Summary of DTL tank 3 BPM pickups

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Introduction

The two BPM pickups now in DTL tank 3 have a variety of defects, many of which are due to a tight delivery schedule that did not allow time to complete a prototype cycle. The pickups now installed in DTL3 *are* the prototypes. The most serious defect is damaged cables. Although they can be used to measure beam position and probably phase, they will never perform as well as they could.

Recommendation: *Fabricate new drift tubes and new BPM pickups. Install after DTL tank 3 is delivered to ORNL but before it sees beam.*
Estimated cost: *$20k for each drift tube, $8k for each BPM, some labor for qualifying the BPMs and swapping out the old ones.*

Details

The following paragraphs detail the problems we've experienced with these pickups.

Electrode ridge

The "ridge" on the end of the electrodes where they connect to the vacuum feedthrough are too large, due to a design oversight.
Impact: *This degrades the high frequency performance of the BPM a little, but the BPM still meets requirements. These BPMs may have slightly different mapping coefficients than the others.*

Vacuum feedthroughs

The vacuum feedthroughs were difficult to weld in, and the success rate was poor. The design has now been changed. Several feedthroughs were cut out and replaced. The BPMs are leak tight, so the cutting and re-welding were successful. The housing did not suffer in any measurable way.
Impact: *Probably none.*

Drift tube welds

When the BPMs were welded into the drift tubes, a slot was accidentally burned into the bore of one of the drift tubes, near the nose cone end. A new extension tube was fabricated for the BPM pickup. The other BPM had a vacuum leak at the joint with the drift tube nose cone. The design of this joint has now been changed.

Impact: *Probably none.*

Drift tube stems

After the BPM is welded into the drift tube, the next step was to weld the water cooling tubes from which the drift tube will eventually be suspended in the DTL. During this process the oval inner tubes were bent on both units. In one case (DT #3-8) a portion of the inner tube had to be cut off about 3 inches above the water diverter and a new one welded on. The stem on the other BPM (DT #3-2) had a leak where the water cooling tubes attach to the drift tube body. Subsequent TDR checks, (see, e.g., Figs. 1-5) showed that the BPM cables inside the stems were damaged, most likely during these repair operations, although there is a slight possibility that the damage occurred during the earlier welding operations for the initial attachments of the water cooling lines. The TDR pulses also exhibited rounded off rather than sharp corners, indicating degraded high frequency performance.

Impact*: The BPM system self calibrates by injecting a pulse at the signal processor end and looking at the reflection. Some reflections will occur at the cable defects rather than at the shorted ends of the electrodes. The electronics will not be able to self calibrate. Manual calibration will be necessary. Rather than continuous calibration, the BPMs can only be calibrated whenever someone goes down into the beam tunnel and performs a manual calibration. Also, the pickup performance may not be stable and position and phase measurement results may be the first to be questioned when there are any measurement problems.*

Deformed electrodes

During the drift tube stem repairs a plug was inserted inside the BPM and tightened down to the point where the electrodes are now permanently deflected. Measurements indicate deflections up to 0.02 inches. We are concerned about the electrical performance and damage to the vacuum seal. The vacuum seal is probably OK since the center pin on the 90-degree Kaman feed through used in the DTL BPMs is somewhat different from the standard Kaman feedthrough. It is supported by a captive bead rather than imbedded in a glass seal. During the electrode deformation the bead should have taken the load from the electrode deformation. It is therefore likely that the copper center pin deformed a little and that the vacuum seal is undamaged. Subsequent leak checks have shown the seals to still be leak tight.

Impact: *Different mapping and phase calibrations compared with the other DTL BPMs. Possible damage to the vacuum feedthroughs that may not show up for some time, although mechanical engineering experts don't think this is likely.*

Cable lengths

During the cable matching procedure one cable on DTL #3-8 was cut too short. It is now 180 deg. shorter than all the other cables.

Impact: *This can be corrected for in the short patch cables that go from the top of the drift tube stem to the DTL tank interface bracket.*

Summary

The DTL tank 3 BPMs have been repaired several times at various stages of the manufacturing and installation processes. Except for the cable damage that occurred during the drift tube stem repairs, the individual repairs are relatively minor. But taken as a whole their weight becomes significant. The cable damage will cause maintenance difficulties and degraded performance for the lifetime of the SNS facility. Although the BPMs will function at a minimal level, we believe it is best to fabricate new BPMs and new drift tubes, and to replace the drift tubes after the DTL tank is delivered to ORNL but before it sees beam.

We have checked on the time needed to supply replacement units. It will take about 5 weeks ARO to get two more drift tubes made (assuming the order is placed soon). We can take two DTL BPMs from the present assembly process without impacting any BPM deliveries needed for the other DTL tanks. The bottom line is that we can have two new drift tubes with BPMs delivered to ORNL by around the beginning of August if the decision to proceed down this path is made in the next week.

