SINGLE PASS COLLIDER MEMO

CN- 242

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TITLE: MASK LOCATIONS IN THE SLC FINAL FOCUS REGION

In this brief note we describe the location of four sets of masks needed to shield against backgrounds in the final focus region of the SLC. We rely heavily on the earlier work of E.S. Miller and J.C. Sens in SLC Workshop Note CN #53 entitled "Backgrounds at the SLC Interaction Point." The main point of this note is to update the results of Miller and Sens taking into account the recent changes that have been made in the optics of the SLC beams. For the latest beam design we use the TRANSPORT output dated 5-13-83. This design aassumes that the final bends will form an 'S' about the interaction point and that the final quadrupoles will be superconducting and will be placed about 8 feet from the interaction point. Some of the features of this design are shown in Fig. 1.

The only serious backgrounds are due to photons and neutrons entering the detector. The neutrons are produced by bremsstrahlung photons hitting masks. This background is adequately discussed in CN #53 and will not be considered further here. Concrete shielding can be placed over the end caps of the detector to reduce this background.

Virtually all the photon backgrounds come from three sources: beamsstrahlung produced by the beams interacting at the interaction point, synchroton radiation produced by the soft bends, and synchrotron radiation produced by the final superconducting quadrupoles. Ther are several other minor backgrounds which are discussed by Miller and Sens, by the SLAC LINEAR COLLIDER CONCEPTUAL DESIGN REPORT (SLAC-Report-229), and by J. Jaros in AATF/80/22. These will not be considered here. In general they are minor backgrounds which will not affect the design of the masks to be discussed below. Each of the three main photon backgrounds will be now be considered in turn.

BEAMSSTRAHLUNG. The interaction of the beams at the interaction point produces a photon beam with a maximum critical energy of about 300 MeV, uniform in direction within a maximum angle of 2.2 mr. It is important that these photons be allowed to leave the detector region unimpeded for a great enough distance so that backscattering into the detector is kept to a minimum. If the quadrupoles located at 60-90 ft on Fig. 1 have an aperture of 5 in. and the beam pipe is allowed to increase in size as indicated, then the beamsstrahlung will not hit anything until it reaches Mask 0 at a distance of 95 ft. from the interaction point. This Mask is made up of 2 radiation lengths of aluminum followed by about 20 or so radiation lengths of lead.

To keep the beamsstrahlung from hitting the beam pipe before it reaches Mask 0, the diameter of the beam pipe must be 5 in. from 20' to 95' from the interaction point. Beyond Mask 0 a 2 cm diameter is sufficient. This means that the final soft and hard bend magnets need have apertures of only 2 cm, also. (This is not shown in Fig. 1 since the pole tips are actually in the plane of the figure.)

MASTER

The characteristics of the backscattering were studied using the program EGS. (We thank Ralph Nelson for helping us run his program.) The most important result obtained from EGS is that the number of backscattered photons at 180 deg per incident photon per unit solid angle lies in the range 0.2-0.4. This result is valid for incident photons in the energy range 50-300 MeV and for absorbers between aluminum and lead with lighter elements tending to have a lower value.

The most important difference between aluminum and lead lies in the energy spectrum of the backscattered photons. This is shown in Fig. 2. For aluminum the energy spectrum peaks near 100 KeV, whereas, for lead the energy spectrum peaks near 500 KeV. The purpose of Mask 0 shown in Fig. 1 is to absorb this beamsstrahlung. Fig. 3 shows the immediate region around the interaction point including Masks 2 and 3. The aperture in Mask 3 assumes that the detector subtends all angles to within 30 mr of the beam direction. In order to calculate the number of photons incident on the detector due to the backscattered photons from the beamsstrahlung dump we need to calculate the solid angle of the aperture in Mask 3, partially shielded by Mask 2 from a uniform extended source, Mask 0. For the geometry shown in Fig. 3 a Monte Carlo calculation gives for the solid angle,

$$\Delta\Omega/2\pi = 0.04\text{x}10^{-9}$$

Assuming that the average fractional energy lost by an electron is $0.5\text{x}10^{-3}$, 300 MeV maximum critical energy, $5\text{x}10^{10}$ electrons per beam, and the above solid angle, then the number of beamsstrahlung backscattered photons into the detector would be ~1 per crossing. This rate is very sensitive to the location and size of mask 2.

