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DRAFT

Visit with Dan Peterson of Cornell

C. Lu, K.T. McDonald, W.R. Sands and A.J.S. Smith

Abstract

We visited Dan Peterson at Wilson Lab on Tuesday, April 30 and had a very fruitful 5-hour discussion with him on all aspects of drift-chamber construction and operation. Some of what we learned is summarized below. A supporting packet of xeroxes from the CLEO III TDR and the drift chamber review of 11/95 is available.

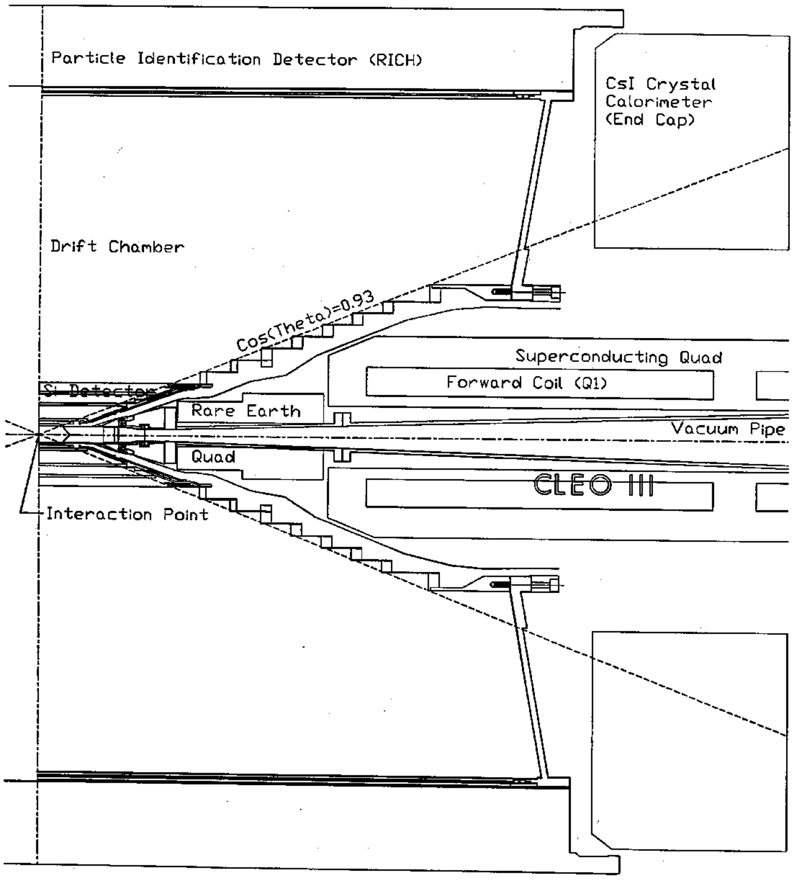

Figure 1: Half section of the CLEO III drift chamber, DR3.

1 Endplates

While the drift chambers of CLEO I and II, so-called DR1 and DR2, were simple right-circular cylinders, the CLEO III chamber, called DR3, has a complex form, shown in Fig. 1. The outer 31 wire layers are strung from conical endplates hogged out of a 6.5″-thick block of 6061-T561 aluminum. The remaining thickness at the wires is 0.6″. In detail, the cone consists of a series of ledges, one per layer. The inner 16 layers are strung off a series of rings that form a cone around the machine quadrupoles.

The conical endplate is stiffened with rather massive rings hogged out of the Al blank, as well as a very heavy stainless steel ring at the inner radius. The resulting endplate deflection will be 1 mm with the load supported only at the outer radius.

2 Drilling

Some 20 vendors were contacted. Alliance of Rochester, NY who drilled DR1 and DR2 are no longer in business. Another Rochester firm, Precise, appeared capable of the job but did not want it. The two final contenders were Brenner, of Croyden, PA (40 minutes from Princeton) and a firm in Manchester, England who drilled the ZEUS chamber.

A drilling sample of 900 holes on a $12'' \times 12''$ Al plate was obtained from both vendors to assess hole-placement accuracy. Brenner delivered all 900 holes with less than 0.002″ between specified and achieved hole centers. The Manchester plate had a bimodal distribution in hole error with one lobe centered at about 0.004″ offset. Brenner broke one bit during the 900-hole test.

While the Manchester bid was slightly lower in dollars Brenner was chosen, in part because of a more plausible program for stress relieving, because of their greater interest in the job, and because of their relative proximity. Job cost, including endplates and all rings and collars of the inner cones: $800k. Time elapsed during the vendor evaluation: 1 year. Award date: Sept. 1995. Anticipated delivery date: Nov. 1996-Feb. 1997.

Apparently it will be hard to get a U.S. vendor to bid on an accuracy of hole placement better than 0.003″ maximum offset between desired and achieved hole centers.

Brenner has a Browne & Sharpe 2305 CMM that can accommodate parts up to about 55″ (?); this is not quite large enough to measure the DR3 plates in a single pass. The contract is for measurement only of the sense wire holes.

