CLAS
Region II Drift Chamber
Blue Ribbon Panel Review
22 November, 1993

Summary Report

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Abstract: *The CLAS Region II drift chambers are being built by Old Dominion University in collaboration with CEBAF. In order to proceed beyond the design stage we had a technical review. This report summarizes very briefly the design choices of the drift chambers and describes the suggestions and concerns of the reviewers. Look at the last page for a super-summary. The report was written by L. Weinstein with comments by the panel members and the collaborators.*

On November 22, 1993 a Blue Ribbon Panel reviewed the status of the CLAS Region II drift chamber project. The Panel consisted of Morris Binkley (FermiLab), Steve Dytman (Pitt), Stan Majewski (CEBAF), and Tom Markiewicz (SLAC). Those present for all or part of the review were Charles Hyde-Wright, Andi Klein, Sebastian Kuhn, Brian Raue, and Larry Weinstein (ODU) and Steve Christo, John O'Meara, John Robb, Walter Tuzel, Mac Mestayer, Bernhard Mecking, Gretchen Doolittle, Volker Burkert, Bogdan N, and Mikhail Kossov (CEBAF) and Rory Miskimen (UMass). The Region II drift chambers are being built by Charles Hyde-Wright, Andi Klein, Sebastian Kuhn, Brian Raue and Larry Weinstein of ODU with lots of help from Mac Mestayer, Steve Christo, John O'Meara, John Robb, Walter Tuzel, Bernhard Mecking, Amrit Yegneswaram and Gretchen Doolittle of CEBAF.

I. Bernhard Mecking gave an overview of the CLAS and Mac Mestayer gave an overview of the design choices of the wirechambers: Hexagonal cells, segmented superlayers, moderate gain, 6^o stereo wires, low wire tension, perpendicular feedthrus, 20μ W sense wires, 140μ Al field wires, Ar/ethane or He/ethane gas and onboard preamps.

Issues raised:

Electrostatic instability of guard wires?

Wire creep under tension? SLD tests indicate some creep that can be compensated for by using a higher initial wire tension.

Chamber aging tests done (mostly to test field wire diameter). ≈ 0.3 Cu/cm gave less than 5% effects. Field wires have 20 kV/cm E field at surface. (SLD has 50 kV/cm). High E fields give too much secondary emission.

Gas: H traps, RGA in gas stream. Might want to bubble the gas thru either H_2O (needs a catcher to not foul molecular sieves) or alcohol (can dissolve glues and gum up filters). Ethane impurities caused trouble previously (Ethylene, HS). Need to remove these. SLD uses He/CO_2/Isobutane (9%) (nonflammable). This would be too slow for us. He/ethane is less sensitive to B field than Ar/ethane (drift velocity slower than Ar/ethane for low field and comparable for high field). He also gives less multiple scattering (good) and less dE/dx (bad).

Background: $\approx 3 \cdot 10^6$ Hz hadronic interaction rate for the entire CLAS. Low energy γ rate much higher (but they don't make tracks) and angle dependent. Minitoroid traps low energy electrons. He much less sensitive to x-rays than Ar.

II. Brian Raue (ODU) then presented the Region II design.

II.1 Endplates:

Endplate contours: Two endplates, one bolted to one cryostat, the other affixed to the opposite cryostat with springs and bearings. One endplate is flat, the other has a step at back angle to accommodate a step in the cryostat. This gives a 4% loss of acceptance at the step. There is no loss of acceptance forward of 47^o.

The endplates are 2 cm thick. This is a compromise between active area and rigidity (gives a maximum of 0.5 mm deflection under wire tension and endplate weight).

