Multiplicity Vertex Detector Subsystem Cage Deflection Studies

Debbie Clark, Jan Boissevain, Jehanne Simon-Gillo, Eric Joseph Ashton-Bosze
Los Alamos National Laboratory
January 22, 1996

PHENIX-MVD-96-3

1. Initial Questions

The Multiplicity Vertex Detector consists of two halves, split on the vertical midplane. Each half has a support frame consisting of two aluminum endplates joined by thin-walled aluminum tube supports (see Figure 1). This frame system was previously tested for deflection characteristics [Phenix-MVD-95-3]. Twelve rohacell foam cages are located between welded fins on the end plates. Thin plastic tube connectors attach the foam cages to each other. The cages form a half-barrel that positions the silicon wafer detectors around the beam line (see Figure 2). Designed to be low mass, the foam cages and silicon wafer span weight approximately 157 g.

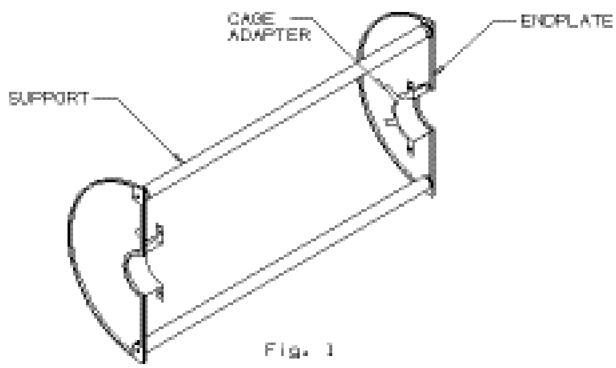

Fig. 1

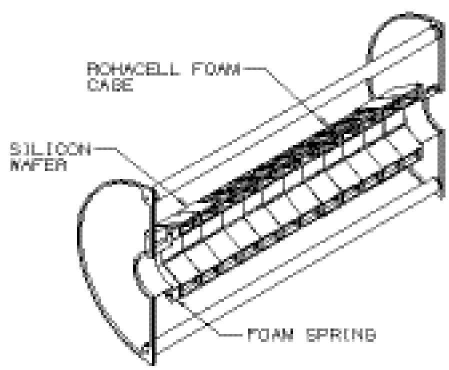

Fig. 2

Figures 1 and 2. Figure 1 shows MVD endplate and tube support frame. Figure 2 includes the rohacell foam cages positioned between the endplates.

There was concern that the low mass components and plastic tube connectors would be unstable and allow the span to sag in the middle or require reinforcement. The question of additional wiring or bracing was discussed. Therefore, it was necessary to evaluate the stability and deflection response ofthe foam cage assembly. The following issues were studied:

- Is the current support frame and endplate design adequate to hold the cage/silicon assembly securely?
- What is the stability of the rohacell foam cage/silicon wafer half-barrel if it is assembled with straws between the 12 cages?
- Does the foam span require further reinforcement?
- What is the force required to hold the assembly together?

2. Assembly of Components

The MVD frame is constructed of two mirror-image endplates bolted to support struts as shown in Figure 1. Each endplate has a welded center piece with four fins. Using a small section of plastic straw, the first cage/silicon assembly is connected to holes in one of the fins. Eleven additional foam cage and straw sections are attached to one another in a similar manner. In a small gap that is left between the silicon/cage span and the fins, a foam 'spring' is used. A picture of the prototype assembly is shown in Figure 3.

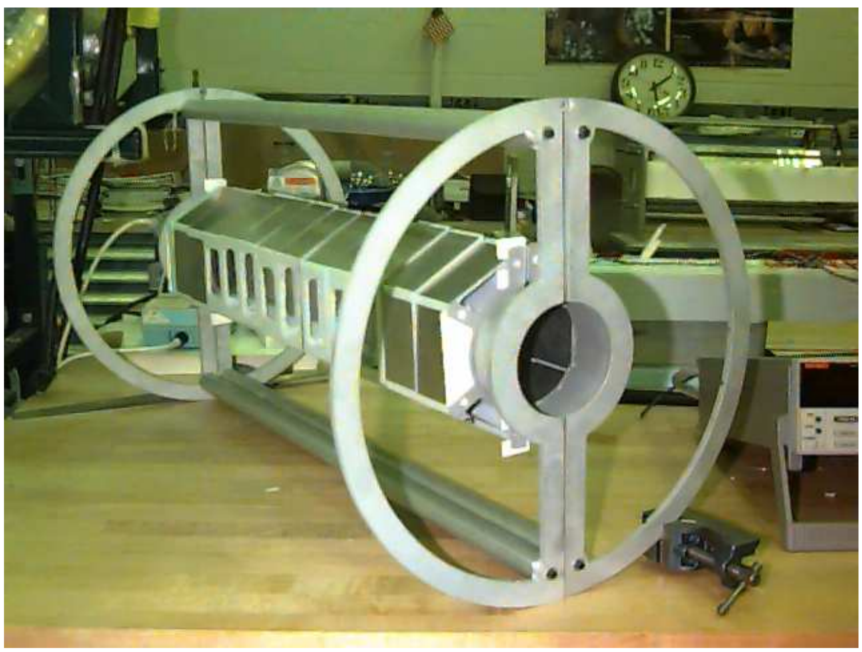

Figure 3. Photograph of the MVD support and foam prototype.

