempt to use the track structure for ionization measurement, thus separating pions from the K/p tracks, and perhaps also resolving the latter on a statistical basis.

3. Construction of a 1 m^2 RICH detector for $\pi/K/p$ identification at $y = 2.5 \pm 0.5$.

4. Increase of our picture analysis speed by automatic pattern recognition by dedicated microprocessors. We expect factors 5 to 20 depending on the complexity of the pictures.

5. Such an upgrade provides us with a device which covers most of 4π for charged particle multiplicity and particle momentum measurements. In particular it allows to
   - select events according to multiplicity and baryonic stopping;
   - determine the phase space asymmetries in S + heavy target collisions;
   - look for rapidity and two-pion correlations forward from midrapidity (free of spectator effects);
   - perform a two-pion correlation analysis on an event by event level;
   - study differences between particles in different charge states (K^+/K^-, π^+/π^- etc.).

Furthermore it opens the possibilty to analyze large numbers of events if the picture analysis is restricted to the straight tracks of the downstream chamber.

II. Details of the upgrade

A. The Downstream Chamber

The deployment of the former WA44 Avalanche Chamber for Experiment NA35 implies only minor modifications to the Chamber body, which will reduce interactions of the beam and of secondaries in the chamber wall. Fig. 4 shows the sharing of the acceptance between the two chambers. This figure replaces Fig. 7 of our initial amendment proposal which contained a numerical mistake. The installation of the chamber together with its High Voltage system has been studied in detail and will not cause major problems. The readout of the chamber will be done with four WA44 image intensifiers. The storage medium film will be replaced, however, by electronic devices. The output of the 4-stage image intensifiers will be projected onto 1000 x 1000 pixel CCD cameras provided by the Lawrence Berkeley Laboratory. The digital picture information will be extracted from the CCD-Cameras by means of a SUN workstation equipped with commercially available (DATA-CUBE) Camera Controllers and picture processing elements, all of which will be provided by the group of Max-Planck Institut in München. First tests of the image intensifiers and the CCD cameras are scheduled for October 1988. The Hard- and Software of the readout system is scheduled to be ready in the middle of 1989. It will be based on our presently employed CCD supervision system. Installation of the Downstream Chamber can start as soon as the project is approved. It will take approximately 8 months, thus a decision in September is desirable in order to ascertain readiness in the middle of 1989. The capital investments necessary for the setting up of the Downstream Chamber is assured by the University of Frankfurt, the Max-Planck-Institut, München, LBL and CERN/EF. It comprises 400 KSFR for the installation and 250 KSFR for the electronic readout, part of which will also be used for the RICH detector (see below); three of the four CCD exist already;

the cost of the fourth one, and of a set of interfaces etc. will be of the order of $ 60 K. Additional manpower support is expected from the EF Division (3 technicians) for the installation of the hardware as well as some help by the instrumentation group in handling of the optics for the readout.

We have checked that the measurement accuracy of the Downstream Chamber is sufficient for two-pion-correlation studies. Fig. 5 shows the invariant momentum correlation function in S + Au as function of the momentum difference of simulated events before and after folding in the measurement resolution. The input parameters are retrieved to within 10%.

As to the planned measurement of the particle ionization in the region of the relativistic rise we base our goals on the experience of the group from the MPI in München [11] as well as on the results of the ionization measurements of WA44. Assuming ionization differences as shown in Fig. 6 [12] ionization ratios (relative to minmum ionizing particles) of 1.48/1.3/1.2 for pions, kaons and protons, respectively, can be expected at a laboratory momentum of 20 GeV/c. With an expected measurement resolution of 7% and the ratio of particle abundance 5/1/1 (π^+, K^+, p) at 20 GeV/c it will be possible to separate pions from protons and kaons on a statistical basis or, alternatively, obtain K^+/p particle samples which contain a contamination in the order of 25% pions only.

B. NA 35 RICH DETECTORS

The proposed detectors are designed to identify particles close to the c.m. rapidities emitted in heavy ion collisions i.e. ^{32}S + Au. On the positive side π^+, K^+ p, d, t, α, can be identified, while on the negative side π^-, K^- and $\bar{p}$ can be identified in the momentum range 1.2 to 4 GeV/c. The schematic view of the position of the RICH detector is shown in Fig. 7. The detector is placed 4 meters from the target position well beyond the vertex magnet, centered vertically, in the median plane of the vertex magnet and at 22.5° from the beam line. The area of the detectors is 1 x 1 m^2.

Under the described conditions the fraction of kaons and protons produced in central S + Au collisions according to the Fritiof model accepted by the RICH counter are shown in fig. 8 . Taking the acceptances shown the Fritiof simulation results in: 34 particles on the average falling on the whole RICH detector per event. The breakdown by species is given in Table I. The first line shows the number of particles produced in all phase space, the second particles of each species accepted by the RICH. The third row takes into account the limits of identification (p $\leq$ 4 GeV/c for π/K, and p $\leq$ 6.5 GeV/c for K/p identification).

TABLE I

Species	π^+	K^+	p	π^-	K^-	$\bar{p}$
Total/Event	223	22	65	239	16	8.6
Accepted/Event	27.6	2.4	6.	28.5	2	.8 1
Identified/Event	25	2.06	5.6	26	1.7	.6

Principle

RADIATOR

The designed RICH counter is using a liquid Freon radiator where the light is focussed using a spherical mirror following the designed proposed and tested by Giomataris and Charpak (Cosmic Ray Conference, Moscow 1987 and I. Giomataris, W. Dominik, A. Gougas, G. Charpak to be published). The principle is shown in fig. 9. The results of this design tested at the P.S. in May 88 are reproduced in fig. 10.

Since the optical properties of a spherical mirror is that the circular patterns for normal incidence at any point in the radiator are all centered on the optical axis, the particle identification capability is limited by the multiple hit probability, that is by the granularity of the mirrors. We have therefore designed the RICH detector as an array of hexagonally shaped spherical mirrors closely packed on a planar support structure so that the focal planes of all mirrors define a common plane at the position of the conversion layer of the detector. The multiple hit probability distribution for central S + Au collisions is shown in fig. 11.

The main parameters of the design are the following:
Radius of curvature of the mirrors: 18 cm
Length of the hexagon : 6.5 cm
Liquid Freon layer thickness: 6.48 cm
Quartz window: 0.5 cm

Our simulation agrees with the experimental results of Giomataris et al. i.e. that on rings of diameter ~ 11 cm 35 photoelectrons are recorded per event after conversion in TMAE. The π/K/p separation at 2.5 GeV/c, 4 GeV/c and 7 GeV/c is shown for the mean radii in fig. 12 for normal incidence. The patterns generated by an event simulated by the FRITIOF code is shown in fig. 13. Fig. 13a shows the patterns before reaching the conversion volume (after quartz). Fig. 13b shows the phototelectrons produced in the conversion layer.

DETECTOR

The detector is a multistep avalanche chamber with optical readout (J. Giomataris, A. Gougas, W. Dominik, G. Charpak) operating with a 97% He, 3% C_2H_6 + TMAE (45°C) at atmospheric pressure. The avalanche results in light spots of 3.0 mm FWHM and a spatial resolution of 220 µm. The particles also ionize the gas in the conversion volume resulting in spots with 5 p. e. on the average. This spot marking the impact point of the particle in the detector is useful for tracking purposes.

MASS IDENTIFICATION

The rings observed in the RICH detector will be matched to the corresponding tracks recorded in the vertex streamer chamber giving thus as input to the mass identification both the momentum and direction of the particle.

The construction of the 1 x 1m RICH is a two phase project. In the first phase a detector of dimensions of 40 x 50 cm would be tested in conjunction with a radiator containing 4 mirrors. This prototype will be ready in Spring 89 and tested in May at the P.S. providing successful tests the full blown module would be put into construction right away allowing tests to be made in Spring 1990 at the S.P.S. in hadron run, and later use in the ^{32}S running period. The construction tasks are divided among groups from Athens, Bari, CERN (Charpak Group), Darmstadt, Frankfurt, Freiburg and Zagreb

C. The digital picture processing

The picture recording for both the Downstream Chamber and the RICH Detector will be done with CCD-cameras. The analog content of each pixel is converted into 8 bits digital information, passed through pipeline processors for online filtering and data compression, and subsequently written onto optical disks (see Fig. 14)

The offline digitizing of the Vertex Chamber pictures has become a routine operation within NA35. The current storage medium for the digital data are Streamer Tapes; they will be replaced by optical disks too. Thus, the picture processing of both Streamer Chambers can be performed using a single analysis system.

