# Test and Calibration Beams at the Superconducting Super Collider

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*Abstract*

Development and operation of the research detectors at the Super Collider will require extensive testing and calibration. This will be done by exposing the detector elements to controlled sources of particles similar to those which will be encountered when the experiments are taking data. The SSC Lab is designing a test beam facility to meet the needs of the proposed experiments using beam extracted from one or more of the booster accelerators in the SSC complex. In this report we describe the beam requirements and the transport, targeting, and civil systems needed to provide them.

## I. INTRODUCTION

Development and operation of the research detectors at the Super Collider will require extensive testing and on site calibration possibilities over a wide energy range. Todays precision measurments of jets as well as single particles dictates calibration from as low as 1 GeV/c$^2$ up to the highest possible energies. Such a dynamic range can not be covered by a single test beam. The arrangement of the Medium Energy Booster (MEB) and the High Energy Booster (HEB) of the accelerator complex of the SSC provides a possibility to extract two primary beams of 200 GeV/c and 2 TeV, respectively, and to bring them to a common switchyard as shown in Fig. 1. For financial reasons the 2 TeV beam will be constructed later since it requires an approximately 8000' tunnel to bring it to the location of the MEB closer to the surface, not to speak of the many additional benders and quadrupoles . For the same reason we would build only three of the six forseen 200 GeV beams in a first phase, see Fig. 2. Here we present a study of a possible minimal switchyard for three 200 GeV test beams which has the potential of accomodating a future 2 TeV beam. This layout deviates from earlier scenarios as e.g. described in [1,2]. This design however gives us a measure of our flexibility in test beam geometry. The footprint is so that it may be "duplicated" across the indicated (dashed) symmetry line in Fig. 2 resulting in a total of six 200 GeV beams ond two 2 TeV beams. Dropping one of the planned three 2 TeV beams as in [1,2] reduces the lateral dimensions of the calibration hall and results in major savings of civil construction costs. The 2 TeV beams would lie on top of the middle 200 GeV secondary beams providing the bigger separation of the test stations to cope with the wider muon cone. The presented footprint and layout is only one of several studied scenarios based on the accelerator layout known at that time. The actual layout will emerge as soon as the accelerator elevations and locations will be frozen.

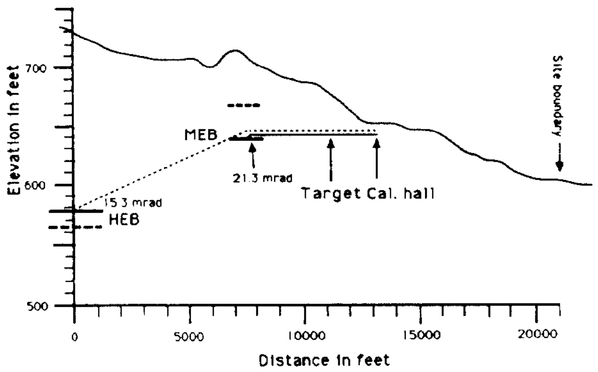

Fig. 1 Elevation View

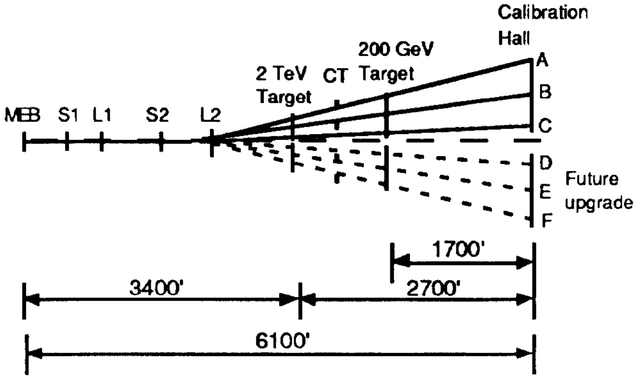

Fig. 2 Test Beam Footprint

## II. LAYOUT

Early in the design it became apparent that the main cost driver is real estate. We therefore tried to minimize the required footage of beamline rather than the number of components like benders and septa. The presented

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switchyard is, however, not the shortest possible one for 200 GeV, but the shortest one which allows for a 2 TeV upgrade. A detailed analysis of the civil construction requirements however dictated a stretch of the primary beamline in order to put the calibration hall as well as the target hall at locations minimizing the large excavations. This layout also optimizes the part of the switchyard which can be constructed by cut and cover rather than by expensive tunneling.

