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PROPOSAL TO CONTINUE THE STUDY OF DI-MUON PRODUCTION BY $\pi^{\pm}$, $K^{\pm}$, p AND $\bar{p}$ AT 40 GeV/c

M.J. Corden, J.D. Dowell, J. Garvey, R.J. Homer, M. Jobes, I.R. Kenyon, T. McMahon, R. Vallance, P. Watkins, J. Wilson
- Birmingham University

J. Gago, M. Jung, P. Sonderegger, P. Woodworth - CERN

M. Bogdanski, D. Perrin - Neuchâtel University

B. Chaurand, L. Fluri, A. Romana, R. Salmeron
- Ecole Polytechnique, Paris

K. Sumorok - Rutherford Laboratory

Spokesman: J.D. Dowell

PROPOSAL TO CONTINUE THE STUDY OF DI-MUON PRODUCTIONS BY $\pi^{\pm}$, $K^{\pm}$, p and $\bar{p}$ AT 40 GeV/c

Birmingham - CERN - Neuchâtel - Paris - Rutherford Collaboration

Summary

We propose to repeat the beam dump experiment in Omega (WA12) using 40 GeV/c $\pi^{\pm}$, $K^{\pm}$, p and $\bar{p}$ with an order of magnitude more events and the aim of

a) obtaining 100 - 200 J/ψ events from $\bar{p}$ and $K^{\pm}$ and determining cross section ratios and x-distributions;

b) studying the Drell-Yan continuum for $\pi^{\pm}$ events, in addition to J/ψ;

c) studying P_t distributions as a function of x and $m_{\mu\mu}$ for $\pi^{\pm}$ events.

Modifications to the beam and trigger counters are proposed to allow a factor 3 higher flux, which can be handled with the optical chamber system. The remaining factor will be obtained from improved SPS performance and longer running time. In all 7 x 5 days are requested in the S1 beam.

1. Physics interest

1.1 We have recently completed an experiment (WA12) to measure the cross sections for ψ production by $\pi^{\pm}$, $K^{\pm}$, p and $\bar{p}$ at 39.5 GeV/c using the S1 beam (see separate preprint). We have compared the relative cross sections with the predictions of the quark annihilation model of Donnachie and Landshoff[1] and the gluon amalgamation model of Ellis, Einhorn and Quigg[2]. Our results are in broad agreement with the former model. However the latter predicts unity for the particle antiparticle ψ production cross section ratios while we observe $\sigma_{\bar{p}}/\sigma_{p} \sim 6 \pm 2$. The $\bar{p}$/p ratio also disagrees with the model of Fritzsch[7] who predicts a much higher number. Furthermore our x-distributions for π-induced πs agree with the quark annihilation model and are very similar to other experimental data at 150 GeV/c[3], 200 GeV/c[4] and 224 GeV/c[5]. However, our statistics for $K^{\pm}$, $\bar{p}$ and p are too poor to obtain meaningful x-distributions and a more precise measurement of the ratios would allow better discrimination between models. An order of magnitude improvement in statistics would provide $\sim$ 100 - 200 events for the rarer particles, in line with our original aim, allowing the cross sections to be determined more precisely and a comparison of the x-distributions to be made.

1.2 Although not mentioned in our original proposal we have observed pion-induced Drell-Yan continuum muon pairs, both above and below the ψ-mass. This will be the subject of a further paper. The ratio of the π^- to π^+ cross sections is $\sim$2 for events just below the ψ. Above the ψ we have about 12 events for π^-, consistent with the number expected for the Drell-Yan process. The value of m^2/s is $\sim$0.25 for these events, considerably higher than that for the data obtained in the corresponding FNAL experiments [3, 5]. With ten times the data on π^- and a comparable amount of π^+ we should have good measurements of the scaling behaviour against the 150 GeV and 224 GeV FNAL data [3, 5].

1.3 With a few thousand pion induced events we would be in a position to check the variation of the P_t dependence of the cross section for both ψs and continuum pairs as a function of x. There is considerable interest in determining this dependence [6] which is relevant to the planning of searches for weak bosons.