Question of G-10 vs Stesalit. Stesalit 4411-W is a proprietary fiberglass-resin composite material with randomly oriented fibers for maximum machinability. There are several reports of aging problems with G-10. These might be due to surface coatings (mold release agents). *Do not use FR4.* Pure G10 (w/o FR4) is hard to get. Sauli says G-50 is OK. Stesalit (the company) can put a 50μ lacquer on the Stesalit (material) to seal it. Stesalit might have significantly cleaner holes which is crucial for feedthrus. *Check this!*

No consensus on which material. SM likes Stesalite, MB sees no problem (probably) with G-10. TM thinks both materials should work. MB worried about dimensional stability. Would want some surface coatings: lacquer sealant and then a slightly conductive layer to dissipate charge. The conductive layer is likely to be messy and poorly controlled. Need to test surface coatings. Use N_2 laser for testing to make predictable tracks. Prototype this and test the rate dependence. Steve Dytman suggested carbon composite endplates. These would be conducting and probably much too expensive.

Machining tests: Stesalit and G-10 appear to have similar machining accuracy (as done by a local machine shop). Needs to be better measured.

Strength test: BR put a 1" diameter bar thru a hole in a Stesalit plate and hung 45 kg from the bar 1 m from the plate. This applied a torque. This did not damage the plate or deform it permanently.

The prototype chamber appears to be efficient 1.3 cm from the endplate. *but where does the drift velocity become regular and the resolution become good?*

What is the charging up time of the endplates? What is the level of stability? Surface coating to prevent charging up? Surface coating or copper traces to control field lines on the endplate? We need to test this with the prototype chamber.

With only 12 layers, we chose to have 6 layers in each of two superlayers (for redundancy in each superlayer) rather than 4 layers in each of 3 superlayers (X, U, V to identify tracks in a high multiplicity environment).

Make sure that HV circuit boards do not cover pretensioning wire locations.

II.2 Wire positioning:

We use flared tubes (trumpets) to position the wires at the endplate. The trumpets are placed into bare holes. The trumpets are positioned to the same height to within $\sigma = 1$ mil. This alignment prototype had no special hole edge treatments. Cost about $0.7 per wire end for feedthru hardware. Wire position should be about 1.5 mil (1 σ) [We haven't measured wire positions yet] – one cell drift resolution is about 6 mils (1σ).

We use plastic inserts glued in to the wire holes to hold the crimp pins. The crimp pins are identical to the region III crimp pin.

SD is still nervous about this. Back flare the trumpet to center the trumpet rear? Want a mechanical stop for the plastic inserts. Don't depend entirely on glue. Cold fit plastic inserts? Is the 3 mil "lip" of the plastic insert enough to hold the crimp pin (RIII uses 1 mil). Need to minimize total (parts plus labor) cost of wire stringing.

Quality control of ALL pieces is critical! Measure everything. SLD looked at **every** hole, trumpet and wire. This is a nontrivial effort (examination plus record keeping).

II.3 Spring fastening:

One endplate bolted and pinned to the cryostat. The other will be fastened with springs and located by bearings. Two bearings per endplate. The bearings will each be a two-axis hinge. *Should the two bearings have colinear axes?*

How do we locate the wires after tension is transferred? What about the transverse forces from the stereo wires? – These need to be taken up by the bearings. Will the bearings 'fight' against the bow and stern plates? Safety precautions in removing the posts? (Don't drop them onto the chamber below.)

Need at least ±4 mm free travel (both directions) from the nominal installed position.

BUILD SEVEN SECTORS. The first one you build will always be inferior.

II.4 Chamber assembly / layup

4 trapezoids fixed in 3-space. Align once, then assemble endplates on them. Design still conceptual.

BM – hard to do this. Want to connect the two center traps to make a rigid structure. This constrains relative endplate motion and the other two traps prevent endplate sag.

We need to design this and choose the easiest method.

Precision bow plate?

Stern plate not precise.

Is Stesalit dimensionally stable? Hygroscopic?

II.5 Gas bag attachment:

Gas: $O_2 < 50$ ppm.

