EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

NP Internal Report 75-8
13 August 1975

THE SPS EXPERIMENTAL PROGRAMME

J.V. Allaby

G E N E V A

1975

CONTENTS

1. INTRODUCTION

The SPS is a separated-function synchrotron capable of accelerating protons up to 400 GeV. It will be located about 40 m underground in a tunnel forming a circle of average diameter about 2.2 km. The protons will be guided in their circular path by about 750 dipole magnets each over 6 m long and contained in the small vacuum chamber by a system of about 220 quadrupoles regularly spaced around the ring.

The protons, after acceleration, will be ejected by one of two independent ejection systems and will pass to one of the experimental areas, called WEST and NORTH areas, respectively.

Figure 1 shows a schematic layout of the accelerator and its experimental areas. The principal use of the high-energy protons is to create secondary beams, i.e. beams of particles of various types produced by the interaction of the protons with external targets. The secondary beams are then used for experiments.

As can be seen in Fig. 1, a total of eight different external targets are planned for the SPS. Targets 1, 3, 5, 7 and 9 produce beams in the West Area, and targets 2, 4 and 6 produce beams in the North Area.

Figure 2 shows a schematic drawing of the complex including the CERN Proton Synchrotron (PS) which is used as injector to the SPS.

2. THE WEST EXPERIMENTAL AREA

The West Area already exists and contains both the 3.5 m liquid hydrogen bubble chamber (BEBC) and the large magnetic spectrometer called Omega, which have been used with beams produced by the 24 GeV protons of the PS. Both of these instruments will be used at the higher energies available from the SPS.

Because of the limited length available, the West Area will be used for secondary beams of momentum $\leq$ 150 GeV/c produced from the interaction of 200 GeV protons, except for the neutrino beams which will be explained later. On the other hand, secondary beams up to the maximum energy of 400 GeV are envisaged for the North Area, which has been designed to accept protons of up to 400 GeV on the targets.

One of the important uses of a big hydrogen bubble chamber such as BEBC is to study neutrino interactions. Hence it was decided to provide a neutrino beam facility in the West Area. There are four principle items necessary for the realization of a neutrino facility. These are:

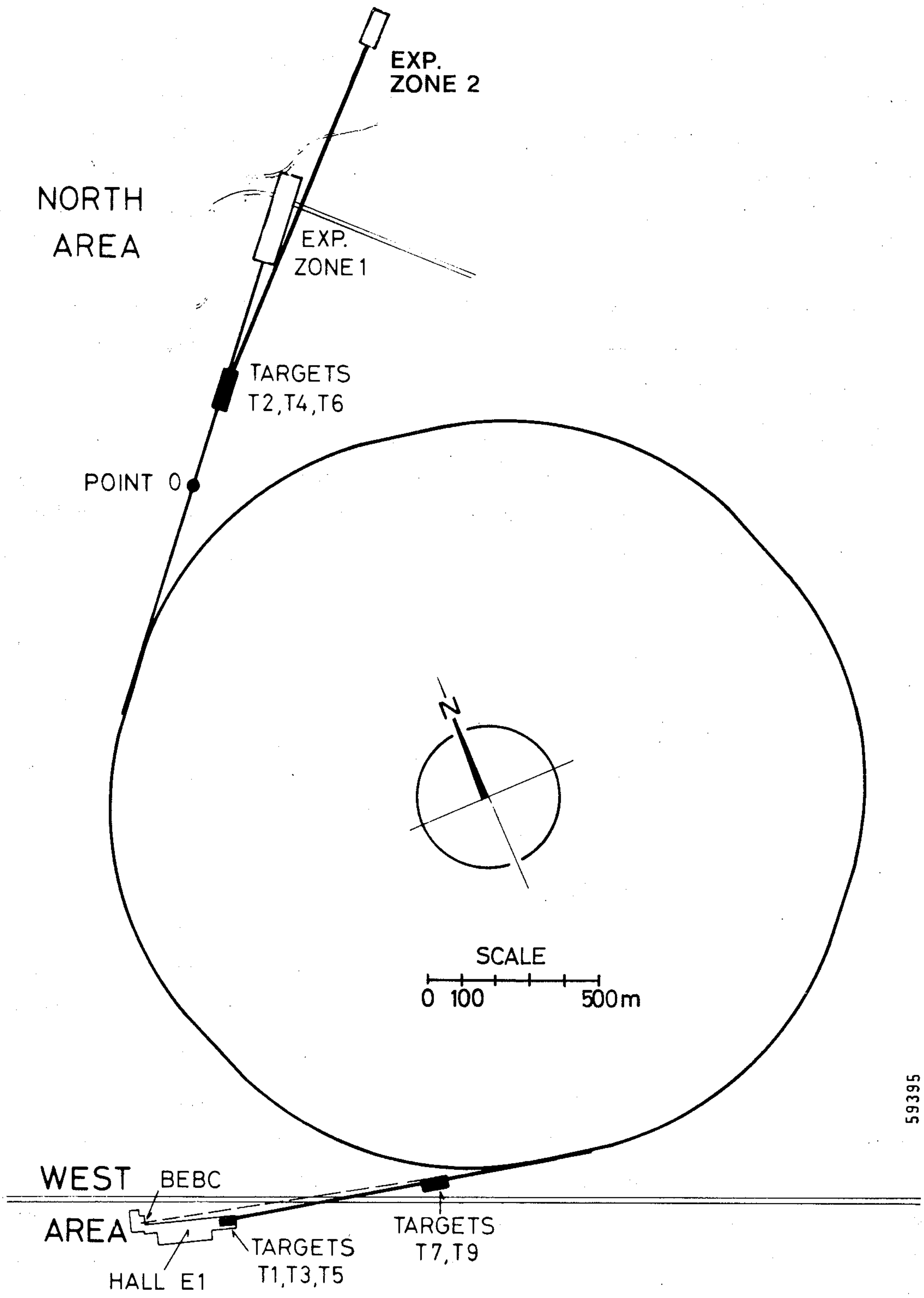


Fig. 1 : Schematic layout of the SPS and its experimental areas

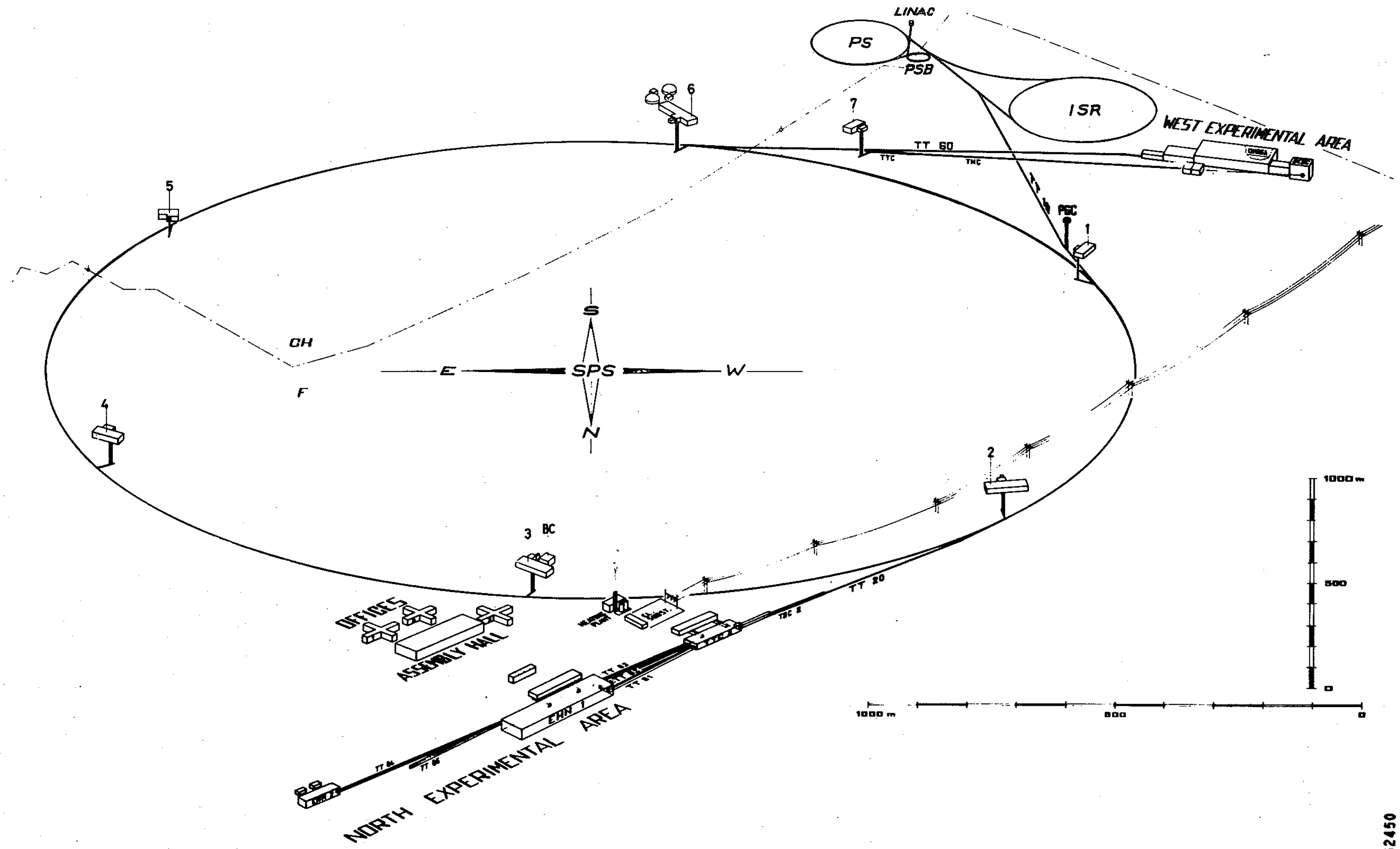


Fig. 2 : Schematic drawing of the SPS accelerator complex including the PS which is used as injector to the SPS

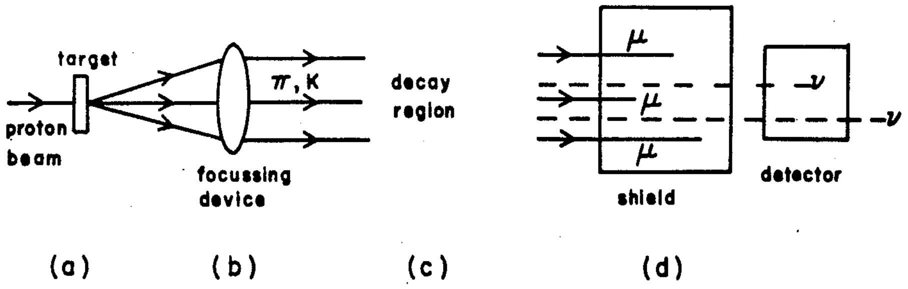
a) A high-intensity, high-energy proton beam incident on a suitable target.

b) A focussing device to focus the hadrons produced in the target into a parallel beam.

c) A long decay tunnel in which π and K mesons can decay and produce neutrinos.

d) A massive shield which absorbs the muons produced in the decay region.

These items are shown schematically below

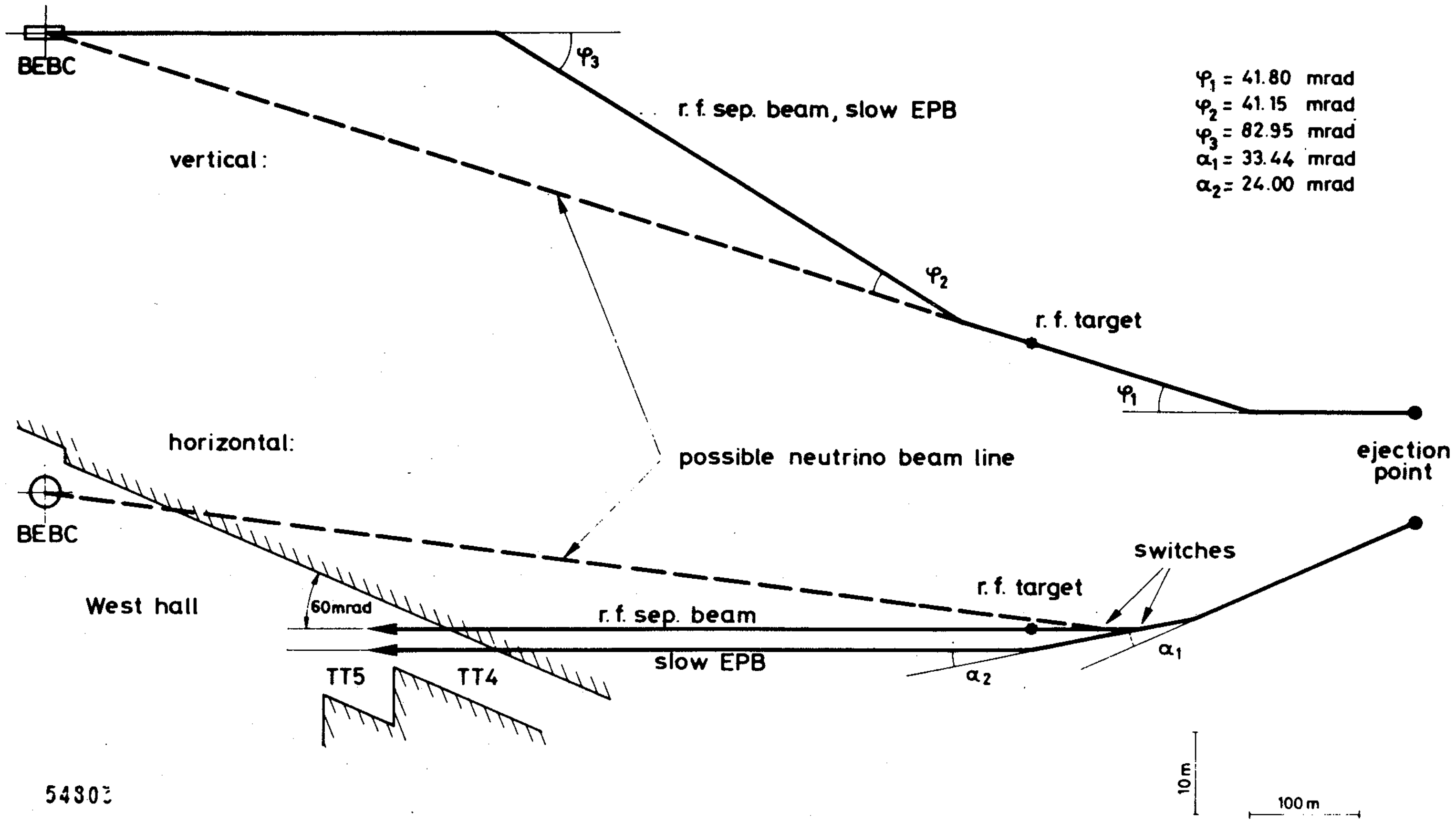


In order to be able to exploit the full energy of the SPS for a neutrino beam it was necessary to locate the target of the neutrino beam underground, as close to the accelerator as possible so that the maximum length is available for the decay region and shield of the neutrino beam. An effective beam at 400 GeV needs about 400 m of decay region and about 400 m of shield, in the case of the SPS this being a combination of steel and earth, in order to stop the muons produced along with the neutrinos by the decay of pions and kaons produced in the target.

Figure 3 shows schematically on a distorted scale how the protons needed to produce the neutrino beam will be directed towards BEBC so that the neutrino beam, which in the wide-band version contains no magnetic deflection of the parent hadrons, will arrive at BEBC. Also shown in Fig. 3 is the RF separated beam for BEBC which has its target in the transfer tunnel so that a 500 m drift space is allowed for the operation of the 6000 MHz RF separator cavities. This beam can produce a pure separated beam of $K^{\pm}$ up to ∿ 75 GeV/c and separated $\bar{p}$ up to about 120 GeV/c. Both the RF separated beam and the slow EPB lines are transported by dipoles and quadrupoles up to the surface and into the West Hall.

