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Effect of a Step in the Front Endplate of the BaBar Drift Chamber

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1 Summary

Fernando Ferroni made the interesting suggestion that a variable thickness front endplate might reduce the peak stress while using minimum material in that part of the endplate within the acceptance of BaBar.

We have modelled endplates that have a step between an inner and outer region each of uniform thickness. Both PLATE and BRICK models were calculated using the ALGOR finite-element analysis program. A notable result is that to a good approximation both the radius of curvature and the stresses in one region are not influenced by the thickness of the plate in another region. However, the deflection of the plate is reduced on thickening even part of the plate.

Given these results, one can use the analytic results of Roark and Young, Chapter 10, Table 24, Cases 2c and 2d to make quick calculations of different options.

The BaBar acceptance is limited to polar angles greater than 350 mrad to the forward direction. Taking the forward endplate to be at $z = 175$ cm, the inner radius of the acceptance on the endplate is 63 cm. As shown in Fig. 1, the large gap between superlayers 4 and 5 is at radius 47 cm, and the gap between superlayers 7 and 8 is at 63 cm. Thus it would be possible to thicken the front endplate to, say, 24 mm out to a radius of either 47 or 63 cm without compromising the scattering of particles within the BaBar acceptance. In case the acceptance of BaBar is extended down to 300 mrad, corresponding to a radius of 54 cm, it would be preferred to have the step at 47 cm.

2 Plate Models

We have performed a simplified finite element analysis using ALGOR. Figure 2 shows results for an 11-mm-thick Al plate under a 3500-kg load simply supported at the inner and outer radii (24 and 80 cm, respectively). The peak deflection is 3.2 mm. We used a PLATE model of a 1°-sector of the endplate, and placed only a single hole at the center of this model. The peak von Mises stress around this hole was 70 MPa.

We next performed an analysis of an Al endplate in which the thickness is 24 mm for $24 < r < 47$ cm and 11 mm for $47 < r < 80$ cm under 3500 kg wire load. The peak deflection would be reduced to 1.8 mm, but the peak von Mises stress around a hole at the center of the plate (where the thickness is still 11 mm) remains at 70 MPa. It appears that we cannot significantly reduce the peak stress in the endplate by increasing the thickness outside the region of peak stress.

Then we performed an analysis of an Al endplate in which the thickness is 24 mm for $24 < r < 63$ cm and 11 mm for $63 < r < 80$ cm under 3500 kg wire load. The peak deflection would be reduced to 0.7 mm, and the peak von Mises stress around a hole at the center of the plate (where the thickness is 24 mm) would be reduced to 14 MPa [$= (11/24)^2 \times 70$, following the $1/(\text{thickness})^2$ scaling law for stress]. See Figure 3.

The model included a hole at radius 64 cm, just beyond the step, where the stress are largest. While the average stress in the endplate in this region is on 25 MPa, it rises to 50 MPa around the hole.

It appears that the reduction in stress around feedthrough holes due to a step on the endplate is insufficient by itself to insure a good safety factor. Increasing the plate thickness from 11 to, say 15 mm in the thin region would reduce the peak stress to $50 \times (11/15)^2 = 27$ MPa, which might be considered safe enough. The same peak stress could be obtained in a flat endplate of 18 mm thickness, which would be much easier to fabricate.