In the first assembly attempt, alignment proved difficult. Distortion was apparently introduced in the cage support fins during the welding process. To remedy this situation, the prototype endplates were field adjusted to achieve two parallel planes. Also at this time, the cage span was found to be slightly flexible. Two stiffening methods were compared, the use of paper shims and the use of a foam spring. The spring was determined to be superior to the shims, as it transmits a uniform force along the span. The foam spring was adjusted empirically for a reasonable compressive force to hold the cage span together. The weight required to compress the foam was 1 kg, which implies 10 newtons of force.

3. Test and Results

After assembly, the MVD Prototype half-shell (200 mm radius x 752 mm long) was tested for vertical deflection or failure under increasing load. Each endplate of the half-shell was held upright in a machine vice on a lab workbench. A graduated scale was mounted on the workbench at the approximate center of the cage span. Various weights were added to the center of the cage assembly to cause sag. The deflection of the span at the center scale was viewed through a surveyor's transit and recorded. In this manner, three independent tests were conducted. The assembly consisted of the items below:

- 2 Aluminum endplates each w/ welded central silicon cage adapter (fins).
- 12 C-shape rigid foam test pieces 50.8 mm thick, 610 mm span total.
- 26 Thin straw connectors 7.2 mm diameter x 10 mm long.
- 56 Thin aluminum plates mounted in the final design pattern on foam cages.
- 2 Aluminum support struts.
- 1 Foam spring, 20 mm thick closed cell flexible foam at 10 N force.

The structure as tested had several minor deviations from the current MVD design proposal. Rigid foam facsimile cages were designed and machined, as finished rohacell cages were not available. Thin aluminum plates were used instead of the silicon wafers. The aluminum plates were attached to the foam cages using double-sided tape. For these types of tests, the most important factor is simulating the correct mass of the components. Each rigid foam/aluminum plate assembly was weighed and compared to an actual cage/wafer assembly. However, the rigid foam cages at 50.8 mm were slightly thinner than the rohacell cages at 53.2 mm.

In addition, electronic cables, having a total distributed weight of 32.2 g, were not represented. Also, a 20 mm thick foam spring was used to compensate for the different size cages. In the proposed design, a foam spring with approximately 3.2 mm compressed length will be used.

4. Test Results

A reasonable deflection curve was produced and no failure of the system as tested was detected. Added weights of 0 to 20 g produced almost no vertical deflection in the span. With a weight addition of 100 g, there was only about 0.64 mm deflection. The assembly successfully supported the highest weight, 350 g, without failure and displayed only a 3 mm deflection (Figure 4). After the largest weights were removed from the span, the system did display a slight time lag or memory before returning to zero.

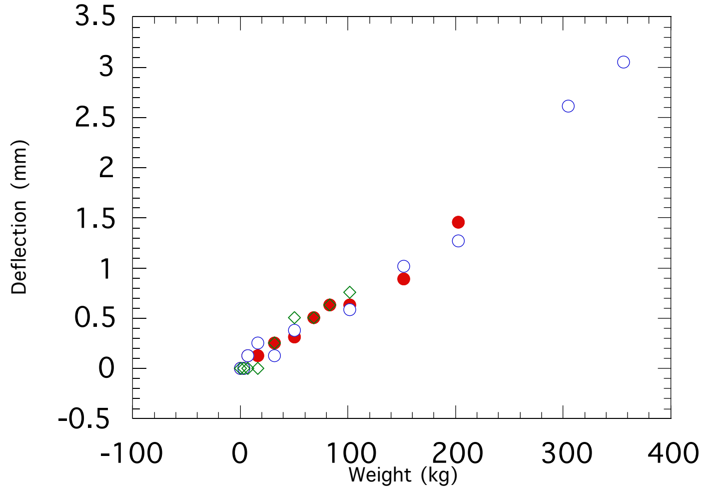

Figure 4. Deflection curve showing deflection in mm as a function of weight in grams.

5. Conclusion

With the low-mass goals of the MVD subsystem, it is not foreseeable that a large amount of mass will be added to the cage/silicon wafer system in the future. Based on the questions and results detailed above, several conclusions can be made:

- There is no measurable sagging in the unweighted rohacell cage/straw assembly with the foam spring. The stability of the system as tested is acceptable.
- Additional reinforcement of the cage assembly (i.e. wire) is not required.
- A thinner foam tensioner will reduce the memory problem seen in the heaviest test results. A 3.2 mm compressed length is recommended.
- It was determined that 10 N force is adequate to tension the foam pieces. This force can be optimized using ESA-DE's finite element analysis model.
- Parallelism tolerance on the welded endplate fins should be specified when machining the actual endplate components, eliminating field adjustments.