Figure 4 shows a true scale drawing of the West Area Neutrino Facility. A decay region of ∿ 430 m length is followed by about 180 m of steel shielding. The beam then passes through earth and the foundations of the West Hall before emerging from the ground about 50 m upstream of BEBC. The beam line has a 4% slope.

In addition to the wide-band neutrino beam, in which the focussing elements are a magnetic horn and reflector to give focussing over a wide momentum band, the West Area Neutrino Facility will be equipped with a <u>dichromatic</u> beam. In



54303

Fig. 3 : Schematic drawing illustrating how the protons needed to produce the neutrino beam will be directed towards BEBC

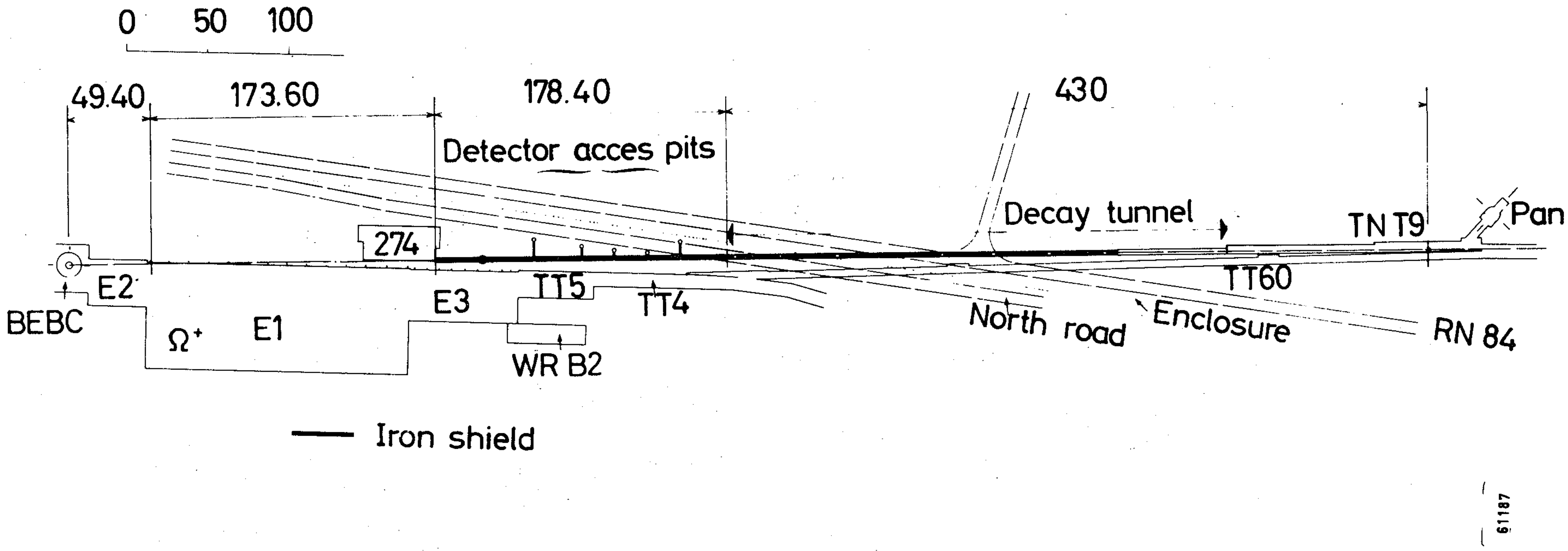


Fig. 4 : Scale drawing of the West Area Neutrino Facility

such a beam the parent hadrons are first momentum analysed and then focussed into a parallel beam using quadrupoles. Since the major decay mode producing neutrinos is the two-body decay into $\mu + \nu$, the knowledge of the parent hadron momentum gives information on the energy of the neutrino when the angle of the neutrino is known.

If a neutrino event from a pencil beam of momentum analysed hadrons is detected at a radial distance r from the beam axis, then the neutrino energy from the two-body decays is known to lie between the limits.

$$k_1 = k_0/(1 + \gamma^2\theta_1^2) \qquad \text{where} \qquad \theta_1 = r/(S + D) \tag{1}$$

and

$$k_2 = k_0/(1 + \gamma^2\theta_2^2) \qquad \text{where} \qquad \theta_2 = r/S \tag{2}$$

The parameters k_0 and γ depend on the energy E_0 and mass m of the decaying hadron through the relations:

$$k_0 = E_0(1 - m_\mu{}^2/m^2) \ ; \quad \gamma = E_0/m \tag{3}$$

Figure 5 shows an idealised spectrum of neutrinos obtained from the decay of 275 GeV/c pions and kaons where integration over all events within a radius 0.56 m has been carried out. The two-peak structure of the spectrum occurs because of the two different hadron masses involved (m_K and m_π) and leads to the name dichromatic for such a beam. The effect of shortening the decay length from 300 m to 150 m is shown by the shaded area which represents the neutrinos lost from the spectrum if this is done.

The ejected proton beam will be transported to the surface at the beginning of the West Area and will be used to produce a number of secondary beams for counter physics. Most efficient use of the protons is achieved by splitting the beam into three branches, thus enabling three targets to be illuminated simultaneously. From these three targets, up to five beams are planned as shown in Fig. 6. N1 is the latter half of the neutrino beam already discussed and S3 is the final stage of the RF separated beam to BEBC. From target T5, the beam H3 will be derived which is a hadron beam producing copious fluxes of pions and kaons up to 150 GeV/c. From target T3 the beam E1/H1 is planned which can produce either hadrons or electrons up to ∿ 100 GeV/c. This beam can be sent to the Omega spectrometer if needed. S1 is a special 40 GeV/c beam for the Omega spectrometer which incorporates superconducting RF cavities to allow experiments with very high fluxes of the rarer particles ($K^\pm$, $\bar{p}$). The unused protons which

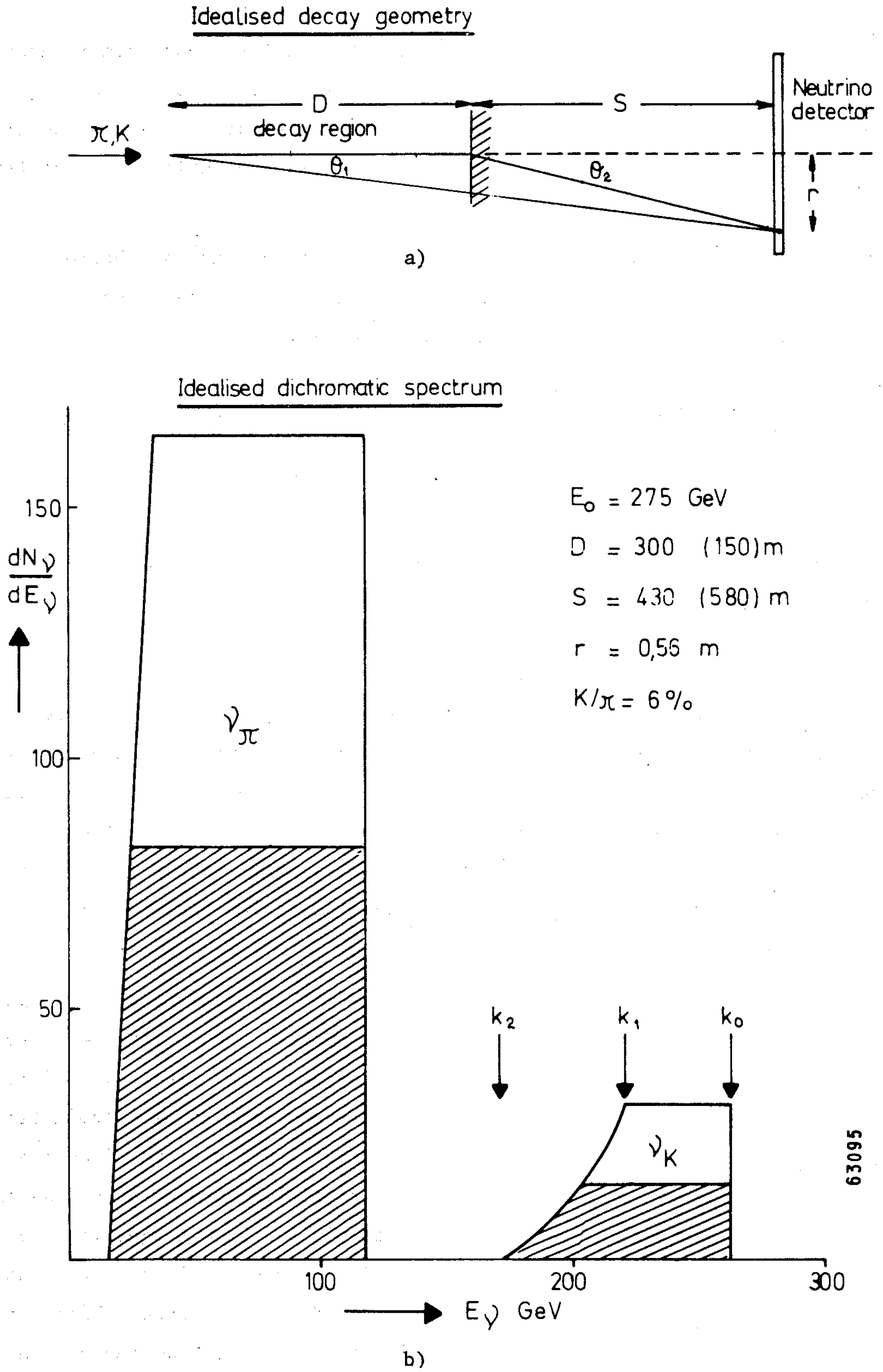


Fig. 5 : a) Idealised decay geometry for a dichromatic neutrino beam

b) Idealised dichromatic spectrum showing the two peaks of neutrinos from π- and K-decay, respectively

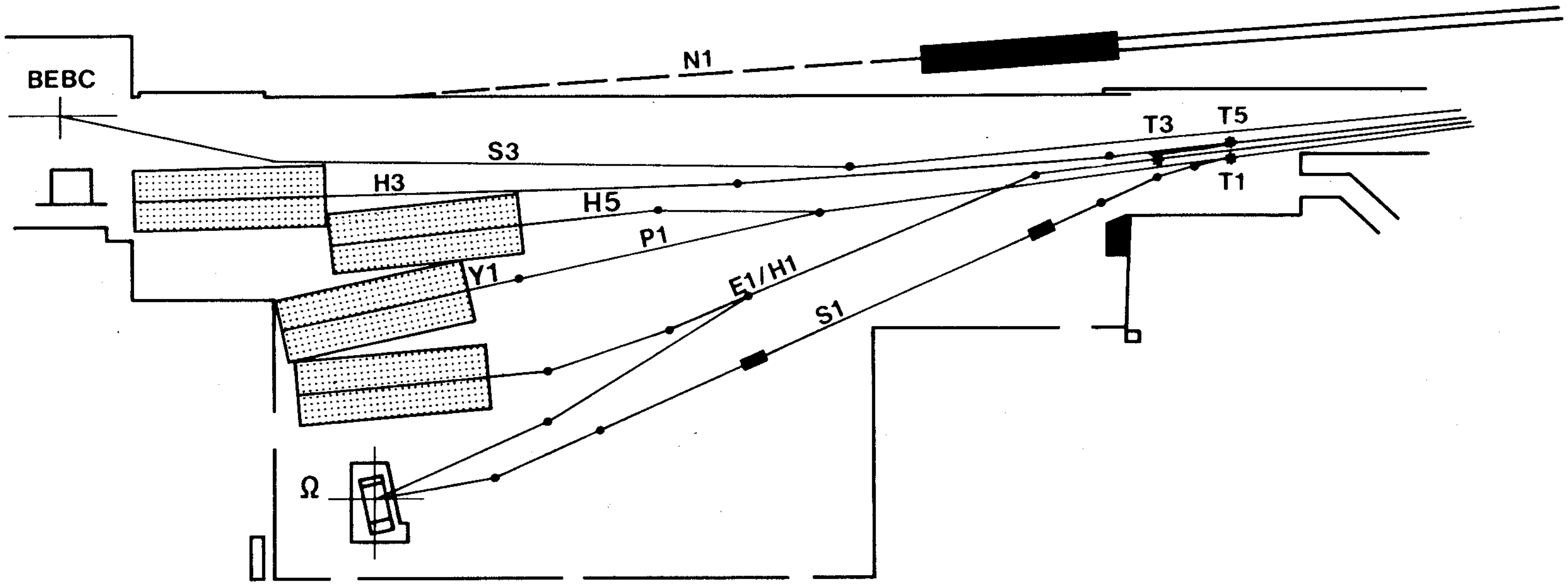


Fig. 6 : Schematic drawing of the West Experimental Area. The vertical scale is twice the horizontal scale to better display the beam lines

pass through the target T1 without interacting will be collected and, after suitable attenuation, will be transported as a proton beam P1 into the main experimental hall to be used to produce special short beams such as hyperon beam Y1. The attenuator will also be the target for a further hadron beam H5 which can operate up to 80 GeV/c. The shaded areas on Fig. 6 give some indication of the space available for experiments. Note that the scale is distorted by a factor of two to illustrate better the beam complex. All the beams in the West Hall itself can operate simultaneously using 200 GeV protons.

3. EXPERIMENTS IN THE WEST AREA

So far, some ten experiments have been approved for the West Area. They are briefly described in the appendix. Each approved experiment receives a code number preceded by WA if it is an experiment operating in the West Area, and by NA if it is a North Area experiment. In addition, to further facilitate the identification and location of beams, West Area beams and targets are numbered with odd numbers whilst in the North Area only even numbers are used. The beam for each of the experiments is indicated in the appendix.

All the experiments approved so far are electronic experiments. In addition to these, there will be a full programme of physics utilizing the two bubble chambers BEBC and Gargamelle. Whilst a primary aim of these chambers will be the study of neutrino interactions, BEBC will also be used for hadronic physics experiments using the RF separated beam S3.

BEBC is a liquid hydrogen bubble chamber which can also operate with deuterium or eventually a neon filling. The possibility of a neon filling has led to proposals to insert a transparent box in the middle of the chamber, which would contain pure hydrogen, surrounded by a mixture of hydrogen and neon in the rest of the chamber. This arrangement is commonly called a "track-sensitive target" or TST. Such a device enables the identification of π^0 and γ-rays produced in the hydrogen because of the relatively short radiation length of neon, in which the γ-rays are converted to electron-positron pairs after emerging from the hydrogen target.

Gargamelle is a heavy-liquid bubble chamber which utilises freon or propane (or mixtures of the two) as a dense material most suitable for neutrino physics. Pioneering work including the discovery of neutral currents has been done with this chamber at the CERN proton synchrotron and it is now being moved to a location behind BEBC in the neutrino beam line. Because neutrinos interact only weakly, both the bubble chambers and counter experiments can take data simultaneously in the neutrino beam.

4. THE NORTH EXPERIMENTAL AREA

The North Area Zone 1 will contain hadronic or electromagnetic counter experiments. The beams planned for this area will go up to 400 GeV/c and include the usual hadron beams with an option for an electron or tagged photon beam. A large experimental hall, EHN1, which is 50 m wide and 290 m long, has been designed to house the experiments. The beams will be produced in a special target area which is about 10 metres below ground and the deflecting magnets used for momentum analysis will also transport the beams up to surface level (or slighly below). In this way the muon background, the most difficult to avoid in the West Area, will largely be eliminated since muons produced in the target area will be absorbed in the earth downstream.

A total of three independent targets T2, T4, T6 are planned each irradiated simultaneously by a split branch of the EPB. Two of the targets will be used to produce four general purpose hadron beams going up through two tunnels to EHN1. A schematic diagram of the North Area is shown in Fig. 7.