3 Brick Models

4 Calculations Using Roark and Young

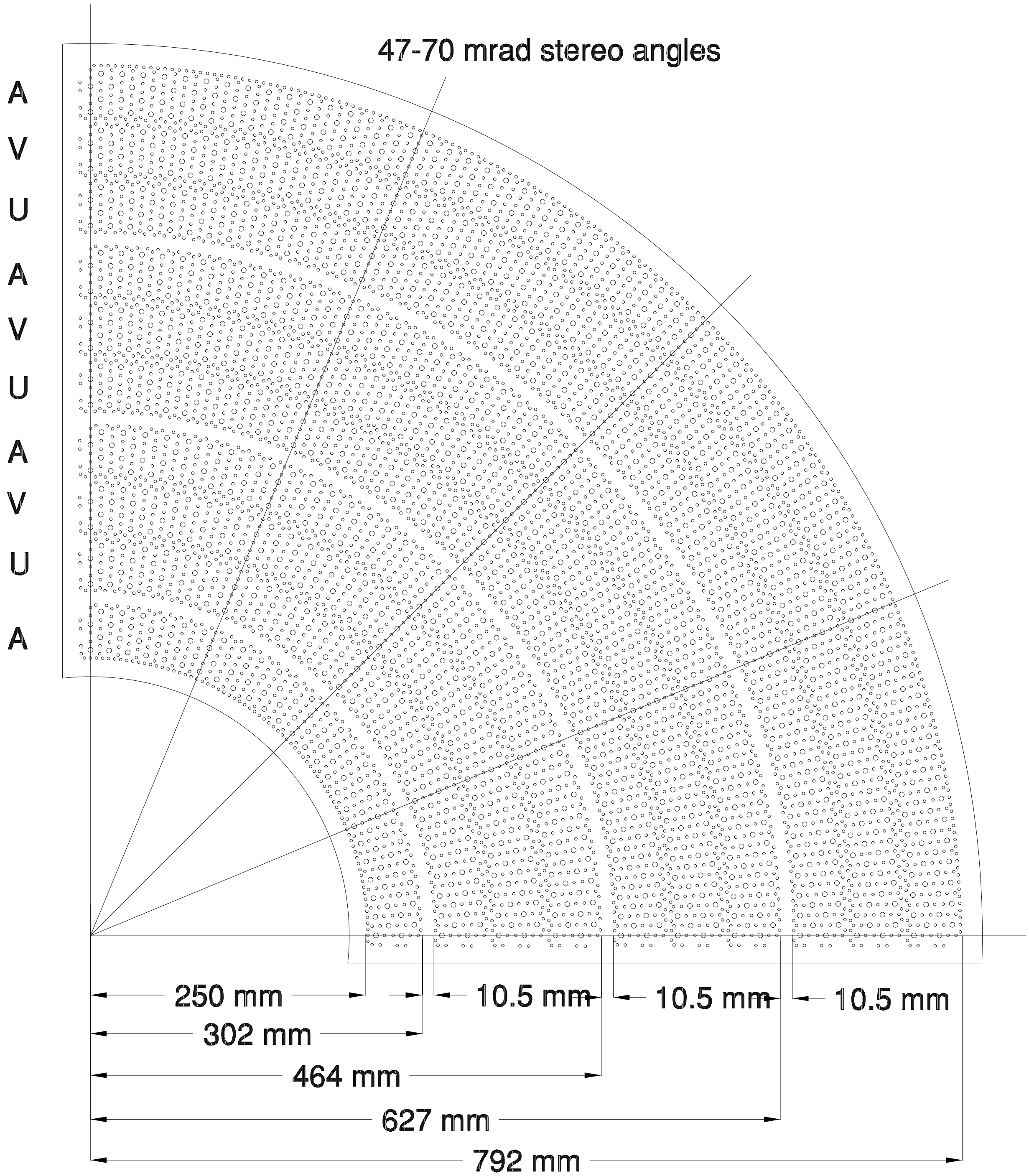

Figure 1: A quarter section of the drift chamber endplate.