The muon shielding requires a certain minimal distance of the calibration hall from the target. CASIM [3] simulations indicate 1700' for the 200 GeV beam and 2700' for the 2 TeV beam in order to have a maximum muon flux of 150 kHz/m$^2$ as requested by the experimental community. The target hall however represents an important cost driver and we studied a possible scenario with a common target hall (dubbed "CT" in Fig. 2). This represents a compromise between particle yield at low energy and increased muon background for the 2 TeV running.

The above mentioned muon background also drives the distance between the individual calibration bays in the calibration hall. For 200 GeV this distance becomes smaller than what is required by purely mechanical and practical requirements (approx. 30'). The dimensions of the calibration hall have a great influence on the overall costs. We therefore decided to restrict the number of 2 TeV beams to a maximum of two, one at "B" and "E" (see Fig. 2) respectively (The muon cone for 2 TeV is much wider).

Care was taken during the design of the footprint to group as many beam elements as possible in order to minimize the number of magnet enclosures and to shorten cable runs.

Potential fire hazard and serviceability of the power supplies requires them to be located above ground, rather than in the tunnel. To distribute the power, as well as cooling water to the magnets, a number of utility shafts of 5' diameter is foreseen along the tunnel.

The split ratio is adjusted by physically moving the septa bank through the beam. The ratio is given by the relative amount of beam that lies to either side of the wires. The septa run at 45 kV/cm, some 90% of their maximum field, to allow trouble free operation. Care has to be taken in the design of the beam optics so that the beam is wide at the location of the septa. This prevents damaging of the wires, reduces scattering and facilitates the adjustment of the splitting ratio.

The beam transport is done with quadrupole doublets. Twelve quads are needed to transport the 3 beams and take care of constraints like magnet apertures and beam size at the septa. No quads are placed downstream of the splitting station. This would refocus the beam and therefore cancel the (small) separation.

Fig. 3 shows the beam envelope.

## III. SECONDARY BEAMS

A wide band beam approach has been chosen. Such a beam at Fermilab [4] has an excellent electron yield as well as a high hadron flux.

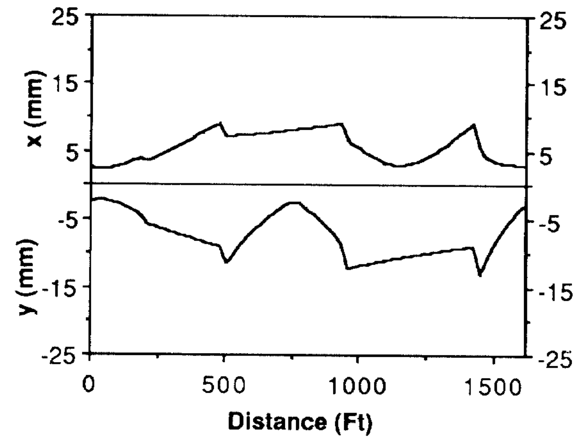

Fig 3 Switchyard Beam Envelope for 200 GeV/c Beam (3 Sigma)

A triplet system acts as a flux gathering system 150' downstream of the target. It provides a point to parallel imaging. The same enclosure contains the first dipole of the double dogleg system which provides muon shielding from the production target. A bend angle of 6 mr allows for reasonable real estate and and for good momentum measurement.

Exactly halfway between the target and the calibration hall are the next two magnets of the dogleg structure. The momentum bite and beam intensity may be varied with a variable aperture collimator sitting in the same enclosure.

An enclosure in front of the calibration hall contains the last dog leg magnet and a triplet focusing the beam on the experimental target.

The beam is never momentum dispersed when it passes through a triplet and has, therefore, a large acceptance of about 6 $\mu$sr%.