Up to now track measurement procedures depend heavily on operator assistance. In view of the needs for higher statistics in the Vertex Chamber analysis and the advent of the Downstream Chamber pictures with straight tracks only, we plan to increase the computing power of the picture analysis system by the installation of a CONVEX or HARRIS HX9 computer. Its configuration is shown in Fig. 15. The main processor is connected via Ethernet to the existing combination of µ-VAX and measuring stations. Its picture processing capabilities are complemented by dedicated devices: a set of DATACUBE modules for fast filtering and data reduction, which serve at the same time the CCD camera for film digitization and an ASP (Associative String Processor [13]) for fast track recognition. The latter is a state of the art multiprocessor system the development of which is currently supported at CERN in the framework of the LAA project. The track recognition procedures to be implemented on this device are well known from earlier work which was done by means of standard general purpose computers [14]. With the envisaged upgrade of the data acquisition hardware we will speed up our picture analysis by about a factor of 10.

This will be relatively simple for the pictures of the Downstream Chamber, which contain straight tracks only. After a debug period of several months we expect to process one event as seeen by the Downstream Chamber in a few minutes without any operator intervention. Then, measuring rates of several ten thousands per year will be possible. Improvements in the track recognition algorithms for the Vertex Chamber will increase the measuring rate for the corresponding pictures, although to a smaller degree, leading to several thousand events measured per year. This upgrade of the picture processing procedures is part of the ongoing effort to develop a fully automatic data acquisistion for the proposed RICH detector and especially its optical readout. For the whole program the Collaboration has forseen investments of 800 KDM and 8 man years of hard- and software effort. We expect the system to be operating by the middle of 1990.

References

1. A. Bamberger et al., Phys. Lett. B184 (1987) 271.
2. A. Bamberger et al., Phys. Lett. B205 (1988) 583.
3. H. Ströbele et al., Z. Phys. C38 (1988) 89.
4. A. Bamberger et al., Phys. Lett. B203 (1988) 320.
5. T. Humanic et al., Z. Phys. C38 (1988) 79.
6. W. Heck et al., Z. Phys. C38 (1988) 19.
7. B. Andersson and W. Hofmann, Phys. Lett. B169 (1986) 364.
8. K.S. Lee and U. Heinz, Univ. Regensburg preprint TPR 88-16 (1988).
9. R. Albrecht et al., Phys. Lett. B201 (1988) 390.
10. A. Bialas and R. Peschanski, Nucl. Phys. B273 (1986) 703.
11. V. Eckardt et al., Nucl. Instr. Meth. 143 (1977) 235.
12. I. Lehraus et al., IEEE Trans. Nucl. Sci. NS/30, 50 (1983); and NIM 200 (1982) 199.
13. ASPEX Microsystems technical report, R.M. Lea et al., Brunel Univ. 1987.
14. F. Pühlhofer et al., Nucl. Instr. Meth. A263 (1988) 360.

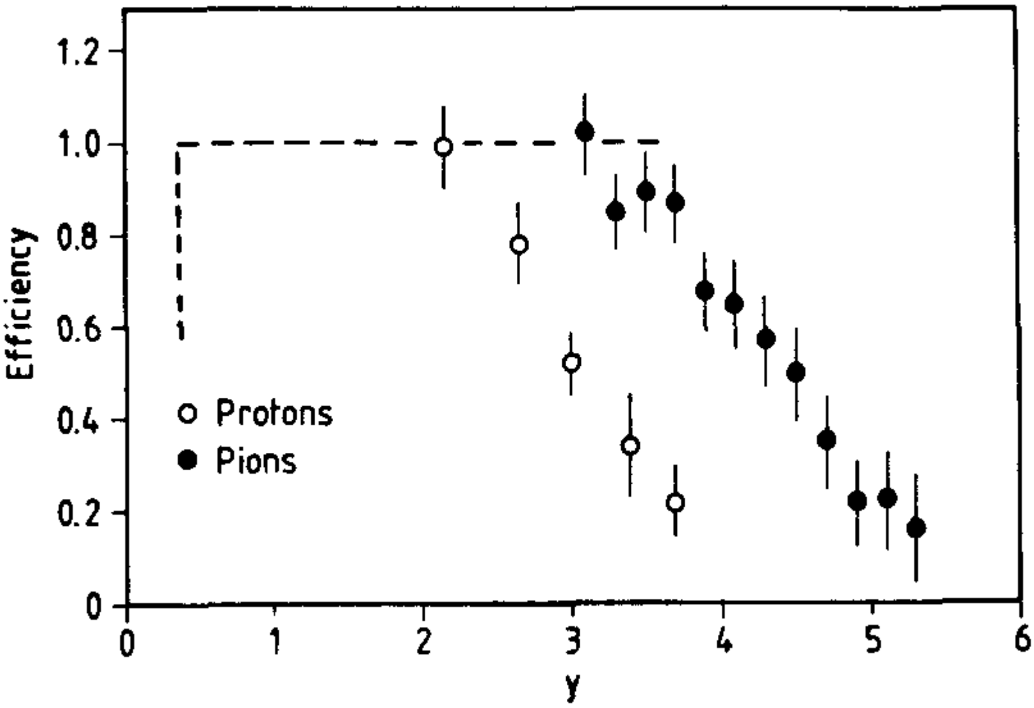


Fig. 1 Track reconstruction efficiency of the Vertex Chamber in S + S central collisions at 200 GeV/nucl., as a function of rapidity.

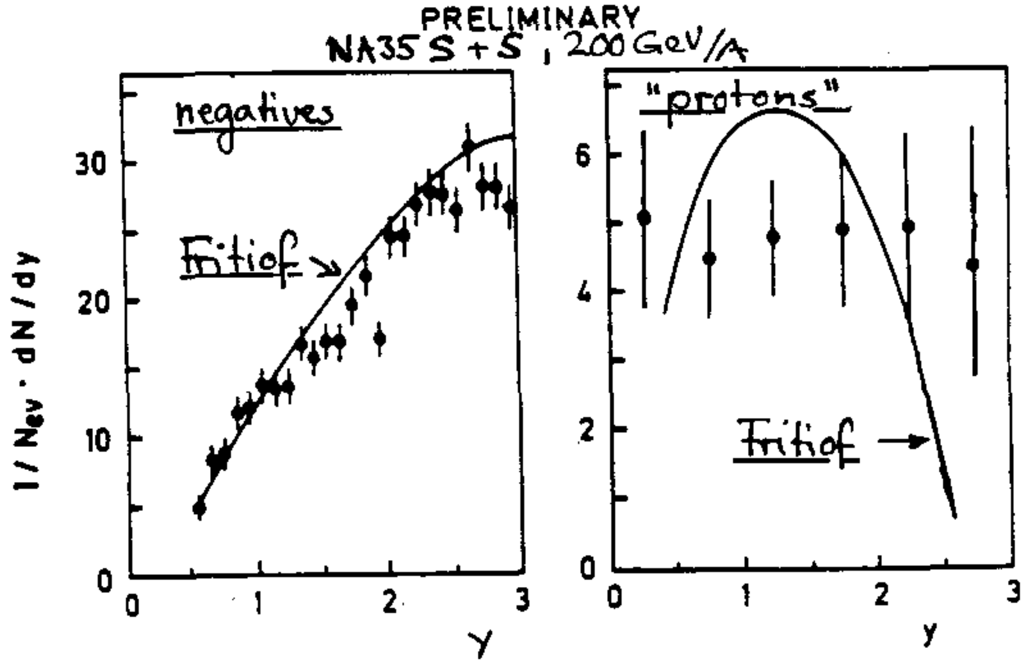


Fig. 2 Rapidity distributions in S + S central collisions, comparing negatively charged particles (left) and "protons" (right) to the corresponding Fritiof model predictions.