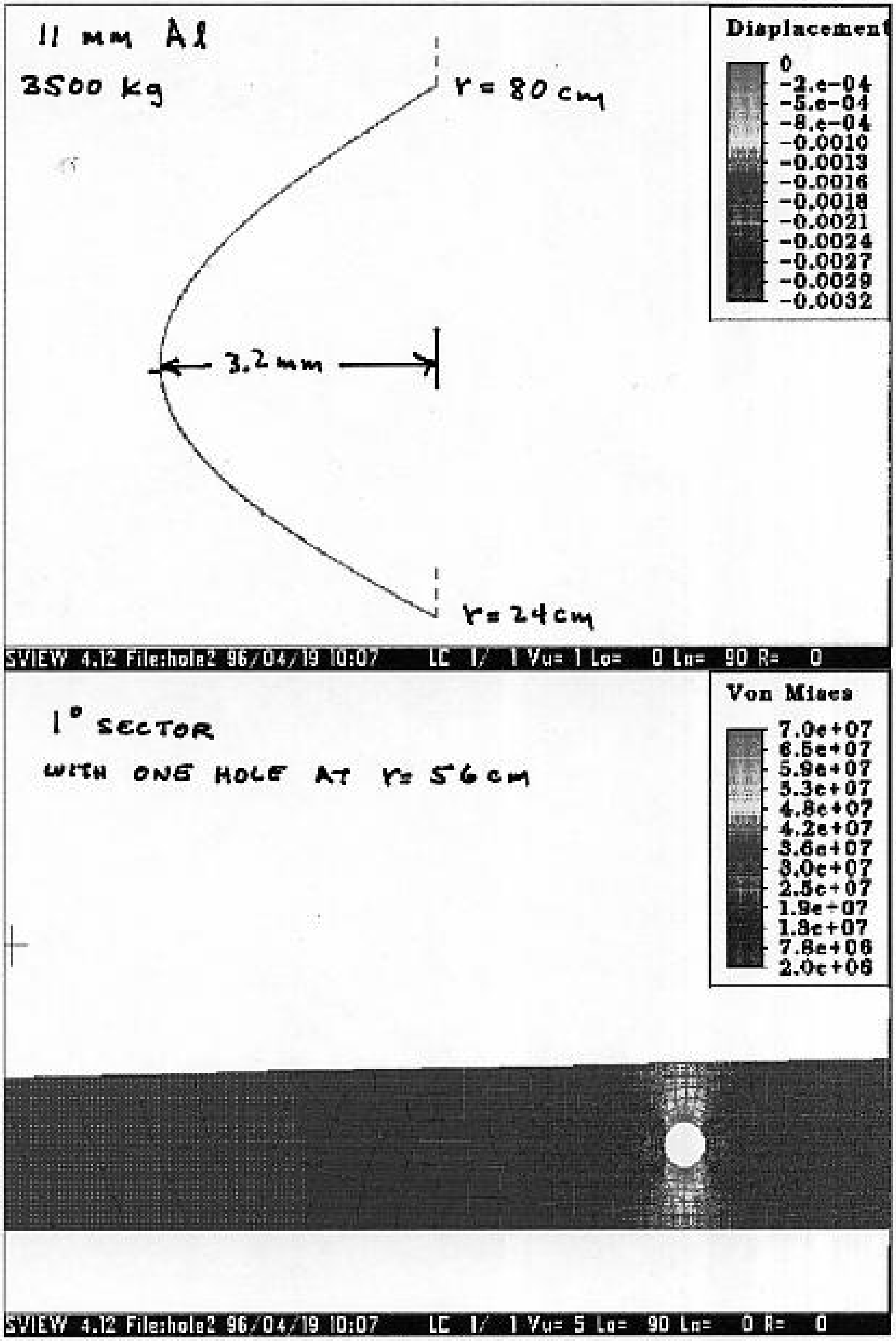

Figure 2: Deflection and von Mises stress in a 11-mm-thick Al endplate under 3500 kg wire load.

