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We present an updated design for the large-angle spectrometer previously described in the 1976 Fermilab Summer Study.¹

As before, the primary objective of the device is to search for heavy stable ($\tau \geq 10^{-8}$ sec) particles by direct measurements of momentum, time-of-flight, energy deposition in a calorimeter, multiple dE/dx samples, and Cerenkov counter information. These quantities determine the charges and masses of stable particles which traverse the spectrometer, and provide a sensitive means of discovering new heavy objects.

Although the search for heavy stable particles is admittedly a long-shot experiment, the "bread-and-butter" physics that can be done with the spectrometer will also be of very great interest. In particular, the spectrometer can be used to measure the $\pi^\pm$, $K^\pm$, p and $\bar{p}$ inclusive cross sections at high transverse momenta. Using the gluon calculations of Cutler and Sivers², we would expect ~ 2 events per $\Delta p_T = 1$ GeV/c bin at $p_T = 50$ GeV/c in a run of $\int \mathcal{L} dt = 10^{36} \text{ cm}^{-2}$ (e.g., 100 hours at $\langle \mathcal{L} \rangle = 3 \times 10^{30} \text{ cm}^{-2} \text{ sec}^{-1}$). If the cross section were instead to continue to fall as parameterized by Field and Feynman³, this counting rate would be encountered at about one third of this p_T value.

The spectrometer could also be combined with other detectors. For example, a multiplicity detector could be used to trigger the spectrometer on "Centauro" events, as seen in

cosmic rays, and the detailed spectrometer information used to identify the nature of the particles produced in such events. Or, a calorimeter on the other side of the beam could be used together with the spectrometer to look at the correlations between jets in the calorimeter and high p_T particles of various types in the spectrometer.

The considerably larger acceptance of the present design may also permit the observation of hadronic jets in the spectrometer itself, and in particular provides the capability for the separate measurement and identification of individual particles within a jet. As in the previous design, the spectrometer is particularly well suited for operation in a high-background environment. It incorporates excellent accessibility and modularity, and can be easily reconfigured and modified to perform second generation experiments.

Plan views of the present spectrometer design are shown in Figures 1 and 2, with the spectrometer axis centered at 65° and 42° (90° in the center-of-mass for $\beta = 1$ particles, for 400 GeV x 1000 GeV and 150 GeV x 1000 GeV collisions respectively). The smaller laboratory angle in the latter case requires the SCM-105 to be positioned somewhat further from the interaction region. Figure 3 shows the elevation view in the 65° configuration. The principal improvements over the previous design are a considerably larger solid angle (2.5% of 4π sr in the center-of-mass for the 42° geometry, 3.1% of 4π sr at 65° : roughly 4 times and 8 times those of the 1976 Summer Study design), and a sophisticated set of drift chambers downstream of the spectrometer magnet. The chambers are similar to those described in

a recent ISR proposal⁴, and make use of charge-division readout to provide automatic association of horizontal and vertical coordinates, in addition to excellent spatial resolution, $\sigma \approx 0.2$ mm in the plane of bending. This method of readout requires the charge to be measured at the ends of each wire, and quite naturally gives ionization information at each chamber for every particle. These multiple measurements of dE/dx in the proposed set of 50 chambers gives an estimate of the velocity of each particle, and thus can be used together with the momentum measurement for particle identification, even in the high energy, relativistic-rise region.

The increased solid-angle acceptance has been achieved through the use of an Argonne SCM-105 dipole magnet with an 0.66 m $\times$ 2.13 m aperture, and a p_T kick of 0.35 GeV/c. In order to position the SCM-105 as close as possible to the interaction point, the wall between the C0 hall and the accelerator tunnel has been opened up (Figures 1 and 2), and the floor level has been lowered to 3 m below beam elevation (Figure 3). The improved resolution of the drift-chamber array approximately compensates for the shorter lever arm compared to the previous design, yielding momentum resolutions of $\sigma_p/p^2 = 0.29\%/GeV$ at 65° and $\sigma_p/p^2 = 0.24\%/GeV$ at 42° . The shorter time-of-flight path (2.8 m to the drift chamber exit) would require the time resolution to be improved from ± 1 nsec to ± 0.3 nsec to maintain the mass resolution shown in the 1976 Summer Study paper.

In order to match the increased solid angle of the spectrometer, the Cerenkov counters and the calorimeters have all become

considerably larger than previously. The calorimeter is designed to cover the full acceptance of the SCM-105 aperture only when it is positioned ahead of the Cerenkovs, at the exit of the drift chambers. The calorimeter design is very similar to that described in Refs. 1 and 5, and makes use of liquid argon and uranium for good hadron energy resolution. The first 15 radiation lengths are read out using 100 horizontal and vertical "strips" for electromagnetic shower identification, and the downstream portion is segmented into 8 rows and 12 columns of "towers", three layers deep. The calorimeter weighs about 45 tons, still lighter than the 110 ton SCM-105 magnet.

We estimate that spectrometer will cost about \$2.0 million to assemble:

Drift chambers and electronics	\$0.5 million
Cerenkov counters	0.4
Calorimeter and electronics	0.4
Proportional wire chambers	0.1
Scintillation counters	0.2
Miscellaneous	0.4
Total	\$2.0 million

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The cost of triggering electronics, the spectrometer magnet, and the on-line computer are not included in this total.

The requirements on the experimental area are modest. The total weight of the spectrometer is about 200 tons, and the floor area required is about 9 m transverse to the beam direction (on one side) by 12 m along the beam direction (9 m in the energy doubler direction plus 3 m in the main ring direction). The area should extend from 3 m below to 5 m above beam elevation

and needs a 35 ton crane to assemble the SCM-105 (largest piece weighs 31.4 tons). Electrical power requirements are mainly set by the spectrometer magnet, which consumes about 0.9 MW.

References

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Figure 1: Plan view of the spectrometer set up in the 400 GeV x 1000 GeV geometry, shown installed in the modified internal target hall at C0.

Figure 2: Plan view of the spectrometer set up in the 150 GeV x 1000 GeV geometry.

Figure 3: Elevation view of the spectrometer set up in the 400 GeV x 1000 GeV geometry, shown installed in the modified C0 hall.