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Letter of Intent for the Study of Multi-Particle Hadron Physics at the CERN-SPS

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Introduction

In September 1973 the Max-Planck-Institut - München in collaboration with the University of München, College de France, Ecole Polytechnique, Orsay and Saclay submitted a Letter of Intent to build a multi-particle spectrometer at the CERN-SPS (CERN/SPSC/I 73-42). Following the recommendation of CERN a group of physicists of these Institutes and of CERN subsequently studied the features of such a facility in more detail and summarized the results and conclusions of this study in a White Book (CERN/SPSC/74-63). The present Letter of Intent is based on this work.

From this previous work it appears that building a general purpose multi-particle hadron spectrometer for the SPS energy range involves a large effort and is difficult to specify now in detail for an experimental program to be carried out in the late 1970 ies and early 1980 ies. However, a number of interesting physical questions can already be studied with a much simpler detector consisting essentially of a magnetic vertex detector combined with suitable triggers. We therefore intend to propose a hadron physics program with such a detector - which later could be extended with a magnetic forward spectrometer - for the North Area of the CERN-SPS.

Physics

Hadronic interactions at high energies are characterized by high multiplicities. In addition many processes (e.g. double diffraction, high p_t-processes, heavy particle production) have small cross sections.

A streamer chamber in a magnetic field appears to be an almost ideal detector for the study of such hadronic interactions at high energies, since it

- has 4π-acceptance
- can tolerate high beam intensities (up to about 10^7 pps), is triggerable and therefore sensitive to small cross sections (considerably less than 1 μb)
- will have less problems with pattern-recognition of high-multiplicity events than any other known electronic detector
- allows particle identification by ionization measurement for low energy particles (separation of π/K, K/p, π/p for $p < 0.7$, 1.0, 1.4 GeV/c resp.).

A streamer chamber vertex detector placed in a medium intensity-high energy $\pi/K/p$-beam in the SPS-North Area therefore can close in some sense the gap existing between ISR-experiments (where only pp-interactions can be studied) and NAL-experiments (where hydrogen bubble chambers so far do not allow the study of small cross sections and electronic detectors have to face pattern recognition problems for the higher multiplicities).

Within the broad physics program that can be studied with such a detector we are considering as a first experiment a systematic and complete study of diffraction dissociation of the target nucleon. Such a study would involve the measurement of the momentum transfer, the mass, the charged multiplicity and the particle composition of the diffractive system. Questions of interest are e.g. scaling of the mass distribution with s, semi-inclusive KNO-scaling of the multiplicity distribution with M^2, occurrence of rare particles in the diffractive system, diffraction dissociation at higher t i.e. for fixed M at higher p_t of the single particle. The fact that with increasing energy higher diffraction masses occur in connection with higher multiplicities ($\bar{n} \sim \log M$) makes a visual vertex detector the most suitable device. Furthermore one would like to study the decay properties of the diffractive system (momenta of decay particles, correlations among them) and the dependence of diffraction dissociation on the momentum and the kind of incident particle

An investigation along these lines would require apart from the vertex detector a forward trigger able to identify a single particle and to determine with high resolution its high (near beam) momentum. This trigger could for instance be provided by a small solid angle focusing spectrometer consisting of beam transport elements.

Other topics that could be studied with this detector are e.g. baryon-exchange by triggering on a fast forward going baryon, quasi-2-body reactions with quantum number exchanges and therefore small cross sections, high p_t-processes with observation of the complete event, search for heavy or rare (exotic or charmed) particles. While these examples are of current interest, other and new questions might come up between now and the time the SPS North Area comes into operation. We believe that a streamer chamber vertex detector with exchangeable trigger devices or forward arms offers a particularly high degree of flexibility.

Apparatus

The streamer chamber and vertex magnet for this type of vertex detector have been described in Appendix 3 of the White Book. Large parts of the apparatus would be designed and constructed in our Institute. We repeat here the main parameters of the detector and refer to the White Book for details.

Streamer chamber: We consider a 3-gap streamer chamber of 200 x 100 x 60 cm^3 overall dimensions operated in avalanche mode. This operation mode not only provides more isotropic conditions and higher resolution than the streamer mode, but also avoids largely the flare problem. The low light output can be overcome by the use of image intensifiers or vidicons.

The chamber can accomodate target cells with lengths up to .5 m. The high voltage system can operate at rates up to 10 pulses/sec.

For event recording we consider for the initial stage a conventional camera set-up using image intensifiers, which in a more advanced stage might be replaced by a filmless system. The present data evaluation system (HPD etc.) of Munich is

Vertex magnet: Since a vertical dipole field seems best suited for the recognition and measurement of higher multiplicities (most particles are produced close to the forward direction and are spread out by a dipole field), we consider a dipole magnet with an opening in the top providing optical access to the streamer chamber.

A suitable magnet could be a scaled down version of the magnet designed by a Saclay Group (comp. White Book Appendix 1) with a gap height of 1 m, a pole diameter of 2 m, a central field of 20 KG.

Future developments

The use of the vertex detector can be extended considerably by completing it - along the lines described in the previous Letter of Intent or the White Book - with a magnetic forward spectrometer equipped with Cerenkov counters. It is planned to carry out this extension in a later series of experiments together with members of the CERN-Munich-Spectrometer-Collaboration.

Proposal

We intend to submit a detailed proposal along the lines discussed in this Letter of Intent by the beginning of 1975.

Munich, August 1974