Magnetic Simulation of the Hall D Spectrometer

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A 2D simulation of the Hall D spectrometer, including the LGD region, has been made. The purpose of the calculation was to obtain estimates of the fringe fields in the regions where detectors will be located. More precise 3D estimates will be carried out by P. Brindza as the spectrometer design evolves.

The calculation was carried out with the Flux2D code. An axially symmetric model of the spectrometer was constructed from Eric Scott's CAD drawing of 15 April. That drawing also forms the basis for the present monte carlo database. We take the coordinate system from that drawing also; the origin is located at the upstream edge of the steel endcap and the z axis is along the beam direction (see Fig. 1). Zero field boundary conditions were set at z = -30m, z = +40m, and r = 40m. A total of about 22,000 elements were used in the calculation. The materials used in the simulation were either 1010 steel or vacuum.

Two major modifications were made to our model since our last report. A closed cylindrical steel box (wall thickness 0.5cm, and 1.1m radius) was constructed around the LGD region to shield the LGD phototubes, and steel was added to the return yoke of the solenoid. The latter filled in the air gaps on the sides of the existing magnet and added 30cm to the side thickness of the yoke. This was necessary in order to achieve manageable fringe fields while still maintaining the desired central field of 2.2T. A total current of 7.5x10**6 A was needed in order to achieve this value. Table 1 lists the magnitude of the B field (in Tesla) at points along the axis of the spectrometer and along radii located near the detectors.

Several important observations can be made from the results of this simulation. Even with added steel in the yoke the field in the side sections goes as high as 2.4T, which is above the saturation field (2.2T). Further improvements in the fringe field would require even more material to be added to the sides, or a reduction in the central field of the magnet. Several alternative modifications were tried, including a thicker downstream endcap, and a steel Cerenkov container. We were unable to identify any modifications that had a dramatic impact on the fringe field, other than using thicker sides.

The magnetic field in the region of the Cerenkov phototubes is an important design consideration. Even with the changes recommended here, we will still need to shield ambient values of 0.05T. This can be achieved with large amounts of conventional shielding material, as was done for the LASS detector.

The LGD shield in the present design was intended to reduce the field near the LGD pmts to a point where local shields will not saturate. The mesh size for the present calculation is rather large so the accuracy of the flux calculation inside the shield material is still in doubt. However it is clear that the steel is at least near saturation if not fully saturated, so further work on the design of this component is justified. Also, since the FLUX2D code is not able to simulate the array of individual shields that will be used in the spectrometer, further calculations will be needed to insure that the system will operate at all. Note that our earlier estimates showed that individual pmt shields of the type used in the E852 experiment will saturate unless they are shielded in some way.

The TOF detectors reside just upstream of the LGD shield. Because of their close proximity to large amounts of magnetic material they will experience a large B field which is hard to calculate accurately, both in magnitude and direction. At radii well outside the LGD shield the field is still on the order of 0.1T. The safe approach in this case is to design the TOF counters with pmts that can withstand high magnetic fields. Published measurements have shown that good timing resolution can be achieved in this way. While it is not impossible to shield tubes from such large fields, the complications of such an approach are large. Careful attention must be paid to the direction of the field, and the mechanical stresses can be large.

In summary, the fringe fields for the Hall D spectrometer can be reduced to levels comparable to those found in the LASS application if added steel is put in place. It will be necessary to pay close attention to the fringe fields in the designs of the Cerenkov, TOF, and LGD detectors.

Table 1: B field

d (meters)	B_{axis} (r=1mm, z=1m+d)	$B_{cerencov}$ (z=5.4m, r=d)	B_{tof} (z=5.8m, r=d)	B_{lgd} (z=6.7m, r=d)
0.0	1.93	0.297	0.203	0.089
0.2	2.05	0.292	0.192	0.087
0.4	2.12	0.278	0.178	0.083
0.6	2.17	0.257	0.167	0.077
0.8	2.19	0.231	0.155	0.071
1.0	2.21	0.205	0.142	0.069
1.2	2.21	0.181	0.129	0.070
1.4	2.21	0.157	0.116	0.069
1.6	2.20	0.133	0.103	0.066
1.8	2.18	0.109	0.091	0.062
2.0	2.15	0.089	0.080	0.058
2.2	2.11	0.075	0.071	0.055
2.4	2.04	0.066	0.065	0.051
2.6	1.95	0.061	0.059	0.048
2.8	1.81	0.057	0.054	0.045
3.0	1.63	0.053	0.051	0.042
3.2	1.40	0.050	0.048	0.040
3.4	1.14	0.048	0.045	0.038
3.6	0.89	0.045	0.042	0.036