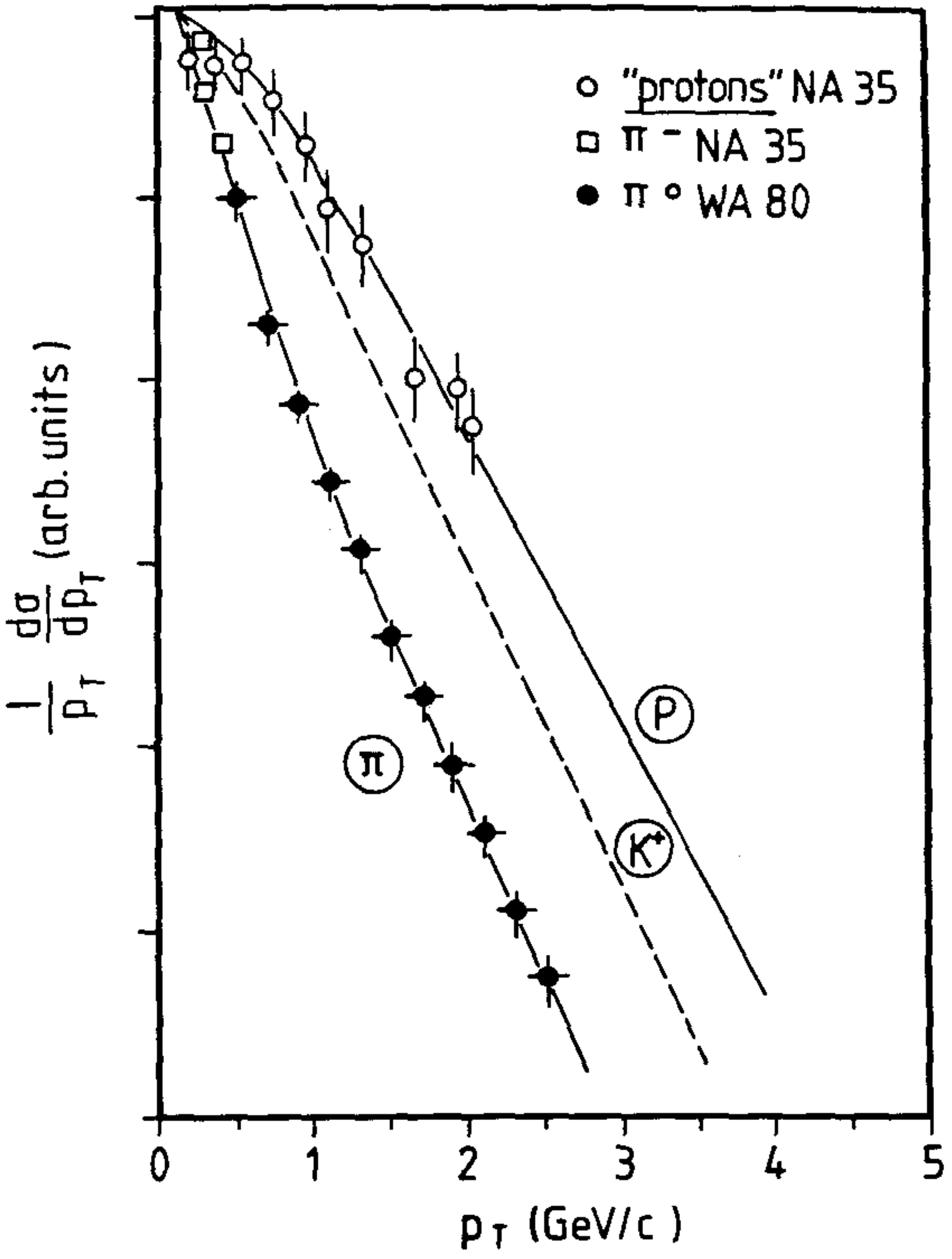


Fig. 3 Transverse momentum distributions of pions and protons compared to predictions of the isentropic expansion model of Lee and Heinz [8].

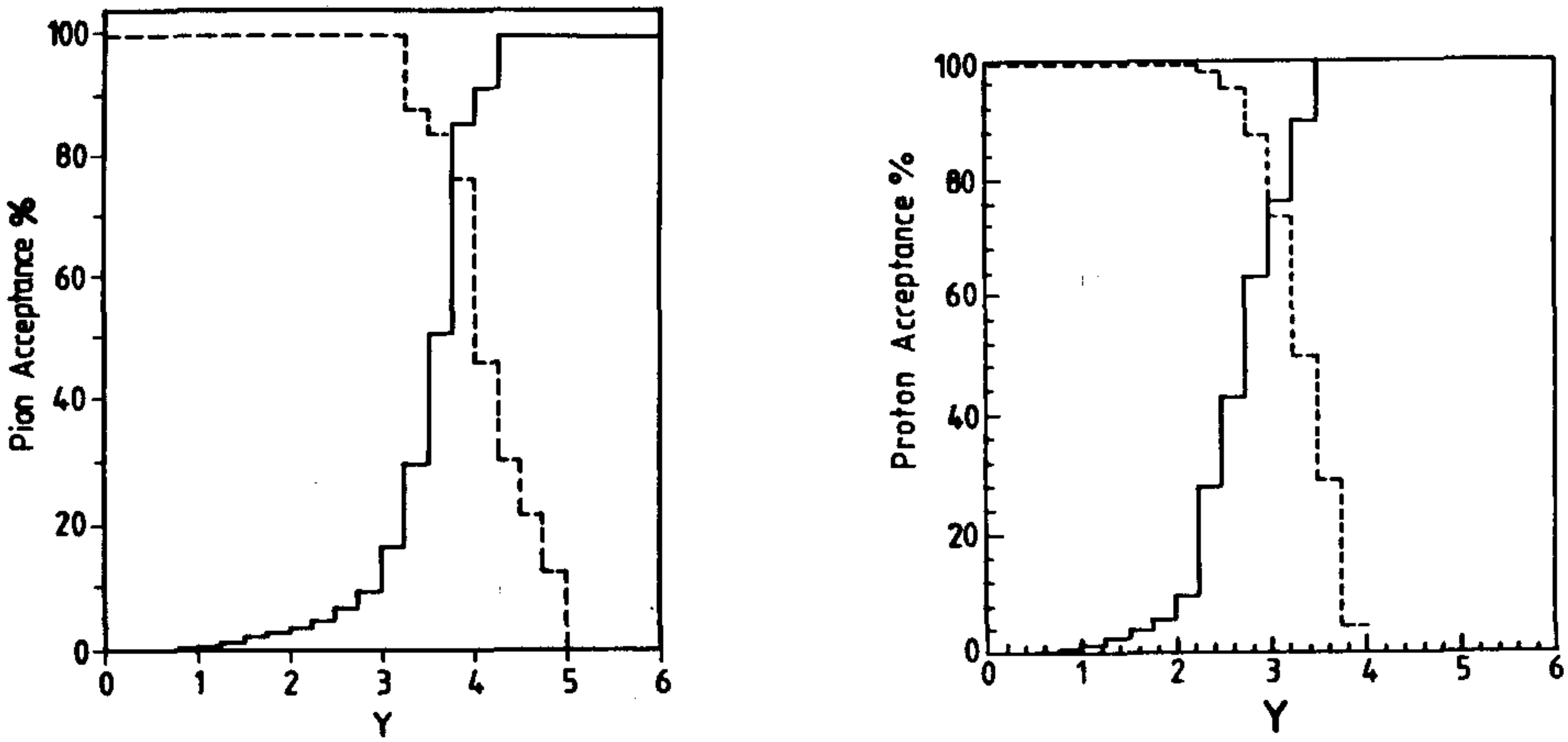


Fig. 4 Pion and proton acceptances of the Vertex and Downstream Chamber, the latter placed 6 m from the target. A cone of $\theta < 6°$ has been assumed to be inaccessible in the former chamber (too high track density).