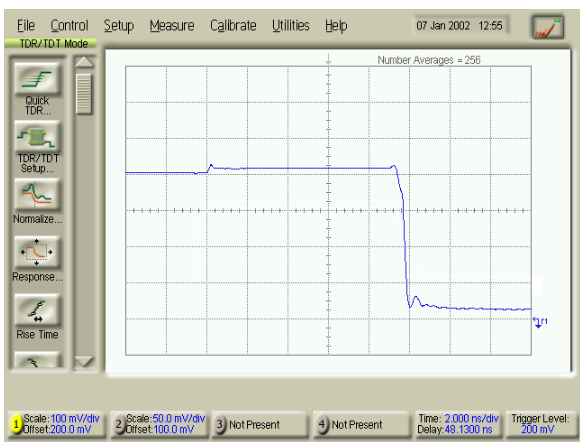

Figure 1. Calibrated TDR trace of 3_2 right lobe cable prior to welding. The cable is undamaged.

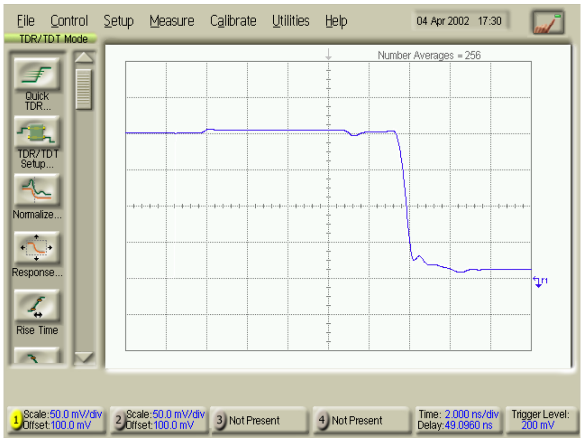

Figure 2. Calibrated TDR trace of 3_2 right lobe cable after welding as delivered to LANL. Damage to the cable can be seen in the region where the stem is welded to the drift tube body.

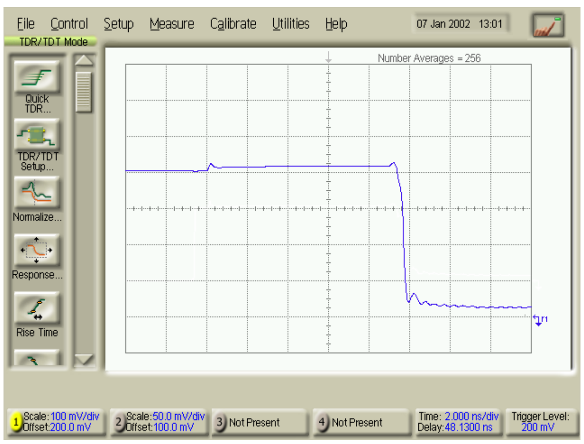

Figure 3. Calibrated TDR trace of 3_8 bottom lobe cable prior to welding. The cable is undamaged.

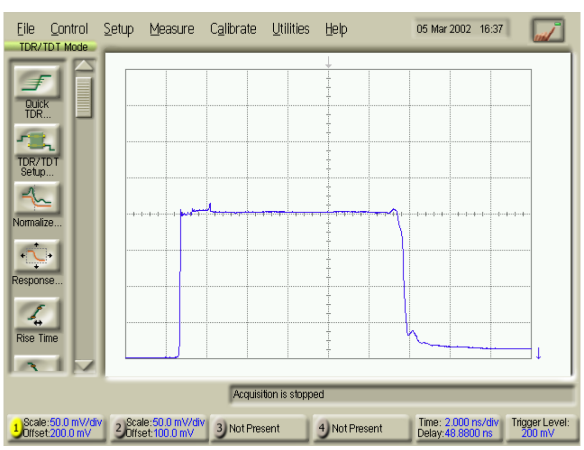

Figure 4. Un-calibrated TDR trace of 3_2 bottom lobe cable after welding and stem repair as observed at Continental Machine Shop. The cable connectors had been removed in the repair so the TDR could not be properly calibrated. The cable appears to be undamaged at this point.

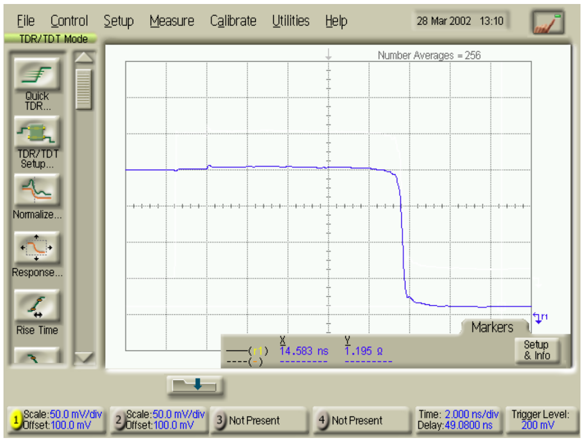

Figure 5. Calibrated TDR trace of 3_8 bottom lobe cable as delivered to LANL. Unusual high-frequency losses near the lobe-end of the cable are unexplained, but indicate undesirable changes in the cable transmission characteristics at 805 MHz (as observed in the S11 network analyzer data).