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ACCELERATOR DEPARTMENT
Informal Report

A MULTIPARTICLE DETECTOR FOR ISABELLE

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A Multiparticle Detector for Isabelle

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The proposed multiparticle spectrometer is designed to study particles produced at small angles ($0.5 < \theta < 20 \text{ mr}$). It is assumed to be part of a larger set-up, where the larger angles are covered by other spectrometers, or at least a 4π detector, such as described by Arnold et al. (CRISP 72-65).

The general layout consists of 4 magnets in a symmetrical arrangement, as shown on Fig. 1. Magnet B_1 introduces dispersion, while B_2 compensates for it. A set of proportional chambers downstream from B_2 can measure both angle and momentum. The apparatus may in fact end here, however, using a second pair of magnets B_3 and B_4 the momenta can be re-combined. Then all tracks will point back to the original interaction point in compact bundle, which may be suitable for particle identification by Čerenkov counters further downstream.¹

Acceptance and Resolution.

Downstream of B_2 the displacement for particles produced at 0° is $5 \frac{Po}{P}$ cm. The divergence due to finite production angle is to be added to this. We assume that the vacuum tank allows particle detection starting 1 cm from the nominal beam center. Then the acceptance in X vs $P_\perp$ space is shown on Fig. 2. The upper limit in $P_\perp$ is determined by the width of the magnet-gap.

In calculating the resolution we assume that the interaction point can be used in track reconstruction, and that it is determined to within $\pm 2\text{mm}$ in the transverse directions. Then with 1mm resolution in the proportional chambers, we get $\frac{\Delta P}{P} \approx \pm 4\%$ at 200 GeV/c , 0.4% at 20 GeV/c . Using two sets of proportional chambers behind B_2 , 3m apart, the production angle is determined to $\Delta\theta \approx 0.5\text{ mr}$. A better measurement can be made with the four-magnet system behind B_4 , where if the interaction point is used, one gets $\Delta\theta \approx 0.1\text{ mr}$.

Magnets, Vacuum chamber.

Each of the proposed magnets has $|Bdl| = 60\text{ kgm}$. To accept $\pm 20\text{mr}$ production angle, and $20\text{--}200\text{ GeV/c}$ momentum bite, the gap dimensions become:

B_1 : 0.32m high $\times$ 0.5m wide

B_2 : 0.56m high $\times$ 1.5m wide

B_3 : 0.8m high $\times$ 1.75m wide

B_4 : 1.0m high $\times$ 1.2m wide

Smaller gap heights lead to a proportional decrease in solid angle acceptance, and economy might dictate cutting all heights by a factor of 2 or so. Then we still have $\pm 20\text{mr}$ in the bending plane, $\pm 10\text{mr}$ in the plane perpendicular to it.

The vacuum tank will fill B_1 and B_2 . It flares out to contain all particles until they emerge from B_2 . Here a thin window allows the particles to escape into the air. It is also here that the first proportional chambers are placed. Out of the window come a small continuation of the vacuum tank ($\sim 12 \times 4\text{cm}^2$), which contains the two beams, whose centers are bent

apart by 10cm at this point (in addition to the separation due to finite crossing angle).

Space and luminosity requirements.

To allow for other detectors near the intersection region, we place the first magnet starting at 4.5m from the intersection point. This puts the downstream end of B_2 at 12.5m, and allowing 3.5 space to measure angles and momenta, the minimal setup ends at about 16m. If we add B_3 and B_4 , the length grows to 27m, but in this case further space is also needed for Cerenkov counters near the beam - a clear space of 50m total would be desirable on one side of the intersection.

A very large fraction of the interactions will produce particles which traverse this apparatus. Therefore the requirement is that the luminosity be set low enough ($\leq 10^{31} \text{ cm}^{-2} \text{ sec}^{-1}$).

Footnote .

(1) It may be useful to use a quadrupole doublet here to render a single momentum parallel. The use of differential Cerenkov counters may then be an attractive possibility: these can be considerably shorter in length than the threshold variety.

Fig. 2.

Acceptance

Note: Inside most of the polygon the acceptance is nearly 100%. There will be some losses due to the particles crossing the beam pipe downstream of B_2 . These losses become appreciable for the shaded region, and reach a maximum of 50% at the edge.