ILC Vertex Detector Mechanical Studies

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The Linear Collider Flavour Identification Collaboration (LCFI) is conducting a research and development programme aimed towards building a vertex detector for the International Linear Collider (ILC). The latest mechanical ideas and study results are discussed along with future plans.

1 Introduction

The LCFI Collaboration's concept for a vertex detector is to have silicon detectors mounted on ladders. These ladders are then mounted in barrels around the detector. In the TESLA TDR[1] it is considered that 5 layers of barrels are needed, with the first barrel as close to the interaction point as possible and the other barrel layers spread evenly throughout the vertex detector. The detector needs to be lightweight, robust and have as uniform a distribution of material as possible within a layer.

In this design the ladders in layers 2-5 have an active length of 250 mm, with layer 1 much shorter at 100 mm. To hold the ladders in barrels around the beam pipe they are attached at their ends to a beryllium support shell with the entire vertex detector enclosed in a foam cryostat to allow cooling, illustrated in Figure 1.

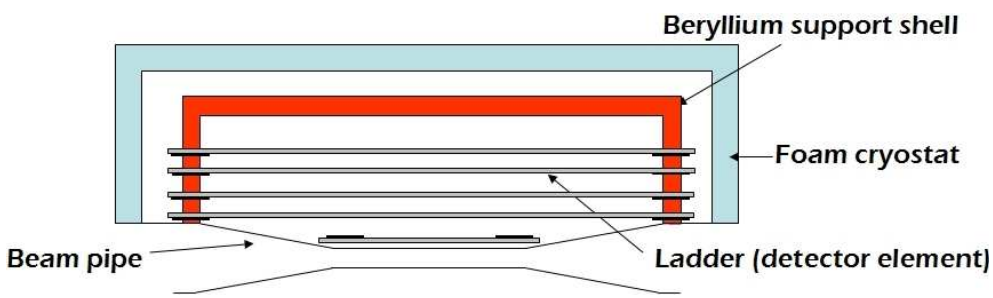

Figure 1: Conceptual design of ladders mounted on support shell, around beam pipe.

The ladders will be attached to the support shell by means of a pair of ceramic blocks, the annulus block attached to the support shell, and the ladder block attached to the ladder, illustrated in Figure 2. The blocks have a V and a flat machined into them to allow relative movement in one dimension, motion out of the plane being prevented by a compressive spring. The blocks at one end of the ladder are then fixed with a pin, those at the other being left free to slide to accommodate differential contraction.

Recent studies have concentrated on two different potential substrate materials: Silicon Carbide foam (SiC) and Reticulated Vitreous Carbon foam (RVC), both supplied by

*for the LCFI Collaboration.

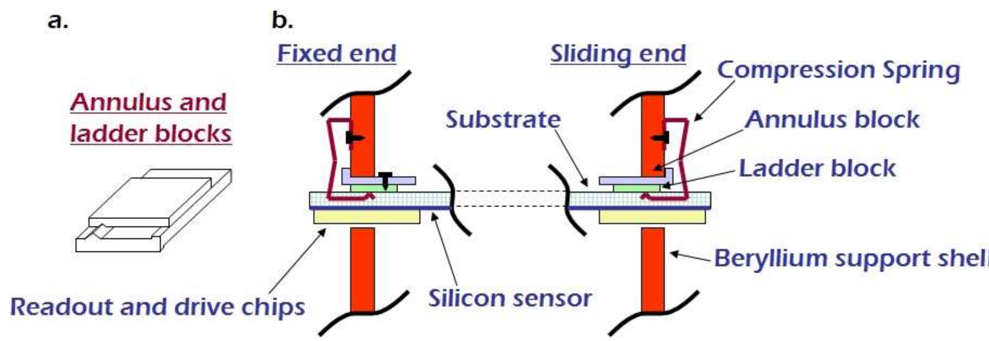

Figure 2: Conceptual designs, 2a showing how a ladder is attached to the support structure, 2b showing a close up of the ladder and annulus block.

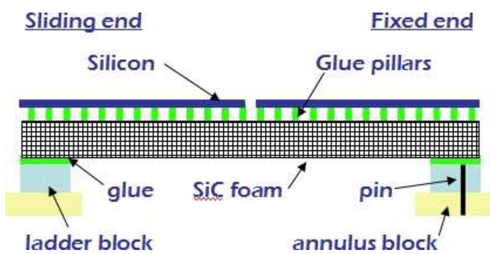

Figure 3: Conceptual design of an SiC ladder.

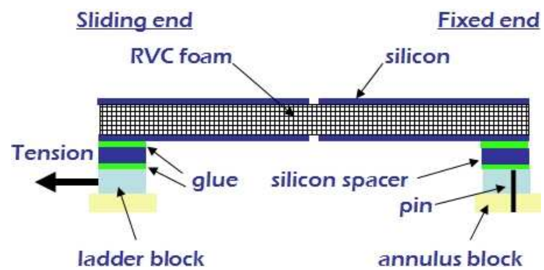

Figure 4: Conceptual design of an RVC ladder.

Erg Materials and Aerospace Corporation [2]. 20 micron thick unprocessed silicon rectangles supplied by Aptek Industries Inc [3] were used in both cases to simulate the detector elements.

2 SiC ladder

The SiC ladder was made by mounting a silicon rectangle on 1.5 mm thick silicon carbide foam. The foam was 8% the density of solid SiC. The silicon was attached to the foam by means of small adhesive pillars placed on a 5 mm grid with the silicon held above the foam such that once cured there was a 200 micron gap between substrate and silicon, illustrated in Figure 3. The material in the ladder corresponds to approximately 0.14% X_0.