Gas bag: 0.6 mil aluminized nylon. Better vapor barrier than mylar. Doesn't tear, stretches instead. Will bow 3" in region III. *Is 0.6 mil enough for safety? It is no good as an RF shield.*

Consider two windows with a separate gas supply to the intermediate region. This gives two gas seals with twice the safety. We could have one bag on the endplate and the other sealing the cryostat. This would also give some RF shielding.

Bubble chamber gas thru alcohol or water (0.2 – 0.8% to reduce aging). Alcohol dissolves conductive epoxy (what else?) *test this!*

Fermilab uses a molecular sieve to remove H_2S from ethane.

Don't let too much He escape. It kills PMTs. Flush around PMTs with N_2?

III. Electronics (presented by Charles Hyde-Wright)

Capacitively ground **all** *HV as much as possible to eliminate cross-talk. It should have more capacitance than the sum of the wires. Capacitively couple HV (field wires) to the HV bus board ground. Connect the HVBB ground to the STB ground.*

SIPPs: 2 mV/μA preamps mounted on PC boards on the endplates.

RC circuit between field and sense wires. C fixed by the maximum current on the wire (should be small – 2 nF or less), R fixed by the time constant of the HV system.

20 m signal cable degrades the rise time from 4 ns to 8 ns.

SLD has two test lines: DAC charges a capacitor on the board, stop pulse discharges it. Gives time and pulse height with two input lines. Uses capacitors, not transformers.

No ground connection from electronics to the chamber.

Power generation on board: 30 mW/channel. *Need to control the temperature since the drift velocity is not saturated throughout the cell. What accuracy? 1° C?* Need to control the board heat and the gas heat. *Too much heat to remove by blowing gas over it? Put in a cooling loop? Where?*

Test all the capacitors first. 24 hour test. Need long term tests in adverse temp and humidity (at least a few capacitors per batch).

SLD used steel crimp pins for W wire and Al crimp pins for Al wire. The Al crimp pins were very mechanically weak at the crimp. They also have one buried crimp pin and one unburied one per wire.

Will we really be able to fit all of the STB traces on 2 layers?

IV. General comments

PROTOTYPE EVERYTHING!

Add 2 cm to endplate for contingencies.

irradiate the paramecium (single celled prototype)

test the spring safeguards somehow

make sure the wires are stretched enough to maintain the tension.

Test wire tension as much as possible.

Quality Control

Build seven sectors.

Check gas seal with lab safety committee; flammable gas escaping thru feedthrus?

Capacitively couple all HV

temperature control

test capacitors

RF shielding

Mechanical stop for plastic insert

Do mechanical stress test on G-10

Use a Nitrogen laser to ionize a predictable track in the gas.

Measure dimensional stability. Put samples in a pressure cooker and measure dimension changes.

Wire creep under tension?

Gas mixture, bubbling?

2 gas seals?

Efficiency of wire near endplate. Drift velocity near endplate.

Charging of endplates? Stability? Surface coating?

ϕ-dimension precision poor. Ministagger?

Test everything.

Super summary:

- The region II drift chamber is in good shape. Many issues are under control. Still many questions unanswered.
- Ideally prototyping would be done prior to endplate procurement. The schedule does not permit this.
- Prototyping (making a 7^{th} chamber) is key to resolving outstanding issues.
- Major open questions / concerns:
  - spring system (test design)
  - forces due to stereo wires
  - wire tension (too low?) and wire creep under tension
  - the feedthrus (recheck accuracy and reliability)
  - choice of Stesalit vs G-10 (need to use Stesalite due to impossiblility of prototyping)
  - questions of gas mixture / gas purity
  - charge buildup / endplate conductivity / surface treatment
  - actual wire position precision
  - gas leakage/safety
  - RF shielding
  - grounding / capacitive coupling of HV wires
  - cooling
  - electronics board designs
- **Prototype!** Need one full-sized (but not fully instrumented) prototype ASAP
- Systematic quality control for manufacturing is required.
- Manpower for extensive testing, prototyping and quality control is needed.