1.4 As both the S1 and H1 beams are available to Omega it is natural to ask whether the experiment would be better carried out at 80 GeV/c. Both cross sections and acceptance would be higher giving an overall improvement of a factor of 5 for π^- and much more from protons, because of the higher beam content. However, the fluxes of kaons and antiprotons are lower at 80 GeV/c so that there would barely be any gain for $\bar{p}$ and about 2 - 3 for kaons. 40 GeV/c is favoured because the differences between $\bar{p}$ and p cross sections are greater there as are the differences between K^- and K^+. In terms of the parton model the valence quarks dominate for $\bar{p}$ and K^- and the sea quarks for protons and K^+ so we are likely to learn more about the particle structure at 40 GeV/c. On the other hand better pion data would be obtained at 80 GeV/c. Ideally one would do both momenta but we have chosen 40 GeV/c on the assumption that running time will be limited and because of the difficulties of providing particle identification in H1 without disturbing the photon tagging system.

2. Modifications to the experiment

2.1 Although in our previous run our statistics were low compared unwise to rely on more than a factor of 2 improvement in data rate due to improved spill and performance of the SPS. A further factor of 2 can be obtained by running for a longer time but we need to obtain a factor of about 3 from improvements to the experiment.

2.2 The basic limitation on the event rate in the previous experiment was not given by accidental tracks in the spark chambers. The average multiplicity of extra tracks on ψ events due to punch-through and halo muons was only 1.0. A factor of 3 increase in this number can be tolerated without affecting the reconstruction efficiency since the tracks are well separated after the dump and in-time muons are recognised by their associated hits in the multiwire chambers and their correct extrapolation to the Birmingham hodoscope. We wish to use the optical spark chambers because

a) the programs are written and work well;

b) they provide the best resolution obtainable with the existing equipment (FWHM on ψ = 350 MeV/c^2), i.e. it is dominated by multiple scattering in the copper absorber. A loss of resolution and acceptance would result if we were to use the existing multiwire chambers and drift chambers to reconstruct events.

However, some tightening of the trigger is necessary if we are not to suffer appreciable dead time losses. During the old run we ran at 10 triggers per burst giving a dead time loss of about 20%.

2.3 The rate limitation came from the threshold Cerenkov counters of the method and to avoid pile-up effects a past-future protection of $\pm$20 nsecs was provided on one of the beam counters. Under these conditions we were able to run at an incident flux of 3×10^6 with 300 msec. effective spill time. To remove this basic limitation we propose

a) to replace the three threshold Cerenkov counters by 2 cedars (or 1 cedar and 1 other differential counter) with one of them counting $\bar{p}(p)$ and the other $K^-(K^+)$;

b) to replace the target box counters by sets of narrow scintillator hodoscopes with target elements between them. One and only one particle within 4 nsec (the separation between RF bunches) would be required in the entrance hodoscope. Non-interacting particles would be vetoed - i.e. those giving one hit in the final hodoscope;

c) to replace the counter S6 by $\sim$20 elements (instead of 4). The trigger would require 2 and only 2 elements and would provide the basic strobe for the MWPC. A timing check would ensure that the same particle which caused the interaction in the target box gave the counts in S6.

The new layout is shown schematically in figure 1. The above changes should allow the beam flux to be raised by the required factor. There will be a 30% accidental rate in the MWPC but accidentals will be mostly recognized by spatial correlation with the S6 counters.

2.4 The remaining problem is to reduce the triggering rate to avoid excessive dead time losses in the spark chambers. The trigger consists of an interaction in the target box, 2 hits in S6, 2 hits in the Birmingham hodoscope (after the yoke) and a mass selective in our previous running where we allowed 2 or 3 hits in the multiplicity chamber to trigger the system. A check of analysed data showed that ψs came almost exclusively from events having 2 hits in the multiplicity chamber, so a reduction will be achieved here which will be improved further by the new S6 requirement (previously ⩾ 1 hits were required in S6).

Two further methods are at our disposal to reduce the triggering rate. Firstly we now have available new correlation logic which can correlate counter and multiwire information to select good events and finally we can scale down pion induced events at the trigger level by any desired factor. The latter is not a desirable method because we want these events for Drell Yan and P_t studies but it would improve the ratio of the rare particle events to pion induced ones.

3. Running time request and timescale

We could be ready to run 4 months after obtaining approval, the time being required to prepare the new counters.

We assume the following improvement factors:-

2 from improved spill and SPS performance

3 from improvements to the experiment.

Based on our original data taking we estimate that this will yield 400 π^- induced ψs per day at 8.4 sec repetition rate. The corresponding numbers of $\bar{p}$ or K^- events are ∿10 each per day. We therefore request 20 days of good beam (4 weekly periods) on negatives and 10 days (2 weekly while other experiments are using Omega.