The ladder was cooled from room temperature to -50 degrees Celsius. On cooling the ladder bowed out of shape by approximately 160 microns. Figure 5 shows the profile of the ladder as it was cooled and heated back up towards room temperature. Figure 6 shows the difference between a profile at a particular temperature and room temperature; from this the overall change in shape and magnitude of that change may be seen (in both figures the feature 155 mm along the length is the gap between the two silicon rectangles).

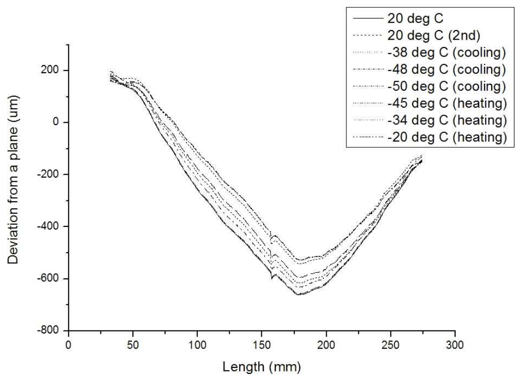

Figure 5: Profiles of an SiC ladder at various temperatures.

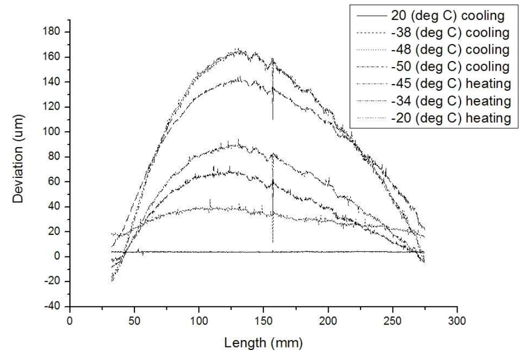

Figure 6: Difference between profiles at a particular temperature and room temperature.

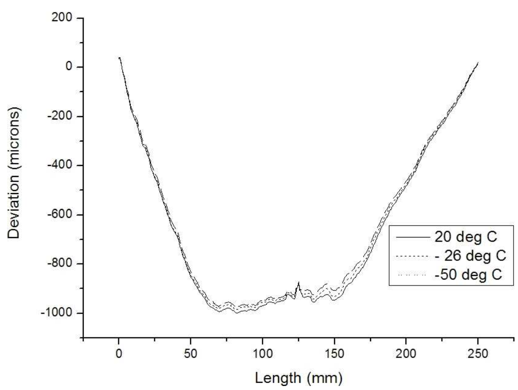

Figure 7: Profile of RVC ladder at various temperatures.

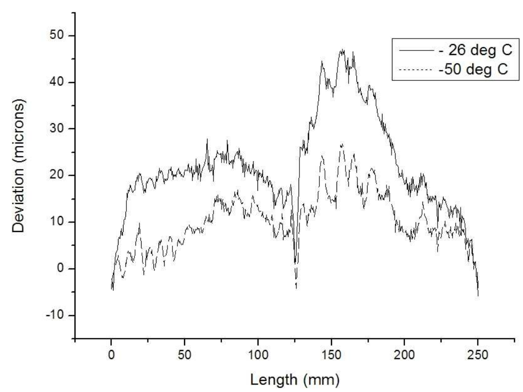

Figure 8: Plots of difference between temperature stated and room temperature for the RVC ladder.

3 RVC foam ladder

The RVC ladder was made by gluing silicon rectangles either side of a RVC foam to make a sandwich structure. The silicon was attached by adhesive pillars on a 5 mm grid sunk into the foam such that the silicon and foam were in contact. In order to keep its shape the ladder was kept tensioned along its length. Figure 4 shows the conceptual desigh of the RVC ladder.

This ladder was also cooled from room temperature to -50 degrees Celsius. Figure 7 shows the profile of the Ladder as it is cooled down and warmed up. Figure 8 shows the difference of the profiles at various temperatures to the profile at room temperature.

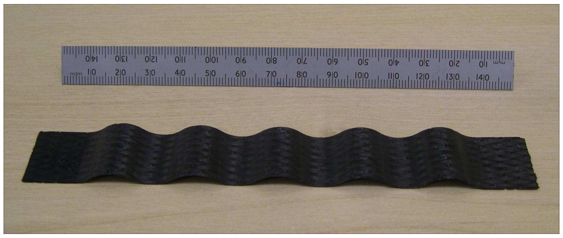

Figure 9: Picture of carbon fibre substrate with ripple.

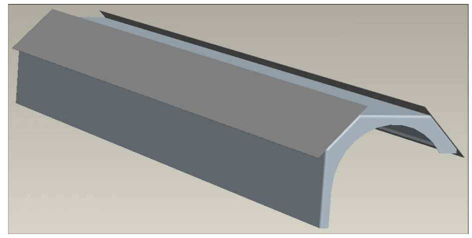

Figure 10: Illustration of half of a carbon fibre shell.

4 Future work

In addition to completing the studies on the above engineering models, alternative substrates and mounting schemes are under consideration. These include carbon fibre substrates, shell structures and double sided detectors using a foam substrate.

Figure 9 shows a carbon fibre substrate with a ripple effect along its length. This would increase the rigidity of the substrate across its width and would be tensioned to maintain its shape along its length.

Carbon fibre will also be investigated for use in shell structures as illustrated in Figure 10, with the first test carbon fibre shell structure under construction.

LCFI are also investigating the possibility of making double sided detectors using a foam substrate and the use of foams to make the shell structure.

References

[1] TESLA TDR, Part 4, A Detector for TESLA. http://tesla.desy.de/new/pages /TDR_CD/PartIV/detect.html

[2] Erg Materials and Aerospace Corporation, http://www.ergaerospace.com

[3] Aptek Industries Inc., http://www.aptekindustries.com