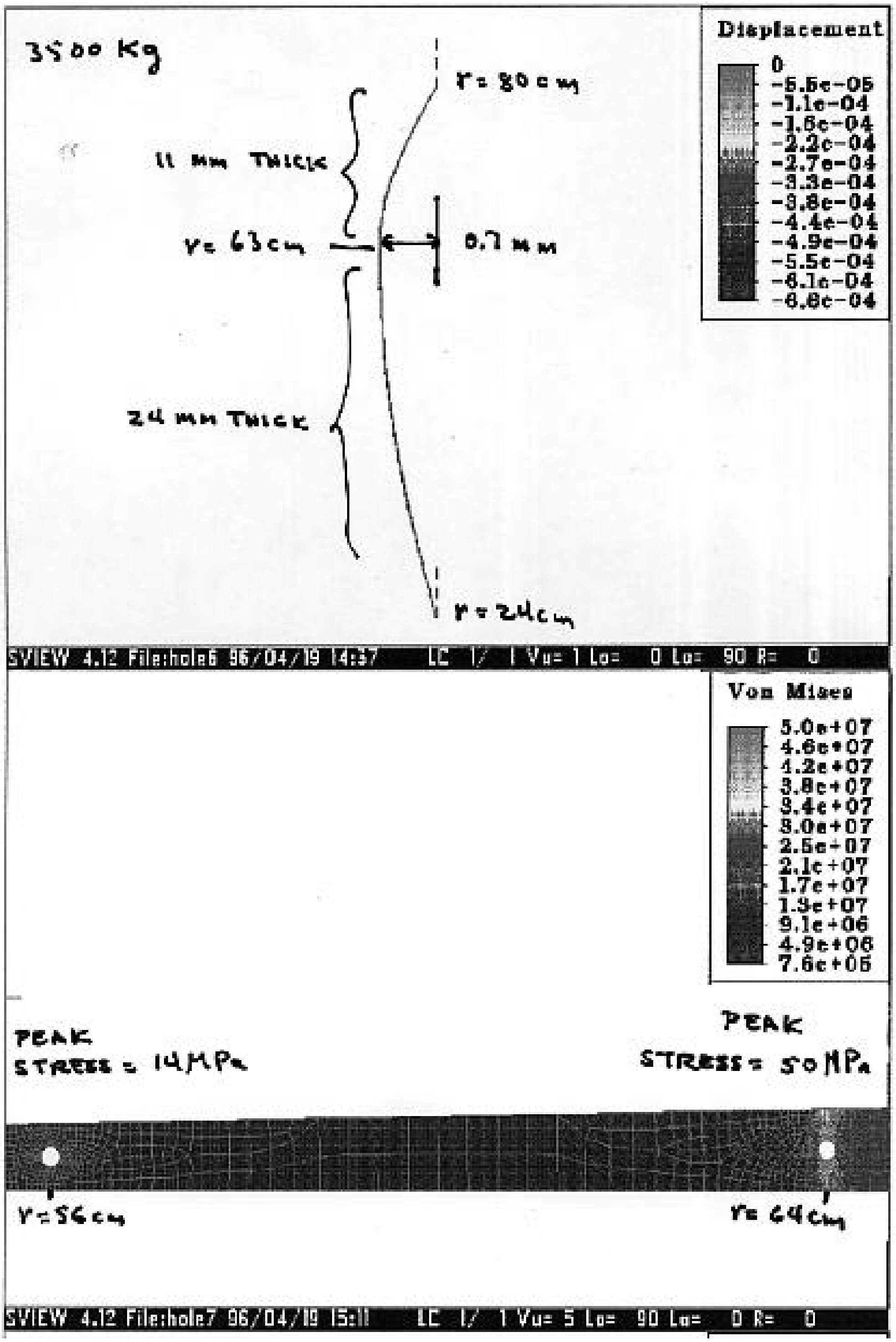

Figure 3: Deflection and von Mises stress in an Al endplate with 24 mm thickness for $24 < r < 63$ cm and 11 mm thickness for $63 < r < 80$ cm under 3500 kg wire load.

