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Finite Element Analysis of Endplates Coupled by Inner and Outer Cylinders

Stress analyses of the entire BABARdrift chamber have been performed by FEA (Hodgson) and analytic approximations (McDonald, Princeton/BABAR/TNDC-96-48), both assuming simply supported joints between the endplates and inner and outer cylinders. However, both joints will be made with screw fasteners which will likely cause nonzero moments to be transmitted across the joints. This might result in significant differences in the geometry of the chamber. In particular, the outer cylinder may not need to be 3.1 mm longer than the inner cylinder to keep the rear endplate 'flat' (*i.e.*, keep the z coordinates of its inner and outer radii the same).

To get a sense of the chamber shape when screws are included we have performed an FEA analysis of an entire chamber consisting of aluminum endplates without holes, and inner and outer cylinders of 4 and 8 mm of aluminum, respectively. The cylinders are taken as only 36 cm long to reduce CPU time, this value having been chosen as sufficient to isolate the perturbations at each end of a cylinder from one another.

The detailed geometry of the joint region follows drawing `joints21.eps` by A. Boyarski.

Since the endplates are simulated without holes they are stronger than the actual ones. Rather than reduce the modulus to correct for this, we increase the wire load by 15%.

The inner joints will be made with screws before any load is applied to the chamber. We consider it likely that these joints will behave as if the endplates and inner cylinder were made out of a single block of metal, with longitudinal slots as shown on drawing `joints21`. Therefore we use that approximation in the FEA.

The situation at the outer joints is less clear, as these will be made only after the wires have been strung. It is possible in principle that no moment is transmitted across this joint. However, if the radial screws joining the outer cylinder to the endplate are tightened well, considerable moments may be transmitted. We have modelled two scenarios for the outer joints:

1. The joint behaves as if the inner surface of the outer cylinder makes radial contact with the endplates, as might arise if the screws were tightened enough. A radial slot exists between the ends of the outer cylinder and the endplate. The cylinders and endplates are modelled as a single block of aluminum.

2. The joint behaves as if the outer cylinder makes longitudinal contact with the endplates, as might hold if the screws were not tightened at all. A small longitudinal slot remains between the inner surface of the outer cylinder and the endplates. Again, the cylinders and endplates are modelled as a single block of aluminum. This is not a simply supported joint, but is less tightly clamped than case 1.

Figure 1 shows the calculated shape of the chamber for the first case of the outer joint. The displacements are exaggerated.

Some numerical results are reported in the Table. The slopes of the endplates at the inner and outer radii can be used to set the input constants in an analytic stress analysis. As expected, clamping forces at the joints make a substantial difference in the deformations of the endplates. See the revised version of Princeton/BaBar/96-48 for further discussion.

Table 1: Results of the FEA calculation. Case 1 = radial contact between the outer cylinder and the endplates, as if the screws are tightened strongly. Case 2 = longitudinal contact between the outer cylinder and the endplates, as if the screws were not tightened at all. Case 3 = simply supported joints, from an analytic stress analysis.

	Case 1	Case 2	Case 3
Δz_{rear} (mm)	0.27	0.41	1.17
$\theta_{\mathrm{rear,\ outer}}$ (mrad)	0.88	0.69	0.1
$\theta_{\mathrm{rear,\ inner}}$ (mrad)	2.1	2.4	4.8
$\theta_{\mathrm{front,\ outer}}$ (mrad)	4.9	6.0	12.7
$\theta_{\mathrm{front,\ inner}}$ (mrad)	3.4	3.6	5.8

Figure 1: FEA analysis of BaBar endplates coupled by 36-cm-long inner and outer cylinders made of 4- and 8-mm-thick aluminum corresponding to Case 1 in the text.