4. Data analysis and computing

The experiment would produce an order of magnitude more data than was obtained in the first run and was processed at CERN. We propose to process the data from the new run at Rutherford and Ecole Polytechnique where we have time available. However, testing and calibration runs will be necessary at CERN for which we request 20 hours of CDC 7600 time to be compared with about 300 hours at the outside laboratories.

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Figure 1

Modified layout for this experiment

The proposed apparatus differs from that used in our previous experiment as follows:

C1 is a Cedar counter and C2 is a second Cedar or the short differential Cerenkov already in use in S1.

T1-4 are finger hodoscopes.

S6 is a segmented scintillator counter.

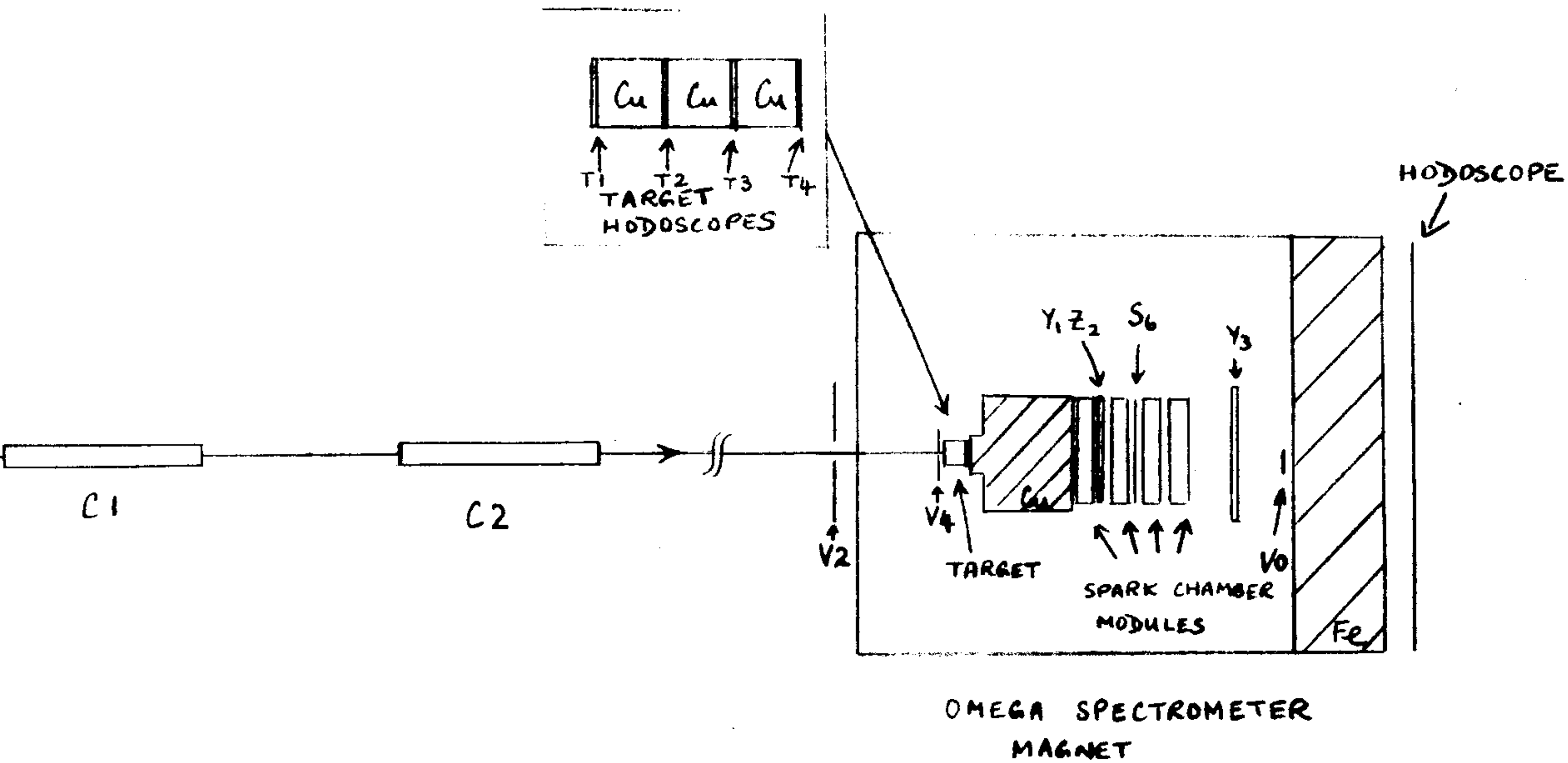

FIGURE 1 SCHEMATIC LAYOUT OF APPARATUS