SOFT BEND SYNCHROTRON RADIATION. In order to reduce the critical energy the final hard bend is followed by a final soft bend. The parameters of these bends are listed below:

BEND	*ANGULAR BEND*	*RADIUS OF CURV.*	*CRITICAL ENERGY*	*PHOTONS/ELECTRON*
Hard	0.903 deg	507 ft.	1.80 MeV	16.3
Soft	0.144 deg	10,944 ft.	0.084 MeV	2.6

For the above parameters we find that approximately 110 photons/crossing will enter the detector due to fluorescence from the inner side of Mask 2 with the geometry of Fig. 3. (Photons emerging from the inner side of Mask 2 must rescatter off Mask 3 in order to enter the detector.) This represents about 40 soft photons/meter^2 on the inner face of the drift chamber. If Mask 3 is closed down so that the mimumum angle of the detector is 200 mr, then the aperture in Mask 3 is reduced from 4 ft. to 1 ft. The background of soft photons from the inner side of Mask 2 becomes 20/crossing, or 7/meter^2 on the inner face of the drift chamber.

To calculate the number of photons incident on the secondary vertex detector we assume a length of 4 cm and an inner radius of 1.5 cm. These values come from a very preliminary design using silicon strips. In contrast to the drift chamber the vertex detector is not shielded by mask 3. However, backgrounds are still small due to its small size and mass. We expect about 30 photons/crossing incident on this detector due to fluorescent photons from soft bend synchrotron radiation on the inner side of Mask 2.

QUADRUPOLE SYNCHROTRON RADIATION. The most serious background for a small angle detector is due synchrotron radiation from the final quadrupoles. These are assumed to be superconducting as in the most recent beam optics design. This radiation is most intense along the beam axis which means that this background <u>increases</u> as the aperture in Mask 2 is <u>decreased</u> due to fluorescence produced by the synchrotron radiation incident on the inner side of Mask 2. The precise amount of background from this source depends sensitively on the location and aperture in the two Masks 2. The minimum aperture is determined by the 2.2 mr maximum angle of the beamsstrahlung. In Fig. 3 we show an aperture with radius 0.7 cm which is about 0.2 cm outside the maximum angle of the beamsstrahlung. The location and aperture of Masks 2 needs further tuning using detailed tracing of electrons thru the quadrupoles. Hobey DeStaebler at SLAC is working on this and will distribute results as soon as they are available.