The four hadron beams will include two which will go up to the full energy of 400 GeV, and two which will operate up to about 270 GeV. Thus the hadron physics in the North Area will be the very-high energy processes.

The third target in the target area will be used to produce a high-intensity beam of π and K mesons which will then travel down a 600 m long decay region equipped with focussing quadrupoles to produce a high-intensity muon beam. The fact that one has not combined the muon and neutrino beams, as has been done at FNAL, allows the use of the quadrupoles which gives a higher efficiency for capturing the decay muons. Figure 8 shows a schematic layout of this beam which is called M2. Notice that the momentum analysis of the muons is performed by bending in the vertical plane after the hadrons have been absorbed by a beryllium absorber. Great care has been taken in the beam design to minimise the "halo" of muons. Figure 9 shows a Monte Carlo generated distribution of muons as a function of radial distance from the beam axis at the position of the experimental apparatus. This example is for μ^+ at 200 GeV/c. As can be seen, about 10^8 muons are contained within a radius of 5 cm (the beam) and between a radius of 20 cm and 200 cm, only about 2% of the beam flux is found (the halo).

I will conclude the description of the North Area by referring again to Fig. 7 to point out the line reserved for further developments. This line, branching off the end of the muon decay tunnel, will be a possible area for experiments using the full intensity proton beam, or as the starting point for development of new beams as yet unthought of.

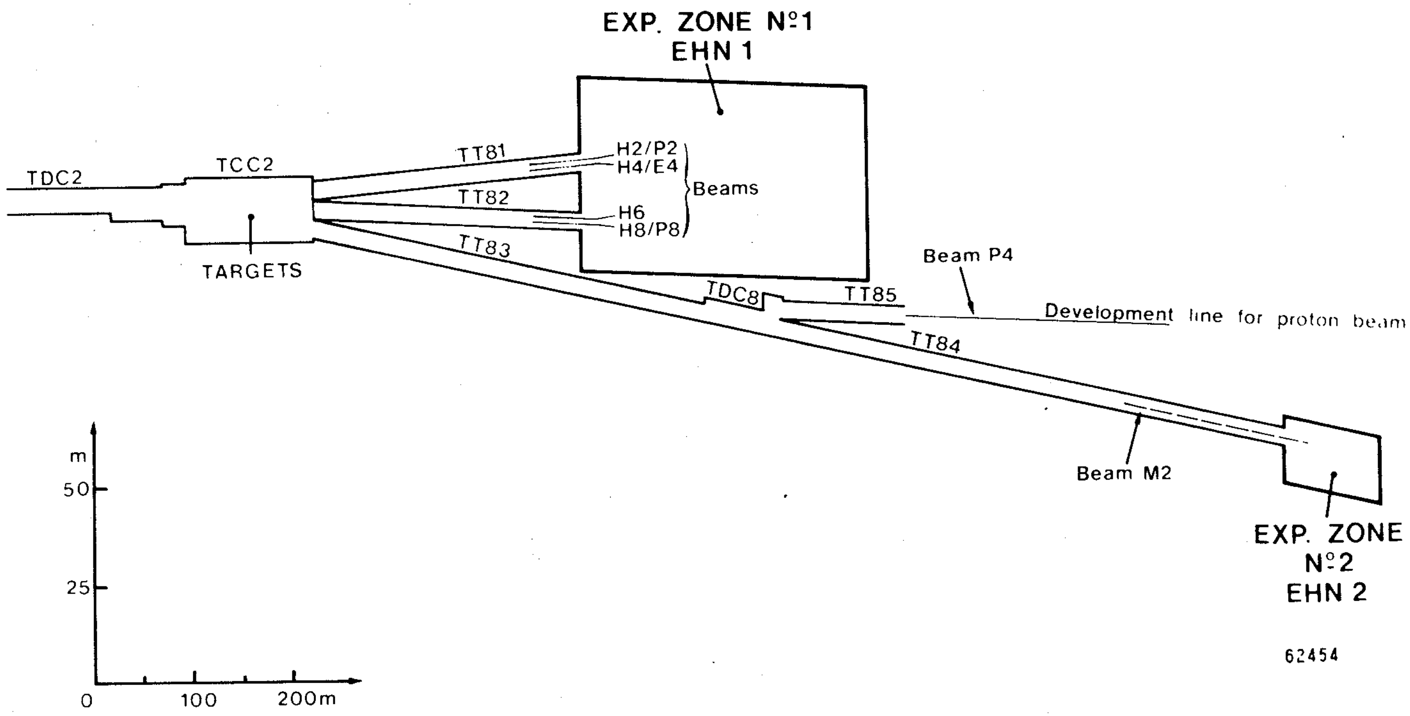


Fig. 7 : Schematic drawing of the North Experimental Area

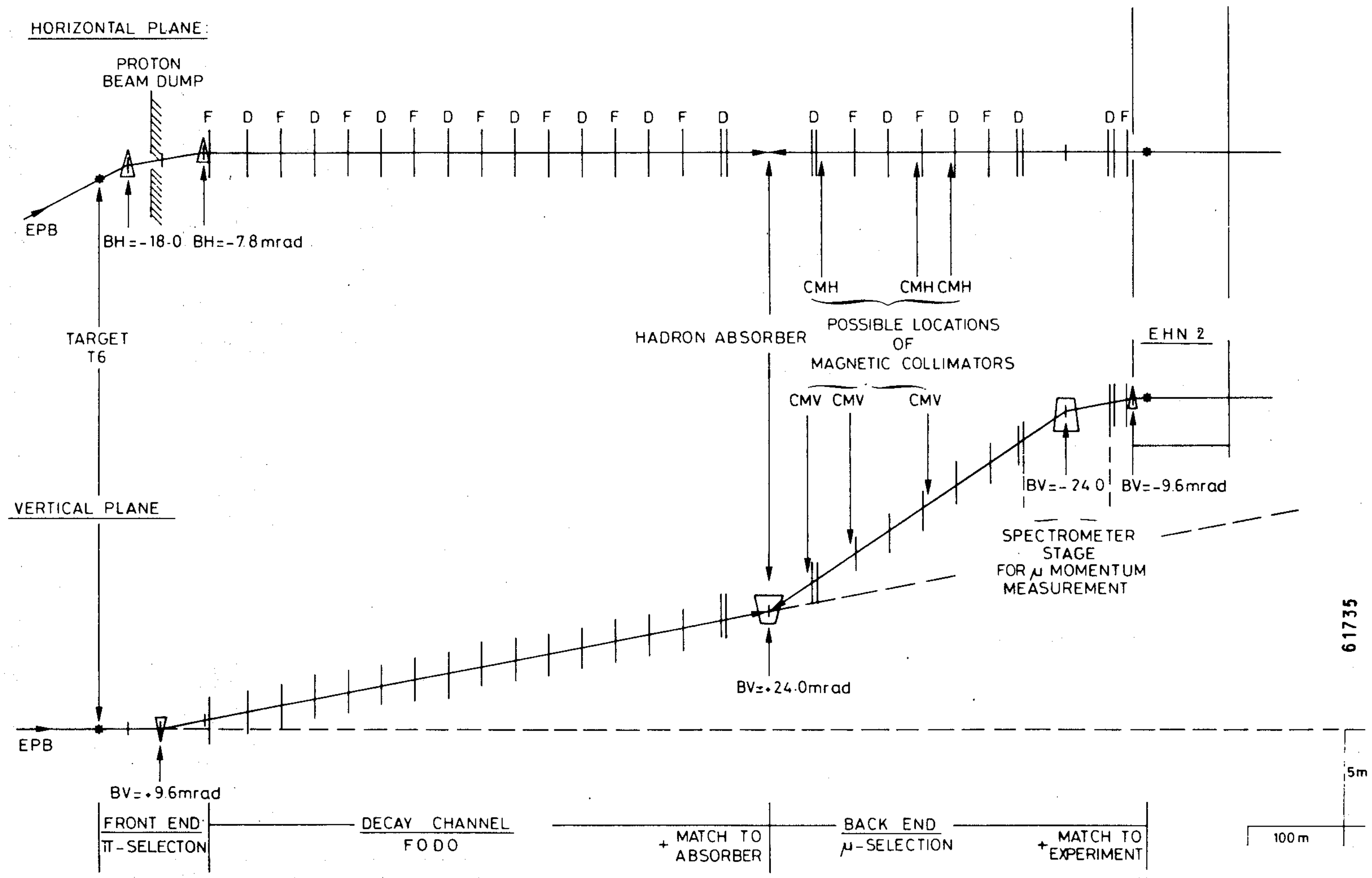


Fig. 8 : Schematic layout of the muon beam M2

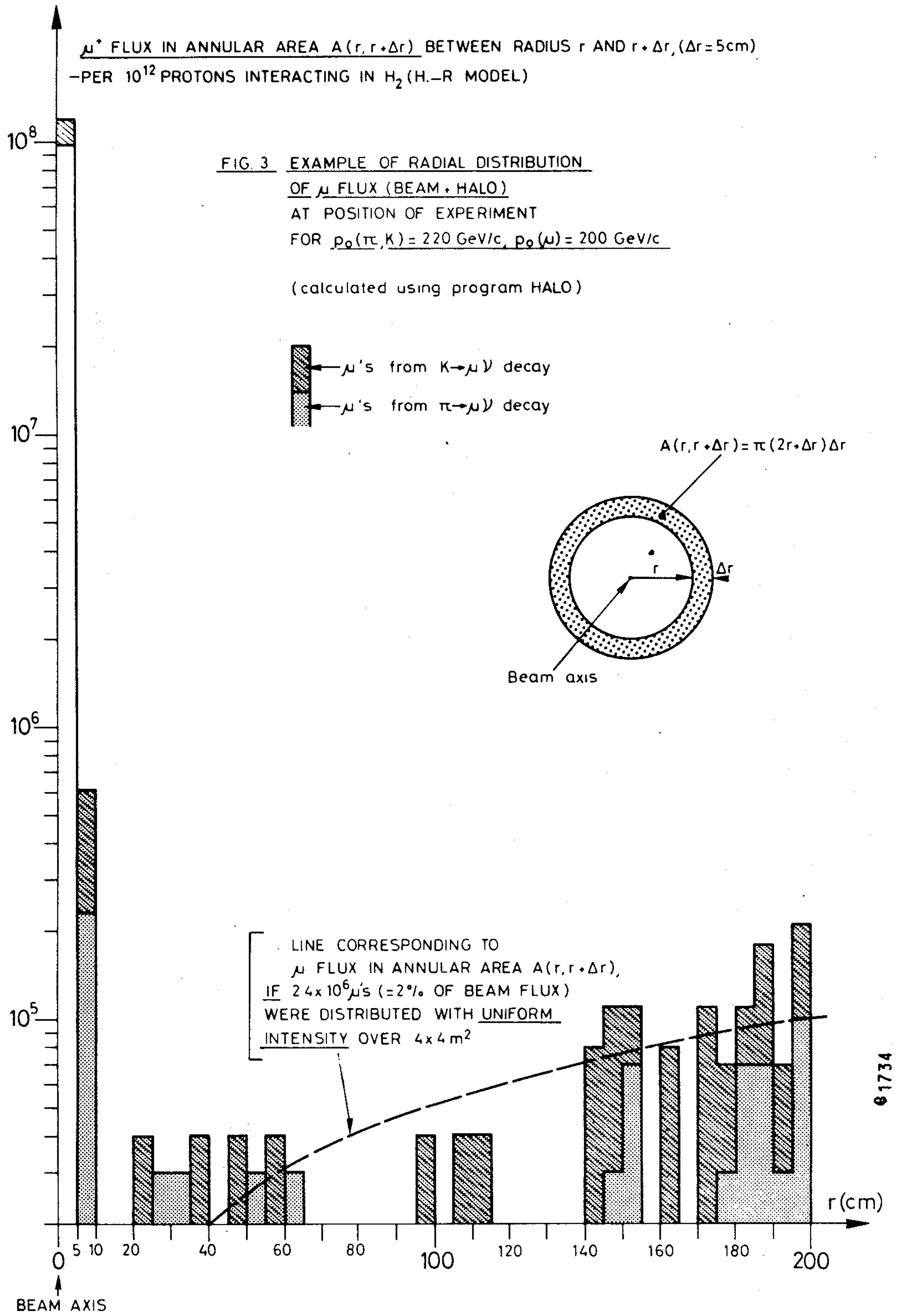


Fig. 9 : Monte Carlo generated distribution of muons at the position of the experiment in Zone 2. The muon flux in an annulus 5 cm wide at radius r cm is plotted against r

5. EXPERIMENTS IN THE NORTH AREA

Up to now, five experiments have been approved for the North Area. They are described in the appendix. These are all experiments using electronic techniques. Two experiments are for the Experimental Zone 2 using the high intensity muon beam M2. The other three are hadron experiments which will be located in Experimental Zone 1 but final beam assignments have not yet been made.

During the coming year, it is anticipated that other experiments will be approved for the North Area. Several proposals under detailed evaluation and refinement at the present time involve the construction of a rapid-cycling bubble chamber (RCBC) which could operate in high energy hadron beams in the North Area Zone 1. This, if approved, would complement the physics to be done with BEBC using the RF separated beam in the West Area.

6. APPENDIX

Summaries of Approved SPS Experiments

The summaries are composed of a single page description of the physics aims and the proposed technique of each experiment together with a single page diagram of the experimental apparatus. The names of the participating physicists and the institutions involved are given under a brief title to identify the experiment. In addition, in the upper right hand corner the code number of the experiment and the beam are given together with the date of approval and status of the experiment. Further details on any experiment can be obtained by consulting the documents given underneath as References.

Expt.	:	WA1
Beam	:	N1
Approved	:	17.04.74
Status	:	preparation

APPENDIX

High Energy Neutrino Interactions

CERN-Dortmund-Heidelberg-Saclay Collaboration

P. Block, B. Devaux, A. Diamant-Berger, F. Dydak, F. Eisele, C. Geweniger, V. Hepp, M. Holder, K. Kleinknecht, E. Kluge, G. Marel, F. Navarria, P. Palazzi, D. Pollman, A. Savoy-Navarro, G. Spahn, J. Steinberger, H. Suter, K. Tittel, R. Turlay, M. Vysočanský, H. Wahl, E.G.H. Williams

This experiment will study neutrino interactions at the highest available energies using principally the dichromatic neutrino beam N1, The basis of the detector is a massive target-calorimeter in which the energy deposited by a neutrino (or anti-neutrino) is measured by electronic techniques and the momentum of outgoing muons is determined by magnetic deflection.

The detector is constructed in the form of a 20 m long iron-cored toroidal magnet, composed of modules each 90 cm long and 3.75 m in diameter. Drift chambers placed in between each module will measure the trajectory of the muons from the neutrino interactions. The individual modules are of two types. The first six modules are constructed of 5 cm iron plates with 1 cm gaps for the insertion of 15 scintillator planes per unit. The final twelve modules are constructed from 15 cm plates with 2 cm gaps for scintillator insertion. The energy deposited in the scintillator is measured by pulse height analysis. The total mass of the detector is ∿ 1400 tons.