The endplates are being hogged out on the same large Mitsubishi horizontal boring mill that will do the drilling. The drilling will be done in quarters. The drilling will be done in a 'snake' pattern within superlayers to maximize local hole placement accuracy. Drilling is performed from the inside surface to the outside.

Brenner's drilling technique uses a 3-flute twist drill at $\sim$ 5000 rpm without pecking or reaming. However, a spot drill is used first to start the hole, and to prepare a chamfered edge to the hole to minimize electric fields in the feedthrough bushings. Drill cooling is via a spray mister.

For comparison, both DR1 and DR2 endplates were made using gun drilling. The two DR2 plates were drilled together, inner faces touching. A relatively large number of drill bits broke off (Peterson recalls 100), requiring the hole to be drilled out and an insert used. Apparently there is little long-term problem with these inserts, but broken drills cause schedule delays. The contract should include statements about procedures in case of broken bits. Peterson does not like Locktite to be used to fix inserts.

The drill coolant should be chlorine free, and tested for compatibility in a small drift chamber.

3 Outer and Inner Cylinders

The outer cylinder is made in 8 panels consisting of 1/32″ Al skins around 3/16″ of polyethylene honeycomb. Two such panels supported test loads of 35,000 lbs before failure.

The joint between the endplates and the panels is a simple butt joint against a step in the endplate. Every four inches a 10-32 screw holds the cylinder to the plate. The gas seal is made with tape! This construction is also used for DR2, which has been holding a 60/40 He/propane gas mixture for the past six months without incident. The outer panels of DR2 were removed during a long shutdown in 1988 to facilitate wire repairs.

The DR3 wire pattern leaves out some field wires on the inner- and outermost layers. Clearing foils must therefore be inserted just inside the inner and outer cylinders.

The DR3 inner cylinder is not load bearing. It is made from 0.1″ Rohacell with 0.001″ Al foil skins for a total thickness of 0.15% X_0.

4 Feedthroughs

The DR3 feedthrough has 3 parts: a Vectra (?) plastic bushing with a collar, a copper tube, and a fine Al crimp pin with 0.006″ inner diameter. The electronics couples to the copper tube, not the Al pin.

The was a lot of trouble in DR2 with electrostatic breakdowns of the Ultem bushings used there; 200 failed over 10 years. The trouble was localized to the outer edge of the hole (which may have not been deburred well enough) and in the region of the tip of the crimp pin which was halfway between faces of the endplate.

The Vectra plastic is supposed to be better than Ultem against breakdowns (ZEUS). The edges of the feedthrough holes in the endplate will be chamfered (one face during machining, and the other by hand later). The new crimp pins extend 1 mm beyond the inner face of the chamber to lower the field between the pin and the endplate.

The feedthrough-hole-diameter tolerance is -0/+0.001″.

DR2 also has a large number of broken wires, essentially all the the crimps. It was determined long ago that copper crimp pins are too agressive mechanically for Al wire. Even with the Al crimp pins, the crimp must squeeze the wire symmetrically to minimize damage that can lead to breakage. Micrographs of sawed-off crimps dramatically showed large deformations of the crimp pin, and it's easy to imagine this as a source of trouble.

Because the crimp-pin inner diameter is much larger than the sense wire, there remains an ambiguity as to where the wire is located. Peterson prefers that the wires end up systematically along one side of the crimp pin, which might be achieved by a slight bend in the crimped end of the pin. (Perhaps more study required here.)

The gas seal of the feedthroughs is made by potting the entire endplate in Silastic. Simple but effective, and easy to repair.

5 Wire

The field wires are all 110-μm Al with 30 ± 10 μinch of gold over 10 μinch of Ni. Supposedly California Fine Wire will not guarantee good gold coverage at 20 μinch.

Micrographs of the gold wire showed pitting similar to that seen in our 80-μm wire samples, as well as occasional larger gouges likely due to handling. Peterson feels that this wire is good quality (stronger than it was 10 years ago and much less flaky), and is buying it as fast as he can in case California Fine Wire suddenly forgets how to make good wire. He has about 150,000$'$ so far.

Their wire acceptance tests now consist mainly of measurements of the breaking strength, and weighing to judge the gold thickness. They use crimp pins to hold the wire during the breakage tests.

6 Stringing

Apparently CLEO III has not committed to a stringing technique yet. The fallback is a repeat of the DR2 method: vertical stringing with semi-automatic wire feeding. Vanderbilt U. is working on a more fully automated vertical stringing scheme.

The modest final deflections of the endplate will be prestressed via tension rods inserted in occasional feedthrough holes. Eight bars hold the endplates apart during stringing.

7 Gas Ports

Gas flows in and out of the chamber via 8 ports in each of the large stainless-steel collars at the inner radii of the endplates.

8 Electronics Cooling

Only the preamps are on the endplate. DR2 cooled these with a nest of polyflow tubes carrying a freon refrigerant. The tubes were not in direct mechanical contract with either the electronics or the endplate, but cooled convectively across air gaps of a few mm.

Peterson has a very strong prejudice that the chamber must not suffer temperature gradients of more than about 1°/hour, to avoid broken wires. The CLEO hall has temperature regulation to about $\pm 5^\circ$ is large part due to this dictum.