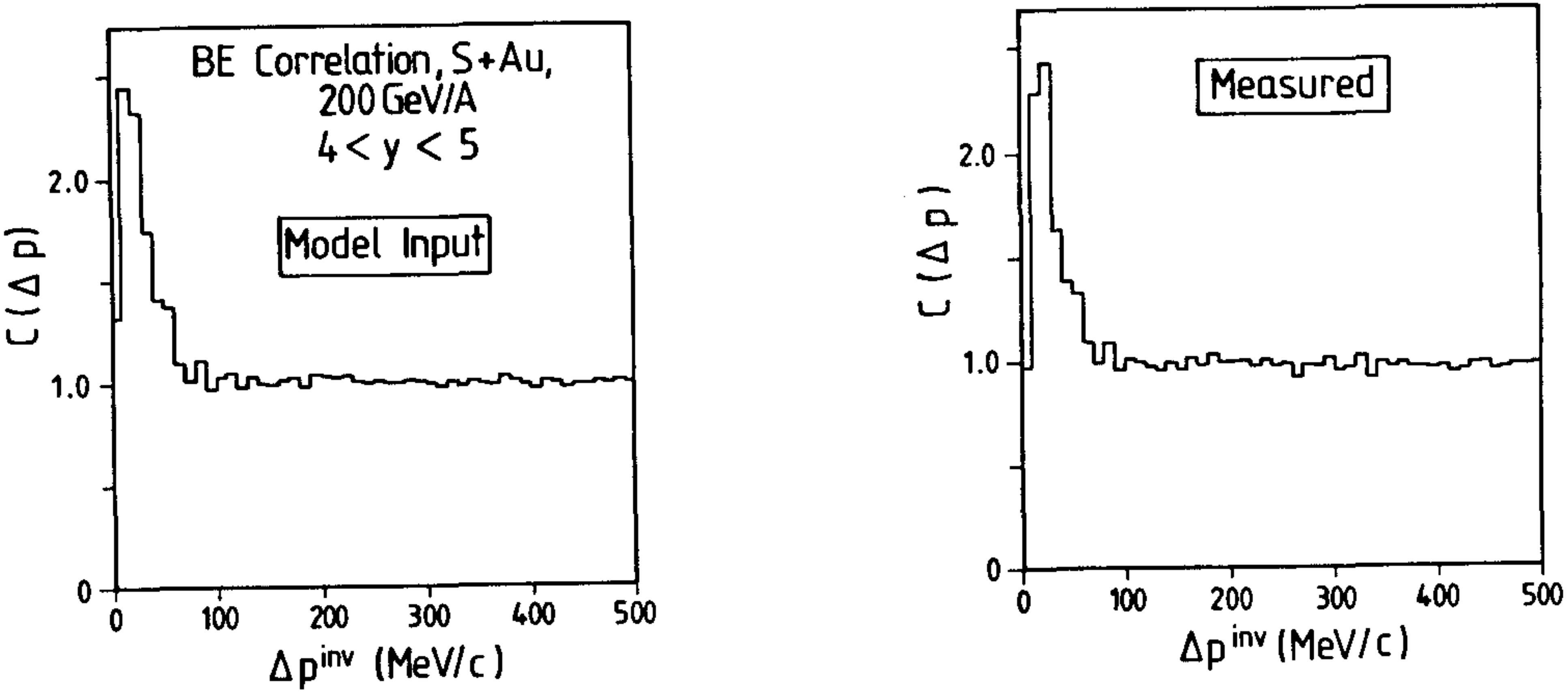


Fig. 5 Effect of the momentum resolution in the Downstream Chamber on the Bose-Einstein two-pion correlation in S + Au at 200 GeV/nucl., $4 < y < 5$, as generated by a MC model.

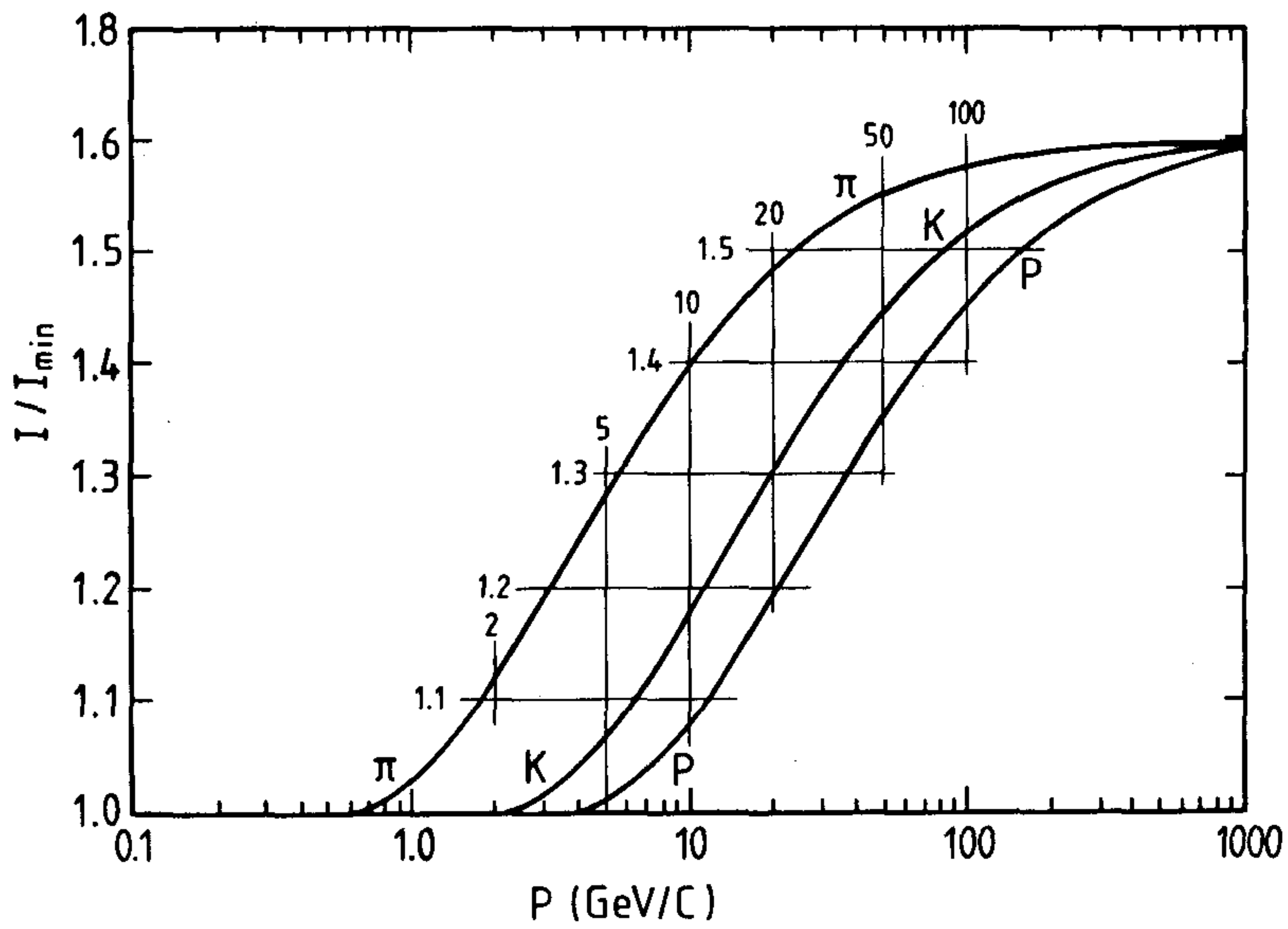


Fig. 6 Ionization of π, K, p in the relativistic rise domain, based on measured data [11, 12] for a 70% Ne, 30% He Stream Chamber gas mixture.

