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COMMENTS ON HYBRID SPECTROMETER SYSTEM

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Several ideas have been proposed using a three or four stage spectrometer system with each successive stage capable of measuring higher momenta particles in a smaller forward cone than the previous one. The first stage has been variously proposed to be a hydrogen bubble chamber, a streamer chamber with a gas and/or liquid hydrogen target region and a hydrogen target surrounded by cylindrical wire chambers. Each of these has certain advantages and each is inexpensive enough that one might wish to build more than one type of device. The expensive parts of the apparatus, as presently outlined in the proposals, are the subsequent stages which are contemplated to be spark chamber plus bending magnets to accurately measure momenta. There is considerable disagreement about the cone of particles it is desirable and economically possible to design for. The purpose of this paper is not to present a spectrometer design but rather to set down criteria on which to judge ideas and to present ideas which must be investigated thoroughly before a sensible spectrometer design can be made.

1. On-line operation. The present generation of high-energy physicists has largely forgotten the considerable advantages of being able to see results in time to make use of them in the remainder of the experiment.

One advantage lies in diagnosing whether the equipment is working. (Are the spark chambers efficient? Is the momentum spread of the beam as small as desired?) A second advantage is in scrutinizing the data to decide what it is interesting to examine more carefully while the experiment is still set up. In many experiments it will be worthwhile sacrificing a large factor in rate in order to have on-line results. Wire spark chambers or wide-gap chambers with vidicon viewing (if they prove practical) have enormous advantages.

2. Position accuracy. A factor of two in position accuracy will save approximately a factor of 4 in spectrometer costs. (The $\int Bdl$ can be smaller by a factor of 2. In addition, the shorter magnet results in a smaller gap for a given acceptance.) At present optical chambers give 0.2 mm accuracy. Present wire chambers in actual experiments give 0.4 mm accuracy. There are reports of higher accuracy with wire chambers. A careful investigation including an experimental program if necessary should be carried out before any work is started on detailed spectrometer magnet design. This investigation should start immediately since all other decisions depend on knowing the accuracy practically attainable.

3. Magnetic field uniformity. There is a considerable saving in computing if the spectrometer field is uniform enough that a simple bending angle approximation with small corrections can be used for momentum analysis. This may seem like a minor point, but it is easily

conceivable that 10 momentum calculations per second will be desirable so that a very nonuniform field would result in momentum calculations which saturate a rather large computer and negate any saving in magnet costs.

4. Solid angle vs rate considerations. Some spectrometer designs have contemplated a very expensive large solid-angle spectrometer for the highest momentum particle. Despite this, some of the potentially most interesting experiments do not fall in a category which easily uses such equipment. One can argue that since even the largest feasible spectrometer must be moved to encompass the t range desired in many experiments, it is better to sacrifice rate and build several small-aperture spectrometers rather than one large one. Considerable flexibility is gained by using this approach, and one can accommodate groups doing a variety of experiments using different techniques. Since much of the machine time is used in setting up and testing equipment, the loss in rate on a single experiment is not too serious and is more than compensated for by the other experiments. The only advantage of a large-aperture spectrometer is the possible reduction of angular biases in some experiments. This advantage must be weighed against the factors mentioned above which I think are very important, especially in the first few years of accelerator operation.

The four points above are considerations which can be answered in a somewhat general way before a detailed spectrometer design is considered. For the sake of completeness, a nonexhaustive list of more detailed and more obvious considerations follow:

a) Magnet configuration. Since a progressively narrower acceptance cone is needed as one goes up in energy, money is saved and flexibility gained by using several stages of momentum analysis. For a given total length a spectrometer having unequal measurement distances before and after the magnet can reduce the magnet gap requirements with little sacrifice in accuracy.

b) There are serious problems with multitrack efficiency in narrow-gap spark chambers especially when the tracks are close together (< 0.5 cm).* In wide gap and streamer chambers the situation is somewhat better and, of course, the bubble chamber is best in this regard.

c) Slow recoils. A practical limit for wire chambers surrounding a liquid H_2 target is about 200 MeV/c for a recoil proton. Streamer chambers with H_2 gas targets are ideally suited for these measurements.

d) Neutral particle detection. Obviously very important in some experiments and very difficult. Since the experimental arrangement will undoubtedly vary widely from experiment to experiment it provides yet another reason for retaining as much flexibility as possible in the rest of the spectrometer rather than building one mammoth semi-permanent facility.

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*Not necessarily, under suitable operating conditions--Ed.

e) Momentum accuracy. 0.1% or better on the primary beam and high momentum secondaries.

f) Rates. Spark chambers in general can use particle fluxes a factor of 10^4 higher than bubble chambers. The loss in solid angle in spark chambers is not nearly as serious as at lower energies. Even with a gas hydrogen target a streamer chamber is a factor of 10 better in event rate than a liquid hydrogen bubble chamber.