The physics aims of this experiment are:

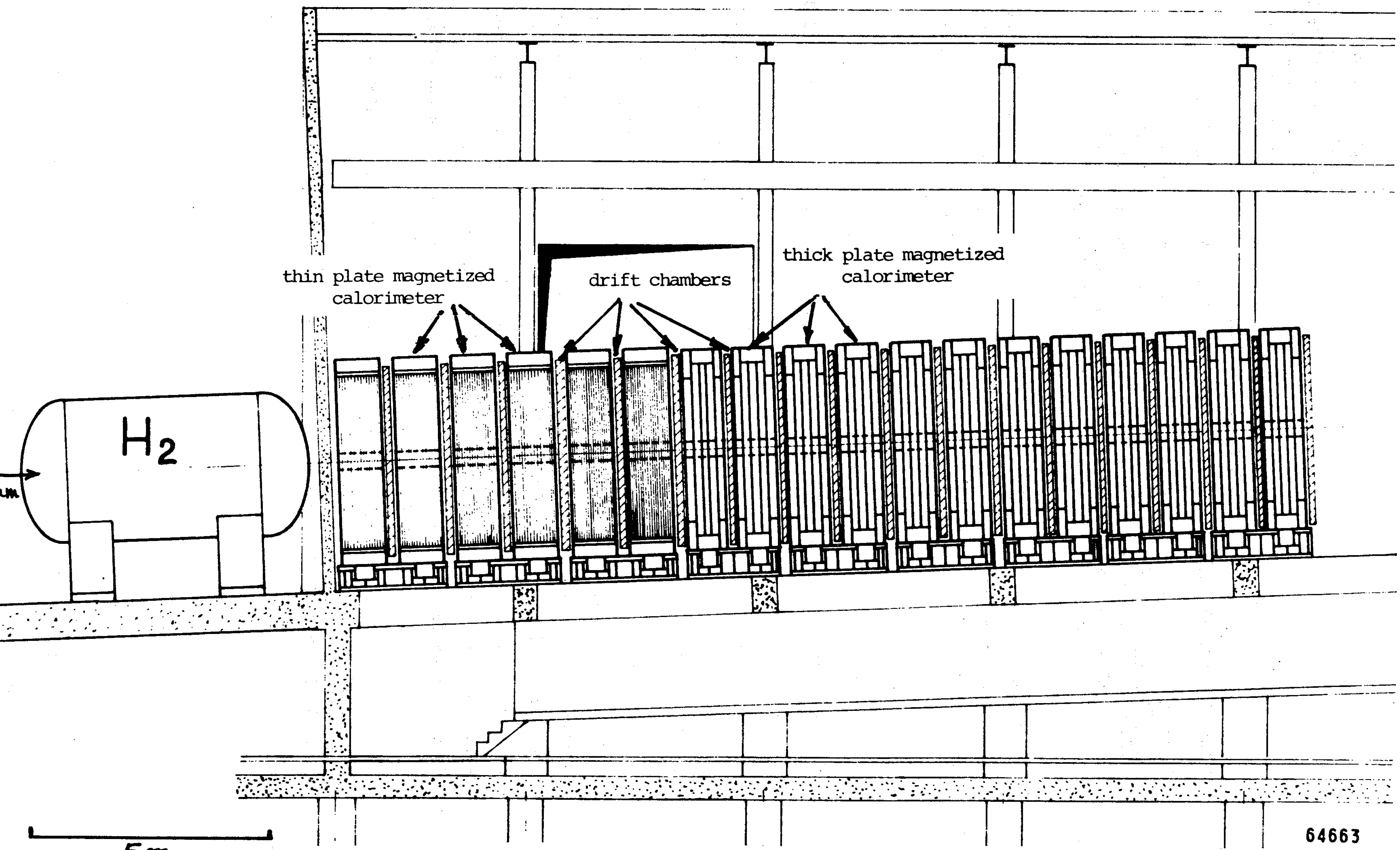
a) inclusive neutrino reactions in Fe

b) search for rare processes, in particular:
   - (i) three lepton production
   - (ii) inverse muon decay
   - (iii) heavy lepton production
   - (iv) intermediate boson production

(Summary edited by J.V. Allaby)

References

SPSC/P73-1, SPSC/P73-1/Add, SPSC/74-6/P1/Add.2, SPSC/74-38/M25



Experiment WA1: High energy neutrino interactions

Expt.	: WA2
Beam	: Y1
Approved	: 12.06.74
Status	: preparation

Leptonic Decays of Hyperons

Bristol-Heidelberg-Geneva-Orsay-Rutherford-Strasbourg Collaboration

M. Bourquin, R.M. Brown, Y. Chatelus, J-C. Chollet, M. Croissiaux, J-M. Gaillard, C.N.P. Gee, W.M. Gibson, R.S. Gilmore, J. Gresser, P. Igo-Kemenes, P. Lennert, J. Malos, B. Merkel, R. Morand, R.J. Ott, J-P. Repellin, G. Sauvage, B. Schiby, P. Schubelin, H.W. Siebert, V.J. Smith, K.P. Streit, R.J. Tapper, J.J. Thresher

The aim of this experiment is to make accurate measurements on the rare decay modes of hyperons. Amongst the decays to be studied are:

a) $\Xi^- \to \Lambda^0 e^- \bar{\nu}$ B.R. = 6×10^{-4} expect ∿ 160/day

b) $\Xi^- \to \Sigma^0 e^- \bar{\nu}$ B.R. = 1×10^{-4} expect ∿ 25/day
$\quad\quad \hookrightarrow \Lambda^0 \gamma$

c) $\Sigma^- \to \Lambda^0 e^- \bar{\nu}$ B.R. = 0.6×10^{-4} expect ∿ 800/day

The expected event rates are based on a beam of 100 GeV/c containing ∿ 10 000 Σ^- per burst.

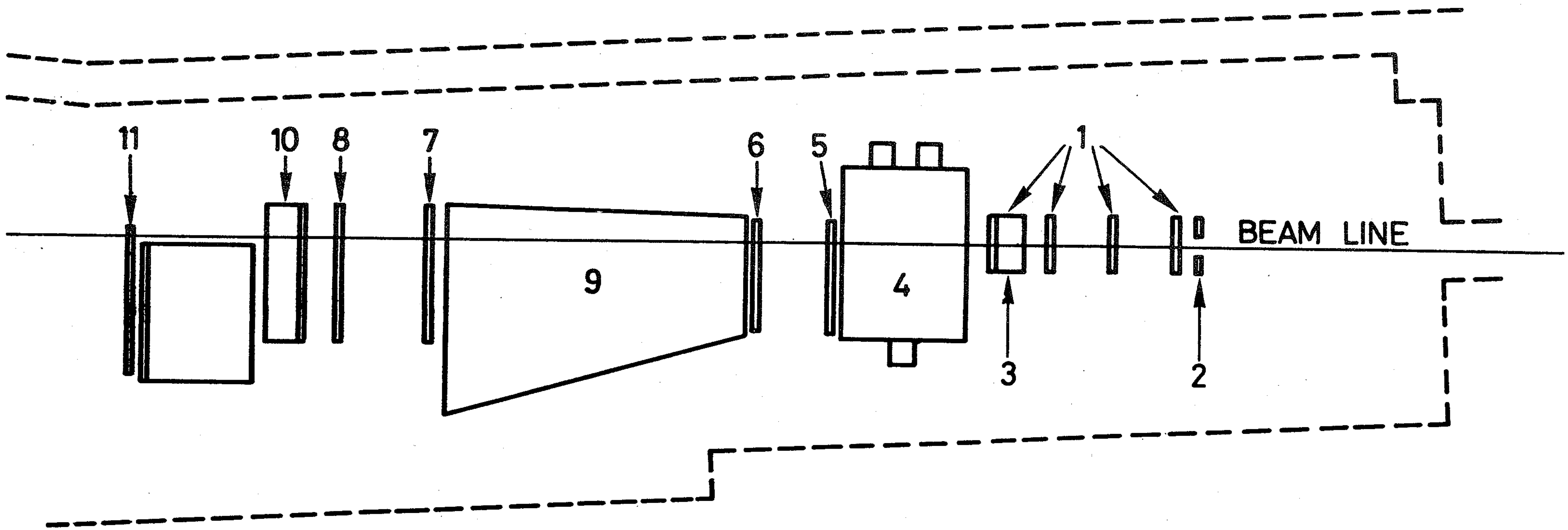
Furthermore, if the background of protons in the positive hyperon beam is sufficiently reduced, the decay of Σ^+ will also be measured. The hyperons will be identified by a special DISC Čerenkov counter.

The experimental equipment includes a set of four drift chambers in front of an analysing magnet and four after the magnet. Identification of electrons is assured by a gas Čerenkov counter and by a lead-glass array. Additional rejection of pions will be given by the inclusion of a transition radiation detector installed directly in front of the magnet. Discrimination between reactions a) and b) will be provided by detection of the γ-rays from the Σ^0 decay using lead-scintillator sandwich counters, and the lead-glass array.

(Summary edited by J.V. Allaby)

References

SPSC/P.73-2, SPSC/74-32/P2/Add.1, SPSC/74-48/M28.



EXPERIMENT WA 2

1 FRONT DRIFT CHAMBER TELESCOPE
2 GAMMA HODOSCOPE
3 TRANSITION RADIATION DETECTOR
4 SPECTROMETER MAGNET
5–8 BACK DRIFT CHAMBER TELESCOPE
9 GAS CERENKOV
10 LEAD GLASS DETECTOR
11 MUON CHAMBER

Experiment WA2: Leptonic Decays of Hyperons

Expt.	:	WA3
Beam	:	H1
Approved	:	12.06.74
Status	:	preparation

Exclusive πp and Kp Interactions

Amsterdam-CERN-Cracow-Munich-Oxford-Rutherford Collaboration

B. Alper, H. Becker, W. Blum, M. Bowler, R. Cashmore, C. Damerell
C. Daum, P. van Deurzen, H. Dietl, A. Dwurazny, L. Hertzberger,
B. Hyams, W. Hoogland, J. Loken, E. Lorenz, G. Lütjens, G. Lutz,
W. Männer, S. Peters, G. Polok, R. Richter, K. Rybicki, U. Stierlin,
G. Thompson, M. Turala, P. Weilhammer

This experiment is a study of the quasi two body hadron reactions $\pi^{\pm}p \to \pi^{+}\pi^{\pm}n$, $\pi^{-}p \to K^{+}K^{-}n$, $\bar{p}pn$, $K^{-}p \to K^{-}\pi^{+}n$, $\pi^{\pm}p \to K^{\pm}K^{0}_{s}p$ and $K^{-}p \to K^{0}_{s}\pi^{-}p$ over a wide kinematic range and at several energies up to 100 GeV. The main aims of this experiment are to investigate the four momentum transfer and energy dependence of the production mechanism in these reactions and in particular to study $\pi\pi$ and $K\pi$ interactions through phase-shift analysis up to high masses. It is also intended to search for high-mass resonances in two body and many body final states.

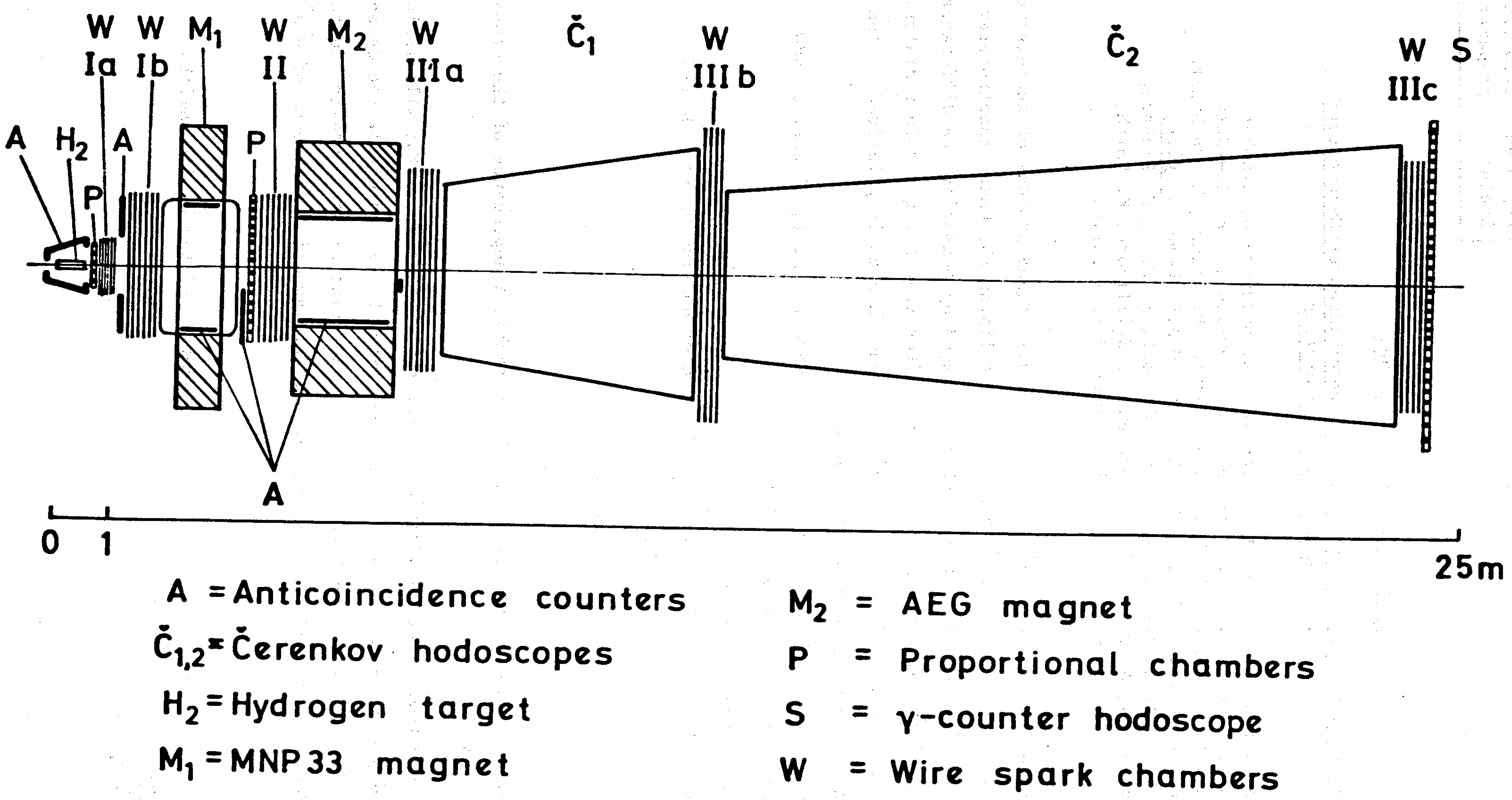
The proposed apparatus consists of a beam telescope of proportional wire chambers, a liquid-hydrogen target surrounded by a 4π solid angle anti-coincidence counter arrangement (except for a small beam entrance window and an exit window for fast forward going particles), and a forward spectrometer equipped with two magnets giving a total bending power of 3Tm, wire spark chambers with a resolution better than 0.3 mm, two large aperture Cerenkov hodoscopes, a trigger system and anticoincidence counters for the detection of charged particles and neutral pions. The two magnet configuration permits the measurement of slow particles with a relatively weak and short magnet directly after the target, while the momentum of fast secondaries is measured with a magnet of higher bending power but reduced acceptance. The trigger system consists essentially of proportional wire planes directly after the target and two counter hodoscopes for the selection of the multiplicity. Particle identification will be possible up to about 80 GeV. In a later phase the wire spark chambers will gradually be replaced by drift chambers.

The apparatus will be ready for data taking in November 1976 in the H1 beam in the West Hall. The initial time request is for 85 days of setting up and running time (assuming $3 \times 10^{5}\pi^{-}$ / pulse, spilltime 1 sec. and 10 000 pulses/day).