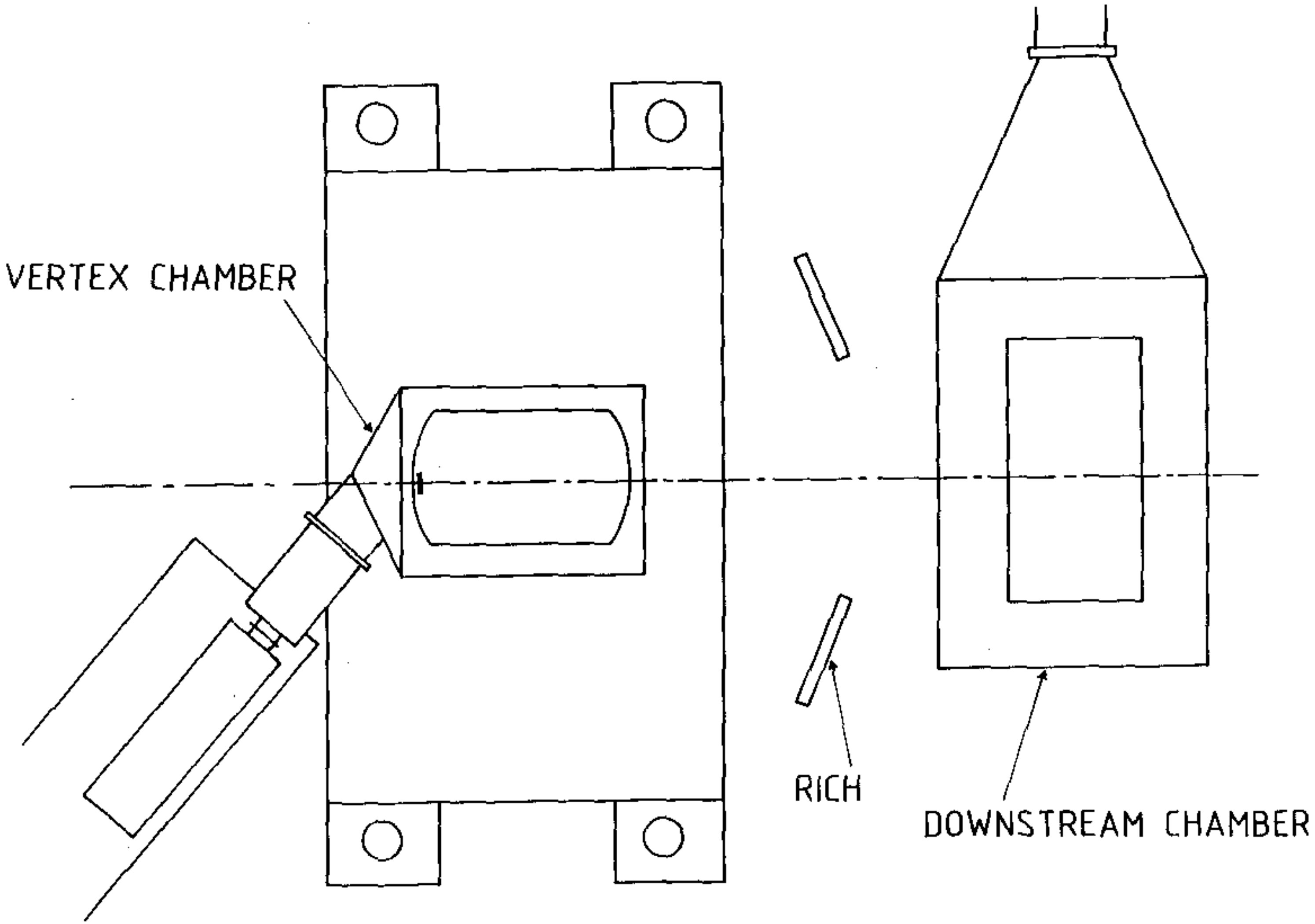
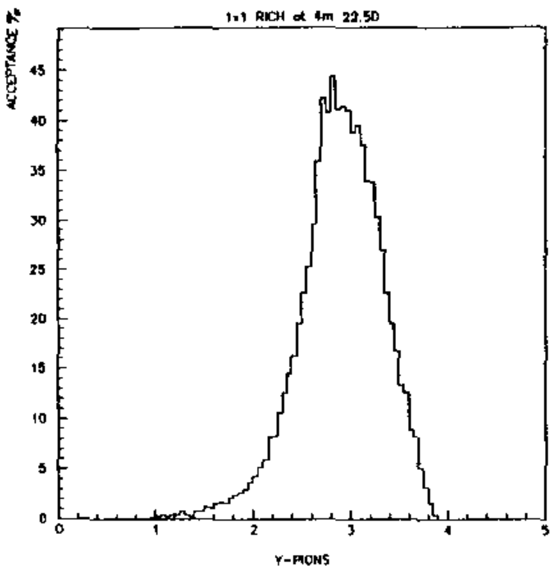
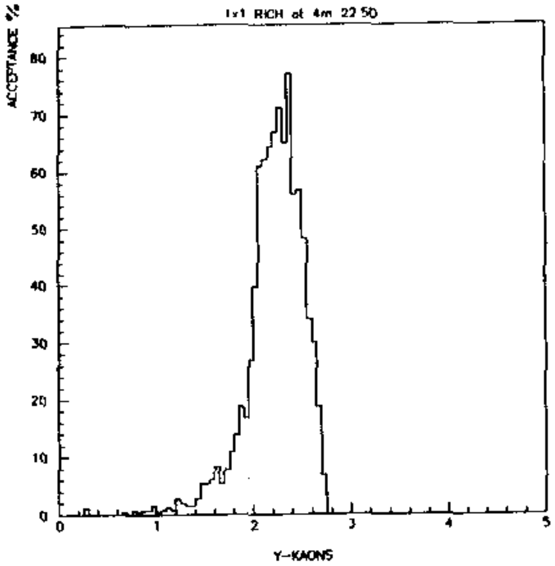


Fig. 7 Schematic view of the RICH detector positions.





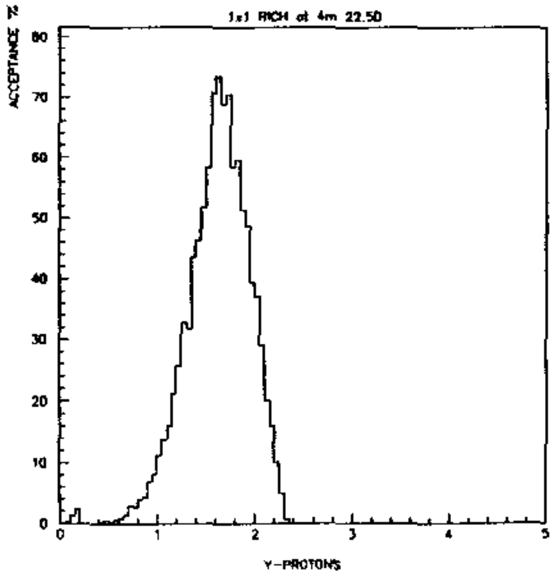


Fig. 8 Acceptances for π, K, p of a 1 m^2 RICH placed at 4 m distance from target, and at a central lab. angle of 22.5°, outside the field of the Vertex magnet.