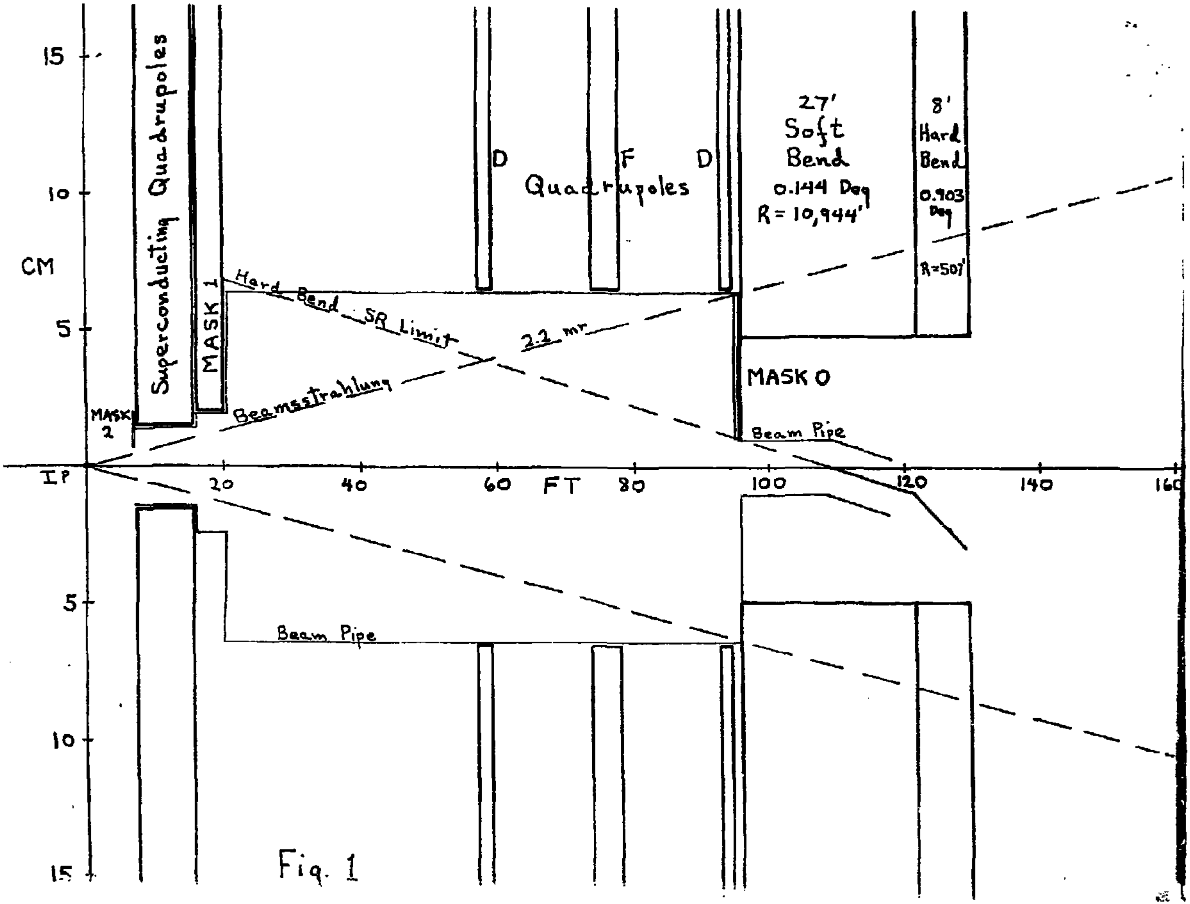

15
10
CM
5
5
10
15
IP
20
40
60
FT
80
100
120
140
160
Superconducting Quadrupoles
MASK 1
MASK 2
D
F
D
Quadrupoles
27'
Soft
Bend
0.144 Deg
R = 10,944'
8'
Hard
Bend
0.903
Deg
R=507'
Hard Bend SR Limit
2.2 mr
Beamsstrahlung
MASK 0
Beam Pipe
Beam Pipe