(Summary edited by J.V. Allaby)

References

SPSC/74-14/P 7



Experiment WA3: Exclusive πp and Kp Interactions

Expt.	: WA4
Beam	: E1
Approved	: 12.06.74
Status	: preparation

Photoproduction of Hadrons

Bonn-CERN-Daresbury-DESY-Ec.Poly.-Glasgow-Lancaster-Manchester-Orsay-Sheffield Collaboration

T. Armstrong, D. Aston, J.K. Bienlien, B. Bouquet, G. Brookes, P. Bussey, A.B. Clegg, B. D'Almagne, B. Drevillon, T.P. Duerdoth, P.J. Duke, R.J. Ellison, P. Feller, A. Ferrer, P. Fleury, W. Galbraith, B. Grossetête, K. Heinloth, M. Ibbotson, M.A.R. Kemp, J. Litt, R. Marshall, K. Müller, D. Newton, P. Petroff, E. Paul, F. Richard, G. de Rosny, A. Rougé, J. Rutherglen, I. Skillicorn, K. Smith, D. Treille, H. Videau, I. Videau, J.P. Wuthrick

The interest of this experiment is to use tagged photons of energies up to 60 GeV in photoproduction measurements utilising the Omega spectrometer as detector. The energy of the photons is tagged by measuring the difference in energy of the electron beam before and after traversing a thin radiator. If the radiator is a suitable crystal, the photon beam is polarized. The reactions which will be studied include:

a) Vector meson photoproduction $\gamma p \rightarrow Vp$ where $V = \rho, \phi, \rho'$ etc. or new states of higher mass

b) Compton scattering $\gamma p \rightarrow \gamma p$

c) Energy dependence of pseudoscaler meson production up to $\sim$ 30 GeV

$$\gamma p \rightarrow \pi^- \Delta^{++}$$
$$\pi^+ \Delta^0$$
$$\pi^0 \Delta^+$$

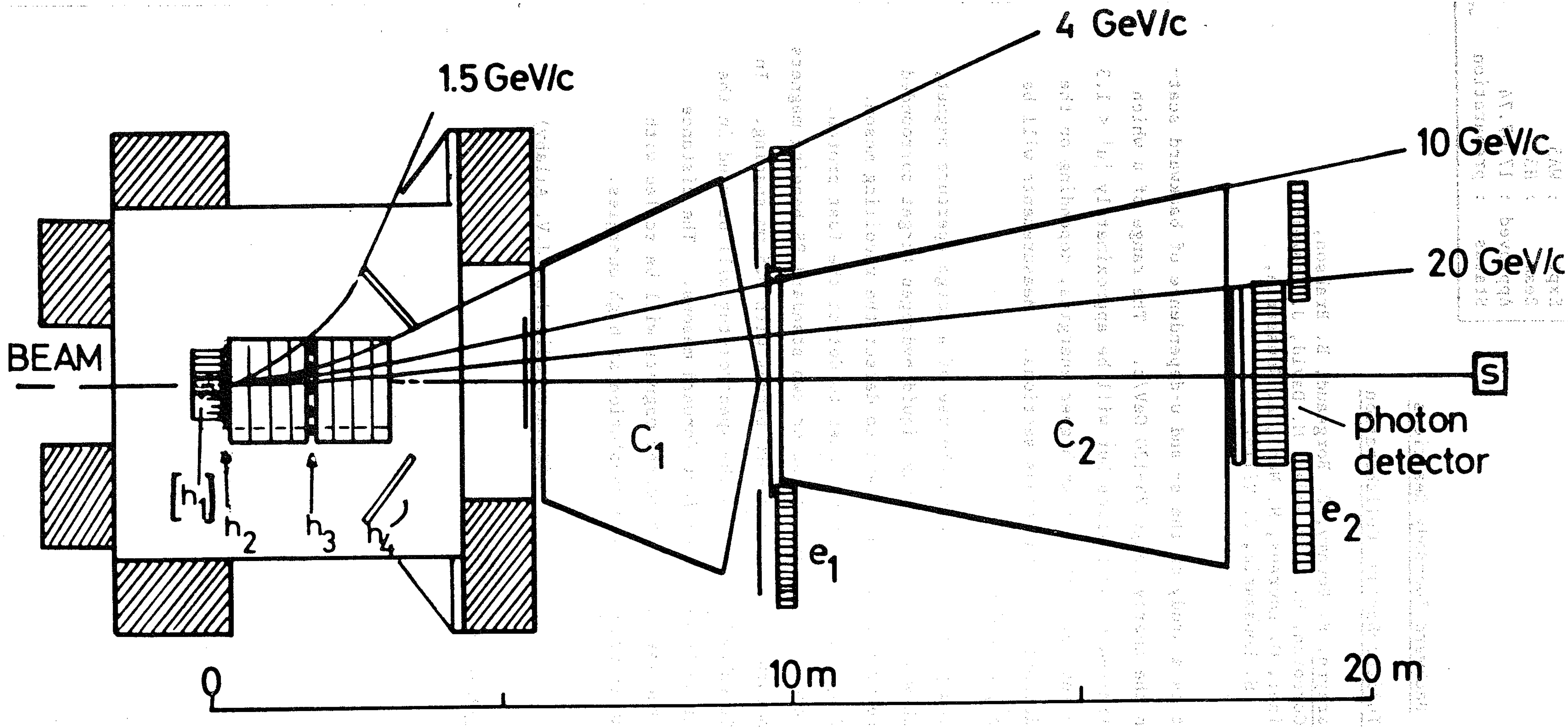
d) Photoprodction in nuclei, shadowing effects, A dependence of the cross-section.

The equipment used in addition to the basic Omega apparatus will include a forward photon detector composed of lead glass blocks to enable the detection of fast π^0 produced in the interaction. Lead scintillator sandwich counters on the median plane will be used to veto electromagnetic background of e^+e^- pairs.

(Summary edited by J.V. Allaby)

References

SPSC/74-29/P 10



$[h_1]$, $h_2 - h_4$	Interaction Trigger
S	Beam veto
e_1, e_2	Electron veto

Experiment WA4: Photoproduction of Hadrons

Expt.	: WA5
Beam	: H3
Approved	: 17.07.74
Status	: preparation

Backward Two-Body Reactions

Indiana-Saclay Collaboration

R. Barate, P. Bareyre, P. Bonamy, P. Borgeaud, B. Brabson,
J.C. Brisson, M. Corcoran, R. Crittenden, M. David, J. Ernwein,
R. Heinz, A. Krider, G. Laurens, H. Neal, A. Roussarie,
H. Roussarie, G. Villet

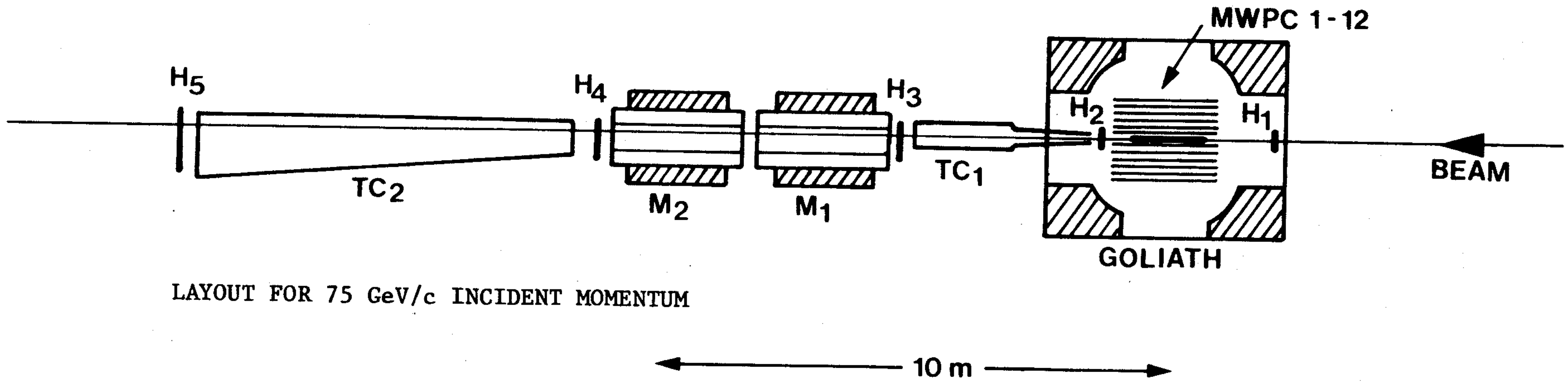
This experiment is a study of the s- and u-dependence of backward scattering of hadrons in the energy range 25-120 GeV/c. The range of u which will be covered is limited by statistics but will be approximately $|u| < 1.3$ GeV^2 up to 50 GeV/c and somewhat less at higher energies, depending on the steepness of the s-dependence of the cross-sections. Measurements will be made with incident $\pi^{\pm}$, $K^{\pm}$ and $\bar{p}$.

The detection equipment is based on the use of a large aperture magnet, GOLIATH, inside which will be the 1 m long liquid hydrogen target surrounded by a set of multiwire proportional chambers to detect the recoiling meson. This is complemented by a forward spectrometer to detect the fast proton. The forward spectrometer is composed of one or two standard PS bending magnets (depending on the momentum) and further MWPC planes with 0.5 mm spacing. In addition threshold Čerenkov counters in the spectrometer will be used in the trigger to reject the background from fast forward mesons. The distance between GOLIATH and the forward spectrometer magnets will be scaled with the incident momentum to maintain good resolution at high energies.

(Summary edited by J.V. Allaby)

References

SPSC/74-10/P 5, SPSC/74-41/P 5/Add.1



LAYOUT FOR 75 GeV/c INCIDENT MOMENTUM

H1 - H5	:	Hodoscopes of Scintillator and MWPC
MWPC 1-12	:	Recoil Multiwire Proportional Chambers
TC1 - TC2	:	Threshold Cerenkov Counters
M1, M2	:	PS Bending Magnets

Experiment WA5: Backward Two-Body Reactions

Expt.	:	WA6
Beam	:	H3
Approved	:	04.09.74
Status	:	preparation

Polarization in pp and πp Elastic Scattering

CERN-Trieste-Vienna Collaboration

W. Bartl, R. Birsa, F. Bradamante, G. Fidecaro, M. Fidecaro, M. Giorgi, G. Leder, W. Majerotto, G. Neuhofer, A. Penzo, M. Pernicka, L. Piemontese, P. Schiavon, M. Steuer, A. Vascotto, A. Villari

The aim of the experiment is to arrive at a better understanding of the role played by spin in high energy hadron-hadron interactions.

Measurements will be made, in the 50-150 GeV/c range, on two-body (and quasi-two-body) reactions induced by protons and pions on polarized protons, for which either the target baryon or the beam particle (or the resonance) are left with a laboratory momentum between 0.5 and 2 GeV/c (for elastic scattering $0.3 \leqslant t,u \leqslant 3\ GeV^2$). The dip observed in the cross-section for elastic proton-proton scattering at the ISR energies is located in this region. Although the design of the experiment is based on measurements of forward elastic scattering, the equipment can measure backward scattering and reactions such as $\pi^{\pm}p \rightarrow K^{+}\Sigma^{\pm}$.

The experimental apparatus consisting of MWPC and scintillation counter hodoscopes is built around a 1 m diameter magnet (0.95 T·m), at the centre of which the polarized target is located. A backward telescope allows the measurement of the low-energy particle over a large polar angle. The total solid angle is ∿ 3 sr. The momentum is obtained by correlating the tracks inside and outside the magnetic field. The time-of-flight is also measured, to allow a mass determination. The apparatus is completed by a forward arm which makes use of two 2 m bending magnets (3.6 T·m each and an acceptance overmatched to the backward arm) and a Cerenkov counter. The apparatus is designed to measure cross-sections down to $10\ nb/GeV^2$, by sending an unseparated beam of 10^8 ppp on a $13\ g\cdot cm^{-2}$ propanediol target.

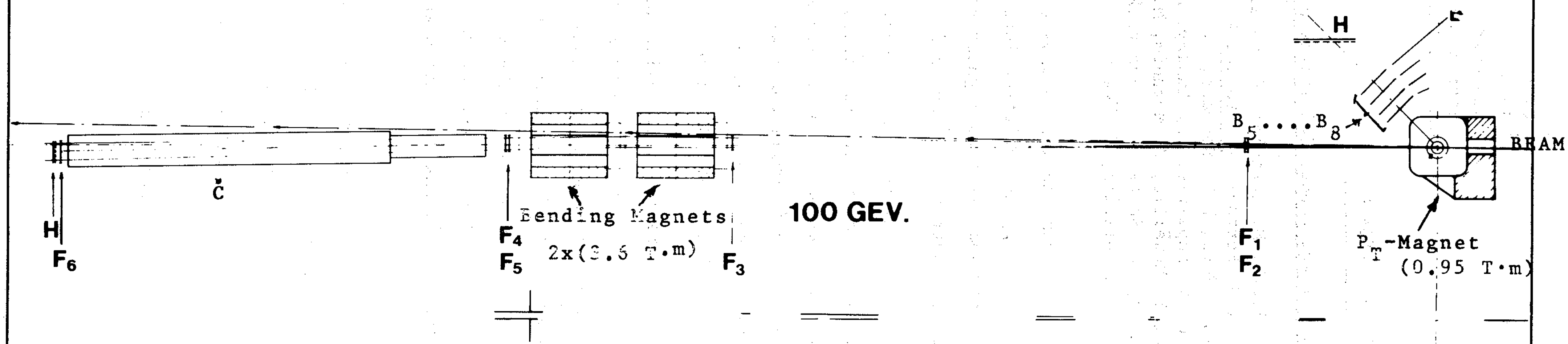
(Summary edited by J.V. Allaby)

References

SPSC/74-17/P 8, SPSC/74-54/P 8/Add.1

CERN-Trieste-Vienna : Polarization Measurement

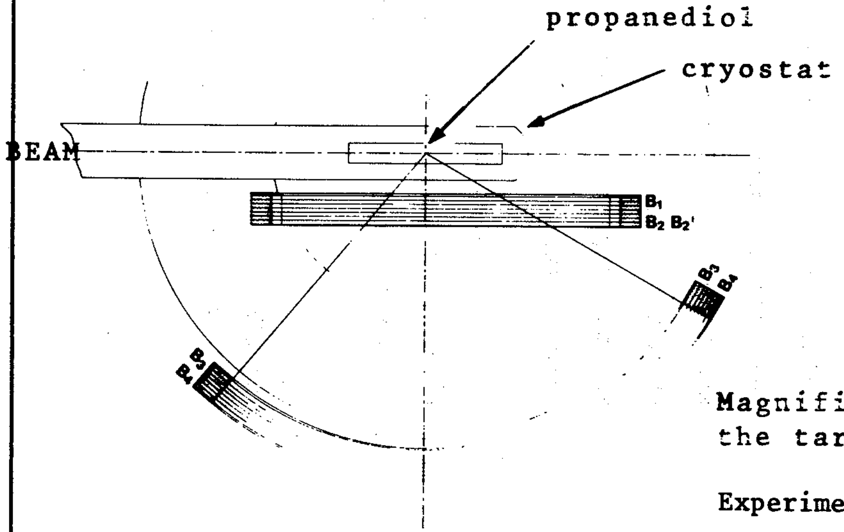
$pp_{\uparrow} \to pp$, $0.3 \leq -t \leq 3$ GeV^2, 100 GeV set-up



B_i $(i = 1 \ldots 8) \equiv$ MWPC

F_i $(i = 1 \ldots 6) \equiv$ MWPC

$H \equiv$ Hodoscopes



Magnified view of
the target area

Experiment WA6: Polarization in pp and πp Elastic Scattering

Expt.	: WA7
Beam	: H1
Approved	: 04.09.74
Status	: preparation

Two-Body Reactions at Large P_T

CERN-Genova-Orsay-Oslo-University College London Collaboration

V. Bakken, M. Bozzo, T. Buran, A. Buzzo, M. Castoldi, C. Caverzasio, J. Dines Hansen, B.G. Duff, A. Eide, S. Ferroni, V. Gracco, K. Guettler, J-P. Guillaud, J. Haldorsen, A.J. Herz, F.F. Heymann, D.C. Imrie, T. Jacobsen, R. Kiesler, K. Kirsebom, V. Lepeltier, A. Lundby, F.J. Lush, M. Macri, M.N. Minard, R. Møllerud, B. Mouëllic, J. Myrheim, M. Poulet, L. Rossi, A. Santroni, B. Schistad, G. Sette, S.J. Sharrock, S.O. Sørensen, H. Watson, T. Willits, M. Yvert

The experiment is aimed at doing 90^o c.m. exclusive physics, and in particular to study elastic scattering and $\bar{p}p$ annihilation into $\pi^+\pi^-$ and K^+K^-. The same kinematics applies, however, also to lighter particles which move slowly in the c.m. system and suffer two-body decay.