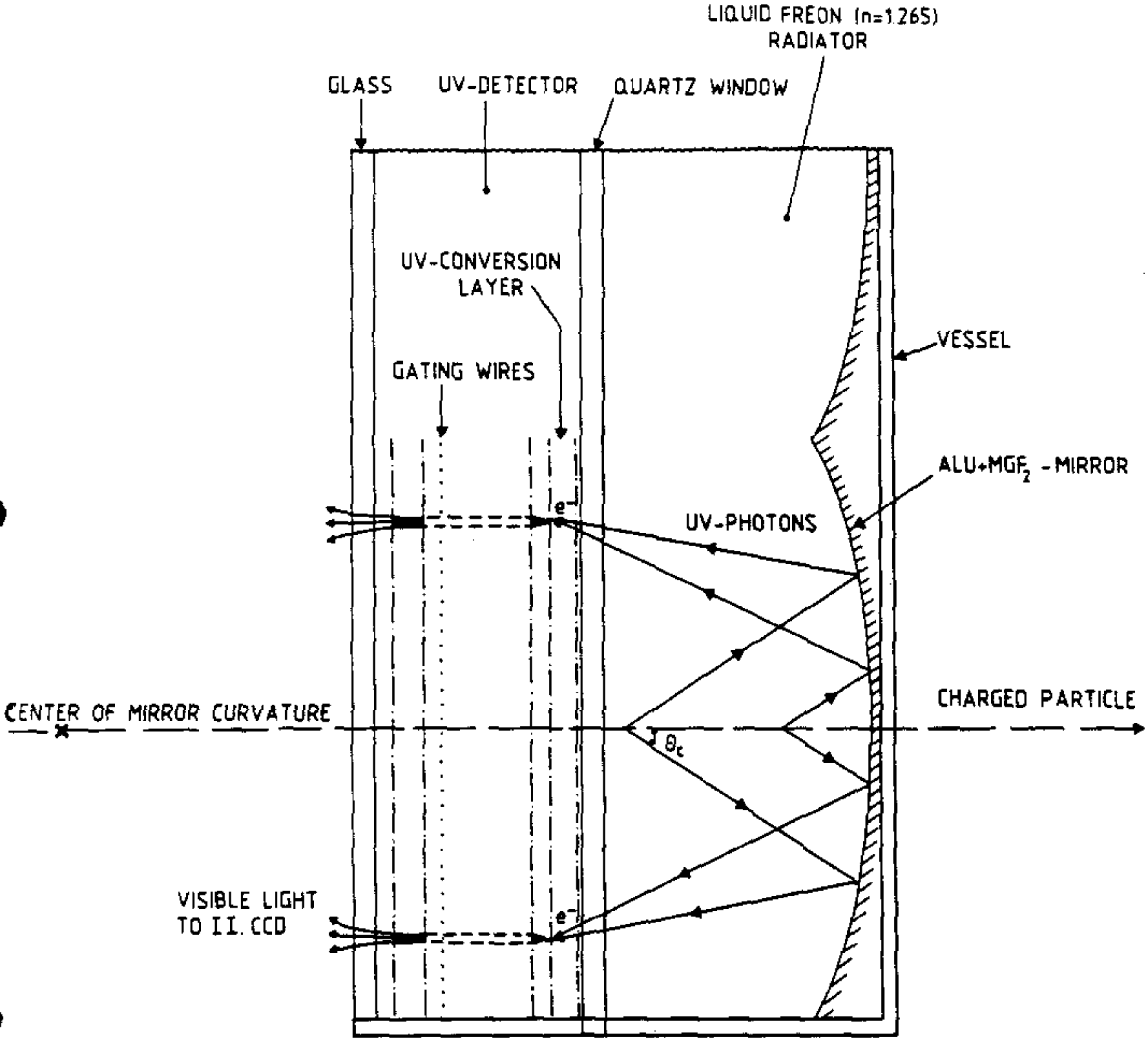


Fig. 9 Focusing scheme and UV detector of the RICH.

Fig. 10 Results of a 13 cm spherical mirror single RICH cell from PS tests with 9 GeV electrons (Giomataris et al.).

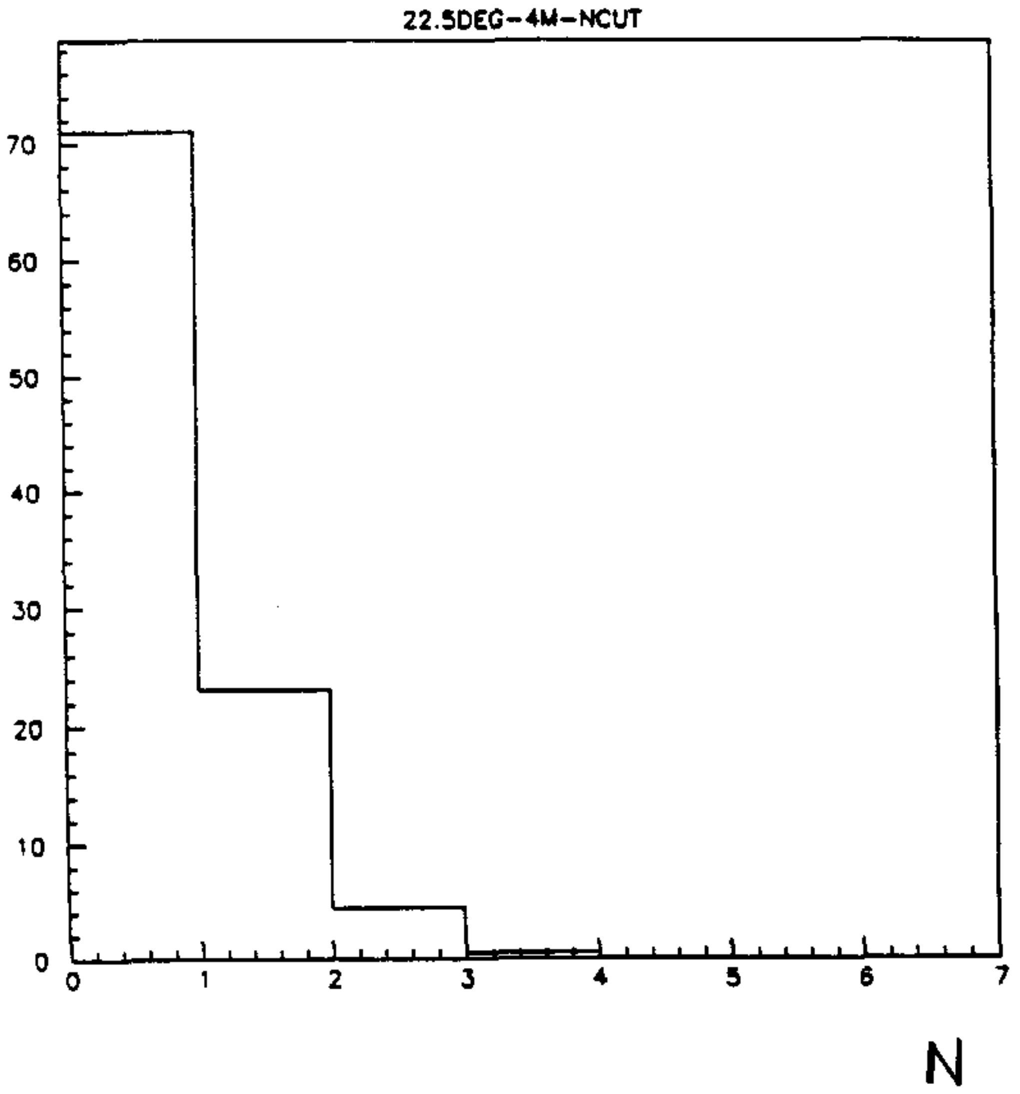
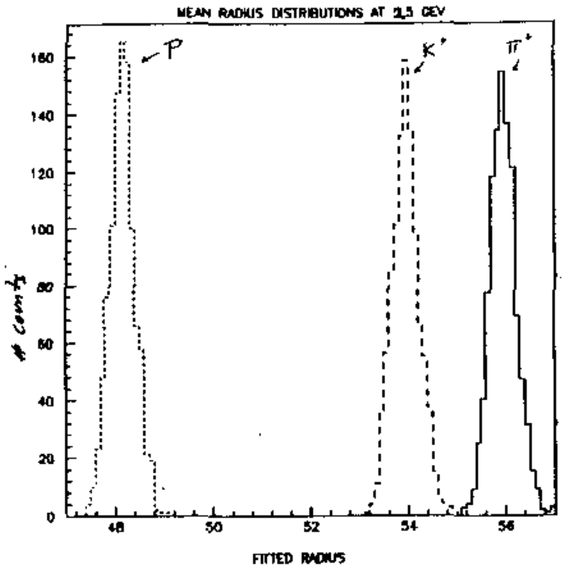
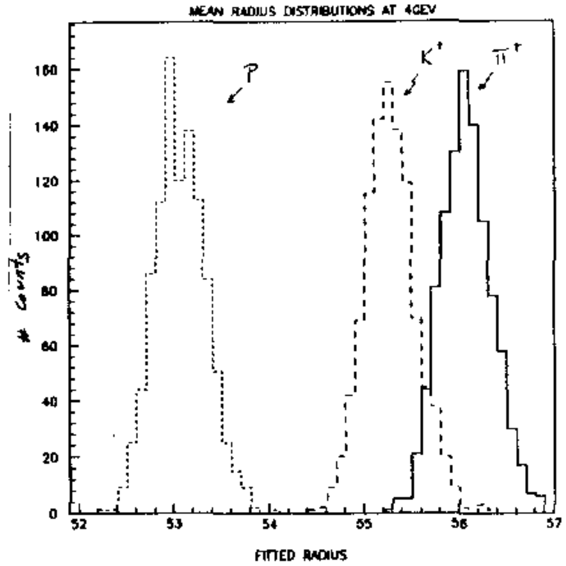


Fig. 11 Multiplicity distribution from Fritiof simulation, S + Au central 200 GeV/nucl., of particles per single RICH cell.