Fig. 1

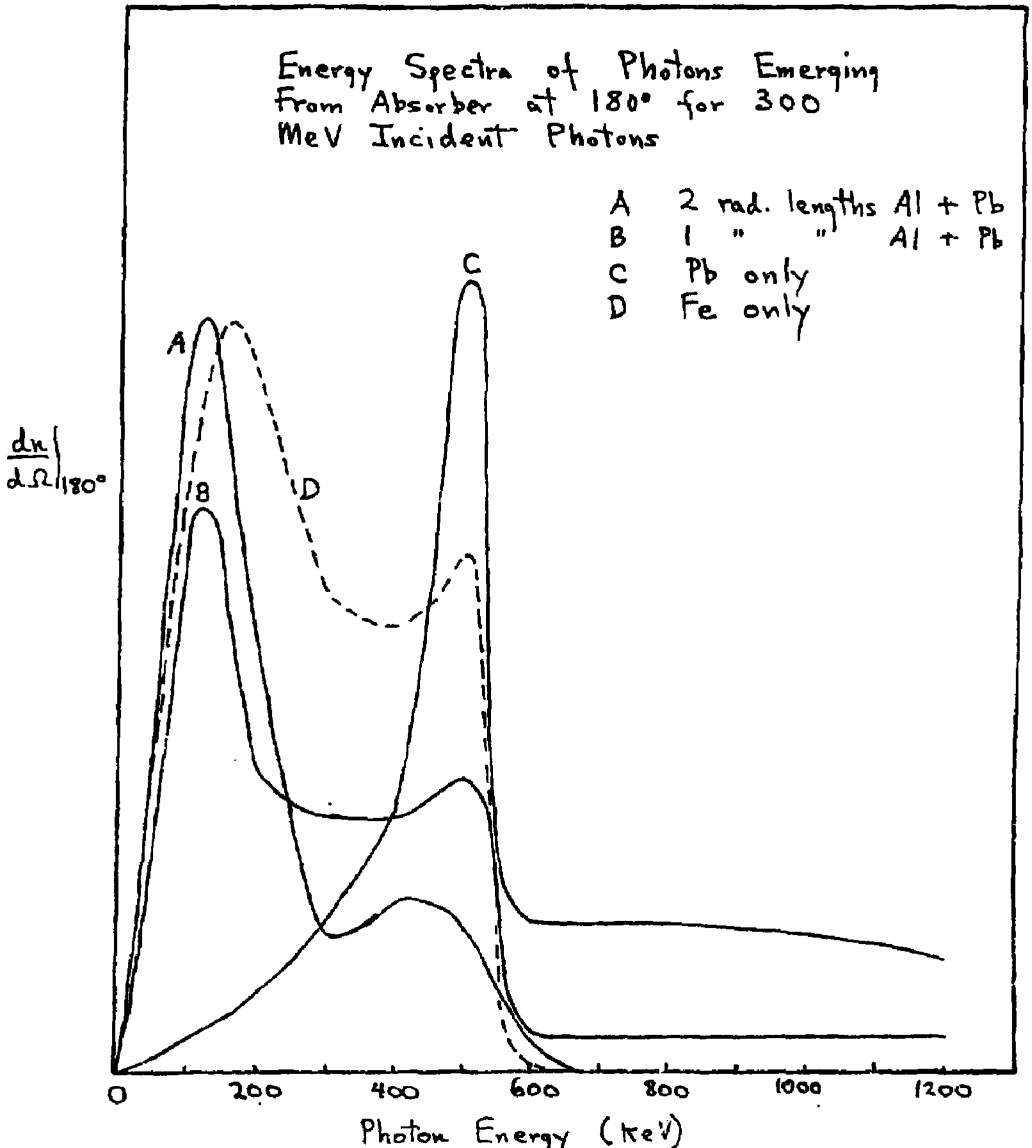
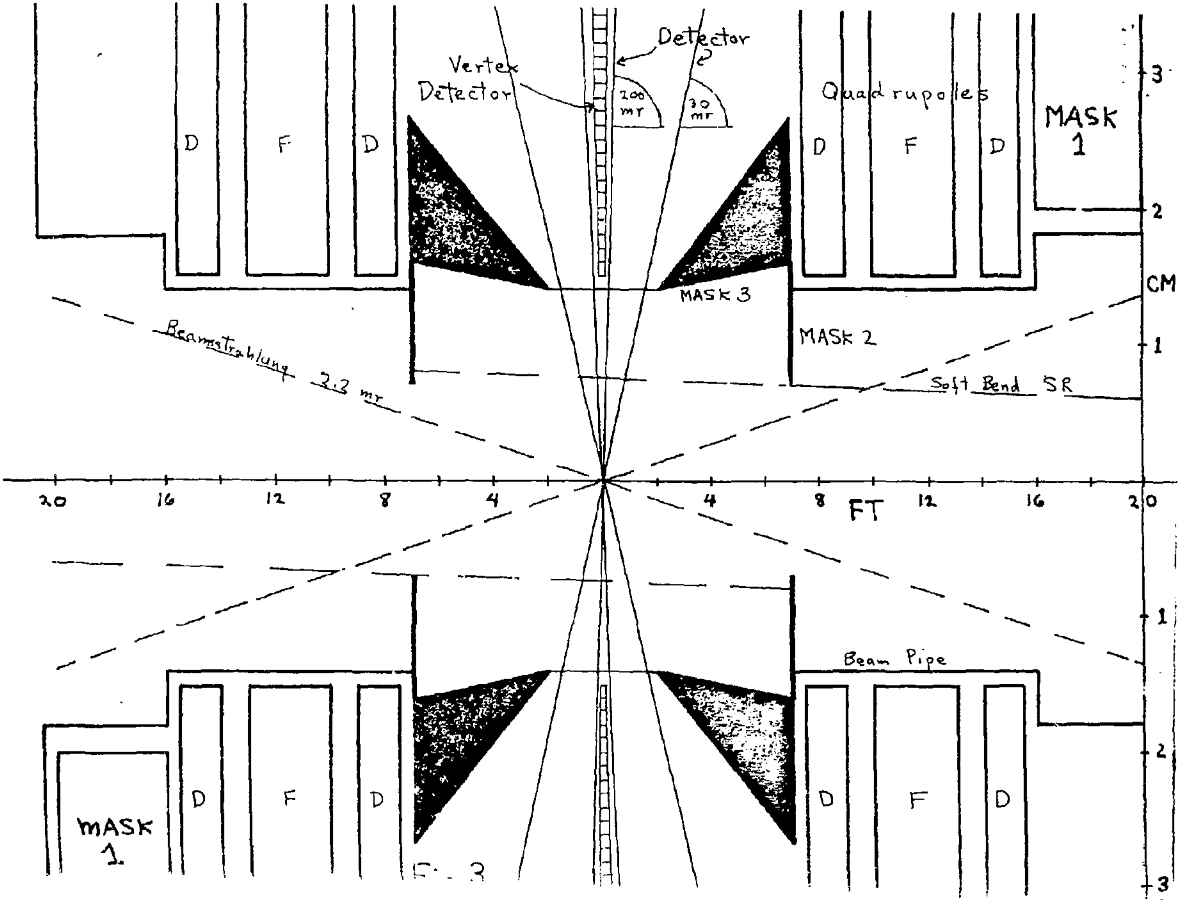
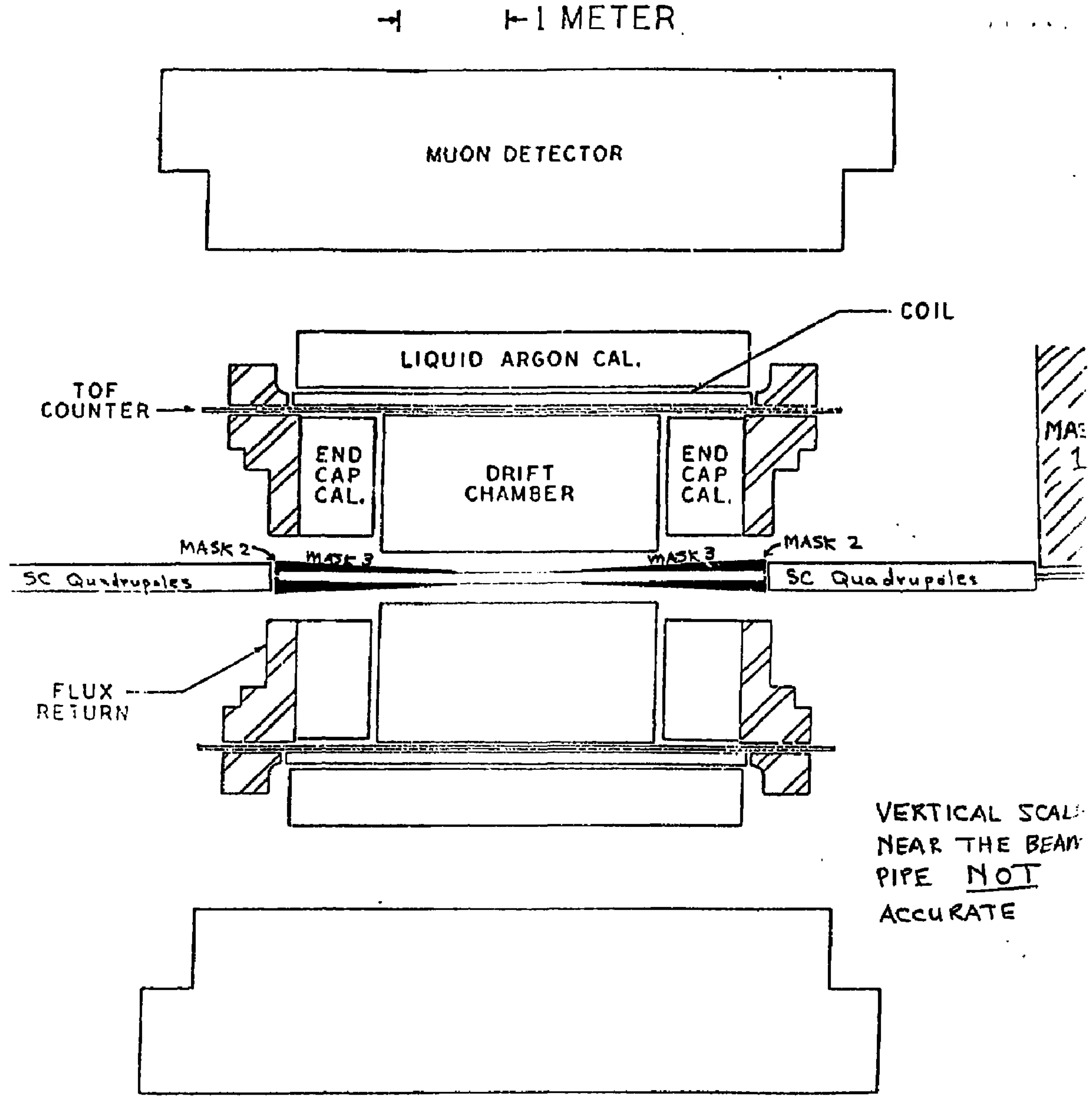

Energy Spectra of Photons Emerging From Absorber at 180° for 300 MeV Incident Photons
A 2 rad. lengths Al + Pb
B 1 " " Al + Pb
C Pb only
D Fe only
A
B
C
D
$\frac{dn}{d\Omega}\Big|_{180°}$
0
200
400
600
800
1000
1200
Photon Energy (keV)

Fig. 2


Vertex
Detector
Detector
200 mr
30 mr
Quadrupoles
D
F
D
D
F
D
MASK 1
MASK 3
MASK 2
Beamstrahlung 2.2 mr
Soft Bend SR
Beam Pipe
CM
3
2
1
1
2
3
20
16
12
8
4
4
8
12
16
20
FT
MASK 1
D
F
D
D
F
D

Fi. 3

HORIZONTAL CROSS SECTION



VERTICAL SCAL
NEAR THE BEAM
PIPE NOT
ACCURATE

Fig. 4