Although the emphasis is on 90^o c.m., the equipment covers a large angular range, and will be placed so as to cover forward angles compatible with trigger rates. At incident intensities of 10^8 particles/sec, the minimum angle will correspond to $-t \simeq 5$ $(GeV/c)^2$, while for lower intensities the equipment will be displaced so as to cover lower t-values. The experiment will run with incident beams at 20, 40, 60 and 80 GeV/c.

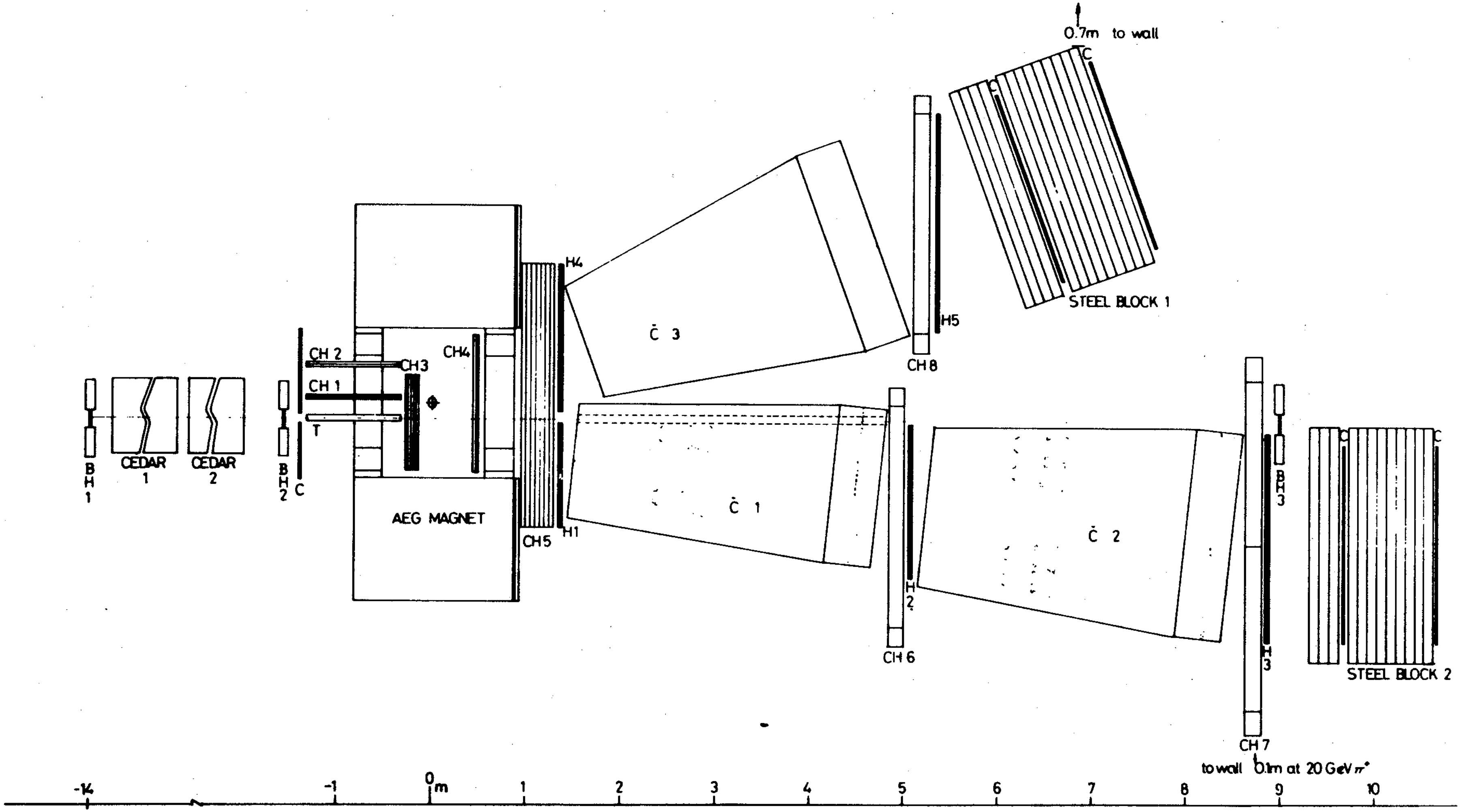
The experiment uses a 1 m liquid H_2 target partly inside an AEG magnet. Correlations between the secondary particles are first established by using pulses from arrays of scintillation counters to make decisions by means of fast coincidence matrices. The pulses from MWPC are stored on delay lines and read into hardware processors, which then decide if the information should be read via a NORD-10 onto magnetic tape. Identifications of the secondary particles are made with threshold Čerenkov counters and iron calorimeters.

The experiment will also use a CEDAR differential counter on the beam-line downstream of the target to enable positive identification of the interacting particle when operating at the highest intensities.

(Summary edited by J.V. Allaby)

References

SPSC/74-28/P 9, SPSC/74-49/P 9/Add.1, SPSC/74-61/P 9/Add.2



C1 - C3 : Threshold Čerenkov Counters

CH1 - CH8 : Multi-Wire Proportional Chambers

BH1 - BH3 : Beam Hodoscope Scintillation Counters

H1 - H5 : Scintillation Counter Hodoscopes

Experiment WA7: Two-Body Reactions at Large P_T

Expt.	: WA8
Beam	: S1
Approved	: 22.01.75
Status	: preparation

Production of Rare Meson States in $K^{\pm}p$ Collisions

University of Birmingham

D.C. Colley, J.D. Dowell, J. Garvey, R.J. Homer, M. Jobes, G.T. Jones, I.R. Kenyon, T. McMahon, P. Watkins and J. Wilson

This experiment will exploit the R.F. separated beam and the Omega spectrometer in order to study the mass spectra and production mechanisms of rare meson states produced in $K^{\pm}p$ interactions. The motivation is based on the fact that mesons composed mainly of strange quarks (e.g. the ϕ meson) are produced more copiously by incident K-mesons than by other hadrons. The specific reactions which will be studied include:

$$K^{\pm}p \rightarrow K^{\mp}K^{\pm}K^{\pm}p$$
$$\rightarrow \bar{p}pK^{\pm}p$$
$$\rightarrow \Lambda\bar{p}p \text{ or } \bar{\Lambda}pp$$
$$\text{and} \quad K^{-}p \rightarrow K^{+}K^{-}\Lambda$$

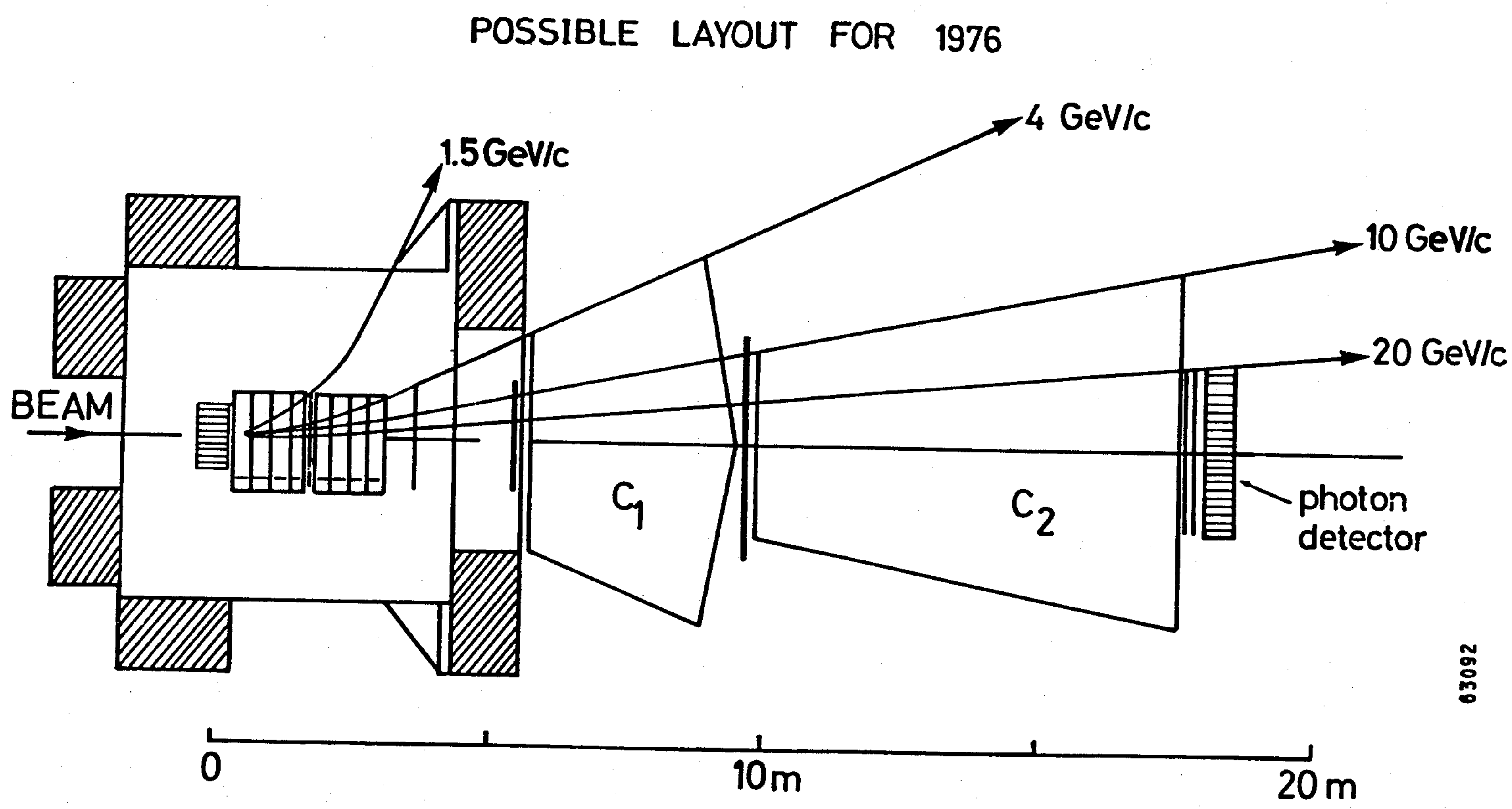
The trigger will be based on the detection of a kaon or baryon of opposite charge to the beam particle. The downstream γ-detector to be used in experiment WA4 will also be used to obtain data on reactions similar to those above, but containing an additional fast π^0.

The experiment will run at two incident momenta, 18 and 32 GeV/c. The second Čerenkov hodoscope of the Omega spectrometer will be shortened for the 18 GeV/c runs and will be displaced off-axis to maximise the acceptance.

(Summary edited by J.V. Allaby)

References

SPSC/74-84/P 21



Experiment WA8: Production of Rare Meson States in $K^{\pm}p$ Collisions

Expt.	:	WA9
Beam	:	H3
Approved	:	22.01.75
Status	:	preparation

High Precision Study of Elastic Scattering in the Coulomb Interference Region

Clermont Ferrand-Leningrad-Lyon-Uppsala Collaboration

J. Berthot, J.P. Burq, M. Chemarin, M. Chevallier, T. Ekelöf, J. Gardès, P. Grafstrom, E. Hagberg, B. Ille, A.P. Kashcjik, G.A. Korolev, P.C. Kulikov, S. Kullander, M. Lambert, J.P. Martin, L. Meritet, M. Querrou, V.A. Shchegelskij, F. Vazeille and A.A. Vorobiev

The aim of this experiment is the determination of the ratio ρ of the real to the imaginary parts of the forward elastic hadronic amplitudes, from measurements of elastic hadron-proton scattering cross sections in the Coulomb interference region. Measurements will be made at several energies from 50 to 150 GeV/c, and for both particles and antiparticles. A high accuracy must be achieved in these measurements. The expectation is to achieve an error on ρ of about .01 for π-p amplitudes, and about .03 for K-p and $\bar{p}$-p amplitudes.

The experiment will be carried out using:

(i) A recoil spectrometer consisting of a hydrogen ionization chamber in which the gas serves both as target and ionizing medium. The pulse height gives the kinetic energy T of the recoil, with an error of a few per cent in the range $1 < T < 10$ MeV. The rise time of the pulse gives the recoil polar angle with a precision of about one degree.

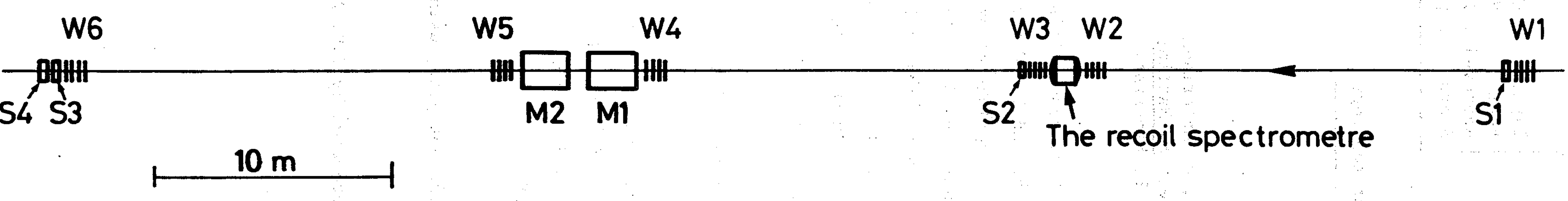
(ii) A forward spectrometer consisting of two CERN standard 2 m bending magnets, and a set of 24 MWPCs distributed along the beam line over three telescopes which measure the direction of the particle upstream and downstream of the target, and after magnetic deflection.

The experiment will take place in the H3 beam, at a maximum intensity of 10^6 particles per second.

(Summary edited by J.V. Allaby)

References

SPSC/74-94/P 26, SPSC/74-56/I 62, SPSC/74-55/M 31



EXPERIMENT WA9

W1	Four MWPC's	x, y, x, y, 1mm pitch,	64 × 64 mm^2
W2		——— " ———	32 × 32 mm^2
W3		——— " ———	32 × 32 mm^2
W4		——— " ———	128 × 128 mm^2
W5		——— " ———	128 × 128 mm^2
W6		——— " ———	256 × 256 mm^2

S1 – S4 Trigger scintillators

M1, M2 Two CERN standard 2m bending magnets

Experiment WA9: High Precision Study of Elastic Scattering in the Coulomb Interference Region

Expt.	:	WA10
Beam	:	H5
Approved	:	12.03.75
Status	:	preparation

Study of $K^{\pm}p \rightarrow K^0_s \pi^{\pm} p$ and reactions of similar topology with high statistics

Geneva-Lausanne Collaboration

R. Baldi, T. Bohringer, A. Delfosse, P.A. Dorsaz, P. Extermann, M.N. Focacci-Kienzle, O. Guisan, V. Hungerbuhler, M. Martin, A. Mermod, P. Muhlemann, C. Nef, P. Rosselet, P. Siegrist, A. Vriens, R. Weill

The aim of this experiment is to measure with very good statistics production and decay properties of S = 0 and 1 bosons and S = 0 baryons produced in quasi two-body reactions. A particular topology of event is chosen in which the final state contains a slow recoil proton, a fast forward meson and a V (from K^0 or Λ^0 decay). In this topology a 2C fit is obtained without the need for a magnet when the recoil proton energy is determined by time-of-flight and all the angles are measured. Thus the event reconstruction and fitting can be achieved very rapidly and handled by the on-line computers.