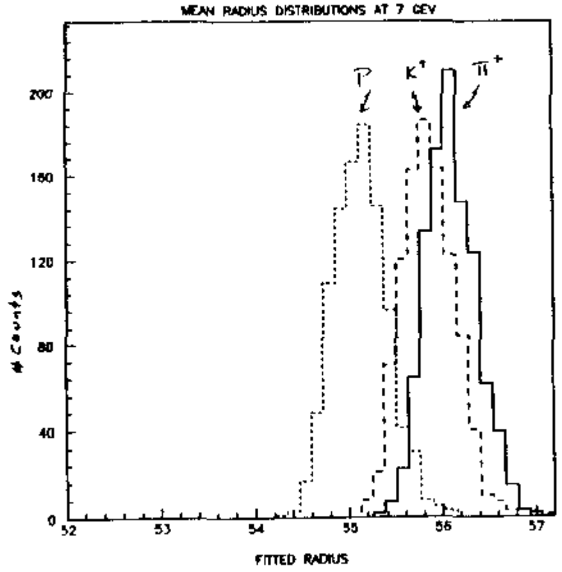


Fig. 12 Monte Carlo simulation of particle separation attained for normal incidence on the RICH, at three different lab. momenta. The effective resolution of imaging and circle-fitting is folded in.

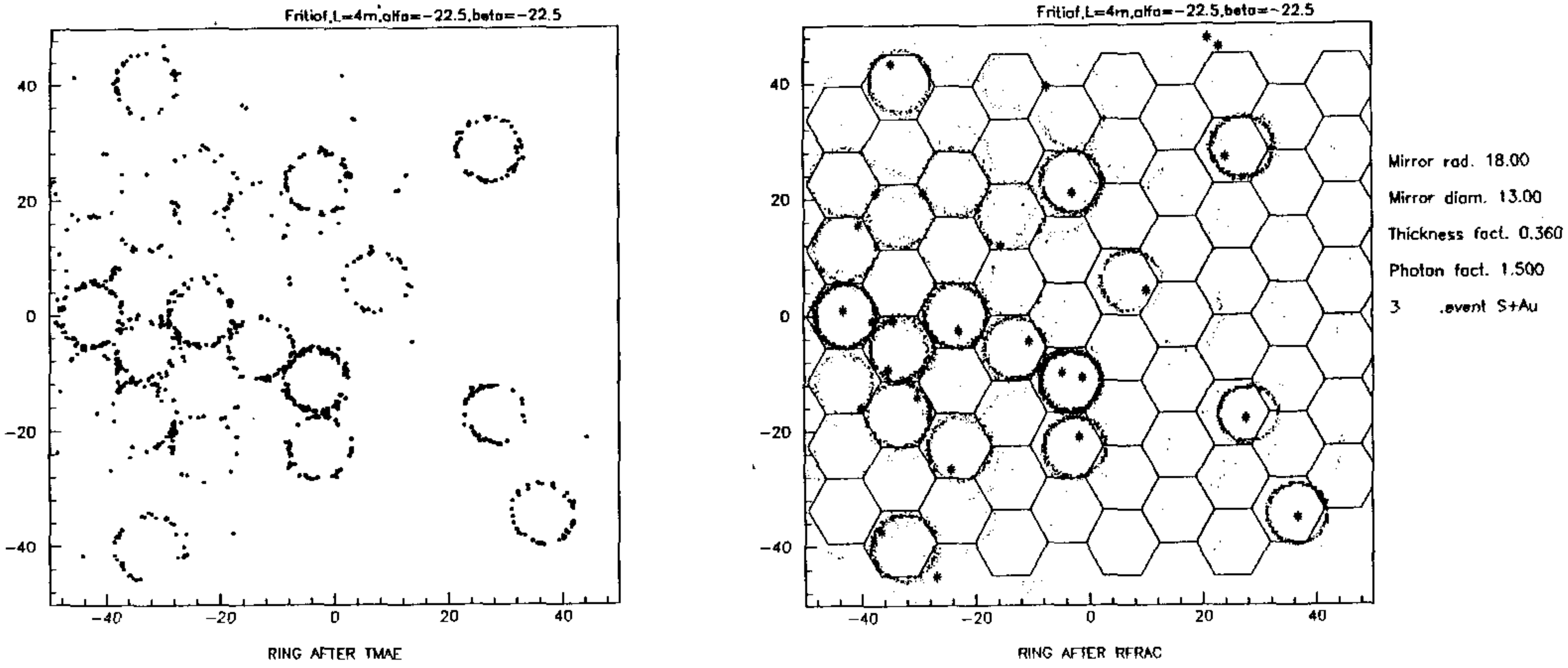
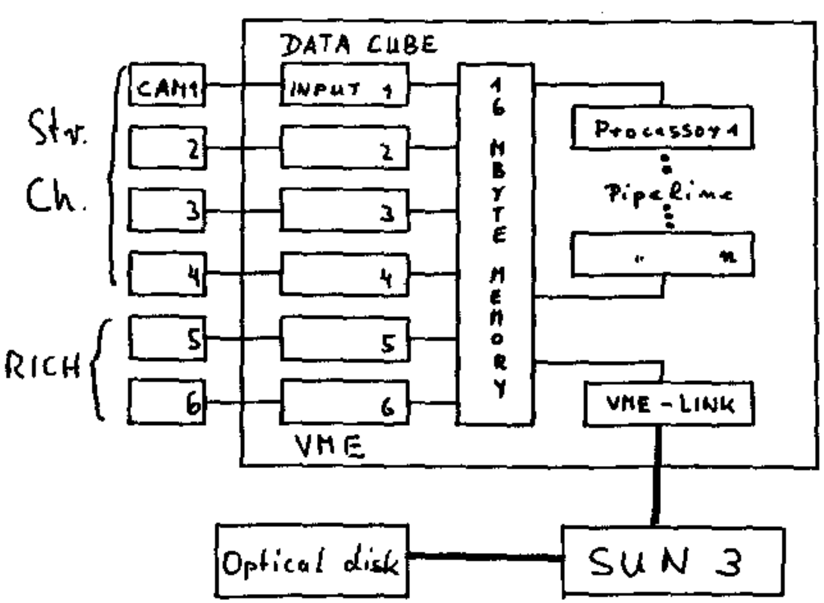


Fig. 13 Photon and photoelectron hit patterns in a 84 element, 1 m^2 surface RICH, before (ri.) and after (left) the TMAE conversion layer, respectively. From MC simulation.



ig. 14 On-line data acquisition outline for the CCD readout, showing 4 CCD's for the Downstream Chamber and two for the RICH detector (1000 x 1000 pix each).

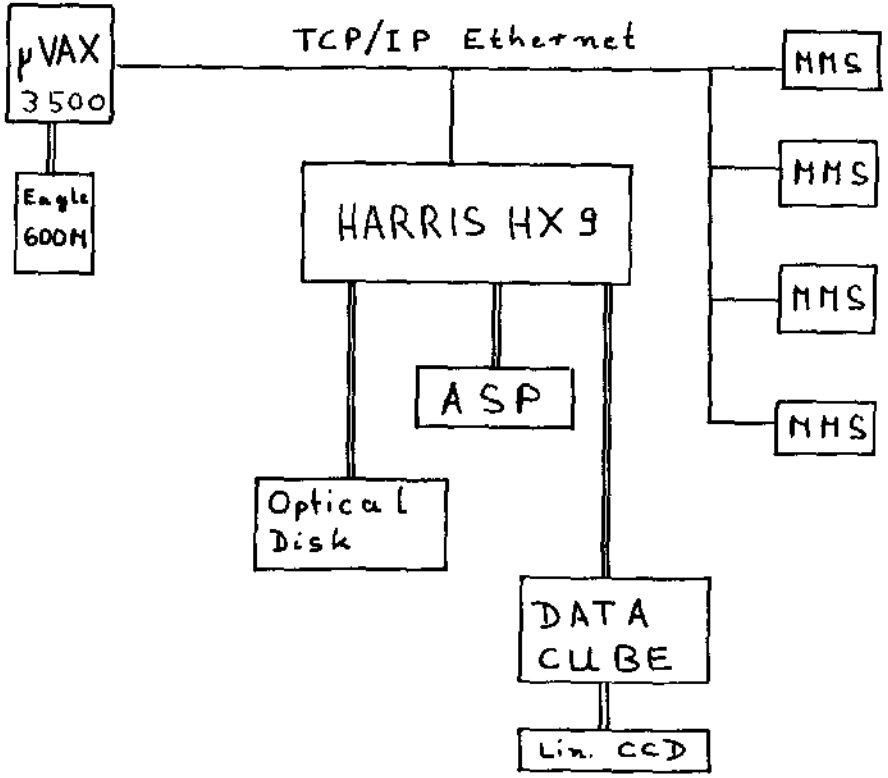


Fig. 15 Hardware configuration for amended fast automatic trac recognition and measurement work station system at