All of the secondary vacuum pipe between the enclosures is direct buried stainless steel pipe of 16" diameter.

## IV. YIELDS AND BACKGROUND

Particle yields were determined using parametrizations of Atherton et al. [6] and taking into account the beamline efficiency by using DECAY TURTLE [5]. Fig. 4 shows expected pion rates for 1E11 incident protons assuming a 1 interaction length Be target. The required rates are easily reached for most of the momenta except for the lowest ones where decay in the secondary beam line introduces a cutoff.Below 3 GeV/c, it is difficult to achieve rates of 100 Hz.

The muon contamination of the pion beam is in the order of 2-3 % over most of the momentum range.

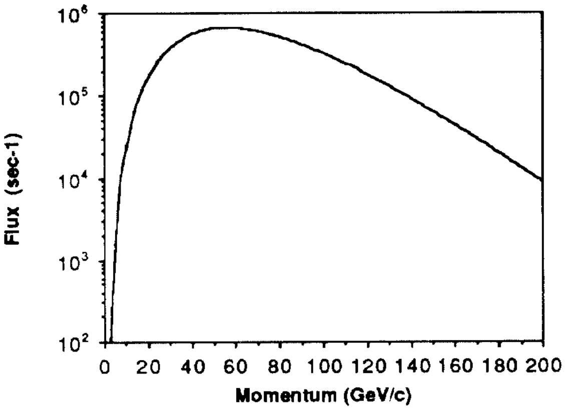

Fig. 4 Pion Rate as a Function of Secondary Momentum, assuming $10^{11}$ Primary Protons/sec

Electron yields, see Fig. 5, fall sharply for higher momenta. For a primary momentum of 200 GeV/c the rate drops below 100Hz above 150 GeV/c. Should the primary momentum be reduced to eg. 180 GeV/c the rate at 150 GeV would drop to a couple of Hz. This shows the importance of preserving the possibility of ramping the primary beam to 200 GeV/c.

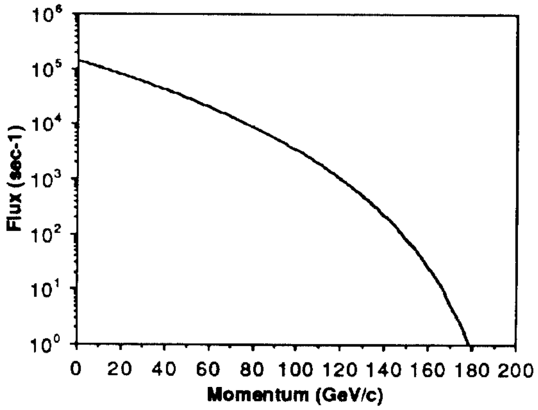

Fig. 5 Electron Rate for 200 GeV/c Protons assuming $10^{11}$ Primary Protons/sec

The muon background (see Fig. 6) was simulated using CASIM. For the 200 GeV beam the shielding is sufficient to yield approximately $10^4$ Hz/m$^2$. For the 2 TeV beam with a common target hall the shortened secondary beamline results in a flux of over 150 kHz/m$^2$. The results shown are for the sweeping plane which explains the dip in the curves.

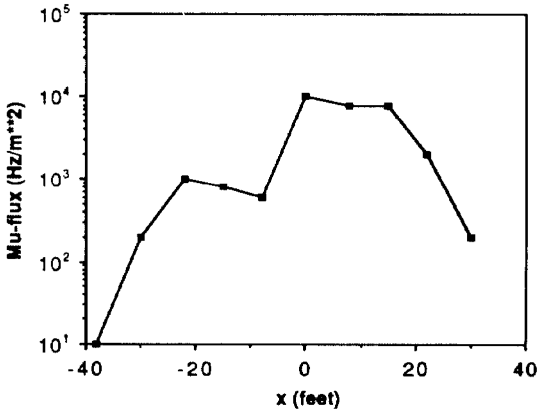

Fig. 6 Muon Flux Density at 1600' from the Target for $10^{11}$ Protons/sec

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