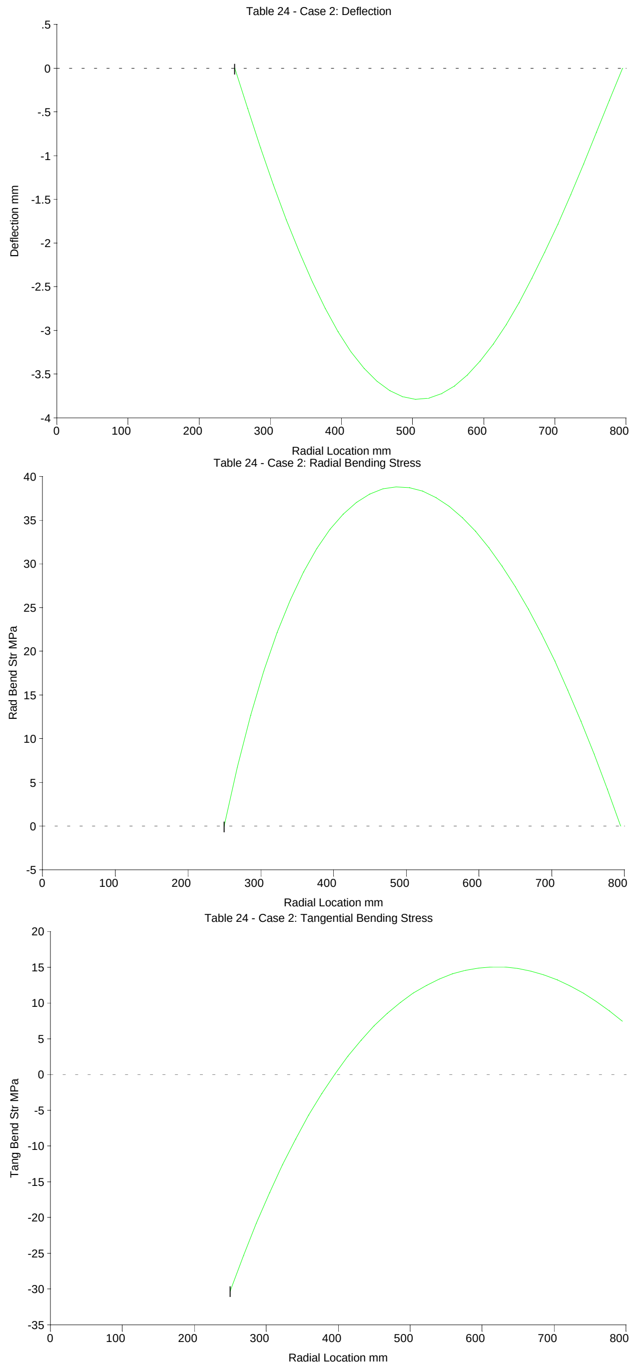

Figure 4: Deflection, radial stress and tangential stress in a flat aluminum plate 10-mm thick with a 3500 kg wire load, simply supported at both the inner and outer radii. Calculated using Case 2c, Table 24, Chater 10 of Roark and Young.

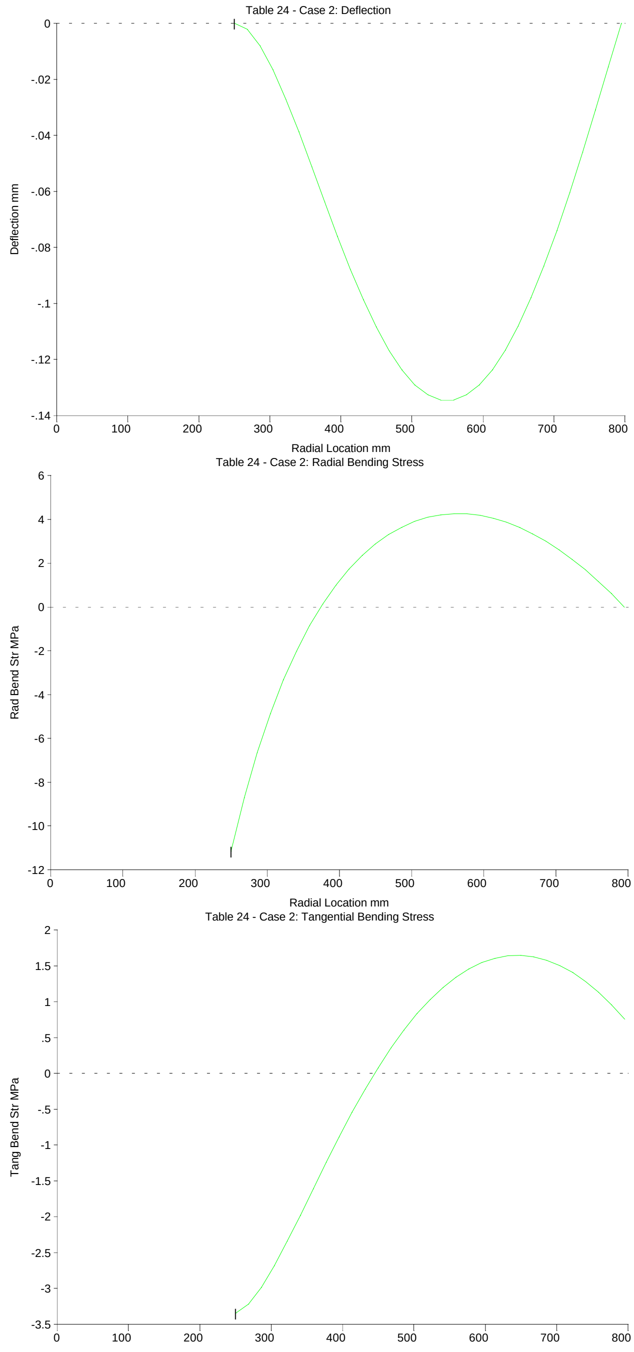

Figure 5: Deflection, radial stress and tangential stress in a flat aluminum plate 10-mm thick with a 3500 kg wire load, clamped at the inner radius and simply supported at the outer radius. Calculated using Case 2d, Table 24, Chater 10 of Roark and Young.