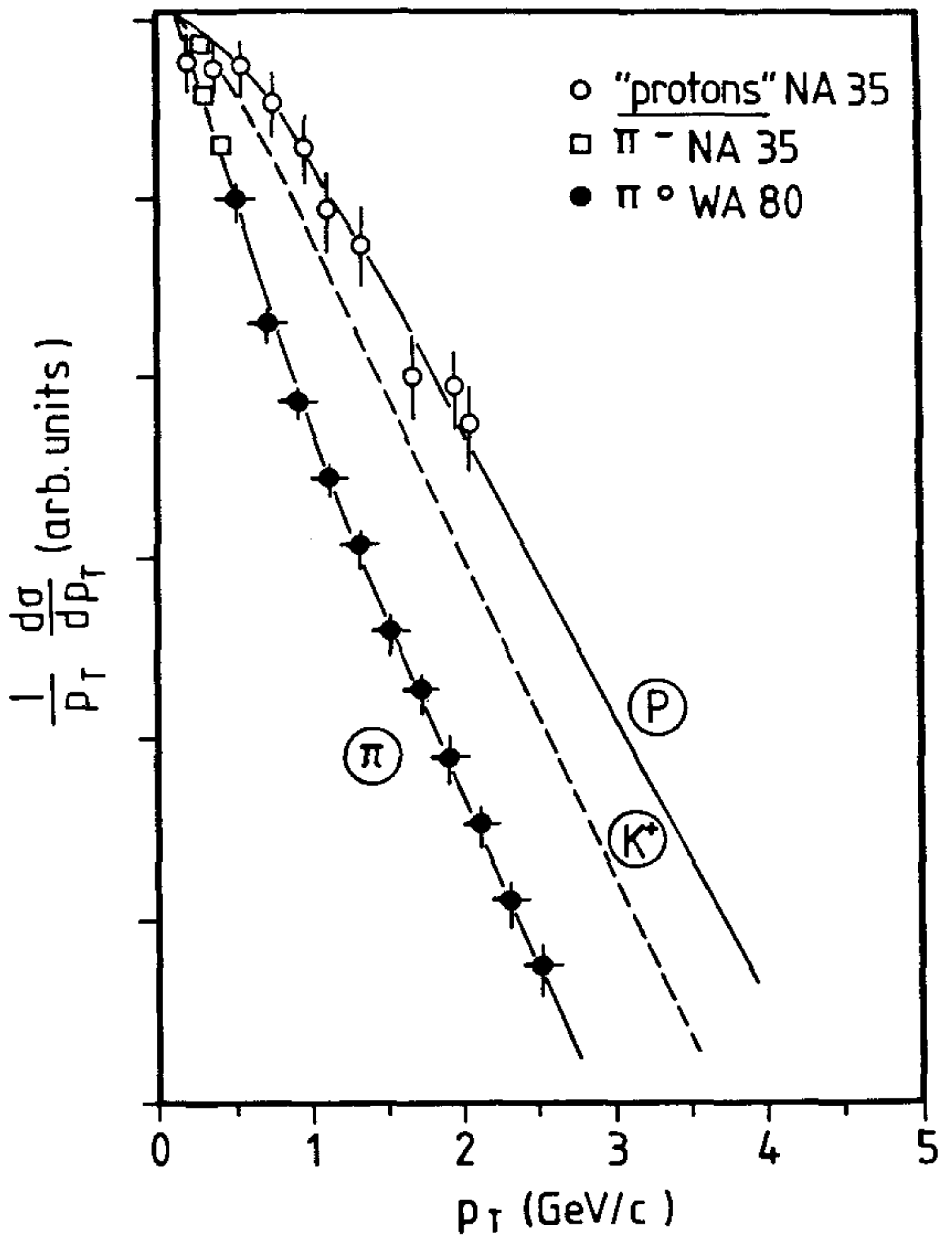


Fig. 3 Transverse momentum distributions of pions and protons compared to predictions of the isentropic expansion model of *Lee and Heinz* [8].

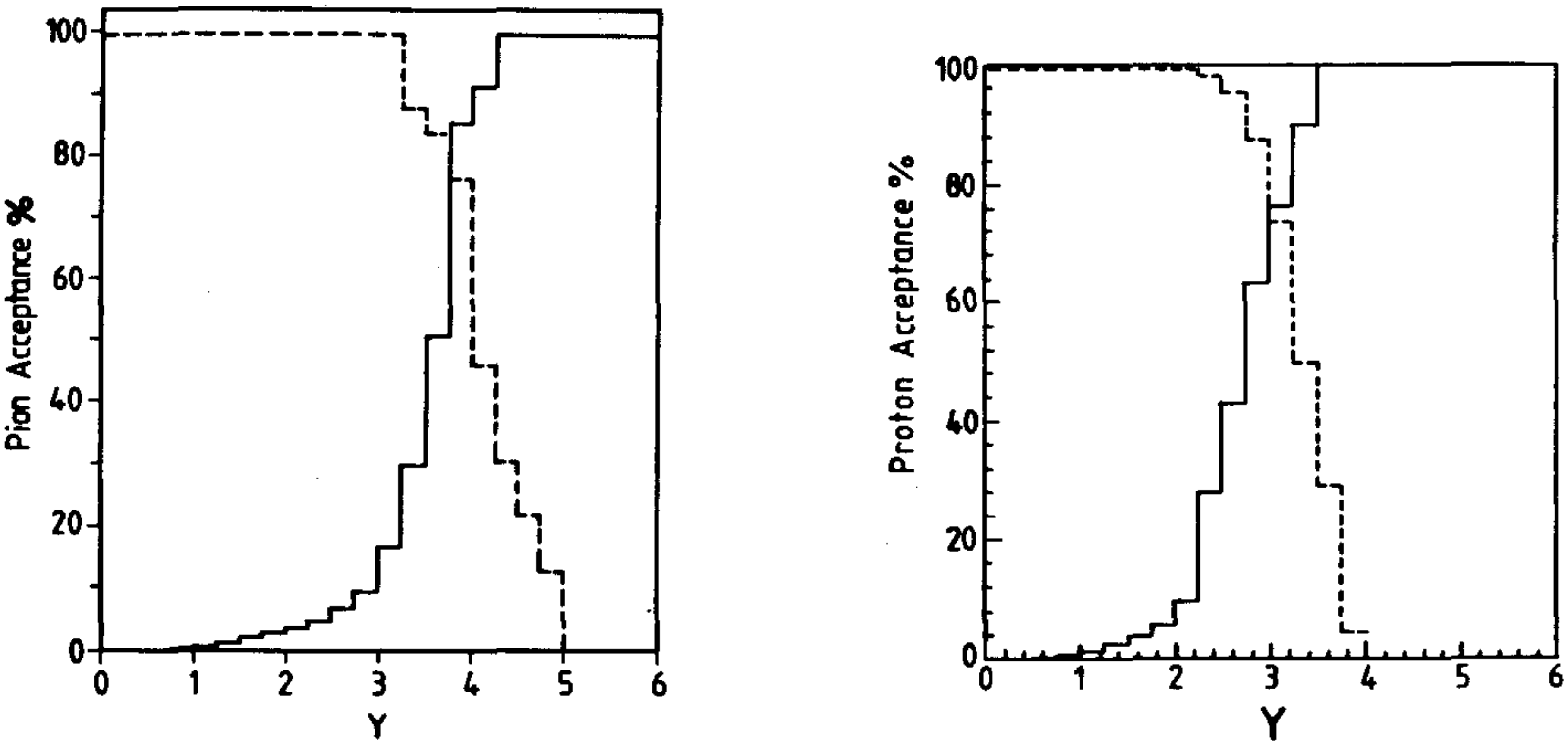


Fig. 4 Pion and proton acceptances of the Vertex and Downstream Chamber, the latter placed 6 m from the target. A cone of θ < 6° has been assumed to be inaccessible in the former chamber (too high track density).