Specific channels to be studied, at incident momenta of 20, 40 and 80 GeV/c are:

$$K^{\pm}p \rightarrow K^{*\pm}p \rightarrow K^0_s \pi^{\pm} p$$

$$\pi^{\pm}p \rightarrow X^{\pm}p \rightarrow K^0_s K^{\pm} p$$

$$\begin{pmatrix} p \\ \bar{p} \end{pmatrix} p \rightarrow N^{*\pm}p \rightarrow \begin{pmatrix} \Lambda K^{+} \\ \bar{\Lambda} K^{-} \end{pmatrix} p$$

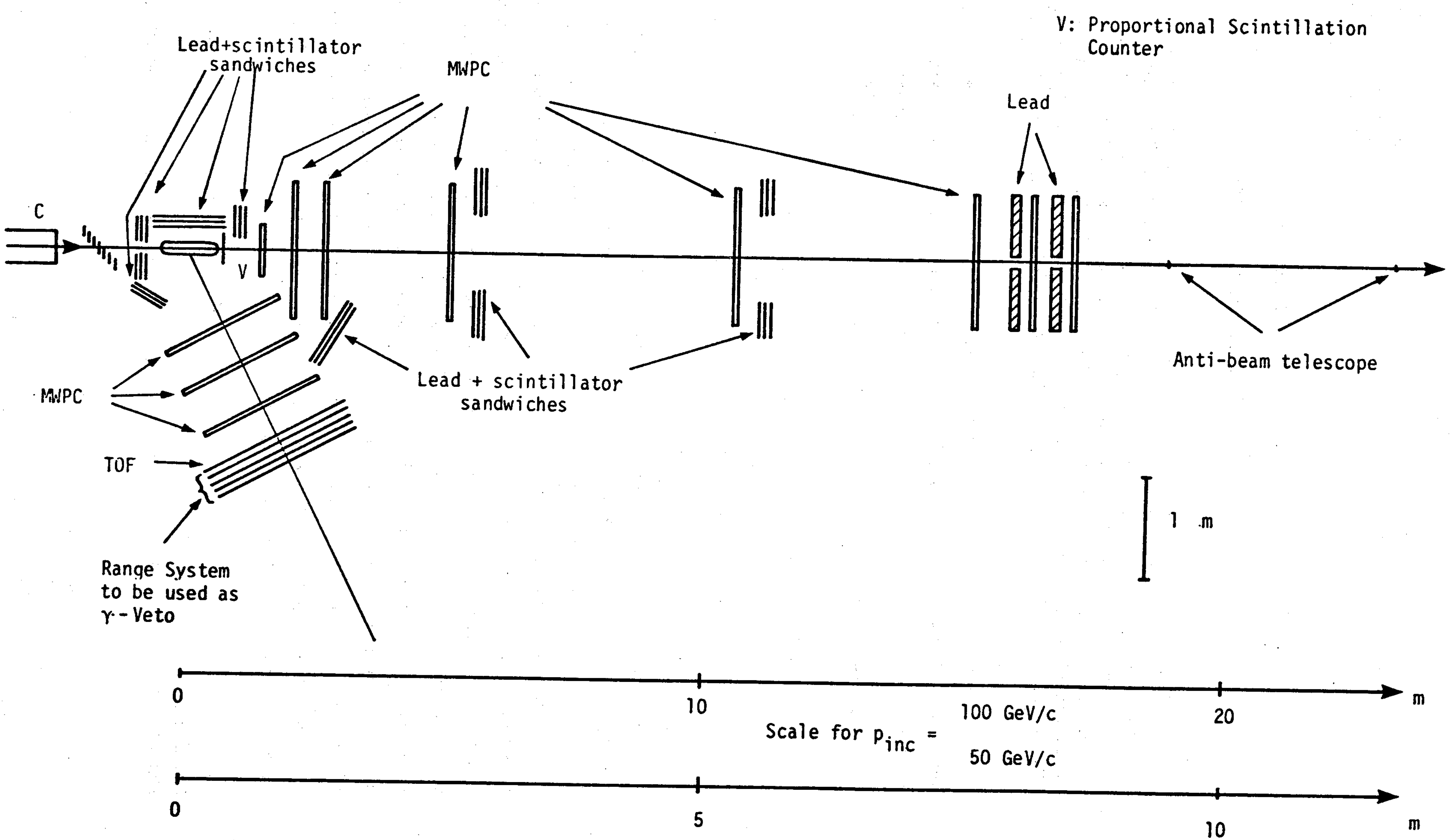
for masses of the resonances up to 5 GeV at 80 GeV/c incident momentum and for the momentum transfer range $0.05 \leqslant |t| \leqslant 1.0\ \mathrm{GeV}^2$

A total of 600 events/burst will be recorded and analysed, using microprocessor buffers.

(Summary prepared by J.V. Allaby)

References

SPSC/74-31/P 11, SPSC/75-6/M43



Experiment WA10: Study of $K^{\pm}p \rightarrow K_s^0\pi^{\pm}p$ and reactions of similar topology

Expt.	:	NA1
Beam	:	Not decided
Approved	:	12.03.75
Status	:	preparation

Comparative Study of Hadron Fragmentation

Frascati-Milan-Pisa-Rome Collaboration (FRAMM)

S.R. Amendolia, G. Bellini, E. Bertolucci, G. Bologna, C. Bradaschia, A. Cantore, A. Del Guerra, B. D'Ettorre Piazzoli, M. De Vincenzi, M. Di Corato, F. Fabbri, M. Fiori, L. Foà, P. Frabetti, A. Giazotto, M. Giorgi, P.F. Manfredi, A. Mannocchi, A. Menzione, E. Meroni, S. Micheletti, L. Moroni, F. Orsitto, F. Palombo, P. Picchi, M. Quaglia, P.G. Rancoita, L. Ristori, G. Rivellini, S. Sala, L. Satta, A. Scribano, M. Severi, P. Spillantini, A. Stefanini, G. Vegni, L. Vincelli, A. Zallo

The aim of the experiment is to study the fragmentation of various incident particles ($\pi^{\pm}$, $K^{\pm}$, p, $\bar{p}$) in their interaction with nucleons and nuclei, from a semi-inclusive point of view. Specific items of this research are:

(i) the comparative study of the diffractive excitation of diffractive hadrons,

(ii) the investigation of the event structure when the projectile is excited into a particular final state,

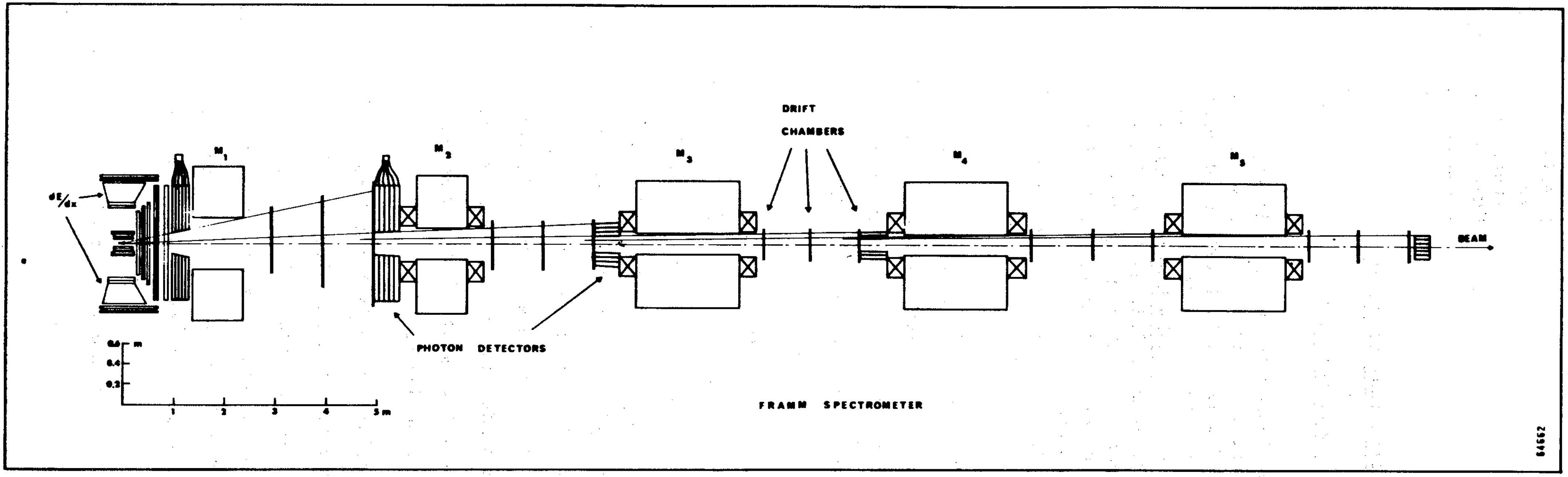
(iii) the study of the development of hadronic showers inside nuclear matter.

The apparatus consists of a forward spectrometer for charged particles and photons and of a large angle detector which provides the topology of individual events over almost 4π. The spectrometer subtends a solid angle of $\sim$ 40 msr and consists of five bending magnets (for an integrated bending power of $\sim$ 10 Tm), interspaced by sets of drift chambers, counter hodoscopes and photon detectors. The momentum resolution for charged particles is 0.3% almost independent of the particle momentum. Photon detectors are constituted by lead-scintillation counter hodoscope sandwiches or lead-glass arrays, depending on their dimensions. The large angle detector, consisting of proportional chambers, drift chambers and scintillation counters, measures the production angle of all charged particles and photons and identifies the recoil proton by a dE/dx measurement.

(Summary edited by J.V. Allaby)

References

SPSC/74-15/P.6, SPSC/74-23/P.6/Add.1, SPSC/74-83/P.6/Add.2, SPSC/75-20/M 47.



Experiment NA1: Comparative Study of Hadron Fragmentation

Expt.	:	NA2
Beam	:	M2
Approved	:	12.03.75
Status	:	preparation

Electromagnetic Interactions of Muons

The European Muon Collaboration

O.C. Allkofer, J.J. Aubert, G. Bassompierre, K.H. Becks, H.J. Behrend, M. Borghini, D. Botterill, X. de Bouard, F.W. Brasse, C. Broll, R. Clifft, G. Coignet, F. Combley, G.R. Court, P. Dalpiaz, P.F. Dalpiaz, W. Dau, J. Drees, F. Farley, J. Favier, M.I. Ferrero, J.H. Field, W. Flauger, C. Franzinetti, E. Gabathuler, R. Gamet, J. Gayler, J.P. Grillet, U. Hahn, P. Hayman, J.R. Holt, H. Jokisch, H. de Kerrett, A. Ladage, L. Massonet, H. Mohr, H. Montgomery, K. Moser, P.R. Norton, U. Opara, P. Payre, H. Pessard, K. Rith, M. Rousseau, E. Schlösser, M. Schneegans, T. Sloan, P. Söding, H.E. Stier, J.P. Thenard, J.J. Thompson, F. Vannucci, M. Vivargent, H. Wahlen, W.S. Williams

This experiment will be the first in a programme of physics experiments with high energy muons using a large spectrometer facility. The aim of this first experiment will be a study of the inelastic scattering of muons from hydrogen to try to understand better the physics of virtual photon interactions over a wide range of four-momentum transfer (q^2).

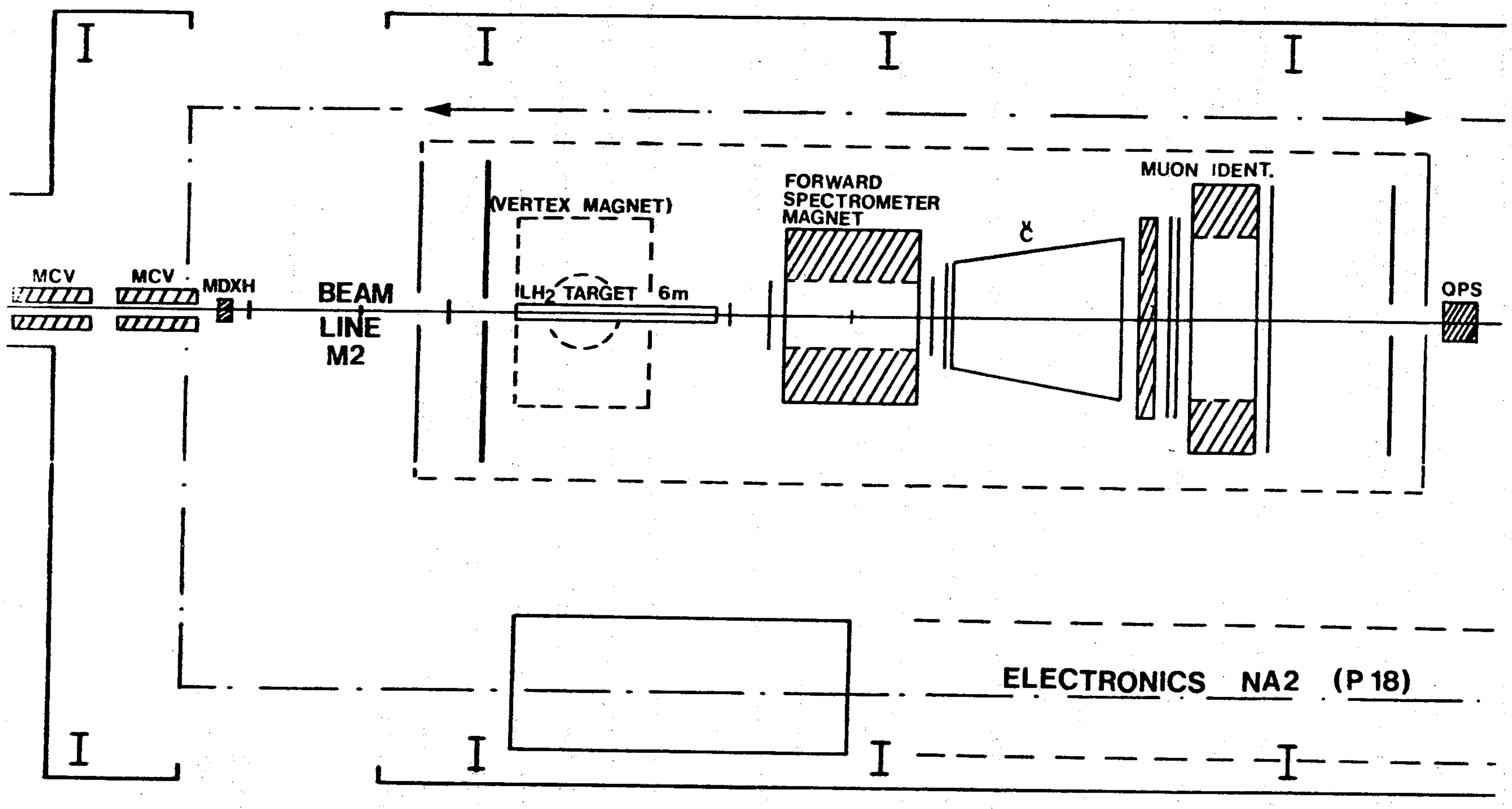
The first stage of the spectrometer facility will include a forward spectrometer comprising a large aperture dipole magnet (2 m x 1 m) of bending power $\sim$ 5 Tm and a magnetised iron filter to distinguish the scattered muons from hadrons. Drift chambers and MWPC will be used before and after the magnet to detect charged products of the interaction and to allow a momentum determination of the scattered muon to an accuracy of $\sim$ 1% at 100 GeV/c, and an angular definition of ±0.1 mrad. The triggering on scattered muons will rely on three planes of scintillation counter hodoscopes before and after the magnetised iron, whose magnetic field serves to eliminate triggers from low momentum muons which will be produced copiously by pion decay.

At a later state it will be possible to replace the liquid hydrogen target by a polarised target to gain information on spin effects. Also a gamma-ray detector and/or Čerenkov hodoscopes can be added. Later experiments using this facility envisage the addition of a vertex magnet surrounding the target to maximise the acceptance for momentum-analysed produced hadrons. It is thought that at this stage a streamer chamber could be installed in the vertex magnet to provide the vertex information.

(Summary prepared by J.V. Allaby)

References

SPSC/74-78/P.18



Experiment NA2: Electromagnetic Interactions of Muons

Expt.	:	NA3
Beam	:	Not decided
Approved	:	12.03.75
Status	:	preparation

High P_T Leptons and Hadrons

CERN-College de France-Ec.Poly.-Orsay-Saclay Collaboration

J. Badier, G. Burgun, P. Charpentier, M. Crozon, D. Decamp, P. Delpierre, P. Le Dû, W. Kienzle, J. Lefrançois, Y. Lemoigne, T. Leray, G. Matthiae, A. Michelini, H. Nguyen, O. Runolfsson, R. Vanderlagen, S. Weiz

This experiment aims to study production of large transverse momentum leptons and hadrons in hadron-nucleon collisions up to the highest energies available at the SPS. The apparatus is planned specifically to study:

a) $\mu^+\mu^-$ pairs } "μ-trigger"
b) e^+e^- pairs in association with hadrons }
c) eμ pairs in association with hadrons } "e-trigger"

The same apparatus can be used to study hadron reactions such as:

d) large P_T hadron-hadron correlations }
e) large P_T hadron resonances } "hadron trigger"
f) search for new high-mass particles }

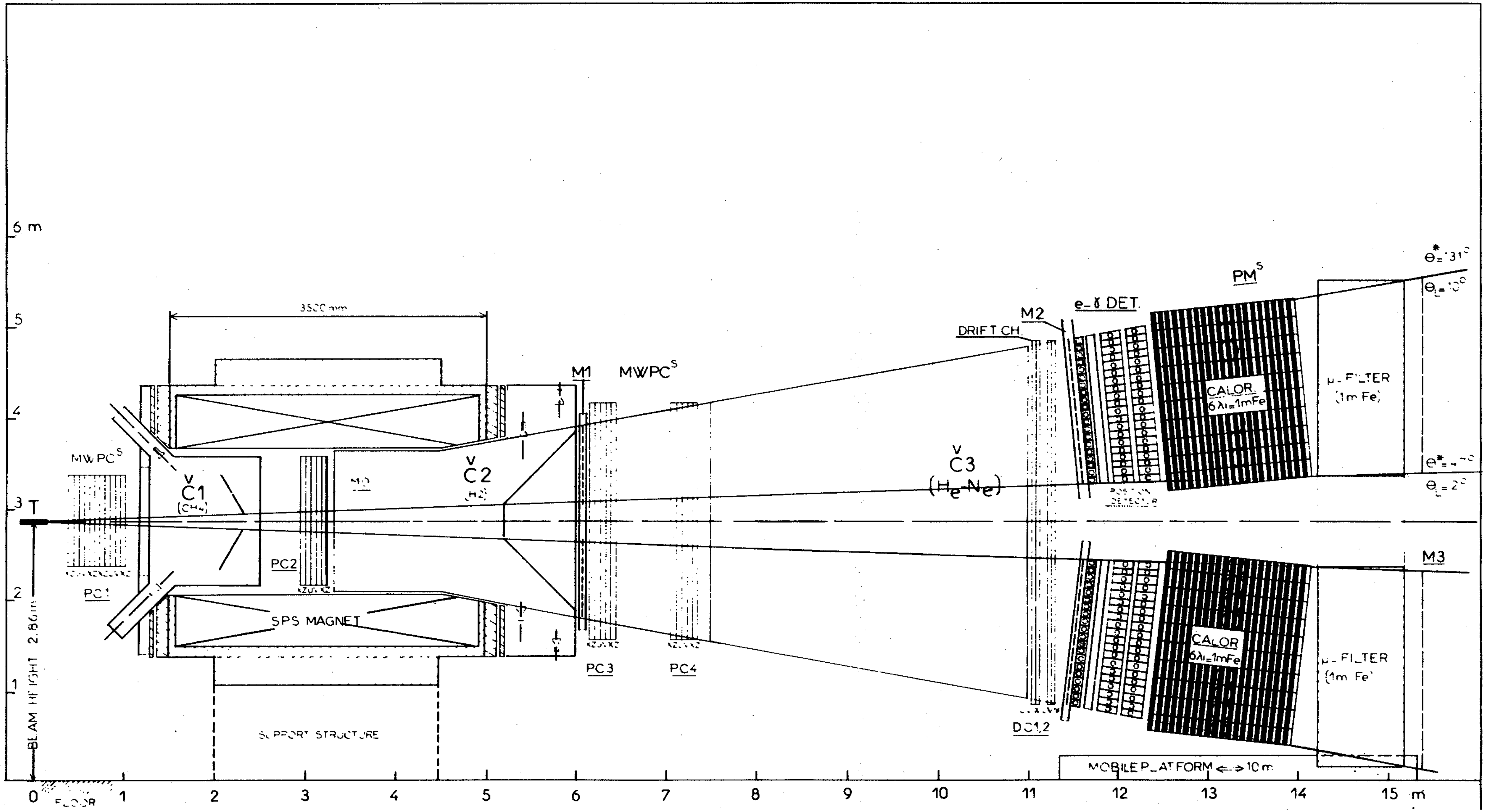
The apparatus includes a large aperture superconducting dipole magnet 3.5 m long and with 1.6 m diameter cylindrical aperture, having a total bending power of 4.6 Tm.

A combination of drift chambers and MWPC located before, after and inside the magnet provide for track location. Threshold Čerenkov counters are included for particle identification. A hadron-electron calorimeter split into two sub-units is used to trigger on the vertical component of P_T. In addition a coincidence matrix requirement is put on the events to define a minimum in the vertical component of P_T. The equipment is completed by a μ-filter behind the calorimeter.

(Summary edited by J.V. Allaby)

References

SPSC/74-90/P 24



PC1-PC4 : Multiwire Proportional Chambers

DC1, 2 : Drift Chambers

T : Liquid Hydrogen Target

MO-M2 : Trigger Hodoscopes

Experiment NA3: High P_T Leptons and Hadrons

NA 3

Expt.	: NA4
Beam	: M2
Approved	: 07.05.75
Status	: preparation

Inclusive Deep Inelastic Muon Scattering

CERN-Dubna-Munich-Rome-Saclay Collaboration

F. Ceradini, M. Conversi, J. Feltess, M. Ferrer, I. Golutvin, H. Hilscher, V. Kukhtin, R. Leiste, A. Levèque, U. Meyer-Berkhout, F. Muller, B. Naroska, E. Pauli, J. Renardy, C. Rubbia, S. Santonico, I. Savin, D. Schinzel, G. Smadja, M. Spiro, A. Staude, G. Tarnopolsky, G. Vestergombi, S. Vitale, J. Zsembery, C. Zupancic

This experiment aims to investigate deep inelastic inclusive muon scattering to the highest energy and q^2 made available by the high intensity muon beam M2. The target has a length of $\sim$ 50 m of either liquid hydrogen or liquid deuterium and is surrounded by a magnetized torus. The properties of the magnetized torus, which will be operated in a saturated mode, are to produce oscillations of scattered muons about the beam axis, where the amplitude of the oscillation is proportional to q^2. This property causes trapping of muons inside the torus leading to a high efficiency for their detection. In addition the triggering can be set on a minimum q^2 for the reaction by demanding that a muon reach a certain minimum distance from the axis.

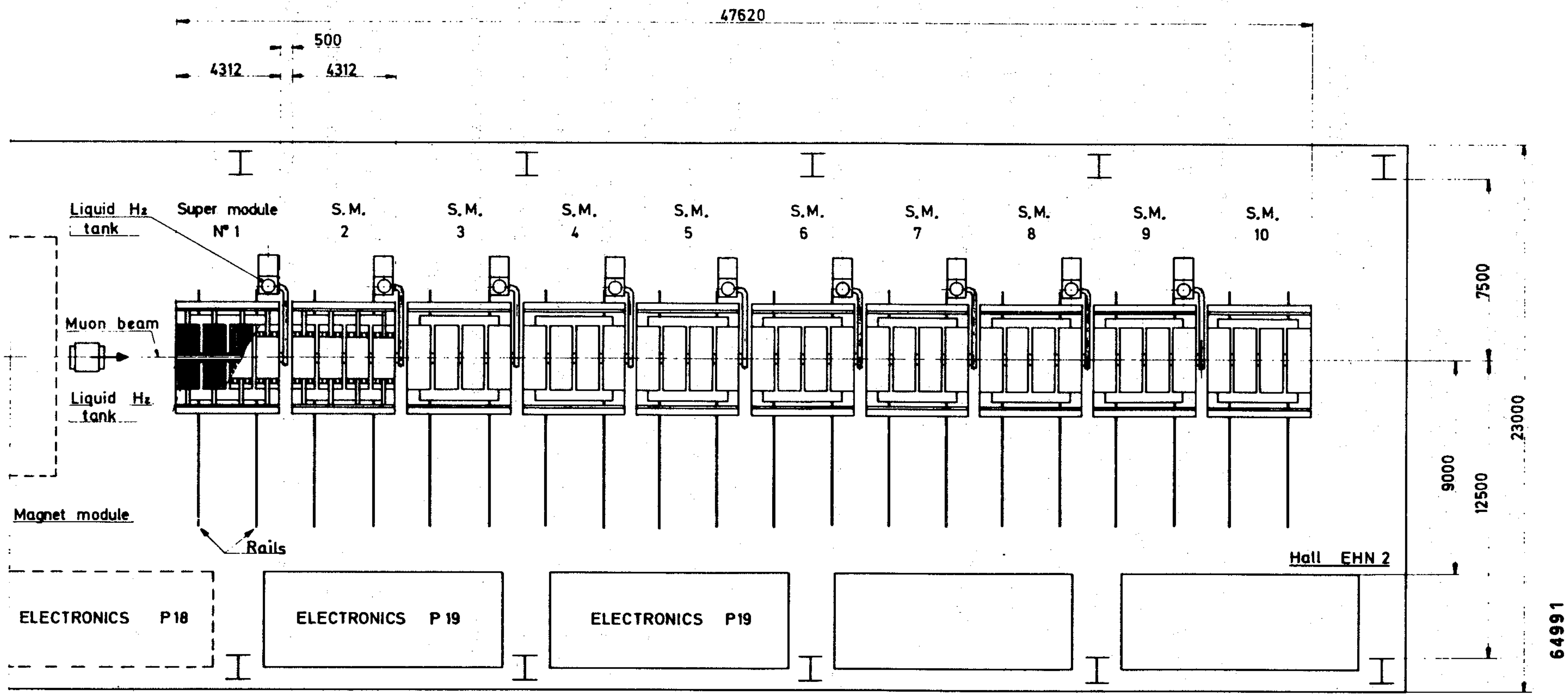
In the proposed device, the magnetized torus has a diameter of 2.7 m and is divided into 10 separate super modules, each with its own 5 m long target. Each super module is divided into 4 modules where each module contains $\sim$ 1 m of steel, a set of MWPC, and trigger counters. Each super module has a separate coil to magnetize the steel. With this device, muons scattered with $q^2 < 0.7\ q^2_{max}$ will be trapped in the torus (where $q^2_{max} = 2\ M_p E_o$). Events escaping the torus are not lost but the accuracy in the determination of the muon momentum is reduced.

The experiment, with the exception of small beam defining counters, has no detector in the direct beam and can operate in incident beam fluxes up to 10^9 particles/pulse.

(Summary edited by J.V. Allaby)

References

SPSC/74-79/P19, SPSC/74-103/P19/Add.1, SPSC/74-108/P19/Add.2, SPSC/74-120/P19/Add.3, SPSC/75-32/R22.



Experiment NA4: Deep Inelastic Muon Scattering

Expt.	: NA5
Beam	: not decided
Approved	: 04.06.75
Status	: preparation

Inelastic Hadron Reactions Using a Streamer Chamber Triggered by a Single-Arm Spectrometer

Max-Planck Institute, Munich

G. Buschorn, I. Derado, V. Eckardt, J. Fent, H-J. Gebauer, U. Kruse, A. Manz, A. Odian, K.P. Pretzl, N. Schmitz, R. Settles, P. Seyboth, J. Seyerlin, G. Wolf

The experiment will study inelastic hadron reactions induced by various incident hadrons (π, K, p) in a liquid hydrogen target. The aim of the experiment is to analyse as completely as possible all charged particles in the final state. The basis of the trigger is to select a particle of particular type and momentum by means of a single arm spectrometer which can be set at a chosen angle (for example 90^{o} c.m.). In the proposal the group discuss the use of the triggering system to select hadrons produced in the transverse momentum range $1.0 < p_T < 3.0$ GeV/c but have pointed out the possibility of adapting their trigger to new physics questions should the high p_T trigger not be the most interesting at the time the experiment is performed.

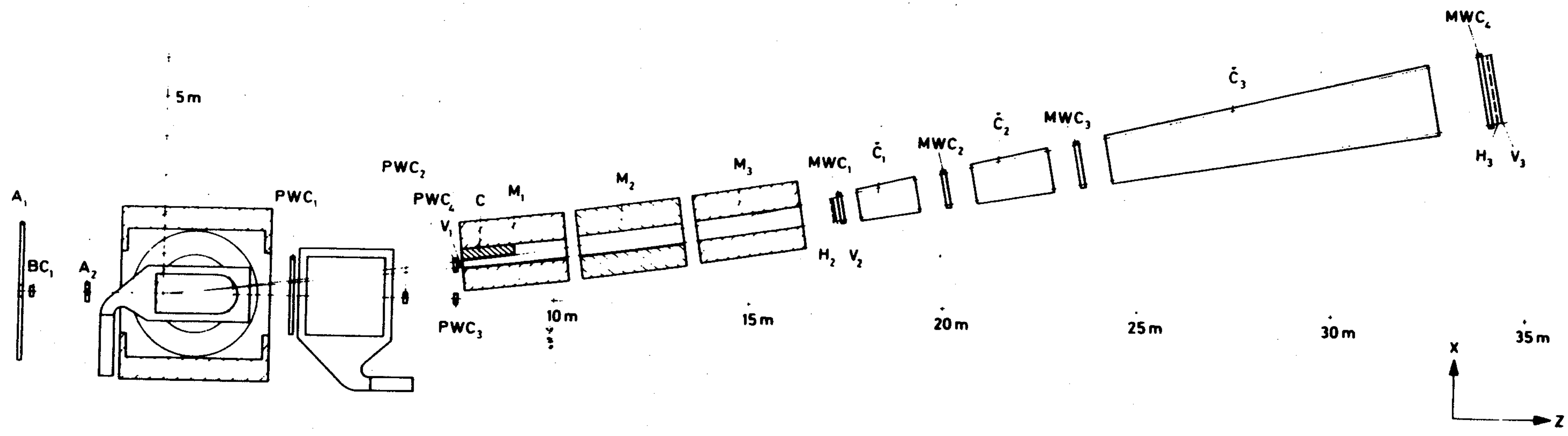
The apparatus comprises a vertex magnet (1 m gap, 2 m diameter) with a 30 cm long hydrogen target inside a large streamer chamber, a second streamer chamber downstream of the magnet to give improved momentum resolution and pattern recognition for forward tracks, and the triggering spectrometer which uses three standard P.S. magnets, wire chambers and three threshold Čerenkov counters to define the momentum and mass of the triggering particle. Four MWPC will be used downstream of the vertex magnet to separate beam tracks and to reconstruct the triggering particle trajectory on-line.

The second streamer chamber will be used to identify produced particles by means of the relativistic rise of ionization. The streamer chambers will each be viewed by 3 cameras equipped with single stage image intensifiers.

(Summary prepared by J.V. Allaby)

References

SPSC/75-1/P37, SPSC/75-38/P37/Add.1.



M1 - M3	:	Standard PS Dipole Magnets
C1 - C3	:	Threshold Cerenkov Counters
PWC1 - PWC4	:	Multiwire Proportional Chambers
MWC1 - MWC4	:	Magnetostrictive Wire Chambers
V1 - V3		
H1 - H3	:	Trigger Hodoscopes

Experiment NA5: Inelastic Hadron Reactions Using a Streamer Chamber